ISUZU

GMC
MEDIUM DUTY TRUCKS

MEDIUM DUTY TRUCKS

ISUZU COMMERCIAL TRUCK
FORWARD
TILTMASTER

NPR/NPR-HD/NQR/NRR

W3500/W4500/W5500/W5500HD

(DIESEL ENGINE)

SERVICE MANUAL
(2006)

GENERAL INFORMATION

General Information

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Cautions and Notices

Battery Disconnect Caution

Caution:
Before servicing any electrical component, the ignition key must be in the LOCK position and all electrical loads must be OFF, unless instructed otherwise in these procedures. If a tool or equipment could easily come in contact with a live exposed electrical terminal, also disconnect the negative battery cable. Failure to follow these precautions may cause personal injury and/or damage to the vehicle or its components.

Fuel Tube Caution

Caution:
In order to reduce the risk of fire and personal injury observe the following items:

- Replace all nylon fuel tubes that are nicked, scratched or damaged during installation, do not attempt to repair the sections of the nylon fuel pipes.
- Do not hammer directly on the fuel harness body clips when installing new fuel pipes. Damage to the nylon tubes may result in a fuel leak.
- Always cover nylon vapor pipes with a wet towel before using a torch near them. Also, never expose the vehicle to temperatures higher than 115°C (239°F) for more than one hour, or more than 90°C (194°F) for any extended period.
- Apply a few drops of clean engine oil to the male pipe ends before connecting fuel pipe fittings. This will ensure proper reconnection and prevent a possible fuel leak. (During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.)

Road Test Caution

Caution:
Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury and vehicle damage.

Safety Glasses Caution

Caution:
Wear safety glasses in order to avoid eye damage.

SIR Caution

Caution:
This vehicle is equipped with a Supplemental Inflatable Restraint (SIR) System. Failure to follow the correct procedure could cause the following conditions:

- Personal injury
- Unnecessary SIR system repairs

In order to avoid the above conditions, observe the following guidelines:

- Refer to SIR Component Views in order to determine if you are performing service on or near the SIR components or the SIR wiring.
- If you are performing service on or near the SIR components or the SIR wiring, disable the SIR system. Refer to Disabling the SIR System in SIR.

Vehicle Lifting Caution

Caution:
To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed.

Belt Dressing Notice

Notice:
Do not use belt dressing on the drive belt. Belt dressing causes the breakdown of the composition of the drive belt. Failure to follow this recommendation will damage the drive belt.

Fastener Notice

Notice:
Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Fasteners requiring replacement or fasteners requiring the use of thread locking compound or sealant are identified in the service procedure. Do not use paints, lubricants, or corrosion inhibitors on fasteners or fastener joint surfaces unless specified. These coatings affect fastener torque and joint clamping force and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems.

Fuel Injector Balance Test Notice

Notice:
Do not repeat any portion of this test before running the engine in order to prevent the engine from flooding.

Sealant Notice

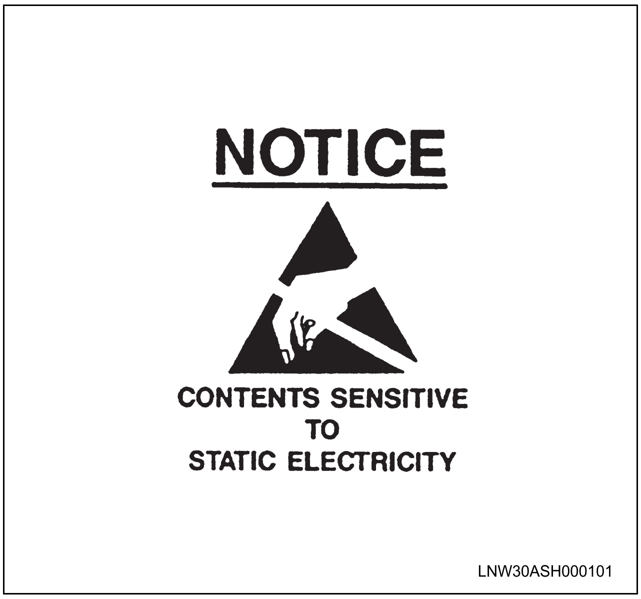
Notice:
Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.

General Information

Handling Electrostatic Discharge (ESD) Sensitive Parts

When handling an electronic part that has as ESD sensitive sticker, the service technician should follow these guidelines to reduce any possible electrostatic charge build-up on the service technician's body and the electronic part in the dealership:

1. Do not open the package until it is time to install the part.
2. Avoid touching the electrical terminals of the part.
3. Before removing the part from its package, ground the package to a known good ground on the vehicle.
4. Always touch a known good ground before handling the part. This should be repeated while handling the part and more frequently after sliding across the seat, sitting down from a standing position or walking a distance.



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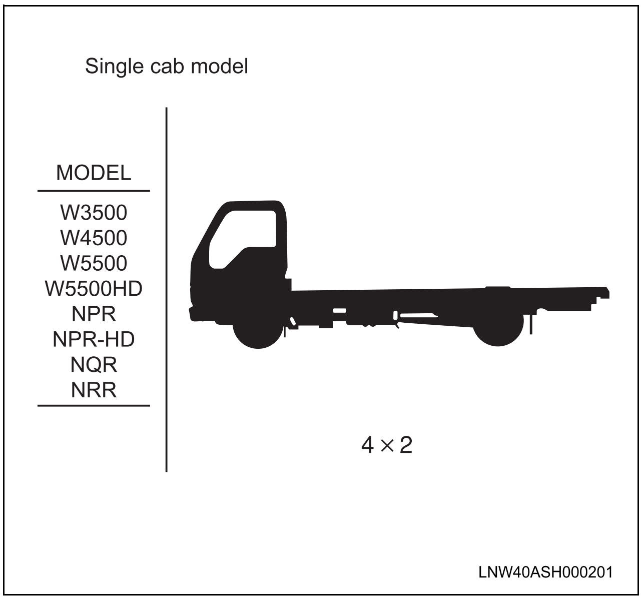
Model Reference

The model covered in this manual are referred to as a NPR, NPR-HD, NQR, NRR. (W3500, W4500, W5500, W5500HD)



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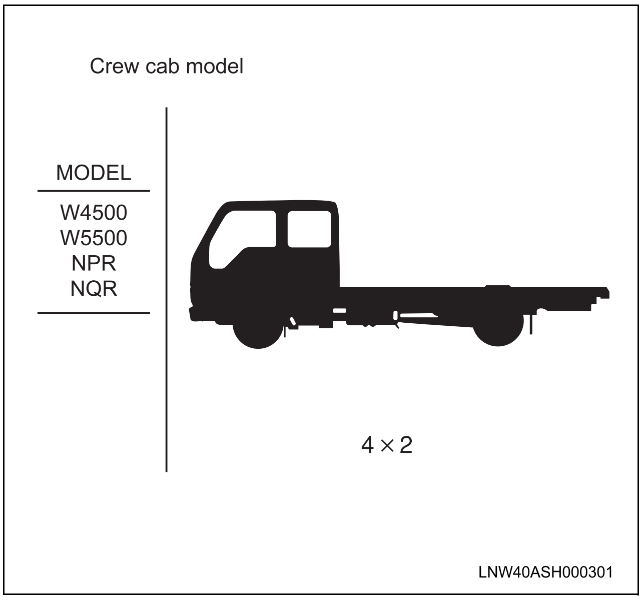

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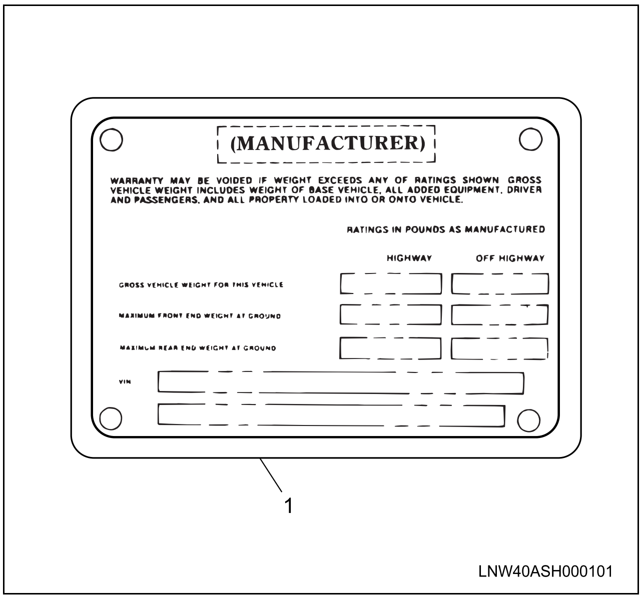
VIN (Vehicle Identification Number) and Weight Rating Plate

The VIN and Weight Rating Plate (1) lists the manufacturer, gross vehicle weight for the vehicle, maximum front end weight at ground, maximum rear end weight at ground, and the VIN (vehicle identification number). This plate is attached to the pillar above the shoulder belt hole on the driver’s side.

The vehicle identification number is a legal identifier of your vehicle. It not only appears on the VIN plate, but also on the Vehicle Certificates of Title and Registration. The vehicle identification number specifically identifies a vehicle by code.



Legend

1. VIN and Weight Rating Plate

Vin Chart

Position	Definition	Character	Description	
			Make	Type
1–3	World Manufacturer Identifier	JAL	ISUZU	Type: Incomplete Vehicle – Medium & Heavy Duty
		J8B	CHEVROLET	Type: Incomplete Vehicle – Medium & Heavy Duty
		J8D	GMC TRUCK	Type: Incomplete Vehicle – Medium & Heavy Duty
4	GVWR and Brake System	B, C, E	B: 10,001-14,000 lbs HYD Brake C: 14,001-16,000 lbs HYD Brake E: 16,001-19,500 lbs HYD Brake	
5	Series Code	4, 5	4: W3500, W4500, NPR / NPR-HD 5: W5500, W5500HD, NQR / NRR	
6	Cab Type Code	B, J	B: Steel Tilt Cab 67 inch Bumper to Back of Cab J: Non Tilt Cab 108 inch Bumper to Back of Cab	
7	Chassis Type Code	1	4 × 2	

Position	Definition	Character	Description
8	Engine Code	6	Isuzu 4HK1-TC
9	Check Digit	*	Check Digit
10	Model Year Code	6	6: 2006
11	Plant Code	7	7: Fujisawa
12	Sequential Numbers	0	Sequential Numbers
13		0	
14		0	
15		0	
16		0	
17		1	

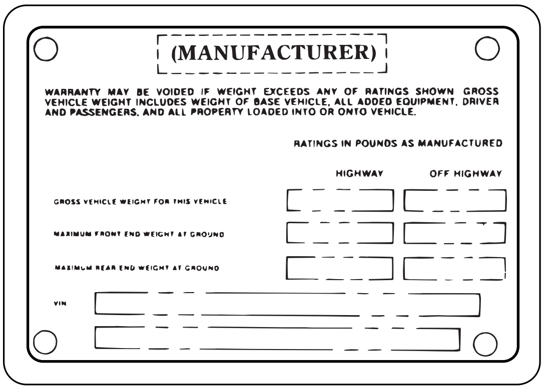
GVWR (Gross Vehicle Weight Rating)

The GVWR is the weight of a vehicle plus the weight of a vehicle’s load. For the gross vehicle weight rating and the gross vehicle combined weight rating, refer to Model Explanation. For the gross vehicle weight rating range refer to the VIN Chart.

Service Parts Identification Label

The "Service Parts Identification" label lists major components and their part numbers plus vehicle options and their codes. The information on the label was printed at the factory; therefore, it represents only the equipment on the vehicle when it was shipped from the factory. **Always** refer to this label when ordering replacement service parts. (Refer to the "NOTICE" on the label.)

The service parts identification label is located on the right-hand step support panel.



WARRANTY MAY BE VOIDED IF WEIGHT EXCEEDS ANY OF RATINGS SHOWN GROSS VEHICLE WEIGHT INCLUDES WEIGHT OF BASE VEHICLE, ALL ADDED EQUIPMENT, DRIVER AND PASSENGERS, AND ALL PROPERTY LOADED INTO OR ONTO VEHICLE.

LNW40ASH000401

Regular Production Options (RPO) Code List

The RPO list contains RPOs available on this model. Also, refer to the Service Parts Identification label for a list of the RPOs used on each specific vehicle.

OPTION CODE	OPTION DESCRIPTION
100	INTERIOR-TRIM COLOR COMBI. (IN WHITE)
153	INTERIOR-TRIM COLOR COMBI. (GRAY)
729	BODY COLOR CODE-ARC WHITE (W301-P801)
890	BODY COLOR CODE-MARINE BLUE (4040-P2)
800	BODY COLOR CODE-IN WHITE
D94	PAINT-TOUCH-UP, ONE COLOR
VG1	WAX-PROTECTIVE UNDERBODY
RWC	CANADIAN EQUIPMENT
YL3	FRIGID ZONE KIT
6JJ	DEALER INSTALLATION OPTION
6FM	US TERRITORY
RQF	GVWR CLASS-3 (10001-14000 LBS)
RQG	GVWR CLASS-4 (14001-16000 LBS)
RQH	GVWR CLASS-5 (16001-19500 LBS)
RQQ	GVWR CLASS-5 (18001-19500 LBS)
7NQ	VEHICLE CATEGORY-NQR
6FZ	FENDER COVER
RWZ	CAB-TILT, MANUAL
EK7	MARK-VEHICLE NAME

OPTION CODE	OPTION DESCRIPTION
6JS	SEAT BELT EXTENSION
D20	SUNVISOR-CO-DRIVER SIDE
C41	HEATER & DEFROSTER
C60	AIR CONDITIONER-MANUAL CONTROL
C55	VENTILATOR-ROOF
F59	STABILIZER SHAFT-FRONT
G73	AXLE REAR-HEAVY DUTY
6CP	AXLE REAR-HEAVY DUTY VAR.2
GV1	FINAL DRIVE GEAR RATIO-5.571 (39/7)
HC6	FINAL DRIVE GEAR RATIO-4.556 (41/9)
RU1	FINAL DRIVE GEAR RATIO-5.125 (41/8)
R41	FINAL DRIVE GEAR RATIO-5.857 (41/7)
S7C	FINAL DRIVE GEAR RATIO-4.300
7QQ	BRAKE SYSTEM-HYDRO BRAKE BOOSTER
NF8	EXHAUST-BRAKE
J52	BRAKES-FT DISK, MULTIPLE PISTON
6PH	BRAKE-WHEEL LOCK CONTROL, (L.S.P.V)
JE5	ANTI LOCK BRAKE SYSTEM
RJS	ENGINE-DIESEL 4CYL L 5.2L 4-VLV (4HK1)
K30	CRUISE CONTROL-AUTOMATIC
K51	TURBO CHARGER
KJ3	AIR INTAKE SYSTEM; RR VERTICAL
6PL	INTERCOOLER
8AA	LONG LIFE COOLANT (50%)
6HT	HEATER-OIL PAN
K05	HEATER-ENGINE BLOCK
RNJ	AUTOMATIC TRANSMISSION 4-SPEED (AISIN)
RSF	MANUAL TRANSMISSION 6-SPEED (MZZ6U)
M11	SHIFT-FLOOR (REMOTE)
V66	POWER TAKE OFF-PROVISIONS FOR
NL7	FUEL TANK-125L, 33GAL
6HU	FUEL SEDIMENTER-WITH HEATER
N33	STEERING COLUMN-TILT TYPE (WITH TELESCOPIC)

OPTION CODE	OPTION DESCRIPTION
N40	STEERING-POWER
ASQ	F/TIRE215/85R16-E, R/TIRE215/85R16-E F&R/DISC 16X6K-127 w/DOT MARK WHITE DISC, (BS BRAND, R187)
AZF	F/TIRE 215/85R16-E, R/TIRE 215/85R16-E F&R/DISC 16X6K-128 w/DOT MARK WHITE DISC (ALL SEASON)
BYS	F/TIRE 215/85R16-E, R/TIRE 215/85R16-E F&R/DISC 16X6K-127 w/DOT MARK WHITE DISC (MICHELIN BRAND, XPS)
CQR	F&R/TIRE 225/70R19.5, F&R/DISC 19.5X6.00-127 WHITE
R46	SPARE TIRE & DISC WHEEL VAR.1
7NC	SPARE TIRE & DISC WHEEL-LESS
P10	CARRIER-SPARE WHEEL (TRUCK)
U01	LAMPS-FIVE, ROOF MARKER
6GZ	RADIO-AM/FM STEREO ETR 2-SPEAKERS
6VL	AM/FM w/CASSETTE 2SP 31N-1
U73	ANTENNA
7FK	SPEAKER OPTION: 2-SPEAKER
C13	WIPER-WITH INTERMITTENT
NB6	EMISSION SYSTEM-CALIFORNIA

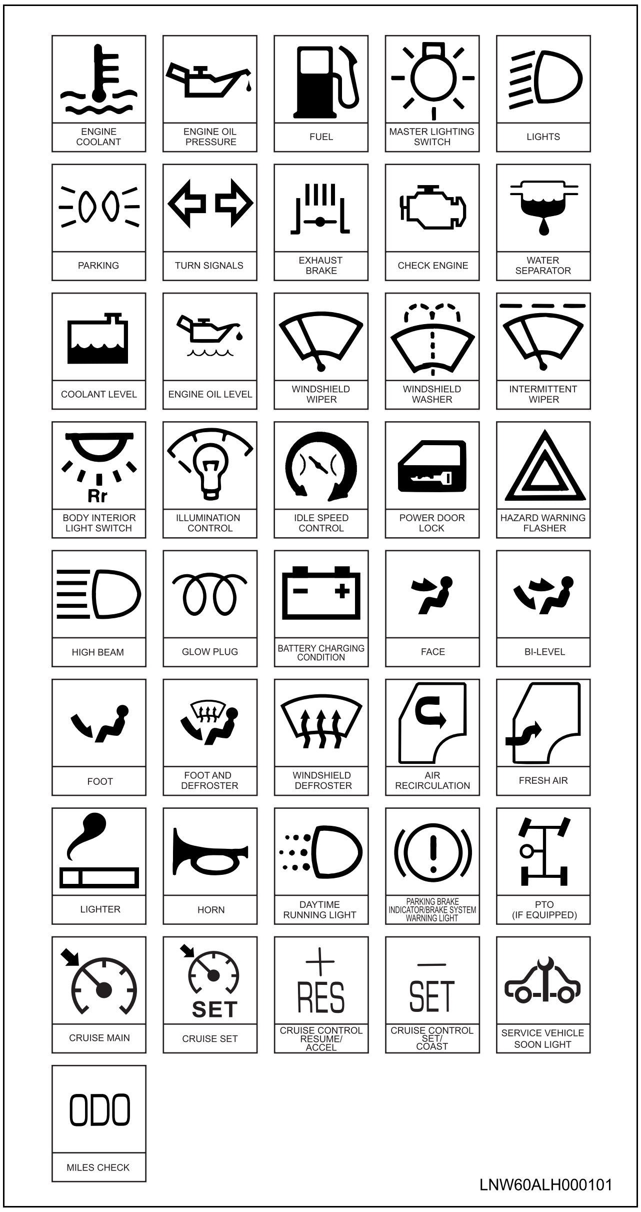
Note; F=Front, R=Rear, w/=With

Engine Serial Number

The engine serial number is located on a boss on the left, rear of the engine block above the oil filter.

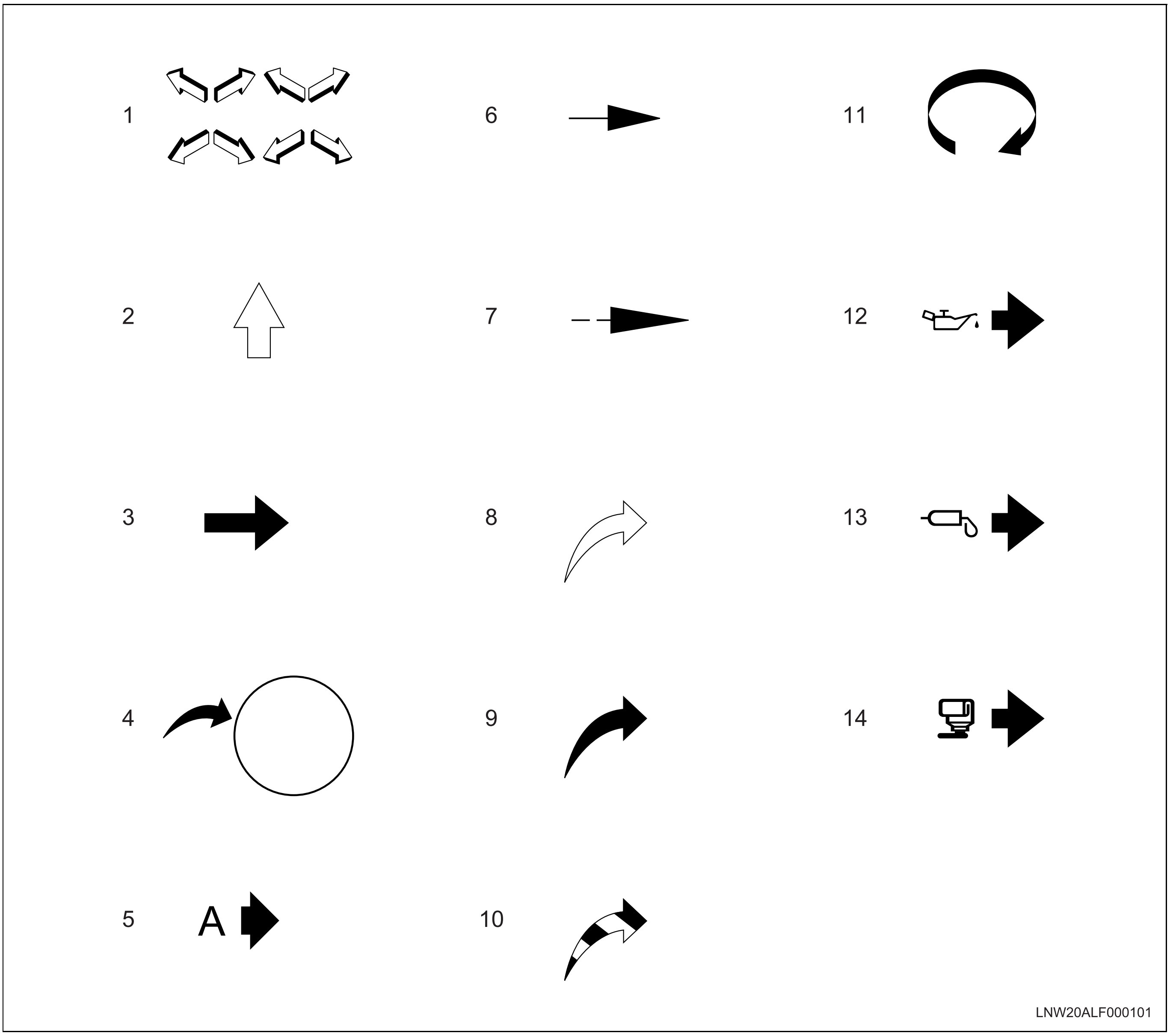
Graphic Symbols

Graphic symbols are used on some controls and displays on the vehicle. Many of these symbols are used internationally.



Arrows and Symbols

This service manual uses various symbols in order to describe different service operations.



Legend

1. Front of Vehicle
2. Up Side
3. Task Related
4. View Detail
5. View Angle
6. Dimension
7. Sectioning
8. Ambient/Clean Air Flow or Cool Air
9. Gas other than Ambient Air or Hot Air Flow
10. Ambient Air Mixed with Another Gas
11. View Angle
12. Lubrication Point Oil or Fluid
13. Lubrication Point Grease
14. Lubrication Point Liquid Gasket

Emergency Starting a Vehicle Due to Discharged Battery

If your vehicle will not start due to a discharged battery, it can often be started by using energy from another battery–a procedure called "jump starting."

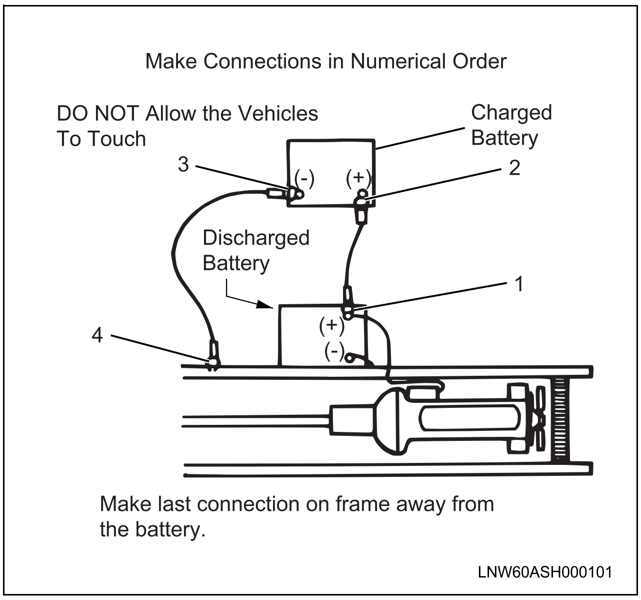
This vehicle has a 12volt starting system and a negative ground electrical system. Be sure that the other vehicle also has a 12volt starting system, and that it is the negative (black "–") terminal which is grounded (attached to the engine block, chassis or frame rail). Its owner's manual may give you that information. DO NOT TRY TO JUMP START IF YOU ARE UNSURE OF THE OTHER VEHICLE’S VOLTAGE OR GROUND (OR IF THE OTHER VEHICLE’S VOLTAGE AND GROUND ARE DIFFERENT FROM YOUR VEHICLE).

Notice:
Never tow the vehicle to start, because the surge forward when the engine starts could cause a collision with the tow vehicle. Also, this vehicle has 12volt batteries. Be sure the vehicle or equipment used to jump-start your engine is also a 12volt. Use of any other system may damage the vehicle's electrical components.

Jump Starting Instructions

Caution:
Batteries produce explosive gases, contain corrosive acid, and supply levels of electrical current high enough to cause burns. Therefore, to reduce the risk of personal injury when working near a battery:

- Always shield your eyes and avoid leaning over a battery whenever possible.
- Do not expose a battery to open flames or sparks.
- Be sure any batteries, that have filler caps, are properly filled with fluid.
- Do not allow battery acid to contact eyes or skin. Flush any contacted area with water immediately and thoroughly, and get medical help.
- Follow each step in the jump starting instructions.



1. Position the vehicle with the good (charged) battery so that the booster (jumper) cables will reach but never let the vehicles touch. Also, be sure the booster cables to be used do not have loose or missing insulation.
2. In both vehicles:
   - Turn off the engine control switch and all lights and accessories except the hazard flasher or any lights needed for the work area.
   - Apply the parking brake firmly, and shift the automatic transmission to Park or manual transmission to Neutral.
3. Make sure the cable clamps do not touch any other metal parts. Clamp one end of the first booster cable to the positive "+" terminal on one battery, and the other end to the positive terminal on the other battery. Never connect "+" to "–".
4. Clamp one end of the second cable to the negative "–" terminal of the good (charged) battery and the final connection (to any solid, stationary metallic object) on the engine at least 450 mm (18 in) from the discharged battery; or the frame rail, chassis or some other well-grounded point, if the battery is mounted outside the engine compartment. Make sure the cables are not on or near pulleys, fans, or other parts that will move when the engine is started.
5. Start the engine of the vehicle with the good (charged) battery and run the engine at a moderate speed for several minutes. Then, start the engine of the vehicle that has the discharged battery.
6. Remove the jumper cables by reversing the above installation sequence exactly. While removing each clamp, take care that it does not touch any other metal while the other end remains attached.

Towing Procedure

Proper equipment must be used to prevent damage to vehicles during any towing. State and local laws that apply to vehicles in tow must be followed.

- Vehicles should not be towed at speeds in excess of 55 mph (90 km/h).
- Connect to the main structural parts of the vehicle.
- DO NOT attach to bumpers, tow hooks or brackets.
- Use only equipment designed for this purpose.
- Follow the instructions of the wrecker manufacturer.
- A safety chain system must be used.
- The procedures below must be followed when towing, to prevent possible damage.

Front End Towing (Front Wheels Off Ground)

Before Towing

To prepare a disabled vehicle for front end towing with front wheels raised off ground, the following steps are necessary.

- Block the wheels and disconnect the propeller shafts at the rear axle. Secure the propeller shaft to the frame or cross-member.

Notice:
Never tow the vehicle with propeller shafts connected; this may cause damage to the automatic transmission.

- Provide wood blocking to prevent towing chain and bar from contacting the bumper.

- If there is damage or suspected damage to the rear axle, remove the axle shafts. Cover the hub openings to prevent the loss of lubricant or entry of dirt or foreign objects.

After Towing

- Block the rear wheels and install the axle and propeller shafts if removed.
- Apply the parking brake before disconnecting from the towing vehicle.
- Check and fill rear axle with oil if required.

Front End Towing (All Wheels On The Ground)

Before Towing

Your vehicle may be towed on all wheels provided the steering is operable. Remember that power steering and brakes will not power assist. There must be a tow bar installed between the towing vehicle and the disabled vehicle.
To prepare a disabled vehicle for front end towing with all wheels on the ground, the following steps are necessary:

- Block the wheels and disconnect the propeller shafts at the rear axle. Secure the propeller shaft to the frame or cross-member.

Notice:
Never tow the vehicle with propeller shafts connected; this may cause damage to the automatic transmission.

- Provide wood blocking to prevent towing chain and bar from contacting the bumper.
- If there is damage or suspected damage to the rear axle, remove the axle shafts. Cover the hub openings to prevent the loss of lubricant or entry of dirt or foreign objects.

After Towing

- Block the rear wheels and install the axle and propeller shafts if removed.
- Apply the parking brake before disconnecting from the towing vehicle.
- Check and fill rear axle with oil if required.

Rear End Towing

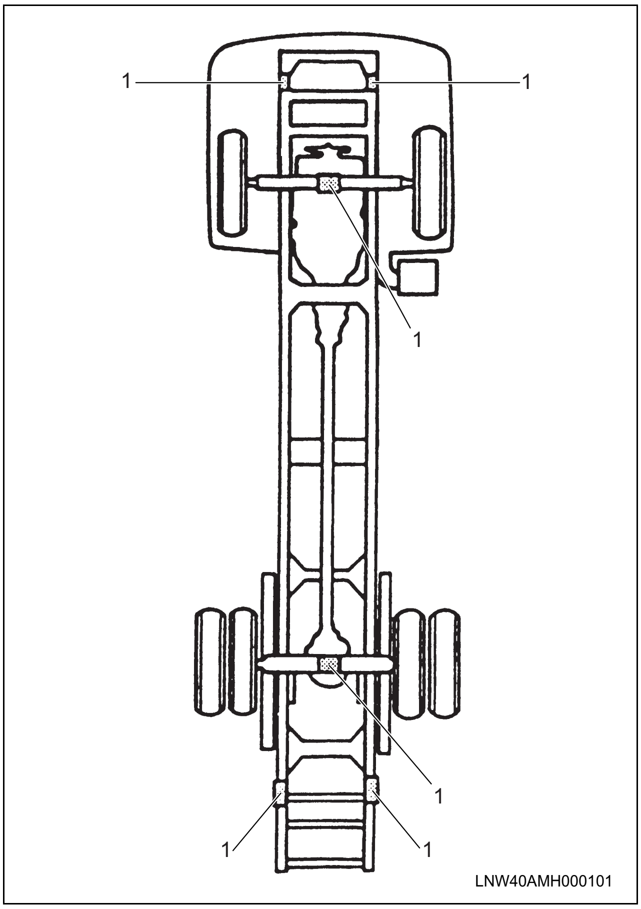
When towing a vehicle with rear wheels raised, secure the steering wheel to maintain straight-ahead position. Make certain that the front axle is not loaded above the front axle Gross Axle Weight Rating (GAWR) as indicated on the vehicle's VIN and Weight Rating Plate.

Special Towing Instructions

1. All state and local laws regarding such items as warning signals, night illumination, speed, etc., must be followed.
2. Safety chains must be used.
3. No vehicle should ever be towed at over 55 mph (90 km/h).
4. Loose or protruding parts of damaged vehicles should be secured prior to moving.
5. A safety chain system completely independent of the primary lifting and towing attachment must be used.
6. Operators should not go under a vehicle that is being lifted by the towing equipment unless the vehicle is adequately supported by safety stands.
7. No towing operation that for any reason jeopardizes the safety of the wrecker operator or any bystanders or other motorists should be attempted.

Vehicle Lifting Points

Caution:
To help avoid personal injury when a vehicle is on a jack stand, provide additional support for the vehicle at the opposite end from which components are being removed. This will reduce the possibility of the vehicle falling off of the stand.



Legend

1. Indicates Area for Jack stand Placement, etc.

Abbreviations Charts

LIST OF AUTOMOTIVE ABBREVIATIONS WHICH MAY BE USED IN THIS MANUAL

A, AMP	Ampere (s)
ABS	Antilock Brake System
AC	Alternating Current
A/C	Air Conditioning
ACCEL	Accelerator
ACC	Accessory
ACL	Air Cleaner
Adj	Adjust
A/F	Air Fuel Ratio
AIR	Secondary Air Injection System
Alt	Altitude
ANT	Antenna
APP	Accelerator Pedal Position
ASM	Assembly
A/T	Automatic Transmission
ATDC	After Top Dead Center
ATF	Automatic Transmission Fluid
Auth	Authority
Auto	Automatic
BARO	Barometric Pressure
Bat	Battery
B+	Battery Positive Voltage
Bbl	Barrel
BHP	Brake Horsepower
BPT	Back Pressure Transducer
BTDC	Before Top Dead Center
°C	Degrees Celsius
CAC	Charge Air Cooler
Calif	California
cc	Cubic Centimeter
CID	Cubic Inch Deplacement
CKP	Crankshaft Position
CKT	Circuit
CL	Closed Loop
CLCC	Closed Loop Carburetor Control
CMP	Camshaft Position
CO	Carbon Monoxide
Coax	Coaxial
Conn	Connector
Conv	Converter
Cu.In.	Cubic Inch
CV	Constant Velocity
DI	Distributor Ignition
Diff	Differential
Dist	Distributor
DLC	Data Link Connector
DMM	Digital Multi Meter
DOHC	Double (or Dual) Overhead Camshaft
DRL	Daytime Running Lights
DTC	Diagnostic Trouble Code
DTM	Diagnostic Test Mode
DTT	Diagnostic Test Terminal
DVM	Digital Voltmeter (10 meg.)
DVOM	Digital Volt Ohmmeter
EBCM	Electronic Brake Control Module
ECM	Engine Control Module
ECT	Engine Coolant Temperature
EEPROM	Electronically Erasable Programmable Read Only Memory
EGR	Exhaust Gas Recirculation
EI	Electronic Ignition
ESD	Electronic Discharge
ETR	Electronically Tuned Receiver
EVAP	Evaporation Emission
Exh	Exhaust
°F	Degrees Fahrenheit
Fed	Federal (All States Except Calif.)
FF	Front Drive Front Engine
FICD	Fast Idle Control Device
FL	Fusible Link
	Front Left
FLW	Fusible Link Wire
FP	Fuel Pump
FR	Front Right
FRT	Front
FT	Fuel Temperature
ft	Foot

FWD	Front Wheel Drive
4WD, 4×4	Four Wheel Drive
4 A/T	Four Speed Automatic Transmission
Gal	Gallon (3.785 l)
GEN	Generator
GND	Ground
Gov	Governor
g	Gram
Harn	Harness
HBB	Hydraulic Brake Booster
HC	Hydrocarbons
HD	Heavy Duty
Hg	Hydrargyrum (Mercury)
HiAlt	High Altitude
HO2S	Heated Oxygen Sensor
HU	Hydraulic Unit
HVAC	Heater-Vent-Air Conditioning
IAC	Idle Air Control
IAT	Intake Air Temperature
IC	Integrated Circuit Ignition Control
ID	Identification Inside Diameter
IGN	Ignition
Inj	Injector
Int	Intake
IP	Instrument Panel
IPC	Instrument Panel Cluster
ISC	Idle Speed Control
J/B	Junction Block
kg	Kilograms
km	Kilometers
km/h	Kilometer per Hour
kPa	KiloPascals
KS	Knock sensor
kV	Kilovolts (Thousands of Volts)
kW	Kilowatts
L	Liter
lb ft	Foot Pounds
lb in	Inch Pounds

LF	Left Front
LH	Left Hand
LR	Left Rear
LS	Left Side
LWB	Long Wheel Base
L-4	In-line Four Cylinder Engine
MAF	Mass Air Flow
MAN	Manual
MAP	Manifold Absolute Pressure
Max	Maximum
MC	Mixture Control
MFI	Multiport Fuel Injection
MIL	Malfunction Indicator Lamp
Min	Minimum
mm	Millimeter
MPG	Miles per Gallon
MPH	Miles per Hour
M/T	Manual Transmission/Transaxle
mv	Millivolt
NA	Natural Aspirated
NC	Normally Closed
N·m	Newton Meter
NO	Normally Open
NOx	Nitrogen, Oxides of
OBD	On-Board Diagnostic
OD	Outside Diameter
O/D	Over Drive
OHC	Overhead Camshaft
OL	Open Loop
O2	Oxygen
O2S	Oxygen Sensor
PAIR	Pulsed Secondary Air Injection System
P/B	Power Brakes
PC	Pressure Control
PCM	Powertrain Control Module
PCV	Positive Crankcase Ventilation
PRESS	Pressure
PROM	Programmable Read Only Memory
PNP	Park/Neutral Position
P/S	Power Steering

PSI	Pounds per Square Inch
PSP	Power Steering Pressure
Pt.	Pint = 1/8 gallon 0.473125 l
PTO	Power Take Off
Pri	Primary
PWM	Pulse Width Modulate
Qt	Quart = 1/4 gallon 0.94625 l
QWS	Quick Warming-up System
REF	Reference
RF	Right Front
RFI	Radio Frequency Interference
RH	Right Hand
RL	Rear Left
RP	Rail Pressure
RPM	Revolutions per Minute
RPM Sensor	Engine Speed Sensor
RPO	Regular Production Option
RPS	Revolution per Second
RR	Right Rear Rear
RS	Right Side
RTV	Room Temperature Vulcanizing
RWAL	Rear Wheel Antilock Brake
RWD	Rear Wheel Drive
SAE	Society of Automotive Engineers
SCV	Suction Control Valve
Sec	Secondary
SFI	Sequential Multiport Fuel Injection
SI	System International
SIR	Supplemental Inflatable Restraint System
SOHC	Single Overhead Camshaft
Sol	Solenoid
SPEC	Specification
Speedo	Speedometer
SRS	Supplemental Restraint System
ST	Start Scan Tool
Sw	Switch
SWB	Short Wheel Base

SYN	Synchronize
Tach	Tachometer
TB	Throttle Body
TBI	Throttle Body Fuel Injection
TCC	Torque Converter Clutch
TCM	Transmission Control Module
TDC	Top Dead Center
Term	Terminal
TEMP	Temperature
TP	Throttle Position
TRANS	Transmission/Transaxle
TURBO	Turbocharger
TVRS	Television & Radio Suppression
TVV	Thermal Vacuum Valve
TWC	Three Way Catalytic Converter
3 A/T	Three Speed Automatic Transmission/ Transaxle
2WD, 4×2	Two Wheel Drive
U-joint	Universal Joint
V	Volt (s)
VAC	Vacuum
VCM	Vehicle Control Module
VDC	Volts DC
VIN	Vehicle Identification Number
VNT	Variable Nozzle turbocharger
VRRRE	Vehicle Refrigerant Recovery and Recycling Equipment
V-ref	ECM Reference Voltage
VSS	Vehicle Speed Sensor
VSV	Vacuum Switching Valve
V6	Six Cylinder “V” Engine
W	Watt (s)
w/	With
w/b	Wheel Base
W/L	Warning Light
w/o	Without
WOT	Wide Open Throttle
WSS	Wheel Speed Sensor

Essential Service Tools

Essential service tools that are shown in this service manual that have tool product numbers beginning with "J" are available for worldwide distribution form:
Kent-Moore
SPX Corporation
29784 Little Mack
Roseville, MI 48066-2298
1-800-328-6657
Mon.-Fri. 8:00 p.m. EST
Telex: 244040 KMTR VR
FAX-1800-578-7375

GENERAL INFORMATION

Maintenance and Lubrication

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Lubrication Detail Information

Lubrication Detail Information

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Engine Oil and Viscosity Recommendations

The oil industry markets various types of engine oil under certain service designation and specification numbers.

The selection of a reliable supplier and close attention to the oil and filter element change recommendations can provide satisfactory lubrication and longer life for the engine.

Using the proper engine oil and following the recommended oil change intervals is your best assurance of continued reliability and performance from your vehicle's engine.

Engine oil containers are labeled with various API (American Petroleum Institute) designations of quality. Be sure the oil you use has the API designation "CD", either alone or shown with other designations such as SF/CD. Oils which are not labeled "CD" should not be used. For example, **do not use oils labeled only SA, SB, SC, SD, SE, CA, CB, CC, or oils with a combination of any of these letters–such as SE/CC, as this may cause engine damage.**

Do not use synthetic oils.

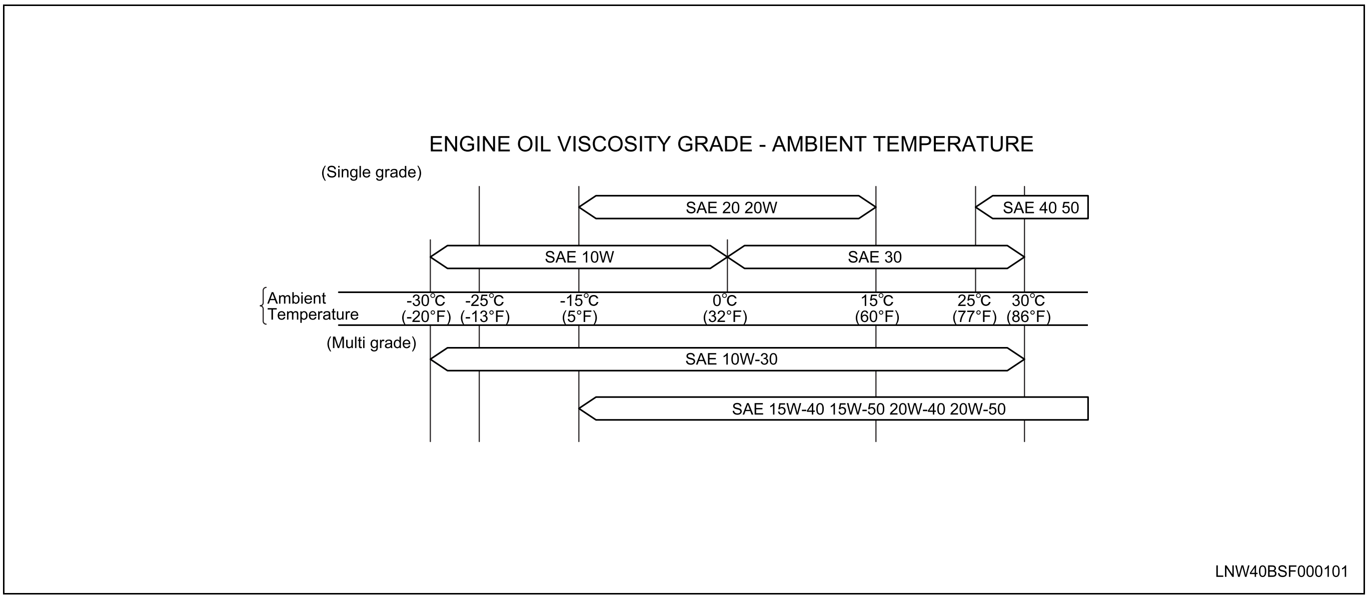
Engine Oil Viscosities

Viscosity numbers make up a classification of lubricants in terms of fluidity or viscosity, but with no reference to any other characteristics or properties.

Where cold weather starting is a problem, it is suggested that oil and coolant system heaters,as well as proper fuel selection, will be helpful. However, if these are not available, lighter viscosity oils may be used only to facilitate starting. Do not use starting aids in the air intake system. Such "aids" can cause immediate engine damage.

The engine oil viscosity specification depends on the temperature of the engine oil at the time of starting the engine. Viscosity recommendations for various starting temperatures are shown in the "Viscosity Chart".

When choosing an oil, consider the range of temperature your vehicle will operate in before the next oil change. Then, select the recommended oil viscosity from the chart.

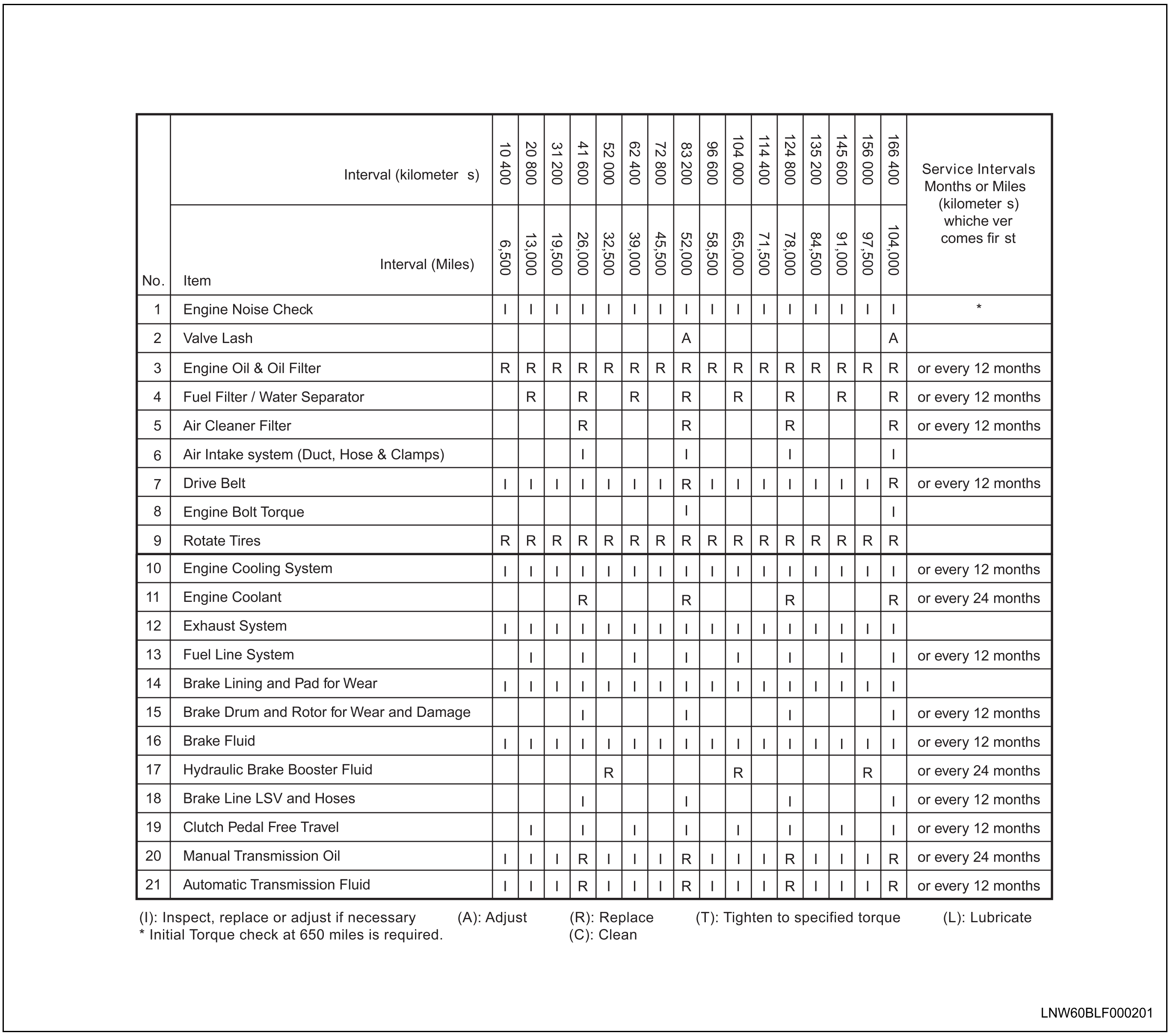


Change Intervals

The oil and oil filter change intervals for your engine are based on the use of recommended oil quality and viscosity, as well as high-quality filters such as ISUZU genuine oil filters. Using oil other than recommended, or oil and filter change intervals longer than recommended, could reduce engine life. Damage to engines due to improper maintenance or use of incorrect oil quality and/or viscosity is not covered by the new vehicle warranty.

Maintenance Schedule

Maintenance Schedule



No.	Interval (kilometers)	10 400	20 800	31 200	41 600	52 000	62 400	72 800	83 200	96 600	104 000	114 400	124 800	135 200	145 600	156 000	166 400	Service Intervals Months or Miles (kilometers) whichever comes first
	Item / Interval (Miles)	6,500	13,000	19,500	26,000	32,500	39,000	45,500	52,000	58,500	65,000	71,500	78,000	84,500	91,000	97,500	104,000	
1	Engine Noise Check	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	*
2	Valve Lash								A								A	
3	Engine Oil & Oil Filter	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	or every 12 months
4	Fuel Filter / Water Separator		R		R		R		R		R		R		R		R	or every 12 months
5	Air Cleaner Filter				R				R				R				R	or every 12 months
6	Air Intake system (Duct, Hose & Clamps)				I				I				I				I	
7	Drive Belt	I	I	I	I	I	I	I	R	I	I	I	I	I	I	I	R	or every 12 months
8	Engine Bolt Torque								I								I	
9	Rotate Tires	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	
10	Engine Cooling System	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	or every 12 months
11	Engine Coolant				R				R				R				R	or every 24 months
12	Exhaust System	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	
13	Fuel Line System		I		I		I		I		I		I		I		I	or every 12 months
14	Brake Lining and Pad for Wear	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	
15	Brake Drum and Rotor for Wear and Damage				I				I				I				I	or every 12 months
16	Brake Fluid	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	or every 12 months
17	Hydraulic Brake Booster Fluid					R					R					R		or every 24 months
18	Brake Line LSV and Hoses				I				I				I				I	or every 12 months
19	Clutch Pedal Free Travel		I		I		I		I		I		I		I		I	or every 12 months
20	Manual Transmission Oil	I	I	I	R	I	I	I	R	I	I	I	R	I	I	I	R	or every 24 months
21	Automatic Transmission Fluid	I	I	I	R	I	I	I	R	I	I	I	R	I	I	I	R	or every 12 months

(I): Inspect, replace or adjust if necessary (A): Adjust (R): Replace (T): Tighten to specified torque (L): Lubricate
* Initial Torque check at 650 miles is required. (C): Clean

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No.	Interval (kilometers)	10 400	20 800	31 200	41 600	52 000	62 400	72 800	83 200	96 600	104 000	114 400	124 800	135 200	145 600	156 000	166 400	Service Intervals Months or Miles (kilometers) whichever comes first
	Item / Interval (Miles)	6,500	13,000	19,500	26,000	32,500	39,000	45,500	52,000	58,500	65,000	71,500	78,000	84,500	91,000	97,500	104,000	
22	External Automatic Transmission Filter Automatic Transmission Filter				R				R				R				R	or every 24 months
23	Differential Gear Oil	I	I	I	R	I	I	I	R	I	I	I	R	I	I	I	R	or every 24 months
24	Power Steering Fluid					R					R					R		or every 24 months
25	Steering Gear Box Torque				T				T				T				T	or every 12 months
26	Propeller Shaft Flange Torque	I	T		T		T		T		T		T		T		T	or every 12 months
27	Leaf Spring U-Bolt Torque*	T		T		T		T		T		T		T		T		
28	Wheel Nut Torque*	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	
29	Kingpin	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	or every 12 months
30	Drive shaft		L		L		L		L		L		L		L		L	or every 12 months
31	Wheel Bearing Grease					R					R					R		or every 12 months
32	Rear Spring Pins	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	
33	Air Conditioner Blower Filter	Cleaned once a month																

(I): Inspect, replace or adjust if necessary (A): Adjust (R): Replace (T): Tighten to specified torque (L): Lubricate

* Initial Torque check at 650 miles is required.

** Be sure to discard used grease seal,and always use new grease seal for installation.

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Explanation of Complete Vehicle Maintenance Schedule

Explanation of Complete Vehicle Maintenance Schedule

The following is a brief explanation of the service listed in the preceding Complete Vehicle Maintenance Schedule.

Normal Vehicle Use

The vehicle maintenance instructions in the Maintenance Schedule are based on the assumption that the vehicle will be used as designed:

- to carry passengers and cargo within the limitations specified on the tire placard.
- to be driven on reasonable road surfaces within legal operating limits.
- to be driven on a daily basis, as a general rule, for at least several miles/kilometers.
- to be driven on proper fuel (See Owner's Manual; Diesel Fuel Requirement.).

Unusual operating conditions will require more frequent vehicle maintenance, as specified in the following section.

1. ENGINE NOISE

These components have an effect on the control of noise emissions.

2. VALVE LASH

Incorrect valve clearance will result in increased engine noise and lower engine output, thereby adversely affecting engine performance. Retorque rocker shaft bracket nuts before checking and adjusting valve clearance. Check and adjust valve clearance at every 52,000 miles (83,200 km).

3. INJECTOR

Check spray condition at every 52,000 miles (83,200 km).

4. ENGINE OIL AND OIL FILTER

Change at interval noted below depending upon driving conditions.

- NORMAL SERVICE
  Change every 6,500 miles (10,400 km) or 12 months whichever occurs first.
- SEVERE SERVICE
  Change every 3,600 miles (5,760 km) or 3 months if the vehicle is often driven under one or more of these conditions (a) driving in dusty areas, (b) frequent idling or idling for long periods, (c) driving four miles (6 km) or less in freezing weather, or other short trips in cold weather, where engine dose not thoroughly warm up. Change oil and filter soon after driving in a dust storm.

5. FUEL FILTER

Replace the fuel filter on the frame rail every 13,000 miles (20,800 km) or 12 months whichever occurs first, or more frequently if clogged. Drain water from the water separator on the frame rail every 6,500 miles (10,400 km).

6. AIR CLEANER FILTER

Replace the engine air cleaner filter under normal operations every 26,000 miles (41,600 km). Operation of vehicle in dusty areas will necessitate more frequent filter replacement.

7. AIR INTAKE SYSTEM

Check if air cleaner hoses and ducts are connected and correctly installed every 26,000 miles (41,600 km).

8. DRIVE BELT

Check belt driving the fan, generator at every 52,000 miles (83,200 km). Look for cracks, fraying, wear, and proper tension.
Replace at every 104,000 miles (166,400 km).

9. ENGINE BOLT TORQUE

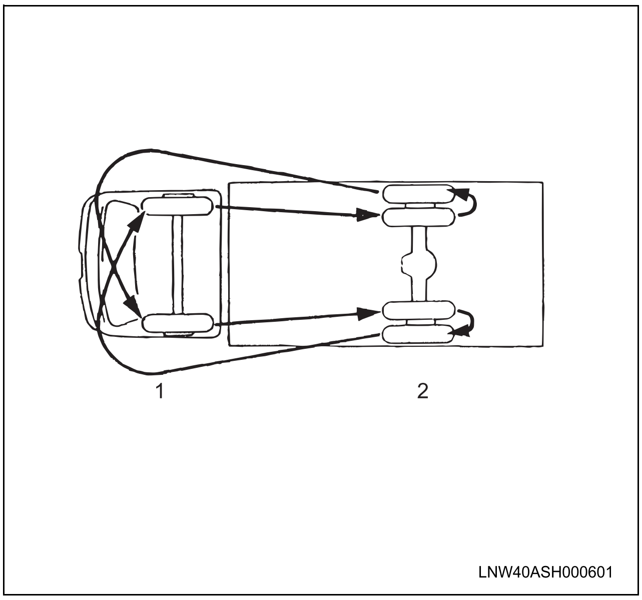
Loosened bolts result in lower engine output. Check and adjust manifold mounting, and injection nozzle to correct torque every 52,000 miles (83,200 km).

Specified tightening torque

INTAKE/EXHAUST, MANIFOLDS	18/34 N·m (13/25 lb ft)
INJECTOR	19 N·m (14 lb ft)

10. ROTATE TIRES

To equalize wear, rotate tires and adjust tire pressures at every 6,500 miles (10,400 km).



Legend

1. Front
2. Rear

11. ENGINE COOLING SYSTEM

At 12 months or 6,500 miles (10,400 km) intervals, rinse radiator cap and filler neck with clean water, pressure test system and radiator cap for proper pressure holding capacity, tighten hose clamps and inspect condition of all cooling and heater hoses. Replace hoses if cracked, swollen or otherwise deteriorated.

Also each 12 months or 6,500 miles (10,400 km), clean exterior of radiator core and if necessary, drain, flush and refill the engine cooling system with a new engine coolant solution as described in the Owner's Manual.

12. ENGINE COOLING

Every 24 months or 26,000 miles (41,600 km), drain the engine coolant by opening the drain cock at the bottom of the radiator core, flush and refill the engine cooling system with a new engine coolant solution.

13. EXHAUST SYSTEM

Check the complete exhaust system at every 6,500 miles (10,400 km). Check body areas near the exhaust system.

Look for broken, damaged, missing, or out-of position parts. Also inspect for open seams, holes, loose connections, or other conditions which could cause heat build-up in the floor pan, which could let exhaust fumes seep into the passenger compartment. Dust or water in the cabin may indicate a leak in the area. Needed repairs should be made at once.

14. FUEL LINE SYSTEM

Inspect the fuel tank, cap and lines for damage at every 13,000 miles (20,800 km). Inspect fuel cap for correct sealing ability and indications of physical damage. Replace any damaged or malfunctioning parts.

15. BRAKE LINING AND PAD FOR WEAR

Check drum brake lining and disc brake pad for wear or cracks at every 6,500 miles (10,400 km). Check brakes (including parking brake) more often if conditions and habits result in frequent braking.

Front disc brake have built-in wear indicators which are designed to make a high pitched squeal or cricket-like warning sound when the brake pads are worn to the point where new pads are needed.

When the vehicle is in motion, the sound may be constant or it may come and go. Pressing the brake pedal firmly may cause the sound to stop.

Have the brake linings or the brake pads replaced, if these conditions exist.

Failure to do so can result in expensive damage to the brake system or a serious accident.

16. BRAKE DRUM AND ROTOR FOR WEAR AND DAMAGE

Check brake drums (rear and parking) and rotor (front) for wear or damage at every 26,000 mile (41,600 km) or 12 months whichever occurs first.

17. BRAKE FLUID

Check the brake fluid level in the brake fluid reservoir every 6,500 miles (10,400 km).

18. HYDRAULIC BRAKE BOOSTER FLUID (NQR, NRR)

Replace power steering fluid every 24 months or 32,500 miles (52,000 km), whichever occurs first.

19. BRAKE LINE, LSV AND HOSES

Check lines and hoses for proper hook-up, binding, leaks, cracks, chafing, etc. every 26,000 miles (41,600 km). Any questionable parts should be replaced or repaired at once. When rubbing or wear is noted on lines or hoses, the cause must be corrected at once.

20. CLUTCH PEDAL CONTROL

Check lines and hoses for proper hook-up, binding, leaks, cracks, chafing, etc. at every 13,000 miles (20,800 km). Any questionable parts should be replaced or repaired.

21. MANUAL TRANSMISSION OIL

Replace lubricant at every 26,000 miles (41,600 km).

Check lubricant level at every 6,500 miles (10,400 km), and add lubricant to level of filler hole if necessary.

22. AUTOMATIC TRANSMISSION FLUID

Check the automatic transmission fluid level at each engine oil change and replace fluid and external filter every 26,000 miles (41,600 km).

How to Check: This operation could be difficult and you may choose to have this done at your ISUZU Dealership Service Department.

If you choose to do it yourself, then be sure to follow all the instructions below or you could get a false reading on the dipstick.

Caution:

Too much or too little transmission oil could damage your transmission. Too much could cause your transmission to overheat and fluid to spill out from the breather hose. Be sure to get an accurate reading if you check your transmission fluid.

Park vehicle on level ground and set parking brake. With engine idling and the regular brakes applied, move the gear selector through all gear positions and ending at “P”.

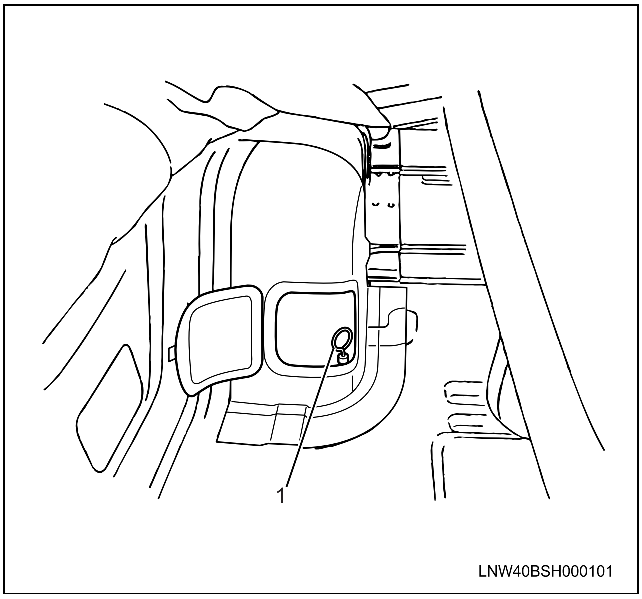
Notice:

Wait at least 30 minutes before checking the transmission fluid if you have been driving at high speed for a long period of time, in city/heavy traffic and or while pulling a trailer.

Single cab: Remove the dipstick located at the rear left of the engine.

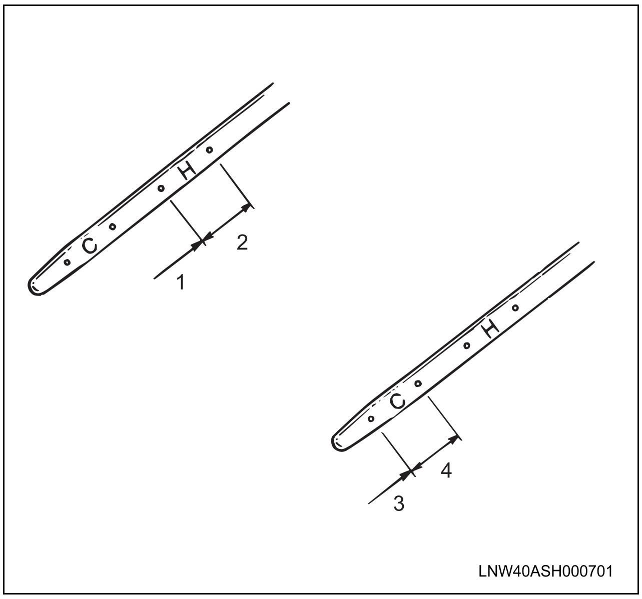
Crew cab: Remove the dipstick located beneath the rear-of-engine inspection panel.

Check fluid in Hot condition. The fluid should be checked while at normal operating temperature (Hot) between 158°F and 176°F (70°C to 80°C). Pull, wipe and clean the dipstick and reinsert all the way, wait at least 3 seconds then pull it back out again for reading. If the level is not in the “H” range then adjust it accordingly.



Legend

1. Dipstick



Legend

1. If Hot Add.
2. If Hot O.K.
3. If Cold Add.
4. If Cold O.K.

Check fluid in cold condition. If outside temperature is near 70°F (21°C) and the vehicle has been sitting overnight then you can use the cold range. If the level is not in the "C" marks then you must perform a Hot condition check before making any level adjustment.

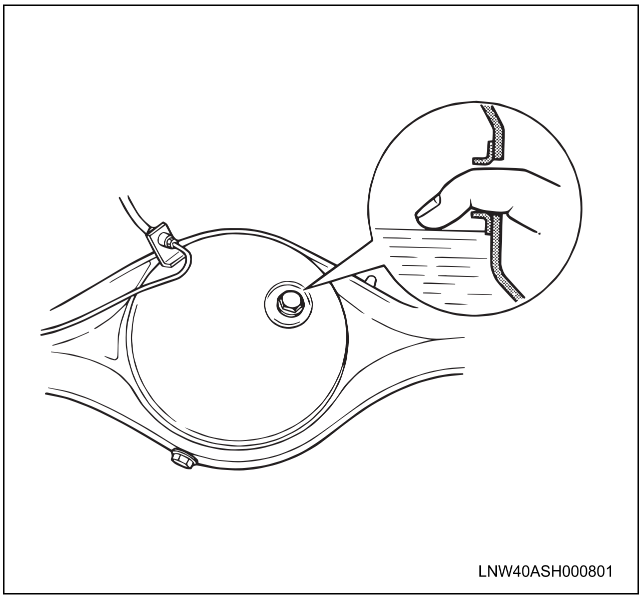
Notice:
The cold range is used for reference only.

23. AUTOMATIC TRANSMISSION FLUID FILTER

Replace filter at every 26,000 miles (41,600 km)

24. DIFFERENTIAL GEAR OIL

Replace lubricant at every 26,000 miles (41,600 km).
Check lubricant level at every 6,500 miles (10,400 km) or every 12 months, and add lubricant to within 0 to 10 mm (0 to 0.4 in) of bottom edge of the filler hole if necessary.



25. POWER STEERING FLUID

Replace power steering fluid every 24 months or 32,500 miles (52,000 km), whichever occurs first.

26. STEERING GEAR BOX TORQUE

Retighten the fixing bolts of the steering gear box to the specified torque at every 26,000 miles (41,600 km).

Specified tightening torque

STEERING GEAR BOX	102 N·m (75 lb ft)

27. PROPELLER SHAFT FLANGE TORQUE

Check the fixing bolts of propeller shaft flange for looseness or damage at first 6,500 miles (10,400 km). Retighten the fixing bolts to the specified torque at every 13,000 miles (20,800 km).

Specified tightening torque

PROPELLER SHAFT FLANGE	103 N·m (76 lb ft)

28. LEAF SPRING U-BOLT TORQUE

Tighten the U-Bolt nuts to the specified torque at 650 miles (1,050 km), 6,500 miles (10,400 km) and thereafter each 13,000 miles (20,800 km).

Specified tightening torque

LEAF SPRING U-BOLT				
ISUZU	NPR A/T	NPR M/T	NQR	NRR
GMC / CHEVROLET	W3500, W4500		W5500	W5500 HD
Front	127 N·m (94 lb ft)		196 N·m (145 lb ft)	
Rear	177 N·m (130 lb ft)	284 N·m (209 lb ft)		

29. WHEEL NUT TORQUE

Check tire for excessive or abnormal wear, or damage. Also check tire inflation pressures and adjust. Be sure wheels are not bent or cracked and that wheel nuts have been tightened to the specified torque at 650 miles (1,050 km) and then every 6,500 mile (10,400 km). Refer to Section 3 for the specified torque.

Specified tightening torque

Front and Rear wheel	440 Nm(325 lb ft)

30. KINGPIN

Lubricate the grease fitting on the kingpins at 12 months or 6,500 miles (10,400 km) whichever occurs first.

31. PROPELLER SHAFT

Lubricate the grease fitting on each universal joint and spline coupling at 12 months or 13,000 miles (20,800 km) whichever occurs first.

32. WHEEL BEARING GREASE

Clean and repack front wheel bearings at every brake relining or 32,500 miles (52,000 km) whichever comes first.

33 AIR CONDITIONER BLOWER FILTER

The air conditioner blower filter should be removed and cleaned once a month.
Remove the 4 screws securing the glove compartment and remove the filter.
Use a vacuum cleaner to remove all dust and dirt adhering to the filter surface.

- Do not use a stiff brush to clean the air conditioner blower filter. Damage to the filter will result.

Owner Safety and Routine Maintenance

Owner Safety and Routine Maintenance

Listed below are vehicle checks which should be made periodically by either the owner or a qualified technician to ensure proper performance and safety of the vehicle. **For your safety and that of others, any of the safety-related components that may have been damaged in an accident should be checked and necessary repairs performed before operating the vehicle.**

At the minimum, these routine checks should be made every 6 months or 6,000 miles (10,000 km), whichever comes first. Whenever repairs are necessary, have them completed before operating the vehicle.

A PARKING BRAKE

Park on a fairly steep hill and hold the vehicle with the parking brake only. This checks holding ability.

Be sure to have enough room around the vehicle. Then firmly apply both the parking brake and the regular brake.

Do not use the accelerator pedal. If the engine starts, be ready to turn off the ignition/engine control switch at once. Take these precautions because the vehicle could move without warning and possibly cause personal injury or property damage.

B STARTER SAFETY SWITCH

Check by trying to start the engine in each gear. The starter should crank only in selector position “P” or “N”.

C TRANSMISSION SHIFT INDICATOR

Check that the indicator points to the gear chosen.

D STEERING

Be alert for any changes in steering action. An inspection or service is needed when the steering wheel is harder to turn or has too much free play, or when there are strange sounds when turning or parking.

E WHEEL ALIGNMENT, BALANCE, AND TIRES

Check tires for abnormal wear or damage. Also, check for damaged wheels. A pull right or left on a straight and level road may show the need for a wheel alignment. A vibration of the steering wheel or seat at normal highway speeds may mean wheel balancing is needed. Check tire pressure when the tires are “cold”, at least monthly, and whenever the vehicle is serviced. (Include the spare, if equipped.)

Check the pressure more often if daily check shows it’s needed. Change tire pressure as needed when changing loads.

F BRAKES

Be alert to illumination of the low vacuum warning light or for the tone alarm, or changes in braking action, such as repeated pulling to one side, unusual sounds when braking or increased brake pedal travel. Check regularly that the brake fluid reservoir is properly filled and check for fluid leaks. Any of these conditions could indicate the need for brake system inspection and/or service.

G EXHAUST SYSTEM

Be alert for any changes in the sound of the exhaust system or any smell of fumes. These are signs the system may be leaking. Have it checked and/or repaired at once.

H WINDSHIELD WIPERS AND WASHERS

Check operation and condition of the wiper blades. Check the flow of the washer spray.

I DEFROSTER

Turn the control lever to “Defrost” and the fan lever to “4”. Then check the airflow from the ducts at the inside base of the windshield. Engine running.

J REARVIEW MIRRORS AND SUN VISORS

Check that friction joints hold mirrors and sun visors in place.

K HORN

Sound the horn periodically to be sure it works.

L LAP-SHOULDER BELTS

Check seat belt system (including webbing, buckles, latch plates, and anchors) for proper operation, and for damage.

M SEAT ADJUSTERS

When adjusting a manual seat, be sure seat adjusters latch by pushing the seat forward and backward.

N LAMPS

Check panel lighting, warning lamps, indicator lamps, and interior lamps. On the outside, check: license plate lamps, side marker lamps, reflectors on outside mirrors, headlamps, parking lamps, identification and clearance lamps, taillights, brake lamps, turn signals, cornering lamps, backup lamps, and hazard warning flashers. Have headlamp aim checked at once if beams seem improperly aimed.

O GLASS, MIRRORS, LIGHTS AND/OR REFLECTORS CONDITION

Look for broken, scratched, dirty or damaged glass, mirrors, lamps or reflectors that could reduce the view or visibility, or cause injury. Replace, clean or repair promptly.

P DOOR LATCHES

Check that doors close, latch, and lock tightly. Check for broken, damaged or missing parts that might prevent tight latching.

Q TILT CAB

Be sure the tilt lever is raised and the lock pin is inserted in the lever bracket.

R FLUID LEAKS

Check for fuel, water, oil, or other fluid leaks by looking at the surface beneath the vehicle after it has been parked for a while. If you notice fuel fumes or fluid at any time, have the cause found and corrected at once.

S SPARE AND JACK

Check that spare tire assembly and jack equipment (if equipped) are securely stowed at all times.

T UNDERBODY

Corrosive materials used for ice removal, snow removal, and dust control can collect on the underbody. If these materials are not removed, accelerated corrosion (rust) can occur on underbody parts such as fuel lines, frame, floor pan, and exhaust system. At least every spring, flush these materials from the underbody with plain water. Take care to clean well any areas where mud and other debris can collect. Sediment packed in closed areas of the frame should be loosened before being flushed.

Noise Emission Control

Noise Control System

The following information relates to compliance with Federal noise emission standards for vehicles with a Gross Vehicle Weight Rating (GVWR) of more than 5,010 kg (11,050 lb) and 6,010 kg (13,250 lb). The Maintenance Schedule provides information on maintaining the noise control system to minimize wear of the noise emission control system during the life of the vehicle. The noise control system warranty is given in the vehicle Warranty Folder.

These standards apply only to vehicles sold in the United States.

Tampering with Noise Control System Prohibited

Federal law prohibits the following acts or the causing thereof:

1. The removal or rendering inoperative by any person other than for purposes of maintenance, repair or replacement of any device or element of design incorporated in any new vehicle for the purpose of noise control, prior to its sale or delivery to the ultimate purchaser or while it is in use.
2. The use of the vehicle after such device or element of design has been removed or rendered inoperative by any person.

   Among those acts presumed to constitute tampering are acts listed below.

Insulation

- Removal of under hood insulation.

Fan and Drive

- Removal of fan clutch or rendering clutch inoperative.
- Removal of fan shroud.

Air Intake

- Removal of air cleaner silencer.
- Reversing air cleaner cover.

Exhaust

- Removal of muffler and/or resonator.
- Removal of exhaust pipes and exhaust pipe clamps.

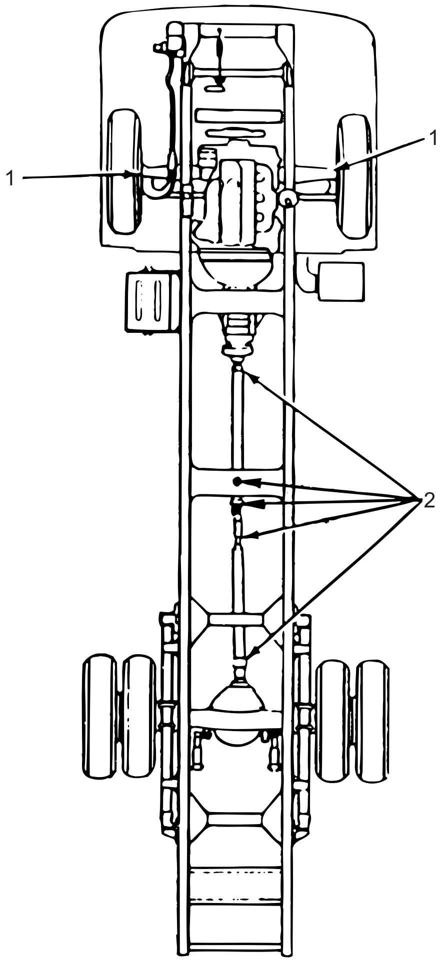
Recommended Fluids and Lubricants

Recommended Fluids and Lubricants

USAGE	FLUIDS/LUBRICANTS
Engine Oil	SG/CE, SF/CD, SE/CD, CD Engine Oil or higher quality
Manual Transmission Oil	SAE 5W-30 SF below 32°C (90°F) or SAE 40 engine oil above 32°C (90°F)
Automatic Transmission Fluid Power Steering Fluid Hydro Brake Boost Fluid	ATF Dexron®-III
Rear Axle	Multi-purpose gear oil SAE90 GL-5
Chassis Lubricant	Multi-purpose grease with high temperature, good quality, lithium soap, extreme pressure grease
Battery Terminals	Petroleum Jelly (outer surfaces)
Clutch and Brake Fluid	Brake fluid DOT 3 or equivalent
Cab-Door Hinges and Latches Lubricant	A semi-fluid grease having extreme pressure properties and containing zinc oxide (Lubricant or equivalent)
Engine Coolant	Mixture of water and good quality ethylene glycol base type anti-freeze conforming to GM Spec., 6277M or ISUZU Factory Fill Long Life Coolant Part No.2-90531-809-0
Windshield Washer Solvent	Washer Solvent
Propeller Shaft, Universal Joints and Sliding Sleeve Lubricant	NLGI #1 or #2 multi-purpose type grease
Propeller Shaft Center Bearing, Wheel Hub Bearing Lubricant	NLGI #2 or #3

Lubrication Chart

Lubrication Chart



LNW40BLF000301

Legend

1. Kingpins (4 fitting)
2. Propeller Shaft Universal Joints, Sliding Sleeve and Center Bearing (5 fitting)

Specifications

Specifications

Engine Crankcase

This capacity is for a normal refill and it is an approximate amount. Keep the level as close as possible to the full mark without overfilling. Do not operate with the level below the low mark.

4HK1-TC	Without Filter	13L (3.4 gal)

This figure includes the full-flow oil filter, which should be changed at each oil change.

Engine Cooling System

Capacity	14.3L (3.8 gal)
Thermostat	82, 85°C (180, 185°F)
Radiator Pressure Cap	108 kPa (16.21 psi)

Fuel Tank

The fuel tank capacity is stated on a metal plate attached to the fuel tank body. Only fill the tank to 95 percent of its capacity. This allows room for expansion of the fuel

Manual Transmission

Capacity	4.4L (9.3 pints)

Automatic Transmission

Capacity	NPR, NPR-HD, NQR	13.5L (28.5 pints)
	NRR	14.0L (29.6 pints)

Rear Axle

Capacity	292 mm	9.7L (20.5 pints)
	320 mm	10.0L (21.1 pints)

Maintenance Item

Air Cleaner Filter	Single Cab	ISUZU Part No. 8-97062-284-0 GM Part No. 97062284
	Crew Cab	ISUZU Part No. 8-94430-250-0 GM Part No. 94430250
Engine Oil Filter Cartridge		ISUZU Part No. 8-97148-270-1 GM Part No. 97148268
Fuel Filter Cartridge		ISUZU Part No. 8-94369-199-3 GM Part No. 94369299

Fastener Torques

Intake Manifold Nut and Bolts	18 N·m (13 lb ft)				
Exhaust Manifold Nut and Bolts	34 N·m (25 lb ft)				
Injector	30 N·m (22 lb ft)				
Steering Gear Box Fixing Nuts and Bolts	102 N·m (75 lb ft)				
Propeller Shaft Flange Nuts	103 N·m (76 lb ft)				
Leaf Spring U-Bolt Nuts	ISUZU	NPR A/T	NPR M/T	NQR	NPR
	GMC / CHEVROLET	W3500, W4500		W5500	W5500HD
	Front	127 N·m (94 lb ft)		196 N·m (145 lb ft)	
	Rear	177 N·m (130 lb ft)	284 N·m (209 lb ft)		
Wheel Nuts	440 N·m (325 lb ft)				

GENERAL INFORMATION

Metric and Fastener Information

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  Recommendations for Reuse Description 0C-3
  Six-Lobed Socket Head Fasteners Description .0C-4
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  Conversion Table Description 0C-5

Description and Operation

Metric Fasteners Description

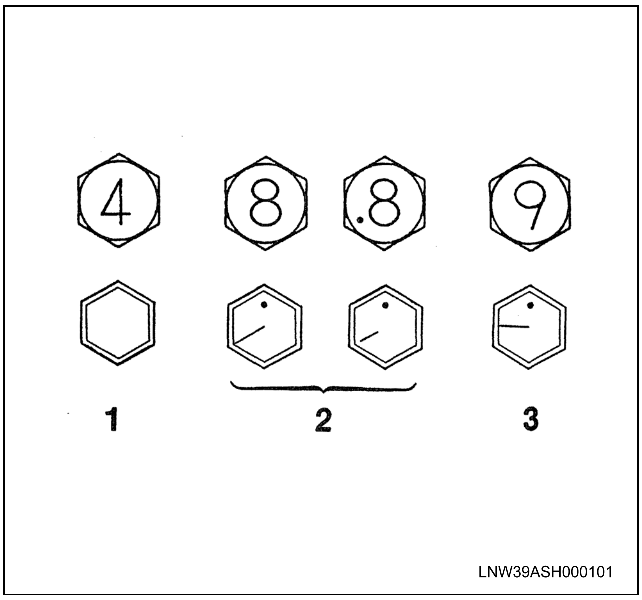
Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Replacement Fasteners Description

During vehicle maintenance, any fasteners used to replace older ones must have the same measurements and strength as those removed, whether metric or inch system. (The numbers on the heads of metric bolts show their strength. The inch system bolts use radial lines to show this.).
Fasteners taken from the vehicle should be saved for reuse in the same spot when possible. Where a fastener cannot be used again, take care to choose a replacement that matches the old one. For information and help, see your dealer.

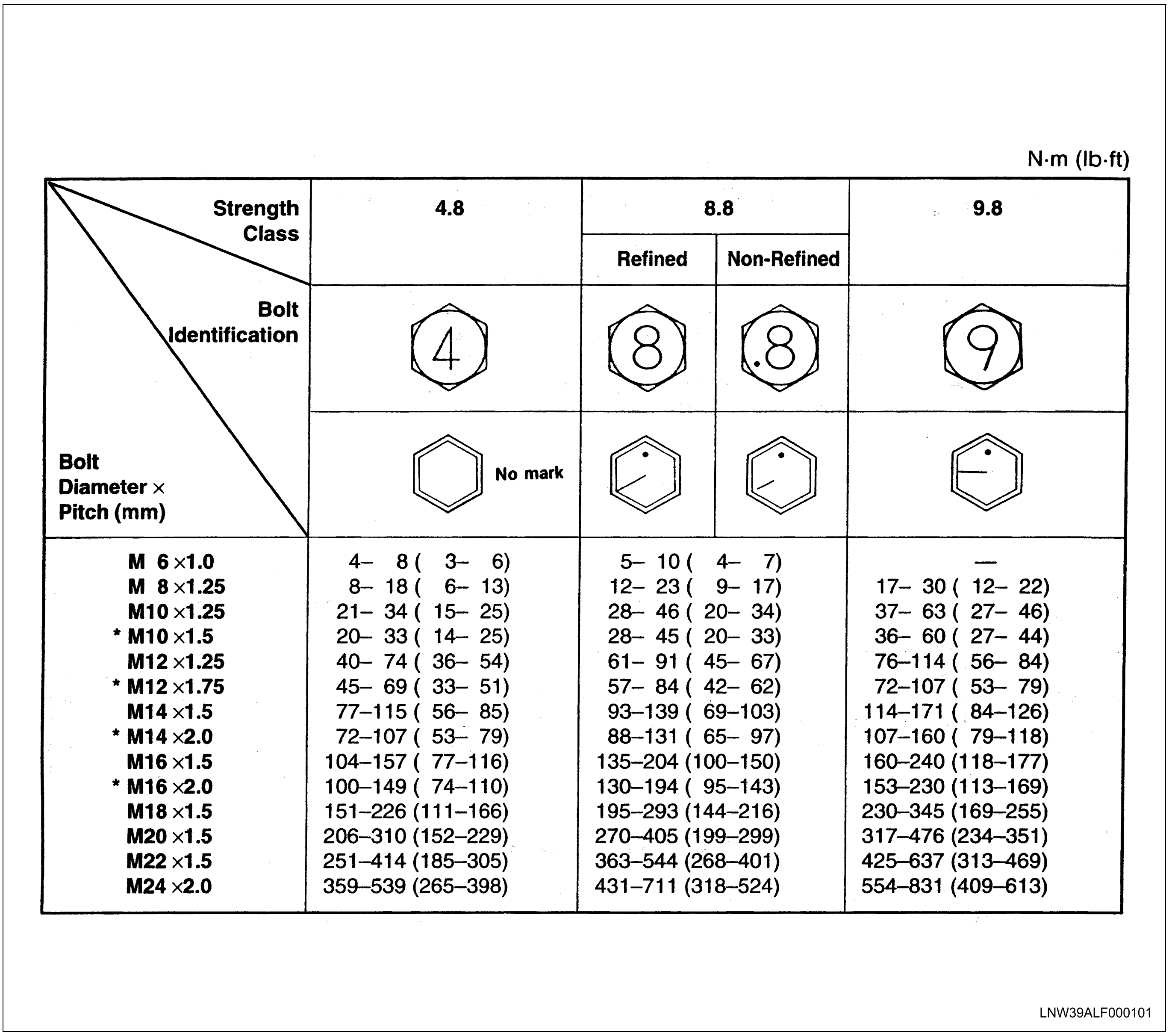
Caution:
This vehicle is primarily dimensioned in the metric system. Most fasteners are metric and many are very close in dimension to well-known inch system fasteners. Mismatched or incorrect fasteners can result in damage to the vehicle or possibly personal injury.

Original equipment metric fasteners (except "beauty" bolts, such as exposed bumper bolts, and cross recess head screws) are identified by a number marking indicating the strength of the material in the fastener as outlined later.



Legend
1. Strength Class 4.8
2. Strength Class 8.8
3. Strength Class 9.8

Fastener Strength Identification Description



N·m (lb·ft)

Strength Class / Bolt Identification / Bolt Diameter × Pitch (mm)	4.8	8.8		9.8
		Refined	Non-Refined	
Bolt Identification	4	8	.8	9
	No mark			
M 6 ×1.0	4– 8 (3– 6)	5– 10 (4– 7)		—
M 8 ×1.25	8– 18 (6– 13)	12– 23 (9– 17)		17– 30 (12– 22)
M10 ×1.25	21– 34 (15– 25)	28– 46 (20– 34)		37– 63 (27– 46)
* M10 ×1.5	20– 33 (14– 25)	28– 45 (20– 33)		36– 60 (27– 44)
M12 ×1.25	40– 74 (36– 54)	61– 91 (45– 67)		76–114 (56– 84)
* M12 ×1.75	45– 69 (33– 51)	57– 84 (42– 62)		72–107 (53– 79)
M14 ×1.5	77–115 (56– 85)	93–139 (69–103)		114–171 (84–126)
* M14 ×2.0	72–107 (53– 79)	88–131 (65– 97)		107–160 (79–118)
M16 ×1.5	104–157 (77–116)	135–204 (100–150)		160–240 (118–177)
* M16 ×2.0	100–149 (74–110)	130–194 (95–143)		153–230 (113–169)
M18 ×1.5	151–226 (111–166)	195–293 (144–216)		230–345 (169–255)
M20 ×1.5	206–310 (152–229)	270–405 (199–299)		317–476 (234–351)
M22 ×1.5	251–414 (185–305)	363–544 (268–401)		425–637 (313–469)
M24 ×2.0	359–539 (265–398)	431–711 (318–524)		554–831 (409–613)

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Notice:
The asterisk * indicates that the bolts are used for female-threaded parts that are made of soft materials such as casting, etc.

Prevailing Torque Fasteners Description

A prevailing torque nut is designed to develop an interference between the nut and bolt threads. This is most often accomplished by distortion of the top of an all-metal nut or by using a nylon patch on the threads in the middle of the hex flat. A nylon Insert may also be used as a method of interferences between nut and bolt threads.

A prevailing torque bolt is designed to develop and interference between bolt and nut threads, or the threads of a tapped hole. This is accomplished by distorting some of the threads or by using a nylon patch or adhesive.

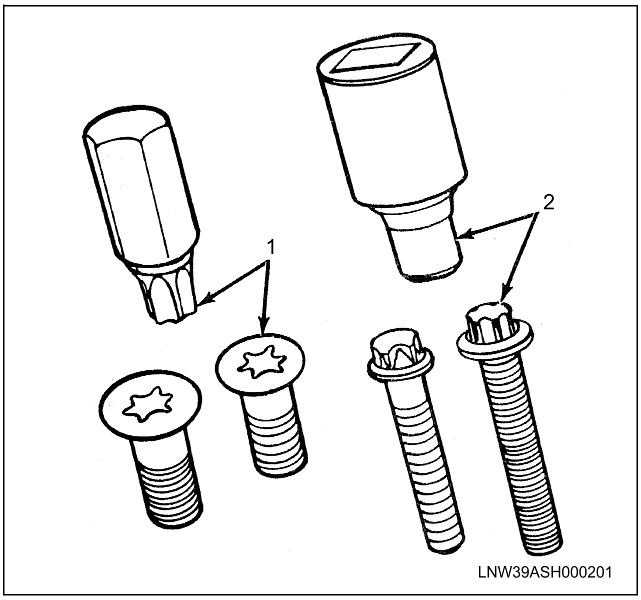
Recommendations for Reuse Description

1. Clean, unrusted prevailing torque nuts and bolts may be reused as follows:
   a. Clean dirt and other foreign material off the nut or bolt.
   b. Inspect the nut or bolt to ensure there are no cracks, elongation, or other signs of abuse or over tightening. (If there is any doubt, replace with a new prevailing torque fastener of equal or greater strength.)
   c. Assemble the parts and hand start the nut or bolt.
   d. Observe that, before fastener seats, it develops torque per the chart. (If there is any doubt, replace with new prevailing torque fastener of equal or greater strength.)
   e. Tighten the fastener to the torque specified in the appropriate section of this manual.

2. Bolts and nuts that are rusty or damaged should be replaced with new parts of equal or greater strength.

Six-Lobed Socket Head Fasteners Description

Six-lobed socket head (Torx) fasteners are used in some applications on vehicles covered in this manual. The door striker bolt is of this design as well as the draftier mounting bolts in some cases.
Tools designed for these fasteners are available commercially. However, in some cases, if the correct tool is not available, a hex socket head wrench may be used.



Legend

1. External Drive
2. Internal Drive

Decimal and Metric Equivalents Description

Fractions	Decimal In.	Metric MM.
1/64	.015625	.39688
1/32	.03125	.79375
3/64	.046875	1.19062
1/16	.0625	1.58750
5/64	.078125	1.98437
3/32	.09375	2.38125
7/64	.109375	2.77812
1/8	.125	3.1750
9/64	.140625	3.57187
5/32	.15625	3.96875
11/64	.171875	4.36562
3/16	.1875	4.76250
13/64	.203125	5.15937
7/32	.21875	5.55625
15/64	.234375	5.95312
1/4	.250	6.3500
17/64	.265625	6.74687
9/32	.28125	7.14375
19/64	.296875	7.54062
5/16	.3125	7.93750
21/64	.328125	8.33437
11/32	.34375	8.73125
23/64	.359375	9.12812
3/8	.375	9.52500
25/64	.390625	9.92187
13/32	.40625	10.31875
27/64	.421875	10.71562
7/16	.4375	11.11250
29/64	.453125	11.50937
15/32	.46875	11.90625
31/64	.484375	12.30312
1/2	.500	12.70000
33/64	.515625	13.09687
17/32	.53125	13.49375
35/64	.546875	13.89062
9/16	.5625	14.28750
37/64	.578125	14.68437
19/32	.59375	15.08125
39/64	.609375	15.47812
5/8	.625	15.87500
41/64	.640625	16.27187
21/32	.65625	16.66875
43/64	.671875	17.06562
11/16	.6875	17.46250
45/64	.703125	17.85937
23/32	.71875	18.25625
47/64	.734375	18.65312

Fractions	Decimal In.	Metric MM.
3/4	.750	19.05000
49/64	.765625	19.44687
25/32	.78125	19.84375
51/64	.796875	20.24062
13/16	.8125	20.63750
53/64	.828125	21.03437
27/32	.84375	21.43125
55/64	.859375	21.82812
7/8	.875	22.22500
57/64	.890625	22.62187
29/32	.90625	23.01875
59/64	.921875	23.41562
15/16	.9375	23.81250
61/64	.953125	24.20937
31/32	.96875	24.60625
63/64	.984375	25.00312
1	1.00	25.40000

Conversion Table Description

LENGTH

Multiply	by	to get equivalent number of :
Inch	25.4	millimeters (mm)
Foot	0.3048	meters (m)
Yard	0.9144	meters
Mile	1.609	kilometers (km)

AREA

Multiply	by	to get equivalent number of :
Inch^2	645.2	millimeters^2 (mm^2)
	6.45	centimeters^2 (cm^2)
Foot^2	0.0929	meters^2 (m^2)
Yard^2	0.8361	meters^2

VOLUME

Multiply	by	to get equivalent number of :
Inch^3	16387	mm^3
	16.387	cm^3
	0.0164	liters (l)
Quart	0.9464	liters
Gallon	3.7854	liters
Yard^3	0.7646	meters^3 (m^3)

MASS

Multiply	by	to get equivalent number of :
Pound	0.4536	kilograms (kg)
Ton	907.18	kilograms (kg)
Ton	0.907	tonne (t)

FORCE

Multiply	by	to get equivalent number of :
Kilogram	9.807	newtons (N)
Ounce	0.2780	newtons
Pound	4.448	newtons

TEMPERATURE

Multiply	by	to get equivalent number of :
Degree Fahrenheit	(t°F-32)÷1.8	degree Celsius (C)

ACCELERATION

Multiply	by	to get equivalent number of :
Foot/sec^2	0.3048	meter/sec^2 (m/s^2)
Inch/sec^2	0.0254	meter/sec^2

TORQUE

Multiply	by	to get equivalent number of :
Pound-inch	0.11298	newton-meters (N-m)
Pound-foot	1.3558	newton-meters

POWER

Multiply	by	to get equivalent number of :
Horsepower	0.746	kilowatts (kW)

PRESSURE OR STRESS

Multiply	by	to get equivalent number of :
Inches of water	0.2491	kilopascals (kPa)
Pounds/sq.in.	6.895	kilopascals

ENERGY OR WORK

Multiply	by	to get equivalent number of :
BTU	1 055	joules (J)
Foot-pound	1.3558	joules
Kilowatt-hour	3 600 000 or 3.6×10^6	joules (J=one W)

LIGHT

Multiply	by	to get equivalent number of :
Foot candle	1.0764	lumens/meter^2 (lm/m^2)

FUEL PERFORMANCE

Multiply	by	to get equivalent number of :
Miles/gal	0.4251	kilometers/liter (km/l)
Gal/mile	2.3527	liter/kilometer (l/km)

VELOCITY

Multiply	by	to get equivalent number of :
Miles/hour	1.6093	kilometers/hr.(km/h)

HVAC

Heating and Ventilation

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Description and Operation

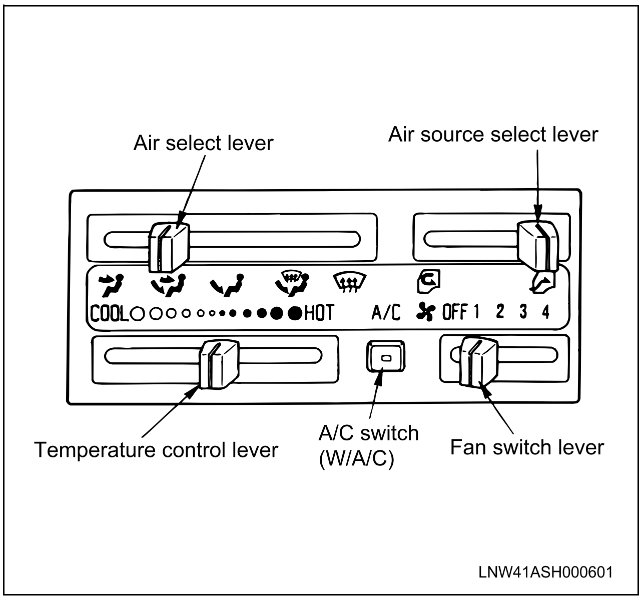
Heater System Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that a application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

When the engine is warming up, the warmed engine coolant is sent out into the heater core. The heater system supplies warm air into the passenger compartment to warm it up.
Outside air is circulated through the heater core of the heater unit and then back into the passenger compartment. By controlling the mixture of outside air and heater core air, the most comfortable passenger compartment temperature can be selected and maintained.
The temperature of warm air sent to the passenger compartment is controlled by the temperature control lever. This lever acts to open and close the air mix door, thus controlling the amount of air passed through the heater core.
The air select lever, with its different modes, also allows you to select and maintain the most comfortable passenger compartment temperature.
The air source select lever is used to select either “Fresh” for the introduction of the outside air, or “Circ” for the circulation of the inside air. When the lever is set to “Fresh”, the outside air is always taken into the passenger compartment.
When setting the lever to “Circ” position, the circulation of air is restricted only to the inside air with no introduction of the outside air and the air in the passenger compartment gets warm quickly. However, the lever is normally set to “Fresh” to prevent the windshield from fogging.

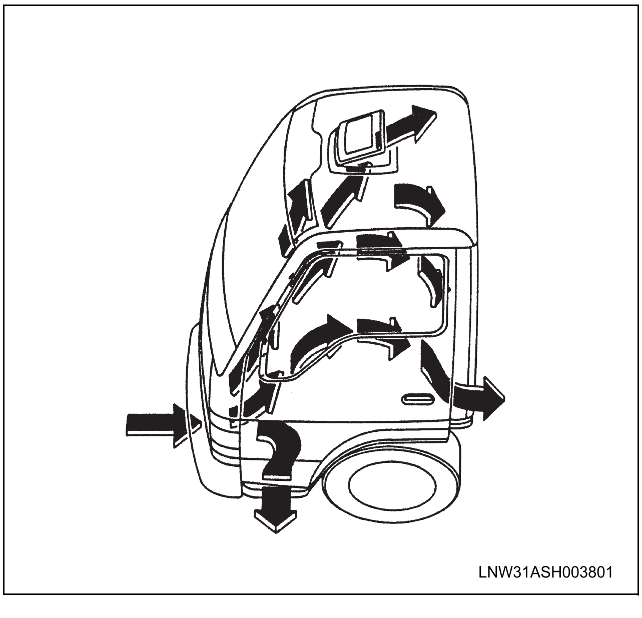
Control Lever Assembly Description

The vehicle has cable-control-type to control by cable the mode and temperature of the heater unit and the mode door for the air source of the blower assembly. The fan control is used to control the amount of air sent out at four levels from “Low” to “High”, by a resistor.



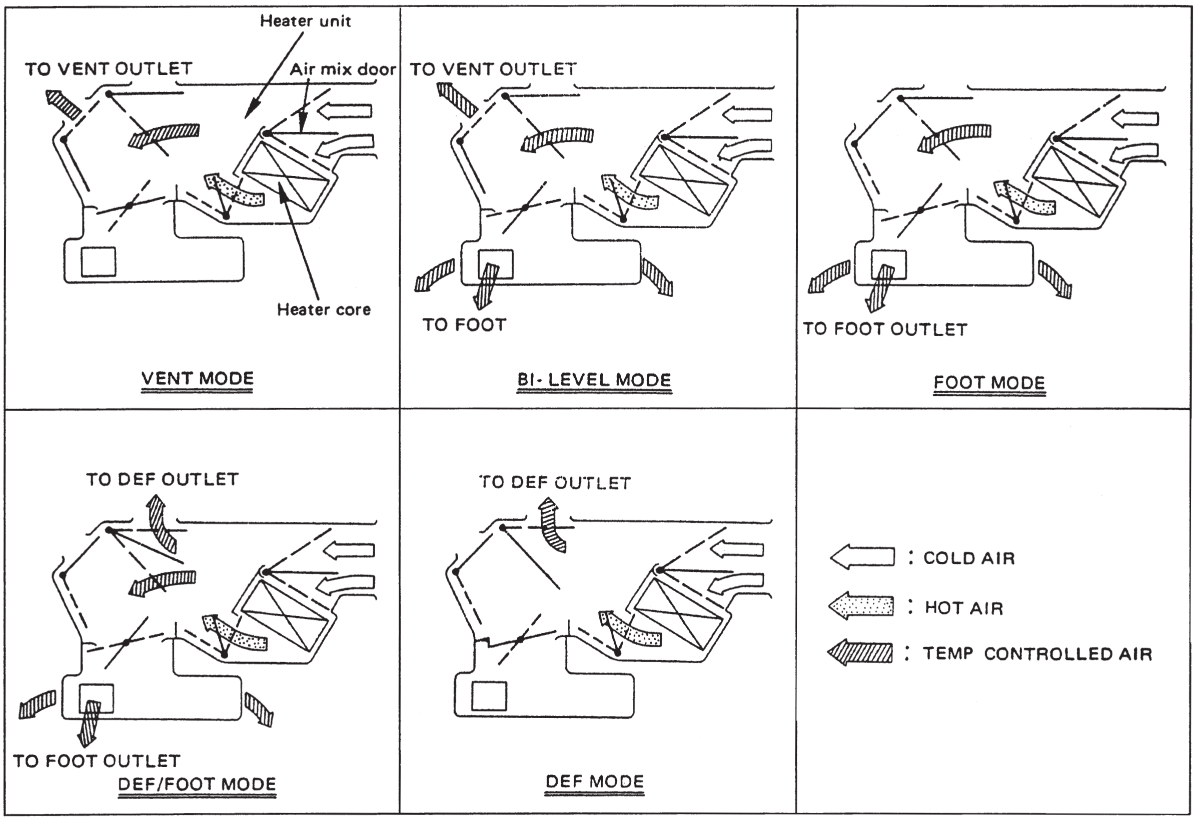
Ventilation System Description

Set “Air Source Select Lever” to “Fresh” position and turn on the blower fan. Heating can be done in this lever position, sending in fresh air from outside.
The blower fan also serves to deliver fresh outside air to the vehicle interior to assure adequate ventilation.



Air Select lever Description

The air selector lever allows you to direct heated air into the passenger compartment through different outlets.



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- **Vent**
  In this position, air is discharged from the upper air outlet. Air quantity is controlled by the fan control knob.
- **Bi - Level**
  In this position, air flow is divided between the upper air outlets and the foot air outlets, with warmer air delivered to the floor outlets than the air delivered to the upper air outlets.
- **Foot**
  In this position, air flow is delivered to the foot only.
- **Def / Foot**
  In this position, air flow is divided to the foot air outlet, while sending approx. 30% of total amount of air to the windshield.
- **Defrost**
  In this position, most of the air is delivered to the windshield and a small amount is delivered to the side windows.

Air Source Select Lever Description

The intake of outside air and the circulation of inside air are controlled by sliding this lever left or right. Moving the air source select lever to the “Circ” position provides the quickest temperature change by closing off outside air. In this position, outside air is not delivered to the passenger compartment.

Fan Switch Description

This lever controls the blower motor speed to regulate the amount of air delivered to the defrost, foot, and ventilation ducts:

- Low
- Medium Low
- Medium High
- High

Temperature Control Lever Description

When the temperature control lever is in the “COLD” position, the air mix door closes to block the flow of air through heater core.

When the temperature control lever is in the “HOT” position, the air mix door opens to allow air to pass through the heater core and heat the passenger compartment.

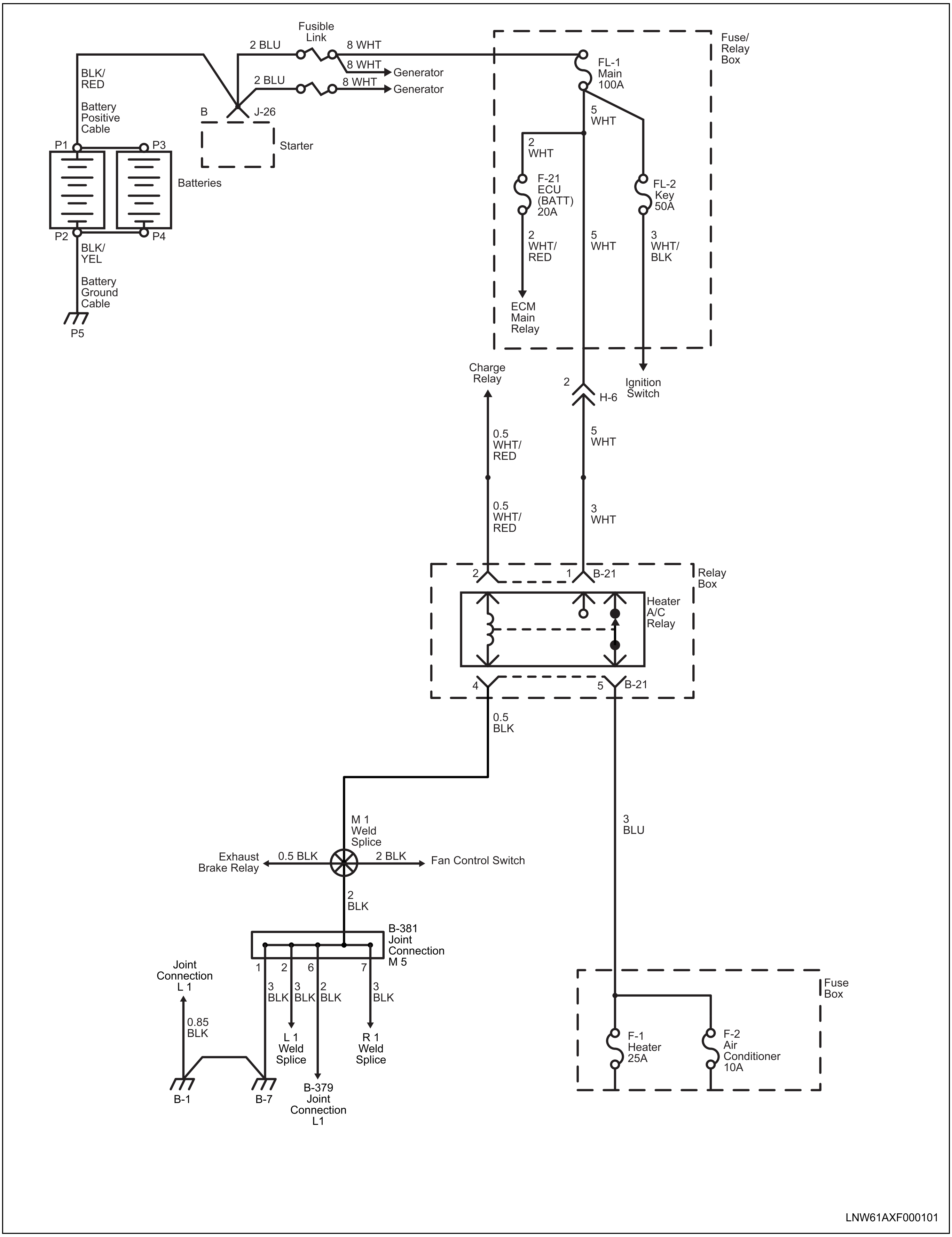
Placing the lever in an intermediate position will cause a lesser or greater amount of air to reach the heater core. In this mode the passenger compartment temperature can be regulated.

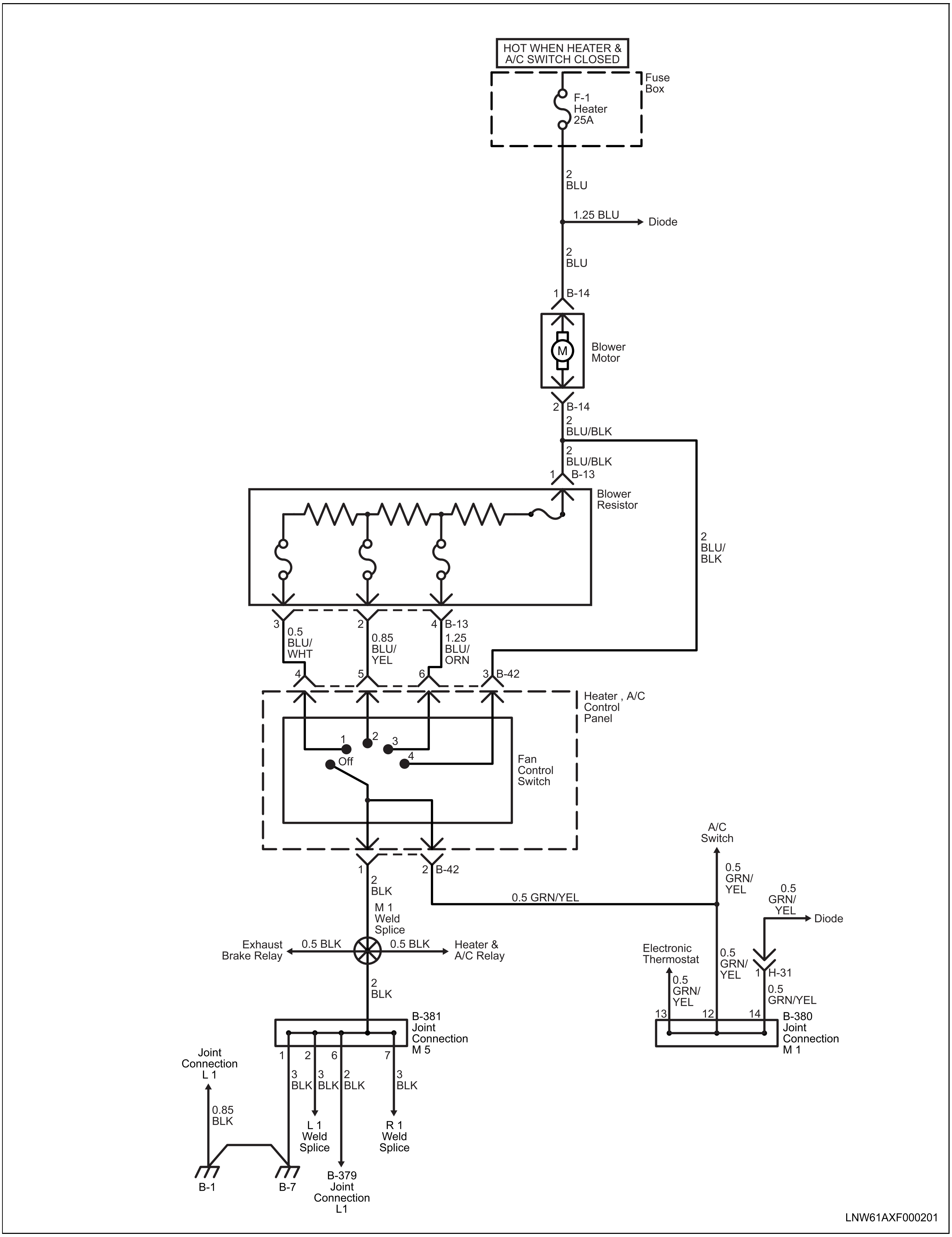
Schematic and Routing Diagrams

Fan Switch Schematic Diagrams

Current flows to the blower motor through the Heater and A/C relay B-21 to activate the rotation of the blower motor by turning ON the fan control lever.

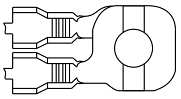
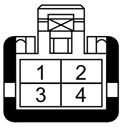
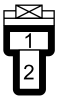
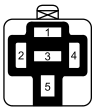
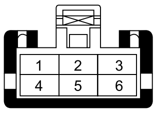
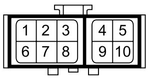
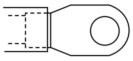
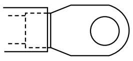
Blower motor speed is controlled in stages by the blower resistor, by operating the switch from Low to High.

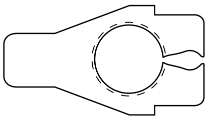
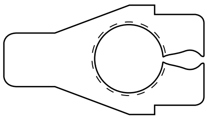
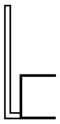

Fusible Link
2 BLU
8 WHT
8 WHT
Generator
2 BLU
8 WHT
Generator
BLK/ RED
Battery Positive Cable
B
J-26
Starter
P1
P3
Batteries
P2
P4
BLK/ YEL
Battery Ground Cable
P5
Fuse/ Relay Box
FL-1 Main 100A
5 WHT
2 WHT
F-21 ECU (BATT) 20A
FL-2 Key 50A
2 WHT/ RED
5 WHT
3 WHT/ BLK
ECM Main Relay
Charge Relay
2
H-6
Ignition Switch
0.5 WHT/ RED
5 WHT
0.5 WHT/ RED
3 WHT
2
1
B-21
Relay Box
Heater A/C Relay
4
5
B-21
0.5 BLK
3 BLU
M 1 Weld Splice
Exhaust Brake Relay
0.5 BLK
2 BLK
Fan Control Switch
2 BLK
B-381 Joint Connection M 5
1
2
6
7
3 BLK
3 BLK
2 BLK
3 BLK
Joint Connection L 1
0.85 BLK
L 1 Weld Splice
R 1 Weld Splice
B-1
B-7
B-379 Joint Connection L1
Fuse Box
F-1 Heater 25A
F-2 Air Conditioner 10A
LNW61AXF000101



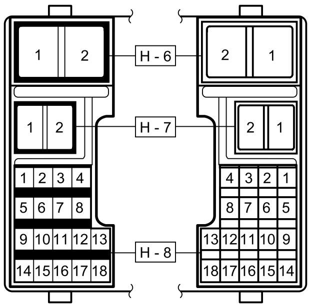
LNW61AXF000201

Connector List

No.	Connector Face
B-7	 Ground; Headlight Bracket-LH
B-13 (BRN)	 Blower Resistor
B-14 (WHT)	 Blower Motor
B-21	 Relay: Heater & A/C
B-42 (WHT)	 Fan Switch
B-381	 Joint Connection-M5
P-1	 Battery (+)
P-2	 Battery (-)

No.	Connector Face
P-3	 Battery (+)
P-4	 Battery (-)
P-5	 Earth: Frame

H-6



Body Harness Connection RR

Diagnostic Information and Procedures

No heating or Insufficient Heating

POSSIBLE CAUSE	CORRECTION
1. Blower motor does not run, or runs improperly. 2. Engine coolant temperature is low.	• Refer to Blower Motor Diagnosis. • Check the engine coolant temperature after warming up the engine and check the thermostat. Replace as necessary. • Add engine coolant as required.
3. Blower motor does not work. 4. Circulation volume of engine coolant is insufficient.	• Check if the water hose to the heater core is clogged, collapsed or twisted. Repair or replace as necessary. • Check water pump function. Repair or replace as necessary. • Clean or replace as necessary.
5. Heater core clogged or collapsed. 6. The heater core is not provided with air sent from the blower motor. 7. Duct connections defective or unsealing.	• Repair the temperature control link unit or mode doors. • Repair or adjust the control cables. • Repair or replace as necessary.

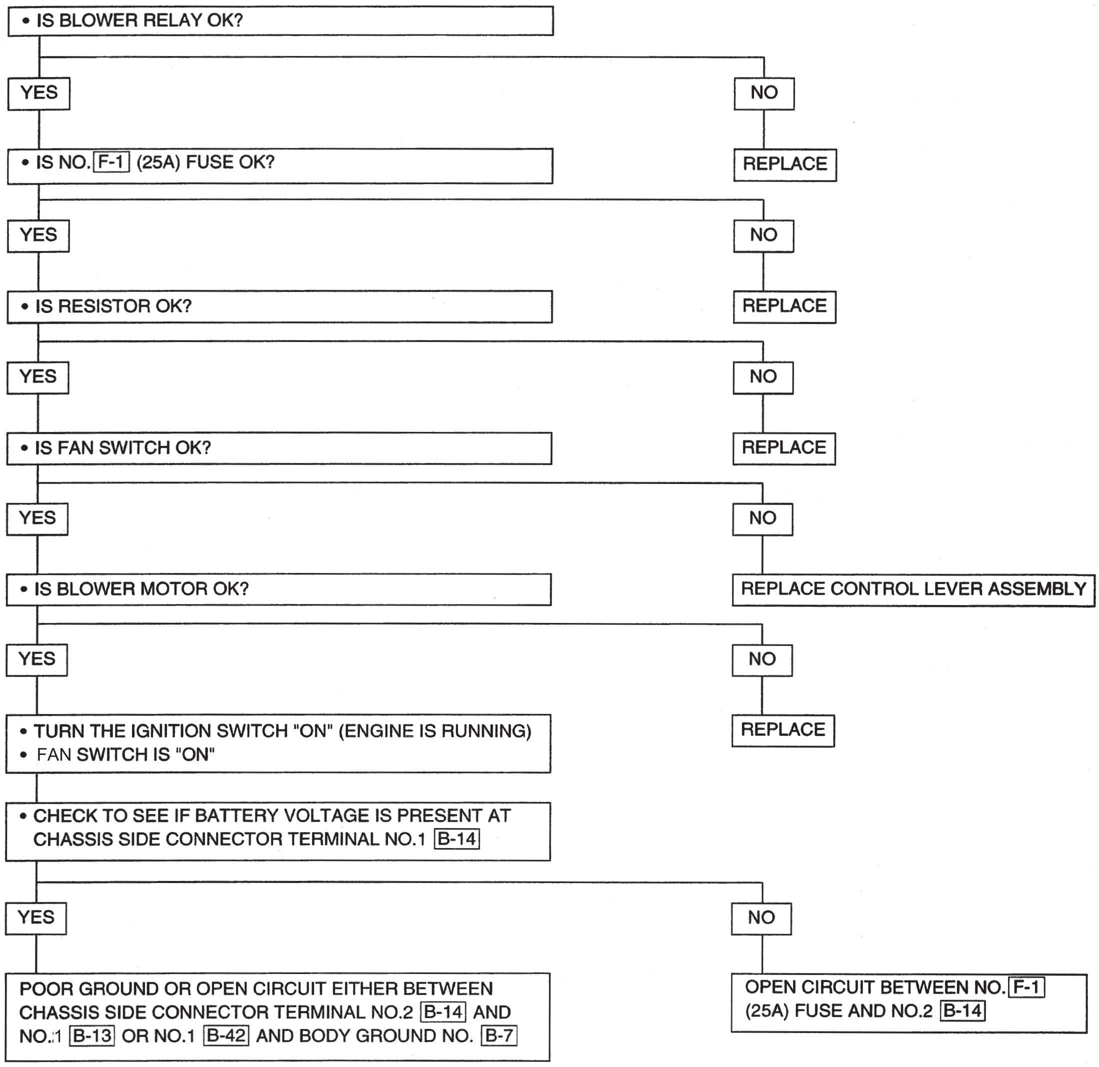
Control Knob Moves But Mode Door Does Not Operate

POSSIBLE CAUSE	CORRECTION
1. Cable attaching clip is not correct.	• Repair.
2. Link unit of heater unit or blower assembly defective.	• Repair.

The Mode Door Cannot Be Set To The Mode Selected

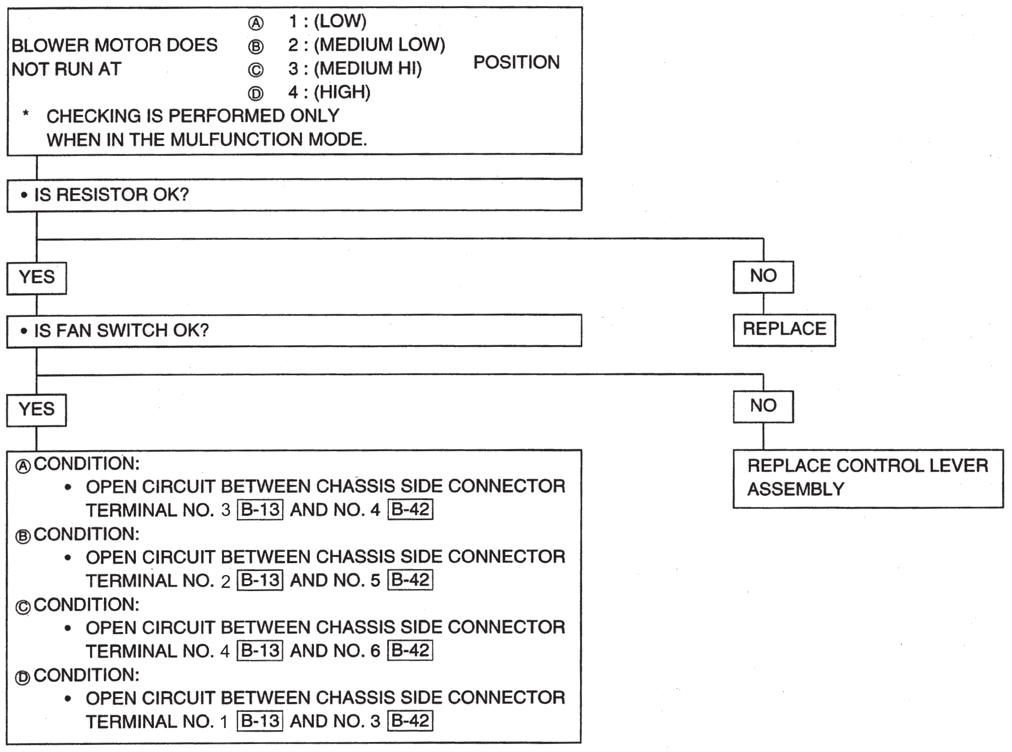
POSSIBLE CAUSE	CORRECTION
1. Link unit of heater unit or blower assembly defective.	• Repair.
2. Control cable is not adjusted.	• Adjust.

Blower Motor Does Not Run



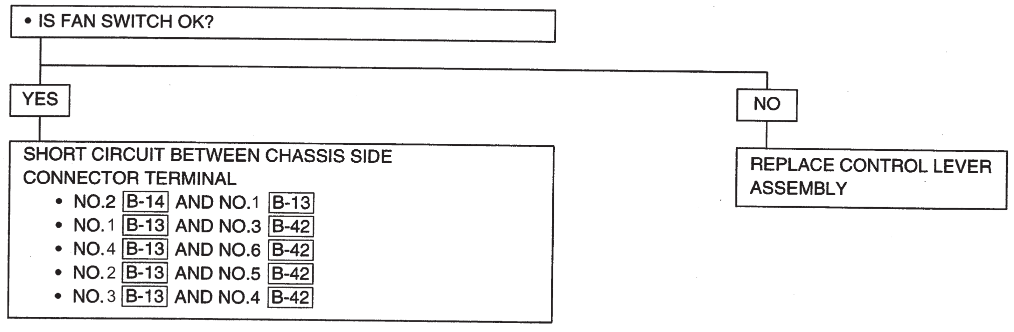
LNW61ALF000301

Blower Motor Does Not Run In Certain Position



LNW41AMF000301

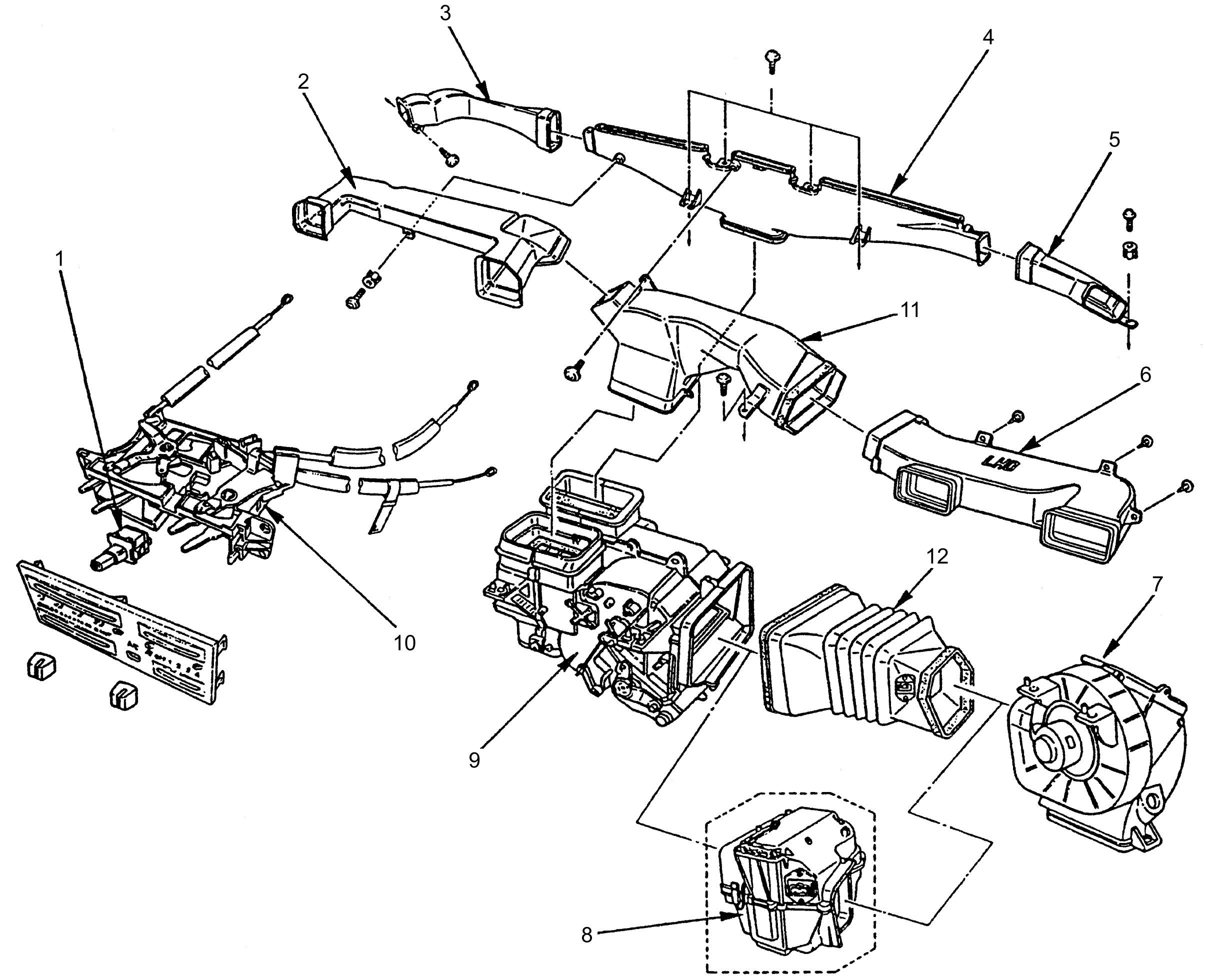
Blower Motor Does Not Stop at OFF Position



LNW41ASF000101

Component Locator

Heater Unit and Heater Core



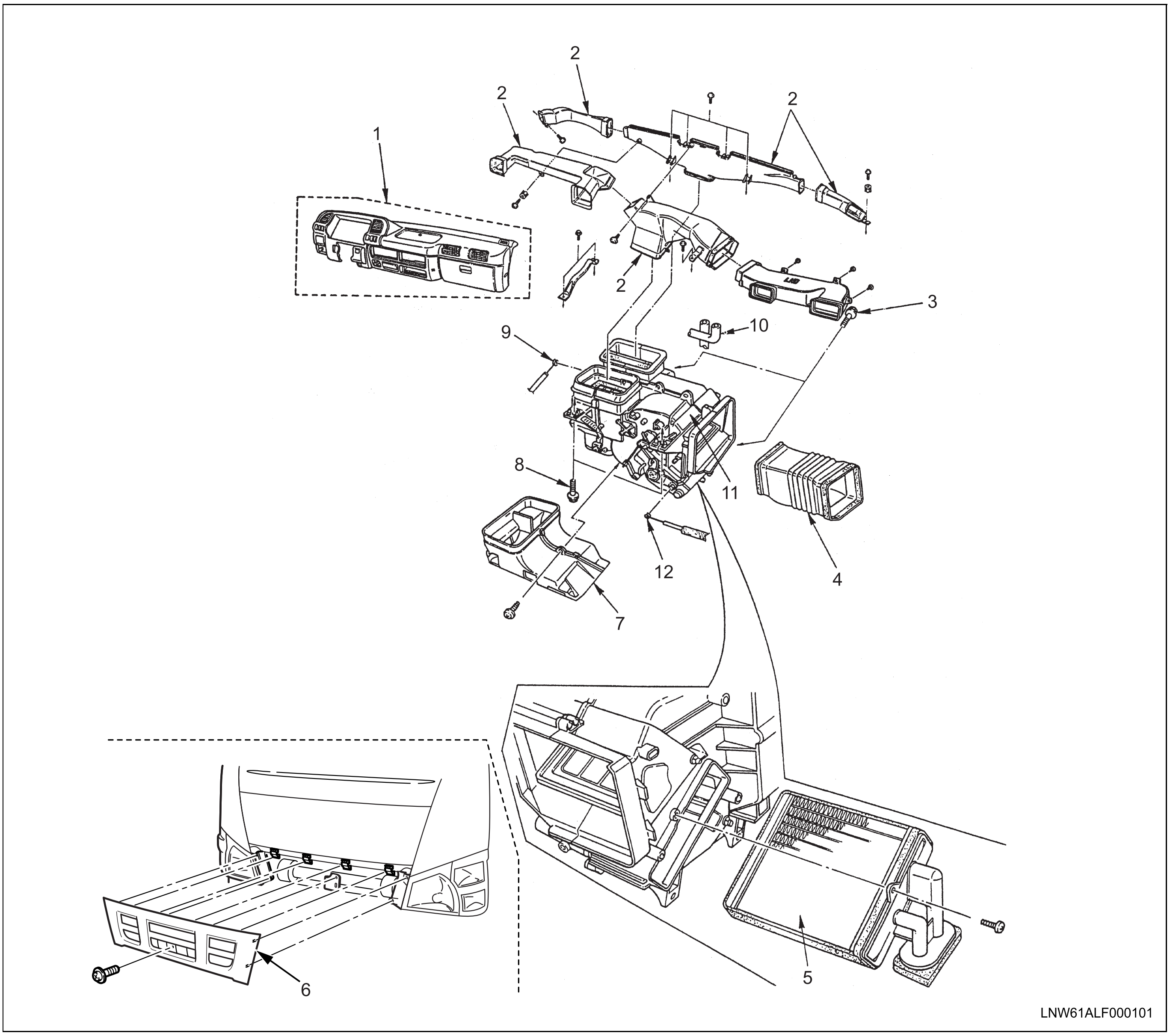
LNW31ALF001001

Legend

1. A/C Switch
2. Ventilation Duct (LH)
3. Side Defroster Nozzle (LH)
4. Defroster Nozzle
5. Side Defroster Nozzle (RH)
6. Ventilation Duct (RH)
7. Blower Assembly
8. Evaporator Assembly (with A/C)
9. Heater Unit
10. Control Lever Assembly
11. Ventilation Duct (Center)
12. Duct

Repair Instructions

Heater Unit and Heater Core



Legend

1. Instrument Panel Assembly
2. Defroster Nozzle and Ventilation Duct
3. Bolt (Panel-Heater Unit)
4. Duct
5. Heater Core
6. Front Grille
7. Foot Duct
8. Bolt (Heater Unit-Reinforce)
9. Heater Control Cable
10. Water Hose
11. Heater Unit
12. Heater Control Cable

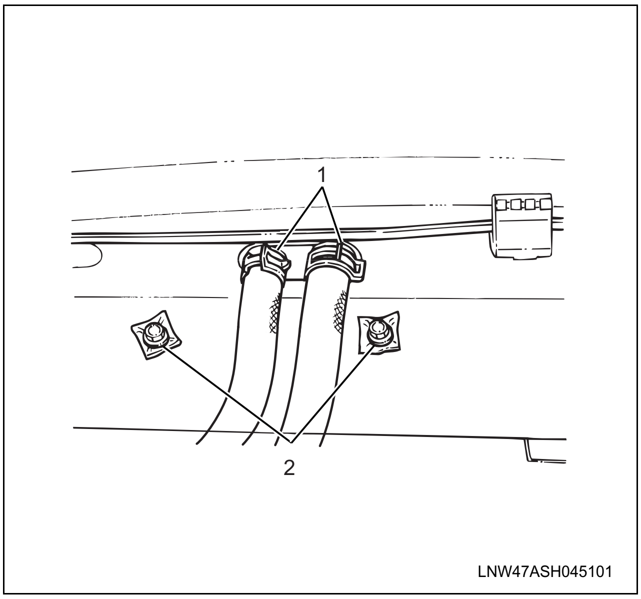
Preparation

Disconnect the battery ground cable.
Drain engine coolant.
Discharge and recover refrigerant. (With Air conditioning)
Refer to Refrigerant Recovery.

Removal Procedure

1. Remove the instrument panel assembly.
   Refer to Steel Tilt Cab for Instrument Panel Assembly removal procedure.
2. Remove the defroster nozzle and ventilation duct.
   Refer to Defroster Nozzle and Ventilation Duct removal procedure in this section.
3. Disconnect the cables from the heater unit.

4. Remove the foot duct.
5. Remove the duct.
6. Remove the front grille.
7. Remove the water hose clips and disconnect the water hose from panel sub dash.

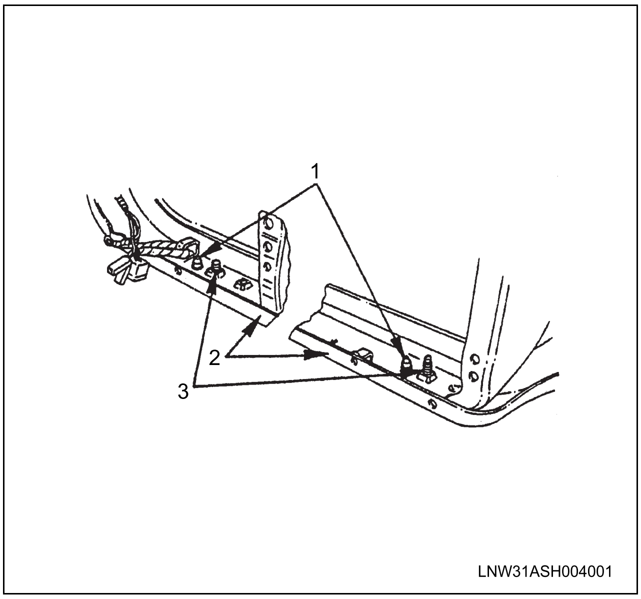


Legend

1. Water Hose Clips
2. Bolts

---

8. Remove the bolt. (Panel-Heater Unit)
9. Remove the fixing bolts from the reinforce.



Legend

1. Pins
2. Reinforce
3. Fixing Bolts (Heater Unit-reinforce)

---

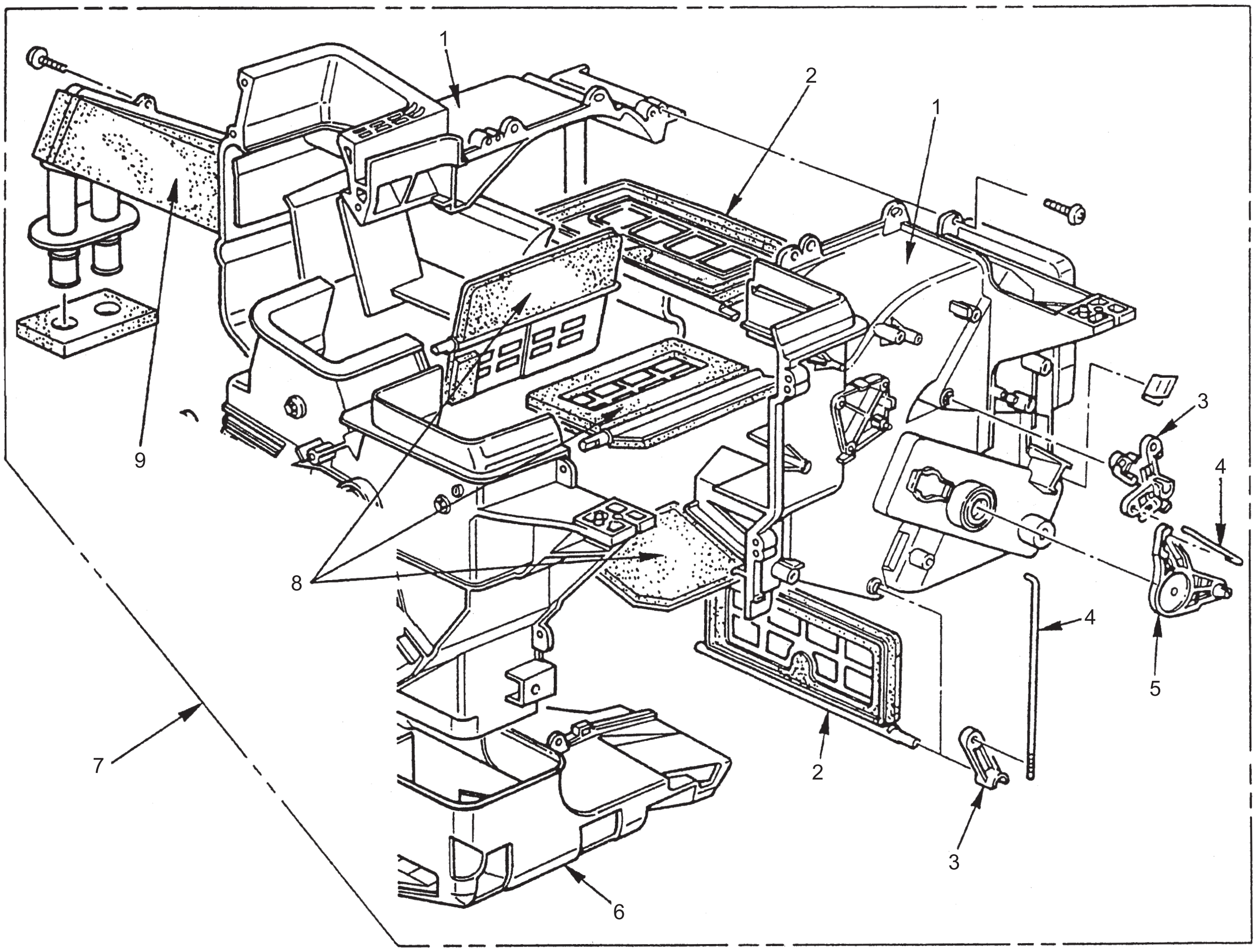
10. Drop the heater unit positioning pins from the reinforce, and remove the heater unit while sliding the engaged section between the evaporator and the heater unit.
11. Remove the heater core.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points.

1. Adjust the control lever assembly cables.
   Refer to Control Lever Assembly installation steps in this section.
2. When installing the heater unit, defroster nozzles and ventilation ducts, be sure that proper seal is made, without any gap between them.
3. Check the engine coolant level. When the level is below the specified amount, replenish engine coolant to the proper level.

Heater Temperature Control Link Unit and Air Mix Door



Legend

1. Upper Case
2. Air Mix Door
3. Door Lever
4. Rod
5. Mix Sub Lever
6. Foot Duct
7. Heater Unit
8. Mode Door
9. Heater Core

Preparation

Disconnect the battery ground cable.
Drain engine coolant.

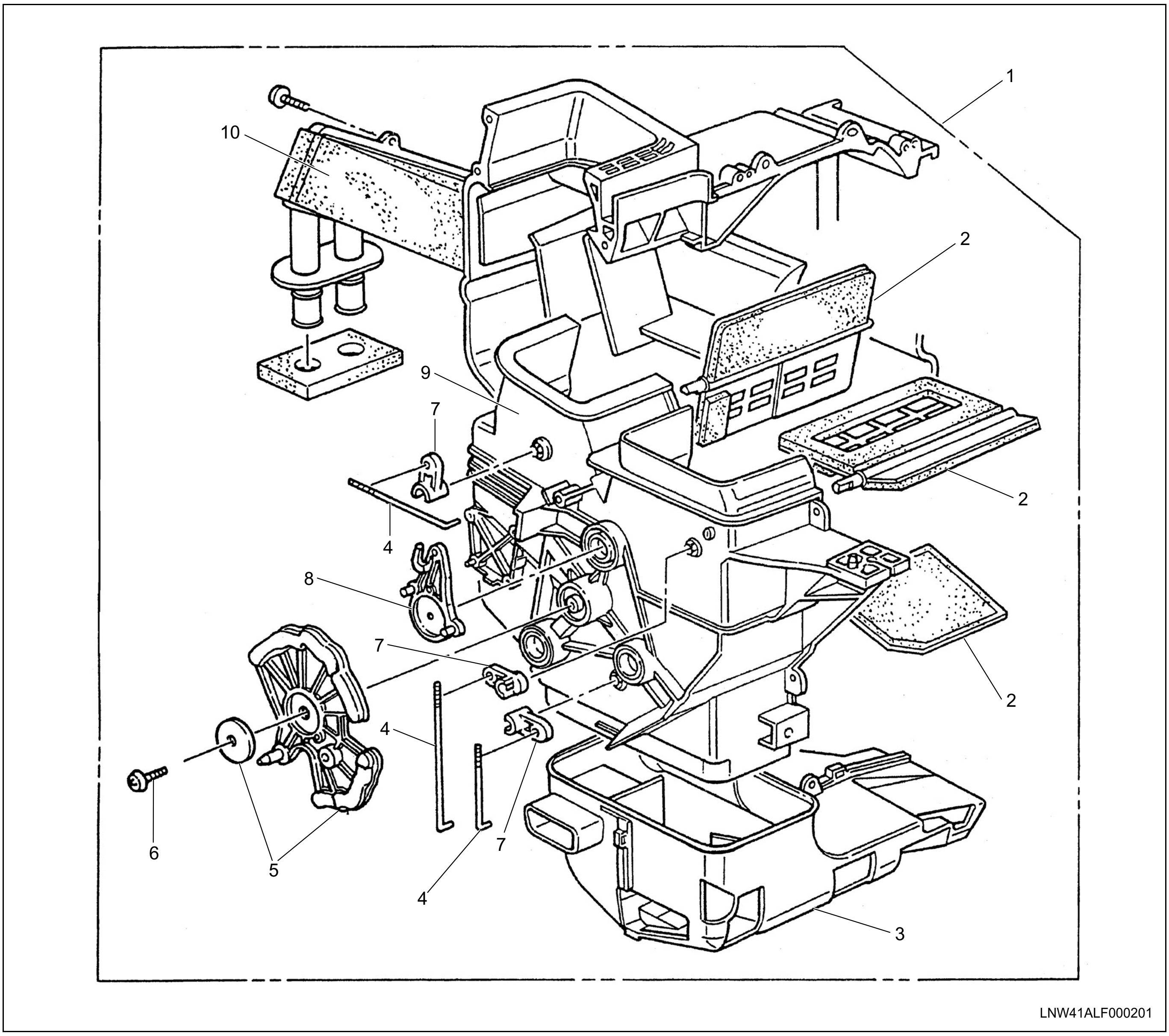
Removal Procedure

1. Remove the heater unit.
   Refer to Heater Unit removal procedure.
2. Remove the rod.
3. Pull out the door lever while raising up the catch of the door lever.
4. Remove the foot duct.
5. Remove the upper case.
   Separate two halves of the upper case.
6. Remove the air mix door.
7. Press the tab of the sub lever inward, and take out the sub lever.

Installation Procedure

To install, follow the removal steps in the reverse order.

Heater Mode Control Link Unit and Mode Door



Legend

1. Heater Unit
2. Door Lever
3. Foot Duct
4. Rod
5. Washer and Mode Main Lever
6. Screw
7. Door Lever
8. Mode Sub Lever
9. Upper Case
10. Heater Core

Preparation

Disconnect the battery ground cable.
Drain engine coolant.

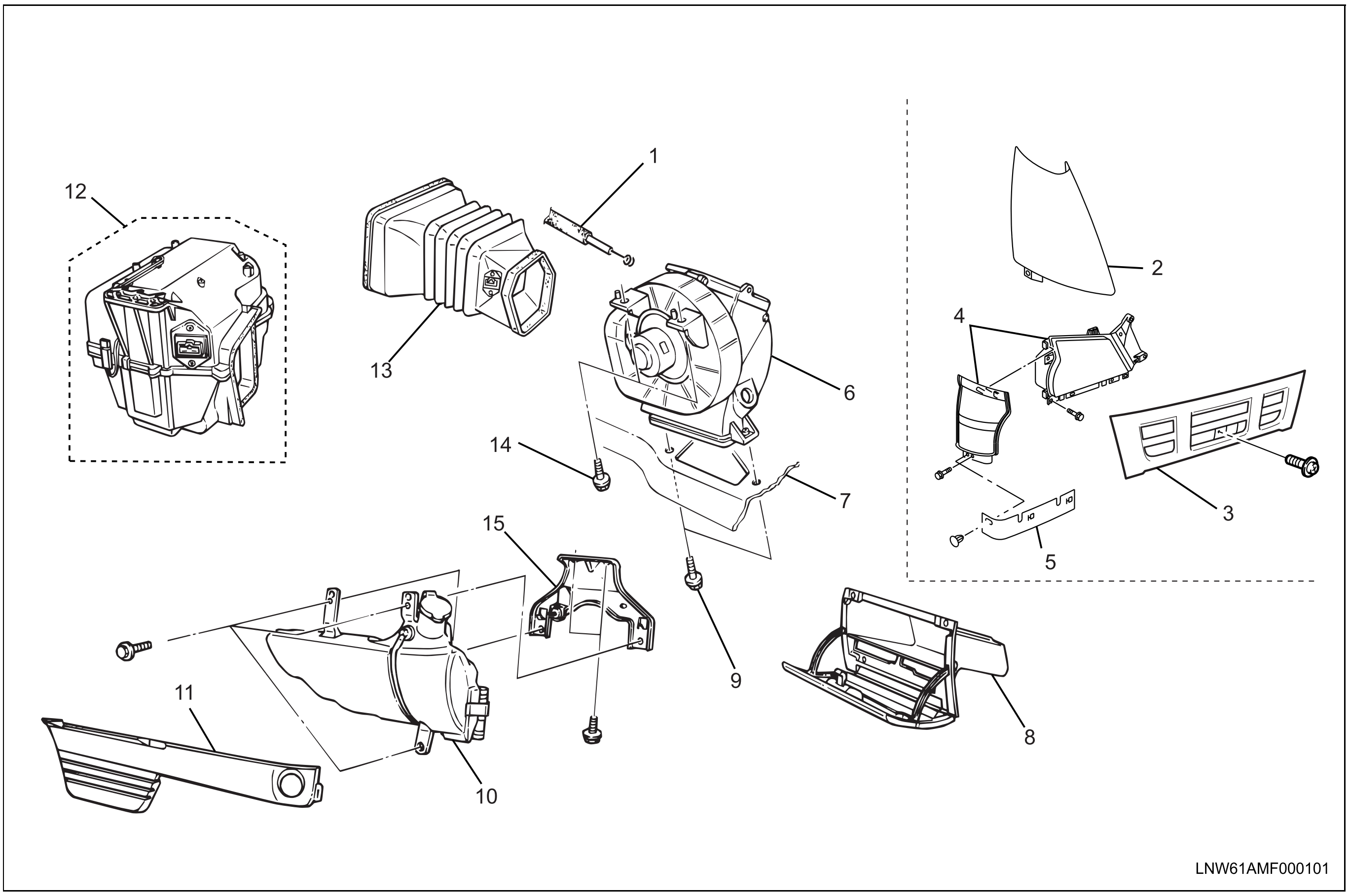
Removal Procedure

1. Remove the heater unit.
   Refer to Heater Unit removal procedure.
2. Remove the screw.
3. Remove the washer and mode main lever.
4. Remove the rod.
5. Pull out the door lever while raising up the catch of the door lever.
6. Remove the foot duct.
7. Remove the upper case.
8. Remove the door lever.
9. Press the tab of the sub lever inward, and take out the sub lever.

Installation Procedure

To install, follow the removal steps in the reverse order.

Blower Assembly



Legend

1. Blower Control Cable
2. Front Side Panel (RH)
3. Front Grille
4. Cornering Light (RH) and Head Light Assembly (RH)
5. Seal Rubber (RH)
6. Blower Assembly
7. Floor Panel
8. Glove Box
9. Bolt (Panel-Blower Assembly)
10. Washer Tank (Without Air Conditioner)
11. Under Cover (Without Air Conditioner)
12. Evaporator Assembly
13. Duct (Without Air Conditioner)
14. Bolt (Blower Assembly-Reinforce)
15. Washer Tank Bracket

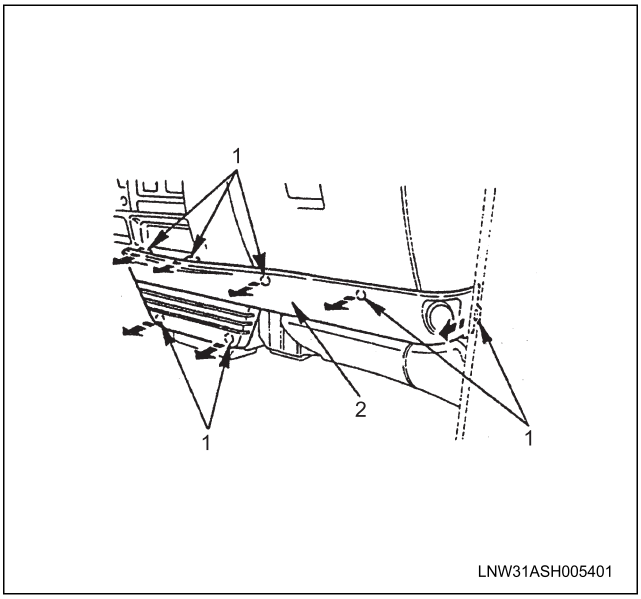
Preparation

Disconnect the battery ground cable.
Discharge and recover refrigerant. (With Air conditioning)
Refer to Refrigerant Recovery.

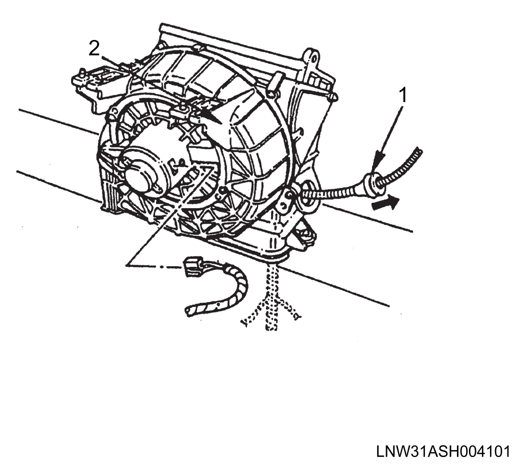
Removal Procedure

1. Remove the evaporator assembly.
   Refer to Air Conditioning for Evaporator Assembly removal procedure.

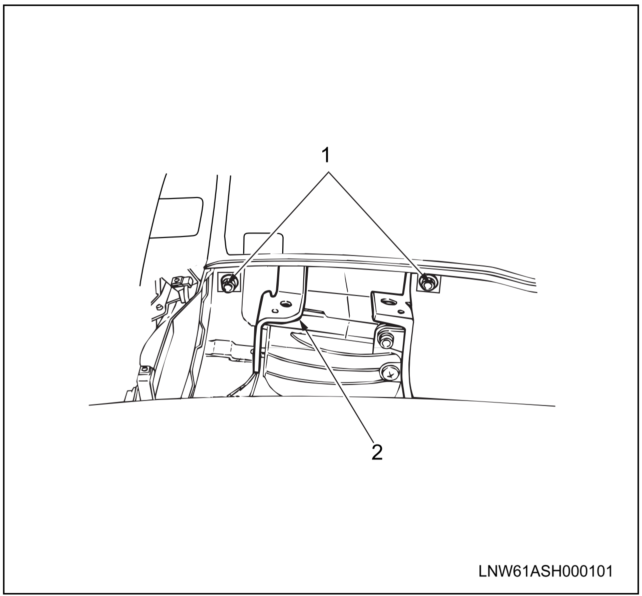
2. Remove the cover by pulling under the clips (1) on the back side of the cover (2).



3. Open the glove box and remove the fixing screws.(Without Air Conditioner)
4. Remove the duct. (Without Air Conditioner)
5. Remove the washer tank fixing three bolts (Upper: two, Lower: one) and disconnect the connector. (Without Air Conditioner)
6. Disconnect the harness connection connector and remove the fixing bolts.
7. Disconnect the blower control cable from the blower assembly.
8. Remove the front grille.
   Refer to Cab for Front grille removal procedure.
9. Remove the seal rubber (RH).
10. Remove the cornering light (RH) and head light assembly (RH).
    Refer to Chassis Eelectrical for cornering light and head light removal procedure.
11. Remove the front side panel (RH).
    Refer to Cab for Front side panel removal procedure.
12. Remove the grommet (1) provided at the lower right side of the blower assembly (2), and pull in the harness to the room through the blower hole.



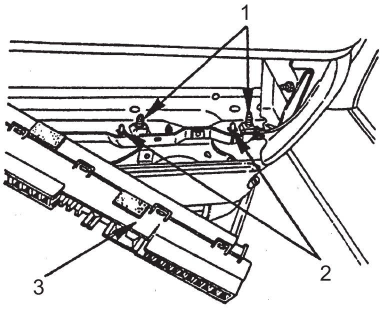
13. Remove the bolts.



Legend

1. Bolts
2. Headlight Bracket (RH)

14. Remove the Bolts. (Blower Assembly-Reinforce)



LNW31ASH004301

Legend

1. Bolts (Blower Assembly-Reinforce)
2. Pins
3. Fuse Box

---

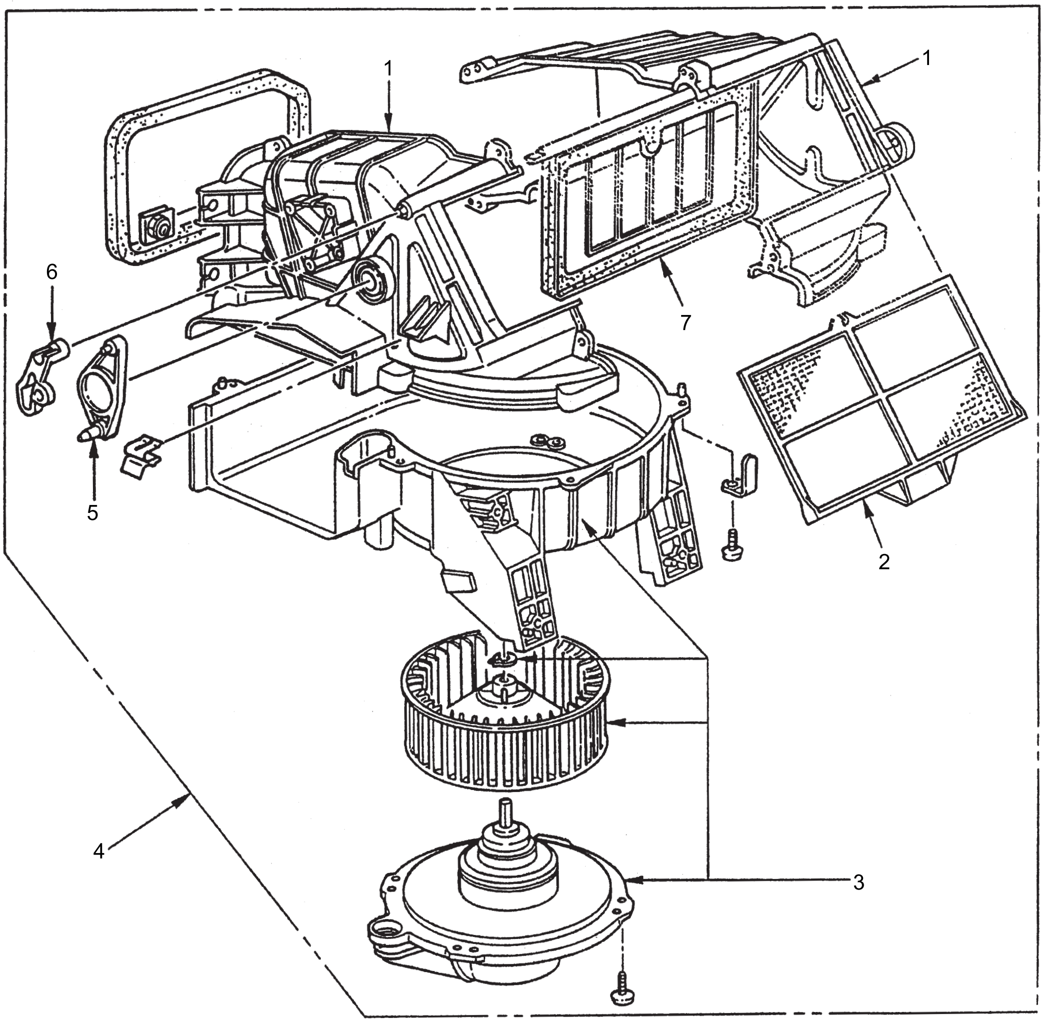
15. Remove the blower fixing bolts.
16. Drop the blower positioning pins from the reinforce to remove them.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points.

1. Adjust the control lever assembly cables.
   Refer to Control Lever Assembly installation steps in this section.

Blower Link Unit and Mode Door



Legend

1. Upper Case
2. Blower Filter (Equipped with Air Conditioner)
3. Lower Case
4. Blower Assembly
5. Mode Sub Lever
6. Door Lever
7. Mode Door

Preparation

Disconnect the battery ground cable.

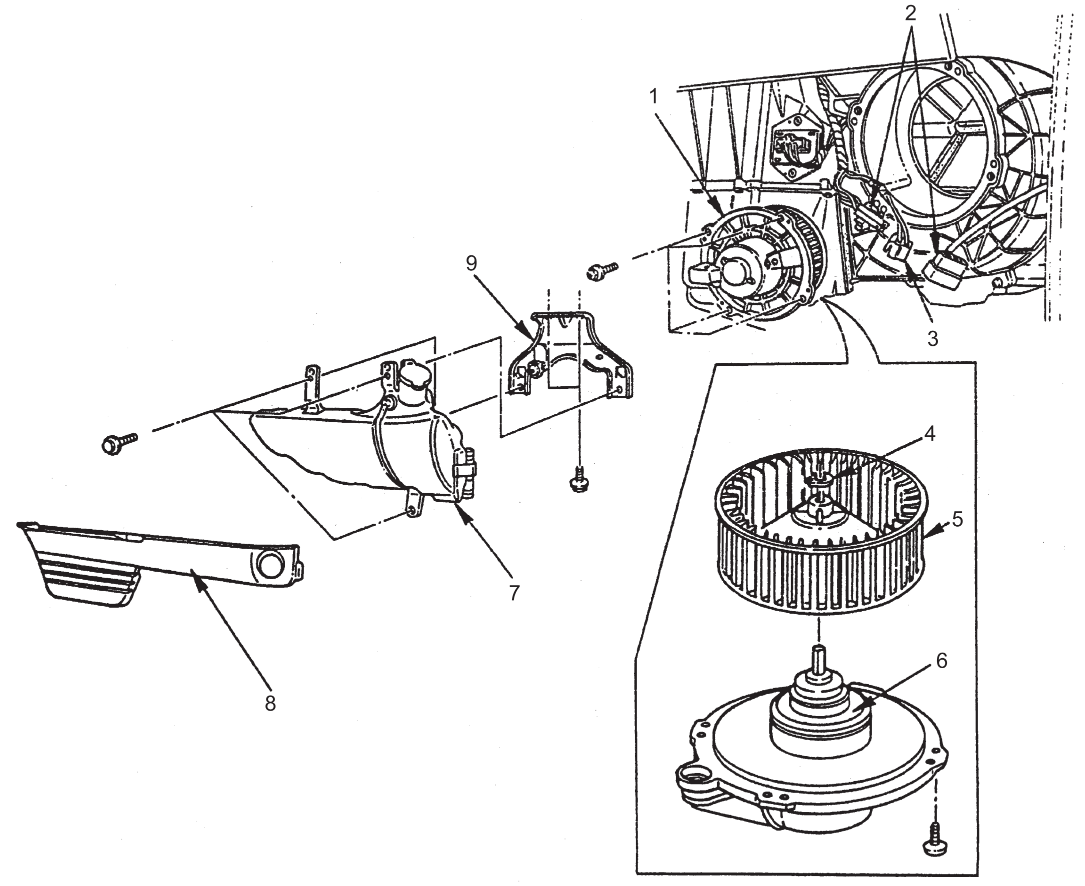
Removal Procedure

1. Remove the blower assembly.
   Refer to Blower Assembly removal procedure in this section.
2. Remove the blower filter. (With Air Conditioner)
3. Pull out the door lever while raising up the catch of the door lever.
4. Remove the lower case.
5. Remove the upper case.
   Separate two halves of the upper case.
6. Remove the mode door.
7. Remove the mode sub lever.

Installation Procedure

To install, follow the removal steps in the reverse order.

Blower Motor



Legend

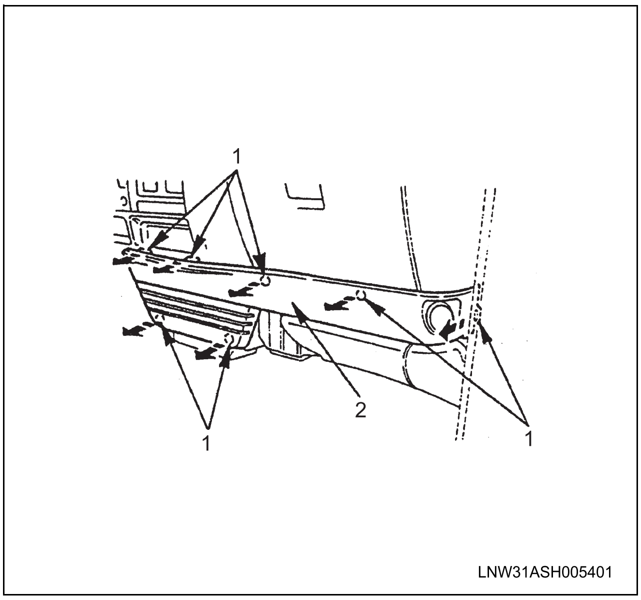
1. Blower Motor Assembly
2. Harness Connection Connector
3. Blower Motor Connector
4. Clip
5. Fan
6. Blower Motor
7. Washer Tank
8. Under Cover
9. Washer Tank Bracket

Preparation

Disconnect the battery ground cable.

Removal Procedure

1. Remove the cover by pulling under the clips on the backside of the cover.



Legend

1. Clips
2. Under Cover

---

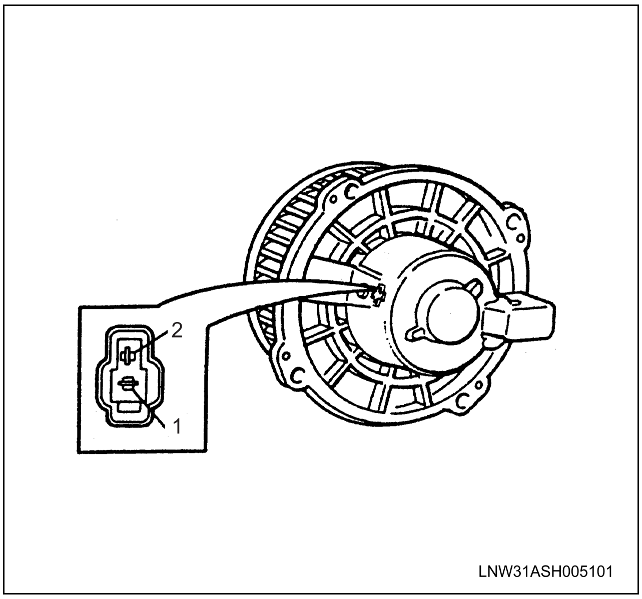
2. Remove the washer tank bolts (Upper: two, Lower: one) and disconnect the connector.
3. Disconnect the harness and remove the fixing bolts.
4. Disconnect the motor connector.
5. Remove the clip.
6. Remove the fan.
7. Remove the blower motor.

Installation Procedure

To install, follow the removal steps in the reverse order.

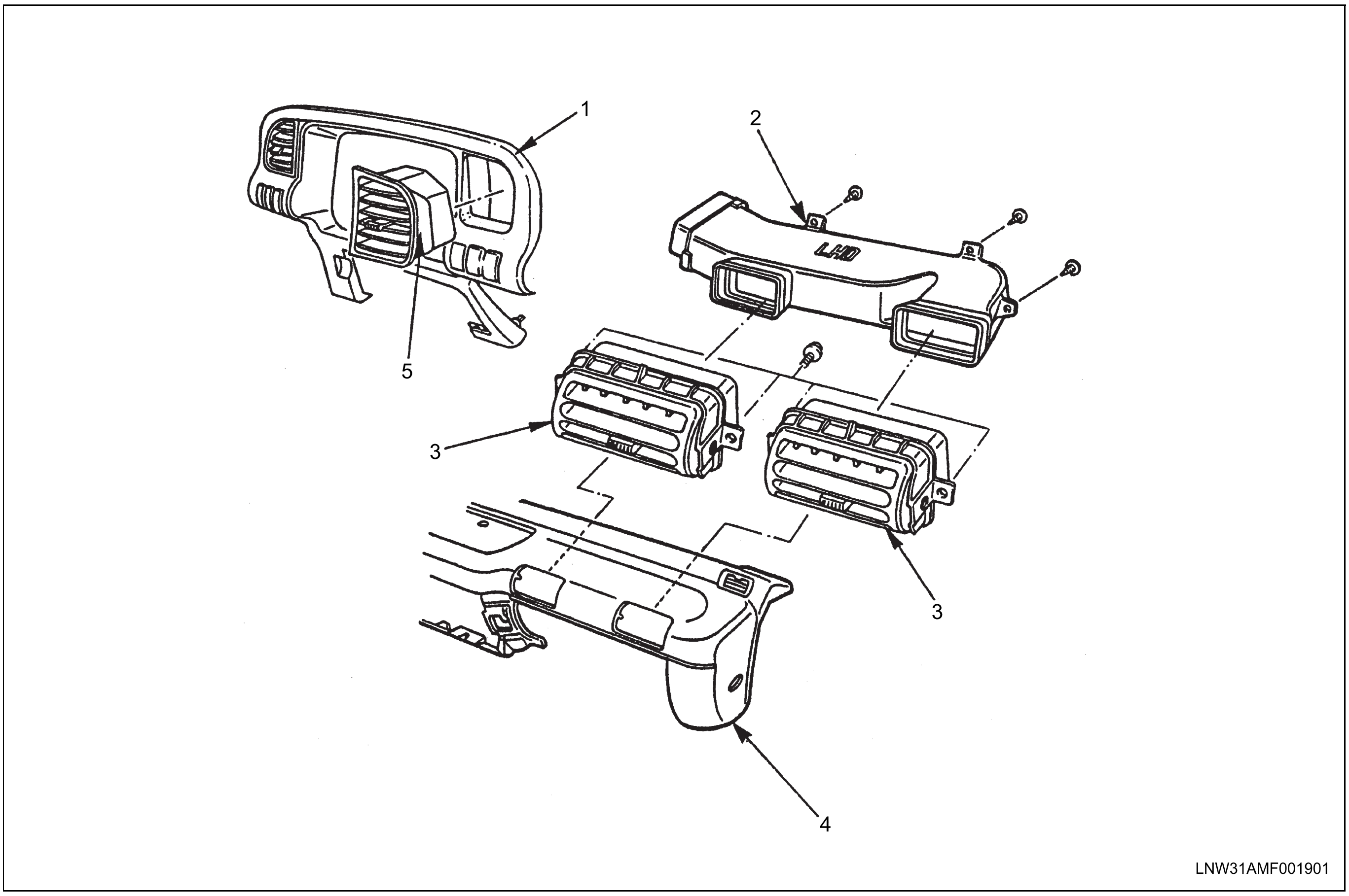
Inspection Procedure

1. Disconnect the blower motor connector from the blower motor.
2. Connect the battery positive terminal to the No.1 terminal of the blower motor and negative to the No.2.



3. Be sure to check to see if the blower motor operates correctly

Ventilation Grille



Legend

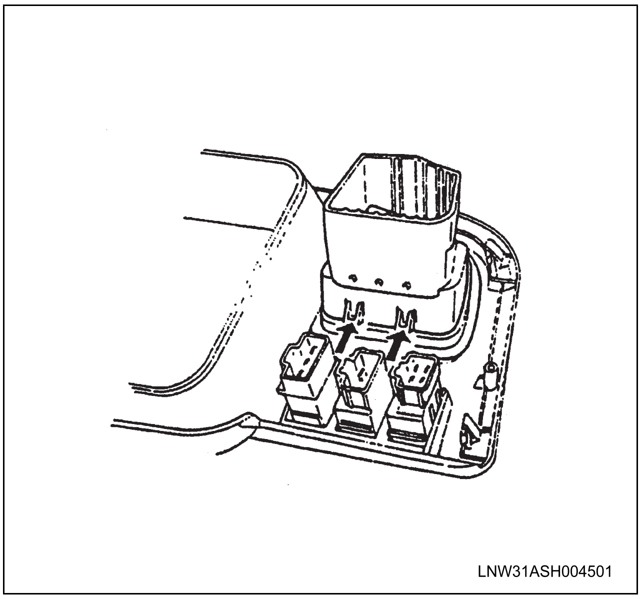
1. Meter Cluster
2. Ventilation Duct
3. Ventilation Grille (RH)
4. Instrument Panel Assembly
5. Ventilation Grille (LH)

Preparation

Disconnect the battery ground cable.

Removal Procedure

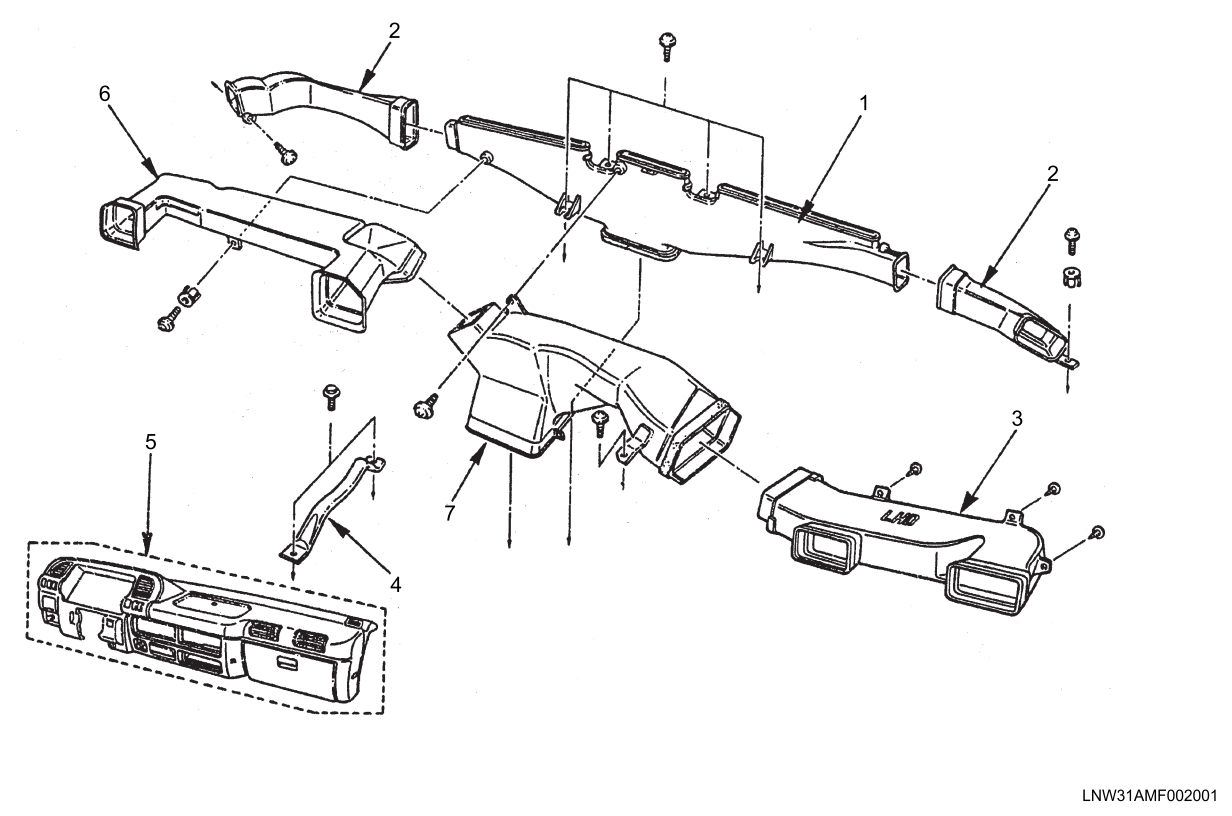
1. Remove the meter cluster.
   Refer to Cab and Chassis Electrical for Meter Cluster removal procedure.
2. Push the catches of the grille on the backside of the cluster to the inside, and remove the ventilation grille (LH).
3. Remove the instrument panel assembly.
   Refer to Steel Tilt Cab for Instrument Panel Components removal procedure.
4. Remove the ventilation duct.
5. Remove the ventilation grille (RH).



Installation Procedure

To install, follow the removal steps in the reverse order.

Defroster Nozzle and Ventilation Duct



Legend

1. Defroster Nozzle
2. Side Defroster Nozzle
3. Ventilation Duct (RH)
4. Reinforcement Stay
5. Instrument Panel Assembly
6. Ventilation Duct (LH)
7. Ventilation Duct (Center)

Preparation

Disconnect the battery ground cable.

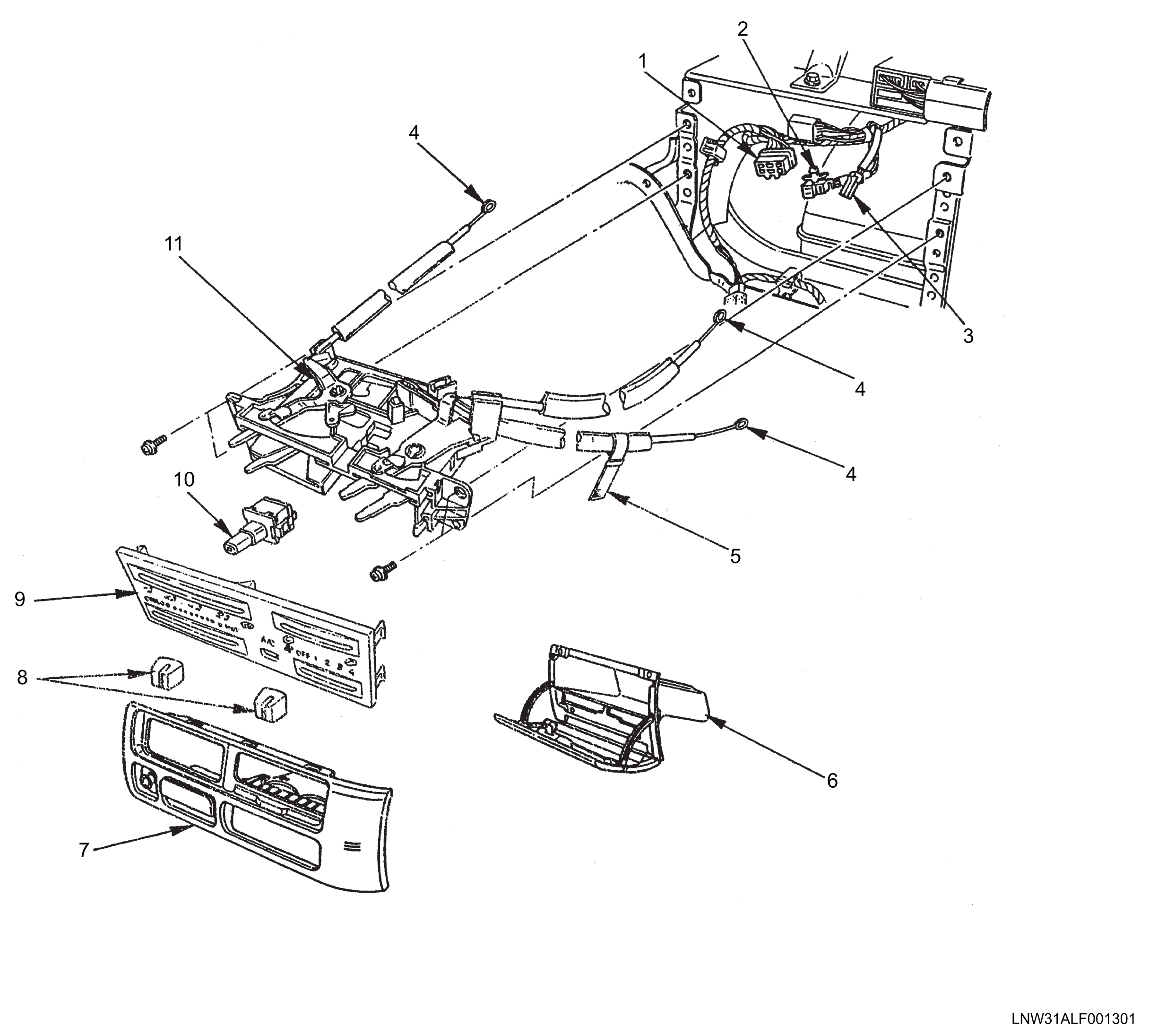
Removal Procedure

1. Remove the instrument panel.
   Refer to Steel Tilt Cab for Instrument Panel Components removal procedure.
2. Remove the ventilation duct. (RH)
3. Remove the ventilation duct. (Center)
4. Remove the ventilation duct. (LH)
5. Remove the reinforcement stay.
6. Remove the defroster nozzle.
7. Remove the side defroster nozzle.

Installation Procedure

To install, follow the removal steps in the reverse order.

Control Lever Assembly



Legend

1. Fan Switch Connector
2. A/C Switch Connector
3. Illumination bulb connector
4. Control Cable
5. Clip
6. Glove Box
7. Center Cluster
8. Knob
9. Control Panel Bezel
10. A/C Switch
11. Control Lever Assembly

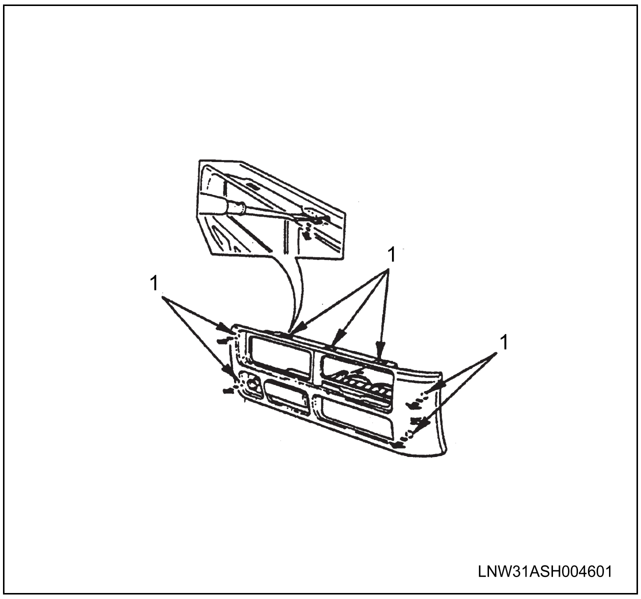
Preparation

Disconnect the battery ground cable.

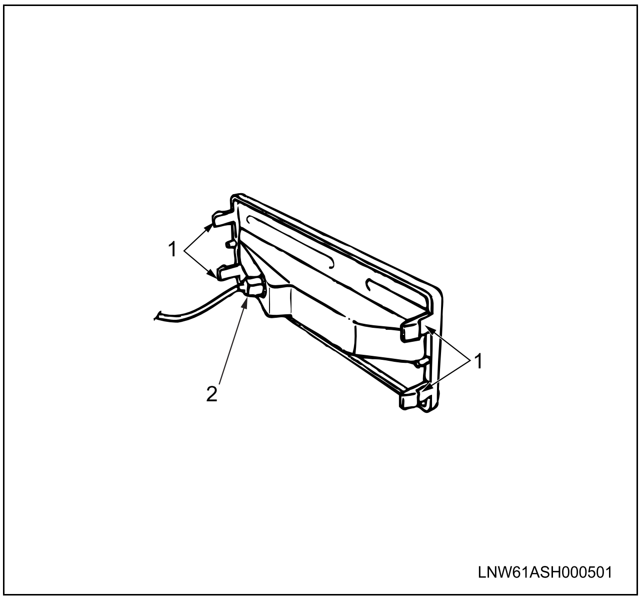
Removal Procedure

1. Open the glove box and remove the fixing screws.

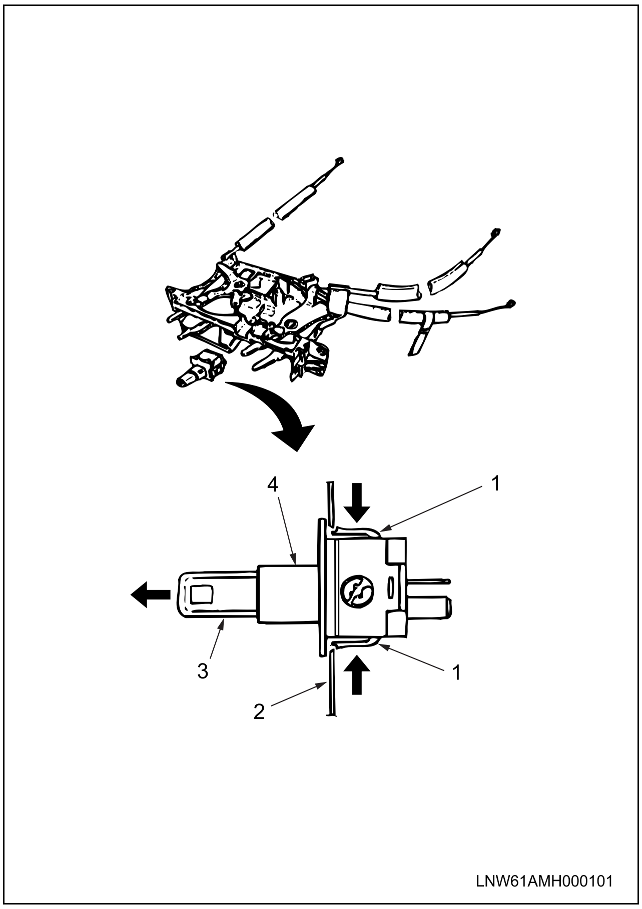
2. While pulling the cluster with care, remove the upper and the backside clips (1). of the cluster.



3. Disconnect the cigar lighter and illumination connectors.
4. Push the four catches (1) at of the bezel to the inside, and remove the illumination bulb (2) from the bezel.



5. Push the two catches at both sides of the inside, and remove the illumination bulb from the bezel.



Legend

1. Catches
2. Control Lever
3. Illumination Bulb
4. A/C Switch

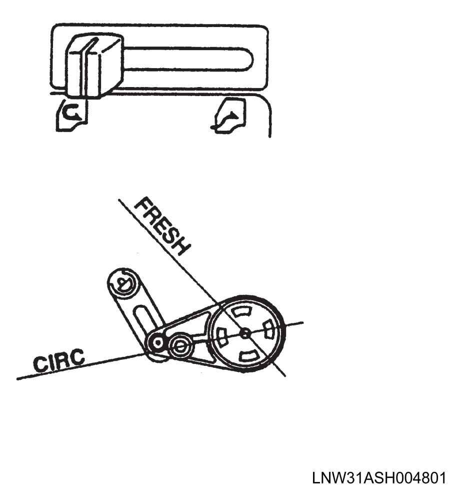
---

6. Remove the lever fixing bolts and pull the lever assembly out.
7. Disconnect the air conditioner switch connector clip and fan switch connector from the lever assembly.
8. Remove the control cable fixing clip.

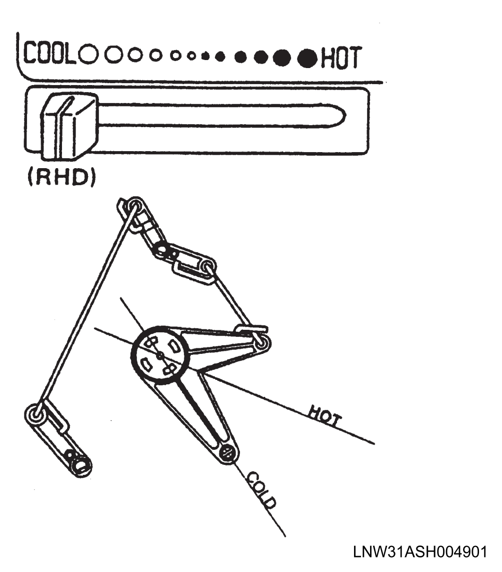
Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points.

1. Adjust the source control cable.
   - Slide the control lever to the left (CIRC Position).
   - Connect the control cable at the CIRC position of the link unit blower assembly and fix with the clip.

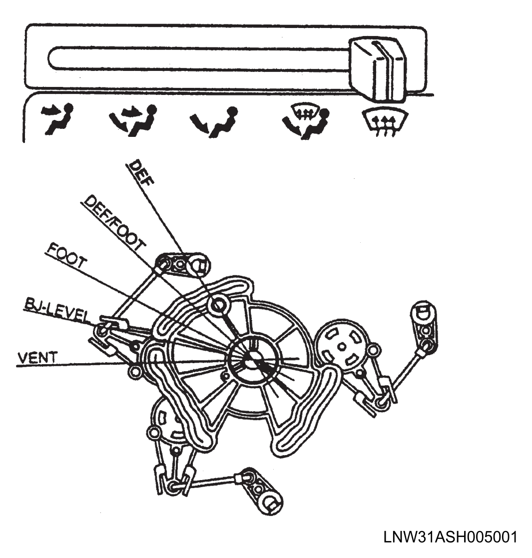


2. Adjust the temperature control cable.
   - Slide the control lever to the left (MAX COOL position).
   - Connect the control cable at the COLD and HOT position of temperature control link of the heater unit and attach it with the clip.



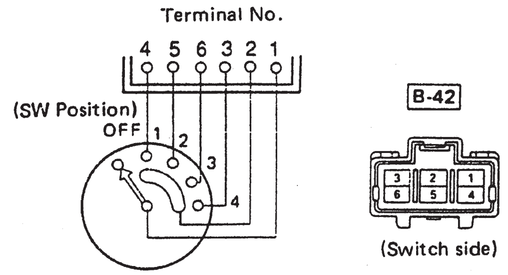
3. Adjustments the air select control cable.
   - Slide the control lever to the right (DEFROST position).
   - Connect the control cable at the "DEFROST" position of the mode control link of the heater unit and fix it with the clip.

4. Check control cable operation.



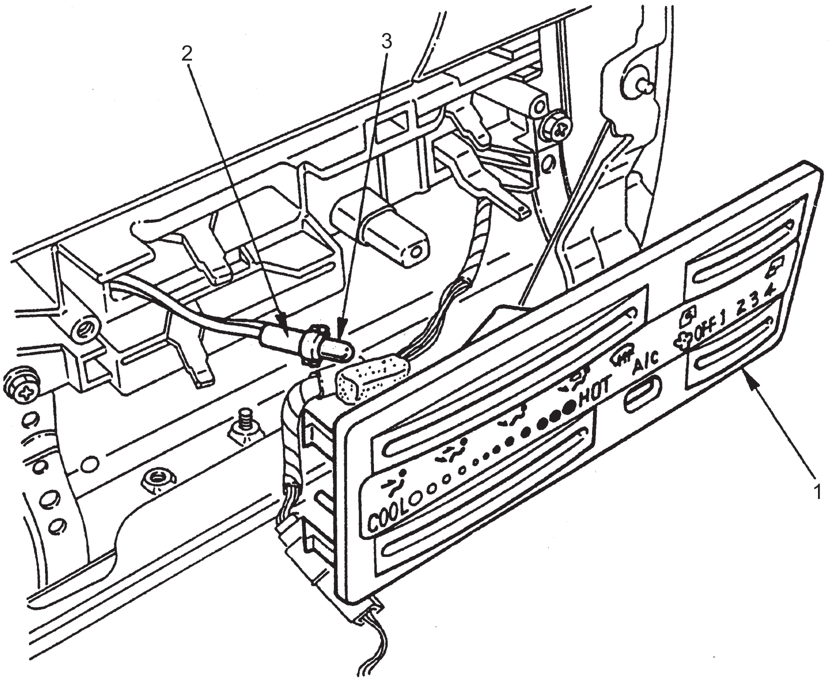
Inspection Procedure

Check for continuity between the terminals of the fan switch.



Terminal No. / SW position	1	2	3	4	5	6
1	○	○		○		
2	○	○			○	
3	○	○				○
4	○	○	○			

Control Panel Illumination Bulb



Legend

1. Control Panel Bezel
2. Socket
3. Control Panel Illumination Bulb

Preparation

Disconnect the battery ground cable.

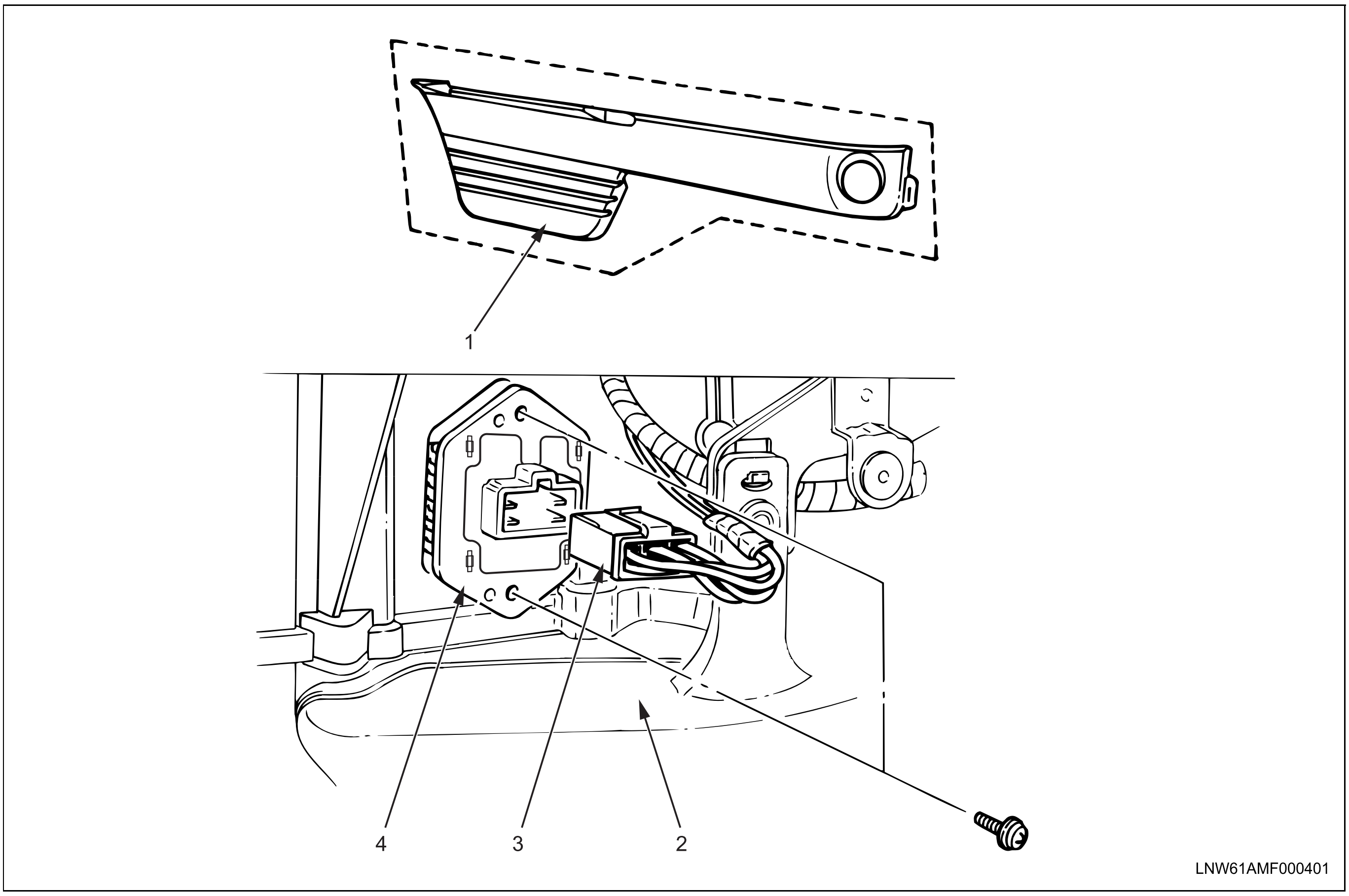
Removal Procedure

1. Remove the control panel bezel.
   Refer to Control Lever Assembly removal procedure.
2. Pull the bulb from the bulb socket.

Installation Procedure

To install, follow the removal steps in the reverse order.

Resistor



Legend

1. Under Cover
2. Washer Tank
3. Resistor Connector
4. Resistor

Preparation

Disconnect the battery ground cable.

Removal Procedure

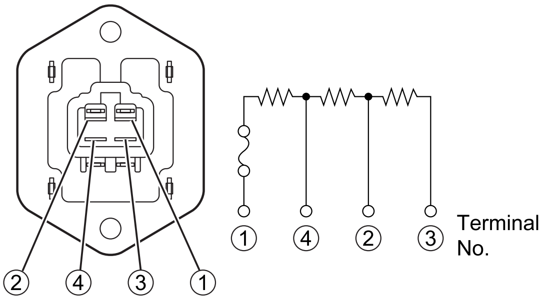
1. Remove the cover by pulling under the clips on the backside of the cover.
2. Disconnect the resistor connector.
3. Remove the resistor.

Installation Procedure

To install, follow the removal steps in the reverse order.

Inspection Procedure

1. Disconnect the resistor connector.
2. Check for continuity and resistance between the terminals of the resistor.



Terminal No. / SW position	1	2	3	4	Resistance value (Ω)
1	○	—	○		2.3
2	○	○			1.0
3	○	—	—	○	0.3
4	○				—

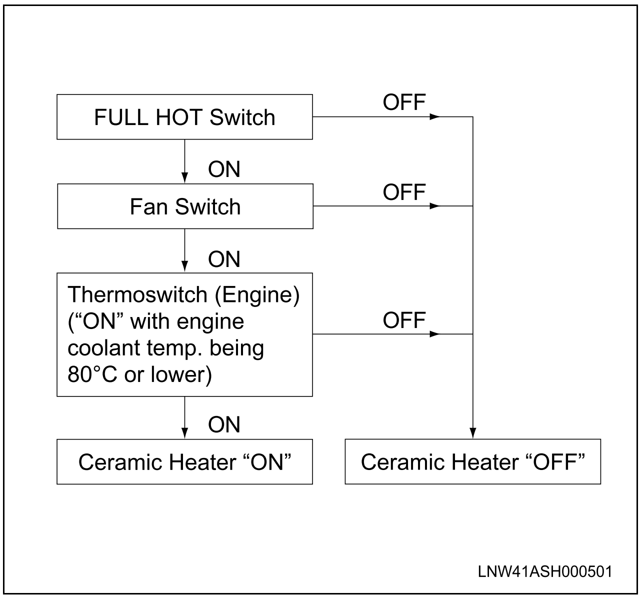
LNW41ASH000101

Heater, Air Conditioning, Condenser Fan and Ceramic Heater (M/T Vechicle Only)

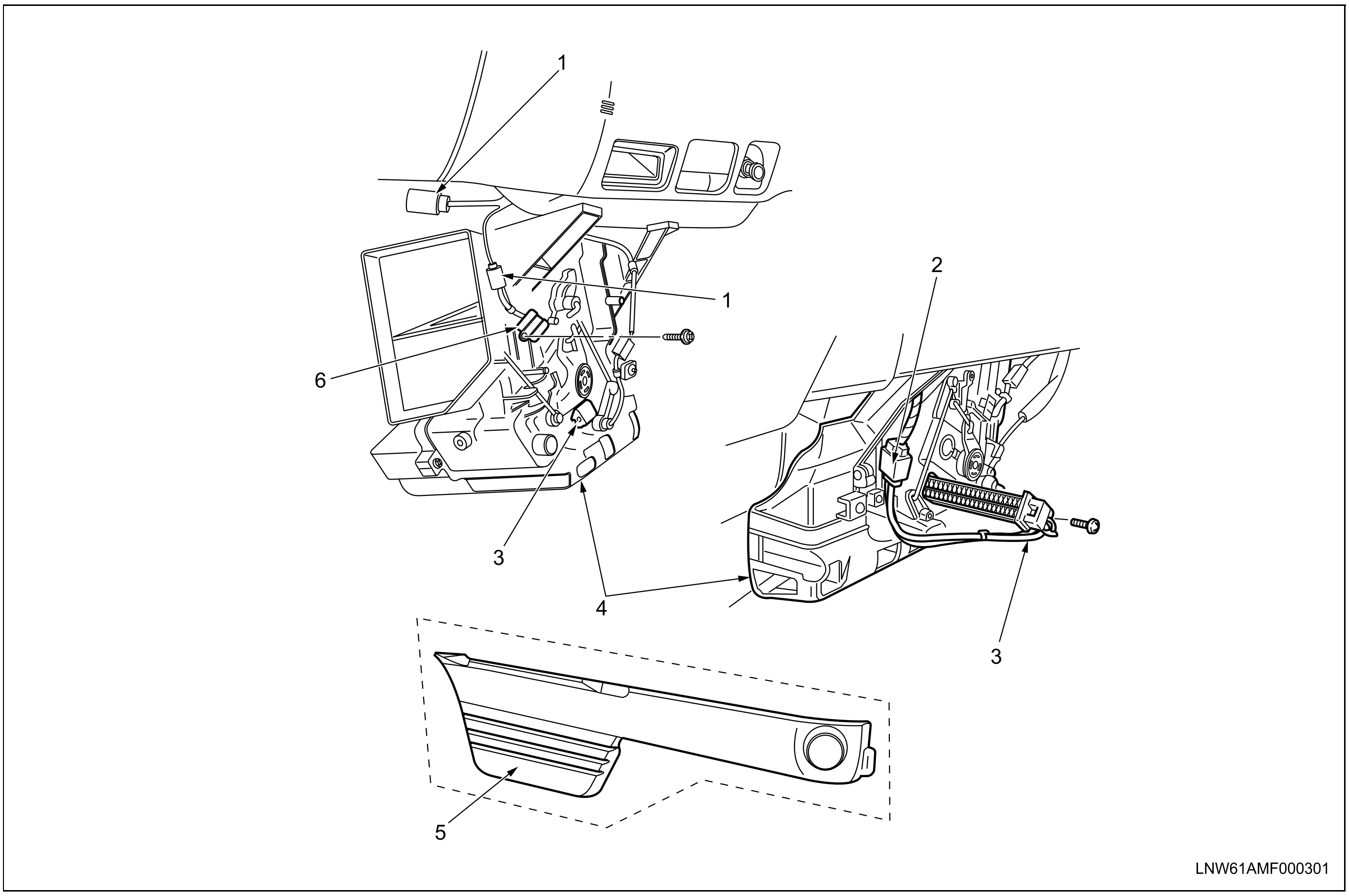
General Description

The air conditioning circuit consists of A/C compressor, condenser fan, A/C switch, fan switch, blower motor, pressure switch, electronic thermostat and blower resistor. When the engine is running, the A/C starts to work with both the A/C and fan switches “ON”, followed by the engagement of the magnetic clutch of the A/C compressor. It stops to work when either the fan switch or the A/C switch turns “OFF”. In addition, the A/C system has the function of temporary stop of its operation by function of the pressure switch when sensing abnormal rise of the refrigerant pressure in the system.

When Fan Control Knob (Fan Switch) is put on with Temp. Control Level being in the “FULL HOT” position (FULL HOT Switch on) Ceramic Heater within Heater Unit generates heat, raising a heater blow-off temperature to enhance heating performance.



Ceramic Heater and/or Full Hot Switch



Legend

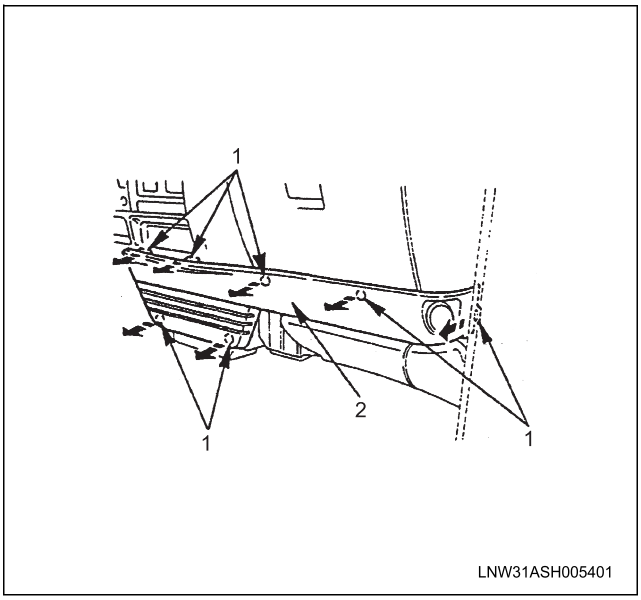
1. Full Hot Switch
2. Heater Connector
3. Ceramic Heater
4. Heater Unit
5. Under Cover
6. Switch Cover

Preparation

Disconnect the battery ground cable.

Removal Procedure

1. Remove the cover by pulling under the clips on the backside of the cover.



Legend

1. Clip
2. Under cover

---

2. Remove the connector and clip for harness fixing, then remove the ceramic heater fixing screw and pull the ceramic heater to forward.
   Remove the ceramic heater.
3. Remove the connector and clip for harness fixing, then remove the full hot switch fixing screw.
   Remove the full hot switch.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. When install the switch in MAX HOT position, temp control link location should be “MAX HOT”. Also confirm contact of connector terminal switch side.

HVAC

Air Conditioning

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Description and Operation

Air Conditioning System Description

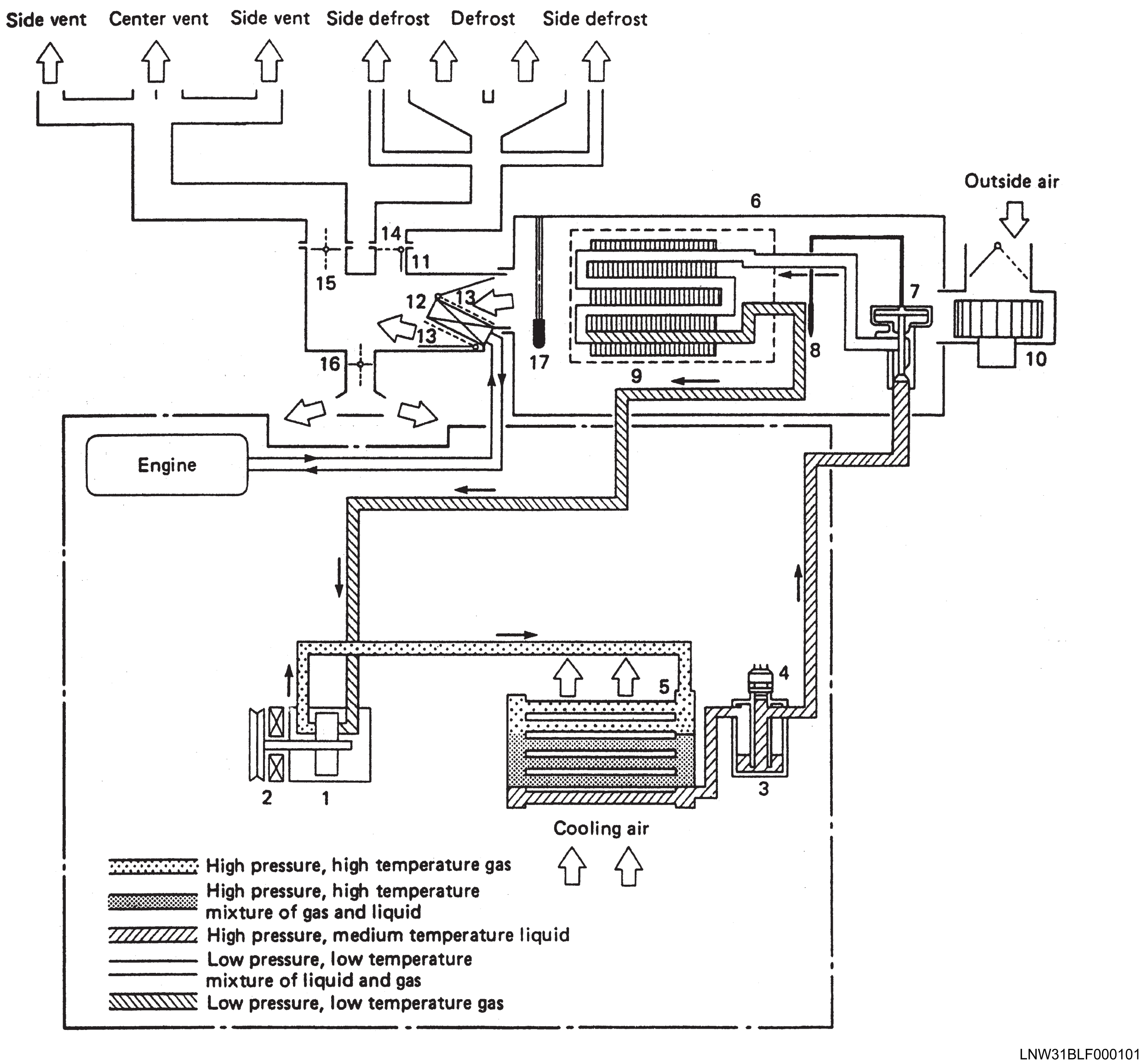
Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

The air conditioning system consists of a compressor, a condenser, an evaporator, a receiver/drier and the necessary controls and safety devices to ensure its safe and reliable operation.

A gas/liquid refrigerant (depending on temperature and pressure) is contained in the system as a heat exchange medium.

Heat is required to change the liquid refrigerant to a gas or vapor.

Cooling of the vehicle cab occurs when the HFC-134a refrigerant changes from a liquid to a gas in the evaporator. Air passing through the evaporator gives up heat to the HFC-134a refrigerant, which absorbs heat while changing to a gas. The cooled air is circulated in the cab by a blower.



Legend

1. Compressor
2. Magnetic Clutch
3. Receiver-Drier
4. Triple Pressure Switch
5. Condenser
6. Evaporator Assembly

7. Expansion Valve
8. Temperature Sensor
9. Evaporator Core
10. Blower Motor
11. Heater Unit
12. Heater Core
13. Temp. Control Door (Air Mix Door)
14. Mode Control Door (DEF)
15. Mode Control Door (VENT)
16. Mode Control Door (HEAT)
17. Electronic Thermostat

Refrigerant Cycle Description

The refrigeration cycle includes the following four processes as the refrigerant changes repeatedly from liquid to gas and back to liquid while circulating.

Evaporation

The refrigerant is changed from a liquid to a gas inside the evaporator. The refrigerant mist that enters the evaporator vaporizes readily. The liquid refrigerant removes the required quantity of heat from the air around the evaporator core cooling fins and rapidly vaporizes. Removing the heat cools the air, which is then radiated from the fins and lowers the temperature of the air inside the vehicle.

The refrigerant liquid sent from the expansion valve and the vaporized refrigerant gas are both present inside the evaporator and the liquid is converted to gas. With this change from liquid to gas, the pressure inside the evaporator must be kept low enough for vaporization to occur at a lower temperature. The vaporized refrigerant is then returned to the compressor.

Compression

The refrigerant is compressed by the compressor until it is easily liquefied at normal temperature.

The vaporized refrigerant in the evaporator is sucked into the compressor. This action maintains the refrigerant inside the evaporator at a low pressure so that it can easily vaporize, even at low temperatures close to 0°C (32°F).

Also, the refrigerant which is returned to the compressor is compressed inside the cylinder to increase the pressure and temperature. The refrigerant can now easily be liquefied at normal ambient temperatures.

Condensation

The refrigerant inside the condenser is cooled by the outside air and changes from gas to liquid.

The high temperature, high pressure gas coming from the compressor is cooled and liquefied by the condenser with outside air and accumulated in the receiver/drier. The heat radiated to the outside air by the high temperature, high pressure gas in the compressor is called heat of condensation. This is the total quantity of heat (heat of vaporization) the refrigerant removes from the vehicle interior via the evaporator and the work (calculated as the quantity of heat) performed for compression.

Expansion

The expansion valve lowers the pressure of the refrigerant liquid so that it can easily vaporize.

The process of lowering the pressure to encourage vaporization before the liquefied refrigerant is sent to the evaporator is called expansion. In addition, the expansion valve controls the flow rate of the refrigerant liquid while decreasing the pressure. That is, the quantity of refrigerant liquid vaporized inside the evaporator is determined by the quantity of heat which must be removed at a prescribed vaporization temperature.

It is important that the quantity of refrigerant be controlled at exactly the right value.

System Components Description

Compressor

A belt-driven, ten-cylinder swash plate type compressor (DKS-15D) is used. Three double end pistons form the six pumping chambers.

Refrigerant flow is controlled by reed valves and internal passages.

Front and rear cylinder heads hold the valves and plates to the main body and are secured by five through bolts.

The compressor is bolted to the right upper side of the engine.

The compressor is lubricated by compressor oil mixed with the refrigerant. An electrically actuated clutch and other controls determine compressor cycling. The rear head of the compressor is provided with pressure relief valve to prevent the malfunction of the compressor due to the abnormally high pressure of refrigerant.

Magnetic Clutch

The clutch consists of a magnetic coil, the drive pulley, the armature and attaching parts. When current is supplied to the magnetic coil, the flexible armature is pulled against the pulley. Since the armature is attached to the compressor shaft and the pulley rolls on a bearing mounted on the front cylinder head, the armature, pulley belt and engine crankshaft pulley then drive the compressor shaft.

The air conditioning starts its operation when both the A/C switch and the fan switch are turned on and the magnetic clutch gets engaged through the A/C thermo relay while the engine is running. The compressor stops when either A/C switch or fan switch is turned off. In addition to these switches, the air conditioning is also stopped by turning off the magnetic clutch temporarily under the predetermined condition when the abnormal refrigerant pressure is sensed by the pressure switch, or when the air temperature is sensed by the electronic thermostat that prevents the evaporator core from freezing.

Condenser

The condenser assembly mounted on the right side of the frame is made up of tube and cooling fins, which carry the refrigerant and provide a rapid transfer of heat. The air passing through the condenser cools the high pressure refrigerant vapor, causing it to condense into a liquid.

Receiver and Drier

The receiver/drier performs four functions;

- As the quantity of refrigerant circulated varies depending on the refrigeration cycle conditions, sufficient refrigerant is stored for the refrigeration cycle to operate smoothly in accordance with fluctuations in the quantity circulated.
- The liquefied refrigerant from the condenser is mixed with refrigerant gas containing air bubbles. If refrigerant containing air bubbles is sent to the expansion valve, the cooling capacity will decrease considerably. Therefore, the liquid and air bubbles are separated and only the liquid is sent to the expansion valve.
- The receiver/drier utilizes a filter and drier to remove the dirt and water mixed in the cycling refrigerant.

A receiver/drier may fail due to a restriction inside the body of the unit. A restriction at the inlet to the receiver/drier will cause high pressures.

Outlet restrictions will be indicated by low pressure and little or no cooling. An excessively cold receiver /drier outlet may indicate a restriction.

The receiver/drier of this vehicle is made of aluminum with a smaller tank. It has 300cc (8.5lmp fl oz) refrigerant capacity.

Triple Pressure Switch

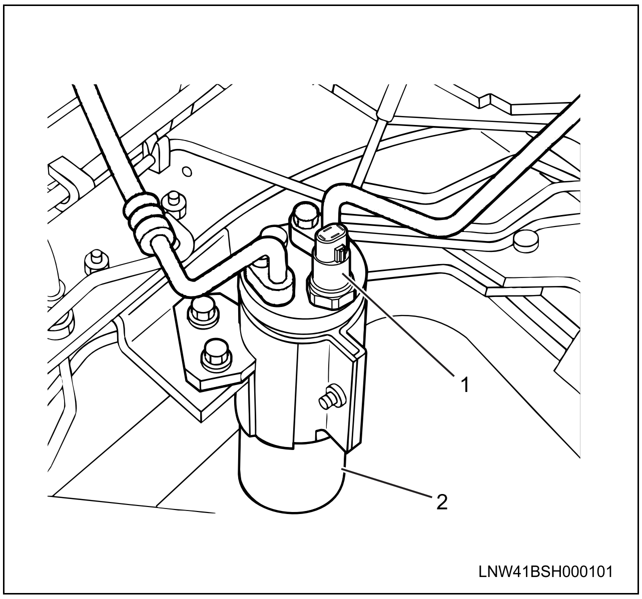
The triple pressure switch is installed on the upper part of the receiver/drier. This switch is constructed with a unitized type of two switches. One of them is a low and high pressure switch (Dual pressure switch) to switch “ON” or “OFF” the magnetic clutch as a result of irregularly high-pressure or low-pressure of the refrigerant. The other one is a medium pressure switch (Cycling switch) to switch “ON” or “OFF” the condenser fan by sensing the condenser high side pressure.

- Low-pressure control (kPa/psi)

  Compressor
  - ON: 206 ± 30 (30 ± 4)
  - OFF: 177 ± 20 (26 ± 3)
- Medium-pressure control

  Condenser fan
  - ON: 1,471 ± 98 (213 ± 14)
  - OFF: 1,079 ± 118 (156 ± 17)
- High-pressure control

  Compressor
  - ON: 2,354 ± 196 (341 ± 28)
  - OFF: 2,942 ± 196 (427 ± 28)



Legend

1. Triple pressure Switch
2. Receiver / Drier

Evaporator

The evaporator cools and dehumidifies the air before the air enters the vehicle. High-pressure liquid refrigerant flows through the expansion valve into the low-pressure area of the evaporator. The heat in the air passing through the evaporator core is lost to the cooler surface of the core, thereby cooling the air.

As heat is lost between the air and the evaporator core surface, moisture in the vehicle condenses on the outside surface of the evaporator core and is drained off as water.

When the evaporator malfunctions, the trouble will show up as inadequate supply of cool air. The cause is typically a partially plugged core due to dirt, or a malfunctioning blower motor.

The evaporator core with a laminate louver fin is a single-sided tank type where only one tank is provided under the core.

Expansion Valve

This expansion valve is an external pressure type and is installed at the evaporator intake port.

The expansion valve converts the high pressure liquid refrigerant sent from the receiver/drier to a low pressure liquid refrigerant by forcing it through a tiny port before sending it to the evaporator.

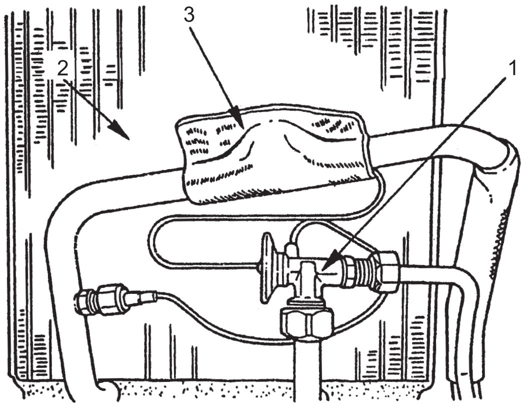
This type of expansion valve consists of a temperature sensor, diaphragm, ball valve, ball seat, spring adjustment screw, etc.

The temperature sensor contacts the evaporator outlet pipe, and converts changes in temperature to pressure. It then transmits these to the top chamber of the diaphragm.

The refrigerant pressure is transmitted to the diaphragms bottom chamber through the external equalizing pressure tube.

The ball valve is connected to the diaphragm. The opening angle of the expansion valve is determined by the force acting on the diaphragm and the spring pressure.

The expansion valve regulates the flow rate of the refrigerant. Accordingly, when a malfunction occurs to the expansion valve, both discharge and suction pressures get low, resulting in insufficient cooling capacity of the evaporator.



LNW31BSH000201

Legend

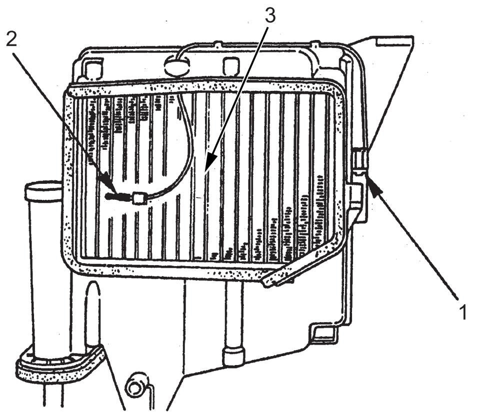
1. Expansion Valve
2. Evaporator Core
3. Insulator

Electronic Thermostat

The thermostat consists of the thermo sensor and thermostat unit which functions electrically to reduce the noises being generated while the system is in operation.

The electronic thermo sensor (2) is mounted at the evaporator core (3) outlet and senses the temperature of the cool air from the evaporator. Temperature signals are inputted to the thermostat unit (1). This information is compared by the thermo unit and the results determine the operation of the A/C thermo relay and turn the magnetic clutch “ON” or “OFF” to prevent evaporator freeze-up.

A characteristic of the sensor is that the resistance decreases as the temperature increases and the resistance increases as the temperature decreases.



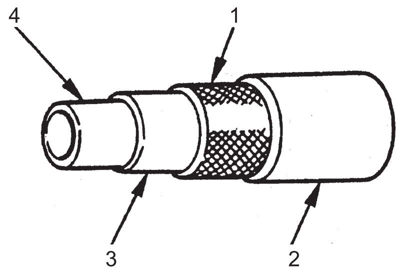
LNW61BSH000401

Refrigerant Line

Restrictions in the refrigerant line will be indicated by :

1. Suction line; A restricted suction line will cause low suction pressure at the compressor, low discharge pressure and little or no cooling.
2. Discharge line; A restriction in the discharge line generally will cause the discharge line to leak.
3. Liquid line; A liquid line restriction will be evidenced by low discharge and suction pressure and insufficient cooling.

Refrigerant flexible hoses that have allow permeability to refrigerant and moisture are used. These low permeability hoses have a special nylon layer on the inside.



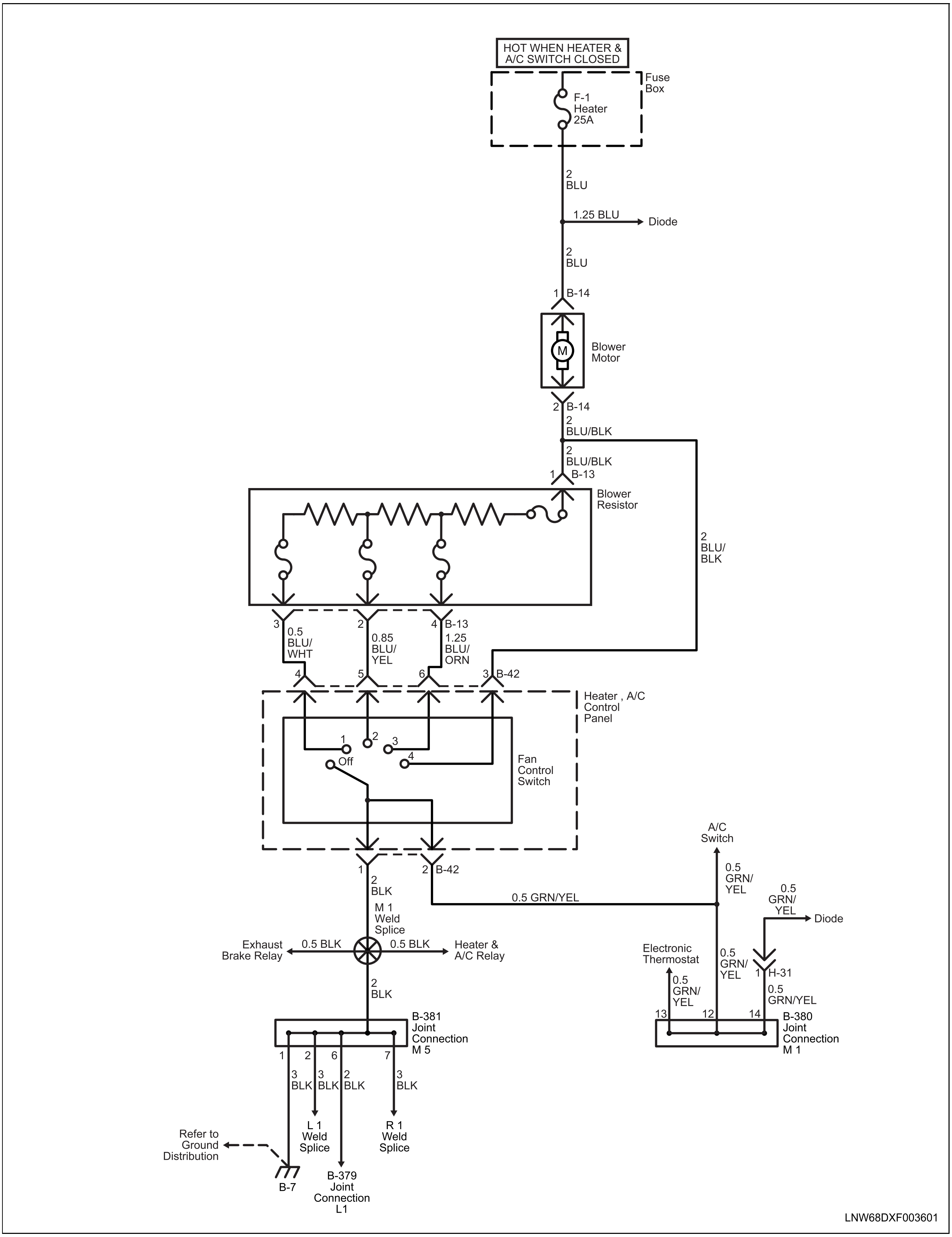
LNW31BSH000401

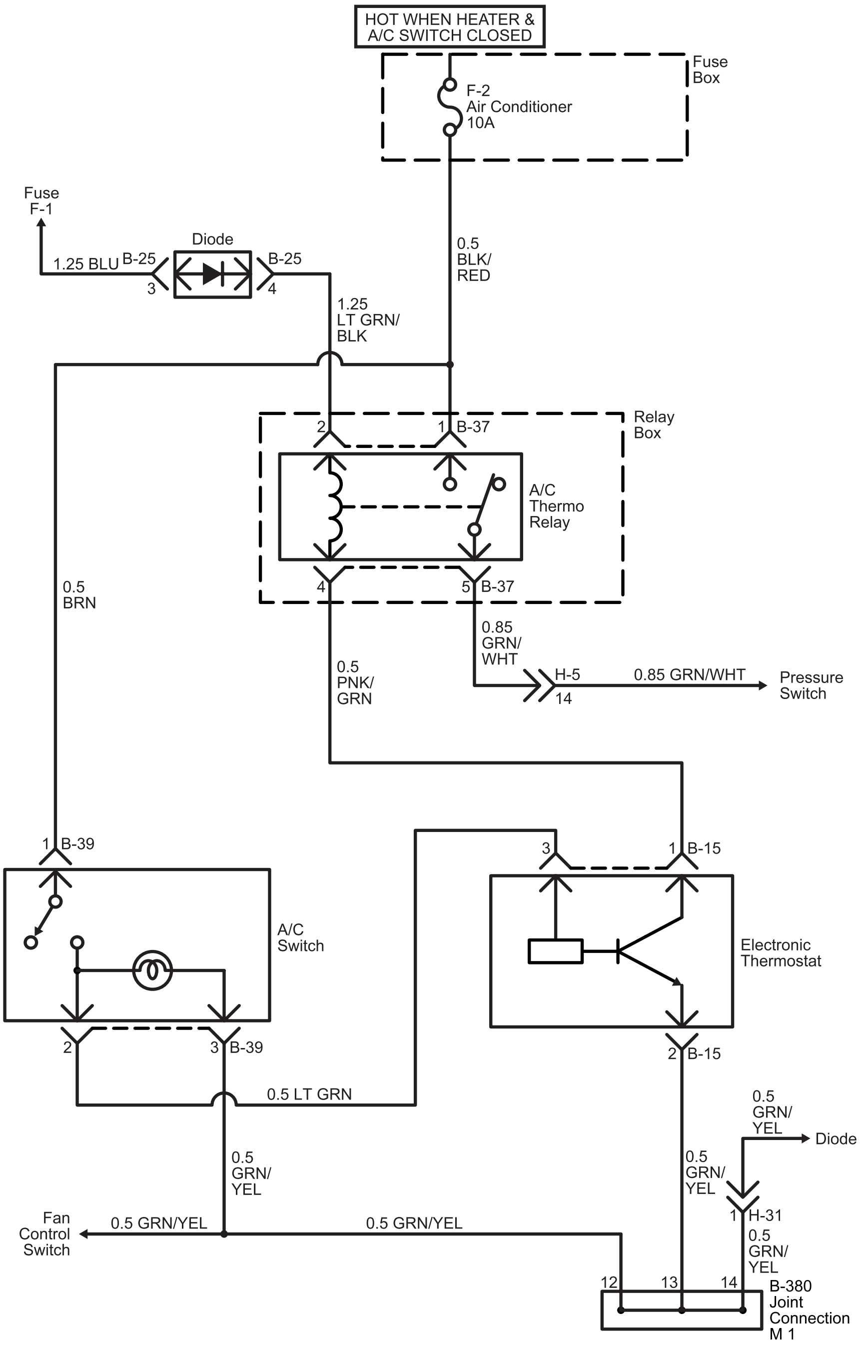
Legend

1. Reinforcement Layer (Polyester)
2. External Rubber Layer
3. Internal Rubber Layer
4. Resin Layer (Nylon)

Schematic and Routing Diagrams

Air Conditioning Switch Schematic





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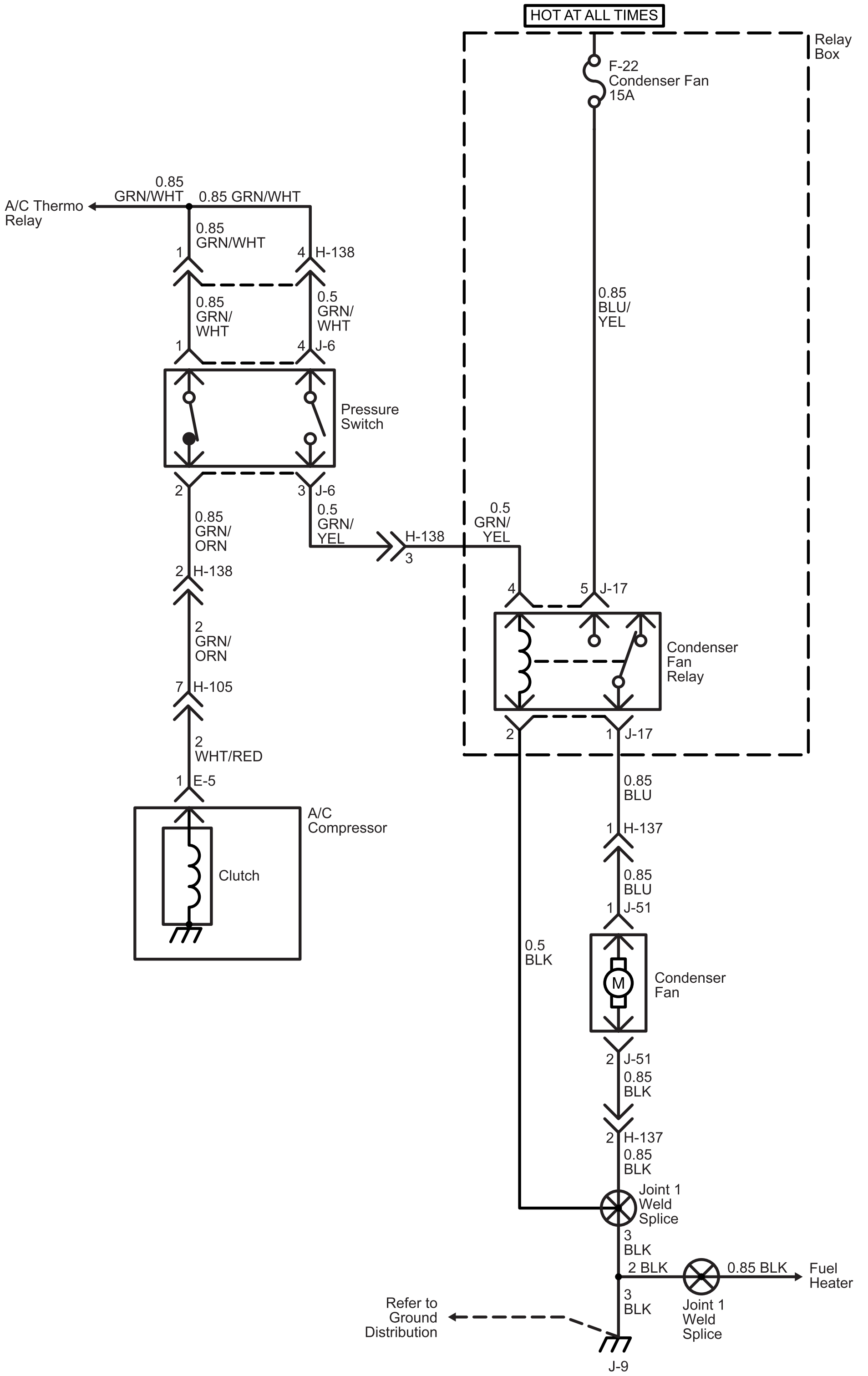
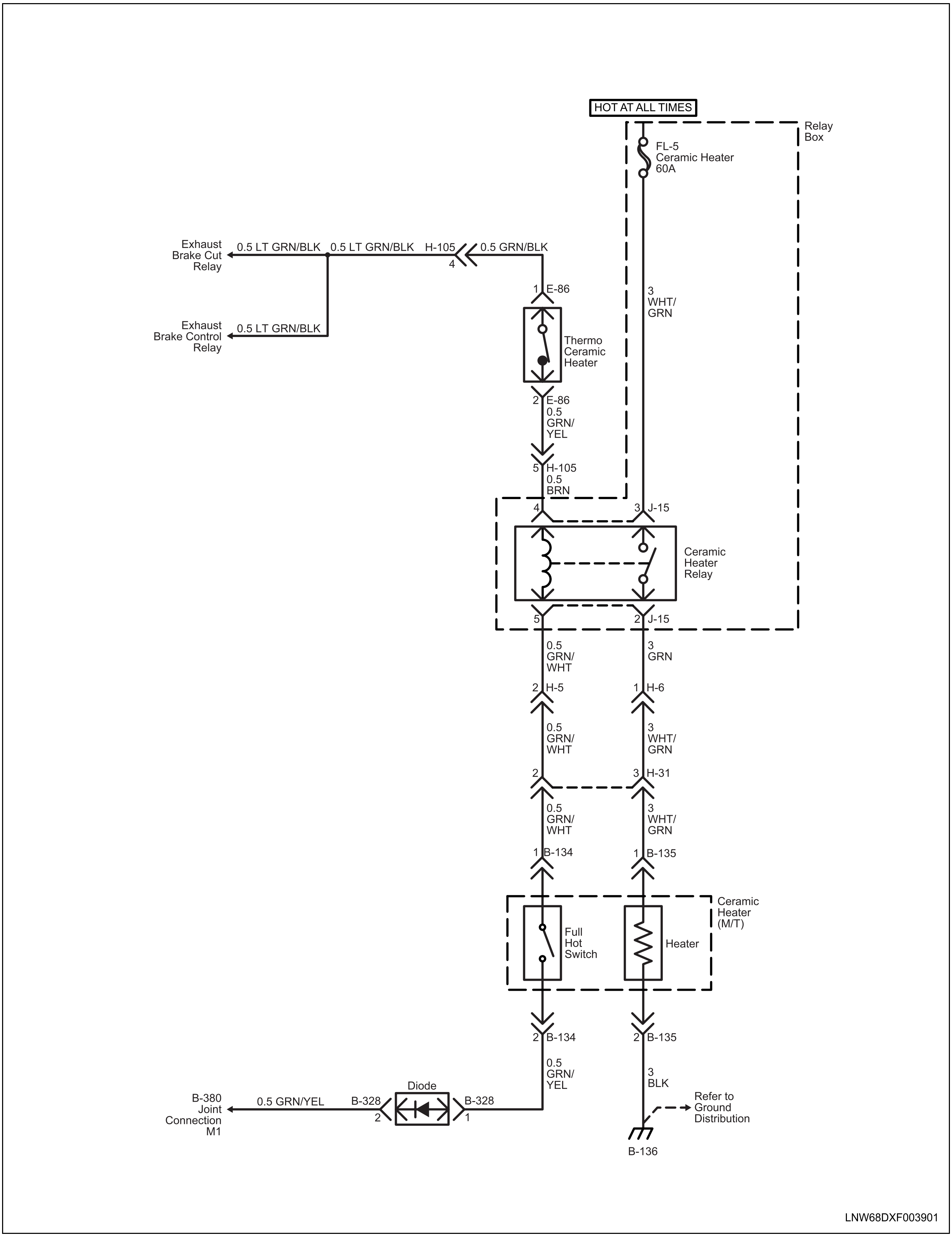
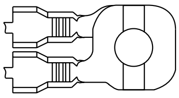
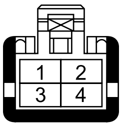
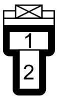
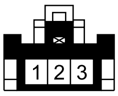
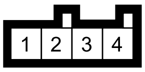
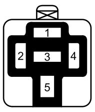
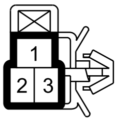
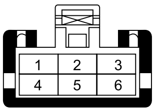
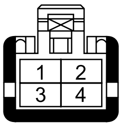
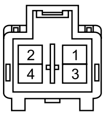
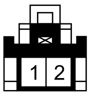
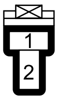
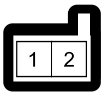
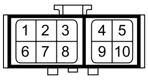
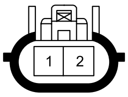
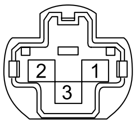


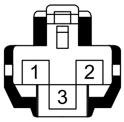
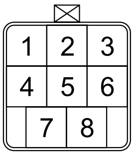
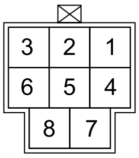
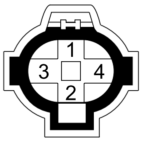
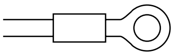
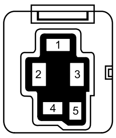
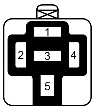
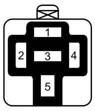
LNW68DXF003801

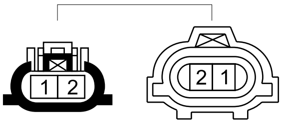

HOT AT ALL TIMES
Relay Box
FL-5
Ceramic Heater
60A
Exhaust Brake Cut Relay
0.5 LT GRN/BLK
0.5 LT GRN/BLK
H-105
4
0.5 GRN/BLK
1 E-86
Exhaust Brake Control Relay
0.5 LT GRN/BLK
3 WHT/ GRN
Thermo Ceramic Heater
2 E-86
0.5 GRN/ YEL
5 H-105
0.5 BRN
4
3 J-15
Ceramic Heater Relay
5
2 J-15
0.5 GRN/ WHT
3 GRN
2 H-5
1 H-6
0.5 GRN/ WHT
3 WHT/ GRN
2
3 H-31
0.5 GRN/ WHT
3 WHT/ GRN
1 B-134
1 B-135
Ceramic Heater (M/T)
Full Hot Switch
Heater
2 B-134
2 B-135
0.5 GRN/ YEL
3 BLK
Diode
B-380 Joint Connection M1
0.5 GRN/YEL
B-328
2
B-328
1
Refer to Ground Distribution
B-136
LNW68DXF003901

Connector List

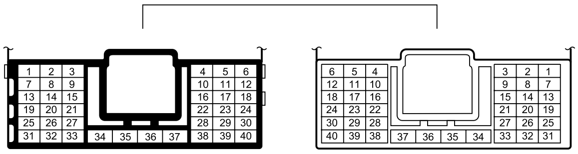
No.	Connector Face
B-7	 000-007 Ground; Headlight Bracket-LH
B-13 (Brown)	 004-015 Blower Resistor
B-14 (White)	 002-012 Blower Motor
B-15 (White)	 003-015 Electro Thermo
B-25 (Black)	 004-021 Diode
B-37 (Black)	 005-012 A/C Thermo Relay
B-39 (White)	 003-009 A/C Switch
B-42 (White)	 006-024 Fan Switch

No.	Connector Face
B-67 (White)	 004-015 Ignition Switch
B-67 (Black)	 004-035 Ignition Switch
B-134	 002-022 Full Hot Switch
B-135	 002-012 Ceramic Heater
B-328 (Black)	 002-043 Diode
B-381 (White)	 010-015 Joint Connection-M5
E-86	 002-006 Thermo Switch
H-31 (Blue)	 003-050 Body H. – Ceramic Heater H.

No.	Connector Face
H-31 (Blue)	 003-049 Body H. – Ceramic Heater H.
H-105 (Black)	 008-060 Frame H. – Engine H.
H-105 (Black)	 008-061 Frame H. – Engine H.
J-6 (White)	 004-029 A/C Pressure Switch
J-9	 000-012 Ground; Frame-LH (Center)
J-15 (Black)	 005-013 Ceramic Heater
J-17 (Black)	 005-012 Condenser Fan Relay
J-18 (Black)	 005-012 Exhaust Brake Control Relay

No.	Connector Face
J-51 (Black)	 002-041 Condenser Fan Motor

H-5 Body H.-Frame H. (Gray)



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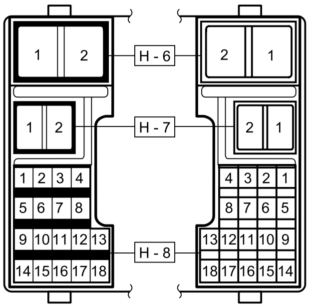
H-6, H-7, H-8 Body H.-Frame H. (Gray)



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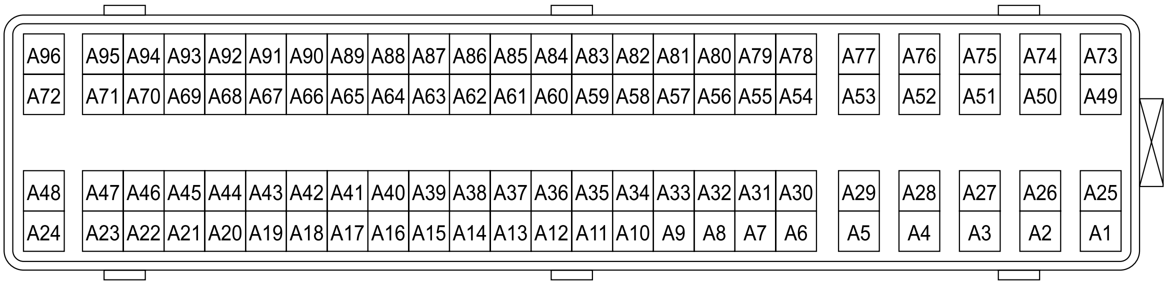
J-218 ECM-2 (Black)



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Diagnostic Information and Procedures

Checking Refrigerant System With Manifold Gauge

Since Refrigerant-134a (HFC-134a) is used in the air conditioning system in this vehicle, be sure to use manifold gauges, charging hoses and other air conditioning service tools for HFC-134a when checking the refrigerant system. (Refer to Precautions for HFC-134a Air Conditioning System in this section.)

Conditions;

- Run the engine at idle
- Air conditioning switch is “ON”
- Run the blower motor at “4” (high) position
- Temperature control knob set at “COLD”
- Close the all doors
- Air source selector lever at “RECIRC”

Normal pressure guideline;

At ambient temperature:

Approx. 30-35°C (86-95°F)

Low-pressure side:

Approx. 127-196 kPa (18.5-28.4 psi)

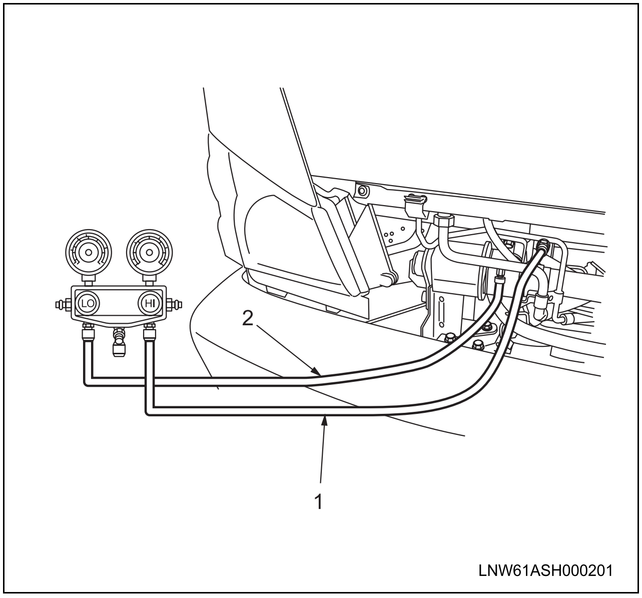
High-pressure side:

Approx. 1,470-1,667 kPa (213.3-241.7 psi)
Refer to the table on refrigerant pressure-tempera-ture relationship.

HFC-134a Pressure-Temperature Relationship			
Pressure		Temperature	
(kPa)	(psi)	(°c)	(°F)
36	5.3	-20	-4.4
67	9.7	-15	5
104	15	-10	14
147	21	-5	23
196	28	0	32

HFC-134a Pressure-Temperature Relationship			
Pressure		Temperature	
(kPa)	(psi)	(°c)	(°F)
255	37	5	41
314	45	10	50
392	57	15	59
471	68	20	68
569	82	25	77
677	98	30	86
785	114	35	95
912	132	40	104
1059	154	45	113
1216	176	50	122

Connect the manifold gauge



Legend

1. High-pressure Hose (HI) - Discharge Side
2. Low-pressure Hose (LOW) - Suction Side

No Cooling or Insufficient Cooling

POSSIBLE CAUSE	CORRECTION
1 Magnetic clutch does not run.	Refer to Magnetic Clutch Diagnosis in this section.

POSSIBLE CAUSE	CORRECTION
2 Compressor is not rotating properly	
• Drive belt loosen or broken.	• Adjust the drive belt specified tension or replace the drive belt.
• Magnetic clutch face is not clean and slips.	• Clean the magnetic clutch face or replace.
• Incorrect clearance between magnetic drive plate and pulley.	• Adjust the clearance (Refer to Compressor Over-Haul in this section.)
• Compressor oil leaks from shaft seal or shell.	• Replace the compressor.
• Compressor seized.	• Replace the compressor.
3 Insufficient or excessive charge of refrigerant.	• Discharge and recover refrigerant. • Recharge to specified amount.
4 Leaks in the refrigerant system.	• Check refrigerant system for leaks and repair as necessary. • Discharge and recover refrigerant. • Recharge to specified amount.
5 Condenser clogged or insufficient radiation .	• Clean the condenser or replace as necessary. • Check radiator or condenser fan function.
6 Temperature control link unit of the heater unit defective.	• Repair the control link unit.
7 Unsteady operation due to foreign substance in expansion valve.	• Replace the expansion valve.
8 Poor operation of electronic thermostat.	• Check electronic thermostat and replace as necessary.

Insufficient Velocity of Cooling Air

POSSIBLE CAUSE	CORRECTION
1 Evaporator clogged or frosted.	• Check evaporator core and clean or replace the core.
2 Air leaking from cooling unit or air duct.	• Check evaporator and duct connection then repair as necessary.
3 Blower motor does not rotate properly.	• Refer to Diagnosis of Heating System.

* For the execution of the charging and discharging operation in the table above, refer to the “Recovery, Recycling, Evacuation and Charging” in this section.

Discharge (High Gauge) Pressure Abnormally High

CHECK POINT / SYMPTOM	TROUBLE CAUSE	CORRECTION
1. Condenser or cooling fan.	1. Condenser clogged or dirty. Cooling fan does not operate properly.	1. Clean the condenser fins. Check cooling fan operation.
2. Insufficient cooling.	2. Excessive refrigerant in system.	2. Discharge and recover refrigerant. Recharge to specified amount.

CHECK POINT / SYMPTOM	TROUBLE CAUSE	CORRECTION
3. High pressure gauge drop (After stopping A/C, pressure drops approx. 196 kPa/28 psi quickly).	3. Air in system.	3. Evacuate and charge refrigerant system.

A/C-Air Conditioning

Discharge (High Gauge) Pressure Abnormally Low

CHECK POINT / SYMPTOM	TROUBLE CAUSE	CORRECTION
1. Insufficient cooling.	1. Insufficient refrigerant in system.	1. • Check for leaks. • Discharge and recover refrigerant. Recharge to specified amount.
2. Low pressure gauge indicates vacuum.	2. Clogged or defective expansion valve.	2. Replace expansion valve.
3. Frost or dew on refrigerant line before and after receiver/drier or expansion valve, and low pressure gauge indicates vacuum.	3. Restriction caused by debris or moisture in receiver/drier.	3. Check system for restriction and replace receiver/drier.
4. High and low pressure gauge balanced quickly (After turned off A/C).	4. • Compressor seal defective. • Poor compression due to defective compressor gasket.	4. Repair or replace the compressor.

A/C-Air Conditioning

Suction (Low Gauge) Pressure Abnormally High

CHECK POINT / SYMPTOM	TROUBLE CAUSE	CORRECTION
1. Low pressure gauge (Low pressure gauge is lowered after condenser is cooled by water).	1. Excessive refrigerant in system.	1. Discharge and recover refrigerant. Recharge to specified amount.
2. Low pressure hose temperature (Low pressure hose temperature around the compressor refrigerant line connector is lower than around evaporator).	2. • Unsatisfactory valve operation due to defective temperature sensor of expansion valve. • Expansion valve opens too long.	2. Replace the expansion valve.
3. High and low pressure gauge balanced quickly (After turned off A/C).	3. Compressor gasket is defective.	3. Repair or replace the compressor.

Suction (Low Gauge) Pressure Abnormally Low

CHECK POINT / SYMPTOM	TROUBLE CAUSE	CORRECTION
1. Insufficient cooling.	1. Insufficient refrigerant in system.	1. • Check for leaks. • Discharge and recover refrigerant. Recharge to specified amount.
2. Frost on the expansion valve inlet line.	2. Expansion valve clogged.	2. Replace the expansion valve.
3. Receiver/drier inlet and outlet refrigerant line temperature (A distinct difference in temperature develops).	3. Receiver/Drier clogged.	3. Replace the receiver/drier.
4. Expansion valve outlet refrigerant line (Not cold and low pressure gauge indicates vacuum).	4. Expansion valve temperature sensor defective.	4. Replace the expansion valve.
5. When the refrigerant line is clogged or blocked, the low pressure gauge reading will decrease, or a vacuum reading may be shown.	5. Clogged or blocked refrigerant line.	5. Replace refrigerant line.
6. Evaporator core is frozen.	6. Thermo switch defective.	6. Replace thermo switch.

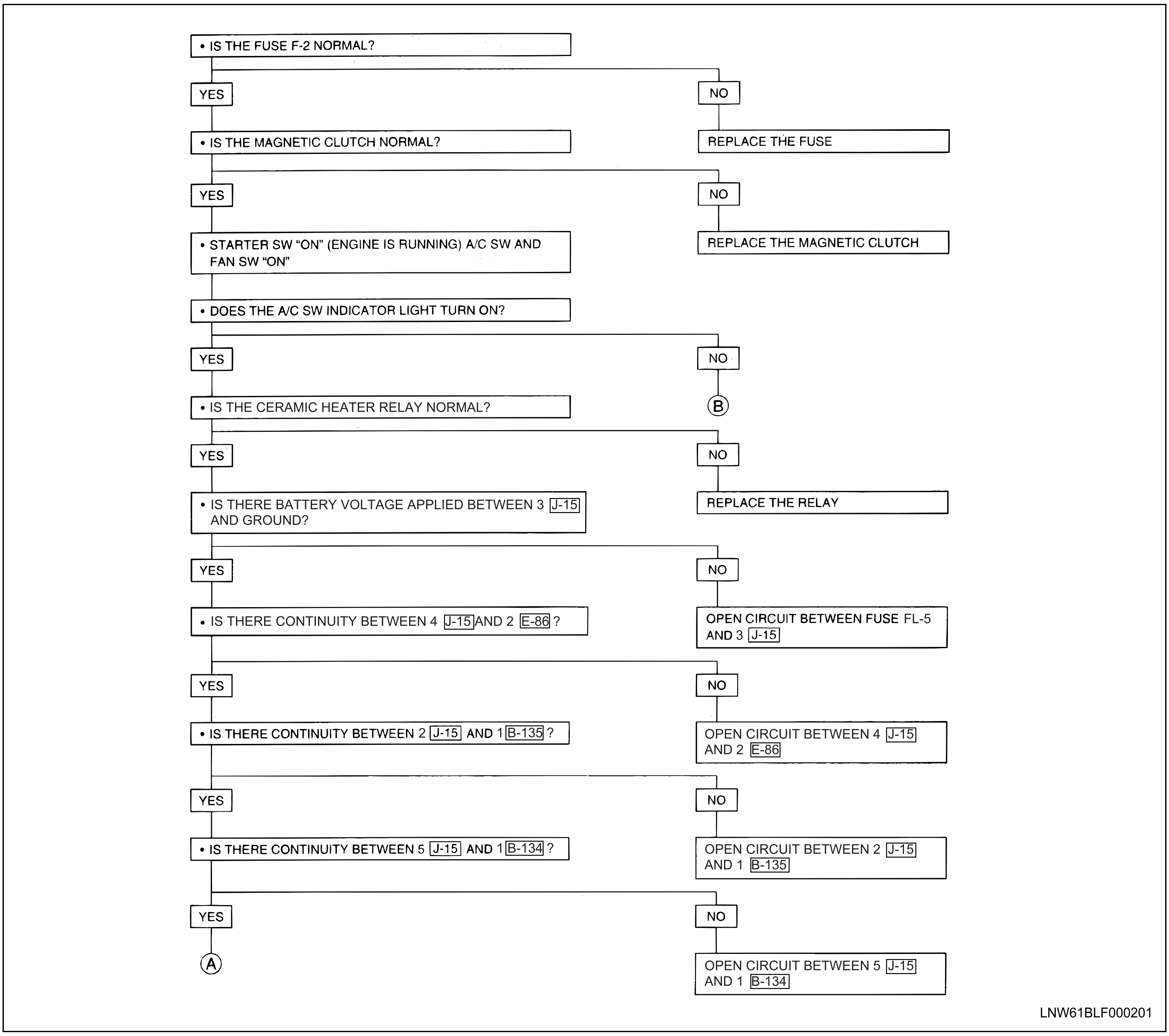
Suction (Low Gauge) And Discharge (High Gauge) Pressure Abnormally High

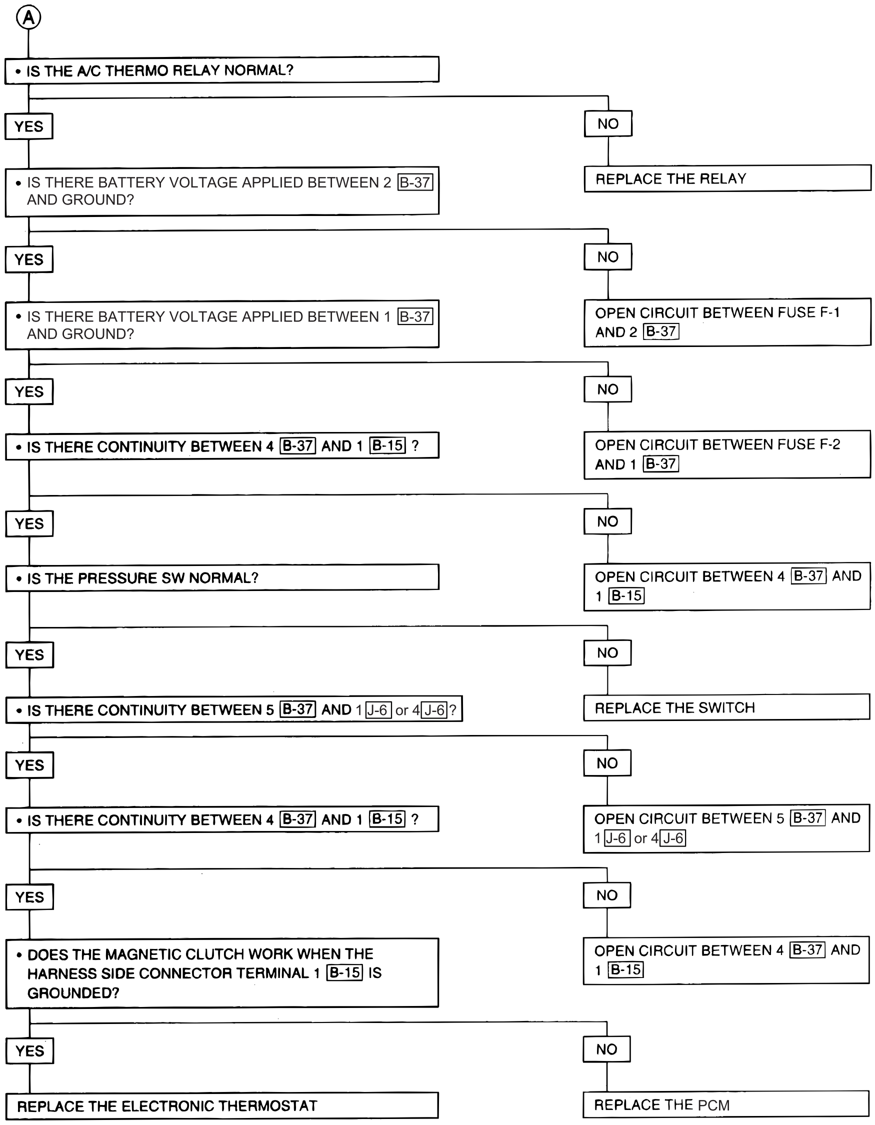
CHECK POINT / SYMPTOM	TROUBLE CAUSE	CORRECTION
1. Insufficient cooling.	1. Excessive refrigerant in system.	1. Discharge and recover refrigerant, then Recharge to specified amount.
2. Condenser.	2. Condenser clogged or dirty.	2. Clean the condenser fin.
3. Suction (Low) pressure hose (Not cold).	3. Air in system.	3. Evacuate and charge refrigerant.

Suction (Low Gauge) And Discharge (High Gauge) Pressure Abnormally Low

CHECK POINT / SYMPTOM	TROUBLE CAUSE	CORRECTION
1. Insufficient cooling.	Insufficient refrigerant in system.	• Check for leaks. • Discharge and recover refrigerant. Recharge to specified amount.

Magnetic Clutch Dose Not Operate





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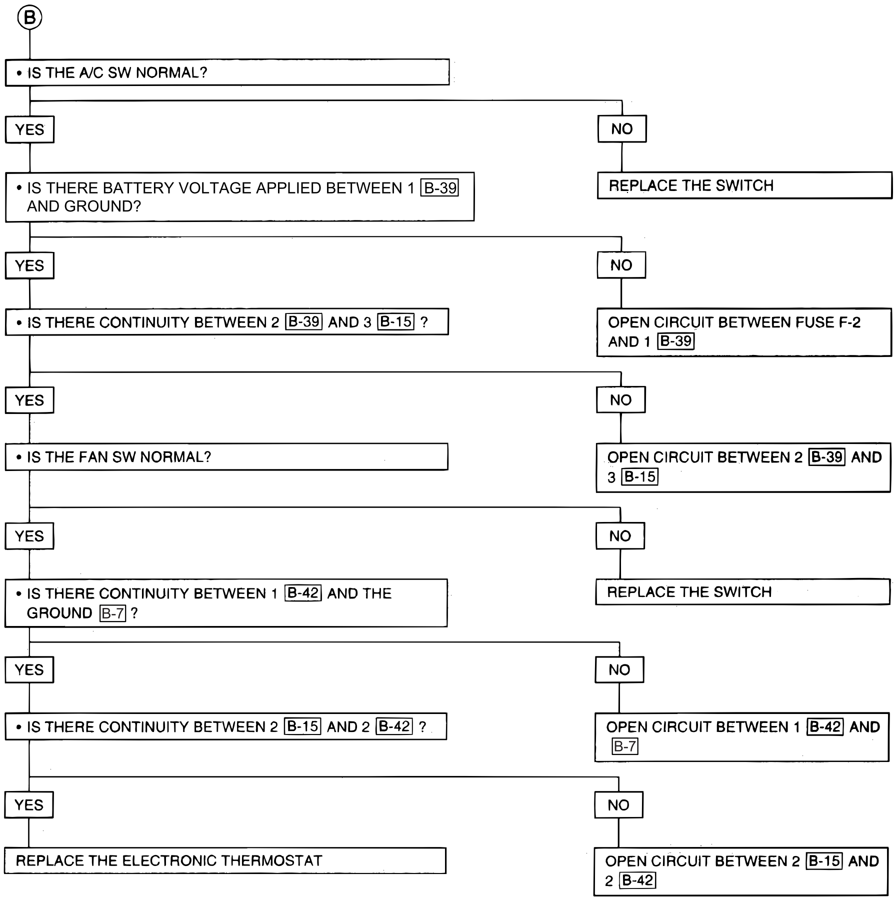

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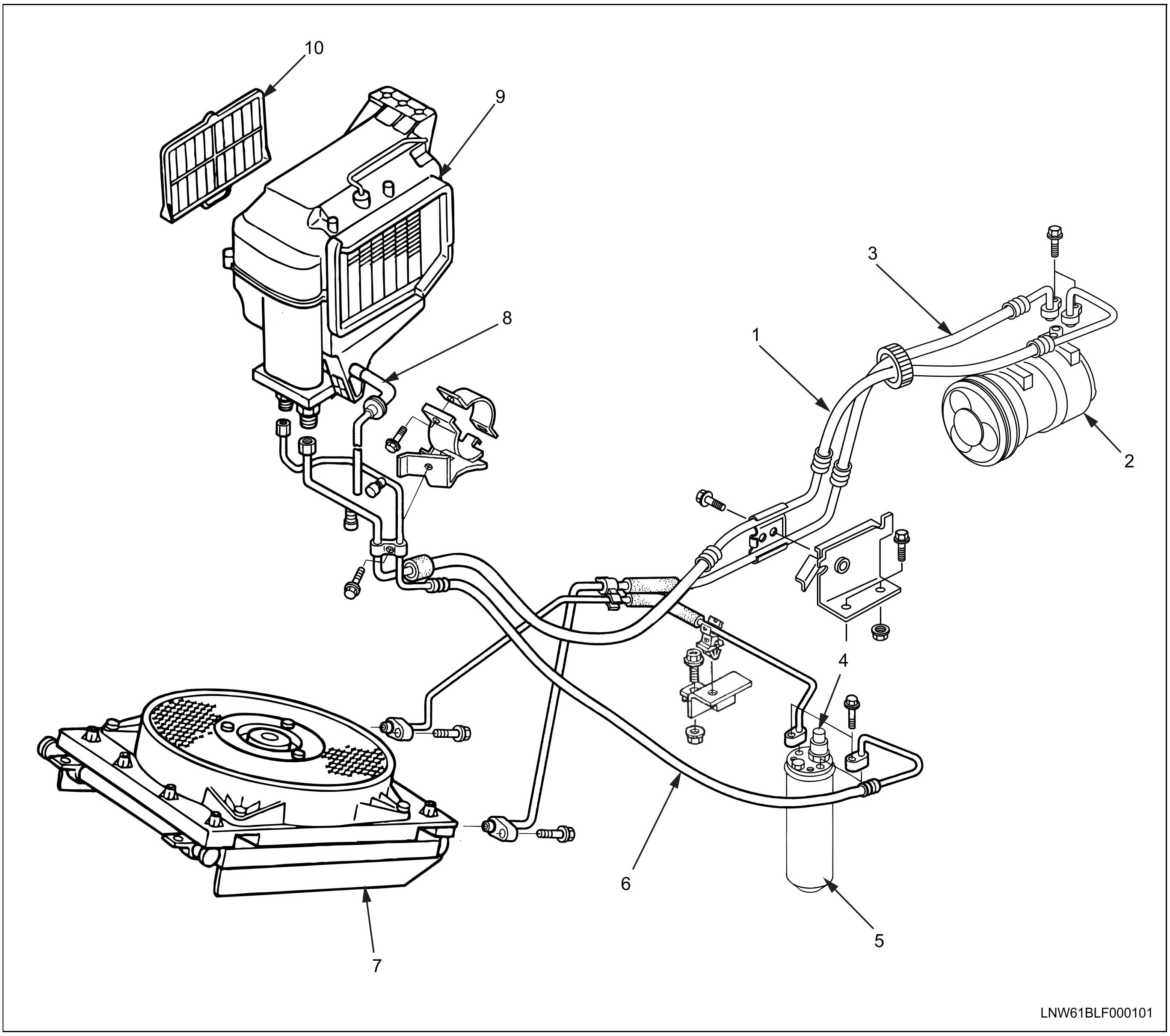
Component Locator

Air Conditioning



Legend

1. Refrigerant Suction Line
2. Compressor
3. Refrigerant Discharge Line
4. Triple pressure Switch
5. Receiver/Drier
6. Refrigerant Liquid Line
7. Condenser
8. Drain Hose
9. Evaporator
10. Blower Filter

Repair Instructions

Precautions for Replacement or Repair of Air Conditioning Parts

There are certain procedures, practices and precautions that should be followed when servicing air conditioning systems:

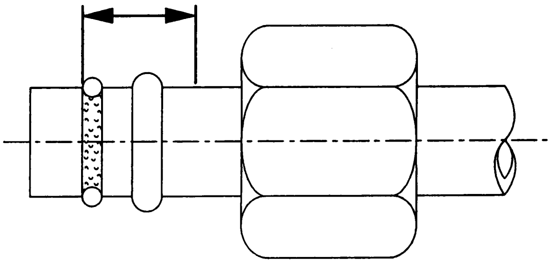
- Keep your work area clean.
- Always wear safety goggles and protective gloves when working on refrigerant systems.
- Beware of the danger of carbon monoxide fumes caused by running the engine.
- Beware of discharged refrigerant in enclosed or improperly ventilated garages.
- Always disconnect the negative battery cable and discharge and recover the refrigerant whenever repairing the air conditioning system.
- When discharging and recovering the refrigerant, do not allow refrigerant to discharge too fast; it will draw compressor oil out of the system.
- Keep moisture and contaminants out of the system. When disconnecting or removing any lines or parts, use plugs or caps to close the fittings immediately. Never remove the caps or plugs until the lines or parts are reconnected or installed.
- When disconnecting or reconnecting the lines, use two wrenches to support the line fitting to prevent from twisting or other damage.
- Always install new O-rings whenever a connection is disassembled.
- Before connecting any hoses or lines, apply new specified compressor oil to the O-rings.
- When removing and replacing any parts which require discharging the refrigerant circuit, the operations described in this section must be performed in the following sequence:
  - Use the J 39500 (ACR^4: HFC-134a Refrigerant Recovery / Recycling / Recharging System) or equivalent to discharge and recover the refrigerant.
  - Remove and replace the defective part.
  - After evacuation, charge the air conditioning system and check for leaks.

Repair of Refrigerant Leaks

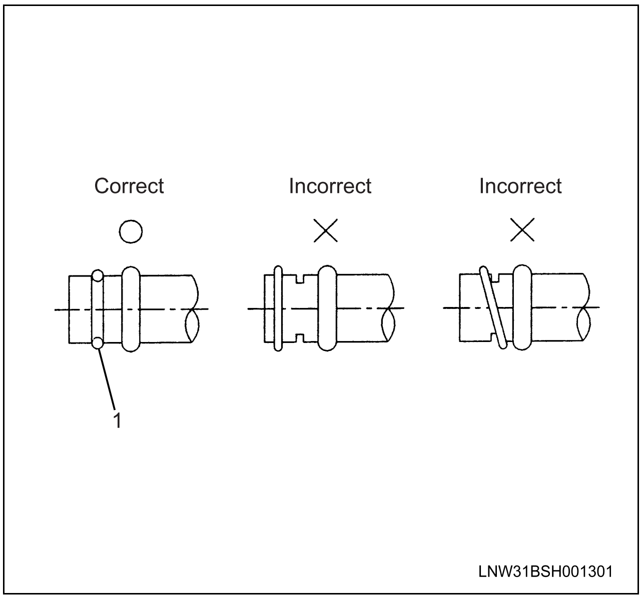
Refrigerant Line Connections

Install new O-rings, if required. When disconnecting or connecting lines, use two wrenches to prevent the connecting portion from twisting or becoming damaged.
When connecting the refrigerant line at the block joint, securely insert the projecting portion of the joint portion into the connecting hole on the unit side and secure with a bolt.
Apply specified compressor oil to the O-rings prior to connecting.

Caution:
Compressor (PAG) oil to be used varies according to compressor model. Be sure to apply oil specified for the model of compressor.



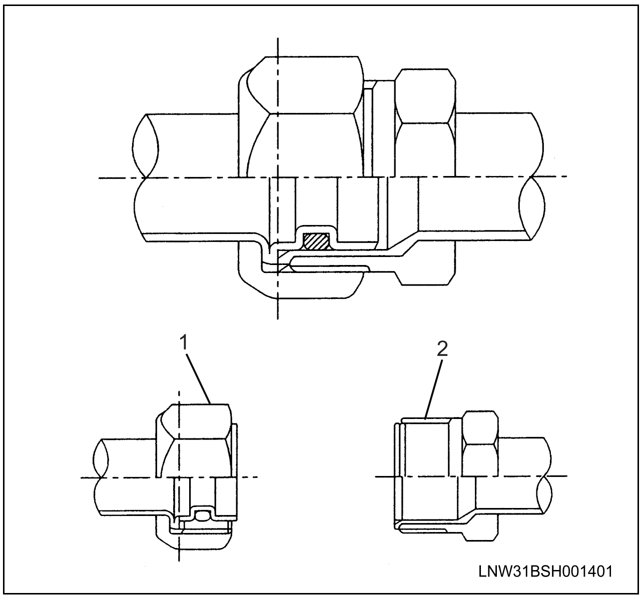
O-rings must be fitted in the groove of refrigerant line.



Legend

1. O-ring

Insert nut into union. First tighten nut by hand as much as possible.
Then, tighten nut to specified torque. (Refer to Specifications for Fastener Torques in this section.)



Legend

1. Union
2. Nut

Leak at Refrigerant Line Connections

1. Check the torque on the refrigerant line fitting and, if too loose, tighten to the specified torque.
    - Use two wrenches to prevent twisting and damage to the line.
    - Do not over tighten.
2. Perform a leak test on the refrigerant line fitting.
3. If the leak is still present, discharge and recover the refrigerant from the system.
4. Replace the O-rings.
    - O-rings cannot be reused. Always replace with new ones.
    - Be sure to apply specified compressor oil to the new O-rings.
5. Retighten the refrigerant line fitting to the specified torque.
    - Use two wrenches to prevent twisting and damage to the line.
6. Evacuate, charge and check the system.

Leaks in the Hose

If the compressor inlet or outlet hose is leaking, the entire hose must be replaced. Refrigerant hose must not be cut or spliced for repair.

1. Locate the leak.
2. Discharge and recover the refrigerant.
3. Remove the hose assembly.
    - Cap the open connections at once.
4. Connect the new hose assembly.
    - Use two wrenches to prevent twisting or damage to the hose fitting.
    - Tighten the hose fitting to the specified torque.
5. Evacuate, charge and check the system.

Compressor Leaks

If leaks are located around the compressor shaft seal or shell, replace or repair the compressor.

Recovery, Recycling, Evacuation and Charging

Handling Refrigerant-134a (HFC-134a):

Air conditioning systems contain HFC-134a. This is a chemical mixture which requires special handling procedures to avoid personal injury.

- Always wear safety goggles and protective gloves.
- Always work in a well-ventilated area. Do not weld or steam clean on or near any vehicle-installed air conditioning lines or components.
- If HFC-134a should come in contact with any part of the body, flush the exposed area with cold water and immediately seek medical help.
- If it is necessary to transport or carry any container of HFC-134a in a vehicle, do not carry it in the passenger compartment.
- If it is necessary to fill a small HFC-134a container from a large one, never fill the container completely. Space should always be allowed above the liquid for expansion.
- HFC-134a and Refrigerant-12 (R-12) should never be mixed as their compositions are not the same.

- HFC-134a PAG oil tends to absorb moisture more quickly than R-12 mineral oil and, therefore, should be handled more carefully.
- Keep HFC-134a containers stored below 40°C (100°F).

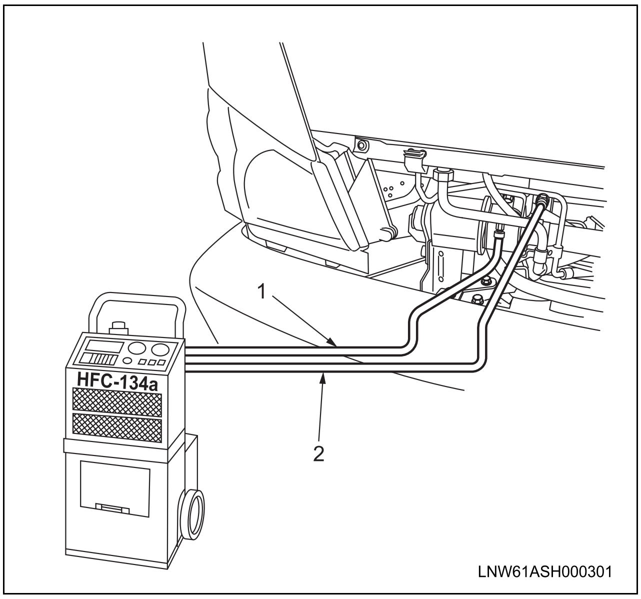
WARNING:

- SHOULD REFRIGERANT-134a (HFC-134a) CONTACT YOUR EYE(S), CONSULT A DOCTOR IMMEDIATELY.
- DO NOT RUB THE AFFECTED EYE(S). INSTEAD, SPLASH QUANTITIES OF FRESH COLD WATER OVER THE AFFECTED AREA TO GRADUALLY RAISE THE TEMPERATURE OF THE REFRIGERANT ABOVE THE FREEZING POINT.
- OBTAIN PROPER MEDICAL TREATMENT AS SOON AS POSSIBLE. SHOULD THE HFC-134a TOUCH THE SKIN, THE INJURY MUST BE TREATED THE SAME AS SKIN WHICH HAS BEEN FROSTBITTEN OR FROZEN.

Refrigerant Recovery

The refrigerant must be discharged and recovered by using the J 39500 (ACR^4: HFC-134a Refrigerant Recovery / Recycling / Recharging System) or equivalent before removing or mounting air conditioning parts.

1. Connect the high and low charging hoses of the ACR^4 set as shown below.



Legend

1. Low Side
2. High Side
3. J 39500

2. Recover the refrigerant by following the ACR^4 Manufacturer's Instructions.
3. When a part is removed, put a cap or a plug on the connecting portion so that dust, dirt or moisture cannot get into it.

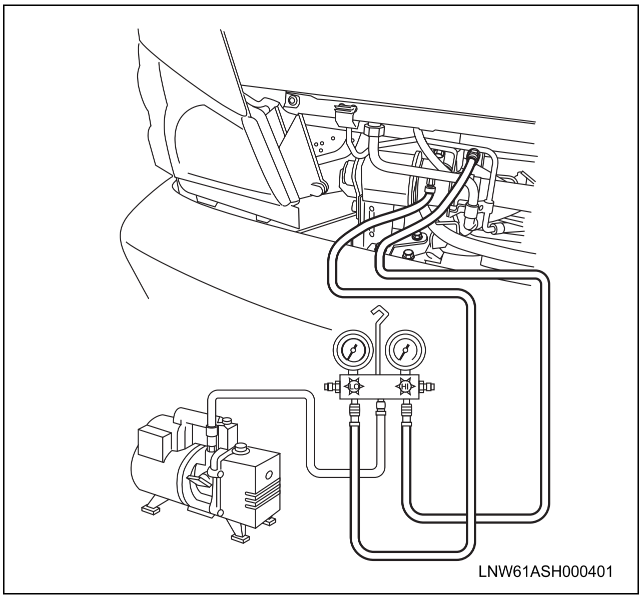
Refrigerant Recycling

Recycle the refrigerant recovered by J 39500 (ACR^4: HFC-134a Refrigerant Recovery / Recycling / Recharging System) or equivalent.
For the details of the actual operation, follow the steps in the ACR^4 Manufacturer’s Instructions.

Evacuation of the Refrigerant System

NOTE:

Explained below is a method using a vacuum pump. Refer to the ACR^4 manufacturer's instructions when evacuating the system with a ACR^4.
Air and moisture in the refrigerant will cause problems in the air conditioning system.
Therefore, before charging the refrigerant, be sure to evacuate air and moisture thoroughly from the system.



1. Connect the gauge manifold.
    - High-pressure valve (HI) - Discharge-side.
    - Low-pressure valve (LOW) - Suction-side.
2. Discharge and recover the refrigerant.
3. Connect the center hose of the gauge manifold set to the vacuum pump inlet.
4. Operate the vacuum pump, open shutoff valve and then open both hand valves.
5. When the low-pressure gauge indicates approx. 750 mmHg (30 inHg), continue the evacuation for 5 minutes or more.
6. Close both hand valves and stop the vacuum pump.
7. Check to ensure that the pressure does not change after 10 minutes or more.
    - If the pressure changes, check the system for leaks.
    - If leaks occur, retighten the refrigerant line connections and repeat the evacuation steps.

8. If no leaks are found, again operate the vacuum pump for 20 minutes or more. After confirming that the gauge manifold pressure is at 750 mmHg (30 inHg), close both hand valves.
9. Close positive shutoff valve. Stop the vacuum pump and disconnect the center hose from the vacuum pump.

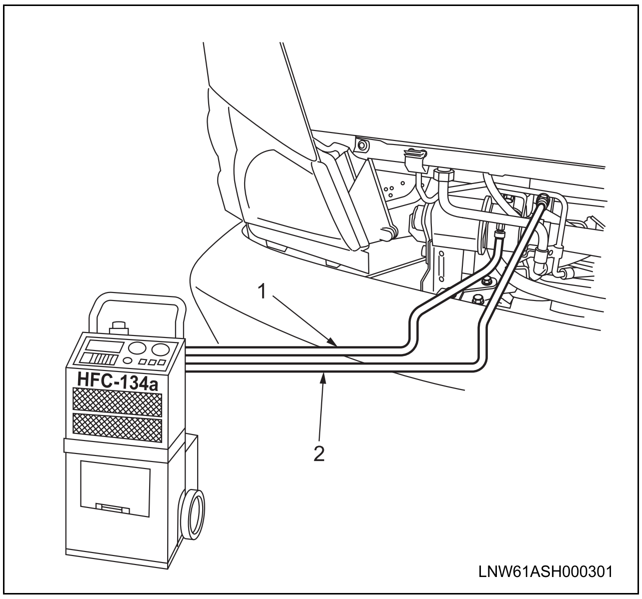
Charging the Refrigerant System

There are various methods of charging refrigerant into the air conditioning system.
These include using J 39500 (ACR^4: HFC-134a Refrigerant Recovery / Recycling / Recharging System) or equivalent and direct charging with a weight scale charging station.

Charging procedure

ACR^4 method

For the charging of refrigerant recovered by ACR^4, follow the manufacturer's instruction.

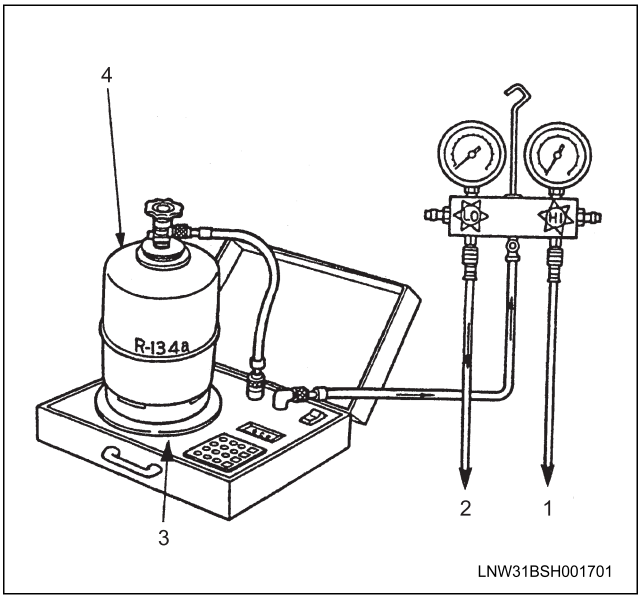


Legend

1. Low Side
2. High Side
3. J 39500

Direct charging with a weight scale charging station method

1. Make sure the evacuation process is correctly completed.
2. Connect the center hose of the manifold gauge to the weight scale.
3. Connect the low pressure charging hose of the manifold gauge to the low pressure side service valve of the vehicle.
4. Connect the high pressure charging hose of the manifold gauge to the high pressure side service valve of the vehicle.



Legend

1. High
2. Low
3. Weight Scale
4. Refrigerant Container

---

5. Place the refrigerant container up right on a weight scale.
   Note the total weight before charging the refrigerant.
   a. Open refrigerant container valve.
   b. Open low side valve on the manifold gauge set. Refer to the manufacturer's instruction's for a weight scale charging station.
6. Perform system leak test.
   - Charge the system with approx. 200g (0.44 lbs) of HFC-134a.
   - Make sure the high pressure valve of the manifold gauge is closed.
   - Check to ensure that the degree of pressure does not change.
   - Check for refrigerant leaks by using a HFC-134a leak detector.
   - If a leak occurs, recover the refrigerant. Repair the leak, and start all over again from the first step of evacuation.
7. If no leaks are found, continue charging refrigerant to the air conditioning system.
   - Charge the refrigerant until the scale reading decreases by the amount of the charge specified.

Specified amount	g (lbs)	600 (1.32)

   - If charging the system becomes difficult:

- Run the engine at idle and close all the vehicle doors.
- Turn A/C switch “ON”.
- Set the fan switch to its highest position.
- Set air source selector lever to “RECIRC”.
- Slowly open the low side valve on the manifold gauge set.

WARNING:
BE ABSOLUTELY SURE NOT TO OPEN THE HIGH PRESSURE VALVE OF THE MANIFOLD GAUGE. SHOULD THE HIGH PRESSURE VALVE BE OPENED. THE HIGH PRESSURE REFRIGERANT WOULD FLOW BACKWARD, AND THIS MAY CAUSE THE REFRIGERANT CONTAINER TO BURST.

8. When finished with the refrigerant charging, close the low pressure valve of the manifold gauge and container valve.
9. Check for refrigerant leaks.

Checking the A/C system

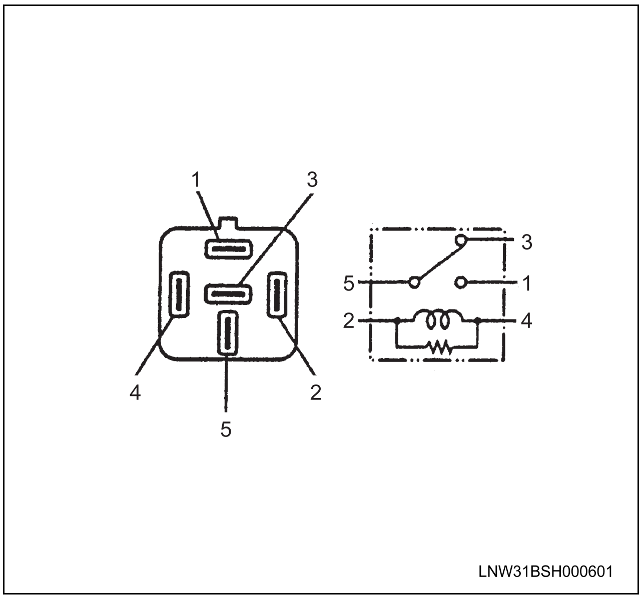
1. Run the engine and open all the vehicle doors.
2. Turn A/C switch “ON”, set the fan switch to its highest position and set temperature lever to full cool position.
3. Check the high and low pressure of the manifold gauge.
   - Immediately after charging refrigerant, both high and low pressure are slightly high, but they settle down to the pressure guidelines shown below:

     Ambient temperature: 30-35 °C (86-95 °F)
     Pressure Guidelines:
     - High-pressure side;
       Approx. 1,470-1,667 kPa (213.3-241.7 psi)
     - Low-pressure side;
       Approx. 127-196 kPa (18.5-28.4 psi)
   - If an abnormal pressure is found, refer to Checking Refrigerant System with Manifold Gauge in this section.
4. Put your hand in front of the air outlet and move the temperature control lever of the control panel to different positions. Check if the outlet temperature changes as selected by the control lever.

Checking the Heater & A/C and A/C Thermo Relay

1. Check for continuity between relay side connector terminals.

(3)-(5)	Continuity
(1)-(5)	No Continuity
(When battery voltage is applied between (2)-(4))	
(3)-(5)	No Continutiy
(1)-(5)	Continuity



Compressor Oil

Inspection Procedure

Oil Specification

Always use HFC-134a Swash Plate Compressor Oil ZXL-100PG (ISUZU Part No. 8-47101-338-0).

Handling of Oil

The oil should be free from moisture, dust, metal powder, etc.
Do not mix with other oil.
The water content in the oil increases when exposed to the air. After use, seal oil from air immediately.
(HFC-134a Swash Plate Compressor Oil absorbs moisture very easily.)
The compressor oil must be stored in steel containers, not in plastic containers.

Compressor oil check

The oil used to lubricate the compressor circulates with the refrigerant.
Whenever replacing any component of the system or a large amount of gas leakage occurs, add oil to maintain the original amount of oil.

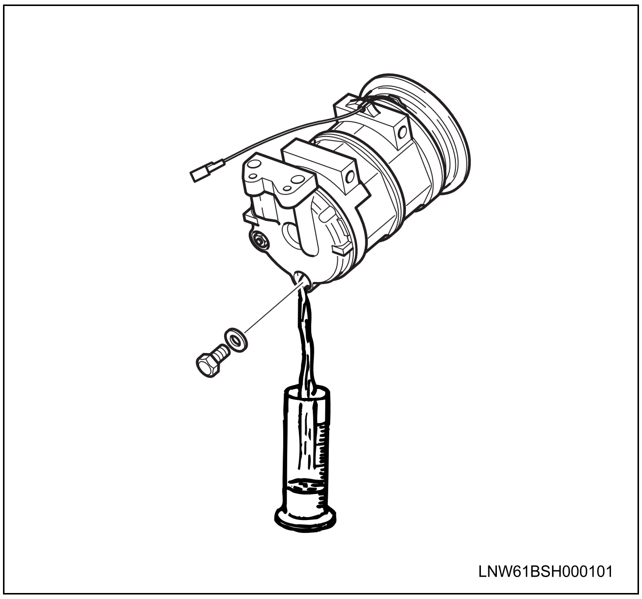
Oil Capacity.

Capacity total in system	180cc (6.08 FL.OZ.)
Compressor (Service parts) charging amount	180cc (6.08 FL.OZ.)

Checking and Adjusting for Used Compressor

1. Perform Oil return operation.
   (Refer to Oil Return Operation in this section.)
2. Discharge and recover refrigerant and remove the compressor.

3. Drain the compressor oil and measure the extracted oil with a measuring cylinder.



4. If the amount of oil drained is much less than 120cc (4.05 FL.OZ.), some refrigerant may have leaked out. Conduct leak tests on connections of each system, and if necessary, repair or replace faulty parts.
5. Check the compressor oil for contamination. (Refer to Contamination of Compressor Oil in this section.)
6. Adjust oil level following the procedure below.

Collected Amount	Charging Amount
more than 120cc (4.05 FL.OZ.)	same as collected amount
below 120cc (4.05 FL.OZ.)	120cc (4.05 FL.OZ.)

7. Install the compressor, then evacuate, charge and perform oil return operation.
8. Check system operation.

When it is impossible to perform oil return operation, the compressor oil should be checked in the following order:

1. Discharge and recover refrigerant and remove the compressor.
2. Drain the compressor oil and measure the extracted oil with a measuring cylinder.
3. Check the oil for contamination.
4. If more than 120cc (4.05 FL.OZ.) of oil is extracted from the compressor, supply same amount of oil to the compressor to be installed. If the amount of oil extracted is less than 120cc (4.05 FL.OZ.), recheck the compressor oil in the following order:
5. Supply 120cc (4.05 FL.OZ.) of oil to the compressor and install it onto the vehicle.
6. Perform oil return operation.
7. Remove the compressor and recheck the amount of oil.
8. Adjust the compressor oil.

Collected Amount	Charging Amount
more than 120cc (4.05 FL.OZ.)	same as collected amount
below 120cc (4.05 FL.OZ.)	120cc (4.05 FL.OZ.)

Checking and Adjusting for Compressor Replacement

180cc (6.08 FL.OZ.) of oil is charged in compressor (service parts). So it is necessary to drain the proper amount of oil from new compressor.

1. Perform oil return operation.
2. Discharge and recover refrigerant and remove the compressor.
3. Drain the compressor oil and measure the extracted oil with a measuring cylinder.
4. Check the compressor oil for contamination.
5. Adjust oil level following the procedure below.

Amount of oil drained from used compressor	Draining amount of oil from new compressor
more than 120cc (4.05 FL.OZ.)	same as collected amount
below 120cc (4.05 FL.OZ.)	120cc (4.05 FL.OZ.)

6. Evacuate, charge and perform oil return operation.
7. Check system operation.

Contamination of Compressor Oil

Unlike engine oil, no cleaning agent is added to the compressor oil. Even if the compressor runs for a long period of time (approximately 1 season), the oil never becomes contaminated as long as there is nothing wrong with the compressor or its method of use.

Inspect the extracted oil for any of the following conditions:

- The capacity of the oil has increased.
- The oil has changed color to red.
- Foreign substances, metal powder, present in the oil.

If any of these conditions exists, compressor oil is contaminated.

Whenever contaminated compressor oil is discovered, the receiver/drier must be replaced.

Oil Return Operation

There is close affinity between the oil and the refrigerant. During normal operation, part of the oil recirculates with the refrigerant in the system.

When checking the amount of oil in the system, or replacing any component of the system, the compressor must be run in advance for oil return operation. The procedure is as follows:

1. Open all doors and engine hood.
2. Air conditioning switch is "ON" and run the blower motor at "Highest" position.
3. Run the compressor for more than 20 minutes between 800 and 1,000 rpm in order to operate the system.

Replacement of Component Parts

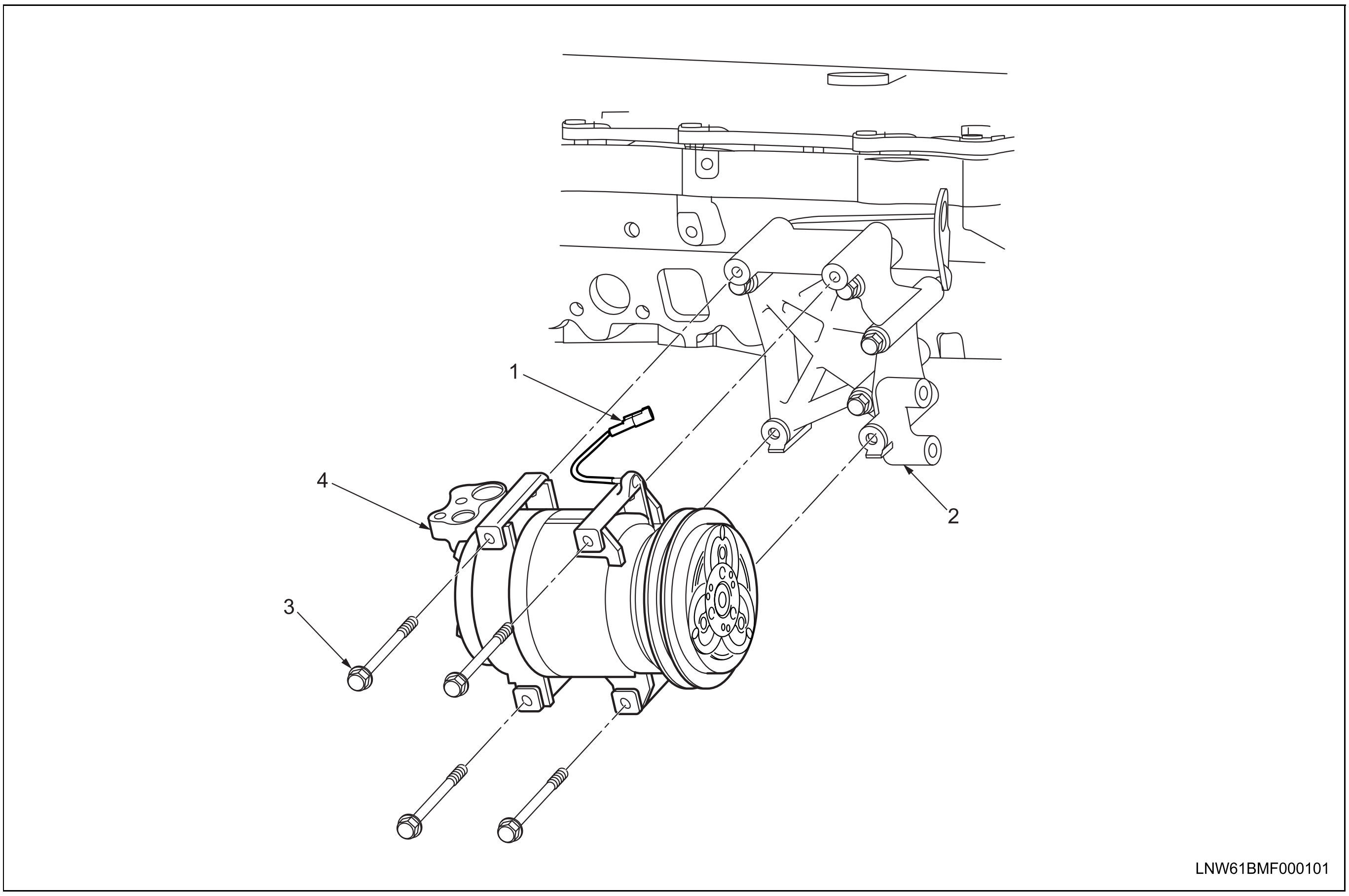
When replacing system component parts, supply the following amount of oil to the component parts to be installed.

Component parts to be installed	Amount of oil
Evaporator	50cc (1.7 FL.OZ.)
Condenser	30cc (1.0 FL.OZ.)
Receiver/drier	30cc (1.0 FL.OZ.)
Refrigerant line (one piece)	10cc (0.33 FL.OZ.)

Refrigeration oil must be replenished if more than two parts are removed at the same time.

After installing these components, check compressor oil.

Compressor



Legend

1. Magnetic Clutch Harness Connector
2. Compressor Bracket
3. Compressor Fixing Bolts
4. Compressor

Preparation

Disconnect the battery ground cable.
Discharge and recover refrigerant ("Refrigerant Recovery" in this section).

Removal Procedure

1. Disconnect the magnetic clutch harness connector.
2. When removing the line connector, connecting part of the line connector and the compressor should immediately be plugged or capped in order to prevent foreign matter and moisture from being mixed into the line and compressor.
3. Loosen the tension pulley lock nut and then loosen the adjusting bolt.
   Remove the drive belt.
4. Remove the compressor fixing bolts.

Installation Procedure

1. Attach the compressor to the compressor bracket using four bolts.

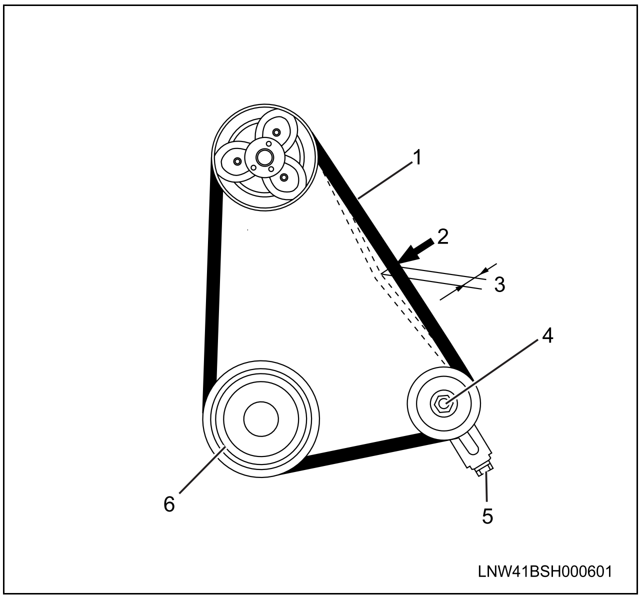
Tighten

- Compressor fixing bolts to 48 N·m (34 lb ft)

2. Push the drive belt with the force of 10 kg (22 lb), and adjust the drive belt tension by tightening idle pulley tension adjustment bolt, until the 10 mm (0.4 in) deflection of the belt is obtained. Then tighten the pulley center nut.
   Install the drive belt.

Tighten

- Drive Belt tension pulley center nut to 4.9 N·m (36 lb ft)



Legend

1. Drive Belt
2. 22 lb (10 kg)
3. 0.31 – 0.47 in
4. Pulley Center Nut
5. Adjustment Bolt
6. Crank Pulley

---

3. O-rings do not reused. Always replace with new ones.
   Be sure to apply new specified compressor oil to the O-rings when connecting refrigerant line.

Tighten

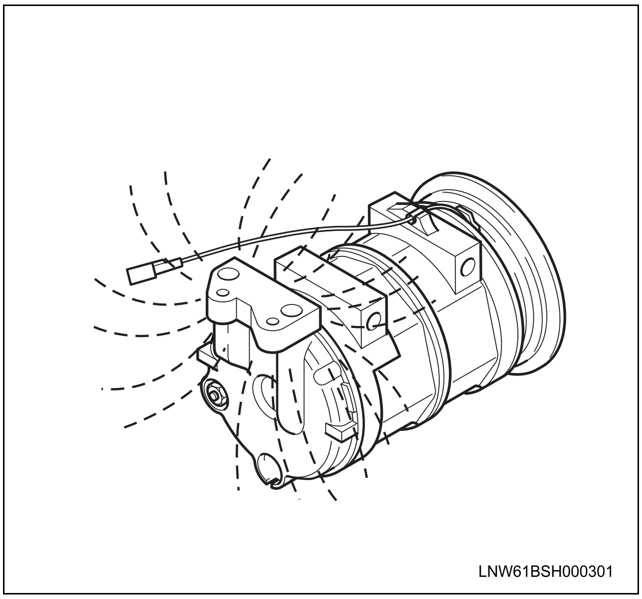
- Refrigerant line connector fixing bolt to 15 N·m (11 lb ft)

4. Connect the magnetic clutch harness connector.
5. Using a socket wrench, rotate the automatic tensioner clockwise by applying torque to the tensioner, then route the drive belt.

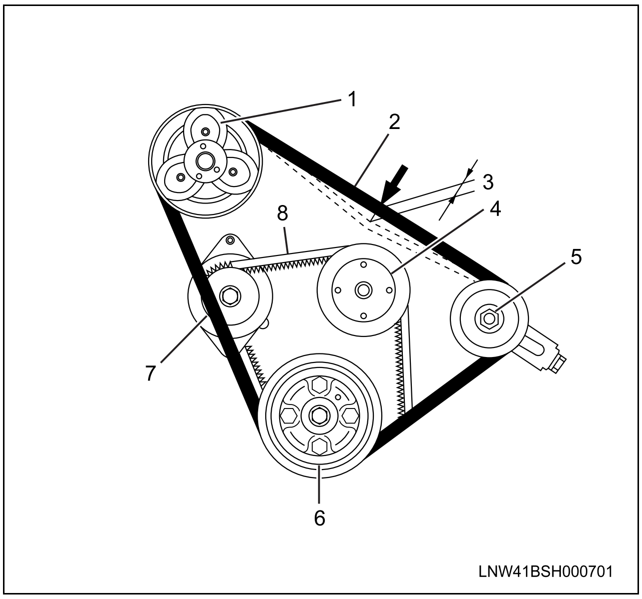
New Compressor Installation

The new compressor is filled with 180cc (6.08 FL.OZ) of oil, perform the following steps;

1. Gently release nitrogen gas from the new compressor by loosing the compressor service plug fixing bolt.
   - Take care not to let the compressor oil flow out.
   - Inspect O-rings and replace if necessary.
2. Turn the compressor several time by hand to prevent any liquid compression.
3. When installing on a new system, the compressor should be installed as it is. When installing on a used system, the compressor should be installed after adjusting the amount of compressor oil.



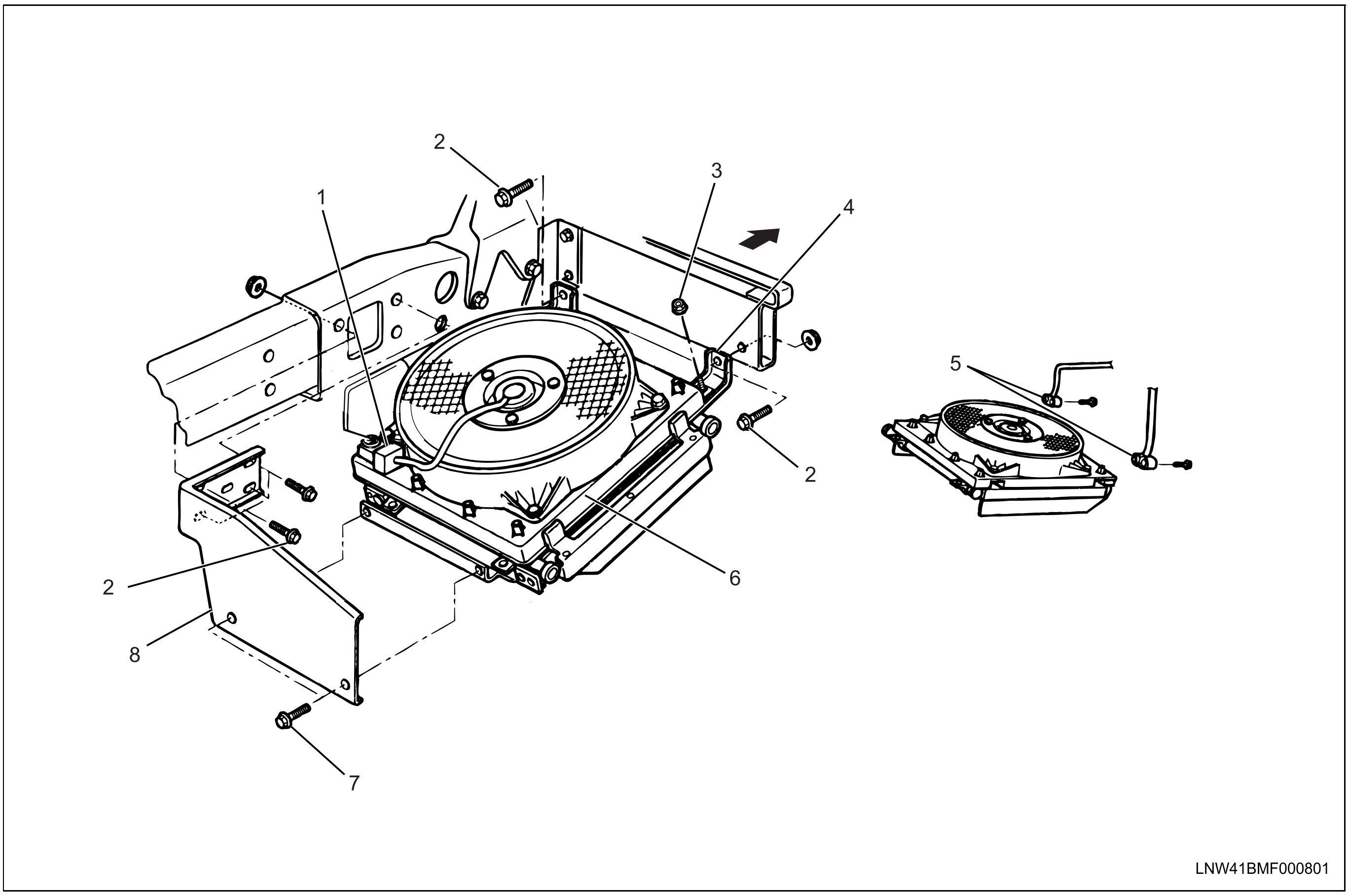
Caution:
The A/C belt must be adjusted after Fan-belt adjustment. If the required procedure is not followed, the A/C-belt may experience excessive tension, and possible premature failure.



Legend

1. A/C Compressor
2. A/C Belt
3. Belt Deflection
4. Fan Pulley
5. Tension Pulley
6. Crank Pulley
7. Generator
8. Fan Belt

Condenser



Legend

1. Condenser Fan Motor Connector
2. Condenser Assembly Fixing Bolt
3. Condenser Front Bracket Fixing Nut
4. Condenser Front Bracket
5. Refrigerant Line Connectors
6. Condenser Assembly
7. Condenser Rear Bracket Fixing Bolt
8. Condenser Rear Bracket

Preparation

Disconnect the battery ground cable.
Discharge and recover refrigerant. Refer to Refrigerant Recovery in this section.
Tilt the cab.

Removal Procedure

1. Disconnect the condenser fan motor connector.
2. Disconnect the refrigerant lines.
   When removing the line connected part, the connecting part should immediately be plugged or capped to prevent foreign matter from being mixed into the line.
3. Remove the condenser assembly fixing bolts
4. Remove the condenser assembly with condenser fan.
5. Remove the condenser front bracket assembly.
6. Remove the condenser rear bracket assembly.

Installation Procedure

1. Install the condenser rear bracket assembly.

Tighten

- Condenser bracket fixing bolt to 18 N·m (13 lb ft).

2. Install the condenser front bracket assembly.

Tighten

- Condenser bracket fixing nuts to 18 N·m (13 lb ft).

3. Install the condenser assembly with condenser fan.
   If installing a new condenser, be sure to add 30cc (1.0FL.OZ) of new compressor oil to a new one.
4. Install the condenser assembly fixing bolts.

Tighten

- Condenser assembly fixing bolts to 36 N·m (27 lb ft).

5. Connect the refrigerant lines.
   - O-ring cannot be reused. Always replace with new ones.

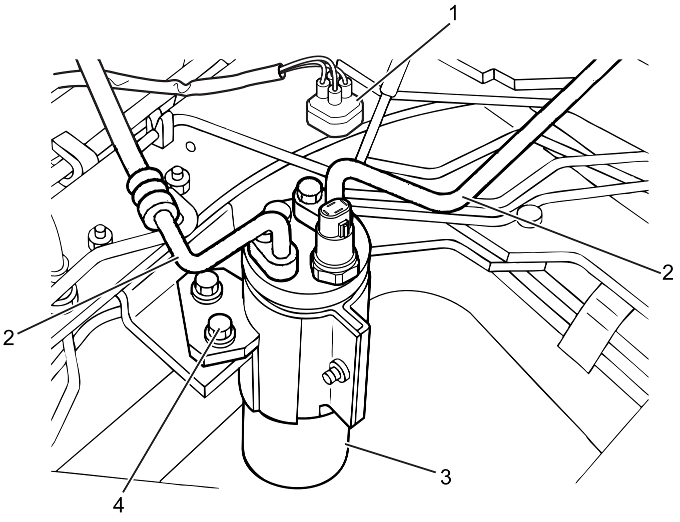
- Be sure to apply new compressor oil to the O-ring when connecting pressure switch.

Tighten

- Suction side to 15 N·m (11 lb ft)
- Discharge side to 6 N·m (52 lb in)

6. Connect the condenser fan motor connector.

Receiver-Drier



LNW41BMF000101

Legend

1. Pressure Switch Connector
2. Refrigerant Line
3. Receiver-Drier
4. Bracket Bolt

Preparation

Disconnect the battery ground cable.
Discharge and recover refrigerant. Refer to Refrigerant Recovery in this section.
Tilt the cab.

Removal Procedure

1. Disconnect the pressure switch connector.
2. Disconnect the refrigerant lines.
   When removing the line connected part, the connecting part should immediately be plugged or capped to prevent foreign matter from being mixed into the line.
3. Remove the bracket bolts and pull out the receiver/drier.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

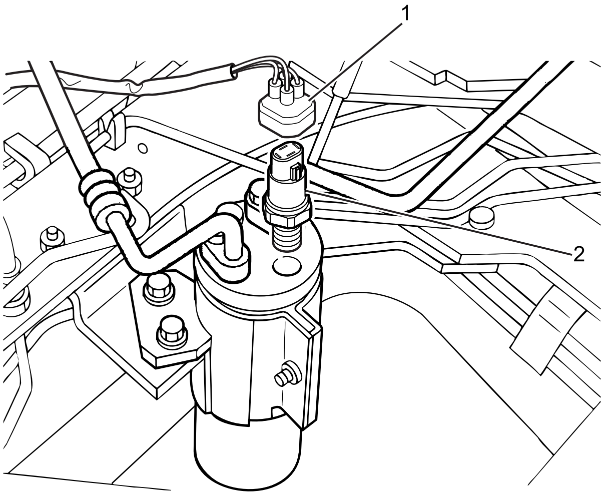
1. If installing a new receiver/drier, be sure to add 30 cc (1.0 FL.OZ) of new compressor oil to a new one.
2. Install the receiver/drier with bracket and connect with the refrigerant line. Check that no excessive force is imposed on the line. Fasten the bracket bolts.
3. O-ring cannot be reused. Always replace with new ones.

4. Be sure to apply new specified compressor oil to the O-rings when connecting refrigerant line.

Tighten

- Refrigerant line connector fixing nut receiver/drier side to 6 N·m (52 lb in)

Pressure Switch



Legend

1. Pressure Switch Connector
2. Pressure Switch

Preparation

Disconnect the battery ground cable.
Discharge and recover refrigerant. Refer to Refrigerant Recovery in this section.
Tilt the cab.

Removal Procedure

1. Disconnect the pressure switch connector.
2. Turn the pressure switch counterclockwise to remove it.
   When removing the switch connected part, the thread should be immediately capped to prevent foreign matter from being mixed into the line.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. O-ring cannot be reused. always replace with new one.
2. Be sure to apply new compressor oil to the O-ring when connecting pressure switch.

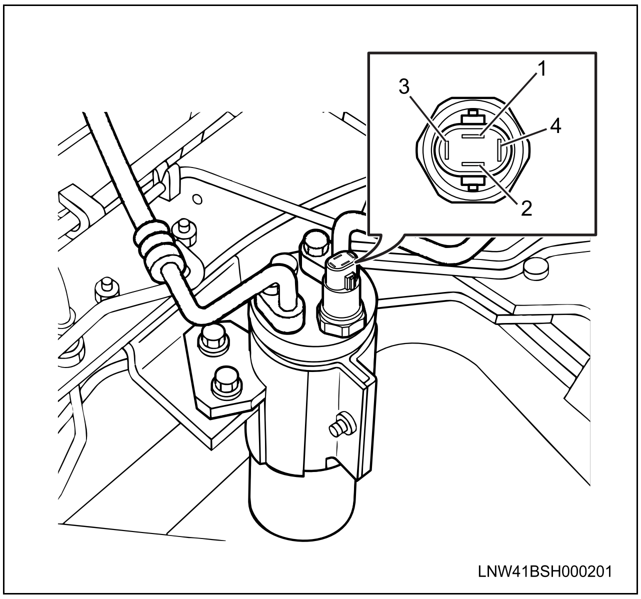
Tighten

- Pressure switch to 13 N·m (113 lb in)

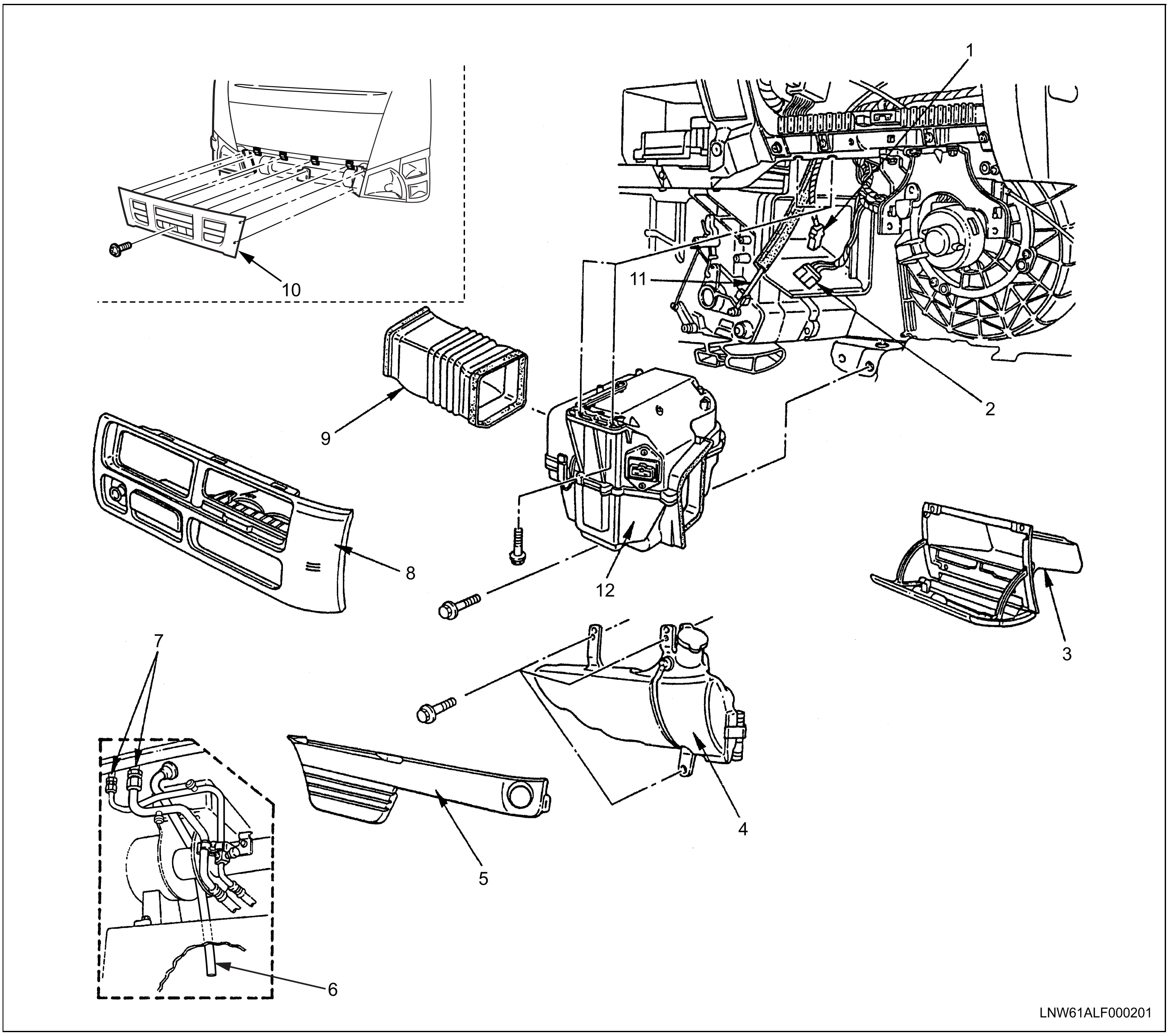
Inspection Procedure

1. Disconnect the connector and check for continuity between pressure switch side connector terminal.

Terminal No.	Control	Continuity
(1)-(2)	Magnetic clutch	Continuity
(3)-(4)	Condenser fan	No Continuity


1
3
4
2
LNW41BSH000201

Evaporator Assembly



Legend

1. Electronic Thermostat Connector
2. Resistor Connector
3. Glove Box
4. Washer Tank
5. Under Cover
6. Drain Hose
7. Refrigerant Line
8. Center Cluster
9. Duct
10. Front Grille
11. Temperature Control Cable
12. Evaporator Assembly

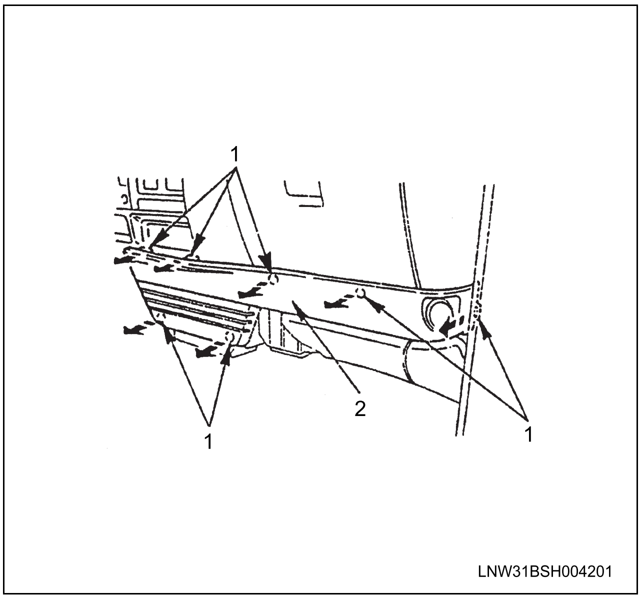
Preparation

Disconnect the battery ground cable.
Discharge and recover refrigerant. Refer to Refrigerant Recovery in this section.

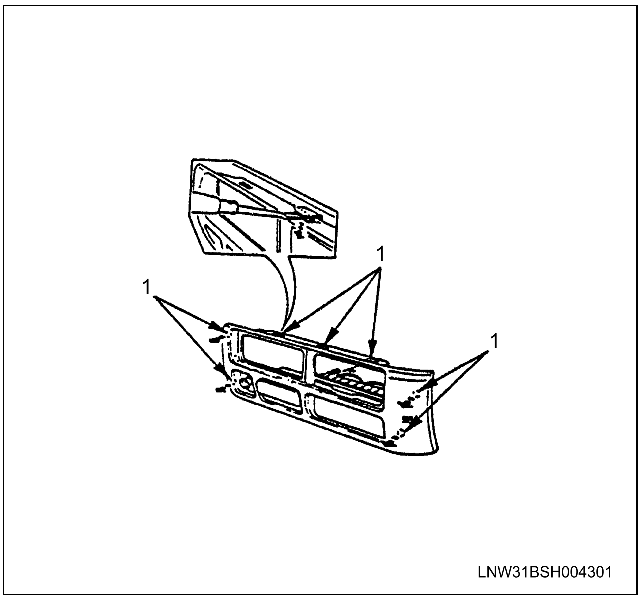
Removal Procedure

1. Open the glove box and remove the fixing screws.

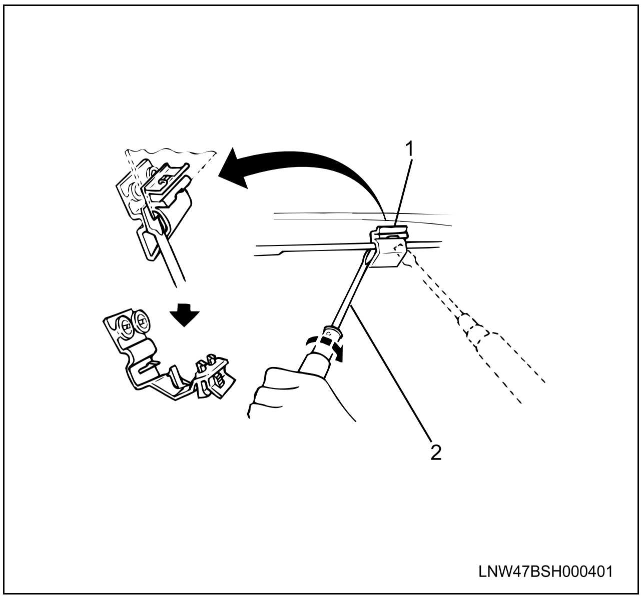
2. While pulling the under cover (2) with care, remove the clips (1) on the back side of the cover.



3. Remove the washer tank fixing three bolts (Upper: two, Lower: one) and disconnect the connector.
   Do not disconnect the washer tank tube.
4. While pulling the cluster with care, remove the upper and the back side clips (1) of the cluster.
   Disconnect the cigarette righter and illumination connectors.



5. Disconnect the temperature control cable of the control lever assembly from the heater unit.
6. Remove the duct.
7. After removing the grille, clip (RH) is removed using a driver.

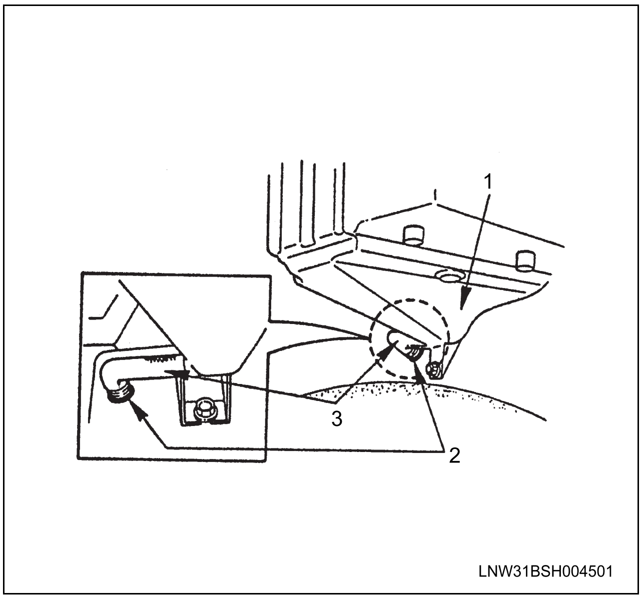


Legend

1. Clip
2. Driver

---

8. Use a backup wrench when disconnecting and reconnecting the refrigerant line.
   When removing the line connected part, the connecting part should immediately be plugged or capped to prevent foreign matter from being mixed into the line.
9. Disconnect the resistor and thermostat connectors.
   Disconnect the drain hose.



Legend

1. Evaporator
2. Grommet
3. Drain Hose

Installation Procedure

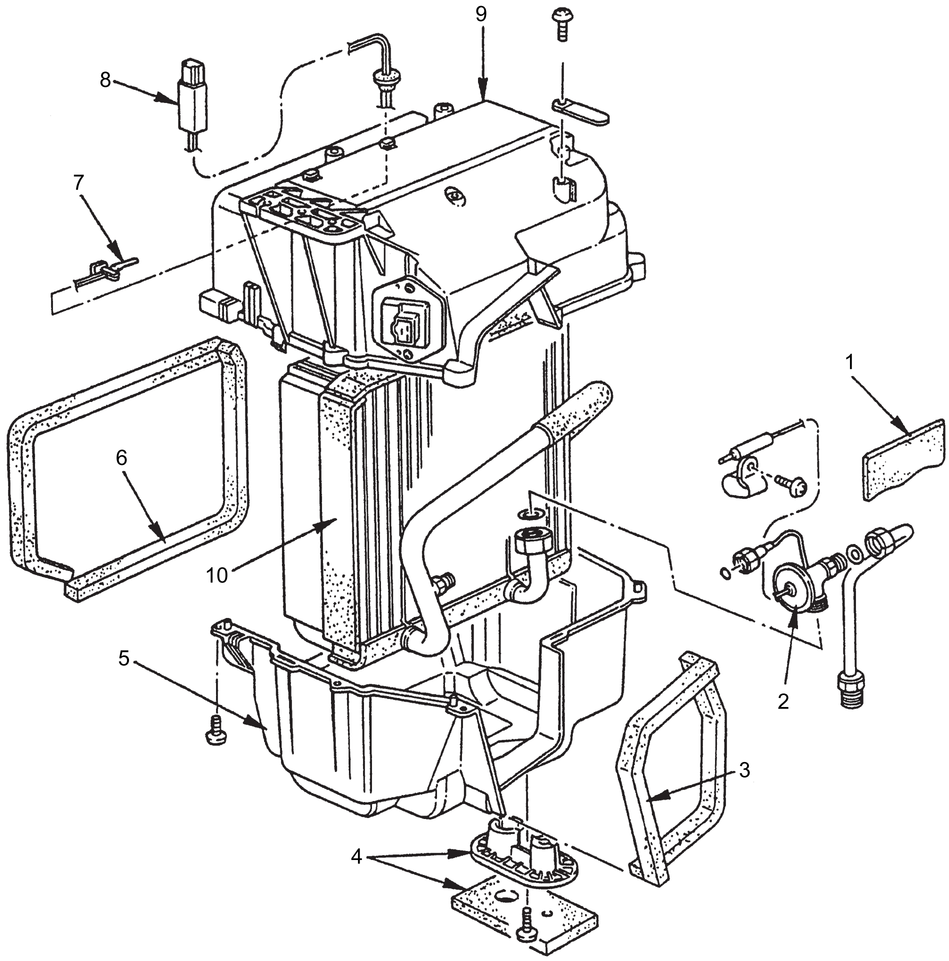
To install, follow the removal steps in the reverse order, noting the following points:

1. To installing a new evaporator assembly, be sure to add 50 cc (1.7 FL.OZ) of new compressor oil to a new one.
2. O-ring cannot be reused. Always replace with new ones.
3. Be sure to apply new specified compressor oil to the O-rings when connecting refrigerant lines.

Tighten

- Refrigerant outlet line to 25 N·m (18 lb ft)
- Refrigerant inlet line to 15 N·m (11 lb ft)

Evaporator Core, Expansion Valve and Thermostat



LNW31BLF000601

Legend

1. Insulator
2. Expansion Valve
3. Lining
4. Insulator and Under Cover
5. Lower Case
6. Lining
7. Thermo Sensor
8. Electronic Thermostat
9. Upper Case
10. Evaporator Core

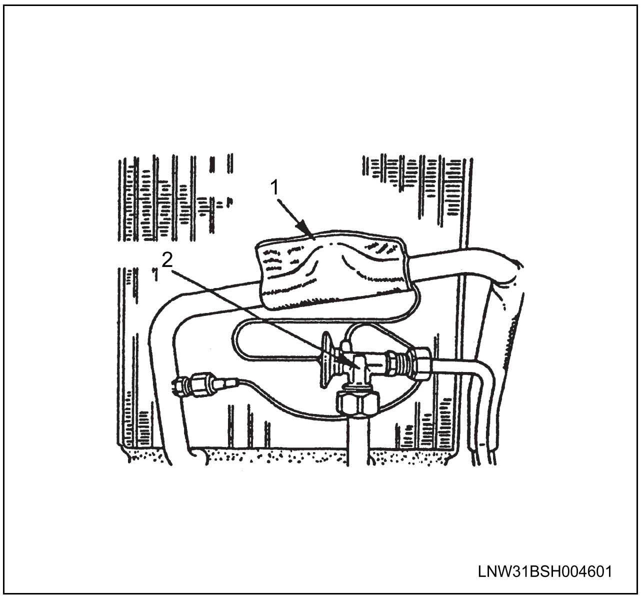
Preparation

Disconnect the battery ground cable.

Discharge and recover refrigerant. Refer to Refrigerant Recovery in this section.

Removal Procedure

1. Refer to Evaporator Assembly removal procedure in this section.
2. Remove the sensor fixing clip.
   Pull out the grommet from the upper case to remove the thermostat.
3. Separate the upper and lower case.
   Slit the case parting face with a knife since the lining is separated.
4. Remove the insulator and under cover.
5. Pull up the core from the lower case.
6. Tear off the insulator carefully.
   Remove the sensor fixing clip.
   Use back-up wrench when disconnecting all refrigerant pipes and remove the expansion valve.



LNW31BSH004601

Legend

1. Insulator
2. Expansion Valve

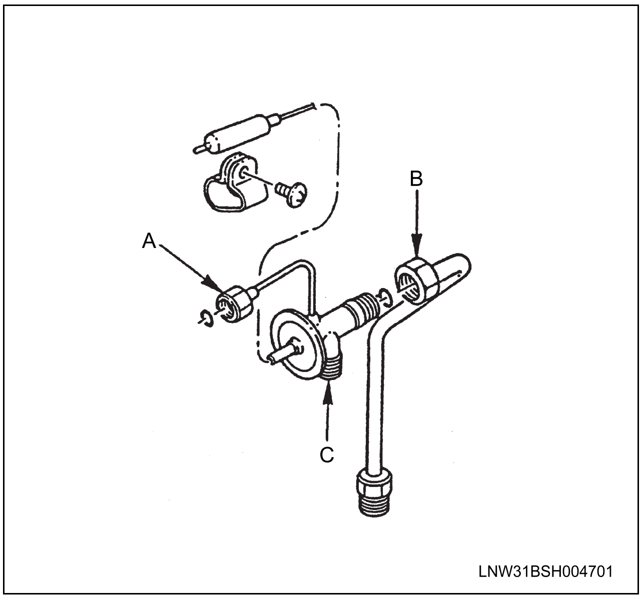
Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. O-rings cannot be reused. Always replace new ones.
2. Be sure to apply new specified compressor oil to the O-rings when connecting lines.
3. Be sure to install the expansion valve sensor and the insulator on the place where they were before.
4. To install a new evaporator core, add 50cc (1.7 FL.OZ) of new specified compressor oil to a new core and install the thermostat sensor to the evaporator core specified position with the clip where it was before.

Tighten

Refrigerant line	position A	10 N·m (87 lb in)
	position B	15 N·m (11 lb ft)
	position C	20 N·m (14 lb ft)



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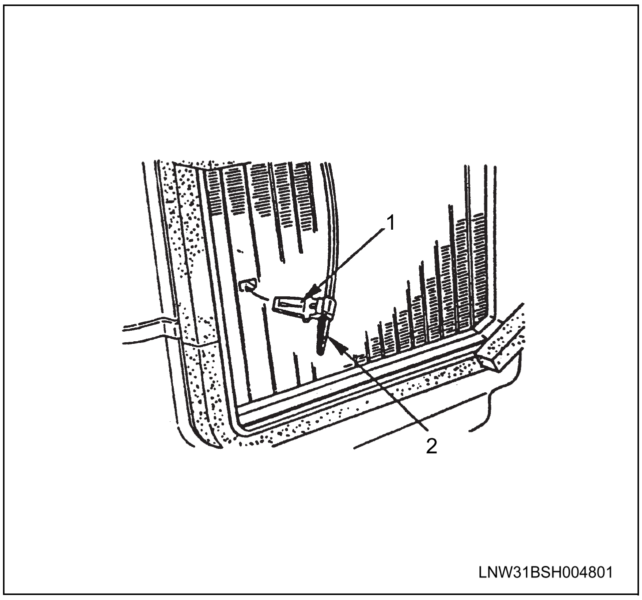
5. Apply an adhesive to parting face of lining when assembling evaporator assembly.
6. The thermostat sensor (2) is installed on the core with the clip (1) and it must not interfere with the core.

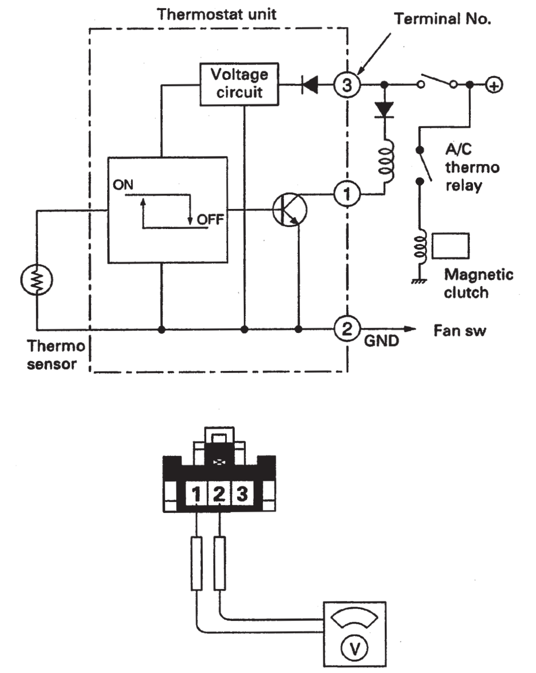


LNW31BSH004801

Inspection Procedure

1. With the air select lever set to “VENT” and the air source select lever to “CIRC”, start the air conditioning.
2. While shifting the temperature control lever from “FULL COOL” through the “FULL HOT”, check to see if the magnetic clutch turns on and off. (* Note that the time required to reach the “OFF” point depends on the warm or cold air at 3.5 ± 0.5 °C at the electronic thermostat thermo sensor.)
3. While the magnetic clutch is turning “ON” and “OFF”, measure the voltage between chassis side connector terminal No.(1) No.(2).

Terminal No.	Magnetic clutch	Voltage
(1)-(2)	ON	0V
	OFF	Battery voltage



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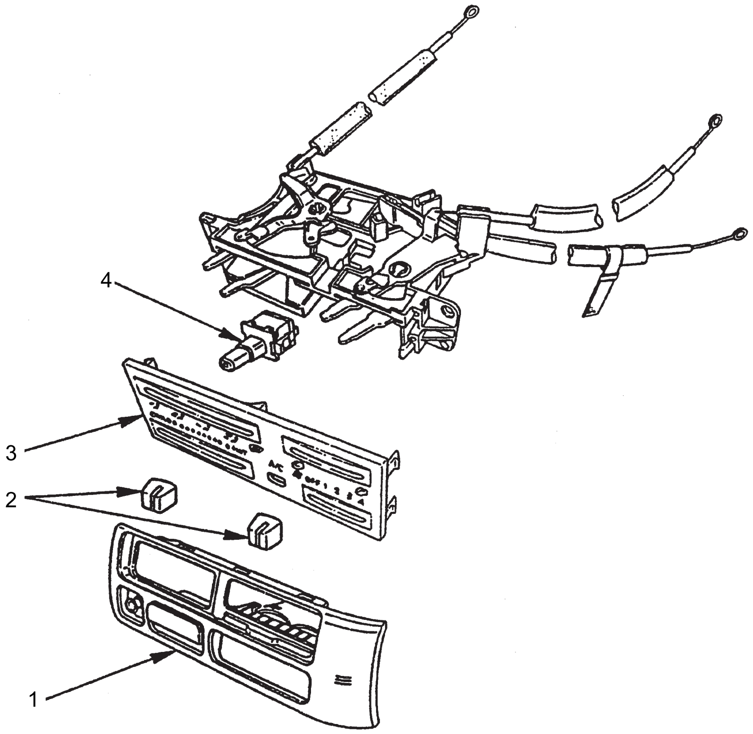
Air Conditioner (A/C) Switch



LNW31BMF000601

Legend

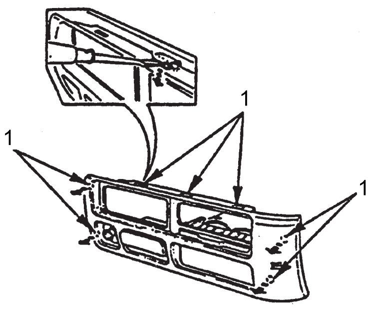
1. Center Cluster
2. Knob
3. Control Panel Bezel
4. A/C (Air conditioning) Switch

Preparation

Disconnect the battery ground cable.

Removal Procedure

1. While pulling the cluster with care, remove the upper and the back side clips (1) of the cluster. Disconnect the cigarette lighter and illumination connectors.



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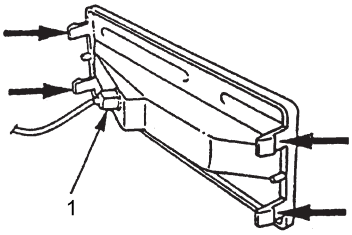
2. Remove the knob.
3. Push the four catches at both sides of the bezel to the inside, and remove the illumination bulb (1) from the bezel.



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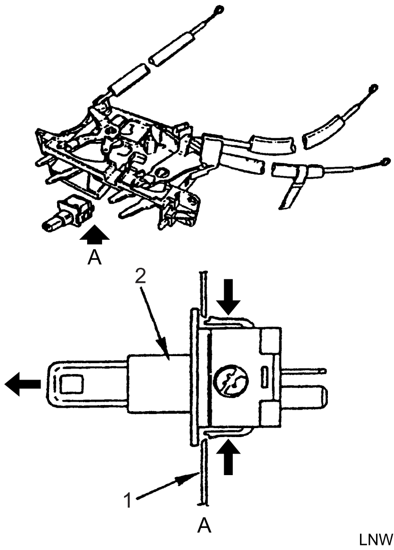
4. A/C switch
   Push the catches at both sides of the A/C switch to the inside, and remove the switch by pulling out.



LNW31BSH001001

Legend

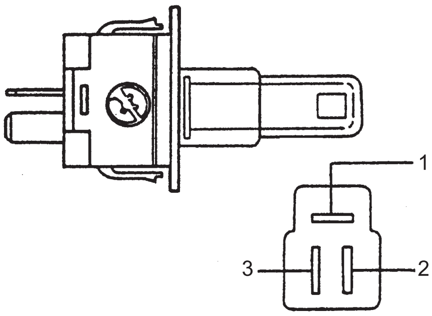
1. Control Lever
2. A/C Switch

Installation Procedure

To install, follow the removal steps in the reverse order.

Inspection Procedure

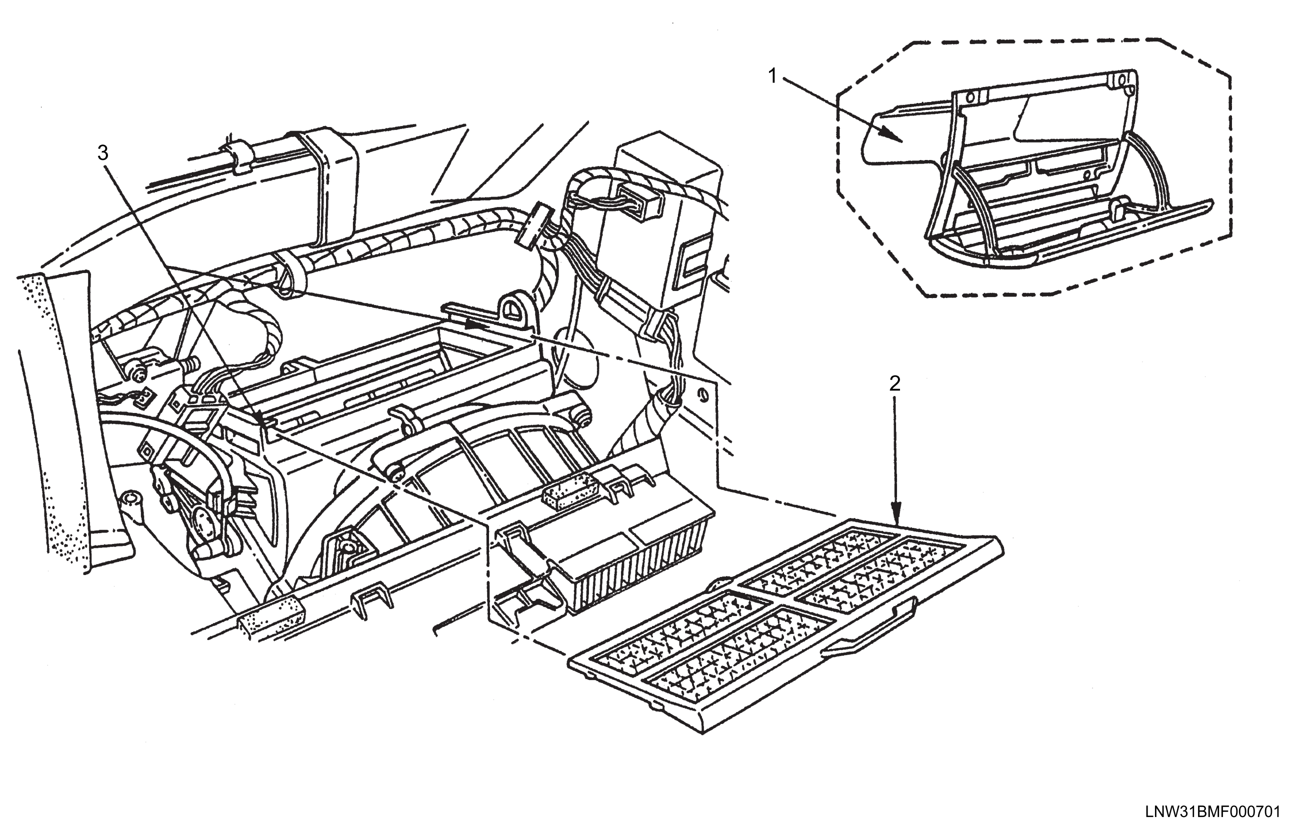
1. Check for continuity between A/C switch side connector terminals.



Terminal No. / SW position	1	2	3
ON	○—	—○—	—○
OFF		○—	—○

LNW31BSH000701

Blower Filter



Legend

1. Glove Box
2. Blower Filter
3. Slit

Preparation

Disconnect the battery ground cable.

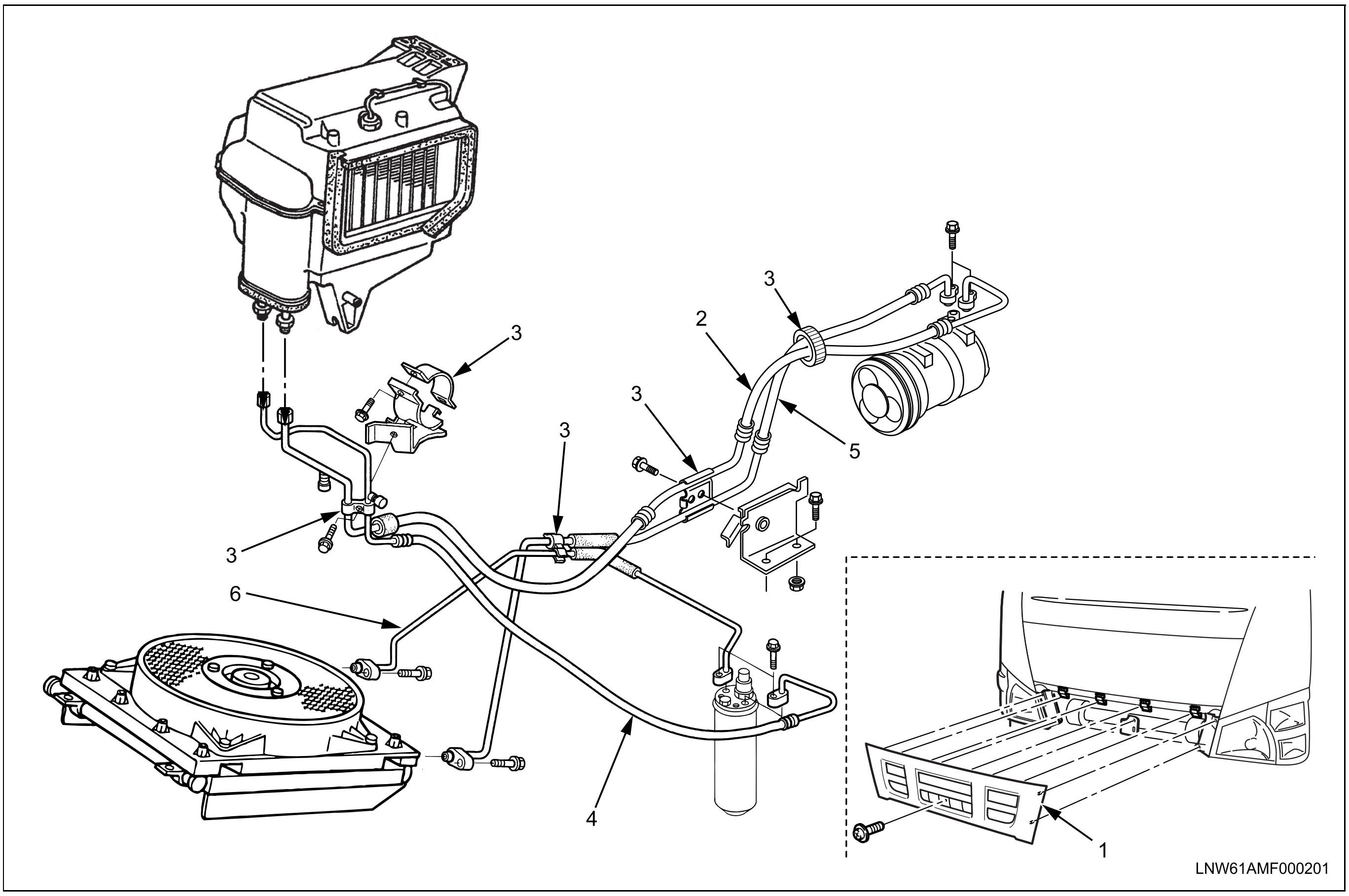
Removal Procedure

1. Open the glove box and remove the fixing screws.
2. Pull out the blower filter from the blower upper slit.

Installation Procedure

To install, follow the removal steps in the reverse order.

Refrigerant Line



Legend

1. Front Grille
2. Suction Line (Receiver/driver-Evaporator)
3. Clip and Bracket
4. Liquid Line (Receiver/drier-Evaporator)
5. Discharge Line (Compressor-Condenser)
6. Liquid Line (Receiver/driver-Condenser)

Preparation

Disconnect the battery ground cable.
Discharge and recover refrigerant. Refer to Refrigerant Recovery in this section.

Removal Procedure

1. After removing the grille, remove the grille fixing clip (RH).
2. Remove the clip and bracket.
3. Disconnect the discharge line (Compressor-Condenser).
4. Disconnect the liquid lines (Condenser-Receiver/drier, Receiver/drier-Evaporator).
5. Disconnect the suction line (Compressor-Evaporator).
6. Use a back-up wrench when disconnecting and reconnecting the refrigerant lines at the evaporator.
   When removing the refrigerant line connecting part, the connecting part should immediately be plugged or capped to prevent foreign matter from being mixed into the line.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. O-rings cannot be reused. Always replace new ones.
2. Be sure to apply new specified compressor oil to the O-rings when connecting refrigerant lines.
3. To install a new refrigerant line (one piece), add 10 cc (0.33 FL.OZ) of new specified compressor oil to a new one.

Tighten

- Refrigerant line to the specified torque. Refer to Torque Specifications in this section.

Specifications

Specifications

BLOWER MOTOR

Type	Sirocco Fan Diameter 140 mm (5.5 in)
Current Consumption	18 amp or less at 13.5 V

HEATER UNIT

Temperature control	Reheat air mix
Capacity	3700Kcal./hr (4.3 kW)
Air flow	280m^3/hr

HEATER CORE

Type	Fin &tube type

EVAPORATOR

Type	Al-laminate louver fin type
Capacity	3800 Kcal./hr (4.4 kW)
Air flow	420m^3/hr

THERMOSTAT SWITCH

Type	Electronic thermostat
	OFF: 3.5 ± 0.5°C (38.3 ± 0.9°F)
	ON: 5.0 ± 0.5°C (41.0 ± 0.9°F)

CONDENSER

Type	Aluminum louvered fins
Capacity	6,700 kcal/hr (7.8 kW)

RECEIVER/DRIER	Assembly includes triple pressure switch Low pressure control ON: 206 ± 30 kPa (30 ± 4 psi) OFF: 177 ± 20 kPa (26 ± 3 psi) Medium-ressure control ON: 1,471 ± 98 kPa (213 ± 14 psi) OFF: 1,079 ± 118 kPa (156 ± 17 psi) High pressure control ON: 2354 ± 196 kPa (341 ± 28 psi) OFF: 2942 ± 196 kPa (427 ± 28 psi)

REFRIGERANT

Type	HFC-134a
Capacity	600g (1.32 lbs)
Oil Type	HFC-134a Swash Plate Compressor Oil (AIPDN PARTS NO.2-90188-300-0)
Oil Capacity	180 cc (6.08 FL.OZ.)

FUSES

Heater (Blower Motor)	25 A
A/C	10 A
Condenser Fan	20 A

COMPRESSOR

Model	DKS-15D
Type	10 Cylinder Swash Plate
Displacement	156 cc/rev (9.52 cu·in/rev)
Rotation	Clockwise (Front side view)
Shaft Seal	Lip type
Weight	6.5 kg (14.3 lbs)

CLUTCH COIL

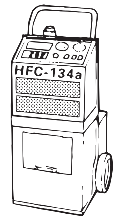
Magnetic Clutch Type	Dry Single Disc
Minimum Working Voltage	10.5 V at 90 °C (194 °F)
Starting Torque	49 N·m (36 lb ft)
Weight	2.1 kg (4.6 lbs)

Fastener Torques

Compressor Fixing Bolts		48 N·m (34 lb ft)
Refrigerant Line Connector (Compresor Side)		15 N·m (11 lb ft)
Drive Belt Tension Pulley Center Nut		49 N·m (36 lb ft)
Condenser Bracket Fixing Bolts and Nuts		18 N·m (13 lb ft)
Condenser Fixing Bolts		36 N·m (27 lb ft)
Refrigerant Outlet Line Connector (Condenser Side)		6 N·m (52 lb in)
Refrigerant Inlet Line Connector (Condenser Side)		15 N·m (11 lb ft)
Refrigerant Line Connector (Receiver-Drier Side)		6 N·m (52 lb in)
Pressure Switch		13 N·m (113 lb in)
Refrigerant Outlet Line Connector (Evaporator Side)		25 N·m (18 lb ft)
Refrigerant Inlet Line Connector (Evaporator Side)		15 N·m (11 lb ft)
Refrigerant line (Expansion Value Side)	Position A	10 N·m (87 lb in)
	Position B	15 N·m (11 lb ft)
	Position C	20 N·m (14 lb ft)

Special Tools

Special Tools

Illustration	Tool Number/ Description
 5884006290	J 39500-A ACR^4 (HFC-134a Refrigerant Recovery / Recycling / Recharging / System)

BODY, CAB, AND ACCESSORIES

Frame and Body Mounts

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Description and Operation

Frame Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

The main parts of a frame are the side rails and cross-members. The rails carry the load and the cross-members stabilize the rails. The entire frame must be stiff enough to support the load it carries. It must also be flexible enough to absorb and distribute the stress placed on it.

These vehicles have straight, full-channel, side rails. The rails should be parallel at all points along their length.

To prevent corrosion, a batten compound must be applied to the mating surface of dissimilar metals.

Example: An aluminum battery box mounted on a steel frame rail.

Proper frame alignment is important to ensure normal life and functioning of many other parts of the vehicle. If the vehicle has been involved in a fire, collision, or has been overloaded, there is cause to check the frame alignment. If, for any other reason poor alignment is suspected, it should be checked. A procedure for this is described later in this section under "Checking Frame Alignment."

It is possible that certain conditions may make the frame appear to be out of alignment when, in fact, it is not. These conditions are also described under "Checking Frame Alignment."

Terms used later in this section are briefly defined as follows:

Section Modulus
This is a measure of the strength of a frame, based on height, width, thickness and shape of the side rails. It does not account for the strength of the material used in the frame.

Yield Strength
This is a measure of the strength of the material from which the frame is made. It is the maximum load (kPa[psi]) that can be placed on a material and still have it return to its original shape.

Resistance to Bending Moment (RBM)
This is a single measure of frame strength that accounts for both the section modulus and the strength of the material used. (It is the product of section modulus and yield strength.)

Sag
This refers to a frame or side rail that is bent down from where it should be.

Buckle
This refers to a frame or side rail that is bent up from where it should be.

Diamond
This refers to the condition where one entire frame rail is moved forward from, or to the rear of, its correct alignment with the other rail.

Twist
This refers to the condition where the entire frame has been twisted. One rail will basically slope up while the other rail will basically slope down.

Sidesway
This refers to a side rail that is bent to the side of where it should be.

Tracking
This refers to the alignment of the vehicle axles with each other. A misaligned frame can cause improper tracking. If the vehicle is tracking correctly, all axles will be parallel to each other and perpendicular to the center line of frame.

Web
The vertical part of a channel-type frame rail.

Minimizing Frame Failures Description

Generally, frame failures can be minimized or eliminated by minimizing the concentration of stress in small areas of the frame:

1. Vehicles should be used only for those purposes for which they were designed.
   a. They should not be overloaded.
   b. They should be loaded evenly;localized overloads should be avoided.
   c. Dump trucks should not be used to spread loads.
   d. Use baffles in tank trucks.
   e. Avoid excessive fifth-wheel settings.
   f. Do not operate the vehicle on extremely rough terrain.
   g. Take into account the forces that will be placed on a frame from the operation of equipment, such as snow plows, when picking a frame for a new vehicle or reinforcing a frame.
2. Follow recommended practices when repairing a frame or when mounting a body or equipment on a frame.
   a. Avoid sudden changes in the section modulus.
   b. Do not drill holes in the frame rail flanges.

c. Space holes in the web section of a rail at least 25 mm (1 in) from one another.
d. Use existing holes whenever possible.
e. Do not cut holes with a torch.
f. Do not cut notches in the rails
g. Do not overheat the frame rails
h. Avoid welding on the flanges
i. Do not allow more than three holes to exist on the same vertical line of the web.
j. Holes made in a reinforcement should be placed at least 20 mm (0.8 in) from the edge of the reinforcement.

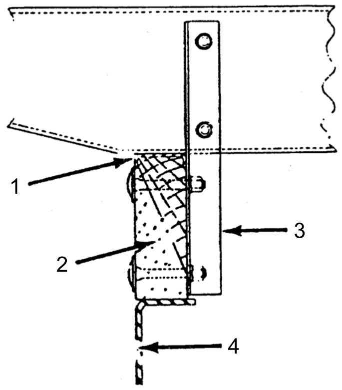
Body Mounts Description

Mounting a platform-type body on the vehicle frame requires several considerations. Construction of the platform will affect the way it can be attached to the frame. The intended use of the platform will determine, in part, how it should be attached to the frame. Concentrations of stress on the frame, resulting from the mounting, must also be considered.

Mounting any structure on the vehicle frame will cause concentrations of stress. Every attempt should be made to keep these concentrations to a minimum. A good way to do this, when mounting a platform body, is to mount it on longitudinal sills as described later in this section. This avoids heating the frame, welding on it, or drilling additional holes in it.

Platform bodies without longitudinal sills should, if possible, have them added to allow longitudinal sill mounting. Sills can be constructed of dry hardwood They are then attached to either wood or metal cross sills by means of angle irons and bolts.

In some cases, longitudinal sill mounting may not be possible. Other mounting methods are discussed briefly, later in this section. It must be stressed, however, that if the recommended procedure is not followed, the strains of load and chassis movement may not be distributed correctly. This could result in damage to the body and/or frame. The only recommended procedure is longitudinal sill mounting.



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Legend

1. Sill Channel
2. Longitudinal Sill
3. Angle Iron
4. Chassis Frame Side Rail

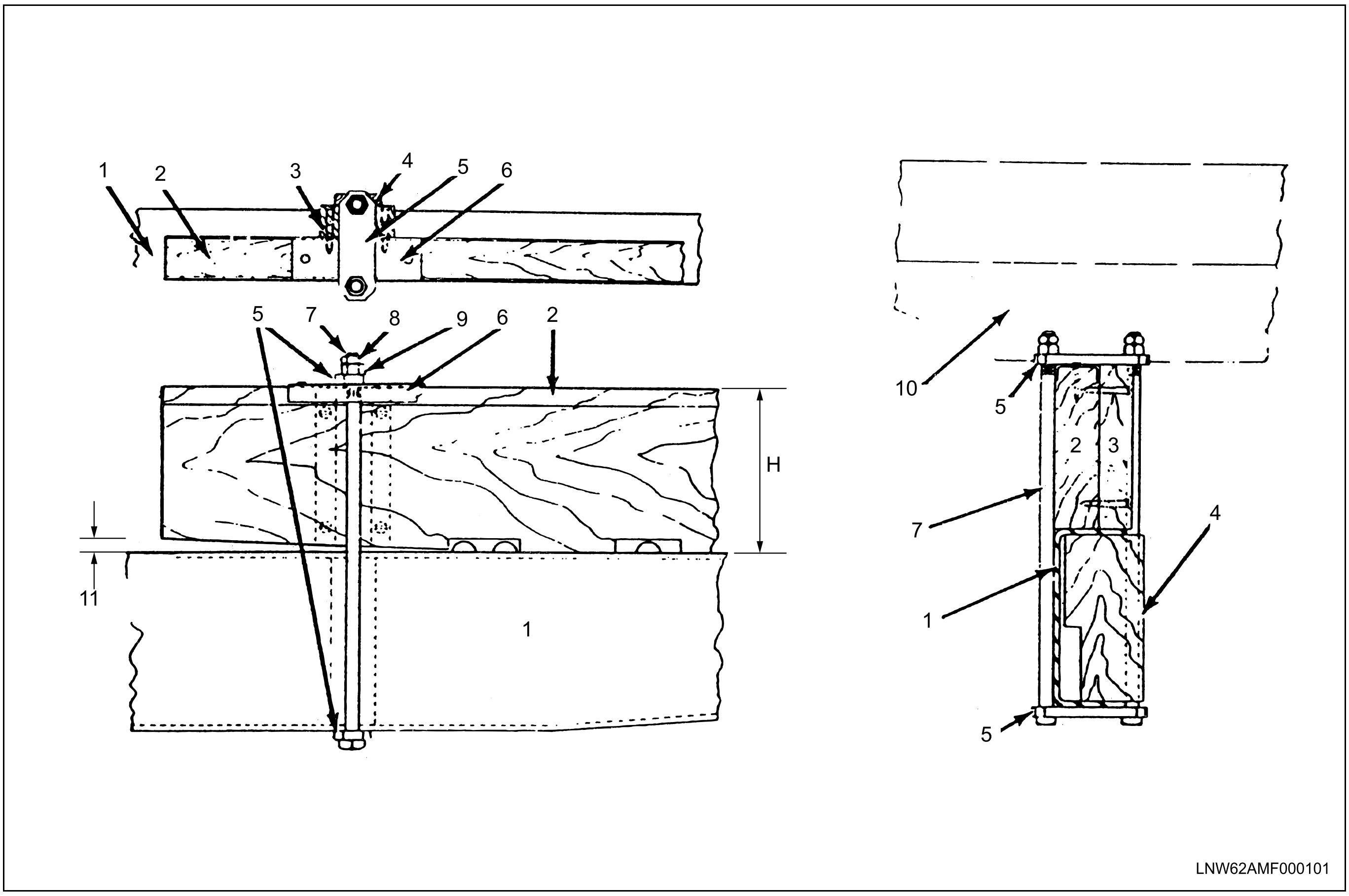
Longitudinal Sill Mounting

Longitudinal sills are on the underside of a platform body and extend from the front edge of the platform to the rear edge. Normally there are two. They are spaced at a distance equal to the width between the frame rails of the vehicle. One sill rests on top of each rail. Ideally, the entire edge of the sill is in contact with the top surface of the rail flange.

Clip plates and bolts hold the sill on top of the rail. The bolts are perpendicular to the sill and frame, but are to the outside of -rather than through- them. A clip plate above the sill and one below the rail hold the bolts in place.

Sill Considerations

The following points concerning sills should be kept in mind.



Legend

1. Frame Side Rail
2. Longitudinal Sill
3. Spacer Block
4. Wood Filler Block
5. Clip Plate
6. Metal Channel
7. Mounting Bolt
8. Nut
9. Prevailing Torque Nut
10. Cross Sill
11. Chamfer Sill-5 mm (0.2 in)

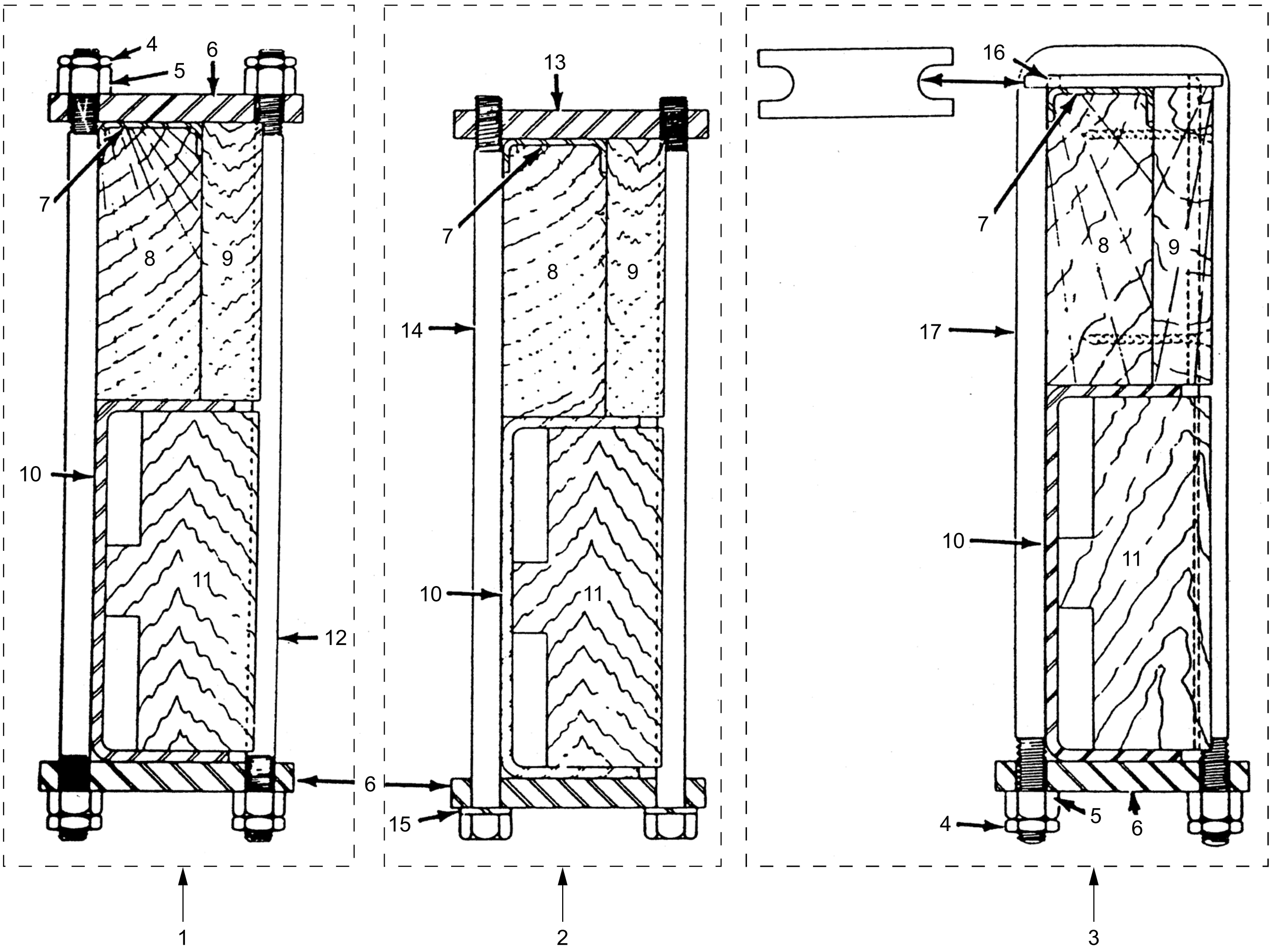
---

1. The height of the sill should be sufficient to prevent the body from striking the tires or other parts of the chassis, with maximum spring deflection. (Take into consideration a full-load operation over extremely rough terrain.)
2. Sills should extend as close as possible to the back of the cab without interfering with the mounting or movement of the cab.
3. Sills should rest squarely on the top flange of the side rails.(If rivet heads prevent a solid bearing of wood sills, countersink the sills just enough to clear the rivet heads. DO NOT USE SPACERS to raise the sills above the rivet heads. If the longitudinal sills are metal, it will be necessary to use a full-length hardwood strip between the sill and rail. Countersink the hardwood strip to clear the rivet heads.

4. Wood sills should be chamfered 5 mm (0.2 in) at the front end. The chamfer should be tapered to meet the frame H/2 to H cm from the end of the sill.
5. Sills may be as wide as the rail flange, but not wider. If sills are narrower than the rail, spacer blocks should be attached to the sill at each point where the sill is held to the rail. These blocks should extend over the edge of the rail. Grooves should be cut in the side of the block to provide clearance for the mounting bolts. The grooves help hold the bolts in place. The blocks should be attached to the sill with screw. The grain of the block should be perpendicular (up and down) to the grain of the sill.
6. Install a sheet metal channel on top of the sill at each point where it will be held to the rail. This is to prevent the clip plate from becoming sunk in the sill. The channel should be a minimum of 4.5 mm sheet metal. The sill should be cut away slightly to provide room for the channel and to allow it to sit flush with the side of the sill.

Point of Attachment

The following rules, concerning each point where the sill is held to the frame, should be kept in mind:



Legend

1. Stud Type Mounting
2. Tapped Plate Type Mounting
3. U-Bolt Type Mounting
4. Jam Nut
5. Nut
6. Clip Plate (not tapped)
7. Metal Channel
8. Longitudinal Sill
9. Spacer Block
10. Frame Side Rail
11. Wood Filler Block
12. Mounting Stud

13. Clip Plate (Tapped)
14. Mounting Bolt
15. Helical Spring Washer
16. U-Bolt Clip
17. U-Bolt

---

1. Each sill should be held to the rail in at least three places. The points of attachment should be spaced, as nearly as possible, the same distance apart.
2. Two hex-head bolts should be used at each point of attachment.
3. Use two nuts on the end of each bolt. Tighten the inner nut firmly; then tighten the outer nut firmly against the inner nut. Do not use a single nut and a helical-spring washer.
4. Bolts should be 13 mm (1/2 in) in diameter.
5. The clip plates above the frame should be of a thickness equal to the diameter of the bolts being used.
6. If the design of the body does not permit the use of bolts and clip plates, a tapped plate can be used instead of a clip plate. Studs would then be used in place of the bolts.
7. U-bolts can be used in place of the bolts or studs, although bolts or studs are preferred.
   If U-bolts are used, they must be the "flatted" type. They should be positioned with the threaded ends of the bolts pointing down. A spreader must be used at the top to increase the bearing surface and provide relief from the corner radii of the bolt.
8. Use a wood block "filler" in the frame channel between the two bolts, studs, or ends of each U-bolt. The block should be long enough to extend beyond the edges of the clip plate and wide enough to overhang the rail flange. Cut grooves on the inside edge of these blocks to provide clearance and a "seating," for the mounting bolts.(It may be necessary to cut the corners off these blocks to avoid interfering with wires, etc., on the rail.)

Other Types of Mountings Description

The recommended mounting for platform bodies on these vehicles is the longitudinal sill mounting described previously in this section. Other types of mountings are possible. However, care must be taken to avoid concentrations of stress that will damage the body and/or frame. A few other methods are described below:

Fish Plate Attachment
A fish plate is welded to the sub frame of the body and bolted to the vehicle frame. This is durable and versatile but usually requires drilling holes in the frame rails. Refer to Reinforcements previously outlined in this section for more information on fish plate attachments.

Clamping Devices
These require less installation time and are, therefore, relatively inexpensive. They also eliminate the need for additional holes in the frame of the vehicle. Since they depend on friction and a maintained clamping force, a bolted connection should be used for safety.

Cross-Sill
This is generally not recommended. The platform tends to ride lower to the wheels than if longitudinal-sill mounting is used. The weight of a load will be concentrated in a relatively small area (the points of intersection of the sills), and frame plates and nuts protrude above the floor of the body. If this type of mounting is still selected, follow the suggestions under "Points of Attachment," previously outlined in this section. Note that the clip plates will be on a diagonal through the intersection of sill and frame rail rather than perpendicular to them.

Guidelines

1. Avoid welding the body to the frame. (Welds are rigid whereas frames must have some flexibility.)
2. If the mounting requires holes in the frame, try to use existing holes.
3. Do not drill holes in the flanges.
4. If holes must be drilled in the web section of a rail, they should be located as closely as possible to the neutral axis of the web. (This is halfway between the rail flanges.)
5. Be sure drills are properly ground if new holes must be made.

Refer to Reinforcements and Minimizing Frame Failures outlined previously in this section for other guidelines when drilling, welding and bolting.

Diagnostic Information and Procedures

Sag

POSSIBLE CAUSE	CORRECTION
1. Loads greater than the frame is designed to carry. 2. Uneven load distribution. 3. Abrupt changes in section modulus. (For a brief definition of section modulus, Refer to the Description at the beginning of this section.) 4. Excessive fifth-wheel settings. 5. Improper body, or accessory, mounting: • Holes drilled in the flange of the frame rail. • Too many holes in the web section of the rail. • Holes in the web section that are too close to each other. • Four or more holes in the same vertical line of the rail web. • Welds on the flange, particularly across the flange or along its edge. • Not using filler blocks in the channel of the rails when a body (or special equipment) has been mounted with the use of U-bolts. • Cutting holes in the rail with a torch • Cutting notches anywhere on the rails. 6. A fire involving the vehicle. 7. A collision involving the vehicle. 8. The use of equipment for which the frame has not been designed or reinforced.	1-8. Straighten and reinforce the frame as described later in this section. Refer to Straightening Frames and Reinforcements.

Buckle

POSSIBLE CAUSE	CORRECTION
1. Operating a dump truck with the box raised to spread loads. 2. The use of equipment such as snow plows for which the frame was not designed. 3. The surging of liquids in a tank truck. 4. A collision involving the vehicle. 5. A fire involving the vehicle. 6. In addition to these causes, refer to the possible causes 3 and 5 under Sag. These may contribute to Buckle.	1-6. Straighten and reinforce the frame as described later in this section. Refer to Straightening Frames and Reinforcements.

Sidesway

POSSIBLE CAUSE	CORRECTION
1. A collision involving the vehicle. 2. A fire involving the vehicle. 3. The use of equipment such as snow plows for which the frame was neither designed nor properly reinforced. 4. In addition to these causes, refer to possible causes 3 and 5 under Sag. These may be contributing factors.	1-4. Straighten and reinforce the frame as described later in this section. Refer to Straightening Frames and Reinforcements.

Diamond

POSSIBLE CAUSE	CORRECTION
1. A collision involving the vehicle. 2. Towing another vehicle with a chain attached to one corner of the frame.	1-2. Straighten and reinforce the frame as described later in this section. Refer to Straightening Frames and Reinforcements.

Twist

POSSIBLE CAUSE	CORRECTION
1. An accident or collision involving the vehicle. 2. Operating the vehicle on very rough terrain.	1-2. Straighten and reinforce the frame as described later in this section. Refer to Straightening Frames and Reinforcements.

Improper Tracking

POSSIBLE CAUSE	CORRECTION
1. Frame is out of alignment.	1. Straighten and reinforce the frame as described later in this section.
2. Front or rear axle has shifted.	2. Realign and secure the axle.
3. Incorrect wheel alignment may make the vehicle appear to be tracking incorrectly.	3. Align the wheels. Refer to Front End Alignment of this manual.

Cracks in the Web of the Rails

POSSIBLE CAUSE	CORRECTION
1. Loose cross-member attaching bolts.	1. Straighten and reinforce the rail. Ream bolt holes and replace with larger bolts if necessary. Retighten bolts.
2. Concentration of stress that may result from many different factors (Refer to Sag under Diagnosis previously described in this chart. Also refer to Minimizing Frame Failures and Reinforcements).	2. Replace, or weld and reinforce the rail. Refer to the appropriate heading.

Repair Instructions

Checking Frame Alignment

Types of frame misalignment can be divided into five groups. The five groups are sag, buckle, diamond, sidesway, and twist. For a brief definition of these terms, refer to Description at the beginning of this section.

A misaligned frame rail may have moved forward from, up or down from, or to the side of where it should be. These causes must all be checked.

The easiest way to check frame alignment is with gauges made for this purpose. Detailed instructions are normally supplied with gauges at the time of purchase. Therefore, instructions for gauge use are not given in this manual.

It is possible to check frame alignment without the proper gauges. The procedure is described later in this section.

Whether alignment is checked with or without gauges, the vehicle must be parked on a level section of floor.

Certain conditions call for preliminary checks before actually checking the frame. Suspension or axle problems may make it appear that the vehicle frame is out of alignment.

If an axle has shifted, Diamond or Sidesway may appear to exist when, in fact, they do not. A weak spring may make the vehicle appear to have a twisted frame.

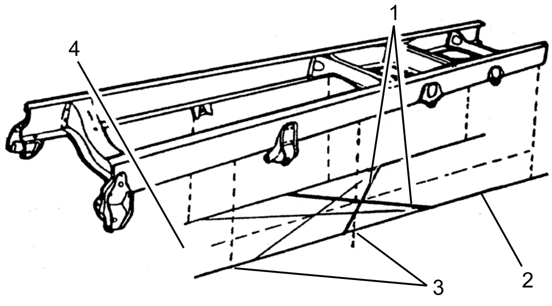
A visual inspection of the top and bottom flanges of each rail may reveal the area where sag or buckle exists. In the case of sag, wrinkles may appear on the top of the upper flange; such wrinkles are definite evidence of sag. Wrinkles on the bottom of the lower flange are definite evidence of buckle.

Checking Alignment Without Gauges

1. Move the vehicle to a level, well-lighted section of floor.
2. Make a diagram of the frame on the floor beneath the vehicle. Do this as follows:
   a. Pick several points on the bottom flange of each frame rail. There should be clear access from these points to the floor. Mark one point at the rear end of each rail. All points should be the same distance from the vertical part (web) of the rail.
   b. Use a plumb bob to transfer the points on the rail to the floor directly beneath them.
   c. Move the vehicle away from the points on the floor.
   d. Use a chalk line to mark a line through the points representing each rail. If the rail is straight and the points are carefully marked, the line should be very close (within 3 mm [1/8 in] to each point). A point or points more than 3 mm (1/8 in) from the line indicates sidesway.

If the rear sections of the rails are straight and there is 85 cm (33.5 in) between the web at the end point of one rail and that of the other rail, consider the rails to be in alignment so far.

3. Check the length of each rail line. They should be the same length.
4. Check the width at the front and rear of the vehicle. The normal widths, by model, are given in the Specifications at the end of this section.
5. Pick a point on one rail line, a given distance from one end of the rail. Mark the point. Mark a point at the same spot on the other rail line.
6. From the two points chosen, mark a diagonal to the opposite rail. Make the diagonals the same length.
7. From the original two points, mark a second pair of diagonals to the opposite rails. These diagonals should be the same length as one another, but longer than the first pair.



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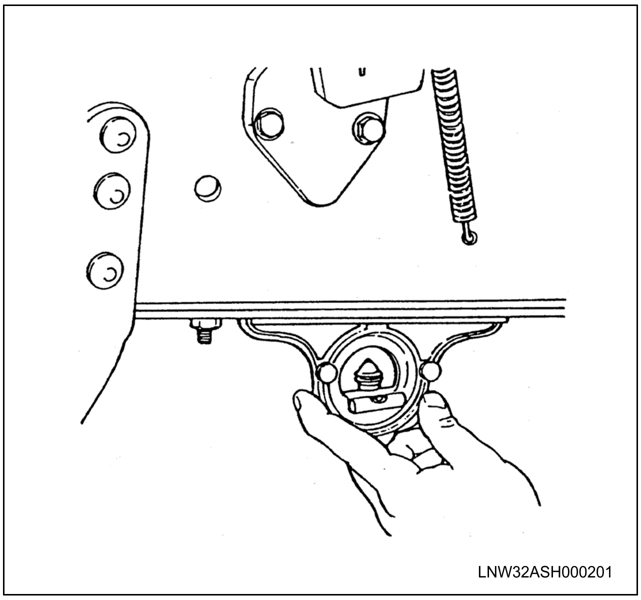
Legend

1. Diagonals of Equal Length from Corresponding Points
2. Line Representing Left-Hand Rail
3. Points on Floor Determined by using a Plumb Bob
4. Centerline

8. Mark a line between the points of intersection of the two pairs of diagonals. If no "diamond" exists, this line should be the same distance from each frame rail at all points along its length.
9. Use a bubble protractor to measure the slope of each rail at different points along its length. The actual slope of the rails is not important but the slope of the two rails should be the same. When using a bubble protractor to measure the slope of a rail, keep the following points in mind:

a. Tires must all be the same size to get a meaningful reading.
b. Tires must all be equally inflated.
c. A weak spring will result in a false reading.



10. An alternative method of checking the vertical alignment of a normally straight rail (step 9) is as follows:
    a. Measure the distance from the rail to the floor at different points along the rail. (The vehicle must be on level section of floor.)
    b. Transfer these distances, in order, to a sheet of graph paper.
    c. Connect the points on the graph paper that represent each distance.
    d. If the rail is straight (vertically) the points should all lie on a straight line.

Straightening Frames

Frame straightening can be complicated, and usually requires special equipment. It should be attempted by competent personnel only.

A complete analysis of the condition of the frame should be made before any steps are taken to straighten it. Analyzing the cause of failure will help determine the correct sequence of steps in the repair. (Refer to Possible Causes under Diagnosis and Minimizing Frame Failure previously outlined in this section.) It is essential that the frame material be identified before any work is done on it. Frame rails of vehicles covered in this manual are J 1392-050 steel.

Corrective procedures should be set up to reverse the flow of the damaging forces. In many instances, to reverse the flow of forces, pressure must be applied from different directions at the same time.

Careful use of controlled heat is important. Too much or too little heat, or the improper application of heat, is a major source of trouble. Frame heating should be done with a large-sized tip (multi-hole heating tip) and a neutral flame should be used (oxygen adjust opened just enough to remove the feathers or stringers from the blue center at tip of torch). Heat the area that will be stretched as frame is straightened. Heat the area AFTER SUFFICIENT PRESSURE HAS BEEN EXERTED to cause a slight checking, or silvery cracks, to appear on the surface of the metal. Gradually increase the pressure while heating. Do not heat beyond 600°C (1200°F). A red glow indicates that the material is overheated. Overheating will cause distortion and stretching, and will change the characteristics of the metal.

Reinforcements

Reinforcements are used to increase the frame strength. They do this by increasing the section modulus of the area reinforced. (For a brief definition of section modulus, refer to the Description at the beginning of this section.) Besides increasing frame strength, reinforcements make the frame less flexible. This must be considered when reinforcing a frame. Too stiff a frame can fail. An effective reinforcement must compensate for factors which caused the original damage but not introduce new factors which produce concentrations of stress.

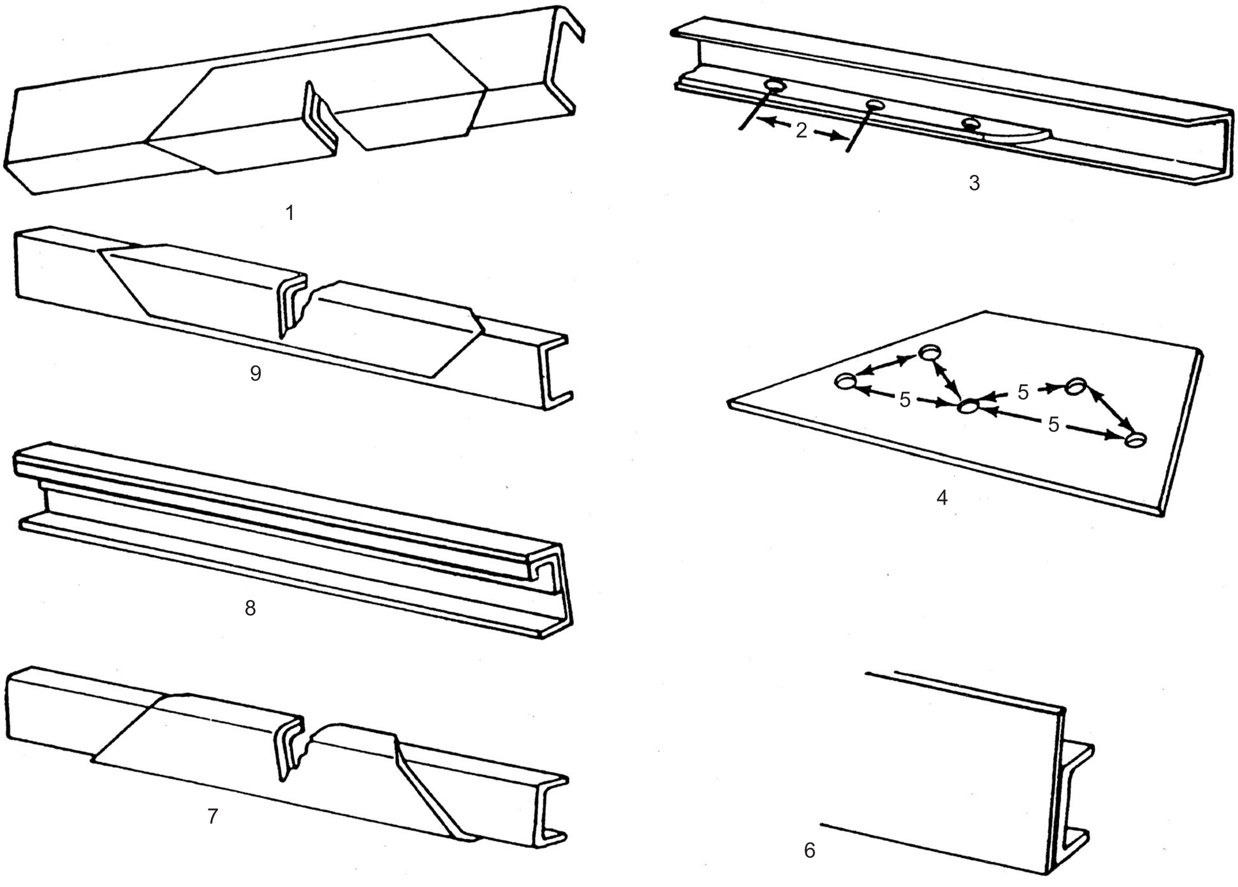
On new vehicles, the strength needed in the frame may be provided with reinforced rails rather than with heavier, one-piece rails. If the wheelbase is long, the unsupported span between the axles may be too great, and reinforcements should be added.

It is not possible to specify the type or length of reinforcements for every situation. Each case must be studied individually. However, several general guidelines should be kept in mind. Care must be taken to avoid abrupt changes in section modulus. This requires reinforcements to be tapered. It also requires certain practices when welding, drilling holes, and using bolts. These are covered later in this section.

A further guideline is that of dissimilar metals. Metals may vary in type and strength. A reinforcement should have as high a strength as the frame it is reinforcing. Refer to the Specifications for yield strengths of different materials.

Types

There are seven types of reinforcements. These reinforcements can be combined in different ways to meet especially heavy demands or the needs of special situations. Refer to the Marking Reinforcements for some reinforcement practices. Reinforcements labeled "wrong" would result in too abrupt a change in section modulus.



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Legend

1. Upright "L" Reinforcement
2. 150 to 200 mm (6 to 8 in)
3. Strap Reinforcement
4. Fish Plate Reinforcement
5. 200 to 250 mm (8 to 10 in)
6. Web Reinforcement
7. Channel Reinforcement
8. Inverted "J" Reinforcement
9. Inverted "L" Reinforcement

Upright "L" Reinforcement

May be used on either the inside or outside of the frame rail. It should be used where maximum stress occurs on the bottom of the lower flange.

Inverted "L" Reinforcement

May be used on either the inside or the outside of the frame rail. It should be used where maximum stress occurs on the upper flange. It can also be used where the frame or hanger bracket design does not allow the use of an upright "L" reinforcement.

Inverted "J" Reinforcement

This is attached to the web section only, on the inside of the rail channel. It is designed to prevent flange buckling due to high torsional inputs or shock loading during tractor hookup operations.

Channel Reinforcement

May be used on the inside or outside of the frame rail.
It reinforces both flanges and the rail web.

Strap Reinforcements

These are used on the rail flange on the inside of channel.
They should be plug-welded at 150 to 200 mm (6 to 8 in) intervals. Do not weld across the end or along the edges of the reinforcement.

Fish Plate Reinforcement

These are used on the outside of the rail web.
They may extend above or below the rail. They stiffen the frame.

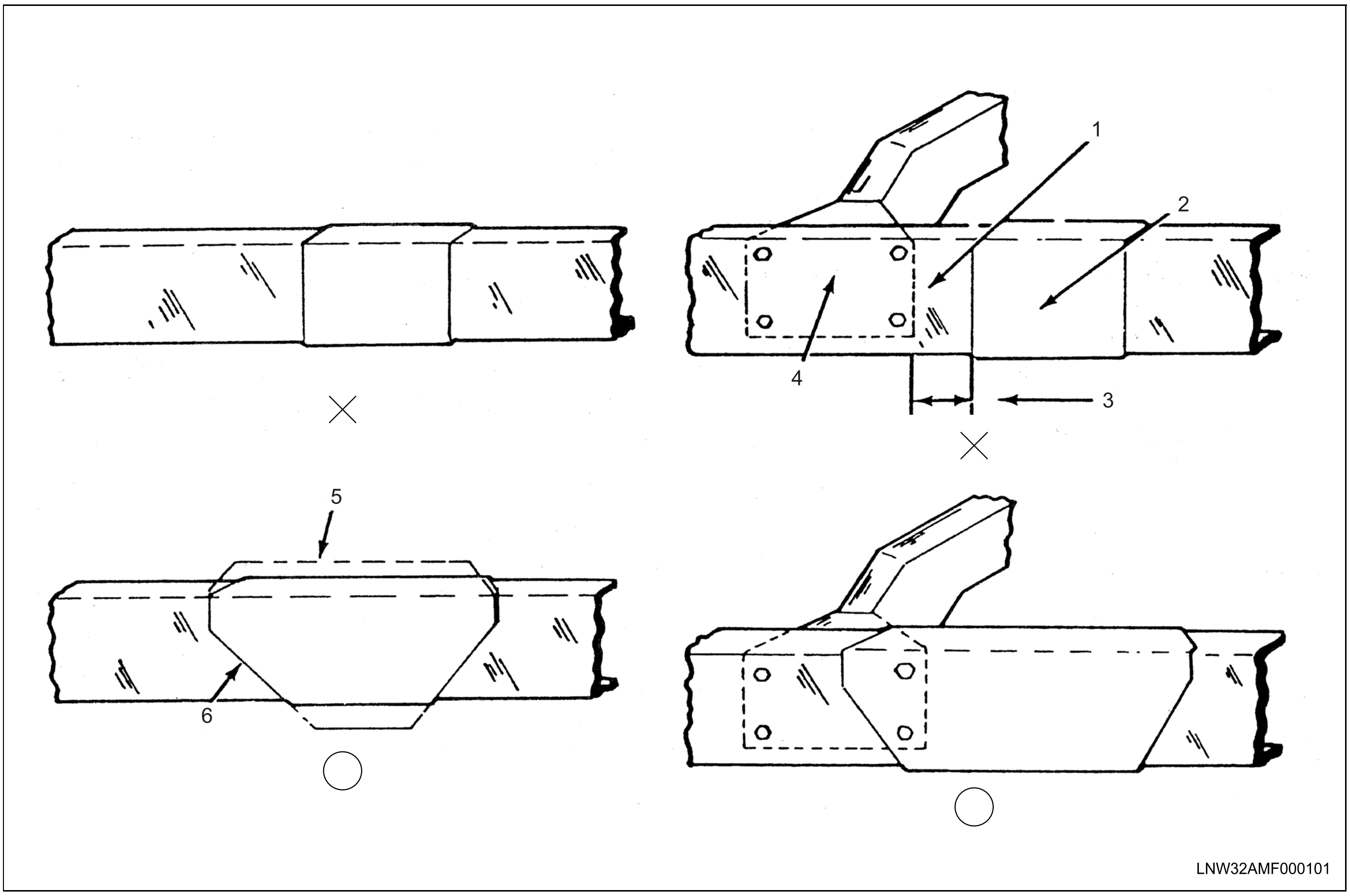
Web reinforcement

These are used on the inside of the rail web. They are plug welded at 150 to 200 mm (6 to 8 in) intervals.

Making Reinforcements

In general, when making a reinforcement of any type, observe the following practices:

1. Taper the reinforcement plates to avoid abrupt changes in section modulus. Angles at the edge of a reinforcement plate should be less than 45 degrees.
2. When reinforcement plates are shaped by use of a cutting torch, all cracks, nicks, and burrs must also be removed from the edges of holes.
3. Avoid gaps caused by reinforcements that stop short of the ends of cross-members, gussets, brackets, etc..
4. Cut reinforcements long enough so that they can be tapered and still extend beyond the critical area.



Legend
1. Original section
2. Reinforced section
3. Section “GAP”
4. Reinforced section
5. Plate before bending
6. 45° or less

Attachment

Use bolts or rivets to attach reinforcements. Bolting is preferred. Avoid attaching the reinforcements by welding. (In some cases, welding may be acceptable. Such cases include the plug weld used on strap or web reinforcements.) Bolt holes that are enlarged or irregularly worn may be reamed to accept the next larger bolt diameter and then used to hold the reinforcement. For critical areas, body-fit bolts with hardened washers can be used. The use of body-fit bolts requires reaming the hole to a nonstandard size to get an interference fit for the bolt. Whenever possible, use existing holes rather than drill new ones.

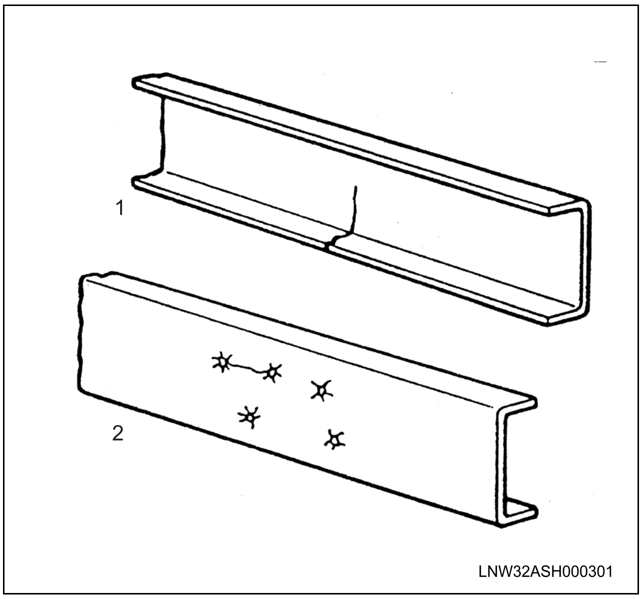
If new holes must be made, use cobalt high-speed drills. (Drills should be sharpened to give 150 degrees included angle with 7 to 15 degrees lip clearance.) If a pilot hole is made, avoid enlarging it in successive stages. Avoid breaking through to full size at the bottom of the hole. (Remove the lip of a hole with a reamer).

In general, when attaching reinforcements, observe the following:

1. Bolt reinforcements to the frame.
2. Use existing holes if possible.
3. Avoid drilling holes in the frame flange.
4. Holes should be made as close to the neutral axis (halfway between the flanges) as possible.
5. Bolt holes should be no larger than those already existing in the frame such as for spring bracket bolts.
6. No more than three holes should be on a vertical line of the web.
7. Holes should be at least 25 mm (1 in) apart.
8. Holes in a reinforcement plate should be at least two times the material thickness from the edge of the plate.

Repairing Cracks

There are two common types of cracks. The straight crack will normally start from the edge of a flange. It will go across the flange and through the web section of a rail. Finally, it will continue through the other flange. This type of stress, in small areas of the frame, can be caused by excessive bending movement, and torsional loading. (Refer to Minimizing Frame Failures, previously outlined in this section.)



Legend

1. Straight Crack
2. Sunburst Cracks

Sunburst crack(s) will radiate from a hole in the web section of a rail or cross-member. They are caused by high loads being applied at a mounting bracket or cross-member which is not securely or properly attached to the rail.

If cracks occur to both the rail and reinforcement at a particular area of the frame, they must be repaired separately. The flanges must react independently to prevent localized stress concentration. Use a copper spacer between cracked base rail flanges and reinforcement flanges.

Cross-member mounting flange cracks may be repaired in the same manner as side rail cracks.

However, the weld bead should be built up to provide a good, smooth radius. If a cross-member is greatly damaged, it should be replaced.

It may be necessary to align the frame and level the rails before repairing the frame.

The following procedure should be used to repair cracks in a rail, reinforcement or cross-member:

1. Remove any equipment that will interfere with access to the crack.
2. Locate the extreme end of the crack and drill a 6 mm (1/4 in) hole.

3. Vee-grind the entire length of the crack from the starting point to the 6 mm (1/4 in) hole at the extreme end. The angle of the "V" will depend on the welding process used. Refer to the "Specifications" at the end of this section, for the correct angle.
4. The bottom of the crack should be opened up 2 mm (1/16 in) to allow good penetration of the weld. (A hacksaw blade may be used for this.)
5. Weld with the proper electrode and proper welding techniques. Refer to the "Welding" outlined later in this section for tips on welding. Refer to the "Specifications" at the end of this section for the proper electrode.
6. Grind the weld smooth on both the inside and the outside of the rail or cross-member. Be extremely careful to eliminate weld buildup or notches on the edge of the flange.

Welding

Improper welding techniques are the cause of many weld and/or frame failures. The following information points out potential areas of difficulty and provides some general guidelines for successful frame welding.

Most weld failures occur at the end of the weld in areas of the frame that are under high stress. By properly finishing the ends of a weld, failures can be reduced; this can be done by making a hole or slot in the part to be attached, and then using a fillet weld around a slot or plug weld. Do not leave a notch at the end of a weld. For a guide to the diameter and depth of plug welds by thickness of material welded, refer to the Specifications. In most cases, less welding, lower cost, and a more successful weld will result.

Over-welding can also be harmful, especially if it in an area of the frame that receives high concentrations of stress.

When Welding:

1. Do not use oxyacetylene welding equipment.
2. Be sure to use the correct electrode. Refer to the Specifications for the electrodes that can be used on frames.
3. Whenever possible, use small diameter electrodes and make several passes; this is preferred to using large diameter electrodes and making fewer passes.
4. Do not use more heat than is necessary to give good penetration.
5. Do not run more passes than necessary.
6. Be sure the weld is free from craters and undercuts.
7. Be sure slag is removed before each successive pass.
8. When repairing a crack, grind the surface of the weld flush with the parent material.
9. When mounting accessories, do not weld across the flanges.
10. When mounting accessories, do not weld within 19 mm (3/4 in) of a flange.
11. Do not weld up to the edge of a part being welded to a frame. Leave 6 mm (1/4 in) between the end of the weld and the edge of the part.
12. Do not weld cast brackets to the frame.
13. Do not weld the flanges of cracked reinforcements and base rails together.
14. Connect the welding machine ground cables as close to the working area as possible.
15. Avoid unnecessary contact between the welding cables and any part of the vehicle.
16. Do not attach the welding cables near the vehicle wiring.

Cross-member

Removal Procedure

1. Disconnect the wires, cables, and/or lines near the cross-member.
2. Remove the brackets, valves, or other components near the cross-member.
3. Remove the cross-member bolts or rivets.
4. Remove the cross-member.

Installation Procedure

1. Install the cross-member to the frame rails.
2. Install the bolts and rivets.
3. Install the brackets, valve, or other components.
4. Connect the wires, cables, and/or lines.

Specifications

Widths Between The Web of Frame Rails

At Front End of Rails	82 cm (32.3 in) (Inside to Inside)
At Rear End of Rails	75 cm (29.5 in) (Inside to Inside)

Yield Strength of Different Metal

SAE J-1392-050	344,750 kPa (50,000 psi)
SAE 1010	137,900 kPa (20,000 psi)
SAE 1020	206,850 kPa (30,000 psi)
SAE 1023	248,220 kPa (36,000 psi)

Welding Chart

Materials To be Welded		SAE J-1392-050 SAE 1010 SAE 1020 SAE 1023
PROCESS	GMAW	SMAW
Electrode	E70S-3	E7011 E7016 E7018
Minimum Yield of Electrode	413,700 kPa (60,000 psi)	413,700 kPa (60,000 psi)
Chamfer used when cutting away the sides of a crack to be welded.	60°	90°

Electrode Chart

Electrodes
E-7011 # E-7016 # E-7018 # E-11018

Available Sizes					Flat Welding	
MM	IN	X	MM	IN	Current Range	Arc Voltage
1.984	0.078	x	229	9	30-60	20-22
2.381	0.094	x	305	12	45-80	21-23
3.175	0.125	x	356	14	80-115	21-23
3.969	0.156	x	356	14	125-165	22-24
4.763	0.188	x	356	14	160-200	22-24
5.556	0.219	x	457	18	200-250	22-24
6.350	0.250	x	457	18	250-320	23-25
7.938	0.313	x	457	18	320-400	24-28

Available Sizes					Overhead Welding	
MM	IN	X	MM	IN	Current Range	Arc Voltage
2.381	0.094	x	305	12	45-75	20-22
3.175	0.125	x	203	8	80-125	20-24
3.969	0.156	x	356	14	120-190	21-24
4.763	0.188	x	356	14	150-240	21-24

Plug Weld Chart

Thickness of Material		Diameter of Plug		Depth of Plug	
MM	IN	MM	IN	MM	IN
6	1/4	19	3/4	6	1/4
9	3/8	25	1	9	3/8
13	1/2	28	1-1/8	11	7/16
16	5/8	31	1-1/4	13	1/2
19	3/4	34	1-3/8	14	9/16
25	1	38	1-1/2	14	9/16

BODY, CAB, AND ACCESSORIES

Cab Maintenance

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Description and Operation

Interior Maintenance Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Care and Cleaning of The Interior

Care of the interior is a fairly simple but important matter. A buildup of dirt mars the appearance of the interior. It can also turn into a hard, gritty substance that will cut into the surface of seats, trim panels, dash pad, floor mats, etc.

Be sure the vehicle is well ventilated while using cleaning agents. Follow the manufacturer's directions when using such products. To avoid possible permanent discoloration of light colored seats or door trim, DO NOT allow materials with unstable dyes (colored denims, corduroys, leathers, suedes, decorative paper, etc,) to come in contact with the trim materials.

With materials made of synthetic plastics and/or man made fibers, it is EXTREMELY IMPORTANT to use proper cleaning methods and cleaners. Failure to do this on the first cleaning may result in water spots, spot rings, or setting of stains.

Dust and loose dirt should be removed often with a vacuum cleaner, wispy broom or soft brush. Vinyl trim should be wiped regularly with a clean damp cloth.

NEVER use gasoline, nail polish remover or acetone lacquer thinners, bleaches, etc. Some basic points should be followed when cleaning.

1. Remove stains as quickly as possible before they become "set."
2. Use a clean cloth or sponge and change to a clean area frequently. (A soft brush may be used it stains persist.)
3. Use solvent-type cleaners in a well ventilated area. Do not saturate the stained area with solvent.
4. If a ring should form after spot cleaning, the entire area of the trim assembly should be cleaned immediately.
5. The cleaning action should be from the outside of the stain, feathering in toward the center of the stain.
6. When using commercial cleaners, follow the instructions provided with them.

Some types of stains or soilage such as lipstick, some inks, certain types of grease, etc., are very difficult and, in some cases, impossible to completely remove. When cleaning this type of stain or soilage, care must be taken not to enlarge the soiled area. It is sometimes more desirable to have a small stain than an enlarged stain as a result of careless cleaning.

Caution:
Some cleaners may be poisonous or flammable, and their improper use may cause personal injury or damage the inside of the vehicle. Therefore, when cleaning the inside of the vehicle, do not use volatile cleaning solvents such as: acetone, lacquer thinners, enamel reducers, nail polish removers; or such cleaning materials as laundry soaps, bleaches or reducing agents, except as noted in the fabric cleaning advice on stain removal which follows. Never use carbon tetrachloride, gasoline, benzene, or naphtha for any cleaning purpose.

Over exposure to these vapors may result in a health problem. This is even more likely to occur in small, unventilated spaces. It is recommended that all vehicle doors be opened for ventilation when any cleaning agents or other chemicals are used in the interior. Approved respiratory protection equipment may be needed. Follow the manufacturer's advice whenever cleaning agents or other chemicals are used, inside or outside the vehicle.

Seats/The Covering of Noise Insulation/Sun Visors/Dash Pad

These items are vinyl. They can normally be cleaned with lukewarm water and a mild soap or liquid household detergent. A saddle or oil soap can also be used. For difficult to remove stains, use a cleaner especially made for use on vinyl. Do not use furniture polishes, oils, varnishes or ammonia.

When cleaning with a mild soap or household detergent.

1. Work up a thin suds on a piece of cheesecloth and apply it to the soiled area.
2. Allow the suds to soak for a few minutes.
3. Rub briskly with a clean, damp area of the cloth.
4. Remove any remaining suds and dirt residue with a clean, damp section of cloth
5. Finish by wiping lightly with a dry, soft cloth.

When cleaning with a vinyl cleaner, follow the directions of the manufacturer.

Floor Mats

Floor mats are rubber. Use any household soap and hot water for cleaning. Stiff brushes can be used. Rinse with clean water.

Door Trim Panels/Steering Wheel

These parts of the vehicle are plastic. They should be cleaned with a mild soap or liquid household detergent and lukewarm water. See the procedure outlined previously under Seats/The Covering of Noise Insulation/Sun Visors/Dash Pad. Stubborn stains can be removed with a multipurpose powdered cleaner. Follow the directions of the manufacturer.

Painted Steel Surfaces

These surfaces can be cleaned with a mild soap or household detergent and lukewarm water. Use the procedure outlined previously under "Seats/The Covering of Noise Insulation/Sun Visors/Dash Pad" in this section.

Lap Belts

Use a mild soap or liquid household detergent and lukewarm water. Follow the procedure outlined previously in this section under "Seats/The Covering of Noise Insulation/Sun Visors/Dash Pad." Do not bleach or dye belts; this may severely weaken them.

Steering Wheel Refinishing

Plastic steering wheels that are not textured or imprinted with a grain can often be refinished if they become nicked or scratched. The following procedure is intended only for the repair of minor damage. Do not attempt to refinish any area of a steering wheel that has a grained surface molded into it.

Refinishing may be accomplished without wheel removal in most cases. It is suggested, however, that the procedure be tried on a discarded wheel before it is done to the wheel of the vehicle.

Any nicks, scratches or other blemishes must be worked out of the wheel to match the contour of the surrounding area. Normally, solvent solution, a cheesecloth, and sandpaper are enough to do the job. Steel wool and a file may prove useful.

Caution:

Be sure procedures are performed in a well ventilated area away from any fire or flame source. Avoid prolonged breathing of solution fumes. When using MEK (methyl ethyl keytone) wear rubber gloves; the solution can be harmful to the skin.

Necessary or Useful Working Materials

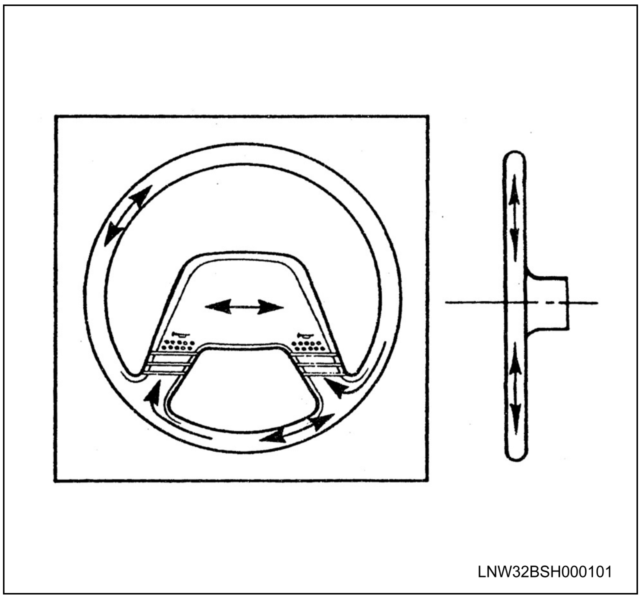
1. Solution of 50 percent MEK and 50 percent alcohol (or a solution of acetone).
2. Bleached, cotton cheesecloth (or white linen).
3. A soft, clean, dry cloth.
4. Fine sandpaper, 300 to 400 fine.
5. Rubber gloves.
6. Fine steel wool, grade 0000 to 000.
7. A small, fine metal file.

Refinishing Procedure

1. Cover vinyl, rubber, or other plastic parts of the vehicle to protect from solvent.
2. Soak the cheesecloth or linen in the solvent; wring out the excess.
3. Rub along the damaged area of the wheel with a quick, continuous motion.
   a. Pressure is important but rubbing too hard will leave a rough surface from the cloth. It is best to make several passes using light pressure.
   b. Lift the cloth from the wheel when stopping; stopping first and then lifting the cloth from the wheel will cause an imprint of the cloth to be left in the plastic.
   c. Follow the lines and contour of the wheel.
   d. Soak and wring out the cloth often to ensure that it is wet but not dripping.
   e. Keep folding the cloth so that the area in contact with the wheel stays clean; it will have a tendency to pick up color from the wheel.
4. Let the wheel dry for several minutes.
5. Buff the wheel lightly with a soft, clean, dry cloth.

Once the wheel has been buffed, do not touch or lay anything against the refinished area for at least 30 minutes; the plastic is soft and can be easily marred.

After the wheel has dried thoroughly, white streaks may appear at the refinished area. These can be removed by rubbing with a clean, dry cloth.



Water Leaks

If water has leaked into the cab, it is possible to test for the leakage points. Spray water under pressure against the cab in the general area where the leak is believed to be located. Have an assistant inside the cab locate, and mark, the point(s) where any water appears.

Water that shows up at a certain place inside the cab may actually be entering the cab at another point. It may be necessary to remove the floor mat, insulation, dash pad, instrument carrier, etc.

Backtrack the path of water to point of entry. If it is still not possible to locate the point of entry, another approach may help:

1. Close all windows and vents.
2. Turn the air conditioner or heater blower motor to "High" position.
3. Place the air lever in position to use outside air.
4. Close the doors.
5. Run a small stream of water over the suspected areas of leakage.
6. Check for pressure bubbles that indicate air is escaping from the cab.

Corrective Measures

Corrective measures depend on the area of leakage. If the leak is around a window held by a weatherstrip, dry the area completely and apply rubber cement both between the glass and the weatherstrip, and the body and weatherstrip. If this does not work, it may be necessary to remove the window and check the weatherstrip. If the weatherstrip is damaged, it should be replaced. Check the flange that held the weatherstrip for any nicks or burrs that may have caused the damage.

If the leak is around a door, it may be because the door is not properly aligned. Realign the door as described in Steel Tilt Cab of this manual. If the door is contacting the weatherstrip correctly, be sure the weatherstrip is seated on the flange of the opening and that it is not damaged. If the weatherstrip is not properly seated, rubber cement can be used to hold It in place. If the weatherstrip is damaged, it may be necessary to replace it.

If the leak is between body panels, use an air drying body sealing compound.

Dust Leaks

It is possible that dust will leak into a cab where water will not, particularly in the lower portion of the cab. Forward motion of the vehicle can create a slight vacuum which pulls air and dust into the cab.

To determine the location of dust leaks:

1. Remove the mats and insulation from the floor and toe panel.
2. Drive the vehicle on a dusty road.
3. Examine the interior of the cab; dust in the shape of a small cone or silt will usually be found at the point of leakage.
4. Mark the points of leakage
5. With cab in an otherwise dark area, shine bright lights on the underside of floor and cowl. While doing this, have an assistant check inside the cab for any points where the light shines through. Mark the points of leakage. Check weld joints and cab mounting areas closely. Sealing of leaks should be done with an air drying body sealing compound.

Exterior Maintenance Description

Exterior Maintenance Description

Panels are welded together by spot and/or continuous welds.

The entire cab is an integrally welded structure. Repairs should be made by competent technicians using proper tools and equipment.

Major cab panels should be regularly checked for damage. Note the condition of the paint and check for corrosion. Give particular attention to chrome.

Checks should be made more often in freezing weather due to the corrosive effect of road deicing materials (salt, calcium chloride, etc.) on metals. Broken welds, punctures, chipped paint, etc. should be repaired. If checks reveal corrosion, paint failure, or bare metal, measures outlined in "Painting Sheet Metal" (later in this section) should be taken as soon as possible. Punctures should be repaired as outlined under "Splits and Holes (also, later in this section.)

Cab Repairs

Cab repairs may require reinforcements. Before reinforcing any part of the vehicle, find the cause of the failure. Cab panels and framing are integral; therefore, driving stresses and strains are transmitted throughout the cab. Reinforcing a point of apparent failure without correcting the underlying cause of the failure may transfer the stress to other parts not engineered for stress, with the result that new failures develop.

To maintain proper body strength, replace the damaged panels or other structural parts with new ones from the factory.

Any parts used that are not steel, but will contact a steel part, including bolts, washers, nuts or rivets, should be coated with paint or plating to prevent corrosive action between the dissimilar metals.

The use of heat when straightening structural parts of body is not recommended since heat will affect the structural characteristics of material. Any parts bent or buckled enough to show strain cracks after straightening should be replaced or properly reinforced.

Cab Panel Replacement

Cab panels can be replaced by removing the damaged part and welding a new piece in. For proper alignment of the panel, clamp it in position before welding.

Any window fence should be spot-welded since it provides a sealing surface.

When replacing a rear panel or a roof panel, give special attention to the proper sealing of joints with sealing and caulking compounds.

Cab Sill Replacement

Remove the damaged sill(s) and smooth the area before installing replacement part(s). The recommended method of installation is plug welding or chain welding.

Splits and Holes

1. Holes of less than 6 mm (1/4 in) diameter in sheet metal panels can be welded and metal finished without backing:
   a. Degrease and mechanically clean the area on the panel(s) with emery or abrasive wheel.
   b. Weld up the hole using E70S-3 filler rod.
   c. If the panel surface is visible, metal finish the area.
2. Holes greater than 6 mm (1/4 in) in diameter but less than 51 mm (2 in) in diameter can be welded by backing the hole with the same material as the parent material.
   a. Degrease and mechanically clean the area on the panels with emery or abrasive wheel.
   b. Weld in a backing plate of the same material as the parent material. Minimum edge overlap at the holes should be 3 mm (1/8 in)* Use E70S-3 filler rod.
   c. If the panel surface is visible, metal finish the area.
3. Cracks in the sheet metal panels that are less than 76 mm (3 in) long and 3 mm (1/8 in) wide can be welded and metal finished without backing.
   a. Degrease and mechanically clean the panels with emery or abrasive wheel.
   b. Establish the start of the crack with dye-penetrant test.
   c. End the split by drilling a hole at the root of the split. The diameter of the hole should be at least one and a half times the metal thickness.
   d. Weld up the crack, using the E70S-3 filler rod.
   e. If the panel is visible, metal finish the area.

Welding

All welding should be done to American Welding Society (AWS) standards.

When welding steel panels of the cab, use TIG, MIG or SMA (stick) welding. If resistance welding equipment is available, it also can be used. Always use good practices as recommended by the AWS.

When welding a cut member, fill or weld the cut completely. Filler material should be of the same material as the parts being welded. Use E70S-3 filler rod.

Cab Alignment and Straightening

Before attempting the repair of a damaged cab, the chassis frame must be checked and, if necessary, aligned. A procedure for checking frame alignment is given in Frame and Body Mounts of this manual.

Never attempt to straighten the cab unless the cab is firmly attached to the chassis. The inner paneling of the cab should be straightened first. A push-pull hydraulic jack together with an extension and adapters is recommended for this type of repair. Crosscheck with an adjustable tram bar as work progresses.

After straightening, it is important that strains, which are set up in the framing, be relieved or "normalized." Normalizing consists of heating the areas of greatest tension with a torch.Hold the torch about 50 mm (2 in) from metal and move it over an area of 75 to 100 mm (3 to 4 in) until the metal barely begins to turn red. Cooling must be slow to avoid changing the characteristics of the metal. Apply slight heat with a torch, if necessary, to slow cooling.

Dinging and Finishing

Paint is quickly scuffed off sharp dents, leaving metal exposed to rusting and corrosion; therefore, damaged panels should be repaired as soon as possible. Repair damaged panels by forcing outward in the direction opposite to the force that caused the damage. In this way, metal strains, set up when the damage occurred, are relieved.

The importance of proper metal finishing, to produce a fairly smooth surface, should not be underestimated. The application of a hammer directly to a panel tends to stretch the metal and cause a great deal of unnecessary work. Whenever possible, a spoon should be used under the hammer when bumping a panel.

Painting Sheet Metal

Repainting

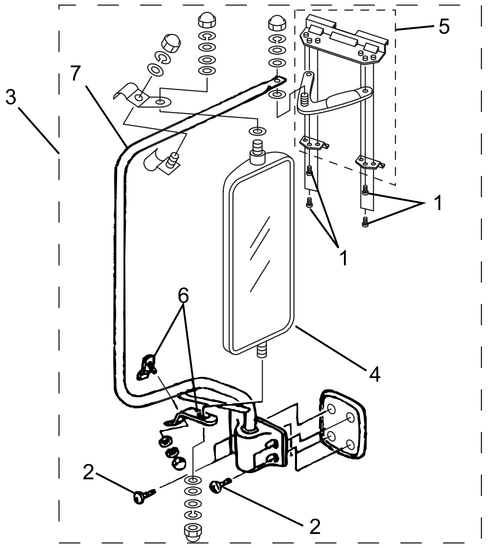
1. Thorough cleaning is necessary. All corrosion, grease, and other foreign matter must be removed. Use of phosphoric base metal conditioners is recommended in preparing steel for painting. These materials vary in method of application and use; they should be used only as directed by the manufacturer. Solvent cleaning, pressure steam cleaning, wire brushing, and hand sanding methods are recommended
2. Completely remove the old paint by use of organic or alkaline solvents. However, if alkaline removers are used, all traces of alkali must be washed off before primer is applied. If the old primer is very difficult to remove, and if there is no evidence of metal corrosion, the old primer may be left in place.
3. Apply primer, preferably by spraying and allow it to dry. Use good oxide primer obtained from a reputable manufacturer.
4. Apply the finish coats.
   a. For the understructure, or other parts not requiring color, apply two coats of good air drying black or other automotive lacquer.
   b. To exposed body parts, apply surfacer and paint in accordance with standard practice.

Painting New Parts

New replacement parts should be thoroughly cleaned and painted, as outlined previously under Repainting. In addition, hidden surfaces of panels should be cleaned and coated with one heavy coat of sheet metal deadener.

Repair Instructions

Outside Rear View Mirror



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Legend

1. Sash Holder Screws
2. Stay to Spacer Screws
3. Outside Rear View Mirror Assembly
4. Mirror Head Assembly
5. Upper Mirror Support Assembly
6. Mirror Stay Bracket
7. Mirror Stay

Removal Procedure

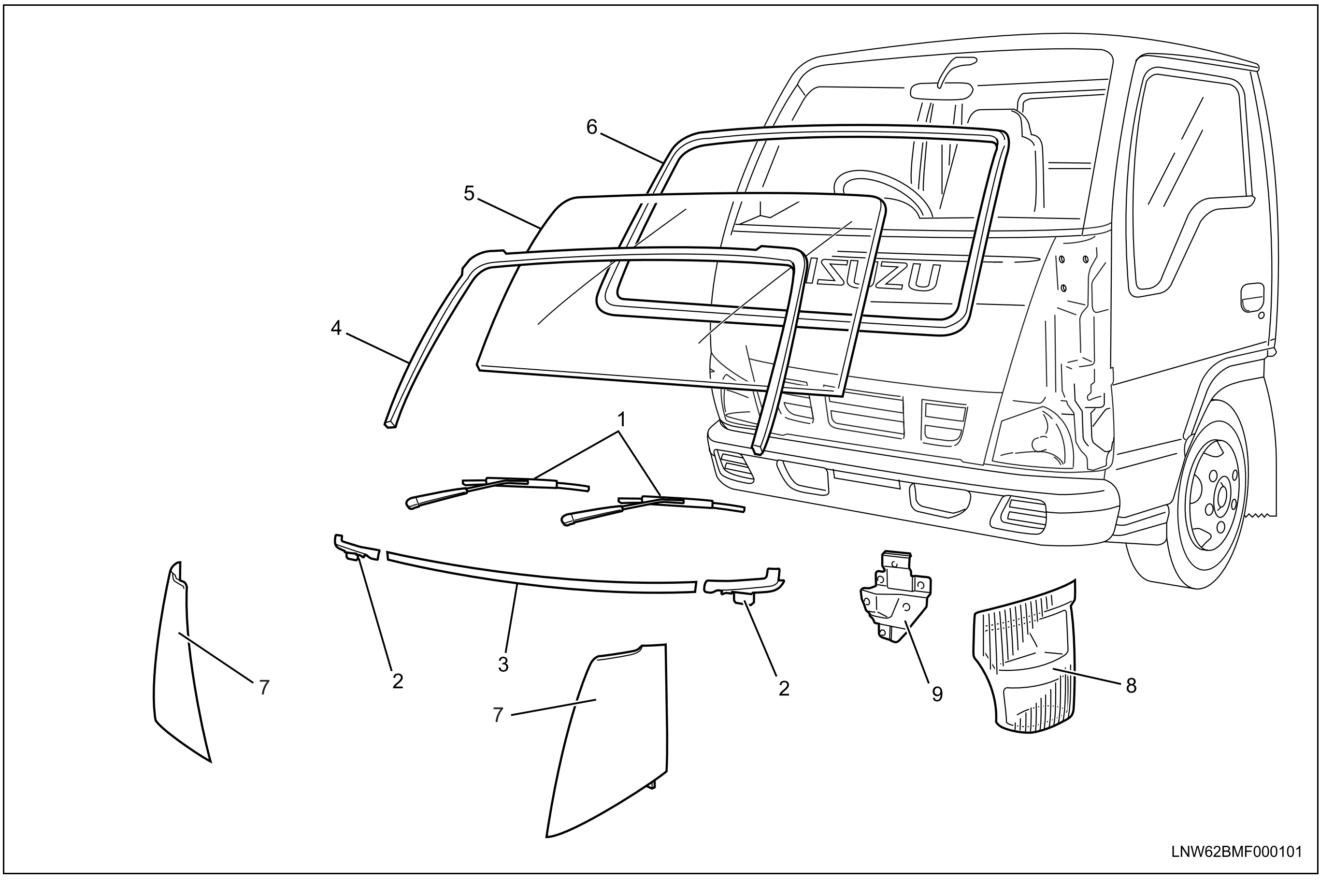
Outside mirrors need little servicing. Any rattle or loosening of the mirrors can usually be stopped by tightening the attaching fasteners.

1. Remove the sash holder screws.
2. Remove the stay to spacer screws.
3. Remove the outside rear view mirror assembly.
4. Remove the mirror head assembly.
5. Remove the upper mirror support assembly.
6. Remove the mirror stay bracket.
7. Remove the mirror stay.

Installation Procedure

1. Install the mirror stay.
2. Install the mirror stay bracket.
3. Install the upper mirror support assembly.
4. Install the mirror head assembly.
5. Install the outside rear view mirror assembly.
6. Install the stay to spacer screws.
7. Install the sash holder screws.

Windshield Glass



Legend

1. Windshield wiper
2. Molding
3. Ornament Panel Upper Molding
4. Windshield Molding
5. Windshield Glass
6. Windshield Glass Finisher
7. Front Panel Side
8. Front Combination Lamp
9. Front Panel Side Attachment

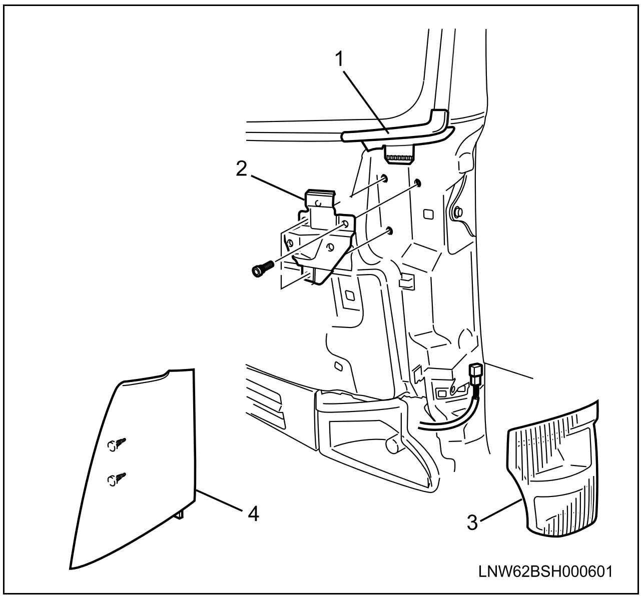
Removal Procedure

Caution:

Always wear heavy gloves when handling glass to minimize the risk of injury.

1. Remove the windshield wiper. Refer to Cab and Chassis Electrical removal procedure.
2. Remove the 1 mounting screw, 1 mounting clip and connectors, and remove the front combination lamp.
3. Remove the 1 mounting bolt and 2 mounting clips to pull out the front corner panel.
4. Remove the front panel side attachment.

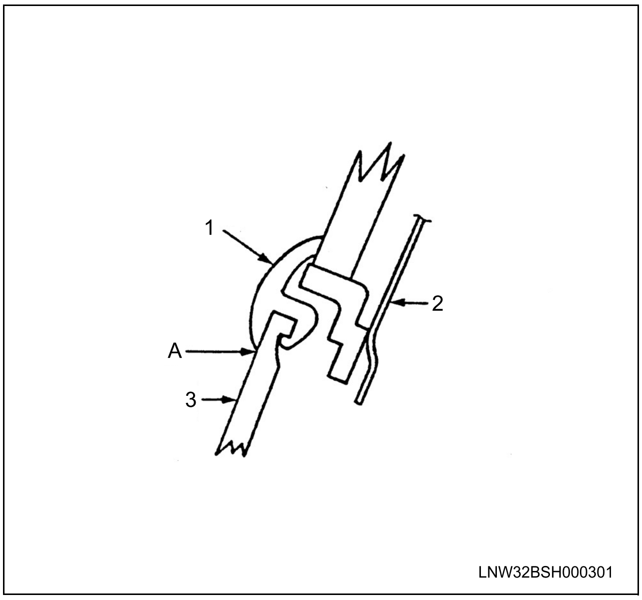
5. Remove the molding.



Legend

1. Molding
2. Front Panel Side Attachment
3. Front Combination Lamp
4. Front Panel Side

6. Remove the ornament panel upper molding with a bladed screwdriver from portion A.

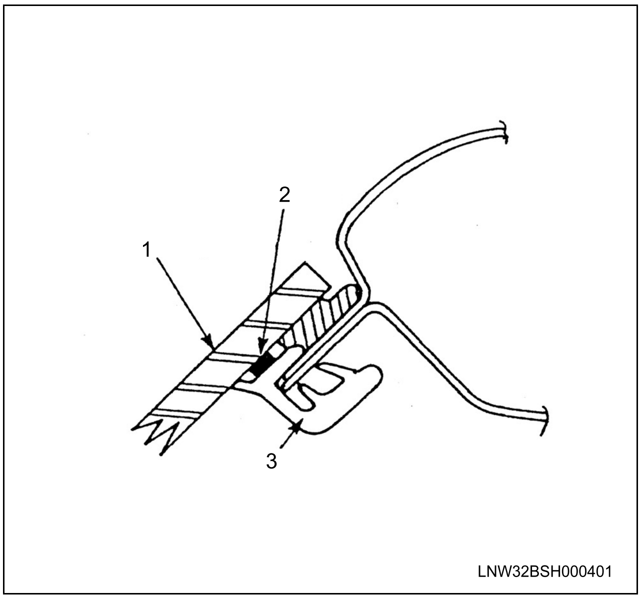


Legend

1. Windshield Glass
2. Tow-sided Adhesive Tape
3. Front Window Finisher

7. Remove the windshield molding according to the same procedure as 4. Don't reuse it.

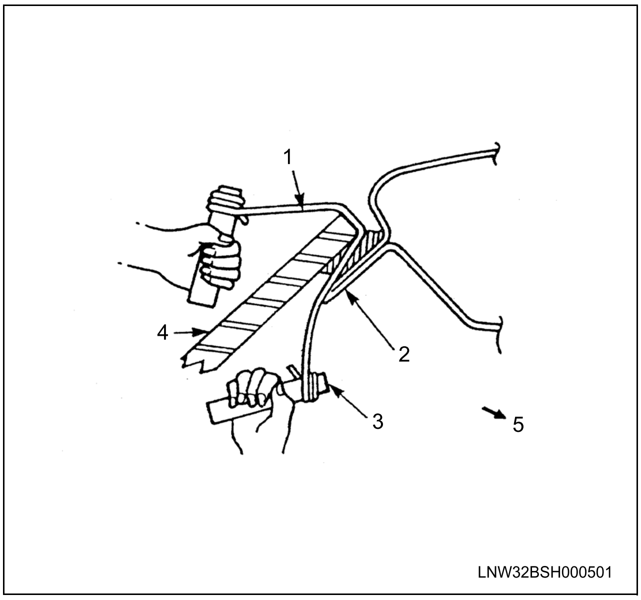
8. Windshield glass finisher. Don't reuse it.



Legend

1. Windshield Glass
2. Two-sided Adhesive Tape
3. Front Window Finisher

9. Pass the piano wire of about ϕ0.5mm to the vehicle interior through the adhesive portion of the windshield glass.
   Bind both ends of this piano wire to a square bar and cut the adhering portions around the whole periphery of the glass pulling the wise back and forth inside and outside the vehicle interior. Remove the glass.



Legend

1. Piano Wire
2. Body Flange
3. Square Bar
4. Windshield Glass
5. Room Inside

Caution:
Completely remove the adhesive remaining on the body flange and perform cleaning. If there is any convex or concave portion, this causes imperfect contact when installing the glass, leading to cracks or water leakage. To reuse the removed glass, perform the same treatment on the adhering surface of the glass side as well as the flange side. When the glass is an adhesion type, take care not to damage the glass stopper which must be reused. If the painted surface of the body flange is scratched, this will cause rust. Accordingly, repair it completely.

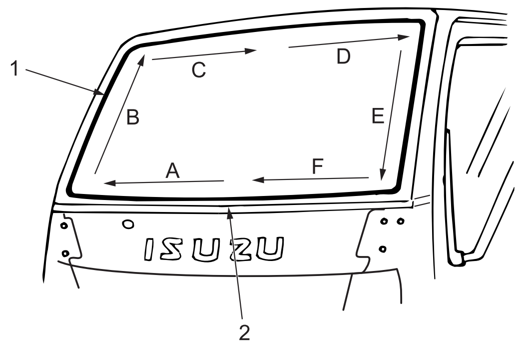
Caution:
Always wear heavy gloves when handling glass to minimize the risk of injury.

Preparation

Before starting installation, be sure check the fixing positions.

Installation Procedure

1. Windshield glass finisher. Be sure to use new finisher. Set the deposit in the central lower part. Insert the flange in the order of A to F as shown in the figure. After setting, proceed to the next step without peeling off the exfoliate paper of two-sided adhesive tape.

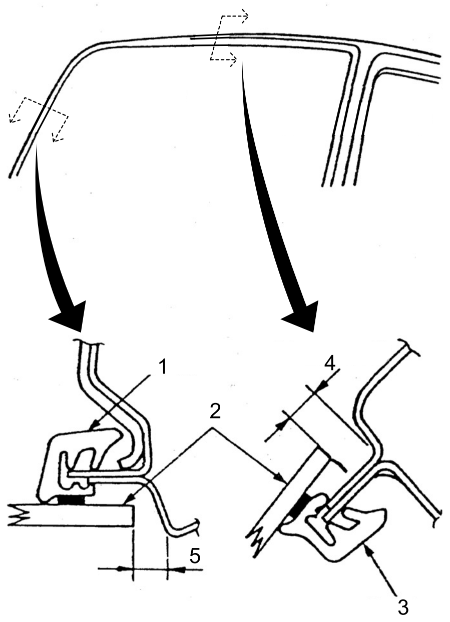


LNW62BSH000301

Legend
1. Windshield glass finisher
2. Deposit

---

2. Windshield glass. Temporarily set the glass, perform positioning marking so that the left/ right clearance A may be uniform. Next, when the clearance B, is equal to the clearance A, proceed to the installation step. At this time, if the clearance B must be adjusted, remove the ornament panel and adjust the glass stopper.



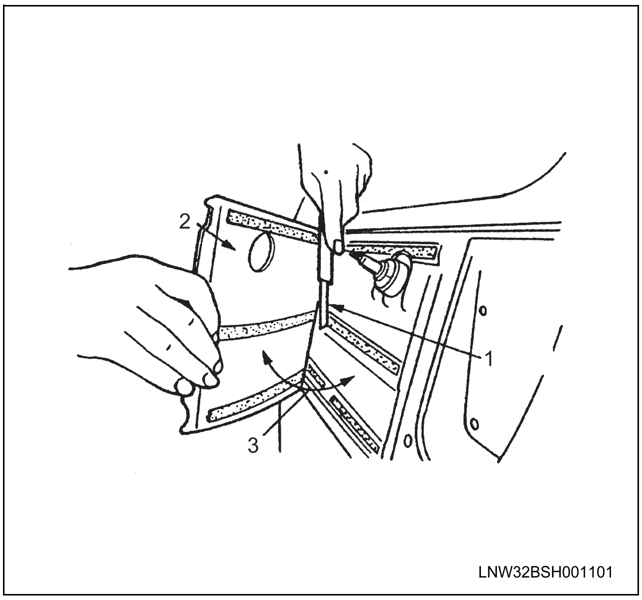
LNW32BMH000201

Legend
1. Finisher
2. Glass
3. Finisher
4. Clearance B
5. Clearance A

Mounting/Dismounting Procedure for Ornament Panel

First, remove the washer nozzle as described in Steel Tilt Cab of this manual, cut off the two-sided adhesive tape fixing the ornament panel with a cutter and remove it from the front panel. At this time, don't bend the ornament panel over 90°. Take care not to scratch the painted surface of the body panel. If it is scratched, repair it completely to prevent rust. When installing the ornament panel, completely remove the two-sided adhesive tape remaining on the ornament panel side and install the ornament panel with a new two-sided adhesive tape.

Caution:
After removing the washer nozzle, take care not to drop the washer tube to the inside of the front panel. After removing the ornament panel, connect the nozzle to the tube and fix.



Legend
1. Cutter
2. Ornament Panel
3. Don’t bend over 90°

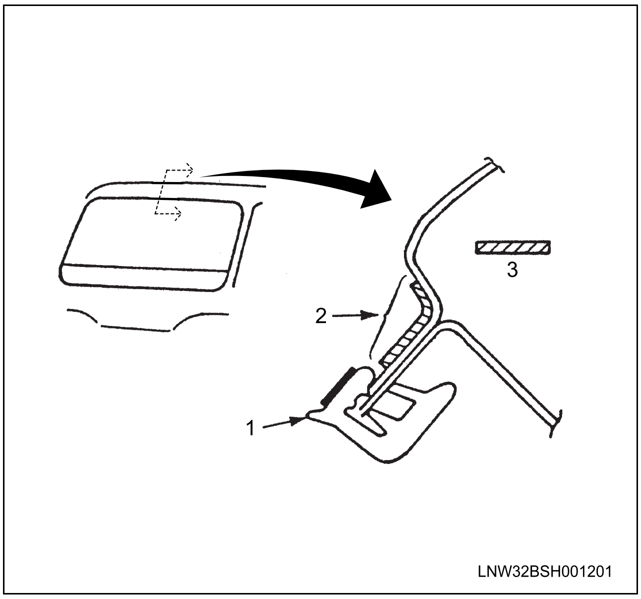
When installing an adhesion type after removing an adhesion type

Removal Procedure

1. Be sure to use a new finisher.
   Apply the primer to the whole periphery.

Caution:
Check that there remains no adhesive on the flange surface to which the primer is to be applied. If the primer is applied on the residual adhesive, the contact of the adhesive for glass to be applied later may be imperfect, resulting in cracks or water leakage. After applying the primer, keep the status for three minutes or more.

Primer: PRIMER RC-50E for painting manufactured by the Yokohama Rubber Co., Ltd. or equivalent.

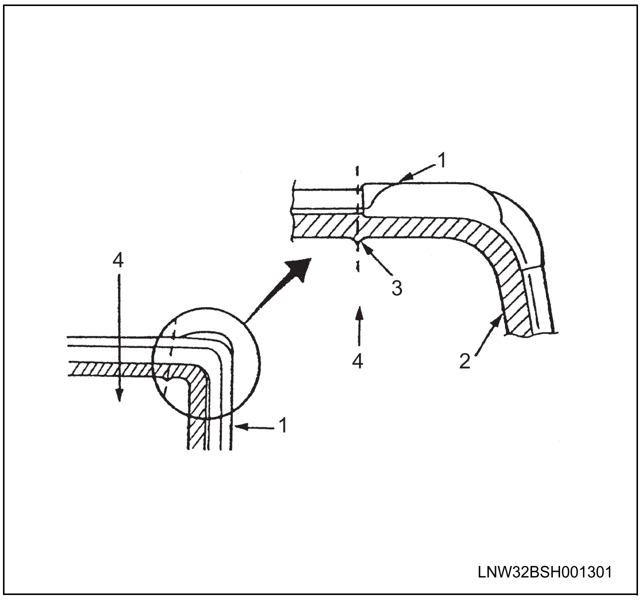


Legend
1. Windshield Glass Finisher
2. Whole Periphery
3. Application of Primer

---

2. Adjust the rising portion of the upper end of the molding corner mold to the match mark of the glass ceramic painted portion and fit the upper end (left/right) and fix the both sides. Be sure to use a new windshield molding.

Caution:
Before reusing the glass, completely remove the residual adhesive and perform cleaning.



Legend
1. Molding
2. Ceramic Painted Portion
3. Match Mark
4. Glass

3. Apply the primer to the outer periphery on the room side of the glass. Apply it over 20mm (0.78in) from the end.

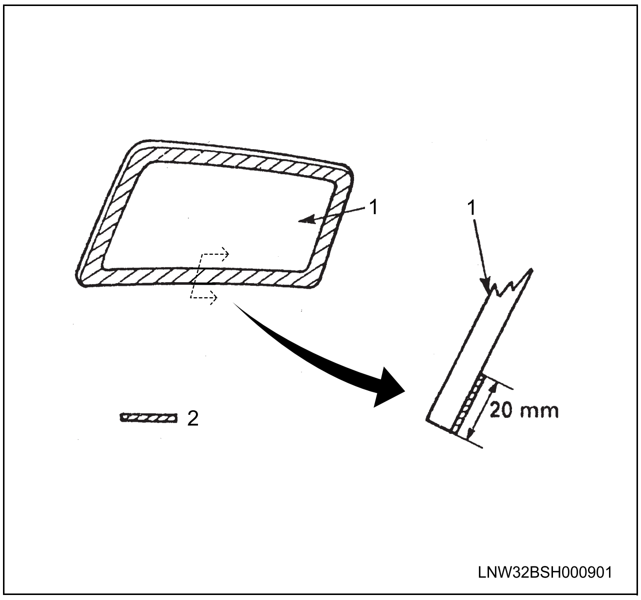
Caution:
Before reusing the glass, completely remove the residual adhesive and perform cleaning. If the primer is applied on the residual adhesive, the contact of the adhesive for glass to be applied later may be imperfect, leading to cracks or water leakage. After applying the primer, keep the status for three minutes or more.

Primer: PRIMER MS-80 for both sides of glass manufactured by the Yokohama Rubber Co., Ltd. or equivalent.

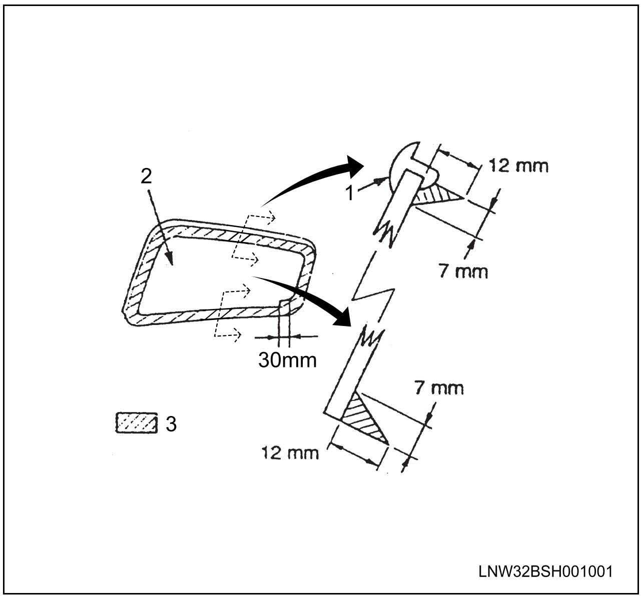
- After keeping the status for three minutes or more after primer application, apply the adhesive. Apply it to the whole outer periphery and make a 30mm (1.18in) lap allowance.

Primer: ADHESIVE WS-90F for glass manufactured by the Yokohama Rubber Co., Ltd. or equivalent.

Caution:
Install the glass on the cab withon five minutes after applying the adhesive. At this time, peel off the exfoliate paper of the two-sided adhesive tape of the windshield glass finisher and set the glass by press accurately at the installation position determined in the positioning procedure described on the previous page. Harden the adhesive at 20 - 30°C for 24 hours. Press the periphery by using a gummed tape as an auxiliary means. Imperfect press fitting will cause water leakage.



Legend
1. Windshield Glass
2. Primer Application Range



Legend
1. Molding
2. Windshield Glass
3. Adhesive Application Range

---

4. Ornament panel upper molding (3).
5. Ornament corner piece/ Molding (2).
   Be sure to use a new two-sided adhesive tape for the molding.
6. Install the front wiper. Refer to Steel Tilt Cab.

Installation Procedure

Caution after installation:

- As described before, fix the periphery by using a gummed tape as an auxiliary means in the period of 24 hours when the adhesive for the windshield glass is hardened.
- After installation, avoid driving vehicle for at least 24 hours.
- After installation, open or close the door with the side window glass or roof ventilator open. When the door must be opened or closed inevitably in the closed status, open it slowly without giving any vibration or shock to it.
- Make a water leakage test.

Rear Window Replacement

Caution:
Always wear heavy gloves when handling glass to minimize the risk of injury.

Preparation

If a glass is cracked but still intact, it should be crisscrossed with masking tape to reduce the risk of injury and/or damage to the vehicle. If a crack extends to the edge of the glass, mark the cab with a piece of chalk at the point where the crack meets the weatherstrip. This will aid the inspection later.

Removal Procedure

1. Weatherstrip seal by running a putty knife between the flange and weatherstrip (inside and outside the cab).
   - Have an assistant outside the cab by the window.
2. Weatherstrip and glass from the flange.
   - Force the weatherstrip from the flange from the inside with a putty knife.
3. Remove the window.

Installation Procedure

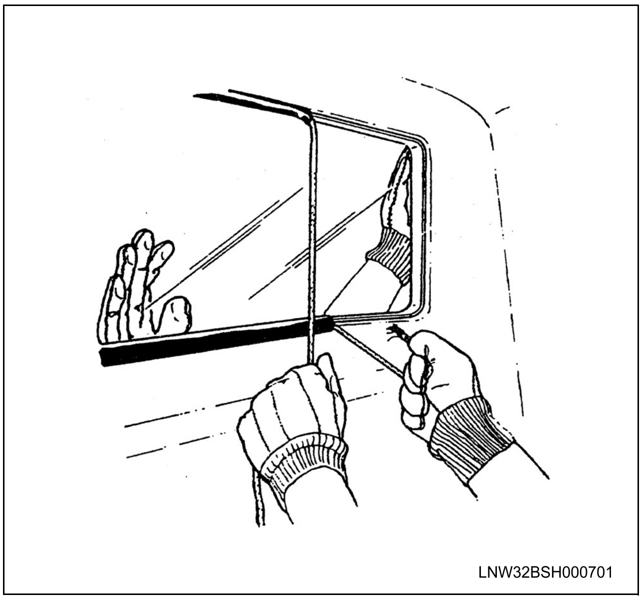
Caution:
Always wear heavy gloves when handling glass to minimize the risk of injury.

To ease installation, the weatherstrip can be heated with a non-flame source. At higher temperatures, the weatherstrip is more pliable. Do not heat above 52°C (125°F), or for more than 1- 1/2 hours.

Avoid hitting the glass on anything that may chip its edges.

Pressure on the glass will tend to concentrate at the chipped areas, causing cracks. If the glass is accidentally chipped, the edge should be ground smooth.

1. Weatherstrip to the glass.
2. A 6 mm (1/4 in) cord in the weatherstrip groove. The ends should overlap about 15 cm (6 in) at the window bottom.
3. Window and weatherstrip on the flange from outside the cab.
   - Brush soapy water on the flange.
   - Have an assistant pull the cord from inside the cab to seat the lip of the weatherstrip on the flange.



Glass Polishing

Minor Scratch and Abrasion Removal

Minor scratches and abrasions can be removed or reduced by following the procedure outlined below. Precautions must be taken, however, to prevent distortions of vision; double vision may result if an attempt is made to remove deep scratches. Deep scratches should not be removed from an area in the driver's line of vision; in such cases, the glass should be replaced.

The procedure that follows was developed using a cerium oxide compound. Follow manufacturer's direction if other materials are used.

Recommended Equipment

1. A low speed (600-1300 rpm) rotary polisher.
2. A wool, felt, rotary polishing pad 76 mm (3 in) in diameter and 51 mm (2 in) thick.
3. Powdered cerium oxide mixed with water. This is the abrasive compound.
4. A wide-mouth container to hold the abrasive compound.

Polishing Procedure

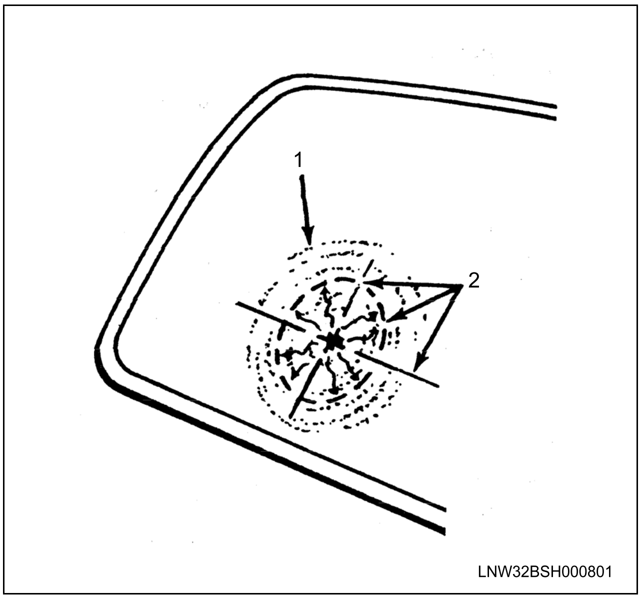
1. Mix at least 4 ml (1.5 oz) of cerium oxide with enough water to obtain a creamy consistency. (If the mixture is too thick it will cake on the felt pad more quickly. If it is too runny, more polishing time will be needed.)
2. Draw a circle around the scratches on the opposite side of the glass with a marking crayon, or equivalent.
3. Draw a line directly behind the scratch(es) to serve as a guide for locating the scratch while polishing.
4. Cover the surrounding area with masking paper to catch the drippings or spattered polish.
5. Dip the felt pad attached to the polisher into the mixture. Do not submerge the pad or allow the pad to stay in the mixture as it may loosen the bond between the pad and the metal plate.

Notice:
Never hold the tool in one spot or operate the tool on the glass any longer then 30 to 45 seconds. If the glass becomes hot to the touch. let it air cool before proceeding further.

Cooling with cold water may crack heated glass. Avoid excessive pressure. It may cause overheating of the glass.

6. Polish the scratched area, but note the following:
   a. Agitate the mixture as often as needed to maintain the creamy consistency of the compound.
   b. Use moderate but steady pressure.
   c. Hold the pad flat against the glass.
   d. Use a feathering-out motion.

   e. Dip the pad into the mixture every 15 seconds to ensure that the wheel and the glass are always wet during the polishing operation. (A dry pad causes excessive heat to develop.)
   f. Keep the pad free of dirt and other foreign substances.
7. After removing the scratch, wipe the area clean of any polish.
8. Clean the polishing pad.



Legend
1. Feather-Out
2. Guidelines

Model and Series Designation Plate Replacement

To remove a plate, carefully pry it off with a flat bladed tool. To install a plate, ensure that the door surface is clean and dry. Peel the paper off the back of the plate and press the plate on the vehicle.

BODY, CAB, AND ACCESSORIES

Sheet Metal

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  Grille Replacement. 2C-3
  Bumper and Bumper Reinforce Replacement . .2C-3
  Battery Box Replacement 2C-4
  Sheet Metal Repair 2C-5

Description and Operation

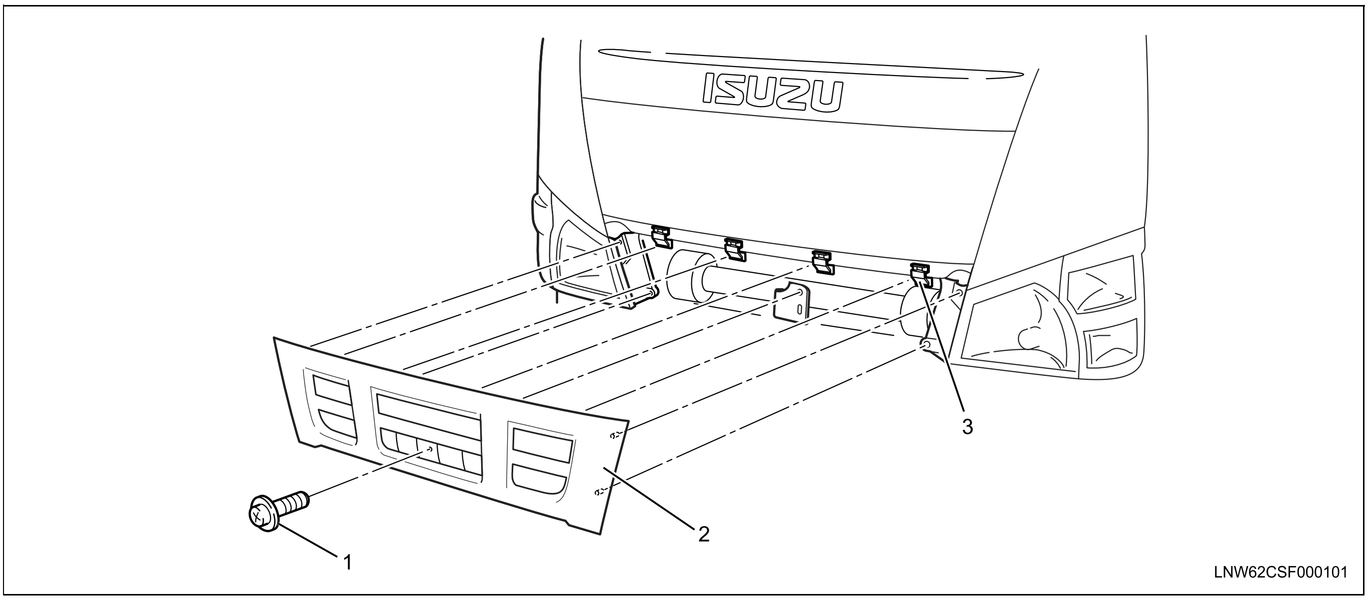
Sheet Metal Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Sheet metal removal and installation is covered in this section. For related body information not covered in this section, refer to Steel Tilt Cab or Cab Maintenance.

Repair Instructions

Grille Replacement



Legend

1. Grille Fixing Screw
2. Grille
3. Clip

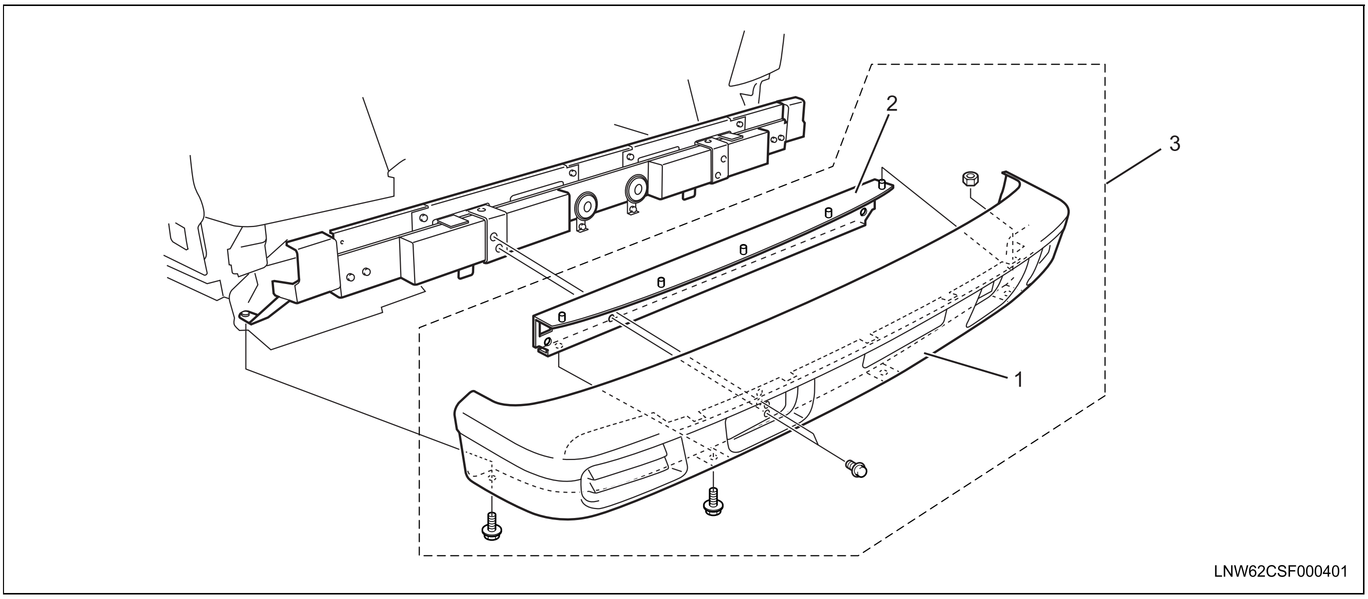
Removal Procedure

1. Remove the grille fixing screw.
2. Remove the grille.
3. Remove the clips.

Installation Procedure

1. Install the clips.
2. Install the grille.
3. Install the grille fixing screw.

Bumper and Bumper Reinforce Replacement



Legend

1. Bumper
2. Bumper Reinforce
3. Bumper Assembly

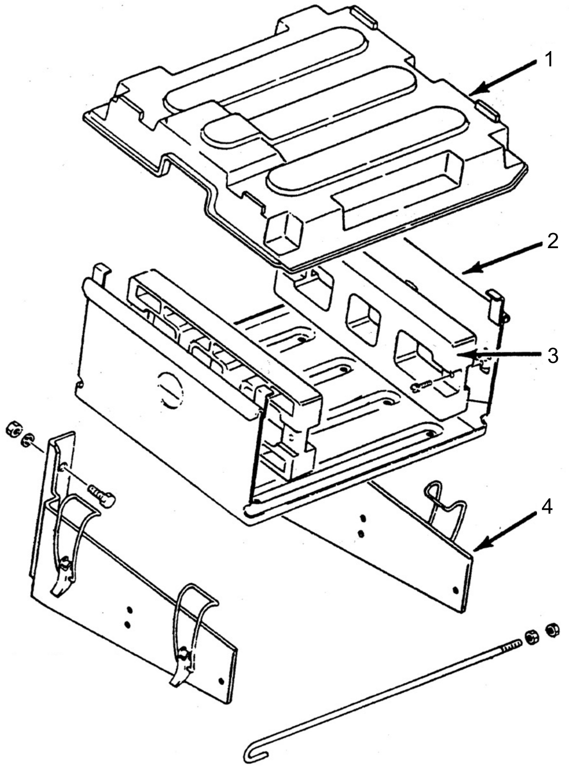
Removal Procedure

1. Remove the six screws securing bumper assembly.
2. Remove the bumper assembly.
3. Remove the 3 screws and the 5 nuts, remove the bumper reinforcement from the bumper assembly.

Installation Procedure

1. Install the bumper reinforcement to bumper.
2. Install the bumper assembly.
3. Install the six screws securing bumper assembly.

Battery Box Replacement



LNW32CMF000101

Legend

1. Cover
2. Box
3. Spacer
4. Bracket

Removal Procedure

1. Remove the cover.
2. Remove the batteries. Refer to Engine Electrical.
3. Remove the bracket to frame bolts.
4. Remove the box.

Installation Procedure

1. Install the box to the frame rail.
2. Install the bracket bolts.
3. Install the batteries. Refer to Engine Electrical.
4. Install the cover.

Sheet Metal Repair

To help prevent rust, special anti-corrosion materials are used on interior surfaces of metal panels.

These materials include special metals such as one-sided and two-sided galvanized, zincro-metal and zinc-iron alloy steels. These specially treated metals are used in fenders, doors, quarter panels, rocker panels, floor pans, and other critical areas.

Spray-on materials such as zinc-rich primers and waxes are also applied to interior surfaces. These are mainly used in areas where moisture might gather. Sealers are applied along exposed joints and moisture repelling asphaltic sound deadeners applied inside wheel wells and doors, and on some underbody parts.

If, while repairing damaged areas these special treatments are disturbed, the metals may be left unprotected. This could lead to corrosion; therefore, these surfaces should be recoated with service-type anti-corrosion materials.

Steps for applying anti-corrosion materials should be:

1. **Clean Up and Preparation**
   Depending on the location of the area, sandblasting, scraping, wire brushing, sandpaper, and steel wool can be used to remove residue.
2. **Applying Primer Coats**
   All bare metal must be primed with an acrylic chromate material.
3. **Applying Sealers**
   All flanged joints, overlap joints, and seams should be sealed with a medium-bodied sealer which stays flexible and is paintable.
   A heavy-bodied caulking material should be used on all open joints that require sealer to close a gap.
4. **Applying Color**
   If areas such as underbody, hem flanges, exposed joints and engine compartment need color, follow conventional refinishing preparation, undercoat build-up, and color application procedures. Rubout and extensive sanding of the undercoats is not necessary.
5. **Applying Deadeners**
   Use a heavy-bodied undercoat with a rubberized or asphaltic base. Areas for application can be determined by original production application.
6. **Applying Anti-Corrosion Material**
   Use a light-bodied material designed to penetrate between close metal-to-metal surfaces such as pinch weld joints, hem flanges, and other attaching points where metal surfaces are difficult to coat with conventional materials.
7. **Conventional Undercoating**
   Apply to large areas such as doors, hoods, fenders, etc. Do not spray material into door hardware such as locks, run channels, and window regulator.
   On the underbody the material should not be applied to any moving or rotating parts.
   After undercoating, ensure that all body drain holes are open.

For more information on sheet metal repair, refer to Cab Repairs.

STEERING

Front End Alignment

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Description and Operation

Steering, Suspension, Wheels and Tires Description

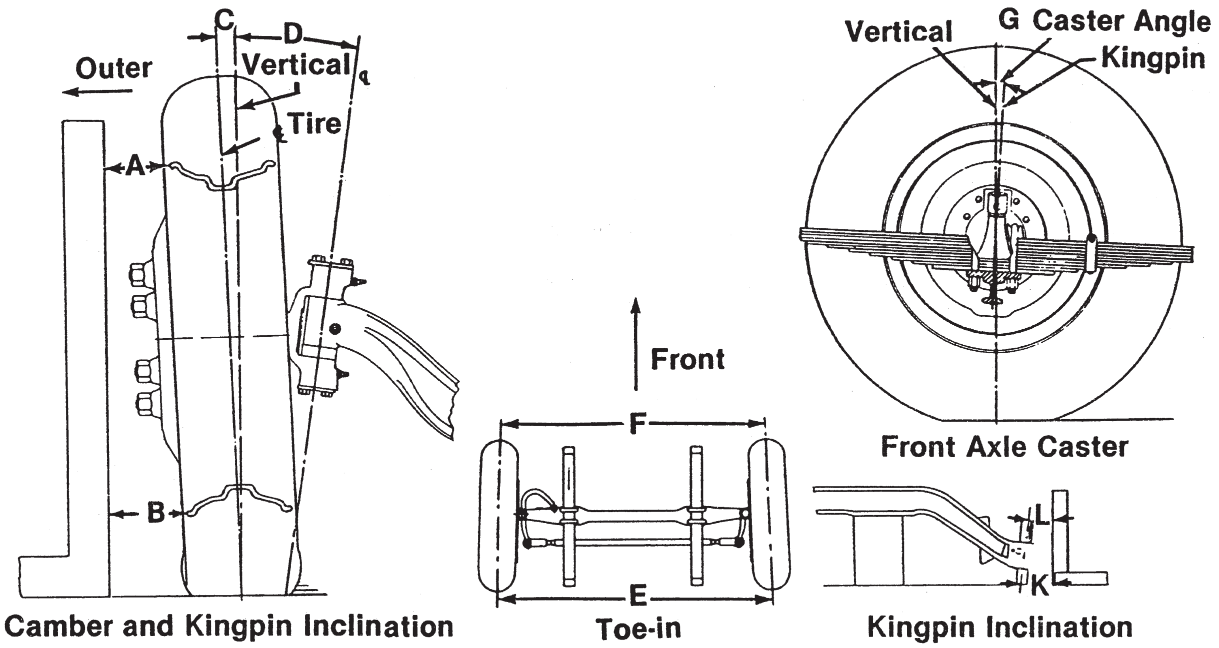
Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Alignment is the proper positioning or state of adjustment of parts in relation to each other.

Proper alignment of front wheels must be maintained to ensure efficient steering and satisfactory tire life. The most important factors of front end alignment are wheel toe-in, wheel camber, and axle caster. Kingpin inclination is designed into the axle end. Front end alignment should be checked at regular intervals, and particularly after the front axle has been subjected to heavy impacts such as a collision or a hard curb impact. Before checking alignment, the wheel bearings must be properly adjusted, since loose wheel bearings will affect the instrument readings when checking the wheel toe in, wheel camber, and axle caster.

When checking the alignment, the instructions outlined in this section should be followed carefully, as well as instructions covering related units such as brakes, springs, steering gear, hubs and bearings, and wheels and tires, which are given in other sections of this manual.

Front End Alignment Chart Description



B Minus A	Camber (Inches)
C	Camber (Degrees Positive)
D	Kingpin Inclination (Degrees)

E Minus F	Toe-in (Inches)
G	Caster (Degrees Positive)
K Minus L	Kingpin Inclination (Inches)

The front end alignment chart indicates the points at which the alignment dimensions are taken.

All alignment checking should be done with precision equipment and instruments. Refer to Specifications at the end of this section.

Wheel Toe-in

The distance between the front wheels is less at the front than at the rear of the axle (E and F).

Wheel Camber

Camber (A) is the amount in inches or degrees the top of the front wheels are tilted outward or inward from the vertical position (C). Camber offsets wheel deflection, due to wear of front axle parts, and prevents a reverse or negative camber condition. A reverse or negative camber is an inward inclination of wheels at the top.

If camber is extreme or unequal between the wheels, improper steering and excessive tire wear will result.

Front Axle Caster

The front axle caster is defined as the kingpin inclination from the vertical plane in the fore and aft direction of the vehicle (G). Incorrect caster may result from sagging springs, bent axle, twisted axle, or uneven tightening of spring U-bolt nuts. Tighten all U-bolt nuts equally. Refer to Front Axle and Suspension for U-bolt torque specifications. Generally, if the axle is twisted, the caster will be unequal for the right and left side.

Kingpin Inclination

Kingpin inclination is designed into the axle end and is the amount that the top of the kingpin is inclined toward center of vehicle. Kingpin(s) are inclined (D) to assist front wheel return to center after a turn is completed

Frame Angle

The caster, camber, and toe-in dimensions are for vehicle at design load (with frame level). If frame is not level on alignment equipment, the frame angle must be considered.

This is especially important when making a caster angle check to obtain a true setting.

Diagnosis Information and Procedures

Noisy Front End

POSSIBLE CAUSE	CORRECTION
1. Loose tie rod ends.	1. Replace ends.
2. Lack of proper Lubrication	2. Refer to Maintenance and Lubrication.
3. Loose shock absorber mounts	3 Refer to Diagnosis of Shock Absorbers.
4. Broken spring leaf.	4. Replace spring leaf.
5. Loose U-bolts or spring clips	5. Tighten

Wheel Bounce

POSSIBLE CAUSE	CORRECTION
1. Unbalanced wheels or tires	1. Refer to Wheels and Tires.
2. Unequal tire pressure	2. Refer to Wheels and Tires.
3. Weak or broken front spring.	3. Replace
4. Excessive wheel or tire run-out	4. Refer to Wheels and Tires.
5. Worn shock absorbers.	5. Refer to Diagnosis of Shock Absorbers

Excessive Tire Wear

POSSIBLE CAUSE	CORRECTION
1. Incorrect wheel alignment	1. Align wheels.
2. Failure to rotate tires	2. Refer to Wheels and Tires.
3. Improper tire inflation	3. Refer to Wheels and Tires.
4. Overloaded or improperly loaded	4. Avoid overloading vehicle

On-Vehicle Service

On-Vehicle Service

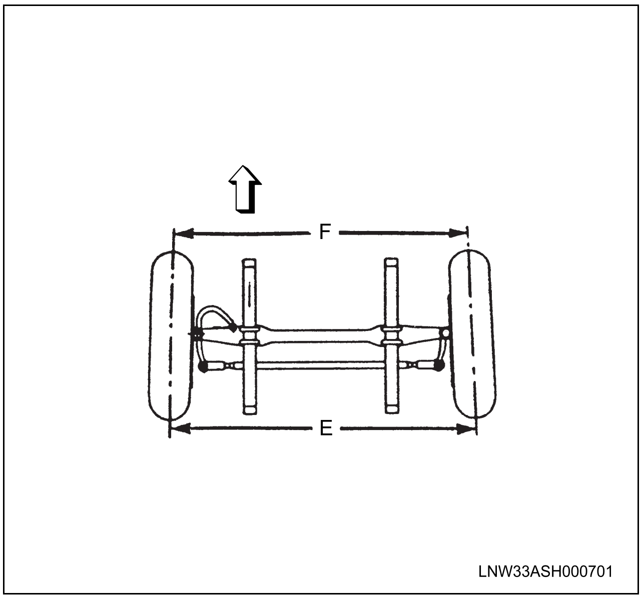
For proper assembly torques of various components, refer to Specifications in Steering Linkage or Front Axle and Suspension in this manual.

Before checking the front end alignment, the following front end inspection should always be made:

Inspection Procedure

1. Tires for proper inflation pressure. Note that the rim-to-floor height should be the same at each wheel.
2. Wheel installation and runout.
3. Wheel bearing alignment.
4. Steering tie rod and drag link ends for looseness.
5. Kingpins for looseness.

Checking and Correcting Toe-In



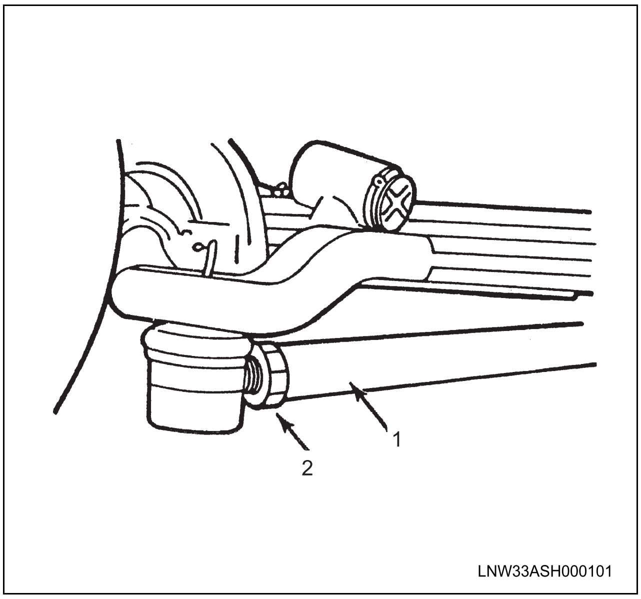
E Minus F	Toe-in (Inches)

Incorrect toe-in results in excessive tire wear caused by side slippage and also unstable steering with a tendency to wander.

Toe-in may be measured from the center of the tire treads or from the inside of the tires. Measure at both the front and rear of the axle (E and F). Note that the toe-in measurements must be made at the horizontal axis of the wheel.

When setting the toe-in adjustment, the front suspension must be neutralized; that is, all component parts must be in the same relative position when making the adjustment as they will be when in operation. To neutralize the suspension, the vehicle must be rolled forward 3.5 to 4.5 meters (12 to 15 ft). By rolling the vehicle forward, all tolerances in the front suspension are taken up and the suspension is then in normal operating position Neutralizing the front suspension is extremely important, especially if the vehicle has been jacked up in order to mark the tires; otherwise, the front wheels will not return to the normal operating position due to the tires gripping the floor surface when the vehicle is lowered on the jack.

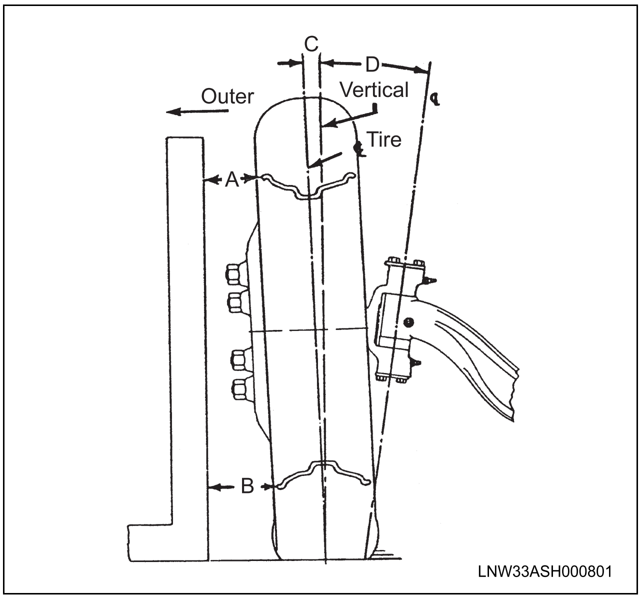
Toe-in is corrected by loosening the nut at the tie rod ends, then turning the tie rod with a wrench or tool that will not damage the tie rod, until wheels have proper toe-in. Right- and left-hand threads are provided to facilitate toe-in adjustment.



Legend

1. Tie Rod
2. Nut

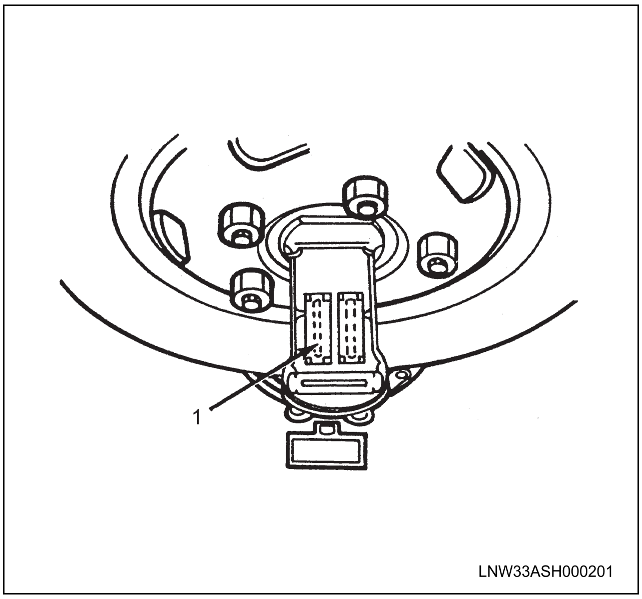
Checking and Correcting Camber



B Minus A	Camber (Inches)
C	Camber (Degrees Positive)
D	Kingpin Inclination (Degrees)

Camber variations may be caused by wear at wheel bearings and steering knuckle bushings, or by a bent steering knuckle or axle center. Camber specifications are listed at the end of this section.

1. Jack up the front of the vehicle, pull the bottom of the wheel outward, and take a camber reading. Then pull the top of the wheel outward and take a camber reading. If the readings vary more than 15 minutes, make the following adjustments:
2. Adjust the wheel bearings as directed in Front Axle and Suspension, then take the center readings as shown on Front End Alignment Chart.
3. Remove the front hub cap. Install camber, caster, and kingpin inclination gauge on end of the knuckle spindle horizontally. When removing the hub cap, take care so as not to cause damage to the gauge fitting face at the end of the spindle. If end of the spindle has been scratched or damaged, correct before setting the gauge. Reading of the camber scale directly indicates the camber angle. If the readings still vary over 15 minutes, replace the steering knuckle bushings and kingpins as instructed in Front Axle and Suspension.
4. Check the wheel run-out as instructed in Wheels and Tires. If the run-out is excessive, straighten or replace the wheel.



Legend

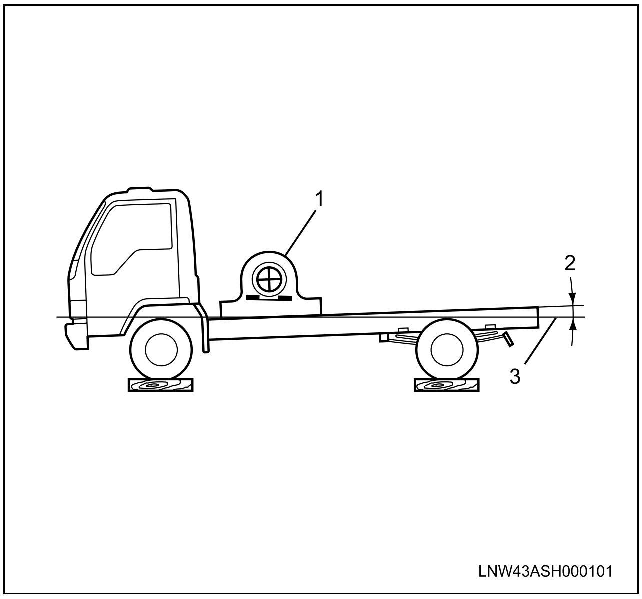
1. Camber Angle

5. Place the vehicle on a level surface, with the normal weight of the vehicle on the wheels, then take the final camber reading. If a camber gauge is not available, the readings can be taken as shown on the Front End-Alignment Chart. Place the square as shown and measure distances A and B. B SHOULD EXCEED A.
   Camber dimensions of the right wheel should not vary over 2.4 mm (3/32 in) from camber dimensions of the left wheel. If the final camber reading is incorrect, either the steering knuckle or the axle is bent.
6. To determine which part is bent, check the kingpin inclination (D). Camber plus kingpin inclination is the included angle of steering knuckle. If the kingpin inclination angle is to specification and the included angle or the camber angle is out of specification, then the knuckle (spindle) must be replaced. Excessive positive camber results in irregular wear of tires at the outer shoulder. Negative or reverse camber causes wear at the inner shoulder Ease of steering is affected by any incorrect camber setting.

Checking and Correcting Caster

Models covered by this manual use shims for adjustment purposes.

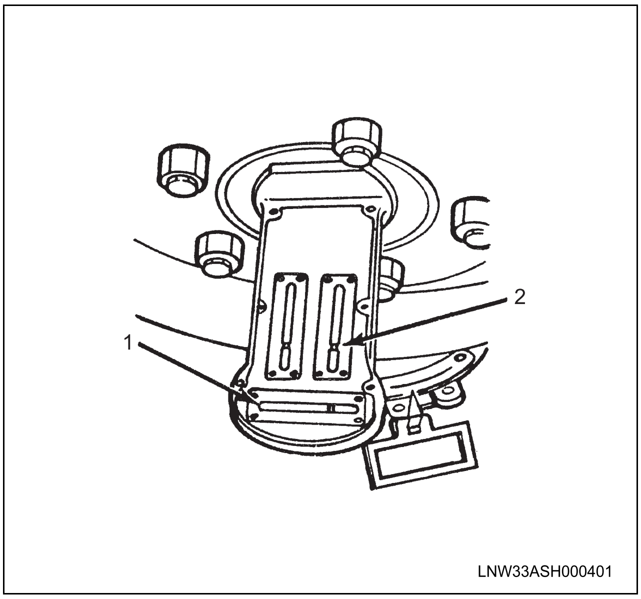
Caster dimensions are for a vehicle carrying its design load. Design load is the load equal to the capacity of the vehicle's suspension, whereby the frame in most cases would be level. If an alignment check is to be made with the frame NOT LEVEL, the frame angle must be determined and added to the caster angle to obtain a true caster reading. To determine frame angle proceed as follows:



Legend
1. Inclinometer
2. Typical Negative Frame Angle "FA"
3. Level Line

---

1. Position the vehicle on a smooth level surface
2. Using inclinometer, measure the frame angle (FA). Frame angle is the degree of tilt in the frame from the level position. Negative frame angle means the frame is high (above level) in the rear. Positive frame angle is when the frame is low (below level) in the rear.
3. Determine the caster angle for the right wheel using the alignment equipment.
4. Calibrate the scale of the turning radius gauge to zero and turn the steering wheel clockwise (counterclockwise for checking caster angle and kingpin inclination on the left side front wheel) until the front wheels are steered 20 degrees from the straight-ahead position.
   Turning the steering wheel with the brake pedal depressed and using a brake pedal pusher will produce a more accurate reading.



Legend
1. Kingpin Inclination
2. Caster Angle

---

5. When the front wheels are turned 20 degrees, calibrate the caster and kingpin scales to zero by turning the camber, caster, and kingpin gauge adjuster.
6. Add the frame angle (FA) found in step 2 to the left wheel caster reading found in step 3 to determine the corrected caster for right wheel To determine corrected caster with various frame and caster readings, the following rules apply:
   a. Negative frame angle must be added to positive caster reading.
   b. Positive frame angle must be subtracted from negative caster reading.
   c. Negative frame angle must be subtracted from negative caster reading.
   d. Positive frame angle must be added to negative caster reading.
      Example: The vehicle wheel caster reading of 30 minutes positive, and the frame angle is negative (high in the rear) 10 minutes The positive caster reading is added to the negative frame angle, giving a 40 minute positive reading as the corrected caster for that wheel. Referring to Specifications, we find that 40 minutes positive caster is within the specified setting.
7. Turn the steering wheel in the opposite direction until the front wheels are steered 20 degrees in the opposite direction for determining left wheel caster. Reading of the caster and kingpin scales directly indicates the caster and kingpin inclination angles being checked.

If the caster is not within specifications, caster can be corrected by installing proper caster shims between the axle and spring.

Checking and correcting Kingpin Inclination

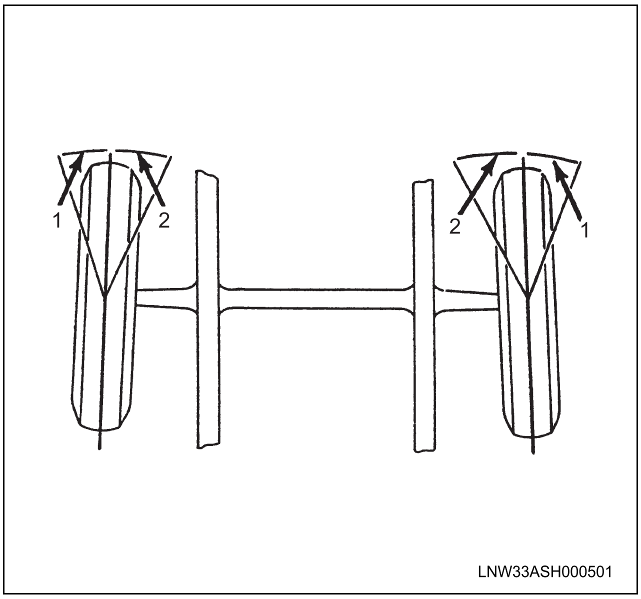
Precision instruments must be used to check kingpin inclination when axle is installed in the vehicle.

Kingpin inclination is built into the axle. Incorrect readings indicate a bent or damaged axle. If the axle is bent or twisted, refer to Front Axle and Suspension in this manual for corrective information. Straightening the axle to correct kingpin inclination will also change camber. Recheck camber after correcting kingpin inclination.

Turning Angle Measurement and Adjustment

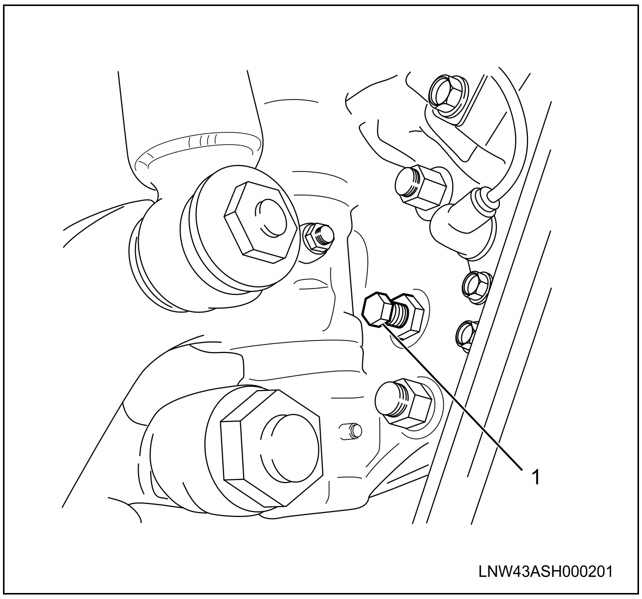
1. Place the front wheels on turning radius gages, with the front wheels in the straight-ahead position.
2. Set the gauges to zero.
3. Turn the steering wheel all the way to lock in both directions, measuring the turning angle of the front wheels.
4. Refer to Specifications at the end of this section for proper readings.

If adjustment is needed, adjust the stop screws in or out as needed. Then tighten the jam nut.



Legend

1. Inner Wheel Maximum Turn Angle
2. Outer Wheel Maximum Turn Angle



Legend

1. Stop Bolt

Specifications

Front End Alignment Settings

Toe-in	-1 to 1mm (-0.04 to 0.04 in)
Camber	-15’ to 45’ (positive)
Caster	RH 2°40’ to 4°40’ (positive) LH 1°50’ to 3°50’ (positive)
Kingpin Inclination (Maximum)	12°40’ (positive)
Turning Angle(Maximum)	Inner Wheel 43° Outer Wheel 33°

STEERING

Steering Linkage

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Description and Operation

Steering Linkage Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

The steering linkage consists of the pitman arm drag link, steering arms, and tie rod.

The pitman arm is attached to the steering gear with a nut and spring washer.

The drag link connects the pitman arm and left steering arm. It is not adjustable for length. The drag link cannot be overhauled.

The left steering arm, which is located on the left side, bolts directly to the steering knuckle. The steering arms are a taper fit in the knuckles, and each is retained by a single nut.

The tie rod connects the left and right steering arms. The tie rod ends are threaded into the tie rod tube, and are locked by two nuts. The tie rod ends are replaced as a unit.

The overall condition of the steering linkage affects steering performance. If parts are bent, damaged, worn, or poorly lubricated, improper and possibly dangerous steering action will result.

Whenever any steering linkage components are repaired or replaced, it is recommended that steering geometry and front end alignment be checked as described in Front End Alignment of this manual.

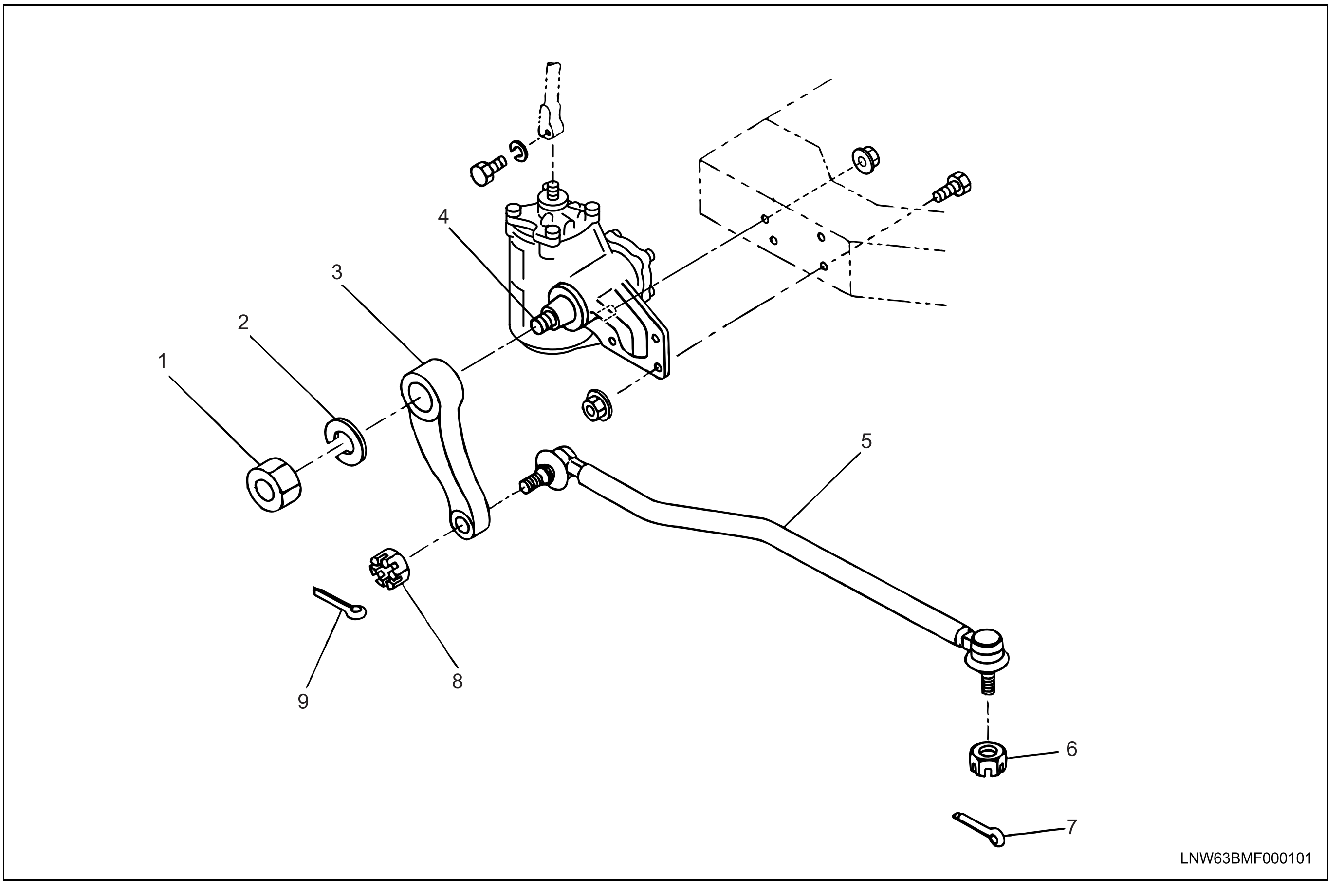
Diagnostic Information and Procedures

Diagnosis of Steering Linkage

Refer to Power Steering in this manual.

Repair Instructions

Pitman Arm



Legend

1. Nut
2. Split Washer
3. Pitman Arm
4. Sector Shaft
5. Drag Link
6. Nut
7. Cotter Pin
8. Nut
9. Cotter Pin

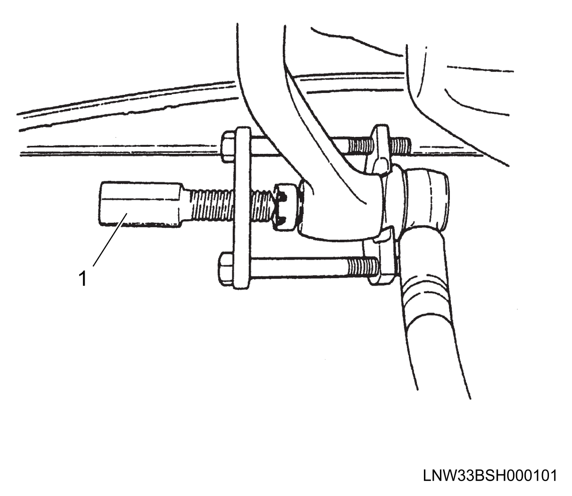
Preparation

The following service should be performed at regular intervals, as specified in Maintenance and Lubrication in this manual.

Removal Procedure

1. Cotter pin.
2. Loosen nut.

3. Drag link from the pitman arm, using J 35707 tool or equivalent.

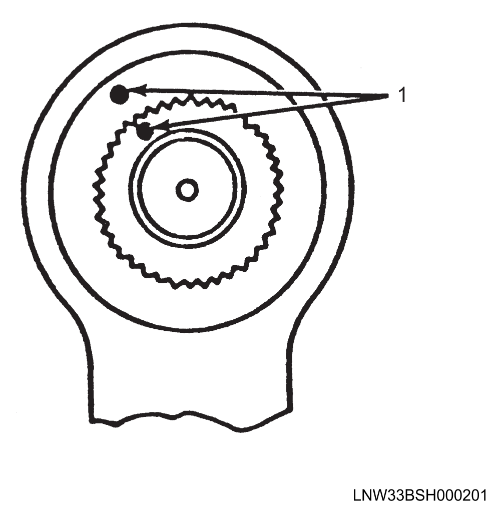


Legend

1. J 35707 or Equivalent

---

4. Nut and split washer.
   - Mark the pitman arm and sector shaft, so the pitman arm can be returned to its original position at assembly.

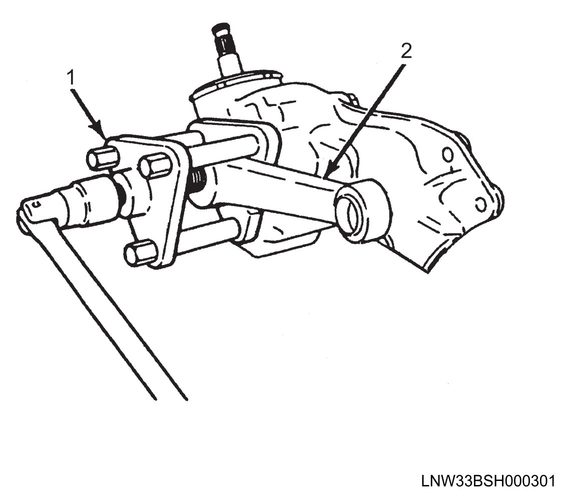


Legend

1. Punch Marks

---

5. Pitman arm, using J 26813-B tool, or equivalent.



Legend

1. J 26813-B or Equivalent
2. Pitman Arm

Installation Procedure

1. Pitman arm to the sector shaft. Align the marks made during removal.
2. Split washer and nut

Notice:
Refer to Description and Operation.

Tighten

- Nut to 294 N·m (217 lb ft)

3. Drag link to the pitman arm.

Tighten

- Nut to 167 N·m (123 lb ft)

4. A new cotter pin of the correct size.

Inspection Procedure

1. Check the pitman arm nut for tightness.
2. Lubricate the steering linkage with chassis lubricant as specified in Maintenance and Lubrication in this manual.
3. Inspect for any loose, missing or damaged parts. Check for deteriorated drag link or tie rod end seals, loose fasteners, etc.
4. If excessive looseness is found in the steering linkage, investigate the cause. Replace any questionable parts.
5. Damaged or broken steering linkage components must always be replaced. Never attempt to repair these parts by welding.

Drag Link

Removal Procedure

1. Cotter pin

2. Loosen nut
3. Drag link from the pitman arm and steering arm, using J 35707 tool or equivalent.

Installation Procedure

1. Drag link to the pitman arm and steering arm.

Tighten

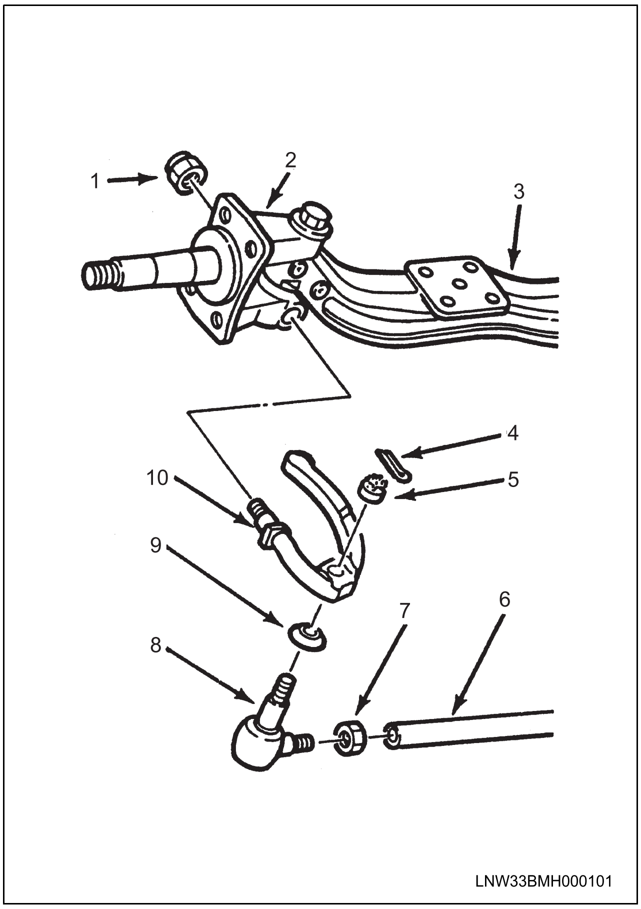
- Nut to 167 N·m (123 lb ft)

2. New cotter pins of the correct size.

Inspection Procedure

- Drag link end boot for damage, grease leak, etc.
- Drag link for bending or damage.

Tie Rod

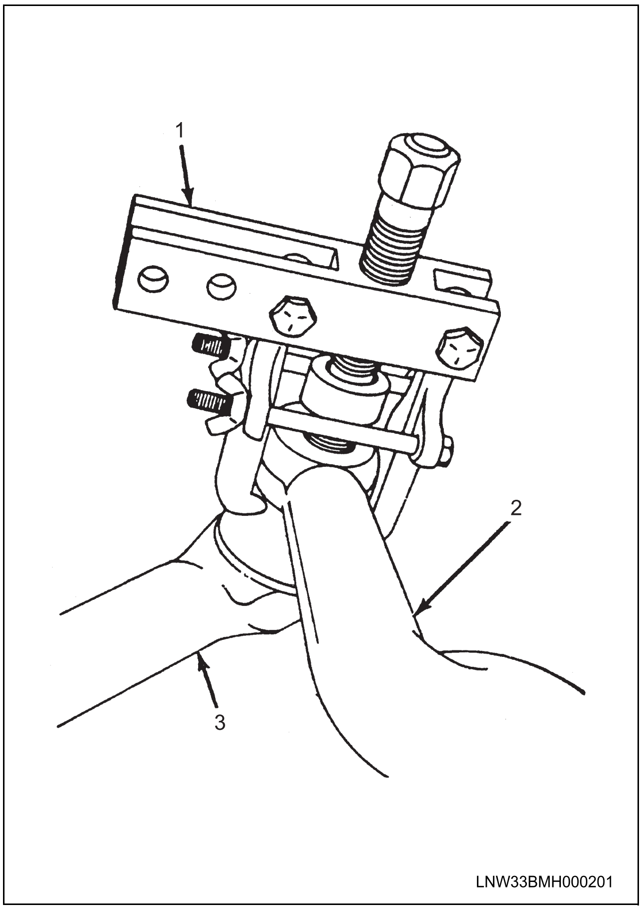


Legend

1. Nut
2. Knuckle
3. Axle
4. Cotter Pin
5. Nut
6. Tie Rod
7. Jam nut
8. Tie Rod End
9. Seal
10. Steering Arm

Removal Procedure

1. Cotter pin and nut.
2. Tie rod assembly from the steering arm. Use suitable tie rod end tool.



Legend

1. J 24319-01 or Equivalent
2. Steering Arm
3. Tie Rod

3. Jam nuts.
4. Tie rod ends. Count the number of turns needed to remove the tie rod ends.

Installation Procedure

1. Apply grease to the tie rod tube threads (if the tie rod ends were removed).
2. Tie rod ends to the rod tube (if removed).
3. Screw on the tie rod assembly the same number of turns as when removed.
4. Tie rod assembly to the lower steering arms.
5. New nuts.

Notice:
Refer to Description and Operation.

Tighten

- Nuts to 108 N·m (80 lb ft). Install the cotter pins.

Inspection Procedure

1. Tie rod tube for bending, or damaged threads.

2. Seals for deterioration or damage.
3. Threads on tie rod ends for stripping or damage.

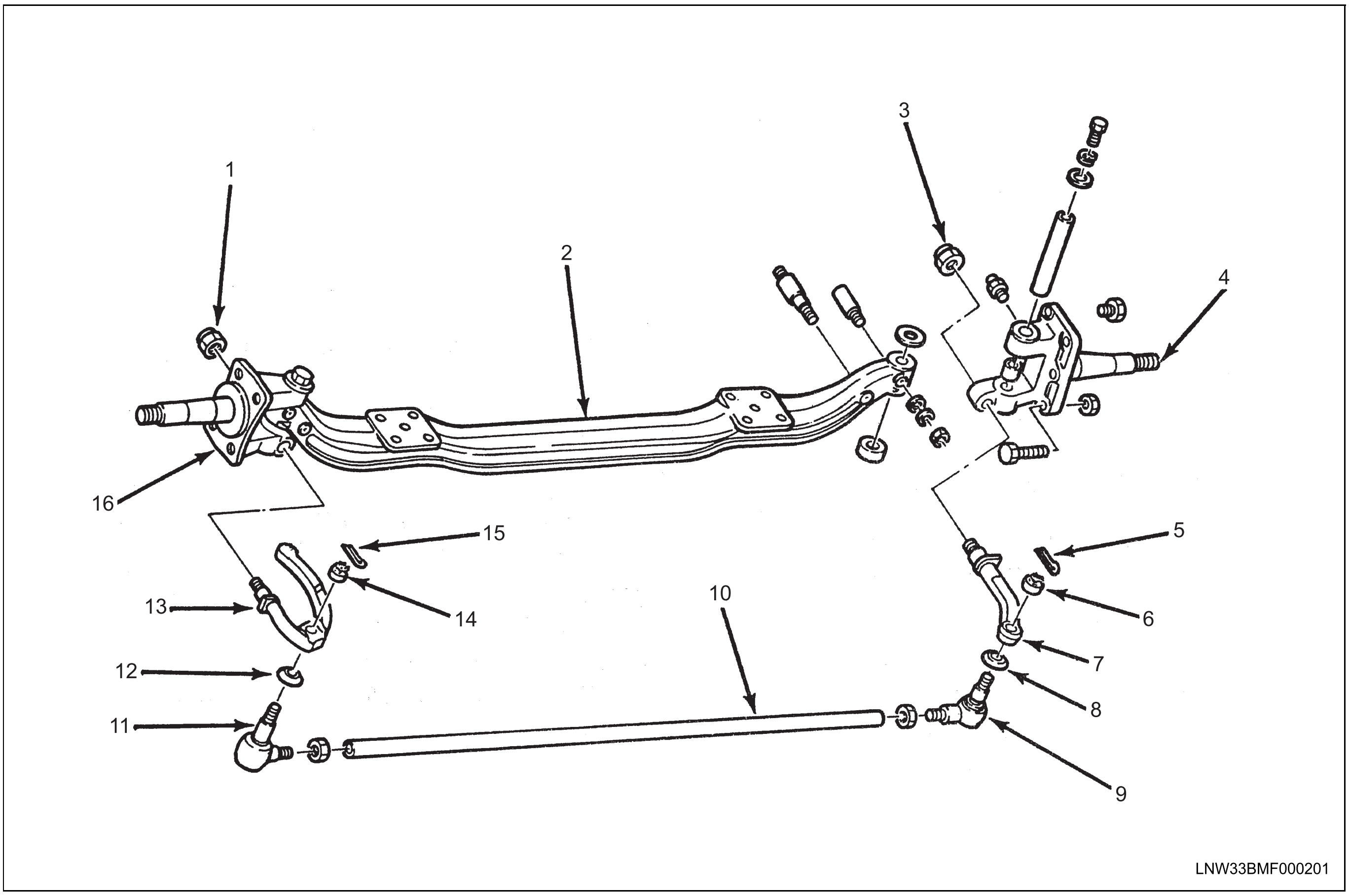
Adjust

- Toe-in. Refer to Front End Alignment in this manual.

Tighten

- Jam Nuts to 113 N·m (83 lb ft).

Left Steering Arm



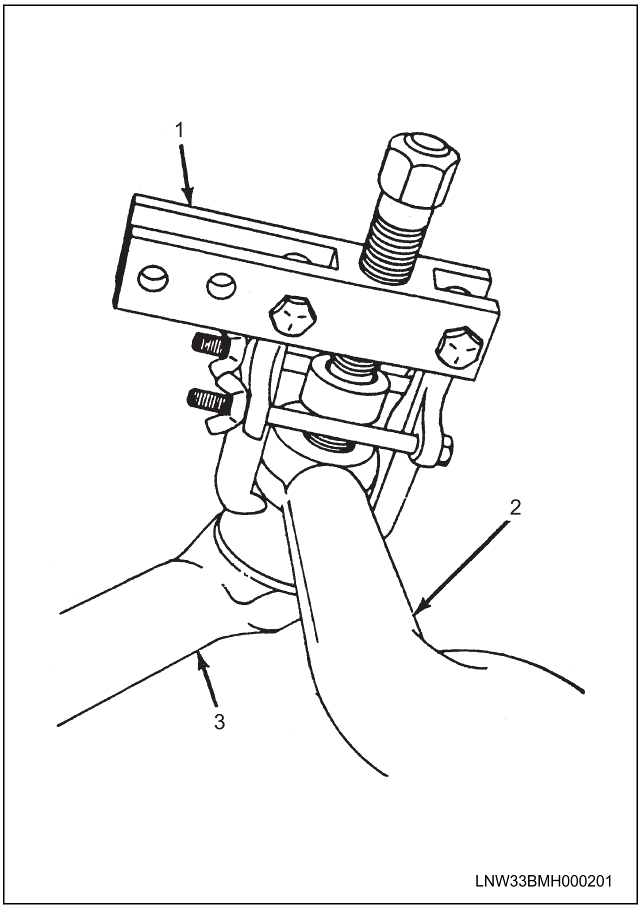
Legend

1. Left Steering Arm Nut
2. Axle
3. Right Steering Arm Nut
4. Right Steering Knuckle (Spindle)
5. Cotter Pin
6. Right Tie Rod End Nut
7. Right Steering Arm
8. Seal
9. Right Tie Rod End
10. Tie Rod
11. Left Tie Rod End
12. Seal
13. Left Steering Arm
14. Left Tie Rod End Nut
15. Cotter Pin
16. Left Steering Knuckle (Spindle)

Removal Procedure

1. Drag link, as outlined previously in this section.

2. Tie rod, cotter pin and nut. Remove left end of tie rod assembly from left steering knuckle. Use removal tool, if necessary, and discard .



Legend

1. J 24319-01 or Equivalent
2. Steering Arm
3. Tie Rod

---

3. Nut.
4. Left steering arm from knuckle.

Installation Procedure

Notice:
For steps 1 and 3, refer to Description and Operation.

1. Left steering arm and nut to knuckle.

Tighten

- Nut to 441 N·m (326 lb ft).

2. Install tie rod end and seal onto steering arm.
3. Install nut.

Tighten

- Nut to 108 N·m (80 lb ft). Install cotter pin

4. Drag link, as outlined previously in this section.

Inspection

Steering arm for damage.

Right Steering Arm

1. Nut.
2. Tap on the threaded end of the steering arm with a hammer until it is loose.
3. Remove the nut and discard.
4. Remove the steering arm.

Installation Procedure

Notice:
For steps 2 and 4, refer to Description and Operation.

1. Right steering arm to the steering knuckle.
2. Nut.

Tighten

- Nut to 441 N·m (326 lb ft)

3. Tie rod end assembly to the right steering arm.
4. Seal and nut.

Tighten

- Nut to 108 N·m (80 lb ft). Install cotter pin.

Inspection

- Steering arm for damage.

Adjust

- Toe-in. Refer to Front End Alignment in this manual.

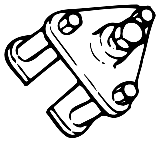
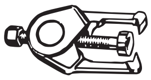
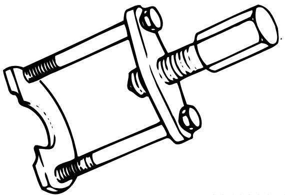
Specifications

Fastener Torques

Pitman Arm Nut	294 N·m (217 lb ft)
Drag Link Nut	167 N·m (123 lb ft)
Tie Rod Tube Jam Nuts	113 N·m (83 lb ft)
Tie Rod End Nuts	108 N·m (80 lb ft)
Steering Arm Nuts	441 N·m (326 lb ft)

Special Tools

Special Tools

Illustration	Tool Number/ Description
 5884020511	J 26813-B Pitman Arm Puller
 AAW0Z0SH000601	J 24319-01 Tie Rod Remover
 5884020170	J 35707 Drag Link Remover

STEERING

Power Steering

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Description and Operation

Power Steering Description

Notice:

When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Vehicles covered by this manual are equipped with power steering as standard equipment.

An integral steering gear is used. In an integral steering gear, the power cylinder and control valve are integrated into the steering gear. No separate power cylinder is necessary.

A vane-type hydraulic pump with reservoir is used. The hydraulic pump is belt driven.

Maintenance Description

The hydraulic system should be kept clean. At regular intervals the power steering fluid level in the reservoir should be checked and fluid added when required. Refer to Maintenance and Lubrication of this manual for the type of fluid to be used, and intervals for filling.

The power steering fluid should be changed at regular intervals. Refer to Maintenance and Lubrication for service intervals.

Correct any hose contact with other parts of the vehicle that could cause chafing or wear.

Power steering hoses and lines must not be twisted, kinked, or tightly bent.

Because of the power assist from the power steering system, it is more difficult to detect defects in the steering system. Therefore, periodic maintenance is very important on a vehicle having power steering.

If the system contains some dirt, flush it, as detailed in "Bleeding the Hydraulic System" later in this section. if it is exceptionally dirty, both the pump and the gear must be completely disassembled before further usage.

All tubes, hoses, and fittings should be inspected for leakage at regular intervals. All fittings must be tight. Be sure clips, clamps supporting tubes and hoses are in place and properly secured.

Fluid Level Adjustment Description

Without Automatic Apply Parking Brake

1. Run the engine until the power steering fluid reaches normal operating temperature, about 80 °C (176 °F), then shut the engine off.
2. Check the fluid level.
3. If the fluid level is low, add the power steering fluid specified in to the proper level and install the reservoir cap.
4. When checking the fluid level after the steering system has been serviced, air must be bled from the system. Refer to "Bleeding the Power Steering System" in this section.

With Automatic Apply Parking Brake

1. Run the engine until the power steering fluid reaches normal operating temperature, about 80 °C (176 °F).
   - Do not turn engine off to check fluid level.
2. Place transmission in neutral, apply the parking brake manual lever.
3. Remove cap from reservoir. Fluid level should be 2 in from bottom of reservoir.
4. If fluid level is low, add the power steering fluid specified in to the proper level and install the reservoir cap.
5. When checking the fluid level after the steering system has been serviced, air must be bled from the system. Refer to "Bleeding the Power Steering System" in this section.

Steering Wheel Free Play Description

Preparation

- Remove the Front grille.
  Refer to Front grille of “Steel Tilt Cab” in this manual.
- Remove the Heating assembly and related parts.
  Refer to Headlight assembly of “Cab and Chassis Electrical” in this manual.

Inspect

1. Check the amount of the steering wheel play by turning the wheel in both directions until the tires begin to move with the front wheels properly in the straight ahead position .

Notice:

If the vehicle is equipped with a power steering unit, the wheel free play should be checked with the engine running.

Steering wheel free play 10-50 mm (0.4-2.0 in)

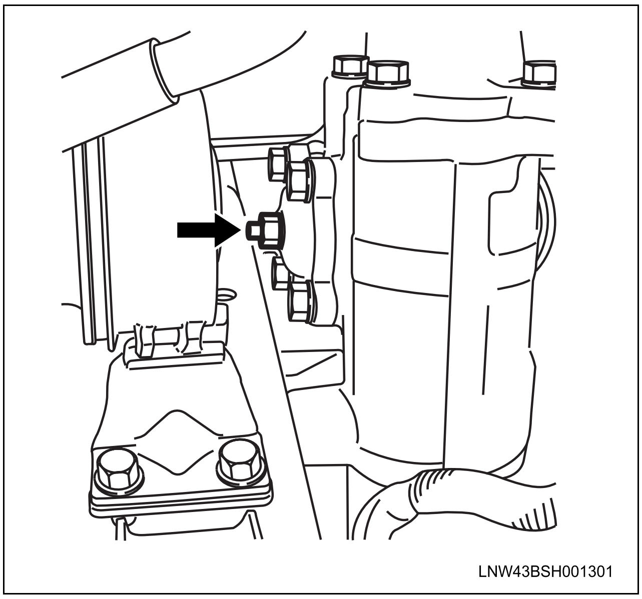
2. Also check the steering wheel for play and looseness in mount by moving it back and forth and sideways. While driving check for hard-steering, shimmy and tendency of steering to pull to one side.

Adjust

1. Align the front wheels properly in the straight ahead position.
2. Loosen the lock nut on the adjusting screw of the steering unit.
3. Turn the adjust screw clockwise to decrease free play or counter-clockwise to increase.
4. After check of specified free play, tighten the lock nut to specified torque.

Tighten

- Lock nut to 69 N·m (51 lb ft).



Steering Gear Adjustment Description

Refer to Power Steering Gear Unit Repair in this section.

Bleeding the Hydraulic System Description

Important:

- Use only DEXRON®-III automatic transmission fluid as described in Maintenance and Lubrication in this section.

1. Raise the vehicle until the front wheels are off the floor. Block the frame.
2. Fill the reservoir with the proper fluid.
3. With the engine stopped, turn the steering wheel slowly from lock to lock in both directions Add fluid as necessary.
4. Start the engine and let it idle for two to three minutes.
5. With the engine idling, turn the steering wheel slowly from lock to lock in both directions several times. Add fluid as needed.
6. Repeat step 5 until the fluid level stabilizes and air bubbles no longer appear in the reservoir.
7. Stop the engine and fill the reservoir to the proper level.
8. Lower the vehicle.

Hydraulic System Flushing Description

1. Raise the front of vehicle off ground until the wheels are free to turn.
2. Disconnect the return hose at the fluid reservoir. Direct the hose into a drain pan.
3. Plug the return hose connector on the fluid reservoir.
4. Remove the fill cap. Have an assistant ready to keep the fluid reservoir full of fluid. Refer to Maintenance and Lubrication for fluid specifications.
5. Start the engine and run it at idle. Turn the steering wheel from lock to lock.

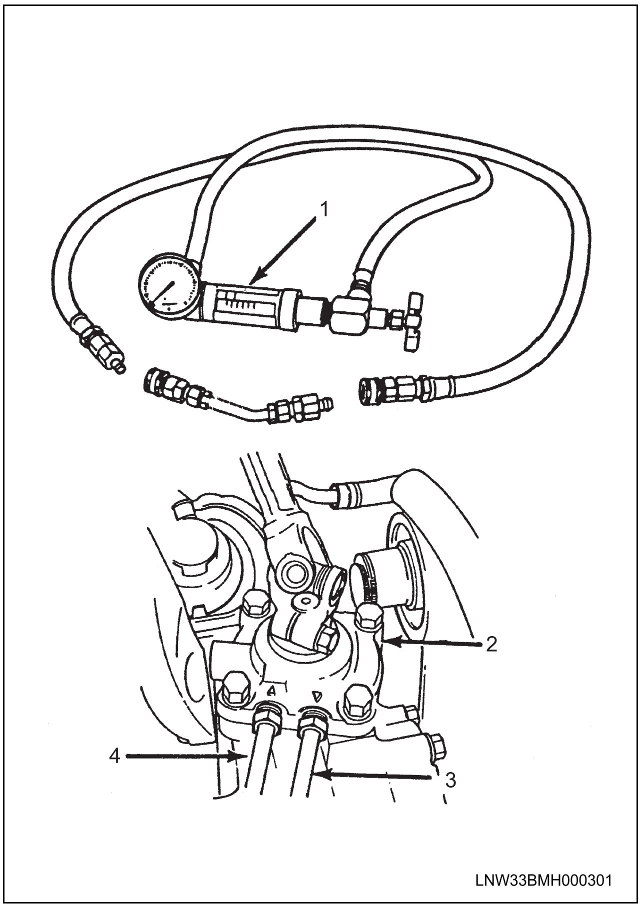
Notice:
DO NOT hold the steering wheel at a lock or fluid flow will stop and the pump will be in the relief pressure mode. A sudden overflow from the reservoir may also develop if the steering wheel is held at a lock.

6. Continue the process until all foreign material has cleared from draining fluid. If foreign material is still evident, the individual components must be flushed out as outlined in the following steps.
7. Stop the engine.
8. Remove all hydraulic lines and hoses. Drain all the lines and blow clear of fluid. Flush the lines with new power steering fluid, drain, and blow clear.
9. Disconnect the lines from the hydraulic pump. Drain the pump and then cap or plug the line connections. Fill with new power steering fluid. Drain and check the fluid for foreign material. Repeat the process as necessary.
10. Install all lines, hoses, and components (if removed) on vehicle. Fill the system with new power steering fluid and bleed the system as described in "Bleeding the Hydraulic System" previously in this section. Operate the engine for approximately 15 minutes.
11. Repeat steps 1 through 6. Check the draining fluid for foreign material. If the fluid shows foreign material, drain the system, refill, bleed system, run engine and recheck for foreign material.
    If foreign material is still evident, replace all lines and repair or replace all hydraulic components.
    Do not reuse any drained power steering fluid.
12. After the flushing operation, clean the power steering fluid filter as outlined previously.

Power Steering System Test Description

Hydraulic System Test

This test requires the Power Steering Analyzer J 26487-A, or equivalent, along with Adapter Kit J 35719. The analyzer consists of a 0-3000 psi pressure gauge, a gate valve, and a 0-10 gpm flow meter.



Legend

1. Power Steering Analyzer J 26487-A
2. Steering Gear
3. Return Line
4. Pressure Line

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1. Be sure the system reservoir has the right kind of fluid and is filled to the mark on the dipstick. Tests should be done with the system at normal operating temperature.
2. Install the analyzer in the pressure line between the pump and the steering gear using Adapter Kit J 35719. The gate valve should be fully open.
    a. Trace the pressure line from the pump to the steering gear.
    b. Disconnect the pressure line at the steering gear. Place a container under the steering gear to catch fluid when disconnecting hoses. Clean the surfaces around fittings before removing them.
    c. Thread the adapter from the adapter kit into the steering gear. Thread the other adapter onto the pressure line.
    d. Connect the analyzer to the adapters.
3. If the analyzer has never been used, it will be necessary to bleed the hydraulic system to remove all air, as directed later in this section. The analyzer gate valve must be open. If the analyzer has been used before, bleeding will probably not be necessary. This is because the power steering fluid is kept in the analyzer by the quick disconnect couplings once it has been used.
4. Run the engine at idle speed with the gate valve open for a few minutes to bleed the system of any air that may still be in it.
5. Check the pressure gauge reading with the engine idling. The gauge should read about 70 psi. If the reading is greater than this, the control valve, fluid filter, or hydraulic lines are restricted or plugged.
6. Increase engine speed to 2000 RPM.

Notice:
Do not keep the gate valve closed longer than 10 seconds. To do so may damage the hydraulic pump.

Notice:
A malfunctioning pressure relief valve may not properly relieve pump pressures. Constantly watch the pressure gauge while closing the gate valve. If pressure rises rapidly, or appears uncontrolled, do not completely close the gate valve, as excessive pressure buildup may cause hose rupture or pump damage.

7. Gradually close the gate valve and read the pressure gauge. IMMEDIATELY OPEN THE GATE VALVE.

The gauge should read 1493 psi. A higher reading indicates a faulty relief valve in the hydraulic pump. A lower reading indicates a worn or malfunctioning hydraulic pump.

Power Steering Gear Unit Repair Description

Power steering gear components are a combination of many machined, polished surfaces with very fine tolerances.

When these components are serviced, care and cleanliness are important. The workbench, hands, tools, and component parts must be kept clean at all times. The entry of even small amounts of dirt into the component may cause an unsatisfactory repair and possible damage to the component. The dirt may also be carried by the power steering fluid to other components in the power steering system, causing damage to other components as well.

Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated. Components should be cleaned in a clean, approved solvent that will not damage the rubber parts.

In some instances, "automatic transmission fluid" will be specified to lubricate parts upon assembly.

In these cases, use automatic transmission fluid as specified in Maintenance and Lubrication in this manual.

Notice:

When repairing a power steering gear or pump, if broken components of foreign material are encountered, the remaining components of the entire hydraulic system should be disassembled, inspected, cleaned, and flushed before servicing is completed or serious damage to the system may result.

Tandem Hydraulic Pump Description

A tandem hydraulic pump has two independent hydraulic pumps inside one casing. Its main parts can be classified into the following three.

- hydraulic pump (vane type)
- flow control valve
- pressure relief valve

The following is a description of the functions and operation of the main parts.

Functions

The heart of the system, namely the part that supplies hydraulic pressure, which operates the hydro boost and the P/S. The hydraulic pump is installed directly to the engine and is driven by gears. It smoothly adapts itself to severe conditions of use, including a wide range of rotation speeds, changes in the temperature at which it is used, and frequent changes in load pressure, and it is able to fully perform its functions.

Operation

Its drive is transmitted by gears from the engine to the drive shaft of the oil pump, and it turns a rotor that is fitted into the spline part of the drive shaft. When the rotor rotates, the ten vanes built into the rotor groove fly out by centrifugal force, are pressed against by the inside surface of the cam ring, and rotate along the inside surface so that the pump operates.

Suction and discharge of the hydraulic oil is done by a pressure plate and side plate attached to both ends of the cartridge.

Suction openings and discharge openings are provided in two locations each in symmetrical positions with respect to the axis of rotation, and because the load on the bearings due to the discharge pressure is balanced, a tandem oil pump is also called a balanced hydraulic pump.

Because it has a double pump effect per rotation, this pump provides large discharge flow in proportion to the space it occupies. Also, some of the hydraulic oil that is discharged is led to the base of the vanes and ensures the quality of the seal between the vane tips and the cam, and even it the vanes and cam rings becomes a little worn, the seal is hardly affected at all (with respect to discharge, oil tightness).

Diagnosis Information and Procedures

Objectionable "Hiss"

POSSIBLE CAUSE	CORRECTION
Noisy relief valve. There is some noise in all power steering systems. One of the most common is a hissing sound most evident at standstill parking. Hiss is a high frequency noise similar to that experienced while slowly closing a water tap. The noise is present in every valve and results from high-velocity fluid passing through valve orifice edges. There is no relationship between this noise and performance of the steering. "Hiss" may be experienced when the steering wheel is at the end of travel or when slowly turning at standstill.	Do not replace valve unless "hiss" is extremely objectionable. A replacement valve will also exhibit slight noise and is not always a cure for the objection.

Rattle or Chuckle Noise in Steering Gear

POSSIBLE CAUSE	CORRECTION
1. Gear loose on frame	1. Check gear mounting. Torque bolts to specifications.
2. Steering linkage looseness	2. Check linkage pivot points for wear. Replace if necessary.
3. Pressure hose touching other parts of truck.	3. Adjust hose position. Do not bend tubing by hand.
4. Loose pitman shaft over center adjustment. A slight rattle may occur on turns because of increased clearance off the "high point." This is normal and clearance must not be reduced below specified limits to eliminate this slight rattle.	4. Adjust.
5. Loose pitman arm	5. Torque pitman arm nut.

Groan Noise in Steering Pump

POSSIBLE CAUSE	CORRECTION
1. Low oil level.	1. Fill reservoir to proper level.
2. Air in the oil. Poor pressure hose connection	2. Torque connector. Bleed system.

Rattle or Knock Noise in Steering Pump

POSSIBLE CAUSE	CORRECTION
Loose pump gear nut	Torque nut.

Rattle Noise in Steering Pump

POSSIBLE CAUSE	CORRECTION
1. Vanes not installed properly.	1. Install properly.
2. Vanes sticking in rotor slots.	2. Repair or replace.

Swish Noise in Steering Pump

POSSIBLE CAUSE	CORRECTION
Defective flow control valve.	Repair or replace.

Whine Noise in Steering Pump

POSSIBLE CAUSE	CORRECTION
Pump shaft bearing scored.	Replace housing and shaft. Flush and bleed system.

Growl Noise in Steering Pump

POSSIBLE CAUSE	CORRECTION
Excessive back pressure in hoses or steering gear caused by restriction.	Locate restriction and correct. Replace part if necessary.

Growl Noise in Steering Pump (Particularly Noticeable at Standstill Parking)

POSSIBLE CAUSE	CORRECTION
1. Scored pressure plates, thrust plate or rotor.	1. Replace parts and flush system.
2. Extreme wear of cam ring.	2. Replace parts.

Excessive Play or Looseness in Steering System (Steering Wanders)

POSSIBLE CAUSE	CORRECTION
1. Front wheel bearings loosely adjusted.	1. Adjust bearings or replace with new parts as necessary.
2. Worn coupling or steering shaft U-joints.	2. Replace.
3. Steering wheel loose on shaft, loose pitman arm, tie rods, steering arms, or steering linkage ball studs.	3. Torque to proper specifications.
4. Steering gear worm bearing loosely adjusted.	4. Adjust preload.
5. Excessive pitman shaft to ball nut lash in steering gear.	5. Adjust preload.

POSSIBLE CAUSE	CORRECTION
6. Toe-in out of adjustment or worn drag link or tie rod sockets.	6. Replace tie rod ends if worn. Adjust to correct toe-in, and inspect steering arm and tie rod for a bent condition.
7. Steering system out of alignment.	7. Align steering complete, caster, camber, and toe-in. Inspect spring components for condition and wear. Repair or replace as required.
8. Tires badly worn, edge of tires are rounded off.	8. Install new tires, and check alignment; abnormal tire wear indicates improper alignment.
9. Lack of lubrication in linkage and kingpins.	9. Free up and lubricate any components that are frozen and will not take lubrication.
10. Air in system.	10. Add oil to pump reservoir and bleed. Check hose connectors and proper torque.
11. Steering gear mounting loose.	11. Tighten attaching bolts to specified torque.

Vibration and Shimmy

POSSIBLE CAUSE	CORRECTION
1. Seal damage and leakage resulting in loss of lubricant, corrosion and excessive wear	1. Replace damaged parts as necessary.
2. Tires, wheels, or brake drums out of balance.	2. Balance tires and wheels, preferably with on-vehicle type balancer, as this method balances entire wheel and drum assembly.
3. Bent wheel or out of round tire. Wheel nuts torque unevenly.	3. Replace wheel, and remount tire, or repair.
4. Loose steering linkage components.	4. Adjust, torque, and repair linkage as necessary.
5. Wheel loose on hub.	5. Inspect wheel bolt holes for damage, and replace wheel or torque nuts.
6. Driveline universal joints rough, or defective. This condition may be confused with steering vibration.	6. Repair driveline.
7. Engine misses or is out of balance, this may also be confused with steering shimmy.	7. Correct miss in engine, or repair out of balance condition, clutch, pressure plate, or harmonic balancer, etc.
8. Faulty shock absorbers.	8. Replace shock absorbers.

Hard Steering Excessive Effort Required at Steering Wheel

POSSIBLE CAUSE	CORRECTION
1. Low or uneven tire pressure.	1. Inflate to specified pressures.
2. Steering linkage kingpins or ball joints need lubrication.	2. Lubricate, and free up kingpins or ball joints. Make certain all fittings take lubricant properly.
3. Tight or frozen drag link or tie rod.	3. Lube or replace as necessary.
4. Steering gear to column misalignment.	4. Align column.
5. Steering gear preload too tight.	5. Adjust preload.
6. Front wheel alignment incorrect.	6. Check alignment and correct as necessary.

POSSIBLE CAUSE	CORRECTION
7. Steering gear selector shaft adjusted too tight.	7. Adjust selector shaft.
8. Frozen or tight shaft bearings.	8. Replace bearings.
9. Lower U-joint flange rubbing against adjuster.	9. Loosen bolt, assembly and torque properly.
10. Tight or binding conditions in steering column.	10. Adjust steering column.

Pump Inoperative, Poor, or no Assist (Hard Steering)

POSSIBLE CAUSE	CORRECTION
1. Low oil level.	1. Fill reservoir to proper level.
2. Air in the oil.	2. Locate source of air leak and correct.
3. Defective hoses or steering gear.	3. Repair or replace.
4. Flow control valve stuck.	4. Repair or replace.
5. Loose nut in end of flow control valve.	5. Torque nut not specifications.
6. Pressure plate not flat against.	6. Repair or replace.
7. Extreme wear of pumping.	7. Repair or replace.
8. Scored pressure plate, thrust plate.	8. Repair or replace.
9. Vanes not installed properly.	9. Repair or replace.
10. Vanes sticking in rotor slots.	10. Repair or replace.
11. Faulty flow control valve assembly.	11. Repair or replace.

Momentary Increase in Effort when Turning Wheel Fast to Right or Left

POSSIBLE CAUSE	CORRECTION
1. Low oil level in pump.	1. Add power steering fluid as required.
2. High internal leakage in hydraulic pump.	2. Check pump pressure. (See pump pressure test.)
3. High internal leakage in steering gear.	3. Repair source of leak.

Steering Wheel Surges or Jerks when Turning with Engine Running Especially During Parking

POSSIBLE CAUSE	CORRECTION
1. Low oil level.	1. Fill as required.
2. Insufficient pump pressure.	2. Check pump pressure. (See pump pressure test.) Replace relief valve if defective.
3. Defective gear relief valve.	3. Replace gear relief valve.
4. Sticky flow control valve.	4. Repair or replace.

Steering Pulls to Left or Right

POSSIBLE CAUSE	CORRECTION
1. Camber or caster incorrectly adjusted. Steering will generally pull to side of axle having greatest positive camber.	1. Adjust camber and caster.
2. Low air pressure in right or left tire. Steering will pull to side having low air pressure.	2. Inflate tire to correct pressure, check for air leak and repair as required.
3. Axle loose and shifted at spring U-bolts.	3. Align axle, and torque U-bolt nuts. Inspect for damaged parts. Replace if required.
4. Rear axle loose at spring. U-bolt if shifted at one side will cause steering to pull.	4. Align rear axle and replace defective parts, if any. Torque U-bolts to specifications.
5. Unbalanced steering gear control or spool valve. If this is caused steering effort will be very light in direction of lead and heavy in opposite direction.	5. Replace valve.

Poor Return of Steering Wheel

POSSIBLE CAUSE	CORRECTION
1. Lack of lubrication in linkage.	1. Lube linkage.
2. Steering gear to column misalignment.	2. Align steering column.
3. Tires not properly inflated.	3. Inflate to specified pressure.
4. Improper front wheel alignment.	4. Check and adjust as necessary.
5. Steering linkage binding.	5. Replace pivots as required.
6. Steering wheel rubbing against directional signal housing. (Turn steering wheel and listen for internal rubbing in column.)	6. Adjust steering jacket.
7. Tight steering shaft bearings.	7. Replace bearings.
8. Sticky or plugged valve spool.	8. Repair or replace valve.
9. Steering gear out of adjustment	9. Check adjustment. Adjust as required.
10. Tight kingpin bushings.	10. Lubricate or replace as required.
11. Lower U-joint flange rubbing against steering gear adjuster plug.	11. Loosen pinch bolt and assembly properly.

Snapping or Chucking in Steering Column or Wheel

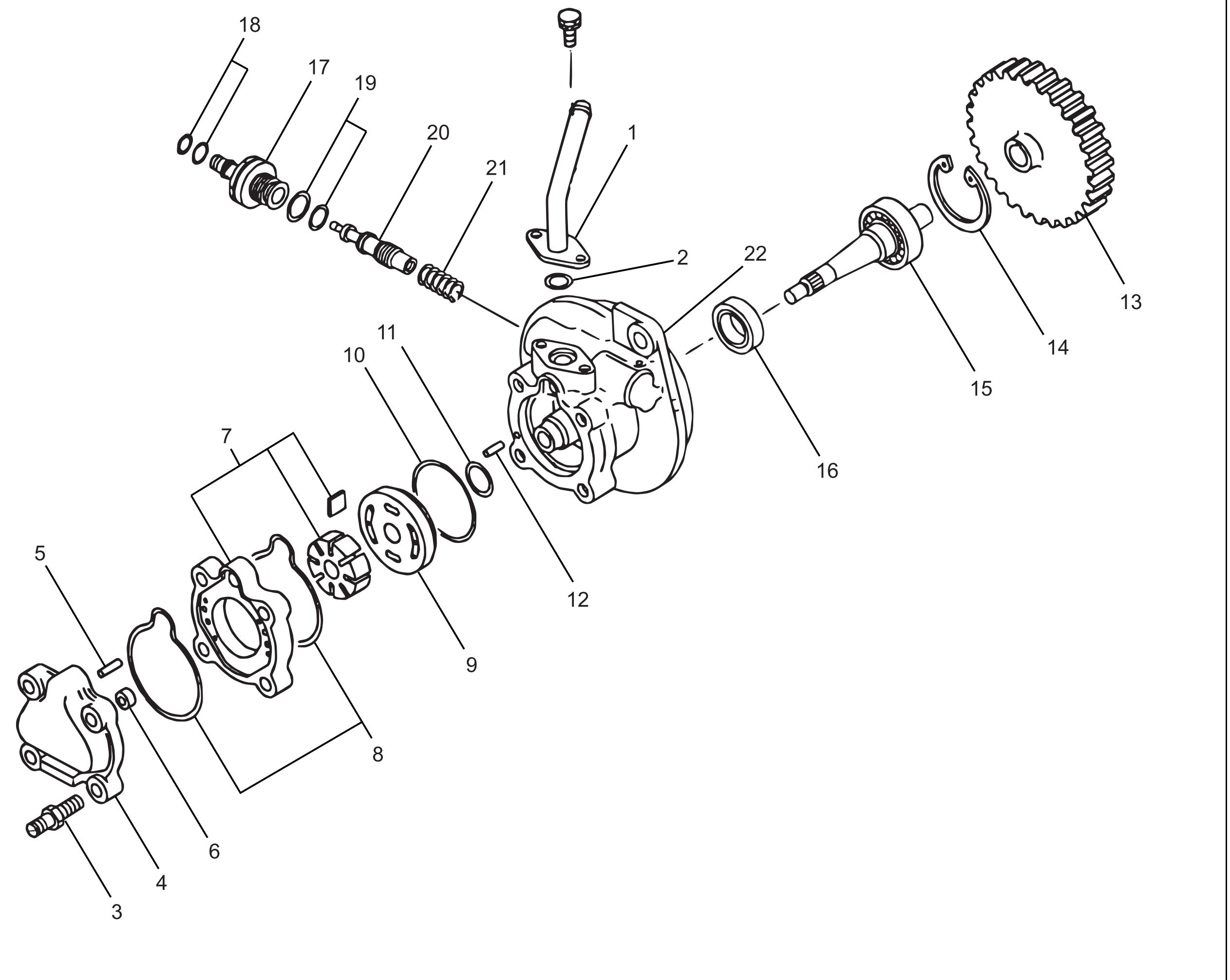
POSSIBLE CAUSE	CORRECTION
1. Loose steering gear at frame.	1. Torque mounting bolts to specifications.
2. Worn steering shaft universal joints.	2. Replace and repair joints as necessary.
3. Worn steering linkage components will telescope through steering system and be felt in steering wheel.	3. Adjust, torque, and repair components.
4. Steering gear incorrectly adjusted.	4. Adjust steering gear.

Excessive Road Shock

POSSIBLE CAUSE	CORRECTION
1. Tire pressure too high.	1. Deflate to correct pressure.
2. Wheel bearings adjusted too loose.	2. Adjust bearings.
3. Camber adjustment incorrect.	3. Adjust camber to specifications.
4. Weak or broken front spring.	4. Replace spring.
5. Defective shock absorbers.	5. Replace shock absorbers.
6. Loose suspension components.	6. Inspect, adjust or repair, and replace as necessary.

Repair Instructions

Power Steering Oil Pump



Legend

1. Suction pipe	12. Pin
2. Seal (O-ring)	13. Gear
3. Bolt	14. Snap ring
4. End cover	15. Shaft assembly
5. Pin	16. Oil seal
6. Bushing	17. Connector
7. Cartridge assembly	18. Seal (O-ring)
8. Seal (O-ring)	19. Seal (O-ring)
9. Side plate	20. Valve assembly
10. Seal (O-ring)	21. Spring
11. Seal (O-ring)	22. Body

Preparation

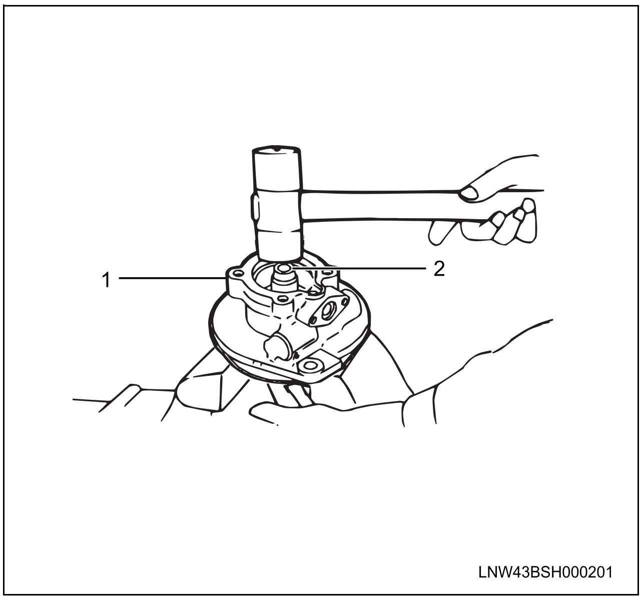
- Hydraulic pump as outlined previously.

Clean

- Exterior of hydraulic pump.

Removal Procedure

1. Suction pipe, and seal (O-ring).
2. Gear.
3. Bolt and end cover.
4. Pin and bushing.
5. Cartridge assembly, and Seal (O-ring).
6. Side plate, seal (O-ring), seal (O-ring), and pin.
7. Snap ring.
8. Shaft assembly.
   - Use a mallet to remove the shaft assembly from the housing.



Legend

1. Housing
2. Shaft Assembly

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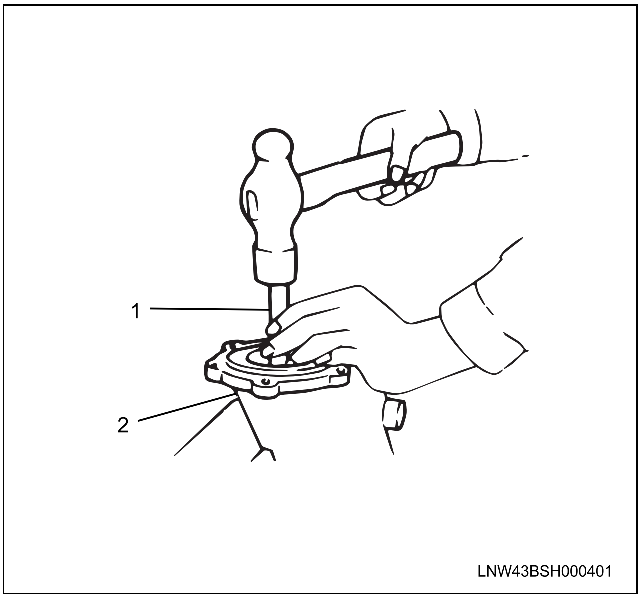
9. Oil seal.
   - Use a brass drift (C) to remove the oil seal from the housing.



Legend

1. Brass Drift
2. Housing

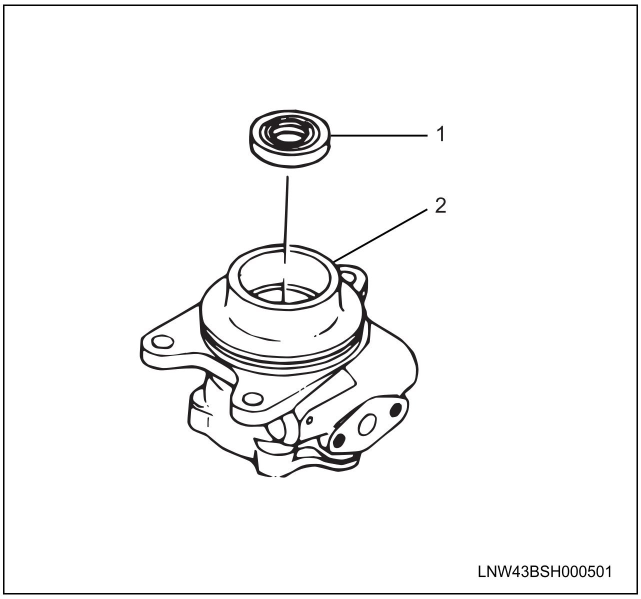
---

10. Seal (O-ring), connector, and seal (O-ring).
11. Valve assembly, and spring.

Installation Procedure

Notice:
'See NOTICE' on page 3B3-2 of this section for steps 7, 10 and 11.

1. Pump shaft oil seal into the pump housing using a proper size rod and press or hammer.



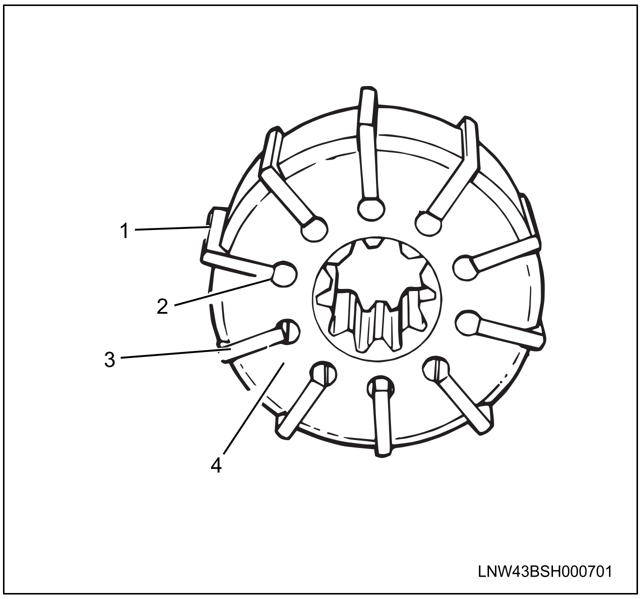
Legend

1. Pump Shaft Oil Seal
2. Pump Housing

---

2. Shaft assembly into the pump housing assembly.
3. Snap ring into the pump housing assembly.
4. Gear onto the shaft assembly. The long hub of the gear faces the pump housing assembly.

5. Vanes in the rotor with the flat edge (E) facing inward.



Legend

1. Rounded Edge
2. Flat Edge
3. Vane
4. Rotor

---

6. Vanes and rotor into the cartridge. Any stamped marked on the cam or rotor face housing.
7. Pin, seal (O-ring), side plate, cartridge assembly, seal (O-ring), pin, bushing, and end cover, to the pump housing assembly.

Tighten

- Cover bolts to 20 N·m (14 lb ft).

8. Spring, flow control valve assembly, seal (O-ring) and connector.

Tighten

- Connector to 49 N·m (36 lb ft).

9. Seal (O-ring) and suction pipe.

Tighten

- Suction pipe bolts to 8 N·m (69 lb in).

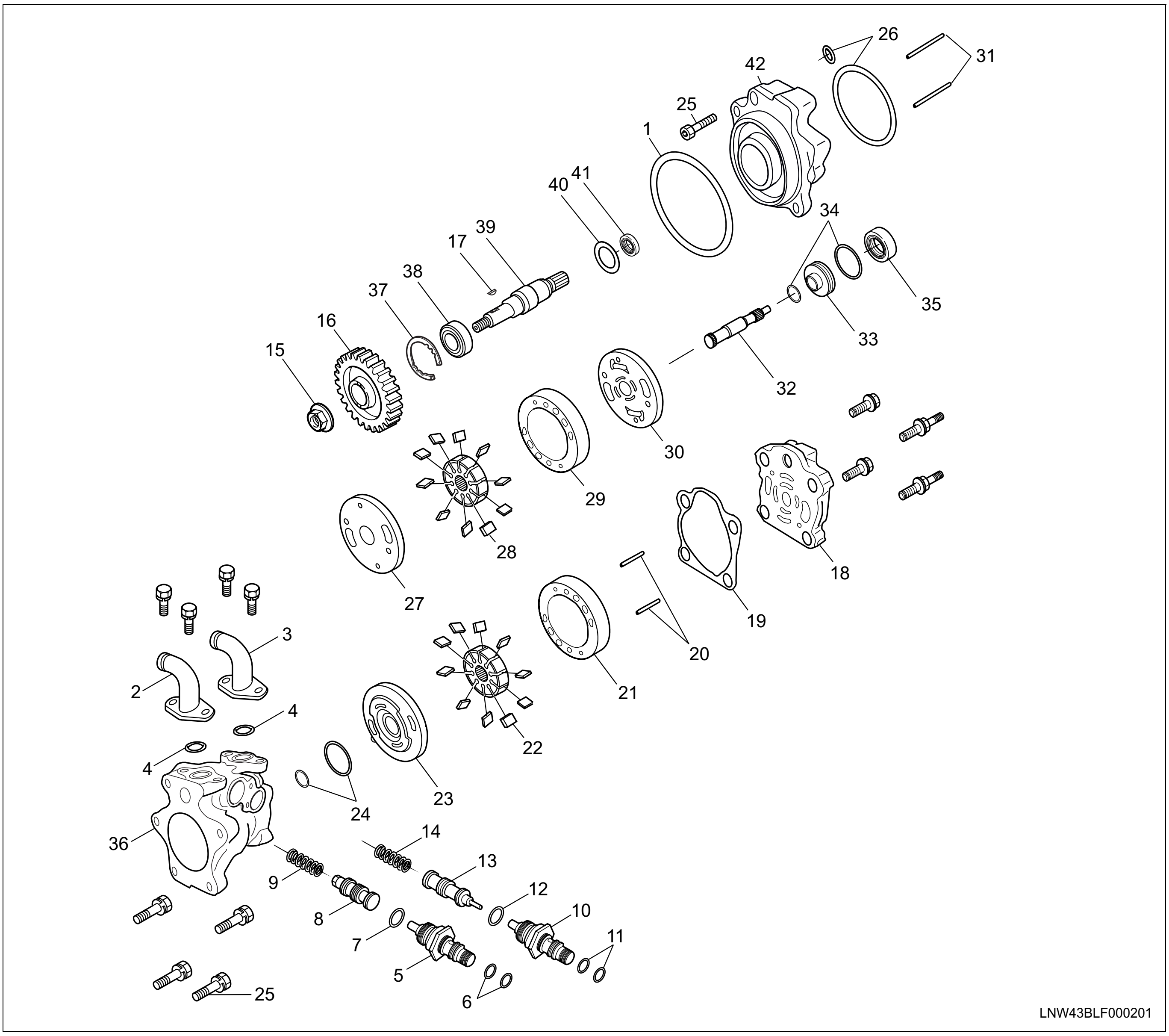
Clean

- All parts in a suitable solvent and blow dry with compressed air. Be sure to use clean solvent to clean internal parts.

Inspection

- Cartridge assembly.
  - Vane tips of cartridge assembly for wear.
  - Vanes for scoring or wear.
  - Inner surface of the ring for scoring, wear, damage, etc.
  - Fit of the vanes in the rotor. The vanes must fit properly in the rotor slots, without sticking or excessive play. Also check for burrs in the rotor slots, and excessive wear at the thrust faces.
  - If heavy wear is present, or if parts are damaged, replace the entire cartridge assembly.
- Side plate for wear at the thrust faces.
  Replace if excessive wear is evident.
- Ball bearing. If the bearing is rough or loose, replace it as outlined later in this section.
- Seal contact area of the shaft assembly. If fretting or roughness is present, replace the shaft.
- Gear for rough or chipped teeth.
- Flow control valve assembly for scoring or burrs. Also, inspect the flow control valve bore in the pump housing for burrs.

Tandem Hydraulic pump



Legend

1. O-ring
2. Hose Connector: HBB (Hydraulic Brake Booster)
3. Hose Connector: PS
4. O-ring
5. Connector: HBB
6. O-ring
7. O-ring
8. Valve
9. Spring
10. Connector: P/S
11. O-ring
12. O-ring
13. Valve
14. Spring
15. Nut
16. Gear
17. Key
18. Rear Body
19. Gasket
20. Pin
21. Cam
22. Rotor and Vane: P/S
23. Pressure Plate
24. O-ring
25. Bolt
26. O-ring
27. Side Plate
28. Rotor and Vane: HBB
29. Cam
30. Pressure Plate
31. Pin
32. Shaft
33. Retainer
34. O-ring
35. Oil Seal
36. Pump Housing
37. Snap Ring
38. Ball Bearing

39. Shaft
40. Retainer Ring
41. Oil Seal
42. Front Body

Preparation

- Hydraulic pump as outlined previously.

Clean

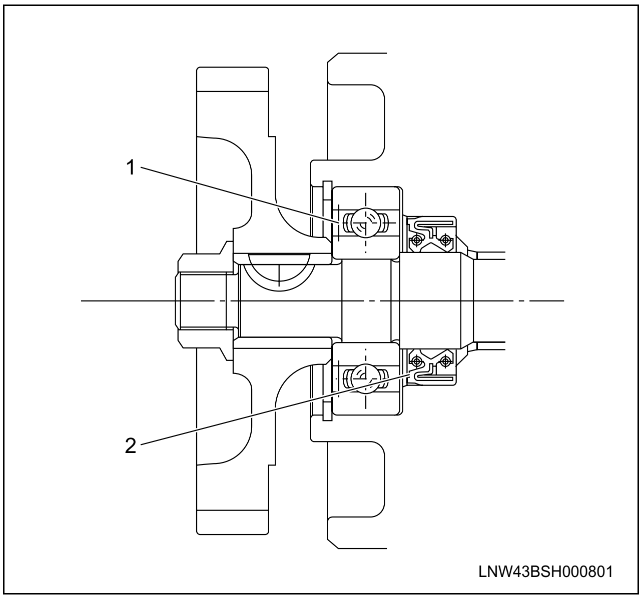
- Exterior of hydraulic pump.

Removal Procedure

1. O-ring (flywheel housing side).
2. Hose connectors.
3. O-rings.
4. Connector, O-rings, valve and spring.
5. Connector, O-rings, valve and spring.
6. Nut, gear and key.
7. Bolts, rear body and gasket.
8. Pins, cam and rotor and vane.
9. Pressure plate and O-rings.
10. Five bolts and O-rings.
11. Pressure plate, cam, rotor and vane, side plate and pins.
12. Shaft, Retainer and O-rings.
13. Oil seal and pump housing.
    - Use a brass drift to remove the oil seal form the pump housing.
14. Snap ring, shaft assembly and retainer ring.
    - Use a mallet to remove the shaft assembly from the front body.
15. Ball Bearing and shaft.
    - A press and rod will be necessary to remove the ball bearing from the shaft.
16. Oil seal and front body.
    - Use a brass drift to remove the oil seal from the front body.

Installation Procedure

1. Oil seal into the front body using a proper size rod and press or hammer.
    - Install oil seal as illustration shows.
2. Press the shaft, into the ball bearing as illustration.

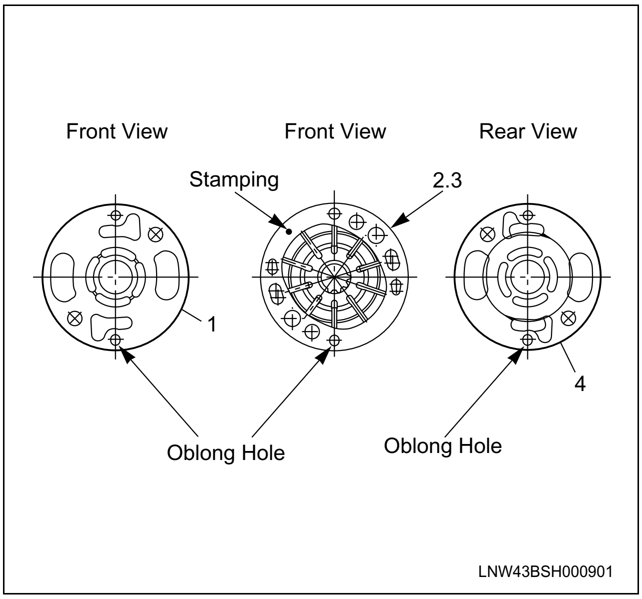


Legend
1. Shield Plate
2. Stamping

---

3. Place the retaining ring in the front body and install the shaft assembly into the front body using a press or hammer.
4. Snap ring into front body.
5. Oil seal into pump housing using a proper size rod and press or hammer.
6. O-rings, retainer and shaft into pump housing.

7. Set pressure plate, cam, rotor and vane, side plate and pins in place as illustration.



Legend

1. Side Plate
2. Rotor and Vane
3. Cam
4. Set Pressure Plate

---

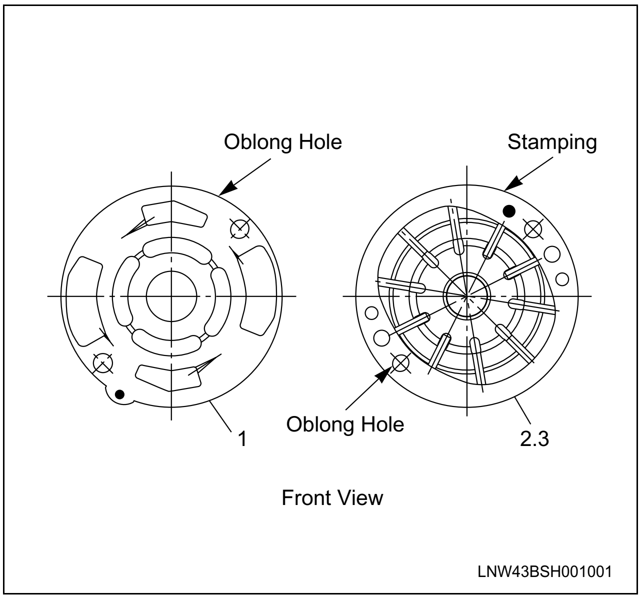
8. Attach O-rings into front body grooves and assemble front body and pump housing by tightening bolts.

Tighten

- 4 (four) Bolts to 54 N·m (40 lb ft)
- 1 (one) Bolt to 25 N·m (18 lb ft)

9. Install O-rings into pump housing.

10. Set pressure plate, rotor and vane, cam and pins into pump housing as illustration.



Legend

1. Set Pressure Plate
2. Cam
3. Rotor and Vane

---

11. Install gasket and rear body.

Tighten

- Bolts to 34 N·m (25 lb ft)

12. Key, gear and nut onto shaft.
    - The long hub of the gear faces front body.

Tighten

- Nut to 103 N·m (76 lb ft)

13. Spring, valve, O-ring, O-rings and connector into pump housing.

Tighten

- Connector to 54 N·m (40 lb ft)

14. Spring, valve, O-ring, O-rings and connector into pump housing.

Tighten

- Connector to 54 N·m (40 lb ft)

15. O-rings and hose connector.

Tighten

- Bolts to 21 N·m (15 lb ft)

16. Attach O-ring.

Clean

- All parts in a suitable solvent and blow dry with compressed air. Be sure to use clean solvent to clean internal parts.

Inspection

- Cartridge assembly.
  - Vane tips of cartridge assembly for wear.

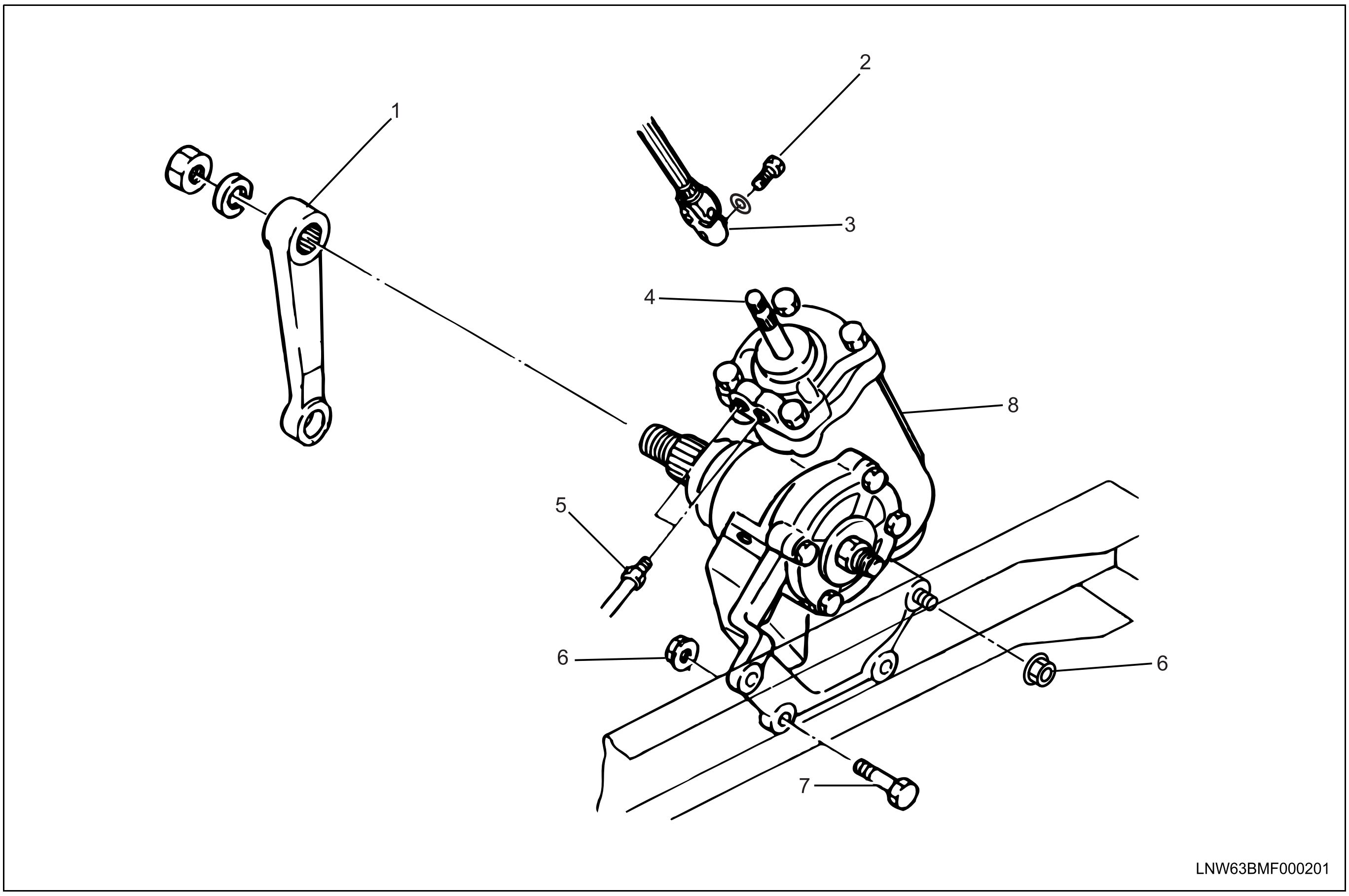
  - Vanes for scoring or wear.
  - Inner surface of the ring for scoring, wear, damage, etc.
  - Fit of the vanes in the rotor. The vanes must fit properly in the rotor slots, without sticking or excessive play. Also check for burrs in the rotor slots, and excessive wear at the thrust faces.
  - If heavy wear is present, or if parts are damaged, replace the entire cartridge assembly.
- Side place for wear at the thrust faces.

Replace if excessive wear as evident.

- Ball bearing. If the bearing is rough or loose, replace it.
- Seal contact area of the shaft. If fretting or roughness is present, replace the shaft.
- Gear for rough or chipped teeth.
- Flow control valve assembly for scoring or burrs. Also, inspect the flow control valve bore in the pump housing for burrs.

If heavy damage is present, replace pump housing assembly together with valves.

Steering Gear



Legend

1. Pitman Arm
2. U-Joint Bolt
3. Steering Shaft U-Joint
4. Steering Gear Input Shaft
5. Hydraulic Line
6. Nut
7. Bolt
8. Steering Gear

Preparation

- Place the steering wheel and front wheels in the straight ahead position.
- Provide a pan for power steering fluid to drain into, when hydraulic lines are disconnected.

Removal Procedure

1. Pitman arm as outlined in Steering Linkage in this manual.
2. U-joint bolt.
3. Put reference marks on the U-joint and input shaft. Then remove steering shaft U-joint from the steering gear input shaft.
4. Hydraulic lines from the steering gear.

5. Nuts and bolts.
6. Steering gear.

Installation Procedure

Notice:
For steps 2 and 5, refer to Description and Operation.

1. Steering gear to the frame.
2. Bolts and nuts.

Tighten

- Steering gear bolts to 103 N·m (76 lb ft).

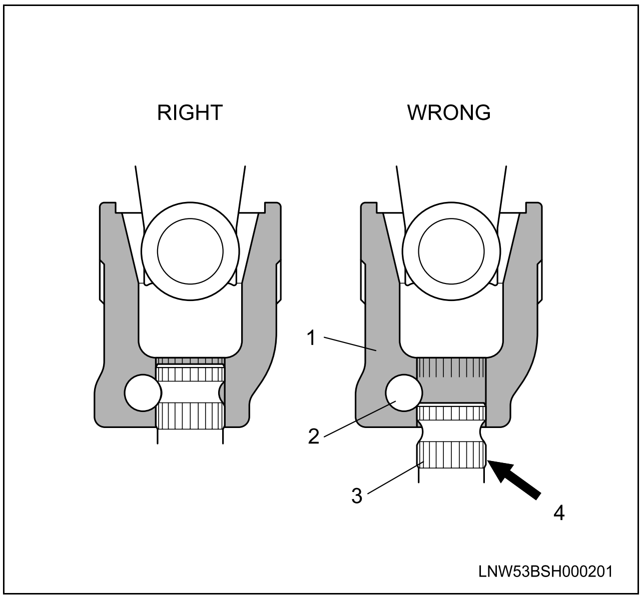
3. Hydraulic lines to the steering gear.
4. Steering shaft U-joint to the steering gear input shaft. Be sure to align the reference marks. Check to be sure the steering wheel is in the straight ahead position.
5. U-joint bolt.

Tighten

- U-joint bolt to 25 N·m (18 lb ft).

Notice:

- The U-Joint Bolt(2) must be removed to install the steering shaft U-Joint (1) to the steering gear input shaft (3).
- Be sure that the U-Joint Bolt passes through the steering gear input shaft groove when it is reinstalled.
- Following steering shaft installation, mark sure that the serrated area (4) is not visible (if it is visible, the installation process has been performed improperly).

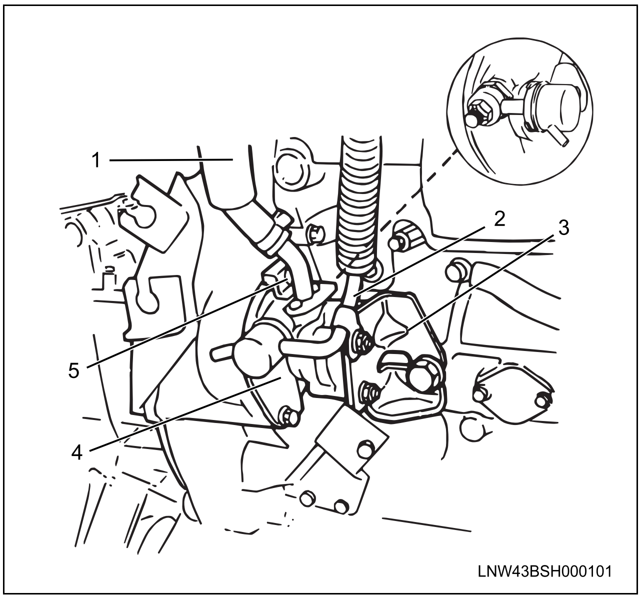


6. Pitman arm to the sector shaft. Refer to Steering Linkage in this manual.
   - Bleed the hydraulic system as outlined in this section.

Power Steering Pump

Removal Procedure

1. Bracket.
2. Pump inlet hose (B).
3. Pump outlet flex hose.
4. Pump bolts, and pump.



Legend

1. Pump Inlet Hose
2. Pump Outlet Flex Hose
3. Bracket
4. Pump
5. Pump Bolt

Installation Procedure

1. New seal (O-ring) to the hydraulic pump.
2. Hydraulic pump to the engine.
3. Steering gear pump bolts.
4. Pump outlet flex hose.
5. Pump inlet hose (B).
6. Bracket.
7. Fill the hydraulic system with DEXRON®-III. Bleed the system as outlined in this section.

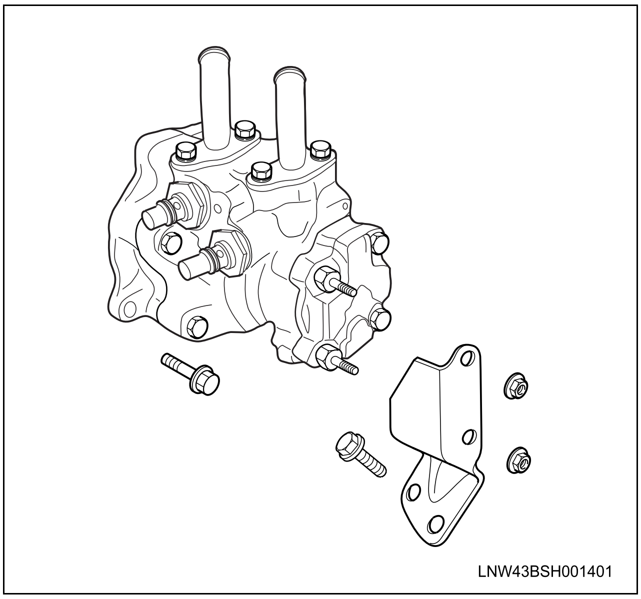
Tandem Hydraulic Pump Assembly Replacement (Hydraulic Booster Brake Model)

Removal Procedure

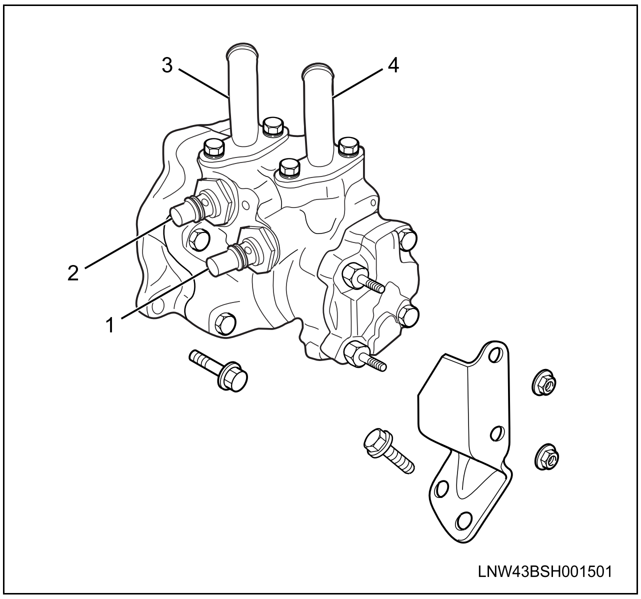
- Block the vehicle wheels and apply the parking brake.
- Battery ground cable.

1. Disconnect air intake hose at turbocharger side.
2. Raise the vehicle and remove front exhaust pipe with exhaust brake.
   - Remove bolts at manifold, silencer and support bracket.

3. Place a container under the hydraulic pump assembly to catch fluid when disconnecting hoses. Clean the surfaces around fittings before removing them.



4. Remove power steering outlet flexible hose and nut.
5. Remove hydraulic booster outlet pipe nut.
6. Remove two clips for hydraulic booster lines on the flywheel housing.
7. Remove clip for hydraulic booster lines on the left side member.
8. Hydraulic booster inlet hose.
9. Power steering inlet hose.



Legend

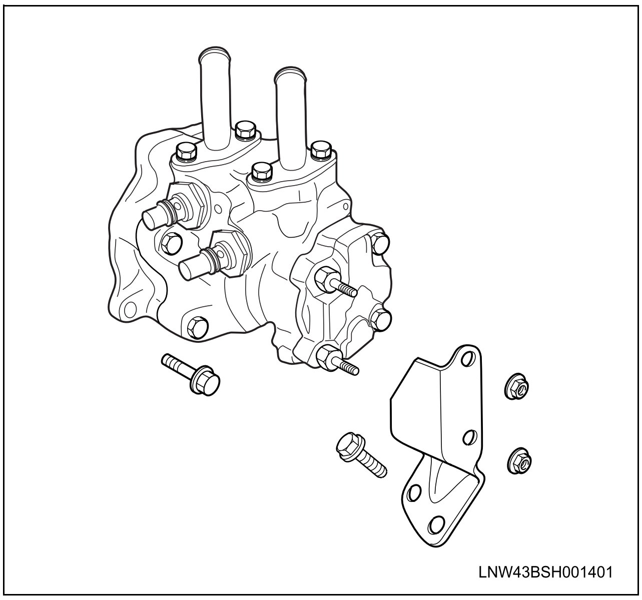
1. Power Steering Outlet
2. Hydraulic Booster Outlet
3. Hydraulic Booster inlet
4. Power Steering inlet

---

10. Remove hydraulic booster pipe from the pump.
11. Remove hydraulic pump assembly with bracket and O-ring.

Installation Procedure

1. Attach new O-ring and install hydraulic pump assembly to the engine.



2. Install booster outlet pipe and nut.

Tighten

- Nut to 23.5 N·m (17 Ib ft)

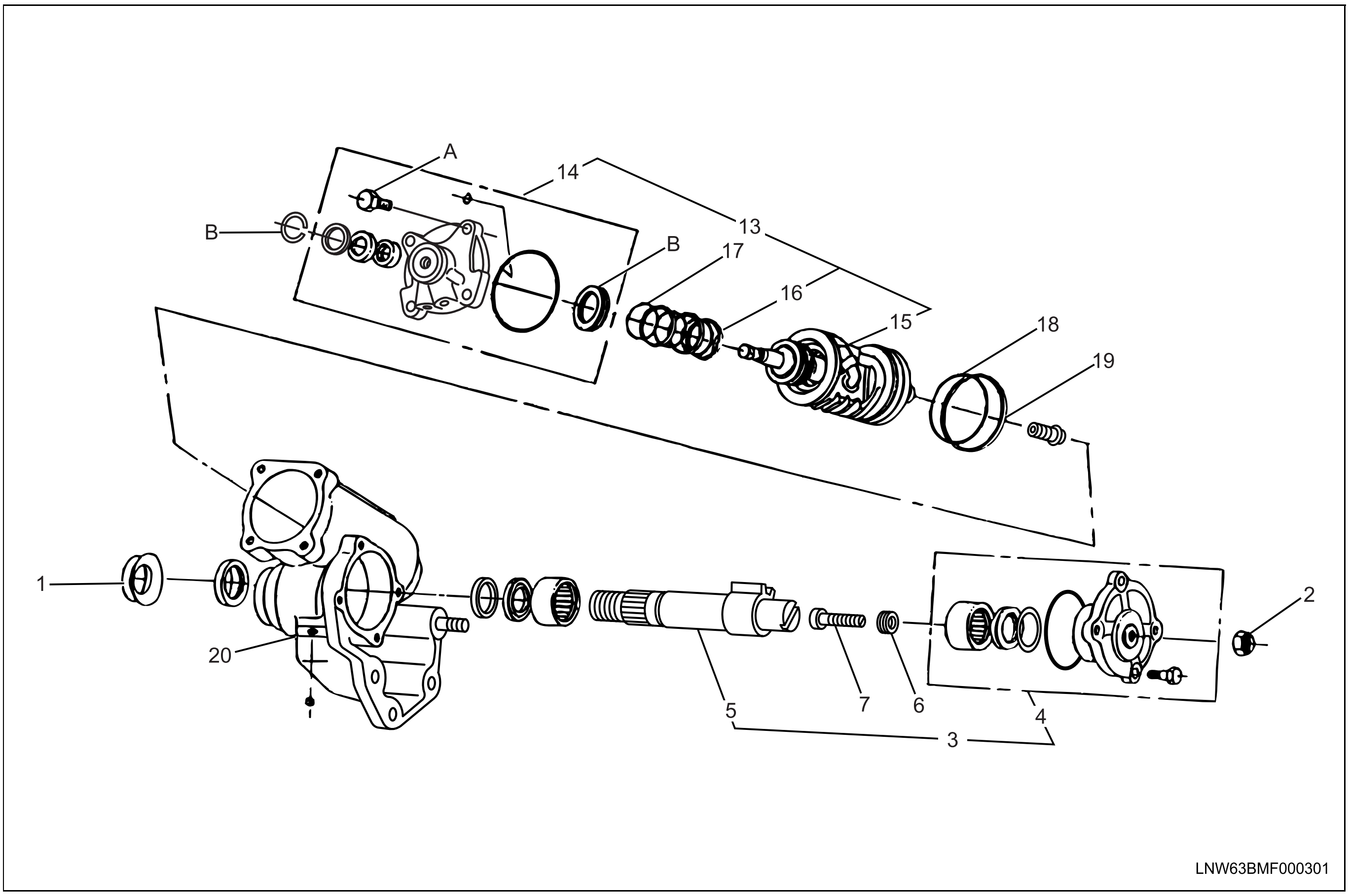
3. Install power steering outlet flexible hose and nut.

Tighten

- Nut to 23.5 N·m (17 Ib ft)

4. Connect hydraulic booster inlet hose.
5. Connect power steering inlet hose.
6. Install clips for hydraulic booster lines.
7. Connect air intake hose.
8. Install exhaust pipe with exhaust brake.
9. Fill the power steering and hydraulic booster systems with DEXRON®-III.
   Bleed the power steering system as outlined in this section.
   Bleed the hydraulic booster system. Refer to HYDRAULIC BOOSTER SYSTEM.

Power Steering Gear Unit



Legend

1. Dust Seal
2. Jam Nut
3. Side Cover and Sector Shaft Assembly
4. Side Cover Assembly
5. Sector Shaft Assembly
6. Retainer
7. Adjusting Screw
13. Valve Housing and Ball Screw Assembly
14. Valve Housing Assembly
15. Ball Nut Assembly
16. Teflon Ring
17. O-Ring
18. Teflon Ring
19. Seal (O-Ring)
20. Gear Housing Assembly

A. Screw

B. Spacer

Preparation

Steering gear, as outlined previously in this section.

Clean

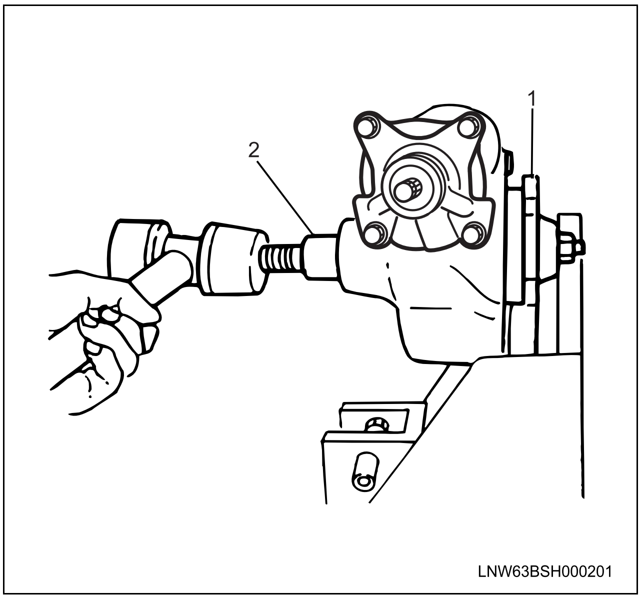
- Exterior of steering gear with solvent.

Removal Procedure

1. Dust seal.
2. Jam nut.
3. Side cover and sector shaft assembly from the rest of the unit.

- Align the sector shaft major components to a neutral position by turning the input shaft of the steering gear to lock and backing off approximately 2.5 turns.
- Turn the adjusting screw counterclockwise slightly. Then remove the bolts from the side cover assembly.

- Then remove the side cover assembly and sector shaft assembly by tapping on the end of the sector shaft with a plastic hammer.

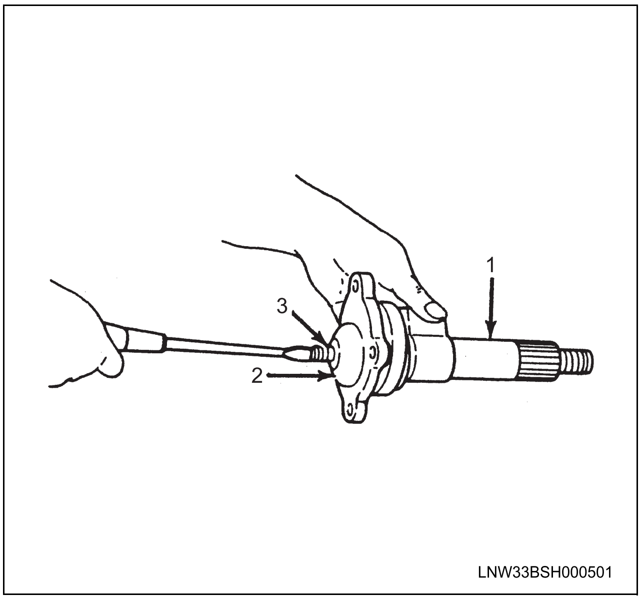


Legend

1. Side Cover Assembly
2. Sector Shaft Assembly

---

4. Sector shaft assembly from side cover assembly by turning the adjusting screw clockwise.

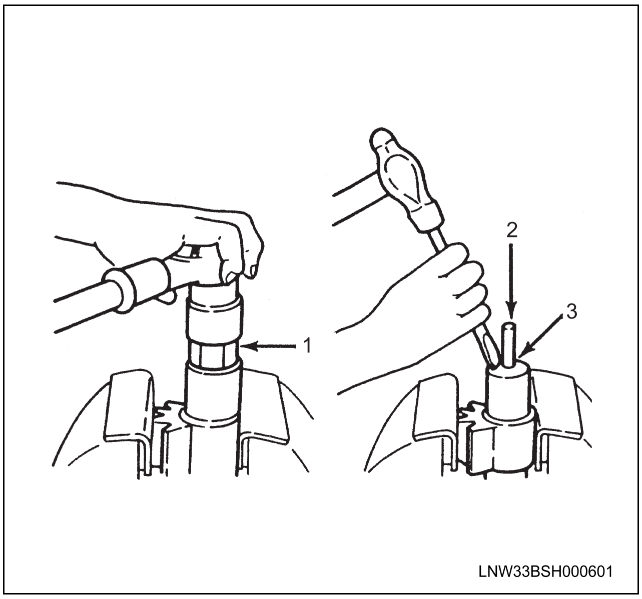


Legend

1. Sector Shaft Assembly
2. Side Cover Assembly
3. Adjusting Screw

---

5. Screw retainer.



Legend

1. Fabricated Tool
2. Sector Shaft Adjusting Screw
3. Screw Retainer

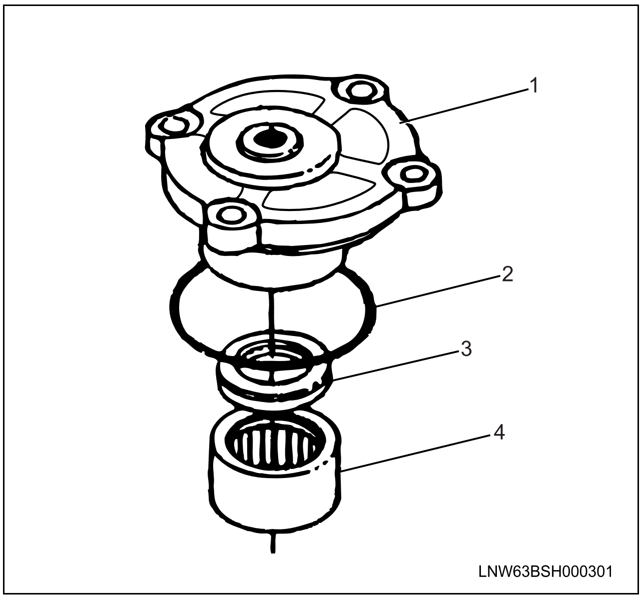
- Flatten out staked portion of the screw retainer and remove retainer.
- A tool must be fabricated to remove and install the retainer.
- Obtain a nut that will fit into the hex cutout in the screw retainer. Weld or braze the nut to a suitable deep-well socket. Drill the nut out if necessary, so the tool will fit over the sector shaft adjusting screw.

6. Sector shaft adjusting screw.
7. Screws retaining valve housing and ball screw assembly to gear housing assembly.
8. Valve housing and ball screw assembly.

Important:

- Always keep the valve housing and ball screw assembly in a horizontal position and avoid holding it vertically, or ball nut will slide out.

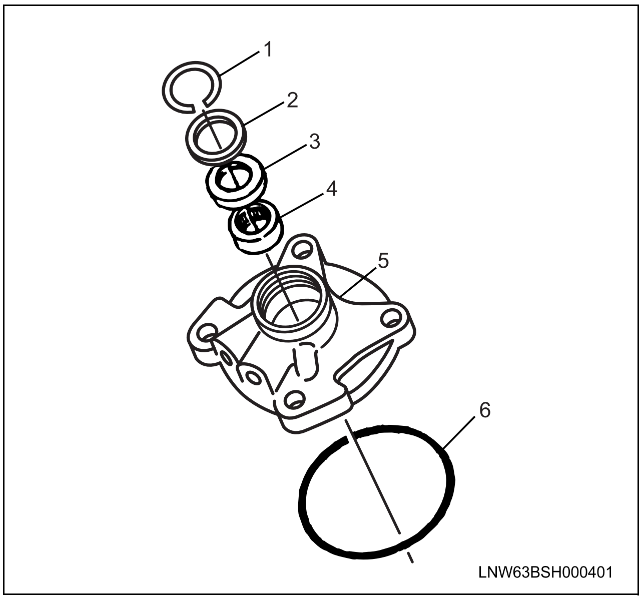
9. Remove the seal (O-ring), the needle bearing, and the seal from the side cover.



Legend

1. Side Cover
2. Seal (O-Ring)
3. Seal
4. Needle Bearing

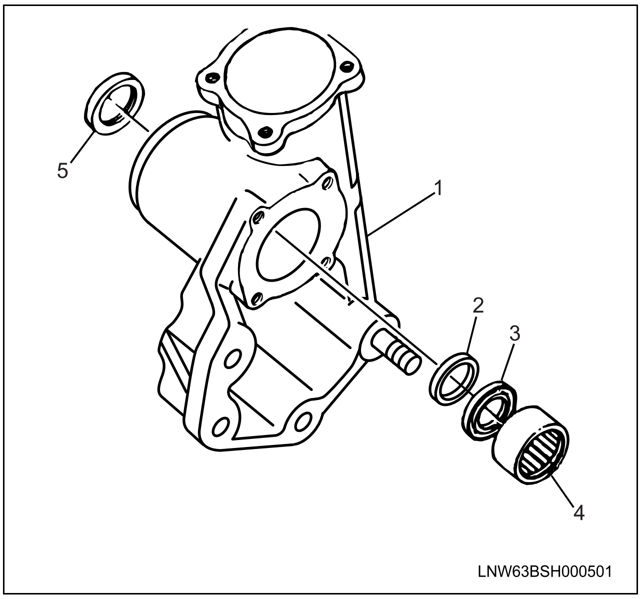
10. Remove the retaining ring, dust seal, oil seal, needle bearing, and seal (O-ring) from the valve housing.



Legend

1. Retaining Ring
2. Dust Seal
3. Oil Seal
4. Needle Bearing
5. Valve Housing
6. Seal (O-Ring)

11. Remove the outer sector shaft seal, the back up ring, the needle bearing, and the inner seal, from the gear housing.



Legend

1. Gear Housing
2. Back Up Ring
3. Inner Seal (Y-Ring)
4. Needle Bearing
5. Outer Sector Shaft Seal

Inspection Procedure

All parts in clean solvent. Blow parts dry with compressed air.

Make necessary corrections or parts replacement if worn, damaged or any other abnormal conditions are found through inspection. Inspect the following parts for wear, damage or other abnormal conditions:

- Housing.
- Sector shaft.
- Needle roller bearing.
- Ball screw assembly
- Oil seal, dust cover, inner seal, seal (O-ring) and retaining ring.

Ball Nut Rotation

Hold the worm shaft vertically and see if the ball nut rotates smoothly. If lowering of the ball nut with its own weight is not smooth, check the worm shaft for bending and ball groove for burrs, dents and the presence of foreign matter.

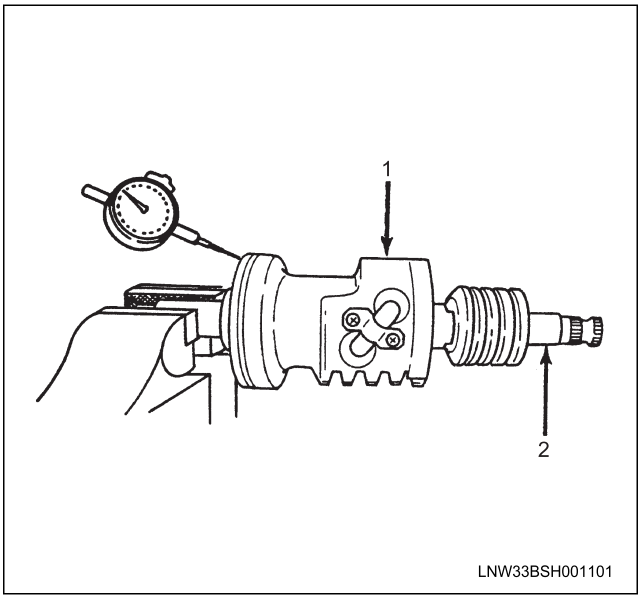
Important:

- When making a test on the ball screw assembly, exercise care not to strike the ball nut against the end of the worm shaft, or damage to the ball tubes will result.

Measure

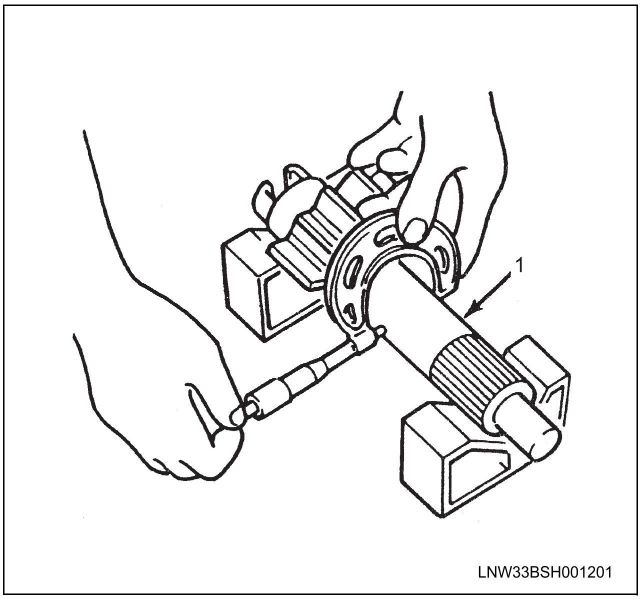
- Ball nut assembly and control valve include precision-finished parts of selective fitting.

- Always keep the ball nut assembly in a horizontal position and avoid holding it vertically, or ball nut will slide out.
- If any defects exist in the ball nut or in the control valve, the assemblies should be replaced with new parts.



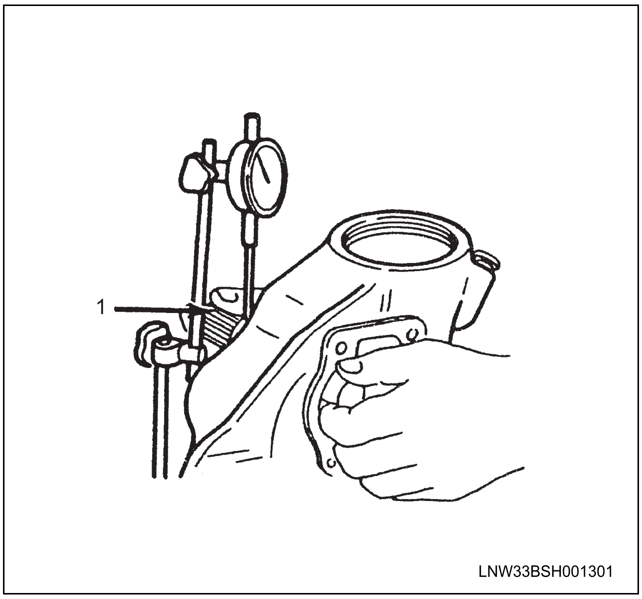
Legend

1. Ball Nut Assembly
2. Worm Shaft



Legend

1. Sector Shaft Diameter



Legend

1. Sector Shaft

1. Ball nut piston axial play. Use a dial indicator to check the axial play.
   If play exceeds 0.2 mm (0.008 in), replace the worm/ball nut piston assembly. The ball nut assembly, worm shaft, and balls are selectively fitted and are not available separately.
2. Ball nut assembly to gear housing assembly bore clearance. Measure the ball nut piston diameter, using a micrometer. Measure the housing bore inside diameter, using an inside micrometer. Subtract the ball nut piston diameter from the housing bore inside diameter to obtain the clearance. The production clearance is 0.1 mm (0.004 in). Replace the piston and/or housing if clearance exceeds specification.

Installation Procedure

1. New Teflon ring to ball nut assembly.
2. New seal (O-ring) to ball nut assembly.
3. New Teflon rings and new seals (O-rings) to ball nut assembly.
4. Keep ball nut assembly clean until ready to assemble into gear housing assembly.
5. Back up ring, inner seal into sector shaft bore.
6. Needle bearing into sector shaft bore.
7. Outer sector shaft seal into outer housing seal bore.
8. Seal mating surfaces for nicks or damage.
9. Gear teeth for wear or damage.
10. Adjusting screw for thread damage. The adjusting screw must turn smoothly in the sector shaft assembly, and not be excessively loose.
    Replace, if necessary, as outlined later.
11. Splines and threads for damage.

Measure

- Sector shaft outside diameter with micrometer. The standard diameter is 38.125 mm (1.501 in). Replace the sector shaft if the diameter is less than 38.043 mm (1.498 in).
- Sector shaft to needle bearing clearance.
- Install a dial indicator.
- Measure the clearance. If more than 0.2 mm (0.008 in), replace the sector shaft and/or bearing as needed.

12. Discard used retainer and install a new one. Use tool fabricated during disassembly. Install and fully tighten the screw retainer and back off 180°. Retighten to a torque 39 N·m (29 lb ft) and back off 20 degrees. Check that the sector shaft adjusting screw turns smoothly.
    Stake the screw retainer in position.

Inspect

- Side cover for cracks or damage to the sealing surface.

13. Seal into side cover.
14. Press needle bearing into side cover.
15. Seal (O-ring) onto side cover.
16. Fit the sector shaft into the side cover.

Adjust

- Turn the adjusting screw counterclockwise until the end of the sector shaft assembly, bottoms in the side cover assembly then turn one full turn clockwise.

Inspect

- For internal scoring and worn grooves.
- Valve housing for cracks
- Snap ring groove to be square

17. Press needle bearing into valve housing.
18. Press oil seal into valve housing with lip facing bearing.
19. Retaining ring in groove.
20. Dust seal.
21. Seal (O-ring) onto valve housing.

Notice:
Refer to Description and Operation.

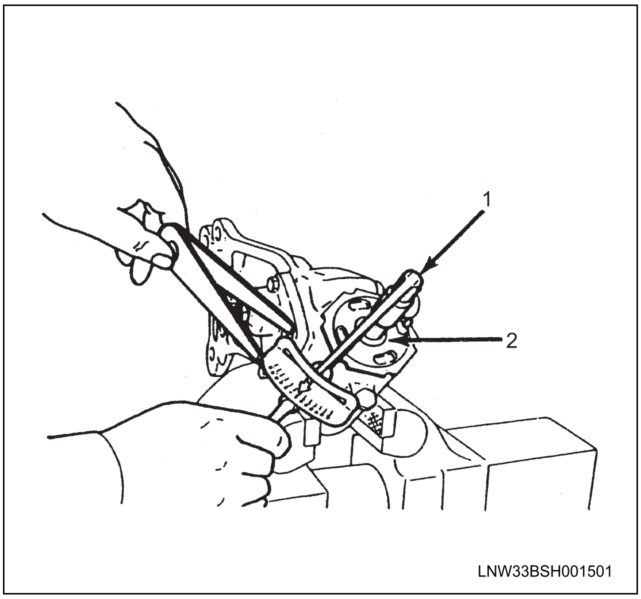
22. Install gear housing in a vise, clamped-by the mounting flange with the ball nut bore horizontal.
    - Lubricate the ball nut assembly with automatic transmission fluid.
23. Spacer on the splined end of the input shaft.
24. Ball nut assembly fully into the gear housing assembly bore.
    - Lubricate the valve housing assembly bearing and seal with automatic transmission fluid.
25. Valve housing assembly onto the gear housing assembly.

Tighten

- Valve housing bolts to 86 N·m (64 lb ft).

Measure

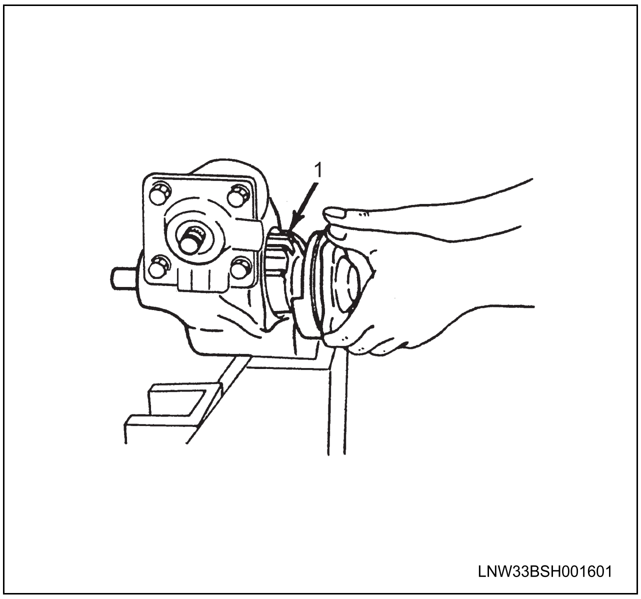
- Place torque wrench and socket J 35717 on the input shaft.



Legend

1. Input Shaft
2. Torque wrench With J 35717

26. Center the ball nut teeth in the sector shaft opening.
27. Lubricate the sector shaft and install it and the side cover assembly in the housing bore, aligning the center tooth of the sector shaft with the center tooth of the ball nut.



Legend

1. Sector Shaft and Side Cover Assembly

Tighten

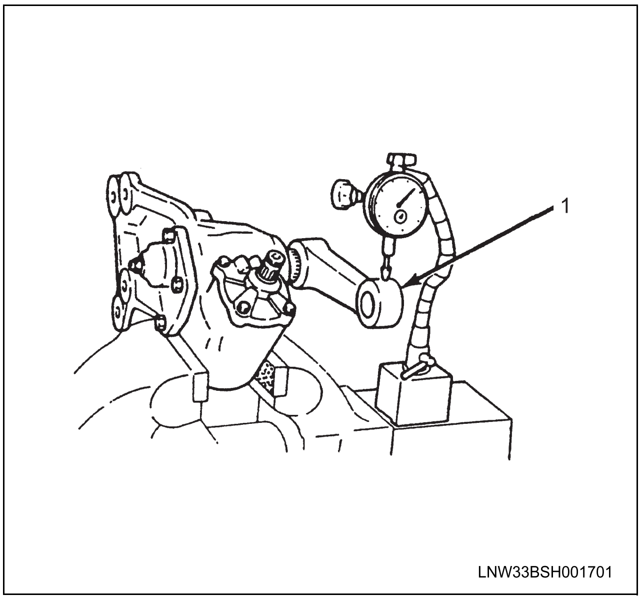
Side cover bolts to 86 N·m (64 lb ft).

28. Pitman arm onto the sector shaft until no looseness or play exists between the arm and shaft .

    Adjust

    a. Center the sector and ball nut teeth in the gear housing by turning the input shaft to the limit of travel in each direction. Count the turns from end to end.
    Then turn the input shaft one half that number of turns from one end.

    b. Set a dial indicator to read pitman arm movement.



Legend

1. Pitman Arm

---

    c. Turn the sector shaft adjusting screw until a maximum of 0.33 mm (0.013 in) movement of the pitman arm exists when measured at the end of the arm.

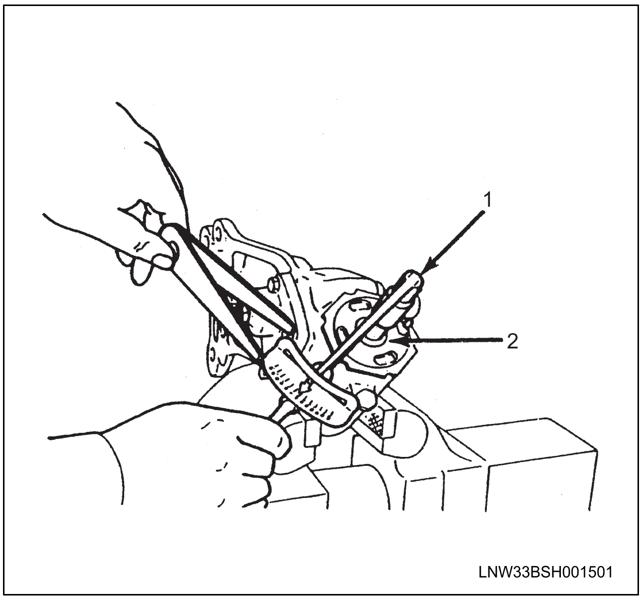
29. Jam nut on end of adjuster screw.

Tighten

- Jam nut to 69 N·m (51 lb ft)

Inspection

- Recheck the total starting torque of the input shaft. When the unit is fully assembled, the specification is 0.7 N·m (0.5 lb in).



Legend

1. Input Shaft
2. Torque wrench With J 35717

Specifications

Steering Gear Specifications

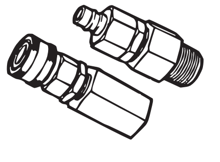
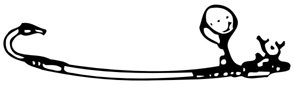
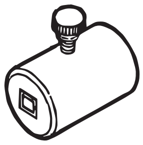
Ball Nut Piston Axial Play	0.2 mm (0.008 in)
Ball Nut Piston to Housing Bore Clearance	0.1 mm (0.004 in)
Sector Shaft Diameter (Standard)	38.125 mm (1.501 in)
Sector Shaft to Needle Bearing Clearance	0.2 mm (0.008 in)
Backlash (Measured at End of Pitman Arm)	0.33 mm (0.013 in)
Final Starting Torque of Input Shaft	0.7 N·m (0.5 lb in)

Fastener Torques

Steering Gear to Frame Rail Bolts	103 N·m (76 lb ft)
Steering Shaft U-Joint Clamp Bolt	25 N·m (18 lb ft)
Sector Screw Retainer (1) Fully Tighten Retainer and Loosen 180°. (2) Torque to 39 N·m (29 lb ft). (3) Loosen 20 degrees.	
Steering Gear Valve Housing Bolts	86 N·m (64 lb ft)
Steering Gear Side Cover Bolts	86 N·m (64 lb ft)
Sector Adjusting Screw Jam Nut	69 N·m (51 lb ft)
Steering Gear Fluid Tube Nuts	45 N·m (33 lb ft)
Pump Gear Nut	59 N·m (43 lb ft)
Power Steering Pump End Cover to Pump Housing Bolts	20 N·m (14 lb ft)
Pump Flow Control Valve Connector	49 N·m (36 lb ft)
Suction Pipe to Pump Housing Bolts	8 N·m (69 lb in)
Tandem Hydraulic Pump Hose Connector Bolt	21 N·m (15 lb ft)
Tandem Hydraulic Pump Valve Connector Bolt	54 N·m (40 lb ft)
Tandem Hydraulic Pump Gear Nut	103 N·m (76 lb ft)
Tandem Hydraulic Pump Rear Body Bolt	34 N·m (25 lb ft)
Tandem Hydraulic Pump Front Body Bolt	25 N·m (18 lb ft)
Tandem Hydraulic Pump Housing Bolt	54 N·m (40 lb ft)
Tandem Hydraulic Pump Outlet Connector Nut	23.5 N·m (17 lb ft)

Special Tools

Special Tools

Illustration	Tool Number/ Description
 AAW0Z0SH000701	J 35719 Adapter Kit
 5884001350	J 26487-A Power Steering Analyzer
 AAW0Z0SH000901	J 35717 Steering Shaft Socket

STEERING

Steering Column

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  Special Tools 3B4-11

Description and Operation

Steering Column Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

The steering column used in the vehicle covered by this manual is two-way adjustable. The column can be tilted forward and backward, and adjusted for height. The right-hand lock handle releases the column for height adjustment and for tilt adjustment.

Headlights, turn signals, hazard flashers, windshield washers and wipers, and exhaust brake are controlled by multi-function levers on the steering column. The engine control switch is also column mounted.

The column shaft is supported at the upper end by a sealed ball bearing and at the lower end by a bushing.

The steering column is connected to the steering gear by a slip-type shaft with two universal joints.

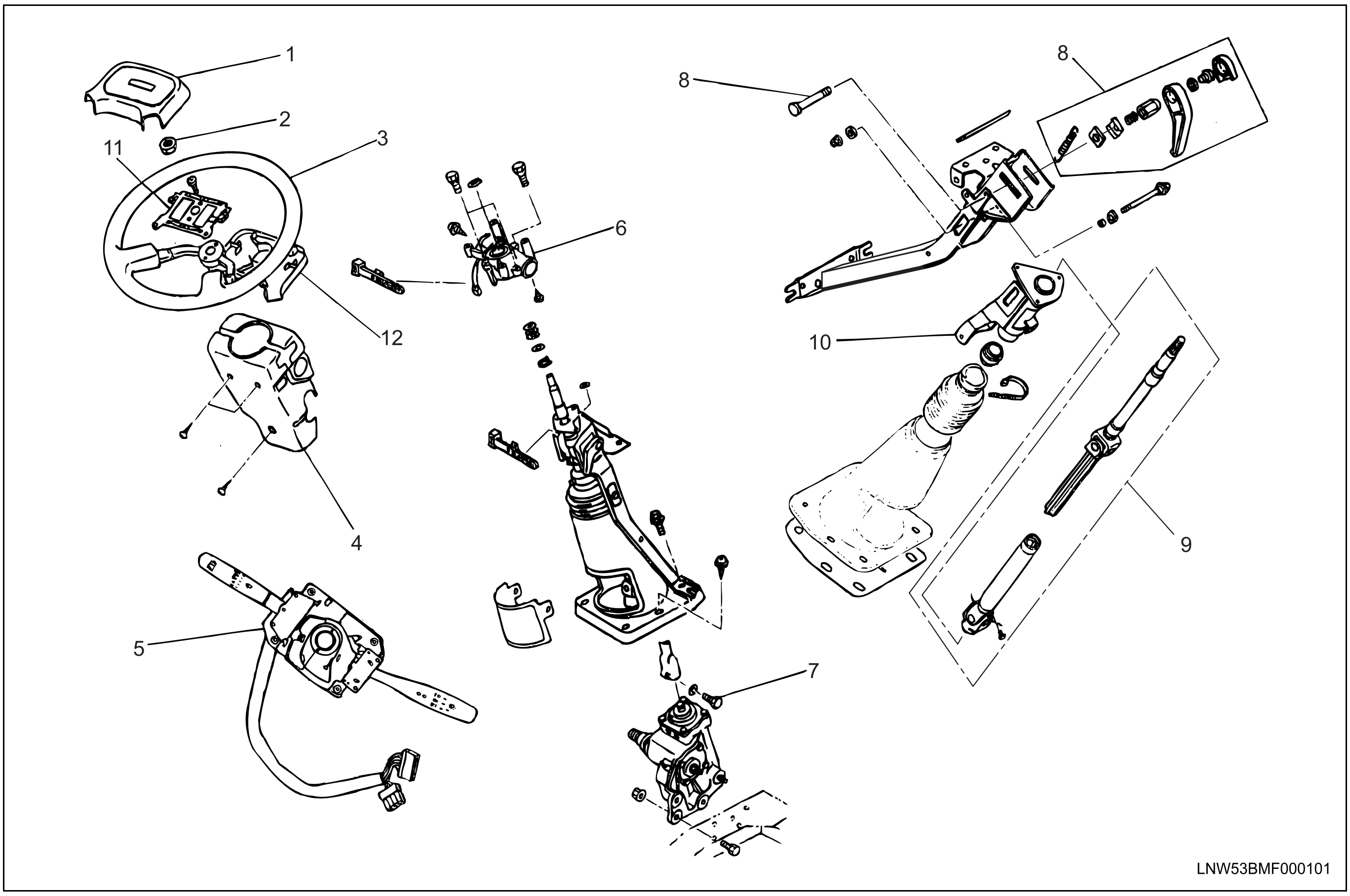
Diagnosis of Steering Column

Diagnosis of Steering Column

Refer to Power Steering in this manual.

Repair Instructions

Steering Wheel



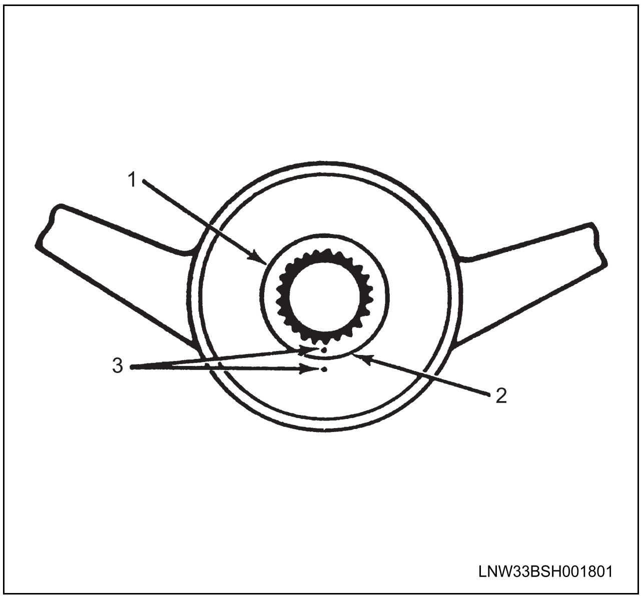
Legend

1. Horn Button
2. Nut
3. Steering Wheel
4. Steering Cowl
5. Combination Switch
6. Key Cylinder with Key Switch
7. Key Bolt
8. Column Lock System
9. Steering Shaft Assembly
10. Steering Column
11. Horn Contact Plate
12. Lower Cover

Removal Procedure

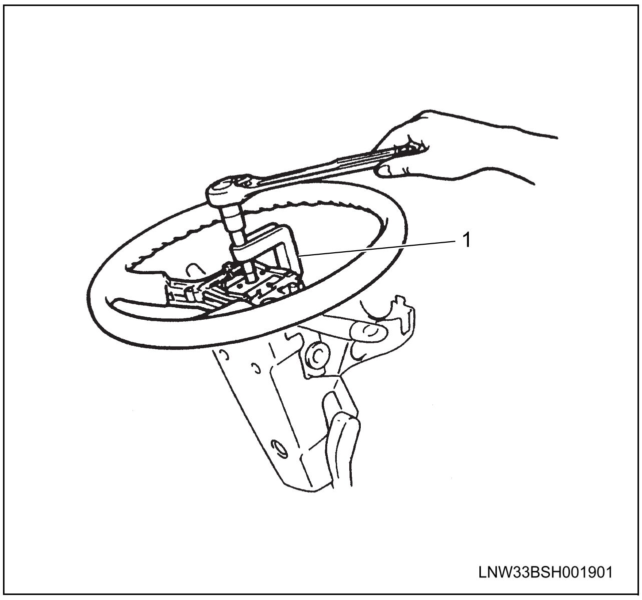
1. Battery ground cable.
2. Horn button. Grasp the horn button at the forward edge and pull it off by hand.

3. Mark the steering wheel and steering shaft.



Legend
1. Steering Wheel
2. Steering Shaft
3. Reference Mark

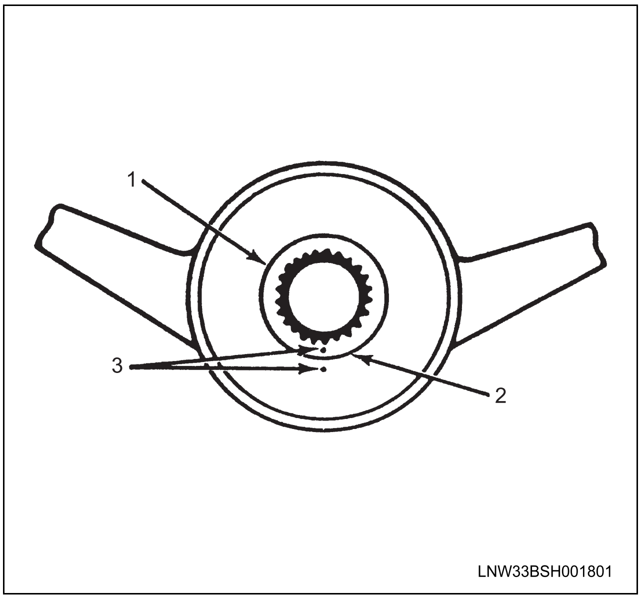
4. Steering wheel assembly using J 24292-B (1) or equivalent



5. Screws then separate the horn contact plate and the lower cover from steering wheel.

Installation Procedure

1. Horn contact plate and lower cover to the steering wheel.
2. Steering wheel assembly to the steering shaft.
   - Align the marks made during removal.



Legend
1. Steering Wheel
2. Steering Shaft
3. Reference Mark

3. Nut.

Notice:
Refer to Description and Operation.

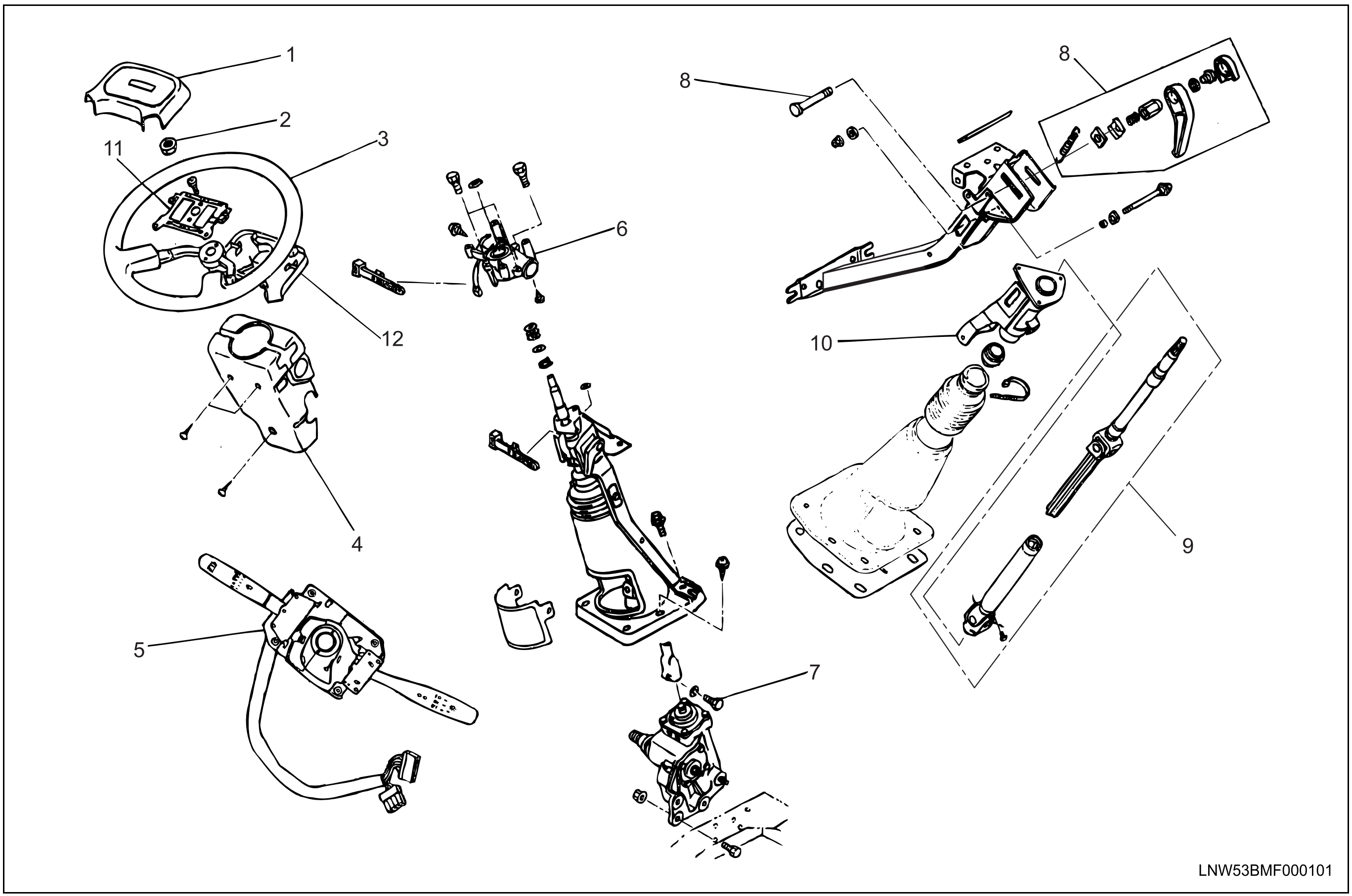
Tighten
- Nut to 42 N·m (31 lb ft).

4. Horn wire to the steering wheel terminal.
5. Horn button.
6. Battery ground cable.

Inspection Procedure

- Steering wheel and steering shaft splines for damage.
- Horn contact plate, horn wire connection for corrosion or damage.
- Horn for proper operation.

Steering Column

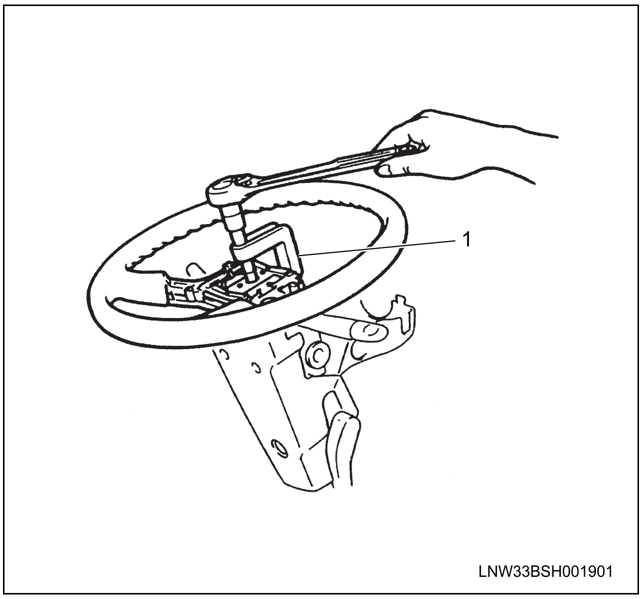


Legend

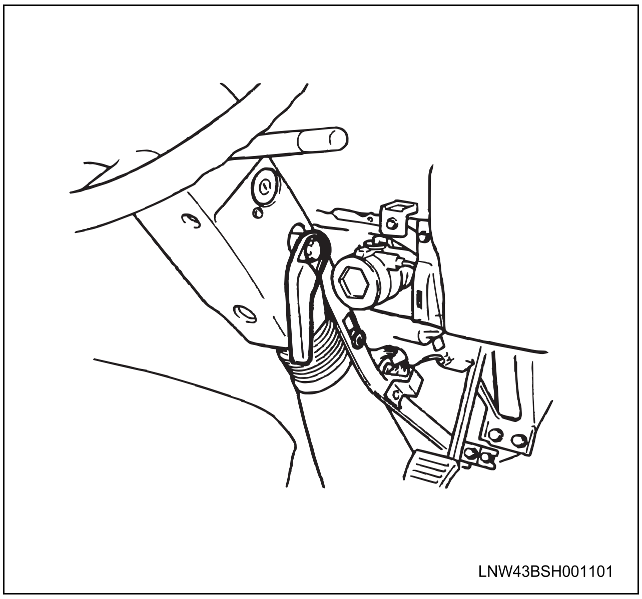
1. Horn Button
2. Nut
3. Steering Wheel
4. Steering Cowl
5. Combination Switch
6. Key Cylinder with Key Switch
7. Key Bolt
8. Column Lock System
9. Steering Shaft Assembly
10. Steering Column
11. Horn Contact Plate
12. Lower Cover

Removal Procedure

1. Battery cable.
2. Steering wheel assembly using J 24292-B (1) or equivalent.

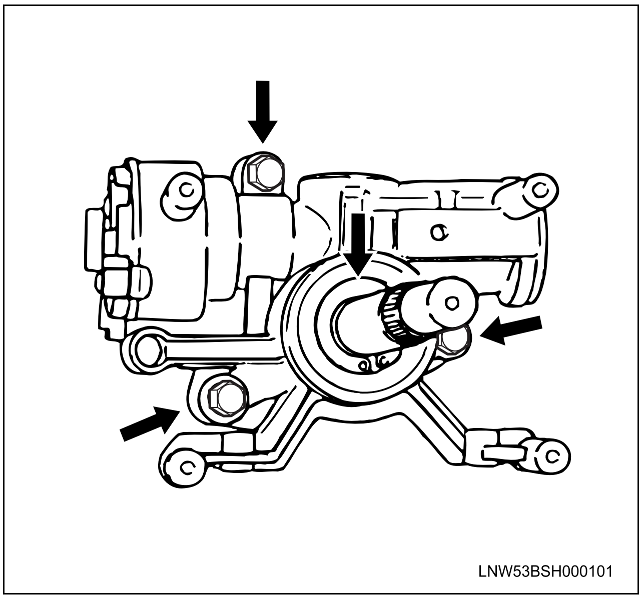


3. Column lock system and cowl.



LNW43BSH001101

4. Starter and combination switch harness connectors .
5. Combination switch.
6. Key cylinder with key switch and snap ring.



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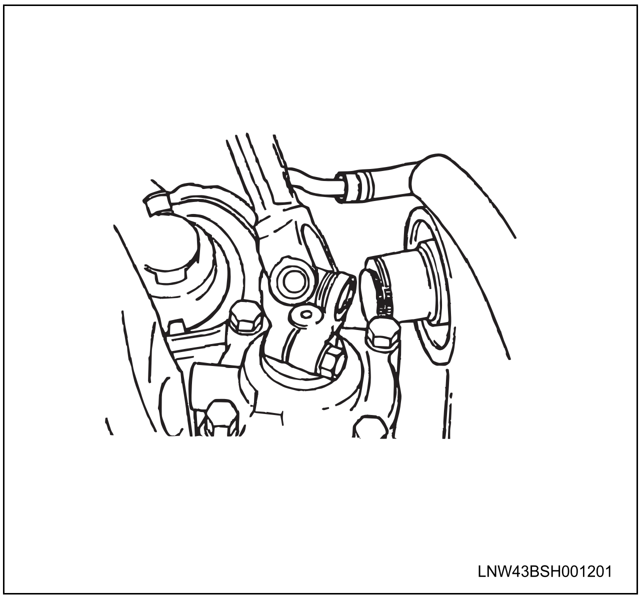
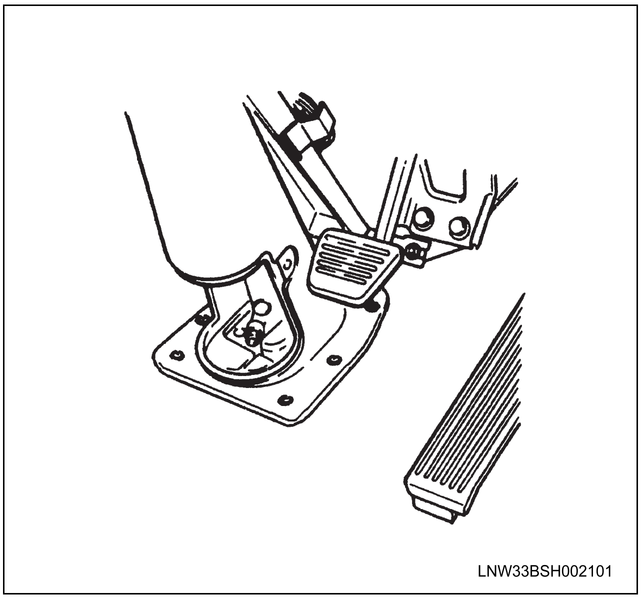
7. Cab tilt and mark steering worm shaft and U-joint yoke. Remove key bolt. (Single cab only)



LNW43BSH001201

8. Remove inspection window and mark steering worm shaft and U-joint yoke. Remove key bolt. (Crew cab only)

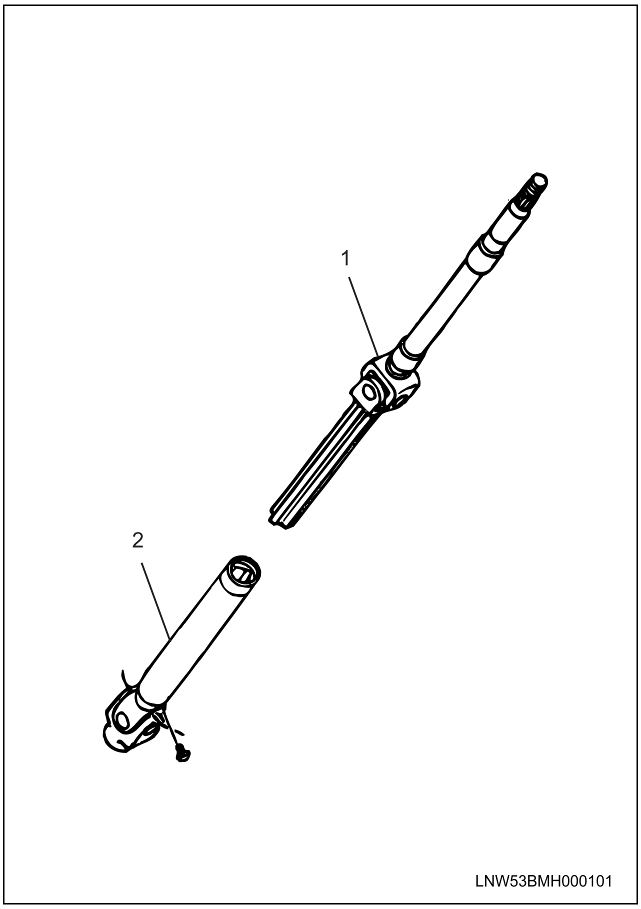


LNW33BSH002101

9. Disconnect the support spring.
10. Remove column support bracket nuts.
11. Steering column.

Notice:
Do not drop the yoke tube during the steering column.

12. Steering shaft assembly.
    - Mark the steering shaft.



Legend

1. Spline Shaft
2. Yoke Tube

Installation Procedure

Notice:

For steps 3 and 6, refer to Description and Operation.

Important:

- The marks on the worm shaft and the U-joint yoke must match.

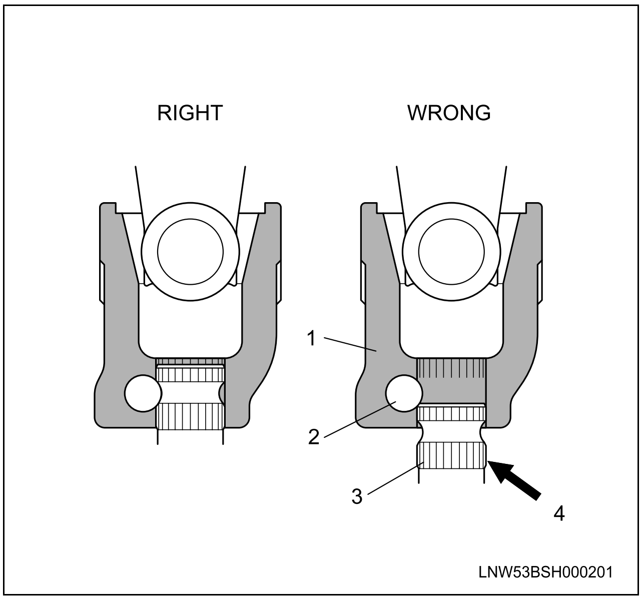
1. Steering shaft.
2. Steering column.
   - U-joint yoke onto the steering gear worm shaft spline.
3. Key bolt in the yoke.

Tighten

- Key bolt to 25 N·m (18 lb ft).

Notice:

- The key bolt(1) must be removed to install the U-Joint yoke (1) to the steering gear worm shaft (3).
- Be sure that the key bolt passes through the steering gear worm shaft groove when it is reinstalled.
- Following steering shaft installation, mark sure that the serrated area (4) is not visible (if it is visible, the installation process has been performed improperly).

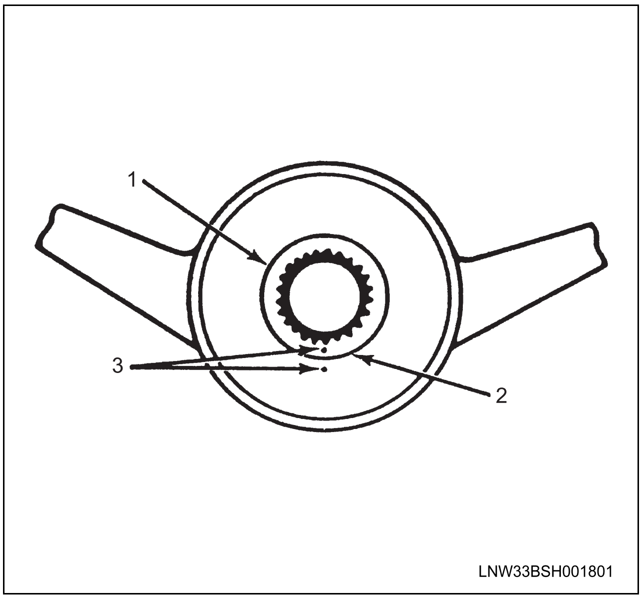


4. Connect the support spring
5. Tighten column support bracket bolts.
6. Column lock system

Tighten

- Lower nut to 14 N·m (122 lb in).
- Upper nut to 16 N·m (12 lb ft).
- Lock lever bolt to 54 N·m (40 lb ft).

7. Connect wiring connectors.
8. Steering cowl.
9. Align the marks made during removal.



Legend

1. Steering Wheel
2. Steering Shaft
3. Reference Mark

---

10. Horn pad.

11. Battery cable.

Inspection Procedure

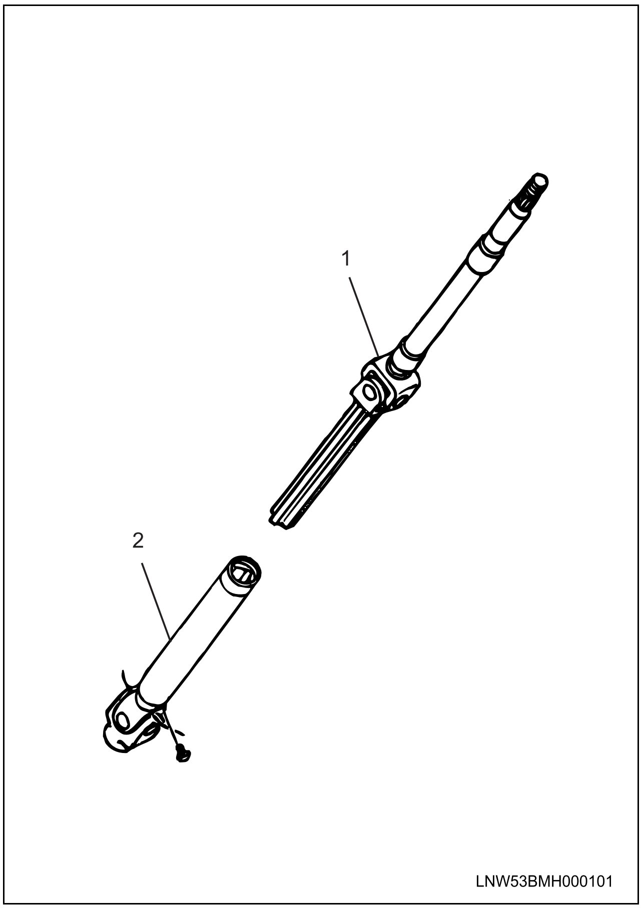
- Operation of horn, headlights, turn signals, hazard flashers, windshield wipers and washers, and exhaust brake.
- Steering shaft for bending or damage.
- Yoke for cracking or damage.
- Universal joint bearing for looseness or roughness.
- Column bushing for wear or damage.
- Switch wiring for cuts or damage.

Notice:
Universal joint cannot be disassembled.

Steering Shaft

Removal Procedure

Steering column assembly, as outlined previously.



Legend

1. Spline Shaft
2. Yoke Tube

---

1. Mark the spline shaft and yoke tube before removal of spline shaft.
2. Yoke tube.

Installation Procedure

1. Lubricate the splined shaft.
2. Align the marks on the splined shaft and on the yoke tube. Assemble the shafts.

Inspection

- Spline shaft for bending or damage.
- Splines and threads for damage.
- Yoke tube for cracking or damage.

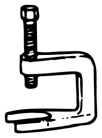
Specifications

Fastener Torques

Steering Wheel Nut	42 N·m (31 lb ft)
Key Bolt	39 N·m (29 lb ft)
Support Bracket Lower Nuts	14 N·m (122 lb in)
Column Lock Lever Nut	16 N·m (12 lb ft)
Column Lock Lever Bolt	54 N·m (40 lb ft)

Special Tools

Special Tools

Illustration	Tool Number/ Description
 AAW0Z0SH018801	J 24292-B Steering Wheel Puller

DRIVELINE/AXLE

Front Axle and Suspension

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Description and Operation

Front Axle and Suspension Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Preliminary axle inspection can be made while the axle is still mounted. Steering knuckles, kingpin bearings, and thrust bearings can be replaced without removing the front axle from the vehicle.
Check the axle for twist with alignment instruments. If equipment is available, use X-ray in section to check axle for minute fractures.
If the axle has been twisted or bent more than five degrees (13 mm [1/2 in]) from the original shape, the axle beam should be replaced.
When a bent condition exists, minute invisible fractures may occur and cause failure under ordinary operating conditions.
The axle can be straightened using the cold method. This process must be performed by personnel who are thoroughly familiar with such operations and the tools involved.
Always straighten axles cold and never apply heat. Also, they should never be repaired by welding, because heating or welding weakens the material strength.
Do not weld any front axle components. The heat from welding will weaken that portion of the material.

Front Axle

The knuckles rotate on roller thrust bearings.
The outer ends of the axle are machined to accept the kingpins and knuckles.
The knuckles turn on roller thrust bearings.

Front Suspension

The front springs are taper leaf type, attached to the front axle with U-bolts. The springs are attached to the frame by means of a shackle at the rear and an eye pin at the front.
Conventional hydraulic shock absorbers are used.

Front Hubs and Bearings Description

The front hubs turn on grease-lubricated, tapered roller bearings. The brake disc is attached to the hub with socket bolts.

Diagnostic Information and Procedures

Hard Steering, Excessive Effort Required at Steering Wheel

POSSIBLE CAUSE	CORRECTION
I. Low or uneven tire pressure.	I. Inflate to specified pressures.
2. Steering linkage or kingpins need lubrication.	2. Lubricate and free up kingpins. Make certain all fittings take lubricant properly.
3. Tight or frozen drag link or tie rod.	3. Lube or replace as necessary.
4. Steering gear to column misalignment.	4. Align column.
5. Steering gear adjusted too tight.	5. Adjust.
6. Front-wheel alignment incorrect.	6. Check alignment and correct as necessary.
7. Binding condition in steering column.	7. Check column mounting and column bearings. Adjust or replace as needed.

Steering Pulls to Left or Right

POSSIBLE CAUSE	CORRECTION
1. Camber incorrectly adjusted. Steering will generally pull to side of axle having greatest positive camber	1. Adjust camber.
2. Low air pressure in right or left tire. Steering will pull to side having low air pressure.	2. Inflate tire to correct pressure, check for air leak, and repair as required.
3. Axle loose and shifted at spring U-bolts.	3. Align axle and torque U-bolt nuts. Inspect for damaged parts. Replace if required.
4. Rear axle loose at spring. U-bolt shifted at one side will cause steering to pull.	4. Align rear axle and replace malfunctioning parts, if any. Torque U-bolt nuts.

Poor Return-ability

POSSIBLE CAUSE	CORRECTION
1. Steering linkage or kingpins need lubrication.	1. Lubricate.
2. Steering gear adjusted too tight.	2. Adjust preload.
3. Front-wheel alignment incorrect.	3. Check alignment and correct as necessary.
4. Steering gear to column misalignment.	4. Align column.

Snapping or Chucking in Steering Column or Wheel

POSSIBLE CAUSE	CORRECTION
1. Loose steering gear at frame.	1. Torque mounting bolts.
2. Worn steering shaft universal joints.	2. Replace and repair joints as necessary.

POSSIBLE CAUSE	CORRECTION
3. Worn steering linkage components. The effect of these components will telegraph through steering system and be felt in steering wheel.	3. Adjust, torque, and repair components.
4. Steering gear incorrectly adjusted.	4. Adjust steering gear.

Spring Noise

POSSIBLE CAUSE	CORRECTION
1. Loose U-bolts.	1. Tighten to recommended torque.
2. Loose or worn eye bushings.	2. Replace eye bushings.
3. Lack of lubrication.	3. Lubricate as required.
4. Worn shock absorbers.	4. Replace shock absorbers.

Spring Sag or Bottom

POSSIBLE CAUSE	CORRECTION
1. Worn shock absorbers.	1. Replace shock absorbers.
2. Broken spring leaf.	2. Replace leaf or spring assembly.
3. Severe operation or overloading.	3. Check load capacity rating.

Spring Breakage

POSSIBLE CAUSE	CORRECTION
1. Loose U-bolts.	1. Tighten to recommended torque.
2. Normal fatigue	2. Replace spring.
3. Overloading.	3. Do not overload vehicle.

Excessive Road Shock

POSSIBLE CAUSE	CORRECTION
1. Tire pressure too high.	1. Deflate to correct pressure.
2. Wheel bearings adjusted too loose.	2. Adjust bearings.
3. Camber adjustment incorrect. (Negative camber contributes to road shock.)	3. Adjust camber.
4. Weak or broken front spring.	4. Replace spring.
5. Worn shock absorbers.	5. Replace shock absorbers.
6. Loose suspension components.	6. Inspect, adjust, or repair, and replace as necessary.

Excessive Play or Looseness in Steering Wheel (Steering Wanders)

POSSIBLE CAUSE	CORRECTION
1. Front-wheel bearings adjusted too loose.	1. Adjust bearings or replace with new parts as necessary.
2. Worn coupling or steering shaft U-joints.	2. Replace.
3. Loose pitman arm, tie rods, steering arms, or steering linkage ball studs.	3. Torque fasteners.
4. Steering gear worm bearings adjusted too loose.	4. Adjust preload.
5. Excessive pitman shaft to ball nut lash in steering gear.	5. Adjust preload.
6. Toe-in out of adjustment or worn drag link or tie rod sockets.	6. Replace drag link and/or tie rod end parts if worn, adjust to correct toe-in, and inspect steering arm and tie rod for bent condition.
7. Steering system out of alignment.	7. Align steering complete, caster, camber, and toe-in. Inspect spring components for condition and wear. Repair or replace as required.
8. Tires badly worn, edge of tires are rounded off.	8. Install new tires, and check alignment; abnormal tire wear indicates improper alignment.
9. Lack of lubrication in linkage and kingpins	9. Lubricate. Free up any components that. are frozen and will not take lubrication.

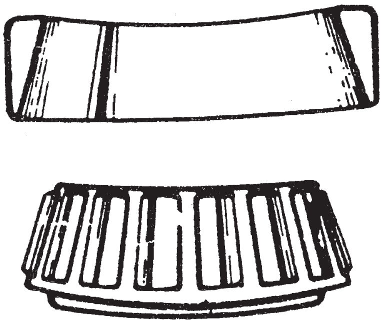
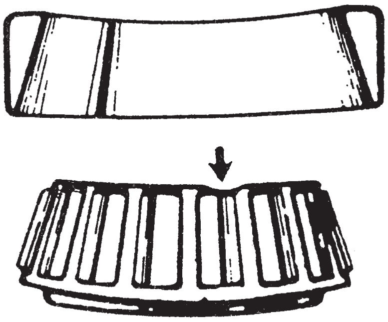
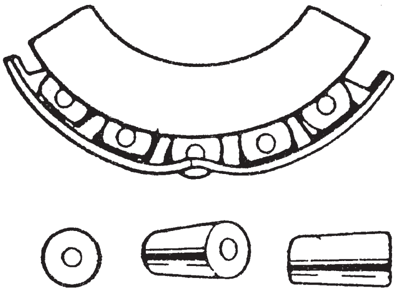
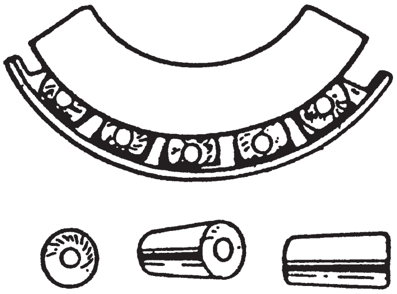
Vibration and Shimmy

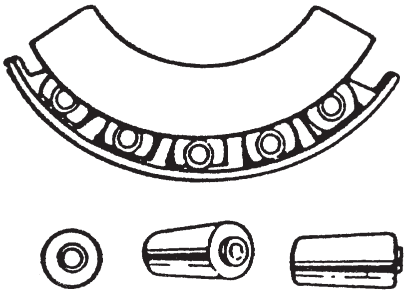
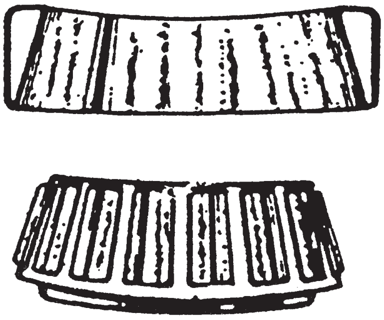
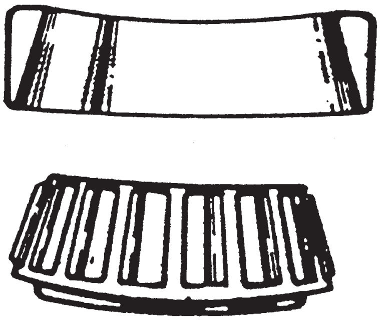
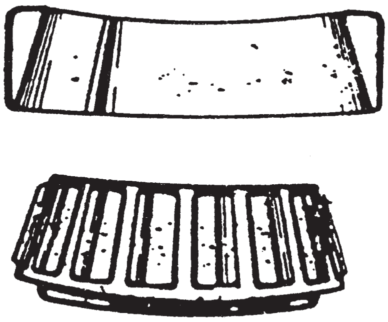
POSSIBLE CAUSE	CORRECTION
1. Wheel bearing seal damage and leakage resulting in loss of lubricant, corrosion, and excessive wear.	1. Replace damaged parts as necessary.
2. Tires, wheels, or brake drums out of balance.	2. Balance tires and wheels, preferably with on-vehicle type balancer, as this method balances.
3. Bent wheel or out-of-round tire. Wheel nuts torque unevenly.	3. Repair wheel and remount tire, or replace.
4. Loose steering linkage components.	4. Adjust, torque, and repair linkage as necessary.
5. Wheel loose on hub.	5. Inspect wheel bolt holes for damage. Replace wheel if needed. Replace all wheel studs.
6. Driveline universal joints rough, or faulty. This condition may be confused with steering vibration.	6. Repair driveline.
7. Engine misses or is out of balance. This may also be confused with steering shimmy.	7. Correct miss in engine, or repair out-of-balance condition, clutch, pressure plate, or harmonic balancer, etc.
8. Worn shock absorbers	8. Replace shock absorbers.

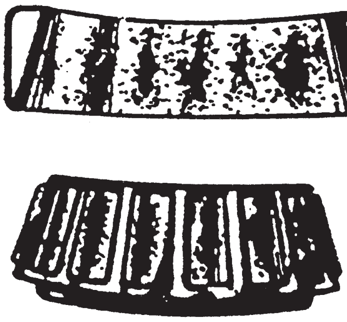
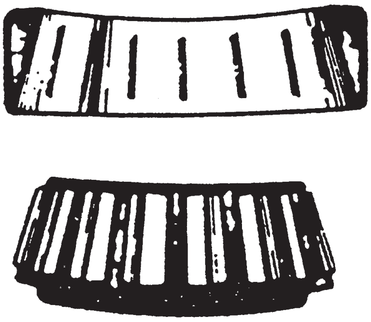
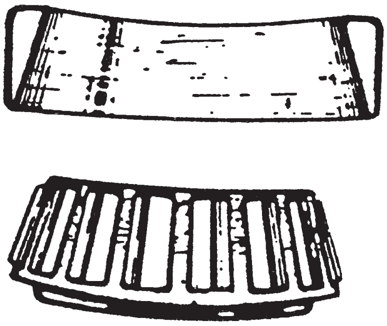
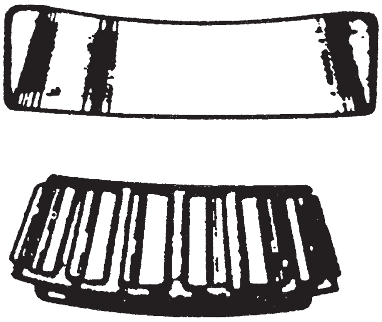
Tapered Roller Bearing Diagnosis

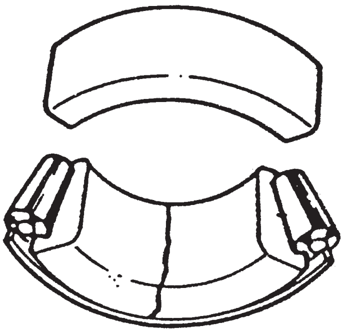
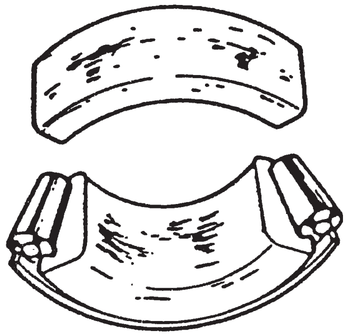
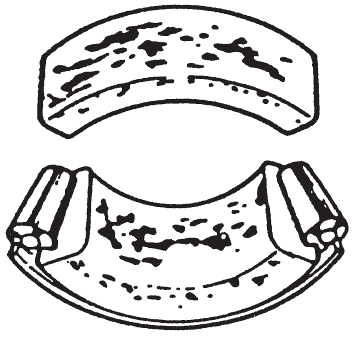
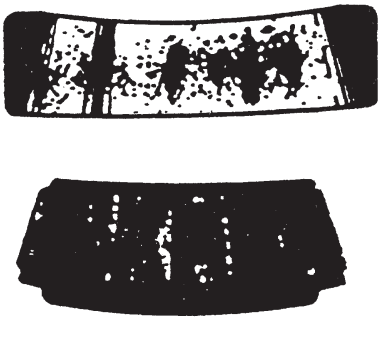
Consider the following factors when diagnosing bearing condition:

1. General condition of all parts during disassembly and inspection.
2. Classify the failure with the aid of the illustrations
3. Determine the cause.
4. Make all repairs following recommended procedures.

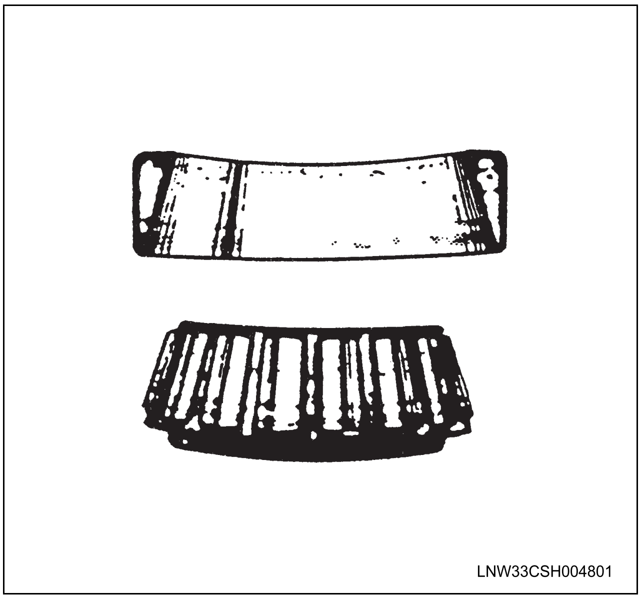
Good Bearing  LNW33CSH003201	**Bent Cage**  LNW33CSH003301 Cage damage due to improper handling or tool usage. Replace bearing.
Bent Cage  LNW33CSH003401 Cage damage due to improper handling or tool usage. Replace bearing.	**Galling**  LNW33CSH003501 Metal smears on roller ends due to overheat. Lubricant failure or overload. Replace bearing - Check seals and check for proper lubrication.

Abrasive Step Wear  Pattern on roller ends caused by fine abrasives. Clean all parts and housings. Check seals and bearings and replace if leaking rough or noisy.	**Etching**  Bearing surfaces appear gray or grayish black in color with related etching away of material usually at roller spacing. Replace bearings - Check seals and check for proper lubrication.
Misalignment  Outer race misalignment due to foreign object. Clean related parts and replace bearing. Make sure races are properly seated.	**Indentations**  Surface depressions on race and rollers caused by hard particles of foreign material. Clean all parts and housings. Check seals and replace bearings if rough or noisy.

Fatigue Spalling	**Brinelling**
 LNW33CSH004001 Flaking of surface metal resulting from fatigue. Replace bearing - Clean all related parts.	 LNW33CSH004101 Surface indentations in raceway caused by rollers either under impact loading or vibrations while the bearing is not rotating. Replace bearing if rough or noisy.
Cage Wear	**Abrasive Roller Wear**
 LNW33CSH004201 Wear around outside diameter of cage and roller pockets caused by abrasive material and inefficient lubrication. Check seals and replace bearing.	 LNW33CSH004301 Pattern on races and rollers caused by fine abrasives. Clean all parts and housings. Check seals and bearings and replace if leaking, rough or noisy.

Cracked Inner Race  LNW33CSH004401 Race cracked due to improper fit. Cocking, or poor bearing seats lubrication.	**Smears**  LNW33CSH004501 Smearing of metal due to slippage. Slippage can be caused by poor fits, lubrication, overheating, overloads or handling damage. Replace bearings, clean related parts and check for proper fit and lubrication. Replace shaft if damaged.
Frettage  LNW33CSH004601 Corrosion set up by small relative movement of parts with no lubrication. Replace bearing. Clean related parts. Check seals and check for proper lubrication.	**Heat Discoloration**  LNW33CSH004701 Heat discoloration can range from faint yellow to dark blue resulting from overload or incorrect lubricant. Excessive heat can cause softening of races or rollers. To check for loss of temper on races or rollers a simple file test may be made. A file drawn over a tempered part will grab and cut metal, whereas. A file drawn over a hard part will glide readily with no metal cutting. Replace bearings if over heating damage is indicated. Check seals and other parts.

Stain Discoloration



LNW33CSH004801

Discoloration can range from light brown to black caused by incorrect lubricant or moisture.
Re-use bearings if stains can be removed by light polishing or if no evidence of overheating is observed.
Check seals and replaced parts for damage.

Shock Absorber Diagnosis

On-Vehicle Test

Shock absorbers are a sealed assembly and must be replaced if faulty.

1. Disconnect both lower shock mountings and pull down on the shock absorber until it is fully extended.
2. Inspect for leaks in the piston rod seal area. Shock fluid is a thin hydraulic fluid, dark brown in color, with a characteristic odor. A slight trace of fluid seepage is permissible, as the seal is designed to seep a slight amount of fluid to provide for piston rod lubrication.
   If a great deal of oil is present, be certain that the oil does not originate from some other source (oil spray from engine, air compressor, etc.) before assuming that the shocks are leaking.
3. Grip the lower end of the shock securely and stroke up (compression stroke) and down (rebound stroke) several times. Rebound resistance (extending the shock) should be greater than the compression resistance. If in doubt, compare resistance of suspected shock with a new one.
   Resistance should be smooth and constant for each stroking rate. Replace shock if any binding or unusual noises are present.
4. Extend shock to the limit of its travel and inspect for a bent damper rod. Replace the unit if necessary.
5. Compare the compression and rebound resistance by stroking both shock absorbers as in step 3. Replace both units if a definite difference in either compression or rebound resistance is felt.
6. Inspect mounting brackets for looseness or wear. Inspect rubber bushings and grommets for wear or deterioration.

Bench Test

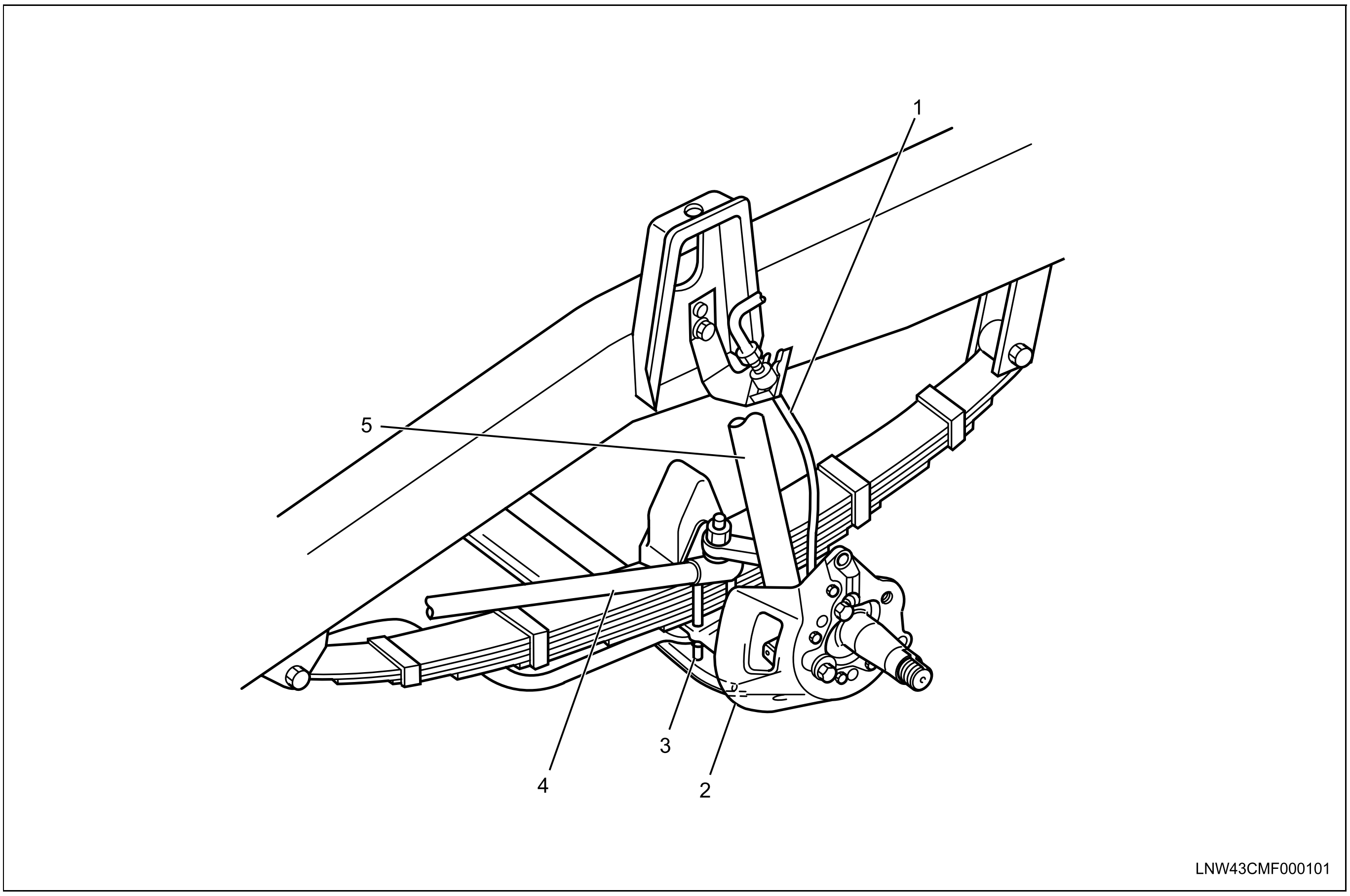
1. The information given previously applies also to the bench test procedure. Bench testing the shock absorbers may be desirable if there is still some doubt as to whether the shocks are worn.
   In addition, the bench test allows a more thorough visual inspection.
2. The shock absorbers must be tested in an upright, vertical position. If tested in any other position, air will enter the damper valve, causing the shock to appear weak.

Notice:
Do not clamp on the reservoir tube, the mounting threads, or distort the mounting eyes to prevent damage.

3. With the shock in an upright, vertical position, clamp the bottom mount in a vise. Extend the shock fully.
4. Follow "On-Vehicle Test," steps 2 through 6 in this section

Repair Instructions

Front Axle



Legend

1. Brake Flexible Hose
2. Axle Assembly
3. U-Bolt Nut
4. Drag Link
5. Shock Absorber

Preparation

Refer to Steering Linkage, Brakes, or Steering Knuckle and Bearing Replacement later in this section, for removal of associated components for axle removal. Raise the front of the vehicle until the tires clear the floor.

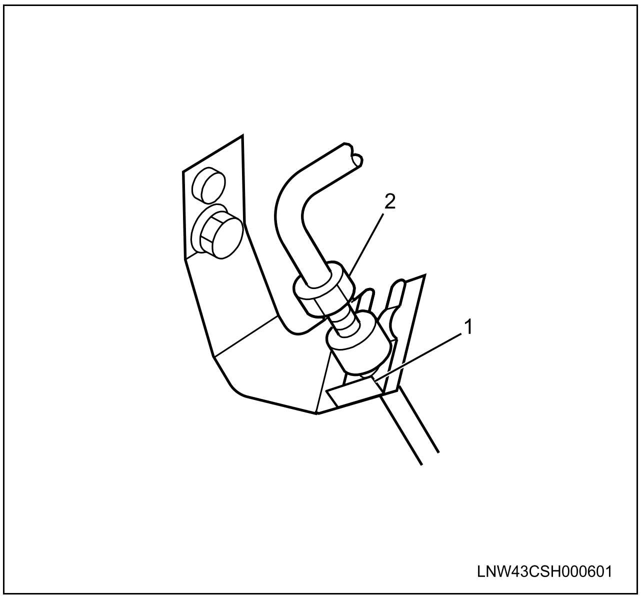
Important:

- Block the frame with safety stands.

Removal Procedure

- Support the axle with a floor jack.

1. Brake flexible hoses. Loosen the nut then remove the clip.

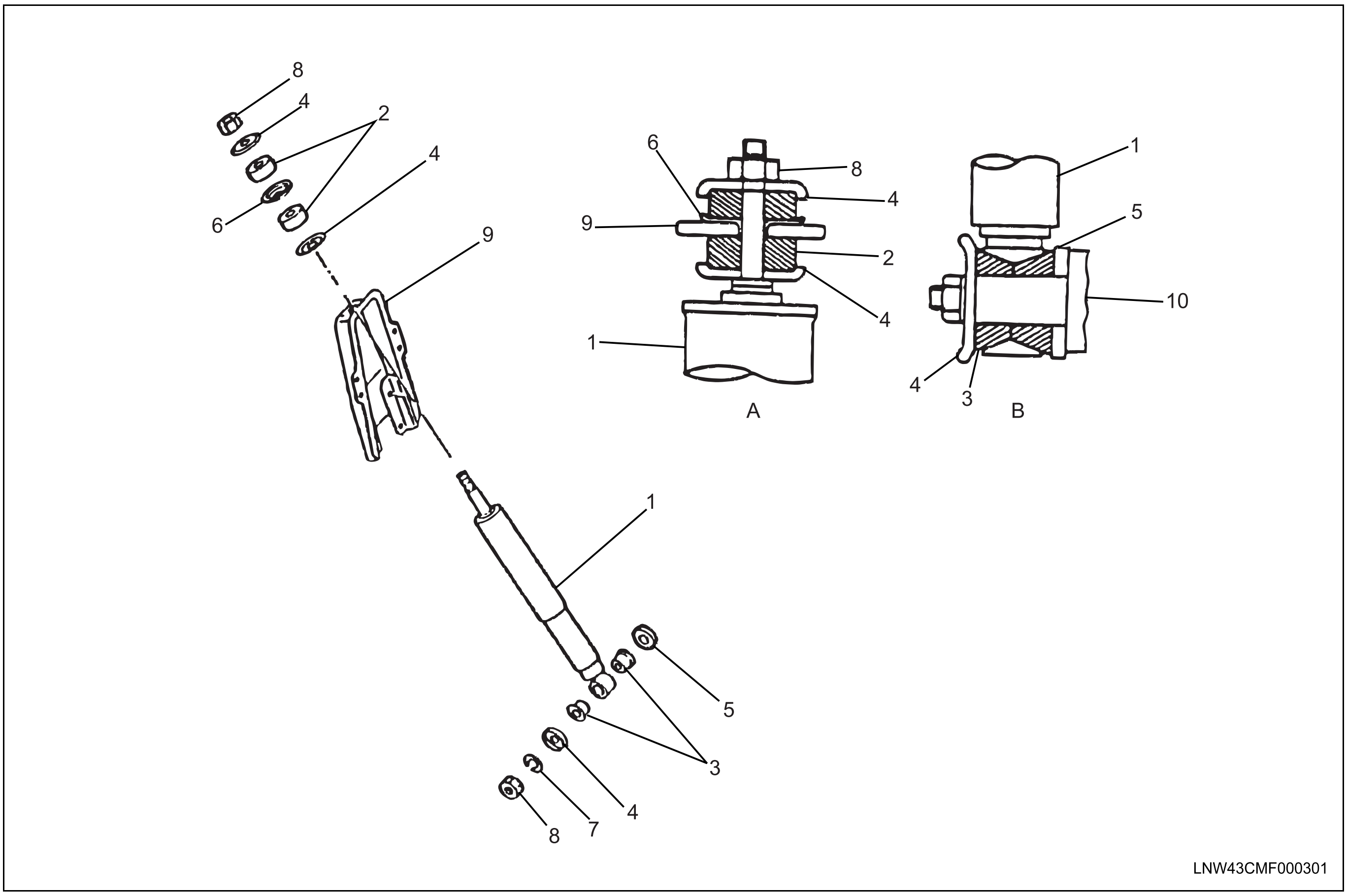


Legend

1. Clip
2. Nut

---

2. Drag link, at the steering arm.
3. Stabilizer bar from bottom spring plate.
4. Shock absorbers at the lower stud. Push the shock absorber into its fully retracted (collapsed) position. This will allow the shock to clear the axle assembly.



Legend

A.	Upper Mount	4.	Dish Washer
B.	Lower Mount	5.	Flat Washer
1.	Shock Absorber	6.	Center Washer
2.	Upper Bushing	7.	Spring Washer
3.	Lower Bushing	8.	Nut

9. Frame Bracket
10. Lower Stud

---

5. U-bolt nuts.
6. Front axle assembly from the vehicle. Lower the axle and pull it out from under vehicle. Note the position of all shims and spacers.

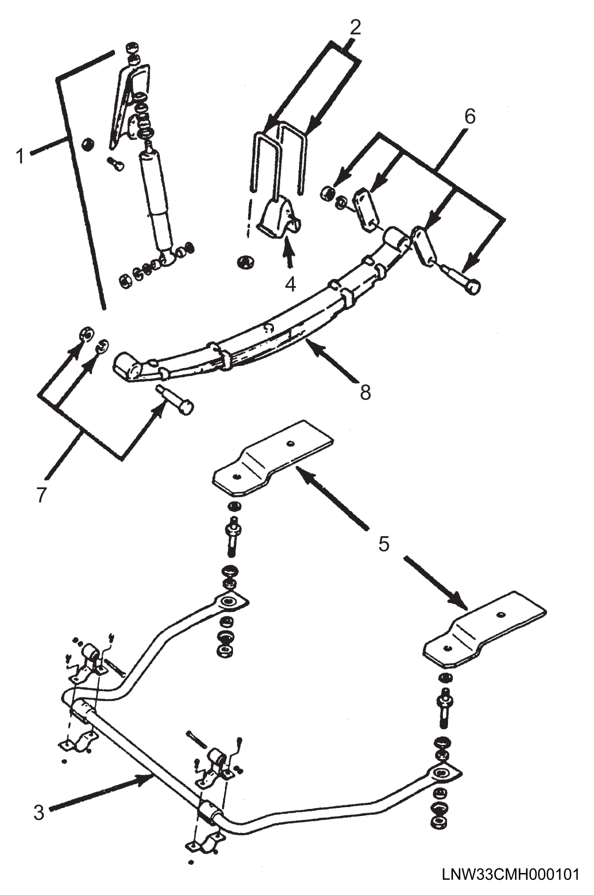
Clean

- The axle in solvent. Remove all traces of old grease and dirt.

Installation Procedure

Notice:
For steps 3, 4 and 7, refer to Description and Operation.

1. Position the axle assembly under the front springs supported by a garage jack.
2. Position any shims or spacers, which were originally used or will be used, between the axle and springs.
3. Raise the axle to the springs and install the bumper stops, U-bolts, bottom plates, and U-bolt washers and nuts.



Legend

1. Shock Absorber Assembly
2. U-Bolt
3. Stabilizer Bar
4. Bumper Stop
5. Stabilizer Bracket
6. Shackle and Bolt
7. Spring Eye Bolt and Nut
8. Leaf Spring

Tighten

- NPR, NPR-HD: Front axle U-bolts to 127 N·m (94 lb ft).
- NQR, NRR(NQR-HD): Front axle U-bolts to 196 N·m (145 lb ft).

4. Shock absorber bushings, washers, and shocks onto the lower stud mounts.

Tighten

- Shock absorber nuts to 95 N·m (70 lb ft)
- Shock absorber bolt to 40 N·m (30 lb ft)

5. Stabilizer bar to bottom spring plate. Install the bushings.

Tighten

- Stabilizer bar nut to 29 N·m (22 lb ft) .

6. Drag link at the steering arm.
   - Refer to Steering Linkage in this manual.
7. Lower the vehicle. Brake flexible hoses in a neutral position.

Tighten

- Brake pipe nut to 15 N·m (11 lb ft).

8. Bleed the brake hydraulic system. Refer to Hydraulic Brakes in this manual.

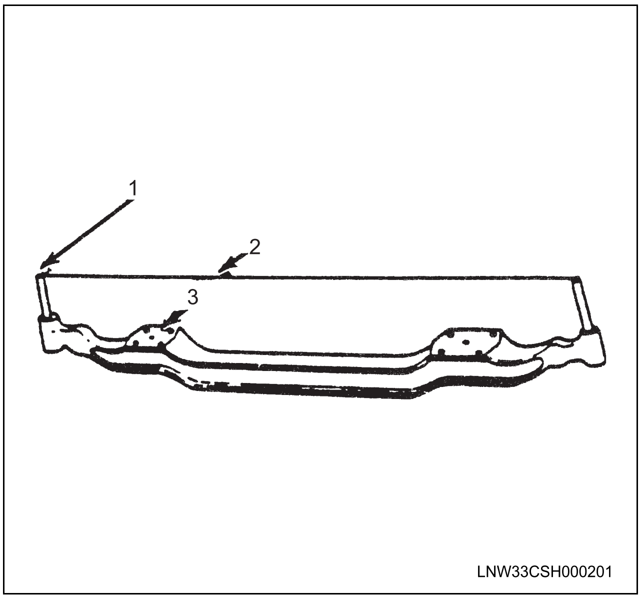
Adjust

- Front end alignment. Refer to Front End Alignment in this manual.

Inspection Procedure

- The following parts for wear, damage, or other abnormal conditions:

1. Fit the kingpin or test bar into the kingpin hole.

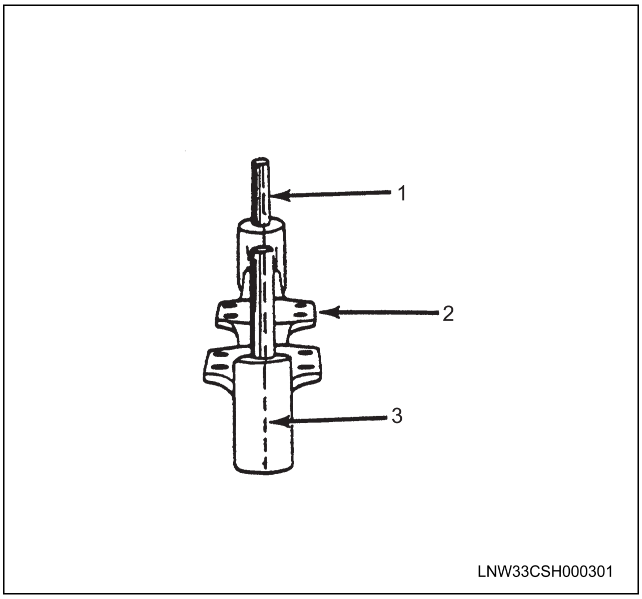


Legend

1. Kingpin or Test Bar
2. Cord
3. Center Bolt Hole

---

2. Stretch a cord across the centers of kingpin or test bars.
3. Check to see if the cord is in line with the centers of the center bolt holes in the spring seat when looked down from above the cord .
4. Also, check to see if the kingpins or test bars are in good vertical alignment as viewed from the side.

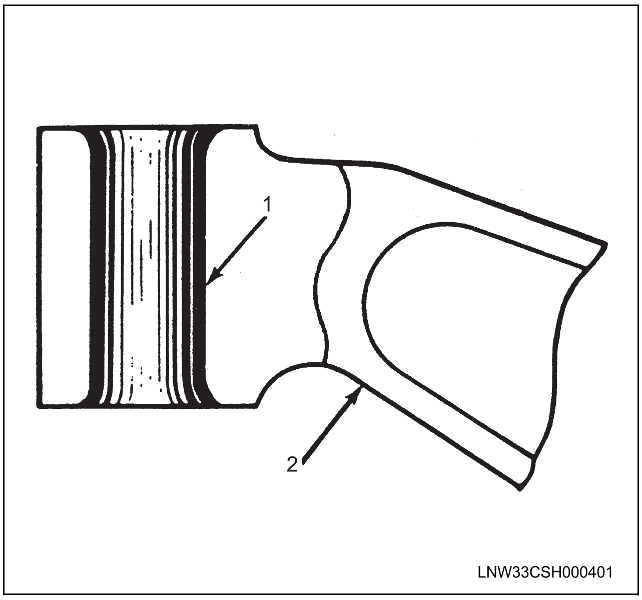


Legend

1. Kingpin or Test Bar
2. Axle
3. Sight Line

---

5. Check to see if the kingpin bores are worn.

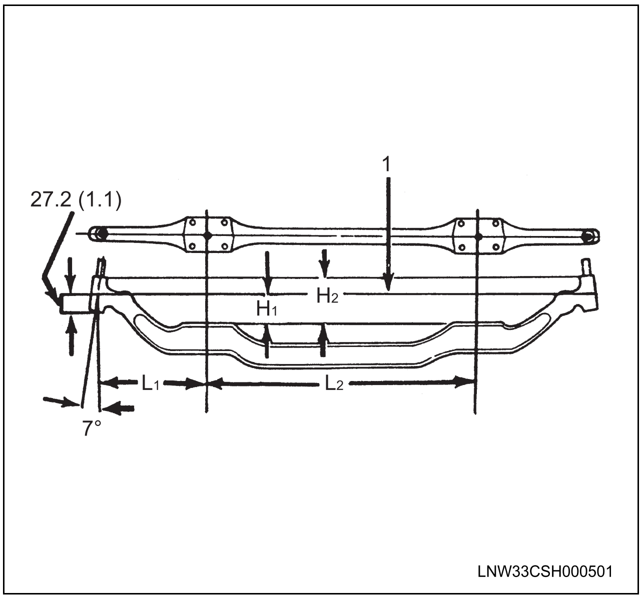


Legend

1. Kingpin Bore
2. Axle

Measure

- Stretch a cord and check the following dimensions.

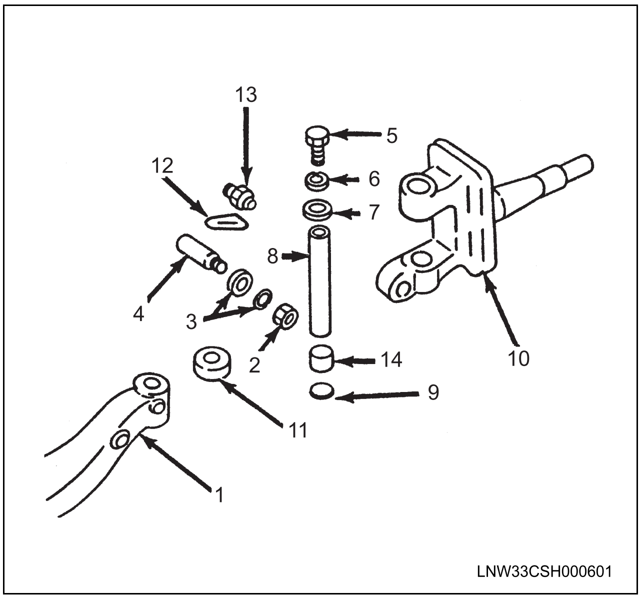


Legend

1. Cord

H_1	H_2	L_1	L_2
83 mm (3.3 in)	120.4 mm (4.74 in)	315 mm (12.4 in)	860 mm (33.9 in)

Steering Knuckle and Bearing



Legend

1. Axle
2. Nut
3. Washer
4. Key Bolt
5. Bolt
6. Washer
7. Dust Cap
8. Kingpin
9. Plug
10. Knuckle
11. Thrust Bearing
12. Shim
13. Grease Fitting
14. Bushing

Preparation

- Raise the vehicle until the tires clear the floor.

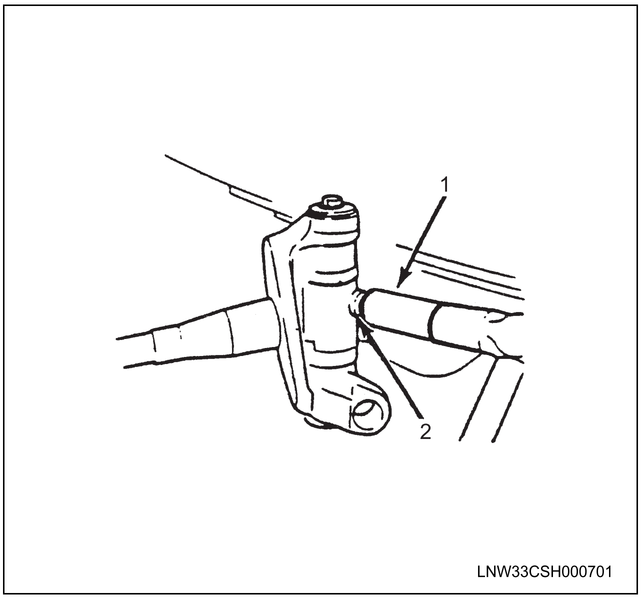
Important:

- Block securely with safety stands.

Removal Procedure

1. Tire and wheel as outlined in Wheels and Tires in this manual.
2. Disc Brake assembly as outlined in Hydraulic Foundation Brakes in this manual.
3. Hub and rotor assembly as outlined in Front Hubs and Bearings On-Vehicle Service in this section.
4. Brake backing plate. Refer to Hydraulic Foundation Brakes in this manual.
5. Steering Linkage. Refer to Steering Linkage in this manual.
   - Tie rod.
   - Drag link (if servicing the left side knuckle).
6. Bolts and washers.

7. Dust cap.
8. Nut, washers and key bolt.
   - Remove the nut.
   - Screw on Remover Tool J 35710.



Legend
1. Tool J 35710
2. Key Bolt

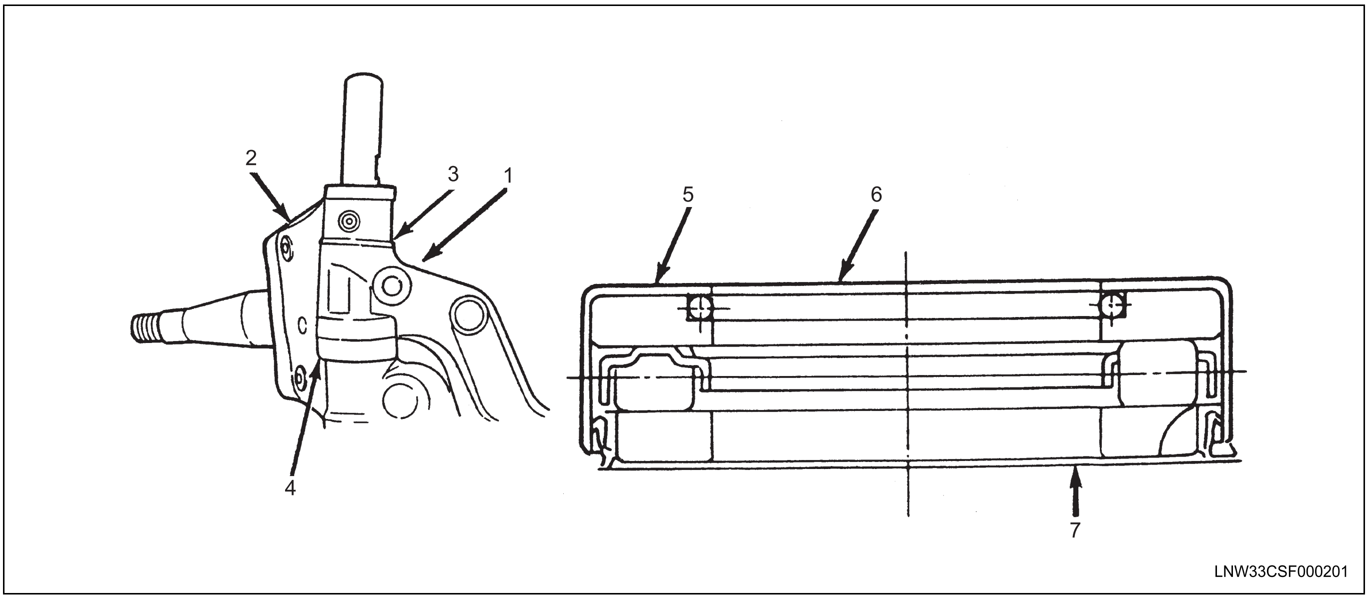
   - Tap end of the tool to loosen the key bolt.
   - Remove the tool.
   - Remove the key bolt.
9. Kingpin. Drive the kingpin and plug out of the knuckle with a brass drift and hammer.
10. Remove the knuckle, thrust bearing, and shim(s).
11. Plug and discard.

Clean

- All parts in solvent. Remove all traces of old grease and dirt. Be sure to get all grease and dirt out of the knuckle bushings.

Installation Procedure

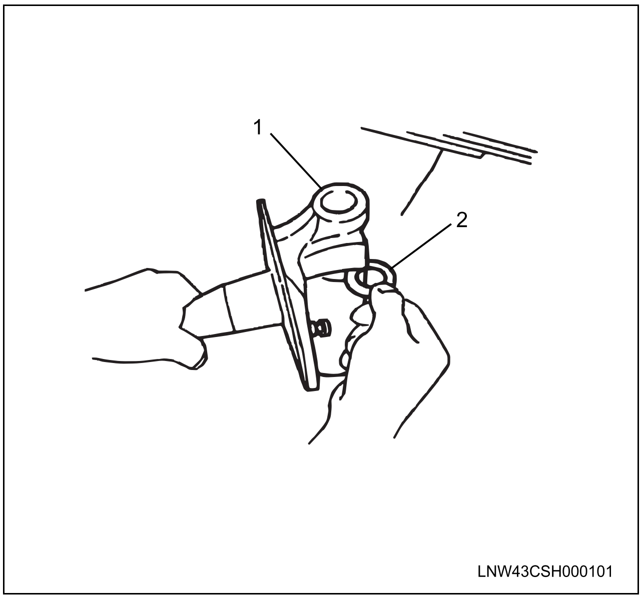
1. Lightly oil the axle bore, the kingpin, and the knuckle bushings.
2. Knuckle and thrust bearing onto the axle Temporarily install the kingpin. Be sure the thrust bearing is installed with the cover side facing up.



Legend
1. Axle
2. Knuckle
3. Shim or Spacer
4. Thrust Bearing
5. Bearing Cover
6. Bearing Upper Side
7. Bearing Lower Side

Measure

- Raise the knuckle and measure the clearance between the top of the axle and the knuckle.



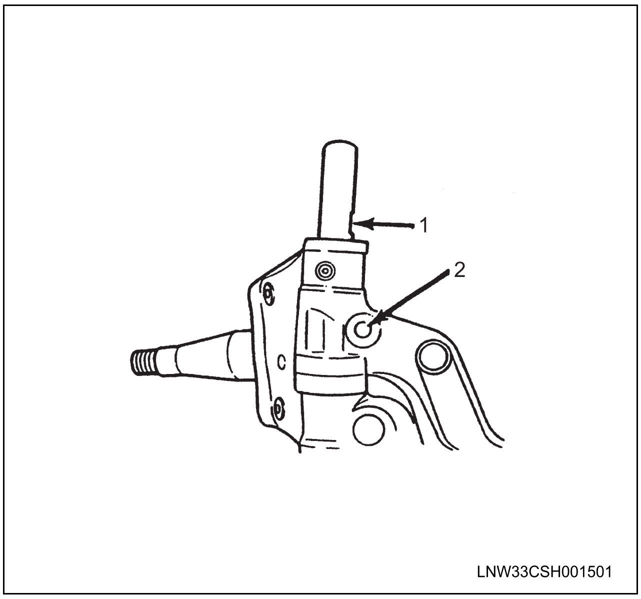
Legend

1. Knuckle (Spindle)
2. Shim

- Note the dimension and select the shims that will give a clearance of 0.10 mm (0.004 in) or less.Shim can be used to two sheets. Shims are available in the following thicknesses:

Thickness mm (in)	
0.50(0.020)	0.70(0.028)
0.55(0.022)	0.80(0.031)
0.60(0.024)	0.90(0.035)
0.65(0.026)	

3. Remove the kingpin, knuckle, and thrust bearing.
   Assemble
   - The selected shim(s). Grease all parts and install the knuckle, thrust bearing, shims, and kingpin onto the axle. Align the notch in the kingpin and key bolt hole in the axle.



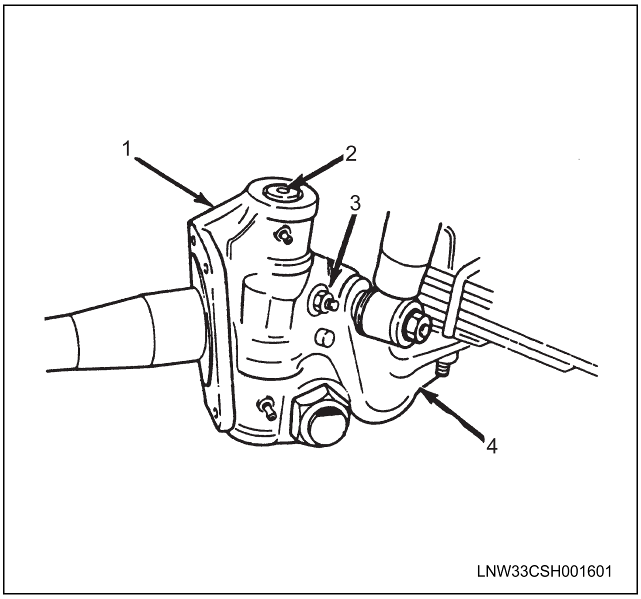
Legend

1. Kingpin Notch
2. Key Bolt Hole

Notice:
Refer to Description and Operation.

Tighten

- Install the key bolt from the rear of the axle. Torque the key bolt nut to 32 N·m (24 lb ft).



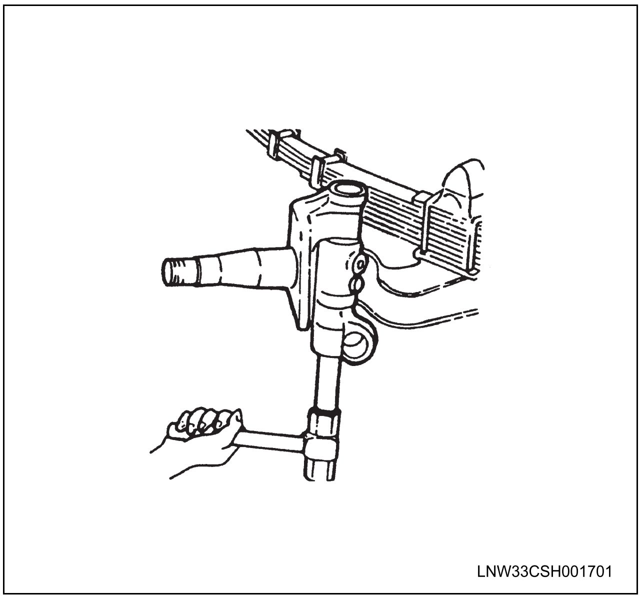
Legend

1. Knuckle (Spindle)
2. Kingpin
3. Key Bolt
4. Axle

---

4. Check the knuckle to assure that it turns freely.

5. Install the sealing plug in the bottom of the knuckle kingpin hole. Use a suitable bar and hammer.

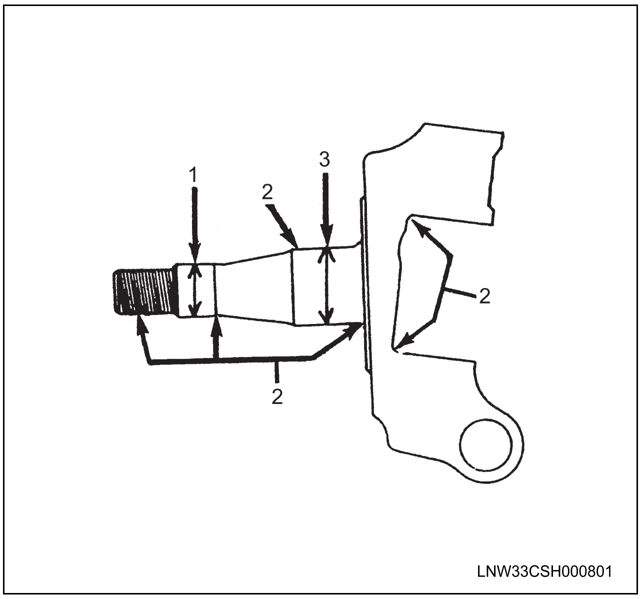


6. Install the upper kingpin seal, washers, and bolt.

Refer to Steering Linkage, Hydraulic Foundation Brakes, Wheels and Tires and Front Hubs and Bearings On-Vehicle Service in this section for remaining component assembly.

Inspection Procedure

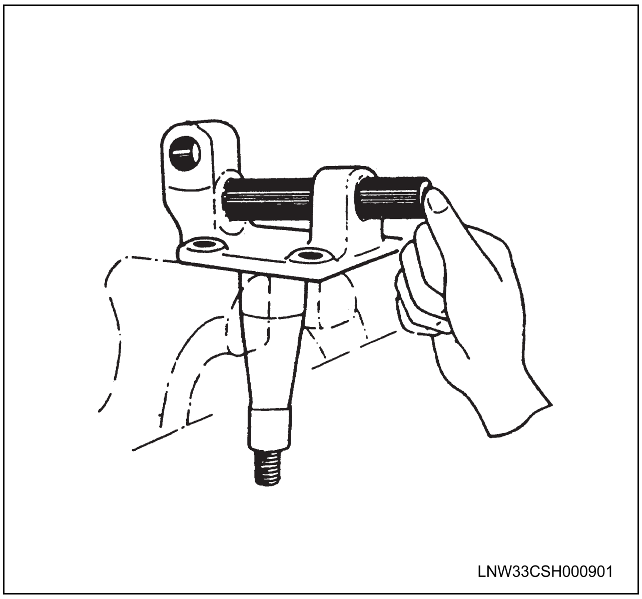
- Knuckle for cracks or damage. Pay special attention to the areas shown by arrows. Use X-ray inspection equipment, if available.



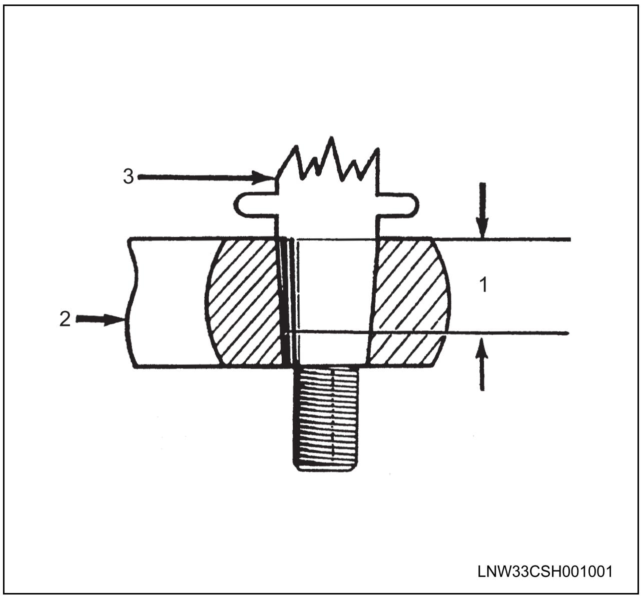
Legend

1. 35 mm (1.38 in)
2. Inspect for cracks.
3. 50 mm (1.97 in)

- Thrust bearing for roughness of operation or damage.
- Key for damage.
- Kingpin for scoring or damage. Check the fit of the kingpin in the axle. If the kingpin fits loosely, replace the axle.
  Kingpin fit into the bushings can be checked in the following manner: Clamp the knuckle in a vise and insert the kingpin into the bushings.
  Check for radial play by moving the kingpin in the direction at a right angle to its axis, and then move the kingpin endwise with your finger.



- Check tapered portion of the steering arms for abnormal contact in the following manner: Apply a thin coat of dye.
  Check evenly for the tapered portion of the arm and insert the arm into the tapered hole. Remove the arm and check impression of contact obtained on the taper. Correction or parts replacement is necessary if the contact is uneven or if contact area is smaller than 3/4 of the entire length of the taper.

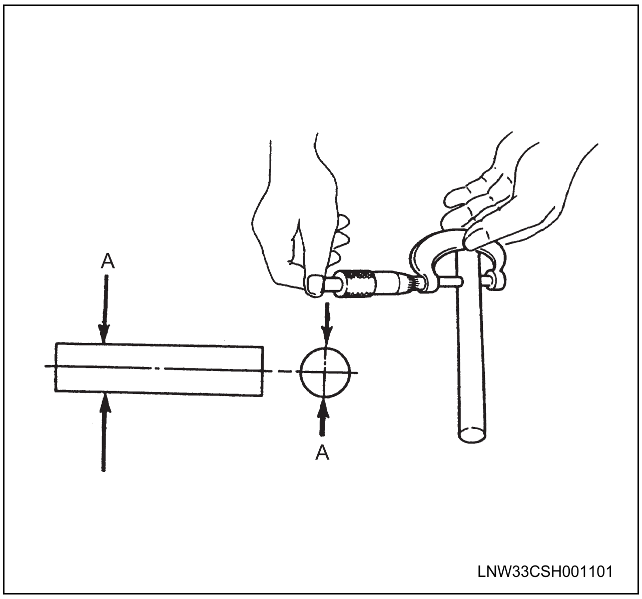


Legend

1. Contact area is longer than 3/4 of the entire length of the taper.
2. Knuckle
3. Steering Arm

Measure

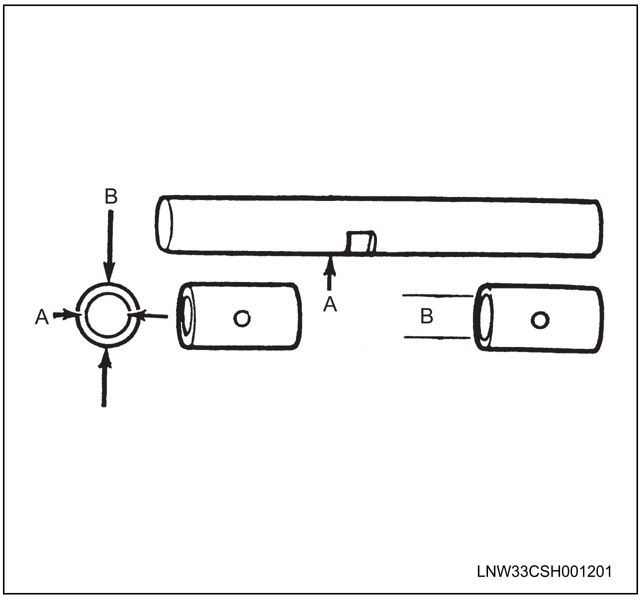
- Diameter of the kingpin. It must be within the limits.



Diameter A

Standard	30 mm (1.181 in)
Limit	29.9 mm (1.177 in)

- The clearance between the kingpin and the bushings.

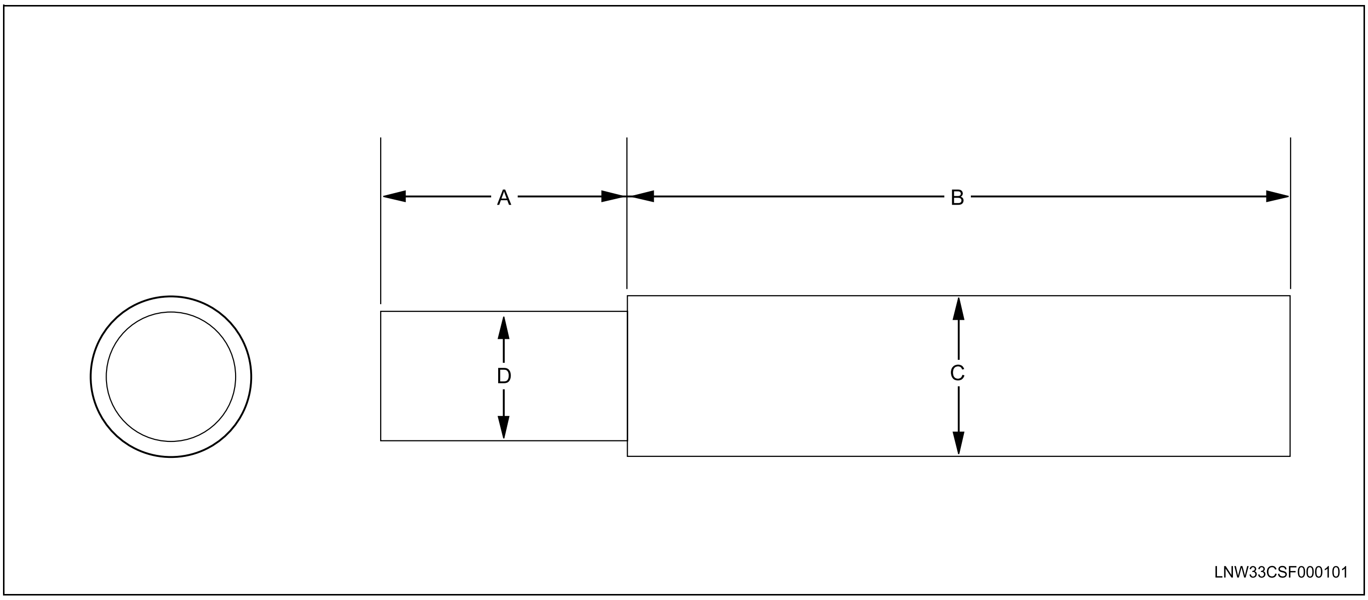


Diameter A

Standard	0.06 mm (0.0024 in)
Limit	0.15 mm (0.0059 in)

Kingpin Bushing Replacement

If the kingpin to bushing clearance is too great, or the kingpin or bushings are damaged, a new kingpin kit must be installed.
Drive the old bushings out with a suitable driver. Clean the holes.
Press in new bushings, being careful to align the grease holes in the bushings and knuckle.
Try the kingpin for proper fit in the bushings. If too tight, the bushings must be reamed to allow a proper fit.

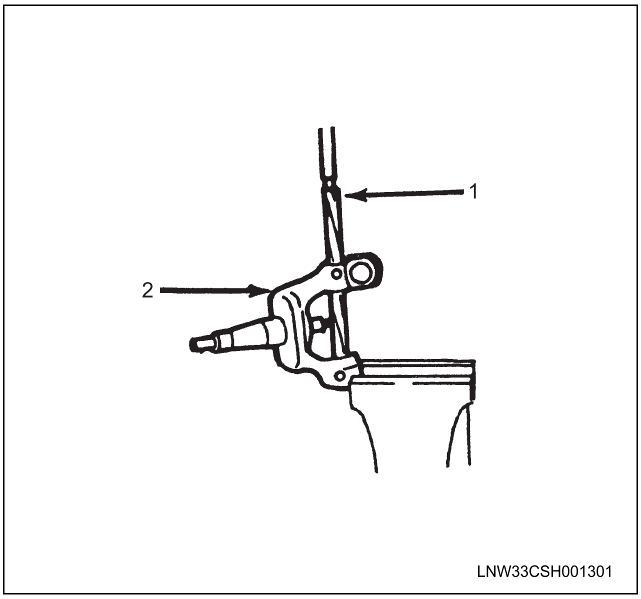


Dimension A is 65 mm (2.5 in).

Dimension B is any suitable length.

Dimension C is 0.25 mm (0.010 in) Less than the steering knuckle bore.

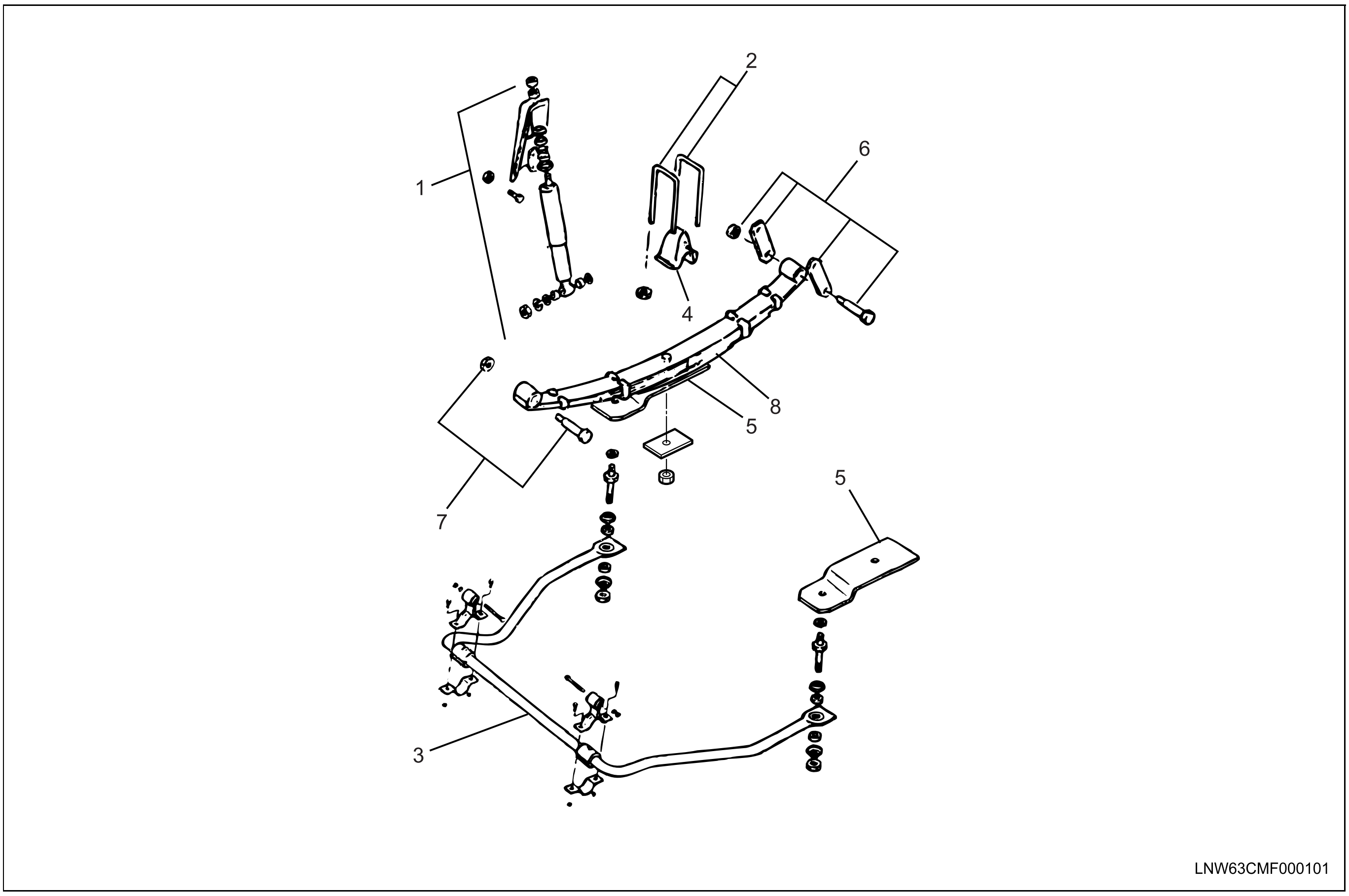
Dimension D is 0.25 mm (0.010 in) Less than the bushing bore.



Legend

1. Reamer
2. Knuckle

Front Spring



Legend

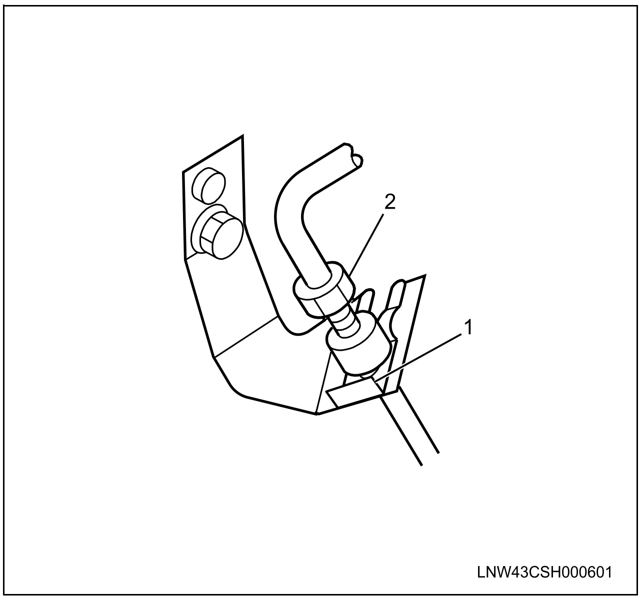
1. Shock Absorber Assembly
2. U-Bolt
3. Stabilizer Bar
4. Bumper Stop
5. Stabilizer Bracket
6. Shackle and Bolt
7. Spring Eye Bolt and Nut
8. Leaf Spring

Preparation

Raise the vehicle until the tires clear the floor. Block the frame with safety stands. Support the front axle with a floor jack.

Removal Procedure

1. Loosen the brake flexible hose tube nut. Pry the clip off of the flexible hose.

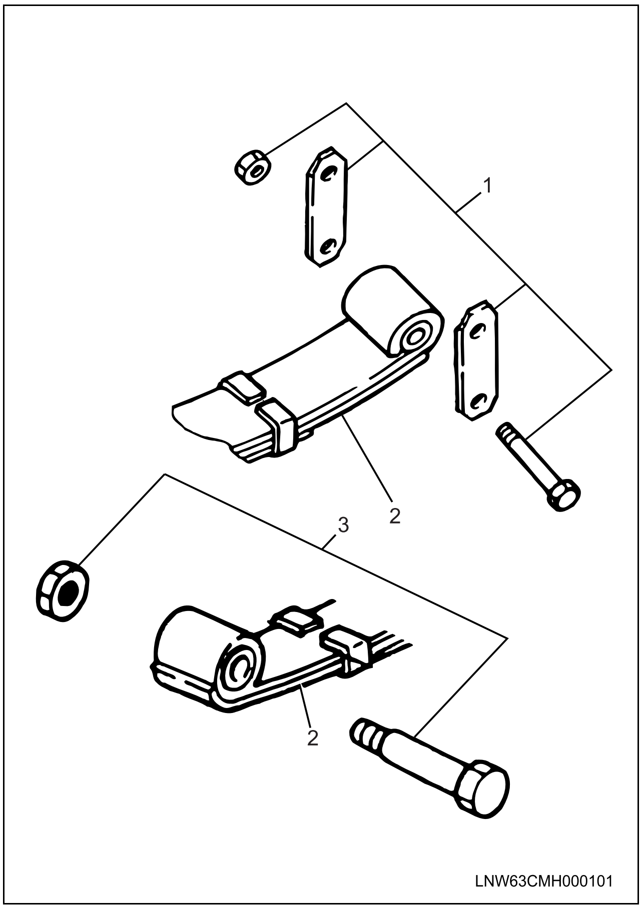


Legend

1. Clip
2. Nut

---

2. Remove the shock absorber.
3. Remove the stabilizer bar.
4. Remove the U-bolts, bumper stop and stabilizer bracket (lower spring plate).
5. Spring rear shackle bolt.



Legend

1. Rear Shackle, Nut and Bolt
2. Spring
3. Front Spring Eye Bolt and Nut

---

6. Front spring eye bolt
7. Remove the spring.

Inspection

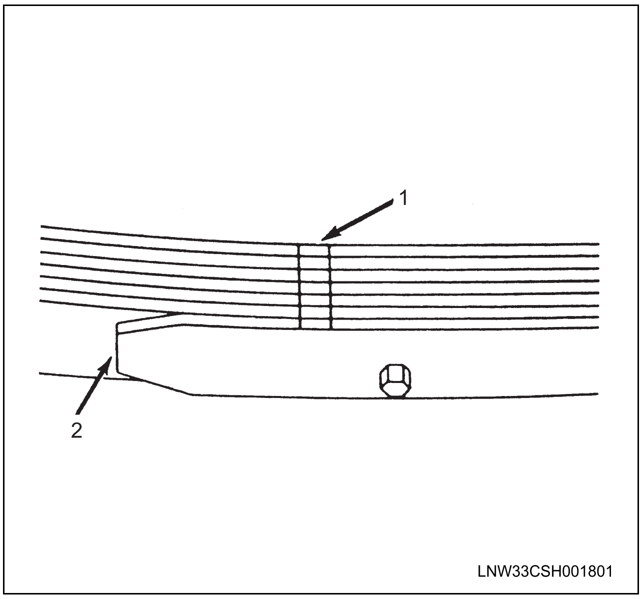
Check the following parts for wear, damage, or other abnormal conditions:

- Spring assembly.
- Clamps.
- Center bolt.
- U-bolts.
- Spring front eye bolt
- Shackle bolt
- Shock absorber
- Bumper stop
- Rubber bushings

Leaf Spring

Disassemble

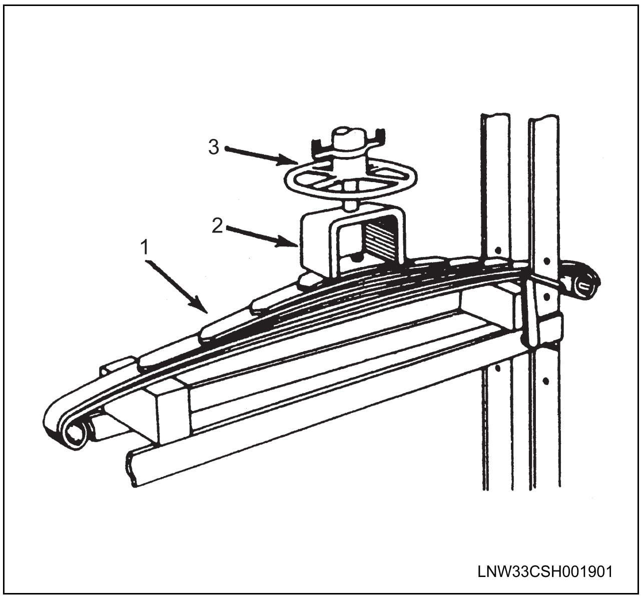
- Apply a reference mark across the springs before disassembling the leaf spring assembly.



Legend

1. Reference Mark
2. Spring

- Use a bench press for disassembly and reassembly.



Legend

1. Spring
2. Adapter
3. Press

- Discard center bolt.

Inspection

- Spring eye bolt and lower shackle bolt for scoring or damage.
- Spring leaf clamps for bending or cracks.
- Spring leaves for cracks or breakage.
- Spring eye bushings for wear or damage.

Assemble

1. Leaf springs and clamps using a press.
    - Be sure to line up the reference marks .
    - Apply grease to both faces of each leaf spring at assembly.

Notice:
Refer to Description and Operation.

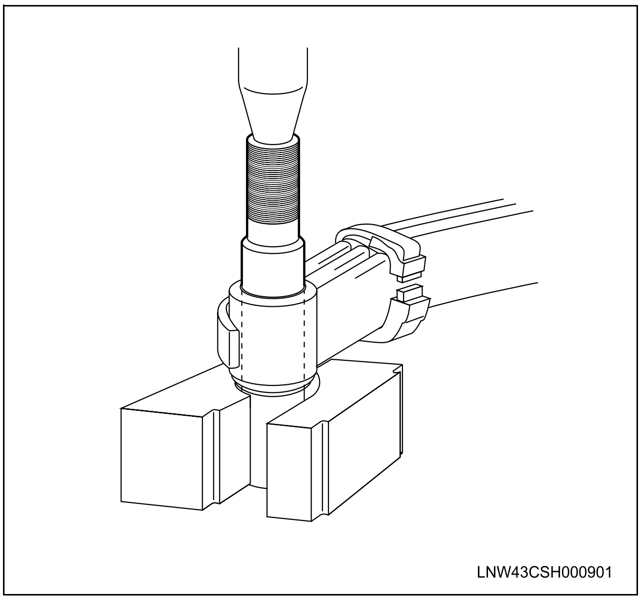
2. Center bolt.

Tighten

- Center bolt to 39 N·m (29 lb ft).

Spring Eye Bushing Replacement

1. Replace the bushing, using suitable pushing tool.



2. Inspect the shackle pin (bolt) for wear or damage.
3. Drive the new bushing into the spring with the same tool that it was removed with.

Installation Procedure

Notice:
For steps 4, 5, 6, 7 and 8, refer to Description and Operation.

1. Place the spring on the axle with the identification mark "+, - , or 0" toward the front facing up.
2. Front eye bolt finger tight.
3. Shackle bolt(s) finger tight.
4. U-bolts, bumper stop, and stabilizer bracket(s).
    - Raise the axle against the spring.

Tighten

- Install the U-bolt nuts and torque them to 127 N·m (94 lb ft) (NPR, NPR-HD), 196 N·m (145 lb ft) (NQR, NRR(NQR-HD)).

5. Shock absorber. See Shock Absorber Replacement in this section.

Tighten

- Shock absorber lower nuts to 95 N·m (70 lb ft).
- Shock absorber bolt to 40 N·m (30 lb ft).

6. Lower the vehicle

Tighten

- Spring eye bolts to 202 N·m (149 lb ft).
- Shackle bolts to 202 N·m (149 lb ft).

7. Stabilizer bar.

Tighten

- Stabilizer bar nut to 30 N·m (22 lb ft).

8. Set the front wheels in a straight ahead position. Install the brake flexible hose. Install the clip. Connect the tube nut.

Tighten

- Tube nut to 15 N·m (11 lb ft).

Shock Absorber

Removal Procedure

1. Safety nut and nut from top of shock absorber. Washer and bushing from top stud.
2. Nut, two washers, and bushing from shock absorber bottom mount stud.
3. Compress shock absorber and remove. Remove remaining bushings and washers.

Installation Procedure

Notice:
For steps 4 and 5, refer to Description and Operation.

1. Washer and inner rubber bushing to the lower bracket.
2. Washer and bushing onto upper stud of shock absorber.
3. Compress and then expand shock absorber into upper bracket.
4. Install upper bushing, washer, and nut(s).

Tighten

- Fixing nut to 20 N·m (14 lb ft).

5. Install outer lower bushing, washer(s), and nut.

Tighten

- Nut to 95 N·m (70 lb ft).

Inspection

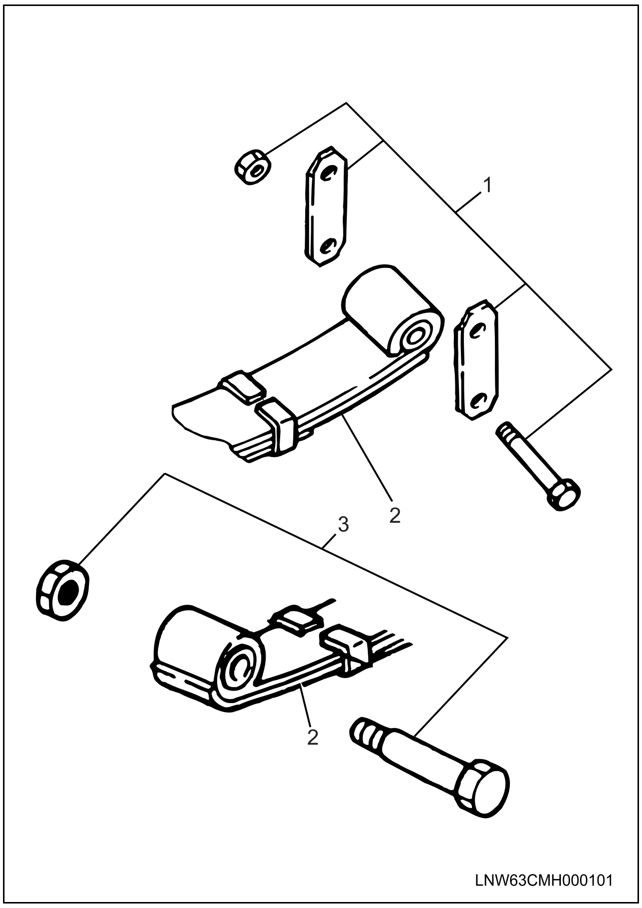
- Shock absorber. Refer to Diagnosis of Shock Absorber in this section.
- Rubber bushings for cracks or deterioration.

Shackle

Raise the vehicle until the tires clear the floor. Block the frame with safety stands. Support the front axle with a floor jack.

Removal Procedure

1. Washers and nuts.



Legend

1. Rear Shackle, Nut and Bolt
2. Spring
3. Front Spring Eye Bolt and Nut

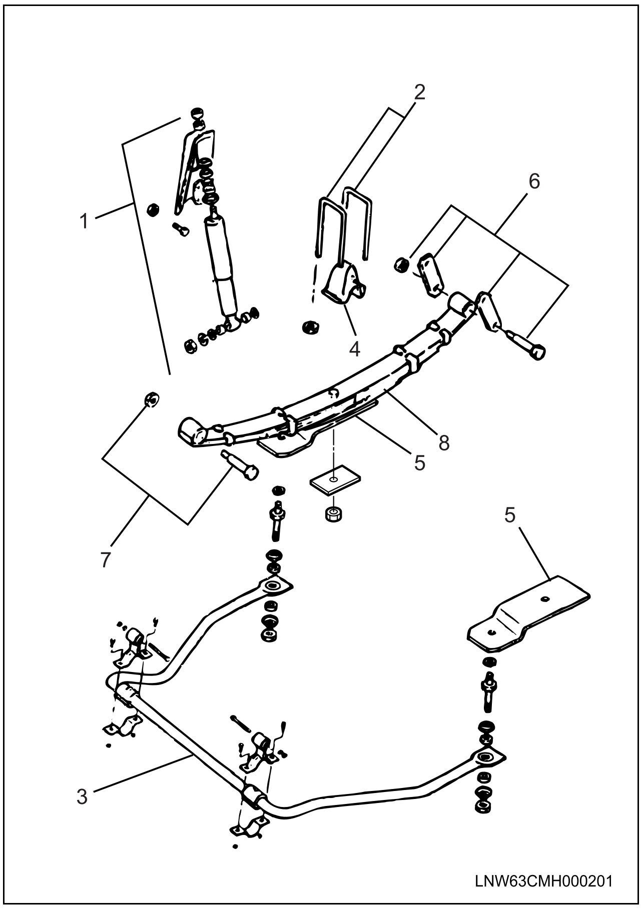
---

2. Drive bolts out, using a brass drift and hammer.
3. Shackle

Inspection Procedure

- Shackle for cracks or damage.
- Upper and lower shackle bolts for scoring or damage.

- Install or Connect.



Legend

1. Shock Absorber Assembly
2. U-Bolt
3. Stabilizer Bar
4. Bumper Stop
5. Stabilizer Bracket
6. Shackle and Bolt
7. Spring Eye Bolt and Nut
8. Leaf Spring

---

1. Shackle.
2. Upper and lower shackle bolts.

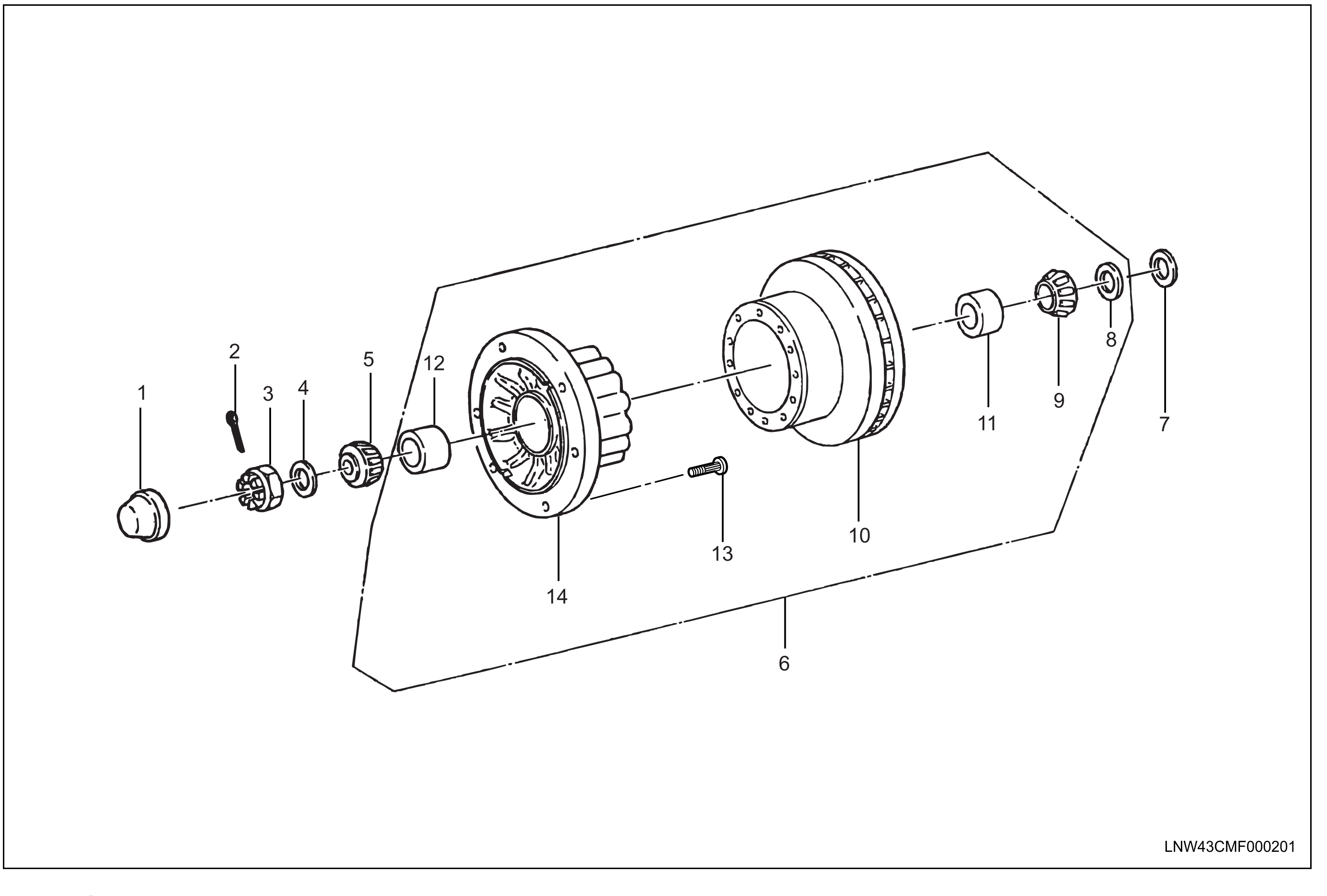
Notice:
Refer to Description and Operation.

3. Washers and nuts.

Tighten

- Shackle nuts and bolts to 202 N·m (149 lb ft).

Front Hubs and Discs



Legend

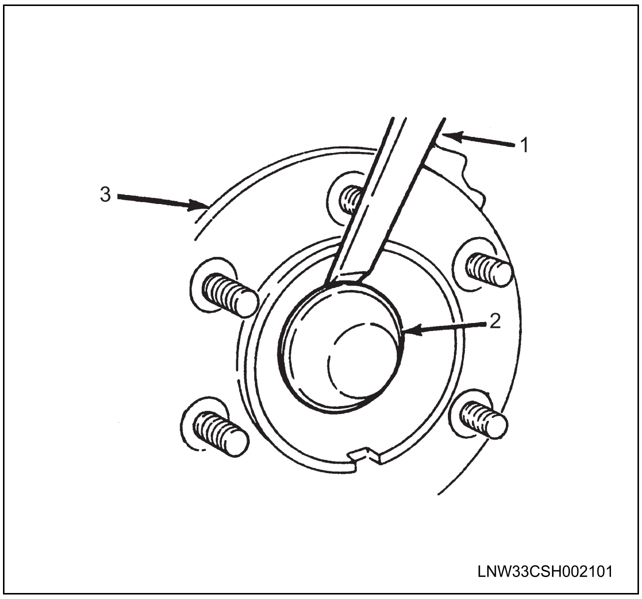
1. Hub Cap
2. Cotter Pin
3. Nut
4. Washer
5. Outer Bearing Inner Race
6. Hub and Disc Assembly
7. Spacer
8. Oil Seal
9. Inner Bearing Inner Race
10. Disc
11. Inner Bearing Outer Race
12. Outer Bearing Outer Race
13. Stud
14. Hub

Removal Procedure

1. Tire and wheel assembly as outlined in Wheels and Tires in this manual.
2. Disc Brake assembly as outlined in Hydraulic Foundation Brakes in this manual.
3. Hub cap

Important:

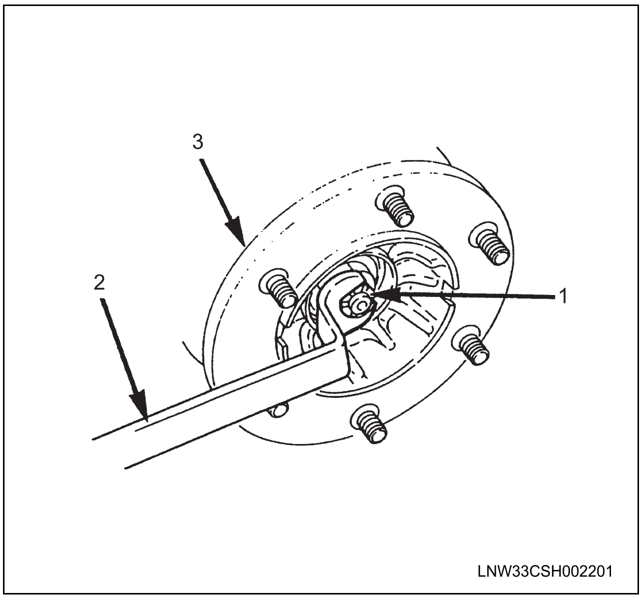
- When removing hub cap, be careful not to scratch or distort the cap sealing face.



Legend

1. Pry Bar
2. Hub Cap
3. Hub and Disc Assembly

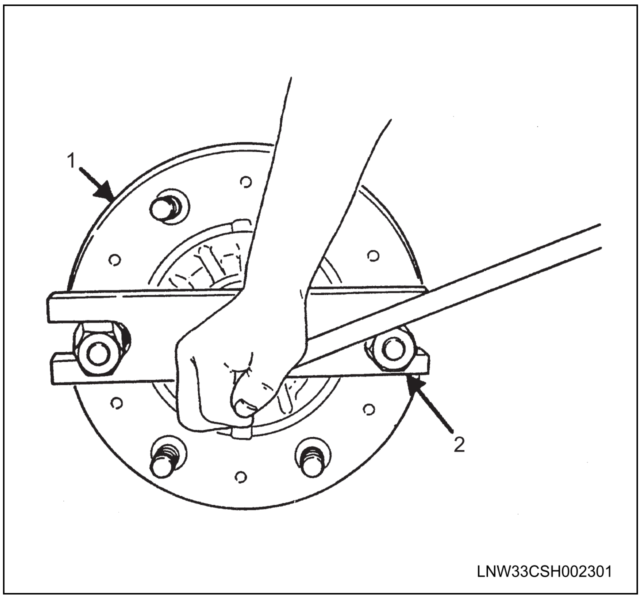
4. Cotter pin from nut and knuckle (spindle).
5. Nut and washer from knuckle (spindle).



Legend

1. Nut
2. Wrench
3. Hub and Disc Assembly

6. Remove front hub and disc assembly.



Legend

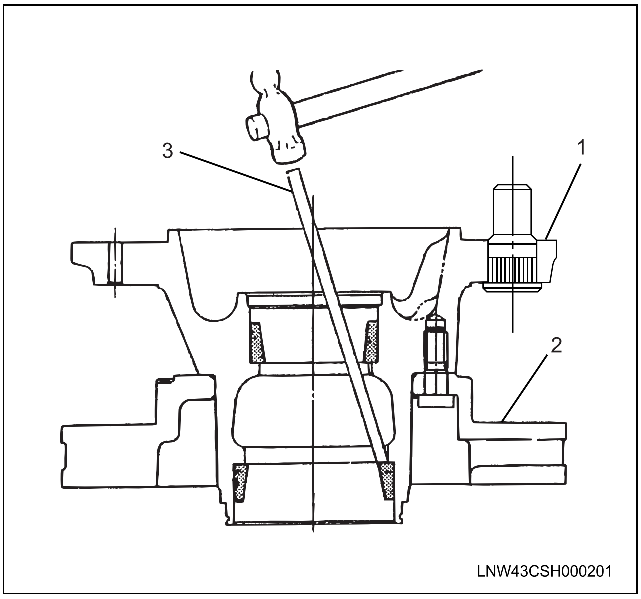
1. Hub
2. J 36429

Important:

- Do not drop the outer bearing as it comes off of the knuckle (spindle).

Installation Procedure

1. Remove excess grease from bearing and race area of hub.
2. Drive the inner and outer bearing races out of the hub.
   The inner race, bearing, seal and spacer will come out as the race is removed.
3. Drive the outer race out from the opposite side.



Legend

1. Hub
2. Disc
3. Brass Bar

Clean

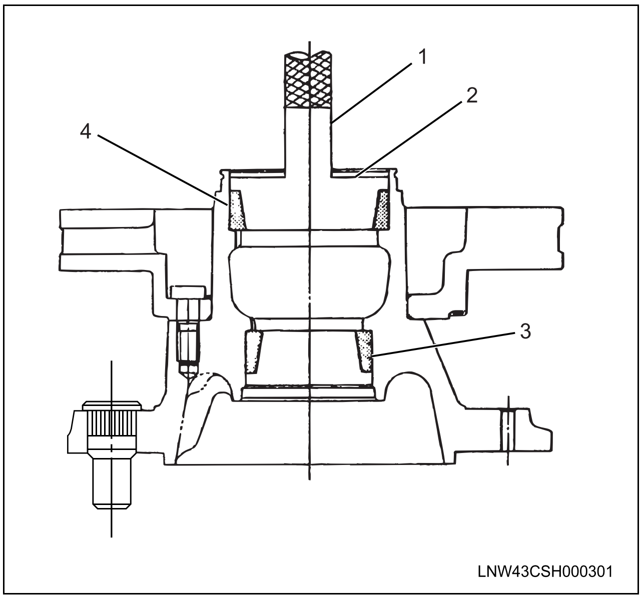
- Hub, bearings, and races with non-flammable solvent and wipe dry.

Inspection Procedure

1. Bearing races. Check the fit of the bearing cups in the hub. If the bearing cups are loose or can be rotated in the bore, the hub must be replaced. If the bearing cups are cracked or pitted, they must be replaced.
2. Bearings. Inspect the bearings for excessive wear, chipped edges, and other damage.
   Refer to Diagnosis of Front Wheel Bearings, previously covered in this section. Slowly roll the rollers around the cone to detect any fat or rough spots. Replace damaged parts.

Assemble

1. Lightly grease the bearing races. Using tools J 8092, J 35712 and J 35713, seat them completely into the hub.



Legend

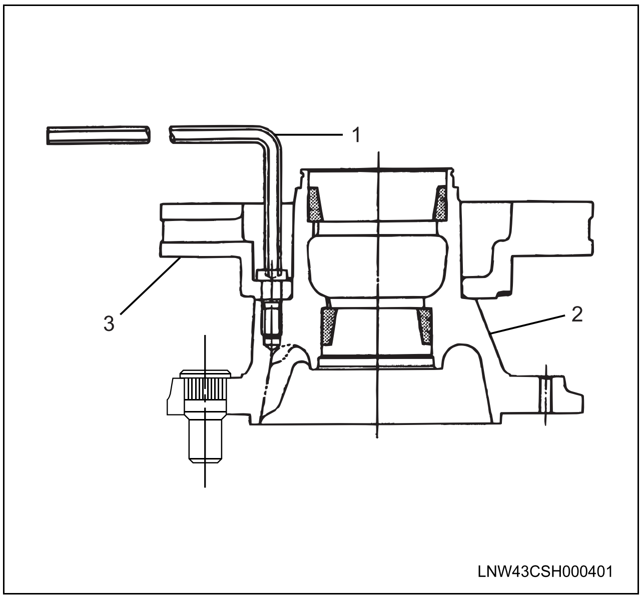
1. Tool Grip J 8092
2. Tool J 35712 (for Inner Bearing), J 35713 (for Outer Bearing)
3. Outer Race
4. Inner Race

---

2. Apply an approved wheel bearing grease into the bearing rollers. The total amount of grease that should be in the hub cavity is 110 grams (3.9 oz) and in the hubcap 40 grams (1.4 oz).
3. Install the inner bearing and the seal with the hollow side of the seal facing the bearing.

Disc Replacement

1. Remove the disc. Use an inner hex wrench to loosen the disc fixing bolts.



Legend

1. Inner Hex Wrench
2. Hub
3. Disc

2. Separate hub and disc.
3. Inspect the disc excessive wear, warped condition and cracks.
4. Measure the disc thickness.

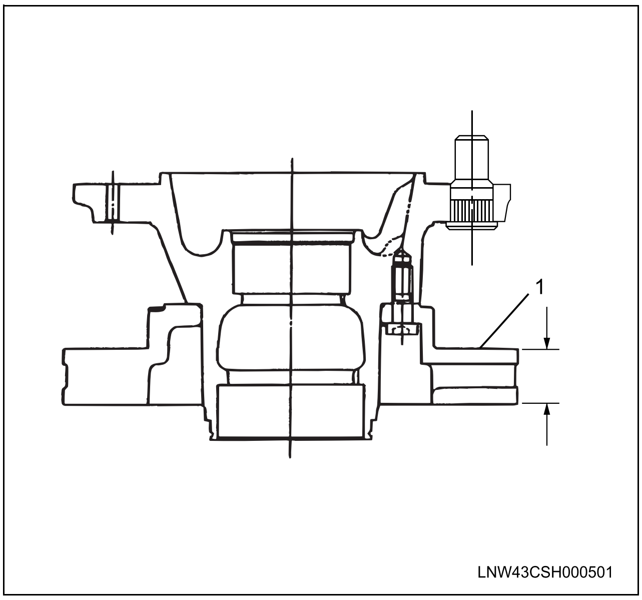
- Disk diameter: 293 mm

  Standard 40.0 mm (1.57 in)

  Limit 37.0 mm (1.46 in)
- Disk diameter: 310 mm

  Standard 42.0 mm (1.65 in)

  Limit 39.0 mm (1.54 in)



Legend

1. Disc

---

5. Assemble hub and disc.

Notice:
For steps 4 and 5, refer to Description and Operation.

Tighten

- Bolts 103 N·m (76 lb ft).

Front Wheel Stud Replacement

Important:

- If any wheel experiences damage to a single stud caused by a loose-running wheel, all the studs should be replaced. A loose-running wheel may cause only one stud to break, but the other studs could have internally fatigued to the point of being damaged. Replacing only the broken stud and remounting the wheel may cause further damage and personal injury. If the stud holes in the wheels become larger in size or distorted, replace the wheel.

1. Remove wheel, hub, and disc as described earlier in this section.
2. Place hub on a suitable work surface and remove the studs, as required, using a hammer.
3. Inspect hub for warped condition, cracks, and enlarged stud holes.
4. Place the hub on a wood workbench or a block of wood approx. 6” by 6” to protect the wheel stud ends and threads.
5. Insert a new wheel stud using hammer.
   Be sure the wheel stud is standed squarely and seats completely.

Notice:
Refer to Description and Operation.

Install or Connect

1. Install the spacer, hub, and disc assembly onto the knuckle (spindle).
2. Install the outer bearing washer and nut onto the knuckle (spindle).

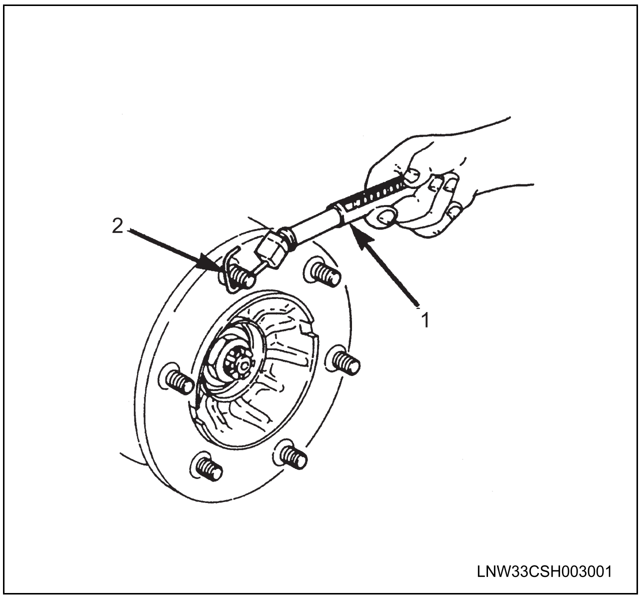
Adjust

- Adjust the wheel bearing as follows:

1. Tighten the nut until you are unable to manually rotate the hub and disc assembly.
2. Loosen the nut.
3. Attach a spring balancer to one stud. Gradually retighten the nut until the hub and disc assembly bearing is adjusted to the specified preload.

Hub bearing preload.

- New Hub Bearing 18 N (4 lb)
- Reused Hub Bearing 13 N (3 lb)



Legend

1. Spring Balancer
2. Stud

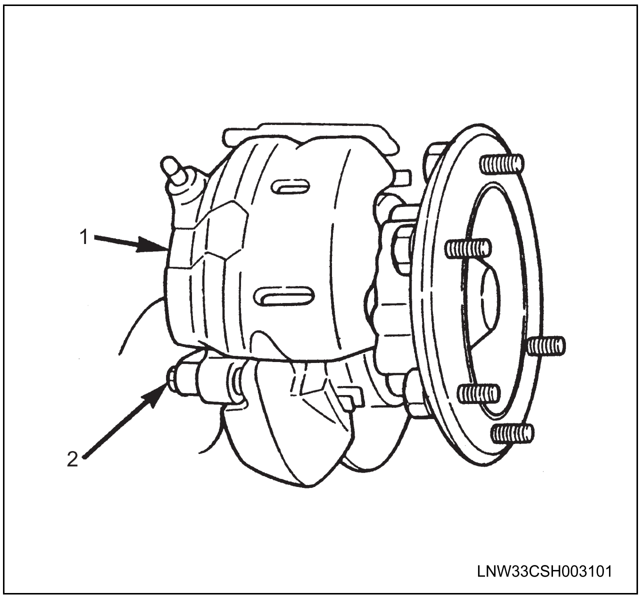
---

4. Install a cotter pin through the nut and knuckle and bend it over.
   - If the notch in the nut dose not line cotter pin hole in the knuckle, tighten the nut until it does. Do not loosen the nut to line up a notch and the knuckle hole.

5. Apply grease into the hub cap and install it.
6. Return the caliper assembly to its original position.

Tighten

- Lock Pin Bolt 137 N·m (101 lb ft).



Legend

1. Caliper Assembly
2. Lock Pin Bolt

Specifications

Front Axle

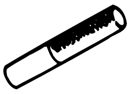
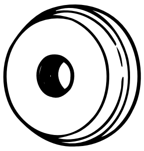
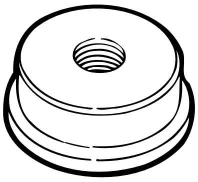
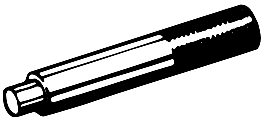
Knuckle Spindle Diameter	
Outer Bearing Race Seat	35 mm (1.377 in)
Inner Bearing Race Seat	50 mm (1.968 in)
Kingpin Diameter	
Production	30 mm (1.181 in)
Service Limit	29.9 mm (1.177 in)
Kingpin to Knuckle Bushing Clearance	
Production	0.06 mm (0.0024 in)
Service Limit	0.15 mm (0.0059 in)
Knuckle to Axle Clearance	
Production	0.10 mm (0.004 in)
Service Limit	0.2 mm (0.008 in)
Front Hub Bearing Preload	
New Bearing	16 N (4 lb)
Reused Bearing	13 N (3 lb)
Front Brake Disc Thickness	
Production	NPR: 40 mm (1.57 in) NPR-HD, NQR, NQR-HD: 42 mm (1.65 in)
Service Limit	NPR: 37 mm (1.46 in) NPR-HD, NQR, NQR-HD: 39 mm (1.54 in)

Fastener Torques

Axle U-bolts	NPR : 127 N·m (94 lb ft) NQR, NRR(NQR-HD): 196 N·m (145 lb ft)
Shock Absorber Lower Fixing Nuts	95 N·m (70 lb ft)
Shock Absorber Upper Fixing Nut	40 N·m (30 lb ft)
Stabilizer Bar	30 N·m (22 lb ft)
Brake Pie Nut	15 N·m (11 lb ft)
King Pin Key Bolt	32 N·m (24 lb ft)
Leaf Spring Center Bolt	39 N·m (29 lb ft)
Leaf Spring Eye Bolts	202 N·m (149 lb ft)
Leaf Spring Shackle Bolts	202 N·m (149 lb ft)
Shock Absorber Upper Fixing Nut	20 N·m (14 lb ft)
Hub to Disc Bolts	103 N·m (76 lb ft)
Caliper Lock Pin Bolts	137 N·m (101 lb ft)

Special Tools

Special Tools

Illustration	Tool Number/ Description
 5884020200	J 35710 King Pin Key Bolt Remover
 5884021630	J 35712 Front Hub Bearing Inner Race Installer
 5884020260	J 35713 Front Hub Bearing Outer Race Installer
 9852211480	J 8092 Grip

SUSPENSION

Rear Suspension

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Description and Operation

Rear Suspension Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

The rear suspension consists of two semi-elliptical leaf springs. They have closed eyes at each end with replaceable bushings. The front of the spring is attached to the vehicle frame with a bolt through a bracket. Shackle links connect the rear of the springs to frame brackets.

Auxiliary springs, bolted to the top of the main springs, have no eyes and slide on the frame brackets .

Telescoping hydraulic shock absorbers are mounted between the spring U-bolt support plate and the vehicle frame.

Spring Maintenance

Lubrication

Spring leaves are lubricated at the time of manufacturing and require no further lubrication unless the spring is disassembled. Metal spring eye bushings require lubrication with chassis lubricant as described in Maintenance and Lubrication in this manual.

Tightening

U-bolts must be kept tight at all times to hold the axle and spring in place. Otherwise, the axle may shift, causing misalignment; also, spring leaf failure in the vicinity of the spring center bolt could result. Refer to Maintenance and Lubrication for tightening intervals.

Diagnosis Information and Procedures

Spring Noise

POSSIBLE CAUSE	CORRECTION
1. Loose U-bolts.	1. Tighten to specified torque.
2. Loose or worn eye bushings.	2. Replace the eye bushings.
3. Lack of lubrication.	3. Lubricate as required.

Spring Sag or Bottom

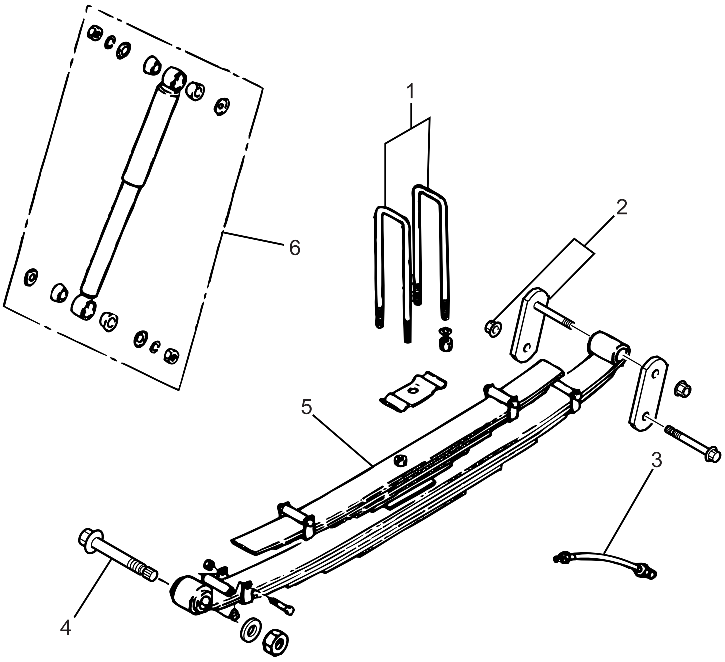
POSSIBLE CAUSE	CORRECTION
1. Broken spring leaf.	1. Replace the leaf or spring assembly.
2. Severe operation or overloading.	2. Check the load capacity rating.

Spring Breakage

POSSIBLE CAUSE	CORRECTION
1. Loose U-bolts.	1. Tighten to specified torque.
2. Normal fatigue	2. Replace the spring.
3. Overloading.	3. Check the load capacity rating

Repair Instructions

Spring



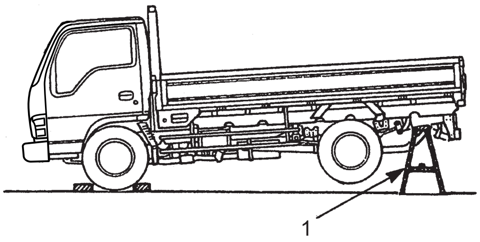
LNW63DMF000101

Legend

1. U-Bolt
2. Shackle Assembly
3. Brake Flexible Hose
4. Front Eye Bolt
5. Spring
6. Shook Absorber Assembly

Removal Procedure

- Raise the vehicle frame and support the frame with jack stands.

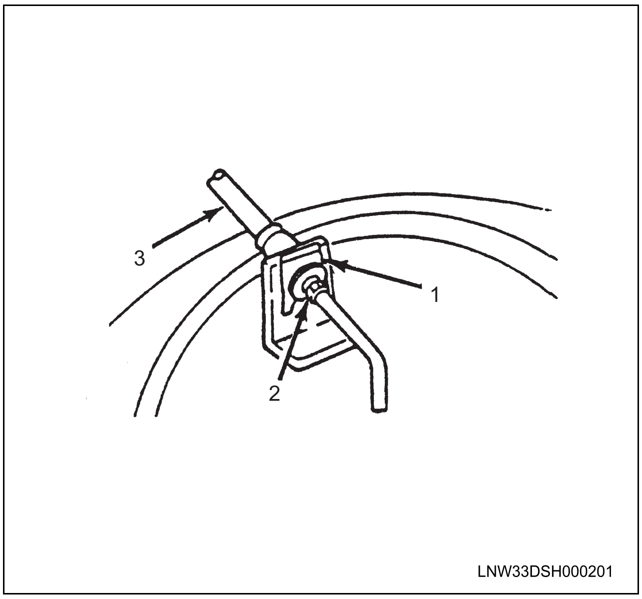


LNW53DSH000101

Legend

1. Jack Stands

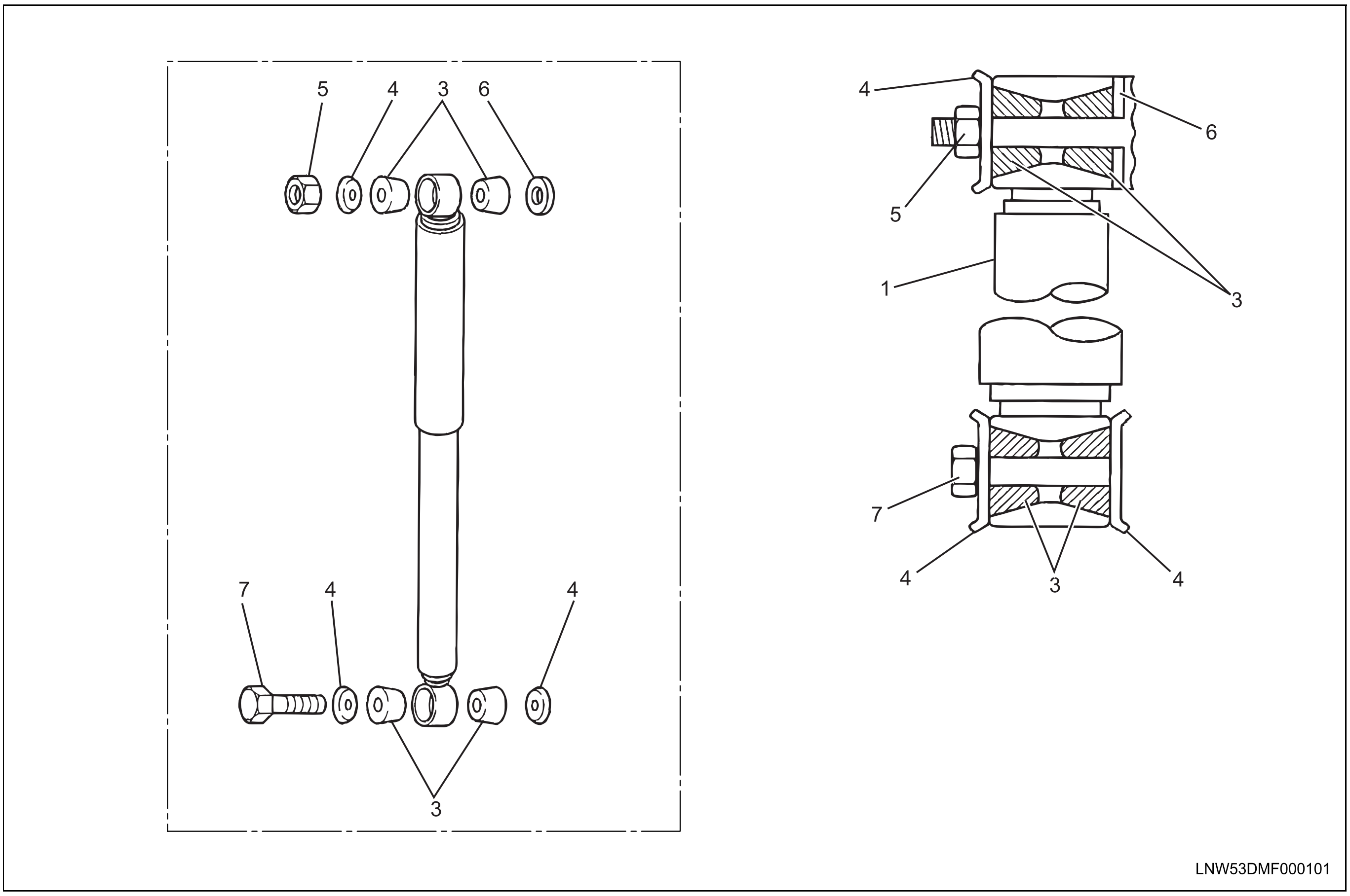
1. The steel tube nut from the brake flexible hose. Pry the hose clip off the flexible hose.



Legend

1. Clip
2. Steel Tube Nut
3. Brake Flexible Hose

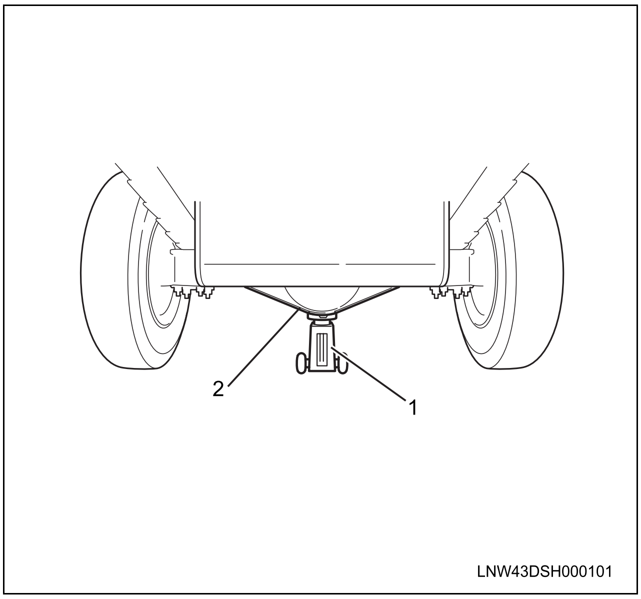
2. Nuts and remove shock absorbers from lower shock absorber mounts.



Legend

1. Shock Absorber
2. Mounting Stud
3. Rubber Bushings
4. Dish Washer
5. Nut
6. Flat Washer
7. Bolt

3. Support the rear axle housing with a jack.

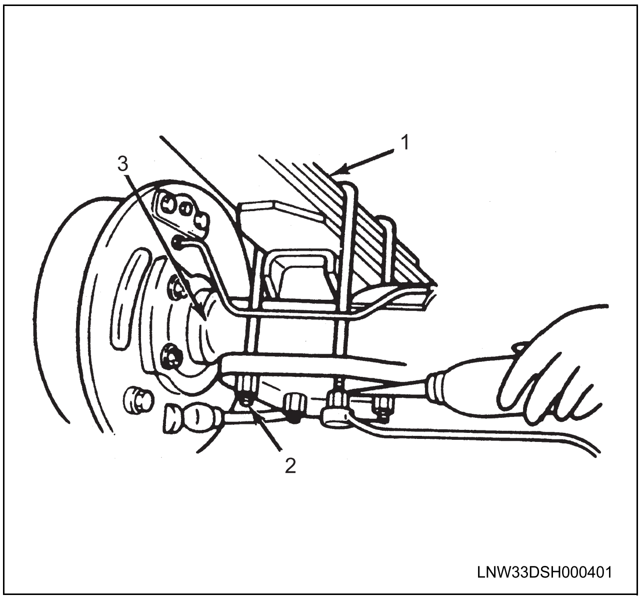


Legend

1. Jack
2. Rear Axle Housing

---

4. The U-bolt nuts and bolts.

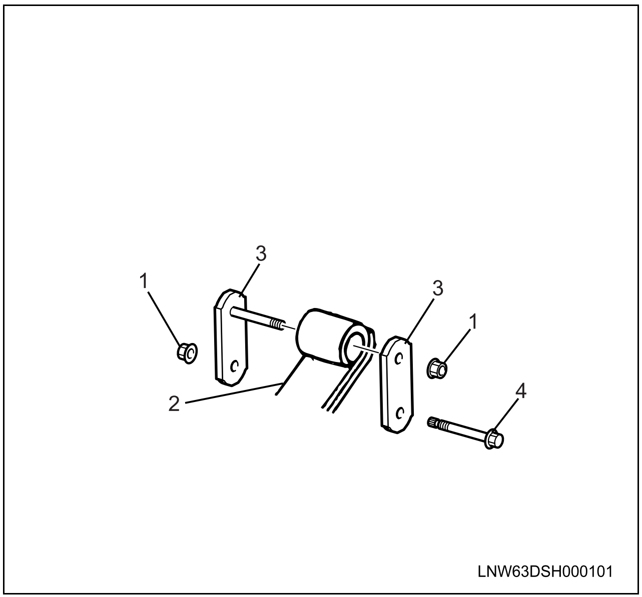


Legend

1. Spring
2. U-Bolt Nut and Bolt
3. Rear Axle Housing

---

5. The shackle nuts and shackles.

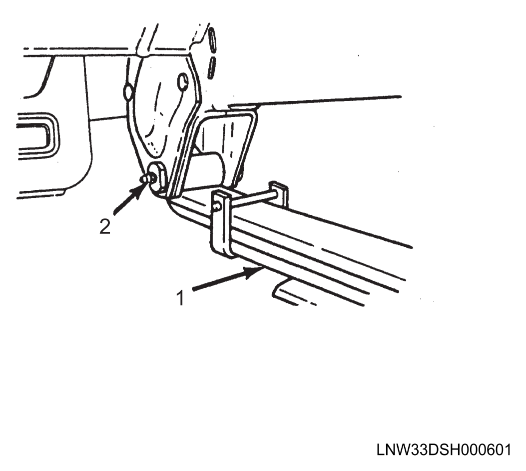


Legend

1. Nut
2. Spring
3. Shackle
4. Pin

---

6. The front eye bolt and spring.



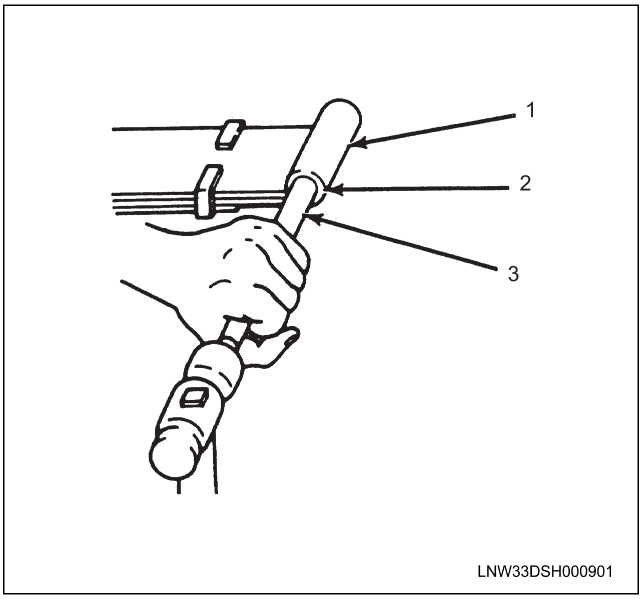
Legend

1. Spring
2. Front Eye Bolt

Installation Procedure

Notice:
For steps 3, 4, 6 and 8, refer to Description and Operation.

1. New spring eye bushing(s) if necessary. Use a suitable bushing tool that will not damage the bushing or spring.

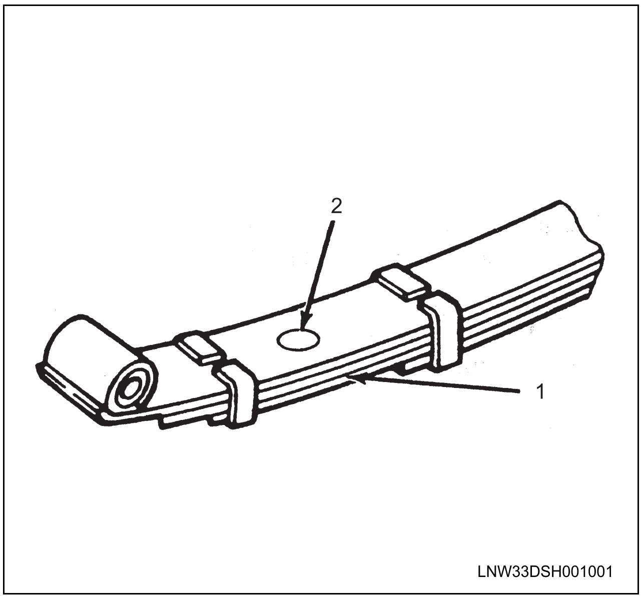


Legend

1. Spring
2. Spring Eye Bushing
3. Bushing Tool

Important:

- Position the spring with the camber mark toward the front.

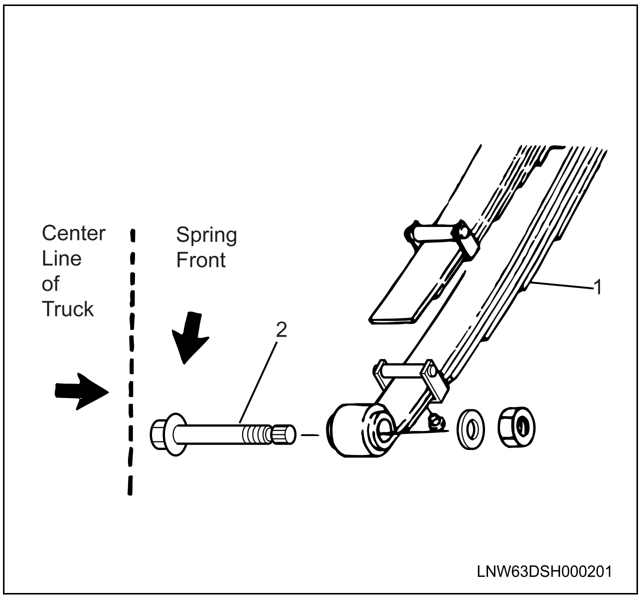


Legend

1. Spring
2. Camber Mark

---

2. The front eye bolt with the head toward the inside or centerline of the vehicle. Install nut finger tight.



Legend

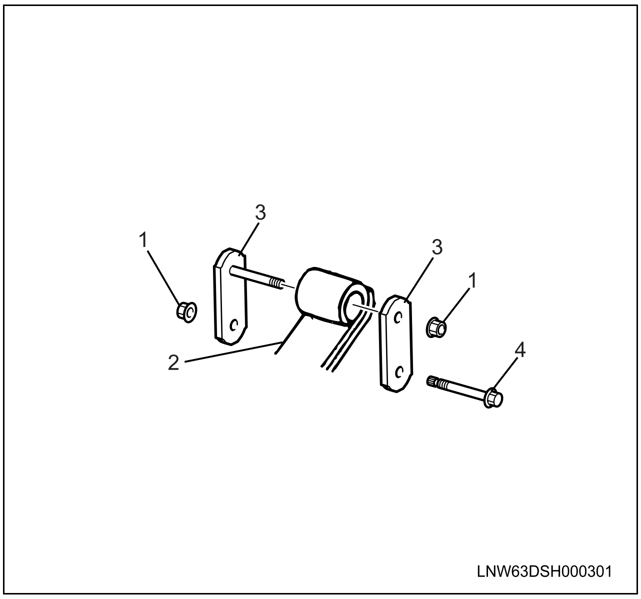
1. Spring
2. Front Eye Bolt

---

3. The shackle bushing and nuts into the rear of the spring and the frame bracket. Install nuts finger tight.

Tighten

- Front eye bolt and shackle nuts to 202 N·m (149 lb ft).



Legend

1. Nut
2. Spring
3. Shackle
4. Pin

---

4. Support the rear axle with a floor jack and install the U-bolts. Oil the U-bolt threads.

Tighten

- U-bolt nuts to 202 N·m (149 lb ft).

5. Shock absorber assembly and attaching parts to the lower shock absorber mount.

Tighten

- Shock absorber nuts to 95 N·m (70 lb ft).
- Shock absorber bolt to 40 N·m (30 lb ft).

6. Brake flexible hose into bracket.
7. Hose clip and steel tube nut.

Tighten

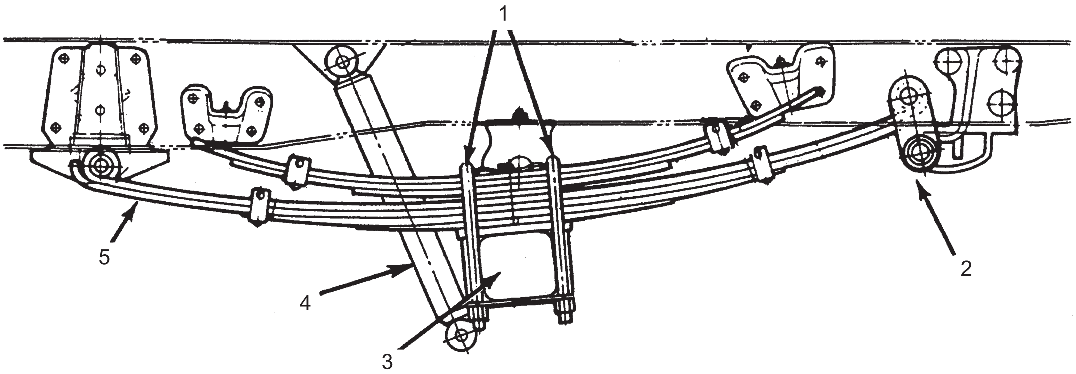
- Steel tube nut to 15 N·m (11 lb ft).

8. Lower the vehicle and bleed the brakes as described in Hydraulic Foundation Brakes.

Inspection Procedure

1. Spring leaves for breaks or cracks.
2. Front eye bolt bushing for wear.
3. Clamps.
4. U-bolts.
5. Center bolt.
6. Brackets.

Spring Leaf



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Legend

1. U-Bolt
2. Shackle
3. Rear Axle Housing
4. Shock Absorber
5. Spring

Preparation

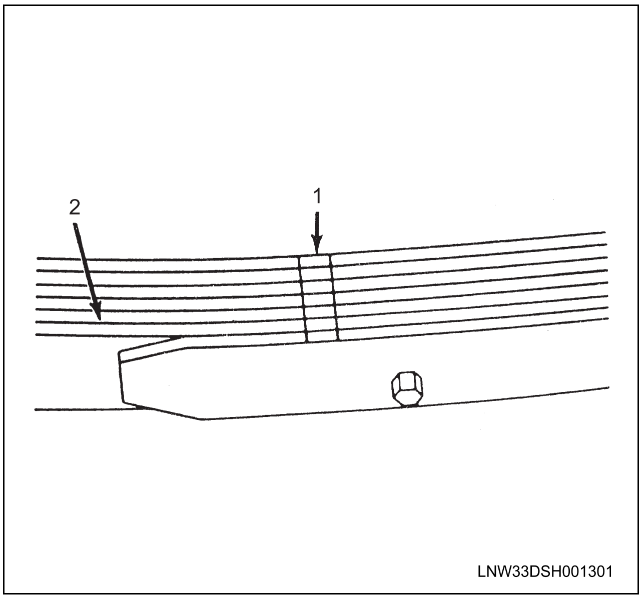
Remove the spring as described in this section.

Clean

- The Spring assembly.

Removal Procedure

1. Mark the spring leaves for reassembly reference.

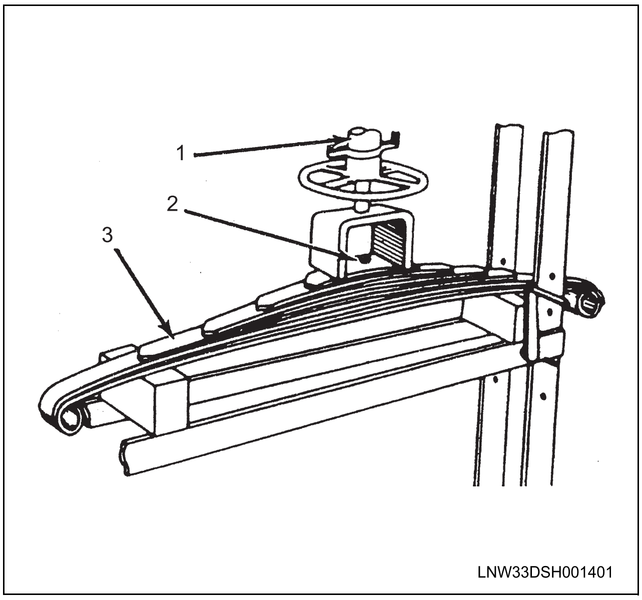


Legend

1. Reference Mark
2. Spring

---

2. Place the spring in a bench press and slightly compress it. Remove the spring center bolt and clamps.



Legend

1. Press Ram
2. Spring Center Bolt
3. Spring

- Discard center bolt and replace with a new one.

3. Remove press pressure and move spring to bench.

Installation Procedure

Notice:
For steps 3 and 4, refer to Description and Operation.

1. Apply a coat of chassis lubricant to each leaf.
2. Assemble the leaves according to the reference mark.
   - Compress the assembly in a press.
3. Install a new spring center bolt and nut.

Tighten

- Spring center bolt nut to 39 N·m (29 lb ft).

4. Rebound clamps

Tighten

- Rebound clamps to 20 N·m (14 lb ft).

Inspection Procedure

1. Spring leaves for breaks or cracks.
2. Rebound clamps.
3. Center bolt holes in leaves for elongation.

Spring Eye Bushing

Spring Eye Bushing Replacement is described under Spring Replacement in this section.

Shock Absorber

Remove or Disconnect

The nuts and bolts attaching the upper and lower shock absorber mounts on the lower U-bolt plate and on the frame side rails.

Installation Procedure

1. Assemble the rubber bushings in the shock absorber eyes.
2. The shock absorbers on the mounting studs or bolts.

Notice:
Refer to Description and Operation.

3. Nuts.

Tighten

- Shock absorber nuts to 95 N·m (70 lb ft).
- Shock absorber bolts to 40 N·m (30 lb ft).

Inspection

Refer to Diagnosis of Shock Absorber in Front Axle and Suspension.

Specifications

Fastener Torques

Front Spring Eye Bolt Nut	202 N·m (149 lb ft)
Shackle Nuts	202 N·m (149 lb ft)
U-Bolts	Differential Gear 292 mm : 177 N·m (130 lb ft)
	320 mm : 284 N·m (209 lb ft)
Shock Absorber Nut	95 N·m (70 lb ft)
Shock Absorber Bolt	40 N·m (30 lb ft)
Brake Steel Tube Nut	15 N·m (11 lb ft)
Spring Center Bolt	39 N·m (29 lb ft)
Spring Rebound Clamps	20 N·m (14 lb ft)

SUSPENSION

Wheels and Tires

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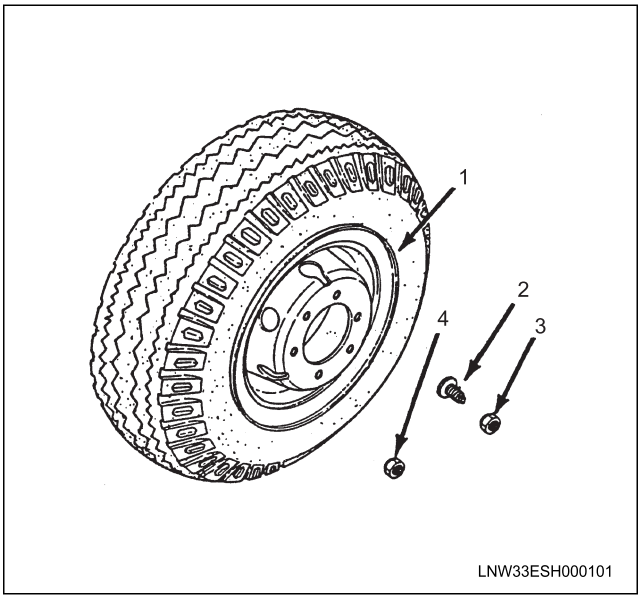
Description and Operation

Wheels and Rims Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

The vehicle is equipped with disc wheels. Disc wheels have the wheel and rim as an integral unit.



Legend
1. Wheel and Tire Assembly
2. Rear Inner Wheel Nut
3. Rear Outer Wheel Nut
4. Front Wheel Nut

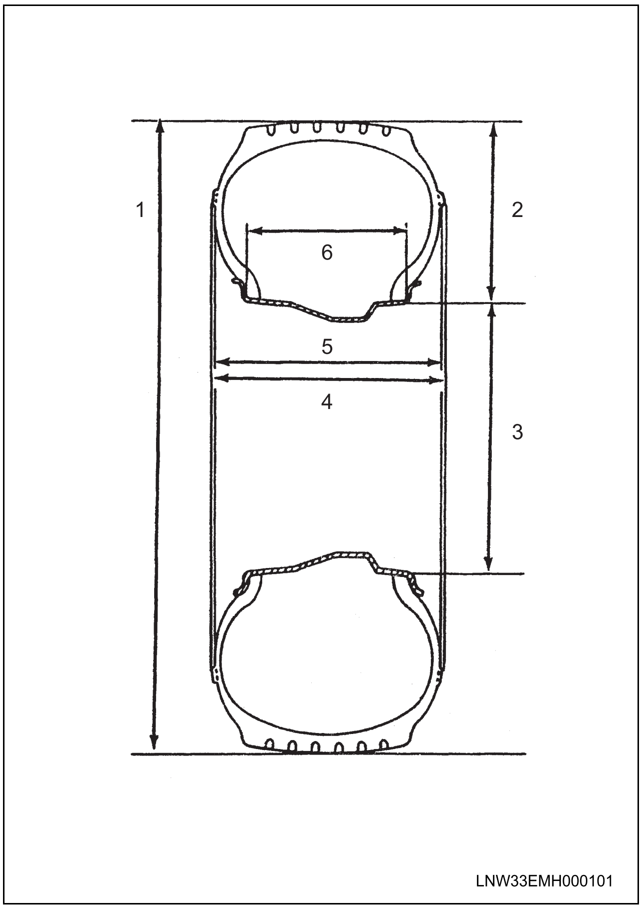
Tires and Tubes Description

Tires on this vehicle have radial-ply construction, and are tube-type. These tires are designed for highway and off-highway use. The proper size tire, in addition to the correct inflation, should be maintained for the load that the truck is designed to carry. For additional information not covered in this section, refer to the tire manufacturer's publication.

Caution:
Do not mix different tire construction types on the vehicle such as radial, bias, and bias-belted tires, except in emergencies, because vehicle handling could be affected and may result in loss of control.

Definition of Terms

The following terms refer to measuring a tire an rim as shown:



Legend
1. Overall Diameter
2. Section Height
3. Rim Diameter
4. Overall Width
5. Section Width
6. Rim Width

Overall Diameter

Overall diameter is twice the section height of a tire (measured from opposite outer tread surfaces) including 24-hour inflation growth, plus the nominal rim diameter.

Section Height

Section height is the distance from rim seat to outer tread surface of a laden tire. (This measurement does not include decorations, markings or borders on tire.)

Nominal Rim Diameter

Nominal rim diameter is measured from opposite rim seats.

Overall Width

Overall width is the width of a new tire, including 24-hour inflation growth, and including protective side ribs, bars and decorations.

Section Width

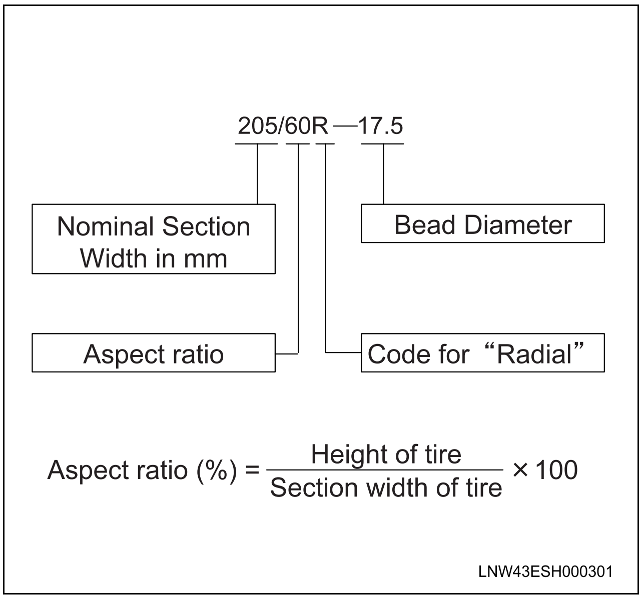
Section width is the width of a new tire (the distance between outside of sidewalls) including 24-hour inflation growth and including normal sidewalls, but not including protective side ribs, bars, or decorations.

Rim Width

Rim width is the specific rim width assigned to each tire size designation to determine basic tire dimensions.

Radial Tubeless-Type Tires

Radial tires approved for use on ISUZU NPR/W4 truck has tubeless-type construction.



$$\text{Aspect ratio (\%)} = \frac{\text{Height of tire}}{\text{Section width of tire}} \times 100$$

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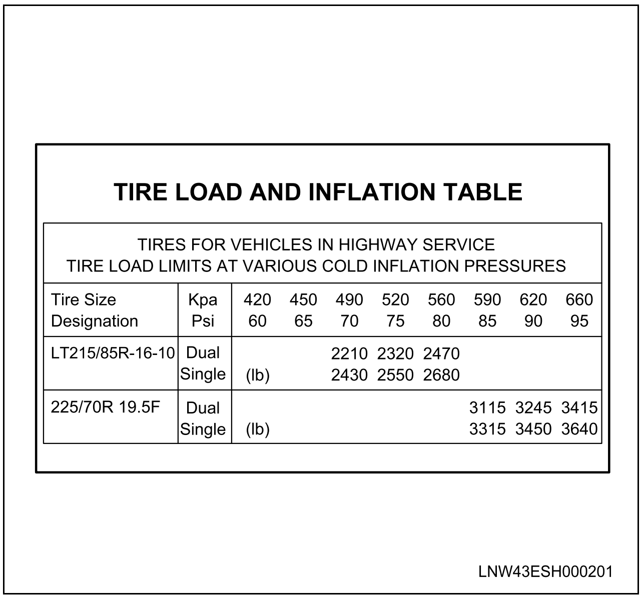

TIRE LOAD AND INFLATION TABLE

TIRES FOR VEHICLES IN HIGHWAY SERVICE
TIRE LOAD LIMITS AT VARIOUS COLD INFLATION PRESSURES

Tire Size Designation	Kpa Psi	420 60	450 65	490 70	520 75	560 80	590 85	620 90	660 95
LT215/85R-16-10	Dual			2210	2320	2470			
	Single	(lb)		2430	2550	2680			
225/70R 19.5F	Dual						3115	3245	3415
	Single	(lb)					3315	3450	3640

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Diagnostic Information and Procedure

Wheel Hop (Vehicle Vibration and Rough Steering)

POSSIBLE CAUSE	CORRECTION
Wheels	
1. Rocks and debris wedged between dual disc wheels.	1. Remove rocks and debris.
2. Out-of-balance tire and/or hub and drum/rotor assembly.	2. Determine the out-of-balance component and balance or replace.
3. Improper positioning of the side rings split.	3. Reassemble with ring split opposite (180 degrees) the valve opening to improve balance.
Vehicle	
Loose or worn driveline or suspension.	Identity location of vibration carefully as it may be transmitted through the frame making a rear end vibration appear to come from the front. Then repair or replace loose or worn parts (Refer to Propeller Shaft)

Wobble (Vehicle Vibrations and Rough Steering)

POSSIBLE CAUSE	CORRECTION
Wheel	
1. Bent or distorted disc from overloading or improper handling.	1. Replace wheel.
2. Loose mountings, damaged studs cap nuts, enlarged stud holes, worn or broken hub face, or foreign material on mounting surfaces.	2. Replace worn or damaged parts. Clean mounting surfaces.
Vehicle	
1. Improper alignment.	1. Have vehicle aligned.
2. Loose, worn or broken suspension parts.	2. Repair or replace.

Cracked or Broken Wheel Discs (Cracks Develop in the Wheel Disc from Handhole to Handhole, from Handhole to Rim, or from Handhole to Stud)

POSSIBLE CAUSE	CORRECTION
Metal fatigue resulting from overloading.	Replace wheel. Check position of wheel on vehicle for working load specifications.

Tire Slippage on Rim

POSSIBLE CAUSE	CORRECTION
1. Improper storage or operating conditions.	1. Correct as required.
2. Poor maintenance.	2. Follow proper maintenance procedures.
3. Rust, corrosion on bead seating.	3. Correct as required.

POSSIBLE CAUSE	CORRECTION
4. Loss of pressure.	4. Follow proper maintenance procedures.

Tire Mounting Difficulties

POSSIBLE CAUSE	CORRECTION
1. Mismatch tire and rim sizes.	1. Correct as required.
2. Defective or mismatched rings for rim use.	2. Correct as required.
3. Over-inflation of tires.	3. Follow recommended tire pressure.
4. Corrosion and dirt.	4. Correct as required.

Tires Show Excessive Wear on Edges of Tread

POSSIBLE CAUSE	CORRECTION
1. Underinflated tires.	1. Properly inflate to recommended pressure.
2. Vehicle overloading.	2. Correct as required.
3. High speed cornering.	3. Correct as required.
4. Incorrect toe-in setting.	4. Set to correct specifications.

Tires Show Excessive Wear in Center of Tread

POSSIBLE CAUSE	CORRECTION
Tires over-inflated.	Properly inflate to recommended pressure.

Excessive Tire Wear

POSSIBLE CAUSE	CORRECTION
1. Improper tire pressure.	1. Properly inflate to recommended pressure.
2. Incorrect tire/wheel usage.	2. Install correct tire/wheel combination.
3. Defective shock absorbers.	3. Repair or replace.
4. Front end out of alignment.	4. Align front end.
5. Loose, worn or damaged steering linkage, Joints, suspension components, bushings and ball joints.	5. Inspect, repair or replace as required.

Dual Tires Rubbing

POSSIBLE CAUSE	CORRECTION
Insufficient wheel spacing.	Check tire and wheel sizes.

Tire Wear

Irregular Tire Wear

Heel and Toe Wear–This is a saw-toothed effect where one end of each tread block is worn more than the other. The end that wears is the one that first grips the road when the brakes are applied.

Heel and toe wear is less noticeable on rear tires than on front tires, because the driving action of the rear wheels creates a force which tends to wear the opposite end of the tread blocks. The two forces, driving and braking, make for a more even wear of the rear tires, whereas only the braking forces act on the front wheels, and the saw-toothed effect is more noticeable.

A certain amount of heel and toe wear is normal.

To correct the problem, in addition to cautioning the driver on his driving habits, rotate the tires regularly.

Side Wear

This may be caused by incorrect wheel camber, underinflation, high-cambered roads, or by taking corners at too high a rate of speed.

The first two causes are the most common.

Camber wear can be readily identified because it happens only on one side of the treads whereas underinflation causes wear on both sides. Camber wear requires correction of the camber first and then interchanging tires. There is, of course, no correction for high cambered roads. Cornering wear is discussed further on.

Misalignment Wear

This wear is due to too much toe-in or toe-out. In either case tires will revolve with a side motion and scrape the tread rubber off both.

If misalignment is severe, the rubber will be scraped off tires; if slight, only one will be affected.

The scraping action against the face of the tire causes a small feather edge of rubber to appear on one side of the tread and this feather edge is an indication of misalignment. To correct, adjust toe-in or check the entire front end alignment.

Cornering Wear

When a vehicle makes a fast turn, the weight is shifted from an even loading on all wheels to an abnormal overload on the outside tires and a very light load on the inside tires, due to centrifugal force. This unequal loading may have two harmful results.

First, the rear tire on the inside of the curve may be relieved of so much load that it is no longer geared to the road and it slips, grinding off the tread on the inside half of the tire. This type of tire shows much the same appearance of tread as tire wear caused by negative camber.

Second, the transfer of weight may also overload the outside tires so much that they are laterally distorted, resulting in too much wear on the outside half of the tire, causing a type of wear like that caused by too much positive camber.

Cornering wear can be set apart from abnormal camber wear by the rounding of the outside shoulder or edge of the tire and by the roughening of the tread surface which shows abrasion.

Cornering wear often produces a fin or raised portion along the inside edge of each row in the tread pattern. In some cases this fin stands out as a toe-in fin, and in others, it tapers into a row of tread blocks to such an extent that the tire has a "step wear" look.

Driving more slowly on curves and turns will avoid grinding rubber off the tires. To offset normal cornering wear as much as possible, tires should be rotated at regular intervals.

Uneven Wear

Uneven or spotty wear is due to unequal caster or camber, bent suspension parts, out-of-balance wheels, brake drums out of round, brakes out of adjustment or other mechanical conditions.

The correction in each case involves locating the mechanical defect and correcting it.

Power and Speed

Too much speed has always been harmful to tires. Speed creates heat and excessive heat may damage tires.

Stops and Starts

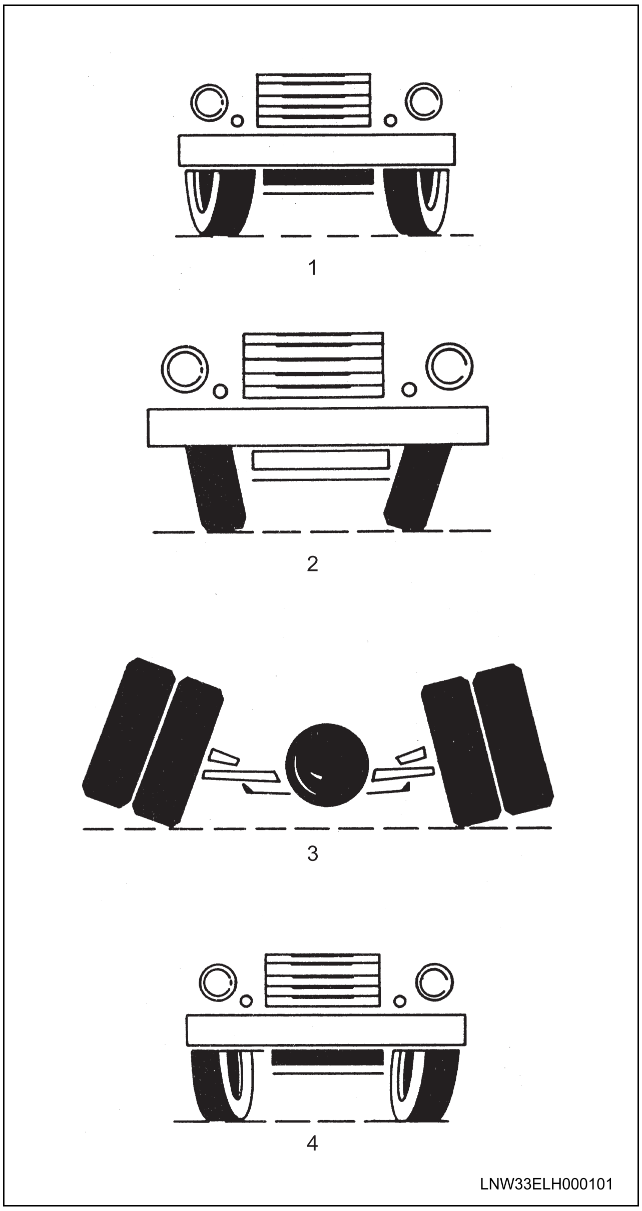
Quick stops and starts grind off tread in a hurry. This may cause flat spots which continue to grow for the life of the tire.

Temperature

Less mileage can be expected from a tire used in all warm weather driving as compared to all cool weather driving, or from a tire first put into service in warm weather.

Tire Wear Due to Mechanical Problems

The following paragraphs include some wheel or vehicle irregularities which may cause rapid or uneven tread wear.



Legend

1. Toe-In
2. Camber
3. Sprung or Sagging Axle
4. Toe-Out

Toe-in
The wheels on the same axle are closer together in the front than they are in the rear. When toe-in is too much the tire wear shows feathered edges on the outside edge of the skid design.

Toe-out
The wheels on the same axle are closer together in the rear than they are in the front. Tire wear shows feathered edges on the outside edge of the skid design.

Camber
This shows the tilt of the wheel. Positive camber is when wheels are closer together at the point of road contact. Negative camber is when the wheels are closer together at the top. Too much camber results in greater wear on one side of the tire.

Caster
This is the backward tilt of the axle or inclination of the kingpin at the top. Too little caster causes the wheel to wander or weave result, spotty wear. Unequal caster causes the wheel to pull to one side, resulting in more and uneven wear.

Sprung or Sagging Axle
Either of these conditions causes uneven spreading of the load. A sprung or sagging axle will cause the inside dual tire to carry the greater load.

Sprung or Twisted Frame
Will cause rapid or uneven tread wear.

Grabbing Brakes
Brakes out of adjustment and out-of-round brake drums cause tire treads to wear rapidly in spots. Out-of-round brake drums usually wear out tires in a single spot. Improperly adjusted brakes produce several worn places.
Worn wheel bearings, loose radius rods and U-bolts, unbalanced wheels, or wobbly wheels all result in uneven and irregular tread wear.
At the first sign of uneven tire tread wear, check and correct all mechanical irregularities.

Damaged Stud Holes (stud Holes Become Worn, Elongated or Deformed, Metal Builds up Around Stud Hole Edges, Cracks Develop from Stud Hole to Stud Hole)

POSSIBLE CAUSE	CORRECTION
Loose wheel mounting.	Replace wheel and check for: • Installation of correct studs and nuts. • Cracked or broken studs – replace. • Worn hub face – replace. • Broken or cracked hub barrel – replace. • Clean mounting surfaces and retorque cap nuts periodically. • Rust streaks fanning out from holes indicate that the cap nuts are or have been loose.

Damaged Stud Threads

POSSIBLE CAUSE	CORRECTION
Sliding wheel across studs during assembly.	Replace stud following proper wheel installation.

Loose Drum

POSSIBLE CAUSE	CORRECTION
Improper drum bolt.	Replace with proper length bolt.

Loose Inner Wheel

POSSIBLE CAUSE	CORRECTION
1. Excessive stud standout from mounting face of hub allowing wheel nut to bottom out.	1. Replace with proper length bolt.
2. Improper torque	2. Use recommended torque procedure.

Broken Wheel Studs

POSSIBLE CAUSE	CORRECTION
1. Loose cap nuts	1. Replace stud and follow proper torque procedures.
2. Overloading.	2. Replace stud.

Stripped Threads

POSSIBLE CAUSE	CORRECTION
Excessive clamp load.	Replace studs follow proper torque procedure.

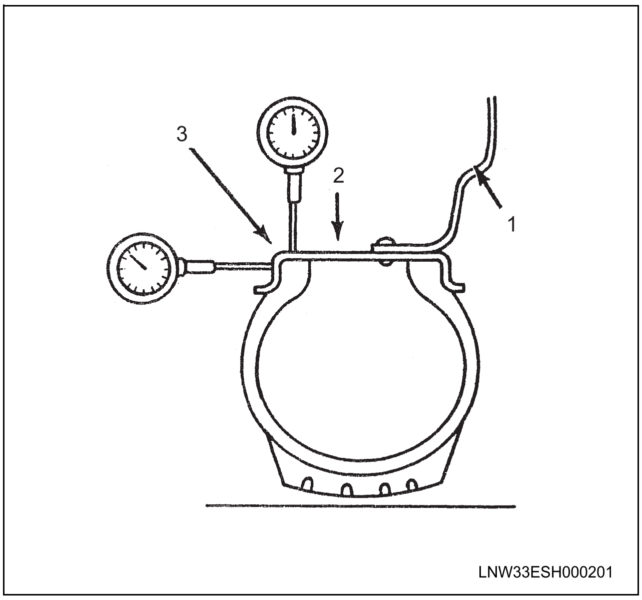
Rust Streaks from Stud Holes Correction

POSSIBLE CAUSE	CORRECTION
Loose cap nuts.	Check complete assembly, replace damaged parts and follow proper torque procedure.

Lateral or Radial Run-out Description

Do not use wheels with bent rims. The continued use of such wheels will cause tire wear and, if the wheel is mounted on the front of the vehicle, difficulty in steering will result. Wheels that are thought to be distorted may be checked as follows, referring to checking points:

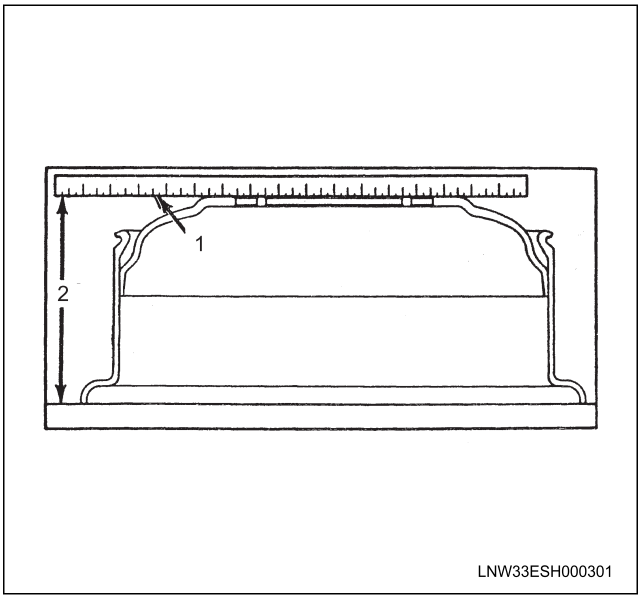
1. Raise the axle and safely support it.
2. Mount a dial indicator at the inside of the wheel as shown. Rotate the wheel and measure the radial runout (out-of-round condition).
   Runout should not exceed 2.3 mm (0.09 in).



Legend

1. Wheel
2. Inside of Wheel
3. Crown of Rim

3. Mount a dial indicator on the crown of the rim as shown. Rotate the wheel and measure lateral runout (side wobble). Runout should not exceed 2.3 mm (0.09 in).
4. If doubt exists whether the wheel or hub is distorted, the hub may be checked as follows: Replace the existing wheel with a wheel known to be true. Turn the wheel and make the previous tests. If the tests are within the limits, the hub is good, but the wheel is sprung.
5. A dismounted wheel may be checked for side wobble by placing a straight-edge on the face or hub of the wheel. Measure the distance from the straight-edge to the edge of the wheel rim. This should be checked at four equally spaced locations. If the distance is the same at all positions, the wheel is not distorted.



Legend

1. Straight Edge
2. Measurements should be taken at four equally spaced locations around the hub of the wheel.

Wheel Studs and Nuts Description

Caution:

If any wheel experiences damage to a single stud caused by a loose-running wheel, all the studs should be replaced. A loose-running wheel may cause only one stud to break, but the other studs could have internally fatigued to the point of being damaged. Replacing only the broken stud and remounting the wheel may cause further damage and personal injury. If the stud holes in the wheels have become larger in size of distorted, replace the wheel.

When a damaged or broken stud is found, replace all the studs. Internal stress cracks could result from the added strain in carrying the load of the broken stud.

Stripped threads on the studs may be the result of over torquing the stud nuts or damage during wheel installation when placing the wheel over the studs.

Where a damaged thread is found, the stud should be replaced.

Broken studs are a result of operating with loose or over torqued stud nuts or improperly seated wheels.

Freezing of a Nut

This condition results from corrosion or galling of the stud and nut assembly which can reach a point where the removal of nuts is difficult. If this is a continuing problem, the threads of the stud should be cleaned with a wire brush. To aid in avoiding this problem use cadmium plated stud nuts with dichromate dip.

Inspection and Maintenance of Wheels on Vehicle

Inspect

- Examine the wheels at frequent intervals for safe operation.
- Particular care should be given to the front wheels. Check all exposed areas often. Clean off dirt and look for cracks or other damage.

Avoid Abuse

Abuse may shorten the life of the wheel. Lack of care in changing a tire, heavy pounding on a wheel rim, overloading or hitting curbs at high speeds, or sharp angle may damage wheels.

Keep Stud Nuts Tight

The wheel stud nuts must be kept tight. Torque all stud nuts after the first use or any wheel change.

Inspect the wheels and check the wheel nuts during service stops. Dirt streaks from stud nuts may indicate looseness.

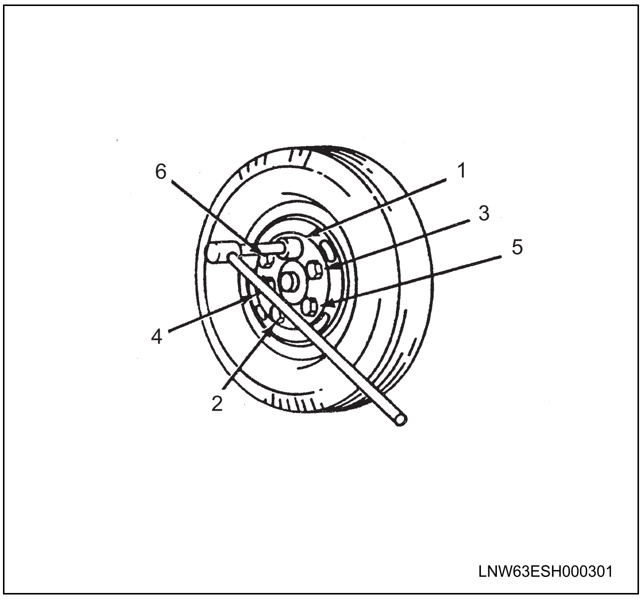
Balance Weight

Lead balance weights are available for all wheels.

Repair Instructions

Wheel

Caution:
Never use oil or grease on studs or nuts. Use the torque specified for the type of wheels on the vehicle, as shown in the following table. Snug all wheel nuts and then tighten to the specified torque in the numerical sequence shown in figure.
Improperly tightened wheel nuts could eventually allow the wheel to come off while the truck is moving, possibly causing loss of control and/or personal injury or damage.
When the truck, wheel, or fasteners are new, have a technician tighten the wheel stud nuts and/or rim clamp nuts with a torque wrench at 650 miles (1,000 km). This is necessary because the clamping system used on the wheel must seat before the fastener will hold a uniform clamp load and remain fully tightened. Also have a technician tighten the wheel stud nuts and/or rim clamp nuts with a torque wrench after installing any wheel. In addition, nut tightness on all wheels should be set with a torque wrench every 6,500 miles (10,400 km).



If a single or dual wheel and tire assembly is to be removed and dismounted, the air should be let out by removing the valve core. This procedure must be done before removing the tire assembly from the vehicle.

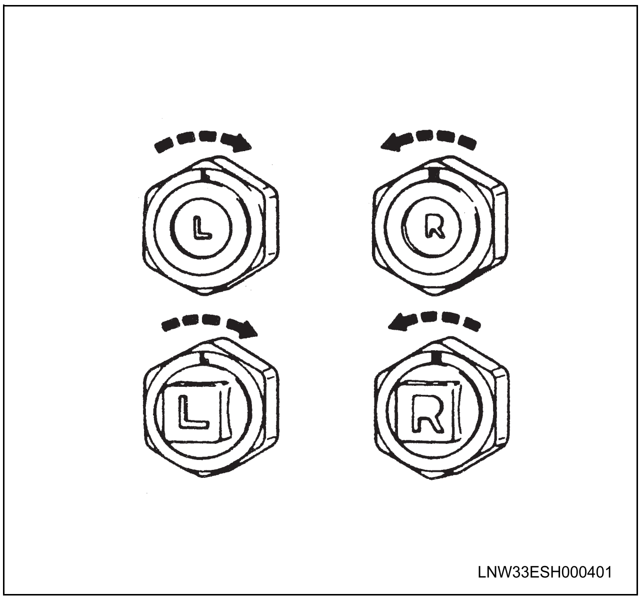
Removal Procedure

- Wheel studs and nuts on right side have right-hand threads, while wheel nuts on the left side have left-hand threads.
- Loosen the stud nuts.
- Raise the axle until the tires clear the floor.

Front Wheel and Rear Outer Wheel

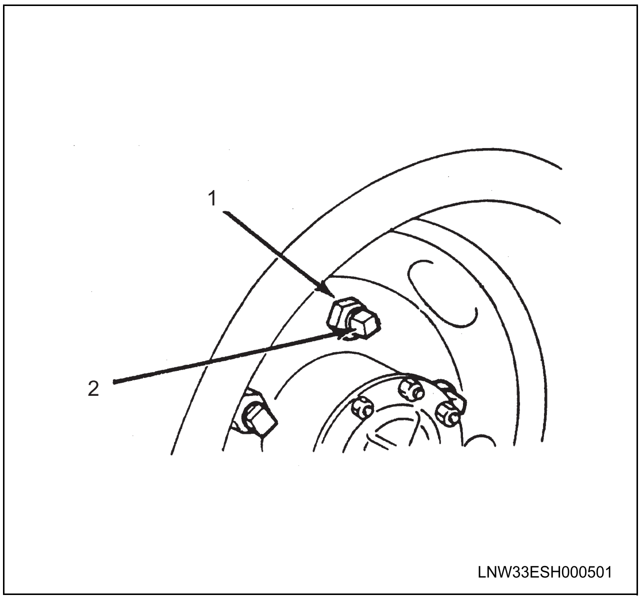
Removal Procedure

1. Stud nuts (outer wheel nuts for rear outer wheel).
2. Wheel and tire assembly.



Rear Inner Wheel

Removal Procedure



Legend
1. Outer Wheel Nut
2. Inner Wheel Nut

---

1. Outer wheel nuts.
2. Outer wheel and tire.
3. Inner wheel nuts.
4. Inner wheel and tire.

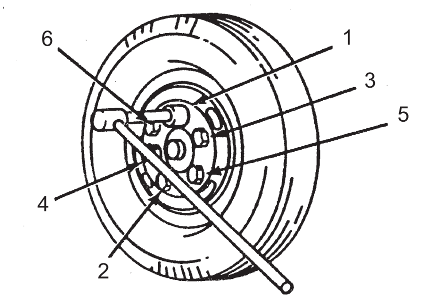
Front and Rear Wheels

Installation Procedure

1. Wheel and tire assembly.

Notice:
Refer to Description and Operation

2. Stud nuts finger tight. Then torque stud nuts in the sequence shown in figure.



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Tighten

- Stud Nuts to

  Front: 440 N·m (325 lb ft)

  Rear : 440 N·m (325 lb ft)

On-Vehicle Service: Tires and Tubes

How To Match Tires on the Rear Axle

The vehicle should be on a level floor, carrying an evenly rated capacity load. Be sure all tires are the same size. (Measure new tires to be sure they will be correctly matched.)

1. Inflate all tires to the same recommended pressure.
2. Carefully measure the rolling circumference of each tire with a steel tape.
3. Mark the size on each tire with chalk and arrange them in order of size, largest to smallest.
4. Mount the two largest tires on one side of the axle and mount the two smallest on the opposite side of the axle.
5. The two tires mounted together on one side of the axle must have diameters within 6 mm (1/4 in) of each other.

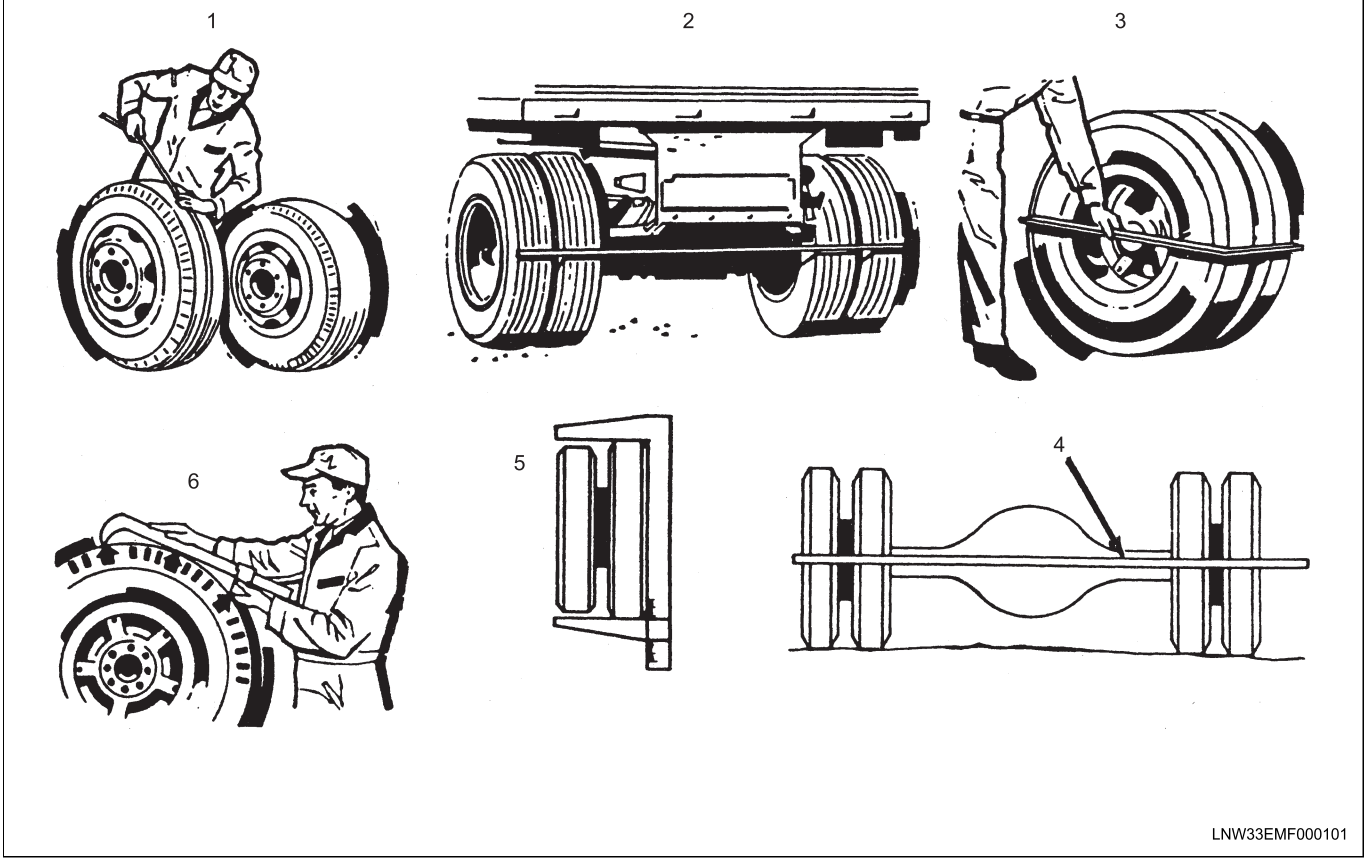
Measuring the circumferences of the tires with a steel tape after they are on the rims and inflated but before they are applied to a vehicle is the most accurate method.

Measuring in this manner takes into account any irregularities in wear. In checking tires already on a vehicle, either a square (similar to but larger than a carpenter's square), a string gauge, a large pair of calipers, or a wooden straight-edge long enough to lie across the treads of all four tires, may be used.

Tire Rotation

It is a good practice to "break in" new tires on front wheels. "Breaking in" on an easy position increases the overall tire life.

The movement of the tires from front to various rear wheel positions depends upon the type of unit being operated. It is necessary to use tires with good nonskid tread design on drive wheels.



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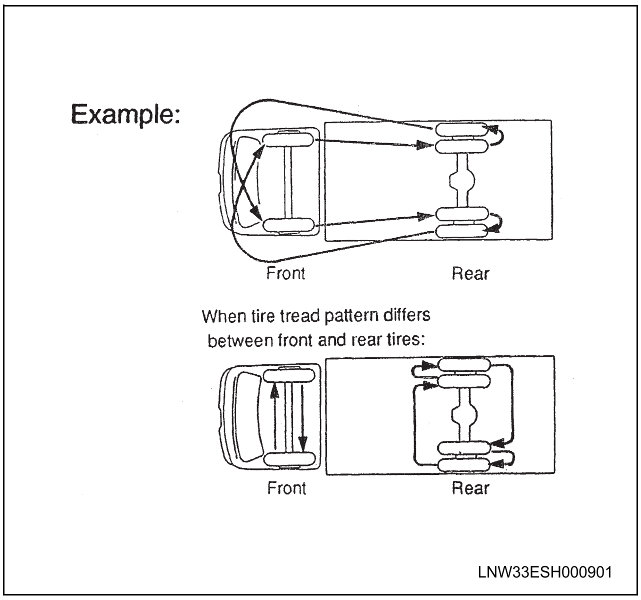
Legend

1. Steel Tape
2. String Gauge
3. Square
4. Straight Edge
5. Matching Stick
6. Caliper

Two-Axle Truck

Tires should be rotated from front to rear wheels when tread depth is 3.2 mm (0.13 in), If there is uneven front wheel tire wear, rotate tires and check vehicle for mechanical irregularities. When tires are moved to the rear, follow the recommendations in matching them with other tires.



Wheel and Tire Balancing

Caution:

When balancing tires on the truck, follow the equipment manufacturer's instructions carefully. On trucks which do not have maximum traction, drive wheel spin should be limited to 35 mph (56 km/h) as indicated on the speedometer. This limit is necessary because the speedometer only indicates one-half of the actual wheel speed when one drive wheel is spinning and the other drive wheel is stopped.

Unless care is taken in limiting the drive wheel spin, the spinning wheel can reach excessive speeds, resulting in possible tire disintegration or differential failure, which could cause personal injury or extensive vehicle damage.

On trucks which do have maximum traction, drive wheel spin should be limited to 70 mph (112 km/h). On such trucks, do not attempt to balance a tire on a drive wheel with the other drive wheel on the ground since the truck may drive through this wheel.

It is recommended, from the standpoints of tire wear and vehicle handling ease, to maintain proper balance of front wheel and tire assemblies on all models. All wheels intended for use on the front of the vehicle, such as those switched during periodic tire rotation and those installed as new or repaired replacement equipment, should be accurately balanced. This may be done by either of two types of balancing systems which balance wheels either on the vehicle or off. The "on-the-vehicle" type is most desirable in that all rolling components (brake drums, bearings, seals, etc.), are included in the balancing procedure and thereby have any existing unbalance corrected.

Static Balance

Static balance (sometimes called still balance) is the equal distribution of weight of the wheel and tire assembly about the axis of rotation in such a manner that the assembly will not rotate by itself, regardless of its position. For example: A wheel with a chunk of dirt on the rim will always rotate by itself until the heavy side is at the bottom. Any wheel with a heavy side like this is statically out-of-balance. Static unbalance of a wheel causes a hopping or pounding action (up and down) which frequently leads to wheel "flutter" and quite often wheel "hop."

Dynamic Balance

Dynamic balance (sometimes called running balance) means that the wheel must be in static balance, and also run smoothly at all speeds on an axis which runs through the center line of the wheel and tire and is straight-up-and-down to the axis of rotation .

To ensure successful, accurate balancing, the following precautions must be observed.

Wheel and tire must be clean and free from all foreign matter. The tires should be in good condition and properly mounted with the balance mark on the tire, if any, lined up with the valve.

Bent wheels that have run-out over 2.3 mm (0.09 in) should be replaced.

Inspect tire and wheel assembly to determine if an uncommon or out-of-round condition exists. Note that this condition, if severe, cannot be "balanced out." An assembly which has an out-of-round condition exceeding 8 mm (0.31 in) is not suitable for use on the front of the vehicle. Its use of the rear should be governed by its general condition and whether the roundness defect seriously detracts from overall ride quality.

What Happens When Tires Get Hot

As a tire becomes heated, the air in the tire expands and the air pressure is raised. This is normal unless the pressure buildup is excessive. Buildups of over 138 kPa(20 psi) are excessive, indicating underinflation, overload, too much speed, too small a tire, or more often, a combination of these factors in Therefore, pressure buildups over 138 kPa (20 psi) should be studied to determine cause and proper corrective action. Normal pressure buildups (not over 138 kPa [20 psi])reduce flexing. Thus, the amount of heat generated allows the tire to reach a heat balance (the temperature at which the rate of heating equals the rate of cooling) at a lower temperature than if the inflation pressure were maintained uniformly by frequently bleeding out air. Tires should never be bled. When the pressure builds up excessively, reduce the speed or the load instead.

A tire operated for a considerable distance at steady highway speeds, in a severely underinflated or flat condition, becomes very hot due to internal friction, and this heat transmits to the tire's outer surface. If, and when, the outer surface temperature reaches the combustion point, the tire bursts into flames. This usually occurs after the vehicle has stopped. Such an event usually involves a dual assembly where one of the tires is flat and the other is extremely overloaded (also underinflated even for normal load). In such cases, either the tire which is severely underinflated or completely flat, or the tire which is extremely overloaded, could get too hot as to reach the point of spontaneous combustion.

Prevention of Tire Fires

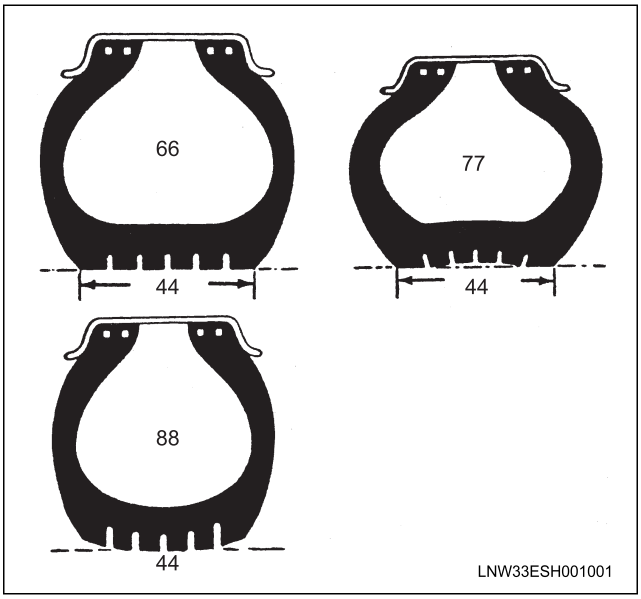
Regardless of the cause of a tire fire, the tire's internal temperature is so high that even if the flames are put out, repeated ignition may occur until internal temperature lowers enough. A fire extinguisher usually will not have enough capacity to control the fire until the burning tire can be removed. Operators should carry special asbestos blankets which, in case of fire, are useful in preventing the fire from spreading to the vehicle and cargo. If possible, a steady stream of water should be placed on the tire until it is cool enough for removal.

The best protection against tire fires is to avoid running on a flat tire, prevent underinflation through regular checking of inflation pressures, and avoid a buildup of grease or oil around the brake drum areas .

Operators carrying cargo which is explosive or easily combustible should check tires at 50 mile (80 km) intervals and should also use a pressure warning device.

Inflation of Tires

Inflate to the correct pressure when the tires are cool. If the tires are always carrying less than the recommended maximum load, adjust the air pressure downward to go along with the actual load carried.



Legend

44. Tread Contact with Road
66. Proper Inflation
77. Underinflation
88. Over-inflation

Never "bleed" the tires to relieve pressure buildup.

Tire temperature will increase when the tire is in service and allows for the normal buildup in air pressure .

Tire temperature and air pressure will stay within limits that are not harmful to the tire when used along with the recommendations for load and air pressure.

If a high buildup of air pressure occurs, overload, underinflation, speed, or a combination of these is responsible. Use the size and type of tire that has the capacity to carry the load at a recommended cold starting pressure.

The fabric, rubber, bead, contour, and size of tires used on these vehicles are designed to obtain maximum length of service under normal operating conditions. THE TIRES ARE SET UP TO OPERATE EFFICIENTLY ONLY ON A SPECIFIED AMOUNT OF AIR. Unless the correct air pressure is always maintained, the tires will not function as they should.

An underinflated tire wears out faster than a properly inflated tire. Also, an underinflated tire affects steering and riding comfort. In addition, an underinflated tire could slip on the rim, resulting in losing the tire, tube, rim, and spacer. Over-inflation may weaken the tire, causing a blowout.

For greater riding comfort, longer tire life, and to reduce wear and tear on the truck chassis, tires should be inflated for loads carried on tires as indicated in the "Tire Load and Inflation Table". In no case should the combined front and rear tire load exceed the maximum recommended load.

Balanced Inflation

Balanced inflation may be described as: All tires on the same axle should always carry the same air pressure. A difference in air pressure of the rear tires and the front tires may be allowed within certain limitation; however, there should not be a difference in pressures between the right and left tires on the same axle. A 34 kPa(5 psi) underinflated tire can lower the efficiency of most brakes. Balance tires for ease of steering, comfort in riding, safety in driving, as well as for minimum fuel use and maximum tire mileage.

Pressure Loss

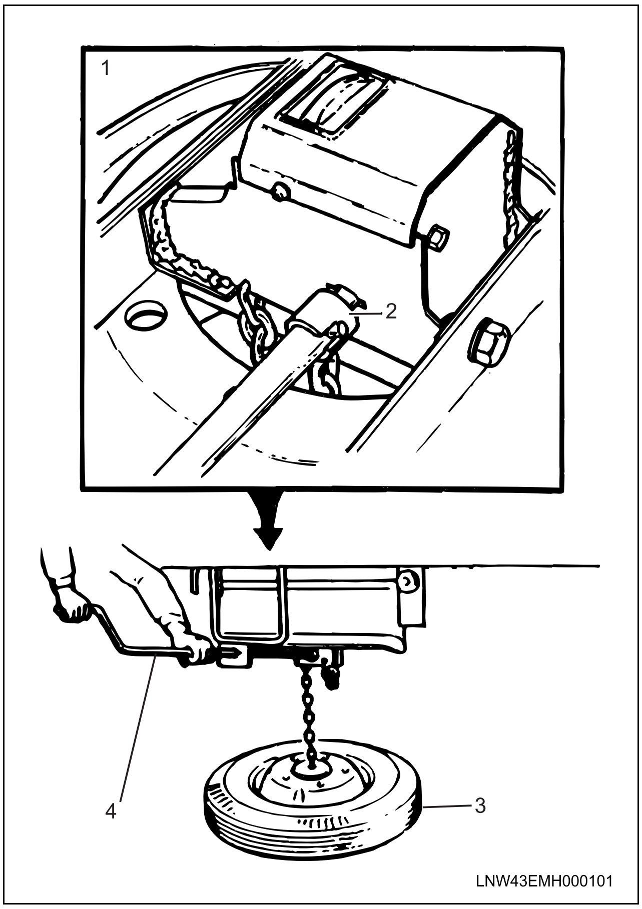
At periodic intervals, each tire should be gauged for pressure loss with an accurate gauge before tires are brought to the correct operating pressure. The purpose of this check is to find out the exact pressure loss in each tire. In other words, if at any time this check is made, and a pressure loss is noted in any one of the tires, an inspection should be made of the tire showing the loss and the cause of the loss corrected. This method should show a "danger signal" on the condition of the tires. The pressure loss check should be made each time with the same gauge, so that any sign of inaccuracy In the gauge will be the same for all tires.

Valve Core and Cap

The valve core is a spring-loaded check valve in the valve stem, allowing inflation or deflation of the tube or tire. This check valve, or core, is not intended to hold the air during operation. The valve cap is provided to seal the air in the tube and tire. When the valve cap is tightened down on the stem, the sealing washer inside the cap is pressed tightly against the top of the stem, preventing air leakage. It is important that valve caps be used at all times.

Spare Tire

The spare tire is secured to the chassis frame with a chain.



Legend

1. Top View
2. Rod Cap
3. Tire and Wheel Assembly
4. Crank Handle

Removal Procedure

1. Insert crank handle into the rod cap and turn counterclockwise until the tire is on the floor.
2. Remove the tire and disc wheel assembly.

Installation Procedure

1. Position tire and disc wheel assembly on the floor beneath the spare tire carrier.

2. Turn the crank handle and wind up the tire and disc wheel until the disc tightens against the bottom of the bracket.
3. Then pull out the crank handle from the rod cap without reversing it.

Specifications

Specifications

Front and Rear Wheel Nut Torques	440 N·m (325 lb ft)

DRIVELINE/AXLE

Rear Axle

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Description and Operation

Rear Axle Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

The axle assembly is a single speed, single-reduction type. The four-pinion differential assembly is mounted in a two-piece case. The axle shafts are full-floating with the inner ends splined to the differential side gears. The differential carrier assembly may be removed while the axle housing is installed on the vehicle.

Diagnosis of the Rear Axle

Diagnosis of the Rear Axle

PROBLEM	POSSIBLE CAUSE	CORRECTION
Noise in Drive	1. Excessive pinion to bevel gear backlash. 2. Worn pinion and bevel gear. 3. Worn pinion bearings. 4. Loose pinion bearings. 5. Excessive pinion end play. 6. Worn differential bearings. 7. Loose differential bearings. 8. Excessive bevel gear run-out. 9. Low oil level. 10. Wrong or poor grade oil. 11. Bent axle housing.	1. Adjust. 2. Replace. 3. Replace. 4. Adjust. 5. Adjust. 6. Replace. 7. Adjust. 8. Replace. 9. Replenish. 10. Replace. 11. Replace.
Constant Noise	1. Flat spot on pinion or bevel gear teeth. 2. Flat spot on bearing. 3. Worn pinion splines. 4. Worn axle shaft dowel holes. 5. Worn studs. 6. Bent axle shaft.	1. Replace. 2. Replace. 3. Replace 4. Replace 5. Replace. 6. Replace
Noisy when Coasting	1. Axle noises heard on drive will usually be heard also on coasting, although not as loud. 2. Pinion and bevel gear too tight (Audible when slowing down and disappears when driving).	1. Adjust or replace 2. Adjust
Intermittent Noise	1. Warped bevel gear. 2. Loose differential case bolts.	1. Replace. 2. Tighten
Noisy on Turns	1. Worn differential side gears and pinions. 2. Worn differential spider. 3. Worn axle shaft splines.	1. Replace. 2. Replace. 3. Replace.
Oil Leak at Rear Axle	1. Oil seals damaged, missing or worn. 2. Rear axle housing.	1. Replace. 2. Replace.
Oil Leak at Pinion Shaft	1. Oil seals damaged, missing or worn. 2. Pinion flange loose or damaged.	1. Replace. 2. Tighten or replace.

Bent Housing Check

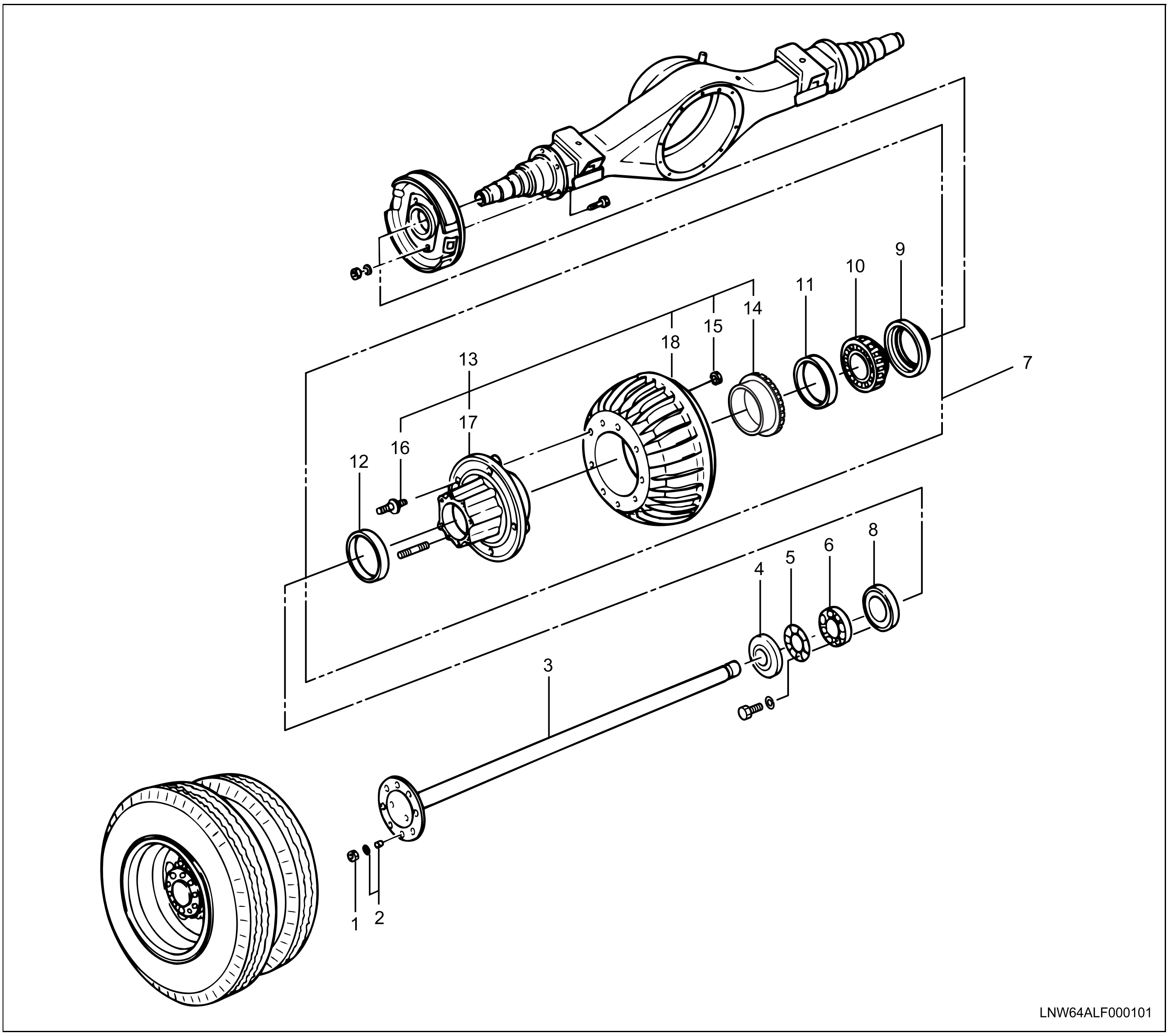
1. Raise the axle housing and install jack stands under the frame. Vehicle tires must be off the floor.
2. Check the wheel bearing adjustment. Refer to "Wheel Bearing Adjustment" in Front Axle and Suspension in this manual.

3. Check the wheel mountings. Refer to Wheels and Tires in this manual.
4. Chalk mark the tires on the outer wall of the outside tires. Turn the wheels to position the chalk marks down.
5. Measure across the tires at the chalk marks.
6. Turn the wheels to position the chalk marks up.
7. Measure across the tires at the chalk marks.
   The axle is bent if the "up" and "down" measurements differ by more than 3 mm (1/8in).
8. Turn the wheels to position the chalk marks forward and level with the axle.
9. Measure across the tires at the chalk mark.
10. Turn the wheels to position the chalk marks rearward and level with the axle.
11. Measure across the tires at the chalk marks. The axle is bent if the "forward" and "rearward" measurements differ by more than 3 mm (1/8 in).

On-Vehicle Service

Axle Shaft Replacement

Remove or Disconnect



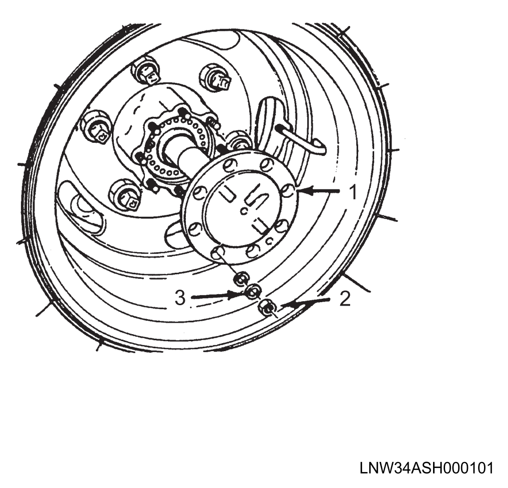
Legend

1. Nut
2. Washer
3. Axle Shaft
4. Outer Oil Seal
5. Lock Washer
6. Bearing Nut
7. Hub and Drum Assembly
8. Outer Bearing Inner Race
9. Inner Oil Seal
10. Inner Bearing Inner Race
11. Inner Bearing Outer Race
12. Outer Bearing Outer Race
13. Hub and Drum
14. ABS Sensor Rotor
15. Wheel Pin Fixing Nut
16. Wheel Pin
17. Hub
18. Drum

---

1. Nuts and washers from the hub.
2. Axle shaft.

Notice:
Do not use a chisel or wedge to loosen the shaft because this could damage the hub or the shaft.



Legend

1. Axle Shaft
2. Nut
3. Washer

Inspect

- Inspect the axle shaft spline for wear, damage, or other abnormal conditions.
- Make necessary correction or parts replacement if wear, damage, or any other abnormal conditions are found through inspection.
- Inspect the outer oil seal. Replace if necessary.

Measure

- Axle shaft run-out. Maximum allowed is 1.0 mm (0.039 in).
- Axle shaft flange run-out. Maximum allowed is 0.15 mm (0.006 in).

Install or Connect

1. Axle shaft.
    - Lubricate the shaft splines
    - Align the shaft splines with the gear splines.

Notice:
See "NOTICE" on page 4A1-2 of this section.

2. Nuts and washers.

Tighten

- Nuts to 49 N·m (36 lb ft).

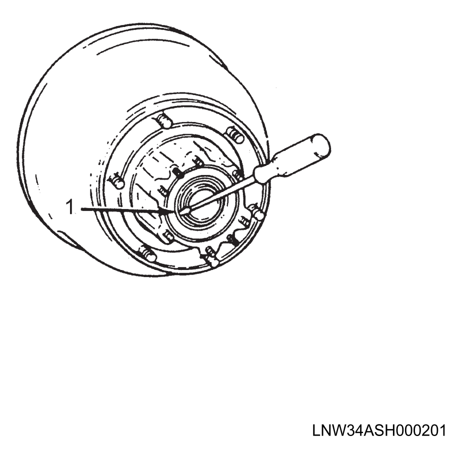
  Lubricate the shaft splines

Hub and Drum Assembly

Remove or Disconnect

Tools Required.
J 35012 Rear Hub Bearing Nut Wrench
J 35013 Rear Hub Remover

1. Remove the drain plug from the axle case and drain the oil (approximately 6 liters/13 pints).
2. Wheel and tire. Refer to Wheels and Tires in this manual.
3. Axle shaft. Refer to "Axle Shaft Replacement" earlier in this section.
4. Outer oil seal. Use screwdriver and a pair of pliers.

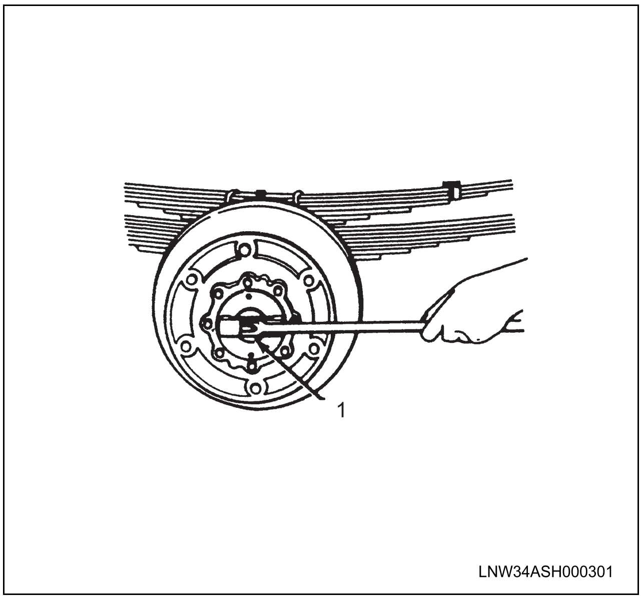


Legend

1. Outer Oil Seal

---

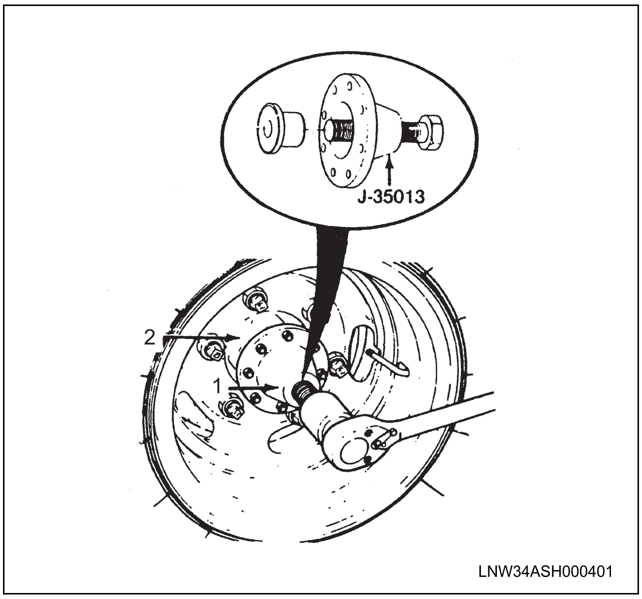
5. Lock washer
6. Bearing nut with J 35012.



Legend

1. J 35012

7. Hub and drum assembly from the housing with J 35013.



Legend

1. J 35013
2. Hub

---

8. ABS Sensor Rotor.
9. Outer bearing inner race and outer bearing outer race.
10. Inner oil seal and inner bearing.
11. Hub from drum

Inspect

- All parts for wear or damage. Replace parts as necessary.

Install or Connect

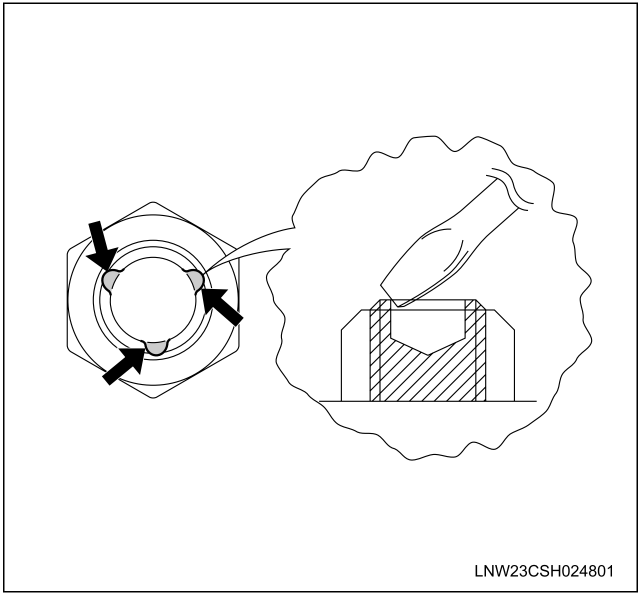
Tools Required:
292 mm differential:
J 39114 Rear Hub Oil Seal Installer
J 35008 Inner Bearing Installer
J 35019 Hub Outer Bearing Race Installer
320 mm differential:
J 43413 Rear Hub Oil Seal Installer
J 43412 Inner Bearing Installer
J 35019 Hub Outer Bearing Race Installer

Notice:
See "NOTICE" on page 4A1-2 of this section.

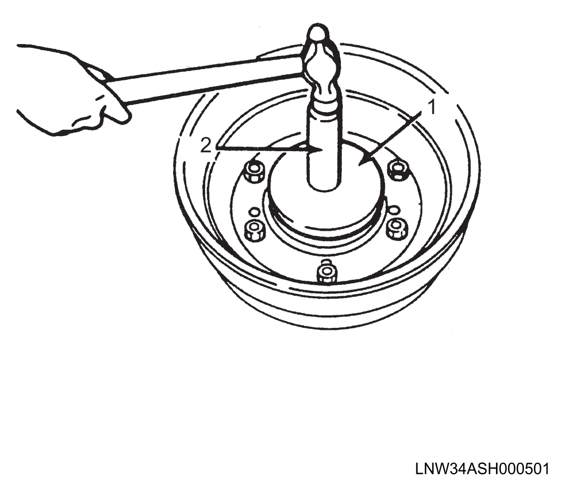
1. Hub to drum.

Tighten

- Nuts to 392 N·m (289 lb ft)
- Stake nuts to prevent them from loosening.



2. ABS Sensor Rotor
3. Inner bearing with J 35008 (292 mm differential) or J 43412 (320 mm differential) and J 8092.

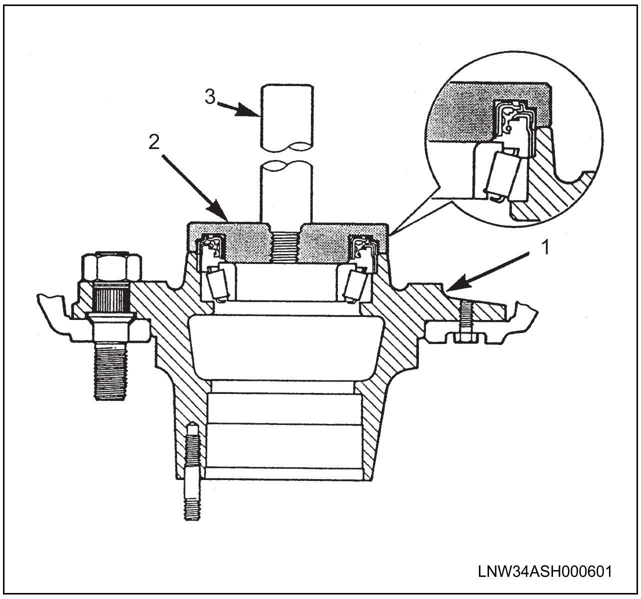


Legend

1. J 35008 or J 43412
2. J 8092

---

4. Inner oil seal with J 39114 (292 mm differential) or J 43412 (320 mm differential) and J 8092.

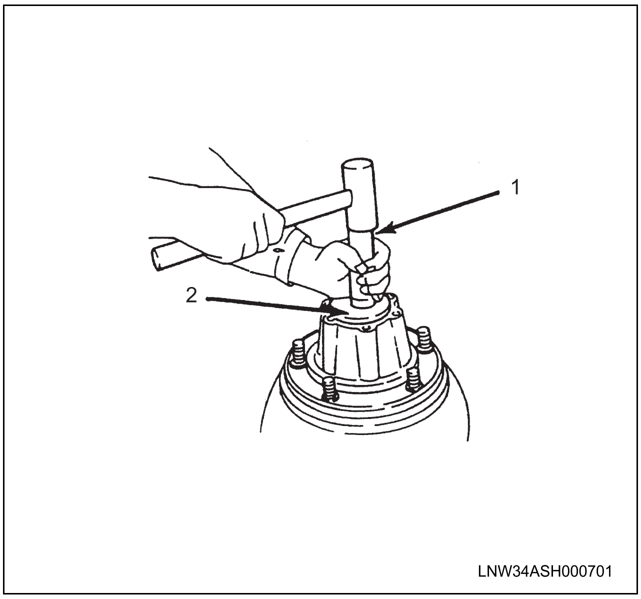


Legend

1. Hub
2. J 39114 or J 43412
3. J 8092

---

5. Oil catcher
6. Outer bearing outer race with J 35019 and J 8092.

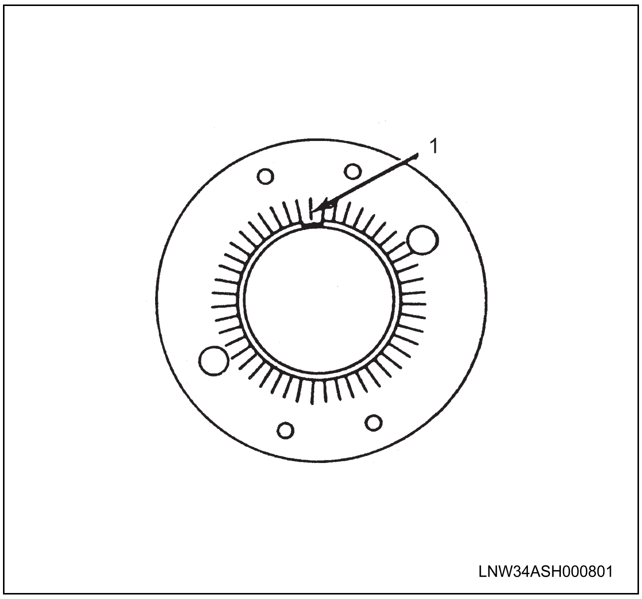


Legend

1. J 8092
2. J 35019

---

7. Outer bearing inner race.
8. Hub and drum assembly.
9. Bearing nut. Position the bearing nut so that the side with the notched line is turned outward. Align the center of the line with the center of the groove in the axle case so that the two threaded holes in the bearing nut line up with the two holes in the lock washer.



Legend

1. Notched Line

Tighten

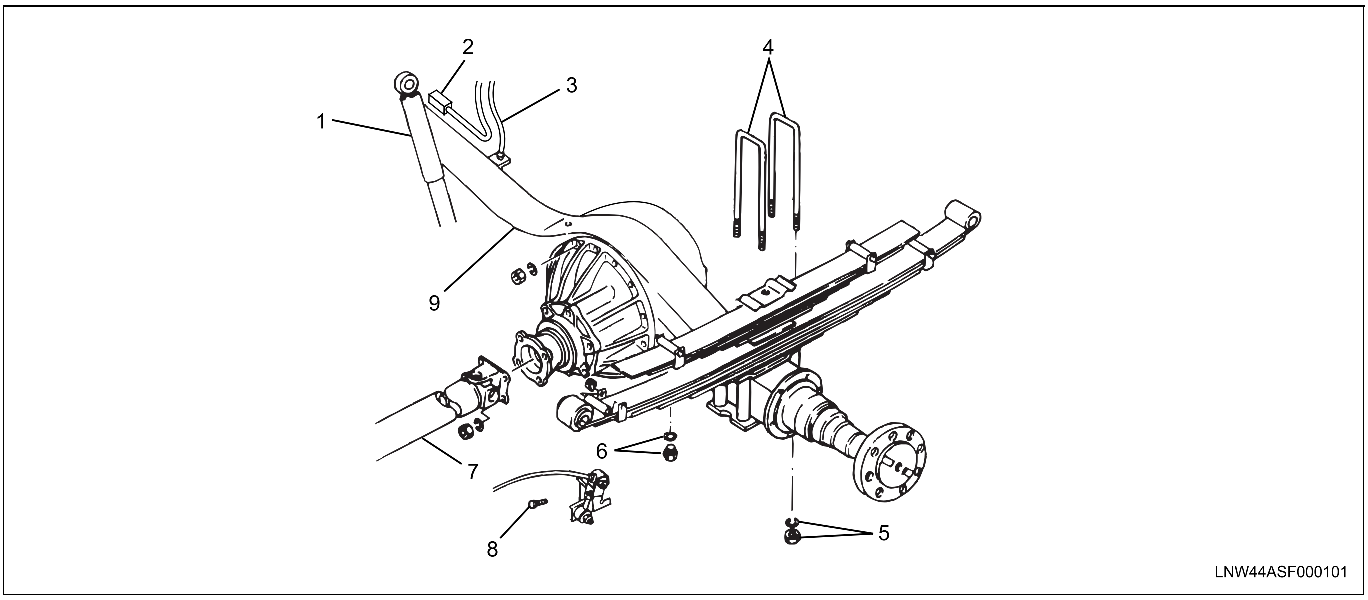
Bearing nut in three stages, as out lined below;

- Stage 1: Tighten bearing nut to 147 N·m (108 lb ft).
- Stage 2: Fully loosen bearing nut.
- Stage 3: Tighten bearing nut to 78 N·m (58 lb ft).

10. Lock washer.
11. Outer oil seal.
12. Axle shaft. Refer to "Axle Shaft Replacement" earlier in this section.
13. Refill differential oil to specified level.

Rear Axle Assembly Replacement

Remove or Disconnect

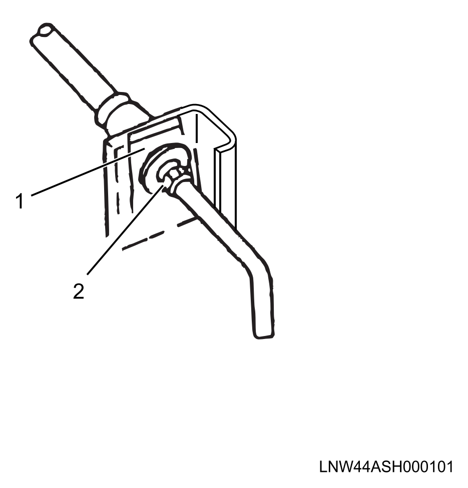


Legend

1. Shock Absorber
2. Speed Sensor Connector
3. Brake Flexible Hose
4. U-Bolt
5. U-Bolt Nut and Washer
6. Drain Plug and Gasket
7. Propeller Shaft
8. Load Sensing Proportioning Valve Bracket Bolt
9. Axle Housing

- Raise the axle and install jack stands under the frame. Vehicle wheels must be off the floor. Support the axle housing with a garage jack.

1. Wheels from the hubs.
    - Refer to Wheels and Tires in this manual.
2. Drain plug and gasket.
    - Provide a pan to catch the oil.
    - Replace the plug and gasket after all oil is drained.
3. Axle shafts.
    - Refer to "Axle Shaft Replacement" earlier in this section.
4. Speed sensor connector.
    - Refer to "Anti-Lock Brake System" in this manual.
5. Brake flexible hose. Loosen the nut and pry off the clip before removing the hose.



Legend

1. Clip
2. Nut

6. Load sensing proportioning valve bracket bolt.
7. Propeller shaft. Refer to Propeller Shaft in this manual.
8. Shock absorbers.
9. Nuts, washers and U-bolts.
10. Axle housing.

Install or Connect

Notice:
For steps 2, 3, 4, 6 see "NOTICE" on page 4A1-2 of this section

1. Axle housing.
2. U-bolts, nuts and washers.

Tighten

- U-bolt nuts to 177 N·m (130 lb ft) (292 mm diff).
- U-bolt nuts to 284 N·m (209 lb ft) (320 mm diff).

3. Shock absorbers.

Tighten

- Shock absorber nuts to 95 N·m (70 lb ft).
- Shock absorber bolt to 40 N·m (30 lb ft).

4. Propeller shaft to differential flange.

Tighten

- Propeller shaft nut to 103 N·m (76 lb ft)

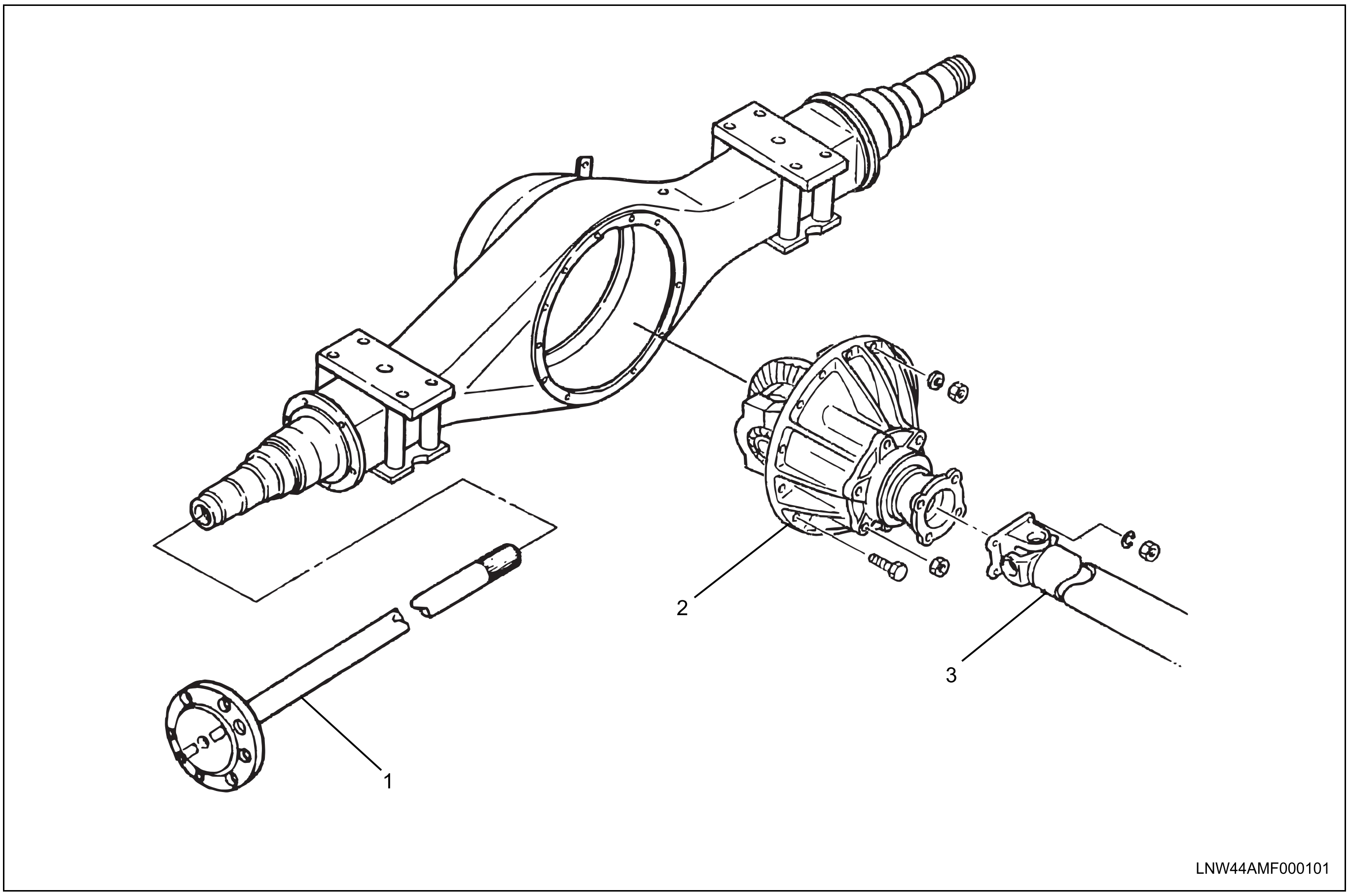
5. Load sensing proportioning valve bracket bolt.
6. Brake flexible hose. Bleed air from the hoses after assembly.

Tighten

- Brake hose nut to 15 N·m (11 lb ft)

7. Speed sensor connector.
8. Axle shaft.
    - Refer to "Axle Shaft Replacement" earlier in this section.
9. Wheels to hubs.
    - Refer to Wheels and Tires in this manual.
10. Axle Lubricant.
    - Refer to Maintenance and Lubrication in this manual.

Differential Carrier



Legend

1. Axle Shaft
2. Differential Carrier
3. Propeller Shaft

Remove or Disconnect

1. Propeller shaft. Refer to Propeller Shaft in this manual.
2. Axle shaft. Refer to "Axle Shaft Replacement" earlier in this section.
3. Differential Carrier.
    - Remove the mounting bolts.
    - Support and remove the differential carrier.

Install or Connect

Notice:
See "NOTICE" on page 4A 1-2 of this section.

1. Differential Carrier.

Tighten

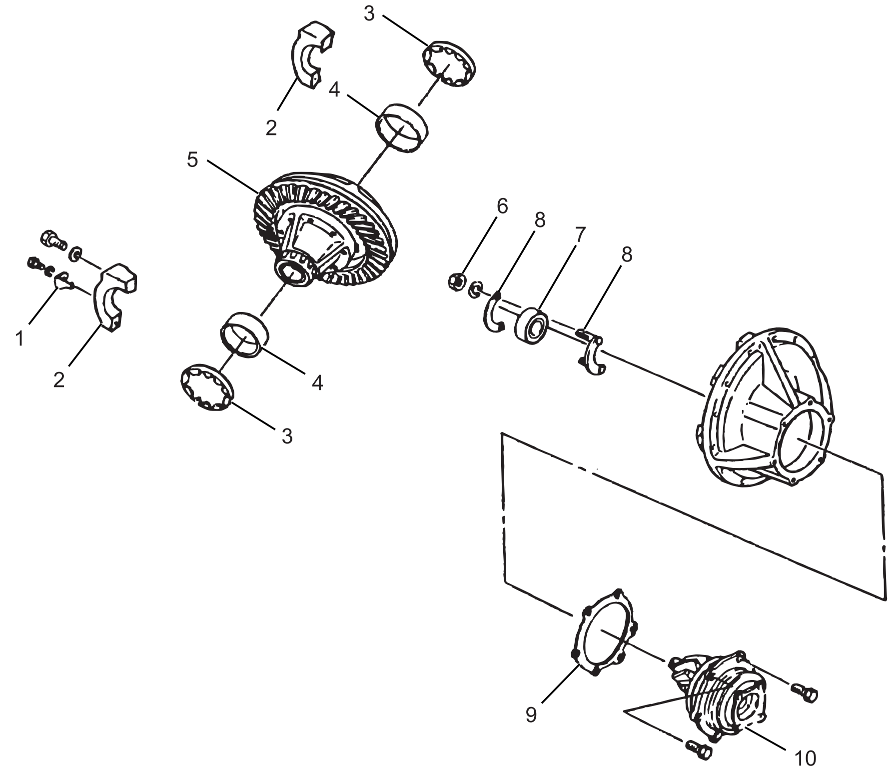
- Differential carrier bolts to 59 N·m (43 lb ft).

2. Axle shaft. Refer to "Axle Shaft Replacement" earlier in this section.
3. Propeller shaft. Refer to Propeller Shaft in this manual.

Unit Repair of 292mm/320mm Differential Carrier Assembly

Unit Repair of Differential Carrier Assembly

This illustration is based on the 292mm differential.



Legend

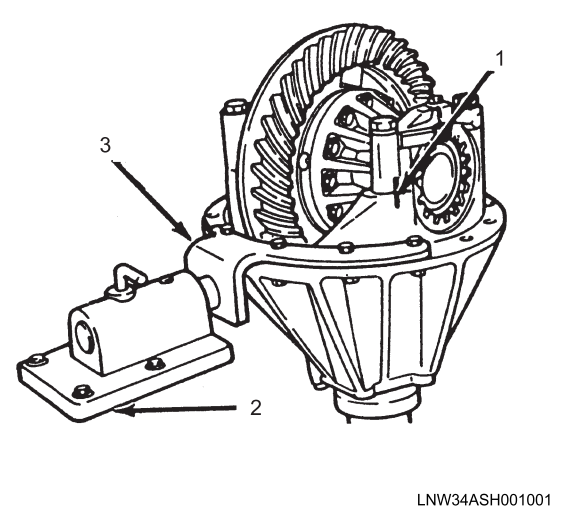
1. Lock Plate
2. Bearing Cap
3. Adjuster Nut
4. Side Bearing Outer Race
5. Differential Cage Assembly and Ring Gear
6. Fixing Nut
7. Pilot Bearing
8. Pilot Bearing Retainer
9. Shim
10. Drive Pinion Assembly

Remove or Disconnect

- Mount the carrier housing in a repair stand.

Important:

- Scribe a reference mark to the right and left side bearing caps to prevent interchanging.
- Check and record the tooth contact pattern and backlash if the gear set is to be reused.



Legend

1. Reference Mark
2. J 3289-20
3. J 35715

1. Lock plates.
2. Bearing caps.
3. Adjuster nuts.
4. Side bearing outer races

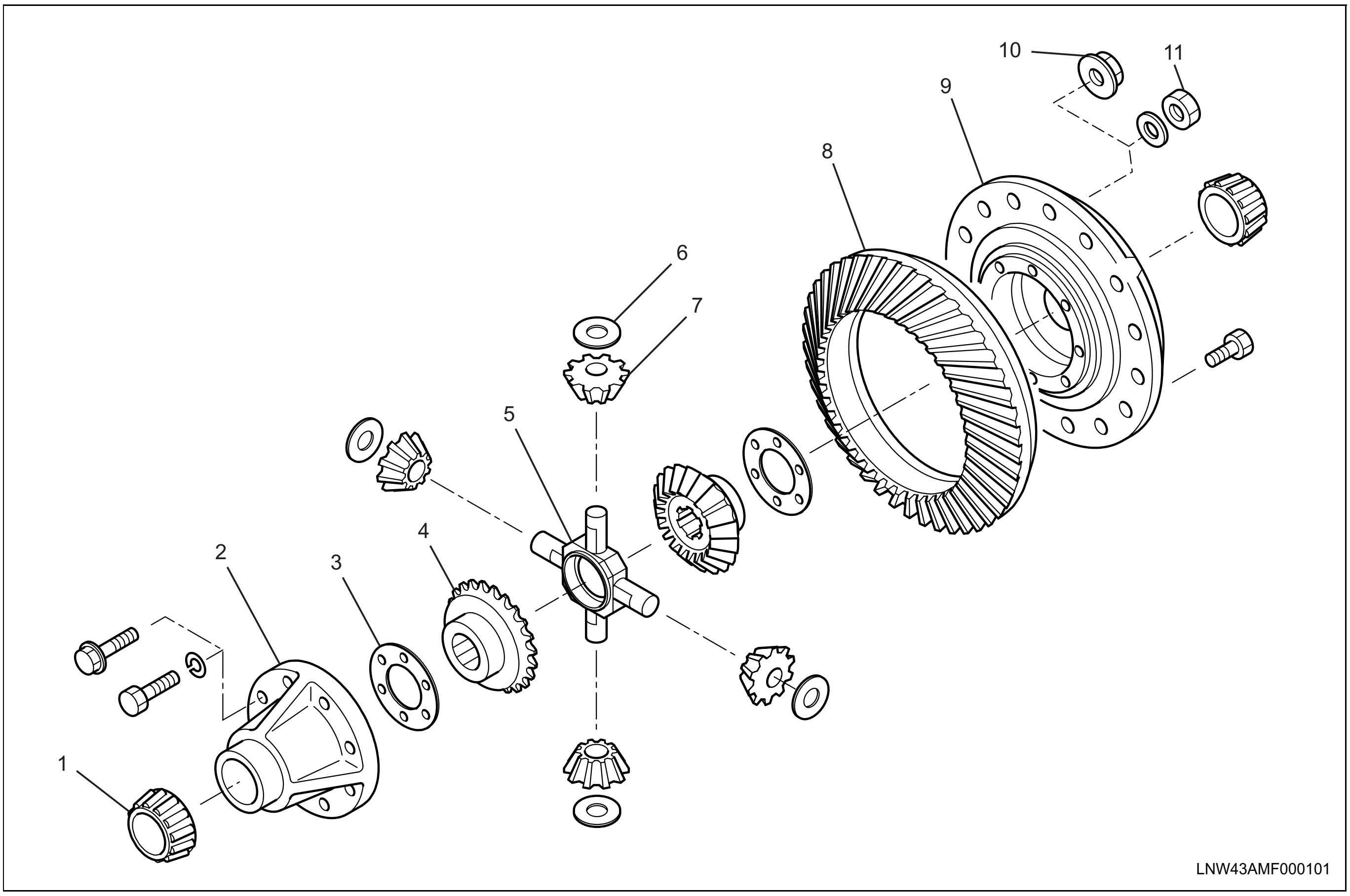
Important:

- Keep the bearings separate. Do not interchange them.

5. Differential cage assembly and ring gear.
6. Drive pinion assembly.
   - Put reference marks on pinion assembly and differential cover before removal.
7. Shim.
8. Pilot bearing retainer.
9. Pilot bearing.

Disassemble

Differential



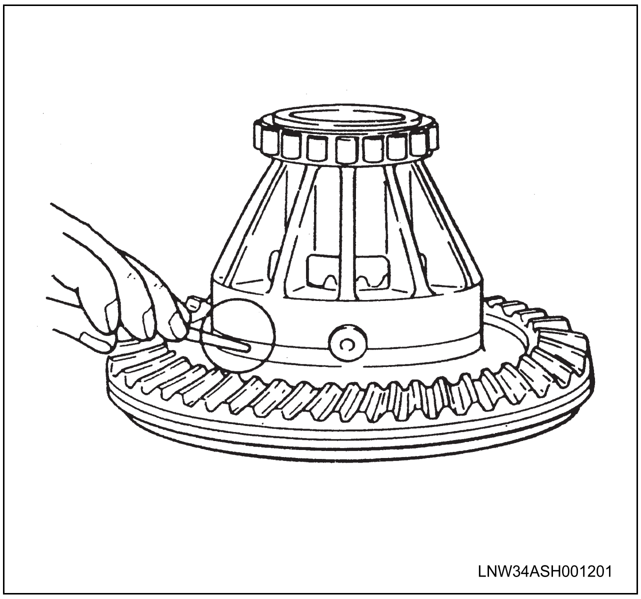
Legend

1. Side Bearing
2. Differential Cage B
3. Washer
4. Side Gear
5. Spider Assembly
6. Pinion Washer (only 320mm differential)
7. Pinion Gear
8. Ring Gear
9. Cage Half A
10. Cage Bolt and Nut (292mm differential)
11. Cage Bolt, Nut and Washer (320mm differential)

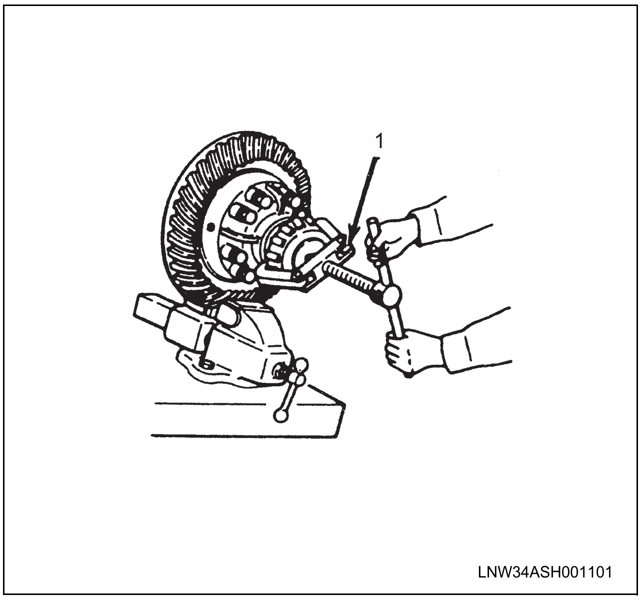
Tool Required:
J 35030 Differential Side Bearing and Rear Hub Puller Pilot
DT47668 Ring Gear Fixing Bolt Wrench

Important:

- Prior to removal, scribe reference mark on the ring gear and cage halves to ensure correct reassembly.



1. Side bearings. Use J 35030 and remover.

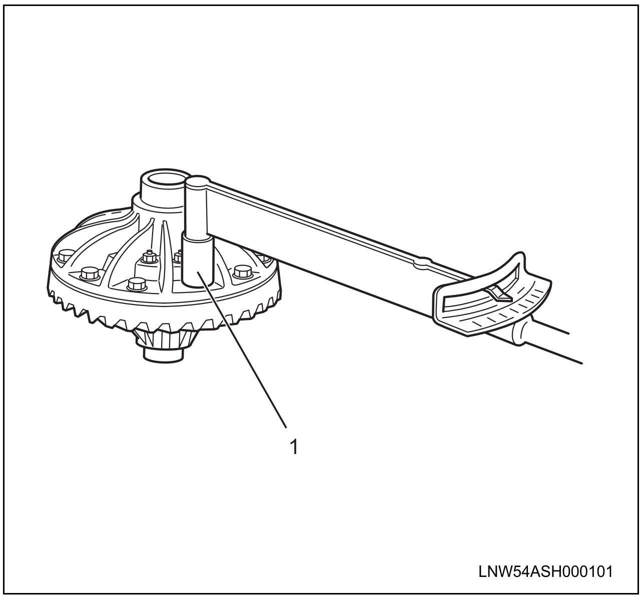


Legend

1. J 35030

---

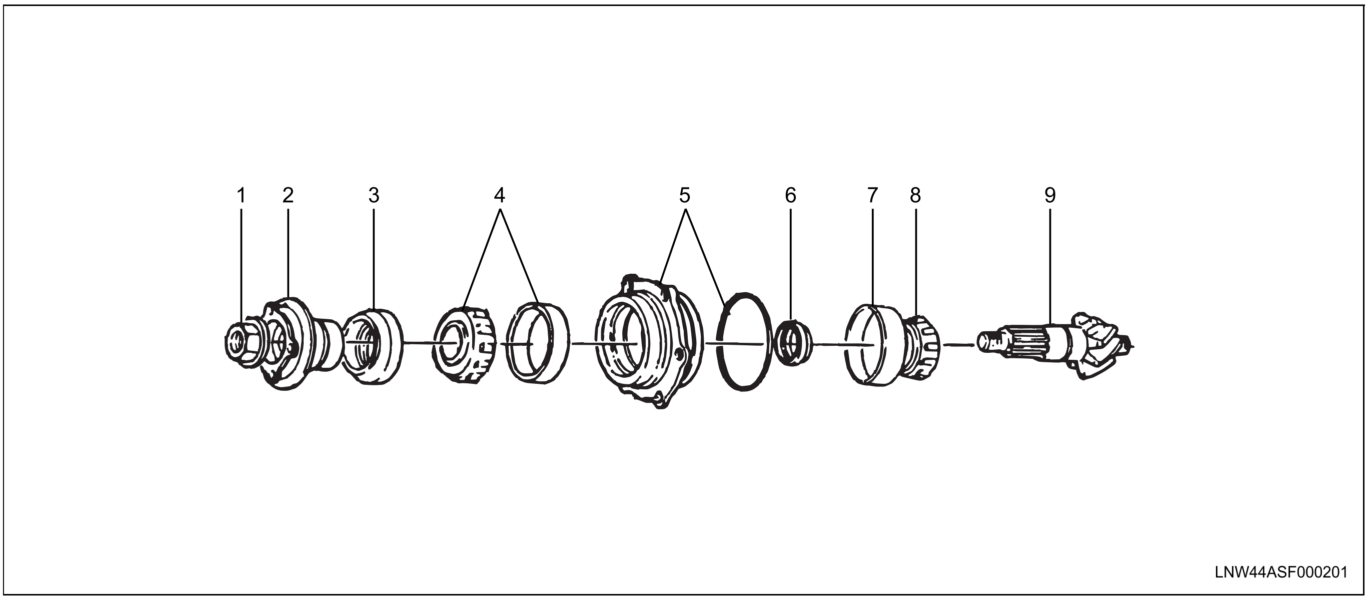
2. Cage bolts. Replace the bolts with new ones.
3. Differential cage B.
4. Lift cage half A from ring gear.
5. Washer.
6. Side gear.
7. Spider assembly.
8. Side gear.
9. Washer.
10. Ring gear bolts. Use DT47668 (only 292mm differential).



Legend

1. DT47668

Pinion Cage

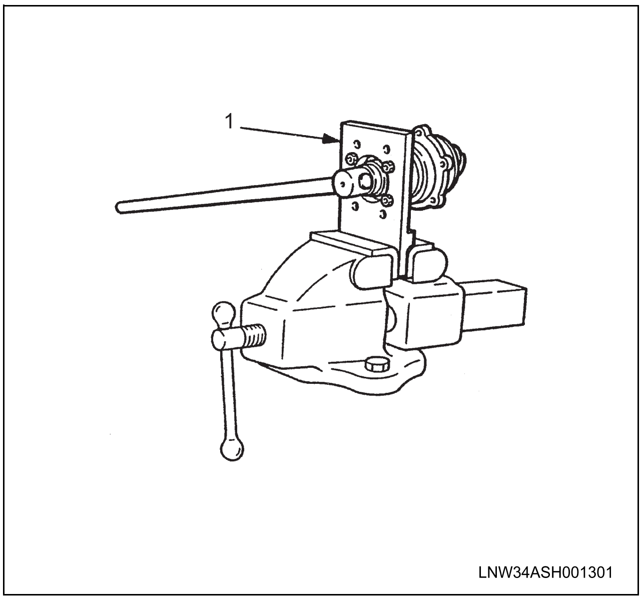


Legend

1. Pinion Nut
2. Flange
3. Oil Seal
4. Outer Bearing with Race
5. Pinion Cage and Seal (O-ring)
6. Spacer
7. Inner Bearing Outer Race
8. Inner Bearing Inner Race
9. Pinion Gear

Tools Required:
J 22912-01 Top Gear Shaft Bearing Separator
J 35016 Drive Pinion Flange Bracket

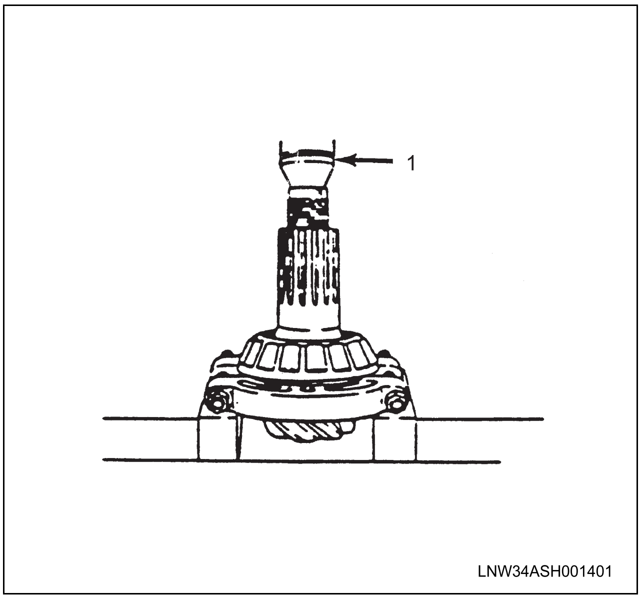
1. Pinion nut. Clamp the pinion in a soft jawed vise using J 35016. Discard pinion nut.



Legend

1. J 35016

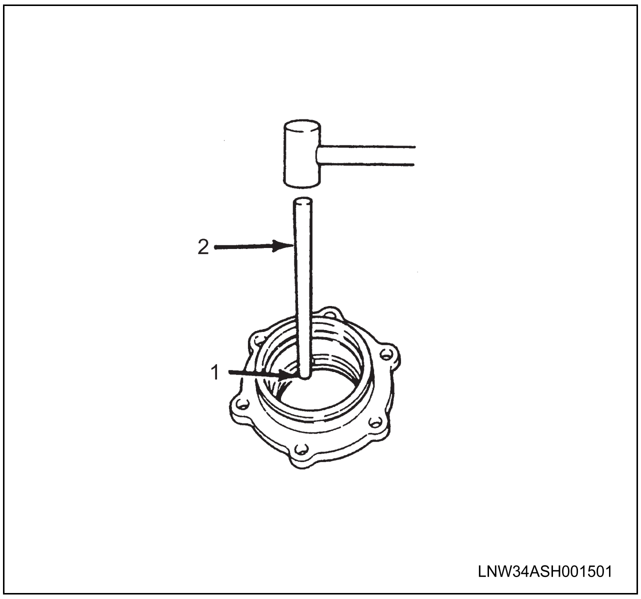
2. Flange.
3. Inner bearing inner race from the pinion gear. Use J 22912-01.



Legend

1. J 22912-01

4. Oil seal and outer bearing with race and inner bearing outer race from the pinion cage by using the proper bar through the two notches.



Legend

1. Notch
2. Pry Bar

5. Pinion cage and seal (O-ring).

Clean

- All parts in a suitable solvent and blow dry. Do not spin the bearings while blow drying with air.

Inspect

- All parts.
- Always replace drive pinion and ring gear as a set.
- Replace any parts found damaged or worn.
- Refer to "Tapered Roller Bearing Diagnosis" in Front Axle and Suspension in this manual.

Measure

- Clearance between the spider assembly and the pinion.

292 mm differential

Standard:

0.07-0.13 mm (0.003-0.005 in)

Maximum allowed:

0.2 mm (0.008 in)

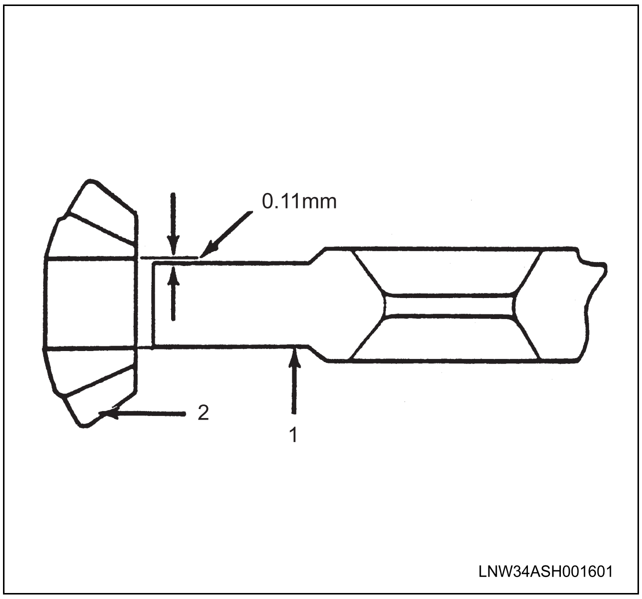
320 mm differential

Standard:

0.05-0.13 mm (0.0020-0.0051 in)

Maximum allowed:

0.2 mm (0.008 in)



Legend

1. Spider Assembly
2. Pinion

- Clearance between the side gear ($d_2\phi$) and differential cage B ($d_1\phi$).

292 mm differential

Standard:

0.05-0.11 mm (0.002-0.004 in).

Maximum allowed:

0.25 mm (0.01 in)

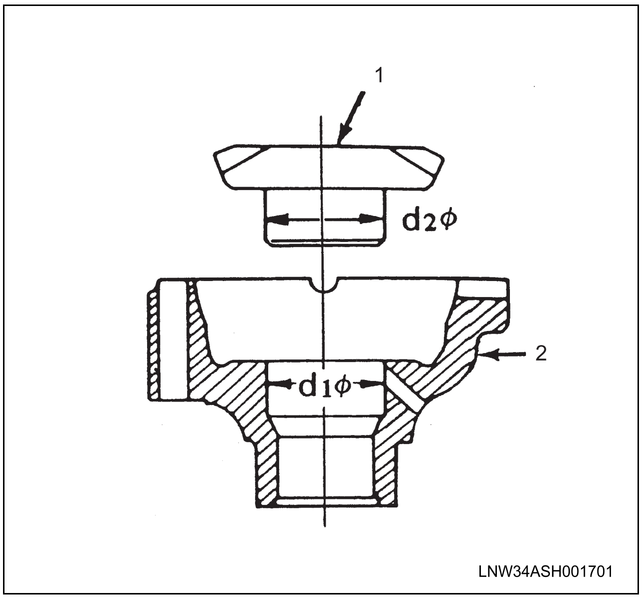
320 mm differential

Standard:

0.13-0.20 mm (0.005-0.008 in)

Maximum allowed:

0.25 mm (0.01 in)



Legend

1. Side Gear
2. Differential Cage B

- Play in the splines between the side gears and axle shaft.

292 mm differential

Standard:

0.08-0.15 mm (0.003-0.006 in).

Maximum allowed:

0.3 mm (0.012 in)

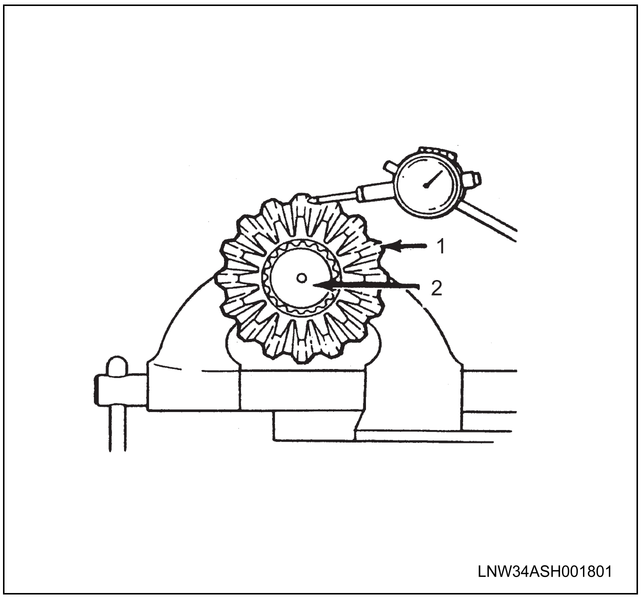
320 mm differential

Standard:

0.2 mm (0.08 in)

Maximum allowed:

0.5 mm (0.02 in)



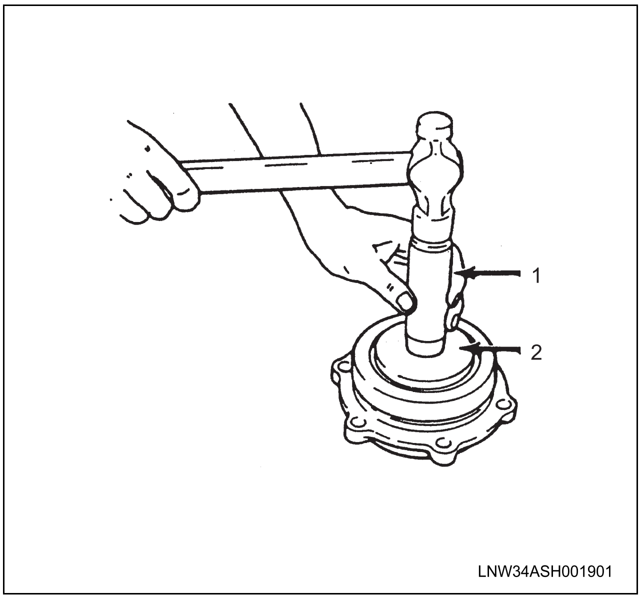
Legend

1. Side Gear
2. Axle Shaft

Assemble

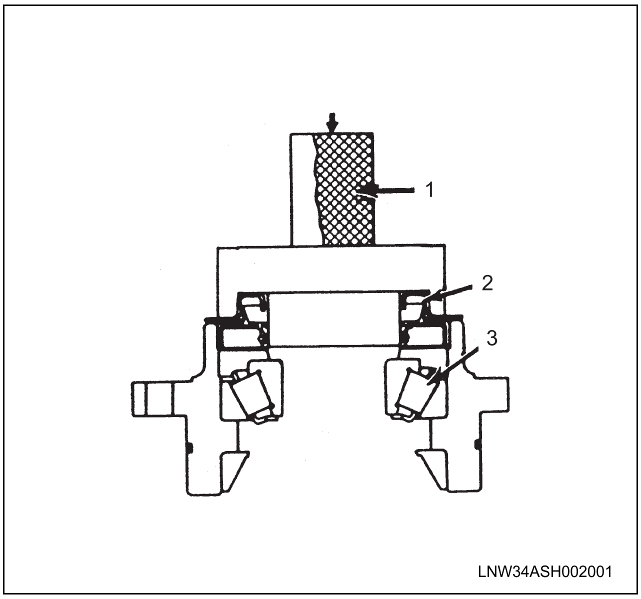
Pinion Cage
Tools Required:
292 mm differential:
J 35014 and J 8092 Oil Seal Installer
J 35020 and J 8092 Inner Bearing Outer Race/Outer Bearing Outer Race Installer
J 35727 Inner Bearing Inner Race Installer
320 mm differential:
J 43411 and J 8092 Oil Seal Installer
J 43410 and J 8092 Inner Bearing Outer Race/Outer Bearing Outer Race Installer
J 35727 Inner Bearing Inner Race Installer

1. Pinion cage and seal (O-ring).
2. Inner bearing with race with J 35020 or J 43410 and J 8092
3. Outer bearing with race with J 35020 or J 43410 and J 8092.
4. Oil seal with J 35014 or J 43411 and J 8092.



Legend

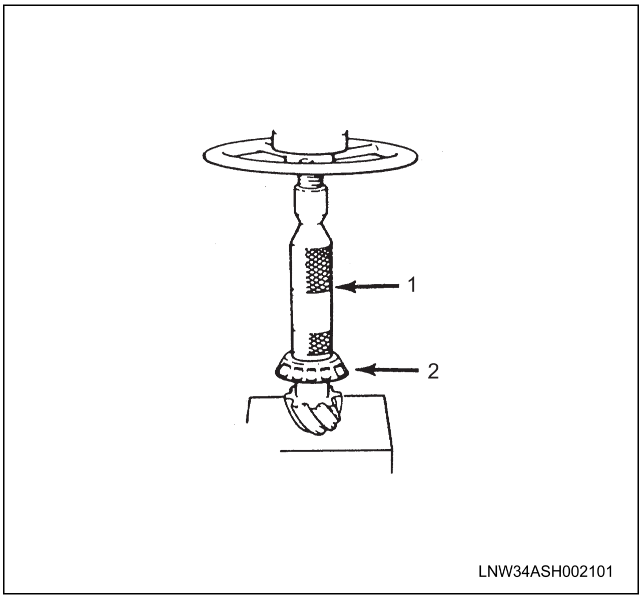
1. J 8092
2. J 35020 or J 43410



Legend

1. J 35014 or J 43411
2. Oil Seal
3. Outer Bearing

5. Inner bearing inner race with J 35727.



Legend

1. J 35727
2. Inner Bearing Inner Race

6. Spacer
   - Discard used spacer and install a new one.
7. Pinion Gear.
8. Flange
   - Discard used pinion nut and install a new one at reassembly.

Notice:
Refer to Rear Axle Description in this section.

9. Pinion nut.

Tighten

- Pinion nut to 245 N·m (181 lb ft).

Notice:
Do not reuse the pinion nut.

Adjust

Tool Required:
J 34913 Tension Gauge (0-25 lb)

- Clamp the pinion in a soft jawed vise.
- Hook spring tension gauge at cage hole.
- Measure the pinion bearing preload with J 34913.

Bearing Preload:

292 mm differential:

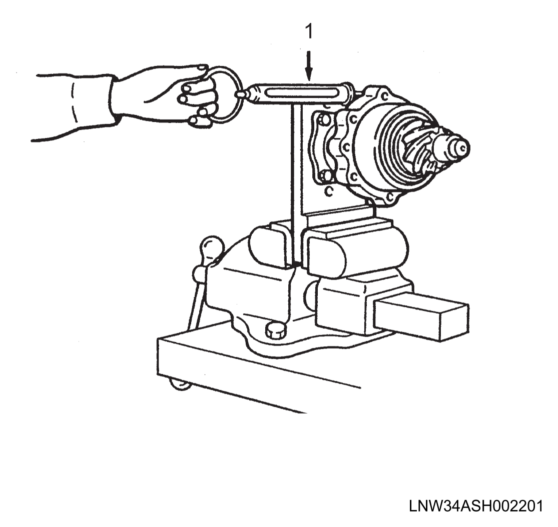
New : 13 - 25 N (2.9 - 5.7 lb)

Used : 6.5 -12.5 N (1.5 - 2.9 lb)

320 mm differential:

New : 26 - 38 N (6.0 - 8.6 lb)

Used : 13 -19 N (3.0 - 4.3 lb)



Legend

1. J 34913

- Adjust the bearing preload by turning in the pinion nut a little at a time to obtain the proper preload.
- The flange nut should be within the specified range when specified preload is obtained.

Flange Nut Torque:

292 mm differential:

324 - 480 N·m (238 - 354 lb ft)

320 mm differential:

441 - 598 N·m (325 - 441 lb ft)

Differential

Notice:
Refer to Rear Axle Description in this section.

1. Cage half A and ring gear.
   - The ring gear should always be replaced with the drive pinion as a matched set. Apply stud lock to the bolts after treatment of the bolts with primer N.

Tighten

- Ring gear bolts to specified torque in sequence shown in next illustration.
- Use DT47668 for tightening ring gear bolts (only 292mm differential).

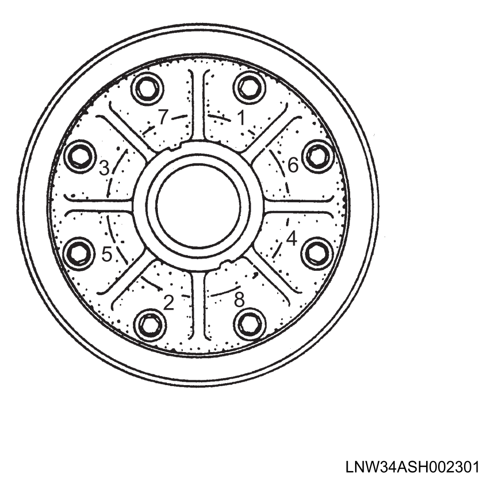
Ring Gear Bolts Torque:

292 mm differential:

181 N·m (134 lb ft)

320 mm differential:

333 N·m (246 lb ft)



2. Washer.
3. Side gear.
4. Spider assembly.
5. Side gear
6. Washer
7. Differential cage B
   - Install differential cage B by aligning reference marks made during disassembly.
   - If necessary, install cage bolts from the ring gear side to prevent interference between cage attaching bolts and drive pinion.
   - Apply oil to thread portion of bolts before installation.

Tighten

- Differential cage bolts to specified torque.

  292 mm differential:

  69 N·m (51 lb ft)

  320 mm differential:

  74 N·m (55 lb ft)

Measure

- Clearance between back face of side gear and differential cage by inserting a feeler gauge through the hole in the case. If the clearance exceeds the limit, replace the thrust washer or the side gear.

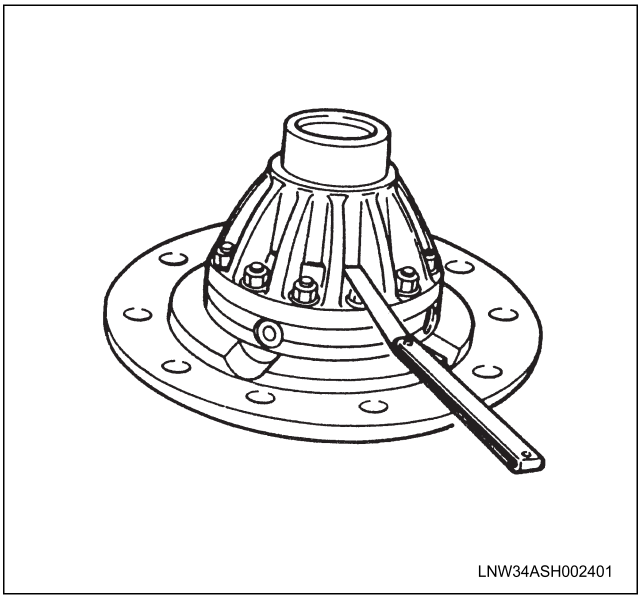
  Clearance:

  292 mm differential:

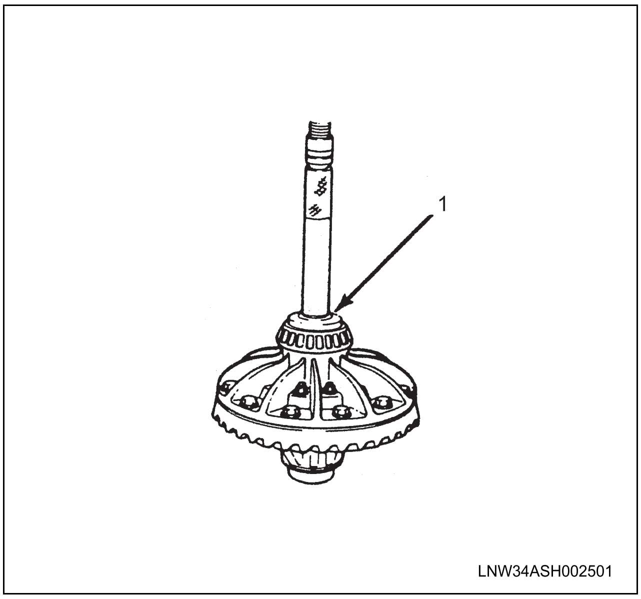
  0.21 - 0.28 mm (0.008 - 0.011 in)

  320 mm differential:

  0.10 - 0.38 mm (0.004 - 0.015 in)



8. Side bearing. Use J 35021 and J 8092.



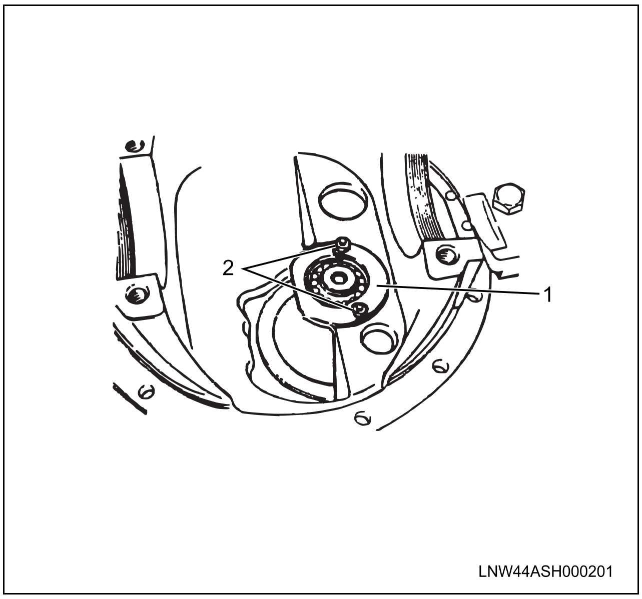
Legend

1. J 35021

Install or Connect

Notice:
Refer to Rear Axle Description in this section.

1. Mount the carrier housing in a repair stand.
2. Pilot bearing.
3. Pilot bearing retainer with the fixing nuts on the inboard side of the case.

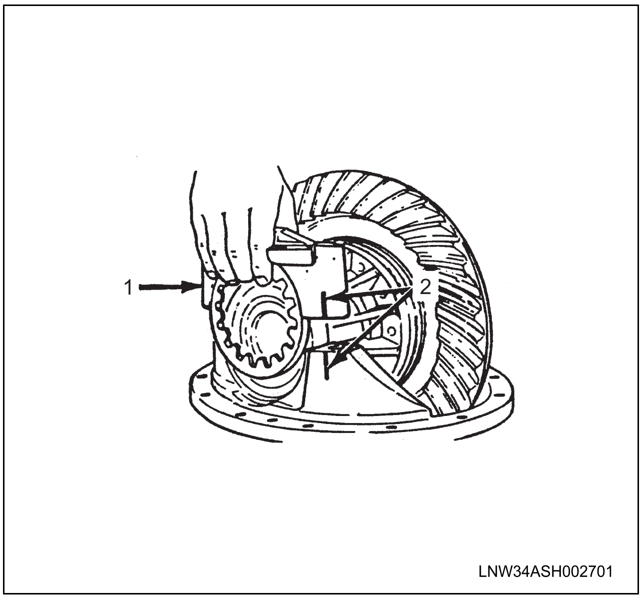


Legend

1. Pilot Bearing Retainer
2. Fixing Nut

---

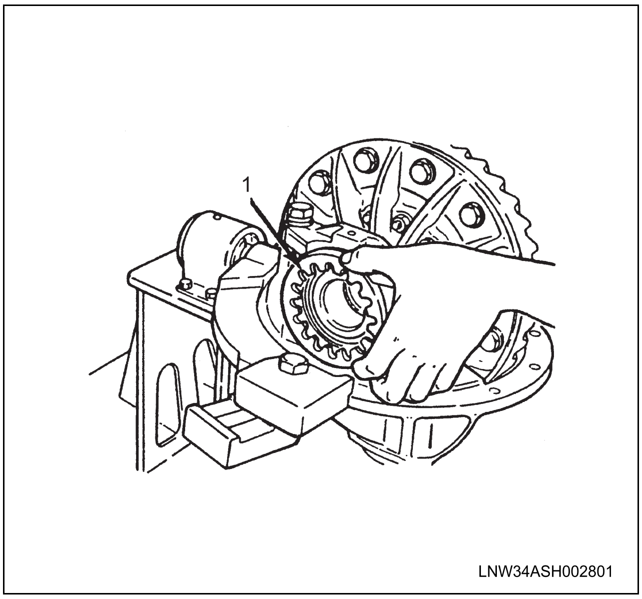
4. Differential cage assembly and ring gear.
5. Side bearing outer race.
   - Be sure to keep the outer races with the bearings they were with at disassembly.
6. Bearing caps and adjuster nuts.
   - Align the reference marks applied at disassembly.



Legend

1. Bearing Cap
2. Reference Mark

- Tighten the adjuster nuts so that they can be turned after installing and semi-tightening the bearing caps.

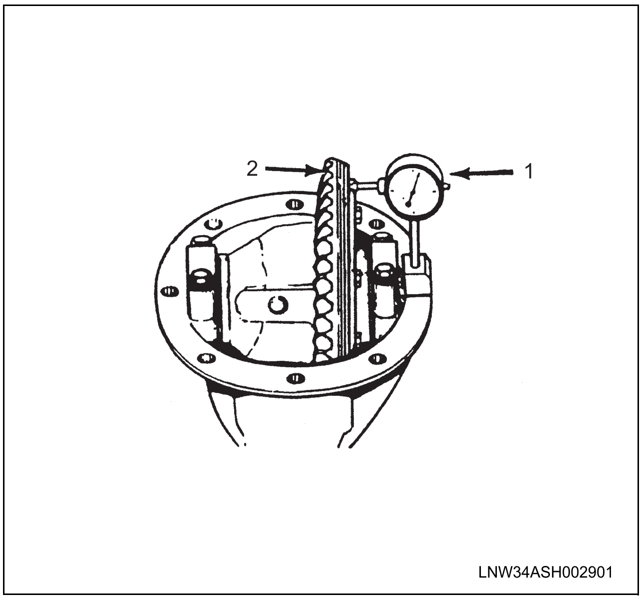


Legend

1. Adjuster Nut

Adjust

- Check ring gear run-out.



Legend

1. Dial Indicator
2. Ring Gear

- Dial indicator should read.
- Check at four places equally spaced.

292 mm differential

Standard:

0.07 mm (0.003 in)

Maximum run-out:

0.2 mm (0.008 in)

320 mm differential

Standard:

0.08 mm (0.003 in)

Maximum run-out:

0.25 mm (0.010 in)

7. Shim and drive pinion assembly.

Important:

- Do not cover oil port when installing shim pack. Use reference marks applied on removal.
- Use new shim of the same thickness as the old one is a new pinion and ring assembly are used.
- Shims are available in the following thicknesses: 0.10 mm (0.0039 in), 0.12 mm (0.0047 in), 0.14 mm (0.0055 in), 0.16 mm (0.0063 in), 0.18 mm (0.0071 in), 0.20 mm (0.0079 in)

Tighten

- Pinion assembly bolts to specified torque.

  292 mm differential:

  M12: 69 N·m (51 lb ft)

  M14: 78 N·m (58 lb ft)

  320 mm differential:

  72 N·m (53 lb ft)

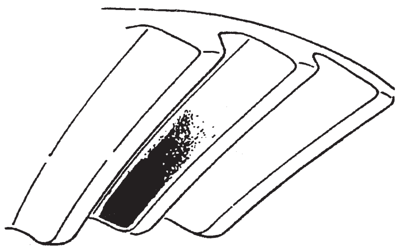
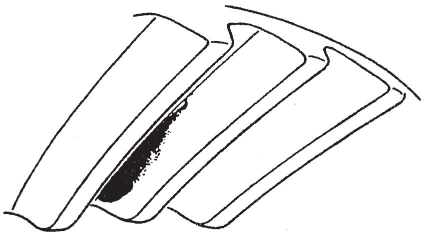
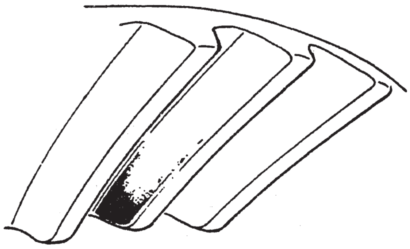
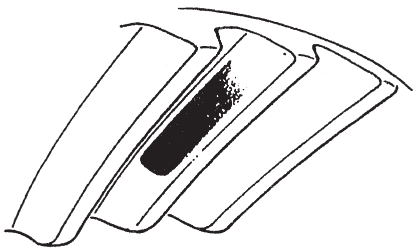
Inspect

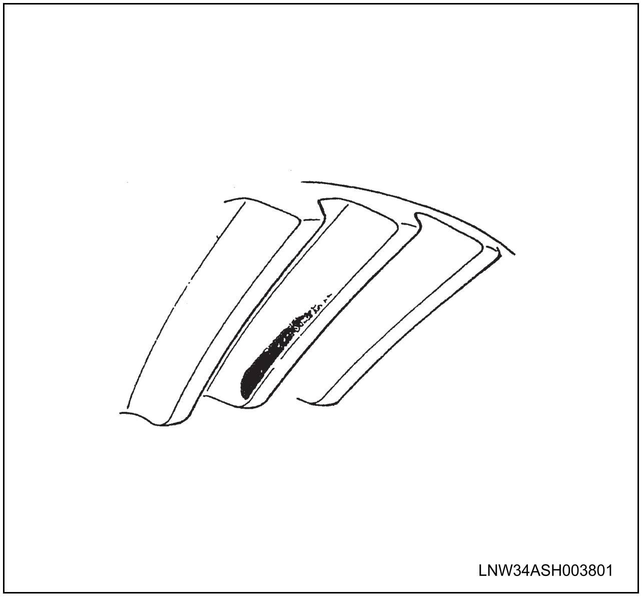
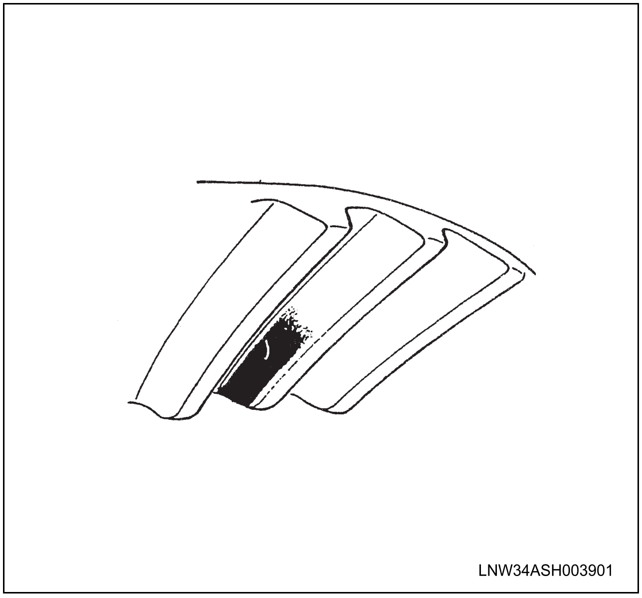
- Ring gear and pinion tooth pattern.
- New gears.
  - Apply a thin coat of red check to the faces of 7-8 teeth of the ring gear.
  - Turn the ring gear to get a contact pattern.
    - ◊ The contact pattern is centered gear tooth as shown in next illustration, with lengthwise contact clear of the toe.
    - ◊ The length of the pattern in an condition is one half to two thirds of the ring gear tooth on most models.
- Used gears.
  - Apply a thin coat of red check to the faces of the 7-8 teeth of the ring gear.
  - Turn the ring gear to get a contact pattern.

◊ Used gears usually do not display square even contact pattern as new gears do. Normally, gear contact is a "pocket" at the toe-end with tails along the gear root. As the gear wears, the tail becomes more dominant.

◊ Adjust a used gear to show the same contact pattern observed before disassembly. A correct pattern is clear of the toe and centered along the face length of the tooth.

- Check the impression of contact obtained on the ring gear teeth and make necessary adjustment as described.

Correct Pattern (New Gears)  LNW34ASH003401 • Could vary in length. Pattern should cover 1/2 tooth or more (face width). • Pattern should be evenly centered between tooth top land and root. • Pattern should be clear of tooth toe.	**Incorrect Pattern (Move Pinion Away From Ring Gear)**  LNW34ASH003501 • Pattern too far along tooth toward tooth heel. • Move ring gear toward pinion to decrease backlash.
Correct Pattern (Used Gears)  LNW34ASH003601 • Pocket may be extended. • Pattern along the face width could be longer.	**Incorrect Pattern (Too Much Backlash)**  LNW34ASH003701 • Pattern too far off tooth toe. • Move ring gear away from pinion to in-crease backlash.

Incorrect Pattern (Move Pinion Toward Ring Gear)	**Incorrect Pattern (Not Enough Backlash)**
 LNW34ASH003801 • Pattern too close or off tooth root. • Move pinion away from ring gear.	 LNW34ASH003901 • Pattern too close to tooth top land and off center. • Move pinion toward ring gear.

Adjust

- Pinion depth and ring gear backlash.
- Backlash adjustment moves the contact pattern along the "face length" of the gear tooth. Pinion position controls contact on the "tooth depth" of the gear tooth.
- These adjustments are inter-related and must be considered together. First adjust the pinion, then the backlash.

Pinion Adjustment

- Pinion position is controlled by the pinion bearing cage shim pack.
- Remove shims if pattern is at the top land of ring gear tooth.
- Add shims if pattern is too close to the root of ring gear tooth.
- Check ring gear backlash after each shim pack change.

Ring Gear Backlash

- Obtain a dial indicator set.
  - Loosen the adjuster nut.
  - Tighten the adjuster nuts to zero backlash, then loosen by one notch.
  - Tighten the adjuster nuts to contact the bearing cup, and tighten three more notches.
  - Check backlash with dial indicator at four positions equally spaced.

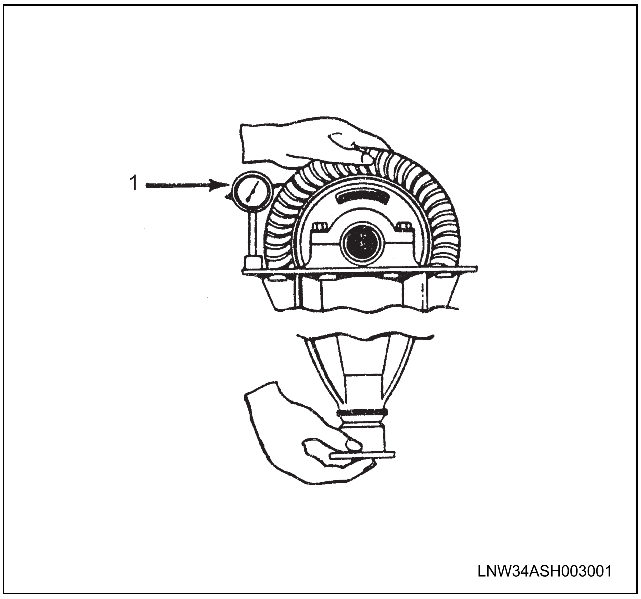
292 mm differential:

0.18 - 0.23 mm (0.007 - 0.009 in)

320 mm differential:

0.19 - 0.29 mm (0.007 - 0.011 in)

- To add backlash, loosen the adjuster nut on cage half A and tighten the adjuster nut on cage half B the same amount.
- To remove backlash, loosen the adjuster nut on cage half B and tighten the adjuster nut on cage half A the same amount.



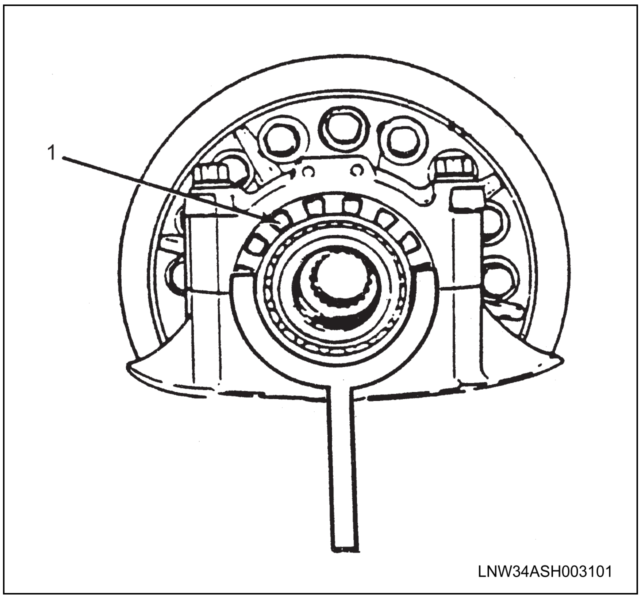
Legend

1. Dial Indicator

Adjust

- Side bearing preload.

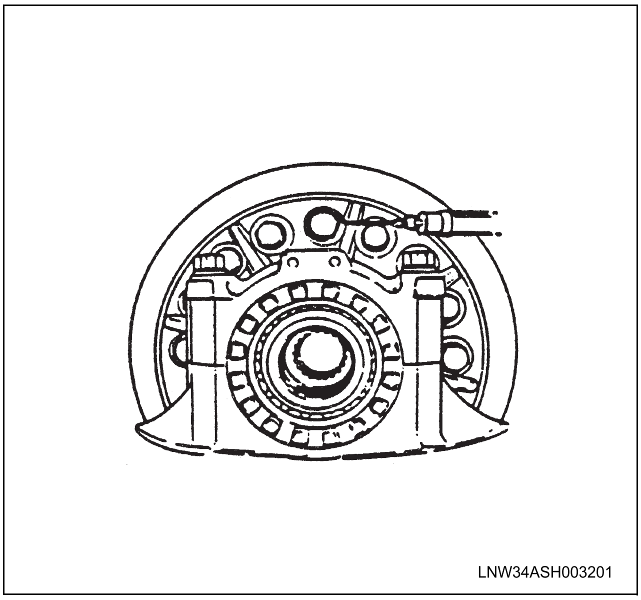
- Tighten the adjuster nut on the ring gear side 2 more notches to give a proper bearing preload when correct backlash and tooth contact are obtained.



Legend

1. Adjuster Nut

- Check the side bearing preload drag with a spring gauge.



◊ NSK Bearing
New : 0.58 - 1.33 kg (1.3 - 2.9 lb)
Used : 0.29 - 0.66 kg (0.7 - 1.4 lb)

◊ Koyo Bearing
New : 1.17 - 1.83 kg (2.6 - 4.0 lb)
Used : 0.59 - 0.91 kg (1.3 - 2.0 lb)

8. Fully tighten bearing caps.

Tighten

- Bearing cap bolts to specified torque.
- Recheck ring gear backlash after tightening the bearing cap bolts.

  292 mm differential:

  108 N·m (80 lb ft)

  320 mm differential:

  157 N·m (116 lb ft)

9. Lock plates.

Tighten

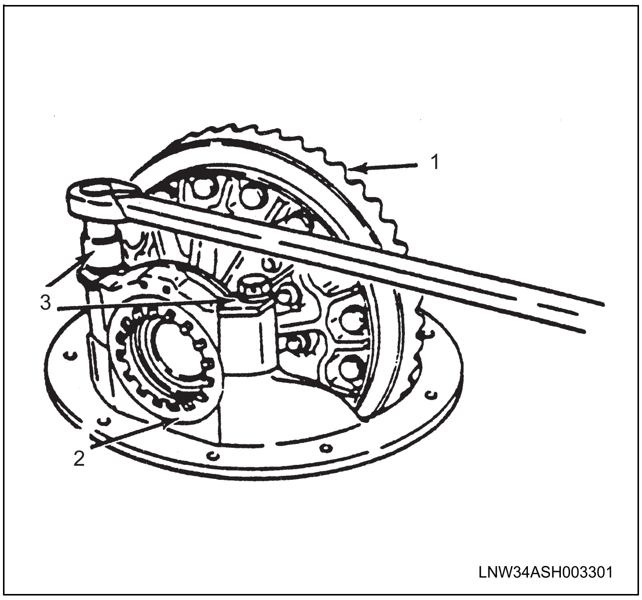
- Lock plates to specified torque.

  292 mm differential:

  29 N·m (22 lb ft)

  320 mm differential:

  13 N·m (113 lb in)



Legend

1. Ring Gear
2. Adjuster Nut
3. Bearing Cap Bolt

Specifications

Specifications

NPR

Type		Banjo-Full Floating
Gear Type		Hypoid
Ring Gear Pitch Diameter		292 mm (11.5 in)
Ring Gear Backlash		0.18-0.23 mm (0.007-0.009 in)
Pinion Bearing Preload Adjustment Method		Spacer
Preload at Cage Bolt Hole (Pitch Circle Diameter 155 mm / 6.10 in)		New : 13-25 N (2.9-5.7 lb)
		Used: 6.5-12.5 N (1.5-2.9 lb)
Flange Bolt Hole Pitch Diameter		100 mm (3.94 in)
Side Bearing Preload Adjustment Method		Adjusting Nut
Preload at Ring Gear Fixing Bolt (Pitch Circle Diameter 240 mm / 9.45 in)	NSK Bearing	New : 0.58-1.33 kg (1.3-2.9 lb)
		Used: 0.29-0.66 kg (0.7-1.4 lb)
	Koyo Bearing	New : 1.17-1.83kg (2.6-4.0 lb)
		Used: 0.59-0.91 kg (1.3-2.0 lb)
Allowance for Side Bearing		0.007-0.014 mm (0.0003-0.0006 in)
Differential Type		Four Pinion
Axle Shaft Type		Integral Shaft and Drive Flange
Oil Capacity		9.7 liter (10.3 qts)

Fastener Torques

NPR

Axle Shaft Nuts	49 N·m (36 lb ft)
Hub to Drum Nuts	392 N·m (289 lb ft)
Bearing Lock Nut	147 N·m (108 lb ft)→0 (Zero)→78 N·m (58 lb ft)
U-bolt Nuts	Differential Gear 292 mm : 177 N·m (130 lb ft)
	320 mm : 284 N·m (209 lb ft)
Shock Absorber Nuts	95 N·m (70 lb ft)
Shock Absorber Bolt	40 N·m (30 lb ft)
Propeller Shaft Nuts	103 N·m (76 lb ft)
Brake Hose Nut	15 N·m (11 lb ft)
Differential Carrier Bolts	59 N·m (43 lb ft)
Pinion Nut	324-480 N·m (238-354 lb ft)
Ring Gear Bolts	181 N·m (134 lb ft)
Differential Cage Bolt	69 N·m (51 lb ft)
Pinion Assembly Bolts	M12: 69 N·m (51 lb ft)
	M14: 78 N·m (58 lb ft)
Bearing Cap Bolts	108 N·m (80 lb ft)
Lock Plates	29 N·m (22 lb ft)

Specifications

NQR

Type	Banjo-Full Floating
Gear Type	Hypoid
Ring Gear Pitch Diameter	320 mm (12.6 in)
Ring Gear Backlash	0.19-0.29 mm (0.007-0.011 in)
Pinion Bearing Preload Adjustment Method	Spacer
Preload at Cage Bolt Hole (Pitch Circle Diameter 155 mm / 6.10 in)	New : 26-38 N (6.0-8.6 lb)

		Used: 13-19 N (3.0-4.3 lb)
Flange Bolt Hole Pitch Diameter		A/T : 100 mm (3.94 in)
		M/T : 110 mm (4.33 in)
Side Bearing Preload Adjustment Method		Adjusting Nut
Preload at Ring Gear Fixing Bolt (Pitch Circle Diameter 240 mm / 9.45 in)	NSK Bearing	New : 0.58-1.33 kg (1.3-2.9 lb)
		Used: 0.29-0.66 kg (0.7-1.4 lb)
	Koyo Bearing	New : 1.17-1.83 kg (2.6-4.0 lb)
		Used: 0.59-0.91 kg (1.3-2.0 lb)
Allowance for Side Bearing		0.007-0.014 mm (0.0003-0.0006 in)
Differential Type		Four Pinion
Axle Shaft Type		Integral Shaft and Drive Flange
Oil Capacity		10 liter (10.6 qts)

Fastener Torques

NQR

Axle Shaft Nuts	49 N·m (36 lb ft)
Hub to Drum Nuts	13 N·m (113 lb in)
Bearing Lock Nut	147 N·m (108 lb ft)→0 (Zero)→78 N·m (58 lb ft)
U-bolt Nuts	284 N·m (209 lb ft)
Shock Absorber Nuts	95 N·m (70 lb ft)
Shock Absorber Bolt	40 N·m (30 lb ft)
Propeller Shaft Nuts	103 N·m (76 lb ft)
Brake Hose Nut	15 N·m (11 lb ft)
Differential Carrier Bolts	59 N·m (43 lb ft)
Pinion Nut	441-598 N·m (325-441 lb ft)
Ring Gear Bolts	333 N·m (246 lb ft)
Differential Cage Bolt	74 N·m (55 lb ft)
Pinion Assembly Bolts	72 N·m (48 lb ft)
Bearing Cap Bolts	157 N·m (116 lb ft)
Lock Plates	13 N·m (113 lb in)

Special Tools

Special Tools

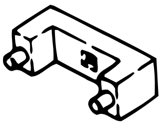
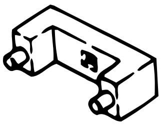
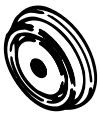
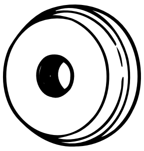
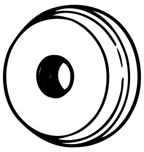
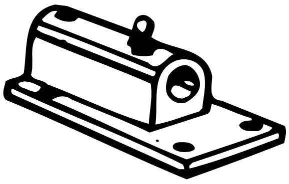
Illustration	Tool Number/ Description
 9852211880	J 35012 Rear Hub Bearing Nut Wrench
 9852211880	J 35013 Rear Hub Bearing Remover
 9852216070	J 39114 Rear Hub Oil Seal Installer
 5884021630	J 35008 Inner Bearing Installer
 5884021630	J 35019 Hub Outer Bearing Outer Race Installer
 5884000030	J 3289-20 Holding Fixture Base

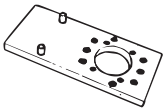
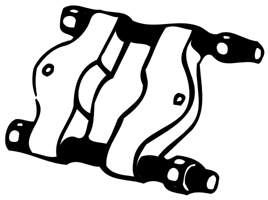
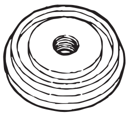
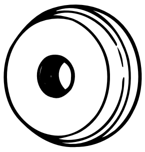
Illustration	Tool Number/ Description
 5884020290	J 35715 Differential Carrier Holding Fixture
 5884020310	J 35030 Differential Side Bearing and Rear Hub Puller Pilot
 AAW0Z0SH001301	J 35016 Drive Pinion Flange Bracket
 5884000150	J 22912-01 Top Gear Shaft Bearing Separator
 AAW0Z0SH001401	J 35014 Rear Hub Oil seal Installer
 5884021630	J 35020 Drive Pinion Inner / Outer Race Installer

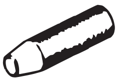
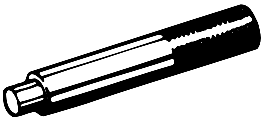
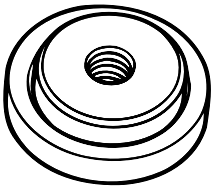
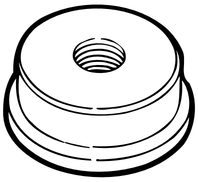
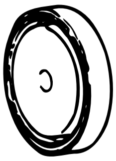
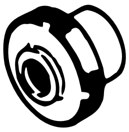
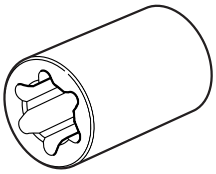
Illustration	Tool Number/ Description
 AAW0Z0SH018901	J 35727 Inner Bearing Inner Race Installer
 AAW0Z0SH001501	J 34913 Tension Gauge
 AAW0Z0SH019001	J 35021 Differential Side Bearing Installer
 9852211480	J 8092 Grip
 5884024270	J 43413 Rear Hub Oil seal Installer
 5884024260	J 43412 Inner Bearing Installer

Illustration	Tool Number/ Description
 5884023770	J 43411 Rear Hub Oil seal Installer
 5884023790	J 43410 Drive Pinion Inner / Outer Race Installer
 5884028300	DT 47668 Ring Gear Fixing Bolt Wrench

DRIVELINE/AXLE

Propeller Shaft

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General Description

General Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Propeller Shaft

Torque is transmitted from the transmission to the rear axle through propeller shaft(s) and universal Joint assemblies.

All propeller shafts are the balanced tubular type using a yoke at the transmission end of the driveline. The slip joint is at the forward end of the rear propeller shaft.

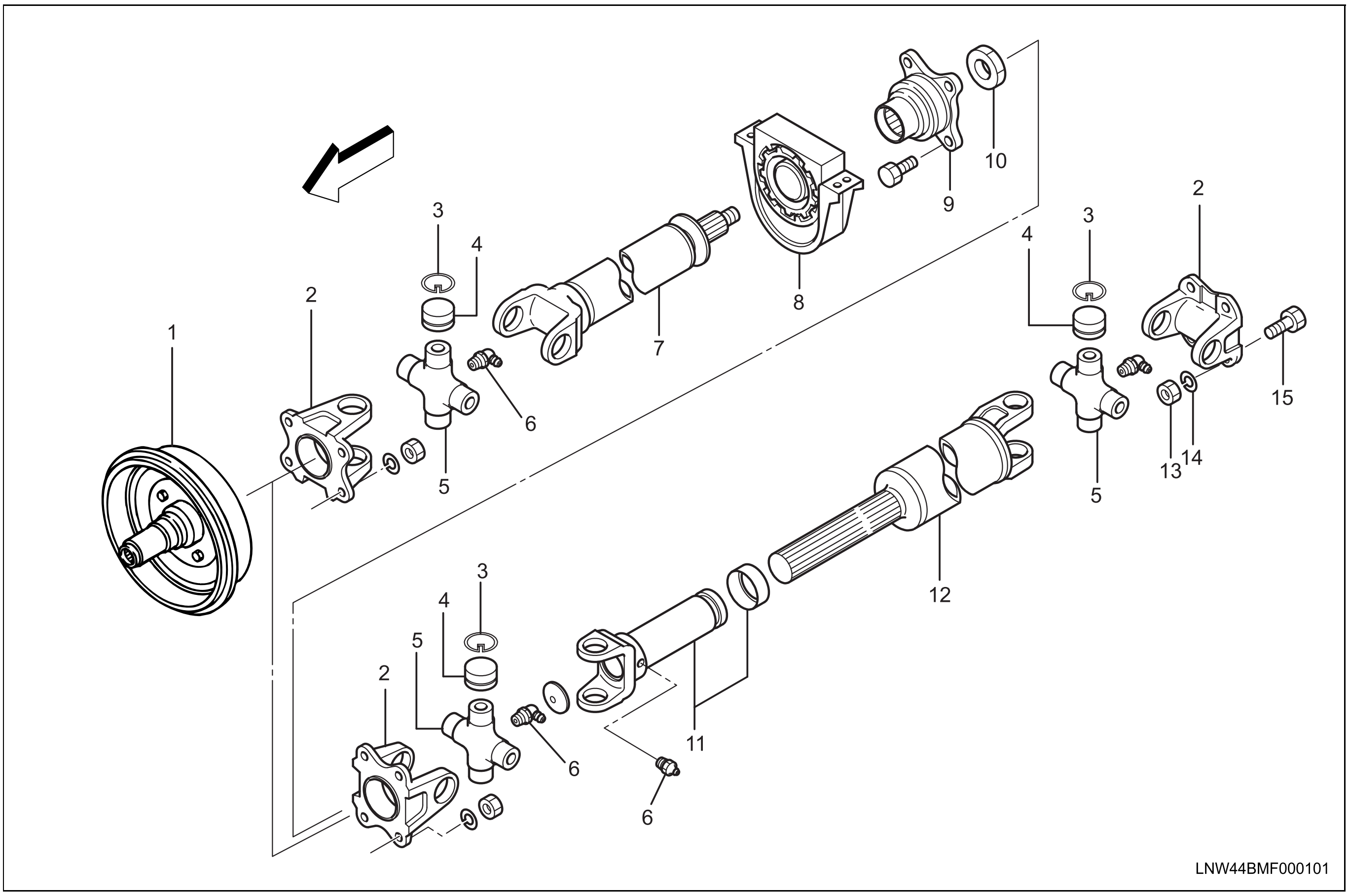
Phasing

The propeller shaft is designed and built with the yoke lugs (ears) in line with each other. This design produces the smoothest running shaft possible, and is called phasing.

Vibration can be caused by an out of phase propeller shaft. The propeller shaft will absorb vibrations from speeding up and slowing down each time the universal joint goes around. This vibration would be the same as a person snapping a rope and watching the "wave" reaction flow to the end. A propeller shaft working in phase would be similar to two persons snapping a rope at the same time, and watching the "waves" meet and cancel each other out. In comparison this would be the same as the universal joints on a propeller shaft. A total cancellation of vibration produces a smooth flow of power in the driveline. It is very important to reference mark the propeller shaft before removal, to ensure phased installation alignment. Some propeller shafts have keyed splined to keep propeller shaft in phase during reassembly.

Center Bearing

Center bearing supports the driveline. The center bearing is a ball-type bearing mounted in a rubber cushion that is attached to a hanger supported by a frame cross-member. The bearing is pre-lubricated and sealed by the manufacturer.



Legend

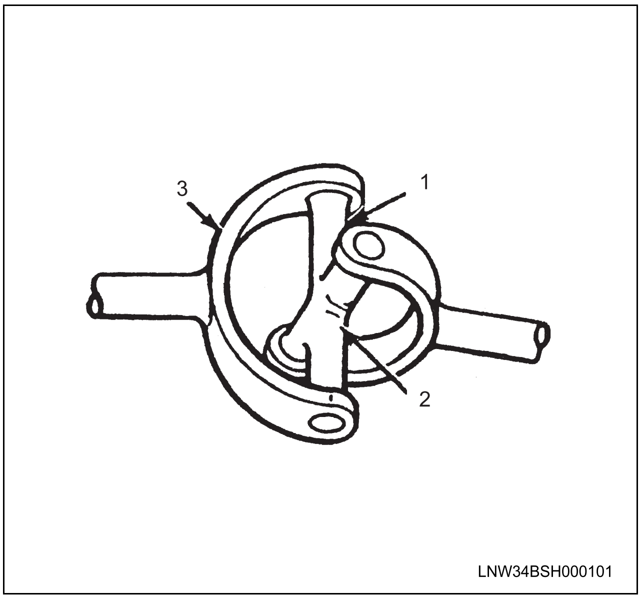
1. Parking Brake Drum
2. Flange Yoke
3. Snap Ring
4. Bearing Cap
5. Spider
6. Grease Fitting
7. 1st Propeller Shaft
8. Center Bearing
9. Coupling Driver
10. Nut
11. Spline Yoke Assembly
12. 2nd Propeller Shaft
13. Nut
14. Spring Washer
15. Bolt

Universal Joint

A universal joint is two Y-shaped yokes connected by a cross-member called a spider. The spider is shaped like a cross having arms of equal length called trunnions.

Universal joints are designed to handle the effects of various loadings and axle windup during acceleration. Within the designed angle variations the universal joint will operate efficiently and safely. When the design angle is changed or exceeded the operational life of the joint may decrease.

The bearings used in universal joints are the needle roller type. The needle rollers are held in place on the trunnions by round bearing cups. The bearing cups are held in the yokes by snap rings, depending on the manufacturer of the joint.



Legend

1. Trunnion
2. Cross or Spider
3. Yoke

Diagnosis of the Propeller Shaft and Universal Joint

Diagnosis of the Propeller Shaft and Universal Joint

PROBLEM	POSSIBLE CAUSE	CORRECTION
Universal Joint Noise	1. Center bearing. 2. Worn universal joint bearings. 3. Improper lubrication. 4. Loose flange bolts.	1. Replace center bearing. 2. Replace. 3. Lubricate as directed. 4. Tighten to “Specifications”.
Ping, Snap, or Click in Drive Line (Usually Heard on Initial Load after the Transmission is in Gear; Forward or Reverse)	1. Loose bushing bolts on the rear springs. 2. Out of phrase companion flange.	1. Tighten the bolts to specified torque. 2. Remove companion flange, turn 180° from its original position, lubricate splines and install. Tighten bolts to specified torque.
Knocking or Clunking Noise in the Driveline when Operating the Vehicle in a Floating Condition in High or Neutral Gear at 16 km/h (10 MPH).	1. Worn or damaged universal joint. 2. Pinion and bevel gear too tight (Audible when slowing down and disappears when driving).	1. Replace the worn or damaged universal joint. 2. Replace the differential case and/or the side gears.

PROBLEM	POSSIBLE CAUSE	CORRECTION
Roughness or Vibration	1. Bent or dented propeller shaft. 2. Undercoating on propeller shaft. 3. Tire unbalance, 48-80 km/h (30-50 mph). Not throttle conscious. 4. Tight universal joints. 5. Worn universal joints. 6. Bent companion flange or flange with excessive run-out. 7. Burrs or gouges on companion flange. Check snap ring locating surfaces on flange yoke. 8. Propeller shaft, parking brake drum is unbalanced. 9. Incorrect rear joint angle. The angle is usually too large when it is a factor. 10. Excessive looseness at the slip spline. 11. Distorted or damaged yokes or flanges. 12 Propeller shaft run-out at 50 mph (80 km/h). Throttle conscious.	1. Replace propeller shaft. 2. Clean propeller shaft. 3. Balance or replace as required. 4. Impact yokes with a shaft hammer to free up. If unable to free up or if joint feels rough when rotated, replace. 5. Replace. 6. Replace necessary parts. 7. Rework or replace the companion flange. 8. Check for a missing balance weight on the propeller shaft. Rotate the companion flange 180 degrees. 9. Check and correct trim height at curb weight. Check and correct Joint angle. 10. Replace necessary parts. 11. Install new yokes or flanges. 12 Check propeller shaft run-out at front and rear. Should be less than specified. If above specification, rotate propeller shaft 180 degrees and recheck. Replace the propeller shaft if run-out is still over specification.
Scraping Noise	Companion flange, or end yoke rubbing on rear axle or center bearing.	Remove the interference.
Roughness Above 56 km/h (35 MPH) Felt and/or Heard	Tires unbalanced or worn.	Balance or replace as required.
Squeak	1. Lack of lubricant. 2. Center bearing.	1. Lubricate joints and splines. Also check for worn or bridled parts. 2. Replace or lubricate.
Whine or Whistle	Center support bearing.	Place the vehicle on a hoist with rear wheels free to rotate and diagnose for source of noise, replace.

PROBLEM	POSSIBLE CAUSE	CORRECTION
Shudder on Acceleration (LOW Speed)	1. Loose or missing bolts at the center bearing or flanges.	1. Replace or tighten bolts to specified torque.
	2. Incorrectly set or excessive Joint angle.	2. Shim under the transmission support mount to change the joint angle. #1254001 std. shim.
	3. Worn universal joint.	3. Replace.
	4. Worn center bearing support cushion. NOTE: Some vertical movement is normal.	4. Replace center bearing.

On-Vehicle Service

Propeller Shaft Balance Check

Remove or Disconnect

- Raise the vehicle on a hoist so the wheels can spin.

1. Wheel and tire assemblies.
2. Brake drums. Refer to SECTION 5A3.

Caution:
Do not apply the brake with the drums removed.

Inspect

- Propeller shaft, universal joints and attachments for mud, undercoating or loose fasteners.

Clean

- Propeller shaft, universal joints and attachments.

Notice:
See "NOTICE" on page 4B-2.

Tighten

- Any loose attachments or fasteners to "Specifications" at the end of this section.

Important:

- Run the vehicle in gear at the speed where the disturbance peaks; observe the intensity of the disturbance. Stop the engine.

3. Propeller shaft.
    - Rotate the propeller shaft 180 degrees from the original position.

Install or Connect

1. Propeller shaft.
    - Determine the position which gives the best balance.
2. Brake drums. Refer to SECTION 5A3.
3. Wheels and tire assemblies.
    - Determine the position which gives the best driveline response by road testing the vehicle for a final check of the propeller shaft balance.
    - If the balance is unacceptable, replace the propeller shaft.

Propeller Shaft Run-out Check

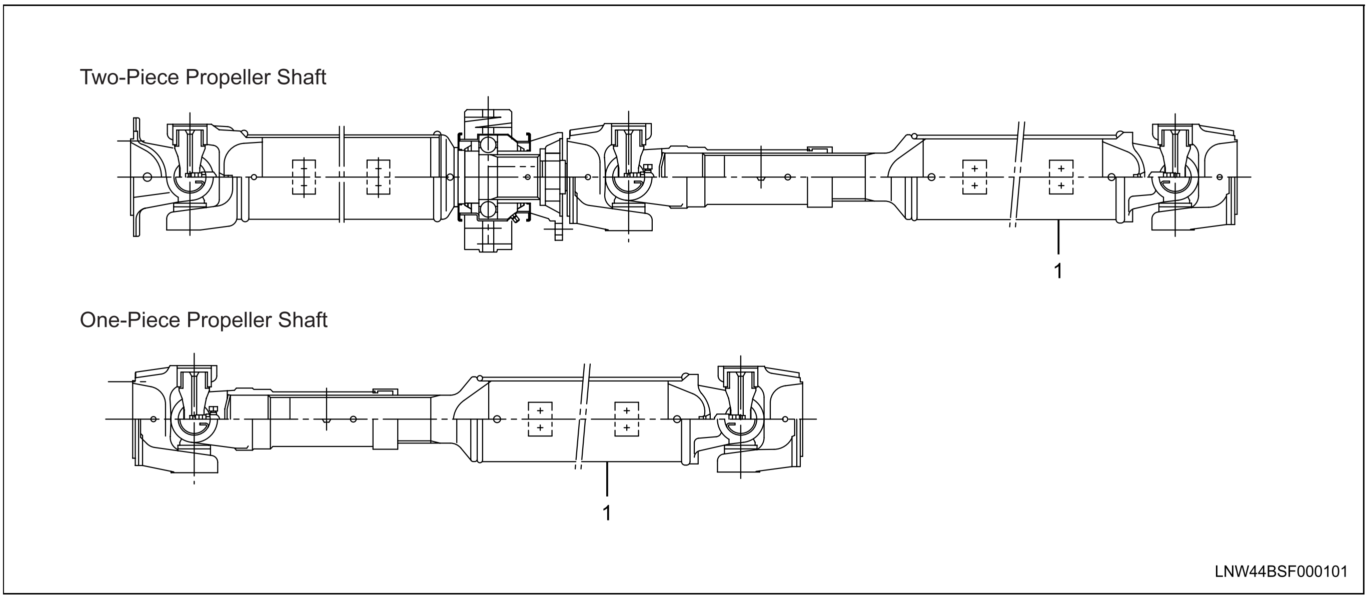
Noise or vibration at high speed could be caused by a bent propeller shaft. The propeller shaft could have been damaged by rough handling or a collision. Check for propeller shaft straightness.

1. Raise the vehicle on a hoist so the wheels can spin.
2. Attach a dial indicator having a magnetic base to a smooth place on the vehicle underbody.

Important:

- Do not attach the dial indicator base at a weld.

3. Take dial indicator readings at the propeller shaft check points shown in next illustration. For run-out specifications, refer to list.
4. With the transmission in neutral, hand rotate the axle pinion flange or the transmission yoke and take the necessary dial indicator readings on the propeller shaft. Record the readings.
    - Two-piece: Measure the 2nd propeller shaft run-out. Reference mark the position of the 2nd propeller shaft yoke to the pinion flange, then remove the 2nd propeller shaft and measure the 1st propeller shaft run-out, both on the tube and at neck of the slip tube shaft. If the run-out exceeds specifications, rotate the rear propeller shaft 180 degrees at the pinion flange and install.
      Check the run-out again.



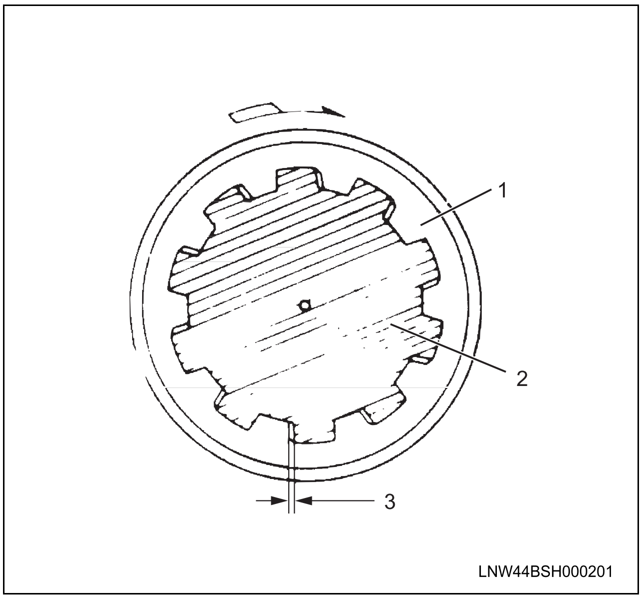
Legend

1. Center Run-out

5. If the run-out is still over specifications at one or more check points, replace the appropriate propeller shaft. Check the run-out on the replacement propeller shaft.
   - If the new propeller shaft run-out is over specifications, check for a bent pinion flange.

Important:

- The splined end of a propeller shaft is critical to the smooth operation of a propeller shaft. Be sure the dial indicator readings are accurate .



Legend

1. Yoke
2. Shaft Spline
3. Wear Limit Measurement

Inspect

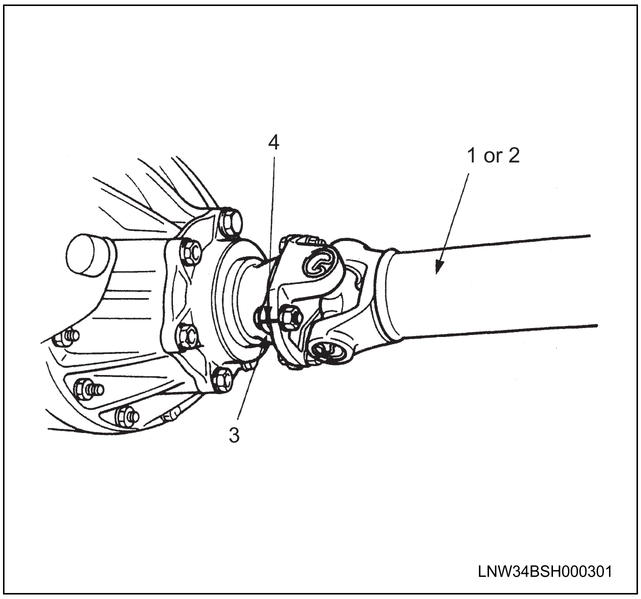
- Shaft run-out 0.5 mm (0.020 in)
- Spline wear 0.5 mm (0.020 in)

Propeller Shaft Replacement

Remove or Disconnect

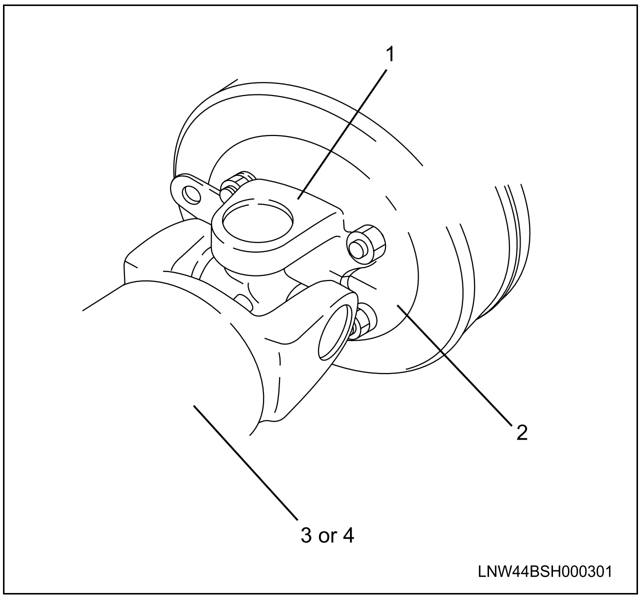
Models with a Two-Piece Propeller Shaft

- Raise vehicle and support with suitable safety stands.
  - Reference mark the 2nd propeller shaft to the pinion flange and center bearing yoke, then reference mark the 1st shaft to the yoke at the transmission.



Legend

1. or 2.	Propeller Shaft
3.	Pinion Flange Yoke
4.	Alignment Mark



Legend

1.	Transmission Yoke
2.	Alignment Mark
3. or 4.	Propeller Shaft or Splined Yoke

1. Bolt, washer and nut at pinion flange.
2. Bolt, washer and nut at center bearing.
3. 2nd propeller shaft

Important:

- Do not pound on the original propeller shaft yoke ears. This may cause damage to the components. Never pry or place any tool between a yoke and a universal joint.
- Then slide shaft rearward off 2nd propeller shaft splines.

4. 1st propeller shaft with center bearing assembly from vehicle.
5. Remove the nut from coupling driver.
6. Remove the coupling driver.
7. Remove the center bearing from 1st propeller shaft.

Important:

- Tape bearing cups onto yoke and U-joints to prevent loss of the needle bearings.

Clean

- All parts.
- Remove paint from the U-joint completely.

Inspect

1. For proper installation and uniform seating of bearing cups.
2. For twisted splined yoke splines or possibly the wrong universal joint.

Install or Connect

Two-Piece Propeller Shaft

Notice:
For steps 4 see "NOTICE" on page 4B-2.

1. Install the center bearing for 1st propeller shaft.

Tighten

- Nut (at the center bearing) to 539 N·m (398 lb ft)

2. 1st propeller shaft up against yoke and install nuts, lining up reference marks.
3. Bolts, at the center bearing support to the cross-member.

Tighten

- Bolts (at the trans end) to 103 N·m (76 lb ft)
- Bolts (at the center bearing) to 40 N·m (30 lb ft)

4. 2nd propeller shaft, lining up reference marks. Slide the front end of the shaft onto the splines of the 2nd shaft.

Important:

- When assembled to mating shaft grease fitting to be in line with wide tooth space in splined yoke.

5. Bolts, washers and nuts.

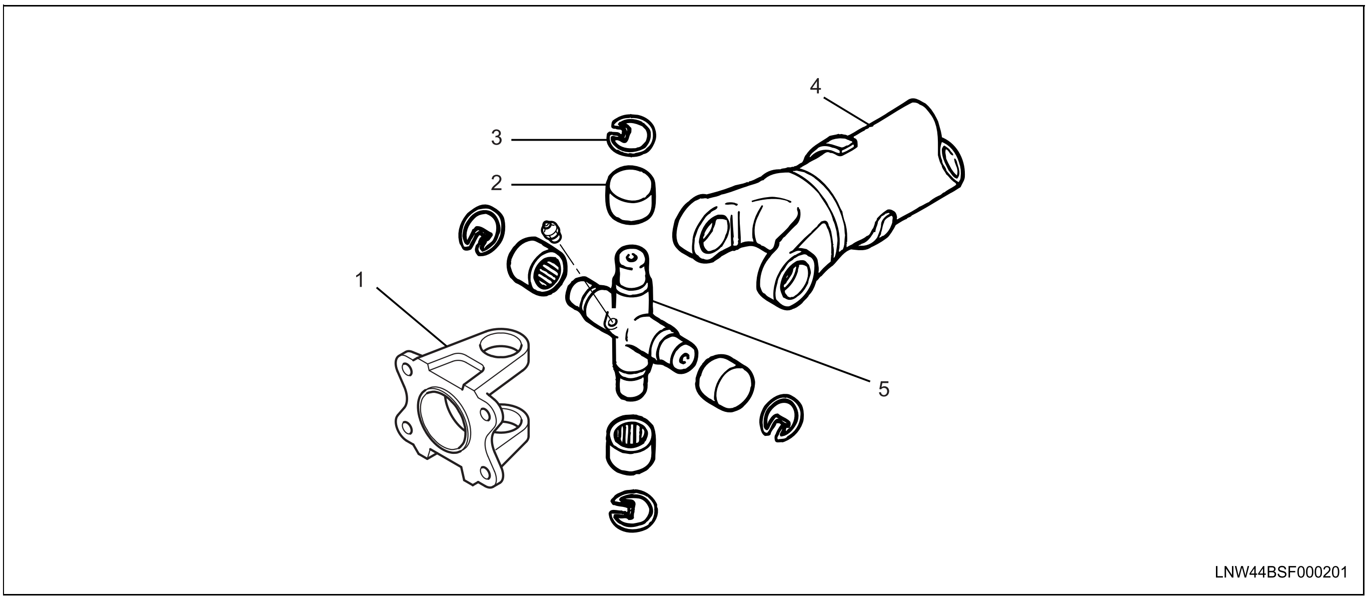
Tighten

- Bolts (at the axle end) to 103 N·m (76 lb ft).

6. Apply rust-preventive paint to the U-joint.
7. Remove safety stands and lower vehicle.

Universal Joint Replacement

Remove or Disconnect



Legend

1. Yoke
2. Bearing Cap
3. Snap Ring
4. Propeller Shaft
5. Spider

- Raise vehicle and support with suitable safety stands.
- Reference mark the propeller shaft for correct alignment.

1. Propeller shaft. Refer to "Propeller Shaft Replacement" in this section.
2. Snap rings.

Important:

- Do not pound on the yoke ears of the propeller shaft or the splined yoke. This may cause damage to the components.

3. Bearing cups from the propeller shaft.
    - Needle roller bearings and cap. Tap one end of the yoke with a soft hammer to force the bearing out of the yoke. Strike opposite side of the yoke to force the opposite bearing out. Remove the other bearings in the same manner.
4. Spider from the yoke.

Clean

- Remove paint from the U-joint completely.

Install or Connect

1. Bearing cups.
    - Set spider in between yoke ears of the propeller shaft and start installing both bearing cups by hand. Continue to drive them inward by squeezing them together using a press or vise.
    - Use a socket with a smaller diameter than the cup and drive it past the snap ring groove.
2. Snap ring.
    - Turn the shaft over.
    - Drive the opposite bearing cup past the snap ring groove.
3. Snap ring
4. Set the splined yoke over the spider and install as outlined in steps 1 through 3.
5. Propeller shaft. Refer to "Propeller Shaft Replacement" in this section.
6. Apply rust-preventive paint to the U-joint.
7. Remove safety stands and lower vehicle.

Splined Yoke Replacement

Remove or Disconnect

- Raise vehicle on hoist and support with suitable stands.

1. Propeller shaft. Refer to "Propeller Shaft Replacement" in this section.
2. Yoke.

Inspect

- Splines for wear, burrs or twisting.
- Yoke ears for damage.

Install or Connect

1. Splined yoke.

Notice:
See "NOTICE" on page 4B-2.

2. Propeller shaft. Refer to "Propeller Shaft Replacement" in this section.
3. Remove safety stands and lower vehicle.

Center Bearing Replacement

Remove or Disconnect

- Raise vehicle and support with suitable safety stands.

1. 2nd propeller shaft. Refer to "Propeller Shaft Replacement" in this section.
2. 1st propeller shaft.
3. Flange nut.
4. Coupling driver.
5. Center bearing.
    - Stand propeller shaft on end in press with center bearing supported by press bars.
    - Press propeller shaft down and off center bearing.

Install or Connect

1. Center bearing onto propeller shaft.
    - Press center bearing onto shaft using a press
2. Coupling driver.
3. Flange nut and washer.

Tighten

- Nut to 539 N·m (398 lb ft)

4. 1st propeller shaft.

Important:

- Center bearing must be aligned to prevent damage to propeller shaft assembly.
- When replacing a center bearing assembly, be sure to fill the entire cavity around the bearing with waterproof grease to shield the bearing from water and contaminations.

5. Rear propeller shaft. Refer to "Propeller Shaft Replacement" in this section.

Notice:
See "NOTICE" on page 4B-2.

Tighten

- Nut to 103 N·m (76 lb ft)

6. Remove safety stands and lower vehicle.

Lubrication

Universal Joints

Universal joints are drilled and provided with a lubrication fitting through which the lubricant travels to all four bearing caps, direct to the needle bearing. Needle bearings are protected against lubricant leakage and the entrance of foreign matter by seats.

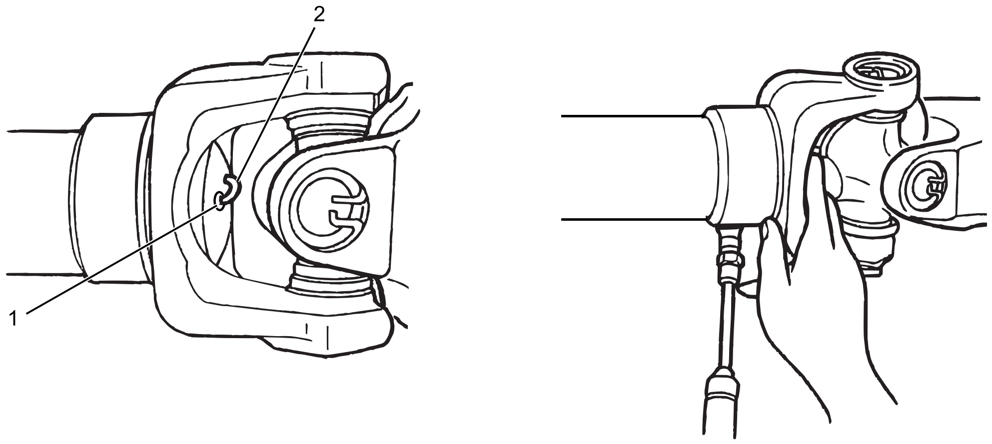
1. Lubricate with a chassis lubricant. Refer to MAINTENANCE AND LUBRICATION (SEC. 0B).
2. When greasing the joint, a flow of grease at all four trunnion seals must be visible to ensure lubrication of the U-joint. If grease does not appear at all four trunnion seals, the universal joint should be rotated while applying lubricant under pressure to relieve any air lock inside the joint which would prevent lubricant from reaching the bearing area.

Tighten

Tighten the bolts and nuts to the torque listed in the specifications at the end of this section.

Sliding Spline Sections (Splined Yoke)

Splines of the splined yoke are lubricated through a grease fitting installed in the splined yoke. Apply grease gun pressure to the grease fitting until lubrication appears at the relief hole as shown in next illustration. Now cover the pressure relief hole with your finger and continue to apply pressure until grease appears at the splined yoke seal. Splined yoke splines should be lubricated at periods specified in SECTION 0B in this manual.



LNW44BSF000301

Legend

1. Pressure Relief Hole
2. Lube

Specifications

Specifications

Propeller Shaft Run-out	0.5 mm (0.02 in)
Spline Wear	0.5 mm (0.02 in)
Center Bearing Grease	Automatic Transmission 20–25 g (0.7–0.9 oz)
	Manual Transmission 40–50 g (1.4–1.8 oz)

Fastener Torques

Propeller Shaft.		
Front:	Hex Head Nuts to Parking Brake Drum Yoke	103 N·m (76 lb ft)
	Hex Head Nut to Propeller Shaft Rear	539 N·m (398 lb ft)
Rear:	Hex Head Nuts to Rear Axle Flange	103 N·m (76 lb ft)
	Hex Head Nut to Coupling Driver	103 N·m (76 lb ft)
Center Bearing Support Bolts/Nuts to Frame Hanger		40 N·m (30 lb ft)

BRAKES

Hydraulic Brakes

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Description and Operation

Description and Operation

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Caution:
When servicing wheel brake parts, do not create dust by grinding or sanding brake linings or by cleaning wheel brake parts with a dry brush or with compressed air. Many wheel brake parts contain asbestos fibers which can become airborne if dust is created during servicing. Breathing dust containing asbestos fibers may cause serious bodily harm. A water-dampened cloth or water-based solution should be used to remove any dust on brake parts. Equipment is commercially available to perform this washing function. These wet methods will prevent asbestos fibers from becoming airborne.

Hydraulic Brakes System Description

The system uses hydraulic foundation brakes of front disc and rear drum brake. The brake booster is a vacuum-loaded servo-type similar to automotive applications (NPR). The other brake booster is the servo-type which used oil pressure (NQR, NRR).
The vehicle is equipped with a Load-Sensing Proportioning Valve (LSPV) that redistributes hydraulic pressure/braking force to the front and rear axle based on the vehicle load.

Hydraulic Brake Fluid Description

Brake fluid is a specially blended liquid which provides a means of transmitting hydraulic pressure between the master cylinder and the wheel cylinders. Brake fluid is one of the most important parts of the hydraulic system. Do not reuse drained brake fluid.
Refer to Maintenance and Lubrication in this manual for description of brake fluid.

Diagnostic Information and Procedure

Road-Testing Brakes

Brakes should be tested on a dry, clean, reasonably smooth and level roadway. A true test of brake performance cannot be made if the roadway is wet, greasy or covered with loose dirt so that tires do not grab the road equally. Testing will also be adversely affected if the roadway is crowned so as to throw the weight of the vehicle toward the wheels on one side or if the roadway is so rough that the wheels tend to bounce.

Test the brakes at different speeds with both light and heavy pedal pressure; however, avoid locking the wheels and sliding the tires on the roadway Locked wheels and sliding tires do not indicate brake efficiency since heavily braked, but turning wheels will stop the vehicle in less distance than locked wheels. More tire-to-road friction is present with a heavily braked turning tire than with a sliding tire.

External Conditions That Affect Brake Performance

- **Tires**–Tires having unequal contact and grip on the road will cause unequal braking. Tires must be equally inflated and tread pattern of the right and left tires must be approximately equal.
- **Vehicle Loading**–When the vehicle has unequal loading, the most heavily loaded wheels require more braking power than others. A heavily loaded vehicle requires more braking effort.
- **Front Wheel Bearing**–A loose front wheel bearing permits the disc and wheel to tilt and have spotty contact with the brake pads causing erratic brake action.
- **Front End Alignment**–Misalignment of the front end will cause the brakes to pull to one side.

No Brakes

POSSIBLE CAUSE	CORRECTION
1. Restricted tubing or hose.	1. Replace defective parts.
2. Brakes out of adjustment.	2. Adjust.
3. No fluid.	

Insufficient Brakes

POSSIBLE CAUSE	CORRECTION
1. Pedal improperly adjusted.	1. Adjust.
2. Worn linings, pads or drums.	2. Replace as necessary.
3. Plugged, crimped, restricted lines.	3. Repair or replace.
4. Malfunctioning rear brakes.	4. Check or adjust LSPV.

Slow Brake Application

POSSIBLE CAUSE	CORRECTION
1. Pedal binding.	1. Lubricate pivot pin, clean-check for foreign objects.
2. Wheel cylinder piston sticking.	2. Repair the wheel cylinder.
3. Restriction in the lines.	3. Remove the restriction or replace the line.
4. Worn linings, pads or drums.	4. Replace as necessary.

Uneven Braking (Front or Rear Brakes not Working)

POSSIBLE CAUSE	CORRECTION
1. Damaged hydraulic lines	1. Repair or replace
2. No brake fluid at the master cylinder	2. Check for plugged, kinked or damaged hose to the reservoir
3. Malfunctioning caliper assembly	3. Check for frozen or sluggish pistons and the lubrication of the retainer bolts Caliper should slide.

Wet Weather: Brakes Grab or won't Hold

POSSIBLE CAUSE	CORRECTION
1. Linings too sensitive to water	1. Replace in axle sets.
2. Dirty brakes.	2. Clean out.
3. Bent mounting plate - opening	3. Replace.
4. Scored drums or discs	4. Machine in pairs. Replace if necessary

Brakes Squeak

POSSIBLE CAUSE	CORRECTION
1. Mounting plate bent or shoes twisted.	1. Replace damaged parts.
2. Metallic particles or dust imbedded in the lining.	2. Replace the linings in axle sets.
3. Lining rivets loose or lining not held tightly against the shoe at the ends.	3. Replace the rivets and/or tighten the lining by riveting.
4. Drums distorted tapered, or not square.	4. Machine or replace drums.
5. Incorrect lining material.	5. Replace the linings in axle sets
6. Mixed size linings.	6. Use all standard or oversize linings in a brake.
7. Weak or broken return spring.	7. Replace the return spring
8. Loose wheel bearings.	8. Tighten to the proper setting
9. Brake assembly attachments missing or loose.	9. Repair as necessary
10. Linings located wrong on the shoes.	10. Install the linings correctly
11. Linings or pads worn out.	11. Replace the lining or pads
12. Linings glazed.	12. Replace.
13. Cracked or threaded drums.	13. Replace in axle pairs

Brakes Chatter

POSSIBLE CAUSE	CORRECTION
1. Incorrect lining to drum clearance	1. Adjust to specification.
2. Loose mounting plate or caliper assembly	2. Tighten securely.
3. Grease, fluid, road dust on the lining or pads	3. Clean or reline.

POSSIBLE CAUSE	CORRECTION
4. Weak or broken return spring.	4. Replace the return spring
5. Loose wheel bearings.	5. Readjust.
6. Drums or discs out-of-round.	6. Machine the drums or discs in axle sets.
7. Cocked or distorted shoes.	7. Straighten or replace
8. Distorted, tapered, or barrel-shaped drums.	8. Machine drums in pairs. Replace if necessary.
9. Incorrect lining or pads material	9. Reline with correct linings or pads
10. Linings or pads worn out.	10. Reline the brake.
11. Linings loose on the shoes.	11. Rerivet the linings to the shoes. Replace if necessary. Check for damaged or distorted shoes
12. Foreign material imbedded in the linings.	12. Replace the linings in axle sets
13. Cracked or threaded drums	13. Replace in axle pairs

Shoe Click

POSSIBLE CAUSE	CORRECTION
1. Return springs weak.	1. Replace the spring
2. Shoe bent.	2. Straighten or replace

Noise and Chatter Squealing, Clicking, or Scraping Sound Upon Brake Application

POSSIBLE CAUSE	CORRECTION
1. Bent, damaged or incorrect shoes	1. Replace with the correct shoes and lining. Always replace in axle sets.
2. Worn out lining or pads	2. Replace the shoes and lining in axle sets.
3. Foreign material embedded in the lining.	3. Replace the shoes and lining in axle sets
4. Broken shoe return spring	4. Replace the return spring
5. Cracked or threaded drums (lathe marks).	5. Replace the drums in axle sets
6. Mixed size linings.	6. Use all standard or oversize linings in a brake.

Pulls to One Side

POSSIBLE CAUSE	CORRECTION
1. Grease or fluid soaked lining	1. Replace in axle sets
2. Loose wheel bearings, loose (or distorted) mounting plate or loose spring bolts.	2. Adjust the wheel bearing, tighten (or replace) the mounting plate to the axle and tighten the spring bolts
3. Linings or pads not of the recommended kind.	3. Install recommended linings Install the shoes correctly

POSSIBLE CAUSE	CORRECTION
4. Tires not properly or evenly inflated or unequal wear of tread Different tread non-skid design.	4. Inflate the tires to recommended pressures. Rearrange the tires so that a pair of non-skid tread surfaces of similar design and equal wear will be installed on the front wheels, and another pair with like tread will be installed on the rear wheels.
5. Water, mud, etc., in the brakes.	5. Remove any foreign material from all of the brake parts and inside of the drums.
6. Wheel cylinder sticking.	6. Repair or replace the wheel cylinder.
7. Weak or broken shoe return spring.	7. Check the spring-replace distorted, open coiled, or cracked spring.
8. Out-of-round drums or different sized drums on the same axle.	8. Refinish or replace the drums in axle pairs.
9. Brake dragging.	9. Check for loose lining. Adjust. (Refer to Dragging Brakes.)
10. Weak chassis springs, loose U-bolts, loose steering gear, etc.	10. Replace the spring, tighten the U-bolts, adjust the steering gear, etc.
11. Loose calipers.	11. Check and torque.
12. Malfunctioning caliper assembly.	12. Check for frozen or sluggish pistons and the lubrication of the retainer bolts. Caliper should slide.
13. Restricted brake line or hose.	13. Check for soft hose or damaged lines Replace as necessary.
14. Wheel cylinder size different on opposite sides.	14. Replace with the correct cylinders.
15. Unmatched tires on the same axle.	15. Same style tires with about the same tread should be used on the same axle.
16. Distorted, damaged, or scored drum.	16. Refinish the drums in axle pairs. Replace if necessary.
17. Front end alignment.	17. Align the front end.
18. Excessively worn lining or pads.	18. Replace in axle sets.
19. Mixed size or incorrect linings or pads.	19. Use all standard or oversize linings in a brake.
20. Wet linings.	20. Apply the brakes a few times while moving at a slow speed to dry the linings.

One Wheel Locks

POSSIBLE CAUSE	CORRECTION
1. Gummy lining.	1. Replace in axle sets.
2. Tire tread slick.	2. Match up tire treads from side to side.
3. Brake adjustment not correct.	3. Adjust the brakes.
4. Restricted brake line or hoses.	4. Check for soft hoses or damaged lines Replace as necessary.
5. Incorrect linings or pads.	5. Replace. Linings or pads must be the same on the axle.
6. Grease or fluid soaked lining.	6. Replace in axle sets.
7. Foreign material in the brakes.	7. Remove the material.

POSSIBLE CAUSE	CORRECTION
8. Mixed size linings or pads.	8. Use all standard or oversize linings or pads.

Light Pedal Pressure-Brakes too Severe (Grabby Brakes)

POSSIBLE CAUSE	CORRECTION
1. Brake adjustment not correct.	1. Adjust the brakes.
2. Loose mounting plate on the front axle.	2. Tighten the plates.
3. A small amount of grease or fluid on the lining.	3. Replace the linings.
4. Incorrect lining.	4. Install factory specified linings.
5. Wheel bearings loose.	5. Adjust the wheel bearings.
6. Lining loose on the shoe.	6. Replace the lining or the shoe and lining.
7. Excessive dust and dirt in the drum.	7. Clean and sand the drums and linings.
8. Out-of-round drum.	8. Turn the drums in pairs or replace.

Low Pedal or Pedal Goes to Floor

POSSIBLE CAUSE	CORRECTION
1. Malfunctioning auto adjuster.	1. Repair as necessary.
2. Master cylinder.	2. Replace or repair as necessary
3. Weak brake hose.	3. Replace with new hose.
4. Leaking wheel cylinder or caliper.	4. Repair as necessary.
5. Air in the hydraulic system.	5. Bleed the hydraulic system.
6. Improper brake fluid (low boiling point).	6. Flush the system and refill with recommended brake fluid.
7. Low fluid level.	7. Fill the reservoir with brake fluid; check for leaks and bleed system.
8. Bent or distorted brake shoes.	8. Replace in axle sets.
9. Leaks at hydraulic line connections.	9. Check for hydraulic leaks and repair.

Slow Brake Release

POSSIBLE CAUSE	CORRECTION
1. Foot pedal binding.	1. Lubricate the pivot pin; clean-check for foreign objects.
2. Restriction in the line.	2. Remove the restriction or replace line.
3. Weak shoe return spring.	3. Replace the spring.

Poor Assist or Loss of Assist

POSSIBLE CAUSE	CORRECTION
1. Low brake fluid level.	1. Fill the reservoir to the proper level Bleed the system.
2. Air in the hydraulic system.	2. Locate the source of the air leak and repair. Bleed the system
3. Weak brake hose.	3. Replace.
4. Loss of vacuum.	4. Inspect for vacuum leaks or malfunctioning pump. Repair or replace as necessary.
5. No brake fluid at the master cylinder.	5. Check for plugged, kinked, or damaged hose to the reservoir.

Brake Fade

POSSIBLE CAUSE	CORRECTION
1. Incorrect lining.	1. Replace with recommended lining.
2. Poor lining contact.	2. Grind the lining to the proper radius; adjust.
3. Thin drum.	3. Replace the drum.
4. Dragging brakes.	4. Adjust.
5. All conditions listed under Pulls to One Side.	5. All corrections listed under Pulls to One Side.

All Brakes Drag when Adjustment is Known to be Correct

POSSIBLE CAUSE	CORRECTION
1. Pedal does not return to stop.	1. Lubricate the pedal linkage; adjust the pedal.
2. Improper fluid.	2. Replace rubber parts and fill with the recommended brake fluid.
3. Use of incorrect rubber parts.	3. Install the proper parts.

One Wheel Drags

POSSIBLE CAUSE	CORRECTION
1. Weak or broken shoe return spring.	1. Replace the return spring.
2. Brake shoe to drum clearance too small.	2. Adjust to specification.
3. Loose wheel bearings.	3. Adjust or replace the wheel bearings.
4. Wheel cylinder piston cups swollen and distorted or piston stuck.	4. Rebuild the cylinders. Flush the hydraulic system and fill with recommended fluid.
5. Pistons sticking in the wheel cylinder.	5. Clean or replace the pistons; clean the cylinder bore.
6. Drum out-of-round.	6. Machine the drum.
7. Restricted brake line or hose.	7. Check for soft hoses or damaged lines Replace as necessary.

POSSIBLE CAUSE	CORRECTION
8. Distorted shoe.	8. Replace.
9. Defective lining.	9. Replace with the recommended lining.
10. Loose or bent mounting plate	10. Tighten the fasteners; replace the plate.

Dragging Brakes

POSSIBLE CAUSE	CORRECTION
1. Improper fluid.	1. Flush the hydraulic system and fill with recommended brake fluid, and replace rubber components.
2. Brake pedal adjustment incorrect.	2. Adjust the pedal.
3. Incorrect shoe return spring.	3. Replace the shoe return spring.
4. Brake pedal linkage interference or binding.	4. Free the linkage and lubricate.
5. Incorrect lining.	5. Replace the linings.
6. All conditions listed under One Wheel Drags.	6. All corrections under One Wheel Drags.

Poor Contact at the Center of Shoe

POSSIBLE CAUSE	CORRECTION
1. Bell-mouthed drum. 2. Distorted mounting plate. 3. Bent brake shoe. 4. Undersize linings. 5. Loose wheel bearing.	1-5. Repair or replace as required.

Unequal Wear on the Shoes in the Same Brake

POSSIBLE CAUSE	CORRECTION
1. Brake linings not a balanced set. 2. Sticking wheel cylinder piston.	1-2. Repair or replace as required.

Material at the Center of the Shoe Excessively Thin

POSSIBLE CAUSE	CORRECTION
1. Undersize linings. 2. Oversize drum.	1-2. Repair or replace as required.

Lining Tapered across the Width

POSSIBLE CAUSE	CORRECTION
1. Bell-mouthed drum. 2. Bent shoe. 3. Distorted mounting plate.	1-3. Repair or replace as required.

Lining Worn at One End

POSSIBLE CAUSE	CORRECTION
Bent mounting plate.	Repair or replace as required.

Linings Glazed

POSSIBLE CAUSE	CORRECTION
1. Grease on lining. 2. Wrong type lining for service involved.	1-2. Repair or replace as required.

Rivets Tear Loose

POSSIBLE CAUSE	CORRECTION
1. Improper set rivet. 2. Improper setting of the rivet. 3. Enlarged rivet holes in the shoe.	1-3. Repair or replace as required.

Unequal Wear Opposite Brakes, Same Axle

POSSIBLE CAUSE	CORRECTION
1. Weak shoe return spring. 2. Obstructed hydraulic line. 3. Stuck wheel cylinder piston. 4. Brake drum surface in poor condition. 5. Loose wheel bearing.	1-5. Repair or replace as required.

Linings at Scored

POSSIBLE CAUSE	CORRECTION
1. Scored drum. 2. Abrasive material between the lining and drum.	1-2. Repair or replace as required.

Cracks at Bolt Holes or Rivet Holes

POSSIBLE CAUSE	CORRECTION
1. Overtightening bolts. 2. Wrong type rivets or bolts. 3. Rivets not properly set. 4. Dirt or rust on the shoe table. 5. Too thick a shim under the lining. 6. Wrong size lining.	1-6. Repair or replace as required.

Elongation of the Bolt Holes or Rivet Holes

POSSIBLE CAUSE	CORRECTION
1. Loose rivets or bolts. 2. Wrong size rivets.	1-2. Repair or replace as required.

Wear on the Edge of the Lining

POSSIBLE CAUSE	CORRECTION
1 Wrong width lining. 2. Holes improperly drilled. 3. Loose wheel bearing. 4. Bent shoe.	1-4. Repair or replace as required.

Groove on the Edge of the Lining

POSSIBLE CAUSE	CORRECTION
1. Lining too wide. 2. Worn drum.	1-2. Repair or replace as required.

Brake Drum Heat Checked in Spots

POSSIBLE CAUSE	CORRECTION
1. Out-of-round brake drum. 2. Eccentric mounting of the drum. 3. Loose wheel bearing.	1-3. Repair or replace as required.

Drum Uniformly Heat Checked

POSSIBLE CAUSE	CORRECTION
1 Improper friction materials. 2. Overworked brake. 3. Driver abuse.	1-3. Repair or replace as required.

Excessive Scoring of the Drum

POSSIBLE CAUSE	CORRECTION
1 Improper friction materials. 2. Overworked brake. 3. Abrasive material between the lining and drum. 4. Soft drum. 5. Bent or warped shoe.	1-5. Repair or replace as required.

Excessive Drum Cracks

POSSIBLE CAUSE	CORRECTION
1. Driver abuse. 2. Weak drum. 3. Wrong friction material. 4. Overworked brake.	1-4. Repair or replace as required.

Brake Pull

POSSIBLE CAUSE	CORRECTION
1. Brake pads hardened.	1. Replace.
2. Brake pads worn excessively.	2. Replace.
3. Brake rotor worn or scored.	3. Grind or replace.
4. Disc brake caliper malfunctioning.	4. Clean or replace.

Brake Roughness-or Chatter (Pulsates)

POSSIBLE CAUSE	CORRECTION
1. Rotor excessive lateral run-out	1. Check per instructions. If not within specifications, replace or machine the rotor.
2. Rotor parallelism not within specifications.	2. Check per instructions. If not within specifications, replace or machine the rotor.
3. Pad reversed (steel against iron).	3. Replace brake pad and machine rotor to within specifications.

Excessive Pedal Effort

POSSIBLE CAUSE	CORRECTION
1. Excessively worn pad.	1. Check and replace pads as a set.
2. Piston in caliper stuck or sluggish.	2. Remove caliper and rebuild.
3. Fading brakes due to incorrect pad.	3. Remove and replace with original equipment pad or equivalent.
4. Grease on the brake pads.	4. Replace or clean.

Brake Drag

POSSIBLE CAUSE	CORRECTION
1. Piston in disc brake caliper sticking.	1. Replace piston seals.
2. Brake pads sticking in caliper.	2. Clean.
3. Rotor warped excessively	3. Grind or replace.

Grabbing or Uneven Braking Action (All conditions listed under “Pull”)

POSSIBLE CAUSE	CORRECTION
1. Corroded caliper assembly.	1. Clean and lubricate

Brake Noisy

POSSIBLE CAUSE	CORRECTION
1. Brake pad worn.	1. Replace.
2. Brake pads hardened.	2. Replace
3. Brake pads in poor contact with rotor.	3. Correct
4. Brake disc(s) warped, worn or damaged.	4. Grind replace
5. Disc brake anti-squeak shims fatigued	5. Replace
6. Front hub bearings loose or preload is incorrect.	6. Adjust or replace
7. Brake disc rusted	7. Grind or replace.

Poor Brake Action

POSSIBLE CAUSE	CORRECTION
1. Disc brake caliper faulty.	1. Clean or replace
2. Water or oil on brake pads	2. Clean or replace
3. Brake pads in poor contact with rotor.	3. Correct
4. Brake pads worn.	4. Replace.
5. Brake disc rusted	5. Grind or replace

Inspection and Repair Instructions

System Inspection

- Maintain proper level of brake fluid in reservoir Refer to Maintenance and Lubrication in this manual for the recommended fluid and checking intervals.
- Adjust the brake shoes at regular intervals. After two or three adjustments, check the brake lining for wear. Reline the brakes before the lining is worn sufficiently to permit the rivets to damage the brake drums. Also check the brake drum for wear.
- Check the brake pad and disc for wear. Also check the piston boot and slide pin boot for damage or breakage.
- Keep the pedal pivot and roller pins lubricated to assure free movement and rapid release of the brakes. Do not over-lubricate.
- Inspect the entire brake system regularly for fluid and vacuum leakage. Correct the leakage immediately.
- Be sure the brake shoes are free on their mounting and that the shoe return spring is not weak, distorted, or broken. Also check that the mounting is not sprung, cracked or loose on the axle or steering knuckle.
- Observe the Brake warning light and make checks and repairs as indicated.

Contamination of Brake System

If the brake fluid becomes contaminated, it will lose some of its original qualities and cause rubber parts to deteriorate.

Use only hydraulic brake fluid recommended in Maintenance and Lubrication in this manual. When other than recommended fluid has been used, drain and flush the entire hydraulic system, using only new, clean brake fluid as a cleaning agent. Disassemble, clean, and inspect the hydraulic units.

Replace all rubber parts. Refill the system with recommended fluid, from a sealed container.

Flush the brake system until all old fluid is removed when performing major brake work. Old fluid should be bled from the system and replaced with clean brake fluid if any of the hydraulic system parts are corroded or the fluid is discolored or dirty. If any of the rubber parts of the hydraulic system are soft or swollen, old fluid should be removed and the hydraulic system should be flushed with clean brake fluid. Do not reuse old brake fluid at any time.

In the event that improper fluid has entered the system, it will be necessary to service the system as follows:

1. Drain the entire system
2. Thoroughly flush the system clean with brake fluid.

Notice:

Use only brake fluid when flushing a system. Usage of other fluids may contribute to contamination and possible failure of rubber components in the system.

3. Replace all rubber parts of the system, including brake hoses and seals.
4. Refill the system with recommended fluid.
5. Bleed the system.

Flushing Brake System

Notice:

Do not use alcohol for flushing the system or cleaning assemblies where alcohol could be trapped and subsequently contaminate the brake fluid.

Contaminated fluid may then cause eventual failure of rubber components in the system.

It is recommended that the entire hydraulic system be thoroughly flushed with clean brake fluid whenever new parts are installed in the hydraulic system.

Flushing is also recommended if there is any doubt as to the grade of fluid in the system or if fluid has been used which contains even the smallest trace of mineral oil. Flush the system whenever there is any question of contamination.

Flushing is performed at each bleeder valve in turn, and in the same manner as the bleeding operation, except that the bleeder valve is opened 1-1/2 turns and fluid is forced through the lines and bleeder valves until it emerges in color. Approximately two or three quarts of fluid is required to flush the hydraulic system thoroughly.

Check reservoir fluid level after flushing at each valve and replenish if required. When flushing is completed at all bleeder valves, make certain the reservoir is filled to the proper level.

Bleeding Brakes

Use only hydraulic brake fluid recommended in Maintenance and Lubrication of this manual when replacing fluid lost during bleeding procedures.

The presence of air in the system is a result of low fluid in the reservoir, or of some part of the system having been disconnected. Bleeder valves are provided on the wheel cylinders.

Bleeding Sequence

It may be necessary to bleed the hydraulic system at all four wheels if air has been introduced through low fluid level or by disconnecting the brake lines. If a brake line is disconnected at the wheel cylinder, then that wheel cylinder only needs to be bled. If brake lines are disconnected at any fitting located between the master cylinder and wheel cylinders, then all the wheel cylinders served by the disconnected line must be bled. Bleeding of the brake hydraulic circuit should be performed in the following sequence:

- Right rear wheel-LSPV-Right front wheel-Left front wheel
- Right rear wheel-LSPV-Left front wheel-Right front wheel

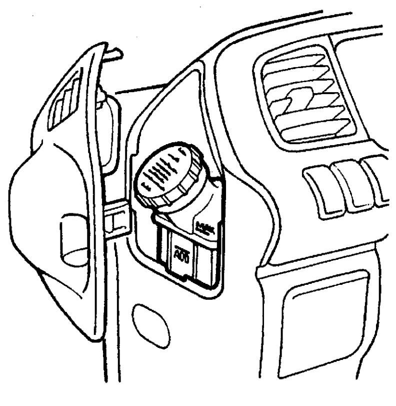
Bleeding Procedure

The vehicle engine must be running to bleed the brakes. Apply the parking brake and block the vehicle wheels.
Fluid in the reservoir must be checked after bleeding it at each valve (bleeder screw) and replenished, if required. Brake pedal should be pumped up and down slowly and should be on the downstroke as the valve is closed.

Caution:

- Air bleeding without starting the engine will result in damage to the brake booster.
- If the vehicle is equipped with ABS, be sure to remove the ABS fuse (60A) from the fuse box before beginning the air bleeding procedure. If this is not done, the ABS may operate and force air into the H/U. Be sure to replace the fuse when the air bleeding procedure is complete.

1. Fill the reservoir with recommended brake fluid and keep at least one-half full of fluid during the bleeding operation.



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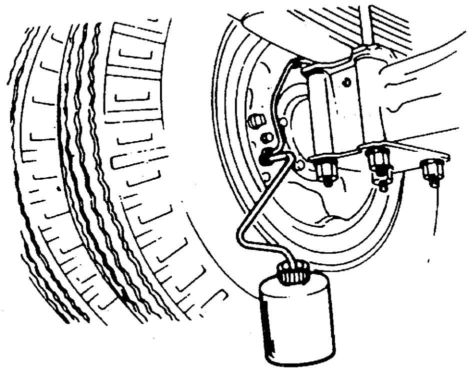
2. Bleed in the sequence recommended previously.
3. Remove the bleeder screw valve cap.
4. With the proper size box end wrench over the bleeder screw, attach a hose over the screw and allow the end to hang in a glass jar containing enough brake fluid to cover the end of the hose.



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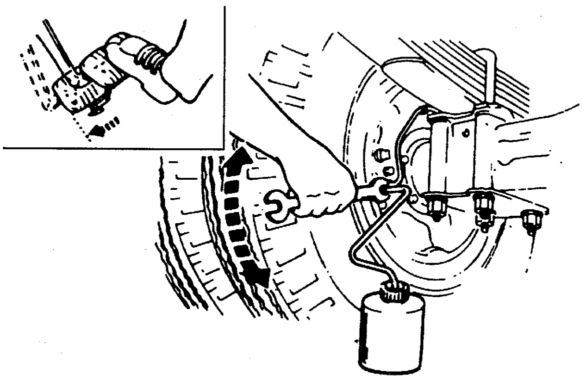
5. Pump the brake pedal two or three times and then hold down.
6. Open the bleeder screw about one-half turn and fully depress the brake pedal.
   Observe flow from the hose



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7. Close the bleeder screw as soon as bubbles stop and the fluid flows in a solid stream.
   Release the brake pedal after closing the bleeder screw.
8. Repeat at the same bleeder until bubbles stop.
9. Repeat at the other bleeder screws in the proper sequence.
10. Replace the bleeder cap.

11. When the bleeding is complete on each wheel, check the level of brake fluid in the reservoir and replenish, as necessary.

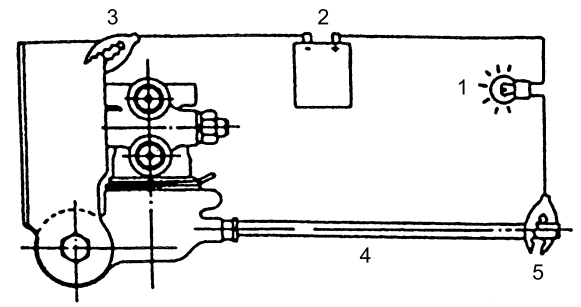
Load-Sensing Proportioning Valve (LSPV) Adjustment

This adjustment should be performed with the battery voltage applied to the valve.

1. Adjust the specified rear axle weight by loading the rear body as necessary.

Model	GVWR (lb)	Wheel Base (in)	Rear Axle Weight kg (lb)
NPR	12,000	109	1200 (2,650)
		132.5	1000 (2,210)
		150	900 (1,990)
		176	900 (1,990)
NPR-HD	14,500	109	1500 (3,310)
		132.5	1400 (3,090)
		150	1300 (2,870)
		176	1300 (2,870)
NQR NRR (NQR-HD)	17,950 or 19,500	109	1400 (3,090)
		132.5	1300 (2,870)
		150	1150 (2,540)
		176	1150 (2,540)

2. Connect the wiring with miniature lamp and a battery between valve bracket and linkage with each end of wiring clipped. This wiring is necessary to find the moment at which piston within the valve assembly is brought into connect with the linkage.



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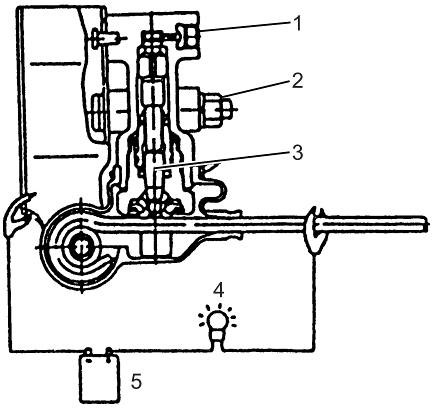
Legend

1. Miniature Lamp
2. Battery
3. Valve Bracket
4. Linkage

Notice:
As the linkage is coated with insulation material, turn the clip with 2 or 3 turns to break insulation.

3. Loosen the nut and raise the valve assembly all the way. Then lower the valve assembly gradually and tighten the nut when miniature lamp turns on. If the miniature lamp goes out as the nut is tightened, lower the valve assembly slightly with the nut loosened, then retighten the nut.



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Legend

1. Valve Assembly
2. Nut
3. Piston
4. Miniature Lamp
5. Battery

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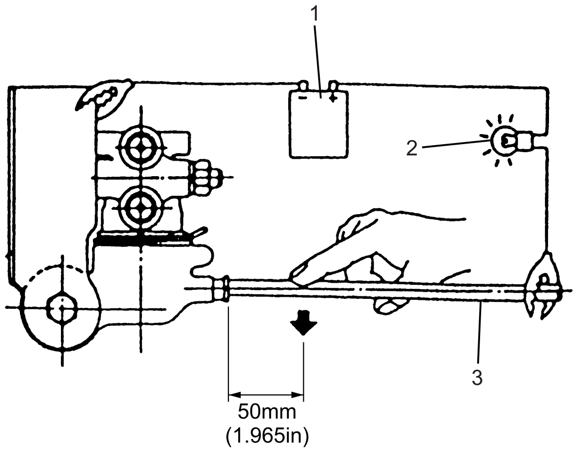
4. Depress the linkage near the valve assembly slightly downward with finger (test pressure: 4.9-7.8 N (1.1-1.7 lb)) and check to see if the miniature lamp goes out.
   Lamp goes out: OK Adjustment is completed.
   Lamp remains on: NG
   Repeat adjustment operation outlined under paragraph 3.
   Excessive force is exerted on linkage by piston within the valve assembly.



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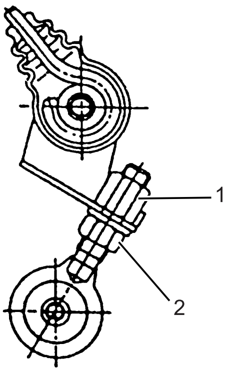
Legend

1. Battery
2. Miniature Lamp
3. Linkage

Notice:
Adjustment can also be made by means of nuts (1) and (2) on shackle at rear axle case side. However, shackle nut is not normally used for adjustment as it is for making fine adjustment.



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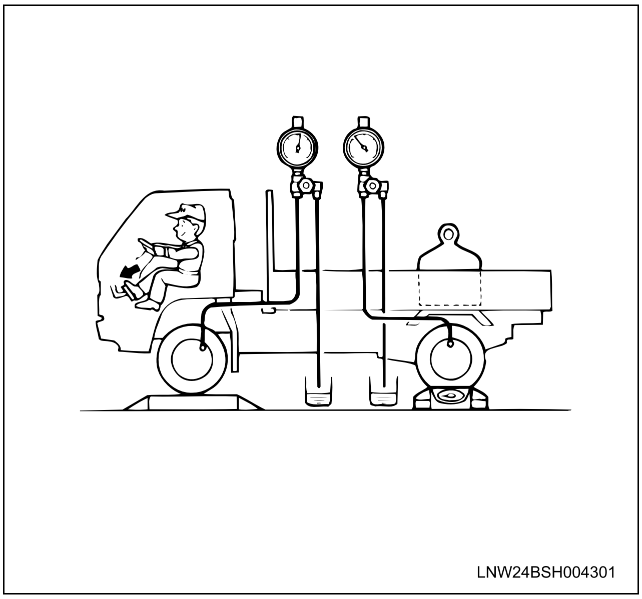
5. Inspection of brake fluid pressure (Reference value)
   a. Adjust the rear axle weight as specified under the paragraph 1.
   b. Install the pressure gauge on bleeder screws on the front and rear brakes.
   c. Depress the brake pedal and take reading of the pressure gauges. The brake fluid pressure is normal if the pressure of fluid within the rear wheel cylinders is within the range of 5,030±590 kPa (730±85 psi) when pressure of fluid within the front wheel cylinders reaches 7,850 kPa (1,138 psi).

Important:
The brake pedal should be depressed gradually until specified pressure is reached without pumping or adjusting foot pressure.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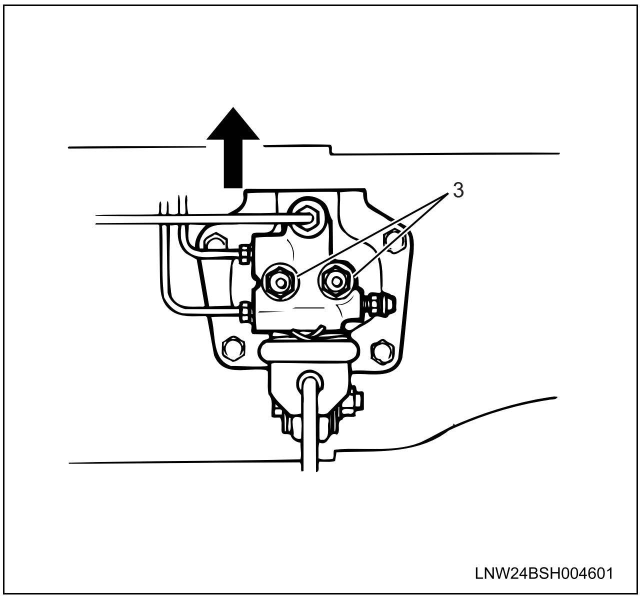
Load-Sensing Proportioning Valve (LSPV) Inspection

1. Loosen the LSPV adjust nut (3). And then lift the LSPV up fully and tighten it up tentatively so that the LSPV spring will not move.

Tighten

- Adjust nut to 13 N·m (113 lb in)



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2. Under the same conditions as 1) above, check the rear wheel cylinder fluid pressure.

Standard	
Master cylinder fluid pressure kPa (psi)	Rear fluid pressure kPa (psi)
2,940 (427)	1,500 – 1,900 (218 – 274)
7,850 (1,138)	2,580 – 3,260 (374 – 474)

Brake Lines

Brake system units are interconnected by flexible hose and special steel tubing. Flexible hose is used between the cab and frame connections, between the frame and front wheel cylinders and between the frame and rear axle brake line.
When the hydraulic lines have been disconnected for any reason, the brake system must be bled, after connecting the lines. Refer to "Bleeding Brakes" in this section.

Caution:
Never use copper tubing for hydraulic brake lines because copper is subject to fatigue, cracking, and corrosion which could result in brake failure.

Flexible Hose

At the front wheel brakes, the hose is threaded into a frame junction and a banjo-type fitting is used at the wheel cylinder elbow. The banjo end and the frame end must be indexed properly to be installed. The line at the rear axle is similar in installation.
Use new copper gaskets at the banjo ends at installation.

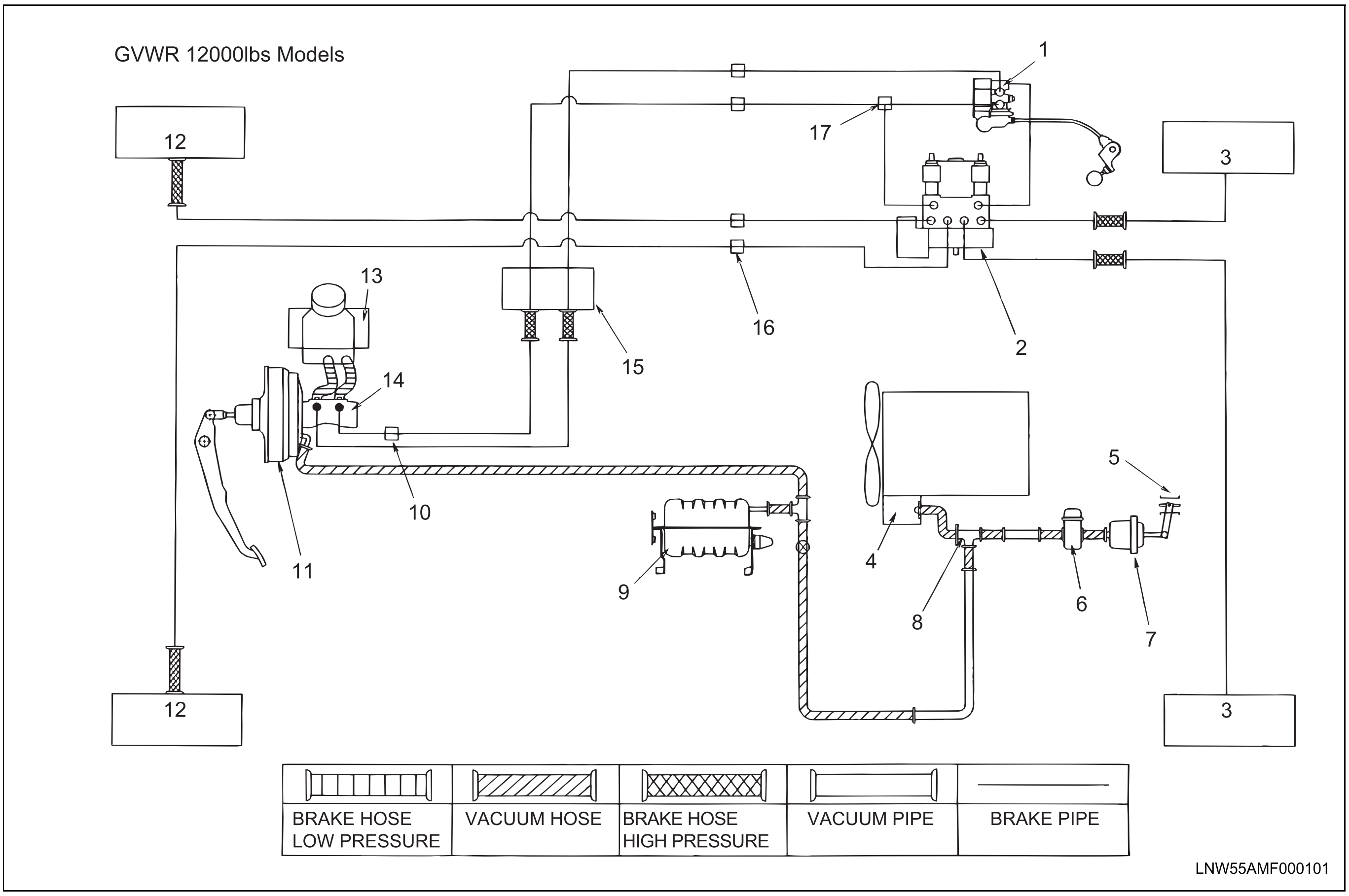
Removal Procedure

1. Remove the union nut.
2. Remove the frame nut.
3. Disconnect the hose end from the frame bracket.
4. Remove the special eye bolt at the banjo end.

Installation Procedure

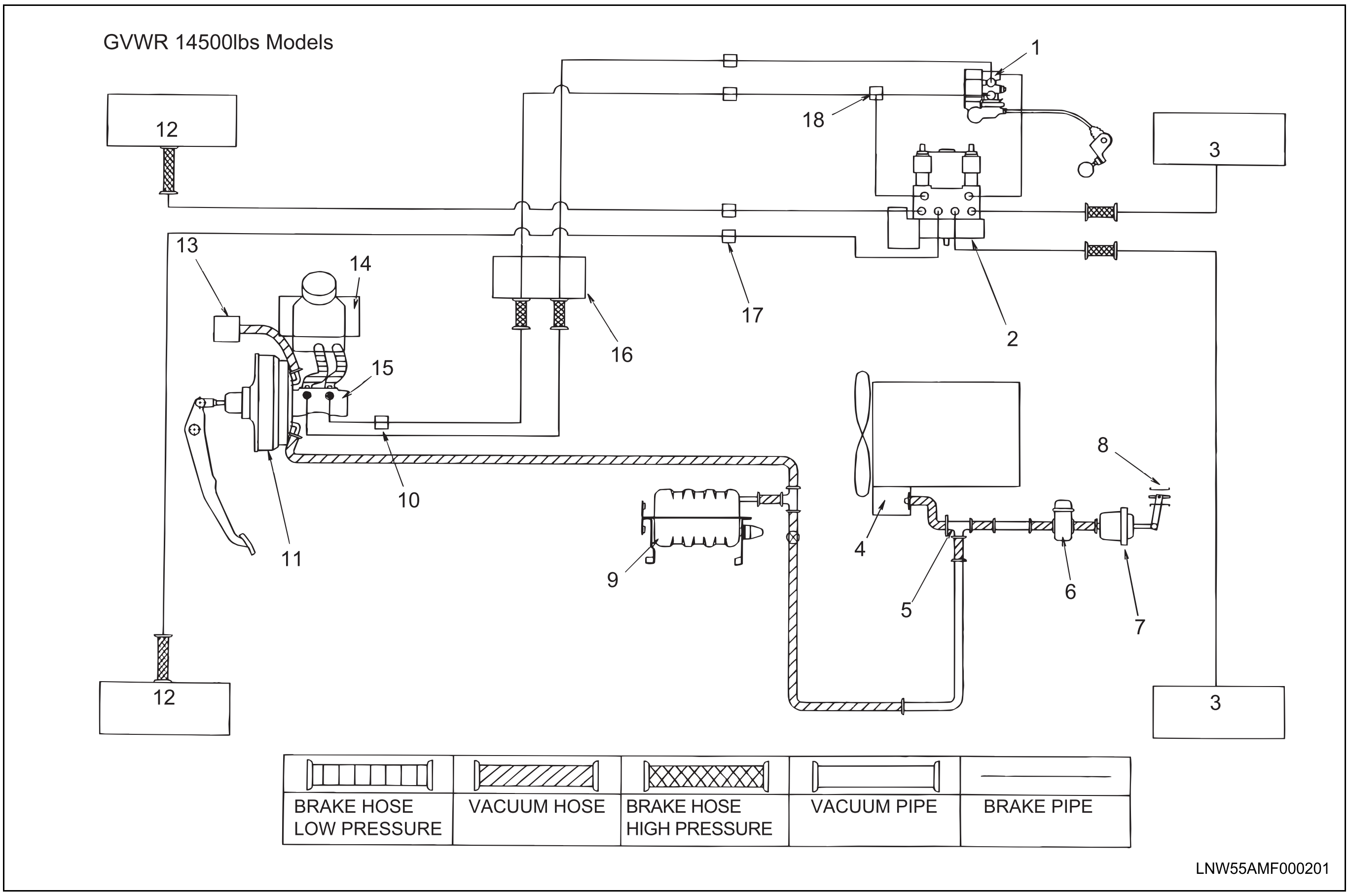
1. Install the special eye bolt at banjo end.
2. Connect the hose end to frame bracket.
3. Install the frame nut.

4. Install the union nut.



Legend

1. Load Sensing Proportioning Valve (LSPV)
2. Electronic Hydraulic Control Unit (EHCU)
3. Rear Wheel Cylinder
4. Vacuum Pump
5. Exhaust Brake Valve
6. Power Chamber
7. Magnetic Valve
8. 3-Way Connector
9. Vacuum Tank
10. Metering Valve
11. Vacuum Booster (Servo Unit)
12. Front Wheel Cylinder
13. Brake Fluid Reservoir
14. Master Cylinder
15. 4-Way Connector
16. 2-Way Connector
17. 3-Way Connector



Legend

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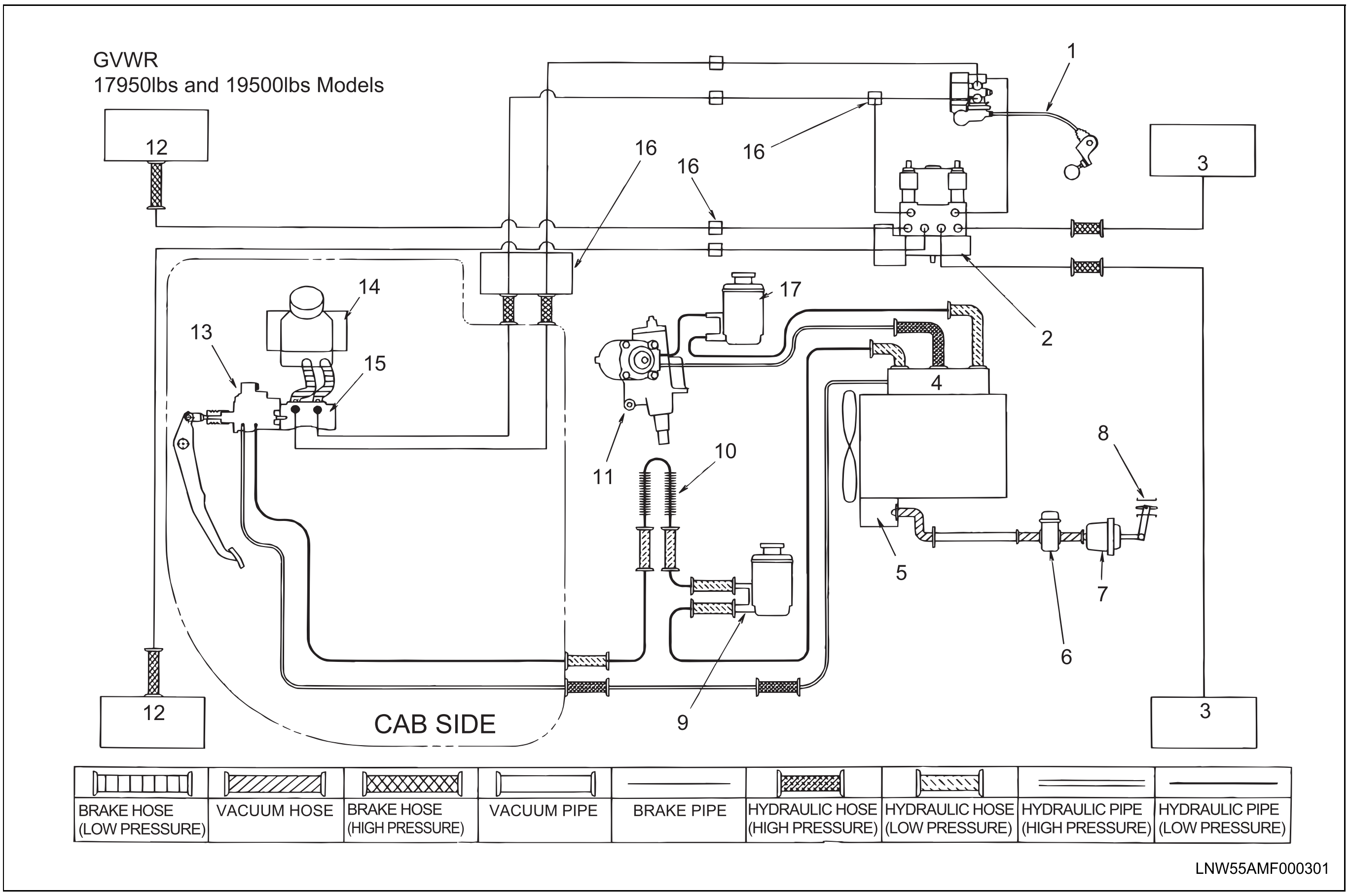
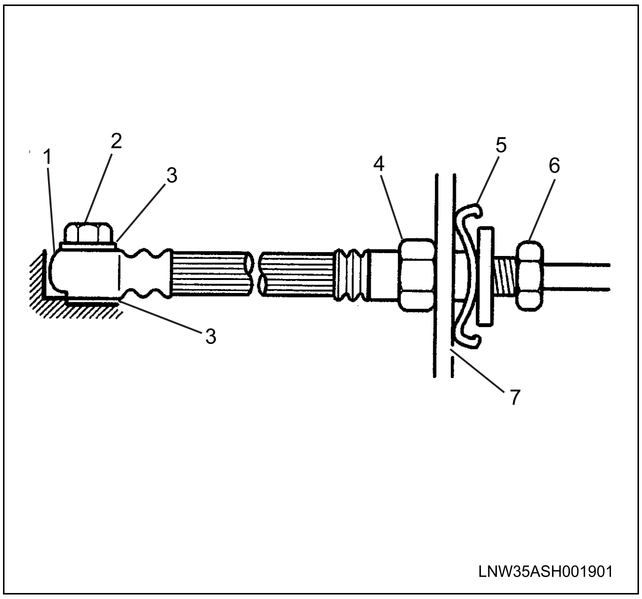
9. Vacuum Tank
10. Metering Valve
11. Vacuum Booster (Servo Unit)
12. Front Wheel Cylinder
13. Elec. Pump
14. Brake Fluid Reservoir
15. Master Cylinder
16. 4-Way Connector
17. 2-Way Connector
18. 3-Way Connector



Legend

1. Load Sensing Proportioning Valve (LSPV)
2. Electronic Hydraulic Control Unit (EHCU)
3. Rear Wheel Cylinder
4. Hydraulic Booster Oil Pump
5. Vacuum Pump
6. Magnetic Valve
7. Power Chamber
8. Exhaust Brake Valve
9. Hydraulic Booster Reservoir
10. Cooler Pipe
11. Power Steering Unit
12. Front Wheel Cylinder
13. Hydraulic Booster Unit
14. Brake Fluid Reservoir
15. Master Cylinder
16. Pipe Connector
17. Power Steering Reservoir



Legend

1. Banjo End
2. Special Eye Bolt
3. Copper Gasket
4. Fitting
5. Clip
6. Union Nut
7. Frame Bracket

Brake Hose Inspection

The flexible hydraulic brake hose should be inspected at least twice a year. The brake hose assembly should be checked for road hazard damage, for cracks and chafing of the outer cover, and for leaks and blisters. A light and mirror may be needed for adequate inspection. If any of the above conditions are observed on the brake hose, it will be necessary to replace it.

Metal Tubing

When necessary to replace metal brake line, always use special metal tubing which is designed to withstand high pressure and to resist corrosion. Ordinary copper tubing is not satisfactory for use as hydraulic brake lines. When replacing tubing, always use the same size as that removed.
Refer to the parts book for preformed lines and bulk brake line.

Caution:
Never use copper tubing for hydraulic brake lines because copper is subject to fatigue, cracking, and corrosion which could result in brake failure.

Brake lines must have a minimum of 6 mm (1/4 in) clearance between lines.

Tube Flaring

In order to ensure a proper flare, a special flaring tool must be used. When using the tool, instructions furnished by the tool manufacturer should always be followed. Always inspect newly formed flares for cracks or malfunctions which might cause leaks.
Double Lap Flaring Kit J 23530 with Tube Cutter J 23533-01 and Metric Adapter J 34912 provides all the necessary components to double lap flare hydraulic brake line. After flaring, blow out the brake lines with compressed air before installing on vehicle.

Notice:
Double lap flaring tool must be used, as single flaring tools cannot produce a flare strong enough to hold the necessary pressure.

Replacement

1. Clean dirt, grease, and other foreign material off the line fittings at both ends.
2. Procure the recommended steel tubing and fitting nuts to the correct size. (Outside diameter of the tubing is used to specify size.)
3. Cut the tubing to length. Correct length may be determined by measuring the old pipe using a cord and adding 3 mm (1/8 in) for each double flare.
4. Install the fitting before starting second flare.
5. Bend the tubing to match the old pipe using a tubing bender. A recommended clearance of 19 mm (3/4 in) should be maintained to all moving or vibrating parts when installed.

Brake Line Supporting Components

It is important that all brake line supports, clips, retainers, grommets, junctions, and supporting brackets be maintained to prevent unnecessary vibrations and eventual loosening or separation of the connections. Clamps are used on the same hoses at the connections with metal lines and components. All clamps and brackets (when used) must be in place and tightened securely in position. Check for missing or deteriorated grommets or loom material. Replace as necessary. Bent, damaged, or missing components should be repaired or replaced.

Vacuum Pump (for GVWR 14,500 lb Model)

1. Turn the starter switch to “ON” position (not to start the engine), and depress the brake pedal several times.
2. Check the vacuum pump operation at the same time as vacuum warning buzzer sounds.
   - Refer to CAB AND CHASSIS ELECTRICAL in this manual.

Brake Line Supporting Components

It is important that all brake line supports, clips, retainers, grommets, junctions, and supporting brackets be maintained to prevent unnecessary vibrations and eventual loosening or separation of the connections. Clamps are used on the same hoses at the connections with metal lines and components. All clamps and brackets (when used) must be in place and tightened securely in position. Check for missing or deteriorated grommets or loom material. Replace as necessary. Bent, damaged, or missing components should be repaired or replaced.

Brake Fluid Reservoir

Removal Procedure

Important:

- Use only DOT 3 brake fluid in this reservoir. Refer to Maintenance and Lubrication in this manual for hydraulic brake fluid recommendations. Refer to "Bleeding Brakes" previously in this section for bleeding the hydraulic brake system.
- Block the vehicle wheels and apply the parking brake.
- Disconnect the battery ground cable.
- Lift up the access cover to the combination brake fluid/clutch fluid reservoir.

1. Attaching bolts.
2. Hose clamps and hoses.
3. Electrical connector.
4. Reservoir assembly.

Disassemble

- Cap.
- Filter holder.
- Filter.
- Baffle.
- Dust cover.

Inspection

- Filter.
- Reservoir tank.
  — If the tank is damaged or the electrical switch is not operating, the assembly must be replaced.

Reassemble

- Dust cover.
- Baffle.
- Filter.
- Filter holder.
- Cap.

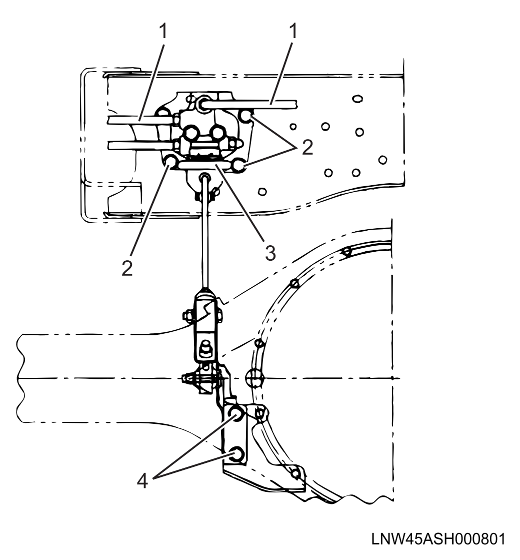
Installation Procedure

1. Clamp hose bands to reservoir.
2. Electrical connector.
3. Retaining bolts.
4. Battery ground cable.
5. Fill the reservoir. Note the warning on the reservoir cap. Fill to MAX on the tank.

Inspection

- Run the engine and bleed the brakes.
- Check for leaks.
- Remove the wheel blocks and check brake application.

Load-sensing Proportioning Valve (LSPV)



Legend

1. Brake Pipe
2. Bolt
3. LSPV Assembly
4. Bolt

Removal Procedure

1. Brake pipe.
2. Bolt (2).
3. Bolt (4).
4. LSPV assembly.

Installation Procedure

Notice:
For steps 2, 3, and 4, refer to Description and Operation.

1. Install the LSPV assembly.
2. Bolt (2).

Tighten

- Bolt to 20 N·m (14 lb ft)

3. Bolt (4).

Tighten

- Bolt to 20 N·m (14 lb ft)

4. Brake pipe.

Tighten

- Brake pipe to 15 N·m (11 lb ft)

Adjust

- LSPV Refer to "Load-Sensing Proportioning Valve Adjustment" in this section.

Master Cylinder

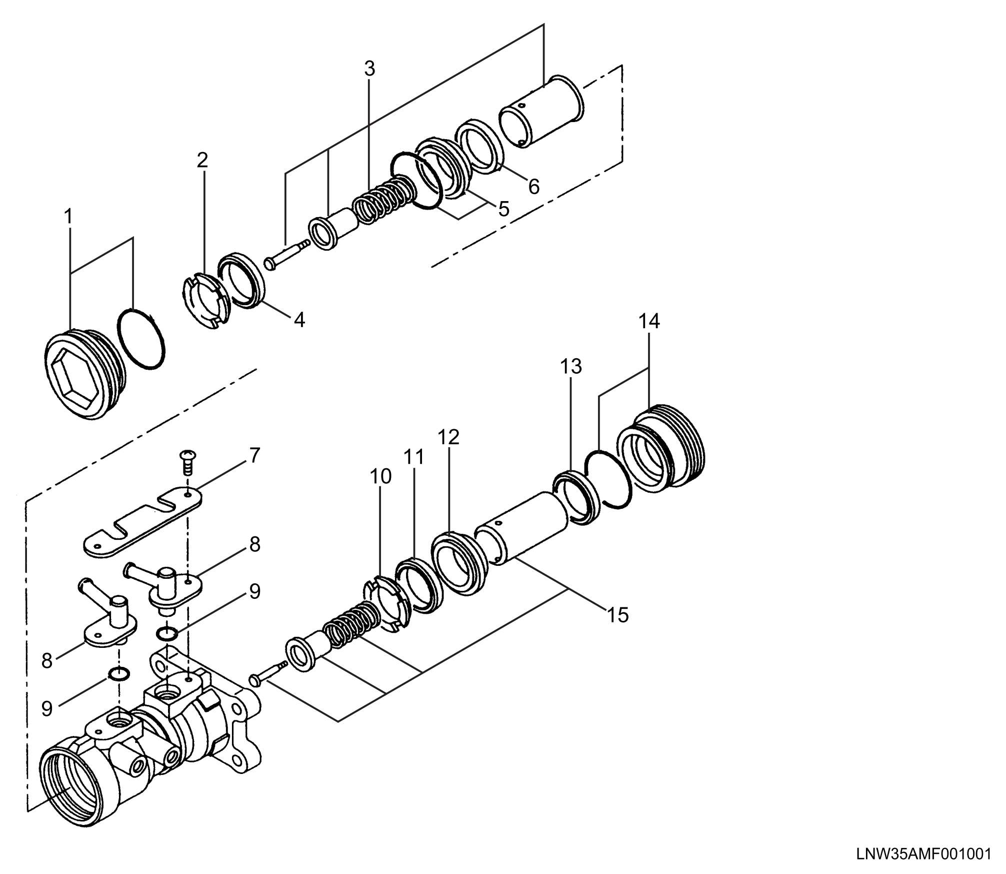
Removal Procedure

Tool Required:
J 41431 Brake Master Cylinder Support Plate or Equivalent
J 41432, CH47691 Brake Master Cylinder Wrench or Equivalent

1. Meter cluster and switch connectors. Refer to Instrument Panel section in this manual.
2. Brake hoses and brake pipes.

Notice:
If brake fluid spillage occurs, wipe it up immediately.

3. Nuts mounting cylinder body to servo.
4. Holder plate.
5. Hose joint.
6. O-ring.
7. Primary piston assembly.
    - Pull out the piston by hand so that it may not be damaged.
8. Plug and O-ring.
    - Install master cylinder on J 41431 support plate or equivalent, fix the support plate in a vice, and loosen plug using J 41432 (Master Cylinder Inside dia. 31.7mm), CH47691 (Master Cylinder Inside dia. 34.9mm) wrench or equivalent.
9. Secondary cup.
10. Bushing.
11. Primary cup.
12. Supporter.
13. Plug and O-ring.
    - Install master cylinder on J 41431 support plate or equivalent, fix the support plate in a vice, and loosen plug using J 41432 (Master Cylinder Inside dia. 31.7mm), CH47691 (Master Cylinder Inside dia. 34.9mm) wrench or equivalent.
14. Supporter.
15. Secondary piston assembly.
16. Primary cup.
17. Bushing.
18. Secondary cup.



Legend

1. Plug and O-ring
2. Supporter
3. Secondary Piston Assembly
4. Primary Cup
5. Bushing and O-ring
6. Secondary Cup
7. Holder Plate
8. Hose Joint
9. O- ring
10. Supporter

11. Primary Cup
12. Bushing
13. Secondary Cup
14. Plug and O-ring
15. Primary piston Assembly

Inspection

- All parts for wear, distortion or other conditions and replace as needed.
- Return port for clogging. If necessary, clean the port with a wire tag and blow away foreign matter with compressed air.

Installation Procedure

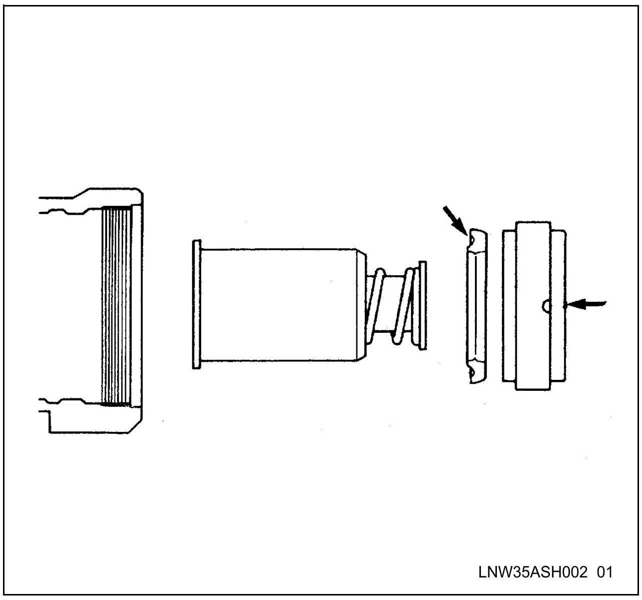
Notice:

For steps 9 and 10 see NOTICE on page 5A-2 of this section.

Important:

- Prior to installing the primary and secondary pistons, lubricate the piston cups with clean brake fluid. When installing the parts, take care not to cause damage to the lipped portion of the piston cup.

1. Secondary cup and bushing to secondary piston assembly.
   - Combine secondary cup and bushing with secondary piston as indicated by allows, and push the assembly in until bushing comes into contact with cylinder body step.



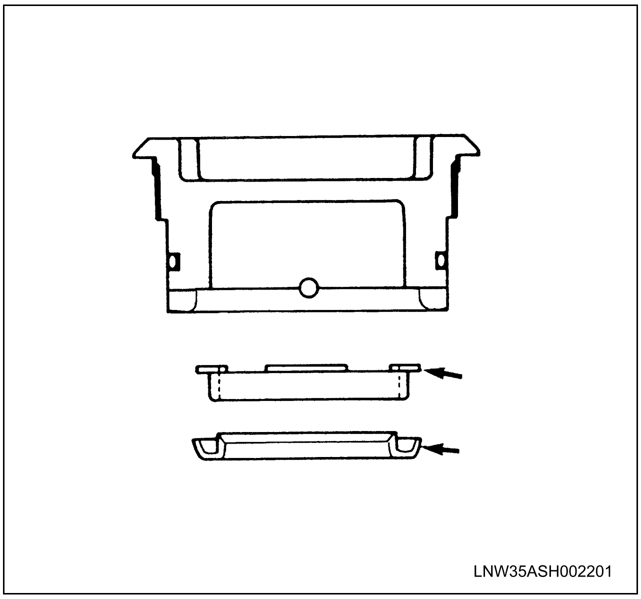
2. Primary cup, supporter, plug and O-ring.
   - Combine primary cup and supporter with plug as indicated by allows.
   - Install master cylinder body on J 41431 support plate or equivalent, fix in a vice, and tighten plug to specified torque using J 41432 (Master Cylinder Inside dia. 31.7mm), CH47691 (Master Cylinder Inside dia. 34.9mm) wrench or equivalent.

Tighten

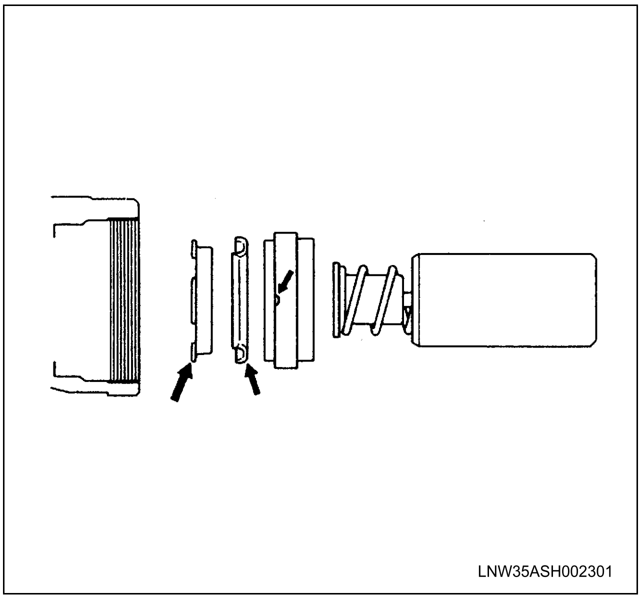
- Master Cylinder Inside dia. 31.7mm; Plug to 44 N·m (33 lb ft).
- Master Cylinder Inside dia. 34.9mm; plug to 49N·m (37 lb ft)

Notice:

If plug tightened to specified torque is found floating from cylinder body, plug should be disassembled again and checked for abnormal parts fitting. Then reassemble.



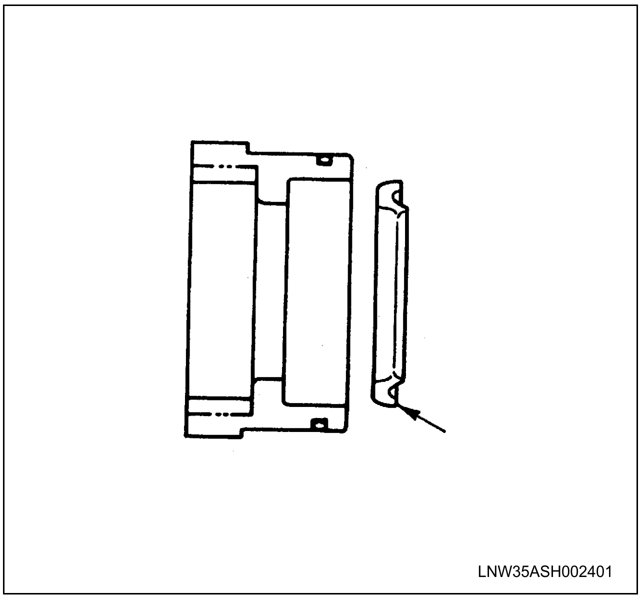
3. Supporter, primary cup and bushing to primary piston assembly.
   - Combined the parts of primary piston as indicated by allows. Then push the assembly in until bushing comes into contact with the step in cylinder body.
   - Pull out primary piston alone taking care not to be let bushing get out of the step.



4. Secondary cup, plug and O-ring.
   - Combine secondary cup with plug as indicated by allow.
   - Install master cylinder body on J 41431 support plate or equivalent, fix in a vice, and tighten plug to specified torque using J 41432 (Master Cylinder Inside dia. 31.7mm) or CH47691 (Master Cylinder Inside dia. 34.9mm) wrench or equivalent.

Tighten

- Master Cylinder Inside dia. 31.7mm; Plug to 44 N·m (33 lb ft).
- Master Cylinder Inside dia. 34.9mm; Plug to 49N·m (37 lb ft)



5. Primary piston assembly.
6. O-ring.
7. Hose joint.
8. Holder plate.
9. Master cylinder assembly to servo.

Tighten

- Nuts to 14 N·m (122 lb in).

10. Brake pipes and hoses.
11. Meter cluster and switch connectors. Refer to Instrument Panel section in this manual.
12. Bleed the brake system. Refer to Breeding Brakes.

Brake Pressure Metering Valve (GVWR 12,000 lb or 14,500 lb Models)

After the preceding measures have been installed on the vehicle and a reasonable service life cannot be achieved, there is a brake pressure metering valve available. The brake pressure metering valve momentarily delays load on front brakes to distribute brake load for improved service life. The metering valve is relatively simple to install and has shown improved disc brake life in severe applications.

Removal Procedure

1. Remove the brake pipe assembly.
2. Remove the brake pipe from metering valve.
3. Remove the bolt.
4. Remove the metering valve.

Installation Procedure

1. Install the metering valve.
2. Install the Bolt.

Tighten

- Metering valve to 9 N·m (78 lb in)

3. Install the brake pipe.

Tighten

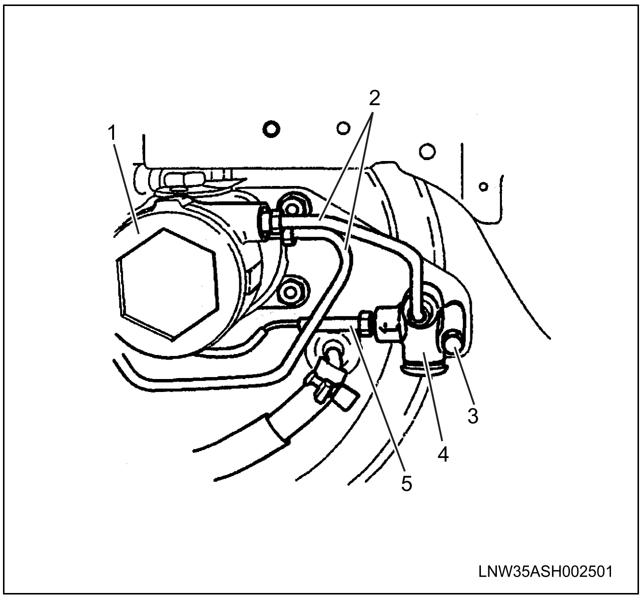
- Brake pipe to 15 N·m (11 lb ft)

4. Install the brake pipe assembly.

Tighten

- Brake pipe to 15 N·m (11 lb ft)

5. Bleed the system.
   - The brake system must be bled, after connecting the lines. Refer to Bleeding Brakes previously in this section.



Legend

1. Master Cylinder
2. Brake Pipe Assembly
3. Bolt
4. Metering Valve
5. Brake Pipe

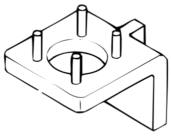
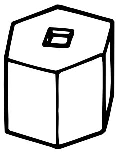
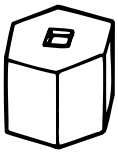
Specifications

Fastener Torques

LSPV Nut	13 N·m (113 lb in)
LSPV Shackle Bracket Bolt	20 N·m (14 lb ft)
LSPV Bracket Bolt	20 N·m (14 lb ft)
Brake Pipe to LSPV	15 N·m (11 lb ft)
Master Cylinder Plug (Master Cylinder Inside dia. 31.7mm)	44 N·m (33 lb ft)
Master Cylinder Plug (Master Cylinder Inside dia. 34.9mm)	49 N·m (37 lb ft)
Master Cylinder Nut	14 N·m (122 lb in)
Reservoir Hose Clamp Bolt	3 N·m (26 lb in)
Brake Pipe	15 N·m (11 lb ft)
Metering Valve Bolt	9 N·m (78 lb in)

Special Tools

Special Tools

Illustration	Tool Number/ Description
 5884023710	J 41431 Master Cylinder Support Plate
 5884023690	J 41432 Master Cylinder Wrench
 CH47691	CH47691 Master Cylinder Wrench

BRAKES

Vacuum Booster Brake System

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  Specifications 5A1-7
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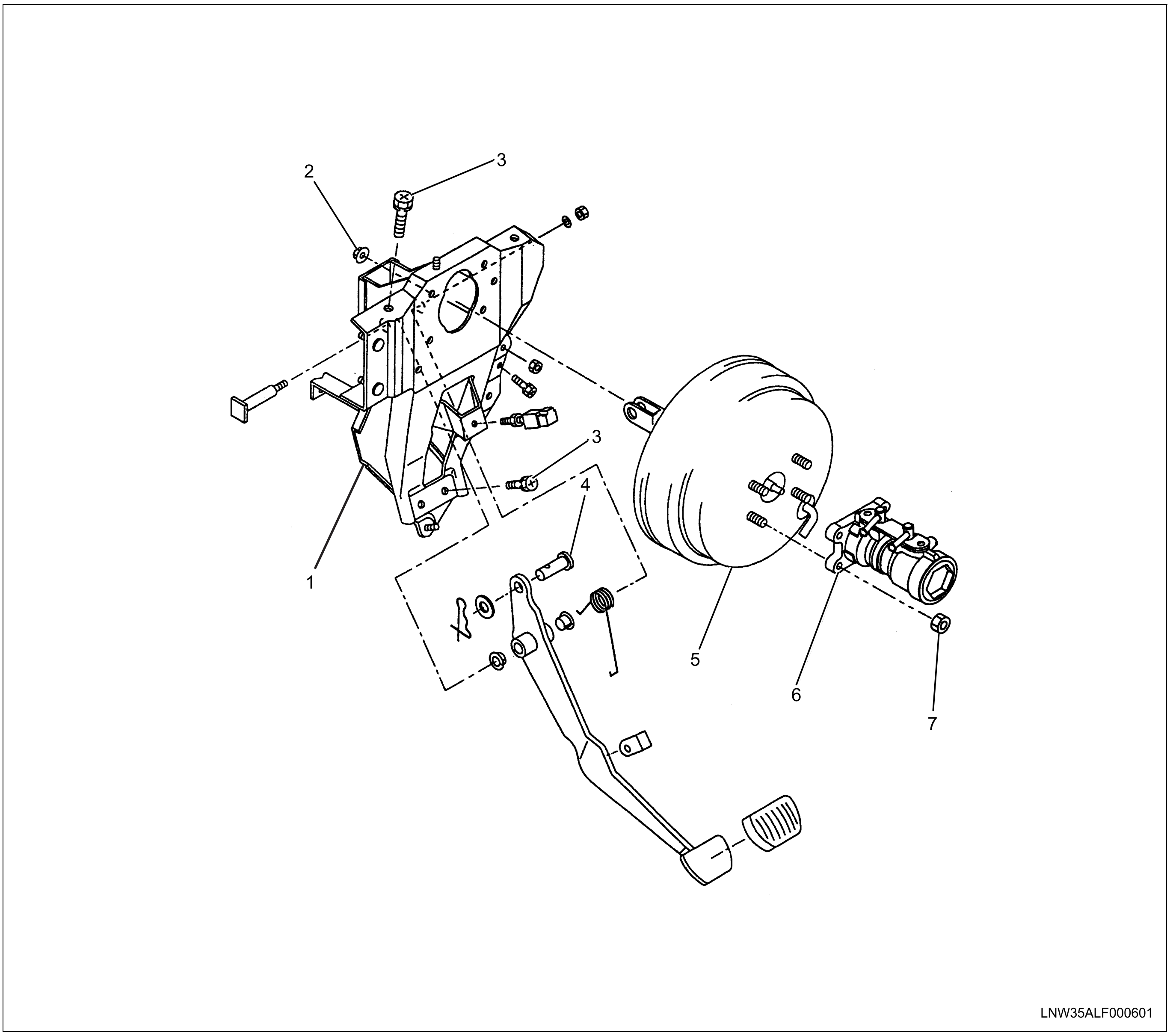
Description and Operation

Vacuum Booster Brake System

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Repair Instructions

Vacuum Booster (SERVO) Replacement



Legend

1. Brake Pedal Bracket
2. Servo Unit Mounting Nut
3. Bracket Mounting Bolt
4. Clevis Pin
5. Servo Unit
6. Master Cylinder
7. Master Cylinder Mounting Nut

Removal Procedure

- Block the vehicle wheels and apply the parking brake.
- Battery ground cable.

1. Steering wheel. Refer to Steering Wheel Replacement.
2. Remove steering column tilt control bolt. Refer to Steering Column Replacement.
3. Instrument panel assembly and ventilation duct Refer to Instrument Panel.
4. Master cylinder hydraulic lines at master cylinder.
5. Vacuum hose at servo unit.
6. Brake pedal assembly with master cylinder and servo unit.
7. Clevis pin.
8. Four servo unit mounting nuts at pedal bracket.
9. Master cylinder with servo unit.
10. Four nuts retaining master cylinder to servo unit.

Inspection

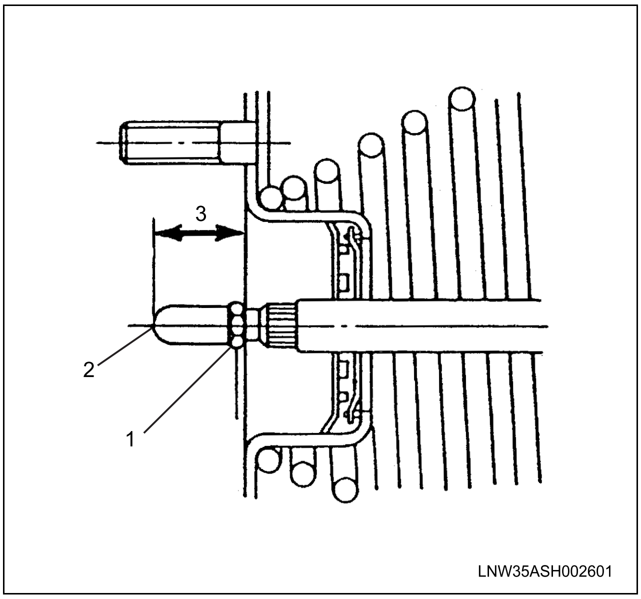
Servo unit cannot be over hauled. If it is found faulty, replace its assembly with a new one.

Push Rod Length Adjustment

- Apply 500 mmHg (19.7 inHg) of negative pressure to the servo unit.
- Use a scale to measure the push rod length (push to flange face clearance).
  Push Rod Length to 18.2 mm (0.717 in).
- If the push rod length is not equal to the specification, it must be adjusted.
  - Loosen the lock nut.
  - Turn the screw bolt in the appropriate direction to adjust the push rod length.
  - Tighten the lock nut.

Tighten

- Lock nut to 14 N·m (122 lb in).



Legend

1. Lock Nut
2. Screw Bolt
3. Push Rod Length

Installation Procedure

Notice:
For Steps 2, 3, 5 and 9, see NOTICE on page 5A1-2 of this section.

1. Servo unit.
2. Master cylinder assembly.

Tighten

- Nuts to 14 N·m (122 lb in).

3. Four servo unit mounting nuts to pedal bracket.

Tighten

- Nuts to 14 N·m (122 lb in)

4. Connect servo unit clevis to brake pedal, and install clevis pin.
5. Brake pedal assembly with master cylinder and servo unit.

Tighten

- Bolts to 42 N·m (32 lb ft).

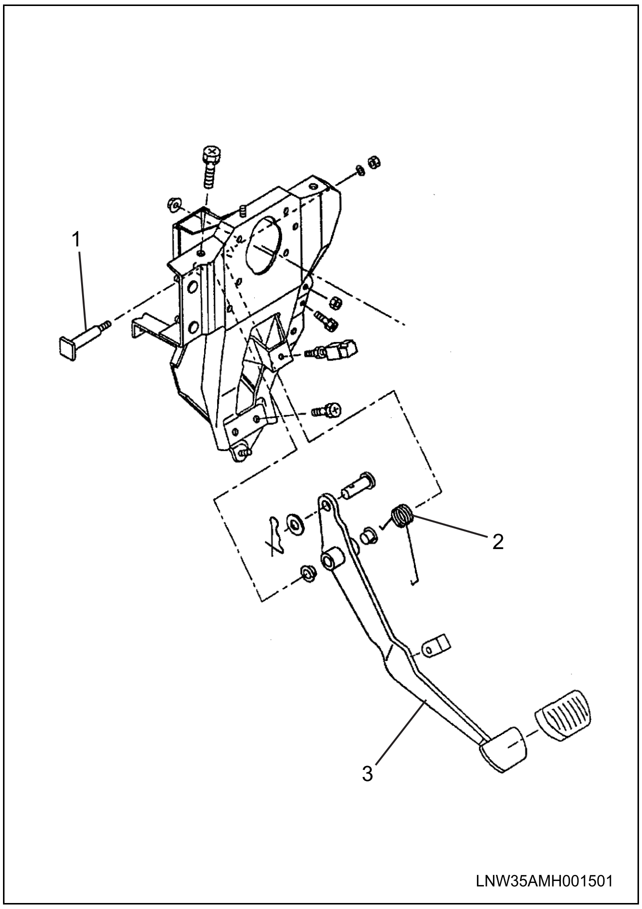
6. Vacuum hose at servo unit.
7. Master cylinder hydraulic lines at master cylinder.
8. Instrument panel assembly and ventilation duct. Refer to Instrument Panel.
9. Steering column lock control bolt. Refer to Steering Column in this manual.

Tighten

- Lower nut to 14 N·m (122 lb in).
- Upper nut to 16 N·m (12 lb ft).
- Lock lever bolt to 54 N·m (40 lb ft).

10. Battery ground cable.
11. Bleed the system.
12. Release the parking brake and remove the wheel blocks.

Brake Pedal



Legend

1. Pedal Shaft
2. Return Spring
3. Brake Pedal

Removal Procedure

- Block the vehicle wheels and apply the parking brake.
- Battery ground cable.

1. Brake pedal bracket with master cylinder and servo. Refer to Hydraulic Booster (SERVO) Replacement of this section.
2. Clevis pin.
3. Servo with master cylinder.
4. Return spring.
5. Pedal shaft from brake pedal assembly.
6. Brake Pedal.

Inspection

- Bushings, return spring and bolt for wear or damage.
- Replace all parts found defective.

Installation Procedure

1. Pedal shaft to brake pedal assembly.

Notice:
Refer to Description and Operation.

2. Return spring.
3. Servo with master cylinder.

Tighten

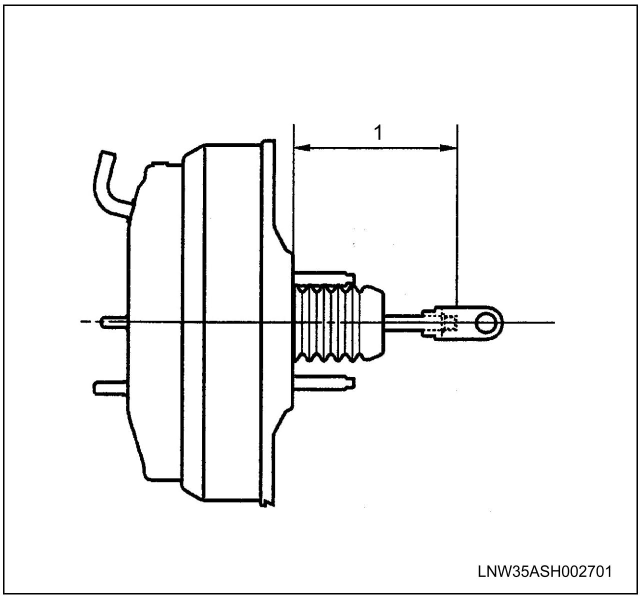
- Nut to 14 N·m (122 lb in).

4. Clevis pin.
5. Battery ground cable.
6. Bleed the system.
7. Release the parking brake and remove the wheel blocks.

Brake Pedal Adjustment

Notice:
For steps 4 and 5 seen NOTICE on page 5A1-2 of this section.

1. Loosen the jam nut at the stop lamp switch.
2. Loosen the jam nut on the vacuum servo push rod.
3. Turn the push rod until the distance from the center of clevis pin hole to mounting surface of the brake pedal bracket should be set at 109±1 mm (4.29±0.04 in).
   When fixed under this condition, there is no need to adjust the brake pedal height and free play.



Legend

1. 109±1 mm (4.29±0.04 in)

4. Tighten the push rod jam nut.

Tighten

- Jam nut to 20 N·m (14 lb ft)

5. Stop lamp switch so that the end of the switch threaded portion contacts the brake pedal, then back-off the switch 1/2 turn.

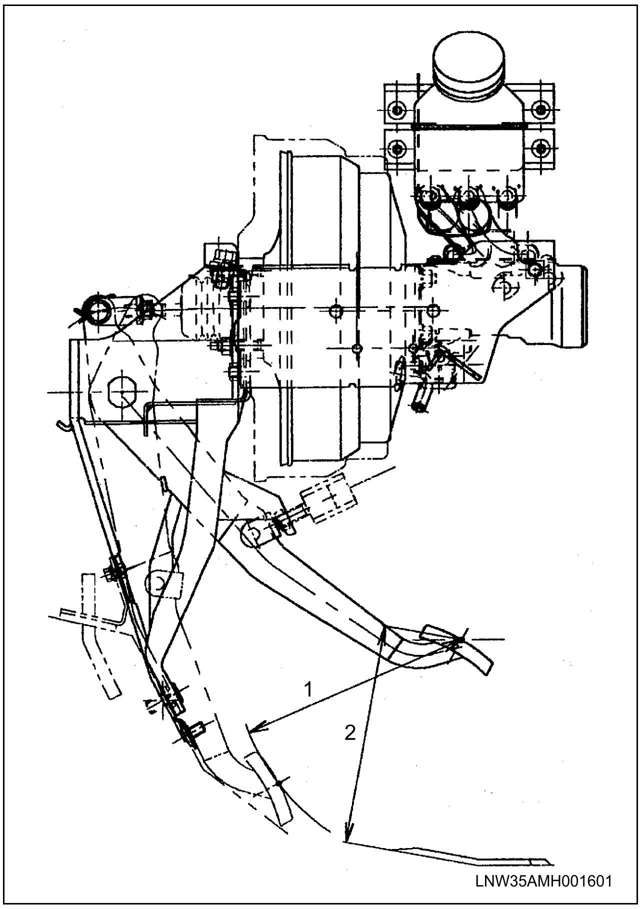
Tighten

- Stop lamp switch lock nut to 20 N·m (14 lb ft)

6. Check brake pedal operation to be sure it's operating properly.

Measurement

- Turn the engine off. Robustly pump the brake pedal 10 times until the vacuum pressure falls to zero.
  Measure the free play.
  Brake pedal normal play is between 4–7 mm (0.16–0.27 in) (reference).
- Pressing the brake pedal with a force of 490N (110 lb) with the engine on, the clearance between the brake pedal and floor panel is more than 40 mm (1.6 in)
- Brake pedal height (2) is 167 mm (6.58 in) (reference).
- Brake pedal travel (1) is between 180±5 mm (7.09±0.2 in) (reference).



Legend

1. Pedal Travel (Reference) 180±5 mm (7.09±0.2 in)
2. Pedal Height (Reference) 167 mm (6.58 in)

Specifications

Specifications

Servo unit Type	Tandem
Servo unit Diaphragm Diameter (GVWR 12,000 and 14,500 lb models)	230 mm + 254 mm (9 in + 10 in)
Push Rod Length	18.2 mm (0.71 in)

Fastener Torques

Master Cylinder Mounting Nuts	14 N·m (122 lb in)
Servo unit Mounting Nuts	14 N·m (122 lb in)
Brake Pedal Bracket Mounting Bolts	42 N·m (32 lb ft)
Push Rod Lock Nut	14 N·m (122 lb in)
Support Bracket Lower Nuts	14 N·m (122 lb in)
Column Lock Lever Nut	16 N·m (12 lb ft)
Column Lock Lever Bolt	54 N·m (40 lb ft)
Push Rod Jam Nut	20 N·m (14 lb ft)
Stop Lamp Switch Lock Nut	20 N·m (14 lb ft)

BRAKES

Hydraulic Booster Brake System

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Description and Operation

Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Booster Assembly Description

The hydraulic booster is a device that applies force to the master cylinder when the brake pedal is applied. The fluid flowing through the booster head is controlled by brake pedal movement.

Fluid from the hydraulic brake booster and power steering pump enters the booster at the inlet port, flows through the control valve and seat, leaves through the outlet port and flow switch, and returns to the hydraulic brake booster pump.

The hydraulic booster cylinder rod attaches to a piston that connects with the spool valve. This assembly moves when brake pedal pressure is applied. The spool valve restricts fluid flow and builds pressure on one side of the piston. The pressure overcomes the return spring and moves the piston to a balanced position. As the piston moves, it pushes the cylinder rod and applies pressure to the master cylinder.

A relief valve inside the pump limits the pressure to 11,770 kPa (1670 psi). This pressure level provides good braking without damaging the brake pipes or hoses. When actuated, the relief valve allows fluid to bypass the piston.

Fluid and Fluid Handling Description

This system uses no special fluids. However, care must be taken to use the correct fluids. The master cylinder and brake system uses brake fluid, while the hydraulic brake booster pump uses power steering fluid.

SUBSTANDARD OR CONTAMINATED FLUID

Notice:
Hydraulic brake systems use two distinct and incompatible fluids. Power steering fluid is used in the hydraulic booster brake system. Brake fluid is used in the master cylinder and brake pipes to the wheels. Be extremely careful when selecting brake system fluids or seal damage can result. Refer to SECTION 0B to select the correct fluid.

Notice:
Do not reuse brake system fluids. Do not mix power steering fluid with brake fluid. Swelling and deterioration of rubber parts can result from fluid contamination. This can lead to reduced brake performance and the eventual loss of braking capability.

Contaminated fluid causes swelling and deterioration of rubber parts that can lead to reduced brake performance and the eventual loss of braking capability. Check the condition of the fluid at regular intervals and note any unusual consistency, color, and signs of contaminants in the fluid. Do not reuse brake system fluids. Always discard used fluids. Do not mix power steering fluid with hydraulic brake fluid. If contamination occurs, flush the hydraulic booster system with clean power steering fluid.

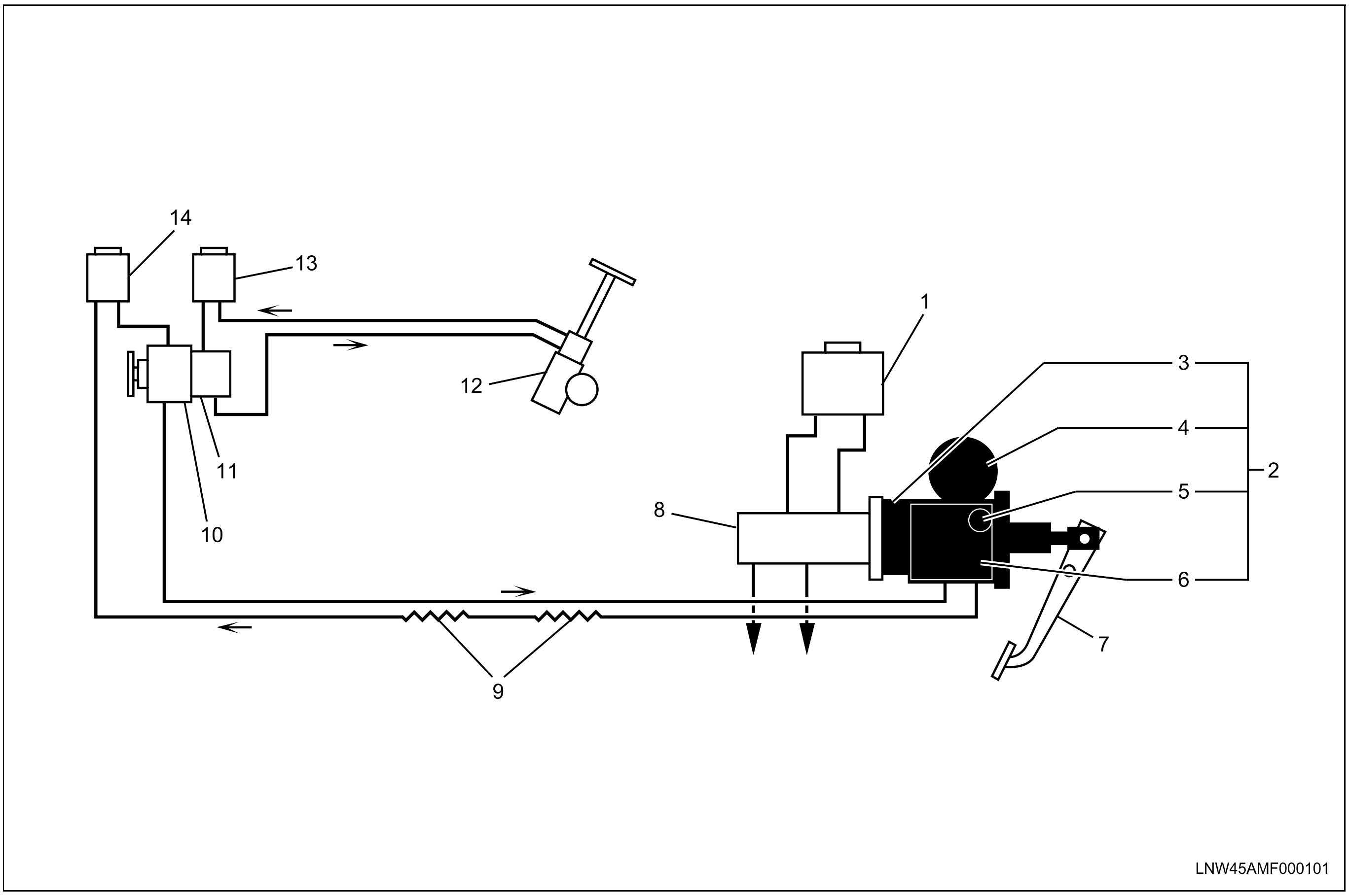
Booster component bench servicing should be done in a clean work area separated from the brake servicing area. Wash hands before changing between brake or booster work areas. Do not use the same containers for fluids.

Flushing The Hydraulic Booster System

Flushing is required when dirt, sludge, or water is found in the system. Flushing involves running clean fluid through the system until the draining fluid appears the same as clean fluid. Contaminated fluid in the booster system can cause rubber parts to deteriorate.

The hydraulic booster system should be cleaned and flushed when the hydraulic pump is replaced. Metal shavings from a worn hydraulic pump often contaminate the system. Pipes and hoses should be removed and blown clean of all metal shavings.

System Outline



Legend

1. Reservoir; Brake Fluid
2. Hydro Boost
3. Booster
4. Accumulator
5. Pressure Switch
6. Charge Valve
7. Brake Pedal
8. Master Cylinder
9. Cooler Pipe
10. Oil Pump; Hydro Boost
11. Oil Pump; Power Steering
12. Power Steering
13. Reservoir; Power Steering
14. Reservoir; Hydro Boost

The Hydro Boost system, which functions as a brake force boosting device that allows the brake to be operated with less force than otherwise, includes the Hydro Boost, which has the booster, accumulator, charge valve, and pressure switch in an integrated structure, a reservoir, and a cooler pipe.

[Functions of the main constituent parts]

Booster:	Controls the hydraulic oil ejected from the oil pump and amplifies the force on the pedal.
Accumulator:	Accumulates the hydraulic oil under pressure for the boosting operation after the pump stops.
Charge valve:	performs switching operation and feeds the hydraulic oil to the accumulator when the accumulator oil pressure declines.
Pressure switch:	Detects that the accumulator oil pressure has declined to the warning set pressure and operates the warning buzzer.
Oil pump:	Is driven by the engine rotation and feeds the hydraulic oil to the hydro boost through the piping.
Reservoir:	The pump stores the hydraulic oil for doing suction and expulsion.

Cooler pipe:	Located before the radiator, facilitates heat radiation of the hydraulic oil in the system piping, and inhibits an increase in the temperature of the oil.

Other units relating to this system include, as shown in the illustration, the power steering, the pump and reservoir for the power steering, the master cylinder, which receives the output of the hydro boost and activates the brake, the reservoir for the master cylinder, and the brake pedal that activates the booster. The master cylinder is integrally bolted to the booster of the hydro boost. The pump for the power steering is integrated as a tandem pump that shares the hydro boost pump and the drive unit. But as systems, the hydro boost and the power steering are independent of each other, and their reservoirs are separate as well.

Hydraulic Booster Troubleshooting

Large force pressing on the brake pedal (boosting insufficient)

Possible Cause	Correction
1. Booster operation insufficient • Large internal leakage • Sticking of the spool valve • Insufficient sliding around the input and output rods	• With the engine on, press the brake pedal repeatedly, and confirm the presence of manual operation. With regard to manual operation, turn the engine off, and judge whether the pedal is as stiff and its play is as small as when the pedal is pressed repeatedly ten times or more. • When there is manual operation, the hydro boost assembly is replaced.

Brake dragging

Possible Cause	Correction
1. Bad dimensions of the booster • The amount of protrusion of the output rod is large	• Confirm whether the amount of protrusion of the output rod (the distance from surface of the master cylinder attachment flange to the end of the rod) is no greater than 18.2 mm. • If the above dimension is outside the range, replace the hydro boost assembly.
2. Bad pedal circumference attachment dimensions • Clevis position dimension is large	• Confirm whether the clevis position dimension (the distance from surface of the vehicle attachment flange to the center of the clevis center) is in the range 1091 mm. • If the above dimension is outside the range, loosen the lock nut and adjust the clevis position dimension to be inside the above range. After making this adjustment, be sure to securely tighten the lock nut and to do a stop lamp switch reconfirmation.
3. Booster return is bad • Input-output rod circumference sticks • Bad spool valve operation	• With the engine on, repeatedly press the brake pedal and confirm the pedal return state. • If the pedal does not return, replace the hydro boost assembly as necessary.

Oil leakage

Possible Cause	Correction
1. Hydro boost assembly external leakage • Leakage from the seal material	• If the oil leakage is caused by looseness in the piping connections, retighten the connections. • If there is oil leakage from the connections of the accumulator, replace the affected seals of the connections with new seals. • If there is any oil leakage from parts other than the above that are included in the hydro boost assembly, replace the hydro boost assembly or the repair setting parts (accumulator).

Bad brake operation (lack of smoothness in operation)

Possible Cause	Correction
1. Poor operation of the booster • Input-output rod circumference sticks • Bad spool valve operation	• With the engine on, repeatedly press the brake pedal and confirm the pedal operation state. • If there is sticking or some other abnormality in the pedal operation, replace the hydro boost assembly as necessary.

Abnormal brake noise (when pressing the pedal)

Possible Cause	Correction
1. Air in the hydraulic booster lines	• With the engine running, check the amount of hydraulic fluid remaining in the reserve tank for the hydraulic booster. • If low, add fluid (Besco ATF III) and bleed to remove air as necessary before starting the engine. Operate the pump and repeatedly step on the pedal to confirm the gear noise (caused by cavitation).
2. Water in the hydraulic fluid	• Check the color of the hydraulic fluid in the reserve tank for the hydraulic booster (normal: purple, abnormal: milky white). • If the hydraulic fluid is milky white, change the fluid (Besco ATF III) and bleed to remove air as necessary before starting the engine. Operate the pump and strongly press the pedal until reaching full boost range to confirm the gear noise (caused by cavitation). The length of time to keep the pedal pressed all the way down is no more than five seconds.

No pedal boosting effect immediately after turning the engine off

Possible Cause	Correction
1. Faulty charge valve • Gas leaking from the accumulator • Leakage inside the charge valve	• Keep the engine running for more than 10 seconds. Turn off the engine, and within 60 seconds, step on the pedal once to confirm boosting effect. Boosting effect means the same pedal effort if the engine was running. • If boosting effect does not exist, either the hydraulic booster assembly or the accumulator may need to be replaced.

Warning buzzer continuously sounds

Possible Cause	Correction
1. Faulty hydraulic booster assembly • Faulty pressure switch • Leakage inside the charge valve	• Confirm that the electric devices (pressure switch, relay, buzzer, etc.) are working correctly. • If all are working correctly, pump the brake pedal at least 10 times after turning the engine off to reduce pressure in the hydraulic booster. Start the engine, and if the vehicle has a manual transmission, release the parking brake (with an automatic, put it in Drive). Check to see if the alarm stops within ten seconds (if it does, the electrical devices are working properly). • When testing the electrical devices, always keep your foot on the brake pedal with just enough pressure to prevent the vehicle from moving. If the alarm does not stop, the hydraulic booster assembly may have to be replaced.

Charge operation remains in effect

Possible Cause	Correction
1. Bad charge valve operation • Bad valve switching operation	• Turn the engine on, and without pressing the brake pedal, check whether any charging sound continues, such as the sound of the fluid. • If it continues and will not stop, replace the hydro boost assembly as necessary.

Notes

1. When the brake pedal is operated after the engine is turned off and the oil pump stops, during a few operations a fluid sound due to the flow of high-pressure oil or a sound of movement by the charge spool may be produced, but this sound is not abnormal; it merely indicates that boosting by the accumulator (accumulator operation) is proceeding normally.
   Also, a similar fluid sound is produced during quick operation of the brake pedal even if the engine is on, but this too is normal.
2. If the pressure of the oil in the accumulator drops with operation of the brake pedal after the engine is turned off or when the engine has been off for a long time, then immediately after the engine is turned on, fluid sound during charge valve operation or switching sound when charging ends will be produced, but this sound is not abnormal; it merely indicates that the accumulator is being normally charged.
   Also, a similar charging operation sometimes occurs and sound is sometimes produced when the pressure inside the accumulator drops even when the engine is on and charging has ended, due to such causes as rapid operation of the brake pedal, internal leakage that is too slight to affect brake performance, or a change in temperature; this too is normal.
3. When the brake pedal is pressed strongly as far as the booster full load region while the engine is on, sometimes sound is produced by the flow of hydraulic oil discharged from the oil pump, but this is not abnormal. Also, pressing the pedal in as far as this booster full load region can cause a significant increase in the oil temperature inside the oil pump and can lead to a failure, so keep the pedal pressed for no longer than 5 seconds.

Supply Parts Replacement

Precautions

1. The hydro boost is a precision part that operates with high-pressure hydraulic oil. Never remove any parts from the hydro boost except replacement parts.
   Trouble may occur if a part other than a replacement part is removed and a non-matching part is included or the assembly is bad. For example, mis-operation may occur and the brake becomes ineffective, or a bad seal may allow high-temperature hydraulic oil under high pressure to spatter and cause a burn.
2. The hydraulic oil to be used for the hydro boost is ATF Dexron®-III. Using any other hydraulic oil could adversely affect the rubber parts and cause poor operation or oil leakage.
   In particular, the hydraulic oil for the hydro boost is quite different from the brake fluid that is used in the master cylinder.
   Be careful that hydro boost parts do not come into contact with the brake fluid for the master cylinder, and that master cylinder parts do not come into contact with the hydraulic oil for the hydro boost.
   Any mixing together of the hydraulic oil for the hydro boost and the brake fluid for the master cylinder could cause degradation such as the swelling of rubber parts, brake failure due to oil leakage or bad operation, or a serious mishap such as a vehicle fire caused by brake friction.
3. Operation of the pump while the engine is on will cause the hydro boost hydraulic oil to get hot. In particular, frequent repeated operation of the brake will sometimes increase the temperature of the hydraulic oil in the hydro boost assembly to 100°C or more. Be careful in handling.
   When performing work such as removing the hydro boost assembly from the vehicle, before starting the work, first turn the engine off, wait 30 minutes, and verify that the temperature has cooled off.
4. Even when a long time passes after the engine is turned off, the high-pressure hydraulic oil in the accumulator of the hydro boost remains stored under pressure.
   Before removing the hydro boost assembly or piping, be sure to repeatedly press the brake pedal at least ten times with the engine off, and make sure the pressure of the hydraulic oil in the accumulator has been reduced to atmospheric pressure before doing the work.
   In particular, when removing the replacement-part accumulator from the hydro boost assembly, the hydraulic oil may spatter if it remains stored under high pressure inside the accumulator, so be careful of this.
5. After removing the hydro boost assembly or piping and making repairs, do not run the vehicle until you perform the below-described air bleeding and then verify that everything is normal, including hydro boost boosting and accumulator operation.
6. How to bleed out the air from the hydro boost when actually attaching it to the vehicle
   a. Attach the hydro boost and the master cylinder to the vehicle and connect the piping.
   b. Fill the hydro boost reservoir with hydraulic oil between its minimum and maximum range.
   c. Turn the engine on for about 5 seconds.
   d. Then turn the engine off and check the quantity of hydraulic oil in the reservoir.
   e. If the hydraulic oil is below the minimum, pour in more hydraulic oil so that it is in the range from minimum to maximum.
   f. Repeat the above steps b-e until there is no foaming or change in the level of the hydraulic oil in the reservoir. But if the hydraulic oil foams during the above steps, let it stand for a while, wait for the foam to dissipate, then continue the work.
   g. With the engine on, repeatedly press the brake pedal slowly about five times.
   h. Then turn the engine off and check the quantity of hydraulic oil in the reservoir. If the hydraulic oil is below the minimum, once again pour in more hydraulic oil so that it is in the range from minimum to maximum.
   i. Leaving the engine off, repeatedly press the brake pedal at least ten times.
   j. Verify that there is no foam or change in the level of the hydraulic oil in the reservoir. If any foam remains, let it stand for a while, wait for the foam to dissipate, then repeat the above steps g-i.
   k. If it is necessary at this time to bleed out the air from the brake fluid pressure system, such as the master cylinder or the wheel cylinder, be sure to first complete step j above and make sure that the engine is on.
   l. With the engine on, strongly press the brake pedal as far as the booster full load region slowly and repeatedly about 30 times (for 1-3 seconds each time). When doing so, do not keep the pedal at the full load region (no longer than 1 second).
   m. Then turn the engine off and repeatedly press the brake pedal at least 10 times.
   n. Check the state of the hydraulic oil in the reservoir, and if there is no foaming or change in the level of the oil, the operation of bleeding the air out is considered completed. If any foam remains, let it stand for a while, wait for the foam to dissipate, then repeat the above steps l-n.

7. Precautions when bleeding the air from the brake fluid pressure system

   When doing air bleeding of the brake fluid pressure system, such as the master cylinder or wheel cylinder, verify that the air has been bled out of the hydro boost, and make sure that the engine is on.

   Be aware that if air bleeding of the brake fluid system is to be done with the engine off, air bleeding cannot be done.

   If air bleeding of the brake fluid pressure system is to be done at the same time as air bleeding of the hydro boost, do so when the operation of the above hydro boost air bleeding method j has been completed.

Repair Instructions

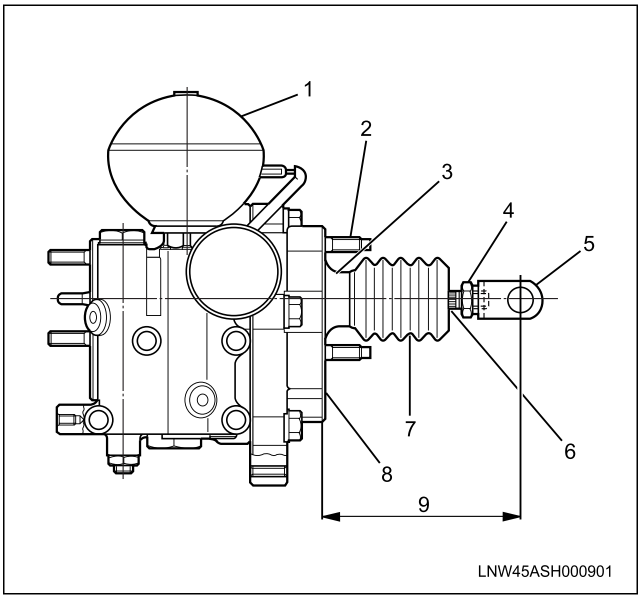
Accumulator and O-ring Replacement

Removal Procedure

- Block the vehicle and apply the parking brake.
- Battery ground cable.
- Reduce the pressure of the hydraulic oil in the accumulator by brake pedal operation with the engine off, and after confirming that the temperature of the hydro boost assembly has been reduced, remove the hydro boost assembly from the vehicle.

1. Remove meter cluster.
2. Remove meter assembly and harness connector.
3. Remove ventilation duct.
   Refer to STEERING COLUMN REPLACEMENT in this manual.
4. Using an oil filter wrench, remove accumulator and O-ring.

Installation Procedure



Legend

1. Accumulator
2. Stud Bolt
3. Cover Boss
4. Lock Nut
5. Clevis
6. Operating Rod
7. Guard
8. Flange
9. Clevis Position Dimension

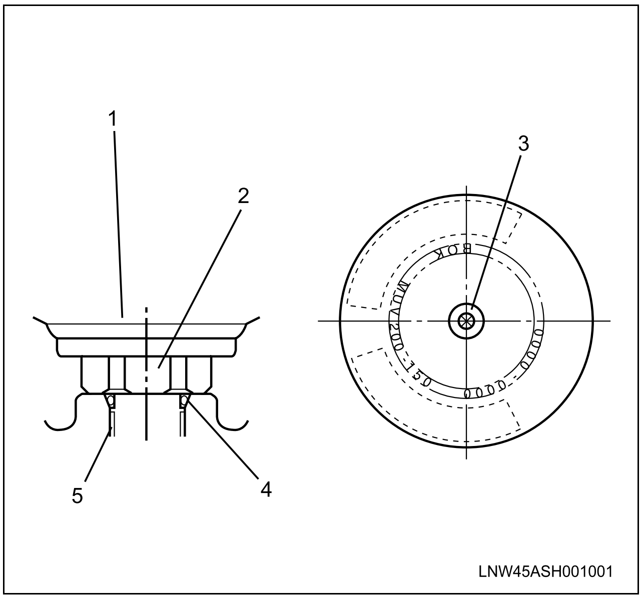
---

1. Verify that there is no foreign matter adhering to the screw part of the accumulator or to the attachment part on the booster side.
2. Put an O-ring coated with new hydraulic oil (ATF Dexron®-III) into the screw part of the accumulator, being careful not to damage it. Always use a new O-ring.
3. Using an oil filter wrench, hold the accumulator shell fixed, and tighten it via the wrench to the specified torque.

Tighten

Accumulator: 24.5-34.3 N·m (18-25 lb ft)

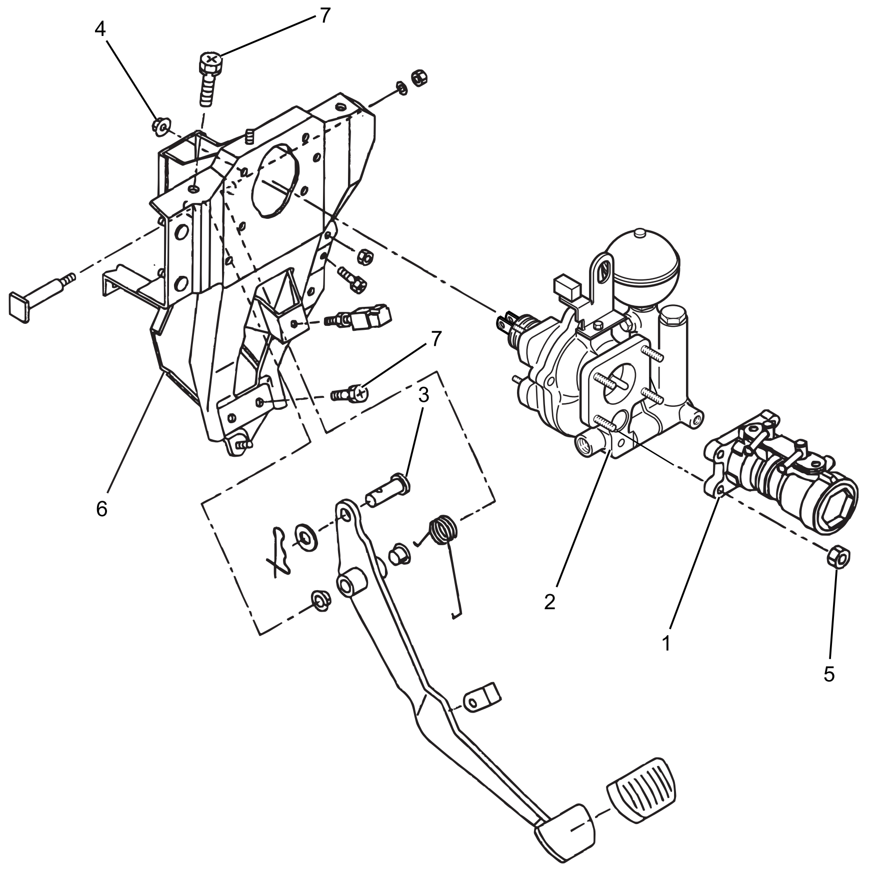
4. Install ventilation duct.
5. Connect harness connector and install meter assembly.
6. Install meter cluster.
7. Battery ground cable.
8. After attaching it to the vehicle, always replenish with new hydraulic oil (ATF Dexron®-III), and completely release the air from the hydro boost.
9. Release the parking brake and remove the wheel blocks.
   - How to dispose of the accumulator.
     To dispose of the accumulator, drill a hole in the position shown in the diagram below according to the indications printed on the accumulator, completely release the nitrogen gas sealed inside the accumulator, then dispose of the accumulator.
     Concerning disposal with the hydro boost assembly as well, dispose of it after first letting out all the nitrogen gas inside the accumulator, by the above method.



Legend

1. Accumulator
2. Hex25
3. Drilling Point for GAS Releasing
4. O-ring
5. Thread

Hydraulic Booster Replacement



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Legend

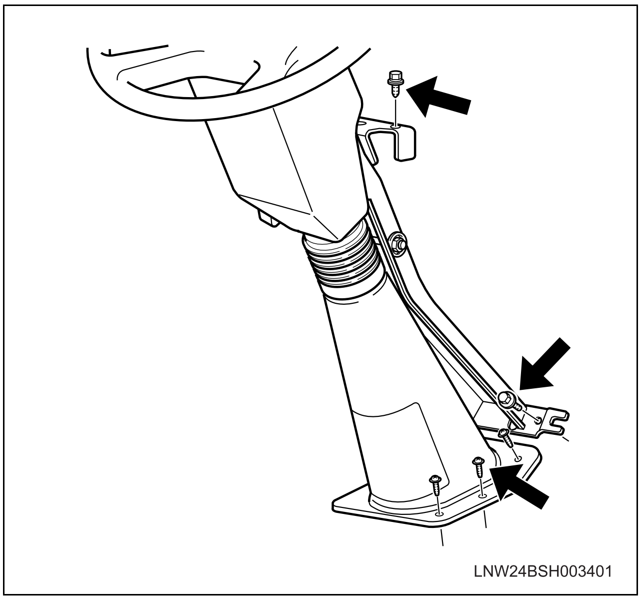
1. Master Cylinder
2. Hydraulic Booster
3. Clevis Pin
4. Hydraulic Booster Mounting Nut
5. Master Cylinder Mounting Nut
6. Brake Pedal Bracket
7. Brake Pedal Bracket Mounting Bolt

Removal Procedure

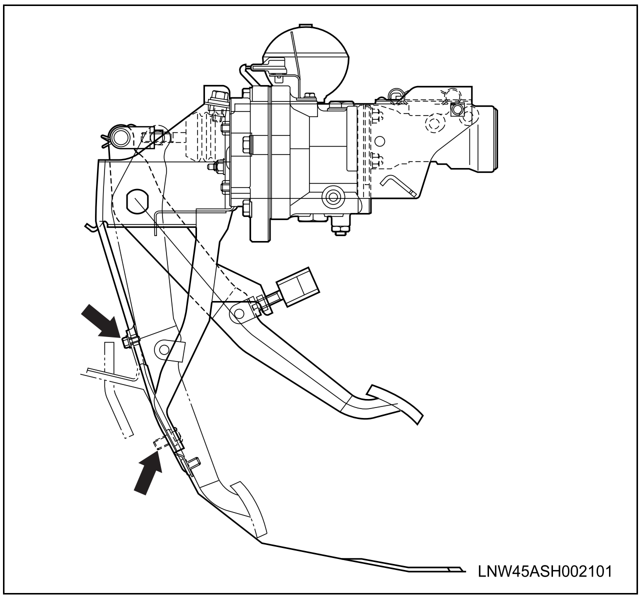
- Block the vehicle wheels and apply the parking brake.
- Battery ground cable.
- By brake pedal operation with the engine off, reduce the pressure of the hydraulic oil in the accumulator, and after confirming that the temperature of the hydro boost assembly has been reduced, remove the hydro boost assembly from the vehicle.

1. Remove meter cluster.
2. Remove meter assembly and harness connector.
3. Remove instrument panel assembly and ventilation duct.
   Refer to INSTRUMENT PANEL in this manual.
4. Remove heat protector under the hydraulic booster.
5. Steering wheel and column assembly.
   - Remove inspection window (only CREW CAB) and mark steering worm shaft and U-joint yoke. Remove key bolt and nut. Refer to STEERING COLUMN in this manual.
   - Remove screws: boots to floor.

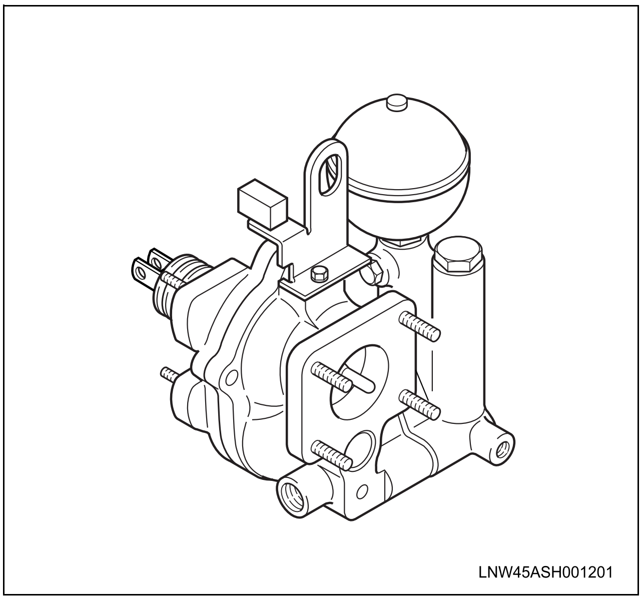
- Remove bolts and nuts: support bracket to floor.
- Remove bolts: steering column bracket to instrument reinforcement assembly.
- Remove bolts: steering column bracket to brake pedal bracket.



6. ATF pipe: inlet and outlet.
   - Disconnect pipes from the booster.
7. Brake pipe and hose: front and rear.
   - Disconnect pipes and hoses from the brake master cylinder.
8. Brake pedal assembly with master cylinder and hydraulic booster.
   - Remove accel pedal bracket. Refer to FUEL SYSTEM in this manual.
   - Remove brake pedal bracket mounting bolts.
   - Remove radiator grille and disconnect ATF inlet pipe from flexible hose in front of the radiator. Remove ATF inlet pipe.
   - Remove brake pedal assembly.



9. Remove hydraulic booster and master cylinder assembly.
10. Clevis pin (3).
11. Four hydraulic booster mounting nuts (4) at pedal bracket (6).
12. Master cylinder (1) with hydraulic booster (2).
13. Four nuts retaining master cylinder (5) to hydraulic booster (2).



Installation Procedure

1. Hydraulic booster (2).
2. Master cylinder assembly (1).

Tighten

- Nuts (5) to 14 N·m (10 lb ft).

3. Four hydraulic booster mounting nuts (4) to pedal bracket (6).

Tighten

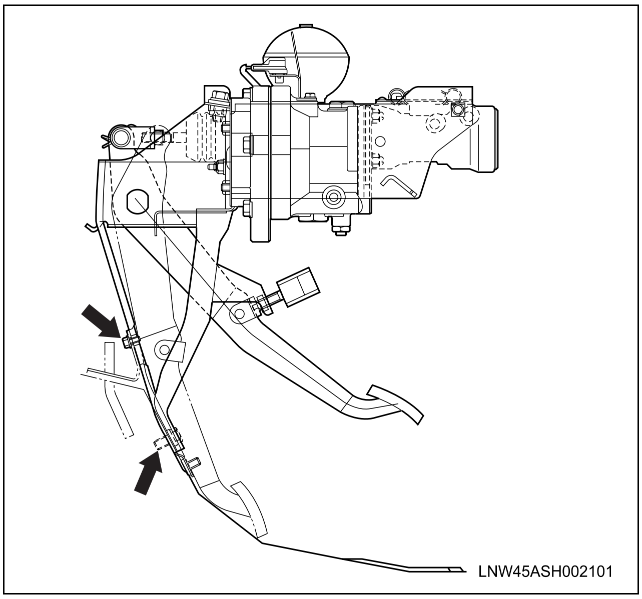
- Nuts (4) to 14 N·m (10 lb ft).

4. Connect servo unit clevis to brake pedal, and install clevis pin (3).
5. Brake pedal assembly with master cylinder and hydraulic booster.
   - Set ATF inlet pipe and install brake pedal assembly.

Tighten

- Bolts to 42 N·m (32 lb ft).
  - Connect ATF inlet pipe with flexible hose.
  - Install accel pedal bracket.

- Install radiator grille.



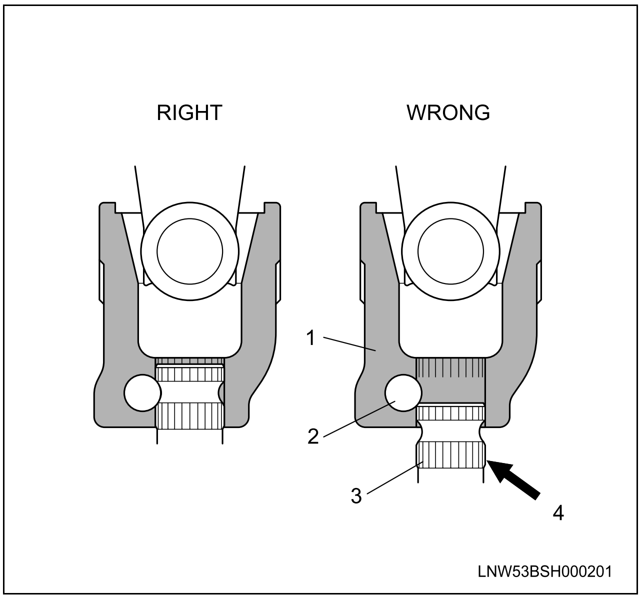
6. Install ATF pipes to hydraulic booster.
7. Install master cylinder hydraulic lines to master cylinder.
8. Steering wheel and column assembly.
   - Set steering wheel and column assembly. Refer to STEERING COLUMN in this manual.
   - Install mounting bolts, nuts and screws to body.
   - Install U-joint bolt and nut.

Tighten

- U-joint bolt to 25 N·m (18 lb ft).
  - Install inspection window.

Notice:

- The U-Joint Bolt(2) must be removed to install the steering shaft U-Joint (1) to the steering gear input shaft (3).
- Be sure that the U-Joint Bolt passes through the steering gear input shaft groove when it is reinstalled.
- Following steering shaft installation, mark sure that the serrated area (4) is not visible (if it is visible, the installation process has been performed improperly).



9. Install hydraulic booster heat protector.
10. Install ventilation duct and instrument panel assembly.
    Refer to INSTRUMENT PANEL in this manual.
11. Install meter assembly and harness connector.
12. Install meter cluster.
13. Battery ground cable.
14. After attaching it to the vehicle, always replenish with new hydraulic oil (Besco ATF III), and completely release the air from the hydro boost.
15. Bleed brake lines. Refer to HYDRAULIC BRAKES in this section.
16. Release the parking brake and remove the wheel blocks.

Clevis and Lock Nut Replacement

Removal Procedure

1. Remove hydraulic booster assembly.
   Refer to “Remove or Disconnect” of HYDRAULIC BOOSTER in this section.
2. Secure the hydro boost assembly to the jig using the four stud bolts on the surface of the flange for attachment to the vehicle.
3. Being careful not to exert any off-center load on the operating rod, loosen the lock nut and remove the clevis and lock nut.

Installation Procedure

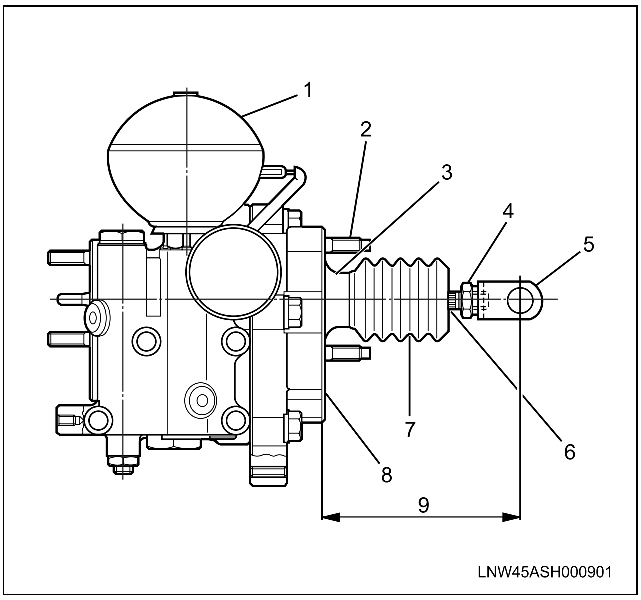
1. Screw the lock nut and then the clevis onto the operating rod.

2. Adjust so that the booster clevis position dimension (the dimension A in the diagram below the distance to the center of the clevis hole from the surface of the flange for attachment to the vehicle) is 109±1 mm (4.29±0.04 in), and tighten the lock nut with the prescribed torque.

Prescribed tightening torque:

19 N·m (14 lb ft)

When tightening the lock nut, be careful not to deform the clevis.



Legend

1. Accumulator
2. Stud Bolt
3. Cover Boss
4. Lock Nut
5. Clevis
6. Operating Rod
7. Guard
8. Flange
9. Clevis Position Dimension (A)

---

3. Attach the hydro boost assembly to the vehicle.
   Refer to “Install or Connect” of HYDRAULIC BOOSTER in this section.

Guard Replacement

Removal Procedure

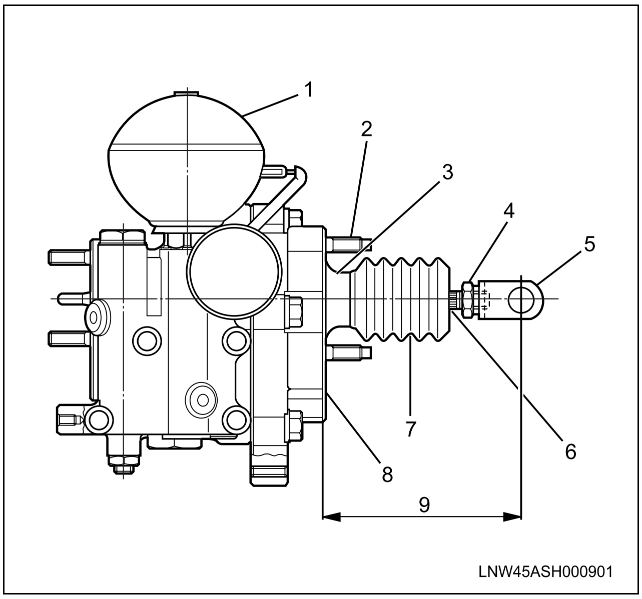
1. Remove hydraulic booster assembly.
   Refer to “Remove or Disconnect” of HYDRAULIC BOOSTER in this section.
2. Secure the hydro boost assembly to the jig using the four stud bolts on the surface of the flange for attachment to the vehicle.
3. Being careful not to exert any off-center load on the operating rod, loosen the lock nut and remove the clevis and lock nut.
4. Remove the guard from the cover boss anchoring groove and from the operating rod anchoring groove, and pull it out.

Installation Procedure

1. With a dry cloth, clean well the cover boss anchoring groove and the operating rod anchoring groove, and verify that no foreign matter is present.
2. Insert from the large diameter hole side of the guard end-face into the operating rod outside diameter part, assemble the small diameter hole part of the guard end-face into the anchoring groove of the operating rod, then assemble the large diameter hole part securely into the anchoring groove of the boss of the cover.
3. Screw the lock nut and then the clevis onto the operating rod.
4. Adjust so that the booster clevis position dimension (the dimension A in the diagram below: the distance to the center of the clevis hole from the surface of the flange for attachment to the vehicle) is 109±1 mm (4.29±0.04 in), and tighten the lock nut with the prescribed torque.
   When tightening the lock nut, be careful not to deform the clevis.

Prescribed tightening torque:

19 N·m (14 lb ft)

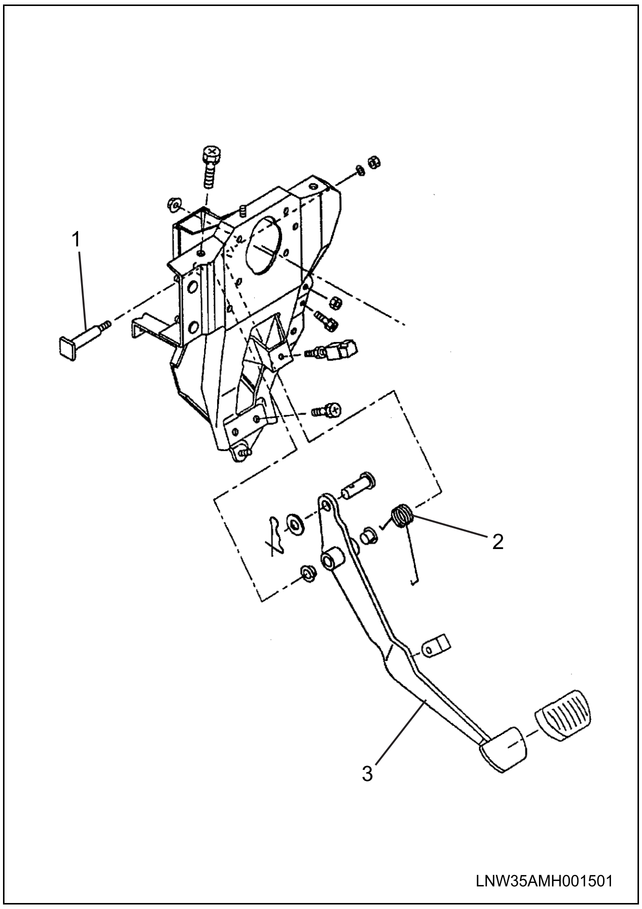


Legend

1. Accumulator
2. Stud Bolt
3. Cover Boss
4. Lock Nut
5. Clevis
6. Operating Rod
7. Guard
8. Flange
9. Clevis Position Dimension (A)

5. Attach the hydro boost assembly to the vehicle. Refer to “Install or Connect” of HYDRAULIC BOOSTER in this section.

Brake Pedal Replacement



Legend

1. Pedal Shaft
2. Return Spring
3. Brake Pedal

Removal Procedure

- Block the vehicle wheels and apply the parking brake.
- Battery ground cable.

1. Brake pedal bracket with master cylinder and hydraulic booster. Refer to HYDRAULIC BOOSTER REPLACEMENT of this section.
2. Clevis pin.
3. Hydraulic booster with master cylinder.
4. Return spring (2).
5. Pedal shaft (1) from brake pedal assembly.
6. Brake Pedal (3).

Inspection

- Bushings, return spring and bolt for wear or damage.
- Replace all parts found defective.

Installation Procedure

1. Pedal shaft (1) to brake pedal assembly (3).
2. Return spring (2).
3. Hydraulic booster with master cylinder.

Tighten

Nut to 14 N·m (10 lb ft).

4. Clevis pin.
5. Install brake pedal assembly with master cylinder and hydraulic booster.
   Refer to HYDRAULIC BOOSTER of this section.

Brake Pedal Adjustment

Adjustment

Notice:
For steps 4 and 5 seen “NOTICE” on page 5A2-2 of this section.

1. Loosen the jam nut at the stop lamp switch.
2. Loosen the jam nut on the hydraulic booster push rod.
3. Turn the push rod until the distance from the center of clevis pin hole to mounting surface of the brake pedal bracket should be set at 109±1mm (4.29±0.04 in).
   When fixed under this condition, there is no need to adjust the brake pedal height and free play.
4. Tighten the push rod jam nut.

Tighten

Lock nut to 19 N·m (14 lb ft).

5. Stop lamp switch so that the end of the switch threaded portion contacts the brake pedal, then back-off the switch 1/2 turn.

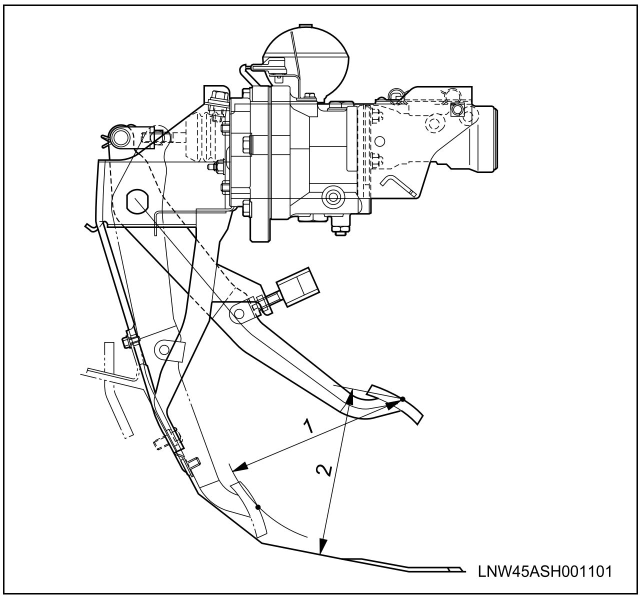
Tighten

Stop lamp switch lock nut to 20 N·m (14 lb ft)

6. Check brake pedal operation to be sure it’s operating properly.

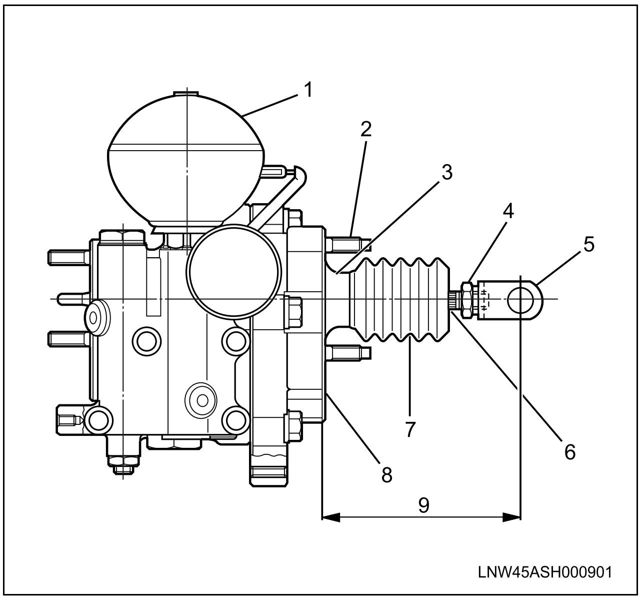
Measurement

- Measure the brake pedal free play, after reducing the pressure of the hydraulic oil in the accumulator by pedal operations at least 10 times with engine off.
  Brake pedal normal play is between 21-24 mm (0.83-0.94 in).
- Pressing the brake pedal with a force of 294 N (66 lb) with the engine on, the clearance between the brake pedal and floor panel is more than 35mm (1.4 in).
- Brake pedal height (2) is 167 mm (6.58 in) (reference).
- Brake pedal travel (1) is between 180±5 mm (7.09±0.2 in) (reference).



Legend

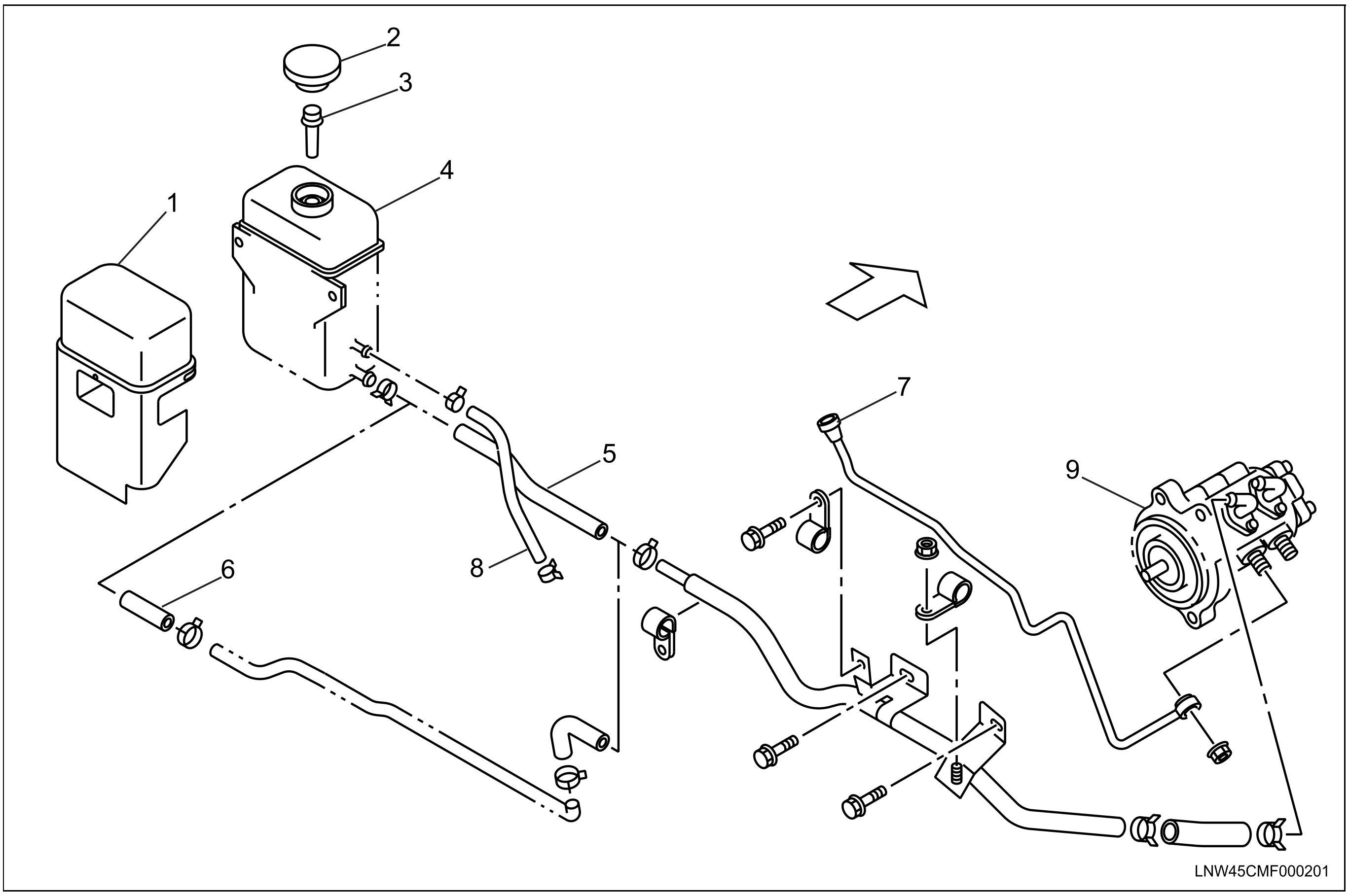
1. Pedal Travel (Reference) 180±5mm (7.90±0.2 in)
2. Pedal Height (Reference) 167 mm (6.58 in)



Legend

1. Accumulator
2. Stud Bolt
3. Cover Boss
4. Lock Nut
5. Clevis
6. Operating Rod
7. Guard
8. Flange
9. Clevis Position Dimension

Hydraulic Booster Brake Fluid and Filter Replacement



Legend

1. Cover
2. Cap
3. Filter
4. Fluid Reservoir
5. Hose (Single Cab)
6. Hose (Crew Cab)
7. Tubing (Hydraulic Pump-Brake Booster)
8. Hose (Reservoir-Brake Booster)
9. Hydraulic Pump

Removal Procedure

1. Remove the cover (1) and cap (2).
2. Remove the filter (3).
3. Clean the filter (3) in clean solvent. Then blow the filter dry with compressed air.
4. Raise the vehicle until the tires are off the floor. Support the frame with stands.
5. Disconnect the reservoir hose (5) single cab, (6) crew cab at the reservoir.
   Drain the fluid reservoir (4).

Installation Procedure

1. Connect the reservoir hose.
   Do Not Start Engine
2. Install the filter (3).
3. Fill and bleed the hydraulic system.
   Refer to page 5A2-8 of this section.
4. Install the cap (2) and cover (1).

Specifications

Specifications

Hydraulic booster	GVWR 17950 lb and 19500 lb Model

Fastener Torques

Accumulater	24.5 – 34.3 N·m (18 – 25 lb ft)
Brake Pedal Bracket Mounting Bolts	42 N·m (32 lb ft)
Steering Shaft U-Joint Bolt	25 N·m (18 lb ft)
Master Cylinder Mounting Nuts	14 N·m (10 lb ft)
Hydraulic Booster Mounting Nuts	14 N·m (10 lb ft)
Push Rod Jam Nut	19 N·m (14 lb ft)
Stop Lamp Switch Lock Nut	20 N·m (14 lb ft)

BRAKES

Hydraulic Foundation Brakes

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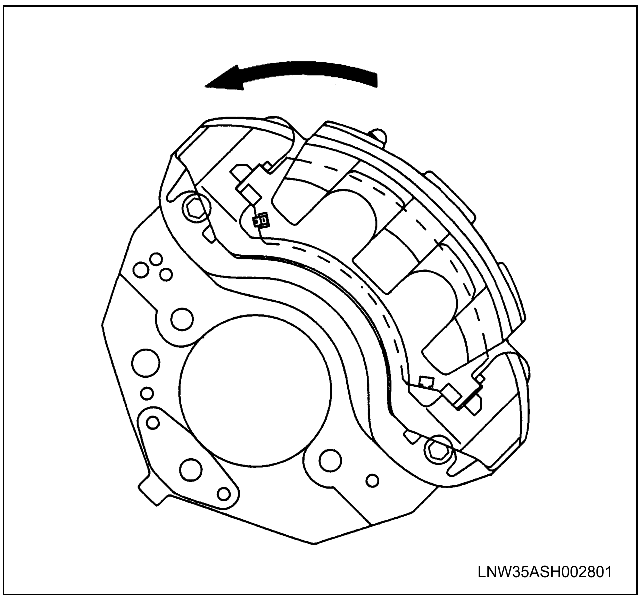
Description and Operation

Hydraulic Foundation Brakes Description

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Caution:
When servicing wheel brake parts, do not create dust by grinding or sanding brake linings or by cleaning wheel brake parts with a dry brush or with compressed air. Many wheel brake parts contain asbestos fibers which can become airborne if dust is created during servicing. Breathing dust containing asbestos fibers may cause serious bodily harm. A water-dampened cloth or water-based solution should be used to remove any dust on brake parts. Equipment is commercially available to perform this washing function. These wet methods will prevent asbestos fibers from becoming airborne.

Wheel brakes are front disc type and rear dual two leading type with auto adjuster.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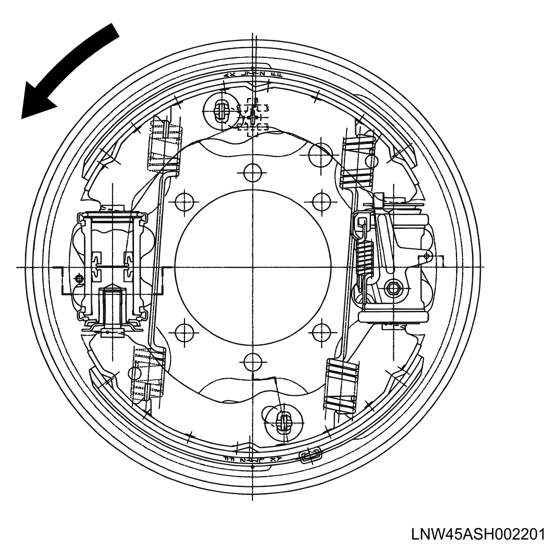
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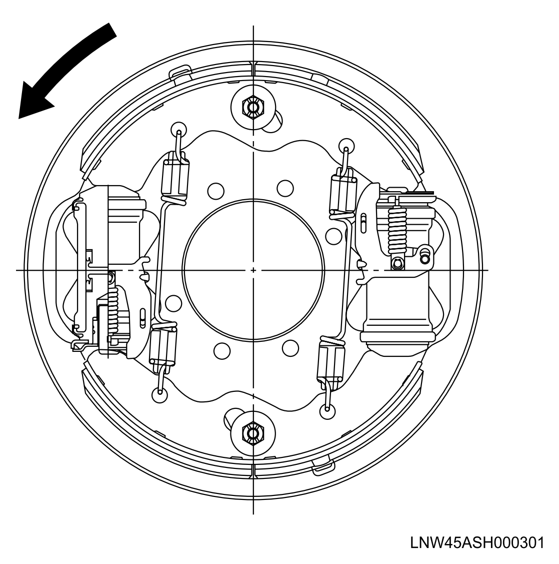
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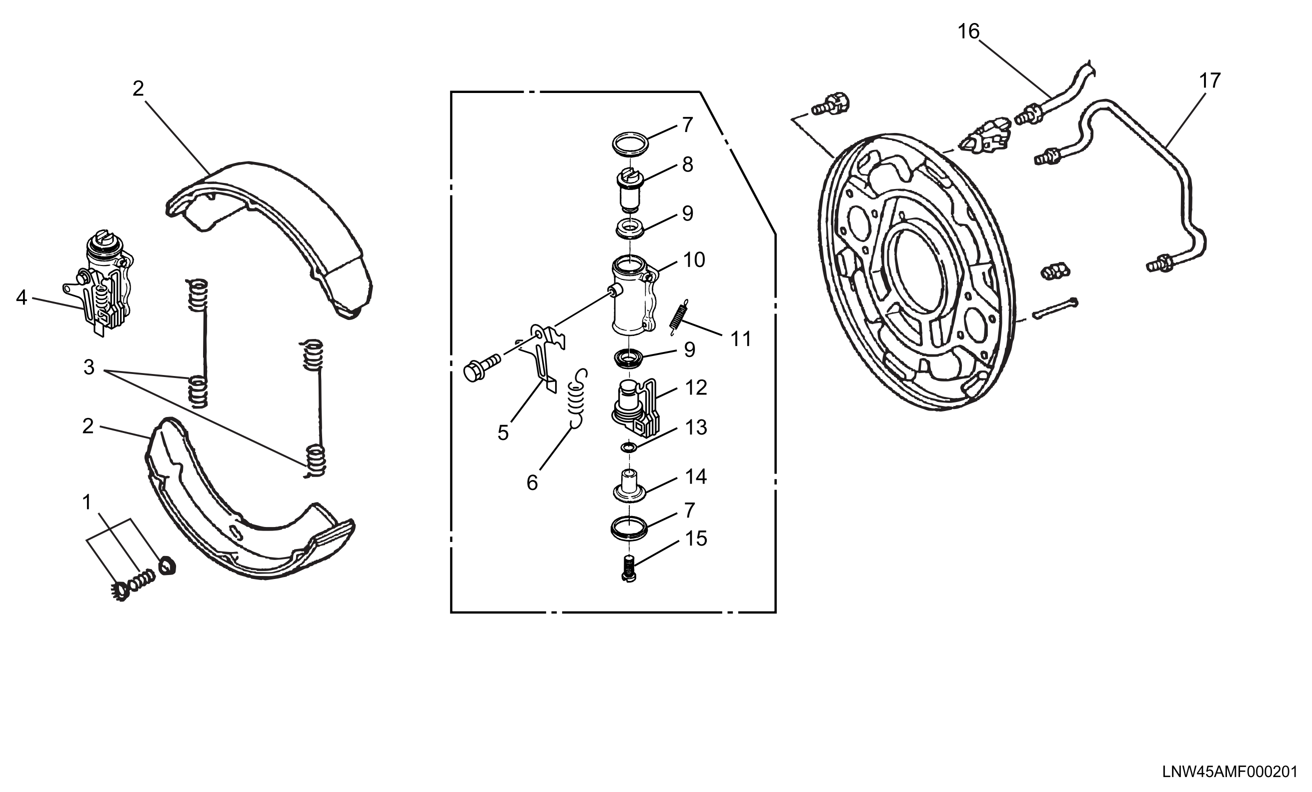
Repair Instructions

Brake Shoe and Lining (Except GVWR 19,500 lb Model)

These procedures are for front and rear wheel brakes except where noted.



Legend

1. Hold-down Spring and Cup
2. Brake Shoe Assembly
3. Return Spring
4. Wheel Cylinder Assembly
5. Adjuster Lever
6. Overtravel Spring
7. Boot
8. Piston
9. Piston Cup
10. Cylinder Body
11. Spring
12. Piston
13. Washer
14. Adjuster Gear
15. Adjusting Screw
16. Brake Pipe
17. Brake Pipe

Removal Procedure

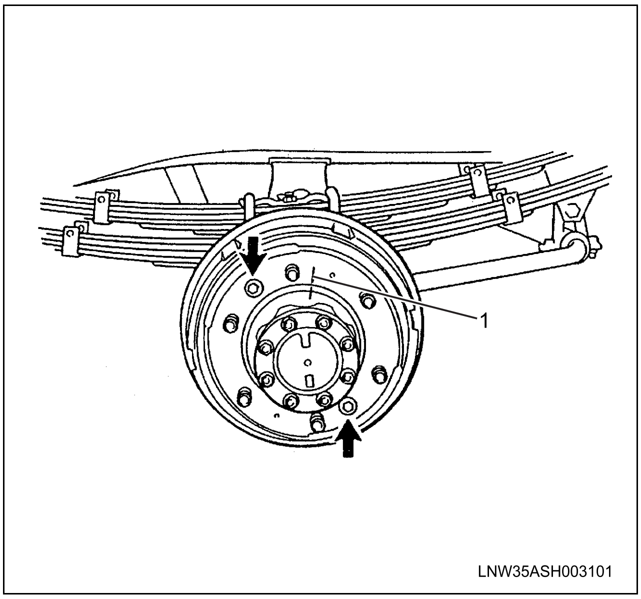
- Block vehicle wheels and apply the parking brake.
- Raise the axle to clear the tire from the ground. Position jack stands under vehicle.

1. Wheel and tire assembly.
   - Refer to Wheels And Tires in this manual.
2. Brake drum.
   - Mark the brake drum to the rear hub.
   - Pushing the adjuster lever and rotate adjusters at back of the brake to provide clearance between lining and drum.
   - Brake drum setting bolts.
3. Hold-down springs and cups.
4. Return springs.
5. Shoe and lining assemblies.

Installation Procedure

1. Shoe and lining assemblies in the mounting plate.
2. Return springs.
3. Hold-down springs and cups.
4. Brake drum.
   - Align the mark made during removal.

- Brake drum setting bolts.



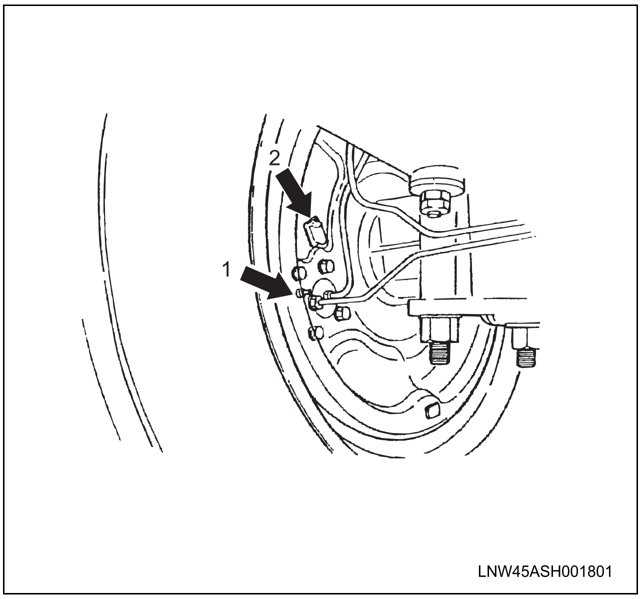
Legend

1. Mark

5. Wheel and tire assembly.
    - Refer to Wheels and Tires section in this manual.

Adjust

- Refer to Brake Drum Removal and Installation later in this section.



Legend

1. Adjuster Lever Release Hole Cover
2. Adjuster Hole Cover

6. Remove jack stands and lower the axle.
7. Remove wheel blocks.
8. Check brake operation.

Brake Assembly Replacement (Except GVWR 19,500 lb Model)

Removal Procedure

- Block vehicle wheels and apply parking brake.
    - Raise the axle to clear the tire from the ground. Position jack stands under vehicle.
- Wheel and tire assembly.
    - Refer to Wheels and tires in this manual.

1. Brake drum.
    - Mark the brake drum to the rear hub.
    - Pushing the adjuster lever and rotate adjusters at back of the brake to provide clearance between lining and drum.
    - Brake drum setting bolts.
2. Hold-down springs and cups.
3. Shoe return springs.
4. Shoe and lining assemblies.
5. Brake pipes.
6. Mounting plate.
7. Wheel cylinders.

Inspection

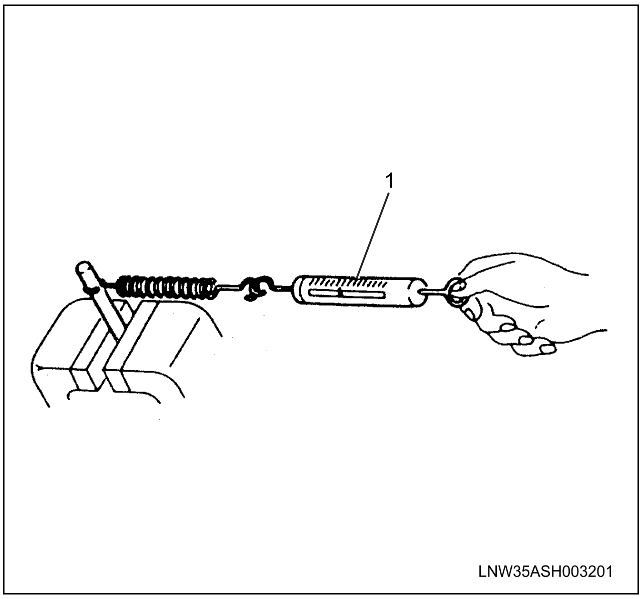
- All components for wear or damage. Replace as necessary.

Measure

Tool Required: J 34913, Tension Scale

- Return spring tension.

		Free length mm (in)	Set length mm (in)	Set load N (lb)
12,000 lb	Rear brake	208.0 (8.19)	224.0 (8.82)	220.6-269.7 (49.6-60.6)
14,500 lb	Rear brake	198.4 (7.81)	219.1 (8.63)	220.6-269.7 (49.6-60.6)
17,950 lb	Rear brake	197.7 (7.78)	219.1 (8.63)	291-356 (65.5-80.0)



Legend

1. J 34913

Installation Procedure

Notice:
For steps 1, 2 and 3 Refer to Description and Operation.

1. Wheel cylinder assemblies.

Tighten

- Wheel cylinder mounting bolts to

  GVWR 12,000 lb: 44 N·m (33 lb ft)

  GVWR 14,500 lb: 75 N·m (55 lb ft)

  GVWR 17,950 lb: 94 N·m (69 lb ft).

2. Mounting plate.

Tighten

- Mounting plate bolts to

  GVWR 12,000 lb: 108 N·m (80 lb ft)

  GVWR 14,500 lb: 108 N·m (80 lb ft)

  GVWR 17,950 lb: 157 N·m (116 lb ft).

3. Brake pipes.

Tighten

- Brake pipe nuts to 15 N·m (11 lb ft).

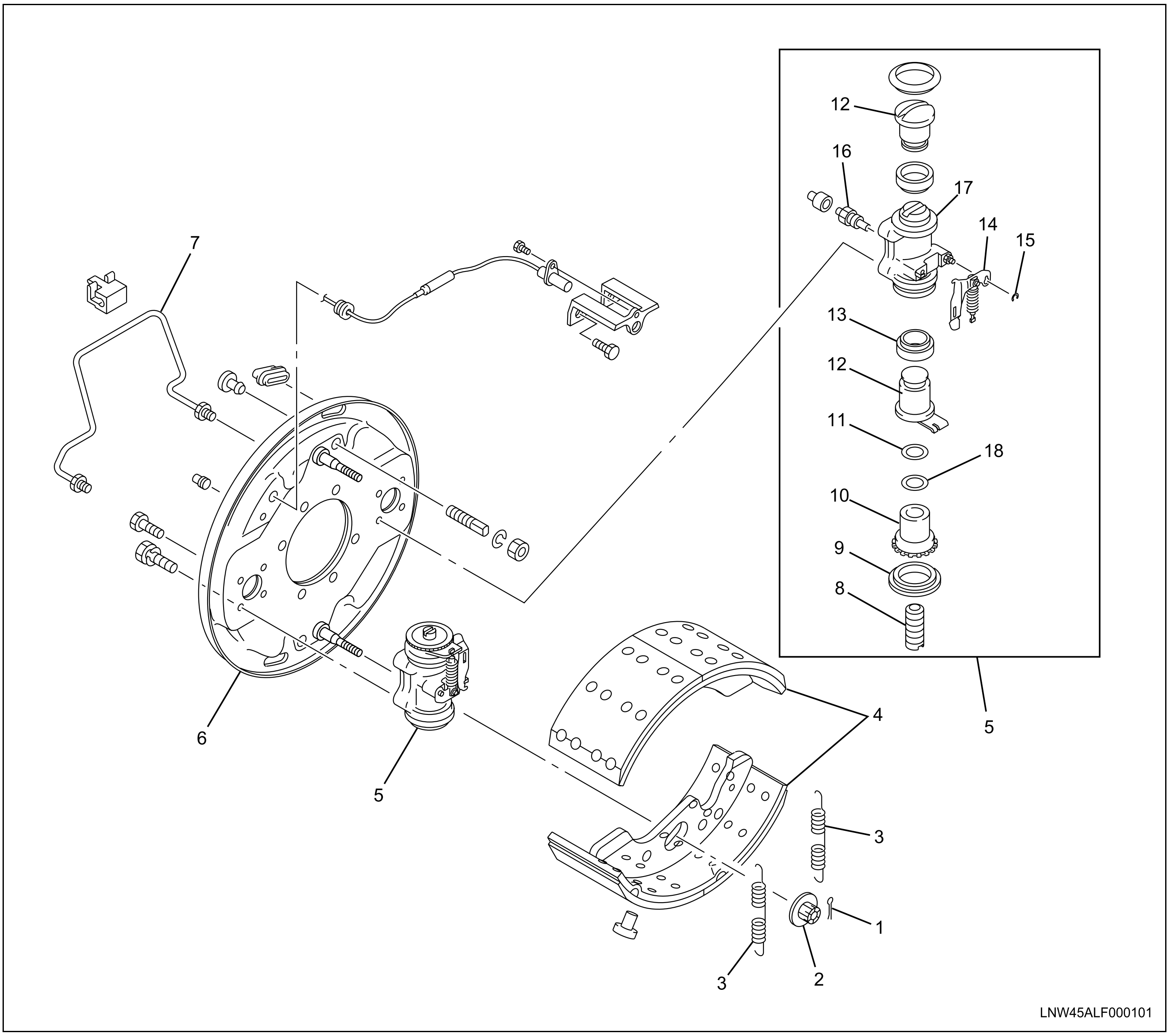
4. Shoe and lining assemblies.
5. Shoe return springs.
6. Hold-down spring and cups.
7. Brake drum.
   - Align the mark made during removal.
   - Brake drum setting bolts.
8. Wheel and tire assembly.
   - Refer to Wheels And Tires section in this manual.

Adjust

- Refer to Brake Drum Removal and Installation later in this section.
- Remove jack stands and lower axle.
- Run engine to build up vacuum.
- Bleed hydraulic brakes.
- Remove wheel blocks.
- Check brake operation.

Brake Shoe and Lining (GVWR 19,500 lb Model)

These procedures are for front and rear wheel brakes except where noted.



Legend

1. Cotter Pin
2. Shoe Hold Nut
3. Brake Shoe Return Spring
4. Brake Shoe Assembly
5. Wheel Cylinder Assembly
6. Back Plate
7. Brake Pipe
8. Adjusting Screw
9. Boot
10. Adjuster Gear
11. Washer (Oil less)
12. Piston
13. Cup
14. Spring and Adjuster Lever Assembly
15. Snap Ring
16. Bleeder Screw
17. Cylinder Body
18. Washer (Stainless steel)

Removal Procedure

- Block vehicle wheels and apply the parking brake.
- Raise the axle to clear the tire from the ground. Position jack stands under vehicle.

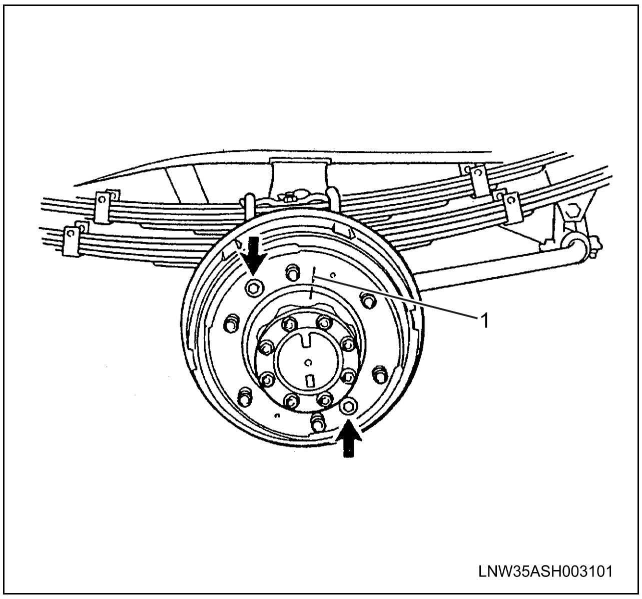
1. Wheel and tire assembly.
   - Refer to Wheels And Tires section in this manual.
2. Brake drum.

- Mark the brake drum to the rear hub.
- Pushing the lever and rotate adjusters at back of the brake to provide clearance between lining and drum.
- Brake drum setting bolts.

3. Holder nuts.
4. Return springs using J-36411.
5. Shoe and lining assemblies.

Installation Procedure

1. Shoe and lining assemblies in the mounting plate.
2. Return springs using J-36411.
3. Holder nuts.
    - Refer to “Brake Assembly Replacement” later in this section.
4. Brake drum.
    - Align the mark made during removal.
    - Brake drum setting bolts.



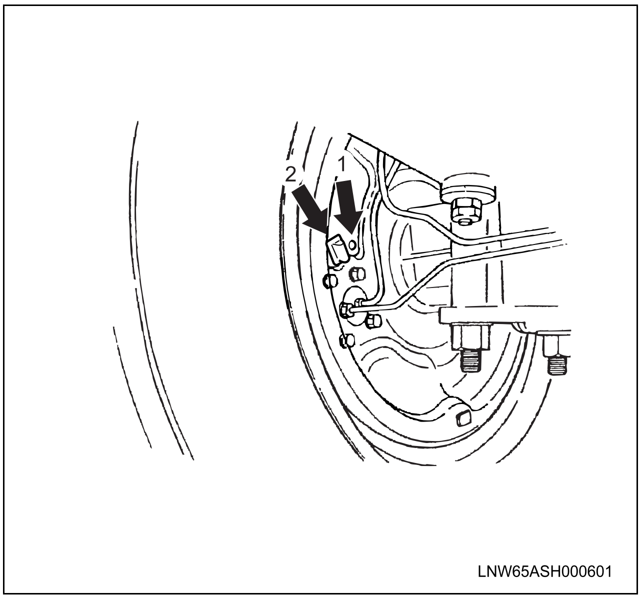
Legend

1. Mark

5. Wheel and tire assembly.
    - Refer to Wheels and Tires section in this manual.

Adjust

- Refer to Brake Drum Removal and Installation later in this section.



Legend

1. Adjuster Lever Release Hole Cover
2. Adjuster Hole Cover

6. Remove jack stands and lower the axle.
7. Remove wheel blocks.
8. Check brake operation.

Brake Assembly Replacement (GVWR 19,500 lb Model)

Removal Procedure

- Block vehicle wheels and apply the parking brake.
- Raise the axle to clear the tire from the ground. Position jack stands under vehicle.

1. Wheel and tire assembly and brake drum and hub assembly.
    - Refer to WHEELS AND TIRES section in this manual.
    - Refer to FRONT AXLE AND SUSPENSION section in this manual.
    - Refer to REAR AXLE section in this manual.
2. Holder nuts.
3. Shoe return springs using J-36411.
4. Shoe and lining assemblies.
5. Brake pipes.

Important:
The brake pipes to the wheel cylinders must be removed before the wheel cylinders can be removed.

6. Brake hose.
7. Back plate.
8. Wheel cylinders.

Inspection

- All components for wear or damage. Replace as necessary.

Measure

Tool Required: J-34913, Tension Scale

- Return spring tension.

Free Length mm (in)	209.3 (8.24)
Set Length mm (in)	226 (8.90)
Set Load N (lb)	292.2-357 (65.7-80.2)

Installation Procedure

Notice:
See “Notice” on page 5A3-2 of this section for Steps 1, 2 and 3.

1. Wheel cylinder assemblies.

Tighten

- Wheel cylinder mounting bolts to 120 N·m (89 lb ft)

2. Back Plate.

Tighten

- Mounting plate bolts to 157 N·m (116 lb ft).

3. Brake pipes and hoses.

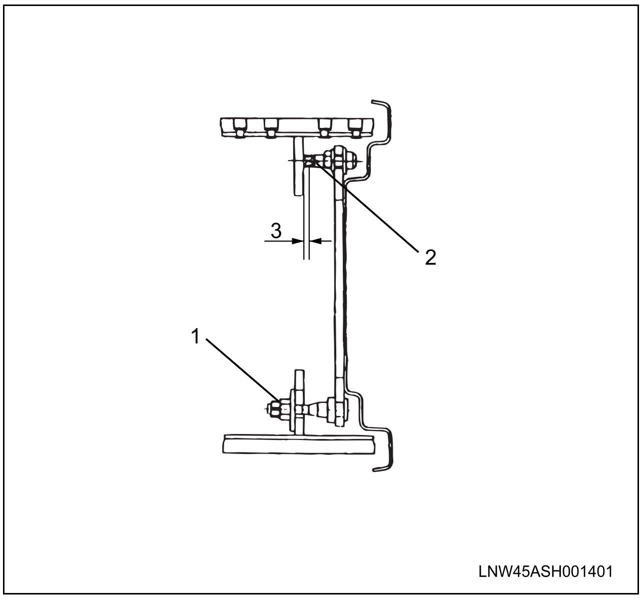
Tighten

- Brake pipe nuts to 15 N·m (11 lb ft).

4. Shoe and lining assemblies.
5. Shoe return spring using J-36411.
6. Holder nuts.
   - Brake holder nut clearance.
     - Turn nut (1) clockwise until shoe comes into contact with the bolts (2).
     - Turn nut (1) counterclockwise 1/3 turn. Back off the nut until the hole in the holding pin lines up with the nearest slot in the nut within 1/6 turn, and install split pin.
     - Check to see if clearance between bolt and shoe in 0.3-0.5 mm (0.012-0.020 inch). If clearance is not specified, should be readjusted.

Caution:
Do not loosen the nuts on the shoe hold bolts during the operation.

7. Cotter pin.
   Use a new cotter pin. Be sure to bend back the legs of the pin.



Legend

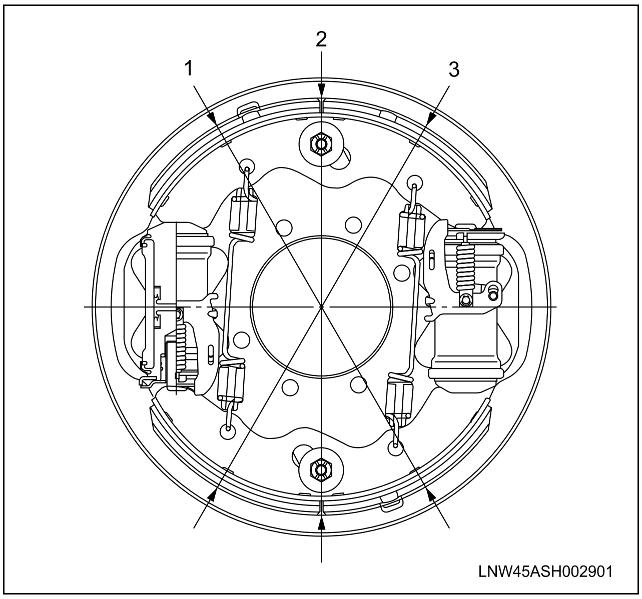
1. Nut
2. Bolt
3. Clearance 0.3-0.5mm (0.012-0.020 in)

8. Hub and drum assembly and wheel and tire assembly. Adjust wheel bearings.
   - Refer to WHEELS AND TIRES section in this manual.
   - Refer to FRONT AXLE AND SUSPENSION section in this manual.
   - Refer to REAR AXLE section in this manual.

Adjust

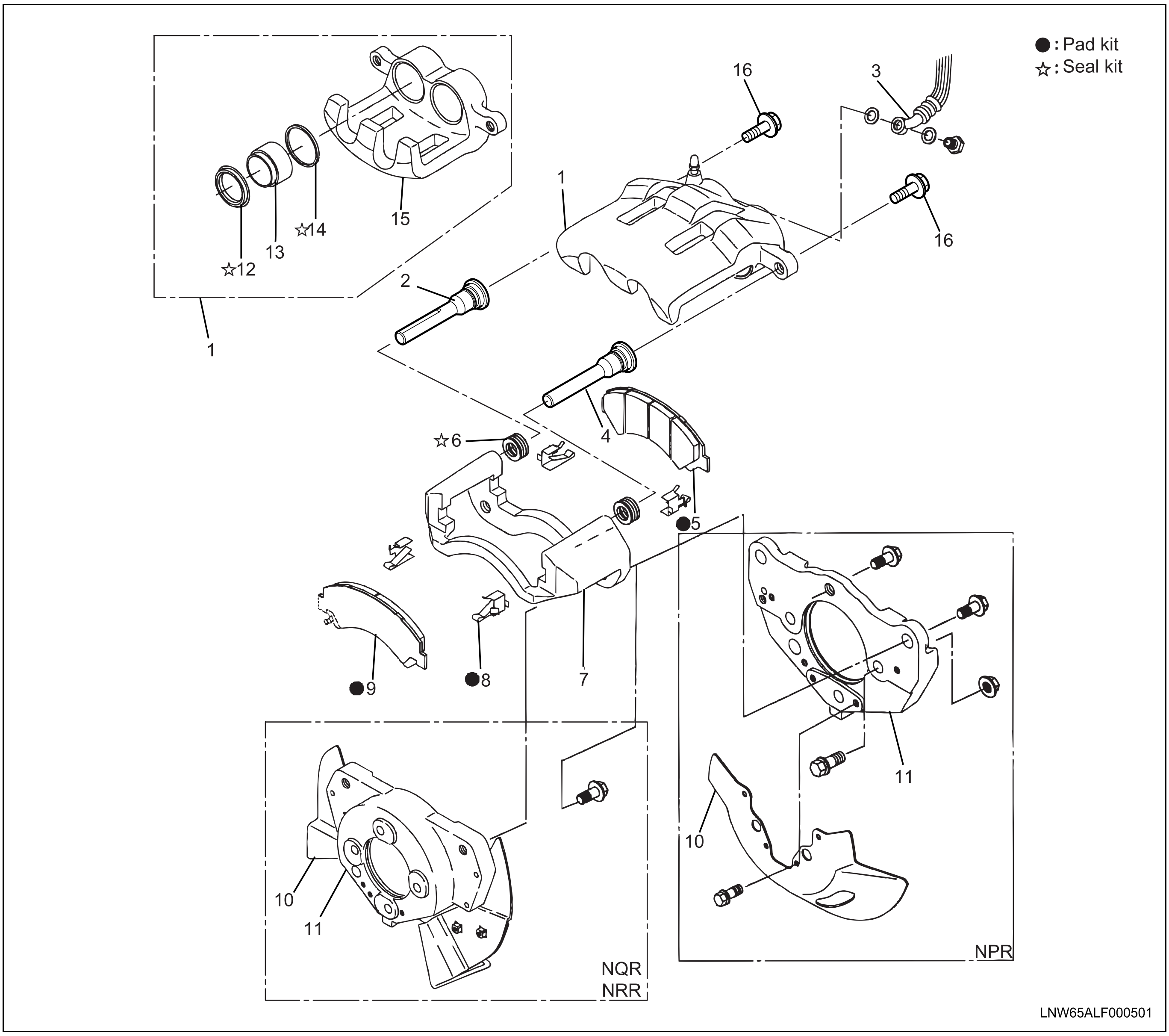
1. After reassembling the brake assembly, adjust the brake lining external diameter to 369.3-369.8 mm (14.54-14.56 inch) by turning the wheel cylinder adjuster gear.
   If the measurement at 1, 2 and 3 point are within the range of specified value, brake drum can be installed easily.

Notice:
Be sure to push up the auto-adjuster lever. Failure to do so will result in damage to the teeth of auto-adjuster gear.
Take care not to damage the rubber boot with the screw driver.



2. Install the brake drum.
3. Rotate the brake drum and depress the brake pedal as far as possible.

Caliper and Support



Legend

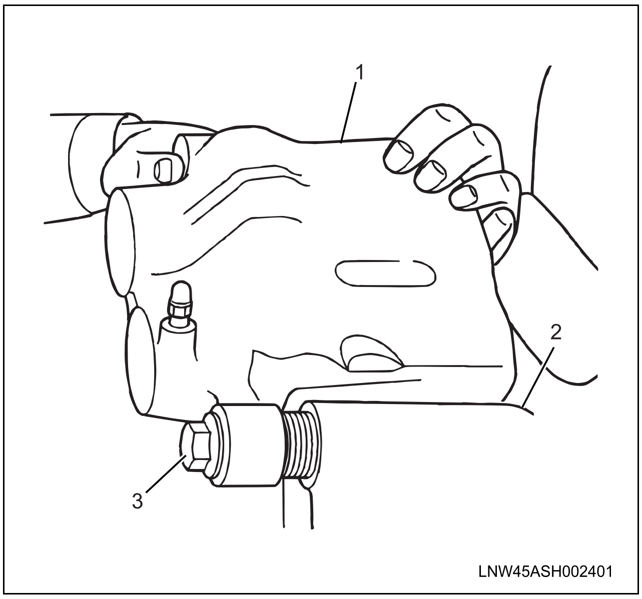
1. Caliper Assembly
2. Guide Pin (Green)
3. Flexible Hose
4. Lock Pin (Yellow)
5. Inner Pad (Pad Kit)
6. Pin Boot (Seal Kit)
7. Support Assembly
8. Pad Clip (Pad Kit)
9. Outer Pad (Pad Kit)
10. Wind Guide
11. Adapter
12. Piston Boot (Seal Kit)
13. Piston
14. Piston Seal (Seal Kit)
15. Body Assembly
16. Pin Bolt

Removal Procedure

- Block vehicle wheels and apply the parking brake.
- Rise the axle to clear the tire from the ground. Position jack stands under vehicle.
- Remove the wheel.

Notice:
Seal parts cannot be reused. When reassembling, be sure to replace with a new seal kit.

1. Flexible hose.
2. Pin bolt (Lock pin side).
3. Caliper assembly.
   - Slide the caliper assembly free from the inside.



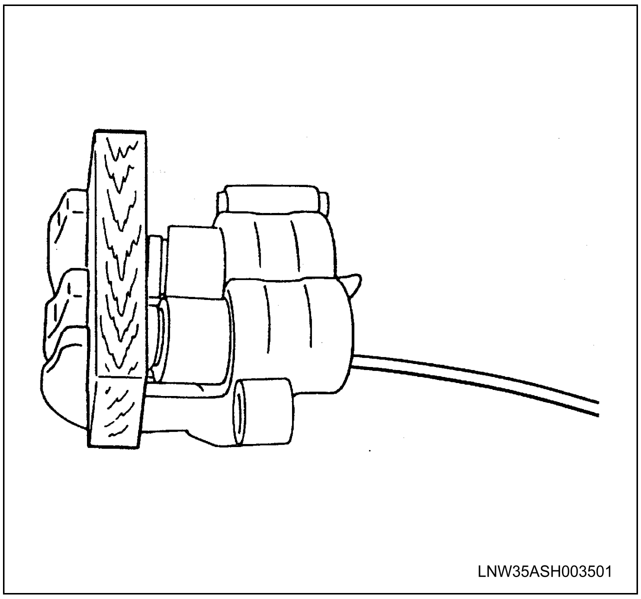
Legend

1. Caliper Assembly
2. Support Assembly
3. Pin Bolt

4. Outer pad.
5. Inner pad.
6. Pad clips.
7. Support assembly.
   - Remove the hub and disc before removing the support assembly.
     Refer to Hub and Disc section in this manual.
8. Wind guide
   - Remove the hub and disc before removing the wind guide.
     Refer to Hub and Disc section in this manual.
9. Adapter.

Disassembly Procedure

1. Place a piece of wood across the body assembly to prevent piston damage.
2. Apply approximately 196 kPa (28 psi) of compressed air to the body assembly oil port to remove the pistons.

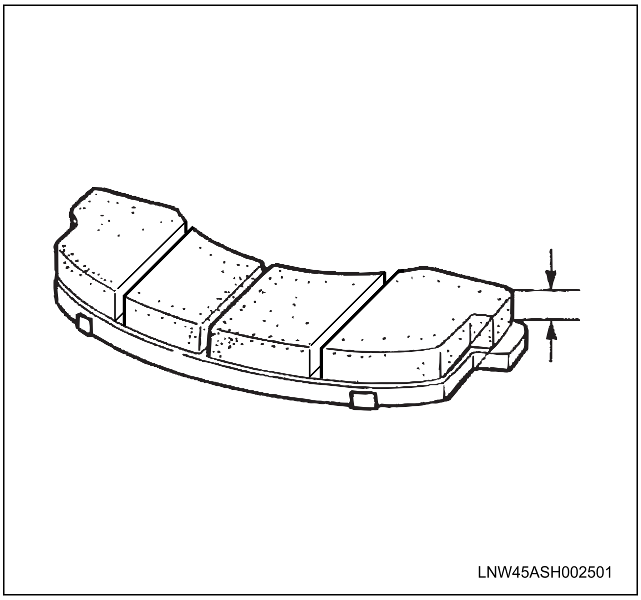


Inspection

1. All parts for wear distortion or other conditions and replace as needed.
2. Inner and outer pads.
   - Use a vernier caliper to measure the inner pad and outer pad thickness.

Pad Thickness	mm (in)
Standard	13 (0.51)
Limit	1 (0.04)

   - If the measured value is less than the specified limit, the pads must be replaced with the repair pad kit.

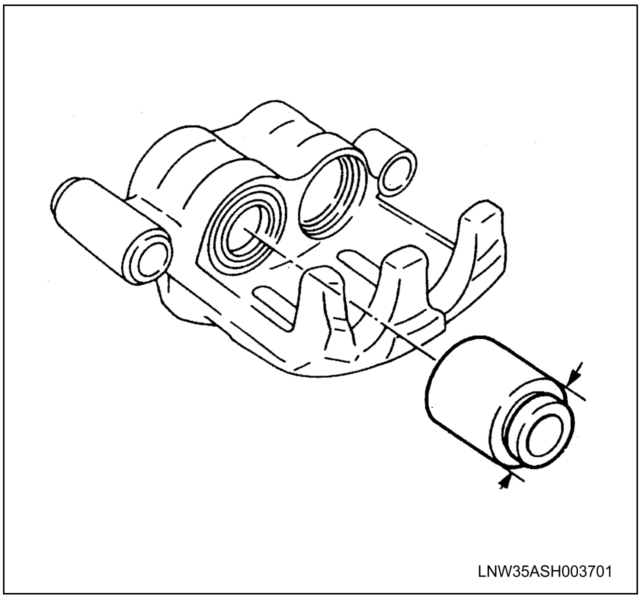


3. Piston and Cylinder Clearance.

- Use a micrometer to measure the piston diameter.
- Use an inside dial indicator to measure the cylinder bore.
- Calculate the piston and cylinder bore clearance.

Piston and cylinder bore clearance	mm (in)
Standard	0.08–0.18 (0.003–0.007)
Limit	0.23 (0.009)

- If the clearance exceeds the specified limit, the piston and/or the body assembly must be replaced along with the repair seal kit.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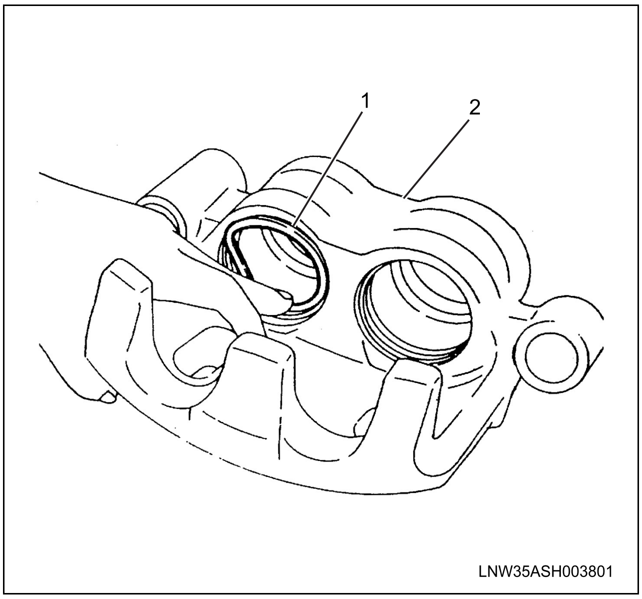
Reassembly Procedure

1. Piston Seal
   - Be sure to use a new seal ring.
   - Apply rubber grease to the piston seal. The rubber grease is included in the seal kit.
   - Install the piston seal to the cylinder bore groove.



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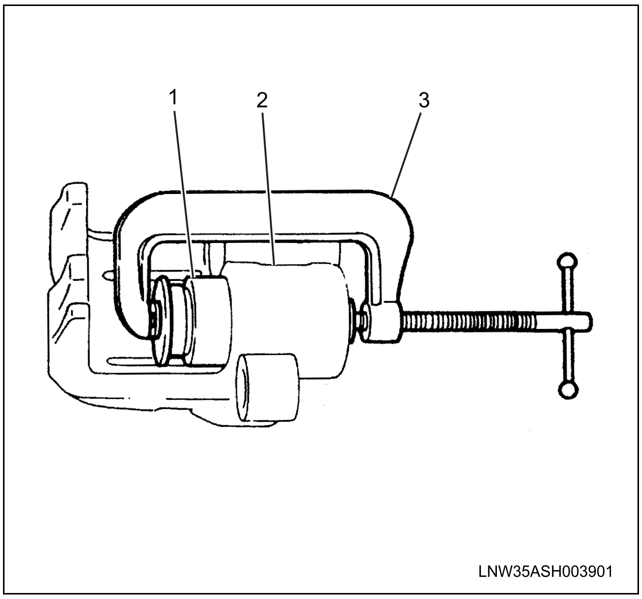
Legend

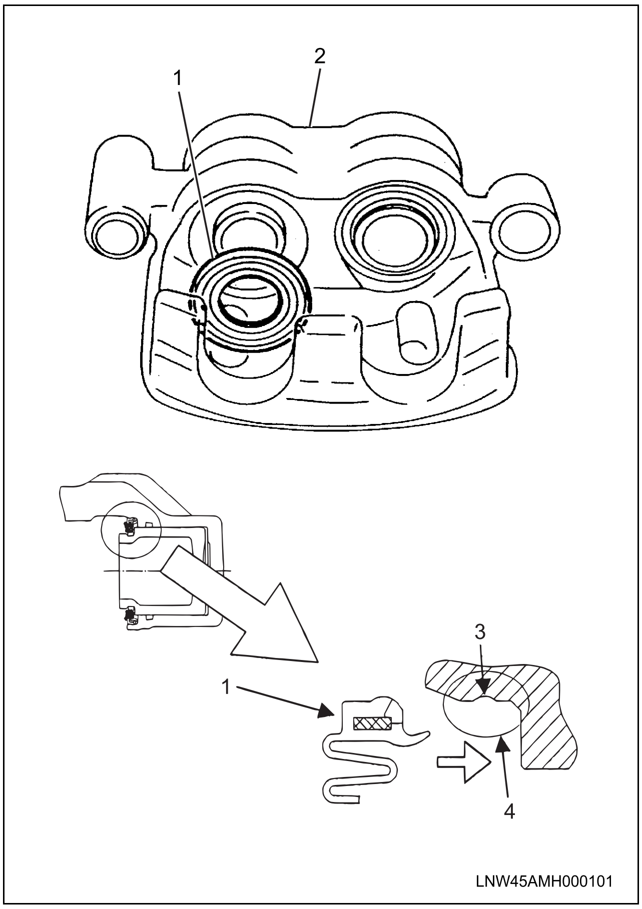
1. Piston Seal
2. Body Assembly

---

2. Piston and Piston Boot.
   - Apply brake oil to the piston outer circumference.
   - Use a hand vise to install the pistons to the cylinder.
   - Apply special grease to the piston.
     This will prevent cylinder and piston corrosion.
   - Use a new piston boot.
     Do not confuse the front and rear sides of the boot.
     Carefully press the insert portion of the boot into the cylinder body groove. Be sure that the insertion depth is uniform.
   - Install the piston boot inner lip to the piston groove.
     Handle the piston boot carefully.



Legend
1. Piston
2. Body Assembly
3. Hand Vise



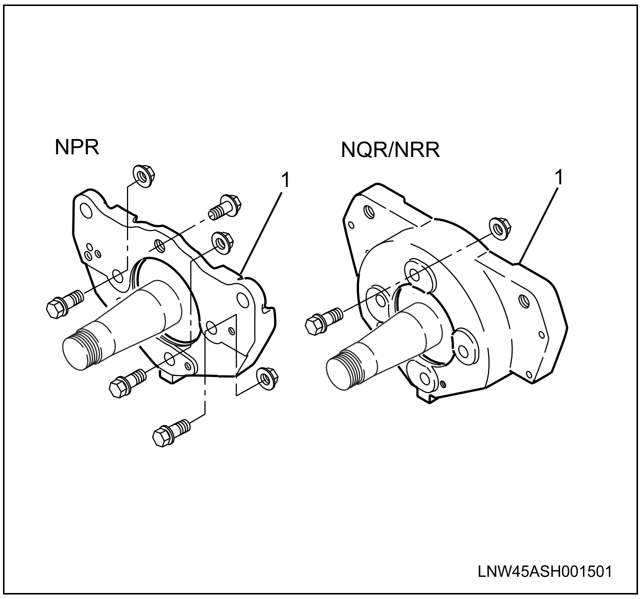
Legend
1. Piston Boot
2. Body Assembly
3. Cylinder Body Groove
4. Boot Insert Portion

Installation Procedure

1. Adapter
   - Install the adapter to the knuckle.
   - Tighten the fixing bolts and nuts to the specified torque.

Tighten

- Fixing bolts and nuts to 162 N·m (119 lb ft).

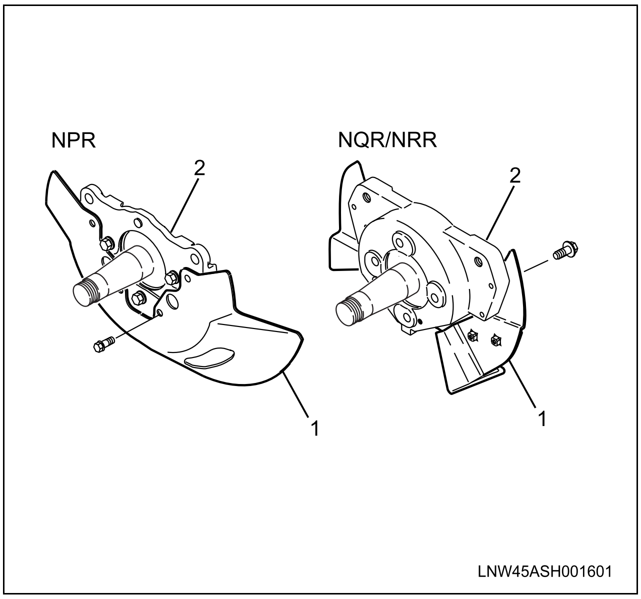


Legend
1. Adapter

2. Wind Guide
   - Tighten the fixing bolts to the specified torque.

Tighten

- Fixing bolts to 13 N·m (113 lb ft).



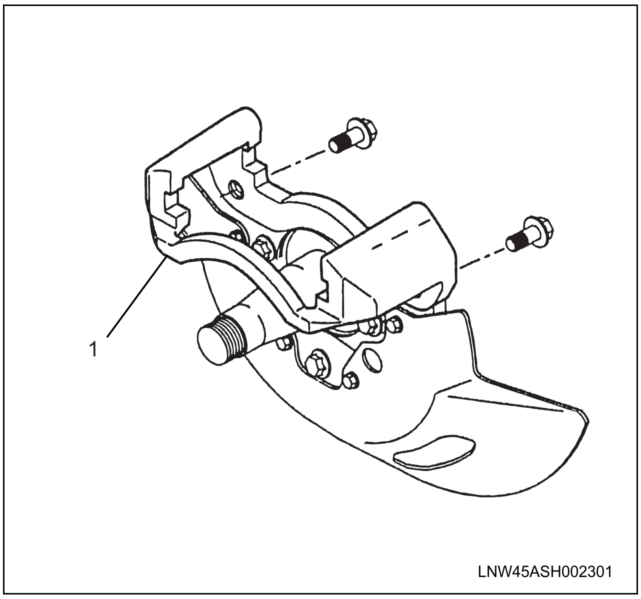
Legend
1. Wind Guide
2. Adapter

3. Support Assembly

- Tighten the fixing bolts to the specified torque.

Tighten

- Fixing nuts to 221 N·m (163 lb ft).

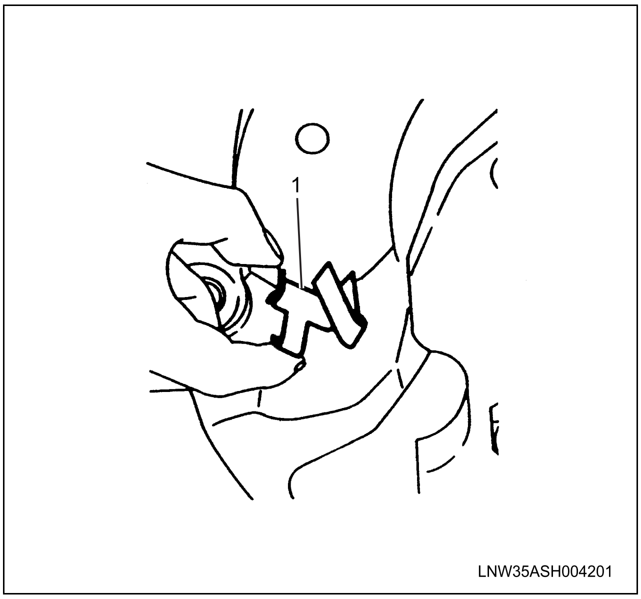


Legend

1. Support Assembly

---

4. Pad Clips
   - Be sure that the clips are completely installed to the support assembly.

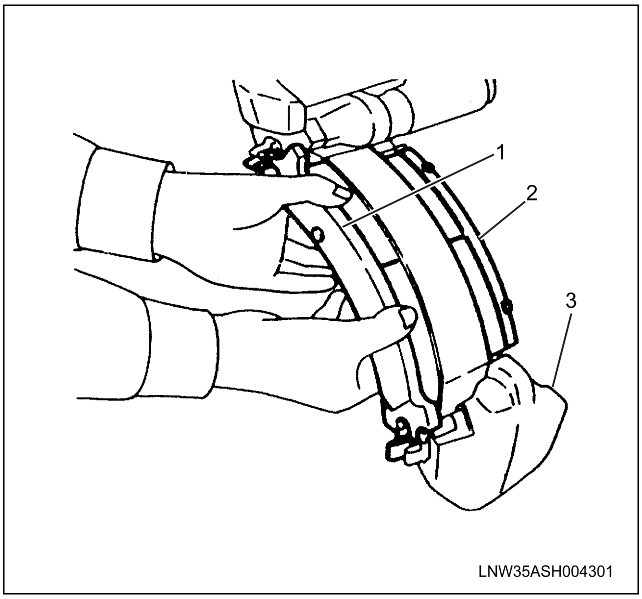


Legend

1. Pad Clip

---

5. Pads
   - Install the inner pad and the outer pad to the support assembly.

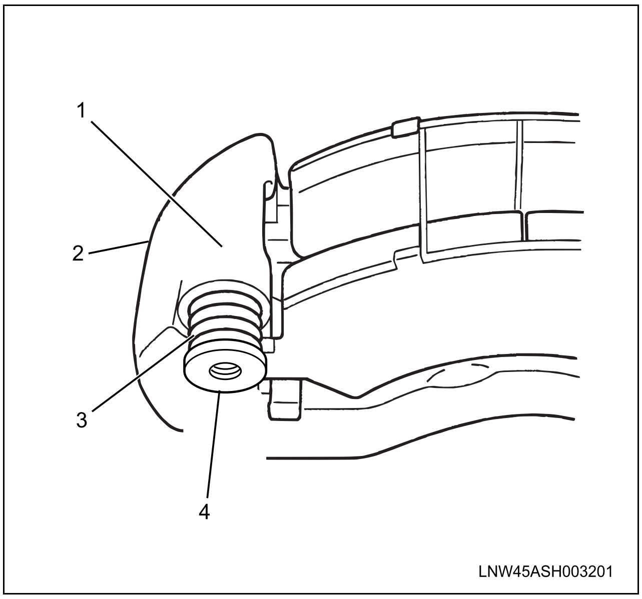


Legend

1. Outer Pad
2. Inner Pad
3. Support Assembly

---

6. Pin Boot
   - Under normal conditions, there is no need to remove the pin boot.
   - Apply approximately 1g (0.035 oz) of special grease to the pin boot bore and pin boss bore of support.
     This will prevent pin corrosion.
     The special grease is included in the seal kit.
   - Install the pin boot to the support assembly.
   - Check that the pin boot is securely inserted to the groove.



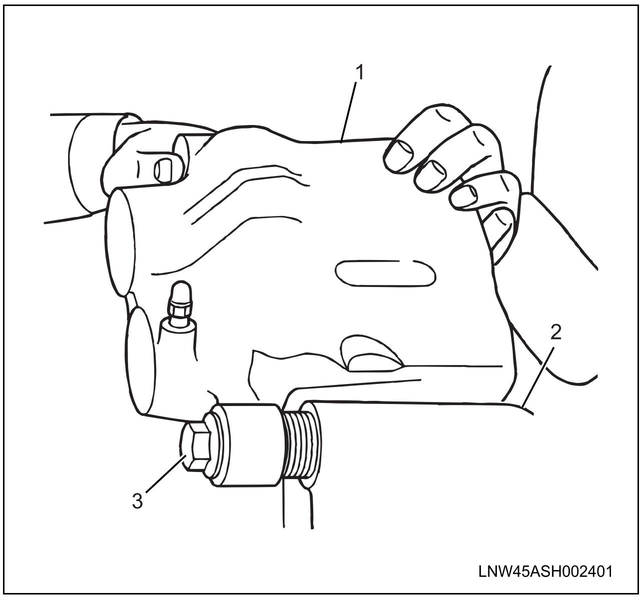
Legend

1. Pin Boss of Support
2. Support Assembly
3. Pin Boot
4. Pin

7. Caliper Assembly and Bolt (Lock pin side)
    - Install the caliper assembly to the support assembly guide pin from the inside.
    - Install the pin boot lip to the guide pin groove.
    - Return the caliper assembly to its original position.
      Take care not to pinch the sleeve boot.
    - Tighten the bolt (lock pin side) to the specified torque.

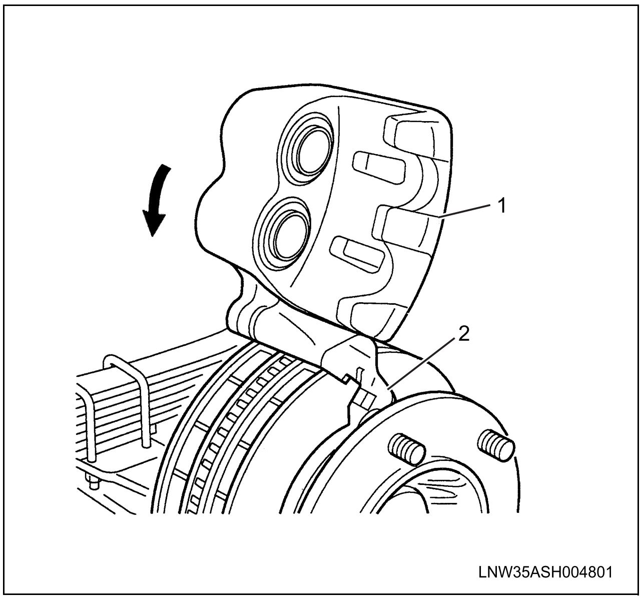
Tighten

- Bolt (Lock pin side) to 125 N·m (92 lb ft).



Legend

1. Caliper Assembly
2. Support Assembly
3. Pin Bolt



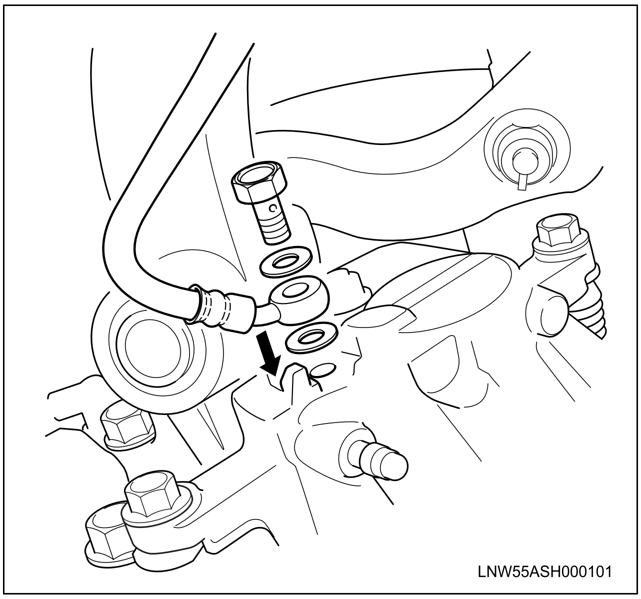
Legend

1. Caliper Assembly
2. Support Assembly

8. Flexible Hose
    - Tighten the flexible hose bolt to the specified torque.

Tighten

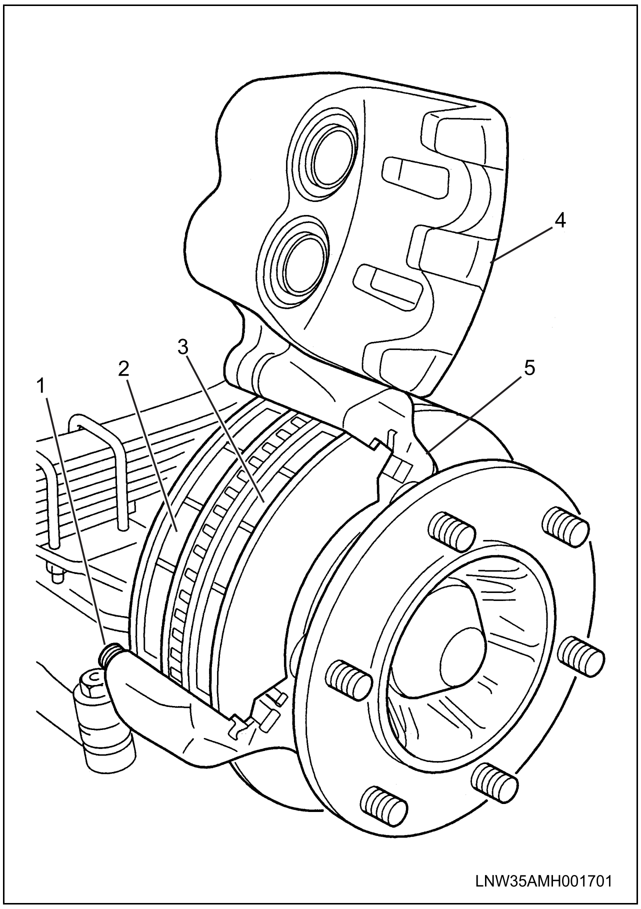
- Hose bolt to 34 N·m (25 lb ft).



Air Bleeding

Refer to Air Bleeding.

Front Disk Brake Pad



Legend

1. Bolt (Lock Pin side)
2. Inner Pad
3. Outer Pad
4. Caliper Assembly
5. Support Assembly

Removal Procedure

- Block vehicle wheels and apply the parking brake.
- Rise the axle to clear the tire from the ground. Position jack stands under vehicle.
- Remove the wheel.

1. Loosen and remove the lock pin bolt from the lower side of the caliper.
2. Turn the caliper assembly up and wire it to the frame firmly so that the hose is not stretched.

Important:

- Do not disconnect the brake hose.

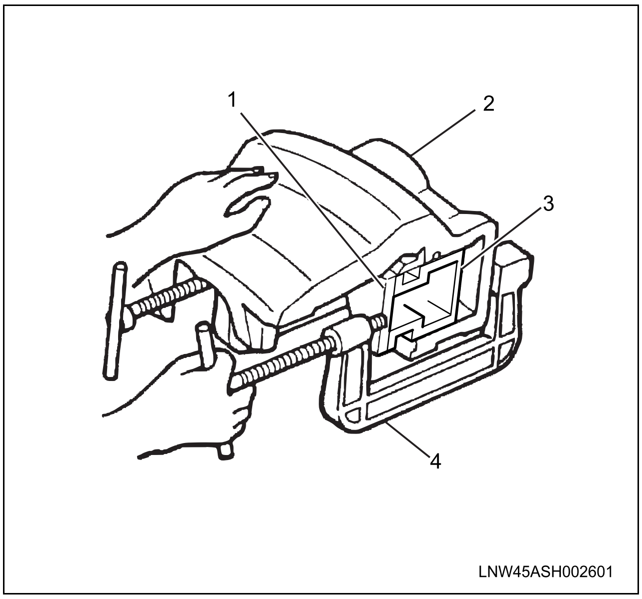
3. Remove the pad assembly with clips.
4. Conduct disc wear check, and resurface or replace it as required.
5. When removing brake disc, slide caliper assembly inside of the vehicle, and take out brake disc from support assembly.
   Take care not to wipe the special grease from guide pin, and prevent from sticking dust or any foreign material to guide pin.
6. Refer to Front Axle and Suspension of this manual for disc wear check and replacement procedures.

Installation Procedure

1. Keep the rotor face away from the brake oil or grease.
2. Use a hand vise to push the piston backward until it reaches the cylinder bottom, as the piston was pushed forward by the distance where the pad worn.

Important:

- When using a hand vise, push the piston at its center.



Legend

1. Steel Plate
2. Caliper Assembly
3. Piston
4. Hand Vise

3. Remove hand vise and install the new pads along with new clips.

Important:

- Be careful not to assemble the inner and outer pad reversely.

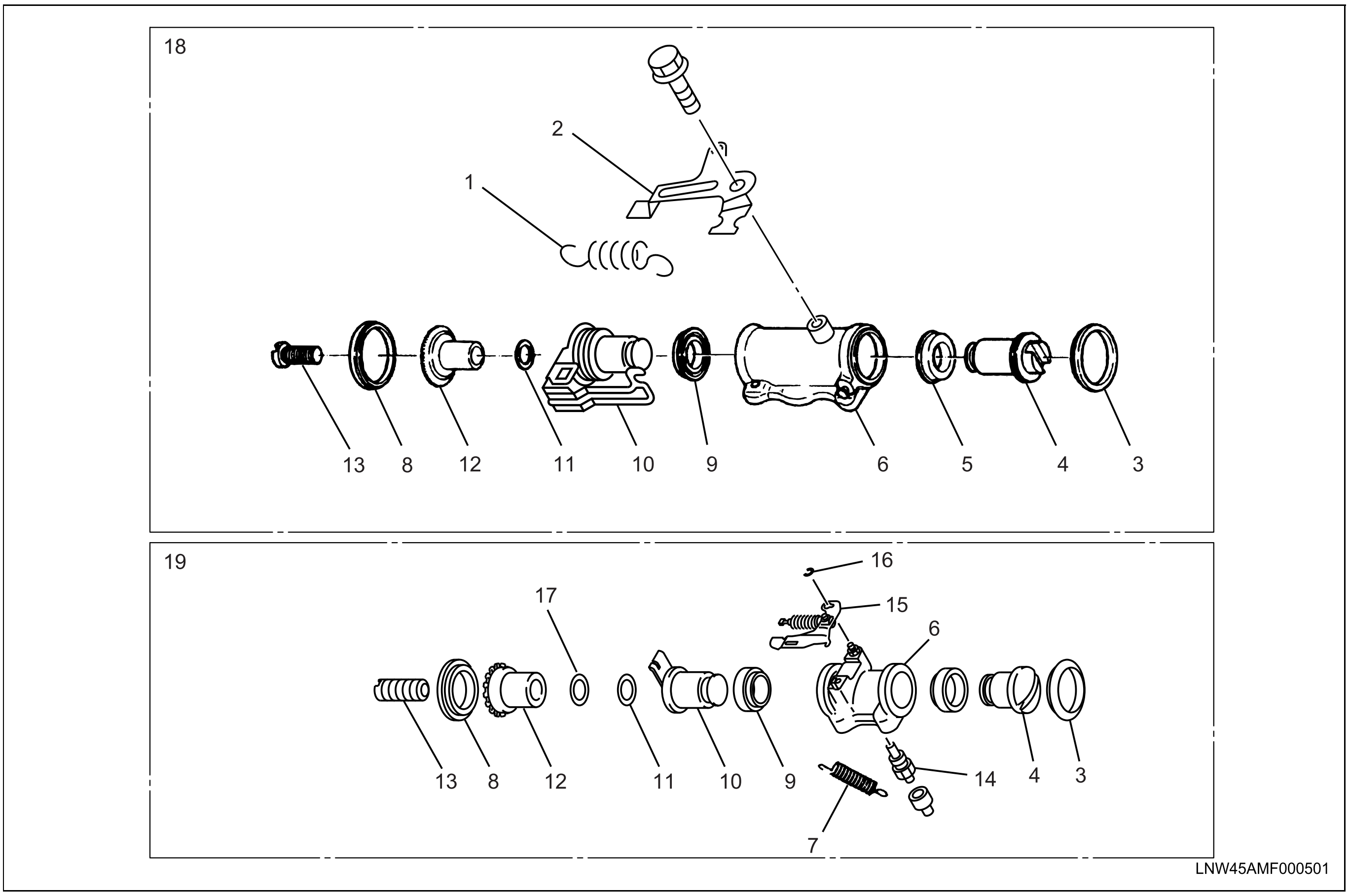
4. Install the bolt (Lock pin side) into the lock pin by turning the caliper carefully so that the piston boot and pin boot may not be wedged.
   After assembling the caliper assembly, make sure that the piston boot and pin boot fitted correctly, and not damaged.

5. Tighten the bolt to the specified torque.

Tighten

- Bolt to 125 N·m (92 lb ft).

Wheel Cylinder



Legend

1. Overtravel Spring
2. Adjuster Lever
3. Boot
4. Piston
5. Piston Cup
6. Cylinder Body
7. Return Spring
8. Boot
9. Piston Cup
10. Piston
11. Washer (Oil less)
12. Adjuster Gear
13. Adjusting Screw
14. Bleeder
15. Adjuster Lever
16. Snap Ring
17. Washer (Stainless Steal)
18. Except GVWR 19,500 lb Model
19. GVWR 19,500 lb Model

Preparation

Remove and install wheel cylinders as described in Brake Disassembly previously in this section.

Disassembly Procedure

1. Auto-adjuster. Refer to Auto-adjuster later in this section.
2. Boot.
3. Piston.
4. Adjusting screw.
5. Adjuster gear.
6. Washer.
7. Piston cup.
8. Piston.
9. Bleeder screw and cap.
10. Cylinder body.

Clean

1. Wash all parts to be reused in clean brake fluid.

2. Allow parts to air-dry on clean paper or lint-free cloth.

Inspection

1. Repair kits are available which contain the parts to be replaced when overhauling wheel cylinders.
   Refer to Parts Book for repair kit part numbers.
2. Inspect cylinder bore for scores, scratches, or corrosion.
   Light scratches or slightly corroded spots may be polished out with crocus cloth. Never use emery cloth or sandpaper.
   If scratches or corrosion are too deep to be polished out, replace cylinder.
   Staining should not be confused with corrosion. Corrosion can be identified as pits or excessive roughness.
3. Check fit of new pistons in the cylinder bore.
   Clearances should be within limits of the following table.

GVWR (lb)	Wheel Cylinder Diameter mm (in)		Clearance mm (in)	
			New	Limit
12,000	Rear	26.99 (1.0626)	0.02-0.105 (0.0008-0.041)	0.15 (0.0059)
14,500	Rear	30.16 (1.1874)	0.03-0.126 (0.0012-0.005)	0.15 (0.0059)
17,950	Rear	33.34 (1.313)	0.025-0.126 (0.001-0.005)	0.15 (0.0059)
19,500	Rear	33.34 (1.313)	0.025-0.126 (0.001-0.005)	0.15 (0.0059)

Notice:
Do not hone wheel cylinder bores. When wheel cylinders are overhauled, it is recommended that the cylinder bore be replaced rather than "cleaned up" by honing the bore. Wheel cylinder bores have a hard, highly polished "bearingized" surface, which is produced by diamond boring followed by ball or roller burnishing under heavy pressure. Honing will destroy this surface, leaving a softer and rougher surface which will cause more rapid wear of rubber seal cups.

It is permissible to clean minute surface irregularities with crocus cloth, providing the irregularity is small enough to clean up by this method.
Before assembling wheel cylinder, clean each part in brake fluid.

Notice:
Dip each internal part in hydraulic brake fluid before assembling. Do not use kerosene or gasoline for cleaning wheel cylinder parts. The use of these as solvents, or any other with a trace of mineral oil, will damage rubber parts.

Installation Procedure

1. Cylinder body.

Notice:
Refer to Description and Operation.

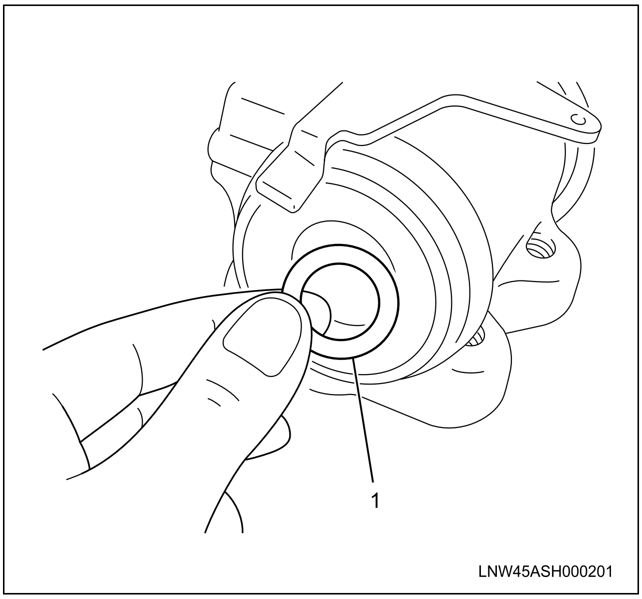
2. Bleeder screw and cap.

Tighten

- Bleeder screw to 9 N·m (78 lb in).

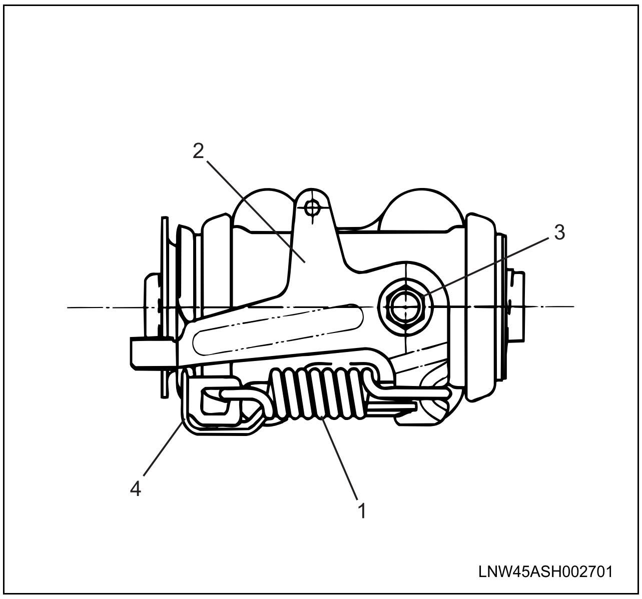
3. Boot.
4. Piston Cup.
5. Piston.
6. Washer.

Caution:
(Except GVWR 19500 lb model)
Install the washer with the copper-colored side facing in (the black-coated side of the washer must be facing the adjuster nut). If the washer is installed backwards, the auto-adjuster will not function correctly.



7. Adjuster gear.
8. Adjusting screw.
9. Piston.
10. Boot.
11. Auto adjuster. Refer to Auto Adjuster.

Auto-Adjuster (Except GVWR 19,500 lb Model)



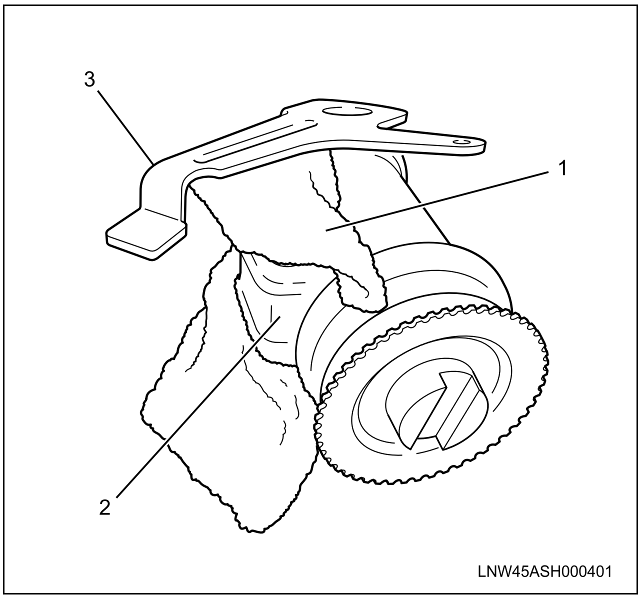
Legend

1. Spring
2. Adjuster Lever
3. Adjuster Lever Fixing Bolt
4. Bracket

Disassembly

- Insert a clean rag between the adjuster lever and the spring. This will prevent damage to the parts.

1. Remove the adjuster lever fixing bolt.
2. Place the adjuster lever on the bracket.

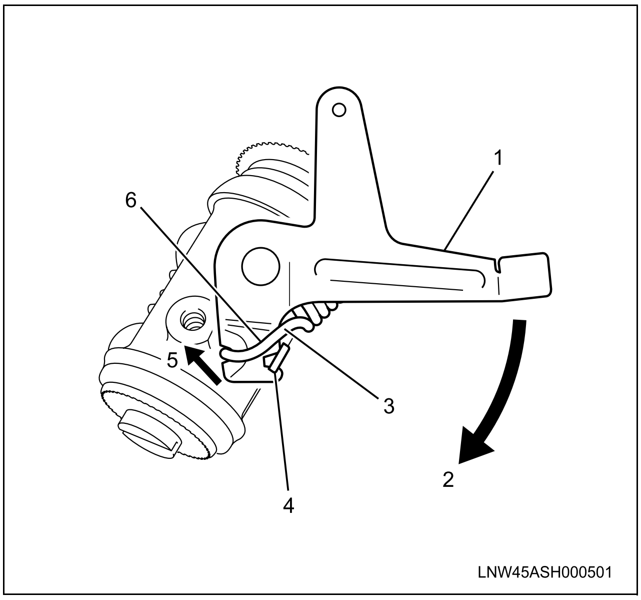


Legend

1. Rag
2. Bracket
3. Adjuster Lever

---

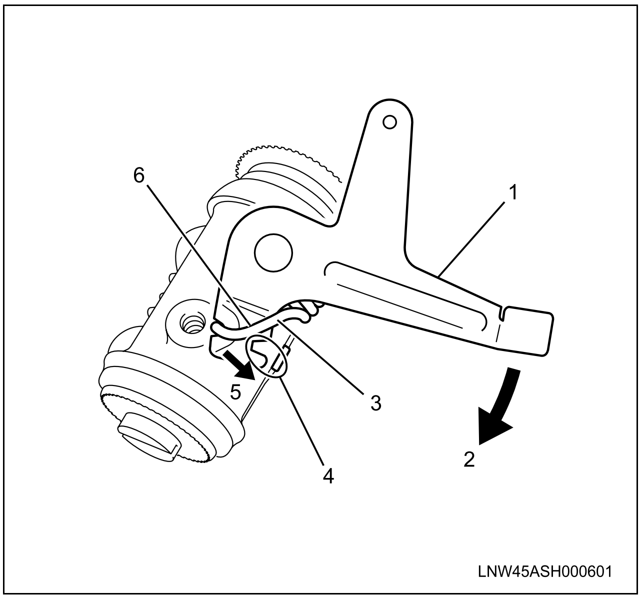
3. Using the lever (1) and spring (6) contact surfaces as a fulcrum (3), turn the lever in the direction of the arrow (2) in the illustration. The lever and bracket (4) will disengage (5) as the spring length increases.



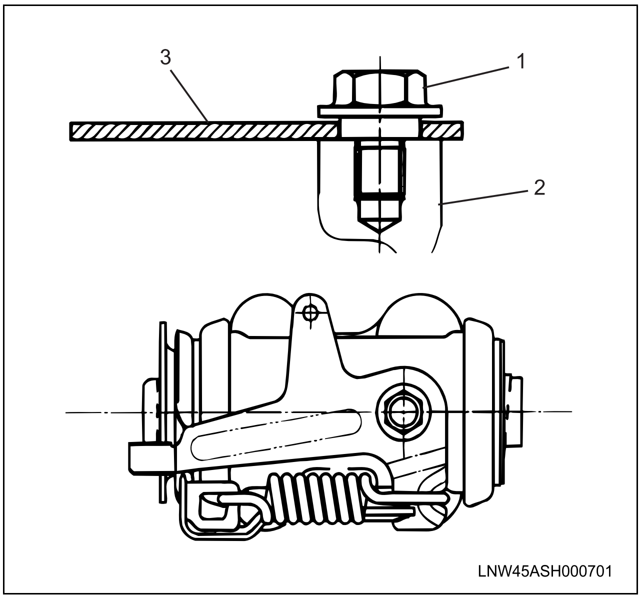
4. Remove the spring.

Reassembly

1. Attach the short spring hook to the square hole in the bracket and the long spring hook to the adjuster lever.
2. Using the lever (1) and spring (6) contact surfaces as a fulcrum (3), turn the lever in the direction of the arrow (2) in the illustration. The lever and bracket (4) will move towards (5) each other as the spring length increases.



3. Tighten the adjuster lever fixing bolt. Do not allow the lever to become pinched between the bolt sleeve and the body.



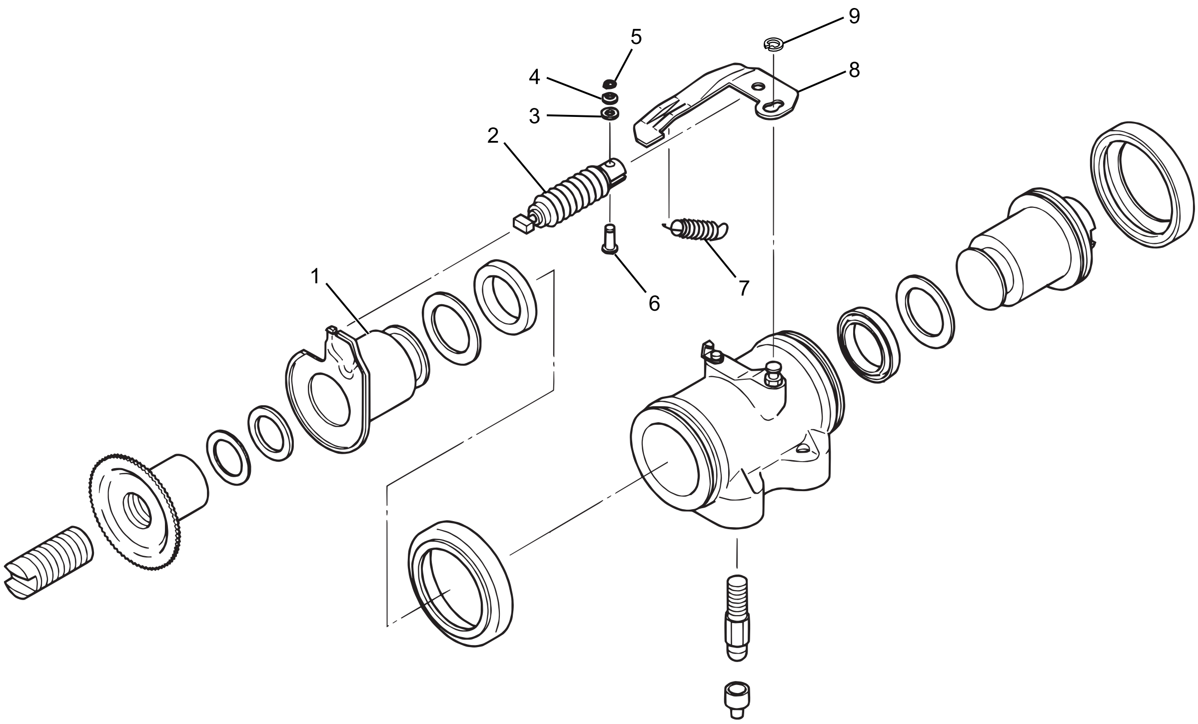
Legend

1. Adjuster Lever Fixing Bolt
2. Wheel Cylinder Body
3. Adjuster Lever

---

4. Check that the lever is pressed against the adjuster gear.

Auto-Adjuster (GVWR 19,500 lb Model)



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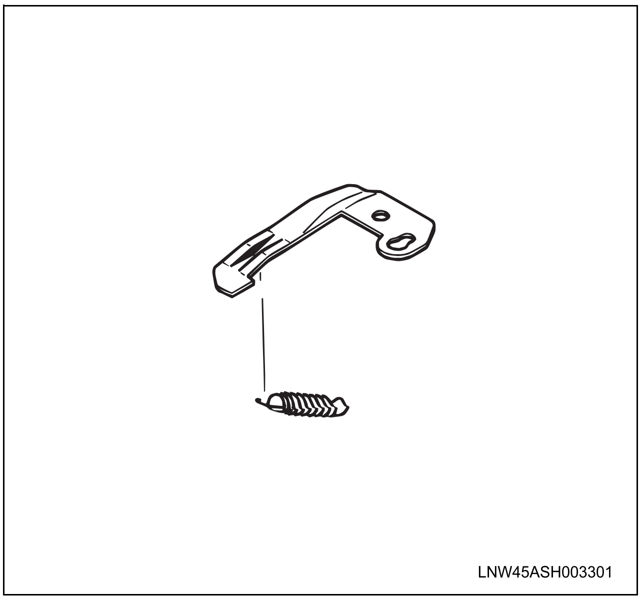
Legend

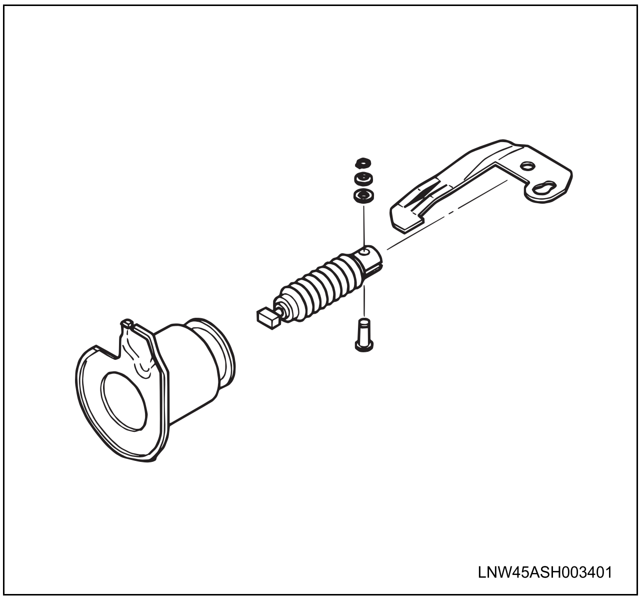
1. Piston
2. Spring Assembly
3. Washer
4. Wave Washer
5. Snap Ring
6. Pin
7. Return Spring
8. Lever
9. E-ring

Removal Procedure

1. Return spring



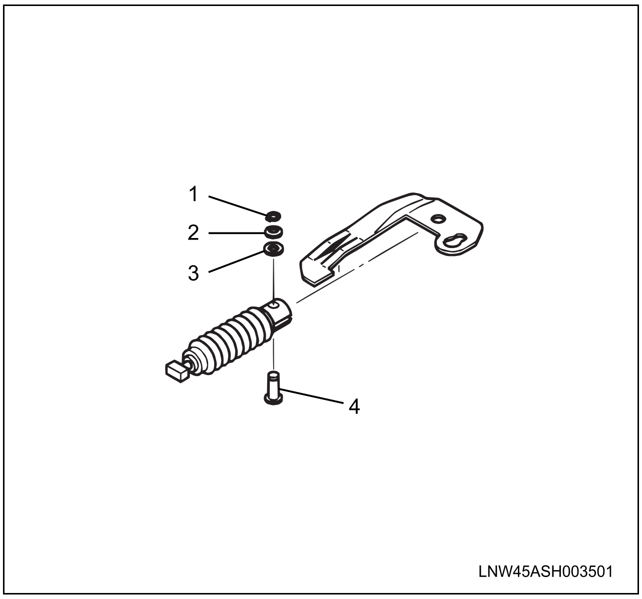
2. E-ring
3. Lever
4. Snap ring
5. Wave washer
6. Washer
7. Pin
8. Spring assembly
    - Do not disassemble the spring assembly.



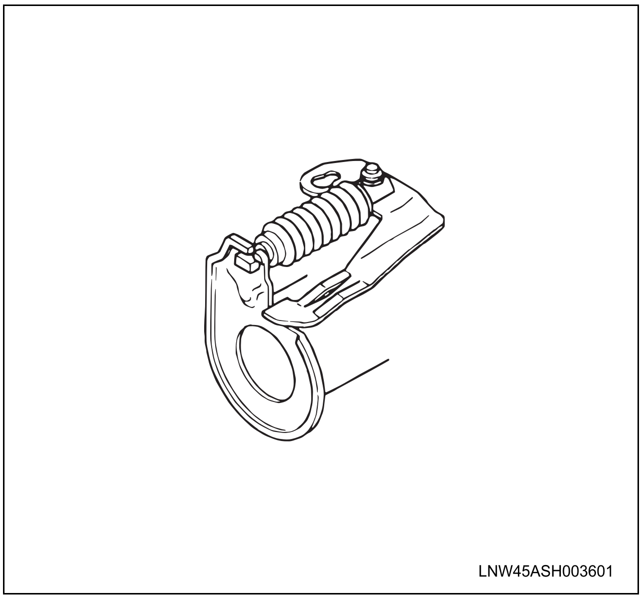
Installation Procedure

1. Lever
2. Pin
3. Washer
4. Wave washer
5. Snap ring
6. Spring assembly
7. E-ring

- Install the pin (4), spring assembly, washer (3), wave washer (2) and snap ring (1) to the lever.

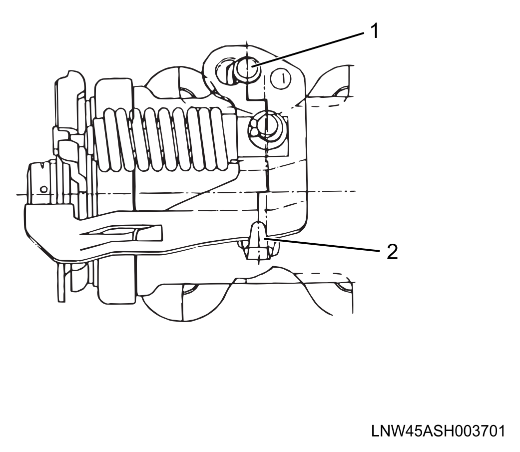


- Place the cylinder assembly in a vise. Install the spring assembly to the piston flange groove.

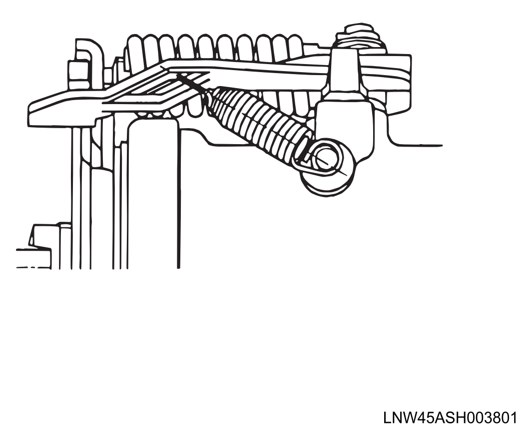


- Bring the lever close to the cylinder hook (2). Stretch the spring assembly and hold it. Install the lever to the cylinder pin (1).

- Install the E-ring.



8. Return spring
   - Install the return spring (coil side with hook) to the cylinder.

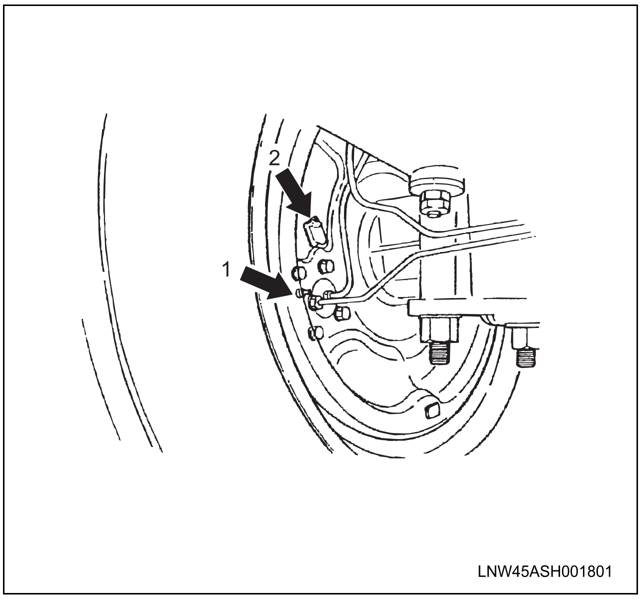


Brake Drum Removal and Installation (Except GVWR 19500 lb)

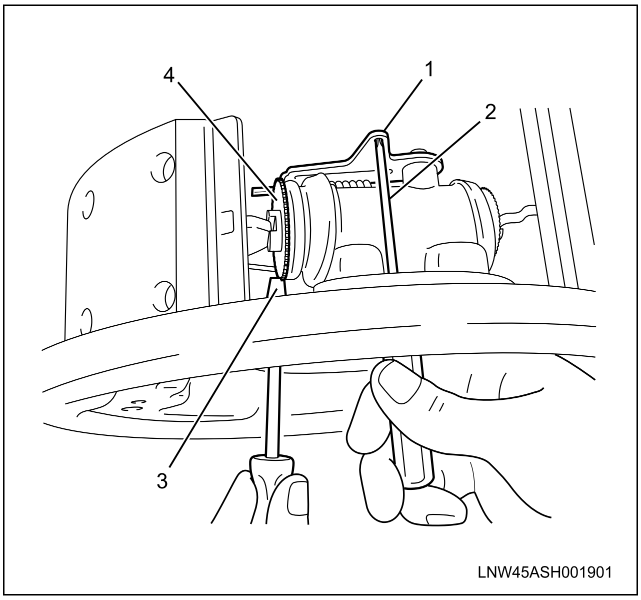
Removal Procedure

- Block vehicle wheels and apply the parking brake.
- Raise the axle to clear the tire from the ground. Position jack stands under vehicle.

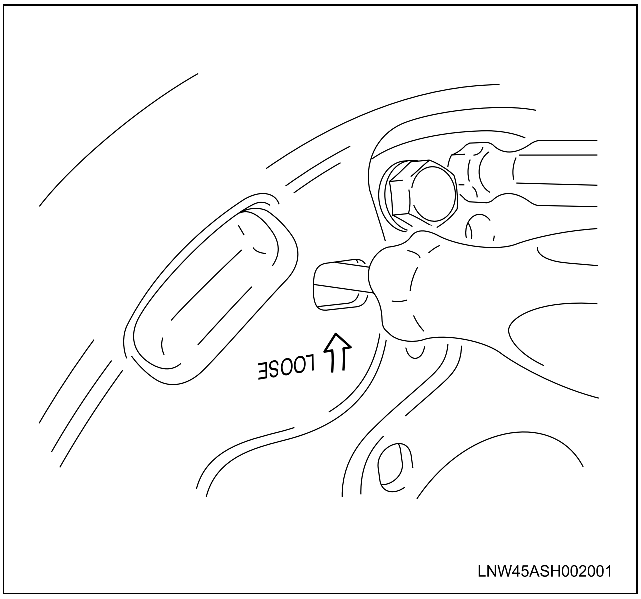
1. Wheel and tire assembly.
   - Refer to Wheels And Tires in this manual.
2. Brake drum.
   - Mark the brake drum to the rear hub.
   - Remove adjuster lever release hole cover (1) and adjuster hole cover (2).



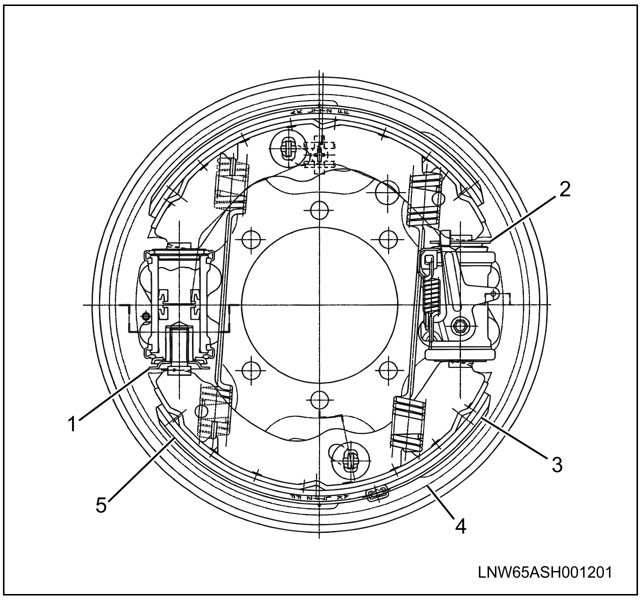
   - Insert a rod (2) through the adjuster lever release hole. Use the rod to press against the adjuster lever (1).
   - Insert a screwdriver (3) through the adjuster hole. Use the screwdriver to rotate the adjuster gear (4) in the direction of the arrow on the back plate. This adjusts the clearance between the brake lining and the brake drum.



- Turn the adjuster gear in the direction of the arrow on the back plate.



Installation Procedure



Legend

1. Adjuster
2. Adjuster
3. A
4. B
5. C

---

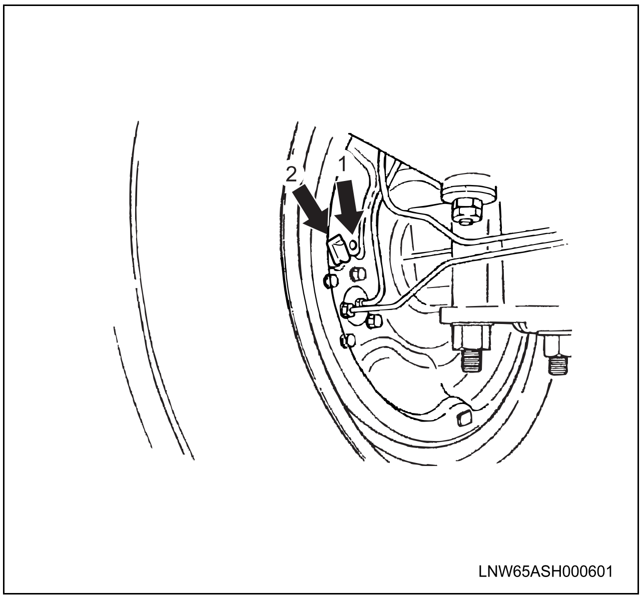
1. Set the brake shoe outside diameter so that the brake lining clearance is approximately 0.6 mm (0.024 in).
   Check the clearance at three positions (A, B and C).
   This will facilitate brake lining clearance adjustment after brake drum installation.
2. Brake drum.
   - Align the mark made during removal.
   - Brake drum setting bolts.
3. Wheel and tire assembly.
   - Refer to Wheels and Tires section in this manual.
4. Rotate the brake drum.
   Depress the brake pedal as far as possible.
5. Repeat Step 4 five times to automatically adjust the brake drum clearance.

Brake Drum Removal and Installation (GVWR 19500 lb)

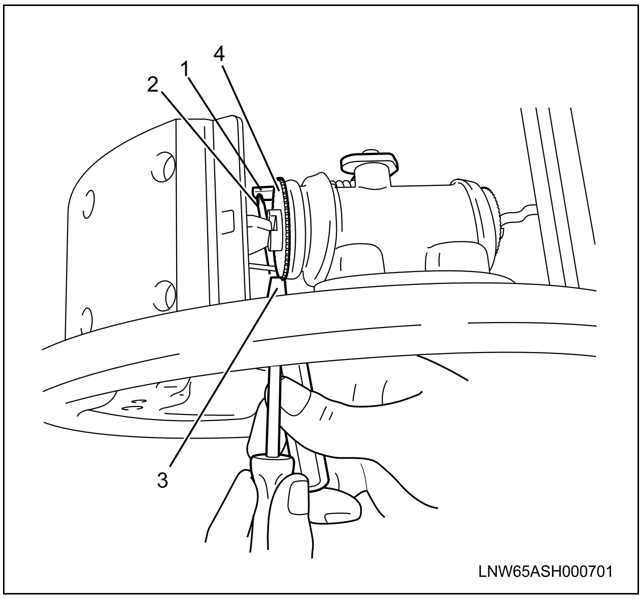
Removal Procedure

- Block vehicle wheels and apply the parking brake.
- Raise the axle to clear the tire from the ground. Position jack stands under vehicle.

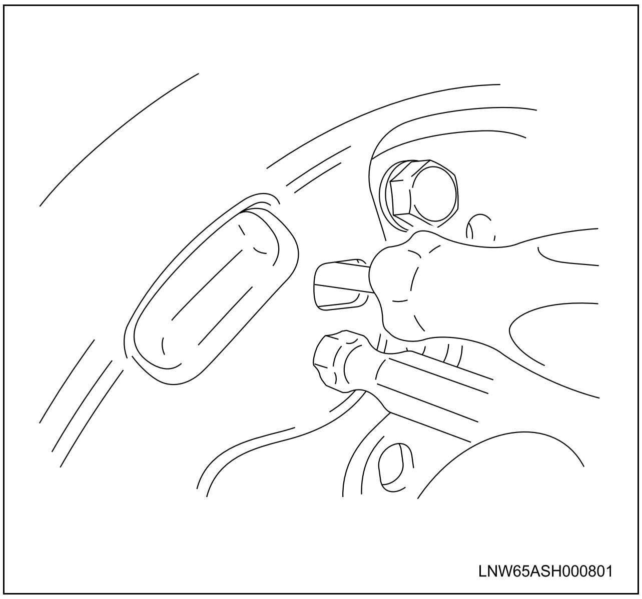
1. Wheel and tire assembly.
   - Refer to Wheels And Tires in this manual.
2. Brake drum.
   - Mark the brake drum to the rear hub.
   - Remove adjuster lever release hole cover (1) and adjuster hole cover (2).



   - Insert a rod (2) through the adjuster lever release hole. Use the rod to press against the adjuster lever (1).
   - Insert a screwdriver (3) through the adjuster hole. Use the screwdriver to rotate the adjuster gear (4) in the direction of the arrow on the back plate. This adjusts the clearance between the brake lining and the brake drum.

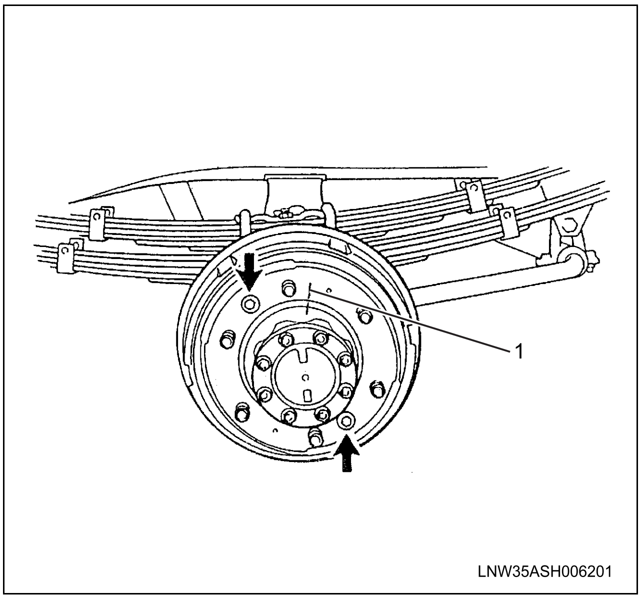


- Turn the adjuster gear.



Caution:
Be sure to press against the adjuster lever when rotating the adjuster gear. Failure to do so will result in damage to the adjuster gear.

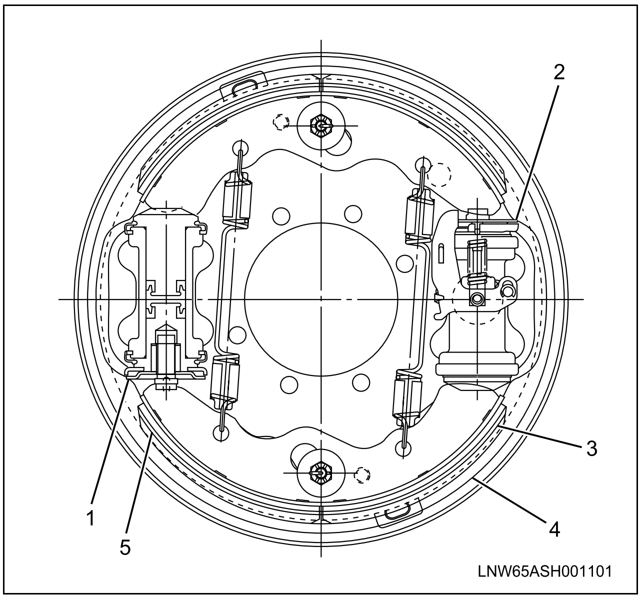
- Brake drum setting bolts.



Legend

1. Mark

Installation Procedure



Legend

1. Adjuster
2. Adjuster
3. A
4. B
5. C

---

1. Set the brake shoe outside diameter so that the brake lining clearance is approximately 0.6 mm (0.024 in).

   Check the clearance at three positions (A, B and C).

   This will facilitate brake lining clearance adjustment after brake drum installation.
2. Brake drum.
   - Align the mark made during removal.

   - Brake drum setting bolts.
3. Wheel and tire assembly.
   - Refer to Wheels and Tires section in this manual.
4. Rotate the brake drum.
   Depress the brake pedal as far as possible.
5. Repeat Step 4 five times to automatically adjust the brake drum clearance.

Notice:
Brake lining clearance can also be automatically adjusted by depressing the brake pedal as far as possible with the vehicle in motion.

Do this several times to ensure accurate adjustment.

Brake Linings

Brake Shoe Relining

Brake linings on these models are riveted to the brake shoes and may be replaced. These linings may be purchased in replacement sets of linings and sufficient rivets of correct specifications for the rear axle. Refer to Parts Book for lining replacement kits. When replacing linings, be sure that shoes have been thoroughly cleaned and all burrs or rough spots have been removed from shoe surface. Do not use shoes with elongated rivet holes. Install linings in a manner that will prevent gaps between lining and shoe.
Do not let brake fluid, oil, or grease tough the brake lining.

Riveting New Linings and Shoes

Before riveting new linings and shoes, be sure shoe and lining contact faces are clean. Have rivets of the correct body diameter, head size and shape, length, and material ready for use.

1. Remove old linings by drilling out rivets.
   Punching out rivets may distort or damage the shoe rim. File off any burrs or high spots.
2. Clamp the lining to the brake shoe with C-clamps so the rivet holes in both pieces are in alignment.
   Keep hands clean while handling brake linings.
3. Locate the C-clamps as close as possible to the rivet holes; clamp firmly in position.
4. Start riveting at center of shoe and lining and work toward the ends.
5. Drive rivets squarely into the holes with a flat head drift.
6. Form the rivet heads with the correct tubular rivet set. A roll set is recommended as a star set might split the tubular end and then the rivet will not fill the hole.
7. After riveting is completed, check lining to shoe contact with 1.0 mm (0.04 in) feeler gauge.
   Measure midway between rivets. It should not be possible to insert a 1.0 mm (0.04 in) feeler gauge between the lining and shoe.

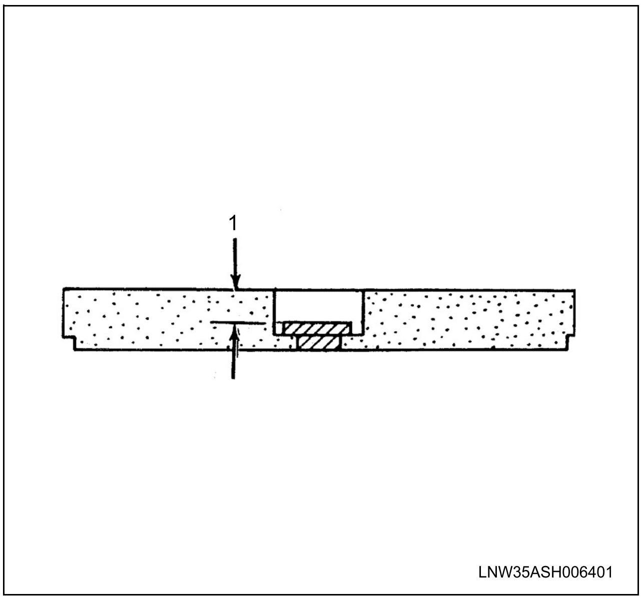
Brake Lining Checks

The following procedure is for use when brake action is unequal, severe, hard, noisy, or otherwise is unsatisfactory and the brake linings have had little wear.

1. Check fluid level in master cylinder reservoir. Add fluid as necessary.
2. Check brake pedal for proper feel and return.
3. Remove wheels and drums. Brake pedal must not be operated while drums are removed.
4. Clean and inspect drums. Replace or recondition as necessary.
5. Clean brake assemblies. Inspect linings for uneven wear, oil soaked, embedded foreign material, and loose rivets. If linings are oil soaked, they should be replaced.
6. If linings are otherwise serviceable, tighten or replace loose rivets, remove embedded foreign material, and clean rivet counterbores.
7. If linings at any wheel show a spotty wear pattern or uneven contact with brake drum, it is an indication that the linings are not centered in the drums. Linings should be circle ground to provide better contact with the drum.
8. Check and torque brake assembly mounting bolt nuts.

Brake Lining Replacement Check

Brake linings are considered to be worn out when worn down to the rivet heads; however, it is suggested that, for practical reasons, linings be replaced when found to be worn to 1.0 mm (0.04 in) over the rivet heads.



Legend

1. Clearance to Rivet Head
   1.0 mm (0.04 in)

Brake Drums

Brake Drum Checks

The brake drum and linings should be checked whenever a wheel and drum assembly is removed from the vehicle.

Inspection

Tool Required:
Starrett No. 124, Inside Micrometer, or equivalent.

1. Visually check drum for cracks, scoring, pitting, or grooves.
2. Check edge of drum for cracks or broken areas.
3. Drum should not be "blue" inside, glazed (glassy appearance), or severely heat-checked. Severe heat-check will cause rapid lining wear. These conditions are a result of severe overheating, possibly from too thin remachined drums, not complete or spotty lining contact, incorrect linings, or overloading of the vehicle. A probable driver complaint would be brake-fade.
4. If linings appear unevenly worn, check the drum for barrel-shaped or bell-mouthed (taper) condition. Maximum allowable taper is 0.08 mm (0.003 in) measured from outside edge to base of drum to lining contact surface.
5. Check for out-of-round condition on the diameter using an inside micrometer, Starrett No. 124, or equivalent. Measure drum of the machined surface at a minimum of 4 locations (45 degrees apart) and record the readings. A maximum of 0.38 mm (0.015 in) out-of-round is allowed. A typical driver complaint would be pulsating brakes.
6. Remove drum from wheel and inspect for stress cracks at mounting bolt holes.

Servicing Brake Drums

Caution:
When servicing wheel brake parts, do not create dust by grinding or sanding brake linings or by cleaning wheel brake parts with a dry brush or with compressed air. Many wheel brake parts contain asbestos fibers which can become airborne if dust is created during servicing.
Breathing dust containing asbestos fibers may cause serious bodily harm. A water-dampened cloth or water-based solution should be used to remove any dust on brake parts. Equipment is commercially available to perform this washing function.
These wet methods will prevent asbestos fibers from becoming airborne.

Clean the outside of the drum of mud, dirt, rust, or other accumulation of materials. Clean inside of drum with a water-dampened cloth. Do not paint the outside of the drum. Paint will act as an insulator and prevents rapid heat dissipation.
New drums must have the protective coating removed from the friction surface before being placed in service. Use a suitable non-toxic, greaseless type and wipe the surface clean with clean cloths.

Notice:
Do not use gasoline, kerosene, or other oil base solvents. These solvents may leave an oily residue on the surface which is damaging to the brake linings and is flammable.

A drum with slight scores or grooves should be polished with fine emery cloth. A grooved drum, if used with a new lining, will not only wear the lining quickly but also will not obtain efficient brake performance.
Severe scoring, pitting or grooves, and barrel-shaped, bell-mouthed, or out-of-round condition, and severe checking requires the drum to be replaced.
A cracked drum is unsafe for further service and must be replaced. Do not weld and reuse a cracked drum.

Machining

Machining or grinding of brake drums increases the inside diameter of the drum and changes the lining to drum fit. When machining drums, it is recommended that the maximum oversizes listed not be exceeded.

Drum Diameter

GVWR	Nominal	Limit
12,000 lb 14,500 lb 17,950 lb	320 mm (12.60 in)	321.5 mm (12.66 in)
19,500 lb	370 mm (14.56 in)	372mm (14.64 in)

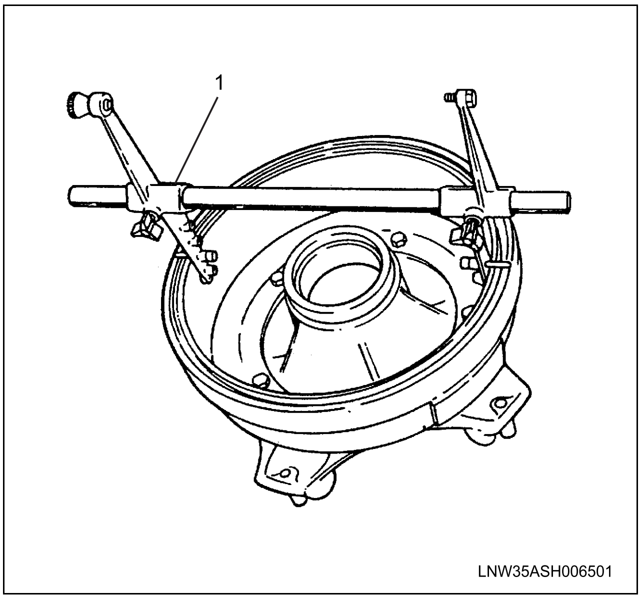
When it is found that machining to this maximum limit does not provide a suitable braking surface, discard the worn drum and replace with a new standard drum.

Notice:
Do not exceed these limits. This is a safety precaution. With severely worn drums, the possibility of drum failure increases and subsequent brake malfunction.

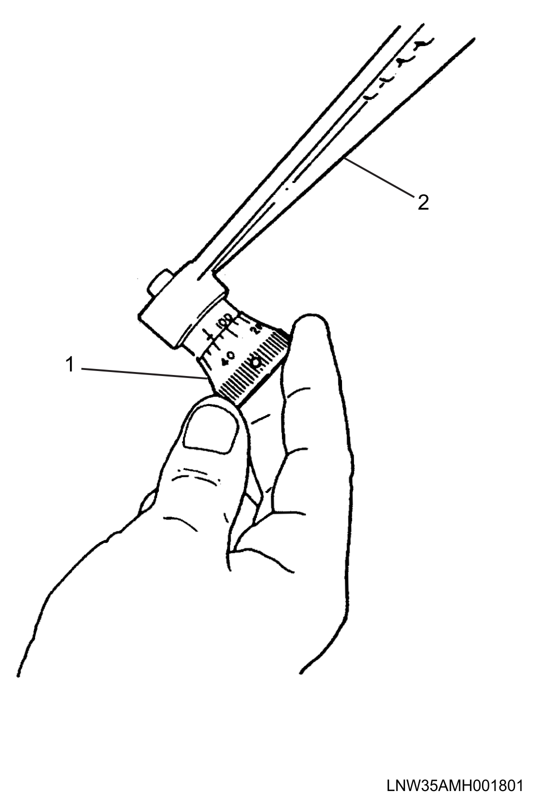
Replacement

Refer to Brake Drum Removal and Installation earlier in this section.
Drum to Lining Clearance Gage J 22364-01 is available to aid in replacement of drums or linings.

1. Measure brake drum inside diameter using tool J 22364-01.
2. Turn adjusting knob to desired clearance, approximately 0.8 mm (0.03 in) is recommended 0.4 mm (0.015 in) to each side.
3. Adjust brake shoes to just touch tool.



Legend
1. J 22364-01



Legend
1. Adjusting Knob
2. J 22364-01

Specifications

Foundation Brake specifications

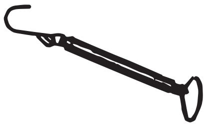
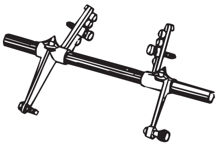
GVWR		12,000 lb	14,500 lb	17,950 lb	19,500 lb
Brake Type	Front	Disc			
	Rear	Drum-Dual Two Leading			
	Adjustment	Self			
Lining Size	Length	307 mm (12.1 in)	335 mm (13.2 in)		387 mm (15.2 in)
	Width	75 mm (2.95 in)	100 mm (3.94 in)	120 mm (4.72 in)	150 mm (5.90 in)
	Thickness	9.6 mm (0.38 in)	11.0 mm (0.43 in)		12.3 mm (0.48in)
	Lining to Rivet Clearance Limit	1.0 mm (0.04 in)			
Shoe Return Springs	Free Length	208.0 mm (8.19 in)	198.4 mm (7.81 in)	197.7 mm (7.78 in)	209.3 mm (8.24 in)
	Set Length	224.0 mm (8.82 in)	219.1 mm (8.63 in)		226.0 mm (8.90 in)
	Set Load	220.6 – 269.7 N (49.6 – 60.6 lb)	220.6 – 269.7 N (49.6 – 60.6 lb)	291-356 N (65.5 – 80.0 lb)	292.2-357 N (65.7-80.2 lb)
Wheel Cylinder	Inside Diameter	26.99 mm (1.063 in)	30.16 mm (1.187 in)	33.34 mm (1.313 in)	
	Piston Clearance	0.02 – 0.105 mm (0.0008 – 0.0041 in)	0.03 – 0.126 mm (0.0012 – 0.005 in)	0.025 – 0.126 mm (0.001 – 0.005 in)	
	Piston Clearance Limit	0.15 mm (0.0059 in)			
Brake Disc	Diameter	293 mm (11.5 in)		363 mm (14.3 in)	
	Thickness	Standard 40 mm (1.57 in) Limit 37 mm (1.46 in)	Standard 42 mm (1.65 in) Limit 39 mm (1.54 in)		
	Pad Thickness	Standard 13 mm (0.51 in) Limit 1 mm (0.04 in)			
	Piston and Cylinder Clearance	Standard 0.08 – 0.18 mm (0.0031 – 0.0071 in) Limit 0.23mm (0.009 in)			
Brake Drum	Inside Diameter	320mm (12.60 in)			370 mm (14.56 in)
	Inside Diameter Limit	321.5 mm (12.66 in)			372 mm (14.64 in)
	Width	75 mm (2.95 in)	100 mm (3.94 in)	120 mm (4.72 in)	150 mm (5.90 in)

Fastener Torques

Wheel Cylinder Mounting Bolts	
GVWR 12,000 lb	44 N·m (33 lb ft)
GVWR 14,500 lb	75 N·m (55 lb ft)
GVWR 17,950 lb	94 N·m (69 lb ft)
GVWR 19,500 lb	120 N·m (89 lb ft)
Rear Mounting Plate Bolts	
GVWR 12,000 lb and 14,500 lb	108 N·m (80 lb ft)
GVWR 17,950 lb and 19,500 lb	157 N·m (116 lb ft)
Brake Pipe Nut	15 N·m (11 lb ft)
Disc Brake Caliper	
Support Fixing Bolts	221 N·m (163 lb ft)
Adapter Fixing Bolts and Nuts	162 N·m (119 lb ft)
Wind Guide Bolts	13 N·m (113 lb in)
Bolt (Lock Pin Side)	125 N·m (92 lb ft)
Flexible Hose Bolt	34 N·m (25 lb ft)
Bleeder Screw	9 N·m (78 lb in)

Special Tools

Special Tools

Illustration	Tool Number/ Description
 AAW0Z0SH001601	J 34913 Tension Scale
 AAW0Z0SH001701	J 22364 01 Drum Clearance Gage

BRAKES

Anti-Lock Brake System (ABS)

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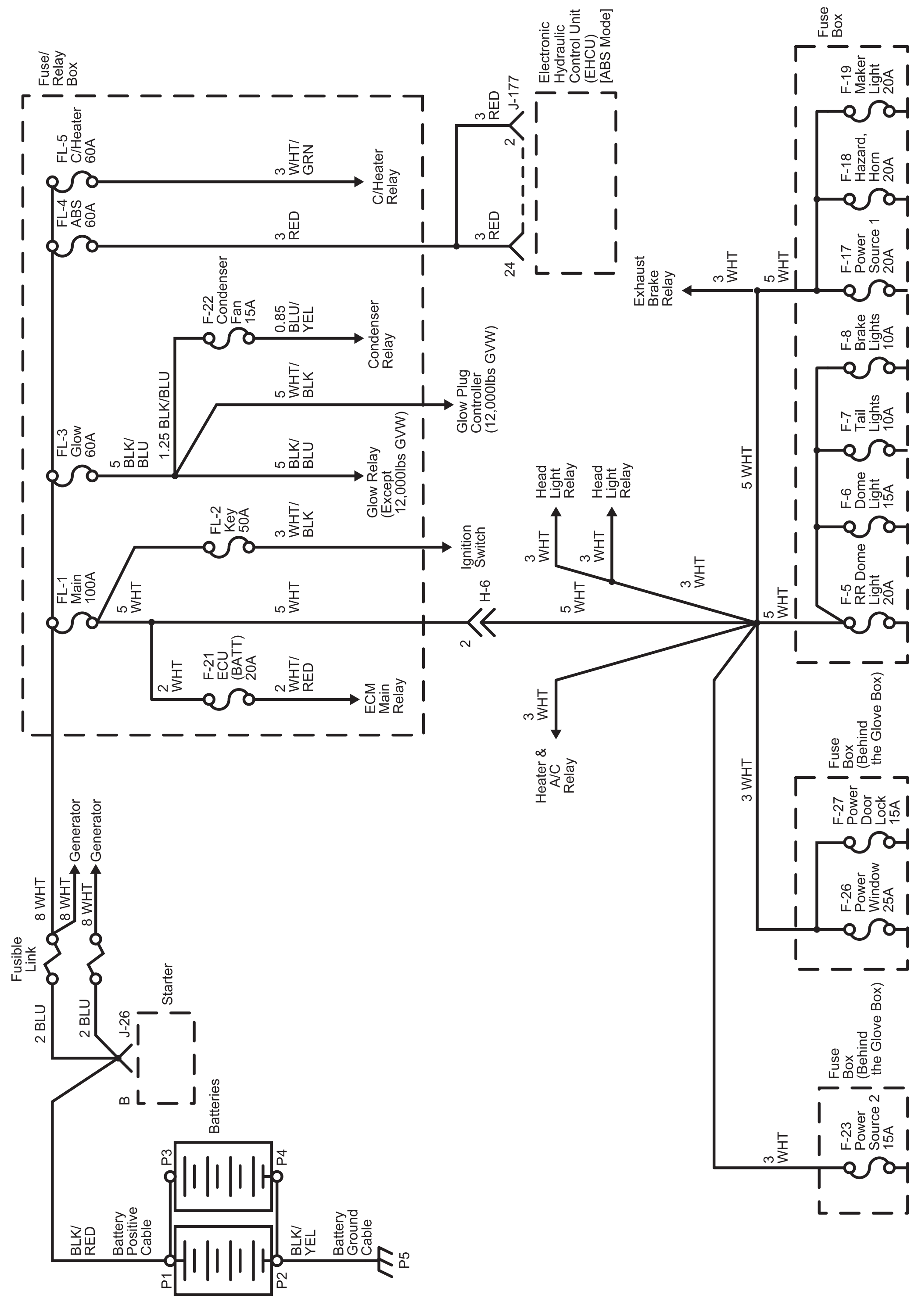
Schematic and Routing Diagrams

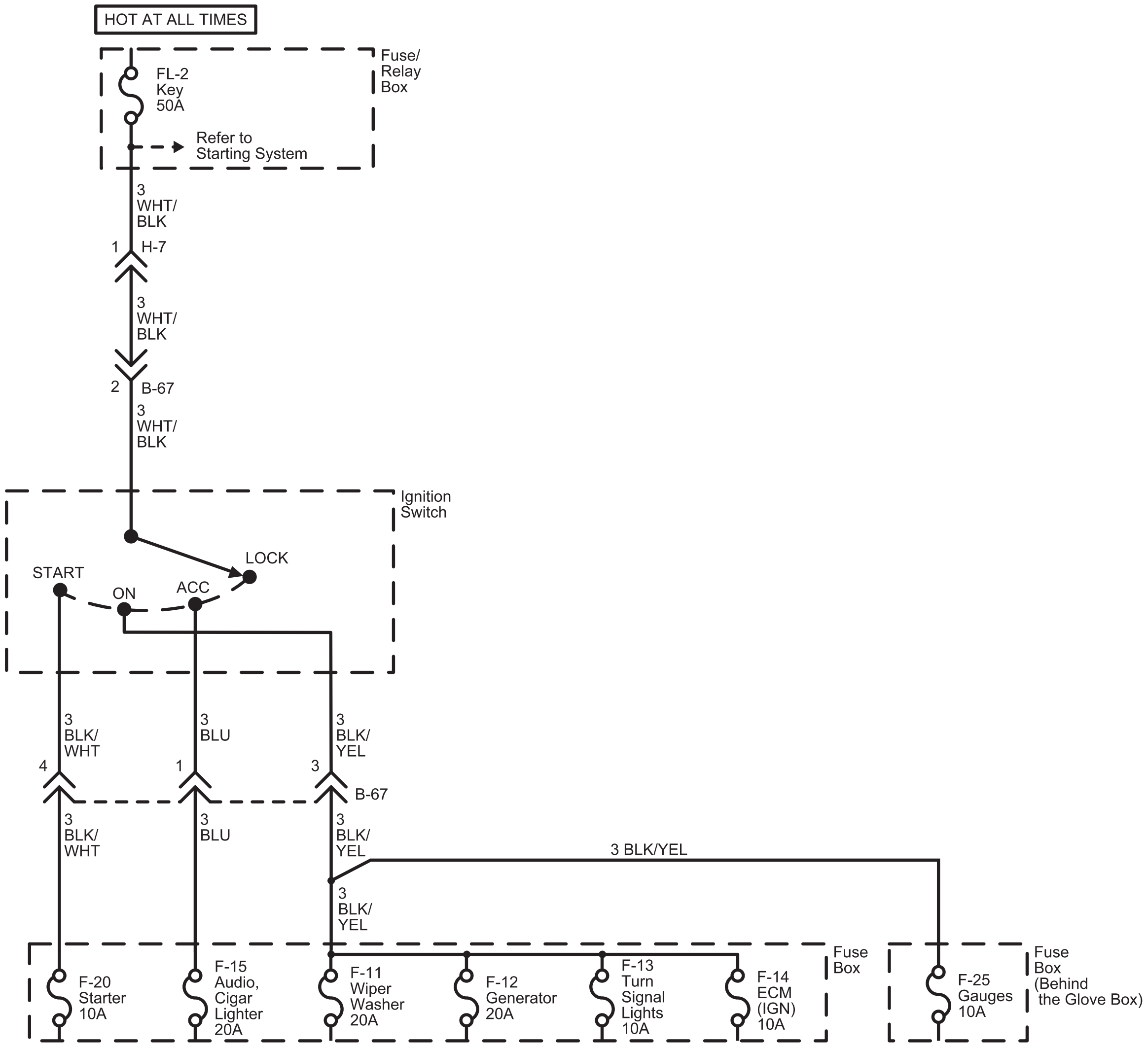
ABS Controls Schematics

Power Distribution (Hot At All Times)



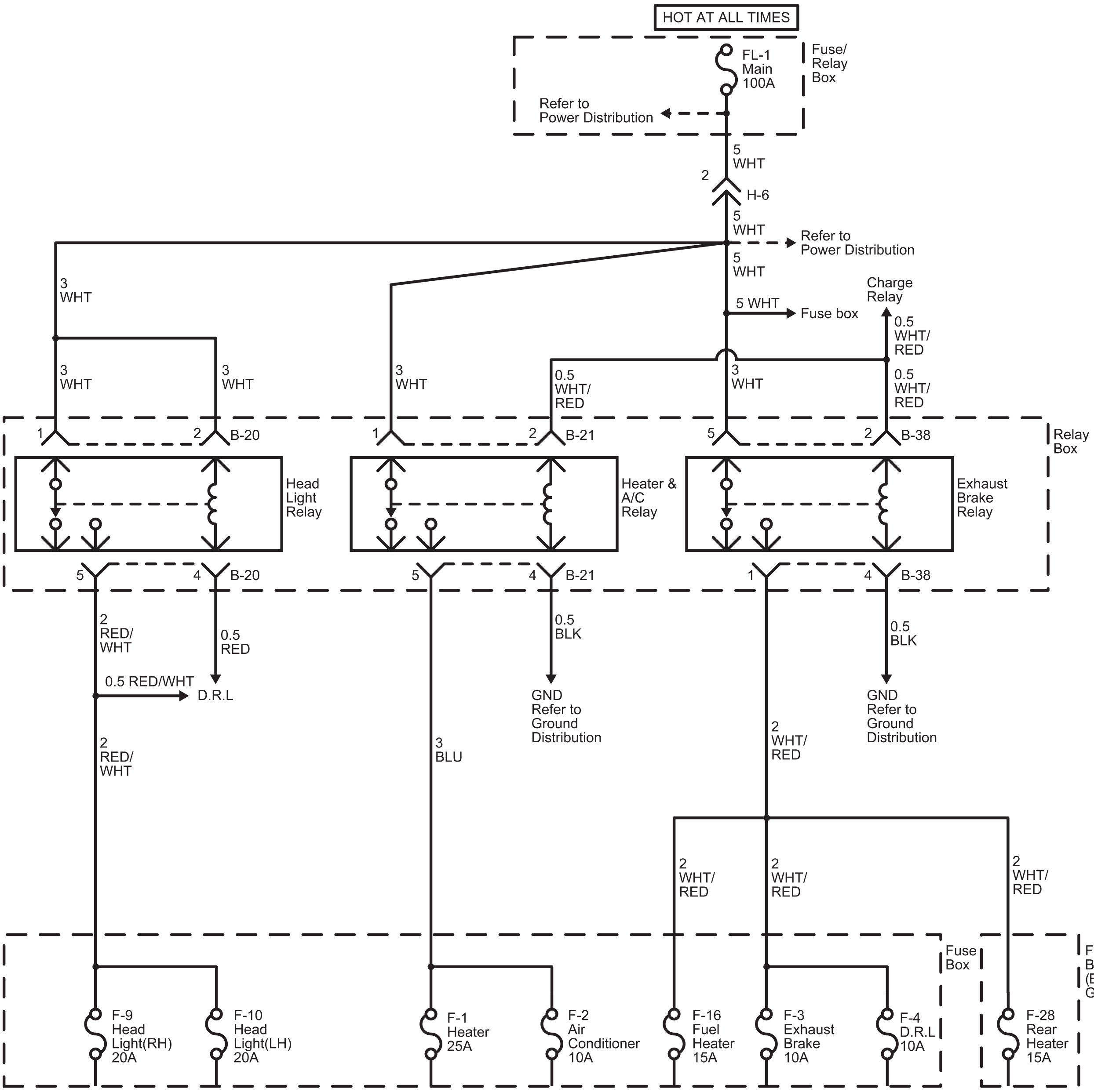
LNW66EXF000101

Power Distribution (Hot In Run) (1)



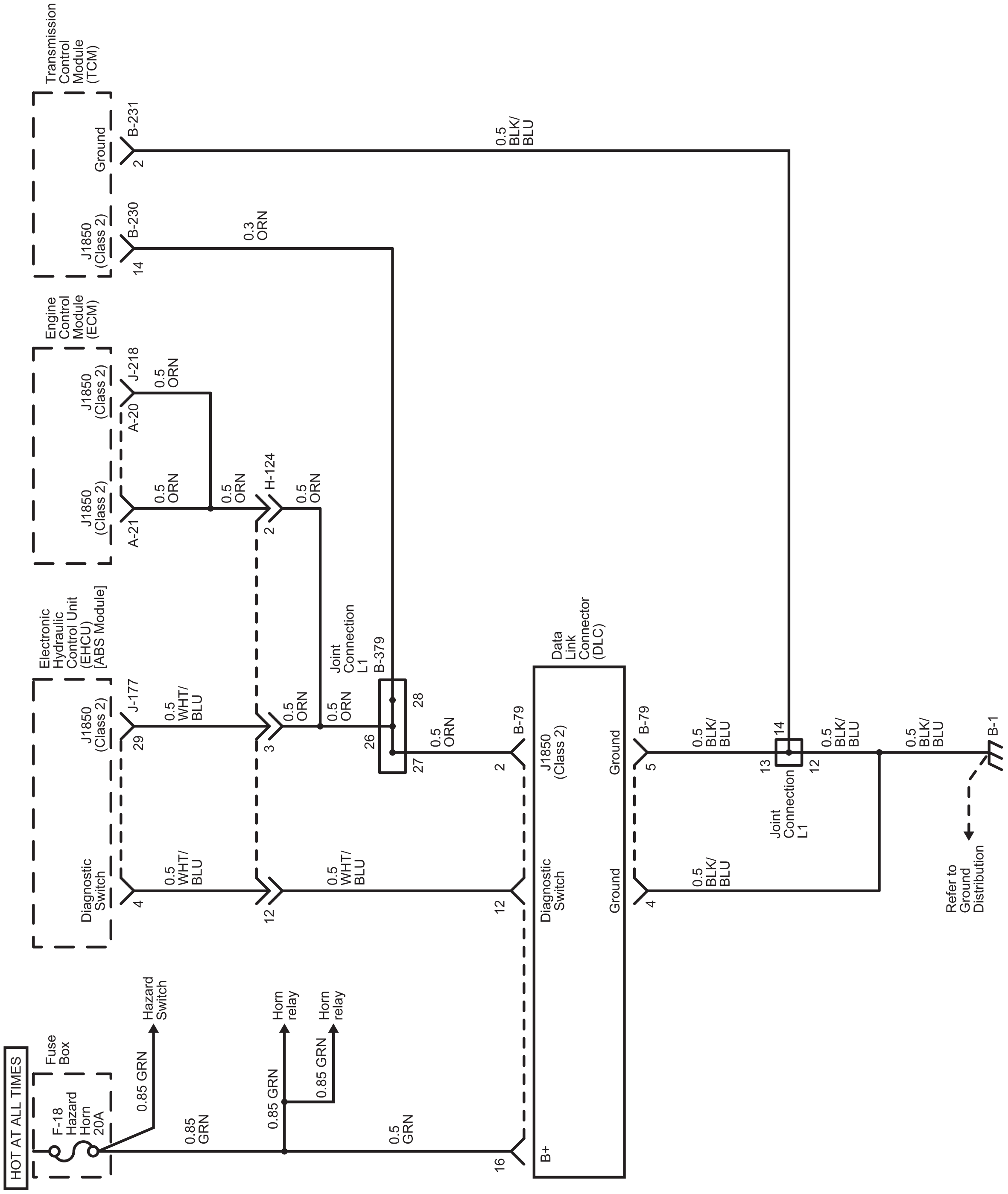
LNW66EXF000301

Power Distribution (Hot In Run) (2)



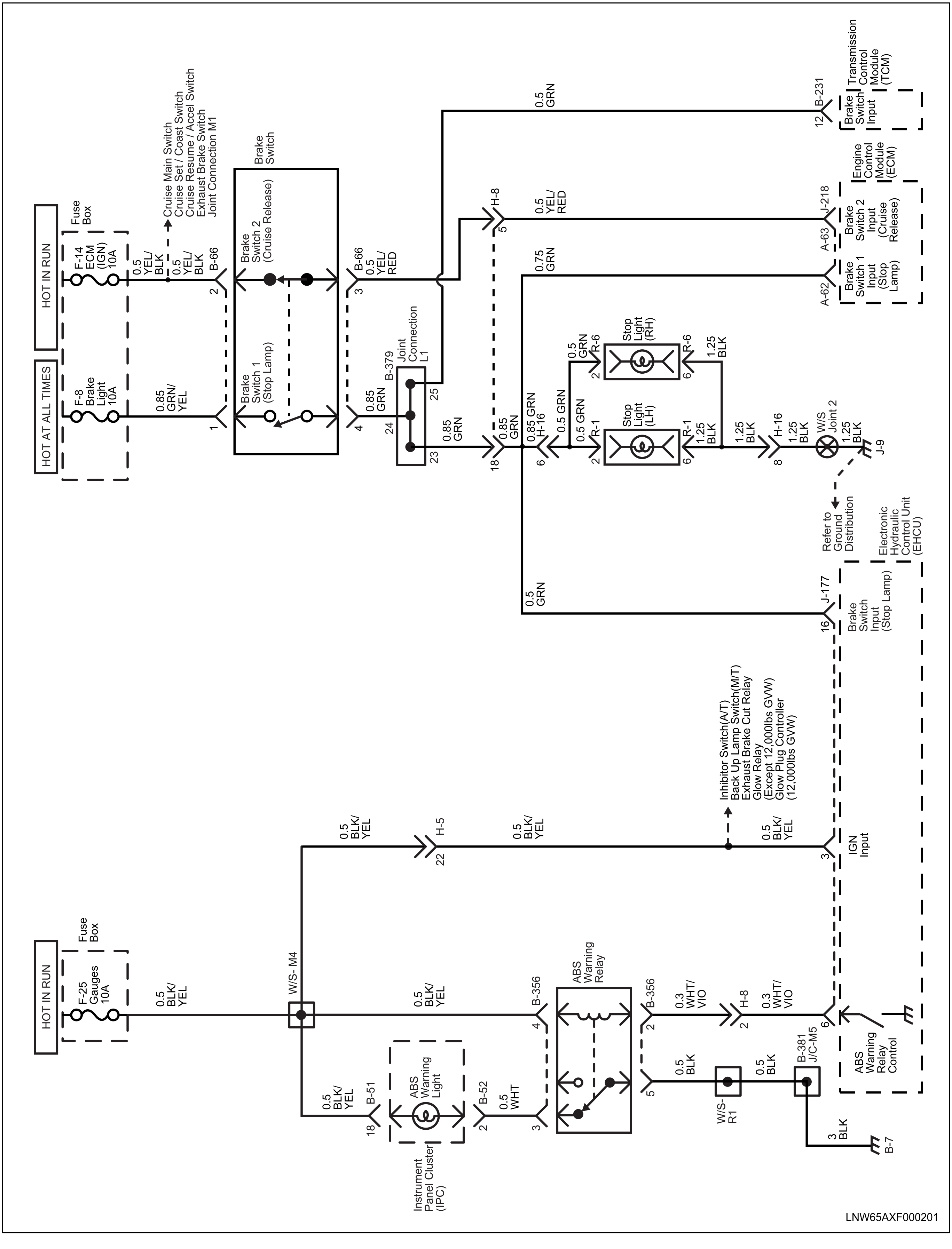
LNW66EXF000201

DLC

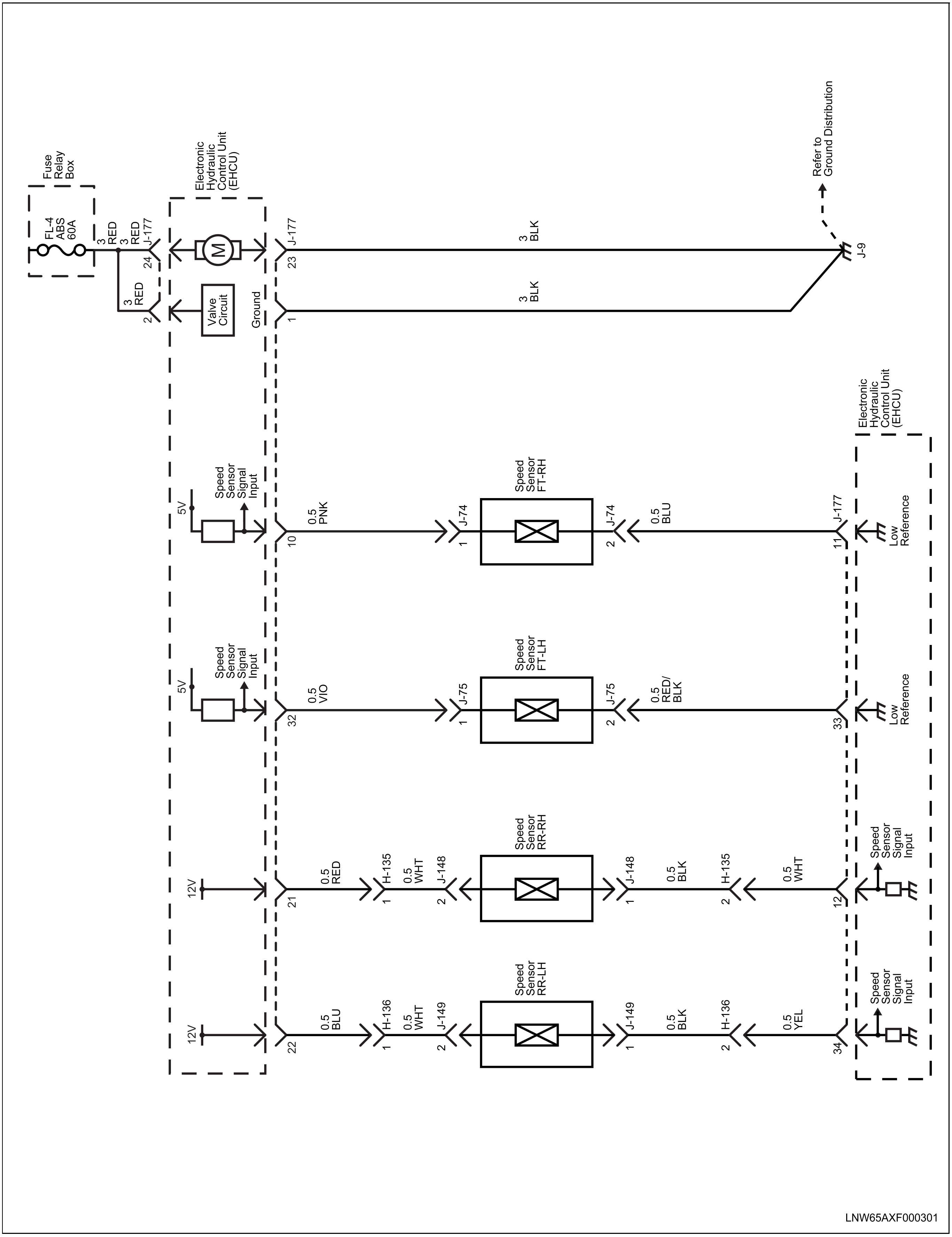


LNW65AXF000101

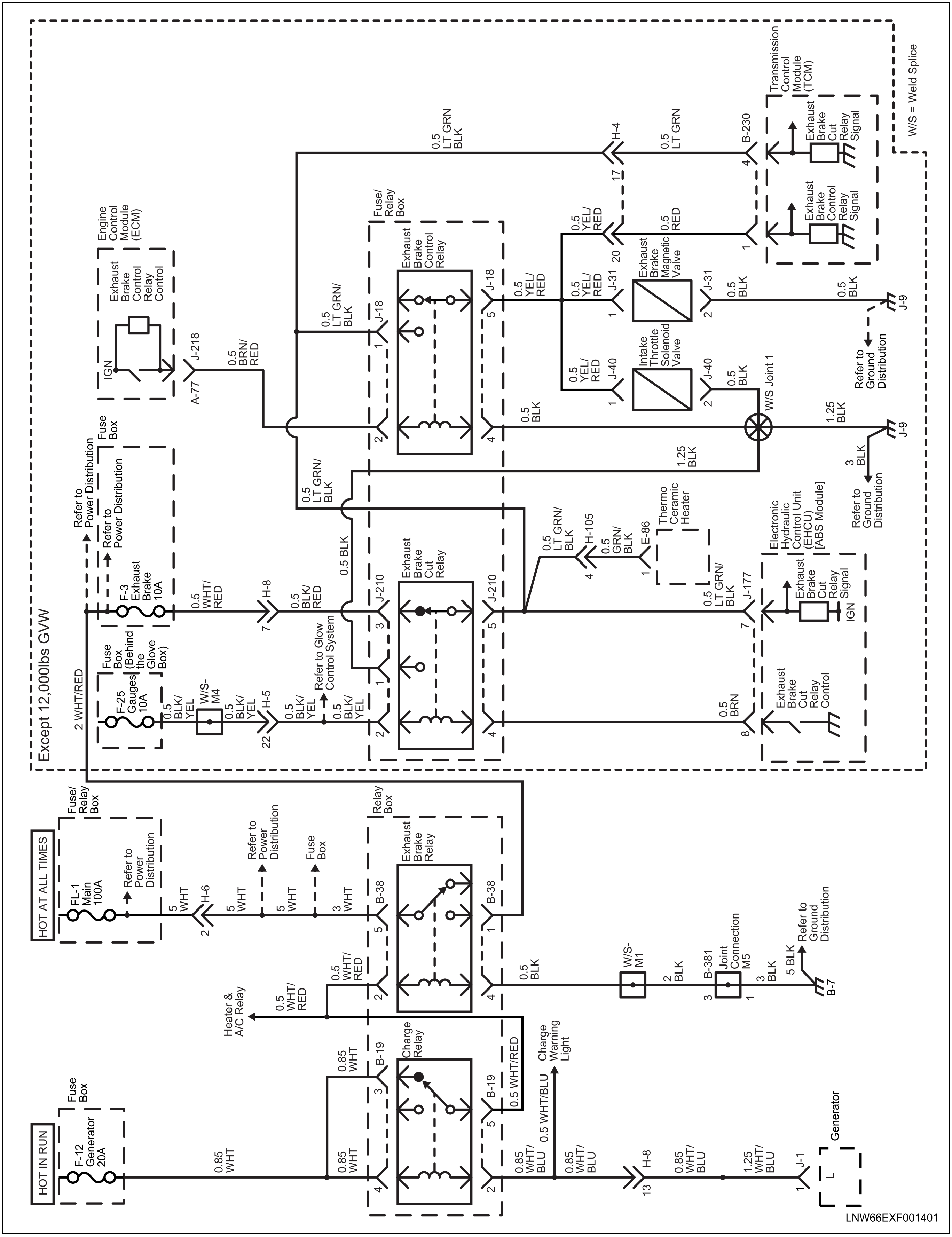
ABS Warning Light and Brake Switch



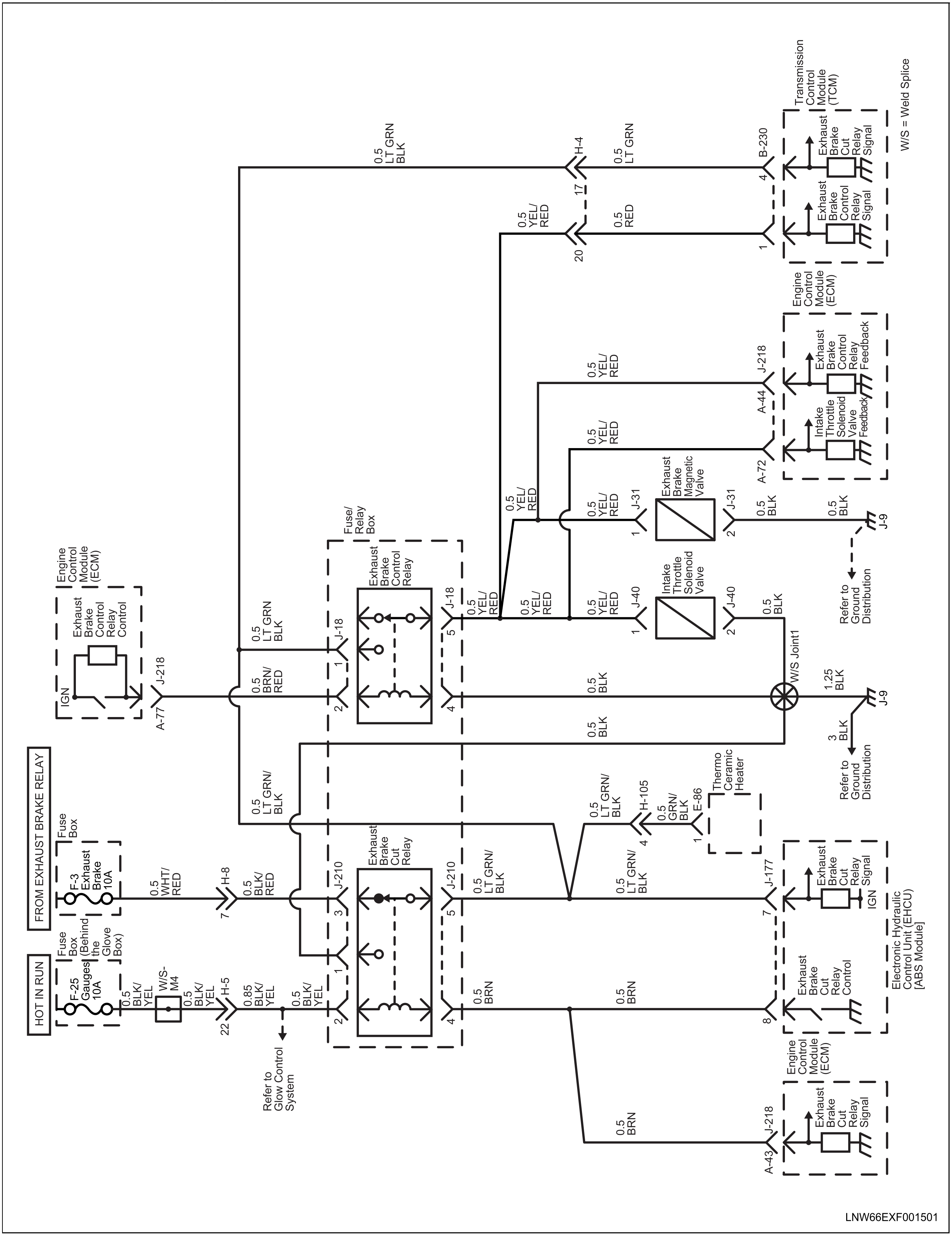
EHCU Power, Ground and Wheel Speed Sensor



Exhaust Brake System (1)



Exhaust Brake System (2) [12,000 lbs GVW]



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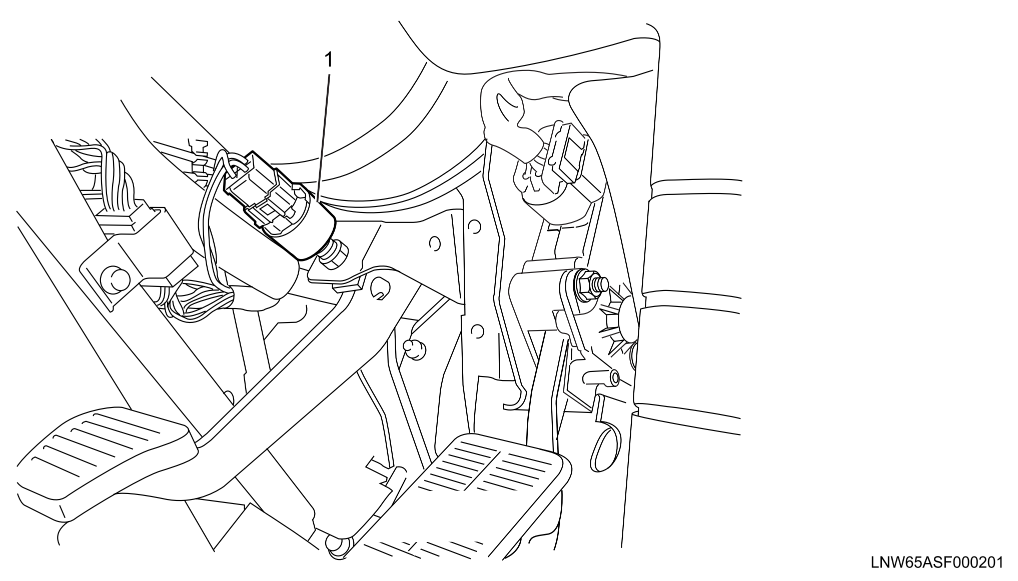
Component Locator

Anti-Lock Brake (ABS) Controls Component Views

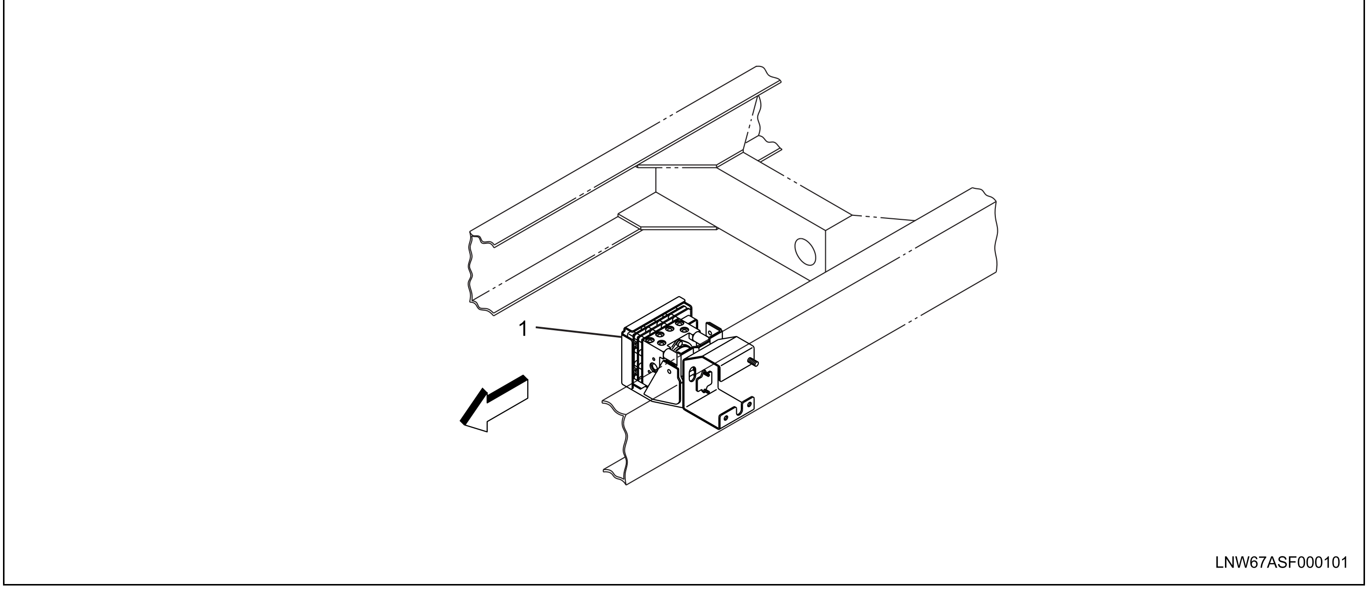
Brake Switch



Legend

1. Brake Switch

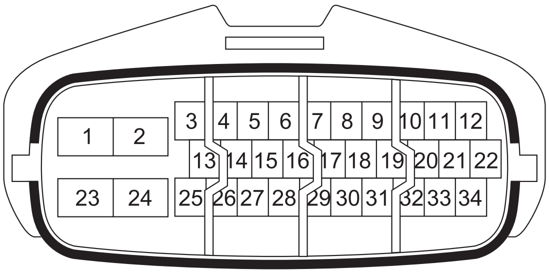
Electronic Hydraulic Control Unit (EHCU)



Legend

1. Electronic Hydraulic Control Unit (EHCU)

Electronic Hydraulic Control Unit (EHCU) Connector End View

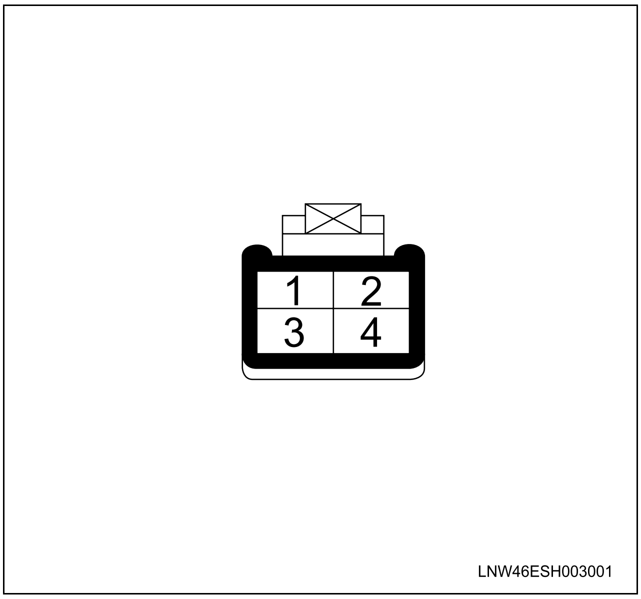


LNW65ASF000301

Connector No.		J-177
Connector Color		Black
Test Adapter No.		J-35616-40 [Pin 1, 2, 23, 24] J-35616-64A [Pin 3-22, 25-34]
Pin	Wire Color	Pin Function
1	BLK	Ground
2	RED	Battery Voltage
3	BLK/YEL	Ignition Voltage
4	WHT/BLU	Diagnostic switch
5	—	Not Used
6	WHT/GRN	ABS Warning Relay Control
7	LT GRN	Exhaust Brake Cut Relay Signal
8	BR	Exhaust Brake Cut Relay Control
9	—	Not Used
10	PIN	Wheel Speed Sensor Front Right Signal
11	BLU	Wheel Speed Sensor Front Right Low Reference
12	WHT	Wheel Speed Sensor Rear Right Signal
13	—	Not Used
14	—	Not Used
15	—	Not Used
16	GRN	Brake Switch
17	—	Not Used
18	—	Not Used
19	—	Not Used
20	—	Not Used
21	RED	Wheel Speed Sensor Rear Right 12V Reference
22	BLU	Wheel Speed Sensor Rear Left 12V Reference
23	BLK	Ground
24	RED	Battery Voltage
25	—	Not Used
26	—	Not Used
27	—	Not Used
28	—	Not Used
29	ORG/BLK	J1850 (Class 2) to DLC
30	—	Not Used
31	—	Not Used
32	VIO	Wheel Speed Sensor Front Left Signal
33	RED/BLK	Wheel Speed Sensor Front Left Low Reference
34	YEL	Wheel Speed Sensor Rear Left Signal

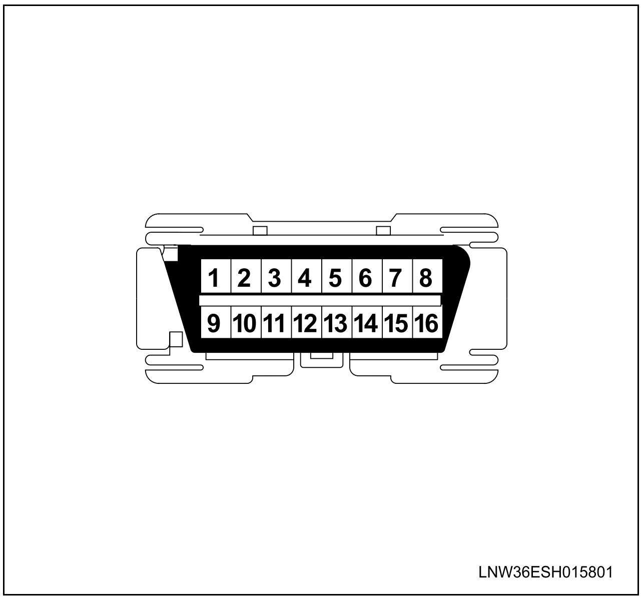
Anti-Lock Brake System (ABS) Controls Connector End Views

Brake Switch



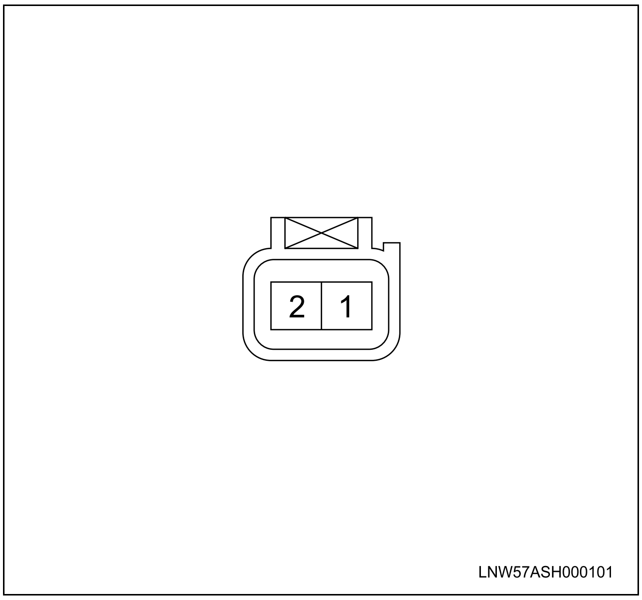
Connector No.		B-66
Connector Color		Brown
Test Adapter No.		J-35616-42
Pin	Wire Color	Pin Function
1	GRN/YEL	Switch 1 +12 V Feed via Brake Light Fuse
2	YEL/BLK	Switch 2 +12 V Feed via ECM (IGN) Fuse
3	YEL/RED	Switch 2 (Cruise Release Switch) Signal
4	GRN	Switch 1 (Stop Lamp Switch) Signal

Data Link Connector (DLC)



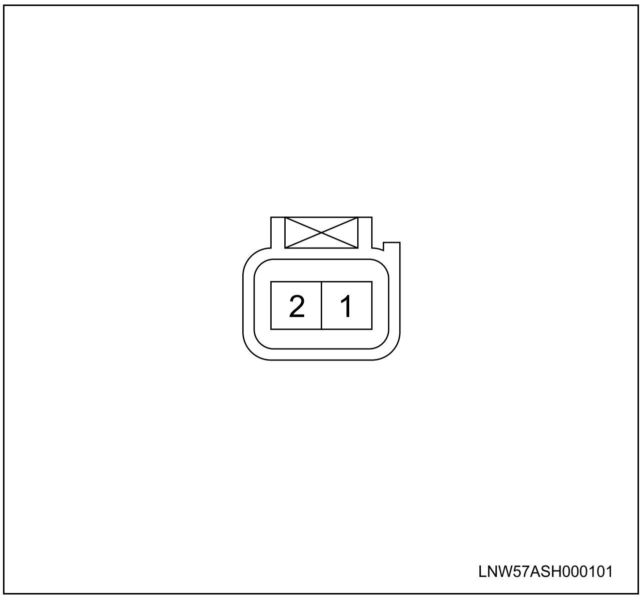
Connector No.		B-79
Connector Color		Black
Test Adapter No.		J-35616-2A
Pin	Wire Color	Pin Function
1	—	Not Used
2	ORN	J1850 (Class 2)
3	—	Not Used
4	BLK/BLU	Ground
5	BLK/BLU	Ground
6	—	Not Used
7	WHT	ISO14230 (KWP2000)
8	—	Not Used
9	—	Not Used
10	—	Not Used
11	BLK/WHT	TCM Diagnostic
12	WHT/BLU	ABS C/U Diagnostic
13	—	Not Used
14	—	Not Used
15	—	Not Used
16	GRN	Power Supply

Wheel Speed Sensor Front Left



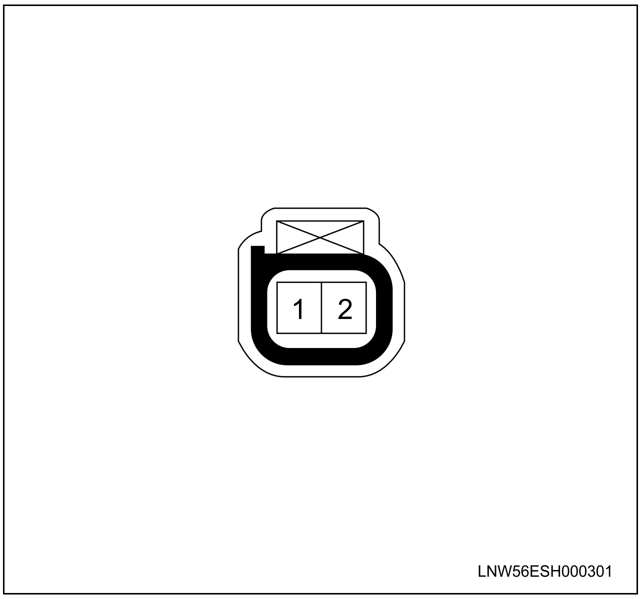
Connector No.		J-75
Connector Color		Black
Test Adapter No.		J-35616-5
Pin	Wire Color	Function
1	VIO	Wheel Speed Sensor Front Left Signal
2	RED/BLK	Wheel Speed Sensor Front Left Low Reference

Wheel Speed Sensor Front Right



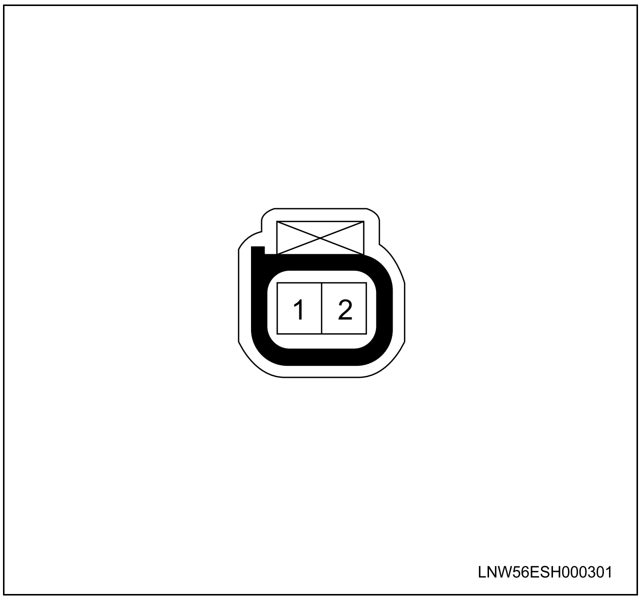
Connector No.		J-74
Connector Color		White
Test Adapter No.		J-35616-5
Pin	Wire Color	Function
1	PNK	Wheel Speed Sensor Front Right Signal
2	BLU	Wheel Speed Sensor Front Right Low Reference

Wheel Speed Sensor Rear Left



Connector No.		J-149
Connector Color		White
Test Adapter No.		J-35616-64A
Pin	Wire Color	Function
1	YEL	Wheel Speed Sensor Rear Left Signal
2	RED/BLK	Wheel Speed Sensor Rear Left 12V Reference

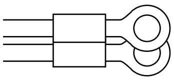
Wheel Speed Sensor Rear Right



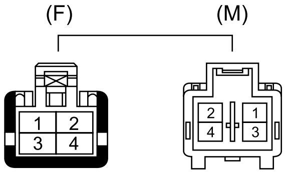
Connector No.		J-148
Connector Color		White
Test Adapter No.		J-35616-64A
Pin	Wire Color	Function
1	WHT	Wheel Speed Sensor Rear Left Signal
2	RED	Wheel Speed Sensor Rear Right 12V Reference

Harness Connector Views

B-1

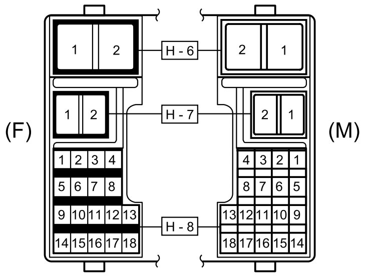


B-67(WHT)



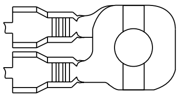
Test Adapter No. : (F) J-35616-42
(M) J-35616-43

H-6, H-7 H-8(GRY)

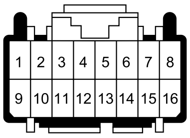


Test Adapter No. : H-7(F) J-35616-42
H-7(M) J-35616-43
H-8(F) J-35616-64A
H-8(M) J-35616-3

B-7

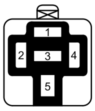


B-230(GRY)



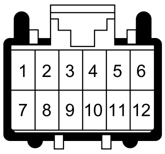
Test Adapter No. : J-35616-64A

B-19, B-20, B-21, B-38, B-356(BLK)



Test Adapter No. : J-35616-42

B-231(GRY)



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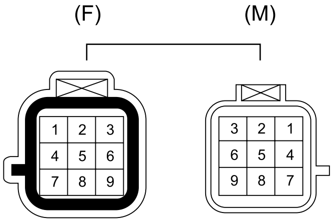
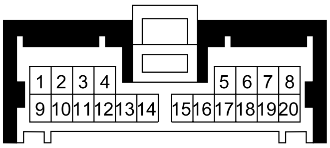
H-16(BLK)



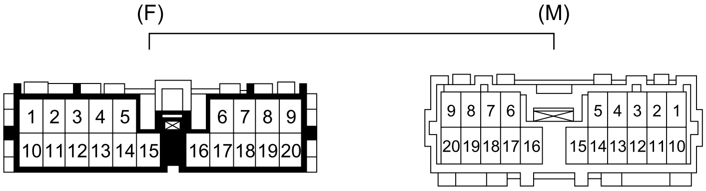
Test Adapter No. : (F) J-35616-64A
(M) J-35616-5

B-51(GRY)



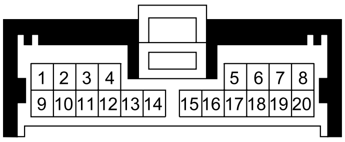
Test Adapter No. : J-35616-64A

H-4(WHT)



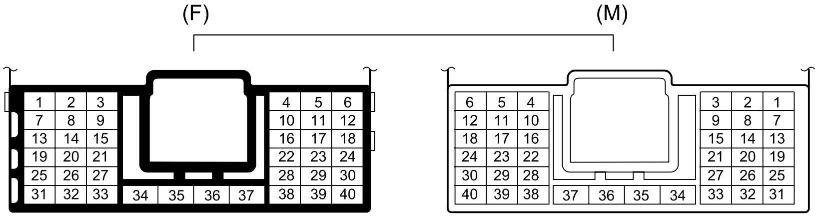
Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

B-52(WHT)



Test Adapter No. : J-35616-64A

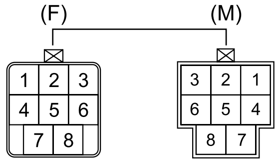
H-5(GRY)



Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

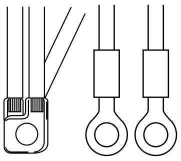
LNW65AXF000401

H-105(BLK)

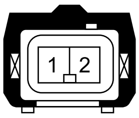


Test Adapter No. : (F) J-35616-64A[Pin 1-6]
(F) J-35616-42[Pin 7-8]
(M) J-35616-5[Pin 1-6]
(M) J-35616-43[Pin 7-8]

J-9

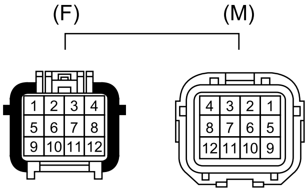


J-40(BRN)



Test Adapter No. : J-35616-4A

H-124(BLK)



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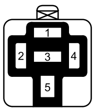
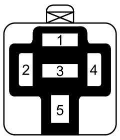
(M) J-35616-3

J-18(BLK)



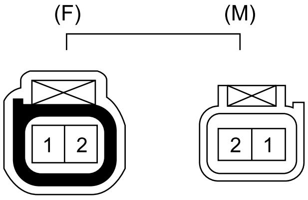
Test Adapter No. : J-35616-42

J-210



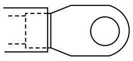
Test Adapter No. : J-35616-42

H-135(WHT)

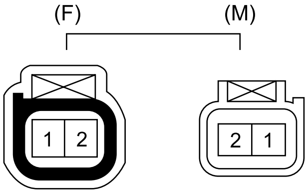


Test Adapter No. : (F) J-35616-64A
(M) J-35616-5

J-26



H-136(BLK)



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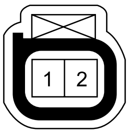
(M) J-35616-5

J-31(BLK)



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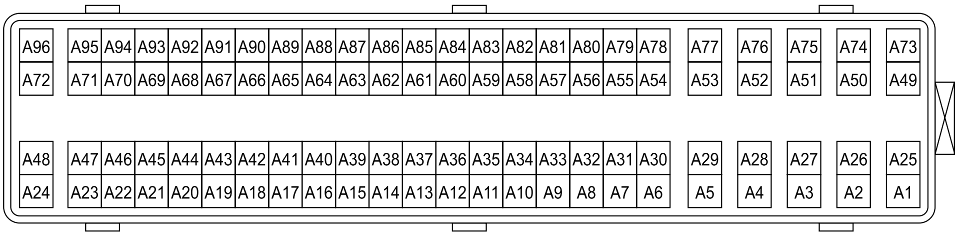
J-218(BLK)



Test Adapter No. : J-35616-64A

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Harness Connector, Joint and Ground Locations

Inline Connector

H-4	Body H. – Frame H.	Lower center of dash
H-5	Body H. – Frame H.	Lower center of dash
H-6	Body H. – Frame H.	Lower center of dash
H-8	Body H. – Frame H.	Lower center of dash
H-124	Frame H. – Body H.	Behind front cross member
H-16	Rr Body H. – Rr Frame H.	Left side of the rear cross member
H-105	Engine H. – Frame H.	Lower left of the engine rear side
H-135	Frame H. – Speed Sensor RH H.	On the rear axle right side
H-136	Frame H. – Speed Sensor LH H.	On the rear axle left side

Joint

B-379	Joint Connection L-1	Under the instrumental panel lower cover of the driver side, near the connector B-67
B-381	Joint Connection M-5	Back of the fuse box in the glove box
	W/S L-1	Behind the idle volume sensor, left side of dash (This is not a connector. Wires are twisted and covered by tube.)
	W/S M-4	Back of the fuse box in the glove box (This is not a connector. Wires are twisted and covered by tube.)
	W/S R-1	Behind the glove box (This is not a connector. Wires are twisted and covered by tube.)
	W/S JOINT 1	Behind front cross member, near terminal H-124 (This is not a connector. Wires are twisted and covered by tube.)
	W/S JOINT 2	Inner side of the left rear frame, near terminal H-122 (This is not a connector. Wires are twisted and covered by tube.)

W/S=Weld Splice

Ground

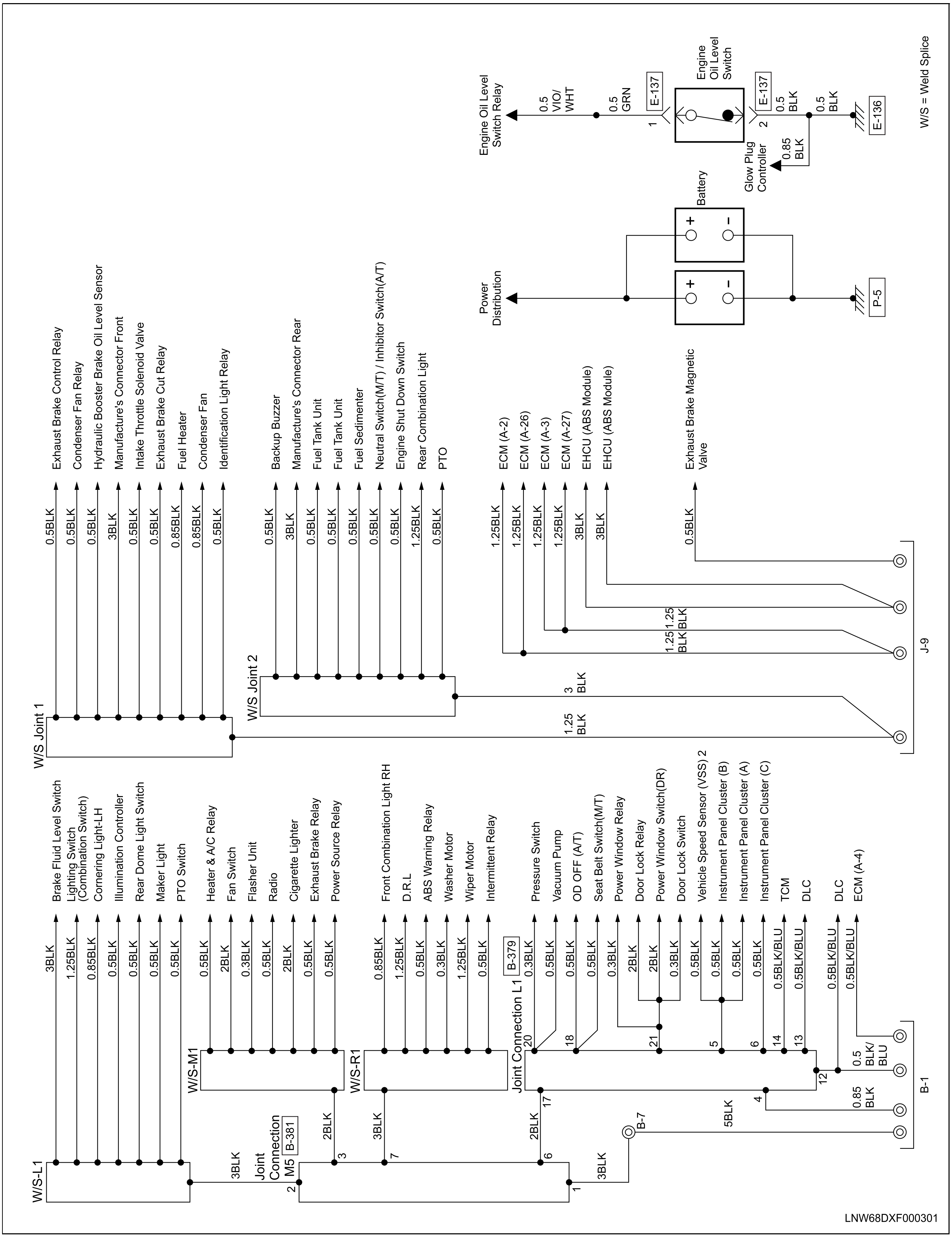
B-1	Frame Earth	Bolted to the left frame, back of the bumper
B-7	Head Light Bracket Earth	Bolted to the body side behind the right turn signal light
J-9	Frame Earth	Bolted to the left frame, ahead of front tire

Others

B-19	Charge Relay	In the relay box under the cab
B-20	Head Light Relay	In the relay box at the dash
B-21	Heater & A/C Relay	In the relay box at the dash
B-38	Exhaust Brake Relay	In the relay box at the dash
B-51	IPC A	Instrument panel cluster (IPC)
B-52	IPC B	Instrument panel cluster (IPC)
B-67	Ignition Switch	Behind the steering cowl
B-229	TCM	Under the instrumental panel lower cover of the driver side

B-230	TCM	Under the instrumental panel lower cover of the driver side
B-231	TCM	Under the instrumental panel lower cover of the driver side
B-356	ABS Warning Light	Behind the glove box
J-9	Frame Earth	Bolted to the left frame, ahead of front tire
J-18	Exhaust Brake Control Relay	In the relay box under the cab
J-26	Starter	Under the fuel supply pump, left hand of engine
J-31	Exhaust Brake Magnetic Valve	On the exhaust pipe, near the silencer
J-40	Intake Throttle Solenoid Valve	On the intake throttle valve
J-74	Front Right Wheel Speed Sensor	On the right shock absorber tower
J-75	Front Left Wheel Speed Sensor	On the left shock absorber tower
J-148	Rear Right Wheel Speed Sensor	On the rear axle
J-149	Rear Right Wheel Speed Sensor	On the rear axle
J-177	EHCU	Inner side of the left rear frame, ahead of rear axle
J-210	Exhaust Brake Cut Relay	In the relay box under the cab
J-217	ECM	Inner side of the left frame, near the transmission
J-218	ECM	Inner side of the left frame, near the transmission
R-1	Rear Combination Light	Right side of the rear cross member
R-6	Rear Combination Light	Left side of the rear cross member

Ground Distribution



Weld Splice (W/S) Distribution

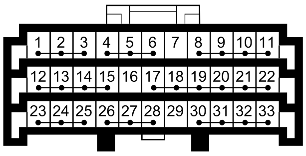
W/S-L1	Joint Connection M5
	Brake Fluid Level Switch Ground
	Cab Interior Light Switch Ground
	Doom Light Ground
	Front Turn Signal Light LH Ground
	Illumination Controller Ground
	PTO Switch Ground
	Rear Dome Light Switch Ground
W/S-L2	Joint Connection L1
	W/S-M2
	Cruise Resume Switch
	Front Turn Signal Light LH
	Illumination Controller
	Oil Level Check Switch
W/S-M1	Joint Connection M5
	Cigar Lighter Ground
	Fan Switch Ground
	Flasher Unit Ground
	Heater A/C Relay Ground
	Power Source Relay Ground
	Radio Ground
W/S-M2	W/S-L2
	Ashtray Illumination
	Cigar Lighter Illumination
	Cruise Main Switch
	Cruise Set Coast Switch
	Front Turn Signal Light RH
	Hazard Warning Switch
	Heater Bezel
	License Plate Light
	Instrument panel cluster (IPC) (A) Illumination (+)
	PTO Switch
	Radio
	Tail Relay Control

W/S-M3	Joint Connection L1
	Ashtray Illumination Ground
	Cigar Lighter Illumination Ground
	Cruise Main Switch Ground
	Cruise Resume Accel Switch Ground
	Cruise Set Coast Switch Ground
	Hazard Warning Switch Ground
	Heater Bezel Ground
	Illumination Controller
	Instrument Panel Cluster (IPC) (B) Illumination (-)
	Oil Level Check Switch Ground
	PTO Switch Ground
	Radio Ground
W/S-M4	Joint Connection M1
	ABS Relay Voltage Feed
	Buzzer Cancel Relay Voltage Feed
	Cornering Relay Voltage Feed
	Fuse Box Gauge
	Inhibitor Switch
	Vehicle Speed Sensor Voltage Feed
	Instrument Panel Cluster (IPC) (A) Voltage Feed
W/S-R1	Joint Connection M5
	ABS Relay Ground
	D.R.L
	Front Turn Signal Light RH Ground
	Intermittent Relay Ground
	Washer Motor Ground
	Wiper Motor Ground

W/S-JOINT 1	Frame Ground
	Exhaust Brake Control Relay Ground
	Condenser Fan Relay Ground
	Hydraulic Booster Brake (HBB) Oil Level Sensor Ground
	Manufacture Connector Front Ground
	Intake Throttle Solenoid Valve
	Exhaust Brake Cut Relay Ground
	Fuel Heater Ground
	Condenser Fan Ground
	Identification Light Relay Ground
W/S-JOINT 2	Back Buzzer Ground
	Manufacture Connector Rear Ground
	Fuel Tank Unit Ground
	Rear Combination Light Ground
	Fuel Sedimenter Ground
	Engine Shut Down Switch
	Frame Ground
	PTO Ground
	Fuel Tank Unit Ground
	Inhibitor Switch (A/T)
	Neutral Switch (M/T)

Joint Connection Distribution

B-379 Joint Connection-L1

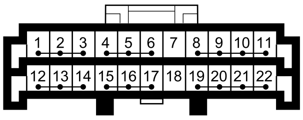


Test Adaptor No. :J-35616-64A

Joint Point	PIN No.	Connection
	1	W/S-L2
	2	A/T Lever Illumination(+)
	3	—
	4	Frame Ground
	5	Instrument Panel Cluster(IPC)(B) Ground
	6	Instrument Panel Cluster(IPC)(C) Ground
	7	—
	8	—
	9	—
	10	—
	11	—
	12	Frame Ground
	13	Data Link Connector(DLC) Ground
	14	Transmission Control Module(TCM) Ground
	15	—
	16	—

Joint Point	PIN No.	Connection
	17	Joint Connection M5
	18	OD OFF Ground(A/T)/Seat Belt Switch Ground(M/T)
	19	—
	20	Pressure Switch / Vacuum Pump
	21	Power Window Switch(DR) Ground
	22	—
	23	Brake Light
	24	Brake Light Switch
	25	Transmission Control Module(TCM) Brake Light Input
	26	EHCU(ABS Module) Class2
	27	Data Link Connector Class2
	28	Transmission Control Module(TCM) Class2
	29	—
	30	W/S-M3
	31	A/T Lever(Illumination(−))
	32	—
	33	—

B-380 Joint Connection-M1

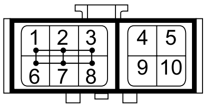


Test Adaptor No. :J-35616-64A

Joint Point	PIN No.	Connection
	1	Brake Fluid Level Switch
	2	Instrument Panel Cluster(IPC)(A) Parking Brake Inhibitor Light
	3	D.R.L / HBB Oil Level Sensor
	4	Charge Relay Voltage Feed
	5	Generator(L)
	6	—
	7	—
	8	W/S-M4
	9	Transmission Control Module(TCM) IGN Voltage Feed
	10	Power Window Relay Voltage Feed
	11	Vacuum Pump Relay Voltage Feed

Joint Point	PIN No.	Connection
	12	Fan Switch
	13	Electro Thermo
	14	Ceramic Heater
	15	Parking Brake Switch
	16	D.R.L
	17	Buzzer Cancel Relay
	18	—
	19	Fuse Box ECM(IGN)
	20	ECM Ignition Voltage Feed
	21	Clutch Switch
	22	PTO Switch

B-381 Joint Connection-M5



Test Adaptor No. :J-35616-42

Joint Point	PIN No.	Connection
	1	Headlight Bracket Ground
	2	W/S-L1
	3	W/S-M1
	4	—
	5	—
	6	Joint Connection L1
	7	W/S-R1
	8	—
	9	—
	10	—

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Diagnostic Information and Procedures

General Information

ABS malfunction can be classified into two types, those which can be detected by the ABS warning light and those which can be detected as a vehicle abnormality by the driver.

In either case, locate the fault in accordance with the "Diagnostic System Check – Anti-Lock Brake System (ABS) Controls" and repair.

Please refer to Section 5A for the diagnosis of mechanical troubles such as brake noise, brake judder (brake pedal or vehicle vibration felt when braking), uneven braking, and parking brake trouble.

ABS Warning Light

Vehicles equipped with the Anti-lock Brake System have an amber "ABS" warning light in the instrument panel. The "ABS" warning light will illuminate if a malfunction in the Anti-lock Brake System is detected by the Electronic Hydraulic Control Unit (EHCU). In case of an electronic malfunction, the EHCU will turn "ON" the "ABS" warning light and disable the Anti-lock braking function.

The "ABS" light will turn "ON" after the ignition switch is to the "ON" position.

If the "ABS" light comes "ON" and stays "ON" while driving, the Anti-lock Brake System should be inspected for a malfunction according to the diagnosis procedure.

If the ignition switch is turned ON, ABS warning light will turn on and an ABS warning light will be turned off after 3 seconds.

Computer System Service Precautions

The Anti-lock Brake System interfaces directly with the Electronic Hydraulic Control Unit (EHCU) which is a control computer that is similar in some regards to the Engine Control Module. These modules are designed to withstand normal current draws associated with vehicle operation. However, care must be taken to avoid overloading any of the EHCU circuits. In testing for opens or shorts, do not ground or apply voltage to any of the circuits unless instructed to do so by the appropriate diagnostic procedure. These circuits should only be tested with a digital multimeter (J-39200) or special tools as described in this section. Power should never be removed or applied to any control module with the ignition in the "ON" position.

Before removing or connecting battery cables, fuses or connectors, always turn the ignition switch to the "OFF" position.

General Service Precautions

The following are general precautions which should be observed when servicing and diagnosing the Anti-lock Brake System and/or other vehicle systems. Failure to observe these precautions may result in Anti-lock Brake System damage.

- If welding work is to be performed on the vehicle using an electric arc welder, the EHCU and valve block connectors should be disconnected before the welding operation begins.
- The EHCU and valve block connectors should never be connected or disconnected with the ignition "ON".
- The Hydraulic Unit of the Anti-lock Brake System is not separately serviceable and must be replaced as assemblies. Do not disassemble any component which is designated as non-serviceable in this Section.
- If only rear wheels are rotated using jacks or drum tester, the system will diagnose a speed sensor malfunction and the "ABS" warning light will illuminate. However, no trouble exists. After inspection stop the engine once and restart it, then make sure that the "ABS" warning light does not illuminate.

Note on Intermittents

As with virtually any electronic system, it is difficult to identify an intermittent failure. In such a case duplicating the system malfunction during a test drive or a good description of vehicle behavior from the customer may be helpful in locating a "most likely" failed component or circuit. The symptom diagnosis chart may also be useful in isolating the failure. Most intermittent problems are caused by faulty electrical connections or wiring. When an intermittent failure is encountered, check suspect circuits for:

- Suspected harness damage.
- Poor mating of connector halves or terminals not fully seated in the connector body (backed out).
- Improperly formed or damaged terminals.

Test Driving ABS Complaint Vehicles

In case of vehicle abnormality detected by the driver, follow the test procedure mentioned below, thereby reproducing the symptom for trouble diagnosis on a symptom basis:

1. Start the engine and make sure that the "ABS" W/L goes OFF. If the W/L remains ON, the Diagnostic Trouble Code (DTC) is may set.
2. Start the vehicle and accelerate to about 30 km/h (19 mph) or more.
3. Slowly brake and stop the vehicle completely.

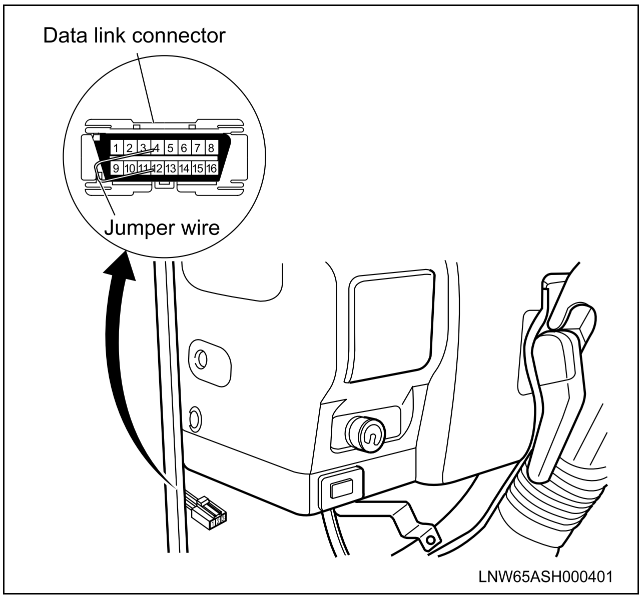
4. Then restart the vehicle and accelerate to about 40 km/h (25 mph) or more.
5. Brake at a time so as to actuate the ABS and stop the vehicle.
6. Be cautious of abnormality during the test. If the W/L is actuated while driving, read the DTC and locate the fault.
7. If the abnormality is not reproduced by the test, make best efforts to reproduce the situation reported by the customer.
8. If the abnormality has been detected, repair in accordance with the “Symptom Diagnosis”.

Notice:

- Be sure to give a test drive on a wide, even road with little traffic.
- If an abnormality is detected, be sure to suspend the test and start trouble diagnosis at once.

Reading Flash Diagnostic Trouble Code (DTC)

The provision for communicating with the EHCU is the Data Link Connector (DLC). The diagnostic trouble code(s) (DTCs) stored in the EHCU's memory can be read either through a hand-held diagnostic scan tool plugged into the DLC or by counting the number of flashes of the ABS warning light when the diagnostic test terminal of the DLC is grounded. The DLC terminal "12" (diagnostic request switch) is pulled "Low" (grounded) by jumped to DLC terminal "4" or "5", which is a ground wire. Once terminals "4" or "5" and "12" have been connected, the ignition switch must be moved to the "ON" position, with the engine not running. First, normal code "12" is indicated three times, next any other flash DTC(s) are started three times from the most recent one which is stored in the EHCU as present or history. If the normal code "12" is flashed repeatedly, the ABS system operation is normal. (Flashing is discontinued after approximately 5 minutes.) The flash DTC display will continue as long as the DLC is shorted.



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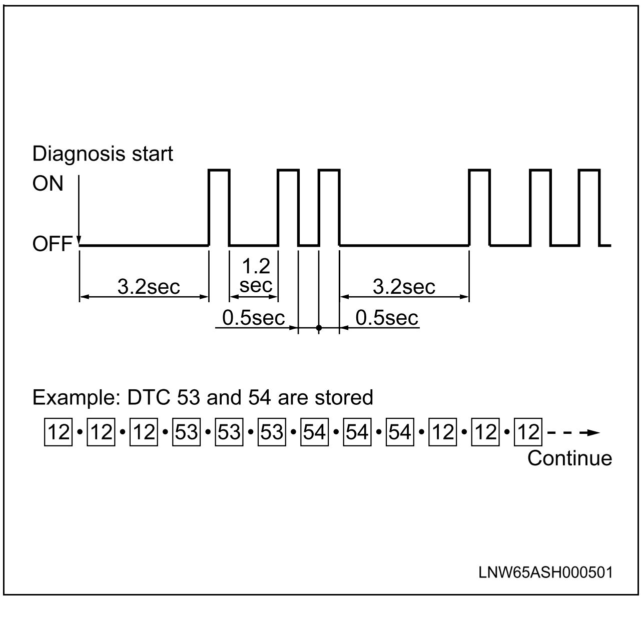

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Clearing Diagnostic Trouble Code (DTC) without Scan Tool

Important:

Do not clear DTCs unless directed to do so by the service information provided for each diagnostic procedure. When DTCs are cleared, the history data which may help diagnose an intermittent fault will also be erased from memory.

- Press and release the brake pedal 6 or more times within 3 seconds of self-diagnosis startup.
- The stored code will not be erased if more than 3 seconds have passed since self-diagnosis startup, or if self-diagnosis has started with brake pedal pressed (brake switch ON).

Diagnostic System Check - Anti-lock Brake system (ABS) Controls

Begin the system diagnosis with Diagnostic System Check - ABS Controls. The Diagnostic System Check - ABS Controls will provide the following information:

- The identification of the control modules which command the system.
- The ability of the control modules to communicate through the serial data circuit.
- The identification of any stored diagnostic trouble codes (DTCs) and the codes' statuses.

The use of the Diagnostic System Check - ABS Controls will identify the correct procedure for diagnosing the system and where the procedure is located.

Diagnostic System Check - Anti-lock Brake system (ABS) Controls Description

The Diagnostic System Check - ABS Controls is an organized approach to identifying a condition that is created by a malfunction in the electronic anti-lock brake control system. The Diagnostic System Check must be the starting point for any driveability concern. The Diagnostic System Check directs the service technician to the next logical step in order to diagnose the concern. Understanding and correctly using the diagnostic table reduces diagnostic time, and prevents the replacement of good parts.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. Lack of communication may be because of a partial or a total malfunction of the class 2 serial data circuit. The specified procedure determines the particular condition.

6. If there are other modules with DTCs set, refer to the DTC list. The DTC list directs you to the appropriate diagnostic procedure. If the control module stores multiple DTCs, diagnose the DTCs in the following order:

- Component level DTCs, such as sensor DTCs, solenoid DTCs, and relay DTCs. Diagnose the multiple DTCs within this category in numerical order. Begin with the lowest numbered DTC, unless the diagnostic table directs you otherwise.

Diagnostic System Check - Anti-lock Brake system (ABS) Controls

Important:

- DO NOT perform this diagnostic if there is not a driveability concern, unless another procedure directs you to this diagnostic.
- Before you proceed with diagnosis, search for applicable service bulletins.
- Unless a diagnostic procedure instructs you, DO NOT clear the DTCs.
- Ensure the battery has a full charge.
- Ensure the battery cables (+) (-) are clean and tight.
- Ensure the EHCU grounds are clean, tight, and in the correct location.
- Ensure the EHCU harness connector is clean and correctly connected.
- Ensure the EHCU terminals are clean and correctly mating.

Step	Action	Value(s)	Yes	No
1	1. Turn ON the ignition, with the engine OFF. 2. Observe the ABS warning light. **Notice:** If a turn ON the ignition, ABS warning light will turn ON and ABS warning light will be turned OFF after 3 seconds. Did the ABS warning light turn ON then turn OFF?	—	Go to Step 2	Go to ABS Warning Light Always On or ABS Warning Light Inoperative
2	Install a scan tool. Does the scan tool turn ON?	—	Go to Step 3	Go to Scan Tool Does Not Power Up

Step	Action	Value(s)	Yes	No
3	1. Turn ON the ignition, with the engine OFF. 2. Attempt to establish communication with the listed control modules. If you are using a scan tool, obtain the information using the Class 2 Message Monitor feature: • Engine control module (ECM) • Transmission control module (TCM) • Electronic hydraulic control unit (EHCU) Does the scan tool communicate with all the listed control modules?	—	Go to Step 4	Go to Scan Tool Does Not Communicate with Class 2 Device
4	Select the DTC display function for the following control modules: • Engine control module (ECM) • Transmission control module (TCM) • Electronic hydraulic control unit (EHCU) Does the scan tool display any DTCs?	—	Go to Step 5	Go to Step 7
5	With a scan tool, select Captured Info in order to store the ABS DTC information. Did you complete the action?	—	Go to Step 6	—
6	Does the scan tool display DTCs which begin with a C?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	—
7	1. Review the following symptoms. 2. Refer to the applicable symptom diagnostic table: • ABS Works Frequently But Vehicle Does Not Decelerate • Uneven Braking Occurs While ABS Works • The Wheels Lock While Braking • Braking Sound (From EHCU) Is Heard While Not Braking • ABS Warning Light Always On • ABS Warning Light Inoperative Did you find and correct the condition?	—	System OK	Go to Intermittent Conditions

Scan Tool Data List

Use the scan tool data values under the following conditions:

- The Diagnostic System Check – Anti-lock Brake System (ABS) Controls completed.
- No diagnostic trouble codes (DTCs) are present.
- On-board diagnostics are functioning properly.

The values below represent a typical display recorded form a properly functioning system.

Important:
A scan tool that displays faulty data should not be used. The scan tool problem should be reported to the manufacturer. Use of a faulty scan tool can result in misdiagnosis and unnecessary parts replacement.
Only the parameters listed below are referenced in this service manual for use in diagnosis.

Scan Tool Parameter	Units	Typical Data Value
Operating Conditions: Engine Run / Vehicle Does Not Run / Brake Pedal Not Applied		
ABS Lamp Command	On / Off	Off
ABS Pump Motor	On / Off	Off
ABS Relay Command	On / Off	On
ABS Stop State	On / Off	Off
Battery Voltage	Volts	11.0 -15.0
Brake Switch Status	On / Off	Off
Diagnostic Connector	Yes / No	No
Diagnostic Trouble Codes	Yes / No	No
Exhaust Brake	Yes / No	No
Left Front Wheel Speed	MPH / km/h	0
Left Rear Wheel Speed	MPH / km/h	0
LF Hold Valve Command	On / Off	Off
LF Hold Valve Feedback	On / Off	Off
LF Release Valve Command	On / Off	Off
LF Release Valve Feedback	On / Off	Off
LR Hold Valve Command	On / Off	Off
LR Hold Valve Feedback	On / Off	Off
LR Release Valve Command	On / Off	Off
LR Release Valve Feedback	On / Off	Off
RF Hold Valve Command	On / Off	Off
RF Hold Valve Feedback	On / Off	Off
RF Release Valve Command	On / Off	Off
RF Release Valve Feedback	On / Off	Off
Right Front Wheel Speed	MPH / km/h	0
Right Rear Wheel Speed	MPH / km/h	0
RR Hold Valve Command	On / Off	Off
RR Hold Valve Feedback	On / Off	Off
RR Release Valve Command	On / Off	Off
RR Release Valve Feedback	On / Off	Off

Scan Tool Data Definitions

ABS Lamp Command

This parameter displays the commanded state of the ABS warning relay control circuit. The ABS warning lamp should be On when the scan tool indicates the ABS Lamp Command is On. The ABS warning lamp should be Off when the scan tool indicates the ABS Lamp Command is Off. The ECM will command the ABS warning lamp On for 3 seconds when the ignition is On in order to perform a bulb check.

ABS Pump Motor

This parameter displays the commanded state of the ABS motor control circuit. The motor should be On when the scan tool indicates the ABS Pump Motor is On. The motor should be Off when the scan tool indicates the ABS Pump Motor is Off.

ABS Relay Command

This parameter displays the commanded state of the fail-safe relay control circuit in the EHCU. The scan tool will display On or Off. On indicates the fail-safe relay control circuit is being grounded by the EHCU. Off indicates the fail-safe relay is not being commanded On by the EHCU that indicates diagnostic trouble code (DTC) is set.

ABS Stop State

This parameter displays the state of the ABS operation. The ABS should be On when the appropriate conditions are met.

Battery Voltage

This represents the system voltage measured by the EHCU at the ECHU battery voltage feed circuit.

Brake Switch Status

This parameter displays the state of the brake pedal as determined by the EHCU based on an input from the stop lamp pedal switch. This switch turns on the stop lamps when the brake pedal is depressed. The scan tool will display On when the brake pedal is depressed.

Diagnostic Connector

This parameter displays the state of the diagnostic request switch as determined by the EHCU based on an input from the diagnostic switch of the data link connector (DLC). The scan tool will display Yes when the diagnostic switch is being grounded to read flash code.

Diagnostic Trouble Codes

This parameter displays Yes if a diagnostic trouble code (DTC) set during the current ignition cycle.

Exhaust Brake

This parameter displays the commanded state of the exhaust brake cut relay control circuit. The scan tool will display Yes or No. Yes indicates the exhaust brake cut relay control circuit is being grounded by the EHCU. No indicates the exhaust brake cut relay is not being commanded On by the EHCU.

Left Front Wheel Speed

This parameter displays the wheel speed calculated by the EHCU based on an input from the left front wheel speed sensor. The scan tool will display a high value at higher vehicle speeds, and a low value at lower vehicle speeds.

Left Rear Wheel Speed

This parameter displays the wheel speed calculated by the EHCU based on an input from the left rear wheel speed sensor. The scan tool will display a high value at higher vehicle speeds, and a low value at lower vehicle speeds.

LF Hold Valve Command

This parameter displays the state of the left front holding valve control circuit based on the EHCU commanded signal. The scan tool will display On or Off. The parameter should be On when the holding valve is commanded On. The parameter should be Off when the holding valve is commanded Off.

LF Hold Valve Feedback

This parameter displays a feedback signal based on the commanded signal of the left front holding valve. The scan tool will display On or Off. The parameter should be On when the holding valve is commanded On. The parameter should be Off when the holding valve is commanded Off.

LF Release Valve Command

This parameter displays the state of the left front release valve control circuit based on the EHCU commanded signal. The scan tool will display On or Off. The parameter should be On when the release valve is commanded On. The parameter should be Off when the release valve is commanded Off.

LF Release Valve Feedback

This parameter displays a feedback signal based on the commanded signal of the left front release valve. The scan tool will display On or Off. The parameter should be On when the release valve is commanded On. The parameter should be Off when the release valve is commanded Off.

LR Hold Valve Command

This parameter displays the state of the left rear holding valve control circuit based on the EHCU commanded signal. The scan tool will display On or Off. The parameter should be On when the holding valve is commanded On. The parameter should be Off when the holding valve is commanded Off.

LR Hold Valve Feedback

This parameter displays a feedback signal based on the commanded signal of the left rear holding valve. The scan tool will display On or Off. The parameter should be On when the holding valve is commanded On. The parameter should be Off when the holding valve is commanded Off.

LR Release Valve Command
This parameter displays the state of the left rear release valve control circuit based on the EHCU commanded signal. The scan tool will display On or Off. The parameter should be On when the release valve is commanded On. The parameter should be Off when the release valve is commanded Off.

LR Release Valve Feedback
This parameter displays a feedback signal based on the commanded signal of the left rear release valve. The scan tool will display On or Off. The parameter should be On when the release valve is commanded On. The parameter should be Off when the release valve is commanded Off.

RF Hold Valve Command
This parameter displays the state of the right front holding valve control circuit based on the EHCU commanded signal. The scan tool will display On or Off. The parameter should be On when the holding valve is commanded On. The parameter should be Off when the holding valve is commanded Off.

RF Hold Valve Feedback
This parameter displays a feedback signal based on the commanded signal of the right front holding valve. The scan tool will display On or Off. The parameter should be On when the holding valve is commanded On. The parameter should be Off when the holding valve is commanded Off.

RF Release Valve Command
This parameter displays the state of the right front release valve control circuit based on the EHCU commanded signal. The scan tool will display On or Off. The parameter should be On when the release valve is commanded On. The parameter should be Off when the release valve is commanded Off.

RF Release Valve Feedback
This parameter displays a feedback signal based on the commanded signal of the right front release valve. The scan tool will display On or Off. The parameter should be On when the release valve is commanded On. The parameter should be Off when the release valve is commanded Off.

Right Front Wheel Speed
This parameter displays the wheel speed calculated by the EHCU based on an input from the right front wheel speed sensor. The scan tool will display a high value at higher vehicle speeds, and a low value at lower vehicle speeds.

Right Rear Wheel Speed
This parameter displays the wheel speed calculated by the EHCU based on an input from the right rear wheel speed sensor. The scan tool will display a high value at higher vehicle speeds, and a low value at lower vehicle speeds.

RR Hold Valve Command
This parameter displays the state of the right rear holding valve control circuit based on the EHCU commanded signal. The scan tool will display On or Off. The parameter should be On when the holding valve is commanded On. The parameter should be Off when the holding valve is commanded Off.

RR Hold Valve Feedback
This parameter displays a feedback signal based on the commanded signal of the right rear holding valve. The scan tool will display On or Off. The parameter should be On when the holding valve is commanded On. The parameter should be Off when the holding valve is commanded Off.

RR Release Valve Command
This parameter displays the state of the right rear release valve control circuit based on the EHCU commanded signal. The scan tool will display On or Off. The parameter should be On when the release valve is commanded On. The parameter should be Off when the release valve is commanded Off.

RR Release Valve Feedback
This parameter displays a feedback signal based on the commanded signal of the right rear release valve. The scan tool will display On or Off. The parameter should be On when the release valve is commanded On. The parameter should be Off when the release valve is commanded Off.

Scan Tool Output Controls

Scan Tool Output Control	Descriptions
ABS Motor	The purpose of this test is for checking whether the ABS motor is operating when commanded ON. Faulty circuit(s) or faulty ABS motor could be considered if not operating when commanded ON.
ABS Relay	The purpose of this test is for checking whether the fail-safe relay in the EHCU is operating when commanded ON. Faulty circuit(s) or faulty fail-safe relay in the EHCU could be considered if not energizing when commanded ON.

ABS Warning Lamp	The purpose of this test is for checking whether the ABS warning relay is operating when commanded ON. Faulty circuit(s), relay or an open bulb could be considered if not operating when commanded ON.
Exhaust Brake Cut	The purpose of this test is for checking whether the exhaust brake cut relay is operating when commanded ON. Faulty circuit(s) or faulty exhaust brake cut relay could be considered if not energizing when commanded ON.
Left Front Hold Valve	**Important:** Lift up left front wheel before this test. The purpose of this test is for checking whether the left front holding valve is operating when commanded ON. Even if the brake pedal is released after the commanded ON, the left front tire cannot be turned by hand. Faulty left front holding valve or circuit in the EHCU could be considered if rotating when released brake pedal.
Left Front Release Valve	**Important:** Lift up left front wheel before this test. The purpose of this test is for checking whether the left front release valve is operating when commanded ON. While the brake pedal is stepped ON and the command is ON, the left front tire can be turned by hand. Faulty left front release valve, ABS motor or circuit in the EHCU could be considered if not rotating when commanded ON.
Left Rear Hold Valve	**Important:** Lift up left rear wheel before this test. The purpose of this test is for checking whether the left rear holding valve is operating when commanded ON. Even if the brake pedal is released after the commanded ON, the left rear tire cannot be turned by hand. Faulty left rear holding valve or circuit in the EHCU could be considered if rotating when the released brake pedal.
Left Rear Release Valve	**Important:** Lift up left rear wheel before this test. The purpose of this test is for checking whether the left rear release valve is operating when commanded ON. While the brake pedal is stepped ON and the command is ON, the left rear tire can be turned by hand. Faulty left rear release valve, ABS motor or circuit in the EHCU could be considered if not rotating when commanded ON.
Right Front Hold Valve	**Important:** Lift up right front wheel before this test. The purpose of this test is for checking whether the right front holding valve is operating when commanded ON. Even if the brake pedal is released after the commanded ON, the right front tire cannot be turned by hand. Faulty right front holding valve or circuit in the EHCU could be considered if rotating when released brake pedal.
Right Front Release Valve	**Important:** Lift up right front wheel before this test. The purpose of this test is for checking whether the right front release valve is operating when commanded ON. While the brake pedal is stepped ON and the command is ON, the right front tire can be turned by hand. Faulty right front release valve, ABS motor or circuit in the EHCU could be considered if not rotating when commanded ON.
Right Rear Hold Valve	**Important:** Lift up right rear wheel before this test. The purpose of this test is for checking whether the right rear holding valve is operating when commanded ON. Even if the brake pedal is released after the commanded ON, the right rear tire cannot be turned by hand. Faulty right rear holding valve or circuit in the EHCU could be considered if rotating when the released brake pedal.

Right Rear Release Valve	**Important:** Lift up right rear wheel before this test. The purpose of this test is for checking whether the right rear release valve is operating when commanded ON. While the brake pedal is stepped ON and the command is ON, the right rear tire can be turned by hand. Faulty right rear release valve, ABS motor or circuit in the EHCU could be considered if not rotating when commanded ON.

Scan Tool Does Not Power Up

Circuit Description

The data link connector (DLC) is a standardized 16 cavity connector. Connector design and location is dictated by an industry wide standard, and is required to provide the following:

- Scan tool power battery positive voltage at terminal 16.
- Scan tool power ground at terminal 4.
- Common signal ground at terminal 5.

The scan tool will power up with the ignition OFF. Some modules however, will not communicate unless the ignition is ON.

Scan Tool Does Not Power Up

Schematic Reference: Anti-lock Brake System (ABS) Controls schematics

Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views

Step	Action	Value(s)	Yes	No
1	**Important:** Make sure the scan tool works properly on another vehicle before using this chart. 1. Turn OFF the ignition. 2. Inspect the Hazard/Horn (20A) fuse in the glove box fuse block Is the Hazard/Horn (20A) fuse open?	—	Go to Step 2	Go to Step 3
2	Replace the Hazard/Hone (20A) fuse. If the fuse continues to open, repair the short to ground on one of the circuits that is fed by the Hazard/Hone (20A) fuse or replace the shorted attached component fed by the Hazard/Horn (20A) fuse. Did you complete the repair?	—	Go to Step 7	—
3	1. Check each circuit at the date link connector (DLC) for a backed out, spread or missing terminal. 2. Repair the terminal as necessary. Did you find and complete the repair?	—	Go to Step 7	Go to Step 4
4	Connect a test lamp between the B+ circuit (pin 16) at the DLC and ground. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 5
5	Repair the open in the battery voltage circuit to the DLC. Did you complete the repair?	—	Go to Step 7	—
6	1. Test each ground circuit at the DLC (pins 4 and 5) for an open circuit and high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Intermittent Conditions
7	1. Connect the scan tool to the DLC. 2. Attempt to turn ON the scan tool. Does the scan tool ON?	—	System OK	Go to Step 1

Scan Tool Does Not Communicate with Class 2 Device

Circuit Description

The engine control module (ECM), transmission control module (TCM) and electronic hydraulic control unit (EHCU) all communicate with the scan tool over the Class 2 serial data link. The EHCU receives transmission parameters necessary for correct ABS functions over the Class 2 link as well. However, the ECM and TCM communicate with each other over the controller area network (CAN) link. The CAN link is not used for communication with the scan tool and is shared only between the ECM and TCM.

Diagnostic Aids

The following conditions will cause a loss of class 2 serial data communication between the TCM and EHCU or between the scan tool and any control modules:

- A class 2 serial data circuit open.
- A class 2 serial data circuit shorted to ground.
- A class 2 serial data circuit shorted to voltage.
- An internal condition within a module or connector on the class 2 serial data circuit, that causes a short to voltage or ground to the class 2 serial data circuit.
- Open ground circuit (pin 5) at the DLC.

The Class 2 Message Monitor may be used to determine if a control module is intermittently communicating over the Class 2 link. The scan tool will indicate INACTIVE if a module is not communicating with the ignition turned ON.

Notice:
If the control module does not communicate as soon as the ignition is turned ON, that module will not be appear on the scan tool until it initially communicates. Therefore, if the scan tool indicates INACTIVE for a module or does not display the module with the ignition ON, the module is not communicating on the Class 2 link.

Scan Tool Does Not Communicate with Class 2 Device

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics
Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Attempt to communicate with each control module on the Class 2 serial data circuit (ECM, TCM and EHCU). If using a Tech 2, obtain this information using the Class 2 Message Monitor feature. Does the scan tool communicate with any module on the Class 2 serial data circuit (If using a Tech 2, the display must read ACTIVE for any controller)?	—	Go to Step 3	Go to Step 7
3	Does the scan tool communicate with the ECM?	—	Go to Step 4	Diagnostic System Check - Engine Controls
4	Does the scan tool communicate with the TCM?	—	Go to Step 5	Diagnostic System Check-Transmission Controls
5	Does the scan tool communicate with the EHCU?	—	Go to Step 6	Go to Lost Communication with the EHCU

Step	Action	Value(s)	Yes	No
6	Test the Class 2 serial data circuit for an intermittent short to ground or intermittent short to voltage. Then, test the Class 2 serial data circuit for an intermittent open (based on which control module did not communicate) at the connection in the circuit. Did you find and correct the condition?	—	Go to Step 15	System OK
7	Test the data link connector (DLC) ground circuit at terminal 5 for an open circuit and for a poor connection. Did you find and correct the condition?	—	Go to Step 15	Go to Step 8
8	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Turn ON the ignition leaving the engine OFF. 4. Attempt to communicate with the TCM and the EHCU. Does the scan tool communicate with the TCM and EHCU?	—	Go to Step 12	Go to Step 9
9	1. Turn OFF the ignition. 2. Reconnect the ECM harness connector. 3. Disconnect the TCM harness connector. 4. Turn ON the ignition leaving the engine OFF. 5. Attempt to communicate with the ECM and EHCU. Does the scan tool communicate with the ECM and EHCU?	—	Go to Step 13	Go to Step 10
10	1. Turn OFF the ignition. 2. Reconnect the TCM harness connector. 3. Disconnect the EHCU harness connector. 4. Turn ON the ignition leaving the engine OFF. 5. Attempt to communicate with the ECM and TCM. Does the scan tool communicate with the ECM and TCM?	—	Go to Step 14	Go to Step 11
11	Repair the short to ground or short to voltage on the Class 2 serial data circuit between the DLC and ECM, TCM or EHCU. Did you complete the repair?	—	Go to Step 15	—
12	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement Fuel Injector Flow Rate Programming & Option Programming (If so equipped) in Engine Control System section. Did you complete the replacement?	—	Go to Step 15	—

Step	Action	Value(s)	Yes	No
13	Replace the TCM. Refer to Transmission Control Module (TCM) Replacement in the Automatic Transmission section. Did you complete the replacement?	—	Go to Step 15	—
14	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 15	—
15	Attempt to communicate with the ECM, TCM and EHCU. Does the scan tool communicate with the ECM, TCM and EHCU?	—	System OK	Go to Step 2

Lost Communications with the Electronic Hydraulic Control Unit (EHCU)

Circuit Description

The engine control module (ECM), transmission control module (TCM) and electronic hydraulic control unit (EHCU) [antilock brake control module] all communicate with the scan tool over the Class 2 data link. The EHCU receives transmission parameters necessary for correct ABS functions over the Class 2 link as well.

Diagnostic Aids

The ABS diagnostic circuit connected to pin 12 at the data link connector (DLC) can also be used to retrieve diagnostic trouble codes (DTCs). When this circuit is grounded, the EHCU will flash the ABS Warning lamp relying any stored DTCs. This circuit is NOT used for any scan tool communication.

If either or both battery voltage feeds to the EHCU are lost, scan tool communication will still exist.

If only the EHCU (pin 23) ground is open, scan tool communications will still exist.

An intermittent communication condition can be found by using the Diagnostic Circuit Check - Class 2 Message Monitor on the scan tool. If the EHCU is not communicating over the Class 2 link with the ignition ON, the display will read Inactive or the controller will not appear in the list.

Lost Communications with the Electronic Hydraulic Control Unit (EHCU)

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics

Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	Attempt to establish EHCU communications with the scan tool. Does the EHCU communicate with the scan tool?	—	Go to Diagnostic Aids	Go to Step 3
3	Check the EHCU connector for a poor connection. Did you find and correct the condition?	—	Go to Step 8	Go to Step 4
4	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Turn ON the starter switch with the engine OFF. 4. Check the Gauges (10A) fuse. If any fuse continues to open, check for a short to ground on each circuit fed by that fuse. 5. Connect a test lamp to ground and check for voltage at the ignition voltage supply circuit at the EHCU. Does the test lamp illuminate?	—	Go to Step 8	Go to Step 5

Step	Action	Value(s)	Yes	No
5	1. Turn OFF the ignition. 2. Connect a DMM between the Class 2 serial data circuit at the EHCU and the data link connector (DLC). 3. Test the circuits for an open circuit and high resistance. 4. Repair the circuit as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 6
6	1. Check for an open in the EHCU (pin 1) ground circuit. 2. Check the EHCU chassis ground for tightness and corrosion. 3. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 7
7	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 8	—
8	1. Turn OFF the ignition. 2. Reconnect all disconnected connectors. 3. Turn the ignition ON, with the engine OFF. 4. Attempt to establish scan tool communications with the EHCU. Does the scan tool communicate with the EHCU?	—	System OK	Go to Step 3

Diagnostic Trouble Code (DTC) List

Provided below is a list of all DTC's for the ABS system. Choose and trace the appropriate flowchart by DTC (Flash Code) to find fault and repair.

DTC	Flash Code	Description	Warning Light	System Control
			ABS	ABS
C0221	52	Right Front Wheel Speed Sen. Ckt. Open or Short	○	○ *A
C0222	62	Right Front Wheel Speed Sensor Signal Missing	○	○ *A, *C
C0225	51	Left Front Wheel Speed Sen. Ckt. Open or Short	○	○ *A
C0226	61	Left Front Wheel Speed Sensor Signal Missing	○	○ *A, *C
C0231	54	Right Rear Wheel Speed Sen. Ckt. Open or Short	○	○ *A
C0232	64	Right Rear Wheel Speed Sensor Signal Missing	○	○ *A, *C
C0235	53	Left Rear Wheel Speed Sen. Ckt. Open or Short	○	○ *A
C0236	63	Left Rear Wheel Speed Sensor Signal Missing	○	○ *A, *C
C0241	43	Solenoid Control Circuit Malfunction	○	–
C0242	45	Solenoid Control Monitor Error	○	–
C0265	41	Solenoid Valve Relay Circuit	○	–
C0267	33	Motor Circuit Fault Detected	○	–
C0268	34	Abnormal ABS Motor Rotation	○	–
C0271	14	EHCU Abnormality	○	–
C0277	15	EHCU Power Supply Low Input or High Input	○	○ *B
C0299	25	Exhaust Brake Cut Relay Circuit	○	○

*A: Prohibition applicable wheel control
*B: If sensor power supply is low then ABS is not controlled by EHCU.
*C: If tire diameter is error then ABS is not controlled by EHCU.
○: ON
–: OFF

C0221 (Flash Code 52)

Circuit Description

The front left wheel speed sensor is a magnetic coil type sensor. The electronic hydraulic control unit (EHCU) supplies 5 volts to the front right wheel speed sensor signal circuit and a ground for the low reference circuit.

If the EHCU detects that the front right wheel speed sensor signal circuit is an open or a short, this DTC will set.

DTC C0221

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics

Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the front right wheel speed sensor harness connector. 3. Connect a DMM across the front right wheel speed sensor terminals. 4. Measure the resistance across the front left wheel speed sensor. Does resistance measure within the specified value?	1 – 1.5kΩ	Go to Step 4	Go to Step 14
4	1. Connect a DMM between the signal circuit (pin 1 of J-74 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	4.3 volts	Go to Step 5	Go to Step 8
5	Does the DMM voltage indicate more than the specified value at Step 4?	5.5 volts	Go to Step 9	Go to Step 6
6	1. Connect a DMM between the low reference circuit (pin 2 of J-74 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	1 volt	Go to Step 11	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Connect a DMM across the signal circuit and the low reference circuit of the front right wheel speed sensor harness (pins 1 and 2 of J-74 connector). 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	4.3 volt	Go to Step 12	Go to Step 10
8	1. Test the signal circuit between the EHCU (pin 10 of J-177 connector) and the front right wheel speed sensor harness connector (pin 1 of J-74 connector) for the following conditions: • An open circuit • A short to ground • A short to the low reference circuit • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct condition?	—	Go to Step 16	Go to Step 13
9	1. Test the signal circuit between the EHCU (pin 10 of J-177 connector) and the front right wheel speed sensor harness connector (pin 1 of J-74 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
10	1. Test the low reference circuit between the EHCU (pin 10 of J-177 connector) and the front right wheel speed sensor harness connector (pin 2 of J-74 connector) for an open circuit and high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 13
11	1. Test the low reference circuit between the EHCU (pin 10 of J-177 connector) and the front right wheel speed sensor harness connector (pin 2 of J-74 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15

Step	Action	Value(s)	Yes	No
12	1. Turn OFF the ignition. 2. Disconnect the front right wheel speed sensor harness connector. 3. Inspect for an intermittent and for poor connections at the harness connector of the front right wheel speed sensor (pins 1 or 2 of J-74 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 14
13	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent and for poor connections on the front right wheel speed sensor circuit at the harness connector of the EHCU (pins 10 or 11 of J-177 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
14	Replace the front right wheel speed sensor. Refer to Front Wheel Speed Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 16	—
15	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition, with the engine OFF. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 17
17	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

C0222 (Flash Code 62)

Circuit Description

The electronic hydraulic control unit (EHCU) monitors wheel speed sensor signal pulse.
If the EHCU detects that the front right wheel speed sensor signal is fault, this DTC will set.

DTC C0222

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics
Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Check for the following conditions: • Size of a tire • Air pressure of a tire 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the front right wheel speed sensor harness connector. 3. Connect a DMM across the front right wheel speed sensor terminals. 4. Measure the resistance across the front right wheel speed sensor. Does the resistance measure within the specified value?	1 – 1.5kΩ	Go to Step 4	Go to Step 9
4	1. Connect a DMM across the front right wheel speed sensor terminals (measure sensor output voltage). 2. Place the DMM on the AC volt scale. 3. Turn ON the ignition, with the engine OFF 4. Monitor the DMM while rotating the tire. Does the DMM indicate an AC voltage increase in accordance with tire rotating speed?	—	Go to Step 7	Go to Step 5
5	1. Remove the front right wheel speed sensor and check for damage, metal particles on magnet. 2. Repair or replace as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 6
6	1. Check for sensor rotor and front right wheel hub bearing. 2. Repair or replace as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Disconnect the front right wheel speed sensor harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the front right wheel speed sensor (pins 1 and 2 of J-74 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 8
8	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent, for poor connections and corrosion on the front right wheel speed sensor circuit at the harness connector of the EHCU (pins 10 and 11 of J-177 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
9	Replace the front right wheel speed sensor. Refer to Front Wheel Speed Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—
10	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Drive the vehicle by speed higher than 20 MPH (32km/h). Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 12
12	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

C0225 (Flash Code 51)

Circuit Description

The front left wheel speed sensor is a magnetic coil type sensor. The electronic hydraulic control unit (EHCU) supplies 5 volts to the front left wheel speed sensor signal circuit and a ground for the low reference circuit.

If the EHCU detects that the front left wheel speed sensor signal circuit is an open or a short, this DTC will set.

DTC C0225

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics

Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the front left wheel speed sensor harness connector. 3. Connect a DMM across the front left wheel speed sensor terminals. 4. Measure the resistance across the front left wheel speed sensor. Does resistance measure within the specified value?	1 – 1.5kΩ	Go to Step 4	Go to Step 14
4	1. Connect a DMM between the signal circuit (pin 1 of J-75 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	4.3 volts	Go to Step 5	Go to Step 8
5	Does the DMM voltage indicate more than the specified value at Step 4?	5.5 volts	Go to Step 9	Go to Step 6
6	1. Connect a DMM between the low reference circuit (pin 2 of J-75 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	1 volt	Go to Step 11	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Connect a DMM across the signal circuit and the low reference circuit of the front left wheel speed sensor harness (pins 1 and 2 of J-75 connector). 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	4.3 volt	Go to Step 12	Go to Step 10
8	1. Test the signal circuit between the EHCU (pin 32 of J-177 connector) and the front left wheel speed sensor harness connector (pin 1 of J-75 connector) for the following conditions: • An open circuit • A short to ground • A short to the low reference circuit • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 13
9	1. Test the signal circuit between the EHCU (pin 32 of J-177 connector) and the front left wheel speed sensor harness connector (pin 1 of J-75 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
10	1. Test the low reference circuit between the EHCU (pin 33 of J-177 connector) and the front left wheel speed sensor harness connector (pin 2 of J-75 connector) for an open circuit and high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 13
11	1. Test the low reference circuit between the EHCU (pin 33 of J-177 connector) and the front left wheel speed sensor harness connector (pin 2 of J-75 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
12	1. Turn OFF the ignition. 2. Disconnect the front left wheel speed sensor harness connector. 3. Inspect for an intermittent and for poor connections at the harness connector of the front left wheel speed sensor (pins 1 or 2 of J-75 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 14

Step	Action	Value(s)	Yes	No
13	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent and for poor connections on the front left wheel speed sensor circuit at the harness connector of the EHCU (pins 32 or 33 of J-177 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
14	Replace the front left wheel speed sensor. Refer to Front Wheel Speed Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 16	—
15	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition, with the engine OFF. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 17
17	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

C0226 (Flash Code 61)

Circuit Description

The electronic hydraulic control unit (EHCU) monitors wheel speed sensor signal pulse.

If the EHCU detects that the front left wheel speed sensor signal is fault, this DTC will set.

DTC C0226

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics

Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Check for the following conditions: • Size of a tire • Air pressure of a tire 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the front left wheel speed sensor harness connector. 3. Connect a DMM across the front left wheel speed sensor terminals. 4. Measure the resistance across the front left wheel speed sensor. Does resistance measure within the specified value?	1-1.5kΩ	Go to Step 4	Go to Step 9
4	1. Connect a DMM across the front left wheel speed sensor terminals (measure sensor output voltage). 2. Place the DMM on the AC volt scale. 3. Turn ON the ignition, with the engine OFF 4. Monitor the DMM while rotating the tire. Does the DMM indicate an AC voltage increase in accordance with tire rotating speed?	—	Go to Step 7	Go to Step 5
5	1. Remove the front left wheel speed sensor and check for damage, metal particles on magnet. 2. Repair or replace as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 6
6	1. Check for sensor rotor and front left wheel hub bearing. 2. Repair or replace as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Disconnect the front left wheel speed sensor harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the front left wheel speed sensor (pins 1 and 2 of J-75 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 8
8	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent, for poor connections and corrosion on the front left wheel speed sensor circuit at the harness connector of the EHCU (pins 32 and 33 of J-177 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
9	Replace the front left wheel speed sensor. Refer to Front Wheel Speed Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—
10	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Drive the vehicle by speed higher than 20 MPH (32km/h). Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 12
12	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

C0231 (Flash Code 54)

Circuit Description

The rear right wheel speed sensor is a hall IC type sensor, which has the following circuits.

- 12 volts feed circuit
- speed sensor signal circuit

If the electronic hydraulic control unit (EHCU) detects that the front right wheel speed sensor signal circuit is an open or a short, this DTC will set.

DTC C0231

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics

Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the rear right wheel speed sensor harness connector. 3. Connect a DMM between the power supply circuit (pin 2 of J-148 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	9 volts	Go to Step 4	Go to Step 6
4	1. Connect a DMM between the low reference circuit (pin 1 of J-148 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	1 volt	Go to Step 7	Go to Step 5
5	1. Connect a DMM between across the power supply circuit and the low reference circuit of the rear right wheel speed sensor harness (pins 1 and 2 of J-148 connector). 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	9 volts	Go to Step 9	Go to Step 8

Step	Action	Value(s)	Yes	No
6	1. Test the right wheel speed sensor circuit between the EHCU (pin 21 of J-177 connector) and the rear right wheel speed sensor harness connector (pin 2 of J-148 connector) for the following conditions: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
7	1. Test the right wheel speed sensor circuit between the EHCU (pin 12 of J-177 connector) and the rear right wheel speed sensor harness connector (pin 1 of J-148 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
8	1. Test the right wheel speed sensor circuit between the EHCU (pin 12 of J-177 connector) and the rear right wheel speed sensor harness connector (pin 1 of J-148 connector) for an open circuit and high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
9	1. Test the right wheel speed sensor circuit between the EHCU (pin 12 of J-177 connector) and the rear right wheel speed sensor harness connector (pin 1 of J-148 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct condition?	—	Go to Step 14	Go to Step 10
10	1. Turn OFF the ignition. 2. Disconnect the rear right wheel speed sensor harness connector. 3. Inspect for an intermittent and for poor connections at the harness connector of the rear right wheel speed sensor (pins 1 and 2 of J-148 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 12

Step	Action	Value(s)	Yes	No
11	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent and for poor connections on the rear right wheel speed sensor circuit at the harness connector of the EHCU (pins 21 or 12 of J-177 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
12	Replace the rear right wheel speed sensor. Refer to Rear Wheel Speed Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 14	—
13	Replace the rear right wheel speed sensor. Refer to Rear Wheel Speed Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 14	—
14	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition, with the engine OFF. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 15
15	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

C0232 (Flash Code 64)

Circuit Description

The electronic hydraulic control unit (EHCU) monitors wheel speed sensor signal pulse.
If the EHCU detects that the rear right wheel speed sensor signal is fault, this DTC will set.

DTC C0232

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics
Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Check for the following conditions: • Size of a tire • Air pressure of a tire 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the rear right wheel speed sensor harness connector. 3. Connect a DMM between the power supply circuit (pin 2 of J-148 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	9 volts	Go to Step 4	Go to Step 7
4	1. Connect a DMM between across the power supply circuit and the low reference circuit of the rear right wheel speed sensor harness (pins 1 and 2 of J-148 connector). 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	9 volts	Go to Step 5	Go to Step 8
5	1. Disconnect the rear right wheel speed sensor harness connector. 2. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the rear right wheel speed sensor (pins 1 and 2 of J-148 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 6

Step	Action	Value(s)	Yes	No
6	1. Remove the rear right brake drum. Refer to Rear Wheel Speed Sensor Replacement in this section. 2. Visually inspect the wheel speed sensor for the following condition: • For physical damage • For loose or improper installation 3. Visually inspect the sensor rotor for the following condition: • For physical damage • For improper installation 4. The following conditions may cause this DTC set: • Excessive air gap between the wheel speed sensor and the sensor rotor. • Electromagnetic interference in the wheel speed sensor circuits. • Foreign material passing between the wheel speed sensor and the sensor rotor. 5. Repair or replace as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 7
7	1. Test the right wheel speed sensor circuit between the EHCU (pin 21 of J-177 connector) and the rear right wheel speed sensor harness connector (pin 2 of J-148 connector) for high resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9
8	1. Test the right wheel speed sensor circuit between the EHCU (pin 12 of J-177 connector) and the rear right wheel speed sensor harness connector (pin 1 of J-148 connector) for high resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9
9	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent, for poor connections and corrosion on the rear right wheel speed sensor circuit at the harness connector of the EHCU (pins 21 or 12 of J-177 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	Replace the rear right wheel speed sensor. Refer to Rear Wheel Speed Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 12	—

Step	Action	Value(s)	Yes	No
11	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Drive the vehicle by speed higher than 20 MPH (32km/h). Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 13
13	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

C0235 (Flash Code 53)

Circuit Description

The rear left wheel speed sensor is a hall IC type sensor, which has the following circuits.

- 12 volts feed circuit
- speed sensor signal circuit

If the electronic hydraulic control unit (EHCU) detects that the front left wheel speed sensor signal circuit is an open or a short, this DTC will set.

DTC C0235

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics

Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the rear left wheel speed sensor harness connector. 3. Connect a DMM between the power supply circuit (pin 2 of J-149 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	9 volts	Go to Step 4	Go to Step 6
4	1. Connect a DMM between the low reference circuit (pin 1 of J-149 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	1 volt	Go to Step 7	Go to Step 5
5	1. Connect a DMM between across the power supply circuit and the low reference circuit of the rear left wheel speed sensor harness (pins 1 and 2 of J-149 connector). 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	9 volts	Go to Step 9	Go to Step 8

Step	Action	Value(s)	Yes	No
6	1. Test the left wheel speed sensor circuit between the EHCU (pin 22 of J-177 connector) and the rear left wheel speed sensor harness connector (pin 2 of J-149 connector) for the following conditions: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
7	1. Test the left wheel speed sensor circuit between the EHCU (pin 34 of J-177 connector) and the rear left wheel speed sensor harness connector (pin 1 of J-149 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
8	1. Test the left wheel speed sensor circuit between the EHCU (pin 34 of J-177 connector) and the rear left wheel speed sensor harness connector (pin 1 of J-149 connector) for an open circuit and high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
9	1. Test the left wheel speed sensor circuit between the EHCU (pin 34 of J-177 connector) and the rear left wheel speed sensor harness connector (pin 1 of J-149 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 10
10	1. Turn OFF the ignition. 2. Disconnect the rear left wheel speed sensor harness connector. 3. Inspect for an intermittent and for poor connections at the harness connector of the rear left wheel speed sensor (pins 1 and 2 of J-149 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 12

Step	Action	Value(s)	Yes	No
11	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent and for poor connections on the rear left wheel speed sensor circuit at the harness connector of the EHCU (pins 22 or 34 of J-177 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
12	Replace the rear left front wheel speed sensor. Refer to Rear Wheel Speed Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 14	—
13	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 14	—
14	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition, with the engine OFF. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 15
15	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

C0236 (Flash Code 63)

Circuit Description

The electronic hydraulic control unit (EHCU) monitors wheel speed sensor signal pulse.
If the EHCU detects that the rear left wheel speed sensor signal is fault, this DTC will set.

DTC C0236

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics
Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Check for the following conditions: • Size of a tire • Air pressure of a tire 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the rear left wheel speed sensor harness connector. 3. Connect a DMM between the power supply circuit (pin 2 of J-149 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	9 volts	Go to Step 4	Go to Step 7
4	1. Connect a DMM between across the power supply circuit and the low reference circuit of the rear left wheel speed sensor harness (pins 1 and 2 of J-149 connector). 2. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	9 volts	Go to Step 5	Go to Step 8
5	1. Disconnect the rear left wheel speed sensor harness connector. 2. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the rear left wheel speed sensor (pins 1 and 2 of J-149 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 6

Step	Action	Value(s)	Yes	No
6	1. Remove the rear left brake drum. Refer to Rear Wheel Speed Sensor Replacement in this section. 2. Visually inspect the wheel speed sensor for the following condition: • For physical damage • For loose or improper installation 3. Visually inspect the sensor rotor for the following condition: • For physical damage • For improper installation 4. The following conditions may cause this DTC set: • Excessive air gap between the wheel speed sensor and the sensor rotor. • Electromagnetic interference in the wheel speed sensor circuits. • Foreign material passing between the wheel speed sensor and the sensor rotor. 5. Repair or replace as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 7
7	1. Test the left wheel speed sensor circuit between the EHCU (pin 22 of J-177 connector) and the rear left wheel speed sensor harness connector (pin 2 of J-149 connector) for high resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9
8	1. Test the left wheel speed sensor circuit between the EHCU (pin 34 of J-177 connector) and the rear left wheel speed sensor harness connector (pin 1 of J-149 connector) for high resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9
9	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent, for poor connections and corrosion on the rear left wheel speed sensor circuit at the harness connector of the EHCU (pins 22 or 34 of J-177 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	Replace the rear left wheel speed sensor. Refer to Rear Wheel Speed Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 12	—

Step	Action	Value(s)	Yes	No
11	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Drive the vehicle by speed higher than 20 MPH (32km/h). Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 13
13	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

C0241 (Flash Code 43)

Description

The electronic hydraulic control unit (EHCU) monitors the internal solenoid drive circuit. If the EHCU detects the internal solenoid drive circuit fault, this DTC will set.

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Ensure that all tool connections are secure. 2. Install a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition, with the engine OFF. 5. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Step 4
3	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 4	—
4	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the DTC Information with a scan tool. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 5
5	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	—

C0242 (Flash Code 45)

Description

The electronic hydraulic control unit (EHCU) monitors the internal solenoid drive and monitor circuit. If the EHCU detects the internal solenoid drive and monitor circuit fault, this DTC will set.

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Ensure that all tool connections are secure. 2. Install a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition, with the engine OFF. 5. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Step 4
3	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 4	—
4	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the DTC Information with a scan tool. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 5
5	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	—

C0265 (Flash Code 41)

Circuit Description

The electronic hydraulic control unit (EHCU) monitors the internal solenoid valve relay and drive circuit system. If the EHCU detects the relay and circuit fault, this DTC will set.

DTC C0265

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics

Connector End View Reference: Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Turn OFF the ignition. 2. Inspect the slow blow fuse ABS (60A) in the relay box. Is the slow blow fuse ABS (60A) open?	—	Go to Step 5	Go to Step 3
3	1. Test the power supply circuits between the EHCU (pins 2 and 24 of J-177 connector) and the slow blow fuse ABS (60A) for an open circuit and high resistance. 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 4
4	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent and for a poor connection on the power supply circuit at the harness connector of the EHCU (pin 2 of J-177 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 6
5	Replace the slow blow fuse ABS (60A). If the fuse continues to open, repair the short to ground that is fed by the slow blow fuse ABS (60A) or replace the shorted attached component fed by the slow blow fuse ABS (60A). Did you complete the repair?	—	Go to Step 7	—
6	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 7	—
7	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. Did you find and correct the condition?	—	Go to Step 2	Go to Step 8
8	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

C0267 (Flash Code 33)

Circuit Description

The electronic hydraulic control unit (EHCU) monitors the internal motor drive circuit system. If the EHCU detects the motor circuit fault, this DTC will set.

DTC C0267

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics
Connector End View Reference: Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Command the ABS Motor ON and OFF with a scan tool. Does the ABS Motor operate when commanded ON and OFF with a scan tool?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Connect a test lamp between the power supply circuit (pin 24 of J-177 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 4	Go to Step 5
4	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent and for a poor connection on the power supply circuit at the harness connector of the EHCU (pin 24 of J-177 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 6
5	Repair the open or high resistance in the power supply circuit between the ABS (60A) slow blow fuse and the EHCU (pin 24 of J-177 connector). Did you complete the repair?	—	Go to Step 7	—
6	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 7	—
7	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn ON the ignition, with the engine OFF. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 8

Step	Action	Value(s)	Yes	No
8	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

C0268 (Flash Code 34)

Description

The electronic hydraulic control unit (EHCU) monitors the motor. If the EHCU detects the motor fault, this DTC will set.

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Ensure that all tool connections are secure. 2. Install a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition, with the engine OFF. 5. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Step 4
3	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 4	—
4	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the DTC Information with a scan tool. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 5
5	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	—

C0271 (Flash Code 14)

Description

This diagnostic applies to internal CPU abnormality within the electronic hydraulic control unit (EHCU).
If the internal CPU calculate abnormality, this DTC will set.

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Ensure that all tool connections are secure. 2. Install a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition, with the engine OFF. 5. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Step 4
3	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 4	—
4	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the DTC Information with a scan tool. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 5
5	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	—

C0277 (Flash Code 15)

Circuit Description

The electronic hydraulic control unit (EHCU) monitors the system voltage on the power supply terminal to make sure that the voltage stays within the proper range. If the EHCU detects an excessively high or low system voltage, this DTC will set. When the charging system detects a malfunction, the charge indicator will light.

DTC C0277

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics
Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Install a scan tool. 2. Start the engine and let idle for 30 seconds. 3. Observe the Battery Voltage parameter with a scan tool. Is the Battery Voltage parameter within the specified value?	10 – 16 volts	Go to Diagnostic Aids	Go to Step 3
3	Test the charging system. Refer to Diagnosis of The Charging System in the Engine Electrical Section. Did you find a charging system problem?	—	Go to Step 4	Go to Step 5
4	Repair the charging system. Refer to Diagnosis of The Charging System in the Engine Electrical Section. Did you complete the repair?	—	Go to Step 9	—
5	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent and for a poor connection or high resistance on the power supply circuit at the harness connector of the EHCU (pin 2 of J-177 connector). 4. Repair the connection(s) or circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 9	Go to Step 6
6	1. Test the ground circuit between the EHCU (pin 1 of J-177 connector) and the chassis ground terminal (J-9) for an open circuit and high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 9	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor tightening and corrosion at the chassis ground terminal (J-9). 3. Repair the tightening or clean the corrosion as necessary. Did you find and correct the condition?	—	Go to Step 9	Go to Step 8
8	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 9	—
9	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition, with the engine OFF. Did you find and correct the condition?	—	Go to Step 2	Go to Step 10
10	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

C0299 (Flash Code 25)

Circuit Description

The electronic hydraulic control unit (EHCU) observes the exhaust brake signal, also controls the exhaust brake cut relay. If the EHCU detects exhaust brake cut relay circuit fault, this DTC will set.

DTC C0299

Schematic Reference: Anti-lock Brake System (ABS) Controls Schematics
Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Command the Exhaust Brake Cut ON and OFF with a scan tool. Does the Exhaust Brake Cut Relay click when commanded ON and OFF with a scan tool?	—	Go to Step 5	Go to Step 3
3	1. Turn OFF the ignition. 2. Remove the exhaust brake cut relay. 3. Connect a test lamp between the voltage feed circuit (pin 2 of J-210 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 4	Go to Step 14
4	1. Connect a test lamp between the voltage feed circuit and relay control circuit of the exhaust rake cut relay (pins 2 and 4 of J-210 connector). 2. Turn ON the ignition, with the engine OFF. 3. Command the Exhaust Brake Cut ON with a scan tool. Does the test lamp illuminate?	—	Go to Step 12	Go to Step 10
5	1. Connect a test lamp between the voltage feed circuit (pin 3 of J-210 connector) and a known good ground. 2. Start the engine. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 15
6	1. Connect a test lamp between the ground circuit (pin 1 of J-210 connector) and the battery voltage. 2. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 7	Go to Step 16

Step	Action	Value(s)	Yes	No
7	1. Connect a test lamp between the ground circuit (pin 5 of J-177 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 11	Go to Step 8
8	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the voltage feed circuit and the signal circuit of the exhaust brake cut relay (pins 3 and 5 of J-210 connector). 3. Disconnect the EHCU harness connector. 4. Connect a test lamp between the signal circuit at EHCU harness (pin 7 of J-177 connector) and a known good ground. 5. Start the engine. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 17
9	1. Turn OFF the ignition. 2. Install the exhaust brake cut relay. 3. Connect a test lamp between the signal circuit (pin 7 of J-177 connector) and a known good ground. 4. Start the engine. Does the test lamp illuminate?	—	Go to Step 13	Go to Step 12
10	1. Test the relay control circuit between the EHCU (pin 8 of J-177 connector) and the exhaust brake cut relay (pin 4 of J-210 connector) for an open circuit and high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 13
11	1. Test the signal circuit between the EHCU (pin 7 of J-177 connector) and the exhaust brake cut relay (pin 5 of J-210 connector) for short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 19
12	1. Turn OFF the ignition. 2. Remove the exhaust brake cut relay. 3. Inspect for an intermittent and for poor connections on each exhaust brake cut relay terminal. 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 18

Step	Action	Value(s)	Yes	No
13	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent and for poor connections on the exhaust brake cut relay circuit at the harness connector of the EHCU (pins 7 or 8 of J-177 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 19
14	Repair the open or high resistance in the voltage feed circuit between the Gauges (10A) fuse and the exhaust brake cut relay (pin 2 of J-210 connector). Did you complete the repair?	—	Go to Step 20	—
15	Repair the open or high resistance in the voltage feed circuit between the Exhaust Brake (10A) fuse and the exhaust brake cut relay (pin 3 of J-210 connector). Check the Exhaust Brake (10 A) fuse first. Did you complete the repair?	—	Go to Step 20	—
16	Repair the open or high resistance in the ground circuit between the exhaust brake cut relay (pin 1 of J-210 connector) and the chassis ground terminal (J-9). Did you complete the repair?	—	Go to Step 20	—
17	Repair the open or high resistance in the signal circuit between the EHCU (pin 7 of J-177 connector) and the exhaust brake cut relay (pin 5 of J-210 connector). Did you complete the repair?	—	Go to Step 20	—
18	Replace the exhaust brake cut relay. Did you complete the replacement?	—	Go to Step 20	—
19	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the replacement?	—	Go to Step 20	—
20	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Drive the vehicle and operate the exhaust brake Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 21
21	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

ABS Warning Light Always On

Description

Battery positive voltage is supplied directly to the ABS warning light. The electronic hydraulic control unit (EHCU) turns the ABS warning light ON by controlling the ABS warning light relay.

ABS Warning Light Always On

Schematic Reference: Anti-lock Brake System (ABS) Control Schematics

Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Command the ABS warning light ON and OFF with a scan tool. Does the ABS warning light always remain ON when commanded ON and OFF with a scan tool?	—	Go to Step 4	Go to Step 3
3	1. Start the engine. 2. Drive the vehicle. **Notice:** The ABS warning light turn OFF, if the 4 wheel speed sensor signals are normally. Does the ABS warning light turn OFF while driving?	—	System OK	Check for DTCs and if none exist Go to Intermittent Conditions
4	Command the ABS warning light ON and OFF with a scan tool while listening to the relay clicking in the fuse block. Does the ABS warning light relay click when the ABS warning light is commanded ON and OFF with a scan tool?	—	Go to Step 14	Go to Step 5
5	1. Turn OFF the ignition. 2. Remove the ABS warning light relay. 3. Probe the ignition voltage (coil) circuit of the ABS warning light relay (pin 4 of B-356 connector) with a test lamp connected to a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 11
6	1. Probe the control circuit of the ABS warning light relay (pin 2 of B-356 connector) with a test lamp connected to battery voltage. 2. Command the ABS warning light ON and OFF using a scan tool. Does the test lamp turn ON and OFF when commanded with a scan tool?	—	Go to Step 7	Go to Step 9

Step	Action	Value(s)	Yes	No
7	1. Inspect for an intermittent and for a poor connection at the ABS warning light relay (coil circuits). 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 8
8	Replace the ABS warning light relay. Did you complete the action?	—	Go to Step 17	—
9	Does the test lamp remain illuminated?	—	Go to Step 10	Go to Step 12
10	1. Test the ABS warning light relay control circuit between the EHCU (pin 6 of J-177 connector) and warning light relay (pin 2 of B-356 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
11	Repair the open in the ignition voltage circuit (coil circuit) of the ABS warning light relay (pin 4 of B-356 connector). Did you complete the repair?	—	Go to Step 17	—
12	1. Test the ABS warning light relay control circuit between the EHCU (pin 6 of J-177 connector) and warning light relay (pin 2 of B-356 connector) for an open or short to voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 13
13	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent or for a poor connection on the ABS warning light relay control circuit at the harness connector of the EHCU (pin 6 of J-177 connector). 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
14	1. Remove the instrument panel cluster (IPC). 2. Disconnect the IPC harness connector. (B-52) 3. Test the ABS warning light ground circuit for a short to ground. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 15
15	Replace the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Body, Cab and Accessories section. Did you complete the replacement?	—	Go to Step 17	—

Step	Action	Value(s)	Yes	No
16	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the action?	—	Go to Step 17	—
17	1. Reconnect or install all previously removed components. 2. Command the ABS warning light ON and OFF with a scan tool. Does the ABS warning light turn ON and OFF when commanded with a scan tool?	—	System OK	Go to Step 2

ABS Warning Light Inoperative

Description

Battery positive voltage is supplied directly to the ABS warning light. The electronic hydraulic control unit (EHCU) turns the ABS warning light ON by controlling the ABS warning light relay. There should be a steady ABS Warning Light with the ignition ON and the engine OFF.

ABS Warning Light Inoperative

Schematic Reference: Anti-lock Brake System (ABS) Control Schematics

Connector End View Reference: Anti-lock Brake System (ABS) Controls Connector End Views or Electronic Hydraulic Control Unit (EHCU) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Anti-lock Brake System (ABS) Controls?	—	Go to Step 2	Go to Diagnostic System Check – ABS Controls
2	1. Verify whether the instrument panel cluster (IPC) is operational. 2. Install a scan tool. 3. Turn ON the ignition, with the engine OFF. 4. Command the ABS warning light ON and OFF with a scan tool. Does the ABS warning light turn ON and OFF when commanded with a scan tool?	—	Go to Intermittent Conditions	Go to Step 3
3	Inspect the Gauges (10 A) fuse that supplies ignition voltage to the ABS warning light. Is the fuse open?	—	Go to Step 4	Go to Step 5
4	Replace the Gauges (10A) fuse. If the fuse continues to open, repair the short to ground on one of the circuits that is fed by the gauges fuse or replace the shorted attached component fed by the Gauges (10A) fuse. Did you complete the repair?	—	Go to Step 19	—
5	Command the ABS warning light ON and OFF with a scan tool while listening to the relay clicking in the fuse block. Does the ABS warning light relay click when the ABS warning light is commanded ON and OFF with a scan tool?	—	Go to Step 12	Go to Step 6
6	1. Turn OFF the ignition. 2. Remove the ABS warning light relay. 3. Probe the control circuit of the ABS warning light relay (pin 2 of B-356 connector) with a test lamp connected to battery voltage. 4. Command the ABS warning light ON and OFF using a scan tool. Does the test lamp turn ON and OFF when commanded with a scan tool?	—	Go to Step 7	Go to Step 9

Step	Action	Value(s)	Yes	No
7	1. Inspect for an intermittent and for a poor connection at the ABS warning light relay (pins 2 and 4 of B-365 connector) . 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 8
8	Replace the ABS warning light relay. Did you complete the action?	—	Go to Step 19	—
9	Does the test lamp remain illuminated?	—	Go to Step 10	Go to Step 11
10	1. Test the ABS warning light relay control circuit between the EHCU (pin 6 of J-177 connector) and warning light relay (pin 2 of B-356 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 18
11	1. Turn OFF the ignition. 2. Disconnect the EHCU harness connector. 3. Inspect for an intermittent or for a poor connection on the ABS warning light relay control circuit at the harness connector of the EHCU (pin 6 of J-177 connector). 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 18
12	1. Remove the ABS warning light relay. 2. Connect a fused jumper wire between the IPC circuit of the ABS warning light relay (pin 3 of B-356 connector) and a known good ground. Does the ABS warning light illuminate?	—	Go to Step 15	Go to Step 13
13	1. Test the IPC to ABS warning light relay circuit and the gauges (10A) fuse to IPC circuit for an open. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 14
14	1. Inspect for an intermittent or for a poor connection at the IPC (pin 18 of B-51 connector and pin 2 of B-52 connector). 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 15
15	1. Inspect for an intermittent or for a poor connection at the ABS warning light relay (pins 3 and 5 of B-356 connector). 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 16

Step	Action	Value(s)	Yes	No
16	1. Test the ABS warning light relay (pin 5 of B-356 connector) to head light bracket ground circuit (B-7) for an open. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 17
17	Replace the ABS warning light bulb or the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in Body, Cab and Accessories section. Did you complete the repair?	—	Go to Step 19	—
18	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in this section. Did you complete the action?	—	Go to Step 19	—
19	1. Reconnect or install all previously removed components. 2. Command the ABS warning light ON and OFF with a scan tool. Does the ABS warning light turn ON and OFF when commanded with a scan tool?	—	System OK	Go to Step 2

Symptom Diagnosis

Use the following five categories to diagnose failures that are not indicated by the ABS warning light.

- ABS works frequently but vehicle does not decelerate.
- Uneven braking occurs while ABS works.
- The wheels lock while braking.
- Braking sound (from EHCU) is heard while not braking.

These are all attributable to problems which cannot be detected by EHCU self-diagnosis. Use the customer complaint and a test drive to determine which symptom is present.

ABS Works Frequently But Vehicle Does Not Decelerate

Step	Action	Value(s)	Yes	No
1	Is braking force distribution normal between front and rear of vehicle?	—	Go to Step 2	Repair brake parts. Go to Step 6
2	Are axle parts installed normally?	—	Go to Step 3	Repair axle parts. Go to Step 6
3	Is there play in each or any wheel speed sensor?	—	Repair wheel speed sensor. Go to Step 6	Go to Step 4
4	Is there damage, or powdered iron sticking to each or any wheel speed sensor/sensor rotor?	—	Replace Wheel Speed sensor or sensor rotor. Go to Step 6	Go to Step 5
5	Is the wheel speed sensor output normal?	—	Go to Step 6	Replace wheel speed sensor or repair harness. Go to Step 6
6	Reconnect all components, ensure all components are properly mounted. Was this step finished?	—	Go to Diagnostic System Check – ABS Controls	—

Uneven Braking Occurs While ABS Works

Step	Action	Value(s)	Yes	No
1	Is there play in each or any wheel speed sensor?	—	Repair. Go to Step 5	Go to Step 2
2	Damage or powdered iron sticking to each or any sensor/sensor rotor?	—	Repair. Go to Step 5	Go to Step 3
3	Is the wheel speed sensor output normal?	—	Go to Step 4	Replace sensor or repair harness. Go to Step 5
4	Are the brake pipes correctly connected to the EHCU and free of damage?	—	Replace EHCU. Go to Step 5	Correctly reconnect brake pipe. Go to Step 5
5	Reconnect all components, ensure all components are properly mounted. Was this step finished?	—	Go to Diagnostic System Check – ABS Controls	—

The Wheels Lock While Braking

Step	Action	Value(s)	Yes	No
1	Is ABS working?	—	Go to Step 2	Go to Step 4
2	Is vehicle speed under 5 km/h?	—	Normal	Go to Step 3
3	Is the wheel speed sensor output normal?	—	Go to Step 4	Replace sensor or repair harness. Go to Step 5
4	Is EHCU grounded properly?	—	Replace EHCU. Go to Step 6	Repair. Go to Step 5
5	Reconnect all components, ensure all components are properly mounted. Was this step finished?	—	Go to Diagnostic System Check – ABS Controls	—

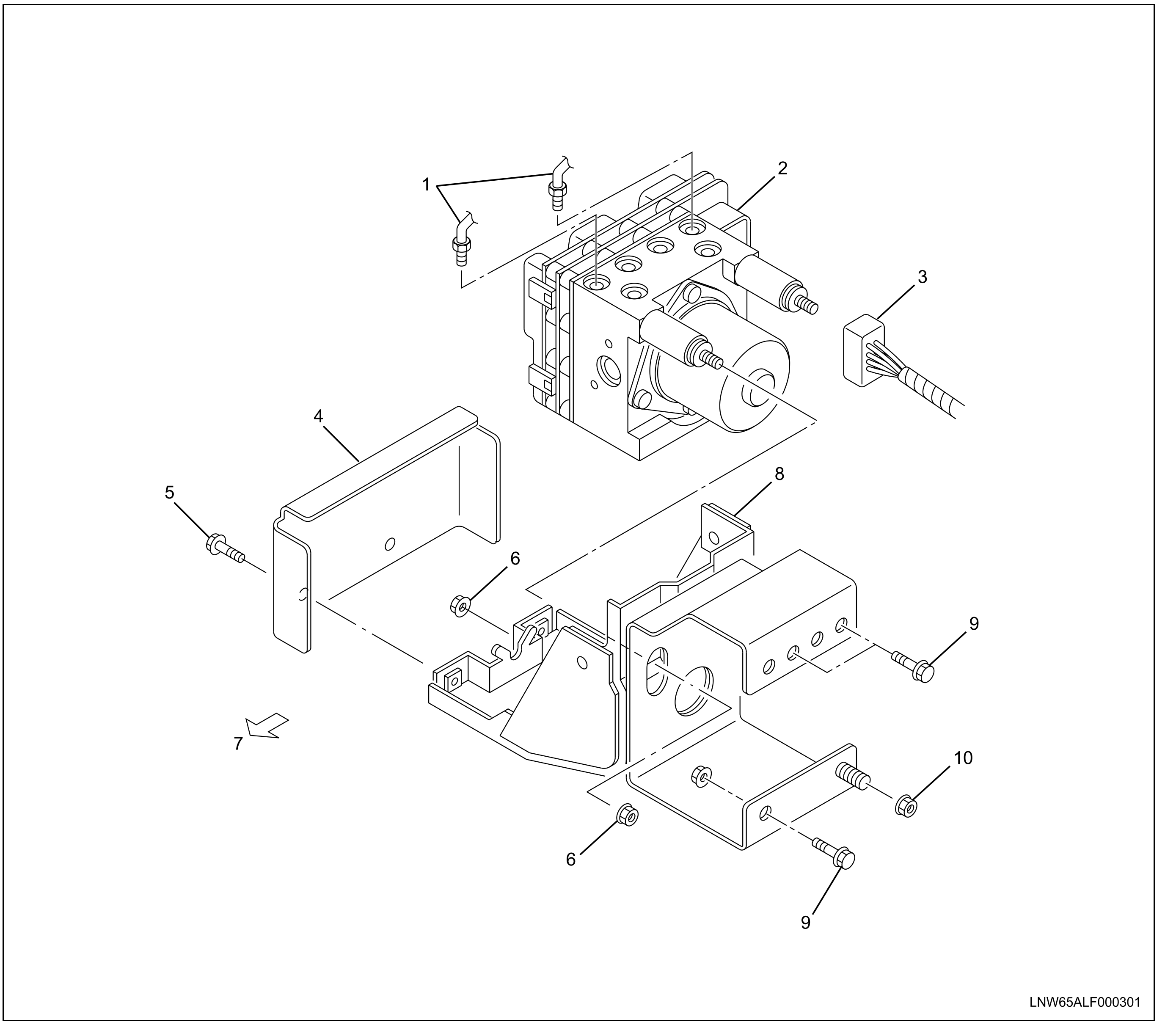
Braking Sound (From EHCU) Is Heard While Not Braking

Step	Action	Value(s)	Yes	No
1	Is this the first vehicle start after engine start?	—	It is self checking sound, normal.	Go to Step 2
2	Is vehicle speed under 10 km/h?	—	It is self checking sound, normal.	Go to Step 3
3	Check for the following condition: 1. At the time of shift down or clutch operation. 2. At the time of low road friction drive (ice or snow road) or rough road drive. 3. At the time of high-speed turn. 4. At the time of climbing up or down curb. 5. At the time of operating electrical equipment switches. 6. At the time of racing the engine. Did it occur under any one condition above?	—	ABS may Sometimes be actuated even when brake pedal is not applied.	Go to Step 4
4	Is there play in each or any sensor/wheel speed sensor rotor?	—	Repair. Go to Step 7	Go to Step 5
5	Damage or powdered iron sticking to each or any sensor/wheel speed sensor rotor?	—	Repair. Go to Step 7	Go to Step 6
6	Is the wheel speed sensor output normal?	—	Check harness / connector for suspected disconnection. If no disconnection is found, replace EHCU Go to Step 7	Go to Step 7
7	Reconnect all components, ensure all components are properly mounted. Was this step finished?	—	Go to Diagnostic System Check – ABS Controls	—

Repair Instructions

Electronic Hydraulic Control Unit (EHCU) Replacement

EHCU and Associated Parts



Legend

1. Brake Pipe
2. EHCU
3. Connector
4. Cover
5. Cover Fixing Bolt
6. EHCU Fixing Nut
7. Front
8. Bracket
9. Bracket Fixing Bolt
10. Bracket Fixing Nut

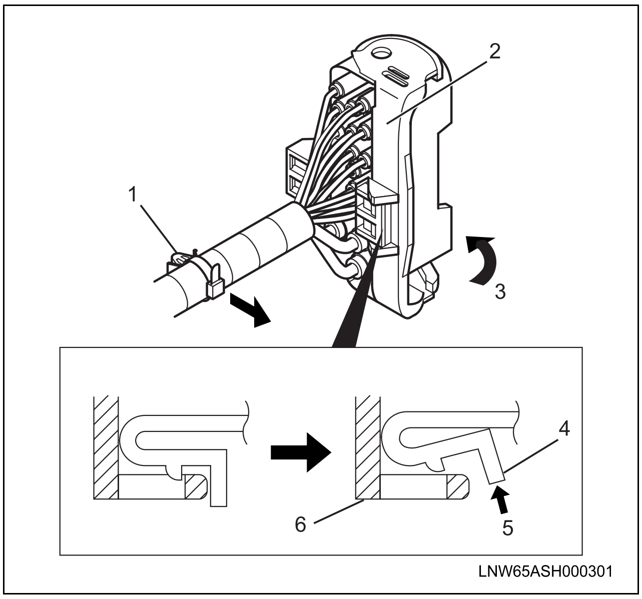
Notice:

- If welding work is to be performed on the vehicle using an electric arc welder, the EHCU should be removed from the vehicle before the welding operation begins.
- Do not put radio equipment etc, that emits strong radio waves near the EHCU.
- Never loosen any screw on the control unit.
- Do not paint the control unit.
- Prevent possible electrostatic discharge damage.
- Do not touch the control unit pin type terminal with a metallic tip of a screwdriver or tester.
- Do not apply voltage to the terminal.

Removal Procedure

1. Disconnect battery ground cable.
2. Remove the cover.
3. Disconnect the harness connector.
    a. Remove the harness fixing clip (1).
    b. Press and hold the lever lock (4) in direction of the allow (5).
    c. Turn the lever (2) in direction of the allow (3). If turning resistance is felt, pull the harness connector while turning the lever.

Notice:
Do not use excessive force to turn the lever. The connector may damage.



Legend

1. Clip
2. Lever
3. Rotation direction
4. Lever lock
5. Press the lever lock
6. Connector housing

---

4. Disconnect 6 (six) brake pipes.
    - After disconnecting brake pipe, cap or tape the openings of the brake pipe to prevent the entry of foreign matter.
5. Remove EHCU fixing nuts.
6. Remove the EHCU.
7. Remove the bracket.

Installation procedure

1. Install the bracket.

Tightening torque

Bracket Fixing Bolt: 45 N·m (33 lb·ft)

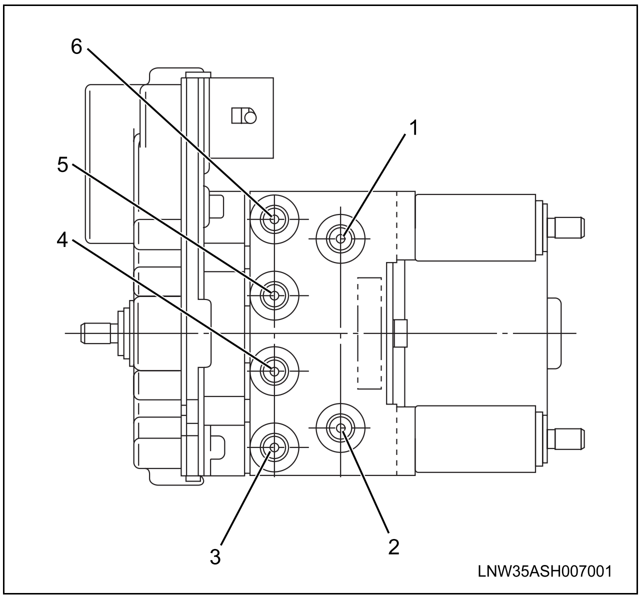
Bracket Fixing Nut: 22 N·m (16 lb·ft)

2. Install the EHCU.

Tightening torque: 20 N·m (15 lb·ft)

3. Connect 6 (six) brake pipes.

Tightening torque: 16 N·m (12 lb·ft)



Legend

1. Master Cylinder (front)
2. Master Cylinder (rear)
3. Rear Right Wheel Cylinder
4. Rear Left Wheel Cylinder
5. Front Right Wheel Cylinder
6. Front Left Wheel Cylinder

Caution:
Make sure brake pipes are correctly connected to EHCU.

4. Connect the harness connector.
    - Be sure that the lever lock is attached to the connector housing of EHCU harness connector.
5. Install the cover.

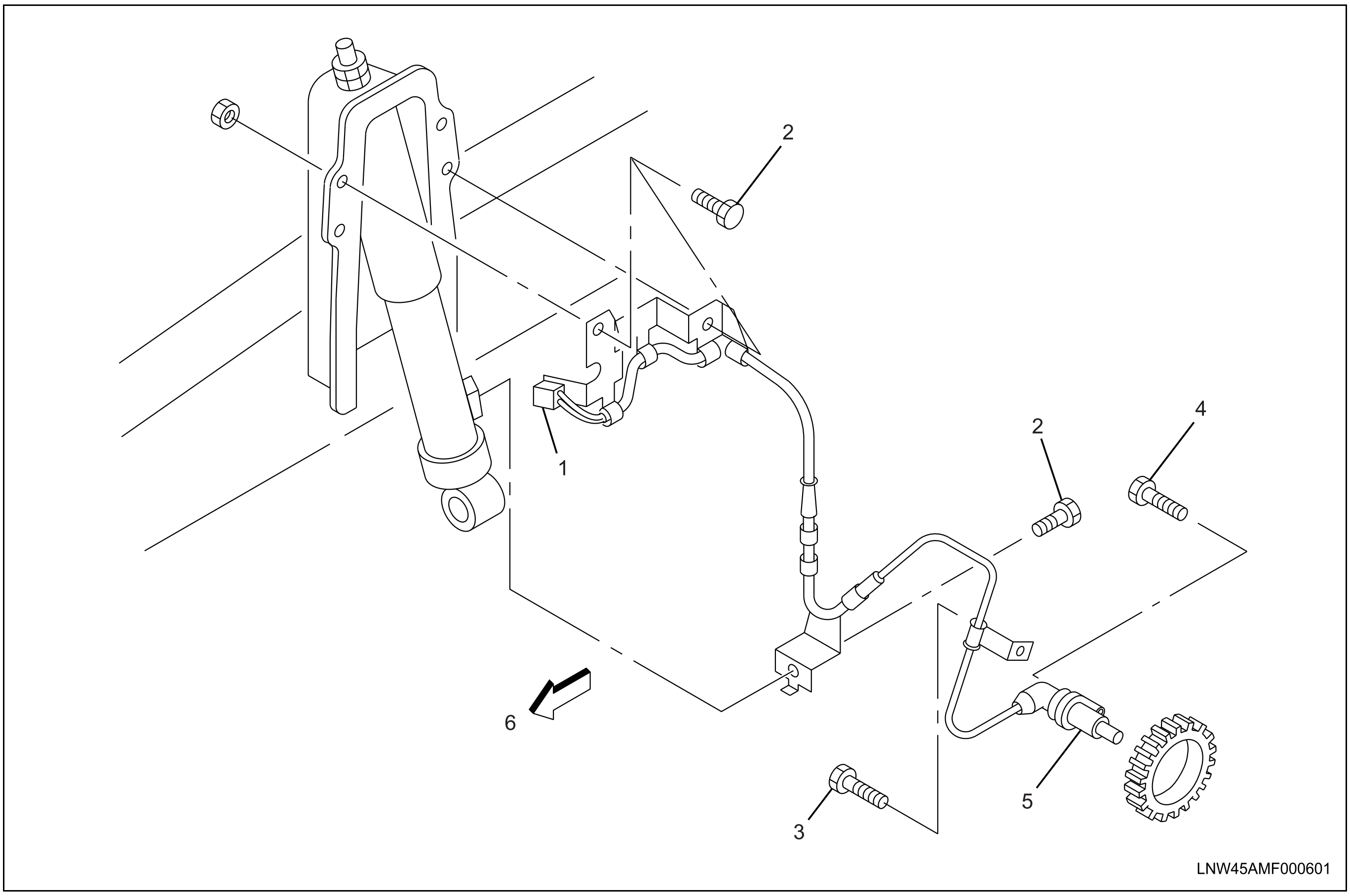
Tightening torque: 22 N·m (16 lb·ft)

6. Connect battery ground cable.

Important:
After installing the EHCU, bleed brakes completely. Refer to Bleeding Brakes in the Hydraulic Brakes section. When bleeding, disconnect the fuse (60A) for ABS hydraulic unit.

Front Speed Sensor Replacement

Front Speed Sensor and Associated Parts



Legend

1. Speed Sensor Connector
2. Sensor Cable Fixing Bolt
3. Sensor Cable Fixing Bolt
4. Sensor Fixing Bolt
5. Speed Sensor
6. Front

Removal Procedure

1. Disconnect speed sensor connector.
2. Remove sensor cable fixing bolts.
3. Remove the speed sensor fixing bolt.
4. Remove speed sensor.

Inspection and Repair

1. Check the speed sensor pole piece for presence of foreign materials; remove any dirt, etc.
2. Check the pole piece for damage; replace speed sensor if necessary.
3. Check the speed sensor cable for short or open circuit, and replace with a new one if necessary.
   To check for cable short or open, bend or stretch the cable while checking for continuity.

Installation Procedure

1. Install speed sensor and take care not to hit the speed sensor pole piece during installation.
2. Install speed sensor fixing bolt and tighten the fixing bolt to the specified torque.

Tightening torque : 22 N·m (16 lb·ft)

3. Install speed sensor cable fixing bolts and tighten the fixing bolt to the specified torque.

Tightening torque

Bolts (2) : 22 N·m (16 lb·ft)

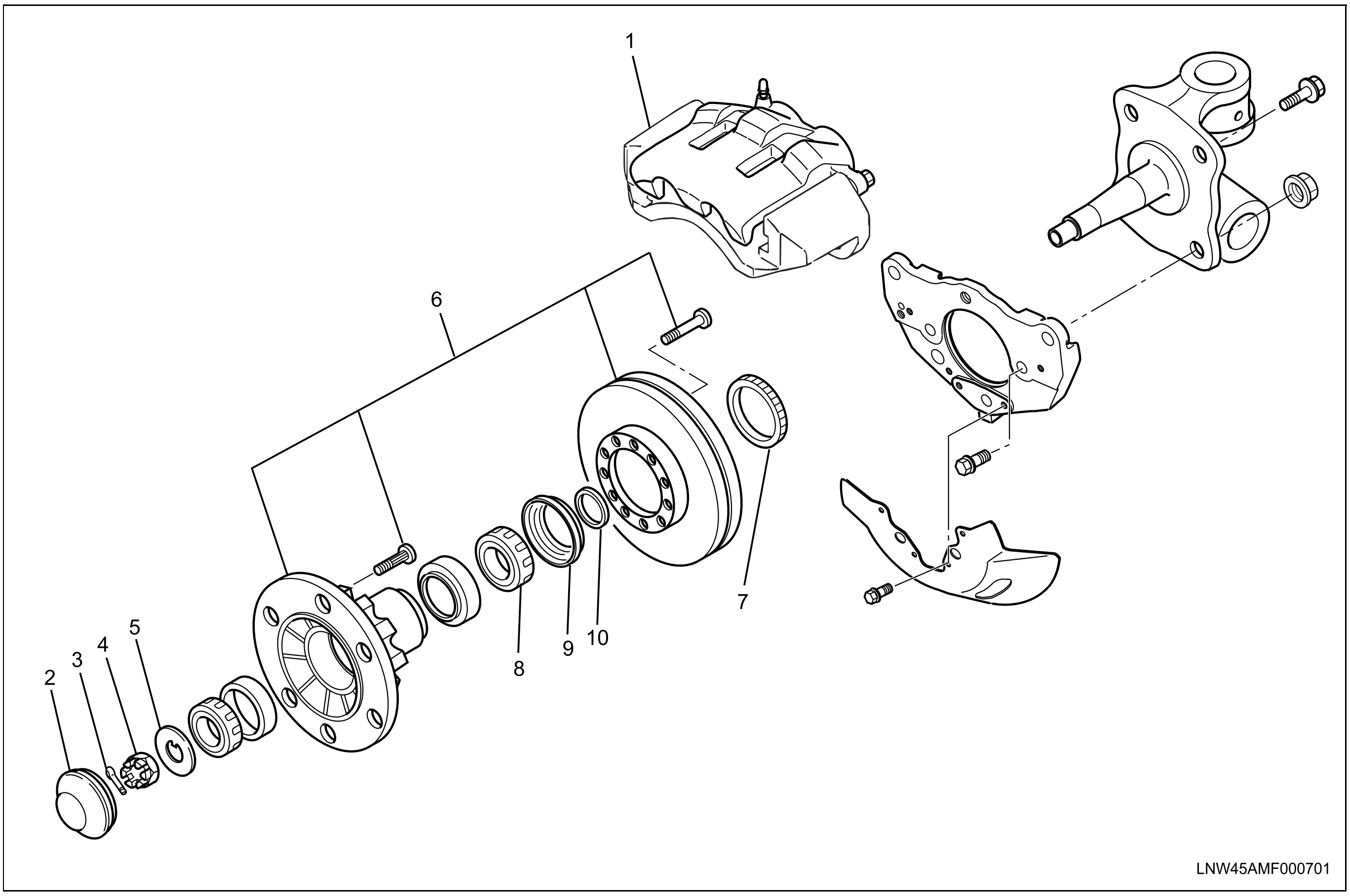
Bolt (3) : 45 N·m (33 lb·ft)

Notice:
Confirm that a white or yellow line marked on the cable is not twisted when connecting the speed sensor cable.

4. Connect speed sensor connector.

Front Speed Sensor Rotor Replacement

Front Speed Sensor Rotor and Associated Parts

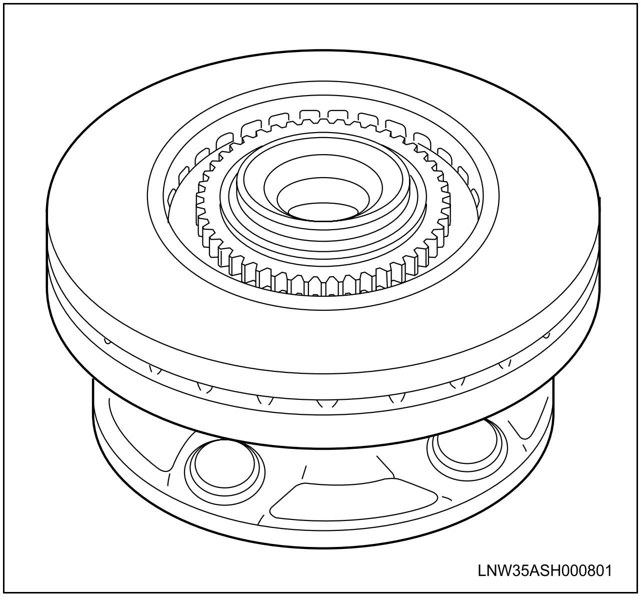


Legend

1. Disc Brake Caliper
2. Hub Cap
3. Cotter Pin
4. Hub Nut
5. Washer
6. Hub and Disc Assembly
7. Speed Sensor Rotor
8. Inner Bearing
9. Oil Seal
10. Spacer

Removal Procedure

1. Remove disc brake assembly and support the caliper assembly so that the brake hose is not stretched or damaged.
2. Remove hub cap.
3. Remove cotter pin and hub nut.
4. Remove washer.
5. Remove hub and disc assembly.



6. Remove speed sensor rotor.
7. Remove inner bearing, oil seal and spacer.

Inspection and Repair

1. Check the speed sensor rotor for damage including tooth chipping, and if damaged, replace the speed sensor rotor.

Installation Procedure

1. Using a bench press, install speed sensor rotor.
2. Install spacer onto the knuckle spindle.
3. Apply grease into the outer and inner bearings and install bearings in the hub.
4. Install oil seal into hub and disc assembly and install hub and disc assembly on to the knuckle spindle.

   Preload Adjustment

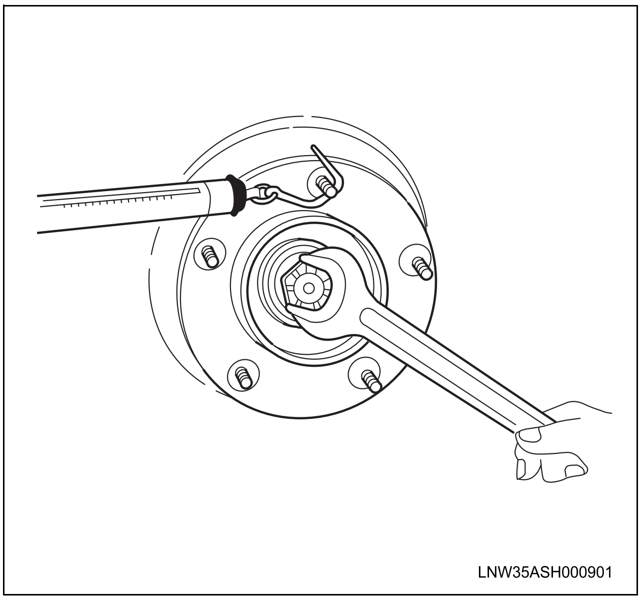
   Adjust the wheel bearing as follows:

   a. Tighten the nut until you are unable to manually rotate the hub and disc assembly.
   b. Loosen the nut.
   c. Attach a spring balancer to one stud. Gradually retighten the nut until the hub and disc assembly bearing is adjusted to the specified preload.

- Hub bearing preload

  New Hub Bearing 9.8-24.5 N (2.2-5.5 lb)

  Reused Hub Bearing 4.9-19.6 N (1.1-4.4 lb)

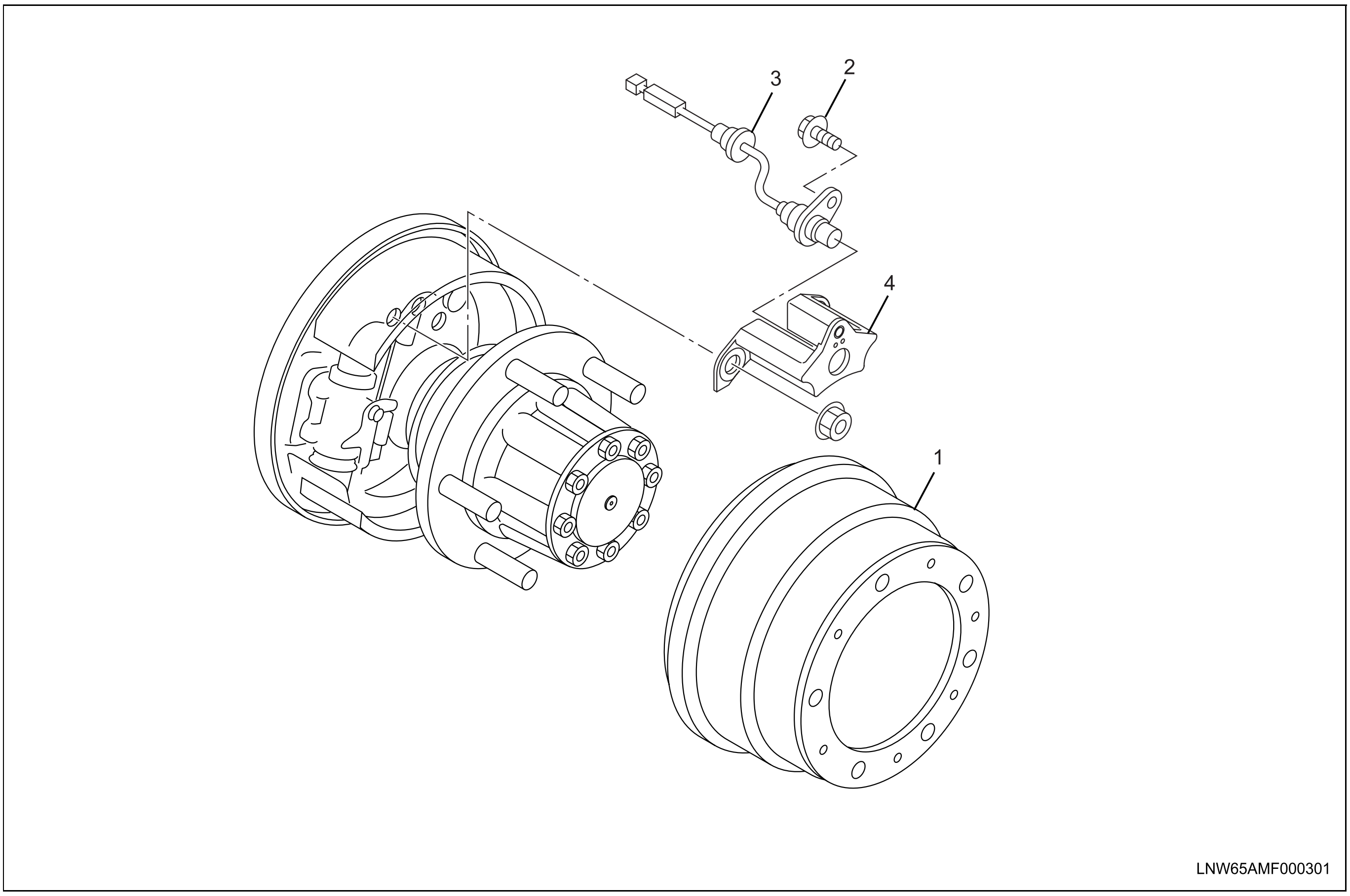


5. Install a cotter pin through the nut and knuckle and bend it over.
   - If the notch in the nut does not line up with the cotter pin hole in the knuckle, tighten the nut until it does. Do not loosen the nut to line up a notch and the knuckle hole.
6. Apply grease into the hub cap and install it.
   - 40g
7. Install the disc brake caliper and tighten two bolts to the specified torque.

Tightening torque : 221 N·m (163 lb·ft)

Rear Speed Sensor Replacement

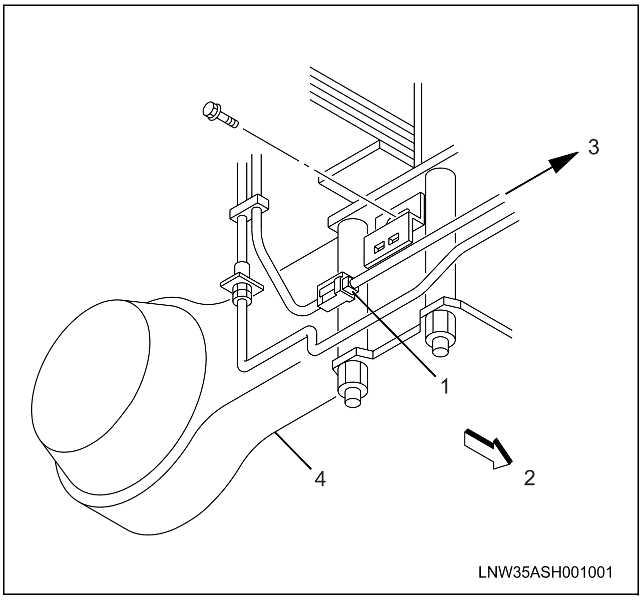
Rear Speed Sensor and Associated Parts



Legend

1. Brake Drum
2. Speed Sensor Fixing Bolt
3. Speed Sensor
4. Speed Sensor Bracket

Removal Procedure



Legend

1. Speed Sensor Connector
2. Front
3. Speed Sensor
4. Rear Axle

1. Disconnect speed sensor connector.
2. Remove brake drum.
3. Remove speed sensor fixing bolt.
4. Remove speed sensor.
5. Remove speed sensor bracket.

Inspection and Repair

1. Check the speed sensor for presence of foreign materials; remove any dirt, etc.
2. Check the speed sensor for damage, and replace the speed sensor if necessary.
3. Check the speed sensor harness for a short or an open, and replace with a new one if necessary. To check for harness short or open, bend or stretch the cable while checking for continuity.

Installation Procedure

1. Install speed sensor bracket and tighten the nut to the specified torque.

Tightening torque

12,000 lbs GVW and 14,500 lbs GVW model 108 N·m (80 lb·ft)

2. Install the speed sensor and take care not to hit the speed sensor during installation.
3. Install the speed sensor fixing bolt and tighten it to the specified torque.

Tightening torque : 18 N·m (13 lb·ft)

4. Install brake drum and tighten bolts to the specified torque.

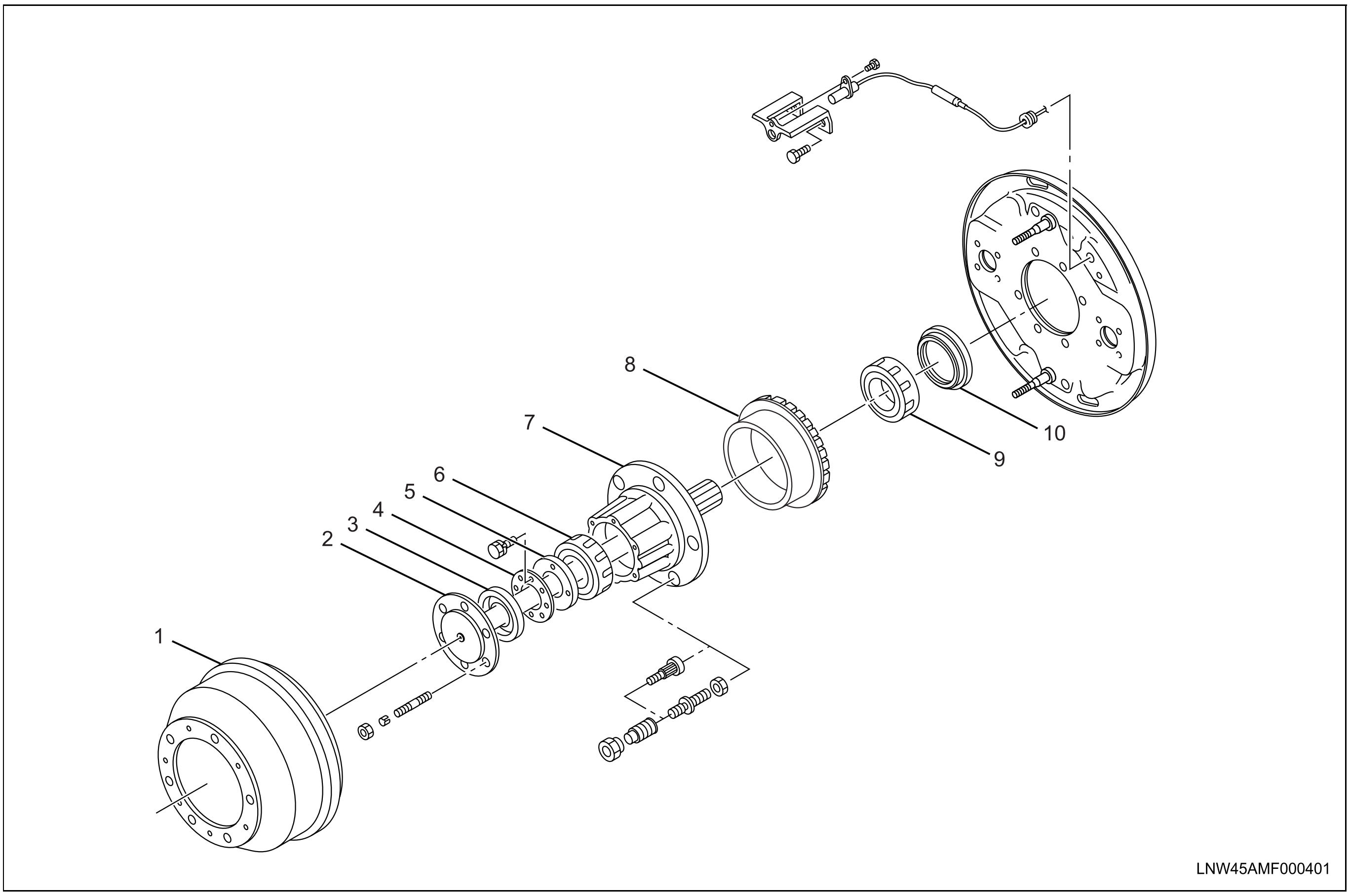
Tightening torque : 13 N·m (113 lb·in)

5. Connect speed sensor connector.

Notice:
Confirm that the harness is not twisted when connecting the speed sensor connector.

Rear Speed Sensor Rotor Replacement

Rear Speed Sensor Rotor and Associated Parts



Legend

1. Brake Drum
2. Axle Shaft
3. Outer Oil Seal
4. Lock Washer
5. Bearing Nut
6. Outer Bearing
7. Rear Hub
8. Speed Sensor Rotor
9. Inner Bearing
10. Inner Oil Seal

Removal Procedure

1. Remove brake drum.
2. Remove axle shaft.
3. Remove outer oil seal, using a screwdriver.
4. Remove lock washer.
5. Remove bearing nut with a hub bearing nut wrench.
6. Remove hub assembly from axle case.
7. Remove outer bearing from hub assembly.
8. Remove speed sensor rotor from hub assembly.
9. Remove inner bearing and inner oil seal from axle case

Inspection and Repair

1. Check the speed sensor rotor for damage including tooth chipping. If damaged, replace speed sensor rotor.

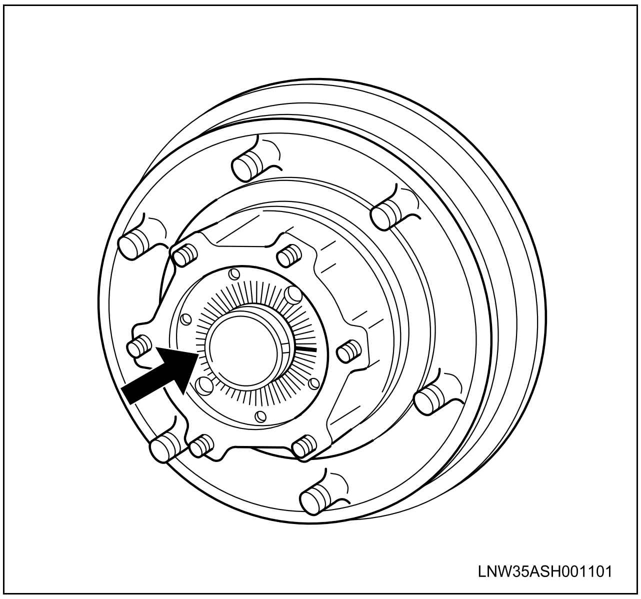
Installation Procedure

1. Using a bench press, install speed sensor rotor.

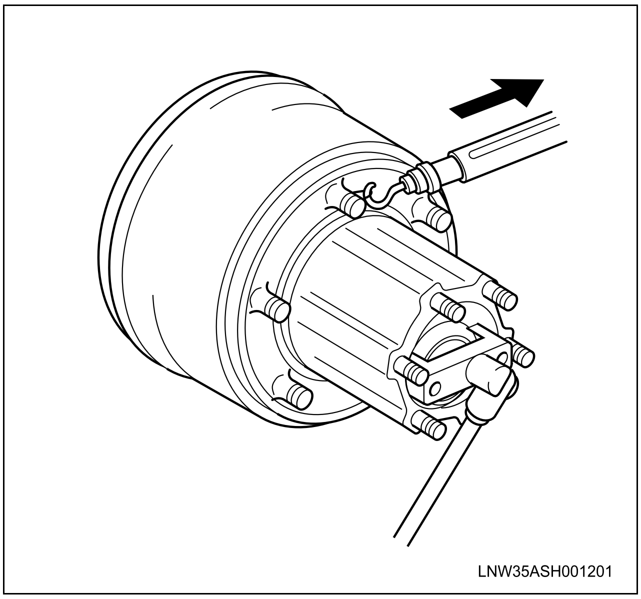
Notice:
Do not reuse the sensor rotor.

2. Install spacer on to the axle case.
3. Apply grease into the outer and inner bearings and install bearings in the hub.
4. Install outer oil seal into hub.

5. Install hub assembly onto the axle case.



6. Set the lock nut with the notched line facing out.
   Preload Adjustment
   a. Turn the hub to the left and right several times to establish bearing conformity.
   b. Use the bearing nut wrench to tighten the bearing nut until the hub can not be manually rotated.
   c. Loosen the bearing nut until hub rotates easily.

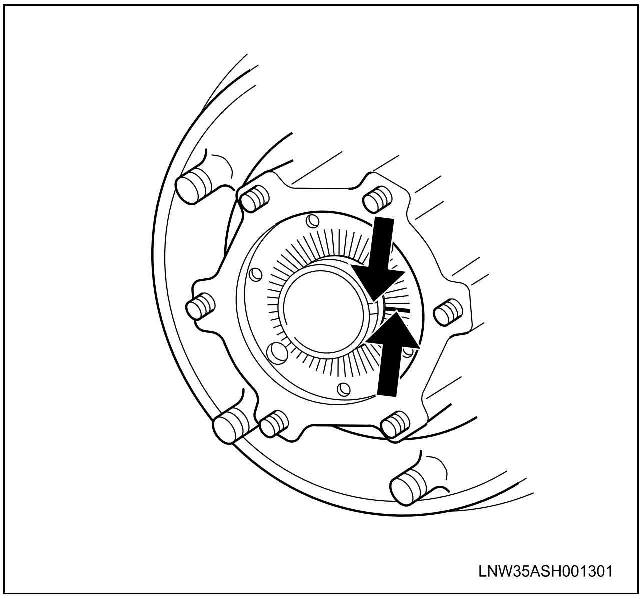


   d. Set the spring balancer to the wheel pin in the position shown in the illustration.
   e. Measure the hub bearing preload by carefully pulling on the spring balancer and noting the indicator reading.

Hub Bearing Preload (At Wheel Pin)

42-52 N (9.5-11.7 lb)

   f. Rotate the hub several times to the right and left.
   g. Measure the bearing preload a second time.



   h. Align the axle case groove with the closest bearing nut slit.

Notice:
If it is difficult to align the axle case and bearing nut, slightly tighten the bearing nut.

7. Install the lock washer with the lock washer tabs inserted to the axle case grooves.
   Install the lock bolts to prevent the bearing nut from loosening.
   Check that the lock washer tabs are inserted to the axle case grooves.
8. Apply grease to the outer oil seal lip inner and outer circumferences and install outer oil seal.
9. Clean the axle shaft.
   Apply gear oil to the axle shaft spline.
   Insert the axle shaft into the axle case.
   Take care not to damage the oil seal.
10. Tighten the axle shaft nuts to the specified torque a little at a time.

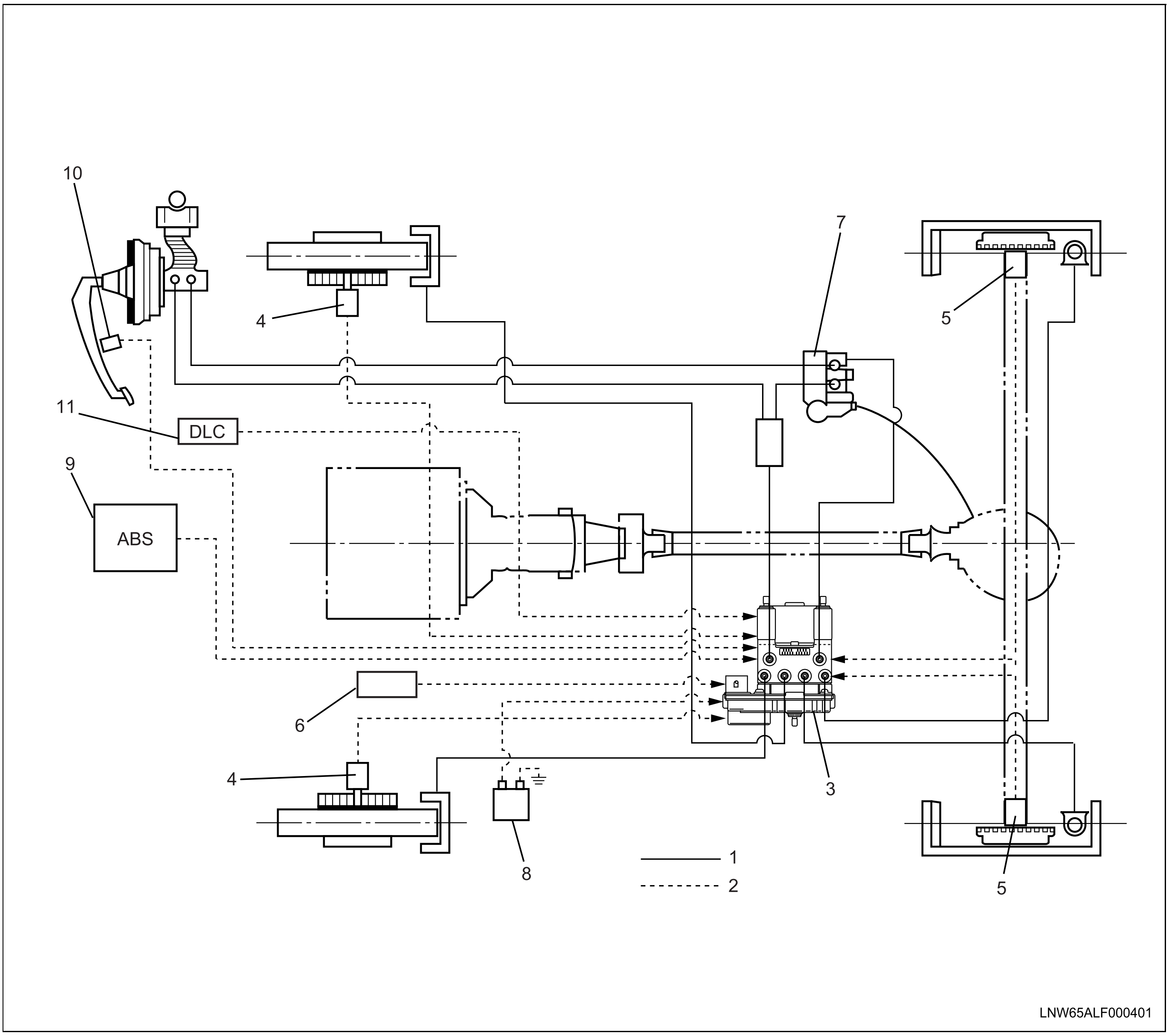
Tightening torque : 46 N·m (34 lb·ft)

11. Install brake drum.

Description and Operation

Anti-lock Brake System (ABS) General Information

The Anti-lock Brake System (ABS) works on all four wheels. A combination of wheel speed sensor and Electronic Hydraulic Control Unit (EHCU) can determine when a wheel is about to stop turning and adjust brake pressure to maintain best braking.
This system helps the driver maintain greater control of the vehicle under heavy braking conditions.



Legend

1. Hydraulic Line
2. Electronic Line
3. Electronic Hydraulic Control Unit (EHCU)
4. Front Wheel Speed Sensor
5. Rear Wheel Speed Sensor
6. Engine Control Module (ECM)
7. Load Sensing Proportioning Valve (LSPV)
8. Battery
9. ABS Warning Light
10. Brake Switch
11. Data Link Connector

System Components

The Anti-lock Brake System consists of a Hydraulic Unit, Electronic Hydraulic Control Unit (EHCU), four Wheel Speed Sensors and Warning Light.

Electronic Hydraulic Control Unit (EHCU)

The EHCU consists of ABS control circuits, fault detector, and a fail-safe. It drives the hydraulic unit according to the signal from each sensor, cancelling ABS to return to normal braking when a malfunction has occurred in the ABS.

The EHCU is self-diagnosing function which can indicate faulty circuits during diagnosis.

The EHCU is located on the frame.

Hydraulic Unit (HU)

The hydraulic unit is mounted on the frame near the rear spring front bracket. It consists of a Motor, Plunger Pump, Solenoid Valves and Check Valve.

On the outside, the relay box containing a motor relay and a valve relay is installed.

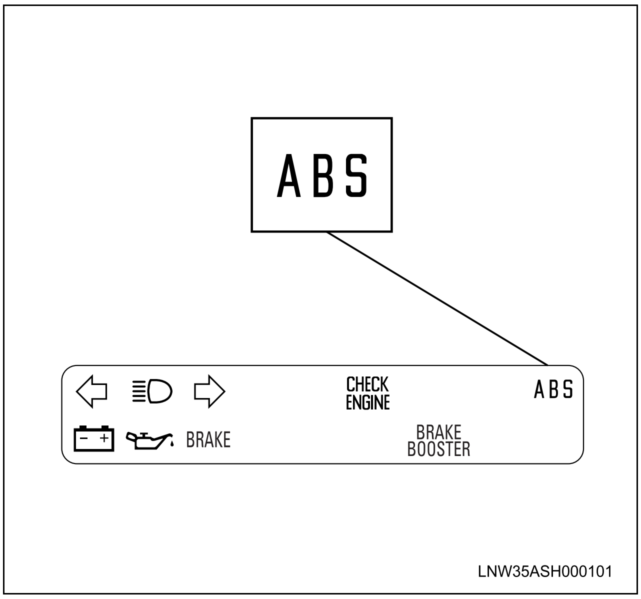
Solenoid Valves: Reduces or holds the caliper fluid pressure for each front disc brake or both rear drum brakes according to the signal sent from the EHCU.

Reservoir: Temporarily holds the brake fluid that returns from the front and rear wheel brake so that pressure of front wheel brake can be reduced smoothly.

Plunger Pump: Feeds the brake fluid held in the reservoir to the master cylinder.

Motor: Drives the pump according to the signal from EHCU. Check Valve: Controls the brake fluid flow.

ABS Warning Light



Vehicles equipped with the Anti-lock Brake System have an amber “ABS” warning light in the instrument panel. The “ABS” warning light will illuminate if a malfunction in the Anti-lock Brake System is detected by the Electronic Hydraulic Control Unit (EHCU). In case of an electronic malfunction, the EHCU will turn “ON” the “ABS” warning light and disable the Anti-lock braking function.

The “ABS” light will turn “ON” after the ignition switch is to the “ON” position.

If the “ABS” light comes “ON” and stays “ON” while driving, the Anti-lock Brake System should be inspected for a malfunction according to the diagnosis procedure.

Wheel Speed Sensor (WSS)

It consists of a sensor and a rotor. The sensor is attached to the knuckle on the front wheels and to the bracket on the brake back plate on the rear wheels.

The front speed sensor is coil type and rear is Hall IC type.

The sensor rotors press-fitted to front and rear wheel hubs.

The EHCU determines vehicle speed based on the speed sensor output pulse frequency.

Normal and Anti-lock Braking

Under normal driving conditions, the Anti-lock Brake System functions the same as a standard power assisted brake system. However, with the detection of wheel lock-up, a slight bump or kick-back will be felt in the brake pedal. This pedal “bump” will be followed by a series of short pedal pulsations which occurs in rapid succession. The brake pedal pulsation will continue until there is no longer a need for the anti-lock function or until the vehicle is stopped. A slight ticking or popping noise may be heard during brake applications when the Anti-lock features is being used.

When the Anti-lock feature is being used, the brake pedal may rise even as the brakes are being applied. This is also normal. Maintaining a constant force on the pedal will provide the shortest stopping distance.

Brake Pedal Travel

Vehicles equipped with the Anti-lock Brake System may be stopped by applying normal force to the brake pedal. Although there is no need to push the pedal beyond the point where it stops or holds the vehicle, by applying more force the pedal will continue to travel toward the floor.

This extra brake pedal travel is normal.

Acronyms and Abbreviations

Several acronyms and abbreviations are commonly used throughout this section:

ABS
Anti-lock Brake System

CKT
Circuit

DLC
Data Link Connector

DTC
Diagnostic Trouble Code

DMM
Digital Multimeter

ECM
Engine Control Module

EHCU
Electronic Hydraulic Control Unit

FL
Front Left

FR
Front Right

GEN
Generator

MV
Millivolts

RL
Rear Left

RR
Rear Right

RPS
Revolution per Second

Sen
Sensor

SW
Switch

TCM
Transmission Control Module

VDC
Volts DC

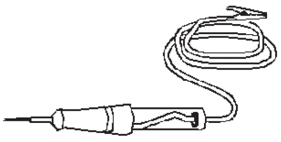
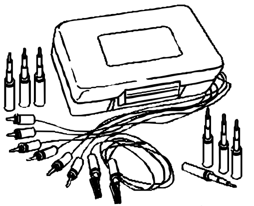
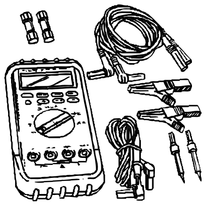
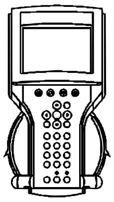
VAC
Volts AC

W/L
Warning Light

WSS
Wheel Speed Sensor

Special Tool and Equipment

Special Tools

Illustration	Tool Number/ Description
 AAW0Z0SH013701	J 34142-B Test Lamp
 AAW0Z0SH014101	J 35616-A Connector Test Adapter Kit
 AAW0Z0SH014701	J 39200 Digital Multimeter
 AAW0Z0SH015701	7000081 Tech2 Kit

BRAKES

Parking Brake

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Description and Operation

Parking Brake Description

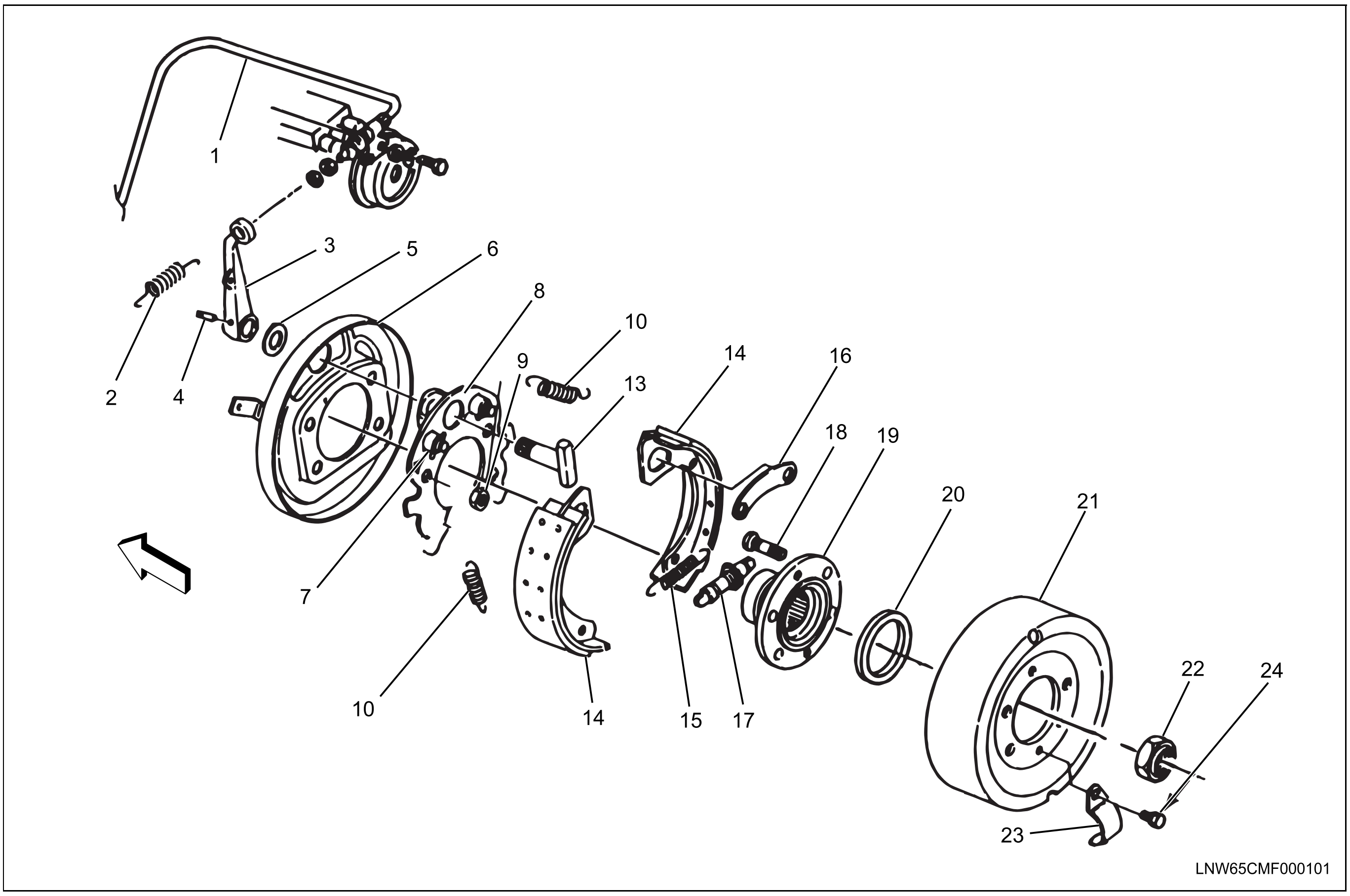
Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Caution:
When servicing wheel brake parts, do not create dust by grinding or sanding brake lining or by cleaning wheel brake parts with a dry brush or with compressed air. Many wheel brake parts contain asbestos fibers which can become airborne if dust is created during servicing. Breathing dust containing asbestos fibers may cause serious bodily harm. A water-dampened cloth or water-based solution should be used to remove any dust on brake parts. Equipment is commercially available to perform this washing function. These wet methods will prevent asbestos fibers from becoming airborne.

The parking brake used on this vehicle is a mechanically operated internal expanding-type drum brake. It is mounted on the rear of the transmission case. A control cable is routed into the cab and is connected to lever at the right side of the driver seat.

Repair Instructions

Parking Brake Assembly



Legend

1. Cable
2. Spring
3. Lever
4. Pin
5. Washer
6. Cover
7. Anchor Pin
8. Plate
9. Nut
10. Spring
13. Camshaft
14. Shoe
15. Spring
16. Brace
17. Adjuster
18. Bolt
19. Flange
20. O-ring Seal
21. Drum
22. Nut
23. Cover
24. Bolt

Preparation

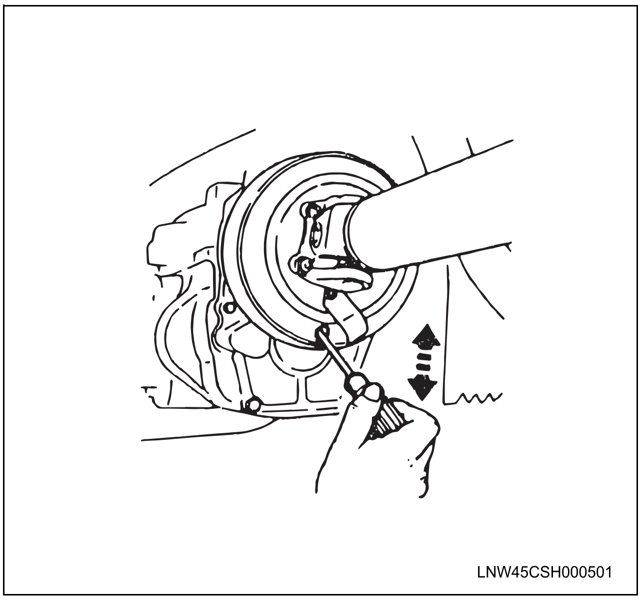
Before doing any service on the parking brake, park the vehicle on a level surface, block the wheels, and place the brake in the release or off position.

Brake shoe Adjustment

1. Disconnect the cable at the control lever.
2. Raise the rear axle so that the tires are off the floor.
3. Rotate the drum to align one of the access holes with the adjusting screw. Remove the hole cover.
4. Move the camshaft lever side-to-side a few times to center the shoes.

Adjust

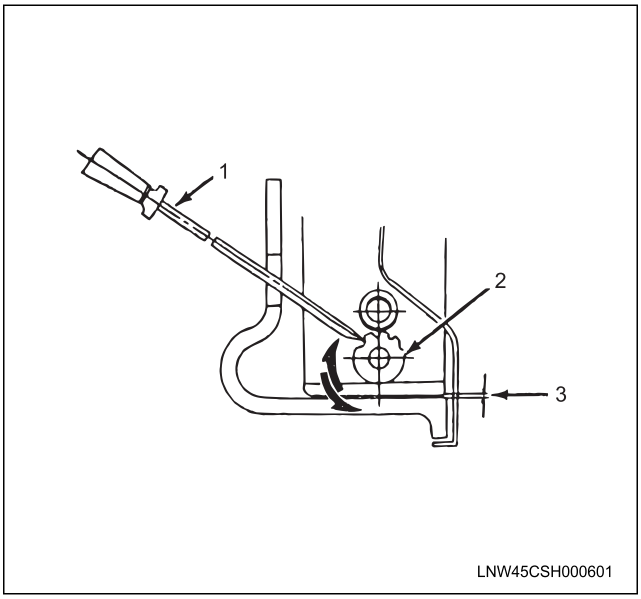
- Insert a screwdriver in the access hole and rotate the adjuster screw until the shoes drag on the drum.
  Rotation direction: upward



- Back off the adjuster screw the specified number of notches.
  Check the gap at the middle of the shoe lining.

Adjuster Screw Notches and Clearance

Notches	Clearance mm (in)
8	0.23 (0.009)



Legend

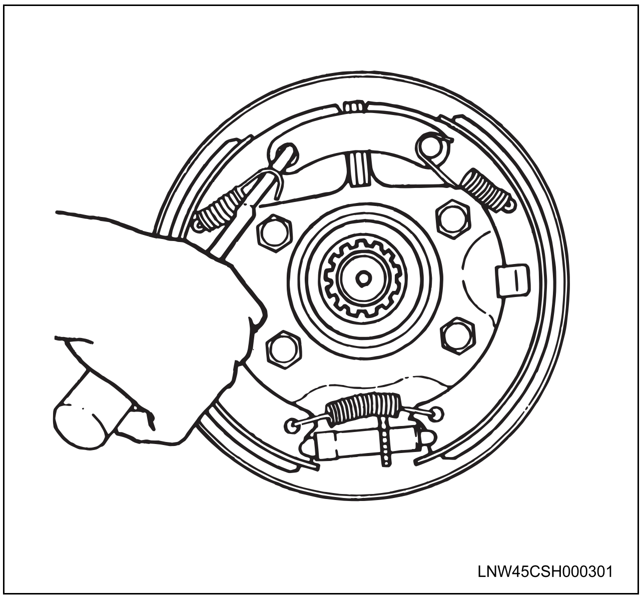
1. Screwdriver
2. Adjuster
3. Clearance

Shoe Replacement

Removal Procedure

- Block the vehicle wheels.
- Release the parking brake.

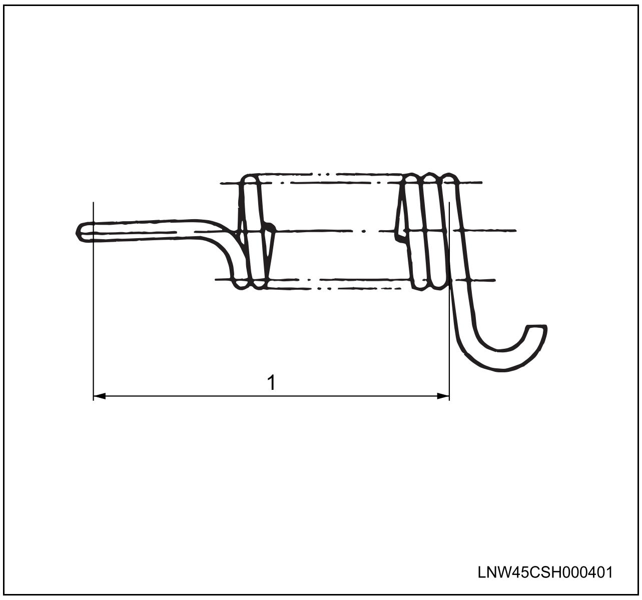
1. Propeller shaft. Refer to PROPELLER SHAFT section in this manual.
2. Nut.
3. Drum and flange.
    - O-ring seal in the flange bore.
      Refer to Transmission section.
4. Spring two places.



5. Spring.
6. Adjuster.
7. Shoes.

Inspection

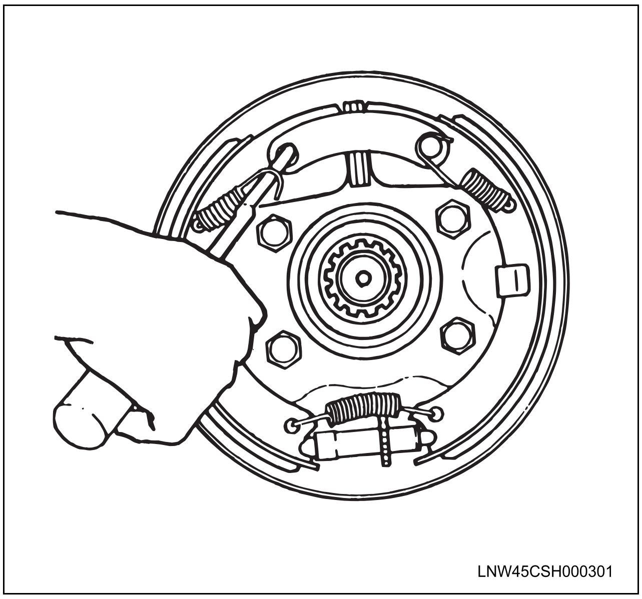
- Return spring. Free length should be specified length.
- 8" Parking Brake 49.9 mm (1.96 in.)



- Shoes. Replace the shoes if the web at the point of cam contact is severely worn.
- Lining. Replace if lining thickness is less than 1 mm (0.04 in.).

Installation Procedure

1. Shoes.
2. Adjuster.
3. Spring.
4. Spring.
   - Install springs to the anchor pins.


LNW45CSH000301

5. Drum and flange.
6. Nut.
   - Refer to Transmission section in this manual.
7. Propeller shaft. Refer to PROPELLER SHAFT section in this manual.

Adjust

- Brake and check operation.

Drum Replacement

Removal Procedure

- Block the vehicle wheels.
- Release the parking brake.

1. Propeller shaft. Refer to PROPELLER SHAFT section in this manual.
2. Bolts and washers.
3. Covers.
4. Drum.

Measure

- Diameter. Replace if the drum ID is greater than maximum limit. See specifications.
- Run-out. Replace if the run-out varies more than 0.05 mm (0.002 in).

Installation Procedure

1. Drum.
2. Covers.
3. Bolts and washers. Align the drum holes with the flange holes.
4. Propeller shaft. Refer to PROPELLER SHAFT section in this manual.
   - Adjust the brake and check operation.

Cover Replacement

Removal Procedure

- Block the vehicle wheels.
- Release the parking brake.

1. Propeller shaft. Refer to PROPELLER SHAFT section in this manual.
2. Nut.
   - Open the staking. Be careful of the shaft threads.
3. Drum and flange.
   Refer to Transmission section in this manual.
4. Cable from the lever.
5. Pin from the lever.
6. Lever from the camshaft.
7. Washer.
8. Bolts, washer and nut.
9. Plate.
   - Leave the shoes and camshaft in place.
10. Spring.
11. Cover.
    - Replace parts as necessary.

Installation Procedure

1. Cover.
2. Spring to the cover bracket.
3. Plate. Be sure brake components are attached.
4. Washers, bolts and nut.
   Refer to Transmission section in this manual.
5. Washer on the camshaft.
6. Camshaft into the lever.
   - Align the holes.
7. Pin into the lever and camshaft holes.
8. Cable to the lever.
   - Attach the spring to the lever eye.
9. Drum and the flange.
   - Be sure O-ring seal is in the flange.
10. Nut.
    Refer to Transmission section in this manual.
11. Propeller shaft. Refer to PROPELLER SHAFT section in this manual.

- Check for proper brake operation and adjust if necessary.

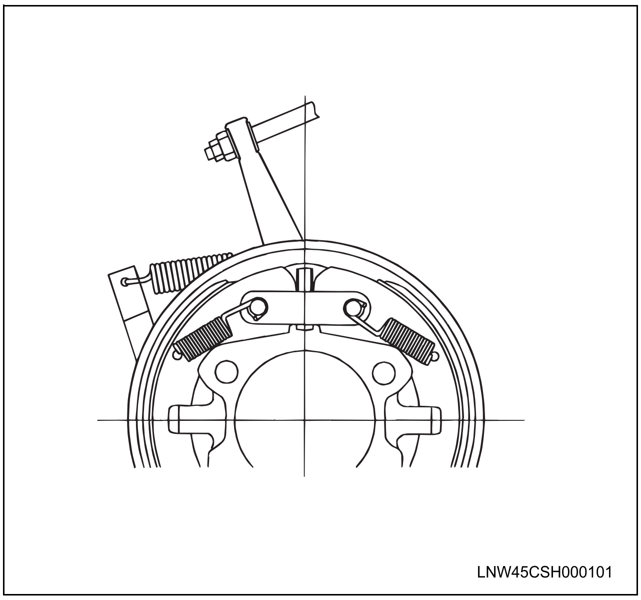
Lever Adjustment

- Block the vehicle wheels.
- Release the parking brake.

1. Loosen the jam nut and adjusting nut.

Adjust

When connecting cable with cam shaft lever, use adjust nut in order to make the clearance 0 mm (0 in) between cam and shoe, then lock adjust nut with lock nut.

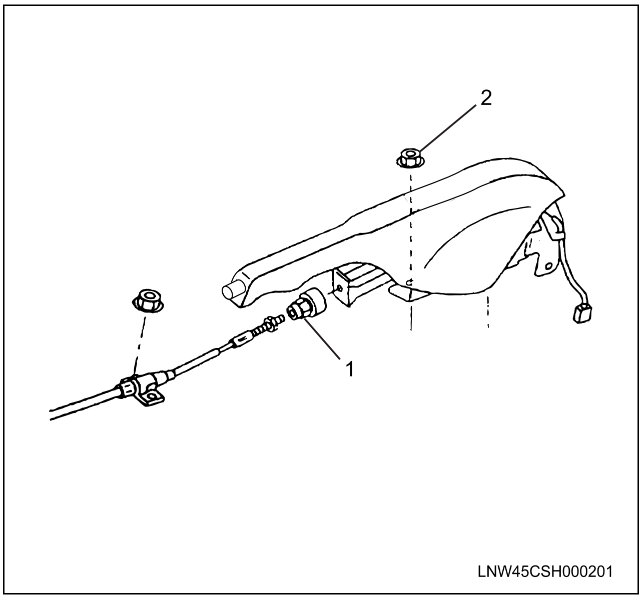


Brake Lever Replacement

Removal Procedure

- Block the vehicle wheels.
- Release the parking brake.

1. Loosen the adjust nut (1), and disconnect the front cable.
2. Loosen the retaining nuts (2) and remove the parking brake lever assembly.



Installation Procedure

1. Install parking brake lever assembly and tighten the retaining nuts.
2. Install the parking brake cable to the brake lever.
3. Turn the adjust nut to adjust the lever travel to 6-8 notches, pulling the parking brake lever at 147 N (33 lb).

Specifications

Parking Brake Specifications

8” Brake Drum

	Standard	Maximum
Inside Diameter	203 mm (8.0 inch)	204 mm (8.03 inch)
Run-Out	–	0.05 mm (0.002 inch)
Clearance	0.23 mm (0.009 inch)	–

8” Brake Lining

	Standard	Minimum
Length	115 x 2 mm (4.53 x 2 inch)	–
Width	50 mm (2.0 inch)	–
Thickness	3.75 mm (0.15 inch)	–
Minimum Thickness	–	1.0 mm (0.039 inch)

ENGINE

ENGINE MECHANICAL (4HK1-TC)

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ISUZU DIESEL ENGINE (4HK1-TC)

Service Precautions

Matters that require attention in terms of maintenance

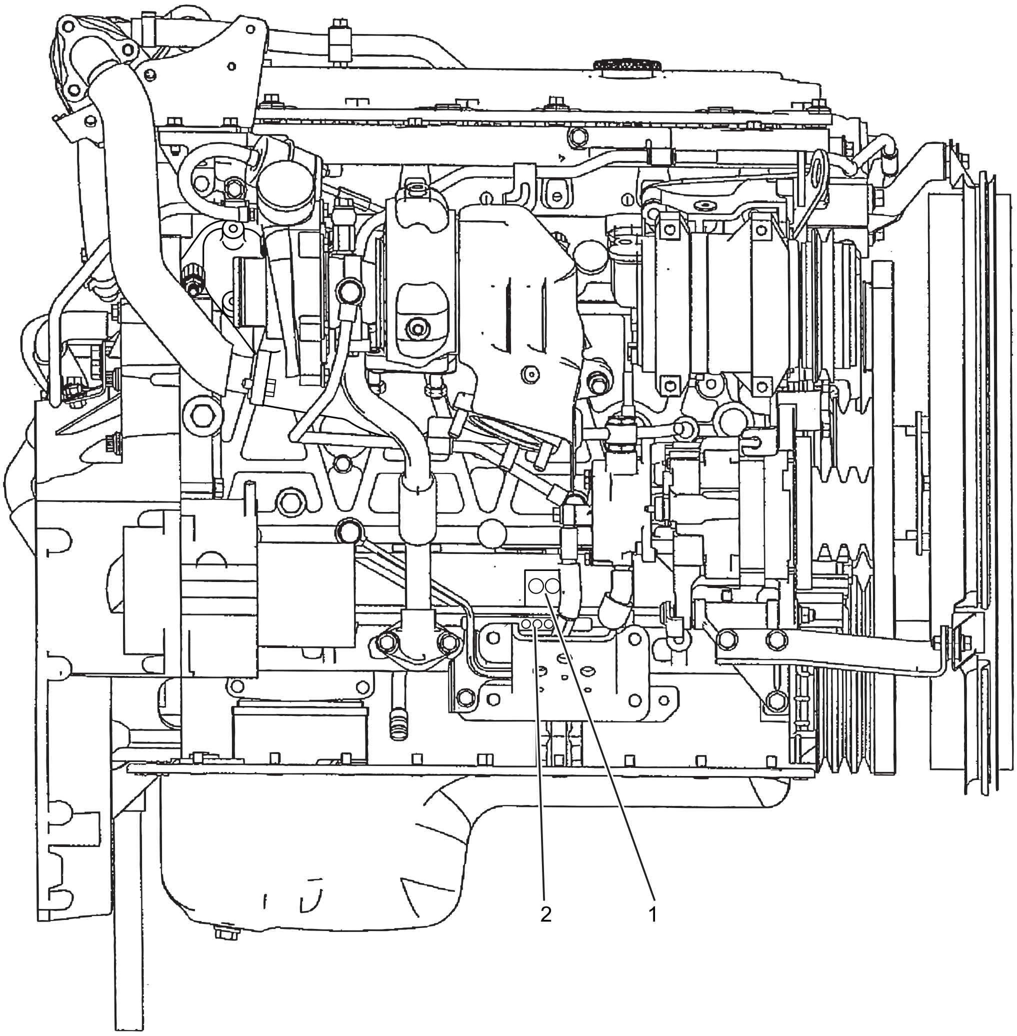
To prevent damage to the engine and ensure reliability of its performance, pay attention to the following in maintaining the engine:

- When lifting up or supporting the engine, do not apply a jack on the oil pan.
  When taking down the engine on the ground, do not make the bearing surface of the oil pan touch directly the ground. Use a wood frame, for example, to support the engine with the engine foot and the flywheel housing.
  Because there is only a small clearance between the oil pan and the oil pump strainer, it can damage the oil pan and the oil strainer.
- When the air duct or air cleaner is removed, cover the air intake opening to prevent foreign matter from getting into the cylinder. If it gets into it, it can considerably damage the cylinder and others while the engine is operating.
- When maintaining the engine, never fail to remove the battery earth cable. If not, it may damage the wire harness or electrical parts. If you need electricity on for the purpose of inspection, for instance, watch out for short circuits and others.
- To protect and lubricate the rotational surface during the initial operation, apply plenty of engine oil to it.
- When valve train parts, pistons, piston rings, connecting rods, connecting rod bearings or crankshaft journal bearings are removed, put them in order and keep them.
- When installing them, put them back to the same location as they were removed.
- Parts, such as gaskets, oil seals and O-rings, have to be replaced by brand-new ones every time the engine is dismantled.
- As for parts where a liquid gasket is used, remove an old liquid gasket completely and clean it up thoroughly so that no oil, water or dust may be clung to them. Then, apply the designated liquid gasket to each place anew before assembly.
- Assemble it within 7 minutes after applying the liquid gasket.
  If 7minutes or longer passed, remove the liquid gasket and apply it again.
- When assembling or installing parts, fasten them with the prescribed tightening torque so that they may be installed properly.

Matters that require attention in specifically dealing with this engine.

Holes or clearances in the fuel system, which serve as a passage of fuel, including the inside of the injector, are made with extreme precision. For this reason, they are highly sensitive to foreign matter and if it gets in, it can lead to an accident on the road, for instance; thus, make sure that foreign matter will be prevented from getting in.

How to read the model



Legend

1. Cast The Engine Model
2. Stamp An Engine Number

Explanation of functions and operations

Electronic engine control

With the control unit, the range from injection to air intake/exhaust, including fuel injection quantity, injection timing, intake air restriction, EGR, and idling rpm, is controlled.

Cylinder block

The cylinder block is cast-iron with the center distance of each bore being equal and is of the highly rigid, symmetrical structure with the crankshaft center being the center. The bearing cap is of the ladder frame structure and tightened up under the plastic range rotation angle method.

Cylinder liner

The cylinder liner is selected to match an internal diameter of a bore of the cylinder block and built, which is imprinted on the left side of the cylinder.

Piston

The piston is aluminum-alloy and an autothermatic piston with a strut cast, while the combustion chamber is a round reentrant type.

Cylinder head

The cylinder head is cast-iron and there are 4 valves per cylinder. The angular tightening method of the cylinder head bolt further increases reliability and durability.

Crankshaft

Tuftriding is given, while on the No. 1 balance weight imprinted is the grade of each journal diameter.

EGR system

Based upon data, including water temperature, engine speeds or engine loads, it is controlled via Engine Control Module (ECM) to purify exhaust by recycling part of it.

Its main components include an EGR valve, an EGR cooler and various sensors.

Connecting rod cap bolt

The angular tightening method of the connecting rod cap bolt further increases reliability and durability.

Common rail-type electronic control injection system

The common rail-type electronic control injection system is composed of a fuel supply pump that sets the target pressure of high-pressure fuel and supply it, a fuel rail that measures such high-pressure fuel and an fuel injector that turns it into a fine spray and injects it. Each is controlled via ECM based upon various signals, while injection timing or fuel injection quantity is controlled under every possible driving condition.

Fuel Injector

The fuel injector is a 7-hole nozzle that adjusts fuel injection quantity or injection timing by opening or closing an electromagnetic valve on the head of the fuel injector.

ECM corrects the dispersion of fuel injection quantity between fuel injectors according to ID code data in memory. At the replacement of fuel injectors, ID code data should be stored in ECM.

Fuel filter with sedimenter

It is a fuel filter with sedimenter that gets rid of water by making use of the difference in specific gravity between light oil and water, which comes with an indicator that notifies you that it is filled with water.

Preheating system

The preheating system consists the ECM, the glow relay, glow plugs and the glow indicator lamp. (OBD II specification consists the ECM, the glow plug controller, glow plugs.) The preheating system is operated when the engine coolant temperature is low, and make the engine easy to start.

Lubrication system

It is an oil filter with full-flow bypass, which uses a water-cool oil cooler and oil jet to cool the piston.

Functional inspection

Inspection/adjustment of valve clearance

1. Inspection of valve clearance
    - Remove the cylinder head cover.
    - Remove the fuel injector harness assembly.
    - Loosen the terminal nuts alternately to remove.
    - Remove the leak off pipe.
    - Rotate the crankshaft to make the No.1 cylinder meet the compression top dead center (TDC).

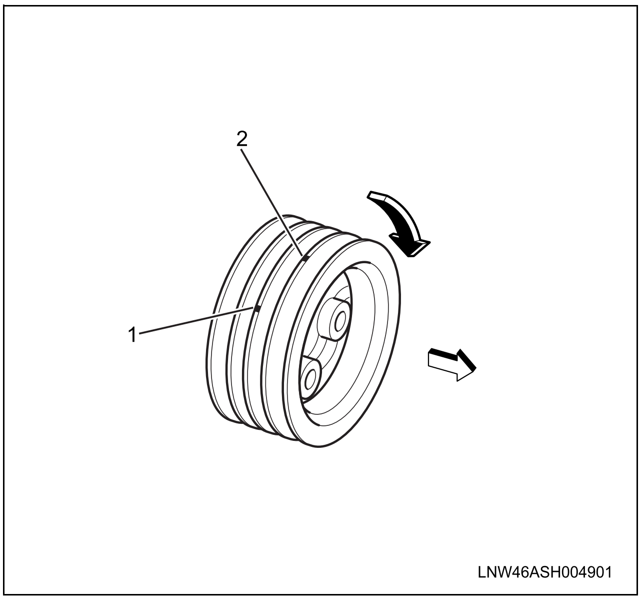
Notice:

There are 2 timing marks on the crankshaft pulley.

Mark (1) is near the cylinder block and is used to bring the 4HK1-TC engine to TDC.

Mark (2) is not applicable to this engine.

Be sure to use mark (1) when bringing the engine to TDC.

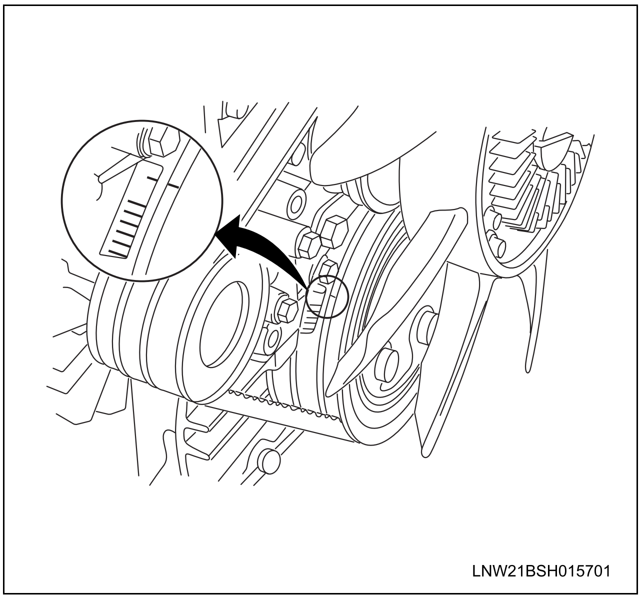


- Insert a 0.4 mm thickness gauge into a clearance between the rocker arm and the bridge to check it and adjust it if needed.

Valve clearance	mm (in)
Intake valve	0.4 (0.016)
Exhaust valve	0.4 (0.016)

Caution:

Adjust while being cold.

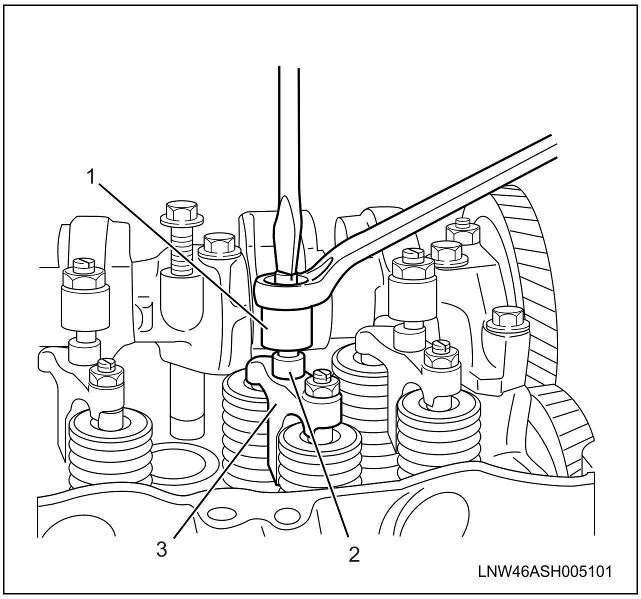


2. Adjustment of valve clearance

Caution:
Adjust valve clearance carefully so that the bridge may become level (hit the end of the 2 valve axes).

a. Completely loosen all of the bridge and rocker arm adjusting nuts and adjusting screws (8 nuts and 8 screws).
b. Place a 0.4 mm thickness gauge between the No. 1 cylinder rocker arm end and the bridge cap.
c. Tighten the rocker arm adjusting screw until the thickness gauge is snug (not tight) between the rocker arm end and the bridge cap.
d. Tighten the rocker arm lock nut.
e. Tighten the bridge adjusting screw until the bridge contacts the valve head.
f. Tighten the bridge lock nut.
g. Check that the thickness gauge is still held snugly between the rocker arm end and the bridge cap. If it is too tight, slightly loosen the bridge adjusting screw and lock nut to restore snugness.
h. Remove the thickness gauge.
i. Repeat Steps 2 through 5 for the remaining cylinders.

Tightening torque: 22 N·m (16 lb ft)

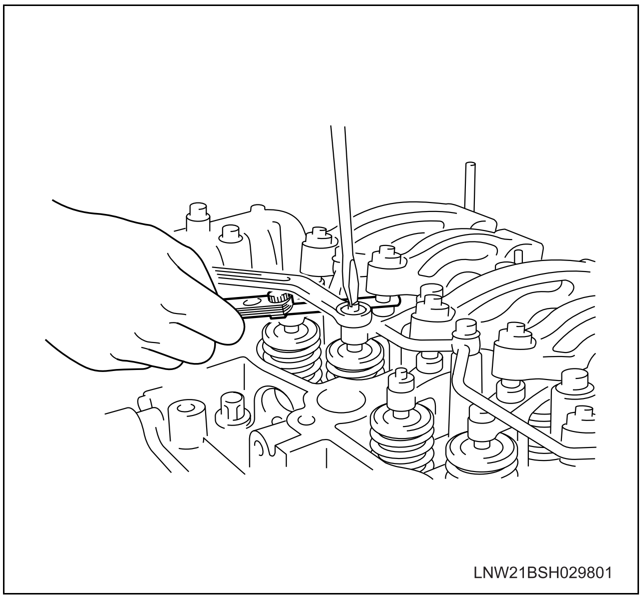


Legend
1. Rooker arm
2. Bridge cap
3. Bridge

- With a thickness gauge kept inserted, tighten an adjusting screw of the bridge lightly and make sure that the tip of the adjusting screw touches the end of valve axis and the movement of the thickness gauge has become tight.
- Then, check if the end of the valve axis on the opposite side is unstable or hits diagonally. If so, loosen the bridge adjusting screw a little so that the end of the valves on both sides may touch properly.
  Valve bridge clearance: ± 0.1 mm (0.0039 in) or less
- After making an adjustment so that the end of the valves on both sides may touch properly, tighten up an adjusting screw nut of the bridge with a minus driver so that the bridge adjusting screw may not rotate.

Tightening torque: 22 N·m (16 lb ft)

Caution:
If the adjusting screw of the bridge is poorly adjusted, the bridge would tilt and be pushed down and seized, which may damage the bridge guide, for example. Thus, adjust it accurately.



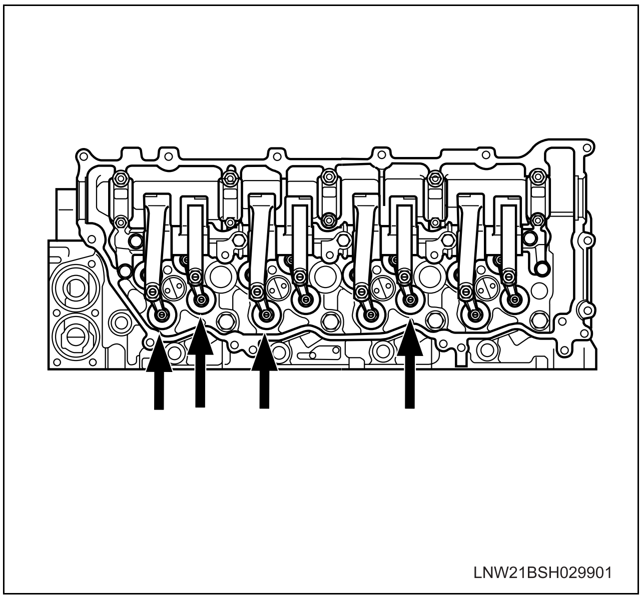
Tightening torque:

Rocker arm adjustment Screw nut	22 N·m (16 lb ft)
Bridge adjustment Screw nut	22 N·m (16 lb ft)

Adjustment table

Cylinder No.	1		2		3		4	
Valve arrangement	IN	EX	IN	EX	IN	EX	IN	EX
No. 1 cylinder Compression TDC	○	○	○			○		
No. 4 cylinder Compression TDC				×	×		×	×

- If the No. 1 cylinder is the compression TDC, adjust a valve clearance with ○ mark given on the table and if the No. 4 cylinder is the compression top dead center, that with × mark.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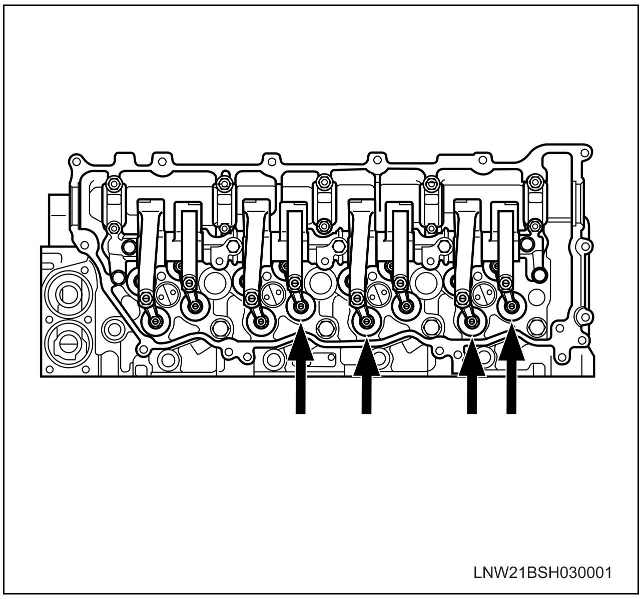
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- Attach the harness assembly to the fuel injector.
  Tighten the harness bracket with the designated torque.

Tightening torque: 48 N·m (35 lb ft)

- Attach the terminal nuts to the fuel injector.

Tightening torque: 2 N·m (17 lb in)

Notice:

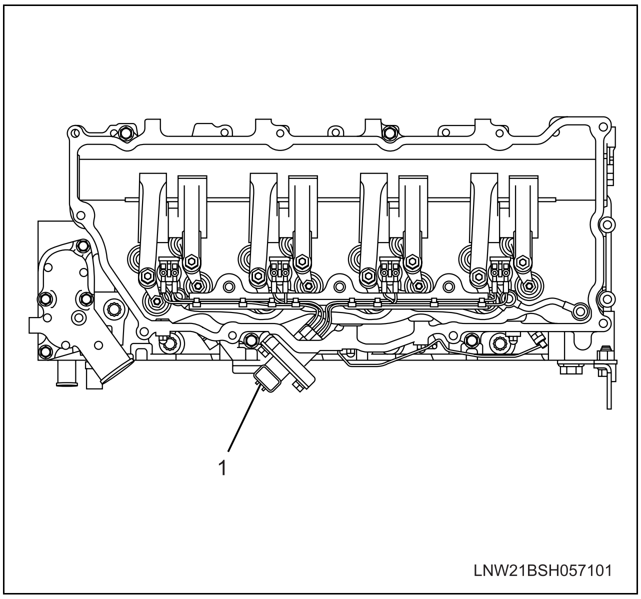
- Tighten the terminal nuts alternately in order to prevent imbalance in tightening because they are unified.
- Do not tighten the nuts too tightly because it leads to damage to the terminal studs.

- Install the cylinder head cover.
  Refer to the "cylinder head cover."

Compression pressure inspection

- Warm up the engine.
- Remove a minus terminal of the battery and remove all the glow plugs.
- Remove the harness connector for the fuel injector built on the lower head cover (no fuel will be injected).

Caution:
When the harness connector is removed, ECM judges that it broke down and DTC is recorded. Upon completion of measurement, never fail to clear memory of ECM.
(For how to clear memory of ECM, refer to the Engine Control System Section)



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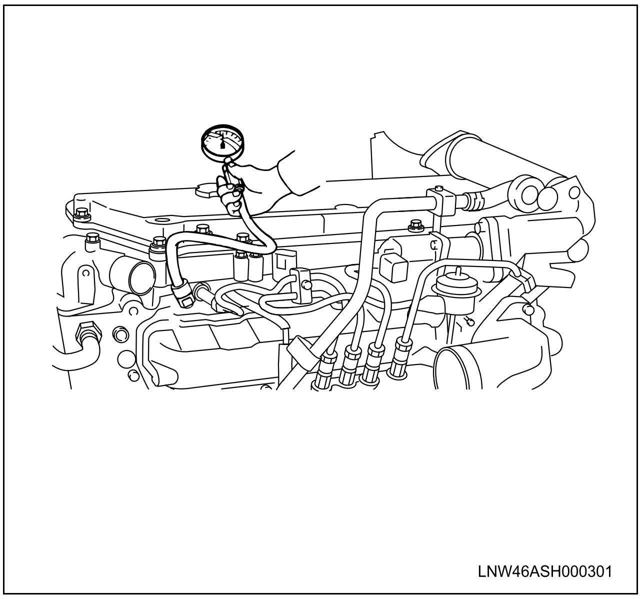
Legend

1. Fuel Injector Harness Connector

- Install the minus terminal of the battery.
- Turn on the starter to emit foreign matter within the cylinders.

- Install an adapter and a gauge of a compression gauge of the special tool.



Compression gauge: J-26999-12
Gauge adapter: EN-46722

- Turn on the starter to inspect compression pressure.

Compression pressure	MPa(psi) / 200 rpm
Standard	2.84 – 3.24 (412 – 469)
Limit	1.96 (284)
Differences among the cylinders	294 kPa (43)

- Measure each cylinder one by one.

Caution:
To keep engine speed at 200 rpm or more, use fully charged batteries.

- Remove a compression gauge of the special tool.
- Remove a minus terminal of the batteries.
- Install a harness connector for the fuel injector built on the lower head cover.
- Install all the glow plugs.

Tightening torque: 20 N·m (15 lb ft)

- Install a minus terminal of the batteries.

A list of defective phenomena

- The engine does not revolve.
- The engine revolves, but does not start.
- Emits plenty of black exhaust.
- Emits plenty of white exhaust.
- The engine knocks.
- Defective revolutions of the engine
- Insufficient charging

Trouble Shooting

Engine does not turn over

Condition	Possible Cause	Correction
Starter motor does not rotate	Dead or weak battery	Charge battery Replace battery
	Incomplete circuit	Connect Repair
	Starter motor brushes stuck, worn, or broken	Replace brushes
	Starter motor internal damage	Repair motor
Starter motor not meshed with flywheel	Ring gear abrasion	Replace ring gear
	Magnetic switch (starter motor) not properly adjusted	Adjust
Starter motor pinion meshed with ring gear but does not rotate	Dead or weak battery	Charge battery Replace battery
	Insufficient contact pressure between starter motor brushes and commutator	Adjust pressure
	Armature (starter motor) stuck	Repair armature
	Engine internal damage (Seizure)	Repair engine

Engine turns over but does not start

Condition	Possible Cause	Correction
Fuel is not delivered to fuel supply pump	Air in fuel system	Bleed air from fuel system
	Air entering fuel pipe	Replace pipe and bleed air from fuel system
	Empty fuel tank	Replenish fuel
	Clogged strainer (fuel suction)	Clean or replace strainer
	Clogged fuel pipe	Clean or replace pipe
	Feed pump malfunction	Replace pump
	Use of wrong fuel for prevailing temperatures	Drain existing fuel and replace with appropriate fuel
	Clogged fuel filter	Replace filter
Fuel is delivered to fuel supply pump	Loose injection pipe connections	Tighten connections
	Loose or broken electrical connectors	Tighten and/or replace connectors
	Bad rotational sensor	Replace sensor
	Engine control system malfunction	System diagnosis
Insufficient or unstable fuel delivery volume	Air in fuel system	Bleed air from fuel system
	Feed pump malfunction	Repair pump
	Loose or broken electrical connectors	Tighten and/or replace connectors
	Clogged fuel filter	Replace filter
	Engine control system malfunction	System diagnosis

Excessive black exhaust smoke

Condition	Possible Cause	Correction
Bad injection timing	Engine control system malfunction	System diagnosis
Bad injection nozzle condition	Carbon deposit at nozzle tip	Clean nozzle tip
	Sticking nozzle	Replace fuel injector assembly
	Engine control system malfunction	System diagnosis
Insufficient compression pressure	Excessive valve clearance	Adjust clearance
	Sticking valve stem (valve open)	Repair or replace valve
	Damaged valve spring	Replace spring
	Valve seat abrasion	Repair valve seat
	Compression leakage due to damaged piston ring	Replace piston ring
	Damaged gasket	Replace gasket
	Piston scoring	Replace piston
Fuel condition	Water in fuel	Drain existing fuel and replace with new fuel
	Poor fuel quality	Drain existing fuel and replace with new fuel
Poor engine aspiration	Clogged intake pipes	Clean or replace pipes
	Clogged air cleaner element	Clean or replace element
Malfunction detected by engine control system	Defective sensor	Replace sensor
	Engine control system malfunction	System diagnosis
EGR valve and/or intake throttle valve malfunction	Intake throttle valve sticking	Repair or replace valve
	EGR valve sticking	Repair or replace valve
	Exhaust brake valve sticking	Repair or replace valve
	Engine control system malfunction	System diagnosis
Turbocharger malfunction	Damaged turbocharger fan	Replace turbocharger
	Rough turbocharger shaft rotation	Replace turbocharger
	Oil leakage from oil seal	Replace turbocharger
	Defective booster sensor	Replace sensor

Excessive white exhaust smoke

Condition	Possible Cause	Correction
Bad injection timing	Engine control system malfunction	System diagnosis
Malfunction detected by engine control system	Defective sensor	Replace sensor
	Control unit malfunction	Replace unit
	Engine control system malfunction	System diagnosis
Insufficient compression pressure	Excessive valve clearance	Adjust clearance
	Sticking valve stem (valve open)	Repair or replace valve
	Damaged valve spring	Replace spring
	Valve seat abrasion	Repair valve seat
	Compression leakage due to damaged piston ring	Replace piston ring
	Damaged gasket	Replace gasket
	Piston scoring	Replace piston

Condition	Possible Cause	Correction
Fuel condition	Water in fuel	Drain existing fuel and replace with new fuel
Excessive oil consumption	Worn or damaged piston ring(s)	Replace ring(s)
	Defective valve stem oil seal	Replace oil seal
	Defective turbocharger oil seal	Replace turbocharger
	Clogged turbocharger oil return pipe	Repair pipe

Engine knocking

Condition	Possible Cause	Correction
Bad timing	Engine control system malfunction	System diagnosis
Malfunction detected by engine control system	Defective sensor	Replace sensor
	Control unit malfunction	Replace unit
	Engine control system malfunction	System diagnosis
Fuel condition	Poor quality fuel	Drain existing fuel and replace with new fuel
Poor engine aspiration	Clogged intake pipes	Clean or replace pipes
	Engine control system malfunction	System diagnosis
Engine break-down	Foreign material in cylinders	Engine overhaul
	Scored pistons and/or bearings	Replace pistons and/or bearings

Abnormal engine rotation

Condition	Possible Cause	Correction
Engine speed cannot be increased	Defective control unit	Replace unit
	Engine control system malfunction	System diagnosis
Engine speed unstable	Defective control unit	Replace unit
	Engine control system malfunction	System diagnosis
	Clogged fuel filter element	Replace element
	Defective fuel injector nozzle(s)	Replace fuel injector assembly
	Water in fuel	Drain existing fuel and replace with new fuel
	Air in fuel system	Bleed air from fuel system
	Exhaust brake valve sticking	Repair or replace valve
Turbocharger malfunction	Damaged turbocharger fan	Replace turbocharger
	Rough turbocharger shaft rotation	Replace turbocharger
	Defective booster sensor	Replace sensor

Abnormal battery charging

Condition	Possible Cause	Correction
No charging	Open or shorted wiring and/or connectors	Repair or replace wiring and/or connectors
	Defective generator	Repair or replace generator
	Defective battery	Replace battery

Condition	Possible Cause	Correction
Insufficient charging	Open or shorted wiring and/or connectors	Repair or replace wiring and/or connectors
	Defective generator	Repair or replace generator
	Loose generator drive belt	Adjust belt tension or replace belt
	Defective battery	Replace battery
Excessive charging	Shorted wiring	Repair or replace wiring
	Defective generator	Repair or replace generator
	Defective battery	Replace battery

Turbocharger Troubleshooting

Condition	Possible Cause	Correction
Engine has less than normal power	Air leakage from intake pipe rubber hose	Repair
	Air leakage from inlet cover	Repair
	Clogged intercooler cooling section	Clean
	Clogged air cleaner element	Clean or replace
	Exhaust brake valve stuck	Repair or replace
	Turbine and housing contact (Interference)	Replace
	Excessive carbon deposit near turbine exhaust port that interferes with turbine	Clean or repair
	Rough turbine shaft rotation	Repair or replace
	Damaged turbine fan	Repair or replace
Blue exhaust smoke	Oil leakage from turbocharger oil seal	Repair or replace
	Clogged turbocharger oil return pipe	Repair
	Clogged center housing oil passages	Repair or replace
	Engine oil deterioration	Change engine oil
Noisy turbocharger operation	Gas leakage from intake or exhaust system	Repair
	Turbine and housing contact (Interference)	Repair or replace
	Damaged turbine fan	Replace
	Turbine shaft bearing abrasion or scoring	Repair or replace
Excessive rotating part wear	Engine oil deterioration	Change engine oil
	Clogged turbocharger oil feed pipe	Repair
	Low engine oil pressure	Repair

Main Data and specifications

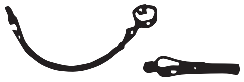
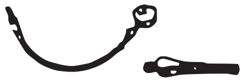
Item			Engine model 4HK1-TC
Type			Diesel/4-cycle/water cooling-type in-line OHC
Combustion chamber type			Direct injection type
Cylinder liner type			Dry type
Number of cylinders -cylinder bore × strokes		mm (in)	4-115 (4.53) × 125 (4.92)
Displacement		cc(cu.in)	5193(317)
Compression ratio			18.5
Compression pressure		MPa (psi)/rpm	3.23 (468)/200
Idling speed		rpm	750
Valve clearance mm (in)	Intake		0.4 (0.016) (cold)
	Exhaust		0.4 (0.016) (cold)
Ignition type			Compressed ignition
Injection order			1 - 3 - 4 - 2
Lubricating system			
Lubricating type			Pressure type
Oil pump type			Gear type
Volume of lubricating oil		L (qts)	13.0 (13.7)
Oil filter type			Full flow filter (cartridge type)
Oil cooling type			Built-in-type, water cooling
Cooling system			
Cooling type			Water cooling type
Radiator type			Corrugated fin(pressure type)
Water pump type			Centrifugal, belt type
Thermostat type			2 wax-type units
Thermostat valve-opening temperature		°C (°F)	82 (180), 85 (185)
Volume of coolant		L (qts)	14 (14.8) (incl. radiator)
Fuel system			
Injection pump type			Electronic control common rail type
Governor type			Electronic type
Timer type			Electronic type
Injection nozzle type			Multi-hole type 7-hole and ϕ0.16 mm (0.0063 in) inside diameter
Charging system			
Generator type			AC type
Power output		V-A	12 - 110
Regulator type			IC
Starting system			

Item		Engine model 4HK1-TC
Starter type		Reduction type
Power output	V-kw	12 - 3.0
Preheat system type		Glow plug
Glow plug standard voltage/ electric current	V-A	12 - 3.5

OBD II Specification

1. Voltage	(curve/profile) DC =	11V	1.2sec
		8V	1.8sec
		5V	4sec
		4.7V	53sec
2. Current flow	current shall be MAX 9A when measured 30 sec after application of the voltage profile 1.		
	Ignition on = (0 sec)	max 27A	
	Igniton on = (after 8 sec)	max 10A	

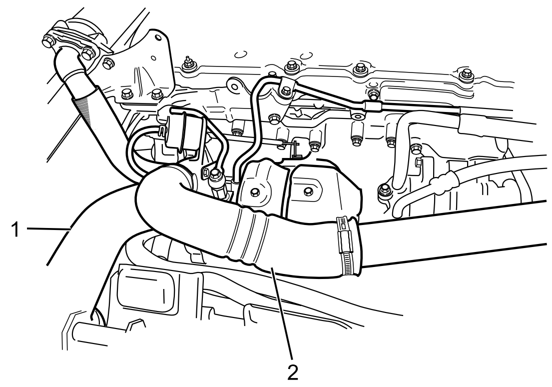
Special tool

Illustration	Tool Number/ Description
 5884020080  5884020080	J-26999-12 Compression gauge EN-46722 Gauge adapter

Engine Assembly

Removal

1. Remove a minus (-) terminal of the battery.
2. Drain the coolant.
3. Remove the starter motor.
    - Disconnect the front frame harness connector in the vicinity of the control box of the transmission and remove each clip that fixes the harness.
    - Remove 2 up and down bolts that fasten the starter and remove the starter from the clutch housing.
    - Fix the starter motor with wire, for instance, in a place that does not get in the way in removing the transmission.
4. Remove the transmission assembly.
    - Remove the propeller shaft on the transmission side and fix it with wire, for instance, to the frame.
    - Remove a cable of the emergency brake.
    - Remove the harness connector.
    - Remove the connector of the speed sensor.
    - Remove an exhaust pipe bracket from the clutch housing.
    - Remove the shift cable.
    - Remove the level gauge guide tube.
    - Remove the converter cover under the housing.
    - Remove the torque converter bolts (8 bolts).
    - Remove the oil pipe.
    - Remove the clutch housing bolts.
    - Set a mission jack.
    - Remove the mounting bolts and remove the transmission.
5. Remove the charge air pipe (turbocharger → intercooler).



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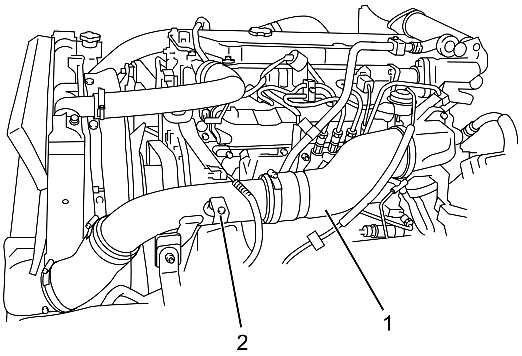
Legend

1. Inlet Pipe
2. Charge Air Pipe

6. Remove the inlet pipe (air cleaner → turbocharger).
7. Remove the charge air pipe (intercooler → inlet duct).
    - Remove the connector of the boost pressure sensor.



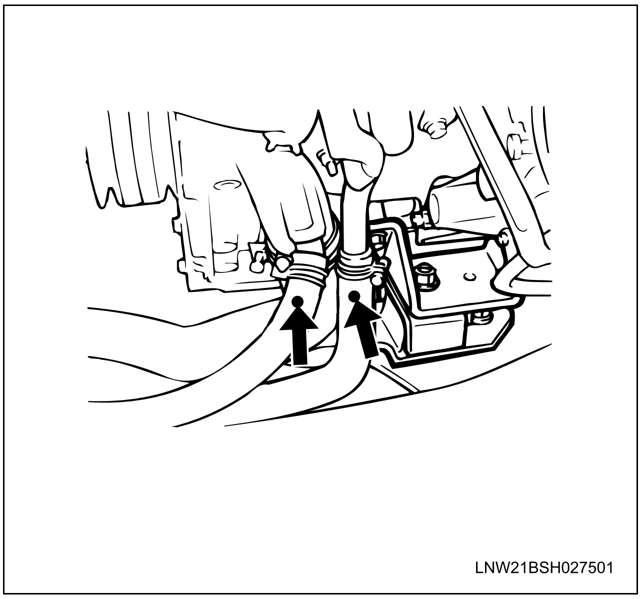
LNW46ASH004201

Legend

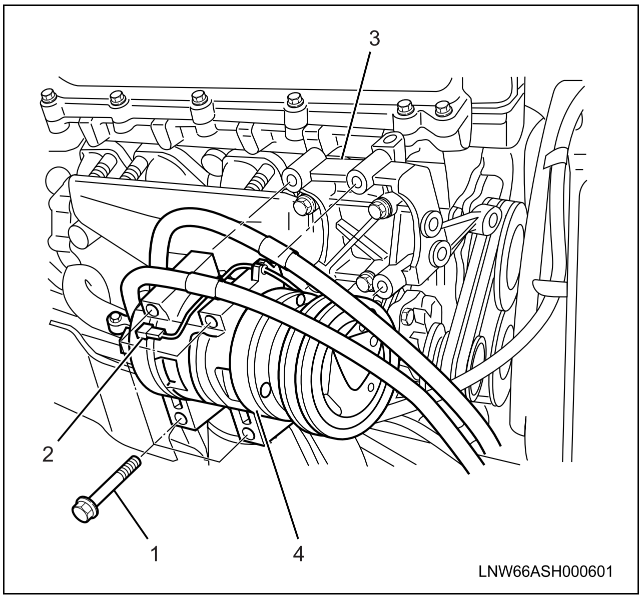
1. Charge Air Pipe
2. Boost Pressure Sensor

8. Remove the upper hose of the radiator.

9. Remove a bracket of the fan guide.
10. Remove the fan assembly.
    - Remove the nuts and pull them out upward.
11. Remove the heater hoses.
    - Remove 2 hoses on the engine side.



12. Remove the engine harness.
13. Remove the A/C compressor.
    - Remove the drive belt.
    - Remove the connector.
    - Remove the A/C compressor and fix it with wire, for example, to an appropriate place along with hoses and others.

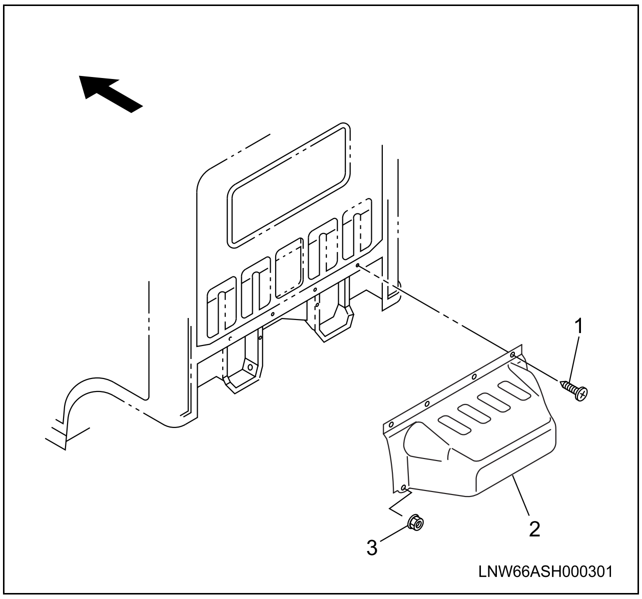


Legend

1. Fixing Bolt
2. Connector
3. Bracket
4. A/C Compressor

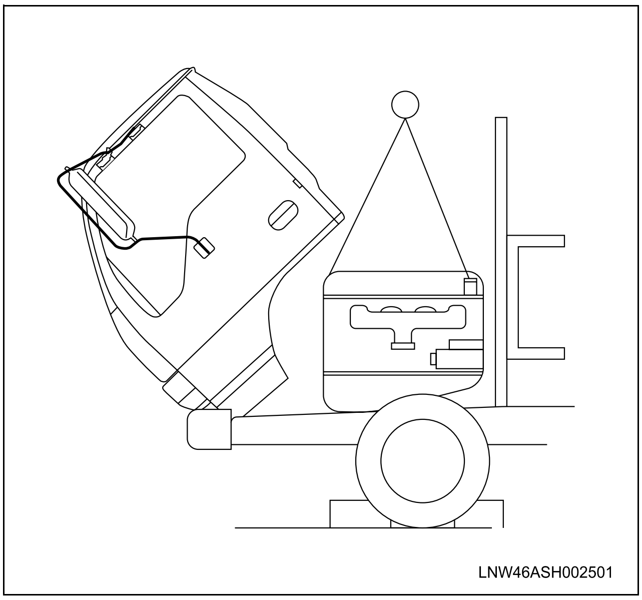
14. Remove the A/C generator harness.
    - Remove the terminal B cable and harness connector from the generator.
15. Remove the vacuum hose on the vacuum pump side.
16. Remove a bracket by the blow-by separator and remove the harness connector and HBB oil hose bracket.
17. Remove the blow-by separator hose.
18. To prevent oil from flowing out when the hydraulic booster brake hose is removed, remove the fastening bolts for the hydraulic booster brake tank to lower the tank.
19. Remove one side of the hydraulic booster brake hose on the high-pressure side.
20. To prevent oil from flowing out when the power steering oil hose is removed, remove the fastening bolts for the power steering reserve tank to lower the tank.
21. Remove the power steering oil hose.
22. Remove the lower hose of the radiator on the engine side.
23. Hang wire on the engine hanger and hoist to lift up the engine slightly.
24. Remove the front exhaust pipe.
    - Remove the front exhaust pipe from the turbo and exhaust brake.
25. Remove the fuel hose on the feed and return sides.
26. Remove the engine mount.
    - Remove the fastening bolts for the engine mount on the chassis frame side.

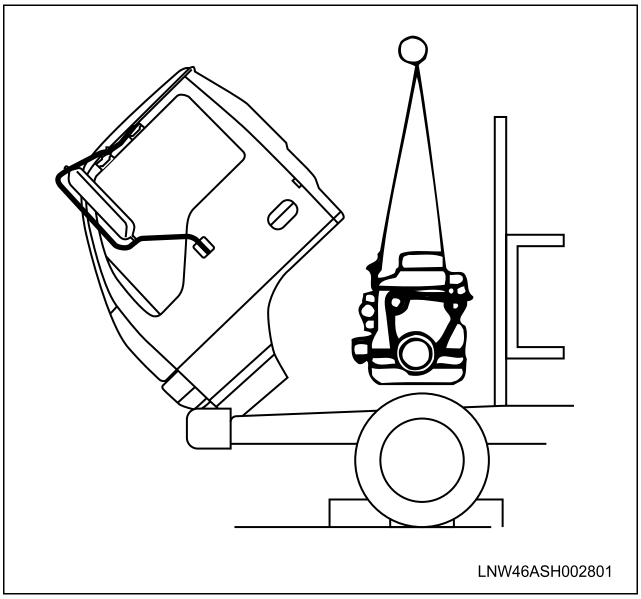
27. Remove the engine assembly.
    - Remove the cab back cover.



Legend
1. Screw
2. Cab Back Cover
3. Nut

- Operate a hoist slowly and hoist the engine until it comes up to the surface of the chassis frame.
- Turn the engine at an angle of 90 degrees to move from the surface of the chassis frame and remove the engine assembly.

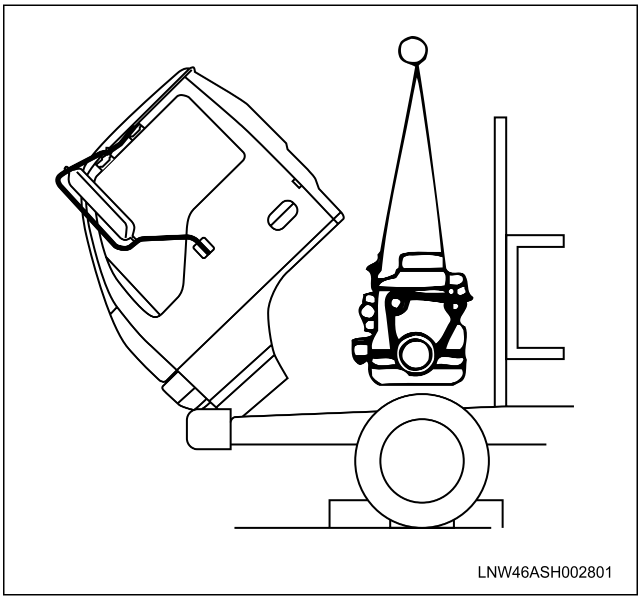




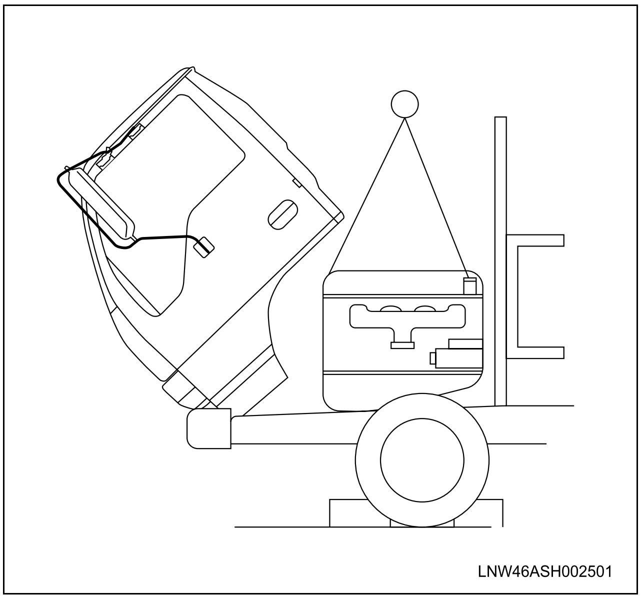
Installation

Notice:
Be absolutely sure that each harness is reconnected to its original position.

1. Install the engine assembly.
    - Hang wire on the engine hanger and hoist to lift up the engine.
    - Operate a hoist slowly to move the engine to the place where it is to be installed.

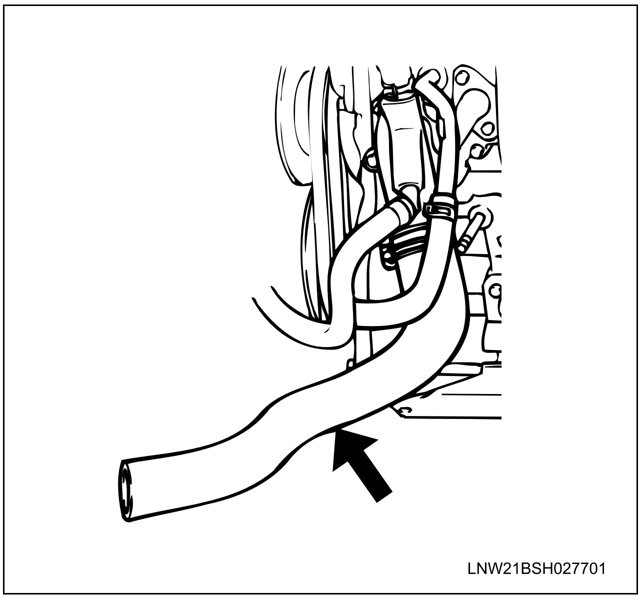


- Turn the engine at an angle of 90 degrees to lower the engine slowly to the place it is to be installed.

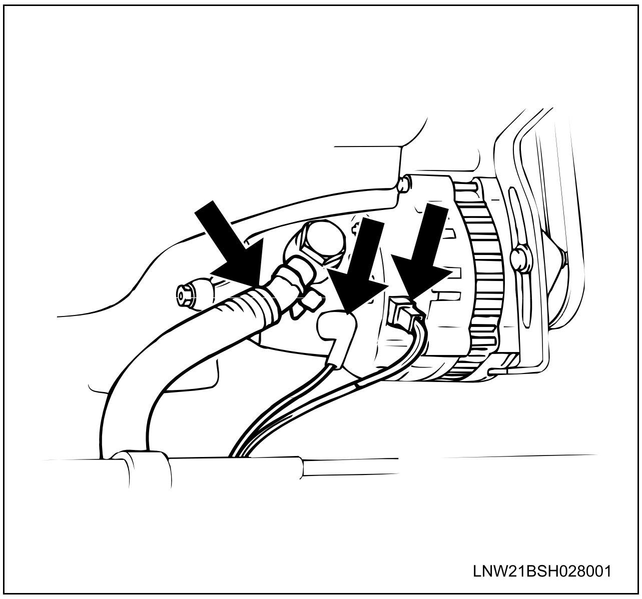


- Make the transmission side lower and operate a hoist slowly, pulling it backward to the engine.

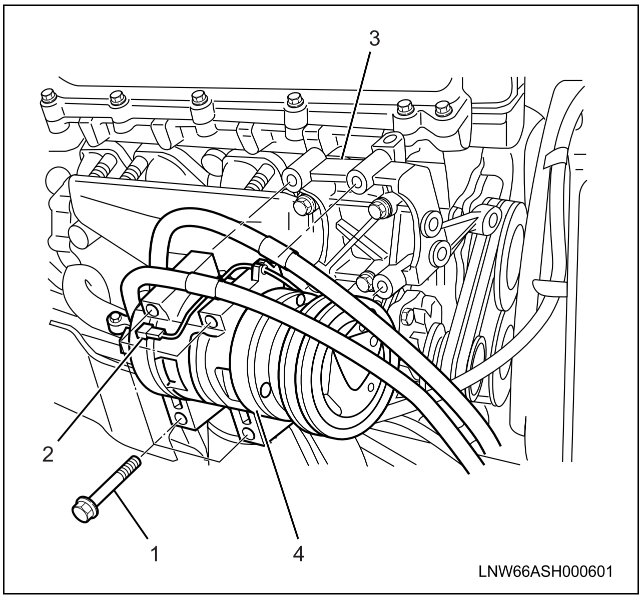
2. Install the engine mount.
   - Install the engine mount to fit into the holes of the engine mounting cross member and tighten it up with the specified torque.
   - Tightening torque: 48 N·m (35 lb ft)
3. Install the feed and return sides of the fuel hose.
4. Install the front exhaust pipe.
5. Install the lower hose of the radiator.



6. Install the power steering oil hose.
7. Install the power steering reserve tank.
8. Install the hydraulic booster brake hose on the high-pressure side.
9. Install the hydraulic booster brake tank.
10. Install the blow-by separator hose.
11. Install a bracket by the blow-by separator and install the harness connector and HBB oil hose bracket.
12. Install a vacuum hose to the vacuum pump.



13. Install the A/C generator harness.
    - Install the terminal B cable and the harness connector to the generator.
14. Install the A/C compressor.
    - Install the connector.

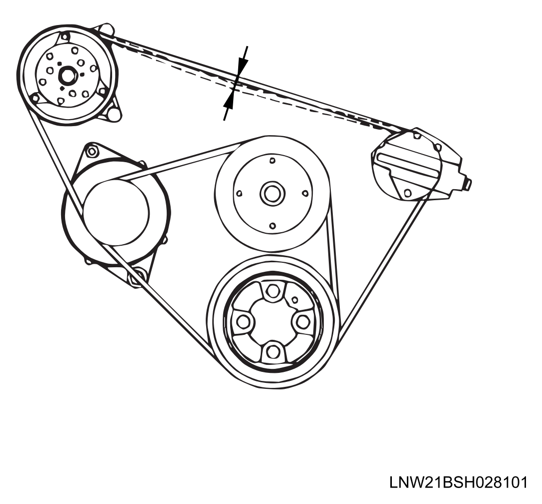


Legend

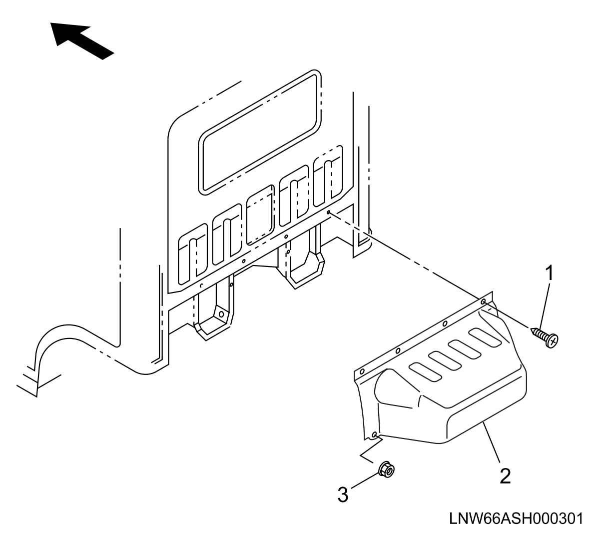
1. Fixing Bolt
2. Connector
3. Bracket
4. A/C Compressor

- Install the drive belt.
- Hang the drive belt to adjust its tension with an adjusting bolt of the tension pulley.
- For further details for adjusting tension of the belt, refer to the “Drive Belt” in the cooling system section.

- Check if a flexure is within the specified range when the center part is pressed by the hand with 98 N (22 lb) by using a scale, for instance. In addition, check if it is not damaged as well.
- Flexure of the A/C compressor belt
- 16 ~ 20 mm (0.62 ~ 0.79 in) (when the belt is new)
- 18 ~ 22 mm (0.71 ~ 0.87 in) (when the belt is reused)
- After adjusting tension of the belt, tighten up the lock nut of the tension pulley.


LNW21BSH028101

15. Install the cab back cover.



LNW66ASH000301

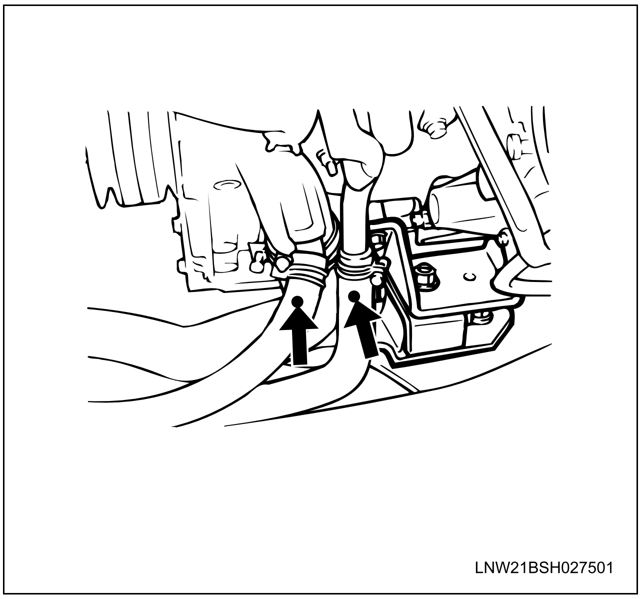
Legend

1. Screw
2. Cab Back Cover
3. Nut

---

16. Install the engine harness.
17. Install the heater hoses.

- Install 2 hoses.

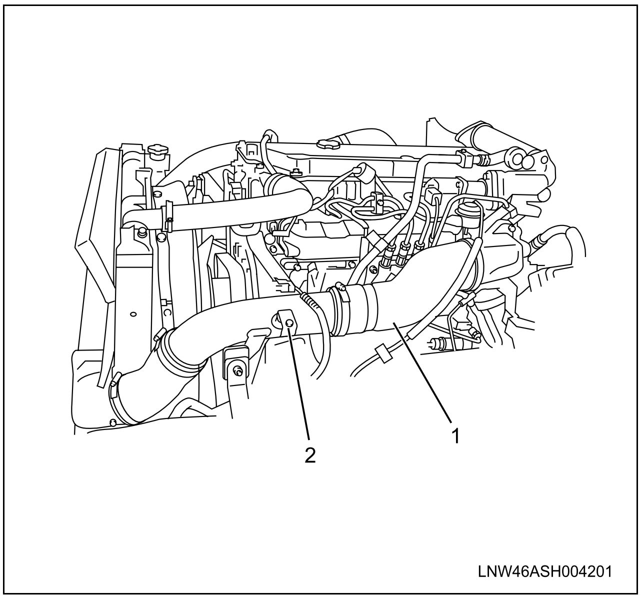

LNW21BSH027501

18. Install the fan assembly.
19. Install a bracket for the fan guide.
20. Install an upper hose of the radiator.


LNW21BSH027601

21. Install the intake pipe (intercooler → inlet duct).

- Install the connector of the boost pressure sensor.



Legend

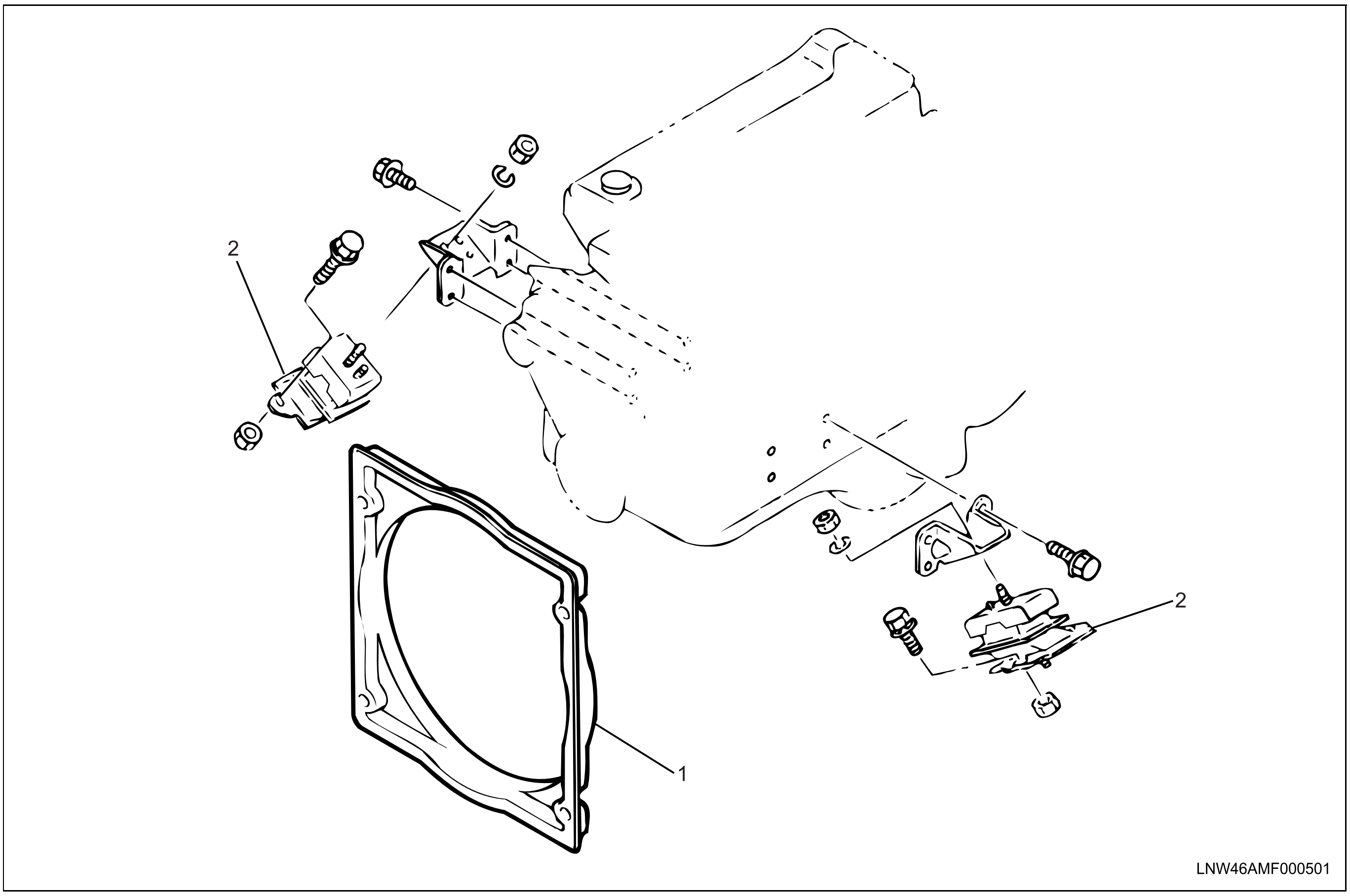
1. Charge Air Pipe
2. Boost Pressure Sensor

---

22. Install the inlet pipe (air cleaner → turbocharger).
23. Install the intake pipe (turbocharger → intercooler).
24. Install the transmission assembly.
    - Mount the transmission and install the mounting bolts.
    - Install the clutch housing bolts.
    - Install the oil pipe.
    - Install the torque converter bolts (8 bolts).
    - Install the converter cover under the housing.
    - Install the level gauge guide tube.
    - Install the shift cable.
    - Install the exhaust pipe bracket to the clutch housing.
    - Install the connector of the speed sensor.
    - Install the harness connector.
    - Install a cable of the emergency brake.
    - Install the propeller shaft, which is removed on the transmission side.
25. Install the starter motor.
    - Install 2 up and down bolts to fasten the starter.
    - Connect the front frame harness connector and install each clip which fixes the harness.
26. Replenish the coolant.
27. Install a minus (–) terminal of the battery.

Engine Mount

Component



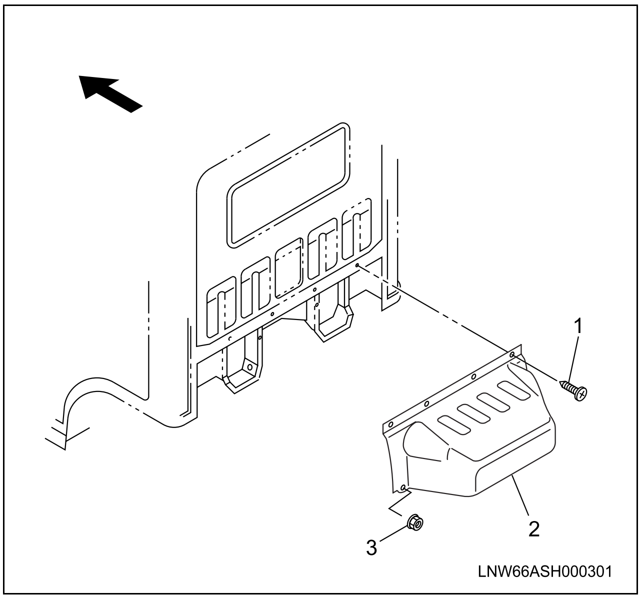
Legend

1. Fan Guide
2. Engine Mount

Removal

1. Remove the fan guide bracket.
2. Remove the engine mount.

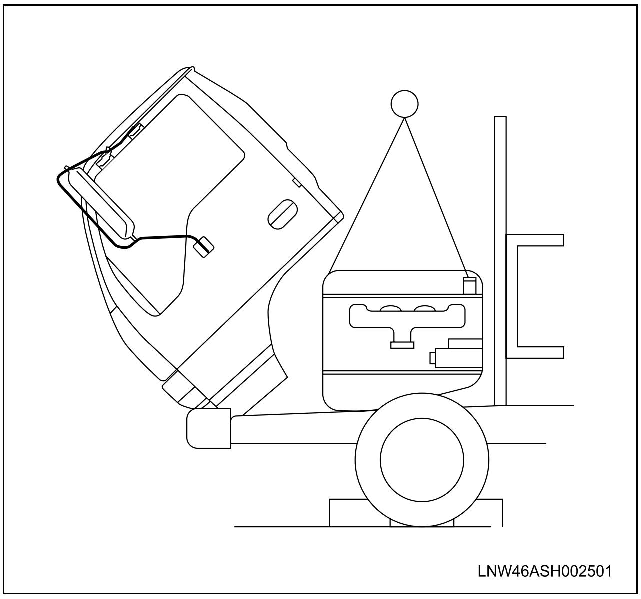
- Remove the cab back cover.



Legend

1. Screw
2. Cab Back Cover
3. Nut

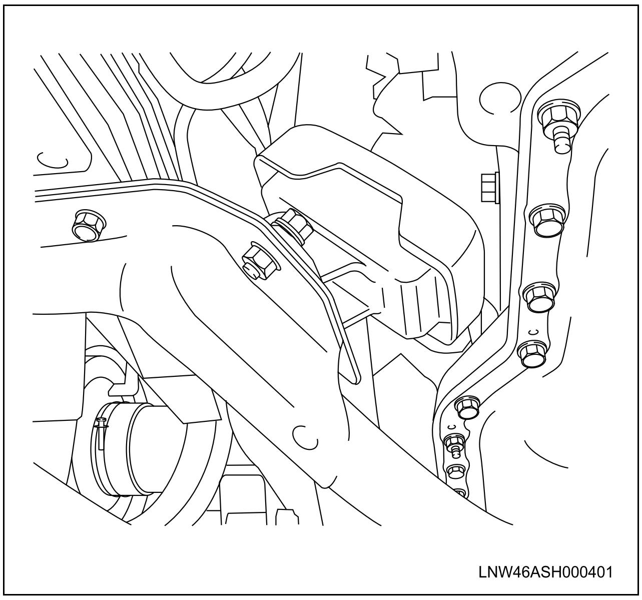
- Before removing the engine mount, hang the engine with a hoist.
- Remove the nuts fastened to the engine foot and engine mount.
- Remove the bolts fastened to the engine mount on the chassis frame side.
- Hoist the engine assembly slightly to remove the engine mount.



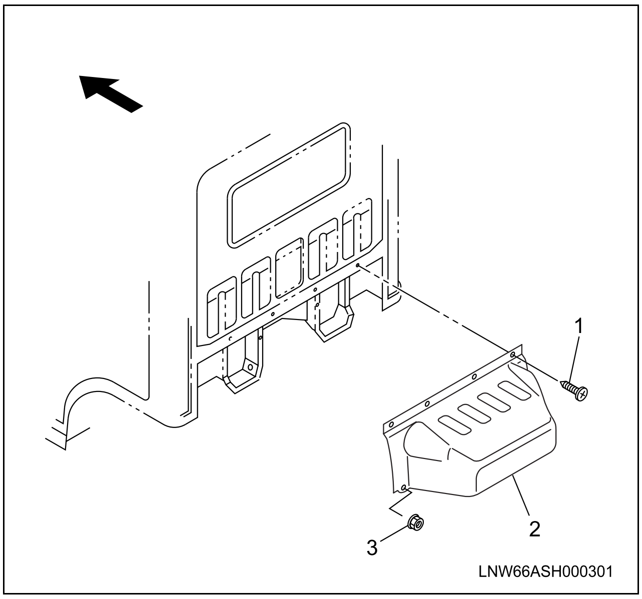
Installation

1. Install the engine mount and tighten up with the specified torque.

The nuts on the chassis frame side
Tightening torque: 40 N·m (30 lb ft)
The bolts on the engine foot side
Tightening torque: 51 N·m (38 lb ft)



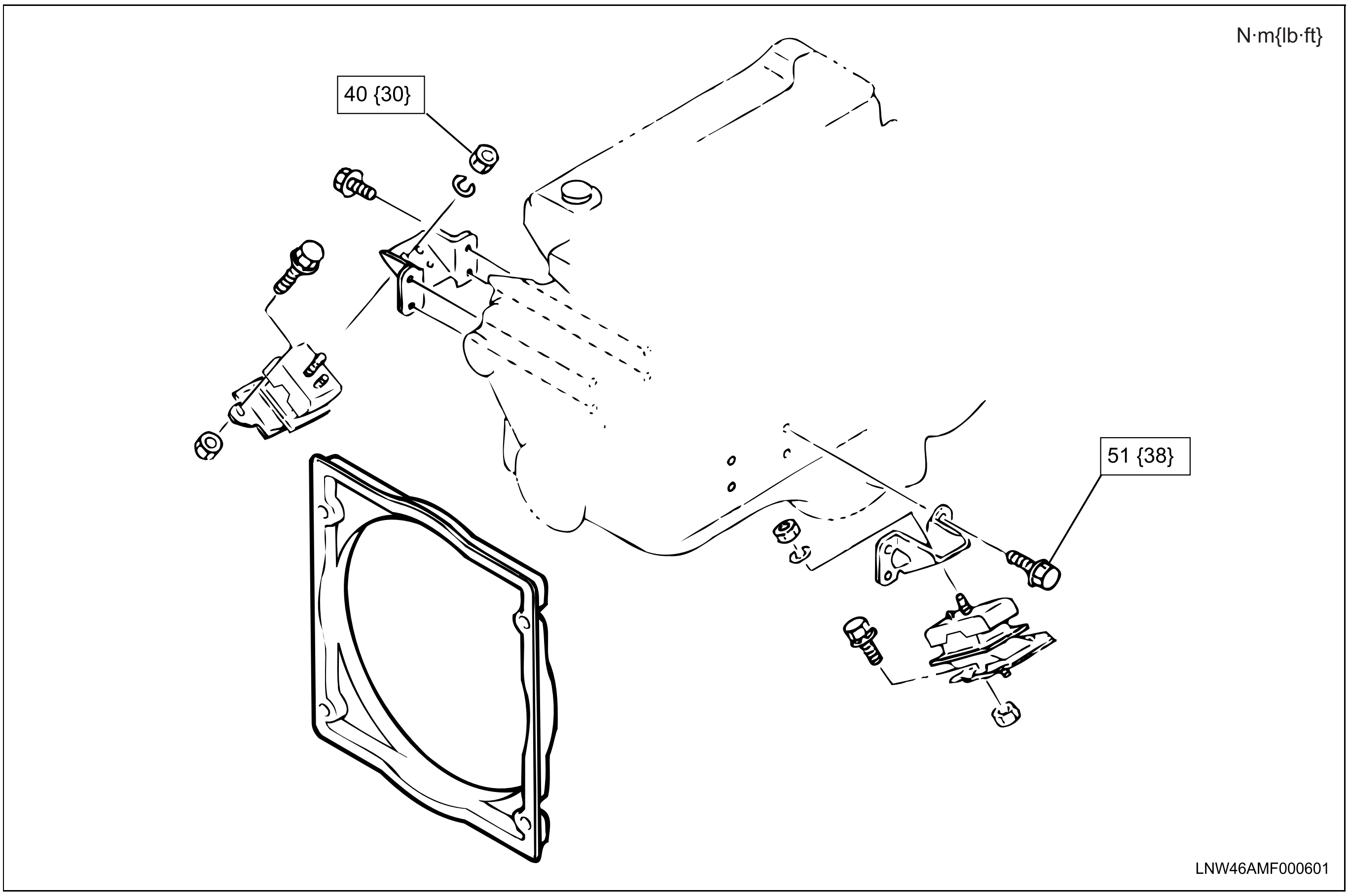
2. Install the fan guide bracket.
   - Check if nothing is wrong with the engine mount by starting the engine.
3. Install the cab back cover.



Legend

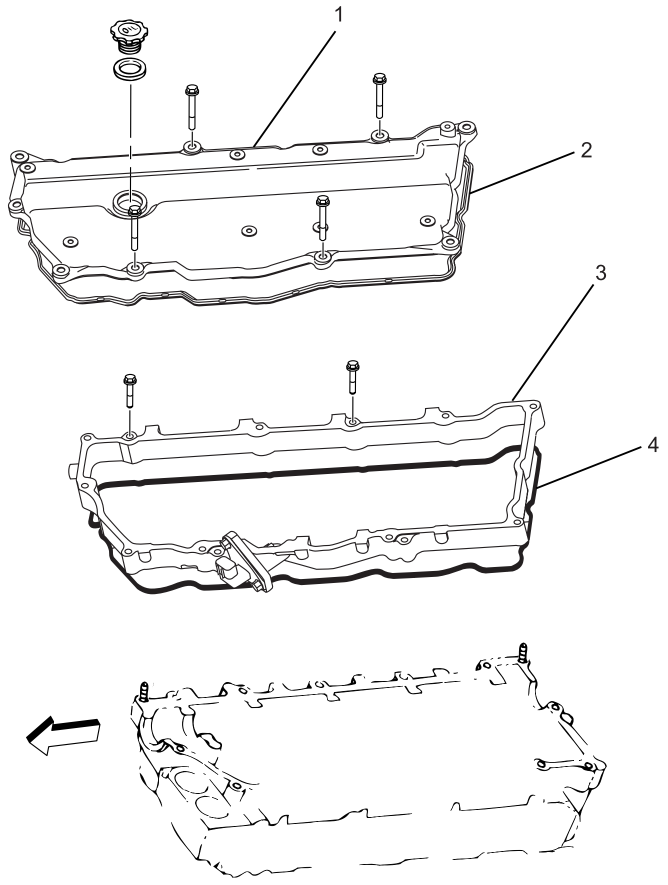
1. Screw
2. Cab Back Cover
3. Nut

Torque Specifications



Cylinder Head Cover

Component



LNW46ALF000901

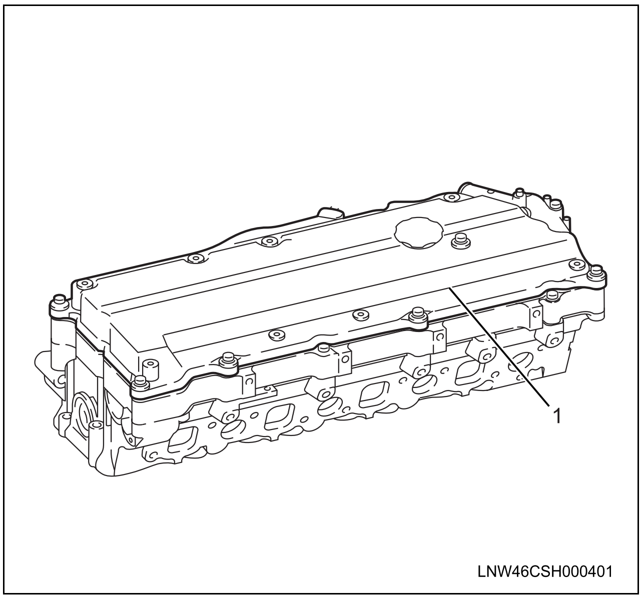
Legend

1. Head Cover
2. Gasket
3. Head Cover Case
4. Gasket

Removal

1. Remove the head cover.

2. Remove the gasket.

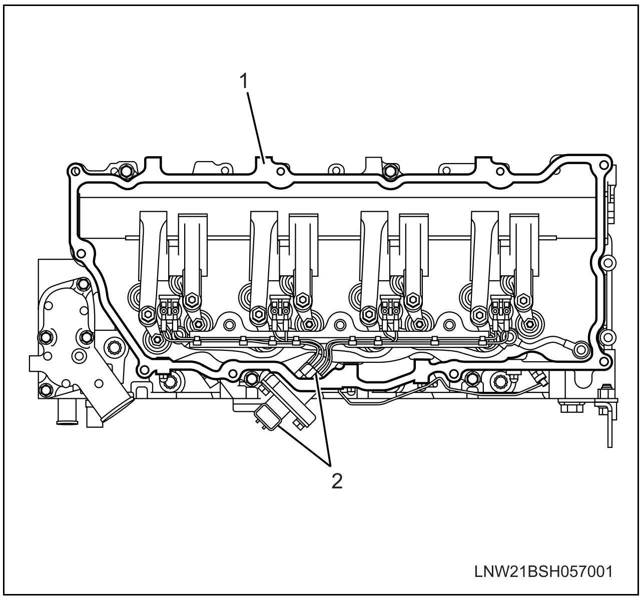


Legend

1. Head Cover

---

3. Remove the fuel injector harness connector.
4. Remove the head cover case.
5. Remove the gasket.



Legend

1. Head Cover Case
2. Fuel Injector Harness Connector

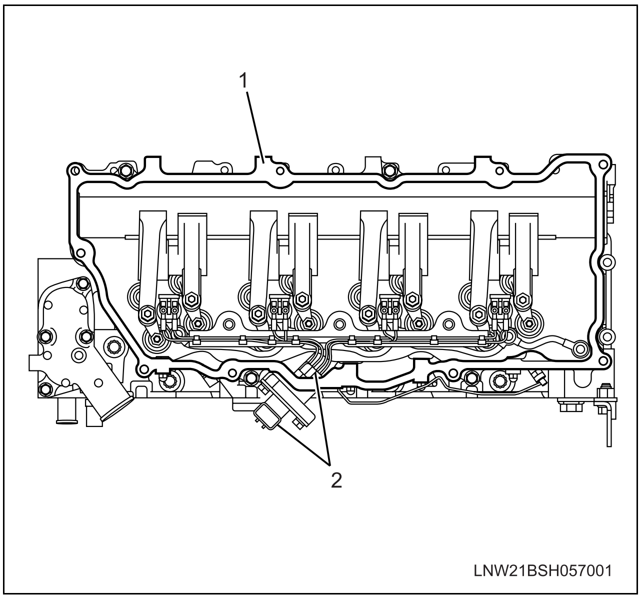
Installation

1. Install the gasket on the lower cover.
2. Install the head cover case.

Tightening torque: 18 N·m (13 lb ft)

3. Install the fuel injector harness connector.

Caution:
Push it in thoroughly until the claws of the lock raise.



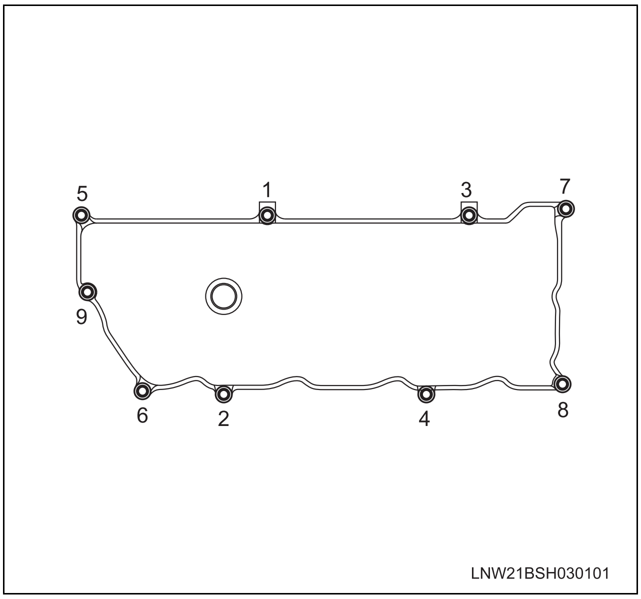
Legend

1. Head Cover Case
2. Fuel Injector Harness Connector

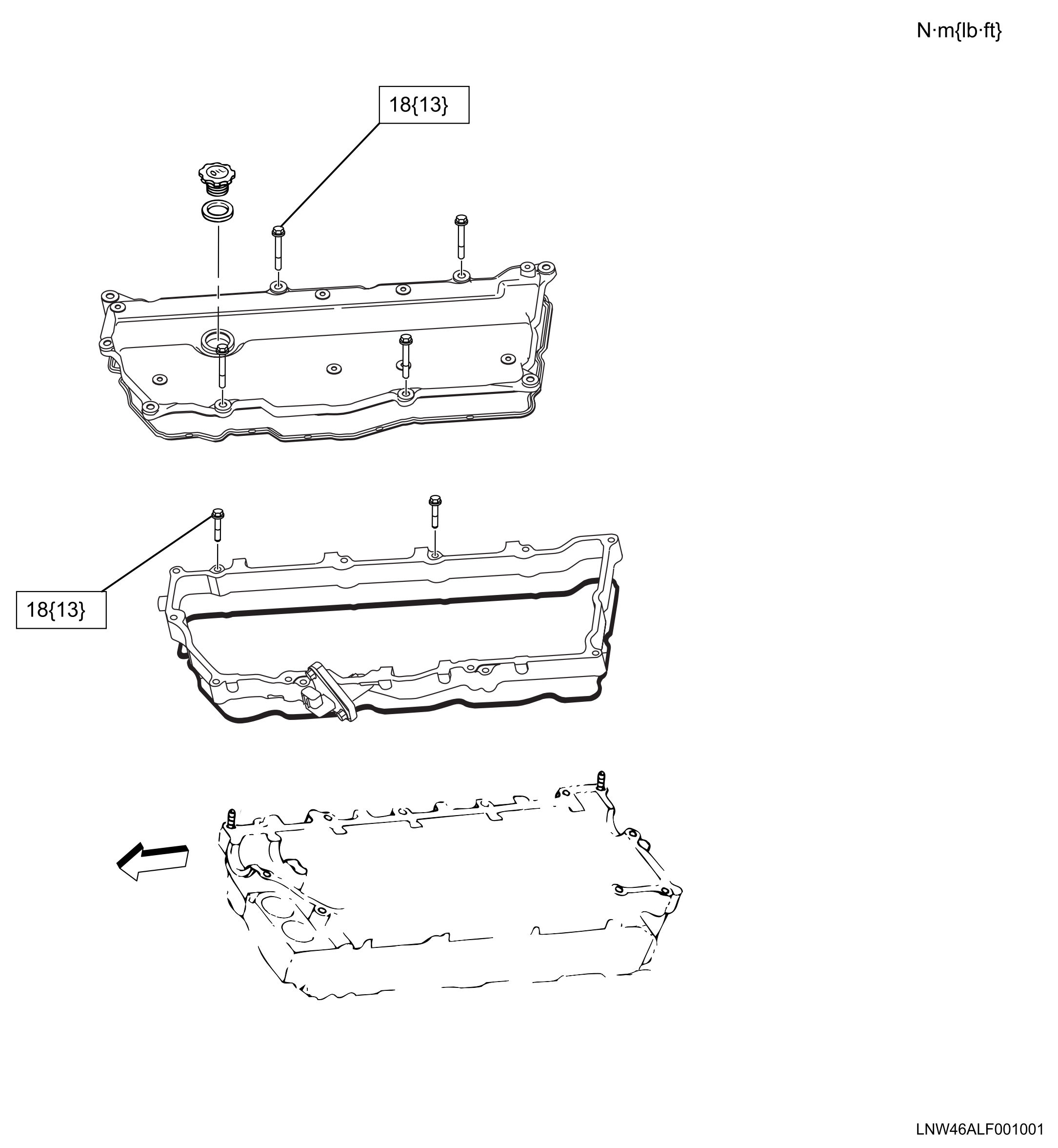
---

4. Install the gasket on the head cover.
5. Install the head cover and tighten up according to the orders given on the figure.

Tightening torque: 18 N·m (13 lb ft)

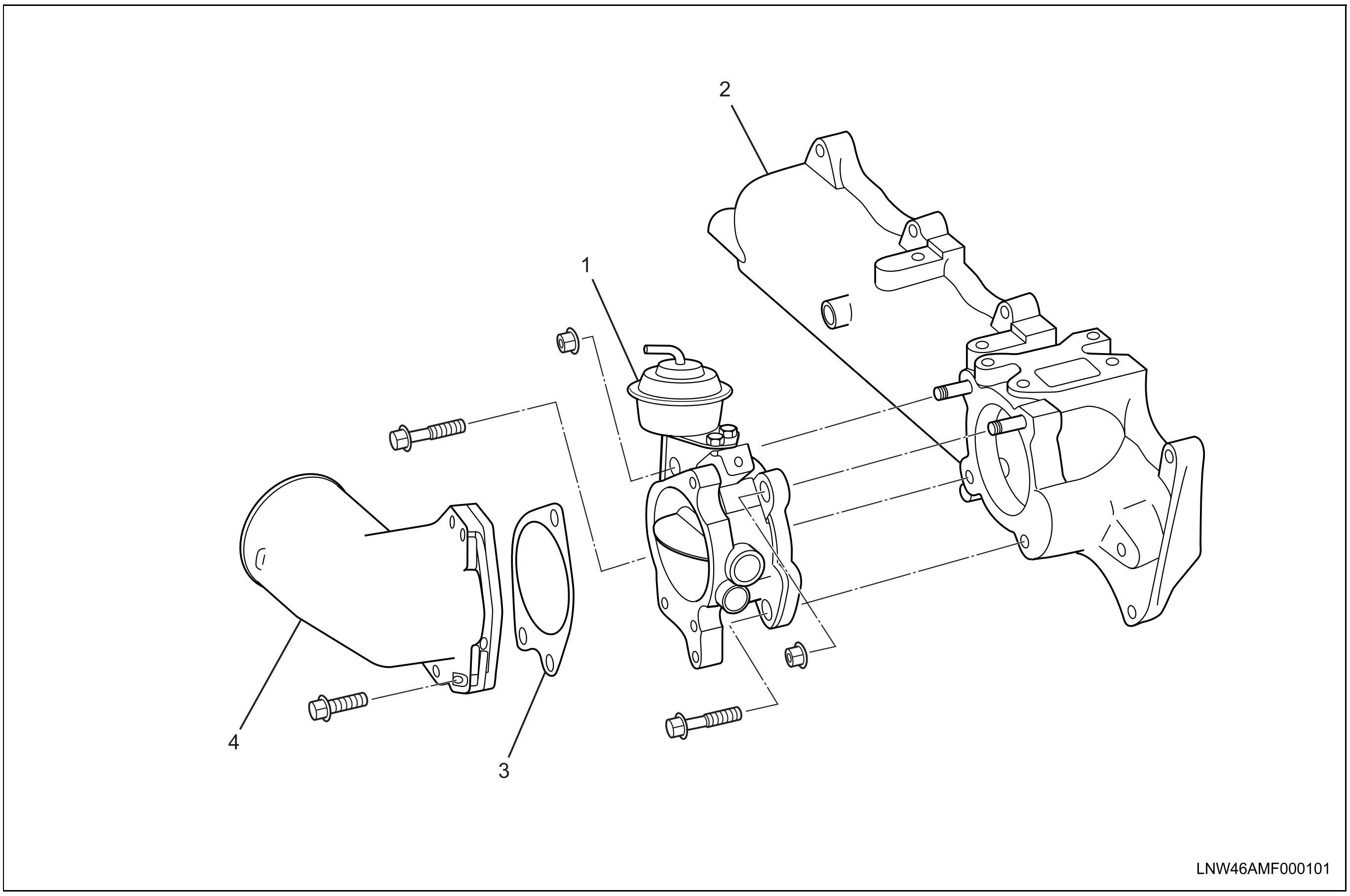


Torque Specifications



Inlet Cover

Component

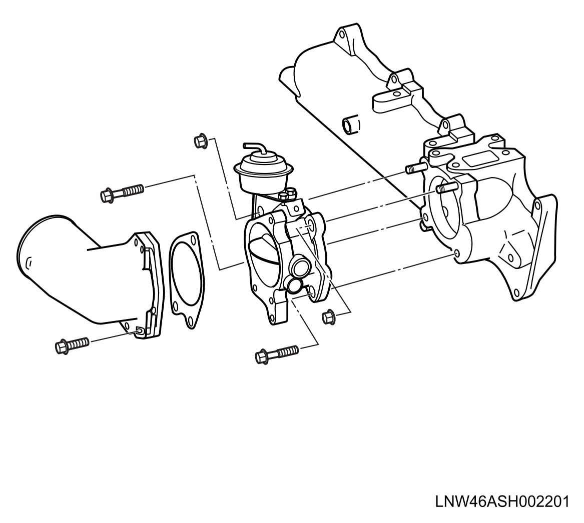


Legend

1. Throttle Assembly
2. Inlet Cover
3. Inlet Pipe Gasket
4. Inlet Pipe

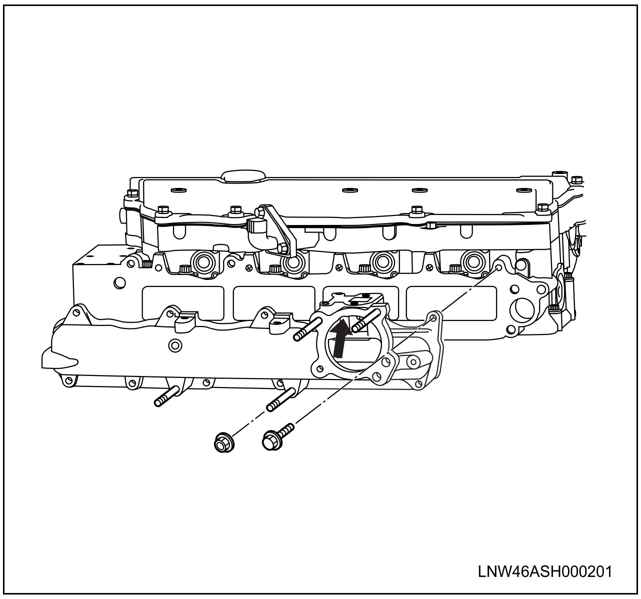
Removal

1. Remove the fuel rail.
   Refer to the “Fuel Rail” in the Fuel System Section.
2. Remove the inlet pipe.
3. Remove the throttle assembly.



4. Remove the inlet cover.

- On the place where the throttle assembly is to be installed inside the inlet cover (arrow) is a bolt. Be careful not to forget to remove it.
- Peel the liquid gasket off carefully.


LNW46ASH000201

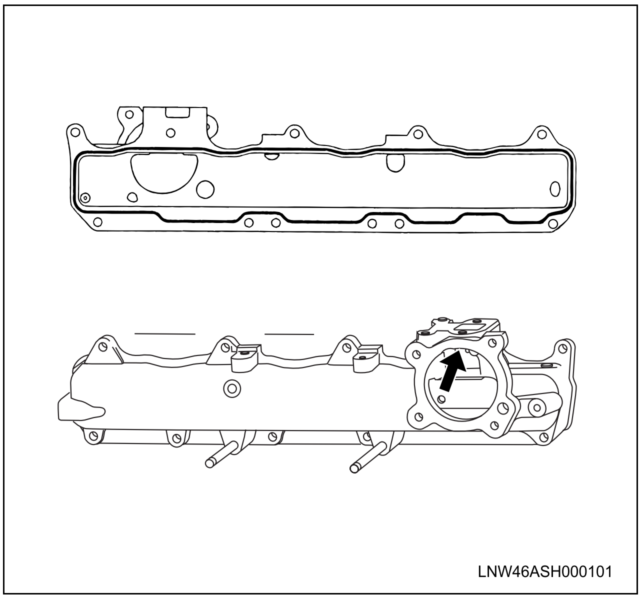
Installation

1. Install the inlet cover.
    - Apply the liquid gasket (ThreeBond 1207C or equivalent) by using a beat diameter of 2.5–5.5 mm (0.1–0.2 in) along a groove of the inlet cover.
    - Install it within 7 minutes after applying the liquid gasket.

Tightening torque: 22 N·m (16 lb ft)

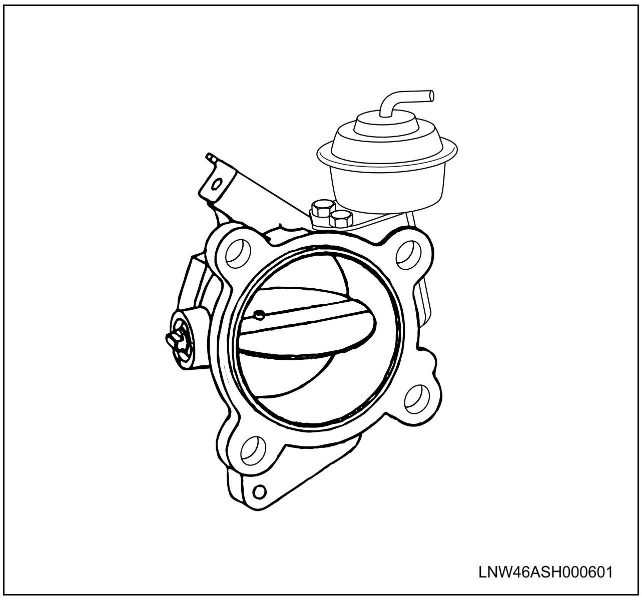
Caution:

- Be careful not to forget to fasten the bolt indicated with an arrow.
- Tighten up the stud part together with the fuel rail.


LNW46ASH000101

2. Install the throttle assembly.
    - Apply the liquid gasket and mount within 7 minutes.

Tightening torque: 24 N·m (17 lb ft)

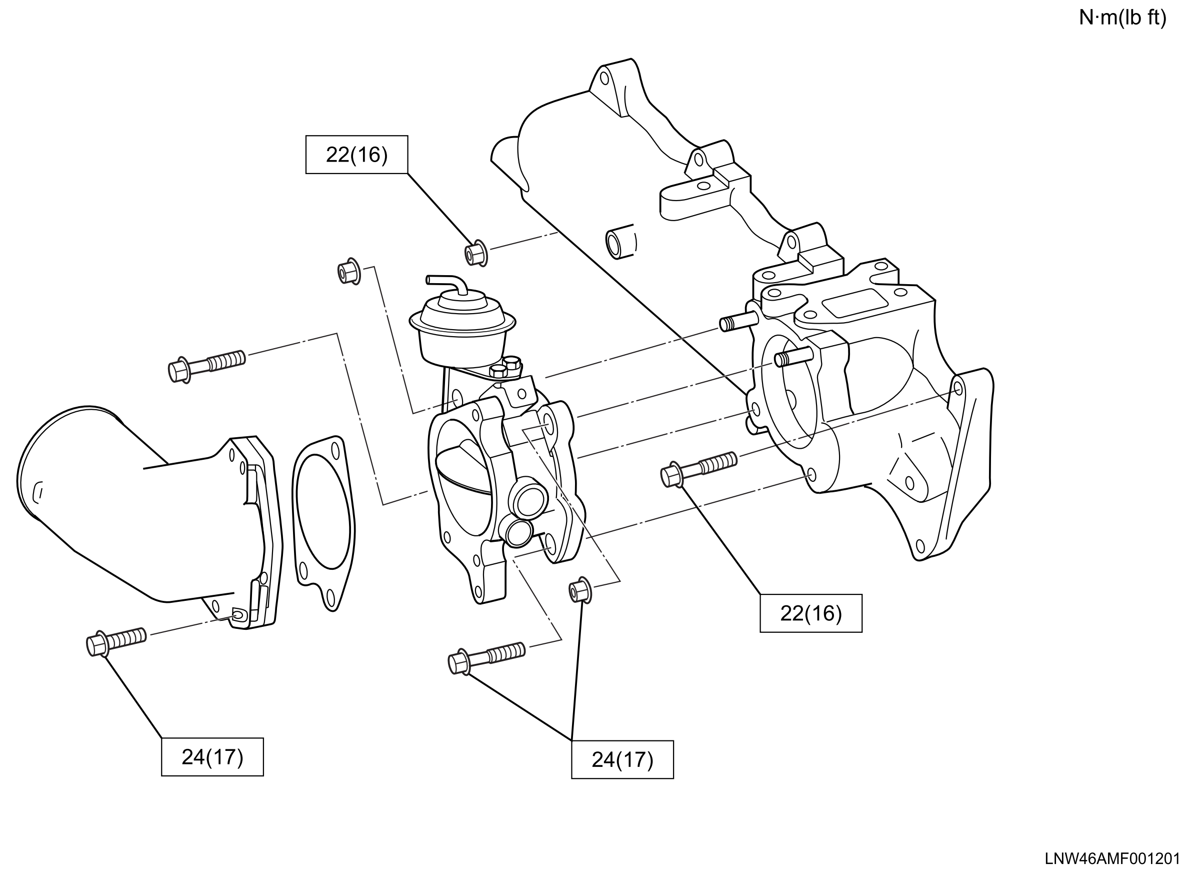

LNW46ASH000601

3. Install the gasket on the inlet pipe and tighten up with the prescribed torque.

Tightening torque: 24 N·m(17 lb ft)

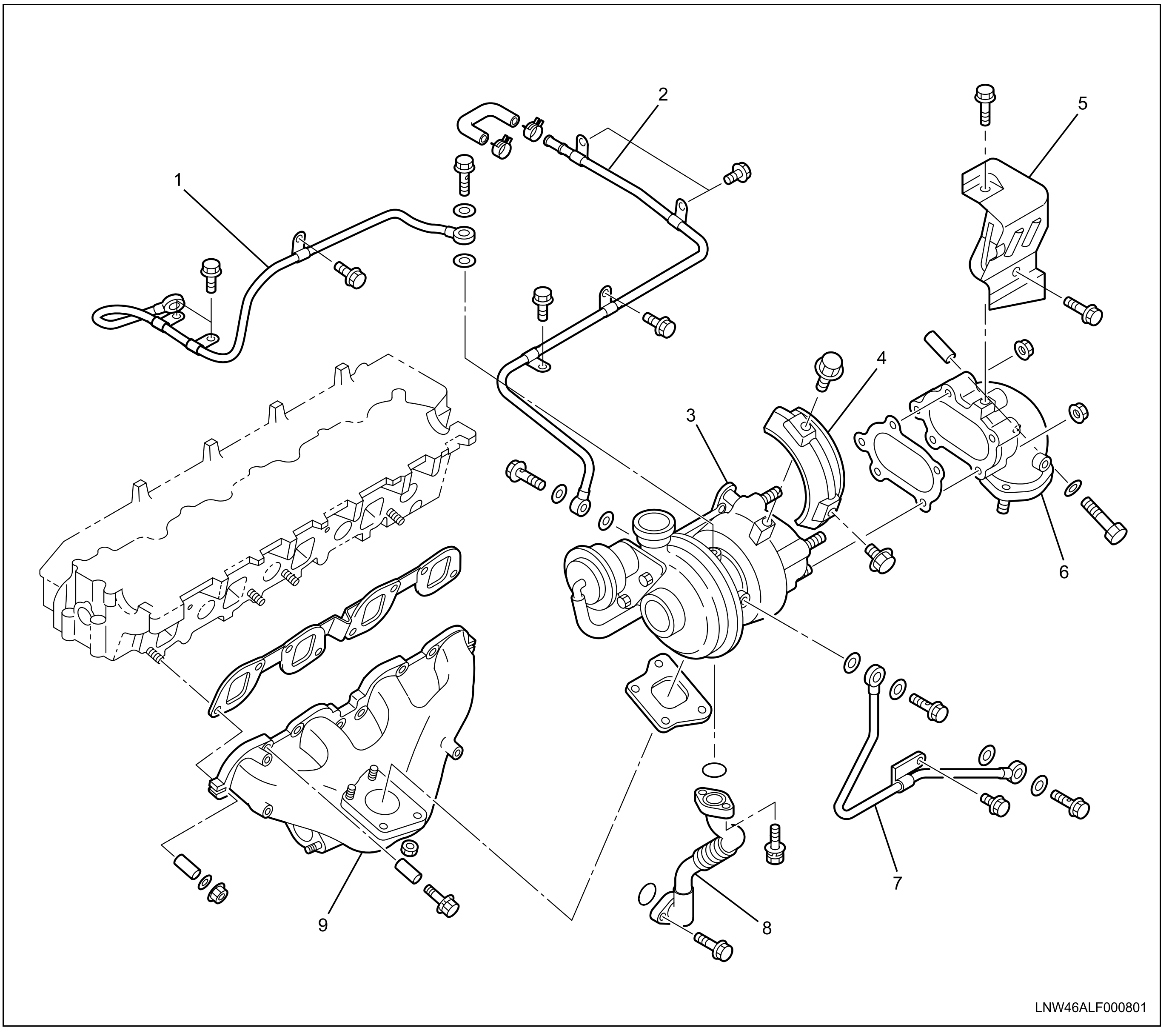
4. Install the fuel rail.
   Refer to the “Fuel Rail” in the Fuel System Section.

Torque Specifications



Turbocharger and Exhaust Manifold

Component



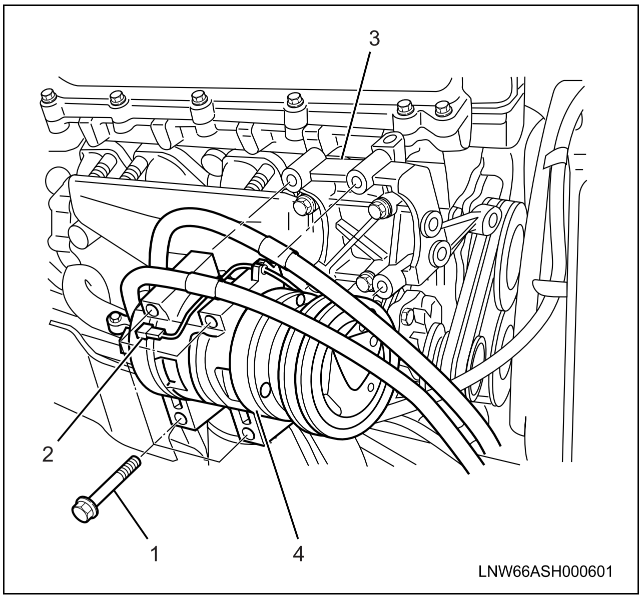
Legend

1. Oil Feed Pipe
2. Water Return Pipe
3. Turbocharger Assembly
4. Heat Protector
5. Heat Protector
6. Exhaust Adapter
7. Water Feed Pipe
8. Oil Return Pipe
9. Exhaust Manifold

Removal

1. Loosen the radiator drain cock to drain coolant.
2. Remove the air intake duct from the turbocharger and the air cleaner.
3. Remove the charge air pipe from the turbocharger and the charge air cooler.
4. Remove the front exhaust pipe.
5. Remove the EGR pipe
6. Remove the A/C compressor harness.
7. Remove the A/C compressor bracket.

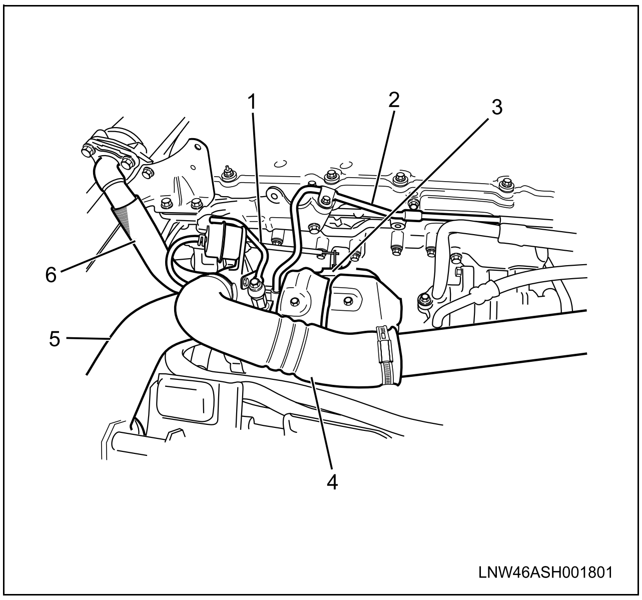
- A/C Without disconnecting the hose of the compressor, remove the compressor from the bracket and remove the compressor bracket from the cylinder head.



Legend

1. Fixing Bolt
2. A/C Compressor Harness
3. A/C Compressor Bracket
4. A/C Compressor

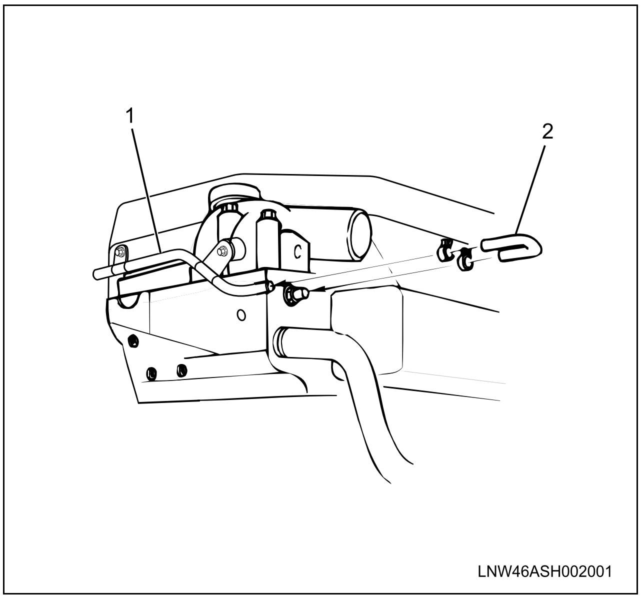
- Remove the oil feed pipe.
- Remove the oil return pipe.
- Remove the oil feed pipe.



Legend

1. Oil Feed Pipe
2. Water Return Pipe
3. Heat Protector
4. Charge Air Pipe
5. Inlet Duct
6. EGR Pipe

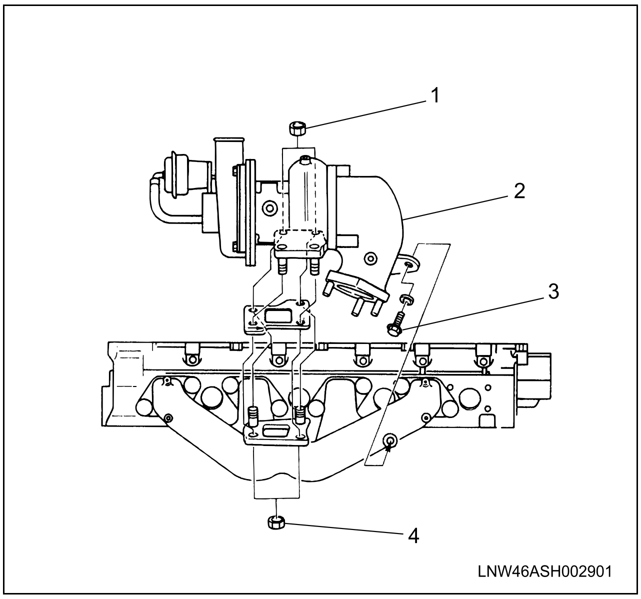
- Remove the water return pipe.



Legend

1. Water Return Pipe
2. Rubber Hose

- Remove the heat protector on the turbocharger.
- Remove the exhaust adapter bolts.
- Remove the four turbocharger clamping nuts.
- Remove the turbocharger from the exhaust manifold.

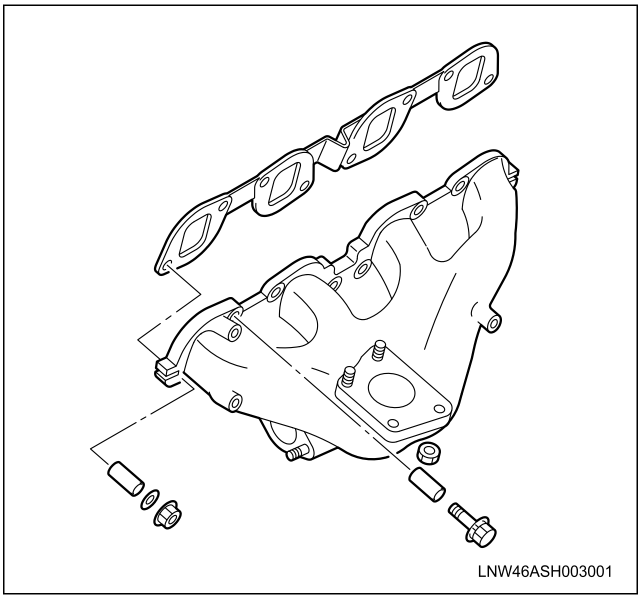


Legend

1. Fixing Nut
2. Exhaust Adapter
3. Fixing Bolt
4. Fixing Nut

8. Remove the exhaust manifold.

- Remove the 2 nuts and 6 bolts to remove the exhaust manifold.

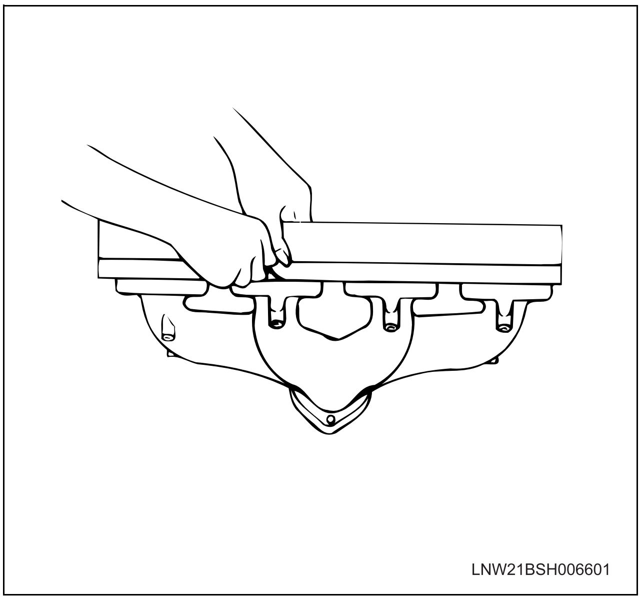

LNW46ASH003001

Inspection

- Inspection of the exhaust manifold
  Inspect the plane surface of the plane on which the manifold and the cylinder head are to be installed.

Manifold installation plane surface	mm (in)
Standard	0.3 (0.01) or lower
Limit	0.5 (0.02)

Caution:
If the plane surface exceeds the limit, replace it.


LNW21BSH006601

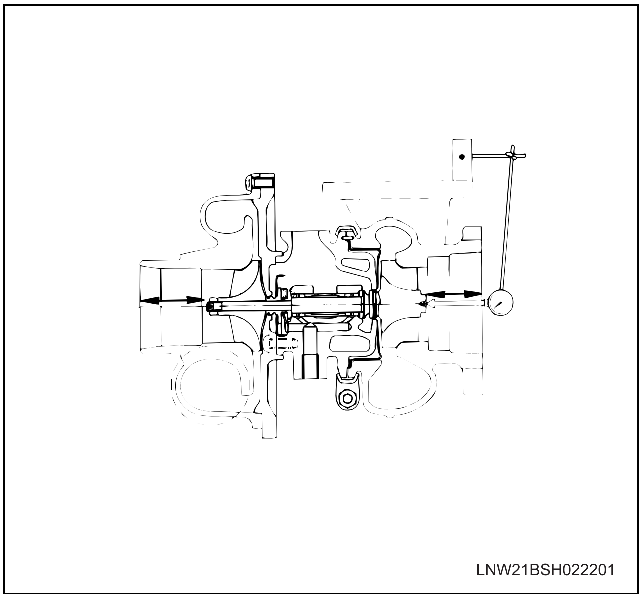
- Check a crack in the exhaust manifold visually.

Carefully inspect he turbocharger for abrasion and/or excessive wear. Make any necessary adjustments, repairs, and/or part replacements.

Wheel shaft axle play

Use a dial gauge to measure the wheel axle shaft play when a fore of 12 N (2.6 lb) is alternately applied to both sides of the compressor wheel.

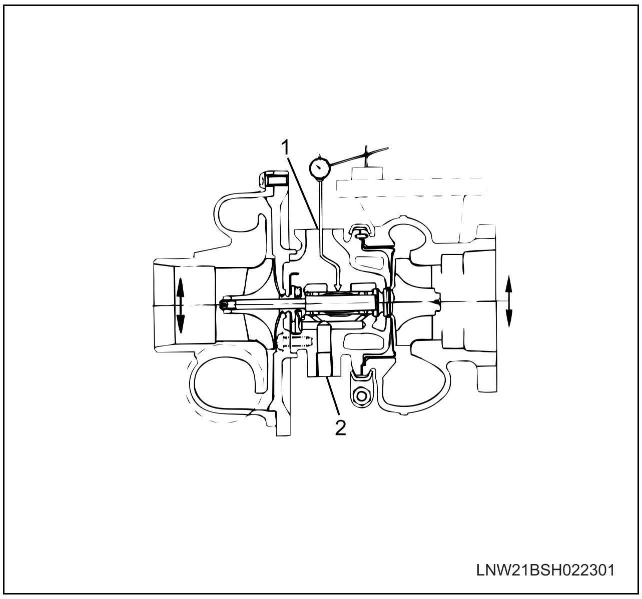
Axle play	mm (in)
Standard	0.03 – 0.06 (0.0012 – 0.0024)
Limit	0.09 (0.0035)


LNW21BSH022201

Wheel shaft and bearing clearance

Use a dial gauge to measure the clearance between the wheel shaft and the bearing.

Clearance	mm (in)
Standard	0.056 – 0.127 (0.0022 – 0.0050)
Limit	0.14 (0.0055)

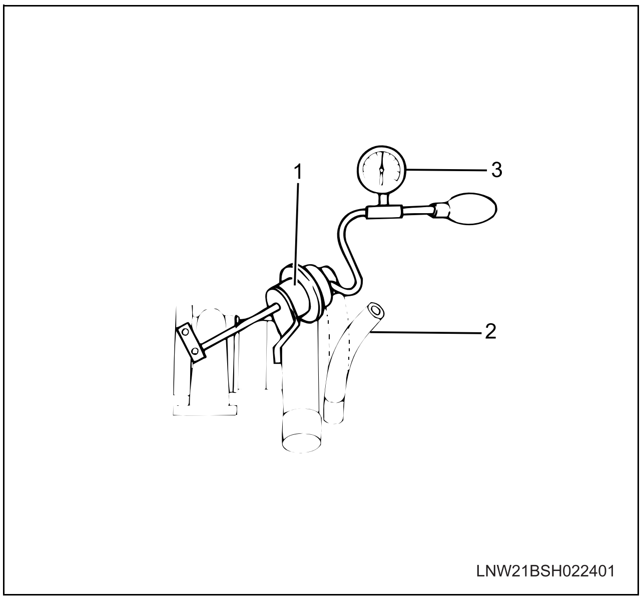


Legend

1. Oil Outlet
2. Oil Inlet

Waste gate operation

1. Remove the hose from the waste gate actuator.
2. Install the pressure gauge (general tool). Refer to the illustration.



Legend

1. Waste Gate Actuator
2. Waste Gate Hose
3. Pressure Gauge (General Tool)

---

3. Use the pressure gauge pump to apply pressure (load) to the waste gate actuator (the engine must be off)
4. Note the pressure at which the control rod moves 2 mm. This pressure must be within the specified limit.

Control rod pressure range:	kPa (psi)
109 – 118 (16 – 17)	

5. Inspect the hose for cracks and other damage. Replace the hose if necessary.
6. Do not apply a pressure of more than 120 kPa (900 mmHg) to the waste gate actuator.

Installation

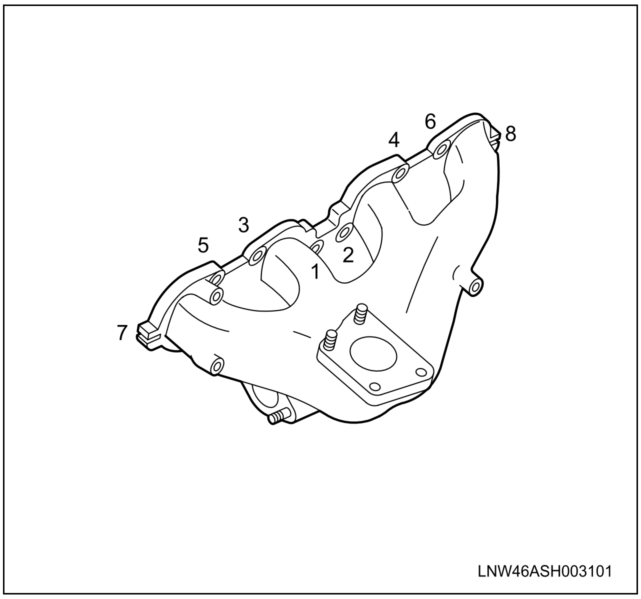
1. Put the gasket in to install the exhaust manifold.
   - Tighten up with the 2 nuts and 6 bolts according to the order given on the figure.

The bolts (1), (2), (3), (4), (5) and (6) and the nuts (7) and (8)

Tightening torque: 34 N·m (25 lb ft)

Caution:

Do not tighten up too much because it hampers expansion and contraction due to the heat from the manifold.

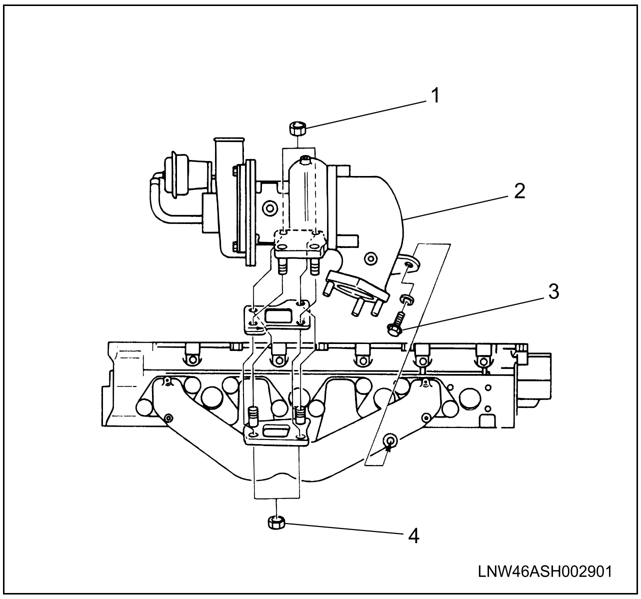


2. Install the gasket and turbocharger to the exhaust manifold. Tighten the nuts to the specified torque.

Tightening torque: 52 N·m (38 lb ft)

3. Tighten the adapter bolts (exhaust manifold side) to the specified torque.

Tightening torque: 25 N·m (19 lb ft)



Legend

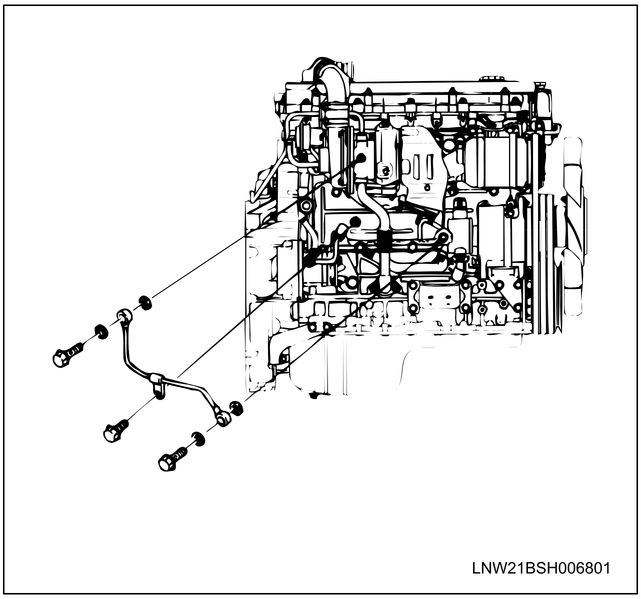
1. Fixing Nut
2. Exhaust Adapter
3. Fixing Bolt
4. Fixing Nut

4. Install the water feed pipe to the turbocharger.
   - Tighten the joint bolts to the specified troque.

Tightening torque: 41 N·m (30 lb ft)

- Install the pipe bracket and tighten the bolts to the specified torque.

Tightening torque: 24 N·m (17 lb ft)



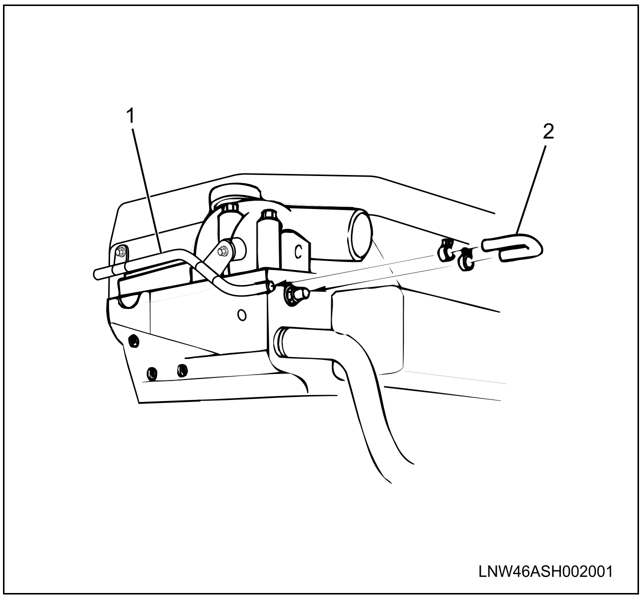
5. Install the water return pipe. Tighten the joint bolts to the specified torque.

Tightening torque: 41 N·m (30 lb ft)

6. Install the water return pipe bracket. Tighten the bolts to the specified torque.

Tightening torque: 24 N·m (17 lb ft)

- Install the rubber hose between the water return pipe and the thermostat housing.



Legend

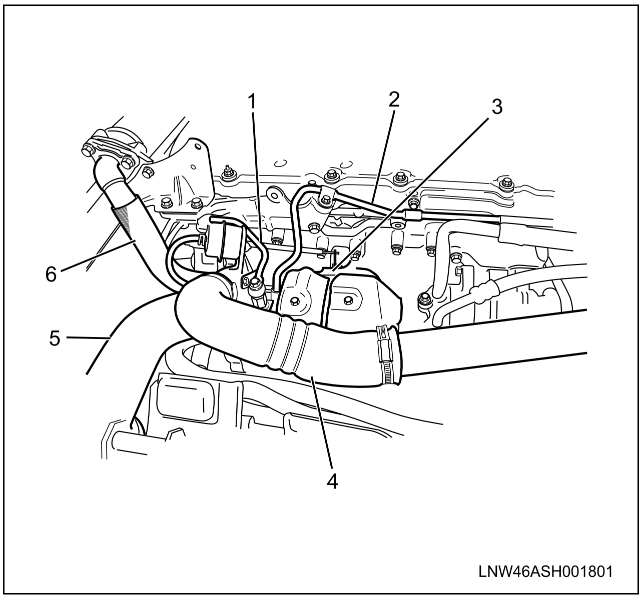
1. Water Return Pipe
2. Rubber Hose

7. Install the turbocharger oil feed pipe to the top of the turbocharger. Tighten the joint bolts to the specified torque.

Tightening torque: 41 N·m (30 lb ft)

- Install the pipe bracket and tighten the bolts to the specified torque.

Tightening torque: 24 N·m (17 lb ft)



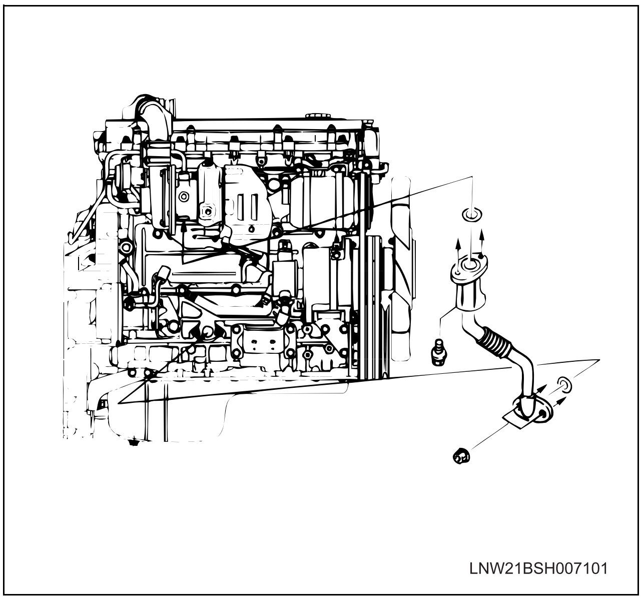
Legend

1. Oil Feed Pipe
2. Water Return Pipe
3. Heat Protector
4. Charge Air Pipe
5. Inlet Duct
6. EGR Pipe

8. Tighten the oil return pipe bolts to the specified torque.

Tightening torque (Turbocharger side): 9 N·m (78 lb in)

Tightening torque (Cylinder block side): 22 N·m (15 lb ft)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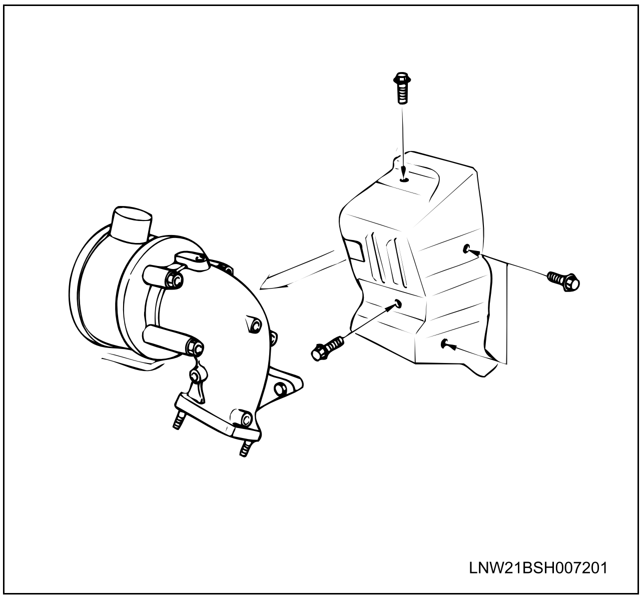
9. Install the heat protector and tighten the bolts to the specified torque.

Tightening torque: 10 N·m (87 lb in)


LNW21BSH007201

10. Install the air intake duct and tighten the bolts to the specified torque.

Tightening torque: 10 N·m (87 lb in)

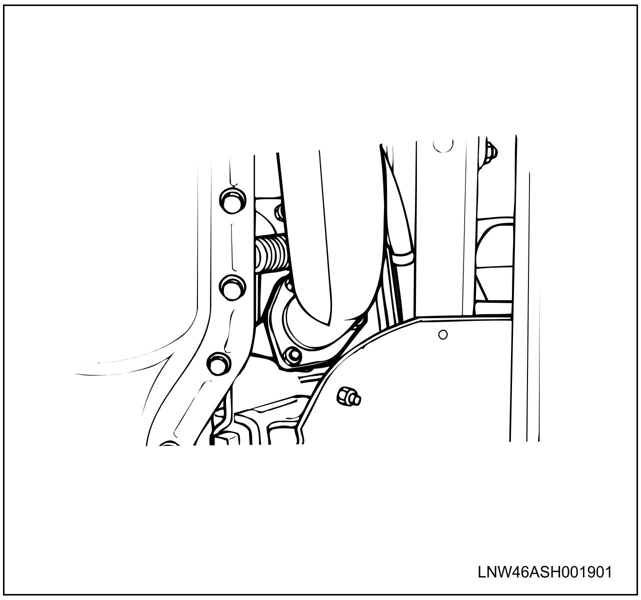
11. Install the charge air pipe in the turbo charger and the charge air cooler.

Tightening torque:

Duct bolt	21 N·m (15 lb ft)
Duct clip	6 N·m (52 lb in)

12. Install the front exhaust pipe to the turbocharger and tighten the nuts to the specified torque.

Tightening torque: 67 N·m (49 lb ft)

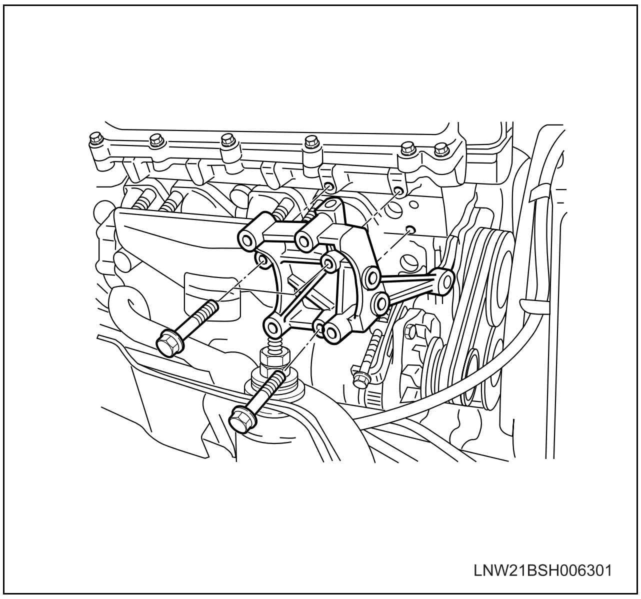

LNW46ASH001901

13. Add cooling water to the radiator.
14. A/C Install the compressor bracket.
    - A/C Install the compressor bracket on the cylinder head and tighten up with the prescribed toque.

Tightening torque: 48 N·m (35 lb ft)

- A/C Install the compressor on the bracket and tighten up with the prescribed torque.

Tightening torque: 24 N·m (17 lb ft)


LNW21BSH006301

Legend

1. A/C Compressor Bracket

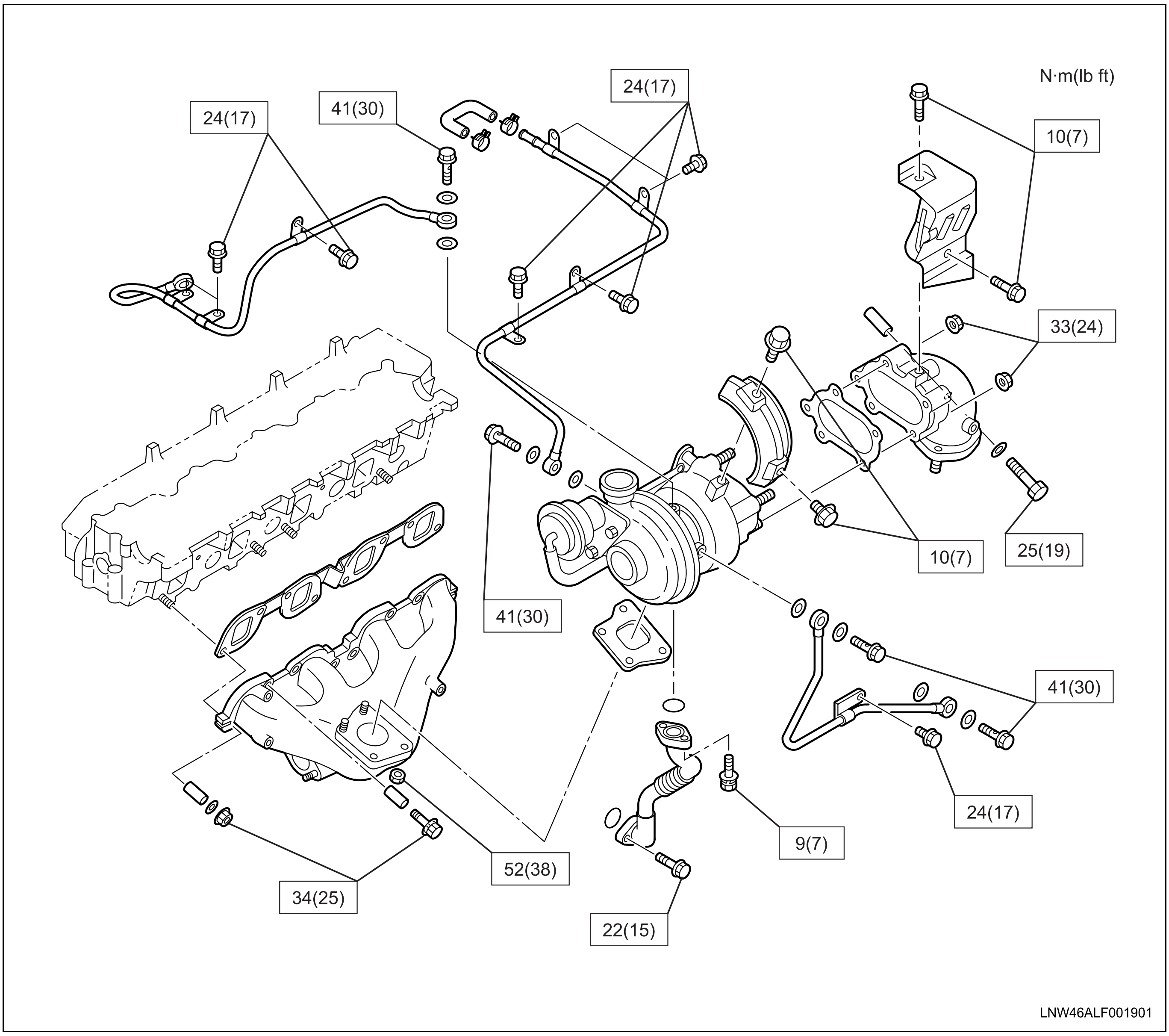
15. Install the EGR pipe.

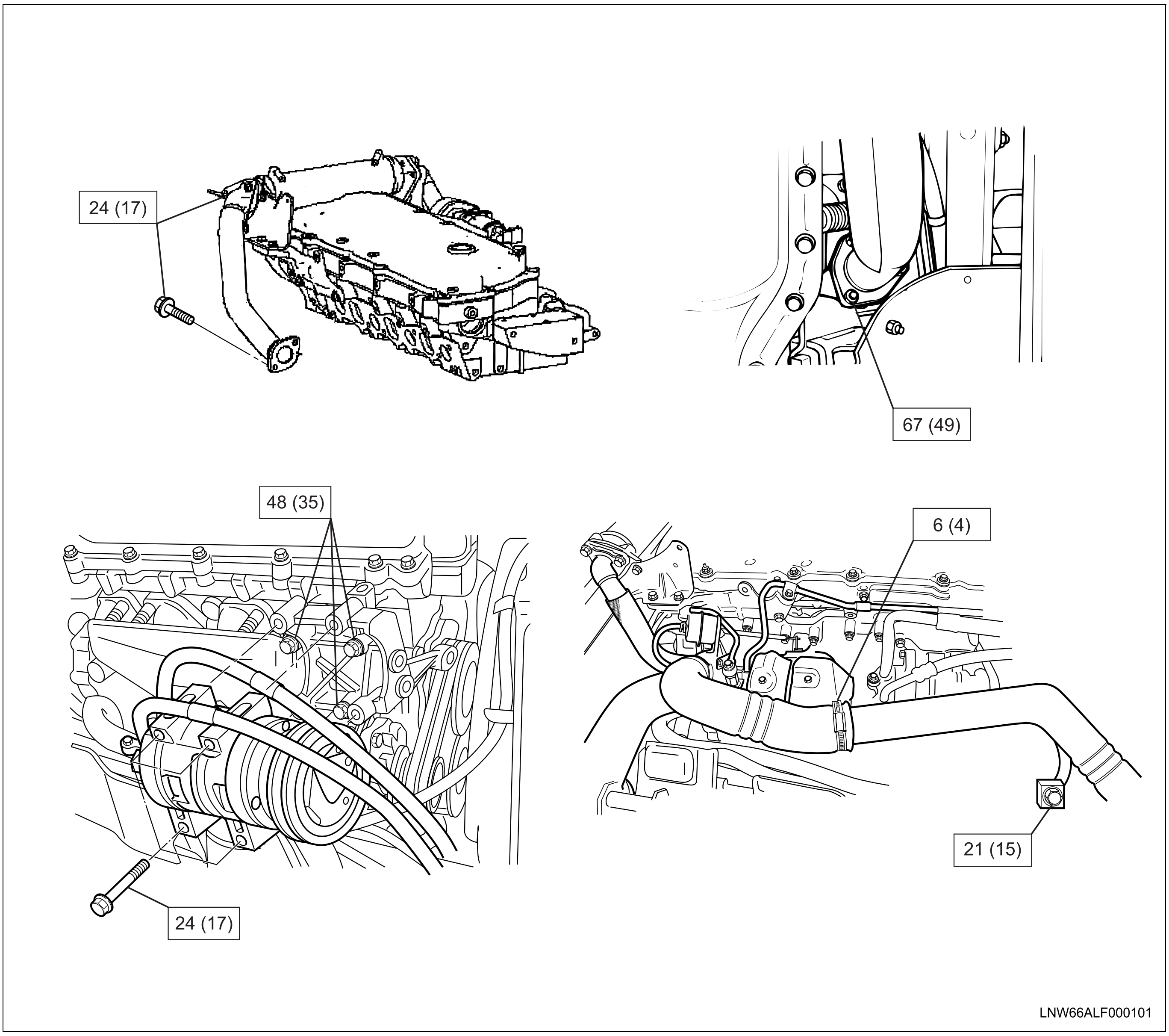
- Put the gasket between both ends of the EGR pipe and install to the specified torque.

Tightening torque: 24 N·m (17 lb ft)

16. Replenish the coolant.

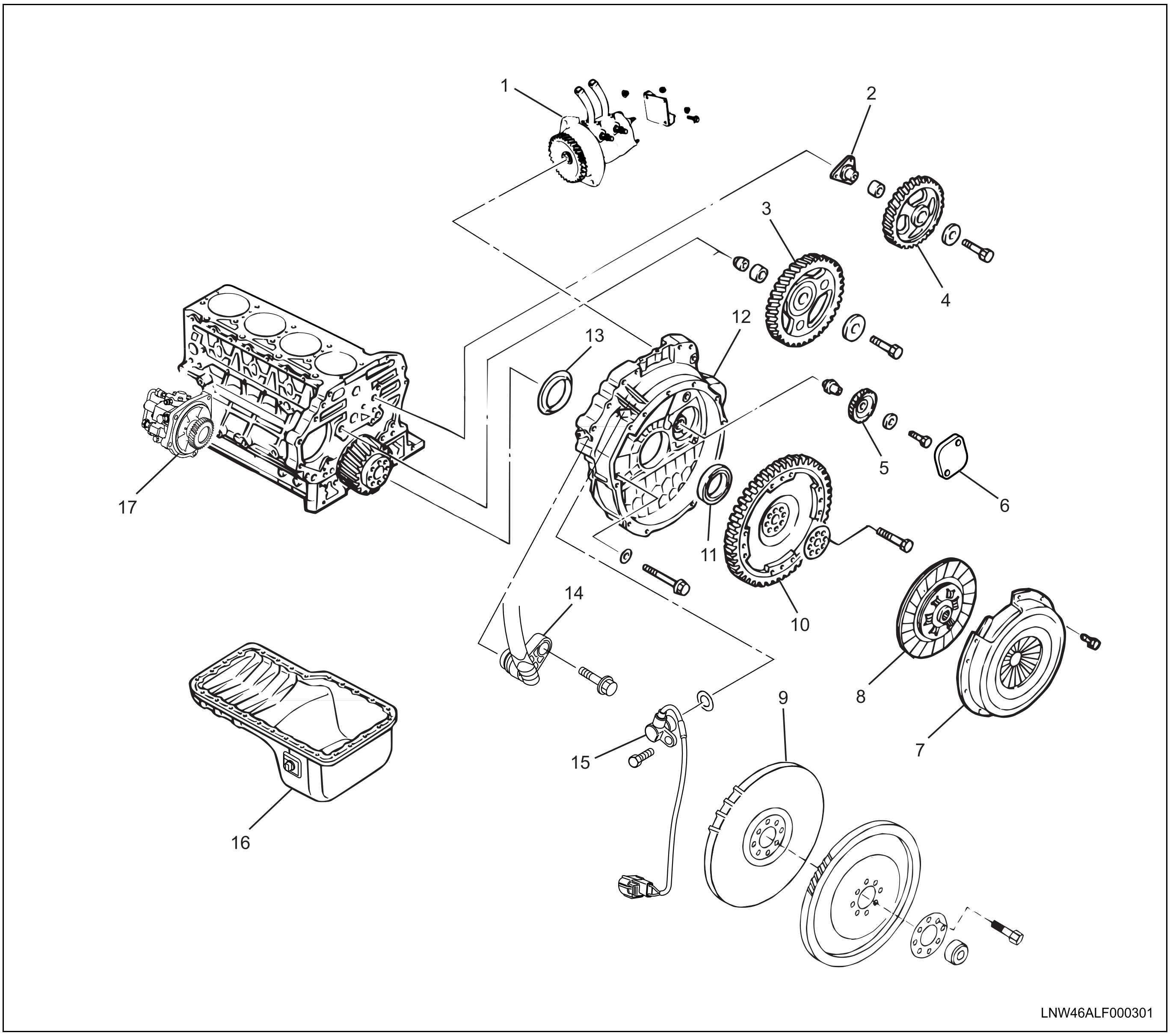
Torque Specifications




24 (17)
67 (49)
48 (35)
6 (4)
21 (15)
24 (17)
LNW66ALF000101

Timing Gear Train

Component



Legend

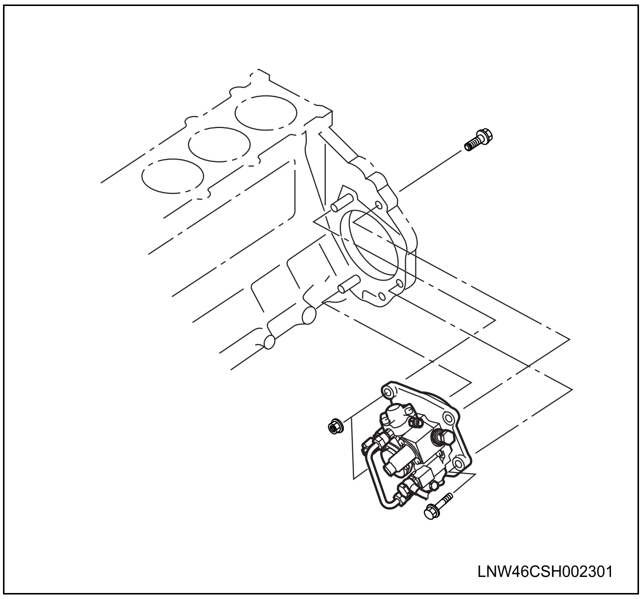
1. Power Steering Pump
2. Idle Gear B Shaft
3. Idle Gear A
4. Idle Gear B
5. Power Steering Pump Idle Gear
6. Power Steering Pump Idle Gear Cover
7. Clutch Pressure Plate
8. Driven Plate
9. Flywheel (A/T)
10. Flywheel (M/T)
11. Rear Oil Seal
12. Flywheel Housing
13. Slinger
14. Oil Drain Adapter
15. Crankshaft Position Sensor
16. Oil Pan
17. Fuel Supply Pump

Removal

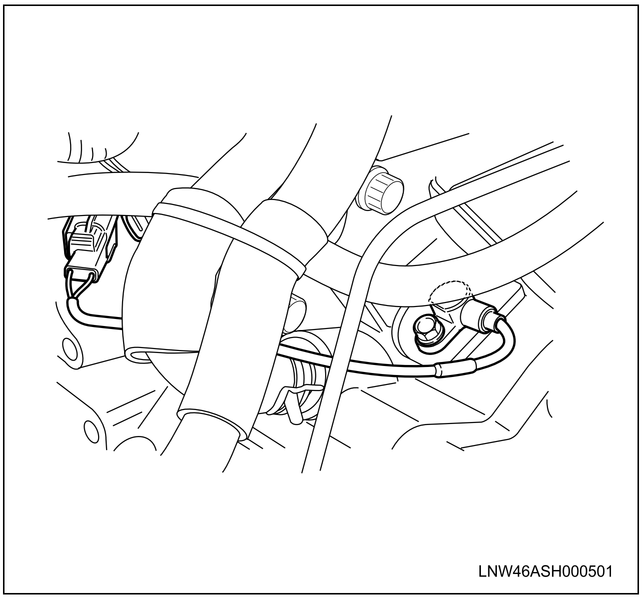
1. Remove the cylinder head cover.

   Refer to the “cylinder head cover”.
2. Remove the rocker arm shaft assembly.
   Refer to the “rocker arm shaft assembly”.
3. Remove the camshaft assembly.
   Refer to the “camshaft assembly”.

4. Remove the cylinder head assembly.
   Refer to the “cylinder head”.
5. Remove the fuel supply pump assembly.
   Refer to the “fuel supply pump” in the fuel system section.



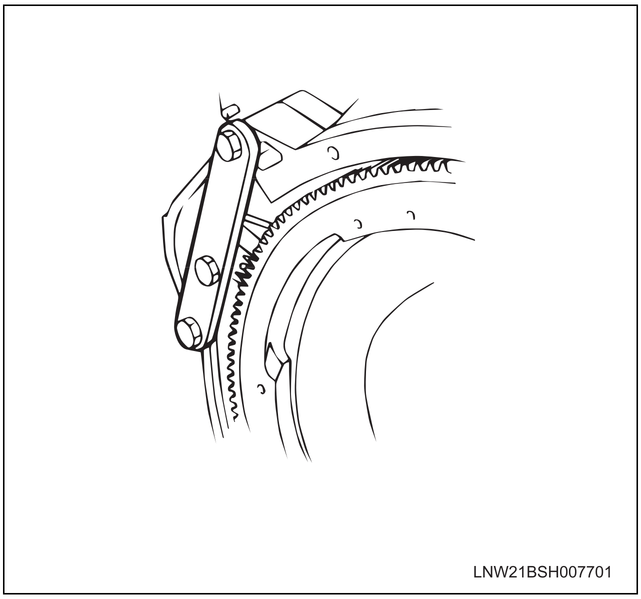
6. Remove the crankshaft position sensor.
   - Remove the crankshaft position sensor before remove flywheel.



7. Remove the flywheel.
   - Install the crankshaft stopper on the starter part of the flywheel housing to stop the crankshaft from rotating.

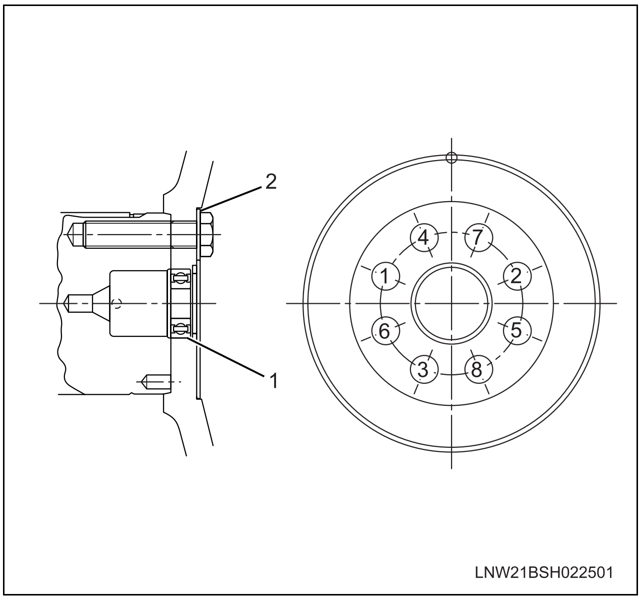
Caution:
Check if the stopper meshes with the ring gear without fail and is installed properly.

Special tool
Crankshaft stopper: EN-47680



- Loosen the fastening bolts of the flywheel little by little according to the order given on the figure.
- After loosening all the bolts, remove the stopper to remove the flywheel.

In the case of A/T, after loosening the bolts to fasten the flywheel, remove the washer, the flexible plate, the flywheel and the sleeve according to this order.

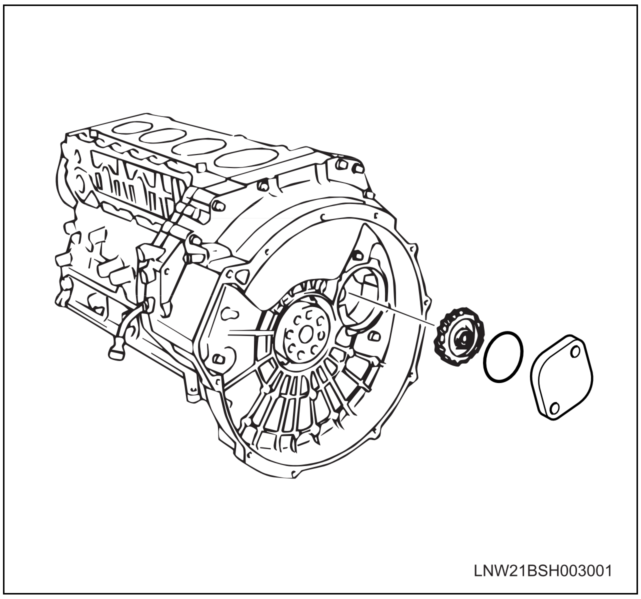


Legend
1. Pilot Bearing
2. Washer

---

8. Remove the rear oil seal and the slinger.
   Refer to the “crankshaft rear oil seal”.
9. Remove the oil pan.
10. Remove the power steering pump.

11. Remove the power steering pump idle gear cover.
12. Remove the power steering pump idle gear.



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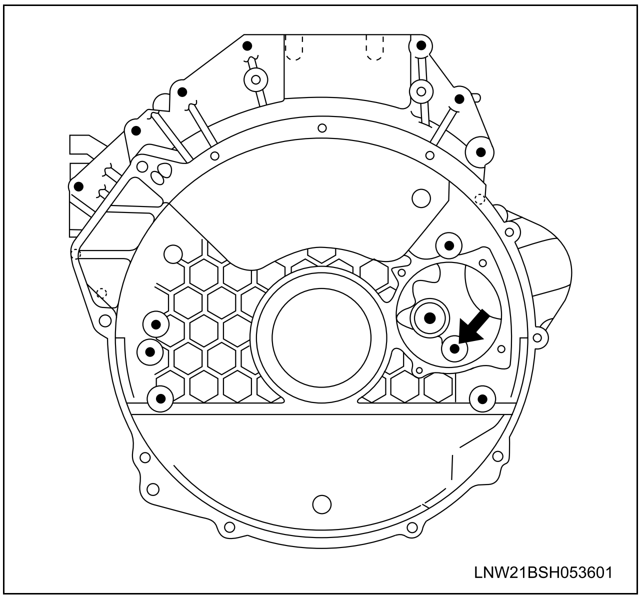
13. Remove the flywheel housing.
    - Never fail to remove the bolt(s) given on the figure.



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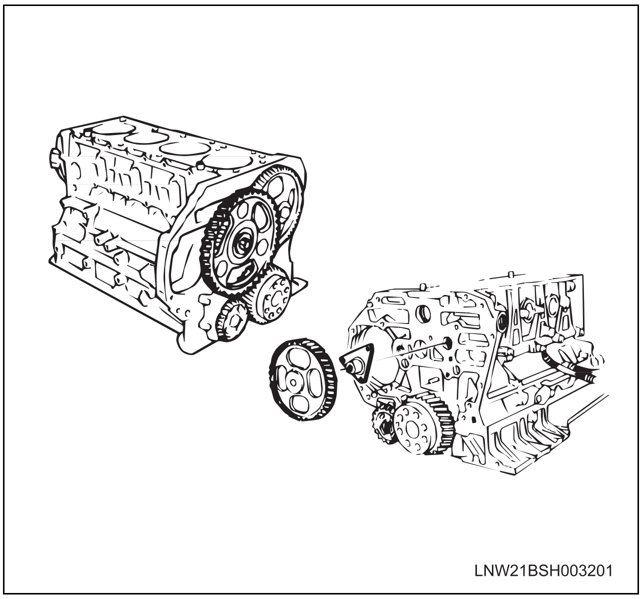
14. Remove the idle gear A.
15. Remove the idle gear B.
16. Remove the idle gear B shaft.



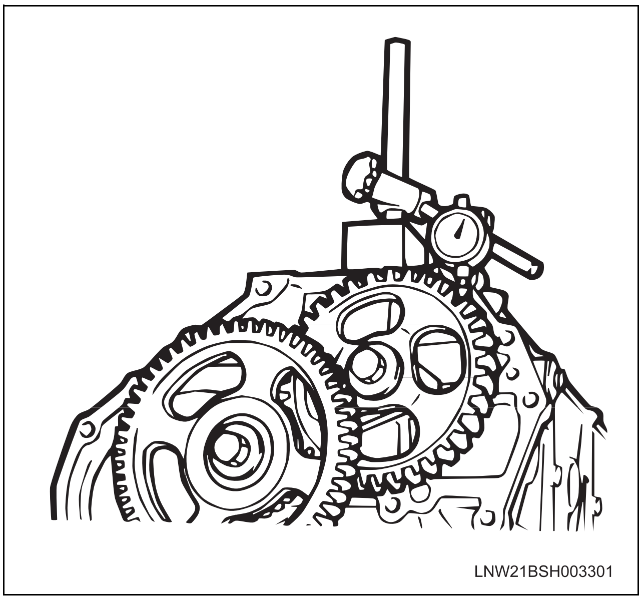
LNW21BSH003201

Inspection

1. Measurement of idle gear backlash
    - Apply a dial gauge on the teeth of the idle gear to be measured and move the gear to right and left lightly to read how much the dial gauge shook (never fail to fix the gear).
    - If the measurement exceeds the limit, replace the idle gear.

Backlash of the timing gear	mm(in)
Standard	0.10 – 0.17 (0.004 – 0.006)
Limit	0.30 (0.01)

- Measure backlash of the idle gear before removing the idle gear A.



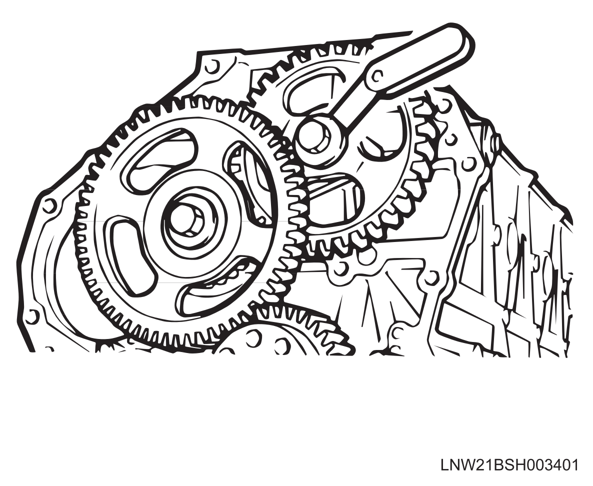
LNW21BSH003301

2. Measurement of end clearance of the idle gear.

- Insert a thickness gauge between the idle gear and the thrust collar to measure a clearance.
- If the measurement exceeds the limit, replace either the idle gear or the thrust collar.

End clearance of the idle gear	mm (in)
Standard	0.080 – 0.155 (0.003 – 0.006)
Limit	0.20 (0.008)

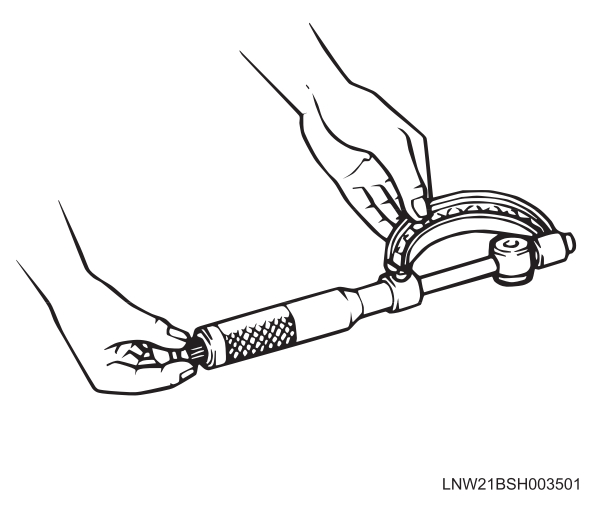
- Measure an end clearance of the idle gear before removing the idle gear B.


LNW21BSH003401

3. External diameter of the idle gear shaft
   - Use a micrometer to measure an external diameter of each idle gear shaft.
   - If the measurement exceeds the limit, replace the shaft.

External diameter of the idle gear shaft	mm (in)
Standard	29.959 – 29.980 (1.179 – 1.180)
Limit	29.80 (1.173)

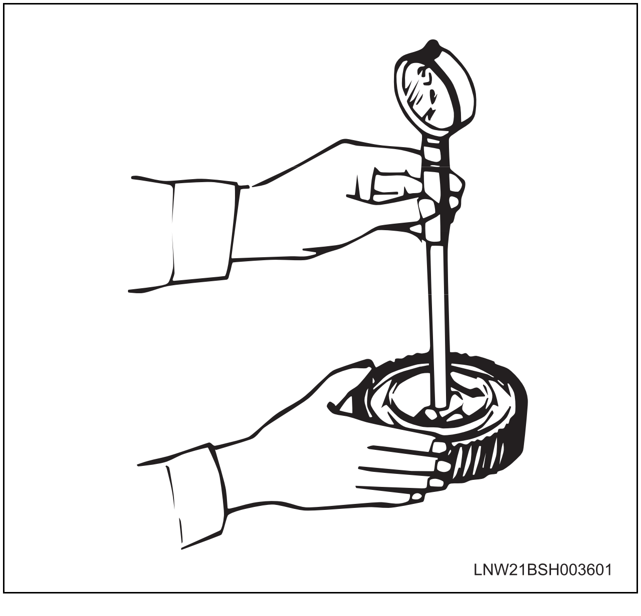
External diameter of the idle gear A shaft	mm (in)
Standard	39.959 – 39.975 (1.573 – 1.574)
Limit	39.80 (1.567)


LNW21BSH003501

4. Clearance between the idle gear and the idle gear shaft
   - Measure an inside diameter of the idle gear bush to calculate a clearance between the idle gear and the idle gear shaft.
   - If the measurement exceeds the limit, replace either the idle gear or the shaft.

Clearance between the idle gear and the shaft	mm (in)
Standard	0.020 – 0.062 (0.0007 – 0.0024)
Limit	0.200 (0.0079)

External diameter of the idle gear A shaft	mm (in)
Standard	0.025 – 0.066 (0.0009 – 0.0026)
Limit	0.200 (0.0079)

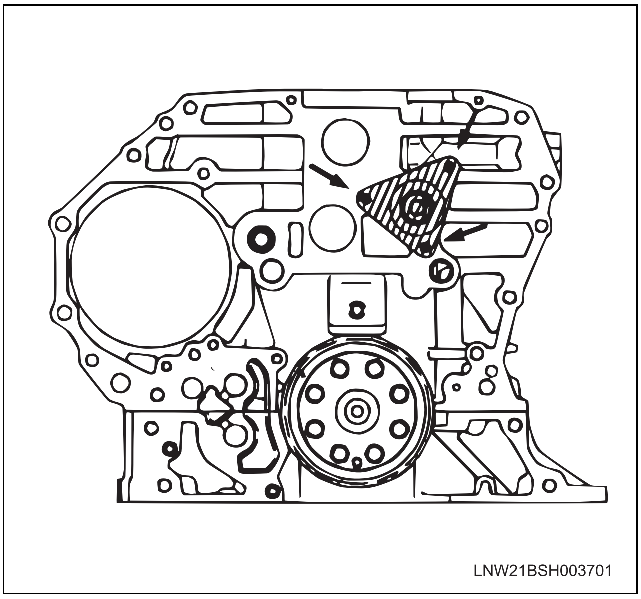

LNW21BSH003601

Installation

1. Install the idle gear B shaft.
   - Tighten up the idle gear B shaft with the prescribed torque.

Tightening torque: 31 N·m (23 lb ft)

- After installation, apply engine oil over the shaft.



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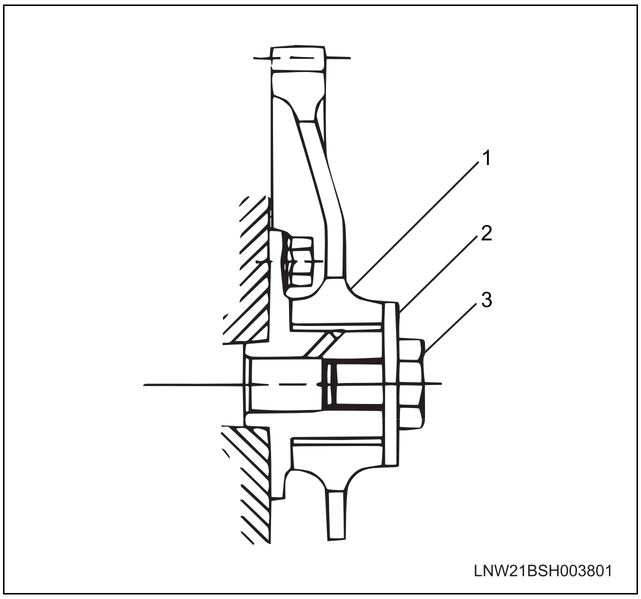
2. Install the idle gear B.
   - Install the idle gear B in the direction given on the figure and tighten up the fastening bolts with the prescribed torque.

Tightening torque: 110 N·m (81 lb ft)



LNW21BSH003801

Legend

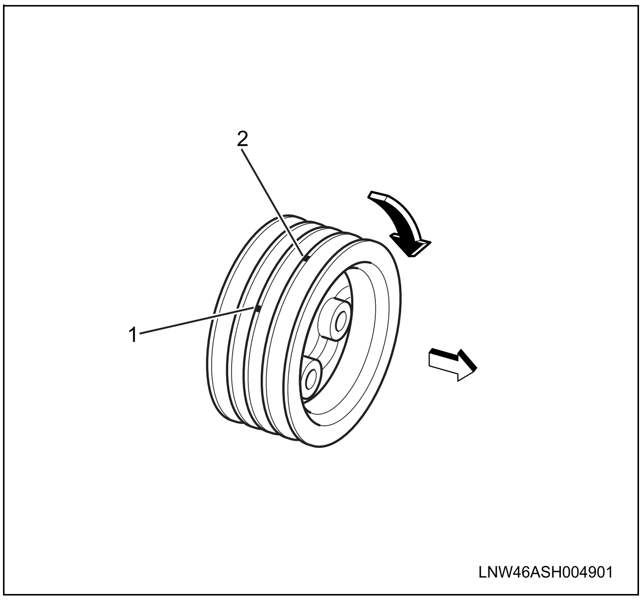
1. Idle Gear
2. Thrust Collar
3. Bolt

---

3. Install the idle gear A.
   - Rotate the crankshaft to make the No.1 cylinder meet the compression top dead center (TDC).

Notice:

There are 2 timing marks on the crankshaft pulley.
Mark (1) is near the cylinder block and is used to bring the 4HK1-TC engine to TDC.
Mark (2) is not applicable to this engine.
Be sure to use mark (1) when bringing the engine to TDC.



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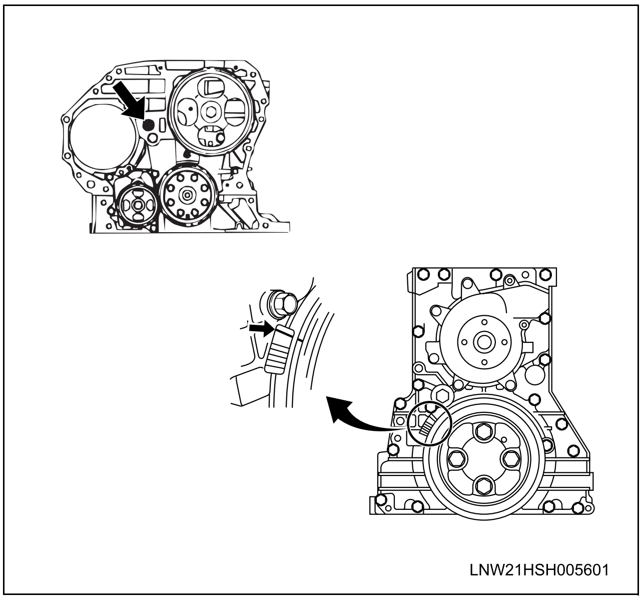
- Make the meeting marks of the crankshaft gear and the idle gear A meet and install it on the cylinder block.
- Tighten up the fastening bolts with the prescribed torque.

Tightening torque: 133 N·m (98 lb ft)



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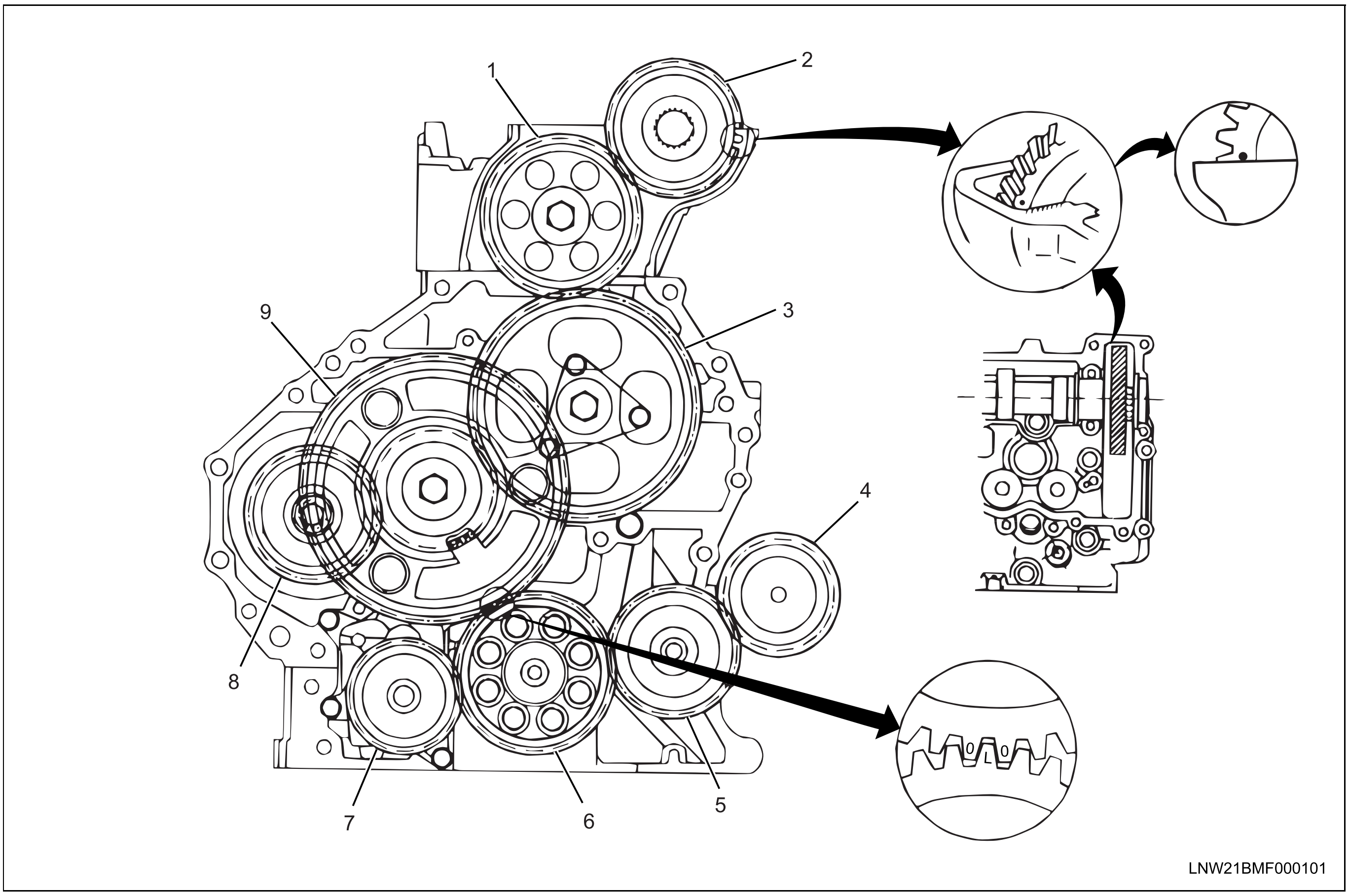
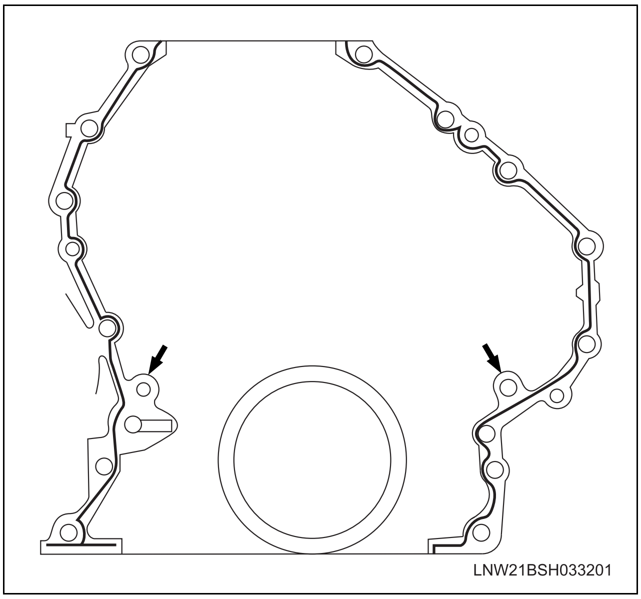


Legend

1. Idle Gear C
2. Camshaft Gear
3. Idle Gear B
4. Power Steering Pump Gear
5. Power Steering Pump Idle Gear
6. Crankshaft Gear
7. Oil pump Drive Gear
8. Fuel Supply Pump Gear
9. Idle Gear A

---

4. Install the flywheel housing
   - Clean the rear side of the cylinder block. In particular, remove overflow liquid gasket thoroughly when the crankcase is installed.
   - As the figure shows, apply the liquid gasket (TreeBond 1207C or equivalent) inside a hole of the bolt (except the bolt holes indicated with an arrow) evenly.



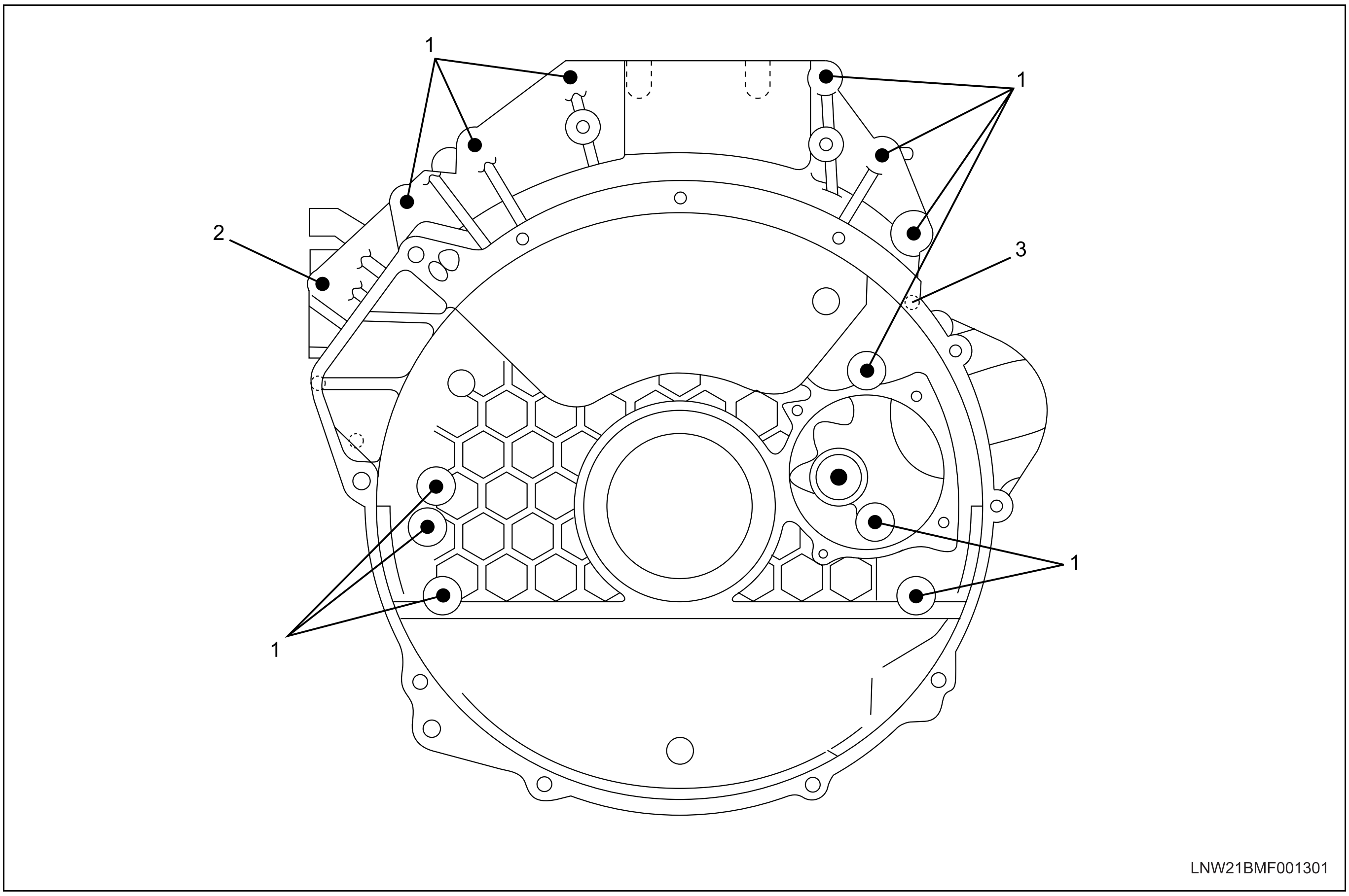
- Along with the dowel pin of the cylinder block, install the flywheel housing.

Tightening torque of the flywheel housing:

N·m (lb ft)

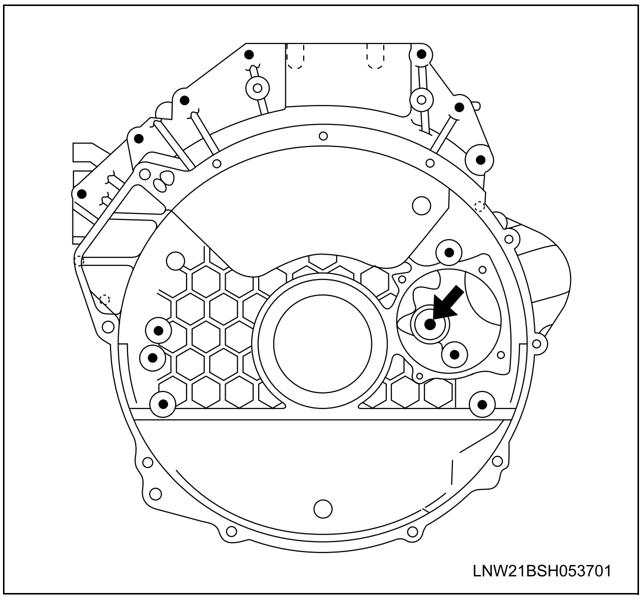
1 = 96 (71) 2 = 77 (57) 3 = 38 (28)

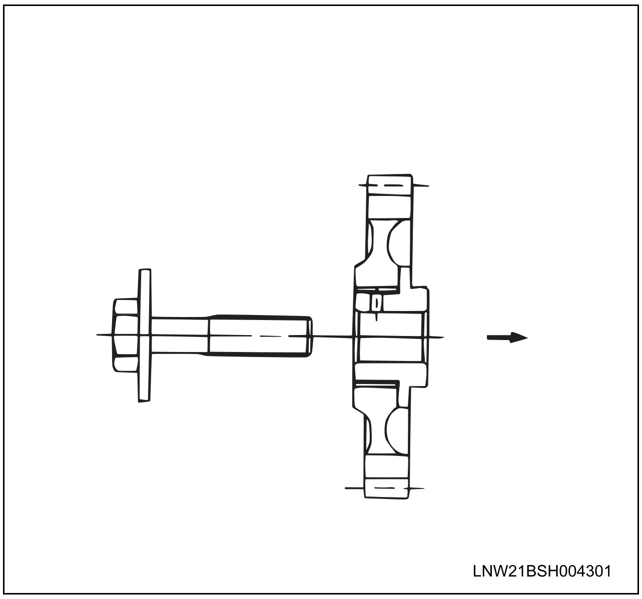
- Tighten up the Mark 3 from the cylinder block side.



5. Install the power steering pump idle gear.
   - Apply engine oil over the part where the gear of the idle gear shaft is to be put together.
   - Put the idle gear and the shaft together and install it on the location given on the figure and tighten up with the prescribed torque.

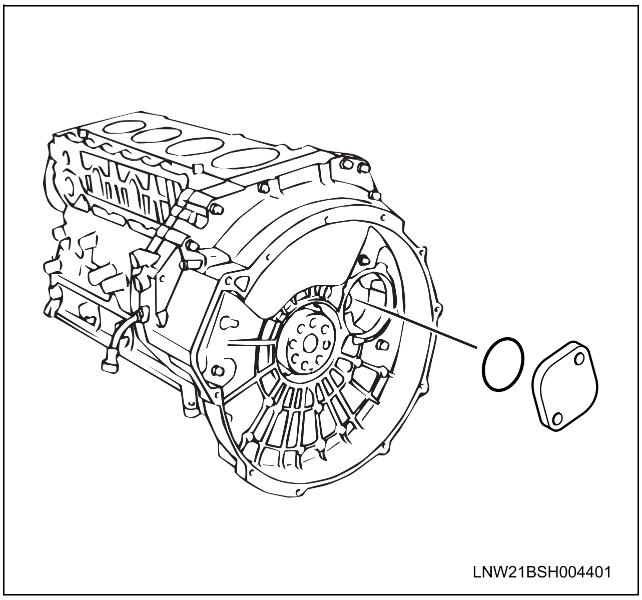
Tightening torque: 133 N·m (98 lb ft)





6. Install the power steering pump idle gear cover.
   - Install the O-ring on the cover and install it on the flywheel housing and tighten up the tightening bolts with the prescribed torque.

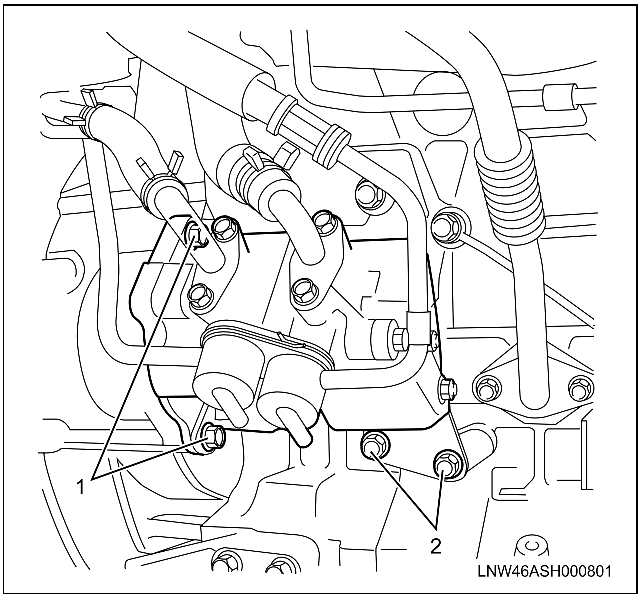
Tightening torque: 19 N·m (14 lb ft)



7. Install the power steering pump
   - Install the power steering pump and tighten up with the prescribed torque.

Fastening bolts for the flywheel housing side
(Bolt 1)
Tightening torque: 43 N·m (32 lb ft)

Fastening bolts for the cylinder block side
(Bolt 2)
Tightening torque: 44 N·m (32 lb ft)

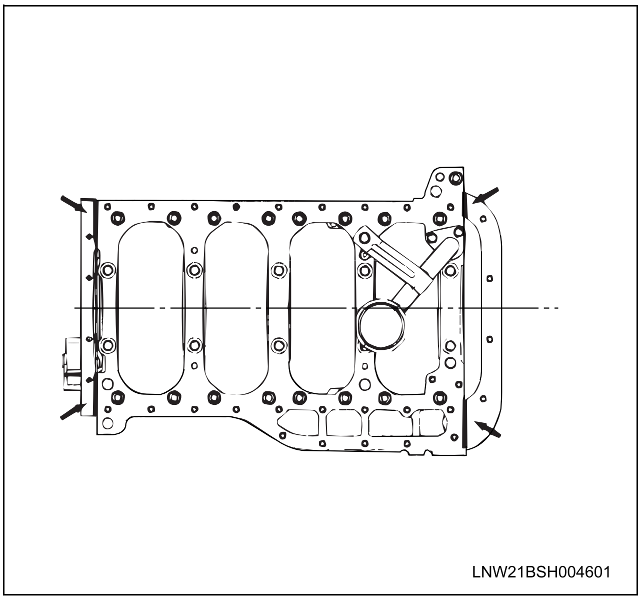


Legend

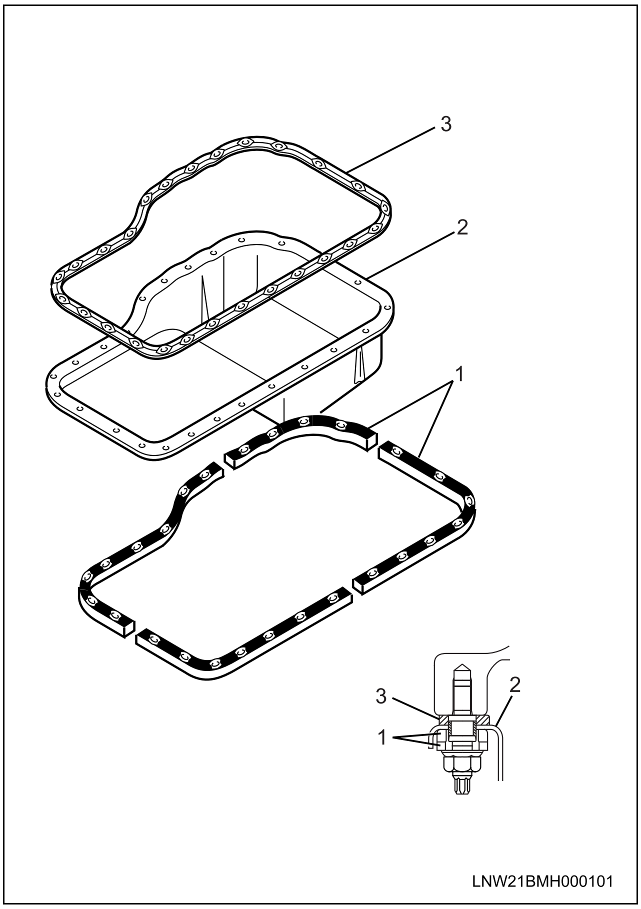
1. Flywheel Housing Fixing Bolt
2. Cylinder Block Fixing Bolt

---

8. Install the oil pan
   - Apply the liquid gasket (TreeBond1207C or equivalent) on a joint between the cylinder block, the front cover and the flywheel housing with a beat diameter of 3 mm (0.1 in).
   - Install the oil pan within 7 minutes after applying the liquid gasket.



- With the flywheel housing, the front cover and the stud of the crankcase as a guide, put together the gasket and put the oil pan on it.
  Then, put the rubber assembly on the oil pan and fix it by fastening bolts and nuts.

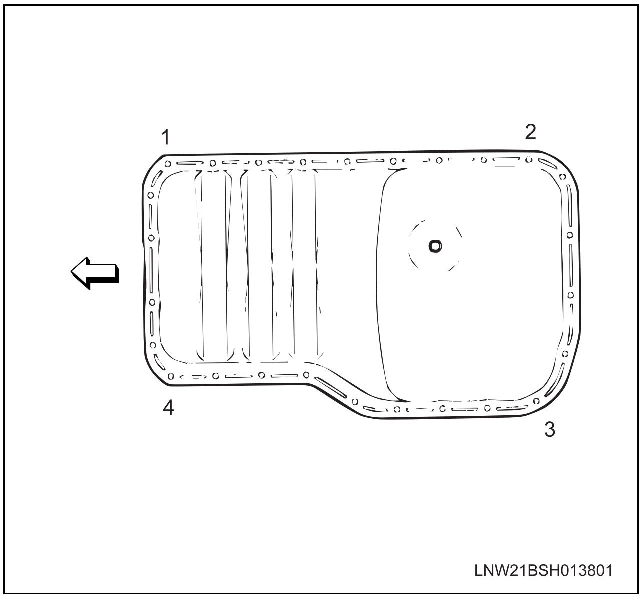


Legend

1. Rubber Assembly
2. Oil Pan
3. Gasket

- After fastening the oil pan at the respective points of (1), (2), (3), and (4), fasten other parts.

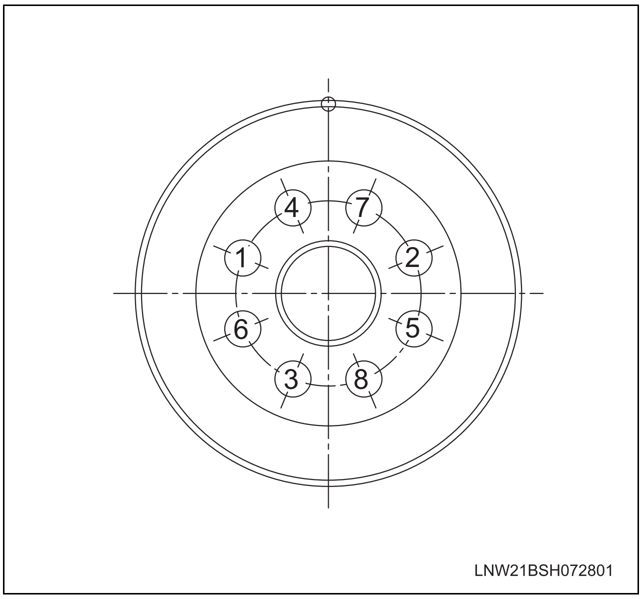
Tightening torque: 11 N·m (95 lb in)



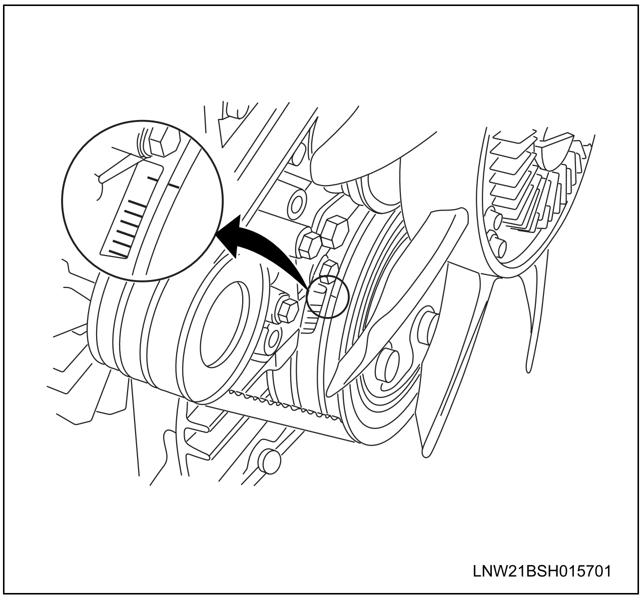
9. Install the rear slinger and the oil seal.
   Refer to the “crankshaft rear oil seal”.
10. Install the flywheel.
    - Along with the knock pin of the crankshaft, install the flywheel and tighten up with the prescribed torque according to the order given on the figure.

Tightening torque:

1st step = 78 N·m (57 lb ft)
2nd step = 120° ~ 150° (degrees)

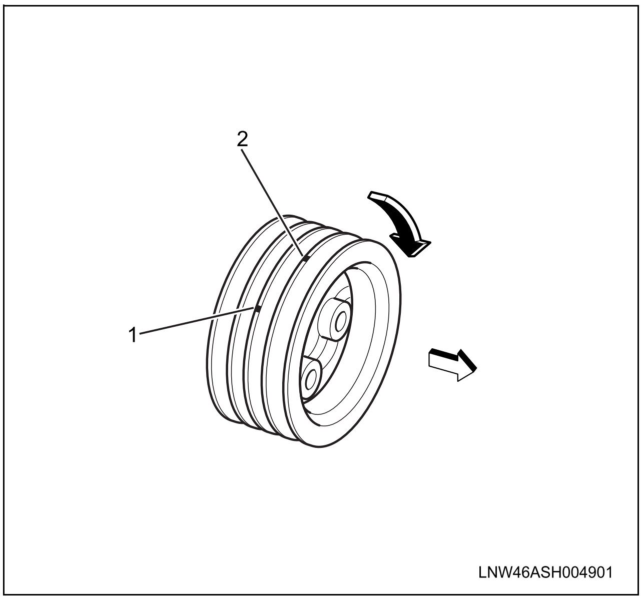


11. Rotate the crankshaft to make the No. 1 cylinder meet the compression TDC.



Notice:

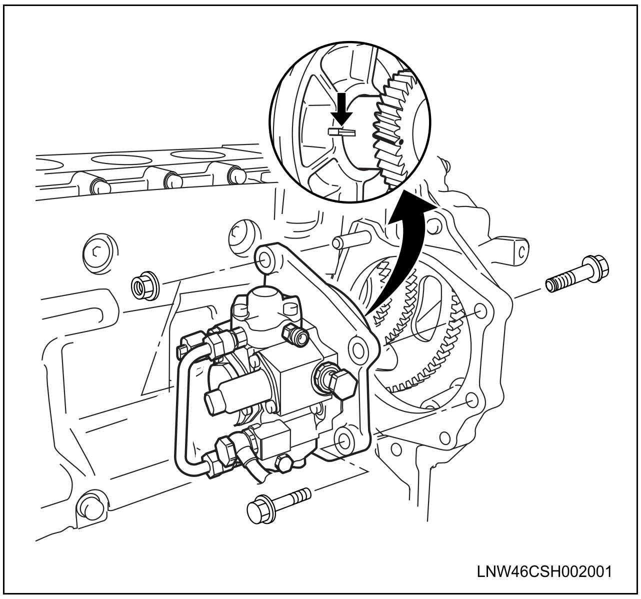
There are 2 timing marks on the crankshaft pulley.
Mark (1) is near the cylinder block and is used to bring the 4HK1-TC engine to TDC.
Mark (2) is not applicable to this engine.
Be sure to use mark (1) when bringing the engine to TDC.



12. Remove the oil drain adapter.
13. Install the O-ring on the fuel supply pump and make the slits with an arrow meet and with the stud bolt as a guide, install the fuel supply pump tentatively.

Caution:

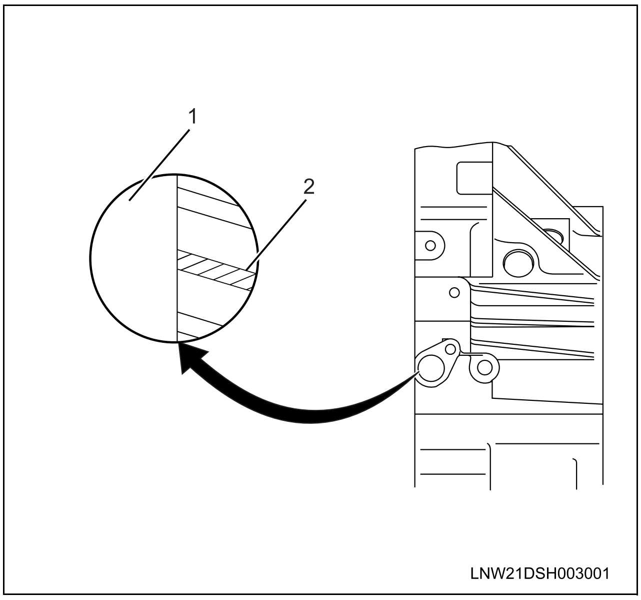
- When removing the fuel supply pump, if the stud bolt on the cylinder block side loosens, or the stud bolt is replaced, apply the Locktite No. 262 on the side where the stud bolt is to be buried before assembly.



- Check if the meeting mark of the gear painted white is at the location given on the figure when viewed from the plug hole and tighten up with the prescribed torque.

Nut tightening torque:	50 N·m (36 lb ft)
Bolt tightening torque:	76 N·m (56 lb ft)

- If the location of the teeth of the painted gear is not in the right place, put it together all over again.



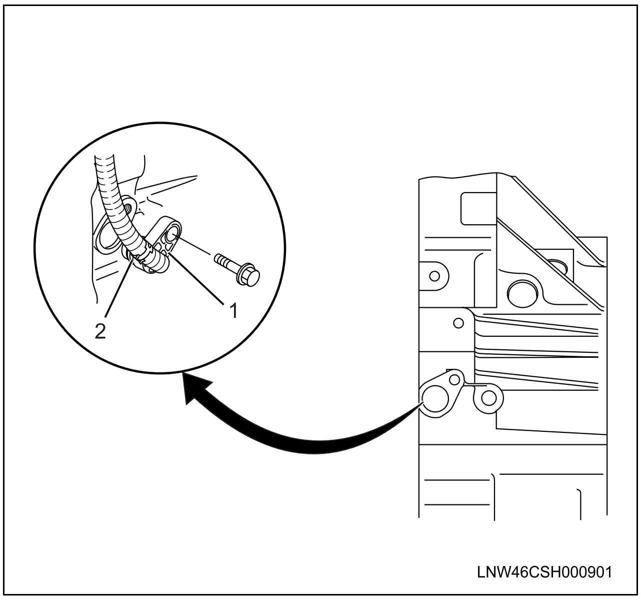
Legend

1. Plug Hole
2. Meeting Mark

14. Install the adapter assembly: oil drain on the plug hole and tighten up with the prescribed torque.

Tightening torque: 8 N·m (69 lb in)

- Apply engine oil over the O-ring nice and thin and install it.



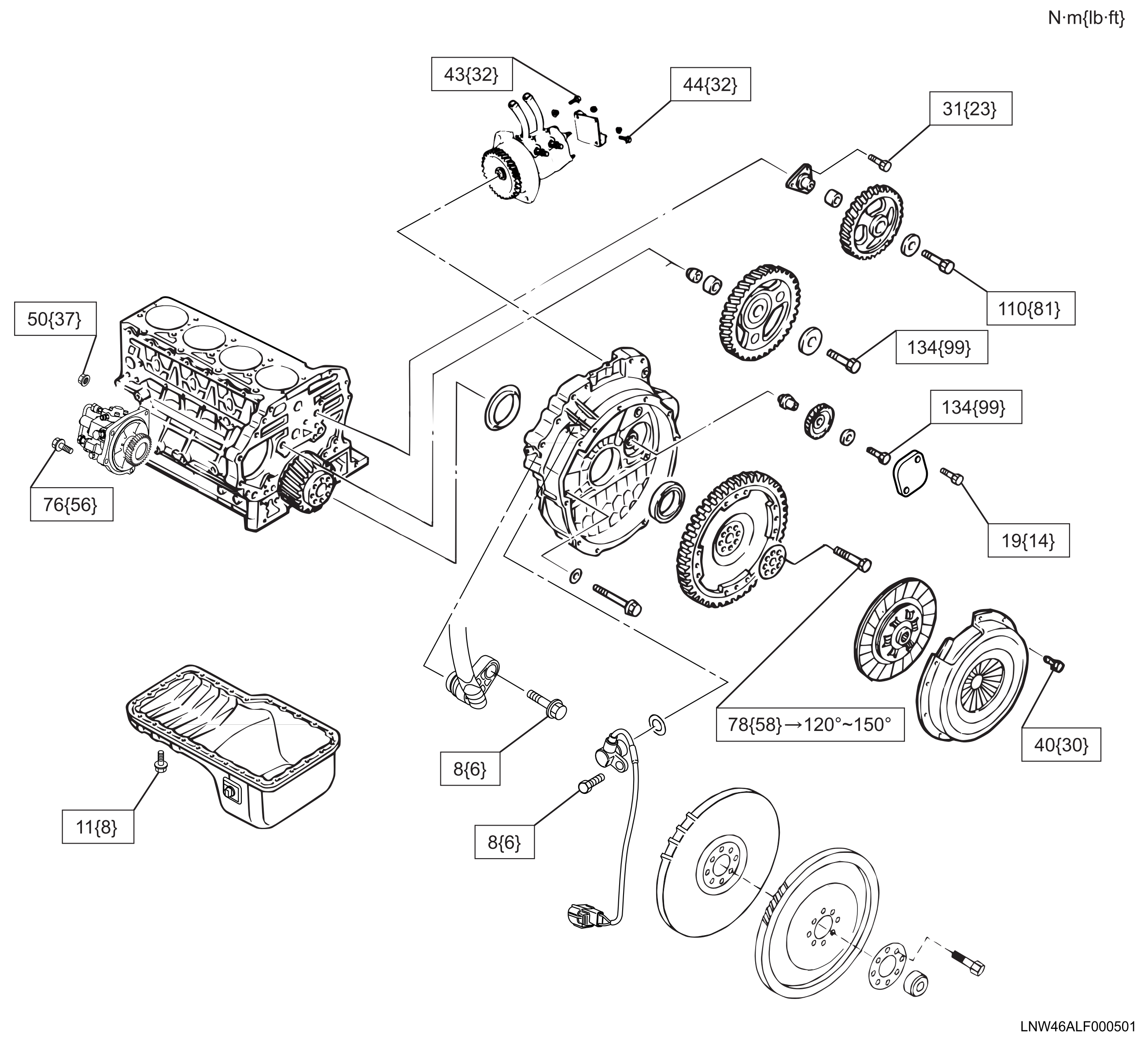
Legend

1. Adapter
2. O-Ring

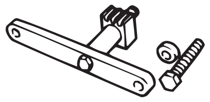
---

15. Install the cylinder head assembly.
    Refer to the “cylinder head”.
16. Install the camshaft assembly.
    Refer to the “camshaft assembly”.
17. Install the rocker arm shaft assembly.
    Refer to the “rocker arm shaft assembly”.
18. Install the cylinder head cover.
    Refer to the “cylinder head cover”.

Torque Specifications

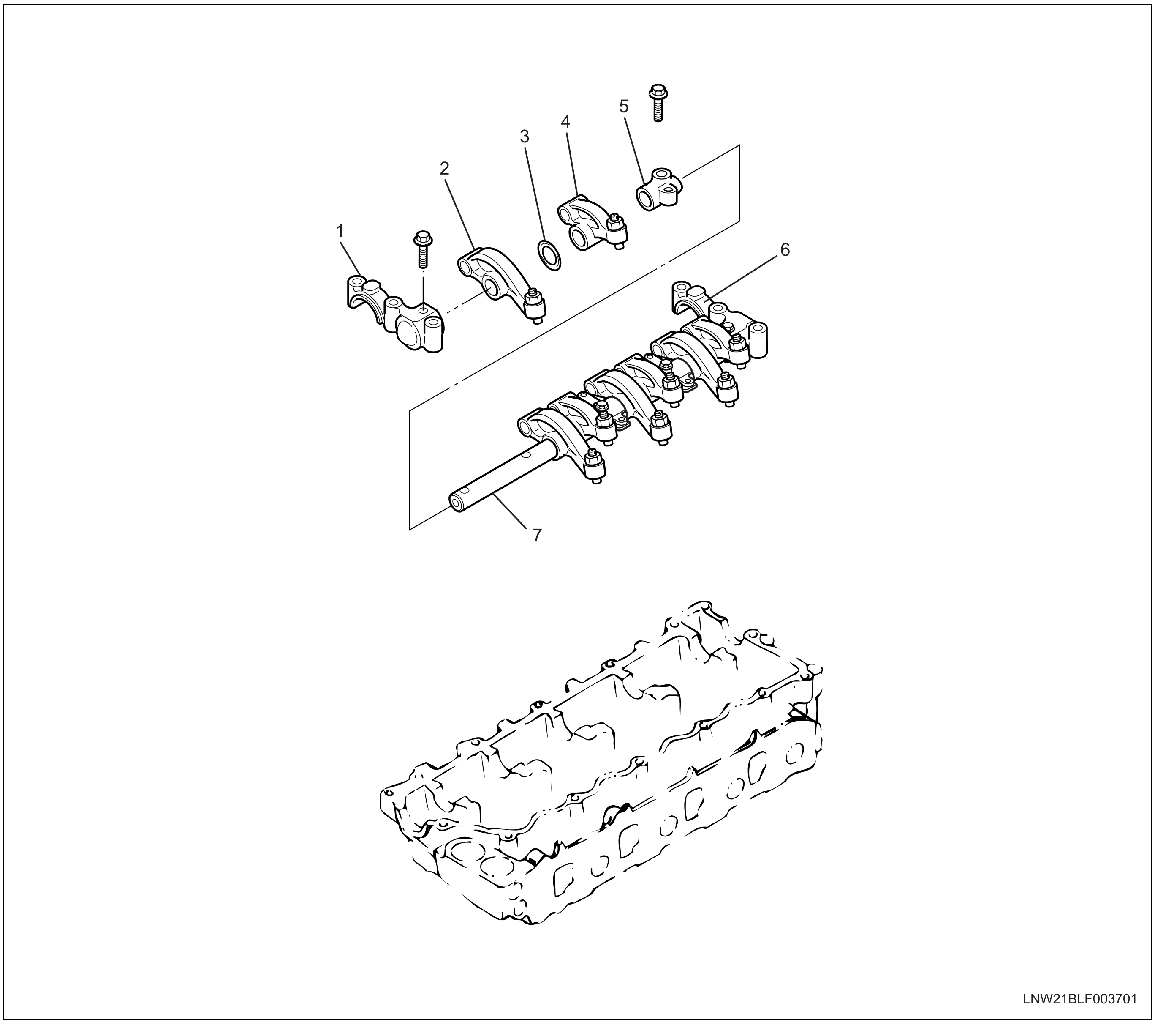


Special tool

Illustration	Tool Number/ Description
 5884022300	EN-47680 Crankshaft stopper

Rocker Arm Shaft Assembly

Component



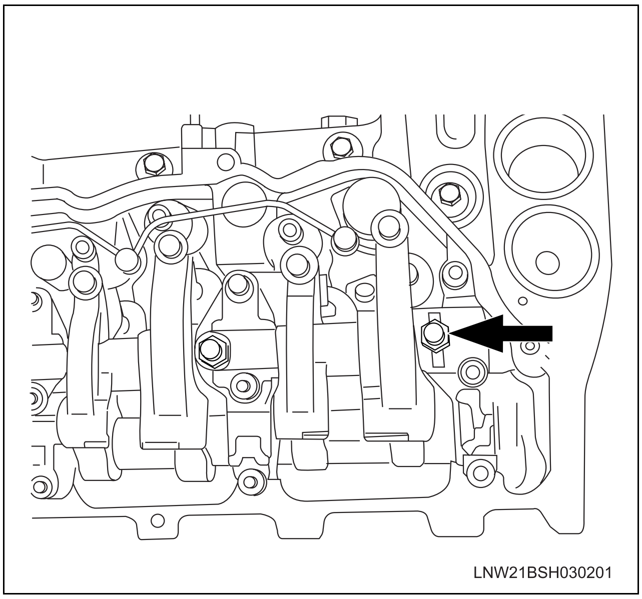
Legend

1. Camshaft Bracket
2. Rocker Arm
3. Wave Washer
4. Rocker Arm
5. Rocker Arm Bracket
6. Camshaft Bracket
7. Rocker Arm Shaft

Removal

1. Remove the cylinder head cover.
   Refer to the “cylinder head cover”.
2. Remove the rocker arm shaft assembly.
   - Along with the camshaft bracket, remove the rocker arm shaft assembly.

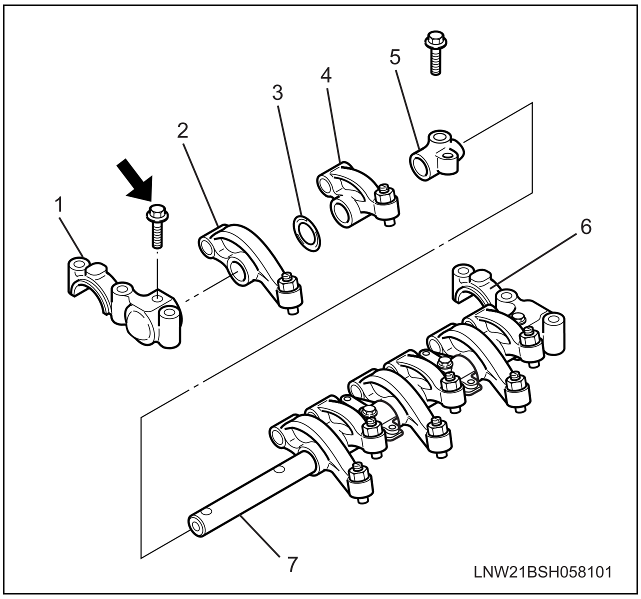
- Because the bolt(s) shown on the figure is are designed to fix the rocker arm shaft, do not remove it for now.



Caution:
Pay full attention so as not to drop the bridge cap in the gear case of the rear part of the cylinder head or the hole into which oil pours back in the front.

Dismount

1. Remove the camshaft bracket.
2. Remove the rocker arm.
3. Remove the wave washer.
4. Remove the rocker arm.
5. Remove the rocker arm bracket.
   - Dismantle according to the order (2) – (4) thereafter.
6. Remove the camshaft bracket to take the shaft out.



Legend
1. Camshaft Bracket
2. Rocker Arm
3. Wave Washer
4. Rocker Arm
5. Rocker Arm Bracket
6. Camshaft Bracket
7. Rocker Arm Shaft

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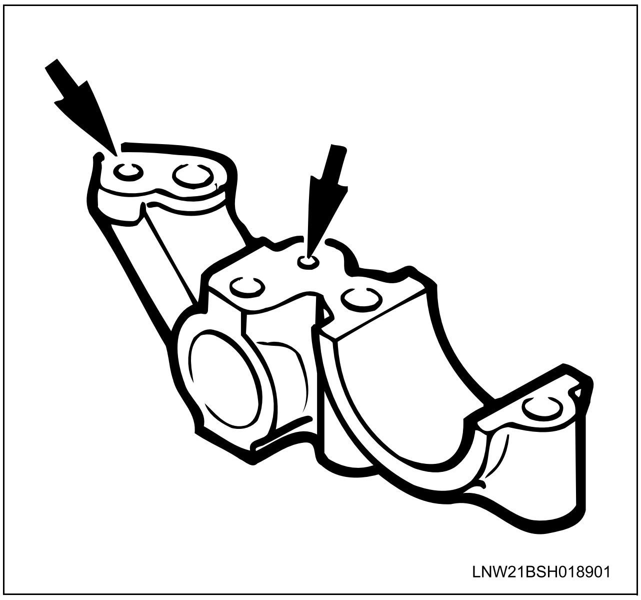
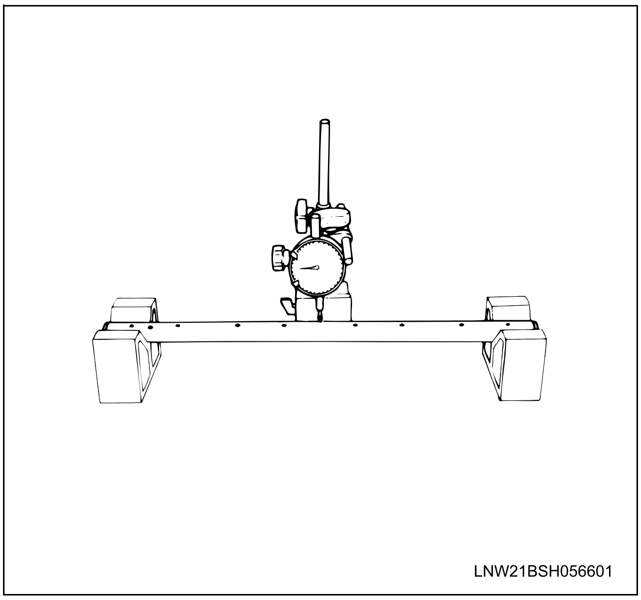
7. Check if the oil hole is clogged of the camshaft bracket (on the rear side).



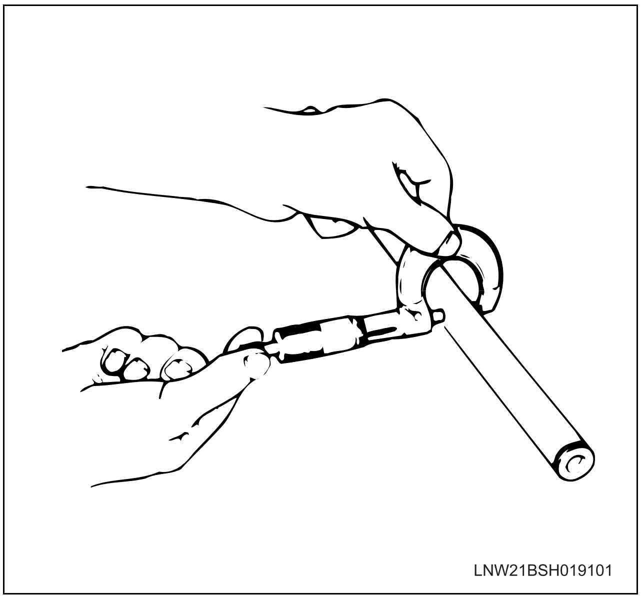
8. Check if the rocker arm shaft is bent.
   - Place the rocker arm shaft on a V block.
   - Check if it is bent by rotating the shaft with a dial gauge on the center of the shaft.
   - As a result of measurement, if its bend is slight, press it to rectify it (while cold).
   - If the bend of the shaft exceeds the limit, replace the shaft.

Bend of the rocker arm shaft	mm (in)
Limit	0.3 (0.012)



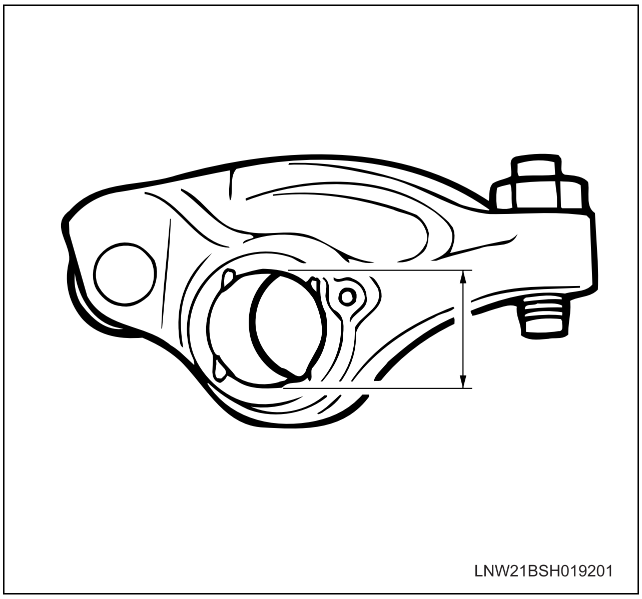
9. Check if the rocker arm shaft is worn.
   - Use a micrometer to measure 8 places of the vibrating part of the rocker arm.
   - If the measurement falls is the limit or less, replace the shaft.

External diameter of the rocker arm shaft	mm (in)
Standard	22.0 (0.866)
Limit	21.85 (0.860)



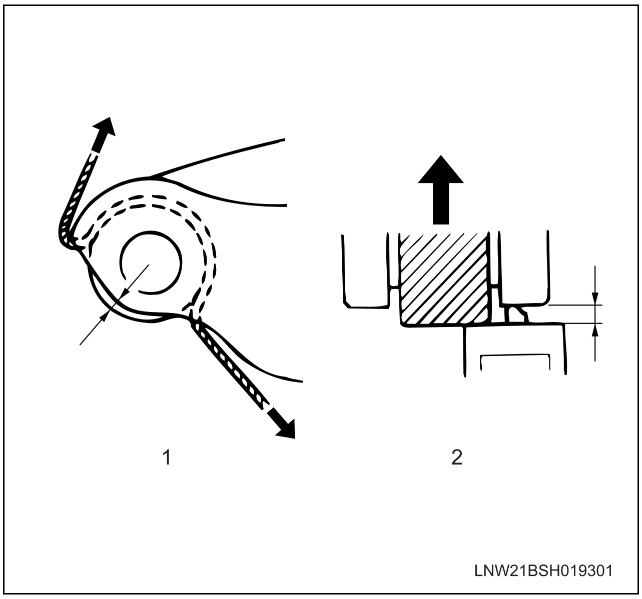
10. Inspect a clearance between the rocker arm and the rocker arm shaft.
    - Use a cylinder gauge to measure an inside diameter of the bush of the rocker arm to measure a clearance between the external diameter of the shaft.
    - If the measurement exceeds the limit, replace the rocker arm and the shaft.

Clearance between the rocker arm and rocker arm shaft	mm (in)
Standard	0.010 – 0.056 (0.0004 – 0.0022)
Limit	0.2 (0.0079)



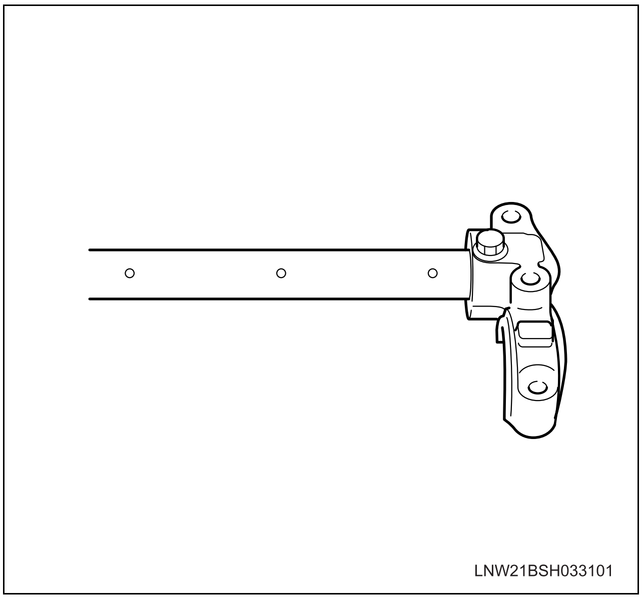
11. Inspect a clearance between the roller of the rocker arm and the rocker arm pin.
    a. Pass a string, for instance, through an opening between the rocker arm and the roller, pull it in the direction indicated with an arrow strongly and measure the gap between the rocker arm and the roller with the roller stuck out. Figure 1
    b. After marking the measuring point, pull the string out and measure the gap of the marked place with the roller pushed deep into the end. Figure 2
    c. The gap between the measurement taken under a. and that under b. will be a clearance between the roller and the rocker arm pin. If it exceeds the limit, replace the rocker arm.

Clearance between the roller and the rocker arm pin	mm (in)
Standard	0.068 – 0.099 (0.0026 – 0.0038)
Limit	0.2 (0.0079)

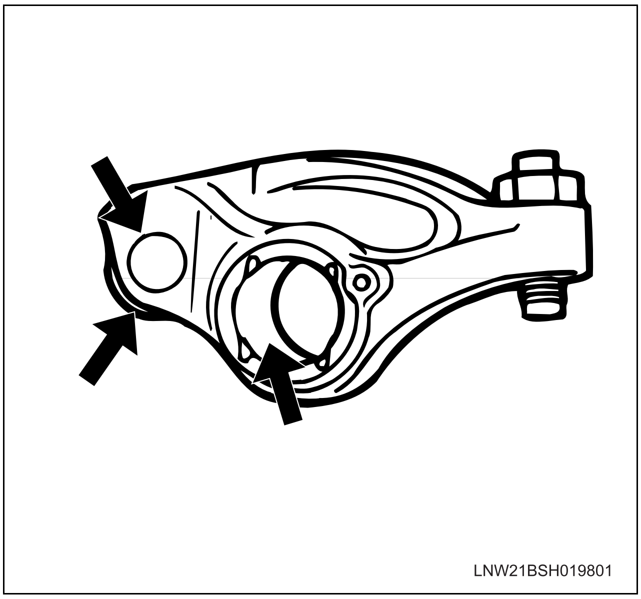


Reassembly

1. Install the camshaft bracket to one side of the rocker arm shaft tentatively first. When the rocker arm shaft assembly is installed on the cylinder head, tighten it up fast.
   - Assemble in the reverse order to dismantling.

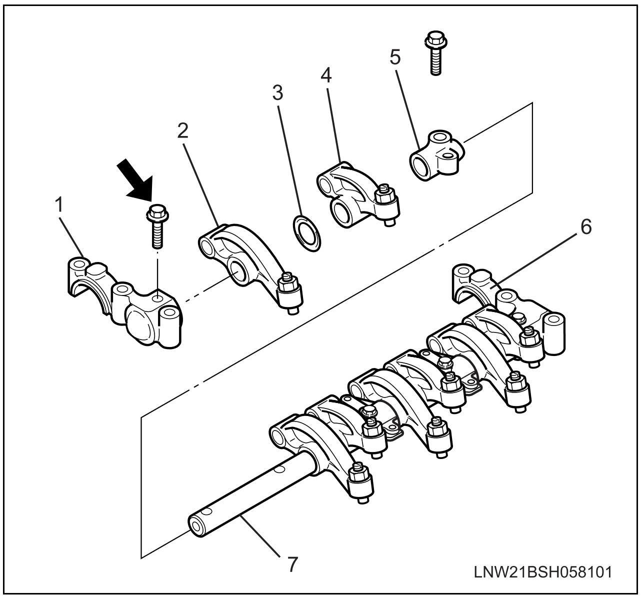


2. Install the rocker arm.
   - Apply engine oil in an inside diameter of the rocker arm, the roller and the rocker arm pin and install it on the rocker arm shaft.



3. Install the wave washer between the rocker arm.
4. Install the rocker arm bracket.
   - Pay attention to the direction in which the bracket is put together and put it together with the rocker arm shaft.
5. Install the camshaft bracket.

- Install the camshaft bracket on the rocker arm shaft with the bolts indicated with an arrow tightened tentatively. When the rocker arm shaft assembly is installed on the cylinder head, tighten them up fast.



Legend

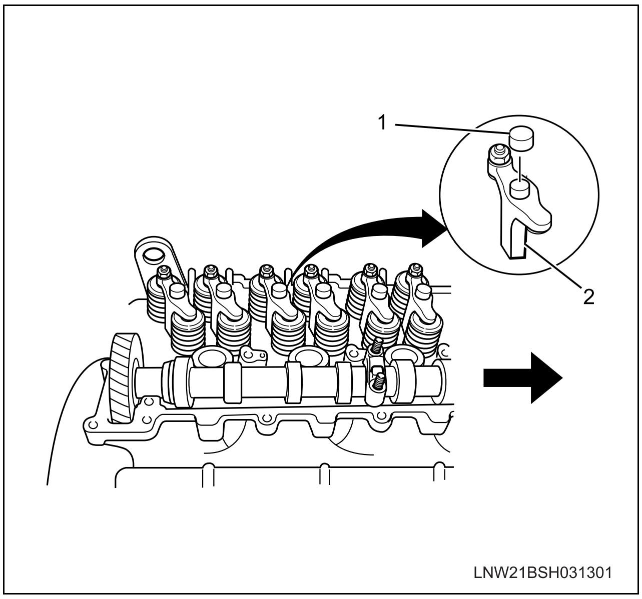
1. Camshaft Bracket
2. Rocker Arm
3. Wave Washer
4. Rocker Arm
5. Rocker Arm Bracket
6. Camshaft Bracket
7. Rocker Arm Shaft

Installation

1. Install the rocker arm shaft assembly.
    - If the bridge cap comes off, apply engine oil over the inside of the bridge cap and put it together with the bridge.

Caution:

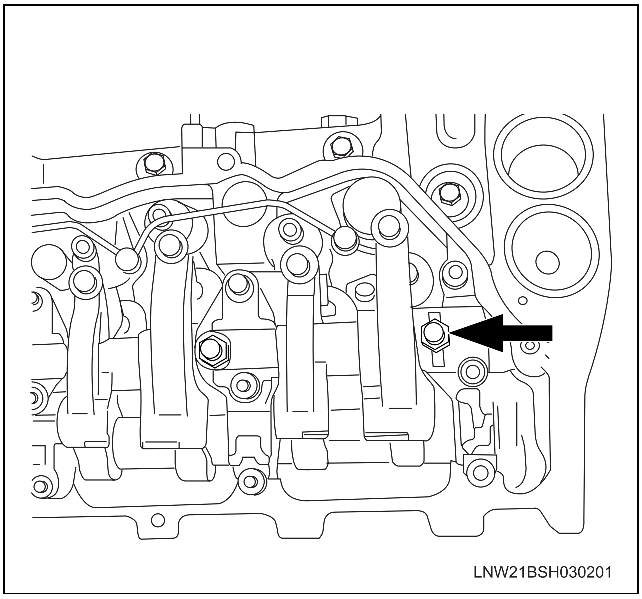
Pay full attention so as not to drop the bridge cap in the gear case of the rear part of the cylinder head or the hole into which oil pours back in the front.



Legend

1. Bridge Cap
2. Bridge

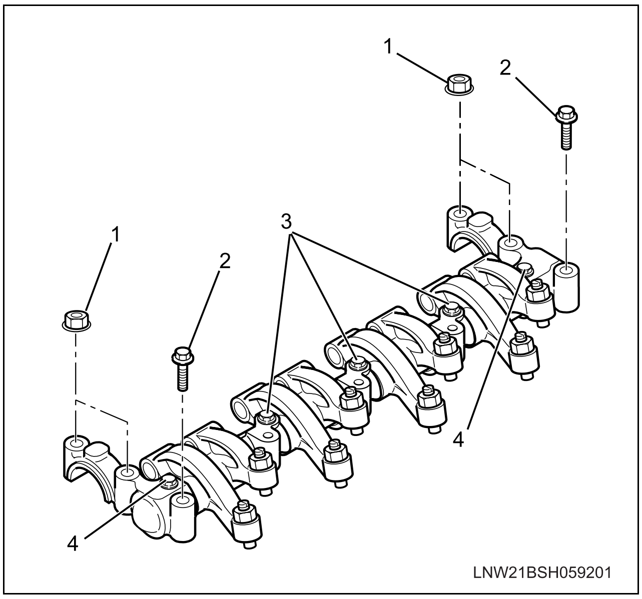
- Loosen an adjusting screw of the rocker arm, apply engine oil over the roller part of the rocker arm and install it on the cylinder head.
- Loosen the bolts indicated with an arrow a little, it will become easier to install it.



- Apply engine oil on a screw of the bolts and nuts.
- Tighten up the tightening bolts and of the rocker arm aseembly tentatively, and gradually tighten up the entire rocker arm assembly horizontally according to the order of the nut on the rocker arm side.

Tightening torque:

Bolt (3) = 56 N·m (41 lb ft)
Nut (1), Bolt (2), (4) = 27 N·m (20 lb ft)



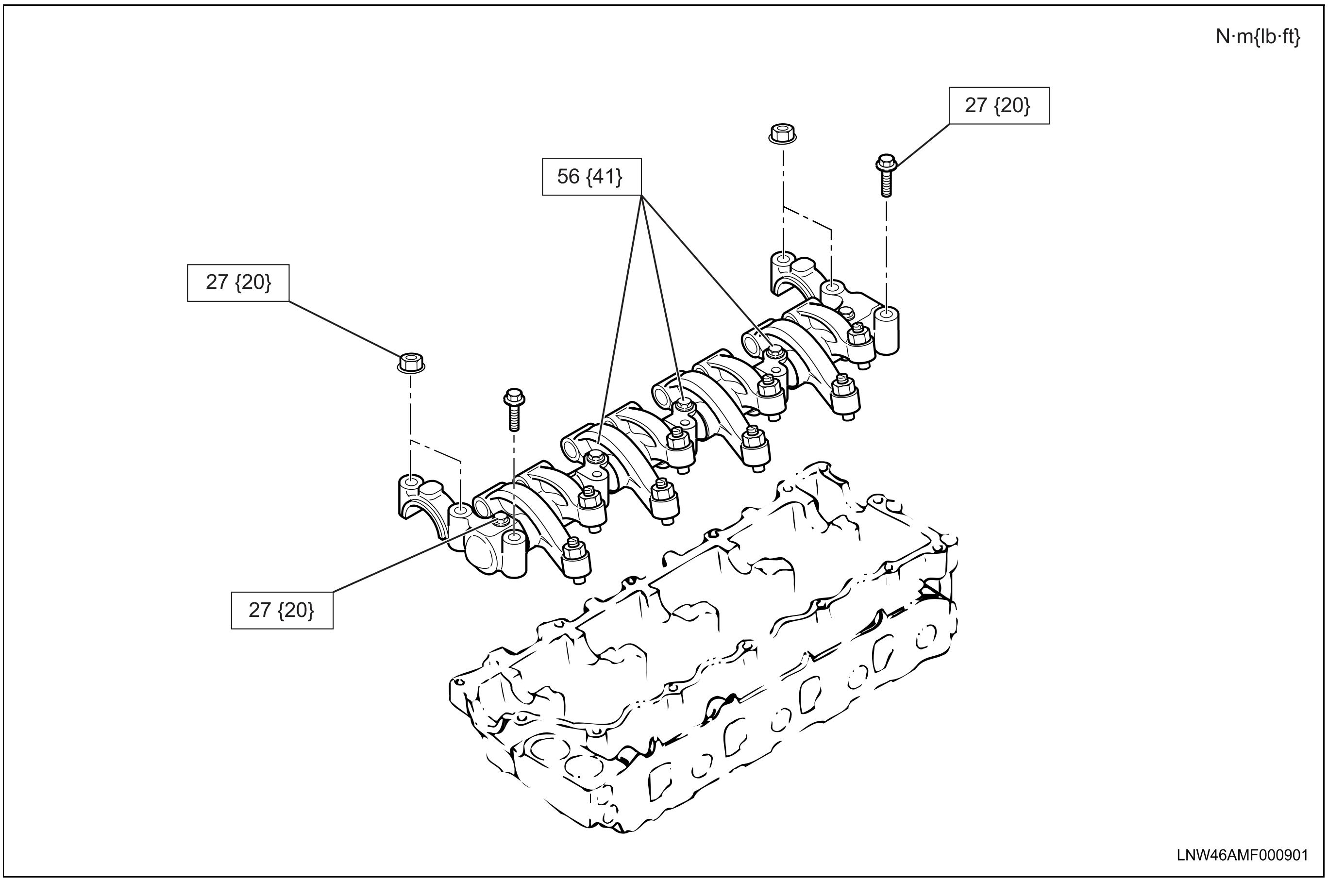
Legend

1. Camshaft Bracket Fixing Nut
2. Camshaft Bracket Fixing Bolt
3. Rocker Arm Bracket Fixing Bolt
4. Rocker Arm Shaft Set Bolt

- Adjust valve clearance
  Refer to “functional inspection”.

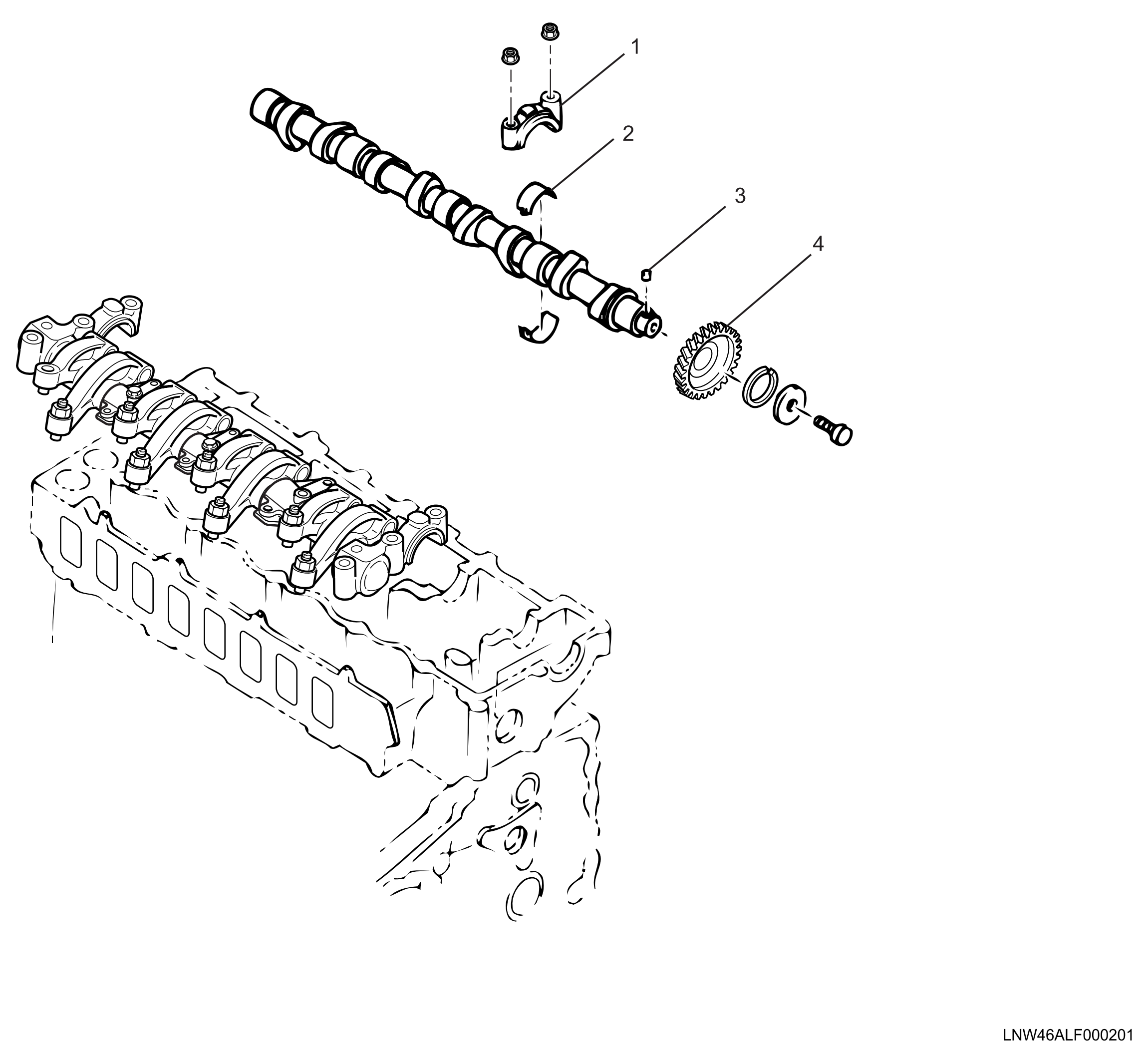
2. Install the cylinder head cover
   Refer to the “cylinder head cover”.

Torque Specifications



Camshaft Assembly

Component



Legend

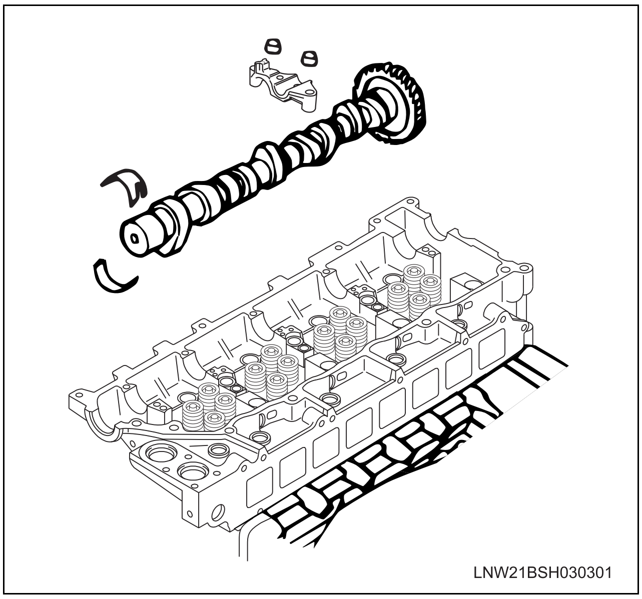
1. Bearing Cap
2. Bearing
3. Dowel Pin
4. Camshaft Gear

Removal

1. Remove the cylinder head cover.

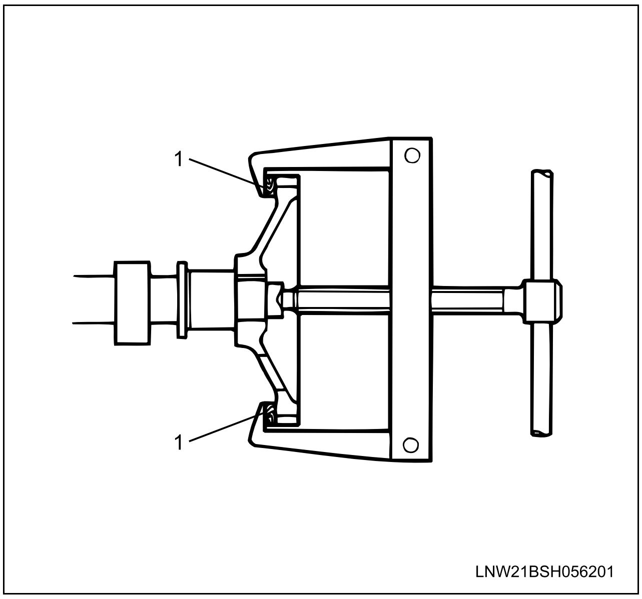
   Refer to the “cylinder head cover”.
2. Remove the rocker arm shaft assembly.
   Refer to the “rocker arm shaft assembly”.
3. Remove the camshaft bearing cap.
4. Remove the bearing upper.
5. Remove the camshaft assembly.
6. Remove the bearing lower.

Caution:
Put the removed bearings in order with a tag, for example, by cylinder.


LNW21BSH030301

Disassembly

1. Remove the camshaft gear.
   - Remove the fastening bolts of the camshaft gear and put the block of wood in a puller to remove the camshaft gear.



LNW21BSH056201

Legend

1. Wood

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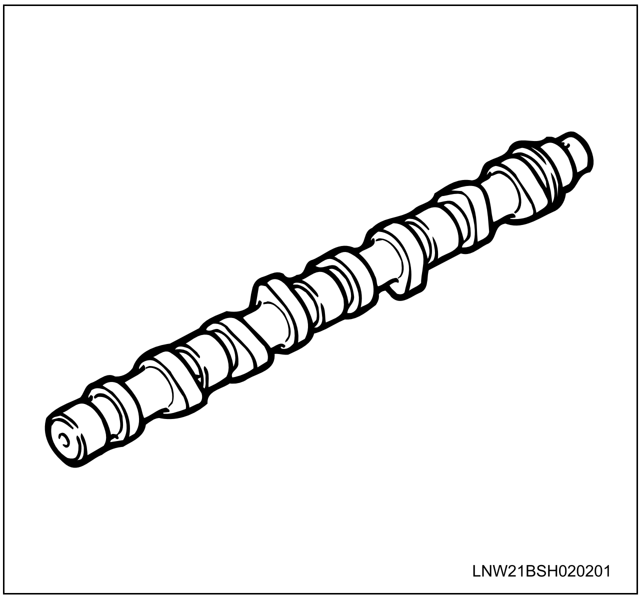
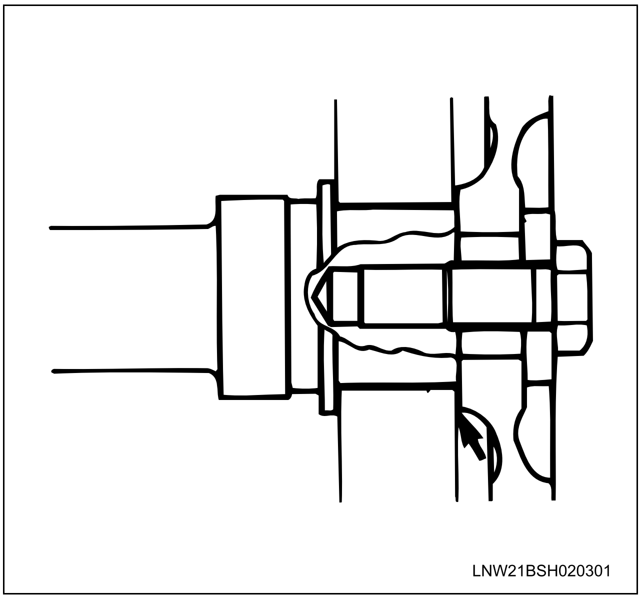
2. Remove the dowel pin.
3. Inspect the camshaft visually.
   - Check if the journal and cam parts of the camshaft are worn or damaged, if so, replace it.


LNW21BSH020201

4. Inspect an end clearance of the camshaft.
   - Use a thickness gauge to measure an end clearance of the camshaft gear and the camshaft bracket.
   - If the measurement exceeds the limit, replace the camshaft gear or the camshaft.

End clearance of the camshaft	mm (in)
Standard	0.085 – 0.205 (0.033 – 0.008)
Limit	0.25 (0.009)

Caution:
Measure an end clearance of the camshaft before disassembling.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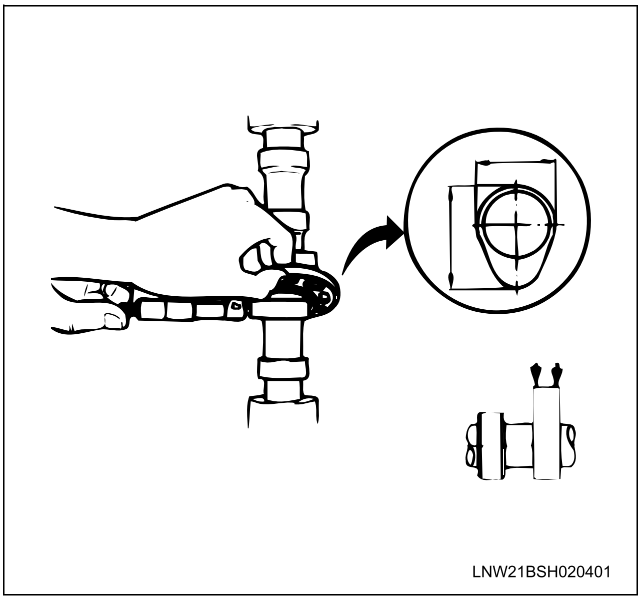
5. Check if the cam lobe is worn.
   - Use a micrometer to measure the height of the cam lobe.

- If the height of the cam lobe is the limit or less, replace the camshaft.

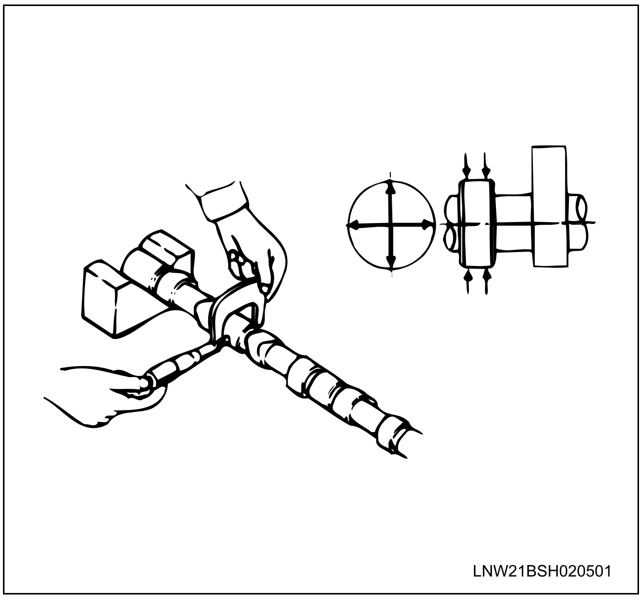
Height of the cam lobe		mm (in)
	Inlet	Exhaust
Standard	52.8 (2.08)	54.5 (2.15)
Limit	51.8 (2.04)	53.5 (2.11)


LNW21BSH020401

6. Check if the camshaft journal is worn.
   - Use a micrometer to measure wear which is not even with a diameter of the camshaft journal.
   - If the measured uneven wear exceeds the limit, replace the camshaft.

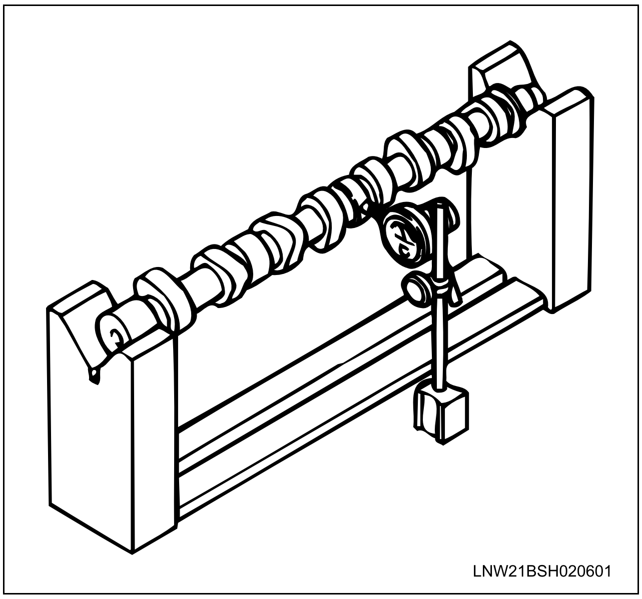
External diameter of the camshaft journal part	mm (in)
Standard	39.950 – 39.975 (1.5728 – 1.5738)
Limit	39.850 (1.5688)

Partial wear of the camshaft journal part	mm (in)
Limit	0.05 (0.0019)


LNW21BSH020501

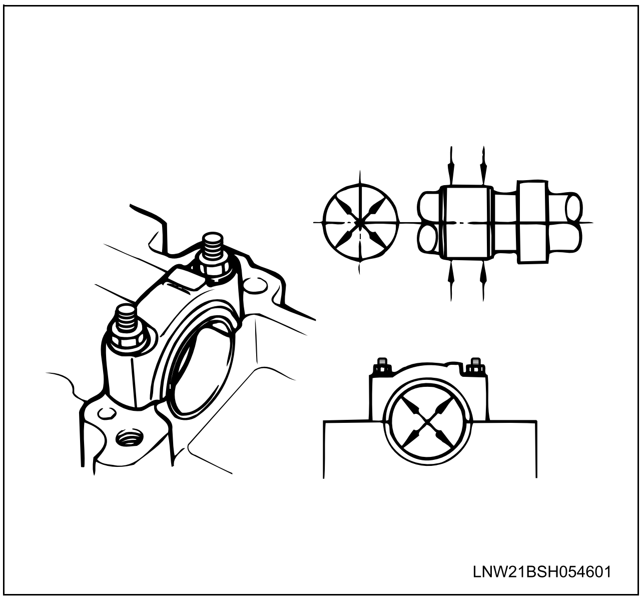
7. Check if the camshaft is bent.
   - Place the camshaft on a V block to measure a bend with a dial gauge.
   - Rotate the camshaft slowly to measure how much the dial indicator shook. If it exceeds the limit, replace the camshaft.

Bent of the camshaft	mm (in)
Limit	0.05 (0.0019)


LNW21BSH020601

8. Measure a camshaft journal oil clearance.
   a. Measure an inside diameter of the camshaft bearing with a dial gauge.
   b. Read the difference between the inside diameter of the camshaft bearing and the diameter of the camshaft journal.
      If the measured oil clearance exceeds the limit, replace the camshaft bearing.

Clearance of the journal part	mm (in)
Standard	0.025 – 0.087 (0.0009 – 0.0034)
Limit	0.15 (0.0059)

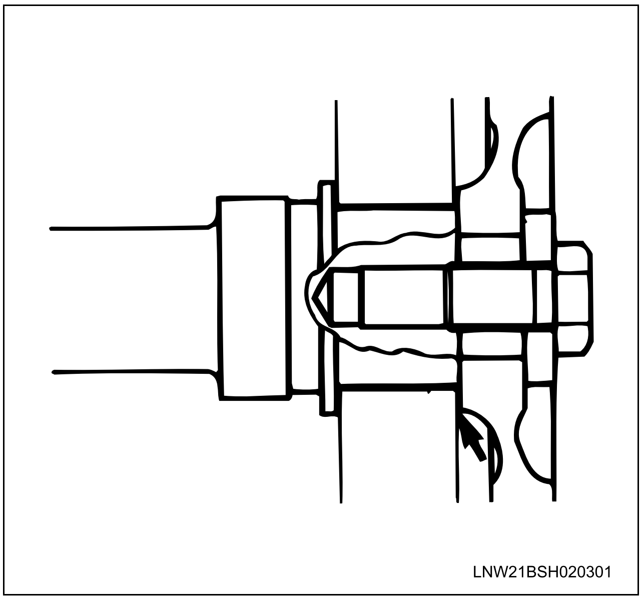

LNW21BSH054601

Reassembly

1. Install the dowel pin.
2. Install the camshaft gear.
   - With the side of the camshaft gear center boss part stuck out being on the camshaft side, install the camshaft gear along with the dowel pin.

Tightening torque: 142 N·m (104 lb ft)

Caution:
Be careful not to damage the cam and journal parts when tightening up the gear.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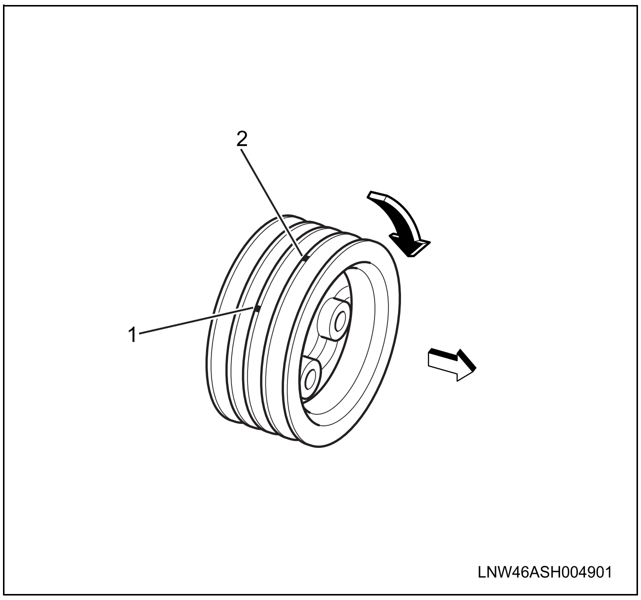
Installation

1. Rotate the crankshaft to make the No. 1 cylinder meet the compression TDC.

Notice:
There are 2 timing marks on the crankshaft pulley.
Mark (1) is near the cylinder block and is used to bring the 4HK1-TC engine to TDC.
Mark (2) is not applicable to this engine.
Be sure to use mark (1) when bringing the engine to TDC.



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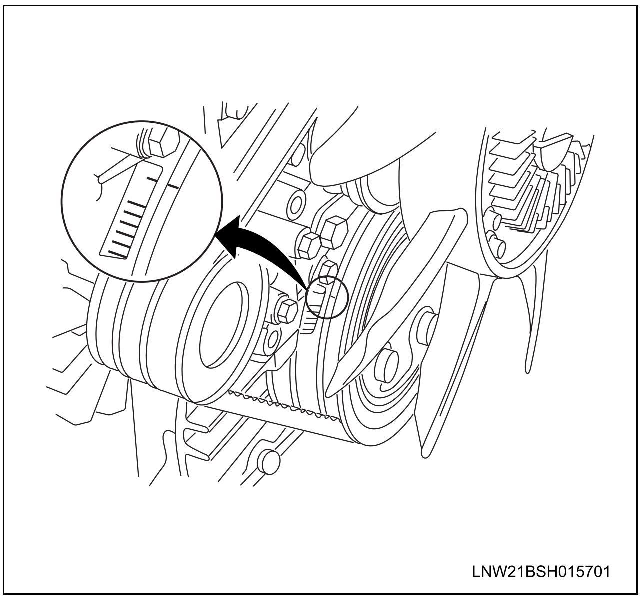
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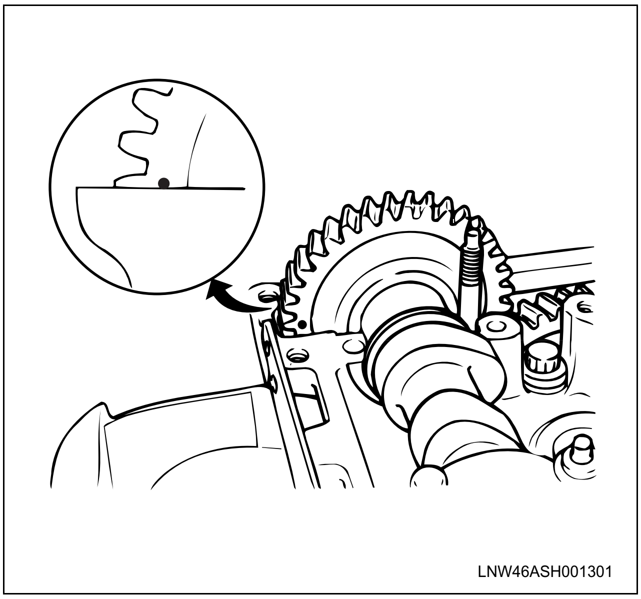
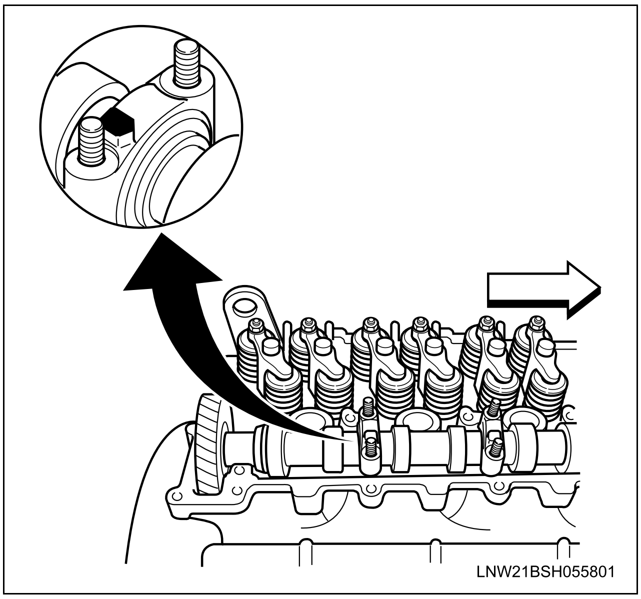
2. Install the camshaft bearing lower.
   - Apply engine oil over the camshaft bearing lower and install it on the cylinder head.
3. Install the camshaft assembly.

- Put together the camshaft assembly so as to make the "•" mark meet the upper face of the cylinder head.

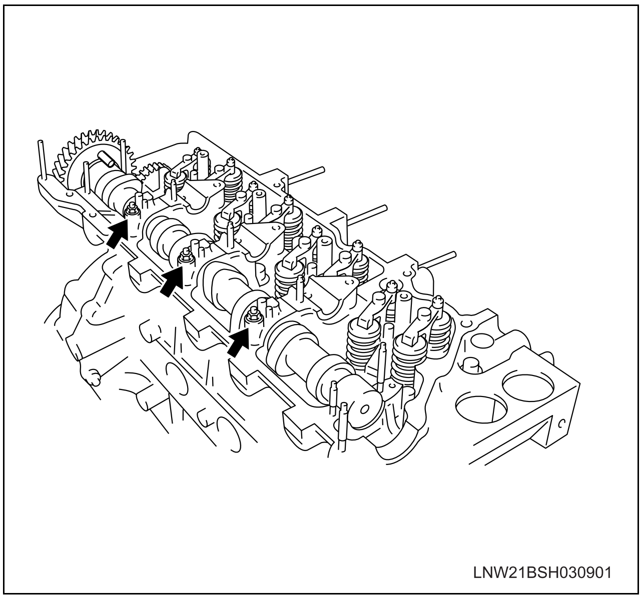


4. Install the baring upper to the bearing cap.
5. Install the bearing cap.
    - Apply engine oil on the bearing upper.
    - Direct the front mark of the bearing cap toward the front of the engine and put it together with the cylinder head in numerical order.



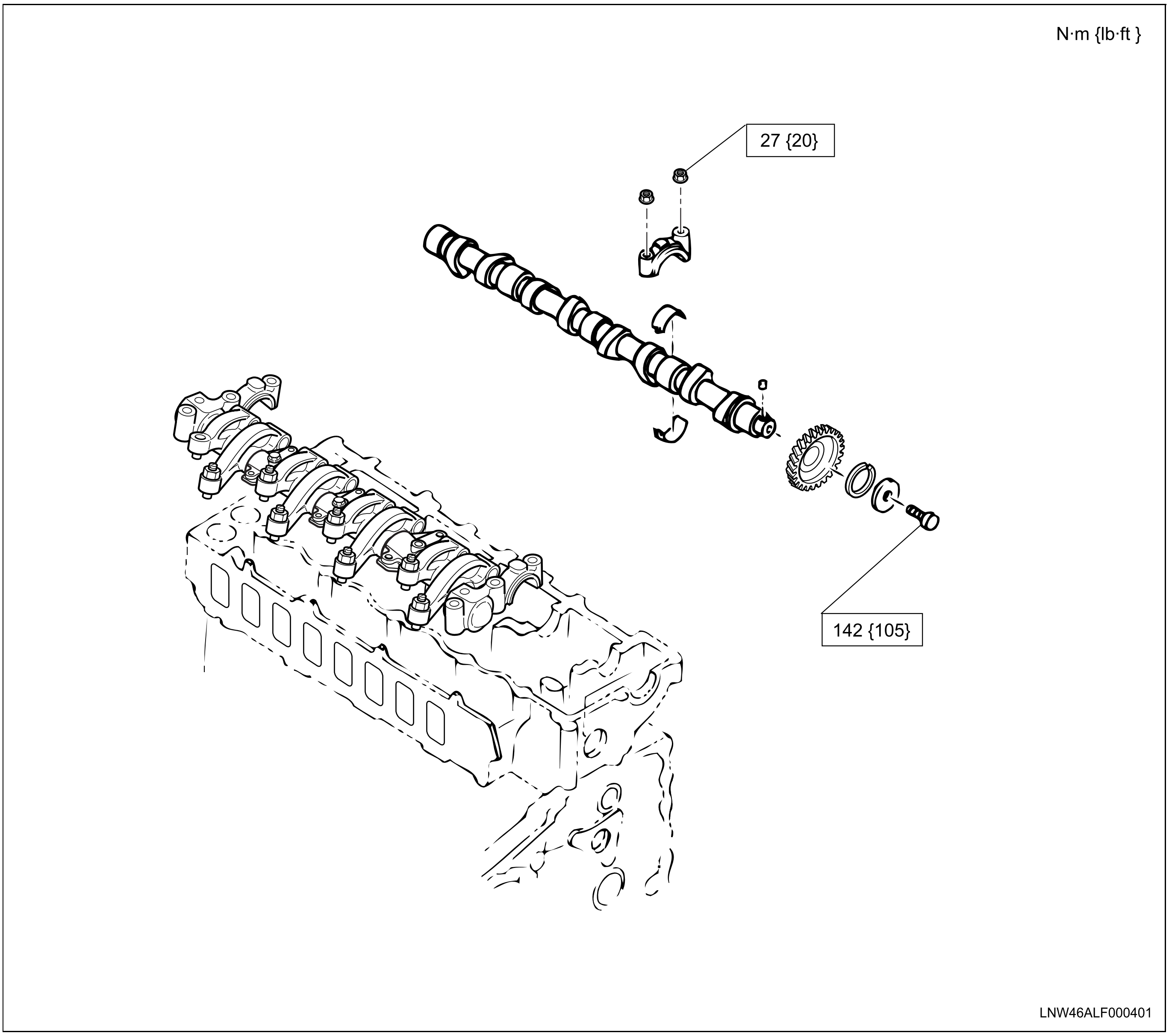
- Apply engine oil over the screw part and tighten up the bearing cap with the prescribed torque.

Tightening torque: 27 N·m (20 lb ft)



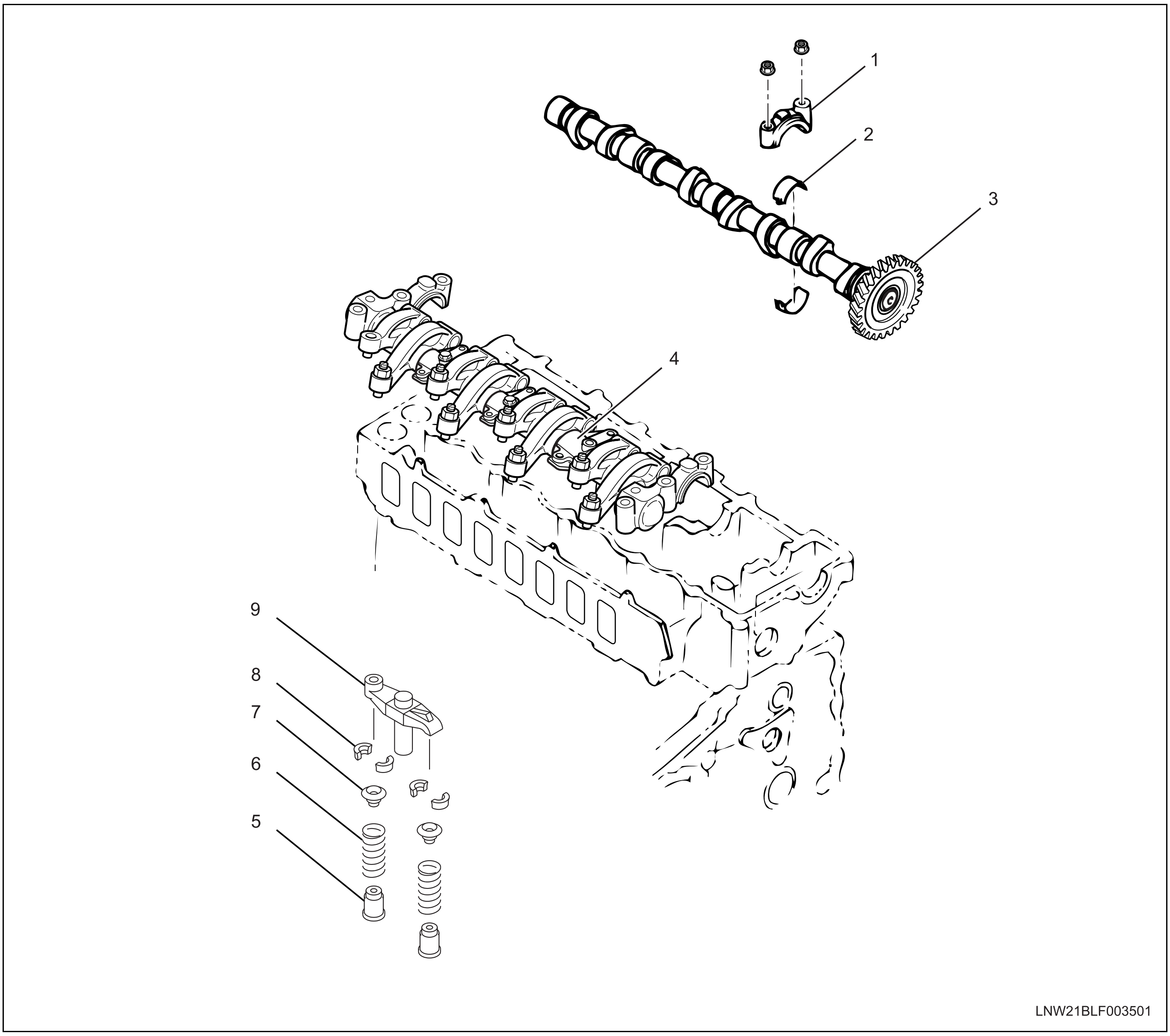
6. Install the rocker arm shaft assembly.
   Refer to the "rocker arm shaft assembly".
7. Install the cylinder head cover.
   Refer to the "cylinder head cover".

Torque Specifications



Valve Stem Seal and Valve Spring

Component



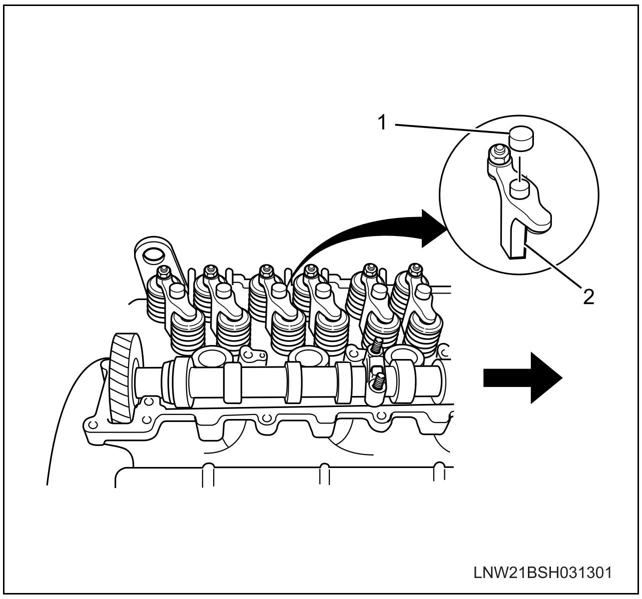
Legend

1. Camshaft Bearing Cap
2. Camshaft Bearing
3. Camshaft
4. Rocker Arm Shaft Assembly
5. Valve Stem Oil Seal
6. Valve Spring
7. Spring Upper Seat
8. Split Collar
9. Bridge

Removal

1. Remove the cylinder head cover.
   Refer to the “cylinder head cover”.
2. Remove the rocker arm shaft assembly.
   Refer to the “rocker arm shaft assembly”.
3. Remove the camshaft assembly.
   Refer to the “camshaft assembly”.
4. Remove the bridge cap (1).
5. Remove the bridge (2).

Caution:
Keep the removed bridge and bridge cap properly so that they may be put back to the original place.



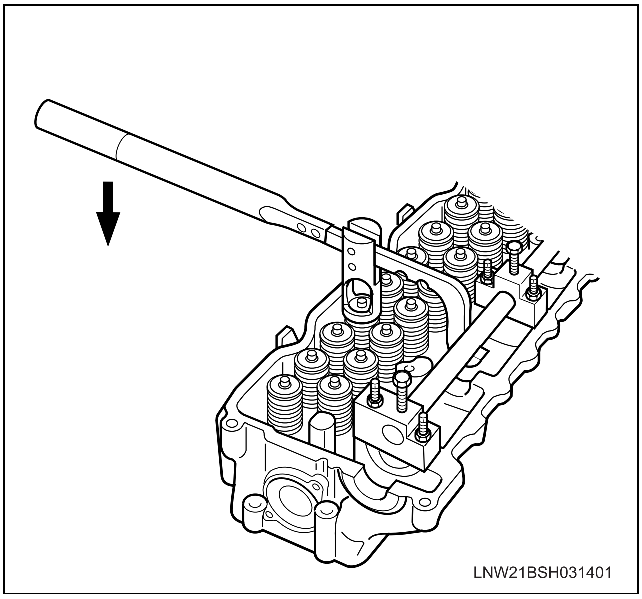
Legend

1. Bridge Cap
2. Bridge

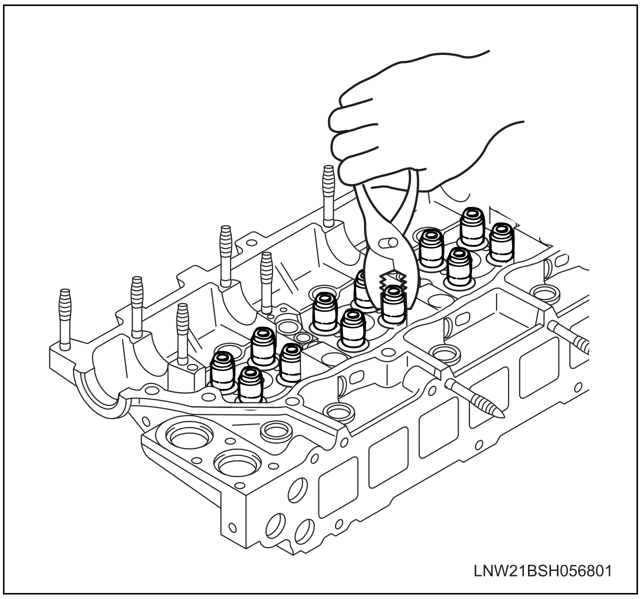
Caution:
Pay full attention so as not to drop the bridge cap in the gear case of the rear part of the cylinder head or a hole into which oil pours back in the front.

6. Remove the split collar.
   - Apply compressed air over the cylinder from a glow plug hole to keep the valve at the home position.
   - Use a replacer to compress the valve spring to remove the split collar.

   Special tool
   Valve spring replacer: J-43263
   Pivot: EN-46721



7. Remove the spring upper seat
   - Remove the special tool to remove the upper seat.
8. Remove the valve spring.
   Put the removed valve springs in order by cylinder number.
9. Remove the valve stem oil seal.
   - Use pliers to remove the oil seal.



Caution:
Do not use the removed oil seal again.

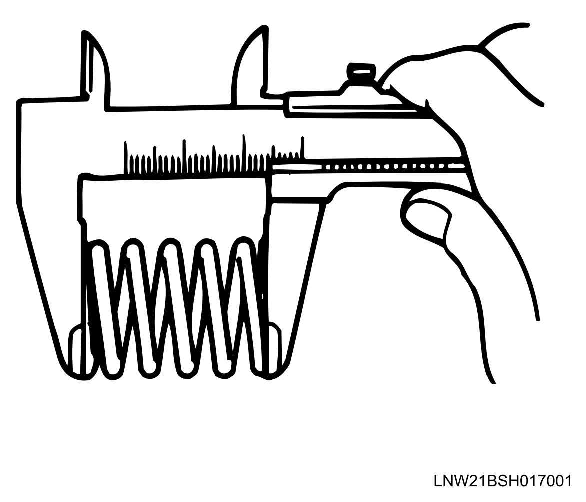
Inspection

Inspect the valve spring

Caution:
Check the valve spring visually and if there is clear damage or wear-out, replace it.

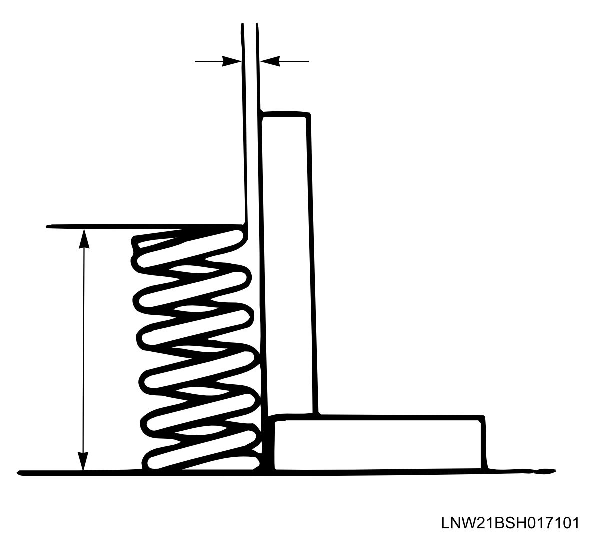
1. Free length
   - Measure free length of the spring and if it is shorter than the prescribed limit, replace the spring.

Free length of the valve spring		mm (in)
	Inlet	Exhaust
Standard	59.9 (2.36)	70.3 (2.76)
Limit	56.9 (2.24)	67.3 (2.65)



2. Valve spring squareness
   - Use a surface plate and a square to measure the valve spring squareness.
     If the measured value exceeds the specified limit, the valve spring must be replaced.

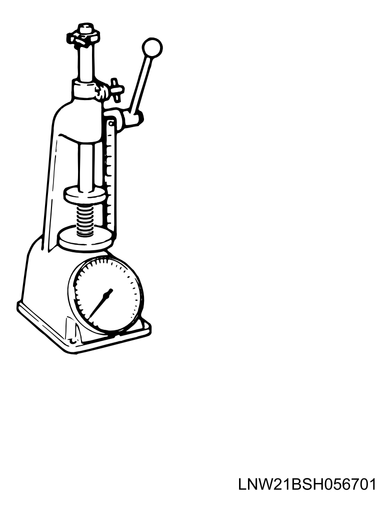
Valve spring squareness	mm (in)
Limit	1.0 (0.04)



3. Tension
   - Use a spring tester to compress the spring to the installation height. Measure tension of the compressed spring. If the measurement is lower than the limit, replace the spring.

Tension of the valve spring N (lb)

	Inlet	Exhaust
Installation length mm (in)	47.0 (1.85)	47.0 (1.85)
Standard	333 (74.9)	490 (110.2)
Limit	315 (71.0)	463 (104.3)

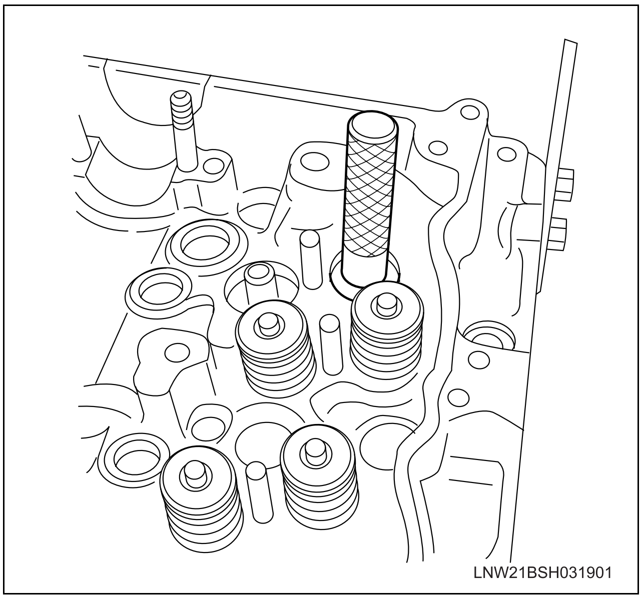


Installation

1. Install the valve stem oil seal.
   - Apply engine oil over the peripheral part of the valve guide and install the oil seal by using a valve stem seal installer.

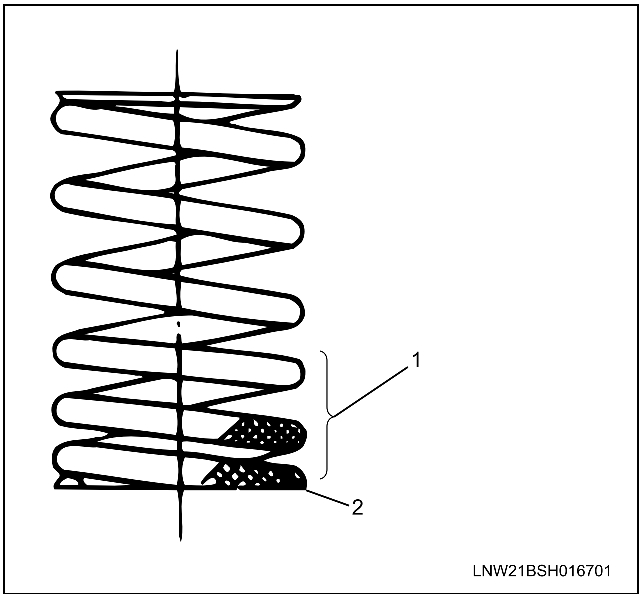
Caution:
After installing the valve stem oil seal, check if it is inserted nice and deep and the oil seal is not tilted or the garter spring has not come off.

Special tool
Valve stem seal installer: EN-47685



2. Install the valve spring.
   - Install it with the paint mark or the narrow side of the spring pitch being the lower side (cylinder head side).

	Paint mark
Inlet	Orange
Exhaust	Red

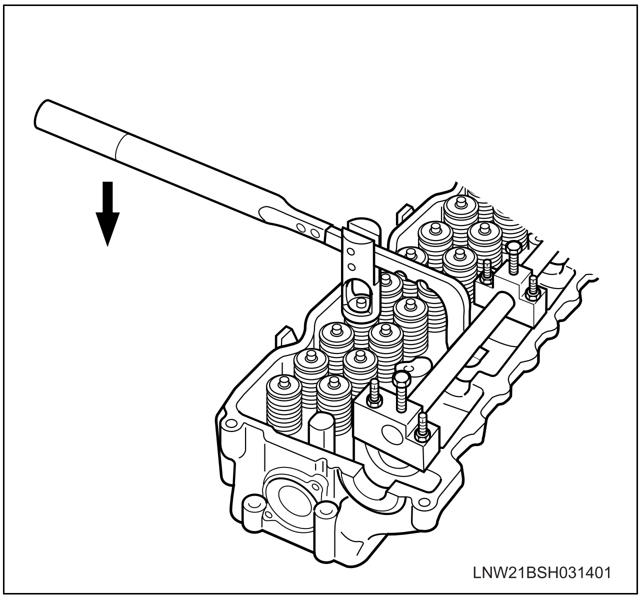


Legend

1. Spring Pitch
2. Paint Mark

3. Install the spring upper seat.
4. Install the split collar.
   - Apply compressed air over the cylinder from the glow plug holes to keep the valve at the home position.
   - Use a replacer to compress the valve spring and install the split collar.

Special tool
Valve spring replacer: J-43263
Pivot: EN-46721

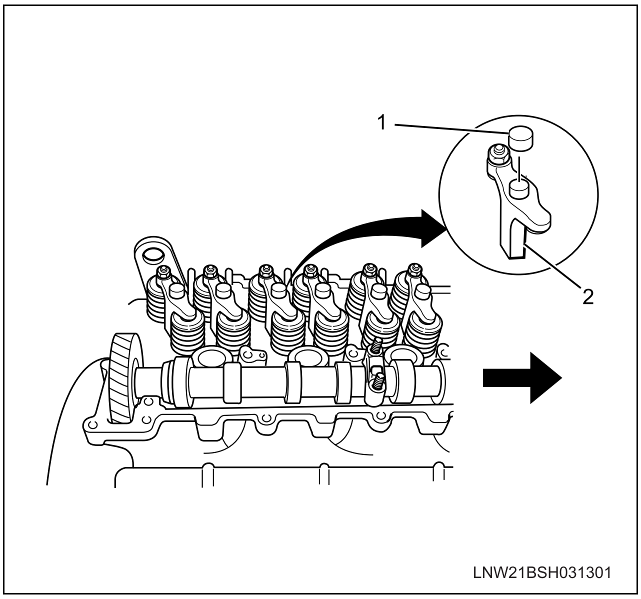


5. Apply engine oil over the bridge and install it.

Caution:
Move it up and down to check if it moves smoothly.

6. Apply engine oil over the bridge cap and install it.

Caution:
Pay full attention so as not to drop the bridge cap in the gear case of the rear part of the cylinder head or the hole into which oil pours back in the front.

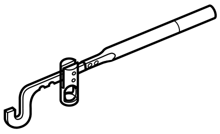
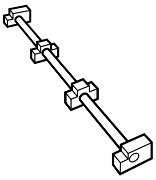
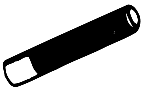


Legend

1. Bridge Cap
2. Bridge

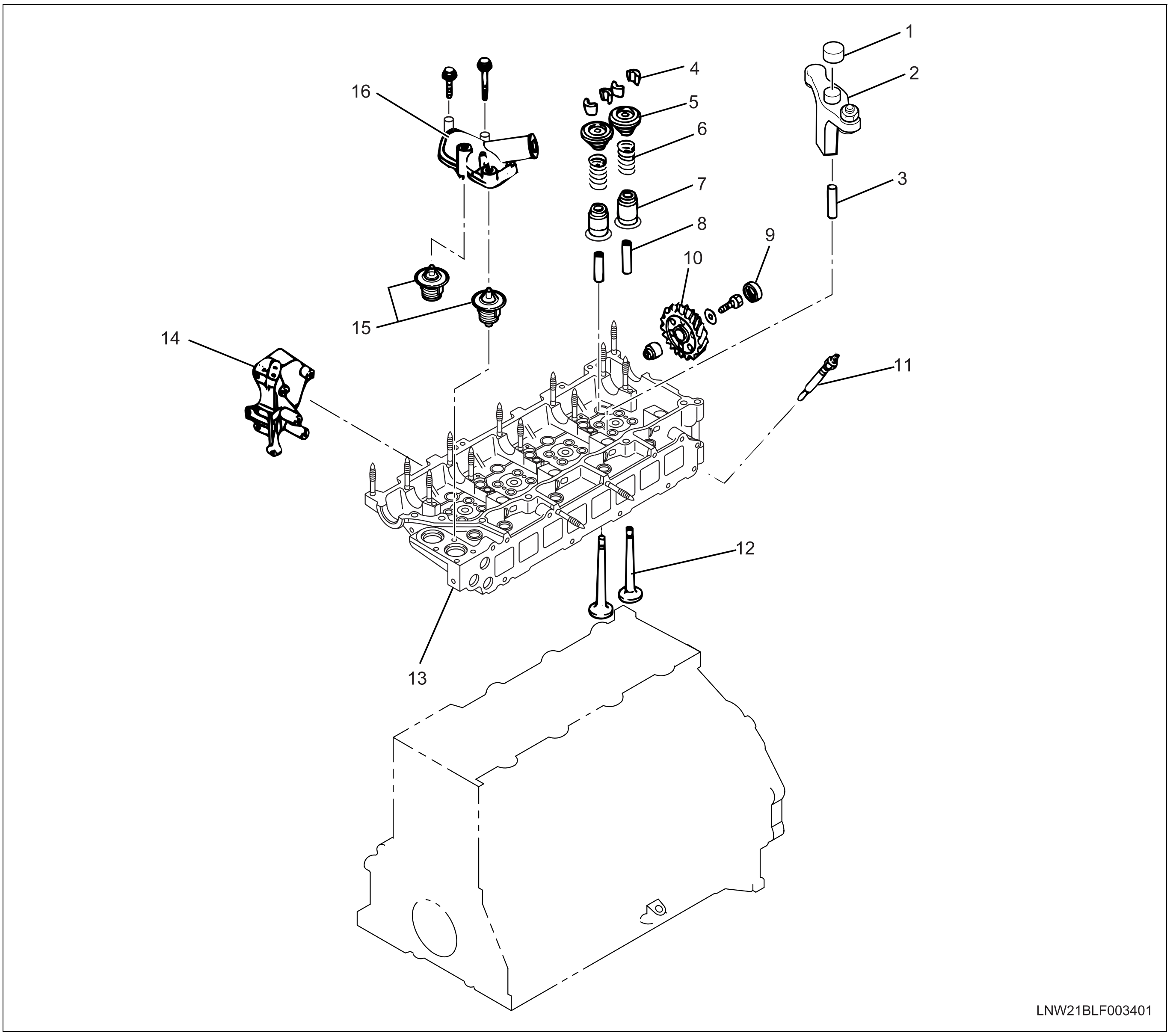
7. Install the camshaft assembly.
   Refer to the "camshaft assembly".
8. Install the rocker arm shaft assembly.
   Refer to the "rocker arm shaft assembly".
9. Install the cylinder head cover.
   Refer to the "cylinder head cover".

Special tool

Illustration	Tool Number/ Description
 5884026210	J-43263 Valve spring replacer
 8943968620	EN-46721 Pivot assembly
 9852212890	EN-47685 Valve stem seal installer

Cylinder Head

Component



Legend

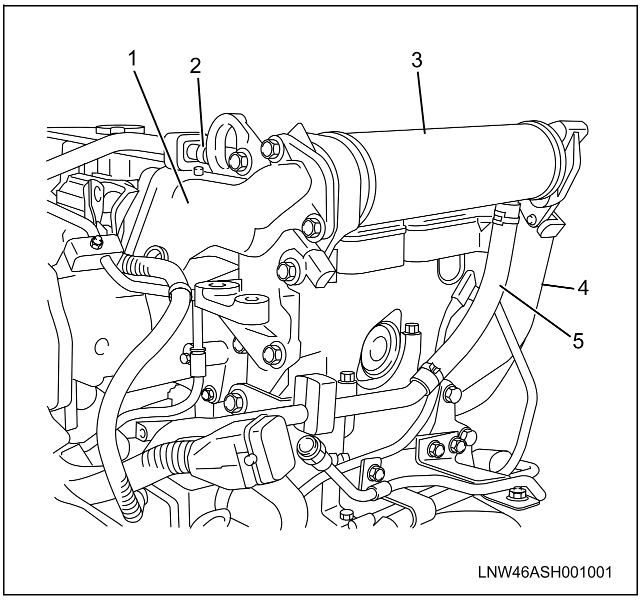
1. Bridge Cap
2. Bridge
3. Bridge Guide
4. Split Collar
5. Spring Upper Sheet
6. Valve Spring
7. Valve Stem Oil Seal
8. Valve Guide
9. Idle Gear C Cover
10. Idle Gear C
11. Glow Plug
12. Intake And Exhaust Valves
13. Cylinder Head
14. A/C Compressor Bracket
15. Thermostat
16. Water Outlet Pipe

Caution:
To avoid electric shock;
Set the switch to the ‘OFF’ position and disconnect battery negative cable before checking or repairing the fuel injector, wiring or/and connectors.

Removal

1. Drain the coolant
2. Remove the engine harness
3. Remove the front exhaust pipe
4. Remove the turbocharger.
   Refer to the “turbocharger and exhaust manifold”.

5. Remove the left-hand EGR adapter and right-hand EGR pipe.
6. Remove the EGR water feed pipe.
7. Remove the EGR water return pipe.
8. Remove the EGR cooler.
9. Remove the water feed pipe for coolant water for the EGR cooler and the water return pipe.

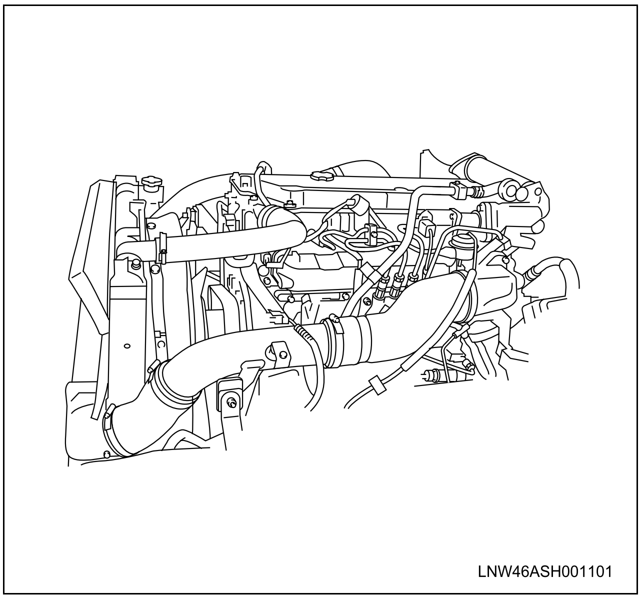


Legend

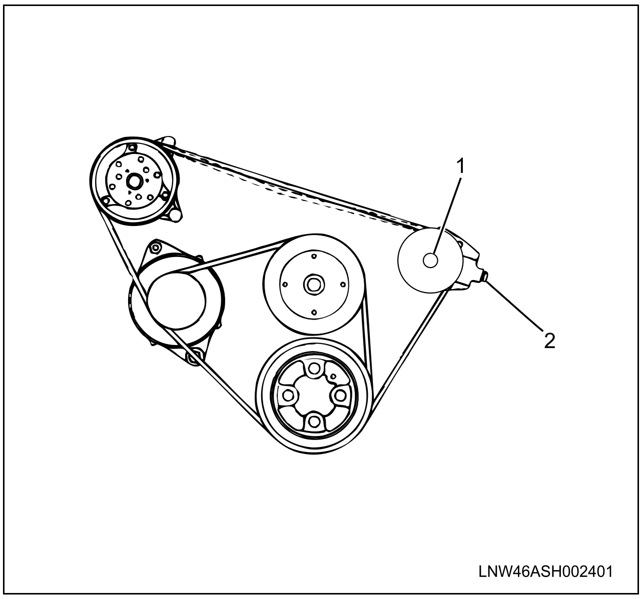
1. EGR Adapter
2. Water Return Pipe
3. EGR Cooler
4. EGR Pipe
5. Water Feed Pipe

---

10. Remove the fan guide bracket.
11. Remove the left-hand intake pipe between the inter-cooler and the inlet duct.



12. Remove the A/C compressor drive belt.
    - Loosen the tension pulley nut and the adjust bolt and remove the drive belt.

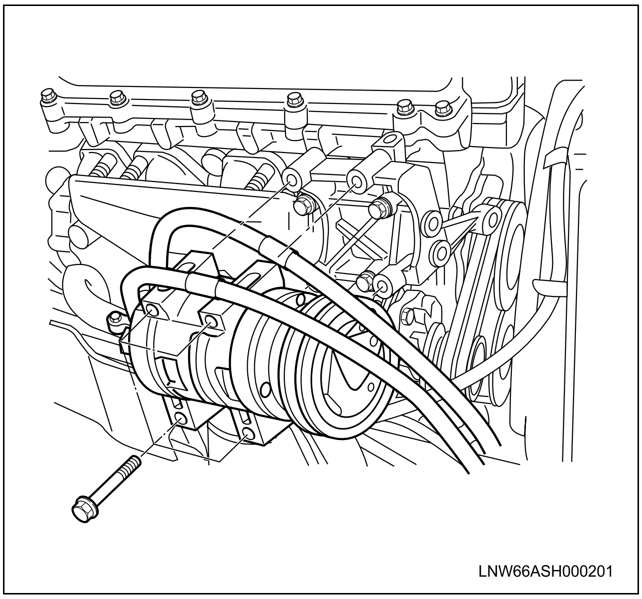


Legend

1. Tension Pulley Nut
2. Adjust Bolt

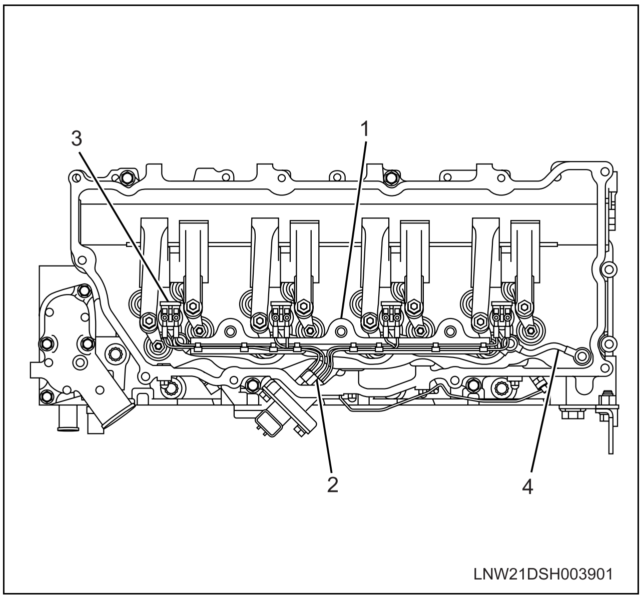
---

13. Remove the A/C compressor.
    - Remove the A/C compressor harness connector, remove the compressor from the A/C compressor bracket, and fix it with wires and others.



14. Remove the cylinder head cover.
    Refer to the “cylinder head cover.”
15. Remove radiator upper hose.
16. Loosen the fuel injector terminal nuts alternately to the same level, and remove the terminal.
17. Loosen the fuel injector harness bracket bolt, remove the inside connector, and remove the harness bracket.

18. Remove the nozzle leak-off pipe (4).

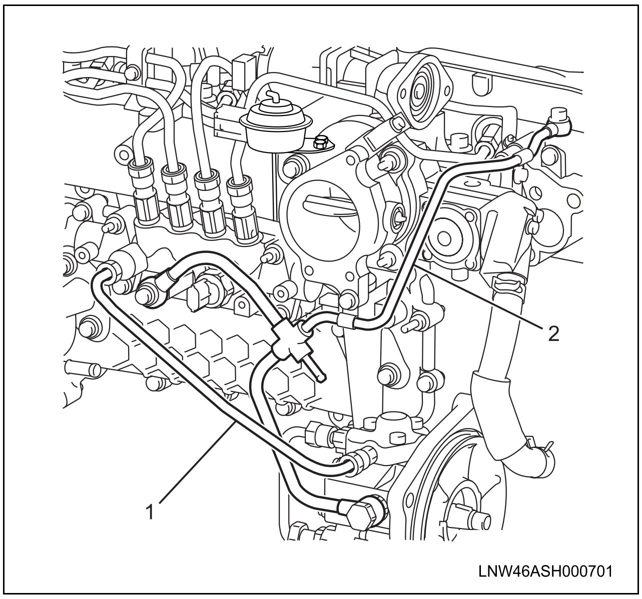


Legend

1. Harness Bracket
2. Harness Connector
3. Fuel Injector Terminal Nut
4. Nozzle Leak-Off Pipe

---

19. Remove the fuel leak-off hose.
20. Remove the fuel leak-off pipe (2).

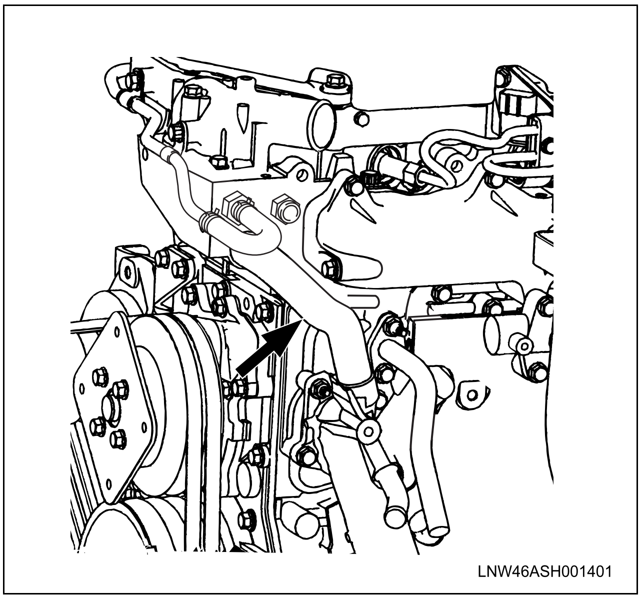


Legend

1. High Pressure Pipe
2. Leak-Off Pipe

---

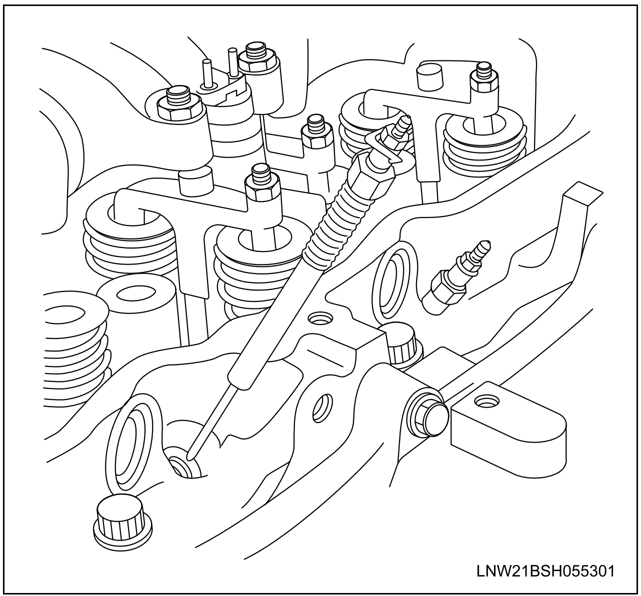
21. Remove the water bypass hose from the cylinder head side.
    - Remove the engine coolant temperature sensor connector.



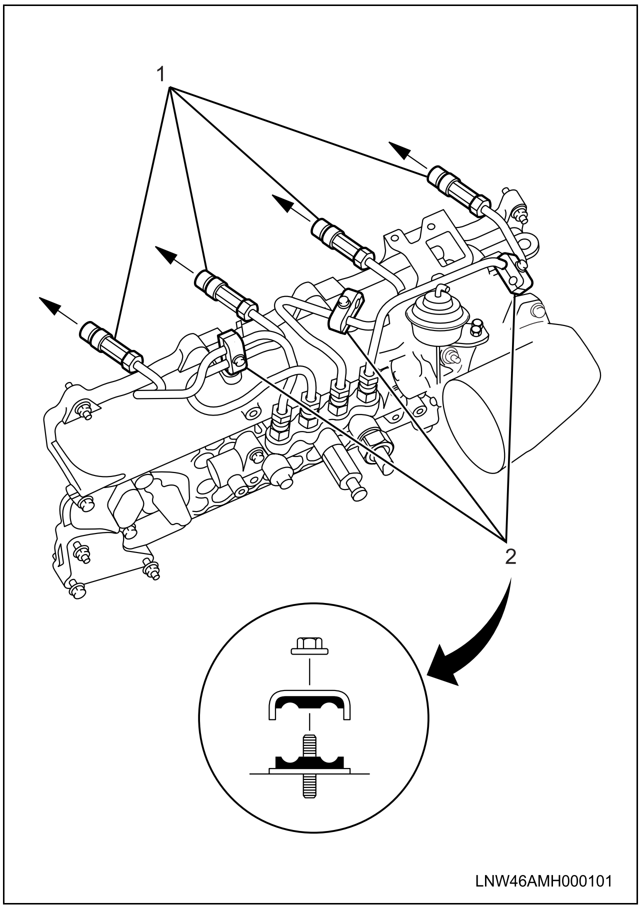
22. Remove the EGR valve and EGR valve connector.
23. Remove the cam angle sensor connector.
24. Remove the rocker arm shaft assembly.
    Refer to the “rocker arm shaft assembly”.
25. Remove the camshaft assembly.
    Refer to the “camshaft assembly”.
26. Remove the bridge cap carefully so that it does not fall into inside the engine.
27. Remove the bridge.

Caution:
Store the removed bridge and bridge cap so that they can be placed in their original locations.

28. Remove the glow plug connector.
29. Remove the glow plug.



30. Remove the injection pipe clip, and remove the injection pipe.



Legend

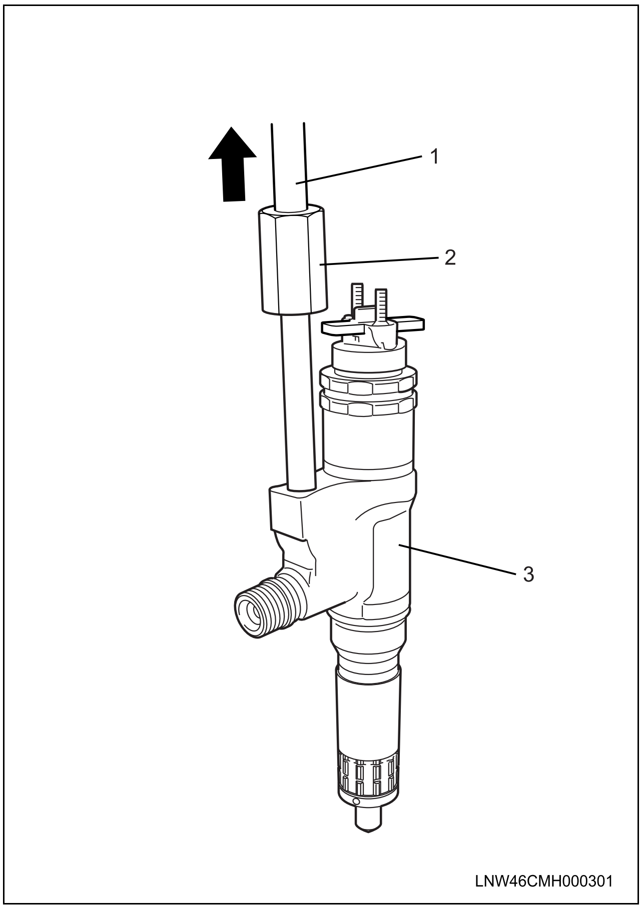
1. Fuel Injection Pipe
2. Fuel Injection Pipe Clip

---

31. Remove the fuel rail.
    - Remove the fuel-rail pressure sensor connector.
32. Remove the fuel injector bracket.
33. If you have difficulty in removing the fuel injector, set the fuel injector remover in the fuel injector, tighten the attachment part on the joint of the leak-off pipe and pull out the fuel injector upward.

    Special tool
    Fuel injector remover: EN-46720
    Sliding hammer: J-23907

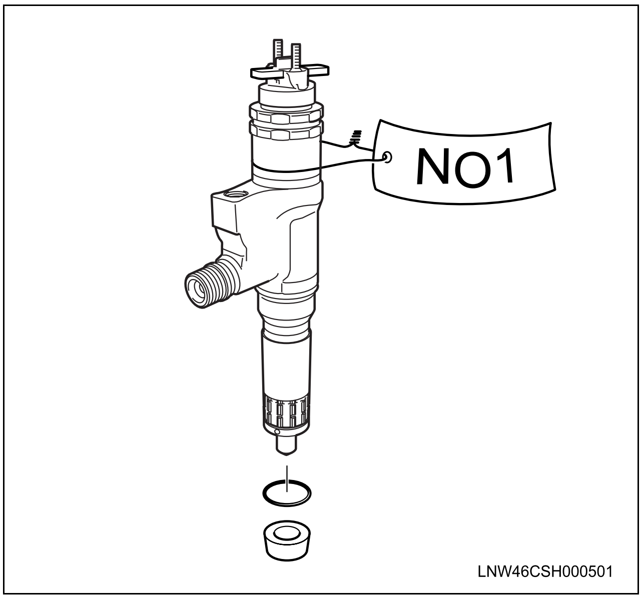
Caution:
When removing an fuel injector ID code, be sure to attach the cylinder number.
When pulling out the fuel injector using a special tool, check that the fuel injector sleeve does not come off.



Legend

1. Sliding Hammer
2. Fuel Injector Remover
3. Fuel Injector Assembly

Caution:
Attach a cylinder number to the removed fuel injector when storing it.
Be sure not to make the nozzle touch something.



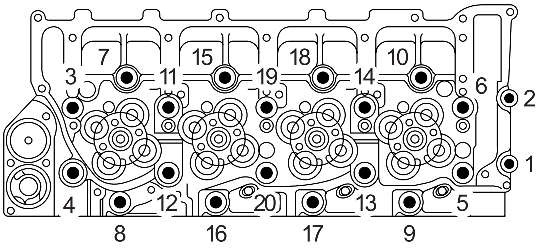
34. Remove the lower head cover.
35. Remove the cylinder head assembly.

- Loosen the cylinder head bolts in the order described in the drawing.

Caution:
Be sure not to overlook (1) and (2) because they are attached with the flywheel housing with M10 bolts.

- Remove the cylinder head gasket.

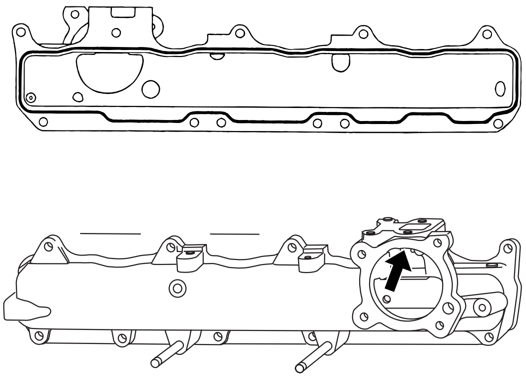
Caution:
Replace the head gasket with a new one once it was removed.



LNW21BSH030401

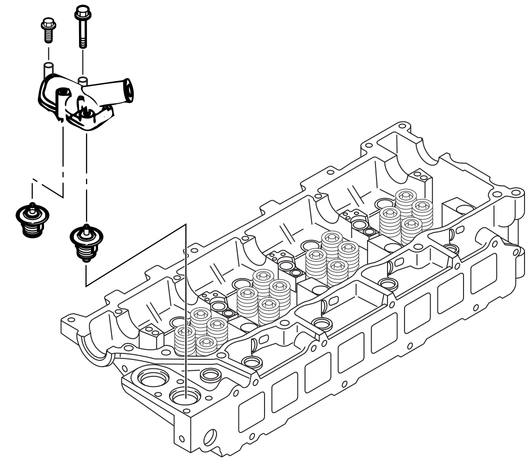
Disassembly

1. Remove the throttle assembly.
    - Remove the intake throttle valve connecter.
    - Be sure not to lose the gasket.
2. Remove the inlet cover.
    - Remove liquid gasket adherent to the removed inlet cover.



LNW46ASH000101

3. Remove the A/C compressor bracket.
4. Remove the exhaust manifold.
    - Remove the heat protector and remove the exhaust manifold.
5. Remove the exhaust gasket.
6. Remove the water outlet pipe.
7. Remove the thermostat.



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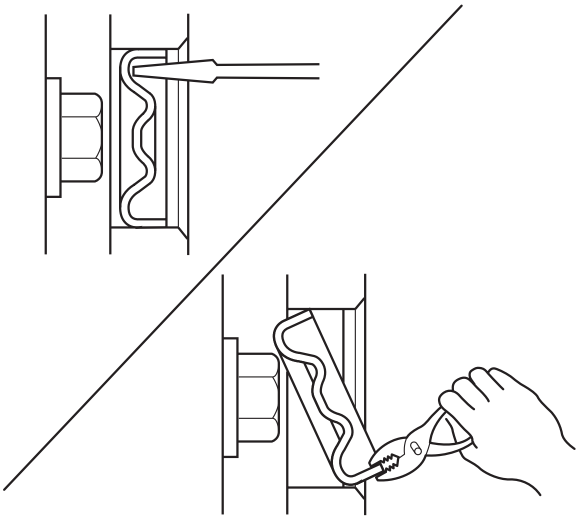
8. Remove the idle gear C cover.
    - Put the edge of a driver on the outer circle of the sealing cup as shown in the drawing, tap it lightly, reverse it, then pull it out with pliers or other equipment.



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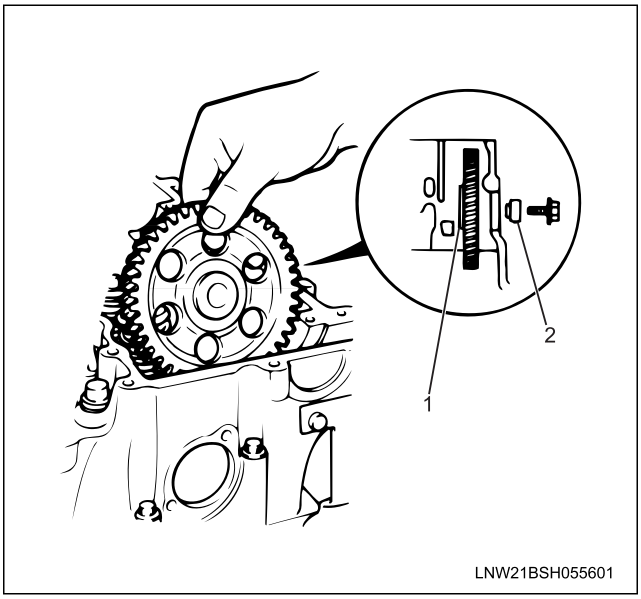
9. Remove the idle gear C.



Legend

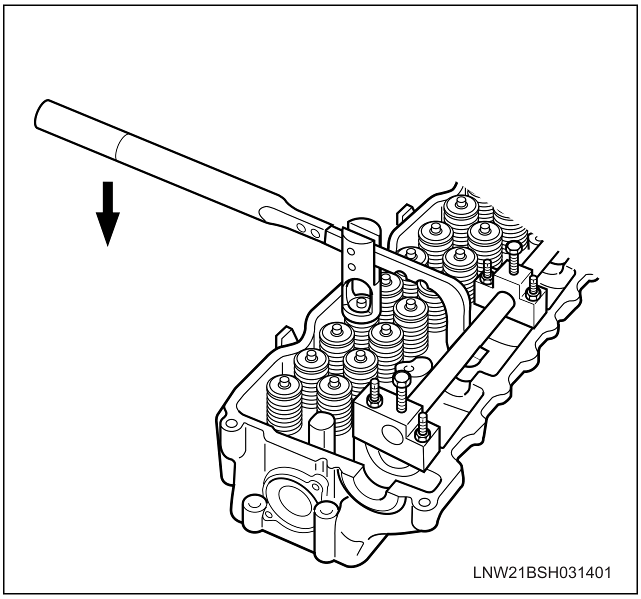
1. Idle Gear C
2. Shaft

---

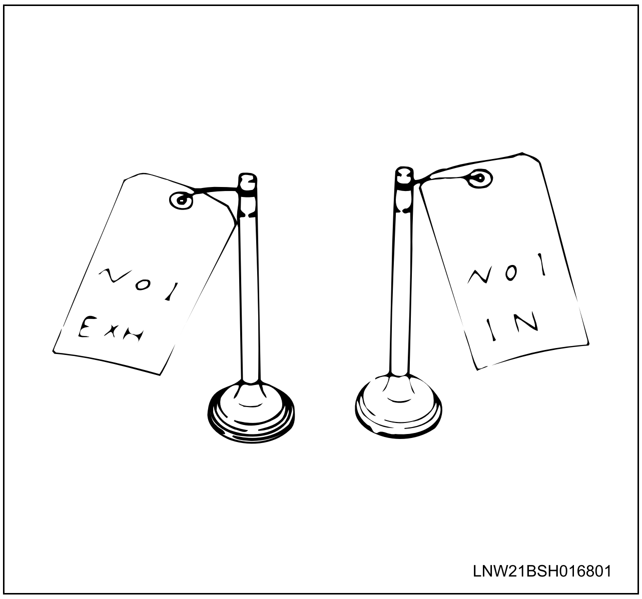
10. Remove the split collar.
11. Remove the spring upper sheet.
12. Remove the valve spring.
    - Use a replacer to compress the valve spring, then remove the split collar.

      Special tool
      Valve spring replacer: J-43263
      Pivot: EN-46721
    - Remove the special tool, then remove the upper sheet and springs.

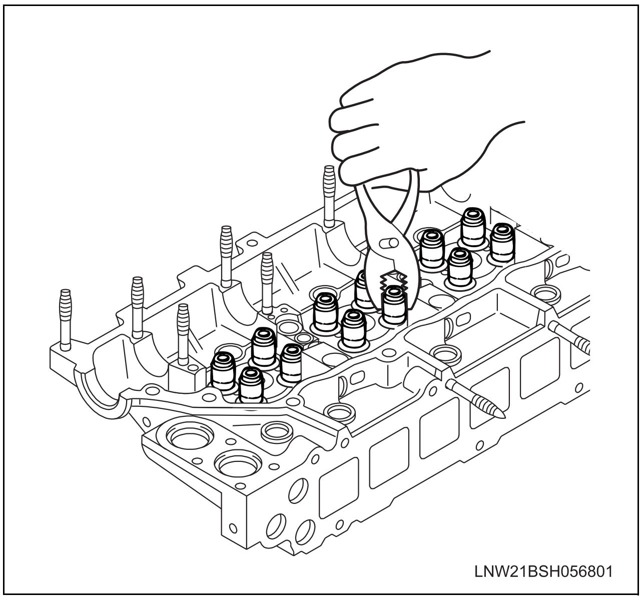
      Sort the removed valve springs by cylinder number.



13. Remove the intake and exhaust valves.
    - Sort the removed valves according to cylinders by using tags and others.



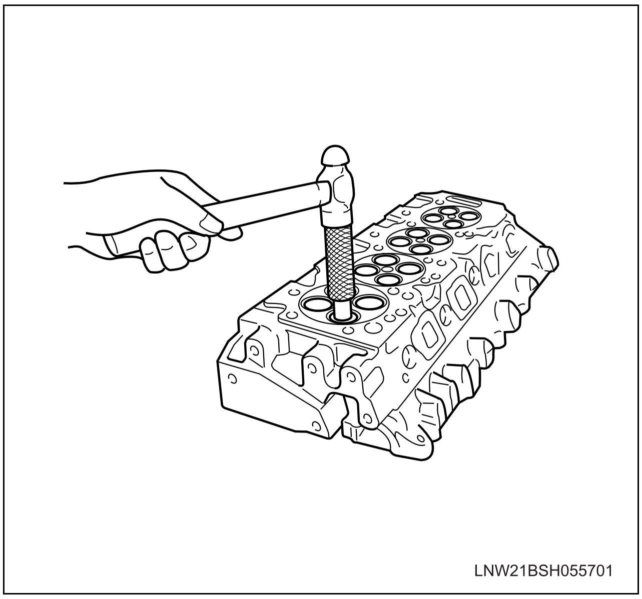
14. Remove the valve stem oil seals.
    - Use pliers to remove the oil seals.



15. Remove the valve guides.

- Use the valve guide replacer to press out the valve guides from the bottom side of the cylinder head.

  Special tool
  Valve guide replacer: J-43272

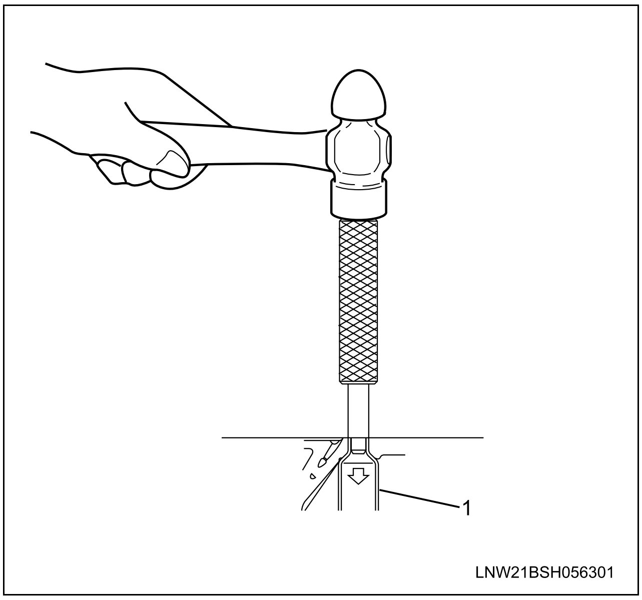


16. Put the nozzle sleeve remover on the nozzle sleeve from the bottom side of the cylinder head, then pull out the nozzle sleeve.

    Special tool
    Nozzle sleeve remover: J-43265

Caution:

- Be sure not to scratch the bottom side of the cylinder head.
- Do not reuse the removed nozzle sleeve.
- Carefully remove sawdust in the screw groove.

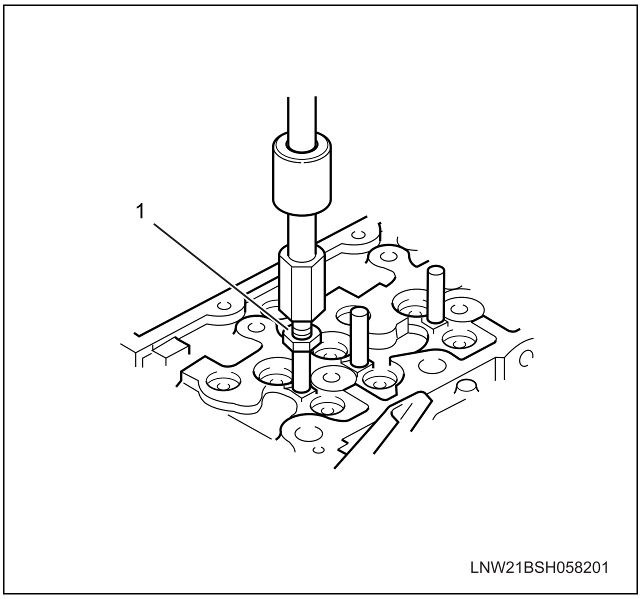


Legend

1. Nozzle Sleeve

---

17. Remove the bridge guide.
    - Electrically weld the nut on the head of the bridge guide, attach the sliding hammer and pull it out.

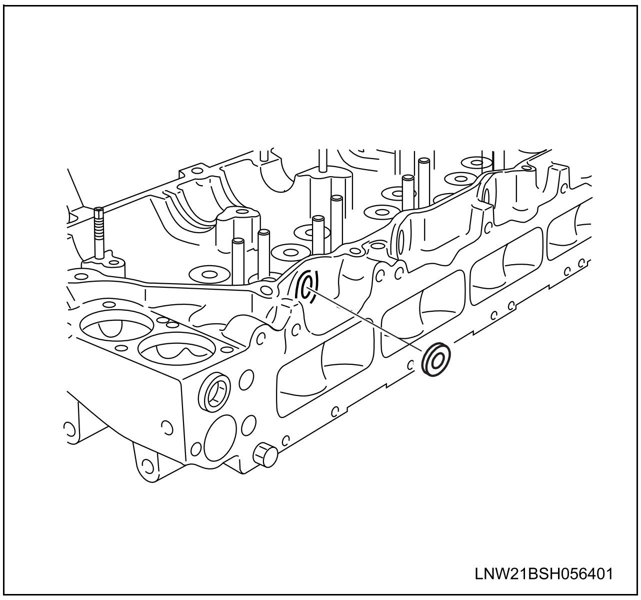


Legend

1. Nut

---

18. Remove the oil seal.
    - Press the tool against the oil seal. Strike the tool to remove the seal from the inside of the cylinder head.



Inspection

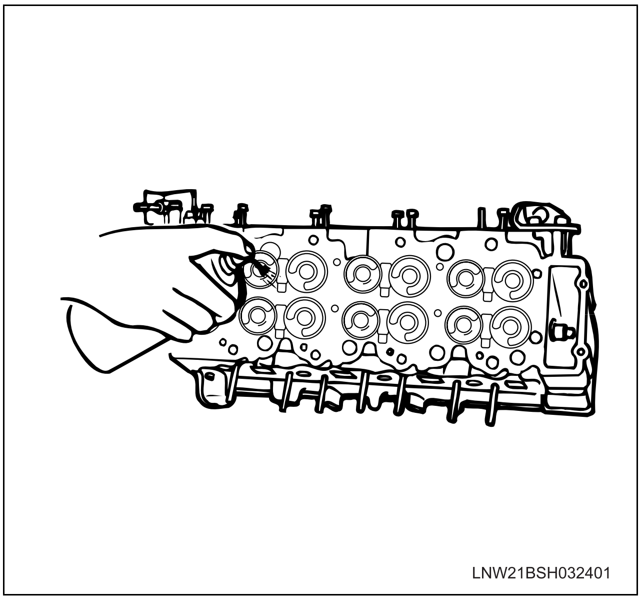
1. Inspect the cylinder head assembly.
   - Remove varnish, soot and others adhered on the metal surface completely. Use metal brush and others so that the seal surface of the surface where the gasket is installed is not hurt.
   - Check the following causes in the case of leak of the seal surface of the cylinder head, corrosion, air leak and defective gasket.

  - Defective installation.
  - Defective tightening of the cylinder head.
  - Winding seal surface of the cylinder block.

a. Damage on the screw surface or extracted cylinder head bolt due to extra tightening torque

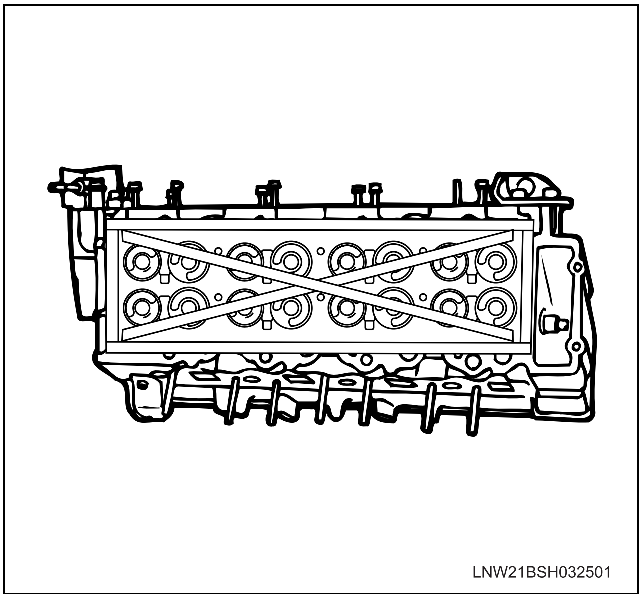
Caution:
Replace suspicious bolt.

b. Inside the combustion chamber, glow plug hole.
  - Check whether there is a crack between the valve sheets and in the cylinder head of the exhaust port part, and replace the cylinder head if there is serious damage or crack. Check the collar if necessary.


LNW21BSH032401

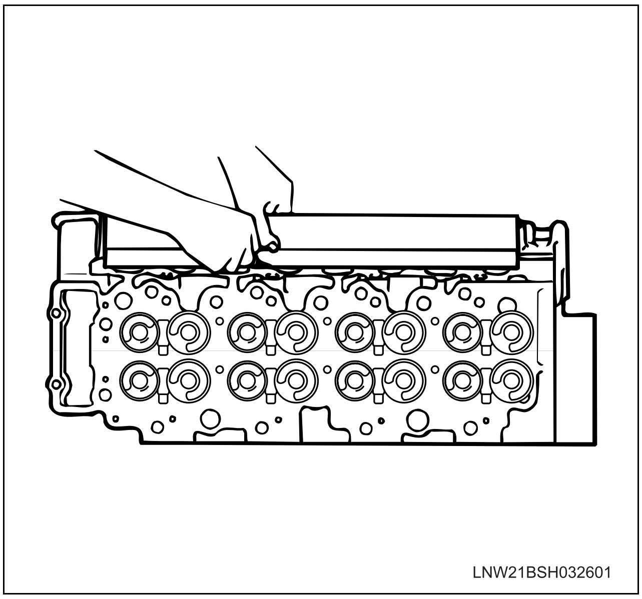
c. Flatness of the under surface of the cylinder head
  - Use a straight edge ruler and sickness gauge to measure the four sides and diagonal lines as shown in the drawing, and replace if they exceed the limit.

Distortion of the under surface of the cylinder head	mm (in)
Standard	0.05 (0.002) or less
Limit	0.20 (0.0079)


LNW21BSH032501

d. Flatness of the surface where the exhaust manifold and inlet cover are installed
  - Use a straight edge ruler and sickness gauge to measure the four sides and diagonal lines as shown in the drawing, and replace if they exceed the limit.

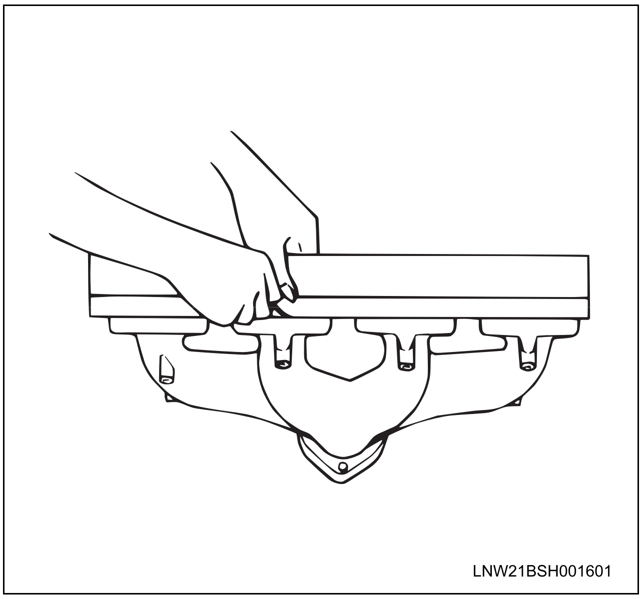
Distortion of the surface where the manifold and cover are installed	mm (in)
Standard	0.05 (0.002) or less
Limit	0.2(0.0079)


LNW21BSH032601

e. Flatness of the exhaust manifold
  - Use a straight edge ruler and sickness gauge to measure the flatness. If it exceeds the limit, replace the exhaust manifold.

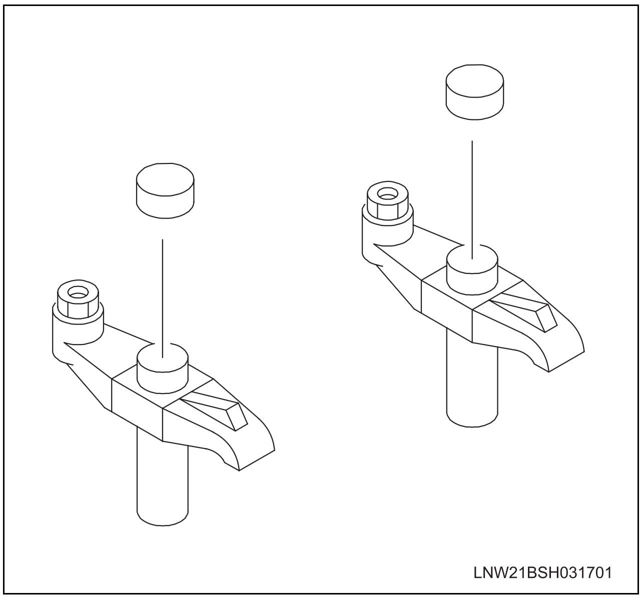
Distortion of the exhaust manifold	mm (in)
Standard	0.3 (0.0118)or less

Distortion of the exhaust manifold	mm (in)
Limit	0.5(0.0197)


LNW21BSH001601

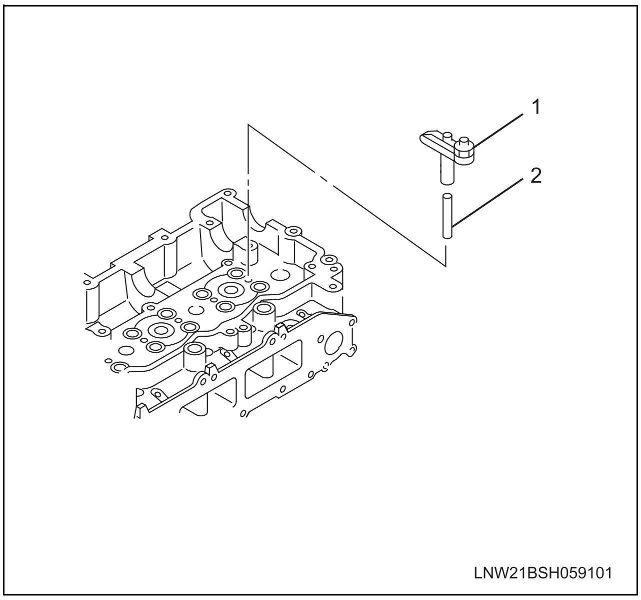
2. Bridge cap
   - Inspect abrasion and deformation of the surface where the cap and the rocker arm adjust bolt contact.
   - If the amount of abrasion is 0.1 mm (0.0039 in) or larger, or if it abrades away in a zonal shape, replace it.

Abrasion of the bridge cap	mm (in)
Limit	0.1 (0.0039)


LNW21BSH031701

3. Bridge
   - Make sure the bridge moves smoothly along the bridge guide .
   - Measure the gap between the bridge and bridge guide .

Gap	mm (in)
Assembly standard	0.020 (0.00079) ~ 0.057 (0.00224)
Usage limit	0.1 (0.0039)



LNW21BSH059101

Legend

1. Bridge
2. Bridge Guide

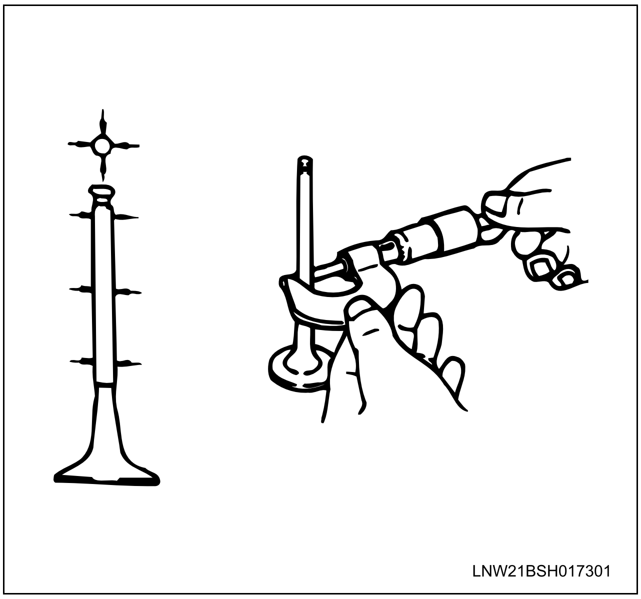
---

4. Inspect the valve guide.

Caution:
If there is a scratch or abnormal abrasion in the valve stem and the inner diameter part of the valve guide, replace it with new one along with valve guide.

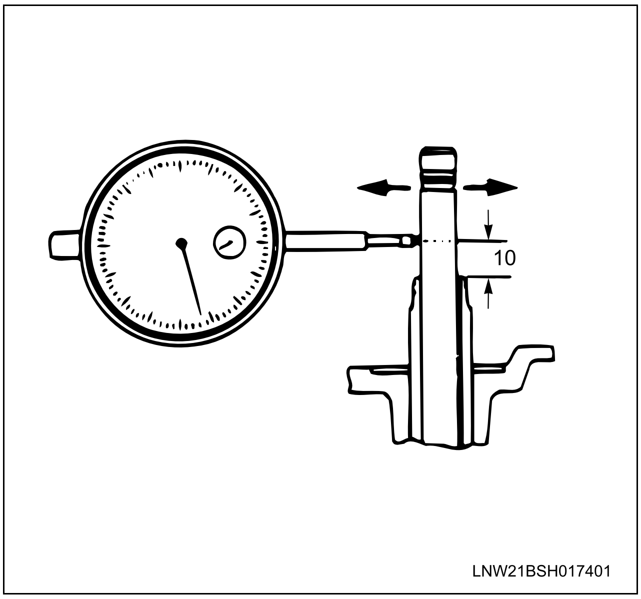
   a. Measure the valve guide clearance.
      - Measure the diameter of the valve stem with a micro meter.
        If the diameter of the valve stem is smaller than the limit, replace the valve and valve stem altogether.

The external diameter of the valve stem mm (in)		
	Standard	Limit
Intake valve	8.946 (0.3522) – 8.962 (0.3528)	8.88 (0.3496)
Exhaust valve	8.921 (0.3512) – 8.936 (0.3518)	8.80 (0.3465)



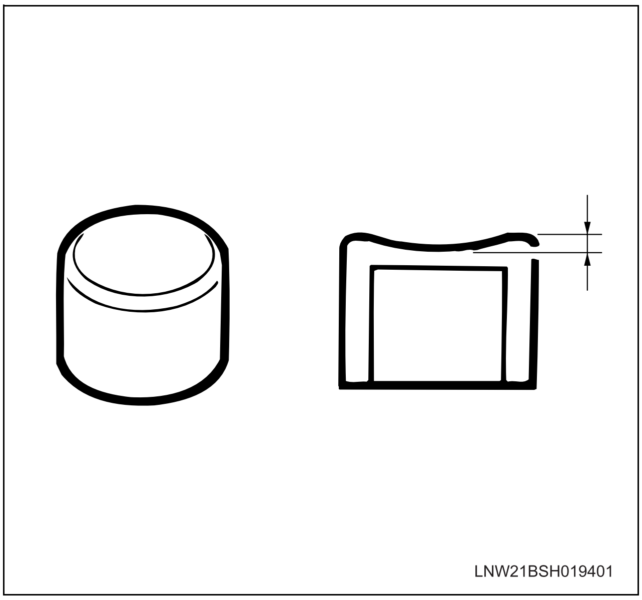
- Measure the gap between the valve guide and valve stem within 10 mm (0.39 in) from the valve guide, using a dial gauge.
- If the measured value exceeds the limit, replace the valve guide and valve altogether.

Gap between the valve guide and valve stem mm (in)		
	Standard	Limit
Intake valve	0.038 (0.00150) – 0.071 (0.00280)	0.20 (0.00787)
Exhaust valve	0.064 (0.00252) – 0.096 (0.00378)	0.25 (0.00984)



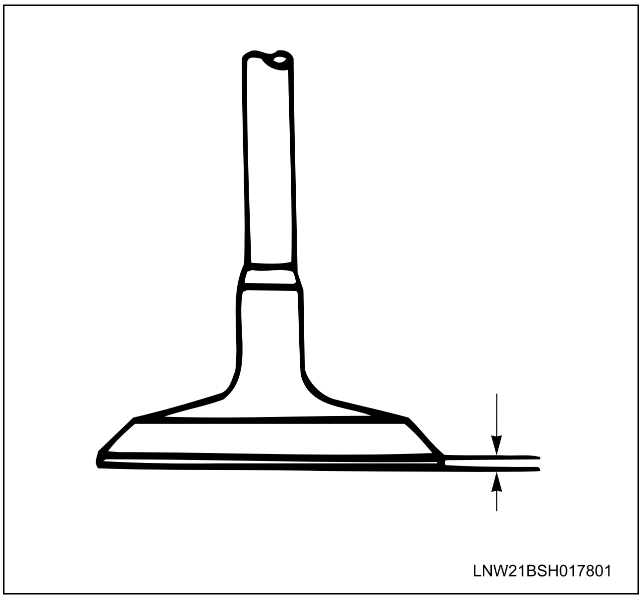
5. Inspect abrasion of the bridge gap.
   - Measure the contact surface of bridge cap and the rocker arm, using a dial gauge.
   - If the abrasion exceeds the limit, or there is an abnormal abrasion (zonal abrasion), replace the bridge cap.

Abrasion of the bridge cap mm (in)	
Limit	0.1 (0.00394)



6. Inspect the valve.
   Thickness of the valve
   - Measure the thickness of the valve.
   - If the measured value exceeds the limit, replace the valve and valve guide altogether.

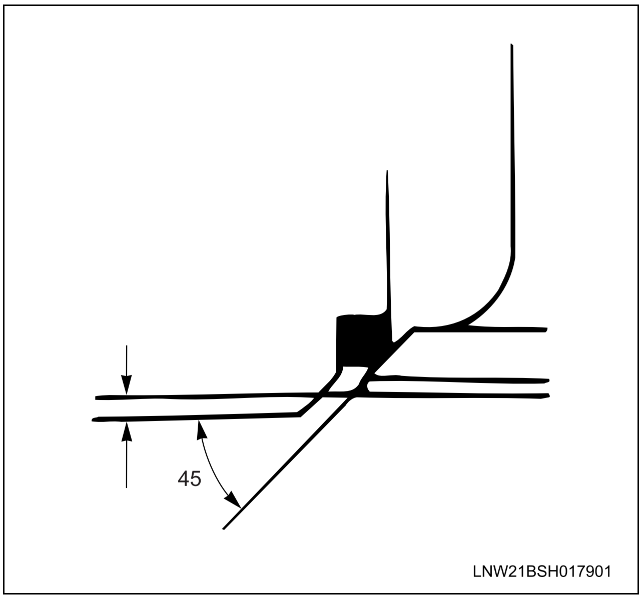
Thickness of the valve mm (in)		
	Standard	Limit
Intake valve	1.8 (0.0709)	1.3 (0.0512)
Exhaust valve	1.75 (0.0689)	1.3 (0.0512)



Valve sheet

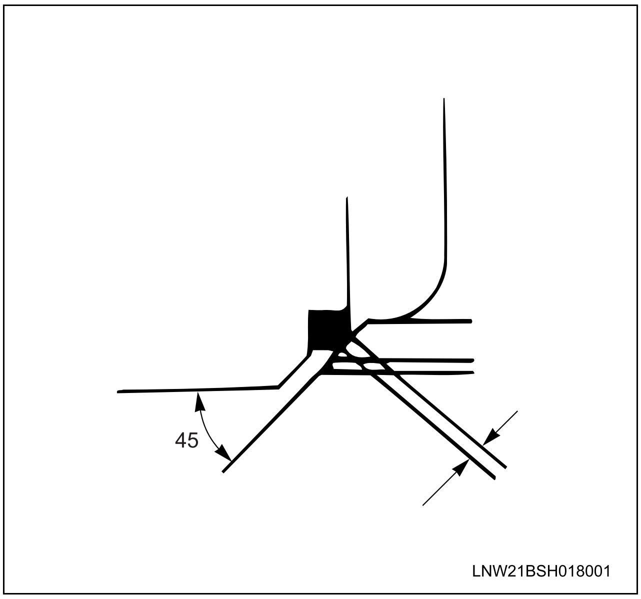
- Remove carbon, water stain and others on the under surface of the cylinder head.
  Install the valve in the cylinder head.
  Measure the depth of the valve from the under surface of the cylinder head, using a depth gauge or straight edge ruler.
  If it exceeds the limit, replace the valve insert or cylinder head assembly.

Depth of the valve	mm (in)
Standard	0.7 (0.0276) ~ 1.2 (0.0472)
Limit	2.5 (0.0984)



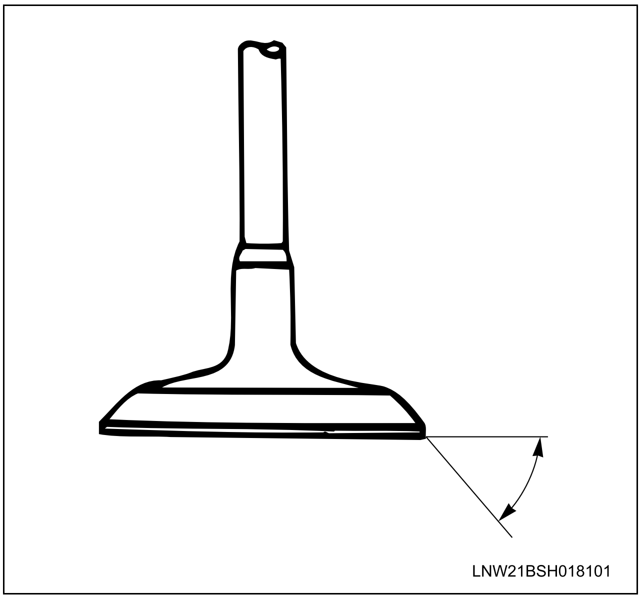
- Measure the contact width of the valve seat. If the seat contact surface has a scratch or is rough, or if the abrasion of the contact surface exceeds the limit, modify or replace it.

Contact width of the valve seat		mm (in)
	Standard	Limit
Intake valve	2.5 (0.0984)	3.0 (0.1181)
Exhaust valve	2.0 (0.0787)	2.5 (0.0984)



Contact surface of the valve seat

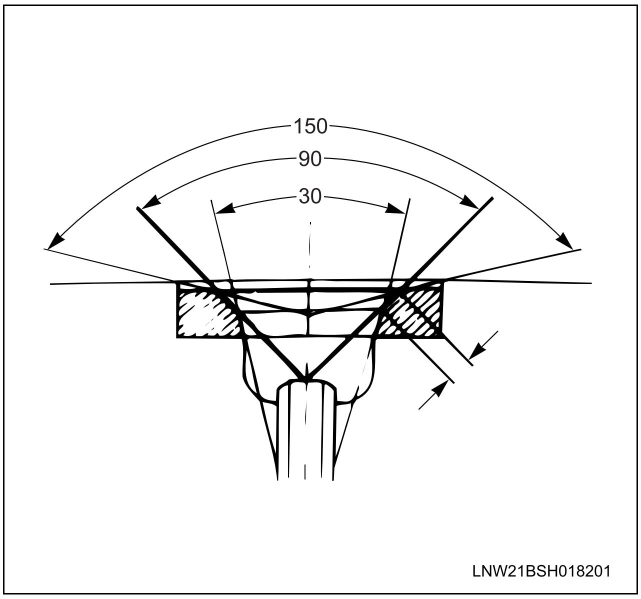
- If the contact surface of the valve seat is defective, modify it or replace the valve, valve guide and valve seat altogether.
  Angle of the contact surface: 45° (degrees)



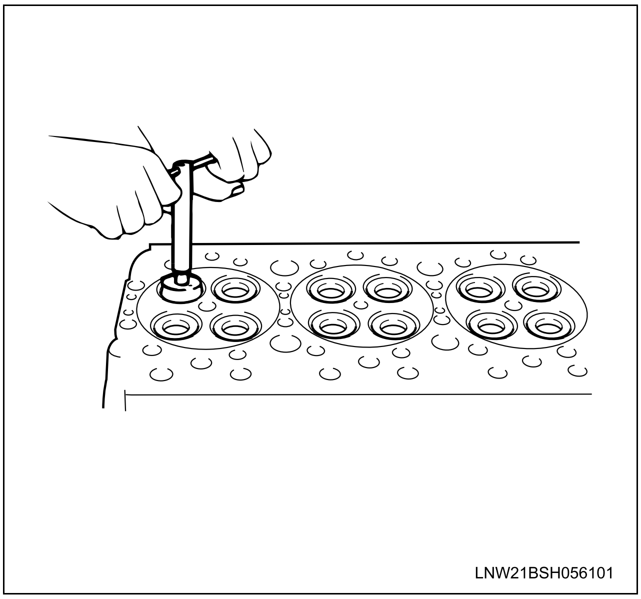
Repair of the seat surface

- Remove carbon from the surface of the valve insert seat.

- Use a seat cutter to minimize the scratch and other roughness (15/45/75 degree-blade), thereby returning the contact width to the standard value.

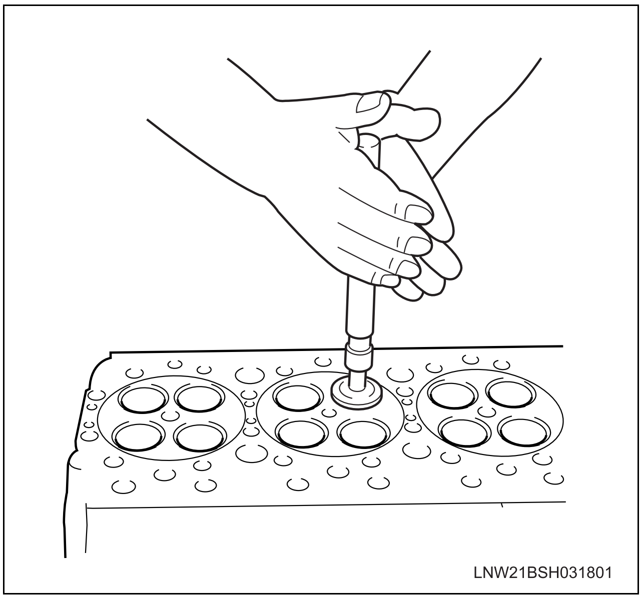


Caution:
Remove only scratches and roughness, and do not cut the surface too much.
Use the free adjustment valve cutter pilot.
Do not let the valve cutter pilot waver inside the valve guide.



- Attach compound in the valve insert seat.
- Insert the valve into the valve guide.
- Attach compound on the valve seat surface, rotate the valve and hit it lightly to grind them, and confirm that it has even contact all round.

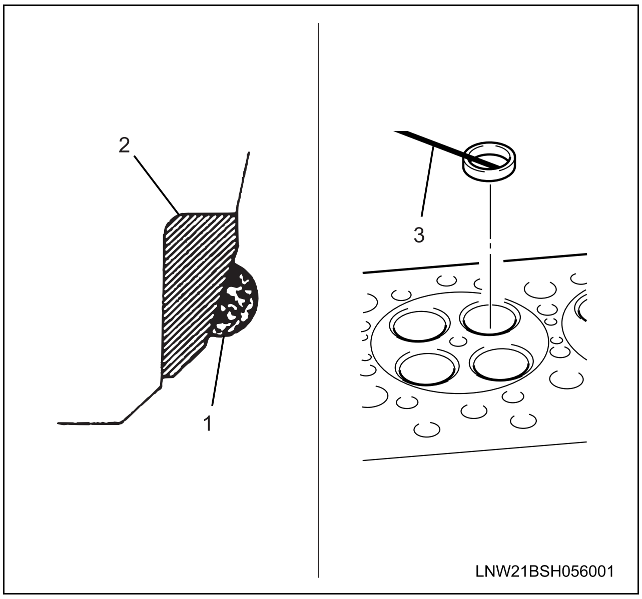
Caution:
Remove compound completely after grinding.



Replace the valve seat insert

Remove the valve seat insert

- Arc-weld the entire inner diameter of the valve seat insert.
- Cool the valve seat insert for two to three minutes. Contraction fur to cooling makes it easier to remove the valve seat insert.
- Remove the valve seat insert, using a screw driver . Be sure not to hurt the cylinder head.



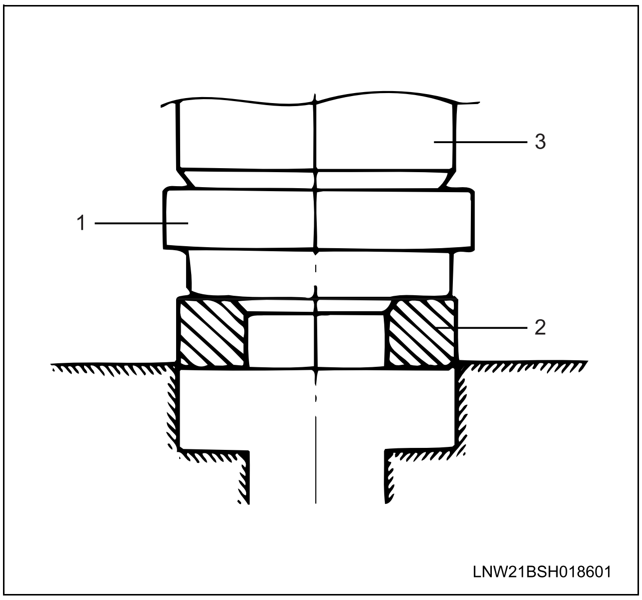
Legend

1. Arc-Weld
2. Valve Seat Insert
3. Screw Driver

Install the valve seat insert

- Carefully place a washer (the outer diameter is smaller than the valve seat insert) on the valve seat insert.
- Use the press to apply pressure gradually on the washer, thereby pushing the valve seat insert.

Caution:
Do not apply too much pressure with the press.
Attach compound on the valve seat surface, rotate the valve and hit it lightly to grind them, and confirm that it has even contact all round.



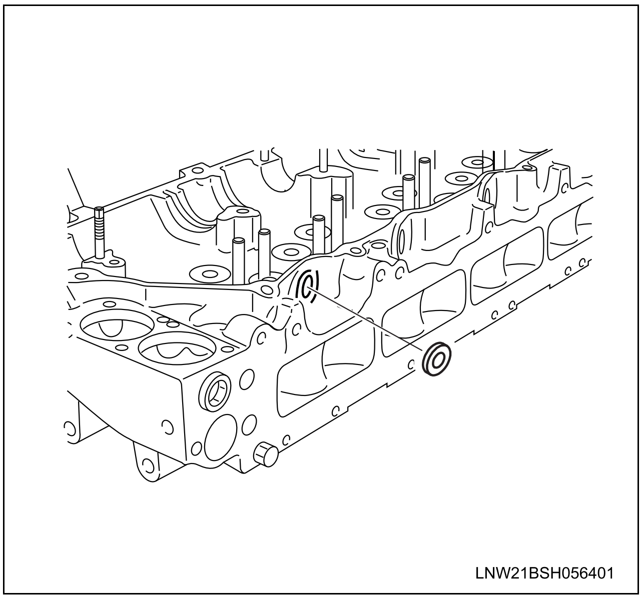
Legend
1. Press
2. Attach Compound
3. Valve Seat

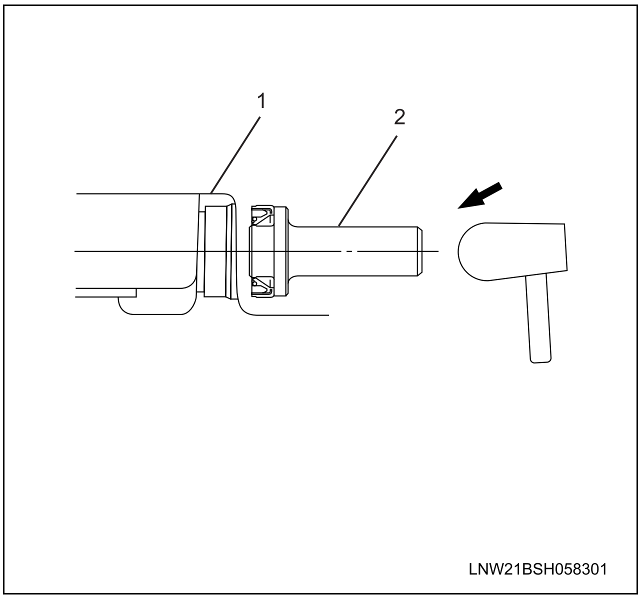
Reassembly

1. Install the oil seal.
    - Install on the surface of injection pipe insert.
    - Hammer it in so that the seal does not incline.

Caution:
Be sure not to hurt the rip.

Special tool
Oil seal installer: J-43269

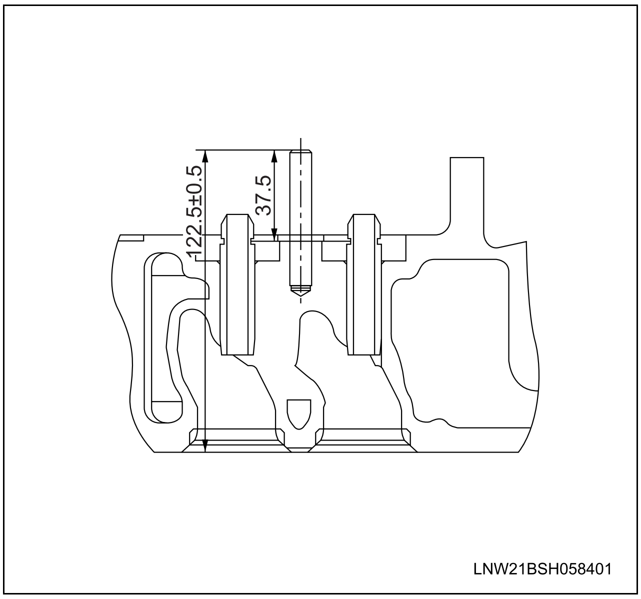




Legend
1. Cylinder Head
2. Oil Seal Installer

2. Install the bridge guide.
    - Apply engine oil on the outer diameter of the guide, then use the installer to hammer it into the depth of the finishing part of the hole of the cylinder head.
      (Note: the height of the bridge guide is about 37.5 mm (1.48 in) from the upper surface of the head)

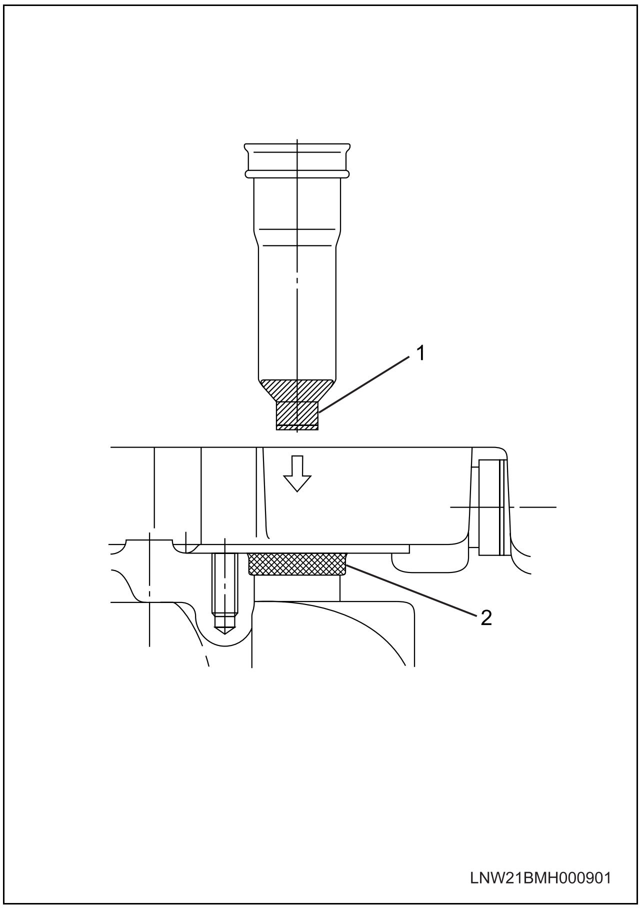
      Special tool
      Bridge guide installer: J-43268
      Engine oil



3. Nozzle sleeve
    - Install the O-ring on the nozzle sleeve, apply engine oil.

- Apply seal material on the taper section.

  Loctite No.TL620



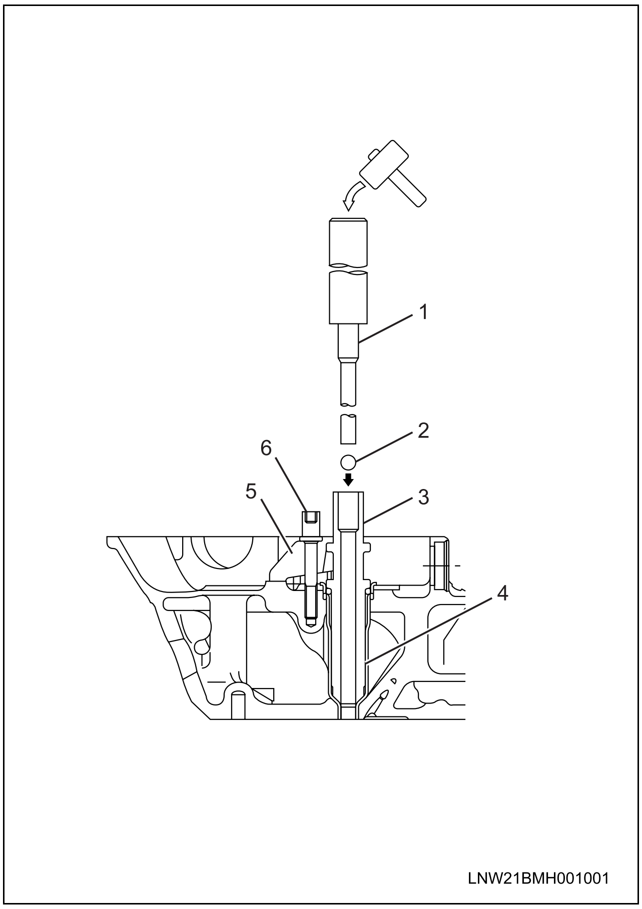
Legend
1. Apply Seal Material
2. O-Ring

- Install the nozzle sleeve on the cylinder head, insert the guide sleeve.
- Use the guide sleeve to push in so that the nozzle sleeve fully contacts with the under surface of the cylinder head.
- Insert the sleeve and fix it with the tighten and bolt.
- Insert the ball (bearing steel ball 9.525 mm 0.375 in) into the guide sleeve, attach the punch bar and hammer out the ball.

Caution:

- Leave the cylinder head floating so that the ball comes off from the under surface.

Special tool
Nozzle sleeve installer: J-43266



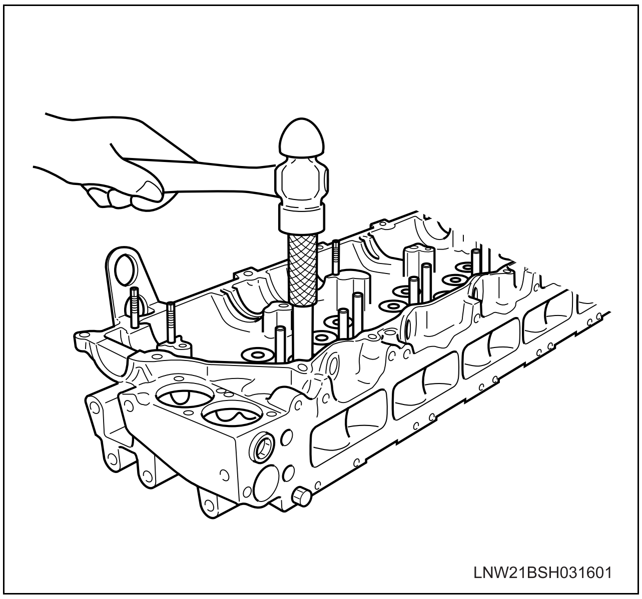
Legend
1. Punch Bar
2. Ball
3. Guide Sleeve
4. Nozzle Sleeve
5. Bracket
6. Bolt

---

4. Install the valve guide.

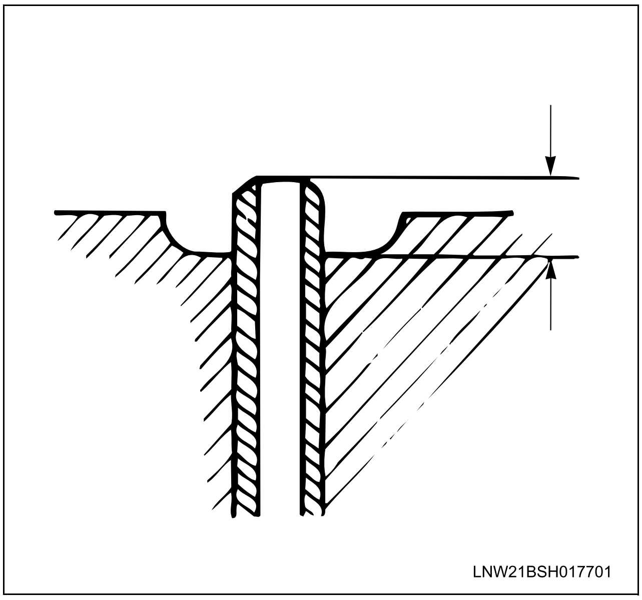
- Hammer in the valve guide from the upper surface of the cylinder head, using the valve guide replacer.

  Special tool
  Valve guide replacer: J-43272



Height from the upper surface of the cylinder head to the edge surface of the valve guide: 13.9 mm (0.5472 in) – 14.3 mm (0.5630 in)

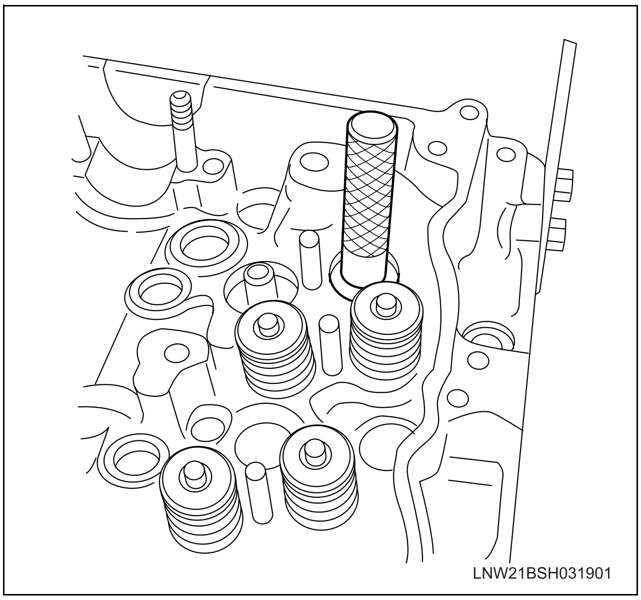
Caution:
When replacing the valve guide, it must be replaced together with the valve.



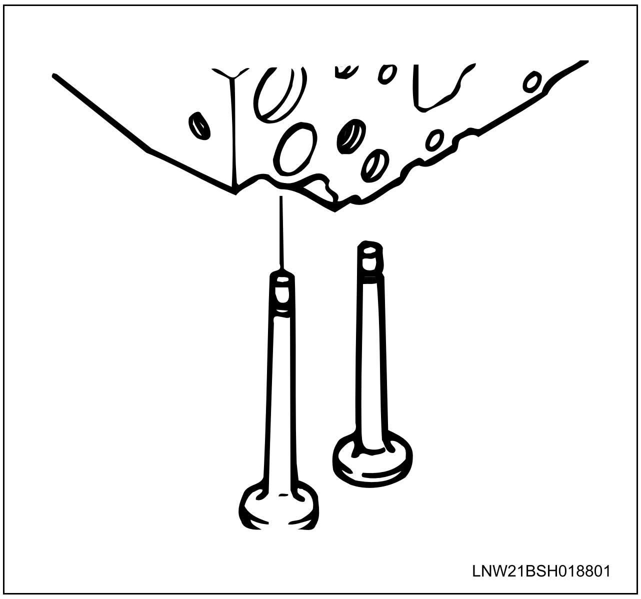
5. Install the valve stem oil seal.
   - Apply engine oil on the outer diameter of the valve guide, use the valve stem seal installer to install the oil seal.

Caution:
After installation of the valve stem seal, confirm that the oil seal is not inclining and the garter spring is in place.

Special tool
Valve stem seal installer: EN-47685

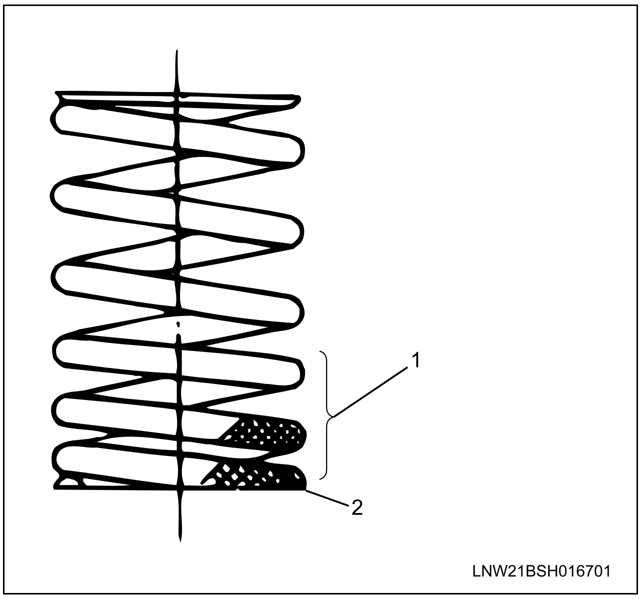


6. Install the intake and exhaust valves.
   - Apply engine oil on the valve stem part and install the valve.



7. Install the valve spring.
   - Install the valve spring with the paint mark or the narrower side of the spring pitch on the under side (the cylinder head side).

	Paint mark
Intake side	Orange
Exhaust side	Red



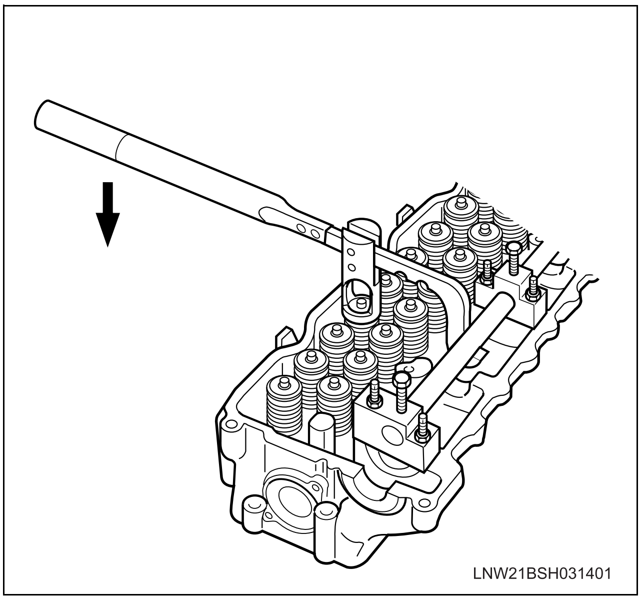
Legend

1. Spring Pitch
2. Paint Mark

---

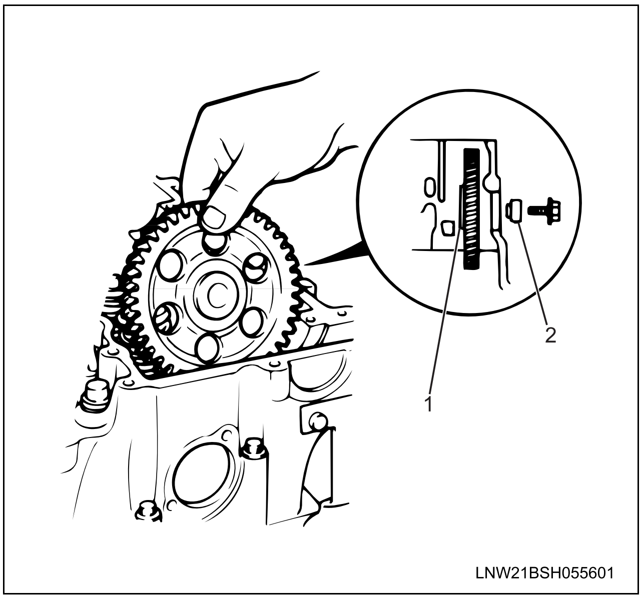
8. Install the spring upper sheet.
9. Install the split collar.
   - Use the replacer to compress the valve spring and install the split collar.

     Special tool
     Valve spring replacer: J-43263
     Pivot: EN-46721



10. Install the idle gear C.
    - Apply engine oil on the idle gear C shaft and the inner diameter of the idle gear, install the idle gear C so that the side with gear groove is on the side of the rear surface of the engine.
    - Tighten the idle gear C with the designated torque.
    - Do not use impact wrench and like.

Tightening torque: 95 N·m (70 lb ft)



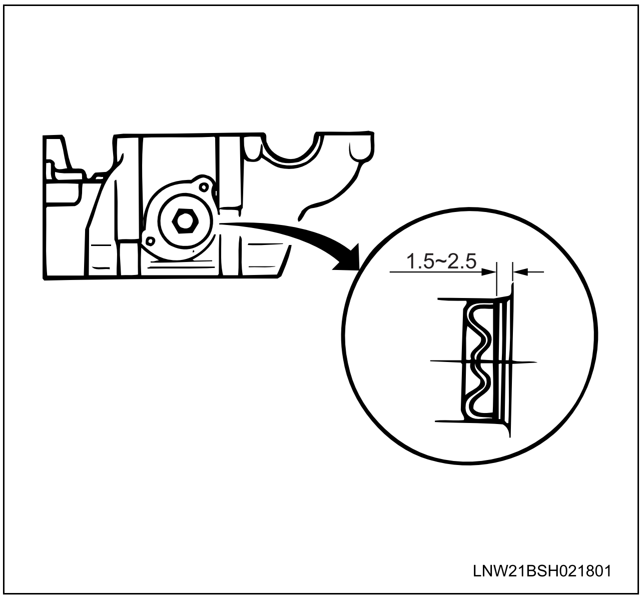
Legend

1. Idle Gear C
2. Shaft

---

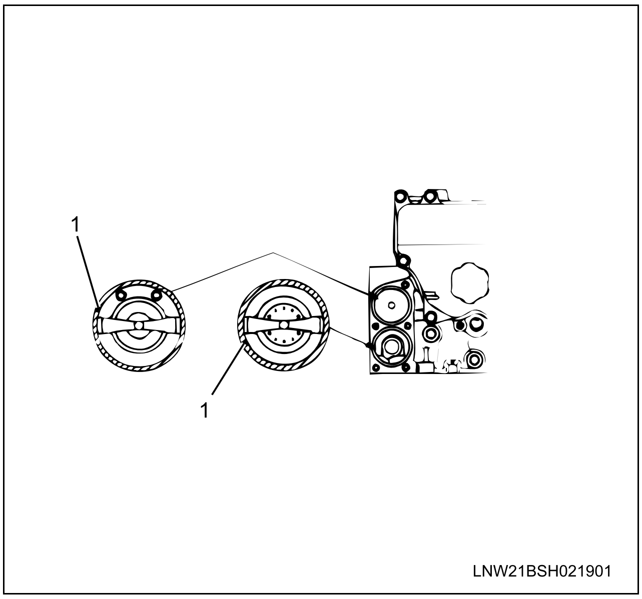
11. Install the idle gear C cover.
    - Apply liquid gasket (Loctite 262) on the outer diameter of the idle gear C cover, use the sealing cup setting tool to hammer it in so that the measurements follow the drawing.

      Special tool
      Sealing cup installer: EN-47690



12. Install the thermostat.

- Install the thermostat on the position shown in the drawing.



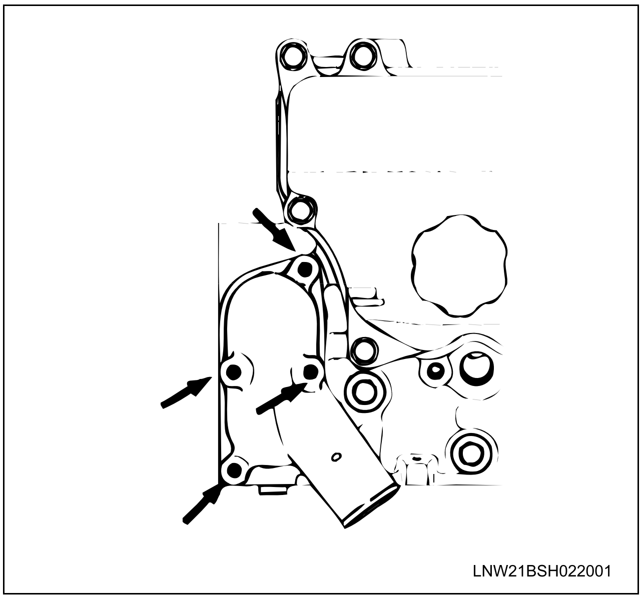
Legend

1. Thermostat

---

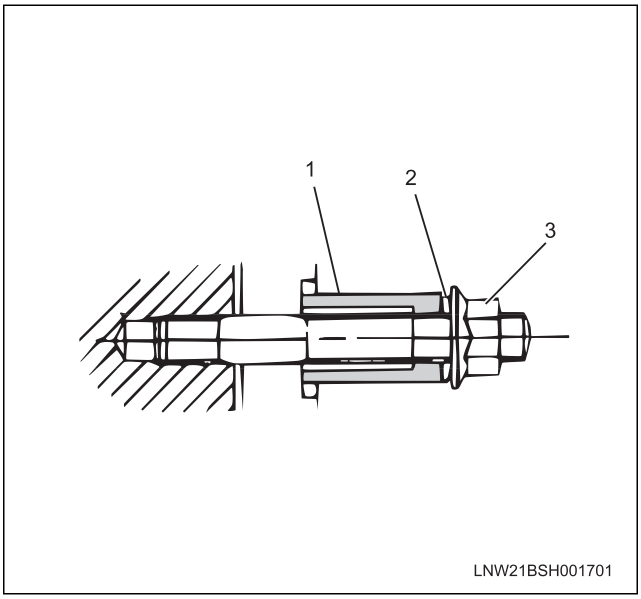
13. Install the water outlet pipe.
    - Tighten the water outlet pipe with the designated torque.

Tightening torque: 24 N·m (18 lb ft)



14. Install the exhaust gasket.
15. Install the exhaust manifold.

- Install the distance tube conical spring and the nut on the stud of the cylinder head in this order.



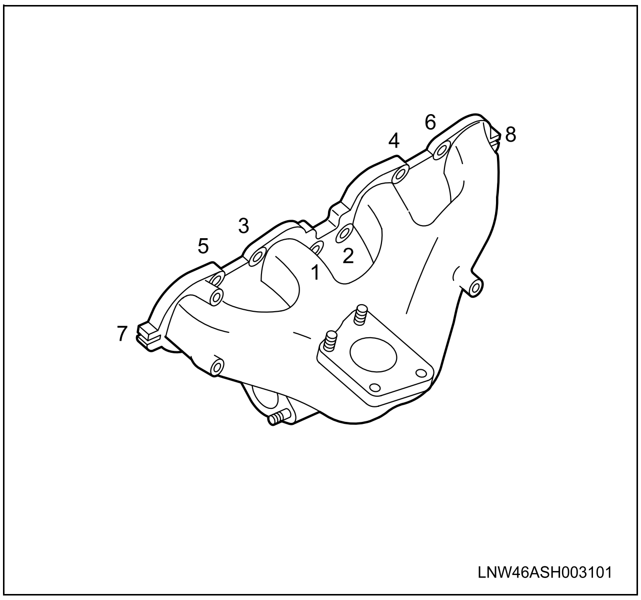
Legend

1. Distance Tube
2. Conical Spring
3. Nut

- Tighten the exhaust manifold in the order described in the drawing.

Bolt (1),(2),(3),(4),(5),(6) Nut (7),(8)
Tightening torque: 34 N·m (25 lb ft)

Caution:
Do not tighten it too much so that it hinders extraction and contraction of the manifold due to heat.

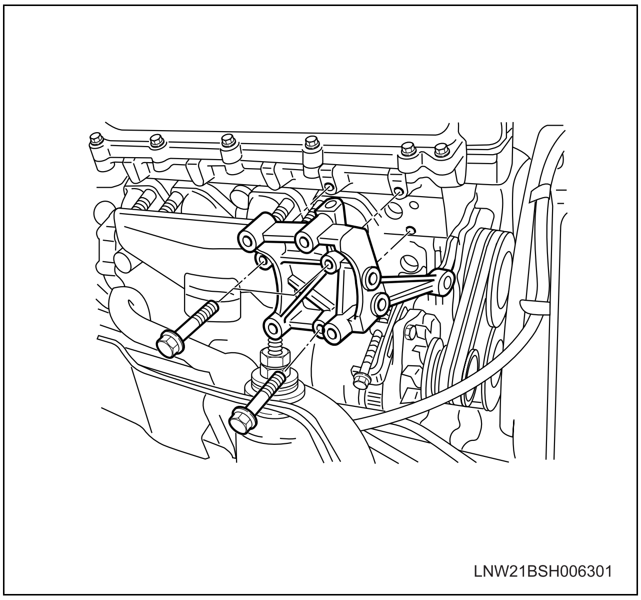


- Install the heat protector.

Tightening torque: 10 N·m (87 lb in)

16. A/C compressor bracket .
    Install the bracket, tighten the bolt with the designated torque.

Tighteningtorque: 48 N·m (35 lb ft)

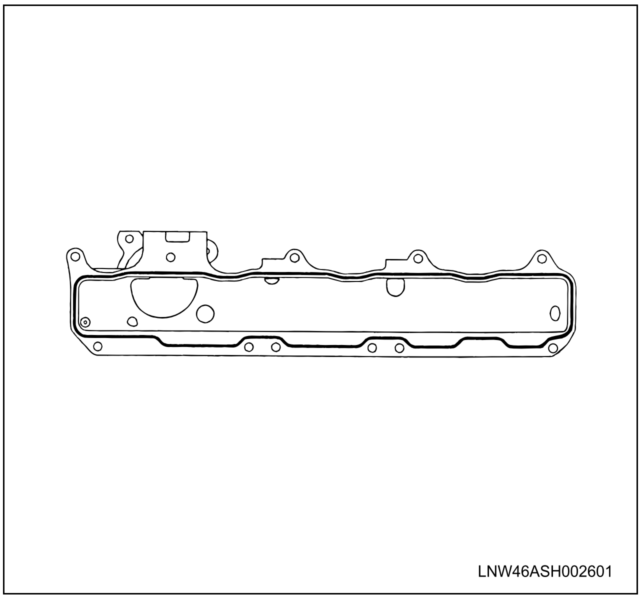

LNW21BSH006301

Legend

1. A/C Compressor Bracket

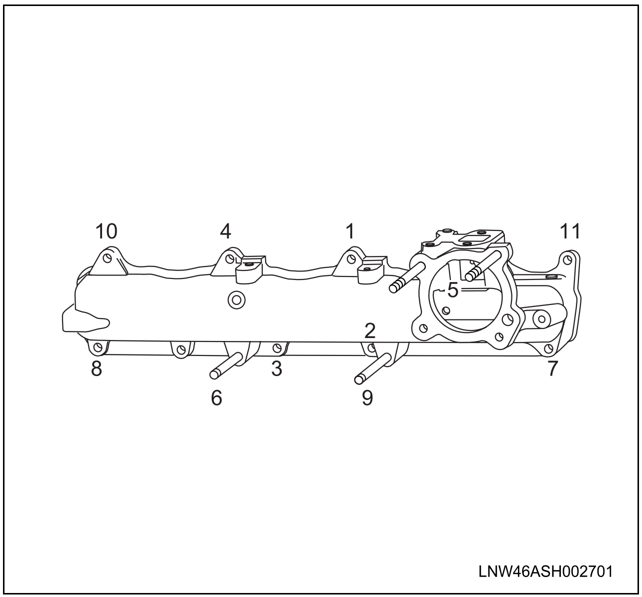
---

17. Install the inlet cover.
    - Apply liquid gasket (TreeBond1207C or equivalent) in accordance with the groove of the inlet cover, with the bead diameter of ϕ2.5 mm (0.0984 in) ~ 5.5 mm (0.2165 in).


LNW46ASH002601

- Tighten in the order described in the drawing.
- Tighten the stud bolts (6) and (9) jointly with the fuel rail.

Tightening torque: 22 N·m (16 lb ft)

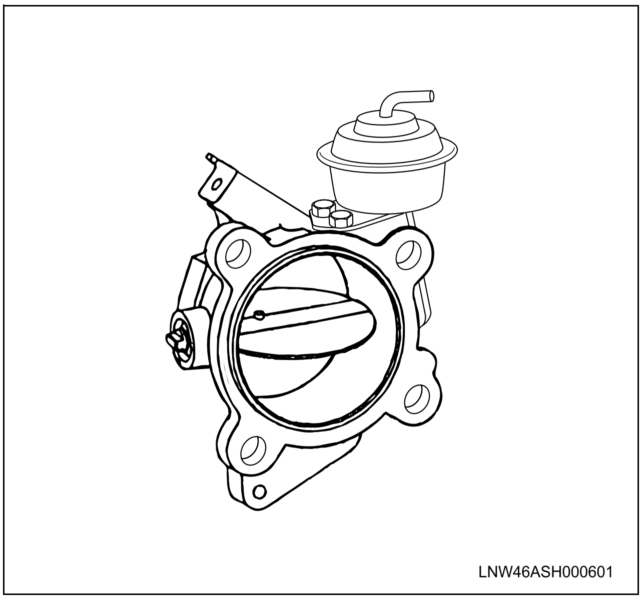


LNW46ASH002701

18. Install the throttle assembly.
    - Coat the fluid gasket and mount within 7 minutes.

Tightening torque: 24 N·m (18 lb ft)

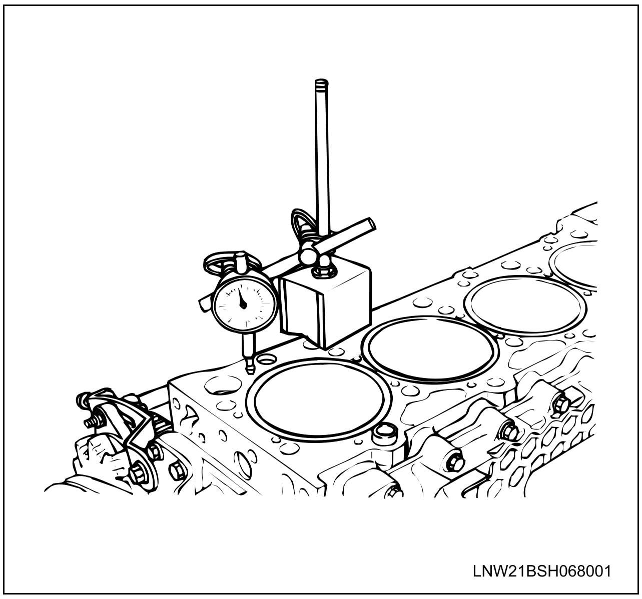
- Install the intake throttle valve connector.


LNW46ASH000601

Installation

1. Install the cylinder head gasket.
    - Select the cylinder head gasket.
    - Clean the head of the piston and the upper surface of the cylinder block.
    - Use a dial gauge to measure the extrusion of the piston. Measure at two points of each cylinder.

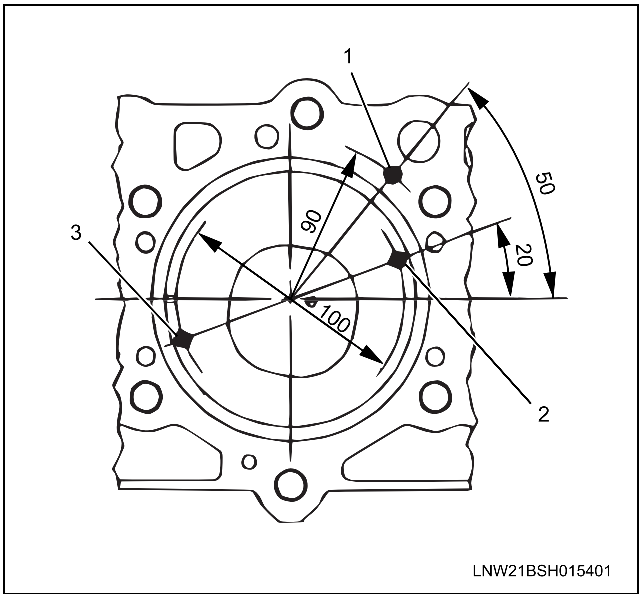
- The following drawing shows the measurement points and the standard point of the cylinder block.


LNW21BSH068001

Measurement points:	Head of the piston	(2) and (3)
Standard point:	Upper surface of the cylinder block	(1)

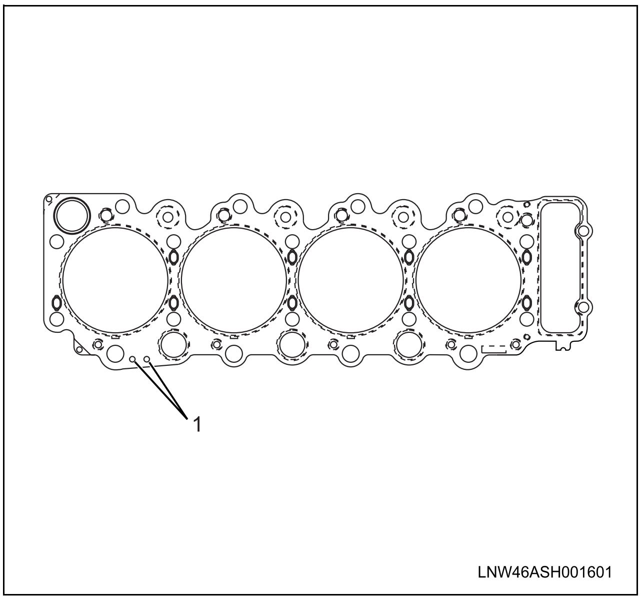
Caution:
Note that there are three options for the head gasket according to the amount of extrusion of piston shown in the following table.

- Calculate the average piston extrusion amount of each cylinder.
- Calculate the maximum amount of the average amount of each cylinder.
- Select a gasket of an appropriate grade based on Timax.



LNW21BSH015401

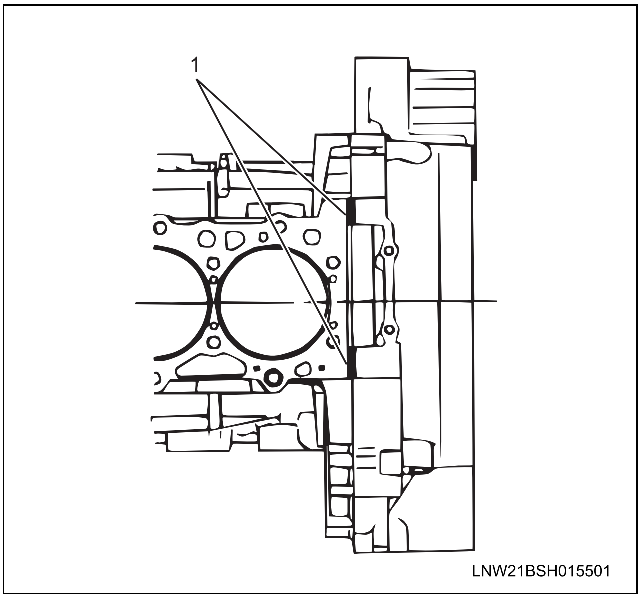
Gasket Grade	Recognized by	Piston extrusion amount mm (in)
A	(no hole)	0.539 (0.2122) ~ 0.618 (0.02433)
B	(1 hole)	0.619 (0.02437) ~ 0.698 (0.02748)
C	(2 holes)	0.699 (0.02752) ~ 0.779 (0.03067)



LNW46ASH001601

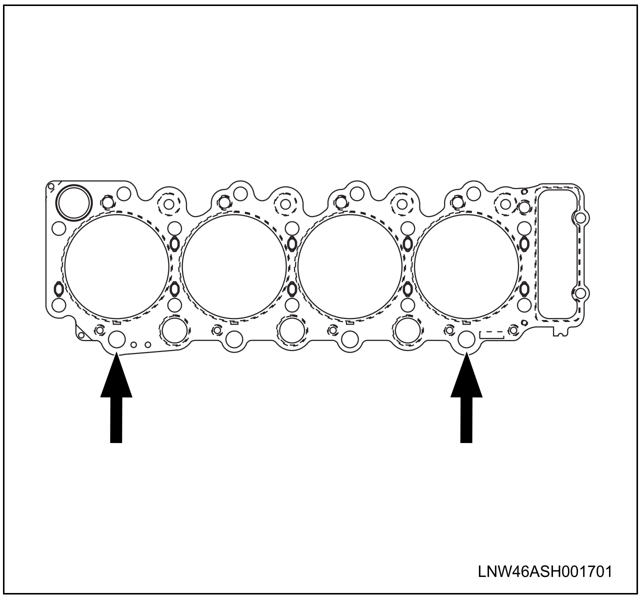
Legend
1. Grade Recognition Hole

- Apply liquid gasket
- Apply liquid gasket (TreeBond 1207C or equivalent) on the joint (1) of the cylinder block and the flywheel housing with the bead diameter of 3 mm (0.118 in).
- Install the cylinder head within seven minutes after applying liquid gasket.



LNW21BSH015501

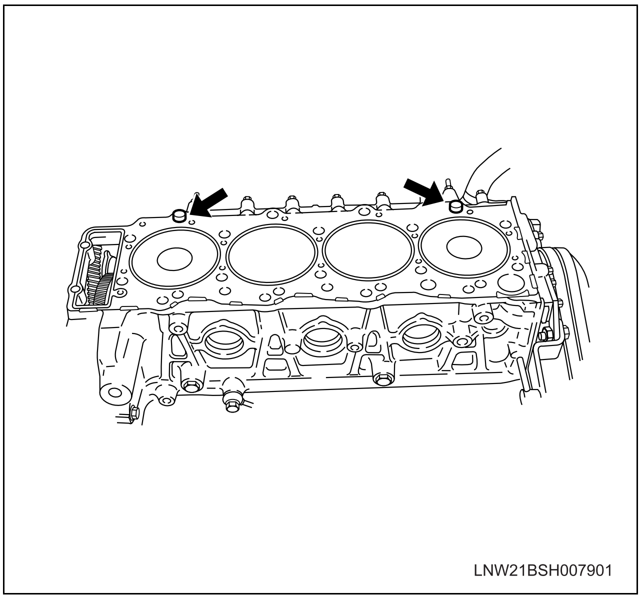
- Install the cylinder head gasket.
- Install the cylinder head gasket with the parts number upside, along with the cylinder head rear gear case and dowel.



LNW46ASH001701

2. Install the cylinder head assembly.
   - Install the cylinder head, adjusting the dowel of the cylinder block.

Caution:
Be sure not to hurt the head gasket when installing it.

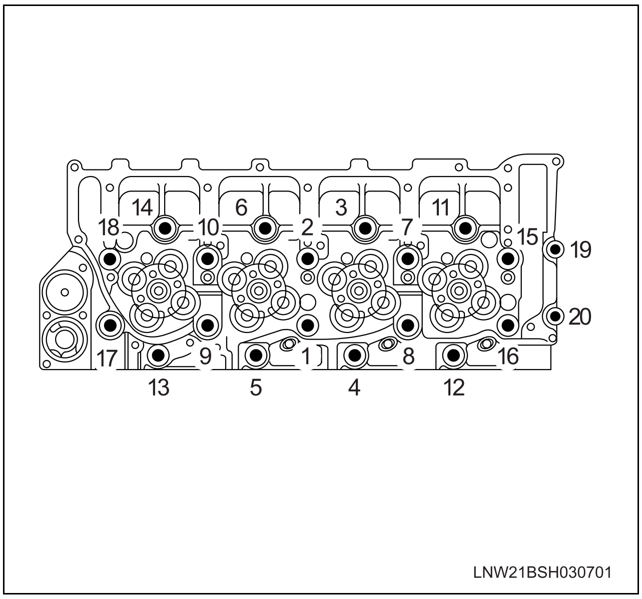


LNW21BSH007901

- Apply molybdenum disulfide on the screw part and setting face of the head bolt of M14, and apply engine oil on the screw part and setting face of the head bolt of M10.
- Use a torque wrench and angle gauge to tighten the head bolts in the order described in the drawing.

Tightening torque:
M14 bolts (1~18)
1st step= 98 N·m (72 lb ft)
2nd step= 147 N·m (108 lb ft)
3rd step= 30°~60° (degrees)
M10 bolts (19, 20)
4th step= 38 N·m (28 lb ft)
Use a stud bolt for (16)

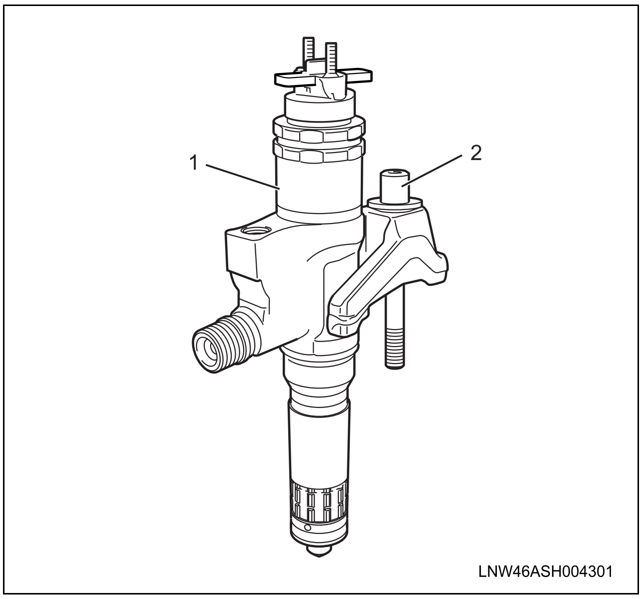
Special tool
Angle gauge: J-45059



LNW21BSH030701

3. Install the fuel injector on the cylinder head.
4. Apply molybdenum disulfide on the screw part and setting face of the fuel injector tighten bolt and tighten it tentatively.

Important:
Reinstall each fuel injector to the original cylinder from which it was removed during the disassembly procedure.



Legend

1. Fuel Injector Assembly
2. Fuel Injector Tighten Bolt

---

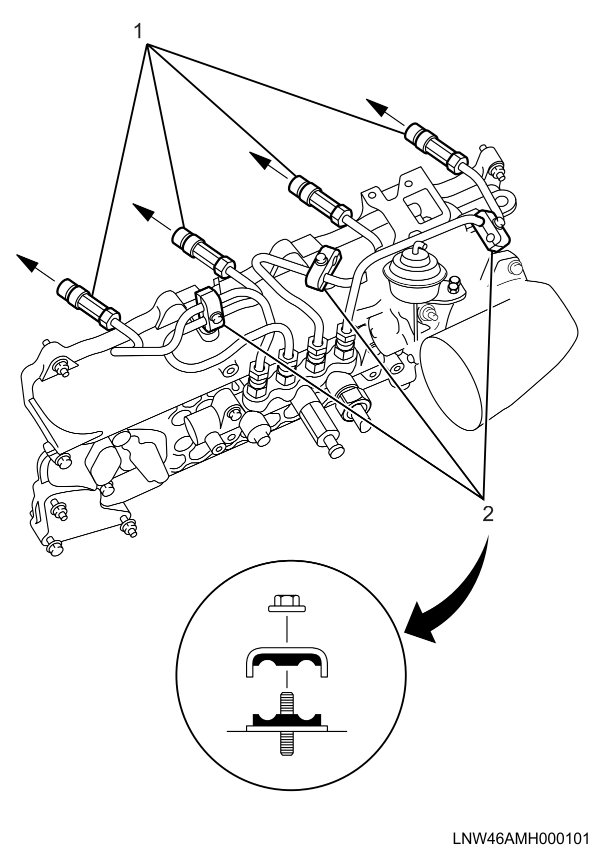
5. Install the fuel rail.

Tightening torque: 19 N·m (14 lb ft)

- Install the fuel rail pressure sensor.

6. Install the injection pipe.
   - Apply a thin coat of engine oil on the outer diameter of the sleeve nut on the side of the fuel injector and install the injection pipe.
   - Use a spanner to tighten the sleeve nut until it completely contacts both on the fuel injector and fuel rail.
   - Tighten the injection pipe clip with the designated torque.

Tightening torque: 6 N·m (52 lb in)



Legend

1. Fuel Injection Pipe
2. Fuel Injection Pipe Clip

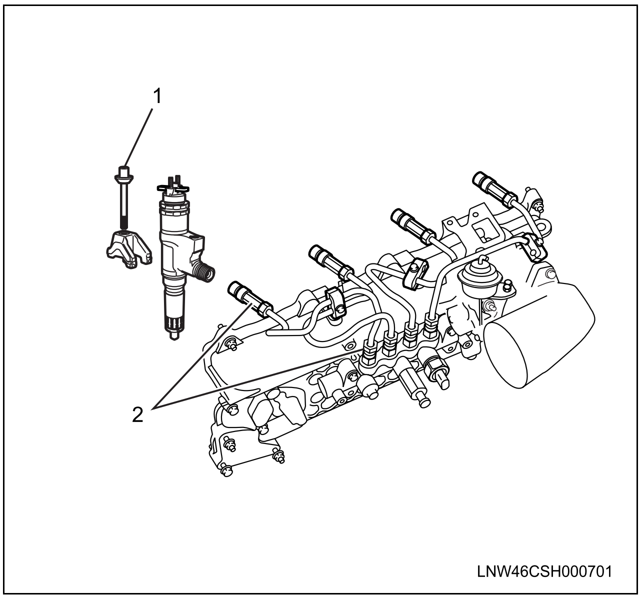
---

7. Final tighten the injection clamp bolts to the specified torque.

Tightening torque: 30 N·m (22 lb ft)

8. Tighten the injection pipes to the specified torque.

Tightening torque: 44 N·m (32 lb ft)



Legend

1. Injection Clamp Bolt
2. Injection Pipe Sleeve Nut

9. Install the glow plug.

Tightening torque: 20 N·m (15 lb ft)

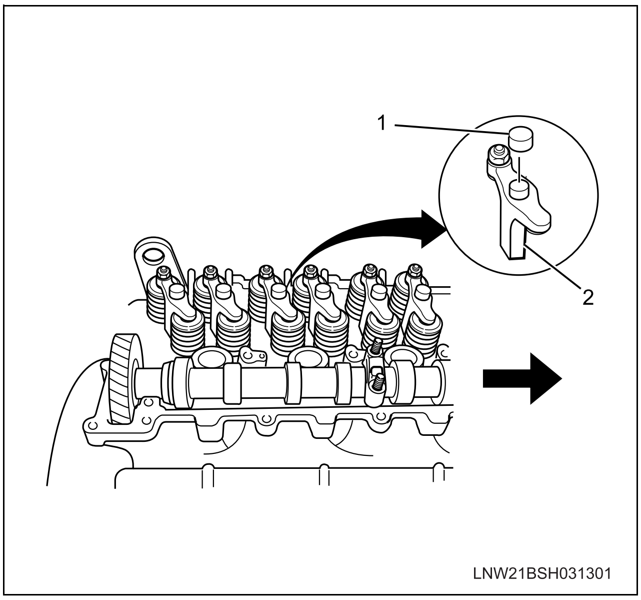
10. Install and tighten the glow connector with the designated torque.

Tightening torque: 1.2 N·m (10.5 lb in)

11. Apply engine oil on the bridge, install it.

Caution:
Move it up and down to confirm that it moves smoothly.

12. Apply a thin coat of engine oil inside the bridge cap, install it.

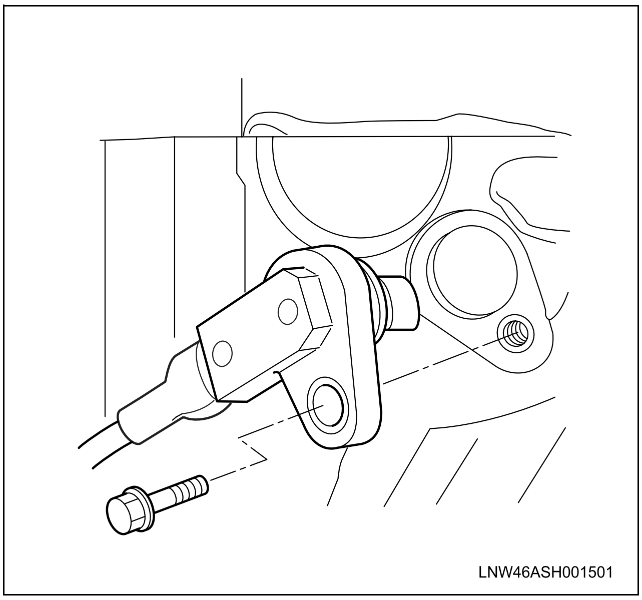


Legend

1. Bridge Cap
2. Bridge

13. Install the camshaft assembly.
    Refer to the “camshaft assembly”.
14. Install the rocker arm shaft assembly.
    Refer to the “rocker arm shaft assembly”.
15. Install and tighten the camshaft speed sensor with the designated torque.

Tightening torque: 8 N·m (69 lb in)

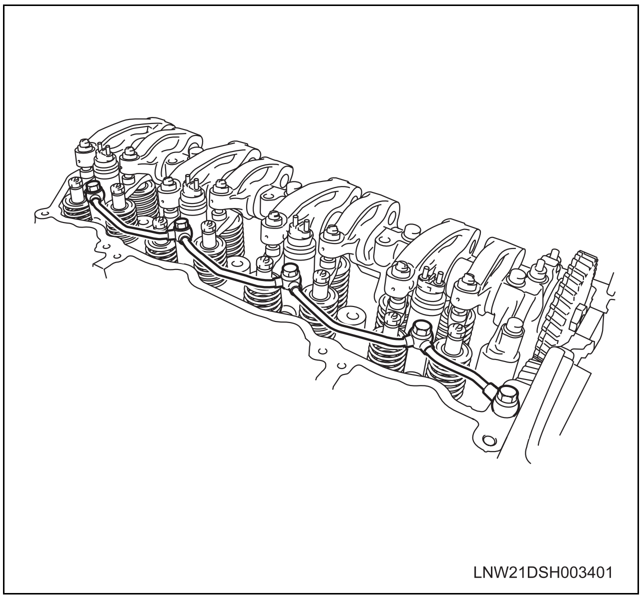


16. Install the water bypass hose.
    - Install the engine coolant temperature sensor on the thermostat housing.
17. Install the leak off pipe.

Leak off pipe tightening torque:
Tightening torque: 12 N·m (104 lb in)

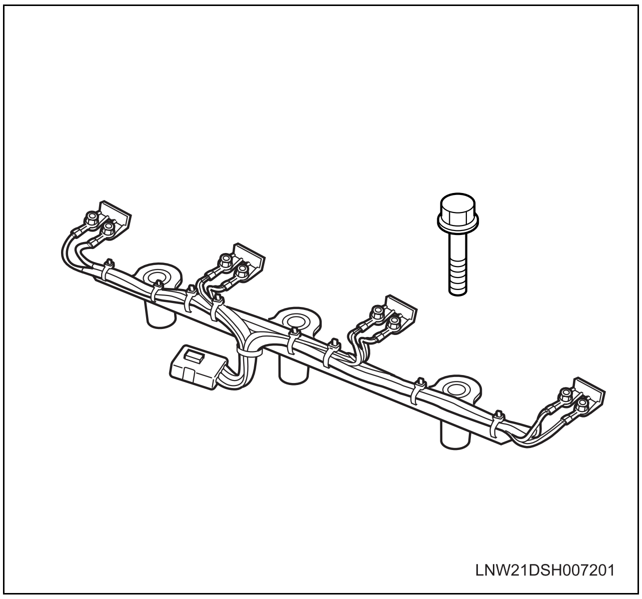
18. Install the fuel leak-off hose.
    - Install the fuel leak-off hose on the fuel leak-off pipe and fix it with a clip.
19. Clip a new gasket to the fuel nozzle leak-off pipe and install the fuel leak-off pipe.

Tightening torque: 12 N·m (104 lb in)



20. Install the fuel injector harness connector from inside, tighten the harness bracket with the designated torque.

Tightening torque: 48 N·m (35 lb ft)

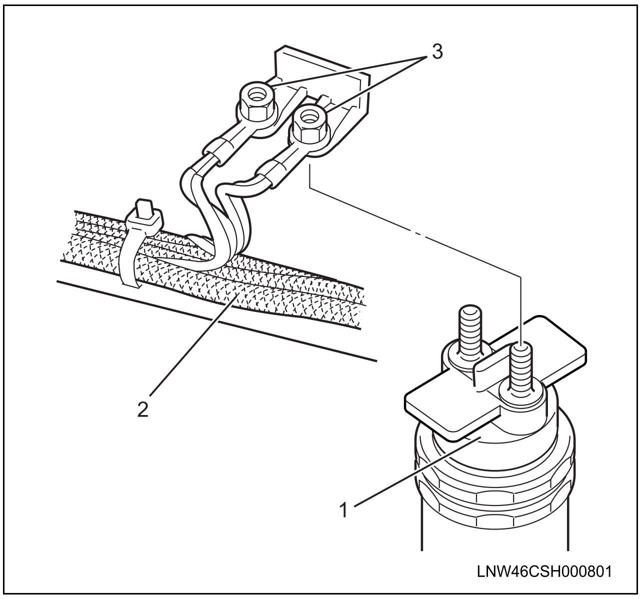


21. Install the terminal nuts on the fuel injector.

Tightening torque: 2 N·m (17 lb in)

Caution:

- Tighten the terminal nuts alternately in order to prevent imbalance in tightening because they are unified.
- Do not tighten the nuts too tightly because it leads to damage to the terminal stud.



Legend

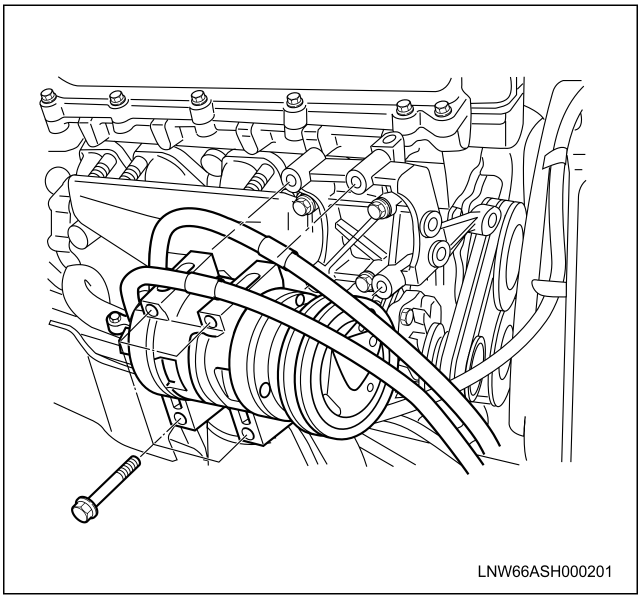
1. Fuel Injector
2. Fuel Injector Harness
3. Fuel Injector Terminal Nut

---

22. Install the cylinder head cover.
    Refer to the “cylinder head cover”.
23. Install the radiator upper hose.
24. Install the A/C compressor.
    - Install the A/C compressor on the A/C compressor and tighten it with the designated torque.

Tightening torque: 24 N·m (18 lb ft)

- Install the A/C compressor harness connector.



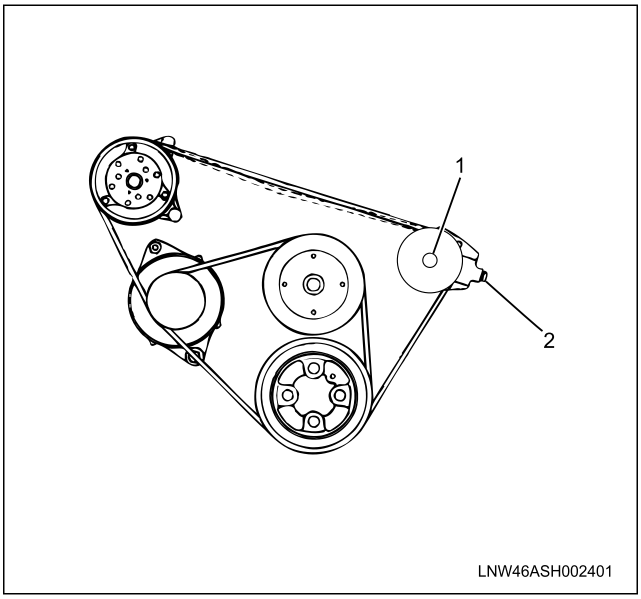
25. Install the A/C compressor drive belt.
    - Place the drive belt and adjust its tension with the adjust bolt of the tension pulley.

- Use a scale or other equipment to inspect whether the flexure of the belt when it was pushed by hand with pressure of 98 N (22 lb) is within the designated range.

A/C belt flexure	mm (in)
new belt:	16 (0.63) ~ 20 (0.79)
reused belt:	18 (0.71) ~ 22 (0.87)

- Tighten the locknut of the tension pulley with the designated torque after adjusting the tension of the belt.

Tightening torque: 27 N·m (20 lb ft)



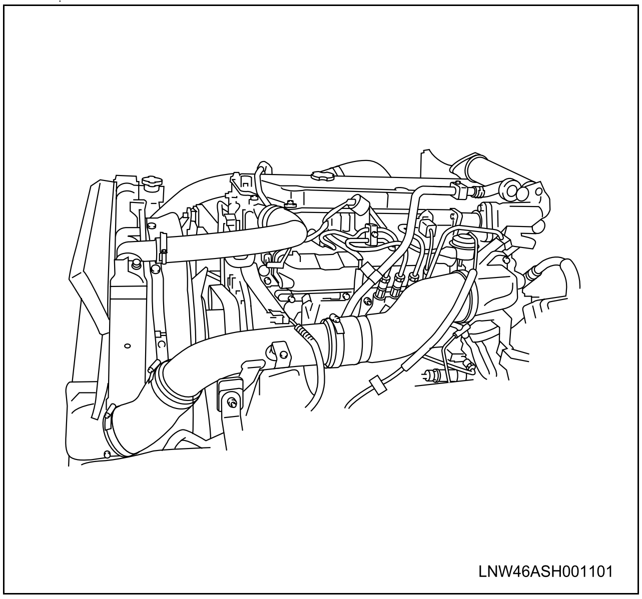
Legend

1. Tension Pulley Lock Nut
2. Tension Pulley Adjusting Bolt

---

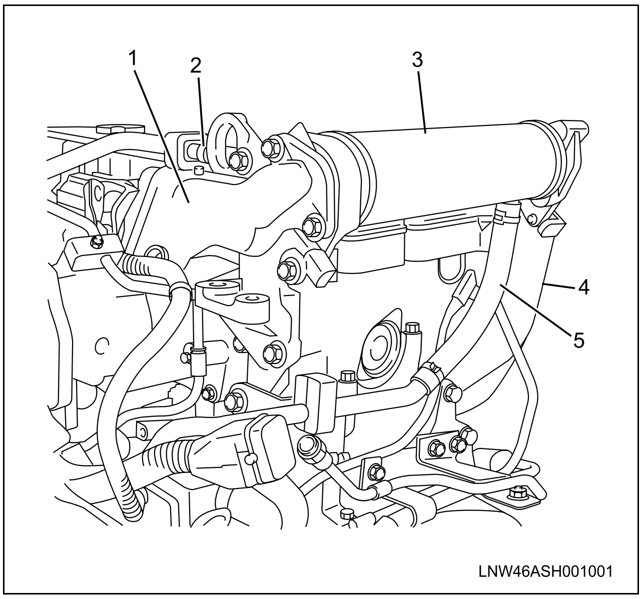
26. Install the intake pipe.
    - Install the bolt and clip band, tighten the bolt with the designated torque.

Tightening torque: 10 N·m (87 lb in)



Install the fan guide bracket.

27. Install the EGR valve & EGR cooler.
    For details of installation, refer to “EGR valve & EGR cooler” of the section of exhaust system.



Legend

1. EGR Adapter
2. Water Return Pipe
3. EGR Cooler
4. EGR Pipe
5. Water Feed Pipe

---

28. Install the oil level gauge and guide tube.
29. Install the exhaust pipe.
    - Install the front exhaust pipe and tighten with the designated torque.

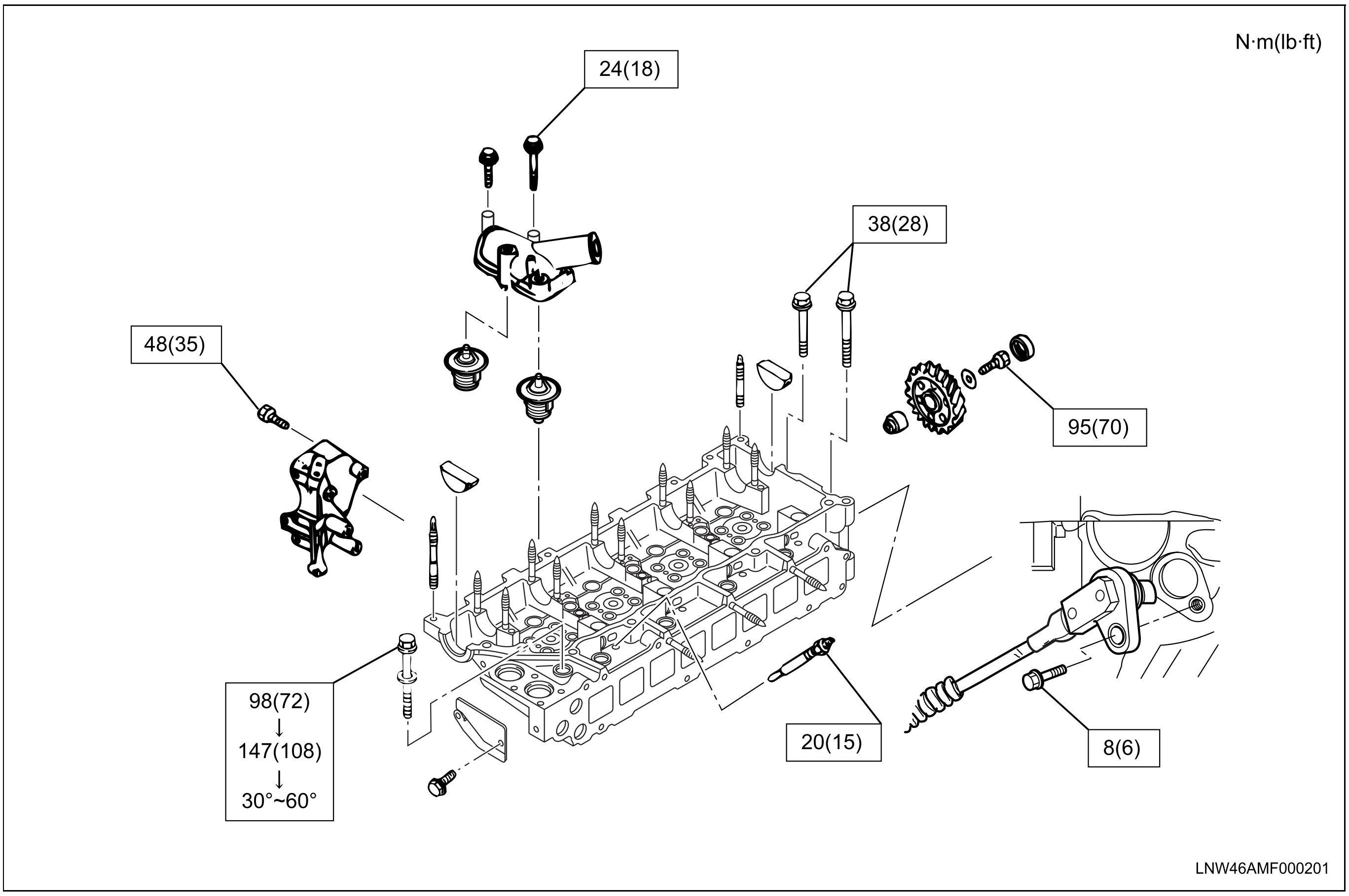
Exhaust manifold side
Tightening torque: 67 N·m (49 lb ft)

Exhaust brake side
Tightening torque: 17 N·m (13 lb ft)

30. Install the engine harness.

31. Replenish the coolant .

Torque Specifications



Special tool

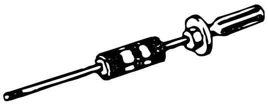
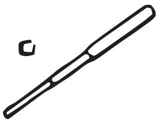
Illustration	Tool Number/ Description
 5884000190	J-23907 Sliding hammer
 5884022270	J-43272 Valve guide replacer

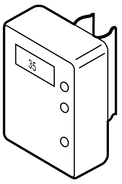
Illustration	Tool Number/ Description
 8943968150	EN-47685 Valve stem seal installer
 J45059	J-45059 Angle gauge

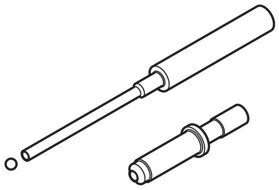
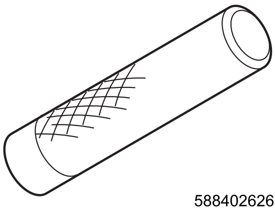
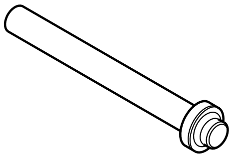
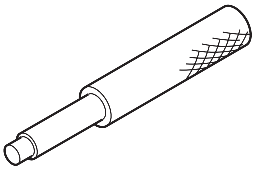
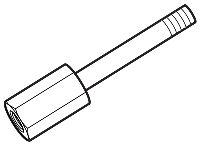
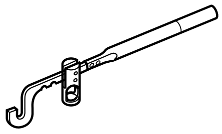
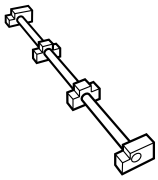
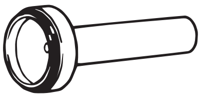
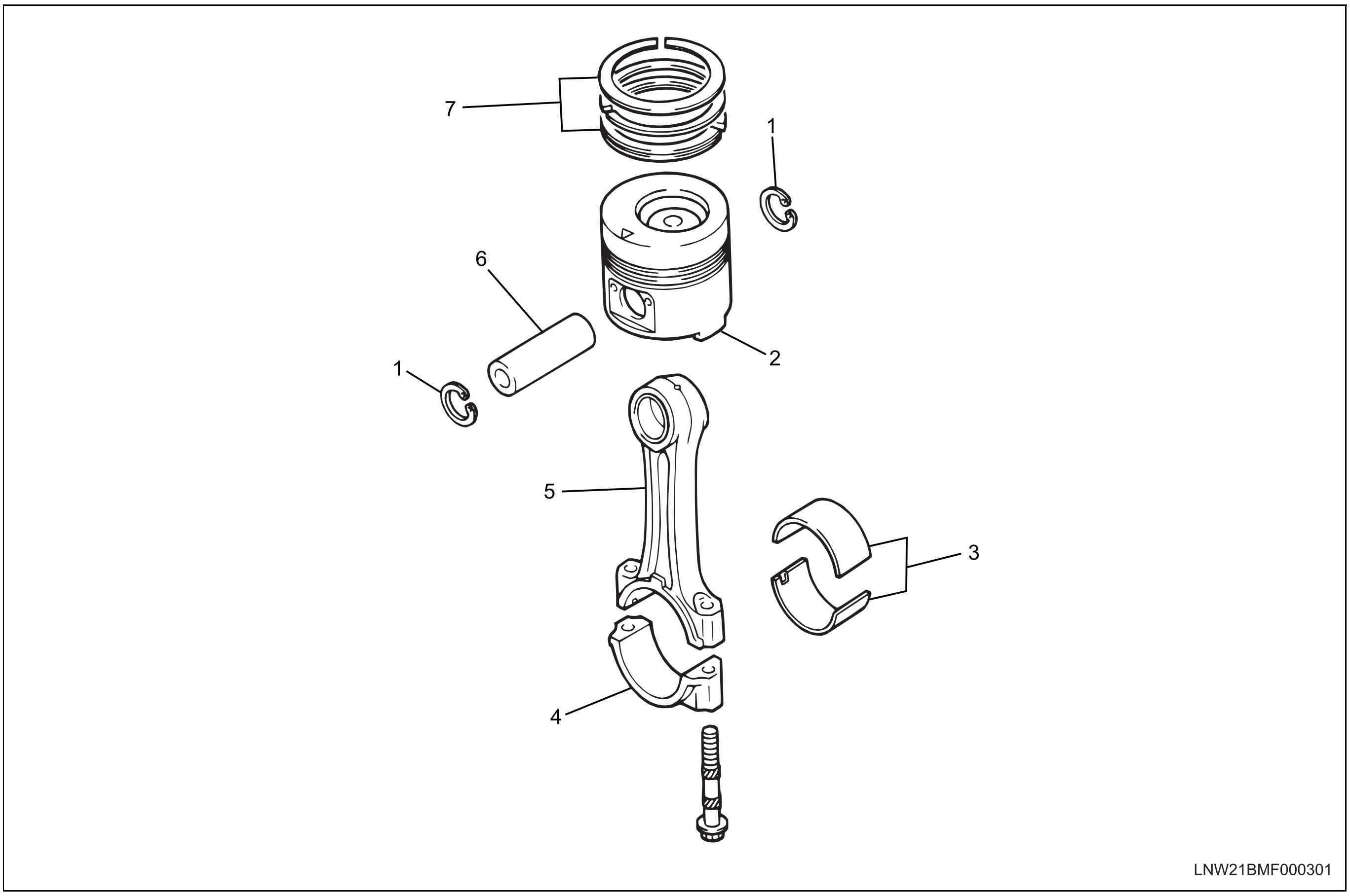
Illustration	Tool Number/ Description
	J-43266 Nozzle sleeve installer
	J-43268 Bridge guide installer
	J-43269 Oil seal installer
	J-43265 Nozzle sleeve remover
	EN-46720 Fuel injector remover
	J-43263 Valve spring replacer

Illustration	Tool Number/ Description
	EN-46721 Pivot assembly
	EN-47690 Sealing cup installer

Piston and Connecting Rod

Component



Legend

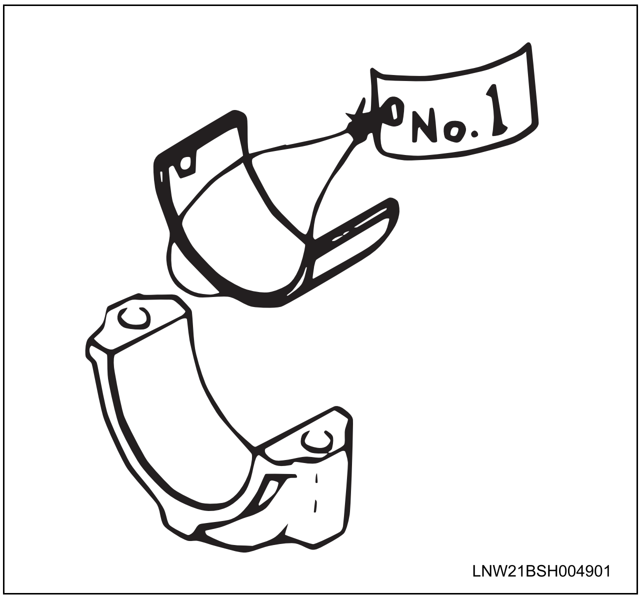
1. Snap Ring
2. Piston
3. Bearing
4. Connecting Rod Cap
5. Connecting Rod
6. Piston Pin
7. Piston Ring

Removal

1. Remove the oil pan.

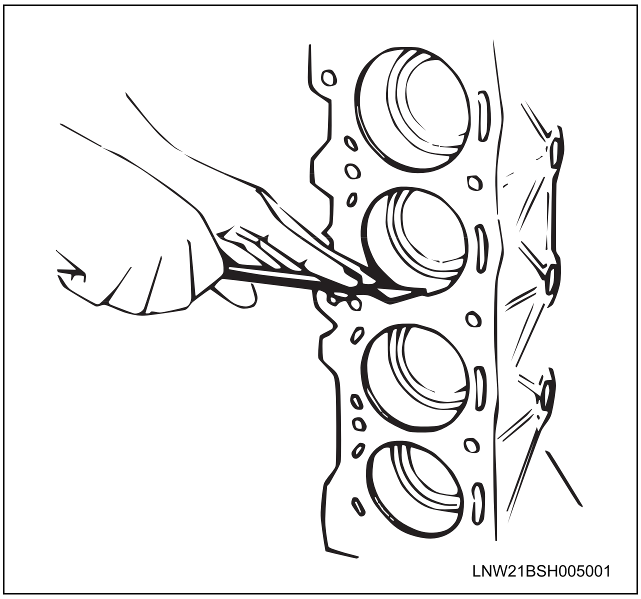
   Refer to the “oil pan” .
2. Remove the cylinder head cover.
   Refer to the “cylinder head cover”.
3. Remove the rocker arm shaft assembly.
   Refer to the “rocker arm shaft assembly”.
4. Remove the camshaft assembly.
   Refer to the “camshaft assembly”.
5. Remove the cylinder head.
   Refer to the “cylinder head”.
6. Remove the connecting rod cap.

Caution:
Sort the removed bearings according to cylinders by using tags.



7. Remove the piston and connecting rod.
   - Remove carbon on the upper side of the cylinder liner with a scraper.
   - Pull out the piston and connecting rod towards the cylinder head.

Caution:
Be sure not to damage the oil jet and cylinder liner when pushing out the connecting rod.



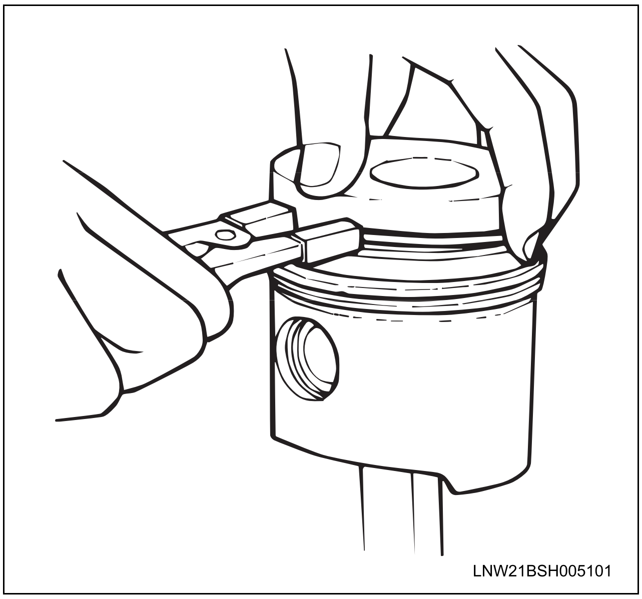
8. Remove the connecting rod bearing.

Caution:
Sort the bearings in the order of cylinders when reusing them so that they will not be confused with the bearing of other cylinders.

Disassembly

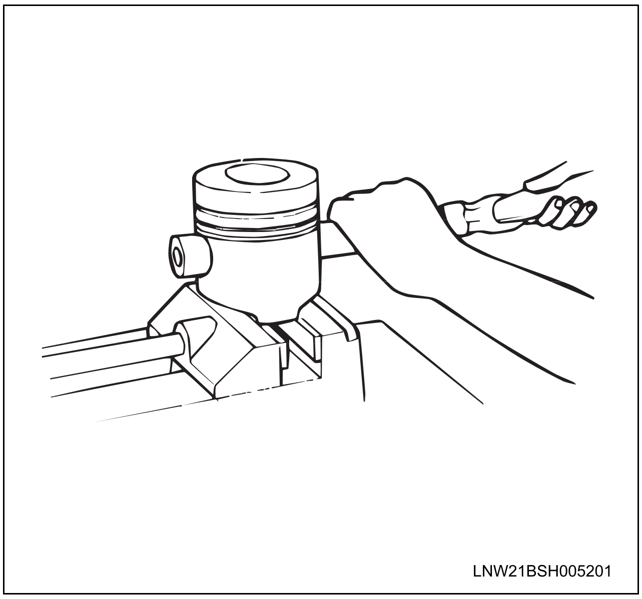
1. Remove the piston ring.
   - Use ring pliers to remove the piston ring.

Caution:
Sort the piston rings in the order of cylinders when reusing them so that they will not be confused with the pistons and piston rings of other cylinders.



2. Remove the snap ring.
3. Remove the piston pin.

Caution:
Sort the disassembled piston pins, pistons and connecting rods together in the order of cylinders.

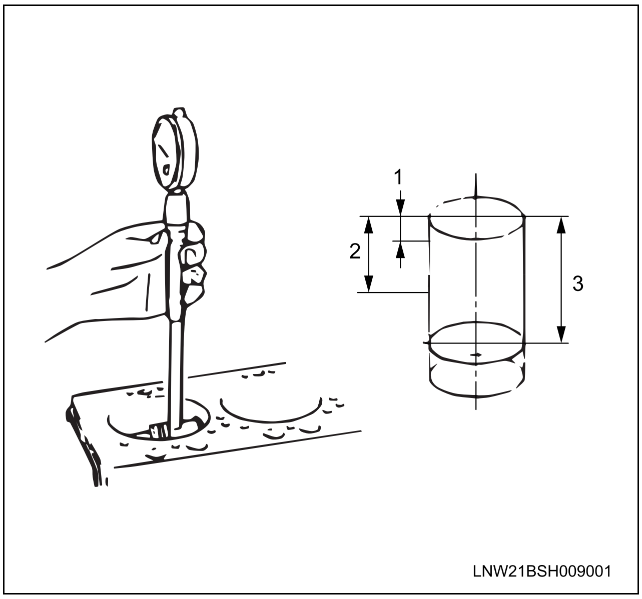


4. Remove the connecting rods from the piston.
5. Piston
   - Clean carbon carefully that is adhered to the head of the piston and the groove of the piston ring.

Caution:
Do not use wire brush to clean the piston because it scratches the piston.
Inspect the piston with eyes for cracks, burns and other excessive wear, and replace it if there is any abnormality.

6. Measure the gap between the piston and the inner diameter of the cylinder liner.
   Inner diameter of the cylinder liner.
   - Use a cylinder bore dial indicator to measure the liner inner diameter both in the thrust and radial directions in the designated position.
   - Measurement position (from the upper surface of the cylinder block)
     1. 20 mm (0.79 in) 2. 110 mm (4.33 in)
     3. 190 mm (7.48 in)
   - Measure the liner inner diameter based on the average value of the actual measurement values on 6 positions.

Cylinder liner inner diameter mm (in)
115.031 ~ 115.050 (4.52877 ~ 4.52952)



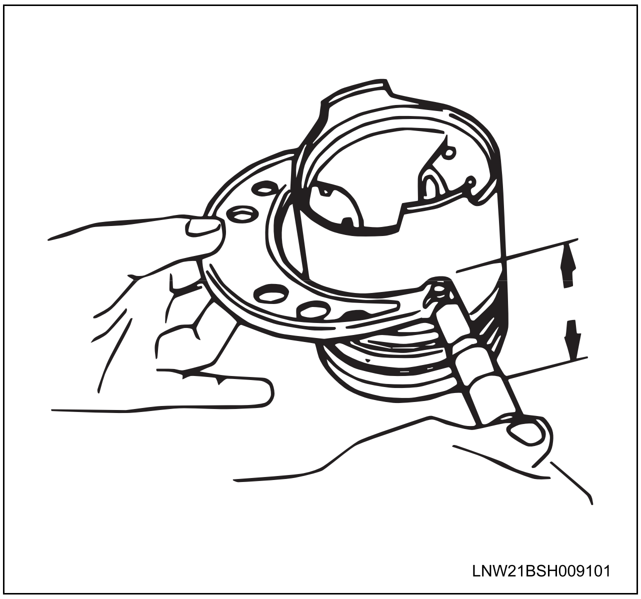
Legend
1. 20 mm (0.79 in)
2. 110 mm (4.33 in)
3. 190 mm (7.48 in)

Piston outside diameter
- Use a micrometer to measure the outside diameter of the piston in the right angle to the piston pin in the designated position.
- Measurement position (from the upper surface of the piston) 82 mm (3.2 in).

Piston diameter	mm (in)
Standard	114.934 ~ 114.949 (4.52495 ~ 4.52554)

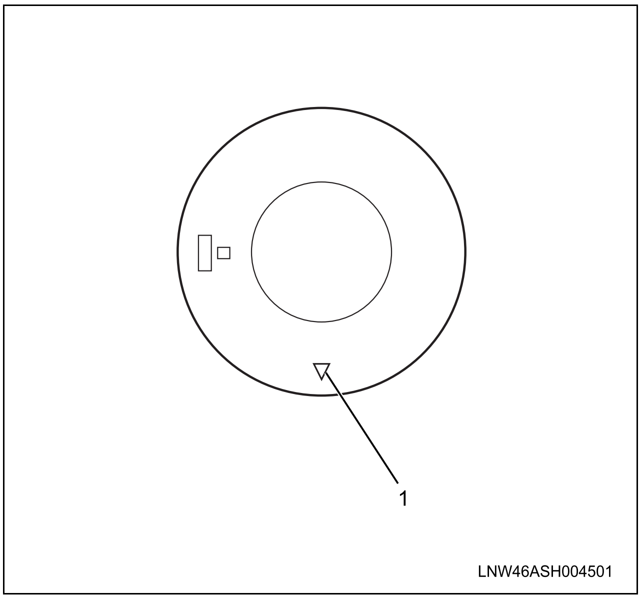
Gap between the piston and the inner diameter of the cylinder liner	mm (in)
Standard	0.082 ~ 0.116 (0.0032 ~ 0.0046)

Caution:
If it is found that the gap between the cylinder liner inner diameter and the piston exceeds the standard value, replace the piston or cylinder liner.



7. Piston replacement
   - You do not need to select grades because there is only one grade for each of the piston and the cylinder liner inner diameter.
     If you replace the cylinder liner, you must select the cylinder block (1, 2, 3) because there are two types of the liner outer diameter.
   - Refer to “cylinder block” if you replace the cylinder liner.

Caution:
The head of piston has a marking of grade B or C when it is shipped from the factory.

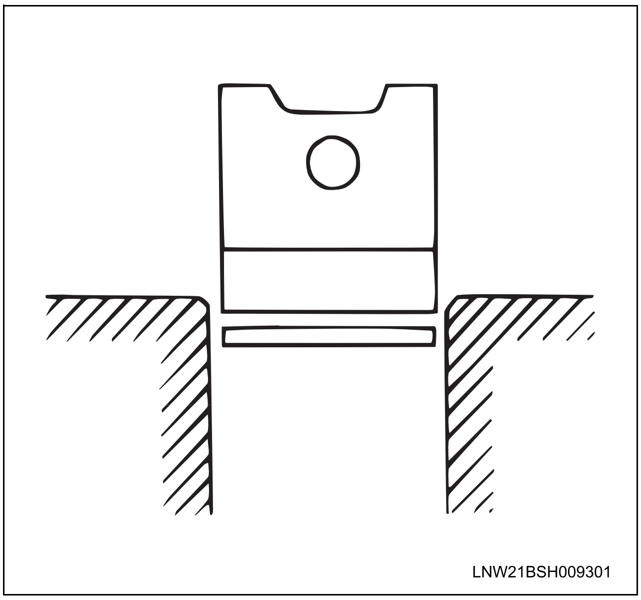


Legend

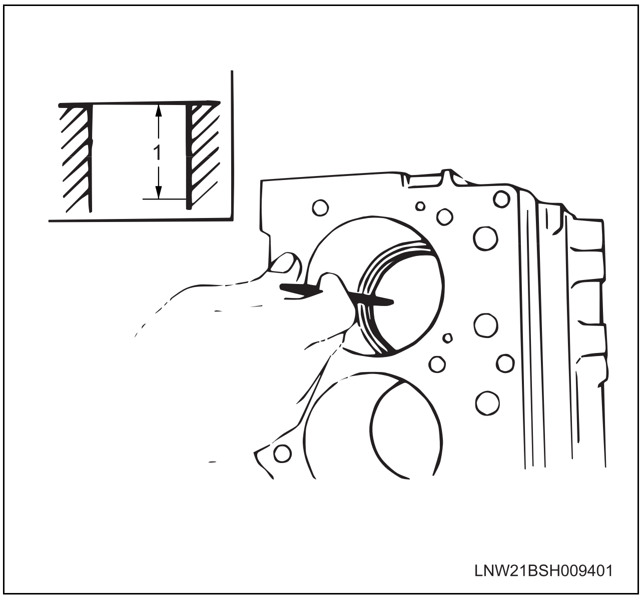
1. Front Mark Cut

---

8. Inspect the piston ring.
   Measure the joint of the piston ring (remove carbon on the ring joint)
   - Insert the piston ring into the cylinder liner.
   - Use the piston to push the ring to reach the under edge of the cylinder liner.



- Use a sickness gauge to measure the gap of the ring joint.



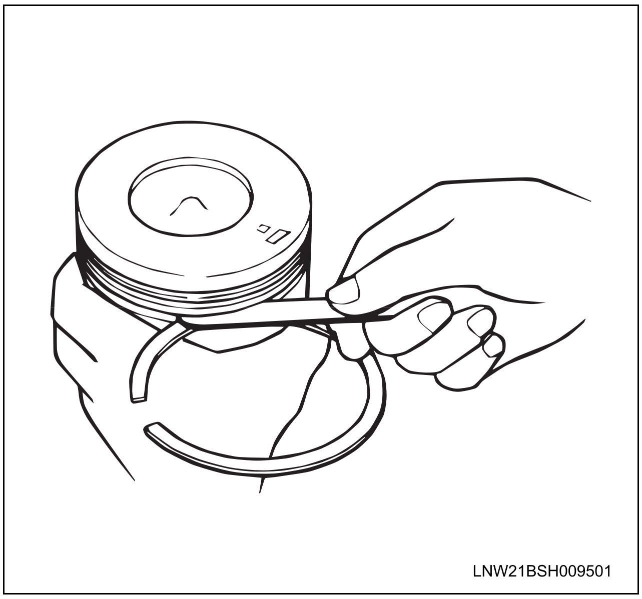
- If the measurement exceeds the limit, replace the piston ring.

Piston ring gap		mm (in)
	Standard	Limit
1st compression ring	0.24 – 0.39 (0.0094 – 0.0154)	1.50 (0.059)
2nd compression ring	0.35 – 0.50 (0.0138 – 0.0197)	1.50 (0.059)
Oil ring	0.15 – 0.35 (0.0059 – 0.0138)	1.50 (0.059)

Measure the clearance between the piston ring groove and the piston.

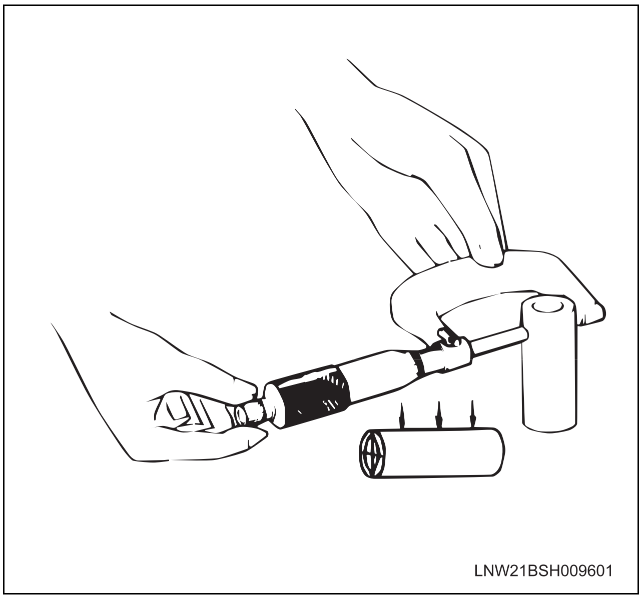
- Remove carbon in the piston ring groove.
- Put the piston ring in the piston ring groove, use a sickness gauge to measure the gap between them.
- If the clearance between the piston ring groove and the piston exceeds the limit, replace the piston and the piston ring.

Piston ring and piston ring groove clearance		mm (in)
Piston ring.	Standard	Limit
1st compression ring	0.06 – 0.09 (0.0024 – 0.0035)	0.20 (0.0079)
2nd compression ring	0.04 – 0.08 (0.0016 – 0.0031)	0.15 (0.0059)
Oil ring	0.02 – 0.06 (0.0008 – 0.0024)	0.15 (0.0059)


LNW21BSH009501

9. Inspect the piston pin.
   - Inspect the piston pin with eyes for cracks, scratches and other damages, replace it if necessary.
   - Use a micrometer to measure the outer diameter of the piston pin. If the measured value exceeds the limit, replace the piston pin.

Piston pin outer diameter	mm (in)
Standard	35.995 – 36.000 (1.4171 – 1.4173)
Limit	35.970 (1.4161)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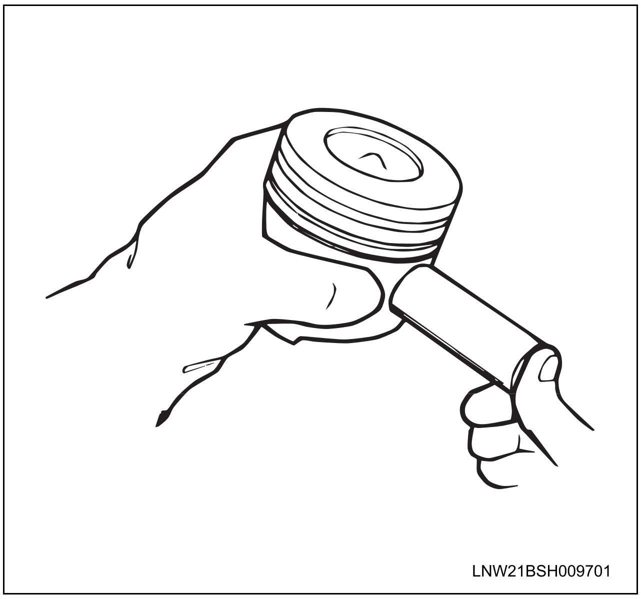
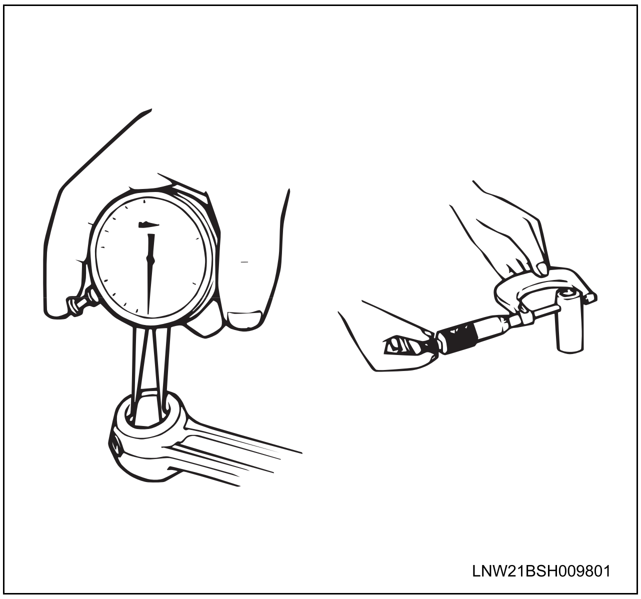
- Inspect to make sure that there is a resistance to the extent which the piston can push the piston pin lightly in normal temperatures.
- If it feels a large looseness or instability in normal temperatures, replace the piston or piston pin.


LNW21BSH009701

- Measure the bush of the small edge of the connecting rod. If the clearance of the bush inner diameter and the pin diameter exceeds the limit, replace the bush or connecting rod assembly, and the pin.

Piston pin and connecting rod small end bushing clearance	mm (in)
Standard	0.012 – 0.027 (0.0005 – 0.0011)
Limit	0.05(0.0020)

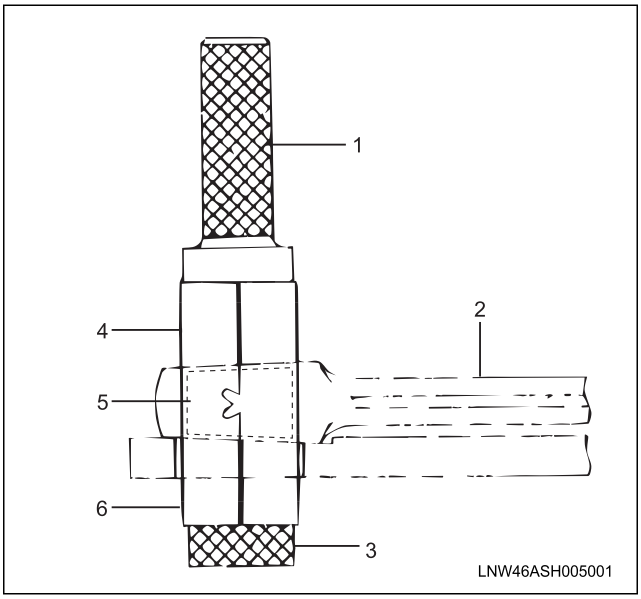

LNW21BSH009801

10. Measure the clearance between the piston and the piston pin.

- Apply engine oil on the piston pin. Use your finger to push it in the piston hole and rotate it. If the pin smoothly rotates without instability, the clearance is normal. If there is instability, measure the clearance. If the clearance exceeds the limit, replace the piston and the piston pin.

Piston pin and piston pin hole clearance	mm (in)
Standard	0.004 – 0.017 (0.00016 – 0.00067)
Limit	0.04 (0.0016)

11. Remove the bush.
    - Set the collar, connecting rod and collar on the setting bar as shown in the drawing.
    - Tighten the nut.

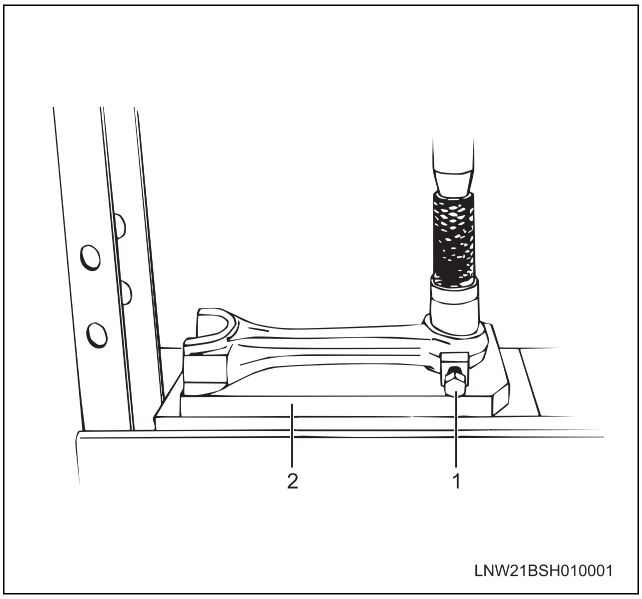


Legend

1. Setting Bar
2. Connecting Rod
3. Nut
4. Collar
5. Bush
6. Collar

- Place the connecting rod bush replacer base on the bench press, tighten the fixation bolt.
- Use the bench press to replace the bush.

  Special tool
  Connecting rod bush replacer: EN-47682



Legend

1. Bolt
2. Connecting Rod Bush Replacer

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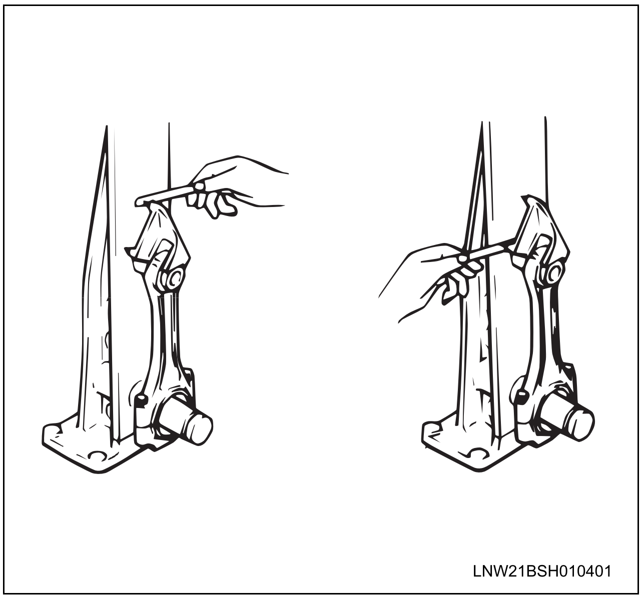
12. Measure the connecting rod alignment.
    - Use a connecting rod aligner to measure the torsion and parallel level of the big end hole and the small end hole. If the measured value exceeds the limit, replace it.

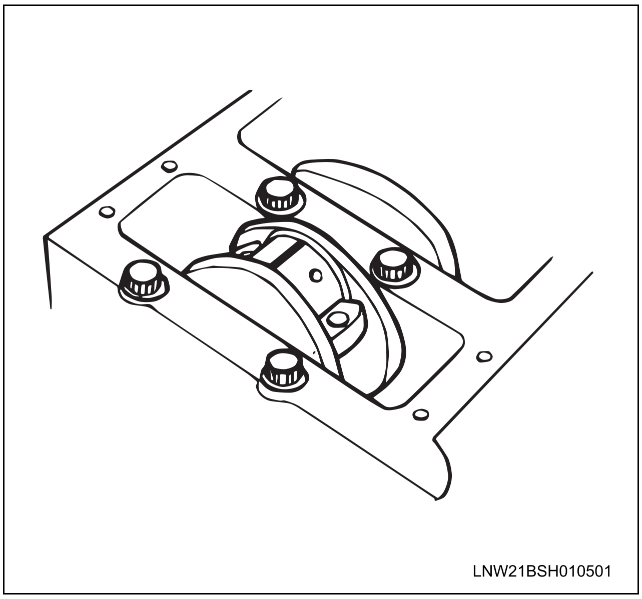
Connecting rod alignment (par length of 100 mm (3.94 in)) mm (in)		
	Standard	Limit
Distortion and Parallelism	0.05 (0.002)	0.20 (0.008)



13. Measure the bearing oil clearance.
    - Measure the oil clearance between the connecting rod bearing and the crank pin with the following method.
        - Remove the connecting rod cap. Sort the removed caps according to the cylinder number.
        - Clean the bearing and the shaft pin.
        - Inspect the bearing. If it is damaged or worn seriously, replace the entire bearing.
    - Place the plastigauge on the crankshaft pin.
    - Install the bearing cap and tighten the bolt with the designated torque.
      Apply molybdenum disulfide on the screw part and the bearing surface.

Connecting rod bearing cap bolt torque:	N·m (lb ft)
1st step	39 (29)
2nd step	60 deg
3rd step	30 deg

Caution:
Do not rotate the crankshaft.

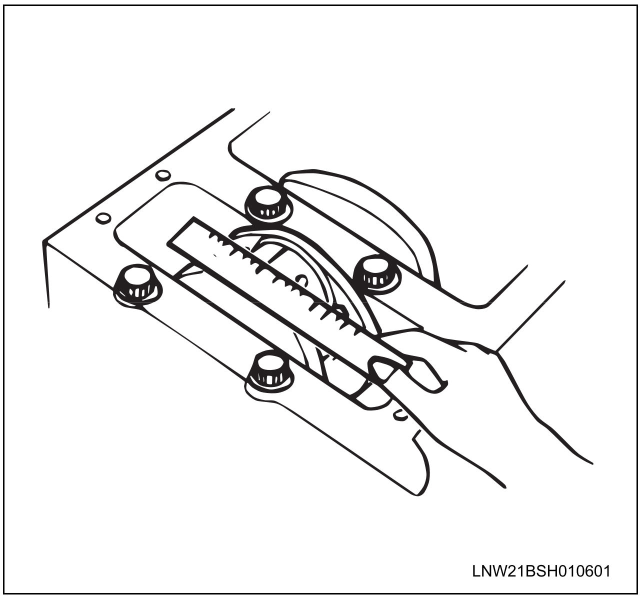


LNW21BSH010501

- Remove the cap.
- Measure the largest width of the plastigauge to calculate the oil clearance. If the clearance exceeds the limit, replace the entire bearing.

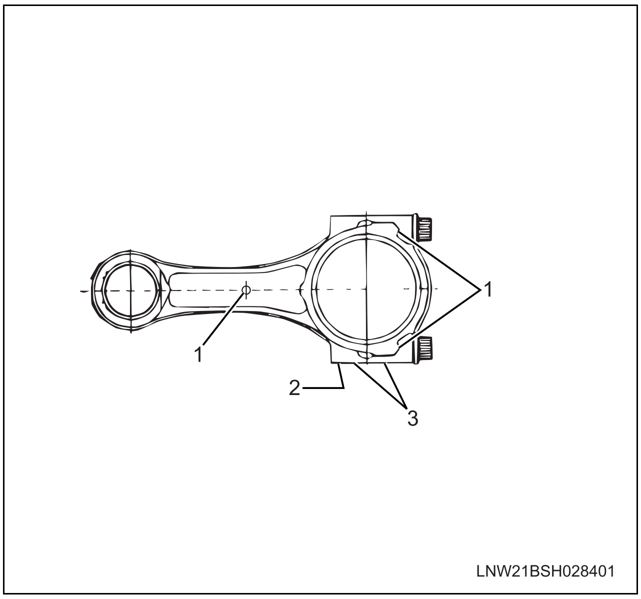
Crankpin and bearing clearance	mm (in)
Standard	0.036 – 0.077 (0.0014 – 0.0030)
Limit	0.10 (0.0039)

- Remove the plastigauge from the bearing and crankpin.



LNW21BSH010601

14. Select the connecting rod bearing.
    - Refer to the bearing selection table when installing a new connecting rod or replacing bearings in use.
    - Select and install the bearing, paying attention to the large edge hole diameter of the connecting rod.



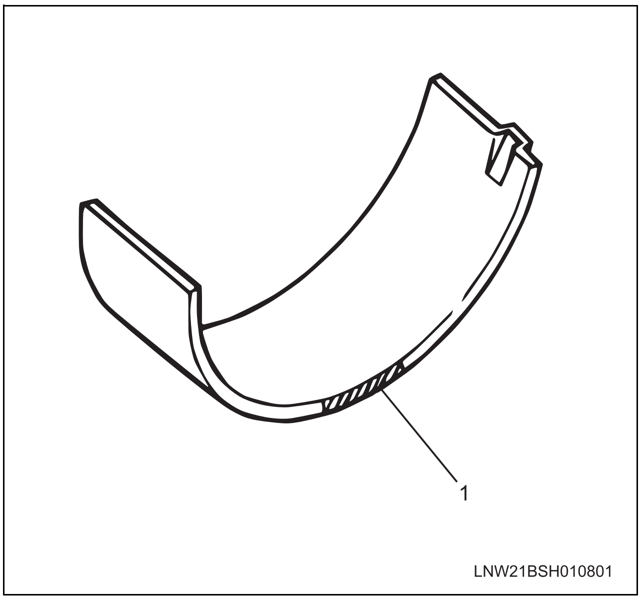
LNW21BSH028401

Legend

1. Top And Back Recognition Boss
2. Big End Diameter Grade Mark
3. Cylinder Number

Bearing selection table

Big end hole diameter Grade	Bearing recognition color	Oil clearance mm (in)
A	Green	0.036 – 0.077 (0.0014 – 0.0030)
B	Yellow	0.036 – 0.077 (0.0014 – 0.0030)



Legend

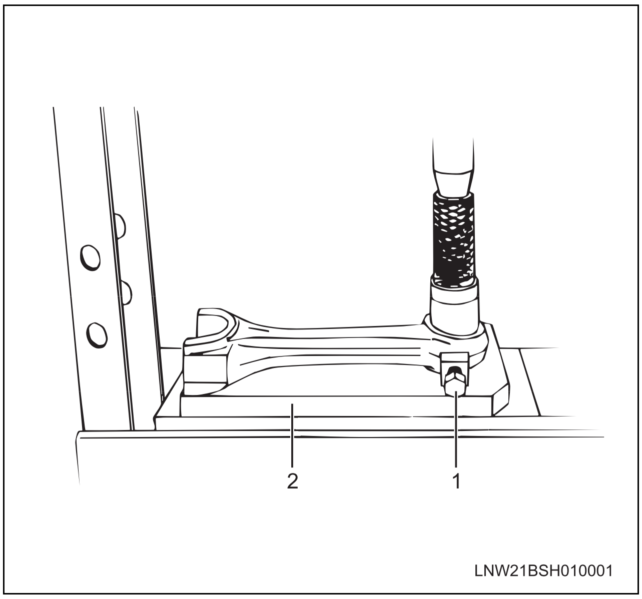
1. Grade Recognition Color

Reassembly

1. Install the bush

- Place the connecting rod bush replacer base on the bench press, set the connecting rod and tighten the fixation bolt.

  Special tool
  Connecting rod bush replacer: EN-47682

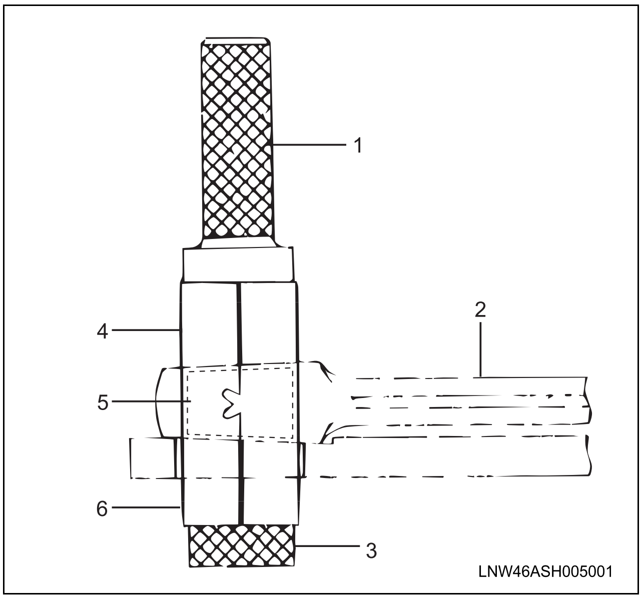


Legend

1. Bolt
2. Connecting Rod Bush Replacer

- Set the collar, new bush and collar on the setting bar as shown in the drawing.
- Tighten the nut.

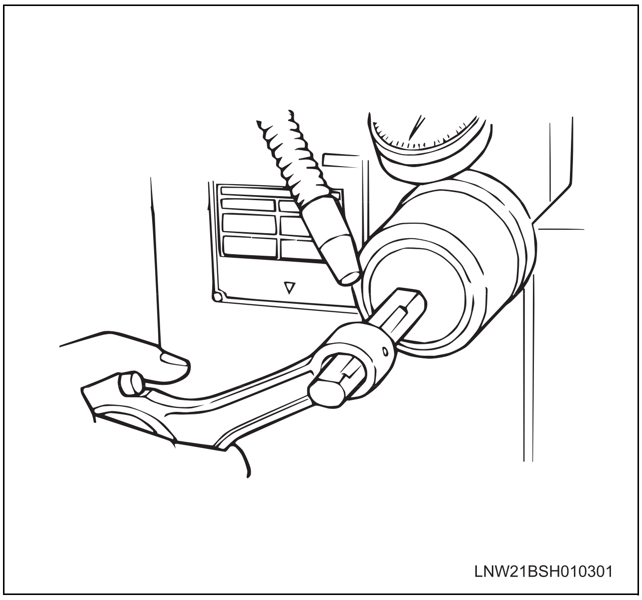
- Adjust the oil hole of the connecting rod and the oil hole of the bush, and use the bench press to install the bush.



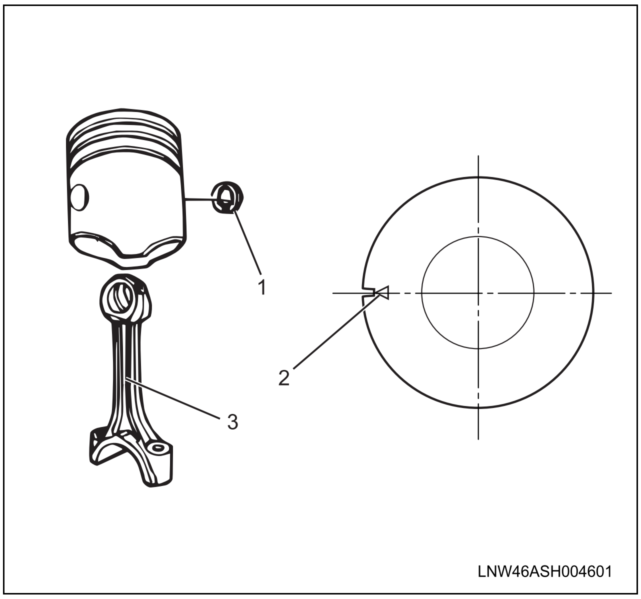
Legend

1. Setting Bar
2. Connecting Rod
3. Nut
4. Collar
5. Bush
6. Collar

- After installing the new bush, use a grinder to machine the pin hole so that the pin clearance equals the standard value.



2. Install the piston.
3. Install the connecting rod.
   - Install it so that the front mark of the head of the piston and the connecting rod forging mark (projecting) on the connecting rod face the same direction.
   - Use snap ring pliers to install the snap ring of one side.



Legend

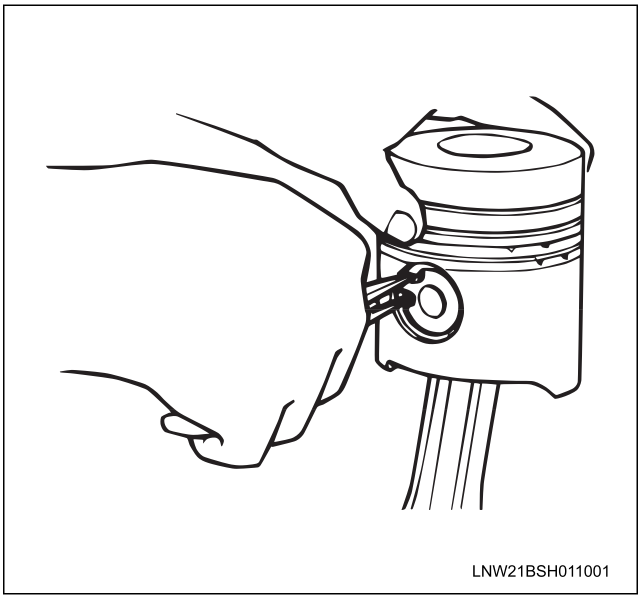
1. Snap Ring
2. Front Mark
3. Forging Mark (Projecting)

---

4. Apply enough engine oil on the piston pin, push it in the piston and the connecting rod small edge.
5. Use snap ring pliers to install the snap ring.

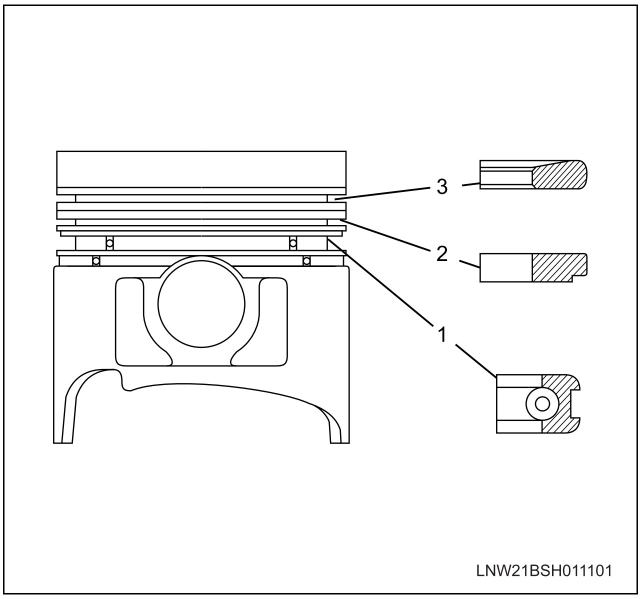
Caution:

Make sure that the snap ring is installed in the ring groove properly. Make sure that the connecting rod moves smoothly.



6. Use ring pliers to install the piston ring.
   - Install the oil ring so that the joint angle of the ring and coil expander is in the opposite 180° direction.

- Install 2nd and 1st compression rings in this order so that the marks “2N”and “1N” face upward.



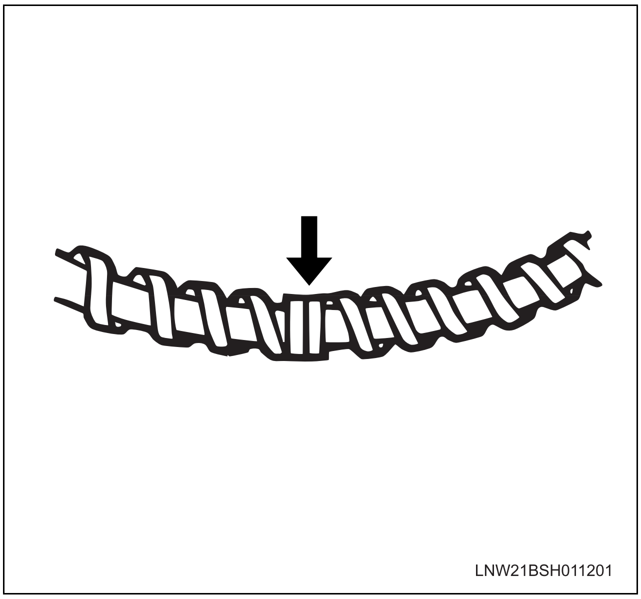
Legend

1. Oil ring
2. Compression Ring 2nd
3. Compression Ring 1st

Caution:

Note that the shapes of compression rings 1st and 2nd are different. (2nd has undercut)

Make sure that there is not gap in the position indicated in the drawing when the oil ring coil expander was installed.



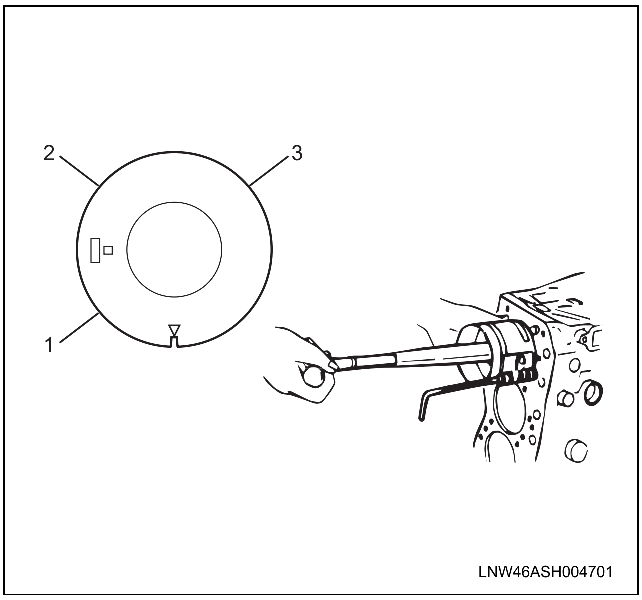
Installation

1. Install the connecting rod bearing.
   - Install the bearing on the connecting rod, apply engine oil on the bearing.
2. Install the piston and connecting rod assembly.
   - Apply enough engine oil on the piston ring, ring groove and piston side surface.
   - Dislocate the piston ring joint so that (1) is 1st ring, (3) is 2nd ring and (2) is oil ring, as shown in the drawing.
   - Face the piston front mark cut to forward, use the piston ring compressor to insert the piston in the cylinder liner.

Caution:

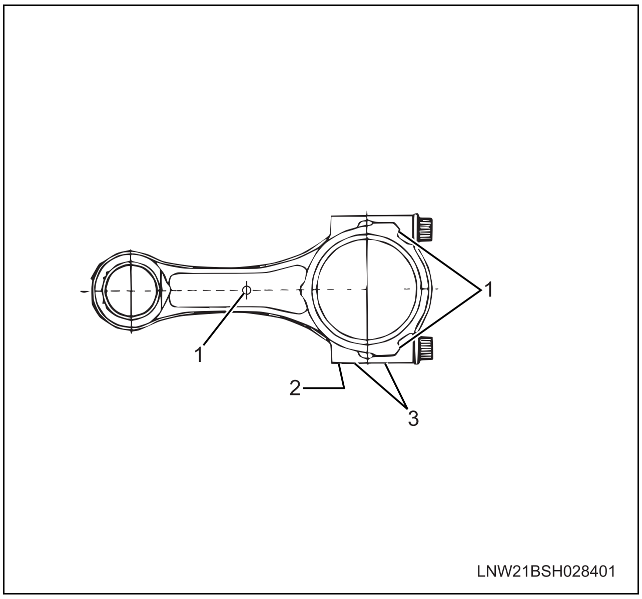
- Be sure not to make the connecting rod touch the oil jet when pushing in the piston.
- Be sure not to hurt the inside of the liner when pushing in the piston.

Special tool
Piston ring compressor: J-8037



3. Install the connecting rod cap.
   - Install the bearing on the connecting rod cap and apply engine oil.

- Install the cap, matching the numbers (1, 2, 3, 4) of the caps and connecting rods.



Legend

1. Back And Top Recognition Boss
2. Big End Hole Diameter Grade Mark
3. Cylinder Number

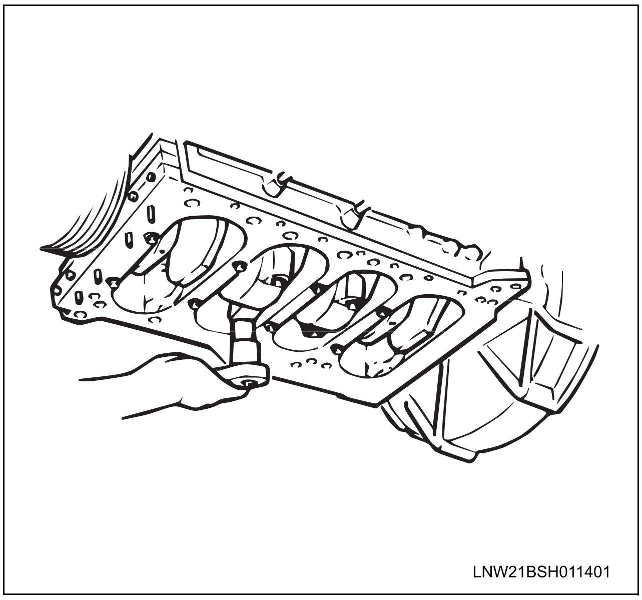
- Apply molybdenum disulfide on the screw part and the setting face of the tightening bolt and tighten it with the designated torque.

Tightening torque:

1st step = 39 N·m (29 lb ft)
2nd step = 60° (degrees)
3rd step = 30° (degrees)

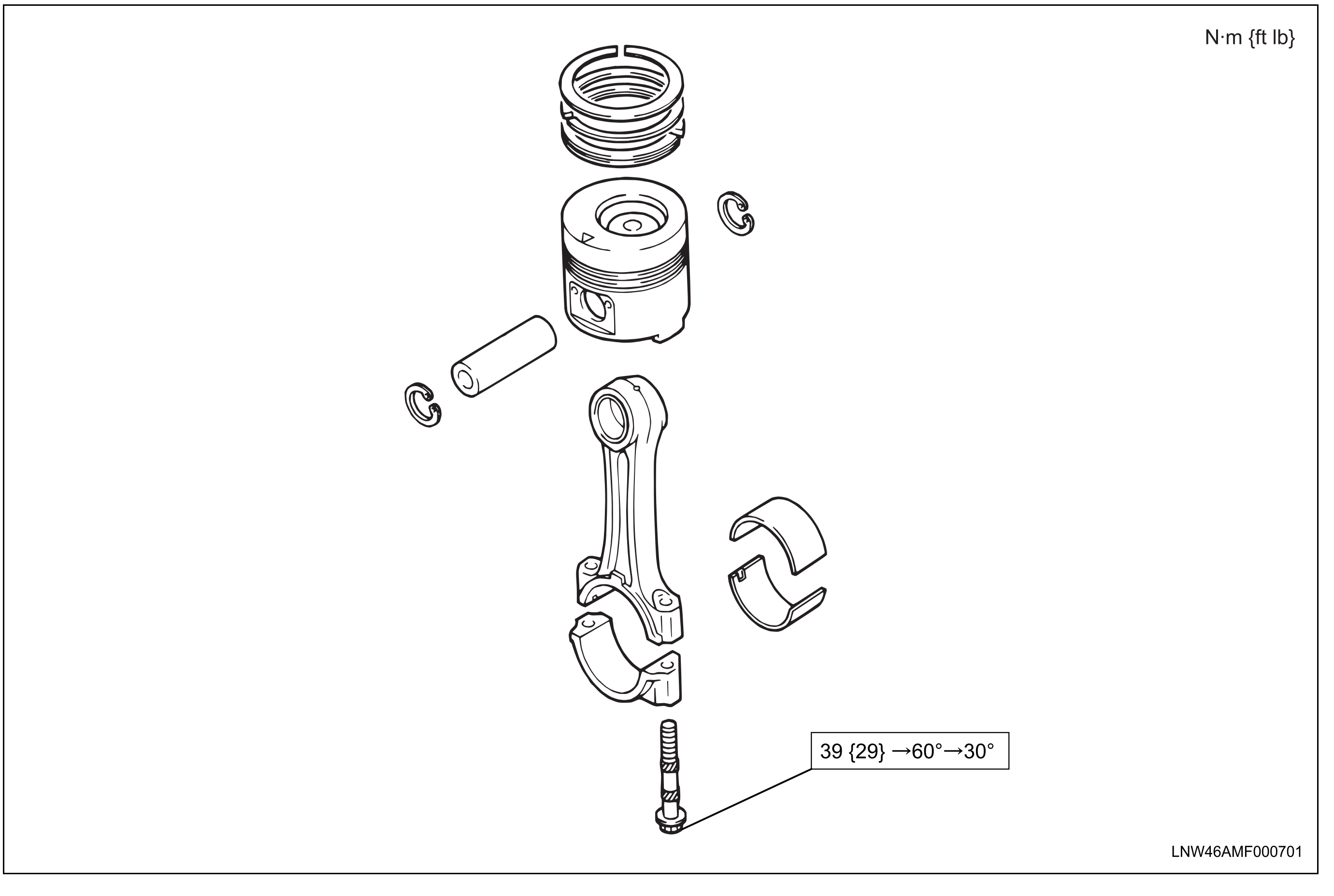
Special tool
Angle gauge: J-45059

Caution:
Make sure that the crankshaft smoothly rotates.



4. Install the cylinder head.
   Refer to the “cylinder head”.
5. Install the camshaft assembly.
   Refer to the “camshaft assembly”.
6. Install the rocker arm shaft assembly.
   Refer to the “rocker arm shaft assembly”.
7. Install the cylinder head cover.
   Refer to the “cylinder head cover”.
8. Install the oil pan.
   Refer to the “oil pan”.

Torque Specifications



Special tool

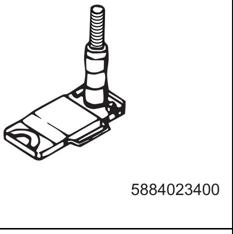
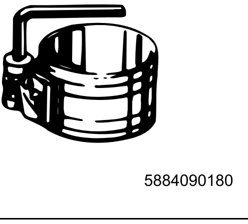
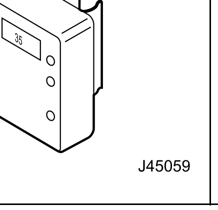
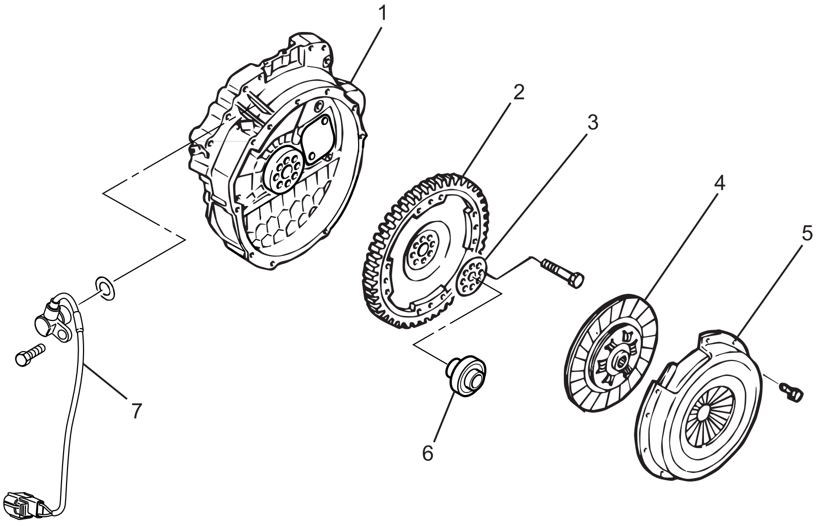
Illustration	Tool Number/ Description
 5884023400	EN-47682 Connecting rod bush replacer
 5884090180	J-8037 Piston ring compressor

Illustration	Tool Number/ Description
 J45059	J-45059 Angle gauge

Flywheel

Component



LNW21BMF004801

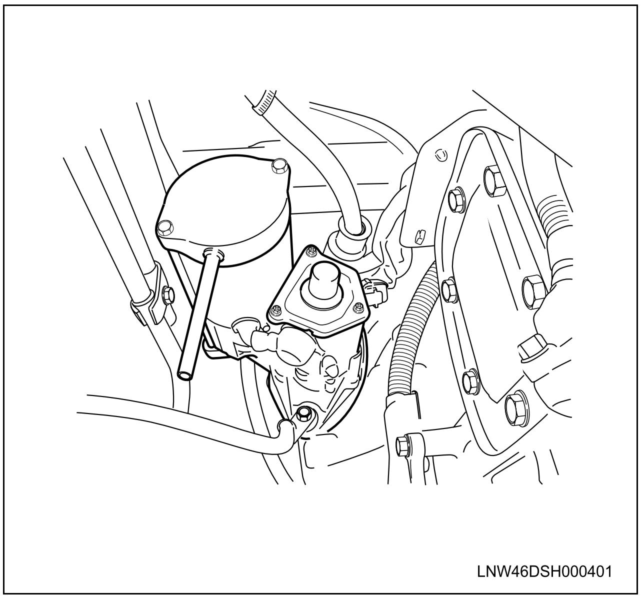
Legend

1. Flywheel Housing
2. Flywheel Assembly
3. Washer
4. Driven Plate
5. Pressure Plate
6. Pilot Bearing
7. Crankshaft Position Sensor

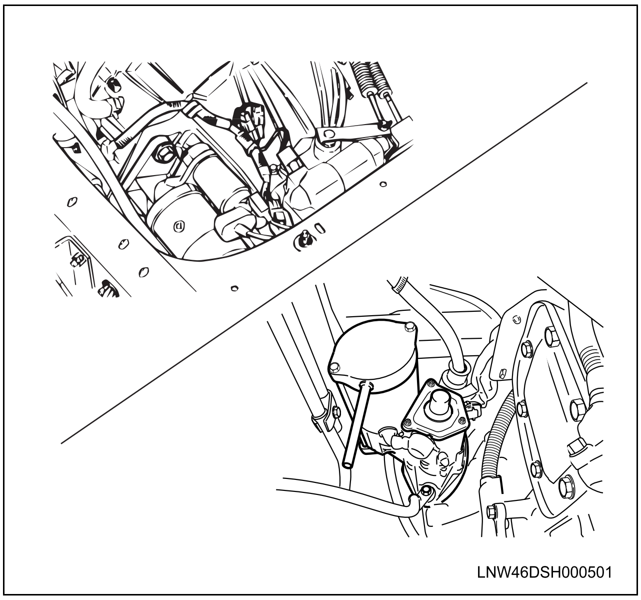
Removal

1. Remove the starter motor.
   - Remove the earth cable of the starter motor.

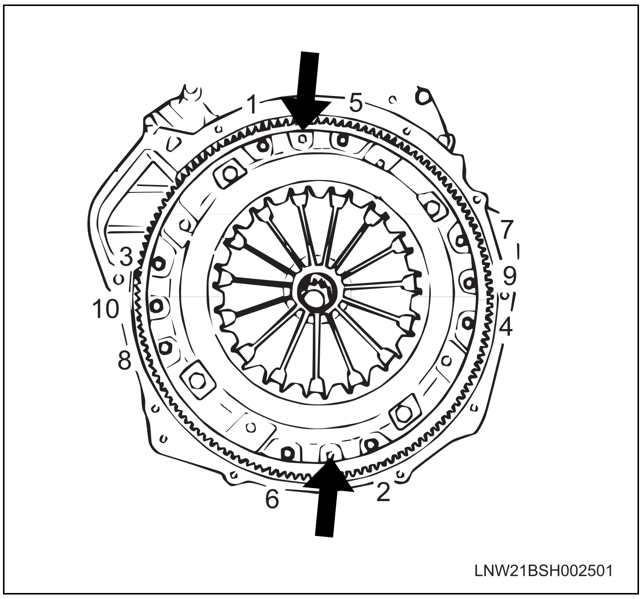
- Disconnect the front frame harness connecter near the control box of the transmission, remove the clips that fix the harness.



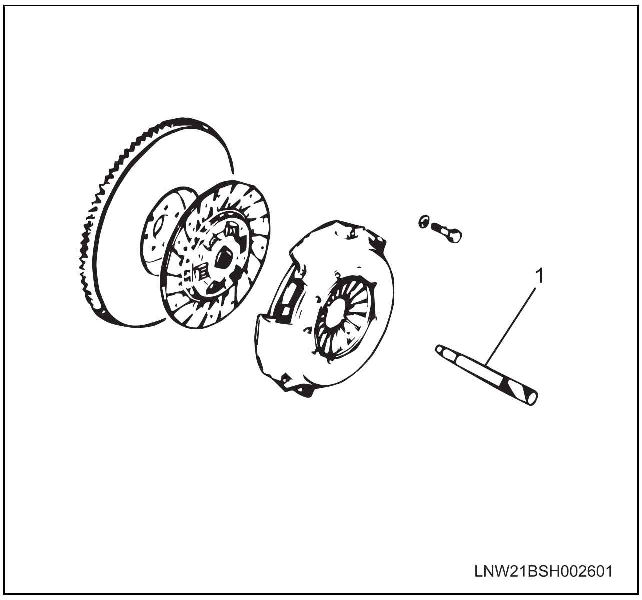
- Remove the two bolts on the upper side and lower side that fix the starter, remove the starter from the clutch housing.
- Use wire to secure the starter to the transmission. Position the wire and starter so that it does not interfere with the transmission removal procedure.



2. Remove the transmission assembly.
   Refer to "transmission assembly removal and installation".
3. Remove the clutch pressure plate.
   - Insert the clutch aligner on the spline of the driven plate.
   - Remove the pressure plate installation bolts in the order shown in the drawing.
   - Remove the pressure plate from the flywheel.



4. Remove the driven plate.
   - Remove the driven plate from the flywheel along with the clutch aligner (1).



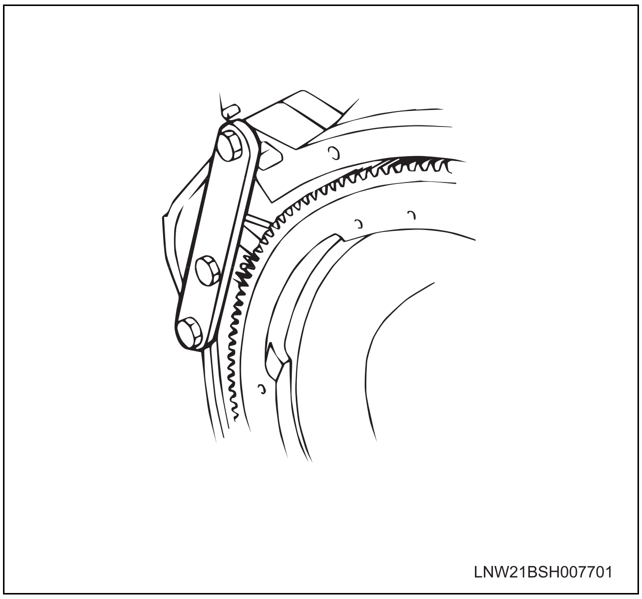
Legend

1. Clutch Aligner

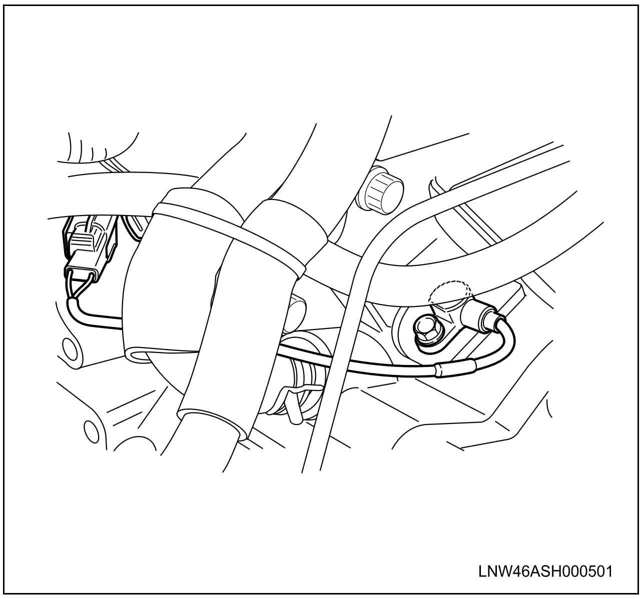
- Install the crankshaft stopper in the starter installation part of the flywheel housing.

Caution:
Make sure that the stopper is applied with the ring gear and installed properly.

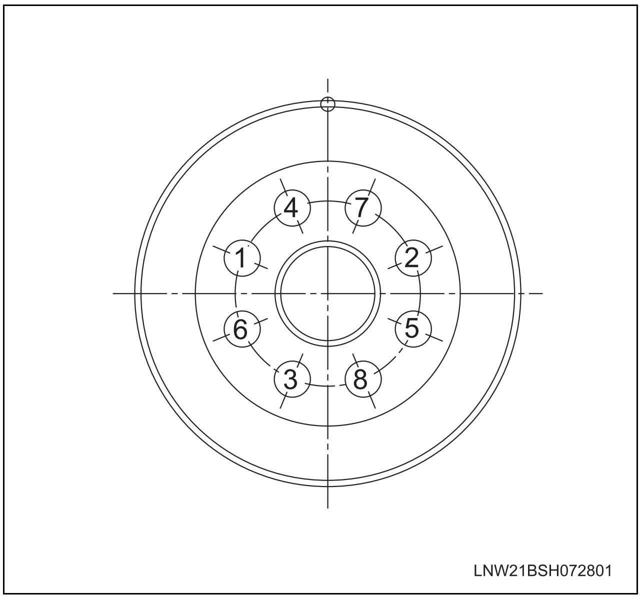
Special tool
Crankshaft stopper: EN-47680


LNW21BSH007701

5. Remove the crankshaft position sensor.
    - Remove to prevent contact damage when the flywheel is removed.
    - Do not throw or drop because it is vulnerable to shock.

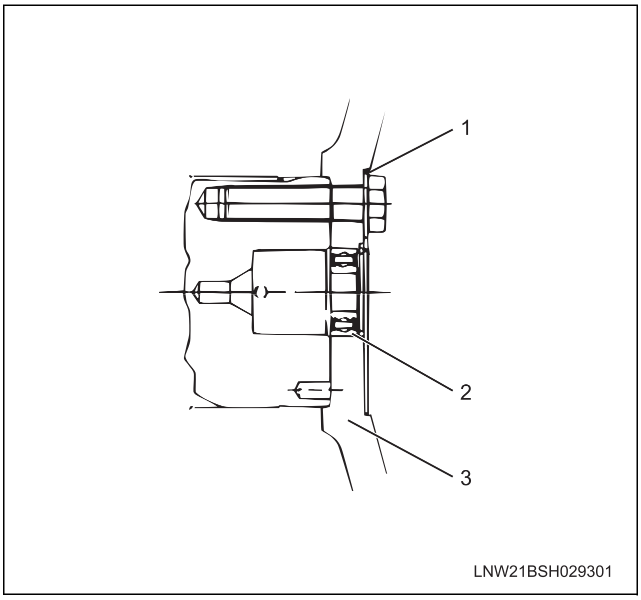

LNW46ASH000501

6. Remove the washer.
7. Remove the flywheel.
    - Gradually loosen the flywheel installation bolts in the order shown in the drawing so that the flywheel does not rotate.
    - After loosening the bolts, remove the stopper and remove the flywheel.
    - In the case of A/T car, after loosening the flywheel installation bolts, remove the washer, flexible plate, flywheel and sleeve in this order.



LNW21BSH072801

8. Remove the pilot bearing.
    - Remove the pilot bearing from the flywheel.



LNW21BSH029301

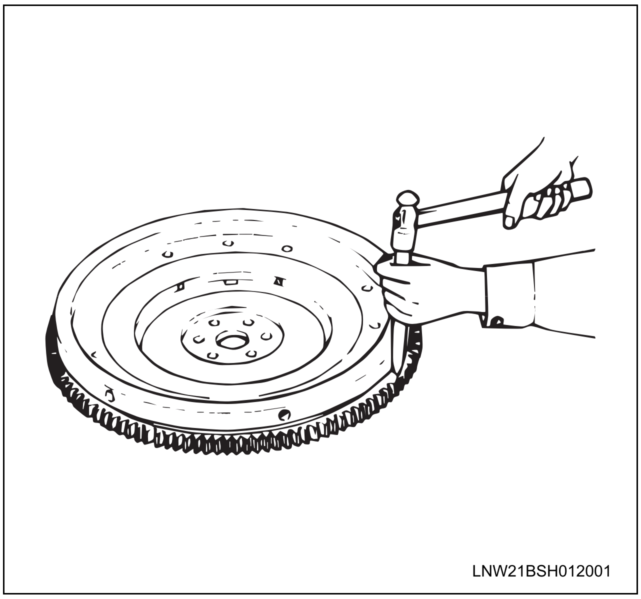
Legend

1. Washer
2. Pilot Bearing
3. Flywheel

---

9. Remove the ring gear.

- Put a bar on the ring gear and hit it with a hammer to remove it.

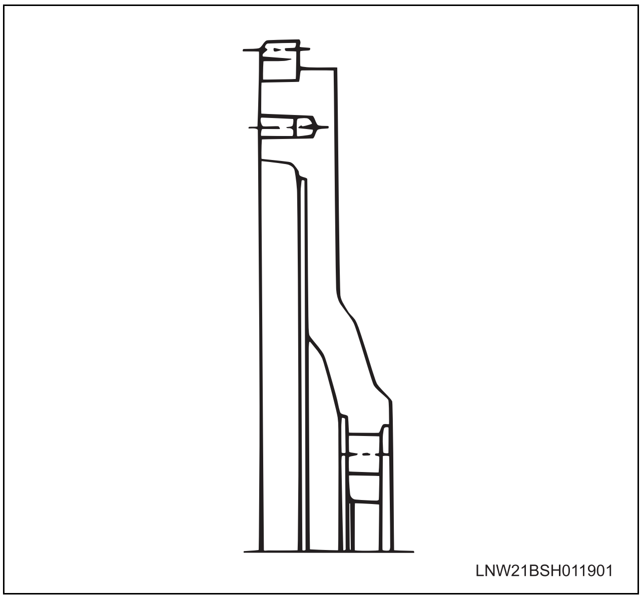

LNW21BSH012001

Inspection

1. Inspection with eyes
   - Inspect the flywheel friction surface for cracks and damages, and replace it if it has abnormality.
   - Inspect the tooth part of the ring gear, replace the ring gear if it has damage or serious wear.
2. Measurement of the friction surface
   - Measure the depth of the friction surface of the flywheel.
   - Adjust it if the measured value is within the standard value and the limit.
   - If the measured value exceeds the limit, replace the flywheel.

Depth of the friction surface of the flywheel mm (in)	
Standard	19 (0.75)
Limit	20 (0.79)

Depth = From the pressure installation surface to the friction surface.

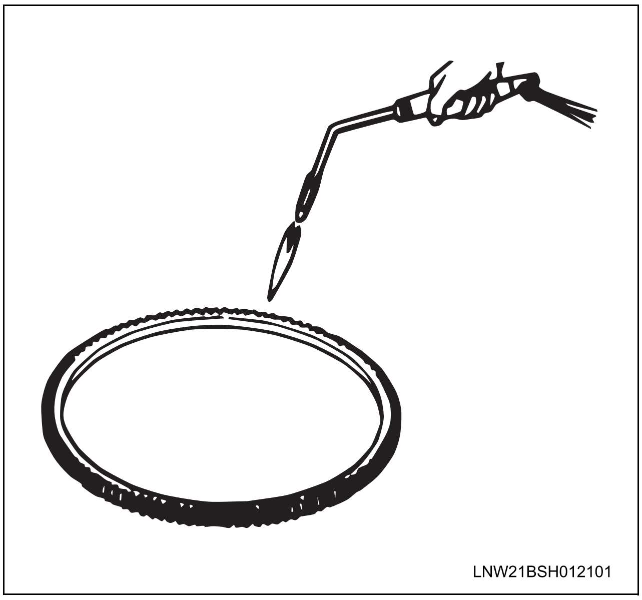

LNW21BSH011901

Installation

1. Install the ring gear.
   - After heating the ring gear with a gas burner equally, install it in the flywheel.
   - In the case of shrinkage cooling of the ring gear, maintain the flatness by applying weight of 68.6 kN (15,400 lbf).

Caution:

- Install the ring gear so that the side with a pattern faces forward.
- Shrink fit the ring gear to the flywheel.
  Make sure that flywheel and ring gear adhesion is complete.


LNW21BSH012101

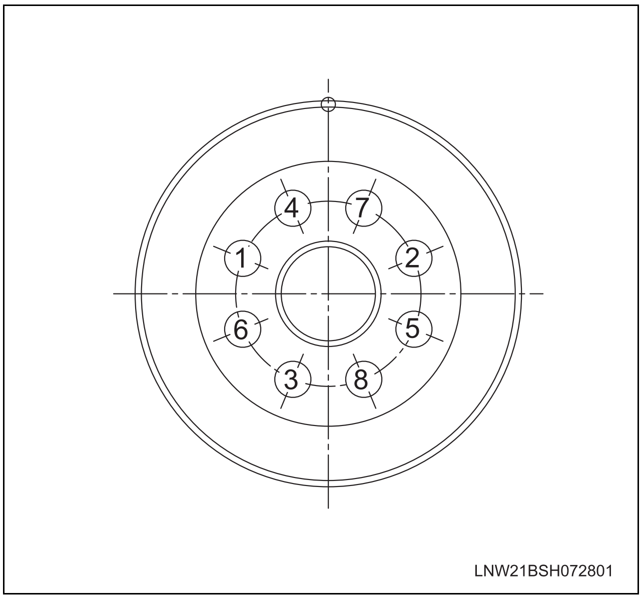
2. Install the flywheel.
3. Install the washer.

M/T specification

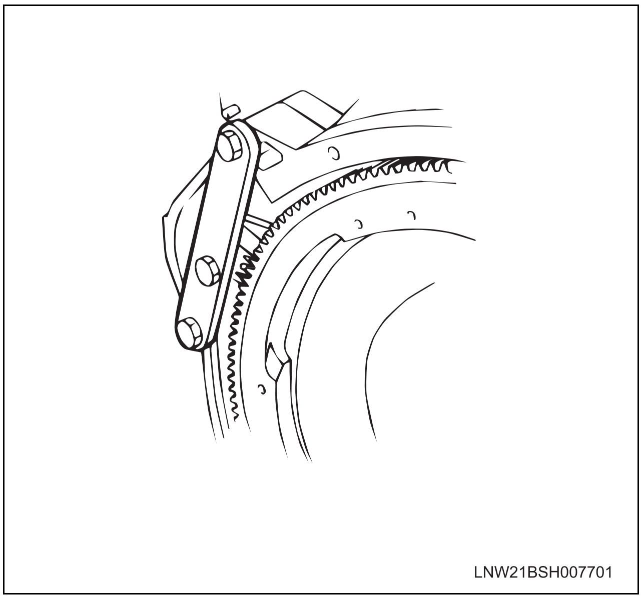
- Install the flywheel to match with the dowel pins of the crankshaft, tighten them in the order shown in the illustration.
- Apply molybdenum disulfide on the screw part and setting face of the bolt.
- Install the crankshaft stopper on the starter installation part of the flywheel housing.

Tightening torque:
1st step = 78 N·m (58 lb ft)
2nd step = 120° ~ 150° (degrees)

Special tool
Crankshaft stopper: EN-47680
Angle gauge: J-45059



LNW21BSH072801

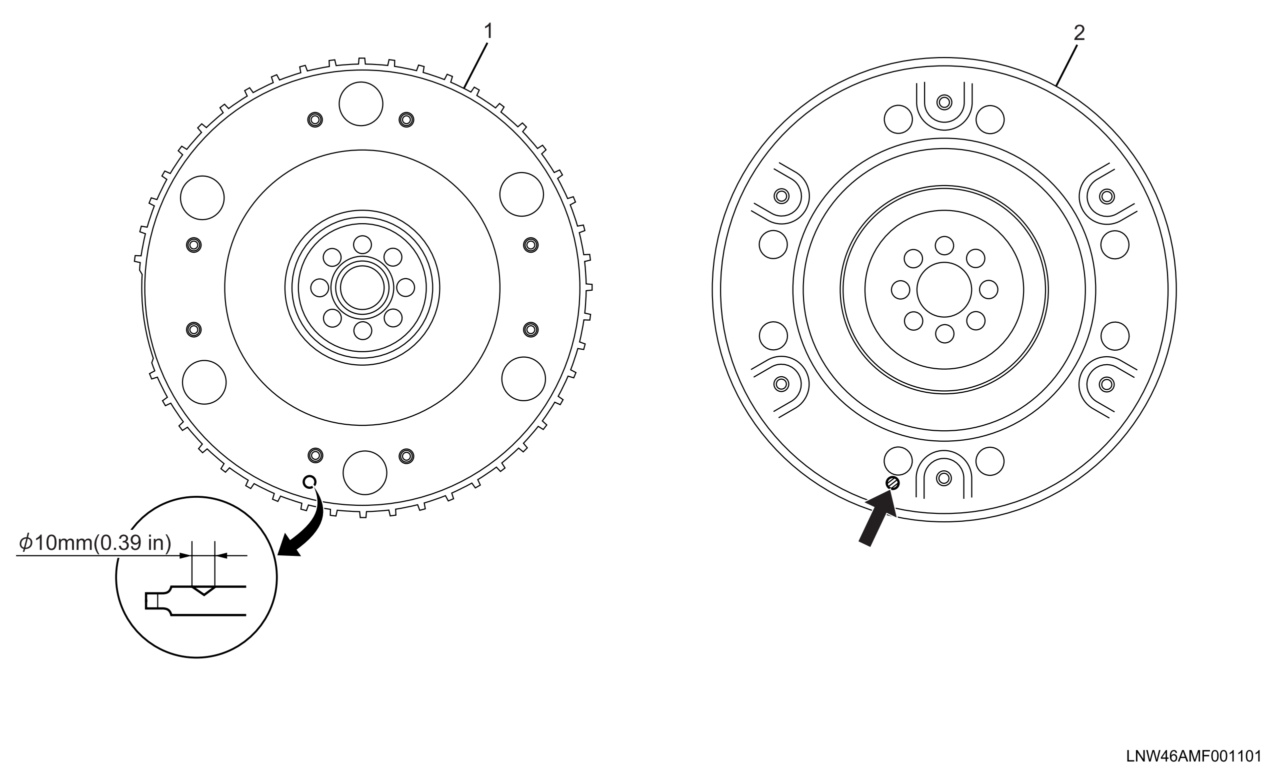


LNW21BSH007701

A/T specification

- Install the flywheel to match with the dowel pins of the crankshaft
- Install it so that the matching mark (white part indicated) of the flexible plate overlaps with the matching mark (ϕ10 countersink) of the flywheel.

- Follow the same tightening step as M/T specification.



Legend

1. Flywheel
2. Flexible Plate

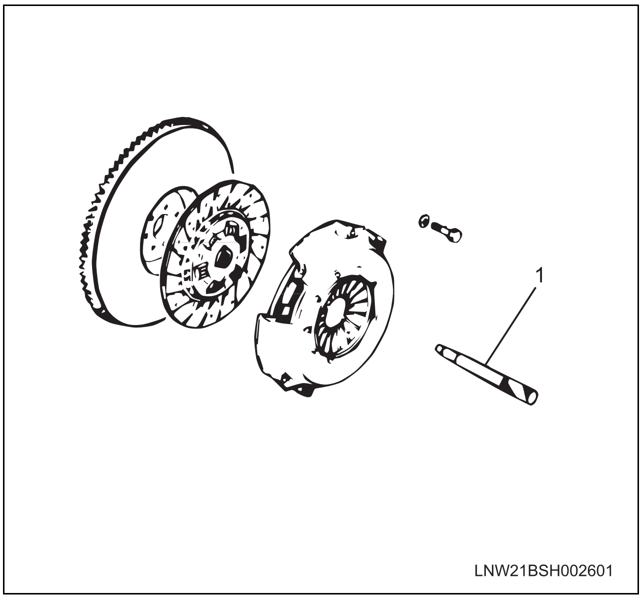
---

4. Install and tighten the Crankshaft Position sensor with the designated torque.

Tighting torque: 8 N·m (69 lb in)

5. Hammer in the pilot bearing until it reaches the edge surface of the crank.
6. Install the driven plate.

- Use a clutch aligner to install the driven plate on the flywheel.



Legend

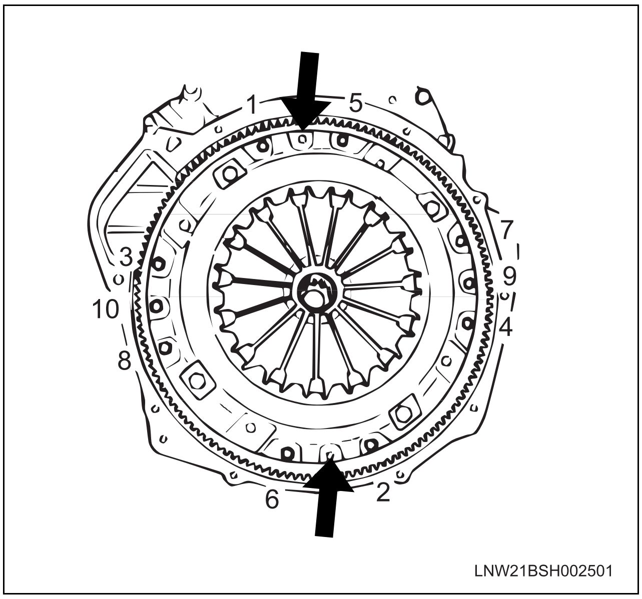
1. Clutch Aligner

---

7. Install the clutch pressure plate.

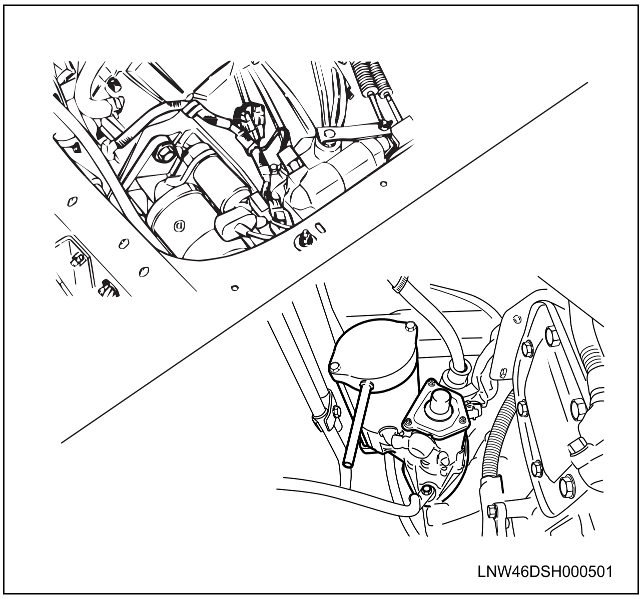
- Install the pressure plate on the flywheel so that the installation hole of the pressure plate matches with the dowel pins of the flywheel.
- Tighten the pressure plate in the order shown in the drawing.

Tightening torque: 40 N·m (30 lb ft)

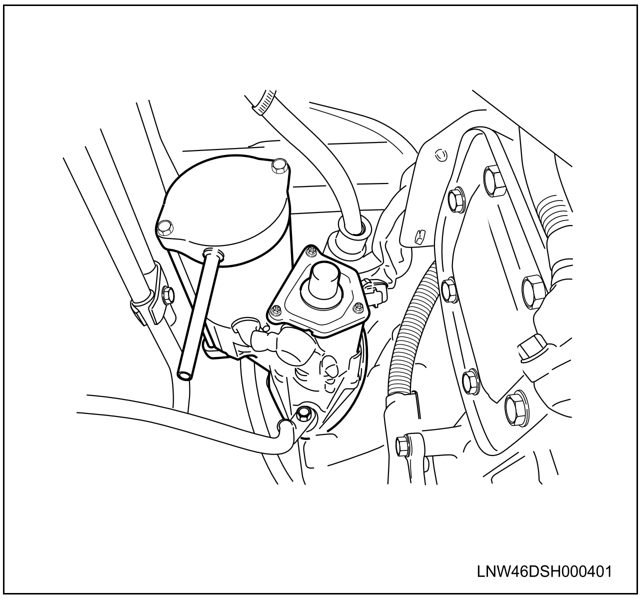


8. Install the transmission assembly.
   Refer to “transmission assembly removal and installation”.
9. Install the starter motor on the clutch housing with bolts and tighten them with the designated torque.

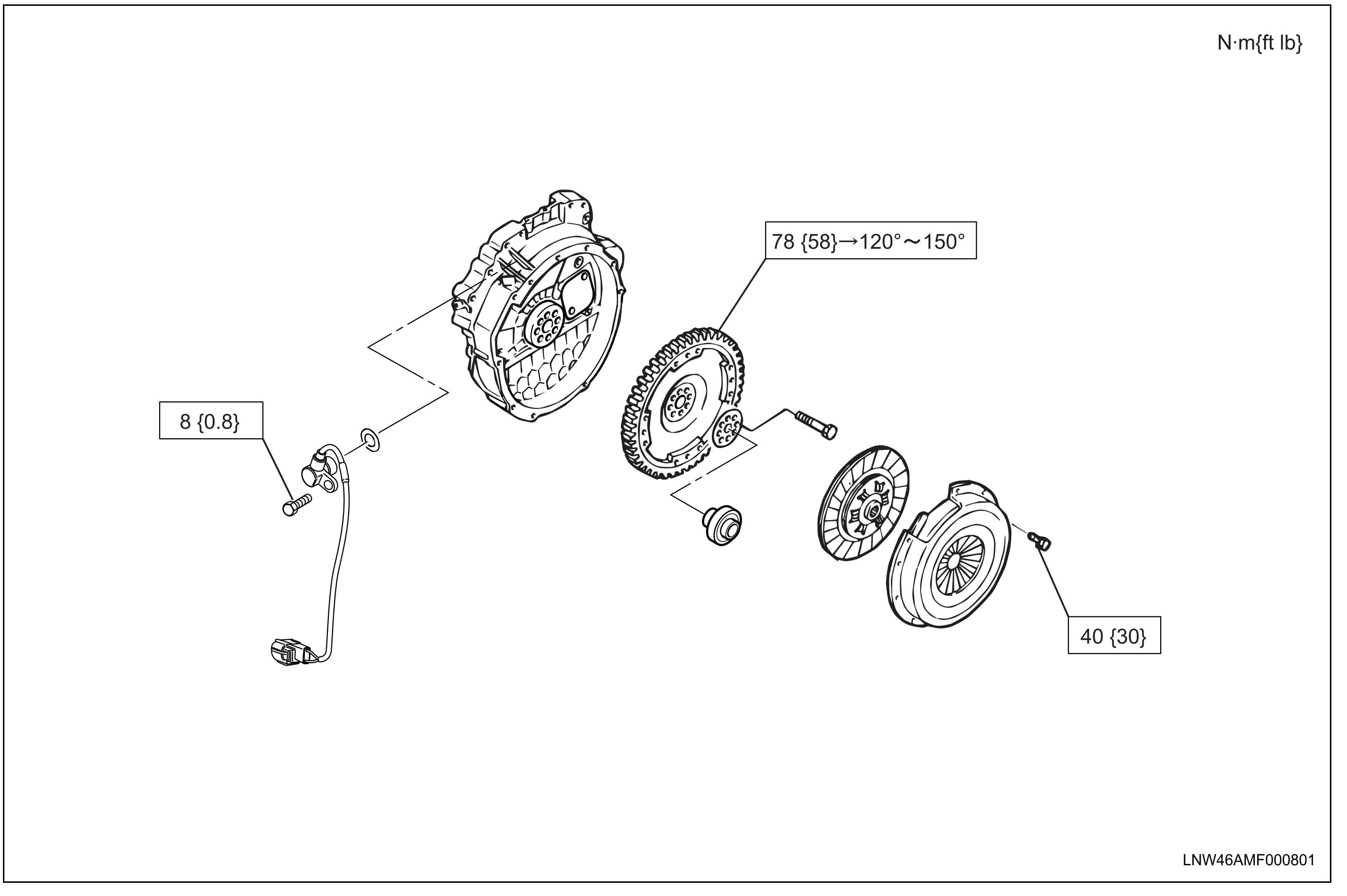
Tightening torque: 76 N·m (56 lb ft)



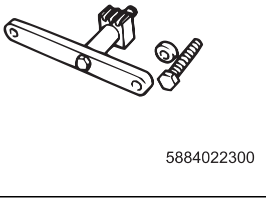
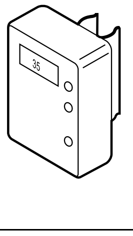
- Install the earth cable of the starter motor.
- Connect the front frame harness connector.



Torque Specifications

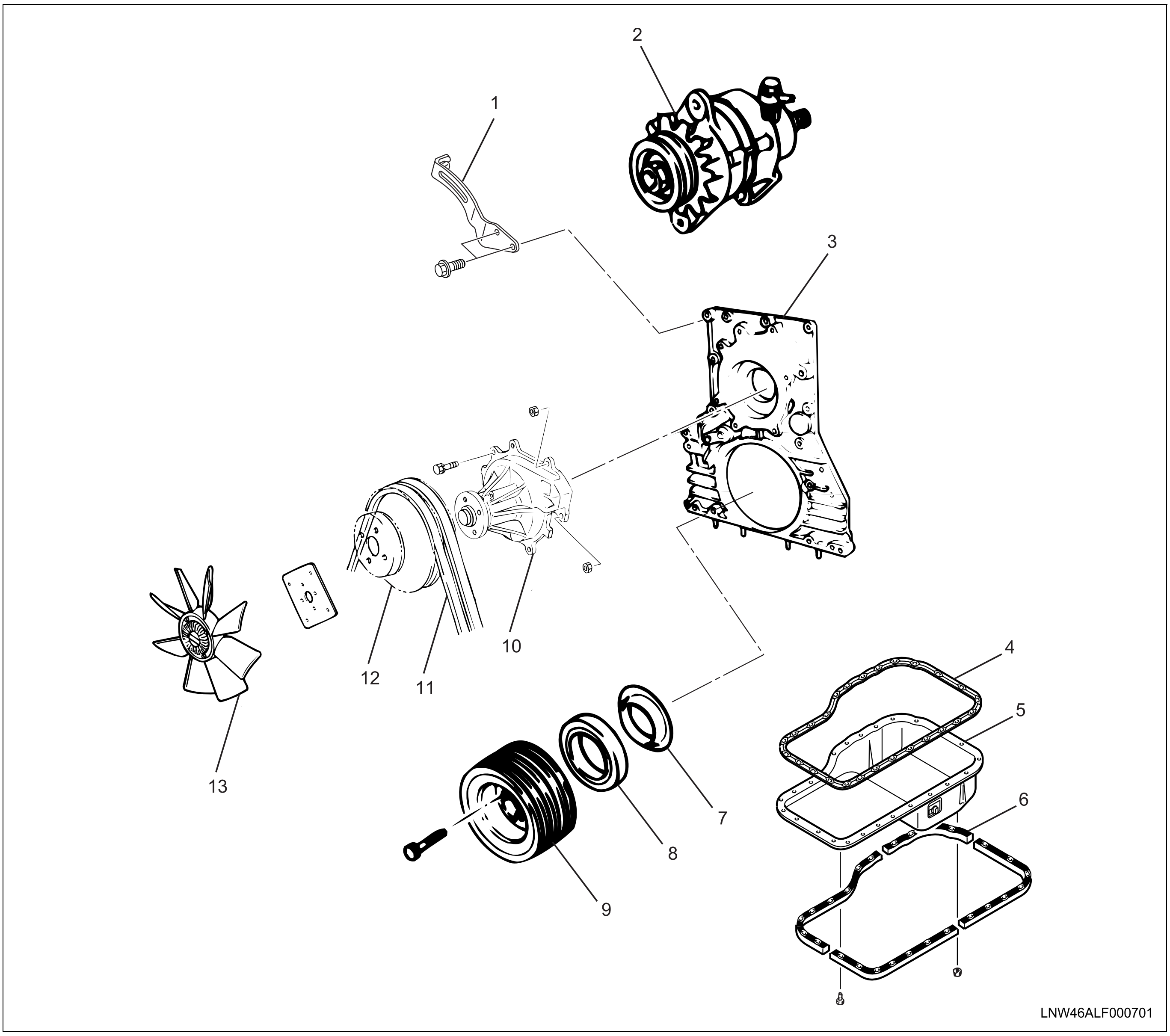


Special tool

Illustration	Tool Number/ Description
 5884022300	EN-47680 Crankshaft stopper
 J45059	J-45059 Angle gauge

Front Cover

Component



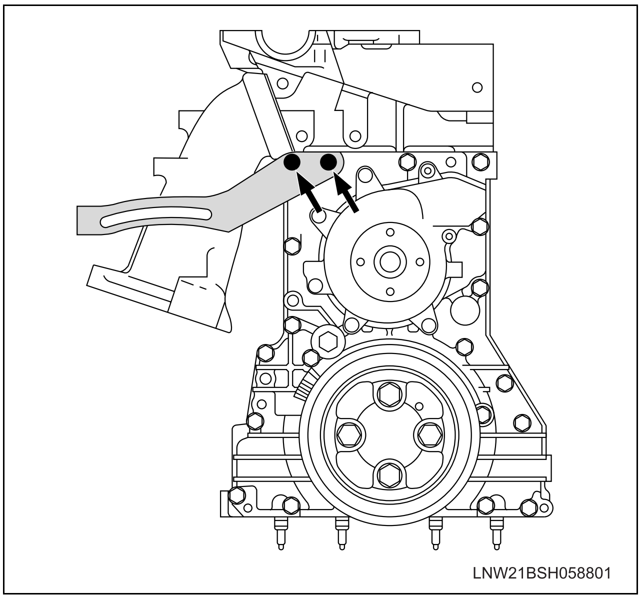
Legend

1. Adjust Plate
2. Generator
3. Front Cover
4. Oil Pan Gasket
5. Oil Pan
6. Rubber Assembly
7. Front Slinger
8. Front Oil Seal
9. Crankshaft Pulley
10. Water Pump Assembly
11. Fan Belt
12. Water Pump Pulley
13. Fan Assembly

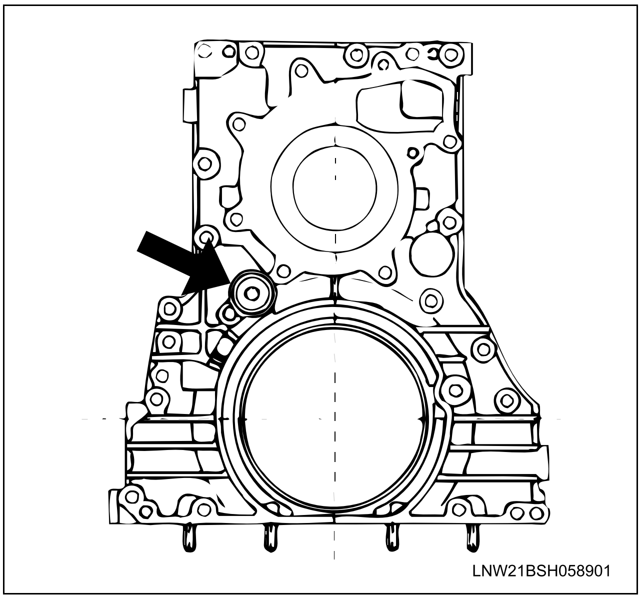
Removal

1. Remove the front oil seal.
   Refer to “crankshaft front oil seal”.
2. Remove the oil pan
   Refer to “oil pan”.
3. Remove the water pump.
   Refer to the “water pump” in the cooling system section.
4. Remove the front cover.

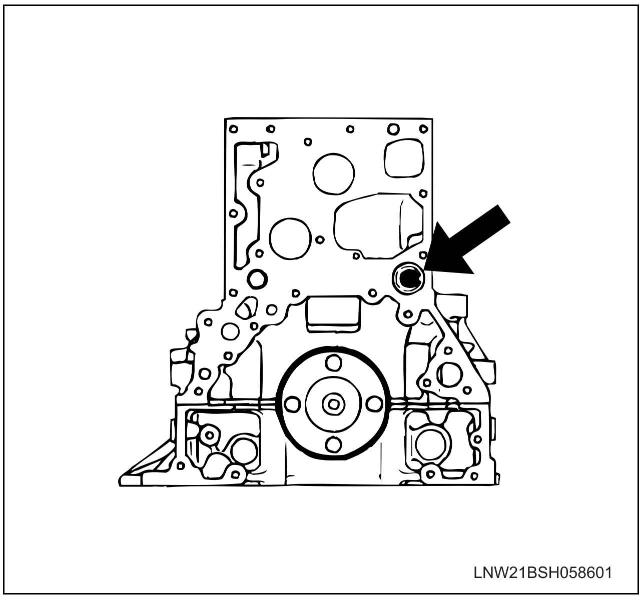
- Remove the generator adjust plate.



- Remove the oil relief valve (arrowed), loosen the front cover installation bolts and remove the front cover.



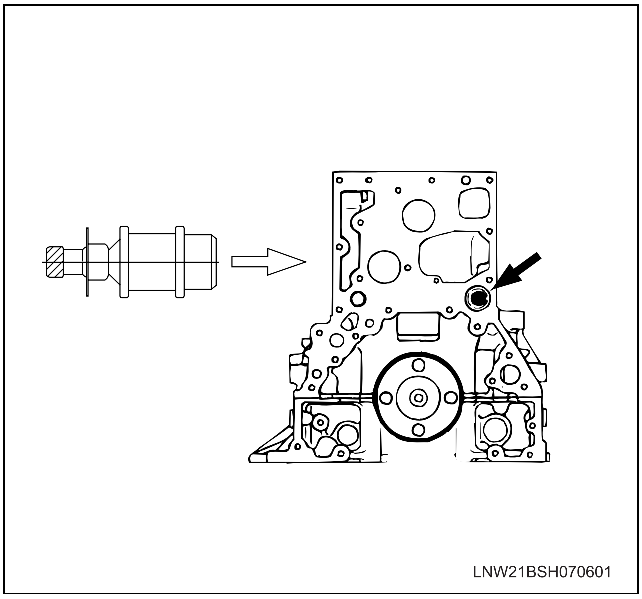
5. Remove the oil thermo valve.
   - Pull out the oil thermo valve from the cylinder block.



Installation

1. Install the oil thermo valve.
   - Insert the oil thermo valve into the cylinder block. Be sure not to insert in a wrong direction.

Caution:
Do not remove the rubber cap of the thermo valve.

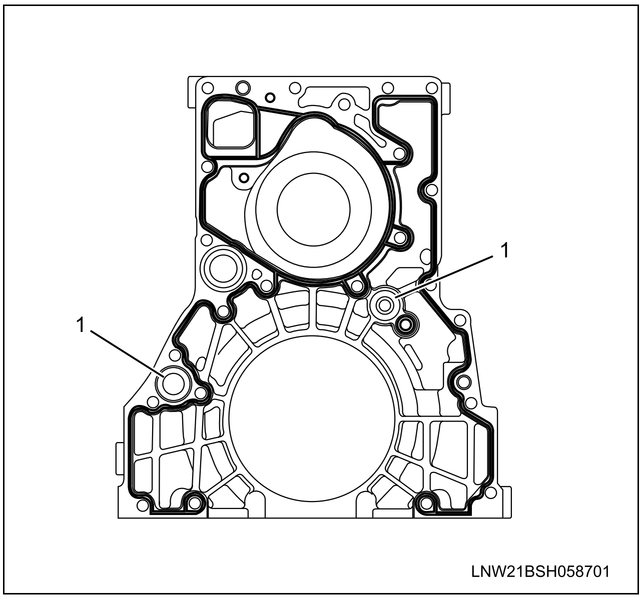


2. Install the front cover.
   - Clean the cylinder block front surface. In particular, remove liquid gasket leaked during installation of the crankcase.
   - Install two O-rings and apply liquid gasket (ThreeBond 1207B or equivalent), (ThreeBond 1207C or equivalent), or each equivalent along with the groove of the front cover installation surface.

Beat width	1.5 ~ 5mm (0.059 ~ 0.20 in)
Beat height	0.3 ~ 1.5mm (0.012 ~ 0.059 in) from the joint surface

- Install within seven minutes after applying liquid gasket.

Caution:
Apply liquid gasket so that it does not adhere to the O-ring.



Legend

1. O-Ring

- Install the front cover to match with the dowel pins of the cylinder block.

Caution:
Along with the front cover, install the water pump assembly (before liquid gasket becomes dry)

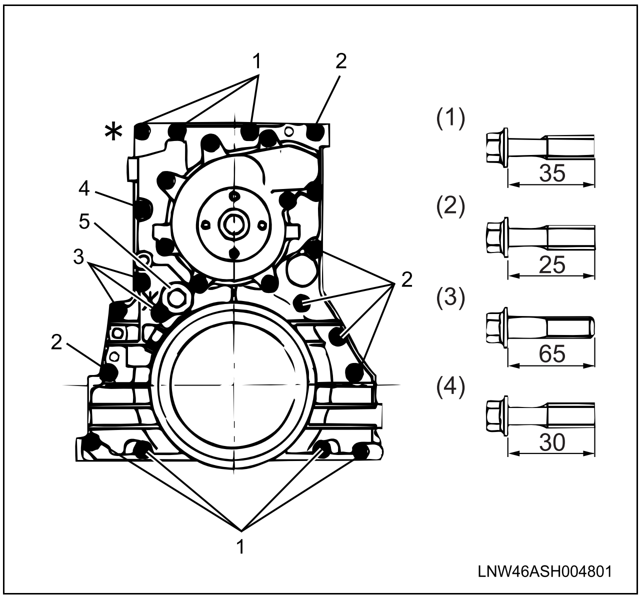
Tightening torque

Front cover bolt: 24 N·m (18 lb ft)

- Tighten bolts with (*) mark together with the adjust plate of the generator.
- Tighten the oil relief valve (5) with the designated torque.

Tightening torque

Oil relief valve: 39 N·m (29 lb ft)



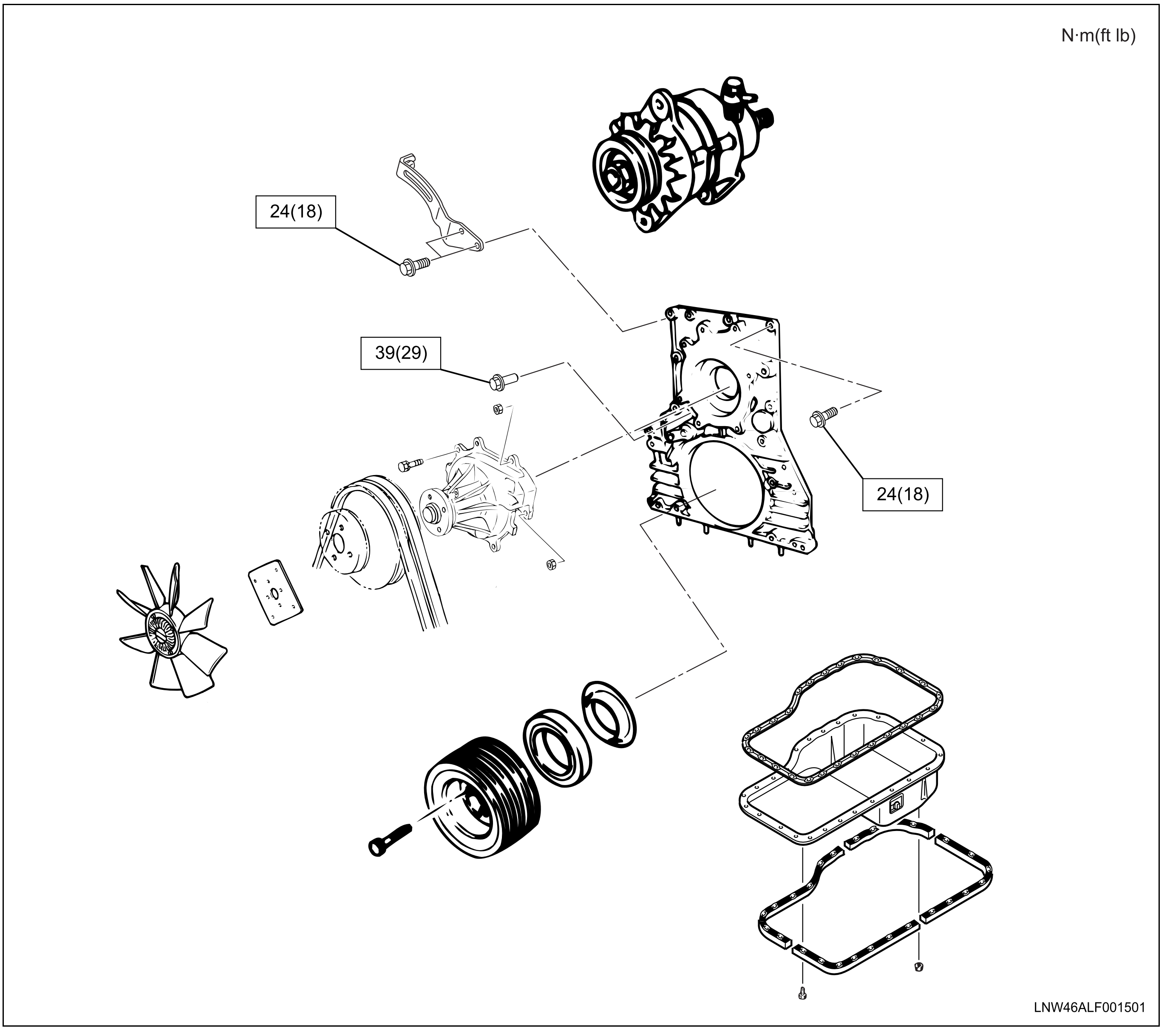
Legend

1. BOLT : L = 35
2. BOLT : L = 25
3. BOLT : L = 65
4. BOLT : L = 30
5. Oil Relief Valve

---

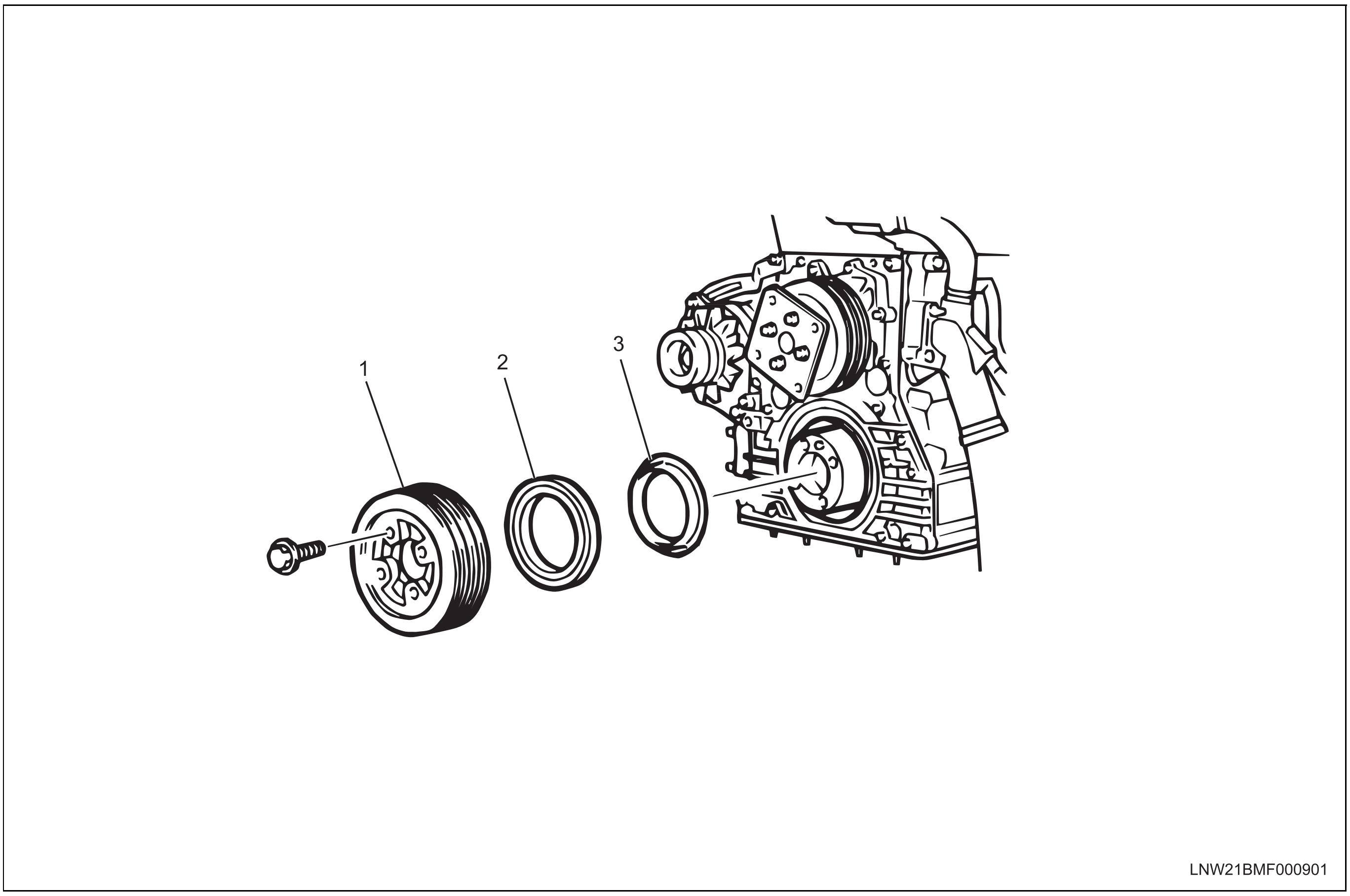
3. Install the water pump.
   Refer to the “water pump” of the section of the “cooling system”
4. Install the oil pan.
   Refer to the “oil pan” .
5. Install the front oil seal.
   Refer to the “crankshaft front oil seal”.

Torque Specifications



Crankshaft Front Oil Seal

Component

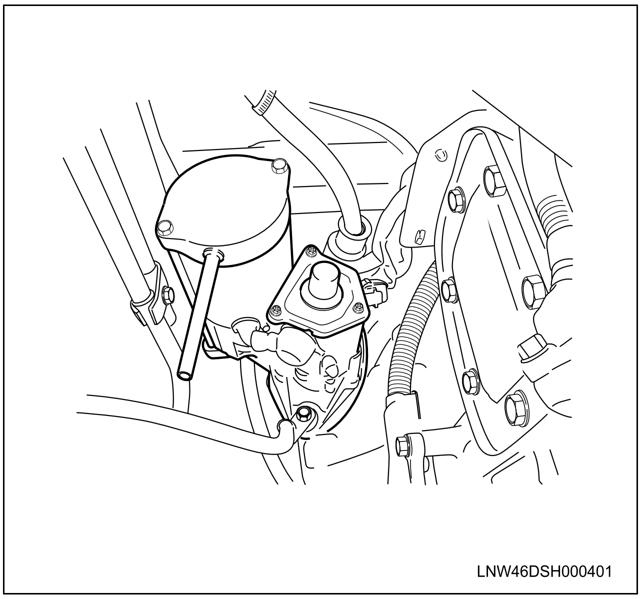


Legend

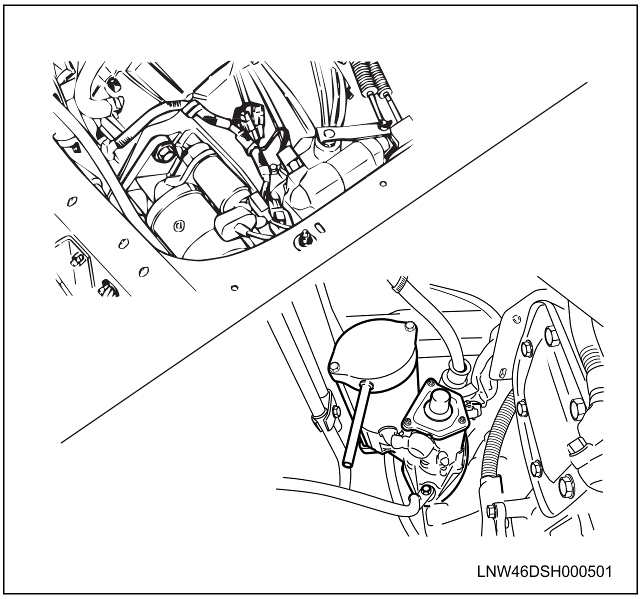
1. Crankshaft Pulley
2. Crankshaft Front Oil Seal
3. Crankshaft Front Slinger

Removal

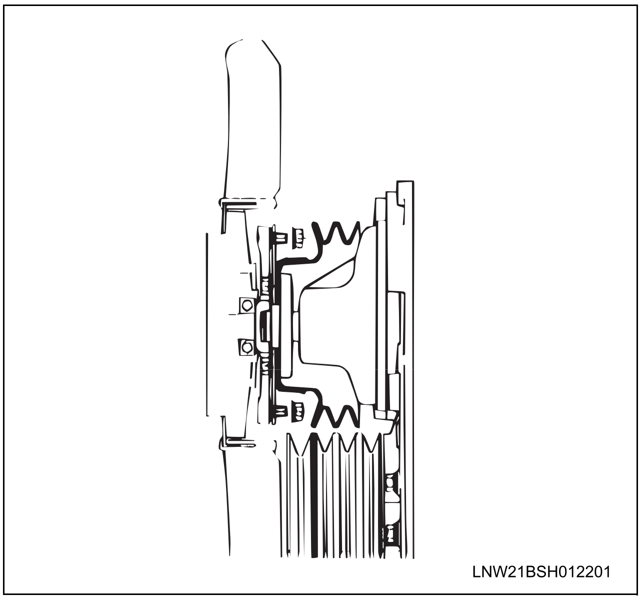
1. Drain coolant.
2. Remove the starter.
   - Disconnect the starter ground cable.
   - Disconnect the front frame harness connector at a position near the transmission control box and unlatch fixing clips from the harness.



- Unscrew two mounting bolts, upper and lower, from the starter to dismount the starter from the clutch housing.
- Fix the detached starter with a wire or the like at a position where it will not be a hindrance to removing the transmission.


LNW46DSH000501

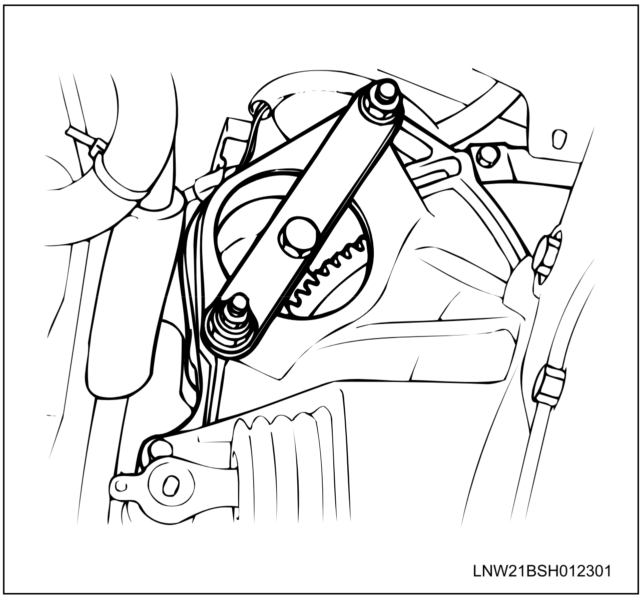
3. Disconnect the upper radiator hose on the engine side.
4. Disconnect the coolant reserve tank hose on the radiator side.
5. Disconnect the lower radiator hose on the engine side.
6. Remove the radiator (with the fan guide) detaching right and left brackets.
7. Remove the fan assembly.
   - Remove the fan assembly unscrewing four mounting nuts.
8. Remove the fan belt.


LNW21BSH012201

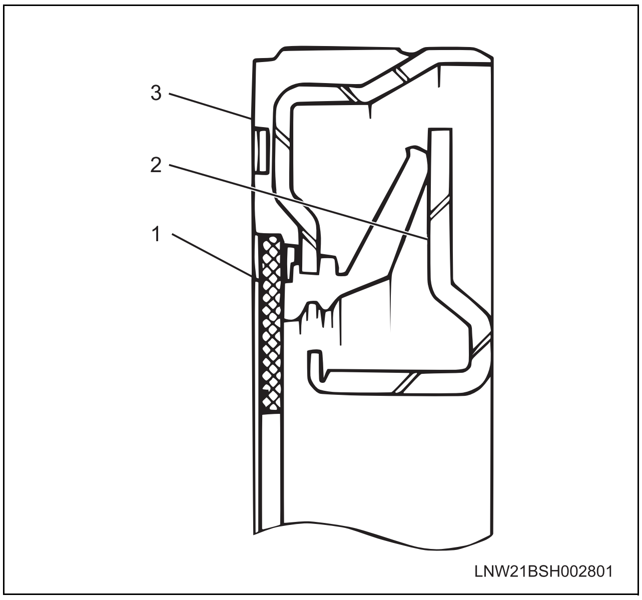
9. Remove the crankshaft pulley.
   - Loosen the pulley nut blocking the crankshaft from turning by placing a crankshaft stopper on the starter mounting position on the flywheel housing.

Caution:
Make sure that the stopper is properly fitted and engaged with the ring gear.

Special tool
Crankshaft stopper: EN-47680


LNW21BSH012301

10. Remove the crankshaft front oil seal.
    - Remove only the oil seal off with a screwdriver or the like avoiding damage to the oil seal contact surface on the front cover and the shaft.



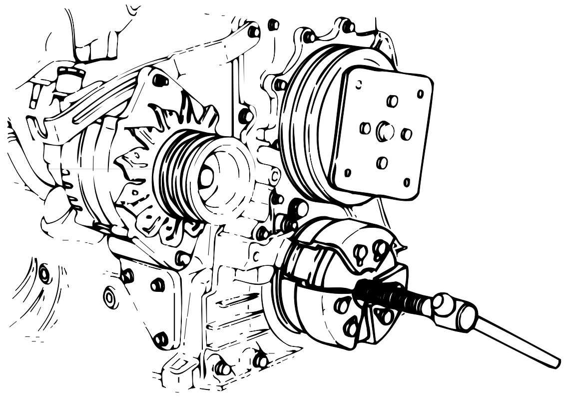
LNW21BSH002801

Legend
1. Felt
2. Slinger
3. Oil Seal

11. Remove the crankshaft front slinger.

- Pull out the slinger using a slinger puller. (Fixing the circumference of the puller with a clip band will make the procedure easier.)

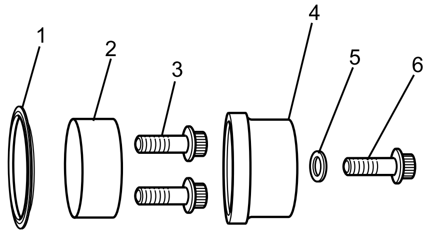
  Special tool
  Slinger puller: J-43285



LNW21BSH012401

Installation

1. Install the crankshaft front slinger.
   - Press-fit the slinger using an oil seal installer kit.



LNW21BSH073201

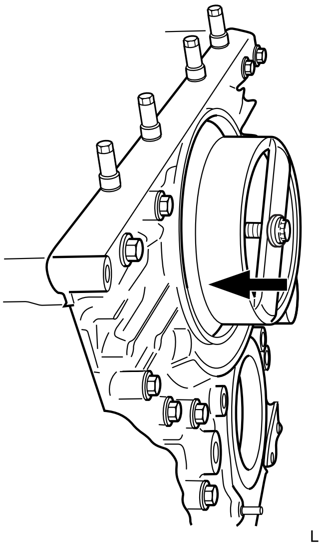
Legend

1. Front Slinger
2. Adapter (Front)
3. Fixing Bolt
4. Sleeve (Front)
5. Washer (Front)
6. Center Bolt

Special tool
Oil seal installer kit: J-43282
(Use the parts listed below for the front oil seal.)

No.	Part Name	Slinger	Oil seal
1	Sleeve (front)	○	○
2	Adapter (front)	○	○
3	Adapter ring (front)	—	○
4	Washer (front)	○	○
5	Center bolt	○	○
6	Fixing bolt	○	○

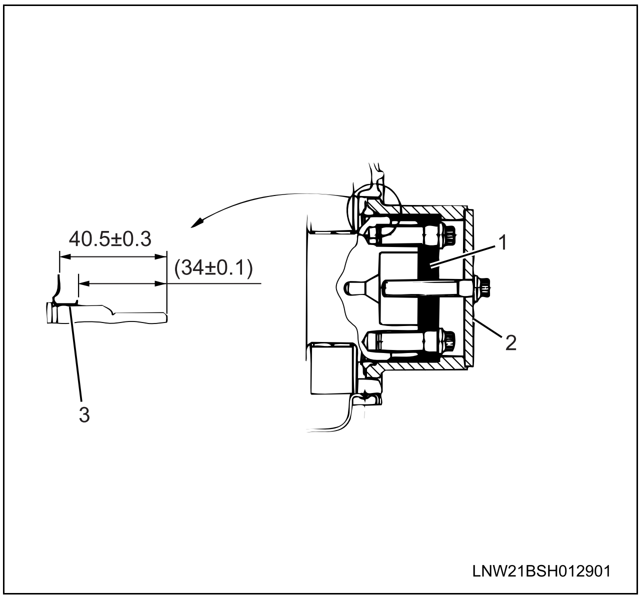
- Insert the front slinger into the end of the front side adapter and fit the adapter on the crankshaft.
- Put the sleeve over the adapter, place a washer on the center bolt and tighten the bolt until the sleeve touches the adapter to press fit the front slinger.



LNW21BSH013301

- After you have pressed in the front slinger, confirm the measurement shown (depth from the end surface of the crankshaft to the flange of the slinger) and check for deflection of the slinger.

Caution:
Be careful not to put the slinger inside out or mistake front side slinger for rear one, and vice versa.Rear side slinger has four right-hand threads on it while front one has four left-hand threads.Slinger and oil seal should always be replaced in pairs.

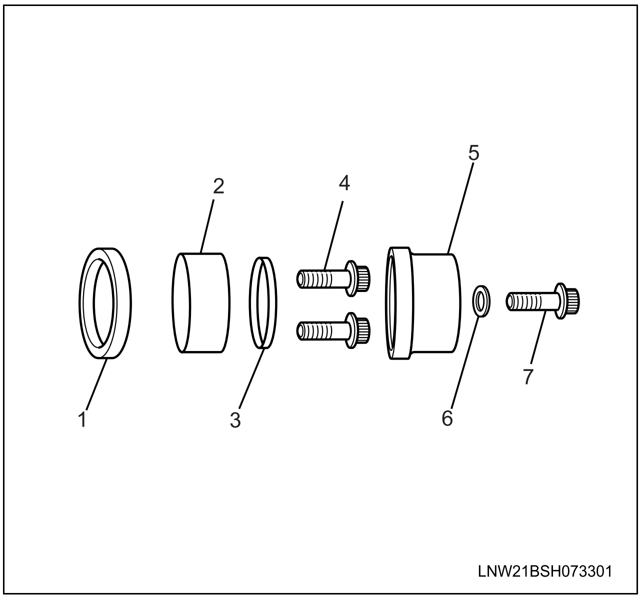


Legend

1. Adapter
2. Sleeve
3. Slinger

---

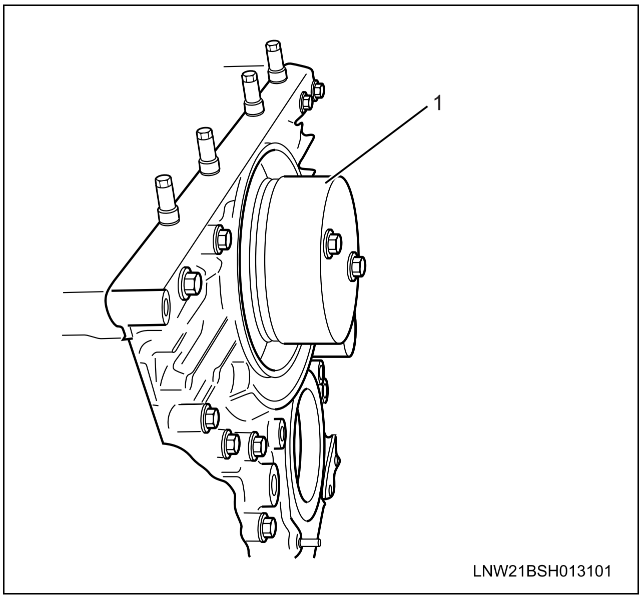
2. Install the crankshaft front oil seal.
    - Press fit the oil seal using an oil seal installer kit.



Legend

1. Oil Seal
2. Adapter (Front)
3. Adapter Ring (Front)
4. Fixing Bolt
5. Sleeve (Front)
6. Washer (Front)
7. Center Bolt

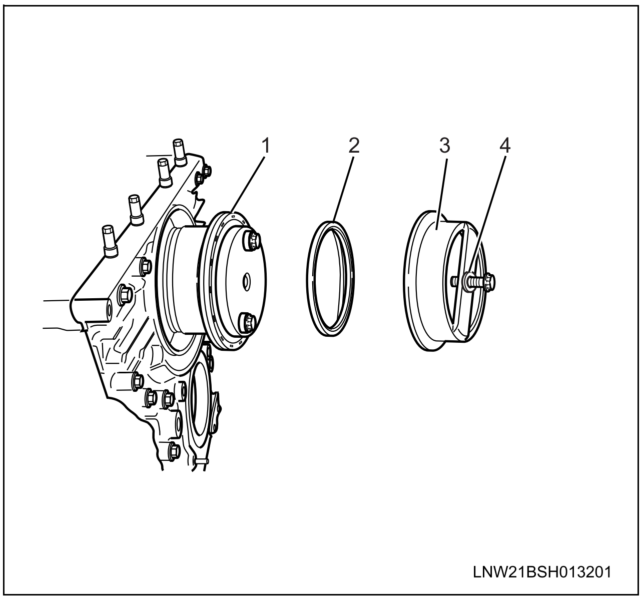
- Mount the adapter onto the crankshaft with fixing bolts.



Legend

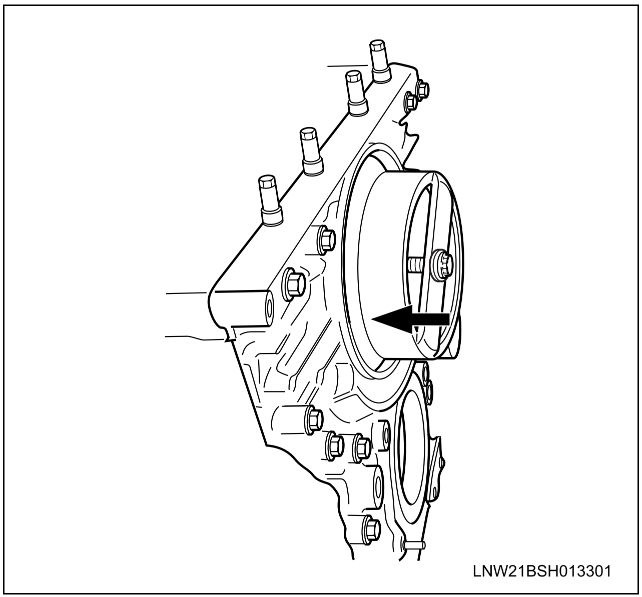
1. Adapter

- Apply engine oil to the lip of the oil seal and place it on the front side adapter.
- Put the front side adapter ring in the sleeve and fix the sleeve on the adapter with the center bolt and a washer.
- Tighten the bolt until the sleeve touches the adapter to press fit the front oil seal.

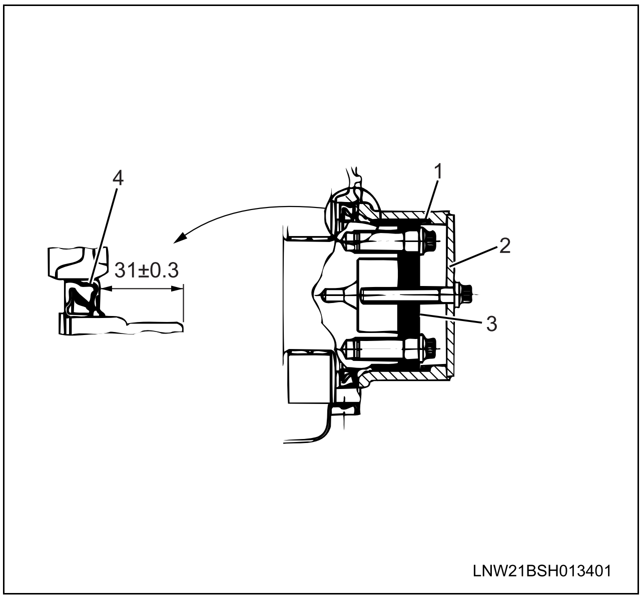


Legend

1. Oil Seal
2. Adapter Ring
3. Sleeve
4. Bolt and Washer



- After you have press-fitted the front oil seal, confirm the measurement shown (depth from the end surface of the crankshaft to the oil seal) and check for deflection of the oil seal.



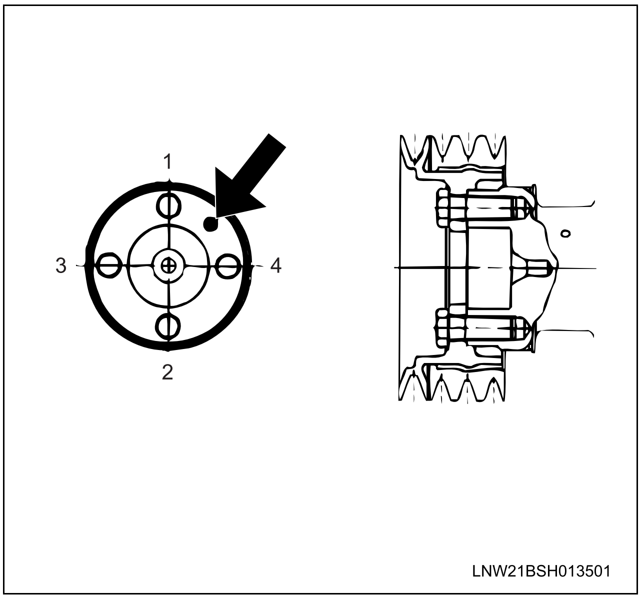
Legend

1. Adapter Ring
2. Sleeve
3. Adapter
4. Oil Seal

---

3. Install the crankshaft pulley.
   - Apply engine oil to the threads of the fastening bolts.
   - Install the crankshaft pulley aligning with the dowel pins on the crankshaft.
   - Tighten in the sequence shown.

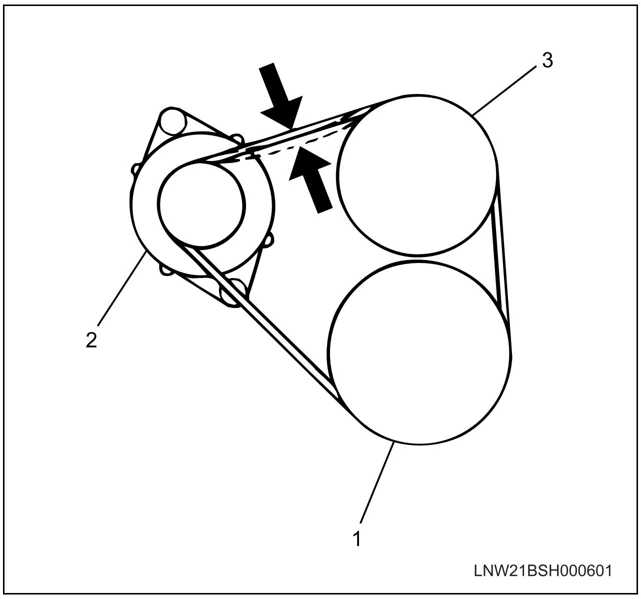
Tightening torque: 200 N·m (148 lb ft)



4. Install the fan belt.
   - When adjusting the fan belt, you should also adjust ACG belt and air conditioner belt at the same time.
   - Fit the fan belt and adjust the tension following the below procedures.
   - Refer to the Drive belt Adjustment Section for details of the belt tension adjustment.

   a. Inspection of fan belt deflection
      - Check with a scale if the belt deflection is within the specified limits when pressure of 98 N (22 lb) is applied mid-way along the belt’s longest run.Also check the belt for damage.

Amount of fan belt deflection	mm (in)
for new belt	8 – 12 (0.31 – 0.47)
for reused belt	10 – 14 (0.39 – 0.55)

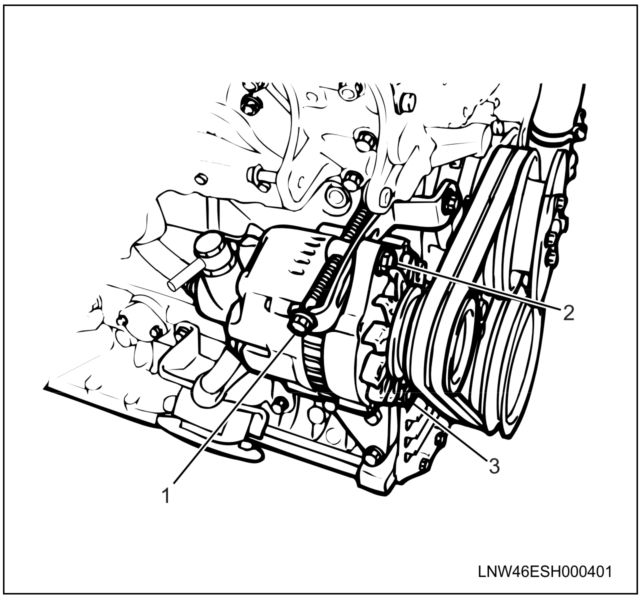


Legend
1. Crankshaft Pulley
2. Generator
3. Fan Pulley

---

b. Adjustment of the fan belt
   - Loosen the adjustment bolt (1) of the AC generator and adjust the fan belt moving the generator.

Tightening torque: (2) = 24 N·m (18 lb ft)
(3) = 40 N·m (30 lb ft)

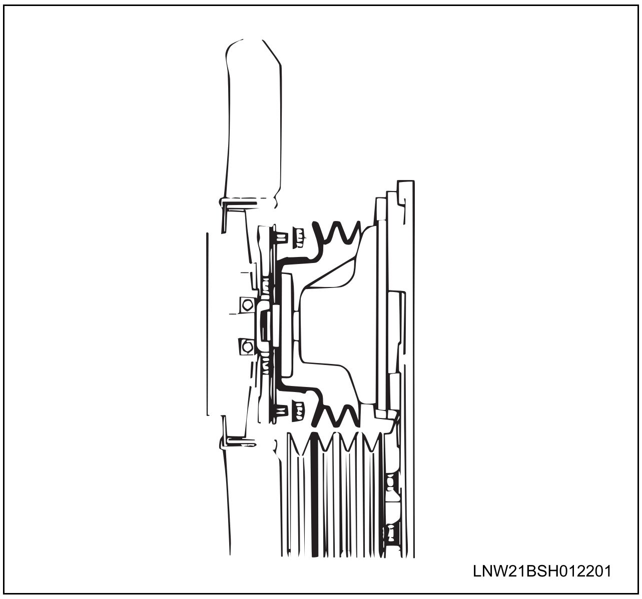


Legend
1. Adjustment Bolt
2. Fixing Bolt
3. Fixing Bolt

---

5. Tighten the fan assembly to the specified tightening torque.

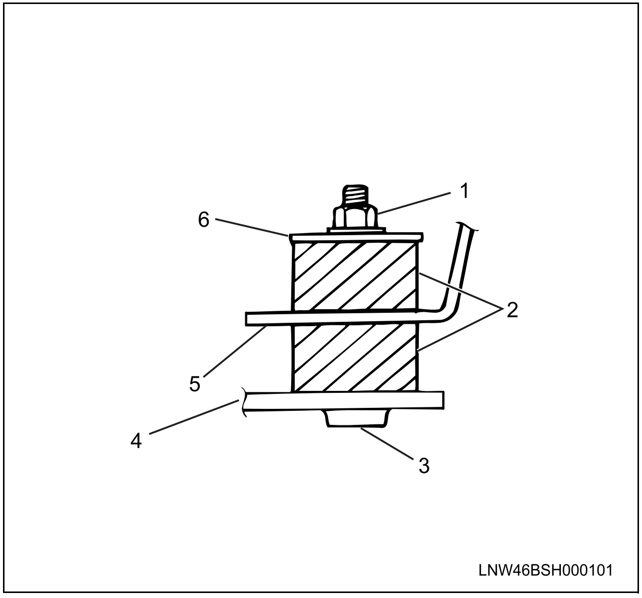
Tightening torque: 24 N·m (18 lb ft)



6. Install the radiator.
   - Attach right and left brackets of the radiator to the brackets on the frame as illustrated.

Tightening torque: 55 N·m (41 lb ft)

Rigid suspension model



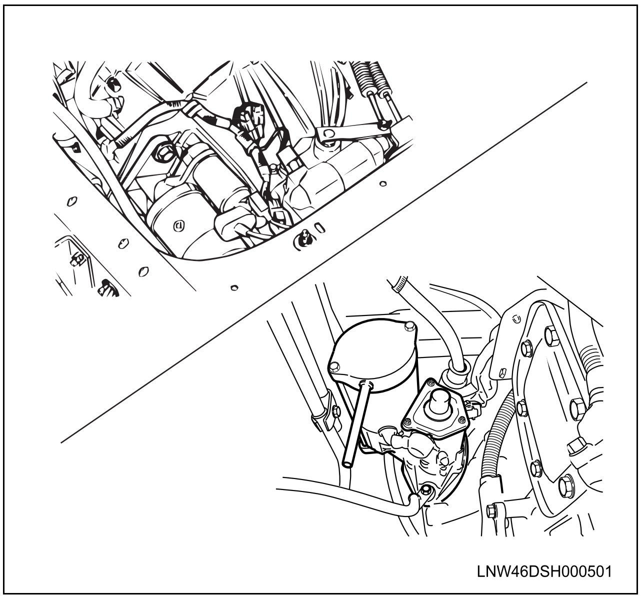
Legend
1. Flange Nut
2. Rubber
3. Stud Bolt
4. Frame Side Bracket
5. Radiator Side Bracket
6. Washer

---

7. Connect the lower radiator hose.
8. Connect the coolant reserve tank hose.
9. Connect the upper radiator hose.
10. Install the starter in the clutch housing with bolts and tighten to the specified tightening torque.

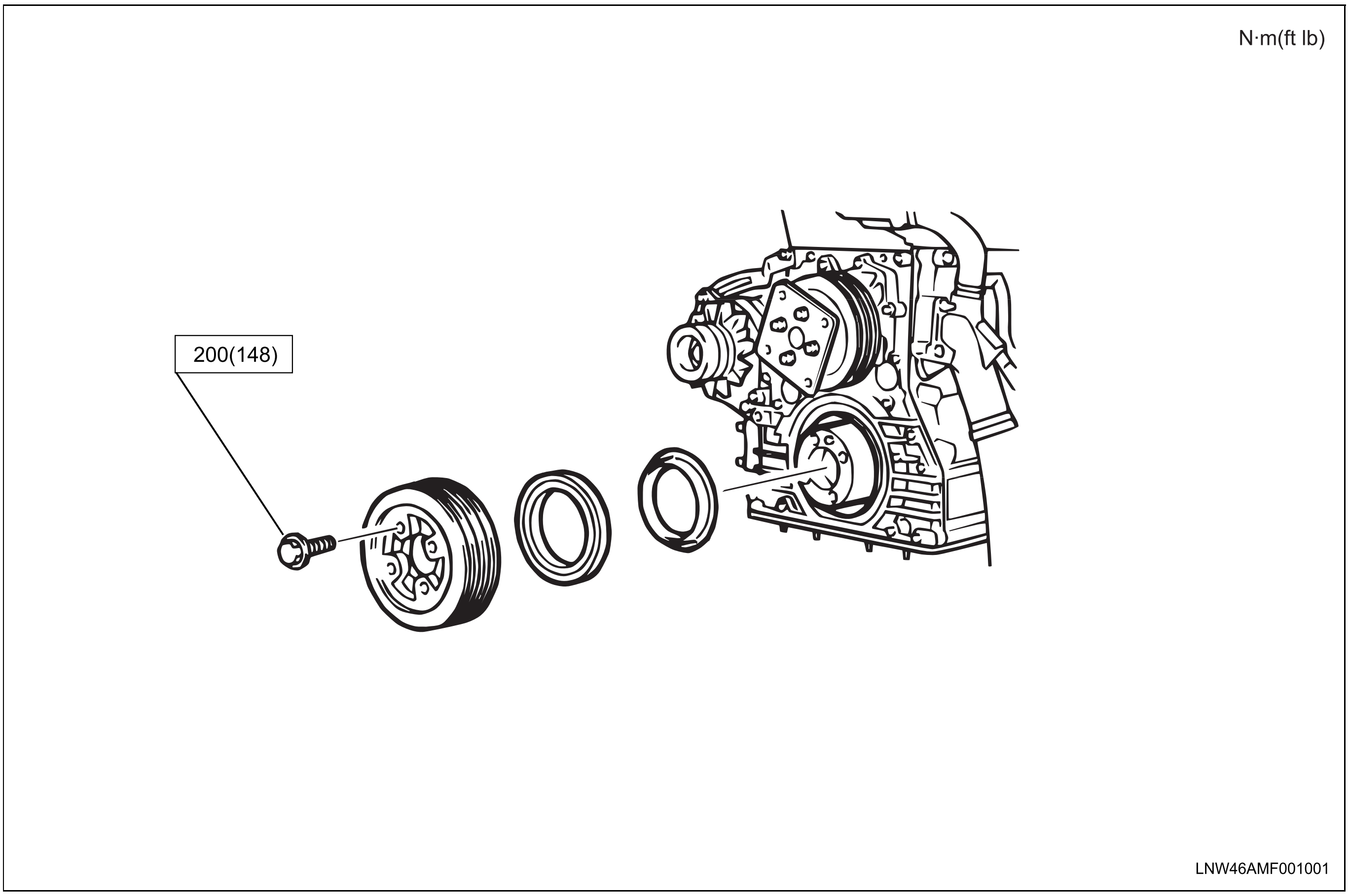
Tightening torque: 76 N·m (56 lb ft)

- Connect the starter ground cable.
- Connect the front frame harness connector.

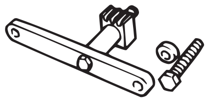
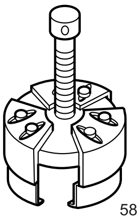
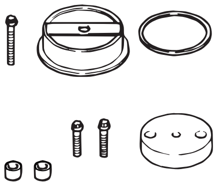


11. Refill the radiator with coolant.

Torque Specifications

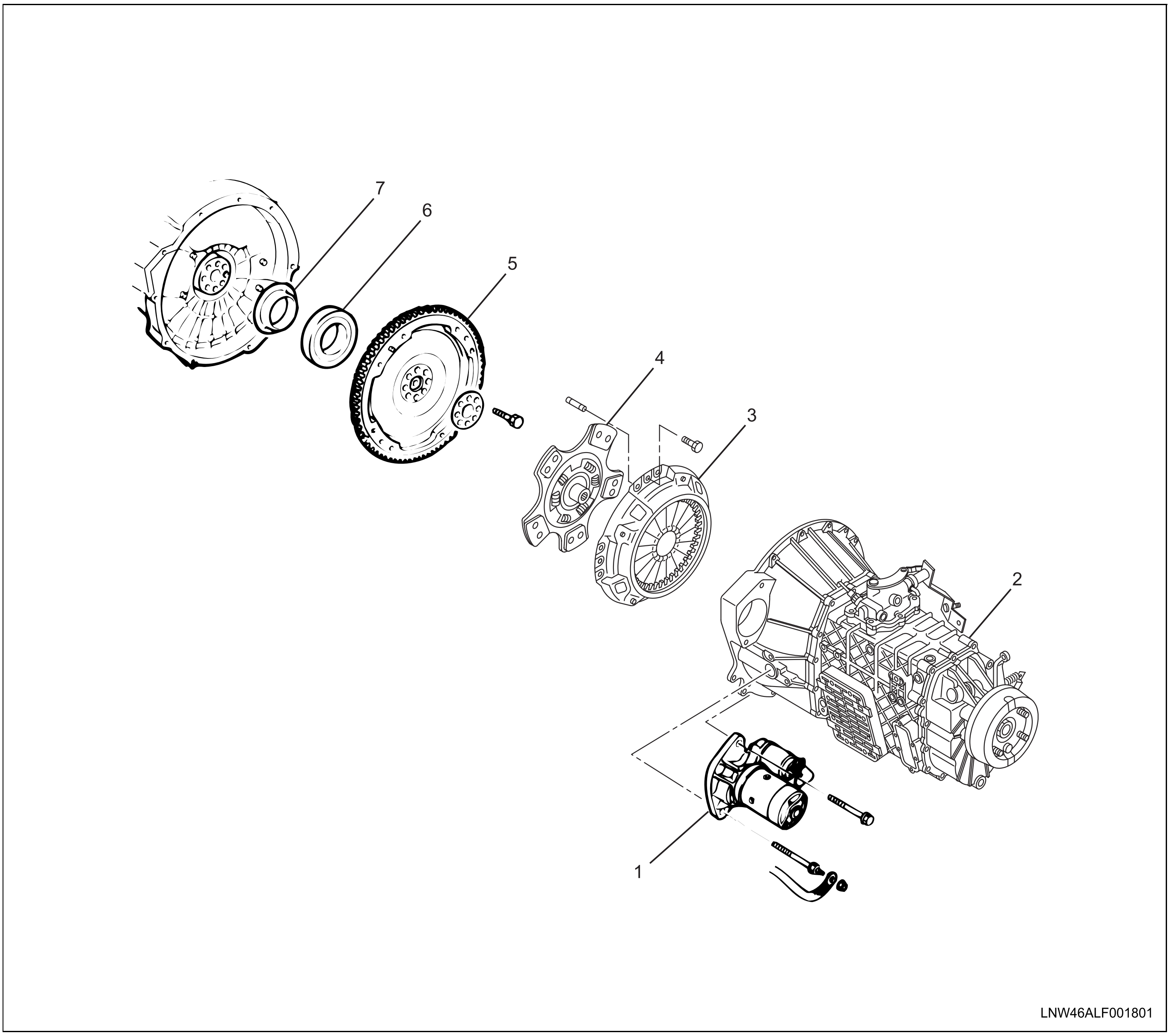


Special tool

Illustration	Tool Number/ Description
 5884022300	EN-47680 Crankshaft stopper
 5884023600	J-43285 Slinger puller
 5884027030	J-43282 Oil seal installer kit

Crankshaft Rear Oil Seal

Component



Legend

1. Starter
2. Transmission Assembly
3. Clutch Pressure Plate
4. Driven Plate
5. Flywheel
6. Crankshaft Rear Oil Seal
7. Crankshaft Rear Slinger

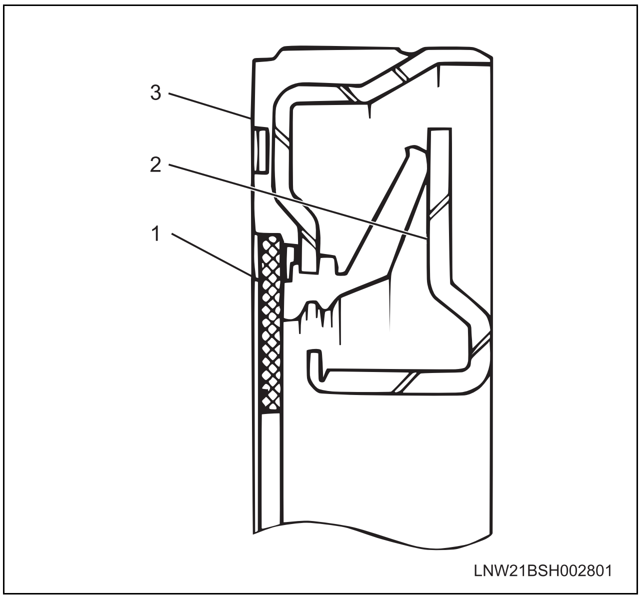
Removal

1. Remove the flywheel.

   Refer to the “flywheel”.

2. Remove the crankshaft rear oil seal.

- Remove only the oil seal off with a screwdriver or the like avoiding damage to the oil seal contact surface on the flywheel housing and the shaft.

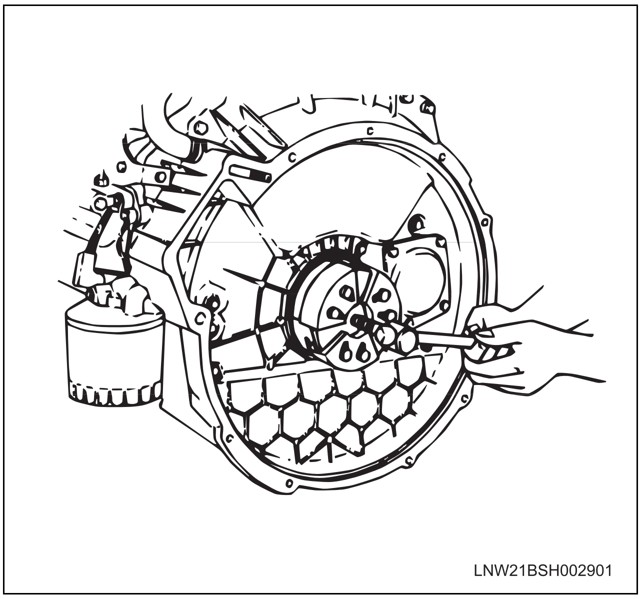


Legend
1. Felt
2. Slinger
3. Oil Seal

---

3. Remove the crankshaft slinger.
   - Pull out the slinger using a slinger puller. (Fixing the circumference of the puller with a clip band will make the procedure easier.)

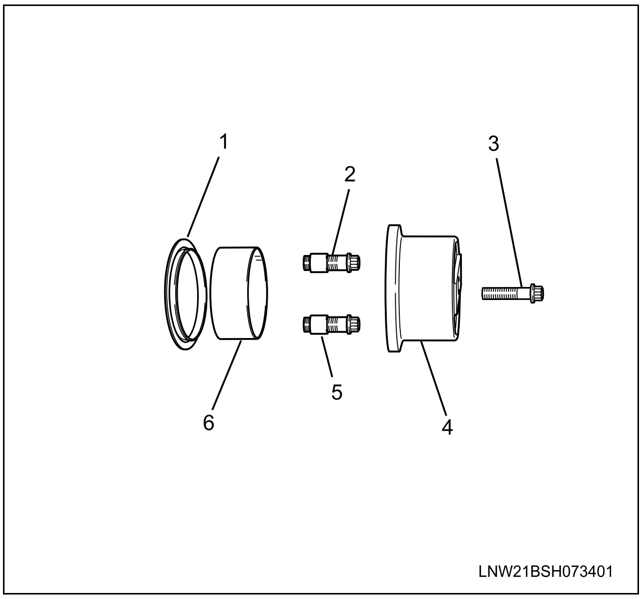
     Special tool
     Slinger puller: J-43285



Installation

1. Install the crankshaft rear slinger.

- Press fit the rear sling using the oil seal installer kit.

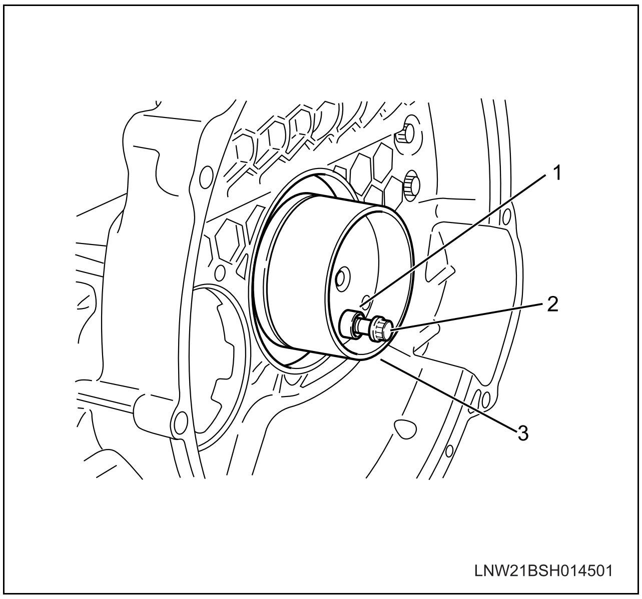


Legend
1. Rear Slinger
2. Fixing Bolt
3. Center Bolt
4. Sleeve (Rear)
5. Collar (Rear)
6. Adapter (Rear)

Special tool
Oil seal installer kit: J-43282

No.	Part Name	Slinger	Oil seal
1	Sleeve (rear)	○	○
2	Adapter (rear)	○	○
3	Collar (rear)	○	○
4	Adapter ring (rear)	—	○
5	Center bolt	○	○
6	Fixing bolt	○	○

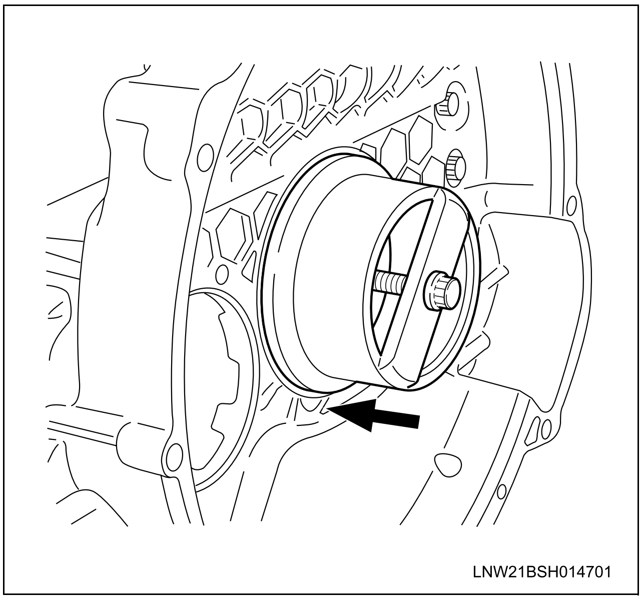
- Insert the rear slinger into the end of the rear side adapter and mount the adapter on the crankshaft with the fixing bolt with a collar placed on it.



Legend

1. Collar
2. Fixing Bolt
3. Adapter

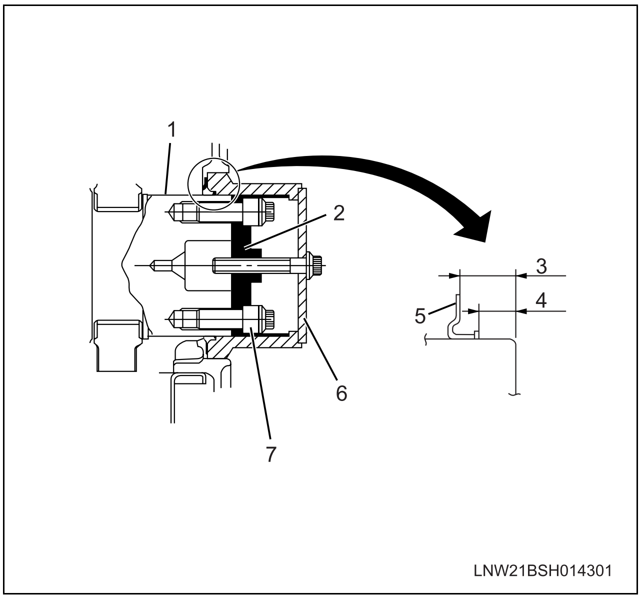
- Put a sleeve over the adapter and tighten the center bolt until the sleeve touches the adapter to press fit the rear slinger.



- After you have press-fitted the rear slinger, confirm the measurement shown (depth from the end surface of the crankshaft to the slinger) and check for deflection of the slinger.

Caution:

Be careful not to put the slinger inside out or mistake the front slinger for the rear one, and vice versa. Rear side slinger has four right-hand threads on it while front one has four left-hand threads.Slinger and oil seal should always be replaced in pairs.

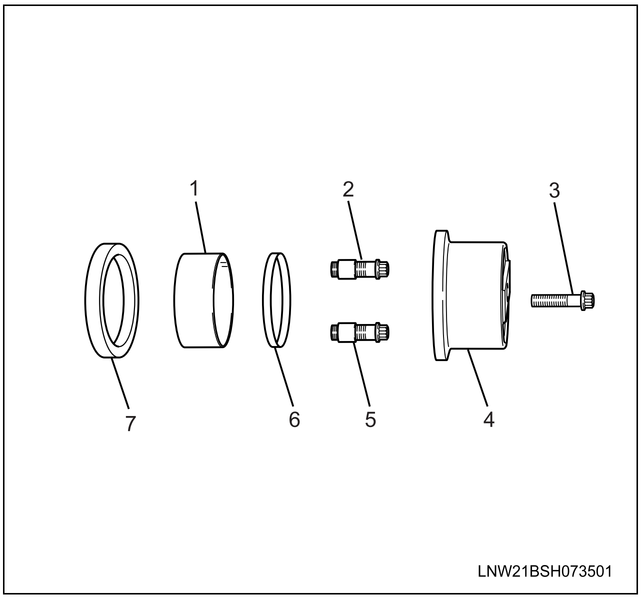


Legend

1. Rear Part of The Crankshaft
2. Adapter
3. 17.3 ± 0.3 mm (0.681 ± 0.012 in)
4. 10.8 ± 0.1 mm (0.425 ± 0.004 in)
5. Slinger
6. Sleeve
7. Collar

---

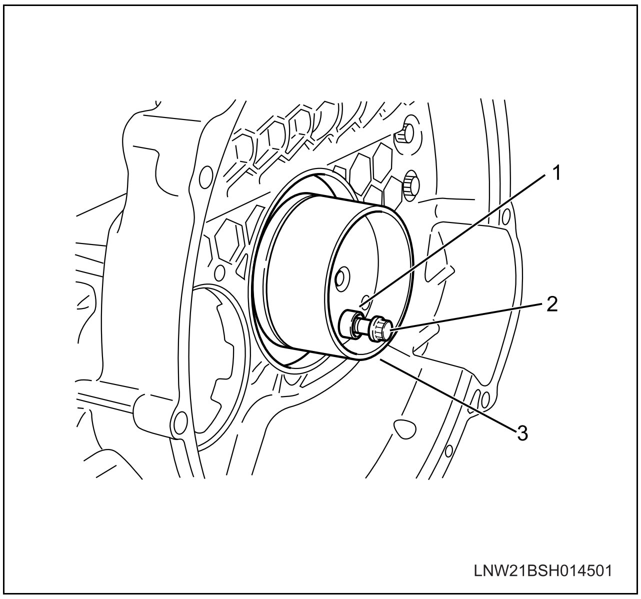
2. Install the crankshaft rear oil sea.
   - Press-fit the rear oil seal using an oil seal installer kit.



Legend

1. Adapter (Rear)
2. Fixing Bolt
3. Center Bolt
4. Sleeve (Rear)
5. Collar (Rear)
6. Adapter Ring (Rear)
7. Oil Seal

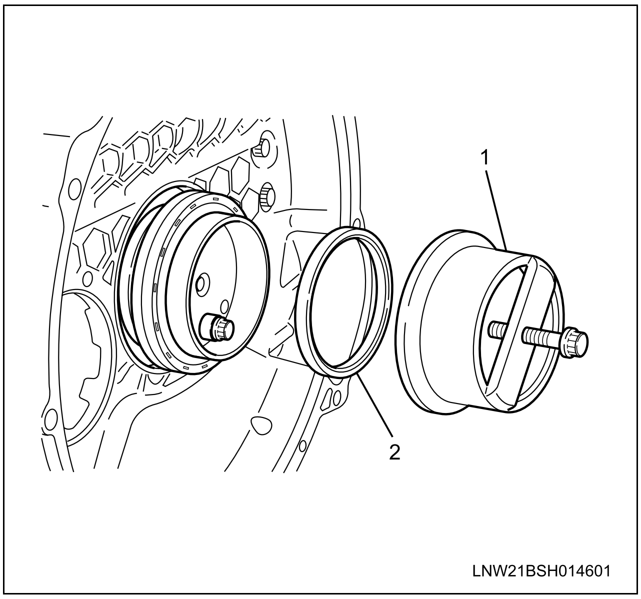
- Put a collar on the fixing bolt and mount the adaptor onto the crankshaft.



Legend

1. Collar
2. Fixing Bolt
3. Adapter

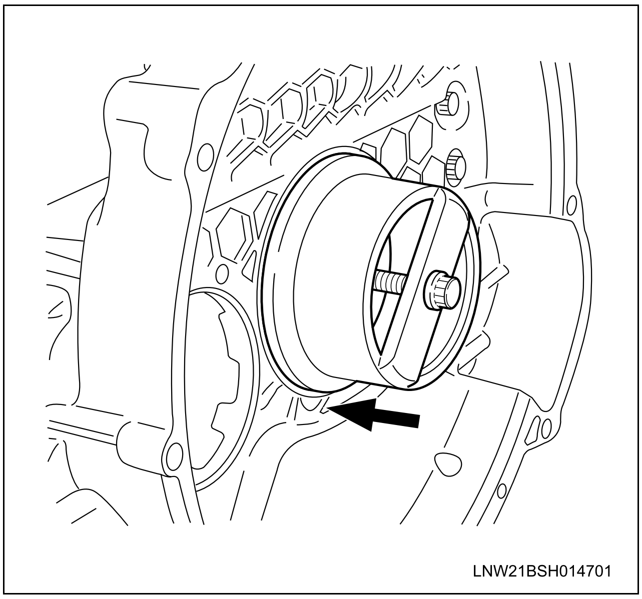
- Apply engine oil to the lip of the oil seal and place it in the rear side adapter.
- Put the rear side adapter ring in the sleeve and put the sleeve on the adapter and fix with the center bolt.



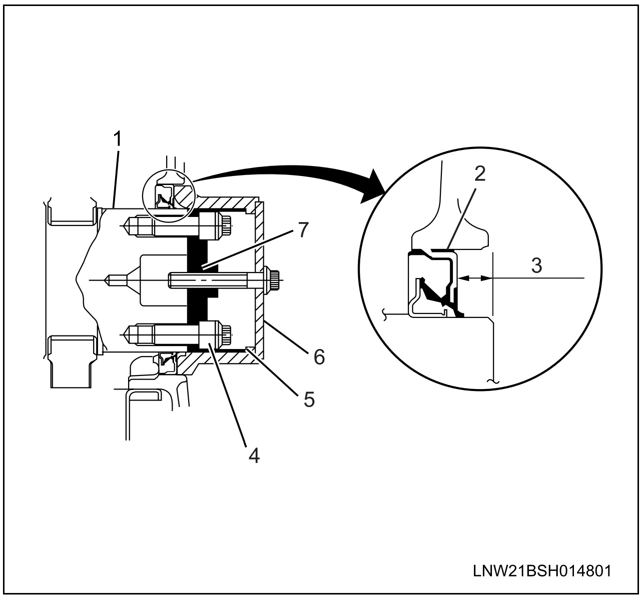
Legend

1. Sleeve
2. Adapter Ring

- Tightening the center bolt until the sleeve touches the adapter to press fit the oil seal.



- After you have pressed in the rear oil seal, confirm the measurement shown (depth from the end surface of the crankshaft to the oil seal).



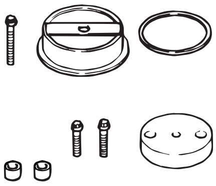
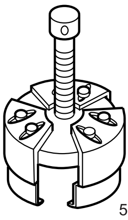
Legend

1. Rear Part of The Crankshaft
2. Oil Seal
3. 7.8 ± 0.3 mm (0.31 ± 0.012 in)
4. Collar
5. Adapter Ring
6. Sleeve
7. Adapter

---

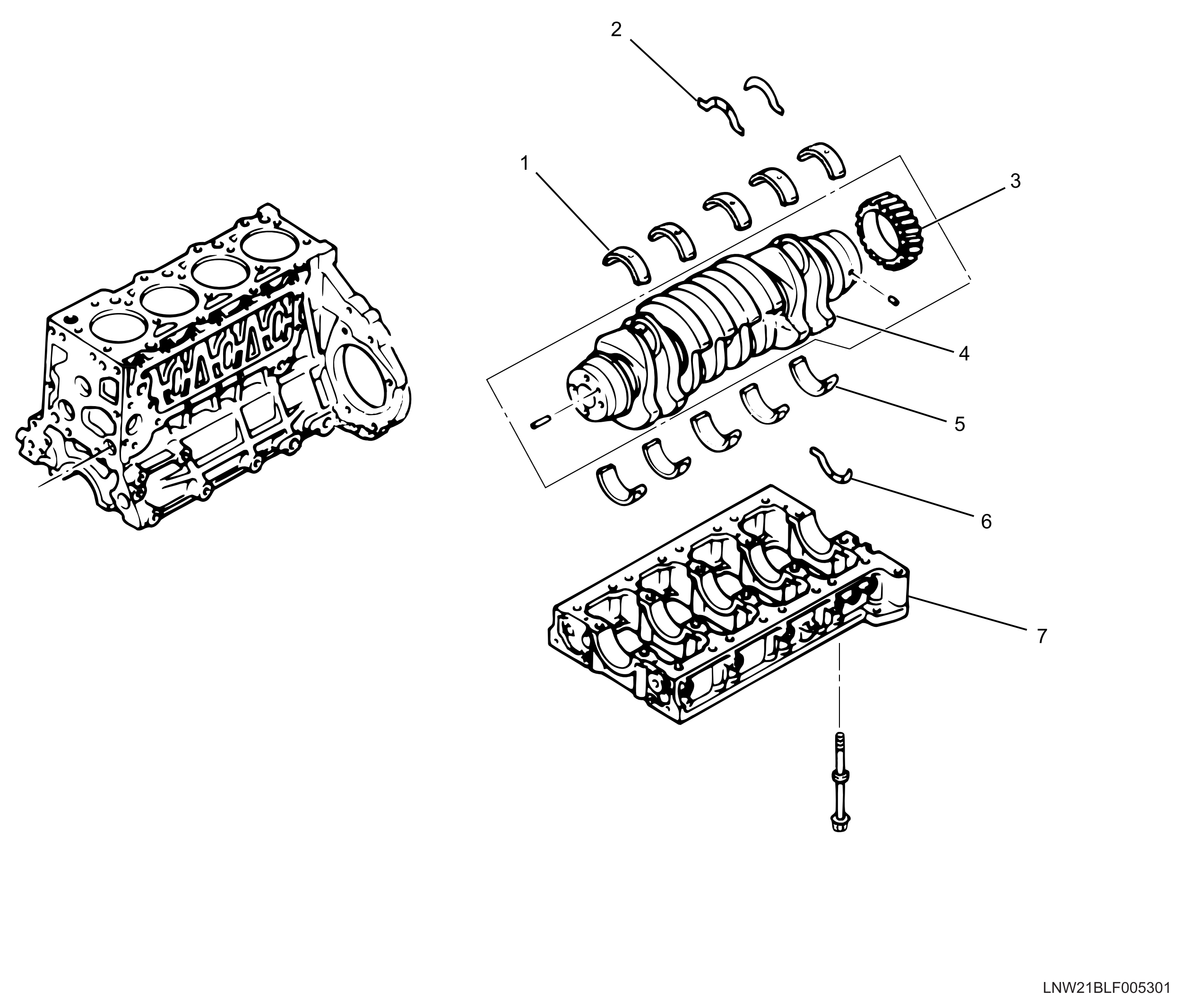
3. Install the flywheel.
   Refer to the “flywheel”.

Special tool

Illustration	Tool Number/ Description
 5884027030	J-43282 Oil seal installer kit
 5884023600	J-43285 Slinger puller

Crankshaft

Component



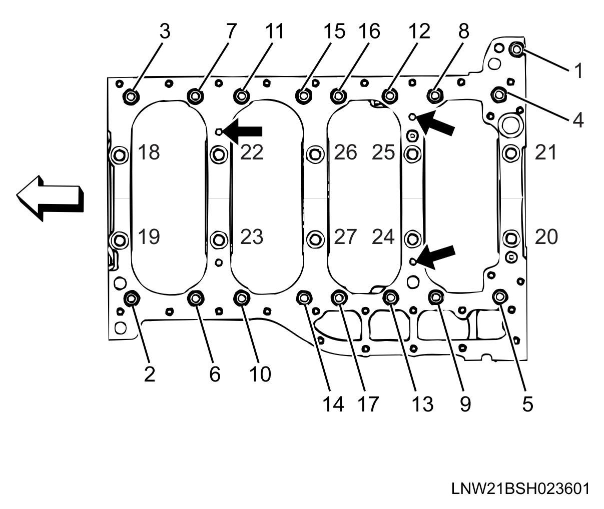
Legend

1. Upper Bearing
2. Upper Thrust Bearing
3. Gear
4. Crankshaft
5. Lower Bearing
6. Lower Thrust Bearing
7. Crankcase

Removal

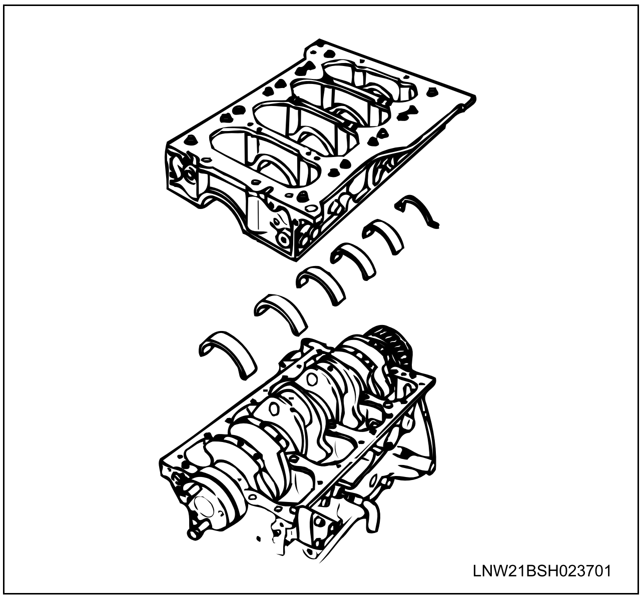
1. Demount the engine assembly.
   Refer to the “engine assembly”.
2. Remove the cylinder head cover.
   Refer to the “cylinder head cover”.
3. Remove the rocker arm shaft.
   Refer to the “rocker arm shaft assembly”.
4. Remove the camshaft.
   Refer to the “camshaft assembly”.
5. Remove the cylinder head.
   Refer to the “cylinder head”.
6. Remove the fuel supply pump.
   Refer to the “fuel supply pump” in the fuel system section.
7. Remove the crankshaft front oil seal.
   Refer to the “crankshaft front oil seal”.
8. Remove the crankshaft rear oil seal.
   Refer to the “crankshaft rear oil seal”.

9. Remove the oil pan.
   Refer to the “oil pan”.
10. Remove the water pump.
    Refer to the “water pump” in the Cooling System Section.
11. Remove the front cover.
    Refer to the “front cover”.
12. Remove the timing gear train.
    Refer to the “timing gear train”.
13. Remove the oil pump.
    Refer to the “oil pump”.
14. Remove pistons and connecting rods.
    Refer to the “pistons and connecting rods”.
15. Remove the crankcase.
    - Gradually loosen crankcase mounting bolts in the sequence shown and remove the crankcase using the three replacer holes (arrowed holes in the figure).



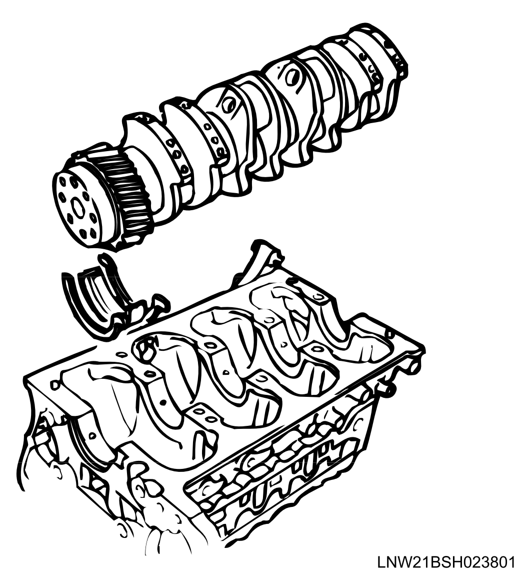
LNW21BSH023601

16. Remove the lower thrust bearing.
17. Remove the lower crankshaft bearings.



LNW21BSH023701

18. Remove the crankshaft assembly.
19. Remove the upper thrust bearing.
20. Remove the upper crankshaft bearings.

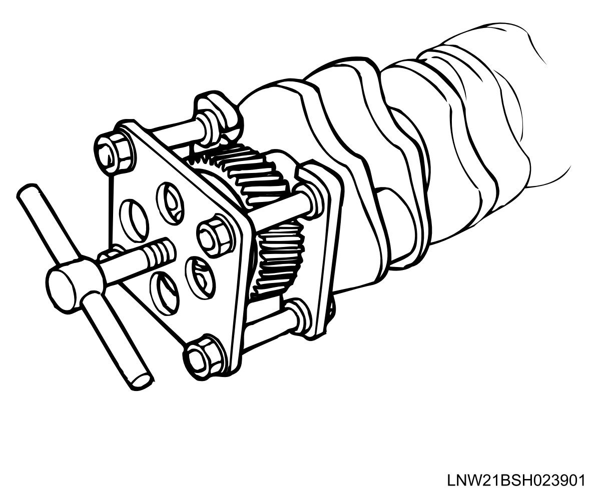


LNW21BSH023801

Disassembly

1. Remove the gear.
   - Remove the gear using a gear puller.

     Special tool
     Crankshaft gear puller: EN-47684



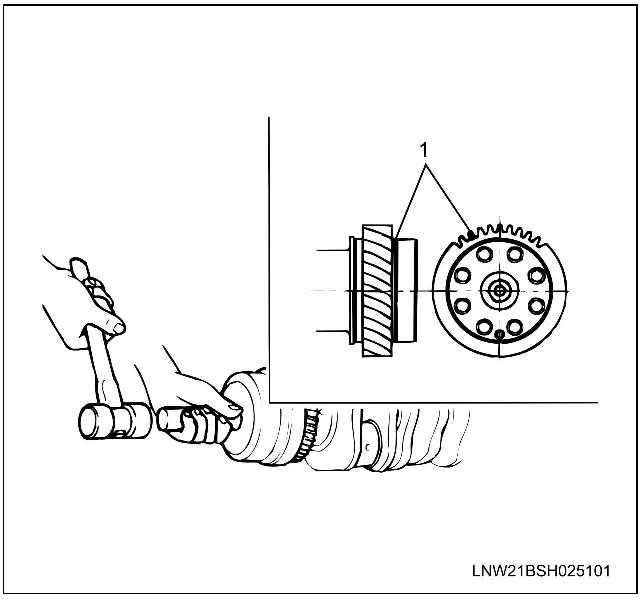
LNW21BSH023901

Reassembly

1. Install the gear
   - Heat the gear to 338 – 482°F (170 – 250°C) and install it aligning the groove on the gear with the pin on the crankshaft.

- Insert the gear at one push into the flange with its end side with the alignment mark “S” facing outward. If you are fitting the gear while it is cold, beat the gear in until it impinges on the end using the installer.

  Special tool
  Crankshaft gear installer: J-41222



Legend

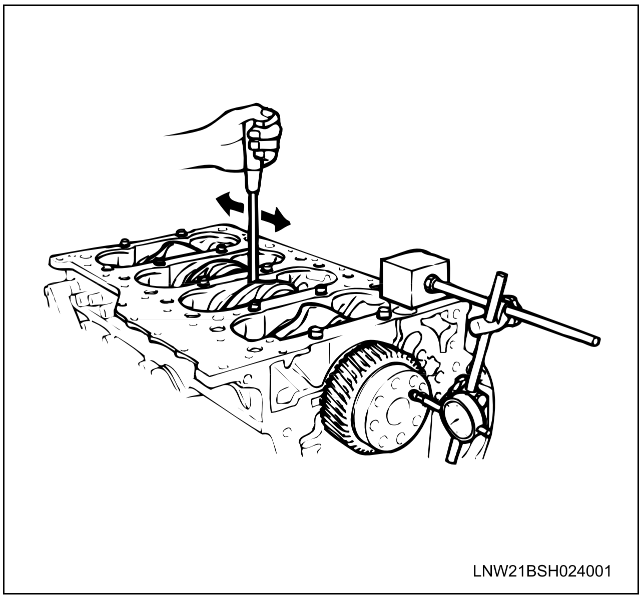
1. Alignment Mark

Inspection

1. Thrust clearance
   - Set a dial gauge as shown and measure the crankshaft thrust clearance.
   - If the thrust clearance exceeds the limit, replace the thrust bearings in a pair.

Axial play of the crankshaft	mm (in)
Standard	0.104 ~ 0.205 (0.0041 ~ 0.0081)
Limit	0.35 (0.0138)

Caution:
Measure the thrust clearance before dismounting.

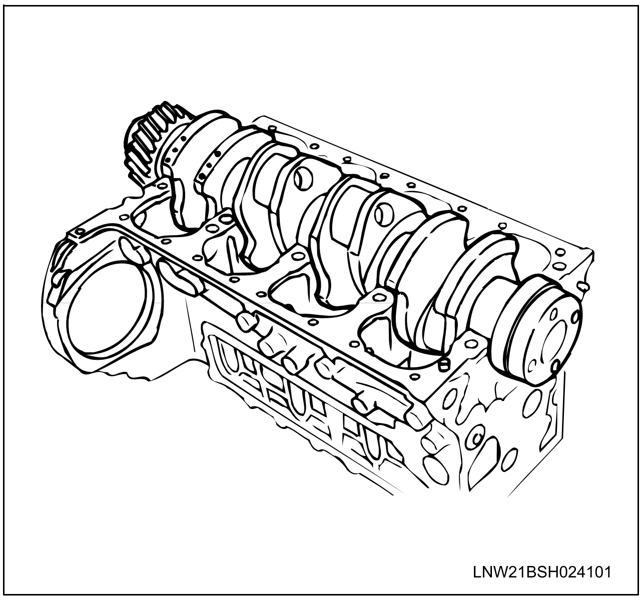


2. Main bearing clearance
   - Remove the crankcase.
     Set out disassembled main bearings in the order of the numbers.
   - Remove the crankshaft. Remove the main bearings.
   - Clean the crankshaft journal and upper and lower bearings.
   - Check the bearings for damage or excessive wear.

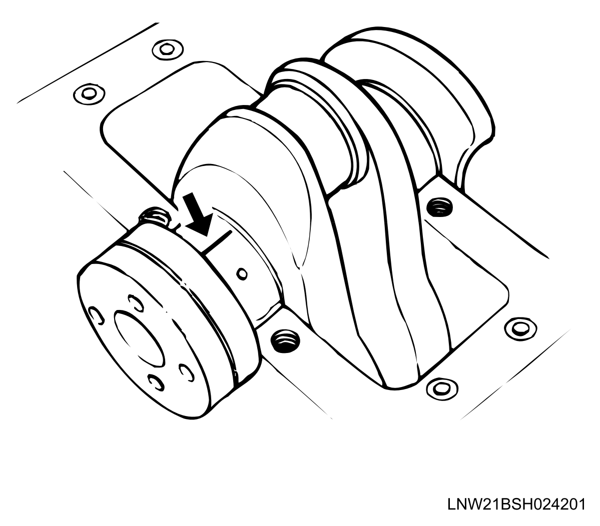
     If you find damage or excessive wear in the check, replace the bearings in pairs.

   - Place the upper bearings and the crankshaft on the cylinder block.Install the crankshaft so that it becomes horizontal.

Caution:
Turn the crankshaft about 30 degrees to allow the bearings to settle in.

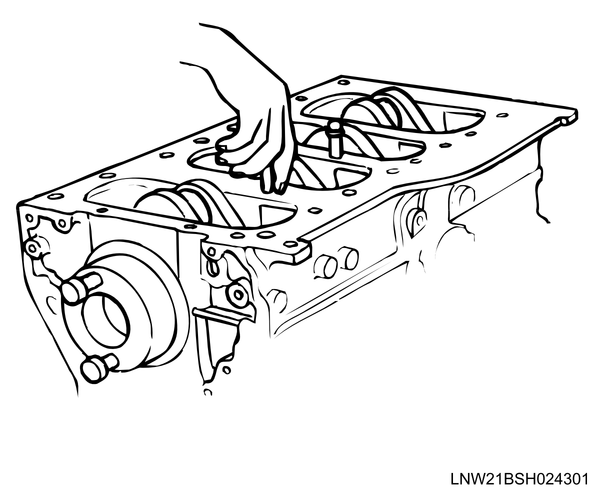


- Place Plastigage on the crankshaft journal as shown.
- Place the lower bearings at original positions on the crankcase.



LNW21BSH024201

- Install the crankcase and tighten bolts to the specified tightening torque.
- Tighten the crankcase in the sequence shown using a torque wrench and an angle gauge.



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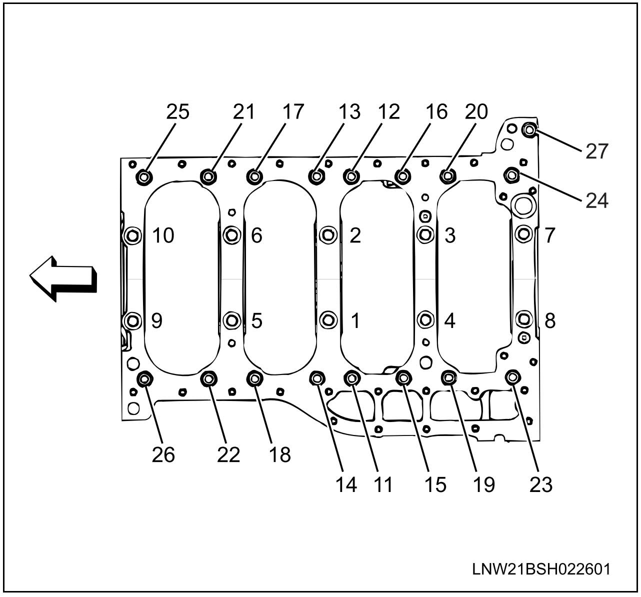

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Tightening torque:

M14 bolts (1~10)

1st step= 98 N·m (72 lb ft)

2nd step= 132 N·m (97 lb ft)

3rd step= 30°~60° (degrees)

M10 bolts (11~27)

4th step= 37 N·m (27 lb ft)

- Tighten the bolts (M14) from 1-10 and confirm that they are tightened to a torque of 167 N·m (123 lb ft) or more.

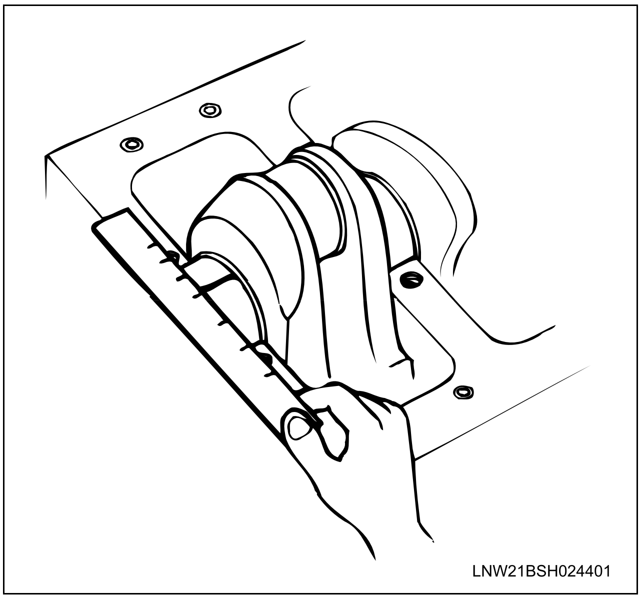
  Special tool
  Angle gauge: J-45059

Caution:

Do not turn the crankshaft after you have tightened the crankcase.

- Loosen the bolts and gently remove the crankcase.
- Measure the widest part of the Plastigage flattened by tightening the crankcase to determine the clearance.

Journal oil clearance		mm (in)
	Standard	Limit
No.1, 2, 4, 5	0.037 ~ 0.072 (0.0015 ~ 0.0028)	0.11 (0.0043)
No.3	0.051 ~ 0.086 (0.0020 ~ 0.0034)	0.11 (0.0043)



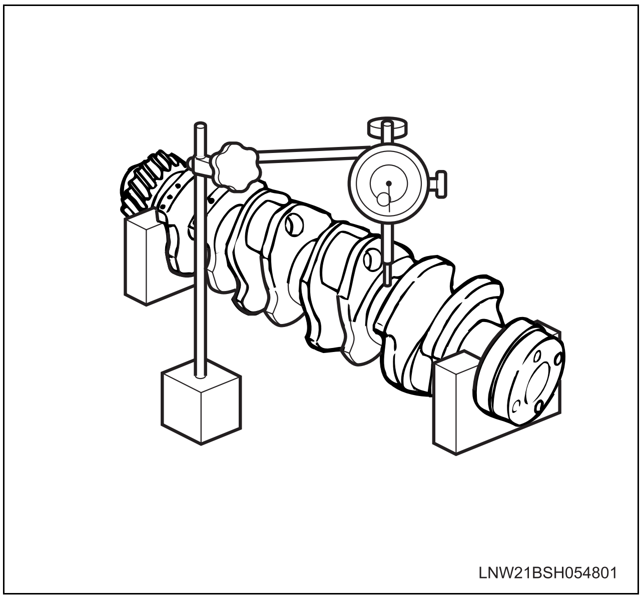
- If the journal oil clearance exceeds the limit, replace the main bearings altogether or the crankshaft.
- Remove the Plastigage from the bearings and the crankshaft.

Inspection of the crankshaft

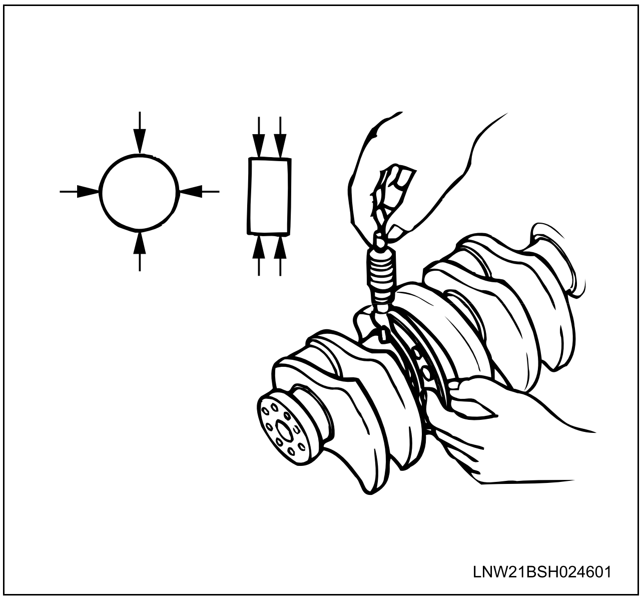
- Check the crankshaft journal and crank pin surfaces for wear and damage. Check the oil seal contact surface for excessive wear and damage.
- Check the oil port for clogging.

3. Crankshaft run-out
   Carefully set the crankshaft on the V block. Slowly turn the crankshaft to measure the run-out. If the crankshaft run-out exceeds the limit, replace the crankshaft.

Crankshaft run-out	mm (in)
Standard	0.05 or less (0.0020 or less)
Limit	0.30 (0.012)



4. Measure the journal and the crankpin diameters and uneven wear.
   - Measure outer diameters of the journal and the pin and calculate differences between the maximum and the minimum values. Take measurements at four positions for both the journal and the pin.

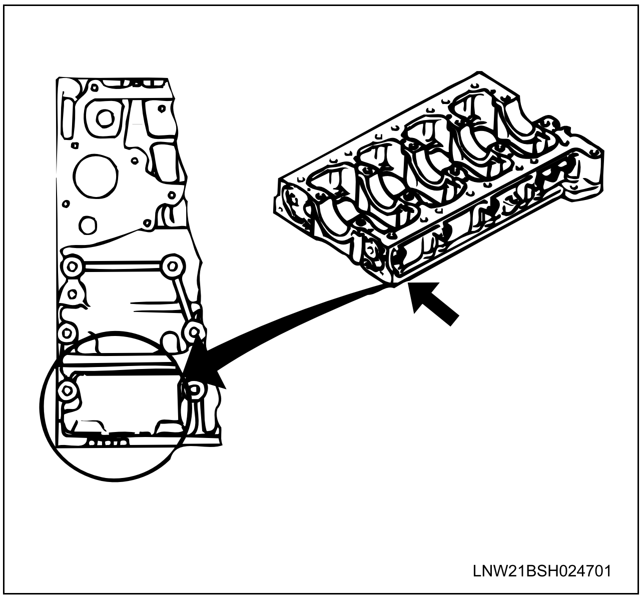


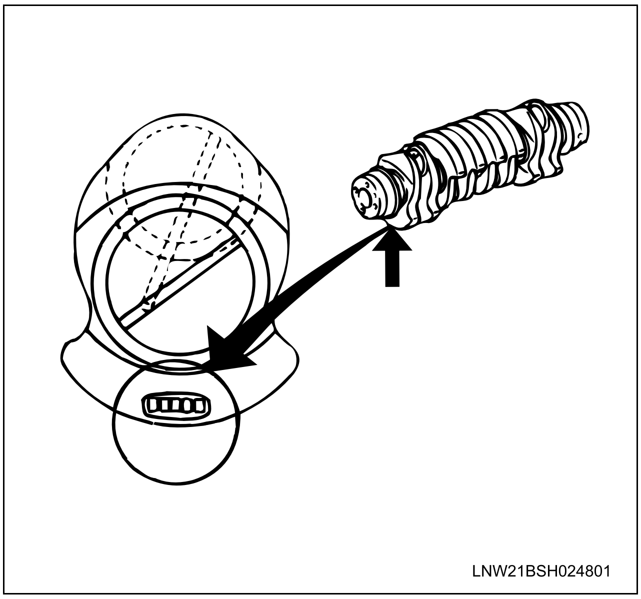
Crankshaft outside diameter		mm (in)
	Standard	Limit
Journal #1, 2, 4, 5	81.905 ~ 81.925 (3.22460 ~ 3.22538)	81.85 (3.222)
Journal #3	81.891 ~ 81.911 (3.22408 ~ 3.22483)	81.85 (3.222)
Pin	65.902 ~ 65.922 (2.59456 ~ 2.59535)	65.850 (2.5925)

Caution:
Tufftriding (soft nitriding treatment) is applied to enhance strength of the crankshaft. Therefore, you shall not polish the surface of the crankshaft.

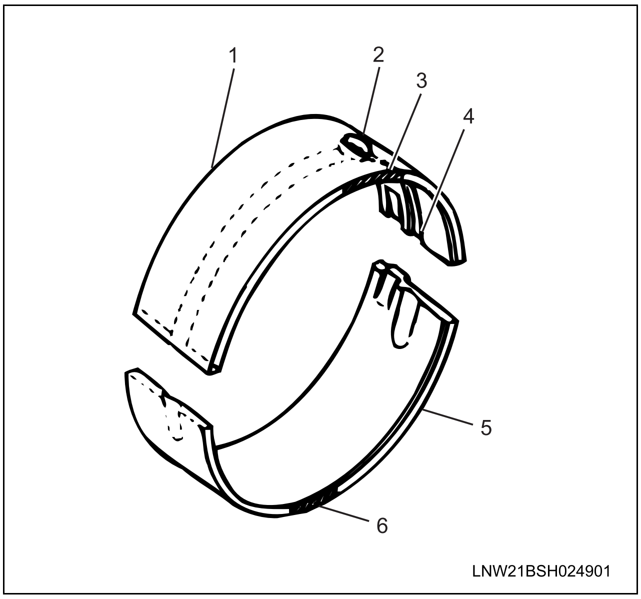
Crankshaft bearing selection

- When installing new crankshaft bearings or replacing bearings in use, make reference to the Bearing Selection Table.
- Select and install new bearings paying close attention to the cylinder block journal internal diameter grade and the crankshaft journal diameter grade.
- Journals are numbered from 1 to 5 from left to right when viewed so that the numbers are in normal reading orientation.





Caution:
Be careful about difference in the shape of the bearings when installing them.



Legend
1. Upper Bearing
2. Oil Gallery
3. Grade Identification Color
4. Oil Groove
5. Lower Bearing
6. Grade Identification Color

Bearing Selection Table

Combination of grades			Oil clearance mm (in)	
Cylinder block Grade	Crank journal Grade	Bearing identification color	#1, 2, 4, 5	#3
1	1	Black	0.039 ~ 0.070 (0.00154 ~ 0.00276)	0.053 ~ 0.084 (0.00209 ~ 0.00331)
1	2	Brown	0.037 ~ 0.068 (0.00146 ~ 0.00267)	0.051 ~ 0.082 (0.00201 ~ 0.00323)

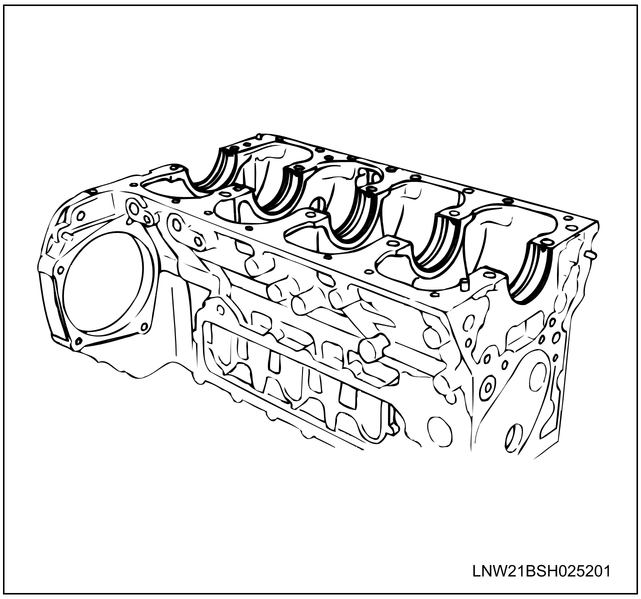
Combination of grades			Oil clearance mm (in)	
Cylinder block Grade	Crank journal Grade	Bearing identification color	#1, 2, 4, 5	#3
2	1	Blue	0.041 ~ 0.072 (0.00161 ~ 0.00283)	0.055 ~ 0.086 (0.00217 ~ 0.00339)
2	2	Black	0.039 ~ 0.070 (0.00154 ~ 0.00276)	0.053 ~ 0.084 (0.00209 ~ 0.00331)

Installation

1. Install the crankshaft upper bearing.
    - Install the upper bearing in the cylinder block and apply oil.

Caution:

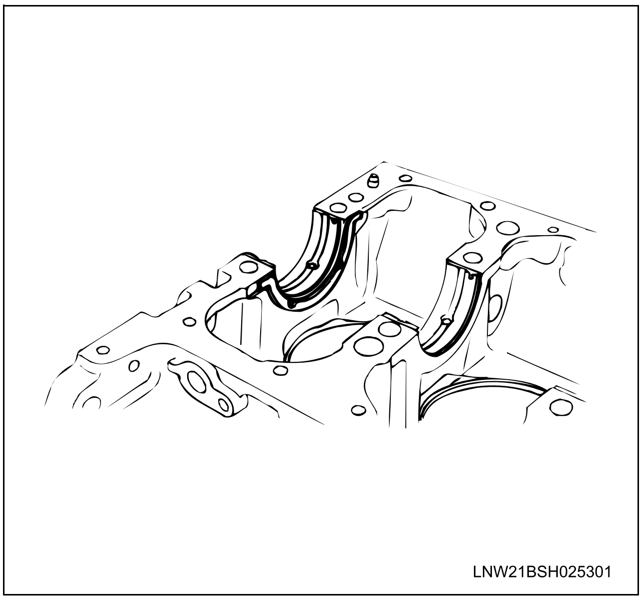
When replacing the crankshaft bearings, select grades referring to the Crankshaft Bearing Grade Selection. Do not apply oil to the bearing installation surface on the cylinder block and external surface of the bearing.



2. Install the upper thrust bearing.
    - Install the upper thrust bearing in the front side of the cylinder block journal No.5. In doing this, you may attach the upper thrust bearing to the cylinder block with grease. Then, be sure to wipe up excess grease.

Caution:

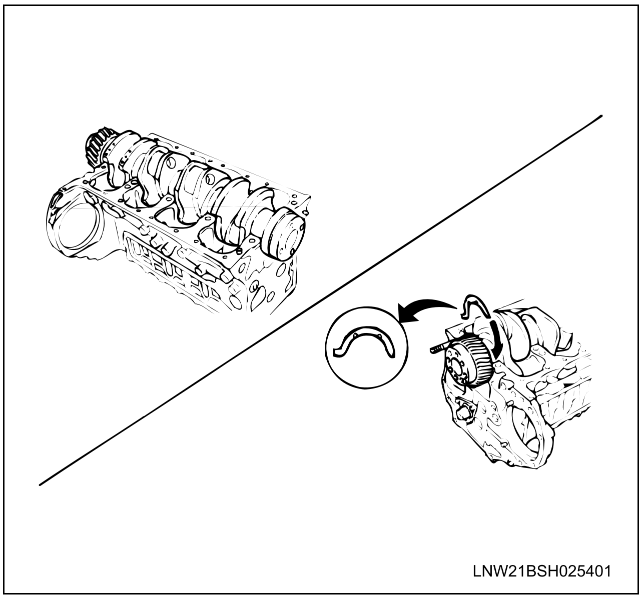
Install the thrust bearing so that the oil groove contacts the crankshaft.



3. Install the crankshaft assembly.
    - Apply engine oil to the crankshaft journal and gently place the crankshaft on the cylinder block.
    - Press the crankshaft to the rear and insert the upper thrust bearing in the rear side of the cylinder block journal No.5.

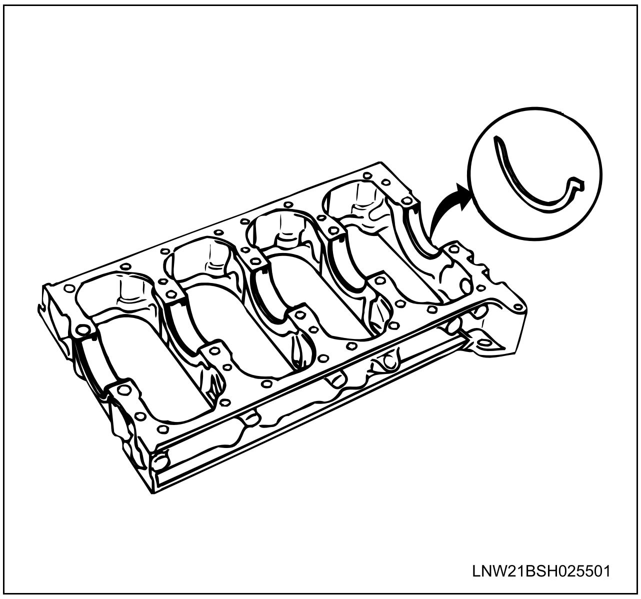
Caution:

Install the thrust bearing so that the oil groove contacts the crankshaft.



LNW21BSH025401

4. Install the lower crankshaft bearing.
5. Install the lower thrust bearing.
    - Install the lower thrust bearing in the rear side of the crankcase journal No.5.
    - Install the thrust bearing so that the oil groove contacts the crankshaft.



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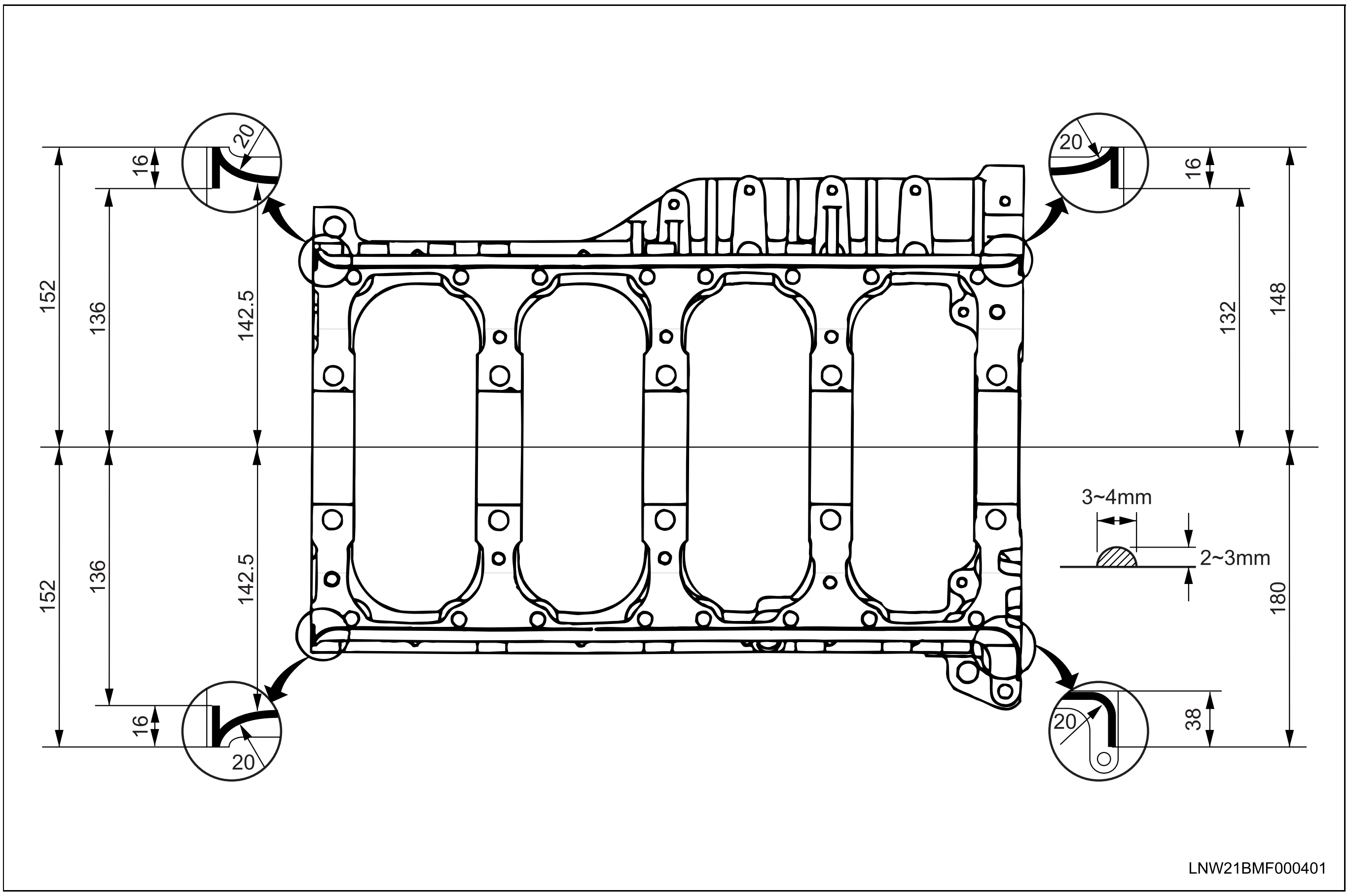
6. Install the crankcase.
    - Apply liquid gasket (ThreeBond 1207C or equivalent) to the crankcase forming beads with diameters of 3 – 4 mm (0.12 – 0.16 in).
    - Install the crankcase within 7 minutes after you have applied the liquid gasket.
    - Gently place the crankcase on the cylinder block.



LNW21BMF000401

- Apply Molybdenum Disulfide to M14 bolts' threads and setting faces and tighten them to the specified tightening torque in the sequence shown.

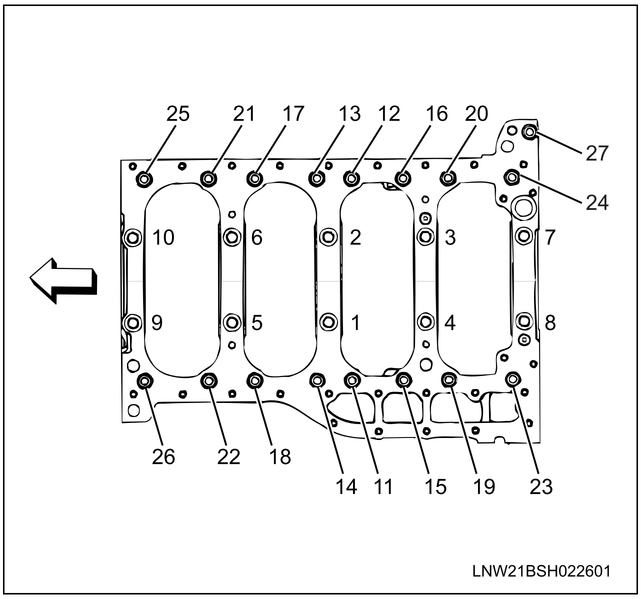
- You need not apply engine oil to M10 bolts.

Tightening torque:
M14 bolts (1~10)
1st step= 98 N·m (72 lb ft)
2nd step= 132 N·m (97 lb ft)
3rd step= 30°~60° (degrees)
M10 bolts (11~27)
4th step= 37 N·m (27 lb ft)

- Tighten bolts from 1-10 (M14) and confirm that they are tightened to a torque of 167 N·m (123 lb ft) or more.

  Special tool
  Angle gauge: J-45059

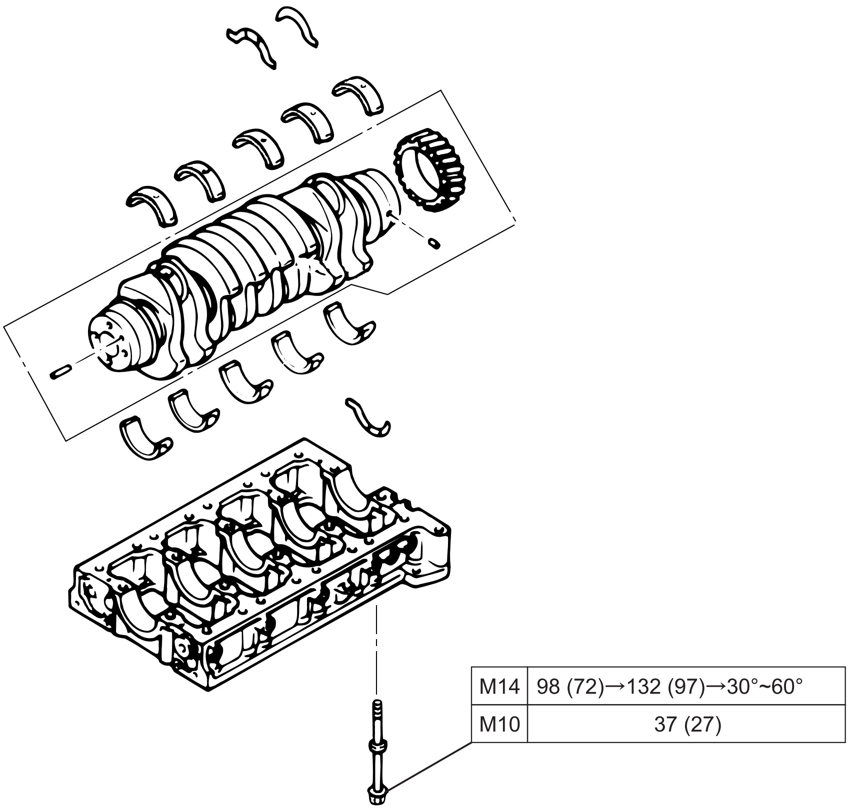
Caution:
Confirm that the crankshaft turns smoothly.



7. Install pistons and connecting rods.
   Refer to the “pistons and connecting rods”.
8. Install the oil pump.
   Refer to the “oil pump”.
9. Install the timing gear train.
   Refer to the “timing gear train”.
10. Install the front cover.
    Refer to the “front cover”.
11. Install the water pump.
    Refer to the “water pump” in the Cooling System Section.
12. Install the oil pan.
    Refer to the “oil pan”.
13. Install the crankshaft rear oil seal.
    Refer to the “crankshaft rear oil seal”.
14. Install the crankshaft front oil seal.
    Refer to the “crankshaft front oil seal”.
15. Install the fuel supply pump.
    Refer to the “fuel supply pump”.
16. Install the cylinder head.
    Refer to the “cylinder head”.
17. Install the camshaft assembly.
    Refer to the “camshaft assembly”.
18. Install the rocker arm shaft assembly.
    Refer to the “rocker arm shaft assembly”.
19. Install the cylinder head cover.
    Refer to the “cylinder head cover”.
20. Mount the engine assembly on the chassis.
    Refer to the “engine assembly”.

Torque Specifications

N·m (ft lb)



M14	98 (72)→132 (97)→30°~60°
M10	37 (27)

LNW46ALF001601

Special tool

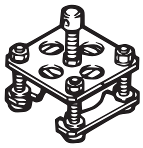
Illustration	Tool Number/ Description
 8943968180	EN-47684 Crankshaft gear puller

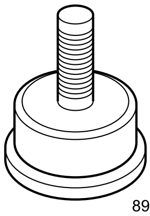
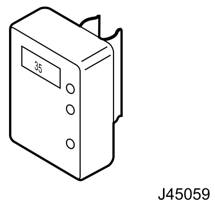
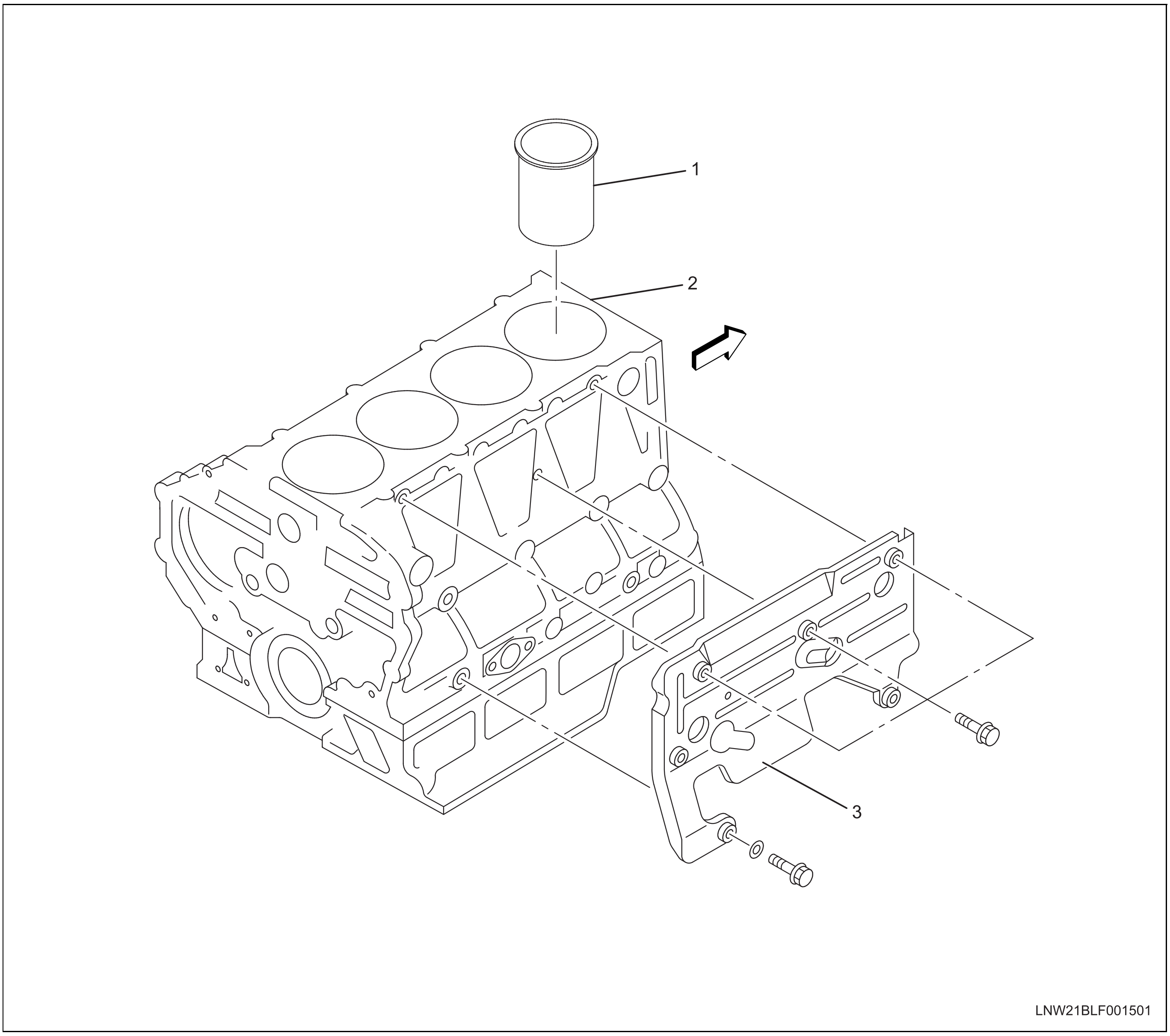
Illustration	Tool Number/ Description
 8943968190	J-41222 Crankshaft gear installer

Illustration	Tool Number/ Description
	J-45059 Angle gauge

Cylinder Block

Component



Legend

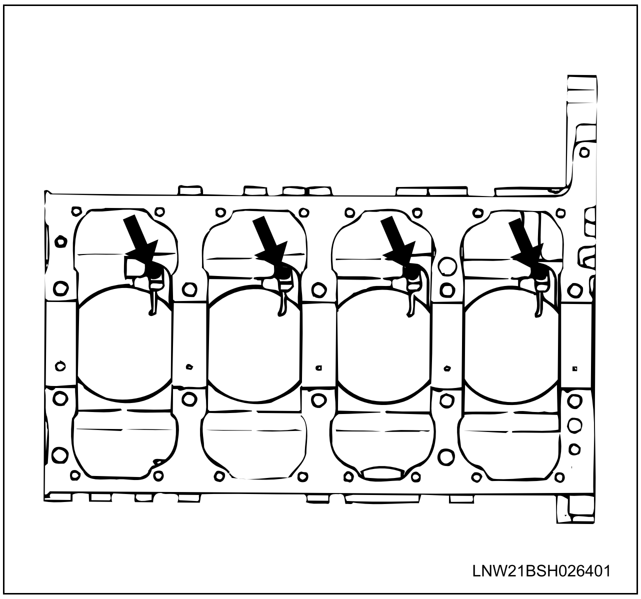
1. Cylinder Liner
2. Cylinder Block
3. Cover

Removal

1. Demount the engine assembly.

   Refer to the “engine assembly”.
2. Remove the cylinder head cover.
   Refer to the “cylinder head cover”.
3. Remove the rocker arm shaft assembly.
   Refer to the “rocker arm shaft assembly”.
4. Remove the camshaft assembly.
   Refer to the “camshaft assembly”.
5. Remove the cylinder head.
   Refer to the “cylinder head”.
6. Remove the fuel supply pump.
   Refer to the “fuel supply pump” in the fuel system section.
7. Remove the crankshaft front oil seal.
   Refer to the “crankshaft front oil seal”.
8. Remove the crankshaft rear oil seal.
   Refer to the “crankshaft rear oil seal”.
9. Remove the oil pan.
   Refer to the “oil pan”.
10. Remove the water pump.
    Refer to the “water pump” in the Cooling System Section.

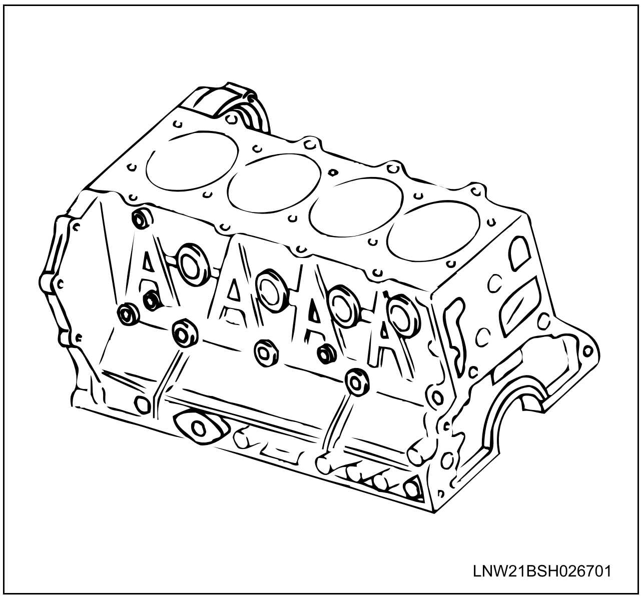
11. Remove the front cover.
Refer to the “front cover”.
12. Remove the timing gear train.
Refer to the “timing gear train”.
13. Remove the oil pump.
Refer to the “oil pump”.
14. Remove pistons and connecting rods.
Refer to the “pistons and connecting rods”.
15. Remove the crankshaft.
Refer to the “crankshaft”.
16. Remove the piston oil jet.


LNW21BSH026401

17. Remove the cylinder liner.
If the cylinder liner cannot be pulled free by hand, tap around the lower side of the liner with a hammer grip or similar object loosen it.

Inspection

1. Carefully remove water stains or other foreign matters on the surface of the cylinder block.
    - Be careful not to damage the cylinder block.
2. Carefully remove the liquid gasket on the crankcase mounting surface.
3. Clean up the cylinder block.
4. Visually inspect the cylinder block.
    - Conduct color check and hydraulic (or pneumatic) test and if you find crack or other damage, replace the cylinder block.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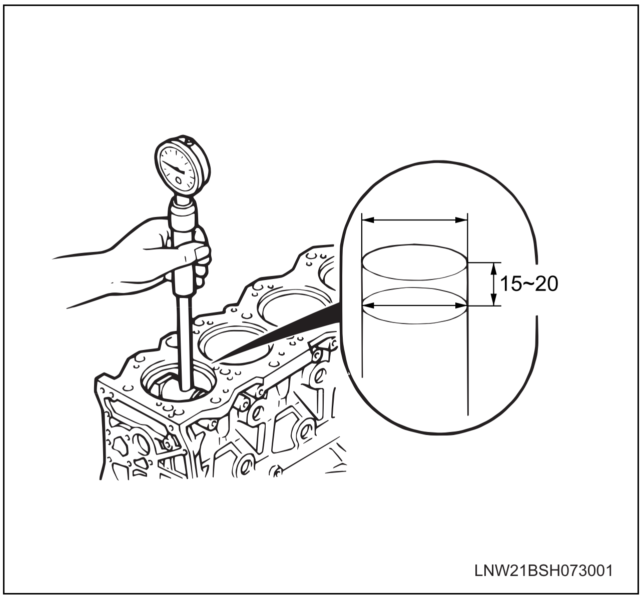
5. Cylinder liner wear measurement
    - Check the internal surface of the liner for flaw or damage.
    - Measure the liner bore diameter at the most worn part (it wears more in the rotation direction) at 15 – 20 mm (0.59 – 0.79 in) from the top end of the liner with the liner installed in the cylinder block. If the wear is over the application limit, replace it.



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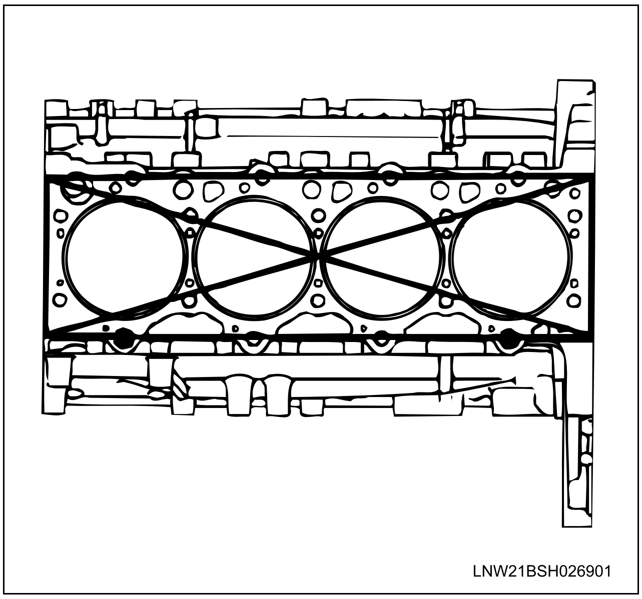
Cylinder liner bore diameter	mm (in)
Standard	115.021 ~ 115.050 (4.52837 ~ 4.52952)
Limit	115.20 (4.5354)

Caution:
You need not select cylinder liner bore grade since the liners are only available in one size.

6. Cylinder block upper face warpage
   - Pull out the cylinder liners and remove water stains on the cylinder block.
   - Measure four sides and two diagonals of the top surface of the cylinder block using a straight edge and a thickness gauge.
   - Replace the cylinder block if the measurements exceed limit values.

Cylinder block upper face warpage	mm (in)
Standard	0.05 or less (0.002 or less)
Limit	0.20 (0.079)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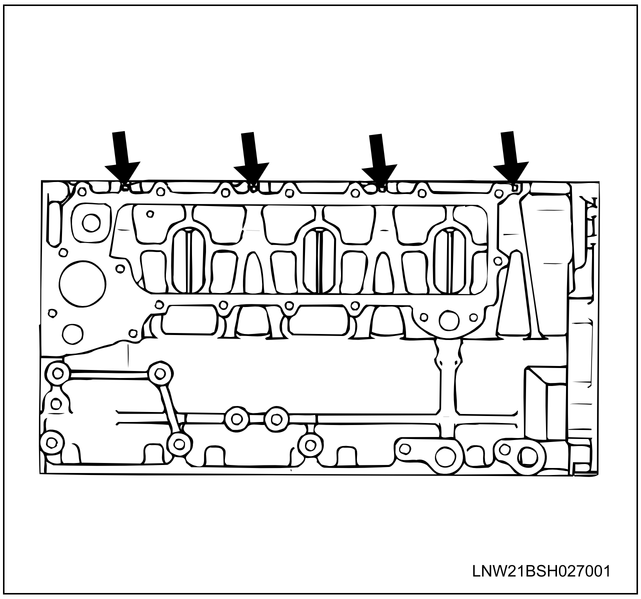
Installation

1. Cylinder liner grade selection
   - Select liner outer diameter grades according to the cylinder block bore grades stamped on the cylinder block at arrowed positions in the figure.
   - Matching the grades of the cylinder block and the liner outer diameter

Cylinder block (stamp)	1, 2	3
Liner outside diameter	1X	3X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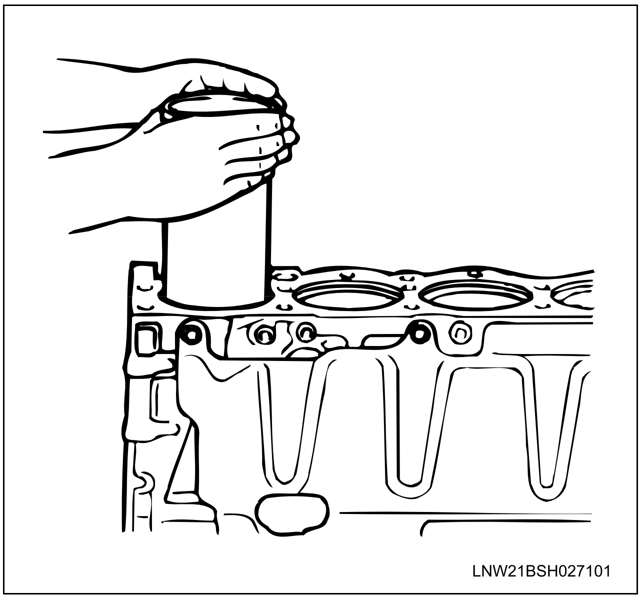
Cylinder block bore and liner grade (for reference) mm (in)

Grade	(1,2)/(1X)	(3)/(3X)
Cylinder block Bore diameter	118.001 ~ 118.020 (4.64699 ~ 4.64654)	118.021 ~ 118.030 (4.64649 ~ 4.64684)
Liner outside diameter	117.991 ~ 118.000 (4.64531 ~ 4.64566)	118.001 ~ 118.010 (4.64570 ~ 4.64605)

(Reference)
When replacing liners, a “liner set” let you obtain a piston of proper grade for a given liner bore diameter only by specifying a liner outside diameter grade.

2. Install the cylinder liners.
   - Install the cylinder liners perpendicular to the cylinder block.
   - Do not hammer the liner or apply excessive forth to insert it.

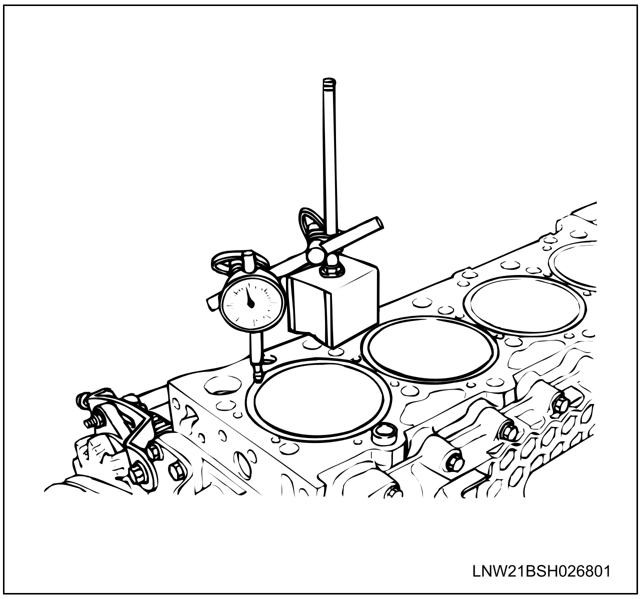
Caution:
Clean up and blow with compressed air the cylinder block and the cylinder liners before installing them.



3. Amount of the cylinder liner extrusion
   Measure the amount of the cylinder liner extrusion using a dial gauge.
   Difference of the amount of the extrusion between adjacent two cylinders should be within 0.03 mm (0.0012 in).

Amount of the cylinder liner extrusion	mm (in)
Standard	0.05 ~ 0.10 (0.0020 ~ 0.0039)

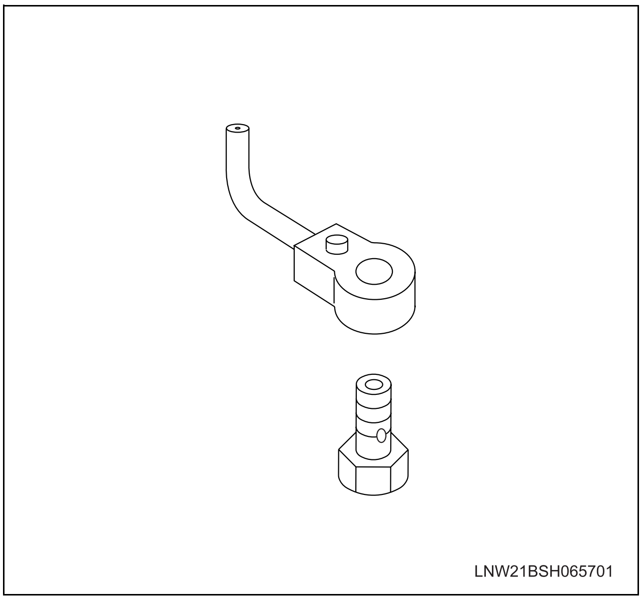
Caution:
Be sure to measure the cylinder liner extrusion whenever you have replaced cylinder liners.



4. Install the piston oil jet.
   - Align the dowel pin of the oil jet with the pin hole on the cylinder block and tighten with the check valve.

Tightening torque: 21 N·m (15 lb ft)

Caution:
Be careful not to deform or damage the oil jet nozzle.



5. Install the crankshaft.
   Refer to the “crankshaft”.
6. Install pistons and connecting rods.
   Refer to the “pistons and connecting rods”.
7. Install the oil pump.
   Refer to the “oil pump”.
8. Install the timing gear train.
   Refer to the “timing gear train”.
9. Install the front cover.
   Refer to the “front cover”.
10. Install the water pump.
    Refer to the “water pump” in the Cooling System Section.
11. Install the oil pan.
    Refer to the “oil pan”.
12. Install the crankshaft rear oil seal.
    Refer to the “crankshaft rear oil seal”.
13. Install the crankshaft front oil seal.
    Refer to the “crankshaft front oil seal”.
14. Install the fuel supply pump.
    Refer to the “fuel supply pump” in the Fuel System Section.
15. Install the cylinder head.
    Refer to the “cylinder head”.
16. Install the camshaft assembly.
    Refer to the “camshaft assembly”.
17. Install the rocker arm shaft assembly.
    Refer to the “rocker arm shaft assembly”.
18. Install the cylinder head cover.
    Refer to the “cylinder head cover”.
19. Mount the engine assembly on the chassis.
    Refer to the “engine assembly”.

Lubrication System

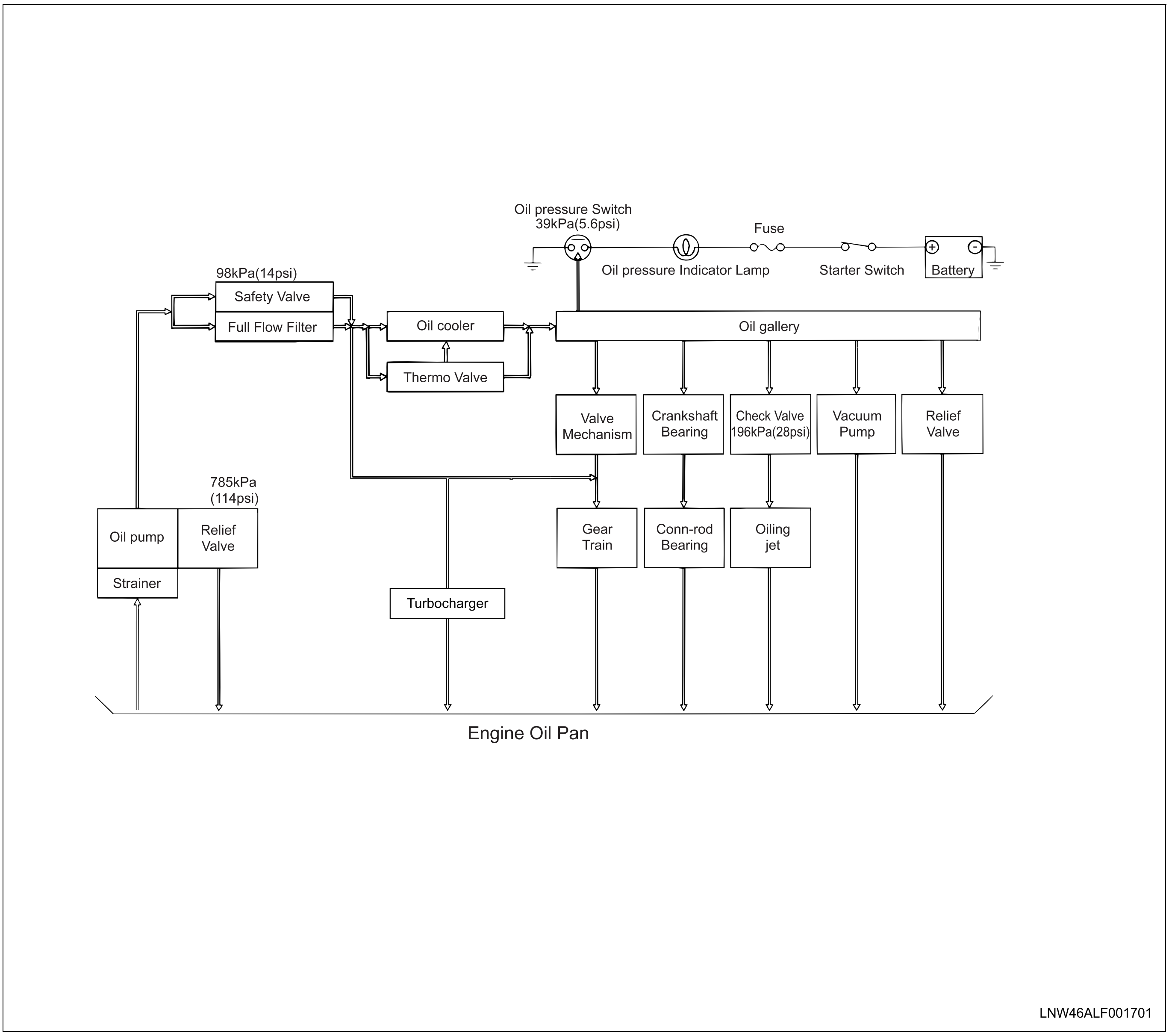
Service Precautions

- During each disassembly, remove the old gasket adhering to each part and mating part completely using a scraper at the location, where the fluid gasket is to be used, clean the traces of oil, moisture, and dirt completely using waste cotton and apply the specified new fluid gasket at each location.
- Avoid excessive or insufficient coating volume. Note that seizure may occur in case of excessive coating due to clogging of the oil gallery and oil jet, and oil and water leakage may occur if the coating is insufficient.
- Always, the start and end of the application should be overlapped.

Explanations on functions and operation

The lubrication system uses the filter element combined with a full flow bypass, water-cooled oil cooler, and oil jet for piston cooling.

Lubricating system diagram



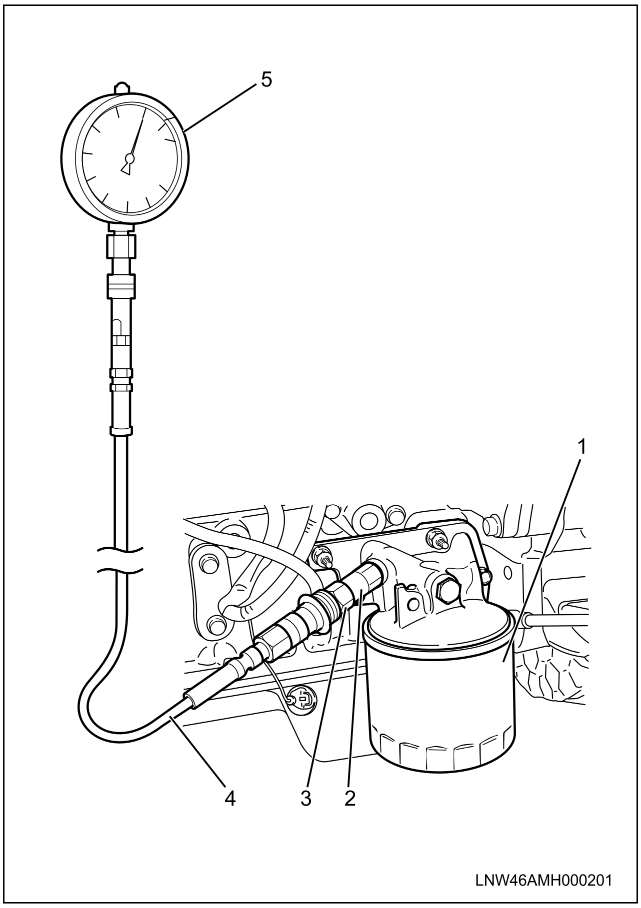
Functional check

Oil pressure check

1. Check whether the engine oil is contaminated with dirt, light oil, or water. If contaminated with dirt, light oil, or water (after examining the cause and taking the appropriate measures for light oil or water contamination), replace the oil.

2. Check the engine oil level. The oil level should be between the two holes of the level gauge. If the oil level is insufficient, replenish it.
3. Remove the oil pressure switch on the oil filter body.
4. Install the oil pressure gauge on the oil filter body.

   Special tool
   Oil pressure gauge: J43620-20
   Hose: J43630
   Connector: J43630-14
   Oil pressure testing adapter: EN-46333



Legend

1. Oil Filter Cartridge
2. Oil Pressure Testing Adapter
3. Connector
4. Hose
5. Oil Pressure Gauge

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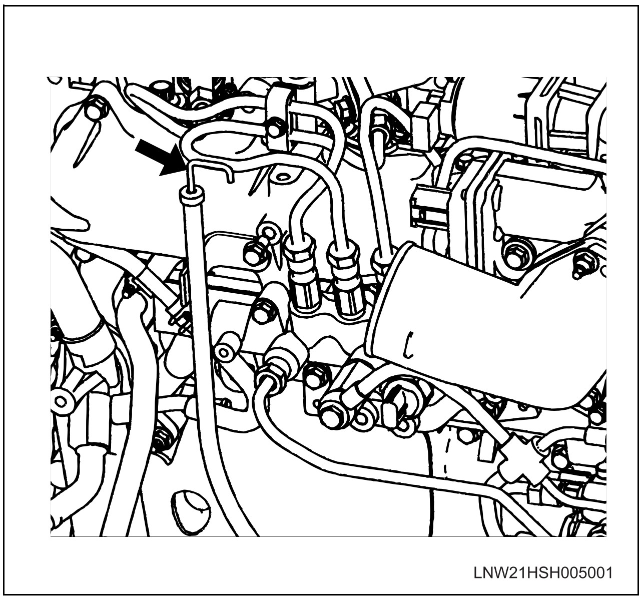
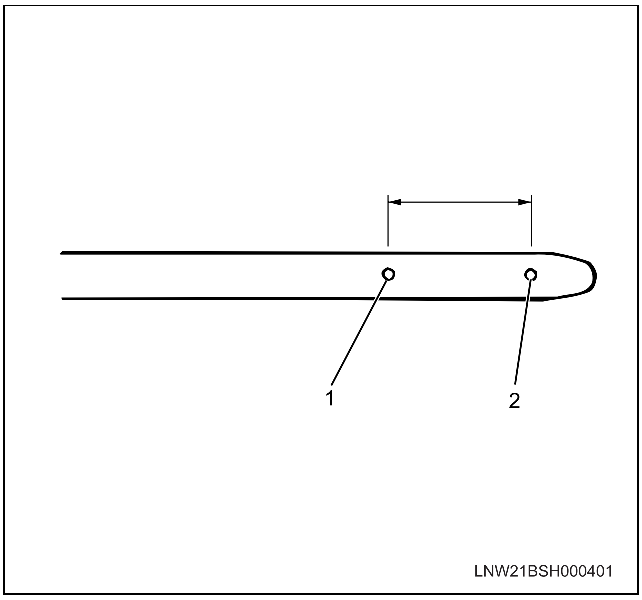
5. Warm the engine.
6. Measure the oil pressure, to check whether it is more than 343 kPa (50 psi) at 3200 rpm.
7. Stop the engine.
8. Remove the oil pressure gauge.
9. Install the oil pressure switch.
10. Start the engine and check for oil leakage.

Engine oil

- Ensure the car is at a level ground. Before starting the engine or when 5 minutes or more have elapsed after stopping the engine, check the engine oil volume using the level gauge. The volume is appropriate if the engine oil is between the upper and lower limits of the level gauge. Replenish the engine oil, if level is below the lower limit. Also, check for contamination of the engine oil.





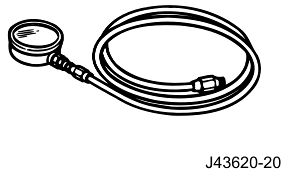
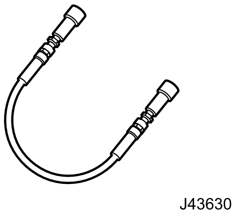
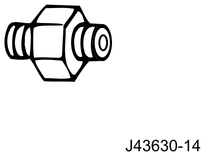
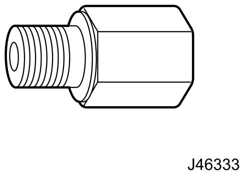
Legend

1. Upper Limit
2. Lower Limit

Engine oil leakage

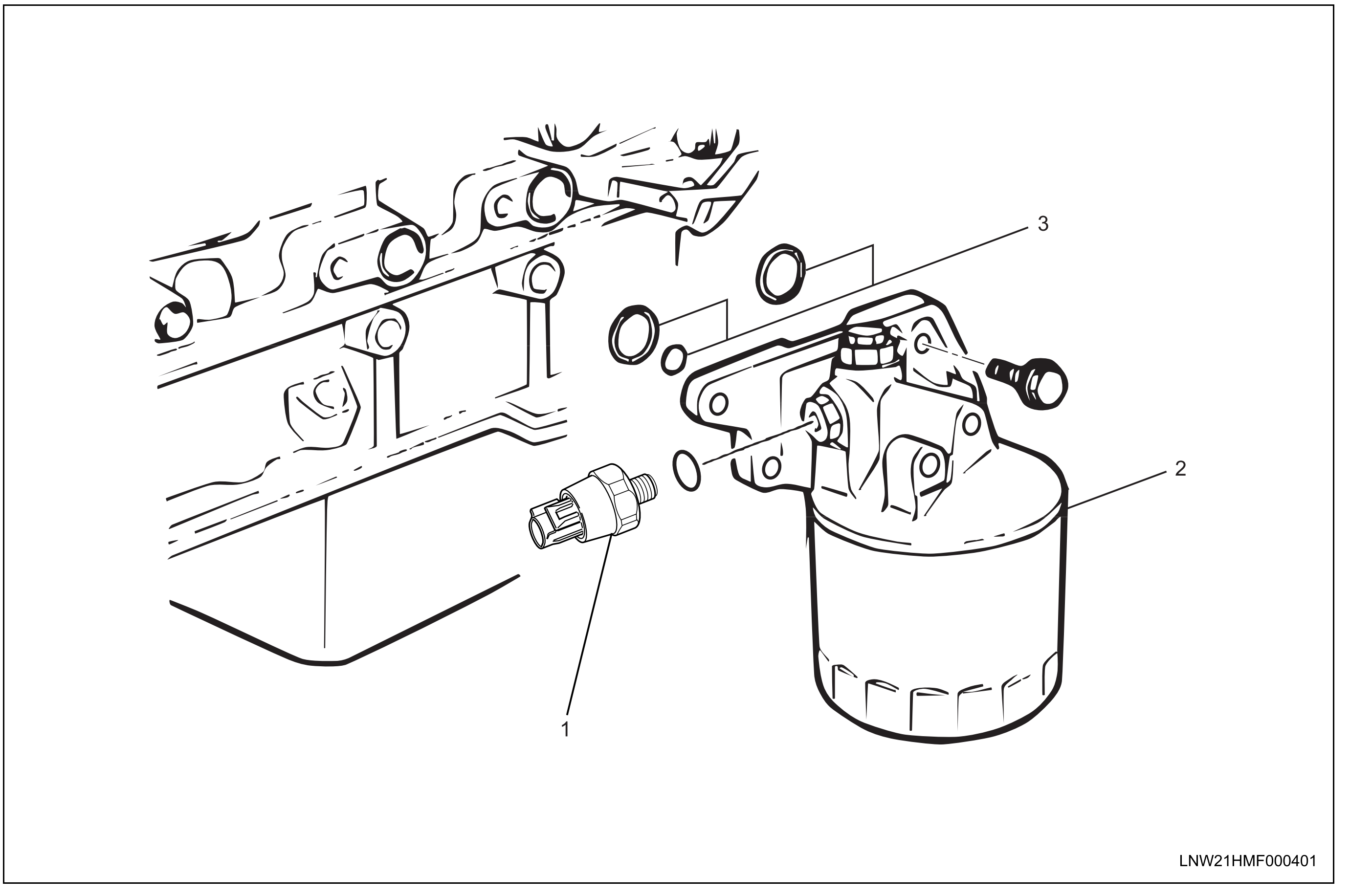
- In the lift up condition, confirm that there are no leaks from the cylinder head cover and oil pan.

Special tool

Illustration	Tool Number/ Description
	J-43620-20 Oil pressure gauge
	J-43630 Hose
	J-43630-14 Connector
	J-46333 Oil pressure testing adapter

Oil Filter Assembly

Components



Legend

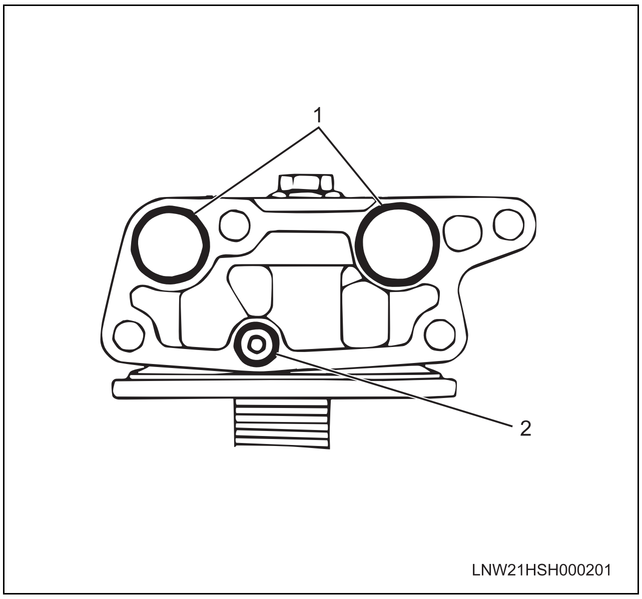
1. Oil Pressure Switch
2. Oil Filter Body
3. O-Ring

Removal

1. Place a tray under the oil filter cartridge.
2. Remove the oil filter cartridge.
3. Remove the oil pressure switch.
4. Remove the oil filter body.
5. Remove the O-ring.

Installation

1. Install the O-rings and on the oil filter body.



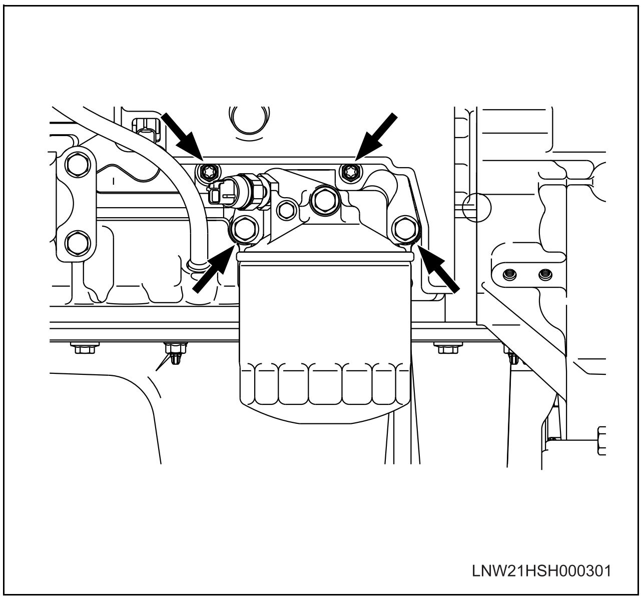
Legend

1. O-Ring
2. O-Ring

---

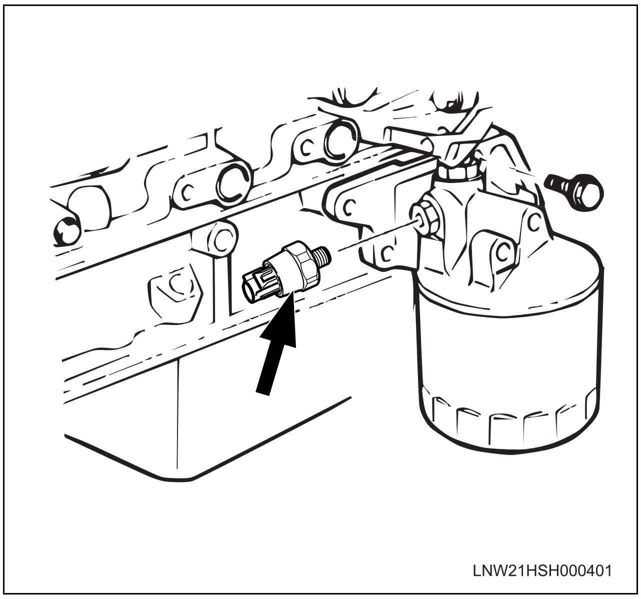
2. Install the oil filter on the cylinder block and tighten it using the specified torque.

Tightening torque: 48 N·m (35 lb ft)



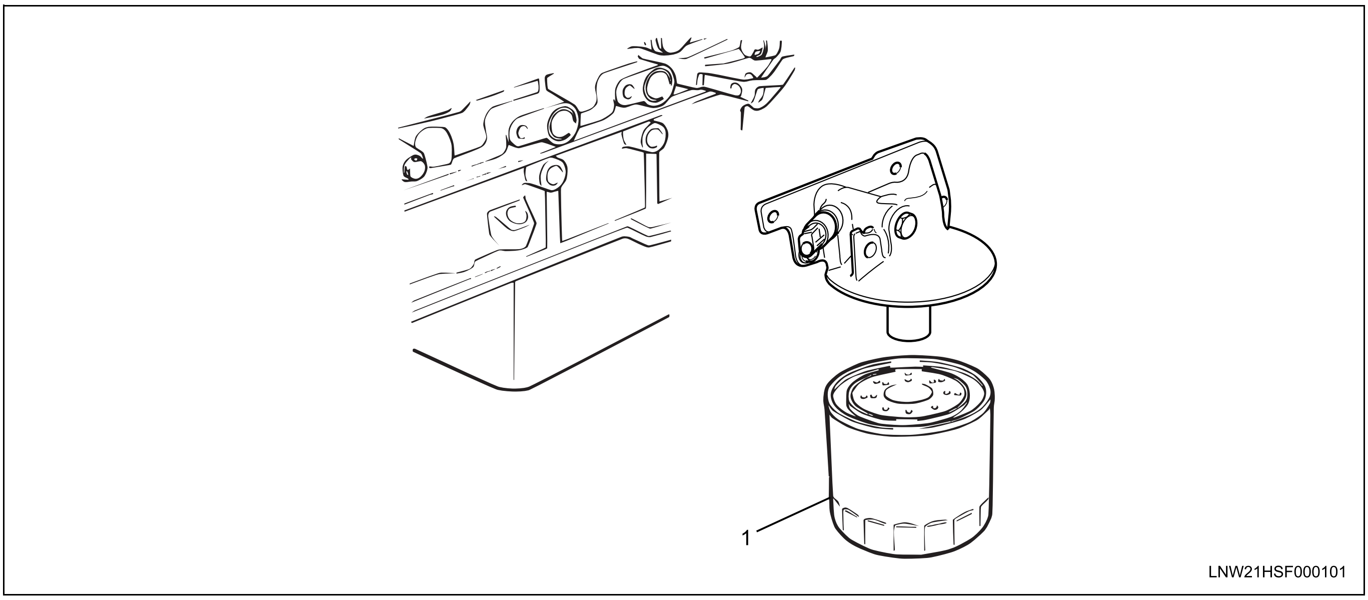
3. Install the oil pressure switch on the oil filter body.
   - Apply the liquid gasket (Loctite 262) on 2 to 3 peaks from the tip of the threaded part of the oil pressure switch and install it at the position shown in the figure.

Tightening torque: 13 N·m (113 lb in)



Oil Filter Cartridge

Components



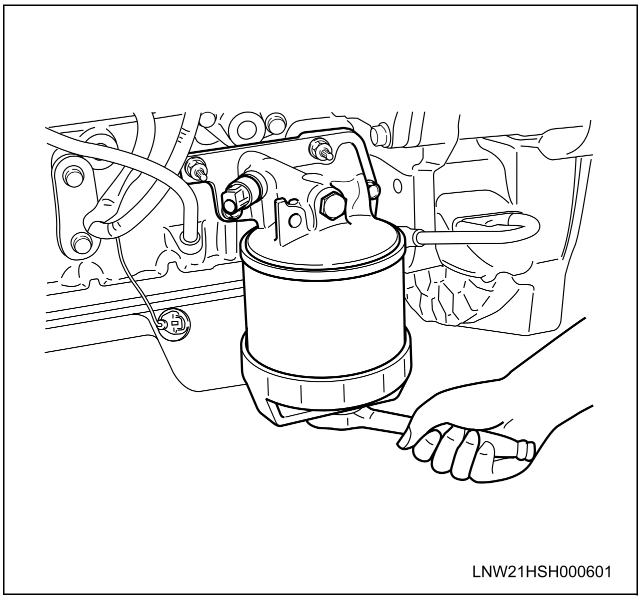
Legend

1. Oil Filter Cartridge

Removal

1. Place a tray under the oil filter cartridge.
2. Remove the oil filter cartridge using the oil filter wrench.

   Special tool
   Oil filter wrench: EN-47683



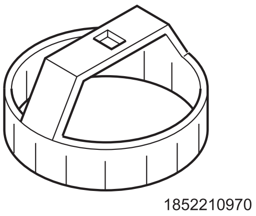
Installation

1. Install the oil filter cartridge.
   - Apply grease or engine oil to the seal in the cartridge and install it using the oil filter wrench.
   - Tighten the cartridge using the specified torque.

Tightening torque: 20 N·m (14 lb ft)
Or
After it comes in contact with the oil seal, tighten it through an additional turn of 1 and 1/4.

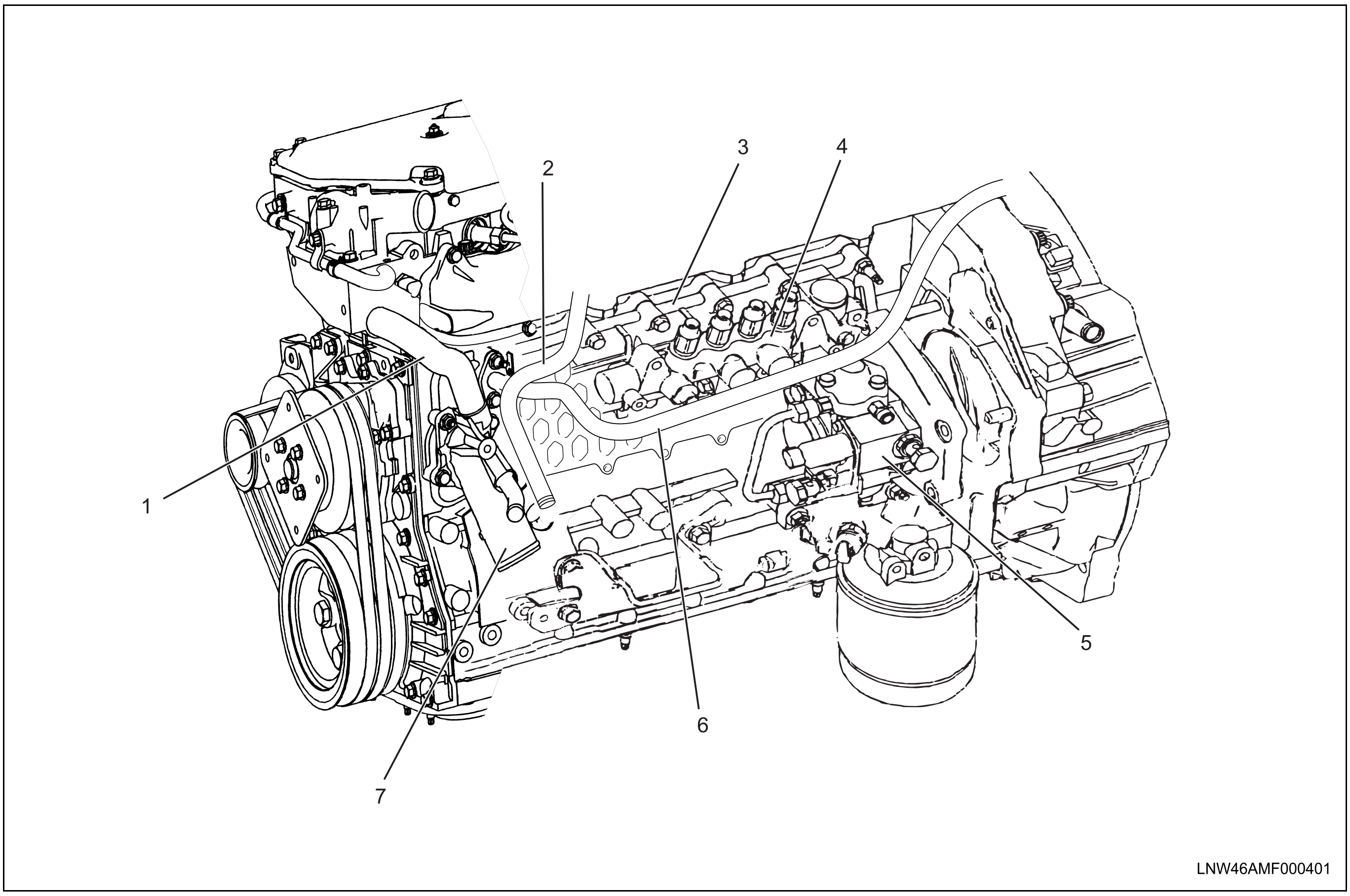
Special tool
Oil filter wrench: EN-47683

Special tool

Illustration	Tool Number/ Description
	EN-47683 Oil filter wrench

Oil Cooler

Components

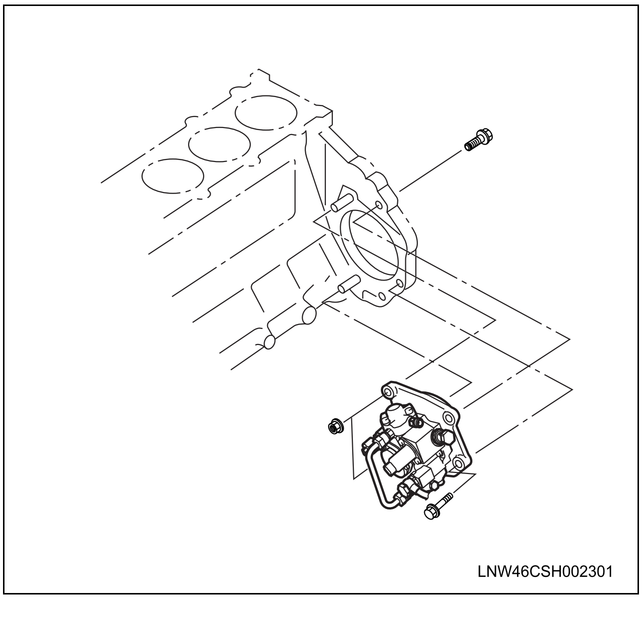


Legend

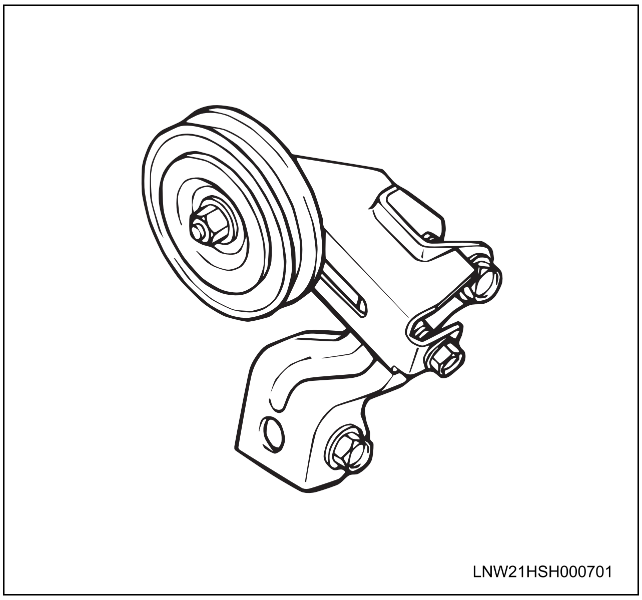
1. Bypass Hose
2. EGR Cooler Water Return Pipe
3. Oil Cooler
4. Fuel Rail
5. Fuel Supply Pump
6. EGR Cooler Water Feed Pipe
7. Suction Pipe

Removal

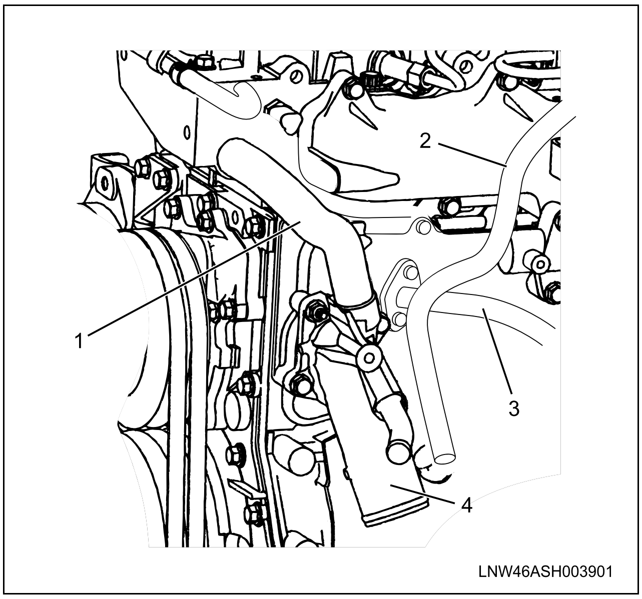
1. Remove the fuel rail.
   Refer to “fuel rail” in the fuel system section.
2. Remove the fuel supply pump.



3. Remove the A/C drive belt.
4. Remove the idling pulley bracket.
   - Remove the drive belt for A/C and the bracket fixing bolts, and then remove the bracket along with tensioner and idling pulley.



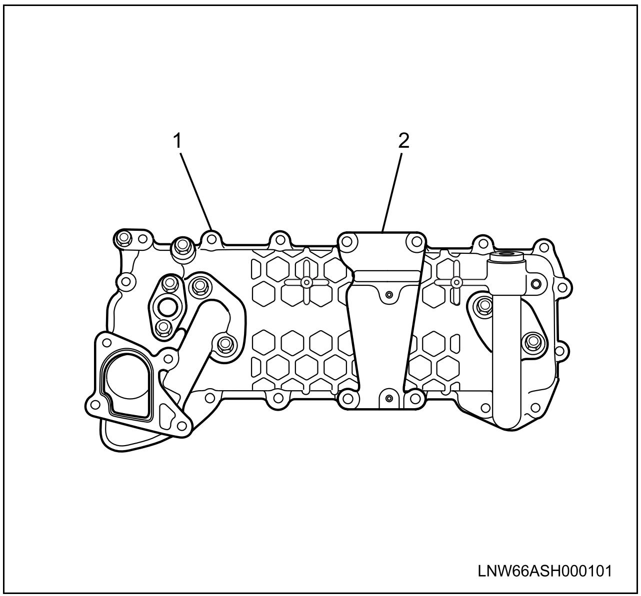
5. Remove the EGR cooler water return pipe.
   - Remove the brackets to the water pipe at two locations to make the pipe unsupported.
6. Remove the EGR cooler water feed pipe.
7. Remove the clip on the head side of the water bypass hose and remove the hose from the suction pipe and assembly.



Legend
1. Bypass Hose
2. EGR Cooler Water Return Pipe
3. EGR Cooler Water Feed Pipe
4. Suction Pipe

---

8. Remove the oil cooler assembly with glow plug controller bracket.
   - Screw the removed fixing bolt of the oil cooler into the replacer hole at the location 1 of the figure and remove the oil cooler.



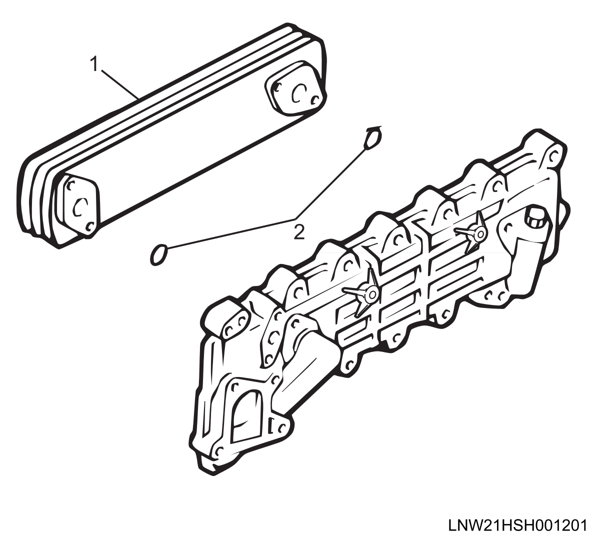
Legend
1. Oil Cooler Assembly
2. Glow Plug Controller Bracket

---

9. Remove the O-ring.

Disassembly

1. Remove the element mounting bolts.
2. Remove the element.
3. Remove the O-ring.



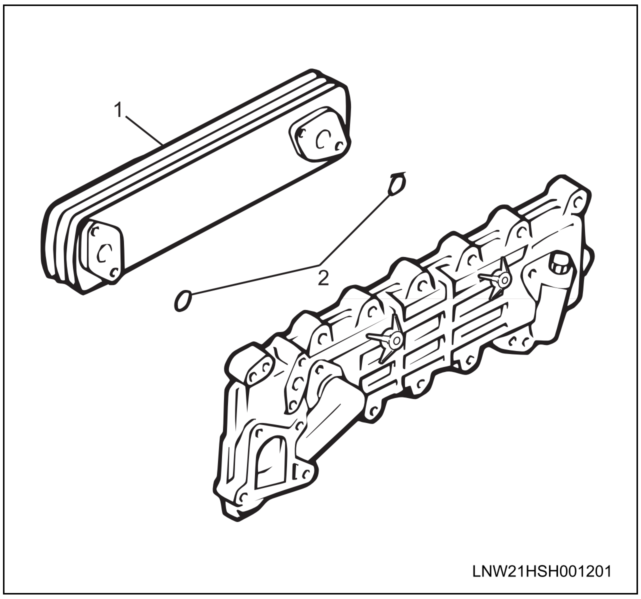
Legend
1. Element
2. O-Ring

Reassembly

1. Install the O-ring on the oil cooler case.

2. Install the element.
3. Tighten the element fixing bolts using the specified torque.

Tightening torque: 20 N·m (15 lb ft)

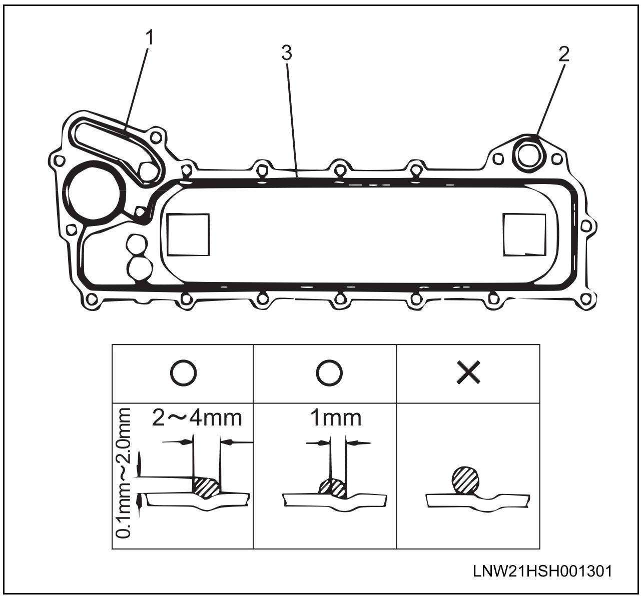


Legend

1. Element
2. O-Ring

Installation

1. Install the oil cooler assembly.
   - Apply liquid gasket (TreeBond1207C or equivalent) to the flange surface groove (cylinder block). Bead diameter must be between 2 and 4mm (0.008 and 0.16in). Refer to the illustration for the offset position (no more than 1 mm (0.04in)).
   - Install the O-rings (1) and (2) to the oil passage inlet and outlet. Do not allow the liquid gasket to contact the O-ring.



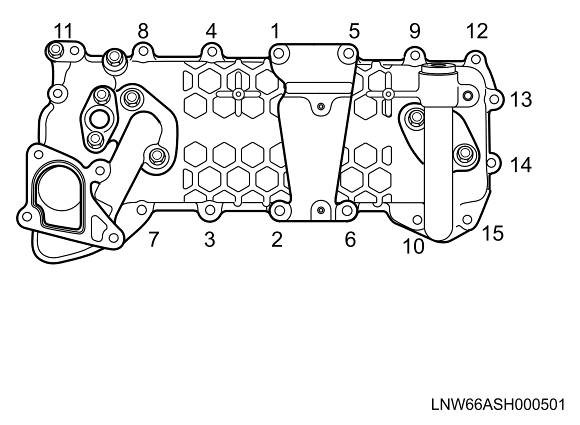
Legend

1. O-Ring
2. O-Ring
3. Liquid Gasket

- Align the oil cooler holes with the cylinder block studs.
- Install the oil cooler and glow plug controller bracket to the cylinder block.
- Tighten the bolts to the specified torque in the order shown in the illustration.

Tightening torque: 24 N·m (18 lb ft)

- Liquid gasket quickly hardens.
  Make it complete within 7 minutes after applying the liquid gasket.



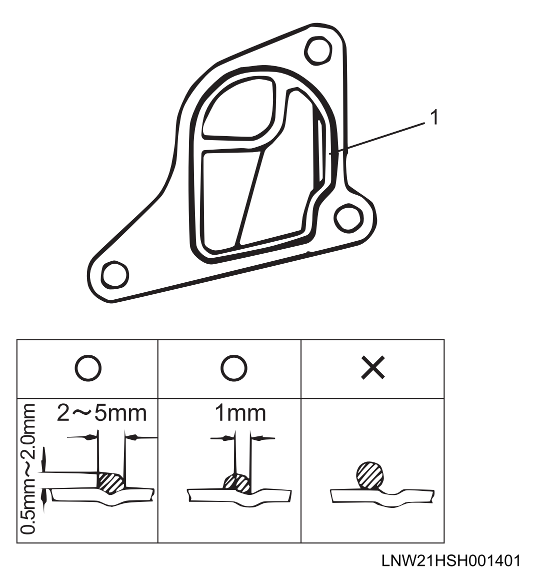
Legend

1. Oil Cooler Assembly
2. Glow Plug Controller Bracket

---

2. Install the water suction pipe.
   - Apply liquid gasket (TreeBond 1207C) to the flange of the water suction pipe. Bead diameter must be between 2 and 5 mm. Refer to the illustration for the offset position (no more than 1 mm).
   - Install the water suction pipe to the oil cooler. Refer to the illustration.
   - Tighten the bolts to the specified torque.

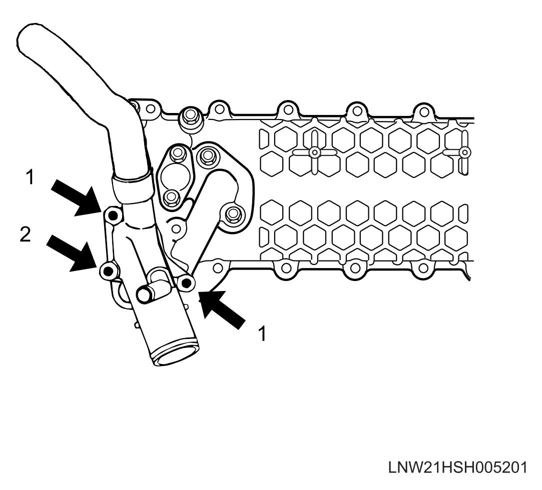
Tightening torque: 24 N·m (18 lb ft)



Legend

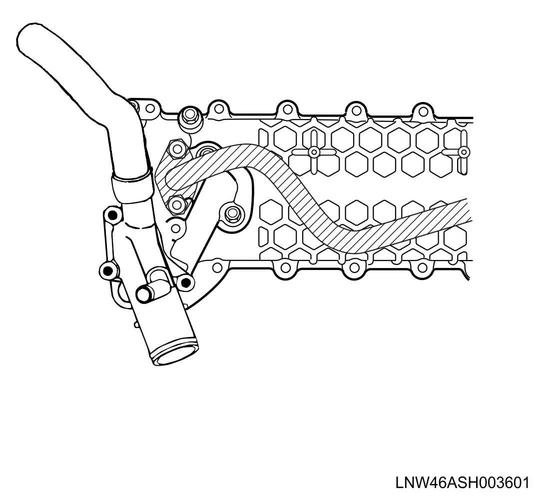
1. Liquid Gasket

Caution:
The water suction pipe must be installed immediately after the oil cooler (the pipe and cooler use the same liquid gasket).



3. Install the EGR cooler water feed pipe.
   - Install the O-ring on the EGR cooler water feed pipe.
   - Install at the position shown in the figure and tighten using the specified torque.

Tightening torque: 24 N·m (18 lb ft)



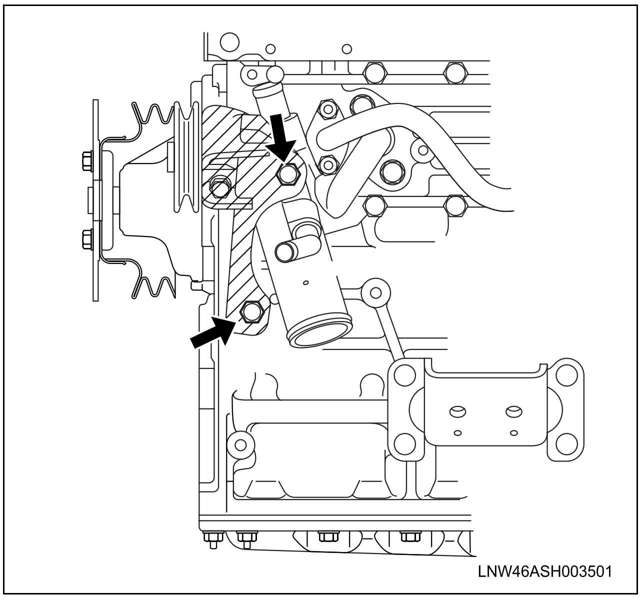
4. Install the EGR cooler water pipe.
5. Install the body cover assembly LH on the surface of the oil cooler and cylinder block and tighten it using the specified torque.

Tightening torque: 19 N·m (14 lb ft)

6. Install the idling pulley bracket and tighten it using the specified torque.

Tightening torque: 24 N·m (18 lb ft)

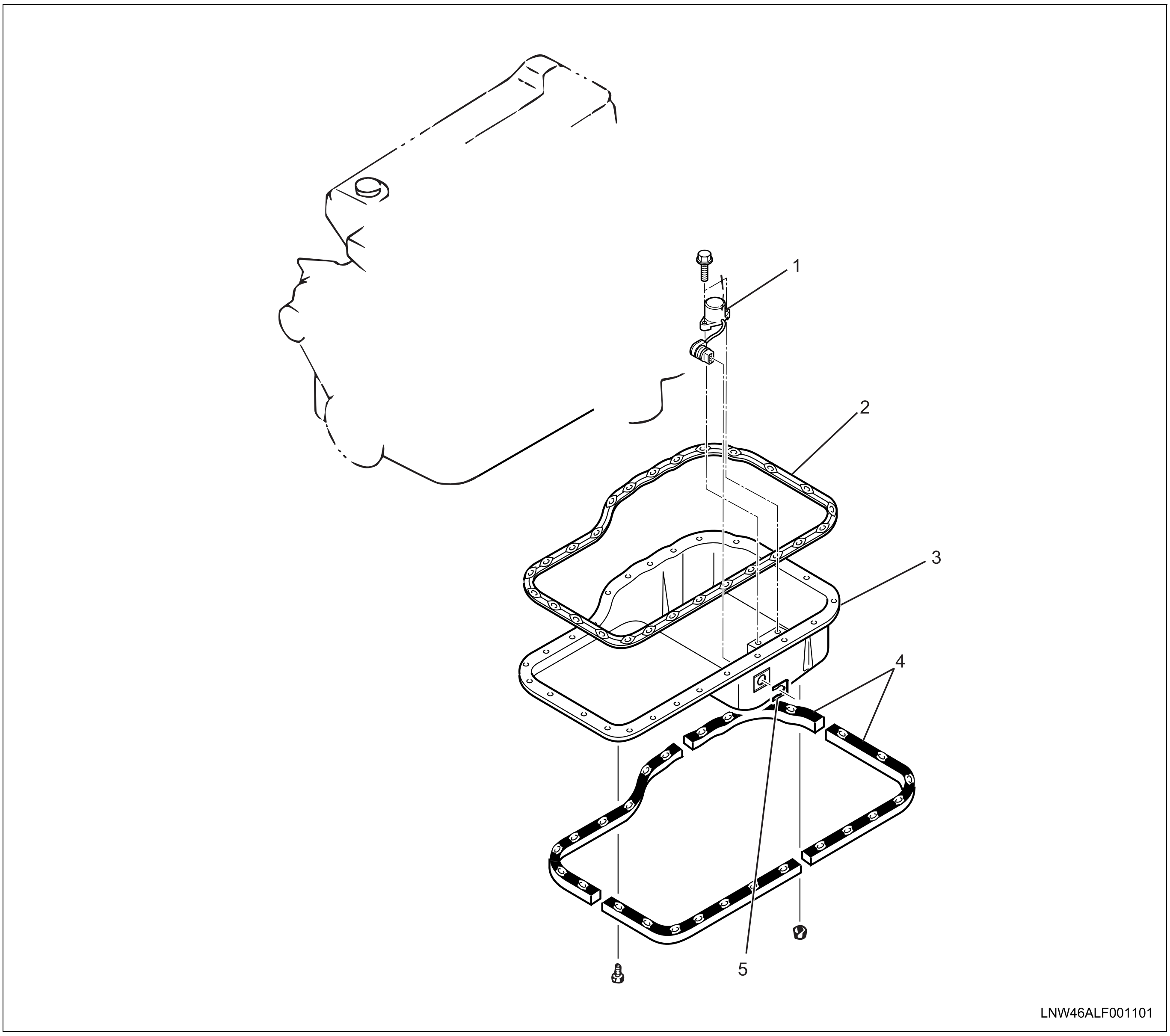
7. Install the A/C drive belt.
   Refer to “Drive belt” in the chapter on cooling water system.



8. Remove the oil drain adapter.
9. Install the fuel supply pump.
   - Refer to “fuel supply pump” in the fuel system section.
10. Install the fuel rail.
    - Refer to “fuel rail” in the fuel system section.

Oil Pan

Components



Legend

1. Oil Level Switch
2. Oil Pan Gasket
3. Oil Pan
4. Oil Pan Rubber
5. Clip

Removal

1. Drain out the engine oil.
2. Disconnect oil level switch connector.
3. Remove the oil pan.
4. Remove the level switch.
    - Remove the clip from the oil level switch connector.
    - Loosen the fixing bolts and nuts remove the oil level switch assembly.

Installation

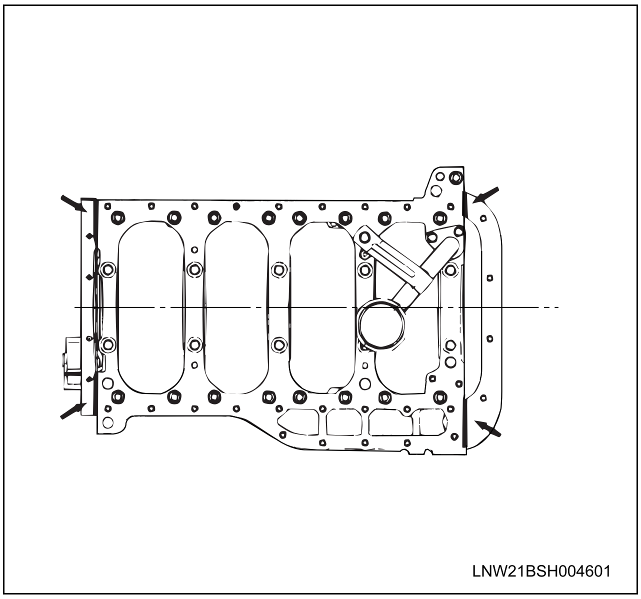
1. Install oil level switch.
    - Attach the oil level switch assembly to the upper of oil pan.

Tightening torque	Nut: 8 N·m (69 lb in) Bolt: 24 N·m (18 lb ft)

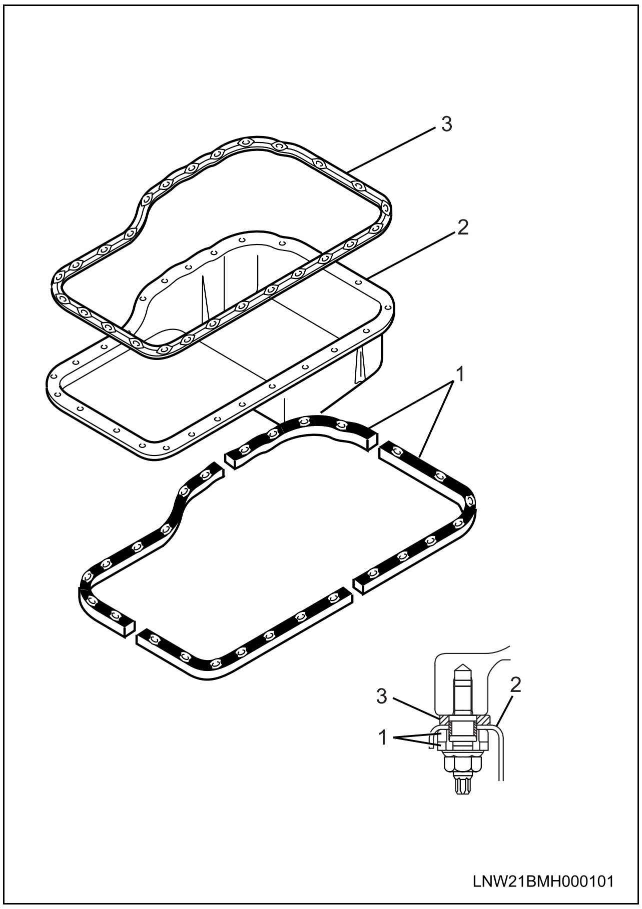
- Install the oil level switch connector into the upper oil pan and secure it with the clip.

2. Install the oil pan.

- At the seam between the cylinder block and the front cover with the flywheel housing, apply the liquid gasket (ThreeBond 1207C or equivalent) to a bead diameter of 3 mm.
- Apply the liquid gasket and install the oil pan within 7 minutes.



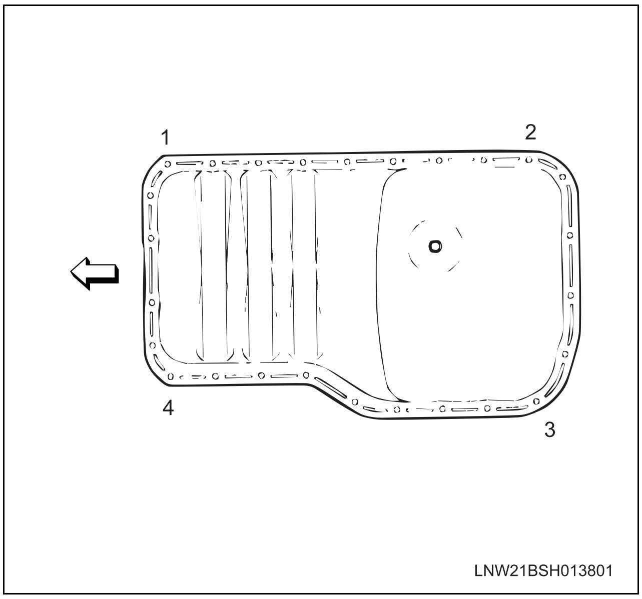
- Install the gasket using the studs of the crankcase, flywheel housing, and front cover as guide and mount the oil pan.
  Install the rubber assembly on the oil pan and secure it using nuts and bolts.



Legend

1. Rubber Assembly
2. Oil Pan
3. Gasket

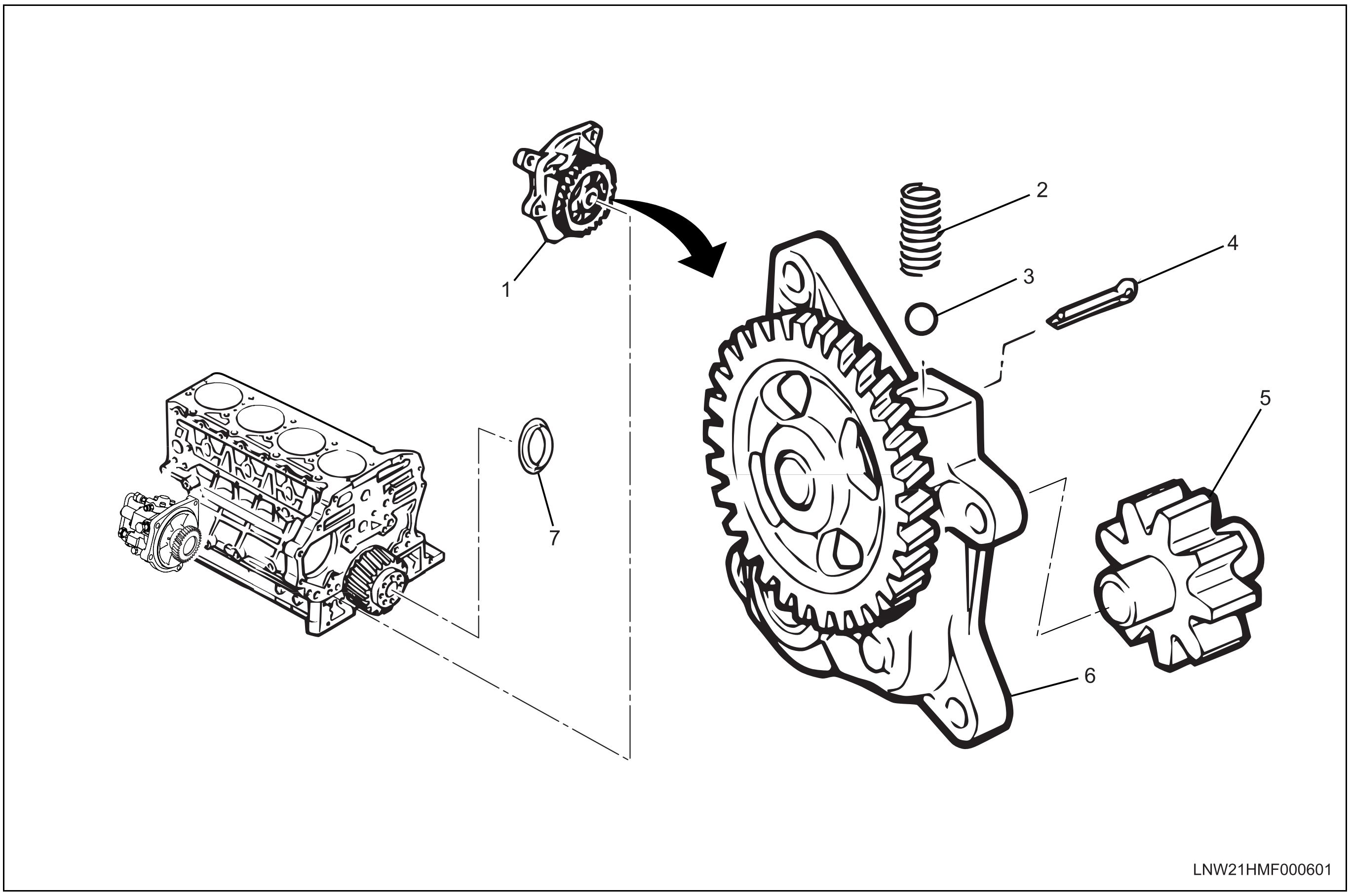
- Tighten the locations (1), (2), (3), and (4) as shown in the figure and then tighten others. (In any sequence)



Tightening torque: 11 N·m (95 lb in)

Oil Pump

Components

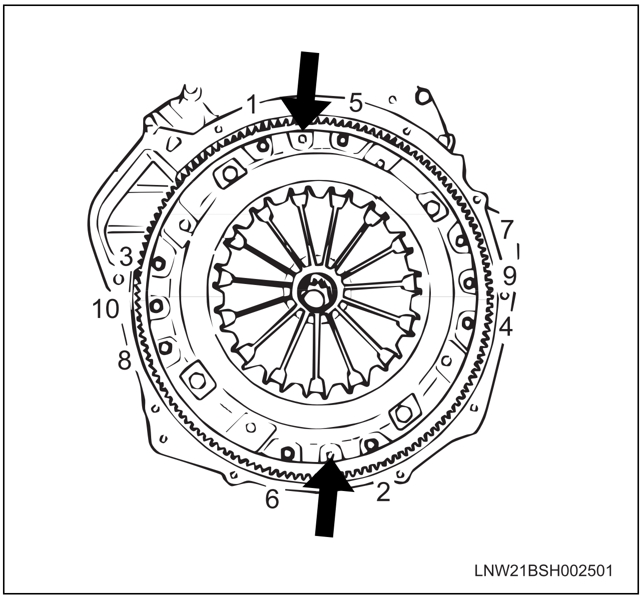


Legend

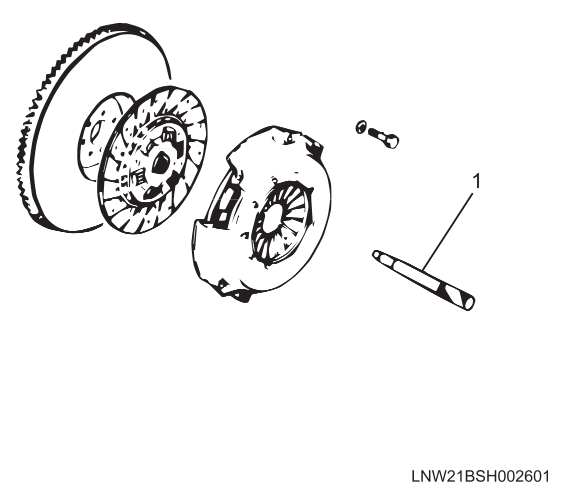
1. Oil Pump Assembly
2. Spring
3. Ball
4. Split Pin
5. Driven Gear And Shaft
6. Oil Pump Body
7. Slinger

Removal

1. Drain out the engine oil.
2. Drain out the cooling water.
3. Remove the cylinder head cover.
   Refer to “Cylinder head cover”.
4. Remove the rocker arm shaft assembly.
   Refer to “Rocker arm shaft assembly”.
5. Remove the camshaft assembly.
   Refer to “Camshaft assembly”.
6. Remove the cylinder head assembly.
   Refer to “Cylinder head”.
7. Clutch pressure plate
   - Insert the clutch aligner in the spline of the driven plate.
   - Remove the pressure plate mounting bolts in the sequence shown in the figure.
   - Remove the pressure plate from the flywheel.



8. Driven plate
   - Remove the driven plate together with the clutch aligner from the flywheel.

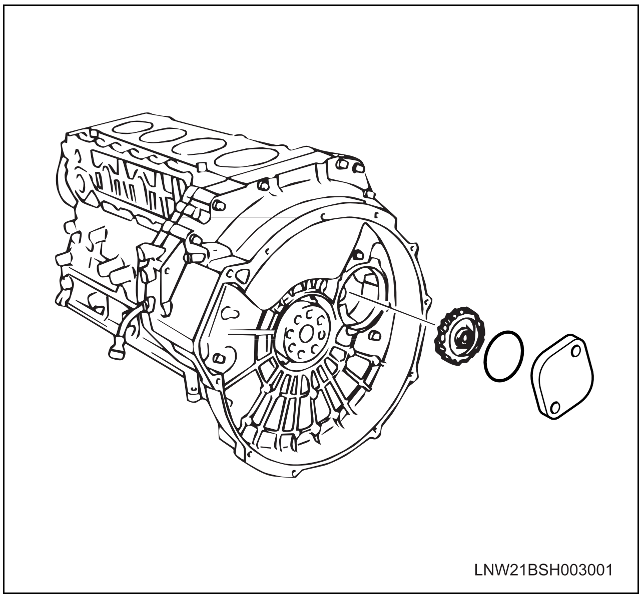


Legend

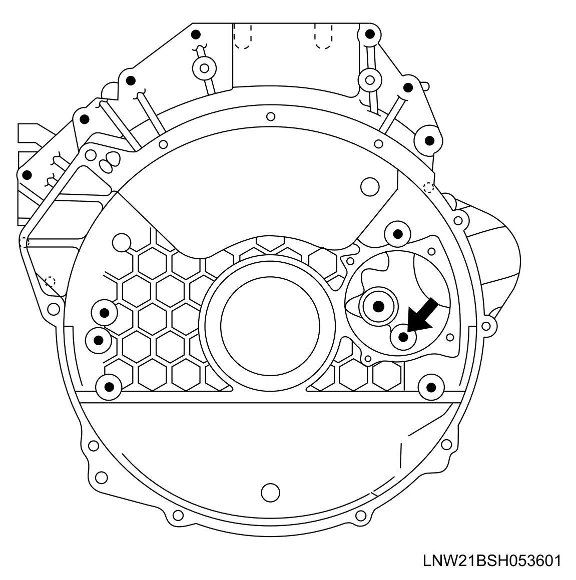
1. Clutch Aligner

---

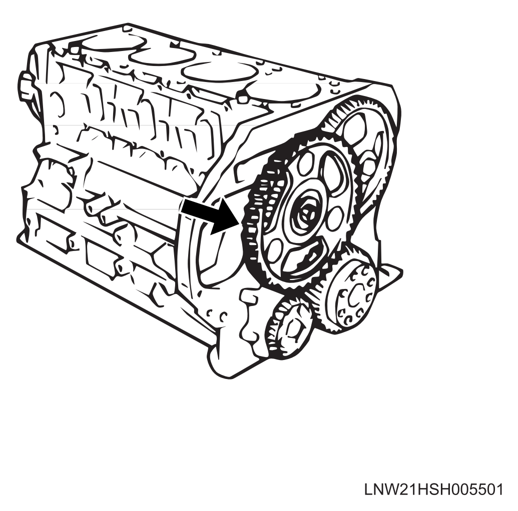
9. Remove the fuel supply pump assembly.
   Refer to “fuel supply pump” in the fuel system section.
10. Remove the flywheel.
    Refer to “Flywheel”.
11. Remove the rear oil seal of the crankshaft.
    Refer to “Rear oil seal of Crankshaft”.
12. Remove the oil pan.
13. Remove the power steering pump.
14. Remove the idle gear cover of the power steering pump.
15. Remove the idle gear of the power steering pump.



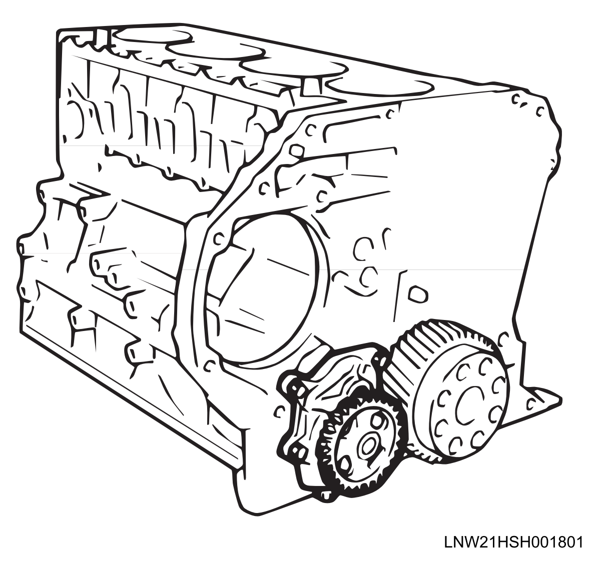
16. Remove the flywheel housing.
    - Make sure you remove the bolts shown in the figure.



17. Remove the idle gear A.



18. Remove the oil pump assembly.

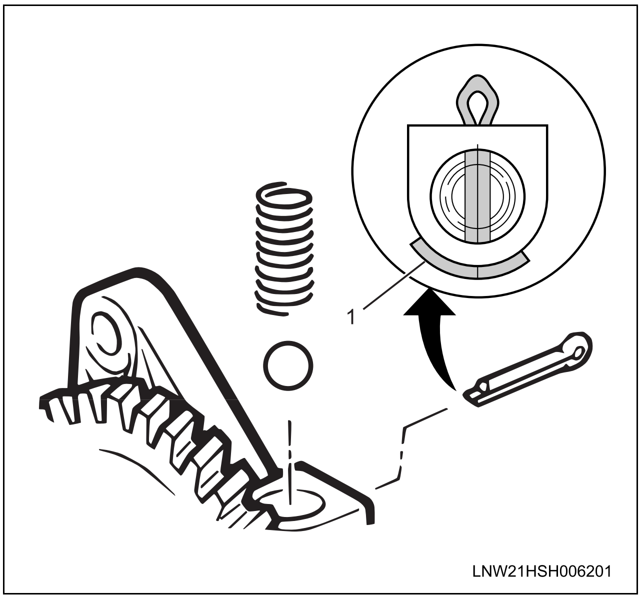


Disassembly

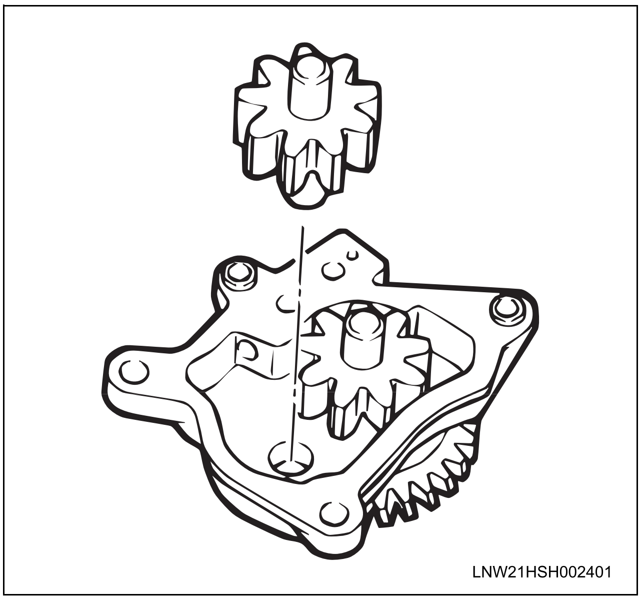
1. Remove the driven gear and shaft.
2. Remove the split pin.
3. Remove the spring.
4. Remove the ball.

Reassembly

1. Install the ball.
2. Install the spring.
3. Install the split pin and fold it according to (1).



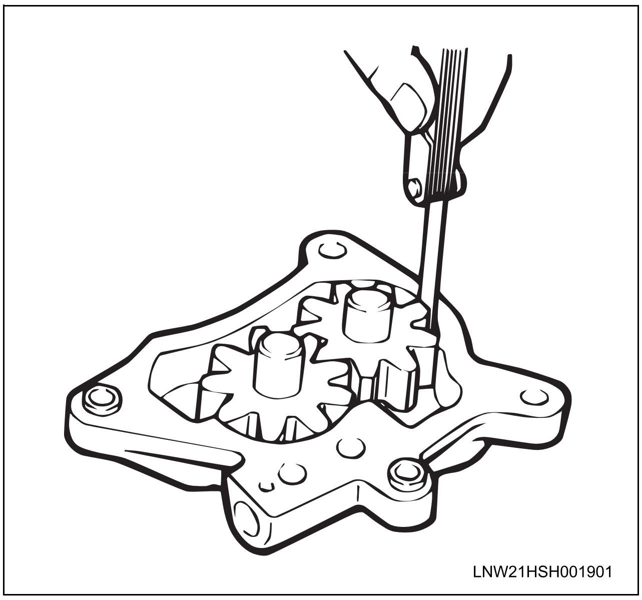
4. Apply engine oil on the driven gear and shaft and mount them on the oil pump body.



Inspection

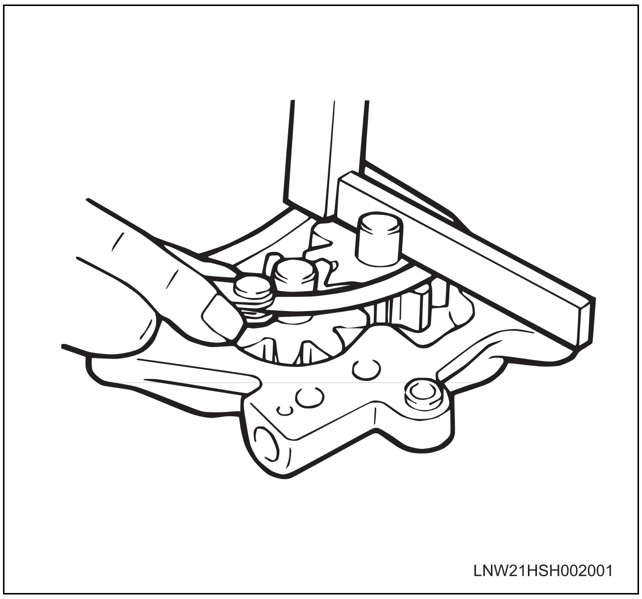
1. Measure the clearance between the gear and the inner wall of the oil pump body.
   - Measure the clearance between the gear and oil pump body using a thickness gauge.
   - If the clearance between the gear and inner wall of the body exceeds the limit, replace the gear assembly or the driven gear assembly.

Clearance between the gear and inner wall of the body mm (in)	
Standard	0.125 ~ 0.220 (0.0049 ~ 0.0087)
Limit	0.30 (0.0118)



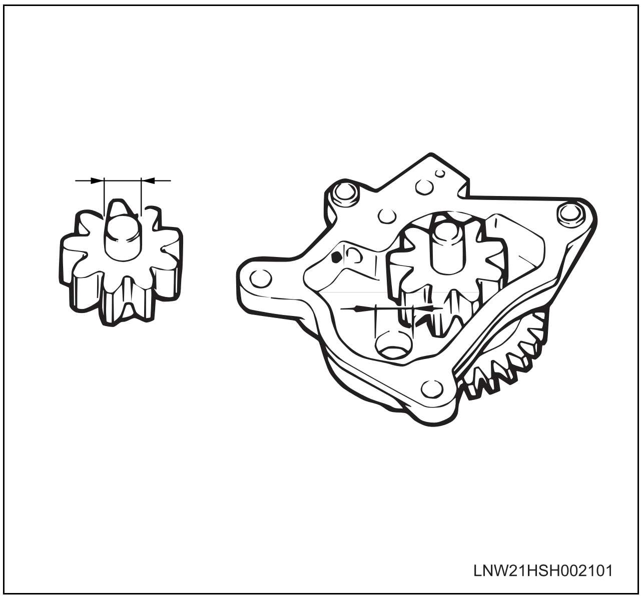
2. Measure the clearance between the gear side surface and the upper surface of the oil pump body.
   - Measure the clearance between the gear surface and the upper surface of the oil pump body using the thickness gauge and square.
   - If the clearance between the gear and inner wall of the body exceeds the limit, replace the gear assembly or the driven gear assembly.

Clearance between the gear side surface and the upper surface of the oil pump body mm (in)	
Standard	0.064 ~ 0.109 (0.0025 ~ 0.0043)
Limit	0.20 (0.0079)



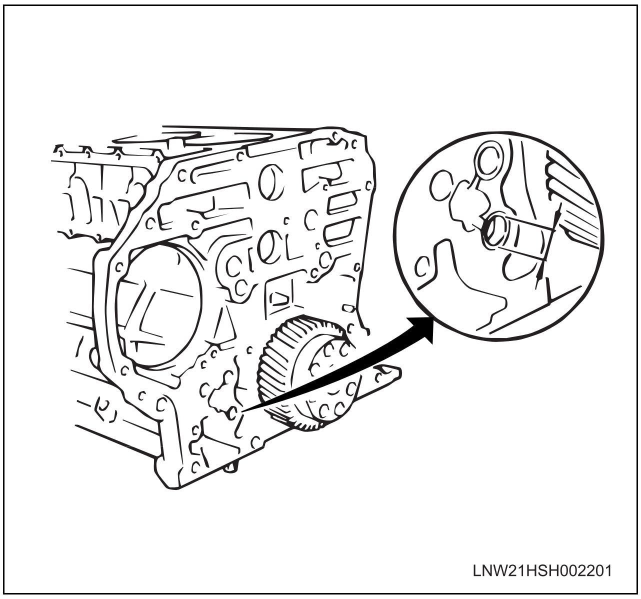
3. Measure the clearance between the driven gear shaft and the bush.
   - Measure the outside diameter of the driven gear shaft using a micrometer.

Outside diameter of the driven gear shaft mm (in)	
Standard	15.989 ~ 16.000 (0.62949 ~ 0.62992)
Limit	15.900 (0.62598)



- Measure the inside diameter of the bushes of the oil pump body and cylinder block using the dial gauge.
- If the clearance between the driven gear shaft and bush exceeds the limit, replace the driven gear assembly.

Clearance between the driven gear shaft and bush mm (in)	
Standard	0.04 ~ 0.07 (0.0016 ~ 0.0028)
Limit	0.20 (0.0079)

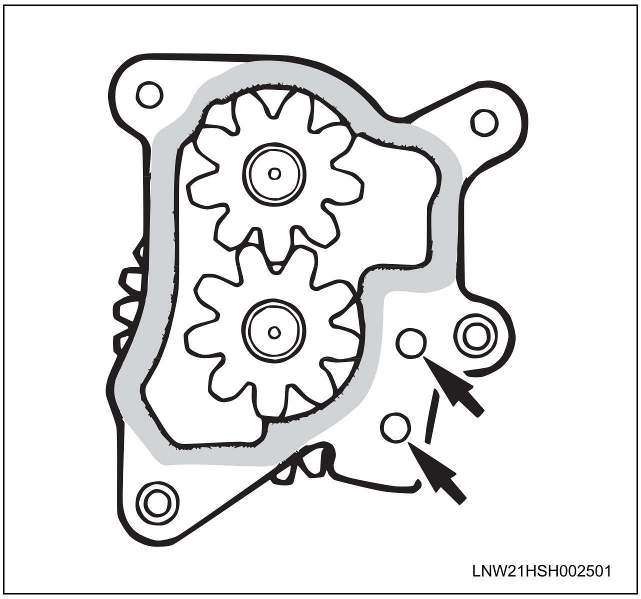


Installation

1. Install the oil pump assembly.
   - Apply the liquid gasket (TreeBond 1141E or equivalent) as shown in the figure, mount it on the cylinder block within one hour, and tighten it using the specified torque.

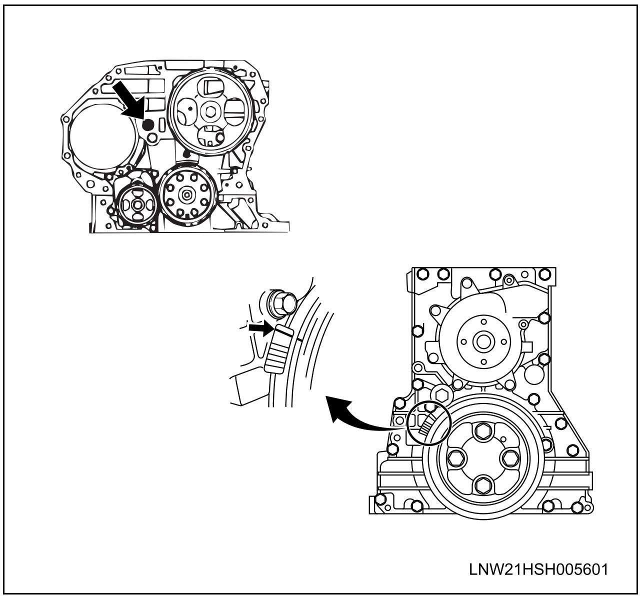
Tightening torque: 24 N·m (18 lb ft)

Caution:
Apply the fluid gasket such that it does not enter the holes shown by arrows in the figure, gear, and the oil pump body.



2. Install the idling gear A.

- Install the idling gear shaft at the position shown in the figure and apply engine oil on the shaft.
- Rotate the crankshaft clockwise and bring the piston of the No.1 cylinder to the top dead center.



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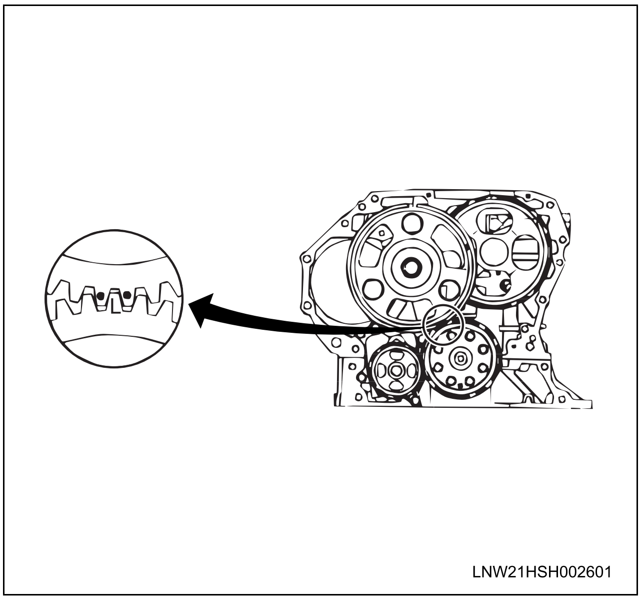
- Match the coincidence marks of the crankshaft gear and the idle gear A, and install them on the cylinder block.



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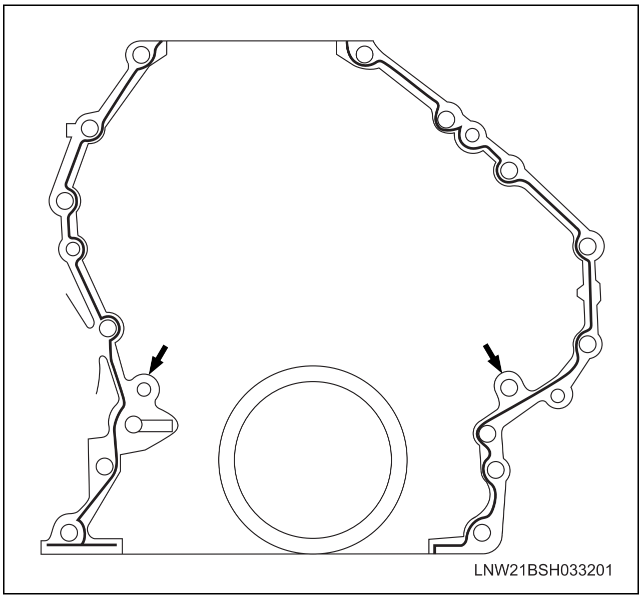
- Tighten the mounting bolts using the specified torque.

Tightening torque: 133 N·m (98 lb ft)

3. Install the flywheel housing.
   - Clean properly the rear surface of the cylinder block. Remove the protruding fluid gasket thoroughly, especially, when mounting the crankcase.
   - Apply the liquid gasket (TreeBond1207C) uniformly on the inside surface of the bolt holes (excluding the bolt holes indicated by arrows) as shown in the figure.
   - After applying the liquid gasket, quickly install it.



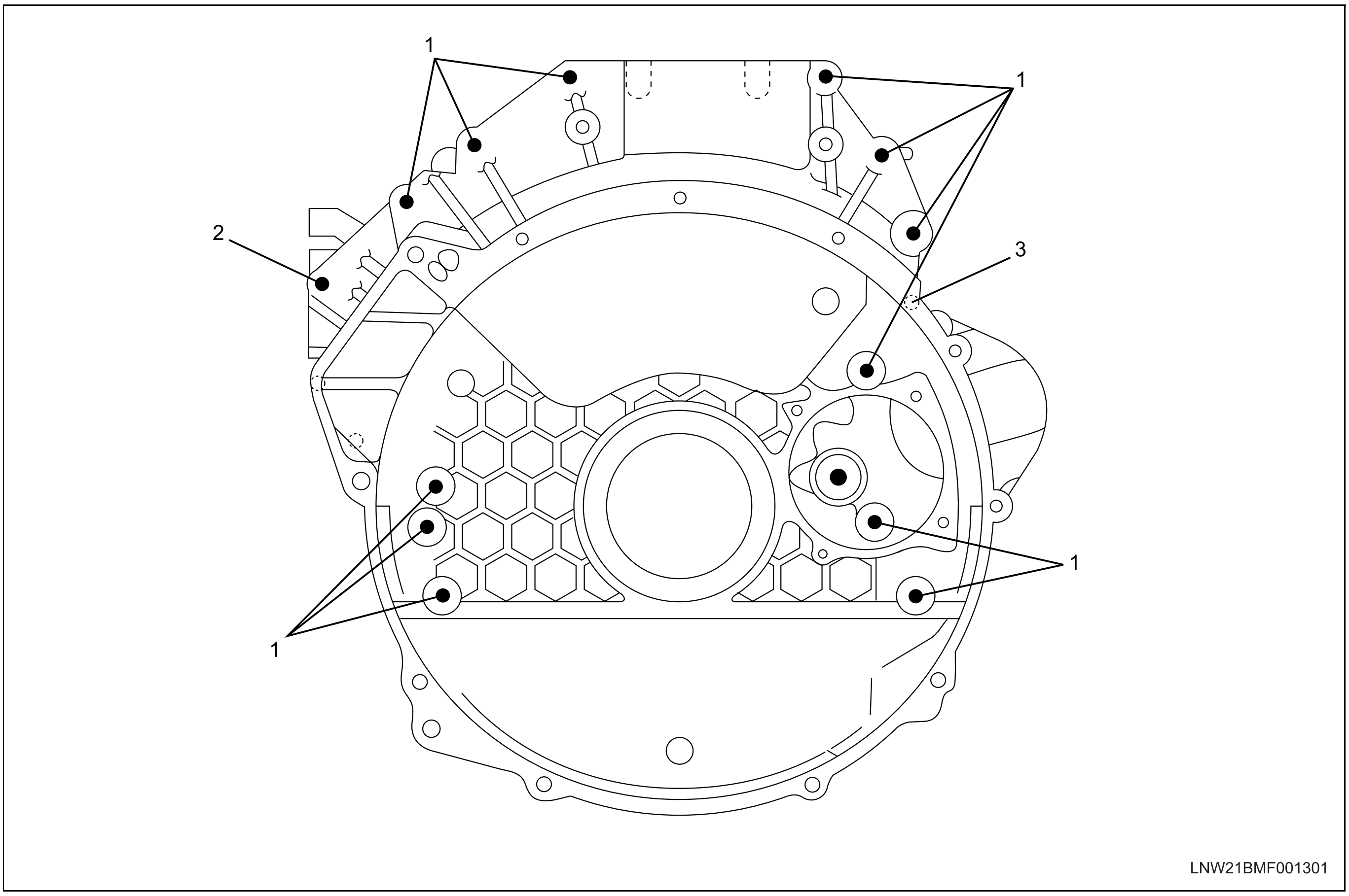
LNW21BSH033201

- Match the dowel pin of the cylinder block and then install the flywheel housing.

Tightening torque:

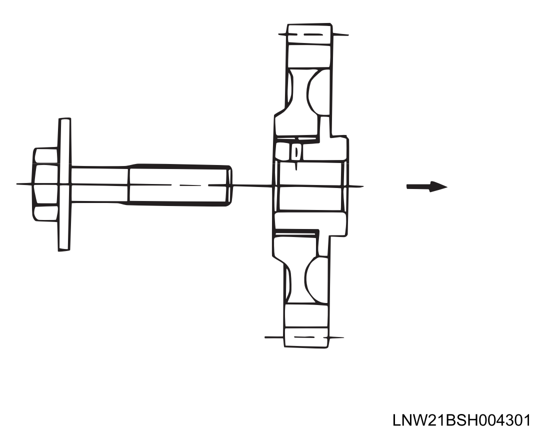
Bolts holes marked with “1” =	96 N·m (71 lb ft)
Bolts holes marked with “2” =	77 N·m (57 lb ft)
Bolts holes marked with “3” =	38 N·m (28 lb ft)

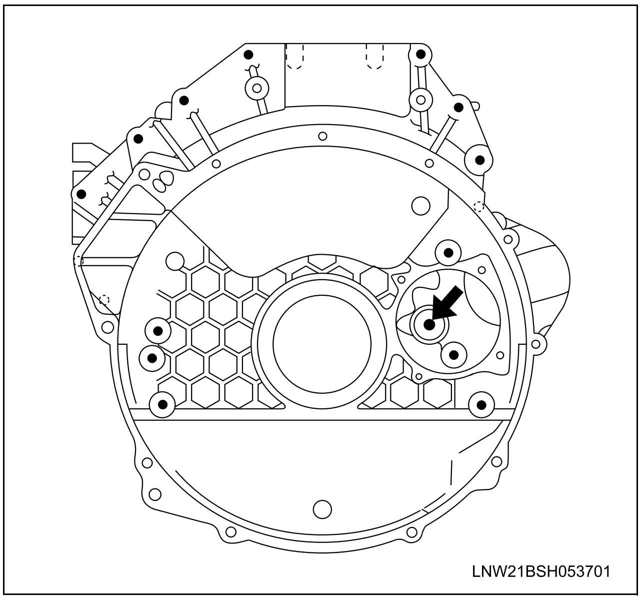
- The seal is tightened from the cylinder block side.



4. Install the power steering pump idling gear.
   - Apply the engine oil on the gear assembly unit of the idling gear shaft.
   - Assemble the idling gear and the shaft in the direction shown in the figure, mount it on the flywheel housing, and tighten it using the specified torque.

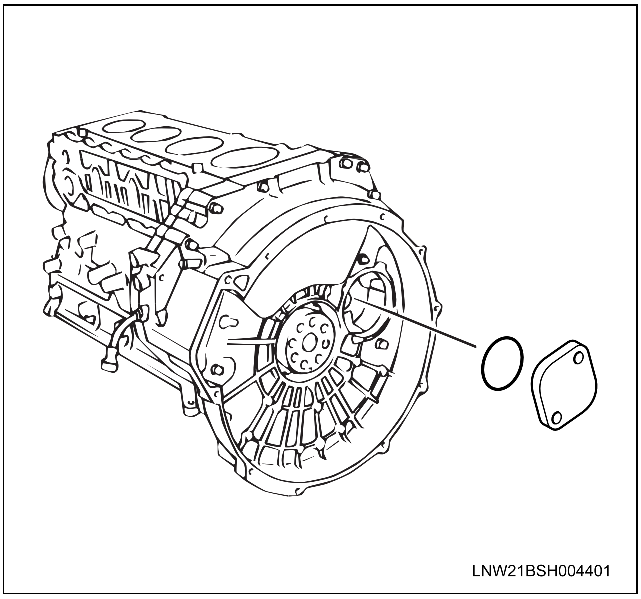
Tightening torque: 133 N·m (98 lb ft)





5. Install the idling gear cover of the power steering pump.
   - Install the O-ring on the cover and on the flywheel housing, and tighten the fixing bolts using the specified torque.

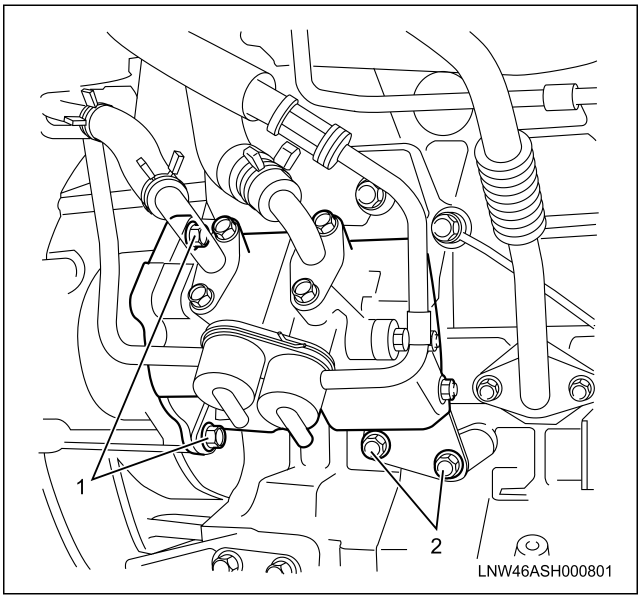
Tightening torque: 15 N·m (11 lb ft)


LNW21BSH004401

6. Install the power steering pump and tighten it using the specified torque.

Flywheel housing fixing bolt
(1 bolt)
Tightening torque: 43 N·m (32 lb ft)

Cylinder block fixing bolts
(2 bolts)
Tightening torque: 44 N·m (33 lb ft)



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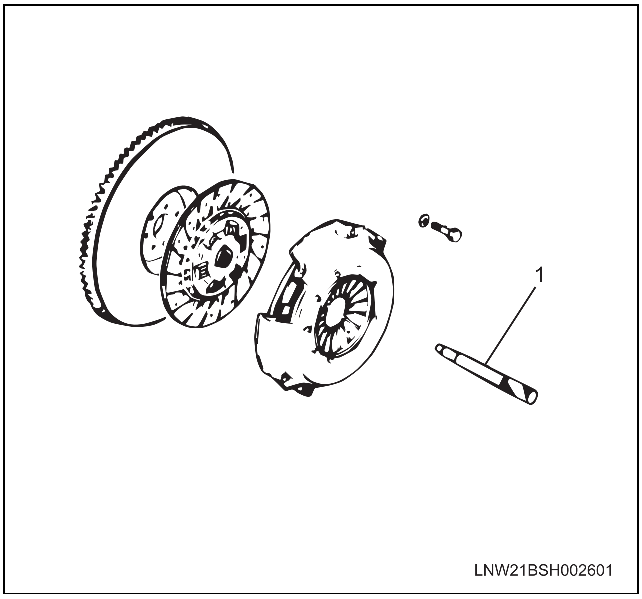
Legend

1. Flywheel Housing Bolt
2. Cylinder Block Bolt

---

7. Install the oil pan.
   Refer to "Oil pan".
8. Install the rear seal of the crankshaft.
   Refer to "Rear oil seal of Crankshaft".
9. Install the flywheel.
   Refer to "Flywheel".
10. Install the fuel supply pump assembly.
    Refer to "fuel supply pump" in the fuel system section.
11. Install the driven plate.
12. Install the clutch pressure plate.
    - Insert the clutch aligner in the spline of the driven plate.
    - Install the driven plate on the flywheel.
    - Match the mounting hole of the pressure plate with the dowel pin of the flywheel, and install the pressure plate on the flywheel.



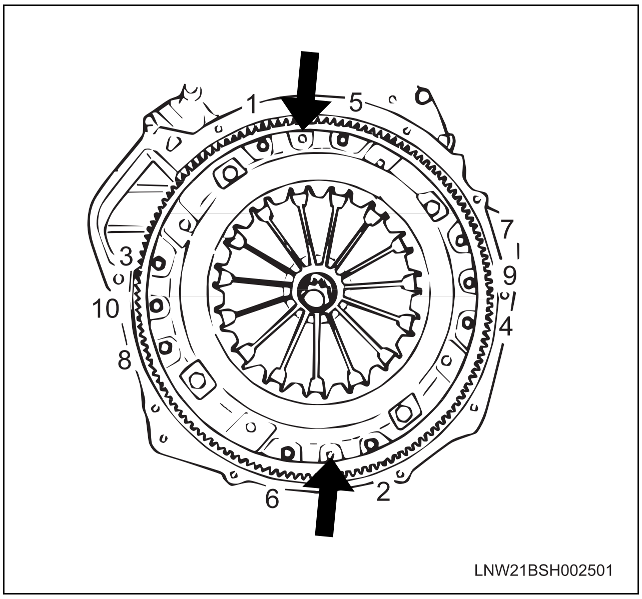
LNW21BSH002601

Legend

1. Clutch Aligner

- Tighten the pressure plate in the sequence shown in the figure using the specified torque.

Tightening torque: 40 N·m (30 lb ft)



LNW21BSH002501

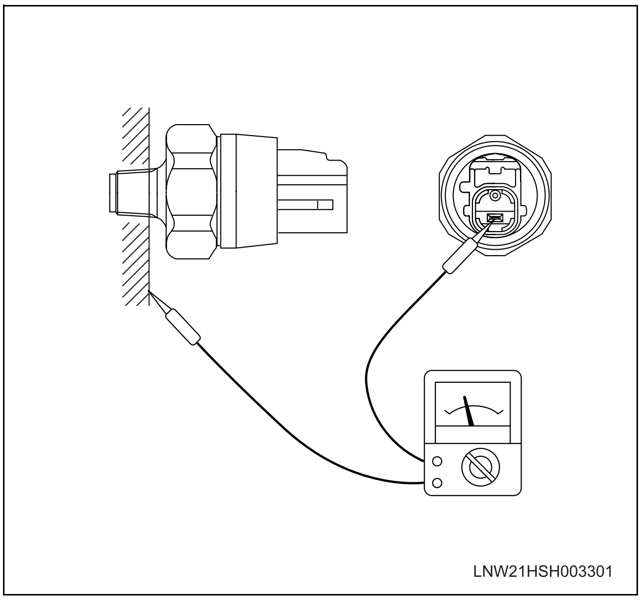
13. Install the cylinder head assembly.
    Refer to "Cylinder head".

14. Install the camshaft assembly.
    Refer to “Camshaft assembly”.
15. Install the rocker arm shaft assembly.
    Refer to “Rocker arm shaft assembly”.
16. Tighten the cylinder head cover.
    Refer to “Cylinder head cover”.

Oil Pressure Switch

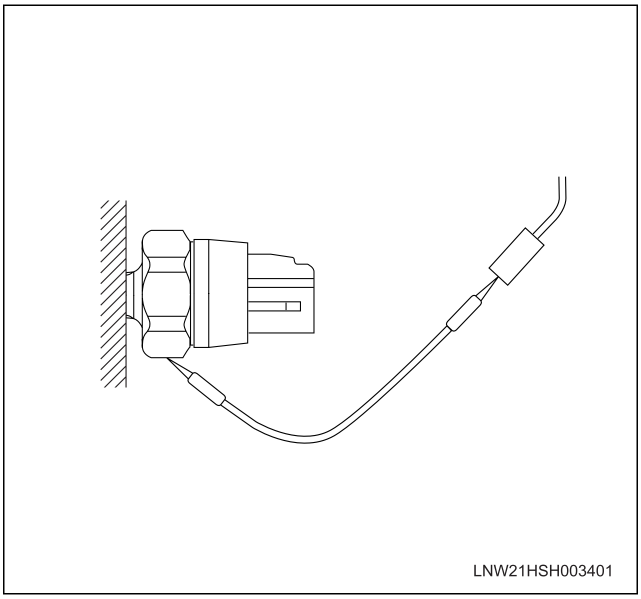
Inspection

Check the continuity between the switch terminal and the body grounding in the no-load condition.
If there is no connectivity, replace with normal parts.



Circuit check

1. Turn the starter switch to ON.
2. Disconnect the oil pressure switch connector, and confirm that the oil pressure-warning lamp lights when the connector on the harness side is grounded.
   If the warning lamp does not light up, check the circuit between the meter and the oil pressure switch, and repair the disconnected locations.



Air Cleaner Element

Removal

1. Remove the air cleaner cover fixing bolt.
2. Remove the air cleaner element assembly.

Inspection

- Check for damage to the element or clogging due to dirt. If the element is damaged, then replace it. If clogged, then clean it.
- The viscous-type (wet type) element cannot be cleaned; therefore, it has to be replaced if it is very dirty.

Replacement period	Every 40,000 km or every two years

Installation

1. Install the air cleaner element assembly.
2. Tighten the air cleaner cover fixing bolt.

Cleaning

Dry type element

- While rotating the element, blow air under 690 kPa (100 psi) and remove the dust.


LNW46ASH003201

- Dissolve the filter cleaner ND1500 in water and soak the element for approximately 30 minutes. Then wash it properly with water and allow it to dry in natural conditions (two to three days.)

ENGINE

Cooling System

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Cooling System

Service Precautions

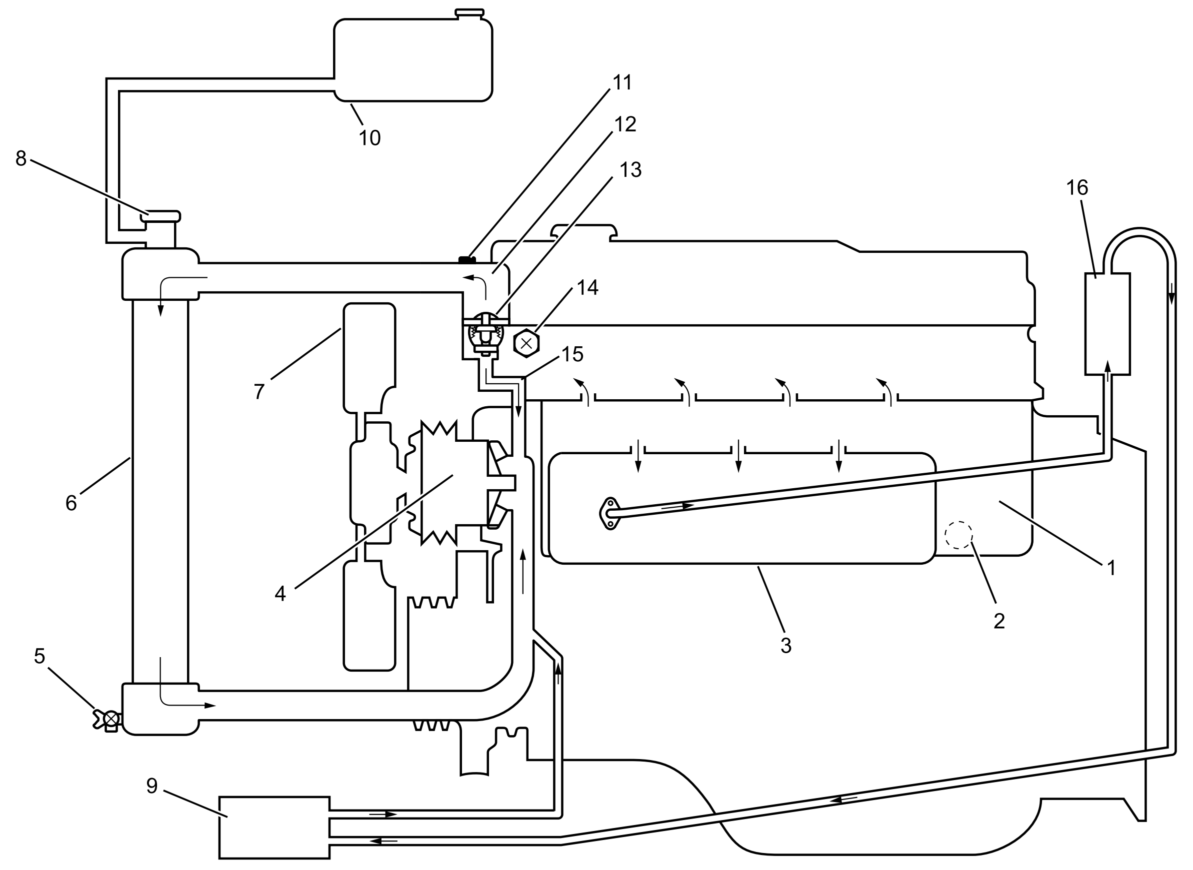
WARNING:

Do not remove the radiator cap when the cooling water is at high temperature. Steam or boiling water will gush out and you may be burnt. To open the radiator cap, cover the cap with a thick cloth when the cooling water is cool, release the pressure by slowly turning the cap, and then remove the cap.

Explanations on functions and operation

Cooling water system

The cooling water system, which is the forced circulation system, consists of a water pump, thermostat, and radiator as its main components. The oil in automatic transmission is cooled due to the cooling water in the radiator.

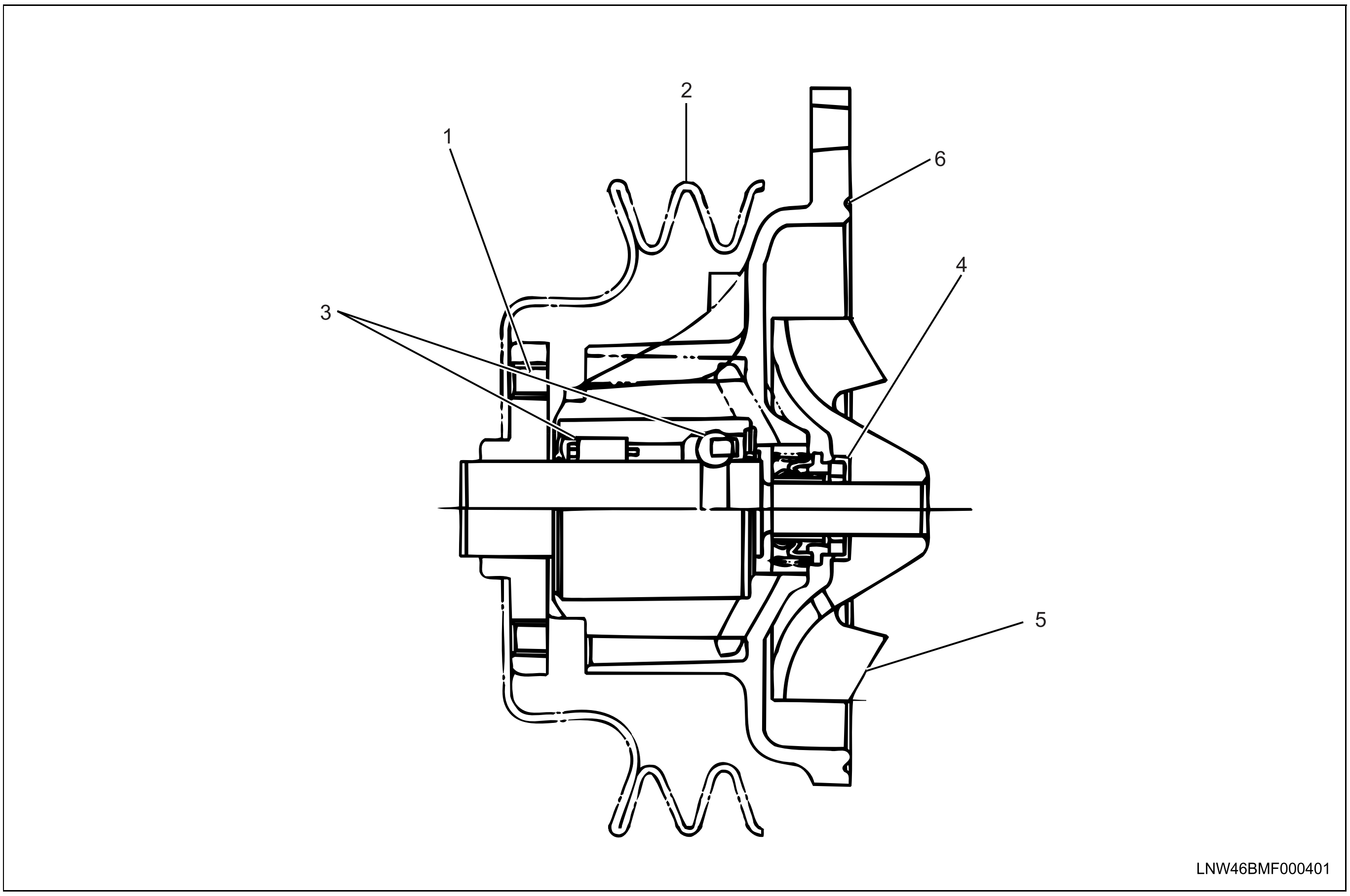


Legend

1. Water Jacket
2. Drain Plug
3. Oil Cooler
4. Water Pump
5. Drain Cock
6. Radiator
7. Cooling Fan
8. Radiator Cap
9. Heater Core
10. Reserve Tank
11. Air Bleeding Plug
12. Water Outlet Pipe
13. Thermostat (2 nos.)
14. Thermometer Unit
15. Bypass Route
16. EGR Cooler

Water pump

The water pump, which uses the centrifugal impeller system, is driven by the engine fan belt.

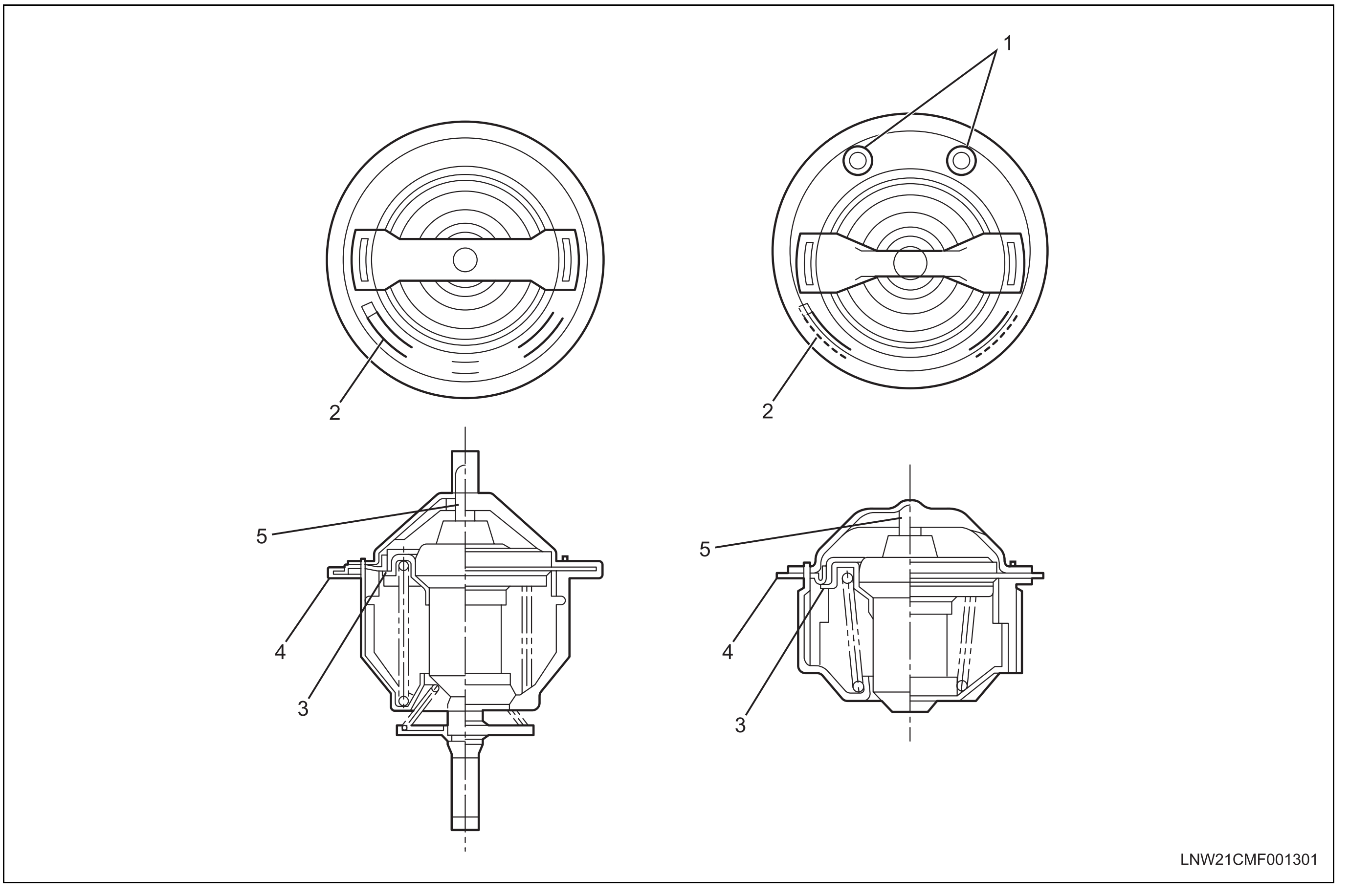


Legend

1. Fan Center
2. Fan Pulley
3. Bearing
4. Seal Unit
5. Impeller
6. Groove

Thermostat

The thermostat is a wax pellet type and consists of two units, in which one unit (bottom bypass type) has an valve initial opening temperature of 82 °C (180 °F) and the second (inline type) has an valve initial opening temperature of 85 °C (185 °F). It is designed such that the water temperature can be adjusted finely and it is mounted within the thermostat-housing unit.

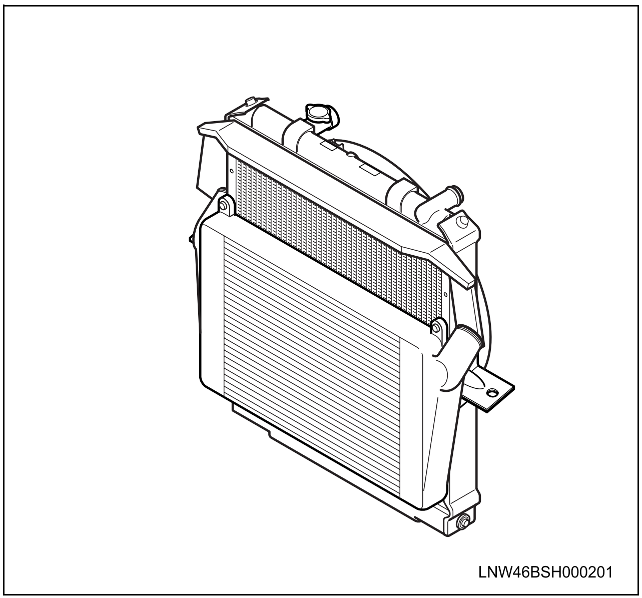


Legend

1. Jiggle Valve
2. Stamp Mark (Valve Initial Opening Temperature)
3. Valve
4. Gasket
5. Piston

Radiator

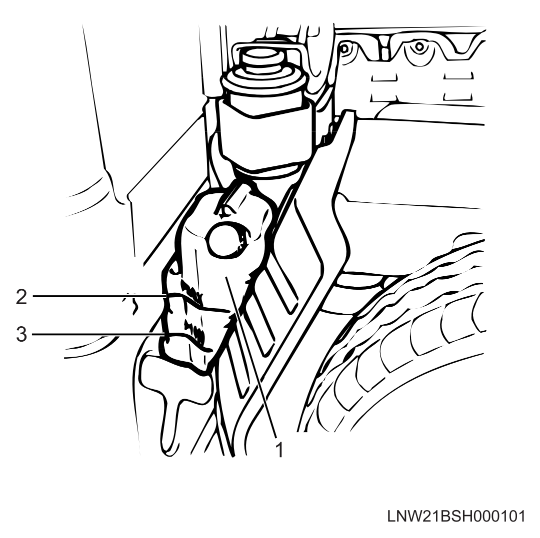
The radiator is a tube with corrugated fins. To increase the boiling point of the cooling water, a radiator cap of injection valve opening pressure of 93 to 122 kPa (13 to 18 psi) is attached.



Functional check

1. Cooling water level check
   - Check the cooling water level within the reserve tank and the level is appropriate when the cooling water level is within the MAX (upper limit) and MIN (lower limit) range. In case the volume of the cooling water is deficient, remove the reserve tank cap and replenish with a mixture of tap water and engine coolant in the ratio of 1:1 until the level comes close to the MAX line.

Standard value	
Cooling water level	14 L (14.8 qts) (between MIN and MAX level)
Replacement period	Every two years or 26,000 miles



Legend

1. Reserve Tank
2. MAX Line (Upper Limit)
3. MIN Line (Lower Limit)

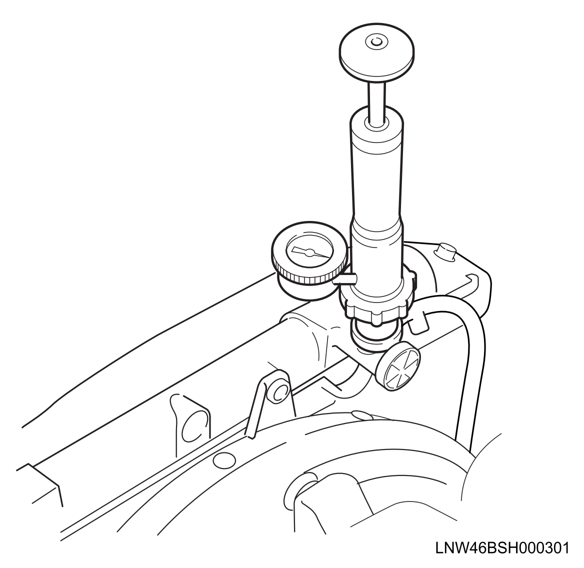
Inspection

Cooling water leak check

- Use the radiator cap tester and apply a pressure of 200 kPa (28.4 psi) and check for leaks in the locations given below. Check that the radiator hose and heater hose are not damaged or degraded and the hose clamp is not loose.

Inspection locations

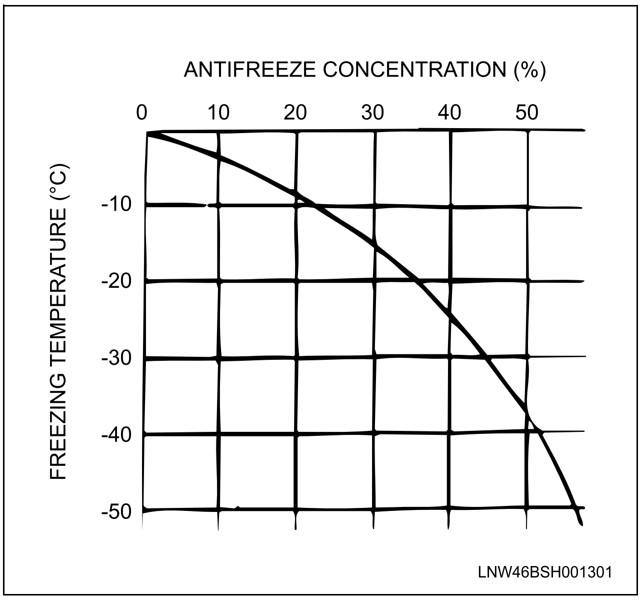
- Radiator assembly, water pump assembly, radiator hose, and heater hose.



Coolant

1. About the engine coolant concentration

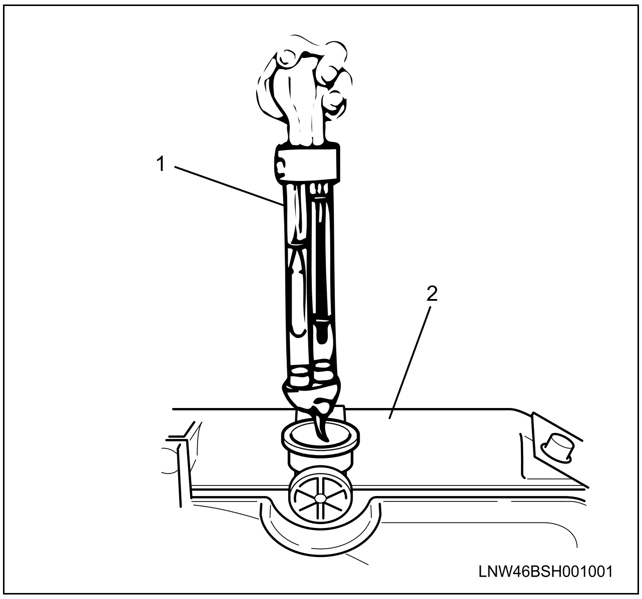
- Take the concentration corresponding to the minimum temperature because the freezing temperature varies according to the concentration of the engine coolant.
- Use only genuine Isuzu engine coolant.
- Use engine coolant with a mix ratio in the range of 30 to 60% because over heating is likely to occur if the ratio is greater than 60% and corrosion prevention is inadequate if the ratio is less than 30%.



Freezing temperature guideline	Mix ratio Liter (qts)		Concentration of engine coolant
	Engine coolant	Tap water	
-18°C (-0.4°F)	4.2 (4.4)	7.8 (8.2)	35%
-25°C (-13°F)	5.0 (5.3)	7.0 (7.4)	42%
-35°C (-31°F)	6.0 (6.3)	6.0 (6.3)	50%
-40°C (-40°F)	6.4 (6.8)	5.6 (5.9)	53%

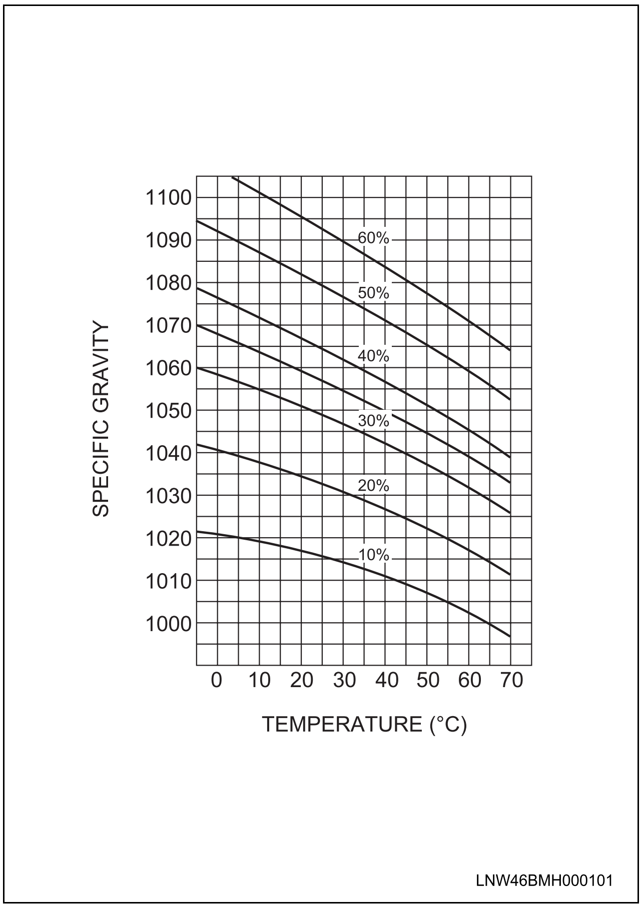
2. Engine coolant density measurement
   Methods for measuring specific gravity
   - Measure the specific gravity and the temperature of the cooling water using an anti-freeze specific gravity meter and thermometer.

     Take precautionary measures as the boiled cooling water may gush out at high temperatures if the cap is removed.
   - Use a deep container to suit the height of the specific gravity meter.



Legend
1. Radiator
2. Anti-Freeze Specific Gravity Meter

- Fix the temperature of the cooling water being measured in the range of 0 to 50 °C (32 to 122 °F).
- Measure the temperature and specific gravity and determine the concentration from the table given below.



Coolant scooping method

- Measure the concentration using the coolant scoop.

A list of defective phenomena

- Engine overheats
- Engine overcools

Main Data and Specifications

Engine overheats

Condition	Possible Cause	Correction
Engine overheats	Cooling water volume is deficit.	Replenish.
	Thermometer unit is defective.	Replace.
	Thermostat is defective.	Replace.
	Radiator pump is defective.	Replace.
	Radiator is clogging.	Clean or replace.
	Radiator cap is defective.	Replace.
	Engine oil volume is deficient or incorrect engine oil is used.	Replenish or change the engine oil.
	Cylinder head gasket is defective.	Replace.
	The fan belt is loose.	Adjust.
	Exhaust system is clogging.	Clean or replace.
	The fuel injection quantity is in surplus.	Diagnose the engine control system.
	Fuel injection timing is incorrect.	Diagnose the engine control system.
	Starting pressure of fuel injection is low.	Diagnose the engine control system.

Engine overcools

Condition	Possible Cause	Correction
Engine overcools	Thermostat is defective.	Replace.

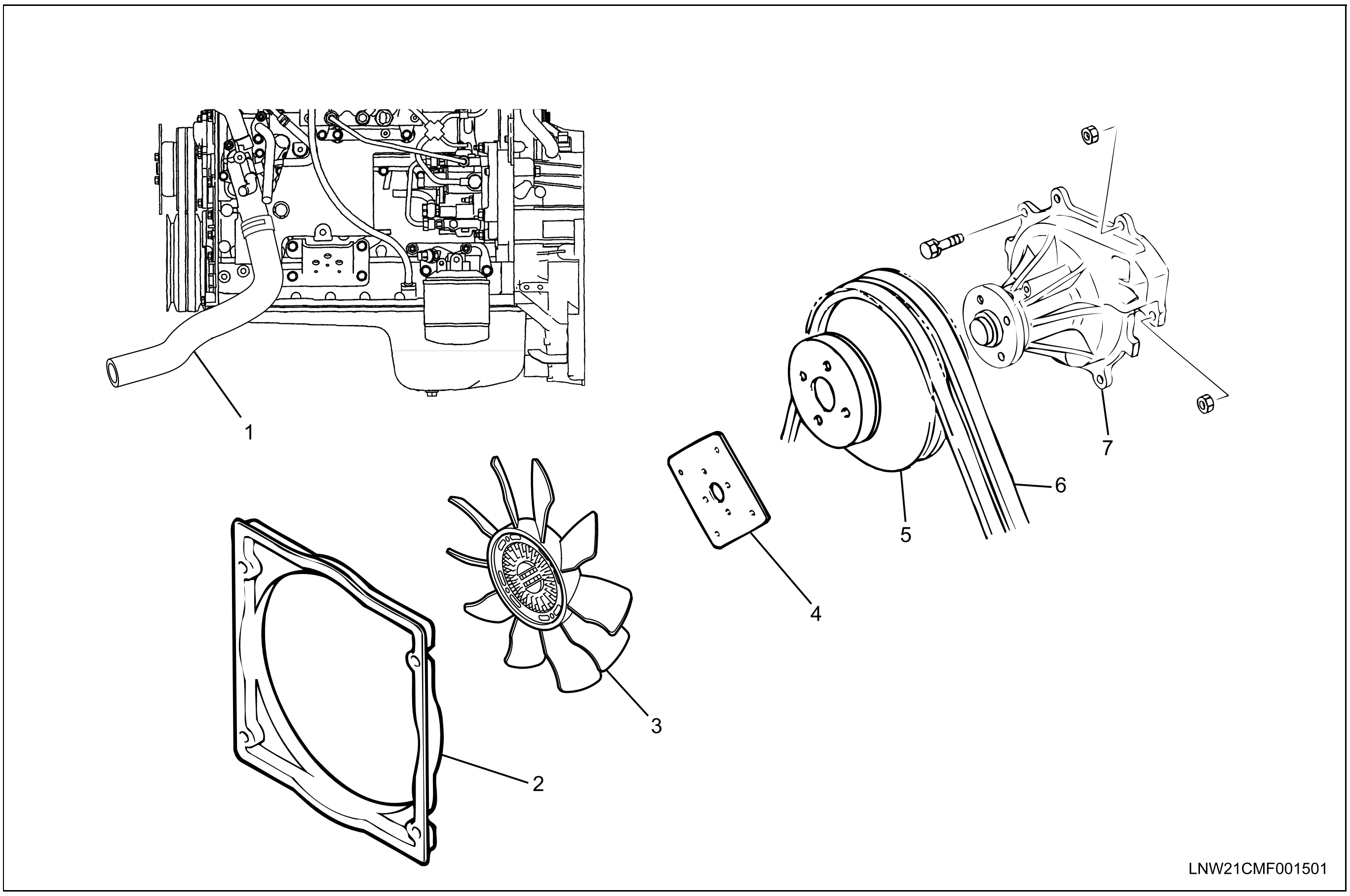
Main Data and Specifications

Cooling methods		Forced circulation system
Radiator		Tubes with corrugated fins
Radiation capacity	kW (kcal/h)	120 (103200)
Radiation area	m^2 (ft^2)	17.78 (191.3)
Frontal area	m^2 (ft^2)	0.367 (4.05)
Dry mass	N (lb)	196 (44.1)
Radiator cap		
Valve opening pressure	kPa (psi)	93 –122 (12.8 – 17.1)
Cooling water capacity	Liter (qts)	3.2 (3.4)
Water pump		Centrifugal impeller system
Pulley ratio		1.190
Thermostat		Wax pellet system

Valve opening temperature	°C (°F)	With jiggle valve 85 (185) Without jiggle valve 82 (180)
Temperature when fully open	°C (°F)	With jiggle valve 100 (212) Without jiggle valve 95 (203)
Cooling water total capacity	Liter (qts)	14 (14.8)

Water Pump

Components

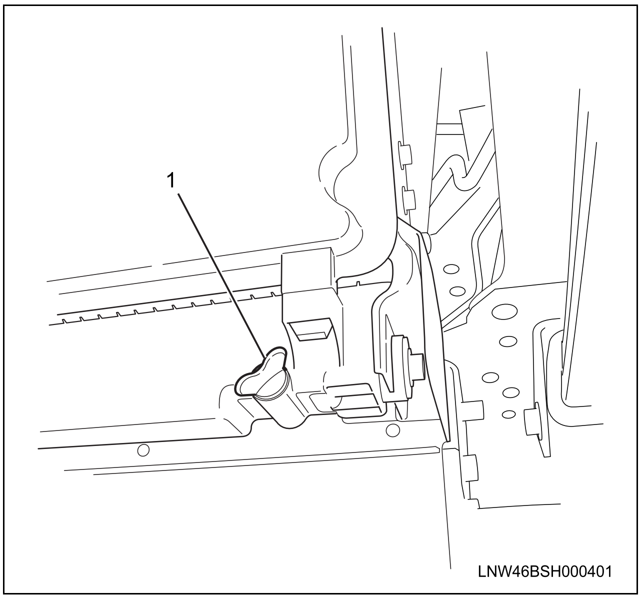


Legend

1. Radiator Lower Hose
2. Fan Guide
3. Fan
4. Setting Plate
5. Water Pump Pulley
6. Fan Belt
7. Water Pump Assembly

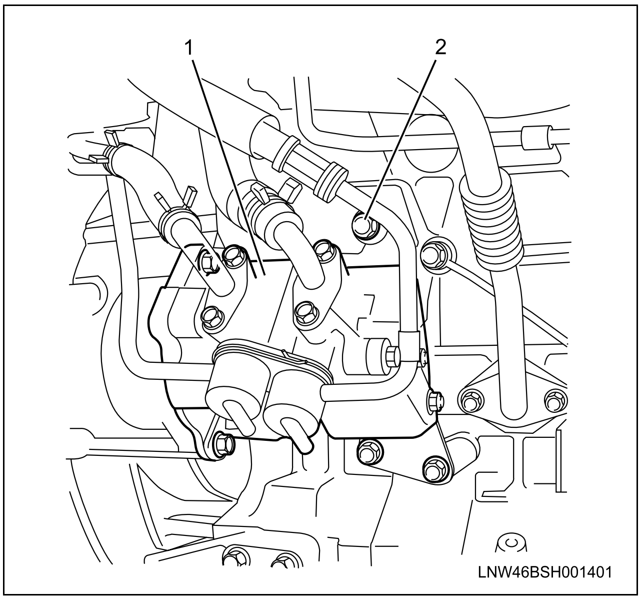
Removal

1. Drain the coolant water.



Legend

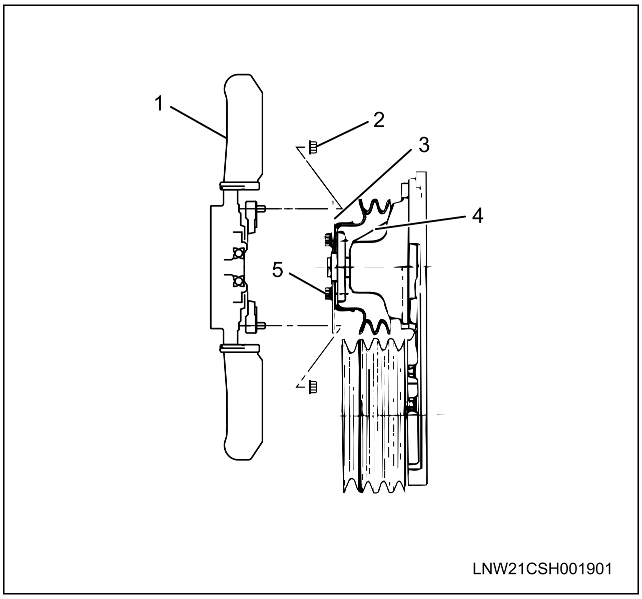
1. Radiator Drain Cock



Legend

1. Power Steering Pump
2. Drain Plug

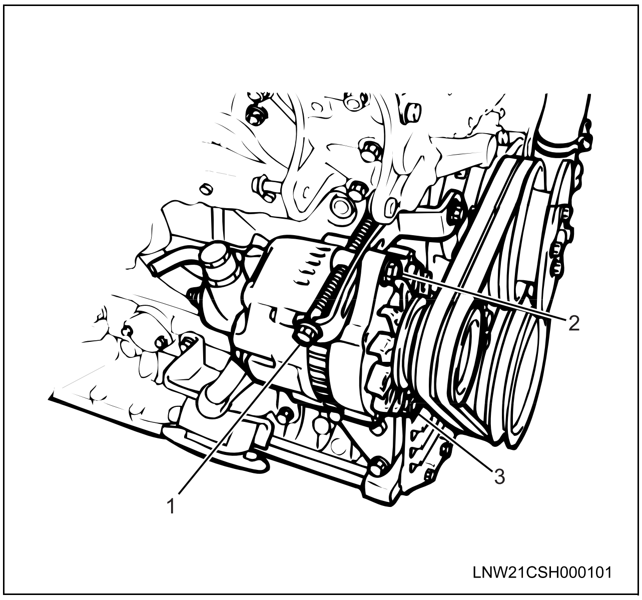
2. Remove the radiator lower hose on the radiator side.
3. Take out the fan guide from below.
4. Remove the four mounting nuts and then the fan assembly. Also, loosen the four bolts for tightening the setting plate and water pump pulley together.



Legend

1. Fan
2. Nut
3. Setting Plate
4. Water Pump Pulley
5. Bolt

5. (2) and (3) that tighten the setting plate and water pump together. Loosen the adjusting bolts (1) in the generator and remove the fan belt.

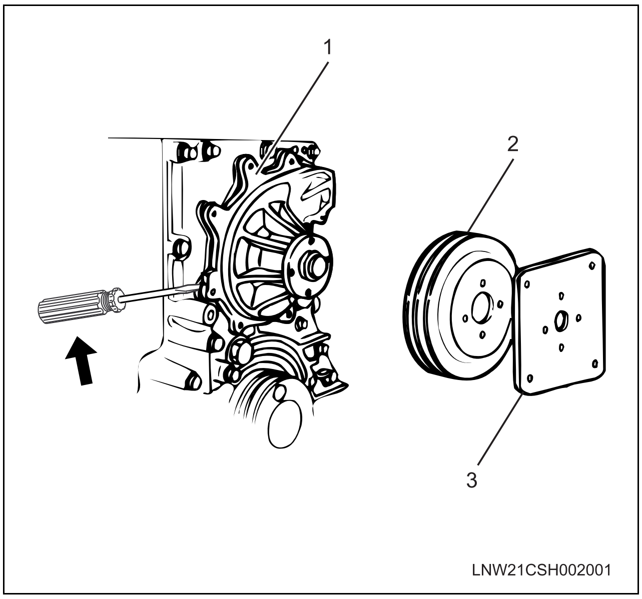


Legend

1. Adjusting Bolt
2. Lock Nut
3. Bolt

6. Remove the setting plate and water pump pulley.

7. Remove the water pump assembly while inserting and scraping with the driver at the position shown in the figure.



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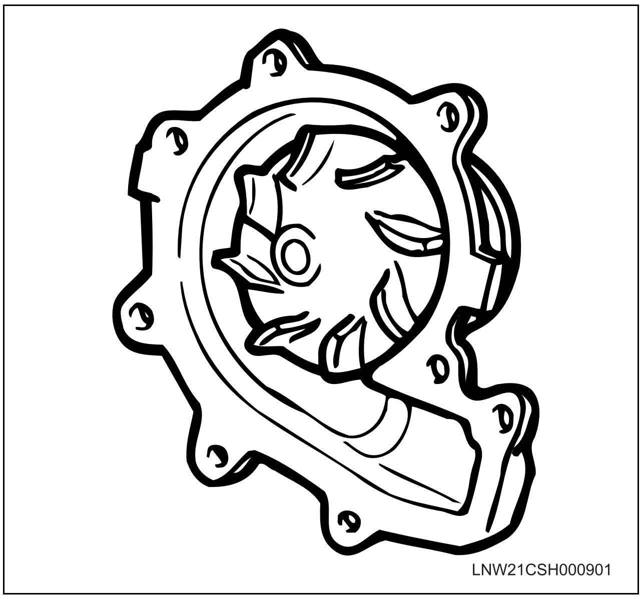
Legend

1. Water Pump
2. Water Pump Pulley
3. Setting Plate

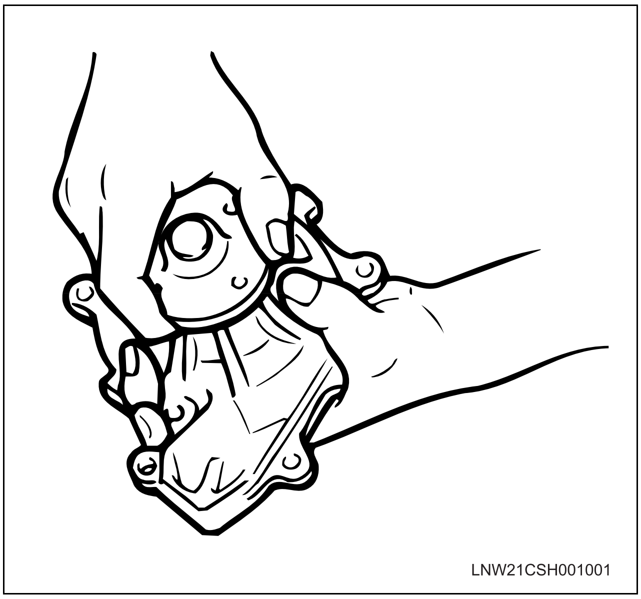
Inspection

1. External check
   - Check for cracks or damage in the pump body.
   - Check for cracks and corrosion in the impeller.
   - Check for water leakage from the seal unit.
   - If you find abnormalities, replace with the water pump assembly.



LNW21CSH000901

2. Bearing nut check
   - Rotate the fan center while pushing it along the radial direction. Confirm that there is no abnormal noise and no excessive play.
   - If you find abnormalities, replace with the water pump assembly.

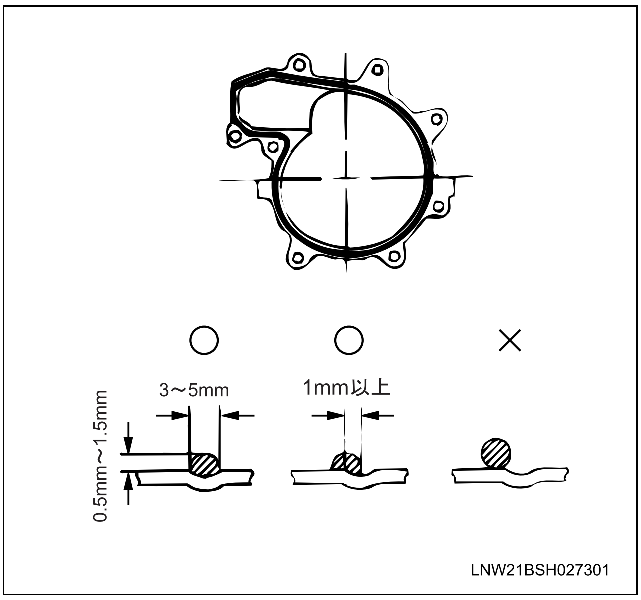


LNW21CSH001001

Installation

1. Mount the water pump assembly.
   - Coat the fluid gasket (ThreeBond 1207C or equivalent) to a bead diameter 3 to 5 mm in the groove of the mounting surface of the water pump.
   - Mount the water pump to match with the studs of the front cover.
   - Coat the fluid gasket and mount within 7 minutes.
   - Refer to the figure for the offset in position of the fluid gasket.

Tightening torque: 24 N·m (17 lb ft)



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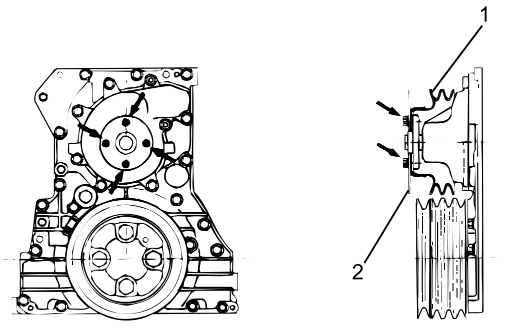
2. Temporarily fit the bolts until the water pump pulley and the setting plate are properly seated in the water pump assembly.



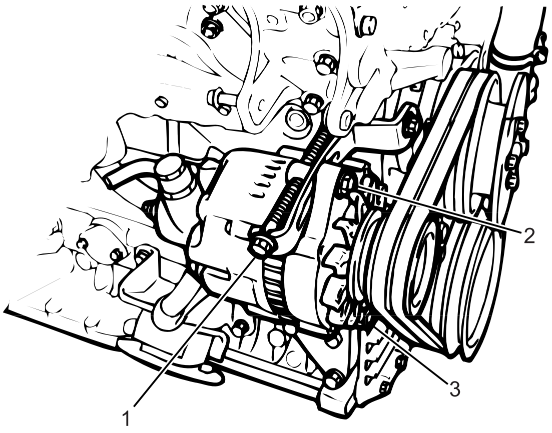
LNW21BSH026101

Legend
1. Fan Pulley
2. Setting Plate

---

3. Mount the fan belt, tighten the adjusting bolts of the generator, and adjust the tension.
    - Refer to the “drive belt”.
4. After fan belt adjustments, tighten the generator using the specified torque.

Tightening torque: 2 members = 24 N·m (17 lb ft)
3 members = 40 N·m (30 lb ft)



LNW21CSH000101

Legend
1. Adjusting Bolt
2. Lock Nut
3. Bolt

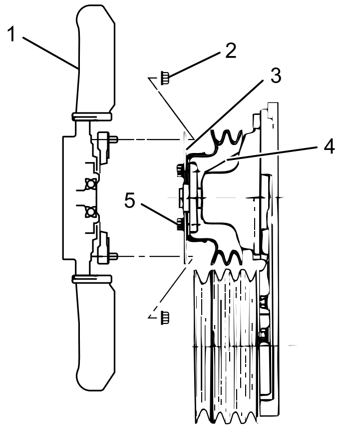
---

5. After the fan belt adjustments, tighten the temporarily fitted fan pulley and setting plate using the specified torque.

Tightening torque: 24 N·m (17 lb ft)

6. Tighten the fan assembly using the specified torque for mounting.

Tightening torque: 24 N·m (17 lb ft)



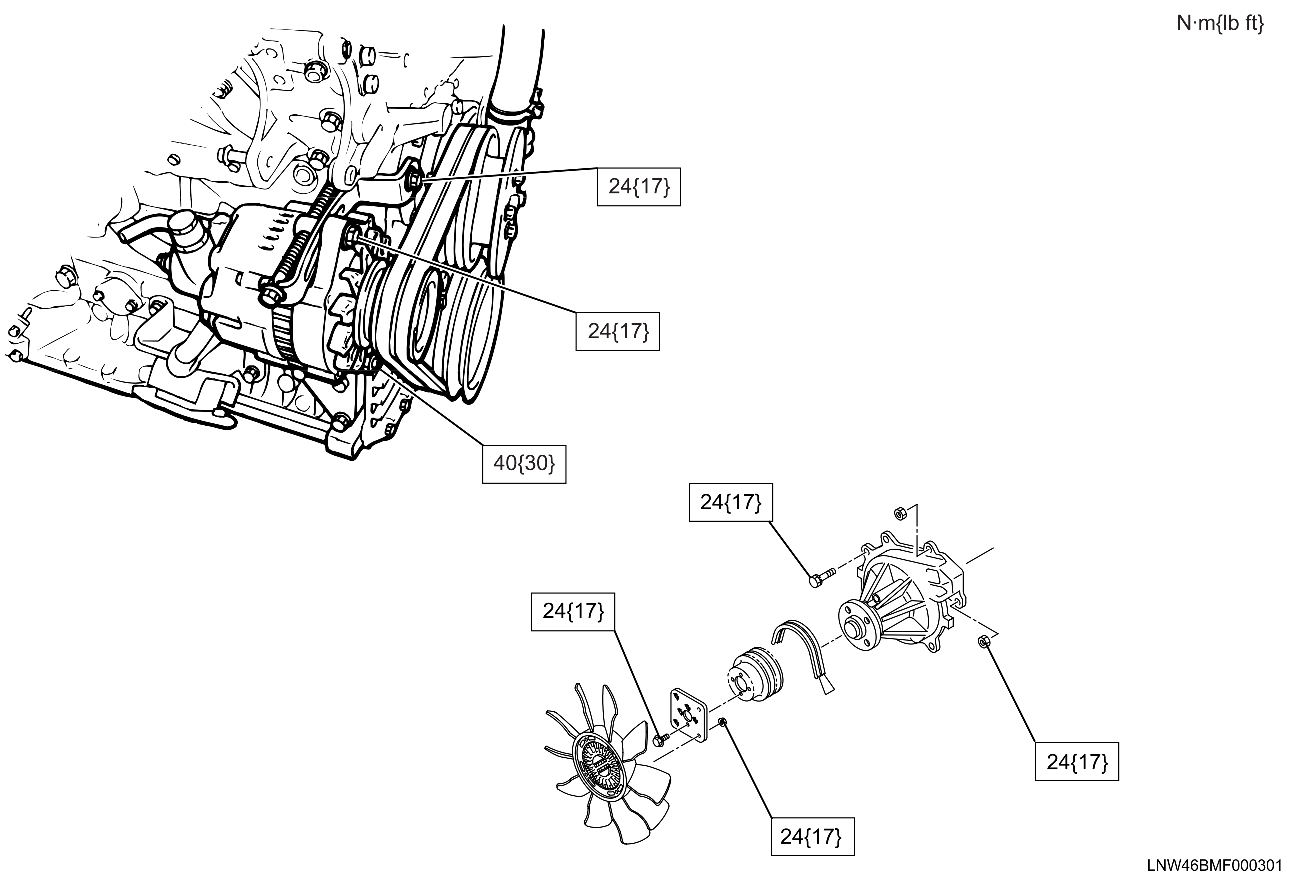
LNW21CSH001901

Legend
1. Fan Assembly
2. Nut
3. Setting Plate
4. Fan Pulley
5. Bolt

---

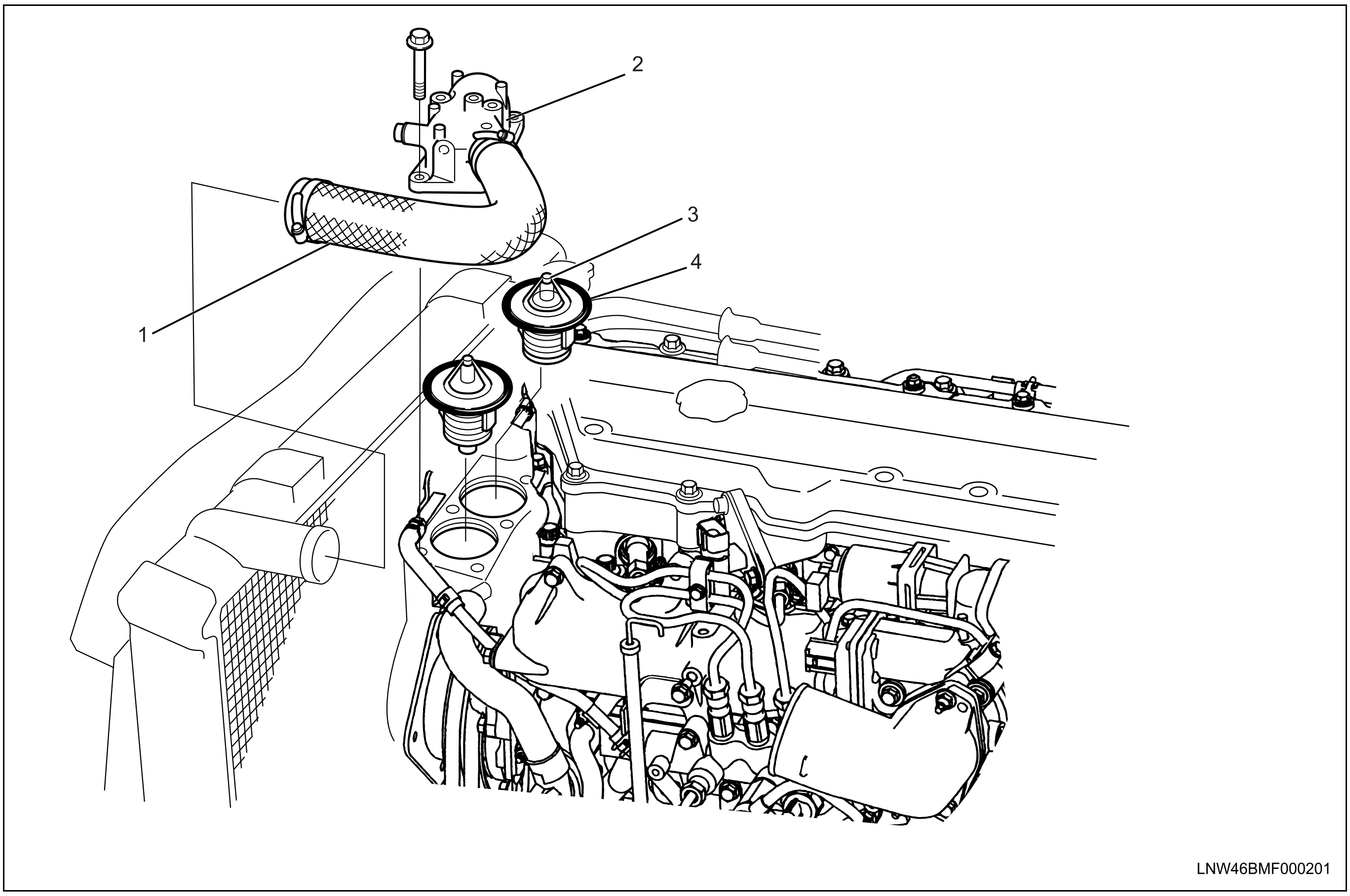
7. Mount the fan guide.
8. Mount the radiator lower hose.
9. Fill the cooling water.

Torque Specifications



Thermostat

Components



Legend

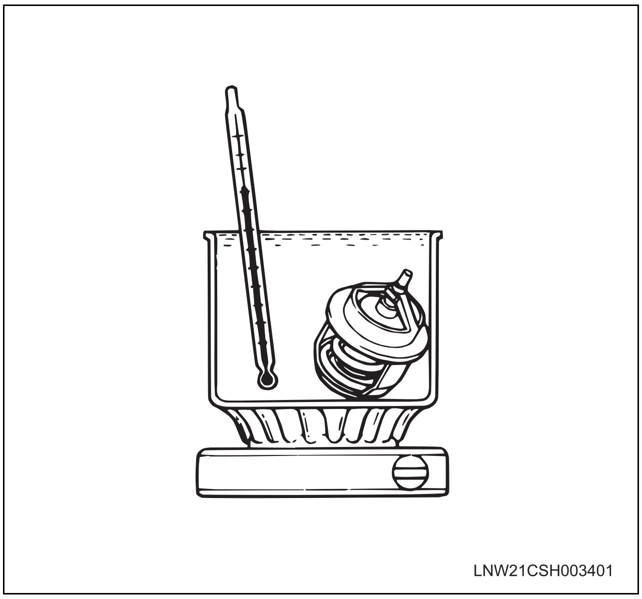
1. Radiator Upper Hose
2. Water Outlet Pipe
3. Thermostat
4. Gasket

Removal

1. Drain the cooling water. Prepare the container for discharging and use it for replenishment when mounting the thermostat. Set the discharge of cooling water such that the water does not flow out of the thermostat housing.
2. Remove the radiator upper hose from the radiator side.
3. Remove the water outlet pipe.
4. Remove the thermostat.
5. Remove the gasket from the thermostat.

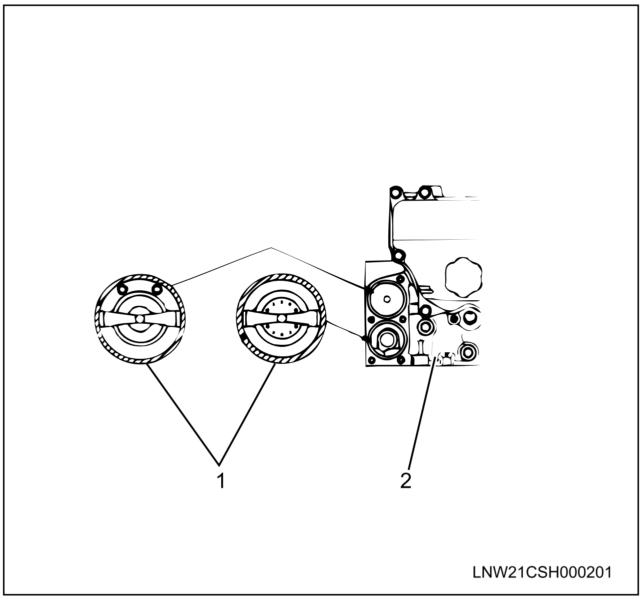
Inspection

- Place the thermostat in water and increase the temperature while stirring it sufficiently.
- Measure the temperature when the valve is just opened and when it is fully open.



Installation

1. Mount the gasket on the thermostat and mount it at the position shown in the figure.
   - Mount the thermostat at the position shown in the figure, as there are two types of thermostats with different shapes.
   - Fit the thermostat gasket ensuring that it does not come out of and on top of the external housing on the cylinder head side.



Legend

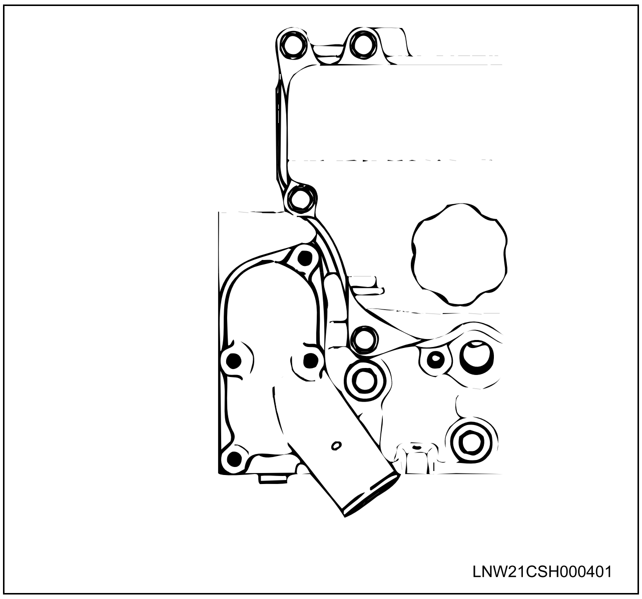
1. Thermostat
2. Cylinder Head

---

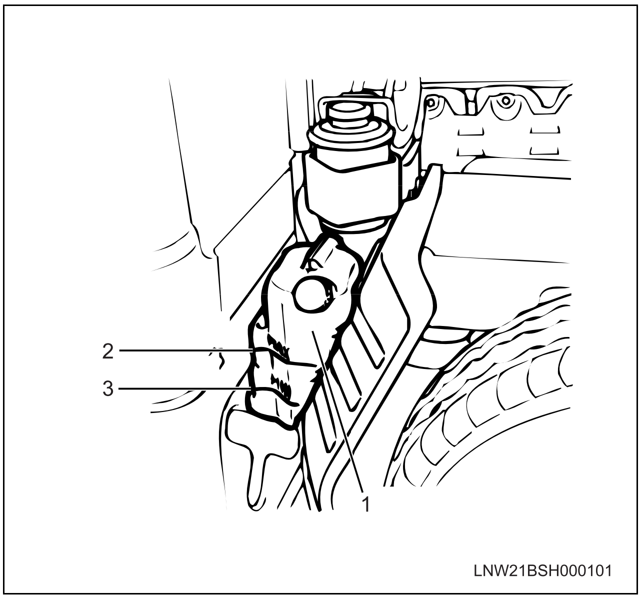
2. Mount the water outlet pipe.

Tightening torque: 24 N·m (17 lb ft)

3. Mount the radiator upper hose.



4. Replenish the cooling water stored during the discharge, and check the volume of the cooling water.

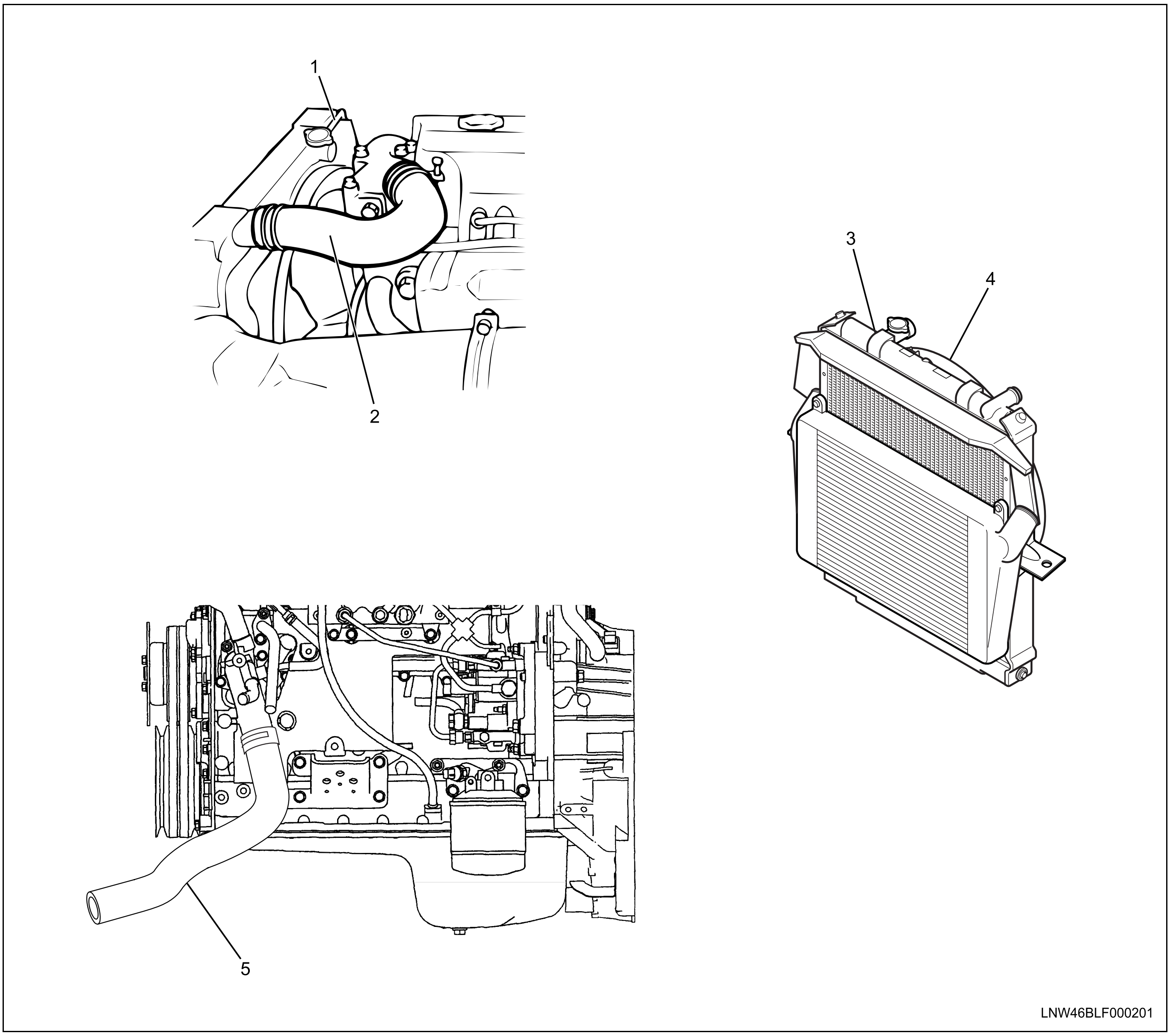


Legend

1. Reserve Tank
2. MAX Line (Upper Limit)
3. MIN Line (Lower Limit)

Radiator and Intercooler

Components



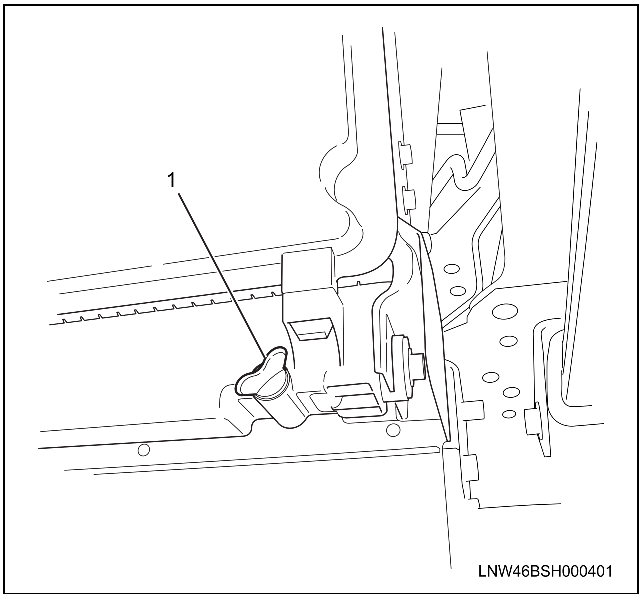
Legend

1. Coolant Reserve Tank Hose
2. Radiator Upper Hose
3. Radiator & Intercooler
4. Fan Guide
5. Radiator Lower Hose

Removal

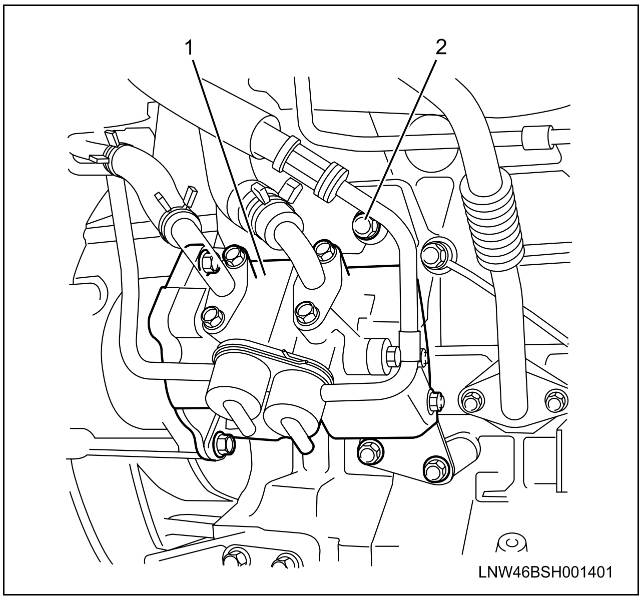
1. Loosen the water drain plug (to the right of the engine toward the rear) and radiator drain plug, and discharge the cooling water completely.

- After discharging the water, tighten the drain cock.



Legend

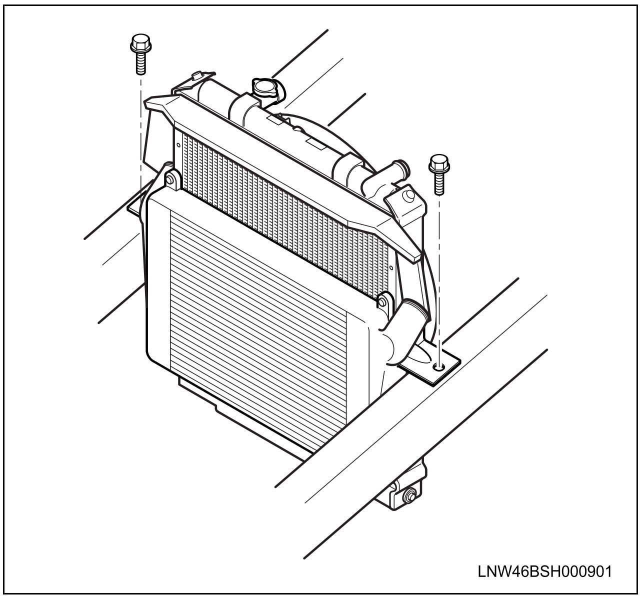
1. Radiator Drain Cock



Legend

1. Power Steering Pump
2. Drain Plug

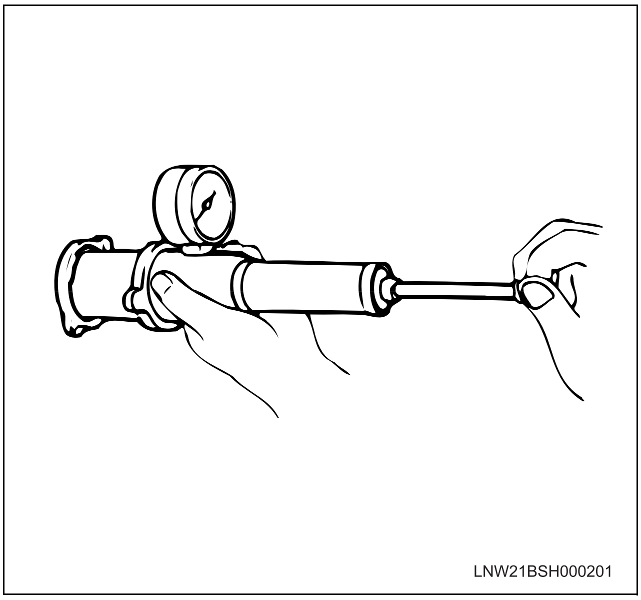
2. Remove the intake pipe from the intake manifold and inter-cooler (right side).
3. Remove the intake pipe from the turbo charger and inter-cooler (left side).
4. Remove the 2 transmission oil pipes on the underside of the radiator.
5. Remove the upper hose on the radiator side.
6. Remove the lower hose on the radiator side.
7. Remove the coolant reserve tank hose from the radiator side.
8. Take care to avoid damage to the radiator core from the fan blade, and remove the brackets on the right and left sides of the radiator. Simultaneously remove the radiator and inter-cooler.



Inspection

Radiator cap

1. Check the valve opening pressure using the radiator cap tester. If the valve opening pressure deviates from the standard value, replace the radiator cap.
   Valve opening pressure = 93 to 122 kPa (12.8 to 17.1 psi)



2. Check the state of the negative pressure valve situated at the center on the valve seat side of the cap. If the valve seat does not function smoothly due to rust or dirt, clean or replace the radiator cap.

Radiator core

1. If the radiator fin is deformed, the radiation effect deteriorates causing overheating. Therefore, modify the fin. Make sure that the root base of the fin is not damaged during modification.
   - Eliminate dust or other foreign matter.

Washing the radiator

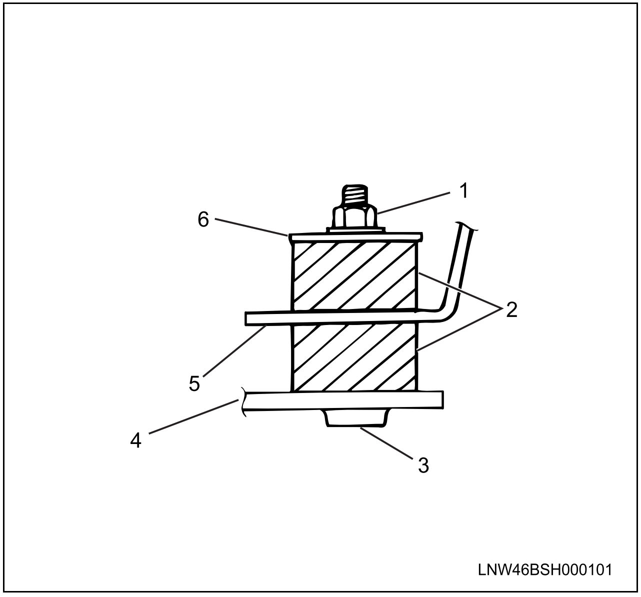
1. Wash the internal parts of the radiator and cooling water passage using water and detergent. Eliminate scale and rust completely.

Installation

1. Ensure that no damage occurs to the radiator core because of the fan blade. Mount the brackets on the left and right sides of the radiator on the frame according to the figure.

Tightening torque: 55 N·m (41 lb ft)

Rigid suspension vehicle



Legend

1. Flange Nut
2. Rubber
3. Stud Bolt
4. Frame
5. Bracket on The Radiator Side
6. Washer

2. Mount the reserve tank hose of the coolant on the radiator.
3. Mount the radiator lower hose.
4. Mount the radiator upper hose.
   - Fill the cooling water.
5. Install the 2 transmission oil pipes on the underside of the radiator.
6. Install the intake pipe from the turbocharger and inter-cooler (left side).
7. Install the intake pipe from the intake manifold and inter-cooler (right side).

Reference

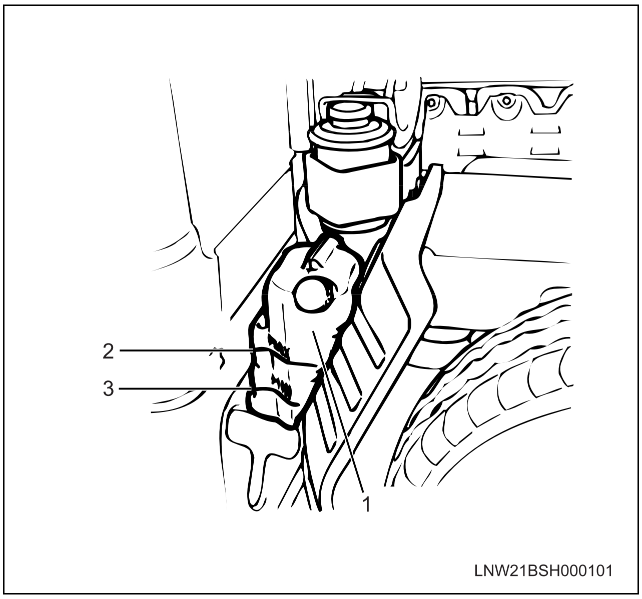
Cooling water injection procedure (in case of changing the cooling water completely)

- Confirm that the engine has cooled.
- Open the radiator cap and the reserve tank cap.
- Pour the cooling water up to the filler neck.
- Pour the cooling water up to the “MAX” line in the reserve tank.
- Close the radiator cap and the reserve tank cap and start the engine. Stop the engine after running for about 2 to 3 minutes at the idling rpm. Open the radiator cap again and replenish if the water level is low.

WARNING:
Do not loosen or remove the radiator cap when the temperature of the cooling water is high. Steam or boiling water will gush out and you may be burnt. To open the radiator cap, cover the cap with a thick cloth when the cooling water is cool, release the pressure by slowly turning the cap, and then remove the cap.

- After tightening the radiator cap, warm up the engine by running it at about 2000 rpm. Also, adjust the temperature of the heater to maximum temperature and circulate the cooling water even in the heater water conduit system.
- When the pointer of the thermometer crosses the median and the thermostat has activated, run at idling rpm for another 5 minutes, then stop the engine and leave it as-is.
- After the engine has cooled down sufficiently, check the water level in the filler neck part and replenish if necessary. If the level is extremely low, check for leaks in the cooling water conduit system and reserve tank hose.

- Pour the cooling water up to the “MAX” line in the reserve tank again.

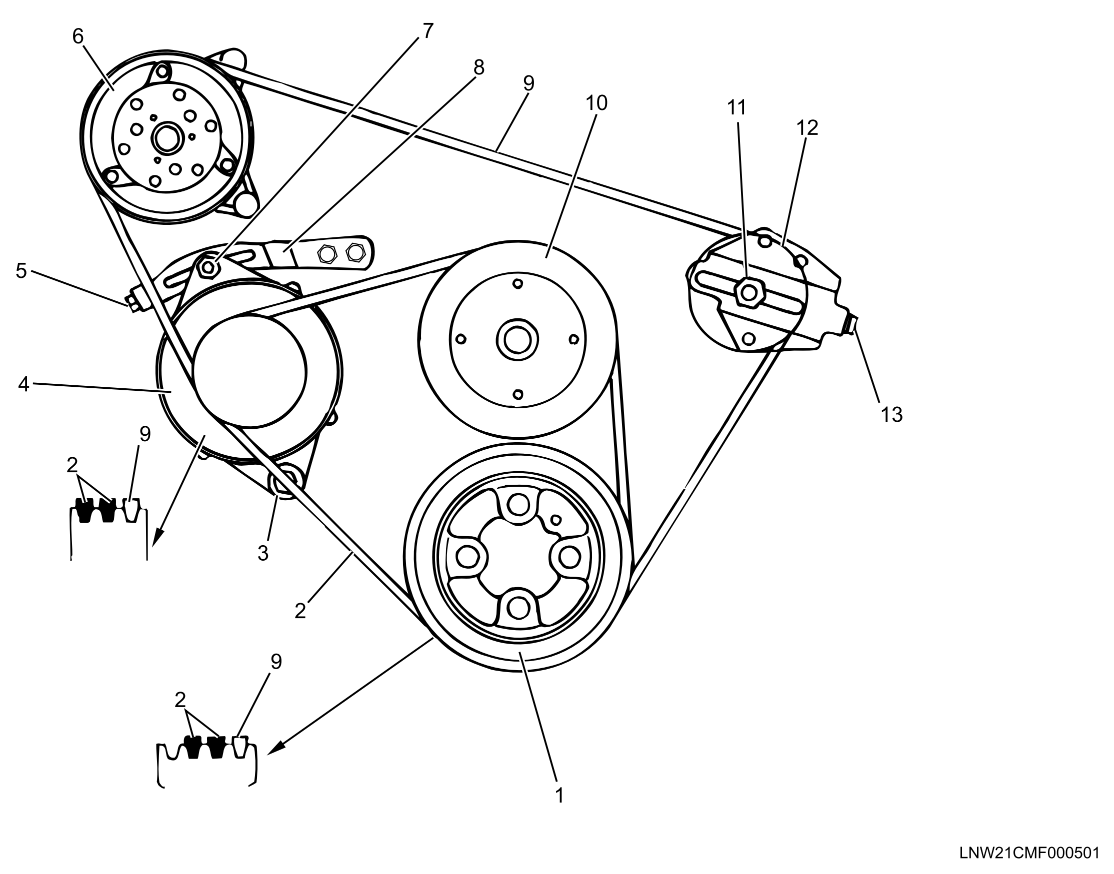


Legend

1. Reserve Tank
2. MAX Line (Upper Limit)
3. MIN Line (Lower Limit)

Drive Belt

Components



Legend

1. Crank Pulley
2. Generator Drive Belt
3. Bolt
4. Generator
5. Adjusting Bolt
6. A/C Compressor
7. Lock Nut
8. Adjusting Plate
9. A/C Compressor Drive Belt
10. Water Pump Pulley
11. Lock Nut
12. Tension Pulley
13. Adjusting Bolt

Inspection

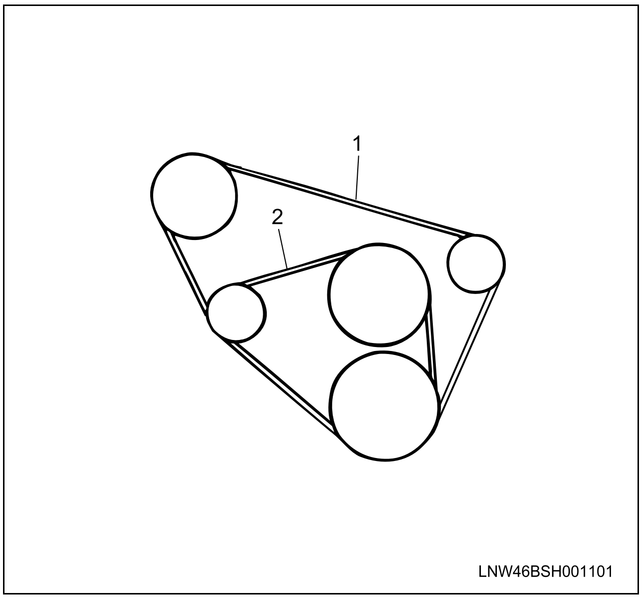
Check for the presence of wear or damage in the drive belt and renew the parts if necessary.
Check the tension of the belt and adjust if necessary.

Inspection procedure

Apply a pressure of 98 N (22 lb) at the center of the long span of each belt and check the deflection of the belt.

Deflection of A/C compressor drive belt
When the belt is new
16 to 20 mm (0.630 to 0.787 in)
When the belt is reused
18 to 22 mm (0.709 to 0.866 in)

Deflection of generator drive belt
When the belt is new
8 to 12 mm (0.315 to 0.472 in)
When the belt is reused
10 to 14 mm (0.394 to 0.551 in)



Legend

1. A/C Compressor Drive Belt
2. Generator Drive Belt

Drive Belts Adjustment

Adjustment procedure

Adjust simultaneously the generator drive belt and A/C compressor drive belt for adjustment of belt.

1. Loosen the tension pulley lock nut and tension pulley adjusting bolt of the tension pulley of the A/C compressor drive belt and bring the belt to free state.
2. Loosen the adjusting plate lock nuts and the mounting bolts of generator on the underside of the generator.
3. Rotate the adjusting bolts of generator and adjust the belt (remove and fit).
   - When replacing the belt, you must always replace both the belts.
4. After adjustments, tighten the adjusting plate lock nuts and the mounting bolts of generator on the underside of the generator using the specified torque.

Tightening torque: 6 members = 24 N·m (17 lb ft)
2 members = 40 N·m (30 lb ft)

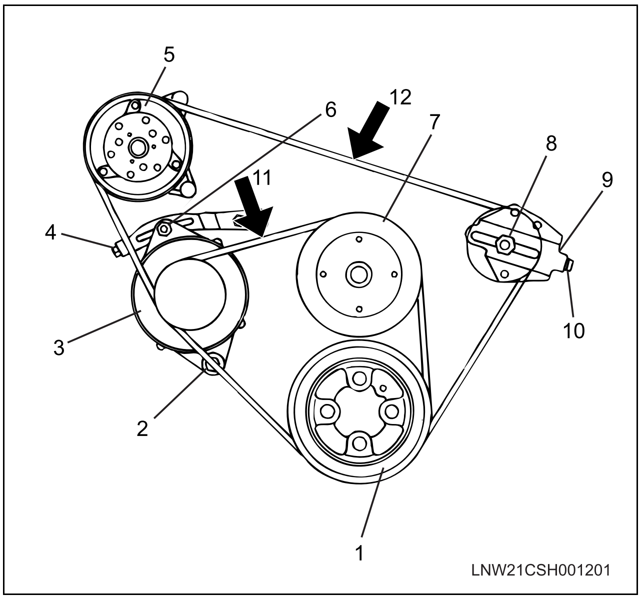
- Finally, adjust the tension of A/C compressor drive belt.

Caution:
You must adjust the tension of A/C compressor drive belt after adjusting generator belt.

a. Rotate the tension pulley adjusting bolt of the tension pulley and adjust the belt (remove and fit).

b. After adjustments, tighten the tension pulley lock nut using the specified torque.

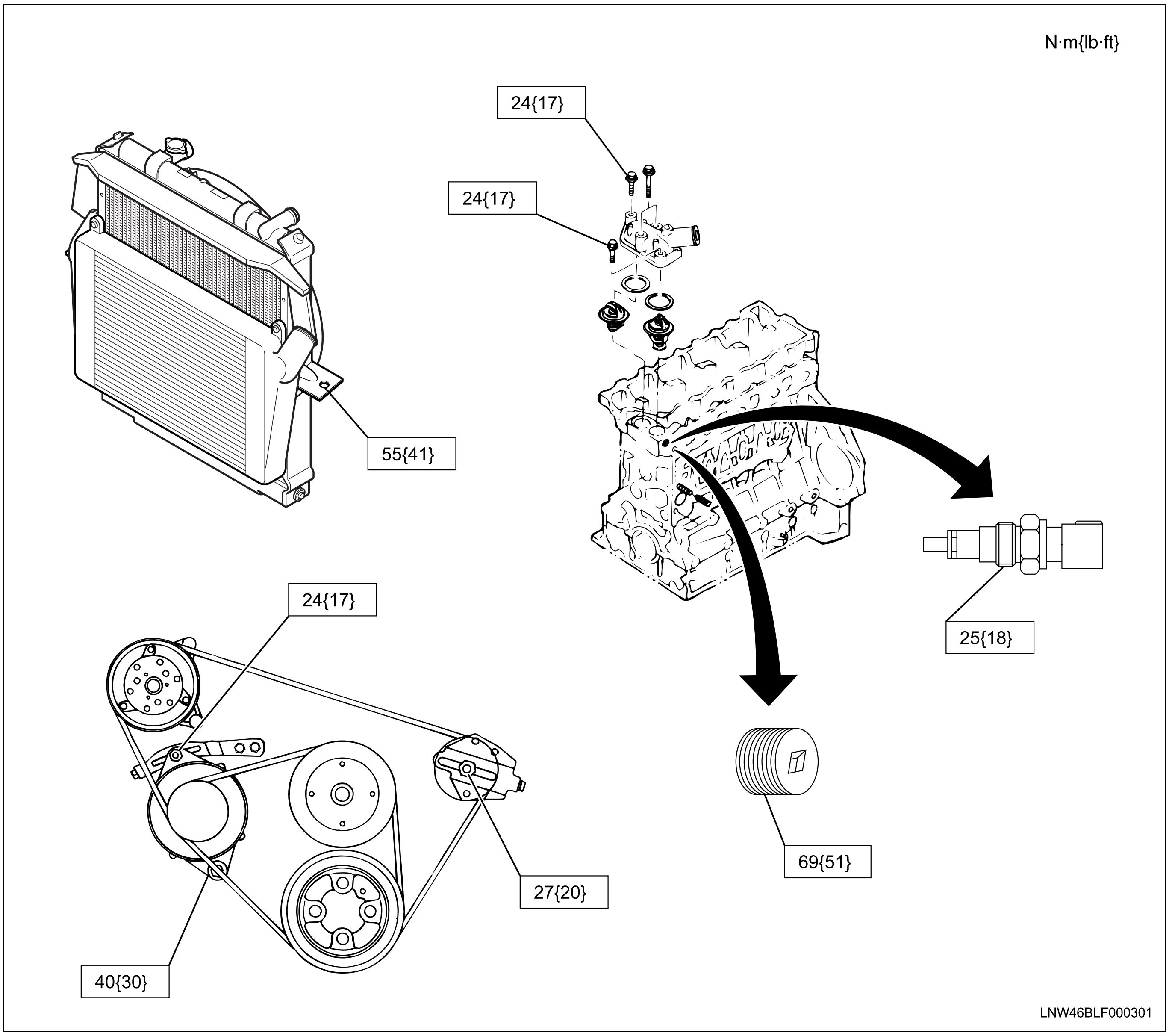
Tightening torque: 27 N·m (20 lb ft)



Legend

1. Crank Pulley
2. Bolt
3. Generator
4. Adjusting Bolt
5. A/C Compressor
6. Lock Nut
7. Water Pump Pulley
8. Lock Nut
9. Tension Pulley
10. Adjusting Bolt
11. Generator Drive Belt
12. A/C Compressor Drive Belt

Torque Specifications



ENGINE

Fuel System

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Fuel System

Service Precautions

Parts of the fuel system such as the internal part of the fuel injector, holes and clearances that form passages for fuel are finished to a very high degree of accuracy. They are therefore highly sensitive to foreign matter and the entry of foreign matter could cause damage to the fuel passage. Therefore, effective measures should be taken to prevent the entry of foreign matter.

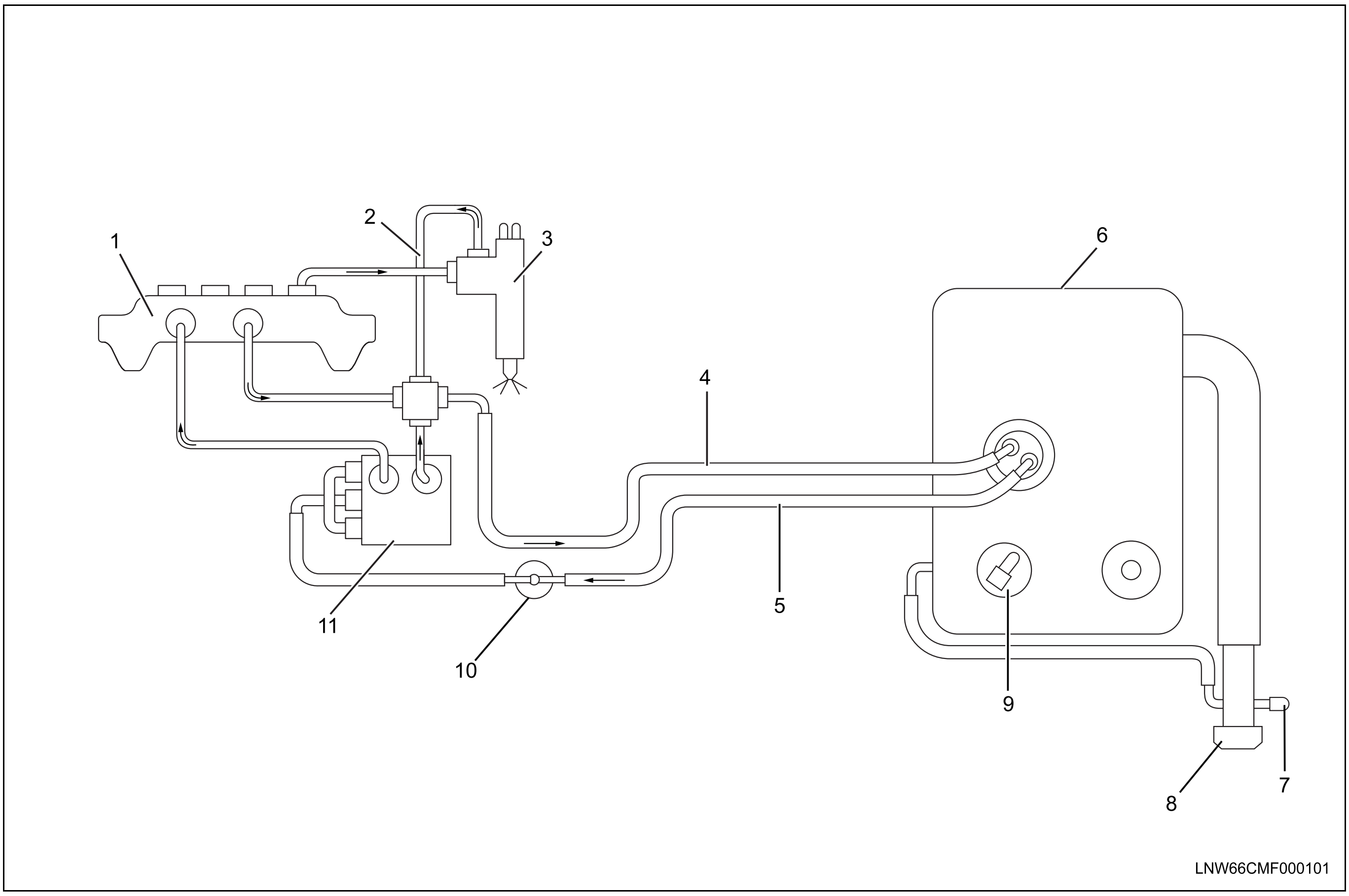
If water removal agent is used in the fuel then it will absorb moisture in the light oil and may cause rust. Therefore, do not use water removal agent in the fuel tank.

Work procedure

- The fuel opening must be quickly sealed when removing the fuel pipe, injection pipe, fuel injector, fuel supply pump, and fuel rail.
- The eyebolts and gasket must be stored in a clean parts box with a lid to prevent adhesion of foreign matter.
- Fuel leakage could cause fires. Therefore, after finishing the work, wipe off the fuel that has leaked out and make sure there is no fuel leakage after starting the engine.

Explanations on functions and operation

Fuel system diagram



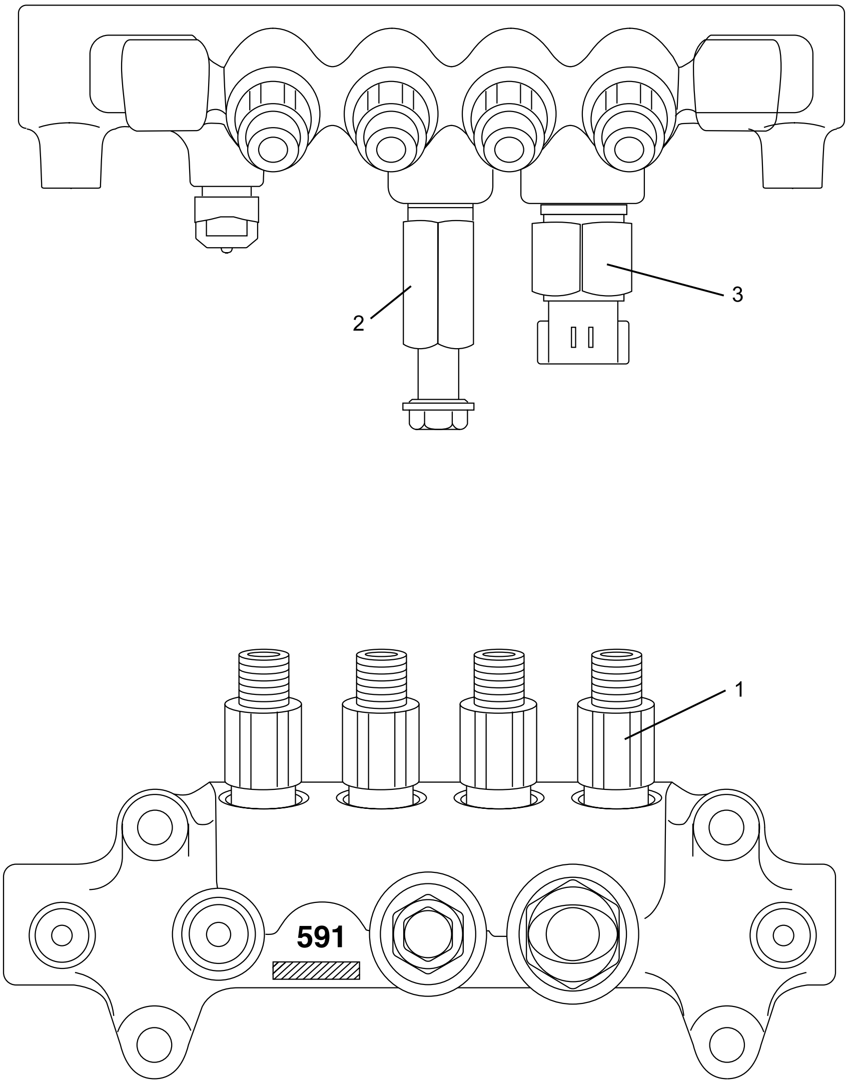
Legend

1. Fuel Rail
2. Leak Off Pipe
3. Fuel Injector
4. Fuel Return Pipe
5. Fuel Feed Pipe
6. Fuel Tank
7. Vent Valve
8. Fuel Filler Cap
9. Fuel Level Sensor
10. Fuel Filter With Sedimenter
11. Fuel Supply Pump

Caution:

Be careful foreign material does not into the fuel system, because the precise fuel system is used.

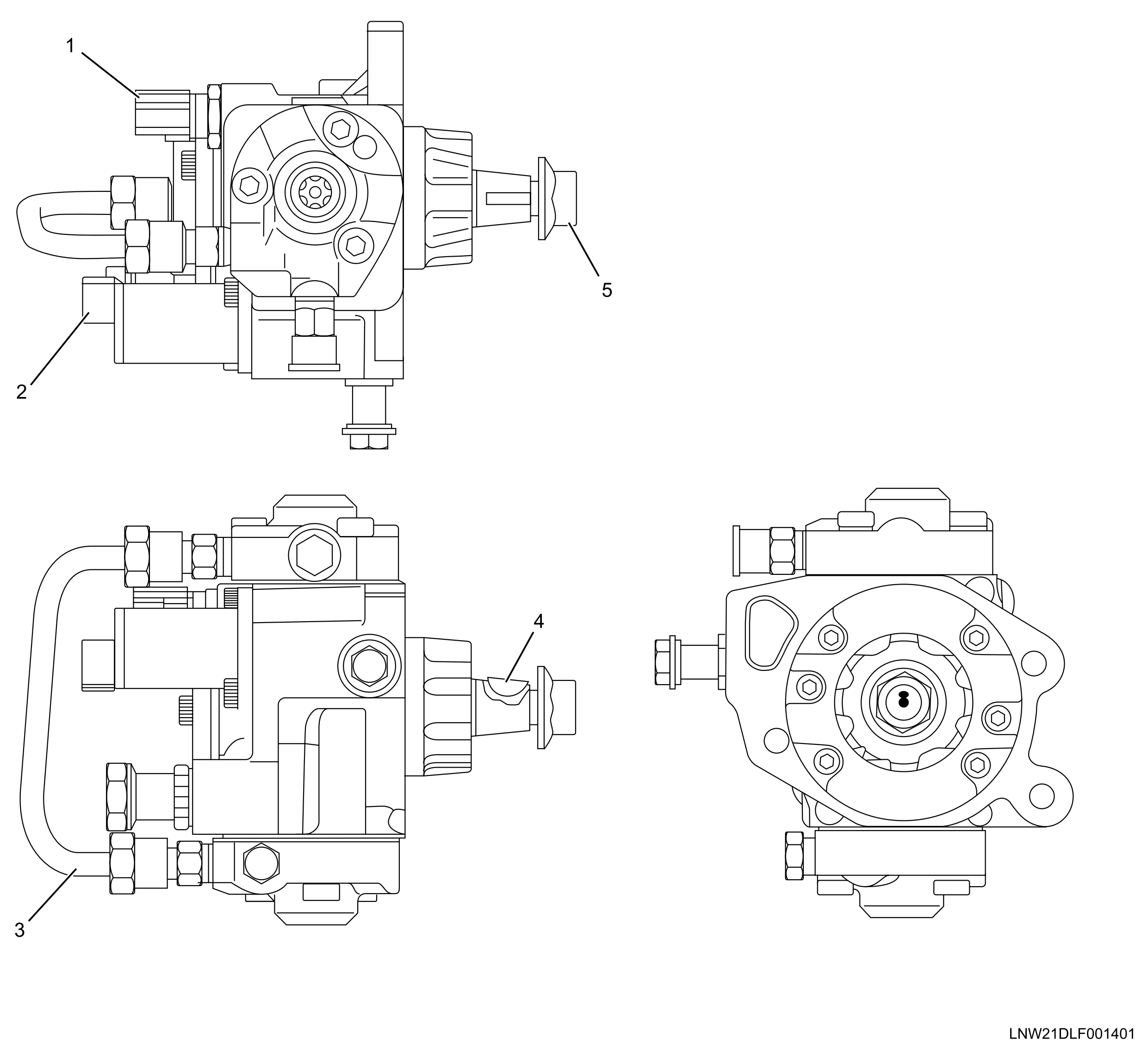
Fuel rail



Legend

1. Flow Damper
2. Pressure Limiter
3. Pressure Sensor

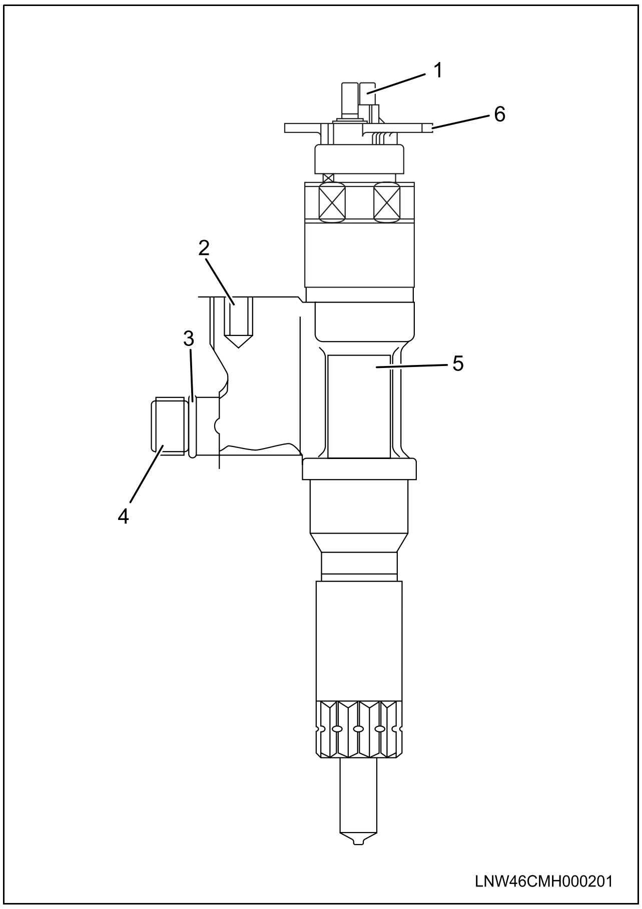
Fuel supply pump



Legend

1. Fuel Temperature Sensor
2. Fuel Rail Pressure Regulator
3. High Pressure Piping
4. Camshaft Key
5. Camshaft Nut

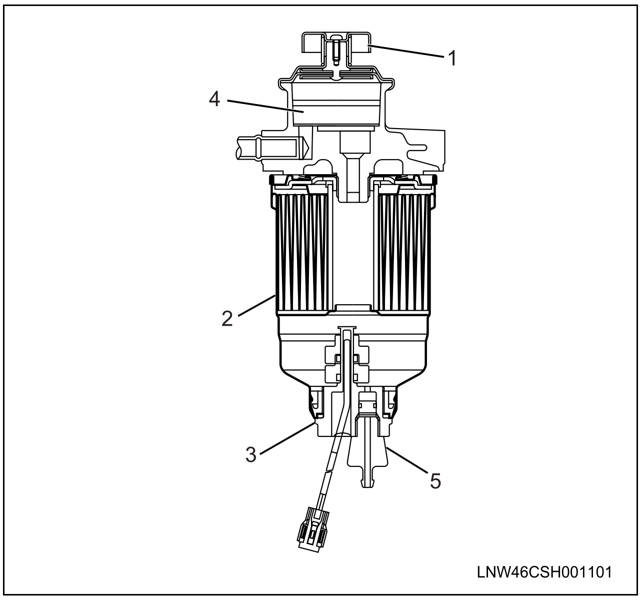
Fuel injector



Legend

1. Terminal Stud
2. Part for Mounting The Leak Off Pipe
3. O-Ring
4. Part for Mounting The Injection Pipe
5. Parts Number
6. ID Code Plate

Fuel filter

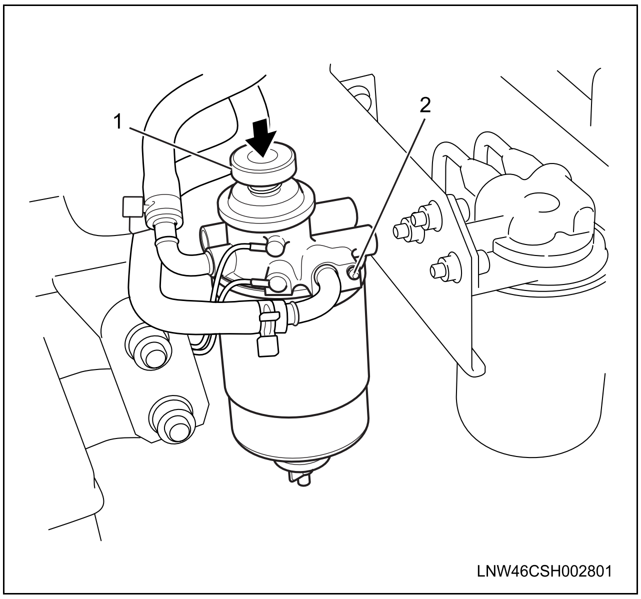


Legend

1. Priming Pump
2. Cartridge
3. Sensor
4. Heater
5. Drain Plug

Functional check

Air bleeding



Legend

1. Priming Pump
2. Air Bleed Plug

1. Before starting the engine
   a. Fit a tray below the fuel filter (below the air bleed plug).
   b. Loosen the plug adequately and operate the priming pump more than 20 times until the fuel near the plug overflows.

   c. Tighten the plug, and operate the priming pump more than 10 times until it is filled with fuel. After waiting for approximately a minute, loosen the plug and bleed out the air in the fuel filter. (This work must be repeated a minimum of three times until no more air comes out from the plug.)
   d. Tighten the plug firmly and wipe the fuel in the surrounding area. Operate the priming pump (10 to 15 times) till it is filled with fuel and then send fuel to the engine.
2. After starting the engine
   a. Start the engine by rotating the starter without depressing the accelerator pedal.
   b. After starting, maintain the idling rotation for 5 seconds.
   c. Slowly rotate the idling control knob clockwise and maintain it for 3 minutes.
   d. Fully depress the accelerator pedal and increase the rotations to maximum. (Repeat this operation several times)
   e. Rotate the idling knob counterclockwise and return to idling mode.

Caution:
If the air bleeding work is insufficient then it could lead to faults in the engine. Therefore, the procedures after starting the engine should always be implemented.

Water drain

A warning lamp will light up if water above the specified volume collects in the sedimenter. In such cases, drain out the water by performing the following operations:

- Set a container at the tip of the plastic hose.
- Loosen the drain plug.
- Operate the priming pump several times to discharge the water.
- Tighten the drain plug after discharging the water.
- Operate the priming pump several times and check for fuel leakage.
- Check that the warning lamp in the meter is off.

Fuel system vacuum check

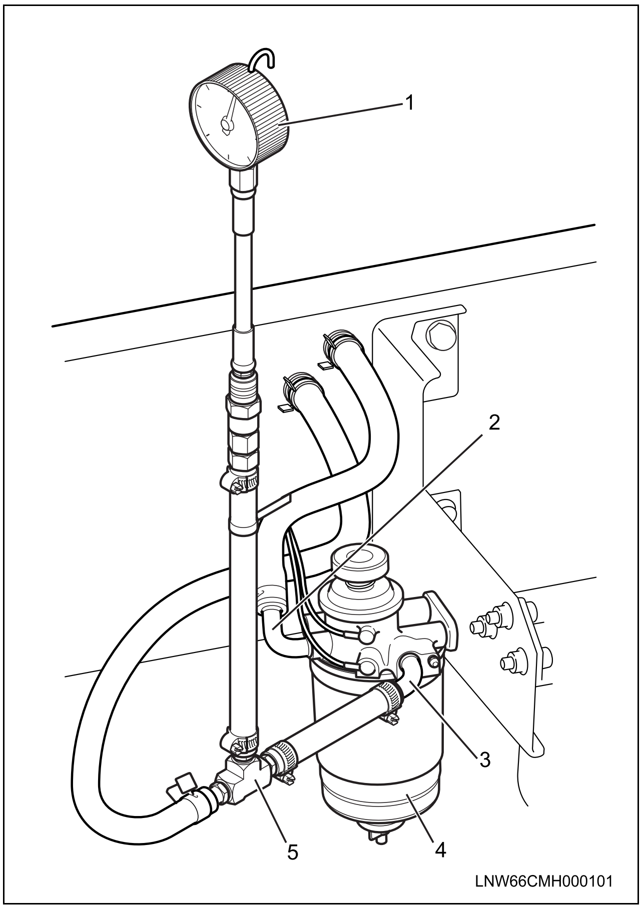
Use this procedure to measure the vacuum (negative pressure) discharge side the fuel system.

Important:
The fuel pressure/vacuum gauge assembly (gauge (1)) and the fuel pressure/vacuum gauge adapter (adapter (5)) must be cleaned before connect to the fuel line. Otherwise, foreign material adherent to the tools may damage the fuel supply pump.

1. Disconnect the fuel hose from the fuel filter housing. (fuel supply pump side).
2. Install the adapter.

   Special tool
   Fuel pressure/vacuum gauge adapter:
   EN-47667
3. Connect the gauge (1) with hose to the adapter (5).

   Special tool
   Fuel pressure/vacuum gauge assembly:
   J-44638



Legend
1. Fuel Pressure/Vacuum Gauge Assembly
2. Fuel Pipe (Intake Side)
3. Fuel Pipe (Discharge Side)
4. Fuel Filter
5. Fuel Pressure/Vacuum Gauge Adapter

---

4. Loosen the air bleeding plug on the supply pump.
5. Use your hand to operate the fuel filter priming pump. Operate the pump until all the air has been bled from the system.
6. Start the engine and allow it to idle.
7. Note the gauge (1) reading. If the reading is normal, go to Step 8. If the fuel vacuum is greater than the specified value, there is a problem in the fuel system. Perform the procedures outlined below.

Standard fuel vacuum	Less than 5 in Hg

- Replace the cartridge fuel filter element.

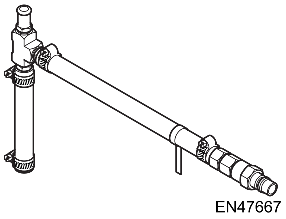
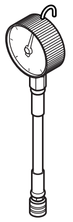
- Check the fuel delivery pipe. If it is clogged, it must be replaced.
- Remove the fuel pipe at the fuel filter inlet. Use high-pressure air forced through the fuel pipe to clean the fuel system.

Caution:

- Remove the fuel filler cap before applying high-pressure air.
- Do not perform this procedure if the fuel tank is nearly full (fuel approaching or flowing into the fuel filler neck). The forced air will spray fuel from the fuel filler neck.

8. Remove the gauge (1) and hose from the adapter (5).
9. Remove the adapter (5).

Special tool

Illustration	Tool Number/ Description
 EN47667	EN-47667 Fuel Pressure/Vacuum Gauge Adapter
 J44638	J-44638 Fuel Pressure/Vacuum Gauge Assembly

10. Connect the fuel hose.
11. Use your hand to operate the fuel filter priming pump. Operate the pump until all the air has been bled from the system.
12. Start the engine and allow it to idle.
13. Inspect the fuel system for fuel leakage.

A list of defective phenomena

- Problems with starting
- Hunting during idling
- Insufficient horsepower
- Maximum engine speed is too low
- Engine does not stop
- Exhaust gas is blue or black.

Trouble Shooting

Problems with starting

Condition	Possible Cause	Correction
Problems with starting	Fuel tank is empty	Fill the tank.
	Air has entered the fuel system.	Bleed the air.
	Fuel line is clogged or damaged. Connection to the fuel line is loose.	Repair or replace the fuel line. Re-tighten the connection.
	Fuel filter element is clogged.	Replace the cartridge.
	Fault in the feed pump	Replace the fuel supply pump.
	Regulating valve is open.	Replace
	Sticking of the fuel injector nozzle	Replace the fuel injector.
	Defective engine control system	Diagnose the engine control system.

Hunting during idling

Condition	Possible Cause	Correction
Hunting during idling	Air has entered the fuel system.	Bleed air from the fuel system.
	Leakage or clogging of the fuel system	Repair or replace the fuel system.
	Drops of water have entered the fuel system.	Replace the fuel.
	Fuel filter element is clogged.	Replace the fuel filter element (cartridge).
	Sticking of the fuel injector nozzle	Replace the fuel injector.
	Defective engine control system	Diagnose the engine control system.

Insufficient horsepower

Condition	Possible Cause	Correction
Insufficient horsepower	Air has entered the fuel system.	Bleed air from the fuel system.
	Leakage or clogging of the fuel system	Repair or replace the fuel system.
	Water mixes in the fuel system	Replace the fuel.
	Fuel filter element is clogged.	Replace the element or the cartridge.
	Sticking of the fuel injector nozzle	Replace the fuel injector.
	Defective engine control system	Diagnose the engine control system.

Maximum engine speed is too low

Condition	Possible Cause	Correction
Maximum engine speed is too low	Fuel line is clogged or damaged.	Repair or replace the fuel line.
	Defective engine control system	Diagnose the engine control system.

Engine does not stop

Condition	Possible Cause	Correction
Engine does not stop	Defective engine control system	Diagnose the engine control system.

Exhaust gas is blue or black

Condition	Possible Cause	Correction
Exhaust gas is blue or black.	Reduction in injection-valve opening pressure or defective atomizing status	Replace the fuel injector.
	Engine control system malfunction	System diagnosis.

Fuel System Check

Description

The common rail fuel system is comprised of two fuel Pressure sections: a suction side between the fuel tank and the fuel supply pump and a high-pressure side between the fuel supply pump and the fuel injectors. Fuel is drawn from the fuel tank via a feed pump and then pumped into the fuel rail by two plungers, all of which are internal to the fuel supply pump. This high pressure is regulated by the engine control module (ECM) using the fuel rail pressure (FRP) regulator dependant upon values from the FRP sensor attached to the fuel rail. In case of fuel rail overpressure, a pressure limiter valve threaded into the fuel rail will open to release overpressure and return fuel back to the fuel tank.

The Fuel System Check diagnostic table directs the service technician to the appropriate fuel system diagnosis. The diagnostic table assumes the following conditions are met:

- The batteries are completely charged.
- The engine cranking speed is normal.
- There is adequate fuel in the fuel tank.
- There is no air in the fuel line.

Diagnostic Aids

- The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight or if there is a crack in one of the fuel hoses. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load.
- If the fuel tank is empty or near empty, air might be allowed to go into the fuel system. With air in the fuel system, smooth flow of fuel into the supply pump is interrupted. Perform bleeding of fuel system after refilling.

Notice:

The Actual Fuel Rail Pressure on scan tool will only update with the engine running or one time after the key is cycled when the ignition has been turned OFF for longer than 10 seconds.

Step	Action	Value(s)	Yes	No
1	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Diagnostic Trouble Code (DTC) Information of the engine control module with a scan tool. Are any DTC(s) set?	—	Refer to Applicable Diagnosis Trouble Code (DTC) in Engine Control Section	Go to Step 2

Step	Action	Value(s)	Yes	No
2	1. Inspect the high pressure side between the fuel supply pump and the fuel injectors for fuel leakage. The following components may contain an external leak: • Fuel supply pump • Fuel rail • Pressure limiter valve • Flow damper valve • Fuel rail pressure (FRP) sensor • Fuel pipe between the fuel supply pump and fuel rail • Fuel pipe between the fuel rail and fuel injectors • Each fuel pipe sleeve nuts **Notice:** Fuel may leak under the cylinder head cover from the inlet high pressure line. In such case, the engine oil level will rise. Inspect for fuel in the engine oil. 2. Repair any fuel system leaks as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 3
3	1. Turn OFF the ignition. 2. Check the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. **Notice:** The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load. 3. Pump the priming pump on the fuel filter until it becomes firm .If there is a leak on the suction side of the fuel system between the priming pump and the fuel supply pump, the priming pump will not build up sufficient firmness and fuel leakage may occur. 4. Repair any fuel system leaks as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 4

Step	Action	Value(s)	Yes	No
4	1. Make sure the fuel tank(s) have adequate fuel and the fuel quality is good (take a sample). 2. Bleed the air from the fuel system as necessary. Refer to Fuel System Air Bleeding in this section. 3. Start the engine and let idle. If the engine does not start, continue to crank. 4. Observe the Actual Fuel Rail Pressure and Desired Fuel Rail Pressure parameter with a scan tool. Is the difference between the Actual Fuel Rail Pressure and Desired Fuel Rail Pressure less than the specified value?	725psi (5MPa)	System OK	Go to Step 5
5	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (H-125) from the cylinder head cover case. 3. Remove the rubber fuel hose from the fuel filter housing (fuel supply pump side). Use a pan to catch the fuel leakage from the removed fuel line. **Important:** The fuel vacuum pump/pressure gauge connector and the adapter hose must be cleaned before connecting to the fuel line. Otherwise, foreign material internal to the tools line may damage the fuel supply pump. 4. Connect the suction side fuel pressure adapter EN-47667 with fuel vacuum/ pressure gauge assembly J-44638 in series with the filter housing and the disconnected fuel hose. Ensure the service tool and fuel line connections are tight. 5. Bleed the fuel system by priming the priming pump until it becomes firm, then crank over the engine for a maximum of 5 seconds. Perform procedure three times. 6. Fully clamp off a fuel hose as close to the fuel tank as possible (this will draw vacuum on the fuel system). You can also disconnect a fuel line and plug it. 7. Crank over the engine (for no longer than 15 seconds) while monitoring the fuel pressure/vacuum gauge. **Notice:** Release the clamp or open the plug when the gauge is likely to be more than 8 inHg during the test. Can a vacuum of at least the specified amount be pulled on the fuel system?	8 inHg	Go to Step 8	Go to Step 6

Step	Action	Value(s)	Yes	No
6	1. Inspect the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. 2. Draw fuel from the fuel tank at the fuel line going to the fuel pickup tube to verify a clean stream of fuel comes out (use the hand-held vacuum pump J-23738-A with a clear hose or equivalent) This will ensure the fuel pickup tube is not cracked drawing air into the fuel line. 3. Repair as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 7
7	1. Replace the fuel filter cartridge. Refer to Fuel Filter Cartridge Replacement in this section. 2. Retest the fuel system vacuum test described in Step 5. Can a vacuum of at least the specified amount be pulled on the fuel system?	8 inHg	Go to Step 18	Go to Step 17
8	1. Unclamp or unplug the fuel line from Step 5 and reconnect the fuel line. 2. Prime the priming pump until firmness is felt. 3. Crank over the engine for 5 seconds. 4. Repeat steps 2 and 3 three times to bleed the fuel system. 5. Crank over the engine (for no longer than 15 seconds at a time) while monitoring the fuel pressure/vacuum gauge. Does the vacuum/pressure gauge ever indicate a larger than the specified value?	5 inHg	Go to Step 9	Go to Step 10
9	1. Inspect the fuel lines between the fuel supply pump and fuel tank for being crushed or kinked. 2. Inspect the fuel cap for a plugged condition. 3. Inspect inside the fuel tank (if possible) for any foreign material that may be getting drawn into the fuel line pickup causing a blocked condition. 4. Repair the condition as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 14

Step	Action	Value(s)	Yes	No
10	1. Turn OFF the ignition. 2. Make sure the in-line harness connector (H-125) is disconnected from the cylinder head cover case. 3. Remove the eyebolt from the cylinder head that connects to the leak-off pipe. 4. Connect the fuel adapter J-45873-103 with hose assembly to the cylinder head. Install the hose into a graduated cylinder from the J-45873-100 kit. 5. Remove the eyebolt from the pressure limiter valve that connects to the leak-off pipe. 6. Connect the fuel adapter J-45873-105 with hose assembly to the pressure limiter valve. 7. Crank over the engine for 10 seconds. Make sure the batteries are fully charged and the engine is cranking at normal speed for each test. **Notice:** Perform this test three times and take the average of the fuel return amount coming from the cylinder head. Is fuel leaking from the pressure limiter valve?	—	Go to Step 15	Go to Step 11
11	Is the average fuel return coming from the cylinder head less than the specified value?	15ml	Go to Step 12	Go to Step 13
12	1. Remove each glow plug from the cylinder head. 2. Inspect the tip of the plugs for wet fuel. Did you find wet fuel on any glow plug?	—	Go to Step 16	Go to Step 17
13	1. Remove the cylinder head cover and injector harness in order to connect the fuel adapter J-45873-101 with hose assembly to each injector leak-off port. Refer to Fuel Injector Replacement in this section. 2. Crank over the engine for 10 seconds. **Important:** Replacement injector must be programmed. 3. Replace the injector(s) that return more fuel than the specified value. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. 4. Retest after replacement of the fuel injector(s). Did you complete the replacement?	3ml	Go to Step 18	—

Step	Action	Value(s)	Yes	No
14	Replace the fuel filter cartridge. Refer to Fuel Filter Cartridge Replacement in this section. Did you complete the replacement?	—	Go to Step 18	—
15	Replace the pressure limiter valve. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 18	—
16	**Important:** Replacement injector must be programmed. Replace the appropriate injector(s) that was leaking fuel found at Step. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 18	—
17	**Important:** The fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM. Replace the fuel supply pump. Refer to Fuel Supply Pump Replacement/Fuel Supply Pump Relearn Procedure in this section. Did you complete the replacement?	—	Go to Step 18	—
18	1. Reconnect all previously disconnected harness connector(s) or components. 2. Turn OFF the ignition for 30 seconds. 3. Bleed the air from the fuel system. Refer to Fuel System Air Bleeding in this section. 4. Start the engine and let idle. 5. Observe the Actual Fuel Rail Pressure and Desired Fuel Rail Pressure parameter with a scan tool. Is the difference between the Actual Fuel Rail Pressure and Desired Fuel Rail Pressure less than the specified value?	725psi (5MPa)	System OK	Go to Step 1

Special tool

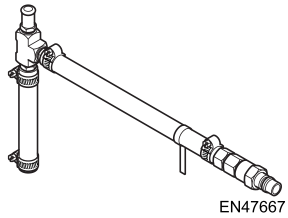
Illustration	Tool Number/ Description
	EN-47667 Fuel Pressure/Vacuum Gauge Adapter

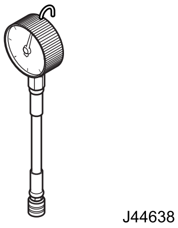
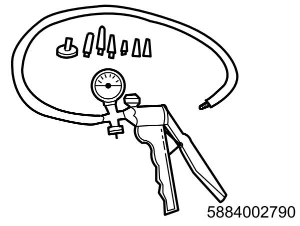
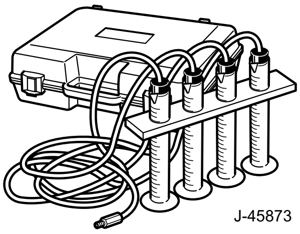
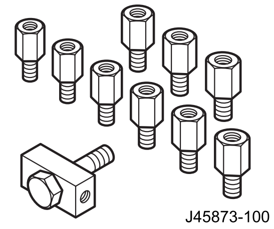
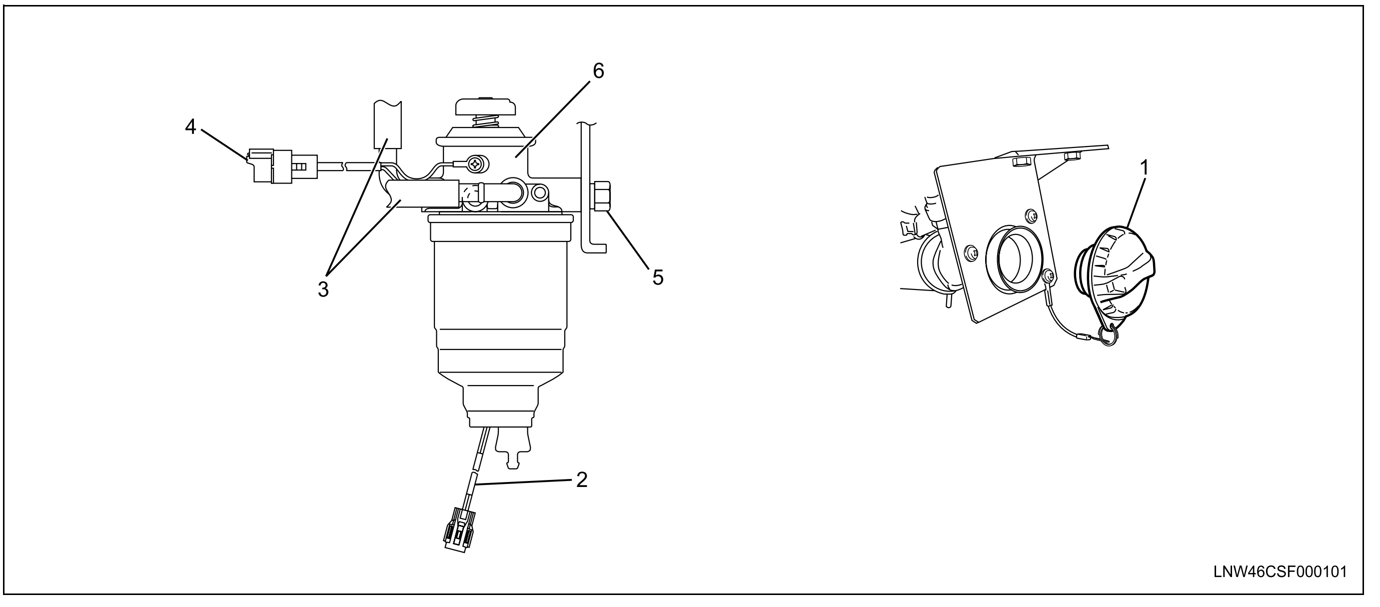
Illustration	Tool Number/ Description
	J-44638 Fuel Pressure/Vacuum Gauge Assembly

Illustration	Tool Number/ Description
 	J-23738-A Vacuum Pump
 	J-45873 Fuel Test Adapter Kit
 	J45873-100 Fuel Test Adapters

Fuel Filter Assembly

Components



Legend

1. Filler Cap
2. Fuel Sedimenter Connector
3. Fuel Hose
4. Fuel Heater Connector
5. Bolt
6. Fuel Filter Assembly

Removal

1. Remove the filler cap.
2. Remove the fuel sedimenter and fuel heater connector.
3. Remove the feed hose and the return hose from the fuel filter and plug it so that the fuel does not flow out.
4. Remove the bolts for mounting the fuel filter.
5. Remove the fuel filter assembly.

Installation

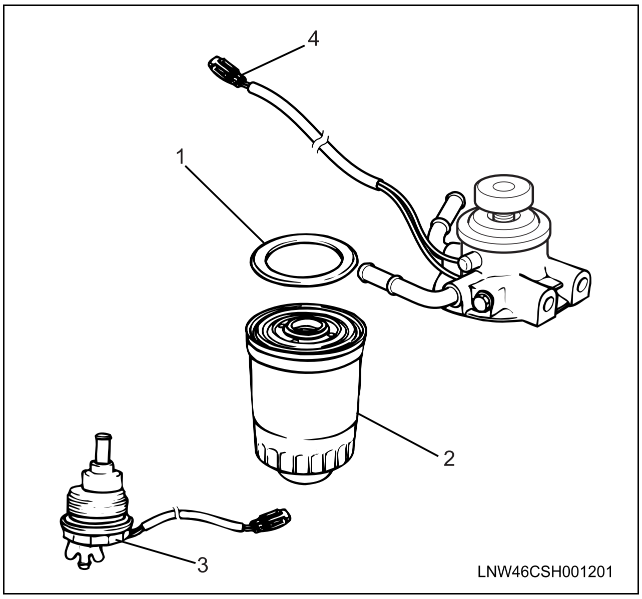
1. Install the fuel filter assembly.
2. Install the bolts for mounting the fuel filter.
3. Install the feed hose and the return hose.
4. Install the fuel sedimenter and fuel heater connector.
5. Install the filler cap.
6. Bleed out the air.
   - Refer to “Fuel System”.

Fuel Filter Cartridge

Removal

1. Remove the cartridge using the filter wrench.

   Special tool
   Filter wrench: J-22700
2. Remove the sedimenter sensor.



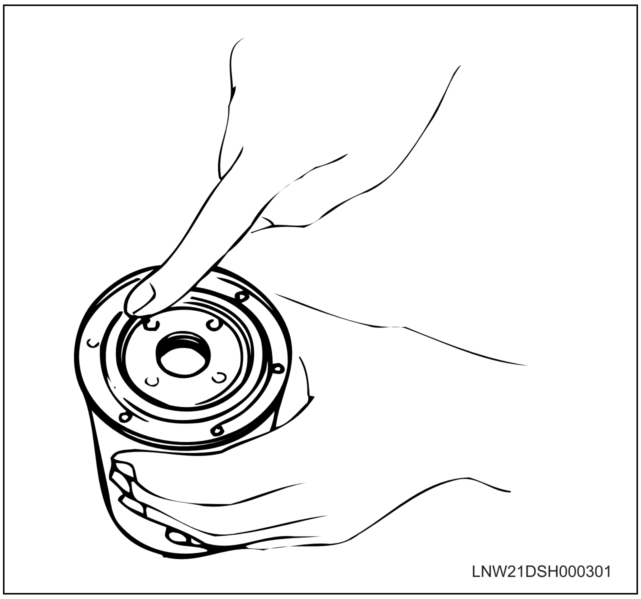
Legend

1. O-Ring
2. Cartridge
3. Sedimenter Sensor
4. Fuel Heater Connector

Installation

1. Assemble the sedimenter sensor in the new cartridge.
2. Clean the cartridge mounting surface in the filter body so that the cartridge can be seated securely.
3. Coat a thin layer of engine oil on the O-ring in the new cartridge.
4. To simplify air bleed, fill light oil on the new cartridge.
5. Tighten the cartridge until the O-ring touches the sealing surface. During this process take adequate care that the light oil that is inside does not flow out.
6. Use the filter wrench and tighten rotating by 1/3 to 2/3.

   Special tool
   Filter wrench: J-22700

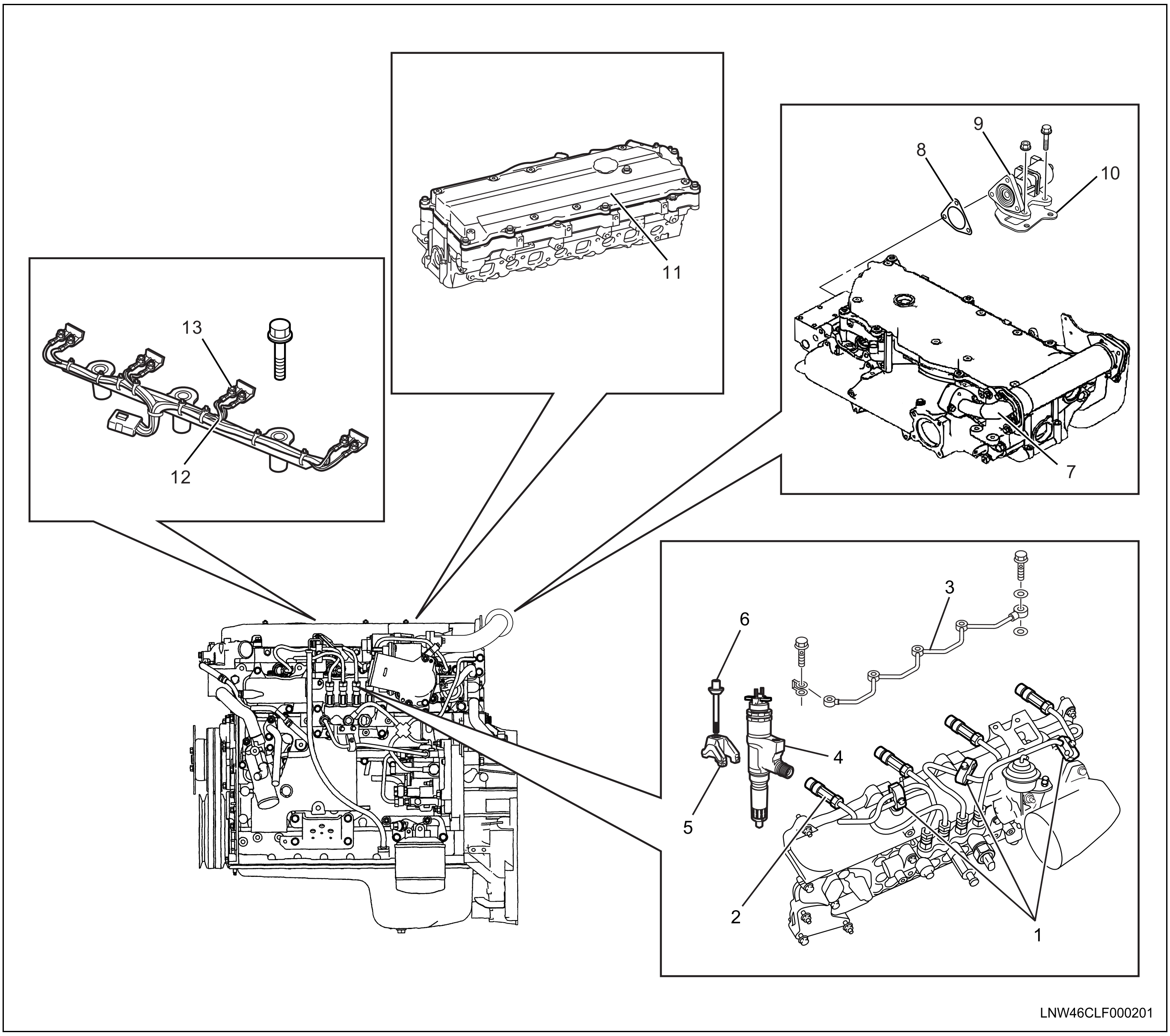


Special tool

Illustration	Tool Number/ Description
 5884002530	J-22700 Filter wrench

Fuel Injector

Components



Legend

1. Fuel Injection Pipe Clip
2. Fuel Injection Pipe
3. Fuel Injector Leak-Off Pipe
4. Fuel Injector
5. Fuel Injector Clamp
6. Fuel Injector Clamp Bolt
7. EGR Adapter
8. EGR Valve Gasket
9. EGR Valve
10. EGR Valve Gasket
11. Cylinder Head Cover
12. Fuel Injector Harness Bracket
13. Fuel Injector Terminal

The fuel system consists of many tiny holes and spaces that allow the movement of fuel from one place to another. These holes and spaces are milled to extremely high precision. This is especially true of the fuel injectors.

The fuel injector is very sensitive to foreign material. Foreign material will result in fuel system breakdown. Exercise great care not to allow the entry of foreign material into the fuel system or fuel injectors during the removal and installation procedure.

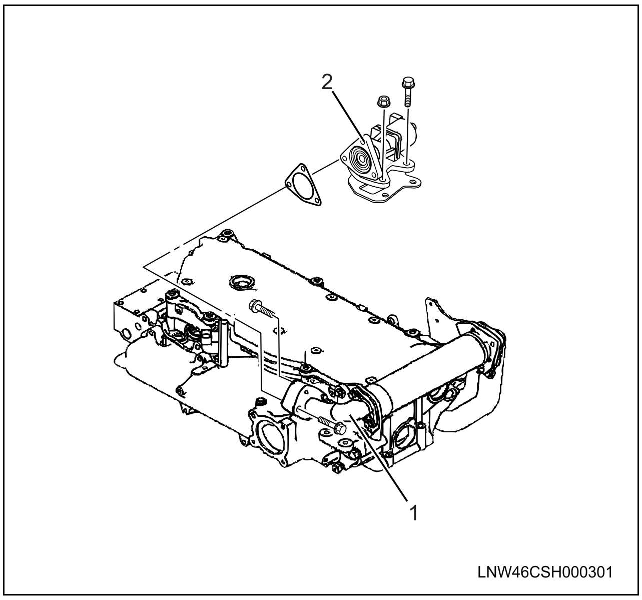
Caution:

To avoid electric shock;

Set the switch to the ‘OFF’ position and disconnect battery negative cable before checking or repairing the fuel injector, wiring or/and connectors.

Removal

1. Remove the engine harness, the throttle position sensor, the EGR valve, the pressure sensor, and all of the fuel injector connectors.
2. Remove the EGR valve and the EGR adapter.
3. Tape the EGR case holes shut to prevent the entry of foreign material.

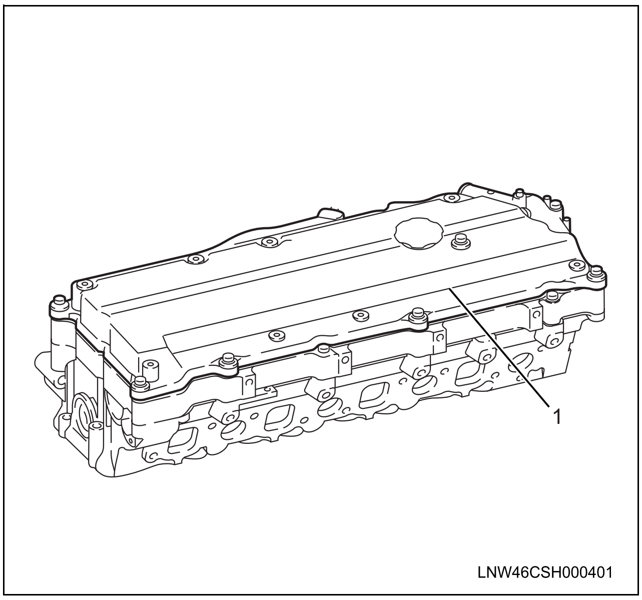


Legend

1. EGR Adapter
2. EGR Valve

---

4. Remove the cylinder head cover.

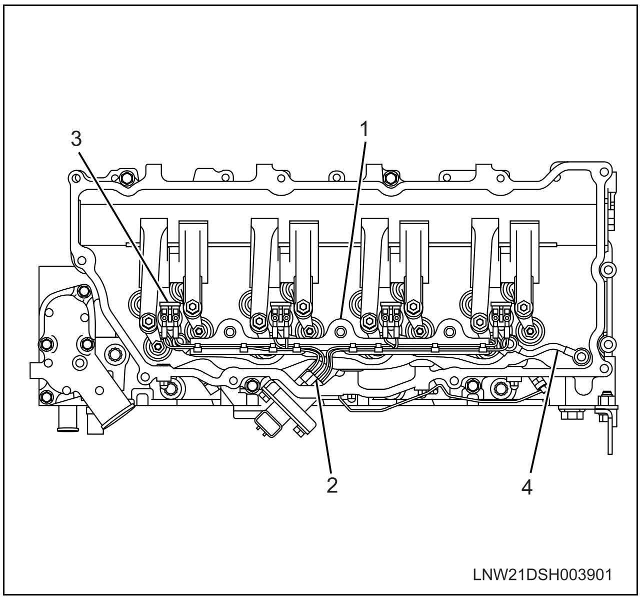


Legend

1. Cylinder Head Cover

---

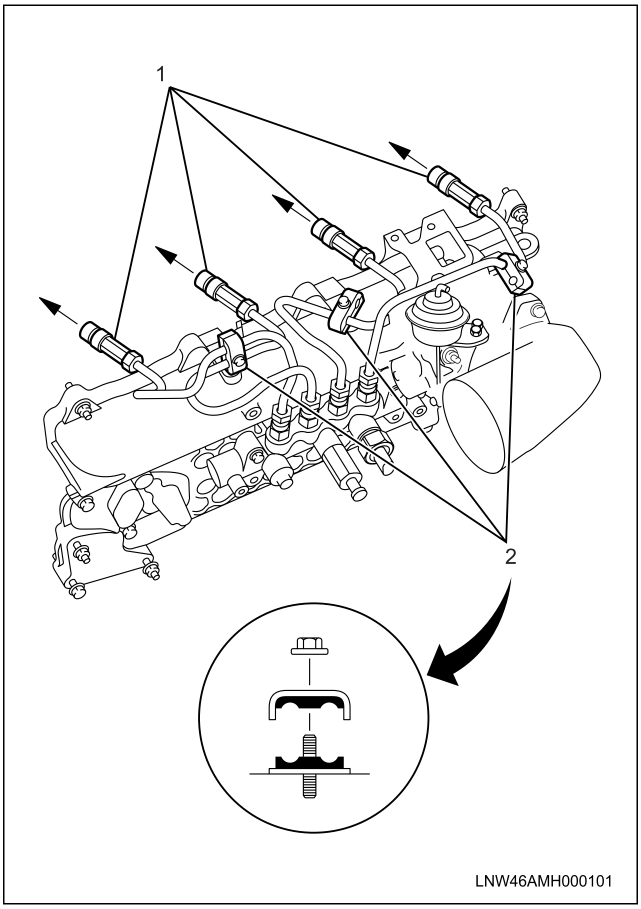
5. Alternately loosen the fuel injector terminal nuts a little at a time in sequence. Several loosening cycles should be required before the nuts are loose.
6. Loosen the fuel injector harness bracket bolts. Remove the inside connector and the harness bracket.
7. Remove the fuel injector leak-off pipe.
8. Remove the lower cover.



Legend

1. Harness Bracket
2. Harness Connector
3. Fuel Injector Terminal
4. Fuel Leak-Off Pipe

9. Remove the fuel injection pipe clips and the injection pipes.



Legend

1. Fuel Injection Pipe
2. Pipe Clip

---

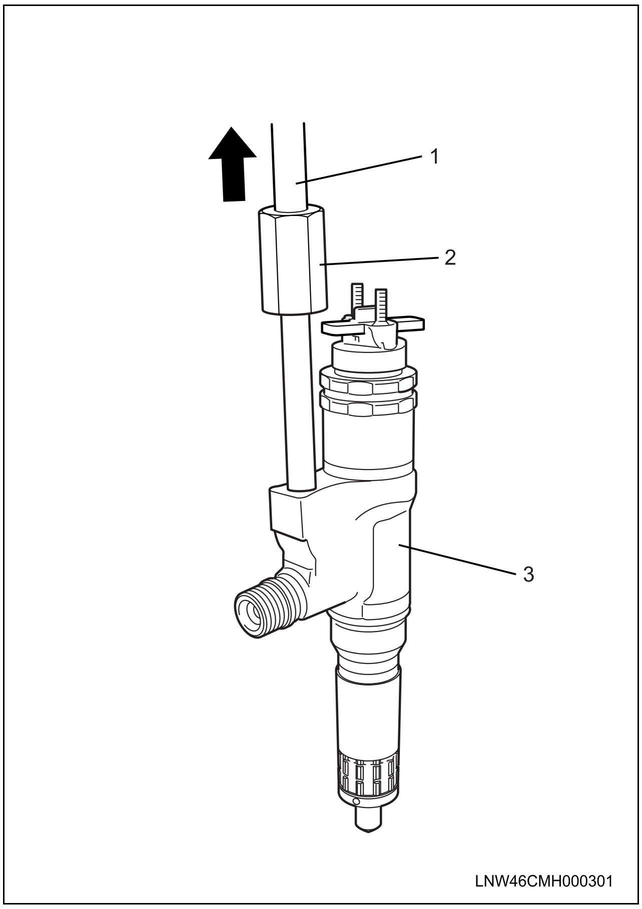
10. Loosen the fuel injector clamp fixing bolts and remove the fuel injectors.

If the fuel injectors are difficult to remove, use the fuel injector remover. Install the fuel injector remover to the leak-off pipe attachment part on the fuel injector. Use a sliding hammer to force the fuel injector clamp off the fuel injector.

Caution:

Do not remove the fuel injector sleeve.

Special tools
Fuel injector remover: EN-46720
Sliding hammer: J-23907



Legend

1. Sliding Hammer
2. Remover
3. Fuel Injector Assembly

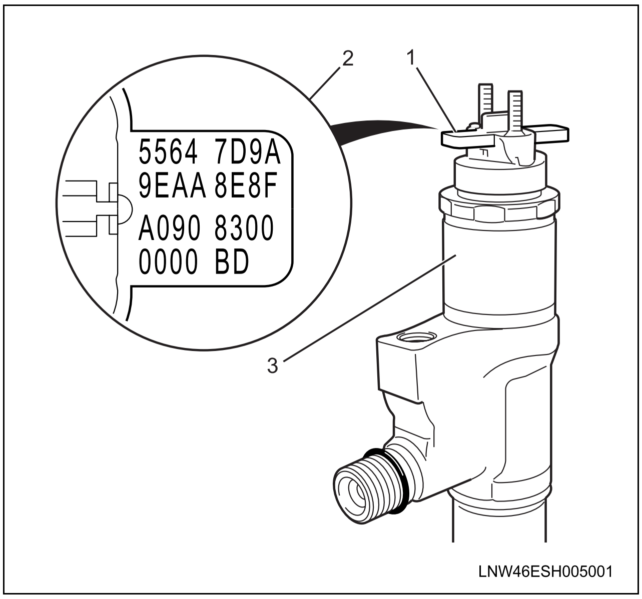
---

11. Mark each fuel injector with the number of the cylinder from which it was removed. Store the fuel injectors in a safe place. Position the fuel injector so that the nozzle is protected.

Caution:

- Do not tamper with the electromagnetic portion of the fuel injector. Reduced electromagnetic function will result in injector failure.

Recording Fuel Injector Flow Rate Information from the QR plate on the replaced injector housing;
Record all numbers of replaced fuel injector's from QR plate.

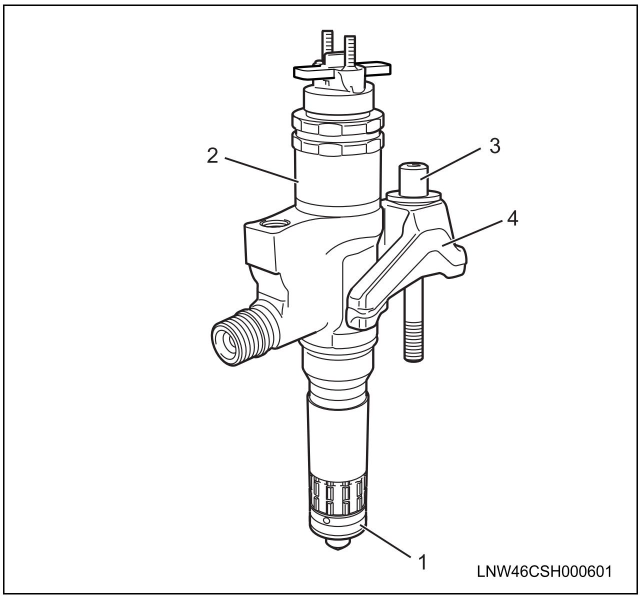


Legend
1. QR Plate
2. Fuel Injector Flow Rate
3. Fuel Injector

Installation

Important:
Install each of the fuel injectors on its original position. (the cylinder from which it was removed)

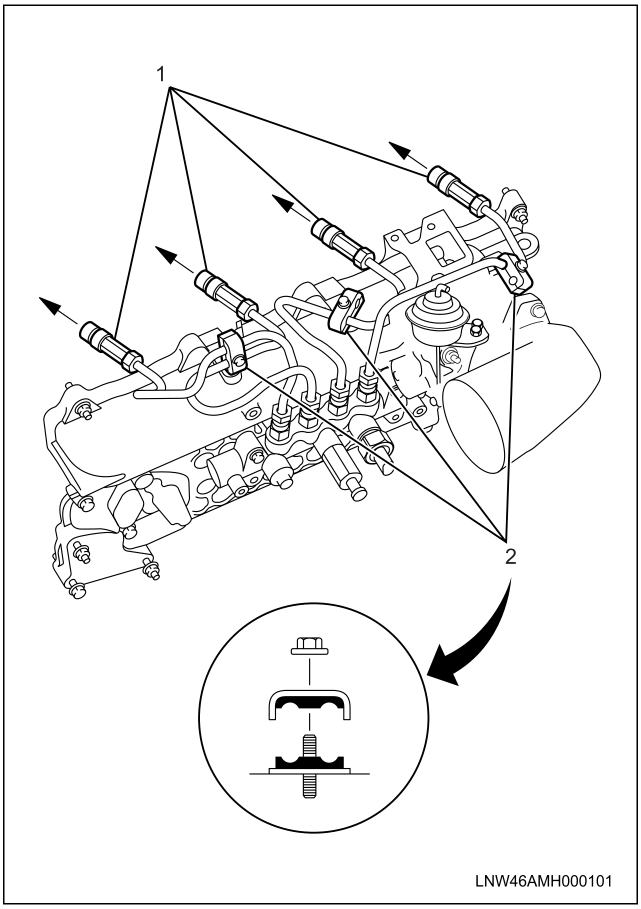
1. Install a new gasket and O-ring to each of the fuel injector clamps. Refer to the illustration.



Legend
1. Gasket
2. Fuel Injector
3. Bolt
4. Fuel Injector Clamp

2. Apply molybdenum to the threads and seating surfaces of the clamp bolts.
3. Install the fuel injector clamps to the cylinder head.
4. Temporarily tighten the clamp bolts.
5. Apply a thin coat of engine oil to the outer surface of the fuel injector side sleeve nuts.
6. Install the fuel injector pipes to the position shown in the illustration.
7. Use a spanner to carefully the sleeve nuts until the fuel injector pipes contact the fuel injector and common rail.
8. Tighten the fuel injection pipe clips to the specified torque.

Tightening torque: 6 N·m (52 lb in)



Legend

1. Fuel Injection Pipe
1. Pipe Clip

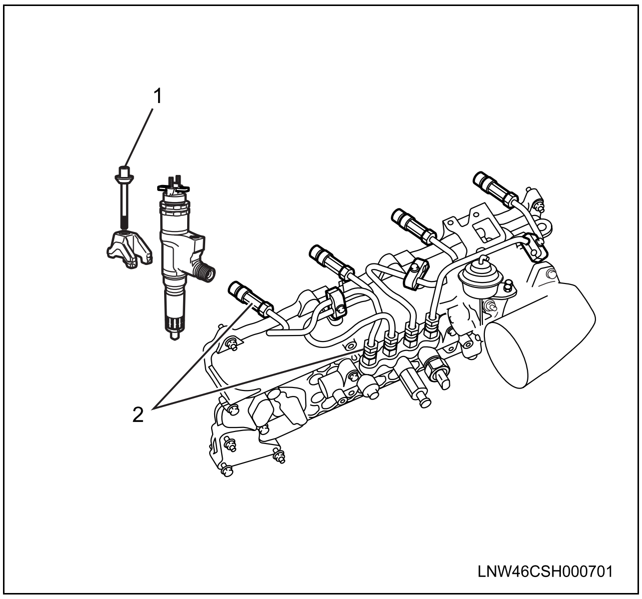
---

9. Final tighten the injection clamp bolts to the specified torque.

Tightening torque: 30 N·m (22 lb ft)

10. Tighten the injection pipes to the specified torque.

Tightening torque: 44 N·m (33 lb ft)



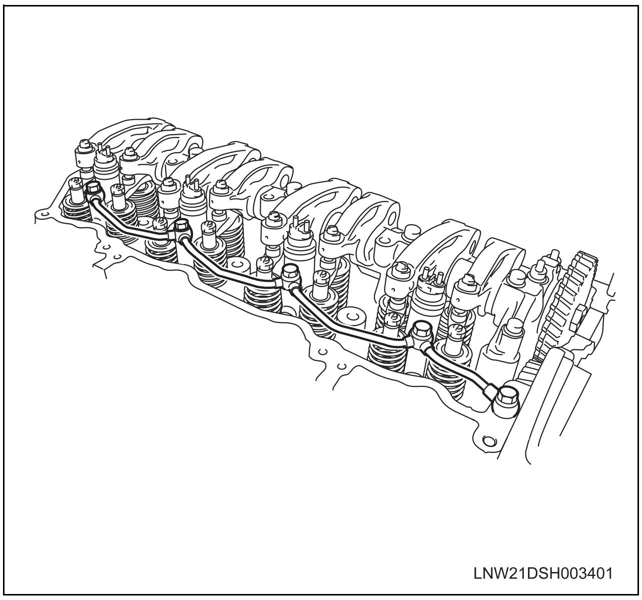
Legend

1. Clamp Bolt
2. Sleeve Nut

---

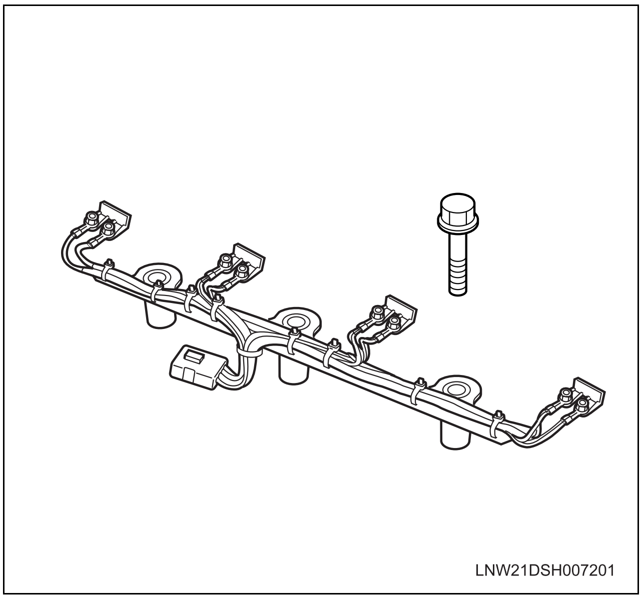
11. Install the nozzle leak off pipes together with the new gaskets. Tighten the pipes to the specified torque.

Tightening torque: 12 N·m (104 lb in)



12. Install the fuel injector harness connectors. Work from the inside out.
13. Install the harness bracket and tighten the bolts to the specified torque.

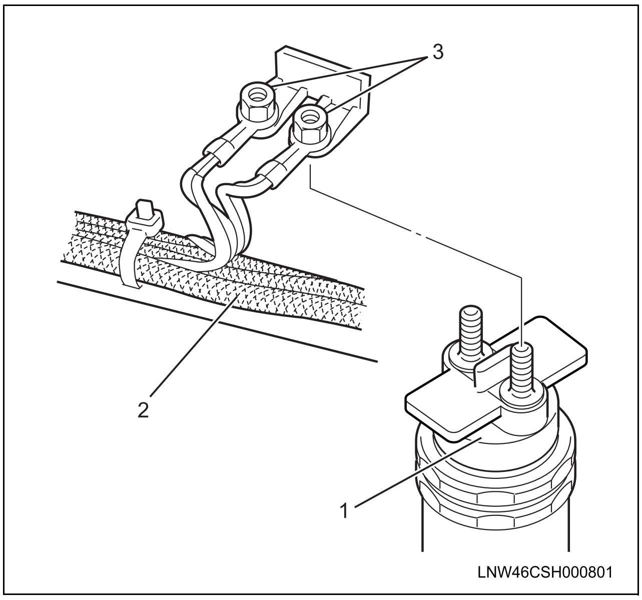
Tightening torque: 48 N·m (35 lb ft)



14. Install the fuel injector terminal nuts to the injector.
15. Alternately tighten each nut 2 or 3 turns at a time until the specified torque is reached.

Tightening torque: 2 N·m (17 lb in)

Caution:
Do not overtighten the nuts. Damage to the terminal studs will result.

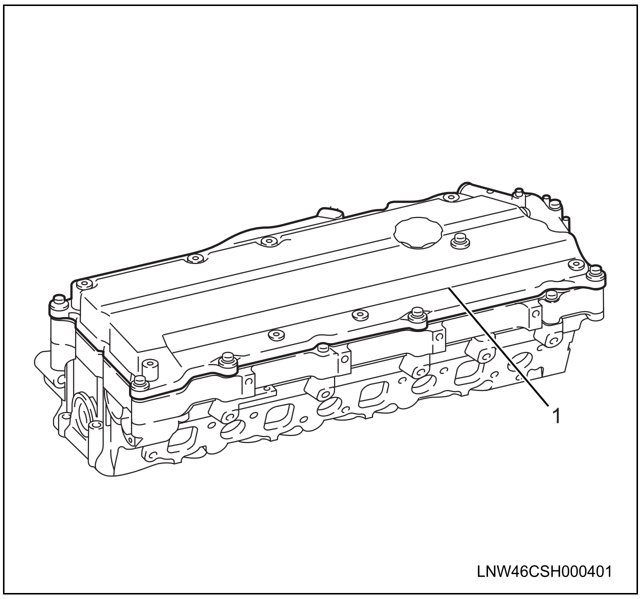


Legend
1. Fuel Injector
2. Harness
3. Terminal Nut

---

16. Install the gasket to the cylinder head cover.
17. Install the cylinder head cover and tighten the bolts to the specified torque.

Tightening torque: 18 N·m (13 lb ft)



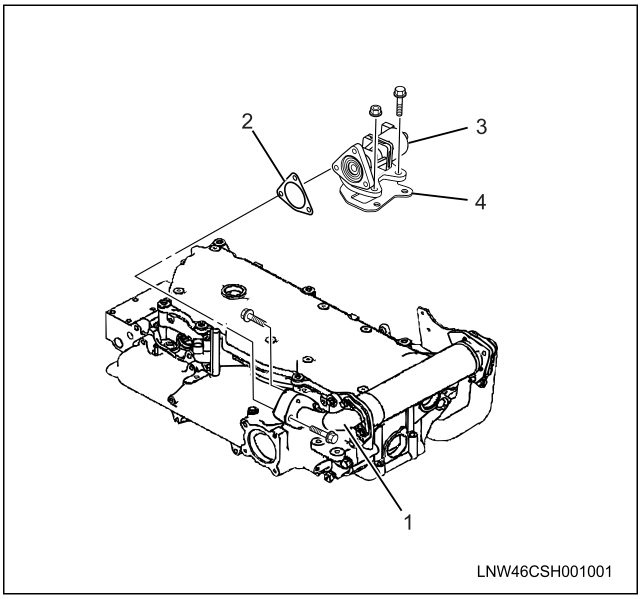
Legend
1. Cylinder Head Cover

18. Install the gasket to the EGR valve and tighten the bolts to the specified torque.

Tightening torque: 24 N·m (17 lb ft)

19. Install the gasket to the EGR adapter and tighten the bolts to the specified torque.

Tightening torque: 24 N·m (17 lb ft)



Legend
1. EGR Adapter
2. EGR Valve Gasket
3. EGR Valve
4. EGR Valve Gasket

20. Attach the engine harness connectors. Each composite connector should make a loud click when it is securely attached.

Before Programming the Fuel Injector Flow Rate

Important:

DO NOT program the fuel injector flow rate unless you are directed by a service procedure or you are directed by a service bulletin. Programming the fuel injector at any other time will not permanently correct a customers concern.

Ensure the following conditions are met before programming the ECM.

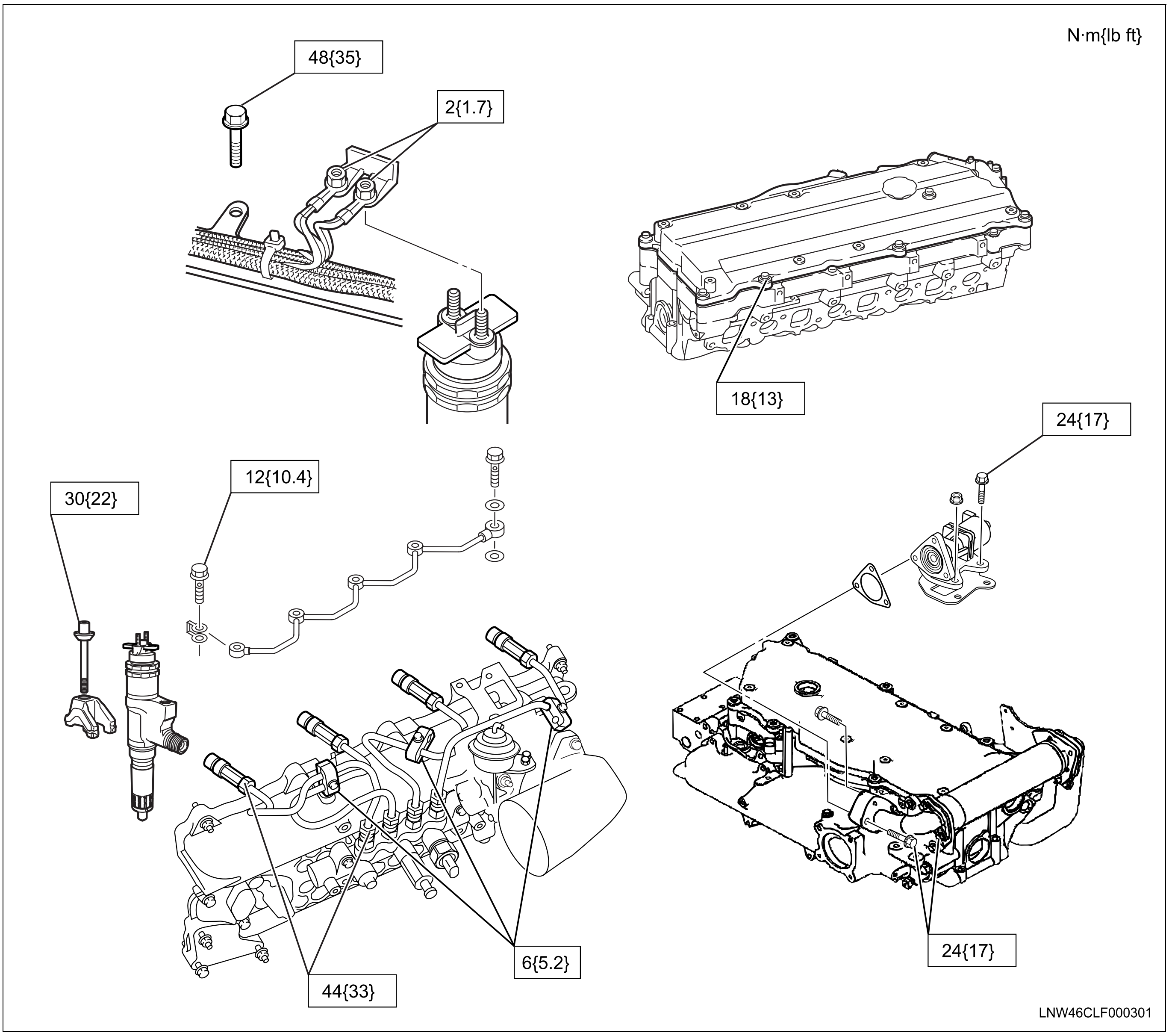
- Vehicle system voltage
  - There is no charging system concern. All charging system concerns must be repaired before programming the ECM.
  - Battery voltage is greater than 12 volts but less than 16 volts. The battery must be charged before programming the ECM if the battery voltage is low.
  - A battery charger is NOT connected to the vehicle's battery. Incorrect system voltage or voltage fluctuations from a battery charger may cause programming failure or ECM damage.
  - Turn OFF or disable and system that may put a load on the vehicle's battery.
- Headlights
- Room lights
- Accessory equipment
- The ignition switch is in the proper position. DO NOT change the position of the ignition switch during the programming procedure, unless instructed to do so.
- All tool connections are secure.
  - RS-232
  - The connection at the data link connector (DLC) is secure.
  - Voltage supply circuit
- DO NOT disturb the tool harness while programming. If an interruption occurs during the programming procedure, programming failure or ECM damage may occur.
- Surrounding environment
  - Surrounding temperature is more than 32°F (0°C) but less than 122°F (50°C) during the programming procedure. Excessively low or high temperature may cause the programming failure or ECM damage.
  - Electromagnetic interference (EMI) on the tool harness and ECM may cause the programming failure or ECM damage.

Fuel Injector Flow Rate Programming Procedure

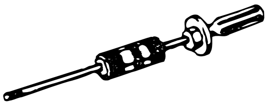
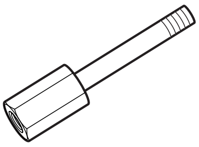
1. Connect the scan tool to the data link connector.
2. Connect the RS-232 to the scan tool and PC.
3. Start TIS 2000 and select the Service Programming System (SPS).
4. In the "Select Diagnostic Tool and Programming Process" screen, select the following menu.
   - Diagnostic tool "Pass-Thru".
   - Select Programming Process "Reprogram ECU".
   - ECU Location on the "Vehicle".

   Then, follow the SPS screen instructions.
5. Ensure that ALL programming contents are entered correctly and were programmed successfully by turning OFF the ignition for 30 seconds.
6. Using the scan tool to check each programmed fuel injector flow rate following this navigation: Diagnostics > (5) 2006 > Isuzu > NPR/NQR/NRR > F0: Powertrain > (6) 5.2L L4 Diesel > Automatic or Manual > F2: Special Functions > F5: Option Programming > F0: Injector Flow Rates.
7. Start the engine and let idle.
8. Inspect for a proper engine running condition and for no DTCs. Refer to the Diagnostic System Check - Engine Control if needed.

Torque Specifications

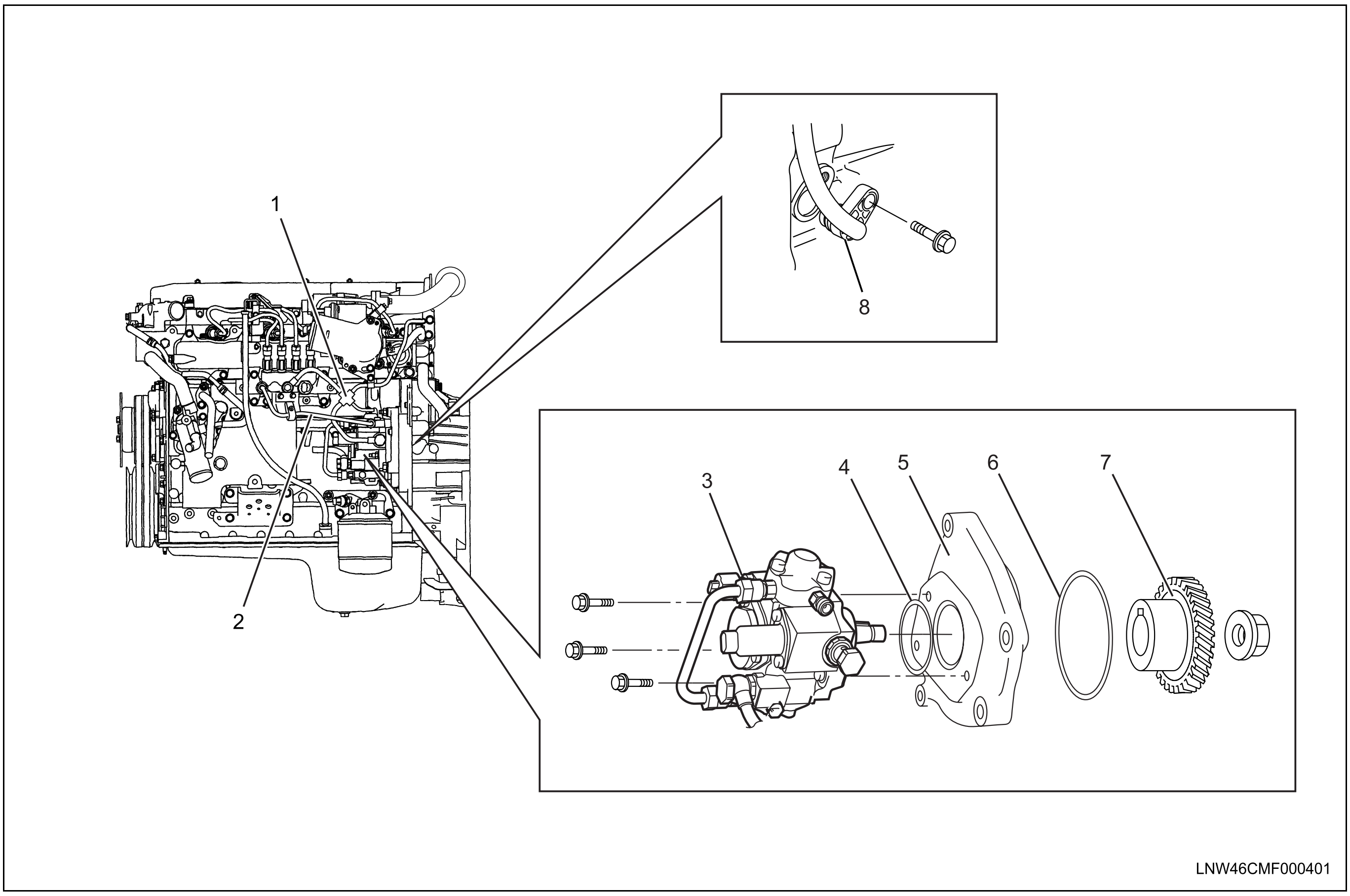


Special Tool

Illustration	Tool Number/ Description	Illustration	Tool Number/ Description
 5884000190	J-23907 Sliding hammer	 EN46720	EN-46720 Fuel injector remover

Fuel Supply Pump

Components



Legend

1. Fuel Leak-Off Pipe
2. Fuel Pipe
3. Fuel Supply Pump
4. O-Ring
5. Bracket
6. Bracket O-Ring
7. Drive Gear
8. Oil Drain Adapter

The fuel system consists of many tiny holes and spaces that allow the movement of fuel from one place to another. These holes and spaces are milled to extremely high precision. This is especially true of the fuel injectors.

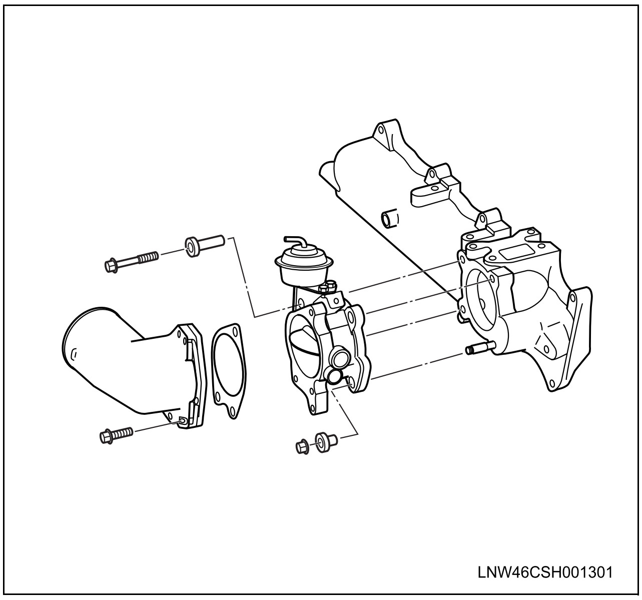
The fuel injector is very sensitive to foreign material. Foreign material will result in fuel system breakdown. Exercise great care not to allow the entry of foreign material into the fuel system or fuel injectors during the removal and installation procedure.

Important:

The Fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM.

Removal

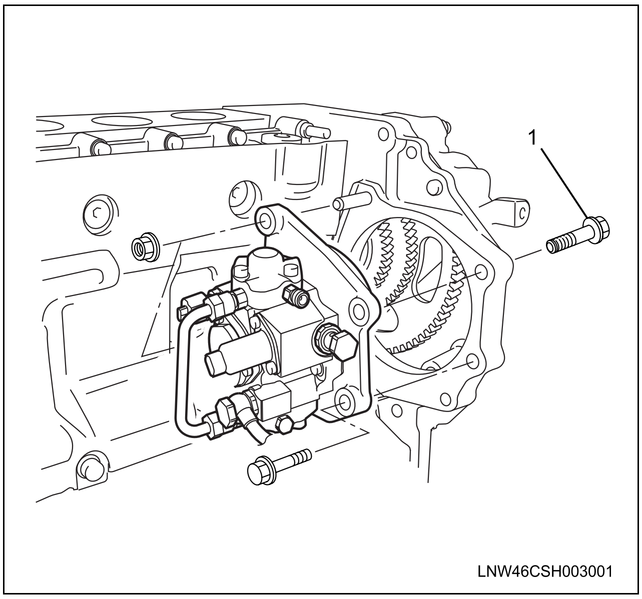
1. Remove the intake pipe and the intake throttle valve.
2. Remove the fuel pipe and fuel leak-off pipe.



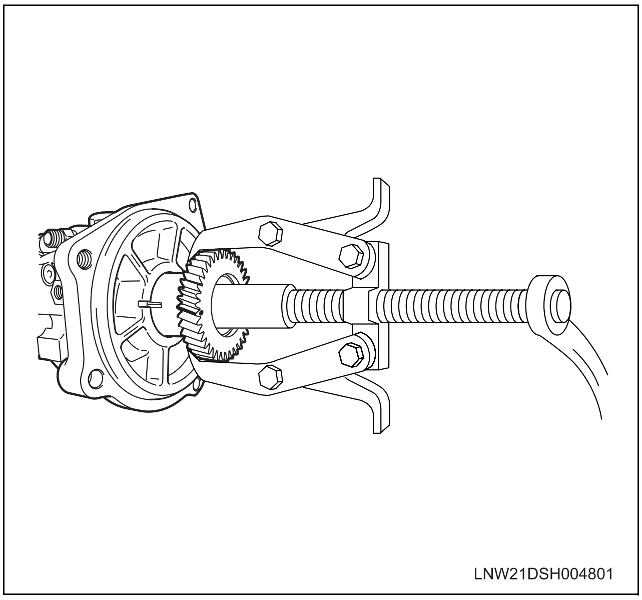
3. Remove the fuel feed hose.

4. Disconnect the connector of fuel temperature sensor and the fuel rail pressure regulator from the fuel supply pump.
5. Remove the fuel supply pump attachment bolts and nuts, then remove the fuel supply pump.

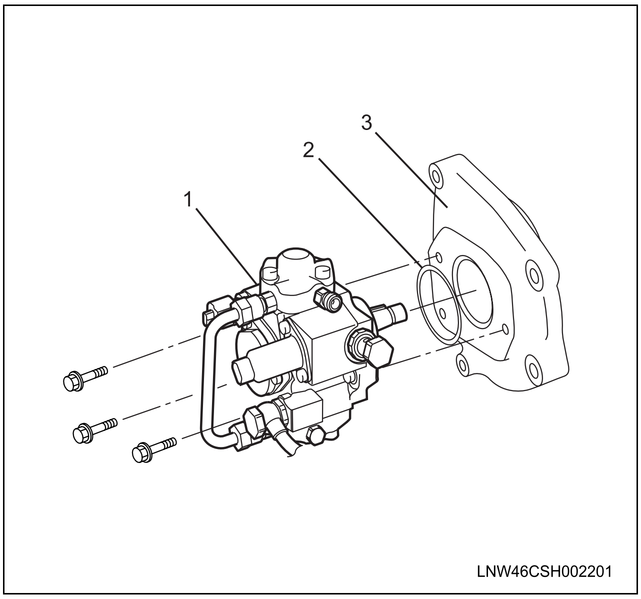
Notice:
One of the attachment bolt (1) secures the fuel supply pump to the flywheel housing as denoted in the picture below.



6. Use a gear puller to remove the fuel supply pump gear and the bracket O-ring.



7. Loosen the 3 bolts holding the fuel supply pump bracket. Remove the bracket and the O-ring.



Legend

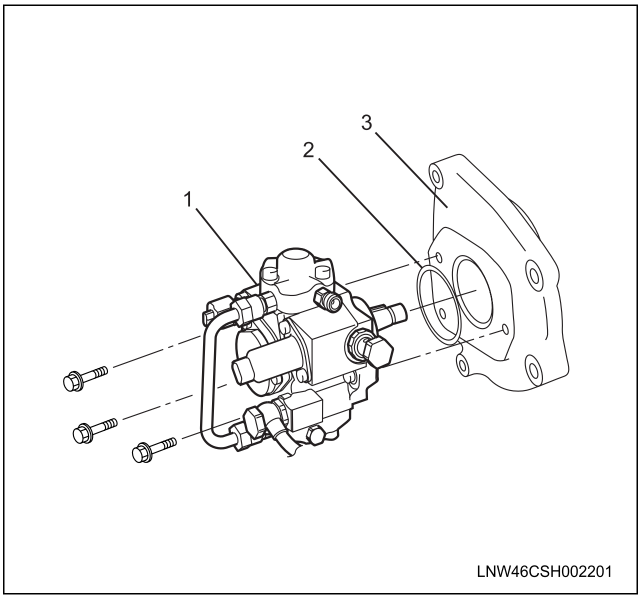
1. Fuel Supply Pump
2. O-Ring
3. Fuel Supply Pump Bracket

Installation

1. Install the O-ring to the fuel supply pump.
2. Install the pump to the bracket and tighten the 3 bolts to the specified torque.

Tightening torque: 19 N·m (14 lb ft)

Caution:
Take care not to twist the O-ring.

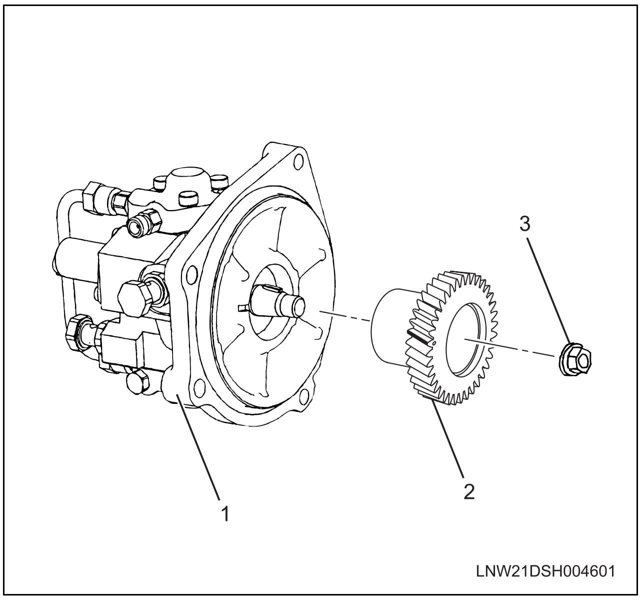


Legend

1. Fuel Supply Pump
2. O-Ring
3. Fuel Supply Pump Bracket

3. Align the fuel supply pump shaft key and gear. Install the gear and tighten the nut to the specified torque.
   There is a round alignment mark on the gear (white paint).

Tightening torque: 64 N·m (47 lb ft)

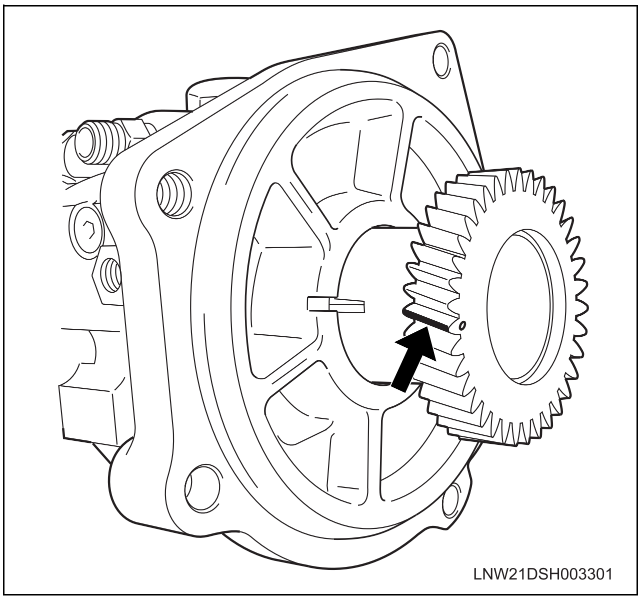


Legend

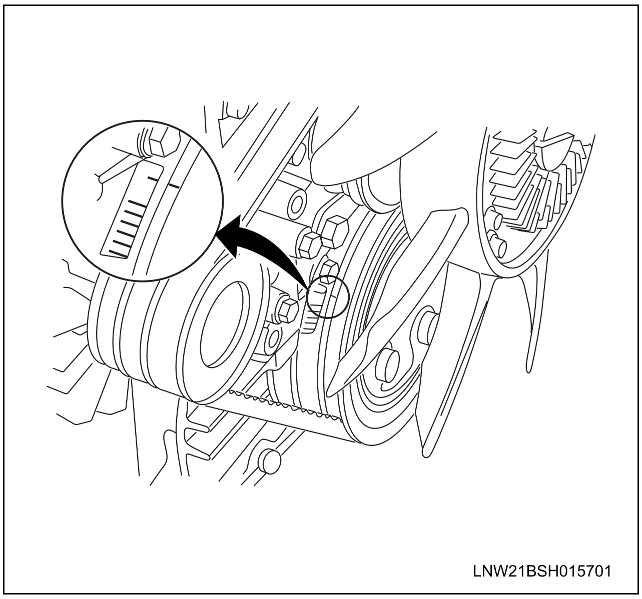
1. Fuel Supply Pump
2. Fuel Supply Pump Gear
3. Nut

---

4. Apply white paint to the top of the fuel supply pump gear tooth directly above the stamped ‘O’ mark. Refer to the illustration.

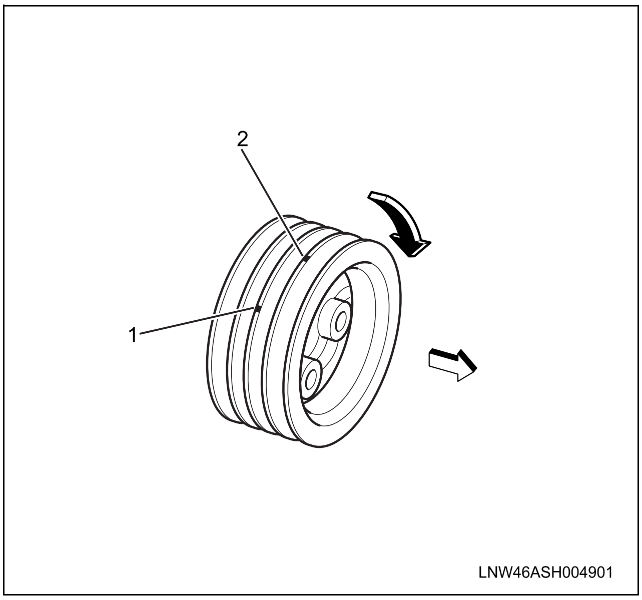


5. Turn the crankshaft in the normal direction of engine rotation until the No. 1 or No. 4 cylinder is at TDC on the compression stroke.
   Refer to the illustration.



Notice:

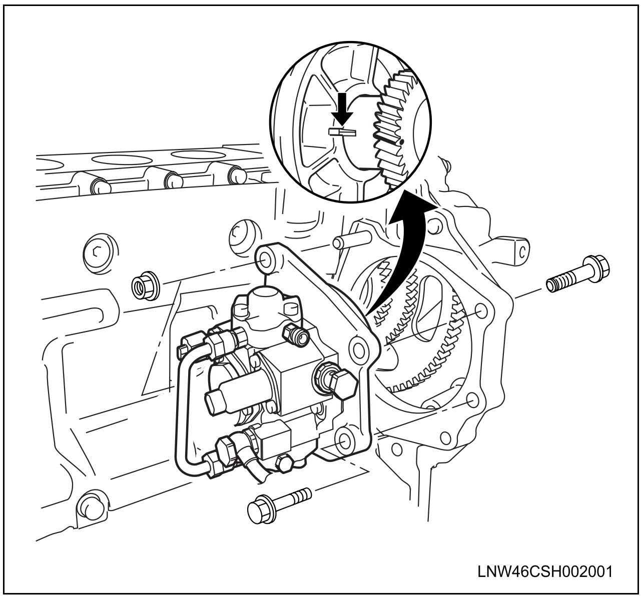
There are 2 timing marks on the crankshaft pulley.
Mark (1) is near the front cover and is used to bring the 4HK1-TC engine to TDC.
Mark (2) is not applicable to this engine.
Be sure to use mark (1) when bringing the engine to TDC.



6. Remove the oil drain adapter.
7. Install the O-ring to the fuel supply pump.
8. Align the slits as shown in the illustration.
9. Insert the stud bolts into the guides and temporarily tighten them.

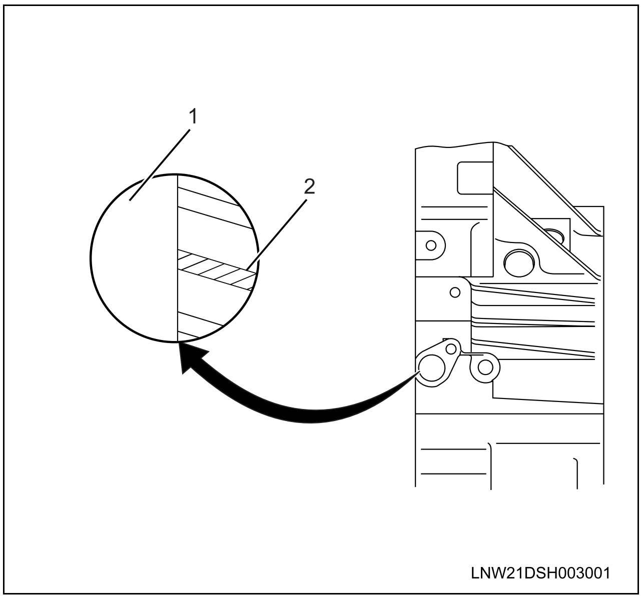
Caution:

- If the stud bolts (cylinder block side) have been loosened or replaced, apply Loctite 262 to the recessed portion of the bolts.


LNW46CSH002001

- Check that the round alignment mark (white paint) is positioned as shown in the illustration when viewed from the plug hole. If necessary, reposition the gear.
- Tighten the stud bolts and the nuts to the specified torque.

Tightening torque nut: 50 N·m (37 lb ft)
bolt: 76 N·m (56 lb ft)



LNW21DSH003001

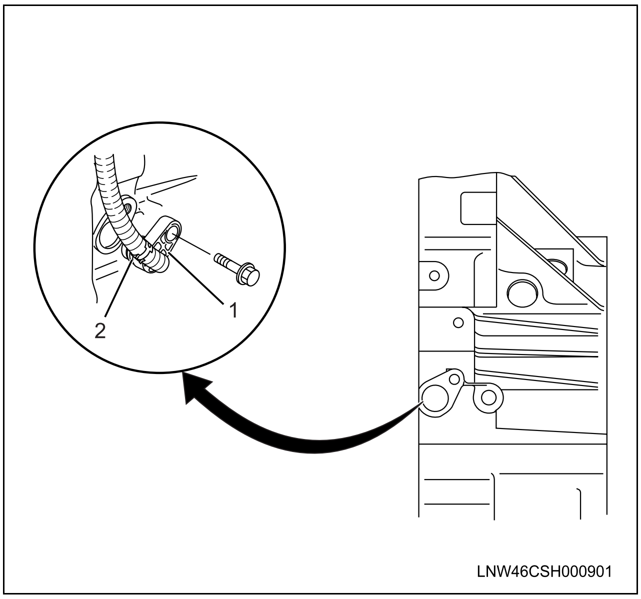
Legend

1. Plug Hole
2. Alignment Mark

---

10. Apply a light coat of engine oil to the O-ring.
11. Install the oil drain adapter to the plug hole. Tighten the bolt to the specified torque.

Tightening torque: 8 N·m (69 lb in)



LNW46CSH000901

Legend

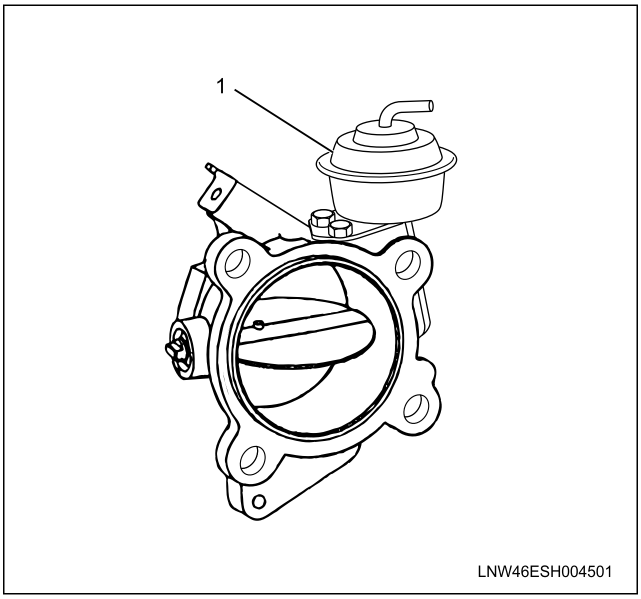
1. Oil Drain Adapter
2. O-Ring

---

12. Connect the fuel temperature sensor and the fuel rail pressure regulator connectors to the fuel supply pump.
13. Install the fuel feed hose.
14. Install the throttle assembly.
    - Coat the fluid gasket and mount within 7 minutes.

Tightening torque: 24 N·m (17 lb ft)

- Install the intake throttle valve chamber hose.



LNW46ESH004501

Legend

1. Throttle Valve chamber

---

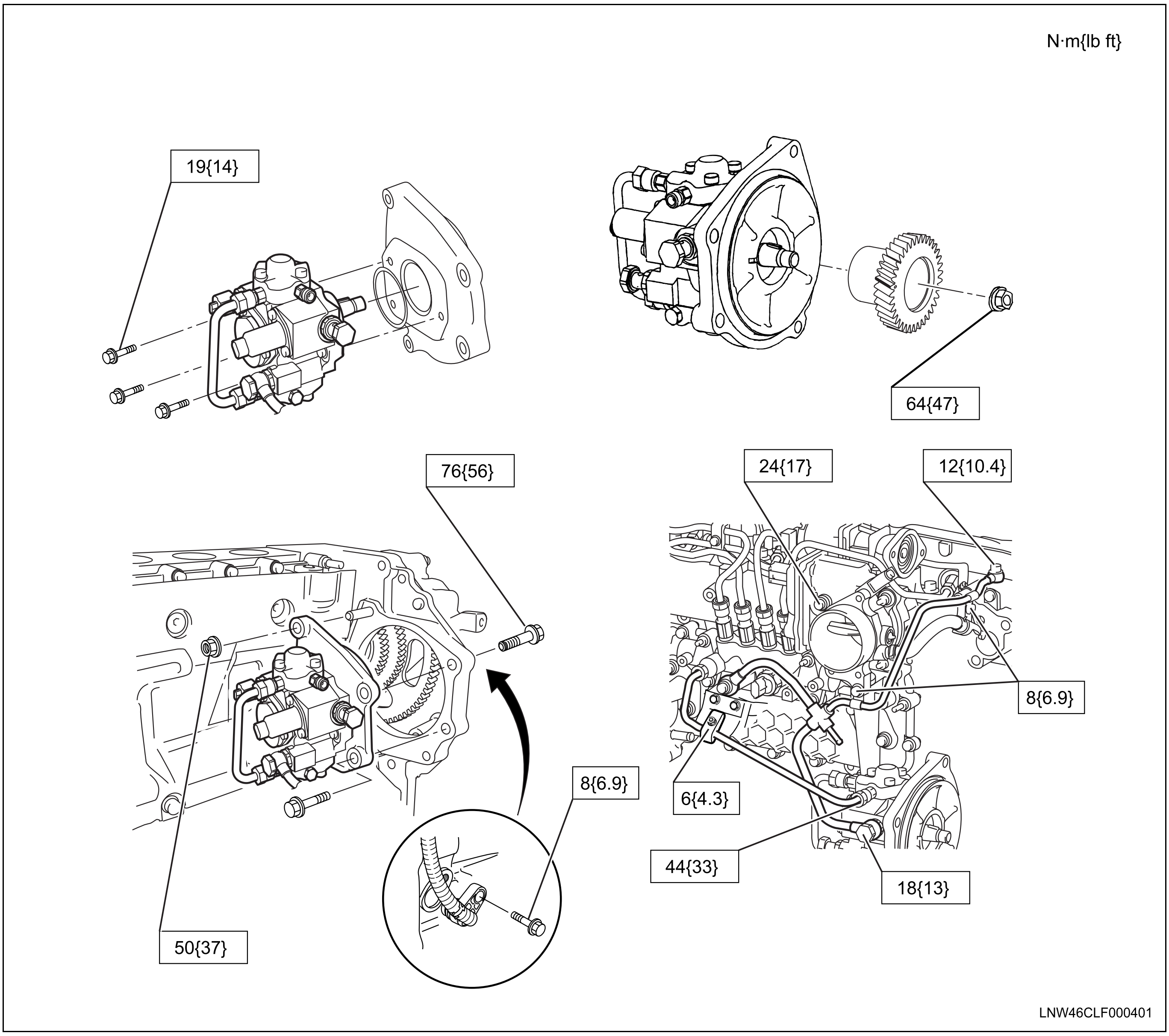
15. Install the fuel pipe and fuel leak-off pipe.

Fuel Supply Pump Relearn Procedure

The ECM gose through a fuel supply pump learn procedure to fine tune the current supplied to the fuel rail pressure (FRP) regurator. This learning process in only performed when the engine is idling.

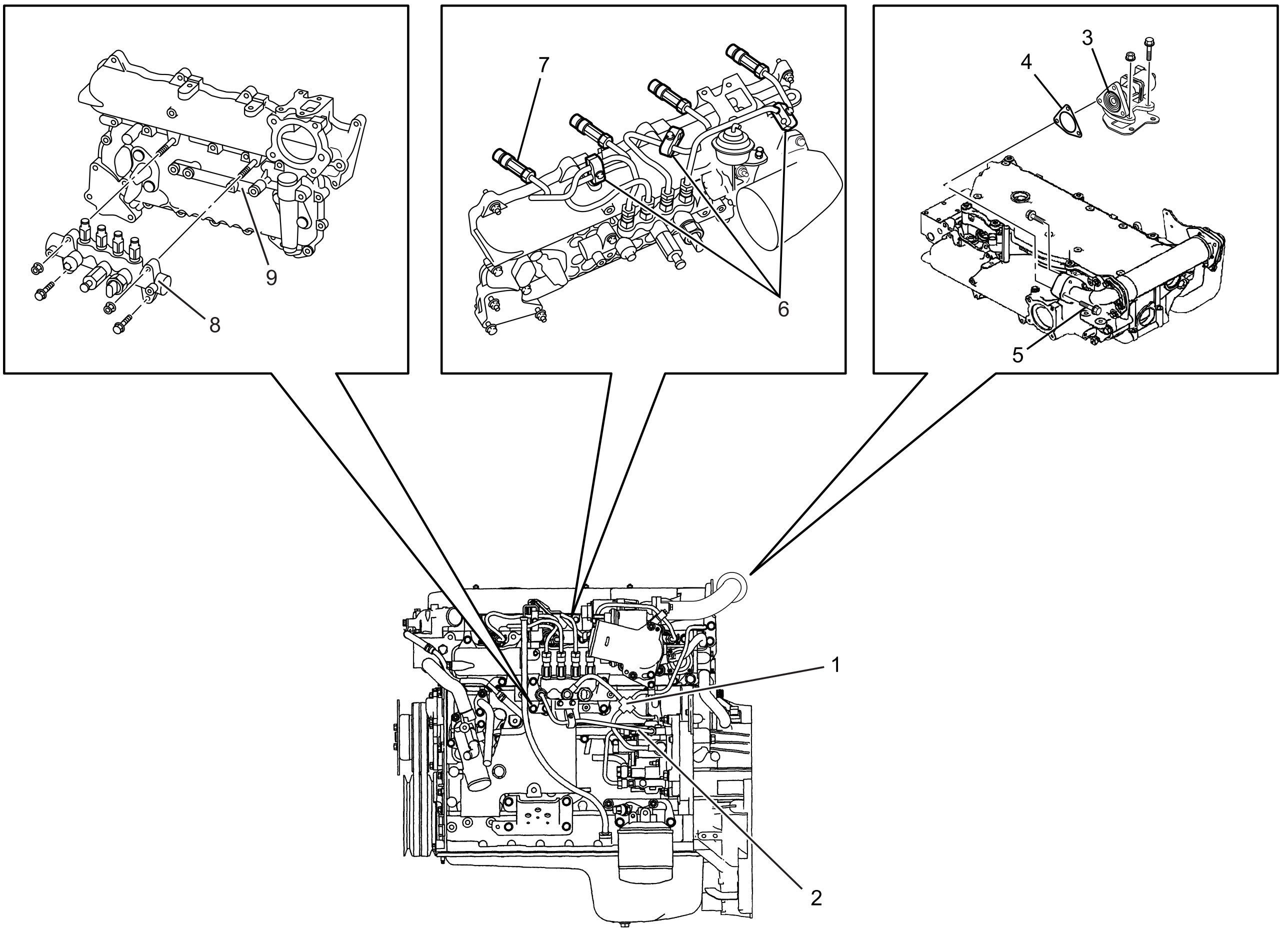
1. Install the scan tool.
2. Turn OFF the ignition for 30 seconds.
3. Turn ON the ignitioin, with the engine OFF.
4. Command the Supply Pump Learn Reset with the scan tool.
5. Observe the Supply Pump Status paremater with the scan tool. Confirm the scan tool indicates Not Learn.
6. Start the engine and let idle until engine coolant temparature (ECT) reads 149°F (65°C) or higher while observing Supply Pump Status parameter with the scant tool. The scan tool changes status Not Lean > Tentative > Learning > Learned.
7. If the ECM has correctly learned the fuel supply pump current adjustment, the Supply Pump Status parameter on the scan tool will indicate Learned.

Torque Specifications



Fuel Rail

Components



LNW46CLF000601

Legend

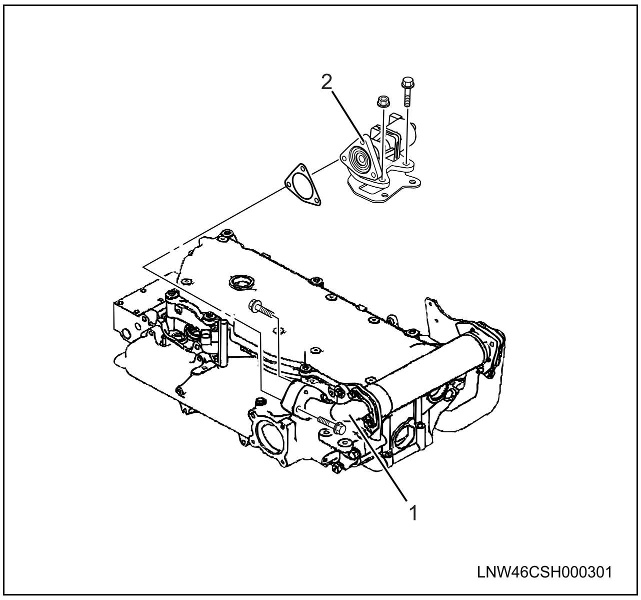
1. Fuel Leak Off Pipe
2. Fuel Pipe
3. EGR Valve
4. EGR Valve Gasket
5. EGR Adapter
6. Injection Pipe Clip
7. Injection Pipe (#1 to #4)
8. Fuel Rail
9. Fuel Rail Bracket

Parts of the fuel system such as the internal part of the fuel injector, holes and clearances that form passages for fuel are finished to a very high degree of accuracy. They are therefore highly sensitive to foreign matter and the entry of foreign matter could cause damage to the fuel passage. Therefore, effective measures should be taken to prevent the entry of foreign matter.

Removal

1. Remove the air intake pipe.
   - Disconnect the connector for the intake air temperature sensor.
2. Remove the fuel leak off hose from the leak off pipe.
   - Cover the removed fuel hose with a lid, keep it facing upward and secure it using wire, etc.

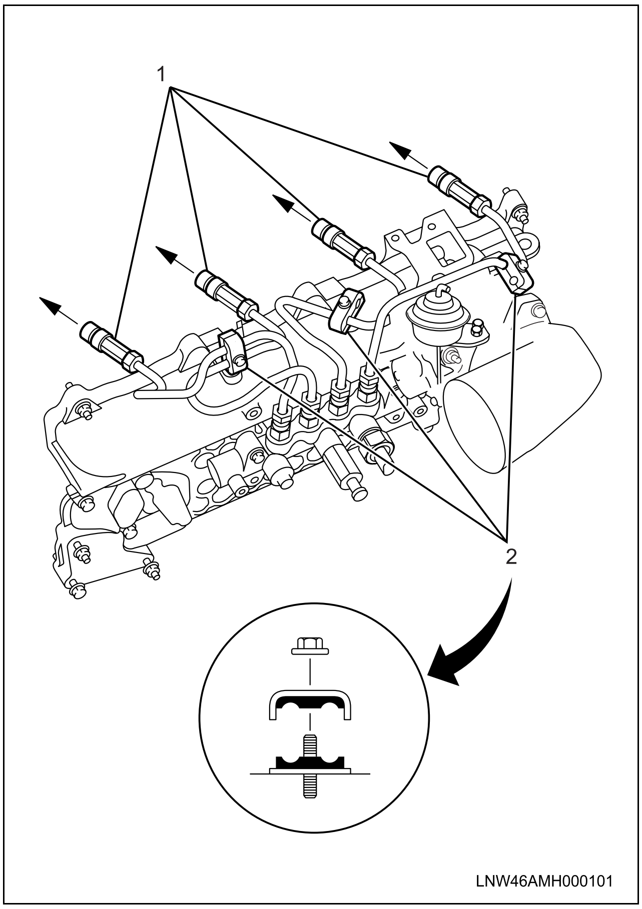
3. Disconnect the connecter of fuel rail pressure sensor, and all the connectors.
4. Remove the EGR valve and the EGR adapter.
5. Tape the EGR case holes shut to prevent the entry of foreign material.



Legend

1. EGR Adapter
2. EGR Valve

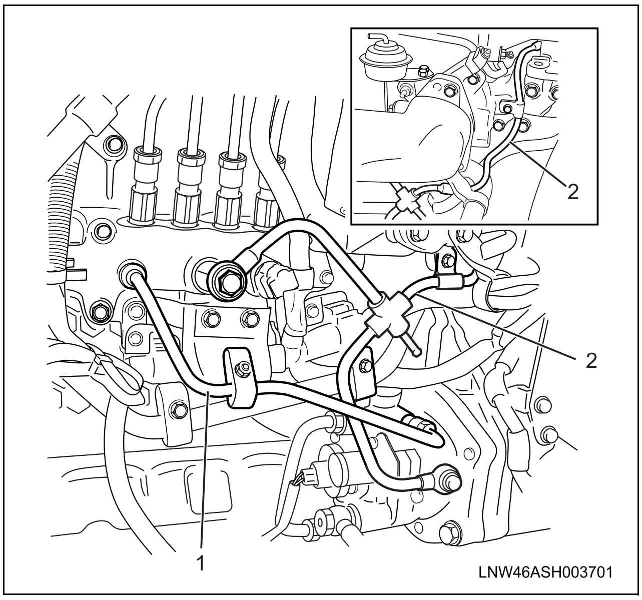
6. Remove the injection pipe clip and remove the injection pipes.



Legend

1. Fuel Injection Pipe
2. Pipe Clip

7. Remove the fuel pipe.
8. Remove the clip and the fuel leak off pipe.

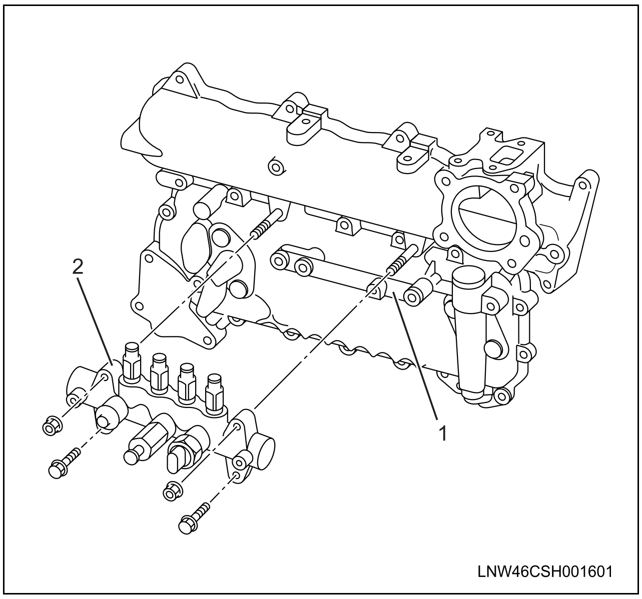


Legend

1. Fuel Pipe
2. Fuel Leak-Off Pipe

9. Remove the fuel rail and the fuel rail bracket.

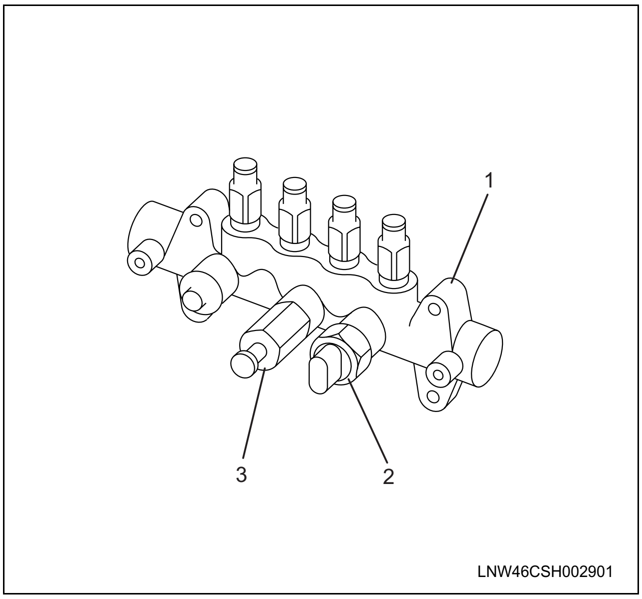
- Should not have the flow damper. Should always have the fuel rail.
- Take care not to damage the connector unit of the pressure sensor.



Legend
1. Fuel Rail Bracket
2. Fuel Rail

Disassembly

1. Remove the fuel pressure limiter.

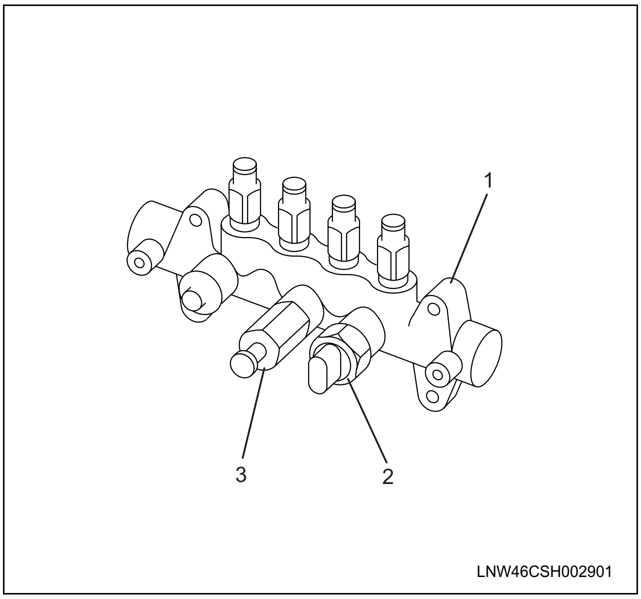


Legend
1. Fuel Rail
2. Fuel Pressure Sensor
3. Fuel Pressure Limiter

Reassembly

1. Insatll the tuel pressure limiter.

Tightening torque: 172 N·m (127 lb ft)



Legend
1. Fuel Rail
2. Fuel Pressure Sensor
3. Fuel Pressure Limiter

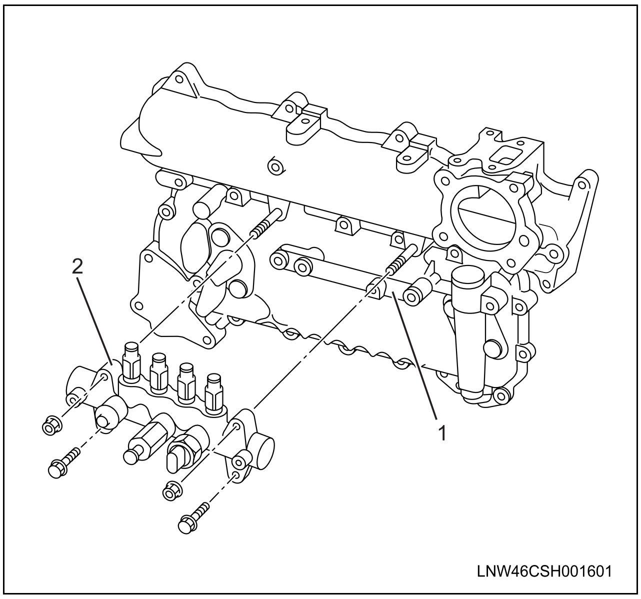
Installation

1. Tighten the fuel rail bracket using the specified mounting torque.

Tightening torque: 19 N·m (14 lb ft)

2. Tighten the fuel rail using the specified mounting torque.

Tightening torque: 19 N·m (14 lb ft)



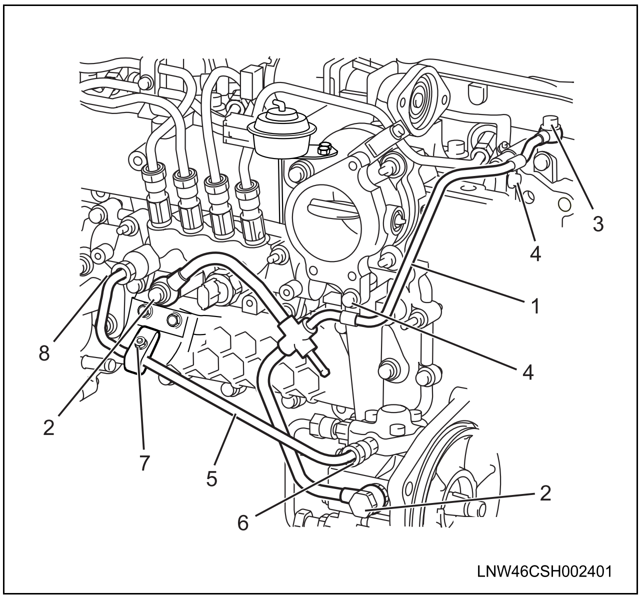
Legend
1. Fuel Rail Bracket
2. Fuel Rail

3. Tighten the fuel leak off pipe (1) using the mounting eyebolt and the clip using the specified torque.

Tightening torque	(2):	18 N·m (13 lb ft)
	(3):	12 N·m (104 lb in)
	(4):	8 N·m (69 lb in)
	(7):	6 N·m (52 lb in)

4. Tighten the fuel pipe (5) using the mounting sleeve nut and the specified torque.

Tightening torque	(6):	44 N·m (33 lb ft)
	(8):	44 N·m (33 lb ft)

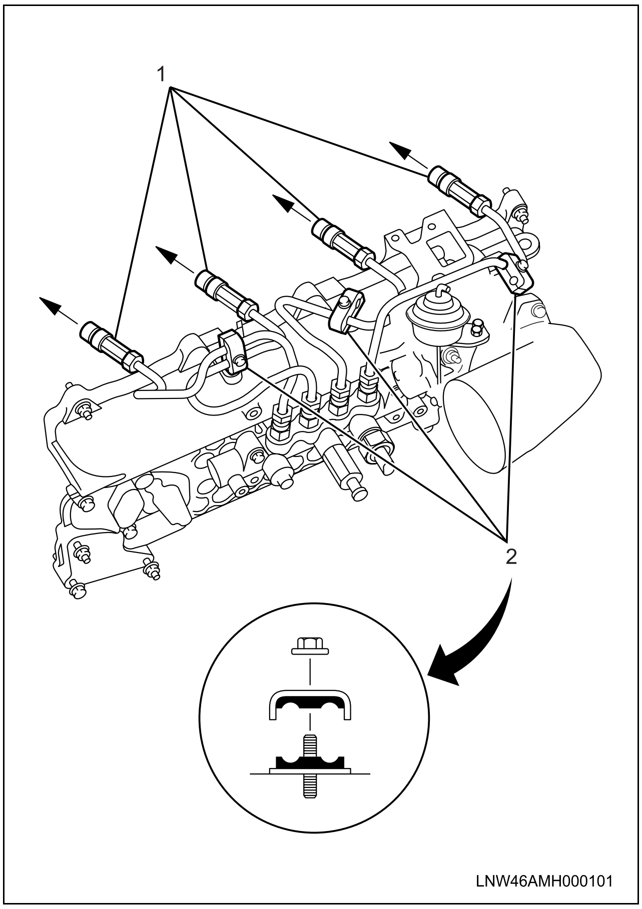


5. Tighten the injection pipe and the clip using the specified mounting torque.

Injection pipe sleeve nut
Tightening torque: 44 N·m (33 lb ft)

Injection pipe clip
Tightening torque: 6 N·m (52 lb in)

- Apply a thin coat of engine oil on the periphery of the sleeve nut on the fuel injector side and assemble.



Legend

1. Fuel Injection Pipe
2. Pipe Clip

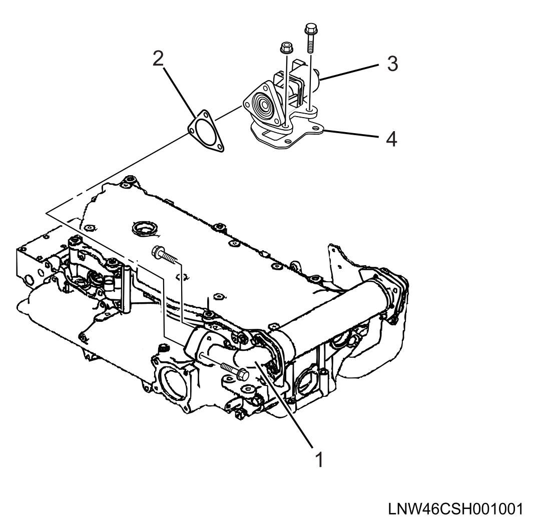
---

6. Install the gasket to the EGR valve and tighten the bolts to the specified torque.

Tightening torque: 24 N·m (17 lb ft)

7. Install the gasket to the EGR adapter and tighten the bolts to the specified torque.

Tightening torque: 24 N·m (17 lb ft)

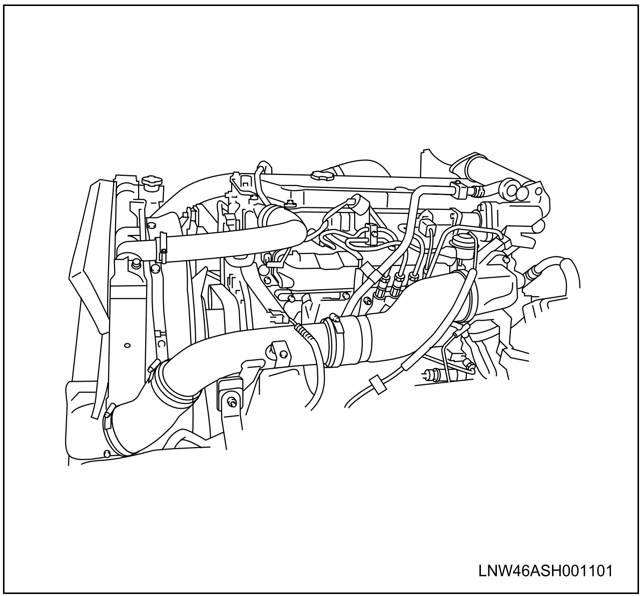


Legend

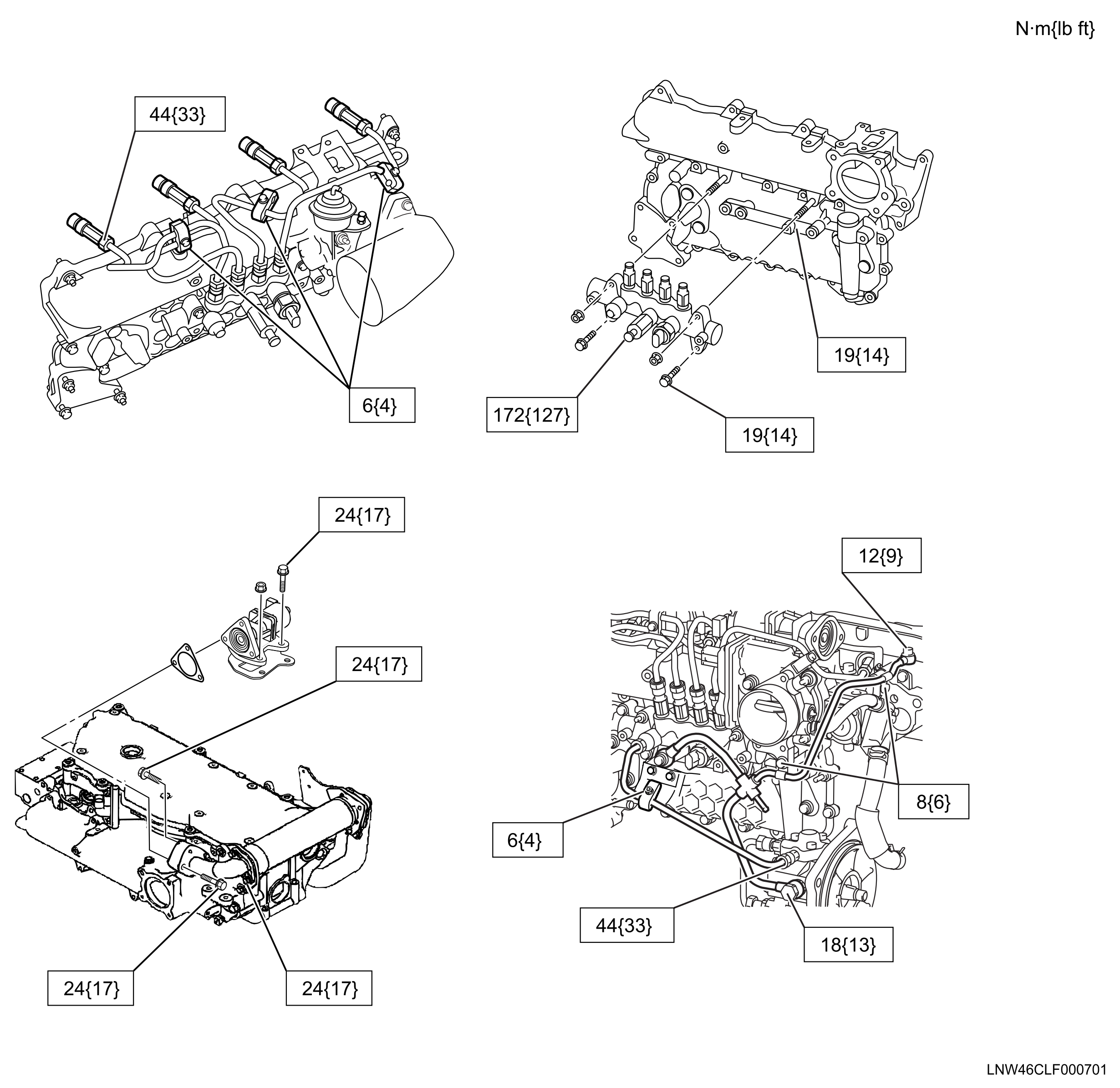
1. EGR Adapter
2. EGR Valve Gasket
3. EGR Valve
4. EGR Valve Gasket

---

8. Install the air intake duct.
   - Connect the connector for the intake air temperature sensor.



Torque Specifications

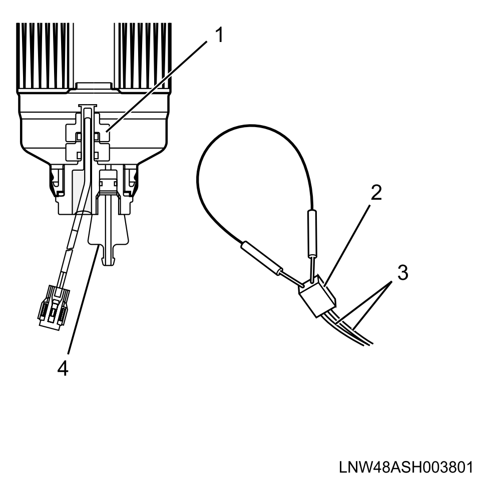


Fuel Sedimenter Switch

Inspection

1. Check that there is continuity between the switch connector terminals when the float in the fuel sedimenter is above the water drain line.
2. Turn on the ignition switch, remove the fuel sedimenter connector, and connect the terminals of the connectors on the harness side. Confirm that the sedimenter warning lamp lights up.

If abnormalities are detected during the check, replace the switch parts and carry out repairs in case of defective connection between circuits or short circuits.



Legend

1. Sensor
2. Connector on The Vehicle Side
3. Harness
4. Drain Cock

Fuel Tank

Service Precautions

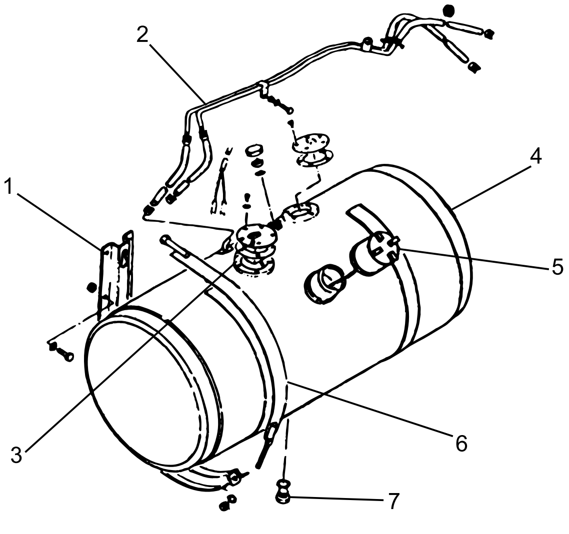
The fuel tank is mounted on the right frame rail and is supported by two brackets. The tank is attached to the bracket by a metal strap backed with a rubber cushion strip. A vent valve is installed at the top of the fuel tank to relieve excess pressure. A drain plug is located in the bottom of the tank for draining purposes. The fuel tank identification tag is located next to the filler cap.

Fuel Tank Replacement

Notice:
To prevent possible accident when working on fuel system, disconnect the vehicle battery negative (-) cable(s) and provide the appropriate fire fighting and safety equipment in accordance with local fire and safety regulations.

Before removing the fuel tank to correct a leak, a careful inspection of the tank should be made to determine the actual source of the leak. “Seam leaks” often turn out to be leaks at the filler neck, fuel line connections, or at the tank sending unit seal. In such cases, fuel runs down the side of the tank to the flanges and drips off at points along the seam giving a false indication of leaking seams. If careful inspection reveals that the tank is actually leaking, remove the tank for repairs as required.

A leaking fuel tank must be repaired or replaced immediately. In addition to increased operating expense, leaking fuel tanks represent a serious fire hazard. No leakage is allowed anywhere in the fuel system lines or tank.



Legend

1. Bracket
2. Fuel Lines
3. Fuel Tank Unit
4. Fuel Tank
5. Filler Cap
6. Mounting Strap
7. Drain Plug

Removal (Side Mounted Type)

1. Battery negative cable.
2. Drain plug.
   - Place a container under the drain plug to catch the fuel.
3. Fuel lines.
4. Wires from the sending unit.
   - On vehicles where the top of the tank is not easily accessible, loosen the mounting strap enough to rotate the tank and disconnect the fuel lines and wires.
   - Place a jack or suitable support under the fuel tank.
5. Nuts from the mounting strap stud bolts.
6. Fuel tank from vehicle.
   - Use a jack or suitable support.

Installation (Side Mounted Type)

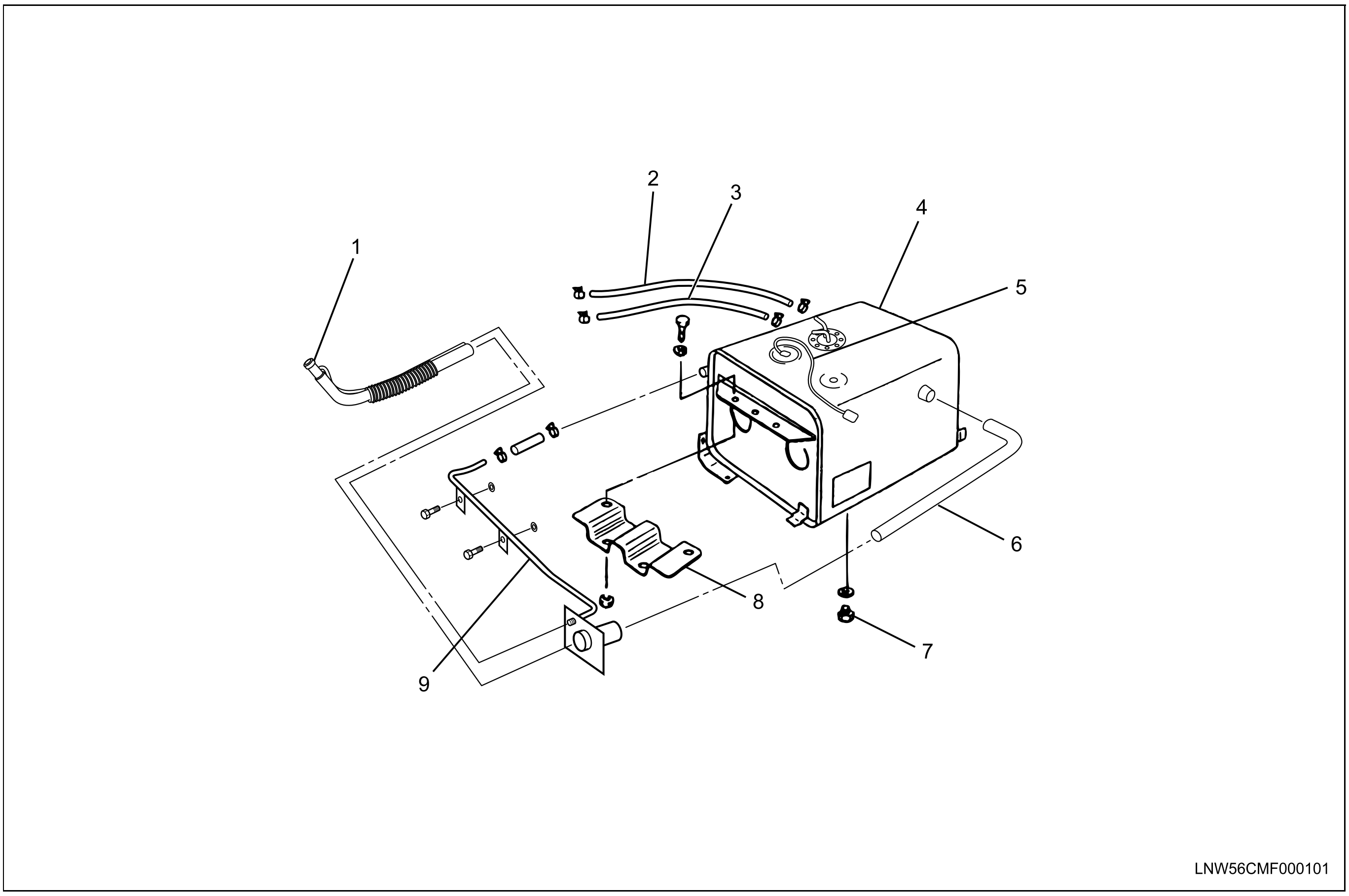
1. Fuel tank onto the bracket.
2. Mounting strap with the rubber cushion strips.

Tightening torque: 30 N·m (22 lb ft)

3. Fuel lines.
4. Wire to fuel tank unit.
5. Drain plug.

Tightening torque: 74 N·m (55 lb ft)

6. Battery negative cable.



Legend

1. Filler Cap
2. Fuel Line
3. Fuel Line
4. Fuel Tank
5. Fuel Tank Unit
6. Fuel Filler Hose
7. Drain Plug
8. Bracket
9. Breather Pipe

Removal (Rear Mounted Type)

1. Battery negative cable.
2. Drain plug.
   - Place a container under the drain plug to catch the fuel.
3. Fuel lines.
4. Wires from the sending unit.
5. Remove the bolts of bracket from tank unit.
   - Use a jack or suitable support.

   Remove the bolts of frame from bracket.
6. Fuel tank from vehicle.
   - Use a jack or suitable support.

Installation (Rear Mounted Type)

1. Temporary install the fuel tank to an attachment position used jack suitable support.
2. Install the bracket.
   - Tighten bolt of bracket frame side.
   - Tighten bolt of bracket fuel tank side.

Tightening torque: 116 N·m (86 lb ft)

3. Fuel lines.
4. Wire to fuel tank unit.
5. Drain plug.
6. Battery negative cable.

Fuel Tank Unit

The fuel tank unit is a float-controlled variable resistor (rheostat). It is mounted on the top of the fuel tank and has a float arm extending inside the tank. The position of the float moves the float arm across the rheostat, thus determining the amount of current sent to the fuel gage in the vehicle. Some models use a protective top to shield the top of the fuel tank unit.

If the fuel tank unit or the dash fuel gage has become inoperative, the only remedy is to replace the inoperative unit.

For checking or diagnosis of fuel tank unit, refer to procedure under the heading of INSTRUMENTS AND GAGES (SEC. 8D) in this manual.

For dash gage replacement, refer to applicable heading under INSTRUMENTS AND GAGES (SEC. 8D) in this manual.

Removal

1. Battery cable.
2. Wires from the top of the fuel tank unit.
3. Fuel tank unit.

Installation

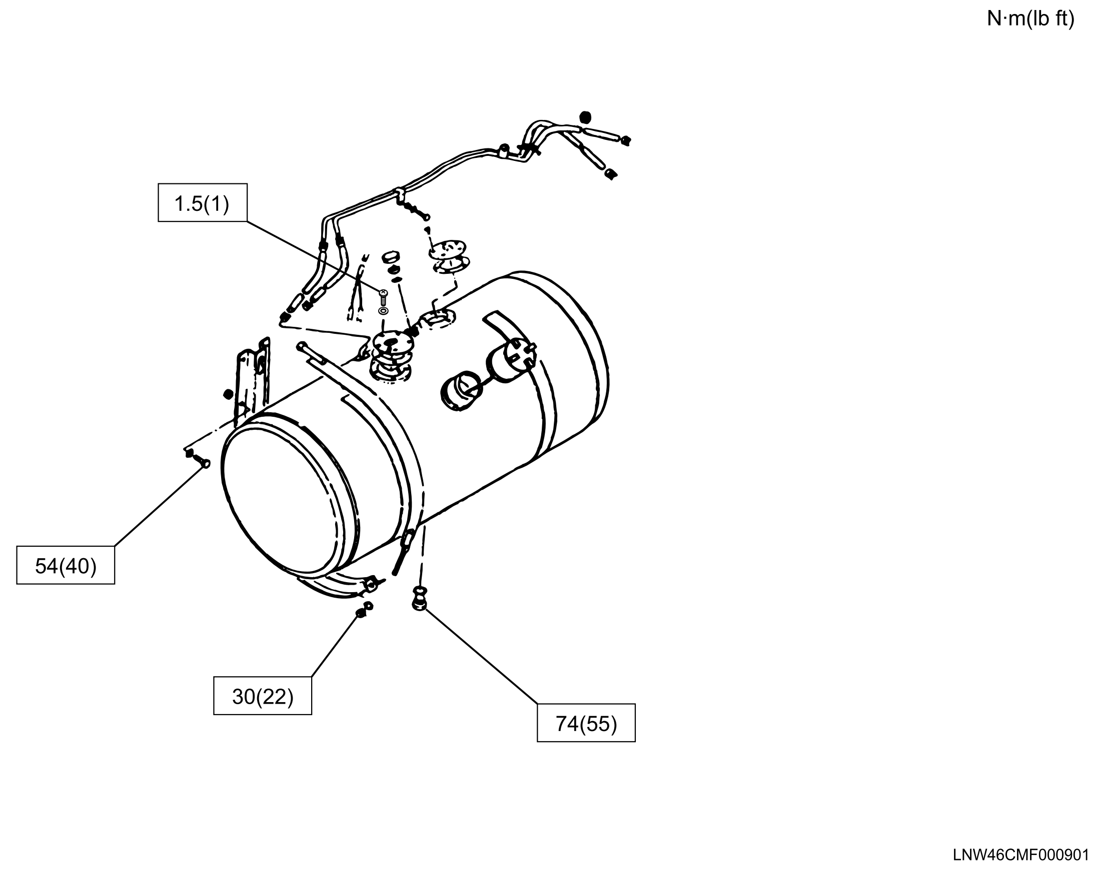
1. Fuel tank unit into the fuel tank.
   - Rotate the fuel tank (Round type) to the correct position.

Tightening torque: 1.5 N·m (13 lb in)

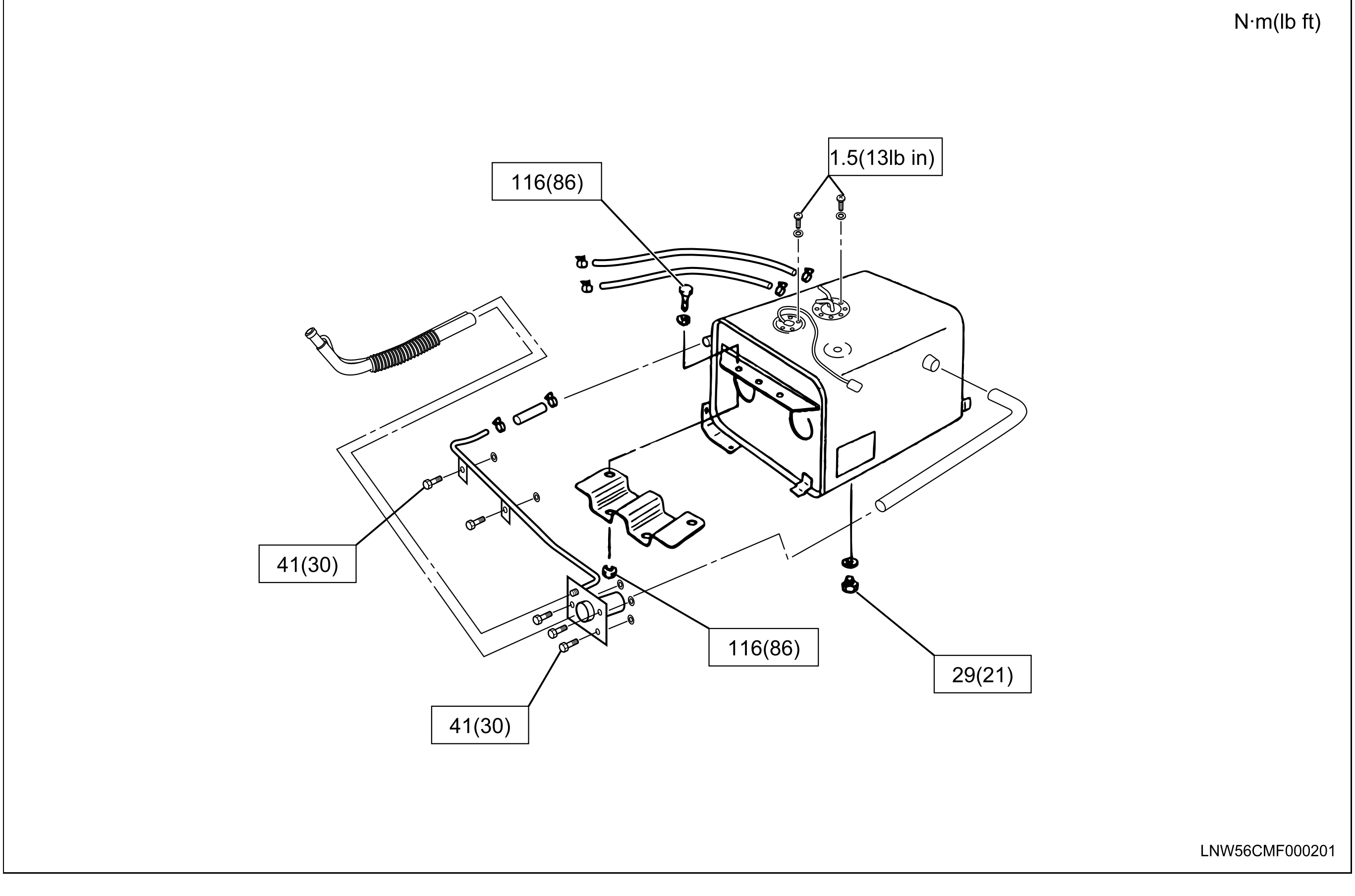
2. Wires to the fuel tank unit.
3. Battery cable.

Torque Specifications

Fuel tank (Side Mounted Type)



Fuel Tank (Rear Mounted Type)



ENGINE

Engine Electrical

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Service Precautions

General Procedure

When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Battery

Description

The battery has three main functions. It provides a source of energy for cranking the engine, acts as a voltage stabilizer for the electrical system and, for a limited time, can provide energy when the electrical load exceeds the output of the generator.

The sealed battery as shown in figure 2 or 3 is standard for all vehicles for 1985. Refer to “Specifications” at the end of this section for specific application.

Water never needs to be added to the sealed battery so there are no filler caps on the cover. The special chemical composition inside the battery reduces gassing to a very small amount at normal charging voltages. There are small vent holes in the cover to allow what little gas is produced inside the battery to escape. The special chemistry is also designed to greatly reduce the possibility of overcharge damage.

Since there are vent holes in the cover, the battery should always be kept in an upright position. A small amount of electrolyte may leak from the top of the battery if it is tipped at an angle of more than 45 degrees.

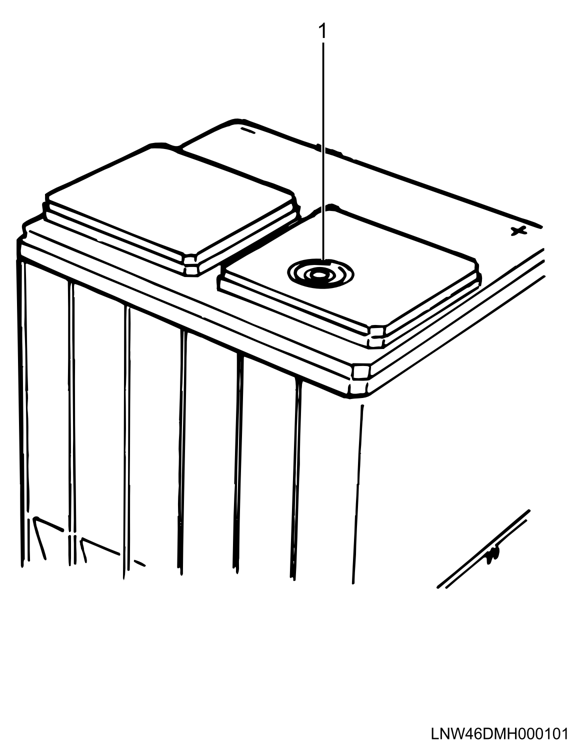
Do not tip the battery more than 45 degrees when carrying or installing it.

Evidence of electrolyte leakage does not necessarily mean that the battery is defective.

Ratings

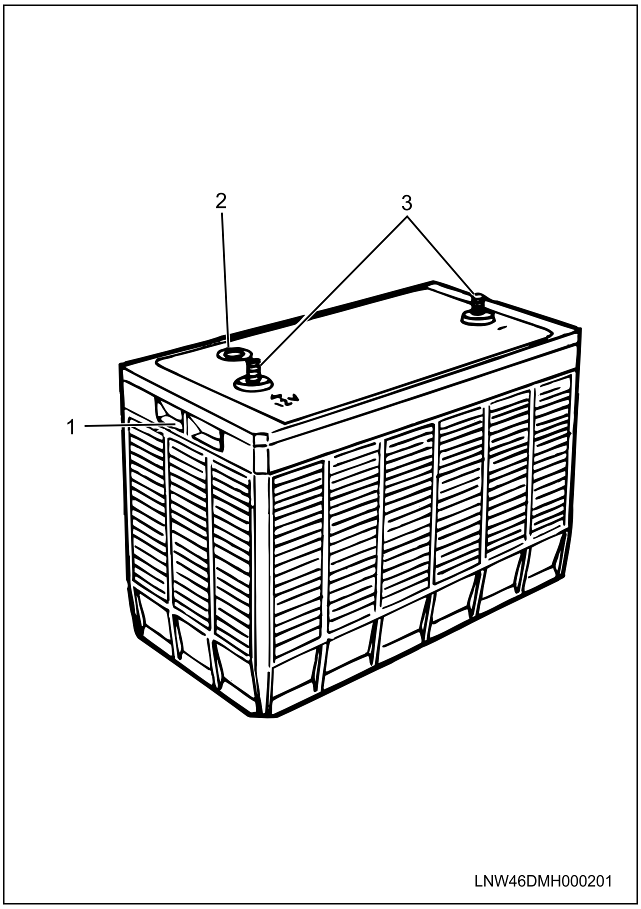
A battery generally has two classifications of ratings:

1. A 20-hour reserve capacity rating at 27°C (80°F).
2. A cold rating at -18°C (0°F), which indicates the cranking load capacity.



Legend

1. Built-in Hydrometer



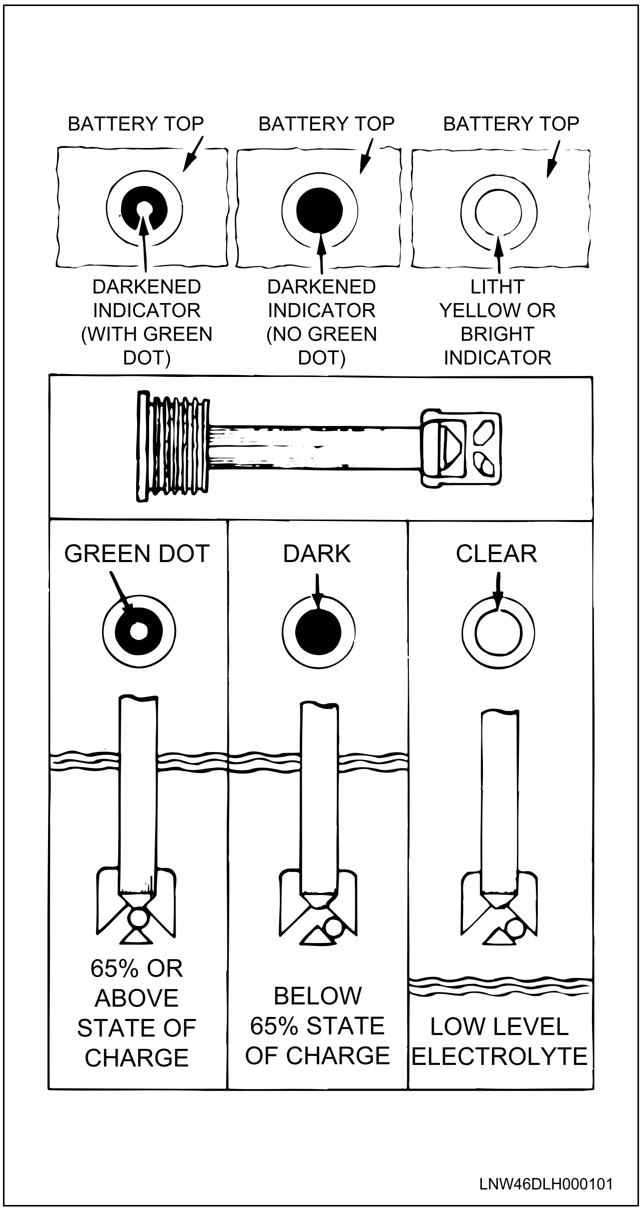
Legend

1. Finger Grip Handles
2. Built-in Hydrometer
3. Terminals

Built-in Hydrometer

The sealed battery has a special temperature compensated hydrometer built into the cover to show the battery's state of charge.

The hydrometer has a green ball within a cage that is attached to a clear plastic rod. The green ball floats at a predetermined specific gravity of the electrolyte representing about a 65 percent state of charge. When the green ball floats, it rises within the cage and positions itself under the rod. A green dot then can be seen in the center of the hydrometer. The built-in hydrometer provides a guide for battery testing and charging. In testing, a visible green dot means the battery is charged enough for testing. If the green dot is not visible, it means the battery must be charged before the test procedure is performed.



In charging, the appearance of the green dot means that the battery is sufficiently charged. Charging can then be stopped to prevent overcharging.

The hydrometer on some batteries may be clear or light yellow. This means the fluid level is below the bottom of the rod and attached cage.

This may have been caused by excessive or prolonged charging, a broken case, excessive tipping or normal battery wearout. If a cranking complaint exists, and the hydrometer is clear or light yellow, replace the battery – do not charge, test or jump start the battery.

In order to properly observe the hydrometer, the top of the battery should be clean. A light may also be required when working in a poorly lit area.

Common Causes of Failure

If tests show that a battery is good, yet it does not perform well in service, one of the following conditions may be the problem:

1. Vehicle accessories left on for an extended period of time.
2. Problem in the charging system, such as a slipping fan belt, high wiring resistance, or a faulty generator or regulator.
3. A vehicle electrical load exceeding the generator capacity, with the addition of electrical devices such as radio equipment, air conditioning, window defoggers, or light systems.
4. Problems in the electrical system, such as shorted or pinched wires.
5. Extended slow-speed driving with many accessories turned on.
6. Loose or poor battery cable-to-post connections, previous improper charging or run-down battery, or loose hold-downs.
7. High-resistance connections or other problems in the cranking system.

Electrolyte Freezing

The freezing point of electrolyte depends on its specific gravity. Since freezing may ruin a battery, it should be protected against freezing by keeping it in a charged condition.

Carrier and Hold-Down

The battery carrier and hold-down should be clean and free from corrosion before installation.

The carrier should be in a sound mechanical condition so that it will support the battery securely and keep it level. Be certain there are no foreign objects in the carrier before installation.

To prevent the battery from shaking in its carrier, the hold-down bolts should be tight. However, the bolts should not be tightened to the point where the battery case or cover will be placed under a severe strain.

Diagnosis of Battery

Visual Inspection

- Battery case or cover for cracks or breaks that could permit loss of electrolyte. Replace the battery if badly damaged, determine the cause of the damage, and correct as needed.

Hydrometer Check

Green Dot Visible

If the hydrometer has a GREEN DOT visible, the battery is ready for testing. Proceed to “Load Test” later in this section.

Green Dot not Visible or Dark

Charge the battery as outlined under the heading “Battery Charging Procedure” later in this section.

Light or Bright Indicator; Illustrated as “CLEAR”

Do not charge, test or jump start the battery.
Replace the battery.

Load Test

Top Terminal Batteries

If there is more than one battery in the vehicle, check each battery separately after disconnecting them from each other.

1. Remove battery cables from battery terminals and proceed as follows:
2. Attach terminal hex nuts, required for testing and charging as shown in figure 5.

Important:

- The alligator clamps of the tester or charger should be placed between the terminal nuts and the lead pads of the terminal studs as shown in figure 5. If the tester clamps cannot be attached between nuts and lead pads of the terminals, the load value of “Load Test” should be 210 amperes.

3. Connect a voltmeter and a battery load tester across the battery terminals.
4. Remove the surface charge from all batteries that have been on charge IF THE GREEN HYDROMETER DOT IS VISIBLE. This includes batteries in the vehicle having been charged by the vehicle generator.

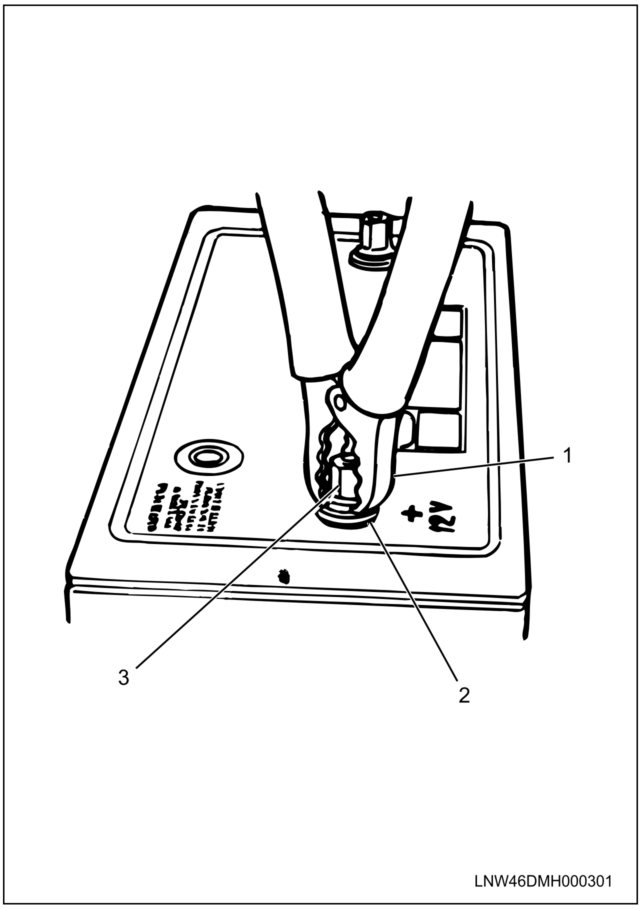
   Do not remove surface charge from batteries that have been in storage. To remove surface charge, apply a 300-ampere load across the terminals for 15 seconds. Then turn off load and wait for 15 seconds to allow the battery to recover.

Voltage and Temperature Chart

Degrees Temperature	Minimum Voltage
21°C (70°F) & Above	9.6

Degrees Temperature	Minimum Voltage
10°C (50°F)	9.4
-1°C (30°F)	9.1
-10°C (14°F)	8.8
-18°C (0°F)	8.5

5. If battery voltage does not drop below the minimum voltage as shown in the previous "Voltage and Temperature Chart," the battery is good and should be returned to service. (The battery temperature must be estimated by feel and by the temperature the battery has been exposed to for the preceding few hours.) If battery voltage drops below the minimum voltage listed, replace the battery.



Legend

1. Alligator Clamp
2. Lead Pad
3. Hex Nut

On-vehicle Service: Battery

Battery Charging Procedure and Rules

The following basic rules apply to any sealed battery charging situation:

1. Do not charge a battery if the hydrometer is clear or light yellow – replace the battery.
2. Charge rates between three and fifty amperes are satisfactory as long as spewing of electrolyte does not occur or the battery does not feel excessively hot (over 52°C (125°F)).
   If spewing occurs or temperature exceeds 52°C (125°F), the charging rate must be reduced or temporarily halted to permit cooling.
3. The battery is sufficiently charged when the green dot in the built-in hydrometer is visible. No further charging is required. Shake or tilt the battery at hourly intervals during charging to mix the electrolyte and see if the green dot appears.
4. Battery charging consists of a charge current in amperes for a period of time in hours. Thus a 25-ampere charging rate for two hours would be 50 ampere-hour charge to the battery. In most cases, batteries whose load test values are less than 200 amperes will have the green dot visible after least a 50 ampere-hour charge. Most batteries whose load test values are greater than 200 amperes will have the green dot visible after at least a 75 ampere-hour charge. In the event that the green dot does not appear, after this amount of charging, continue charging for another 50 to 75 ampere-hours. If the green dot still does not appear, replace the battery.
5. The time required for a charge will vary because:
   a. Size of Battery – Example: A completely discharged large heavy-duty battery requires more than twice the recharging as a completely discharged small passenger car battery.
   b. Temperature – Example: A longer time will be needed to charge any battery at -18°C (0°F) than at 27°C (80°F). When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first, then in time the battery will accept a higher rate as it warms up.
   c. State of Charge – Example: A completely discharged battery requires more than twice as much as a half-charged battery. Because of a completely discharged battery the electrolyte is nearly pure water and a poor conductor, thus current flow accepted is very low at first. As the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.
   d. Charger Capacity – Example: A charger that can supply only 5 amperes will require a much longer period of charging than a charger that can supply 30 amperes or more.

Battery Cables

Excessive resistance caused by poor terminal connections and partial short circuits through defective cable insulation will result in abnormal voltage drop in the starter cable. Low voltage at the starter will cause hard starting.

Caution:
To prevent the vehicle from moving and the engine from starting while performing these checks, engage the parking brake and place the transmission in "Neutral" position.

On diesel engines, disconnect the battery feed terminal connector at the fuel shutoff valve, or pull the "Engine Stop" knob out, as equipped.

Measure

1. Voltage drop between negative (–) battery terminal and vehicle frame.
    - Place one prod of test voltmeter on grounded battery post (not on cable clamp) and the other on frame. Operate starter and note the voltage reading.
2. Voltage drop between the positive (+) battery terminal and starter terminal stud with starter operating.
3. Voltage drop between starter housing and frame with starter operating.
   If the voltage drop in any of the above is more than 1.0 volt, there is excessive resistance in the circuit. To eliminate resistance, the cables should be disconnected and connections cleaned. If cables are frayed or the clamps excessively corroded, the cables should be replaced. When selecting new cables, be sure they are at least as large as the ones being replaced.

Jump Starting

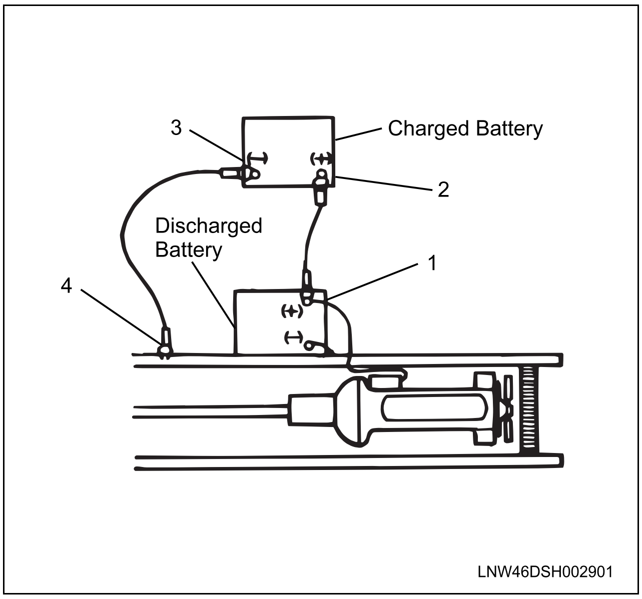
If vehicle has a discharged battery, it can be started by using energy from another battery – a procedure called "jump starting."

Caution:
The instructions below must be followed exactly or personal injury (particularly to eyes) or property damage may result from battery explosion, battery acid, or electrical (short circuit) burns.
The major safety precaution is to make the final connection to ground on the engine at some distance from the battery. This helps reduce the chance of an explosion due to sparks.
To lessen the chance of an explosion, never expose the battery to open flames or electric sparks. Also do not smoke near the battery.
Batteries give off a gas that is flammable and explosive.
To lessen the risk of injury in case an explosion does occur, wear eye protection or shield your eyes when working near any battery. Do not lean over a battery.
Do not allow battery fluid to contact eyes, skin, fabrics, or painted surfaces because battery fluid is a corrosive acid. Flush any contacted area with water immediately and thoroughly. Also get medical help if eyes are affected.
To lessen the risk of a short circuit, remove rings, metal watch bands and other metal jewelry. Also do not allow metal tools to contact the positive battery terminal (or metal in contact with it) and any other metal on the vehicle.
Be certain when attaching the jumper cable clamps" to the positive terminals of the batteries that neither clamp contacts any other metal.

1. This vehicle has a 12-volt starting system and a negative ground electrical system. Be sure that the other vehicle also has a 12-volt starting system and negative ground. Its owner's manual may give you that information.
   IF YOU ARE UNSURE OF THE OTHER VEHICLE'S VOLTAGE (OR IF THE VOLTAGE AND GROUND ARE DIFFERENT FROM YOUR VEHICLE), DO NOT TRY TO JUMP START, AS PERSONAL INJURY OR SEVERE DAMAGE TO ELECTRICAL AND ELECTRONIC PARTS MAY RESULT.
   Because of the extra torque needed to start many diesel engines, diesel powered vehicles often have more than one battery. While it is possible to use the procedure described here to jump start a single-battery vehicle from a vehicle with more than one battery, the opposite may not be true. For example, at low temperature it may not be possible to start a diesel engine. Never connect "+" (red) to "-" (black), or "-" to "+".
2. Position the vehicle with the good (charged) battery so that the jump starting cables will reach. DO NOT ALLOW THE VEHICLES TO TOUCH.

3. Turn off all electrical motors and accessories in both vehicles. Turn off all lights except those needed to protect the vehicle or light up the work area. Turn off the ignition, apply the parking brake firmly. If the vehicle(s) have an automatic transmission, shift to “PARK” (if no “PARK” position, shift to “NEUTRAL”. If the vehicle(s) has a manual transmission, shift to “NEUTRAL”. Do this in both vehicles. For vehicles with AC wheel lock control, refer to step 10.
4. If the discharged battery has filler caps, check the fluid level. DO NOT CHECK NEAR AN OPEN FLAME AND DO NOT SMOKE. Add clear drinking water to the proper level if low, and replace caps before jump starting.
5. Connect the first jumper cable from positive “+” (red) terminal on one battery to the “+” (red) terminal on the other battery. Never connect “+” (red) to “-” (black), or “-” to “+”.
6. Connect one end of the second cable to the grounded negative “-” (black) terminal of the good (charged) battery.
7. Connect the other end of the second jumper cable to a solid, stationary, metallic point on the engine of the vehicle with the discharged battery but at a point AWAY FROM THE BATTERY, 450 mm (18 in) or more from the battery if possible. Do not connect it to pulleys, fans, or other parts that will move when the engine is started.
   Do not touch hot manifolds as they can cause severe burns. If hot or moving parts can be avoided, the MOUNTING BRACKETS for the generator, or the air conditioning compressor, generally make a good point for this final ground attachment point. Take care that the jumper cable does not contact moving parts on or near the generator or compressor.
8. Start the engine on the vehicle with the good (charged) battery and run the engine at a moderate speed.
9. Start the engine of the vehicle that has the discharged battery.
10. Jump Starting – AC Wheel Lock Controls – if it is necessary to jump start the vehicle from a booster battery, the circuit boards in the wheel lock control may be damaged. In order to avoid this condition, the following procedure should be used for jump starting vehicles equipped with wheel lock control:
    a. Connect the jumper cables between the booster battery and the discharged vehicle battery, per normal recommended procedures.
    b. Start the vehicle per normal procedures.
    c. Turn on major electrical accessories including lights and heater blower.
    d. Disconnect the jumper cables from the vehicle battery per normal procedures.
    The above procedure allows the transient energy to be dissipated through several circuits rather than having it all flow through the wheel lock control system.
11. Remove the battery cables by reversing the connecting sequence exactly. Begin by removing the last clamp first; that is, remove the jumper cable from the engine of the vehicle with the discharged battery as the first step.

Notice:
Make connections in numerical order.
Do not allow the vehicles to touch.
Make last connection on frame away from the battery.



Battery Replacement

When handling a battery, the following safety precautions should be observed:

1. Hydrogen gas is produced by the battery. A flame or spark near the battery may cause the gas to ignite.
2. Battery fluid is highly acidic. Avoid spilling on clothing or other fabric. Any spilled electrolyte should be flushed with large quantities of water and cleaned immediately.

Removal

1. Negative cable from negative terminal.
2. Positive cable from positive terminal.
3. Battery hold-down clamp.
4. Battery.

Inspection

- Battery for physical damage, such as a cracked top or battery case, and correct.

Installation

1. Battery.
   - Draw down the hold-down clamp, being careful not to distort or crack the case or cover.
   - Check polaritiy to be sure the battery is not revered with respect to the generator.
2. Positive cable to positive terminal.
3. Negative cable to negative terminal.

Tightening torque:

- Battery cables to the battery: no more than 13 N·m (6 lb ft) for side-mounted terminal batteries, or 20 N·m (14 lb ft) for top mounted terminals.

Specifications

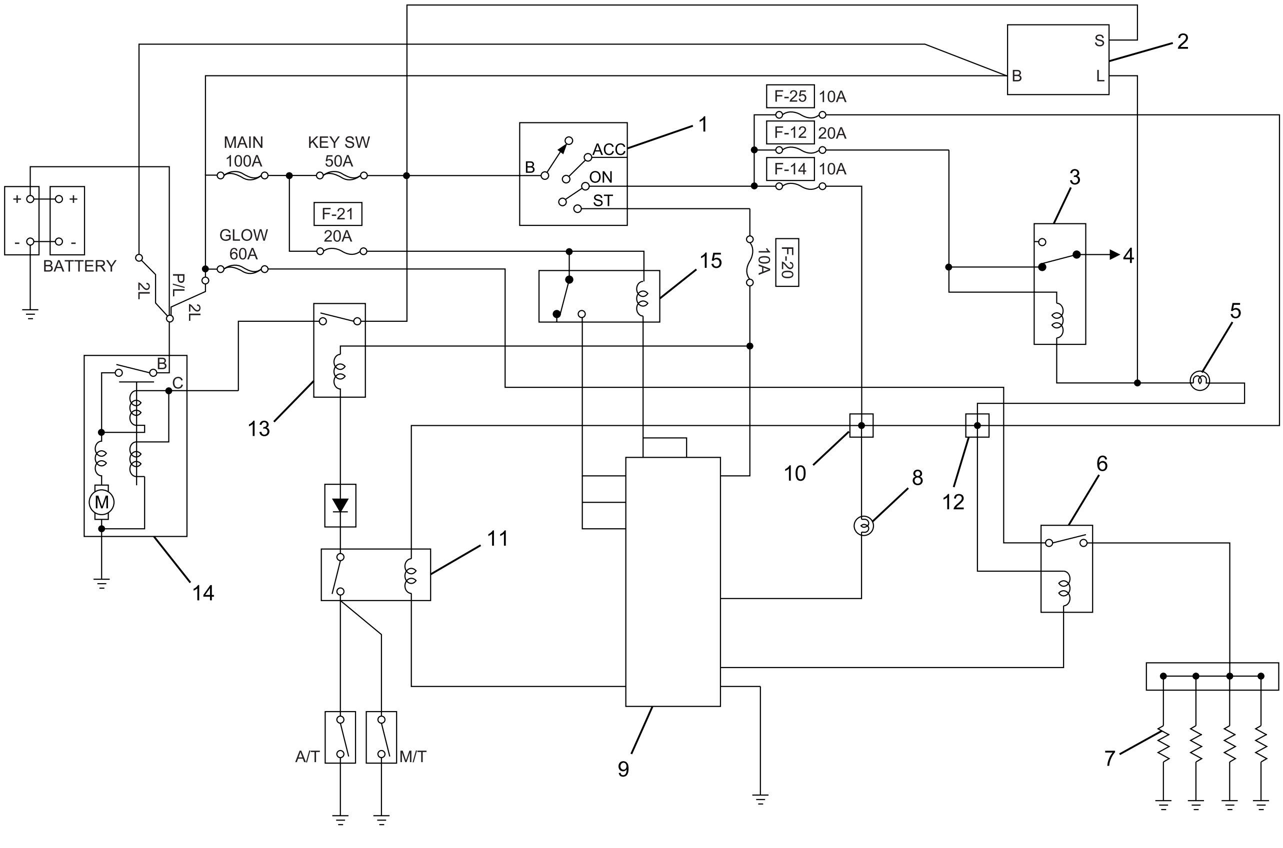
Type	Delco 31-750
Cold Crank Capacity	750 amp
Reserve Capacity (25 Amperes)	160 Minutes

Charging System

General Description

The main charging system components are the batteries, the generator and the battery discharge indicator light circuit. The generator is a 110-amp, selfrectifying type with a built-in regulator. The battery discharge indicator light is mounted in the instrument panel. For more details on this circuit refer to INDICATOR AND WARNING LIGHTS (Section 8).

Circuit Diagram



LNW66DLF000401

Legend

1. Engine control Switch
2. Generator (integral Regulator)
3. Charge Relay
4. To Exhaust Brake Relay
5. Low Charge Indicator Light
6. Glow Plug Relay
7. Glow Plugs
8. Glow Plug Indicator Light
9. ECM
10. Joint Connection – M1
11. Starter Cut Relay
12. Weld Splice – M4
13. Starter Relay
14. Starter.

15. ECM Main Relay

Maintenance

The most common indication of charging system troubles is an undercharged or overcharged battery.

Since the battery itself may be defective, the first step should be to check its condition as described under "Diagnosis of Battery." In the case of an undercharged battery, check for battery drain caused by grounds or by accessories left turned on.

Keep the generator and all other electrical system terminals clean and tight. A loose or badly corroded terminal connection will create excessive resistance in the system and result in hard starting, dim lights etc.

Inspect the generator system at regular intervals and correct any potential causes of trouble before vehicle performance is affected.

Diagnosis of Charging System

Trouble in the charging system will be evidenced as one or more of the following three conditions:

1. The battery discharge warning light will stay on.
2. An undercharged battery as evidenced by slow cranking.
3. An overcharge, or overvoltage, condition.

Undercharged Battery

Inspection

1. Accessories to be sure none were left on for extended periods.
2. Drive belt for proper tension. Refer to "Generator Drive Belt" later in this section.
3. The ECM main relay has been ON stuck at the ignition switch OFF position. (Battery voltage is consumed.)
4. Battery. Refer to "Diagnosis of Battery" earlier in this section.
5. Wiring and connections for corrosion or looseness.

Overcharge (or Overvoltage) condition

A charging rate in excess of 15-volts for a prolonged period may cause early electrical system failure.

Blown fuses. light bulbs burned out, and even battery failure may result. If this condition exists, test the generator as described under "Generator Output Test" later in this section.

Noisy Generator

Inspection

1. Drive pulley for looseness.
2. Mounting bolts for looseness.
3. Bearings for dirt, damage, or wear.
   Generator noise may also be caused by worn or damaged diodes and/or starter.

Electrical Tests

Before performing the following generator electrical tests on the vehicle, be certain that the system wiring is not defective and generator belts are not slipping. Also, the battery must be fully charged for a valid test of the charging system.

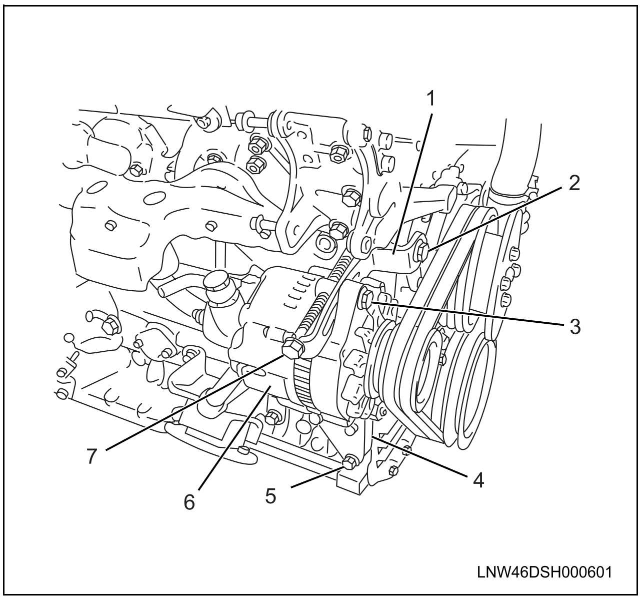
Notice:
To avoid damage to the vehicle electrical system, always observe the following precautions:

- Do not polarize the generator.
- Do not short across or ground any of the terminals in the charging circuit except as specifically instructed herein.
- NEVER operate the generator with the output terminal open-circuited.
- Be sure the generator and battery have the same ground polarity.
- When connecting a charger or booster battery to the vehicle battery, connect negative to negative and positive to positive.

1. With the engine control switch "ON" and engine not running, connect a voltmeter from terminal "E" to ground. The voltmeter should read zero volts.
2. With the engine control switch "ON," and engine not running, connect a voltmeter from terminal "B" to ground. The voltmeter should read at least 12 volts.
3. With the engine control switch "ON" and the engine not running, connect a voltmeter from white wire side of the connector to ground. The voltmeter should show 12 volts.
4. With the engine control switch "ON" and the engine not running, the "charge" light should be on. This shows that the other circuit in the connection is working.
5. With the engine running and the headlight high beams turned on, read the voltage at the "B" post on the generator. The voltage should be at least 13.5 volts.
6. If steps 1 through 4 are not OK, check connectors in the harness for looseness or corrosion and retest.
7. If step 5 voltage is low, substitute a known good regulator and test again. If the voltage is still low, bench test the generator.

Generator

Component



Legend

1. Generator Adjusting Bracket
2. Bracket Mounting Bolt
3. Generator Adjusting Nut
4. Generator Bracket
5. Generator Bracket Mounting Bolt
6. Generator
7. Generator Adjusting Bolt (Model equipped with A/C only)

Repair Instruction

Description of Generator

The generator is a 12 volt, 110-amp, model with a solid state regulator mounted to the brush holder. The generator must be disassembled to remove the regulator or brush holder assembly. The generator rotor bearings contain enough grease to eliminate periodic lubrication. Two brushes carry current through two slip rings to the field coil.

The stator windings are assembled on the inside of a laminated core that forms part of the generator frame. A rectifier bridge connected to the stator windings contains six diodes that change the stator AC voltages to a DC voltage.

The vacuum pump is attached to the rear of the generator.

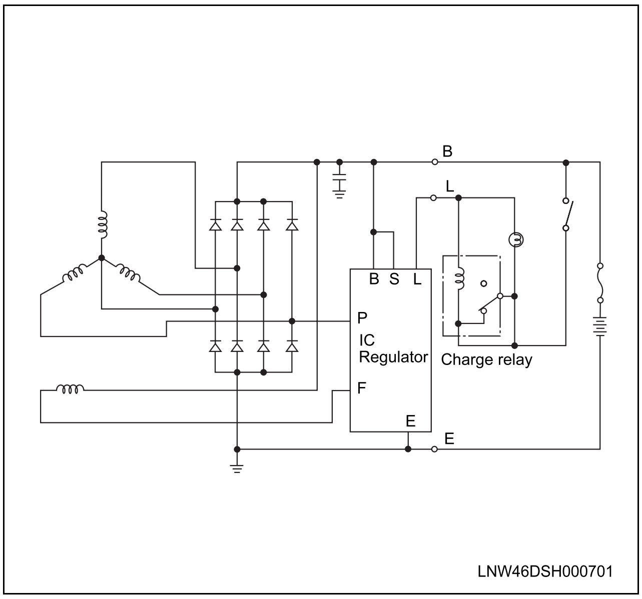
Generator Output Tests

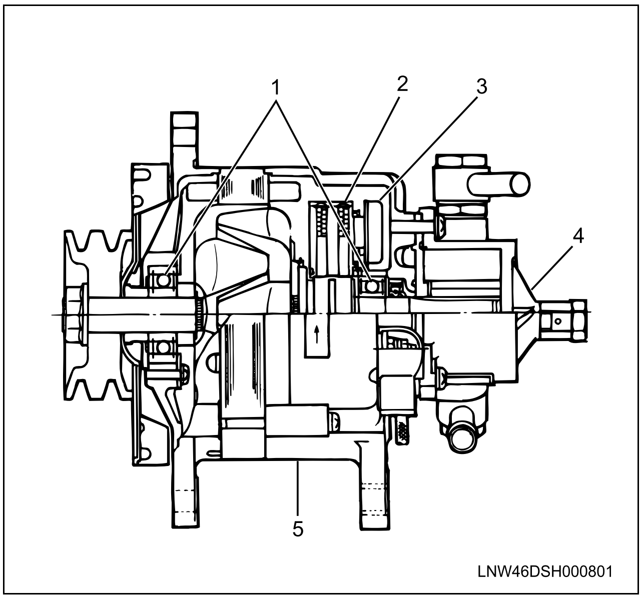
To check the generator in a test stand, proceed as follows:

Important:

- Use a fully charged battery when performing these tests.

1. Connect an ammeter from the positive (+) battery side to the generator output wire. This is 8 mm (0.032 in) (black) wire. Leave the carbon pile disconnected.
2. Slowly increase the generator speed and observe the voltage meter. If voltage is uncontrolled with speed and increases above 15.5 volts on a 12-volt system, replace the regulator and check the rotor winding. If the voltage is below 15.5 volts, connect the carbon pile across the battery.
3. Run the generator at 5,000 RPM and adjust the carbon pile to obtain maximum current output, which should be more than 104 amperes at 14.1 to 14.7 volts.
4. If the output is not within 10 amperes of the rated output, check the rotor winding, rectifier bridge, and stator as described later under “Inspection and Repair” and “Electrical Bench Tests.”





Legend

1. Ball Bearings
2. Brush Holde
3. Voltage Regulator
4. Vacuum Pump
5. Generator

Inspection

- Before performing the generator output test, all charging system components, wires and terminals for wear or damage. Repair or replace any parts found defective.

Removal

- Battery negative cable.
- Remove the A/C compressor. (refer to 6A–16)

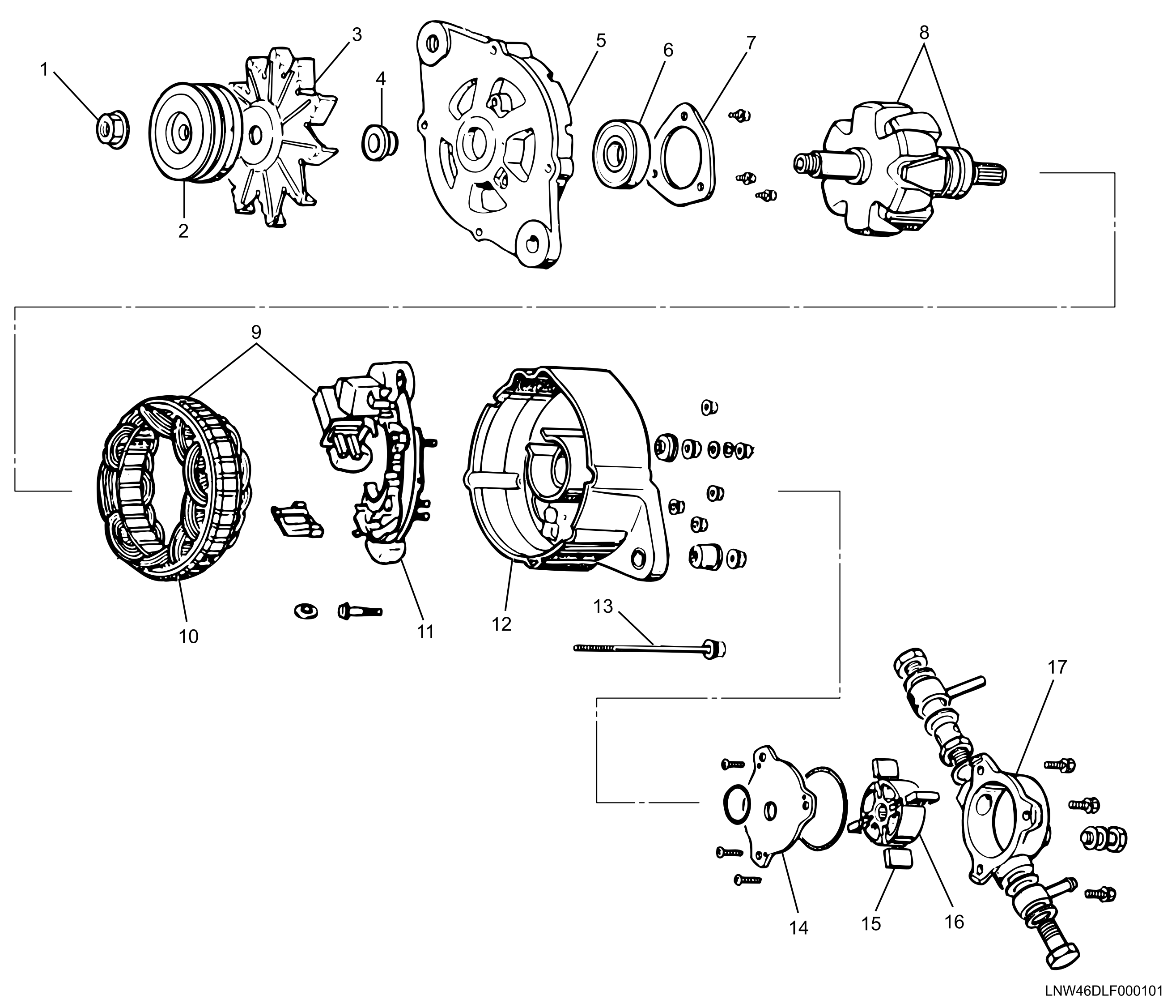
1. Electrical wiring at the generator.
2. Vacuum and oil hoses attached to the rear of the vacuum pump.
3. Loosen the lower mounting bolts.
4. Loosen the adjusting Nut.
5. Drive belts.
6. Adjusting bolts.
7. Generator.

Inspection

- Mount brackets for damage.
- Drive belts for wear or damage.

Disassembly

1. Vacuum pump assembly.
   - Remove the vacuum pump screws attached to the back of the generator. Hold the center plate to prevent the rotor and vanes from dropping out, then remove the vacuum pump in the direction in line with the rotor shaft.
     Remove the center plate fixing screws and the center plate, then remove the rotor and vanes.
2. Through bolts.
   - Separate the front cover assembly from the rear cover assembly.
     When separating the front and rear cover assemblies, be sure the stator assembly stays seated in the rear cover.
3. Pulley and rotor assembly.
   - Be sure not to damage the oil seal when removing the pulley and rotor assembly from the rear cover assembly.
   - Tape the rotor shaft splines to prevent accidental damage.
4. Rear cover and stator assembly.
5. Pulley nut.
   - Clamp the rotor assembly in a vise to remove the pulley nut.
6. Pulley.
7. Fan.
8. Spacer.
9. Rotor and rear bearing.
10. Bearing retainer.
11. Front ball bearing.
12. Front cover.
13. Rear cover.
    - Remove nuts at the rear cover battery terminal and diode holder assembly.
14. Stator and diode assembly
15. Diode assembly.
    - Separate the diodes from the stator by melting the solder on the stator coils, diodes and N terminal leads. When melting solder, hold the lead wire with long-nose pliers to prevent heat from being transferred to the diodes.
16. Stator.



Legend

1. Nut
2. Pulley
3. Fan
4. Spacer
5. Front Cover
6. Front Ball Bearing
7. Bearing Retainer
8. Rotor and Rear Bearing
9. Stator and Diode Assembly
10. Stator
11. Diode Assembly
12. Rear Cover
13. Through Bolt
14. Center Plate
15. Vane
16. Rotor
17. Vacuum Pump

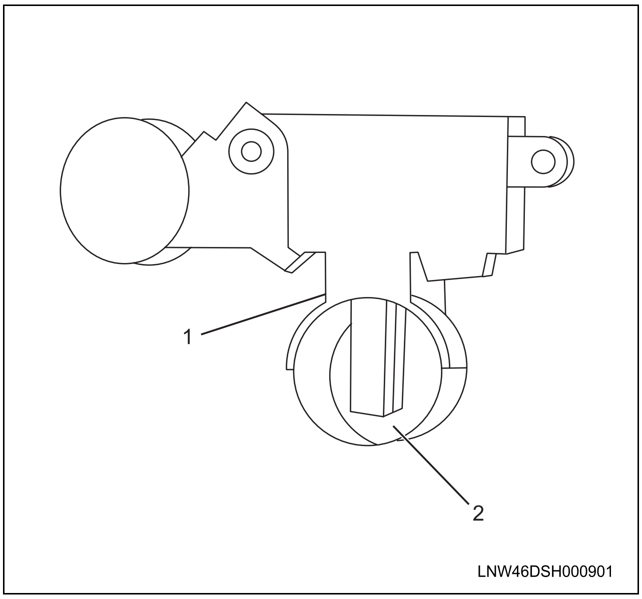
Important:

- Separate the stator and rear cover. Be sure you identify the proper position of the insulated washers to prevent improper installation.

Inspection

- All metal parts except the voltage rectifier bridge, stator, rotor and bearing assemblies in a suitable solvent.
- Wipe or blow the components dry.
- Brush holder and brushes. The brushes have a line that indicates their limit. If the brushes are shorter than 6.5 mm (0.256 in) replace the brushes.
- Voltage regulator for damage or corrosion.

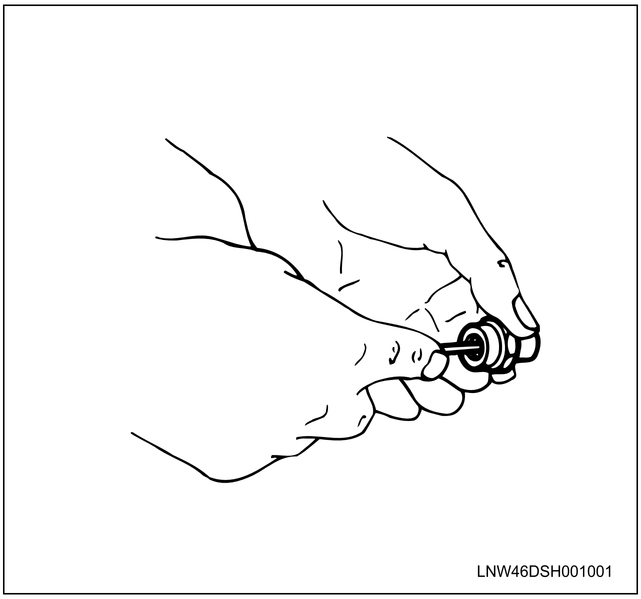
- Bearings and spacer. Rotate the bearing and check for roughness or excessive drag. If in doubt about the bearing, replace it.



Legend

1. Brush Holder
2. Brushes

- Rotor and stator windings for burned insulation or broken terminal connectors, wires, etc.
  Burned insulation may appear as very dark or blackened wiring, and sometimes charred paint or a combination of the two. Replace the rotor or stator if the windings are burned.
- Generator frames. Check for distortion, cracks or damage. Replace as necessary.
- Rotor slip rings. If the rings are dirty, clean them with 500–600 grain or finer polishing cloth.
  Clean the slip rings with rubbing alcohol if the rings are contaminated. Spin the rotor and hold the polishing cloth against the rings until they are clean. Slip rings which are rough, scored, or out-of-round, must be machined in a lathe to 31.7 mm (1.248 in). Finish the slip rings with 500–600 grain or finer polishing cloth and blow away all dust particles after the machining process.
- All vacuum pump components for wear, damage or other abnormal conditions.
- Check valve. Apply a light pressure onto the check valve with a screwdriver and check the valve to be sure it's operating smoothly.



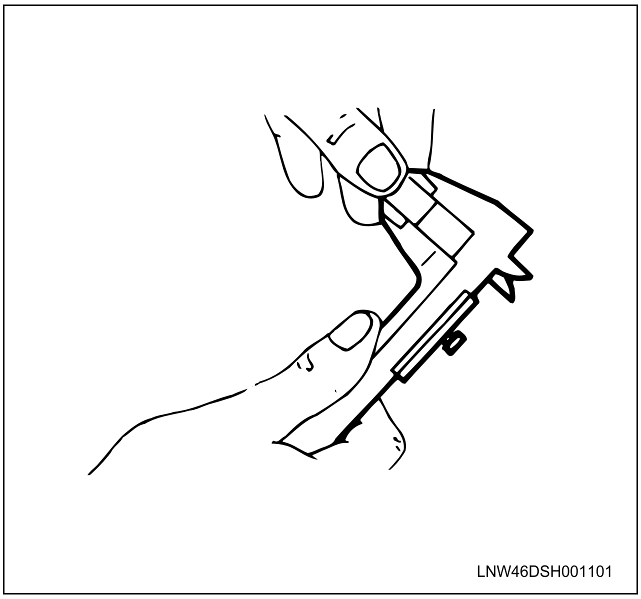
- Oil seal (O-ring). Check the inner face of the rear cover for traces of oil leakage. Be sure the inner face of the oil seal is not worn or damaged.
  If worn or damaged, use a screwdriver to remove the oil seal (O-ring) from the rear cover.
  Install a new oil seal (O-ring) using an oil seal installer or equivalent.

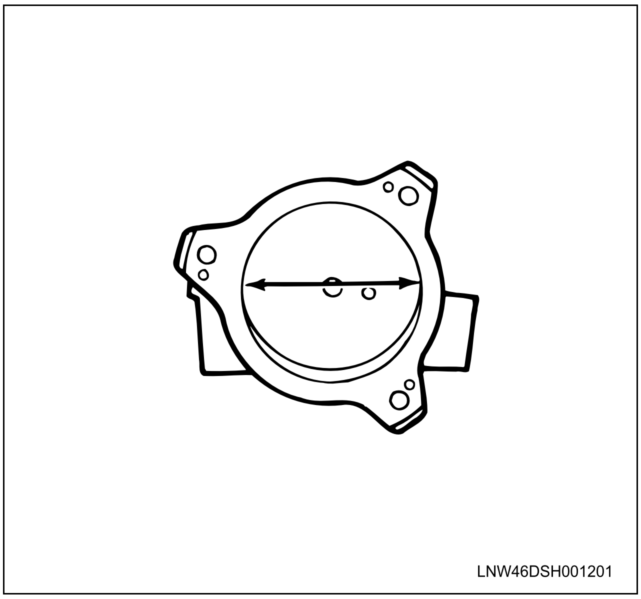
Measure

The length of the vanes	mm (in)
The length	14.0–15.0 (0.551–0.591)

Replace the housing if not within these specifications.

The inside diameter of the vacuum pump housing	mm (in)
The diameter	60.0–60.1 (2.362–2.366)





Electrical Bench Tests (Generator)

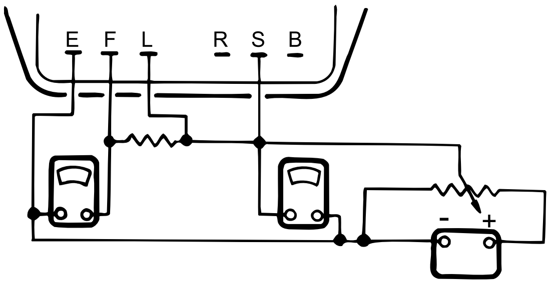
- For an open circuit by connecting a self-powered test light or ohmmeter to each slip ring. If the test light does not come on or if the ohmmeter reading is high (infinite), the winding is open.
- For a grounded winding by connecting a self-powered test light or ohmmeter from one slip ring to the armature shaft. if the light lights or continuity exists, the armature is grounded.
- Shorted winding or high resistance by connecting a 12-volt battery and 0–10 amp ammeter in series with the two slip rings.
- The ammeter should read about 4.1 amps at 12 volts. The specified resistance is 2.9 Ω. An ammeter reading above the specified value indicates shorted windings. An ammeter reading below the specified value indicates excessive resistance. If readings are not to specifications replace the rotor.
- Stator for continuity across the stator leads. If no continuity exists, replace the stator.
- Stator for grounds by first unsoldering the rectifier bridge from the stator. Be sure to mark where the leads go. Then connect a self-powered test light or ohmmeter from each stator lead to the frame. If the test light lights or the ohmmeter indicates continuity, the stator is grounded and must be replaced.
- Check the diodes for continuity with an ohmmeter across the positive (+) side diodes and negative (–) side diodes. If continuity exists, the diode is in satisfactory condition. If no continuity exists, the diode is faulty. Reverse the ohmmeter test leads and check continuity. If no continuity exists, the diode is in satisfactory condition. If continuity exists at any point, the diode is defective and must be replaced.

  Resolder the rectifier bridge leads to the diodes. Then resolder the rectifier bridge to the stator terminals.
- IC voltage regulator. Measure the voltage across the E and F terminals. Voltage must be between 14.1–14.7 volts at 20°C (68°F). The meter should show a varying resistance gradually from zero using a rheostat. The voltage should increase abruptly about 2 volts. If the voltage if interrupted, replace the regulator.
- Measure the voltage across the L, S, and E terminals. Voltage must be 14.1–14.7 volts at 20°C (68°F). The meter should show a varying resistance gradually from zero using a rheostat. The voltage should increase abruptly 2–6 volts.

  If the voltage is interrupted, replace the regulator.
- Measure the voltage across the B, L and E terminals. Voltage must be 14.9–16.5 volts at 20°C (68°F).

  The meter should show a varying resistance gradually from zero using a rheostat.

  The voltage should increase abruptly. If the voltage is interrupted, replace the regulator.



Reassembly

Important:

- When connecting the stator coil leads and diode leads using solder, use long-nose pliers and work as quickly as possible to prevent the heat from transferring to the diodes.

1. Stator.
2. Diode assembly.
3. Stator and diode assembly.
4. Rear cover
5. Front cover.
6. Front ball bearing.
7. Bearing retainer.
8. Rotor and rear bearing
9. Spacer.
10. Fan.
11. Pulley.
12. Pulley nut.

Tightening torque:

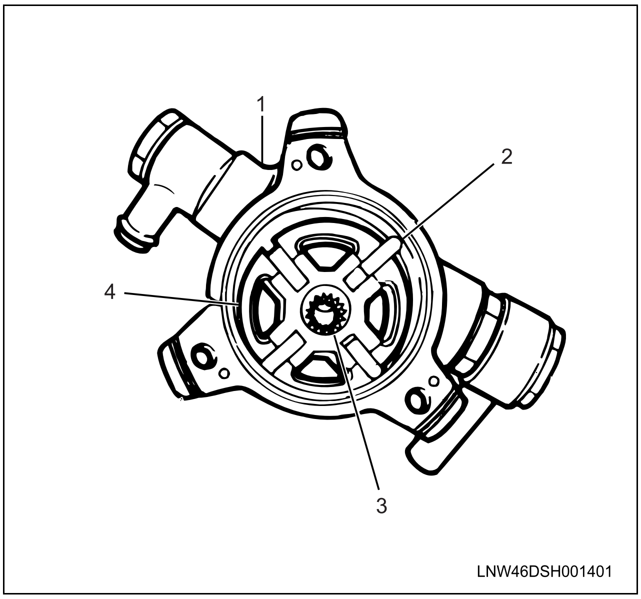
Pulley nut: 84 N·m (62 lb ft)

13. Rear cover and stator assembly.
    - Position the projected portion of the ring on the bearing so that the projection becomes minimal.
14. Pulley and rotor assembly.
    - Install the pulley and rotor assembly holding the brushes pushed in with a paper clip. Remove the tape on the rotor shaft splines and insert the pulley and rotor assembly into the rear cover assembly.
15. Through bolts.
    - Place a guide bar through the holes in the front cover and rear cover flange for proper alignment. Install the through bolts.

Tightening torque:

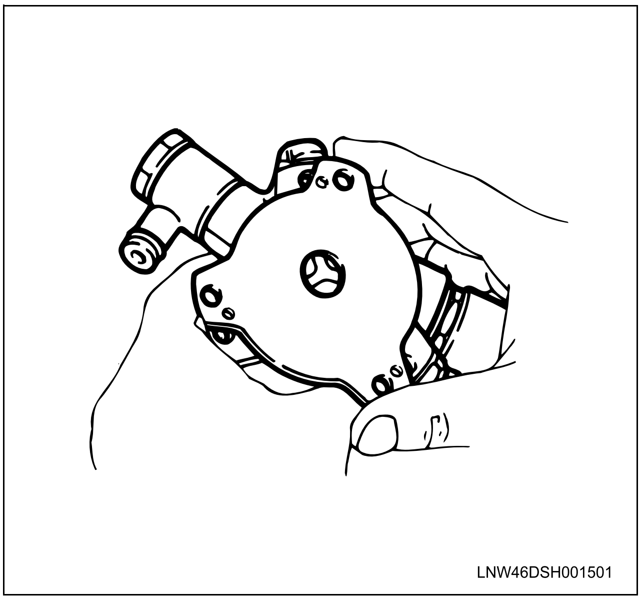
Through bolts: 4 N·m (35 lb in)

16. Vacuum pump assembly.
    - Position the rotor, with the serrated boss turned up, on the center plate and housing.



Legend
1. Vacuum Pump
2. Vane
3. Serrated Boss
4. Rotor

- Align the holes in the center plate and rotor.
- Install vanes into the slits in rotor.
  The vanes must be installed with the round side turned outward.
- After installation of seal (O-ring), install the center plate.



- Install the vacuum pump assembly to the back of the generator with 3 screws.

Tightening torque:

Vacuum pump screws: 7 N·m (61 lb in)

- Install 5 cc (0.016 oz) engine oil in the filler port, then check that the generator pulley can be turned smoothly by hand.

Installation

1. Generator.

Tightening torque:
Bracket Mount Bolt 46 N·m (34 lb ft)

2. Adjusting bolts.

Tightening torque:
Adjusting Nut 24 N·m (17 lb ft)

3. Drive belts.

Tightening torque:
Lower mount bolt 40 N·m (30 lb ft)

4. Vacuum and oil hoses at the vacuum pump.
5. Electrical wiring at the generator.
   - Battery negative cable.
6. Install the A/C compressor. (refer to 6A–18)

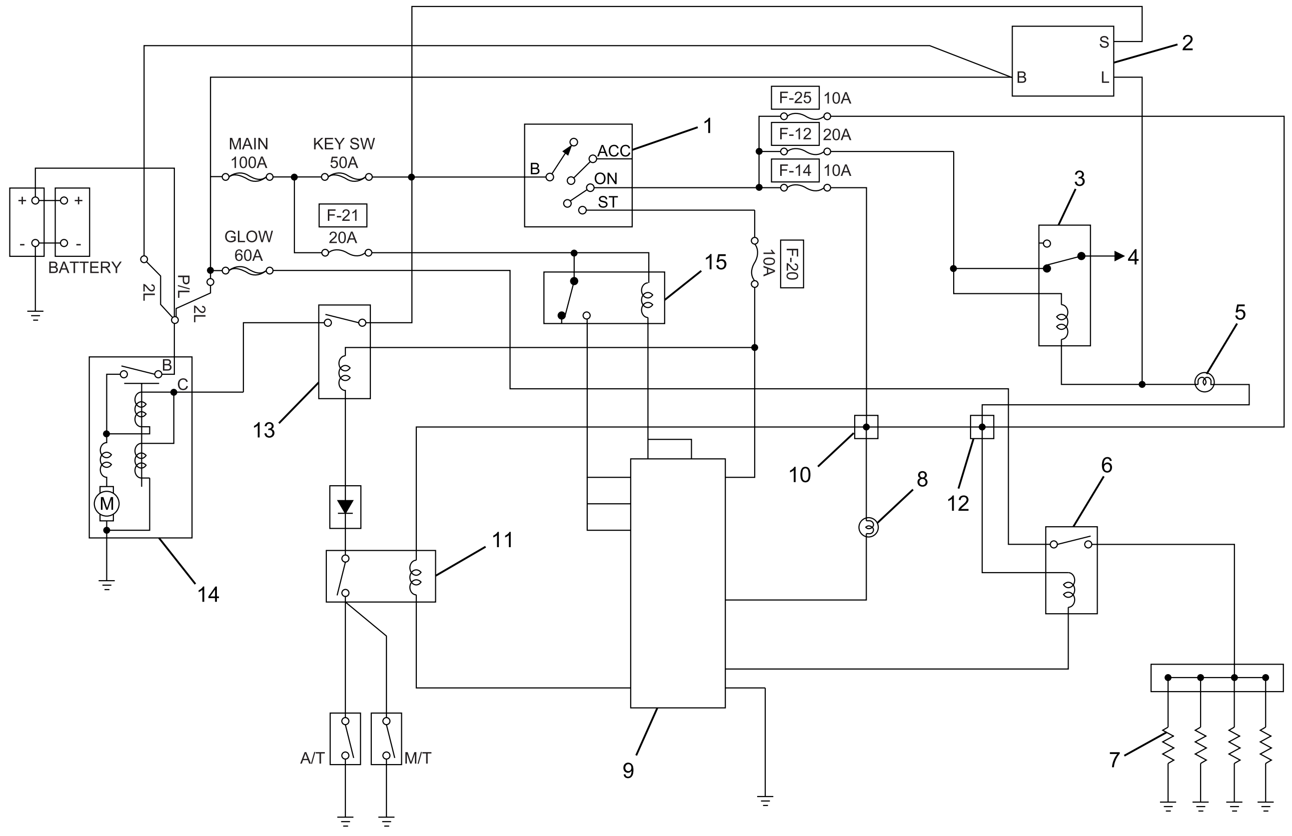
Main Data and Specifications

Rated Voltage	12 V
Rated Output	110 amp
Rated Output at 5000 RPM	More than 104 amp
Regulated Voltage	14.1 – 14.7 V
Brush Length	
Standard	25 mm (0.984 in)
Limit	6.5 mm (0.256 in)
Slip Ring Diameter	
Standard	31.7 mm (1.248 in)
Limit	30.6 mm (1.205 in)
Generator Pulley Direction (Viewed From Pulley Side) Clockwise Pulley	
Pulley Diameter	82 mm (3.23 in)
Generator Weight (With Vacuum Pump)	83 N (18.7 lb)
Maximum Vacuum Pump Output	90.7 kPa (26.8 in Hg)
Vacuum Pump Vane	
Standard Length	14.0–15.0 mm (0.551–0.591 in)
Vacuum Pump Housing Inside Diameter	
Standard	60.0–60.1 mm (2.362–2.366 in)

Starting System

General Description

Circuit Diagram



LNW66DLF000401

Legend

1. Engine control Switch
2. Generator (Integral Regulator)
3. Charge Relay
4. To Exhaust Brake Relay
5. Low Charge Indicator Light
6. Glow Plug Relay
7. Glow Plugs
8. Glow Plug Indicator Light
9. ECM
10. Joint Connection – M1
11. Starter Cut Relay
12. Weld splice – M4
13. Starter Relay
14. Starter
15. ECM Main Relay

Starter and Glow Plug Relays

The starter is a 3 kilowatt, reduction drive model.

The gear housing and armature end bearing housings are aluminum. The brush assembly has replaceable brushes. The commutator bars are mica insulated and are undercut.

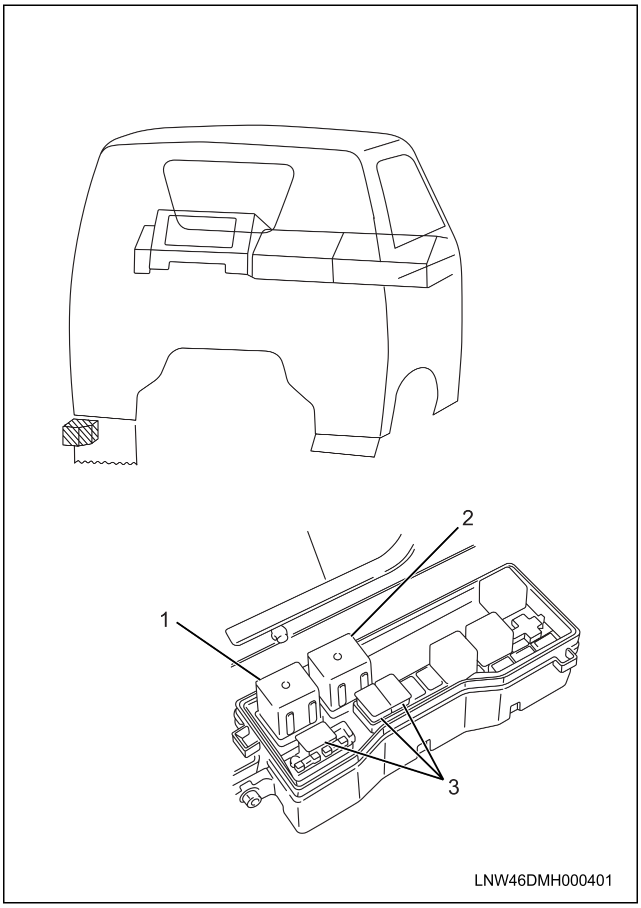
The starter circuit starts at the batteries. The battery cable goes to the large terminal on the starter.

From that terminal wires lead to the engine control switch and the starter relay.

From the engine control switch the starter circuit goes through Fuse #3 and the transmission neutral switch to the starter relay. When the engine control switch is turned to start and the transmission neutral switch is closed, the starter relay closes to complete the circuit from the batteries to the starter solenoid. The starter circuit is also connected to the

Engine Control Module (ECM). The Engine Control Module (ECM) operates when the engine control switch is turned to the “ON” position.

The starter and glow plug relays are located on the frame at the left rear side of the cab.



Legend

1. Starter Relay
2. Glow Plug Relay (exclude OBD II specification)
3. Slow Blow Fuse

Maintenance

Keep the starter’s exterior clean. Remove corrosion from the terminals, leads, and connectors.

Tighten the starter to engine mounting bolts and the electrical cable retaining nuts.

Diagnosis of Starting System

No Cranking, No Sound

- Discharged batteries. Turn on the headlights and check the brightness. If the headlights are dim, charge the batteries. Check for the cause of the discharged batteries.
- Sulfated battery terminals. Turn on the headlights. The headlights will be bright. Attempt to start the engine. The headlights will be very dim or go out. Clean all the battery terminals and cable ends.
- A starter that draws too much current.
- Starter relay won’t work. Attempt to start and listen for a “click” at the starter relay. If there is no “click,” check the starter relay control terminals with a test light. If the test light shows that power is getting to the starter relay, check the ground circuit with the test light. If the ground circuit is OK, replace the starter relay.
- Engine control switch start circuit won’t close.
  With the engine control switch turned to start, check the starter relay with a test light. If the test light doesn’t come on, check the starter circuit at the engine control switch with the test light. If the test light comes on, check the harness for an open and repair. If the test light does not come on, replace the engine control switch.
- Starter relay power circuit isn’t closing. Attempt to start. The starter relay “clicks.” Check the secondary terminals with a test light. If the test light lights on the battery side only, replace the starter relay. If the test light lights on both terminals, check for an open at the starter.
- Starter clicks when start is attempted. Check all power connections for corrosion. Clean connections if corrosion is present. Terminal on starter should have at least 9 volts on it when cranking the engine. If voltage is OK, replace the starter.
- Starter cut relay
  If the problem found, repair the flowing circuit as necessary.
  - Starter cut relay ground circuit. (Between starter cut relay and ECM.)
  - ECM power supply circuit. (Between fuse 10 A and starter cut relay circuit.)
- Neutral switch or inhibitor switch
  If the problem found, repair thr flowing circuit as necessary.
  - Neutral switch or inhibitor switch ground circuit. (Between Frame-LH and neutral switch.)

  - Starter relay power supply circuit. (Between fuse 10 A and starter relay.)
  - Starter relay ground circuit. (Between starter cut relay and diode.)

Slow Cranking, Solenoid Clicks or Chatters

- Discharged batteries. Turn on the headlights and check the brightness. If the headlights are dim, charge the batteries. Check for cause of discharged batteries.
- Corrosion on the battery terminals. Check for corrosion. Hint: Test for warm terminals. Clean all the battery terminals and connectors.
- Loose or dirty connections. Measure the cranking voltage at the battery terminals. If the voltage is less than 9.6 volts, load test the battery. If the battery is bad, replace the battery. If the battery is good, repair the starter.

If the voltage is 9.6 volts or more, measure the voltage from the battery NEGATIVE terminal to the engine block. If the voltage is 0.5 volt or more, repair the ground cable and connections.

If the voltage is less than 0.5 volt, measure the voltage at the battery cable terminal on the starter. If the voltage is 9 volts or more, repair the starter. If the voltage is less than 9 volts, clean and tighten the positive cable connections. If the voltage is still less than 9 volts, replace the positive cable.

On-vehicle Service: Starter System

Maintenance

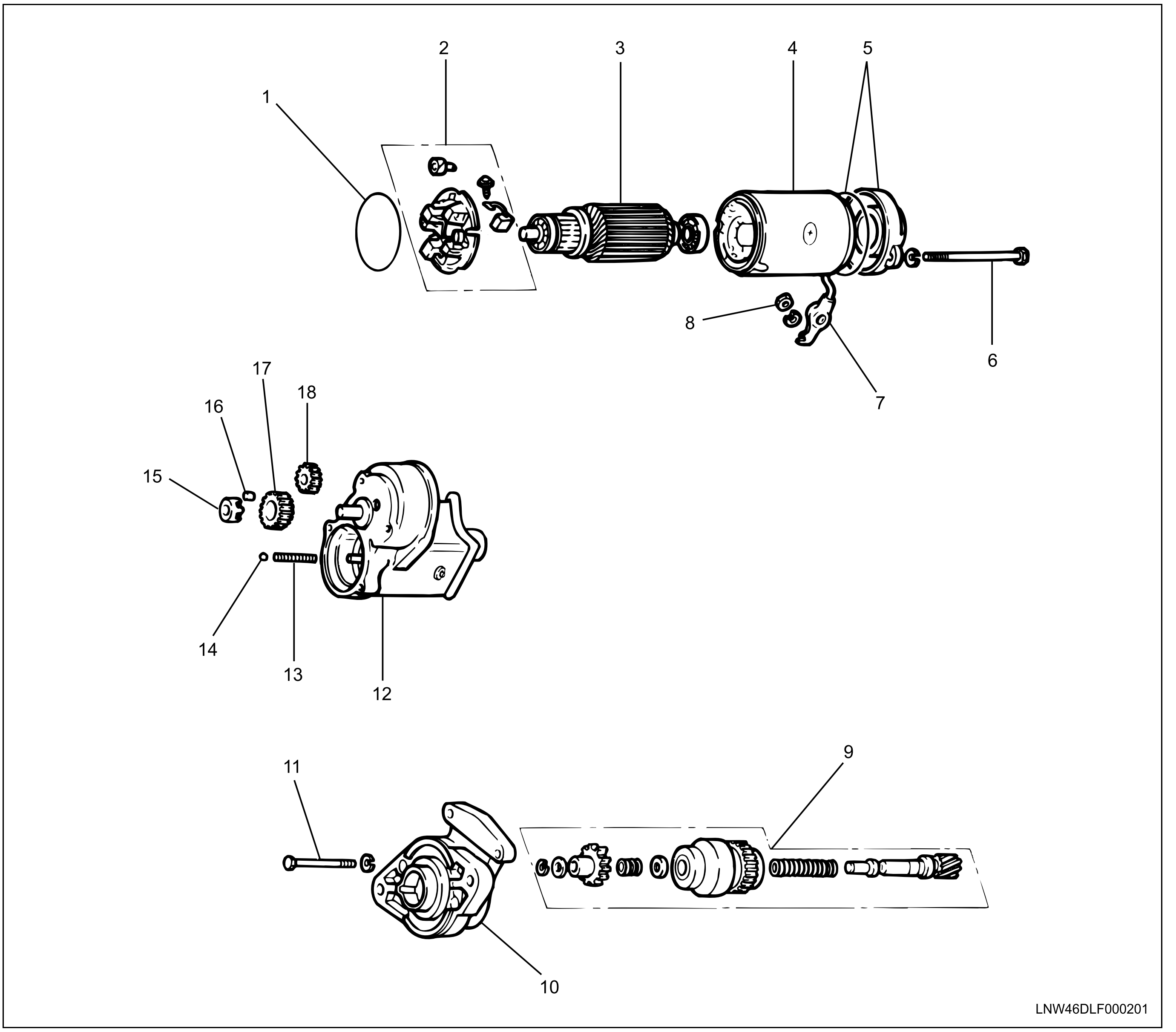
Keep starter terminals and all other terminals in the electrical system clean and tight. A loose or corroded connection or terminal will cause excessive resistance in the system that will result in hard starting.

At regular intervals, inspect the starting system to locate and correct potential causes of trouble before the system performance is affected.

Starting motors do not require lubrication except during overhaul.

Starter

Components



Legend

1. Seal
2. Brush and Brush Holder
3. Armature
4. Field Frame
5. End Frame
6. Through Bolt
7. Lead Wire
8. Nut
9. Clutch Assembly
10. Drive Housing
11. Screw
12. Solenoid Housing Assembly
13. Ball Spring
14. Steel Ball
15. Retainer
16. Roller
17. Pinion
18. Pinion

Repair Instruction

Description of Starter Motor

The 3 kw starter motor is a gear-reduction type with a direct-acting solenoid working through the gear clutch. The ball bearings on the clutch assembly are serviced as part of the whole clutch assembly. The starter is constructed of three main assemblies. The starter housing, starter field frame assembly, and starter end frame. The starter housing encloses the starter clutch assembly. The starter field frame contains the starter armature and field coils, and the starter end frame encloses the rear of the starter field frame that has two through bolts attaching to the starter housing.

Diagnosis Prior to Disassembly

Before disassembling the starter motor for repair, the following test should be made.

Notice:
Never operate the starter motor more than 30 seconds at a time. Allow it to cool at least two minutes before operating again.
Overheating, caused by too much cranking will damage the starter motor.

Starter Motor Tests

With the starter motor removed from the engine, the pinion gear should be checked for freedom of operation by turning it on the spline shaft. The armature should be checked for freedom of rotation by turning the pinion gear with a screwdriver. Keep in mind that there is more drag with a gear reduction starter motor. Tight bearings, a bent armature shaft, thick grease or a loose pole shoe will cause a high level of drag. If the drag is low with no sounds of grinding or jamming, the motor should be given a no-load test before disassembly.
Before giving the starter a no-load test, test the solenoid operation as follows:

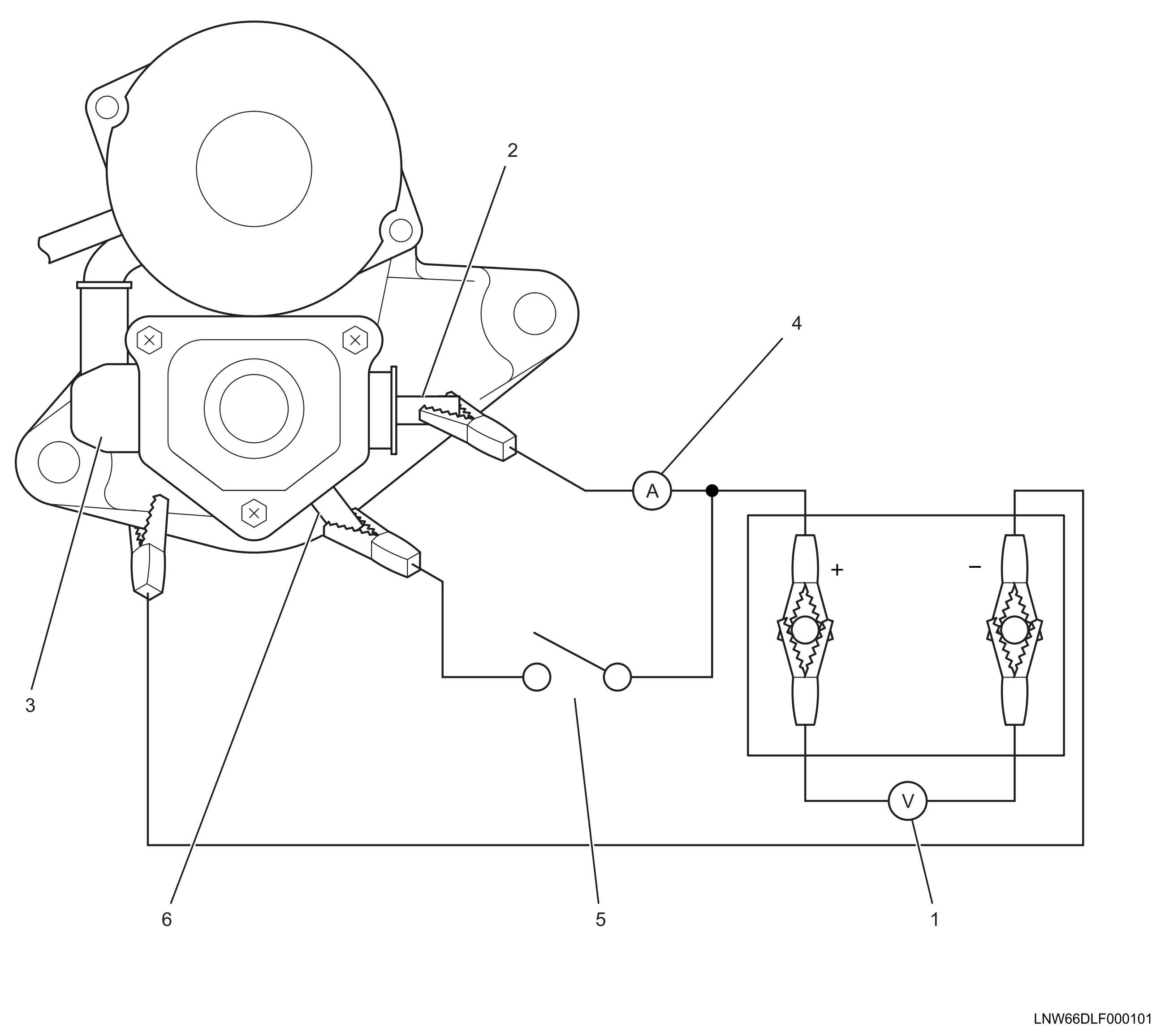
1. Connect a 12V battery source, and turn on the switch.
2. The solenoid should pull in as indicated by the pinion gear moving to the end of the shaft.
3. If the solenoid does not operate properly, repair the solenoid before giving the starter a no-load test. Refer to “Disassembly of Starter Motor,” later in this section.

No-Load Test

1. Secure the starter in a vice. Do not clamp around field frame.
2. Connect the starter motor and ammeter in series, being sure the battery is fully charged (12 volts). Observe the operation of the starter after the pinion clutch gear engages.
   The starter should draw 11.0 volts and 220 amps or less. The armature speed should be 4,200 RPM or more as indicated on the tachometer.
   - It is not necessary to obtain the exact voltage specified as a good reading can be made by understanding that if the voltage is slightly higher, the RPM will be slightly higher, with current remaining basically unchanged. However, if the exact voltage is desired, a carbon pile connected across the battery can be used to reduce the voltage to the specified value.
     If more than one 12-volt battery is used in series, connect the carbon pile across only one of the 12-volt batteries.

No-Load Test Results

1. Rated current draw and no-load speed indicates normal condition of the starter motor.
2. Low free speed and high current draw indicates:
   - Too much friction. Tight, dirty or worn bearings, bent armature shaft or loose pole shoes allowing the armature to drag.
   - Shorted armature. This can be furthers checked on a growler after disassembly.
   - Grounded armature or fields. Check further after disassembly.
3. Starter motor is not turning. Ammeter shows high current draw. This indicates:
   - A direct ground in the terminal or fields.
   - “Frozen” bearings. This should have been noted by turning the armature manually.
4. Starter motor is not turning. Ammeter shows no current draw. This indicates:
   - Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing the circuit with a test light.
   - Open armature coils. Inspect the commutator for badly burned bars after disassembly.
   - Broken brush springs, worn brushes, high insulation between the commutator bars or other causes that would prevent good contact between the brushes and commutator.
5. Low no-load speed and low current draw indicates a high internal resistance due to:
   - Poor connections.
   - Faulty leads.
   - Dirty commutator.
   - Causes listed under number 4.



Legend

1. Voltmeter
2. Solenoid Battery Terminal
3. Solenoid Motor Terminal
4. Ammeter
5. Switch
6. Solenoid Start Terminal

6. High free speed and high current draw indicate shorted fields.
   If shorted fields are suspected, replace the field coil assembly and check for improved performance.

Removal

1. Battery negative cable from the battery.
2. Cables and electrical leads from the starter.
3. Two mounting bolts.
4. Starter.

Disassembly

- Clean the outside of the starter motor and scribe alignment marks across the drive housing and field frame.

1. Nut and lead wire.
   Disconnect the nut and lead wire from the solenoid.
2. Through bolts and end frame.
   Remove two through bolts and end frame from the field frame.
3. Field frame.
   Separate the field frame from the solenoid.
4. Field frame seal (O-ring).

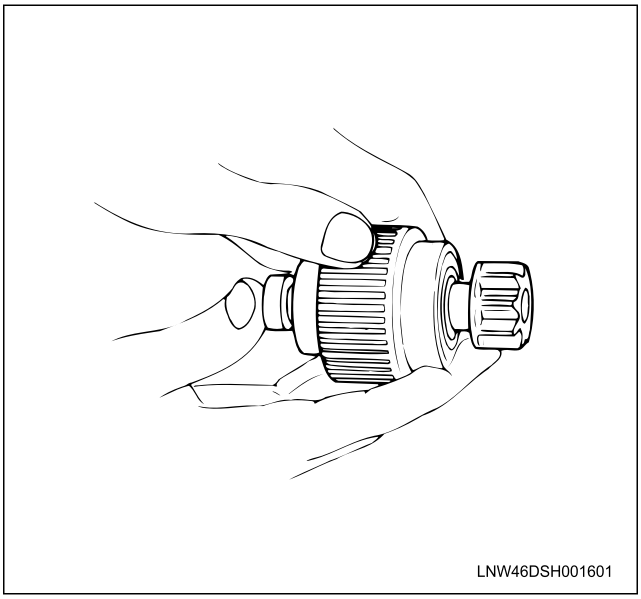
5. Brush and brush holder.
   Using long-nose pliers, remove the brushes and pull out the brush holder from the armature.
6. Armature.
   Using a plastic hammer, tap on the field frame end to separate the armature from the field frame.
7. Screws.
   Remove three screws from the drive housing and separate the drive housing from the magnetic switch.
8. Drive housing.
9. Pinions.
   Remove two pinions and remove the overrunning clutch and retainer.
10. Retainer.
11. Roller.
12. Pinion clutch assembly.
13. Steel ball.
    Remove the steel ball from the clutch assembly.
14. Ball spring.
    Remove the steel ball from the clutch assembly.
15. Solenoid housing assembly.

Inspection

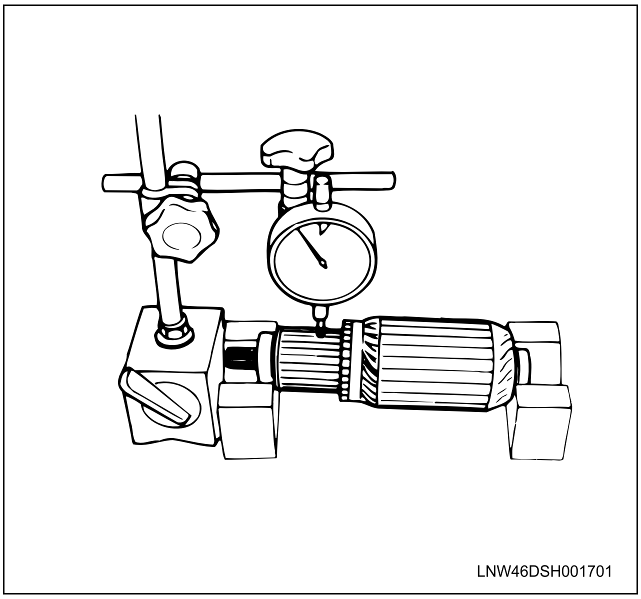
Clean

- All disassembled parts.
- Be careful not to let solvent get into the clutch assembly or the sealed bearing. Don't wash the armature bearings in solvent.
- Use electrical parts cleaner on the solenoid coil, brushes, armatures, and field coils.

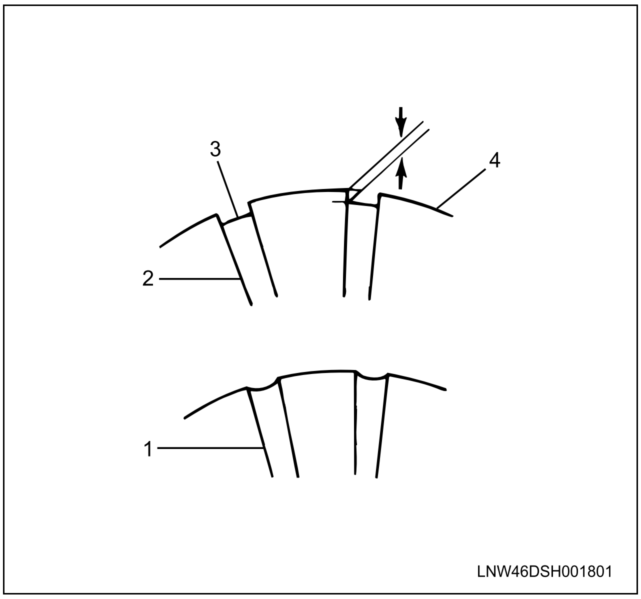
1. Starter housing.
   - Housing for cracks or damage.
   - Clutch bearing bore for signs of bearing spin.
   - Flange surface for flatness.
   - Replace the housing if worn or damaged.
2. Clutch assembly.
   - Pinion gear for badly worn or chipped teeth, or for wobble on the shaft.



   - Bearings for wobble, roughness or damage.
   - Clutch for roughness or slipping.
   - Drive gear for badly worn or chipped teeth.
     Replace the clutch assembly if its condition is doubtful.
3. Pinion gears.
   - Teeth for wear or damage.
   - Inner surface for wear or damage.
4. Roller bearing for wear. Assemble the gear and bearing on the solenoid housing stub shaft and check for wobble.
5. Solenoid housing for cracks or other damage.
6. Solenoid for damage.
7. Armature.
   - Commutator to runout and replace the armature if runout is less than 0.2 mm (0.0079 in).



- Commutator segments for wear or damage. The depth of each segment must not be less than 0.2 mm (0.0079 in).

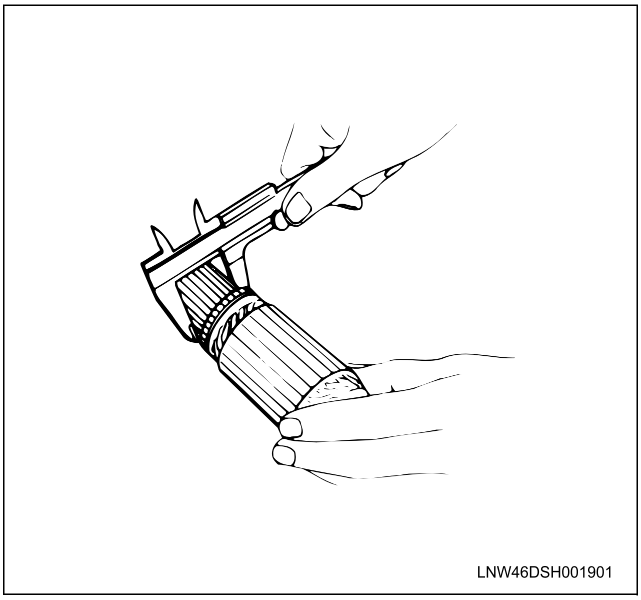


LNW46DSH001801

Legend

1. Incorrect
2. Correct
3. Insulator
4. Commutator Segments

- Commutator outer diameter. The diameter must not be less than 42 mm (1.654 in).



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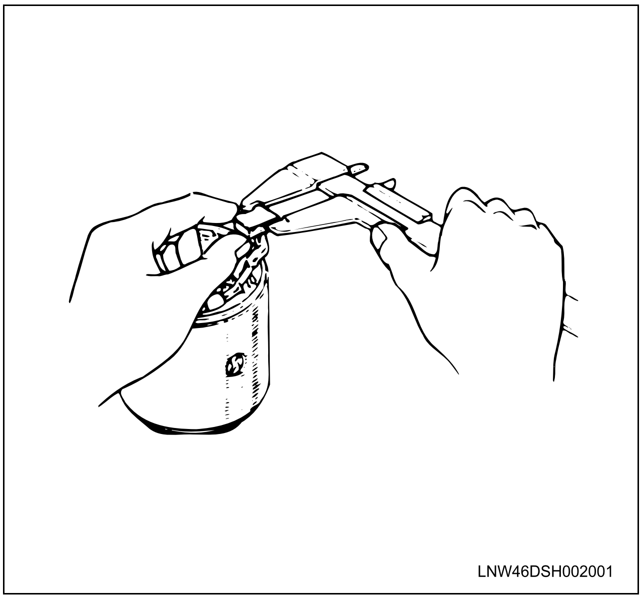
- Armature bearings for wear and damage. If the bearings are noisy while turning them by hand, they must be replaced.

8. Brush and brush holder.

- Replace the brushes if the brush length is less than 13 mm (0.51 in).



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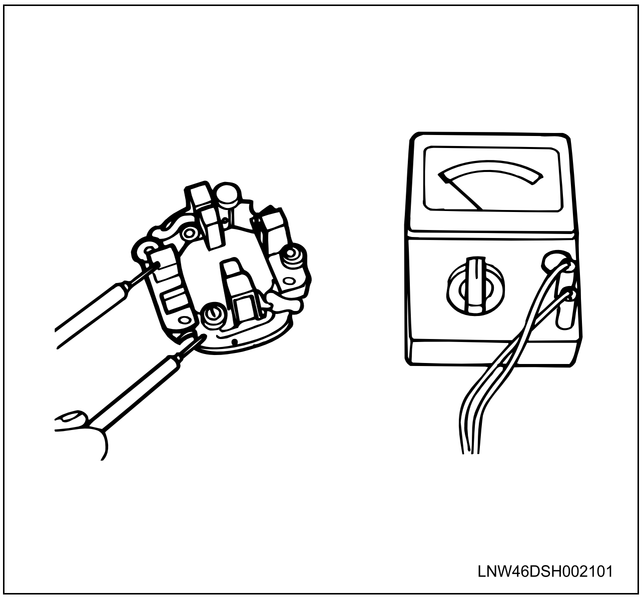
- Brush springs for wear, damage or other abnormal conditions.
- The movement of the brush in the brush holder. If the brush movement within the brush holder is sluggish, check the brush holder for distortion and sliding faces or contamination. Clean or repair as necessary.
- Touch one probe of the ohmmeter or self-powered test light across the insulated brush holder positive (+) side and the other probe to the grounded brush holder negative (–) side. If the light lights or continuity is indicated at the ohmmeter, the brush holder is grounded and must be replaced.



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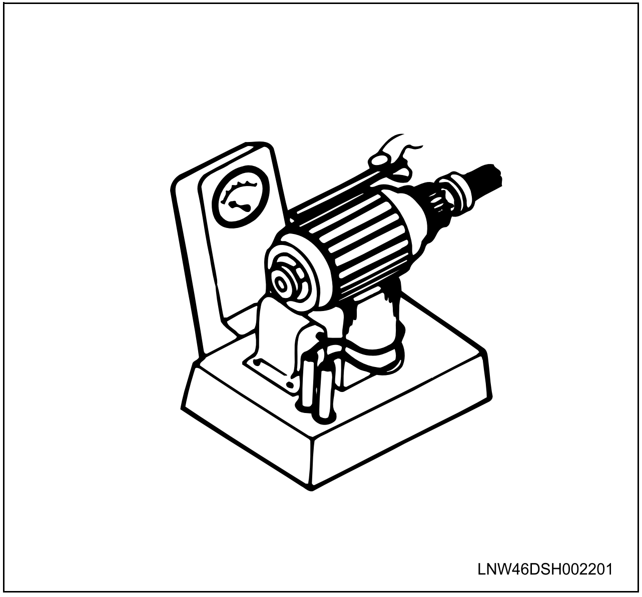
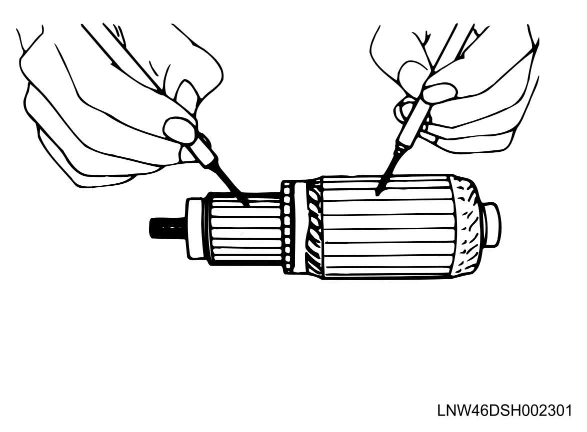
Electrical Bench Tests (Starter)

1. Armature for short circuit.
   Short circuits are detected by rotating the armature in a growler with a steel strip such as a hacksaw blade held on the armature parallel to the shaft. The steel strip will vibrate on the area of the short circuit. Shorts between the bars are sometimes caused by brush dust.


LNW46DSH002201

2. Armature for grounds.
   Grounds in the armature can be detected by the use of a self-powered test light or ohmmeter. Touch one probe of the ohmmeter or test light to the commutator segment and the other probe to the armature core. If the light lights or continuity is indicated at the ohmmeter the armature is grounded and must be replaced.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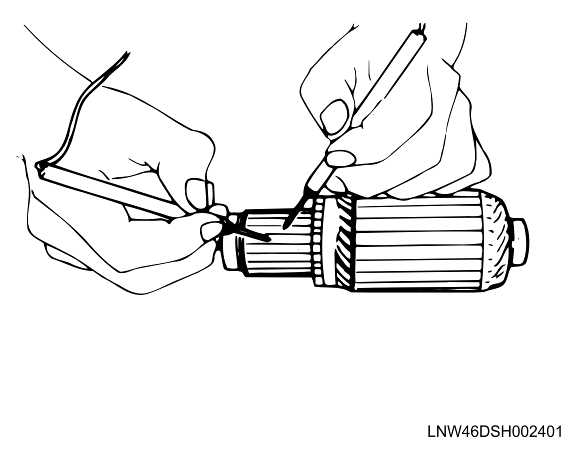
3. Armature for opens.
   Touch one probe of the ohmmeter or self-powered test light across two segments of the commutator. There must be continuity at any locations on the commutator.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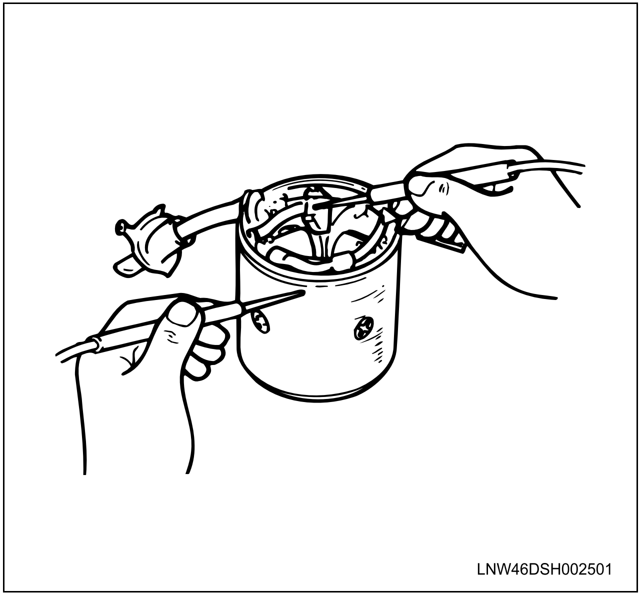
4. Field ground test.
   Touch one probe of the ohmmeter or self-powered test light to the field winding end or brush and other probe to outside surface of the field frame body. Replace the field frame assembly if continuity exists.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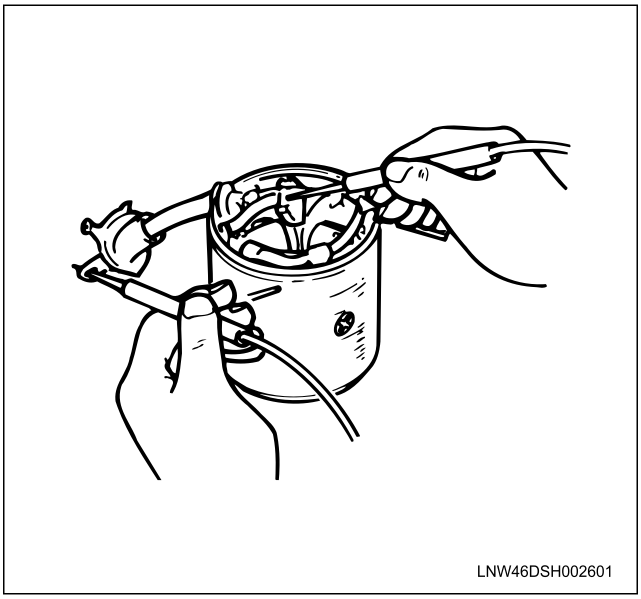
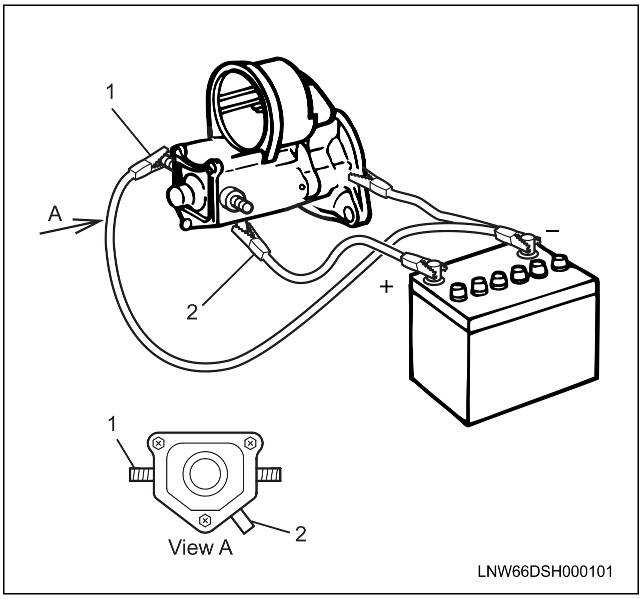
5. Field winding open test.
   Touch one probe of the ohmmeter or self-powered test light to the starter lead wire terminal and the other probe to brush. Replace the field frame assembly if no continuity exists.



6. Solenoid assembly.
   - The solenoid should be tested with starter assembled.
   - Disconnect the field frame lead wire.
   - Each test should be completed in a short time (3–5 seconds) to prevent the coils from burning.

Solenoid Pull-Out Test

- Connect a jumper wire from the battery negative (–) side to the starter housing and solenoid Motor terminal.
- Connect a jumper wire from the battery positive (+) side to the solenoid start terminal.

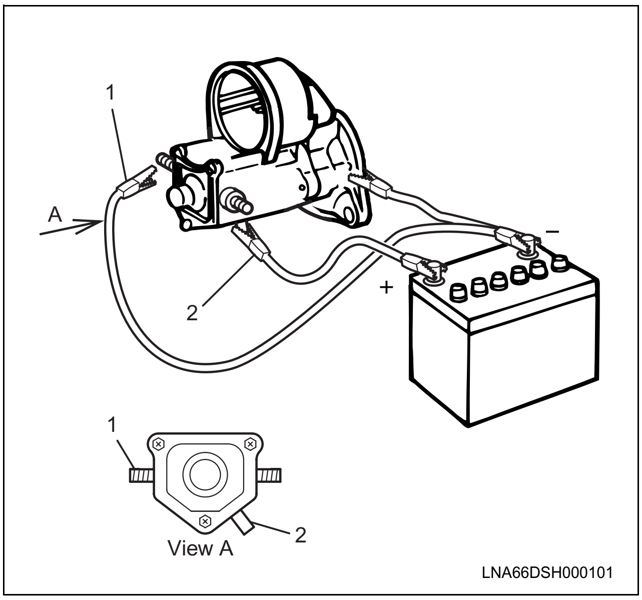


Legend

1. Solenoid Motor Terminal
2. Solenoid Start Terminal

Solenoid Hold-In Test

- This test is performed the same way as the pull-out test except the jumper wire is disconnected from the solenoid start terminal.
- The pinion gear must be held in the pulled-out position. Replace the solenoid if the pinion gear doesn’t stay in the hold position.



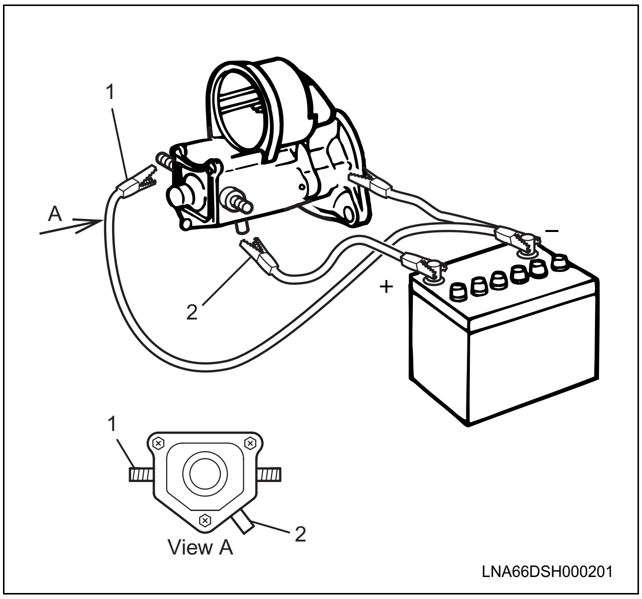
Legend

1. Solenoid Motor Terminal
2. Solenoid Start Terminal

Solenoid Return Test

- Disconnect a jumper wire from the battery positive (+) side to the solenoid start terminal.

- The pinion gear must return to its proper position. Replace the solenoid if the pinion gear doesn’t return to the proper position.



Legend
1. Solenoid Motor Terminal
2. Solenoid Start Terminal

Reassembly

1. Solenoid housing assembly.
2. Ball spring.
3. Steel ball.
4. Pinion clutch assembly.
5. Roller.
6. Retainer.
7. Pinions.
8. Pinion drive housing.
9. Screws.

Tightening torque:
Pinion drive housing screws: 9 N·m (78 lb in)

10. Armature.
11. Brush and brush holder.
12. Field frame seal (O-ring).
13. Field frame.
14. End frame and through bolts.

Tightening torque:
End plate through bolts: 14 N·m (122 lb in)

15. Lead wire and nut.

Tightening torque:
Lead wire nut: 22 N·m (16 lb ft)

Installation

1. Starter.
2. Two mounting bolts.

Tightening torque:
Mounting bolts: 76 N·m (56 lb ft)

3. Cables and electrical leads to the starter.
4. Battery negative cable to the battery.

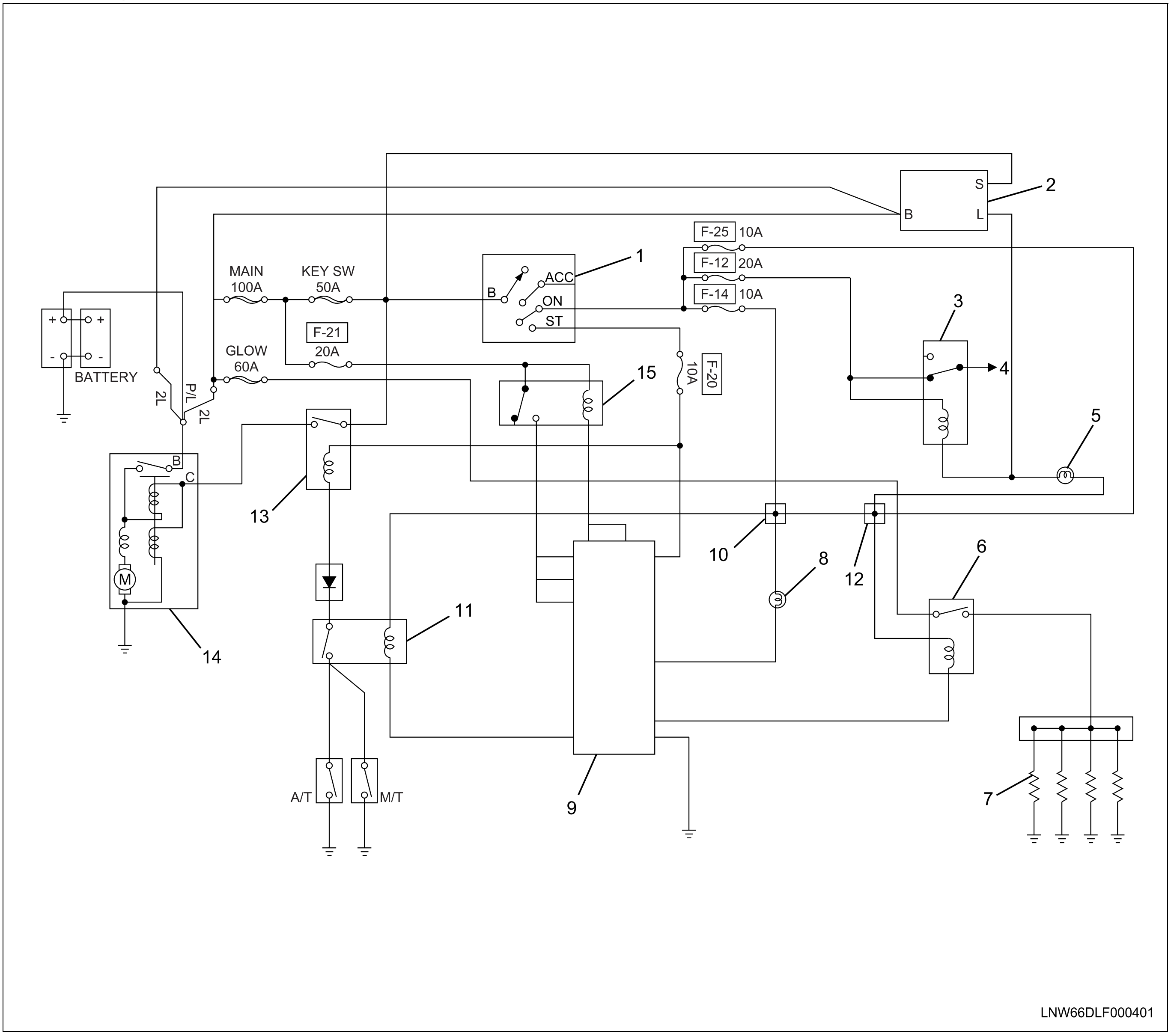
Main Data and Specifications

Rated Voltage	12 V
Rated Output	3 kw
Terminal Voltage (No Load)	11 V
Maximum Current (No Load)	220 amp
Minimum RPM (No Load)	4,200 RPM
Maximum Voltage (Load)	7 V
Maximum Current (Load)	890 amp
Minimum RPM (Load)	940 RPM
Maximum Solenoid Voltage	3 V
Maximum Solenoid Current	1,800 amp
Maximum Cranking Time	30 second
Number of Pinion Gear Teeth	11
Pinion Gear Rotation (View From Pinion Side)	Clockwise
Brush Length	
Standard	20.5 mm (0.81 in)
Limit	13 mm (0.51 in)
Commutator Diameter	
Standard	43 mm (1.693 in)
Limit	42 mm (1.654 in)
Mica Segment Undercut	
Standard	0.7–0.9 mm (0.028–0.035 in)
Limit	0.2 mm (0.0079 in)
Starter Motor Weight	10.5 kg (23 lb)

Preheating System

Glow Plug Replacement

Circuit Diagram



Legend

1. Engine control Switch
2. Generator (Integral Regulator)
3. Charge Relay
4. To Exhaust Brake Relay
5. Low Charge Indicator Light
6. Glow Plug Relay
7. Glow Plugs
8. Glow Plug Indicator Light
9. ECM
10. Joint Connection – M1
11. Starter Cut Relay
12. Weld splice – M4
13. Starter Relay
14. Starter
15. ECM Main Relay

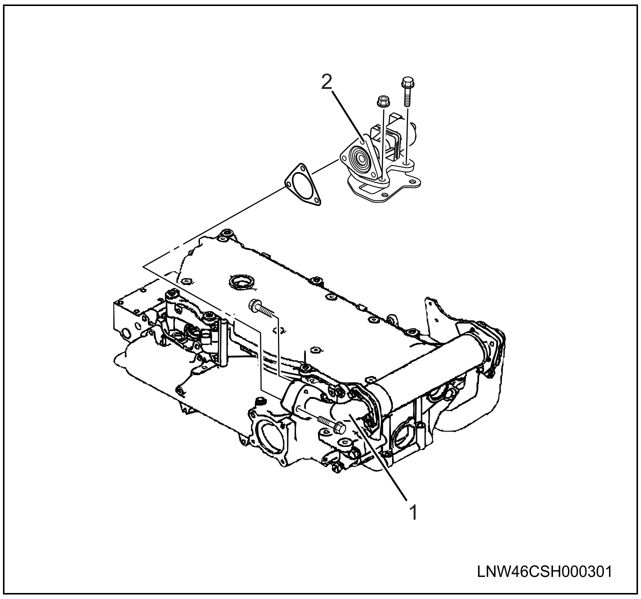
Precautions during maintenance

Adequate care should be taken as over-tightening the glow plug could lead to damage.

Removal Procedure

1. Remove the engine harness, the throttle position sensor, the EGR valve, the pressure sensor, and all of the fuel injector connectors.

2. Remove the EGR valve and the EGR adapter.
3. Tape the EGR case holes shut to prevent the entry of foreign material.

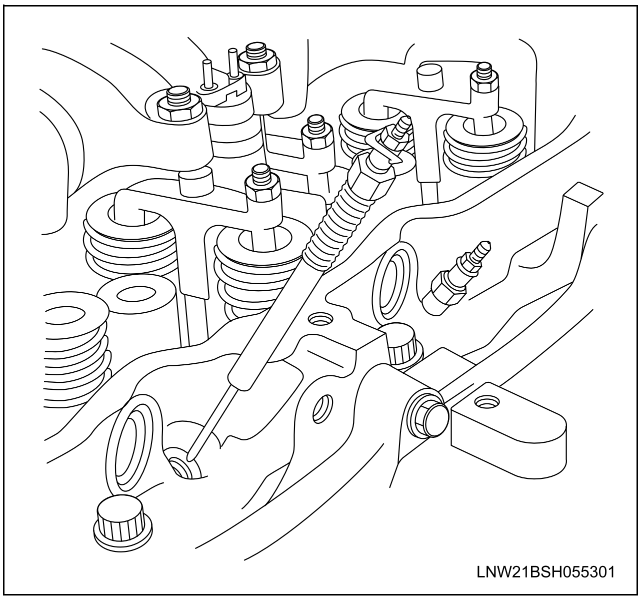


Legend

1. EGR Adapter
2. EGR Valve

---

4. Remove the glow connector.
5. Remove the glow plug.



Installation Procedure

1. Install the glow plug.

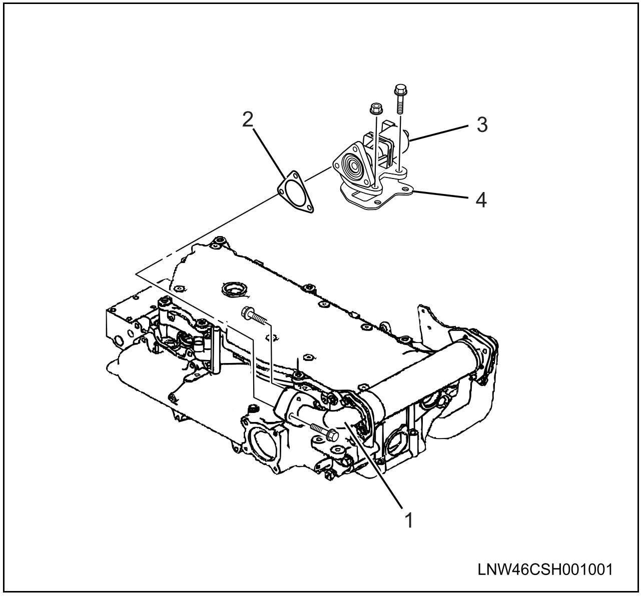
Tightening torque: 20 N·m (15 lb ft)

2. Install and tighten the glow connector with the designated torque.

Tightening torque: 1.2 N·m (9 lb ft)

3. Install the EGR valve and the EGR adapter.

Tightening torque: 24 N·m (17 lb ft)



Legend

1. EGR Adapter
2. EGR Valve Gasket
3. EGR Valve
4. EGR Valve Gasket

---

4. Attach the engine harness connectors. Each composite connector should make a loud click when it is securely attached.

Service Precautions

Adequate care should be taken as over-tightening the glow plug could lead to damage.

Explanations on functions and operation

The preheating system consists the ECM, the glow relay, glow plugs and the glow indicator lamp. The preheating system is operated when the engine coolant temperature is low, and make the engine easy to start.

Functional check

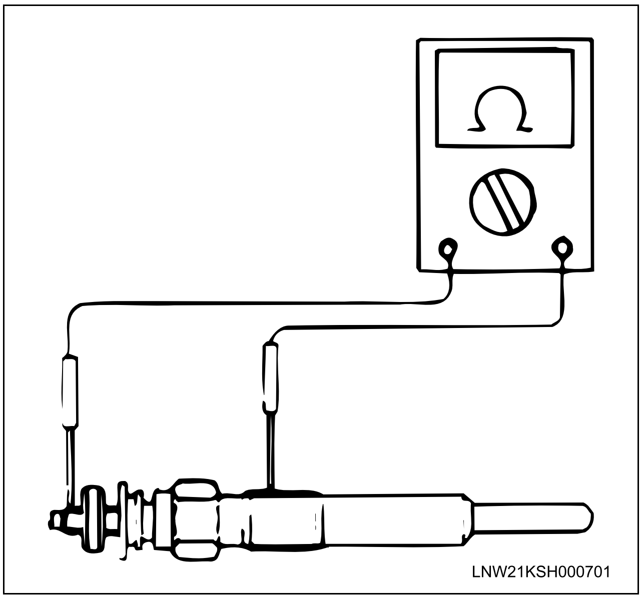
Refer to the 6E section (Glow control system check). Except the glow plug.

Glow plug check

- Use the circuit tester and measure the resistance of the glow plug.
- If the measured value deviates from the specified value, then replace the glow plug.

  Resistance value of glow plug is approximately less than 5Ω.

Caution:
Use a set of four glow plugs from the same manufacturer.



- Preheating does not work.
- The preheating time is too long or too short.

Trouble Shooting

A list of defective phenomena

- The glow indicator lamp does not light up.

The glow indicator lamp does not light up.

Condition	Possible Cause	Correction
The glow indicator lamp does not light up.	Slow blow fuse has blown.	Replace the slow blow fuse.
	Fuse is unavailable.	Replace the fuse.
	Indicator valve is burnt out.	Replace the indicator valve.
	Engine control system is faulty.	Refer to the “6E section”.

Preheating does not work.

Condition	Possible Cause	Correction
Preheating does not work.	Slow blow fuse has blown.	Replace the slow blow fuse.
	Defective or faulty glow plug relay connector contact.	Re-mount or replace the glow plug relay.
	Engine control system is faulty.	Refer to the “6E section”.

Preheating time is too long or too short.

Condition	Possible Cause	Correction
The Preheating time is too long or too short.	Thermosensor fault and break in circuit or short circuit.	Replace the thermosensor. Repair the circuit.
	Fault in glow plug.	Replace or tighten the glow plug.
	Engine control system is faulty.	Refer to the “6E” section.

Main Data and Specifications

Item		Model
Preheating device model		Glow plug
Glow plug rated voltage/ current	(V-A)	12 – 3.5

Glow Plug Controller (12,000 lbs GVW)

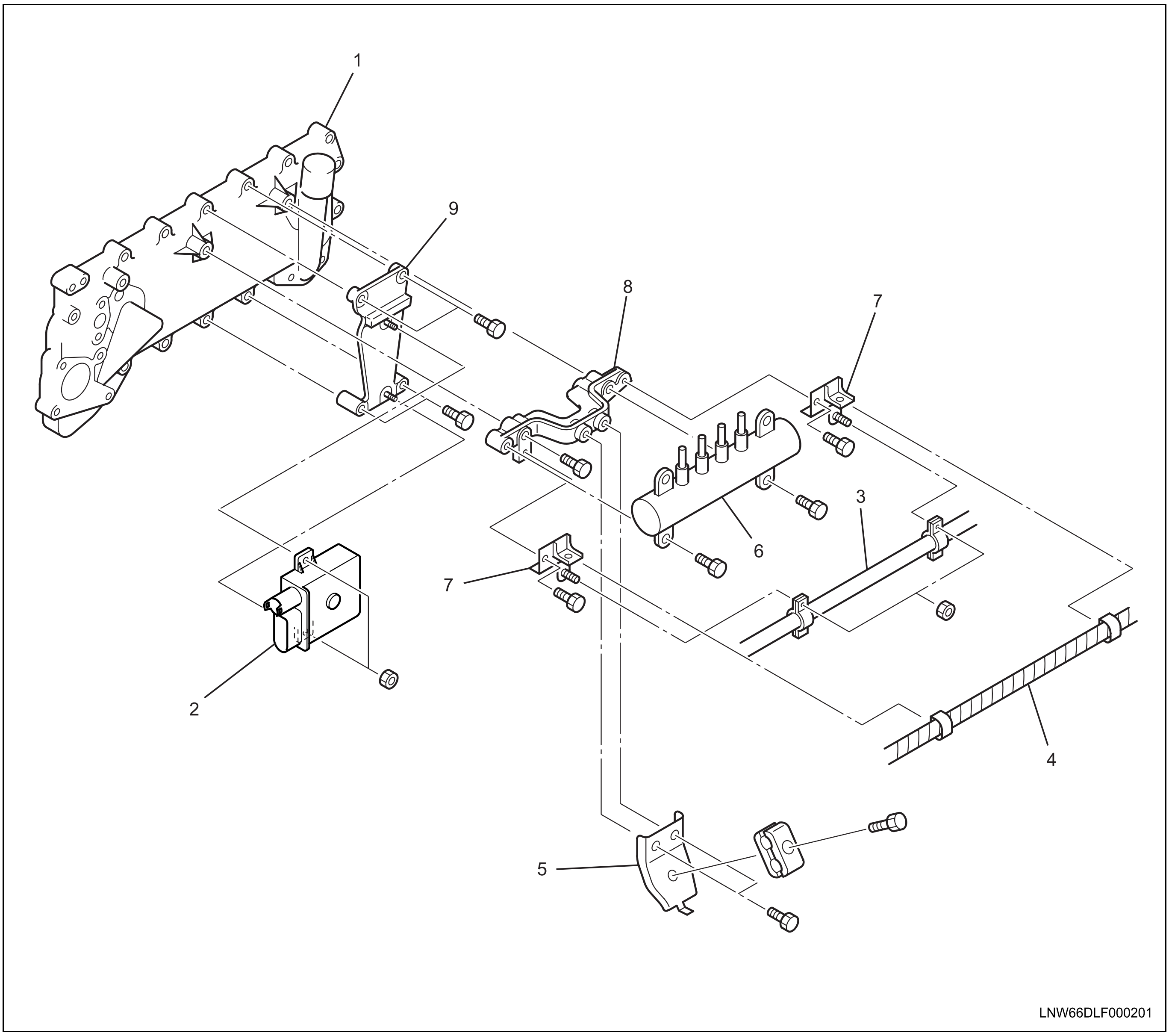
1. Glow Plug Controller Replacement

Removal

1. Remove the engine harness (4) from the engine harness bracket (7) for easy work.
2. Remove the Fuel pipe bracket (5).
3. Remove the engine harness bracket (7).
4. Remove the fuel rail bracket (8).
5. Remove the glow plug controller (2).

Installation

1. Install the glow plug controller (2).
2. Install the fuel rail bracket (8).
3. Install the engine harness bracket (7).
4. Install the Fuel pipe bracket (5).
5. Install the engine haeness (4).



Legend

1. Oil Cooler
2. Glow Plug Controller
3. EGR Cooler Water feed Pipe
4. Engine Harness
5. Fuel Pipe Bracket
6. Fuel Rail
7. Engine Harness Bracket
8. Fuel Rail Bracket
9. Glow Plug Controller Bracket

---

2. Glow Plug Tightening Torque. :Under 25 N·m (18 lb ft)

3. Glow Plug Connector Tightnening Torque :Under 3 N·m (26 lb in)

4. Explanations of Function and Operation.

The preheating system consist the ECM, the glow controller, glow plugs. The preheating system is operated when the engine coolant temperature is low and make the engine easy to start.

The glow plug controller operates the instant-start glow plugs in the engine. The control unit can be controlled via a CAN interface.

4.1 Basic Function of the Glow Plug Control Unit

The glowing system described below differs from the previously used combination of self-controlling steel glow plugs and a control unit that switched the glow plugs on and off with a relay. The new generation of glow plugs are not designed for continuous operation on the vehicle electrical system and require activation with a voltage-time profile. This voltage-time profile is generated by clocking, i.e. pulse width modulation PWM, the on-board voltage applied at the glow plugs. The voltage at every glow plug is switched on and off individually by a solid state switch assigned to every glow plug. By clocking the on-board voltage the rms voltage at the glow plugs and thus their temperature can be widely varied. In addition, individual diagnosis of every glow plug circuit is possible.

4.2 System Components

The glowing system consists of an electronic glow plug controller GPCU and optimum performance instant-start glow plugs GP. In comparison with the previousuly used standard GPs, these GPs are designed for an operating voltage well below the on-board voltage (low-voltage design). Due to the performance optimisation, the new GPs have a greatly reduced energy and power requirement in comparison with the previous GPs. About 60% less electrical energy is required for heating up the GPs to 1,000°C for example. The power consumption of the GP in the idle state is also reduced by about 60%. This leads to a noticeable relief on the vehicle electrcal system especially in engines with a large number of cylinders and thus number of glow plugs. In addution, a lower power consumption enables faster heating of the GPs and therefore leads to an appropriately shorter pre-glowing time.

5. Functional Check

The GPCU receives the glow enable command and all information neede via a CAN data interface and feeds back diagnostic and status information by the same route.

Refer to the 6E section. Except the glow plug.

6. Main Data and Specifications

1	volltage	(curve/profile) DC =	11V 8V 5V 4.7V	1.2 sec 1.8 sec 4 sec 53 sec
2	current flow	current shall be MAX 9A when measured 30 sec after application of the voltage profile.		
		Ignition on = (0 sec) Igniton on = (after 8 sec)	max 27A max 10A	

ENGINE

Engine Control System - 5.2L

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Specifications

Temperature vs Resistance

Engine Coolant Temperature vs. Resistance

°C	°F	Ω
Temperature vs. Resistance Value (Approximately)		
120	248	120
110	230	160
100	212	200
90	194	260
80	176	350
70	158	470
60	140	640
50	122	880
40	104	1250
30	86	1800
20	68	2650
10	50	4000
0	32	6180
-10	14	9810
-20	-4	16000
-30	-22	27000
-40	-40	47300

Intake Air Temperature vs. Resistance

°C	°F	Ω
Temperature vs. Resistance Value (Approximately)		
100	212	190
90	194	240
80	176	320
70	158	430
60	140	590
50	122	810
40	104	1150
30	86	1650
25	77	2000
20	68	2430
10	50	3660
0	32	5650
-10	14	8970
-20	-4	14700
-30	-22	24700
-40	-40	43300

Altitude vs Barometric Pressure

Altitude Measured in Meters (m)	Altitude Measured in Feet (ft)	Barometric Pressure Measured in Kilopascals (kPa)
Determine your altitude by contacting a local weather station or by using another reference source.		
4267	14000	56-64
3962	13000	58-66
3658	12000	61-69
3353	11000	64-72
3048	10000	66-74
2743	9000	69-77
2438	8000	71-79
2134	7000	74-82
1829	6000	77-85
1524	5000	80-88
1219	4000	83-91
914	3000	87-95
610	2000	90-98
305	1000	94-102
0	0 Sea Level	96-104
-305	-1000	101-105

Diagnostic Trouble Code (DTC) Type Definitions

Emissions Related DTCs

Action Taken When the DTC Sets - Type A

- The engine control module (ECM) illuminates the Malfunction Indicator Lamp (MIL) when the diagnostic runs and fails.

Action Taken When the DTC Sets - Type B

- The ECM illuminates the MIL on the second consecutive driving cycle when the diagnostic runs and fails.

Conditions for Clearing the MIL/DTC - Type A or Type B

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail (12,000 lbs GVW).
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Use a scan tool in order to clear the MIL and the DTC.

Non-Emissions Related DTCs

Action Taken When the DTC Sets - Type C

- The ECM will not illuminate the MIL but illuminates the Service Vehicle Soon (SVS) lamp when the diagnostic runs and fails.

Action Taken When the DTC Sets - Type D

- The ECM will not illuminate the MIL or SVS lamp.

Conditions for Clearing the DTC - Type C or Type D

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp. (Type C)
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic. (Type D)
- Use a scan tool in order to clear the SVS lamp and the DTC. (Type C)
- Use a scan tool in order to clear the DTC. (Type D)

ECM Diagnostic Trouble Code (DTC)

DTC	NPR (12,000 lbs GVW)	NPR HD/NQR/NRR (Except 12,000 lbs GVW)	Note
P0016	B	-	
P0087	A	A	
P0088	D	D	First Stage
P0088	A	A	Second Stage
P0089	A	A	
P0091	A	A	
P0092	A	A	
P0093	A	A	
P0101	B	-	
P0102	A	A	
P0103	A	A	
P0112	B	B	
P0113	B	B	
P0116	A	-	
P0117	A	A	
P0118	A	A	

DTC	NPR (12,000 lbs GVW)	NPR HD/NQR/NRR (Except 12,000 lbs GVW)	Note
P0126	B	-	
P0128	B	-	
P0181	A	-	
P0182	A	A	
P0183	A	A	
P0192	A	A	
P0193	A	A	
P0201	A	A	
P0202	A	A	
P0203	A	A	
P0204	A	A	
P0219	D	D	
P0234	A	A	
P0237	A	A	
P0238	A	A	
P0261	A	D	
P0264	A	D	
P0267	A	D	
P0270	A	D	
P0299	A	A	
P0300	A	-	
P0301	B	D	
P0302	B	D	
P0303	B	D	
P0304	B	D	
P0335	A	A	
P0336	B	-	
P0340	A	A	
P0341	B	-	
P0381	B	-	
P0382	-	B	
P0401	B	-	
P0403	A	D	
P0404	A	A	Control Duty Signal Error
P0404	B	-	Open Position Error
P0405	A	A	
P0406	A	A	
P0477	B	-	

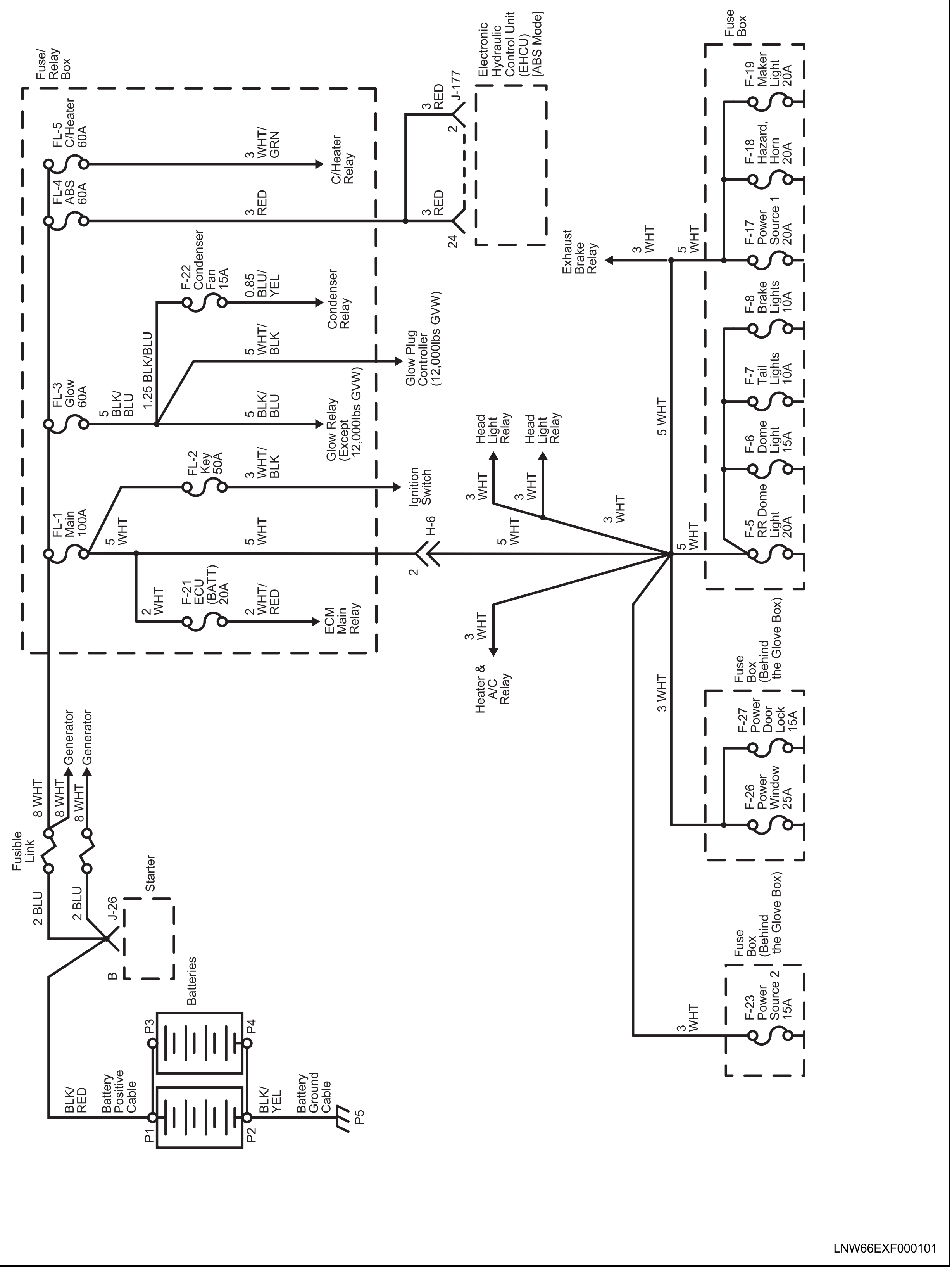
DTC	NPR (12,000 lbs GVW)	NPR HD/NQR/NRR (Except 12,000 lbs GVW)	Note
P0478	A	-	
P0500	B	B	
P0506	B	-	
P0507	B	-	
P0512	B	B	
P0562	C	B	
P0563	C	B	
P0567	C	B	
P0568	C	B	
P0571	C	B	
P0602	A	A	
P0606	A	A	
P0642	A	A	
P0643	A	A	
P0650	B	-	
P0652	B	B	
P0653	B	B	
P0670	B	-	
P0671	A	-	
P0672	A	-	
P0673	A	-	
P0674	A	-	
P0687	D	D	
P0698	B	B	
P0699	B	B	
P0700	A	-	
P0802	B	-	
P1093	B	-	
P1125	B	B	
P1293	A	A	
P1404	B	-	
P1593	C	B	
P1594	C	B	
P1597	C	B	
P1621	A	A	
P2122	C	B	
P2123	C	B	
P2127	C	B	

DTC	NPR (12,000 lbs GVW)	NPR HD/NQR/NRR (Except 12,000 lbs GVW)	Note
P2128	C	B	
P2132	C	B	
P2133	C	B	
P2138	C	B	
P2139	C	B	
P2140	C	B	
P2146	A	A	
P2147	A	A	
P2148	A	A	
P2149	A	A	
P2150	A	A	
P2151	A	A	
P2227	B	-	
P2228	A	A	
P2229	A	A	
P2293	C	D	Pressure Oscillation
P2293	D	D	High Fuel Pressure
U0073	B	B	
U0101	A	A	
U0106	B	-	

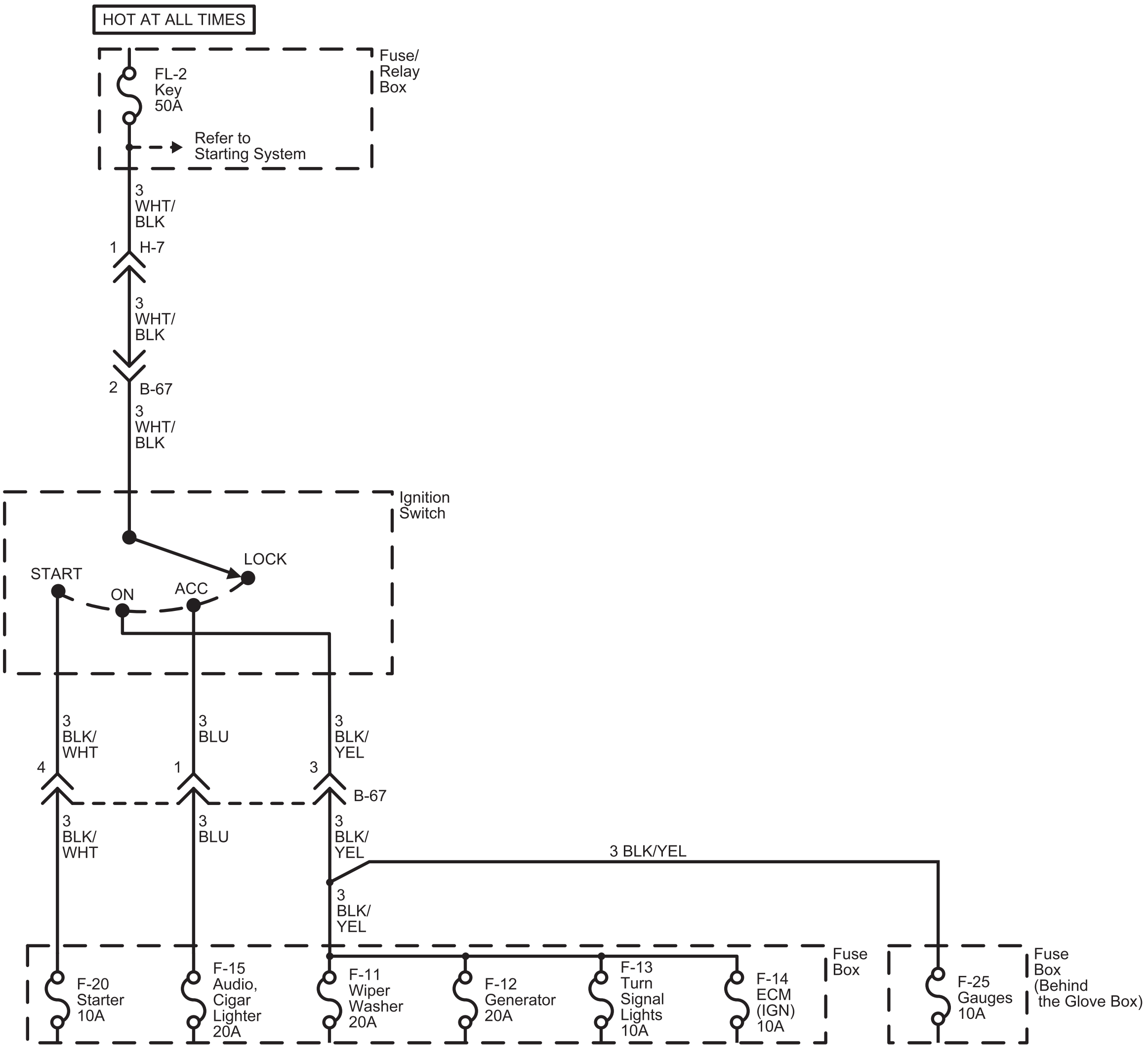
Schematic and Routing Diagrams

Engine Controls Schematics

Power Distribution (Hot At All Times)



Power Distribution (Hot In Run) (1)



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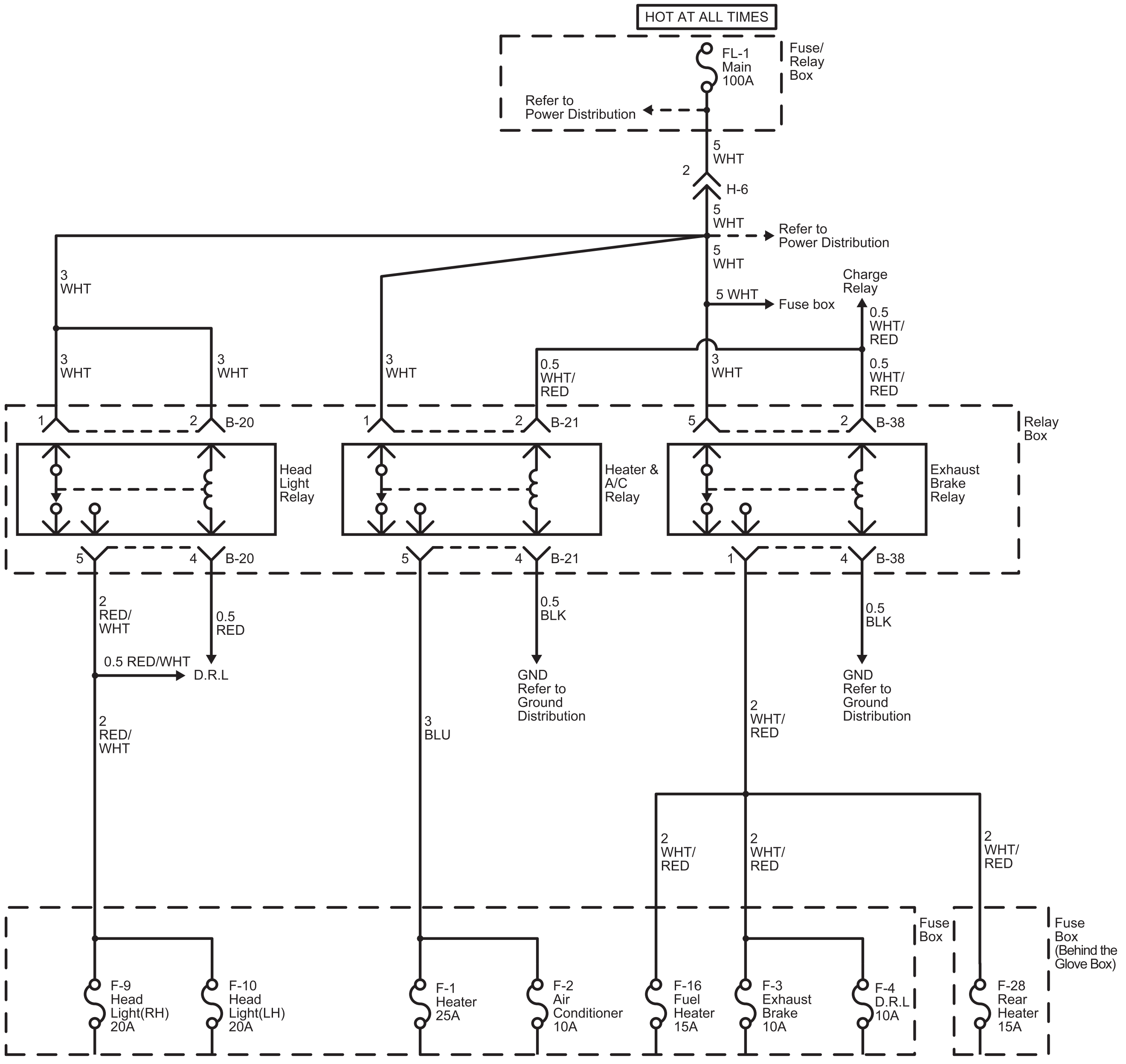
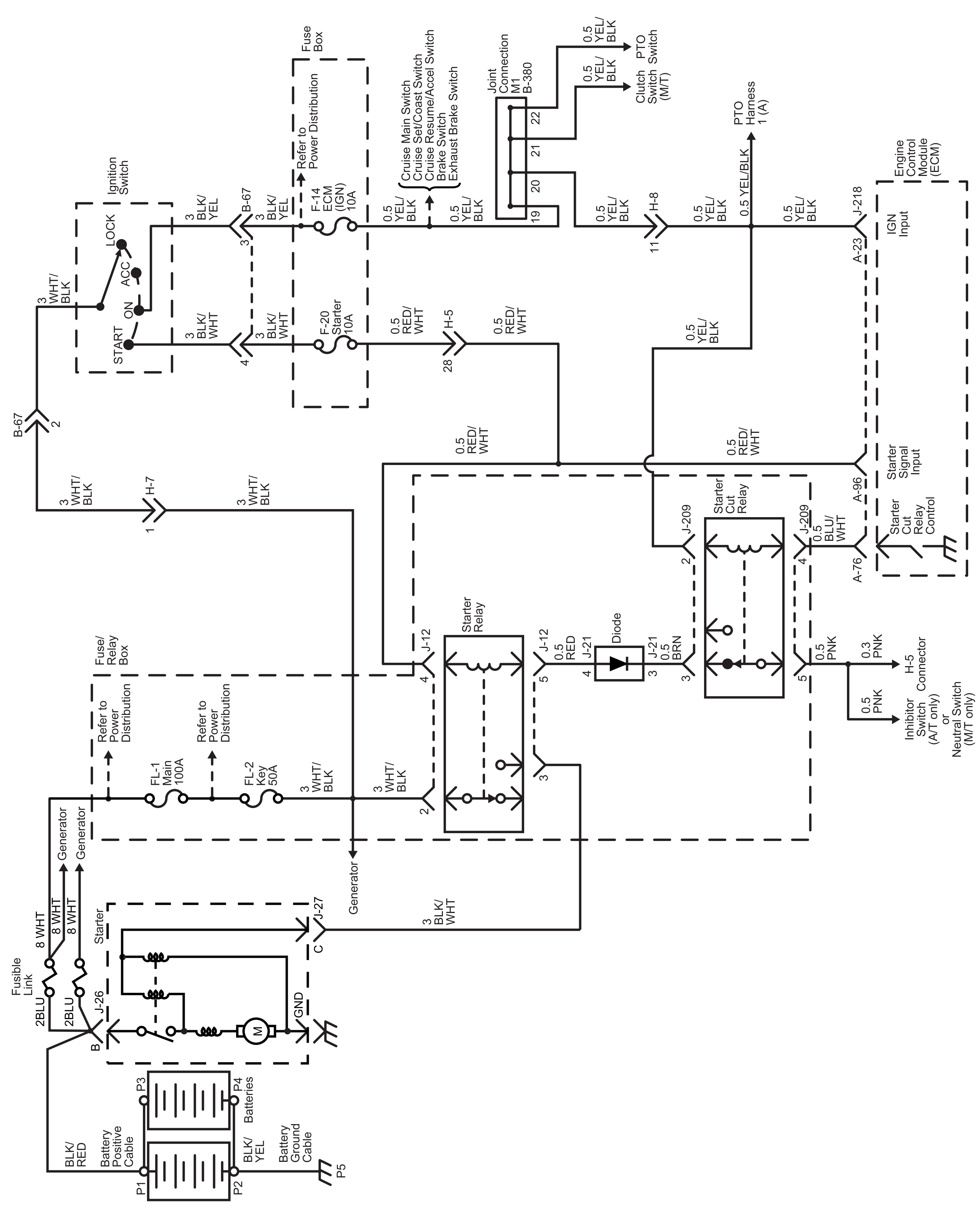
Power Distribution (Hot In Run) (2)

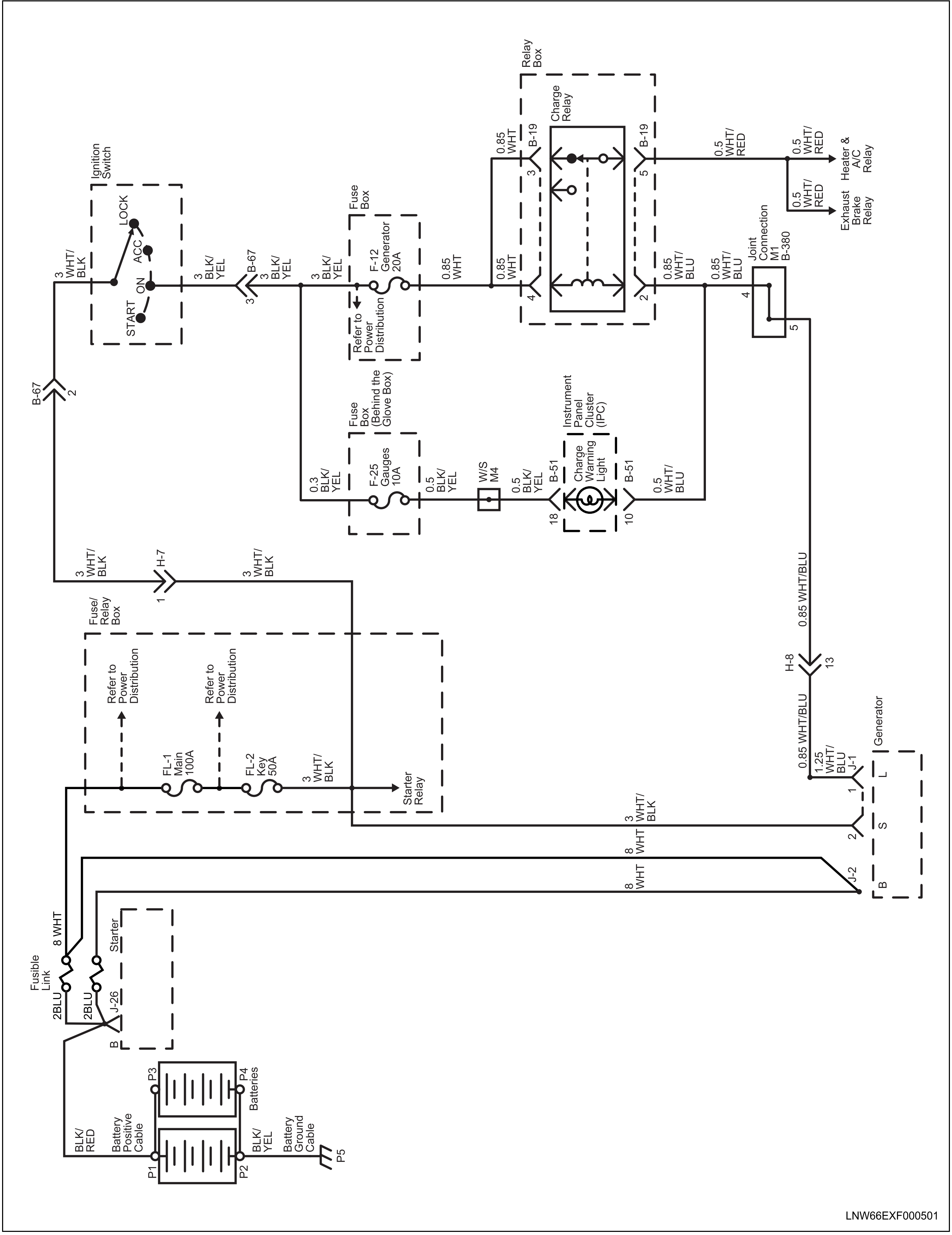


LNW66EXF000201

Starting System

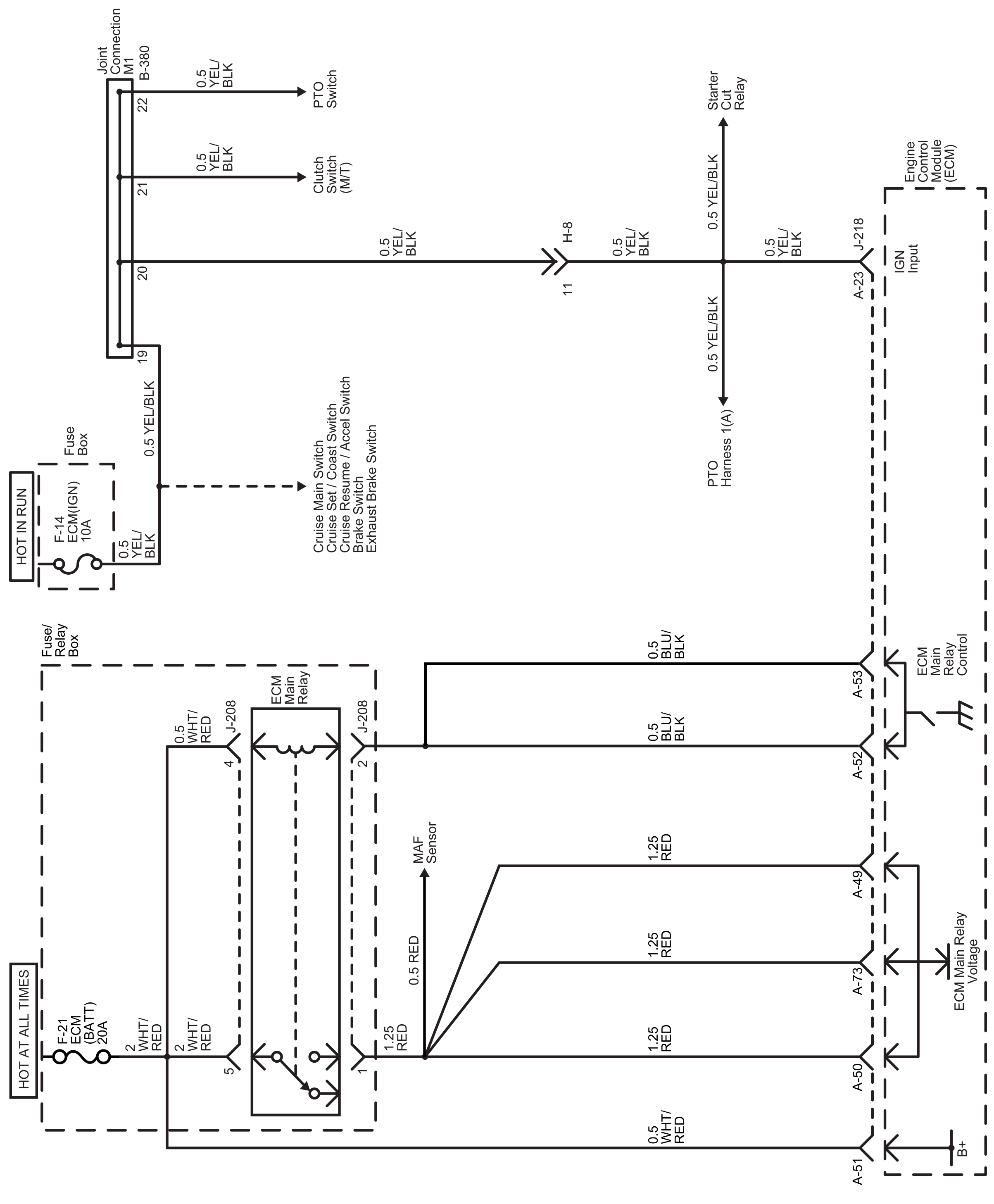


Charging System



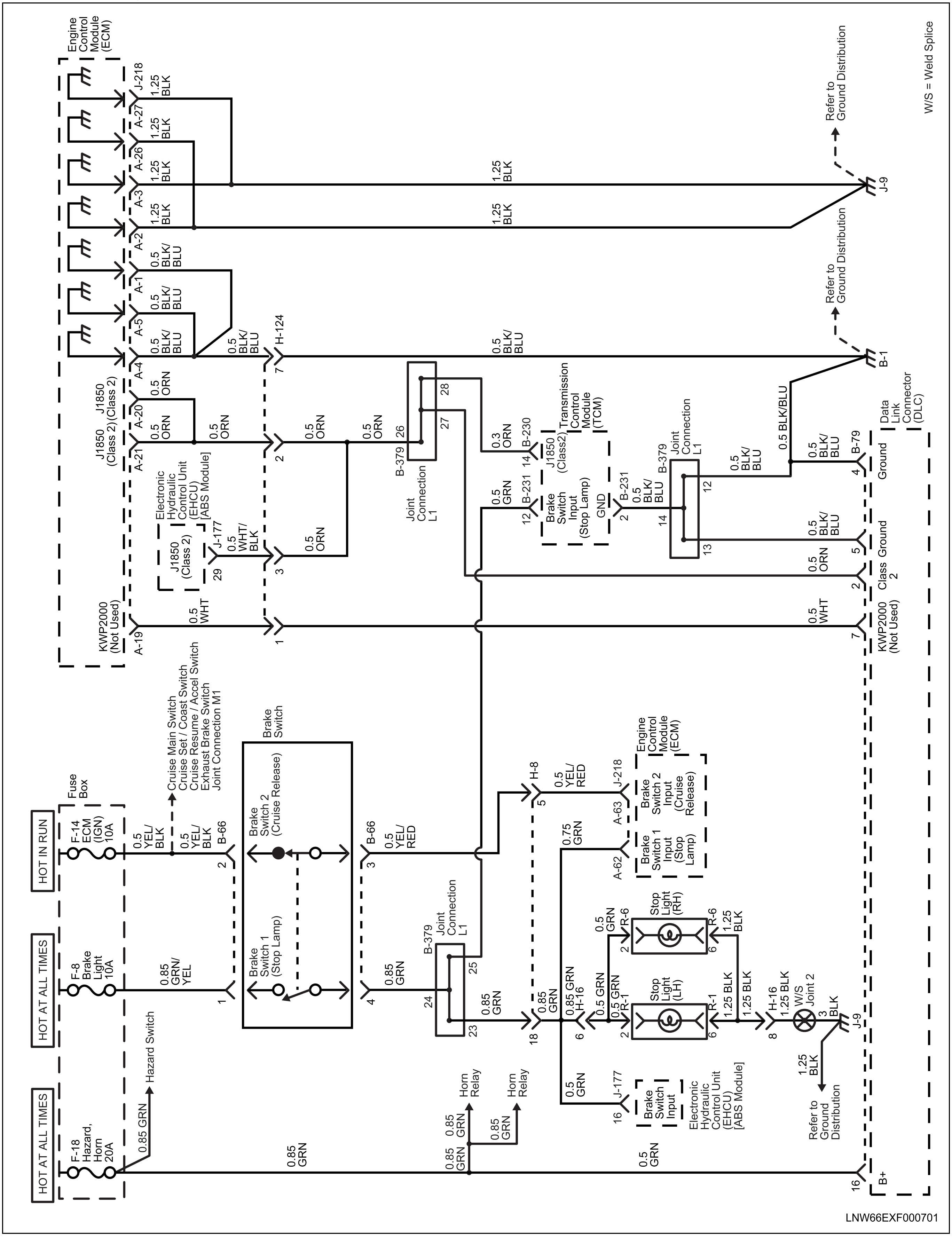
LNW66EXF000501

ECM Power

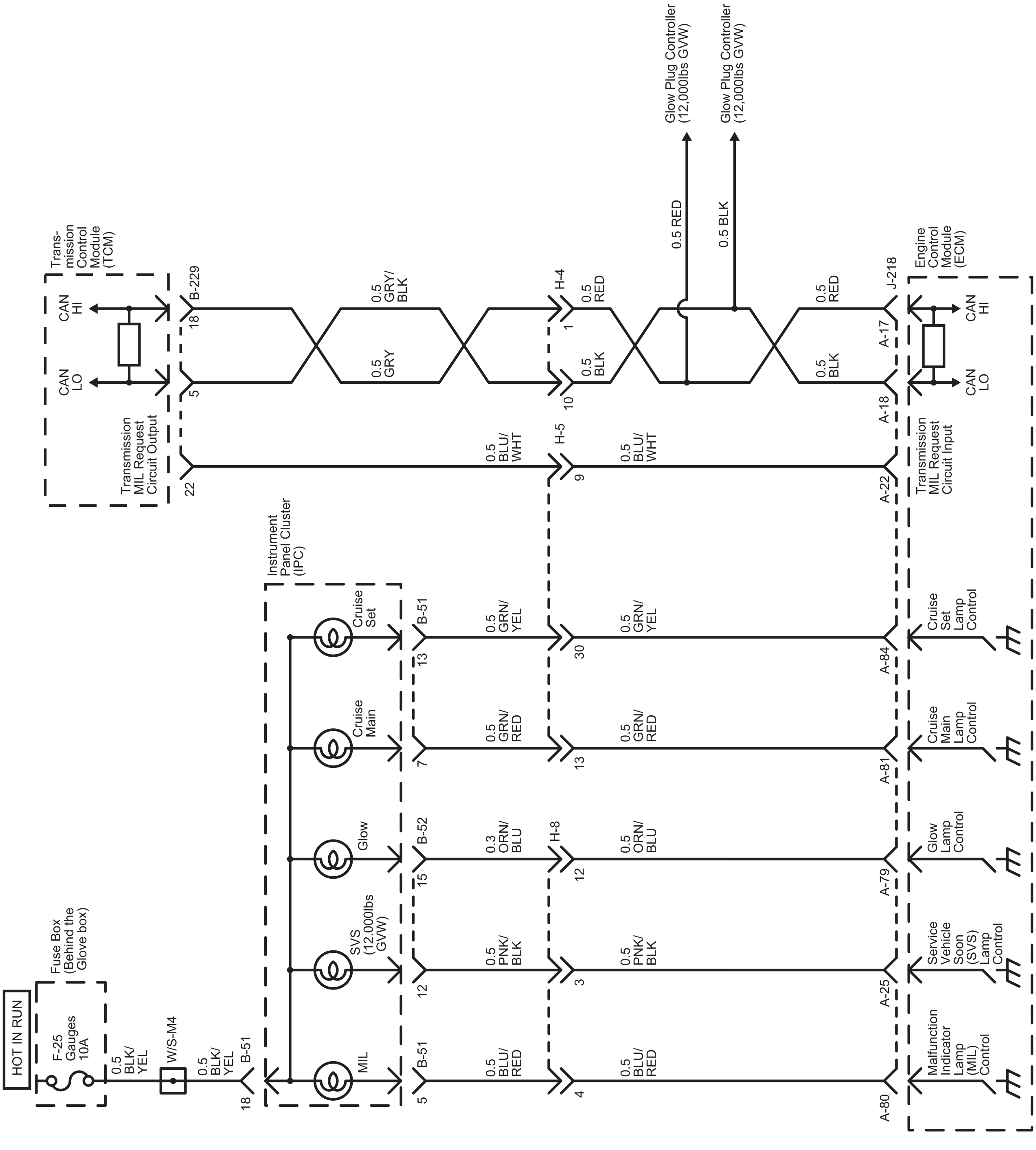


LNW66EXF000601

ECM Grounding, DLC and Brake Switch

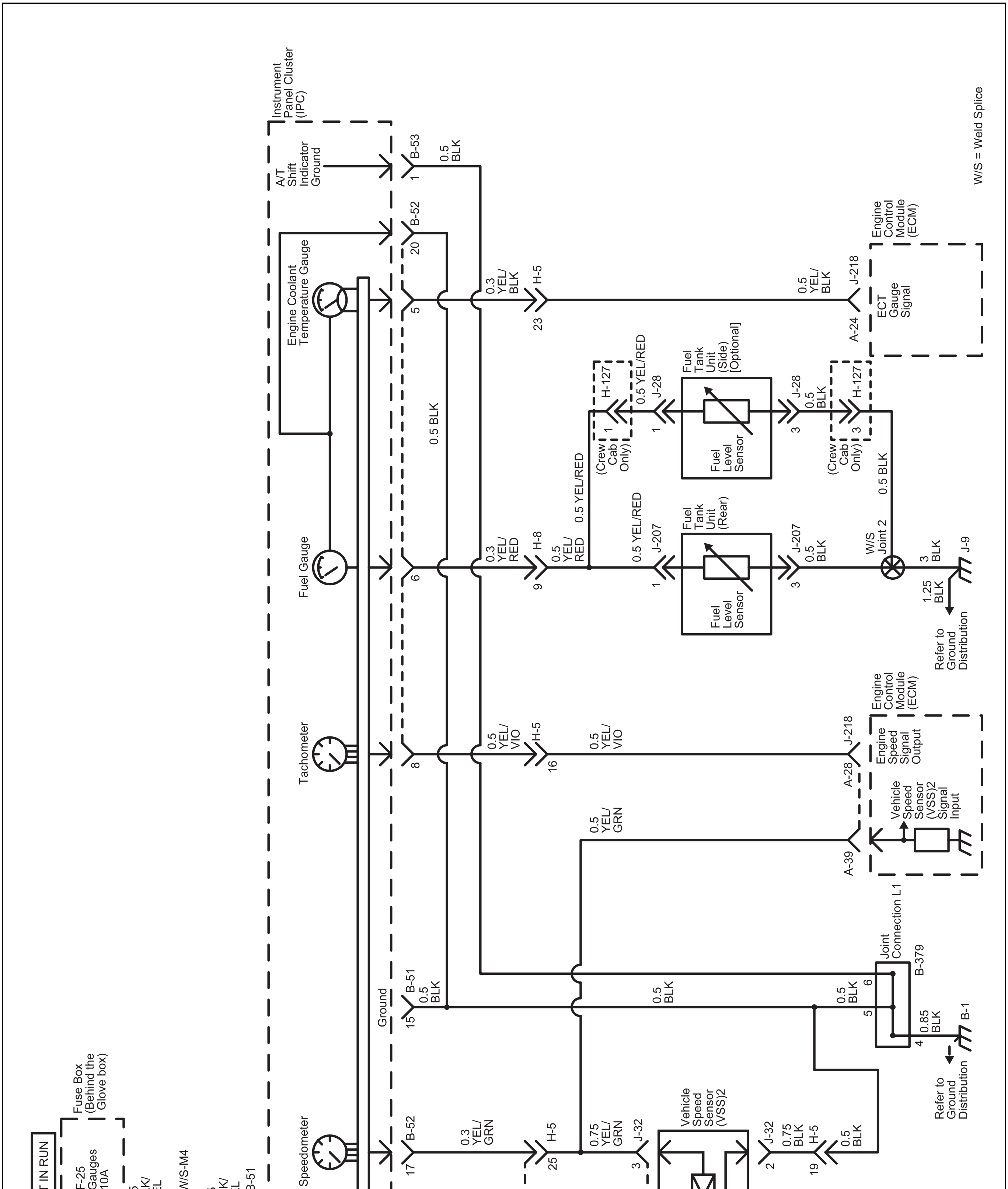


Warning Lamps and CAN System

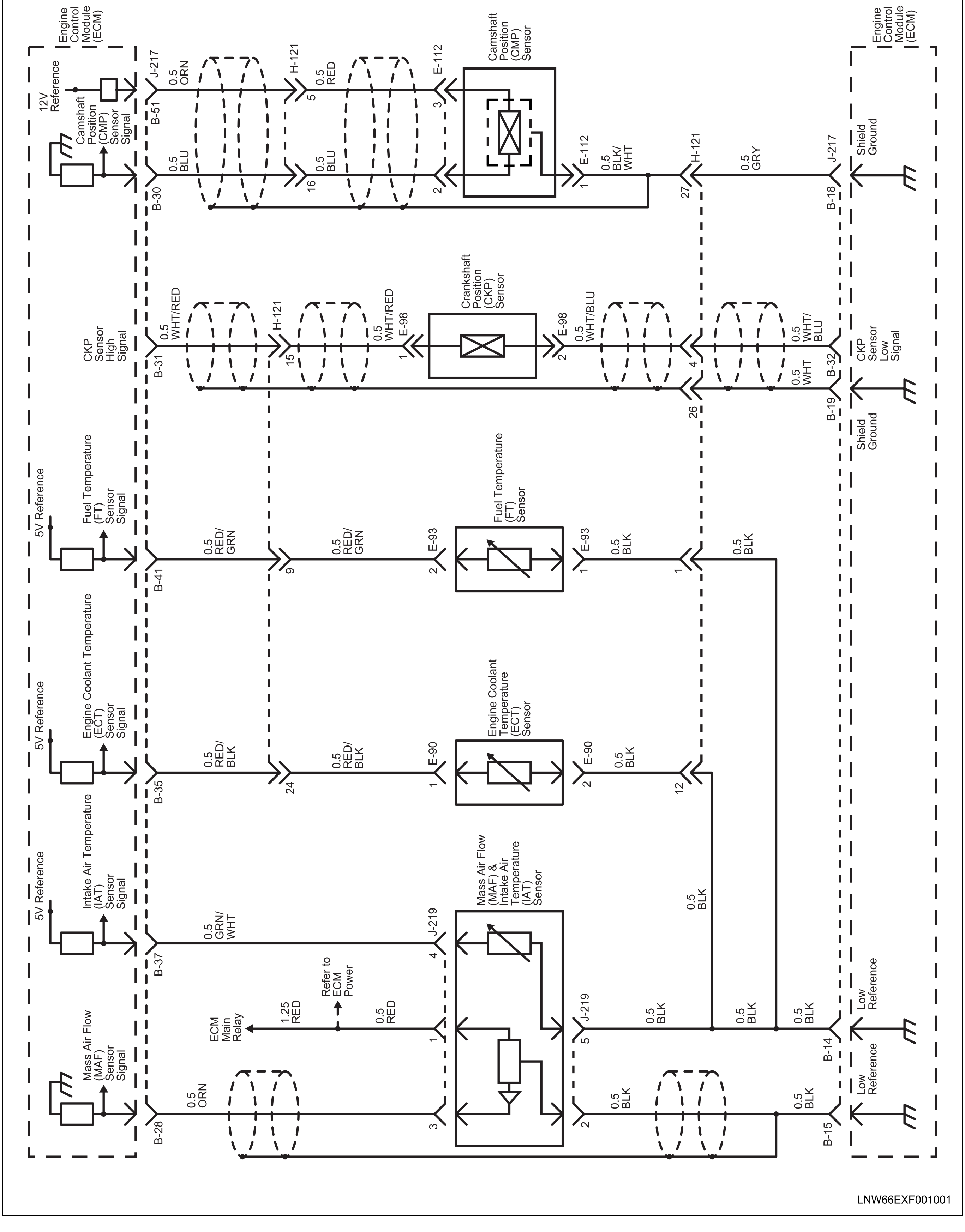


LNW66EXF000801

Gauges

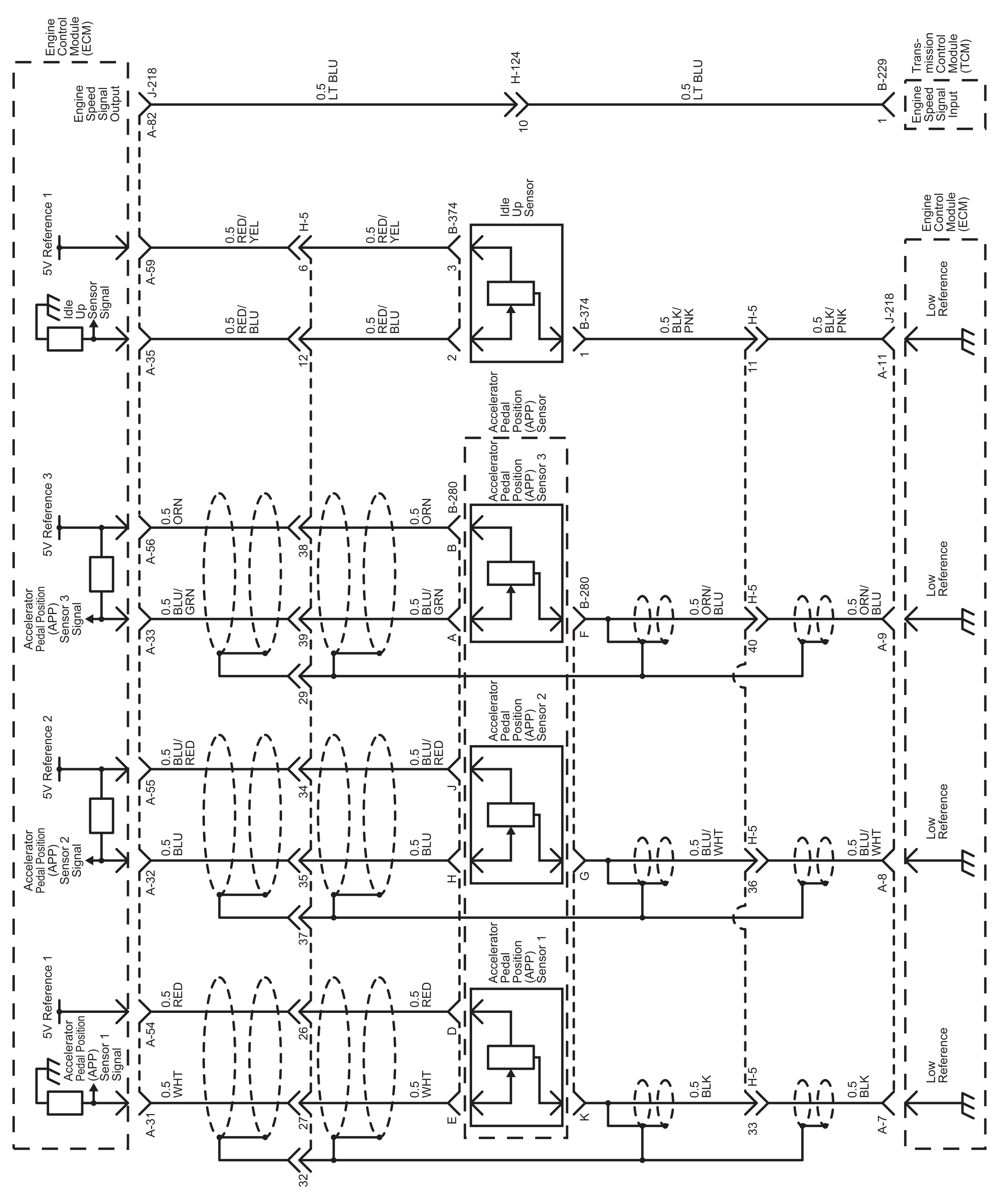

HOT IN RUN
Fuse Box (Behind the Glove box)
F-25 Gauges 10A
0.5 BLK/YEL
W/S-M4
0.5 BLK/YEL
B-51
18
Instrument Panel Cluster (IPC)
A/T Shift Indicator Ground
Engine Coolant Temperature Gauge
Fuel Gauge
Tachometer
Speedometer
Ground
B-53
1
0.5 BLK
B-52
20
5
6
8
0.5 BLK
0.3 YEL/BLK
H-5
23
0.5 YEL/BLK
J-218
A-24
ECT Gauge Signal
Engine Control Module (ECM)
W/S = Weld Splice
0.3 YEL/RED
H-8
9
0.5 YEL/RED
0.5 YEL/RED
H-127
1
(Crew Cab Only)
0.5 YEL/RED
J-28
1
Fuel Tank Unit (Side) [Optional]
Fuel Level Sensor
J-28
3
0.5 BLK
H-127
3
(Crew Cab Only)
0.5 BLK
0.5 YEL/RED
J-207
1
Fuel Tank Unit (Rear)
Fuel Level Sensor
J-207
3
0.5 BLK
W/S Joint 2
3 BLK
J-9
1.25 BLK
Refer to Ground Distribution
0.5 YEL/VIO
H-5
16
0.5 YEL/VIO
J-218
A-28
Engine Control Module (ECM)
Engine Speed Signal Output
Vehicle Speed Sensor (VSS)2 Signal Input
0.5 YEL/GRN
A-39
Joint Connection L1
B-379
6
5
4
0.5 BLK
0.5 BLK
0.85 BLK
B-1
Refer to Ground Distribution
B-51
15
0.5 BLK
0.5 BLK
B-52
17
0.3 YEL/GRN
H-5
25
0.75 YEL/GRN
J-32
3
Vehicle Speed Sensor (VSS)2
J-32
2
0.75 BLK
H-5
19
0.5 BLK
0.5 BLK/YEL
31
0.75 RED/GRN
1
LNW66EXF000901

MAF & IAT, ECT, FT, CKP and CMP Sensors



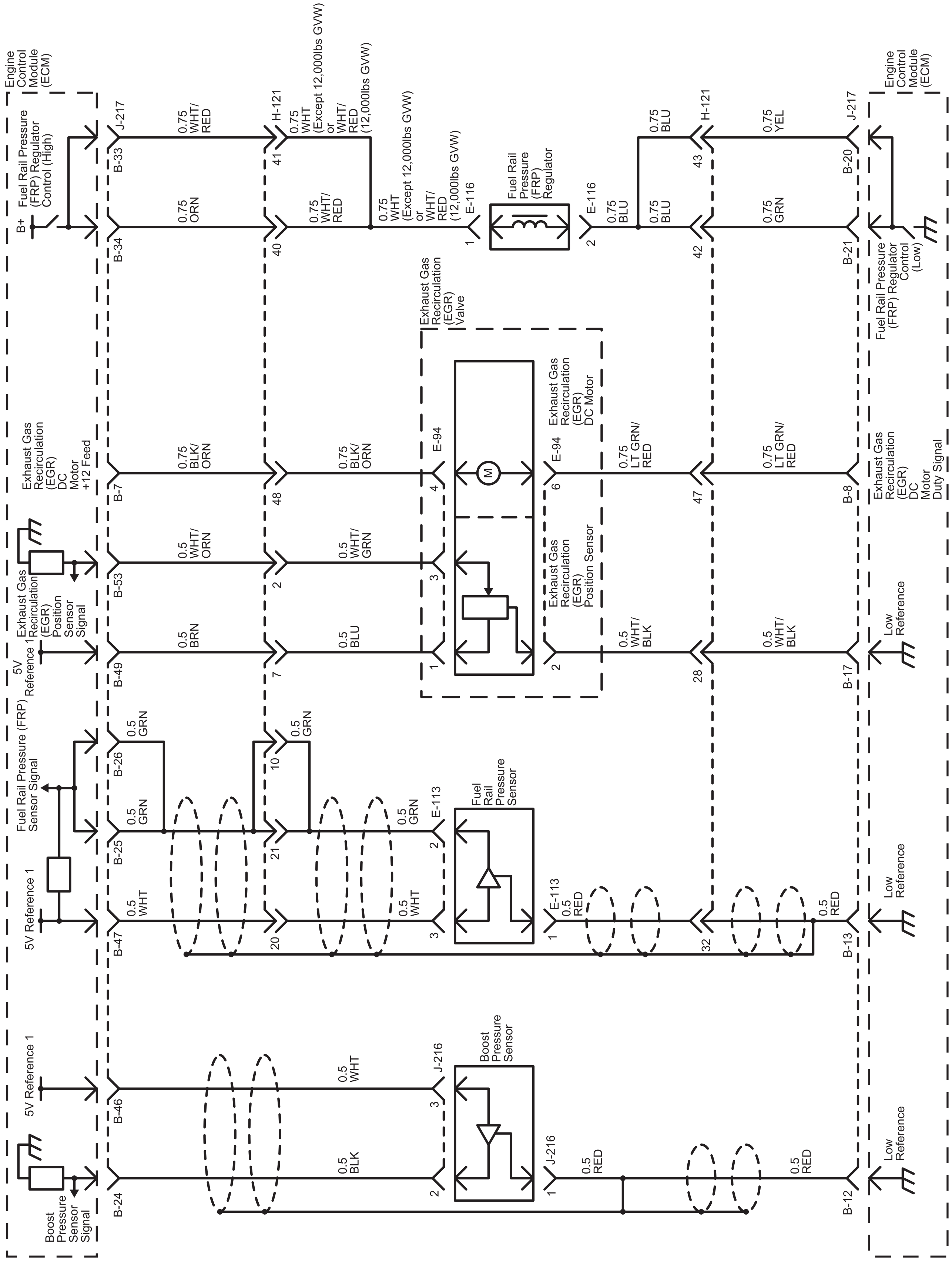
LNW66EXF001001

APP Sensor and Idle Up Sensor



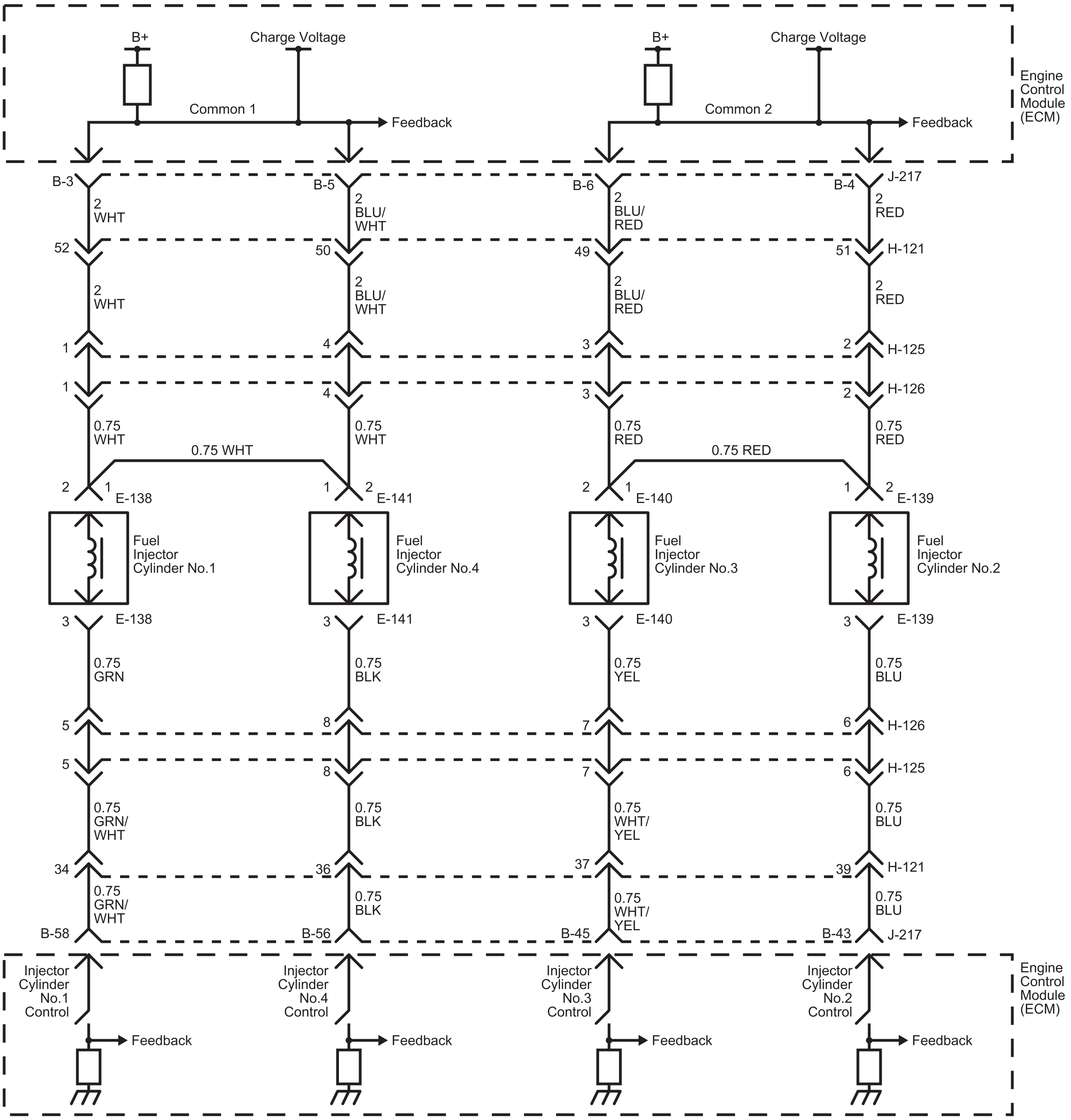
LNW66EXF001101

Boost Pressure Sensor, Fuel Rail Pressure (FRP) Sensor, EGR Valve and FRP Regulator



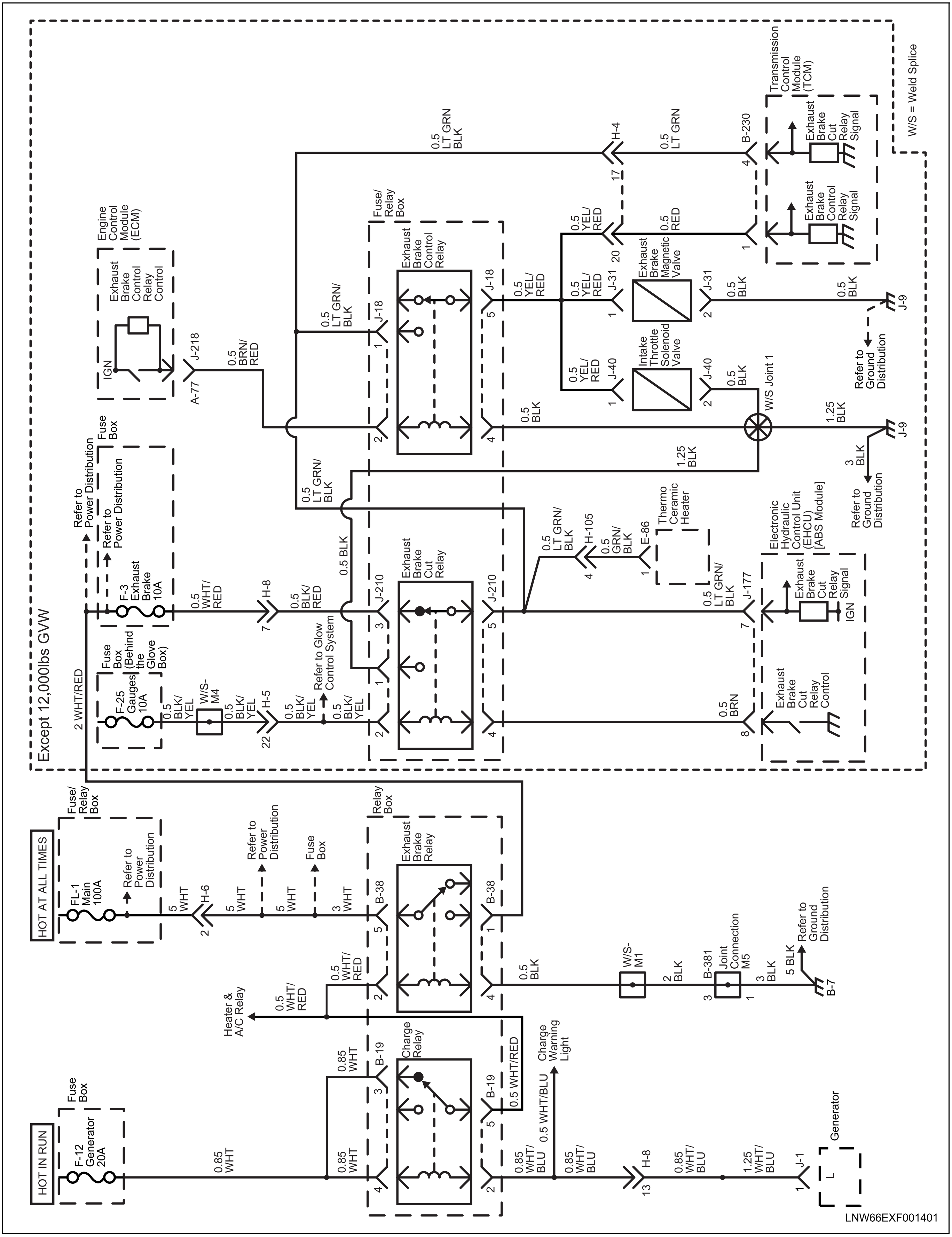
LNW66EXF001201

Injection Control System



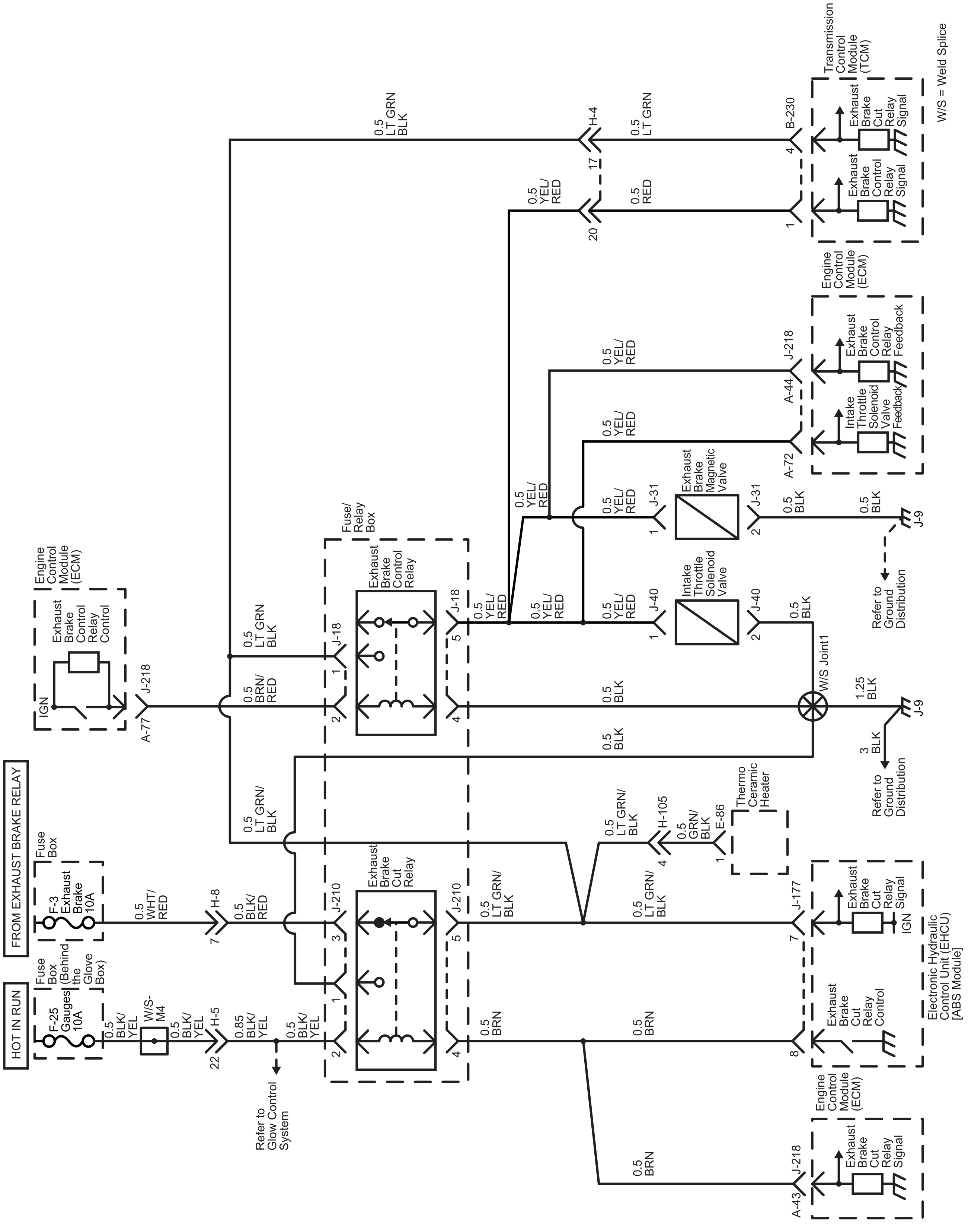
LNW66EXF001301

Exhaust Brake System (1)



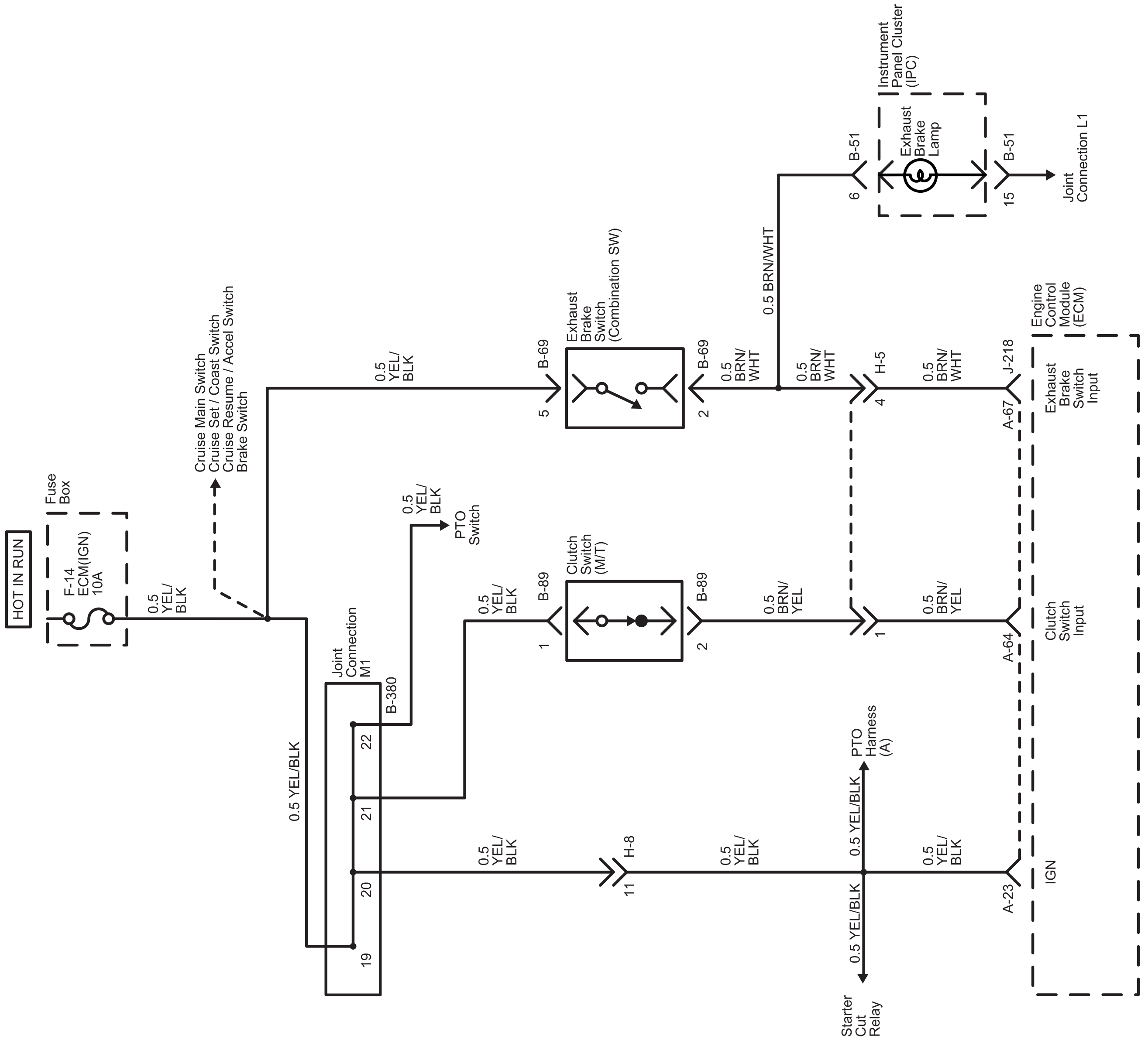
LNW66EXF001401

Exhaust Brake System (2) [12,000 lbs GVW]



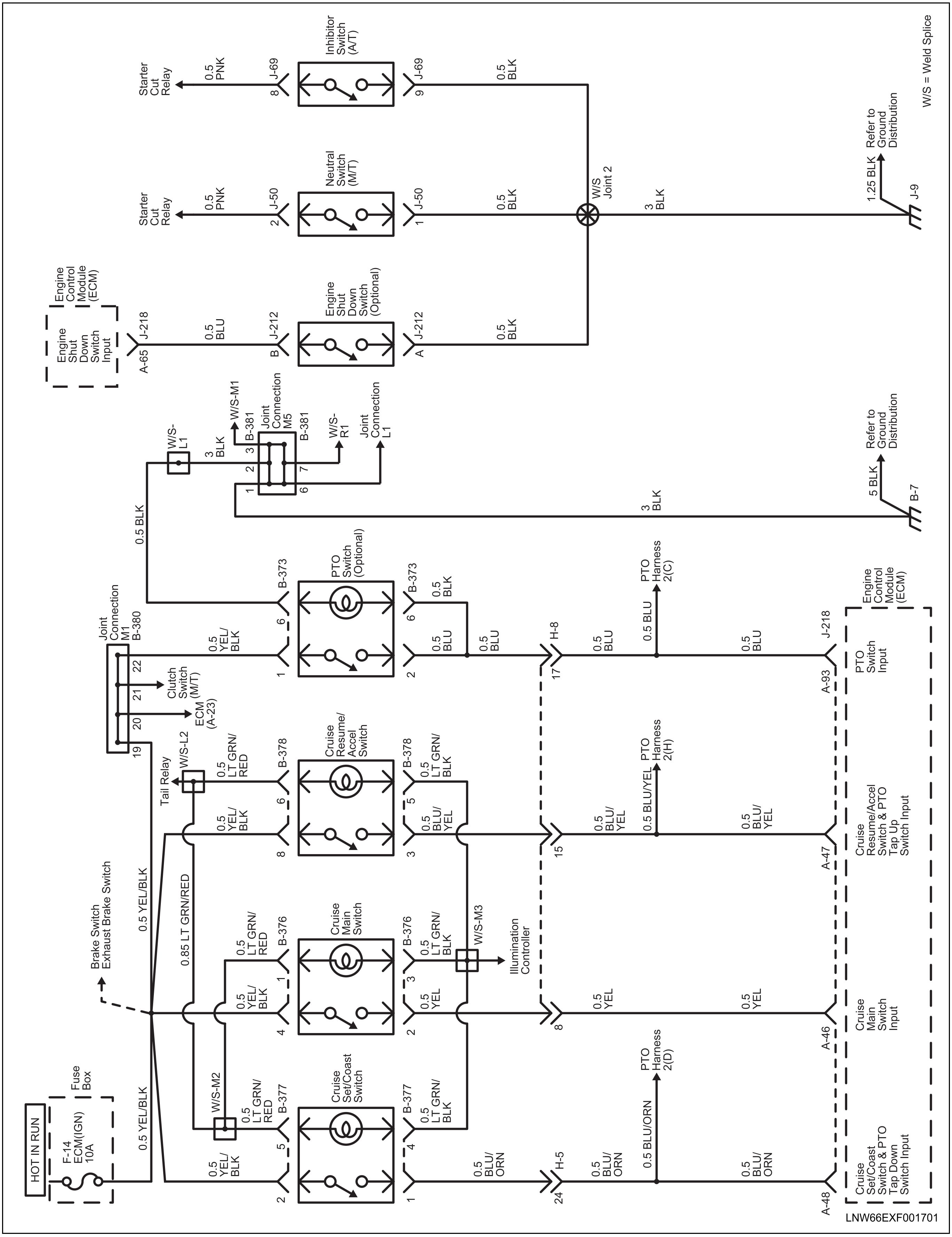
LNW66EXF001501

Clutch Switch and Exhaust Brake Switch

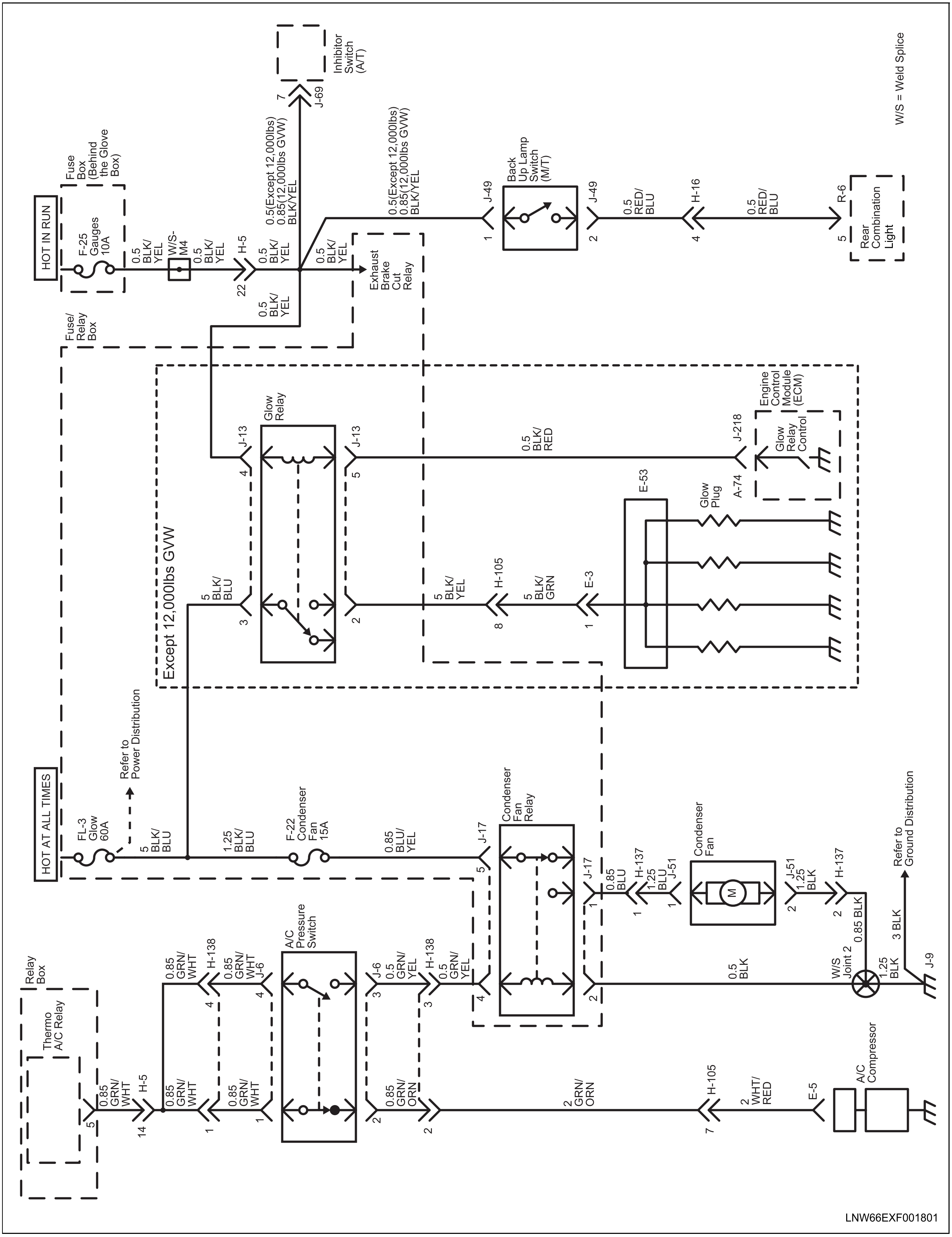


LNW66EXF001601

Cruise Control System, Neutral Switch, Inhibitor Switch and Engine Shut Down Switch

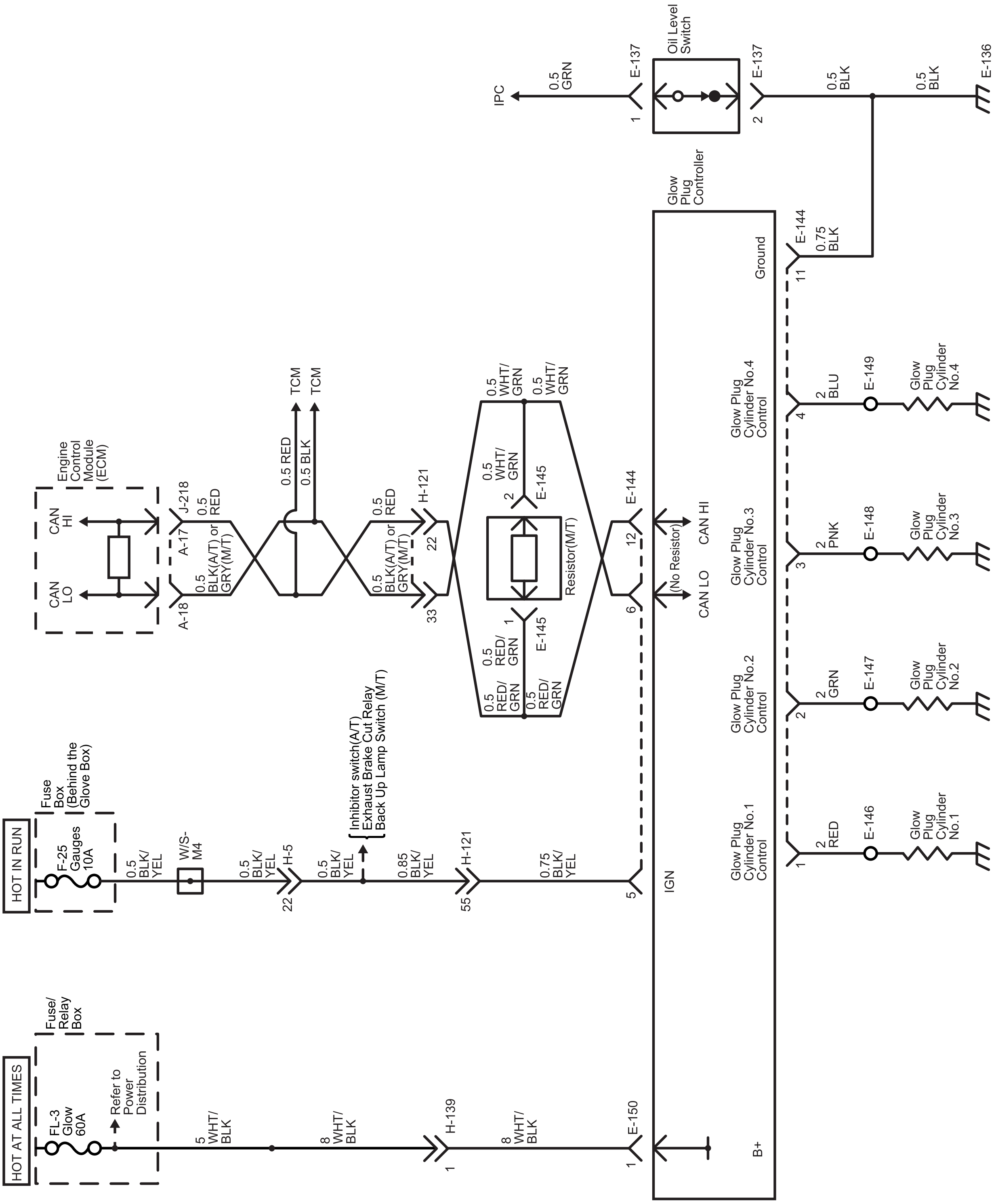


A/C Control System, Backup Lamp Switch and Glow Control System [Except 12,000 lbs GVW]



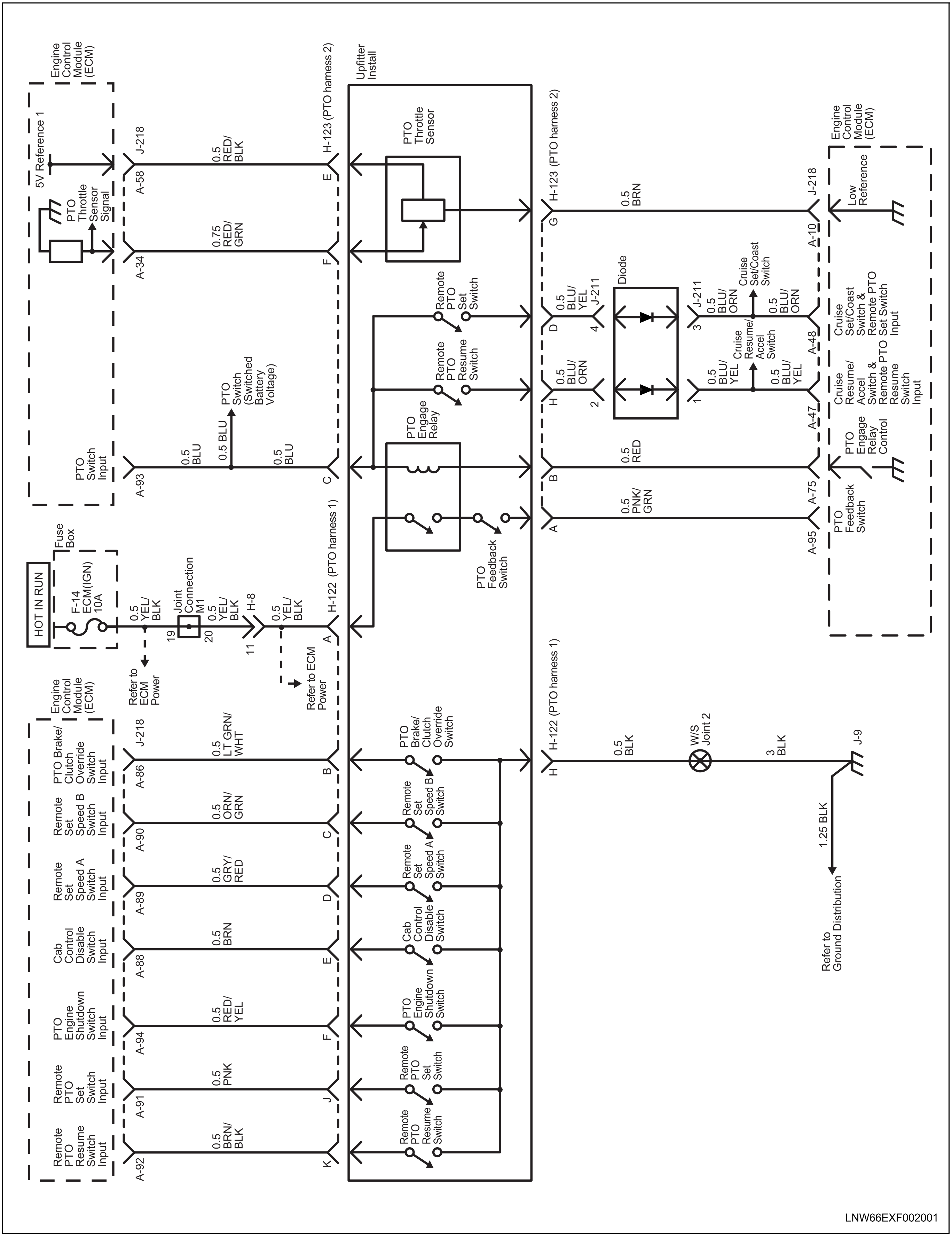
LNW66EXF001801

Glow Control System [12,000 lbs GVW]



LNW66EXF001901

PTO System

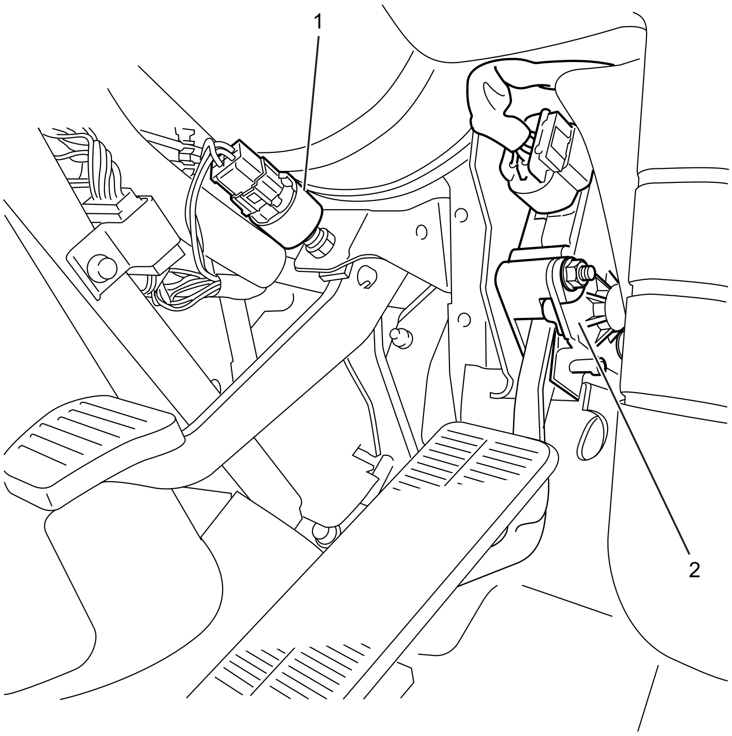


LNW66EXF002001

Component Locator

Engine Controls Component Views

Accelerator Pedal Position (APP) Sensor, Brake Switch

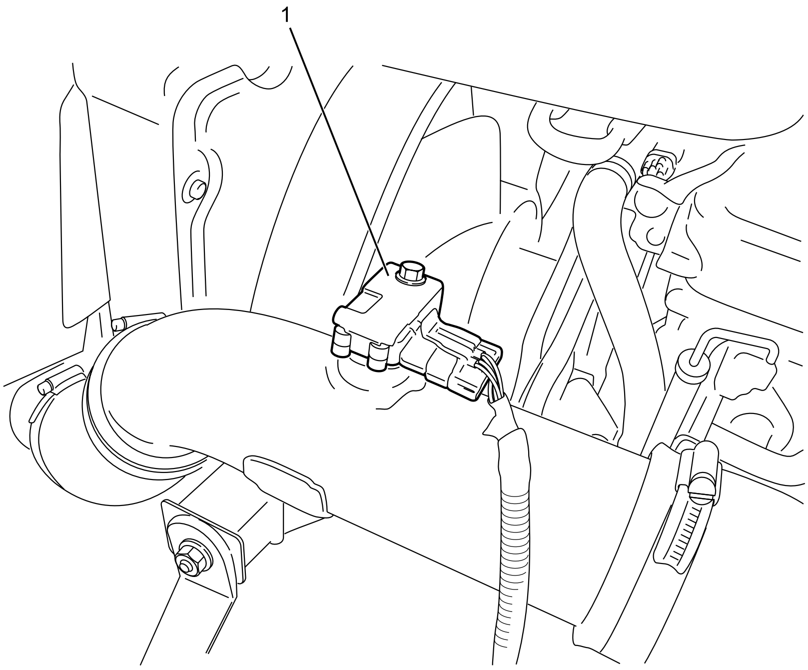


LNW46EMF000401

Legend

1. Brake Switch
2. Accelerator Pedal Position (APP) Sensor Assembly

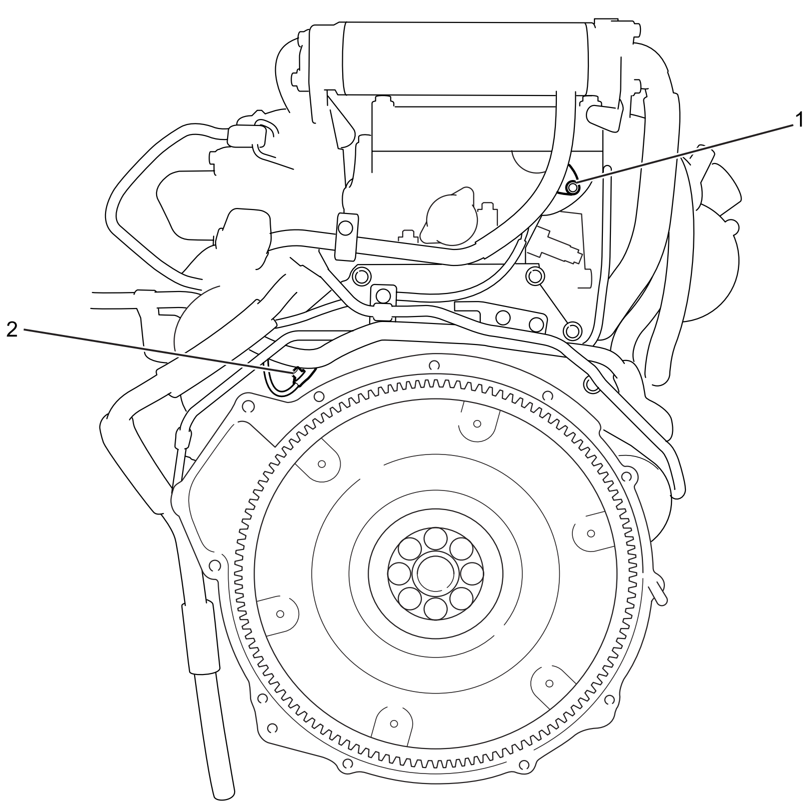
Boost Pressure Sensor



Legend

1. Boost Pressure Sensor

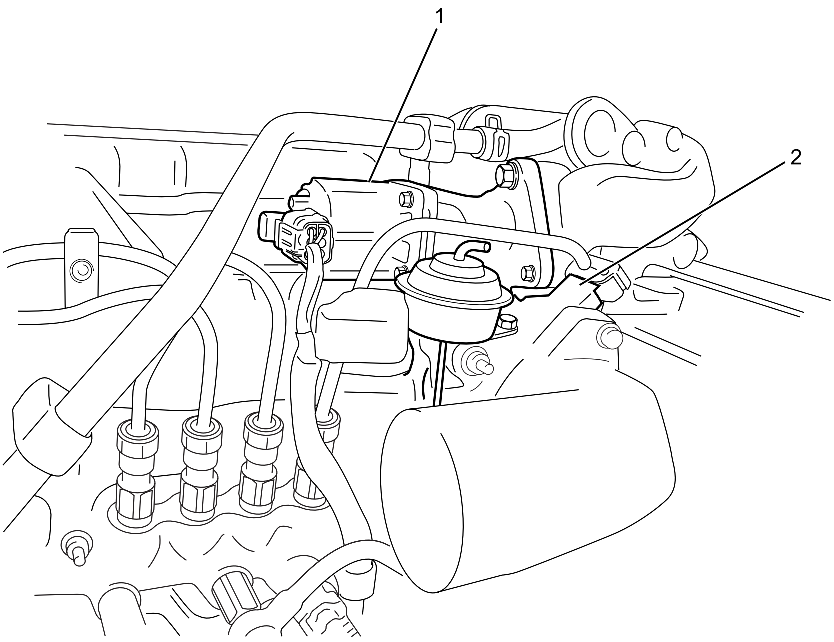
Camshaft Position (CMP), Crankshaft Position (CKP) Sensors



Legend

1. Camshaft Position (CMP) Sensor
2. Crankshaft Position (CKP) Sensor

Exhaust Gas Recirculation (EGR) Valve and Intake Throttle Valve

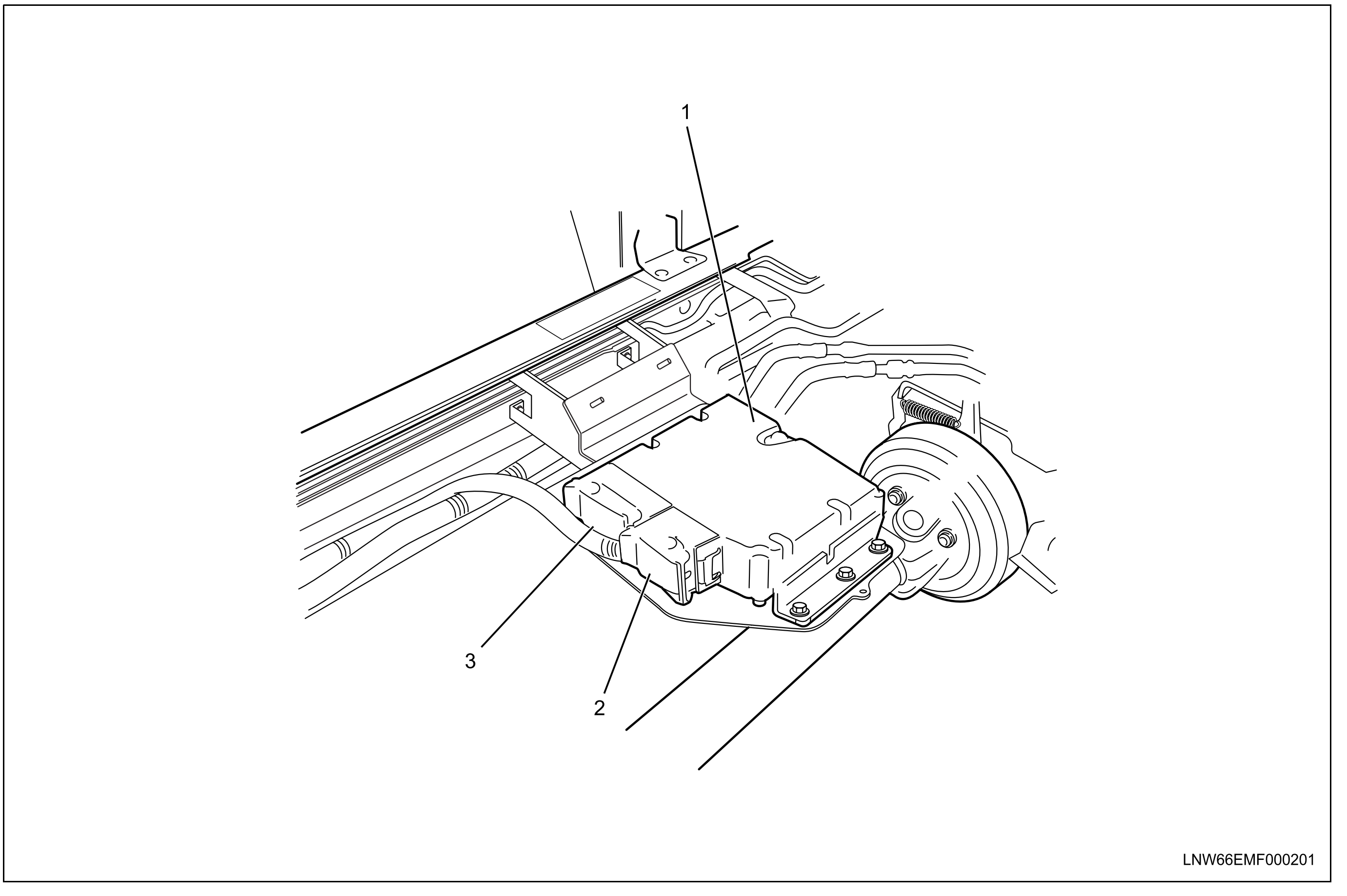


LNW46EMF001201

Legend

1. Exhaust Gas Recirculation (EGR) Valve
2. Intake Throttle Valve

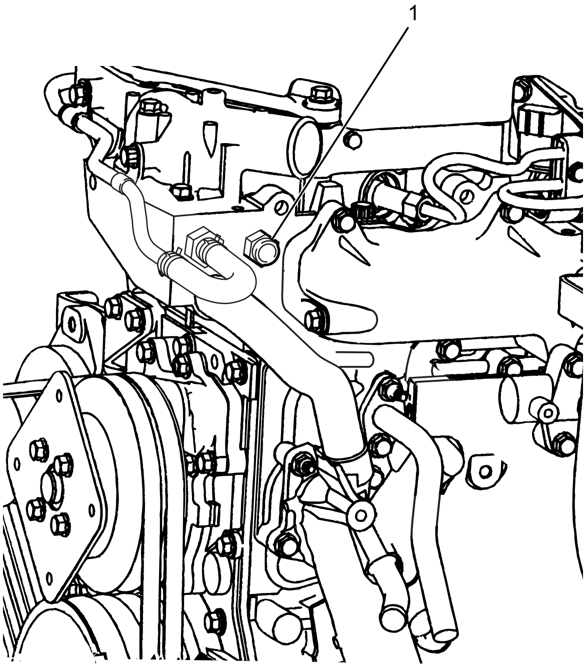
Engine Control Module (ECM)



Legend

1. Engine Control Module (ECM)
2. ECM B Harness Connector
3. ECM A Harness Connector

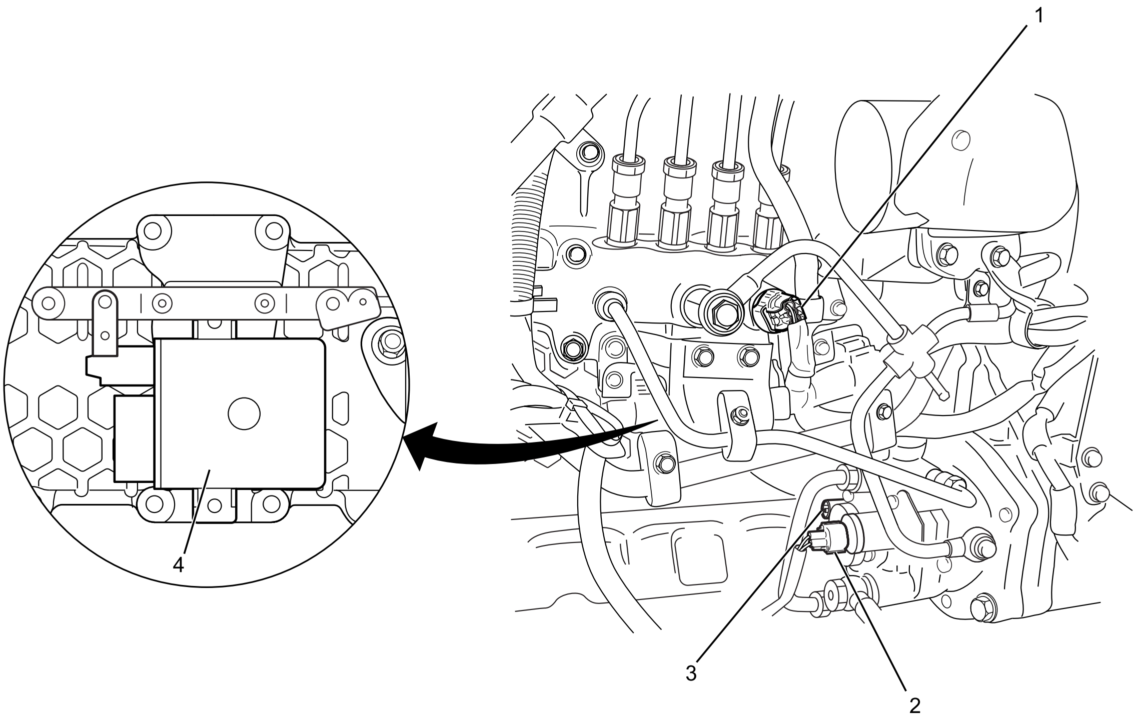
Engine Coolant Temperature (ECT) Sensor



Legend

1. Engine Coolant Temperature (ECT) Sensor

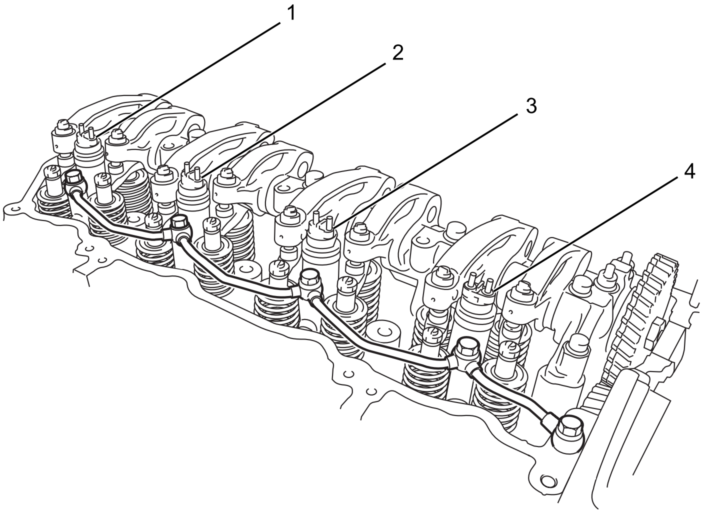
Fuel Rail Pressure (FRP) Sensor, Fuel Temperature (FT) Sensor, Fuel Rail Pressure (FRP) Regulator and Glow Plug Controller



Legend

1. Fuel Rail Pressure (FRP) Sensor
2. Fuel Rail Pressure (FRP) Regulator
3. Fuel Temperature (FT) Sensor
4. Glow Plug Controller

Fuel Injector

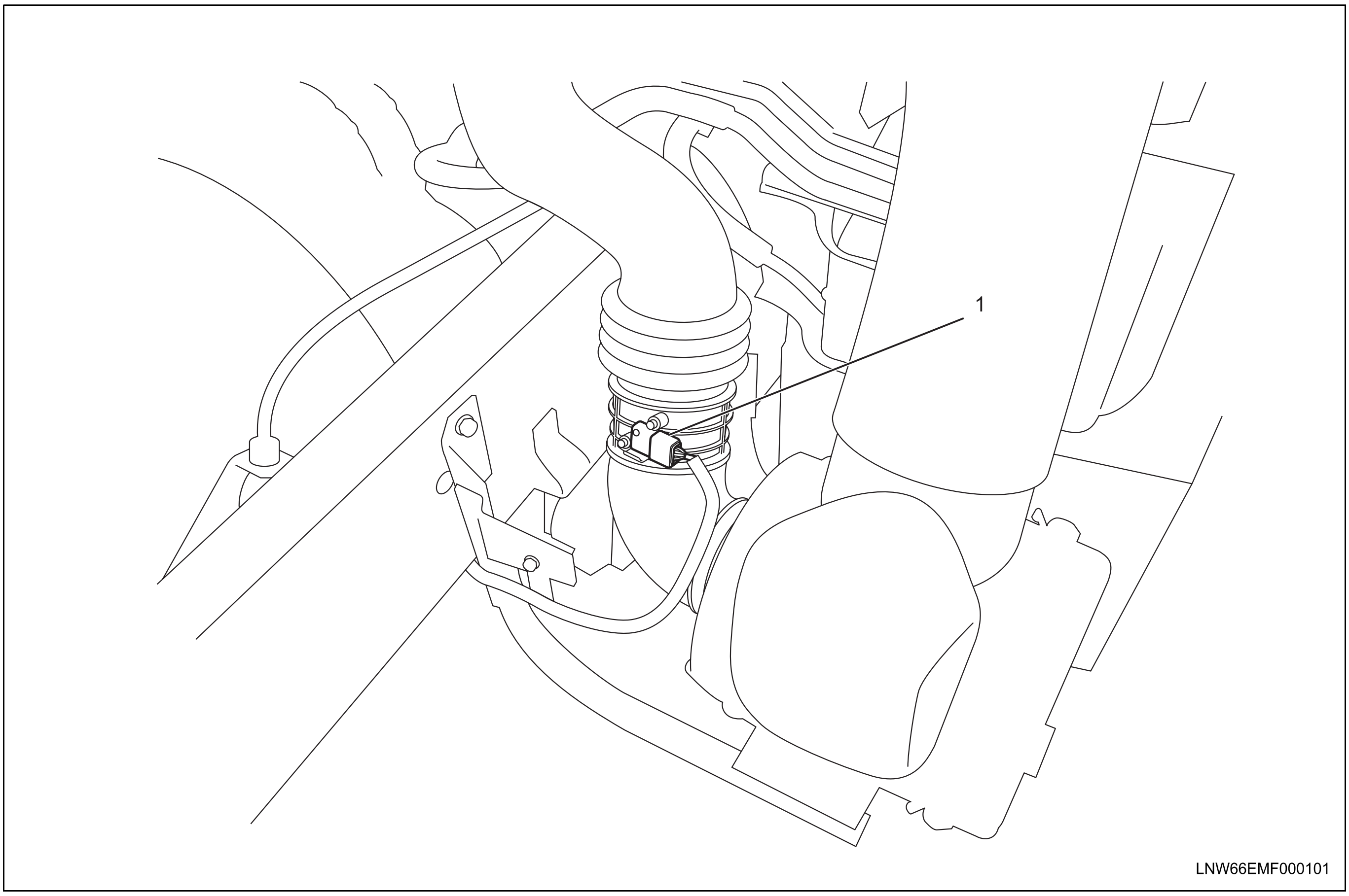


LNW46EMF001401

Legend

1. Cylinder #1 Injector
2. Cylinder #2 Injector
3. Cylinder #3 Injector
4. Cylinder #4 Injector

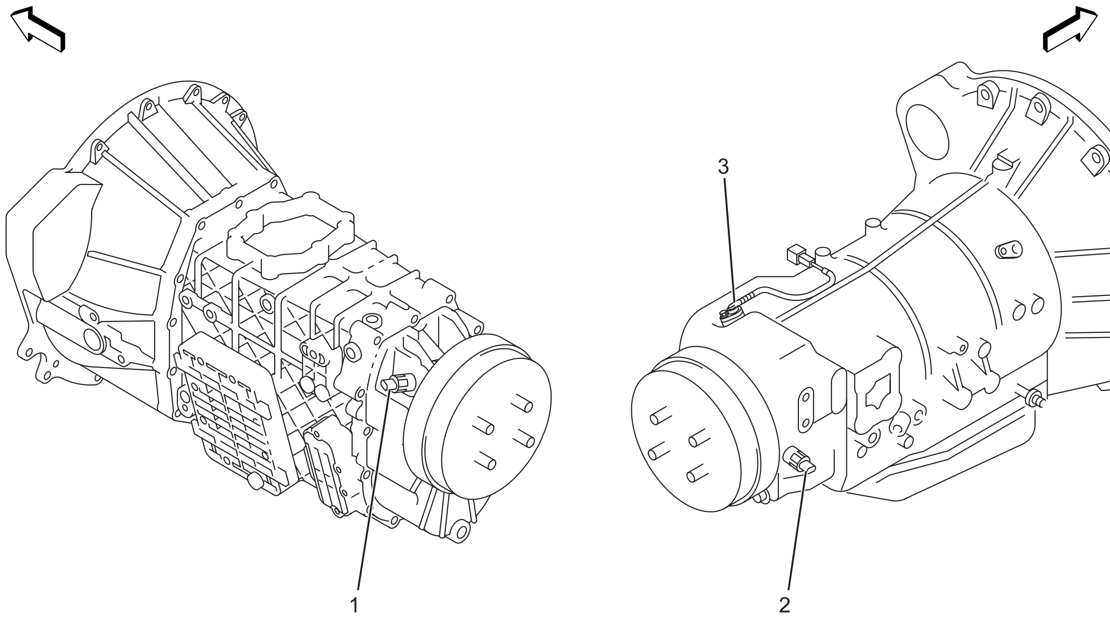
Mass Air Flow (MAF) Sensor / Intake Air Temperature (IAT) Sensor



Legend

1. Mass Air Flow (MAF) Sensor & Intake Air Temperature (IAT) Sensor (IAT sensor is internal to MAF sensor)

Vehicle Speed Sensor (VSS)



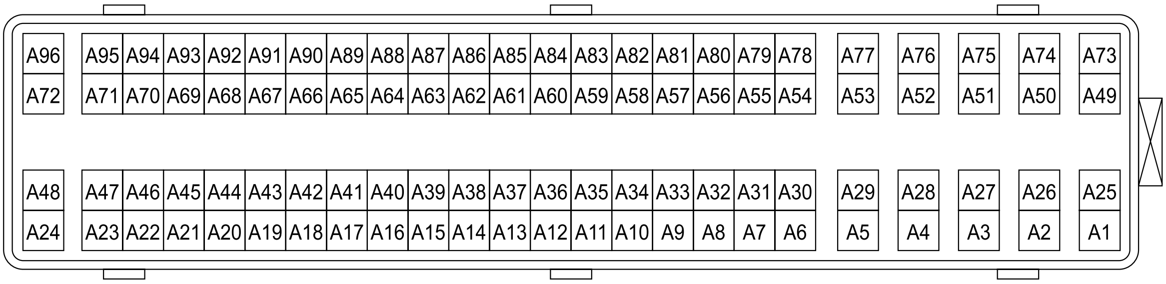
LNW66EMF000601

Legend

1. Vehicle Speed Sensor (VSS) 2 (M/T)
2. Vehicle Speed Sensor (VSS) 2 (A/T)
3. Vehicle Speed Sensor (VSS) 1 (A/T)

Engine Control Module (ECM) Connector End Views

Engine Control Module (ECM)-A



LNW48ASF000101

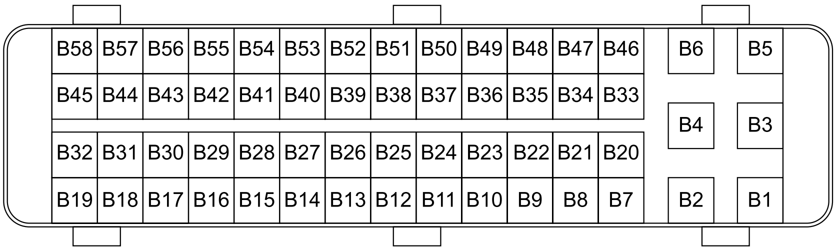
Connector No.		J-218
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
A-1	BLK/BLU	Case Ground
A-2	BLK	Power Ground
A-3	BLK	Power Ground
A-4	BLK/BLU	Signal Ground
A-5	BLK/BLU	Signal Ground
A-6	—	Not Used
A-7	BLK	APP Sensor 1 Low Reference
A-8	BLU/WHT	APP Sensor 2 Low Reference
A-9	ORN/BLU	APP Sensor 3 Low Reference
A-10	BRN	PTO Throttle Sensor Low Reference
A-11	BLK/PNK	Idle Up Sensor Low Reference
A-12	—	Not Used
A-13	—	Not Used
A-14	—	Not Used
A-15	—	Not Used
A-16	—	Not Used
A-17	RED	CAN High Signal
A-18	BLK	CAN Low Signal
A-19	WHT	ISO 14230 (KWP 2000) to DLC [Not Used]
A-20	ORN	J1850 (Class 2) to DLC
A-21	ORN	J1850 (Class 2) to DLC
A-22	BLU/WHT	Transmission MIL Request Signal
A-23	YEL/BLK	Ignition Voltage Feed Via ECM (IGN) Fuse
A-24	YEL/BLK	Engine Coolant Temperature Gauge Signal
A-25	PNK/BLK	Service Vehicle Soon (SVS) Lamp Control [12,000 lbs GVW]
A-26	BLK	Power Ground
A-27	BLK	Power Ground

Connector No.		J-218
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
A-28	YEL/VIO	Engine Speed Signal Output to IPC
A-29	—	Not Used
A-30	—	Not Used
A-31	WHT	APP Sensor 1 Signal
A-32	BLU	APP Sensor 2 Signal
A-33	BLU/GRN	APP Sensor 3 Signal
A-34	RED/GRN	PTO Throttle Sensor Signal
A-35	RED/BLU	Idle Up Sensor Signal
A-36	—	Not Used
A-37	—	Not Used
A-38	—	Not Used
A-39	YEL/GRN	VSS 2 Signal
A-40	—	Not Used
A-41	—	Not Used
A-42	—	Not Used
A-43	BRN	Exhaust Brake Cut Relay Signal [12,000 lbs GVW]
A-44	YEL/RED	Exhaust Brake Control Relay Feedback Signal [12,000 lbs GVW]
A-45	—	Not Used
A-46	YEL	Cruise Main Switch
A-47	BLU/YEL	Cruise Resume/ Accel Switch & Remote PTO Resume Switch
A-48	BLU/ORN	Cruise Set/ Coast Switch & Remote PTO Set Switch
A-49	RED	ECM Main Relay Voltage
A-50	RED	ECM Main Relay Voltage
A-51	WHT/RED	Battery Power (Back-Up) Feed via ECU (BATT) Fuse
A-52	BLU/BLK	ECM Main Relay Control
A-53	BLU/BLK	ECM Main Relay Control
A-54	RED	APP Sensor 1 5 V Reference
A-55	BLU/RED	APP Sensor 2 5 V Reference
A-56	ORN	APP Sensor 3 5 V Reference
A-57	—	Not Used

Connector No.		J-218
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
A-58	RED/BLK	PTO Throttle Sensor 5 V Reference
A-59	RED/YEL	Idle Up Sensor 5 V Reference
A-60	—	Not Used
A-61	—	Not Used
A-62	GRN	Stop Lamp Pedal Switch (Brake Pedal 1 Switch)
A-63	YEL/RED	Cruise Release Brake Switch (Brake Pedal 2 Switch)
A-64	BRN/YEL	Clutch Switch (M/T Only)
A-65	BLU	Engine Shut Down Switch
A-66	—	Not Used
A-67	BRN/WHT	Exhaust Brake Switch
A-68	—	Not Used
A-69	—	Not Used
A-70	—	Not Used
A-71	—	Not Used
A-72	YEL/RED	Intake Throttle Solenoid Valve Feedback Signal [12,000 lbs GVW]
A-73	RED	ECM Main Relay Voltage
A-74	BLK/RED	Glow Relay Control [Except 12,000 lbs GVW]
A-75	RED	PTO Engage Relay Control
A-76	BLU/WHT	Starter Cut Relay Control
A-77	BRN/RED	Exhaust Brake Control Relay Control
A-78	—	Not Used
A-79	ORN/BLU	Glow Lamp Control
A-80	BLU/RED	Malfunction Indicator Lamp (MIL) Control
A-81	GRN/RED	Cruise Main Lamp Control
A-82	LT BLU	Engine Speed Signal Output to TCM (A/T Only)
A-83	—	Not Used
A-84	GRN/YEL	Cruise Set Lamp Control
A-85	—	Not Used

Connector No.		J-218
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
A-86	LT GRN/ WHT	PTO Brake/Clutch Override Switch
A-87	—	Not Used
A-88	BRN	Cab Control Disable Switch
A-89	GRY/RED	Remote Set Speed A Switch
A-90	ORN/GRN	Remote Set Speed B Switch
A-91	PNK	Remote PTO Set Switch
A-92	BRN/BLK	Remote PTO Resume Switch
A-93	BLU	PTO Switch
A-94	RED/YEL	PTO Engine Shutdown Switch
A-95	PNK/GRN	PTO Feedback Switch
A-96	RED/WHT	Starter Signal Switch

Engine Control Module (ECM)-B



AAW46ESF000101

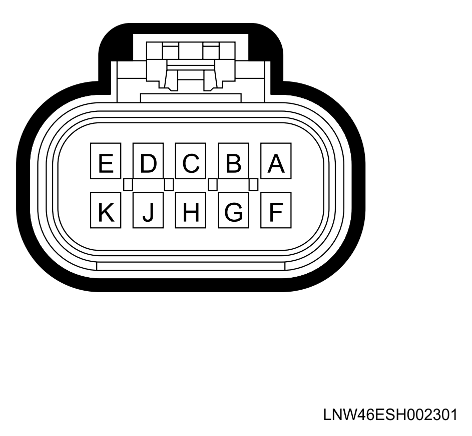
Connector No.		J-217
Connector Color		Black
Test Adapter No.		J-35616-64A [Pin B-1 – B-6] J-35616-64A [Pin B-7 – B-58]
Pin	Wire Color	Pin Function
B-1	—	Not Used
B-2	—	Not Used
B-3	WHT	Cylinder #1, #4 Injector Power Supply
B-4	RED	Cylinder #2, #3 Injector Power Supply
B-5	BLU/WHT	Cylinder #1, #4 Injector Power Supply
B-6	BLU/RED	Cylinder #2, #3 Injector Power Supply
B-7	BLK/ORN	EGR DC Motor +12 V Feed
B-8	LT GRN/ RED	EGR DC Motor Duty Signal
B-9	—	Not Used
B-10	—	Not Used
B-11	—	Not Used
B-12	RED	Boost Pressure Sensor Low Reference
B-13	RED	Fuel Rail Pressure Sensor Low Reference
B-14	BLK	IAT, ECT & FT Sensor Low Reference
B-15	BLK	MAF Sensor Low Reference
B-16	—	Not Used

Connector No.		J-217
Connector Color		Black
Test Adapter No.		J-35616-64A [Pin B-1 – B-6] J-35616-64A [Pin B-7 – B-58]
Pin	Wire Color	Pin Function
B-17	WHT/BLK	EGR Position Sensor Low Reference
B-18	GRY	CMP Sensor Shield
B-19	WHT	CKP Sensor Shield
B-20	YEL	Fuel Rail Pressure (FRP) Regulator Low Control
B-21	GRN	Fuel Rail Pressure (FRP) Regulator Low Control
B-22	—	Not Used
B-23	—	Not Used
B-24	BLK	Boost Pressure Sensor Signal
B-25	GRN	Fuel Rail Pressure Sensor Signal
B-26	GRN	Fuel Rail Pressure Sensor Signal
B-27	—	Not Used
B-28	ORN	MAF Sensor Signal
B-29	—	Not Used
B-30	BLU	CMP Sensor Signal
B-31	WHT/RED	CKP Sensor High Signal
B-32	WHT/BLU	CKP Sensor Low Signal
B-33	WHT/RED	Fuel Rail Pressure (FRP) Regulator High Control

Connector No.		J-217
Connector Color		Black
Test Adapter No.		J-35616-64A [Pin B-1 – B-6] J-35616-64A [Pin B-7 – B-58]
Pin	Wire Color	Pin Function
B-34	ORN	Fuel Rail Pressure (FRP) Regulator High Control
B-35	RED/BLK	ECT Sensor Signal
B-36	—	Not Used
B-37	GRN/WHT	IAT Sensor Signal
B-38	—	Not Used
B-39	—	Not Used
B-40	—	Not Used
B-41	RED/GRN	FT Sensor Signal
B-42	—	Not Used
B-43	BLU	Cylinder #2 Injector Control
B-44	—	Not Used
B-45	WHT/YEL	Cylinder #3 Injector Control
B-46	WHT	Boost Pressure Sensor 5 V Reference
B-47	WHT	Fuel Rail Pressure Sensor 5 V Reference
B-48	—	Not Used
B-49	BRN	EGR Position Sensor 5 V Reference
B-50	—	Not Used
B-51	ORN	CMP Sensor 12 V Reference
B-52	—	Not Used
B-53	WHT/ORN	EGR Position Sensor Signal
B-54	—	Not Used
B-55	—	Not Used
B-56	BLK	Cylinder #4 Injector Control
B-57	—	Not Used
B-58	GRN/WHT	Cylinder #1 Injector Control

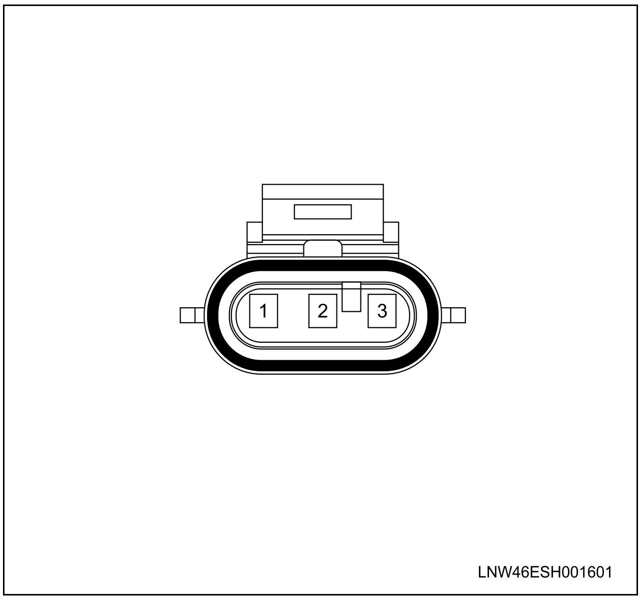
Engine Controls Connector End Views

Accelerator Pedal Position (APP) Sensor



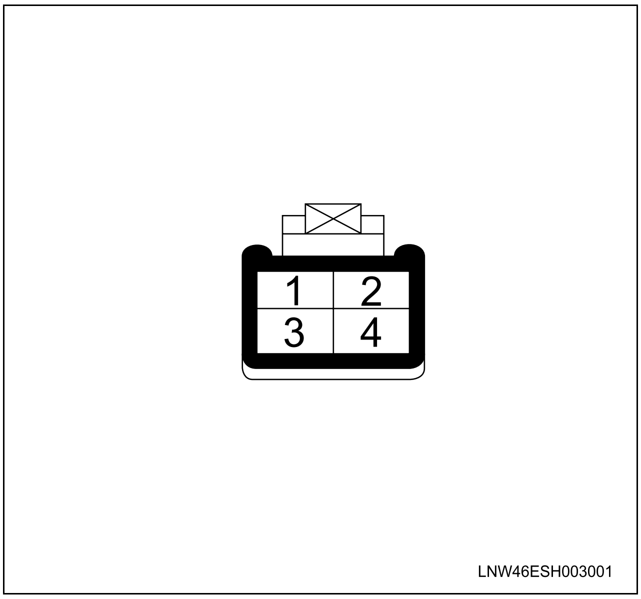
Connector No.		B-280
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
A	BLU/GRN	APP Sensor 3 Signal
B	ORN	APP Sensor 3 5 V Reference
C	—	Not Used
D	RED	APP Sensor 1 5 V Reference
E	WHT	APP Sensor 1 Signal
F	ORN/BLU	APP Sensor 3 Low Reference
G	BLU/WHT	APP Sensor 2 Low Reference
H	BLU	APP Sensor 2 Signal
J	BLU/RED	APP Sensor 2 5 V Reference
K	BLK	APP Sensor 1 Low Reference

Boost Pressure Sensor



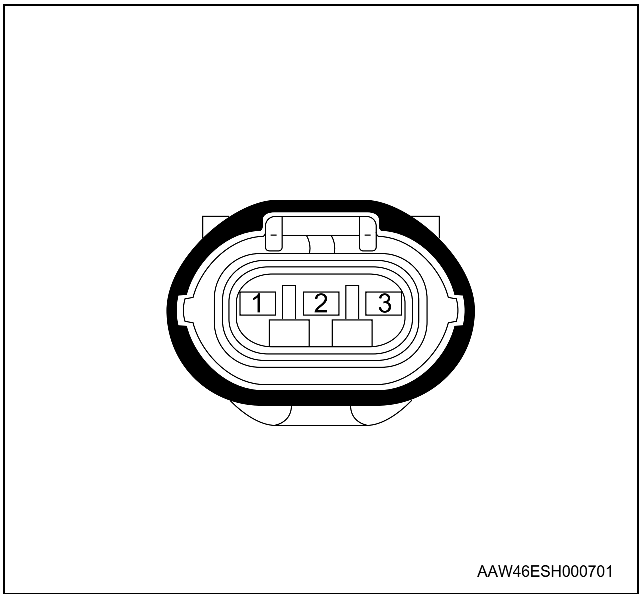
Connector No.		J-216
Connector Color		Gray
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	RED	Sensor Low Reference
2	BLK	Sensor Signal
3	WHT	Sensor 5 V Reference

Brake Switch



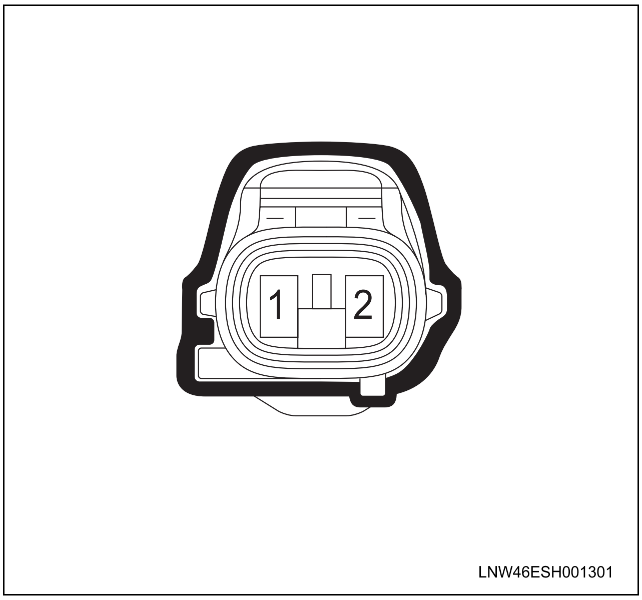
Connector No.		B-66
Connector Color		Brown
Test Adapter No.		J-35616-42
Pin	Wire Color	Pin Function
1	GRN/YEL	Switch 1 +12 V Feed via Brake Light Fuse
2	YEL/BLK	Switch 2 +12 V Feed via ECM (IGN) Fuse
3	YEL/RED	Switch 2 (Cruise Release Switch) Signal
4	GRN	Switch 1 (Stop Lamp Switch) Signal

Camshaft Position (CMP) Sensor



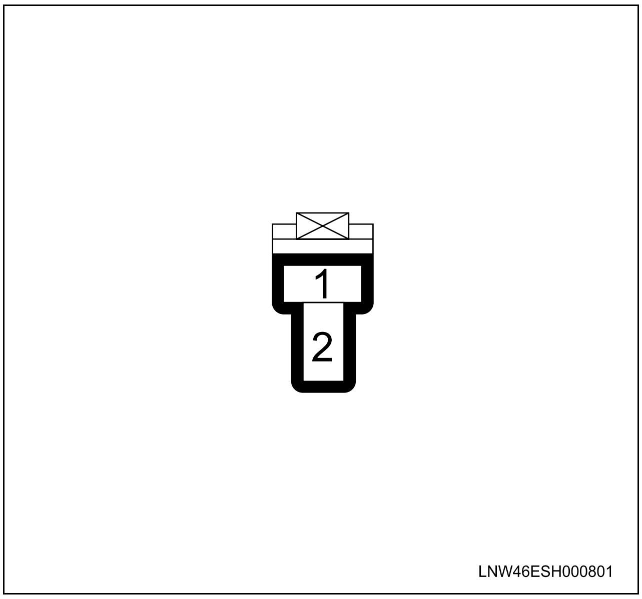
Connector No.		E-112
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	BLK/WHT	Sensor Shield
2	BLU	Sensor Signal
3	RED	Sensor +12 V Reference

Crankshaft Position (CKP) Sensor



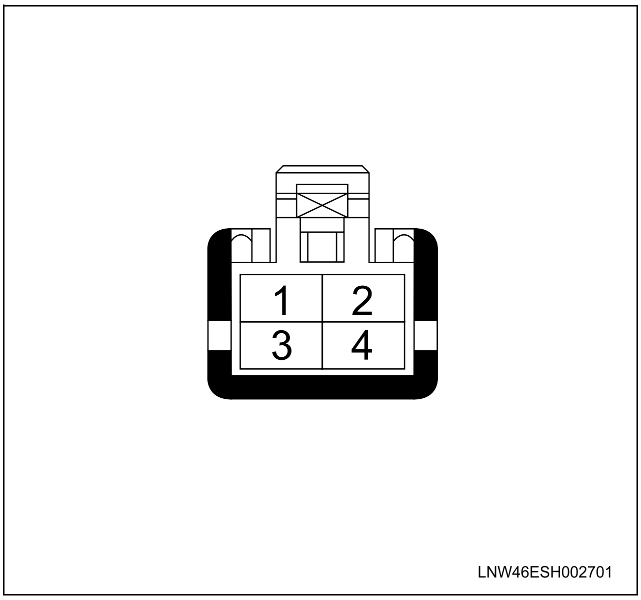
Connector No.		E-98
Connector Color		Gray
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	WHT/RED	Sensor High Signal
2	WHT/BLU	Sensor Low Signal

Clutch Switch



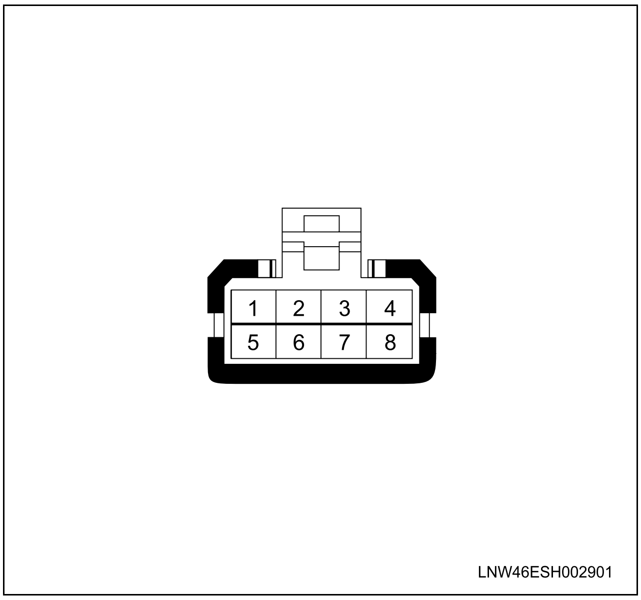
Connector No.		B-89
Connector Color		White
Test Adapter No.		J-35616-42
Pin	Wire Color	Pin Function
1	YEL/BLK	+12 V Feed via ECM (IGN) Fuse
2	BRN/YEL	Switch Signal

Cruise Main Switch



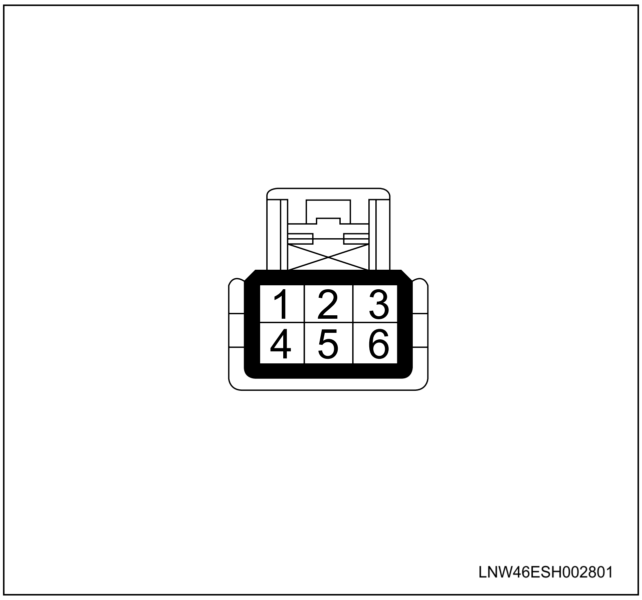
Connector No.		B-376
Connector Color		White
Test Adapter No.		J-35616-44
Pin	Wire Color	Pin Function
1	LT GRN/ RED	Illumination Lamp +12 V Feed
2	YEL	Main Switch Signal
3	LT GRN/ BLK	Illumination Lamp Ground
4	YEL/BLK	+12 V Feed via ECM (IGN) Fuse

Cruise Resume / Accel Switch



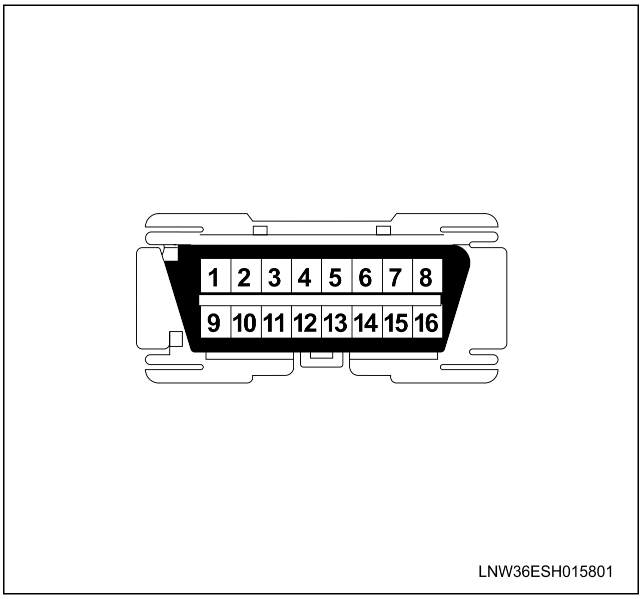
Connector No.		B-378
Connector Color		White
Test Adapter No.		J-35616-4A
Pin	Wire Color	Pin Function
1	—	Not Used
2	—	Not Used
3	BLU/YEL	Resume Accel Switch Signal
4	—	Not Used
5	LT GRN/ BLK	Illumination Lamp Ground
6	LT GRN/ RED	Illumination Lamp +12 V Feed
7	—	Not Used
8	YEL/BLK	+12 V Feed via ECM (IGN) Fuse

Cruise Set / Coast Switch



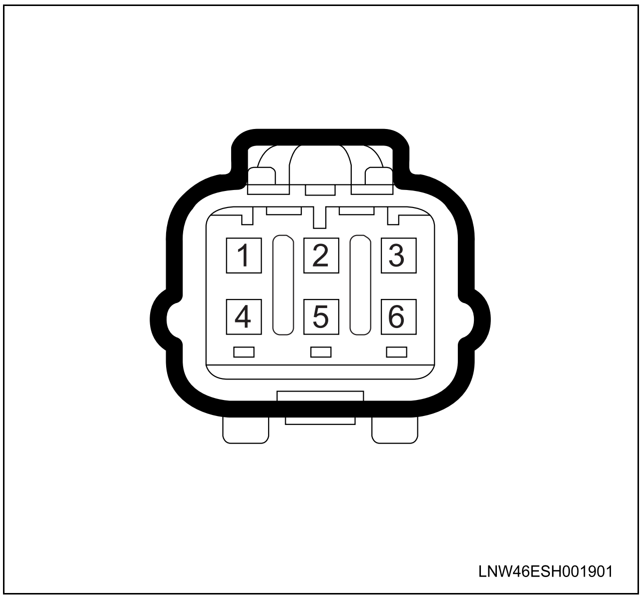
Connector No.		B-377
Connector Color		White
Test Adapter No.		J-35616-4A
Pin	Wire Color	Pin Function
1	BLU/ORN	Set Coast Switch Signal
2	YEL/BLK	+12 V Feed via ECM (IGN) Fuse
3	—	Not Used
4	LT GRN/ BLK	Illumination Lamp Ground
5	LT GRN/ RED	Illumination Lamp +12 V Feed
6	—	Not Used

Data Link Connector (DLC)



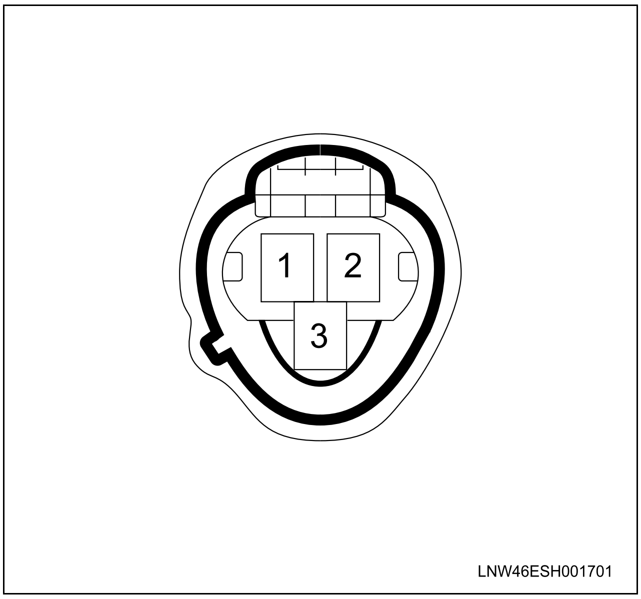
Connector No.		B-79
Connector Color		Black
Test Adapter No.		J-35616-2A
Pin	Wire Color	Pin Function
1	—	Not Used
2	ORN	J1850 (Class 2)
3	—	Not Used
4	BLK/BLU	Ground
5	BLK/BLU	Ground
6	—	Not Used
7	WHT	ISO14230 (KWP2000) [Not Used]
8	—	Not Used
9	—	Not Used
10	—	Not Used
11	BLK/WHT	TCM Diagnostic
12	WHT/BLU	EHCU [ABS Module] Diagnostic
13	—	Not Used
14	—	Not Used
15	—	Not Used
16	GRN	Power Supply

EGR Valve



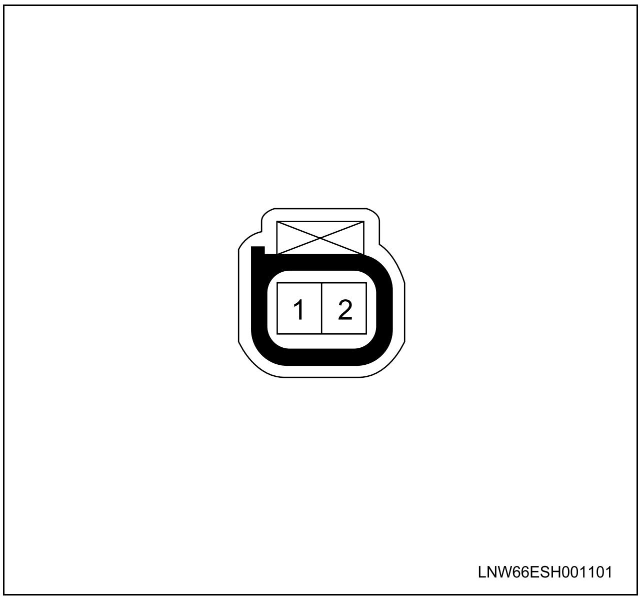
Connector No.		E-94
Connector Color		Gray
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	BLU	Position Sensor 5 V Reference
2	WHT/BLK	Position Sensor Low Reference
3	WHT/GRN	Position Sensor Signal
4	BLK/ORN	EGR DC Motor +12 V Feed
5	—	Not Used
6	LT GRN/ RED	EGR DC Motor Duty Signal

Engine Coolant Temperature Coolant (ECT) Sensor



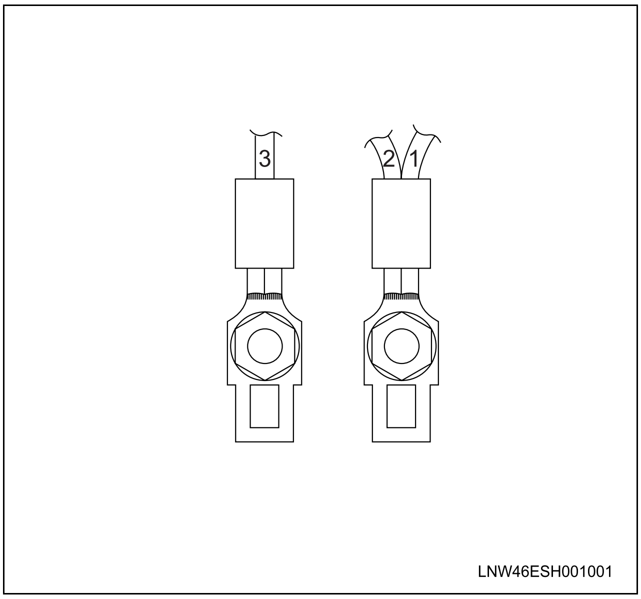
Connector No.		E-90
Connector Color		Gray
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	RED/BLK	Sensor Signal
2	BLK	Sensor Low Reference
3	—	Not Used

Exhaust Brake Magnetic Valve



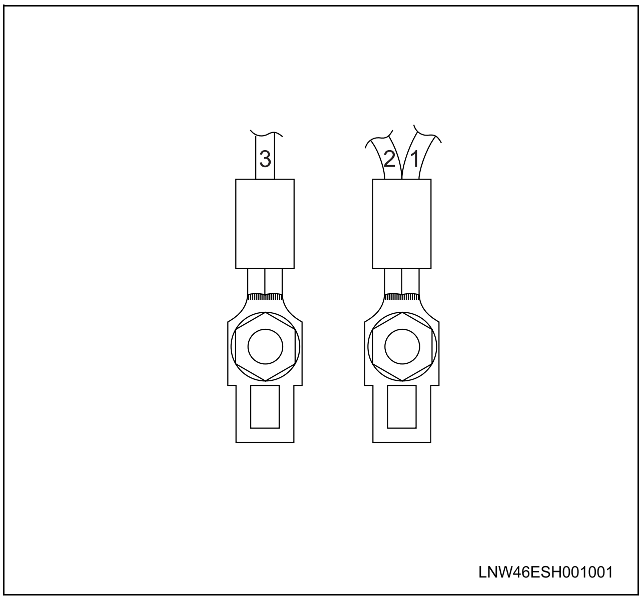
Connector No.		J-31
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	YEL/RED	Power Supply from Relay
2	BLK	Ground

Fuel Injector Cylinder No.1



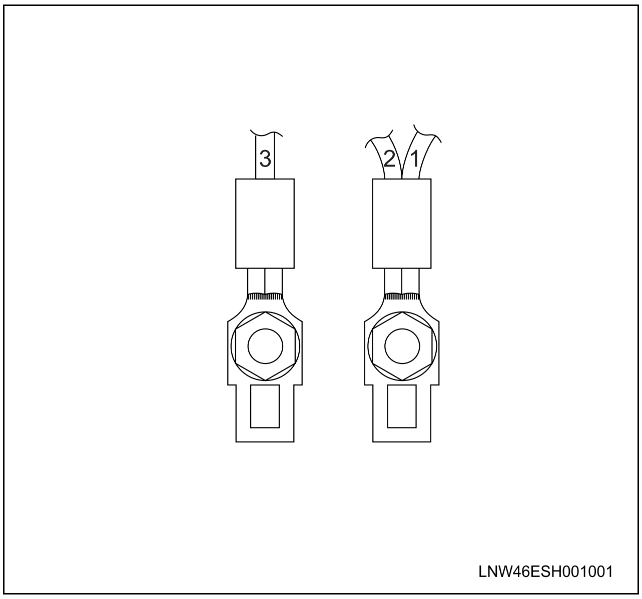
Connector No.		E-138
Connector Color		Silver
Pin	Wire Color	Pin Function
1	WHT	Injector Power Supply
2	WHT	Injector Power Supply
3	GRN	Injector Control

Fuel Injector Cylinder No.2



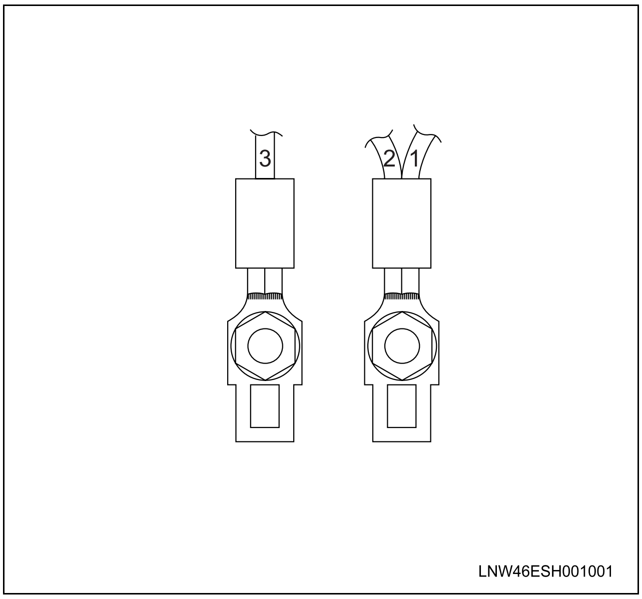
Connector No.		E-139
Connector Color		Silver
Pin	Wire Color	Pin Function
1	RED	Injector Power Supply
2	RED	Injector Power Supply
3	BLU	Injector Control

Fuel Injector Cylinder No.3



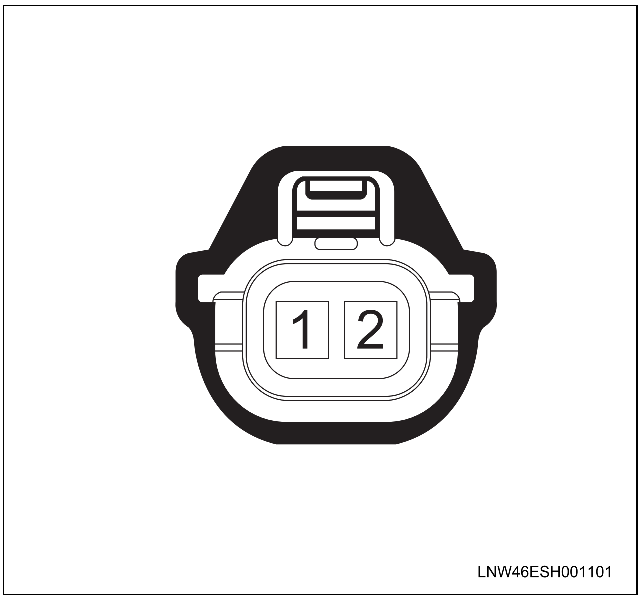
Connector No.		E-140
Connector Color		Silver
Pin	Wire Color	Pin Function
1	RED	Injector Power Supply
2	RED	Injector Power Supply
3	YEL	Injector Control

Fuel Injector Cylinder No.4



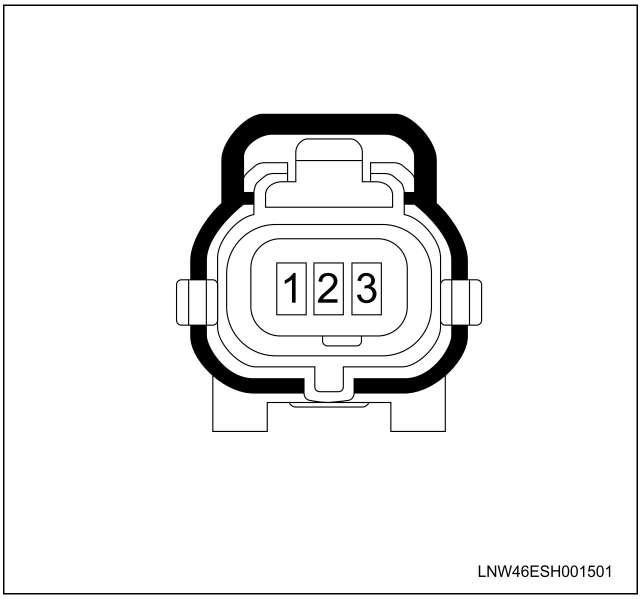
Connector No.		E-141
Connector Color		Silver
Pin	Wire Color	Pin Function
1	WHT	Injector Power Supply
2	WHT	Injector Power Supply
3	BLK	Injector Control

Fuel Rail Pressure (FRP) Regulator



Connector No.		E-116
Connector Color		Gray
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	WHT	FRP Regulator High Control
2	BLU	FRP Regulator Low Control

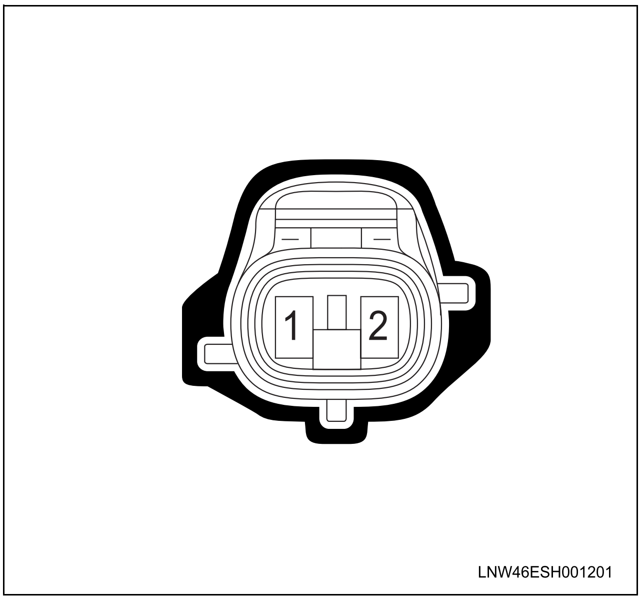
Fuel Rail Pressure Sensor



Connector No.		E-113
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	RED	Sensor Low Reference

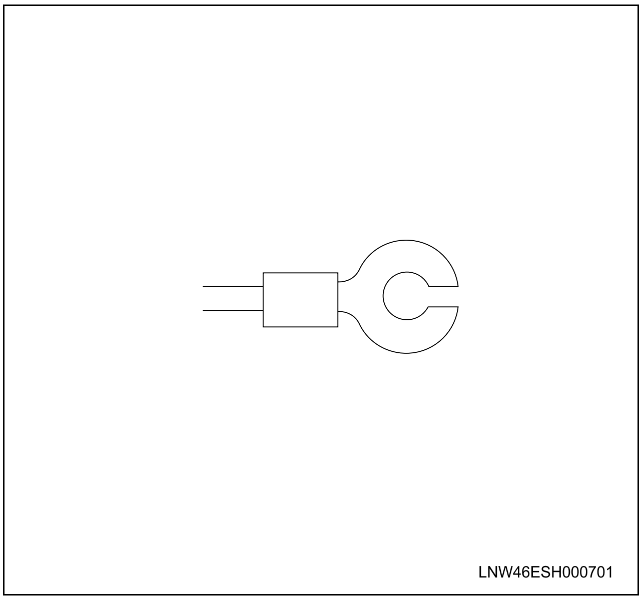
Connector No.		E-113
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
2	GRN	Sensor Signal
3	WHT	Sensor 5 V Reference

Fuel Temperature (FT) Sensor



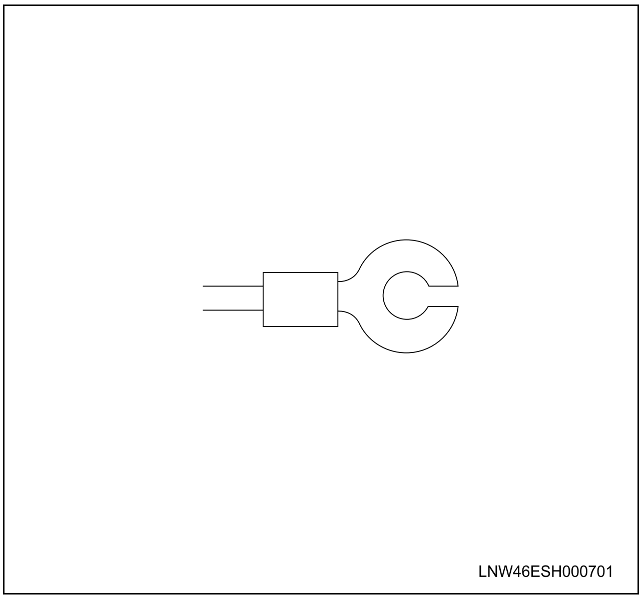
Connector No.		E-93
Connector Color		Green
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	BLK	Sensor Low Reference
2	RED/GRN	Sensor Signal

Glow Plug [Except 12,000lbs GVW]



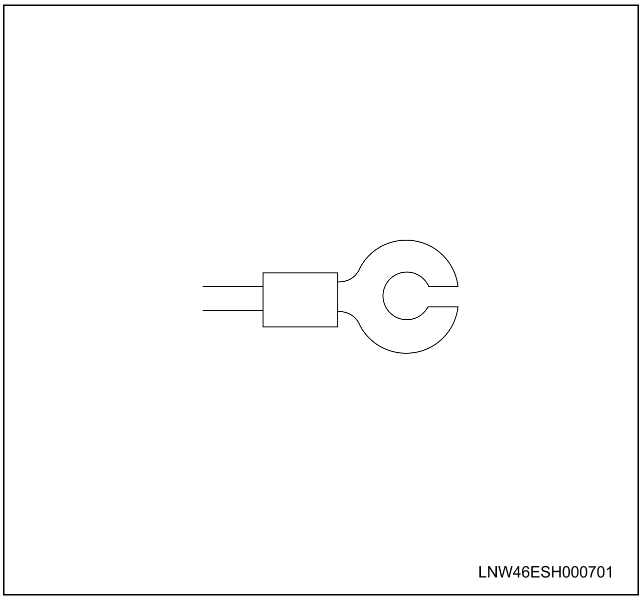
Connector No.		E-3
Connector Color		Silver
Pin	Wire Color	Pin Function
1	BLK/GRN	Power Supply from Relay

Glow Plug Cylinder No.1 [12,000lbs GVW]



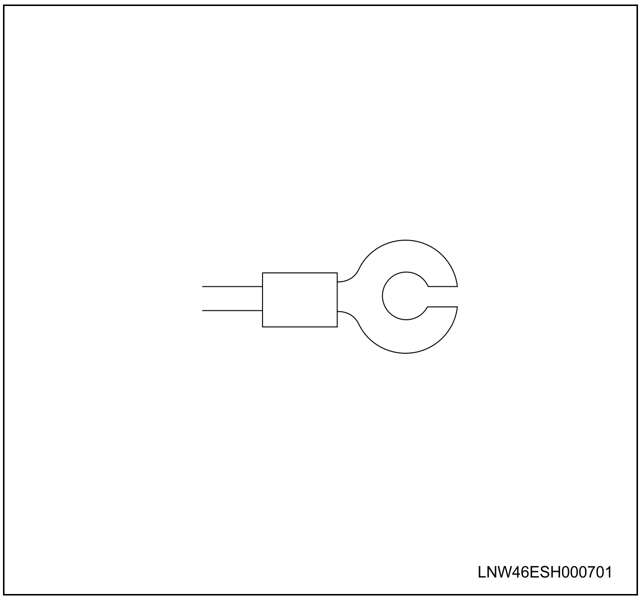
Connector No.		E-146
Connector Color		Silver
Pin	Wire Color	Pin Function
1	RED	Power Supply

Glow Plug Cylinder No.2 [12,000lbs GVW]



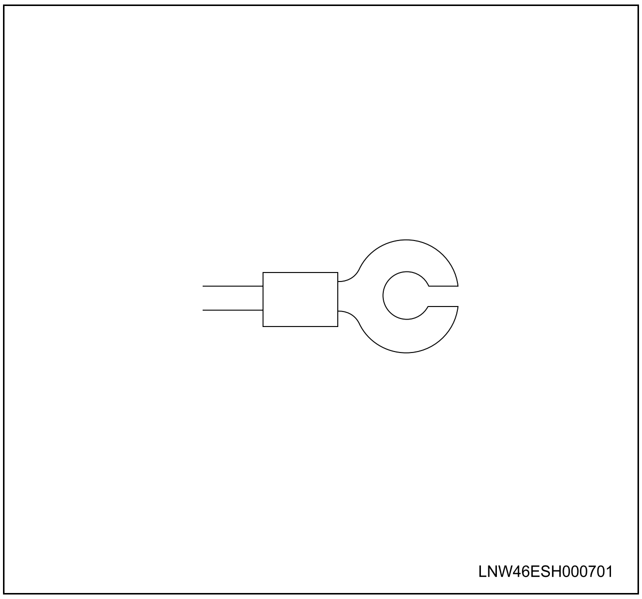
Connector No.		E-147
Connector Color		Silver
Pin	Wire Color	Pin Function
1	GRN	Power Supply

Glow Plug Cylinder No.4 [12,000lbs GVW]



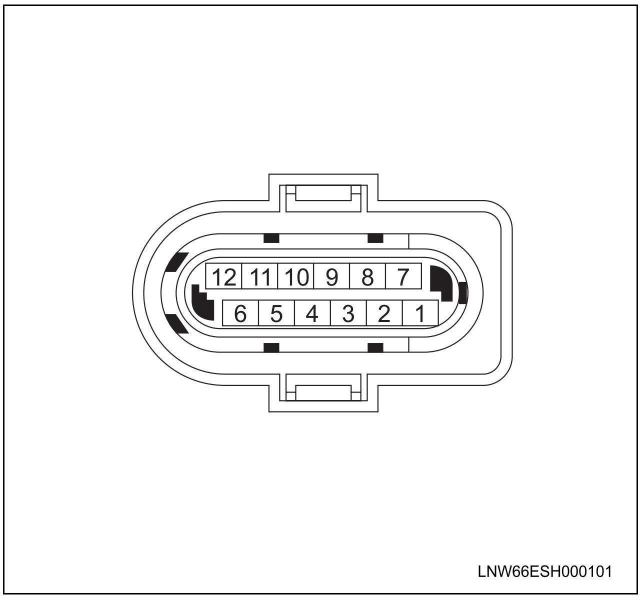
Connector No.		E-149
Connector Color		Silver
Pin	Wire Color	Pin Function
1	BLU	Power Supply

Glow Plug Cylinder No.3 [12,000lbs GVW]



Connector No.		E-148
Connector Color		Silver
Pin	Wire Color	Pin Function
1	PNK	Power Supply

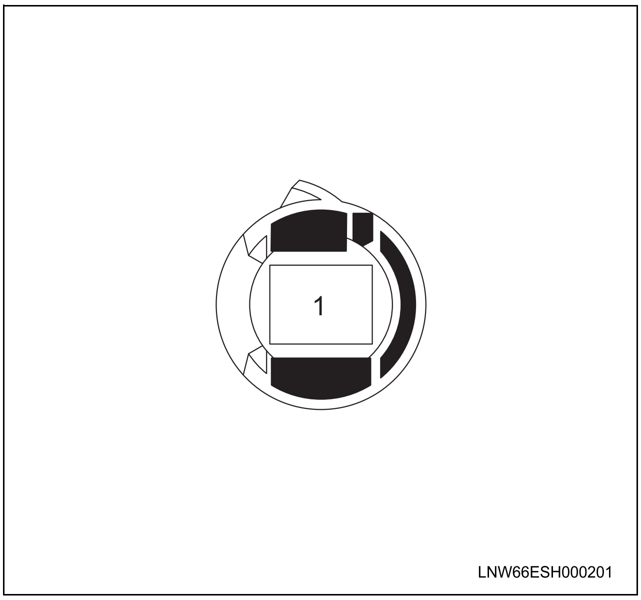
Glow Plug Controller (12pin) [12,000lbs GVW]



Connector No.		E-144
Connector Color		Black
Test Adapter No.		J-35616-2A
Pin	Wire Color	Pin Function
1	RED	Glow Plug Cylinder No.1 Control
2	GRN	Glow Plug Cylinder No.2 Control
3	PNK	Glow Plug Cylinder No.3 Control

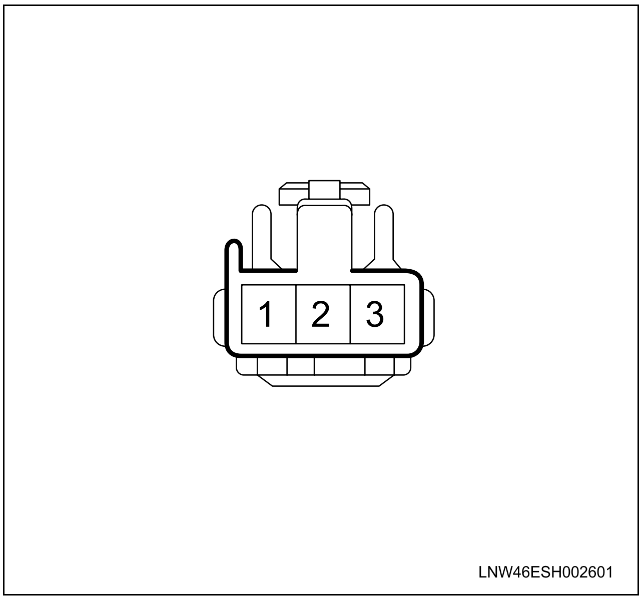
Connector No.		E-144
Connector Color		Black
Test Adapter No.		J-35616-2A
Pin	Wire Color	Pin Function
4	BLU	Glow Plug Cylinder No.4 Control
5	BLK/YEL	Ignition Voltage Feed Via Gauges Fuse
6	WHT/ORN	CAN High
7	—	Not Used
8	—	Not Used
9	—	Not Used
10	—	Not Used
11	BLK	Ground
12	RED/GRN	CAN Low

Glow Plug Controller (1pin) [12,000lbs GVW]



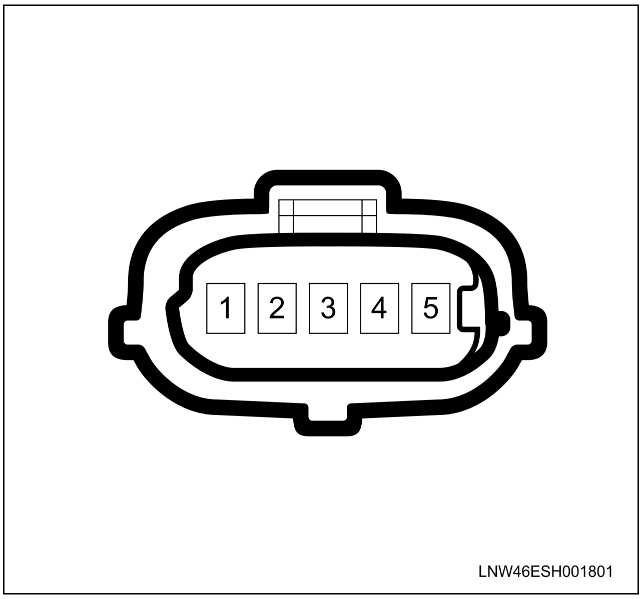
Connector No.		E-150
Connector Color		Black
Test Adapter No.		J-35616-44
Pin	Wire Color	Pin Function
1	WHT/BLK	Battery Voltage

Idle Up Sensor



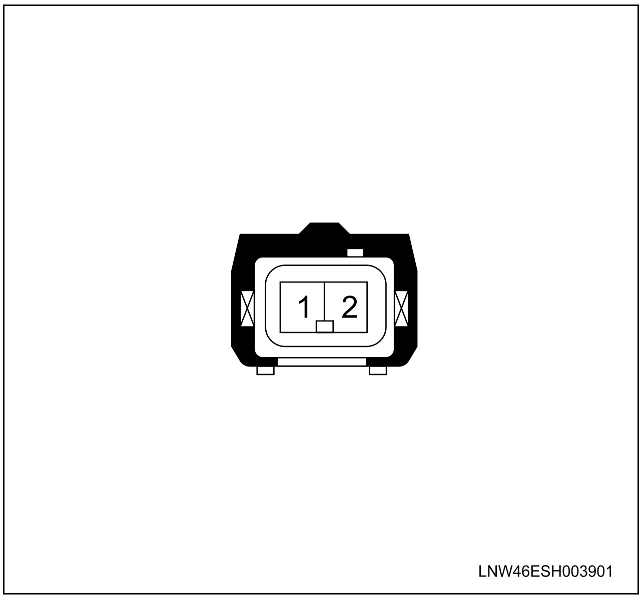
Connector No.		B-374
Connector Color		White
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	BLK/PNK	Sensor Low Reference
2	RED/BLU	Sensor Signal
3	RED/YEL	Sensor 5 V Reference

Mass Air Flow (MAF) / Intake Air Temperature Sensor



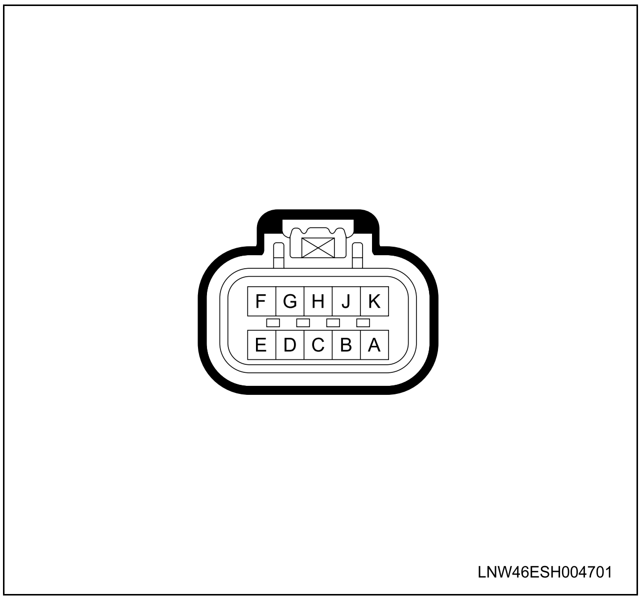
Connector No.		J-219
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	RED	MAF Sensor +12 V Feed
2	BLK	MAF Sensor Low Reference
3	ORN	MAF Sensor Signal
4	GRN/WHT	IAT Sensor Signal
5	BLK	IAT Sensor Low Reference

Intake Throttle Solenoid Valve



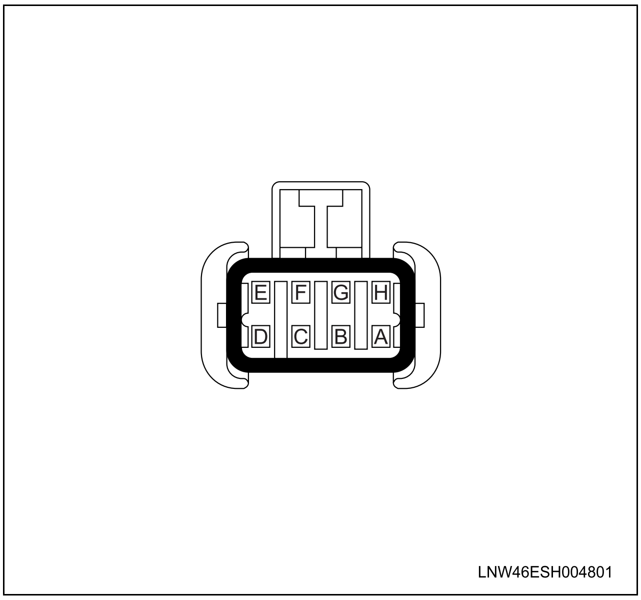
Connector No.		J-40
Connector Color		Brown
Test Adapter No.		J-35616-4A
Pin	Wire Color	Pin Function
1	YEL/RED	Power Supply from Relay
2	BLK	Ground

PTO Harness 1



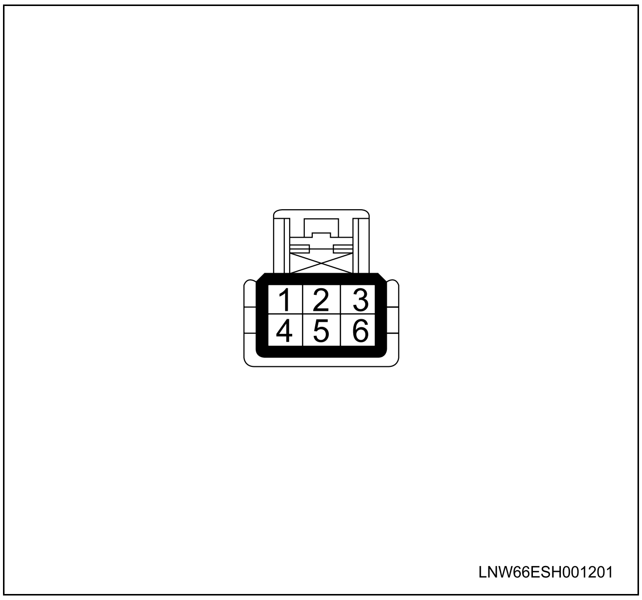
Connector No.		H-122
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
A	YEL/BLK	+12 V Feed Via ECM (IGN) Fuse
B	LT GRN/ WHT	PTO Brake/Clutch Override Switch
C	ORN/GRN	Remote Set Speed B Switch
D	GRY/RED	Remote Set Speed A Switch
E	BRN	Cab Control Disable Switch
F	RED/YEL	PTO Engine Shutdown Switch
G	—	Not Used
H	BLK	Ground
J	PNK	Remote PTO Set Switch
K	BRN/BLK	Remote PTO Resume Switch

PTO Harness 2



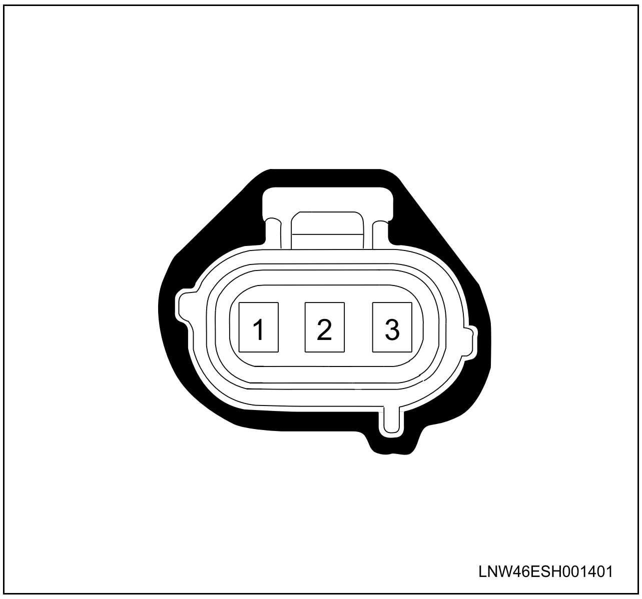
Connector No.		H-123
Connector Color		Black
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
A	PNK/GRN	PTO Feedback Switch
B	RED	PTO Enable Relay Control
C	BLU	PTO Switch
D	BLU/YEL	Remote PTO Set Switch
E	RED/BLK	PTO Throttle Sensor 5 V Reference
F	RED/GRN	PTO Throttle Sensor Signal
G	BRN	PTO Throttle Sensor Low Reference
H	BLU/ORN	Remote PTO Resume Switch

PTO Switch



Connector No.		H-373
Connector Color		White
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	YEL/BLK	+12V Feed Via ECM (IGN) Fuse
2	BLU	PTO Switch Signal
3	BLU	Switch Indicator Lamp + 12V Feed
4	LT GRN/ RED	Illumination Lamp + 12V Feed
5	LT GRN/ BLK	Illumination Lamp Ground
6	BLK	Switch Indicator Lamp Ground

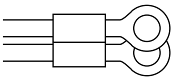
Vehicle Speed Sensor (VSS) 2



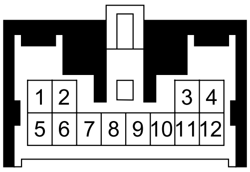
Connector No.		J-32
Connector Color		Gray
Test Adapter No.		J-35616-64A
Pin	Wire Color	Pin Function
1	RED/GRN	Sensor +12 V Feed
2	BLK	Sensor Low Reference
3	YEL/GRN	Sensor Signal

Harness Connector Views

B-1

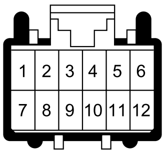


B-53(WHT)



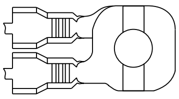
Test Adapter No. : J-35616-64A

B-231(GRY)

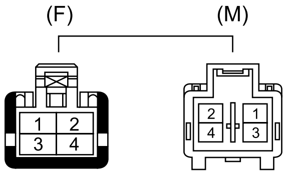


Test Adapter No. : J-35616-64A

B-7

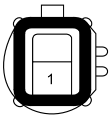


B-67(WHT)



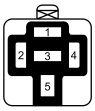
Test Adapter No. : (F) J-35616-42
(M) J-35616-43

E-5(BLK)



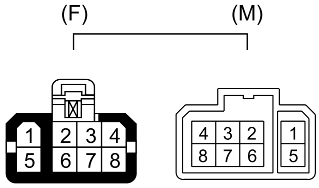
Test Adapter No. :J-35616-64A

B-19, B-20, B-21, B-38(BLK)



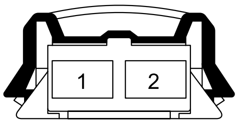
Test Adapter No. : J-35616-42

B-69(BLU)



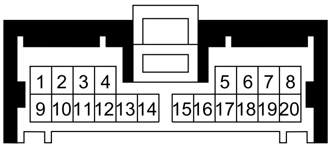
Test Adapter No. : (F) J-35616-4A
(M) J-35616-5

E-137(BRN)



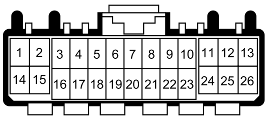
Test Adapter No. :J-35616-4A

B-51(GRY)



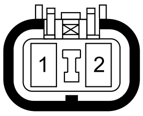
Test Adapter No. : J-35616-64A

B-229(GRY)



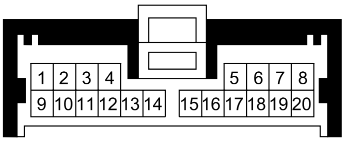
Test Adapter No. : J-35616-64A

E-145



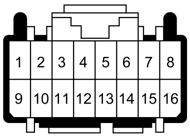
Test Adapter No. :J-35616-42

B-52(WHT)



Test Adapter No. : J-35616-64A

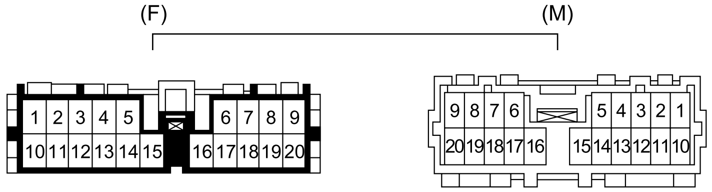
B-230(GRY)



Test Adapter No. : J-35616-64A

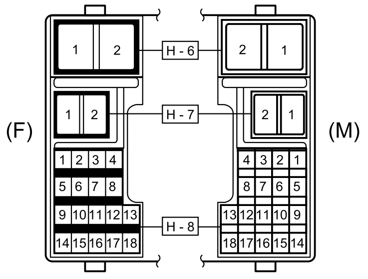
LNW66EXF004301

H-4(WHT)



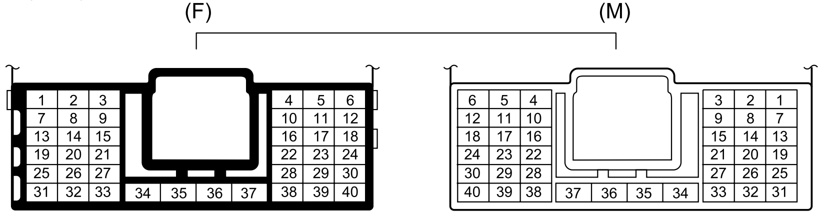
Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

H-6, H-7 H-8(GRY)



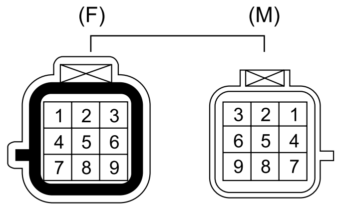
Test Adapter No. : H-7(F) J-35616-42
H-7(M) J-35616-43
H-8(F) J-35616-64A
H-8(M) J-35616-3

H-5(GRY)



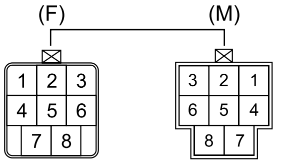
Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

H-16(BLK)



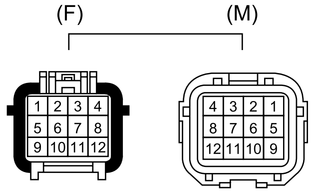
Test Adapter No. : (F) J-35616-64A
(M) J-35616-5

H-105(BLK)



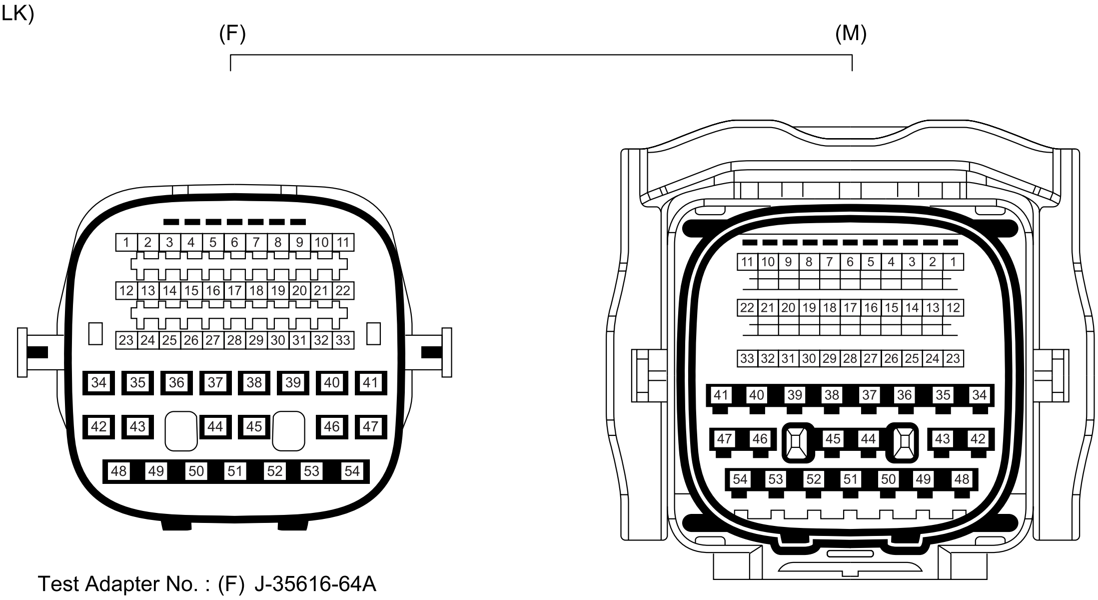
Test Adapter No. : (F) J-35616-64A[Pin 1-6]
(F) J-35616-42[Pin 7-8]
(M) J-35616-5[Pin 1-6]
(M) J-35616-43[Pin 7-8]

H-124(BLK)



Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

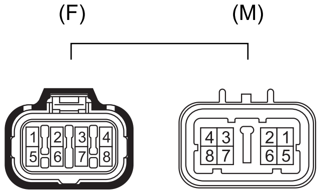
H-121(BLK)



Test Adapter No. : (F) J-35616-64A
(M) J-35616-3[Pin 1-33]
(M) J-35616-5[Pin 34-54]

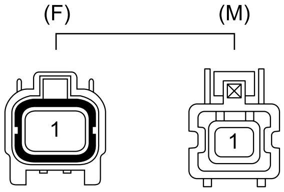
LNW66EXF004101

H-125(GRY)

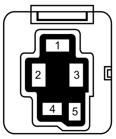


Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

H-139(BLK)

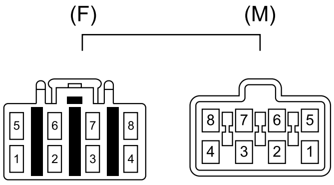


J-12, J-13(BLK)



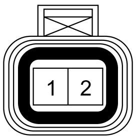
Test Adapter No. : J-35616-42

H-126(GRY)



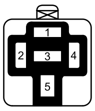
Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

J-1(GRY)



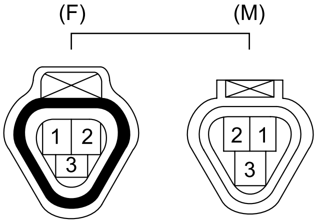
Test Adapter No. : J-35616-42

J-17,J-18(BLK)



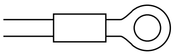
Test Adapter No. : J-35616-42

H-127(BLK)

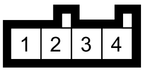


Test Adapter No. : (F) J-35616-64A
(M) J-35616-5

J-2

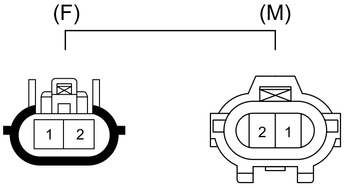


J-21



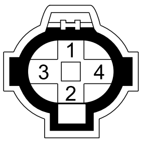
Test Adapter No. : J-35616-64A

H-137(BLK)



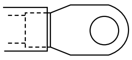
Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

J-6(BLK)

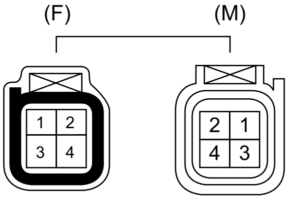


Test Adapter No. : J-35616-64A

J-26

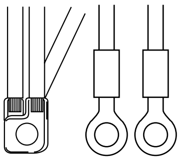


H-138(BLK)

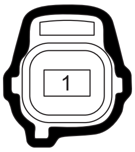


Test Adapter No. : (F) J-35616-64A
(M) J-35616-5

J-9



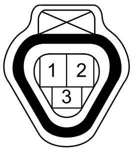
J-27(GRY)



Test Adapter No. : J-35616-44

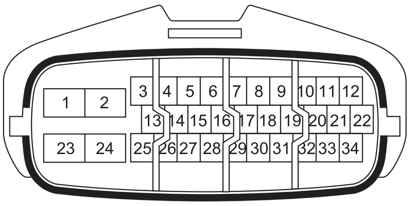
LNW66EXF004201

J-28(BLK)



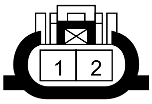
Test Adapter No. : J-35616-64A

J-177(BLK)



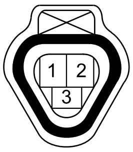
Test Adapter No. : J-35616-40[Pin 1, 2, 23, 24]
J-35616-64A[Pin 3-22, 25-34]

J-49(BRN)



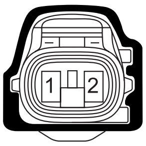
Test Adapter No. : J-35616-64A

J-207(BLK)



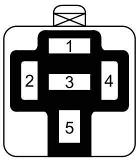
Test Adapter No. : J-35616-64A

J-50(GRY)



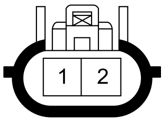
Test Adapter No. : J-35616-64A

J-208,J-209,J-210(BLK)



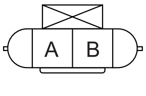
Test Adapter No. : J-35616-42

J-51(BLK)



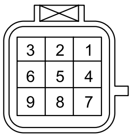
Test Adapter No. : J-35616-64A

J-212(BLK)



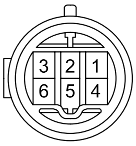
Test Adapter No. : J-35616-5

J-69(BLK)



Test Adapter No. : J-35616-64A

R-1,R-6(WHT)



Test Adapter No. : J-35616-5

LNW66EXF004601

Harness Connector, Joint and Ground Locations

Inline Connector

No.	Connection	Location
H-4	Body H. – Frame H.	Lower center of dash
H-5	Body H. – Frame H.	Lower center of dash
H-6	Body H. – Frame H.	Lower center of dash
H-7	Body H. – Frame H.	Lower center of dash
H-8	Body H. – Frame H.	Lower center of dash
H-16	Rr Body H. – Rr. Frame H.	Left side of the rear cross member
H-105	Engine H. – Frame H.	Lower left of the engine rear side
H-121	Frame H. – Engine H.	Lower left of the engine rear side
H-122	PTO H.	Under the left side frame, near the ABS control unit
H-123	PTO H.	Under the left side frame, near the ABS control unit
H-124	Frame H. – Body H.	Behind front cross member
H-125	Intermediate Connector – Engine H.	At the cylinder head, outside of cylinder head (to engine harness)
H-126	Intermediate Connector – Injector	At the cylinder head, under cylinder head cover (to injectors)
H-127	Fuel Tank H. - Frame H.	Inner the right side frame, near the parking brake dram
H-137	Condenser Fan H. - Frame H.	Behind the front Grille
H-138	A/C Pressure H. - Frame H.	Behind the front Grille
H-139	Frame H. – Glow Plug Control H.	Lower left of the engine rear side

Joint

No.	Joint	Location
B-379	Joint Connection L-1	Under the instrument panel lower cover of the driver side, near the connector B-67
B-380	Joint Connection M-1	Lower center of dash
B-381	Joint Connection M-5	Back of the fuse box in the glove box
	W/S M-1	Lower center of dash (This is not a connector. Wires are twisted and covered by tube.)
	W/S M-4	Back of the fuse box in the glove box (This is not a connector. Wires are twisted and covered by tube.)
	W/S JOINT 1	Behind front cross member, near terminal H-124 (This is not a connector. Wires are twisted and covered by tube.)
	W/S JOINT 2	Inner side of the left rear frame, near terminal H-122 (This is not a connector. Wires are twisted and covered by tube.)

W/S=Weld Splice

Ground

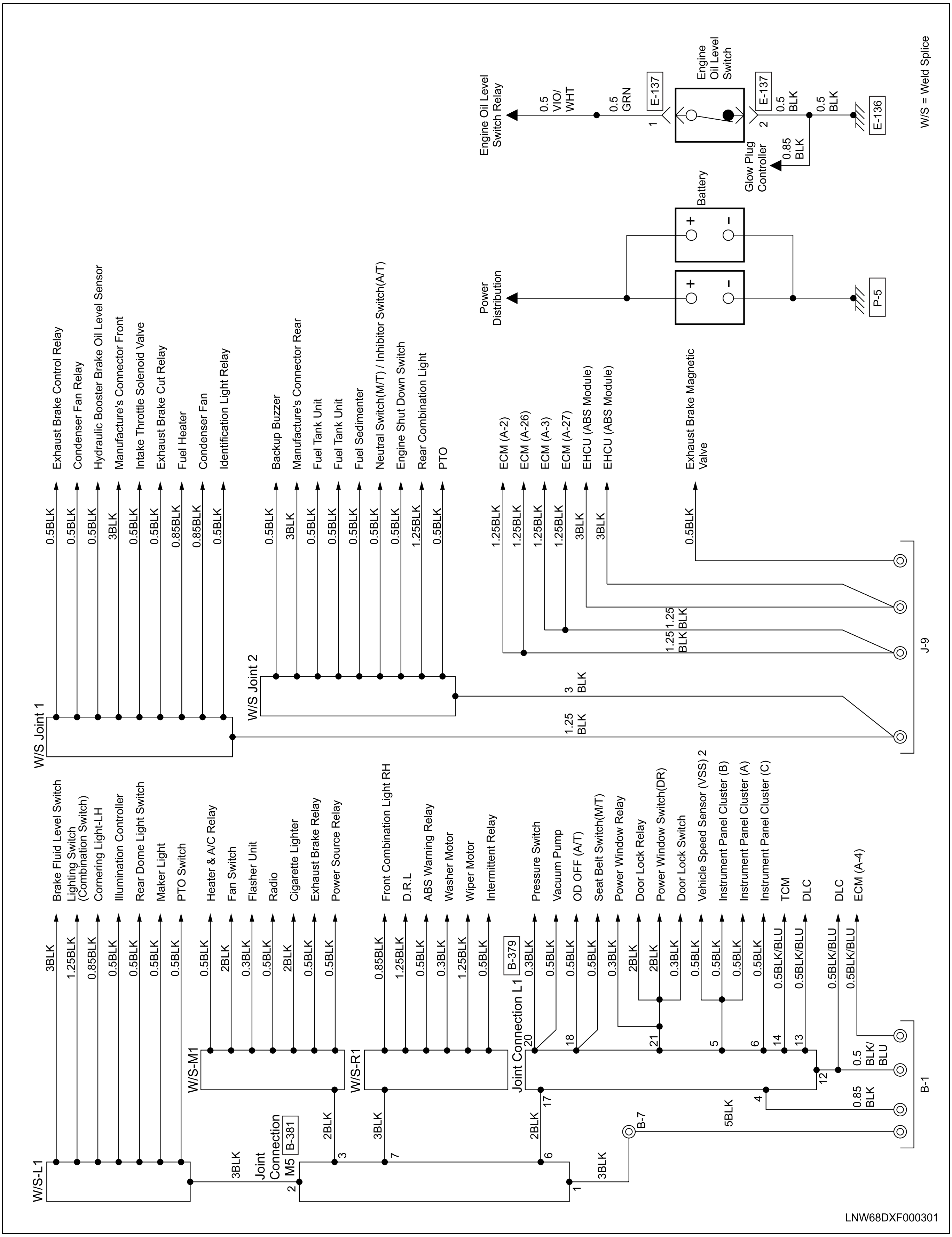
No.	Ground	Location
B-1	Frame Earth	Bolted to the left frame, back of the bumper
B-7	Head Light Bracket Earth	Bolted to the body side behind the right turn signal light

No.	Ground	Location
E-136	Engine Earth	Bolted to the left hand of engine
J-9	Frame Earth	Bolted to the left frame, ahead of front tire
P-5	Body Earth	Bolted to the starter

Others

No.	Connection	Location
B-19	Charge Relay	In the relay box under the cab
B-38	Exhaust Brake Relay	In the relay box at the dash
B-51	IPC A	Instrument panel cluster (IPC)
B-52	IPC B	Instrument panel cluster (IPC)
B-53	IPC C	Instrument panel cluster (IPC)
B-67	Ignition Switch	Behind the steering cowl
B-69	Exhaust Brake Switch (Combination Switch)	Behind the steering cowl
B-229	TCM	Under the instrument panel lower cover of the driver side
B-230	TCM	Under the instrument panel lower cover of the driver side
B-231	TCM	Under the instrument panel lower cover of the driver side
B-373	PTO Switch	On the instrument panel
E-145	Resistor (M/T)	Lower of fuel rail, left hand of engine
E-137	Oil Level Switch	Left side of oil pan
J-12	Starter Relay	In the relay box under the cab.
J-13	Glow Relay	In the relay box under the cab.
J-18	Exhaust Brake Control Relay	In the relay box under the cab.
J-28	Side Fuel Tank Unit	On the side fuel tank
J-49	Back Up Lamp SW (MT)	On the transmission
J-50	Neutral SW (MT)	On the transmission
J-51	Condenser Fan	Front right side under the cab
J-69	Inhibitor SW	Above the automatic transmission front side
J-177	Electronic Hydraulic Control Unit (EHCU) [ABS module]	Inner side of the left rear frame, ahead of rear axle
J-207	Rear Fuel Tank Unit	On the rear fuel tank
J-208	ECM Main Relay	In the relay box under the cab.
J-209	Starter Cut Relay	In the relay box under the cab.
J-210	Exhaust Brake Cut Relay	In the relay box under the cab.
J-212	Engine Shut Down SW	Under the left side frame, near the ECM
R-1	Rear Combination Light	Left side of the rear cross member
R-6	Rear Combination Light	Right side of the rear cross member

Ground Distribution



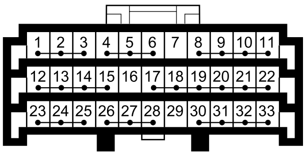
Weld Splice (W/S) Distribution

W/S-L1	Joint Connection M5
	Brake Fluid Level Switch Ground
	Cab Interior Light Switch Ground
	Dome Light Ground
	Front Turn Signal Light LH Ground
	Illumination Controller Ground
	PTO Switch Ground
	Rear Dome Light Switch Ground
W/S-L2	Joint Connection L1
	W/S-M2
	Cruise Resume Switch
	Front Turn Signal Light LH
	Illumination Controller
	Oil Level Check Switch
W/S-M1	Joint Connection M5
	Cigar Lighter Ground
	Exhaust Brake Relay Ground
	Fan Switch Ground
	Flasher Unit Ground
	Heater A/C Relay Ground
	Power Source Relay Ground
	Radio Ground
W/S-M2	W/S-L2
	Ashtray Illumination
	Cigar Lighter Illumination
	Cruise Main Switch
	Cruise Set Coast Switch
	Front Turn Signal Light RH
	Hazard Warning Switch
	Heater Bezel
	License Plate Light
	IPC (A) Illumination (+)
	PTO Switch
	Radio
	Tail Relay Control
W/S-M3	Joint Connection L1
	Ashtray Illumination Ground
	Cigar Lighter Illumination Ground
	Cruise Main Switch Ground
	Cruise Resume / Accel Switch Ground
	Cruise Set / Coast Switch Ground
	Hazard Warning Switch Ground
	Heater Bezel Ground
	Illumination Controller
	IPC (B) Illumination (-)
	Oil Level Check Switch Ground
	PTO Switch Ground
	Radio Ground
W/S-M4	Joint Connection M1
	ABS Relay Voltage Feed
	Buzzer Cancel Relay Voltage Feed
	Cornering Relay Voltage Feed
	Fuse Box Gauge
	Inhibitor Switch
	Vehicle Speed Sensor Voltage Feed
	IPC (A) Voltage Feed
W/S-R1	Joint Connection M5
	ABS Relay Ground
	D.R.L Ground
	Front Turn Signal Light RH Ground
	Intermittent Relay Ground
	Washer Motor Ground
	Wiper Motor Ground

W/S-JOINT 1	Condenser Fan Ground
	Condenser Fan Relay Ground
	Exhaust Brake Control Relay Ground
	Exhaust Brake Cut Relay Ground
	Frame Ground
	Fuel Heater Ground
	Hydraulic Booster Brake (HBB) Oil Level Sensor Ground
	Identification Light Relay Ground
	Intake Throttle Solenoid Valve Ground
	Manufacture Connector Front Ground
W/S-JOINT 2	Back Buzzer Ground
	Engine Shut Down Switch
	Frame Ground
	Fuel Sedimenter Ground
	Fuel Tank Unit Ground
	Fuel Tank Unit Ground
	Inhibitor Switch (A/T)
	Manufacture Connector Rear Ground
	Neutral Switch (M/T)
	PTO Ground
	Rear Combination Light Ground

Joint Connection Distribution

B-379 Joint Connection-L1

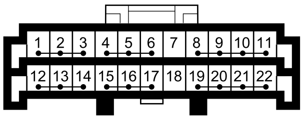


Test Adaptor No. :J-35616-64A

Joint Point	PIN No.	Connection
	1	W/S-L2
	2	A/T Lever Illumination(+)
	3	—
	4	Frame Ground
	5	Instrument Panel Cluster(IPC)(B) Ground
	6	Instrument Panel Cluster(IPC)(C) Ground
	7	—
	8	—
	9	—
	10	—
	11	—
	12	Frame Ground
	13	Data Link Connector(DLC) Ground
	14	Transmission Control Module(TCM) Ground
	15	—
	16	—

Joint Point	PIN No.	Connection
	17	Joint Connection M5
	18	OD OFF Ground(A/T)/Seat Belt Switch Ground(M/T)
	19	—
	20	Pressure Switch / Vacuum Pump
	21	Power Window Switch(DR) Ground
	22	—
	23	Brake Light
	24	Brake Light Switch
	25	Transmission Control Module(TCM) Brake Light Input
	26	EHCU(ABS Module) Class2
	27	Data Link Connector Class2
	28	Transmission Control Module(TCM) Class2
	29	—
	30	W/S-M3
	31	A/T Lever(Illumination(−))
	32	—
	33	—

B-380 Joint Connection-M1

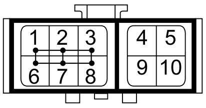


Test Adaptor No. :J-35616-64A

Joint Point	PIN No.	Connection
	1	Brake Fluid Level Switch
	2	Instrument Panel Cluster(IPC)(A) Parking Brake Inhibitor Light
	3	D.R.L / HBB Oil Level Sensor
	4	Charge Relay Voltage Feed
	5	Generator(L)
	6	—
	7	—
	8	W/S-M4
	9	Transmission Control Module(TCM) IGN Voltage Feed
	10	Power Window Relay Voltage Feed
	11	Vacuum Pump Relay Voltage Feed

Joint Point	PIN No.	Connection
	12	Fan Switch
	13	Electro Thermo
	14	Ceramic Heater
	15	Parking Brake Switch
	16	D.R.L
	17	Buzzer Cancel Relay
	18	—
	19	Fuse Box ECM(IGN)
	20	ECM Ignition Voltage Feed
	21	Clutch Switch
	22	PTO Switch

B-381 Joint Connection-M5



Test Adaptor No. :J-35616-42

Joint Point	PIN No.	Connection
	1	Headlight Bracket Ground
	2	W/S-L1
	3	W/S-M1
	4	—
	5	—
	6	Joint Connection L1
	7	W/S-R1
	8	—
	9	—
	10	—

LNW57AXF001001

Diagnostic Information and Procedures

Diagnostic Starting Point - Engine Controls

Begin the system diagnosis with Diagnostic System Check – Engine Controls. The Diagnostic System Check – Engine Controls will provide the following information:

- The identification of the control modules which command the system.
- The ability of the control modules to communicate through the serial data circuit.
- The identification of any stored diagnostic trouble codes (DTCs) and the their statuses.

The use of the Diagnostic System Check – Engine Controls will identify the correct procedure for diagnosing the system and where the procedure is located.

Diagnostic System Check – Engine Controls

Description

The Diagnostic System Check – Engine Controls is an organized approach to identifying a condition that is created by a malfunction in the electronic engine control system. The Diagnostic System Check must be the starting point for any driveability concern. The Diagnostic System Check directs the service technician to the next logical step in order to diagnose the concern. Understanding and correctly using the diagnostic table reduces diagnostic time, and prevents the replacement of good parts.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. Lack of communication may be because of a partial or a total malfunction of the class 2 serial data circuit. The specified procedure determines the particular condition.

6. The presence of DTCs which begin with U, indicate that some other module is not communicating. Following the specified procedure will gather all the available information before you perform the tests.

9. If there are other modules with DTCs set, refer to the DTC list. The DTC list directs you to the appropriate diagnostic procedure. If the control module stores multiple powertrain DTCs, diagnose the DTCs in the following order:

- Component level DTCs, such as sensor DTCs, solenoid DTCs, and relay DTCs. Diagnose the multiple DTCs within this category in numerical order. Begin with the lowest numbered DTC, unless the diagnostic table directs you otherwise.

Diagnostic System Check – Engine Controls

Important:

- DO NOT perform this diagnostic if there is not a driveability concern, unless another procedure directs you to this diagnostic.
- Before you proceed with diagnosis, search for applicable service bulletins.
- Unless a diagnostic procedure instructs you, DO NOT clear the DTCs.
- If there is a condition with the starting system, refer to the Starting System section.
- Ensure the battery has a full charge.
- Ensure the battery cables (+) (-) are clean and tight.
- Ensure the ECM grounds are clean, tight, and in the correct location.
- Ensure the ECM A & B harness connectors are clean and correctly connected.
- Ensure the ECM terminals are clean and correctly mating.
- Ensure the fuel injector flow rate data is correctly programmed.

Step	Action	Value(s)	Yes	No
1	Install a scan tool. Does the scan tool turn ON?	—	Go to Step 2	Go to Scan Tool Does Not Power Up

Step	Action	Value(s)	Yes	No
2	1. Turn ON the ignition, with the engine OFF. 2. Attempt to establish communication with the listed control modules. If you are using a Tech 2, obtain the information using the Class 2 Message Monitor feature: • Engine control module (ECM) • Transmission control module (TCM) • Electronic hydraulic control unit (EHCU) [ABS module] Does the scan tool communicate with all the listed control modules?	—	Go to Step 3	Go to Scan Tool Does Not Communicate with Class 2 Device
3	Attempt to start the engine. Does the engine start and idle?	—	Go to Step 4	Go to Engine Cranks but Does Not Run
4	Select the DTC display function for the following control modules: • Engine control module (ECM) • Transmission control module (TCM) • Electronic hydraulic control unit (EHCU) Does the scan tool display any DTCs?	—	Go to Step 5	Go to Step 10
5	With a scan tool, select Captured Info in order to store the ECM DTC information. Did you complete the action?	—	Go to Step 6	—
6	Does the scan tool display DTCs which begin with a U?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 7
7	Does the scan tool display ECM DTCs P0602, P0606 or P1621?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 8
8	Does the scan tool display ECM DTCs P0562 or P0563?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 9
9	Are there any other code in any controller that has not been diagnosed?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 10
10	Is the customer’s concern with the automatic transmission?	—	Go to Diagnostic System Check – Transmission Control	Go to Step 11

Step	Action	Value(s)	Yes	No
11	Is the customer's concern with the anti-lock brake system?	—	Go to Diagnostic System Check – Anti-lock Brake Control	Go to Step 12
12	1. Review the following symptoms. 2. Refer to the applicable symptom diagnostic table: • Engine Starts and Stalls • Hard Start • Rough, Unstable, or Incorrect Idle and Stalling • High Idle • Cuts Out, Misses • Surge/Chuggles • Lack of Power, Sluggishness, or Sponginess • Hesitation, Sag Stumble • Fuel Knock/Combustion Noise • Poor Fuel Economy • Excessive Smoke (Black Smoke) or Excessive Smoke (Blue or Gray Smoke) or Excessive Smoke (White Smoke) Did you find and correct the condition?	—	System OK	Go to Intermittent Conditions

Scan Tool Data List

The Engine Scan Tool Data List contains all engine related parameters that are available on the scan tool. The list is arranged in alphabetical order. A given parameter may appear in any one of the data lists, and in some cases may appear more than once, or in more than one data list in order to group certain related parameters together. Use the Engine Scan Tool Data List only after the following is determined:

- The Engine Controls Diagnostic System Check is completed.
- No diagnostic trouble codes (DTCs) are present.
- On-board diagnostics are functioning properly.

Scan tool values from a properly running engine may be used for comparison with the engine you are diagnosing. The Engine Scan Tool Data List represents values that would be seen on a normal running engine.

Important:
A scan tool that displays faulty data should not be used. The scan tool problem should be reported to the manufacturer. Use of a faulty scan tool can result in misdiagnosis and unnecessary parts replacement.

Only the parameters listed below are referenced in this service manual for use in diagnosis.
The column labeled Data List indicates where a parameter can be located on the scan tool. Refer to the scan tool operating manual for the exact locations of the data lists. The following is a description of each term listed:
All: The parameter is in all of the data lists indicated below.
Eng1: Engine Data 1 List
Eng2: Engine Data 2 List
FS: Fuel Data List
EGR: EGR Data List

Scan Tool Data List

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value At Engine Idle	Typical Data Value At 1600 RPM
Operating Conditions : Engine Idling or 1600 RPM/ Engine Coolant Temperature is Between 167-185°F (75-85°C)/ Accelerator Pedal is Constant/ Park or Neutral/ Accessories OFF/ Vehicle Located at Sea Level.				
5 Volt Reference 1	Eng 1	Volts	Nearly 5 volts	Nearly 5 volts
5 Volt Reference 2	Eng 1	Volts	Nearly 5 volts	Nearly 5 volts
5 Volt Reference 3	Eng 1	Volts	Nearly 5 volts	Nearly 5 volts
A/C Request Signal	Eng 1, Eng 2	Yes/No	No	No
Actual FRP Regulator	FS	mA	1200 - 1900	1200 - 1900
Actual Fuel Rail Pressure	All	psi / MPa	3626 - 5076 psi / 25.0 - 35.0 MPa	More than 10152 psi / 70.0 MPa
APP Indicated Angle	All	%	0	31 - 37
APP Sensor 1	Eng 1	Volts	0.52 - 0.80	1.20 - 1.40
APP Sensor 2	Eng 1	Volts	4.25 - 4.53	3.55 - 3.85
APP Sensor 3	Eng 1	Volts	3.95 - 4.13	3.45 - 3.75
Balancing Rate Cyl. 1	FS	mm^3	-5.0 - 5.0 (Varies)	-5.0 - 5.0 (Varies)
Balancing Rate Cyl. 2	FS	mm^3	-5.0 - 5.0 (Varies)	-5.0 - 5.0 (Varies)
Balancing Rate Cyl. 3	FS	mm^3	-5.0 - 5.0 (Varies)	-5.0 - 5.0 (Varies)
Balancing Rate Cyl. 4	FS	mm^3	-5.0 - 5.0 (Varies)	-5.0 - 5.0 (Varies)
BARO	Eng 1	Volts	Nearly 3.6 volts at sea level	Nearly 3.6 volts at sea level
Barometric Pressure	Eng 1	psi / kPa	Nearly 14.5 psi / 100 kPa at sea level	Nearly 14.5 psi / 100 kPa at sea level
Basic Fuel Rate	FS	mm^3	-28.0 - -24.0	13.0 - 18.0
Battery Voltage	Eng 1	Volts	11.0 - 15.0	11.0 - 15.0
Boost Pressure Sensor	All	psi / kPa	Difference between BARO is less than 1.1 psi / 7.5 kPa	Difference between BARO is less than 2.9 psi / 20 kPa

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value At Engine Idle	Typical Data Value At 1600 RPM
Cam Signal Present	Eng 1	Yes/No	Yes	Yes
Clutch Pedal Switch	Eng 1, Eng 2	Applied/ Released	Released	Released
Crank Signal Present	Eng 1	Yes/No	Yes	Yes
Cruise Control Active	Eng 2	Yes/No	No	No
Cruise Main Lamp Command	Eng 2	On/Off	Off	Off
Cruise On/Off Switch	Eng 2	On/Off	Off	Off
Cruise Release Brake Pedal Switch	Eng 1, Eng 2	Applied/ Released	Released	Released
Cruise Resume/Accel. Switch	Eng 2	On/Off	Off	Off
Cruise Set/Coast Switch	Eng 2	On/Off	Off	Off
Cruise Set Lamp Command	Eng 2	On/Off	Off	Off
Desired FRP Regulator	FS	mA	1200 - 1900	1200 - 1900
Desired Fuel Rail Pressure	All	psi / MPa	3626 - 5076 psi / 25.0 - 35.0 MPa	More than 10152 psi / 70.0 MPa
Desired Idle Speed	Eng 1	RPM	750	750
DTC Set This Ignition	Eng 1	Yes/No	No	No
ECT Sensor	All	°F / °C	167 - 185°F / 75 - 85°C	167 - 185°F / 75 - 85°C
EGR Learned Minimum Position	EGR	mm	Less than 1mm	Less then 1mm
EGR Position Sensor	All	%	Less than 45%	Less than 45%
EGR Position Sensor	EGR	Volts	Less then 2.4 volts	Less then 2.4 volts
EGR Position Variance	EGR	%	Less than 5%	Less than 5%
EGR Solenoid Command	EGR	%	Less than 40%	Less than 40%
Engine Load	All	%	10 - 15	13 - 17
Engine Run Time	All	seconds	Varies	Varies
Engine Speed	All	RPM	700 - 800	1550 - 1650
Exhaust Brake Relay (If Equipped)	Eng 2	On/Off	Off	Off
Exhaust Brake Relay Command (If Equipped)	Eng 2	On/Off	Off	Off
Exhaust Brake Switch (If Equipped)	Eng 2	On/Off	Off	Off
Final Fuel Rate	FS	mm^3	Less than 30.0 mm^3	Less than 30.0 mm^3
Final Fuel Rate Correction	FS	mm^3	9.0 - 15.0	13.0 - 18.0
FRP Regulator Command	FS	%	40 - 60	40 - 60
FRP Regulator Fuel Flow	FS	mm^3		
Fuel Rate at Start	FS	mm^3	More than 50.0 mm^3	More than 50.0 mm^3
Fuel Temperature Sensor	Eng 1, FS	°F / °C	50 - 122°F / 10 - 50°C	50 - 122°F / 10 - 50°C
Glow Plug Lamp Command	Eng 2	On/Off	Off	Off

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value At Engine Idle	Typical Data Value At 1600 RPM
Glow Plug Relay	Eng 2	On/Off	Off	Off
IAT Sensor	Eng 1	°F / °C	50 - 104°F / 10 - 40°C	50 - 104°F / 10 - 40°C
Idle Up Sensor	Eng 1	Volts	0.30 - 0.50	0.30 - 0.50
Ignition 1 Signal	All	Volts	11.0 - 15.0	11.0 - 15.0
Injector 1 Command	Eng 1, FS	ms	0.90 - 1.40	0.50 - 0.90
Intake Throttle Solenoid	Eng 2	On/Off	Off	Off
MAF Sensor	Eng 1, EGR	g/s	More than 25 g/s at sea level	More than 50 g/s at sea level
MAF Sensor	Eng 1, EGR	Volts	More than 1.9 volts at sea level	More than 2.5 volts at sea level
Main Injection Fuel Rate	FS	mm^3	8.0 - 12.0	11.0 - 15.0
Main Injection Timing	FS	°CA	-4.0	-4.0 - -5.0
MIL Command	Eng 2	On/Off	Off	Off
Pilot Injection Fuel Rate	FS	mm^3	3.0 - 4.0	3.0 - 4.0
Power Relay Status	Eng 1	On/Off	On	On
PTO Enable (If Equipped)	Eng 2	Yes/No	No	No
PTO Engage Relay Command (If Equipped)	Eng 2	On/Off	Off	Off
PTO Engine Shutdown Signal (If Equipped)	Eng 2	Yes/No	No	No
PTO Feedback Signal (If Equipped)	Eng 2	On/Off	Off	Off
PTO Remote Throttle Sensor	Eng 2	Volts	0	0
Start Up ECT	Eng 1	°F /°C	Varies	Varies
Start Up Fuel Temperature	Eng 1	°F / °C	Varies	Varies
Start Up IAT	Eng 1	°F / °C	Varies	Varies
Starter Relay Status	Eng 1	On/Off	Off	Off
Stoplamp Pedal Switch	Eng 1, Eng 2	Applied/ Released	Released	Released
Supply Pump Adjustment	FS	mA	-100 - 100	-100 - 100
Supply Pump Status	FS	Not Learn/ Tentative/ Learning/ Learned	Learned	Learned
SVS Lamp Command	Eng 2	On/Off	Off	Off
Vehicle Speed Sensor	All	MPH / km/h	0	0

Scan Tool Data Definitions

A list of each data message displayed on the scan tool will be explained in Engine Controls. This information will assist in emission or driveability problems. The displays can be viewed while the vehicle is being driven. Always perform the Diagnostic System Check – Engine Controls first. The Diagnostic System Check will confirm proper system operation.

5 Volt Reference 1
This parameter displays the voltage level of 5 volts reference 1 circuit to the various sensor's power supplies.

5 Volt Reference 2
This parameter displays the voltage level of 5 volts reference 2 circuit to the various sensor's power supplies.

5 Volt Reference 3
This parameter displays the voltage level of 5 volts reference 3 circuit to the various sensor's power supplies.

A/C Request Signal
This parameter displays the state of the air conditioning (A/C) request input to the ECM from the heating, ventilation, and air conditioning (HVAC) controls.

The scan tool will display Yes or No. Yes indicates the ECM is receiving a request from the HVAC system to ground the A/C clutch relay control circuit, engaging the A/C compressor clutch. No indicates the ECM is not receiving a request from the HVAC system to ground the A/C clutch relay control circuit.

Actual FRP Regulator
This parameter displays the fuel rail pressure (FRP) regulator control feedback current as calculated by the ECM. This can be compared to the Desired FRP Regulator to determine FRP regulator accuracy or fuel supply pump problems.

Actual Fuel Rail Pressure
This parameter displays the fuel rail pressure as calculated by the ECM using the signal from the fuel rail pressure (FRP) sensor. The actual fuel rail pressure is a range of values indicating a low pressure when the fuel rail pressure is low to a high pressure when the fuel rail pressure is high. This value is listed in psi or MPa. Note that this parameter will only update with the engine running or one time after the key is cycled when the ignition has been turned OFF for longer than 10 seconds.

APP Indicated Angle
This parameter displays the angle of the accelerator pedal as calculated by the ECM using the signals from the accelerator pedal position sensors. The APP indicated angle is a range of values indicating a low percentage when the accelerator pedal is not depressed to a high percentage when the accelerator pedal is fully depressed.

APP Sensor 1
This parameter displays the voltage signal sent to the ECM from accelerator pedal position (APP) sensor 1 of the APP sensor assembly. APP sensor 1 is a range of values indicating a low voltage when the accelerator pedal is not depressed to a high voltage when the accelerator pedal is fully depressed.

APP Sensor 2
This parameter displays the voltage signal sent to the ECM from accelerator pedal position (APP) sensor 2 of the APP sensor assembly. APP sensor 2 is a range of values indicating a high voltage when the accelerator pedal is not depressed to a middle voltage when the accelerator pedal is fully depressed.

APP Sensor 3
This parameter displays the voltage signal sent to the ECM from accelerator pedal position (APP) sensor 3 of the APP sensor assembly. APP sensor 3 is a range of values indicating a high voltage when the accelerator pedal is not depressed to a middle voltage when the accelerator pedal is fully depressed.

Balancing Rate Cyl. 1
This parameter displays the adjustment in fuel volume for cylinder 1 at low engine speed area (from idle to around 1000 RPM) as calculated by the ECM. The scan tool will display a negative balancing rate if the fuel volume is lowered. The scan tool will display a positive balancing rate if the fuel volume is increased. If there is a cylinder that is excessively high or low, it may indicate a faulty injector, weak or slightly seized cylinder or an incorrectly programmed fuel injector flow rate.

Balancing Rate Cyl. 2
This parameter displays the adjustment in fuel volume for cylinder 2 at low engine speed area (from idle to around 1000 RPM) as calculated by the ECM. The scan tool will display a negative balancing rate if the fuel volume is lowered. The scan tool will display a positive balancing rate if the fuel volume is increased. If there is a cylinder that is excessively high or low, it may indicate a faulty injector, weak or slightly seized cylinder or an incorrectly programmed fuel injector flow rate.

Balancing Rate Cyl. 3
This parameter displays the adjustment in fuel volume for cylinder 3 at low engine speed area (from idle to around 1000 RPM) as calculated by the ECM. The scan tool will display a negative balancing rate if the fuel volume is lowered. The scan tool will display a positive balancing rate if the fuel volume is increased. If there is a cylinder that is excessively high or low, it may indicate a faulty injector, weak or slightly seized cylinder or an incorrectly programmed fuel injector flow rate.

Balancing Rate Cyl. 4
This parameter displays the adjustment in fuel volume for cylinder 4 at low engine speed area (from idle to around 1000 RPM) as calculated by the ECM. The scan tool will display a negative balancing rate if the fuel volume is lowered. The scan tool will display a positive balancing rate if the fuel volume is increased. If there is a cylinder that is excessively high or low, it may indicate a faulty injector, weak or slightly seized cylinder or an incorrectly programmed fuel injector flow rate.

BARO Sensor
This parameter displays the voltage signal from the barometric pressure (BARO) sensor internal to the ECM. BARO sensor has a range of values from a low voltage in high altitude to high voltage in low altitude.

BARO
This parameter displays the barometric pressure as calculated by the ECM using barometric pressure (BARO) sensor inside of the ECM.

Basic Fuel Rate
This parameter displays the basic fuel rate as calculated by the ECM based on engine speed and accelerator pedal position. The scan tool will display more fuel rate if the engine load is increased as the accelerator pedal is stepped on at constant engine speed.

Battery Voltage
This represents the system voltage measured by the ECM at the ECM battery voltage feed circuit.

Boost Pressure Sensor
This parameter displays the amount of turbo boost pressure in the intake manifold. True boost pressure is determined by subtracting BARO from the actual reading.

Cam Signal Present
This parameter displays the status of the Camshaft Position (CMP) Sensor signal to the ECM. The scan tool will display Yes or No. Yes indicates the CMP signal is being received by the ECM. No indicates the CMP signal is not being received by the ECM.

Clutch Pedal Switch
This parameter displays the current state of the clutch pedal switch when the vehicle has a manual transmission.

Crank Signal Present
This parameter displays the status of the Crankshaft Position (CKP) Sensor signal to the ECM. The scan tool will display Yes or No. Yes indicates the CKP signal is being received by the ECM. No indicates the CKP signal is not being received by the ECM.

Cruise Control Active
This parameter displays the status of the cruise control system as determined by the ECM. The scan tool will display Yes when the cruise control system is in control of vehicle speed. The scan tool will display No when the cruise control system is not operating.

Cruise Main Lamp Command
This parameter displays the commanded state of the cruise main lamp control circuit. The cruise main lamp should be On when the cruise control main switch is pushed and the scan tool indicates the Cruise Main Lamp Command is On. The cruise control main lamp should be Off when the cruise control main switch is pushed again and the scan tool indicates the Cruise Main Lamp Command is Off.

Cruise On/Off Switch
This parameter displays the state of the Cruise On/Off switch input to the ECM. When the Cruise Main switch is pushed, the scan tool displays On.

Cruise Release Brake Switch
This parameter displays the state of the Cruise Release Brake Switch as determined by the ECM. The scan tool will display Released or Applied. Released indicates the brake pedal is not being pushed down, allowing the cruise control to be enabled. Applied indicates the brake switch is being applied, disabling cruise control operation.

Cruise Resume/Accel. Switch
This parameter displays the state of the Cruise Resume/Accel. switch input to the ECM. When the Resume/Accel. switch is pushed, the scan tool displays On.

Cruise Set/Coast Switch
This parameter displays the state of the Cruise Set/ Coast switch input to the ECM. When the Set/Coast switch is pushed, the scan tool displays On.

Cruise Set Lamp Command
This parameter displays the commanded state of the cruise set lamp control circuit. The cruise set lamp should be ON when the cruise control set/coast switch is pushed in cruise control enable condition and the scan tool indicates the Cruise Set Lamp Command is On.

Desired FRP Regulator
This parameter displays the fuel rail pressure (FRP) regulator control current by the ECM based on current sensor inputs. This can be compared to the Actual FRP Current to determine FRP regulator accuracy or fuel supply pump problems.

Desired Fuel Rail Pressure
This parameter displays fuel rail pressure desired by the ECM based on current sensor inputs. This can be compared to the actual fuel rail pressure to determine sensor accuracy or fuel pressure problems.

Desired Idle Speed
This parameter displays the idle speed requested by the ECM. The ECM will compensate for various engine loads based on engine coolant temperature (ECT) to keep the engine at the desired speed.

DTC Set This Ignition
This parameter displays Yes if a diagnostic trouble code (DTC) set during the current ignition cycle.

ECT Sensor
This parameter displays the temperature of the engine coolant based on a voltage input from the engine coolant temperature (ECT) sensor to the ECM. The scan tool will display a low temperature when signal voltage is high, and a high temperature when the signal voltage is low.

EGR Learned Minimum Position
This parameter displays the learned position at the EGR valve closed position using the signal from the EGR valve position sensor.

EGR Position Sensor
This parameter displays the EGR valve position calculated by the ECM using the signal from EGR position sensor. The EGR valve current position is a range of values indicating a low percentage when the EGR valve is closed to a high percentage when the ERG valve is opened.

EGR Position Sensor
This parameter displays the voltage signal sent to the ECM from the EGR position sensor. EGR Position Sensor is a range of values indicating a low voltage when the EGR valve is closed to a high voltage when the EGR valve is opened.

EGR Position Variance
This parameter displays the amount of the EGR valve deviation between the desired EGR valve position and the actual EGR valve position using the signal from the EGR valve position sensor.

EGR Solenoid Command
This parameter displays the EGR valve control duty ratio commanded by the ECM using the signal from engine speed, engine coolant temperature and injection volume.

Engine Load
This parameter displays the engine load in percent based on inputs to the ECM from various engine sensors. The scan tool will display a low percentage when the engine is at idle with little or no load. The scan tool will display a high percentage when the engine is running at high engine speed under a heavy load.

Engine Run Time
This parameter displays the time elapsed since the ignition switch is ON. The scan tool will display the time in hours, minutes and seconds. The engine run time will reset to zero as soon as the ignition switch is OFF.

Engine Speed
This parameter displays the speed of the crankshaft as calculated by the ECM based on inputs from the crankshaft position (CKP) sensor or camshaft position (CMP) sensor. The scan tool will display the engine speed in revolution per minute (RPM).

Exhaust Brake Relay (If Equipped)
This parameter displays a feedback signal based on the signal from the exhaust brake control relay. The scan tool will display On or Off. On indicates the exhaust brake control relay has closed, allowing voltage to the exhaust brake magnetic valve and intake throttle solenoid. Off indicates the exhaust brake control relay is open and exhaust brake will not engage.

Exhaust Brake Relay Command (If Equipped)
This parameter displays the commanded state of the exhaust brake control relay circuit. The scan tool will display On or Off. On indicates the exhaust brake control relay circuit is being energized by the ECM. Off indicates the exhaust brake control relay is not being commanded On by the ECM.

Exhaust Brake Switch (If Equipped)
This parameter displays the input status of the exhaust brake switch to the ECM. The scan tool will display On or Off. On indicates the exhaust brake switch is closing the exhaust brake request circuit to the ECM. Off indicates the exhaust brake switch is open.

Final Fuel Rate
This parameter displays the final fuel rate as calculated by the ECM. The basic fuel rate calculated from the engine speed and accelerator pedal position is compared with the fuel rate which added the compensation by the various sensor inputs to the maximum fuel rate calculated from the engine speed. The fewer one is determined as the final fuel rate.

Final Fuel Rate Correction
This parameter displays the compensated final fuel rate as calculated by the ECM based on the final fuel rate and engine running condition (fuel temperature and balancing rate).

FRP Regulator Command
This parameter displays the fuel rail pressure (FRP) regulator control duty ratio signal based on inputs to the ECM from various engine sensors. The scan tool will display a low percentage when the FRP regulator is controlled to open (fuel supply quantity to the fuel rail is increased). The scan tool will display a high percentage when the FRP regulator is controlled to close (fuel supply quantity to the fuel rail is reduced).

FRP Regulator Fuel Flow
This parameter displays the commanded fuel quantity of the fuel rail pressure (FRP) regulator to the fuel rail.

Fuel Rate at Start
This parameter displays the fuel rate at startup as calculated by the ECM based on the signal from the engine coolant temperature (ECT) sensor and starter switch input signal. The scan tool will display more fuel rate if the engine coolant is cold.

Fuel Temperature Sensor
This parameter displays the temperature of the fuel based on a voltage input from the fuel temperature (FT) sensor to the ECM. The scan tool will display a low temperature when signal voltage is high, and a high temperature when the signal voltage is low.

Glow Plug Lamp Command
This parameter displays the commanded state of the glow indicator lamp control circuit. The glow indicator lamp should be On when the scan tool indicates the Glow Plug Lamp Command is On. The glow indicator should be Off when the scan tool indicates the Glow Plug Command is Off.

Glow Plug Relay
This parameter displays the commanded state of the glow plug relay control circuit. The scan tool will display On or Off. On indicates the glow plug relay control circuit is being grounded by the ECM, allowing voltage to the glow plugs. Off indicates the glow plug relay is not being commanded on by the ECM.

IAT Sensor
This parameter displays the temperature of the intake air based on a voltage input from the intake air temperature (IAT) sensor to the ECM. The scan tool will display a low temperature when signal voltage is high, and a high temperature when the signal voltage is low. Note that the IAT sensor is internal to the MAF sensor and the MAF sensor is heated.

Idle Up Sensor
This parameter displays the voltage signal sent to the ECM from the idle up sensor. The idle up sensor has a range of values indicating a low voltage when the idle up sensor rotates in a counterclockwise direction to a high voltage when the idle up sensor rotates in a clockwise direction.

Ignition 1 Signal
This parameter displays the voltage measured at the ignition feed circuit of the ECM. Voltage is applied to the ECM when the ignition switch is ON position.

Injector 1 Command
This parameter is the time the ECM turns on the fuel injector for cylinder No. 1. The scan tool will display a higher value with a longer pulse width, or a lower value with a shorter pulse width.

Intake Throttle Solenoid
This parameter displays a feedback signal based on the signal from the exhaust brake control relay. The scan tool will display On or Off. On indicates the exhaust brake control relay has closed, allowing voltage to the exhaust brake magnetic valve and intake throttle solenoid. Off indicates the exhaust brake control relay is open and exhaust brake will not engage.

MAF Sensor
This parameter displays the air flow into the engine as calculated by the ECM based on the mass air flow (MAF) sensor input. The scan tool will display a high value at higher engine speeds, and a low value at idle.

MAF Sensor
This parameter displays the voltage signal sent to the ECM from the mass air flow (MAF) sensor. The scan tool will display a high voltage at higher engine speeds, and a low voltage at idle.

Main Injection Fuel Rate
This parameter displays a main injection quantity desired by the ECM based on current driving conditions.

Main Injection Timing
This parameter is the injection timing calculated by the ECM based on the CKP sensor and CMP sensor inputs using a target injection timing map. This timing is compensated by engine coolant temperature, altitude, and intake air temperature, etc.

MIL Command
This parameter displays the commanded state of the malfunction indicator lamp (MIL) control circuit. The MIL should be on when the scan tool indicates the MIL Command is On. The MIL should be off when the scan tool indicates the MIL Command is Off The ECM will command the MIL On when the ignition is On with the engine Off in order to perform a bulb check.

Pilot Injection Fuel Rate
This parameter displays a pilot injection quantity desired by the ECM based on current driving conditions.

Power Relay Status
This parameter displays the commanded state of the ECM Main Relay control circuit. The scan tool will display On or Off. On indicates the ECM Main Relay control circuit is being grounded by the ECM, allowing the main relay to supply voltage to the other circuits of the ECM. Off indicates the main relay is not being commanded On by the ECM.

PTO Enable (If Equipped)
This parameter displays input status of the PTO switch to the ECM. The scan tool will display Yes or No. Yes indicates the PTO switch is pushed On, supplying ignition voltage to the ECM.

PTO Engage Relay Command (If Equipped)
This parameter displays the commanded state of the PTO relay control circuit. The scan tool will display On or Off. On indicates the PTO relay control circuit is being grounded by the ECM, allowing voltage to the load engage switch. Off indicates the PTO relay is not being commanded on by the ECM.

PTO Engine Shutdown Signal (If Equipped)
This parameter displays the input status of the PTO engine shutdown switch to the ECM. The scan tool will display Yes or No. Yes indicates the PTO engine shutdown switch is closed, grounding the engine shutoff signal circuit to the ECM. No indicates the engine shutoff switch is open, allowing normal engine and PTO operation.

PTO Feedback Signal (If Equipped)
This parameter displays a feedback signal based on the signal from the PTO relay feedback switch. The scan tool will display On or Off. On indicates the PTO relay has closed, allowing voltage to the load engage switch. Off indicates the PTO relay is open and the PTO will not engage.

PTO Remote Throttle Sensor (if Equipped)
This parameter displays the voltage signal sent to the ECM from the PTO throttle sensor. The PTO throttle sensor is a range of values indicating a low voltage when the throttle sensor is not operated to a high voltage when the throttle sensor is fully operated.

Start Up ECT
This parameter displays the engine coolant temperature at start up, as calculated by the ECM based on the input from the engine coolant temperature sensor. The scan tool will display a higher value at higher start up temperatures.

Start Up Fuel Temperature
This parameter displays the fuel temperature (FT) at start up, as calculated by the ECM based on the input from the FT sensor. The scan tool will display a higher value at higher start up temperature.

Start Up IAT
This parameter displays the intake air temperature (IAT) at start up, as calculated by the ECM based on the input from the IAT sensor. The scan tool will display a higher value at higher start up temperature.

Starter Relay Status
This parameter displays the input status state of the starter relay. The scan tool will display On or Off. On indicates the ignition switch is at the start position, allowing voltage to the starter relay. Off indicates the ignition switch is anything other than the start position and starter relay will not engage.

Stoplamp Pedal Switch
This parameter displays the state of the brake pedal as determined by the ECM based on an input from the stop lamp pedal switch. This switch turns on the stop lamps when the brake pedal is depressed. The scan tool will display Applied when the brake pedal is depressed.

Supply Pump Adjustment
The ECM has ability to learn the fuel supply pump variation and this parameter displays the adjustment current supplied to the fuel rail pressure (FRP) regulator. Note that the supply pump adjustment value must be reset when the fuel supply pump or engine is replaced, or an ECM from another vehicle is installed.

Supply Pump Status
This parameter displays the learning state of the fuel supply pump. The scan tool will display Not Learn, Tentative, Learning or Learned. Not Learn indicates initialized state that is replaced to a new ECM or adjustment value is reset. Tentative indicates tentative learning state that is started at idle speed as soon as possible. After engine is warm upped, real leaning will start at idle speed. Learning indicates real learning state. Learned indicates learning process is completed state.

SVS Lamp Command
This parameter displays the commanded state of the service vehicle soon (SVS) lamp control circuit. The SVS lamp should be On when the scan tool indicates the SVS Lamp Command is On. The SVS lamp should be Off when the scan tool indicates the SVS Lamp Command is Off. The ECM will command the SVS lamp On when the ignition is On with the engine Off in order to perform a bulb check.

Vehicle Speed Sensor
This parameter displays the vehicle speed calculated by the ECM based on an input from the vehicle speed sensor (VSS). The scan tool will display a high value at higher vehicle speeds, and a low value at lower vehicle speeds.

Scan Tool Output Controls

Scan Tool Output Control	Additional Menu Selection(s)	Descriptions
Coolant Temp. Gauge	Engine Output Controls	The purpose of this test is for checking whether the engine coolant temperature gauge in the instrument panel cluster (IPC) is correctly operated with command. Faulty circuit(s) or gauge could be considered when not operating with command.
Cruise Main Lamp	Engine Output Controls	The purpose of this test is for checking whether the cruise control main lamp is operating when commanded ON. Faulty circuit(s) or an open bulb could be considered when not operating when commanded ON.
Cruise Set Lamp	Engine Output Controls	The purpose of this test is for checking whether the cruise control set lamp is operating when commanded ON. Faulty circuit(s) or an open bulb could be considered when not operating when commanded ON.
Cylinder Power Balance	Fuel System	The purpose of this test is for checking whether the fuel injector is operating when commanded ON/OFF. Faulty injector(s) could be considered if engine does not change speed when commanded OFF.
EGR Solenoid	Engine Output Controls	The purpose of this test is for checking whether the actual position of the EGR valve is correctly moved with command. Restricted valve movement by foreign materials, excessive deposits or a faulty valve could be considered if the EGR position difference is large.
Exhaust Brake Control	Engine Output Controls	The purpose of this test is for checking whether the exhaust brake relay is operating when commanded ON. Faulty circuit(s) or a faulty exhaust brake relay could be considered if not energizing when commanded ON.
Glow Plug	Engine Output Controls	The purpose of this test is for checking whether the glow relay is operating when commanded ON. Faulty circuit(s) or a faulty glow relay could be considered if not energizing when commanded ON.
Glow Plug Lamp	Engine Output Controls	The purpose of this test is for checking whether the glow indicator lamp is operating when commanded ON. Faulty circuit(s) or an open bulb could be considered when not operating when commanded ON.
Injector Flow Test	Fuel System	The purpose of this test is for checking whether the fuel injector is correctly operating when commanded ON/OFF. Faulty injector(s) could be considered if it does not create a clicking noise (solenoid operating noise), contains an interrupted noise or has abnormal noise when commanded ON.
Malfunction Indicator Lamp	Engine Output Controls	The purpose of this test is for checking whether the malfunction indicator lamp (MIL) is operating when commanded ON. Faulty circuit(s) or open bulb could be considered if not operating when commanded ON.
Pilot Injector Stop	Fuel System	The purpose of this test is for checking whether the pilot fuel injection is operated when it is commanded to Stop. Faulty injector(s) could be considered if engine speed does not change when commanded to Stop.
PTO Relay	Engine Output Control	The purpose of this test is for checking whether the PTO enable relay is operating when commanded ON. Faulty circuit(s) or a faulty PTO enable relay could be considered if not energizing when commanded ON.

Scan Tool Output Control	Additional Menu Selection(s)	Descriptions
RPM Control	Fuel System	The purpose of this test is for checking whether the engine idle speed can change to match the commanded RPM.
Service Vehicle Soon Lamp Control	Engine Output Controls	The purpose of this test is for checking whether the service vehicle soon (SVS) lamp is operating when commanded ON. Faulty circuit(s) or an open bulb could be considered if not operating when commanded ON.
Supply Pump Learn	Fuel System	The purpose of this test to reset the fuel supply pump adjustment value. **Important:** The fuel supply pump relearn procedure must be done when the fuel supply pump or engine is replaced, or an ECM from another vehicle is installed. Refer to Fuel Supply Pump Replacement/ Fuel Supply Pump Relearn Procedure in this section.
Tachometer Output	Engine Output Controls	The purpose of this test is for checking whether the tachometer in the instrument panel cluster (IPC) is correctly operated as commanded. Faulty circuit(s) or tachometer could be considered when not operating correctly with command.

Scan Tool Does Not Power Up

Circuit Description

The data link connector (DLC) is a standardized 16 cavity connector. Connector design and location is dictated by an industry wide standard, and is required to provide the following:

- Scan tool power battery positive voltage at terminal 16
- Scan tool power ground at terminal 4
- Common signal ground at terminal 5

The scan tool will power up with the ignition OFF. Some modules however, will not communicate unless the ignition is ON.

Scan Tool Does Not Power Up

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views

Step	Action	Value(s)	Yes	No
1	**Important:** Make sure the scan tool works properly on another vehicle before using this chart. 1. Turn OFF the ignition. 2. Inspect the Hazard/Horn (20 A) fuse in the fuse box. Is the Hazard/Horn (20 A) fuse open?	—	Go to Step 2	Go to Step 3
2	Replace the Hazard/Horn (20 A) fuse. If the fuse continues to open, repair the short to ground on one of the circuits that is fed by the Hazard/Horn (20 A) fuse or replace the shorted attached component fed by the Hazard/Horn (20 A) fuse. Did you complete the repair?	—	Go to Step 7	—
3	1. Check each circuit at the data link connector (DLC) for a backed out, spread or missing terminal. 2. Repair the terminal as necessary. Did you find and complete the repair?	—	Go to Step 7	Go to Step 4
4	Connect a test lamp between the B+ circuit (pin 16) at the DLC and ground. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 5
5	Repair the open in the battery voltage circuit to the DLC. Did you complete the repair?	—	Go to Step 7	—
6	1. Test each ground circuit at the DLC (pins 4 and 5) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Intermittent Conditions
7	1. Connect the scan tool to the DLC. 2. Attempt to turn ON the scan tool. Does the scan tool ON?	—	System OK	Go to Step 1

Scan Tool Does Not Communicate with Class 2 Device

Circuit Description

The engine control module (ECM), transmission control module (TCM) and electronic hydraulic control unit (EHCU) [ABS module] all communicate with the scan tool over the Class 2 serial data link. The EHCU receives transmission parameters necessary for correct ABS functions over the Class 2 link as well. However, the ECM and TCM communicate with each other over the controller area network (CAN) link. The CAN link is not used for communication with the scan tool and is shared only between the ECM and TCM (Except 12,000 lbs GVW) or between the ECM, TCM and glow plug controller (12,000 lbs GVW).

Diagnostic Aids

The following conditions will cause a loss of class 2 serial data communication between the TCM and EHCU or between the scan tool and any control module:

- A Class 2 serial data circuit open
- A Class 2 serial data circuit shorted to ground
- A Class 2 serial data circuit shorted to voltage
- An internal condition within a module or connector on the class 2 serial data circuit, that causes a short to voltage or ground to the class 2 serial data circuit.
- Open ground circuit (pin 5) at the DLC

The Class 2 Message Monitor may be used to determine if a control module is intermittently communicating over the Class 2 link. The scan tool will indicate INACTIVE if a module is not communicating with the ignition turned ON.

Notice:

If the control module does not communicate as soon as the ignition is turned ON, that module will not be appear on the scan tool until it initially communicates. Therefore, if the scan tool indicates INACTIVE for a module or does not display the module with the ignition ON, the module is not communicating on the Class 2 link.

Scan Tool Does Not Communicate with Class 2 Device

Schematic Reference: Engine Controls Schematics

Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Attempt to communicate with each control module on the Class 2 serial data circuit (ECM, TCM and EHCU). If using a Tech 2, obtain this information using the Class 2 Message Monitor feature. Does the scan tool communicate with any module on the Class 2 serial data circuit (If using a Tech 2, the display must read ACTIVE for any controller)?	—	Go to Step 3	Go to Step 7
3	Does the scan tool communicate with the ECM?	—	Go to Step 4	Go to Lost Communication with the ECM
4	Does the scan tool communicate with the TCM?	—	Go to Step 5	Go to Diagnostic System Check – Transmission Controls
5	Does the scan tool communicate with the EHCU?	—	Go to Step 6	Go to Diagnostic System Check – Anti-lock Brake Controls

Step	Action	Value(s)	Yes	No
6	Test the Class 2 serial data circuit for an intermittent short to ground or intermittent short to voltage. Then, test the Class 2 serial data circuit for an intermittent open (based on which control module did not communicate) at the connection in the circuit. Did you find and correct the condition?	—	Go to Step 15	System OK
7	Test the data link connector (DLC) ground circuit at terminal 5 for an open circuit and for a poor connection. Did you find and correct the condition?	—	Go to Step 15	Go to Step 8
8	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Turn ON the ignition leaving the engine OFF. 4. Attempt to communicate with the TCM and the EHCU. Does the scan tool communicate with the TCM and EHCU?	—	Go to Step 12	Go to Step 9
9	1. Turn OFF the ignition. 2. Reconnect the ECM harness connector. 3. Disconnect the TCM harness connector. 4. Turn ON the ignition leaving the engine OFF. 5. Attempt to communicate with the ECM and EHCU. Does the scan tool communicate with the ECM and EHCU?	—	Go to Step 13	Go to Step 10
10	1. Turn OFF the ignition. 2. Reconnect the TCM harness connector. 3. Disconnect the EHCU harness connector. 4. Turn ON the ignition leaving the engine OFF. 5. Attempt to communicate with the ECM and TCM. Does the scan tool communicate with the ECM and TCM?	—	Go to Step 14	Go to Step 11
11	Repair the short to ground or short to voltage on the Class 2 serial data circuit between the DLC and ECM, TCM or EHCU. Did you complete the repair?	—	Go to Step 15	—
12	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 15	—

Step	Action	Value(s)	Yes	No
13	Replace the TCM. Refer to Transmission Control Module (TCM) Replacement in the Automatic Transmission section. Did you complete the replacement?	—	Go to Step 15	—
14	Replace the EHCU. Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in the Anti-lock Brake section. Did you complete the replacement?	—	Go to Step 15	—
15	Attempt to communicate with the ECM, TCM and EHCU. Does the scan tool communicate with the ECM, TCM and EHCU?	—	System OK	Go to Step 2

Lost Communications With The Engine Control Module (ECM)

Circuit Description

The engine control module (ECM), transmission control module (TCM) and electronic hydraulic control unit (EHCU) [ABS module] all communicate with the scan tool over the Class 2 serial data link. The EHCU receives transmission parameters necessary for correct ABS functions over the Class 2 link as well. However, the ECM and TCM communicate with each other over the controller area network (CAN) link. The CAN link is not used for communication with the scan tool and is shared only between the ECM and TCM (Except 12,000 lbs GVW) or between the ECM, TCM and glow plug controller (12,000 lbs GVW).

Notice:
If the battery supply voltage at the ECM (pin A-51) is lost, the ECM will still communicate with the scan tool and the engine will start and run normally. If ECM main relay voltage to the ECM is lost (must lose-voltage on all three ECM main relay power circuits), the scan tool will not communicate with the ECM.

Lost Communications With The Engine Control Module (ECM)

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	Attempt to establish ECM communications with the scan tool. Does the ECM communicate with the scan tool?	—	Go to Intermittent Conditions	Go to Step 3
3	Check the ECM A and B harness connectors for poor connections. Did you find and correct the condition?	—	Go to Step 15	Go to Step 4
4	1. Turn ON the ignition, with the engine OFF. 2. Check the Main (100 A), Key SW (50 A), ECM (BATT) (20 A) and ECM (IGN) (10 A) fuses. Replace and retest if open. If any fuse continues to open, check for a short to ground on each circuit fed by that fuse. 3. Turn OFF the ignition. 4. Disconnect the ECM A harness connector. 5. Turn the ignition ON, with the engine OFF. 6. Connect a test lamp to ground and check for voltage at the battery and ignition voltage supply circuits at the ECM. Does the test lamp illuminate for both circuits?	—	Go to Step 5	Go to Step 12
5	1. Turn OFF the ignition. 2. Connect a DMM between the Class 2 serial data circuit at the ECM and the data link connector (DLC). 3. Test the circuits for an open circuit or high resistance. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 6

Step	Action	Value(s)	Yes	No
6	**Important:** Any one open in a ground circuit at the ECM will not cause a loss of communication. 1. Check each ECM ground for corrosion and tightness. 2. Clean or tighten grounds as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 7
7	1. Turn OFF the ignition. 2. Reconnect the ECM A harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Replace the ECM main relay with the ID light relay or replace with a known good relay. 5. Attempt to establish scan tool communications with the ECM. Does the ECM communicate with the scan tool?	—	Go to Step 13	Go to Step 8
8	1. Turn the ignition OFF. 2. Remove the ECM main relay. 3. Using a test lamp, check for battery voltage at both of the battery voltage supply circuits to the ECM main relay. 4. Repair an open in the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 9
9	1. Reinstall the ECM main relay. 2. Turn the ignition ON and OFF while listening or feeling for the ECM main relay click. Wait 5 seconds between transitions. Does the ECM main relay click when the ignition is turned ON or OFF?	—	Go to Step 11	Go to Step 10
10	1. Check both ECM main relay control circuits for the following conditions: • An open circuit • A short to battery or ignition voltage • High resistance or a poor connection at both the ECM and ECM main relay 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14

Step	Action	Value(s)	Yes	No
11	1. Check all three ECM main relay voltage circuits for the following conditions: • An open circuit • A short to battery or ignition voltage • High resistance or a poor connection at both the ECM and ECM main relay 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
12	Repair the open in the battery or ignition voltage circuit to the ECM. Did you complete the repair?	—	Go to Step 15	—
13	Replace the ECM main relay. Did you complete the replacement?	—	Go to Step 15	—
14	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 15	—
15	1. Turn OFF the ignition. 2. Reconnect all disconnected connectors. 3. Turn the ignition ON, with the engine OFF. 4. Attempt to establish scan tool communications with the ECM. Does the scan tool communicate with the ECM?	—	System OK	Go to Step 3

Engine Cranks but Does Not Run

Description

The Engine Cranks but Does Not Run diagnostic table is an organized approach to identifying a condition that causes an engine to not start. The diagnostic table directs the service technician to the appropriate system diagnosis. The diagnostic table assumes the following conditions are met:

- The battery is completely charged and terminals are cleaned and tight.
- The engine cranking speed is normal.
- There is adequate fuel in the fuel tank.
- There is no air in the fuel line.
- Filters (Air, Fuel) are clean.
- Fuses and slow blow fuses are normal.

Notice:
The engine will start even if exhaust brake is fully engaged.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at engine control module (ECM): Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.

Notice:

The Actual Fuel Rail Pressure on scan tool will only update with the engine running or one time after the key is cycled when the ignition has been turned OFF for longer than 10 seconds.

Test Description

The numbers below refers to the step number on the diagnostic table.
5. If the fuel rail pressure (FRP) regulator low control circuits between the ECM and the FRP regulator are shorted to ground, “Actual FRP Regulator” will be approximately 500 mA lower as compared with “Desired FRP Regulator”.

Engine Cranks but Does Not Run

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Crank the engine for the specified amount of time. 3. Monitor the diagnostic trouble code (DTC) Information with a scan tool. Does the scan tool display any DTCs that failed this ignition?	15 seconds	Go to Diagnostic Trouble Code (DTC) List	Go to Step 3
3	1. Turn OFF the ignition. 2. Wait 2 minutes for the fuel pressure to bleed down from the fuel rail. 3. Turn ON the ignition, with the engine OFF. DO NOT start the engine. 4. Observe the Actual Fuel Rail Pressure (FRP) parameter with a scan tool. Is the Actual FRP parameter the specified value?	0 psi (0 MPa)	Go to Step 4	Go to Step 6

Step	Action	Value(s)	Yes	No
4	**Notice:** If the vehicle has run out of fuel, air may be trapped in the fuel system. 1. Make sure the fuel tank(s) have adequate fuel and the fuel quality is good (take a sample). 2. Observe the Actual Fuel Rail Pressure parameter on the scan tool while cranking over the engine for 5 seconds. Does the Actual Fuel Rail Pressure reach the minimum specified value during crank?	3630 psi (25 MPa)	Go to Step 9	Go to Step 5
5	Observe the Actual Fuel Rail Pressure (FRP) Regulator parameter on the scan tool while cranking over the engine for 5 seconds. Does the Actual FRP Regulator Current reach the desired value during crank?	900 mA	Go to Fuel System Check - Fuel System Section	Go to Step 8
6	1. Turn OFF the ignition. 2. Disconnect the FRP sensor harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the FRP sensor (pins1, 2 and 3 of E-113 connector). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP sensor circuit at the harness connector of the ECM (pins B-13, B-25, B-26 and B-47 of J-217 connector). 6. Test for high resistance on each FRP sensor circuit. 7. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 7
7	Replace the fuel rail pressure (FRP) sensor. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 12	—
8	1. Test the FRP regulator low control circuits between the engine control module (ECM) (pins B-20 & B-21 of J-217 connector) and the FRP regulator (pin 2 of E-116 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11

Step	Action	Value(s)	Yes	No
9	1. Check for normal readings at key up for the following sensor inputs: Use the Scan Tool Data List or a known good vehicle to determine nominal values. • Engine Coolant Temperature (ECT) Sensor • Mass Air Flow (MAF) Sensor • Barometric Pressure (BARO) • EGR Valve Position Sensor • Cam Signal Present • Crank Signal Present 2. Repair the circuit(s) or replace the sensor as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10
10	1. Other possible causes for the no-start condition: • Engine mechanical timing • Flywheel installed incorrectly causing the crankshaft position (CKP) sensor to be incorrectly timed to the engine. Disconnect sensor and attempt to start engine to verify. • Heavily restricted intake, exhaust or catalytic converter plugged solid. • Poor engine compression. • Water or gasoline contamination in fuel. 2. Repair as necessary. Did you find and correct the condition?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Turn OFF the ignition for 30 seconds. 3. Attempt to start the engine. Does the engine start and continue to run?	—	Go to Step 9	Go to Step 2
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

Engine Starts and Stalls

The engine control module (ECM) constantly monitors the information from various sensors. The ECM controls the systems that affect engine performance. The ECM performs the diagnostic function of the system. The ECM can recognize operational conditions, alert the driver through the malfunction indicator lamp (MIL), and store diagnostic trouble codes (DTCs). DTCs identify the faulty areas to aid the technician in making repairs.
The main relay supplies power to external output devices.

Diagnostic Aids

Inspect for the following conditions:

- Poor connection at the main relay
  Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connection.
- Damaged harness
  Inspect the wiring harness for damage, shorts to ground, shorts to battery, and open circuits. If the harness appears to be OK, observe the power supply or data list display on the scan tool while moving connectors and wiring harnesses related to the main relay. A change in the scan tool display will indicate the location of the fault.
- Air/ water contamination in the fuel system.

Engine Starts and Stalls

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	Does the engine fail to start?	—	Go to Engine Cranks But Does Not Run	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Perform the following checks before proceeding with this chart: • Make sure the idle up sensor knob on the left side of the instrument panel is all the way counterclockwise. • Check for an adequate supply of fuel in the fuel tanks and the quality of the fuel (water or gasoline contamination). If the outside temperature is very cold, the fuel may be gelled. • Check the battery cables for corrosion and for tightness. • Make an under cab visual inspection for obvious fuel leaks and for fuel system line problems. • Make a vehicle inspection for obvious intake or exhaust restrictions (collapsed induction tubing or crushed exhaust). • Check the engine control module (ECM) connectors and ring terminal grounds for tightness. • Check the engine oil level viscosity and quality. • Check the engine shutdown switch is not enabled. 2. Repair as necessary. Did you find and correct the condition?	—	Go to Step 6	Go to Step 4
4	1. Turn ON the ignition with the engine OFF. 2. Install a scan tool if not installed. 3. Observe the Engine Data 1 parameters for skewed sensor readings. Check the following: • Fuel Rail Pressure (FRP) Sensor (should read 0 psi (0 MPa) after engine has been OFF for 2 minutes)[cycle ignition before taking reading] • Barometric Pressure (BARO) Sensor • Mass Air Flow (MAF) Sensor • Engine Coolant Temperature (ECT) Sensor • Engine Speed 4. Refer to the Scan Tool Data List for nominal values if unknown. 5. Refer to appropriate DTC or schematic if a problem was found and repair as necessary. Did you find and correct the condition?	—	Go to Step 6	Go to Step 5

Step	Action	Value(s)	Yes	No
5	1. Other possible causes of engine stall: • Incorrect crank to cam timing or sensor tooth damage/incorrect machining • Poor fuel quality (water or gasoline contamination) • Heavily restricted catalytic converter • Fuel supply pump problem • Sticking fuel injectors • ECM main relay circuit malfunction • ECM power/grounding problem 2. Repair as necessary. Did you find and correct the condition?	—	Go to Step 6	Possible fuel related. Refer to Fuel System Check in the Fuel System section
6	1. Turn OFF the ignition for 10 seconds. 2. Start the engine and accelerate up and down the RPM band. Does the engine continue to run?	—	System OK	Go to Step 2

DTC P0016

Circuit Description

The crankshaft position (CKP) sensor is located on top of the flywheel housing. There are 56 notches spaced 6° apart and a 24° section that is uncut. This uncut portion allows for the detection of cylinder #1 top dead center (TDC).

The camshaft position (CMP) sensor is installed on the cylinder head at the rear of the camshaft gear. The CMP sensor detects a total of five through holes (four holes arranged equally every 90° and one reference hole on the camshaft gear flange surface).

Detecting the uncut portion from the CKP sensor and one reference hole from the CMP sensor, the engine control module (ECM) determines cylinder #1 compression top dead center (TDC) to ensure they correlate with each other. If the ECM detects both signals are out of synchronization, this DTC will set.

Condition for Running the DTC

- DTCs P0116, P0117, P0118, P0335, P0336, P0340 and P0341 are not set.
- The ignition switch is ON.
- The battery voltage is between 10 - 16 volts.
- The engine speed is lower than 4000 RPM.
- The CKP sensor signal is detected.
- The CMP sensor signal is detected.

Condition for Setting the DTC

- The ECM detects that the CKP sensor signals and CMP sensor signals are out of synchronization during 5 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- This DTC is caused by an incorrect mechanical timing condition, which was most likely cased by wrong installation of timing gear, flywheel or camshaft.

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Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Start the engine. **Notice:** Slight start delay may be noticed. If the engine does not start, attempt to crank. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0335, P0336, P0340 or P0341 set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3
3	Inspect the engine mechanical timing. Refer to the Engine Mechanical section. Repair as necessary. **Notice:** If the flywheel dowel pin is missing or pushed in and the flywheel is incorrectly installed, this DTC may set. Did you complete the repair?	—	Go to Step 4	—

Step	Action	Value(s)	Yes	No
4	1. Reconnect all previously disconnected harness connector(s) if disconnected. 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 5
5	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0087

Description

The common rail fuel system is comprised of two fuel pressure sections: a suction side between the fuel tank and the fuel supply pump and a high-pressure side between the fuel supply pump and the fuel injectors. Fuel is drawn from the fuel tank via a feed pump and then pumped into the fuel rail by two plungers, all of which are internal to the fuel supply pump. This high pressure is regulated by the engine control module (ECM) using the fuel rail pressure (FRP) regulator dependant upon values from the FRP sensor attached to the fuel rail. In case of fuel rail overpressure, a pressure limiter valve threaded into the fuel rail will open to release overpressure and return fuel back to the fuel tank.

If the ECM detects that the fuel pressure went excessively high, then sharply decreased, this DTC will set indicating high fuel pressure, which activated the pressure limiter valve.

Condition for Running the DTC

- DTCs P0091, P0092, P0192, P0193, P0602, P0642 and P0643 are not set.

Condition for Setting the DTC

- The ECM detects that the pressure limiter valve is activated with overpressure (more than 27560 psi [190 MPa]) in the fuel rail.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits accelerator control range within 55%.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits cruise control.
- The ECM inhibits PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- An intermittently sticking fuel rail pressure (FRP) regulator may have allowed the fuel pressure to become high enough to open the pressure limiter valve.
- Normal Actual Fuel Rail Pressure readings on the scan with the engine running in Park or Neutral at idle are around 3650 to 5050 psi (25 to 35 MPa) and around 14500 to 21750 psi (100 to 150 MPa) in Park or Neutral at W.O.T. (accelerator pedal full travel).
- A shorted FRP regulator or a short between the high and low control circuit will set P0087 and may not set an electrical P0091 or P0092 DTC.
- An intermittently sticking fuel injector may have allowed the fuel pressure to drop too much. Use a scan tool to perform the Cylinder Power Balance test for each injector. Verify a consistent engine speed change when commanding each fuel injector ON and OFF.
- A skewed FRP sensor value (shifted to a higher pressure) can set this DTC. The Actual Fuel Rail Pressure on the scan tool should read 0 psi (0 MPa) with the key ON and engine OFF after the engine has stopped running for a minimum of 2 minutes.

Notice:
The Actual Fuel Rail Pressure on scan tool will only update with the engine running or one time after the key is cycled when the ignition has been turned OFF for longer than 10 seconds.

Notice:
The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight or if there is a crack in one of the fuel hoses. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load, which may set this DTC.

Notice:
If the fuel tank is empty or near empty, air might be allowed to go into the fuel system. With air in the fuel system, smooth flow of fuel into the supply pump is interrupted and this DTC may set. Perform bleeding of fuel system after refilling.

Test Description

The numbers below refer to the step number on the diagnostic table.

6. This step checks for a fuel restriction by determining if a high vacuum is being pulled on the fuel system during normal operation.

7. This step checks for an air leak on the suction side of the fuel system by determining if a vacuum can be pulled when a fuel line is plugged.

DTC P0087

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Start the engine. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0089, P0091, P0092, P0192, P0193, P0201-P0204, P0261, P0264, P0267, P0270 or P2146-P2151 set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3
3	1. Turn OFF the ignition for 30 seconds. 2. Place the transmission in Park or Neutral and set the park brake. 3. Start the engine. 4. Accelerate the engine between idle and W.O.T. (accelerator pedal full travel) many times while observing the DTC Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Wait 2 minutes for the fuel pressure to bleed down from the fuel rail. 3. Turn ON the ignition with the engine OFF, do not start the engine. 4. Observe the Actual Fuel Rail Pressure parameter with a scan tool. Is the Actual Fuel Rail Pressure parameter the specified value?	0 psi (0 MPa)	Go to Step 5	Go to Step 12

Step	Action	Value(s)	Yes	No
5	1. Turn OFF the ignition. 2. Check the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. **Notice:** The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load, which may set this DTC. 3. Pump the priming pump on the fuel filter until it becomes firm. If there is a leak on the suction side of the fuel system between the priming pump and the fuel supply pump, the priming pump will not build up sufficient firmness and fuel leakage may occur. 4. Start the engine and check for suction side fuel system leaks at the fuel supply pump and fuel rail. **Notice:** Fuel may leak under the cylinder head cover from the inlet high pressure line. In such case, the engine oil level will rise . Inspect for fuel leakage into the engine oil. 5. Repair any fuel system leaks as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 6

Step	Action	Value(s)	Yes	No
6	1. Turn OFF the ignition. 2. Remove the rubber fuel hose from the fuel filter housing (fuel supply pump side). Use a pan to catch the fuel leakage from the removed fuel line. **Important:** The fuel vacuum pump/pressure gauge connector and the adapter hose must be cleaned before connecting to the fuel line. Otherwise, foreign material internal to the tools line may damage the fuel supply pump. 3. Connect the suction side fuel pressure adapter EN-47667 with fuel vacuum/ pressure gauge assembly J-44638 in series with the filter housing and the disconnected fuel hose. Ensure the service tool and fuel line connections are tight. 4. Bleed the fuel system by priming the priming pump until it becomes firm, then crank over the engine for a maximum of 5 seconds. Repeat as necessary until the engine starts. 5. Let the engine run at idle for at least 1 minute. 6. Monitor the fuel vacuum/pressure gauge while holding the engine speed higher than 2500 RPM for a minimum of 1 minute. Does the vacuum/pressure gauge ever indicate a larger vacuum than the specified amount during the test?	5 inHg	Go to Step 8	Go to Step 7
7	1. Fully clamp off a fuel hose as close to the fuel tank as possible (this will draw vacuum on the fuel system). You can also disconnect a fuel line and plug it. 2. Start the engine and turn the idle up control knob to the highest position. (Full clockwise direction. The idle speed is increased up to 1600 RPM.) 3. Monitor the fuel pressure/vacuum gauge. **Notice:** Release the clamp or open the plug when the gauge is likely to be more than 8 inHg during the test. Can a vacuum of at least the specified amount be pulled on the fuel system?	8 inHg	Go to Step 10	Go to Step 9

Step	Action	Value(s)	Yes	No
8	1. Inspect the fuel lines between the fuel supply pump and fuel tank for being crushed or kinked. 2. Inspect for a plugged fuel tank vent valve. 3. Inspect inside the fuel tank (if possible) for any foreign material that may be getting drawn into the fuel line pickup causing a blocked condition. 4. Repair as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 13
9	1. Turn OFF the ignition. 2. Check the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. 3. Repair as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 11
10	1. Turn OFF the ignition. 2. Unclamp or unplug the fuel line from the previous step and reconnect the fuel line (if disconnected). 3. Start the engine and allow it to run for at least 1 minute. 4. Perform the Cylinder Power Balance test with a scan tool. 5. Command each injector OFF and verify an engine speed change for each injector. Is there an injector that does not change engine speed when commanded OFF?	—	Go to Step 15	Go to Step 11
11	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure (FRP) regulator harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the FRP regulator (pins 1 and 2 of E-116). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP regulator circuit at the harness connector of the ECM (pins B-20, B-21, B-33 and B-34 of J-217 connector). 6. Test for high resistance on each FRP regulator circuit. 7. Repair the connection(s) or circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16

Step	Action	Value(s)	Yes	No
12	1. Turn OFF the ignition. 2. Disconnect the FRP sensor harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the FRP sensor (pins1, 2 and 3 of E-113 connector). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP sensor circuit at the harness connector of the ECM (pins B-13, B-25, B-26 and B-47 of J-217 connector). 6. Test for high resistance on each FRP sensor circuit. 7. Repair the connection(s) or circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 14
13	Replace the fuel filter cartridge. Refer to Fuel Filter Cartridge Replacement in the Fuel System Section. Did you complete the replacement?	—	Go to Step 17	—
14	Replace the fuel rail pressure sensor. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 17	—
15	**Important:** Replacement injector must be programmed. Replace the appropriate fuel injector that does not change engine speed when commanded OFF. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 17	—
16	**Important:** The fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM. **Notice:** Always replace the fuel filter cartridge when a fuel supply pump is replaced. Replace the fuel supply pump and fuel filter cartridge. Refer to Fuel Supply Pump Replacement/Fuel Supply Pump Relearn Procedure in this section and Fuel Filter Cartridge Replacement in Fuel System section. Did you complete the replacement?	—	Go to Step 17	—

Step	Action	Value(s)	Yes	No
17	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 18
18	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0088

Description

The common rail fuel system is comprised of two fuel pressure sections: a suction side between the fuel tank and the fuel supply pump and a high-pressure side between the fuel supply pump and the fuel injectors. Fuel is drawn from the fuel tank via a feed pump and then pumped into the fuel rail by two plungers, all of which are internal to the fuel supply pump. This high pressure is regulated by the engine control module (ECM) using the fuel rail pressure (FRP) regulator dependant upon values from the FRP sensor attached to the fuel rail. In case of fuel rail overpressure, a pressure limiter valve threaded into the fuel rail will open to release overpressure and return fuel back to the fuel tank.
If the ECM detects that the fuel pressure went excessively high for a certain length of time, this DTC will set (First Stage). If the ECM detects that during the same ignition cycle the fuel pressure rose even higher than the amount to set DTC P0088 (Second Stage) for a certain length of time, the MIL will be illuminated. If the MIL is illuminated, the fuel pressure was too high and the pressure limiter valve did not active or did not activate quick enough.

Condition for Running the DTC

First Stage

- DTCs P0091, P0092, P0192, P0193, P0602, P0642 and P0643 are not set.
- The ignition switch is ON.

Second Stage

- DTCs P0091, P0092, P0192, P0193, P0602, P0642 and P0643 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

First stage

- The ECM detects that the fuel rail pressure is more than 26850 psi (185 MPa) for longer than 9 seconds.

Second Stage

- The ECM detects that the fuel rail pressure is momentarily more than 30200psi (208MPa) anytime during the ignition cycle after first stage has occurred. This indicates the fuel rail pressure is too high and pressure limiter valve most likely did not active.

Action Taken When the DTC Sets

First Stage

- The ECM will not illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Second Stage

- The ECM illuminate the MIL when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM limits accelerator control range within 55%.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits cruise control.
- The ECM inhibits PTO control.

Condition for Clearing the MIL/DTC

First Stage

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

Second Stage

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- An intermittently sticking fuel rail pressure (FRP) regulator may have allowed the fuel pressure to become high enough to set this DTC.

- Normal Actual Fuel Rail Pressure readings on the scan with the engine running in Park or Neutral at idle are around 3650 to 5050 psi (25 to 35 MPa) and around 14500 to 21750 psi (100 to 150 MPa) in Park or Neutral at W.O.T. (accelerator pedal full travel).
- A skewed FRP sensor value (shifted to a higher pressure) can set this DTC. The Actual Fuel Rail Pressure on the scan tool should read 0 psi (0 MPa) with the key ON and engine OFF after the engine has stopped running for a minimum of 2 minutes.
- Resistance in the FRP sensor low reference circuit can set this DTC. Ensure that the sensor low reference circuit has no resistance and the connectors are tight and free of corrosion.

Notice:
The Actual Fuel Rail Pressure on scan tool will only update with the engine running or one time after the key is cycled when the ignition has been turned OFF for longer than 10 seconds.

Test Description

The numbers below refer to the step number on the diagnostic table.
6. This step checks for a fuel restriction by determining if a high vacuum is being pulled on the fuel system during normal operation.
7. This step checks for an air leak on the suction side of the fuel system by determining if a vacuum can be pulled when a fuel line is plugged.
17. This DTC indicates that the fuel pressure went high and if the MIL was illuminated due to the second stage, then there is a possibility that the pressure limiter valve did not active.

DTC P0088

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Start the engine. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0087, P0089, P0091, P0092, P0192, P0193, P0201-P0204, P0261, P0264, P0267, P0270 or P2146-P2151 set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3
3	1. Turn OFF the ignition for 30 seconds. 2. Place the transmission in Park or Neutral and set the park brake. 3. Start the engine. 4. Observe the Actual Fuel Rail Pressure parameter with a scan tool. 5. Accelerate the engine between idle and W.O.T. (accelerator pedal full travel) many times while observing the scan tool. Does the Actual Fuel Rail Pressure parameter ever exceed the specified value?	26830 psi (185 MPa)	Go to Step 4	An intermittent problem by foreign material in the fuel is suspected. Go to Step 13
4	1. Turn OFF the ignition. 2. Wait 2 minutes for the fuel pressure to bleed down from the fuel rail. 3. Turn ON the ignition with the engine OFF, do not start the engine. 4. Observe the Actual Fuel Rail Pressure parameter with a scan tool. Is the Actual Fuel Rail Pressure parameter the specified value?	0 psi (0 MPa)	Go to Step 5	Go to Step 12

Step	Action	Value(s)	Yes	No
5	1. Turn OFF the ignition. 2. Check the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. **Notice:** The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load, which may set this DTC. 3. Pump the priming pump on the fuel filter until it becomes firm. If there is a leak on the suction side of the fuel system between the priming pump and the fuel supply pump, the priming pump will not build up sufficient firmness and fuel leakage may occur. 4. Start the engine and check for suction side fuel system leaks at the fuel supply pump and fuel rail. **Notice:** Fuel may leak under the cylinder head cover from the inlet high pressure line. In such case, the engine oil level will rise. Inspect for fuel leakage into the engine oil. 5. Repair any fuel system leaks as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 6

Step	Action	Value(s)	Yes	No
6	1. Turn OFF the ignition. 2. Remove the rubber fuel hose from the fuel filter housing (fuel supply pump side). Use a pan to catch the fuel leakage from the removed fuel line. **Important:** The fuel vacuum pump/pressure gauge connector and the adapter hose must be cleaned before connecting to the fuel line. Otherwise, foreign material internal to the tools line may damage the fuel supply pump. 3. Connect the suction side fuel pressure adapter EN-47667 with fuel vacuum/ pressure gauge assembly J-44638 in series with the filter housing and the disconnected fuel hose. Ensure the service tool and fuel line connections are tight. 4. Bleed the fuel system by priming the priming pump until it becomes firm, then crank over the engine for a maximum of 5 seconds. Repeat as necessary until the engine starts. 5. Let the engine run at idle for at least 1 minute. 6. Monitor the fuel vacuum/pressure gauge while holding the engine speed higher than 2500 RPM for a minimum of 1 minute. Does the vacuum/pressure gauge ever indicate a larger vacuum than the specified amount during the test?	5 inHg	Go to Step 8	Go to Step 7
7	1. Fully clamp off a fuel hose as close to the fuel tank as possible (this will draw vacuum on the fuel system). You can also disconnect a fuel line and plug it. 2. Start the engine and turn the idle up control knob to the highest position. (Full clockwise direction. The idle speed is increased up to 1600 RPM.) 3. Monitor the fuel pressure/vacuum gauge. **Notice:** Release the clamp or open the plug when the gauge is likely to be more than 8 inHg during the test. Can a vacuum of at least the specified amount be pulled on the fuel system?	8 inHg	Go to Step 10	Go to Step 9

Step	Action	Value(s)	Yes	No
8	1. Inspect the fuel lines between the fuel supply pump and fuel tank for being crushed or kinked. 2. Inspect for a plugged fuel tank vent valve. 3. Inspect inside the fuel tank (if possible) for any foreign material that may be getting drawn into the fuel line pickup causing a blocked condition. 4. Repair as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 13
9	1. Turn OFF the ignition. 2. Check the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. 3. Repair as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 11
10	1. Turn OFF the ignition. 2. Unclamp or unplug the fuel line from the previous step and reconnect the fuel line (if disconnected). 3. Start the engine and allow it to run for at least 1 minute. 4. Perform the Cylinder Power Balance test with a scan tool. 5. Command each injector OFF and verify an engine speed change for each injector. Is there an injector that does not change engine speed when commanded OFF?	—	Go to Step 15	Go to Step 11
11	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure (FRP) regulator harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the FRP regulator (pins 1 and 2 of E-116 connector). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP regulator circuit at the harness connector of the ECM (pins B-20, B-21, B-33 and B-34 of J-217 connector). 6. Test for high resistance on each FRP regulator circuit. 7. Repair the connection(s) or circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16

Step	Action	Value(s)	Yes	No
12	1. Turn OFF the ignition. 2. Disconnect the FRP sensor harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the FRP sensor (pins 1, 2 and 3 of E-113 connector). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP sensor circuit at the harness connector of the ECM (pins B-13, B-25, B-26 and B-47 of J-217 connector). 6. Test for high resistance on each FRP sensor circuit. 7. Repair the connection(s) or circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 14
13	Replace the fuel filter cartridge. Refer to Fuel Filter Cartridge Replacement in the Fuel System Section. Did you complete the replacement?	—	Go to Step 17	—
14	Replace the fuel rail pressure sensor. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 17	—
15	**Important:** Replacement injector must be programmed. Replace the appropriate fuel injector that does not change engine speed when commanded OFF. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 17	—
16	**Important:** The fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM. **Notice:** Always replace the fuel filter cartridge when a fuel supply pump is replaced. Replace the fuel supply pump and fuel filter cartridge. Refer to Fuel Supply Pump Replacement/Full Supply Pump Relearn Procedure in this section and Fuel Filter Cartridge Replacement in Fuel System section. Did you complete the replacement?	—	Go to Step 17	—

Step	Action	Value(s)	Yes	No
17	**Notice:** There is a possibility that the pressure limiter valve did not activate, if DTC P0088 illuminated the MIL. If the MIL was not illuminated due to this DTC, Skip to Step 18. Replace the pressure limiter valve. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 18	—
18	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 19
19	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0089

Description

The common rail fuel system is comprised of two fuel pressure sections: a suction side between the fuel tank and the fuel supply pump and a high-pressure side between the fuel supply pump and the fuel injectors. Fuel is drawn from the fuel tank via a feed pump and then pumped into the fuel rail by two plungers, all of which are internal to the fuel supply pump. This high pressure is regulated by the engine control module (ECM) using the fuel rail pressure (FRP) regulator dependant upon values from the FRP sensor attached to the fuel rail. In case of fuel rail overpressure, a pressure limiter valve threaded into the fuel rail will open to release overpressure and return fuel back to the fuel tank.

If the ECM detects that fuel pressure is a certain pressure higher than the commanded fuel pressure after the FRP regulator has been commanded to OFF (full current) for a certain length of time, this DTC will set.

Condition for Running the DTC

- DTCs P0091, P0092, P0192, P0193, P0602, P0642 and P0643 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.
- The injectors are operating.

Condition for Setting the DTC

- The ECM detects that the actual fuel rail pressure is higher than desired pressure 10 MPa (1450 psi) for longer than 30 seconds when commanded fuel supply is OFF.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM limits accelerator control range to idle.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits cruise control.
- The ECM inhibits PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- An intermittently sticking fuel rail pressure (FRP) regulator may have allowed the fuel pressure to become high enough to set this DTC.
- Normal Actual Fuel Rail Pressure readings on the scan with the engine running in Park or Neutral at idle are around 3650 to 5050 psi (25 to 35 MPa) and around 14500 to 21750 psi (100 to 150 MPa) in Park or Neutral at W.O.T. (accelerator pedal full travel)
- A skewed FRP sensor value (shifted to a higher pressure) can set this DTC. The Actual Fuel Rail Pressure on the scan tool should read 0 psi (0 MPa) with the key ON and engine OFF after the engine has stopped running for a minimum of 2 minutes.
- Resistance in the FRP sensor low reference circuit can set this DTC. Ensure that the sensor low reference circuit has no resistance and the connectors are tight and free of corrosion.

Notice:
The Actual Fuel Rail Pressure on scan tool will only update with the engine running or one time after the key is cycled when the ignition has been turned OFF for longer than 10 seconds.

DTC P0089

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Start the engine. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0091, P0092, P0192, P0193, P0201-P0204, P0261, P0264, P0267, P0270 or P2146-P2151 set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3
3	1. Turn OFF the ignition. 2. Wait 2 minutes for the fuel pressure to bleed down from the fuel rail. 3. Turn ON the ignition with the engine OFF, do not start the engine. 4. Observe the Actual Fuel Rail Pressure parameter with a scan tool. Is the Actual Fuel Rail Pressure parameter the specified value?	0 psi (0 MPa)	Go to Step 4	Go to Step 5
4	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure (FRP) regulator harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion at the harness connector of the FRP regulator (pins 1 and 2 of E-116 connector). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP regulator circuit at the harness connector of the ECM (pins B-20, B-21, B-33 and B-34 of J-217 connector). 6. Test for high resistance on each FRP regulator circuit. 7. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 6
5	1. Turn OFF the ignition. 2. Disconnect the FRP sensor harness connector. 3. Inspect for an intermittent, for poor connection and corrosion at the harness connector of the FRP sensor (pins 1, 2 and 3 of E-113 connector). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connection and corrosion on each FRP sensor circuit at the harness connector of the ECM (pins B-13, B-25, B-26 and B-47 of J-217 connector). 6. Test for high resistance on each FRP sensor circuit. 7. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 8

Step	Action	Value(s)	Yes	No
6	1. Turn OFF the ignition for 30 seconds. 2. Place the transmission in Park or Neutral and set the Park brake. 3. Start the engine. 4. Let the engine idle with the engine coolant temperature between 140-185°F (60-85°C) and accessories OFF while observing the Actual Fuel Rail Pressure parameter with a scan tool. Is the Actual Fuel Rail Pressures parameter less than the specified valve?	5800 psi (40 MPa)	Go to Step 7	Go to Step 9
7	**Notice:** An intermittent problem by foreign material in the fuel is suspected. Replace the fuel filter cartridge. Refer to the Fuel Filter Cartridge Replacement in fuel system section. Did you complete the replacement?	—	Go to Step 10	—
8	Replace the fuel rail pressure sensor. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 10	—
9	**Important:** The fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM. **Notice:** Always replace the fuel filter cartridge when a fuel supply pump is replaced. Replace the fuel supply pump and fuel filter cartridge. Refer to Fuel Supply Pump Replacement/Fuel Supply Pump Relearn Procedure in this section and Fuel Filter Cartridge Replacement in Fuel System section. Did you complete the replacement?	—	Go to Step 10	—
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0091

Circuit Description

The fuel rail pressure (FRP) regulator is installed to the fuel supply pump and controls the suction fuel quantity into the fuel rail. The FRP regulator is fully opened in the normal state and larger drive current results in smaller opening. The engine control module (ECM) calculates desired fuel rail pressure and fuel flow rate and it compares the calculated desired fuel rail pressure to the actual value to determine the FRP regulator position. When the actual fuel rail pressure is higher than the desired value, the FRP regulator is closed to decease the flow rate. If the ECM detects an excessively low FRP regulator solenoid drive current, this DTC will set.

Condition for Running the DTC

- DTCs P0092, P0642 and P0643 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The fuel supply pump control is stable.

Condition for Setting the DTC

- The ECM detects that the FRP regulator solenoid drive current is less than 400mA when the drive duty cycle is more than 70%.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM limits accelerator control range to idle.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections.
- Misrouted harness.
- Rubbed through wire insulation.
- Broken wire inside the insulation.

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Actual FRP Regulator" display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Test Description

The numbers below refers to the step number on the diagnostic table.

3. If the FRP regulator low control circuits between the ECM and the FRP regulator are short to battery or ignition voltage, this DTC may not set. DTC P0092 may set dependent upon location of a short.

9. If the FRP regulator low control circuits between the ECM and the FRP regulator are short to ground, this DTC may not set. This condition will cause engine stall or no engine start.

DTC P0091

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition, with the engine OFF. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure (FRP) regulator harness connector. 3. Connect a test lamp between the FRP regulator low control circuit (pin 2 of E-116 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. DO NOT start the engine. Does the test lamp illuminate?	—	Go to Step 8	Go to Step 4
4	1. Turn OFF the ignition. 2. Connect a test lamp between the FRP regulator high control circuit (pin 1 of E-116 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. DO NOT start the engine. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 5
5	1. Turn OFF the ignition. 2. Connect a test lamp between the FRP regulator high control circuit (pin 1 of E-116 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. DO NOT start the engine. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 10
6	1. Turn OFF the ignition. 2. Connect a test lamp between the FRP regulator low control circuit (pin 2 of E-116 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. DO NOT start the engine. Does the test lamp continuously illuminate (note that the test lamp will blink then go out normally)?	—	Go to Step 11	Go to Step 7
7	Did the test lamp blink then go out at step 6?	—	Go to Step 13	Go to Step 12
8	Repair the FRP regulator low control circuit between the engine control module (ECM) (pins B-20 & B-21 of J-217 connector) and the FRP regulator (pin 2 of E-116 connector) for a short to battery or ignition voltage. Did you complete the repair?	—	Go to Step 17	—

Step	Action	Value(s)	Yes	No
9	1. Test the FRP regulator high control circuits between the ECM (pins B-33 & B-34 of J-217 connector) and the FRP regulator (pin 1of E-116 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
10	1. Test the FRP regulator high control circuits between the ECM (pins B-33 & B-34 of J-217 connector) and the FRP regulator (pin 1 of E-116 connector) for the following conditions: • A short to FRP regulator low control circuit • An open circuit • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 14
11	1. Test the FRP regulator low control circuits between the ECM (pins B-20 & B-21 of J-217 connector) and the FRP regulator (pin 2 of E-116 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
12	1. Test the FRP regulator low control circuits between the ECM (pins B-20 & B-21 of J-217 connector) and the FRP regulator (pin 2 of E-116 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 14
13	1. Turn OFF the ignition. 2. Disconnect the FRP regulator harness connector. 3. Inspect for an intermittent and for poor connections at the FRP regulator (pins 1 and 2 of E-116 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 15
14	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for poor connections on the FRP regulator circuits at the harness connector of the ECM (pins B-20 & B-21 or B-33 & B-34 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16

Step	Action	Value(s)	Yes	No
15	**Important:** The fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM. Replace the fuel supply pump. Refer to Fuel Supply Pump Replacement/Fuel Supply Pump Relearn Procedure in this section. (FRP regulator is part of the fuel supply pump assembly) Did you complete the replacement?	—	Go to Step 17	—
16	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 17	—
17	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 18
18	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0092

Circuit Description

The fuel rail pressure (FRP) regulator is installed to the fuel supply pump and controls the suction fuel quantity into the fuel rail. The FRP regulator is fully opened in the normal state and larger drive current results in smaller opening. The engine control module (ECM) calculates desired fuel rail pressure and fuel flow rate and it compares the calculated desired fuel rail pressure to the actual value to determine the FRP regulator position. When the actual fuel rail pressure is higher than the desired value, the FRP regulator is closed to decease the flow rate. If the ECM detects an excessively high FRP regulator solenoid drive current, this DTC will set.

Condition for Running the DTC

- DTCs P0091, P0642 and P0643 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The fuel supply pump control is stable .

Condition for Setting the DTC

- The ECM detects that the FRP regulator solenoid drive current is more than 2700mA when the drive duty cycle is less than 20%.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM limits accelerator control range to idle.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness.
- Rubbed through wire insulation.

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Actual FRP Regulator" display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0092

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition, with the engine OFF. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure (FRP) regulator harness connector. 3. Connect a test lamp between the FRP regulator low control circuit (pin 2 of E-116 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. DO NOT start the engine. Does the test lamp illuminate?	—	Go to Step 5	Go to Step 4
4	1. Turn OFF the ignition. 2. Disconnect the FRP regulator harness connector. 3. Remove the ECM IGN (10 A) fuse in the glove box fuse block. (This will allow the high control circuit driver in the ECM to be OFF when testing for a short to voltage.) 4. Turn ON the ignition, with the engine OFF. DO NOT start the engine. 5. Connect a test lamp between the FRP regulator high circuit (pin 1 of E-116 connector) and a known good ground. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 7
5	Repair the FRP regulator low control circuit between the engine control module (ECM) (pins B-20 & B-21 of J-217 connector) and the FRP regulator (pin 2 of E-116 connector) for a short to battery or ignition voltage. Did you complete the repair?	—	Go to Step 8	—
6	Repair the FRP regulator high circuit between the ECM (pins B-33 & B-34 of J-217 connector) and the FRP regulator (pin 1 of E-116 connector) for a short to battery or ignition voltage. Did you complete the repair?	—	Go to Step 8	—
7	Reinstall the ECM IGN (10 A) fuse in the glove box fuse block. **Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 8	—

Step	Action	Value(s)	Yes	No
8	1. Reconnect all previously disconnected fuse and harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 9
9	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0093

Description

The common rail fuel system is comprised of two fuel pressure sections: a suction side between the fuel tank and the fuel supply pump and a high-pressure side between the fuel supply pump and the fuel injectors. Fuel is drawn from the fuel tank via a feed pump and then pumped into the fuel rail by two plungers, all of which are internal to the fuel supply pump. This high pressure is regulated by the engine control module (ECM) using the fuel rail pressure (FRP) regulator dependant upon values from the FRP sensor attached to the fuel rail.

If the ECM detects that the fuel pressure is lower than the desired value, this DTC will set. This most likely indicates some loss of fuel pressure or intermittently loss of fuel pressure by fuel leak from the high pressure side.

Condition for Running the DTC

- DTCs P0089, P0091, P0092, P0192, P0193, P0335, P0602, P0642 and P0643 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.
- The engine is running.
- The fuel supply pump control is stable.

Condition for Setting the DTC

- The ECM detects that the difference of fuel leak quantity is larger than a threshold.

OR

- The ECM detects that the fuel rail pressure is dropped more than a threshold after an injection event compared with the previous injection.

OR

- The ECM detects that the fuel rail pressure is less than 18 MPa (2600 psi).

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM limits accelerator control range to idle.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits cruise control.
- The ECM inhibits PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- An intermittently sticking fuel rail pressure (FRP) regulator may have allowed the fuel pressure to drop suddenly.
- Normal Actual Fuel Rail Pressure readings on the scan with the engine running in Park or Neutral at idle are around 3650 to 5050 psi (25 to 35 MPa) and around 14500 to 21750 psi (100 to 150 MPa) in Park or Neutral at W.O.T. (accelerator pedal full travel).
- An intermittently sticking fuel injector may have allowed the fuel pressure to drop too much. Use a scan tool to perform the Cylinder Power Balance test for each injector. Verify a consistent engine speed change when commanding each fuel injector ON and OFF.
- A skewed FRP sensor value (shifted to a lower pressure) can set this DTC. The Actual Fuel Rail Pressure on the scan tool should read 0 psi (0 MPa) with the key ON and engine OFF after the engine has stopped running for a minimum of 2 minutes.
- Resistance in the FRP sensor low reference circuit can set this DTC. Ensure that the sensor low reference circuit has no resistance and the connectors are tight and free of corrosion.

Notice:

This DTC most likely indicates a loss of fuel pressure by a fuel leak from the high pressure side. Inspect the high pressure side fuel leakage between the fuel supply pump and fuel injector FIRST.

Notice:

The Actual Fuel Rail Pressure on scan tool will only update with the engine running or one time after the key is cycled when the ignition has been turned OFF for longer than 10 seconds.

Notice:
The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight or if there is a crack in one of the fuel hoses. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load, which may set this DTC.

Notice:
If the fuel tank is empty or near empty, air might be allowed to go into the fuel system. With air in the fuel system, smooth flow of fuel into the supply pump is interrupted and this DTC may set. Perform bleeding of fuel system after refilling.

Test Description

The numbers below refer to the step number on the diagnostic table.
7. This step checks for a fuel restriction by determining if a high vacuum is being pulled on the fuel system during normal operation.
8. This step checks for an air leak on the suction side of the fuel system by determining if a vacuum can be pulled when a fuel line is plugged.

DTC P0093

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Inspect the high pressure side between the fuel supply pump and the fuel injectors for fuel leakage. The following components may contain an external leak. • Fuel supply pump • Fuel rail • Pressure limiter valve • Flow damper valve • Fuel rail pressure (FRP) sensor • Fuel pipe between the fuel supply pump and fuel rail • Fuel pipe between the fuel rail and fuel injectors • Each fuel pipe sleeve nuts **Notice:** Fuel may leak under the cylinder head cover from the inlet high pressure line. In such case, the engine oil level will rise. Inspect for fuel leakage into the engine oil. **Notice:** Remove and inspect the inlet high pressure joint to the fuel injectors for fuel leaking from the sleeve nut(s). Replace the fuel injector and injection pipe when foreign material was in contact . 2. Repair any fuel system leaks as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Remove each glow plug from the cylinder head. 2. Inspect the tip of the plugs for wet fuel. **Notice:** Use the engine compression gauge J-26999-12 and adapter EN-46722 to inspect the damage of engine. If poor engine compression (less than 284 psi [1960 kPa]) or variation of each cylinder (more than 43 psi [294 kPa]) is found, inspect the engine mechanical. Refer to the Engine Mechanical section. Repair as necessary. Did you find wet fuel on the glow plug(s) ?	—	Go to Step 16	Go to Step 4
4	1. Install a scan tool. 2. Start the engine. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0087, P0091, P0092, P0192, P0193, P0201-P0204, P0261, P0264, P0267, P0270 or P2146-P2151 set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 5
5	1. Turn OFF the ignition. 2. Wait 2 minutes for the fuel pressure to bleed down from the fuel rail. 3. Turn ON the ignition with the engine OFF, do not start the engine. 4. Observe the Actual Fuel Rail Pressure parameter with a scan tool. Is the Actual Fuel Rail Pressure parameter the specified value?	0 psi (0 MPa)	Go to Step 6	Go to Step 13

Step	Action	Value(s)	Yes	No
6	1. Turn OFF the ignition. 2. Check the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. **Notice:** The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load, which may set this DTC. 3. Pump the priming pump on the fuel filter until it becomes firm. If there is a leak on the suction side of the fuel system between the priming pump and the fuel supply pump, the priming pump will not build up sufficient firmness and fuel leakage may occur. 4. Start the engine and check for high side fuel system leaks at the fuel supply pump and fuel rail. **Notice:** Fuel may leak under the cylinder head cover from the inlet high pressure line. In such case, the engine oil level will rise. Inspect for fuel leakage into the engine oil. 5. Repair any fuel system leaks as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Remove the rubber fuel hose from the fuel filter housing (fuel supply pump side). Use a pan to catch the fuel leakage from the removed fuel line. **Important:** The fuel vacuum pump/pressure gauge connector and the adapter hose must be cleaned before connecting to the fuel line. Otherwise, foreign material internal to the tools line may damage the fuel supply pump. 3. Connect the suction side fuel pressure adapter EN-47667 with fuel vacuum/ pressure gauge assembly J-44638 in series with the filter housing and the disconnected fuel hose. Ensure the service tool and fuel line connections are tight. 4. Bleed the fuel system by priming the priming pump until it becomes firm, then crank over the engine for a maximum of 5 seconds. Repeat as necessary until the engine starts. 5. Let the engine run at idle for at least 1 minute. 6. Monitor the fuel vacuum/pressure gauge while holding the engine speed higher than 2500 RPM for a minimum of 1 minute. Does the vacuum/pressure gauge ever indicate a larger vacuum than the specified amount during the test?	5 inHg	Go to Step 9	Go to Step 8
8	1. Fully clamp off a fuel hose as close to the fuel tank as possible (this will draw vacuum on the fuel system). You can also disconnect a fuel line and plug it. 2. Start the engine and turn the idle up control knob to the highest position. (Full clockwise direction. The idle speed is increased up to 1600 RPM.) 3. Monitor the fuel pressure/vacuum gauge. **Notice:** Release the clamp or open the plug when the gauge is likely to be more than 8 inHg during the test. Can a vacuum of at least the specified amount be pulled on the fuel system?	8 inHg	Go to Step 11	Go to Step 10

Step	Action	Value(s)	Yes	No
9	1. Inspect the fuel lines between the fuel supply pump and fuel tank for being crushed or kinked. 2. Inspect for a plugged fuel tank vent valve. 3. Inspect inside the fuel tank (if possible) for any foreign material that may be getting drawn into the fuel line pickup causing a blocked condition. 4. Repair as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 14
10	1. Turn OFF the ignition. 2. Check the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. 3. Repair as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 12
11	1. Turn OFF the ignition. 2. Unclamp or unplug the fuel line from the previous step and reconnect the fuel line (if disconnected). 3. Start the engine and allow it to run for at least 1 minute. 4. Perform the Cylinder Power Balance test with a scan tool. 5. Command each injector OFF and verify an engine speed change for each injector. Is there an injector that does not change engine speed when commanded OFF?	—	Go to Step 17	Go to Step 19
12	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure (FRP) regulator harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the FRP regulator (pins 1 and 2 of E-116). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP regulator circuit at the harness connector of the ECM (pins B-20, B-21, B-33 and B-34 of J-217 connector). 6. Test for high resistance on each FRP regulator circuit. 7. Repair the connection(s) or circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 18

Step	Action	Value(s)	Yes	No
13	1. Turn OFF the ignition. 2. Disconnect the FRP sensor harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the FRP sensor (pins 1, 2 and 3 of E-113 connector). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP sensor circuit at the harness connector of the ECM (pins B-13, B-25, B-26 and B-47 of J-217 connector). 6. Test for high resistance on each FRP circuit. 7. Repair the connection(s) or circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 15
14	Replace the fuel filter cartridge. Refer to Fuel Filter Cartridge Replacement in the Fuel System Section. Did you complete the replacement?	—	Go to Step 20	—
15	Replace the fuel rail pressure sensor. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 20	—
16	**Important:** Replacement injector must be programmed. Replace the appropriate injector that was leaking fuel found at Step 3. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 20	—
17	**Important:** Replacement injector must be programmed. Replace the appropriate fuel injector that does not change engine speed when commanded OFF. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 20	—

Step	Action	Value(s)	Yes	No
18	**Important:** The fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM. **Notice:** Always replace the fuel filter cartridge when a fuel supply pump is replaced. Replace the fuel supply pump and fuel filter cartridge. Refer to Fuel Supply Pump Replacement/Fuel Supply Pump Relearn Procedure in this section and Fuel Filter Cartridge Replacement in Fuel System section. Did you complete the replacement?	—	Go to Step 20	—
19	**Notice:** There is a possibility that the pressure limiter valve stuck open or opening pressure has fallen. Replace the pressure limiter valve. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 20	—
20	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 21
21	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0101

Circuit Description

The mass air flow (MAF) sensor is an air flow meter that measures the amount of air that enters the engine. It is fitted between the air cleaner and turbocharger. A small quantity of air that enters the engine indicates deceleration or idle. A large quantity of air that enters the engine indicates acceleration or a high load condition. The MAF sensor has the following circuits.

- Ignition voltage circuit
- Low reference circuit
- MAF sensor signal circuit

The engine control module (ECM) monitors the MAF sensor signal voltage. This output voltage will display on the scan tool as a voltage parameter and as a grams per second (g/s) parameter. The ECM will calculate a predicted MAF value. The ECM compares the actual MAF sensor voltage signal to the predicted MAF value. This comparison will determine if the signal is stuck, or is too low or too high for a given operating condition. If the ECM detects that the actual MAF sensor signal voltage is not within a predetermined range of the calculated MAF value, this DTC will set.

Condition for Running the DTC

- DTCs P0016, P0102, P0103, P0112, P0113, P0116, P0117, P0118, P0201, P0202, P0203, P0204, P0261, P0264, P0267, P0270, P0300, P0301, P0302, P0303, P0304, P0335, P0336, P0401, P0403, P0404, P0405, P0406, P0477, P0478, P0500, P0506, P0507, P0602, P0642, P0643, P1125, P1293, P2146, P2147, P2148 P2149, P2150, P2151, P2227, P2228 and P2229 are not set.

AND following conditions are met longer than 3 seconds.

- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.
- The engine is running.
- The barometric pressure (BARO) is between 10.9 - 17.4 psi (75 - 120 kPa).
- The intake air temperature (IAT) is between 19 - 248°F (-7 - 120°C).
- The engine coolant temperature (ECT) is between 149 - 198°F (65 - 92°C).
- The engine speed is lower than 3600 RPM.
- The engine speed does not vary more than 50 RPM.
- The fuel injection quantity does not vary more than 10 mm^3.
- The EGR control is commanded OFF.
- The exhaust brake control is commanded OFF.

Condition for Setting the DTC

- The ECM detects that the MAF sensor signal voltage is not within a predetermined range of the calculated MAF value for longer than 8 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- Any unmetered air that enters the engine downstream of the MAF sensor may cause this DTC to set.
- High resistance in the MAF sensor circuit may set this DTC.
- A short between the signal circuit of the MAF sensor and the signal circuit of the intake air temperature (IAT) sensor will skew the MAF sensor lower than normal at higher air flows.
- Normal MAF reading on the scan tool with the engine running in Park or Neutral at idle are around 25 g/s to 220 g/s or more in Park or Neutral at W.O.T. (accelerator pedal full travel).

If an intermittent condition is suspected, the following may cause an intermittent:

- The MAF sensor harness routed too closely to fuel injection wiring or components.
- The MAF sensor harness routed too closely to after-market add-on electrical equipment.
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "MAF Sensor" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Test Description

The number below refers to the step number on the diagnostic table.

3. A skewed barometric pressure (BARO) sensor value can set this DTC. The BARO on the scan tool should read near boost pressure with the key ON and engine OFF.

DTC P0101

Schematic Reference: Engine Controls Schematics

Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check -Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Turn OFF the ignition. 2. Inspect for the following conditions: • Restricted air cleaner element, restricted or collapsed air tubing between the air cleaner and the intake manifold. • Any contamination or debris on the sensing elements of the MAF sensor. • Any water intrusion in the induction system. • Any type of restriction in the exhaust system. • Intake throttle plate sticking at any position. Move intake throttle plate rod by hand to verify smooth operation. • Air leaking around any of the air induction tubing between the air cleaner and the intake manifold. • An exhaust gas recirculation (EGR) valve gasket that is missing or damaged. • An EGR valve that is stuck open or closed. 3. Repair the condition as necessary. Did you find and correction the condition?	—	Go to Step 10	Go to Step 3
3	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition, with the engine OFF. 4. Observe the Boost Pressure Sensor and Barometric Pressure (BARO) with a scan tool. Does the scan tool indicate that the difference between the Boost Pressure Sensor and BARO is more than the specified value?	1.1 psi (7.5 kPa)	Go to DTC P2227	Go to Step 4

Step	Action	Value(s)	Yes	No
4	1. Test the ignition voltage feed circuit between the engine control module (ECM) Main Relay (pin 1 of J-208 connector) and the MAF sensor (pin 1 of J-219 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 5
5	1. Test the signal circuit between the ECM (pin B-28 of J-217 connector) and the MAF sensor (pin 3 of J-219 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 6
6	1. Test the low reference circuit between the ECM (pin B-15 of J-217 connector) and the MAF sensor (pin 2 of J-219 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 7
7	1. Turn OFF the ignition. 2. Inspect for an intermittent, for a poor connection and corrosion at the harness connector of the MAF sensor (pins 1, 2 and 3 of J-219 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 8
8	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion on these MAF sensor circuits at the harness connector of the ECM (pins B-15 and B-28 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 9
9	Replace the MAF sensor. Refer to Mass Air Flow (MAF) Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 10	—

Step	Action	Value(s)	Yes	No
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0102

Circuit Description

The mass air flow (MAF) sensor is an air flow meter that measures the amount of air that enters the engine. It is fitted between the air cleaner and turbocharger. A small quantity of air that enters the engine indicates deceleration or idle. A large quantity of air that enters the engine indicates acceleration or a high load condition. The MAF sensor has the following circuits.

- Ignition voltage circuit
- Low reference circuit
- MAF sensor signal circuit

The engine control module (ECM) monitors the MAF sensor signal for voltage outside the normal range of the MAF sensor. If the ECM detects an excessively low MAF sensor signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0103, P0642 and P0643 are not set.
- The battery voltage is more than 10 volts.
- The ignition switch is ON.
- The engine speed is higher than 600 RPM.
- The engine run time is longer than 30 seconds.

Condition for Setting the DTC

- The ECM detects that the MAF sensor signal voltage is less than 0.08 volts for longer than 7 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "MAF Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0102

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the Mass Air Flow (MAF) Sensor parameter with a scan tool. Is the MAF Sensor parameter less than the specified value?	0.1 volts	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the MAF sensor harness connector. 3. Connect a test lamp between the ignition voltage feed circuit of the MAF sensor harness (pin 1 of J-219 connector) and a known good ground. 4. Turn ON the ignition, with engine OFF. Does the test lamp illuminate?	—	Go to Step 4	Go to Step 5
4	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the ignition voltage feed circuit and the signal circuit of the MAF sensor harness (pins 1 and 3 of J-219 connector). 3. Turn ON the ignition, with the engine OFF. 4. Observe the MAF Sensor parameter with a scan tool. Is the MAF Sensor parameter more than the specified value?	4.7 volts	Go to Step 7	Go to Step 6
5	1. Test the ignition voltage feed circuit between the engine control module (ECM) Main Relay (pin 1 of J-208 connector) and the MAF sensor (pin 1 of J-219 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Diagnostic Aids
6	1. Test the signal circuit between the ECM (pin B-28 of J-217 connector) and the MAF sensor (pin 3 of J-219 connector) for the following conditions: • An open circuit • A short to ground • A short to the low reference circuit • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 8
7	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the MAF sensor (pins 1 and 3 of J-219 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 9

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the MAF sensor circuit at the harness connector of the ECM (pin B-28 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
9	Replace the MAF sensor. Refer to Mass Air Flow Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—
10	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 11	—
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 12
12	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0103

Circuit Description

The mass air flow (MAF) sensor is an air flow meter that measures the amount of air that enters the engine. It is fitted between the air cleaner and turbocharger. A small quantity of air that enters the engine indicates deceleration or idle. A large quantity of air that enters the engine indicates acceleration or a high load condition. The MAF sensor has the following circuits.

- Ignition voltage circuit
- Low reference circuit
- MAF sensor signal circuit

The engine control module (ECM) monitors the MAF sensor signal for voltage outside the normal range of the MAF sensor. If the ECM detects an excessively high MAF sensor signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0102, P0642 and P0643 are not set.
- The battery voltage is more than 10 volts.
- The ignition switch is ON.
- The engine speed is higher than 600 RPM.
- Intake air temperature (IAT) is more than 19°F (-7°C) OR the IAT is less than 19°F (-7°C) when the engine speed is lower than 3600 RPM.
- The engine run time is longer than 30 seconds.

Condition for Setting the DTC

- The ECM detects that the MAF sensor signal voltage is more than 4.7 volts for longer than 6 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "MAF Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0103

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the Mass Air Flow (MAF) Sensor parameter with a scan tool. Is the MAF Sensor parameter more than the specified value?	4.7 volts	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the MAF sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the MAF Sensor parameter with a scan tool. Is the MAF Sensor parameter less than the specified value?	0.1 volts	Go to Step 4	Go to Step 5
4	1. Turn OFF the ignition. 2. Connect a test lamp between the low reference circuit of the MAF sensor harness (pin 2 of J-219 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 7	Go to Step 6
5	**Important:** The MAF sensor may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuit between the engine control module (ECM) (pin B-28 of J-217 connector) and the MAF sensor (pin 3 of J-219 connector) an open circuit or high resistance. • A short to battery or ignition voltage • A short to any 5 volts reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
6	1. Test the low reference circuit between the ECM (pin B-15 of J-217 connector) and the MAF sensor (pin 2 of J-219 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 8
7	1. Turn OFF the ignition. 2. Inspect for an intermittent and for a poor connection at the harness connector of the MAF sensor (pin 2 of J-219 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 9

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the MAF sensor circuit at the harness connector of the ECM (pin B-15 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
9	Replace the MAF sensor. Refer to Mass Air Flow Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—
10	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 11	—
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 12
12	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0112

Circuit Description

The intake air temperature (IAT) sensor is fitted between the air cleaner and turbocharger internal to the mass air flow (MAF) sensor. The IAT sensor is a variable resistor. The IAT sensor has a signal circuit and a low reference circuit. The IAT sensor measures the temperature of the air entering the engine. The engine control module (ECM) supplies 5 volts to the IAT signal circuit and a ground for the IAT low reference circuit. When the IAT sensor is cold, the sensor resistance is high. When the air temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the IAT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the IAT signal circuit. If the ECM detects an excessively low IAT signal voltage, indicating a high temperature, this DTC will set.

Condition for Running the DTC

- DTC P0113 is not set.
- The battery voltage is more than 7 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the IAT sensor signal voltage is less than 0.1 volts for longer than 3 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM uses an IAT substitution of 77°F (25°C) when the DTC is set.
- The ECM uses an IAT substitution of -20°F (-29°C) for engine starting.
- The ECM uses an IAT substitution of 77°F (25°C) for engine running.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- When the vehicle is at ambient temperature the IAT sensor and engine coolant temperature (ECT) sensor temperature should be relatively close to each other.
- Use the Temperature vs. Resistance table to test the IAT sensor at various temperature levels to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to Temperature vs. Resistance.

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "IAT Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

Notice:

The MAF sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature.

DTC P0112

Schematic Reference: Engine Controls Schematics

Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Intake Air Temperature (IAT) Sensor parameter with a scan tool. Is the IAT Sensor parameter more than the specified value?	212°F (100°C)	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the mass air flow/intake air temperature (MAF/IAT) sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the IAT Sensor parameter with a scan tool. Is the IAT Sensor parameter less than the specified value?	-31°F (-35°C)	Go to Step 5	Go to Step 4
4	1. Test the signal circuit between the engine control module (ECM) (pin B-37 of J-217 connector) and the IAT sensor (pin 4 of J-219 connector) for the following conditions: • A short to ground • A short to the low reference circuit 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 6
5	Replace the IAT sensor. Refer to Mass Air Flow Sensor Replacement in this section. (IAT sensor is internal to MAF sensor) Did you complete the replacement?	—	Go to Step 8	—
6	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect connections on the IAT sensor circuits at the harness connector of the ECM (pins B-14 and B-37 of J-217 connector) for corrosion. 4. Repair or clean the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 7
7	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 8	—

Step	Action	Value(s)	Yes	No
8	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 9
9	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0113

Circuit Description

The intake air temperature (IAT) sensor is fitted between the air cleaner and turbocharger internal to the mass air flow (MAF) sensor. The IAT sensor is a variable resistor. The IAT sensor has a signal circuit and a low reference circuit. The IAT sensor measures the temperature of the air entering the engine. The engine control module (ECM) supplies 5 volts to the IAT signal circuit and a ground for the IAT low reference circuit. When the IAT sensor is cold, the sensor resistance is high. When the air temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the IAT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the IAT signal circuit. If the ECM detects an excessively high IAT signal voltage, indicating a low temperature, this DTC will set.

Condition for Running the DTC

- DTC P0112 is not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine run time is longer than 10 seconds.

Condition for Setting the DTC

- The ECM detects that the IAT sensor signal voltage is more than 4.95 volts for longer than 3 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM uses an IAT substitution of 77°F (25°C) when the DTC is set.
- The ECM uses an IAT substitution of -20°F (-29°C) for engine starting.
- The ECM uses an IAT substitution of 77°F (25°C) for engine running.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- When the vehicle is at ambient temperature the IAT sensor and engine coolant temperature (ECT) sensor temperature should be relatively close to each other.
- Use the Temperature vs. Resistance table to test the IAT sensor at various temperature levels to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to Temperature vs. Resistance.

If an intermittent condition is suspected, the following may cause an intermittent:

- IAT sensor may have an intermittent open as it heats up.
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "IAT Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

Notice:

The MAF sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature.

Test Description

The number below refers to the step number on the diagnostic table.

5. This step tests for the proper operation of the circuit in the low voltage range. If the fuse in the jumper opens when you perform this test, the signal circuit is shorted to voltage.

DTC P0113

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Intake Air Temperature (IAT) Sensor parameter with a scan tool. Is the IAT Sensor parameter less than the specified value?	-31°F (-35°C)	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the mass air flow/intake air temperature (MAF/IAT) sensor harness connector. 3. Connect a DMM between the signal circuit of the Intake Air Temperature (IAT) sensor harness (pin 4 of J-219 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	5.5 volts	Go to Step 4	Go to Step 5
4	**Important:** The IAT sensor may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuit between the engine control module (ECM) (pin B-37 of J-217 connector) and the IAT sensor (pin 4 of J-219 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
5	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit and the low reference circuit of the IAT sensor harness (pins 4 and 5 of J-219 connector). 3. Turn ON the ignition, with the engine OFF. 4. Observe the IAT Sensor parameter with a scan tool. Is the IAT Sensor parameter more than the specified value?	212°F (100°C)	Go to Step 9	Go to Step 6

Step	Action	Value(s)	Yes	No
6	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit of the IAT sensor harness (pin 4 of J-219 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. 4. Observe the IAT Sensor parameter with a scan tool. Is the IAT Sensor parameter more than the specified value?	212°F (100°C)	Go to Step 8	Go to Step 7
7	1. Test the signal circuit between the ECM (pin B-37 of J-217 connector) and the IAT sensor (pin 4 of J-219 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
8	1. Test the low reference circuit between the ECM (pin B-14 of J-217 connector) and the IAT sensor (pin 5 of J-219 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
9	1. Test the signal circuit between the ECM (pin B-37 of J-217 connector) and the IAT sensor (pin 4 of J-219 connector) for a short to any 5 volts reference circuit. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 10
10	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the IAT sensor (pins 4 and 5 of J-219 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 12
11	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these IAT sensor circuits at the harness connector of the ECM (pins B-14 and B-37 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
12	Replace the IAT sensor. Refer to Mass Air Flow Sensor Replacement in this section. (IAT sensor is internal to MAF sensor) Did you complete the replacement?	—	Go to Step 14	—

Step	Action	Value(s)	Yes	No
13	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 14	—
14	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 15
15	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0116

Circuit Description

The engine coolant temperature (ECT) sensor is a variable resistor. The ECT sensor has a signal circuit and a low reference circuit. The ECT sensor measures the temperature of the engine coolant. The engine control module (ECM) supplies 5 volts to the ECT signal circuit and a ground for the ECT low reference circuit. When the ECT sensor is cold, the sensor resistance is high. When the engine coolant temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the ECT signal circuit. If the ECM detects that the difference of engine coolant temperature is smaller than the calculated range during the predetermined engine run time, this DTC will set. This DTC will only run once per ignition cycle within the enabling condition.

Condition for Running the DTC

- DTCs P0117, P0118, P0335, P0336, P0602, P0642, P0643 and P1125 are not set.
- The ignition switch is ON.
- The engine run time is longer than 10 minutes.
- The engine coolant temperature (ECT) is between 104 - 246°F (40 - 119°C).

Condition for Setting the DTC

- The ECM detects that the difference of maximum ECT and minimum ECT is less than 1.8°F (1°C) for longer than 5 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- Use the Temperature vs. Resistance table to test the ECT sensor at various temperature levels to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to Temperature vs. Resistance.

If an intermittent condition is suspected, the following may cause an intermittent:

- Damaged harness: inspect the wiring harness for damage. If the harness appears to be OK, observe the "ECT Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

Test Description

The number below refers to the step number on the diagnostic table.
3. This step tests for excessive resistance in the ECT sensor circuit.

DTC P0116

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check -Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	Inspect the cooling system coolant level. Is the cooling system coolant low?	—	Go to Cooling System Section	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Install a scan tool. 3. Disconnect the engine coolant temperature (ECT) sensor harness connector. 4. Connect a 3-amp fused jumper wire between the signal circuit and the low reference circuit of the ECT sensor harness (pins 1 and 2 of E-90 connector). 5. Turn ON the ignition, with the engine OFF. 6. Observe the ECT Sensor parameter with a scan tool. Is the ECT Sensor parameter more than the specified value?	230°F (110°C)	Go to Step 5	Go to Step 4
4	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit of the ECT sensor harness (pin 1 of E-90 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. 4. Observe the ECT Sensor parameter with a scan tool. Is the ECT Sensor parameter more than the specified value?	230°F (110°C)	Go to Step 7	Go to Step 6
5	1. Turn OFF the ignition. 2. Inspect for an intermittent, for a poor connection and corrosion at the harness connector of the ECT sensor (pins 1 and 2 of E-90 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 9
6	1. Test the signal circuit between the engine control module (ECM) (pin B-35 of J-217 connector) and the ECT sensor (pin 1 of E-90 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 8
7	1. Test the low reference circuit between the ECM (pin B-14 of J-217 connector) and the ECT sensor (pin 2 of E-90 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 8

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion on these ECT sensor circuits at the harness connector of the ECM (pins B-14 and B-35 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Diagnostic Aids
9	Replace the ECT sensor. Refer to Engine Coolant Temperature (ECT) Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 10	—
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0117

Circuit Description

The engine coolant temperature (ECT) sensor is a variable resistor. The ECT sensor has a signal circuit and a low reference circuit. The ECT sensor measures the temperature of the engine coolant. The engine control module (ECM) supplies 5 volts to the ECT signal circuit and a ground for the ECT low reference circuit. When the ECT sensor is cold, the sensor resistance is high. When the engine coolant temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the ECT signal circuit. If the ECM detects an excessively low ECT signal voltage, indicating a high temperature, this DTC will set.

Condition for Running the DTC

- DTC P0118 is not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the ECT sensor signal voltage is less than 0.09 volts for longer than 3.2 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM uses an ECT substitution of 77°F (25°C) when the DTC is set.
- The ECM uses an ECT substitution of -20°F (-29°C) for engine starting.
- The ECM uses an ECT substitution of 32°F (0°C) for engine running.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- Use the Temperature vs. Resistance table to test the ECT sensor at various temperature levels to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to Temperature vs. Resistance.

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "ECT Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0117

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Engine Coolant Temperature (ECT) Sensor parameter with a scan tool. Is the ECT Sensor parameter more than the specified value?	230°F (110°C)	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the ECT sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the ECT Sensor parameter with a scan tool. Is the ECT Sensor parameter less than the specified value?	-31°F (-35°C)	Go to Step 5	Go to Step 4
4	1. Test the signal circuit between the engine control module (ECM) (pin B-35 of J-217 connector) and the ECT sensor (pin 1 of E-90 connector) for the following conditions: • A short to ground • A short to the low reference circuit 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 6
5	Replace the ECT sensor. Refer to Engine Coolant Temperature Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 8	—
6	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect connections on the ECT sensor circuits at the harness connector of the ECM (pins B-14 and B-35 of J-217 connector) for corrosion. 4. Repair or clean the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 7
7	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 8	—
8	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 9

Step	Action	Value(s)	Yes	No
9	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0118

Circuit Description

The engine coolant temperature (ECT) sensor is a variable resistor. The ECT sensor has a signal circuit and a low reference circuit. The ECT sensor measures the temperature of the engine coolant. The engine control module (ECM) supplies 5 volts to the ECT signal circuit and a ground for the ECT low reference circuit. When the ECT sensor is cold, the sensor resistance is high. When the engine coolant temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the ECT signal circuit. If the ECM detects an excessively high ECT signal voltage, indicating a low temperature, this DTC will set.

Condition for Running the DTC

- DTC P0117 is not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the ECT sensor signal voltage is more than 4.95 volts for longer than 3.2 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM uses an ECT substitution of 77°F (25°C) when the DTC is set.
- The ECM uses an ECT substitution of -20°F (-29°C) for engine starting.
- The ECM uses an ECT substitution of 32°F (0°C) for engine running.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- Use the Temperature vs. Resistance table to test the ECT sensor at various temperature levels to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to Temperature vs. Resistance.

If an intermittent condition is suspected, the following may cause an intermittent:

- ECT sensor may have an intermittent open as it heats up.
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "ECT Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

Test Description

The number below refers to the step number on the diagnostic table.

5. This step tests for the proper operation of the circuit in the low voltage range. If the fuse in the jumper opens when you perform this test, the signal circuit is shorted to voltage.

DTC P0118

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Engine Coolant Temperature (ECT) Sensor parameter with a scan tool. Is the ECT Sensor parameter less than the specified value?	-31°F (-35°C)	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the ECT sensor harness connector. 3. Connect a DMM between the signal circuit of the ECT sensor harness (pin 1 of E-90 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	5.5 volts	Go to Step 4	Go to Step 5
4	**Important:** The ECT sensor may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuit between the engine control module (ECM) (pin B-35 of J-217 connector) and the ECT sensor (pin 1 of E-90 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
5	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit and the low reference circuit of the ECT sensor harness (pins 1 and 2 of E-90 connector). 3. Turn ON the ignition, with the engine OFF. 4. Observe the ECT Sensor parameter with a scan tool. Is the ECT Sensor parameter more than the specified value?	230°F (110°C)	Go to Step 9	Go to Step 6
6	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit of the ECT sensor harness (pin 1 of E-90 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. 4. Observe the ECT Sensor parameter with a scan tool. Is the ECT Sensor parameter more than the specified value?	230°F (110°C)	Go to Step 8	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Test the signal circuit between the ECM (pin B-35 of J-217 connector) and the ECT sensor (pin 1 of E-90 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
8	1. Test the low reference circuit between the ECM (pin B-14 of J-217 connector) and the ECT sensor (pin 2 of E-90 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
9	1. Test the signal circuit between the ECM (pin B-35 of J-217 connector) and the ECT sensor (pin 1 of E-90 connector) for a short to any 5 volts reference circuit. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 10
10	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the ECT sensor (pins 1 and 2 of E-90 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 12
11	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these ECT sensor circuits at the harness connector of the ECM (pins B-14 and B-35 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
12	Replace the ECT sensor. Refer to Engine Coolant Temperature Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 14	—
13	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 14	—

Step	Action	Value(s)	Yes	No
14	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 15
15	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0126

Circuit Description

The engine coolant temperature (ECT) sensor is a variable resistor. The ECT sensor has a signal circuit and a low reference circuit. The ECT sensor measures the temperature of the engine coolant. The engine control module (ECM) supplies 5 volts to the ECT signal circuit and a ground for the ECT low reference circuit. When the ECT sensor is cold, the sensor resistance is high. When the engine coolant temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the ECT signal circuit. If the coolant temperature does not increase normally, or does not reach the regulating temperature of the thermostat, the engine is considered not warm enough for stable low emission operation. Additionally other diagnostics that use engine coolant temperature as enabling criteria, may not run when expected. If the ECM detects that the calibrated amount of fuel has been burnt and the ECT has not reached the minimum calibrated temperature, this DTC will set. This DTC will only run once per ignition cycle within the enabling conditions.

Condition for Running the DTC

- DTCs P0016, P0112, P0113, P0116, P0117, P0118, P0201, P0202, P0203, P0204, P0261, P0264, P0267, P0270, P0234, P0299, P0300, P0301, P0302, P0303, P0304, P0335, P0336, P0500, P0602, P0642, P0643, P1293, P2146, P2147, P2148, P2149, P2150 and P2151 are not set.
- The ignition switch is ON.
- The intake air temperature (IAT) is more than 19°F (-7°C).
- The startup engine coolant temperature (ECT) is between -40 - 147°F (-40 - 64°C).
- The engine run time is longer than the calculated value by an continuous threshold depending on engine coolant temperature, intake air temperature and fuel injection quantity.
- The accumulation fuel injection quantity since engine start is less than a threshold.
- The idling time rate (idling time/engine run time) is smaller than 35%.

Condition for Setting the DTC

- The ECM detects that the maximum ECT is less than 149°F (65°C) for longer than 1 second.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- This DTC is designed to detect a faulty thermostat(s).
- Use the Temperature vs. Resistance table to test the ECT sensor at various temperature levels to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns.

If an intermittent condition is suspected, the following may cause an intermittent:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "ECT Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

Test Description

The number below refers to the step number on the diagnostic table.
3. This step tests for excessive resistance in the ECT sensor circuit.

DTC P0126

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check -Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	Inspect the cooling system coolant level. Is the cooling system coolant low?	—	Go to Cooling System Section	Go to Step 3
3	1. Turn OFF the ignition. 2. Install a scan tool. 3. Disconnect the engine coolant temperature (ECT) sensor harness connector. 4. Connect a 3-amp fused jumper wire between the signal circuit and the low reference circuit of the ECT sensor harness (pins 1 and 2 of E-90 connector). 5. Turn ON the ignition, with the engine OFF. 6. Observe the ECT Sensor parameter with a scan tool. Is the ECT Sensor parameter more than the specified value?	230°F (110°C)	Go to Step 5	Go to Step 4
4	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit of the ECT sensor harness (pin 1 of E-90 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. 4. Observe the ECT Sensor parameter with a scan tool. Is the ECT Sensor parameter more than the specified value?	230°F (110°C)	Go to Step 7	Go to Step 6
5	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the ECT sensor (pins 1 and 2 of E-90 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 9
6	1. Test the signal circuit between the engine control module (ECM) (pin B-35 of J-217 connector) and the ECT sensor (pin 1 of E-90 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 8
7	1. Test the low reference circuit between the ECM (pin B-14 of J-217 connector) and the ECT sensor (pin 2 of E-90 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 8

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion on these ECT sensor circuits at the harness connector of the ECM (pins B-14 and B-35 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Diagnostic Aids
9	1. Possible causes of low engine coolant temperature. • Abnormally low ambient temperature • Thermostat(s) stuck open • ECT sensor skewed low 2. Repair the condition as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Diagnostic Aids
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0128

Circuit Description

The engine coolant temperature (ECT) sensor is a variable resistor. The ECT sensor has a signal circuit and a low reference circuit. The ECT sensor measures the temperature of the engine coolant. The engine control module (ECM) supplies 5 volts to the ECT signal circuit and a ground for the ECT low reference circuit. When the ECT sensor is cold, the sensor resistance is high. When the engine coolant temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the ECT signal circuit. If the coolant temperature does not increase normally, or does not reach the regulating temperature of the thermostat, the engine is considered not warm enough for stable low emission operation. Additionally other diagnostics that use engine coolant temperature as enabling criteria, may not run when expected. If the ECM detects that the calibrated amount of fuel has been burnt and the ECT has not reached the minimum calibrated temperature, this DTC will set. This DTC will only run once per ignition cycle within the enabling conditions.

Condition for Running the DTC

- DTCs P0016, P0112, P0113, P0116, P0117, P0118, P0201, P0202, P0203, P0204, P0261, P0264, P0267, P0270, P0234, P0299, P0300, P0301, P0302, P0303, P0304, P0335, P0336, P0500, P0602, P0642, P0643, P1293, P2146, P2147, P2148, P2149, P2150 and P2151 are not set.
- The ignition switch is ON.
- The intake air temperature (IAT) is more than 19°F (-7°C).
- The startup engine coolant temperature (ECT) is between -40 - 14°F (-40 - 61°C).
- The engine run time is longer than the calculated value by an continuous threshold depending on engine coolant temperature, intake air temperature and fuel injection quantity.
- The accumulation fuel injection quantity since engine start is less than a threshold.
- The idling time rate (idling time/engine run time) is smaller than 35%.

Condition for Setting the DTC

- The ECM detects that the maximum ECT is less than 162°F (72°C) for longer than 1 second.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- This DTC is designed to detect a faulty thermostat(s).
- Use the Temperature vs. Resistance table to test the ECT sensor at various temperature levels to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns.

If an intermittent condition is suspected, the following may cause an intermittent:

- Damaged harness: inspect the wiring harness for damage. If the harness appears to be OK, observe the "ECT Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

Test Description

The number below refers to the step number on the diagnostic table.
3. This step tests for excessive resistance in the ECT sensor circuit.

DTC P0128

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check -Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	Inspect the cooling system coolant level. Is the cooling system coolant low?	—	Go to Cooling System Section	Go to Step 3
3	1. Turn OFF the ignition. 2. Install a scan tool. 3. Disconnect the engine coolant temperature (ECT) sensor harness connector. 4. Connect a 3-amp fused jumper wire between the signal circuit and the low reference circuit of the ECT sensor harness (pins 1 and 2 of E-90 connector). 5. Turn ON the ignition, with the engine OFF. 6. Observe the ECT Sensor parameter with a scan tool. Is the ECT Sensor parameter more than the specified value?	230°F (110°C)	Go to Step 5	Go to Step 4
4	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit of the ECT sensor harness (pin 1 of E-90 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. 4. Observe the ECT Sensor parameter with a scan tool. Is the ECT Sensor parameter more than the specified value?	230°F (110°C)	Go to Step 7	Go to Step 6
5	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the ECT sensor (pins 1 and 2 of E-90 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 9
6	1. Test the signal circuit between the engine control module (ECM) (pin B-35 of J-217 connector) and the ECT sensor (pin 1 of E-90 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 8
7	1. Test the low reference circuit between the ECM (pin B-14 of J-217 connector) and the ECT sensor (pin 2 of E-90 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 8

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion on these ECT sensor circuits at the harness connector of the ECM (pins B-14 and B-35 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Diagnostic Aids
9	1. Possible causes of low engine coolant temperature. • Abnormally low ambient temperature • Thermostat(s) stuck open • ECT sensor skewed low 2. Repair the condition as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Diagnostic Aids
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed??	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0181

Circuit Description

The fuel temperature (FT) sensor is a variable resistor. The FT sensor has a signal circuit and a low reference circuit. The FT sensor measures the fuel temperature of the fuel. The engine control module (ECM) supplies 5 volts to the FT signal circuit and a ground for the FT low reference circuit. When the FT sensor is cold, the sensor resistance is high. When the fuel temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the FT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the FT signal circuit. If the ECM detects a difference of fuel temperature smaller than the calculated range during the predetermined engine run time, this DTC will set.

Condition for Running the DTC

- DTCs P0016, P0116, P0117, P0118, P0182, P0183, P0201, P0202, P0203, P0204, P0261, P0264, P0267, P0270, P0234, P0299, P0300, P0301, P0302, P0303, P0304, P0335, P0336, P0500, P0602, P0642, P0643, P1293, P2146, P2147, P2148, P2149, P2150 and P2151 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.
- The engine is running.
- The engine coolant temperature (ECT) is more than 140°F (60°C).
- The engine run time is between 100 seconds and 840 seconds.
- The fuel burned since startup is more than 390000 mm^3.
- The vehicle speed is higher than 16 MPH (25 km/h).

Condition for Setting the DTC

- The ECM detects that the difference of maximum FT and minimum FT is less than 1.8°F (1°C).

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 50%.
- The ECM limits fuel rail pressure within 11600 psi (80MPa)
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Damaged harness: inspect the wiring harness for damage. If the harness appears to be OK, observe the "FT Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

Test Description

The number below refers to the step number on the diagnostic table.
2. This step tests for excessive resistance in the FT sensor circuit.

DTC P0181

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition. 3. Disconnect the fuel temperature (FT) sensor harness connector. 4. Connect a 3-amp fused jumper wire between the signal circuit and the low reference circuit of the ECT sensor harness (pins 1 and 2 of E-93 connector). 5. Turn ON the ignition, with the engine OFF. 6. Observe the FT Sensor parameter with a scan tool. Is the FT Sensor parameter more than the specified value?	212°F (100°C)	Go to Step 4	Go to Step 3
3	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit of the FT sensor harness (pin 2 of E-93 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. 4. Observe the FT Sensor parameter with a scan tool. Is the FT Sensor parameter more than the specified value?	212°F (100°C)	Go to Step 6	Go to Step 5
4	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the FT sensor (pins 1 and 2 of E-93 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 9	Go to Step 8
5	1. Test the signal circuit between the ECM (pin B-41 of J-217 connector) and the FT sensor (pin 2 of E-93 connector) for the high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 9	Go to Step 7
6	1. Test the low reference circuit between the ECM (pin B-14 of J-217 connector) and the ECT sensor (pin 1 of E-93 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 9	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion on these FT sensor circuits at the harness connector of the ECM (pins B-14 and B-41 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 9	Go to Diagnostic Aids
8	**Important:** The fuel supply pump must be timed to the engine. Replace the fuel supply pump. Refer to Fuel Supply Pump Replacement in this section. (FT sensor is part of the fuel supply pump assembly) Did you complete the replacement?	—	Go to Step 9	—
9	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 10
10	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0182

Circuit Description

The fuel temperature (FT) sensor is a variable resistor. The FT sensor has a signal circuit and a low reference circuit. The FT sensor measures the fuel temperature of the fuel. The engine control module (ECM) supplies 5 volts to the FT signal circuit and a ground for the FT low reference circuit. When the FT sensor is cold, the sensor resistance is high. When the fuel temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the FT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the FT signal circuit. If the ECM detects an excessively low FT signal voltage, indicating a high temperature, this DTC will set.

Condition for Running the DTC

- DTCs P0183, P0602 and P0603 are not set.
- The battery voltage is more than 10 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the FT sensor signal voltage is less than 0.1 volts for longer than 1 second.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM uses a FT substitution of 77°F (25°C) when the DTC is set.
- The ECM uses a FT substitution of -20°F (-29°C) for engine starting.
- The ECM uses a FT substitution of 219°F (104°C) for engine running.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- Before starting a cold engine, FT sensor and engine coolant temperature (ECT) sensor temperature should be relatively close to each other.

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Fuel Temperature Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0182

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Fuel Temperature (FT) Sensor parameter with a scan tool. Is the FT Sensor parameter more than the specified value?	212°F (100°C)	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the FT sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the FT Sensor parameter with a scan tool. Is the FT Sensor parameter less than the specified value?	-31°F (-35°C)	Go to Step 5	Go to Step 4
4	1. Test the signal circuit between the engine control module (ECM) (pin B-41 of J-217 connector) and the FT sensor (pin 2 of E-93 connector) for the following conditions: • A short to ground • A short to the low reference circuit 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 6
5	**Important:** The fuel supply pump must be timed to the engine. Replace the fuel supply pump. Refer to Fuel Supply Pump Replacement in this section. (FT sensor is part of the fuel supply pump assembly) Did you complete the replacement?	—	Go to Step 8	—
6	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect connections on the FT sensor circuit at the harness connector of the ECM (pins B-14 and B-41 of J-217 connector) for corrosion. 4. Repair or clean the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 7
7	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 8	—

Step	Action	Value(s)	Yes	No
8	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 9
9	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0183

Circuit Description

The fuel temperature (FT) sensor is a variable resistor. The FT sensor has a signal circuit and a low reference circuit. The FT sensor measures the fuel temperature of the fuel. The engine control module (ECM) supplies 5 volts to the FT signal circuit and a ground for the FT low reference circuit. When the FT sensor is cold, the sensor resistance is high. When the fuel temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the FT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the FT signal circuit. If the ECM detects an excessively high FT signal voltage, indicating a low temperature, this DTC will set.

Condition for Running the DTC

- DTCs P0182, P0602 and P0603 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the FT sensor signal voltage is more than 4.8 volts for longer than 1 second.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM uses a FT substitution of 77°F (25°C) when the DTC is set.
- The ECM uses a FT substitution of -20°F (-29°C) for engine starting.
- The ECM uses a FT substitution of 219°F (104°C) for engine running.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- Before starting a cold engine, FT sensor and engine coolant temperature (ECT) sensor temperature should be relatively close to each other.

If an intermittent condition is suspected, the following may cause an intermittent:

- FT sensor may have an intermittent open as it heats up.
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Fuel Temperature Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change the in the display will indicate the location of the fault.

Test Description

The number below refers to the step number on the diagnostic table.
5. This step tests for the proper operation of the circuit in the low voltage range. If the fuse in the jumper opens when you perform this test, the signal circuit is shorted to voltage.

DTC P0183

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Fuel Temperature (FT) Sensor parameter with a scan tool. Is the FT Sensor parameter less than the specified value?	-31°F (-35°C)	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the FT sensor connector. 3. Connect a DMM between the signal circuit of the FT sensor harness (pin 2 of E-93 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	5.5 volts	Go to Step 4	Go to Step 5
4	**Important:** The FT sensor may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuit between the engine control module (ECM) (pin B-41 of J-217 connector) and the FT sensor (pin 2 of E-93 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
5	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit and the low reference circuit at the FT sensor harness (pins 1 and 2 of E-93 connector). 3. Turn ON the ignition, with the engine OFF. 4. Observe the FT Sensor parameter with a scan tool. Is the FT Sensor parameter more than the specified value?	212°F (100°C)	Go to Step 9	Go to Step 6
6	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit of the FT sensor harness (pin 2 of E-93 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. 4. Observe the FT Sensor parameter with a scan tool. Is the FT Sensor parameter more than the specified value?	212°F (100°C)	Go to Step 8	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Test the signal circuit between the ECM (pin B-41 of J-217 connector) and the FT sensor (pin 2 of E-93 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
8	1. Test the low reference circuit between the ECM (pin B-14 of J-217 connector) and the FT sensor (pin 1 of E-93 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
9	1. Test the signal circuit between the ECM (pin B-41 of J-217 connector) and the FT sensor (pin 2 of E-93 connector) for a short to any 5 volts reference circuit. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 10
10	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the FT sensor (pins 1 and 2 of E-93 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 12
11	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these FT sensor circuits at the harness connector of the ECM (pins B-14 and B-41 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
12	**Important:** The fuel supply pump must be timed to the engine. Replace the fuel supply pump. Refer to Fuel Supply Pump Replacement in this section. (FT sensor is part of the fuel supply pump assembly) Did you complete the replacement?	—	Go to Step 14	—
13	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 14	—

Step	Action	Value(s)	Yes	No
14	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 15
15	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0192

Circuit Description

The fuel rail pressure sensor is installed to the fuel rail and it detects the fuel pressure in the fuel rail, converts the pressure into a voltage signal, and sends the signal to the engine control module (ECM). The fuel rail pressure sensor has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- Fuel rail pressure sensor signal circuit

The ECM supplies 5 volts to the fuel rail pressure sensor on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. Higher fuel rail pressure provides higher fuel pressure sensor voltage while lower pressure provides lower fuel pressure sensor voltage. The ECM calculates actual fuel rail pressure (fuel pressure) from the voltage signal and uses the result in fuel injection control and other control tasks. The ECM monitors the fuel rail pressure sensor signal for voltage outside the normal range. If the ECM detects an excessively low fuel rail pressure sensor signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0193, P0642 and P0643 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the fuel rail pressure sensor signal voltage is less than 0.7 volts.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM limits accelerator control range within 40%.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Actual Fuel Rail Pressure" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

Notice:
The Actual Fuel Rail Pressure on scan tool will only update with the engine running or one time after the key is cycled when the ignition has been turned OFF for longer than 10 seconds.

DTC P0192

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is P0642 also set?	—	Go to DTC P0642	Go to Step 3
3	1. Start the engine. 2. Observe the Actual Fuel Rail Pressure parameter with a scan tool. Is the Actual Fuel Rail Pressure parameter less than the specified value?	725 psi (5 MPa)	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the Actual Fuel Rail Pressure parameter with a scan tool. Is the Actual Fuel Rail Pressure sensor parameter more than the specified value?	25380 psi (175 MPa)	Go to Step 5	Go to Step 6
5	1. Turn OFF the ignition. 2. Connect a DMM between the 5 volts reference circuit of the fuel rail pressure sensor harness (pin 3 of E-113 connector) and a known good ground. 3. Turn ON the ignition, with engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 8	Go to Step 7
6	1. Test the signal circuits between the engine control module (ECM) (pins B-25 & B-26 of J-217 connector) and the fuel rail pressure sensor (pin 2 of E-113 connector) for the following conditions: • A short to ground • A short to the low reference circuit 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
7	1. Test the 5 volts reference circuit between the ECM (pin B-47 of J-217 connector) and the fuel rail pressure sensor (pin 3 of E-113 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Inspect for an intermittent and for a poor connection at the harness connector of the fuel pressure sensor (pin 3 of E-113 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the fuel rail pressure sensor circuit at the harness connector of the ECM (pin B-47 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	Replace the fuel rail pressure sensor. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 13
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0193

Circuit Description

The fuel rail pressure sensor is installed to the fuel rail and it detects the fuel pressure in the fuel rail, converts the pressure into a voltage signal, and sends the signal to the engine control module (ECM). The fuel rail pressure sensor has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- Fuel rail pressure sensor signal circuit

The ECM supplies 5 volts to the fuel rail pressure sensor on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. Higher fuel rail pressure provides higher fuel pressure sensor voltage while lower pressure provides lower fuel pressure sensor voltage. The ECM calculates actual fuel rail pressure (fuel pressure) from the voltage signal and uses the result in fuel injection control and other control tasks. The ECM monitors the fuel rail pressure sensor signal for voltage outside the normal range. If the ECM detects an excessively high fuel rail pressure sensor signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0192, P0642 and P0643 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the fuel rail pressure sensor signal voltage is more than 4.7 volts.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM limits accelerator control range within 40%.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Actual Fuel Rail Pressure" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

Notice:
The Actual Fuel Rail Pressure on scan tool will only update with the engine running or one time after the key is cycled when the ignition has been turned OFF for longer than 10 seconds.

DTC P0193

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0643 also set?	—	Go to DTC P0643	Go to Step 3
3	1. Start the engine. 2. Observe the Actual Fuel Rail Pressure parameter with a scan tool. Is the Actual Fuel Rail Pressure parameter more than the specified value?	25380 psi (175 MPa)	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure sensor harness connector. 3. Connect a DMM between the signal circuit of the fuel rail pressure sensor harness (pin 2 of E-113 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	5.5 volts	Go to Step 10	Go to Step 5
5	1. Turn OFF the ignition. 2. Connect a test lamp between the signal circuit of the fuel rail pressure sensor harness (pin 2 of E-113 connector) and a known good ground. 3. Connect a DMM between the probe of the test lamp and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 9	Go to Step 6
6	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit and the low reference circuit of the fuel rail pressure sensor harness (pins 2 and 1 of E-113 connector). 3. Turn ON the ignition, with the engine OFF. 4. Observe the Actual Fuel Rail Pressure parameter with a scan tool. Is the Actual Fuel Rail Pressure parameter less than the specified value?	725 psi (5 MPa)	Go to Step 11	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Test the low reference circuit between the engine control module (ECM) (pin B-13 of J-217 connector) and the fuel pressure sensor (pin 1 of E-113 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 8
8	1. Test the signal circuits between the ECM (pins B-25 & B-26 of J-217 connector) and the fuel pressure sensor (pin 2 of E-113 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 12
9	1. Test the signal circuits between the ECM (pins B-25 & B-26 of J-217 connector) and the fuel pressure sensor (pin 2 of E-113 connector) for a short to any 5 volts reference circuit. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
10	**Important:** The fuel pressure sensor may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuits between the ECM (pins B-25 & B-26 of J-217 connector) and the fuel pressure sensor (pin 2 of E-113 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
11	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the fuel pressure sensor (pins 1 and 2 of E-113 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 13
12	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these fuel rail pressure sensor circuits at the harness connector of the ECM (pins B-25, B-26 and B-13 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14

Step	Action	Value(s)	Yes	No
13	Replace the fuel rail pressure sensor. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 15	—
14	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 15	—
15	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 16
16	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0201 – P0204

Circuit Description

The engine control module (ECM) calculates the optimum fuel injection on time using data sent from various engine sensors. The ECM supplies a high voltage of near 120 volts along with grounding the injector control circuit when it needs to energize the fuel injector (turn it ON). The ECM also supplies 12 volts at all times to the injector control circuit in order to verify circuit integrity. If the injector solenoid control circuit is open, DTC P0201-P0204 will set depending upon which cylinder injector circuit failed.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the fuel injector solenoid coil control circuit is open during 16 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM limits fuel rail pressure within 17400 psi (120 MPa).
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P0201 - P0204" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Notice:

Each Diagnostic Trouble Code (DTC) agrees with engine cylinder order.
P0201: Cylinder No. 1 fuel injector
P0202: Cylinder No. 2 fuel injector
P0203: Cylinder No. 3 fuel injector
P0204: Cylinder No. 4 fuel injector

DTC P0201 – P0204

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the in-line connector (H-125) from the cylinder head cover case. 3. Measure the resistance through the intermediate connector (H-125 male side connector) between the injector drive circuit and the appropriate injector solenoid control circuit. • P0201: Between pins 5 and 1 of H-125 male side intermediate connector • P0202: Between pins 6 and 2 of H-125 male side intermediate connector • P0203: Between pins 7 and 3 of H-125 male side intermediate connector • P0204: Between pins 8 and 4 of H-125 male side intermediate connector Does the resistance measure less than the specified value?	2.0 Ω	Go to Step 4	Go to Step 5
4	1. Test the appropriate injector solenoid control circuits between the engine control module (ECM) and the in-line connector (H-125) for an open circuit or high resistance. • P0201: Between pins B-58 of J-217 connector and 5 of H-125 in-line connector • P0202: Between pins B-43 of J-217 connector and 6 of H-125 in-line connector • P0203: Between pins B-45 of J-217 connector and 7 of H-125 in-line connector • P0204: Between pins B-56 of J-217 connector and 8 of H-125 in-line connector 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 8
5	1. Remove the cylinder head cover. Refer to Fuel Injector Replacement in this section. 2. Visually inspect the injector harness for loose injector terminal nuts. Did you find and correct the condition?	—	Go to Step 12	Go to Step 6

Step	Action	Value(s)	Yes	No
6	1. Inspect for an intermittent and for poor connections at the intermediate connector. • P0201: Pins 5 of H-125 and H-126 connector • P0202: Pins 6 of H-125 and H-126 connector • P0203: Pins 7 of H-125 and H-126 connector • P0204: Pins 8 of H-125 and H-126 connector 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 7
7	1. Test the appropriate injector solenoid control circuit on the injector harness between the injector terminal and intermediate connector for an open circuit or high resistance. • P0201: Between pins 3 of E-138 terminal and 5 of H-126 connector • P0202: Between pins 3 of E-139 terminal and 6 of H-126 connector • P0203: Between pins 3 of E-140 terminal and 7 of H-126 connector • P0204: Between pins 3 of E-141 terminal and 8 of H-126 connector Did you find an open circuit or high resistance?	—	Go to Step 9	Go to Step 10
8	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the injector solenoid control circuit at the harness connector of the ECM. • P0201: Pin B-58 of J-217 connector • P0202: Pin B-43 of J-217 connector • P0203: Pin B-45 of J-217 connector • P0204: Pin B-56 of J-217 connector 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
9	Replace the injector harness. Refer to Fuel Injector Replacement in this section. Did you complete the replacement?	—	Go to Step 12	—
10	**Important:** Replacement injector must be programmed. Replace the appropriate injector. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 12	—

Step	Action	Value(s)	Yes	No
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 13
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0219

Circuit Description

The crankshaft position (CKP) sensor is located on top of the flywheel housing. The engine control module (ECM) calculates the engine speed and exact position of the crankshaft based on the signal from the CKP sensor. If the ECM detects an engine overrun condition, this DTC will set.

Condition for Running the DTC

- DTCs P0642 and P0643 are not set.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the engine speed is higher than 3900 RPM.

Action Taken When the DTC Sets

- The ECM will not illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Condition for Clearing the DTC

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

Diagnostic Aids

- This DTC is caused by an engine overspeed condition, which was most likely caused by driver error (i.e. downshifting a manual transmission on a steep grade). Since this DTC does not illuminate any lamps, clear the DTC and ensure there are no signs of engine damage. Excessive engine overspeed may damage internal engine components.
- Make sure the CKP sensor is tight and the sensor wheel teeth are not damaged.

DTC P0219

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 4	Go to Step 3
3	Ask the driver if overrun is caused by gear slip-out, shift error, down-slope driving, etc. If engine overrun has experienced, the engine must be inspected and repaired as necessary. Did you complete the action?	—	Go to Step 17	—
4	1. Remove the crankshaft position (CKP) sensor. Refer to CKP Sensor replacement in this section. 2. Visually inspect the CKP sensor for the following conditions: • For physical damage • For being loose • For improper installation Did you find and correct the condition?	—	Go to Step 17	Go to Step 5

Step	Action	Value(s)	Yes	No
5	Visually inspect for damage, metal particles on magnet and for flywheel teeth damage. Did you find and correct the condition?	—	Go to Step 17	Go to Step 6
6	1. Turn OFF the ignition. 2. Disconnect the CKP sensor harness connector. 3. Connect a DMM across the CKP sensor terminals. 4. Measure the resistance across the CKP sensor. Does the CKP sensor resistance measure within the specified range?	108-145 Ω	Go to Step 7	Go to Step 15
7	1. Connect a DMM across the CKP sensor terminals (measure sensor output voltage.) 2. Place the DMM on the AC volt scale. 3. Start the engine. 4. Monitor the DMM while accelerating the engine between idle and W.O.T. (accelerator pedal full travel). Does the DMM indicate an AC voltage increase in accordance with an engine speed increase?	—	Go to Step 8	Go to Step 15
8	1. Turn ON the ignition, with the engine OFF. 2. Connect a DMM between the CKP sensor harness (pin 1 of E-98 connector) and a known good ground. 3. Connect a DMM between the CKP sensor harness (pin 2 of E-98 connector) and a known good ground. Is each DMM voltage within the specified value?	0.4-1.4 volts	Go to Step 10	Go to Step 9
9	Is the DMM voltage more than the specified value at Step 8?	—	Go to Step 12	Go to Step 11
10	1. Test the CKP sensor between the engine control module (ECM) (pins B-31 and B-32 of J-217 connector) and CKP sensor (pins 1 and 2 of E-98 connector) for a short to each other. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 13

Step	Action	Value(s)	Yes	No
11	1. Test the CKP sensor circuits between the ECM (pins B-31 and B-32 of J-217 connector) and CKP sensor (pins 1 and 2 of E-98 connector) for the following: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 14
12	1. Test the CKP sensor circuits between the ECM (pins B-31 and B-32 of J-217 connector) and CKP sensor (pins 1 and 2 of E-98 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
13	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the CKP sensor (pins 1 and 2 of E-98 connector). 3. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
14	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these CKP sensor circuits at the harness connector of the ECM (pins B-19, B-31 and B-32 of the J-217 connector). 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
15	Replace the CKP sensor. Refer to Crankshaft Position Sensor (CKP) Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 17	—
16	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 17	—

Step	Action	Value(s)	Yes	No
17	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Observe the Engine Speed with a scan tool. 6. Accelerate the engine between idle and W.O.T. (accelerator pedal full travel) many times while observing the scan tool. Does the Engine Speed parameter ever exceed the specified value?	3700 RPM	Go to Step 4	Go to Step 18
18	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0234

Circuit Description

The boost pressure sensor is located in the air induction tubing. The sensor is a transducer that varies voltage according to changes in the air pressure inside the air tubing. The engine control module (ECM) monitors the boost pressure sensor signal for abnormal values. If the ECM detects that the boost pressure sensor signal is excessively high, this DTC will set.

Condition for Running the DTC

- DTCs P0112, P0113, P0116, P0117, P0118, P0237, P0238, P0401, P0403, P0404, P0405, P0406, P0602, P0606, P0642, P0643, P1125, P1404, P2227, P2228 and P2229 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects excessive high boost pressure for longer than 3 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- High resistance in the boost pressure low reference return circuit may set this DTC.
- Check the waste gate for a sticking or stuck condition. Refer to Waste Gate Operation in the Engine Mechanical section.
- Use the scan tool to verify the integrity of the boost pressure sensor signal. Compare the sensor values under all load conditions for an excessively high value. Use the scan tool data list values for nominal sensor readings.
- The fuel with which gasoline was mixed may set this DTC.

Test Description

The numbers below refer to the step number on the diagnostic table.

2. A skewed boost pressure sensor value (shifted to a higher pressure) can set this DTC. The Boost Pressure on the scan tool should read near barometric pressure with the key ON and engine OFF.

3. A skewed barometric pressure (BARO) sensor value (shifted to a lower pressure) can set this DTC. The BARO on the scan tool should read near surrounding barometric pressure.

DTC P0234

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Boost Pressure Sensor and Barometric Pressure (BARO) with a scan tool. Does the scan tool indicate that the difference between the Boost Pressure Sensor and BARO is more than the specified value?	1.1 psi (7.5 kPa)	Go to Step 3	Go to Step 4

Step	Action	Value(s)	Yes	No
3	1. Observe the BARO parameter with a scan tool. 2. Compare the BARO value to the range specified in the altitude vs. barometric pressure table. Refer to Altitude vs Barometric Pressure. Is the BARO parameter within the range specified?	—	Go to Step 5	Go to Step 9
4	1. Inspect the following for possible causes of high boost pressure. • Waste gate for a stuck closed condition. Refer to the Turbocharger in Engine Mechanical section for diagnosis. • Restricted intake or collapsed hose between the intake throttle and the boost pressure sensor. • Intake throttle plate sticking in the closed position. Move intake throttle plate rod by hand to verify smooth operation. • Oil in the air induction tubing causing an incorrect boost pressure sensor signal. When there is adhesion of oil inside of the tubing, intercooler or turbocharger it needs to be wiped off. 2. Repair the condition as necessary. Did you find and correction the condition?	—	Go to Step 10	Go to Diagnostic Aids
5	1. Turn OFF the ignition. 2. Disconnect the boost pressure sensor harness connector. 3. Inspect for an intermittent and for a poor connection at the boost pressure sensor harness connector (pin 1 of J-216 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 6
6	1. Turn ON the ignition, with the engine OFF. 2. Connect a test lamp between battery voltage and the boost pressure sensor low reference circuit (pin 1 of J-216 connector). Does the test lamp illuminate?	—	Go to Step 8	Go to Step 7
7	Repair the high resistance in low reference circuit between the engine control module (ECM) (pin B-12 of J-217 connector) and boost pressure sensor (pin 1 of J-216 connector). Did you complete the repair?	—	Go to Step 10	—

Step	Action	Value(s)	Yes	No
8	Replace the boost pressure sensor. Refer to Boost Pressure Sensor Replacement in this section. Did you complete the repair?	—	Go to Step 10	—
9	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 10	—
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle with in the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0237

Circuit Description

The boost pressure sensor is located in the air induction tubing. The boost pressure sensor is a transducer that varies voltage according to changes in the air pressure inside the air tubing. The boost pressure sensor has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- Boost pressure sensor signal circuit

The engine control module (ECM) supplies 5 volts to the boost pressure sensor on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. The boost pressure sensor provides a signal to the ECM on the boost pressure signal circuit which is relative to the pressure changes in the manifold. The ECM should detect a low signal voltage at a low boost pressure, such as low engine load. The ECM should detect high signal voltage at a high boost pressure, such as high engine load. The ECM monitors the boost pressure sensor signal for voltage outside the normal range of the boost pressure sensor. If the ECM detects an excessively low boost pressure sensor signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0238, P0642 and P0643 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the boost pressure sensor signal voltage is less than 0.1 volts.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM uses a boost pressure substitution of 14.7 psi (101.3 kPa) when the DTC is set.
- The ECM uses a boost pressure substitution of 27.6 psi (190 kPa) for engine starting and running.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Boost Pressure Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0237

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0642 also set?	—	Go to DTC P0642	Go to Step 3
3	1. Start the engine. 2. Observe the Boost Pressure Sensor parameter with a scan tool. Is the Boost Pressure Sensor parameter less than the specified value?	7 psi (49 kPa)	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Disconnect the boost pressure sensor harness connector. 3. Connect a DMM between the 5 volts reference circuit of the boost pressure sensor harness (pin 3 of J-216 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 5	Go to Step 6
5	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the 5 volts reference circuit and the signal circuit of the boost pressure sensor harness (pins 3 and 2 of J-216 connector) . 3. Turn ON the ignition, with the engine OFF. 4. Observe the Boost Pressure Sensor parameter with a scan tool. Is the Boost Pressure Sensor parameter more than the specified value?	36 psi (254 kPa)	Go to Step 8	Go to Step 7
6	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin B-46 of J-217 connector) harness and the boost pressure sensor (pin 3 of J-216 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9

Step	Action	Value(s)	Yes	No
7	1. Test the signal circuit between the ECM (pin B-24 of J-217 connector) and the boost pressure sensor (pin 2 of J-216 connector) for the following conditions: • An open circuit • A short to ground • A short to the low reference circuit • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9
8	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the boost pressure sensor (pins 2 and 3 of J-216 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these boost pressure sensor circuits at the harness connector of the ECM (pins B-24 and B-46 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	Replace the boost pressure sensor. Refer to Boost Pressure Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 13

Step	Action	Value(s)	Yes	No
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0238

Circuit Description

The boost pressure sensor is located in the air induction tubing. The boost pressure sensor is a transducer that varies voltage according to changes in the air pressure inside the air tubing. The boost pressure sensor has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- Boost pressure sensor signal circuit

The engine control module (ECM) supplies 5 volts to the boost pressure sensor on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. The boost pressure sensor provides a signal to the ECM on the boost pressure signal circuit which is relative to the pressure changes in the manifold. The ECM should detect a low signal voltage at a low boost pressure, such as low engine load. The ECM should detect high signal voltage at a high boost pressure, such as high engine load. The ECM monitors the boost pressure sensor signal for voltage outside the normal range of the boost pressure sensor. If the ECM detects an excessively high boost pressure sensor signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0237, P0642 and P0643 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the boost pressure sensor signal voltage is more than 4.8 volts.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM uses a boost pressure substitution of 14.7 psi (101.3 kPa) when the DTC is set.
- The ECM uses a boost pressure substitution of 27.6 psi (190 kPa) for engine starting and running.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Boost Pressure Sensor" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0238

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the Boost Pressure Sensor parameter with a scan tool. Is the Boost Pressure Sensor parameter more than the specified value?	36 psi (254 kPa)	Go to Step 3	Go to Diagnostic Aids
3	1. Start the engine. 2. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0643 also set?	—	Go to Step 4	Go to Step 5
4	1. Turn OFF the ignition. 2. Disconnect the boost pressure sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the Boost Pressure Sensor parameter with a scan tool. Is the Boost Pressure Sensor parameter less than the specified value?	7 psi (49 kPa)	Go to DTC P0643	Go to Step 7
5	1. Turn OFF the ignition. 2. Disconnect the boost pressure sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the Boost Pressure Sensor parameter with a scan tool. Is the Boost Pressure Sensor parameter less than the specified value?	7 psi (49 kPa)	Go to Step 6	Go to Step 7
6	1. Turn OFF the ignition. 2. Connect a test lamp between the low reference circuit of the boost pressure sensor harness (pin 1 of J-216 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 8
7	**Important:** The boost pressure sensor may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuit between the engine control module (ECM) (pin B-24 of J-217 connector) and the boost pressure sensor (pin 2 of J-216 connector) for the following conditions: • A short to battery or ignition voltage • A short to any 5 volts reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12

Step	Action	Value(s)	Yes	No
8	1. Test the low reference circuit between the ECM (pin B-12 of J-217 connector) and the boost pressure sensor (pin 1 of J-216 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 10
9	1. Turn OFF the ignition. 2. Inspect for an intermittent and for a poor connection at the harness connector of the boost pressure sensor (pin 1 of J-216 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 11
10	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the boost pressure sensor circuit at the harness connector of the ECM (pin B-12 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12
11	Replace the boost pressure sensor. Refer to Boost Pressure Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 13	—
12	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 13	—
13	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 14
14	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0261, P0264, P0267 & P0270

Circuit Description

The engine control module (ECM) calculates the optimum fuel injection on timing using data sent from various engine sensors. The common 1 injector drive circuit is a high-voltage (near 120 volts) which drives injectors for cylinder 1 and 4 in conjunction with the ECM grounding the fuel injector solenoid control circuit. The common 2 injector drive circuit which drives injectors for cylinder 2 and 3 in conjunction with the ECM grounding the fuel injector solenoid control circuit. The ECM also supplies 12 volts at all times to the injector control circuit in order to verify circuit integrity. If the fuel injector solenoid control circuit is shorted to injector drive circuit, DTC P0261, P0264, P0267 or P0270 will set depending upon which cylinder fuel injector circuit failed.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the fuel injector solenoid coil control circuit is shorted to fuel injector drive circuit during 16 engine rotations.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM limits fuel rail pressure within 17400 psi (120 MPa).
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Except 12,000 lbs GVW

- The ECM will not illuminate the MIL when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Except 12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P0261, P0264, P0267 or P0270" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Notice:
Each Diagnostic Trouble Code (DTC) agrees with following engine cylinder.
P0261: Cylinder No. 1 fuel injector
P0264: Cylinder No. 2 fuel injector
P0267: Cylinder No. 3 fuel injector
P0270: Cylinder No. 4 fuel injector

DTC P0261, P0264, P0267 & P0270

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the inline connector (H-125) from the cylinder head cover case. 3. Test the appropriate fuel injector solenoid control circuit and drive circuit for a short to each other between the engine control module (ECM) and the in-line connector (H-125). • P0261: Between pins B-58 of J-217 connector and 5 of H-125 connector for a short to common 1 circuit • P0264: Between pins B-43 of J-217 connector and 6 of H-125 connector for a short to common 2 circuit • P0267: Between pins B-45 of J-217 connector and 7 of H-125 connector for a short to common 2 circuit • P0270: Between pins B-56 of J-217 connector and 8 of H-125 connector for a short to common 1 circuit 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 4
4	1. Turn OFF the ignition. 2. Remove the cylinder head cover. Refer to Fuel Injector Replacement in this section. 3. Visually inspect the injector harness for objects touching the appropriate fuel injector terminals. • P0261: Cylinder No. 1 • P0264: Cylinder No. 2 • P0267: Cylinder No. 3 • P0270: Cylinder No. 4 Did you find and correct the condition?	—	Go to Step 10	Go to Step 5

Step	Action	Value(s)	Yes	No
5	1. Loose the injector terminal nuts and disconnect from the appropriate fuel injector. 2. Measure continuity through the intermediate harness connector (H-125 male side connector) between the injector drive circuits and the appropriate fuel injector solenoid control circuit. • P0261: Between pins 5 and 1 or 4 of H-125 male side intermediate connector • P0264: Between pins 6 and 2 or 3 of H-125 male side intermediate connector • P0261: Between pins 7 and 2 or 3 of H-125 male side intermediate connector • P0261: Between pins 8 and 1 or 4 of H-125 male side intermediate connector Does continuity exist for any measurement?	—	Go to Step 7	Go to Step 6
6	Measure fuel injector coil resistance on the appropriate cylinder. Does the resistance measure less than the specified value?	0.5 Ω	Go to Step 8	Go to Step 9
7	Replace the injector harness. Refer to Fuel Injector Replacement in this section. Did you complete the replacement?	—	Go to Step 10	—
8	**Important:** Replacement injector must be programmed. Replace the appropriate injector. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 10	—
9	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 10	—

Step	Action	Value(s)	Yes	No
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0299

Circuit Description

The boost pressure sensor is located in the air induction tubing. The sensor is a transducer that varies voltage according to changes in the air pressure inside the air tubing. The engine control module (ECM) monitors the boost pressure sensor signal for abnormal values. If the ECM detects that the boost pressure sensor signal is excessively low, this DTC will set.

Condition for Running the DTC

- DTCs P0016, P0089, P0091, P0092, P0101, P0102, P0103, P0112, P0113, P0116, P0117, P0118, P0201, P0202, P0203, P0204, P0237, P0238, P0261, P0264, P0267, P0270, P0335, P0336, P0401, P0403, P0404, P0405, P0406, P0478, P0602, P0642, P0643, P1125, P1293, P1404, P2146, P2147, P2148 P2149, P2150, P2151, P2227, P2228 and P2229 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The accumulation fuel injection quantity is more than 100 mm^3.
- The actual mass air flow is higher than desired by 600 mg/cyl.

AND following conditions are met longer than 3 seconds.

- The engine speed is between 2000-3600 RPM.
- The engine speed does not vary more than 100 RPM.
- The fuel injection quantity is less than 300 mm^3.
- The fuel injection quantity does not vary more than 10 mm^3.
- The intake air temperature is higher than 50°F (10°C).
- The coolant temperature is higher than 149°F (65°C).

Condition for Setting the DTC

- The ECM detects excessive low boost pressure for longer than 5 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits accelerator control range within 40%.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits cruise control.
- The ECM inhibits PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- Induction air leakage can cause a low boost pressure condition. A whistling noise may be heard if a component is allowing air to enter the induction system. Close the throttle plate, remove the boost pressure sensor and introduce shop air into the line. Feel around the air tubing for leaks.
- Check for cracked air tubing that may only open during certain engine movement conditions.
- Check the waste gate for a sticking or stuck open condition. Refer to Waste Gate Operation in the Engine Mechanical section.
- Use the scan tool to verify the integrity of the boost pressure sensor signal. Compare the sensor values under all load conditions for an excessively low value. Use the scan tool data list values for nominal sensor readings.

Test Description

The numbers below refer to the step number on the diagnostic table.
3. A skewed boost pressure sensor value (shifted to a low pressure) can set this DTC. The Boost Pressure on the scan tool should read near barometric pressure with the key ON and engine OFF.
4. A skewed barometric pressure (BARO) sensor value (shifted to a higher pressure) can set this DTC. The BARO on the scan tool should read near surrounding barometric pressure.

DTC P0299

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Inspect the following for possible causes of low boost pressure. • Air leakage around the boost pressure sensor or debris in the sensor hole. • Air leaking around any of the air induction tubing between the turbocharger and intake manifold. Check for damaged components and for loose clamps. • Turbine shaft binding causing lower turbocharger shaft spinning speeds. Refer to the Turbocharger in Engine Mechanical section for diagnosis. • Turbocharger waste gate for a stuck open condition. Refer to the Turbocharger in Engine Mechanical section for diagnosis. • Restricted air cleaner element, restricted or collapsed air tubing between the air cleaner and the boost pressure sensor. • Oil in the air induction tubing causing an incorrect boost pressure sensor signal. When there is adhesion of oil inside of the tubing, intercooler or turbocharger it needs to be wiped off. 2. Repair the condition as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 3
3	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Boost Pressure Sensor and Barometric Pressure (BARO) with a scan tool. Does the scan tool indicate that the difference between the Boost Pressure Sensor and BARO is more than the specified value?	1.1 psi (7.5 kPa)	Go to Step 4	Go to Diagnostic Aids
4	1. Observe the BARO parameter with a scan tool. 2. Compare the BARO value to the range specified in the altitude vs. barometric pressure table. Refer to Altitude vs Barometric Pressure. Is the BARO parameter within the range specified?	—	Go to Step 5	Go to Step 7

Step	Action	Value(s)	Yes	No
5	1. Turn OFF the ignition. 2. Disconnect the boost pressure sensor harness connector. 3. Inspect for a intermittent and for poor connections at the boost pressure sensor harness connector (pins 2 and 3 of J-216 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 6
6	Replace the boost pressure sensor. Refer to Boost Pressure Sensor Replacement in this section. Did you complete the repair?	—	Go to Step 8	—
7	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 8	
8	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 9
9	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0300

Circuit Description

The engine control module (ECM) monitors changes in crankshaft speed using inputs from the crankshaft position (CKP) sensor. The ECM adjusts the fuel delivery amount to each cylinder in order to minimize crankshaft speed changes. If the ECM identifies a cylinder or cylinders requiring an excessive amount of fuel in order to maintain the correct crankshaft speed, it is considered a misfire and DTC P0301 - P0304 will set depending upon which cylinder failed. If it occurred in more than one cylinder, this DTC will set.

Condition for Running the DTC

- DTCs P0016, P0089, P0091, P0092, P0093, P0112, P0113, P0116, P0117, P0118, P0192, P0193, P0201, P0202, P0203, P0204, P0261, P0264, P0267, P0270, P0335, P0336, P0500, P0506, P0507, P0602, P0642, P0643, P1093, P1125, P1293, P2146, P2147, P2148, P2149, P2150, P2151, P2227, P2228 and P2229 are not set.
- The battery voltage is between 10 - 16 volts.

Condition for Setting the DTC

- The ECM detects that the misfire has occurred in more than one cylinder for longer than 70 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- An engine mechanical or fuel injector problem will cause this DTC to set.
- Use a scan tool to observe the "Balancing Rate" for each cylinder at idle. A cylinder that is excessively large or small balancing rate may indicate incorrect fuel injector flow rate, faulty fuel injectors, and weak or slightly seized cylinder.
- DTC P0300 should always be set with a P0301-P0304.
- If multiple cylinder are misfiring, problem in the fuel system, low fuel level or contaminated fuel may exist.

DTC P0300

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition, with the engine OFF. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is only one specified cylinder misfire DTC set?	—	Go to DTC P0301 – P0304	Go to Diagnostic Aids

DTC P0301 - P0304

Circuit Description

The engine control module (ECM) monitors changes in crankshaft speed using inputs from the crankshaft position (CKP) sensor. The ECM adjusts the fuel delivery amount to each cylinder in order to minimize crankshaft speed changes. If the ECM identifies a cylinder or cylinders requiring an excessive amount of fuel in order to maintain the correct crankshaft speed, it is considered misfire and DTC P0301 - P0304 will set depending upon which cylinder failed.

Condition for Running the DTC

- DTCs P0016, P0089, P0091, P0092, P0093, P0112, P0113, P0116, P0117, P0118, P0192, P0193, P0201, P0202, P0203, P0204, P0261, P0264, P0267, P0270, P0335, P0336, P0500, P0506, P0507, P0602, P0642, P0643, P1093, P1125, P1293, P2146, P2147, P2148, P2149, P2150, P2151, P2227, P2228 and P2229 are not set.
- The battery voltage is between 10 - 16 volts.
- The engine coolant temperature (ECT) is more than 19°F (-7°C).
- The engine speed is between 500 - 1050 RPM.
- The desired engine idle speed does not vary more than 100 RPM.
- The desired fuel injection quantity is between -30 - 300 mm^3.
- The vehicle speed is less than 2 MPH (3 km/h).

Condition for Setting the DTC

- The ECM detects that the fuel injection balancing rate is more than 30 mm^3 for longer than 70 seconds.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM closes the EGR valve and holds to close position.

Except 12,000 lbs GVW

- The ECM will not illuminate the MIL when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Except 12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

Diagnostic Aids

- An engine mechanical or fuel injector problem will cause this DTC(s) to set.
- Use a scan tool to observe the "Balancing Rate" for each cylinder at idle. A cylinder that is excessively large or small balancing rate may indicate incorrect fuel injector flow rate, faulty fuel injector(s), and weak or slightly seized cylinder.

Notice:

Each Diagnostic Trouble Code (DTC) agrees with the engine cylinder order.

P0301: Cylinder No. 1
P0302: Cylinder No. 2
P0303: Cylinder No. 3
P0304: Cylinder No. 4

DTC P0301 - P0304

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Are any DTCs other than P0300 or P0301-P0304 set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3
3	1. Start the engine. 2. Observe the Balancing Rate for each cylinder at idle for 2 minutes with the engine at normal operating temperature. Is the Balancing Rate greater than $30mm^3$ for any one specific cylinder (note that if 2 or more cylinders are greater than $30mm^3$ go to DTC P0300)?	—	Go to Step 4	Go to Diagnostic Aids
4	Can any abnormal engine mechanical noise be heard?	—	Go to Engine Mechanical Section	Go to Step 5
5	1. Inspect the programmed fuel injector flow rate for the cylinder that has a high balancing rate. Refer to Fuel Injector Replacement in this section. 2. If the programmed fuel injector flow rate is not correct on the affected injector, reprogram the fuel injector flow rate. Did you find and correct the condition?	—	Go to Step 11	Go to Step 6
6	1. Turn ON the ignition, with the engine OFF. 2. Perform the Fuel Injector Flow Test with a scan tool. 3. Command ON and verify clicking noise (solenoid operating noise) on the affected injector(s). Are there injector(s) that do not click (solenoid operating noise), exhibit interrupted noise or possess abnormal noise when commanded ON?	—	Go to Step 8	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Remove the affected cylinder glow plug(s) from the cylinder head. 2. Inspect the engine compression on appropriate cylinder. **Notice:** Use the engine compression gauge J-26999-12 and adapter EN-46722. If poor engine compression (less than 284 psi [1960 kPa]) or variation of each cylinder (more than 43 psi [294 kPa]) is found, inspect the engine mechanical. 3. Repair the engine mechanical as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 9
8	**Important:** Replacement injector must be programmed. Replace the appropriate fuel injector that exhibits the problem. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 11	—
9	**Important:** Replacement injector must be programmed. Replace the appropriate injector. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
10	**Notice:** There is a possibility that the flow damper valve stuck closed. Replace the fuel rail. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 12
12	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0335

Circuit Description

The crankshaft position (CKP) sensor is located on top of the flywheel housing. There are 56 notches spaced 6° apart and a 24° section that is uncut. This uncut portion allows for the detection of cylinder #1 top dead center (TDC). The CKP sensor is a magnetic coil type sensor, which generates an AC signal voltage based on the crankshaft rotational speed. The engine control module (ECM) monitors both the CKP sensor and camshaft position (CMP) sensor signals to ensure they correlate with each other. If the ECM receives a certain amount of CMP sensor signal pulses without a CKP sensor signal, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The CMP sensor signal pulse is detected.

Condition for Setting the DTC

- The ECM detects that the CKP sensor pulses are not generated during 10 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- A ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- Ensure the sensor is tight and the flywheel teeth are not damaged.

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Crank Signal Present" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0335

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine (Note a slight start delay may be noticed). 4. Observe the Crank Signal Present parameter with a scan tool. Does the scan tool indicate Yes when the engine is running?	—	Go to Diagnostic Aids	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the crankshaft position sensor (CKP) harness connector. 3. Connect a DMM across the CKP sensor terminals. 4. Measure the resistance across the CKP sensor. Does the CKP sensor resistance measure within the specified range?	108-145 Ω	Go to Step 4	Go to Step 13
4	1. Connect a DMM across the CKP sensor terminals (measure sensor output voltage). 2. Place the DMM on the AC volt scale. 3. Start the engine. 4. Monitor the DMM while accelerating the engine between idle and W.O.T. (accelerator pedal full travel). Does the DMM indicate an AC voltage increase in accordance with an engine speed increase?	—	Go to Step 5	Go to Step 10
5	1. Turn ON the ignition, with the engine OFF. 2. Connect a DMM between the CKP sensor harness (pin 1 of E-98 connector) and a known good ground. 3. Connect a DMM between the CKP sensor harness (pin 2 of E-98 connector) and a known good ground. Is each DMM voltage within the specified value?	0.4-1.4 volts	Go to Step 7	Go to Step 6
6	Is the DMM voltage more than the specified value at Step 5?	—	Go to Step 9	Go to Step 8
7	1. Test the CKP sensor circuits between the ECM (pins B-31 and B-32 of J-217 connector) and CKP sensor (pins 1 and 2 of E-98 connector) for a short to each other. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 11
8	1. Test the CKP sensor circuits between the engine control module (ECM) (pins B-31 and B-32 of J-217 connector) and CKP sensor (pins 1 and 2 of E-98 connector) for the following conditions: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 12

Step	Action	Value(s)	Yes	No
9	1. Test the CKP sensor circuits between the ECM (pins B-31 and B-32 of J-217 connector) and CKP sensor (pins 1 and 2 of E-98 connector) for the following conditions: • A short to battery or ignition voltage • A short to any 5 volts reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
10	1. Inspect the CKP sensor for tightness. Retest if the sensor was loose. 2. Remove the CKP sensor and check for damage, metal particles on magnet and for flywheel teeth damage. Did you find and correct the condition?	—	Go to Step 15	Go to Step 13
11	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the CKP sensor (pins 1 and 2 of E-98 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
12	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these CKP sensor circuits at the harness connector of the ECM (pins B-19, B-31 and B-32 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
13	Replace the CKP sensor. Refer to Crankshaft Position (CKP) Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 15	—
14	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 15	—

Step	Action	Value(s)	Yes	No
15	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 16
16	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0336

Circuit Description

The crankshaft position (CKP) sensor is located on top of the flywheel housing. There are 56 notches spaced 6° apart and a 24° section that is uncut. This uncut portion allows for the detection of cylinder #1 top dead center (TDC). The CKP sensor is a magnetic coil type sensor, which generates an AC signal voltage based on the crankshaft rotational speed. The engine control module (ECM) monitors both the CKP sensor and camshaft position (CMP) sensor signals to ensure they correlate with each other. If the ECM receives extra or missing CKP sensor signal pulses, this DTC will set.

Condition for Running the DTC

- DTCs P0335 or P0340 are not set.
- The battery voltage is between 10-16 volts.
- The engine speed is higher than 350 RPM.
- The CKP sensor signal is detected.

Condition for Setting the DTC

- The ECM detects extra or missing CKP sensor pulses during 50 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs an fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- An intermittent CKP sensor signal may set this DTC.
- Ensure the sensor is tight and the flywheel teeth are not damaged.

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Crank Signal Present" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0336

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Inspect all of the circuits going to the crankshaft position (CKP) sensor for the following: • Routed too closely to fuel injection wiring or components • Routed too closely to after-market add-on electrical equipment • Routed too closely to solenoids, relays, and motors 2. If you find incorrect routing, correct the harness routing. Did you find and correct the condition?	—	Go to Step 8	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the CKP sensor harness connector. 3. Inspect for an intermittent and for poor connections at the harness connector of the CKP sensor (pins 1 and 2 of E-98 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 4
4	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) harness connector. 3. Inspect for an intermittent and for a poor connection on these CKP sensor circuits at the harness connector of the ECM (pins B-19, B-31 and B-32 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 5
5	1. Remove the CKP sensor. Refer to Crankshaft Position (CKP) Sensor Replacement in this section. 2. Visually inspect the CKP sensor for the following conditions: • Physical damage • Loose or improper installation 3. The following conditions may cause this DTC to set: • Excessive air gap between the CKP sensor and the sensor rotor • Electromagnetic interference in the CKP sensor circuits • Foreign material passing between the CKP sensor and the sensor rotor Did you find and correct the condition?	—	Go to Step 8	Go to Step 6

Step	Action	Value(s)	Yes	No
6	Inspect the CKP sensor rotor for the following conditions: • Physical damage • Improper installation Refer to Flywheel Replacement in Engine Mechanical section. Did you find and correct the condition?	—	Go to Step 8	Go to Step 7
7	Replace the CKP sensor. Refer to Crankshaft Position (CKP) Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 8	—
8	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTC with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 9
9	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0340

Circuit Description

The camshaft position (CMP) sensor is installed on the cylinder head at the rear of the camshaft gear. The CMP sensor has the following circuits.

- 12 volts feed circuit
- CMP sensor signal circuit
- CMP sensor shield circuit

The engine control module (ECM) supplies 12 volts to the CMP sensor on the 12 volts feed circuit. The CMP sensor provides a signal to the ECM on the CMP signal circuit. The CMP sensor detects a total of five through holes (four holes arranged equally every 90° and one reference hole on the camshaft gear flange surface) and sends signals to the engine control module (ECM). Receiving these signals, the ECM determines cylinder #1 compression top dead center (TDC). If the ECM detects that CMP sensor signals are not generated, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The crankshaft position (CKP) sensor signal pulse is detected.

Condition for Setting the DTC

- The ECM detects that the CMP sensor pulses are not generated during 10 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Cam Signal Present" display on the scan tool with the engine running while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0340

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine (Note a slight start delay may be not noticed). 4. Observe the Cam Signal Present parameter with a scan tool. Does the scan tool indicate Yes when the engine is running?	—	Go to Diagnostic Aids	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the camshaft position (CMP) sensor harness connector. 3. Connect a DMM between the 12 volts feed circuit (pin 3 of E-112 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	10 volts	Go to Step 4	Go to Step 7
4	1. Turn OFF the ignition. 2. Connect a DMM between the signal circuit (pin 2 of E-112 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the DMM voltage indicate more than the specified value?	10 volts	Go to Step 5	Go to Step 8
5	1. Turn OFF the ignition. 2. Connect a test lamp between the signal circuit (pin 2 of E-112 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 6
6	1. Turn OFF the ignition. 2. Connect a test lamp between the shield circuit (pin 1 of E-112 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 11	Go to Step 10
7	1. Test the CMP sensor 12 volts feed circuit between the engine control module (ECM) (pin B-51 of J-217 connector) and the CMP sensor (pin 3 of E-112 connector) for the following conditions: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 12

Step	Action	Value(s)	Yes	No
8	1. Test the CMP sensor signal circuit between the ECM (pin B-30 of J-217 connector) and the CMP sensor (pin 2 of E-112 connector) for the following conditions: • An open circuit • A short to battery or ignition voltage • A short to any 5 volts reference • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 12
9	1. Test the CMP sensor signal circuit between the ECM (pin B-30 of J-217 connector) and the CMP sensor (pin 2 of E-112 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
10	1. Test the CMP sensor shield circuit between the ECM (pin B-18 of J-217 connector) and the CMP sensor (pin 1 of E-112 connector) for the following conditions: • An open circuit • A short to battery or ignition voltage • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 12
11	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the CMP sensor (pins 1, 2 and 3 of E-112 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 13
12	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these CMP sensor circuits at the harness connector of the ECM (pins B-18, B-30 and B-51 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16

Step	Action	Value(s)	Yes	No
13	1. Remove the CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement in this section. 2. Visually inspect the CMP sensor for the following conditions: • For physical damage • For being loose • For improper installation Did you find and correct the condition?	—	Go to Step 17	Go to Step 14
14	Visually inspect the camshaft gear surface for damage. Did you find and correct the condition?	—	Go to Step 17	Go to Step 15
15	Replace the CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 17	—
16	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 17	—
17	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 18
18	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0341

Circuit Description

The camshaft position (CMP) sensor is installed on the cylinder head at the rear of the camshaft gear. The CMP sensor has the following circuits.

- 12 volts feed circuit
- CMP sensor signal circuit
- CMP sensor shield circuit

The engine control module (ECM) supplies 12 volts to the CMP sensor on the 12 volts feed circuit. The CMP sensor provides a signal to the ECM on the CMP signal circuit. The CMP sensor detects a total of five through holes (four holes arranged equally every 90° and one reference hole on the camshaft gear flange surface) and sends signals to the engine control module (ECM). Receiving these signals, the ECM determines cylinder #1 compression top dead center (TDC). If the ECM receives extra or missing CMP sensor signal pulses, this DTC will set.

Condition for Running the DTC

- DTC P0340 is not set.
- The battery voltage is between 10-16 volts.
- The engine speed is higher than 350 RPM.
- The CMP sensor signal is detected.

Condition for Setting the DTC

- The ECM detects extra or missing CMP sensor pulses during 100 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- An intermittent CMP sensor signal may set this DTC.
- Ensure the sensor is tight and the camshaft gear surface is not damaged.

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Cam Signal Present" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0341

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Inspect all of the circuits going to the camshaft position (CMP) sensor for the following: • Routed too closely to fuel injection wiring or components • Routed too closely to after-market add-on electrical equipment • Routed too closely to solenoids, relays, and motors 2. If you find incorrect routing, correct the harness routing. Did you find and correct the condition?	—	Go to Step 8	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the CMP sensor harness connector. 3. Inspect for an intermittent and for poor connections at the harness connector of the CMP sensor (pins 1, 2 and 3 of E-112 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 4
4	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) harness connector. 3. Inspect for an intermittent and for a poor connection on these CMP sensor circuit at the harness connector of the ECM (pins B-18, B-30 and B-51 of J-217 connector). Did you find and correct the condition?	—	Go to Step 8	Go to Step 5
5	1. Remove the CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement in this section. 2. Visually inspect the CMP sensor for the following conditions: • Physical damage • Loose or improper installation 3. The following conditions may cause this DTC to set: • Excessive air gap between the CMP sensor and the camshaft gear surface (sensor rotor) • Electromagnetic interference in the CMP sensor circuits • Foreign material passing between the CMP sensor and the camshaft gear surface (sensor rotor) Did you find and correct the condition?	—	Go to Step 8	Go to Step 6

Step	Action	Value(s)	Yes	No
6	Inspect the camshaft gear surface (CMP sensor rotor) for physical damage. Did you find and correct the condition?	—	Go to Step 8	Go to Step 7
7	Replace the CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 8	—
8	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 9
9	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0381

Circuit Description

The glow indicator lamp is located on the instrument panel cluster (IPC). The glow control system is operated when the engine coolant temperature is low, which allows easier engine starting. If the ignition switch is turned ON when the engine coolant temperature is low, the engine control module (ECM) illuminates the glow indicator lamp and turns ON the glow plugs via glow plug controller. After a fixed time passes, the ECM turns OFF the glow indicator lamp and the glow plugs via glow plug controller.

The ECM monitors the glow indicator lamp control circuit for conditions that are incorrect for the commanded state of the glow indicator lamp. For example, a failure condition exists if the ECM detects low voltage when the glow indicator lamp is commanded OFF, or high voltage when the glow indicator lamp is commanded ON. If the ECM detects an improper voltage on the glow indicator control circuit, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- Low voltage condition on the glow indicator lamp control circuit when the indicator is commanded OFF for longer than 1 second.

OR

- High voltage condition on the glow indicator lamp control circuit when the indicator is commanded ON for longer than 1 second.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P0381" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0381

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Verify whether the instrument cluster is operational. If the instrument panel cluster (IPC) is completely inoperative, refer to Diagnostic System Check. 2. Install a scan tool. 3. Command the Glow Indicator ON and OFF with a scan tool. Does the glow indicator lamp turn ON and OFF when commanded with a scan tool?	—	Go to Step 15	Go to Step 3
3	1. Turn OFF the ignition. 2. Inspect the Gauges (10A) fuse behind the glove box. Is the Gauges (10A) fuse open?	—	Go to Step 4	Go to Step 5
4	Replace the Gauges (10A) fuse. If the fuse continues to open, repair the short to ground on one of the circuits that is fed by the Gauges (10A) fuse or replace the shorted attached component fed by the Gauges (10A) fuse. Did you complete the repair?	—	Go to Step 18	—
5	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) A harness connector. 3. Turn ON the ignition, with the engine OFF. Is the glow indicator lamp OFF?	—	Go to Step 6	Go to Step 12
6	1. Remove the Gauges (10A) fuse that supplies voltage to the glow indicator lamp. 2. Turn ON the ignition, with the engine OFF. 3. Measure the voltage from the glow indicator control circuit in the ECM harness connector (pin A-79 of J-218 connector) to a good ground. Is the voltage less than the specified value?	1 volt	Go to Step 7	Go to Step 13
7	1. Turn OFF the ignition. 2. Install the Gauges (10A) fuse that supplies ignition voltage to the glow indicator lamp. 3. Turn ON the ignition, with the engine OFF. 4. Connect a 3-amp fused jumper wire between the glow indicator control circuit of the ECM harness connector (pin A-79 of J-218 connector) and a good ground. Is the glow indicator lamp illuminated?	—	Go to Step 11	Go to Step 8

Step	Action	Value(s)	Yes	No
8	1. Turn ON the ignition, with the engine OFF. 2. Remove the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Accessories Body and Cab Section. 3. Probe the glow indicator ignition voltage circuit of the IPC harness connector (pin 18 of B-51 connector) with a test lamp that is connected to a known good ground. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 14
9	1. Test the glow indicator control circuit between the ECM (pin A-79 of J-218 connector) and the IPC (pin 15 of B-52 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 10
10	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the IPC (pin 18 of B-51 and 15 of B-52 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 16
11	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the glow indicator control circuit at the harness connector of the ECM (pin A-79 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 17
12	Repair the short to ground on the control circuit of the glow indicator lamp between the ECM (pin A-79 of J-218 connector) and the IPC (pin 15 of B-52 connector). Did you complete the repair?	—	Go to Step 18	—
13	Repair the short to battery or ignition voltage on the control circuit of the glow indicator lamp between the ECM (pin A-79 of J-218 connector) and the IPC (pin 15 of B-52 connector). Did you complete the repair?	—	Go to Step 18	—
14	Repair the open or high resistance on the ignition voltage circuit of the glow indicator lamp between the Gauges (10A) fuse and the IPC (pin 18 of B-51 connector). Did you complete the repair?	—	Go to Step 18	—

Step	Action	Value(s)	Yes	No
15	1. Turn OFF the ignition for 30 seconds. 2. Turn ON the ignition, with the engine OFF. 3. Monitor DTC P0381 with a scan tool. Does DTC P0381 Last Test indicate Failed?	—	Go to Step 17	Go to Diagnostic Aids
16	Repair or replace the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Accessories Body and Cab Section. Did you complete the repair or replacement?	—	Go to Step 18	—
17	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 18	—
18	1. Reconnect all previously disconnected fuse and harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 19
19	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0382

Circuit Description

The engine control module (ECM) controls the glow relay which supplies power to the glow plugs based on engine coolant temperature. In the after glow phase, the glow indicator light is not illuminated but glow plugs remain active for a certain period. If the ECM detects an open circuit or short circuit on the glow relay control circuit, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects a low voltage condition on the glow relay control circuit for longer than 10 seconds when the glow relay is commanded OFF.

OR

- The ECM detects a high voltage condition on the glow relay control circuit for longer than 10 seconds when the glow relay is commanded ON.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty relay
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P0382" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the relay. A change in the display will indicate the location of the fault.

Test Description

The numbers below refers to the step number on the diagnostic table.

2. Listen for an audible click when the glow relay operates. Command both the ON and OFF states.
3. Tests for voltage at the coil side of the glow relay. The Gauges 10 A fuse supplies power to the coil side of the glow relay.
4. Verifies that the engine control module (ECM) is providing ground to the glow relay.
5. Tests if ground is constantly being applied to the glow relay.

DTC P0382

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Command the Glow Relay ON and OFF with a scan tool . Does the glow relay click when commanded ON and OFF with a scan tool?	—	Go to Step 3	Go to Step 4

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition for 30 seconds. 2. Turn ON the ignition, with the engine OFF. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 11	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Replace the glow relay with the starter relay or replace with a known good relay. 3. Turn ON the ignition, with the engine OFF. 4. Command the Glow Relay ON and OFF with a scan tool. Does the glow relay click when commanded ON and OFF with a scan tool?	—	Go to Step 8	Go to Step 5
5	1. Turn OFF the ignition. 2. Remove the glow relay. 3. Turn ON the ignition, with the engine OFF. 4. Probe the voltage feed circuit of the glow relay coil side (pin 4 of J-13 connector) with a test lamp that is connected to a known good ground. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 7
6	1. Test the control circuit of glow relay between the engine control module (ECM) (pin A-74 of J-218 connector) and the glow relay (pin 5 of J-13 connector) for the following conditions: • An open circuit • A short to ground • A short to battery or ignition voltage 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9
7	Repair the open in the voltage feed circuit of the glow relay coil side (pin 4 of J-13 connector). Check the Gauges (10 A) fuse first. Did you complete the repair?	—	Go to Step 12	—
8	1. Turn OFF the ignition. 2. Remove the glow relay. 3. Inspect for an intermittent and for a poor connection on each glow plug relay terminal. 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10

Step	Action	Value(s)	Yes	No
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the glow relay circuit at the harness connector of the ECM (pin A-74 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	Replace the glow relay. Did you complete the replacement?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected fuse, relay or harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 13
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0401

Circuit Description

The engine control module (ECM) controls the EGR valve opening based on the atmospheric pressure, engine speed, engine coolant temperature, intake air temperature and fuel injection quantity. The ECM controls the EGR valve by controlling the EGR DC motor. The EGR valve position is detected by the EGR position sensor, and relayed to ECM. When the proper enabling conditions are met, the ECM will open the EGR valve while monitoring the mass air flow (MAF) signal. An expected MAF difference should be detected between the closed and open positions. If the ECM detects the MAF difference less than expected, this DTC will set.

This DTC will only run once per ignition cycle within the enabling conditions.

Condition for Running the DTC

- DTCs P0101, P0102, P0103, P0112, P0113, P0116, P0117, P0118, P0201, P0202, P0203, P0204, P0261, P0264, P0267, P0270, P0300, P0301, P0302, P0303, P0304, P0335, P0336, P0403, P0405, P0406, P0478, P0500, P0506, P0507, P0602, P0642, P0643, P1125 P1293, P2146, P2147, P2148, P2149, P2150, P2151, P2227, P2228 and P2229 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.
- The engine speed is between 700 - 800 RPM.
- The fuel injection quantity is between 5 - 40mm^3.
- The engine coolant temperature (ECT) is between 149 - 178°F (65 - 92°C).
- The intake air temperature (IAT) is between 19 - 246°F (-7 – 119°C)
- The barometric pressure (BARO) is more than 10.9 psi (75 kPa).
- The accelerator pedal is not pressed.
- The vehicle is stationary.

Condition for Setting the DTC

- The ECM detects that the MAF amount is not within the calculated range for longer than 9 seconds during the EGR flow test. This indicates insufficient amount of EGR flow.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- A sticking or intermittently sticking the EGR valve may set this DTC.
- A restricted EGR passage between the exhaust manifold and the EGR valve may set this DTC.

DTC P0401

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine and let idle until engine coolant temperature (ECT) reads 149°F (65°C) or higher. 4. Command the EGR Solenoid to 100% while observing the mass air flow (MAF) sensor parameter with a scan tool. Does the MAF sensor voltage decrease by at least 0.2 volts when commanding the EGR solenoid from 0 to 100%?	—	Go to Diagnostic Aids	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Inspect for the following conditions: • An exhaust gas recirculation (EGR) valve gasket that is missing or damaged. • EGR gas leakage from any of the EGR passages between the exhaust manifold and intake manifold. • Restricted or collapsed EGR passages between the exhaust manifold and EGR valve. • An EGR valve that is stuck open or closed. • Any type of restriction in the exhaust system. • Any air induction leak between MAF sensor and EGR valve. • Contaminated or slow MAF sensor. 3. Repair the condition as necessary. Did you find and correction the condition?	—	Go to Step 5	Go to Step 4
4	Replace the EGR valve. Refer to EGR Valve Replacement in this section. Did you complete the replacement?	—	Go to Step 5	—
5	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 6
6	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0403

Circuit Description

The engine control module (ECM) controls the EGR valve opening based on the atmospheric pressure, engine speed, engine coolant temperature, intake air temperature and fuel injection quantity. The ECM controls the EGR valve by controlling the EGR DC motor. The EGR valve position is detected by the EGR position sensor, and relayed to ECM via the EGR position sensor. If the ECM detects an electrical malfunction on the EGR motor circuits, this DTC will set.

Condition for Running the DTC

- DTCs P0642 and P0643 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON for 2 seconds.
- The engine is running.
- The engine coolant temperature (ECT) is more than 149°F (65°C).
- The EGR valve commanded duty cycle is between 5-95%.

Condition for Setting the DTC

- The ECM detects that the EGR valve control pulse width modulation (PWM) signal is not inputted.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Except 12,000 lbs GVW

- The ECM will not illuminate the MIL when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Except 12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty EGR valve
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "EGR Current Position" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0403

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition, the engine OFF. 4. Command the EGR Solenoid to 100% while observing the EGR Position Sensor parameter with a scan tool. Does the EGR Position Sensor parameter change in accordance with the EGR solenoid command?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the EGR valve harness connector. 3. Connect a test lamp between the 12 volts feed circuit of the EGR valve motor harness (pin 4 of E-94 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 4	Go to Step 5
4	1. Turn OFF the ignition for 30 seconds. 2. Connect a test lamp between the duty signal control circuit of the EGR valve motor harness (pin 6 of E-94 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF while monitoring the test lamp. Does the test lamp turn ON, blink, then go OFF as the ignition is turned OFF then turned ON?	—	Go to Step 7	Go to Step 6
5	1. Test the EGR valve motor 12 volts feed circuit between the engine control module (ECM) (pin B-7 of J-217 connector) and the EGR valve (pin 4 of E-94 connector) for the following conditions: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 8
6	1. Test the EGR valve motor duty signal control circuit between the ECM (pin B-8 of J-217 connector) and the EGR valve (pin 6 of E-94 connector) for the following condition: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 8

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the EGR valve motor (pins 4 and 6 of E-94 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 9
8	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) harness connector. 3. Inspect for an intermittent and for a poor connection on these EGR valve motor circuits at the harness connector of the ECM (pins B-7 and B-8 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
9	Replace the EGR valve. Refer to EGR Valve Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—
10	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 11	—
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 12
12	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0404

Circuit Description

The engine control module (ECM) controls the EGR valve opening based on the atmospheric pressure, engine speed, engine coolant temperature, intake air temperature and fuel injection quantity. The ECM controls the EGR valve by controlling the EGR DC motor. The EGR valve position is detected by the EGR position sensor, and relayed to ECM.

If the ECM detects an excessively high EGR valve control duty cycle, this DTC will set. (Control Duty Signal Error DTC)

If the ECM detects a variance between the actual EGR position and desired EGR position for a calibrated amount of time while the EGR valve is commanded open, this DTC will also set. (Open Position Error DTC)

Condition for Running the DTC

Control Duty Signal Error DTC

- DTCs P0401, P0403, P0404, P0405, P0406, P0642, P0643 and P1404 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON for 2 seconds.

Open Position Error DTC (12,000 lbs GVW)

- DTCs P0112, P0113, P0116, P0117, P0118, P0403, P0405, P0406, P0642, P0643, P2227, P2228 and P2229 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON for 5 seconds.
- The engine coolant temperature (ECT) is between 149 - 178°F (65 - 92°C).
- The intake air temperature (IAT) is between 19 - 302°F (-7 - 150°C).
- The barometric pressure (BARO) is between 10.9 - 17.4 psi (75 - 120 kPa).
- The desired EGR valve position does not vary more than 5%.

Condition for Setting the DTC

Control Duty Signal Error DTC

- The ECM detects that the EGR valve control duty signal is more than 70% for longer than 8 seconds.

Open Position Error DTC (12,000 lbs GVW)

- The ECM detects that the actual EGR valve position is 10% lower than the desired EGR valve position for longer than 8 seconds.

Action Taken When the DTC Sets

Control Duty Signal Error DTC

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Open Position Error DTC (12,000 lbs GVW)

- The ECM illuminates the MIL on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- A sticking or intermittently sticking EGR valve may set this DTC.

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty EGR valve
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "EGR Current Position" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Test Description

The number below refers to the step number on the diagnostic table.

3. Operate the vehicle within the same conditions as when the DTC failed. If you can not duplicate this DTC, use the information in the Freeze Frame/Failure Records data can help to locate an intermittent condition.

DTC P0404

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0403, P0405 or P0406 also set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3
3	Command the EGR solenoid to 100% while observing the EGR Position Sensor parameter with a scan tool. Does the EGR Position Sensor parameter change in accordance with the EGR Solenoid Command?	—	Go to Diagnostic Aids	Go to Step 4
4	1. Turn OFF the ignition. 2. Disconnect the EGR valve harness connector. 3. Connect a test lamp between the duty signal control circuit of the EGR valve motor harness (pin 6 of E-94 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 5
5	1. Connect a test lamp between the 12 volts feed circuit of the EGR valve motor harness (pin 4 of E-94 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 8	Go to Step 7
6	Repair the EGR valve motor duty control circuit between the engine control module (ECM) (pin B-8 of J-217 connector) and the EGR valve (pin 6 of E-94 connector) for a short to battery, ignition voltage or short to EGR valve motor 12 volts feed circuit. Did you complete the repair?	—	Go to Step 11	—
7	Repair the EGR valve motor 12 volts feed circuit between the ECM (pin B-7 of J-217 connector) and the EGR valve (pin 4 of E-94 connector) for a short to ground. Did you complete the repair?	—	Go to Step 11	—

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the EGR valve position sensor (pins 1, 2 and 3 of E-94 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 9
9	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion on these EGR valve position sensor circuits at the harness connector of the ECM (pins B-17, B-49 and B-53 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
10	Replace the EGR valve. Refer to EGR Valve Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 12
12	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0405

Circuit Description

The exhaust gas recirculation (EGR) valve position sensor is installed on the EGR valve body together with the EGR valve control motor. The EGR valve position sensor changes output voltage according to EGR valve position. The EGR position sensor has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- EGR valve position sensor signal circuit

The engine control module (ECM) supplies 5 volts to the EGR valve position sensor on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. The EGR valve position sensor provides a signal to the ECM on the EGR valve position signal circuit, which is relative to the position changes of the EGR valve. The ECM monitors the EGR position sensor signals for voltage outside the normal range of the EGR position. If the ECM detects an excessively low EGR valve position signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0403, P0406, P0642 and P0643 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the EGR position sensor signal voltage is less than 0.5 volts for longer than 3 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "EGR Position Sensor" display on the scan tool with the ignition ON, engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0405

Schematic Reference: Engine Controls Schematics

Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0642 also set?	—	Go to DTC P0642	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Turn ON the ignition, with the engine OFF. 2. Observe the EGR Position Sensor parameter with a scan tool. Is the EGR Position Sensor parameter less than the specified valve?	0.5 volts	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Disconnect the EGR valve harness connector. 3. Connect a DMM between the 5 volts reference circuit of the EGR position sensor harness (pin 1 of E-94 connector) and a known good ground. 4. Turn ON the ignition, with engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 5	Go to Step 6
5	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the 5 volts reference circuit and the signal circuit of the EGR Position Sensor harness (pins 1 and 3 of E-94 connector). 3. Turn ON the ignition, with the engine OFF. 4. Observe the EGR Position Sensor parameter with a scan tool. Is the EGR Position Sensor parameter more than the specified valve?	4.5 volts	Go to Step 8	Go to Step 7
6	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin B-49 of J-217 connector) and the EGR position sensor (pin 1 of E-94 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9
7	1. Test the signal circuit between the ECM (pin B-53 of J-217 connector) and the EGR position sensor (pin 3 of E-94 connector) for the following conditions: • An open circuit • A short to ground • A short to the low reference circuit • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Disconnect the EGR valve harness connector. 3. Inspect for an intermittent and for poor connections at the harness connector of the EGR position sensor (pins 1 and 3 of E-94 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for poor connections on these EGR position sensor circuits at the harness connector of the ECM (pins B-49 and B-53 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	Replace the EGR valve. Refer to EGR Valve Replacement in this section. (EGR valve position sensor is internal to EGR valve) Did you complete the replacement?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 13
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0406

Circuit Description

The exhaust gas recirculation (EGR) valve position sensor is installed on the EGR valve body together with the EGR valve control motor. The EGR valve position sensor changes output voltage according to EGR valve position. The EGR position sensor has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- EGR valve position sensor signal circuit

The engine control module (ECM) supplies 5-volts to the EGR valve position sensor on the 5-volts reference circuit. The ECM also provides a ground on the low reference circuit. The EGR valve position sensor provides a signal to the ECM on the EGR valve position signal circuit which is relative to the position changes of the EGR valve. The ECM monitors the EGR position sensor signals for voltage outside the normal range of the EGR position. If the ECM detects an excessively high EGR valve position signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0403, P0405, P0642 and P0643 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the EGR position sensor signal voltage is more than 4.5 volts for longer than 3 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "EGR Position Sensor" display on the scan tool with the ignition ON, engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0406

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the EGR Position Sensor parameter with a scan tool. Is the EGR Position Sensor parameter more than the specified valve?	4.5 volts	Go to Step 3	Go to Diagnostic Aids
3	1. Start the engine. 2. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0643 also set?	—	Go to Step 4	Go to Step 5
4	1. Turn OFF the ignition. 2. Disconnect the EGR valve harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the EGR Position Sensor parameter with a scan tool. Is the DMM voltage less than the specified value?	0.5 volts	Go to DTC P0643	Go to Step 7
5	1. Turn OFF the ignition. 2. Disconnect the EGR valve harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the EGR Position Sensor parameter with a scan tool. Is the DMM voltage less than the specified value?	0.5 volts	Go to Step 6	Go to Step 7
6	1. Turn OFF the ignition. 2. Connect a test lamp between the low reference circuit of the EGR position sensor harness (pin 2 of E-94 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 8
7	**Important:** The EGR position sensor may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuit between the engine control module (ECM) (pin B-53 of J-217 connector) and the EGR position sensor (pin 3 of E-94 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12

Step	Action	Value(s)	Yes	No
8	1. Test the low reference circuit between the ECM (pin B-17 of J-217 connector) and the EGR position sensor (pin 2 of E-94 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 10
9	1. Turn OFF the ignition. 2. Disconnect the EGR position sensor connector. 3. Inspect for an intermittent and for a poor connection at the harness connector of the EGR position sensor (pin 2 of E-94 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 11
10	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the EGR position sensor circuit at the harness connector of the ECM (pin B-17 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12
11	Replace the EGR valve. Refer to EGR Valve Replacement in this section. (EGR valve position sensor is internal to EGR valve) Did you complete the replacement?	—	Go to Step 13	—
12	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 13	—
13	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 14

Step	Action	Value(s)	Yes	No
14	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0477

Circuit Description

The engine control module (ECM) controls the exhaust brake control relay which supplies power to the intake throttle solenoid valve and exhaust brake magnetic valve based on vehicle running condition. The ECM monitors the exhaust brake control relay operating status through the exhaust brake relay feedback circuit and the intake throttle solenoid feedback circuit. If the ECM detects a low voltage condition on the exhaust brake control relay control circuit or either of the feedback circuits when the exhaust brake is commanded ON, this DTC will set.

Condition for Running the DTC

- DTCs P0478, P0642, P0643, U0073 and U0101 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON time is longer than 5 seconds.
- The engine is running.
- The exhaust brake cut is not controlled.

Condition for Setting the DTC

- The ECM detects a low voltage condition on the exhaust brake control relay control circuit for longer than 1 second.

OR

- The ECM detects a low voltage condition on the exhaust brake control relay feedback circuit or intake throttle solenoid valve feedback circuit for longer than 1.5 seconds when the exhaust brake control relay is commanded ON.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM inhibits the cruise control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty exhaust brake control relay
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Exhaust Brake Relay" or "Intake Throttle Solenoid" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Notice:
If the exhaust brake control relay control circuit is open circuit, DTC P0478 will also set.

DTC P0477

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0478 also set?	—	Go to Step 13	Go to Step 3
3	1. Start the engine. 2. Command the Exhaust Brake Control Relay ON with a scan tool. 3. Observe the Exhaust Brake Relay and Intake Throttle Solenoid parameter with a scan tool. Are both parameters the specified value when commanded ON?	ON	Go to Diagnostic Aids	Go to Step 4
4	Is the Exhaust Brake Relay parameter the specified value when commanded ON at Step 2?	ON	Go to Step 12	Go to Step 5
5	Is the Intake Throttle Solenoid parameter the specified value when commanded ON at Step 2?	ON	Go to Step 11	Go to Step 6
6	Does the exhaust brake control relay click when commanded ON and OFF at Step 2?	—	Go to Step 10	Go to Step 7
7	1. Turn OFF the ignition. 2. Replace the exhaust brake control relay with a known good relay. 3. Start the engine. 4. Command the Exhaust Brake Control Relay ON with a scan tool. 5. Observe the Exhaust Brake Relay and Intake Throttle Solenoid parameter with a scan tool. Are both parameters the specified value when commanded ON?	ON	Go to Step 18	Go to Step 8
8	1. Turn OFF the ignition. 2. Remove the exhaust brake control relay. 3. Probe the voltage supply circuit of the exhaust brake control relay coil side (pin 2 of J-18 connector) with a test lamp that is connected to a known good ground. 4. Turn ON the ignition, with the engine OFF. 5. Command the Exhaust Brake Control Relay ON with a scan tool. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 14
9	Probe the ground circuit of the exhaust brake control relay coil side (pin 4 of J-18 connector) with a test lamp that is connected to battery voltage. Does the test lamp illuminate?	—	Go to Step 18	Go to Step 15

Step	Action	Value(s)	Yes	No
10	1. Turn OFF the ignition. 2. Remove the exhaust brake control relay. 3. Probe the voltage feed circuit of the exhaust brake control relay switch side (pin 1 of J-18 connector) with a test lamp that is connected to a known good ground. 4. Start the engine. Does the test lamp illuminate?	—	Go to Step 18	Go to Step 17
11	1. Test the exhaust brake control relay feedback circuit between the engine control module (ECM) (pin A-44 of J-218 connector) and the exhaust brake control relay (pin 5 of J-18 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 19
12	1. Test the intake throttle solenoid feedback circuit between the ECM (pin A-72 of J-218 connector) and the exhaust brake control relay (pin 5 of J-18 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 19
13	1. Test the exhaust brake control relay control circuit between the ECM (pin A-77 of J-218 connector) and the exhaust brake control relay (pin 2 of J-18 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 19
14	1. Test the exhaust brake control relay control circuit between the ECM (pin A-77 of J-218 connector) and the exhaust brake control relay (pin 2 of J-18 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 21
15	1. Test the ground circuit between the exhaust brake control relay (pin 4 of J-18 connector) and the chassis ground terminal (J-9) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 16
16	Repair poor tightening and corrosion at the chassis ground terminal (J-9). Did you complete the repair?	—	Go to Step 22	—

Step	Action	Value(s)	Yes	No
17	Repair the exhaust brake control relay voltage feed circuit between the exhaust brake cut relay (pin 5 of J-210 connector) and the exhaust brake control relay (pin 1 of J-18 connector) for an open circuit or high resistance. Did you complete the repair?	—	Go to Step 22	—
18	1. Turn OFF the ignition. 2. Inspect for an intermittent and for a poor connection on each exhaust brake control relay terminal. 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 20
19	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these exhaust brake control relay circuits at the harness connector of the ECM (pin A-44, A-72 or A-77 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 21
20	Replace the exhaust brake control relay. Did you complete the replacement?	—	Go to Step 22	—
21	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 22	—
22	1. Reconnect all previously disconnected relay or harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 23
23	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0478

Circuit Description

The engine control module (ECM) controls the exhaust brake control relay which supplies power to the intake throttle solenoid valve and exhaust brake magnetic valve based on vehicle running condition. The ECM monitors the exhaust brake control relay operating status through the exhaust brake relay feedback circuit and the intake throttle solenoid feedback circuit. If the ECM detects a high voltage condition on exhaust brake control relay control circuit or either of the feedback circuits when the exhaust brake is commanded ON, this DTC will set.

Condition for Running the DTC

- DTCs P0477, P0642, P0643, U0073 and U0101 are not set.
- The battery voltage is more than 10 - 16 volts.
- The ignition switch is ON time is longer than 5 seconds.
- The engine is running.
- The exhaust brake cut is not controlled.

Condition for Setting the DTC

- The ECM detects a high voltage condition on the exhaust brake control relay control circuit for longer than 1 second.

OR

- The ECM detects a high voltage condition on the exhaust brake control relay feedback circuit or intake throttle solenoid valve feedback circuit for longer than 1.5 seconds when the exhaust brake control relay is commanded OFF.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 50%.
- The ECM limits fuel rail pressure within 11600 psi (80MPa).
- The ECM closes the EGR valve and holds to close position.
- The ECM limits accelerator pedal control range within 40%.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty exhaust brake control relay
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Exhaust Brake Relay" or "Intake Throttle Solenoid" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Notice:

If the exhaust brake control relay control circuit is open circuit, DTC P0477 will also set.

DTC P0478

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor The Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0477 also set?	—	Go to DTC P0477	Go to Step 3
3	1. Start the engine. 2. Observe the Exhaust Brake Relay and Intake Throttle Solenoid parameter with a scan tool. Are both parameters the specified value?	OFF	Go to Diagnostic Aids	Go to Step 4
4	1. Turn OFF the ignition. 2. Remove the exhaust brake control relay. 3. Start the engine. 4. Observe the Exhaust Brake Relay and Intake Throttle Solenoid parameter with a scan tool. Are both parameter the specified value?	OFF	Go to Step 6	Go to Step 5
5	1. Turn OFF the ignition. 2. Disconnect the transmission control module (TCM) harness connector (B-230). 3. Start the engine. 4. Observe the Exhaust Brake Relay and Intake Throttle Solenoid parameter with a scan tool. Are both parameter the specified value?	OFF	Go to Step 10	Go to Step 8
6	1. Turn OFF the ignition. 2. Replace the exhaust brake control relay with a known good relay. 3. Start the engine. 4. Observe the Exhaust Brake Relay and Intake Throttle Solenoid parameter with a scan tool. Are both parameter the specified value?	OFF	Go to Step 9	Go to Step 7
7	1. Test the exhaust brake control relay control circuit between the engine control module (ECM) (pin A-77 of J-218 connector) and the exhaust brake control relay (pin 2 of J-18 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11

Step	Action	Value(s)	Yes	No
8	1. Test the exhaust brake control relay feedback circuit between the exhaust brake control relay (pin 5 of J-18 connector) and the following components for a short to battery or ignition voltage: • Intake throttle solenoid (pin 1 of J-40 connector) • Exhaust brake solenoid (pin 1 of J-31 connector) • ECM (pins A-44 and A-72 of J-218 connector) • TCM (pin 1 of B-230 connector) 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
9	Replace the exhaust brake control relay. Did you complete the replacement?	—	Go to Step 12	—
10	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Transmission Control Module (TCM) Replacement in the Automatic Transmission section. Did you find and correct the condition?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected relay or harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 13
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0500

Circuit Description

The vehicle speed sensor (VSS) 2 is used by the engine control module (ECM) and speedometer, which generates a speed signal from the transmission output shaft rotational speed. The VSS 2 has the following circuits.

- 12 volts feed circuit
- VSS 2 signal circuit
- VSS 2 low reference circuit

The VSS 2 uses a hall effect element. It interacts with the magnetic field created by the rotating magnet and outputs a square wave pulse signal. The ECM calculates the vehicle speed by the VSS 2.

If the ECM detects a difference of VSS 1 signal input from the transmission control module (TCM) higher than the VSS 2 signal inputted to the ECM, this DTC will set (Automatic Transmission).

If the ECM detects the VSS 2 signal inputted to the ECM lower than a predetermined speed during the calculated engine condition, this DTC will set (Manual Transmission).

Condition for Running the DTC

Automatic Transmission

- DTCs P0643, P0700, U0073 and U0101 are not set.
- The ignition switch ON time is longer than 3 seconds.

Manual Transmission

- DTCs P0643, P0700, U0073 and U0101 are not set.
- The ignition switch ON time is longer than 2 seconds.
- The engine speed is higher than 1100 RPM.
- The engine coolant temperature (ECT) is more than 68°F (20°C).
- The fuel injection quantity is more than a calculated value.

Condition for Setting the DTC

Automatic Transmission

- The ECM detects that the VSS 1 signal from the TCM is 15 MPH higher than the VSS 2 signal inputted to the ECM for 10 seconds.

Manual Transmission

- The ECM detects that the VSS 2 signal inputted to the ECM is lower than a predetermined speed for 10 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Vehicle Speed Sensor" display on the scan tool while driving the vehicle. A change in the display to 0 MPH (0 km/h) indicates a fault is occurring.

DTC P0500

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Drive the vehicle. 3. Observe the Vehicle Speed Sensor (VSS) parameter with a scan tool. Does the VSS parameter indicate correct vehicle speed?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Turn OFF the ignition. 2. Inspect the Gauges (10 A) fuse behind the glove box . Is the Gauges (10 A) fuse open?	—	Go to Step 4	Go to Step 5
4	Replace the Gauges (10 A) fuse. If the fuse continues to open, repair the short to ground on one of the circuits that is fed by the Gauges (10 A) fuse or replace the shorted attached component fed by the Gauges (10 A) fuse. Did you complete the repair?	—	Go to Step 20	—
5	1. Remove the VSS 2. Refer to Vehicle Speed Sensor (VSS) 2 Replacement in this section. 2. Visually inspect the VSS 2 for the following conditions: • For physical damage • For being loose • For improper installation • For transmission output shaft teeth damage 3. Repair as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 6
6	1. Turn OFF the ignition. 2. Disconnect the VSS 2 sensor harness connector. 3. Connect a test lamp between the 12 volts feed circuit of the VSS 2 harness (pin 1 of J-32 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 7	Go to Step 11
7	Connect a test lamp between the low reference circuit of the VSS 2 harness (pin 2 of J-32 connector) and battery voltage. Does the test lamp illuminate?	—	Go to Step 8	Go to Step 12

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Connect a test lamp between the signal circuit of the VSS 2 harness (pin 3 of J-32 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 13	Go to Step 9
9	1. Turn OFF the ignition. 2. Connect a test lamp between the signal circuit of the VSS 2 harness (pin 3 of J-32 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 14	Go to Step 10
10	1. Turn ON the ignition, with engine OFF. 2. Intermittently jump the signal circuit of the VSS 2 (pin 3 of J-32 connector) with a test lamp that is connected to a known good ground, while monitoring the VSS parameter with a scan tool. Does the scan tool indicate any vehicle speed when the circuit is intermittently pulled to ground?	—	Go to Step 16	Go to Step 15
11	Repair the open or high resistance in the VSS 2 voltage feed circuit between the Gauges (10 A) fuse and the VSS 2 (pin 1 of J-32 connector). Did you complete the repair?	—	Go to Step 20	—
12	Repair the open or high resistance in the VSS 2 low reference circuit between the VSS 2 (pin 2 of J-32 connector) and the chassis ground (B-1 terminal). Did you complete the repair?	—	Go to Step 20	—
13	1. Test the VSS 2 signal circuit between the engine control module (ECM) (pin A-39 of J-218 connector) then the VSS 2 (pin 3 of J-32 connector), then between the meter assembly (pin 17 of B-52 connector) and the VSS 2 (pin 2 of J-32 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 19

Step	Action	Value(s)	Yes	No
14	1. Test the VSS 2 signal circuit between the ECM (pin A-39 of J-218 connector) and the VSS 2 (pin 3 of J-32 connector), then between the meter assembly (pin 17 of B-52 connector) and the VSS 2 (pin 3 of J-32 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 19
15	1. Test the VSS 2 signal circuit between the ECM (pin A-39 of J-218 connector) and the VSS 2 (pin 3 of J-32 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 17
16	1. Turn OFF the ignition. 2. Disconnect the VSS 2 harness connector. 3. Inspect for an intermittent and for poor connections at the harness connector of the VSS 2 (pins 1, 2 and 3 of J-32 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 18
17	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the VSS 2 circuit at the harness connector of the ECM (pin A-39 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 19
18	Replace the VSS 2. Refer to Vehicle Speed Sensor (VSS) 2 Replacement in this section. Did you complete the replacement?	—	Go to Step 20	—
19	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 20	—

Step	Action	Value(s)	Yes	No
20	1. Reconnect all previously disconnected fuse and harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Drive the vehicle. 5. Observe the VSS parameter with a scan tool. Does the VSS parameter indicate correct vehicle speed?	—	Go to Step 21	Go to Step 2
21	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0506

Circuit Description

The engine control module (ECM) adjusts the fuel delivery in order to control crankshaft speed at idle. If the ECM detects that the engine idle speed is lower than desired within a calibrated time, this DTC will set.

Condition for Running the DTC

- DTCs P0116, P0117, P0118, P0300, P0335, P0336, P0500, P0507, P0602, P0642, P0643, P1125, P1293, P2146, P2147, P2148, P2149, P2150 and P2151 are not set.

AND following conditions are met longer than 3 seconds.

- The ignition switch is ON.
- The engine coolant temperature (ECT) is more than 149°F (65°C).
- The fuel injection quantity does not vary more than 10 mm^3.
- The desired idle speed does not vary more than 10 RPM.
- The engine speed does not vary more than 20 RPM.
- The vehicle speed is less than 1 MPH (1.6 km/h).

Condition for Setting the DTC

- The ECM detects that the actual idle speed is 200 RPM lower than the desired idle speed for 10 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Test Description

The number below refers to the step number on the diagnostic table.
4. This test determines if the engine can achieve the commanded RPM.

DTC P0506

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the scan tool display any other DTCs set?	—	Go to Diagnostic Trouble Code (DTC) List	Go to Step 3
3	Can any abnormal engine mechanical noise be heard?	—	Go to Engine Mechanical Section	Go to Step 4

Step	Action	Value(s)	Yes	No
4	1. Place the transmission in Park or Neutral and set the park brake. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine and let idle. 4. Use the idle up control knob to increase different idle speeds. 5. Observe the Engine Speed and Desired Idle Speed parameter with a scan tool. Does the Engine Speed parameter follow the Desired Idle Speed parameter within 200 RPM?	—	Go to Step 5	Go to Step 6
5	1. Observe the Freeze Frame/Failure Records for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Does the DTC fail this ignition?	—	Go to Step 6	Go to Intermittent Conditions
6	1. Inspect the fuel system for the following conditions: • Fuel quality and type. • Air in the fuel system. • Fuel lines between the fuel tank and fuel supply pump for being crushed or kinked. • Fuel tank vent hose for a plugged or kinked. • Fuel lines between the fuel tank and fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. 2. Inspect the air intake system for the following conditions: • Air cleaner and air intake ducts for a restriction, holes, or leaks. • Restriction in turbocharger inlet duct. • Restriction or leak in the intake manifold. 3. Inspect the exhaust system for the following conditions: • Restriction in the exhaust pipes. 4. Power take off (PTO) device loading engine excessively. Did you complete the repair?	—	Go to Step 7	—

Step	Action	Value(s)	Yes	No
7	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 8
8	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0507

Circuit Description

The engine control module (ECM) adjusts the fuel delivery in order to control crankshaft speed at idle. If the ECM detects that the engine idle speed is higher than desired within a calibrated time, this DTC will set.

Condition for Running the DTC

- DTCs P0116, P0117, P0118, P0335, P0336, P0500, P0506, P0602, P0642, P0643 and P1125 are not set.

AND following conditions are met longer than 3 seconds.

- The ignition switch is ON.
- The engine coolant temperature (ECT) is more than 149°F (65°C).
- The fuel injection quantity does not vary more than 10 mm^3.
- The desired idle speed does not vary more than 10 RPM.
- The engine speed does not vary more than 20 RPM.
- The vehicle speed is less than 1 MPH (1.6 km/h).

Condition for Setting the DTC

- The ECM detects that the actual idle speed is 100 RPM higher than the desired idle speed for 10 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Test Description

The number below refers to the step number on the diagnostic table.
3. This test determines if the engine can achieve the commanded RPM.

P0507

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the scan tool display and other DTCs set?	—	Go to Diagnostic Trouble Code (DTC) List	Go to Step 3
3	1. Place the transmission in Park or Neutral and set the park brake. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine and let idle. 4. Perform the RPM Control with a scan tool. 5. Command the Desired Idle Speed Increase and Decrease with a scan tool. Does the Engine Speed parameter follow the Desired Idle Speed parameter?	—	Go to Step 4	Go to Step 5

Step	Action	Value(s)	Yes	No
4	1. Observe the Freeze Frame/Failure Records for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Does the DTC fail this ignition?	—	Go to Step 5	Go to Intermittent Conditions
5	1. Inspect the fuel system for the following conditions: • Fuel quality and type. • Fuel injector(s). (Injector tip(s) may damaged) • Fuel return lines from the fuel supply pump and fuel injectors for being crushed or kinked. • Engine oil level. **Notice:** If the engine oil level is risen, fuel may leak under the cylinder head cover from the high pressure line. 2. Inspect the engine control sensors for for the following conditions: • Use a scan tool, compare the Engine Coolant Temperature (ECT) with the Intake Air Temperature (IAT) and Fuel Temperature (FT) on a cold engine condition. If the difference among temperature reading is more than 9°F (5°C) on a cold engine, check for high resistance on low reference circuit and signal circuit or skewed sensor. **Notice:** The mass air flow (MAF) sensor is heated and as a result the IAT may indicate a higher than normal intake air temperature if the ignition switch is being ON. Did you complete the repair?	—	Go to Step 6	—
6	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 7

Step	Action	Value(s)	Yes	No
7	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0512

Circuit Description

The starter switch signal is inputted to the engine control module (ECM) during the ignition switch "START" position. The ECM uses the starter switch input for fuel crank mode and starter cut relay control. If the ECM detects the starter switch signal is ON when the engine is running, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine speed is higher than 1000 RPM.

Condition for Setting the DTC

- The ECM detects that the starter switch signal circuit is in the ON position (high voltage) for longer than 10 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If the engine does not crank normally, refer to the Starting System section.

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty ignition switch
- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Starter Relay Status" display on the scan tool with the engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0512

Schematic Reference: Engine Controls Schematics & Starting and Charging Schematics

Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the Status OFF. 3. Observe the Starter Relay Status with a scan tool. Is the Starter Relay Status parameter the specified value?	OFF	Go to Diagnostic Aids	Go to Step 3
3	1. Remove the Starter (10A) fuse in the glove box fuse block. 2. Observe the Starter Relay Status with a scan tool. Is the Starter Relay Status parameter the specified value?	OFF	Go to Step 5	Go to Step 4

Step	Action	Value(s)	Yes	No
4	1. Turn OFF the ignition. 2. Disconnect the ignition switch harness connector. 3. Measure the continuity among each terminal of the ignition switch with the ignition switch in the ON position. • Between pins 2 and 4 of B-67 ignition switch side connector • Between pins 3 and 4 of B-67 ignition switch side connector Is there any continuity between both terminals?	—	Go to Step 8	Go to Step 6
5	1. Test the starter switch signal circuit between the engine control module (ECM) (pin A-96 of J-218 connector) and the Starter (10 A) fuse or starter relay (pin 4 of J-12 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 7
6	Repair the starter switch signal circuit between the ignition switch (pin 4 of B-67 connector) and the Starter (10 A) fuse for a short to battery or ignition voltage. Did you complete the repair?	—	Go to Step 10	—
7	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect the connection on the starter switch signal circuit at the harness connector of the ECM (pin A-96 of J-218 connector) for corrosion. 4. Repair or clean the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 9
8	Repair or replace the ignition switch. Did you complete the action?	—	Go to Step 10	—
9	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 10	—

Step	Action	Value(s)	Yes	No
10	1. Reconnect all previously disconnected fuse, relay or harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0562

Circuit Description

The engine control module (ECM) monitors the system voltage on the ignition feed terminal to make sure that the voltage stays within the proper range. If the ECM detects an excessively low system voltage, this DTC will set. When the charging system detects a malfunction, the charge indicator will light.

Condition for Running the DTC

- The engine speed is higher than 500 RPM.

Condition for Setting the DTC

- The ECM detects that the ignition 1 feed circuit voltage is less than 7.8 volts for longer than 10 seconds.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- If the ignition voltage feed to the ECM is open, the engine will not start and the scan tool will not communicate with the ECM.
- A charging system problem may set this DTC.
- An intermittent or poor connection at the ignition 1 signal voltage feed (pin A-23 of J-218 connector) may set this DTC.

DTC P0562

Schematic Reference: Engine Controls Schematics & Starting and Charging Schematics

Connector End View Reference: Engine Control Module (ECM) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Start the engine and let idle for 30 seconds. 3. With the scan tool monitor the ignition 1 voltage. 4. Load the electrical system by turning ON the headlights, A/C, etc. 5. Observe the Ignition 1 Signal parameter with a scan tool. Is the Ignition 1 Signal parameter more than the specified value?	10 volts	Go to Diagnostic Aids	Go to Step 3

Step	Action	Value(s)	Yes	No
3	Test the charging system. Refer to Diagnosis of The Charging System in the Charging System Section. Did you find a charging system problem?	—	Go to Step 4	Go to Step 5
4	Repair the charging system. Refer to Diagnosis of The Charging System in the Charging System Section. Did you complete the repair?	—	Go to Step 7	—
5	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion of the ignition 1 voltage feed at the harness connector of the ECM (pin A-23 of J-218 connector). 4. Repair or clean the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 6
6	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 7	—
7	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Observe the Ignition 1 Signal parameter with a scan tool. Is the Ignition 1 Signal parameter more than the specified value?	10 volts	Go to Step 8	Go to Step 2
8	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0563

Circuit Description

The engine control module (ECM) monitors the system voltage on the ignition feed terminal to make sure that the voltage stays within the proper range. If the ECM detects an excessively high system voltage, this DTC will set.

Condition for Setting the DTC

- The ECM detects that the ignition 1 feed circuit voltage is more than 16.5 volts for longer than 5 seconds.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- A charging system problem may set this DTC.
- Jump starting the vehicle or a battery charger may have set this DTC.

DTC P0563

Schematic Reference: Engine Controls Schematics & Starting and Charging Schematics

Connector End View Reference: Engine Control Module (ECM) Connector End View

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	Was the vehicle recently jump started or a battery charger placed on the batteries?	—	Go to Step 7	Go to Step 3
3	1. Install a scan tool. 2. Start the engine and let idle for 30 seconds. 3. Observe the Ignition 1 Signal parameter with a scan tool. Is the Ignition 1 Signal parameter less than the specified value?	16 volts	Go to Diagnostic Aids	Go to Step 4
4	Test the charging system. Refer to Diagnosis of The Charging System in the Charging System Section. Did you find a charging system problem?	—	Go to Step 5	Go to Step 6
5	Repair the charging system. Refer to Diagnosis of The Charging System in the Charging System Section. Did you complete the repair?	—	Go to Step 7	—

Step	Action	Value(s)	Yes	No
6	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 7	—
7	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Observe the Ignition 1 Signal parameter with a scan tool. Is the Ignition 1 Signal parameter less than the Specified value?	16 volts	Go to Step 8	Go to Step 4
8	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0567

Circuit Description

The cruise control keeps the vehicle running at a driver's set speed. When the cruise main switch is turned ON, battery voltage is provided to the engine control module (ECM). When a signal from the control switch is inputted to the ECM, the cruise control system is activated. The "cruise main" indicator light in the meter assembly will light up when the cruise main switch is ON. When the cruise resume switch is turned "ON", the switch signal is provided to the ECM and the vehicle speed is reset to the previous set speed. If the ECM detects the cruise resume switch signal continuously "ON", this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the cruise resume/accel. switch signal is stuck at the ON position (high voltage) for longer than 1 minute.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty cruise resume/accel switch
- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Cruise Resume/Accel. Switch" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the switch. A change in the display will indicate the location of the fault.

Notice:
This DTC will set if the cruise resume/accel. switch continues being pushed for longer than 1 minute.

DTC P0567

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Cruise Resume/Accel. Switch parameter with a scan tool. Is the Cruise Resume/Accel. Switch parameter the specified value?	OFF	Go to Diagnostic Aids	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the cruise resume/accel. switch harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the Cruise Resume/Accel. Switch parameter with a scan tool. Is the Cruise Resume/Accel. Switch parameter the specified value?	OFF	Go to Step 7	Go to Step 4
4	**Notice:** If no remote PTO resume switch is installed, skip to step 5. 1. Disconnect the remote PTO resume switch (if installed) harness connector. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Cruise Resume/Accel. Switch parameter with a scan tool. Is the Cruise Resume/Accel. Switch parameter the specified value?	OFF	Go to Step 8	Go to Step 5
5	1. Test the cruise resume/accel. switch circuit between the engine control module (ECM) (pin A-47 of J-218 connector) and the cruise resume/accel. switch (pin 3 of B-378 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 6
6	**Notice:** If no remote PTO resume switch is installed, skip to step 9. 1. Test the remote PTO resume switch circuit between the ECM (pin A-47 of J-218 connector) and the remote PTO resume switch (pin H of H-123 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 9
7	Replace the cruise resume/accel. switch. Did you complete the replacement?	—	Go to Step 10	—
8	Replace the remote PTO resume switch (if installed). Did you complete the replacement?	—	Go to Step 10	—

Step	Action	Value(s)	Yes	No
9	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 10	—
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0568

Circuit Description

The cruise control keeps the vehicle running at a driver's set speed. When the cruise main switch is turned ON, battery voltage is provided to the engine control module (ECM). When a signal from the control switch is inputted to the ECM, the cruise control system is activated. The "cruise main" indicator light in the meter assembly will light up when the cruise main switch is ON. When the cruise set switch is turned "ON", the switch signal is provided to the ECM and the vehicle speed is set. If the ECM detects the cruise set switch signal continuously "ON", this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the cruise set/coast switch signal is stuck at the ON position (high voltage) for longer than 1 minute.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty cruise set/coast switch
- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Cruise Set/Coast Switch" display on the scan tool will the ignition ON and engine OFF while moving connectors and the wiring harness related to the switch. A change in the display will indicate the location of the fault.

Notice:
This DTC will set if the cruise set/coast switch continues being pushed for longer than 1 minute.

DTC P0568

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Cruise Set/Coast Switch parameter with a scan tool. Is the Cruise Set/Coast Switch parameter the specified value?	OFF	Go to Diagnostic Aids	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the cruise set/coast switch harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the Cruise Set/Coast Switch parameter with a scan tool. Is the Cruise Set/Coast Switch parameter the specified value?	OFF	Go to Step 7	Go to Step 4
4	**Notice:** If no remote PTO set switch is installed, skip to step 5. 1. Turn OFF the ignition. 2. Disconnect the remote PTO set switch (if installed) harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the Cruise Set/Coast Switch parameter with a scan tool. Is the Cruise Set/Coast Switch parameter the specified value?	OFF	Go to Step 8	Go to Step 5
5	1. Test the cruise set/coast switch circuits between the engine control module (ECM) (pin A-48 of J-218 connector) and the cruise set/coast switch (pin 1 of B-377 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 6
6	**Notice:** If no remote PTO set switch is installed, skip to step 9. 1. Test the remote PTO set switch circuit between the ECM (pin A-48 of J-218 connector) and the remote PTO set switch (pin D of H-123 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 9
7	Replace the cruise set/coast switch. Did you complete the replacement?	—	Go to Step 10	—
8	Replace the remote PTO set switch. Did you complete the replacement?	—	Go to Step 10	—

Step	Action	Value(s)	Yes	No
9	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 10	—
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0571

Circuit Description

The brake pedal switch is installed on the brake pedal bracket. The brake pedal 1 switch is a normally open type switch and the brake pedal 2 switch is a normally closed type switch. When the brake pedal is pressed, the brake pedal 1 switch signal is provided to the engine control module (ECM) and the stoplights are turned ON. Then, the brake pedal 2 switch signal to the ECM is stopped (low voltage) and the ECM cancels the cruise control. If the ECM detects the brake switch signals out of correlation, this DTC will set.

Condition for Running the DTC

- DTCs P0500, P0642, P0643, P0652, P0653, P0698 and P0699 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects a brake pedal 1 switch (normally open type switch) signal and brake pedal 2 switch (normally closed type switch) signal correlation error for 3 seconds while heavy braking.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty brake pedal 1 or 2 switch
- Misadjusted brake pedal switch
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Stoplamp Pedal Switch (Brake Pedal 1 Switch)" and "Cruise Release Brake Pedal Switch (Brake Pedal 2 Switch)" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the switch. A change in the display will indicate the location of the fault.

DTC P0571

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Stoplamp Pedal Switch (brake pedal 1 switch) parameter with a scan tool while fully depressing and releasing the brake pedal. Does the scan tool indicate Applied when the brake pedal is applied and Released when the brake pedal is released?	—	Go to Step 13	Go to Step 3
3	1. Check to ensure the brake switch is adjusted correctly. The plunger should be all the way in when the pedal is released, yet should not impede with the brake pedal full upward travel. 2. Adjust the brake switch as necessary. Did you find and correct the condition?	—	Go to Step 24	Go to Step 4
4	1. Turn OFF the ignition. 2. Inspect the Brake Light (10 A) fuse in the glove box fuse block. Is the Brake Light (10 A) fuse open?	—	Go to Step 5	Go to Step 6
5	Replace the Brake Light (10 A) fuse. If the fuse continues to open, repair the short to ground one of the circuits that is fed by the Brake Light (10 A) fuse or replace the shorted attached component fed by the Brake Light (10 A) fuse. Did you complete the repair?	—	Go to Step 24	—
6	1. Disconnect the brake pedal switch harness connector. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Stoplamp Pedal Switch (brake pedal 1 switch) parameter with a scan tool while momentarily jumping across the stop lamp pedal switch harness connector between pins 1 and 4 of the B-66 connector. Does the scan tool indicate Applied when the circuit is jumpered and Released when the circuit is not jumpered?	—	Go to Step 22	Go to Step 7
7	Connect a test lamp between the voltage feed circuit of the stoplamp pedal switch (brake pedal 1 switch) harness (pin 1 of B-66 connector) and a known good ground. Does the test lamp illuminate?	—	Go to Step 8	Go to Step 11

Step	Action	Value(s)	Yes	No
8	Connect a test lamp between the signal circuit of the stoplamp pedal switch (brake pedal 1 switch) harness (pin 4 of B-66 connector) and a known good ground. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 10
9	1. Test the switch signal circuit between the engine control module (ECM) (pin A-62 of J-218 connector) and the stoplamp pedal switch (brake pedal 1 switch) (pin 4 of B-66 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 24	Go to Step 23
10	1. Test the stoplamp pedal switch (brake pedal 1 switch) signal circuit between the ECM (pin A-62 of J-218 connector) and the stoplamp pedal switch (pin 4 of B-66 connector) for an open circuit. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 24	Go to Step 12
11	Repair the open in the stoplamp pedal switch (brake pedal 1 switch) voltage feed circuit. Did you complete the repair?	—	Go to Step 24	—
12	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the stoplamp pedal switch circuit at the harness connector of the ECM (pin A-62 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 24	Go to Step 23
13	Observe the Cruise Release Brake Pedal Switch (brake pedal 2 switch) parameter with a scan tool while fully depressing and releasing the brake pedal. Does the scan tool indicate Applied when the brake pedal is applied and Released when the brake pedal is released?	—	Go to Diagnostic Aids	Go to Step 14
14	1. Check to ensure the brake switch is adjusted correctly. The plunger should be all the way in when the pedal is released, yet should not impede with the brake pedal full upward travel. 2. Adjust the brake switch as necessary. Did you find and correct the condition?	—	Go to Step 24	Go to Step 15

Step	Action	Value(s)	Yes	No
15	1. Disconnect the brake pedal switch harness connector. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Cruise Release Brake Pedal Switch (brake pedal 2 switch) parameter with a scan tool while momentarily jumping across the brake pedal 2 switch harness connector between pins 2 and 3 of the B-66 connector. Does the scan tool indicate Applied when the circuit is jumpered and Released when the circuit is not jumpered?	—	Go to Step 22	Go to Step 16
16	Connect a test lamp between the voltage feed circuit of the cruise release brake switch (brake pedal 2 switch) harness (pin 2 of B-66 connector) and a known good ground. Does the test lamp illuminate?	—	Go to Step 17	Go to Step 20
17	Connect a test lamp between the signal circuit of the cruise release brake switch harness (pin 3 of B-66 connector) and a known good ground. Does the test lamp illuminate?	—	Go to Step 18	Go to Step 19
18	1. Test the cruise release brake switch signal circuit between the ECM (pin A-63 of J-218 connector) and the cruise release brake switch (pin 3 of B-66 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 24	Go to Step 23
19	1. Test the cruise release brake switch signal circuit between the ECM (pin A-63 of J-218 connector) and the cruise release brake switch (pin 3 of B-66 connector) for an open circuit. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 24	Go to Step 21
20	Repair the open in the cruise release brake switch (brake pedal 2 switch) voltage feed circuit. Did you complete the repair?	—	Go to Step 24	—
21	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the cruise release brake switch circuit at the harness connector of the ECM (pin A-63 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 24	Go to Step 23

Step	Action	Value(s)	Yes	No
22	Replace the brake pedal switch. Refer to Brake Switch Replacement in this section. Did you complete the replacement?	—	Go to Step 24	—
23	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 24	—
24	1. Reconnect all previously disconnected fuse or harness connector(s). 2. Turn ON the ignition, with the engine OFF. 3. Clear the DTCs with a scan tool. 4. Observe the Stoplamp Pedal Switch (brake pedal 1 switch) and the Cruise Release Brake Pedal Switch (brake pedal 2 switch) while fully depressing and releasing the brake pedal. Does the scan tool indicate Applied when the brake pedal is applied and Released when the brake pedal is released for both parameter?	—	Go to Step 25	Go to Step 2
25	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0602

Circuit Description

This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM). This diagnostic also addresses if the ECM is not programmed.

Condition for Running the DTC

- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects a malfunction in its internal EEPROM.

OR

- The ECM detects that the fuel injector flow rate is not programmed.

OR

- The ECM detects an error in the programmed fuel injector flow rate.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM limits fuel rail pressure within 17400 psi (120 MPa).

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Important:
Clear the DTC with a scan tool after programming the fuel injector flow rate.

DTC P0602

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Ensure that all tool connections are secure. 2. Ensure that programming equipment is operating correctly. 3. Install a scan tool. 4. Turn OFF the ignition for 30 seconds. 5. Turn ON the ignition, with the engine OFF. 6. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Step 5
3	1. Verify the correct fuel injector flow rates are entered into the engine control module (ECM) with a scan tool against each fuel injector or using the head cover label. Refer to Engine Control Module (ECM) Replacement in this section. If the fuel injector flow rate are correctly entered, clear the DTC with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition with the engine OFF. Does the DTC fail the ignition?	—	Go to Step 4	Go to Step 5

Step	Action	Value(s)	Yes	No
4	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 5	—
5	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the DTC Information with a scan tool. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 6
6	Observe the stored information, Capture Info with a scan tool. Any there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0606

Circuit Description

This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM).

Condition for Setting the DTC

- The ECM detects that the ECM internal main CPU malfunction or ECM internal monitoring IC malfunction.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM limits accelerator control range to idle. (Main CPU malfunction)
- The ECM limits accelerator control range within 40%. (Monitoring IC malfunction)
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Test Description

The numbers below refers to the step number on the diagnostic table.
3. If the ground circuit(s) are not connected properly, this DTC may set.

DTC P0606

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition, with the engine OFF. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Step 8
3	1. Test each ground circuit between the engine control module (ECM) and the chassis ground terminal for an open circuit or high resistance. • Between A-2, A-3, A-26 & A-27 of J-218 connector and J-9 terminal • Between A-1, A-4 & A-5 of J-218 connector and B-1 terminal 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 4

Step	Action	Value(s)	Yes	No
4	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor tightening and corrosion at the chassis ground terminal (B-1 & J-9). 3. Repair the tightening or clean the corrosion as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 5
5	1. Test each ECM main relay voltage feed circuit between the ECM (pins A-19, A-50 & A-73 of J-218 connector) and the ECM main relay (pin 1 of J-208 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 6
6	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the ECM (pins A-1, A-2, A-3, A-4, A-5, A-23, A-26, A-27, A-49, A-50 & A-73 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 7
7	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 8	—
8	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 9
9	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0642

Circuit Description

The engine control module (ECM) provides 5 volts reference voltage through the reference circuit 1 to the following sensors:

- Accelerator pedal position (APP) sensor 1
- PTO throttle sensor
- Idle up sensor
- Boost pressure sensor
- Fuel rail pressure sensor
- EGR valve position sensor

The 5 volts reference circuits are independent of each other outside the ECM, but are bussed together inside the ECM. Therefore, a short circuit condition on one sensor 5 volts reference circuit may affect the entire 5 volt reference circuit 1. The ECM monitors the voltage on the 5 volts reference circuit 1. If the ECM detects the voltage is excessively low, this DTC will set.

Condition for Running the DTC

- DTC P0643 is not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the 5 volts reference circuit 1 voltage is less than 4.5 volts.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM limits accelerator control range within 40%.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "5 Volt Reference 1" display on the scan tool with ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0642

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter less than the specified value?	4.5 volts	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the accelerator pedal position (APP) sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter less than the specified value?	4.5 volts	Go to Step 4	Go to Step 15
4	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-54 of J-218 connector) and the APP sensor 1 (pin D of B-280 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 5
5	1. Turn OFF the ignition. 2. Disconnect the idle up sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter less than the specified value?	4.5 volts	Go to Step 6	Go to Step 16
6	1. Test the 5 volts reference circuit between the ECM (pin A-59 of J-218 connector) and the idle up sensor (pin 3 of B-374 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 7
7	**Notice:** If no PTO throttle sensor is installed, skip to step 8. 1. Turn OFF the ignition. 2. Disconnect the PTO throttle sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter less than the specified value?	4.5 volts	Go to Step 8	Go to Step 17
8	1. Test the 5 volts reference circuit between the ECM (pin A-58 of J-218 connector) and the PTO throttle sensor (pin E of H-123 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 9

Step	Action	Value(s)	Yes	No
9	1. Turn OFF the ignition. 2. Disconnect the boost pressure sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter less than the specified value?	4.5 volts	Go to Step 10	Go to Step 18
10	1. Test the 5 volts reference circuit between the ECM (pin B-46 of J-217 connector) and the boost pressure sensor (pin 3 of J-216 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 11
11	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter less than the specified value?	4.5 volts	Go to Step 12	Go to Step 19
12	1. Test the 5 volts reference circuit between the ECM (pin B-47 of J-217 connector) and the fuel rail pressure sensor (pin 3 of E-113 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 13
13	1. Turn OFF the ignition. 2. Disconnect the EGR valve harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter less than the specified value?	4.5 volts	Go to Step 14	Go to Step 20
14	1. Test the 5 volts reference circuit between the ECM (pin B-49 of J-217 connector) and the EGR position sensor (pin 1 of E-94 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 22	Go to Step 21

Step	Action	Value(s)	Yes	No
15	Replace the APP sensor. Refer to Accelerator Pedal Position Sensor Replacement in this section. (APP sensor 1 is internal to APP sensor assembly) Did you complete the replacement?	—	Go to Step 22	—
16	Replace the idle up sensor. Refer to Idle Up Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 22	—
17	Replace the PTO throttle sensor (if installed). Did you complete the replacement?	—	Go to Step 22	—
18	Replace the boost pressure sensor. Refer to Boost Pressure Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 22	—
19	Replace the fuel rail pressure sensor. Refer to Fuel Rail Pressure Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 22	—
20	Replace the EGR valve. Refer to EGR Valve Replacement in this section. (EGR valve position sensor is internal to EGR valve) Did you complete the replacement?	—	Go to Step 22	—
21	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 22	—
22	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 23
23	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0643

Circuit Description

The engine control module (ECM) provides 5 volts reference voltage through the reference circuit 1 to the following sensors:

- Accelerator pedal position (APP) sensor 1
- PTO throttle sensor
- Idle up sensor
- Boost pressure sensor
- Fuel rail pressure sensor
- EGR valve position sensor

The 5 volts reference circuits are independent of each other outside the ECM, but are bussed together inside the ECM. Therefore, a short circuit condition on one sensor 5 volts reference circuit may affect the entire sensor 5 volt reference circuit 1. The ECM monitors the voltage on the 5 volts reference circuit 1. If the ECM detects the voltage is excessively high, this DTC will set.

Condition for Running the DTC

- DTC P0642 is not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the 5 volts reference circuit 1 voltage is more than 5.5 volts.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel rail pressure within 11600 psi (80MPa).
- The ECM limits accelerator control range within 40%.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "5 Volt Reference 1" display on the scan tool with ignition ON, engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0643

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter more than the specified value?	5.5 volts	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the accelerator pedal position (APP) sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter more than the specified value?	5.5 volts	Go to Step 4	Go to Step 15
4	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-54 of J-218 connector) and the APP sensor 1 (pin D of B-280 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 5
5	1. Turn OFF the ignition. 2. Disconnect the idle up sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter more than the specified value?	5.5 volts	Go to Step 6	Go to Step 15
6	1. Test the 5 volts reference circuit between the ECM (pin A-59 of J-218 connector) and the idle up sensor (pin 3 of B-374 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 7
7	**Notice:** If no PTO throttle sensor is installed, skip to step 8. 1. Turn OFF the ignition. 2. Disconnect the PTO throttle sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter more than the specified value?	5.5 volts	Go to Step 8	Go to Step 15

Step	Action	Value(s)	Yes	No
8	1. Test the 5 volts reference circuit between the ECM (pin A-58 of J-218 connector) and the PTO throttle sensor (pin E of H-123 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 9
9	1. Turn OFF the ignition. 2. Disconnect the boost pressure sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter more than the specified value?	5.5 volts	Go to Step 10	Go to Step 15
10	1. Test the 5 volts reference circuit between the ECM (pin B-46 of J-217 connector) and the boost pressure sensor harness (pin 3 of J-216 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 11
11	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter more than the specified value?	5.5 volts	Go to Step 12	Go to Step 15
12	1. Test the 5 volts reference circuit between the ECM (pin B-47 of J-217 connector) and the fuel rail pressure sensor (pin 3 of E-113 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 13
13	1. Turn OFF the ignition. 2. Disconnect the EGR valve harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 1 parameter with a scan tool. Is the 5 Volt Reference 1 parameter more than the specified value?	5.5 volts	Go to Step 14	Go to Step 15

Step	Action	Value(s)	Yes	No
14	1. Test the 5 volts reference circuit between the ECM (pin B-49 of J-217 connector) and the EGR position sensor (pin 1 of E-94 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
15	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 17
17	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0650

Circuit Description

The malfunction indicator lamp (MIL) is located on the instrument panel cluster (IPC). The MIL informs the driver that an emission system fault has occurred and that the engine control system requires service.

The engine control module (ECM) monitors the MIL control circuit for conditions that are incorrect for the commanded state of the MIL. For example, a failure condition exists if the ECM detects low voltage when the MIL is commanded OFF, or high voltage when the MIL is commanded ON. If the ECM detects an improper voltage on the MIL control circuit, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- Low voltage condition on the MIL control circuit when the indicator is commanded OFF for longer than 1 second.

OR

- High voltage condition on the MIL control circuit when the indicator is commanded ON for longer than 1 second.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P0650" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0650

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Verify whether the instrument cluster is operational. If the instrument panel cluster (IPC) is completely inoperative, refer to Diagnostic System Check. 2. Install a scan tool. 3. Command the MIL ON and OFF with a scan tool. Does the MIL turn ON and OFF when commanded with a scan tool?	—	Go to Step 15	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Inspect the Gauges (10A) fuse behind the glove box. Is the Gauges (10A) fuse open?	—	Go to Step 4	Go to Step 5
4	Replace the Gauges (10A) fuse. If the fuse continues to open, repair the short to ground on one of the circuits that is fed by the Gauges (10A) fuse or replace the shorted attached component fed by the Gauges (10A) fuse. Did you complete the repair?	—	Go to Step 18	—
5	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) A harness connector. 3. Turn ON the ignition, with the engine OFF. Is the MIL OFF?	—	Go to Step 6	Go to Step 12
6	1. Remove the Gauges (10A) fuse that supplies voltage to the MIL. 2. Turn ON the ignition, with the engine OFF. 3. Measure the voltage from the MIL control circuit in the ECM harness connector (pin A-80 of J-218 connector) to a good ground. Is the voltage less than the specified value?	1 volt	Go to Step 7	Go to Step 13
7	1. Turn OFF the ignition. 2. Install the Gauges (10A) fuse that supplies ignition voltage to the MIL. 3. Turn ON the ignition, with the engine OFF. 4. Connect a 3-amp fused jumper wire between the MIL control circuit of the ECM harness connector (pin A-80 of J-218 connector) and a good ground. Is the MIL illuminated?	—	Go to Step 11	Go to Step 8
8	1. Turn ON the ignition, with the engine OFF. 2. Remove the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Accessories Body and Cab Section. 3. Probe the MIL ignition voltage circuit of the IPC harness connector (pin 18 of B-51 connector) with a test lamp that is connected to a known good ground. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 14

Step	Action	Value(s)	Yes	No
9	1. Test the MIL control circuit between the ECM (pin A-80 of J-218 connector) and the IPC (pin 5 of B-51 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 10
10	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the IPC (pins 5 and 18 of B-51 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 16
11	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the MIL control circuit at the harness connector of the ECM (pin A-80 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 17
12	Repair the the short to ground on the control circuit of the MIL between the ECM (pin A-80 of J-218 connector) and the IPC (pin 5 of B-51 connector). Did you complete the repair?	—	Go to Step 18	—
13	Repair the short to battery or ignition voltage on the control circuit of the MIL between the ECM (pin A-80 of J-218 connector) and the IPC (pin 5 of B-51 connector). Did you complete the repair?	—	Go to Step 18	—
14	Repair the open or high resistance on the ignition voltage circuit of the MIL between the Gauges (10A) fuse and the IPC (pin 18 of B-51 connector). Did you complete the repair?	—	Go to Step 18	—
15	1. Turn OFF the ignition for 30 seconds. 2. Turn ON the ignition, with the engine OFF. 3. Monitor DTC P0650 with a scan tool. Does DTC P0650 Last Test indicate failed?	—	Go to Step 17	Go to Diagnostic Aids
16	Repair or replace the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Accessories Body and Cab Section. Did you complete the repair or replacement?	—	Go to Step 18	—

Step	Action	Value(s)	Yes	No
17	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 18	—
18	1. Reconnect all previously disconnected fuse or harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 19
19	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0652

Circuit Description

The engine control module (ECM) provides 5 volts reference voltage through the reference circuit 2 to the accelerator pedal position (APP) sensor 2. The ECM monitors the voltage on the 5 volts reference circuit 2. If the ECM detects the voltage is excessively low, this DTC will set.

Condition for Running the DTC

- DTC P0653 is not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the 5 volts reference circuit 2 voltage is less than 4.5 volts.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "5 Volt Reference 2" display on the scan tool with ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0652

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the 5 Volt Reference 2 parameter with a scan tool. Is the 5 Volt Reference 2 parameter less than the specified value?	4.5 volts	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the accelerator pedal position (APP) sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 2 parameter with a scan tool. Is the 5 Volt Reference 2 parameter less than the specified value?	4.5 volts	Go to Step 4	Go to Step 5

Step	Action	Value(s)	Yes	No
4	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-55 of J-218 connector) and the APP sensor 2 (pin J of B-280 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 6
5	Replace the APP sensor. Refer to Accelerator Pedal Position (APP) Sensor Replacement in this section. (APP sensor 2 is internal to APP sensor assembly) Did you complete the replacement?	—	Go to Step 7	—
6	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 7	—
7	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 8
8	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0653

Circuit Description

The engine control module (ECM) provides 5 volts reference voltage through the reference circuit 2 to the accelerator pedal position (APP) sensor 2. The ECM monitors the voltage on the 5 volts reference circuit 2. If the ECM detects the voltage is excessively high, this DTC will set.

Condition for Running the DTC

- DTC P0652 is not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the 5 volts reference circuit 2 voltage is more than 5.5 volts.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "5 Volt Reference 2" display on the scan tool with ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0653

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the 5 Volt Reference 2 parameter with a scan tool. Is the 5 Volt Reference 2 parameter more than the specified value?	5.5 volts	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the accelerator pedal position (APP) sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 2 parameter with a scan tool. Is the 5 Volt Reference 2 parameter more than the specified value?	5.5 volts	Go to Step 4	Go to Step 5

Step	Action	Value(s)	Yes	No
4	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-55 of J-218 connector) and the APP sensor 2 (pin J of B-280 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 6	Go to Step 5
5	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 6	—
6	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 7
7	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0670

Circuit Description

The glow control system is operated when the engine coolant temperature is low, which allows easier engine starting. If the ignition switch is turned ON when the engine coolant temperature is low, the engine control module (ECM) illuminates the glow indicator lamp and turns ON the glow plugs via the glow plug controller. After a fixed time passes, the ECM turns OFF the glow indicator lamp and the glow plugs via the glow plug controller.

The glow plug controller has the ability to perform internal diagnostics for voltage and the output state of the glow plugs. If the glow plug controller senses an open in the voltage feed circuit to the glow plugs, or a glow plug controller system voltage error, the glow plug controller will send an error message to the ECM via the controller area network (CAN) communication bus.

Condition for Running the DTC

- DTCs U0073 and U0106 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The glow plug controller detects system voltage is too low.

OR

- The glow plug controller detects an open in all 4 glow plug circuits.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- A charging system problem may set this DTC.

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty glow plugs
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at glow plug controller: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P0670 Last Test" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0670

Schematic Reference: Engine Controls Schematics

Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. 3. Turn ON the ignition, with the engine OFF. Is DTC P0671-P0674 also set?	—	Go to Step 3	Go to Step 8

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Visually inspect the glow plug control harness for objects touching the glow plug terminals and for loose terminal nuts. Did you find and correct the condition?	—	Go to Step 21	Go to Step 4
4	1. Turn OFF the ignition. 2. Connect a test lamp between the glow plug terminals and battery voltage. Does the test lamp illuminate at all glow plug terminals?	—	Go to Step 5	Go to Step 7
5	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of all the glow plugs. 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 21	Go to Step 6
6	1. Turn OFF the ignition. 2. Disconnect the glow plug controller harness connector. 3. Inspect for an intermittent, poor connections and corrosion on all glow plug control circuits at the harness connector of the glow plug controller (pins 1, 2, 3 and 4 of E-144 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 21	Go to Step 20
7	Replace the affected glow plugs. Refer to Glow Plug Replacement in the Engine Electrical section. Did you find and correct the condition?	—	Go to Step 21	—
8	1. Turn OFF the ignition. 2. Inspect the Glow (60A) slow blow fuse in the fuse & relay box. Is the Glow (60A) slow blow fuse open?	—	Go to Step 9	Go to Step 10
9	Replace the Glow (60A) slow blow fuse. If the slow blow fuse continues to open, repair the short to ground on one of the circuits that is fed by the Glow (60A) slow blow fuse or replace the shorted attached component fed by the slow blow fuse. Did you complete the repair?	—	Go to Step 21	—
10	1. Turn OFF the ignition. 2. Inspect the Gauges (10A) fuse behind the glow box. Is the Gauges (10A) fuse open?	—	Go to Step 11	Go to Step 12

Step	Action	Value(s)	Yes	No
11	Replace the Gauges (10A) fuse. If the fuse continues to open, repair the short to ground on one of the circuits that is fed by the Gauges (10A) fuse or replace the shorted attached component fed by the fuse. Did you complete the repair?	—	Go to Step 21	—
12	1. Turn OFF the ignition. 2. Inspect for an intermittent, for a poor tightening and corrosion at the engine ground terminal (E-136). 3. Repair the loose connection or clean the corrosion as necessary. Did you find and correct the condition?	—	Go to Step 21	Go to Step 13
13	1. Turn OFF the ignition. 2. Disconnect both glow plug controller harness connectors. 3. Inspect for an intermittent, poor connections and corrosion on the voltage feed circuits and ground circuit at the harness connector of the glow plug controller (pin 1 of E-150 connector and pins 5 and 11 of E-144 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 21	Go to Step 14
14	1. Turn OFF the ignition. 2. Connect a DMM between the battery voltage feed circuit (pin 1 of E-150 connector) and a known good ground. Is the DMM voltage more than the specified value?	10 volts	Go to Step 15	Go to Step 17
15	1. Turn OFF the ignition. 2. Connect a DMM between the ignition voltage feed circuit (pin 5 of E-144 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	10 volts	Go to Step 16	Go to Step 18
16	1. Turn OFF the ignition. 2. Connect a DMM between the ignition voltage feed circuit and ground circuit (pins 5 and 11 of E-144 connector). 3. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	10 volts	Go to Step 20	Go to Step 19

Step	Action	Value(s)	Yes	No
17	Repair the open circuit or high resistance in the battery voltage feed circuit between the Glow (60A) slow blow fuse and the glow plug controller (pin 1 of E-150 connector). Did you complete the repair?	—	Go to Step 21	—
18	Repair the open circuit or high resistance in the ignition voltage feed circuit between the Gauges (10A) fuse and the glow plug controller (pin 5 of E-144 connector). Did you complete the repair?	—	Go to Step 21	—
19	Repair the open circuit or high resistance in the ground circuit between the engine ground terminal (E-136) and the glow plug controller (pin 11 of E-144 connector). Did you complete the repair?	—	Go to Step 21	—
20	Replace the glow plug controller. Refer to Glow Pug Controller Replacement in this section. Did you complete the replacement?	—	Go to Step 21	—
21	1. Reconnect all previously disconnected fuse or harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 22
22	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0671 - P0674

Circuit Description

The glow control system is operated when the engine coolant temperature is low, which allows easier engine starting. If the ignition switch is turned ON when the engine coolant temperature is low, the engine control module (ECM) illuminates the glow indicator lamp and turns ON the glow plugs via the glow plug controller. After a fixed time passes, the ECM turns OFF the glow indicator lamp and the glow plugs via the glow plug controller. The glow plug controller has the ability to perform internal checks, an open or a short circuit on each of the glow plug circuits. If the glow plug controller senses a problem in a glow pug circuit, the glow plug on the affected cylinder will be disabled and the glow plug controller will send an error message to the ECM via the controller area network (CAN) communication bus. DTC P0671 - P0674 will set depending upon which cylinder failed. This DTC will only run once per ignition cycle within the enabling condition.

Condition for Running the DTC

- DTCs U0073 and U0106 are not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The glow plug controller detects an open or a short circuit in the glow plug circuit.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty glow plug(s)
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at glow plug controller: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P0671 - P0674 Last Test" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Notice:
Each Diagnostic Trouble Code (DTC) agrees with the engine cylinder order.
P0671: Cylinder No. 1
P0672: Cylinder No. 2
P0673: Cylinder No. 3
P0674: Cylinder No. 4

DTC P0671 - P0674

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. 3. Turn ON the ignition, with the engine OFF. Is DTC P0670 also set?	—	Go to DTC P0670	Go to Step 3

Step	Action	Value(s)	Yes	No
3	Monitor DTC P0671-P0674 with a scan tool. Does DTC P0671, P0672, P0673 or P0674 Last Test indicate Failed?	—	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Visually inspect the glow plug control harness for objects touching the affected glow plug terminal(s). Did you find and correct the condition?	—	Go to Step 13	Go to Step 5
5	1. Turn OFF the ignition. 2. Disconnect the affected glow plug harness connector(s). 3. Turn ON the ignition, with the engine OFF. 4. Connect a DMM between the disconnected harness connector(s) and a known good ground. Is the voltage reading within the specified range?	4 - 7 volts	Go to Step 6	Go to Step 8
6	1. Turn OFF the ignition. 2. Connect a test lamp between the affected glow plug terminal(s) and battery voltage. Does the test lamp illuminate?	—	Go to Step 7	Go to Step 11
7	Measure resistance between the glow plug terminal and a known good ground. Compare this reading to the other three glow plugs (disconnecting the other three is not necessary). Are the resistance within the specified value each other?	1Ω	Go to Step 9	Go to Step 11
8	**Important:** The glow plug may be damaged if the glow plug control circuit is shorted to a voltage source. 1. Test the affected glow plug control circuit(s) between the glow plug controller and glow plug for the following conditions: • An open circuit • A short to ground • A short to battery or ignition voltage • High resistance P0671: Between pin 1 of E-144 & E-146 connector P0672: Between pin 2 of E-144 & E-147 connector P0673: Between pin 3 of E-144 & E-148 connector P0674: Between pin 4 of E-144 & E-149 connector 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 10

Step	Action	Value(s)	Yes	No
9	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the affected glow plug(s). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 11
10	1. Turn OFF the ignition. 2. Disconnect the glow plug controller harness connector. 3. Inspect for an intermittent, poor connections and corrosion on the affected glow plug control circuit(s) at the harness connector of the glow plug controller. • P0671: Pin 1 of E-144 connector • P0672: Pin 2 of E-144 connector • P0673: Pin 3 of E-144 connector • P0674: Pin 4 of E-144 connector 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12
11	Replace the affected glow plug(s). Refer to Glow Plug Replacement in the Engine Electrical section. Did you find and correct the condition?	—	Go to Step 13	—
12	Replace the Glow Plug Controller. Refer to Glow Plug Controller Replacement in this section. Did you complete the replacement?	—	Go to Step 13	—
13	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 14
14	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0687

Circuit Description

The engine control module (ECM) main relay is energized when the ECM receives an ignition switch ON signal. If the ECM detects the ECM main relay has been ON since the ignition switch was turned OFF, this DTC will set.

Condition for Running the DTC

- The ignition switch is OFF.
- The engine is stopped.

Condition for Setting the DTC

- The ECM detects that the ECM main relay has been ON (high voltage) for longer than 5 seconds since the ignition switch was turned OFF.

Action Taken When the DTC Sets

- The ECM will not illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Condition for Clearing the DTC

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty or sticking ECM main relay
- Misrouted harness
- Rubbed through wire insulation
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P0687" display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Test Description

The numbers below refers to the step number on the diagnostic table.
2. If this DTC is present condition, scan tool can communicate to the ECM with the ignition OFF.

DTC P0687

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail with the ignition OFF?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Disconnect the engine control module (ECM) main relay. 2. Monitor the DTC Information with a scan tool. Does the DTC fail with the ignition OFF?	—	Go to Step 6	Go to Step 4
4	1. Turn OFF the ignition. 2. Connect a test lamp between the control circuit of the ECM main relay harness (pin 2 of J-208 connector) and battery voltage. 3. Keep the ignition OFF. Does the test lamp illuminate?	—	Go to Step 5	Go to Step 8

Step	Action	Value(s)	Yes	No
5	1. Test the control circuits of ECM main relay between the ECM (pins A-52 & A-53 of J-218 connector) and the ECM main relay (pin 2 of J-208 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 7
6	1. Test the power circuit of the ECM main relay between the ECM (pins A-49, A-50 & A-73 of J-218 connector) and the ECM main relay (pin 1 of J-208 connector) for a short to battery. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 7
7	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect connections on the ECM main relay circuit at the harness connector of the ECM (pins A-49, A-50, A-52, A-53 & A-73 of J-218 connector) for corrosion. 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 9
8	Replace the ECM main relay. Did you complete the replacement?	—	Go to Step 10	—
9	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 10	—
10	1. Reconnect all previously disconnected relay or harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Monitor the DTC Information with a scan tool. Did the DTC with the ignition OFF?	—	Go to Step 3	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0698

Circuit Description

The engine control module (ECM) provides 5 volts reference voltage through the reference circuit 3 to the accelerator pedal position (APP) sensor 3. The ECM monitors the voltage on the 5 volts reference circuit 3. If the ECM detects the voltage is excessively low, this DTC will set.

Condition for Running the DTC

- DTC P0699 is not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the 5 volts reference circuit 3 voltage is less than 4.5 volts.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "5 Volt Reference 3" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0698

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the 5 Volt Reference 3 parameter with a scan tool. Is the 5 Volt Reference 3 parameter less than the specified value?	4.5 volts	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the accelerator pedal position (APP) sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 3 parameter with a scan tool. Is the 5 Volt Reference 3 parameter less than the specified value?	4.5 volts	Go to Step 4	Go to Step 5

Step	Action	Value(s)	Yes	No
4	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-56 of J-218 connector) and the APP sensor 3 (pin B of B-280 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 6
5	Replace the APP sensor. Refer to Accelerator Pedal Position (APP) Sensor Replacement in this section. (APP sensor 3 is internal to APP sensor assembly). Did you complete the replacement?	—	Go to Step 7	—
6	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 7	—
7	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 8
8	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0699

Circuit Description

The engine control module (ECM) provides 5 volts reference voltage through the reference circuit 3 to the accelerator pedal position (APP) sensor 3. The ECM monitors the voltage on the 5 volts reference circuit 3. If the ECM detects the voltage is excessively high, this DTC will set.

Condition for Running the DTC

- DTC P0698 is not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the 5 volts reference circuit 3 voltage is more than 5.5 volts.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "5 Volt Reference 3" display on the scan tool while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0699

Schematic Reference: Engine Controls Schematics

Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the 5 Volt Reference 3 parameter with a scan tool. Is the 5 Volt Reference 3 parameter more than the specified value?	5.5 volts	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the accelerator pedal position (APP) sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the 5 Volt Reference 3 parameter with a scan tool. Is the 5 Volt Reference 3 parameter more than the specified value?	5.5 volts	Go to Step 4	Go to Step 5

Step	Action	Value(s)	Yes	No
4	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-56 of J-218 connector) and the APP sensor 3 (pin B of B-280 connector) for a short battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 6	Go to Step 5
5	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 6	—
6	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 7
7	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0700

Circuit Description

The transmission control module (TCM) requests to illuminate the malfunction indicator lamp (MIL) through the request circuit to the engine control module (ECM) when the TCM sets a MIL request DTC(s). If the ECM detects the MIL illumination request signal, this DTC will set.

Condition for Running the DTC

- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the MIL illumination is requested by the TCM for longer than 6 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

Notice:
Under normal conditions if the TCM sets a DTC that requests the MIL to be illuminated, P0700 will set.

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P0700 Last Test" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Test Description

The number below refers to the step number on the diagnostic table.

2. If the TCM has diagnostic trouble codes (DTCs) set that are requesting MIL illumination, diagnose that DTC FIRST.

9. If the TCM has DTCs set, clear the DTCs in the TCM FIRST.

DTC P0700

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check -Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Start the engine. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Are there any transmission DTCs set?	—	Refer to Applicable Diagnostic Trouble Code (DTC) in Automatic Transmission Control	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the transmission control module (TCM) harness connector. 3. Connect a DMM between the MIL request circuit (pin 22 of B-229 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	10 volts	Go to Step 5	Go to Step 4
4	1. Test the MIL request circuit between the engine control module (ECM) (pin A-22 of J-218 connector) and the TCM (pin 22 of B-229 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 9	Go to Step 6
5	1. Turn OFF the ignition. 2. Inspect connections on the MIL request circuit at the harness connector of the TCM (pin 22 of B-229 connector) for corrosion and for short to another circuit. 3. Repair or clean the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 9	Go to Step 7
6	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect connections on the MIL request circuit at the harness connector of the ECM (pin A-22 of J-218 connector) for corrosion and for short to another circuit. 4. Repair or clean the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 9	Go to Step 8
7	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Transmission Control Module (TCM) Replacement in the Automatic Transmission section. Did you complete the replacement?	—	Go to Step 9	—
8	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did the DTC fail this ignition?	—	Go to Step 9	—

Step	Action	Value(s)	Yes	No
9	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 10
10	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0802

Circuit Description

The transmission control module (TCM) requests to illuminate the malfunction indicator lamp (MIL) through the request circuit to the engine control module (ECM) when the TCM sets a MIL request DTC(s). If the ECM detects the MIL request circuit is open or the voltage level high when MIL illumination is commanded ON by the TCM, this DTC will set.

This DTC will only run once per ignition cycle within the enabling condition.

Condition for Running the DTC

- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the MIL request circuit is open or the voltage level is high for longer than 2 seconds when MIL illumination is commanded ON by the TCM.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM and TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.

Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P0802 Last Test" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0802

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check -Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Turn OFF the ignition. 2. Disconnect the transmission control module (TCM) harness connector. 3. Connect a DMM between the MIL request circuit (pin 22 of B-229 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	10 volts	Go to Step 4	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Test the MIL request circuit between the engine control module (ECM) (pin A-22 of J-218 connector) and the TCM (pin 22 of B-229 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 7
4	**Important:** The transmission control module (TCM) may be damaged if the MIL request circuit is shorted to a voltage source. 1. Test the MIL request circuit between the ECM (pin A-22 of J-218 connector) and the TCM (pin 22 of B-229 connector) for a short to battery or ignition voltage. **Notice:** Perform this by connecting a test lamp between the TCM (pin 22 of B-229 connector) and a known good ground. If the test lamp illuminates, the circuit is shorted to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 5
5	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the MIL request circuit of the TCM harness connector (pin 22 of B-229 connector) and a known good ground. 3. Clear the DTCs with a scan tool. Does DTC P0700 set, but not DTC P0802?	—	Go to Step 6	Go to Step 9
6	1. Turn OFF the ignition. 2. Inspect for an intermittent and for a poor connection at the harness connector of the TCM (pin 22 of B-229 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 8
7	1. Turn OFF the ignition. 2. Inspect for an intermittent and for a poor connection at the harness connector of the ECM (pin A-22 of J-218 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 9
8	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Transmission Control Module (TCM) Replacement in the Automatic Transmission section. Did you complete the replacement?	—	Go to Step 10	—

Step	Action	Value(s)	Yes	No
9	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/ Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 10	—
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1093

Description

The common rail fuel system is comprised of two fuel pressure sections: a suction side between the fuel tank and the fuel supply pump and a high-pressure side between the fuel supply pump and the fuel injectors. Fuel is drawn from the fuel tank via a feed pump and then pumped into the fuel rail by two plungers, all of which are internal to the fuel supply pump. This high pressure is regulated by the engine control module (ECM) using the fuel rail pressure (FRP) regulator dependant upon values from the FRP sensor attached to the fuel rail.

If the ECM detects that the fuel pressure is a certain pressure lower than the desired fuel rail pressure for a certain length of time, this DTC will set.

Condition for Running the DTC

- DTCs P0089, P0091, P0092, P0192, P0193, P0335, P0336, P0602, P0642 and P0643 are not set.
- The battery voltage is between 10 - 16 volts.
- The barometric pressure (BARO) is more than 11 psi (75 kPa).
- The fuel rail pressure (FRP) regulator commanded fuel flow is more than a threshold.

Condition for Setting the DTC

- The ECM detects that the actual fuel rail pressure is less than desired pressure by 4350 psi (30 MPa) for longer than 10 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails
- The ECM inhibits cruise control.
- The ECM inhibits PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- An intermittently sticking fuel rail pressure (FRP) regulator may have allowed the fuel pressure to drop.
- Normal Actual Fuel Rail Pressure readings on the scan with the engine running in Park or Neutral at idle are around 3650 to 5050 psi (25 to 35 MPa) and around 14500 to 21750 psi (100 to 150 MPa) in Park or Neutral at W.O.T. (accelerator pedal full travel).
- An intermittently sticking fuel injector may have allowed the fuel pressure to drop too much. Use a scan tool to perform the Cylinder Power Balance test for each injector. Verify a consistent engine speed change when commanding each fuel injector ON and OFF.
- A skewed FRP sensor value (shifted to a lower pressure) can set this DTC. The Actual Fuel Rail Pressure on the scan tool should read 0 psi (0 MPa) with the key ON and engine OFF after the engine has stopped running for a minimum of 2 minutes.
- Resistance in the FRP sensor low reference circuit can set this DTC. Ensure that the sensor low reference circuit has no resistance and the connectors are tight and free of corrosion.

Notice:
This DTC most likely indicates a loss of fuel pressure by a restricted suction side fuel line. Inspect the suction side fuel restriction between the fuel supply pump and fuel tank.

Notice:
The Actual Fuel Rail Pressure on scan tool will only update with the engine running or one time after the key is cycled when the ignition has been turned OFF for longer than 10 seconds.

Notice:
The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight or if there is a crack in one of the fuel hoses. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load, which may set this DTC.

Notice:
If the fuel tank is empty or near empty, air might be allowed to go into the fuel system. With air in the fuel system, smooth flow of fuel into the supply pump is interrupted and this DTC may set. Perform bleeding of fuel system after refilling.

Test Description

The numbers below refer to the step number on the diagnostic table.

5. This step checks for a fuel restriction by determining if a high vacuum is being pulled on the fuel system during normal operation.
6. This step checks for an air leak on the suction side of the fuel system by determining if a vacuum can be pulled when a fuel line is plugged.

DTC P1093

Schematic Reference: Engine Controls Schematics

Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Start the engine. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0087, P0091, P0092, P0192, P0193, P0201-P0204, P0261, P0264, P0267, P0270 or P2146-P2151 set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3
3	1. Turn OFF the ignition. 2. Wait 2 minutes for the fuel pressure to bleed down from the fuel rail. 3. Turn ON the ignition with the engine OFF, do not start the engine. 4. Observe the Actual Fuel Rail Pressure parameter with a scan tool. Is the Actual Fuel Rail Pressure parameter the specified value?	0 psi (0 MPa)	Go to Step 4	Go to Step 11

Step	Action	Value(s)	Yes	No
4	1. Turn OFF the ignition. 2. Check the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. **Notice:** The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load, which may set this DTC. 3. Pump the priming pump on the fuel filter until it becomes firm. If there is a leak on the suction side of the fuel system between the priming pump and the fuel supply pump, the priming pump will not build up sufficient firmness and fuel leakage may occur. 4. Start the engine and check for high side fuel system leaks at the fuel supply pump and fuel rail. **Notice:** Fuel may leak under the cylinder head cover from the inlet high pressure line. In such case, the engine oil level will rise. Inspect for fuel leakage into the engine oil. 5. Repair any fuel system leaks as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 5

Step	Action	Value(s)	Yes	No
5	1. Turn OFF the ignition. 2. Remove the rubber fuel hose from the fuel filter housing (fuel supply pump side). Use a pan to catch the fuel leakage from the removed fuel line. **Important:** The fuel vacuum pump/pressure gauge connector and the adapter hose must be cleaned before connecting to the fuel line. Otherwise, foreign material internal to the tools line may damage the fuel supply pump. 3. Connect the suction side fuel pressure adapter EN-47667 with fuel vacuum/ pressure gauge assembly J-44638 in series with the filter housing and the disconnected fuel hose. Ensure the service tool and fuel line connections are tight. 4. Bleed the fuel system by priming the priming pump until it becomes firm, then crank over the engine for a maximum of 5 seconds. Repeat as necessary until the engine starts. 5. Let the engine run at idle for at least 1 minute. 6. Monitor the fuel vacuum/pressure gauge while holding the engine speed higher than 2500 RPM for a minimum of 1 minute. Does the vacuum/pressure gauge ever indicate a larger vacuum than the specified amount during the test?	5 inHg	Go to Step 7	Go to Step 6
6	1. Fully clamp off a fuel hose as close to the fuel tank as possible (this will draw vacuum on the fuel system). You can also disconnect a fuel line and plug it. 2. Start the engine and turn the idle up control knob to the highest position. (Full clockwise direction. The idle speed is increased up to 1600 RPM.) 3. Monitor the fuel pressure/vacuum gauge. **Notice:** Release the clamp or open the plug when the gauge is likely to be more than 8 inHg during the test. Can a vacuum of at least the specified amount be pulled on the fuel system?	8 inHg	Go to Step 9	Go to Step 8

Step	Action	Value(s)	Yes	No
7	1. Inspect the fuel lines between the fuel supply pump and fuel tank for being crushed or kinked. 2. Inspect for a plugged fuel tank vent valve. 3. Inspect inside the fuel tank (if possible) for any foreign material that may be getting drawn into the fuel line pickup causing a blocked condition. 4. Repair as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 12
8	1. Turn OFF the ignition. 2. Check the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. 3. Repair as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 10
9	1. Turn OFF the ignition. 2. Unclamp or unplug the fuel line from the previous step and reconnect the fuel line (if disconnected). 3. Start the engine and allow it to run for at least 1 minute. 4. Perform the Cylinder Power Balance test with a scan tool. 5. Command each injector OFF and verify an engine speed change for each injector. Is there an injector that does not change engine speed when commanded OFF?	—	Go to Step 14	Go to Step 16
10	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure (FRP) regulator harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the FRP regulator (pins 1 and 2 of E-116). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP regulator circuit at the harness connector of the ECM (pins B-20, B-21, B-33 and B-34 of J-217 connector). 6. Test for high resistance on each FRP regulator circuit. 7. Repair the connection(s) or circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 15

Step	Action	Value(s)	Yes	No
11	1. Turn OFF the ignition. 2. Disconnect the FRP sensor harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the FRP sensor (pins 1, 2 and 3 of E-113 connector). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP sensor circuit at the harness connector of the ECM (pins B-13, B-25, B-26 and B-47 of J-217 connector). 6. Test for high resistance on each FRP circuit. 7. Repair the connection(s) or circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 13
12	Replace the fuel filter cartridge. Refer to Fuel Filter Cartridge Replacement in the Fuel System Section. Did you complete the replacement?	—	Go to Step 17	—
13	Replace the fuel rail pressure sensor. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 17	—
14	**Important:** Replacement injector must be programmed. Replace the appropriate fuel injector that does not change engine speed when commanded OFF. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 17	—
15	**Important:** The fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM. **Notice:** Always replace the fuel filter cartridge when a fuel supply pump is replaced. Replace the fuel supply pump and fuel filter cartridge. Refer to Fuel Supply Pump Replacement/Fuel Supply Pump Relearn Procedure in this section and Fuel Filter Cartridge Replacement in Fuel system section. Did you complete the replacement?	—	Go to Step 17	—
16	**Notice:** There is a possibility that the pressure limiter valve stuck open or opening pressure has fallen. Replace the pressure limiter valve. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 17	—

Step	Action	Value(s)	Yes	No
17	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 18
18	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1125

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal control assembly. The sensor is made up of three individual sensors within one housing. The APP sensor 1, APP sensor 2 and APP sensor 3 are potentiometer type sensors, each with the following circuits.

- 5 volts reference circuit
- Low reference circuit
- Signal circuit

The engine control module (ECM) supplies 5 volts to the APP sensor on the 5 volts reference circuits. The ECM also provides a ground on the low reference circuits. The APP sensor provides a signal to the ECM on the APP sensor signal circuits, which is relative to the position changes of the accelerator pedal angle. The APP sensor 1 signal voltage is low at rest and increases as the pedal is depressed. The APP sensor 2 signal voltage is high at rest and decreases as the pedal is depressed. The APP sensor 3 signal is high at rest and decreases as the pedal is depressed. If the ECM detects two or more APP sensors open, this DTC will set.

APP Sensor Position Table

APP Sensor	Actual Pedal Position	% Depressed as Observed on a Scan Tool	Voltage as Observed on a Scan Tool
1	Pedal at reset	0	0.52–0.80
1	Pedal at full travel	100	2.12–2.78
2	Pedal at reset	0	4.25–4.53
2	Pedal at full travel	100	2.24–2.93
3	Pedal at reset	0	3.95–4.13
3	Pedal at full travel	100	2.69–3.16

Condition for Running the DTC

- DTCs P0642, P0643, P0652, P0653, P0698 and P0699 are not set.

Condition for Setting the DTC

- Two of the three APP sensor signals contain an open circuit.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "APP Sensor 1,2 and 3" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

Notice:
A disconnected APP sensor may set this DTC.

DTC P1125

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition, with the engine OFF. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0642, P0643, P0652, P0653, P0698 or P0699 also set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3
3	This DTC indicates that two or more accelerator pedal position (APP) sensor DTCs are set. Are other APP sensor DTCs set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 4
4	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the APP sensor 1, 2 and 3 (pins A, B, D, E, F, G, H, J and K of B-280 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 6	Go to Step 5
5	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) harness connector. 3. Inspect for an intermittent and for a poor connection on these APP sensor 1, 2 and 3 circuits at the harness connector of the ECM (pins A-7, A-8, A-9, A-31, A-32, A-33, A-54, A-55 and A-56 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 6	Go to Diagnostic Aids
6	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 7

Step	Action	Value(s)	Yes	No
7	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1293

Circuit Description

The charge up circuit in the engine control module (ECM) steps up the voltage for injectors and is divided into two banks, common 1 and 2. The common 1 covers injectors in cylinders 1 and 4, and the common 2 covers injectors in cylinders 2 and 3. If the common 1 or 2 injector charge up voltage circuit in the ECM is excessively high or low, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the injector charge up circuit is of insufficient charge or has an overcharge.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM limits fuel rail pressure within 17400 psi (120 MPa).

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

DTC P1293

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Step 4
3	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 4	—
4	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 5
5	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1404

Circuit Description

The engine control module (ECM) controls the EGR valve opening based on the atmospheric pressure, engine speed, engine coolant temperature, intake air temperature and fuel injection quantity. The ECM controls the EGR valve by controlling the EGR DC motor. The EGR valve position is detected by the EGR position sensor, and relayed to ECM. If the ECM detects a difference between the learned closed position and the commanded closed position for a calibrated amount of time, this DTC will set.

Condition for Running the DTC

- DTCs P0112, P0113, P0116, P0117, P0118, P0403, P0405, P0406, P0642, P0643, P2227, P2228 and P2229 are not set.
- The ignition switch is ON for 2 seconds.
- The desired EGR valve position is stable.

Condition for Setting the DTC

- The ECM detects that the EGR learned minimum position is more than 5mm and actual EGR valve position is more than 5% for 3 seconds.

OR

- The ECM detects that the EGR learned minimum position is less than -5mm and actual EGR valve position is more than 5% for 3 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes after the key is cycled.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- A sticking or intermittently sticking the EGR valve may set this DTC.

If an intermittent condition is suspected, the following may cause an intermittent:

- Faulty EGR valve
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "EGR Current Position" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Test Description

The number below refers to the step number on the diagnostic table.

8. Operate the vehicle within the same conditions as when the DTC failed. If you can not duplicate this DTC, use the information in the Freeze Frame/Failure Records data can help to locate an intermittent condition.

DTC P1404

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0403, P0405 or P0406 also set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the EGR valve harness connector. 3. Connect a test lamp between the duty signal control circuit of the EGR valve motor harness (pin 6 of E-94 connector) and battery voltage. 4. Turn ON the ignition, with the engine OFF. Does the test lamp continuously illuminate (note that the test lamp will blink then go out normally)?	—	Go to Step 4	Go to Step 5
4	1. Test the EGR valve motor duty control circuit between the engine control module (ECM) (pin B-8 of J-217 connector) and the EGR valve (pin 6 of E-94 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
5	1. Test the low reference circuit between the ECM (pin B-17 of J-217 connector) and the EGR valve (pin 2 of E-94 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 6
6	1. Turn OFF the ignition. 2. Inspect for an intermittent, for a poor connection and corrosion at the harness connector of the EGR valve position sensor (pin 2 of E-94 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 7
7	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion on the EGR valve position sensor circuit at the harness connector of the ECM (pin B-17 of J-217 connector). Did you find and correct the condition?	—	Go to Step 11	Go to Step 8

Step	Action	Value(s)	Yes	No
8	Command the EGR Solenoid to 100% while observing the EGR Position Sensor parameter with a scan tool. Does the EGR Position Sensor parameter change in accordance with the EGR Solenoid Command?	—	Go to Diagnostic Aids	Go to Step 9
9	Replace the EGR valve. Refer to EGR Valve Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—
10	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 11	—
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 12
12	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1593

Circuit Description

The idle up sensor controls the idle speed during warm-up and it is installed in the driver's side instrument panel. This sensor is active only when the gear position is in the neutral position (parking or neutral position for automatic transmission vehicle). When the shift lever is moved to another position, the signal is ignored. The engine control module (ECM) receives the idle up signal from the idle up sensor and controls the fuel injection quantity. The idle up sensor has following circuits.

- 5 volts reference circuit
- Low reference circuit
- Idle up sensor signal circuit

The ECM monitors the idle up sensor signals for voltages outside the normal range of the idle up sensor. If the ECM detects an excessively low idle up sensor voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0642 and P0643 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the idle up sensor signal voltage is less than 0.3 volts for longer than 1.5 seconds.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.
- The ECM disables idle up sensor control.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM disables idle up sensor control.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Idle up sensor intermittent open (turn knob and use scan tool to check voltage)
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Idle Up Sensor" display on the scan tool with ignition On and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

Test Description

The number below refers to the step number on the diagnostic table.

3. Turn the idle up sensor to the lowest position (full counterclockwise direction). The Idle Up Sensor parameter may exceed the low threshold value at lowest position if the low reference circuit is shorted to a ground circuit.

DTC P1593

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0642 also set?	—	Go to DTC P0642	Go to Step 3
3	1. Turn ON the ignition, with the engine OFF. 2. Turn the idle up sensor to lowest position (full counterclockwise direction). 3. Observe the Idle Up Sensor parameter with a scan tool. Is the Idle Up Sensor parameter less than the specified value?	0.3 volts	Go to Step 4	Go to Diagnostic Aids
4	1. Turn ON the ignition, with the engine OFF. 2. Turn the idle up sensor to highest position (full clockwise direction). 3. Observe the Idle Up Sensor parameter with a scan tool. Is the Idle Up Sensor parameter less than the specified value?	0.3 volts	Go to Step 5	Go to Step 9
5	1. Turn OFF the ignition. 2. Disconnect the idle up sensor harness connector. 3. Connect a DMM between the 5 volts reference circuit of the idle up sensor harness (pin 3 of B-374 connector) and a known good ground. 4. Turn ON the ignition, with engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 6	Go to Step 7
6	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the 5 volts reference circuit and the signal circuit of the idle up sensor harness (pins 3 and 2 of B-374 connector). 3. Turn ON the ignition, with the engine OFF. 4. Observe the Idle Up Sensor parameter with a scan tool. Is the Idle Up Sensor parameter more than specified value ?	4.5 volts	Go to Step 10	Go to Step 8

Step	Action	Value(s)	Yes	No
7	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-59 of J-218 connector) and the idle up sensor harness (pin 3 of B-374 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
8	1. Test the signal circuit between the ECM (pin A-35 of J-218 connector) and the idle up sensor (pin 2 of B-374 connector) for the following conditions: • An open circuit • A short to ground • A short to the low reference circuit • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
9	1. Test the low reference circuit between the ECM (pin A-11 of J-218 connector) and the idle up sensor (pin 1 of B-374 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 11
10	1. Turn OFF the ignition. 2. Disconnect the idle up sensor harness connector. 3. Inspect for an intermittent and for poor connections at the harness connector of the idle up sensor (pins 2 and 3 of B-374 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 12
11	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these idle up sensor circuits at the harness connector of the ECM (pins A-35 and A-59 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
12	Replace the idle up sensor. Refer to Idle Up Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 14	—

Step	Action	Value(s)	Yes	No
13	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 14	—
14	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 15
15	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1594

Circuit Description

The idle up sensor controls the idle speed during warm-up and it is installed in the driver's side instrument panel. This sensor is active only when the gear position is in the neutral position (parking or neutral position for automatic transmission vehicle). When the shift lever is moved to another position, the signal is ignored. The engine control module (ECM) receives the idle up signal from the idle up sensor and controls the fuel injection quantity. The idle up sensor has following circuits.

- 5 volts reference circuit.
- Low reference circuit.
- Idle up sensor signal circuit.

The ECM monitors the idle up sensor signals for voltages outside the normal range of the idle up sensor. If the ECM detects an excessively high idle up sensor voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0642 and P0643 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the idle up sensor signal voltage is more than 4.8 volts for longer than 1.5 seconds.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.
- The ECM disables idle up sensor control.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM disables idle up sensor control.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Idle Up Sensor" display on the scan tool with ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P1594

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the Idle Up Sensor parameter with a scan tool. Is the Idle Up Sensor parameter more than the specified value?	4.8 volts	Go to Step 3	Go to Diagnostic Aids
3	1. Start the engine. 2. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0643 also set?	—	Go to Step 4	Go to Step 5
4	1. Turn OFF the ignition. 2. Disconnect the idle up sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the Idle Up Sensor parameter with a scan tool. Is the Idle Up Sensor parameter less than the specified value?	0.3 volts	Go to DTC P0643	Go to Step 7
5	1. Turn OFF the ignition. 2. Disconnect the idle up sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the Idle Up Sensor parameter with a scan tool. Is the Idle Up Sensor parameter less than the specified value?	0.3 volts	Go to Step 6	Go to Step 7
6	1. Turn OFF the ignition. 2. Connect a test lamp between the low reference circuit of the idle up sensor harness (pin 1 of B-374 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 8
7	**Important:** The idle up sensor may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuit between the engine control module (ECM) (pin A-35 of J-218 connector) and the idle up sensor (pin 2 of B-374 connector) for the following conditions: • A short to battery or ignition voltage • A short to any 5 volts reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12

Step	Action	Value(s)	Yes	No
8	1. Test the low reference circuit between the ECM (pin A-11 of J-218 connector) and the idle up sensor (pin 1 of B-374 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 10
9	1. Turn OFF the ignition. 2. Inspect for an intermittent and for a poor connection at the harness connector of the idle up sensor (pin 1 of B-374 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 11
10	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the idle up sensor circuit at the harness connector of the ECM (pin A-11 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12
11	Replace the idle up sensor. Refer to Idle Up Sensor Replacement in this section. Did you complete the replacement?	—	Go to Step 13	—
12	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 13	—
13	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 14
14	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1597

Circuit Description

The power take off (PTO) throttle sensor (upfitter installed) detects the PTO control throttle angle. The engine control module (ECM) receives the PTO control throttle angle from the throttle sensor and controls the fuel injection quantity (engine speed) during PTO. The PTO throttle sensor has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- PTO throttle sensor signal circuit

The ECM supplies 5 volts to the PTO throttle sensor on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. The ECM monitors the PTO throttle sensor signal for voltages outside the normal range of the PTO throttle sensor. If the ECM detects an excessively high PTO throttle sensor signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0642 and P0643 are not set.
- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the PTO throttle sensor signal voltage is more than 4.9 volts for longer than 1 second.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.
- The ECM inhibits PTO control.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM inhibits PTO control.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "PTO Remote Throttle Sensor" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P1597

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the PTO Remote Throttle Sensor parameter with a scan tool. Is the PTO Remote Throttle Sensor parameter more than the specified value?	4.9 volts	Go to Step 3	Go to Diagnostic Aids
3	1. Start the engine. 2. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0643 also set?	—	Go to Step 4	Go to Step 5
4	1. Turn OFF the ignition. 2. Disconnect the PTO throttle sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the PTO Remote Throttle Sensor parameter with a scan tool. Is the PTO Remote Throttle Sensor parameter less than the specified value?	0.5 volts	Go to DTC P0643	Go to Step 7
5	1. Turn OFF the ignition. 2. Disconnect the PTO throttle sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the PTO Remote Throttle Sensor parameter with a scan tool. Is the PTO Remote Throttle Sensor parameter less than the specified value?	0.5 volts	Go to Step 6	Go to Step 7
6	1. Turn OFF the ignition. 2. Connect a test lamp between the low reference circuit at the PTO throttle sensor harness (pin G of H-123 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 8
7	**Important:** The PTO throttle sensor may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuit between the engine control module (ECM) (pin A-34 of J-218 connector) and the PTO throttle sensor (pin F of H-123 connector) for the following conditions: • A short to battery or ignition voltage • A short to any 5 volts reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12

Step	Action	Value(s)	Yes	No
8	1. Test the low reference circuit between the ECM (pin A-10 of J-218 connector) and the PTO throttle sensor (pin G of H-123 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 10
9	1. Turn OFF the ignition. 2. Inspect for an intermittent and for a poor connection at the harness connector of the PTO throttle sensor (pin G of H-123 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 11
10	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the PTO throttle sensor circuit at the harness connector of the ECM (pin A-10 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12
11	Replace the PTO throttle sensor. Did you complete the replacement?	—	Go to Step 13	—
12	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 13	—
13	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 14
14	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1621

Circuit Description

This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM).

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the calculated checksum does not agree with the ECM internal registered checksum.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM limits fuel injection quantity within 70%.
- The ECM limits fuel rail pressure within 17400 psi (120MPa).
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

P1621

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Step 4
3	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 4	—
4	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 5
5	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2122

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal control assembly. The sensor is made up of three individual sensors within one housing. The engine control module (ECM) uses the APP sensors to determine the amount of acceleration or deceleration desired by the person driving the vehicle via the fuel injector control. The APP sensor 1 has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- APP sensor 1 signal circuit

The ECM supplies 5 volts to the APP sensor 1 on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. The APP sensor 1 provides a signal to the ECM on the APP sensor 1 signal circuit, which is relative to the position changes of the accelerator pedal angle. The ECM monitors the APP sensor 1 signal for voltages outside the normal range of the APP sensor 1. If the ECM detects an excessively low APP sensor 1 signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0642 and P0643 are not set.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the APP sensor 1 signal voltage is less than 0.25 volts.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- APP sensor 1 may have an intermittent open somewhere in the pedal range
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "APP Sensor 1" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P2122

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0642 also set?	—	Go to DTC P0642	Go to Step 3
3	1. Turn ON the ignition, with the engine OFF. 2. Observe the accelerator pedal position (APP) Sensor 1 parameter with a scan tool. Is the APP Sensor 1 parameter less than the specified value?	0.25 volts	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Disconnect the APP sensor harness connector. 3. Connect a DMM between the 5 volts reference circuit of the APP sensor 1 harness (pin D of B-280 connector) and a known good ground. 4. Turn ON the ignition, with engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 5	Go to Step 6
5	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the 5 volts reference circuit and the signal circuit of the APP sensor 1 harness (pins D and E of B-280 connector). 3. Turn ON the ignition, with the engine OFF. 4. Observe the APP Sensor 1 parameter with a scan tool. Is the APP Sensor 1 parameter more than the specified value?	4.5 volts	Go to Step 8	Go to Step 7
6	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-54 of J-218 connector) and the APP sensor 1 (pin D of B-280 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9

Step	Action	Value(s)	Yes	No
7	1. Test the signal circuit between the ECM (pin A-31 of J-218 connector) and the APP sensor 1 (pin E of B-280 connector) for the following conditions: • An open circuit • A short to ground • A short to the low reference circuit • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9
8	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the APP sensor (pins D and E of B-280 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these APP sensor 1 circuits at the harness connector of the ECM (pins A-31 and A-54 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	Replace the APP sensor. Refer to Accelerator Pedal Position (APP) Sensor Replacement in this section. (APP sensor 1 is internal to APP sensor assembly) Did you complete the replacement?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 13

Step	Action	Value(s)	Yes	No
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2123

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal control assembly. The sensor is made up of three individual sensors within one housing. The engine control module (ECM) uses the APP sensors to determine the amount of acceleration or deceleration desired by the person driving the vehicle via the fuel injector control. The APP sensor 1 has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- APP sensor 1 signal circuit

The ECM supplies 5 volts to the APP sensor 1 on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. The APP sensor 1 provides a signal to the ECM on the APP sensor 1 signal circuit, which is relative to the position changes of the accelerator pedal angle. The ECM monitors the APP sensor 1 signal for voltages outside the normal range of the APP sensor 1. If the ECM detects an excessively high APP sensor 1 signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0642 and P0643 are not set.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the APP sensor 1 signal voltage is more than 4.75 volts.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- An open in the sensor during part of the pedal travel
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "APP Sensor 1" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P2123

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the accelerator pedal position (APP) Sensor 1 parameter with a scan tool. Is the APP Sensor 1 parameter more than the specified value?	4.75 volts	Go to Step 3	Go to Diagnostic Aids
3	1. Start the engine. 2. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0643 also set?	—	Go to Step 4	Go to Step 5
4	1. Turn OFF the ignition. 2. Disconnect the APP sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the APP Sensor 1 parameter with a scan tool. Is the APP Sensor 1 parameter less than the specified value?	0.25 volts	Go to DTC P0643	Go to Step 7
5	1. Turn OFF the ignition. 2. Disconnect the APP sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the APP Sensor 1 parameter with a scan tool. Is the APP Sensor 1 parameter less than the specified value?	0.25 volts	Go to Step 6	Go to Step 7
6	1. Turn OFF the ignition. 2. Connect a test lamp between the low reference circuit of the APP sensor 1 harness (pin K of B-280 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 8

Step	Action	Value(s)	Yes	No
7	**Important:** The APP sensor 1 may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuit between the engine control module (ECM) (pin A-31 of J-218 connector) and the APP sensor 1 (pin E of B-280 connector) for the following conditions: • A short to battery or ignition voltage • A short to any 5 volts reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12
8	1. Test the low reference circuit between the ECM (pin A-7 of J-218 connector) and the APP sensor 1 (pin K of B-280 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 10
9	1. Turn OFF the ignition. 2. Inspect for an intermittent and for a poor connection at the harness connector of the APP sensor (pin K of B-280 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 11
10	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the APP sensor 1 circuit at the harness connector of the ECM (pin A-7 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12
11	Replace the APP sensor. Refer to Accelerator Pedal Position (APP) Sensor Replacement in this section. (APP sensor 1 is internal to APP sensor assembly) Did you complete the replacement?	—	Go to Step 13	—
12	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 13	—

Step	Action	Value(s)	Yes	No
13	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 14
14	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2127

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal control assembly. The sensor is made up of three individual sensors within one housing. The engine control module (ECM) uses the APP sensors to determine the amount of acceleration or deceleration desired by the person driving the vehicle via the fuel injector control. The APP sensor 2 has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- APP sensor 2 signal circuit

The ECM supplies 5 volts to the APP sensor 2 on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. The APP sensor 2 provides a signal to the ECM on the APP sensor 2 signal circuit, which is relative to the position changes of the accelerator pedal angle. The ECM monitors the APP sensor 2 signal for voltages outside the normal range of the APP sensor 2. If the ECM detects an excessively low APP sensor 2 signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0652 and P0653 are not set.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the APP sensor 2 signal voltage is less than 0.25 volts.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- APP sensor 2 may have an intermittent open somewhere in the pedal range
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "APP Sensor 2" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P2127

Schematic Reference: Engine Controls Schematics

Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0652 also set?	—	Go to DTC P0652	Go to Step 3
3	1. Turn ON the ignition, with the engine OFF. 2. Observe the accelerator pedal position (APP) Sensor 2 parameter with a scan tool. Is the APP Sensor 2 parameter less than the specified value?	0.25 volts	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Disconnect the APP sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the APP Sensor 2 parameter with a scan tool. Is the APP Sensor 2 parameter more than the specified value?	4.5 volts	Go to Step 5	Go to Step 6
5	1. Turn OFF the ignition. 2. Connect a DMM between the 5 volts reference circuit of the APP sensor 2 harness (pin J of B-280 connector) and a known good ground. 3. Turn ON the ignition, with engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 8	Go to Step 7
6	1. Test the signal circuit between the engine control module (ECM) (pin A-32 of J-218 connector) and the APP sensor 2 (pin H of B-280 connector) for the following conditions: • A short to ground • A short to the low reference circuit 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
7	1. Test the 5 volts reference circuit between the ECM (pin A-55 of J-218 connector) and the APP sensor 2 (pin J of B-280 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Inspect for an intermittent and for a poor connection at the harness connector of the APP sensor (pin J of B-280 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the APP sensor 2 circuit at the harness connector of the ECM (pin A-55 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	Replace the APP sensor. Refer to Accelerator Pedal Position (APP) Sensor Replacement in this section. (APP sensor 2 is internal to APP sensor assembly) Did you complete the replacement?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 13
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2128

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal control assembly. The sensor is made up of three individual sensors within one housing. The engine control module (ECM) uses the APP sensors to determine the amount of acceleration or deceleration desired by the person driving the vehicle via the fuel injector control. The APP sensor 2 has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- APP sensor 2 signal circuit

The ECM supplies 5 volts to the APP sensor 2 on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. The APP sensor 2 provides a signal to the ECM on the APP sensor 2 signal circuit which is relative to the position changes of the accelerator pedal angle. The ECM monitors the APP sensor 2 signal for voltages outside the normal range of the APP sensor 2. If the ECM detects an excessively high APP sensor 2 signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0652 and P0653 are not set.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the APP sensor 2 signal voltage is more than 4.75 volts.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- An open in the sensor during part of the pedal travel
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "APP Sensor 2" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P2128

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0653 also set?	—	Go to DTC P0653	Go to Step 3
3	1. Turn ON the ignition, with the engine OFF. 2. Observe the accelerator pedal position (APP) Sensor 2 parameter with a scan tool. Is the APP Sensor 2 parameter more than the specified value?	4.75 volts	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Disconnect the APP sensor harness connector. 3. Connect a DMM between the signal circuit of the APP sensor 2 harness (pin H of B-280 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	5.5 volts	Go to Step 10	Go to Step 5
5	1. Turn OFF the ignition. 2. Connect a test lamp between the signal circuit of the APP sensor 2 harness (pin H of B-280 connector) and a known good ground. 3. Connect a DMM between the probe of the test lamp and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 9	Go to Step 6
6	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit and the low reference circuit of the APP sensor 2 harness (pins H and G of B-280 connector). 3. Turn ON the ignition, with the engine OFF. 4. Observe the APP Sensor 2 parameter with a scan tool. Is the APP Sensor 2 parameter less than the specified value?	0.25 volts	Go to Step 11	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Test the low reference circuit between the engine control module (ECM) (pin A-8 of J-218 connector) and the APP sensor 2 (pin G of B-280 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 8
8	1. Test the signal circuit between the ECM (pin A-32 of J-218 connector) and the APP sensor 2 (pin H of B-280 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 12
9	1. Test the signal circuit between the ECM (pin A-32 of J-218 connector) and the APP sensor 2 (pin H of B-280 connector) for short to any 5 volts reference circuit. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
10	**Important:** The APP sensor 2 may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuit between the ECM (pin A-32 of J-218 connector) and the APP sensor 2 (pin H of B-280 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
11	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the APP sensor (pins H and G of B-280 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 13
12	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these APP sensor 2 circuits at the harness connector of the ECM (pins A-8 and A-32 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
13	Replace the APP sensor. Refer to Accelerator Pedal Position (APP) Sensor Replacement in this section. (APP sensor 2 is internal to APP sensor assembly) Did you complete the replacement?	—	Go to Step 15	—

Step	Action	Value(s)	Yes	No
14	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 15	—
15	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 16
16	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2132

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal control assembly. The sensor is made up of three individual sensors within one housing. The engine control module (ECM) uses the APP sensors to determine the amount of acceleration or deceleration desired by the person driving the vehicle via the fuel injector control. The APP sensor 3 has the following circuits.

- 5 volts reference circuit
- Low reference circuit
- APP sensor 3 signal circuit

The ECM supplies 5 volts to the APP sensor 3 on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. The APP sensor 3 provides a signal to the ECM on the APP sensor 3 signal circuit which is relative to the position changes of the accelerator pedal angle. The ECM monitors the APP sensor 3 signal for voltages outside the normal range of the APP sensor 3. If the ECM detects an excessively low APP sensor 3 signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0698 and P0699 are not set.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the APP sensor 3 signal voltage is less than 0.25 volts.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- APP sensor 3 may have an intermittent open somewhere in the pedal range
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "APP Sensor 3" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P2132

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0698 also set?	—	Go to DTC P0698	Go to Step 3
3	1. Turn ON the ignition, with the engine OFF. 2. Observe the accelerator pedal position (APP) Sensor 3 parameter with a scan tool. Is the APP Sensor 3 parameter less than the specified value?	0.25 volts	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Disconnect the APP sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the APP Sensor 3 parameter with a scan tool. Is the APP Sensor 3 parameter more than the specified value?	4.5 volts	Go to Step 5	Go to Step 6
5	1. Turn OFF the ignition. 2. Connect a DMM between the 5 volts reference circuit of the APP sensor 3 harness (pin B of B-280 connector) and a known good ground. 3. Turn ON the ignition, with engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 8	Go to Step 7
6	1. Test the signal circuit between the engine control module (ECM) (pin A-33 of J-218 connector) and the APP sensor 3 (pin A of B-280 connector) for the following conditions: • A short to ground • A short to the low reference circuit 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
7	1. Test the 5 volts reference circuit between the ECM (pin A-56 of J-218 connector) and the APP sensor 3 (pin B of B-280 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Inspect for an intermittent and for a poor connection at the harness connector of the APP sensor (pin B of B-280 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on the APP sensor 3 circuit at the harness connector of the ECM (pin A-56 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	Replace the APP sensor Refer to Accelerator Pedal Position (APP) Sensor Replacement in this section. (APP sensor 3 is internal to APP sensor assembly) Did you complete the replacement?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 13
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2133

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal control assembly. The sensor is made up of three individual sensors within one housing. The engine control module (ECM) uses the APP sensors to determine the amount of acceleration or deceleration desired by the person driving the vehicle via the fuel injector control. The APP sensor 3 has the following circuits.

- 5 volts reference circuit.
- Low reference circuit.
- APP sensor 3 signal circuit.

The ECM supplies 5 volts to the APP sensor 3 on the 5 volts reference circuit. The ECM also provides a ground on the low reference circuit. The APP sensor 3 provides a signal to the ECM on the APP sensor 3 signal circuit which is relative to the position changes of the accelerator pedal angle. The ECM monitors the APP sensor 3 signal for voltages outside the normal range of the APP sensor 3. If the ECM detects an excessively high APP sensor 3 signal voltage, this DTC will set.

Condition for Running the DTC

- DTCs P0698 and P0699 are not set.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the APP sensor 3 signal voltage is more than 4.75 volts.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- An open in the sensor during part of the pedal travel
- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "APP Sensor 3" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P2133

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0699 also set?	—	Go to DTC P0699	Go to Step 3
3	1. Turn ON the ignition, with the engine OFF. 2. Observe the accelerator pedal position (APP) Sensor 3 parameter with a scan tool. Is the APP Sensor 3 parameter more than the specified value?	4.75 volts	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Disconnect the APP sensor harness connector. 3. Connect a DMM between the signal circuit of the APP sensor 3 harness (pin A of B-280 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	5.5 volts	Go to Step 10	Go to Step 5
5	1. Turn OFF the ignition. 2. Connect a test lamp between the signal circuit of the APP sensor 3 harness (pin A of B-280 connector) and a known good ground. 3. Connect a DMM between the probe of the test lamp and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 9	Go to Step 6
6	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit and the low reference circuit of the APP sensor 3 harness (pins A and F of B-280 connector). 3. Turn ON the ignition, with the engine OFF. 4. Observe the APP Sensor 3 parameter with a scan tool. Is the APP Sensor 3 parameter less than the specified value?	0.25 volts	Go to Step 11	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Test the low reference circuit between the engine control module (ECM) (pin A-9 of J-218 connector) and the APP sensor 3 (pin F of B-280 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 8
8	1. Test the signal circuit between the ECM (pin A-33 of J-218 connector) and the APP sensor 3 (pin A of B-280 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 12
9	1. Test the signal circuit between the ECM (pin A-33 of J-218 connector) and the APP sensor 3 (pin A of B-280 connector) for a short to any 5 volts reference circuit. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
10	**Important:** The APP sensor 3 may be damaged if the sensor signal circuit is shorted to a voltage source. 1. Test the signal circuit between the ECM (pin A-33 of J-218 connector) and the APP sensor 3 (pin A of B-280 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
11	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the APP sensor (pins A and F of B-280 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 13
12	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these APP sensor 3 circuits at the harness connector of the ECM (pins A-9 and A-33 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
13	Replace the APP sensor. Refer to Accelerator Pedal Position (APP) Sensor Replacement in this section. (APP sensor 3 is internal to APP sensor assembly) Did you complete the replacement?	—	Go to Step 15	—

Step	Action	Value(s)	Yes	No
14	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 15	—
15	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 16
16	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2138

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal control assembly. The sensor is made up of three individual sensors within one housing. The APP sensor 1, APP sensor 2 and APP sensor 3 are potentiometer type sensors, each with the following circuits.

- 5 volts reference circuit
- Low reference circuit
- Signal circuit

The engine control module (ECM) supplies 5 volts to the APP sensor on the 5 volts reference circuits. The ECM also provides a ground on the low reference circuits. The APP sensor provides a signal to the ECM on the APP sensor signal circuits, which is relative to the position changes of the accelerator pedal angle. The APP sensor 1 signal voltage is low at rest and increases as the pedal is depressed. The APP sensor 2 signal voltage is high at rest and decreases as the pedal is depressed. The APP sensor 3 signal is high at rest and decreases as the pedal is depressed. If the ECM detects that the APP sensor 1 signal and the APP sensor 2 signal are out of the correlation, this DTC will set.

APP Sensor Position Table

APP Sensor	Actual Pedal Position	% Depressed as Observed on a Scan Tool	Voltage as Observed on a Scan Tool
1	Pedal at reset	0	0.52–0.80
1	Pedal at full travel	100	2.12–2.78
2	Pedal at reset	0	4.25–4.53
2	Pedal at full travel	100	2.24–2.93
3	Pedal at reset	0	3.95–4.13
3	Pedal at full travel	100	2.69–3.16

Condition for Running the DTC

- DTCs P0642, P0643, P0652 and P0653 are not set.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the APP sensor 1 and 2 are more than 10% out of range of each other.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "APP Sensor 1" and "APP Sensor 2" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P2138

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	**Important:** If DTC P0642, P0643, P0652, P0653, P0698, P0699, P2132 or P2133 also set, diagnose that DTC first. 1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. 5. Fully depress and release the accelerator pedal. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	Monitor the DTC Information with a scan tool. Is DTC P2140 also set?	—	Go to Step 5	Go to Step 4
4	Monitor the DTC Information with a scan tool. Is DTC P2139 also set?	—	Go to Step 8	Go to Step 11
5	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-55 of J-218 connector) and the APP sensor 2 harness (pin J of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 6
6	1. Test the low reference circuit between the ECM (pin A-8 of J-218 connector) and the APP sensor 2 (pin G of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 7
7	1. Test the signal circuit between the ECM (pin A-32 of J-218 connector) and the APP sensor 2 (pin H of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 8

Step	Action	Value(s)	Yes	No
8	1. Test the 5 volts reference circuit between the ECM (pin A-54 of J-218 connector) and the APP sensor 1 (pin D of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 9
9	1. Test the low reference circuit between the ECM (pin A-7 of J-218 connector) and the APP sensor 1 (pin K of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 10
10	1. Test the signal circuit between the ECM (pin A-31 of J-218 connector) and the APP sensor 1 (pin E of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 11
11	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-56 of J-218 connector) and the APP sensor 3 harness (pin B of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 12
12	1. Test the low reference circuit between the ECM (pin A-9 of J-218 connector) and the APP sensor 3 (pin F of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 13
13	1. Test the signal circuit between the ECM (pin A-33 of J-218 connector) and the APP sensor 3 harness (pin A of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 14
14	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the APP sensor 1, 2 or 3 (pins D, E, K or J, H, G or B, A, F of B-280 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 15

Step	Action	Value(s)	Yes	No
15	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these APP sensor 1, 2 or 3 circuits at the harness connector of the ECM (pins A-54, A-31, A-7 or A-55, A-32, A-8 or A-56, A-33, A-9 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 16
16	Replace the APP sensor. Refer to Accelerator Pedal Position (APP) Sensor Replacement in this section. (APP sensor 1, 2 or 3 is internal to APP sensor assembly) Did you complete the replacement?	—	Go to Step 17	—
17	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Monitor the DTC Information with a scan tool. 6. Fully depress and release the accelerator pedal. Does the DTC fail this ignition?	—	Go to Step 18	Go to Step 20
18	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 19	—
19	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 20
20	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2139

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal control assembly. The sensor is made up of three individual sensors within one housing. The APP sensor 1, APP sensor 2 and APP sensor 3 are potentiometer type sensors, each with the following circuits.

- 5 volts reference circuit
- Low reference circuit
- Signal circuit

The engine control module (ECM) supplies 5 volts to the APP sensor on the 5 volts reference circuits. The ECM also provides a ground on the low reference circuits. The APP sensor provides a signal to the ECM on the APP sensor signal circuits, which is relative to the position changes of the accelerator pedal angle. The APP sensor 1 signal voltage is low at rest and increases as the pedal is depressed. The APP sensor 2 signal voltage is high at rest and decreases as the pedal is depressed. The APP sensor 3 signal is high at rest and decreases as the pedal is depressed. If the ECM detects that the APP sensor 1 signal and the APP sensor 3 signal are out of the correlation, this DTC will set.

APP Sensor Position Table

APP Sensor	Actual Pedal Position	% Depressed as Observed on a Scan Tool	Voltage as Observed on a Scan Tool
1	Pedal at reset	0	0.52–0.80
1	Pedal at full travel	100	2.12–2.78
2	Pedal at reset	0	4.25–4.53
2	Pedal at full travel	100	2.24–2.93
3	Pedal at reset	0	3.95–4.13
3	Pedal at full travel	100	2.69–3.16

Condition for Running the DTC

- DTCs P0642, P0643, P0698 and P0699 are not set.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the APP sensor 1 and 3 are more than 10% out of range of each other.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "APP Sensor 1" and "APP Sensor 3" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P2139

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	**Important:** If DTC P0642, P0643, P0652, P0653, P0698, P0699, P2127 or P2128 is also set diagnose that DTC first. 1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. 5. Fully depress and release the accelerator pedal. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	Monitor the DTC Information with a scan tool. Is DTC P2138 also set?	—	Go to DTC P2138	Go to Step 4
4	Monitor the DTC Information with a scan tool. Is DTC P2140 also set?	—	Go to DTC P2140	Go to Step 5
5	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-55 of J-218 connector) and the APP sensor 2 harness (pin J of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 6
6	1. Test the low reference circuit between the ECM (pin A-8 of J-218 connector) and the APP sensor 2 (pin G of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 7
7	1. Test the signal circuit between the ECM (pin A-32 of J-218 connector) and the APP sensor 2 (pin H of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 8

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the APP sensor 2 (pins J, H or G of B-280 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 9
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these APP sensor 2 circuits at the harness connector of the ECM (pins A-8, A-32 or A-55 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 10
10	Replace the APP sensor. Refer to Accelerator Pedal Position (APP) Sensor Replacement in this section. (APP sensor 2 is internal to APP sensor assembly) Did you complete the replacement?	—	Go to Step 11	—
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Monitor the DTC Information with a scan tool. 6. Fully depress and release the accelerator pedal. Does the DTC fail this ignition?	—	Go to Step 12	Go to Step 14
12	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 13	—
13	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 14

Step	Action	Value(s)	Yes	No
14	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2140

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal control assembly. The sensor is made up of three individual sensors within one housing. The APP sensor 1, APP sensor 2 and APP sensor 3 are potentiometer type sensors, each with the following circuits.

- 5 volts reference circuit
- Low reference circuit
- Signal circuit

The engine control module (ECM) supplies 5 volts to the APP sensor on the 5 volts reference circuits. The ECM also provides a ground on the low reference circuits. The APP sensor provides a signal to the ECM on the APP sensor signal circuits, which is relative to the position changes of the accelerator pedal angle. The APP sensor 1 signal voltage is low at rest and increases as the pedal is depressed. The APP sensor 2 signal voltage is high at rest and decreases as the pedal is depressed. The APP sensor 3 signal is high at rest and decreases as the pedal is depressed. If the ECM detects that the APP sensor 2 signal and the APP sensor 3 signal are out of the correlation, this DTC will set.

APP Sensor Position Table

APP Sensor	Actual Pedal Position	% Depressed as Observed on a Scan Tool	Voltage as Observed on a Scan Tool
1	Pedal at reset	0	0.52–0.80
1	Pedal at full travel	100	2.12–2.78
2	Pedal at reset	0	4.25–4.53
2	Pedal at full travel	100	2.24–2.93
3	Pedal at reset	0	3.95–4.13
3	Pedal at full travel	100	2.69–3.16

Condition for Running the DTC

- DTCs P0652, P0653, P0698 and P0699 are not set.
- The ignition switch is ON.

Condition for Setting the DTC

- The ECM detects that the APP sensor 2 and 3 are more than 10% out of range of each other.

Action Taken When the DTC Sets

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when t the diagnostic runs and fails.

Condition for Clearing the MIL/DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- The ECM turns OFF the MIL when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "APP Sensor 2" and "APP Sensor 3" display on the scan tool with the ignition ON and engine OFF while moving connectors and the wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P2140

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	**Important:** If DTC P0642, P0643, P0652, P0653, P0698, P0699, P2122 or P2123 is also set, diagnose that DTC first. 1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. 5. Fully depress release the accelerator pedal. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	Monitor the DTC Information with a scan tool. Is DTC P2138 also set?	—	Go to DTC P2138	Go to Step 4
4	Monitor the DTC Information with a scan tool. Is DTC P2139 also set?	—	Go to Step 5	Go to Step 8
5	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-56 of J-218 connector) and the APP sensor 3 harness (pin B of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 6
6	1. Test the low reference circuit between the ECM (pin A-9 of J-218 connector) and the APP sensor 3 (pin F of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 7
7	1. Test the signal circuit between the ECM (pin A-33 of J-218 connector) and the APP sensor 3 harness (pin A of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 8

Step	Action	Value(s)	Yes	No
8	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin A-54 of J-218 connector) and the APP sensor 1 harness (pin D of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 9
9	1. Test the low reference circuit between the ECM (pin A-7 of J-218 connector) and the APP sensor 1 (pin K of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 10
10	1. Test the signal circuit between the ECM (pin A-31 of J-218 connector) and the APP sensor 1 harness (pin E of B-280 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 11
11	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the APP sensor 1 or 3 (pins D, E, K or B, A, F of B-280 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
12	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent and for a poor connection on these APP sensor 1 or 3 circuits at the harness connector of the ECM (pins A-54, A-31, A-7 or A-56, A-33, A-9 of J-218 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 13
13	Replace the APP sensor. Refer to Accelerator Pedal Position (APP) Sensor Replacement in this section. (APP sensor 1 or 3 is internal to APP sensor assembly) Did you complete the replacement?	—	Go to Step 14	—

Step	Action	Value(s)	Yes	No
14	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Monitor the DTC Information with a scan tool. 6. Fully depress and release the accelerator pedal. Does the DTC fail this ignition?	—	Go to Step 15	Go to Step 17
15	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 17
17	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2146

Circuit Description

The common 1 injector drive circuit is a high-voltage supply (near 120 volts) which drives injectors for cylinder 1 and 4 in conjunction with the engine control module (ECM) grounding the injector control circuit. The ECM supplies battery voltage on the injector drive circuit to allow for fault detection. If the common 1 injector drive circuit supply to the cylinder 1 and 4 is open, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the common 1 fuel injector drive circuit is open during 8 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM disables cylinder 1 and 4 fuel injector operation.
- The ECM limits fuel injection quantity within 50%.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P2146" display on the scan tool with the engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P2146

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	**Important:** If DTC P0201 or P0204 is also set, diagnose that DTC first. 1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the in-line connector (H-125) from the cylinder head cover case. 3. Connect a DMM independently between the cylinder 1 and 4 injector drive circuit (pins 1 and 4 of H-125 female side connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is this DMM voltage more than the specified value?	6.0 volts	Go to Step 4	Go to Step 8
4	Measure the resistance through the intermediate connector (H-125 male side connector) between both injector drive circuits (pins 1 and 4 of H-125 connector). Does the resistance measure less than the specified value?	1.0 Ω	Go to Step 5	Go to Step 6
5	1. Inspect for an intermittent and for poor connections of the in-line connector and the intermediate connector (pins 1 and 4 of H-125 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
6	1. Remove the cylinder head cover. Refer to Fuel Injector Replacement in this section. 2. Visually inspect the injector harness for loose injector terminal nuts on the cylinder 1 and 4 injectors. Did you find and correct the condition?	—	Go to Step 12	Go to Step 7
7	1. Inspect for an intermittent and for poor connections between the intermediate connector and injector harness connector (pins 1 and 4 of H-126 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10
8	1. Test the injector drive circuit between the engine control module (ECM) (pin B-3 of J-217 connector) and the in-line connector (pin 1 of H-125 connector), then between the ECM (pin B-5 of J-217 connector) and the in-line connector (pin 4 of H-125 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9

Step	Action	Value(s)	Yes	No
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Test for an intermittent and for poor connections on the cylinder 1 and 4 injector drive circuits at the harness connector of the ECM (pins B-3 and B-5 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	Replace the injector harness. Refer to Fuel Injector Replacement in this section. Did you complete the replacement?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 13
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2147

Circuit Description

The common 1 injector drive circuit is a high-voltage supply (near 120 volts) which drives injectors for cylinder 1 and 4 in conjunction with the engine control module (ECM) grounding the injector control circuit. The ECM supplies battery voltage on the injection drive circuit to allow for fault detection. If the common 1 injector drive circuit supply to the cylinder 1 and 4 is shorted to a ground circuit, this DTC will set. Or, if the injector solenoid control circuit 1 or 4 is shorted to ground, this DTC will also set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the common 1 fuel injector drive circuit or cylinder 1 or 4 fuel injector solenoid control circuit is shorted to ground during 8 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM disables cylinder 1 and 4 fuel injector operation.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM limits accelerator control range to idle.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P2147" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P2147

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the in-line connector (H-125) from the cylinder head cover case. 3. Connect a test lamp between the injector control circuit (pin 5 of H-125 female side connector) and battery voltage. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 8	Go to Step 4
4	Connect a test lamp between the injector control circuit (pin 8 of H-125 female side connector) and battery voltage. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 5
5	Connect a test lamp between the injector drive circuit (pin 1 or 4 of H-125 female side connector) and battery voltage. Does the test lamp illuminate?	—	Go to Step 10	Go to Step 6
6	1. Remove the cylinder head cover. Refer to Fuel Injector Replacement in this section. 2. Visually inspect the injector harness for objects touching the injector terminals. Did you find and correct the condition?	—	Go to Step 14	Go to Step 7
7	1. Disconnect the injector harness from the No. 1 and 4 cylinder's injector (E-138 & E-141 connector). 2. Measure the insulation resistance of the No. 1 and 4 cylinder's injector between each injector terminal and a known good ground. Does the resistance measure more than the specified value?	1 MΩ	Go to Step 11	Go to Step 12
8	1. Test the injector control circuit between the engine control module (ECM) (pin B-58 of J-217 connector) and the in-line connector (pin 5 of H-125 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
9	1. Test the injector control circuit between the ECM (pin B-56 of J-217 connector) and the in-line connector (pin 8 of H-125 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13

Step	Action	Value(s)	Yes	No
10	1. Test the injector drive circuit between the ECM (pin B-3 of J-217 connector) and the in-line connector (pin 1 of H-125 connector), then between the ECM (pin B-5 of J-217 connector) and the in-line connector (pin 4 of H-125 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
11	Replace the injector harness. Refer to Fuel Injector Replacement in this section. Did you complete the replacement?	—	Go to Step 14	—
12	**Important:** Replacement injector must be programmed. Replace the appropriate injector. Refer to Fuel Injector Replacement/Restore Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 14	—
13	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 14	—
14	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 15
15	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2148

Circuit Description

The common 1 injector drive circuit is a high-voltage supply (near 120 volts) which drives injectors for cylinder 1 and 4 in conjunction with the engine control module (ECM) grounding the injector control circuit. The ECM supplies battery voltage on the injector drive circuit to allow for fault detection. If the common 1 injector drive circuit supply to the cylinder 1 and 4 is shorted to a voltage circuit, this DTC will set. Or, if the injector solenoid control circuit 1 or 4 is shorted to voltage, this DTC will also set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the common 1 fuel injector drive circuit or cylinder 1 or 4 fuel injector solenoid control circuit is shorted to voltage during 8 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM disables cylinder 1 and 4 fuel injector operation.
- The ECM limits fuel injection quantity within 50%.
- The ECM limits fuel rail pressure within 11600 psi (80MPa).
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P2148" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P2148

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the in-line connector (H-125) from the cylinder head cover case. 3. Connect a test lamp between the injector control circuit (pin 5 of H-125 female side connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 4
4	Connect a test lamp between the injector control circuit (pin 8 of H-125 female side connector) and a known good ground. Does the test lamp illuminate?	—	Go to Step 7	Go to Step 5
5	Connect a DMM between the injector drive circuit (pin 1 or 4 of H-125 female side connector) and a known good ground. Is the DMM voltage less than the specified value?	8.0 volts	Go to Step 9	Go to Step 8
6	1. Test the injector control circuit between the engine control module (ECM) (pin B-58 of J-217 connector) and the in-line connector (pin 5 of H-125 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
7	1. Test the injector control circuit between the ECM (pin B-56 of J-217 connector) and the in-line connector (pin 8 of H-125 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
8	1. Test the injector drive circuit between the ECM (pin B-3 of J-217 connector) and the in-line connector (pin 1 of H-125 connector), then between the ECM (pin B-5 of J-217 connector) and the in-line connector (pin 4 of H-125 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
9	Replace the injector harness. Refer to Fuel Injector Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—

Step	Action	Value(s)	Yes	No
10	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 11	—
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 12
12	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2149

Circuit Description

The common 2 injector drive circuit is a high-voltage supply (near 120 volts) which drives injectors for cylinder 2 and 3 in conjunction with the engine control module (ECM) grounding the injector control circuit. The ECM supplies battery voltage on the injector drive circuit to allow for fault detection. If the common 2 injector drive circuit supply to the cylinder 2 and 3 is open, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the common 2 fuel injector drive circuit is open during 8 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM disables cylinder 2 and 3 fuel injector operation.
- The ECM limits fuel injection quantity within 50%.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P2149" display on the scan tool with the engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P2149

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	**Important:** If DTC P0202 or P0203 is also set, diagnose that DTC first. 1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the in-line connector (H-125) from the cylinder head cover case. 3. Connect a DMM independently between the cylinder 2 and 3 injector drive circuit (pins 2 and 3 of H-125 female side connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	6.0 volts	Go to Step 4	Go to Step 8
4	Measure the resistance through the intermediate connector (H-125 male side connector) between both injector drive circuits (pins 2 and 3 of H-125 connector). Does the resistance measure less than the specified value?	1.0 Ω	Go to Step 5	Go to Step 6
5	1. Inspect for an intermittent and for poor connections of the in-line connector and the intermediate connector (pins 2 and 3 of H-125 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
6	1. Remove the cylinder head cover. Refer to Fuel Injector Replacement in this section. 2. Visually inspect the injector harness for loose injector terminal nuts on the cylinder 2 and 3 injectors. Did you find and correct the condition?	—	Go to Step 12	Go to Step 7
7	1. Inspect for an intermittent and for poor connections between the intermediate connector and injector harness connector (pins 2 and 3 of H-126 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10
8	1. Test the injector drive circuit between the engine control module (ECM) (pin B-6 of J-217 connector) and the in-line connector (pin 3 of H-125 connector), then between the ECM (pin B-4 of J-217 connector) and the in-line connector (pin 2 of H-125 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9

Step	Action	Value(s)	Yes	No
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Test for an intermittent and for poor connections on the cylinder 2 and 3 injector drive circuits at the harness connector of the ECM (pin B-4 and B-6 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	Replace the injector harness. Refer to Fuel Injector Replacement in this section. Did you complete the replacement?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 13
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2150

Circuit Description

The common 2 injector drive circuit is a high-voltage supply (near 120 volts) which drives injectors for cylinder 2 and 3 in conjunction with the engine control module (ECM) grounding the injector control circuit. The ECM supplies battery voltage on the injector drive circuit to allow for fault detection. If the common 2 injector drive circuit supply to the cylinder 2 and 3 is shorted to a ground circuit, this DTC will set. Or, if the injector solenoid control circuit 2 or 3 is shorted to ground, this DTC will also set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the common 2 fuel injector drive circuit or cylinder 2 or 3 fuel injector solenoid control circuit is shorted to ground during 8 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM disables cylinder 2 and 3 fuel injector operation.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM limits accelerator control range to idle.
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.
- The ECM inhibits the PTO control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P2150" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P2150

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the in-line connector (H-125) from the cylinder head cover case. 3. Connect a test lamp between the injector control circuit (pin 7 of H-125 female side connector) and battery voltage. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 8	Go to Step 4
4	Connect a test lamp between the injector control circuit (pin 6 of H-125 female side connector) and battery voltage. Does the test lamp illuminate?	—	Go to Step 9	Go to Step 5
5	Connect a test lamp between the injector drive circuit (pin 2 or 3 of H-125 female side connector) and battery voltage. Does the test lamp illuminate?	—	Go to Step 10	Go to Step 6
6	1. Remove the cylinder head cover. Refer to Fuel Injector Replacement in this section. 2. Visually inspect the injector harness for objects touching the injector terminals. Did you find and correct the condition?	—	Go to Step 14	Go to Step 7
7	1. Disconnect the injector harness from the No. 2 and 3 cylinder's injector (E-139 & E-140 connector). 2. Measure the insulation resistance of the No. 2 and 3 cylinder's injector between each injector terminal and a known good ground. Does the resistance measure more than the specified value?	1 MΩ	Go to Step 11	Go to Step 12
8	1. Test the injector control circuit between the engine control module (ECM) (pin B-45 of J-217 connector) and the in-line connector (pin 7 of H-125 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
9	1. Test the injector control circuit between the ECM (pin B-43 of J-217 connector) and the in-line connector (pin 6 of H-125 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13

Step	Action	Value(s)	Yes	No
10	1. Test the injector drive circuit between the ECM (pin B-6 of J-217 connector) and the in-line connector (pin 3 of H-125 connector), then between the ECM (pin B-4 of J-217 connector) and the in-line connector (pin 2 of H-125 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
11	Replace the injector harness. Refer to Fuel Injector Replacement in this section. Did you complete the replacement?	—	Go to Step 14	—
12	**Important:** Replacement injector must be programmed. Replace the appropriate injector. Refer to Fuel Injector Replacement/Restore Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 14	—
13	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 14	—
14	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 15
15	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2151

Circuit Description

The common 2 injector drive circuit is a high-voltage supply (near 120 volts) which drives injectors for cylinder 2 and 3 in conjunction with the engine control module (ECM) grounding the injector control circuit. The ECM supplies battery voltage on the injector drive circuit to allow for fault detection. If the common 2 injector drive circuit supply to the cylinder 2 and 3 is shorted to a voltage circuit, this DTC will set. Or, if the injector solenoid control circuit 2 or 3 is shorted to voltage, this DTC will also set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the common 2 fuel injector drive circuit, cylinder 2 or 3 fuel injector solenoid control circuit is shorted to voltage during 8 engine rotations.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM disables cylinder 2 and 3 fuel injector operation.
- The ECM limits fuel injection quantity within 50%.
- The ECM limits fuel rail pressure within 11600 psi (80 MPa).
- The ECM closes the EGR valve and holds to close position.
- The ECM inhibits the cruise control.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation

Check for the following conditions:

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC P2151" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P2151

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Disconnect the in-line connector (H-125) from the cylinder head cover case. 3. Connect a test lamp between the injector control circuit (pin 7 of H-125 female side connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 4
4	Connect a test lamp between the injector control circuit (pin 6 of H-125 female side connector) and a known good ground. Does the test lamp illuminate?	—	Go to Step 7	Go to Step 5
5	Connect a DMM between the injector drive circuit (pin 2 or 3 of H-125 female side connector) and a known good ground. It the DMM voltage less than the specified value?	8.0 volts	Go to Step 9	Go to Step 8
6	1. Test the injector control circuit between the engine control module (ECM) (pin B-45 of J-217 connector) and the in-line connector (pin 7 of H-125 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
7	1. Test the injector control circuit between the ECM (pin B-43 of J-217 connector) and the in-line connector (pin 6 of H-125 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
8	1. Test the injector drive circuit between the ECM (pin B-6 of J-217 connector) and the in-line connector (pin 3 of H-125 connector), then between the ECM (pin B-4 of J-217 connector) and the in-line connector (pin 2 of H-125 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
9	Replace the injector harness. Refer to Fuel Injector Replacement in this section. Did you complete the replacement?	—	Go to Step 11	—

Step	Action	Value(s)	Yes	No
10	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 11	—
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 12
12	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2227

Circuit Description

The barometric pressure (BARO) sensor is installed inside of the engine control module (ECM) and converts the barometric pressure (BARO) into a voltage signal. The ECM uses this voltage signal to calibrate the fuel injection quantity and injection timing for altitude compensation. Within the ECM, the diagnostic compares the BARO sensor input to the boost pressure sensor input. If the ECM detects that the inputs are not within a specified amount of each other, this DTC will set.

Condition for Running the DTC

- DTCs P0116, P0117, P0118, P0237, P0238, P0478, P0500, P0506, P0507, P0602, P1125 are not set.
- The ignition switch is ON.
- The engine run time is longer than 30 seconds.
- The engine speed is between 650-1050 RPM.
- The mass air flow (MAF) is less than 1600 mg/cyl.
- The engine coolant temperature (ECT) is more than 68°F (20°C).
- The accelerator pedal position (APP) is less than 2%.
- The vehicle speed is less than 2 MPH(3 km/h).
- Above conditions are met for 3 seconds.

Condition for Setting the DTC

- The ECM detects that the difference between the BARO pressure and the boost pressure is more than 1.1 psi (7.5 kPa) for longer than 5 seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

Condition for Clearing the DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- High resistance in the boost pressure sensor 5 volts reference circuit, signal circuit or low reference circuit may set this DTC.
- Use the Altitude vs Barometric Pressure table to test the boost pressure sensor and BARO sensor to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to Altitude vs Barometric Pressure.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

3. A skewed boost pressure sensor value (shifted to a higher pressure or lower pressure) can set this DTC. The Boost Pressure on the scan tool should read near surrounding barometric pressure with the key ON and engine OFF.

5. A skewed barometric pressure (BARO) sensor value (shifted to a lower pressure or higher pressure) can set this DTC. The BARO on the scan tool should read near surrounding barometric pressure.

DTC P2227

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Start the engine. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is the DTC P0237, P0238, P2228 or P2229 also set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Turn ON the ignition, with the engine OFF. 2. Compare the Boost Pressure Sensor parameter to the Barometric Pressure (BARO) parameter with a scan tool. Are both parameter within the range specified of each other?	1.1 psi (7.5 kPa)	Go to Diagnostic Aids	Go to Step 4
4	Determine the outside barometric pressure from your location specified in the altitude vs barometric pressure table. Refer to Altitude vs Barometric Pressure. Is the BARO parameter on scan tool close to the outside barometric pressure?	—	Go to Step 5	Go to Step 11
5	1. Test the 5 volts reference circuit between the engine control module (ECM) (pin B-46 of J-217 connector) harness and the boost pressure sensor (pin 3 of J-216 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 6
6	1. Test the signal circuit between the ECM (pin B-24 of J-217 connector) and the boost pressure sensor (pin 2 of J-216 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 8
7	1. Test the low reference circuit between the ECM (pin B-24 of J-217 connector) and the boost pressure sensor (pin 1 of J-216 connector) for high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 8
8	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the boost connector sensor (pins 1 , 2 or 3 of J-216 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 9
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion on these boost pressure sensor circuits at the harness connector of the ECM (pins B-12, B-24 and B-46 of J-217 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10

Step	Action	Value(s)	Yes	No
10	Replace the boost pressure sensor. Refer to Boost Pressure Sensor Replacement in this section. Did you complete the repair?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 13
13	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2228

Circuit Description

The barometric pressure (BARO) sensor is installed inside of the engine control module (ECM) and converts the BARO into a voltage signal. The ECM uses this voltage signal to calibrate the fuel injection quantity and injection timing for altitude compensation. If the ECM detects an excessively low BARO signal voltage, this DTC will set.

Condition for Running the DTC

- DTC P2229 is not set.
- The battery voltage is more than 7 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the BARO sensor signal voltage is less than 1.5 volts for longer than 1 second.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM uses a BARO substitution of 14.7 psi (101.3 kPa) when the DTC is set.
- The ECM uses a BARO substitution of 10.5 psi (72.4 kPa) for engine starting and running.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

DTC P2228

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Step 4
3	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 4	—
4	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 5

Step	Action	Value(s)	Yes	No
5	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2229

Circuit Description

The barometric pressure (BARO) sensor is installed inside of the engine control module (ECM) and converts the BARO into a voltage signal. The ECM uses this voltage signal to calibrate the fuel injection quantity and injection timing for altitude compensation. If the ECM detects an excessively high BARO signal voltage, this DTC will set.

Condition for Running the DTC

- DTC P2228 is not set.
- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.
- The engine is running.

Condition for Setting the DTC

- The ECM detects that the BARO sensor signal voltage is more than 4.5 volts.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM uses a BARO substitution of 14.7 psi (101.3 kPa) when the DTC is set.
- The ECM uses a BARO substitution of 10.5 psi (72.4 kPa) for engine starting and running.
- The ECM limits fuel injection quantity within 70%.
- The ECM closes the EGR valve and holds to close position.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

DTC P2229

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Step 4
3	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 4	—
4	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 5

Step	Action	Value(s)	Yes	No
5	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P2293

Description

The common rail fuel system is comprised of two fuel pressure sections: a suction side between the fuel tank and the fuel supply pump and a high-pressure side between the fuel supply pump and the fuel injectors. Fuel is drawn from the fuel tank via a feed pump and then pumped into the fuel rail by two plungers, all of which are internal to the fuel supply pump. This high pressure is regulated by the engine control module (ECM) using the fuel rail pressure (FRP) regulator dependant upon values from the FRP sensor attached to the fuel rail.

Under normal conditions, the fuel pressure will oscillate slightly due to the characteristics of the two-plunger fuel supply pump system. However, if one of the plungers is stuck or the cylinder it rides in is worn out, fuel pressure oscillations will be much higher. If the ECM detects that the fuel pressure is oscillating too much continuously for a certain length of time, this DTC will set. (Pressure Oscillation DTC)

In case of fuel rail overpressure, a pressure limiter valve threaded into the fuel rail will open to release overpressure and return fuel back to the fuel tank. If the ECM detects that the fuel pressure went high for a lengthy period of time this DTC will also set. (High Fuel Pressure DTC)

Condition for Running the DTC

Pressure Oscillation DTC

- DTCs P0016, P0089, P0091, P0092, P0192, P0193, P0201, P0202, P0203, P0204, P0261, P0264, P0267, P0270, P0300, P0301, P0302, P0303, P0304, P0335, P0336, P0602, P0642, P0643, P1293, P2146, P2147, P2148, P2149, P2150 and P2151 are not set.
- The desired fuel rail pressure does not vary more than 290 psi (2 MPa).
- The fuel injection quantity does not vary more than 2 mm^3.

High Fuel Pressure DTC

- DTCs P0089, P0091, P0092, P0192, P0193, P0642 and P0643 are not set.
- The battery voltage is between 10 - 16 volts
- The engine is running.

Condition for Setting the DTC

Pressure Oscillation DTC

- The ECM detects that the oscillation of fuel feed quantity is more than a threshold. And oscillations have occurred continuously for 1000 times. (2 tests per crankshaft revolution)

High Fuel Pressure DTC

- The ECM detects that the actual fuel rail pressure is more than 28550 psi (197 MPa) for longer than 35 seconds.

OR

- The ECM detects that the actual fuel rail pressure is more than 33350 psi (230 MPa) for longer than 1 second.

Action Taken When the DTC Sets

Pressure Oscillation DTC

12,000 lbs GVW

- The ECM illuminates the service vehicle soon (SVS) lamp when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Except 12,000 lbs GVW

- The ECM will not illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

High Fuel Pressure DTC

- The ECM will not illuminate the MIL when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Failure Records.

Condition for Clearing the MIL/DTC

Pressure Oscillation DTC

12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic after the ECM turns OFF the SVS lamp.
- Clear the SVS lamp and the DTC with a scan tool.

Except 12,000 lbs GVW

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

High Fuel Pressure DTC

- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.

- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

Diagnostic Aids

Pressure Oscillation DTC

- Make sure the fuel pressure sensor wiring is not interfering with the crankshaft position (CKP), camshaft position (CMP) sensor and fuel injector(s) wire or after-market add-on electrical equipment.

High Fuel Pressure DTC

- A sticking fuel rail pressure (FRP) regulator) may have allowed the fuel pressure to become high enough to set this DTC.
- Normal Actual Fuel Rail Pressure readings on the scan with the engine running in Park or Neutral at idle are around 3650 to 5050 psi (25 to 35 MPa) and around 14500 to 21750 psi (100 to 150 MPa) in Park or Neutral at W.O.T. (accelerator pedal full travel).
- A skewed FRP sensor value (shifted to a higher pressure) can set this DTC. The Actual Fuel Rail Pressure on the scan tool should read 0 psi (0 MPa) with the key ON and engine OFF after the engine has stopped running for a minimum of 2 minutes.
- Resistance in the FRP sensor low reference circuit can set this DTC. Ensure that the sensor low reference circuit has no resistance and the connectors are tight and free of corrosion.

Notice:

The Actual Fuel Rail Pressure on scan tool will only update with the engine running or one time after the key is cycled when the ignition has been turned OFF for longer than 10 seconds.

Notice:

The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight or if there is a crack in one of the fuel hoses. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load, which may set this DTC.

Notice:

If the fuel tank is empty or near empty, air might be allowed to go into the fuel system. With air in the fuel system, smooth flow of fuel into the supply pump is interrupted and this DTC may set. Perform bleeding of fuel system after refilling.

Test Description

The numbers below refer to the step number on the diagnostic table.

7. This step checks for a fuel restriction by determining if a high vacuum is being pulled on the fuel system during normal operation.

8. This step checks for an air leak on the suction side of the fuel system by determining if a vacuum can be pulled when a fuel line is plugged.

19. This DTC indicates that the fuel pressure went high and it’s possible that the pressure limiter valve did not active.

DTC P2293

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Start the engine. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0087, P0088, P0089, P0091, P0092, P0192, P0193, P0201-P0204, P0261, P0264, P0267, P0270 or P2146-P2151 set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition for 30 seconds. 2. Start the engine and let idle 2 minutes. 3. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 5	Go to Step 4
4	1. Turn OFF the ignition for 30 seconds. 2. Place the transmission in Park or Neutral and set the park brake. 3. Start the engine. 4. Observe the Actual Fuel Rail Pressure parameter with a scan tool. 5. Accelerate the engine between idle and W.O.T. (accelerator pedal full travel) many times while observing the scan tool. Does the Actual Fuel Rail Pressure ever exceed the specified value?	28550 psi (197 MPa)	Go to Step 5	An intermittent problem by foreign material in the fuel is suspected. Go to Step 15
5	1. Turn OFF the ignition. 2. Wait 2 minutes for the fuel pressure to bleed down from the fuel rail. 3. Turn ON the ignition with the engine OFF, do not start the engine. 4. Observe the Actual Fuel Rail Pressure parameter with a scan tool. Is the Actual Fuel Rail Pressure parameter the specified valve?	0 psi (0 MPa)	Go to Step 6	Go to Step 13

Step	Action	Value(s)	Yes	No
6	1. Turn OFF the ignition. 2. Check the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. **Notice:** The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load, which may set this DTC. 3. Pump the priming pump on the fuel filter until it becomes firm. If there is a leak on the suction side of the fuel system between the priming pump and the fuel supply pump, the priming pump will not build up sufficient firmness and fuel leakage may occur. 4. Start the engine and check for suction side fuel system leaks at the fuel supply pump and fuel rail. **Notice:** Fuel may leak under the cylinder head cover from the inlet high pressure line. In such case, the engine oil level will rise. Inspect for fuel leakage into the engine oil. 5. Repair any fuel system leaks as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 7

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Remove the rubber fuel hose from the fuel filter housing (fuel supply pump side). Use a pan to catch the fuel leakage from the removed fuel line. **Important:** The fuel vacuum pump/pressure gauge connector and the adapter hose must be cleaned before connecting to the fuel line. Otherwise, foreign material internal to the tools line may damage the fuel supply pump. 3. Connect the suction side fuel pressure adapter EN-47667 with fuel vacuum/ pressure gauge assembly J-44638 in series with the filter housing and the disconnected fuel hose. Ensure the service tool and fuel line connections are tight. 4. Bleed the fuel system by priming the priming pump until it becomes firm, then crank over the engine for a maximum of 5 seconds. Repeat as necessary until the engine starts. 5. Let the engine run at idle for at least 1 minute. 6. Monitor the fuel vacuum/pressure gauge while holding the engine speed higher than 2500 RPM for a minimum of 1 minute. Does the vacuum/pressure gauge ever indicate a larger vacuum than the specified amount during the test?	5 inHg	Go to Step 9	Go to Step 8
8	1. Fully clamp off a fuel hose as close to the fuel tank as possible (this will draw vacuum on the fuel system). You can also disconnect a fuel line and plug it. 2. Start the engine and turn the idle up control knob to the highest position. (Full clockwise direction. The idle speed is increased up to 1600 RPM.) 3. Monitor the fuel pressure/vacuum gauge. **Notice:** Release the clamp or open the plug when the gauge is likely to be more than 8 inHg during the test. Can a vacuum of at least the specified amount be pulled on the fuel system?	8 inHg	Go to Step 11	Go to Step 10

Step	Action	Value(s)	Yes	No
9	1. Inspect the fuel lines between the fuel supply pump and fuel tank for being crushed or kinked. 2. Inspect for a plugged fuel tank vent valve. 3. Inspect inside the fuel tank (if possible) for any foreign material that may be getting drawn into the fuel line pickup causing a blocked condition. 4. Repair as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 15
10	1. Turn OFF the ignition. 2. Check the fuel system line connections between the fuel tank and the fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. 3. Repair as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 12
11	1. Turn OFF the ignition. 2. Unclamp or unplug the fuel line from the previous step and reconnect the fuel line (if disconnected). 3. Start the engine and allow it to run for at least 1 minute. 4. Perform the Cylinder Power Balance test with a scan tool. 5. Command each injector OFF and verify an engine speed change for each injector. Is there an injector that does not change engine speed when commanded OFF?	—	Go to Step 17	Go to Step 12
12	1. Turn OFF the ignition. 2. Disconnect the fuel rail pressure (FRP) regulator harness connector. 3. Inspect for an intermittent, for poor connection and corrosion at the harness connectors of the FRP regulator (pins 1 and 2 of E-116 connector). 4. Disconnect the engine control module (ECM) harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP regulator circuit at the harness connector of the ECM (pins B-20, B-21, B-33 and B-34 of J-217 connector). 6. Test for high resistance on each FRP regulator circuit. 7. Repair the connection(s) or circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 14

Step	Action	Value(s)	Yes	No
13	1. Turn OFF the ignition. 2. Disconnect the FRP sensor harness connector. 3. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the FRP sensor (pins 1, 2 and 3 of E-113 connector). 4. Disconnect the ECM harness connector. 5. Inspect for an intermittent, for poor connections and corrosion on each FRP sensor circuit at the harness connector of the ECM (pins B-13, B-25, B-26 and B-47 of J-217 connector). 6. Test for high resistance on each FRP sensor circuit. 7. Repair the connection(s) or circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 16
14	1. Inspect the routing of the FRP sensor harness. Make sure its not in interference with the following wiring: • Crankshaft position (CKP) sensor • Camshaft position (CMP) sensor • Fuel injector(s) • After-market add-on electrical equipment 2. Reroute harness as necessary. Did you find and correct the condition?	—	Go to Step 19	Go to Step 18
15	Replace the fuel filter cartridge. Refer to Fuel Filter Cartridge Replacement in the Fuel System Section. Did you complete the replacement?	—	Go to Step 19	—
16	Replace the fuel rail pressure sensor. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 19	—
17	**Important:** Replacement injector must be programmed. Replace the appropriate fuel injector that does not change engine speed when commanded OFF. Refer to Fuel Injector Replacement/Fuel Injector Flow Rate Programming in this section. Did you complete the replacement?	—	Go to Step 19	—

Step	Action	Value(s)	Yes	No
18	**Important:** The fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM. **Notice:** Always replace the fuel filter cartridge when a fuel supply pump is replaced. Replace the fuel supply pump and fuel filter cartridge. Refer to Fuel Supply Pump Replacement /Fuel Supply Pump Relearn Procedure in this section and Fuel Filter Cartridge Replacement in Fuel System section. Did you complete the replacement?	—	Go to Step 19	—
19	**Notice:** There is a high possibility that the pressure limiter valve did not activate, if DTC P2293 set and Actual Fuel Rail Pressure went over the specified valve at Step 4. If the value did not go over, skip to step 20. Replace the pressure limiter valve. Refer to Fuel Rail Replacement in this section. Did you complete the replacement?	—	Go to Step 20	—
20	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 21
21	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC U0073, U0101 & U0106

Circuit Description

The engine control module (ECM), the transmission control module (TCM) and the glow plug controller communicate control and diagnostic information via a controller area network (CAN) communication bus. The ECM monitors CAN operational status by expecting a constant flow of messages from the TCM and the glow plug controller. If the ECM fails to receive an expected message from the TCM or glow plug controller, DTC U0073, U0101 or U0106 will set depending on what communication is lost.

Condition for Running the DTC

U0073

- The battery voltage is between 8 - 16 volts.
- The ignition switch is ON.

U0101

- DTC U0073 is not set.
- The battery voltage is between 8 - 16 volts.
- The ignition switch is ON.

U0106

- The battery voltage is between 10 - 16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

U0073

- The ECM detects that the CAN Bus reset counter is overrun.

U0101

- The ECM detects that the CAN Bus messages from the TCM are not being received.

U0106

- The ECM detects that the CAN Bus messages from the glow plug controller are not being received.

Action Taken When the DTC Sets

U0073 & U0106

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records on the second consecutive driving cycle when the diagnostic runs and fails.

U0101

- The ECM illuminates the MIL when the diagnostic runs and fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.

Condition for Clearing the MIL/DTC

- The ECM turns OFF the MIL after 3 consecutive driving cycles when the diagnostic runs and does not fail. (12,000 lbs GVW)
- The ECM turns OFF the MIL when the diagnostic runs and does not fail. (Except 12,000 lbs GVW)
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic after the ECM turns OFF the MIL.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at the ECM, TCM or glow plug controller: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "DTC U0073", "DTC U0101" and "DTC U0106" display on the scan tool with engine running while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

Notice:
If the TCM has DTCs set, clear the DTCs in the TCM FIRST.

DTC U0073, U0101 & U0106

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Chart for 12,000 lbs GVW with A/T

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check-Engine Controls
2	1. Install a scan tool. 2. Attempt to communicate with the transmission control module (TCM) via the Transmission Data Display table. Does the scan tool communicate with the TCM?	—	Go to Step 3	Go to Diagnostic System Check-Transmission Controls
3	1. Turn OFF the ignition, for 30 seconds. 2. Start the engine. 3. Monitor the engine control module (ECM) Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0670 also set?	—	Go to Go to DTC P0670	Go to Step 4
4	1. Turn ON the ignition, with the engine OFF. 2. Record all DTCs in the ECM and TCM along with any pertinent information from the ECM Failure Records. 3. Clear the DTC information in the ECM and the TCM with a scan tool. 4. Turn OFF the ignition for 30 seconds. 5. Start the engine and let run for 30 seconds. RECORD ANY DTCS SET IN BOTH THE ECM AND TCM, AS THIS WILL BE ASKED IN STEP 9. Does DTC U0106 set in the ECM without U0073 or U0101 setting in the ECM and without U2104 or U2015 setting in the TCM?	—	Go to Step 11	Go to Step 5
5	Is DTC U0106, U0073 and/or U0101 set in the ECM?	—	Go to Step 6	Go to Diagnostic Aids
6	1. Turn OFF the ignition. 2. Remove the TCM from its bracket for easier testing. 3. Turn ON the ignition with the engine OFF. 4. Connect a DMM between the controller area network (CAN) Low circuit at the TCM (pin 5 of B-229 connector) and a known good ground by back probing the TCM (keep the TCM connected). Record the voltage reading. 5. Connect a DMM between the CAN High circuit at the TCM (pin 18 of B-229 connector) and a known good ground by back probing the TCM (keep the TCM connected). Record the voltage reading. Are both voltage readings within the specified range?	1.5-3.5 volts	Go to Step 7	Go to Step 13

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Measure the resistance between the CAN Low circuit (pin 5 of B-229 connector) and the CAN High circuit (pin 18 of B-229 connector) at the TCM by back probing the TCM (keep the TCM connected). Does the resistance measure within the specified range (parallel resistance of the 120 Ω resistor in the ECM and the 120 Ω resistor in the TCM should be 60Ω)?	50-70 Ω	Go to Step 8	Go to Step 16
8	1. Disconnect the TCM B-229 harness connector. 2. Disconnect the H-121 inline harness connector located above and to the right of the outside relay box. 3. Turn ON the ignition, with the engine OFF. 4. Connect a DMM between the CAN Low circuit (pin 5 of B-229 connector) and a known good ground at the TCM harness connector. Record the voltage reading. 5. Connect a DMM between the CAN High circuit (pin 18 of B-229 connector) and a known good ground at the TCM harness connector. Record the voltage reading. Are both voltage readings within the specified range?	1.5-3.5 volts	Go to Step 9	Go to Step 26
9	1. Turn OFF the ignition. 2. Reconnect the TCM harness connector. 3. Disconnect the ECM harness connector(s). 4. Connect a DMM between the CAN Low circuit (pin 33 of H-121 connector) and a known good ground. Record the voltage reading. 5. Connect a DMM between the CAN High circuit (pin 22 of H-121 connector) and a known good ground. Record the voltage reading. Are both voltage readings within the specified range?	1.5-3.5 volts	Go to Step 10	Go to Step 22
10	Did DTC U0106 set in the ECM at step 4?	—	Go to Step 26	Go to Step 27

Step	Action	Value(s)	Yes	No
11	1. Turn OFF the ignition. 2. Remove components enough to disconnect the glow control module (located directly under the fuel rail). 3. Turn ON the ignition with the engine OFF. 4. Connect a DMM between the CAN High circuit (pin 12 of E-144 connector) and a known good ground. Is the voltage reading within the specified range?	1.5-3.5 volts	Go to Step 12	Go to Step 24
12	Connect a DMM between the CAN Low circuit (pin 6 of E-144 connector) and a known good ground at the harness connector of the glow plug controller. Is the voltage reading within the specified range?	1.5-3.5 volts	Go to Step 23	Go to Step 25
13	1. Turn OFF the ignition. 2. Disconnect the ECM harness connectors. 3. Disconnect the TCM B-229 harness connector. 4. Disconnect the glow plug controller harness connector. 5. Turn On the ignition with the engine OFF. 6. Test for a short to ground and short to voltage on the CAN Low and CAN High circuits between the TCM, ECM and glow plug controller. 7. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 29	Go to Step 14
14	1. Turn OFF the ignition. 2. Reconnect the ECM harness connectors. 3. Turn ON the ignition, with the engine OFF. 4. Connect a DMM between the CAN Low circuit (pin 5 of B-229 connector) and a known good ground at the TCM harness connector. Record the voltage reading. 5. Connect a DMM between the CAN High circuit (pin 18 of B-229 connector) and a known good ground at the TCM harness connector. Record the voltage reading. Are both voltage readings within the specified range?	1.5-3.5 volts	Go to Step 15	Go to Step 26

Step	Action	Value(s)	Yes	No
15	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector(s). 3. Reconnect the glow plug controller harness connector. 4. Turn ON the ignition, with the engine OFF. 5. Connect a DMM between the CAN Low circuit (pin 5 of B-229 connector) and a known good ground at the TCM harness connector. Record the voltage reading. 6. Connect a DMM between the CAN High circuit (pin 18 of B-229 connector) and a known good ground at the TCM harness connector. Record the voltage reading. Are both voltage readings within the specified range?	1.5-3.5 volts	Go to Step 27	Go to Step 28
16	1. Keep the ignition OFF. 2. Disconnect the TCM B-229 harness connector. 3. Disconnect the H-121 inline harness connector located above and to the right of the outside relay box (this will remove the glow plug controller CAN circuits). 4. Turn ON the ignition, with the engine OFF. 5. Connect a DMM between the CAN Low circuit (pin 5 of B-229 connector) and a known good ground at the TCM harness connector. Record the voltage reading. 6. Connect a DMM between the CAN High circuit (pin 18 of B-229 connector) and a known good ground at the TCM harness connector. Record the voltage reading. Are both voltage readings within the specified range?	1.5-3.5 volts	Go to Step 17	Go to Step 18
17	1. Turn OFF the ignition. 2. Keep the TCM B-229 harness connector disconnected. 3. Reconnect the H-121 inline harness connector. 4. Measure the resistance between the CAN Low and CAN High circuits (pins 5 and 18 of B-229 connector) at the TCM harness connector. Does the resistance measure within the specified range?	110-130 Ω	Go to Step 22	Go to Step 19

Step	Action	Value(s)	Yes	No
18	1. Test for an open or high resistance in the CAN Low or CAN High circuit (which ever voltage reading did not read between 1.5-3.5 volts in step 16) between the ECM and TCM. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 29	Go to Step 21
19	1. Turn OFF the ignition. 2. Disconnect the ECM, TCM B-229 and glow plug controller harness connectors. 3. Test for a short across the CAN Low and CAN High circuits by measuring the resistance between the CAN Low and the CAN High circuits (pins 5 and 18 of B-229 connector) at the TCM harness connector. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 29	Go to Step 20
20	1. Keep the ignition OFF. 2. Reconnect the ECM harness connectors. 3. Measure the resistance between the CAN Low and the CAN High circuits (pins 5 and 18 of B-229 connector) at the TCM harness connector. Does the resistance measure within the specified range?	110-130 Ω	Go to Step 28	Go to Step 26
21	1. Inspect for an intermittent, for poor connections or corrosion on the CAN Low and CAN High circuits at the ECM (pins A-18 and A-17 of J-218 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 29	Go to Step 26
22	1. Inspect for an intermittent and for poor connections on the CAN Low and CAN High circuits at the TCM (pins 5 and 18 of B-229 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 29	Go to Step 27
23	1. Inspect for an intermittent, poor connections and corrosion on the CAN Low and CAN High circuits at the glow plug controller (pins 6 and 12 of E-144 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 29	Go to Step 28
24	Repair the open or high resistance in the CAN High circuit between the glow plug controller and splice. Did you complete the repair?	—	Go to Step 29	—

Step	Action	Value(s)	Yes	No
25	Repair the open or high resistance in the CAN Low circuit between the glow plug controller and splice. Did you complete the repair?	—	Go to Step 29	—
26	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 29	—
27	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Transmission Control Module (TCM) Replacement in the Automatic Transmission section. Did you complete the replacement?	—	Go to Step 29	—
28	Replace the glow plug controller. Refer to Glow Plug Controller Replacement in this section. Did you complete the replacement?	—	Go to Step 29	—
29	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 30
30	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

Chart for 12,000 lbs GVW with M/T

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check- Engine Controls
2	1. Turn OFF the ignition for 30 seconds. 2. Start the engine. 3. Monitor the engine control module (ECM) Diagnostic Trouble Code (DTC) Information with a scan tool. Is DTC P0670 also set?	—	Go to DTC P0670	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Turn ON the ignition, with the engine OFF. 2. Record all DTCs in the ECM along with any pertinent information from the ECM Failure Records. 3. Clear the DTC information in the ECM with a scan tool. 4. Turn OFF the ignition for 30 seconds. 5. Start the engine and let run for 30 seconds. 6. Monitor the diagnostic trouble codes (DTCs) with a scan tool. Does DTC U0073 or U0106 set?	—	Go to Step 4	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Disconnect the resistor harness connector (resistor is located near the fuel rail on the left side of the engine). 3. Measure the resistance of the resistor. Does the resistance measure within the specified range?	110-130 Ω	Go to Step 5	Go to Step 18
5	1. Turn ON the ignition, with the engine OFF. 2. Connect a DMM between the controller area network (CAN) Low circuit (pin 2 of E-145 connector) and a known good ground at the resistor harness connector. Record the voltage reading. 3. Connect a DMM between the CAN High circuit (pin 1 of E-145 connector) and a known good ground at the resistor harness connector. Record the voltage reading. Are both voltage readings within the specified range?	1.5-3.5 Volts	Go to Step 6	Go to Step 9
6	1. Turn OFF the ignition. 2. Disconnect the ECM harness connectors. 3. Turn ON the ignition with the engine OFF. 4. Connect a DMM between the CAN Low circuit (pin 2 of E-145 connector) and a known good ground at the resistor harness connector. Record the voltage reading. 5. Connect a DMM between the CAN High circuit (pin 1 of E-145 connector) and a known good ground at the resistor harness connector. Record the voltage reading. Are both voltage readings within the specified range?	1.5-3.5 volts	Go to Step 7	Go to Step 12

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Reconnect the ECM harness connectors. 3. Remove enough components to disconnect the glow plug controller. 4. Disconnect the glow plug controller. 5. Turn ON the ignition with the engine OFF. 6. Connect a DMM between the CAN Low circuit (pin 2 of E-145 connector) and a known good ground at the resistor harness connector. Record the voltage reading. 7. Connect a DMM between the CAN High circuit (pin 1 of E-145 connector) and a known good ground at the resistor harness connector. Record the voltage reading. Are both voltage readings within the specified range?	1.5-3.5 volts	Go to Step 8	Go to Step 11
8	1. Turn OFF the ignition. 2. Reconnect the glow plug controller harness connector. 3. Measure the resistance between the CAN Low circuit (pin 2 of E-145 connector) and the CAN High circuit (pin 1 of E-145 connector) at the resistor harness connector. Does the resistance measure within the specified range?	110-130 Ω	Go to Step 15	Go to Step 13
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connectors. 3. Disconnect the glow plug controller harness connector. 4. Turn On the ignition with the engine OFF. 5. Test for a short to ground and short to voltage on the CAN Low and CAN High circuits between the ECM, glow plug controller and resistor. 6. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 21	Go to Step 10

Step	Action	Value(s)	Yes	No
10	1. Turn OFF the ignition. 2. Reconnect the ECM harness connectors. 3. Turn ON the ignition with the engine OFF. 4. Connect a DMM between the CAN Low circuit (pin 2 of E-145 connector) and a known good ground at the resistor harness connector. Record the voltage reading. 5. Connect a DMM between the CAN High circuit (pin 1 of E-145 connector) and a known good ground at the resistor harness connector. Record the voltage reading. Are both voltage readings within the specified range?	1.5-3.5 volts	Go to Step 20	Go to Step 19
11	1. Test for an open or high resistance in the CAN Low or CAN High circuit (which ever voltage reading did not read between 1.5-3.5 volts in step 7) between the resistor harness and ECM. 2. Repair the circuit(s) as necessary. Did you find and correct the condition??	—	Go to Step 21	Go to Step 16
12	1. Test for an open or high resistance in the CAN Low or CAN High circuit (which ever voltage reading did not read between 1.5-3.5 volts in step 6) between the resistor harness and glow plug controller. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 21	Go to Step 17
13	1. Keep the ignition Off. 2. Disconnect the ECM harness connectors. 3. Disconnect the glow plug controller harness connector. 4. Test for a short across the CAN Low and CAN High circuits by measuring the resistance between the CAN Low and the CAN High circuits (pins 1 and 2 of E-145 connector) at the resistor harness connector. 5. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 21	Go to Step 14
14	1. Keep the ignition OFF. 2. Reconnect the ECM harness connectors. 3. Measure the resistance between the CAN Low and the CAN High circuits (pins 1 and 2 of E-145 connector) at the resistor harness connector. Does the resistance measure within the specified range?	110-130Ω	Go to Step 20	Go to Step 19

Step	Action	Value(s)	Yes	No
15	1. Inspect for an intermittent, for poor connections and for corrosion on the CAN Low and CAN High circuits (pins 1 and 2 of E-145 connector) at the resistor harness connector. 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 21	Go to Step 19
16	1. Inspect for an intermittent, for poor connections and for corrosion on the CAN Low and CAN High circuits (pins A-18 and A-17 of J-218 connector) at the ECM harness connector. 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 21	Go to Step 19
17	1. Inspect for an intermittent, for poor connections and for corrosion on the CAN Low and CAN High circuits (pins 6 and 12 of E-144 connector) at the glow plug controller harness connector. 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 21	Go to Step 20
18	Replace the resistor. Did you complete the replacement?	—	Go to Step 21	—
19	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Content Programming in this section. Did you complete the replacement?	—	Go to Step 21	—
20	Replace the glow plug controller. Refer to Glow Plug Controller Replacement in this section. Did you complete the replacement?	—	Go to Step 21	—
21	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Step 2	Go to Step 22
22	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

Chart for Except 12,000 lbs GVW

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the engine control module (ECM) Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	Attempt to communicate with the transmission control module (TCM) via the Transmission Data table. Does the scan tool communicate with the TCM?	—	Go to Step 4	Go to Diagnostic System Check – Transmission Controls
4	1. Turn OFF the ignition. 2. Remove the TCM from its bracket for easier testing. 3. Measure the resistance across the controller area network (CAN) Low and High circuit by back probing the TCM (pins 5 and 18 of B-229 connector) (TCM is located near the base of the steering column). Does the resistance measure within the specified range (parallel resistance of the 120 Ω resistor in the ECM and the 120 Ω resistor in the TCM should be 60 Ω)?	50-70 Ω	Go to Step 5	Go to Step 9
5	1. Disconnect the TCM harness connector. 2. Connect a DMM between the CAN Low circuit harness (pin 5 of B-229 connector) and a known good ground. 3. Turn ON the ignition, with engine OFF. Is the voltage reading within the specified range?	1.5-3.5 volts	Go to Step 6	Go to Step 10
6	1. Connect a DMM between the CAN High circuit harness (pin 18 of B-229 connector) and a known good ground. 2. Turn ON the ignition, with engine OFF. Is the voltage reading within the specified range?	1.5-3.5 volts	Go to Step 7	Go to Step 11

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Reconnect the TCM harness connector. 3. Disconnect the engine control module (ECM) harness connector. 4. Connect a DMM between the CAN Low circuit by back probing the TCM (pin 5 of B-229 connector) and a known goof ground. 5. Turn ON the ignition, with engine OFF. Is the voltage reading within the specified range?	1.5-3.5 volts	Go to Step 8	Go to Step 14
8	1. Connect a DMM between the CAN High circuit by back probing the TCM (pin 5 of B-229 connector) and a known good ground. 2. Turn ON the ignition, with engine OFF. Is the voltage reading within the specified range?	1.5-3.5 volts	Go to Step 12	Go to Step 14
9	1. Test the CAN Low and High circuit between the ECM (pins A-17 and A-18 of J-218 connector) and the TCM (pins 5 and 18 of B-229 connector) for an open circuit or high resistance. 2. Inspect for an intermittent and for poor connections on the CAN Low and High circuits at the ECM and TCM. 3. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
10	1. Test the CAN Low circuit between the ECM (pin A-18 of J-218 connector) and the TCM (pin 5 of B-229 connector) for the following conditions: • A short to ground • A short to battery or ignition voltage 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
11	1. Test the CAN High circuit between the ECM (pin A-17 of J-218 connector) and the TCM (pin 18 of B-229 connector) for the following conditions: • A short to ground • A short to battery or ignition voltage 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15

Step	Action	Value(s)	Yes	No
12	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the DTC Information with a scan tool. Does DTC U0073 and U0101 set?	—	Go to Step 15	Go to Step 13
13	Does only U0101 set at Step 12?	—	Go to Step 14	Go to Diagnostic Aids
14	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Transmission Control Module (TCM) Replacement in Automatic Transmission section. Did you find and correct the condition?	—	Go to Step 16	—
15	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 17
17	Observe the stored information, Capture Info with a scan tool. Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

Malfunction Indicator Lamp (MIL) Inoperative

Description

Battery positive voltage is supplied directly to the malfunction indicator lamp (MIL). The engine control module (ECM) turns the MIL ON by grounding the MIL control circuit. There should be a steady MIL with the ignition ON and the engine OFF.

MIL Operation

The MIL is located on the instrument panel cluster (IPC).

MIL Function

- The MIL informs the driver that a malfunction has occurred and the vehicle should be taken in for service as soon as possible.
- The MIL illuminates during a bulb test and a system test.
- A DTC will be stored if the MIL is requested by the ECM.

MIL Illumination

- The MIL will illuminate with ignition switch ON and the engine not running.
- The MIL will turn OFF when the engine is started.
- The MIL will remain ON if the self-diagnostic system has detected a malfunction.
- The MIL may turn OFF if the malfunction is not present.
- If the MIL is not illuminated and the engine stalls, the MIL will not illuminate until the ignition switch is cycled OFF, then ON.
- If the MIL is illuminated and then the engine stalls, the MIL will remain illuminated so long as the ignition switch is ON.

Test Description

The number below refers to the step number on the diagnostic table.

4. This step tests for a short to voltage on the MIL control circuit. With the fuse removed there should be no voltage on the MIL control circuit.

Malfunction Indicator Lamp (MIL) Inoperative

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Verify whether the instrument panel cluster (IPC) is operational. 2. Install a scan tool. 3. Turn ON the ignition, with the engine OFF. 4. Command the Malfunction Indicator Lamp (MIL) ON and OFF with a scan tool. Does the malfunction indicator lamp (MIL) turn ON and OFF when commanded with a scan tool?	—	Go to Intermittent Conditions	Go to Step 3
3	Inspect the Gauges (10 A) fuse that supplies ignition voltage to the MIL. Is the fuse open?	—	Go to Step 10	Go to Step 4

Step	Action	Value(s)	Yes	No
4	1. Turn OFF the ignition. 2. Remove the Gauges (10 A) fuse that supplies voltage to the MIL. 3. Disconnect the engine control module (ECM) A harness connector (J-218 connector). 4. Turn ON the ignition with the engine OFF. DO NOT start the engine. 5. Measure the voltage from the MIL control circuit at the ECM to a known good ground. Is the voltage less than the specified value?	0.5 volts	Go to Step 5	Go to Step 11
5	1. Turn OFF the ignition. 2. Install the Gauges (10 A) fuse that supplies voltage to the MIL. 3. Turn ON the ignition, with the engine OFF. 4. Connect a 3-amp fused jumper wire between the MIL control circuit in the ECM harness connector and a known good ground. Is the MIL illuminated?	—	Go to Step 9	Go to Step 6
6	1. Turn ON the ignition. 2. Operate the cruise main switch while observing the cruise main lamp in the IPC. Does the Cruise Main lamp operate correctly?	—	Go to Step 7	Go to Step 12
7	1. Turn OFF the ignition. 2. Disconnect the IPC harness connector (B-51). 3. Test the MIL control circuit for an open or high resistance. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 8
8	1. Test for an intermittent and for a poor connection at the IPC (pin 5 of B-51). 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 13
9	1. Test for an intermittent and for a poor connection at the ECM harness connector (pin A-80 of J-218 connector). 2. Repair the connector(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
10	Replace the Gauges (10 A) fuse. If the fuse continues to open, repair the short to ground on the ignition voltage circuit or check for a shorted component. Did you complete the repair?	—	Go to Step 15	—

Step	Action	Value(s)	Yes	No
11	Repair the short to voltage on the MIL control circuit. Did you complete the repair?	—	Go to Step 15	—
12	Repair the open in the MIL ignition voltage circuit. Did you complete the repair?	—	Go to Step 15	—
13	Repair or replace the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Body, Cab and Accessories section. Did you complete the repair or replacement?	—	Go to Step 15	—
14	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 15	—
15	1. Remove all test equipment. 2. Connect any disconnected components or any disconnected fuse. 3. Turn ON the ignition, with the engine OFF. 4. Command the MIL ON and OFF with a scan tool. Does the MIL turn ON and OFF when commanded with a scan tool?	—	Go to Step 16	Go to Step 2
16	1. Turn OFF the ignition for 30 seconds. 2. Start the engine and operate the vehicle checking for acceptable performance and driveability. 3. Observe the MIL, the vehicle performance and the driveability. Does the vehicle operate correctly, without any MIL illumination and without any stored DTCs?	—	System OK	Go to Diagnostic Trouble Code (DTC) List or Symptom Charts

Malfunction Indicator Lamp (MIL) Always On

Description

Battery positive voltage is supplied directly to the malfunction indicator lamp (MIL). The engine control module (ECM) turns the MIL ON by grounding the MIL control circuit.

MIL Operation

The MIL is located on the instrument panel cluster (IPC).

MIL Function

- The MIL informs the driver that a malfunction has occurred and the vehicle should be taken in for service as soon as possible.
- The MIL illuminates during a bulb test and a system test.
- A DTC will be stored if the MIL is requested by the ECM.

MIL Illumination

- The MIL will illuminate with ignition switch ON and the engine not running.
- The MIL will turn OFF when the engine is started.
- The MIL will remain ON if the self-diagnostic system has detected a malfunction.
- The MIL may turn OFF if the malfunction is not present.
- If the MIL is illuminated and then the engine stalls, the MIL will remain illuminated so long as the ignition switch is ON.
- If the MIL is not illuminated and the engine stalls, the MIL will not illuminate until the ignition switch is cycled OFF, then ON.

Malfunction Indicator Lamp (MIL) Always On

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Command the Malfunction Indicator Lamp (MIL) ON and OFF with a scan tool. Does the MIL always remain ON when commanded ON and OFF with a scan tool?	—	Go to Step 3	Check for DTCs and if none exist Go to Intermittent Conditions
3	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) A harness connector. 3. Turn ON the ignition, with the engine OFF. DO NOT start the engine. 4. Observe the MIL. Is the MIL illuminated?	—	Go to Step 4	Go to Step 6
4	1. Remove the instrument panel cluster (IPC). 2. Disconnect the IPC harness connector (B-51). 3. Test the MIL control circuit for a short to ground. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 5
5	Replace the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Body, Cab and Accessories section. Did you complete the replacement?	—	Go to Step 7	—

Step	Action	Value(s)	Yes	No
6	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 7	—
7	1. Remove all test equipment. 2. Connect any disconnected components. 3. Turn ON the ignition, with the engine OFF. 4. Command the MIL ON and OFF with a scan tool. Does the MIL always remain ON when commanded ON and OFF with a scan tool?	—	Go to Step 2	Go to Step 8
8	1. Turn OFF the ignition for 30 seconds. 2. Start the engine and operate the vehicle checking for acceptable performance and driveability. 3. Observe the MIL, the vehicle performance, and the driveability. Does the vehicle operate correctly, without any MIL illumination and without any stored DTCs?	—	System OK	Go to Diagnostic Trouble Code (DTC) List or Symptom Charts

Service Vehicle Soon (SVS) Lamp Inoperative [12,000 lbs GVW]

Description

Battery positive voltage is supplied directly to the Service Vehicle Soon (SVS) Lamp. The engine control module (ECM) turns the SVS lamp ON by grounding the SVS lamp control circuit. There should be a steady SVS lamp with the ignition ON and the engine OFF.

SVS Lamp Operation

The SVS lamp is located on the instrument panel cluster (IPC).

SVS Lamp Function

- The SVS lamp informs the driver that a malfunction has occurred and the vehicle should be taken in for service as soon as possible.
- The SVS lamp illuminates during a bulb test and a system test.
- A DTC will be stored if the SVS lamp is requested by the ECM.

SVS lamp Illumination

- The SVS lamp will illuminate with ignition switch ON and the engine not running.
- The SVS lamp will turn OFF when the engine is started.
- The SVS lamp will remain ON if the self-diagnostic system has detected a malfunction.
- The SVS lamp may turn OFF if the malfunction is not present.
- If the SVS lamp is not illuminated and the engine stalls, the SVS lamp will not illuminate until the ignition switch is cycled OFF, then ON.
- If the SVS lamp is illuminated and then the engine stalls, the SVS lamp will remain illuminated so long as the ignition switch is ON.

Test Description

The number below refers to the step number on the diagnostic table.
4. This step tests for a short to voltage on the SVS lamp control circuit. With the fuse removed there should be no voltage on the SVS lamp control circuit.

Service Vehicle Soon (SVS) Lamp Inoperative [12,000 lbs GVW]

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Verify whether the instrument panel cluster (IPC) is operational. 2. Install a scan tool. 3. Turn ON the ignition, with the engine OFF. 4. Command the Service Vehicle Soon (SVS) Lamp Control ON and OFF with a scan tool. Does the SVS lamp turn ON and OFF when commanded with a scan tool?	—	Go to Intermittent Conditions	Go to Step 3
3	Inspect the Gauges (10 A) fuse that supplies ignition voltage to the SVS lamp. Is the fuse open?	—	Go to Step 10	Go to Step 4

Step	Action	Value(s)	Yes	No
4	1. Turn OFF the ignition. 2. Remove the Gauges (10 A) fuse that supplies voltage to the SVS lamp. 3. Disconnect the engine control module (ECM) A harness connector (J-218 connector). 4. Turn ON the ignition with the engine OFF. DO NOT start the engine. 5. Measure the voltage from the SVS lamp control circuit at the ECM to a known good ground. Is the voltage less than the specified value?	0.5 volts	Go to Step 5	Go to Step 11
5	1. Turn OFF the ignition. 2. Install the Gauges (10 A) fuse that supplies voltage to the SVS lamp. 3. Turn ON the ignition, with the engine OFF. 4. Connect a 3-amp fused jumper wire between the SVS lamp control circuit in the ECM harness connector and a known good ground. Is the SVS lamp illuminated?	—	Go to Step 9	Go to Step 6
6	1. Turn ON the ignition. 2. Operate the cruise main switch while observing the cruise main lamp in the IPC. Does the Cruise Main lamp operate correctly?	—	Go to Step 7	Go to Step 12
7	1. Turn OFF the ignition. 2. Disconnect the IPC harness connector (B-51). 3. Test the SVS lamp control circuit for an open or high resistance. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 8
8	1. Test for an intermittent and for a poor connection at the IPC (pin 12 of B-52). 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 13
9	1. Test for an intermittent and for a poor connection at the ECM harness connector (pin A-25 of J-218 connector). 2. Repair the connector(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
10	Replace the Gauges (10 A) fuse. If the fuse continues to open, repair the short to ground on the ignition voltage circuit or check for a shorted component. Did you complete the repair?	—	Go to Step 15	—

Step	Action	Value(s)	Yes	No
11	Repair the short to voltage on the SVS lamp control circuit. Did you complete the repair?	—	Go to Step 15	—
12	Repair the open in the SVS lamp ignition voltage circuit. Did you complete the repair?	—	Go to Step 15	—
13	Repair or replace the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Body, Cab and Accessories section. Did you complete the repair or replacement?	—	Go to Step 15	—
14	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 15	—
15	1. Remove all test equipment. 2. Connect any disconnected components or any disconnected fuse. 3. Turn ON the ignition, with the engine OFF. 4. Command the SVS Lamp Control ON and OFF with a scan tool. Does the SVS lamp turn ON and OFF when commanded with a scan tool?	—	Go to Step 16	Go to Step 2
16	1. Turn OFF the ignition for 30 seconds. 2. Start the engine and operate the vehicle checking for acceptable performance and driveability. 3. Observe the SVS lamp, the vehicle performance and the driveability. Does the vehicle operate correctly, without any SVS lamp illumination and without any stored DTCs?	—	System OK	Go to Diagnostic Trouble Code (DTC) List or Symptom Charts

Service Vehicle Soon (SVS) Lamp Always On [12,000 lbs GVW]

Description

Battery positive voltage is supplied directly to the Service Vehicle Soon (SVS) Lamp. The engine control module (ECM) turns the MIL ON by grounding the SVS lamp control circuit.

SVS Lamp Operation

The SVS lamp is located on the instrument panel cluster (IPC).

SVS Lamp Function

- The SVS lamp informs the driver that a malfunction has occurred and the vehicle should be taken in for service as soon as possible.
- The SVS lamp illuminates during a bulb test and a system test.
- A DTC will be stored if the SVS lamp is requested by the ECM.

SVS Lamp Illumination

- The SVS lamp will illuminate with ignition switch ON and the engine not running.
- The SVS lamp will turn OFF when the engine is started.
- The SVS lamp will remain ON if the self-diagnostic system has detected a malfunction.
- The SVS lamp may turn OFF if the malfunction is not present.
- If the SVS lamp is illuminated and then the engine stalls, the SVS lamp will remain illuminated so long as the ignition switch is ON.
- If the SVS lamp is not illuminated and the engine stalls, the SVS lamp will not illuminate until the ignition switch is cycled OFF, then ON.

Service Vehicle Soon (SVS) Lamp Always On [12,000 lbs GVW]

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Command the Service Vehicle Soon (SVS) Lamp Control ON and OFF with a scan tool. Does the SVS lamp always remain ON when commanded ON and OFF with a scan tool?	—	Go to Step 3	Check for DTCs and if none exist Go to Intermittent Conditions
3	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) A harness connector. 3. Turn ON the ignition, with the engine OFF. DO NOT start the engine. 4. Observe the SVS lamp. Is the SVS lamp illuminated?	—	Go to Step 4	Go to Step 6
4	1. Remove the instrument panel cluster (IPC). 2. Disconnect the IPC harness connector (B-52). 3. Test the SVS lamp control circuit for a short to ground. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 5

Step	Action	Value(s)	Yes	No
5	Replace the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Body, Cab and Accessories section. Did you complete the replacement?	—	Go to Step 7	—
6	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 7	—
7	1. Remove all test equipment. 2. Connect any disconnected components. 3. Turn ON the ignition, with the engine OFF. 4. Command the SVS Lamp Control ON and OFF with a scan tool. Does the SVS lamp always remain ON when commanded ON and OFF with a scan tool?	—	Go to Step 2	Go to Step 8
8	1. Turn OFF the ignition for 30 seconds. 2. Start the engine and operate the vehicle checking for acceptable performance and driveability. 3. Observe the SVS lamp, the vehicle performance, and the driveability. Does the vehicle operate correctly, without any SVS lamp illumination and without any stored DTCs?	—	System OK	Go to Diagnostic Trouble Code (DTC) List or Symptom Charts

EGR Control System Check

Description

The engine control module (ECM) controls the EGR valve opening based on the atmospheric pressure, engine speed, engine coolant temperature, intake air temperature and fuel injection quantity. The ECM controls the EGR valve by controlling the EGR DC motor. The EGR valve position is detected by the EGR position sensor, and relayed to ECM .

Condition for running the EGR control:

- The battery voltage is more than 11 volts.
- The barometric pressure is more than 11.6 psi (80 kPa).
- The engine speed is higher than 570 RPM.
- The engine coolant temperature is between 149°F (65°C) and 198°F (92°C).
- The intake air temperature is between -40°F (-40°C) and 185°F (85°C).

Condition for canceling the EGR control:

- The barometric pressure went less than 11.3 psi (78 kPa).
- The engine speed dropped below 570 RPM.
- The engine coolant temperature exceeded 203°F (95°C), or dropped below 144°F (62°C).
- The intake air temperature exceeded 185°F (85°C), or dropped below -49°F (-45°C).
- Certain DTCs have been set.

EGR Control System Check

Step	Action	Value(s)	Yes	No
1	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition, with the engine OFF. 4. Monitor the Diagnostic Trouble Code (DTC) Information of the engine control system with a scan tool and check whether any of the following DTC(s) are set: DTC P0016, P0087, P0088, P0089, P0091, P0092, P0093, P0101, P0102, P0103, P0116, P0117, P0118, P0126, P0181, P0182, P0183, P0192, P0193, P0201-P0204, P0237, P0238, P0239, P0261, P0264, P0267, P0270, P0299, P0300-P0304, P0335, P0401, P0403, P0404, P0405, P0406, P0478, P0493, P0606, P0642, P0643, P1093, P1404, P2146-P2151, P2228, P2229 or P2293 Are any of the above DTC(s) set?	—	Refer to Applicable Diagnosis Trouble Code (DTC)	Go to Step 2
2	1. Inspect the EGR components for the following conditions: • EGR gas leaking from any of the EGR passages between the exhaust manifold and intake manifold. Check for damaged components and for loose components. • Restricted or collapsed EGR passage between the exhaust manifold and EGR valve. 2. Repair the condition as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Start the engine and let idle. 2. Warm up the engine (engine coolant temperature is between 149°F (65°C) and 198°F (92°C). 3. Observe the Desired EGR Position and EGR Position Sensor parameter with a scan tool. Is the difference between the Desired EGR Position and EGR Position Sensor less than 5%?	—	System OK	Go to Step 4
4	Command the EGR Solenoid to 100% while observing the EGR Position Sensor parameter with a scan tool. Does the EGR Position Sensor parameter change in accordance with the EGR Solenoid Command?	—	Go to Step 6	Go to Step 5
5	1. Remove the EGR valve. 2. Inspect the EGR valve for restriction. 3. Repair the condition as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 6
6	Replace the EGR valve. Refer to EGR valve Replacement in the section. Did you complete the replacement?	—	Go to Step 7	—
7	1. Install a scan tool. 2. Start the engine and let idle. 3. Warm up the engine (engine coolant temperature is more than 149°F (65°C). 4. Observe the EGR Solenoid Command and EGR Position Sensor parameter with a scan tool. Is the difference between the EGR Solenoid Command and EGR Position Sensor less than 5%?	—	System OK	Go to Step 2

Glow Control System Check [Except 12,000 lbs GVW]

Description

The glow control system consists of the engine control module (ECM), the glow relay, glow plugs and the glow indicator lamp. The glow control system is operated when the engine coolant temperature is low, which allows easier engine starting. If the ignition switch is turned ON when the engine coolant temperature is low, the ECM turns ON the glow relay and illuminates the glow indicator lamp. After a fixed time passes, the ECM turns OFF the glow relay and the glow indicator lamp.

Glow Control Operation

- The glow control system operates when the engine coolant temperature is less than 50°F (10°C).
- The glow indicator lamp is illuminated between 3 seconds and 10 seconds according to the engine coolant temperature.
- The glow relay is ON between 15 seconds and 30 seconds according to the engine coolant temperature.

Glow Control System Check [Except 12,000 lbs GVW]

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Chart 1 of 2

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Diagnostic Trouble Code (DTC) Information of the engine control module with a scan tool. Is DTC P0117, P0118 or P0382 set?	—	Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 3
3	1. Start the engine and allow the engine coolant temperature (ECT) to exceed 50°F (10°C). 2. Turn OFF the ignition. 3. Perform a Glow Lamp (lower right of instrument panel cluster [IPC]) bulb check by turning the ignition ON for 2 seconds and OFF for 2 seconds. The glow lamp should illuminate for less than 1 second and go out each time the ignition is cycled if the glow system is not active. 4. Perform check several times. Does the Glow Lamp operate correctly?	—	Go to Chart 2 of 2	Go to Step 4
4	1. Turn ON the ignition, with the engine OFF. 2. Make sure the engine coolant temperature (ECT) is above 50°F (10°C). Is the Glow Lamp always illuminated?	—	Go to Step 5	Go to Step 7

Step	Action	Value(s)	Yes	No
5	1. Turn OFF the ignition 2. Disconnect the engine control module (ECM) A harness connector (J-218). 3. Turn ON the ignition, with the engine OFF. DO NOT start the engine. 4. Observe the Glow Lamp. Is the Glow Lamp illuminated?	—	Go to Step 6	Go to Step 19
6	1. Remove the IPC in order to disconnect the B-51 harness connector. 2. Disconnect the IPC harness connector (B-51). 3. Test the glow lamp control circuit for a short to ground. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 18
7	Inspect the Gauges (10 A) fuse that supplies ignition voltage to the Glow Lamp. Is the fuse open?	—	Go to Step 16	Go to Step 8
8	1. Turn OFF the ignition. 2. Remove the Gauges (10 A) fuse that supplies voltage to the Glow Lamp. 3. Disconnect the ECM A harness connector (J-218 connector). 4. Turn ON the ignition, with the engine OFF. 5. Measure the voltage from the Glow Lamp control circuit at the fuse end to a known good ground. Is the voltage less than the specified value?	0.5 volts	Go to Step 9	Go to Step 14
9	1. Turn OFF the ignition. 2. Install the Gauges (10 A) fuse that supplies voltage to the Glow Lamp. 3. Turn ON the ignition, with the engine OFF. 4. Connect a 3-amp fused jumper wire between the glow lamp control circuit in the ECM harness and a known good ground. Is the Glow Lamp illuminated?	—	Go to Step 12	Go to Step 10
10	1. Turn ON the ignition. 2. Operate the Cruise Main switch, while observing the Cruise Main lamp in the IPC. Does the Cruise Main Lamp operate correctly?	—	Go to Step 11	Go to Step 15

Step	Action	Value(s)	Yes	No
11	1. Turn OFF the ignition. 2. Test the Glow Lamp control circuit for an open or high resistance. 3. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 13
12	1. Test for an intermittent and for a poor connection on the glow lamp control circuit at the ECM (pin A-79 of J-218 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 13
13	1. Test for an intermittent and for a poor connection on the glow lamp control circuit at the IPC (pin 15 of B-52 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 20	Go to Step 17
14	Repair the short to voltage in the glow lamp control circuit. Did you complete the repair?	—	Go to Step 20	--
15	Repair the open in the glow lamp ignition voltage circuit. Did you complete the repair?	—	Go to Step 20	--
16	Replace the Gauges 10 A (fuse). If the fuse continues to open, repair the short to ground on the ignition voltage circuit. Did you complete the repair?	—	Go to Step 20	--
17	Replace the glow lamp bulb in the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in Body, Cab and Accessories section. Did you complete the replacement?	—	Go to Step 20	--
18	Replace the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Body, Cab and Accessories section. Did you complete the replacement?	—	Go to Step 20	--
19	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 20	--

Step	Action	Value(s)	Yes	No
20	1. Turn OFF the ignition. 2. Reconnect any disconnected connectors. 3. Start the engine and allow the engine coolant temperature to exceed 50°F (10°C). 4. Turn OFF the ignition. 5. Perform a Glow Lamp (lower right of IPC bulb check by turning the ignition ON for 2 seconds and OFF for 2 seconds. The glow lamp should illuminate for less than 1 second and go out each time the ignition is cycled if the glow system is not active. 6. Perform check several times. Does the Glow Lamp operate correctly?	—	Go to Chart 2 of 2	Go to Step 4

Chart 2 of 2

Step	Action	Value(s)	Yes	No
1	1. Turn OFF the ignition. 2. Make sure the metal bus bar that connects switched battery voltage to all glow plugs is secured tightly to each glow plug. 3. Turn ON the ignition, with the engine OFF. 4. Connect a test lamp between the metal bus bar (glow plug power supply E-53) and a known good ground. 5. Note the test lamp. 6. Command the Glow Plug relay ON with a scan tool and note the test lamp. Does the test lamp turn ON only when commanded ON with a scan tool?	—	Go to Step 2	Go to Step 3
2	1. Turn OFF the ignition. 2. Remove the metal bus bar from the glow plugs. 3. Using a DMM, measure resistance of each glow plug from the tip to the body. Make sure to record all measurements and take them quickly as to not allow engine temperature changes between measurements. Are the resistances all within the specified value of each other?	1 Ω	System OK	Go to Step 13

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Replace the glow relay with the starter relay or replace with a known good relay. 3. Turn ON the ignition, with the engine OFF. 4. Connect a test lamp between the metal bus bar (glow plug power supply E-53) and a known good ground. 5. Note the test lamp. 6. Command the Glow Plug relay ON with a scan tool and note the test lamp. Does the test lamp turn ON only when commanded ON with a scan tool?	—	Go to Step 7	Go to Step 4
4	Inspect the Glow (60 A) slow blow fuse in the relay box. Is the fuse open?	—	Go to Step 8	Go to Step 5
5	1. Turn OFF the ignition. 2. Remove the glow relay. 3. Connect a test lamp between pin 3 of the glow relay cavity and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 9
6	Connect a DMM between pin 2 of the glow relay cavity and a known good ground. Is the DMM voltage greater than the specified value?	0.5 volts	Go to Step 11	Go to Step 10
7	1. Test for an intermittent and for a poor connection at the glow relay cavities (pins 2 and 3 of J-13). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 12
8	1. Replace the Glow (60 A) slow blow fuse. If the fuse continues to open, use the Power Distribution schematics to identify the short to ground on a circuit fed by the fuse or check for a shorted attached component. 2. Repair the short to ground or replace the component as necessary. Did you complete the repair?	—	Go to Step 14	—
9	Repair the open in the battery voltage supply circuit between the Glow (60 A) slow blow fuse and the glow relay. Did you complete the repair?	—	Go to Step 14	—

Step	Action	Value(s)	Yes	No
10	Repair the open in the switched battery voltage supply circuit between the glow relay and the glow plugs. Did you complete the repair?	—	Go to Step 14	—
11	Repair the short to voltage in the switched battery voltage supply circuit between the glow relay and the glow plugs. Did you complete the repair?	—	Go to Step 14	—
12	Replace the glow relay. Did you complete the replacement?	—	Go to Step 14	—
13	Replace the appropriate glow plug. Did you complete the replacement?	—	Go to Step 14	—
14	1. Turn OFF the ignition. 2. Reconnect any disconnected connectors and install the glow relay if removed. 3. Connect a test lamp between the metal bus bar (glow plug power supply) and a known good ground. 4. Note the test lamp. 5. Command the Glow Plug relay ON with a scan tool and note the test lamp. Does the test lamp turn ON only when commanded ON with a scan tool?	—	Go to Step 2	Go to Step 3

Cruise Control System Check

Description

The cruise control system consists of the engine control module (ECM), the cruise main switch, set/coast switch and resume/accel. switch. The cruise control keeps the vehicle running at a fixed speed without pressing the accelerator pedal. The vehicle speed is increased or decreased if the set/coast switch or the resume/accel. switch is pushed.

Cruise Control Operation

Conditions for running the cruise control:

- The vehicle speed is between 30 MPH (48 km/h) and 75 MPH (121 km/h).
- The engine coolant temperature is more than 68°F (20°C).
- The cruise main switch is ON.

Conditions for canceling the cruise control:

- When the brake pedal is depressed.
- When the clutch pedal is depressed (MT) or when the transmission gear position is shifted to the "N" or "1st" position (A/T).
- The vehicle speed becomes approximately 25 MPH (40 km/h) or lower.
- The cruise main switch is turned OFF.
- The ignition switch is turned OFF.
- The DTCs relating to the cruise control system are set.

1. Function of "SET"
   If the set/coast switch is pressed and released while conditions for running the cruise control are satisfied, the ECM memorizes and maintains the vehicle speed at the time.
2. Function of "COAST"
   If the set/coast switch is pressed while the cruise control system is operating, the vehicle speed is decreased. Then, when the set/coast switch is released, the vehicle will maintain the vehicle speed at that time.
3. Function of "RESUME"
   If the resume/accel. switch is pressed while the cruise control system is operating and the ECM memorizes the vehicle speed, the vehicle speed is returned to the vehicle speed memorized by the ECM.
4. Function of "ACCEL"
   If the resume/accel. switch is pressed while the cruise control system is operating, the vehicle speed is increased. Then, when the resume/accel. switch is released, the vehicle will maintain the vehicle speed at that time.
5. Function of "TAP UP"
   If the resume/accel. switch is tapped while the cruise control system is operating, the vehicle speed is increased 1 MPH (1.6 km/h) at a time. The function is possible to operate 10 times continuously until vehicle speed is increased to 75 MPH (120 km/h).
6. Function of "TAP DOWN"
   If the set/coast switch is tapped while the cruise control system is operating, the vehicle speed is decreased 1 MPH (1.6 km/h) at a time. The function is possible to operate 10 times continuously until the vehicle speed is decreased to 30 MPH (48 km/h).
7. Function of Temporary Acceleration
   If the accelerator pedal is pressed while the cruise control system is operating, the vehicle speed is increased.
8. Function of Temporary Cancellation
   The cruise control is canceled temporarily if the following condition is satisfied:
   - The brake pedal is pressed.
   - The clutch pedal is pressed (M/T).
   - The transmission gear position is not 2nd, 3rd, or 4th (A/T).

Diagnostic Aids

Notice:
The operational speed range of the cruise control system can change by request of a user within the following allowable range.

- Maximum cruise control speed limit is lower than 75 MPH (121 km/h).
- Minimum cruise control speed limit is higher than 25 MPH (40 km/h).

Refer to the Cruise Control Option Programming in this section for ECM programming.

Notice:
The ECM has the capability to be programmed so that the during cruise control the exhaust brake may be used to maintain the set speed.
Refer to the Exhaust Brake Option Programming in this section for ECM programming.

Cruise Control System Check

Schematic Reference: Engine Controls Schematics
Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views

Chart 1 of 2

Step	Action	Value(s)	Yes	No
1	1. Start the engine. 2. Allow the engine coolant temperature to reach at least 68°F (20°C). 3. Turn ON the cruise main switch. 4. Drive the vehicle at 50 MPH (80 km/h) on a flat level road. 5. Press and release the cruise set/coast switch. 6. Verify the 50 MPH (80 km/h) vehicle speed is maintained. 7. Tap the cruise set/coast switch 10 times. Did the vehicle maintain the set speed of 50 MPH (80 km/h), and then decrease by 1 MPH (1.6 km/h) each time the switch was tapped?	—	Go to Step 2	Go to Step 5
2	Tap the cruise resume/accel. switch 10 times. Does the vehicle speed increase by 1 MPH (1.6 km/h) each time the switch was tapped?	—	Go to Step 3	Go to Step 14
3	Are the cruise main and cruise set lamps in the instrument panel illuminated while in cruise control?	—	Go to Step 4	Go to Chart 2 of 2
4	Press and release the brake pedal. Does the cruise control cancel?	—	System OK	Refer to DTC P0571 for Brake Switch Diagnosis
5	1. Park the vehicle. 2. Turn ON the ignition, with the engine OFF. 3. Install a scan tool. 4. Check the Diagnostic Trouble Code (DTC) Information with a scan tool. Are any DTCs set in which the “Action Taken When the DTC Sets” under that particular code states, “The ECM Inhibits the Cruise Control”?	—	The ECM is not allowing cruise control. Refer to Applicable Diagnostic Trouble Code (DTC)	Go to Step 6
6	Observe the Cruise On/Off Switch parameter with a scan tool while pressing and releasing the cruise main switch several times. Does the Cruise On/Off Switch parameter on a scan tool indicate ON then OFF each time the switch is depressed?	—	Go to Step 7	Go to Step 8
7	Monitor the Cruise Set/Coast Switch parameter with a scan tool while pressing and releasing the cruise set/coast switch several times. Does the Cruise Set/Coast Switch parameter on scan tool indicate ON when the switch is depressed and OFF when the switch is released?	—	Problem Intermittent. Refer to Conditions for Running and Canceling the Cruise Control above.	Go to Step 11

Step	Action	Value(s)	Yes	No
8	**Notice:** If the ECM (IGN) (10 A) fuse supplying battery voltage to the cruise main switch is open, the engine will not start. 1. Turn OFF the ignition. 2. Remove the bezel surrounding the instrument panel cluster (IPC) enough to disconnect the cruise main switch harness connector. 3. Disconnect the cruise main switch harness connector. 4. Turn ON the ignition, with the engine OFF. 5. Momentarily jumper across the cruise main switch harness connector (pins 2 and 4 of B-376 connector) while monitoring the Cruise On/Off Switch parameter on the scan tool. Does the parameter indicate ON when the circuit is jumpered and OFF when the circuit is not jumpered?	—	Go to Step 17	Go to Step 9
9	Connect a test lamp between the voltage feed circuit of cruise main switch harness (pin 4 of B-376 connector) and a known good ground. Does the test lamp illuminate?	—	Go to Step 10	Go to Step 21
10	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Test the cruise main switch circuit between the ECM (pin A-46 of J-218 connector) and the cruise main switch (pin 2 of B-376 connector) for an open circuit or high resistance. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 28	Go to Step 20

Step	Action	Value(s)	Yes	No
11	**Notice:** If the ECM (IGN) (10 A) fuse supplying battery voltage to the cruise set/ coast switch is open, the engine will not start. 1. Turn OFF the ignition. 2. Remove the bezel surrounding the IPC enough to disconnect the cruise set/coast switch harness connector. 3. Disconnect the cruise set/coast switch harness connector. 4. Turn ON the ignition, with the engine OFF. 5. Momentarily jumper across the cruise set coast switch harness connector (pins 1 and 2 of B-377 connector) while monitoring the Cruise Set/Coast Switch parameter on the scan tool. Does the parameter indicate ON when the circuit is jumpered and OFF when the circuit is not jumpered?	—	Go to Step 18	Go to Step 12
12	Connect a test lamp between the voltage feed circuit of cruise set/coast switch harness (pin 2 of B-377 connector) and a known good ground. Does the test lamp illuminate?	—	Go to Step 13	Go to Step 22
13	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Test the cruise set/coast switch circuit between the ECM (pin A-48 of J-218 connector) and the cruise set/coast switch (pin 1 of B-377 connector) for an open circuit or high resistance. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 28	Go to Step 20

Step	Action	Value(s)	Yes	No
14	**Notice:** If the ECM (IGN) (10 A) fuse supplying battery voltage to the cruise resume/accel. switch is open, the engine will not start. 1. Turn OFF the ignition. 2. Remove the bezel surrounding the IPC enough to disconnect the cruise resume/ accel. switch harness connector. 3. Disconnect the cruise resume/accel. switch harness connector. 4. Turn ON the ignition, with the engine OFF. 5. Momentarily jumper across the cruise resume/accel. switch harness connector (pins 3 and 8 of B-378 connector) while monitoring the Cruise Resume/Accel. Switch parameter on the scan tool. Does the parameter indicate ON when the circuit is jumpered and OFF when the circuit is not jumpered?	—	Go to Step 19	Go to Step 15
15	Connect a test lamp between the voltage feed circuit of the cruise resume/accel. switch harness (pin 8 of B-378 connector) and a known good ground. Does the test lamp illuminate?	—	Go to Step 16	Go to Step 23
16	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Test the cruise resume/accel. switch circuit between the ECM (pin A-47 of J-218 connector) and the cruise resume/ accel. switch (pin 3 of B-378 connector) for an open circuit or high resistance. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 28	Go to Step 20
17	1. Inspect for an intermittent and for a poor connection at the harness connector of the cruise main switch (pins 2 and 4 of B-376 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 28	Go to Step 24
18	1. Inspect for an intermittent and for a poor connection at the harness connector of the cruise set/coast switch (pins 1 and 2 of B-377 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 28	Go to Step 25

Step	Action	Value(s)	Yes	No
19	1. Inspect for an intermittent and for a poor connection at the harness connector of the cruise resume/accel. switch (pins 3 and 8 of B-378 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 28	Go to Step 26
20	1. Inspect for an intermittent and for a poor connection at the harness connector of the ECM (pins A-46, A-47 or A-48 of J-218 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 28	Go to Step 27
21	Repair the open circuit between the ECM (IGN) (10 A) fuse and the cruise main switch (pin 4 of B-376 connector). Did you complete the repair?	—	Go to Step 28	—
22	Repair the open circuit between the ECM (IGN) (10 A) fuse and the cruise set/coast switch (pin 2 of B-377 connector). Did you complete the repair?	—	Go to Step 28	—
23	Repair the open circuit between the ECM (IGN) (10 A) fuse and the cruise resume/accel. switch (pin 8 of B-378 connector). Did you complete the repair?	—	Go to Step 28	—
24	Replace the cruise main switch. Did you complete the replacement?	—	Go to Step 28	—
25	Replace the cruise set/coast switch. Did you complete the replacement?	—	Go to Step 28	—
26	Replace the cruise resume/accel. switch. Did you complete the replacement?	—	Go to Step 28	—
27	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 28	—
28	1. Turn OFF the ignition. 2. Reconnect any disconnected connectors. 3. Reinstall the IPC bezel. Is the action complete?	—	Go to Step 1	—

Chart 2 of 2

Step	Action	Value(s)	Yes	No
1	1. Turn ON the ignition, with the engine OFF. 2. Inspect the Gauges (10 A) fuse that supplies ignition voltage to the cruise main and cruise set lamps. If the MIL is illuminated, the fuse is OK. Is the fuse open?	—	Go to Step 14	Go to Step 2
2	Is the cruise main lamp inoperative?	—	Go to Step 3	Go to Step 6
3	1. Turn OFF the ignition. 2. Remove the Gauges (10 A) fuse. 3. Disconnect the engine control module (ECM) harness connector. 4. Turn ON the ignition, with the engine OFF. 5. Connect a DMM between the cruise main lamp control circuit at the ECM harness connector (pin A-81 of J-218 connector) and a known good ground. Is the voltage less than the specified value?	0.5 volts	Go to Step 4	Go to Step 12
4	1. Turn OFF the ignition. 2. Install the Gauges (10 A) fuse. 3. Turn ON the ignition, with the engine OFF. 4. Connect a 3-amp fused jumper wire between the cruise main lamp control circuit at the ECM harness connector (pin A-81 of J-218 connector) and a known good ground. Is the cruise main lamp illuminated?	—	Go to Step 11	Go to Step 5
5	1. Turn OFF the ignition. 2. Remove the IPC enough to disconnect the B-51 harness connector. 3. Test the cruise main lamp control circuit between the IPC and the ECM for an open circuit or high resistance. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 9
6	1. Turn OFF the ignition. 2. Remove the Gauges (10 A) fuse. 3. Disconnect the ECM harness connector. 4. Turn ON the ignition, with the engine OFF. 5. Connect a DMM between the cruise set lamp control circuit at the ECM harness connector (pin A-84 of J-218 connector) and a known good ground. Is the voltage less than the specified value?	0.5 volts	Go to Step 7	Go to Step 13

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Install the Gauges (10 A) fuse. 3. Turn ON the ignition, with the engine OFF. 4. Connect a 3-amp fused jumper wire between the cruise set lamp control circuit at the ECM harness connector (pin A-84 of J-218 connector) and a known good ground. Is the cruise set lamp illuminated?	—	Go to Step 11	Go to Step 8
8	1. Turn OFF the ignition. 2. Remove the IPC connector. 3. Test the cruise set lamp control circuit between the IPC (pin 13 of B-51 connector) and the ECM (pin A-84 of J-218 connector) for an open circuit or high resistance. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 10
9	1. Test for an intermittent and for a poor connection on the cruise main lamp control circuit at the IPC (pin 7 of B-51 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 15
10	1. Test for an intermittent and for a poor connection on the cruise set lamp control circuit at the IPC (pin 13 of B-51 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 16
11	1. Test for an intermittent and for a poor connection at the ECM harness connector (pins A-81 or A-84 of J-218 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 18	Go to Step 17
12	Repair the short to voltage on the cruise main lamp control circuit. Did you complete the repair?	—	Go to Step 18	—
13	Repair the short to voltage on the cruise set lamp control circuit. Did you complete the repair?	—	Go to Step 18	—

Step	Action	Value(s)	Yes	No
14	Replace the Gauges (10 A) fuse. If the fuse continues to open, refer to the Power Distribution schematics to locate the short to ground or check for a shorted attached component. Did you complete the repair?	—	Go to Step 18	—
15	Replace the cruise main lamp bulb or the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in Body, Cab and Accessories section. Did you complete the replacement?	—	Go to Step 18	—
16	Replace the cruise set lamp bulb or the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in Body, Cab and Accessories section. Did you complete the replacement?	—	Go to Step 18	—
17	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 18	—
18	1. Turn OFF the ignition. 2. Reconnect any disconnected connectors. Is the action complete?	—	Go to Chart 1 of 2 Step 1	—

Symptoms - Engine Controls

Symptoms - Engine Controls

Important Preliminary Inspections Before Starting

Perform Diagnostic System Check - Engine Controls before using the symptom tables, and verify that all of the following are true:

- The engine control module (ECM) and malfunction indicator lamp (MIL) are operating correctly.
- There are no diagnostic trouble codes (DTCs) stored, or a DTC exists but without the MIL.
- The scan tool data is within the normal operating range. Refer to Scan Tool Data List in this section.
- Verify the customer concern and locate the correct symptom in the table of contents. Inspect the items indicated under that symptom.

Visual and Physical Inspection

Several of the symptom procedures ask for careful visual and physical inspection. This step is extremely important. The visual and physical inspection can lead to correcting a problem without further inspections, and can save valuable time. Ensure that:

- The ECM grounds are clean, tight, and in their proper location.
- The vacuum hoses are not split or kinked, and properly connected. Inspect thoroughly for any type of leak or restriction.
- The mass air flow (MAF) sensor is properly installed.
- The air intake ducts are not collapsed or damaged.
- There are no leaks at the MAF sensor, any connections or intake manifold sealing surfaces.
- The engine harness wiring and terminals are properly connected and are not pinched or cut.

Intermittent

Important:
Inspect for improper installation of electrical components if an intermittent condition exists. Inspect for aftermarket add-on electrical equipment devices, lights, and cellular phones. Verify that no aftermarket equipment is connected to the Class 2 serial data circuit. If you cannot locate an intermittent condition, a cellular phone communication signal may cause the condition.

Important:
The problem may or may not turn ON the MIL or store a DTC. Faulty electrical connections or wiring cause most intermittent problems. Perform a careful visual and physical inspection of the suspect connectors for the following conditions:

- Improperly mated connector halves
- Terminals that are not seated
- Terminals that are damaged or improperly formed

Reform or replace connector terminals in the problem circuit in order to ensure proper contact tension. Remove the terminal from the connector body in order to inspect for poor terminal wire connection.

Road test the vehicle with the DMM connected to the suspected circuit. An abnormal reading that occurs when the malfunction occurs is a good indication that there is a malfunction in the circuit being monitored.

Use the scan tool in order to help detect intermittent conditions. Useful features of the Tech 2 scan tool include the following:

- Trigger the Snapshot feature in order to capture and store engine parameters when the malfunction occurs. Review this stored information in order to see the specific running conditions that caused the malfunction.
- Freeze Frame/Failure Records can also aid in locating an intermittent condition. Review and capture the information in the Freeze Frame/ Failure Record associated with the intermittent DTC being diagnosed. Drive the vehicle within the conditions that were present when the DTC originally set.
- Use the Plot Function on the scan tool in order to plot selected data parameters. Review this stored information to aid in locating an intermittent problem. Refer to the scan tool Users Guide for more information.

Important:
If the intermittent condition exists as a start and then stall, test for DTCs relating to the vehicle theft deterrent system. Test for improper installation of electrical options such as lights, cellular phones, etc.

Any of the following may cause an intermittent MIL with no stored DTC:

- The ECM grounds are loose or dirty. Refer to Engine Controls Schematics.
- The MIL circuit intermittently shorted to ground.
- Electrical system interference caused by a malfunctioning relay, ECM driven solenoid, or switch. The electrical component can cause a sharp electrical surge. Normally, the problem will occur when the malfunctioning component is operating.
- There are any open diodes.

Important:
The following symptom tables contain groups of possible causes for each symptom. The order of these procedures is not important. If the scan tool readings do not indicate the problems, then proceed in a logical order, easiest to check or most likely to cause first. In order to determine if a specific vehicle is using a particular system or component, refer to Engine Controls Schematics for an application.

Use the following tables when diagnosing a symptom complaint:

- Intermittent Conditions
- Hard Start
- Rough, Unstable, or Incorrect Idle and Stalling
- High Idle
- Cuts Out, Misses
- Surge/Chuggles
- Lack of Power, Sluggishness, or Sponginess
- Hesitation, Sag, Stumble
- Fuel Knock/Combustion Noise
- Poor Fuel Economy
- Excessive Smoke (Black Smoke)
- Excessive Smoke (Blue or Gray Smoke)
- Excessive Smoke (White Smoke)

Intermittent Conditions

Checks	Action
DEFINITION: The problem is not currently present but is indicated in DTC History. OR There is a customer complaint, but the symptom cannot currently be duplicated, if the problem is not DTC related.	
Preliminary Checks	• Refer to Symptoms - Engine Controls before starting.
Harness/Connector	Many intermittent open or shorted circuits are affected by harness/connector movement that is caused by vibration, engine torque, bumps/rough pavement, etc. Test for this type of condition by performing the applicable procedure from the following list: • Move related connectors and wiring while monitoring the appropriate scan tool data. • Move related connectors and wiring with the component commanded ON, and OFF, with the scan tool. Observe the component operation. • With the engine running, move related connectors and wiring while monitoring engine operation. If harness or connector movement affects the data displayed, component/ system operation, or engine operation, inspect and repair the harness/ connections as necessary. Refer to Electrical Connections or Wiring.
Electrical Connections or Wiring	Poor electrical connections, terminal tension or wiring problems cause most intermittent. To perform the following inspections: • Inspect for poor mating of the connector halves, or terminals improperly seated in the connector body. • Inspect for improperly formed or damaged terminals. Test for poor terminal tension. • Inspect for poor terminal to wire connections including terminals crimped over insulation. This requires removing the terminal from the connector body. • Inspect for corrosion/water intrusion. Pierced or damaged insulation can allow moisture to enter the wiring. The conductor can corrode inside the insulation, with little visible evidence. Look for swollen and stiff sections of wire in the suspect circuits. • Inspect for wires that are broken inside the insulation. • Inspect the harness for pinched, cut or rubbed through wiring. • Ensure that the wiring does not come in contact with hot exhaust components.

Checks	Action
Control Module Power and Grounds Component Power and Grounds	Poor power or ground connections can cause widely varying symptoms. • Test all control module power supply circuits. Many vehicles have multiple circuits supplying power to the control module. Other components in the system may have separate power supply circuits that may also need to be tested. Inspect connections at the module/component connectors, fuses, and any intermediate connections between the power source and the module/component. A test lamp or a DMM may indicate that voltage is present, but neither tests the ability of the circuit to carry sufficient current. Ensure that the circuit can carry the current necessary to operate the component. • Test all control module ground and system ground circuits. The control module may have multiple ground circuits. Other components in the system may have separate grounds that may also need to be tested. Inspect grounds for clean and tight connections at the grounding point. Inspect the connections at the component and in splice packs, where applicable. Ensure that the circuit can carry the current necessary to operate the component.
Temperature Sensitivity	• An intermittent condition may occur when a component/connection reaches normal operating temperature. The condition may occur only when the component/connection is cold, or only when the component/ connection is hot. • Freeze Frame, Failure Records, or Snapshot data may help with this type of intermittent condition, where applicable. • If the intermittent is related to heat, review the data for a relationship with the following: - High ambient temperatures - Underhood/engine generated heat - Circuit generated heat due to a poor connection, or high electrical load - Higher than normal load conditions, towing, etc. • If the intermittent is related to cold, review the data for the following: - Low ambient temperatures. - In extremely low temperatures, ice may form in a connection or component. Test for water intrusion. - The condition only occurs on a cold start. - The condition goes away when the vehicle warms up. • Information from the customer may help to determine if the trouble follows a pattern that is temperature related.

Checks	Action
Electromagnetic Interference (EMI) and Electrical Noise	Some electrical components/circuits are sensitive to EMI or other types of electrical noise. Inspect for the following conditions: • A misrouted harness that is too close to high voltage/high current devices such as injection components, motors, generator etc. These components may induce electrical noise on a circuit that could interfere with normal circuit operation. • Electrical system interference caused by a malfunctioning relay, or the engine control module (ECM) driven solenoid or switch. These conditions can cause a sharp electrical surge. Normally, the problem will occur when the malfunctioning component is operating. • Improper installation of non-factory or aftermarket add on accessories such as lights, 2-way radios, amplifiers, electric motors, remote starters, alarm systems, cell phones, etc. These accessories may lead to an emission related OBD II failure while in use, but do not fail when the accessories are not in use. • Test for an open diode across the A/C compressor clutch and for other open diodes. Some relays may contain a clamping diode. • Test the generator for a bad rectifier bridge that may be allowing AC noise into the electrical system.
Incorrect ECM Programming	• There are only a few situations where reprogramming a ECM is appropriate: - A ECM from another vehicle is installed. - Revised software/calibration files have been released for this vehicle. **Important:** DO NOT reprogram the ECM with the SAME software/calibration files that are already present in the ECM. This is not an effective repair for any type of driveability problem. • Verify that the ECM contains the correct software/calibration. If incorrect programming is found, reprogram the ECM with the most current software/ calibration.
Duplicating Failure Conditions	• If none of the previous tests are successful, attempt to duplicate and/or capture the failure conditions. • Freeze Frame/Failure Records data, where applicable, contains the conditions that were present when the DTC set. - Review and record Freeze Frame/Failure Records data - Clear the DTCs using the scan tool - Turn the key to OFF and wait 15 seconds. - Operate the vehicle under the same conditions that were noted in Freeze Frame/Failure Records data, as closely as possible. The vehicle must also be operating within the Conditions for Running the DTC. Refer to Conditions for Running the DTC in the supporting text of the DTC being diagnosed. - Monitor DTC Status for the DTC being tested. The scan tool will indicate Ran, when the enabling conditions have been satisfied long enough for the DTC to run. The scan tool will also indicate whether the DTC passed or failed. • An alternate method is to drive the vehicle with the DMM connected to a suspected circuit. An abnormal reading on the DMM when the problem occurs, may help you locate the problem.

Checks	Action
Scan Tool Snapshot	The scan tool can be set up to take a Snapshot of the parameters available via serial data. The Snapshot function records live data over a period of time. The recorded data can be played back and analyzed. The scan tool can also graph parameters singly or in combinations of parameters for comparison. The Snapshot can be triggered manually at the time the symptom is noticed, or set up in advance to trigger when a DTC sets. An abnormal value captured in the recorded data may point to a system or component that needs to be investigated further. Refer to the scan tool user instructions for more information on the Snapshot function.

Hard Start

Checks	Action
DEFINITION: The engine cranks OK, but does not start for a long time. The engine does eventually run, or may start but immediately dies.	
Preliminary Checks	• Diagnostic System Check - Engine Controls. • Ensure the driver is using the correct starting procedure. • Inspect the engine control module (ECM) grounds for being clean, tight, and in their proper locations. • Inspect that the harness connectors are correctly connected. • Inspect the fuel type and quality. • Inspect the programmed fuel injector flow rate. • Inspect the Scan Tool Data List in this section. • Inspect the Service Bulletins for ECM software updates.
Sensor Checks	Inspect the engine control sensors for the following conditions: • Use the scan tool to compare the Engine Coolant Temperature (ECT) with the Intake Air Temperature (IAT) and Fuel Temperature (FT) on a cold engine. If the difference among temperature reading is more than 9°F (5°C) on a cold engine, check for high resistance on the low reference circuit and signal circuit or for a skewed sensor. **Notice:** The mass air flow (MAF) sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature if the ignition switch is left ON. • Use the scan tool to observe the Actual Fuel Rail Pressure (FRP) parameter with the engine OFF. Actual FRP parameter should be less than 441 psi (3 MPa) after the ignition is cycled. If not, check for high resistance in the 5 volts reference circuit, low reference circuit, signal circuits or for a skewed sensor. • Inspect the crankshaft position (CKP) sensor and camshaft position (CMP) sensor signal. Use the scan tool to observe the Crank Signal Present and Cam Signal Present for a “No“ value to identify an intermittent condition.

Checks	Action
Fuel System Checks	Inspect the fuel system for the following conditions. Refer to Fuel System Check Chart and appropriate procedure in the Fuel System section. • Inspect for air in the fuel system. • Inspect for water contamination in the fuel. • Inspect for external fuel leaks or high engine oil level. • Measure the fuel return rate from the fuel injectors. • Inspect the fuel lines between the fuel tank and fuel supply pump for being crushed or kinked. • Inspect for a plugged fuel tank vent valve. • Inspect inside the fuel tank for any foreign material that may be getting drawn into the fuel line pickup causing a blocked condition. • Inspect the fuel lines between the fuel tank and fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. • Inspect the fuel supply pump operation. **Notice:** The fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM. • Perform the Cylinder Power Balance Test with a scan tool. Replace the appropriate fuel injector that does not change engine speed when commanded OFF. • Inspect the fuel rail pressure (FRP) regulator control current on the scan tool.
Air Intake System Checks	Inspect the air intake system for the following conditions. • Inspect the air cleaner and air intake ducts for a restriction, holes, or leaks. • Inspect for a restriction in the turbocharger inlet duct. • Inspect the intake throttle valve for a stuck closed position. • Inspect for a restriction or leak in the intake manifold.
Exhaust System Check	Inspect the exhaust system for a possible restriction. Refer to the Exhaust System section. • Inspect the exhaust brake valve for a stuck closed position. • Inspect for a restriction in the exhaust pipes.
Engine Mechanical Checks	Inspect the engine mechanical for the following conditions. Refer to the Engine Mechanical section. • Inspect for poor cylinder compression. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa). • Improper valve timing • Improper valve gap • Worn rocker arms • Broken or weak valve springs • Worn camshaft lobes
Electrical System Checks	Inspect the engine electrical for the following conditions. Refer to the Engine Electrical section. • Inspect the glow plug control (preheating) system operation. • Inspect the fuel filter heater operation. • Inspect for slow cranking speed. • Inspect for weakened batteries. • Inspect the block heater operation. (Optional equipment)

Rough, Unstable, or Incorrect Idle and Stalling

Checks	Action
DEFINITION: Engine runs unevenly at idle. If severe, the engine or vehicle may shake. Engine idle speed may vary in RPM. Either condition may be severe enough to stall the engine.	
Preliminary Checks	• Diagnostic System Check - Engine Controls. • Remove the air cleaner and check for dirt, or for air ducts being plugged or restricted. Replace as necessary. • Inspect the engine control module (ECM) grounds for being clean, tight, and in their proper locations. • Inspect the programmed fuel injector flow rate. • Inspect the Scan Tool Data List in this section. • Inspect the Service Bulletins for ECM software updates.
Sensor Checks	Inspect the engine control sensors for the following conditions. Refer to the Scan Tool Data List in this section. • Use the scan tool to compare the Engine Coolant Temperature (ECT) with the Intake Air Temperature (IAT) and Fuel Temperature (FT) on a cold engine. If the difference among temperature reading is more than 9°F (5°C) on a cold engine, check for high resistance on the low reference circuit and signal circuit or for a skewed sensor. **Notice:** The mass air flow (MAF) sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature if the ignition switch is left ON. • Use the scan tool to observe the Actual Fuel Rail Pressure (FRP) parameter with the engine OFF. Actual FRP parameter should be less than 441 psi (3 MPa) after the ignition is cycled. If not, check for high resistance in the 5 volts reference circuit, low reference circuit, signal circuits or for a skewed sensor. • Use the scan tool to observe the Actual FRP and the Desired FRP parameters at idle and W.O.T. (accelerator pedal full travel) in Park or Neutral. Actual and Desired FRP parameters should always be within the 1450 psi (10 MPa) of each other. • Inspect the crankshaft position (CKP) sensor and camshaft position (CMP) sensor signal. Use the scan tool to observe the Crank Signal Present and Cam Signal Present for a “No“ value to identify an intermittent condition.

Checks	Action
Fuel System Checks	Inspect the fuel system for the following conditions. Refer to Fuel System Check Chart and appropriate procedure in the Fuel System section. • Inspect for air in the fuel system. • Inspect for water contamination in the fuel. • Inspect the fuel lines between the fuel tank and fuel supply pump for being crushed or kinked. • Inspect for a plugged fuel tank vent valve. • Inspect inside the fuel tank for any foreign material that may be getting drawn into the fuel line pickup causing a blocked condition. • Inspect the fuel lines between the fuel tank and fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. • Inspect the fuel supply pump operation. **Notice:** The fuel supply pump must be timed to the engine and adjustment value must be leaned to the ECM. • Perform the Cylinder Power Balance test with a scan tool. Replace the appropriate injector that does not change engine speed when commanded OFF. • Inspect the fuel injectors. Remove the injectors and visually inspect. • Measure the fuel return from the fuel injectors. • Inspect the fuel rail pressure (FRP) regulator control current on the scan tool.
Air Intake System Checks	Inspect the air intake system for the following conditions. • Inspect the air cleaner and air intake ducts for a restriction, holes, or leaks. • Inspect for a restriction in the turbocharger inlet duct. • Inspect the intake throttle valve for a stuck closed position. • Inspect for a restriction or leak in the intake manifold. • Inspect for a restriction or damage at the mass air flow (MAF) sensor.
Exhaust System Check	Inspect the exhaust system for a possible restriction. Refer to the Exhaust System section. • Inspect the exhaust brake valve for a stuck closed position. • Inspect for a restriction in the exhaust pipes.
Engine Mechanical Checks	Inspect the engine mechanical for the following conditions. Refer to the Engine Mechanical section. • Inspect for poor cylinder compression. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa). • Improper valve timing • Improper valve gap • Worn rocker arms • Broken or weak valve springs • Worn camshaft lobes • Inspect for incorrect basic engine parts such as camshaft, cylinder head, pistons, etc.

Checks	Action
Additional Checks	• Electromagnetic interference (EMI) on the reference circuit can cause an engine miss condition. A scan tool can usually detect EMI by monitoring the engine speed. A sudden increase in speed with little change in actual engine speed change indicates that EMI is present. If a problem exists, check routing of high voltage components, such as fuel injector wiring, near the sensor circuits. • Inspect for faulty engine mounts. • Inspect faulty crank pulley. • Inspect faulty generator & A/C compressor. • Inspect the generator output voltage. Repair if less than 9 volts or more than 16 volts. • Inspect the EGR system. Refer to the EGR Control in this section. • Inspect the A/C operation.

High Idle

Checks	Action
DEFINITION: Engine idle speed is higher than normal in regardless of engine coolant temperature.	
Preliminary Checks	• Diagnostic System Check - Engine Controls. • Inspect that the harness connectors are correctly connected. • Inspect the idle up control knob turned fully counterclockwise. • Use the scan tool to compare the engine speed and tachometer on the instrument panel cluster (IPC). • Inspect the fuel type and quality. • Inspect the engine oil level. • Inspect the scan tool Data List in this section. • Inspect the Service Bulletins for ECM software updates.

Checks	Action
Sensor Checks	Inspect the engine control sensors for the following conditions. Refer to the Scan Tool Data List in this section. • Use the scan tool to compare the Engine Coolant Temperature (ECT) with the Intake Air Temperature (IAT) and Fuel Temperature (FT) on a cold engine. If the difference among temperature reading is more than 9°F (5°C) on a cold engine, check for high resistance on the low reference circuit and signal circuit or for a skewed sensor. **Notice:** The mass air flow (MAF) sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature if the ignition switch is left ON. • Use the scan tool to observe the Actual Fuel Rail Pressure (FRP) parameter with the engine OFF. Actual FRP parameter should be less than 441 psi (3 MPa) after the ignition is cycled. If not, check for high resistance in the 5 volts reference circuit, low reference circuit, signal circuits or skewed sensor. • Use the scan tool to observe the Actual FRP and the Desired FRP parameters at idle and W.O.T. (accelerator pedal full travel) in Park or Neutral. Actual and Desired FRP parameters should always be within the 1450 psi (10 MPa) of each other. • Use the scan tool to observe the Idle Up Sensor parameter. Idle Up Sensor parameter should be less than 0.75 volts at full turned counterclockwise. If not, check for high resistance in low reference circuit or skewed sensor. • Use the scan tool to observe the Accelerator Pedal Position (APP) Indicated Angle. APP Indicated Angle parameter should change linearly from 0% to 100% according to the accelerator pedal operation.
Fuel System Checks	Inspect the fuel system for the following conditions. Refer to the Fuel System section. • Inspect the fuel injectors. Remove the injectors and visually inspect. (Injector tip(s) may be damaged) • Measure the fuel return from the fuel injectors. See Fuel System Check Chart in the Fuel System section.

Cuts Out, Misses

Checks	Action
DEFINITION: A constant jerking that follows the engine speed, usually more pronounced as the engine load increase. The exhaust has a steady spitting sound at idle, low speed, or hard acceleration for the fuel starvation that can cause the engine to cut-out.	
Preliminary Check	• Diagnostic System Check - Engine Controls. • Inspect that the harness connectors are correctly connected. • Inspect the engine control module (ECM) grounds for being clean, tight, and in their proper locations. • Inspect the Scan Tool Data List in this section. • Inspect the Service Bulletins for ECM software updates.

Checks	Action
Sensor Checks	Inspect the engine control sensors for the following conditions. Refer to the Scan Tool Data List in this section. • Use the scan tool to observe the Actual Fuel Rail Pressure (FRP) parameter with the engine OFF. Actual FRP parameter should be less than 441 psi (3 MPa) after the ignition is cycled. If not, check for high resistance in the 5 volts reference circuit, low reference circuit, signal circuits or for a skewed sensor. • Use the scan tool to observe the Actual FRP and the Desired FRP parameters at idle and W.O.T. (accelerator pedal full travel) in Park or Neutral. Actual and Desired FRP parameters should always be within the 1450 psi (10 MPa) of each other. • Inspect the crankshaft position (CKP) sensor and camshaft position (CMP) sensor signal. Use the scan tool to observe the Crank Signal Present and Cam Signal Present for a “No“ value to identify an intermittent condition. • Use the scan tool to observe the Accelerator Pedal Position (APP) Indicated Angle. APP Indicated Angle parameter should change linearly from 0% to 100% according to the accelerator pedal operation.
Fuel System Checks	Inspect the fuel system for the following conditions. Refer to Fuel System Check Chart and appropriate procedure in the Fuel System section. • Inspect for air in the fuel system. • Inspect for water contamination in the fuel. • Inspect the fuel lines between the fuel tank and fuel supply pump for being crushed or kinked. • Inspect for a plugged fuel tank vent valve. • Inspect inside the fuel tank for any foreign material that may be getting drawn into the fuel line pickup causing a blocked condition. • Inspect the fuel lines between the fuel tank and fuel supply pump for tightness and all fuel hoses for cuts, cracks and for the use of proper clamps. • Perform the Cylinder Power Balance Test with a scan tool. Replace the appropriate fuel injector that does not change engine speed when commanded OFF.
Air Intake System Checks	Inspect the air intake system for the following conditions. • Inspect the air cleaner and air intake ducts for a restriction, holes, or leaks. • Inspect for a restriction in the turbocharger inlet duct. • Inspect the intake throttle valve for a stuck closed position. • Inspect for a restriction or leak in the intake manifold. • Inspect for a restriction or damage at the mass air flow (MAF) sensor.
Exhaust System Check	Inspect the exhaust system for a possible restriction. Refer to the Exhaust System section. • Inspect the exhaust brake valve for a stuck closed position. • Inspect for a restriction in the exhaust pipes.

Checks	Action
Engine Mechanical Checks	Inspect the engine mechanical for the following conditions. Refer to the Engine Mechanical section. • Inspect for poor cylinder compression. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa). • Improper valve timing • Improper valve gap • Worn rocker arms • Broken or weak valve springs • Worn camshaft lobes
Additional Checks	• Inspect the generator output voltage. Repair if less than 9 volts or more than 16 volts. • Electromagnetic interference (EMI) on the reference circuit can cause an engine miss condition. A scan tool can usually detect EMI by monitoring the engine speed. A sudden increase in speed with little change in actual engine speed change indicates that EMI is present. If a problem exists, check routing of high voltage components, such as fuel injector wiring, near the sensor circuits.

Surges/Chuggles

Checks	Action
DEFINITION: The engine has a power variation under a steady throttle or cruise. The vehicle seems to speed up and slow down with no change in the accelerator pedal.	
Preliminary Checks	• Diagnostic System Check - Engine Controls. • Ensure the driver understands the torque converter clutch (TCC) operation. • Ensure the driver understands the A/C compressor operation. • Use the scan tool in order to make sure the Vehicle Speed Sensor parameter reading matches the vehicle speedometer. • Inspect the engine control module (ECM) grounds for being clean, tight, and in their proper locations. • Inspect that the harness connectors are correctly connected. • Inspect the fuel type and quality. • Inspect the programmed fuel injector flow rate. • Inspect the Scan Tool Data List in this section. • Inspect the Service Bulletins for ECM software updates.

Checks	Action
Sensor Checks	Inspect the engine control sensors for the following conditions. Refer to the Scan Tool Data List in this section. • Use the scan tool to observe the Actual fuel rail pressure (FRP) parameter with the engine OFF. Actual FRP parameter should be less than 441 psi (3 MPa) after the ignition is cycled. If not, check for high resistance in the 5 volts reference circuit, low reference circuit, signal circuits or skewed sensor. • Use the scan tool to observe the Actual FRP and the Desired FRP parameters at idle and W.O.T. (accelerator pedal full travel) in Park or Neutral. Actual and Desired FRP parameters should always be within the 1450 psi (10 MPa) of each other. • Use the scan tool to observe the Accelerator Pedal Position (APP) Indicated Angle. APP Indicated Angle parameter should change linearly from 0% to 100% according to the accelerator pedal operation. Also inspect the APP indicated angle when the accelerator pedal is steady. If the indicating angle fluctuates, check for an intermittently open or high resistance in the circuits or for a skewed sensor.
Fuel System Checks	Inspect the fuel system for the following conditions. Refer to Fuel System Check Chart and appropriate procedure in the Fuel System section. • Install a J-44638 Vacuum/Pressure Gauge between the fuel filter and fuel tank to check the fuel pressure. If the fuel pressure at any engine speed is a larger vacuum than 5 inHg, a restriction exists in the fuel supply lines between the fuel tank and the fuel supply pump. • Inspect the fuel supply pump operation. **Notice:** The fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM. • Perform the Cylinder Power Balance Test with a scan tool. Replace the appropriate fuel injector that does not change engine speed when commanded OFF.
Air Intake System Checks	Inspect the air intake system for the following conditions. • Inspect the air cleaner and air intake ducts for a restriction, holes, or leaks. • Inspect for a restriction in the turbocharger inlet duct. • Inspect the intake throttle valve for being stuck at any position. • Inspect for a restriction or leak in the intake manifold. • Inspect for a restriction or damage at the mass air flow (MAF) sensor.
Additional Checks	• Inspect the generator output voltage. Repair if less than 9 volts or more than 16 volts. • Inspect the EGR system. Refer to the EGR Control in this section. • Inspect the A/C operation. • Inspect the torque converter clutch (TCC) operation (A/T only).

Lack of Power, Sluggishness, or Sponginess

Checks	Action
DEFINITION: The engine delivers less than expected power. There is little or no increase in speed when partially applying the accelerator pedal.	

Checks	Action
Preliminary Checks	• Diagnostic System Check - Engine Controls. • Compare the vehicle with a similar unit. Ensure the vehicle has an actual problem. • Remove the air cleaner and check for dirt, or for air ducts being plugged or restricted. Replace as necessary. • Have the tire sizes changed? • Are excessively heavy loads being carried? • Inspect for clutch slip. • Inspect brake drag. • Inspect for a proper transmission shift pattern and down shift operation. • Inspect the fuel quality (cetane index). • Inspect the engine oil level and quality. • Use the scan tool in order to make sure the Vehicle Speed parameter reading matches the vehicle speedometer. • Inspect the engine control module (ECM) grounds for being clean, tight, and in their proper locations. • Inspect the Scan Tool Data List in this section. • Inspect the programmed fuel injector flow rate. • Inspect the Service Bulletins for ECM software updates.
Sensor Checks	Inspect the engine control sensors for the following conditions. Refer to the Scan Tool Data List in this section. • Use the scan tool to compare the Engine Coolant Temperature (ECT) with the Intake Air Temperature (IAT) and Fuel Temperature (FT) on a cold engine. If the difference among temperature reading is more than 9°F (5°C) on a cold engine, check for high resistance on the low reference circuit and signal circuit or for a skewed sensor. **Notice:** The mass air flow (MAF) sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature if the ignition switch is left ON. • Use the scan tool to observe the Actual Fuel Rail Pressure (FRP) parameter with the engine OFF. Actual FRP parameter should be less than 441 psi (3 MPa) after the ignition is cycled. If not, check for high resistance in the 5 volts reference circuit, low reference circuit, signal circuits or for a skewed sensor. • Use the scan tool to observe the Actual FRP and the Desired FRP parameters at idle and W.O.T. (accelerator pedal full travel) in Park or Neutral. Actual and Desired FRP parameters should always be within the 1450 psi (10 MPa) of each other. • Use the scan tool to observe the Boost Pressure Sensor and Barometric Pressure (BARO) with ignition ON and engine OFF. Boost Pressure Sensor and BARO parameters should be within the 1.1 psi (7.5 kPa) each other. • Use the scan tool to observe the Accelerator Pedal Position (APP) Indicated Angle. APP Indicated Angle parameter should change linearly from 0% to 100% according to the accelerator pedal operation.

Checks	Action
Fuel System Checks	Inspect the fuel system for the following conditions. Refer to Fuel System Check Chart and appropriate procedure in the Fuel System section. • Install a J-44638 Vacuum/Pressure Gauge between the fuel filter and fuel tank to check the fuel pressure. If the fuel pressure at any engine speed is a larger vacuum than 5 inHg, a restriction exists in the fuel supply lines between the fuel tank and the fuel supply pump. • Inspect the fuel supply pump operation. **Notice:** The fuel supply pump must be timed to the engine and adjustment value must be leaned to the ECM. • Perform the Cylinder Power Balance Test with a scan tool. Replace the appropriate fuel injector that does not change engine speed when commanded OFF.
Air Intake System Checks	Inspect the air intake system for the following conditions. • Inspect the air cleaner and air intake ducts for a restriction, holes, or leaks. • Inspect for a restriction or leak in the intercooler. • Inspect for a restriction in the turbocharger inlet duct. • Inspect the intake throttle valve for a stuck closed position. • Inspect for a restriction or leak in the intake manifold. • Inspect for a restriction or damage at the mass air flow (MAF) sensor. • Inspect for a worn or damaged turbocharger turbine wheel, shaft or compressor wheel. Refer to turbocharger inspection in the Engine Mechanical section. • Inspect for turbocharger waste gate valve operation. Refer to waste gate valve inspection in the Engine Mechanical section.
Exhaust System Checks	Inspect the exhaust system for a possible restriction. Refer to the Exhaust System section. • Inspect the exhaust brake valve for a stuck closed position. • Inspect for a restriction in the exhaust pipes.
Engine Mechanical Check	Inspect the engine mechanical for the following conditions. Refer to the Engine Mechanical section. • Inspect for poor cylinder compression. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa). • Improper valve timing • Improper valve gap • Broken or weak valve springs • Improper or worn camshaft
Additional Checks	• Inspect the generator output voltage. Repair if less than 9 volts or more than 16 volts. • Inspect the EGR system. Refer to the EGR Control in this section. • Inspect for an engine overheat condition. Refer to the Engine Cooling section. • Inspect the A/C operation. • Inspect the torque converter clutch (TCC) operation (A/T only).

Hesitation, Sag, Stumble

Checks	Action
DEFINITION: The vehicle has a momentary lack of response when pushing down on the accelerator. The condition can occur at any vehicle speed. The condition is usually most severe when trying to make the vehicle move from a stop. If severe enough, the condition may cause the engine to stall.	
Preliminary Check	• Diagnostic System Check - Engine Controls. • Compare the vehicle with a similar unit. Ensure the vehicle has an actual problem. • Remove the air cleaner and check for dirt, or for air ducts being plugged or restricted. Replace as necessary. • Inspect for a proper transmission shift pattern and down shift operation. Inspect the fuel quality (cetane index). • Inspect the engine oil level and quality. • Inspect the Scan Tool Data List in this section. • Inspect the engine control module (ECM) grounds for being clean, tight, and in their proper locations. • Inspect the programmed fuel injector flow rate. • Inspect the Service Bulletins for ECM software updates.
Sensor Checks	Inspect the engine control sensors for the following conditions. Refer to the Fuel System check in Scan Tool Data List in this section. • Use the scan tool to compare the Engine Coolant Temperature (ECT) with the Intake Air Temperature (IAT) and Fuel Temperature (FT) on a cold engine. If the difference among temperature reading is more than 9°F (5°C) on a cold engine, check for high resistance on the low reference circuit and signal circuit or for a skewed sensor. **Notice:** The mass air flow (MAF) sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature if the ignition switch is left ON. • Use the scan tool to observe the Actual Fuel Rail Pressure (FRP) parameter with the engine OFF. Actual FRP parameter should be less than 441 psi (3 MPa) after the ignition is cycled. If not, check for high resistance in the 5 volts reference circuit, low reference circuit, signal circuits or for a skewed sensor. • Use the scan tool to observe the Actual FRP and the Desired FRP parameters at idle and W.O.T. (accelerator pedal full travel) in Park or Neutral. Actual and Desired FRP parameters should always be within the 1450 psi (10 MPa) of each other. • Use the scan tool to observe the Boost Pressure Sensor and Barometric Pressure (BARO) with ignition ON and engine OFF. Boost Pressure Sensor and BARO parameters should be within the 1.1 psi (7.5 kPa) each other. • Use the scan tool to observe the Accelerator Pedal Position (APP) Indicated Angle. APP Indicated Angle parameter should change linearly from 0% to 100% according to the accelerator pedal operation. • Inspect the crankshaft position (CKP) sensor and camshaft position (CMP) sensor signal. Use the scan tool to observe the Crank Signal Present and Cam Signal Present for a “No“ value to identify an intermittent condition.

Checks	Action
Fuel System Checks	Inspect the fuel system for the following conditions. Refer to Fuel System Check Chart and appropriate procedure in the Fuel System section. • Install a J-44638 Vacuum/Pressure Gauge between the fuel filter and fuel tank to check the fuel pressure. If the fuel pressure at any engine speed is a larger vacuum than 5 inHg, a restriction exists in the fuel supply lines between the fuel tank and the fuel supply pump. • Inspect the fuel supply pump operation. **Notice:** The fuel supply pump must be timed to the engine and adjustment value must be leaned to the ECM. • Perform the Cylinder Power Balance Test with a scan tool. Replace the appropriate injector that does not change engine speed when commanded OFF.
Air Intake System Checks	Inspect the air intake system for the following conditions. • Inspect the air cleaner and air intake ducts for a restriction, holes, or leaks. • Inspect for a restriction or leak in the intercooler. • Inspect for a restriction in the turbocharger inlet duct. • Inspect the intake throttle valve for being stuck any positions. • Inspect for a restriction or leak in the intake manifold. • Inspect for a restriction or damage at the mass air flow (MAF) sensor. • Inspect for a worn or damaged turbocharger turbine wheel, shaft or compressor wheel. Refer to turbocharger inspection in the Engine Mechanical section. • Inspect for turbocharger waste gate valve operation. Refer to waste gate valve inspection in the Engine Mechanical section.
Exhaust System Checks	Inspect the exhaust system for a possible restriction. Refer to the Exhaust System section. • Inspect for a restriction in the exhaust pipes.
Engine Mechanical Checks	Inspect the engine mechanical for the following conditions. Refer to the Engine Mechanical section. • Inspect for poor cylinder compression. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa). • Improper valve timing • Improper valve gap • Broken or weak valve springs • Improper or worn camshaft
Additional Checks	• Inspect the generator output voltage. Repair if less than 9 volts or more than 16 volts. • Inspect the EGR system. Refer to the EGR Control in this section. • Inspect the A/C operation. • Inspect the torque converter clutch (TCC) operation (A/T only).

Fuel Knock/Combustion Noise

Checks	Action
DEFINITION: A mild to severe ping, usually worse under acceleration. The engine makes sharp metallic knocks that change with the throttle opening.	

Checks	Action
Preliminary Checks	• Diagnostic System Check - Engine Controls. • Ensure the vehicle has an actual problem. • Inspect for smoke associated with the combustion noise. • Inspect the fuel quality (cetane index). • Inspect the Scan Tool Data List in this section. • Inspect the programmed fuel injector flow rate. • Inspect the Service Bulletins for engine control module (ECM) software updates.
Sensor Checks	Inspect the engine control sensors for the following conditions. Refer to the Scan Tool Data List in this section. • Use the scan tool to compare the Engine Coolant Temperature (ECT) with the Intake Air Temperature (IAT) and Fuel Temperature (FT) on a cold engine. If the difference among temperature reading is more than 9°F (5°C) on a cold engine, check for high resistance on the low reference circuit and signal circuit or for a skewed sensor. **Notice:** The mass air flow (MAF) sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature if the ignition switch is left ON. • Use the scan tool to observe the Actual Fuel Rail Pressure (FRP) parameter with the engine OFF. Actual FRP parameter should be less than 441 psi (3 MPa) after the ignition is cycled. If not, check for high resistance in the 5 volts reference circuit, low reference circuit, signal circuits or for a skewed sensor. • Inspect the crankshaft position (CKP) sensor and camshaft position (CMP) sensor signal. Use the scan tool to observe the Crank Signal Present and Cam Signal Present for a “No“ value to identify an intermittent condition.
Fuel System Checks	• If excessive smoke is present, check for a stuck open fuel injector. Remove each glow plug from the cylinder head and inspect the tip of the glow plugs for wet fuel. Use the cylinder compression gauge. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa). If poor compression is observed, inspect the engine mechanical. • Inspect the fuel injectors. Remove the injectors and visually inspect. • Perform the Cylinder Power Balance Test with a scan tool. Replace appropriate injector that does not change engine speed when commanded OFF. • Perform the Pilot Injector Stop Test with the scan tool. Replace injector(s) that does not change engine noise when commanded to Stop.
Engine Mechanical Checks	Inspect the engine mechanical for the following conditions. Refer to the Engine Mechanical section. • Inspect for poor cylinder compression. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa). • Inspect for incorrect basic engine parts such as camshaft, cylinder head, pistons, etc. • Inspect for any excessive oil entering combustion chamber.
Additional Checks	• Inspect the EGR system. Refer to the EGR Control in this section. • Inspect other possible causes that can make similar noise such as loosing component parts, bracket, mount and weak clutch damper spring.

Poor Fuel Economy

Checks	Action
DEFINITION: Fuel economy, as measured by actual road tests and several tanks of fuel, is noticeably lower than expected. Also, the economy is noticeably lower than it was on this vehicle at one time, as previously shown by actual road tests.	
Preliminary Checks	• Remove the air cleaner and check for dirt, or for air ducts being plugged or restricted. Replace as necessary. • Inspect the driving habits of the owner. • Is the A/C ON full time, defroster mode ON? • Are the tires at the correct pressure? • Have the tire sizes changed? • Are excessively heavy loads being carried? • Is the acceleration too much, too often? • Inspect for clutch slip. • Inspect for brake drag. • Inspect dive belt tension. • Inspect for a proper transmission shift pattern and down shift operation (A/T only). • Inspect the fuel quality (cetane index). • Inspect the engine oil level and quality. • Suggest to the owner to fill the fuel tank and recheck the fuel economy. • Suggest to the driver to read the Important Facts on Fuel Economy in the Owner Manual. • Inspect that the odometer is correctly operating. • Inspect the programmed fuel injector flow rate. • Inspect the Service Bulletins for engine control module (ECM) software updates.
Sensor Checks	Inspect the engine control sensors for the following conditions. Refer to the Scan Tool Data List in this section. • Use the scan tool to compare the Engine Coolant Temperature (ECT) with the Intake Air Temperature (IAT) and Fuel Temperature (FT) on a cold engine. If the difference among temperature reading is more than 9°F (5°C) on a cold engine, check for high resistance on the low reference circuit and signal circuit or for a skewed sensor. **Notice:** The mass air flow (MAF) sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature if the ignition switch is left ON.
Fuel System Checks	Inspect the fuel system for the following conditions. Refer to the Fuel System section. • Inspect the fuel type and quality. • Check for fuel leak.
Cooling System Checks	Inspect the cooling system for the following conditions. Refer to the Cooling System Section. • Inspect the engine coolant level. • Inspect the engine thermostats for always being open or for the wrong heat range. • Inspect for engine cooling fan clutch operation.

Checks	Action
Air Intake System Checks	Inspect the air intake system for the following conditions. • Inspect the air cleaner and air intake ducts for a restriction, holes, or leaks. • Inspect for a restriction or leak in the intercooler. • Inspect for a restriction in the turbocharger inlet duct. • Inspect the intake throttle valve for a stuck closed position. • Inspect for a restriction or leak in the intake manifold. • Inspect for a restriction or damage at the mass air flow (MAF) sensor.
Exhaust System Check	Inspect the exhaust system for a possible restriction. Refer to the Exhaust System section. • Inspect the exhaust brake valve is stuck at closed position. • Inspect for a restriction in the exhaust pipes.
Engine Mechanical Checks	Inspect the engine mechanical for the following conditions. Refer to the Engine Mechanical section. • Inspect for poor cylinder compression. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa).
Additional Checks	• Inspect the Scan Tool Data List in this section. • Inspect the torque converter clutch (TCC) operation (A/T only). • Check for dragging brakes.

Excessive Smoke (Black Smoke)

Checks	Action
DEFINITION: Black smoke under load, idle or start up hot or cold.	
Preliminary Check	• Ensure the vehicle has an actual problem. • Inspect the ECM grounds for being clean, tight, and in their proper locations. • Remove the air cleaner and check for dirt, or for air ducts being plugged or restricted. Replace as necessary. • Inspect the fuel quality (cetane index). • Inspect the engine oil level and quality. • Inspect the programmed fuel injector flow rate. • Inspect the Service Bulletins for engine control module (ECM) software updates.

Checks	Action
Sensor Checks	Inspect the engine control sensors for the following conditions. Refer to the Scan Tool Data List in this section. • Use the scan tool to compare the Engine Coolant Temperature (ECT) with the Intake Air Temperature (IAT) and Fuel Temperature (FT) on a cold engine. If the difference among temperature reading is more than 9°F (5°C) on a cold engine, check for high resistance on the low reference circuit and signal circuit or for a skewed sensor. **Notice:** The mass air flow (MAF) sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature if the ignition switch is left ON. • Use the scan tool to observe the Actual Fuel Rail Pressure (FRP) parameter with the engine OFF. Actual FRP parameter should be less than 441 psi (3 MPa) after the ignition is cycled. If not, check for high resistance in the 5 volts reference circuit, low reference circuit, signal circuits or for a skewed sensor. • Use the scan tool to observe the Actual FRP and the Desired FRP parameters at idle and W.O.T. (accelerator pedal full travel) in Park or Neutral. Actual and Desired FRP parameters should always be within the 1450 psi (10 MPa) of each other. • Use the scan tool to observe the Boost Pressure Sensor and Barometric Pressure (BARO) with ignition ON and engine OFF. Boost Pressure Sensor and BARO parameters should be within the 1.1 psi (7.5 kPa) each other. • Use the scan tool to observe the BARO parameter. BARO parameter should agree with surrounding barometric pressure. • Use the scan tool to observe the Accelerator Pedal Position (APP) Indicated Angle. APP Indicated Angle parameter should change linearly from 0% to 100% according to the accelerator pedal operation.
Fuel System Checks	Inspect the fuel system for the following conditions. Refer to the Fuel System section. • Inspect the fuel supply pump. **Notice:** The fuel supply pump must be timed to the engine and adjustment value must be leaned to the ECM. • Perform the Cylinder Power Balance test with a scan tool. Replace the appropriate injector that does not change engine speed when commanded OFF. • Inspect the fuel injectors. Remove the injectors and visually inspect.
Air Intake System Check	Inspect the air intake system for the following conditions. • Inspect the air cleaner and air intake ducts for a restriction, holes, or leaks. • Inspect for a restriction or leak in the intercooler. • Inspect for a restriction in the turbocharger inlet duct. • Inspect the intake throttle valve for a stuck closed position. • Inspect for a restriction or leak in the intake manifold. • Inspect for a restriction or damage at the mass air flow (MAF) sensor. • Inspect for a worn or damaged turbocharger turbine wheel, shaft or compressor wheel. Refer to turbocharger inspection in the Engine Mechanical section.
Exhaust System Check	Inspect the exhaust system for a possible restriction. Refer to the Exhaust System section. • Inspect the exhaust brake valve for a stuck closed position. • Inspect for a restriction in the exhaust pipes.

Checks	Action
Engine Mechanical Check	Inspect the engine mechanical for the following conditions. Refer to the Engine Mechanical section. • Inspect for high cylinder compression. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa). • Inspect for incorrect basic engine parts such as camshaft, cylinder head, pistons, etc. • Inspect for any excessive oil entering combustion chamber. • Improper valve timing • Improper valve gap • Broken or weak valve springs • Worn camshaft lobes
Additional Checks	• Inspect the EGR system. Refer to the EGR Control in this section. • Inspect for excessive blow-by gasses. • Inspect the Scan Tool Data List in this section.

Excessive Smoke (Blue or Gray Smoke)

Checks	Action
DEFINITION: Gray or blue smoke under load, idle or start up hot or cold.	
Preliminary Check	• Ensure the vehicle has an actual problem. • Inspect the ECM grounds for being clean, tight, and in their proper locations. • Inspect the fuel quality (cetane index). • Inspect the engine oil level and quality.
Sensor Checks	Inspect the engine control sensors for the following conditions. Refer to the Scan Tool Data List in this section. • Use the scan tool to compare the Engine Coolant Temperature (ECT) with the Intake Air Temperature (IAT) and Fuel Temperature (FT) on a cold engine. If the difference among temperature reading is more than 9°F (5°C) on a cold engine, check for high resistance on the low reference circuit and signal circuit or for a skewed sensor. **Notice:** The mass air flow (MAF) sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature if the ignition switch is left ON. • Use the scan tool to observe the Actual Fuel Rail Pressure (FRP) parameter with the engine OFF. Actual FRP parameter should be less than 441 psi (3 MPa) after the ignition is cycled. If not, check for high resistance in the 5 volts reference circuit, low reference circuit, signal circuits or for a skewed sensor. • Use the scan tool to observe the Actual FRP and the Desired FRP parameters at idle and W.O.T. (accelerator pedal full travel) in Park or Neutral. Actual and Desired FRP parameters should always be within the 1450 psi (10 MPa) of each other.

Checks	Action
Fuel System Checks	Inspect the fuel system for the following conditions. Refer to the Fuel System section. • Inspect for engine oil in the fuel. • Inspect the fuel supply pump. **Notice:** The fuel supply pump must be timed to the engine and adjustment value must be leaned to the ECM. • Perform the Cylinder Power Balance test with a scan tool. Replace the appropriate injector that does not change engine speed when commanded OFF. • Inspect the fuel injectors. Remove the injectors and visually inspect.
Air Intake System Checks	Inspect the air intake system for the following conditions. • Inspect the air cleaner and air intake ducts for a restriction, holes, or leaks. • Inspect for a restriction or leak in the intercooler. • Inspect for a restriction in the turbocharger inlet duct. • Inspect for oil or fuel entering the air intake system. • Inspect for a restriction or damage at the mass air flow (MAF) sensor. • Inspect for a worn or damaged turbocharger turbine wheel, shaft or compressor wheel. Refer to turbocharger inspection in the Engine Mechanical section.
Exhaust System Check	Inspect the exhaust system for a possible restriction. Refer to the Exhaust System section. • Inspect for a restriction in the exhaust pipes. • Inspect for oil or fuel entering the exhaust system.
Engine Mechanical Check	Inspect the engine mechanical for the following conditions. Refer to the Engine Mechanical section. • Inspect for poor cylinder compression. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa). • Inspect for incorrect basic engine parts such as camshaft, cylinder head, pistons, etc. • Inspect for any excessive oil or fuel entering combustion chamber. • Improper valve timing • Improper valve gap • Broken or weak valve springs • Worn camshaft lobes
Additional Checks	• Inspect the EGR system. Refer to the EGR Control in this section. • Inspect the Scan Tool Data List in this section.

Excessive Smoke (White Smoke)

Checks	Action
DEFINITION: White smoke under load, idle or start up hot or cold.	

Checks	Action
Preliminary Check	• Ensure the vehicle has an actual problem. • Inspect the ECM grounds for being clean, tight, and in their proper locations. • Inspect the fuel quality (cetane index). • Inspect the programmed fuel injector flow rate. • Inspect the Service Bulletins for engine control module (ECM) software updates.
Sensor Check	Inspect the engine control sensors for the following conditions. Refer to the Scan Tool Data List in this section. • Use the scan tool to compare the Engine Coolant Temperature (ECT) with the Intake Air Temperature (IAT) and Fuel Temperature (FT) on a cold engine. If the difference among temperature reading is more than 9°F (5°C) on a cold engine, check for high resistance on the low reference circuit and signal circuit or for a skewed sensor. **Notice:** The mass air flow (MAF) sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature if the ignition switch is left ON. • Use the scan tool to observe the Actual Fuel Rail Pressure (FRP) parameter with the engine OFF. Actual FRP parameter should be less than 441 psi (3 MPa) after the ignition is cycled. If not, check for high resistance in the 5 volts reference circuit, low reference circuit, signal circuits or for a skewed sensor. • Use the scan tool to observe the Actual FRP and the Desired FRP parameters at idle and W.O.T. (accelerator pedal full travel) in Park or Neutral. Actual and Desired FRP parameters should always be within the 1450 psi (10 MPa) of each other. • Inspect the crankshaft position (CKP) sensor and camshaft position (CMP) sensor signal. Use the scan tool to observe the Crank Signal Present and Cam Signal Present for a “No“ value to identify an intermittent condition. • Use the scan tool to observe the Boost Pressure Sensor and Barometric Pressure (BARO) with ignition ON and engine OFF. Boost Pressure Sensor and BARO parameters should be within the 1.1 psi (7.5 kPa) each other. • Use the scan tool to observe the BARO parameter. BARO parameter should agree with surrounding barometric pressure.
Fuel System Checks	• Check for a stuck open fuel injector. Remove each glow plug from the cylinder head and inspect the tip of the glow plugs for wet fuel. Use the cylinder compression gauge. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa). If poor compression is observed, inspect the engine mechanical. • Perform the Cylinder Power Balance test with a scan tool. Replace the appropriate injector that does not change engine speed when commanded OFF. • Inspect the fuel injectors. Remove the injectors and visually inspect.

Checks	Action
Air Intake System Checks	Inspect the air intake system for the following conditions. • Inspect the air cleaner and air intake ducts for a restriction, holes, or leaks. • Inspect the intake throttle valve for a stuck closed position. • Inspect for a restriction in the turbocharger inlet duct. • Inspect for a restriction or leak in the intake manifold. • Inspect for a restriction or damage at the mass air flow (MAF) sensor. Inspect for a restriction or leak in the intercooler. • Inspect for a worn or damaged turbocharger turbine wheel, shaft or compressor wheel. Refer to turbocharger inspection in the Engine Mechanical section.
Engine Mechanical Checks	Inspect the engine mechanical for the following conditions. Refer to the Engine Mechanical section. • Inspect poor cylinder compression. Proper compression is more than 284 psi (1960 kPa) and variation of each cylinder is less than 43 psi (294 kPa). • Inspect for incorrect basic engine parts such as camshaft, cylinder head, pistons, etc. • Improper valve timing • Improper valve gap • Broken or weak valve springs • Worn camshaft lobes • Inspect for any excessive fuel entering combustion chamber. • Inspect for coolant entering the combustion chamber.
Electrical System Checks	Inspect the engine electrical for the following conditions. Refer to the Engine Electrical section. • Inspect the glow plug control (preheating) system operation.

Repair Instructions

Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming

Engine Control Module (ECM) Replacement Procedure

The following A-G steps provide an overview procedure to replace and reprogram an ECM. Each A-G step is explained further in this section.

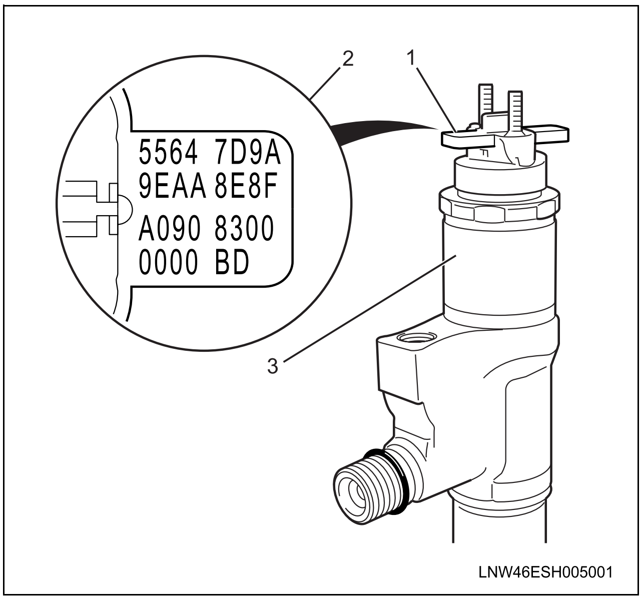
- A) Record the Fuel Injector Flow Rates manually from the old ECM. The fuel injector flow rates can be obtained using the scan tool Special Function Option Reprogramming - Injector Flow Rates.
- B) Capture the Option Content from the old ECM using the scan tool Special Function Capture and Restore Option Content.
- C) Replace the old ECM with the new ECM.
- D) Program the latest software and calibrations into the new ECM using the Service Programming System Remote Programming procedure (Select Diagnostic Tool - Tech2).
- E) Program the recorded Fuel Injector Flow Rates into the ECM using the Service Programming System Pass-Thru procedure (Select Diagnostic Tool - Pass Thru).
- F) Restore the original Option Content into the new ECM by using the scan tool Special Function Capture and Restore Option Content.
- G) Perform the fuel supply pump relearn procedure by allowing the engine to idle in Park or Neutral until normal operating temperature is achieved.

A. Recording Fuel Injector Flow Rates

Each fuel injector is designated with 30 hexadecimal characters (0-9 or A-F) that MUST be programmed into the ECM for correct engine fueling for each specific cylinder. These characters can be located in one of three places:

- Fuel Injector ID plate located on the top of each fuel injector. (Preferred Method) The correct order for the fuel injector flow rates for the following illustration are as follows:

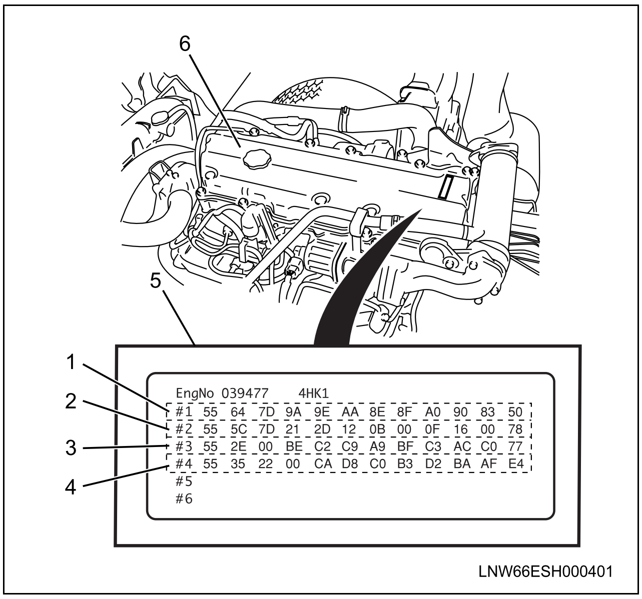
  5564 7D9A 9EAA 8E8F A090 8300 0000 BD



Legend

1. Fuel Injector ID Plate
2. Fuel Injector Flow Rate
3. Fuel Injector

- Scan Tool Special Function Option Reprogramming - Injector Flow Rates
- Cylinder Head Cover Label



Legend

1. Cylinder Number 1 Fuel Injector Flow Rate
2. Cylinder Number 2 Fuel Injector Flow Rate
3. Cylinder Number 3 Fuel Injector Flow Rate
4. Cylinder Number 4 Fuel Injector Flow Rate
5. Injector Flow Rate Label
6. Cylinder Head Cover

Important:
When entering the injector flow rates into the Service Programming System (SPS), 30 characters are needed. However, only 24 characters will show up on the scan tool AND 24 characters on the cylinder head cover label. This is because characters 23-28 are always 0. These 0's must be entered into the SPS in the correct location.

Important:
They only way to be assured that the injector flow rates on the scan tool or on the cylinder head cover label are correct is to check them against each fuel injector ID plate.

B. Capturing Option Content

The scan tool has the ability to capture all of the option content from the old ECM so it can be transferred to the new ECM. This is located under the Special Function Capture and Restore Option Content. The following is a list of the supported option content that will be stored in the scan tool:

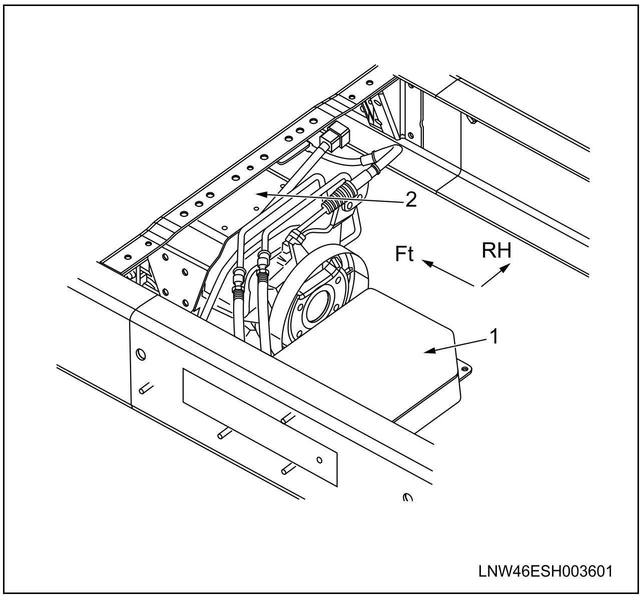
- Power Take Off (PTO) Options
- Cruise Control Options
- Exhaust Brake Options
- Vehicle Speed Limit

If communications cannot be established with the old ECM, the technician will need to ask the customer which of the above option content was previously being used.

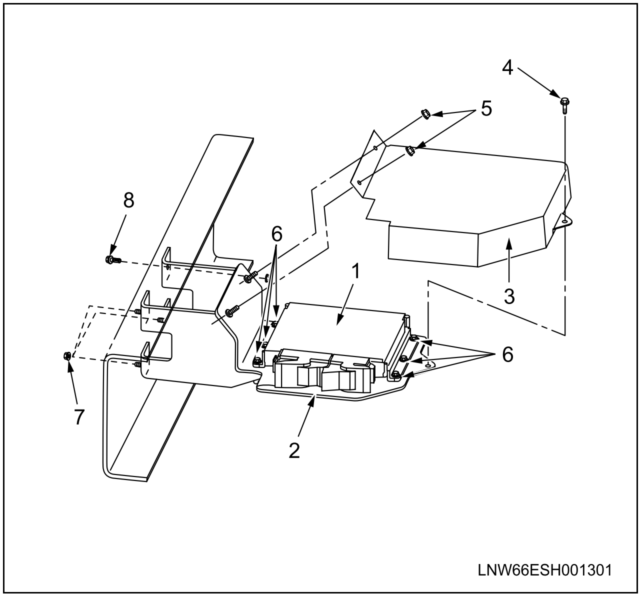
C. Removal and Installation

Removal Procedure

- ECM (1) is attached in the left rear side of transmission (2).



1. Turn OFF the ignition.
2. Disconnect the negative battery cable.
3. Remove the ECM cover nuts (5) and bolt (4).
4. Remove the ECM cover (3).
5. Disconnect the ECM connectors.
6. Remove the ECM fixing bolts (6).
7. Remove the ECM (1).



Installation Procedure

1. Install the ECM (1).
2. Tighten the ECM fixing bolts (6).

ECM fixing bolts

Tightening Torque: 8 N·m (69 lb·in)

3. Connect the ECM connectors.
4. Install the ECM cover (3).
5. Tighten the ECM cover nuts (5) and bolt (4).

ECM Cover nuts

Tightening Torque: 7 N·m (61 lb·in)

ECM cover bolt

Tightening Torque: 8 N·m (69 lb·in)

6. Connect the negative battery cable.

D. Programming Software and Calibrations

1. Make sure the hardware lock is installed on the TIS2000 terminal printer (LPT) port unless you are using a satellite-connected server.
2. Launch TIS2000 and click on Service Programming System.
3. Select the following from the Select Diagnostic Tool and Programming Process screen:
   - Select Diagnostic Tool - Tech 2
   - Select Programming Process - Reprogram ECU
   - Select ECU Location - Vehicle
4. Click Next.
5. Follow the instructions on the Preparing for Communication screen, which will Request Info. from the ECM.
6. Turn On the ignition with the engine OFF.

7. Use the scan tool to Request Info. from the new ECM located under the Service Programming System option from the scan tool Main Menu. Follow the On-Screen instructions.
8. Turn OFF the ignition.
9. Take the scan tool to the TIS2000 terminal, connect the 110 volt power supply to the scan tool then turn it ON.

Important:
The ribbon cable cannot exceed 25 feet or programming errors may occur.

10. Connect the ribbon cable between the TIS2000 terminal RS-232 port and the scan tool side port.
11. Continue to follow the SPS On-Screen instructions to download the correct software and calibrations to the scan tool.
12. Bring the scan tool to the vehicle then connect it to the data link connector (DLC) ensuring a robust connection.
13. Disconnect the ABS module harness connector (walk the connector out as to not damage the lock tab). The ECM will not program unless the ABS module Class 2 communications are disabled.
14. Turn ON the ignition with the engine OFF.
15. Before ECM programming, ensure the following are met:
    - Vehicle batteries are fully charged and there is no charging system concern. All charging system concerns must be repaired before programming the ECM.
    - Ensure NO battery charger is connected.
    - Turn OFF all accessories that may put a load on the batteries.
    - Do not change the ignition position unless instructed to do so.
    - Program only when the ECM is exposed to temperatures in the 32-122°F (0-50°C) range.

Caution:
An interruption of the tool harness connection during programming may cause ECM damage.

16. Use the scan tool to reprogram the ECM by choosing to Reprogram ECU under the Service Programming System option from the scan tool Main Menu.
17. Turn OFF the ignition and the scan tool.
18. Reconnect the ABS module harness connector.
19. Turn ON the ignition with the engine OFF.
20. Clear DTCs in the transmission control module (TCM) as a CAN communication DTC may have set during the programming event.

E. Programming Fuel Injector Flow Rates

1. Connect the scan tool to the data link connector (DLC).

Important:
The ribbon cable cannot exceed 25 feet or programming errors may occur.

2. Connect the ribbon cable between the TIS2000 terminal RS-232 port and the scan tool side port.
3. Make sure the hardware lock is installed on the TIS2000 terminal printer port (LPT) unless you are using a satellite-connected server.
4. Turn ON the ignition with the engine OFF.
5. Turn ON the scan tool.
6. Launch TIS2000 and click on Service Programming System.
7. Select the following from the Select Diagnostic Tool and Programming Process screen:
    - Select Diagnostic Tool - Pass Thru
    - Select Programming Process - Reprogram ECU
    - Select ECU Location - Vehicle
8. Follow the SPS On-Screen instructions to program the Injector Flow Rates.
9. Turn OFF the ignition for 30 seconds.
10. Turn ON the ignition with the engine OFF.
11. Use the scan tool to verify each programmed fuel injector flow rate was entered correctly. See "Recording Fuel Injector Flow Rates" for their location on scan tool.

F. Restoring Option Content

Use the scan tool to restore the previously captured option content under Special Functions Capture and Restore Option Content. If the information was not captured or could not be captured from the old ECM, each option content parameter must be re-entered using the scan tool Special Function Option Reprogramming. The technician will need to ask the customer which of the supported option content was previously being used.

G. Fuel Supply Pump Relearn Procedure

The ECM goes through a fuel supply learn procedure to fine tune the current supplied to the fuel rail pressure (FRP) regulator. This learning process is only performed when the engine is idling.

1. Install the scan tool.
2. Turn OFF the ignition for 30 seconds.
3. Start the engine and let idle until engine coolant temperature (ECT) reads 149°F (65°C) or higher while observing the Supply Pump Status parameter with the scan tool. The scan tool changes status Not Learn > Tentative > Leaning > Learned.

4. If the ECM has correctly learned the fuel supply pump current adjustment, the Supply Pump Status parameter on the scan tool will indicate Learned.

Fuel Injector Flow Rate Programming

Follow Step A: Recording Fuel Injector Flow Rates then Step E: Programming Fuel Injector Flow Rates above to program the fuel injector flow rates into the ECM.

Option Programming

All Option Content programming is performed using either the scan tool under Special Function Option Reprogramming or the TIS 2000 system. The following options are available for reprogramming:

- Power Take Off (PTO) Options
- Cruise Control Options
- Exhaust Brake Options
- Vehicle Speed Limit

Power Take Off (PTO) Options

The PTO Option Programming must be done when any of the following procedures are performed:

- When the upfitter installed a PTO.
- When the ECM is replaced.
- When a change of the PTO settings are needed.

Refer the detail programming contents and settings of the Power Take Off (PTO) System in this section.

Cruise Control Options

The Cruise Control Option Programming must be done when any of the following procedures are performed:

- When the ECM is replaced.
- When a change of the minimum cruise control speed is needed.
- When a change of the maximum cruise control speed is needed.

The operational speed range of the cruise control system can change by user request within the following allowable range.

- Minimum: 25 MPH (40 km/h)
- Maximum: 75 MPH (120 km/h)

Exhaust Brake Options

The Exhaust Brake Option Programming must be done when any of the following procedures are performed:

- When the ECM is replaced.
- When a change of the exhaust brake assist in cruise control is needed.

It is set up during the cruise control so that the exhaust brake may be effective when the actual vehicle speed is higher than set speed. It can change by user request. This exhaust brake assist in cruise control is enabled when the following conditions are met:

- Exhaust brake in cruise mode is programmed.
- Exhaust brake request switch is ON.
- In cruise control.
- Accelerator pedal is not pressed.
- Actual vehicle speed is higher than 4 MPH (6.4 km/h) from set speed.
- Fuel injection quantity is 0mm^3/stk.

This exhaust brake assist in cruise is disabled when the one of the following conditions is met.

- Exhaust brake in cruise mode is not programmed.
- Exhaust brake request switch is OFF.
- Not being the cruise control.
- Accelerator pedal is pressed.
- Actual vehicle speed is less than 1.5 MPH (2.4 km/h) of set speed.
- Fuel injection quantity more than 1 mm^3/stk.

Vehicle Speed Limit

The Vehicle Speed Limit Option Programming must be done when any of the following procedures are performed:

- When the ECM is replaced.
- When a change of the maximum vehicle speed is needed.

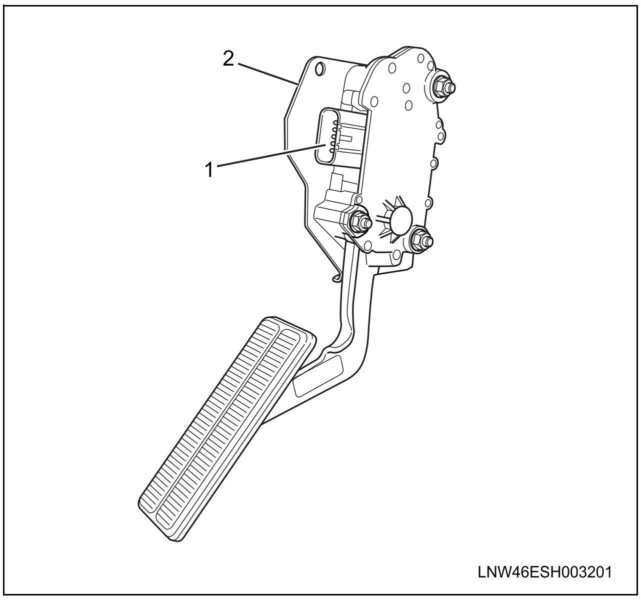
The maximum vehicle speed can change by user request within the following allowable range.

- Minimum: 20 MPH (32 km/h)
- Maximum: 75 MPH (118 km/h)

Accelerator Pedal Position (APP) Sensor Replacement

Removal Procedure

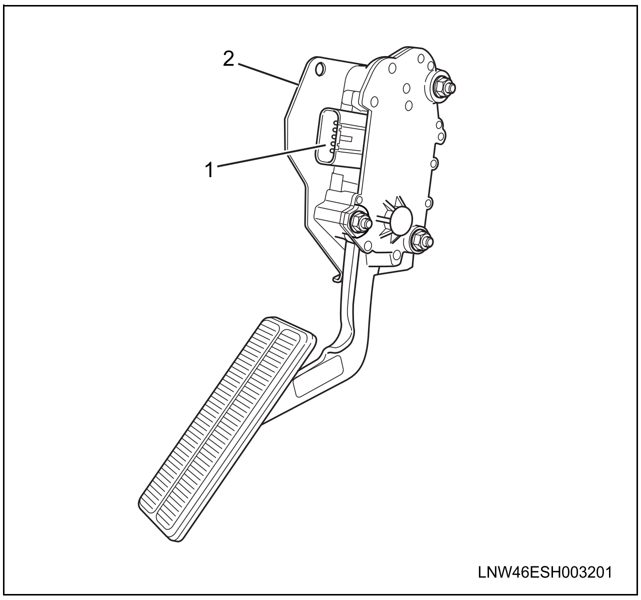
1. Turn off the ignition.
2. Disconnect the APP sensor connector (1).



3. Remove the accelerator pedal assembly with accelerator pedal bracket (2).
4. Remove the accelerator pedal assembly from accelerator pedal bracket (2).

Installation Procedure

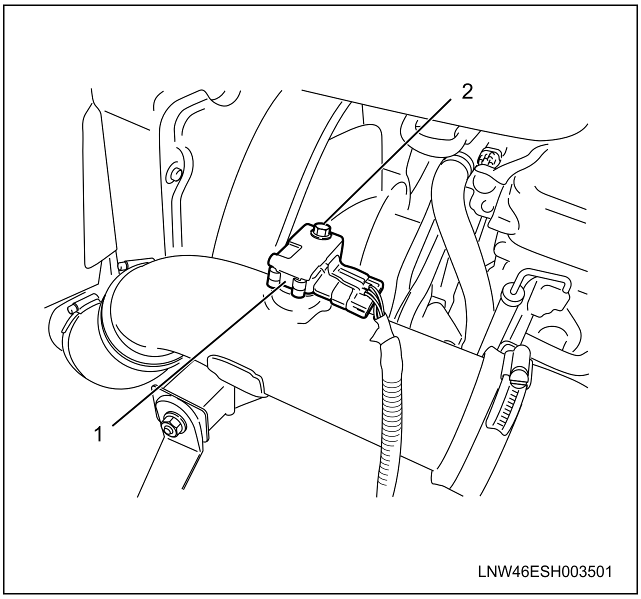
1. Install the accelerator pedal assembly in accelerator pedal bracket (2).
2. Install the accelerator pedal assembly with accelerator pedal bracket (2).
3. Connect the APP sensor connector (1).



Boost Pressure Sensor Replacement

Removal Procedure

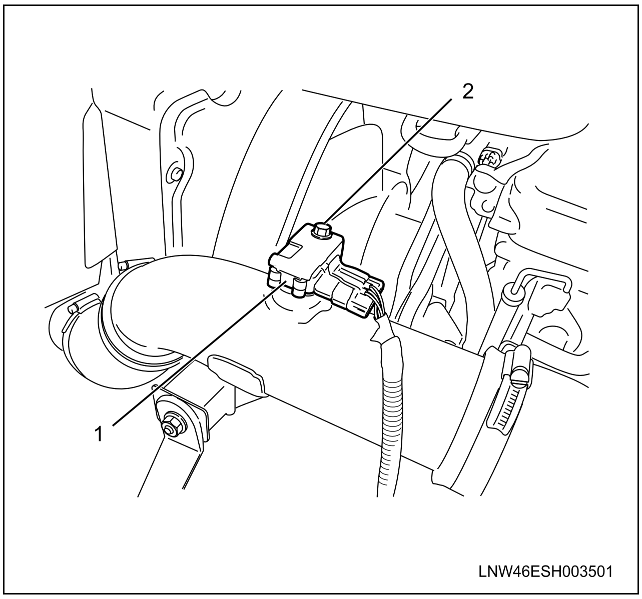
1. Turn off the ignition.
2. Loosen the boost pressure sensor bolt (2).
3. Disconnect the boost pressure sensor connector.
4. Remove the boost pressure sensor (1).



Installation Procedure

1. Install the boost pressure sensor (1).
2. Tighten the boost pressure sensor bolt (2).

Tightening torque: 8 N·m (69 lb in)

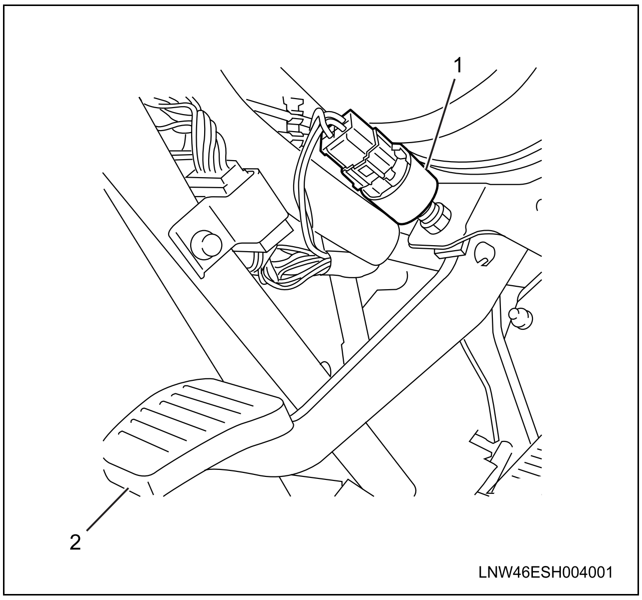


3. Connect the boost pressure sensor connector.

Brake Switch Replacement

Removal Procedure

1. Disconnect the negative battery cable.
2. Disconnect the brake switch connector.



Legend

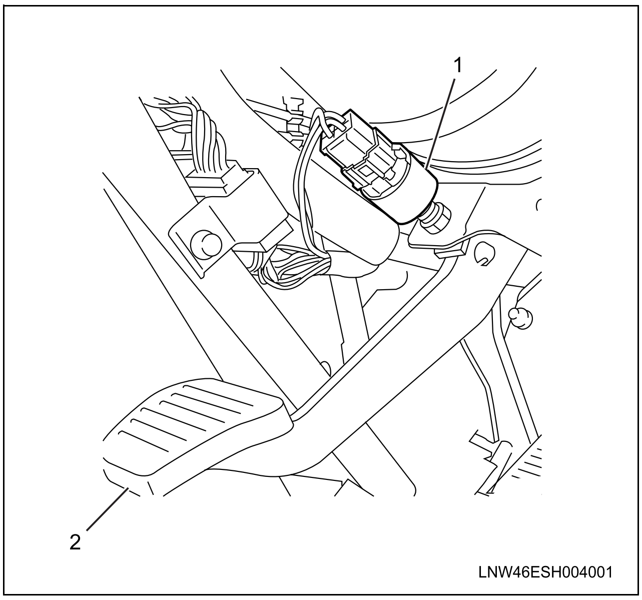
1. Brake Switch
2. Brake Pedal

---

3. Loose the lock nut.
4. Remove the brake switch (1) by turning.

Installation Procedure

1. Install the brake switch.



Legend

1. Brake Switch
2. Brake Pedal

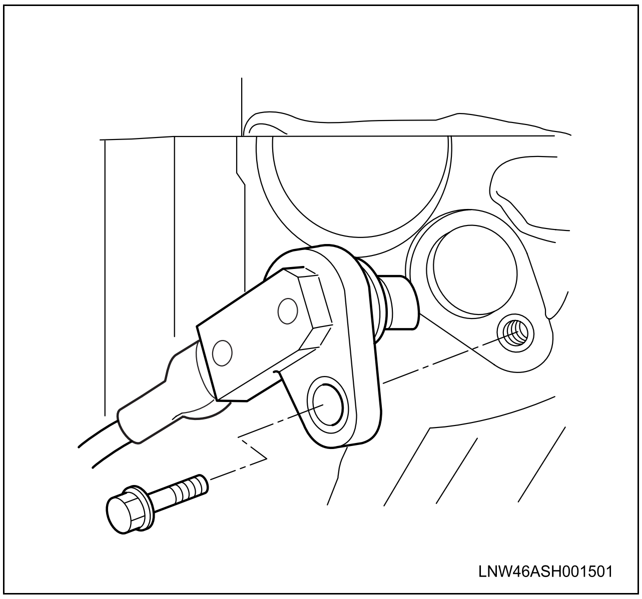
---

2. Turn the brake switch counter clockwise until the space between the tip of the threaded portion and the pedal arm is 0.5 to 1.0 mm (0.02–0.04 in).
3. Connect the brake switch connector.
4. Make sure the brake switch is adjusted correctly.

Camshaft Position (CMP) Sensor Replacement

Removal Procedure

1. Turn off the ignition.
2. Loosen the CMP sensor retaining bolt.

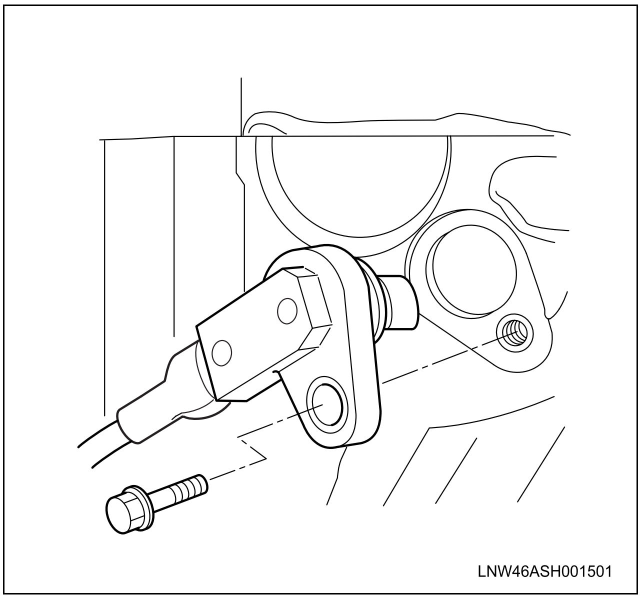


3. Remove the CMP sensor.

Installation Procedure

1. Install the CMP sensor.
   - Apply a thin layer of engine oil over the O-ring and install it.
2. Tighten the CMP sensor retaining bolt.

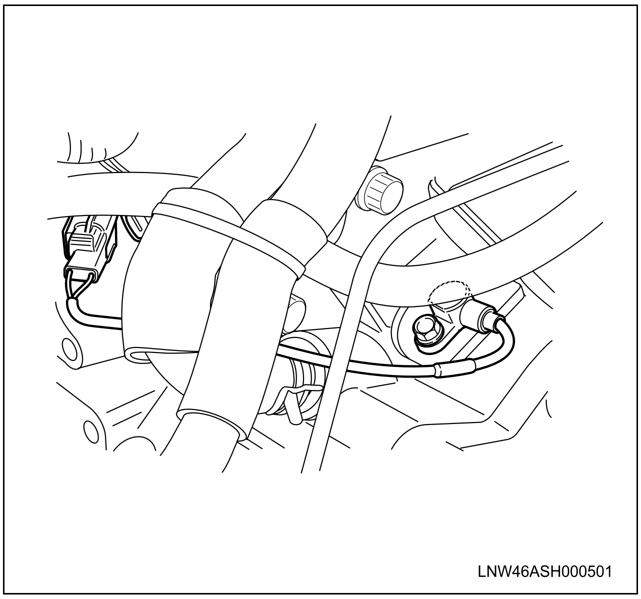
Tightening torque: 8 N·m (69 lb in)



Crankshaft Position (CKP) Sensor Replacement

Removal Procedure

1. Disconnect the negative battery cable.
2. Loosen the CKP sensor retaining bolt.

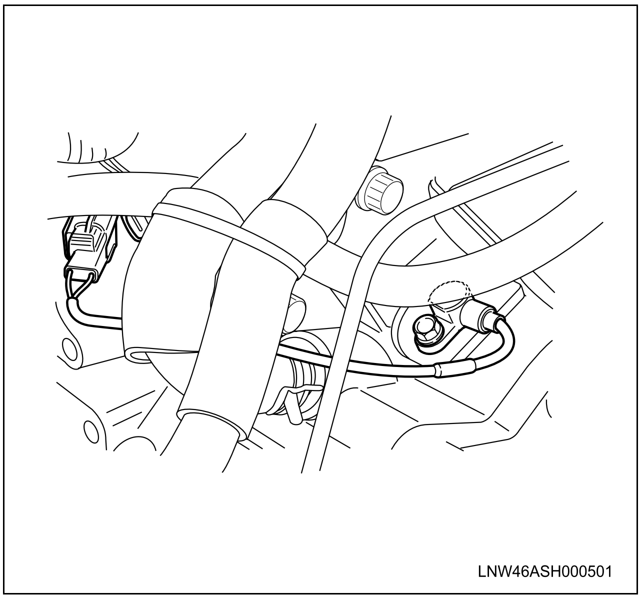


3. Remove the CKP sensor.

Installation Procedure

1. Install the CKP sensor.
2. Tighten the CKP sensor retaining bolt.

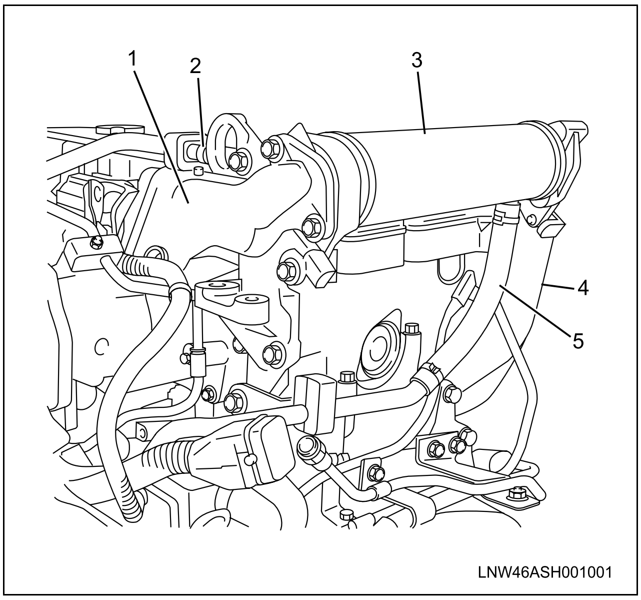
Tighten torque: 8 N·m (69 lb in)



EGR Valve Replacement

Removal Procedure

1. Drain the engine coolant. Refer to Engine Cooling System section.
2. Remove the EGR valve connector.
3. Remove the EGR pipe.



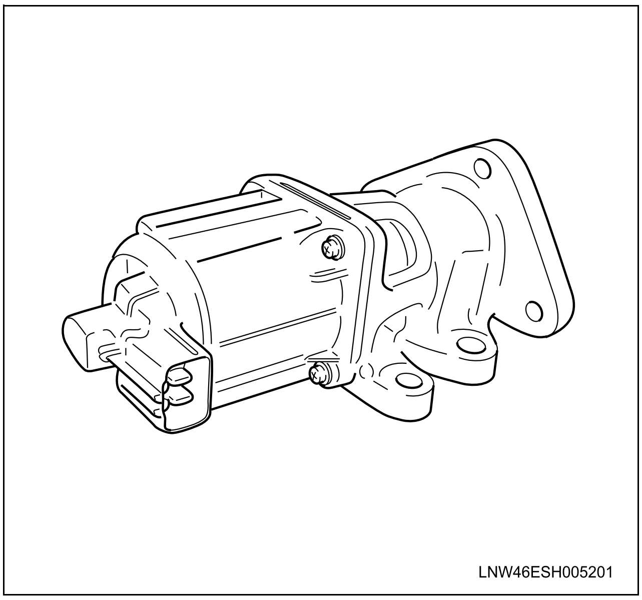
Legend

1. EGR Adapter
2. Water Return Pipe
3. EGR Cooler
4. EGR Pipe
5. Water Feed Pipe

---

4. Remove the cooling water pipes.
5. Remove the EGR adapter.
6. Remove the EGR cooler.
7. Remove the EGR valve.

Caution:
After removing the EGR valve and EGR adapter, seal the opening so that foreign matter does not enter.



Inspection Procedure

Gas leak check

- Check for gas leak in various parts of the EGR gas line.
  If the results of the check show abnormalities, repair or replace the defective parts.

EGR valve check

- Refer to Engine Control System for details on the method of checking the EGR valve.

Installation Procedure

1. Mount the EGR valve.
   - Insert the gasket and temporarily fit the EGR valve.

Notice:
Temporarily tighten the bolts.

2. Install the EGR cooler.
   - Temporarily fit the EGR cooler to the bracket.

Notice:
Temporarily tighten the bolts.

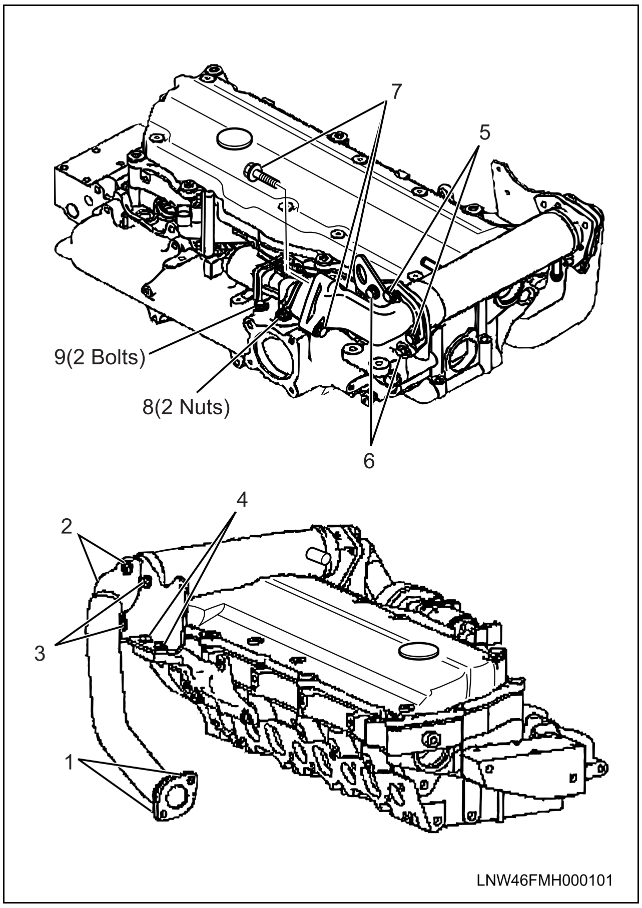
3. Install the EGR adapter.
   - Temporarily fit the EGR adapter between the EGR cooler and exhaust manifold.

Notice:
Temporarily tighten the bolts.

4. Install the EGR pipe.
   - Insert the gasket between the two ends of the EGR pipe and temporarily fit it.

Notice:
Temporarily tighten the bolts.

During temporary assembly, tighten the nuts and bolts to the specified torque in the order shown in the illustration.



Legend

1 ~ 9 Show The Order of Tighten Bolts and Nuts.

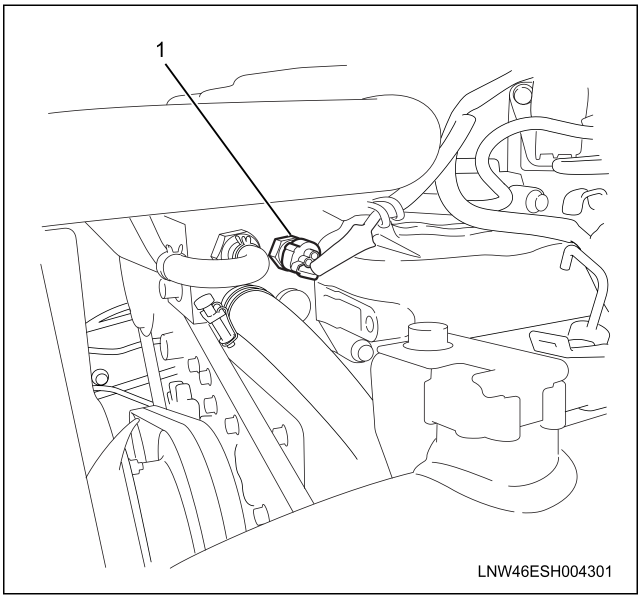
Tightening torque

1:	31 N·m (23 lb ft)
2, 4:	28 N·m (21 lb ft)
3, 5, 6, 7, 8, 9:	24 N·m (17 lb ft)

Engine Coolant Temperature (ECT) Sensor Replacement

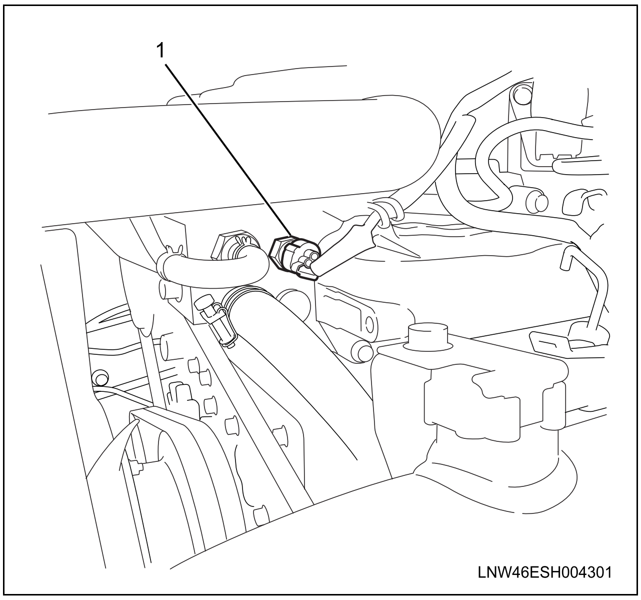
Removal Procedure

1. Turn off the ignition.
2. Disconnect the engine coolant temperature sensor connector.
3. Remove the engine coolant temperature sensor (1).



Installation Procedure

1. Install the engine coolant temperature sensor (1).



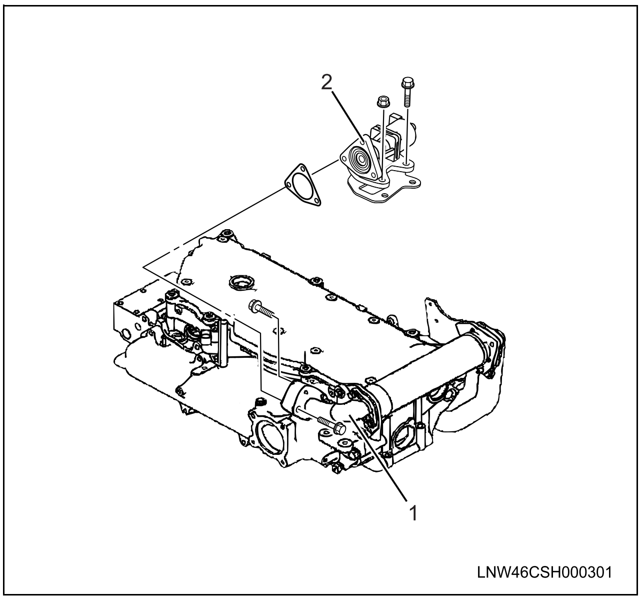
2. Connect the engine coolant temperature sensor connector.
3. Replenish any lost engine coolant.

Fuel Injector Replacement/ Fuel Injector Flow Rate Programming

Important:
The Fuel Injector Flow Rate Programming must be done when the injector is being replaced. The Fuel Injector Flow Rate information must be recorded before assembling the cylinder head cover. Refer to the Engine Control Module (ECM) Replacement for recording and programming fuel injector flow rates.

Removal Procedure

1. Remove the engine harness, the throttle position sensor, the EGR valve, the pressure sensor, and all of the fuel injector connectors.
2. Remove the EGR valve and the EGR adapter.
3. Tape the EGR case holes shut to prevent the entry of foreign material.

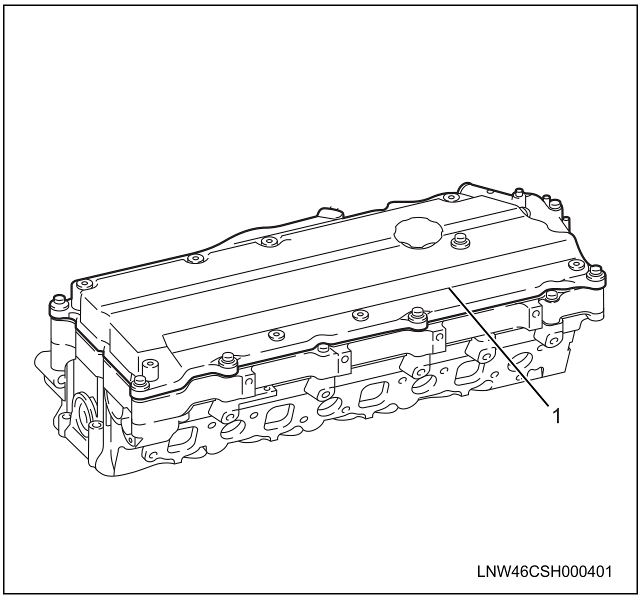


Legend

1. EGR Adapter
2. EGR Valve

---

4. Remove the cylinder head cover.

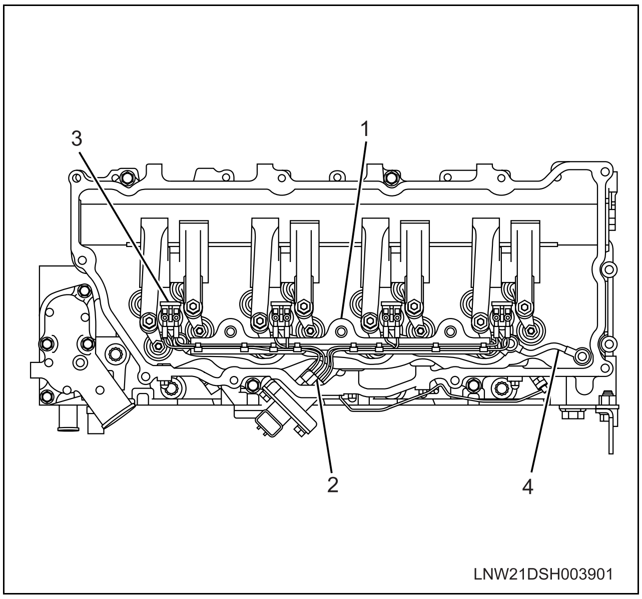


Legend

1. Cylinder Head Cover

---

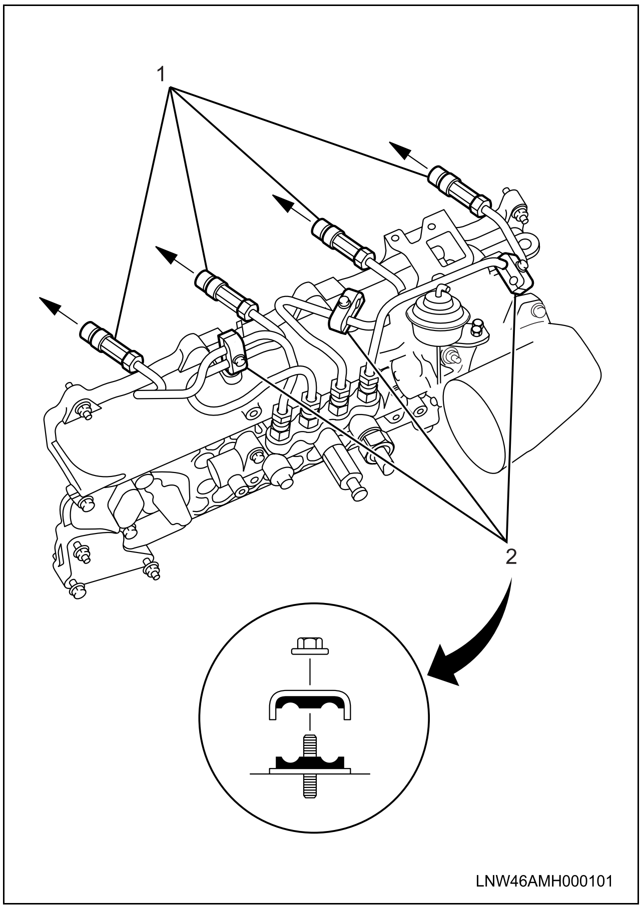
5. Alternately loosen the fuel injector terminal nuts a little at a time in sequence. Several loosening cycles should be required before the nuts are loose.
6. Loosen the fuel injector harness bracket bolts. Remove the inside connector and the harness bracket.
7. Remove the fuel injector leak-off pipe.
8. Remove the lower cover.



Legend

1. Fuel Injector Harness Bracket
2. Fuel Injector Harness Connector
3. Fuel Injector Terminal
4. Leak-Off Pipe

9. Remove the fuel injection pipe clips and the fuel injection pipes.



Legend

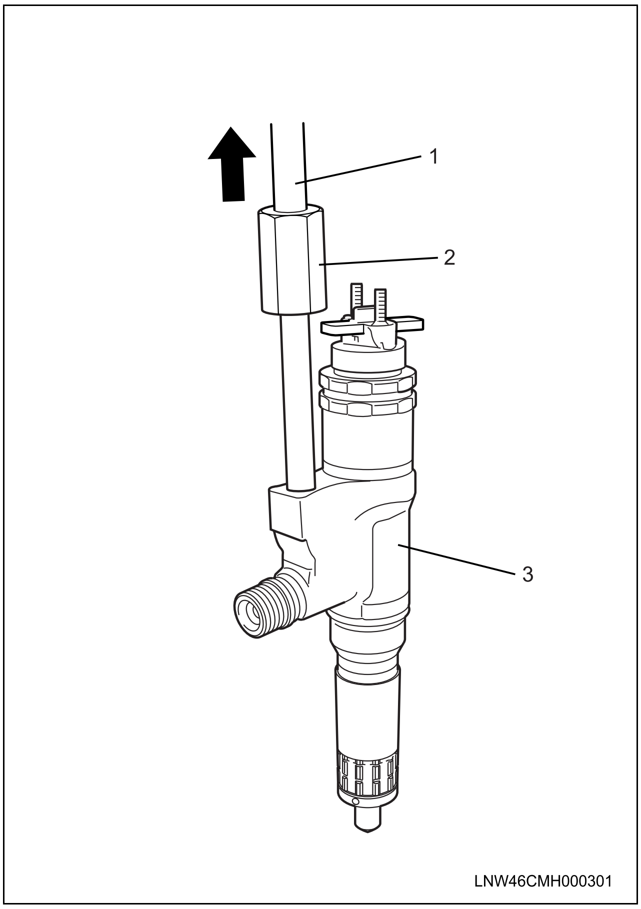
1. Fuel Injection Pipe
2. Fuel Injection Pipe Clip

---

10. Loosen the fuel injector clamp fixing bolts and remove the fuel injectors.
    If the fuel injectors are difficult to remove, use the fuel injector remover. Install the fuel injector remover to the leak-off pipe attachment part on the fuel injector. Use a sliding hammer to force the fuel injector clamp off the fuel injector.

Caution:
Do not remove the fuel injector sleeve.

Special tools
Fuel injector remover: EN-46720
Sliding hammer: J-23907



Legend

1. Sliding Hammer
2. Fuel Injector Remover
3. Fuel Injector

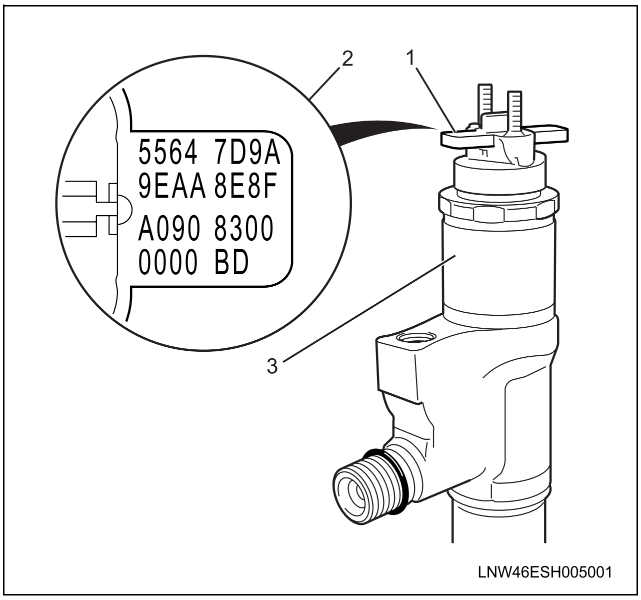
---

11. Mark each fuel injector with the number of the cylinder from which it was removed. Store the fuel injectors in a safe place. Position the fuel injector so that the nozzle is protected.

Caution:
Do not tamper with the electromagnetic portion of the fuel injector. Reduced electromagnetic function will result in fuel injector failure.

Recording Fuel Injector Flow Rate Information from the Fuel Injector ID plate on the replaced injector housing;

Record all numbers of replaced fuel injector's from ID plate.

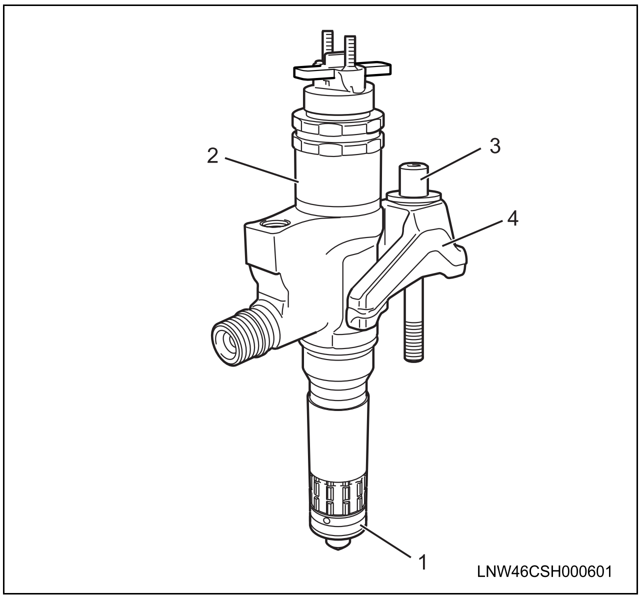


Legend

1. Fuel Injector ID Plate
2. Fuel Injector Flow Rate
3. Fuel Injector

Installation Procedure

1. Install a new gasket and O-ring to each of the fuel injector clamps. Refer to the illustration.



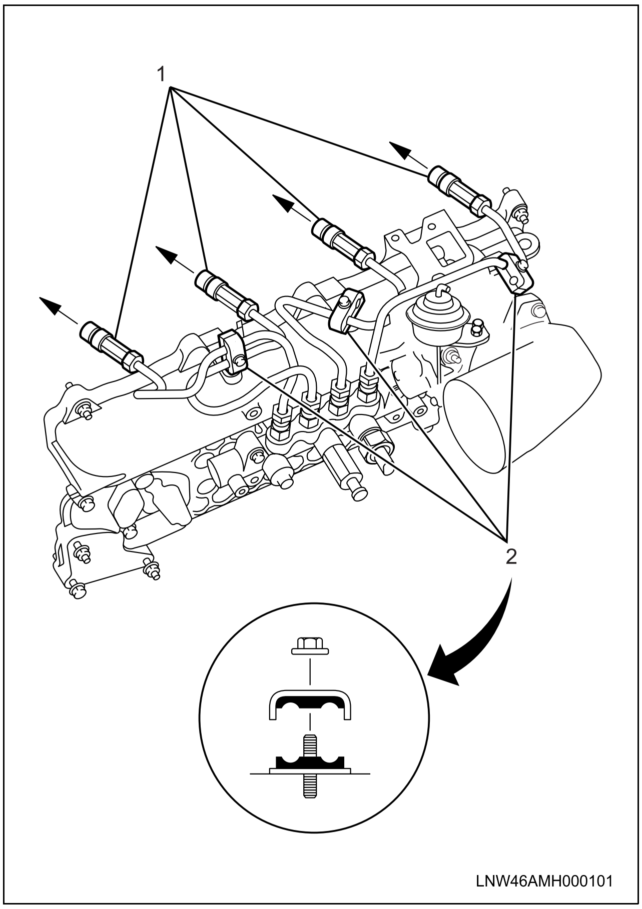
Legend

1. Gasket
2. Fuel Injector
3. Bolt
4. Fuel Injector Clamp

---

2. Apply molybdenum to the threads and seating surfaces of the clamp bolts.
3. Install the fuel injector clamps to the cylinder head.
4. Temporarily tighten the clamp bolts.
5. Apply a thin coat of engine oil to the outer surface of the fuel injector side sleeve nuts.
6. Install the fuel injector pipes to the position shown in the illustration.
7. Use a spanner to carefully, then tighten the sleeve nuts until the fuel injector pipes contact the fuel injector and common rail.
8. Tighten the fuel injection pipe clips to the specified torque.

Tightening torque: 6 N·m (52 lb in)



Legend

1. Fuel Injection Pipe
2. Fuel Injection Pipe Clip

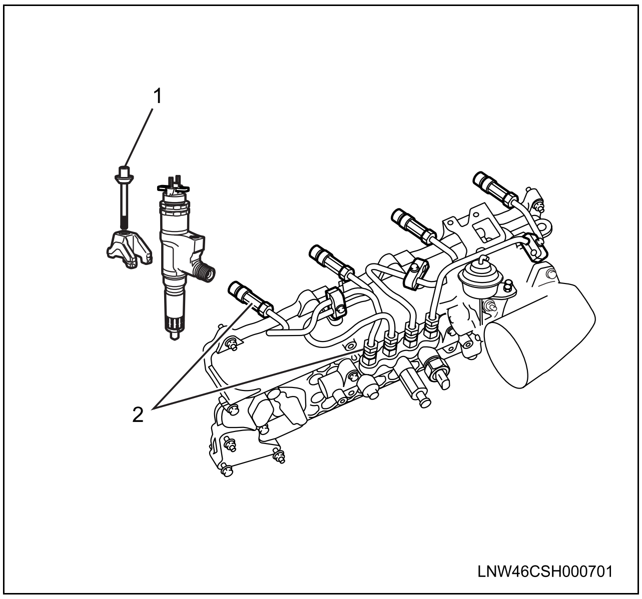
---

9. Final tighten the injection clamp bolts to the specified torque.

Tightening torque: 30 N·m (22 lb ft)

10. Tighten the injection pipes to the specified torque.

Tightening torque: 44 N·m (33 lb ft)



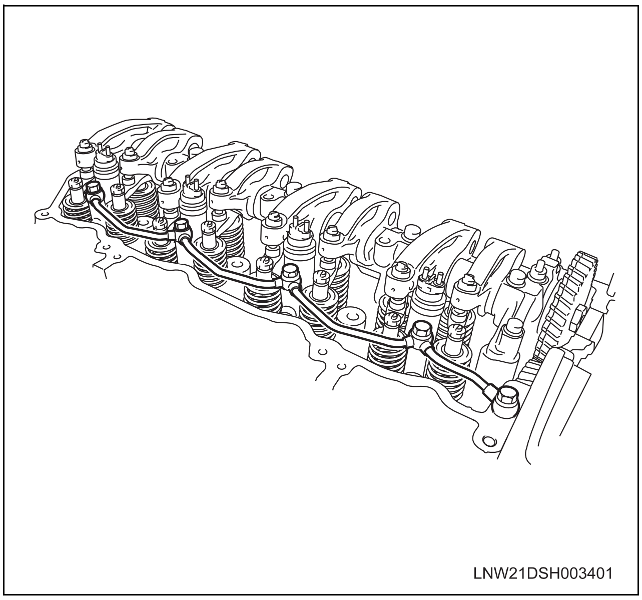
Legend

1. Injection Clamp Bolt
2. Injection Pipe Sleeve Nut

---

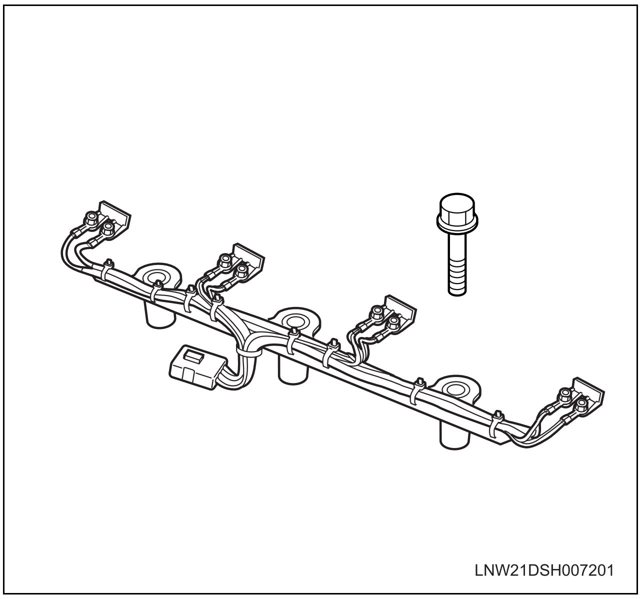
11. Install the nozzle leak off pipes together with the new gaskets. Tighten the pipes to the specified torque.

Tightening torque: 12 N·m (10 lb ft)



12. Install the fuel injector harness connectors. Work from the inside out.
13. Install the harness bracket and tighten the bolts to the specified torque.

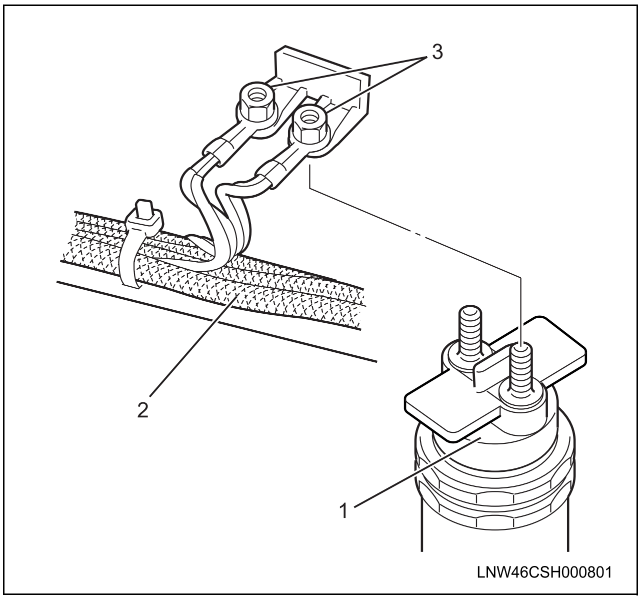
Tightening torque: 48 N·m (35 lb ft)



14. Install the fuel injector terminal nuts to the injector.
15. Alternately tighten each nut 2 or 3 turns at a time until the specified torque is reached.

Tightening torque: 2 N·m (17 lb in)

Caution:
Do not over tighten the nuts. Damage to the terminal studs will result.



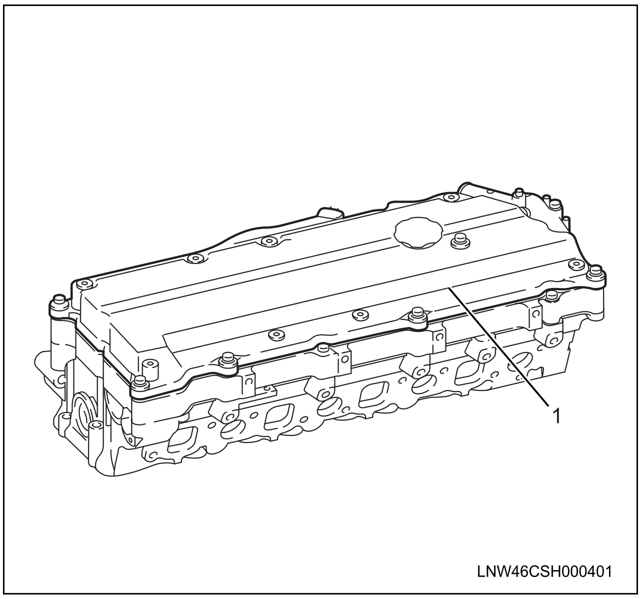
Legend

1. Fuel Injector
2. Injector Harness
3. Injector Terminal Nut

---

16. Install the gasket to the cylinder head cover.
17. Install the cylinder head cover and tighten the bolts to the specified torque.

Tightening torque: 18 N·m (13 lb ft)



Legend

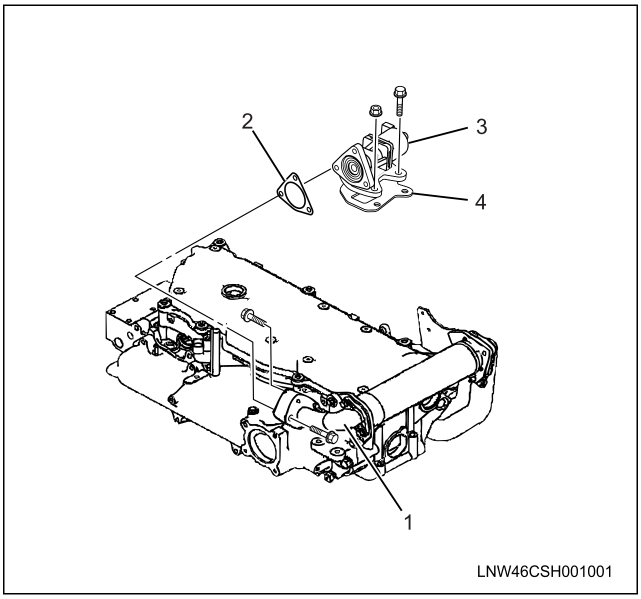
1. Cylinder Head Cover

18. Install the gasket to the EGR valve and tighten the bolts to the specified torque.

Tightening torque: 24 N·m (17 lb ft)

19. Install the gasket to the EGR adapter and tighten the bolts to the specified torque.

Tightening torque: 24 N·m (17 lb ft)



Legend

1. EGR Adapter
2. EGR Valve Gasket
3. EGR Valve
4. EGR Valve Gasket

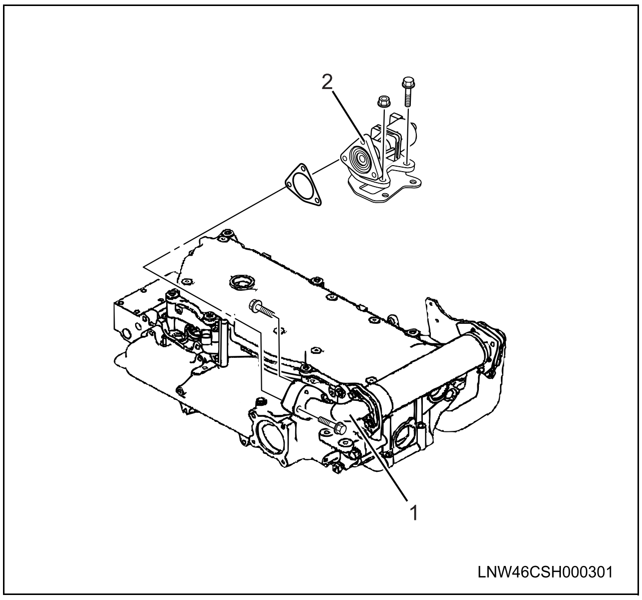
20. Attach the engine harness connectors. Each composite connector should make a loud click when it is securely attached.

Fuel injector Flow Rate Programming Procedure
Refer to the Engine Control Module (ECM) Replacement for programming fuel injector flow rates.

Fuel Rail Replacement

Removal Procedure

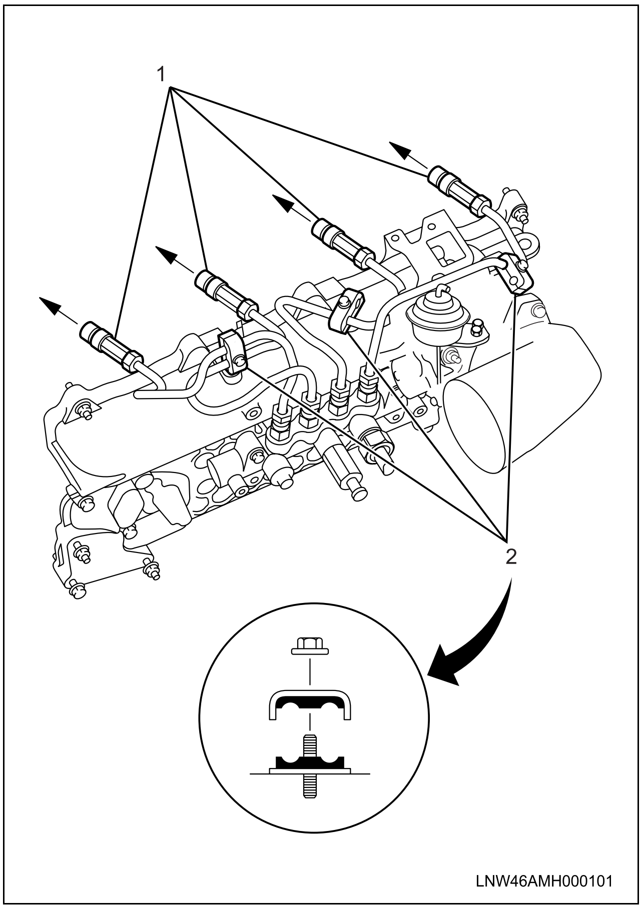
1. Remove the air intake pipe.
    - Disconnect the connector for the intake air temperature sensor.
2. Remove the fuel leak off hose from the leak off pipe.
    - Cover the removed fuel hose with a lid, keep it facing upward and secure it using wire, etc.
3. Disconnect the fuel rail pressure sensor harness connector.
4. Remove the EGR valve and the EGR adapter.
5. Tape the EGR case holes shut to prevent the entry of foreign material.



Legend

1. EGR Adapter
2. EGR Valve

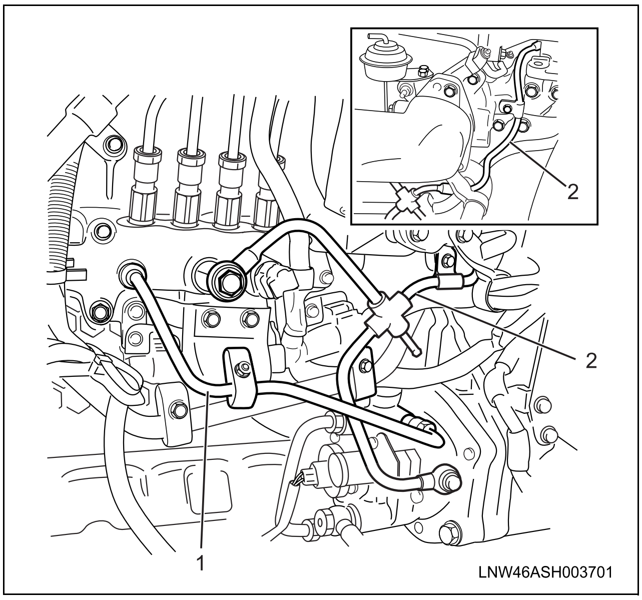
6. Remove the injection pipe clip and remove the injection pipes.



Legend
1. Fuel Injection Pipe
2. Fuel Injection Pipe Clip

---

7. Remove the fuel pipe.
8. Remove the clip and the fuel leak off pipe.

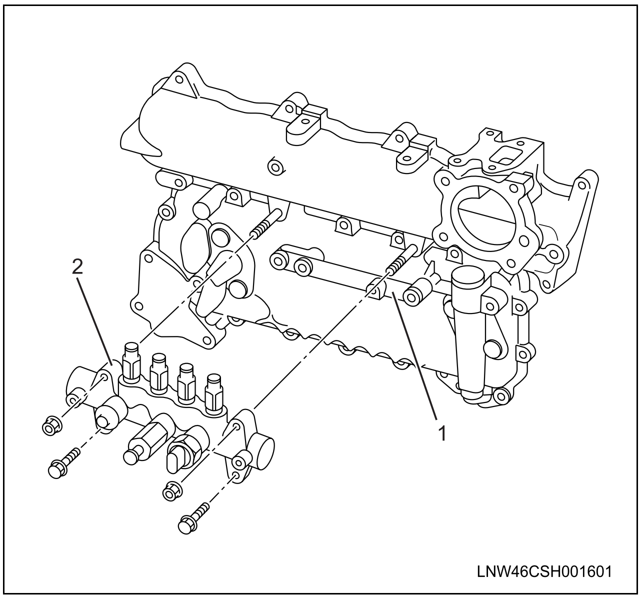


Legend
1. Fuel Pipe
2. Fuel Leaf-Off Pipe

---

9. Remove the fuel rail and the fuel rail bracket.

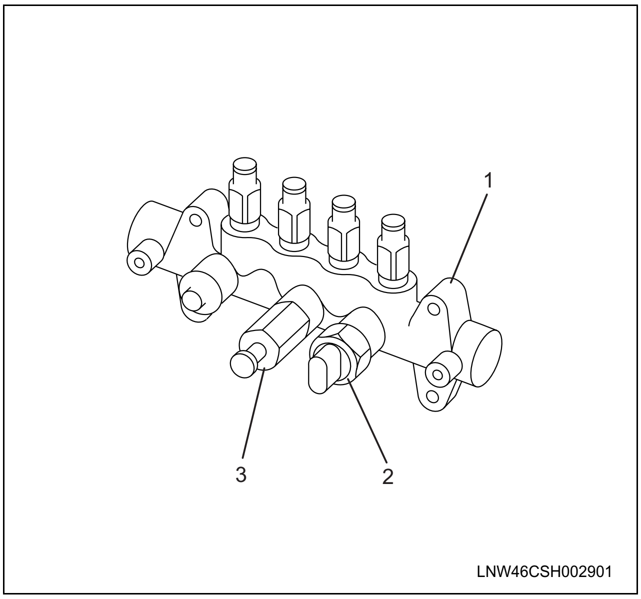
- Do not remove the flow damper. The dampers should always remain in the fuel rail.
- Take care not to damage the connector unit of the pressure sensor.



Legend
1. Fuel Rail Bracket
2. Fuel Rail

Disassembly

1. Remove the fuel pressure limiter.
2. Remove the fuel rail pressure sensor.



Legend
1. Fuel Rail
2. Fuel Rail Pressure Sensor
3. Fuel Pressure Limiter

Reassembly

1. Install the fuel pressure limiter.

Tightening torque: 172 N·m (127 lb ft)

2. Install the fuel rail pressure sensor.

Tightening torque: 98 N·m (72 lb ft)

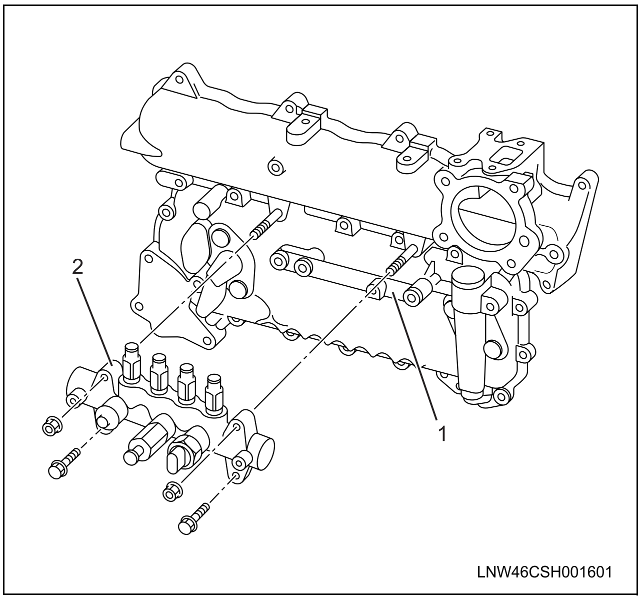
Installation Procedure

1. Tighten the fuel rail bracket using the specified mounting torque.

Tightening torque: 19 N·m (14 lb ft)

2. Tighten the fuel rail using the specified mounting torque.

Tightening torque: 19 N·m (14 lb ft)



Legend

1. Fuel Rail Bracket
2. Fuel Rail

---

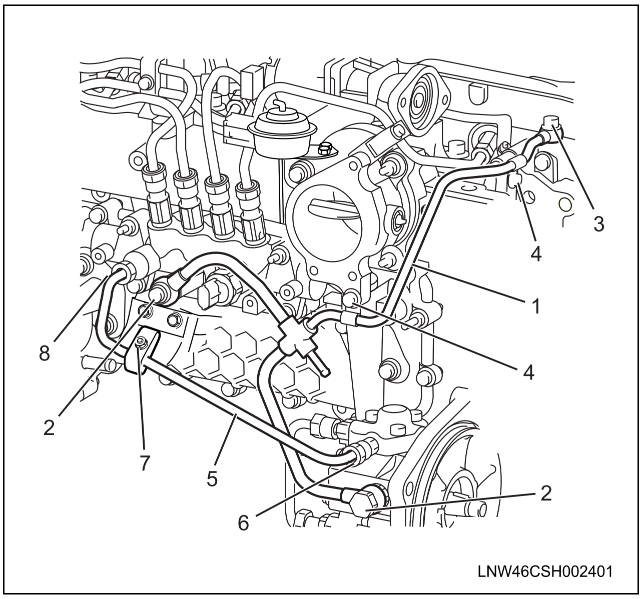
3. Tighten the fuel leak off pipe (1) using the mounting eyebolt and the clip using the specified torque.

Tightening torque (2): 18 N·m (13 lb ft)
(3): 12 N·m (9 lb ft)
(4): 8 N·m (69 lb in)
(7): 6 N·m (52 lb in)

4. Tighten the fuel pipe (5) using the mounting sleeve nut and the specified torque.

Tightening torque (6): 44 N·m (33 lb ft)
(8): 44 N·m (33 lb ft)

Caution:
The fuel pipe (5) has a specific orientation. Thus, the sleeve nut is to be mounted such that its surface-treated color is yellow on the fuel rail side and green on the supply pump side.

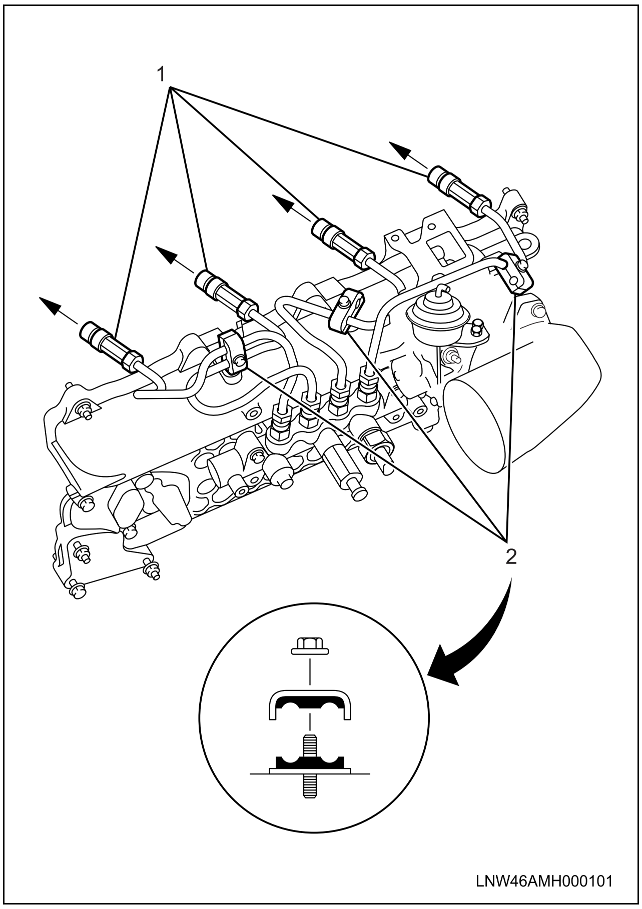


5. Tighten the injection pipe and the clip using the specified mounting torque.

Injection pipe sleeve nut
Tightening torque: 44 N·m (33 lb ft)

Injection pipe clip
Tightening torque: 6 N·m (52 lb in)

- Apply a thin coat of engine oil on the periphery of the sleeve nut on the injector side and assemble.



Legend

1. Fuel Injection Pipe
2. Fuel Injection Pipe Clip

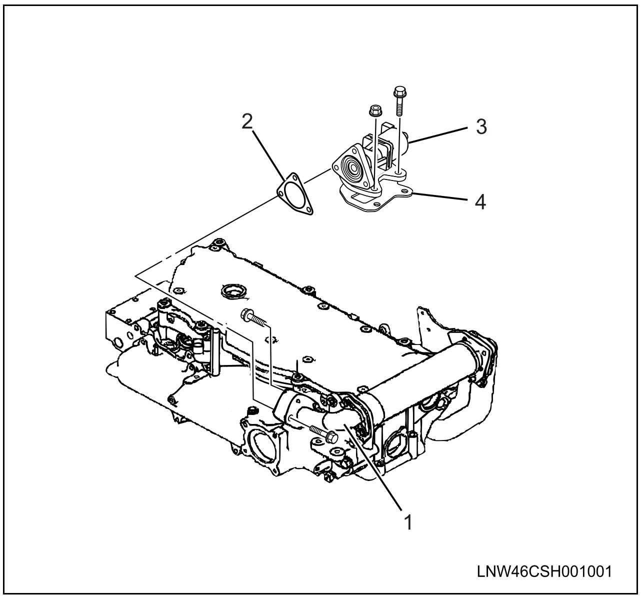
---

6. Install the gasket to the EGR valve and tighten the bolts to the specified torque.

Tightening torque: 24 N·m (17 lb ft)

7. Install the gasket to the EGR adapter and tighten the bolts to the specified torque.

Tightening torque: 24 N·m (17 lb ft)

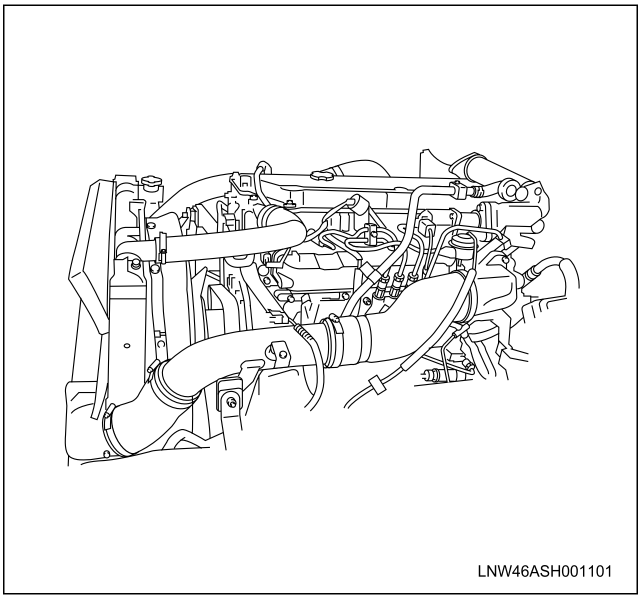


Legend

1. EGR Adapter
2. EGR Valve Gasket
3. EGR Valve
4. EGR Valve Gasket

---

8. Install the air intake duct.
   - Connect the connector for the intake air temperature sensor.



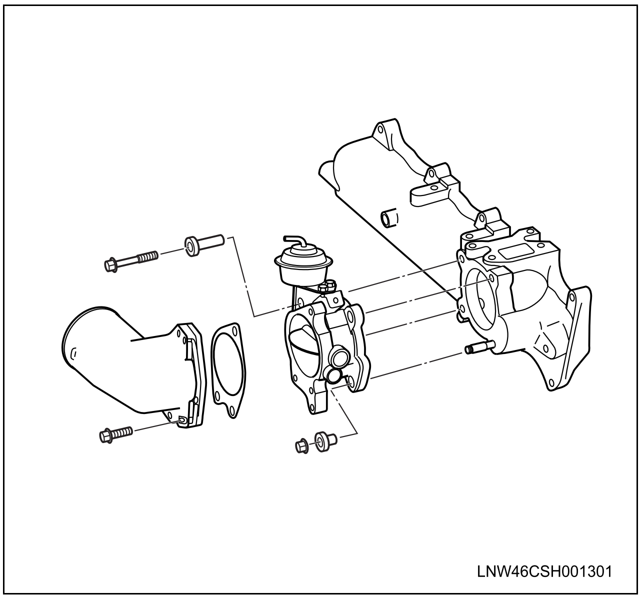
Fuel Supply Pump Replacement / Fuel Supply Pump Relearn Procedure

Removal Procedure

Important:

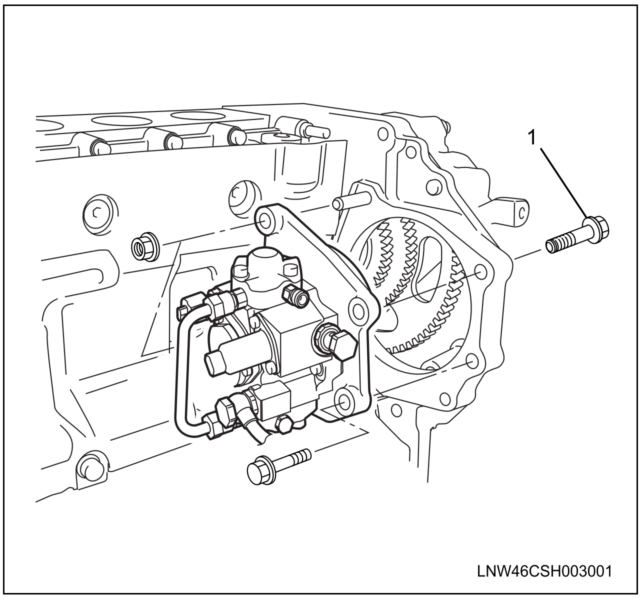
The fuel supply pump must be timed to the engine and adjustment value must be learned to the ECM.

1. Remove the intake pipe and the intake throttle valve.
2. Remove the fuel pipe and fuel leak-off pipe.


LNW46CSH001301

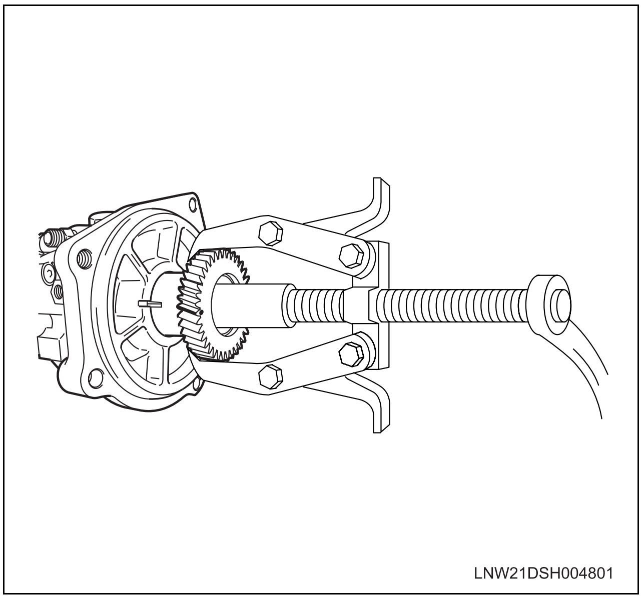
3. Remove the fuel feed hose.
4. Disconnect the fuel temperature sensor and the fuel rail pressure regulator harness connector from the fuel supply pump.
5. Remove the fuel supply pump attachment bolts and nuts, then remove the fuel supply pump.

Notice:
One of the attachment bolt (1) secures the fuel supply pump to the flywheel housing as denoted in the picture below.

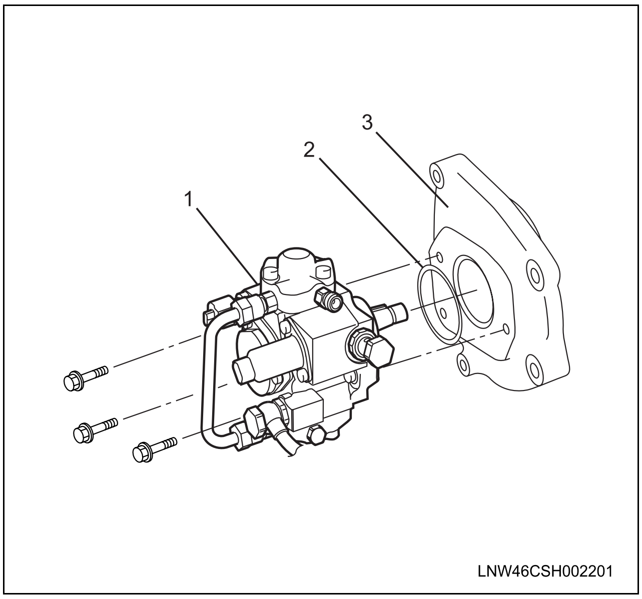


LNW46CSH003001

6. Use a gear puller to remove the fuel supply pump gear and the O-ring.


LNW21DSH004801

7. Loosen the 3 bolts holding the fuel supply pump bracket. Remove the bracket and the O-ring.



LNW46CSH002201

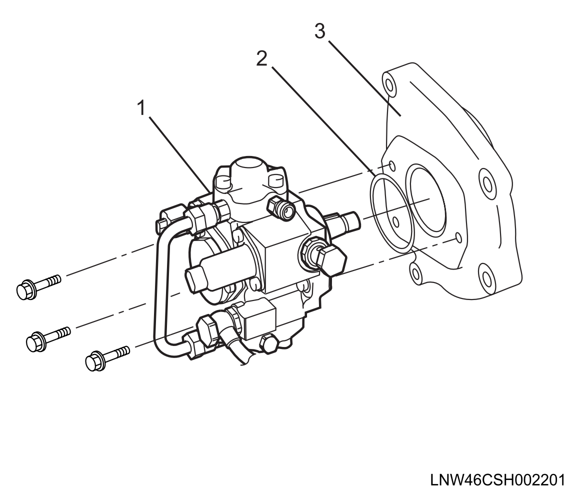
Legend
1. Fuel Supply Pump
2. O-Ring
3. Fuel Supply Pump Bracket

Installation Procedure

1. Install the O-ring to the fuel supply pump.
2. Install the pump to the bracket and tighten the 3 bolts to the specified torque.

Tightening torque: 19 N·m (14 lb ft)

Caution:
Take care not to twist the O-ring.



Legend

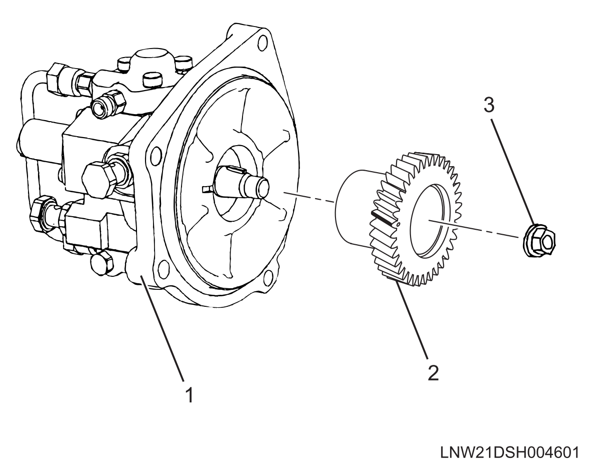
1. Fuel Supply Pump
2. O-Ring
3. Fuel Supply Pump Bracket

---

3. Align the fuel supply pump shaft key and gear. Install the gear and tighten the nut to the specified torque.

   There is a round alignment mark on the gear (white paint).

Tightening torque: 64 N·m (47 lb ft)

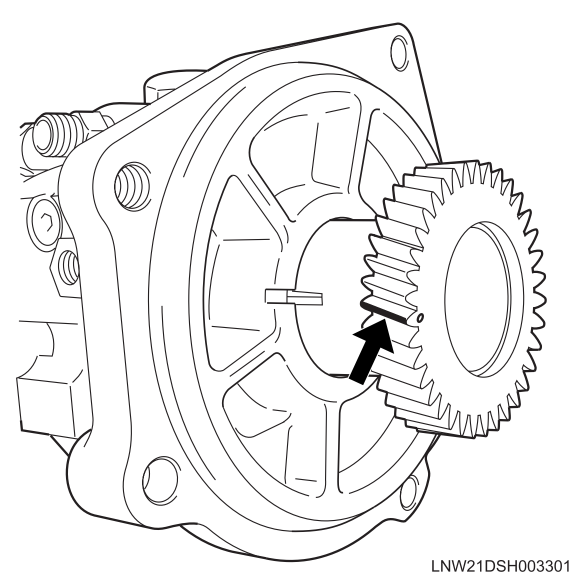


Legend

1. Fuel Supply Pump
2. Fuel Supply Gear
3. Nut

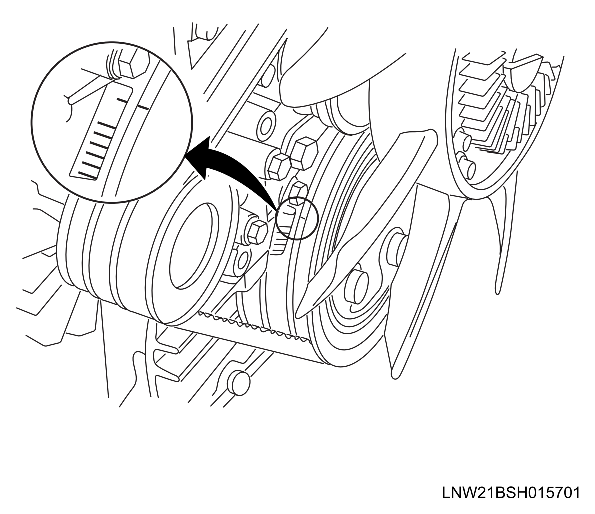
---

4. Apply white paint to the top of the fuel supply pump gear tooth directly above the stamped 'O' mark. Refer to the illustration.

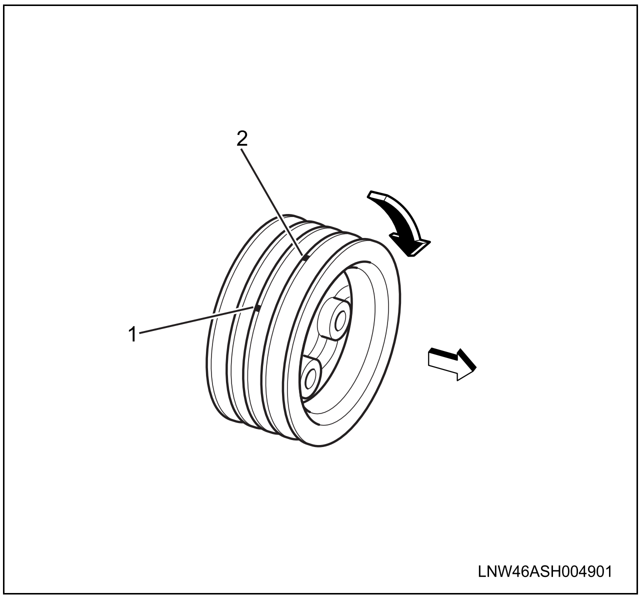


5. Turn the crankshaft in the normal direction of engine rotation until the No.1 or No.4 cylinder is at TDC on the compression stroke.

   Refer to illustration.



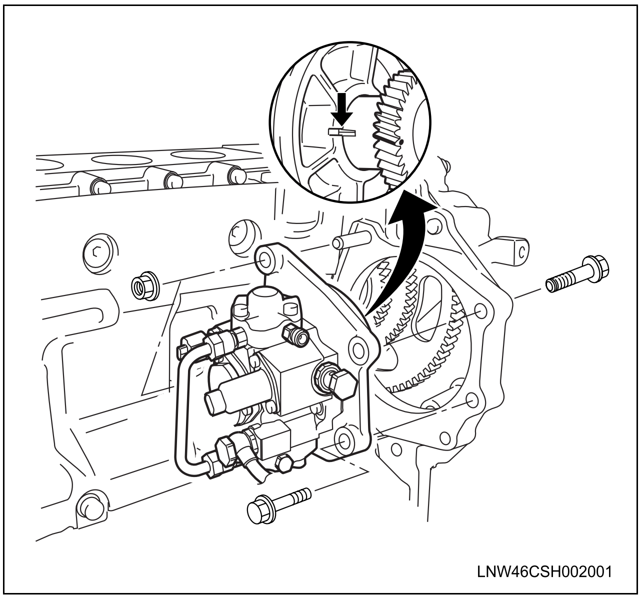
Notice:
There are 2 timing marks on the crankshaft pulley.
Mark (1) is near the front cover and is used to bring the 4HK1-TC engine to TDC.
Mark (2) is not applicable to this engine.
Be sure to use mark (1) when bringing the engine to TDC.



6. Remove the oil drain adapter.
7. Install the O-ring to the fuel supply pump.
8. Align the slits as shown in the illustration.
9. Insert the stud bolts into the guides and temporarily tighten them.

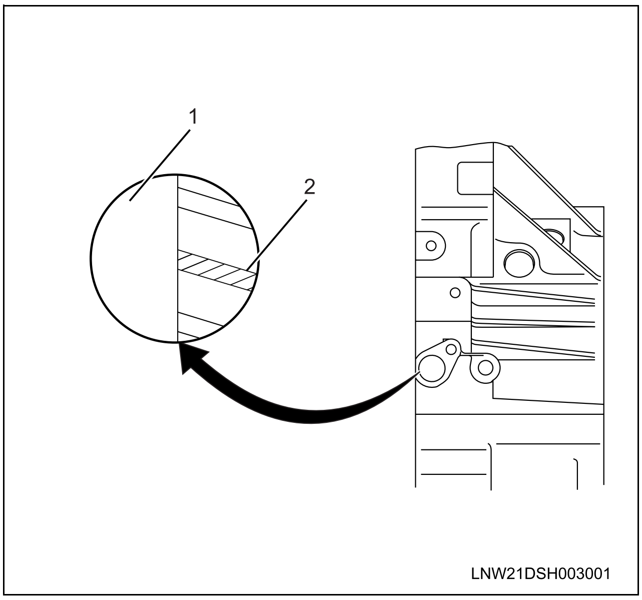
Caution:

- If the stud bolts (cylinder block side) have been loosened or replaced, apply Locktite No. 262 to the recessed portion of the bolts.



- Check that the round alignment mark (white paint) is positioned as shown in the illustration when viewed from the plug hole. If necessary, reposition the gear.
- Tighten the stud bolts and the nuts to the specified torque.

Tightening torque	nut: 50 N·m (37 lb ft) bolt: 76 N·m (56 lb ft)

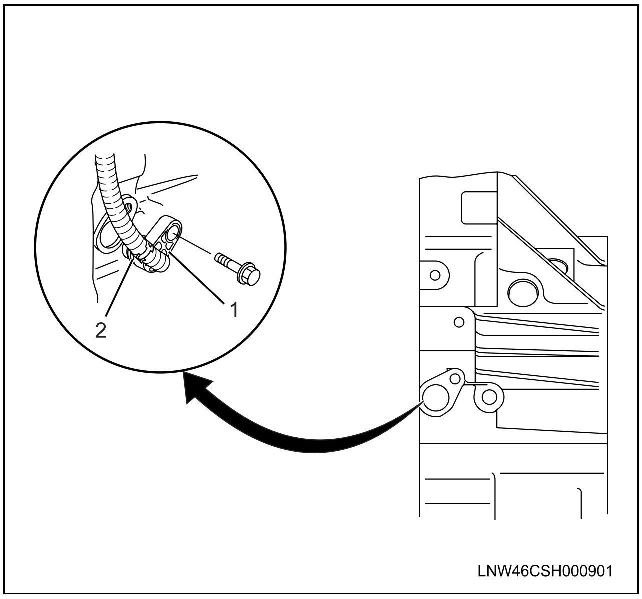


Legend
1. Plug Hole
2. Alignment Mark

---

10. Apply a light coat of engine oil to the O-ring.
11. Install the oil drain adapter to the plug hole. Tighten the bolt to the specified torque.

Tightening torque: 8 N·m (6.9 lb ft)



Legend
1. Oil Drain Adapter
2. O-Ring

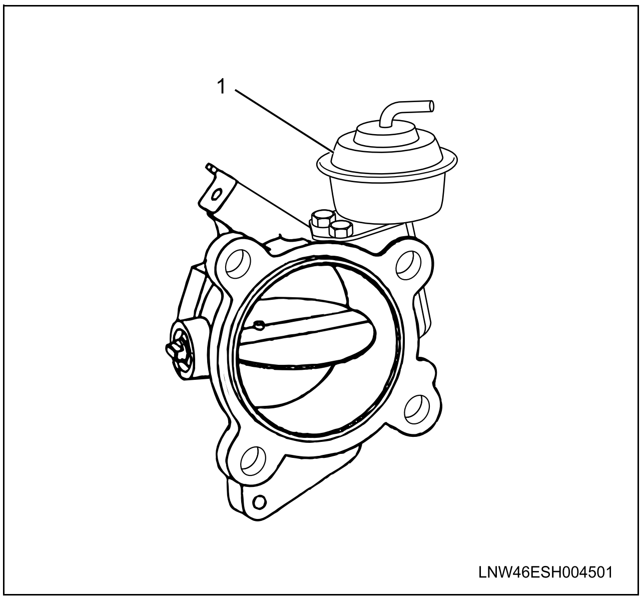
---

12. Connect the fuel temperature sensor and the suction control valve connectors to the fuel supply pump.
13. Install the fuel feed hose.

14. Install the throttle assembly.
    - Coat the fluid gasket and mount within 7 minutes.

Tightening torque: 24 N·m (17 lb ft)

- Install the intake throttle valve chamber hose.



Legend

1. Intake throttle Valve Chamber

---

15. Install the fuel pipe and fuel leak-off pipe.

Fuel Supply Pump Relearn Procedure

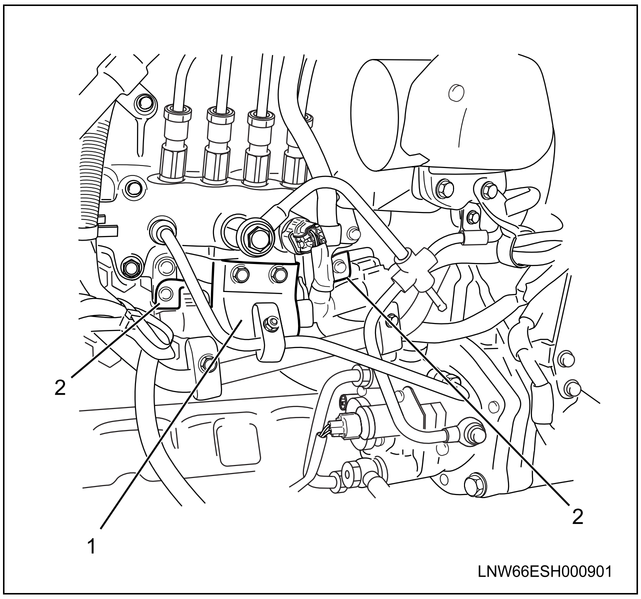
The ECM goes through a fuel supply pump learn procedure to fine tune the current supplied to the fuel rail pressure (FRP) regulator. This learning process in only performed when the engine is idling.

1. Install the scan tool.
2. Turn OFF the ignition for 30 seconds.
3. Turn ON the ignition, with the engine OFF.
4. Command the Supply Pump Learn Reset with the scan tool.
5. Observe the Supply Pump Status parameter with the scan tool. Confirm the scan tool indicates Not Learn.
6. Start the engine and let idle until engine coolant temperature (ECT) reads 149°F (65°C) or higher while observing Supply Pump Status parameter with the scant tool. The scan tool changes status Not Lean > Tentative > Learning > Learned.
7. If the ECM has correctly learned the fuel supply pump current adjustment, the Supply Pump Status parameter on the scan tool will indicate Learned.

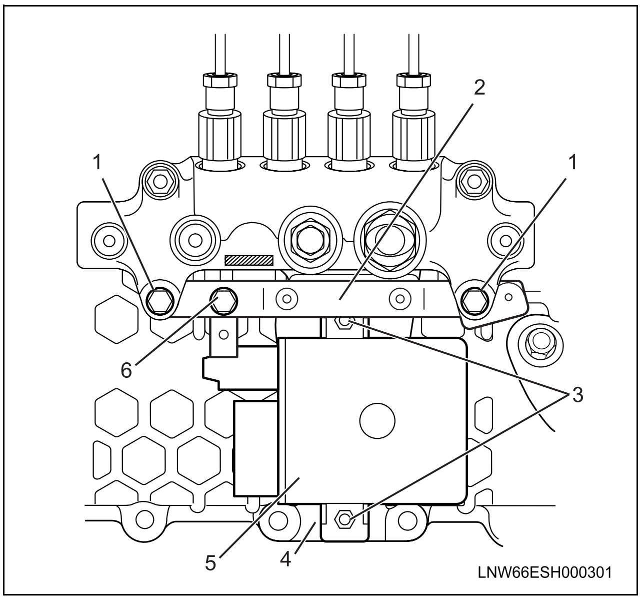
Glow Plug Controller Replacement

Removal Procedure

1. Disconnect the negative battery cable
2. Remove the fuel pipe bracket (1) and the engine harness bracket (2).



3. Disconnect the glow plug controller harness connector.
4. Loosen the fuel rail bolts.
5. Remove the fuel rail bracket.
6. Remove the glow plug controller from glow plug controller bracket.



Legend

1. Fuel rail bolts
2. Fuel rail bracket
3. Glow plug controller nuts
4. Glow plug controller bracket
5. Glow plug controller
6. Fuel rail bracket bolt

Installation Procedure

1. Install the glow plug controller in glow plug controller bracket.

Tightening torque: 8 N·m (69 lb in)

2. Connect the glow plug controller harness connector.

3. Install the fuel rail bracket.

Tightening torque: 19 N·m (14 lb ft)

4. Tighten the fuel rail bolts.

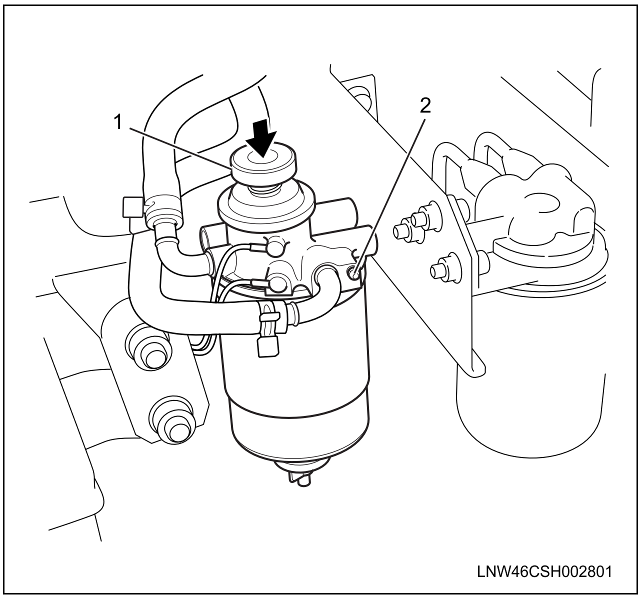
Tightening torque: 19 N·m (14 lb ft)

5. Install the fuel pipe bracket and the engine harness bracket.
6. Connect the negative battery cable.

Fuel System Air Bleeding

Functional check

Bleed air



Legend

1. Priming Pump
2. Air Bleed Plug

---

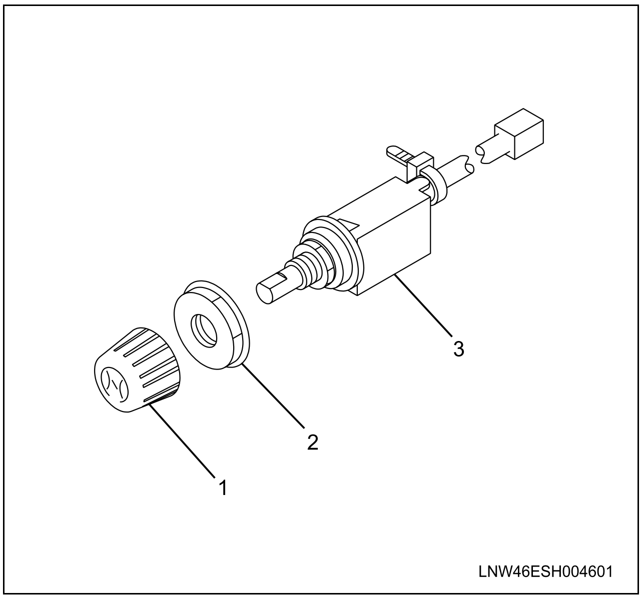
1. Before starting the engine
   a. Fit a tray below the fuel filter (below the air bleed plug).
   b. Loosen the plug adequately and operate the priming pump more than 20 times until the fuel.
   c. Tighten the plug, and operate the priming pump more than 10 times until it is filled with fuel. After waiting for approximately a minute, loosen the plug and bleed out the air in the fuel filter. (This work must be repeated a minimum of three times until no more air comes out from the plug.)
   d. Tighten the plug firmly and wipe the fuel in the surrounding area. Operate the priming pump (10 to 15 times) till it is filled with fuel and then send fuel to the engine.
2. After starting the engine
   a. Start the engine without depressing the accelerator pedal.
   b. After starting, maintain idle for 5 seconds.
   c. Slowly rotate the idle control knob clockwise and maintain it for 3 minutes.
   d. Fully depress the accelerator pedal and increase the rotations to maximum. (Repeat this operation several times)
   e. Rotate the idling knob counterclockwise and return to idling mode.

Caution:
If the air bleeding work is insufficient it could lead to a possible DTC. Therefore, the procedures after starting the engine should always be implemented.

Idle Up Sensor Replacement

Removal Procedure

1. Turn off the ignition.
2. Remove the idle up sensor knob (1).
3. Disconnect the idle up sensor connector.
4. Remove the idle up sensor holder (2).



5. Remove the idle up sensor.

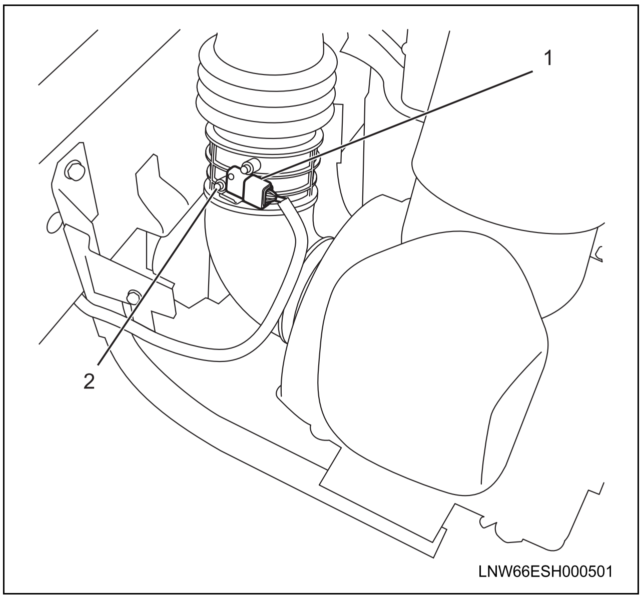
Installation Procedure

1. Install the idle up sensor.
2. Install the idle up sensor holder (2).
3. Install the idle up sensor knob (1).
4. Connect the idle up sensor connector.

Mass Air Flow (MAF)/Intake Air Temperature (IAT) Sensor Replacement

Removal Procedure

1. Turn off the ignition.
2. Disconnect the MAF/IAT sensor connector.
3. Loosen the MAF/IAT sensor screw (2).
4. Remove the MAF/IAT sensor (1).



Installation Procedure

1. Install the MAF/IAT sensor (1).
2. Tighten the MAF/IAT sensor screw (2).

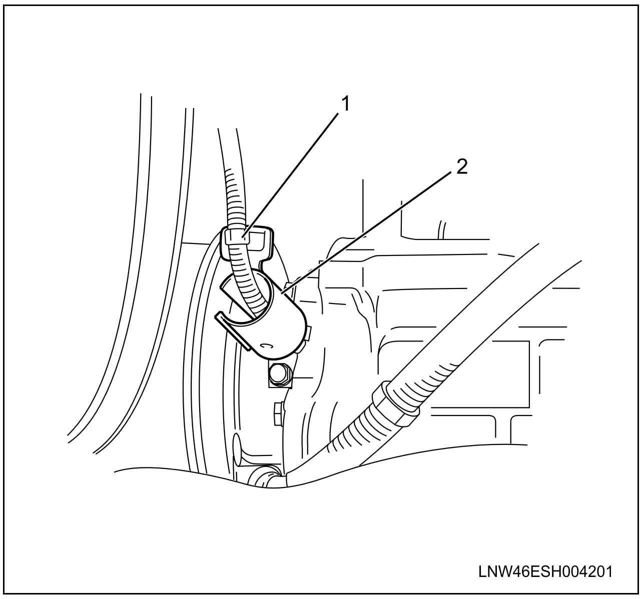
Tightening torque: 8 N·m (69 lb in)

3. Connect the MAF/IAT sensor connector.

Vehicle Speed Sensor (VSS) 2 Replacement

Removal procedure

1. Turn off the ignition.
2. Remove the cover(2) and clip(1).
3. Disconnect the vehicle speed sensor 2 connector.



4. Remove the vehicle speed sensor 2.

Installation procedure

1. Tighten the vehicle speed sensor 2.

Tightening torque: 27 N·m (20 lb ft)

2. Connect the vehicle speed sensor 2 connector.
3. Install the cover (2) and clip (1).

Power Take Off (PTO) System

PTO Control System Description

The engine control module (ECM) has the functionality to accommodate one of three different PTO systems depending on upfitter specification. These systems consist of the following:

- Stationary Preset PTO Mode
- Stationary Variable PTO Mode
- Mobile Variable PTO Mode

Each mode is used with the specification of upfitter installation, which can be programmed to a tailored use. Moreover, there are the following functions that are common with each PTO mode:

- PTO Standby Speed
- PTO Maximum Engine Speed
- PTO Engine Shutdown
- PTO Engage Relay
- PTO (Relay Maximum) Engage Speed
- PTO Feedback

Each vehicle is factory equipped with two PTO chassis electrical connectors (PTO harness 1 and PTO harness 2) located on the inner left frame rail across from the back of the transmission. The purpose of these connectors is to allow the upfitter to easily connect to the ECM PTO inputs without having to alter any of the factory-installed wiring.

Stationary Preset PTO Mode

In Stationary Preset PTO Mode, the PTO control is performed while the vehicle is stopped by arbitrarily selecting one of multiple preset (up to four not including PTO Standby Speed) engine speeds as the PTO desired engine speed.

Notice:
If the engine speed the driver requests by pressing on the accelerator pedal is higher than the PTO desired engine speed, the accelerator pedal engine speed is used. However, the accelerator pedal engine speed cannot go higher than the PTO Maximum Engine Speed.

Notice:
The idle up sensor overrides the PTO Set Speed and PTO Maximum Engine Speed.

Hardware Configuration

The Stationary Preset PTO Mode is enabled based on the following hardware inputs to the ECM.

Factory-option:

1. PTO Switch
   The factory-option dash mounted PTO Switch is used to enable or cancel PTO mode. The engine speed will be set to the PTO Standby Speed when the PTO switch is pressed. The switch is a push-lock type switch. The input circuit is connected to the ECM A-93 of J-218 connector.

Notice:
The PTO Standby Speed can change within the following allowable range.

- Minimum: 750 RPM
- Maximum: 1300 RPM
- Preset value: 800 RPM

Notice:
The PTO Maximum Engine Speed can change within the following allowable range.

- Minimum: PTO Standby Speed
- Maximum: 3050 RPM
- Preset value: 3050 RPM

2. Cruise Set/Coast Switch
   The factory-installed dash mounted Cruise Set/Coast Switch can be used in PTO mode to set the PTO Set Speed (one fixed engine speed) when this switch is pressed. The switch is a momentary switch. The input circuit is connected to the ECM A-48 of J-218 connector.

Notice:
The PTO Set Speed can change within the following allowable range:

- Minimum: PTO Standby Speed
- Maximum: 3050 RPM
- Preset value: 1300 RPM

Notice:
The PTO Set Speed cannot be higher than the PTO Resume Speed.

Notice:
The PTO Resume Speed cannot be higher than the PTO Maximum Engine Speed.

3. Cruise Resume/Accel. Switch
   The factory-installed dash mounted Cruise Resume/Accel. Switch can be used in PTO mode to set the PTO Resume Speed (another fixed engine speed) when this switch is pressed. The switch is a momentary switch. The input circuit is connected to the ECM A-47 of J-218 connector.

Notice:
The PTO Resume Speed can change within the following allowable range:

- Minimum: PTO Set Speed
- Maximum: 3050 RPM
- Preset value: 1700 RPM

Notice:
The PTO Resume Speed cannot be lower than the PTO Set Speed.

Notice:
The PTO Resume Speed cannot be higher than the PTO Maximum Engine Speed.

Upfitter-installed:

1. Remote PTO Set Switch
   The upfitter-installed Remote PTO Set Switch can be used in PTO mode to set the Remote PTO Set Switch (same engine speed as the PTO Set Speed) when this switch is pressed. The function of this switch is the same as the Cruise Set/Coast Switch in the cab. The switch needs to be a momentary switch. The PTO harness 1 connector is equipped with an input circuit to the ECM A-91 of J-218 connector through the J of H-122 connector.

Notice:
The Remote PTO Set Switch engine speed uses the PTO Set Speed value.

Notice:
The Remote PTO Set Switch MUST be enabled (programmed) in the ECM.

2. Remote PTO Resume Switch
   The upfitter-installed Remote PTO Resume Switch can be used in PTO mode to set the Remote PTO Resume Switch (same engine speed as the PTO Resume Speed) when this switch is pressed. The function of this switch is the same as the Cruise Resume/Accel. Switch in the cab. The switch needs to be a momentary switch. The PTO harness 1 connector equipped with input circuit to the ECM A-92 of J-218 connector through the K of H-122 connector.

Notice:
The Remote PTO Resume Switch engine speed uses the PTO Resume Speed value.

Notice:
The Remote PTO Resume Switch MUST be enabled (programmed) in the ECM.

3. Remote Set Speed A Switch
   The upfitter-installed Remote Set Speed A Switch can be used in PTO mode to set the PTO Set Speed A when this switch is pressed. The switch needs to be a toggle or push-lock switch. The PTO harness 1 connector equipped with input circuit to the ECM A-89 of J-218 connector through the D of H-122 connector.

Notice:
The Remote Set Speed A Switch engine speed can change within the following allowable range:

- Minimum: PTO Standby Speed
- Maximum: 3050 RPM
- Preset value: 800 RPM

Notice:
The Remote Set Speed A Switch engine speed cannot be higher than the Remote Set Speed B Switch engine speed.

Notice:
The Remote Set Speed A Switch engine speed cannot be higher than the Maximum PTO Engine Speed.

Notice:
The Remote Set Speed A Switch MUST be enabled (programmed) in the ECM.

4. Remote Set Speed B Switch
   The upfitter-installed Remote Set Speed B Switch can be used in PTO mode to set the PTO Set Speed B when this switch is pressed. The switch needs to be a toggle or push-lock switch. The PTO harness 1 connector equipped with an input circuit to the ECM A-90 of J-218 connector through C of H-122 connector.

Notice:
The Remote Set Speed B Switch engine speed can change within the following allowable range:

- Minimum: PTO Standby Speed
- Maximum: 3050 RPM
- Preset value: 800 RPM

Notice:
The Remote Set Speed B Switch engine speed cannot be lower than the Remote Set Speed A Switch engine speed.

Notice:
The Remote Set Speed B Switch engine speed cannot be higher than the PTO Maximum Engine Speed.

Notice:
The Remote Set Speed B Switch MUST be enabled (programmed) in the ECM.

5. PTO Engage Relay
   The upfitter-installed PTO Engage Relay can be used to supply switched battery voltage to operate a PTO hydraulic solenoid. The solenoid in turn allows fluid to flow to a PTO hydraulic pump. The relay is controlled via the ECM grounding the relay coil control circuit. The PTO harness 2 C of H-123 connector is equipped with the voltage feed circuit to the relay. Also, the PTO harness 2 connector is equipped with a grounding circuit to ECM A-75 of J-218 connector through B of the H-123 connector.

Notice:
The PTO Engage Relay turn ON (ECM grounding coil control circuit) engine speed can change within the following allowable range:

- Minimum: PTO Standby Speed
- Maximum: 2500 RPM
- Preset value: 1050 RPM

Notice:
The PTO Engage Relay cannot be higher than any PTO speed except the PTO Standby Speed.

6. PTO Feedback Switch
   Some applications require that the operator press an upfitter installed momentary switch usually located outside the cab before entering any PTO set speed (not PTO Standby Speed). The switch is normally tied into the PTO Engage Relay switch circuit. Once the switch is pressed with the relay turned ON, the ECM should detect a high voltage at the PTO Feedback Switch input. This momentarily high input will allow the operator to use any of the PTO speeds above the PTO Standby Speed until PTO mode is cancelled. The PTO harness 1 A of H-122 connector is equipped with a voltage feed circuit to the PTO Engage Relay. Also, the PTO harness 2 connector is equipped with an input circuit to the ECM A-95 of J-128 connector through A of H-123 connector.

Notice:
PTO Feedback input to the ECM can be set via ECM programming.

- Preset Value: No

7. PTO Brake/Clutch Override Switch
   The upfitter-installed PTO Brake/Clutch Override Switch can be used in PTO mode to keep the PTO Set Speed enabled if a brake or clutch switch input is detected by the ECM. Under default conditions, the ECM will return the engine to PTO Standby Speed if a brake or clutch transition occurs. The switch needs to be a toggle or push-lock switch. The PTO harness 1 connector is equipped with an input circuit to the ECM A-86 of J-218 connector through the B of H-122 connector.

Notice:
The PTO Brake/Clutch Override Switch input to the ECM MUST be enabled (programmed) in the ECM AND the ECM must detect a low voltage input at pin A-86 of J-218 connector. These both are necessary for this disable feature to operate.

- Preset value: No

Notice:
In PTO Standby Speed, PTO mode is disabled by pressing the clutch pedal switch even when the override switch is ON. (M/T only)

8. PTO Engine Shutdown Switch
   The upfitter-installed PTO Engine Shutdown Switch can be used in PTO mode to turn Off the engine. The switch needs to be a toggle or push-lock switch. The PTO harness 1 connector equipped with an input circuit to the ECM A-94 of J-218 connector through the F of H-122 connector.

Notice:
The time preceding the engine shutdown once the input has been received can be set within the following allowable range:

PTO Engine Shutdown Time Delay:

- Minimum: 0 seconds
- Maximum: 254 seconds
- Preset value: 0 seconds

Notice:
PTO Engine Shutdown Switch input MUST be enabled (programmed) in the ECM AND the ECM must detect a low voltage input at pin A-94 of J-218 connector. These both are necessary for this shutdown feature to operate.

Stationary Variable PTO Mode

In Stationary Variable PTO Mode, the PTO control is performed while the vehicle is stopped by arbitrarily selecting an engine speed as the PTO desired engine speed.

Notice:
If the engine speed the driver requests by pressing on the accelerator pedal is higher than the PTO desired engine speed, the accelerator pedal engine speed is used.

Hardware Configuration

The Stationary Variable PTO Mode is enabled based on the following hardware inputs to the ECM.

Factory-option:

1. PTO Switch
   The factory-option dash mounted PTO Switch is used to enable or cancel PTO mode. The engine speed will be set to the PTO Standby Speed when the PTO switch is pressed. The switch is a push-lock type switch. The input circuit is connected to the ECM A-93 of J-218 connector.

Notice:
The PTO Standby Speed can change within the following allowable range.

- Minimum: 750 RPM
- Maximum: 1300 RPM
- Preset value: 800 RPM

Notice:
The PTO Maximum Engine Speed can change within the following allowable range.

- Minimum: PTO Standby Speed
- Maximum: 3050 RPM
- Preset value: 3050 RPM

2. Cruise Set/Coast Switch
   The factory-installed dash mounted Cruise Set/ Coast Switch can be used in PTO mode to decrease the engine speed when this switch is tapped or while this switch is pressed. The switch is a momentary switch. The input circuit is connected to the ECM A-48 of J-218 connector.

Notice:
The PTO Increase RPM Rate (increment or decrement by pressing) can change within the following allowable range:

- Minimum: 0 RPM
- Maximum: 1000 RPM
- Preset value: 25 RPM

Notice:
The PTO Reduce RPM Rate (decrement by pressing) can change within the following allowable range

- Minimum: 0 RPM
- Maximum: 1000 RPM
- Preset value: 30 RPM

3. Cruise Resume/Accel. Switch
   The factory-installed dash mounted Cruise Resume/Accel. Switch can be used in PTO mode to increase the engine speed when this switch is tapped or while this switch is pressed. The switch is a momentary switch. The input circuit is connected to the ECM A-47 of J-218 connector.

Notice:
The PTO Accel RPM Rate (increment per second by pressing) can change within the following allowable range:

- Minimum: 0 RPM/sec.
- Maximum: 1000 RPM/sec.
- Preset value: 20 RPM/sec.

Upfitter-installed:

1. Remote PTO Set Switch
   The upfitter-installed Remote PTO Set Switch can be used in PTO mode to decrease the engine speed when this switch is tapped or while this switch is pressed. The function of this switch is same as the Cruise Set/Coast Switch in the cab. The switch needs to be a momentary switch. The PTO harness 1 connector equipped with an input circuit to the ECM A-91 of J-218 connector through the J of H-122 connector.

Notice:
The Remote Set/Resume Switches use the PTO Increase RPM Rate, PTO Reduce RPM Rate and Accel RPM Rate values.

Notice:
The Remote PTO Set Switch MUST be enabled (programmed) in the ECM.

2. Remote PTO Resume Switch
   The upfitter-installed Remote PTO Resume Switch can be used in PTO mode to increase the engine speed at when this switch is tapped or while this switch is pressed. The function of this switch is same as the Cruise Resume/Accel. Switch in the cab. The switch needs to be a momentary switch. The PTO harness 1 connector equipped with an input circuit to the ECM A-92 of J-218 connector through the K of H-122 connector.

Notice:
The Remote Set/Resume Switch use the PTO Increase RPM Rate, PTO Reduce RPM Rate and Accel RPM Rate values.

Notice:
The Remote PTO Resume Switch MUST be enabled (programmed) in the ECM.

3. Remote PTO Throttle
   The upfitter-installed Remote PTO Throttle can be used in PTO mode to increase or decrease the engine speed the same as an accelerator pedal. The device needs to be a potentiometer. The ECM supplies 5 volts reference circuit to the Remote PTO Throttle from the ECM A-58 of J-218 connector through the E of H-123 connector. The ECM also provides a ground on the low reference circuit from the ECM A-10 of J-218 connector through the G of H-123 connector. The ECM monitors the Remote PTO Throttle signal on the ECM A-34 of J-218 connector through the F of H-123 connector.

Notice:
The Remote PTO Throttle engine speed can be controlled within the following allowable range:

- Minimum: 0 RPM
- Maximum: 2900 RPM - PTO Standby Speed
- Preset value: 2900 RPM - PTO Standby Speed

Notice:
It is necessary to program the Remote PTO Throttle signal inputs to the ECM at position 0% and 100%.

- Preset value at 0%: 0.85 volts
- Preset value at 100%: 3.75 volts

Notice:
If the ECM the detects the Remote PTO Throttle signal more than 4.9 volts, DTC P1597 will set.

Notice:
The Remote PTO Throttle MUST be enabled (programmed) in the ECM.

4. PTO Engage Relay
   The upfitter-installed PTO Engage Relay can be used to supply switched battery voltage to operate a PTO hydraulic solenoid. The solenoid in turn allows fluid to flow to a PTO hydraulic pump. The relay is controlled via the ECM grounding the relay coil control circuit. The PTO harness 2 C of H-123 connector is equipped with the voltage feed circuit to the relay. Also, the PTO harness 2 connector is equipped with a grounding circuit to ECM A-75 of J-218 connector through B of the H-123 connector.

Notice:
The PTO Engage Relay turn ON (ECM grounding coil control circuit) engine speed can change within the following allowable range:

- Minimum: PTO Standby Speed
- Maximum: 2500 RPM
- Preset value: 1050 RPM

Notice:
The PTO Engage Relay cannot be higher than any PTO speed except the PTO Standby Speed

5. PTO Feedback Switch
   Some applications require that the operator press an upfitter installed momentary switch usually located outside the cab before entering any PTO set speed (not PTO Standby Speed). The switch is normally tied into the PTO Engage Relay switch circuit. Once the switch is pressed with the relay turned ON, the ECM should detect a high voltage at the PTO Feedback Switch input. This momentarily high input will allow the operator to use any of the PTO speeds above the PTO Standby Speed until PTO mode is cancelled. The PTO harness 1 A of H-122 connector is equipped with a voltage feed circuit to the PTO Engage Relay. Also, the PTO harness 2 connector is equipped with an input circuit to the ECM A-95 of J-128 connector through A of H-123 connector.

Notice:
PTO Feedback input to the ECM can be set via ECM programming.

- Preset Value: No

6. PTO Brake/Clutch Override Switch
   The upfitter-installed PTO Brake/Clutch Override Switch can be used in PTO mode to keep the PTO Set Speed enabled if a brake or clutch switch input is detected by the ECM. Under default conditions, the ECM will return the engine to PTO Standby Speed if a brake or clutch transition occurs. The switch needs to be a toggle or push-lock switch. The PTO harness 1 connector is equipped with an input circuit to the ECM A-86 of J-218 connector through the B of H-122 connector.

Notice:
The PTO Brake/Clutch Override Switch input to the ECM MUST be enabled (programmed) in the ECM AND the ECM must detect a low voltage input at pin A-86 of J-218 connector. These both are necessary for this disable feature to operate.

- Preset value: No

Notice:
In PTO Standby Speed, PTO mode is disabled by pressing the clutch pedal switch even when the override switch is ON. (M/T only)

7. PTO Engine Shutdown Switch
   The upfitter-installed PTO Engine Shutdown Switch can be used in PTO mode to turn Off the engine. The switch needs to be a toggle or push-lock switch. The PTO harness 1 connector equipped with an input circuit to the ECM A-94 of J-218 connector through the F of H-122 connector.

Notice:
The time preceding the engine shutdown once the input has been received can be set within the following allowable range:
PTO Engine Shutdown Time Delay:

- Minimum: 0 seconds
- Maximum: 254 seconds
- Preset value: 0 seconds

Notice:
PTO Engine Shutdown Switch input MUST be enabled (programmed) in the ECM AND the ECM must detect a low voltage input at pin A-94 of J-218 connector. These both are necessary for this shutdown feature to operate.

Mobile Variable PTO Mode

In Mobile Variable PTO Mode, the PTO control is performed while the vehicle is running by arbitrarily selecting engine speeds as the PTO desired engine speed. The system allows increases or decreases above the PTO Standby Speed by two switch inputs into the ECM while the vehicle is moving.

Notice:
If the engine speed the driver requests by pressing on the accelerator pedal is higher than the PTO desired engine speed, the accelerator pedal engine speed is used.

Notice:
The PTO Maximum Vehicle Speed for Mobile Variable PTO Mode can change within the following allowable range:

- Minimum: 1MPH (0.6 km/h)
- Maximum: 75MPH (121 km/h)
- Preset value: 75MPH (121 km/h)

Hardware Configuration

Mobile Variable Mode uses only switches in the cab and is enabled based on the following hardware inputs to the ECM.

Factory-option:

1. PTO Switch
   The factory-option dash mounted PTO Switch is used to enable or cancel PTO mode. The engine speed will be set to the PTO Standby Speed when the PTO switch is pressed. The switch is a push-lock type switch. The input circuit is connected to the ECM A-93 of J-218 connector.

Notice:
The PTO Standby Speed can change within the following allowable range.

- Minimum: 750 RPM
- Maximum: 1300 RPM
- Preset value: 800 RPM

Notice:
The PTO Maximum Engine Speed can change within the following allowable range.

- Minimum: PTO Standby Speed
- Maximum: 3050 RPM
- Preset value: 3050 RPM

2. Cruise Set/Coast Switch
   The factory-installed dash mounted Cruise Set/ Coast Switch can be used in PTO mode to decrease the engine speed when this switch is tapped or while this switch is pressing. The switch is a momentary switch. The input circuit is connected to the ECM A-48 of J-218 connector.

Notice:
The PTO Increase RPM Rate (increment or decrement by pressing) can change within the following allowable range:

- Minimum: 0 RPM
- Maximum: 1000 RPM
- Preset value: 25 RPM

Notice:
The PTO Reduce RPM Rate (decrement by pressing) can change within the following allowable range:

- Minimum: 0 RPM
- Maximum: 1000 RPM
- Preset value: 30 RPM

3. Cruise Resume/Accel. Switch
   The factory-installed dash mounted Cruise Resume/Accel. Switch can be used in PTO mode to increase the engine speed when this switch is tapped or while this switch is pressed. The switch is a momentary switch. The input circuit is connected to the ECM A-47 of J-218 connector.

Notice:
The PTO Accel RPM Rate (increment per second by pressing) can change within the following allowable range:

- Minimum: 0 RPM/sec.
- Maximum: 1000 RPM/sec.
- Preset value: 20 RPM/sec.

Upfitter-installed:

1. PTO Engage Relay
   The upfitter-installed PTO Engage Relay can be used to supply switched battery voltage to operate a PTO hydraulic solenoid. The solenoid in turn allows fluid to flow to a PTO hydraulic pump. The relay is controlled via the ECM grounding the relay coil control circuit. The PTO harness 2 C of H-123 connector is equipped with the voltage feed circuit to the relay. Also, the PTO harness 2 connector is equipped with a grounding circuit to ECM A-75 of J-218 connector through B of the H-123 connector.

Notice:
The PTO Engage Relay turn ON (ECM) grounding coil control circuit) engine speed can change within the following allowable range:

- Minimum: PTO Standby Speed
- Maximum: 1500 RPM
- Preset value: 1050 RPM

Notice:
The PTO Enable Relay cannot be higher than any PTO speed except the PTO Standby Speed

2. PTO Feedback Switch
   Some applications require that the operator press an upfitter installed momentary switch usually located outside the cab before entering any PTO set speed (not PTO Standby Speed). The switch is normally tied into the PTO Engage Relay switch circuit. Once the switch is pressed with the relay turned ON, the ECM should detect a high voltage at the PTO Feedback Switch input. This momentarily high input will allow the operator to use any of the PTO speeds above the PTO Standby Speed until PTO mode is cancelled. The PTO harness 1 A of H-122 connector is equipped with a voltage feed circuit to the PTO Engage Relay. Also, the PTO harness 2 connector is equipped with an input circuit to the ECM A-95 of J-128 connector through A of H-123 connector.

Notice:
PTO Feedback input to the ECM can be set via ECM programming

- Preset Value: No

3. PTO Engine Shutdown Switch
   The upfitter-installed PTO Engine Shutdown Switch can be used in PTO mode to turn Off the engine. The switch needs to be a toggle or push-lock switch. The PTO harness 1 connector equipped with an input circuit to the ECM A-94 of J-218 connector through the F of H-122 connector.

Notice:
The time preceding the engine shutdown once 0MPH(0 km/h) vehicle speed has been received can be set within the following allowable range:
PTO Engine Shutdown Time Delay:

- Minimum: 0 seconds
- Maximum: 254 seconds
- Preset value: 0 seconds

Notice:
PTO Engine Shutdown Switch input MUST be enabled (programmed) in the ECM AND the ECM must detect a low voltage input at pin A-94 of J-218 connector. These both are necessary for this shutdown feature to operate.

PTO Option Programming

The PTO Option Programming must be done when any of the following procedures are performed:

- When the upfitter installed a PTO.
- When the ECM is replaced.
- When a change of the PTO setting is needed.

Before Programming the PTO Option

Notice:
DO NOT program the ECM unless you are directed by a service procedure or you are directed by a service bulletin. Programming the ECM at any other time will not permanently correct a customers concern.

Ensure the following conditions are met before programming the ECM.

- Vehicle system voltage
  - There is no charging system concern. All charging system concerns must be repaired before programming the ECM.
  - Battery voltage is greater than 12 volts but less than 16 volts. The battery must be charged before programming the ECM if the battery voltage is low.
  - A battery charger is NOT connected to the vehicle's battery. Incorrect system voltage or voltage fluctuations from a battery charger may cause a programming failure or ECM damage.
  - Turn OFF or disable and system that may put a load on the vehicle's battery.
- Headlights
- Room lights
- Accessory equipment
- The ignition switch is in the proper position. DO NOT change the position of the ignition switch during the programming procedure, unless instructed to do so.
- All tool connections are secure.
  - RS-232
  - The connection at the data link connector (DLC) is secure.
  - Voltage supply circuit
- DO NOT disturb the tool harness while programming. If an interruption occurs during the programming procedure, programming failure or ECM damage may occur.
- Surrounding environment
  - Surrounding temperature is more than 32°F (0°C) but less than 122°F (50°C) during the programming procedure. Excessively low or high temperature may cause the programming failure or ECM damage.
  - Electromagnetic interference (EMI) on the tool harness and ECM may cause the programming failure or ECM damage.

PTO Option Programming Procedure

1. Connect the scan tool to the data link connector.
2. Connect the RS-232 to the scan tool and PC.
3. Start TIS 2000 and select the Service Programming System (SPS).

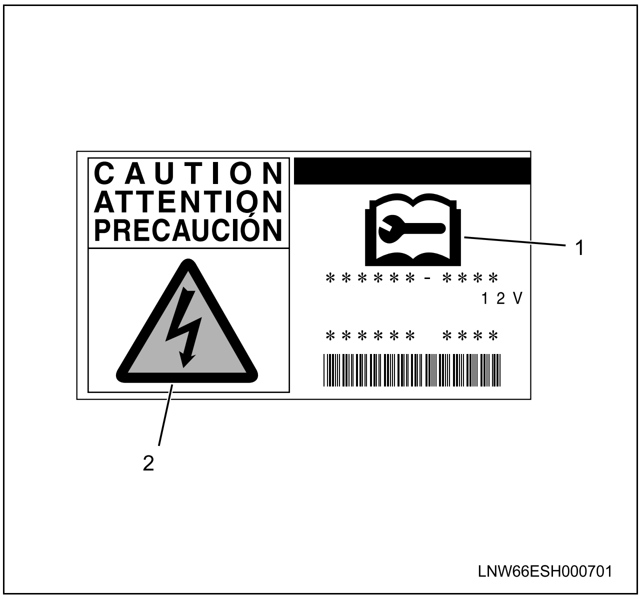
4. In the "Select Diagnostic Tool and Programming Process" screen, select the following menu.
   - Diagnostic tool "Pass-Thru".
   - Select Programming Process "Reprogram ECU".
   - ECU Location on the "Vehicle".

   Then, follow the SPS screen instructions.
5. Ensure that ALL programming contents are entered correctly and were programmed successfully by turning OFF the ignition for 30 seconds.
6. Using the scan tool to check each programmed PTO option value under the Special Functions menu.
7. Start the engine and let idle.
8. Inspect for a proper engine running condition and for any DTCs. Refer to the Diagnostic System Check – Engine Control if needed.
9. Perform test drive or verify the PTO control system.

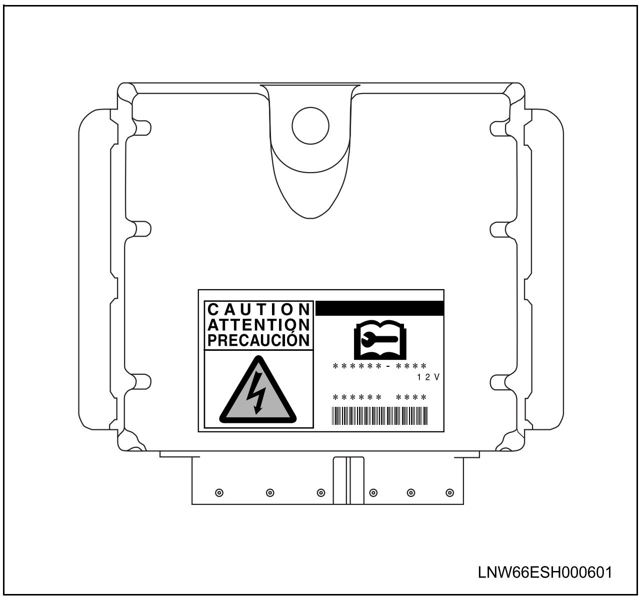
Description and Operation

Engine Control Module (ECM) Description

Engine Control Module (ECM) Service Precautions



Important:
Symbol (1) indicates that important procedural information is contained in the Workshop Manual. Refer to this manual before starting any work. Follow the instructions exactly to avoid equipment damage and personal injury.
Symbol (2) warns you of an electric shock hazard. To avoid shock and possible serious injury, do not touch the terminals.



The engine control module (ECM) is designed to withstand normal current draws associated with vehicle operation. Avoid overloading any circuit. When testing for opens and shorts, do not ground or apply voltage to any of the ECM circuits unless instructed to do so. In some cases, these circuits should only be tested using a digital multimeter (DMM). The ECM should remain connected to the ECM harness.
The engine control module (ECM) is located on the chassis frame side near the transmission. The ECM controls the following:

- The fuel supply control
- The fuel injection timing control
- The exhaust gas recirculation (EGR) control
- The preheating control (glow control)
- The on-board diagnostics for engine control

The ECM constantly observes the information from various sensors. The ECM controls the systems that affect vehicle performance. The ECM performs the diagnostic function of the system. The ECM can recognize operational problems, alert the driver through the malfunction indicator lamp (MIL), and store diagnostic trouble codes (DTCs). DTCs identify the system faults to aid the technician in making repairs.

ECM Voltage Description

The engine control module (ECM) supplies a buffered voltage to various switches and sensors. The ECM can do this because in some cases, resistance in the ECM is high enough value that a test lamp may not illuminate when connected to the circuit. An ordinary shop voltmeter may not give an accurate reading because the voltmeter input impedance is too low. Use a 10 MΩ input impedance DMM, to ensure accurate voltage readings. The input and/or output devices in the ECM include analog-to-digital converters, signal buffers, counters, and special drivers. The ECM controls most components with electronic switches which complete a ground circuit when turned ON.

Aftermarket Electrical and Vacuum Equipment

Aftermarket or add-on electrical and vacuum equipment is defined as any equipment which connects to the vehicle's electrical or vacuum systems that is installed on a vehicle after the vehicle leaves the factory. No allowances have been made in the vehicle design for this type of equipment. No add-on vacuum equipment should be added to this vehicle.

Add-on electrical equipment must only be connected to the vehicle's electrical system at the battery power and ground.

Add-on electrical equipment, even when installed to these guidelines, may still cause the powertrain system to malfunction. This may also include equipment not connected to the vehicle electrical system such as portable telephones and audios. Therefore, the first step in diagnosing any powertrain fault is to eliminate all aftermarket electrical equipment from the vehicle. After this is done, if the fault still exists, the fault may be diagnosed in the normal manner.

Electrostatic Discharge Damage

Electronic components used in the engine control module (ECM) are often designed to carry very low voltage. Electronic components are susceptible to damage caused by electrostatic discharge. By comparison, as much as 4,000 volts may be needed for a person to feel even the zap of a static discharge. There are several ways for a person to become statically charged. The most common methods of charging are by friction and induction.

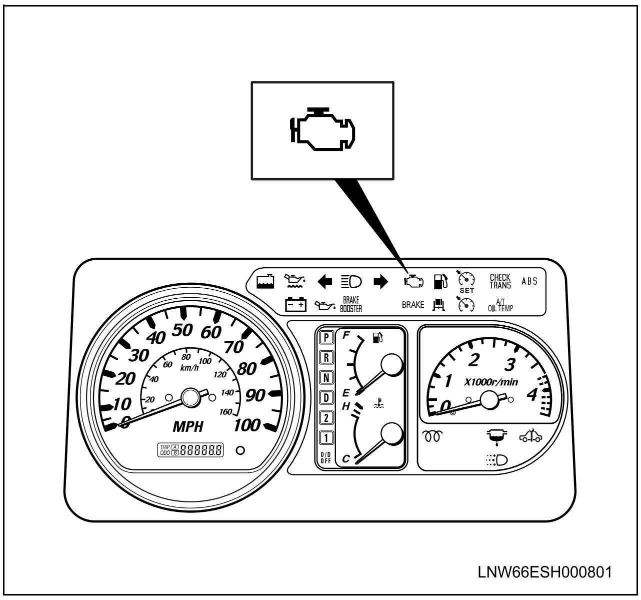
- An example of charging by friction is a person sliding across a vehicle seat.

Important:
To prevent possible electrostatic discharge damage, follow these guidelines:

- Do not touch the ECM connector pins or soldered components on the ECM circuit board.
- Do not open the replacement part package until the part is ready to be installed.
- Before removing the part from the package, ground the package to a known good ground on the vehicle.
- If the part has been handled while sliding across the seat, while sitting down from a standing position, or while walking a distance, touch a known good ground before installing the part.
- Charge by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off leaving the person highly charged with opposite polarity.

Malfunction Indicator Lamp (MIL) Operation

The malfunction indicator lamp (MIL) is located in the instrument panel cluster. The MIL will display the following symbol when commanded ON:

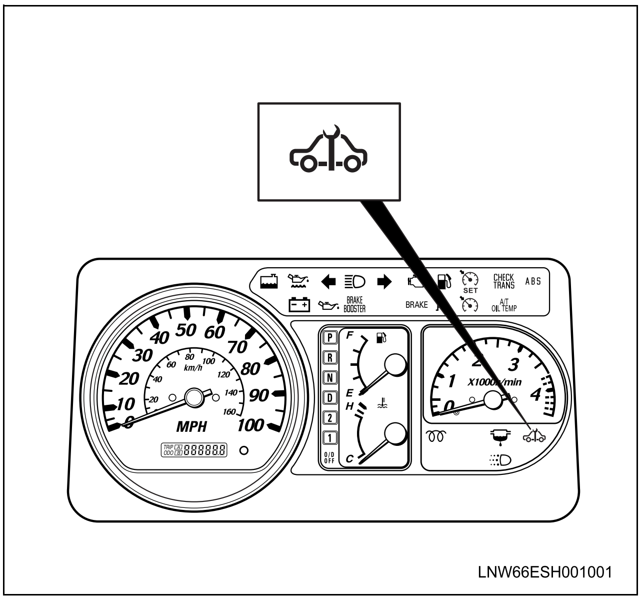


The MIL indicates that an emission related fault (Type A, B DTC) has occurred and vehicle service is required. The following is a list of the modes of operation for the MIL:

- The MIL illuminates when the ignition switch is turned ON, with the engine OFF. This is a bulb test to ensure the MIL is able to illuminate.
- The MIL turns OFF after the engine is started if a diagnostic fault is not present.
- The MIL remains illuminated after the engine is started if the engine control module (ECM) detects a fault. A diagnostic trouble code (DTC) is stored any time the ECM illuminates the MIL due to an emission related fault.

Service Vehicle Soon (SVS) Lamp Operation [12.000lbs GVW]

The service vehicle soon (SVS) lamp is located in the instrument panel cluster. The SVS lamp will display the following symbol when commanded ON:

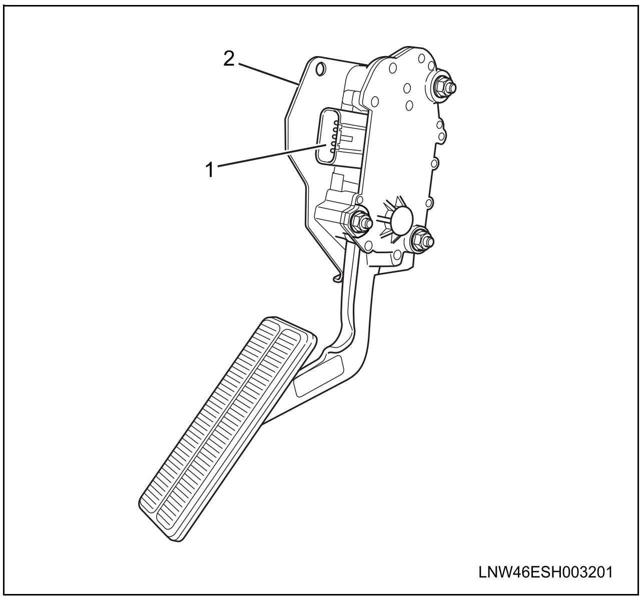


The SVS lamp indicates that a non-emission related fault (Type C DTC) has occurred and vehicle service required. The following is a list of the modes of operation for the SVS lamp (Only 12,000 GVW):

- The SVS lamp illuminates when the ignition switch is turned ON, with the engine OFF. This is a bulb test to ensure the SVS lamp is able to illuminate.
- The SVS lamp turns OFF after the engine is started if a diagnostic fault is not present.
- The SVS lamp remains illuminated after the engine is started if the engine control module (ECM) detects a fault. A diagnostic trouble code (DTC) is stored any time the ECM illuminates the SVS lamp due to a non-emission related fault.

Engine Control Component Description

Accelerator Pedal Position (APP) Sensor

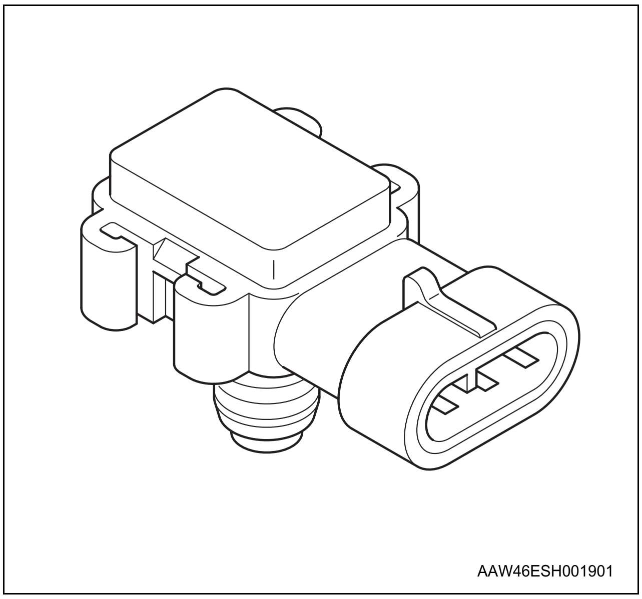


Legend

1. Accelerator pedal position (APP) sensor

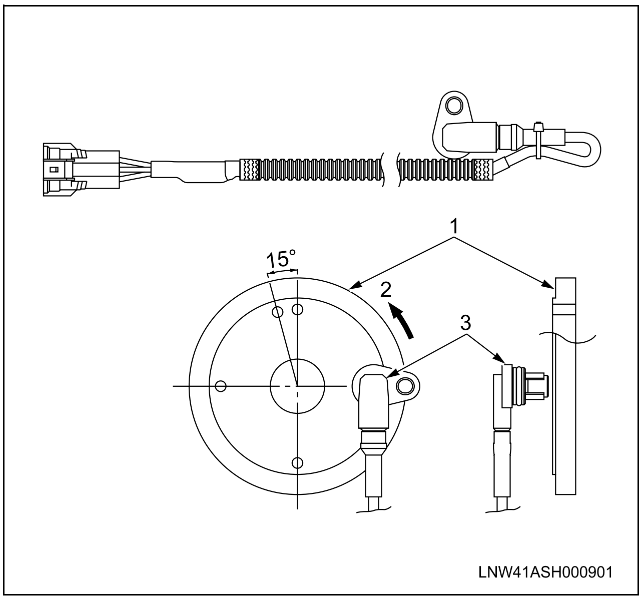
The accelerator pedal position (APP) sensor is mounted on the accelerator pedal control assembly. The sensor is made up of three individual sensors within one housing. The engine control module (ECM) uses the APP sensor to determine the amount of acceleration or deceleration desired by the person driving the vehicle via the fuel injector control.

Boost Pressure Sensor



The boost pressure sensor is located in the air induction tubing. The boost pressure sensor is a transducer that varies voltage according to charges in the air pressure inside the tubing. The generated voltage is input to the engine control module (ECM) for the boost sensor signal. The ECM should detect a low signal voltage at a low boost pressure, such as low engine load. The ECM should detect high signal voltage at a high boost pressure, such as high engine load.

Camshaft Position (CMP) Sensor

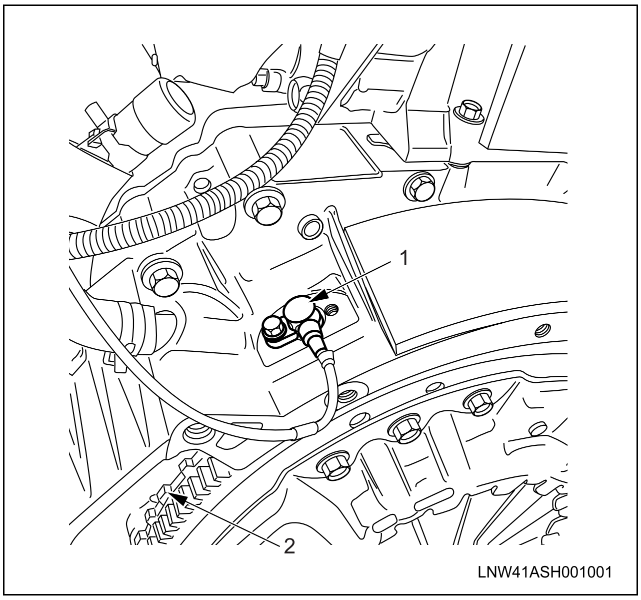


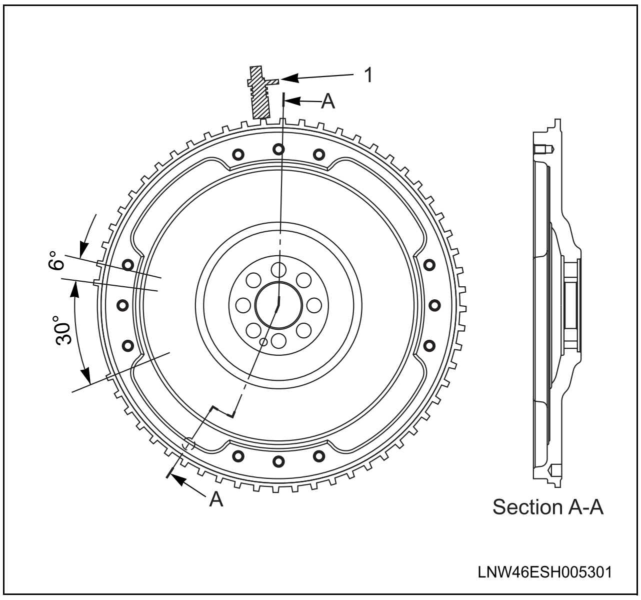
Legend

1. Camshaft gear
2. Gear rotating direction
3. Camshaft position (CMP) sensor

The camshaft position (CMP) sensor is installed on the cylinder head at the rear of the camshaft gear. The CMP sensor detects a total five through holes (four holes arranged equally every 90 deg. and one reference hole, on the camshaft gear flange surface) and sends signals to the engine control module (ECM). Receiving these signals, the ECM determines cylinder #1 compression top dead center (TDC). If the CMP sensor fails, the crankshaft position (CKP) sensor signals will substitute for the CMP sensor signals back up.

Crankshaft Position (CKP) Sensor



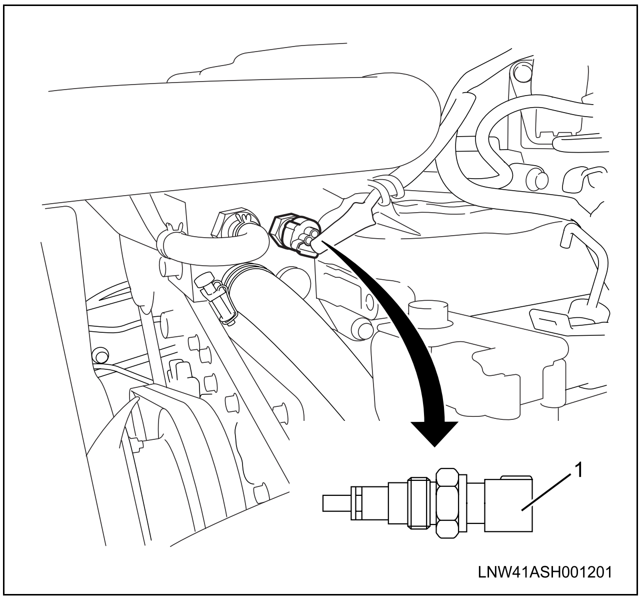


Legend

1. Crankshaft position (CKP) sensor
2. Flywheel hollow

The crankshaft position (CKP) sensor is located on top of the flywheel housing. There are 56 notches spaced 6° apart and a 24° section that is uncut. This uncut portion allows for the defection of top dead center (TDC). The CKP sensor is a magnet coil type sensor, which generates an AC signal voltage based on the crankshaft rotational speed. If the CKP sensor fails, the camshaft position sensor (CMP) sensor signals will substitute for the CKP sensor signals back up.

Engine Coolant Temperature (ECT) Sensor

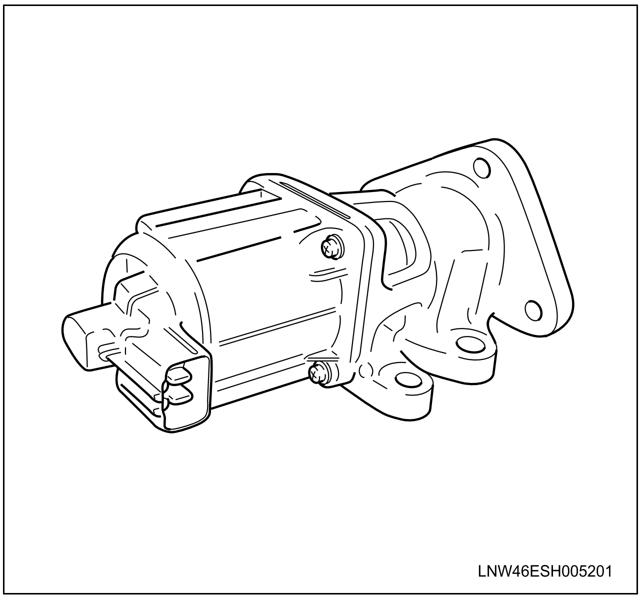


Legend

1. Engine coolant temperature (ECT) sensor

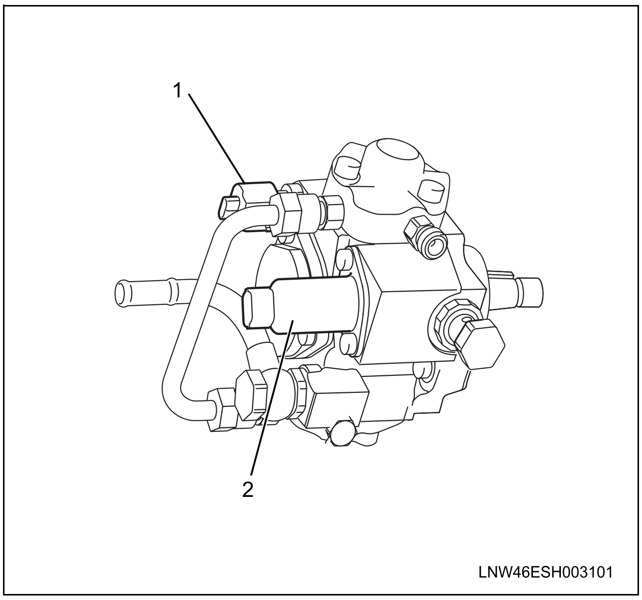
The engine coolant temperature (ECT) sensor is installed on the thermostat housing. It is a variable resistor. The ECT sensor has a signal circuit and a low reference circuit. The ECT sensor measures the temperature of the engine coolant. The engine control module (ECM) supplies 5 volts to the ECT signal circuit and a ground for the ECT low reference circuit. When the ECT sensor is cold, the sensor resistance is high. When the engine coolant temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the ECT signal circuit.

Exhaust Gas Recirculation (EGR) Valve and Position Sensor



The control current from the engine control module (ECM) operates the DC motor to control the lift amount of the EGR valve. Also, a valve position sensor is provided at the rear of the motor to feed actual valve lift amount back to the ECM for more precise control of the EGR amount. The EGR valve position sensor is applied with reference voltage (5 volts) at all times from the ECM to detect the EGR valve lift amount in the form of voltage change and sends its signal to the ECM.

Fuel Temperature (FT) Sensor

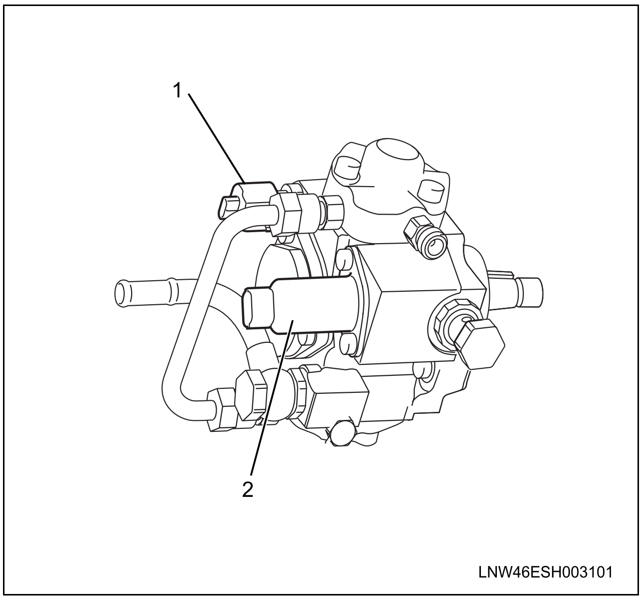


Legend

1. Fuel temperature (FT) sensor
2. Fuel rail pressure (FRP) regulator

The fuel temperature (FT) sensor is installed on the fuel supply pump. It is a variable resistor. The FT sensor has a signal circuit and a low reference circuit. The FT sensor measures the fuel temperature of the fuel. The engine control module (ECM) supplies 5 volts to the FT signal circuit and a ground for the FT low reference circuit. When the FT sensor is cold, the sensor resistance is high. When the air temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the FT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the FT signal circuit.

Fuel Rail Pressure (FRP) Regulator

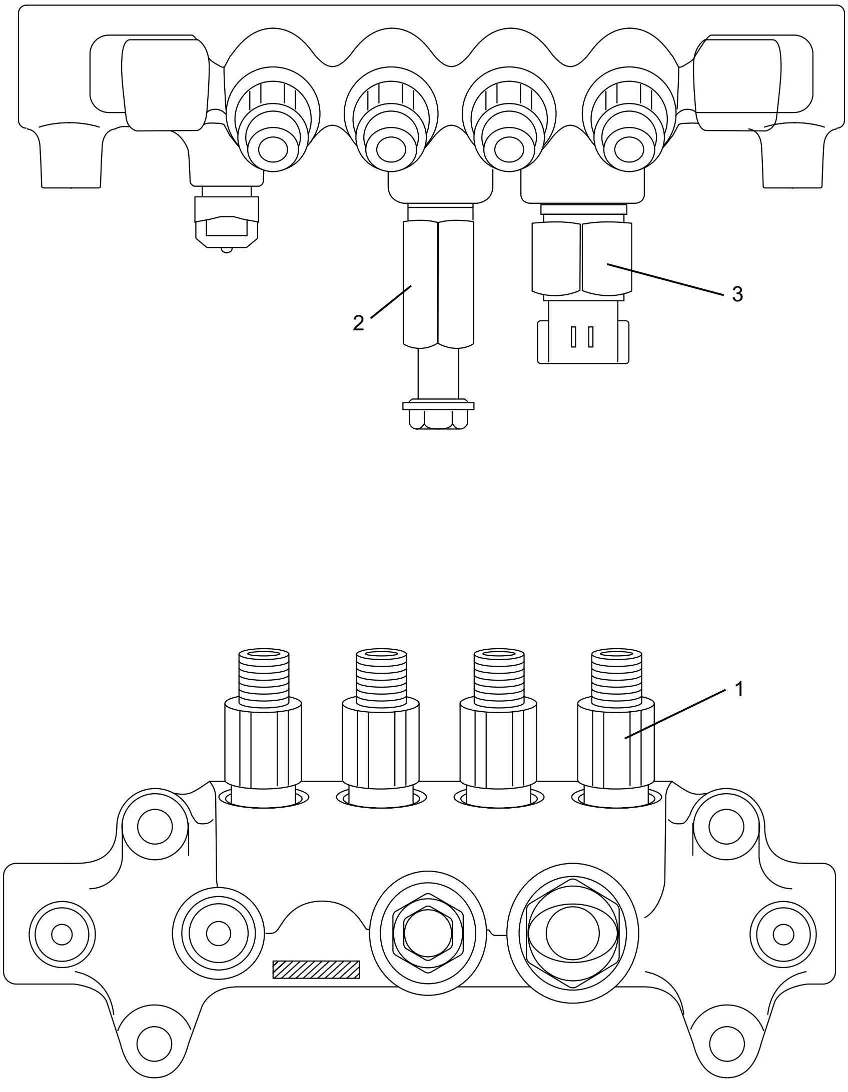


Legend

1. Fuel temperature (FT) sensor
2. Fuel rail pressure (FRP) regulator

The Fuel rail pressure (FRP) regulator is installed to the fuel supply pump and controls the suction fuel quantity into the fuel pump. The FRP regulator is fully opened in the normal state and larger drive current results in smaller opening. The engine control module (ECM) calculates desired fuel rail pressure and fuel flow rate and compares the calculated desired fuel rail pressure to the actual value to determine the FRP regulator position. When the actual fuel rail pressure is higher than the desired value, the FRP regulator is closed to decease the flow rate.

Fuel Rail Pressure Sensor

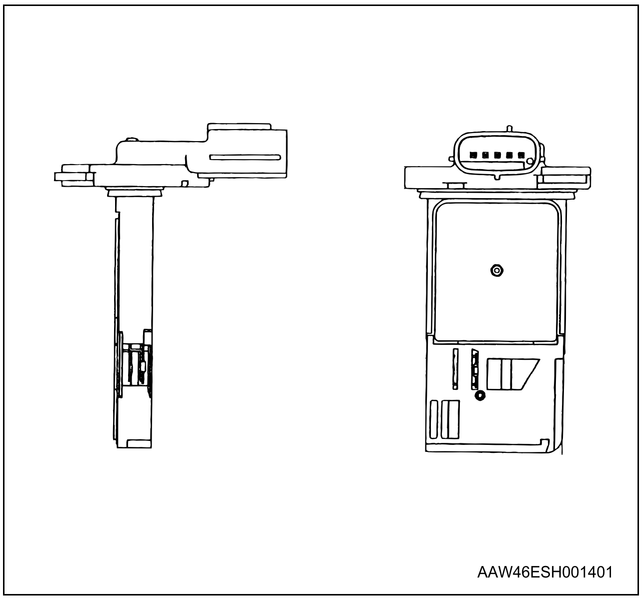


Legend

1. Flow damper
2. Pressure limiter
3. Fuel rail pressure sensor

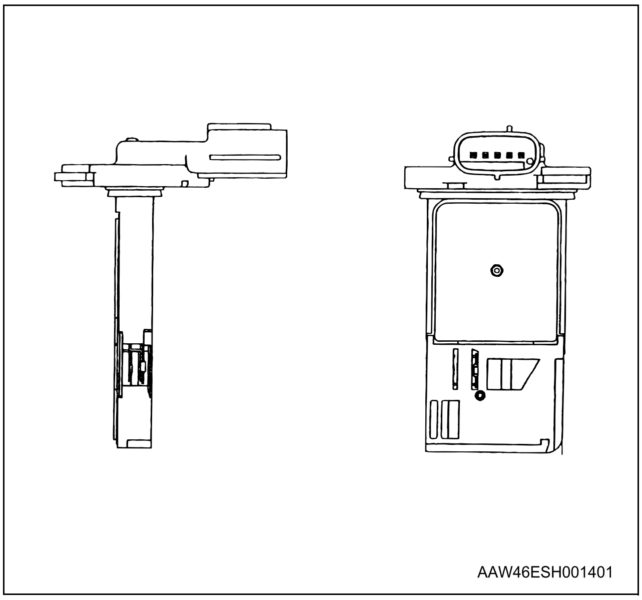
The fuel rail pressure sensor is installed to the fuel rail and it detects the fuel pressure in the fuel rail, converts the pressure into a voltage signal, and sends the signal to the engine control module (ECM). Higher fuel rail pressure provides higher fuel pressure sensor voltage while lower pressure provides lower fuel pressure sensor voltage. The ECM calculates actual fuel rail pressure from the voltage signal and uses the result in fuel injection control and other control tasks.

Intake Air Temperature (IAT) Sensor



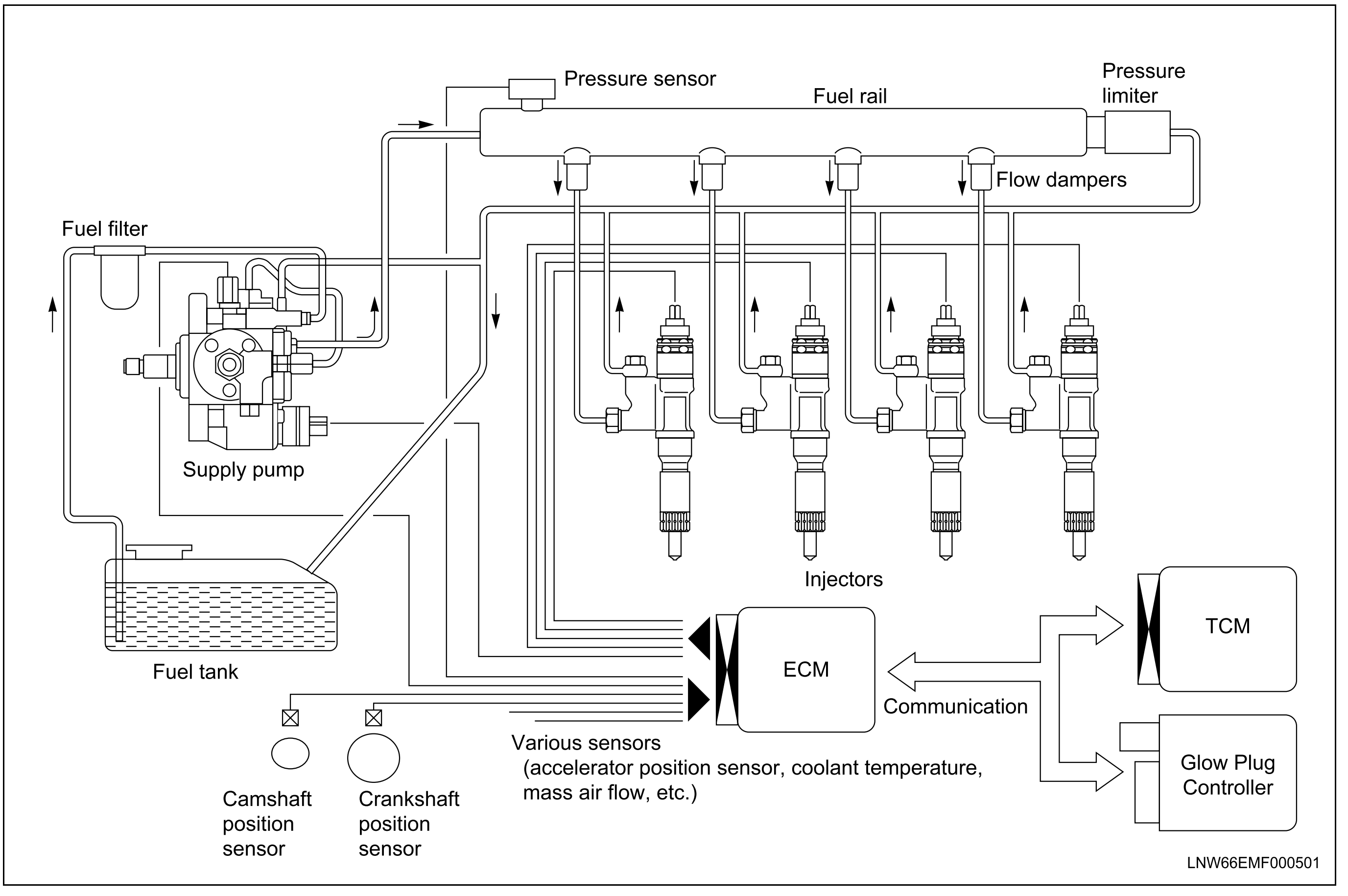
The intake air temperature (IAT) sensor is fitted between the air cleaner and turbocharger internal to the mass air flow (MAF) sensor. The IAT sensor is a variable resistor. The IAT sensor has a signal circuit and a low reference circuit. The IAT sensor measures the temperature of the air entering the engine. The engine control module (ECM) supplies 5 volts to the IAT signal circuit and a ground for the IAT low reference circuit. When the IAT sensor is cold, the sensor resistance is high. When the air temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the IAT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the IAT signal circuit.

Mass Air Flow (MAF) Sensor



The mass air flow (MAF) sensor is an air flow meter that measures the amount of air that enters the engine. It is fitted between the air cleaner and turbocharger. A small quantity of air that enters the engine indicates deceleration or idle. A large quantity of air that enters the engine indicates acceleration or a high load condition. The mass air flow (MAF) sensor assembly consists of a mass air flow (MAF) sensor element and an intake air temperature sensor that are both exposed to the air flow to be measured. The mass air flow (MAF) sensor element measures the partial air mass through a measurement duct on the sensor housing.

Fuel System Description



The common rail system uses a type of accumulator chamber called the fuel rail to store pressurized fuel, and injectors that contain electronically controlled solenoid valves to spray the pressurized fuel in the combustion chambers. The injection system (injection pressure, injection rate, and injection timing) is controlled by the engine control module (ECM), and therefore the common rail system can be controlled independently, free from the influence of engine speed and load. This ensures a stable injection pressure at all times, particularly in the low engine speed range, so that black smoke specific to diesel engines generated during vehicle starting or acceleration can be reduced dramatically. As a result, exhaust gas emissions are low, and higher output is achieved.

1. High Pressure Control

- Enables high pressure injection from low engine speed range.
- Optimizes control to minimize particulate matter and NOx emissions.

2. Injection Timing Control

- Enables finely tuned optimized control in accordance with running conditions.

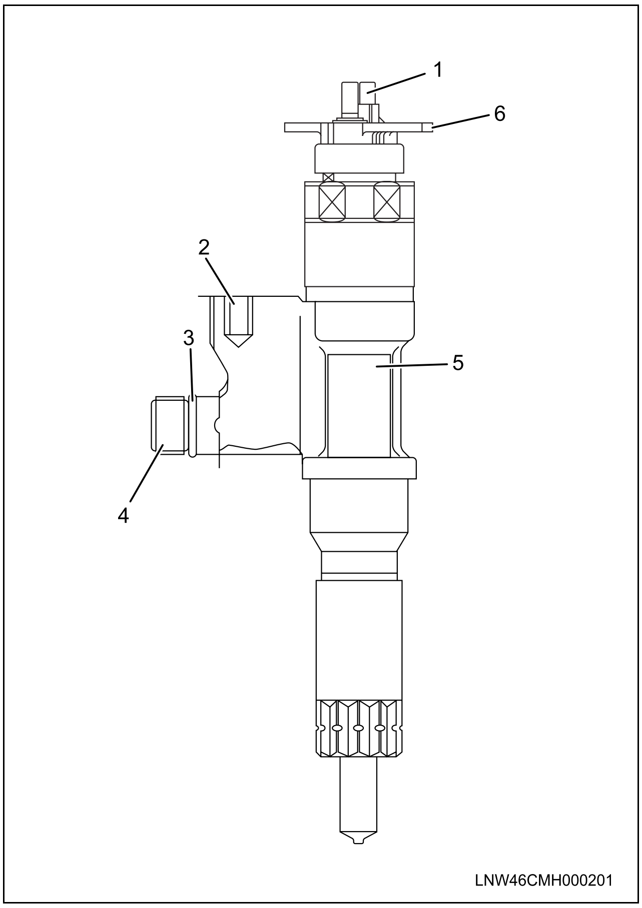
3. Injection Rate Control

- Pilot injection control that performs a small amount of injection before the main injection.

The fuel rail system consists primarily of a fuel supply pump, fuel rail, injectors, and engine control module (ECM).

Fuel System Component Description

Injector



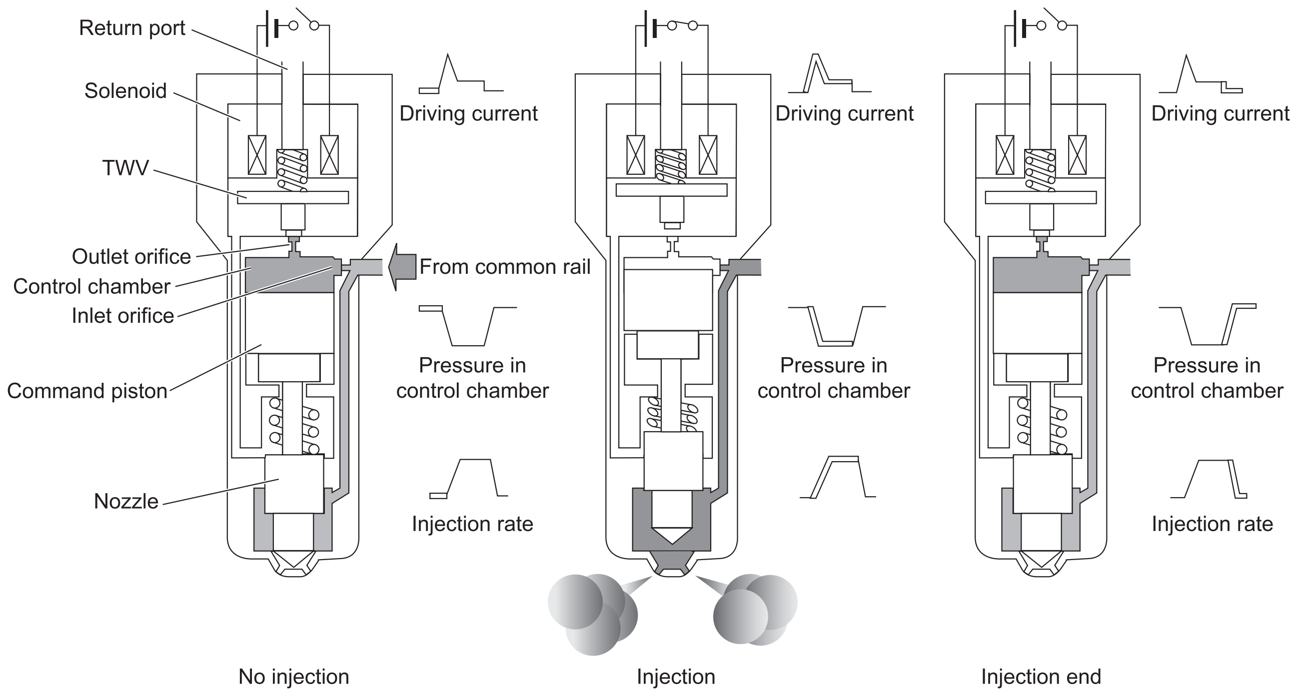
Legend

1. Terminal Stud
2. Fuel Leak Off Port
3. O-ring
4. Fuel Inlet Port
5. Injector Parts Number Marking
6. Fuel Injector ID Plate

Electronic control type injectors controlled by the engine control module (ECM) are used. Compared with conventional injection nozzles, a command piston, solenoid valve, etc. are added.

ID codes displaying various injector characteristics are laser marked in the plate, and ID codes showing these in numeric form (30 alphanumeric figures are displayed and only 24 are used) are laser marked in the plate. This system uses fuel injector flow rate information (ID codes) to optimize injection quantity control. When an injector is newly installed in a vehicle, it is necessary to input the ID codes in the ECM.

QR (Quick Response) codes or fuel injector flow rate (ID codes) have been adopted to enhance the injection quantity precision of the injectors. The adoption of codes enables injection quantity dispersion control throughout all pressure ranges, contributing to improvement in combustion efficiency, reduction in exhaust gas emissions and consistent horsepower throughout the vehicle built.



1) Non-injection state

The two way valve (TWV) closes the outlet orifice by means of a spring force, when no current is supplied from the engine control module (ECM) to the solenoid. At this time, the fuel pressure applied to the nozzle leading end is equal to the fuel pressure applied to the control chamber through the inlet orifice. As for the force competition in this state, the pressure on the command piston upper surface + nozzle spring force defeat the pressure on the nozzle leading end, and consequently the nozzle is pushed downward to close the injection holes.

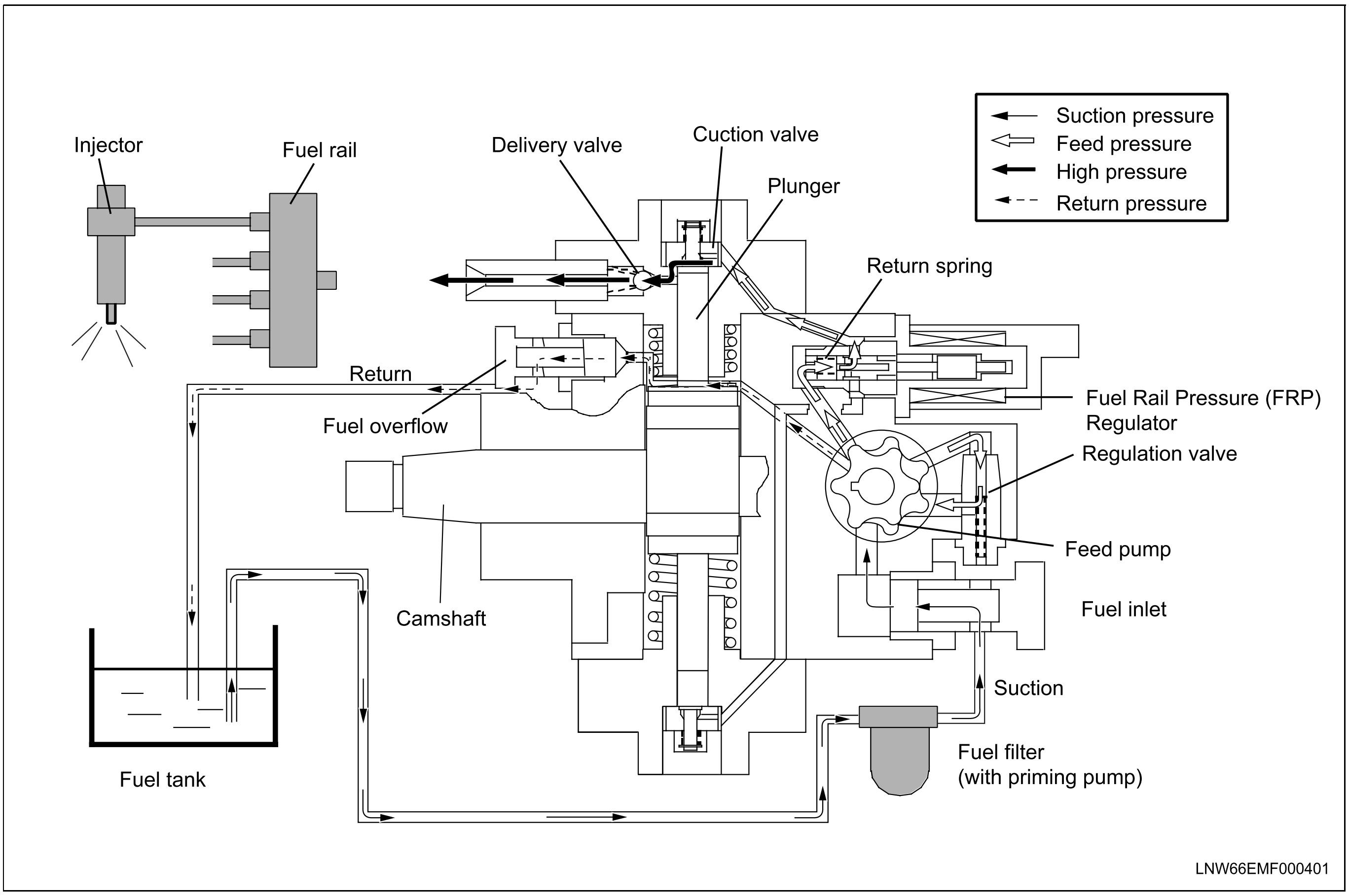
2) Injection start

The TWV is pulled up to open the outlet orifice, and thus the fuel leaks toward the return port, when the current is supplied from the ECM to the solenoid. As a result, the nozzle is pushed up together with the command piston by the fuel pressure applied to the nozzle leading end, and then the nozzle injection holes open to inject the fuel.

3) Injection end

The TWV lowers to close the outlet orifice, when the ECM shuts off a current supply to the solenoid. As a result, the fuel cannot leak from the control chamber, and thus the fuel pressure in the control chamber rises abruptly and then the nozzle is pushed down by the command piston to close the nozzle injection holes, resulting in the end of fuel injection.

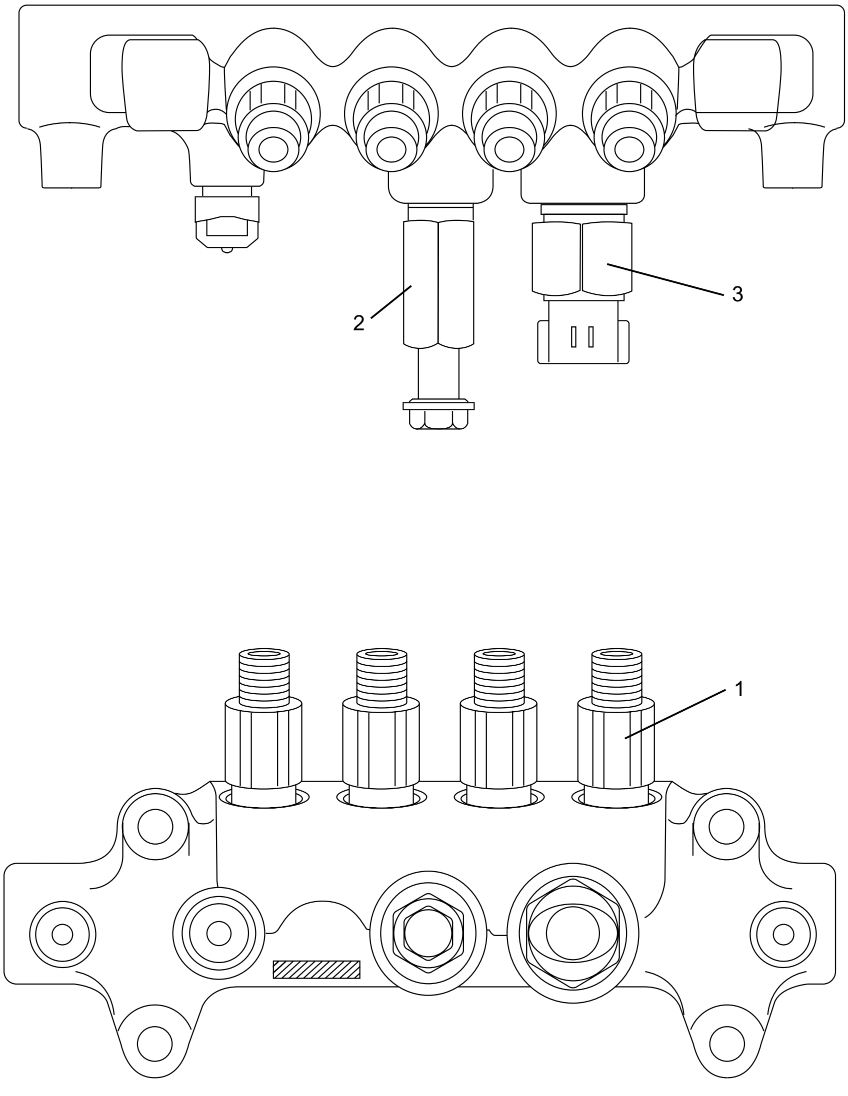
Fuel Supply Pump



The fuel supply pump is the heart of the common rail type electronic fuel injection system. The fuel supply pump is installed at the same location as the conventional injection type pump, which spins at a 1 to 1 ratio of fuel supply pump to crankshaft speed. A fuel rail pressure (FRP) regulator and fuel temperature sensor are part of the fuel supply pump assembly.

Fuel is drawn from the fuel tank via the fuel supply pump by the use of an internal feed pump (trochoid type). This feed pump pumps fuel into a 2-plunger chamber also internal to the fuel supply pump. Fuel into this chamber is regulated by the FRP regulator solely controlled by current supplied from the engine control module (ECM). No current to the solenoid results in maximum fuel flow whereas full current to the solenoid produces no fuel flow. As the engine spins, these two plungers produce high pressure in the fuel rail. Since the ECM controls the flow of fuel into this 2-plunger chamber, it therefore controls the quantity and pressure of the fuel supply to the fuel rail. This optimizes performance, improves economy and reduces NOx emissions.

Fuel Rail (Common Rail)



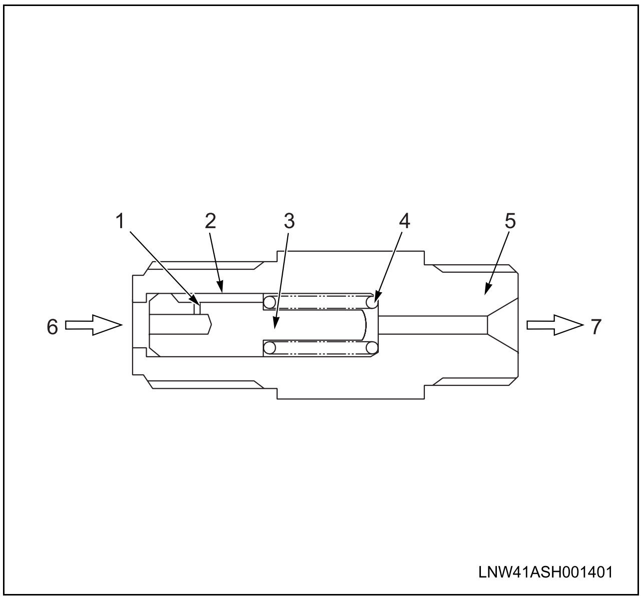
LNW46ELF000101

Legend

1. Flow damper
2. Pressure limiter
3. Fuel rail pressure sensor

Along with the employment of a common rail type electronic control fuel injection system, the fuel rail is provided to store high pressure fuel between supply pump and injectors. A pressure sensor and a pressure limiter are installed on the fuel rail. The pressure sensor detects the fuel pressure inside the fuel rail and sends its signal to the engine control module (ECM). Based on this signal, the ECM controls the fuel pressure inside the fuel rail via the fuel rail pressure (FRP) regulator of the fuel supply pump. The pressure limiter opens the valve mechanically to relieve the pressure when the fuel pressure inside the fuel rail is excessive.

Flow Damper



Legend

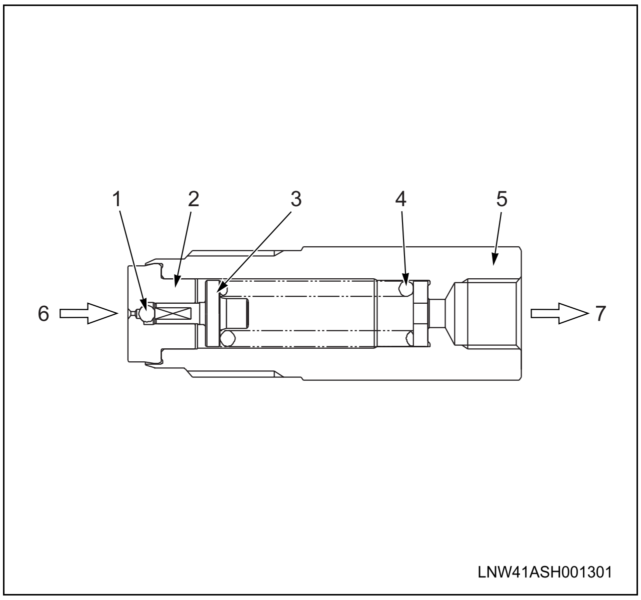
1. Orifice
2. Slit
3. Piston
4. Return Spring
5. Housing
6. Fuel Rail
7. Injector

The flow dampers are installed at the outlet of the fuel rail to dumper the pulsation of fuel pressure inside the fuel rail or to cut off the fuel supply when the fuel leaks downstream of the flow damper. The fuel is supplied to the injectors through an orifice of the piston. The pressure pulsation occurring in the fuel rail is dampered by a resistive force of the return spring and a passing resistance of the orifice, wherein the piston acts as a damper. Also, the leading end of the piston closes the fuel supply port to cut off the fuel supply, if the fuel leak occurs in the injection pipe or injectors. Since the fuel pressure on the downstream side of the flow damper supplied through an orifice + resistive force of return spring do not balance, the fuel pressure applied on the piston surface prior to the orifice will allow the fuel to be cut off. The piston will return when the fuel pressure inside the fuel rail is less than 145 psi (1.0 MPa).

Fuel Rail Pressure Sensor

Refer to Engine Control Component Description.

Pressure Limiter

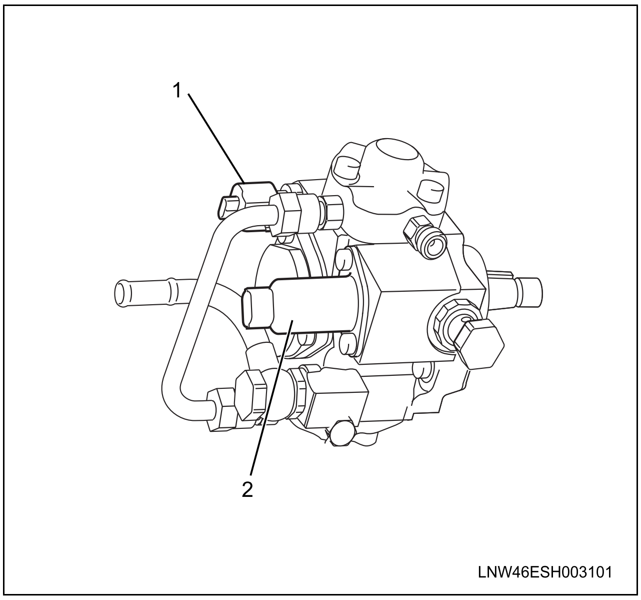


Legend

1. Valve
2. Valve Body
3. Valve Guide
4. Spring
5. Housing
6. Fuel Rail
7. Fuel Return Pipe

The pressure limiter relieves pressure by opening the valve if abnormally high pressure is generated. The valve opens when pressure in the rail reaches approximately 29000 psi (200 MPa), and closes when pressure falls to approximately 8700 psi (60 MPa). Fuel leakage through the pressure limiter re-turns to the fuel tank.

Fuel Rail Pressure (FRP) Regulator



Legend
1. Fuel temperature (FT) sensor
2. Fuel rail pressure (FRP) regulator

The engine control module (ECM) controls the duty ratio of the linear type fuel rail pressure (FRP) regulator (the length of time that the current is applied to the FRP regulator), in order to control the quantity of fuel that is supplied to the high-pressure plungers. Since only the quantity of fuel that is required for achieving the target rail pressure is drawn in, the drive load of the supply pump is decreased.

When current flows to the FRP regulator, variable electromotive force is created in accordance with the duty ratio, moving the armature to the left side. The armature moves the cylinder to the left side, changing the opening of the fuel passage and thus regulating the fuel quantity. With the FRP regulator OFF, the return spring contracts, completely opening the fuel passage and supplying fuel to the plungers (Full quantity intake and full quantity discharge). When the FRP regulator is ON, the force of the return spring moves the cylinder to the right, closing the fuel passage (normally opened).

By turning the FRP regulator ON/OFF, fuel is supplied in an amount corresponding to the actuation duty ratio, and fuel is discharged by the plungers.

Fuel Injection Quantity Control Description

This control determines the fuel injection quantity by adding coolant temperature, fuel temperature, intake air temperature, and boost pressure corrections to the basic injection quantity calculated by the engine control module (ECM), based on the engine operating conditions and driving conditions.

Normal Running (Basic Injection Quantity) Control

During normal running, optimum fuel injection quantity is controlled according to the engine speed and accelerator pedal pressing amount. Combined with high pressure injection of atomized fuel, this control improves exhaust gas and ensures proper fuel consumption. Compared with conventional mechanical governors, an electronic control system provides higher degree of freedom of fuel injection quantity control, thereby presenting high accelerator response.

Maximum Fuel Injection Quantity Control

The maximum injection quantity is calculated by adding the boost pressure correction, intake air temperature correction, barometric pressure correction and cold operation maximum injection quantity correction to the basic maximum injection quantity that is determined by the engine speed.

Starting Injection Quantity Control

At engine starting (after the key switch is turned to the START position to start the engine, up to the return of the key switch to the ON position), optimum fuel injection quantity is controlled based on the information on the starter switch, engine speed, and coolant temperature. At low temperature, the fuel injection quantity increases. When the engine started completely, this boosted quantity mode at the starting is cancelled and normal running mode is restored.

Idle Speed Variation Stabilize Control

1. Idle Speed Control

A control is made so as to achieve stable idling speed at all time regardless of engine secular changes or engine condition variations. The engine control module (ECM) sets target idling speed and controls the fuel injection quantity according to the engine conditions (actual engine speed, coolant temperature, engine load ON/OFF signals of air conditioner) to follow actual engine speed to the target idling speed so as to ensure stable idling speed.

2. Idle Vibration Control

A control is made so as to reduce the engine vibration caused by torque variations between cylinders due to variations in fuel injection quantity of each cylinder or injector performance. The engine control module (ECM) corrects the injection quantity between cylinders based on the revolution signals from the crankshaft position (CKP) sensor. Normal range of correction quantity between cylinders is within ± 5 mm^3.

Fuel Injection Timing Control Description

The injection timing suitable for all vehicle conditions is controlled based on inputs from respective sensors. The injection timing is determined by comparing actual measured values of pulse signals from the crankshaft position (CKP) sensor and camshaft position (CMP) sensor with the target injection timing stored in the map of the ECM.

Coolant Temperature Compensation

The engine control module will advance the fuel injection timing with a decrease in engine coolant temperature. This is performed to reduce white smoke emission.

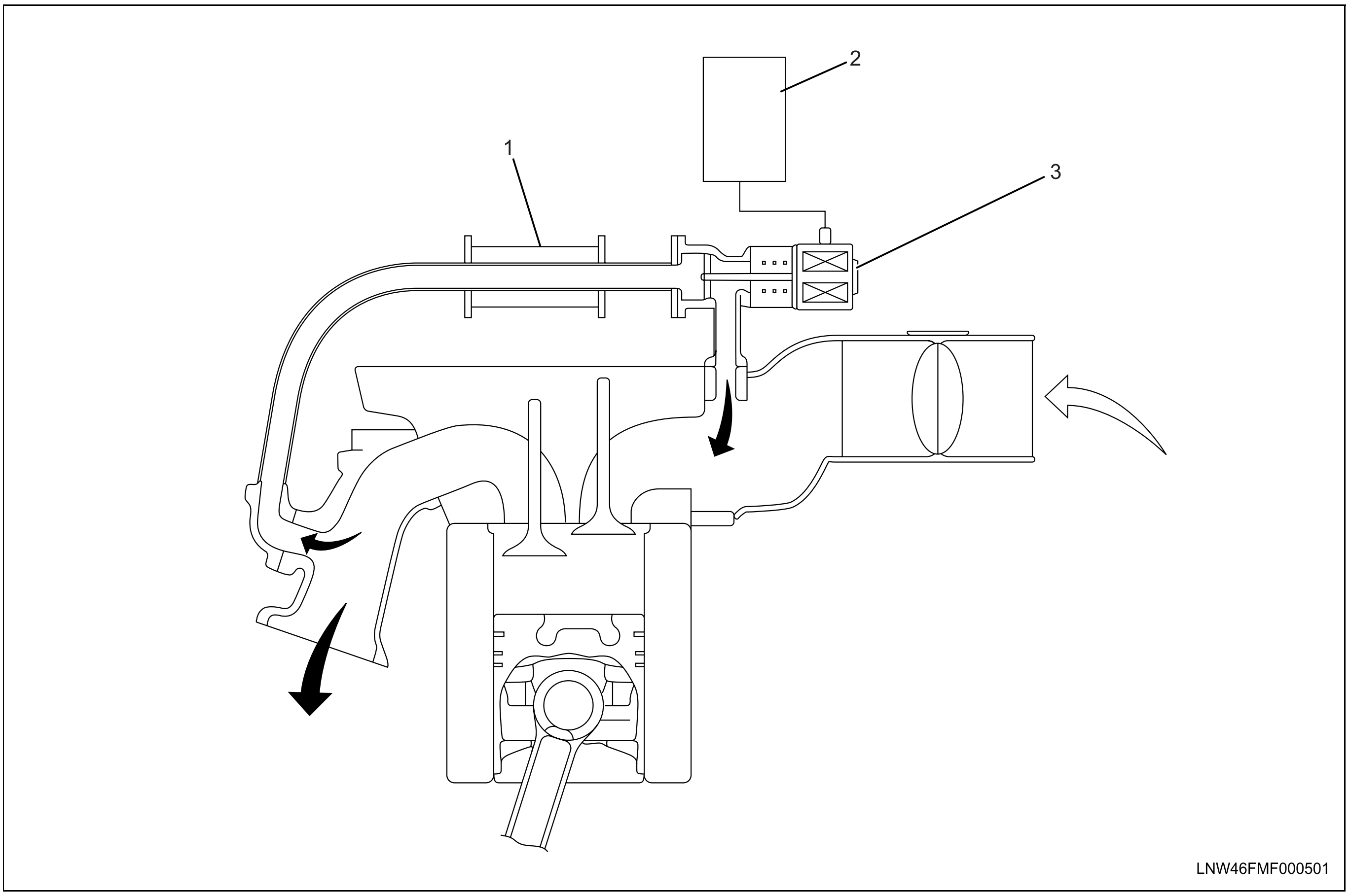
High Altitude Compensation

The engine control module with advance the fuel injection timing with an increase in altitude due to the lower air density. This is performed to reduce white smoke emission.

Cold Start Compensation

The engine control module will advance the fuel injection timing with a decrease in intake air temperature. This is performed to reduce white smoke emission.

Exhaust Gas Recirculation (EGR) System Description



Legend

1. EGR Cooler
2. ECM
3. EGR Valve

The EGR system recirculates a part of the exhaust gas back into the intake manifold, which results in reducing nitrogen oxide (NOx) emissions. The EGR control system uses an electronic control system to ensure both driveability and low emission. The control current from the engine control module (ECM) operates the motor to control the lift amount of the EGR valve. Also, an EGR position sensor is provided at the rear of the motor to feed actual valve lift amount back to the ECM for more precise control of the EGR amount.

The EGR control starts when the conditions for engine speed, engine coolant temperature, and barometric pressure are satisfied. Then, the valve opening is calculated according to the engine speed, and target fuel injection quantity. Based on this valve opening, the drive duty of the motor is determined and the motor is driven accordingly.

A potentiometer (variable resistor) type EGR valve position sensor is employed and installed on the EGR valve body. The EGR valve position sensor is supplied reference voltage (5V) and ground at all times from the ECM. The ECM reads the EGR position sensor voltage input and determines the EGR lift position.

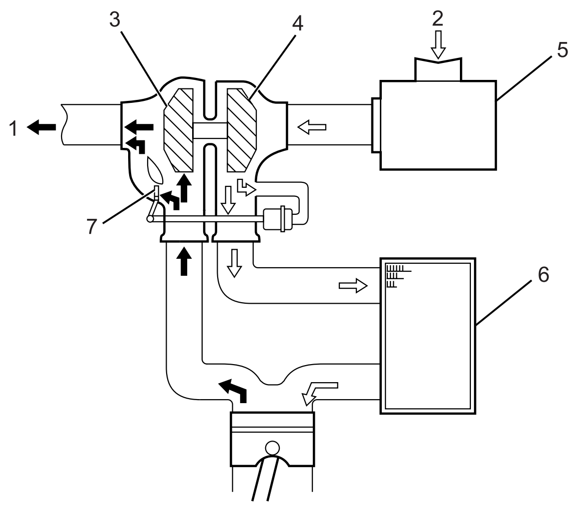
Glow Plug Controller Description (12,000lbs GVW)

The glow control system consists of the engine control module (ECM), the glow plug controller, glow plugs and the glow indicator lamp. The glow control system is operated when the engine coolant temperature is low, which allows for easier engine starting.

If the ignition switch is turned ON when the engine coolant temperature is low, the ECM illuminates the glow indicator lamp and turns ON the glow plugs via the glow plug controller. After a fixed time passes, the ECM turns OFF the glow indicator lamp and the glow plugs via the glow plug controller.

The glow plug controller has the ability to perform internal diagnostics for voltage and output state checks of the glow plugs. The glow plug controller will send an error message to the ECM via the controller area network (CAN) communication bus.

Turbocharger Description



Legend

1. Exhaust Gas
2. Clean Air
3. Turbine Wheel
4. Compressor Wheel
5. Air Cleaner
6. Charge Air Cooler (Intercooler)
7. Waste Gate Valve

The turbocharger is used to increase the amount of air that enters the engine cylinders. This allows a proportional increase of fuel to be injected into the cylinders, resulting in increased power output, more complete combustion of fuel, and increased cooling of the cylinder heads, pistons, valves, and exhaust gas. This cooling effect helps extend engine life.

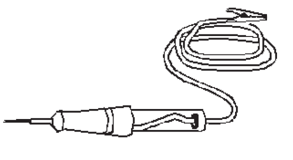
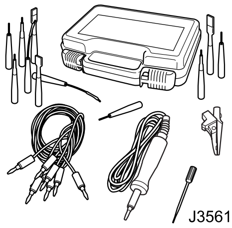
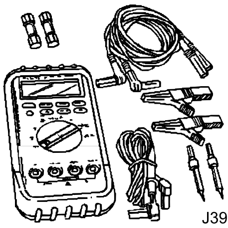
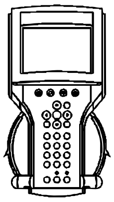
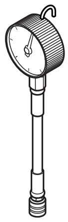
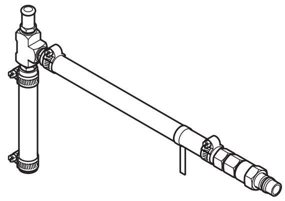
Heat energy and pressures in the engine exhaust gas are utilized to drive the turbine. Exhaust gas is directed to the turbine housing. The turbine housing acts as a nozzle to direct the shaft wheel assembly. Since the compressor wheel is attached directly to the shaft, the compressor wheel rotates at the same speed as the turbine wheel. Clean air from the air cleaner is drawn into the compressor housing and wheel. The air is compressed and delivered through a crossover pipe to the engine air intake manifold, then into the cylinders. The amount of air pressure rise and air volume delivered to the engine from the compressor outlet is regulated by a waste gate valve in the exhaust housing. The position of the waste gate valve is controlled by the amount of pressure built up on the intake side of the turbocharger. The diaphragm on the inside of the waste gate is pressure sensitive, and controls the position of the valve inside the turbocharger. The position of the valve will increase or decrease the amount of boost to the turbocharger.

The charge air cooler also helps the performance of the diesel. Intake air is drawn through the air cleaner and into the turbocharger compressor housing. Pressurized air from the turbocharger then flows forward through the charge air cooler located in the front of the radiator. From the charge air cooler, the air flows back into the intake manifold.

The charge air cooler is a heat exchanger that uses air flow to dissipate heat from the intake air. As the turbocharger increases air pressure, the air temperature increases. Lowering the intake air temperature increases the engine efficiency and power by packing more air molecules into the same space.

Special Tools and Equipment

Special Tools and Equipment

Illustration	Tool Number/ Description
 AAW0Z0SH013701	J-34142-B Test Lamp
 J35616-C	J-35616-C Connector Test Adapter Kit(with Test Lamp)
 J39200	J-39200 Digital Multimeter
 AAW0Z0SH015701	7000081 Tech2 Kit
 J44638	J-44638 Fuel Pressure/Vacuum Gauge Assembly
 EN47667	EN-47667 Suction Side Fuel Pressure/Vacuum Gauge Adapter

ENGINE

Exhaust System

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EGR System

Service Precautions

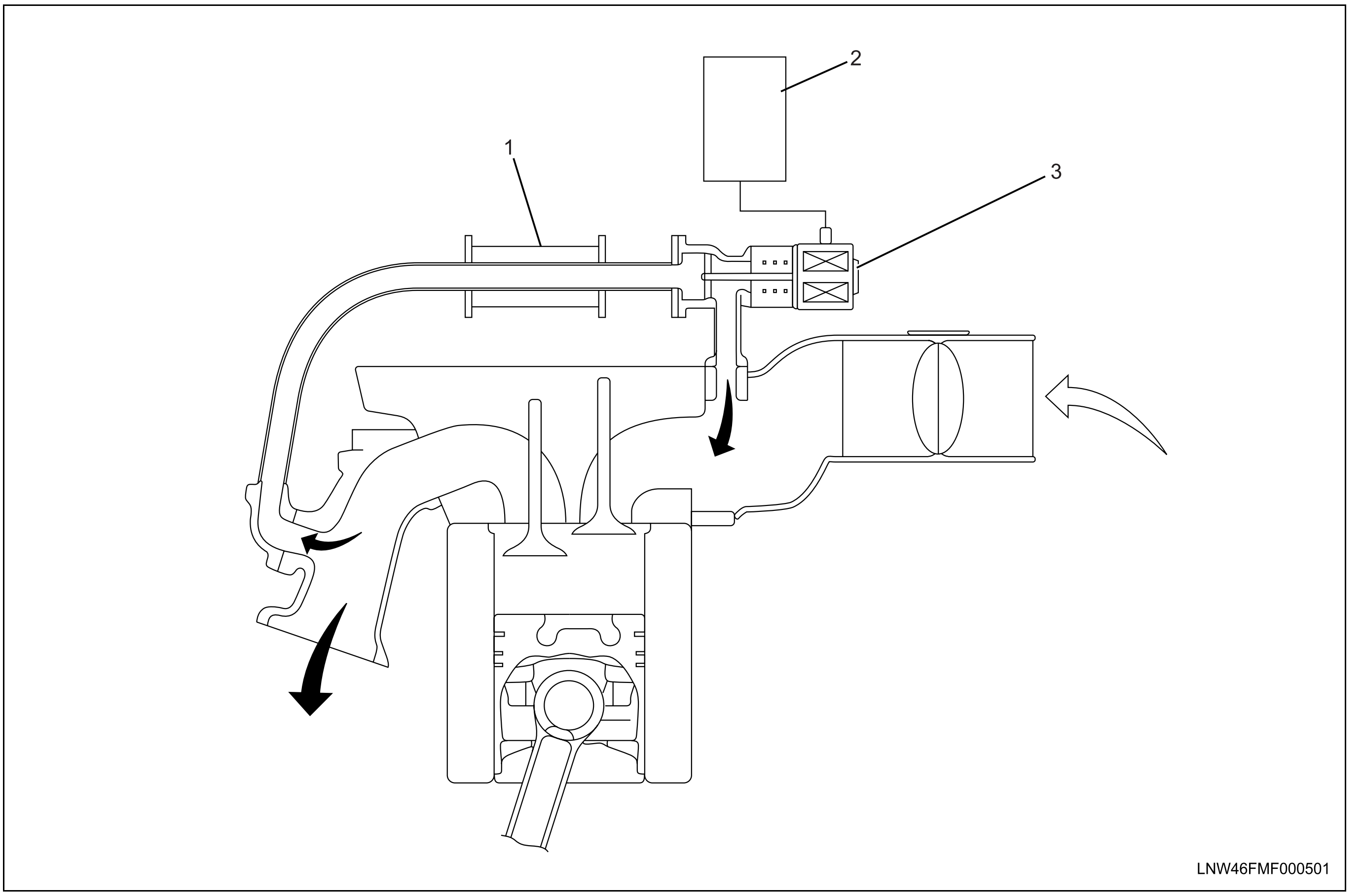
Perform EGR related assembly according to the usual procedure of temporarily fitting and then permanently tightening the parts so that unnecessary stresses are not applied on the parts.

Explanations on functions and operation

Re-circulate a part of the exhaust gas of the EGR system in the intake manifold. Reduce the combustion temperature and inhibit NOx generation since inert gases may be mixed up in the intake air.

An electronic control system is used in this EGR to balance the requirements of operability and low emissions. A DC motor is operated using the control current of the Engine Control Module (ECM) to control the EGR.

Refer to the chapter on Engine Control System for details on fault diagnosis of the EGR system.

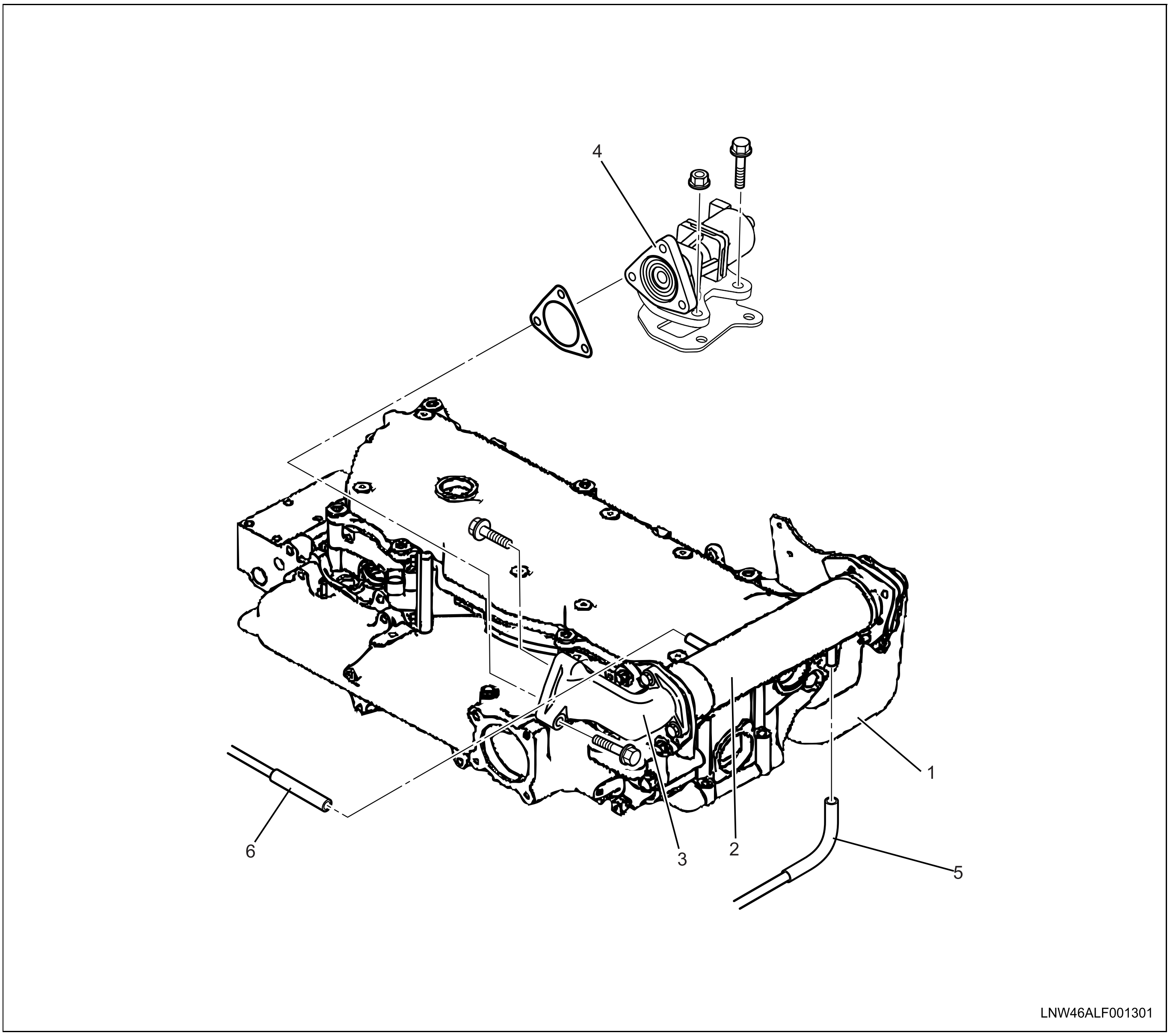


Legend

1. EGR Cooler
2. Engine Control Module (ECM)
3. EGR Valve DC Motor

EGR Valve and EGR Cooler

Components



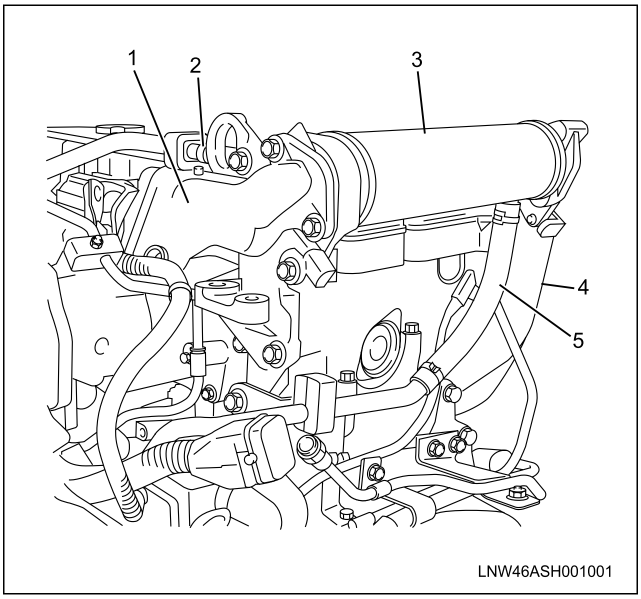
Legend

1. EGR Pipe
2. EGR Cooler
3. EGR Adapter
4. EGR Valve
5. Cooling Water Pipe (IN)
6. Cooling Water Pipe (OUT)

Removal

1. Drain cooling water.
2. Disconnect the EGR valve connector.

3. Remove the EGR pipe.



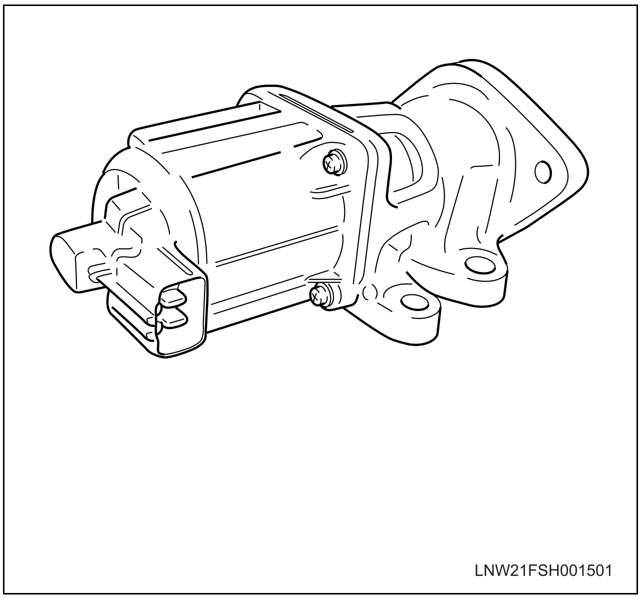
Legend

1. EGR Adapter
2. Cooling Water Pipe (out)
3. EGR Cooler
4. EGR Pipe
5. Cooling Water Pipe (in)

---

4. Remove the cooling water pipes.
5. Remove the EGR adapter.
6. Remove the EGR cooler.
7. Remove the EGR valve.

Caution:
After removing the EGR valve and EGR adapter, seal so that foreign matter does not enter.



Inspection

Gas leak check

- Check for gas leak in various parts of the EGR gas line.
  If the results of the check show abnormalities, repair or replace the defective parts.

EGR valve check

- Refer to the chapter on Engine Control System for details on the method of checking the EGR valve.

Installation

1. Mount the EGR valve.
   - Insert the gasket and temporarily fit the EGR valve.

Notice:
Temporarily tighten the bolts.

2. Install the EGR cooler.
   - Temporarily fit the EGR cooler to the bracket.

Notice:
Temporarily tighten the bolts.

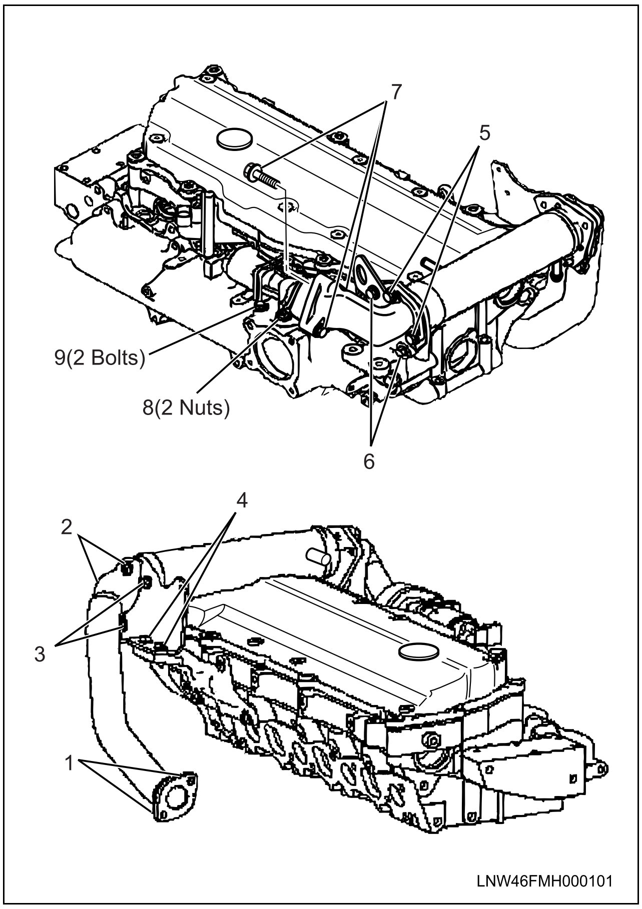
3. Install the EGR adapter.
   - Temporarily fit the EGR adapter between the EGR cooler and exhaust manifold.

Notice:
Temporarily tighten the bolts.

4. Install the EGR pipe.
   - Insert the gasket between the two ends of the EGR pipe and temporarily fit it.

Notice:
Temporarily tighten the bolts.

During temporary assembly, tighten the nuts and bolts to the specified torque in the order shown in the illustration.



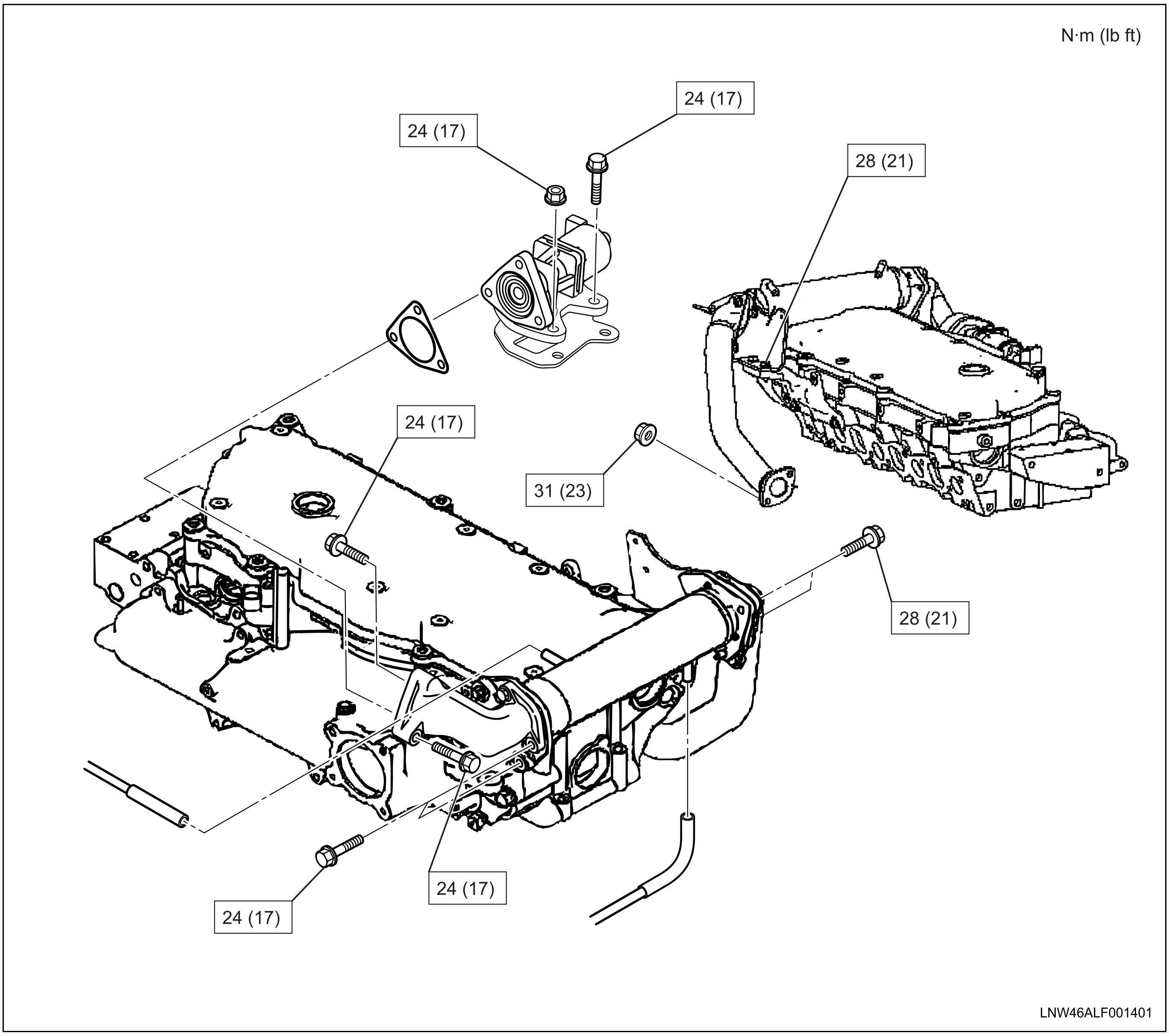
Legend

1 ~ 9	Show The Order of Tighten Bolts and Nuts.

Tightening torque

1:	31 N·m (23 lb ft)
2, 4 ALL:	28 N·m (21 lb ft)
3, 5, 6, 7, 8, 9 ALL:	24 N·m (17 lb ft)

Torque Specifications



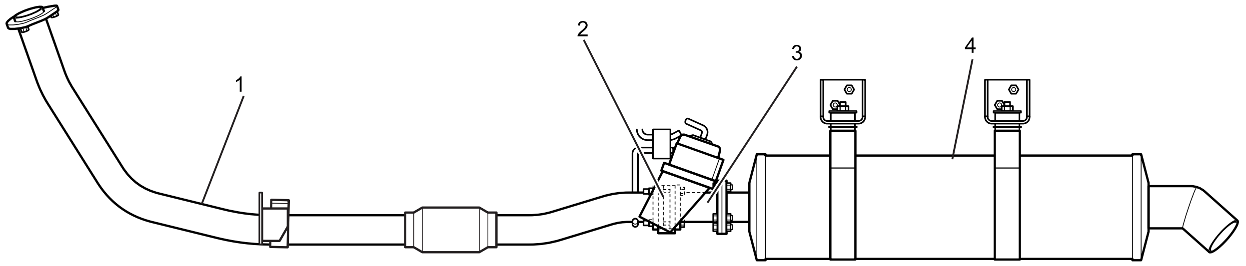
Exhaust System

Service Precautions

Offset in position of the exhaust system during assembly may sometimes cause vibrations or rattling noise. Therefore, temporarily tighten the bolts until all the parts have been positioned, and sequentially tighten from the engine side to the rear pipe side.

Explanations on functions and operation

The exhaust brake assembly operates the auxiliary brakes by adjusting the exhaust pressure. The silencer has a built-in catalytic converter and the catalyst is a ceramic monolith (honeycomb). This reduces the CO and HC in the exhaust gas. The tail pipe has a built-in post silencer. This improves the silencing effect.
The main parts consist of the front exhaust pipe, center exhaust pipe, exhaust brake unit, silencer with built-in catalyst, and tail pipe.



Legend

1. Front Exhaust Pipe A
2. Exhaust Brake Assembly
3. Front Exhaust Pipe B
4. Silencer (built-in catalyst)

Functional check

- During check or repairs of the exhaust system, confirm that the clearance between the body and the floor is adequate.
- Adequate care should be taken to prevent damage due to heating or vibrations in the body panel as it may lead to exhaust gas entering the cabin.
- Check for loose or damaged connectors and leakage of exhaust gas.
- Check for degradation, cracks or damage to the clamp or rubber.
- If the pipe or silencer is damaged or has a dent then repair or replace it.
- Check for dents, damage, holes or cracks due to corrosion, and abnormal noise during operation.
- If CO or HC value in the exhaust gas increases when measuring the exhaust gas (vehicle inspection, etc.), replace the silencer (built-in catalyst)

List of abnormal phenomena

- Vibration or rattling noise from the exhaust system

- Clogging of the exhaust system
- Exhaust leakage or noise

Trouble Shooting

Vibration or rattling noise from the exhaust system

Condition	Possible Cause	Correction
Vibration or rattling noise from the exhaust system	Loose or misaligned components	Match the joints and then re-tighten. Or, check for damage in the hanger, mounting brackets and clamps.

Clogging of the exhaust system

Condition	Possible Cause	Correction
Clogging of the exhaust system	The exhaust brake is in the ON status.	Refer to the Engine Control Systems in 6E section, check the electric system and repair if there are abnormalities. Check if the shaft movement in the exhaust brake throttle valve moves is jerky and replace if there is an abnormality.
	Clogging or deformation of the exhaust piping	Repair or replace the exhaust piping.

Exhaust leakage or noise

Condition	Possible Cause	Correction
Exhaust leakage or noise	Defect or misalignment in mounting	Match the joints and then re-tighten.
	Damage or burn-out of exhaust piping or silencer	Replace the damaged parts.
	Defective components in the exhaust system (clamps, pipes, silencer)	Replace the defective parts.
	Internal damage to silencer	Replace the silencer

Exhaust System Check

Description

The exhaust brake system consists the exhaust brake valve, exhaust brake magnetic valve, the exhaust brake switch, relays and ECM. The exhaust brake valve is opened or closed by the exhaust brake magnetic valve. If exhaust brake switch is turned ON and conditions of the vehicle are satisfied, the ECM turn ON the exhaust brake control relay and the exhaust brake magnetic valve. And then the vacuum is supplied to the exhaust brake valve, and it is closed.

Conditions of Exhaust Brake Operation

- The exhaust brake switch is ON.
- The vehicle speed is higher than 5MPH (8.0km/h): M/T
- The accelerator pedal is not pressed.
- The brake pedal is not pressed.
- The clutch pedal is not pressed.
- When the TCM is lock up, shift up and shift down control , Exhaust brake is OFF. Vehicle speed is higher than 30 MPH (48km/h) : A/T

Schematic Reference: Engine Controls Schematics

Step	Action	Value(s)	Yes	No
1	1. Turn OFF the ignition switch. 2. Install a scan tool. 3. Monitor the Diagnostic Trouble Code (DTC) Information of the engine control system with a scan tool. Is DTC P0500, P0571, P1125, P2122, P2123, P2127, P2128, P2132 or P2133, U2104, U2106 set?	—	Go to applicable DTC	Go to Step 2
2	1. Turn OFF the ignition switch. 2. Inspect the exhaust brake (10A) fuse that the supplies to the exhaust brake relay, exhaust brake cut relay, brake solenoid valve and intake throttle solenoid valve. 3. If fuse is open that replace the fuse. Did you complete the action?	—	Go to Step 3	—
3	1. Operate the vehicle within the vehicle speed is higher than 30MPH (48km/h). 2. Turn ON the exhaust brake switch. 3. Remove your foot from the accelerator pedal. (Do not press the brake pedal and clutch pedal) Is the exhaust brake operated?	—	System OK	Go to Step 4
4	1. Turn OFF the ignition switch. 2. Install a scan tool. 3. Exhaust brake switch is ON. 4. Observe the exhaust brake switch parameter with a scan tool. Is the exhaust brake switch parameter ON?	—	Go to Step 7	Go to Step 5

Step	Action	Value(s)	Yes	No
5	1. Test the exhaust brake switch circuit for the following condition: • An open circuit • A short to ground circuit 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 3	Go to Step 6
6	Replace the exhaust brake switch. Did you complete the replacement?	—	Go to Step 3	—
7	1. Turn OFF the ignition switch. 2. Remove the exhaust brake control relay and exhaust brake cut relay. 3. Test the exhaust brake control relay and exhaust brake cut relay. 4. Replace the relay(s) as necessary. Did you complete the action?	—	Go to Step 8	—
8	1. Inspect the vacuum hose fitted the exhaust brake magnetic valve for a restriction, holes, or leaks. 2. Repair or replace the vacuum hose as necessary. Did you complete the action?	—	Go to Step 9	—
9	1. Turn OFF the ignition switch. 2. Disconnect the exhaust brake magnetic valve. 3. Measure the resistance for the exhaust brake magnetic valve. Is the resistance measure within the specified range?	37-44Ω	Go to Step 11	Go to Step 10
10	Replace the exhaust brake magnetic valve. Did you complete the replacement?	—	Go to Step 11	—
11	1. Remove the exhaust brake assembly. 2. Connect the J 23738-A vacuum pump. 3. Apply the vacuum (400 - 700mmHg {53.3 - 93.3kPa}) to the power chamber. Is the exhaust valve closed?	—	Go to Step 13	Go to Step 12
12	Replace the exhaust brake assembly. Did you complete the replacement?	—	Go to Step 13	—

Step	Action	Value(s)	Yes	No
13	Inspect the exhaust brake magnetic valve operation. 1. Restores the vehicle. 2. Connect the scan tool. 3. Turn ON the ignition. 4. Clear the DTC. 5. Perform the exhaust brake relay test. 6. Check the exhaust brake magnetic valve operation. Was a problem found?	—	Go to Step 14	System OK
14	1. Turn OFF the ignition switch. 2. Disconnect electronic hydraulic control unit (EHCU) . 3. Disconnect exhaust brake control relay. 4. Disconnect transmission control module (TCM). 5. Turn ON the ignition with the engine OFF. 6. Measure the voltage from the exhaust brake power supply circuit in the EHCU harness connector to a known good ground. 7. Measure the voltage from the exhaust brake power supply circuit in the exhaust brake control relay connector to a known good ground. 8. Measure the voltage from the exhaust brake power supply circuit in the TCM connector to a known good ground. 9. Repair the circuit(s) as necessary. Did you complete the action?	—	Go to Step 15	—
15	1. Turn OFF the ignition switch. 2. Disconnect the engine control module (ECM). 3. Disconnect exhaust breke cut relay . 4. Test the exhaust brake control relay circuit (between ECM and exhaust brake control relay, between exhaust breke cut relay and exhaust brake contorl relay, between exhaust brake control relay and ground) for the following condition: • An open circuit • A short to ground circuit • A short to power supply circuit 5. Repair the circuit(s) as necessary. Did you complete the action?	—	Go to Step 16	—

Step	Action	Value(s)	Yes	No
16	1. Turn OFF the ignition switch. 2. Test the exhaust brake magnetic valve circuit (between exhaust brake magnetic valve and exhaust brake control relay, exhaust brake magnetic valve and ground) for the following condition: • An open circuit • A short to ground circuit • A short to power supply circuit 3. Repair the circuit(s) as necessary. Did you complete the action?	—	Go to Step 17	—
17	Inspect the exhaust brake magnetic valve operation. 1. Restores the vehicle. 2. Connect the scan tool. 3. Turn ON the ignition. 4. Clear the DTC. 5. Perform the exhaust brake relay test. 6. Check the exhaust brake magnetic valve operation. Was a problem found?	—	Go to Step 18	System OK
18	1. Turn OFF the ignition switch. 2. Disconnect electronic hydraulic control unit (EHCU) . 3. Turn ON the ignition. 4. Clear the DTC. 5. Perform the exhaust brake relay test. 6. Check the exhaust brake magnetic valve operation. Was a problem found?	—	Go to Step 20	Go to Step 19
19	Repair or replace the electronic hydraulic control unit (EHCU). Did you complete the replacement?	—	Go to Step 20	—
20	1. Turn OFF the ignition switch. 2. Install a scan tool. 3. Monitor the Diagnostic Trouble Code (DTC) Information of the transmission control system with a scan tool. Is DTC P0475, U2100 set?	—	Go to applicable DTC	Go to Step 21

Step	Action	Value(s)	Yes	No
21	Inspect the exhaust brake magnetic valve operation. 1. Restores the vehicle. 2. Disconnect transmission control unit (TCM) . 3. Connect the scan tool. 4. Turn ON the ignition. 5. Clear the DTC. 6. Perform the exhaust brake relay test. 7. Check the exhaust brake magnetic valve operation. Was a problem found?	—	Go to Step 22	Go to Step 23
22	**Important**: Replacement ECM must be programmed. Replace the ECM. Refer to “Engine Control Module (ECM) Replacement” in the engine control system section. Did you complete the replacement?	—	Go to Step 24	—
23	Replace the TCM. **Notice:** The TCM does not require any programming or reprogramming. Did you complete the replacement?	—	Go to Step 24	—
24	1. Restores the vehicle. 2. Operate the vehicle within the vehicle speed is highe than 30MPH (48km/h). 3. Turn ON the exhaust brake switch. 4. Remove your foot from the accelerator pedal. (Do not press the brake pedal and clutch pedal) Is the exhaust brake operated?	—	System OK	Go to Step 2

Exhaust Pipe

Removal

1. Remove the silencer fixing nut.
2. Remove the silencer brackets.
3. Remove the silencer.
4. Remove the front exhaust pipe B.
5. Remove the exhaust brake assembly.
6. Remove the front exhaust pipe A.
    - Remove the clamps and then the front exhaust pipe.

Inspection

- Adequate care should be taken to prevent damage due to heating or vibrations in the body panel as it may lead to exhaust gas entering the cabin.
- Check for loose or damaged connectors and leakage of exhaust gas.
- Check for degradation, cracks or damage to the clamp or rubber.
- Check for dents in the pipes or silencer and also for cracks due to corrosion, and repair or replace in case of damage.

Installation

Caution:

- Offset in the position of the exhaust system during assembly may sometimes cause vibrations or rattling noise. Therefore, temporarily tighten the bolts until all the parts have been positioned and then tighten sequentially from engine side to the tail pipe side.
- Do not reuse the removed gasket or nuts.

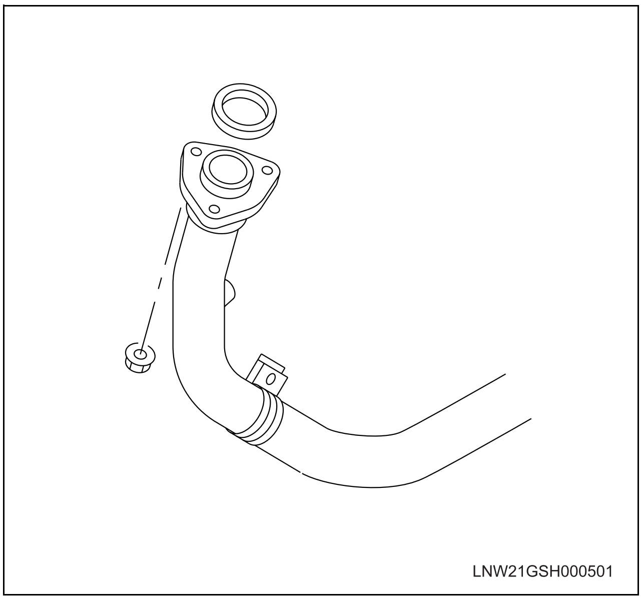
1. Mount the front exhaust pipe A.
    - Assemble the gasket, mount the front exhaust pipe in the turbo charger, and tighten to the specified torque.

Tightening torque: 67 N·m (49 lb ft)

- Clamp the front exhaust pipe.

Tightening torque: M10 = 41 N·m (30 lb ft)

Caution:
Tighten the front exhaust pipe evenly and take care to avoid gas leakage.

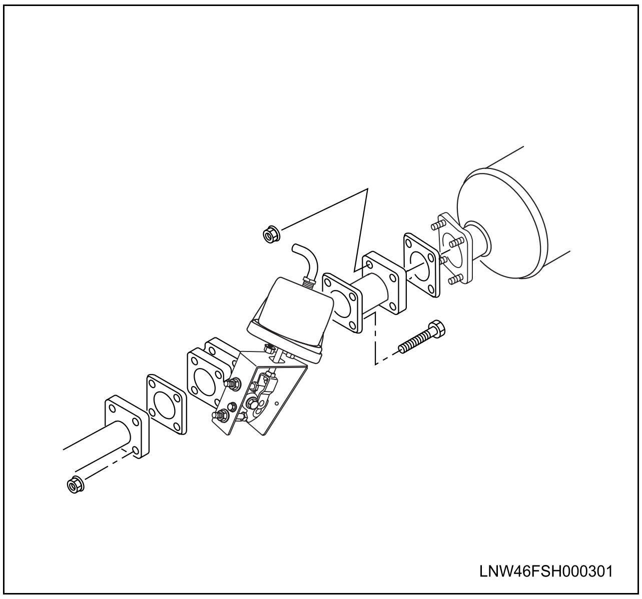


2. Mount the exhaust brake assembly.
    - Assemble the gasket, connect the front exhaust pipe and the front exhaust pipe B, and tighten.

Tightening torque: 17 N·m (12 lb ft)

3. Mount the silencer.
    - Assemble the gasket, mount to the front exhaust pipe B, and tighten to the specified torque.

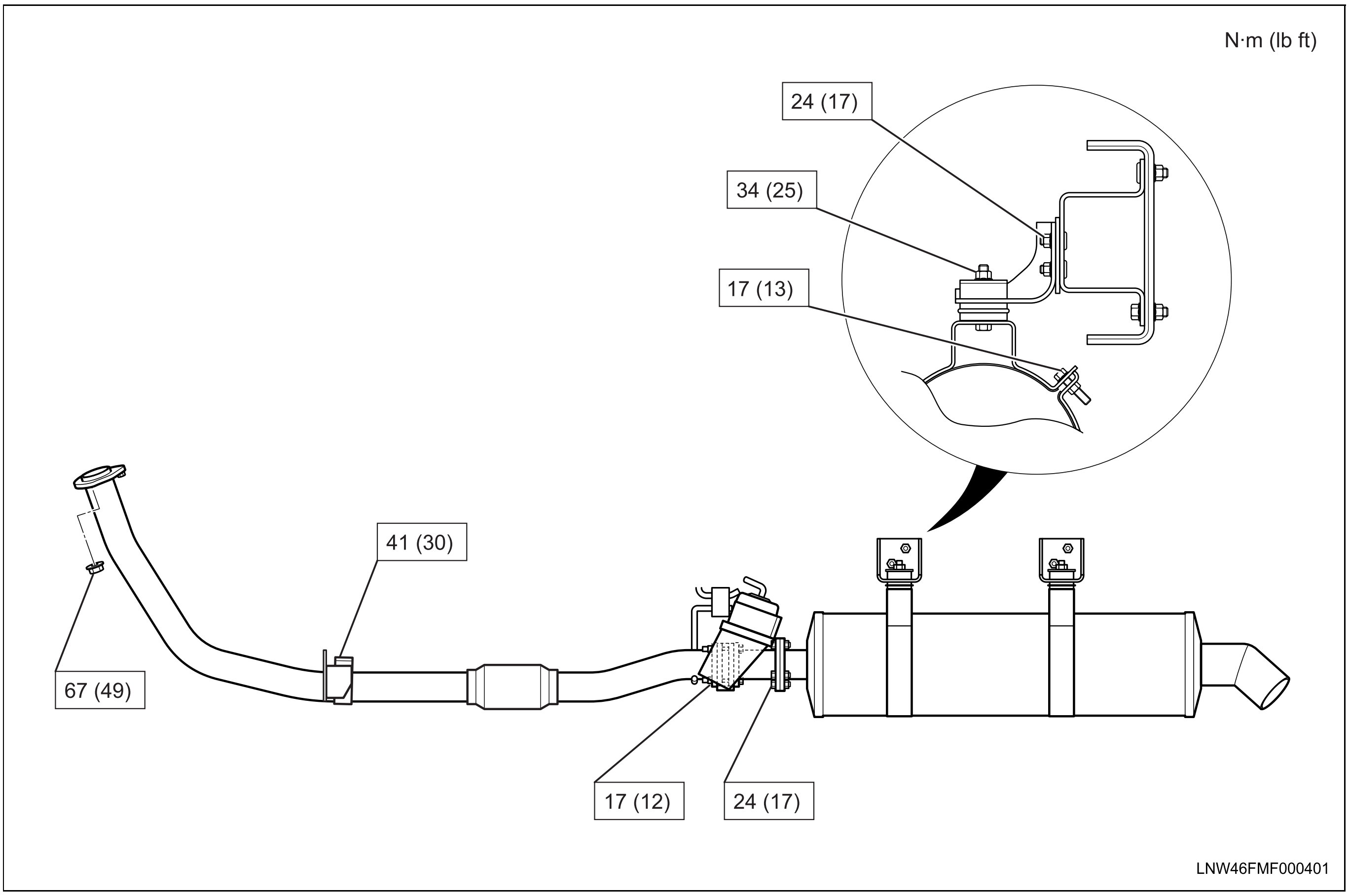
Tightening torque: 24 N·m (17 lb ft)



4. Mount the silencer brackets.
    - Mount the silencer in the brackets.

Tightening torque: 34 N·m (25 lb ft)

Torque Specifications

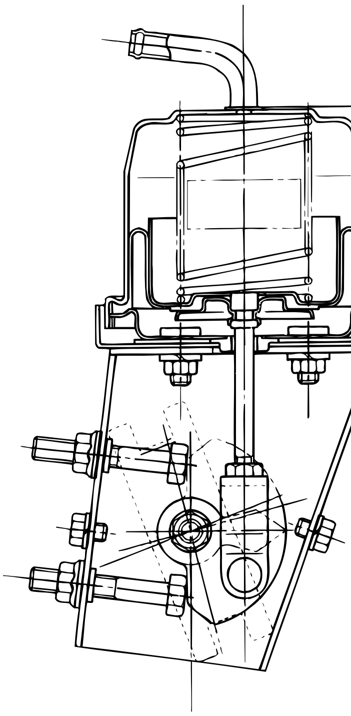


Exhaust Brake System

Service Precautions

During assembly and mounting, mount the parts appropriately at the specified tightening torque value.

Explanations on functions and operation



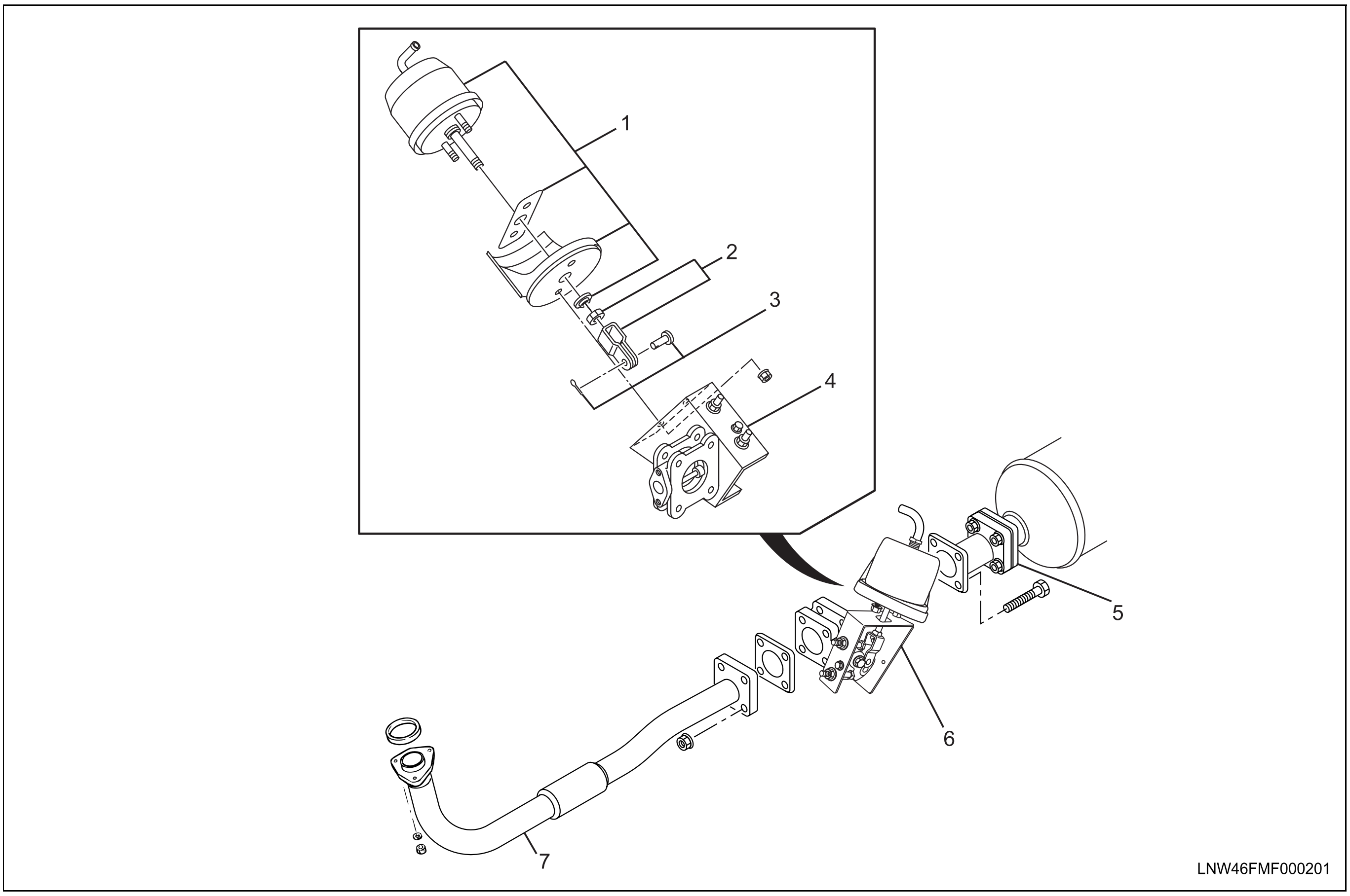
Functional check

Operational check

- Confirm the sound of the valve touching the stopper when the exhaust brake is operated in the idling condition.

Exhaust Brake

Components



Legend

1. Power Chamber, Insulator, Gasket and Bearing
2. Lock Nuts and Clevis Joint
3. Split Pin and Washer
4. Exhaust Brake Valve
5. Front Exhaust Pipe B
6. Exhaust Brake Assembly
7. Front Exhaust Pipe A

Removal

1. Remove the vacuum hose and clips.
2. Remove the nut.
3. Remove the exhaust pipe.
4. Remove the exhaust brake assembly.

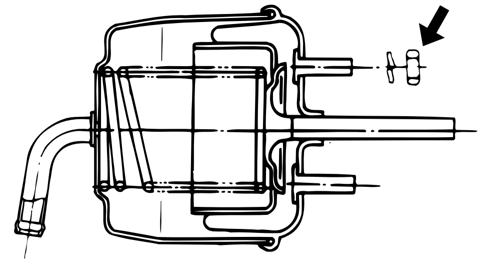
Disassembly

1. Remove the split pin.
2. Remove the lock nuts.
3. Remove the clevis joint.
4. Remove the power chamber.

Reassembly

1. Mount the power chamber.

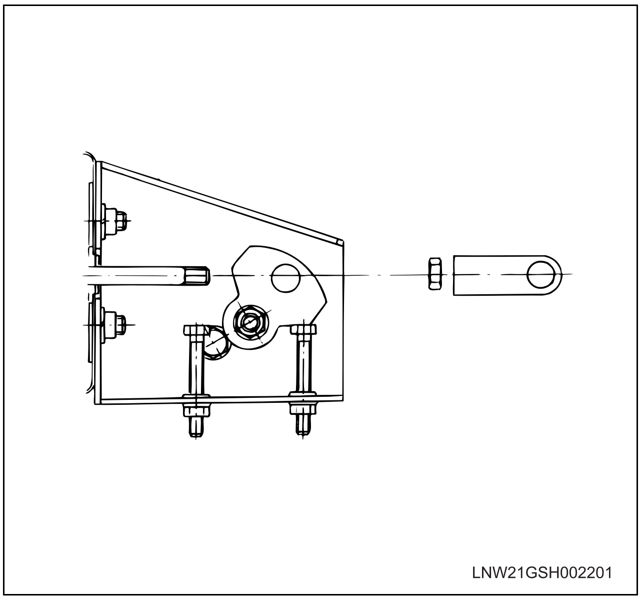
Tightening torque : 14 N·m (10 lb ft)



2. Mount the lock nuts.

3. After mounting the clevis joint, tighten the lock nuts to the specified torque.

Tightening torque: 13 N·m (9 lb ft)



4. Mount the split pin.

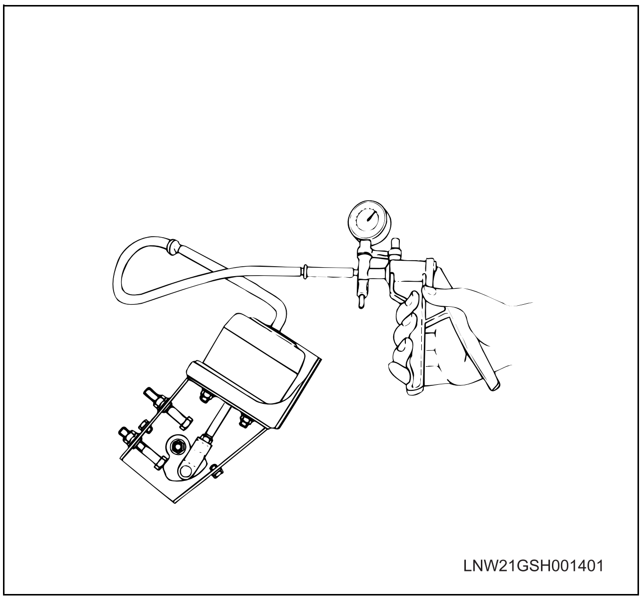
Inspection

Check for damage or degradation in the parts mentioned below.

- Exhaust brake valve
- Exhaust brake shaft
- Butterfly valve
- Bush
- Power chamber

Unit check

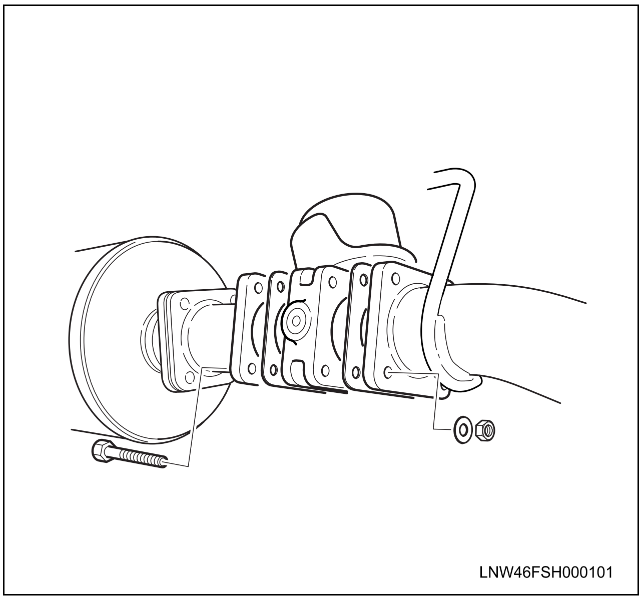
- Negative pressure in the power chamber caused by the vacuum pump
  When a pressure of 53.3 to 93.3 kPa (400 to 700 mmHg) is applied, the exhaust brake valve should open or close smoothly.



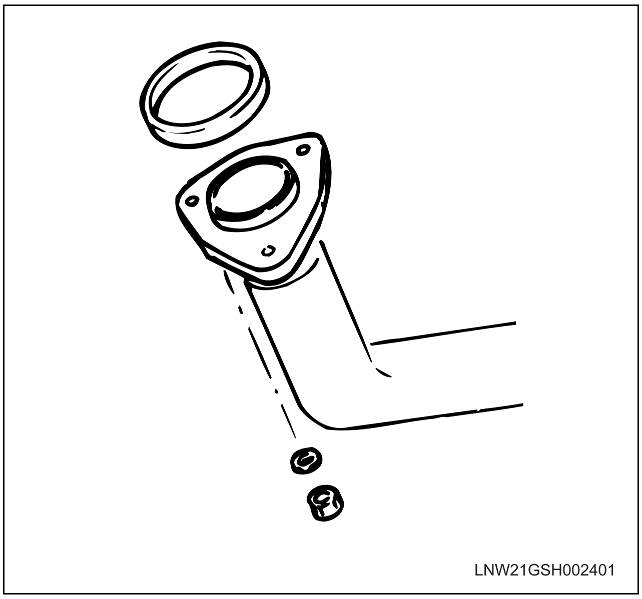
Installation

1. Mount the exhaust brake assembly.

Tightening torque: 17 N·m (12 lb ft)



2. Mount the exhaust pipe.

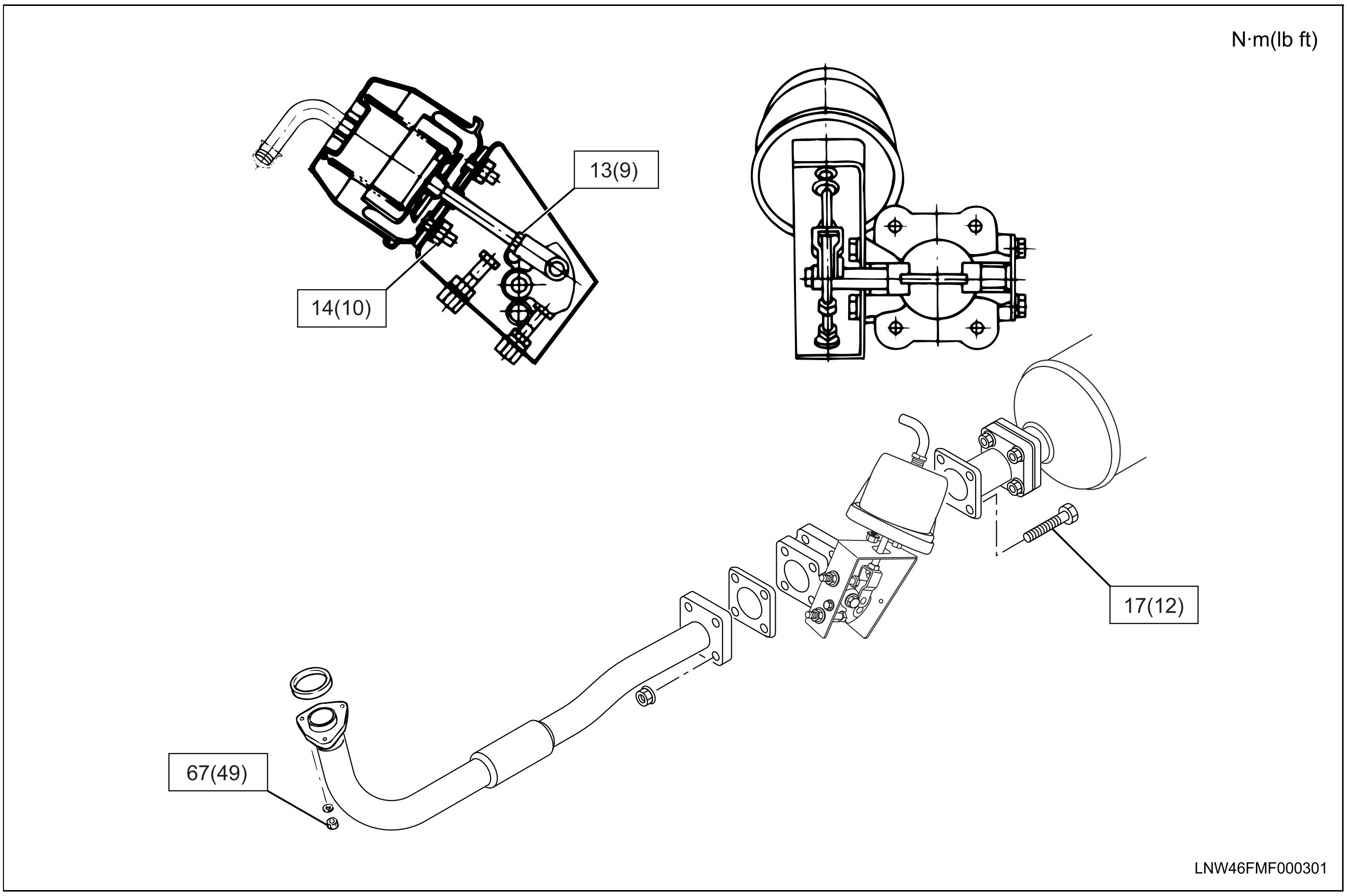


3. Mount the nuts.

Tightening torque : 67 N·m (49 lb ft)

4. Mount the vacuum hose and the clips.

Torque Specifications



TRANSMISSION/TRANSAXLE

Automatic Transmission 450-43LE

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Specifications

Component Item Diameter, Clearance, Thickness and Piston Stroke

Application				Specification	
				Metric	English
Oil Pump	Pump body bushing inside diameter		STD	42.050 to 42.075 mm	1.6555 to 1.6565 in.
			Limit	42.13 mm	1.6587 in.
	Pump cover bushing inside diameter	Front	STD	24.000 to 24.021 mm	0.9449 to 0.9457 in.
			Limit	24.070 mm	1.9476 in.
		Rear	STD	26.500 to 26.521 mm	1.0433 to 1.0441 in.
			Limit	26.57 mm	1.0461 in.
Overdrive (OD) Planetary Gear and Direct Clutch	OD input shaft thrust clearance (OD planetary gear)		STD	0.40 to 0.90 mm	0.0157 to 0.0354 in.
			Limit	0.90 mm	0.0345 in.
	OD input shaft thrust bearing race thickness			0.8 mm	0.031 in.
				1.0 mm	0.039 in.
				1.4 mm	0.055 in.
	OD direct clutch flange thickness			4.6 mm	0.181 in.
				4.77 mm	0.188 in.
				4.94 mm	0.194 in.
				5.11 mm	0.201 in.
	Piston stroke			1.80 to 2.00 mm	0.0709 to 0.0787 in.
	OD direct clutch drum bushing inside diameter		STD	26.500 to 26.521 mm	1.0433 to 1.0441 in.
			Limit	26.57 mm	1.0461 in.
	OD planetary gear bushing inside diameter		STD	12.000 to 12.018 mm	0.4724 to 0.4731 in.
			Limit	12.07 mm	0.4752 in.
	Planetary piston gear thrust clearance		STD	0.20 to 0.59 mm	0.0079 to 0.0232 in.
			Limit	0.80 mm	0.315 in.
OD Brake	Piston stroke			1.25 to 1.85 mm	0.0492 to 0.0728 in.
	OD case bushing inside diameter		STD	33.100 to 33.150 mm	1.3031 to 1.305 in.
			Limit	32.20 mm	1.3071 in.

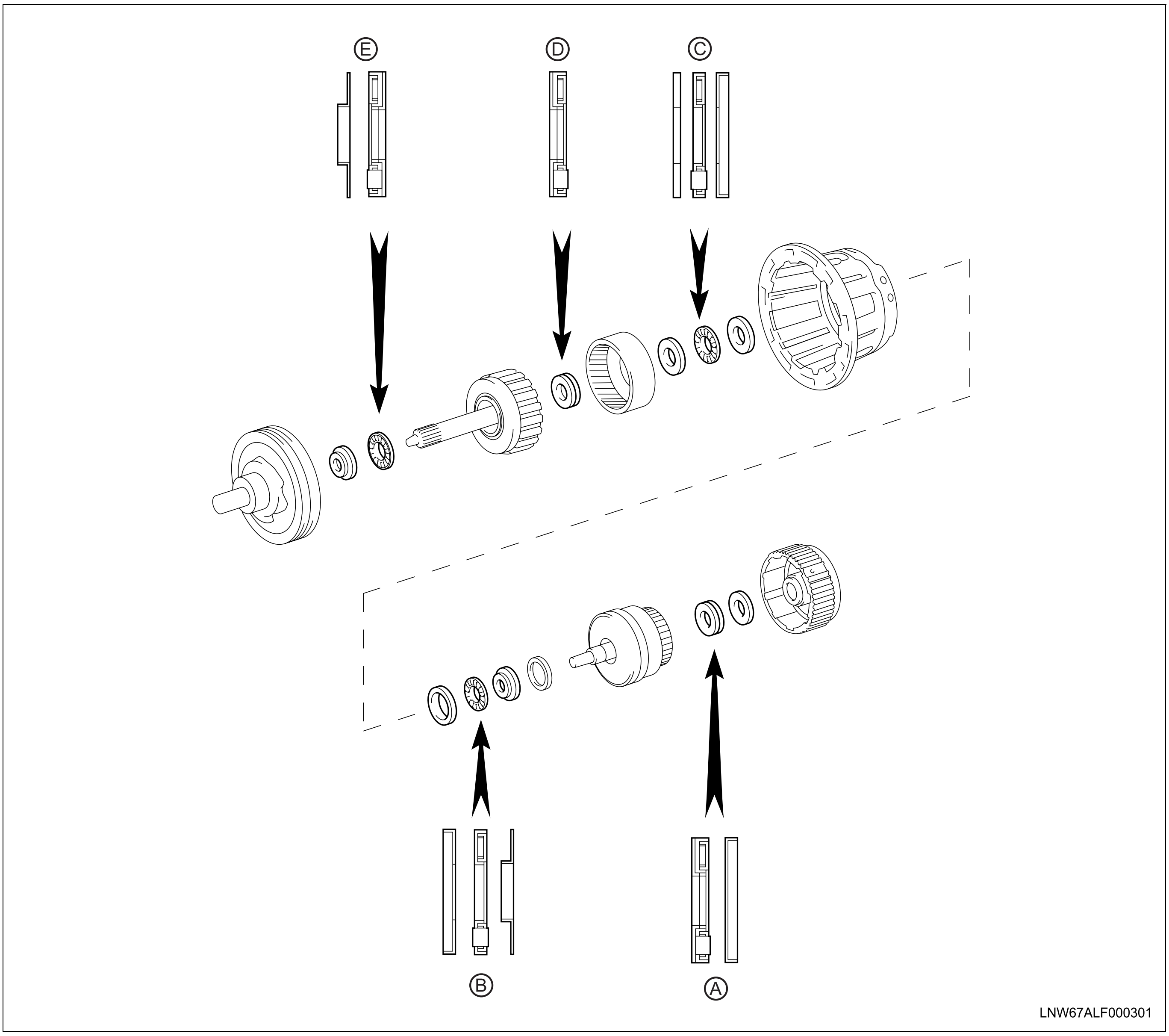
Application			Specification	
			Metric	English
Front Clutch	Input shaft thrust clearance (forward clutch hub)	STD	0.30 to 0.70 mm	0.0118 to 0.0276 in.
		Limit	0.70 mm	0.0276 in.
	Input shaft spacer thickness		0.9 mm	0.035 in.
			1.2 mm	0.047 in.
			1.5 mm	0.059 in.
			1.8 mm	0.071 in.
			2.1 mm	0.083 in.
	Piston stroke		3.93 to 4.23 mm	0.1547 to 0.1665 in.
	Front clutch plate thickness		1.8 mm	0.071 in.
			2.0 mm	0.079 in.
			2.2 mm	0.084 in.
			2.4 mm	0.094 in.
Rear Clutch	Piston stroke		2.00 to 2.20 mm	0.0790 to 0.0866 in.
	Rear clutch flange thickness		4.6 mm	0.181 in.
			4.8 mm	0.189 in.
			5.0 mm	0.197 in.
			5.2 mm	0.205 in.
Second Brake	Center support thrust clearance	STD	0.30 to 0.70 mm	0.0118 to 0.0276 in.
		Limit	0.90 mm	0.0345 in.
	Center support thrust washer thickness		1.5 mm	0.059 in.
			1.8 mm	0.071 in.
			2.1 mm	0.083 in.
			2.4 mm	0.094 in.
			2.7 mm	0.106 in.
	Piston stroke		1.86 to 2.06 mm	0.0732 to 0.0811 in.
	Center support bushing inside diameter	STD	35.000 to 35.025 mm	1.3780 to 1.3789 in.
		Limit	35.08 mm	1.3811 in.
	Front planetary sun gear bushing inside diameter	STD	25.500 to 25.521 mm	1.0039 to 1.0048 in.
		Limit	25.57 mm	1.0067 in.
	Second brake flange thickness		5.0 mm	0.197 in.
			5.2 mm	0.205 in.
			5.4 mm	0.213 in.
			5.6 mm	0.220 in.
Planetary Gears, One-way Clutch and Output Shaft	Output shaft bushing inside diameter	STD	17.000 to 17.021 mm	0.6693 to 0.6701 in.
		Limit	17.07 mm	0.6720 in.
	Planetary pinion gear thrust clearance	STD	0.20 to 0.59 mm	0.0079 to 0.0232 in.
		Limit	0.75 mm	0.0295 in.

Application			Specification	
			Metric	English
First and Reverse Brake	Piston stroke		3.3 to 3.8 mm	0.130 to 0.150 in.
	First and reverse brake flange thickness		6.65 mm	0.2618 in.
			7.05 mm	0.2776 in.
			7.45 mm	0.2933 in.
Parking Lock Pawl	Parking lock pawl bracket distance		49.76 to 49.86 mm	1.959 to 1.963 in.
Upper Valve Body	Check ball diameter		6.4 mm	0.252 in.
Lower Valve Body	Check ball diameter		8.7 mm	0.343 in.
	Check ball spring	Free length	14.0 mm	0.551 in.
		Outer diameter	9.8 mm	0.386 in.
	Pressure relief valve spring	Free length	24.0 mm	0.945 in.
		Outer diameter	8.2 mm	0.323 in.

Automatic Transmission Fluid (ATF) Temperature Sensor Specifications

Temperature	Temperature	Resistance
°C	°F	Ω
-30	-22	29613
-20	-4.4	16704
-10	14	9842
0	32	6028
10	50	3822
20	68	2500
30	86	1681
40	104	1160
50	122	819
60	140	590
70	158	433
80	176	324
90	194	246
100	212	190
110	230	148
120	248	117
130	266	94
140	284	76
150	302	62

Bearings and Races Diameter



Mark	Thrust Bearing Diameter Inside/ Outside mm (in.)	Front Race Diameter Inside/ Outside mm (in.)	Rear Race Diameter Inside/ Outside mm (in.)
A	32.8 / 52.0 (1.291 / 2.047)	—	37.0 / 52.0 (1.457 / 2.047)
B	34.7 / 52.0 (1.366 / 2.047)	37.0 / 52.0 (1.457 / 2.047)	32.8 / 50.4 (1.291 / 1.984)
C	34.7 / 58.4 (1.366 / 2.299)	34.6 / 58.2 (1.362 / 2.291)	37.0 / 60.5 (1.457 / 2.382)
D	23.2 / 42.0 (0.913 / 1.654)	—	—
E	28.5 / 48.0 (1.122 / 1.819)	27.1 / 43.0 (1.067 / 1.693) 27.9 / 43.0 (1.098 / 1.693) 28.3 / 43.0 (1.114 / 1.693)	—

Pistons and Springs Specifications

Mark	Piston diameter mm (in.)	Spring Free length / Outer Diameter mm (in.)	Spring Color mm (in.)
B_0	35.9 (1.413)	67.9 / 21.1 (2.673 / 0.831)	White
B_1	43.9 (1.728)	66.0 / 25.1 (2.598 / 0.988) 30.4 / 11.0 (1.197 / 0.433)	Yellow Yellow
C_1	34.4 (1.354)	93.3 / 17.7 (3.673 / 0.697)	Red
C_2	39.9 (1.571)	81.8 / 22.4 (3.220 / 0.882)	Beige

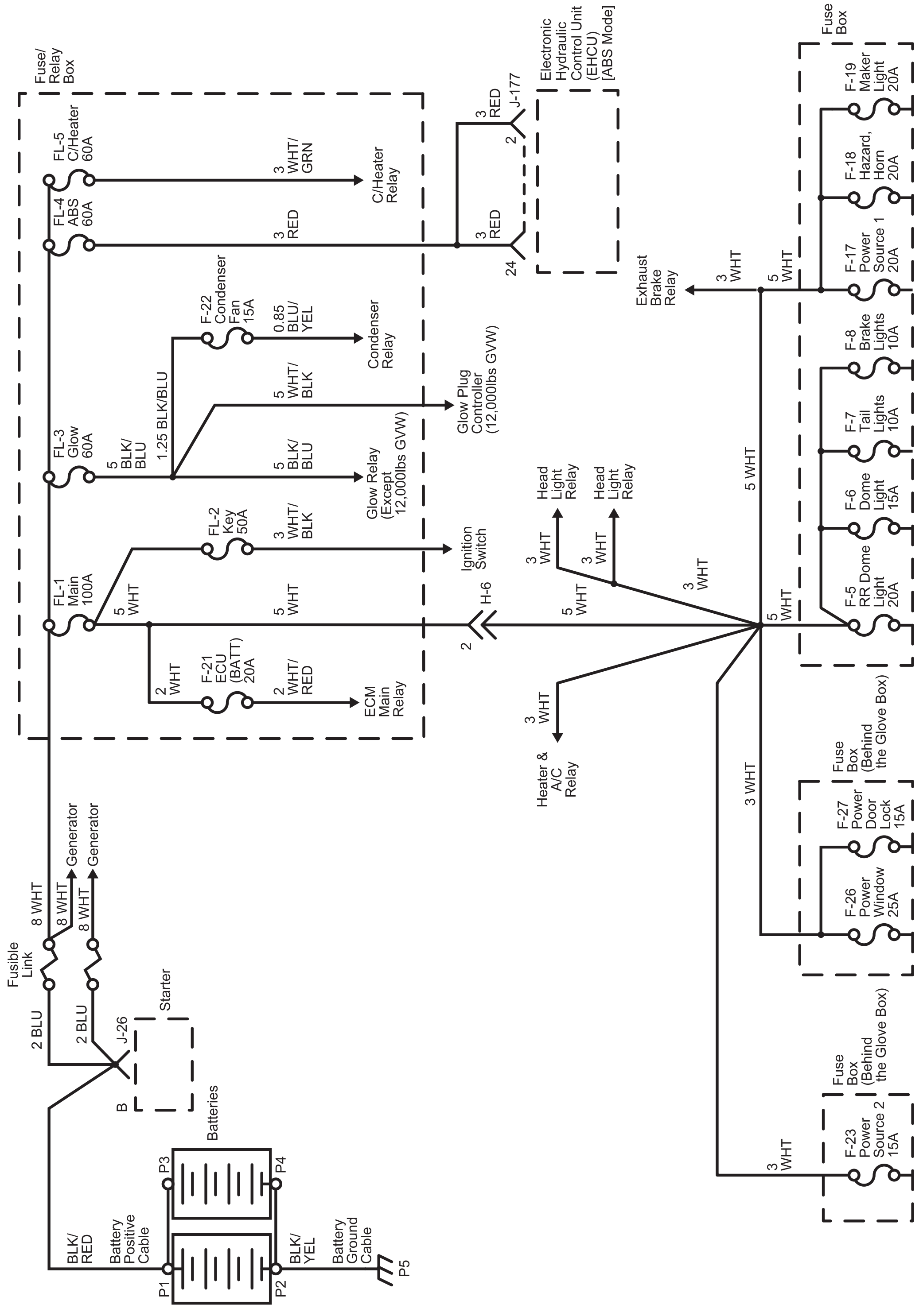
Fastener Torques

Part tightened	N·m	lb ft (lb in)	kg·m (kg·cm)
Oil pump cover – Oil pump body	21	15	2.1
Upper valve body – Lower valve body	5.5	4	55
Manual detent spring – Lower valve body	5.5	(47)	(55)
Parking lock pawl bracket – Extension housing	19	14	1.9
C1 accumulator cover – Transmission case	8	(69)	(80)
Transmission case – Extension housing	37	27	3.8
Center support set bolt	25	18	2.5
Oil pan – Transmission case	7	(61)	(70)
Transmission case – Transmission housing	64	47	6.5
ATF temperature sensor – Transmission case	25	18	2.5
Oil cooler union – Transmission case	29	22	3
Inhibitor switch – Transmission case	12.5	(78)	(130)
Inhibitor switch – Manual valve shaft	7	(61)	(70)
Control shaft – Transmission case	12.5	(78)	(130)
Oil pump – Transmission case	25	18	2.5
Valve body – Transmission case	10	(87)	1
Solenoid valve – Valve body	10	(87)	1
Oil strainer – Valve body	10	(87)	1
Drain plug – Oil pan	27	20	2.8
Speedometer sleeve lock plate – Transmission case	12.5	(78)	(130)
Speed sensor – Transmission case	8	(69)	(80)
Solenoid wire – Transmission case	8	(69)	(80)
PTO cover – Transmission case	15	11	1.5

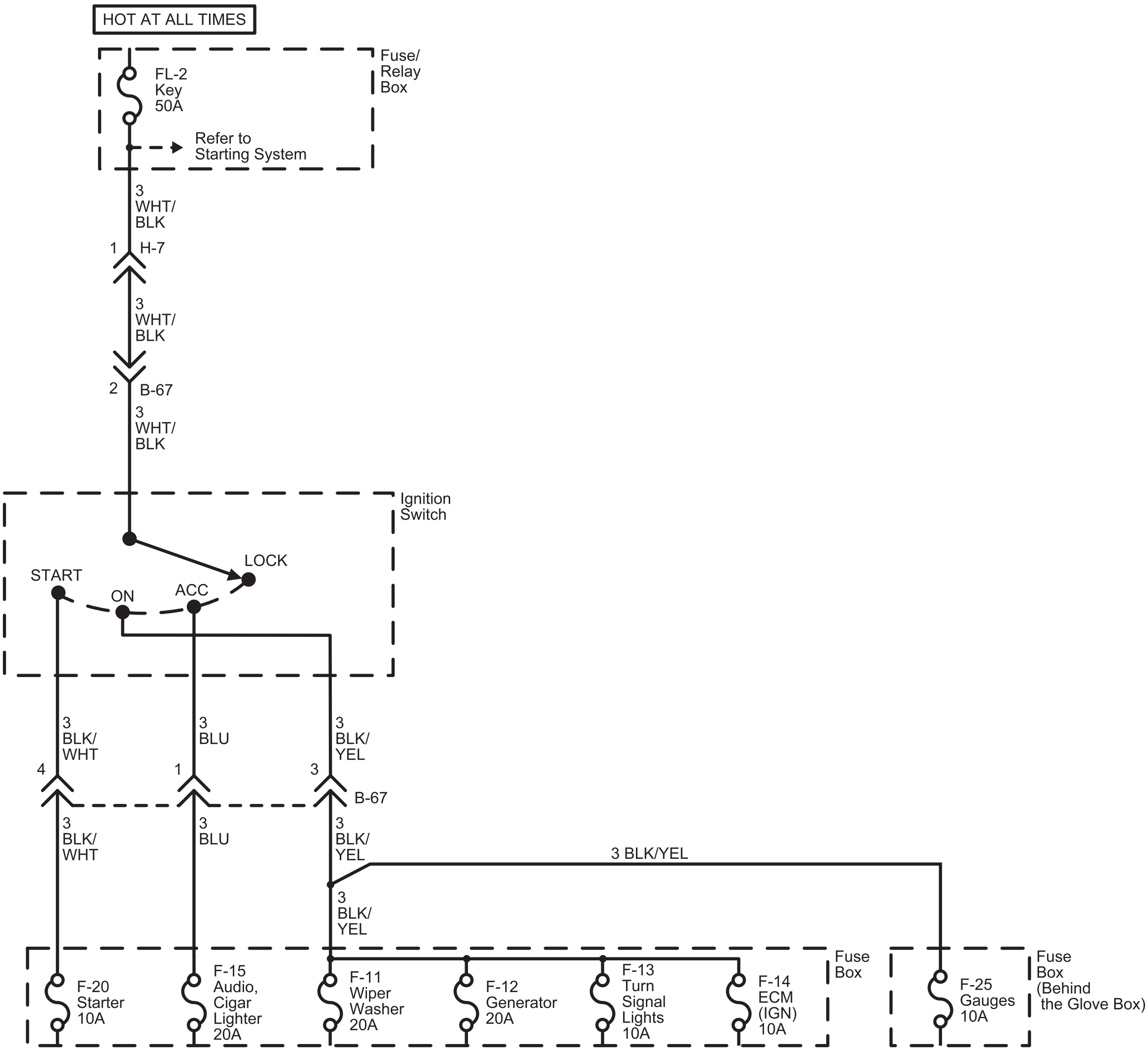
Schematic and Routing Diagrams

Transmission Controls Schematics

Power Distribution (Hot AT ALL Times)

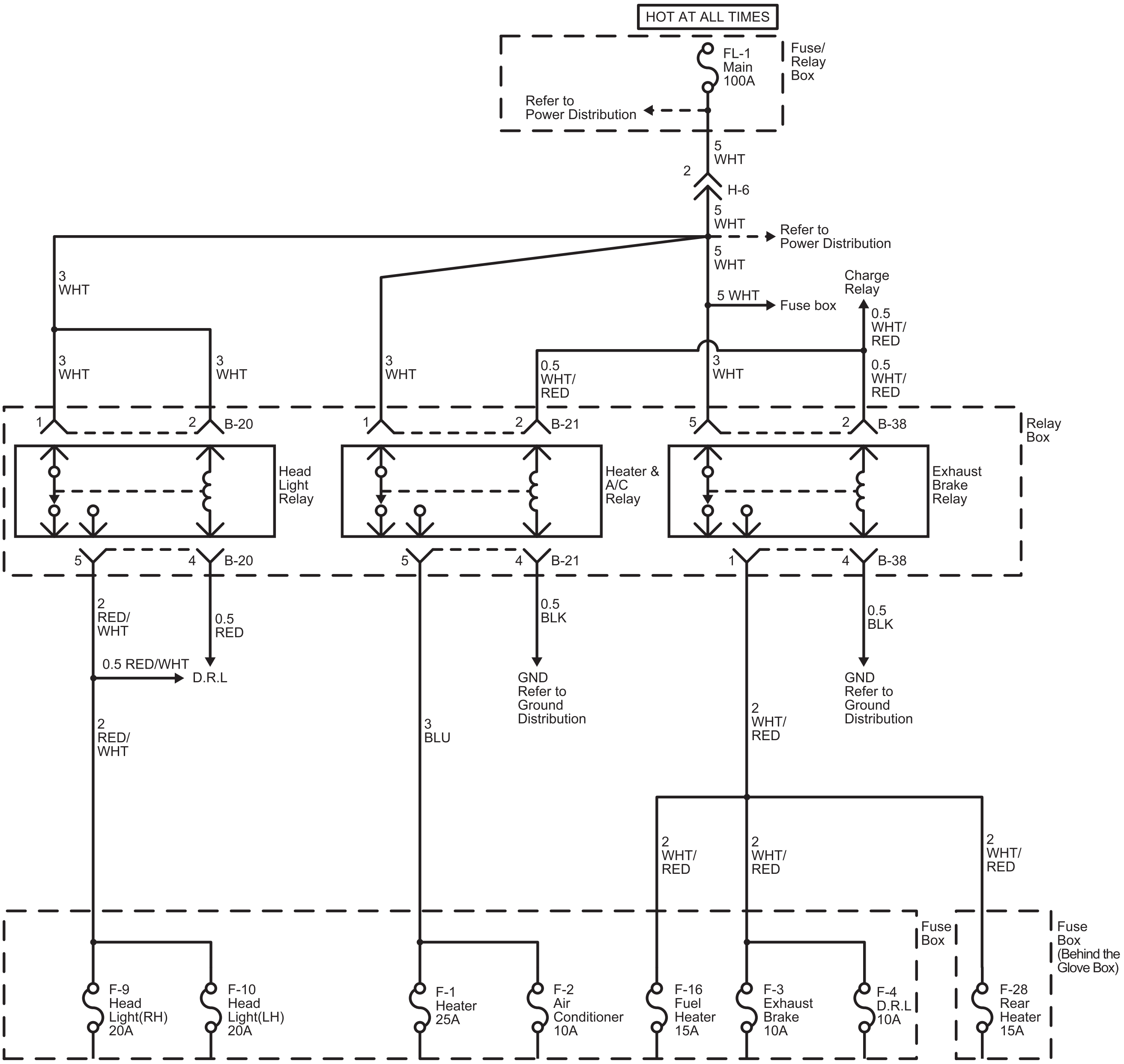


Power Distribution (Hot In Run) (1)



LNW66EXF000301

Power Distribution (Hot In Run) (2)



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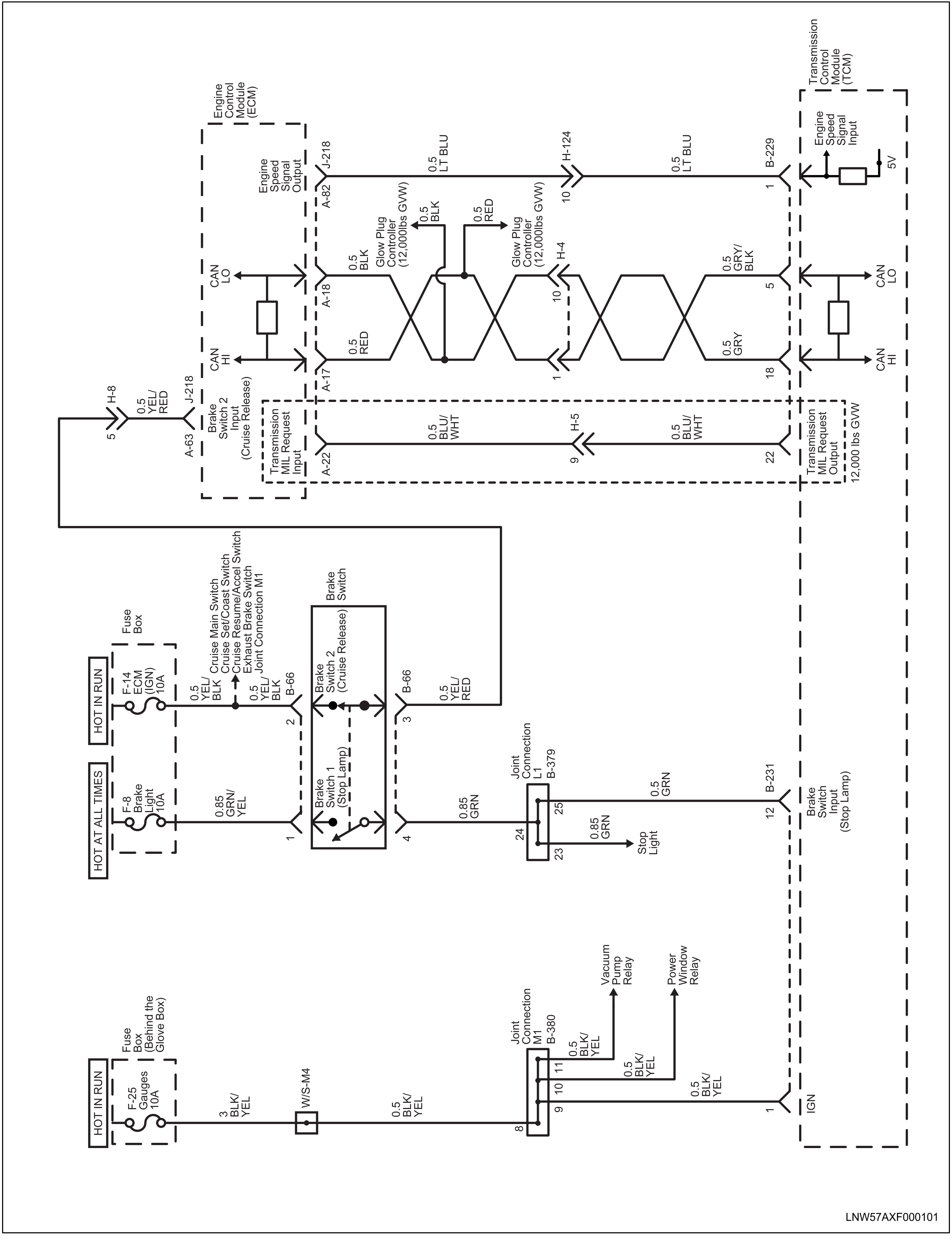
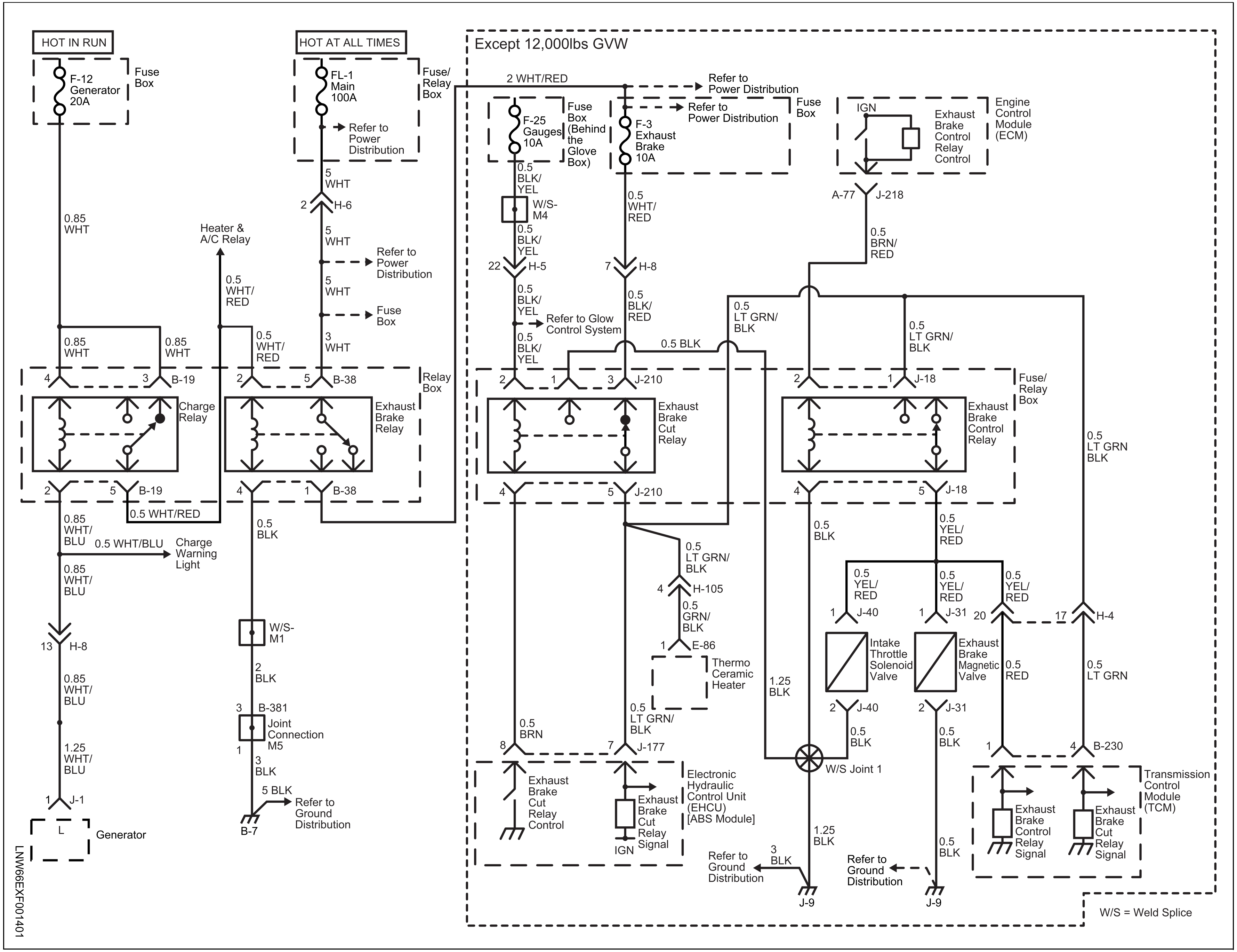
Transmission Control Module (TCM) Power, Brake Switch and CAN

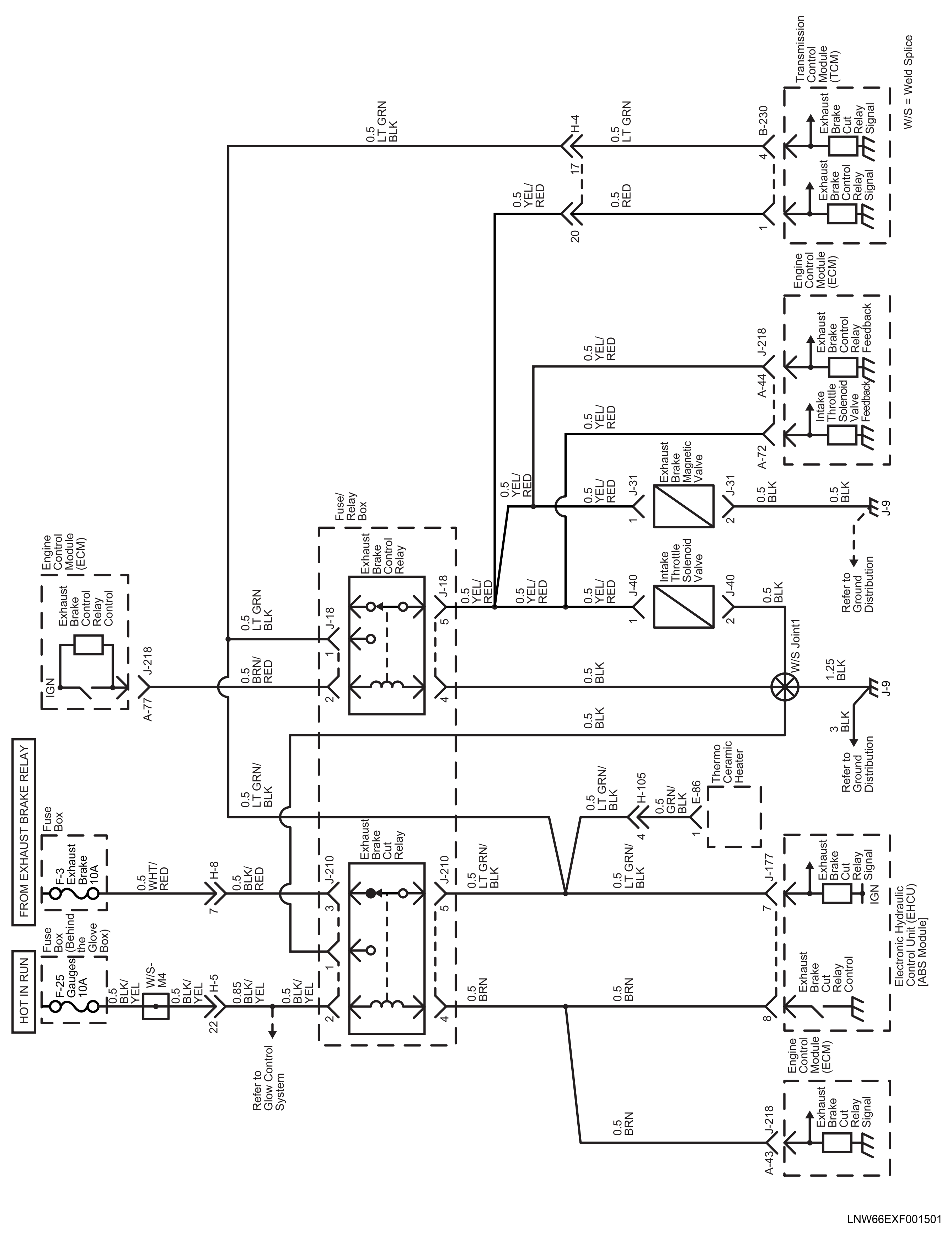


LNW57AXF000101

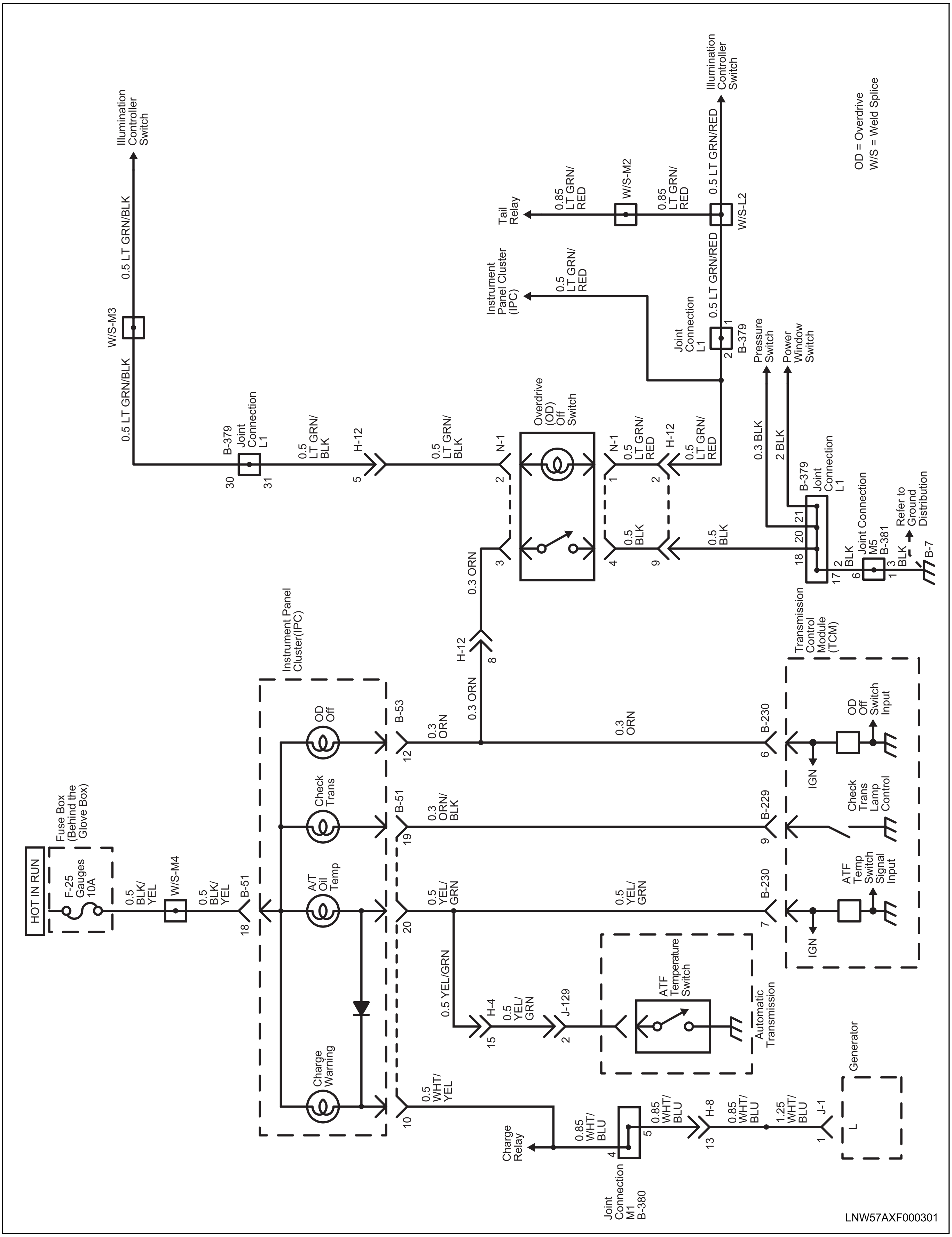
Exhaust Brake System (1)



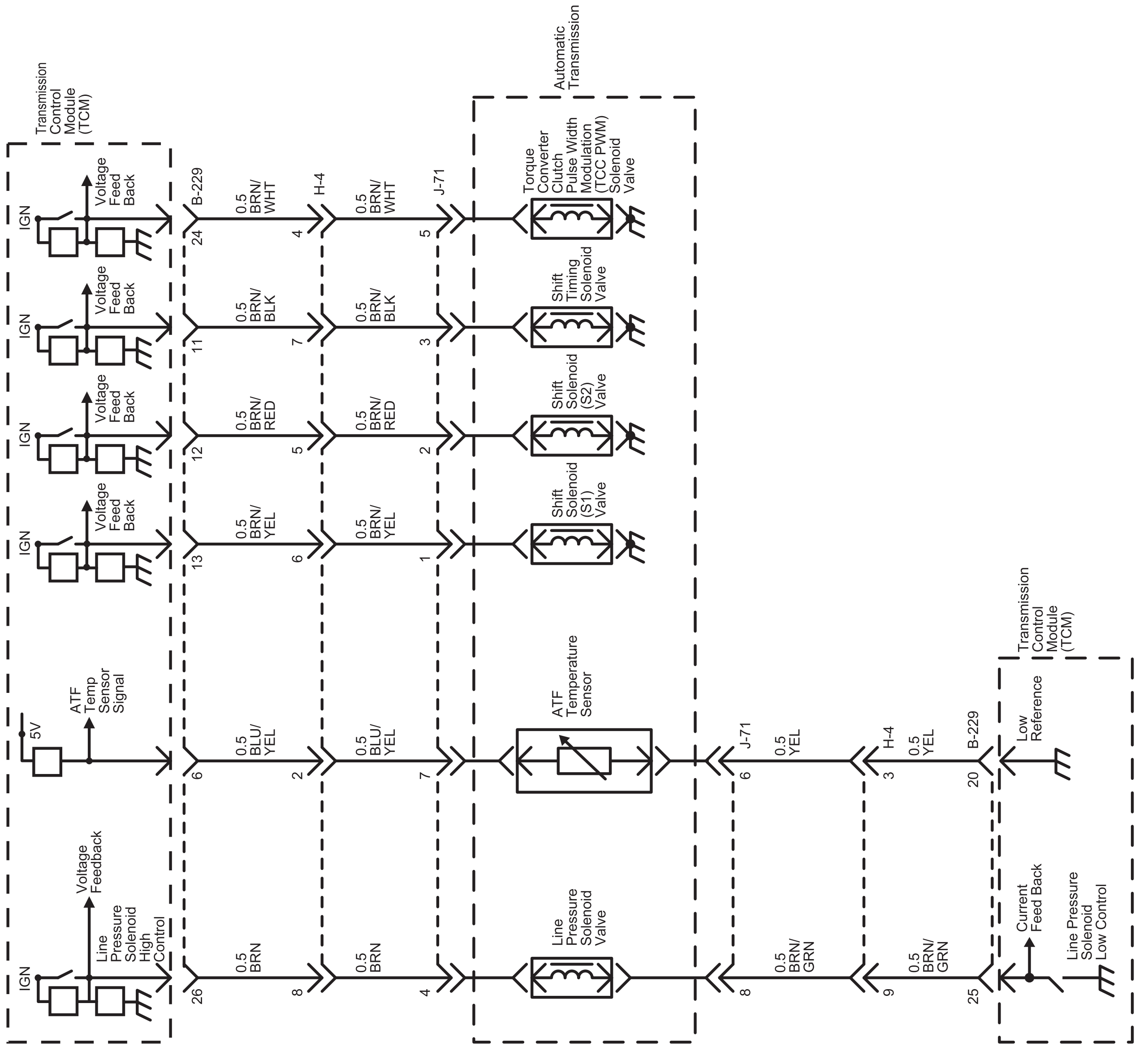
Exhaust Brake System (2) [12,000 lbs GVW]



Warning Light and OD Off Switch

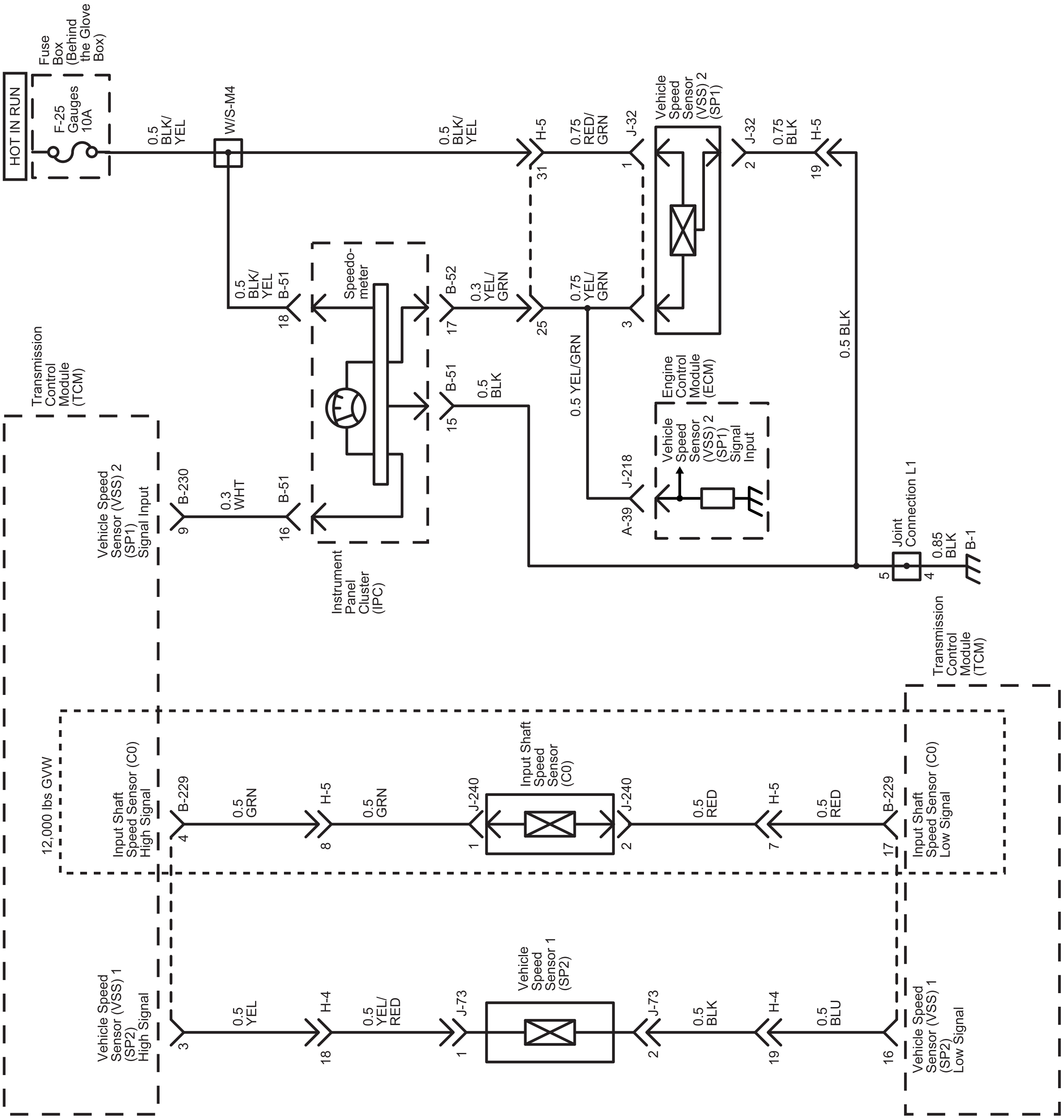


ATF Temperature Sensor, Oil Light Sensor, Line Pressure, Shift (S1), Shift (S2), Shift Timing and Lock-Up Solenoids



LNW57AXF000401

Vehicle Speed Sensors, Input Shaft Speed Sensor (C0)



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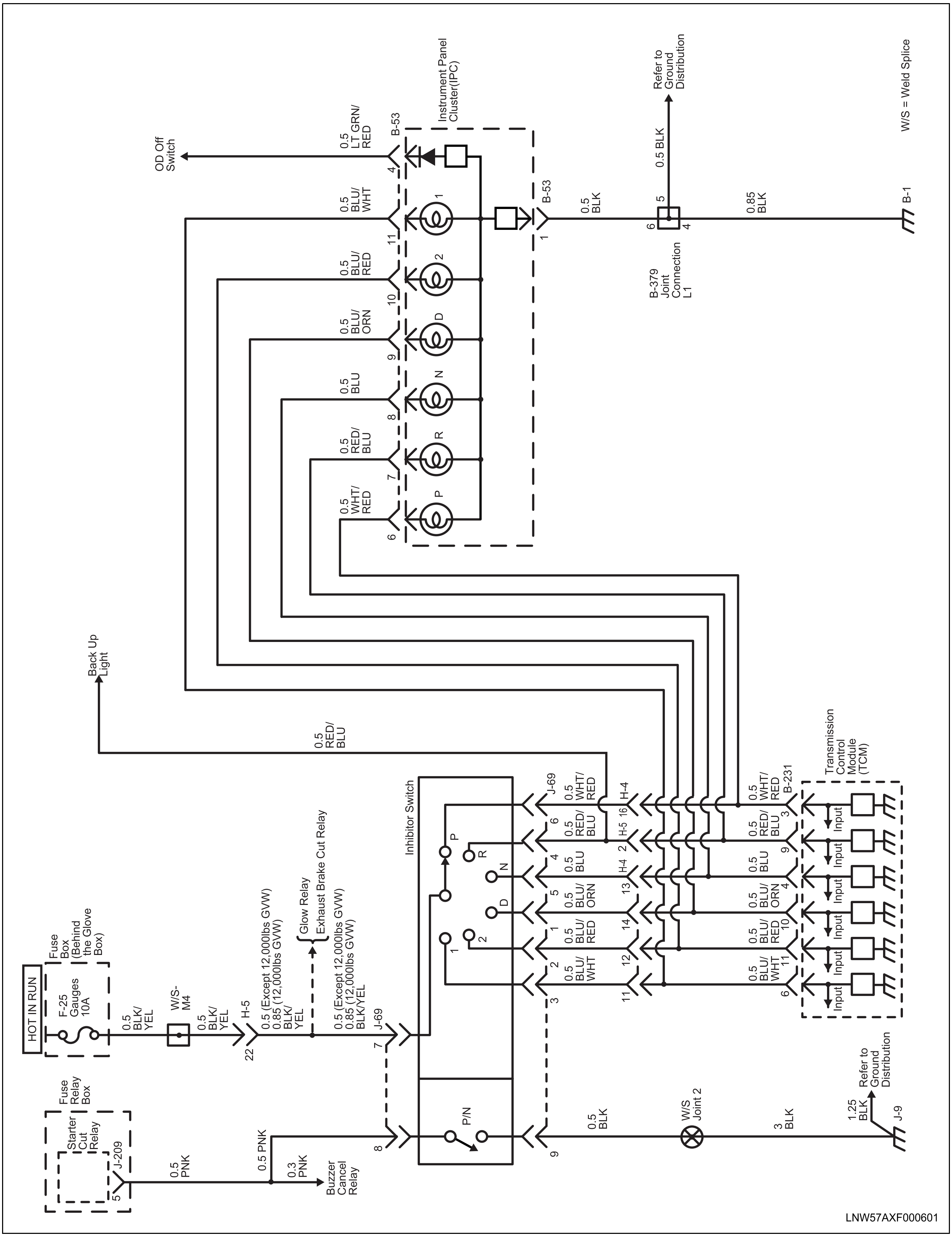
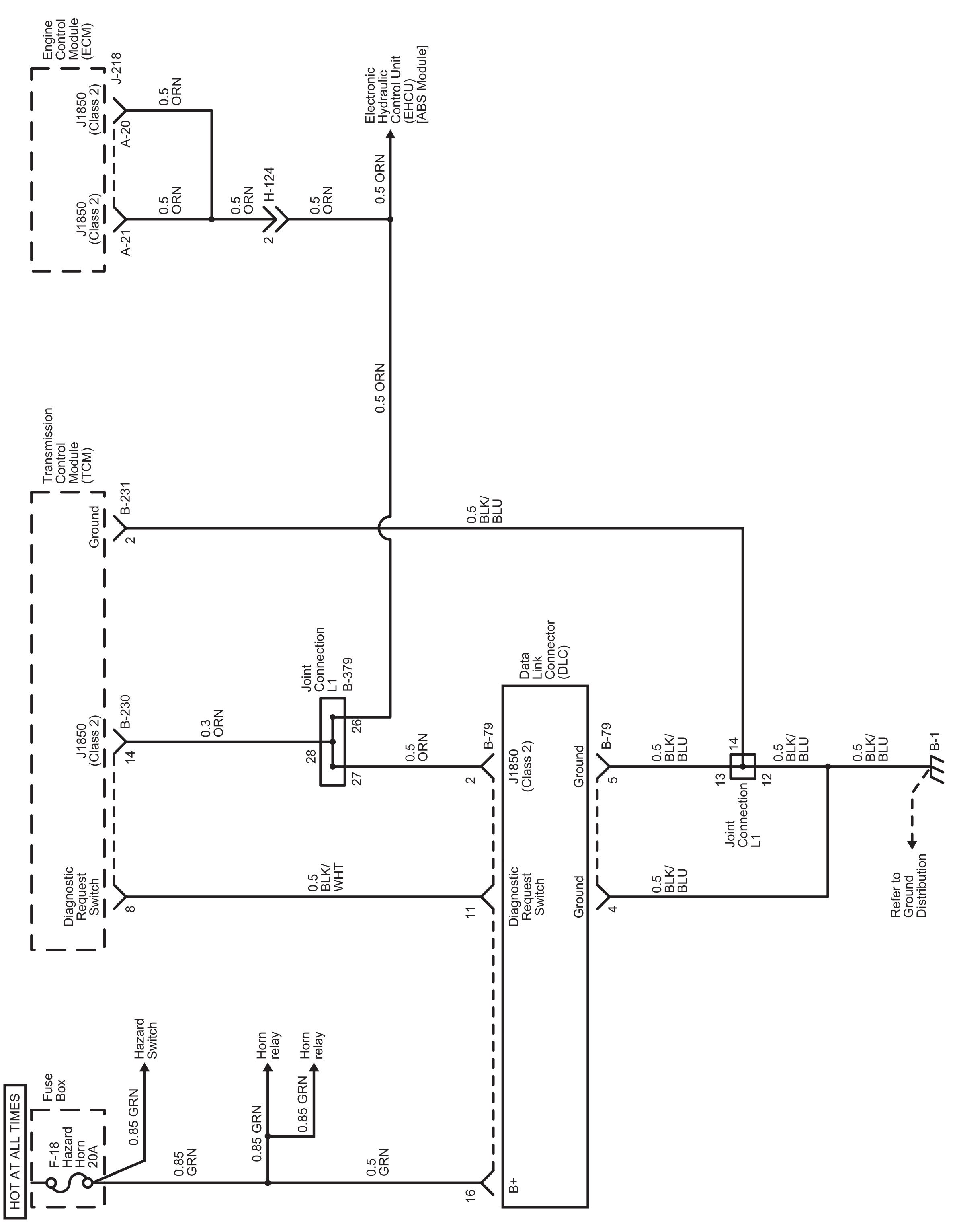
Inhibitor Switch and Shift Indicator Light



Transmission Control Module (TCM) Grounding, Data Link Connector (DLC)



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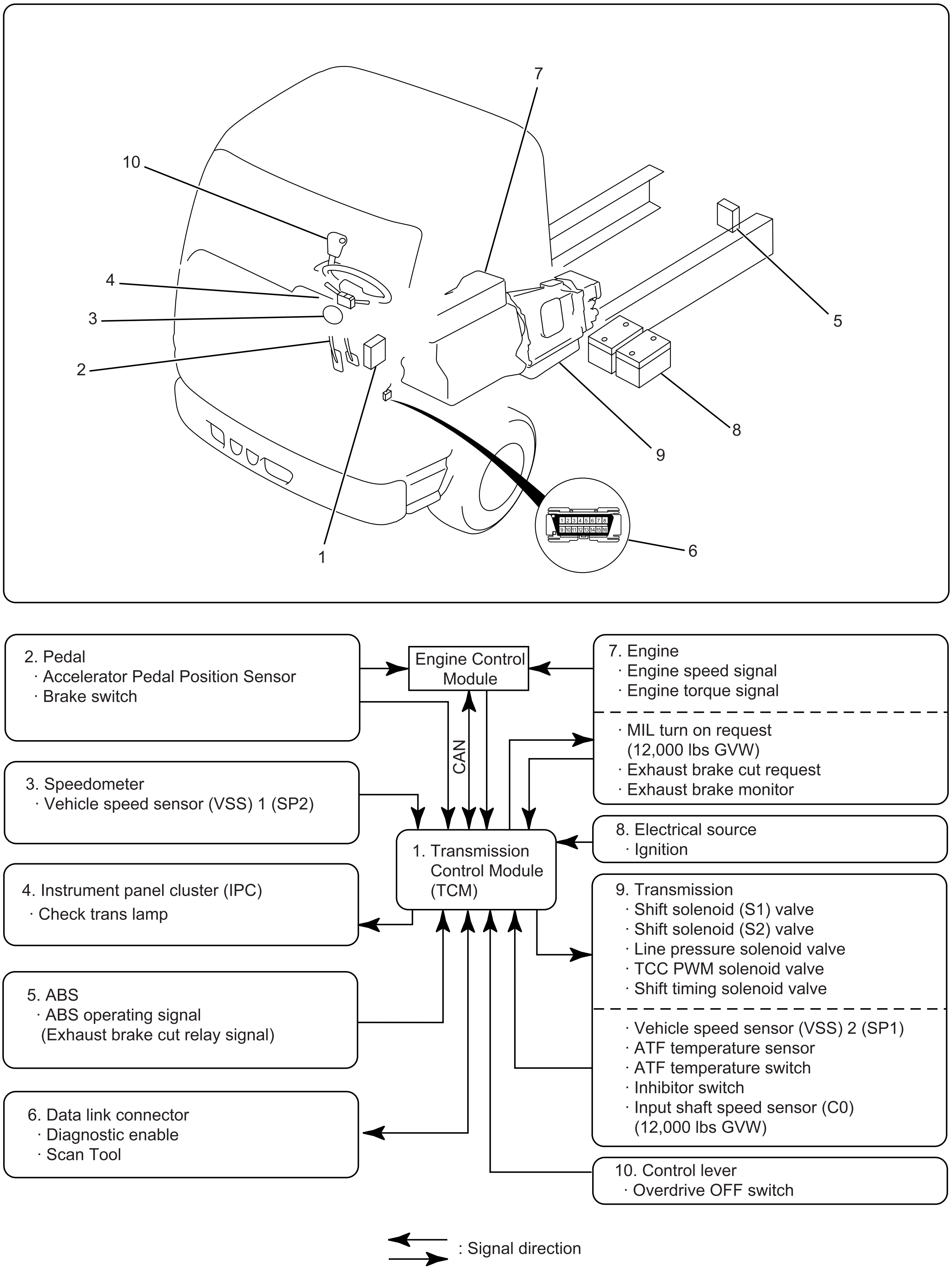
Component Locator

Component Location



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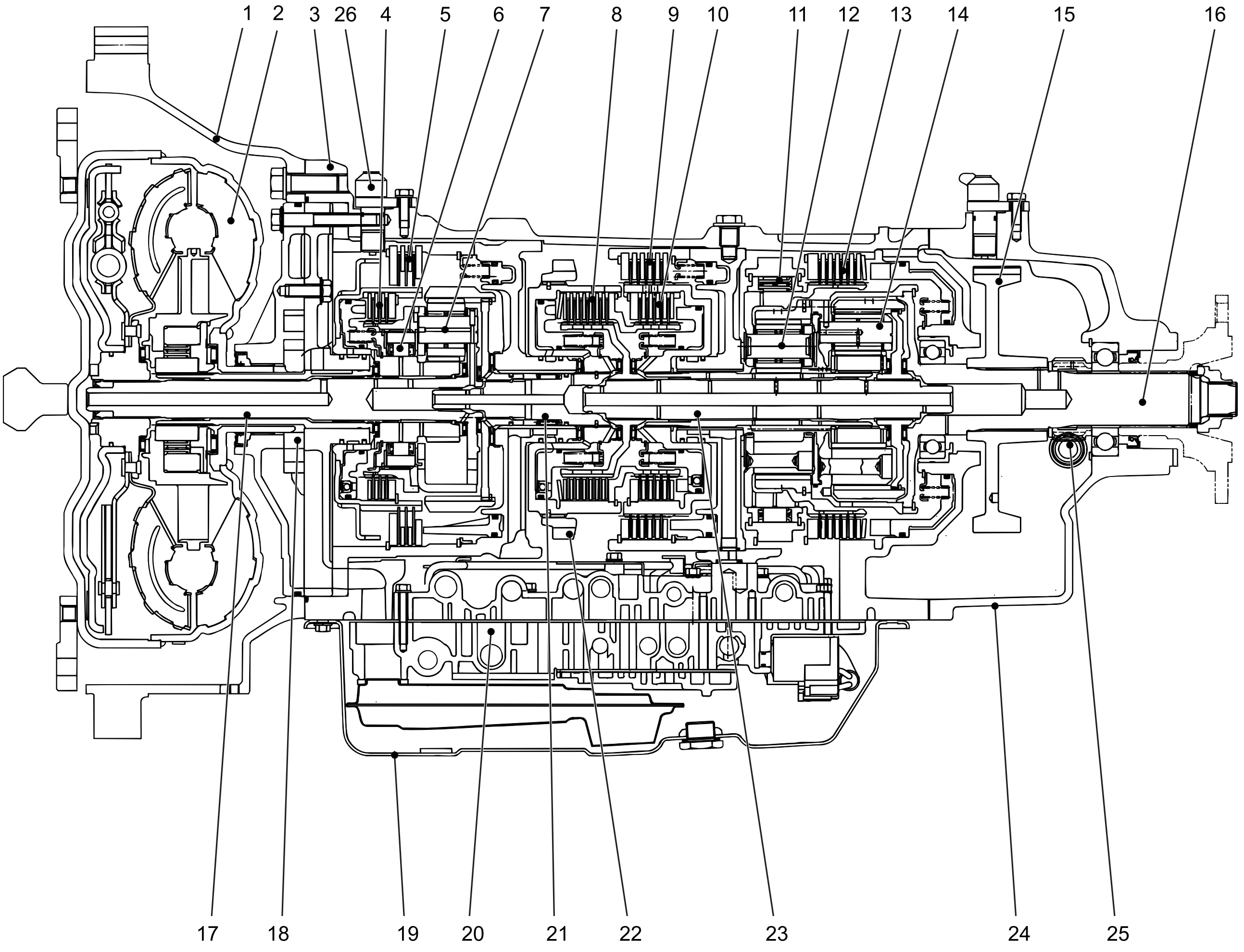
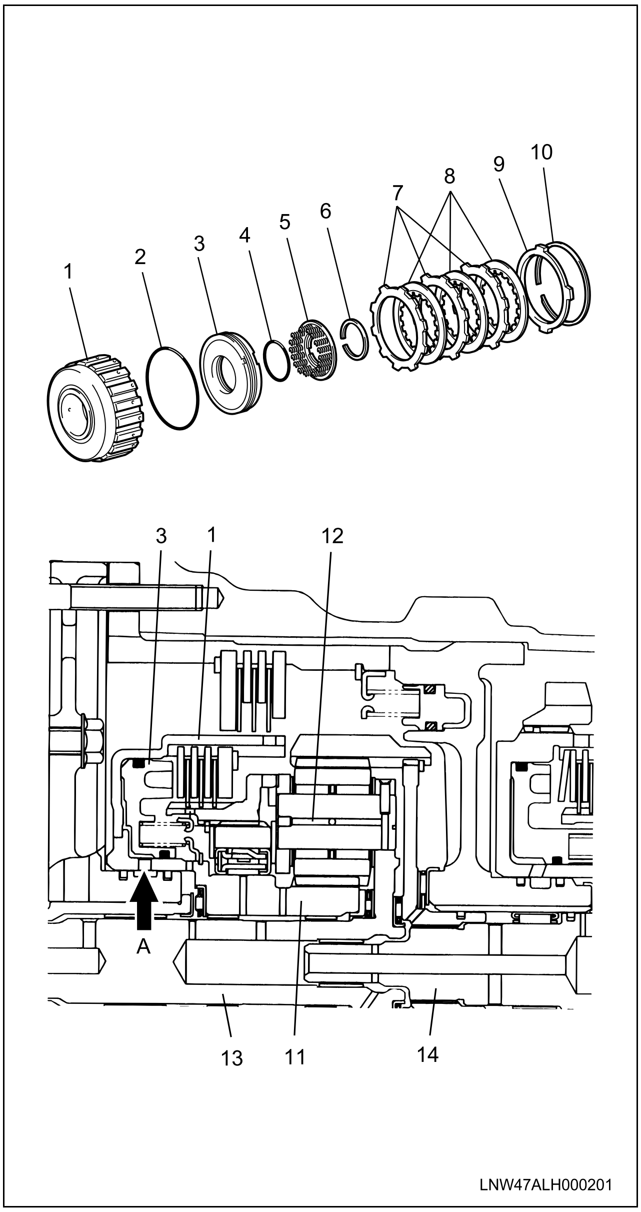
Automatic Transmission Mechanical Component



Legend

1. Torque Converter Housing
2. Torque Converter
3. Transmission Case
4. Overdrive Direct Clutch
5. Overdrive Brake
6. Overdrive One-way Clutch
7. Overdrive planetary Gear
8. Front Clutch
9. 2nd Brake
10. Rear Clutch
11. Front Planetary Gear
12. No.2 One-way Clutch
13. 1st and Reverse Brake
14. Rear Planetary Gear
15. Parking Lock Gear
16. Output Shaft
17. Overdrive Input Shaft
18. Oil Pump
19. Oil Pan
20. Valve Body
21. Input Shaft
22. PTO Drive Gear
23. Intermediate Shaft
24. Extension Housing
25. Speedometer Drive Gear
26. Input shaft speed sensor (C0) [12,000 lbs GVW]

Overdrive Direct Clutch

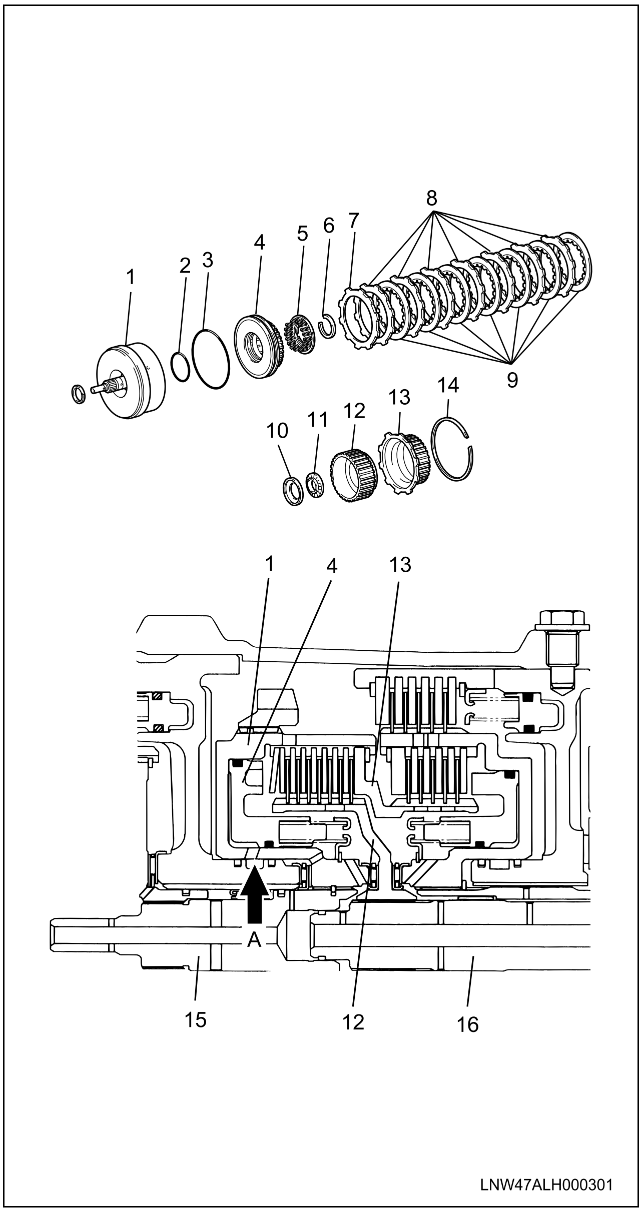


Legend

1. Overdrive (OD) Direct Clutch Drum
2. O-ring
3. OD Direct Clutch Piston
4. O-ring
5. OD Direct Clutch Return Spring
6. Snap Ring
7. Clutch Plate
8. Clutch Disc
9. Clutch Flange
10. Snap Ring
11. OD Planetary Sun Gear
12. OD Planetary Carrier
13. OD Input Shaft
14. Input Shaft

A. Operating Pressure

Front Clutch

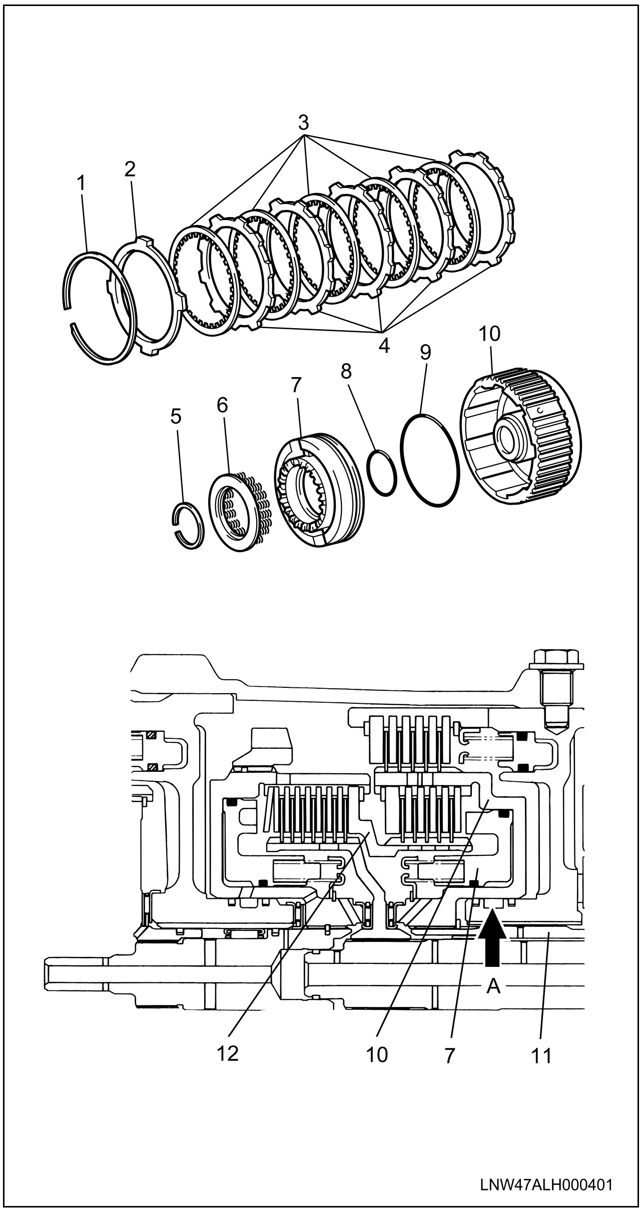


Legend

1. Front Clutch Drum
2. O-ring
3. O-ring
4. Front Clutch Piston
5. Front Clutch Return Spring
6. Snap Ring
7. Clutch Cushion Plate
8. Clutch Plate
9. Clutch Disk
10. Thrust Bearing Race
11. Thrust Bearing
12. Front Clutch Hub
13. Rear Clutch Hub
14. Snap Ring
15. Input Shaft
16. Intermediate Shaft

A. Operating Pressure

Rear Clutch

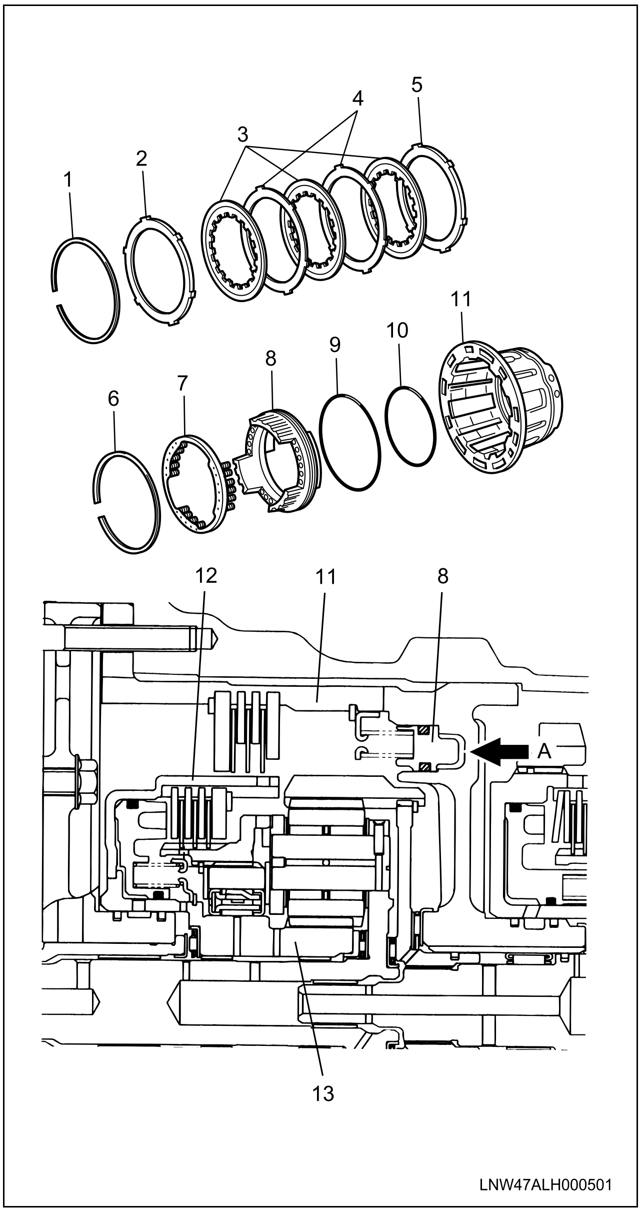


Legend

1. Snap Ring
2. Clutch Flange
3. Clutch Disk
4. Clutch Plate
5. Snap Ring
6. Rear Clutch Piston Return Spring
7. Rear Clutch Piston
8. O-ring
9. O-ring
10. Rear Clutch Drum
11. Front Planetary Sun Gear
12. Rear Clutch Hub

A. Operating Pressure

Overdrive (OD) Brake

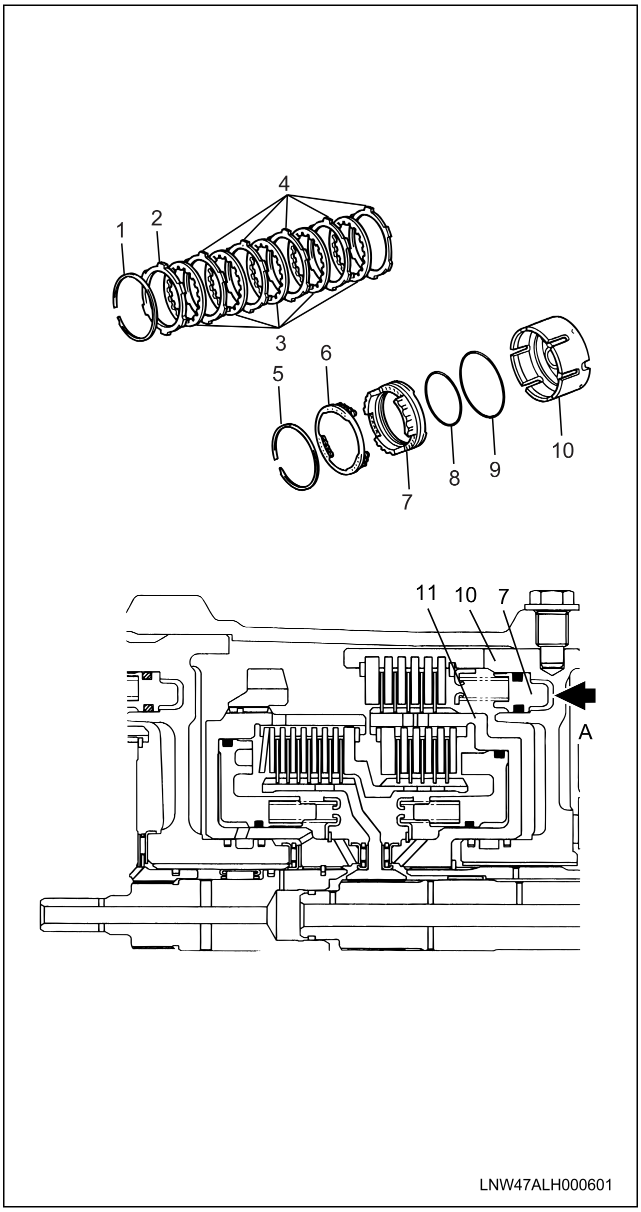


Legend

1. Snap Ring
2. Brake Flange
3. Clutch Disk
4. Brake Plate
5. Brake Plate
6. Snap Ring
7. OD Brake Return Spring
8. OD Brake Piston
9. O-ring
10. O-ring
11. OD Case
12. OD Direct Clutch
13. OD Planetary Sun Gear

A. Operating Pressure

2nd Brake

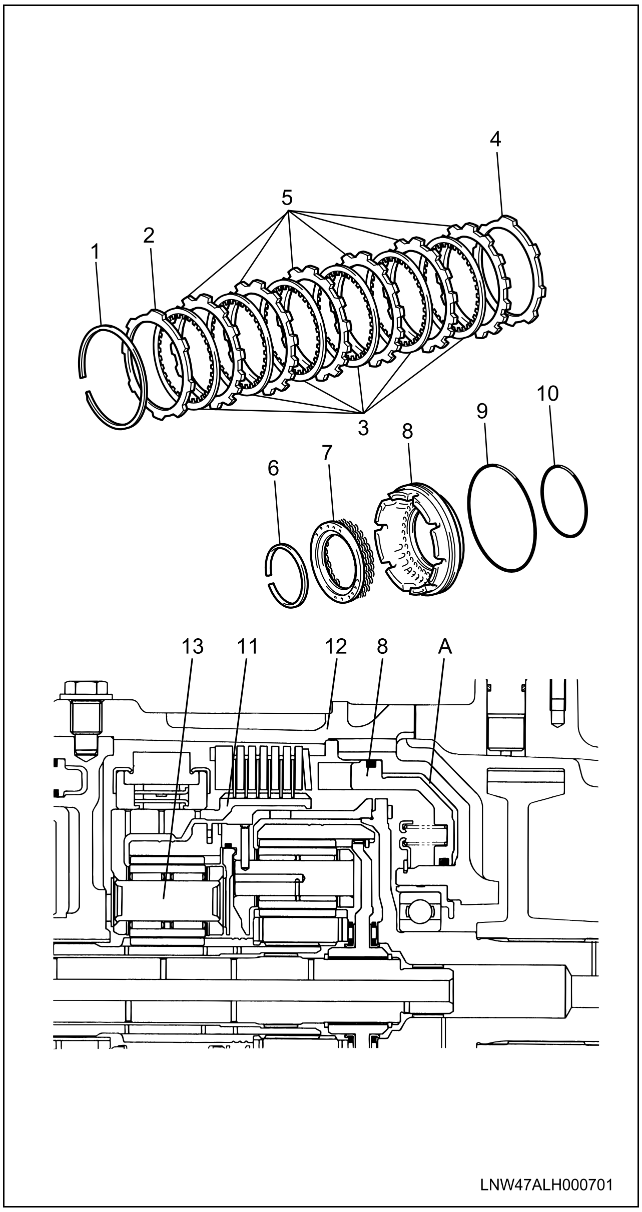


Legend

1. Snap Ring
2. Brake Flange
3. Clutch Disk
4. Brake Plate
5. Snap Ring
6. 2nd Brake Return Spring
7. Brake Piston No.1
8. O-ring
9. O-ring
10. Center Support
11. Rear Clutch

A. Operating Pressure

1st and Reverse Brake

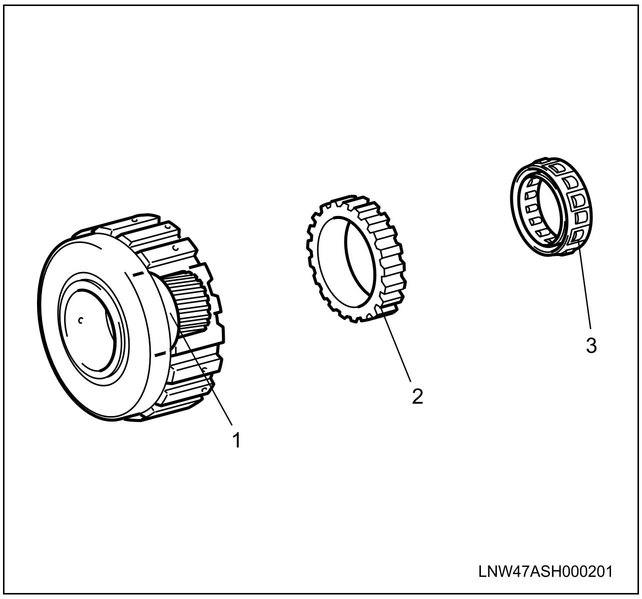


Legend

1. Snap-Ring
2. Brake Flange
3. Clutch Disk
4. Brake Cushion Plate
5. Brake Plate
6. Snap Ring
7. 1st and Reverse Brake Return Spring
8. 1st and Reverse Brake Piston
9. O-ring
10. O-ring
11. 1st and Reverse Brake Hub
12. Transmission Case
13. Front Planetary Carrier

A. Operating Pressure

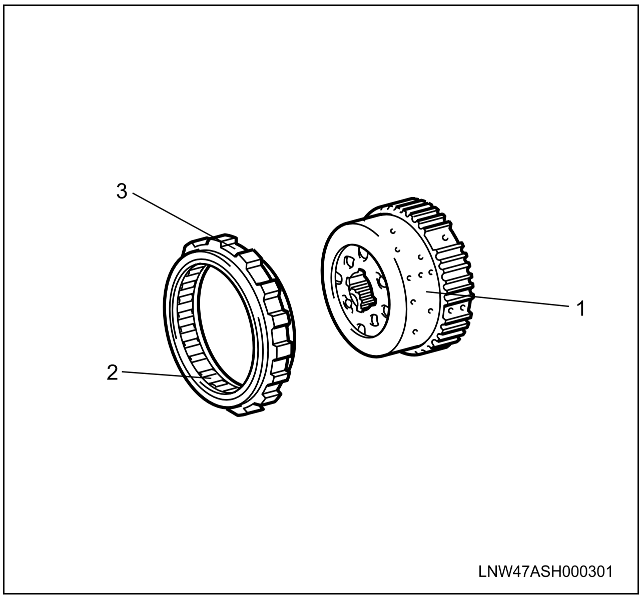
Overdrive (OD) One-way Clutch



Legend

1. OD Direct Clutch Drum and OD One-way Clutch Inner Race
2. OD One-way Clutch Outer Race
3. OD One-way Clutch

One-way Clutch No.2

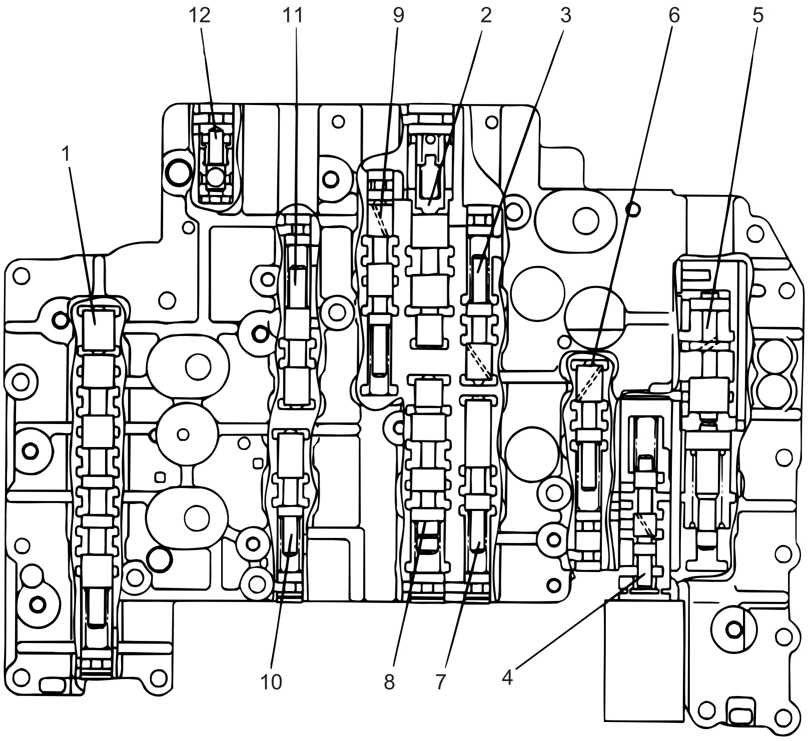


Legend

1. Front Planetary Carrier and One-way Clutch No.2 Inner Race
2. One-way Clutch No.2
3. One-way Clutch No.2 Outer Race

Valve Body

Upper Valve Body:

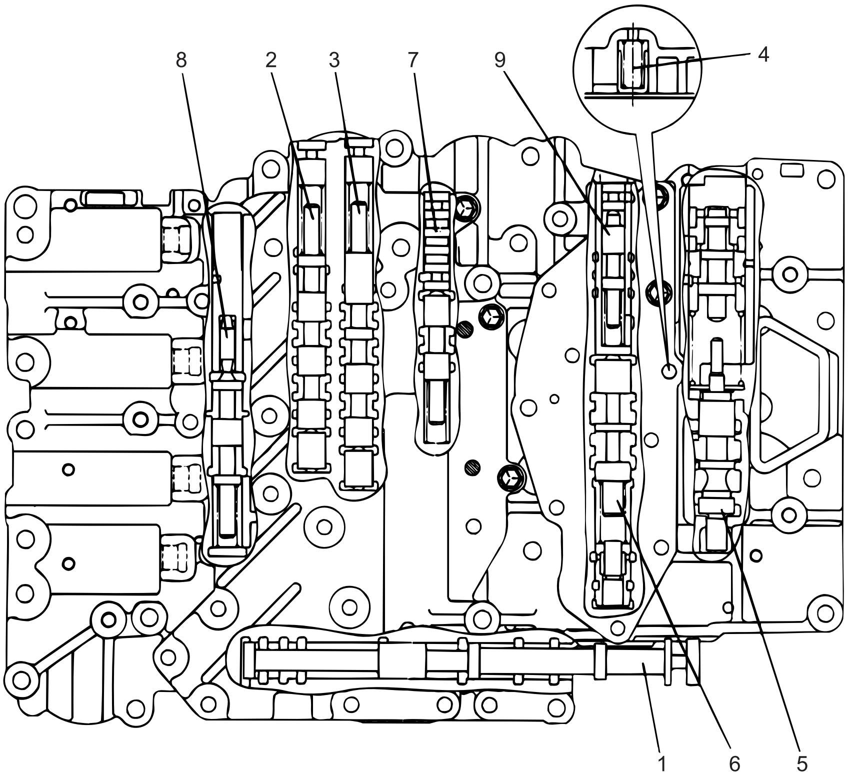


LNW47ALF000401

Legend

1. 2-3 Shift Valve
2. Reverse Inhibitor Valve
3. Modulator Valve
4. Throttle Valve
5. Secondary Regulator Valve
6. Reducing Valve
7. Lock-up Signal Valve
8. Accumulator Control Valve
9. Low Coast Modulator Valve
10. Orifice Control Valve
11. Low Inhibitor Valve
12. Check Valve

Lower Valve Body:



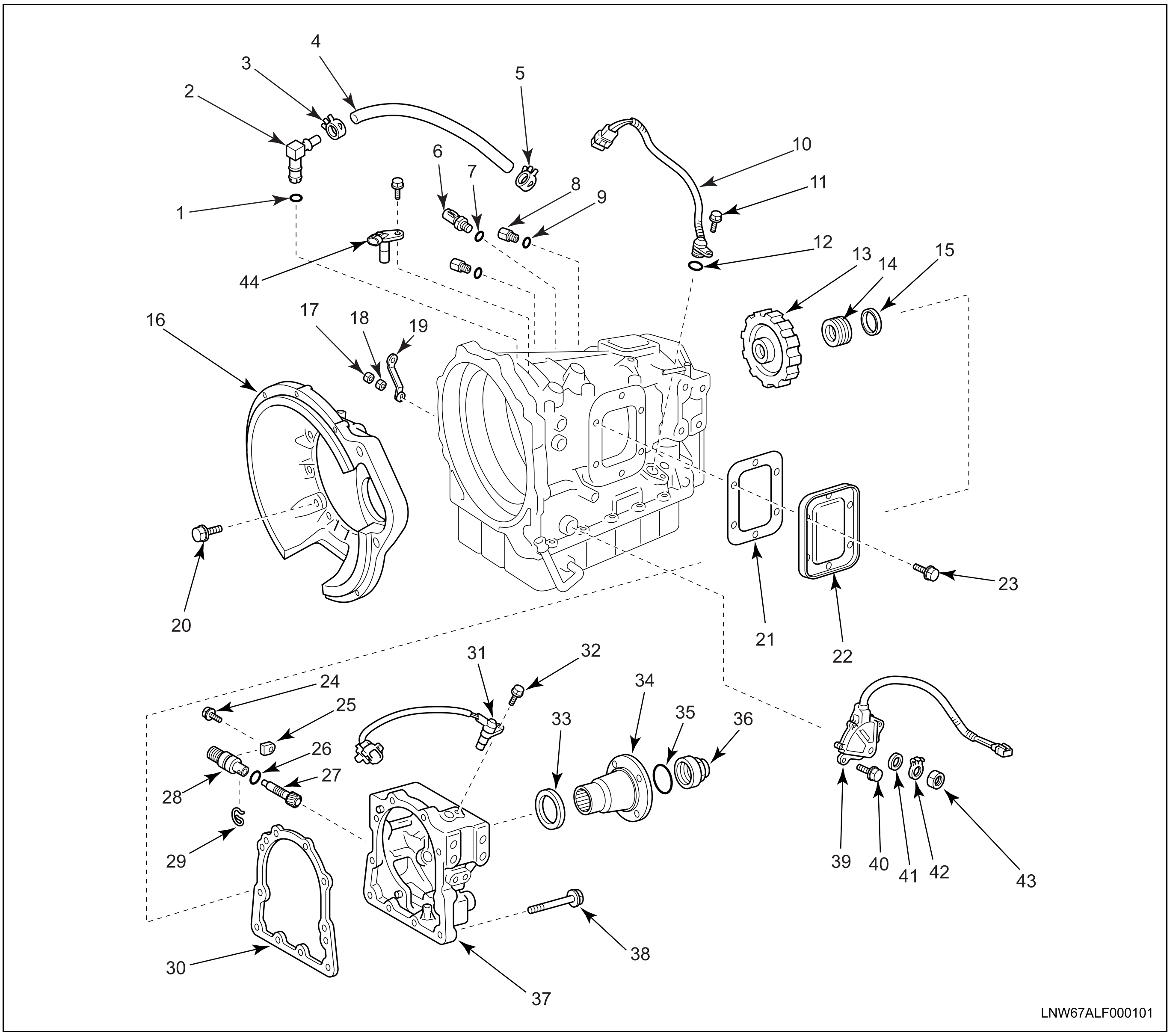
LNW47ALF000501

Legend

1. Manual Valve
2. 1-2 Shift Valve
3. 3-4 Shift Valve
4. Pressure Relief Valve
5. Primary Regulator Valve
6. Lock-up Control Valve
7. OD Direct Clutch Exhaust Valve
8. 2-3 Timing Valve
9. Cut-back Valve

Disassemble Views

Case Associated Parts (1 of 3)

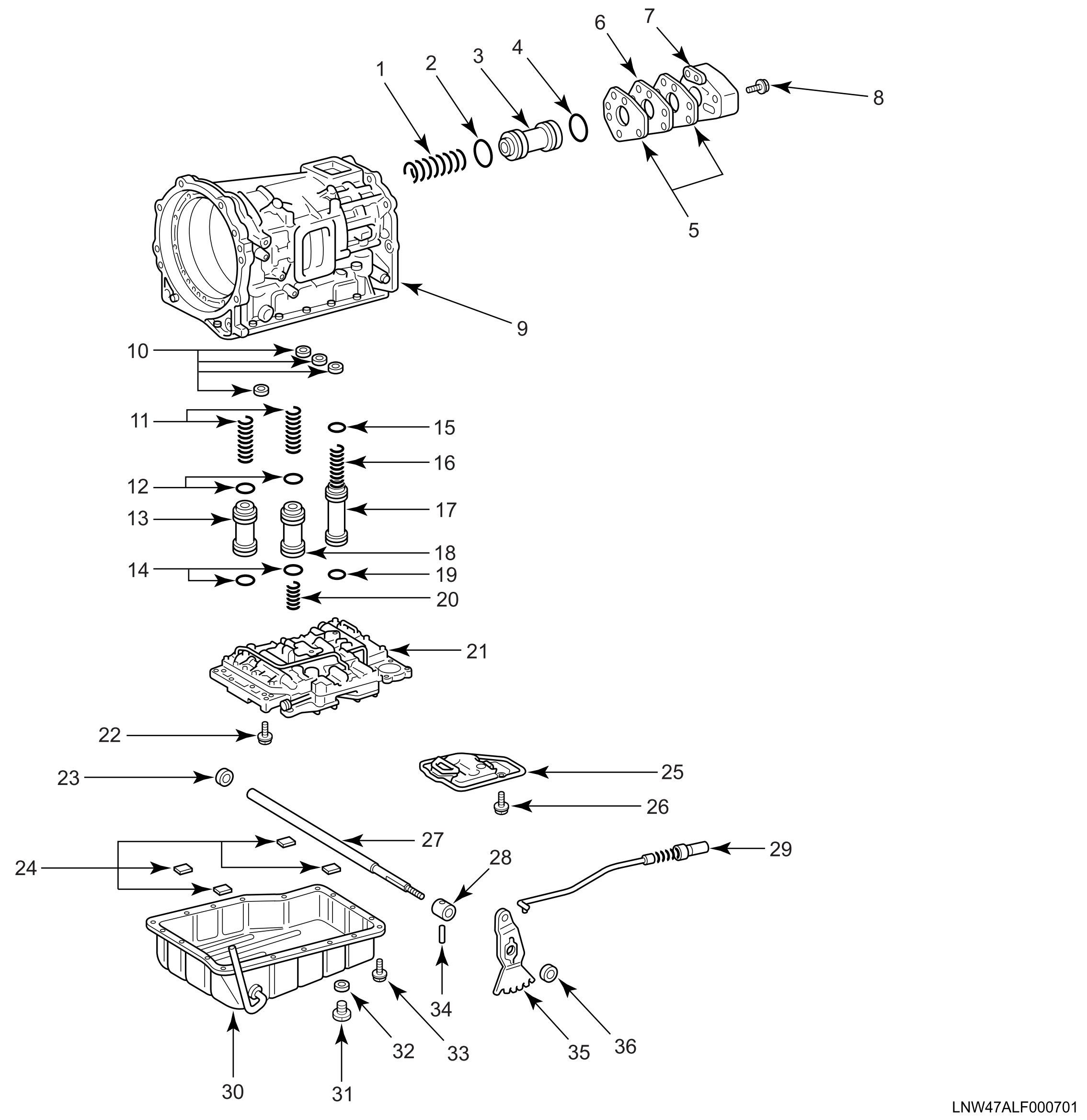


Legend

1. O-ring	19. Control Shaft Lever
2. Oil Cooler Union	20. Bolt
3. Clip	21. Gasket
4. Hose	22. PTO Cover
5. Clip	23. Bolt
6. ATF Temperature Switch	24. Bolt
7. O-ring	25. Lock Plate
8. Oil Cooler Union	26. O-ring
9. O-ring	27. Speedometer Driven Gear
10. Transmission Solenoid Wire	28. Speedometer Sleeve
11. Bolt	29. Clip
12. O-ring	30. Gasket
13. Parking Lock Gear	31. Vehicle Speed Sensor 1 (SP2)
14. Speedometer Drive Gear	32. Bolt
15. Spacer	33. Oil Seal
16. Torque Converter Housing	34. Companion Flange
17. Nut	35. O-ring
18. Nut	36. Lock Nut

37. Extension Housing
38. Bolt
39. Inhibitor Switch
40. Bolt
41. Grommet
42. Lock Washer
43. Nut
44. Input Shaft Speed Sensor (C0) [12,000 lbs GVW]

Case and Associated Parts (2 of 3)

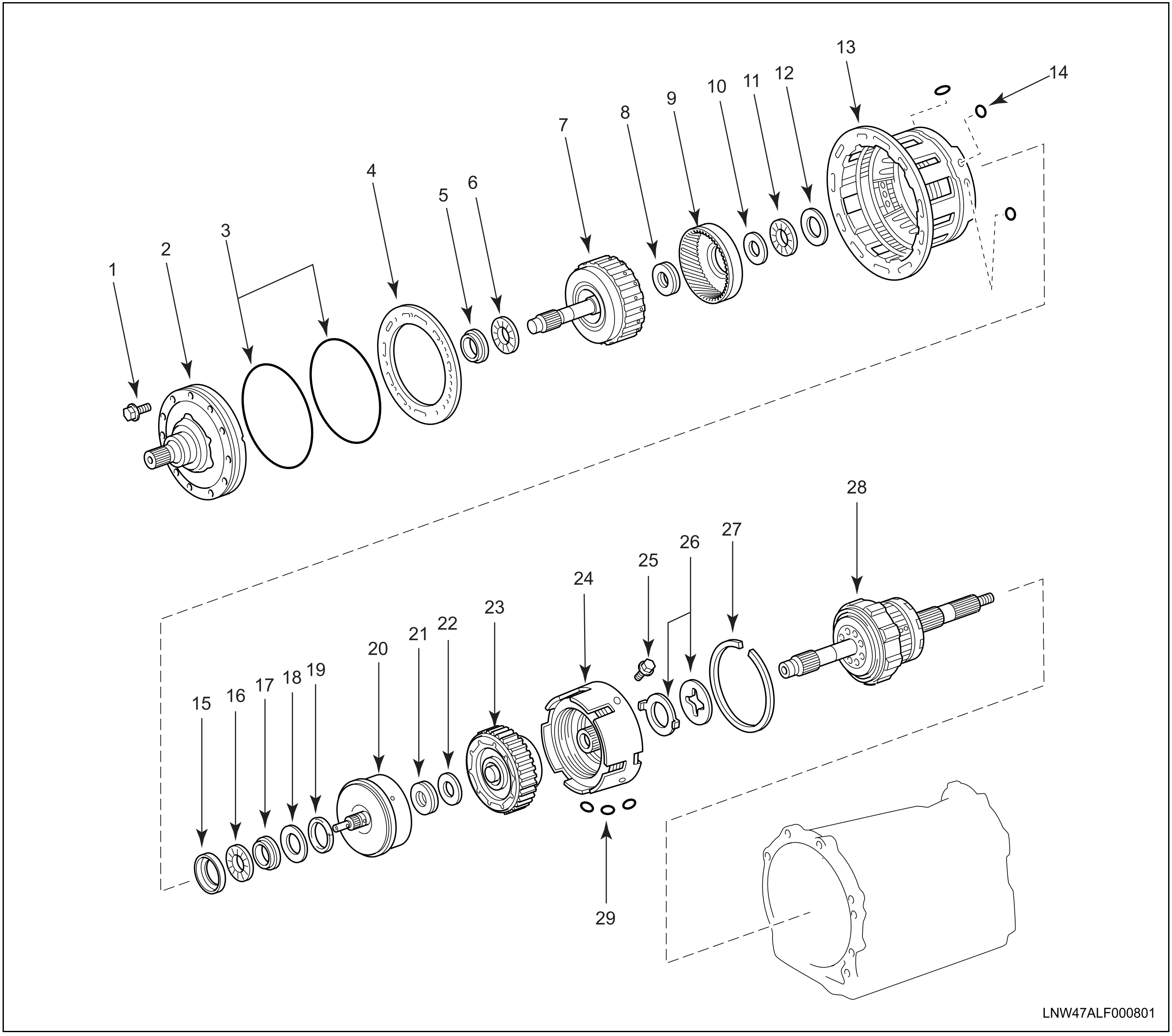


Legend

1. Spring
2. O-ring
3. Front Clutch Accumulator
4. O-ring
5. Gasket
6. Plate
7. Front Clutch Accumulator Cover
8. Bolt
9. Transmission Case
10. Center Support Apply Gasket
11. Spring
12. O-ring
13. OD Brake Accumulator Piston
14. O-ring
15. O-ring
16. Spring
17. Rear Clutch Accumulator Piston
18. 2nd Brake Accumulator Piston
19. O-ring
20. Spring
21. Valve Body Assembly
22. Bolt
23. Oil Seal
24. Magnet

25. Oil Strainer
26. Bolt
27. Manual Valve Lever Shaft
28. Spacer
29. Parking Lock Rod
30. Oil Pan
31. Drain Plug
32. Gasket
33. Bolt
34. Pin
35. Manual Valve Lever
36. Oil Seal

Case and Associated Parts (3 of 3)

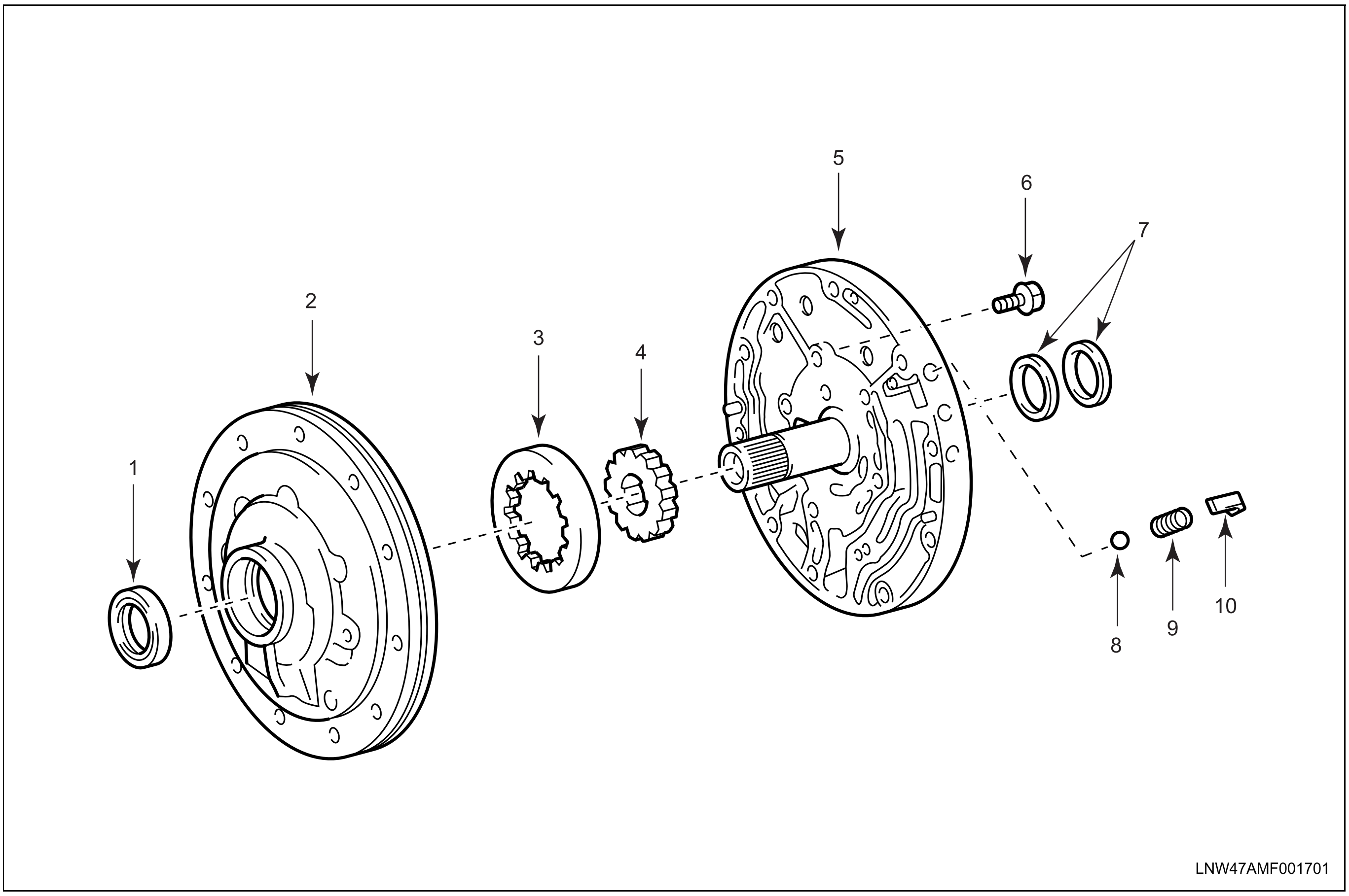


Legend

1. Bolt
2. Oil Pump
3. O-ring
4. Gasket
5. Race
6. Thrust Gearing
7. Overdrive (OD) Planetary Gear, OD Direct Clutch and One-way Clutch Assembly
8. Thrust Bearing
9. OD Ring Gear assembly
10. Race
11. Thrust Bearing
12. Race
13. OD Case Assembly
14. O-ring
15. Race
16. Thrust Bearing
17. Race
18. Spacer
19. Oil Seal ring
20. Front Clutch Assembly
21. Thrust Bearing

22. Race
23. Rear Clutch Assembly
24. Center Support Assembly
25. Bolt
26. Thrust Washer
27. Snap Ring
28. Planetary Gear, One-way Clutch and Output Shaft Assembly
29. O-ring

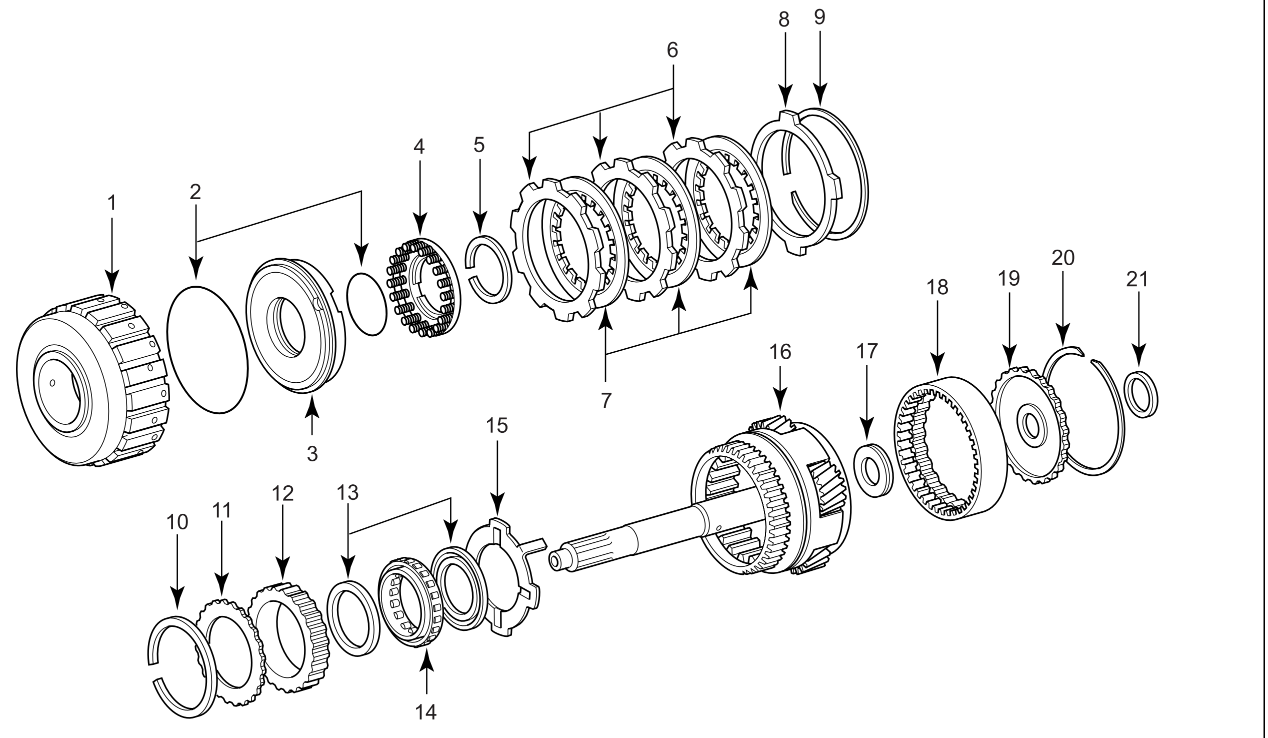
Oil Pump Assembly



Legend

1. Oil Seal
2. Oil Pump Body
3. Oil Pump Driven Gear
4. Oil Pump Drive Gear
5. Oil Pump Cover
6. Bolt
7. Oil Seal Ring
8. Check Ball
9. Spring
10. Spring Seat

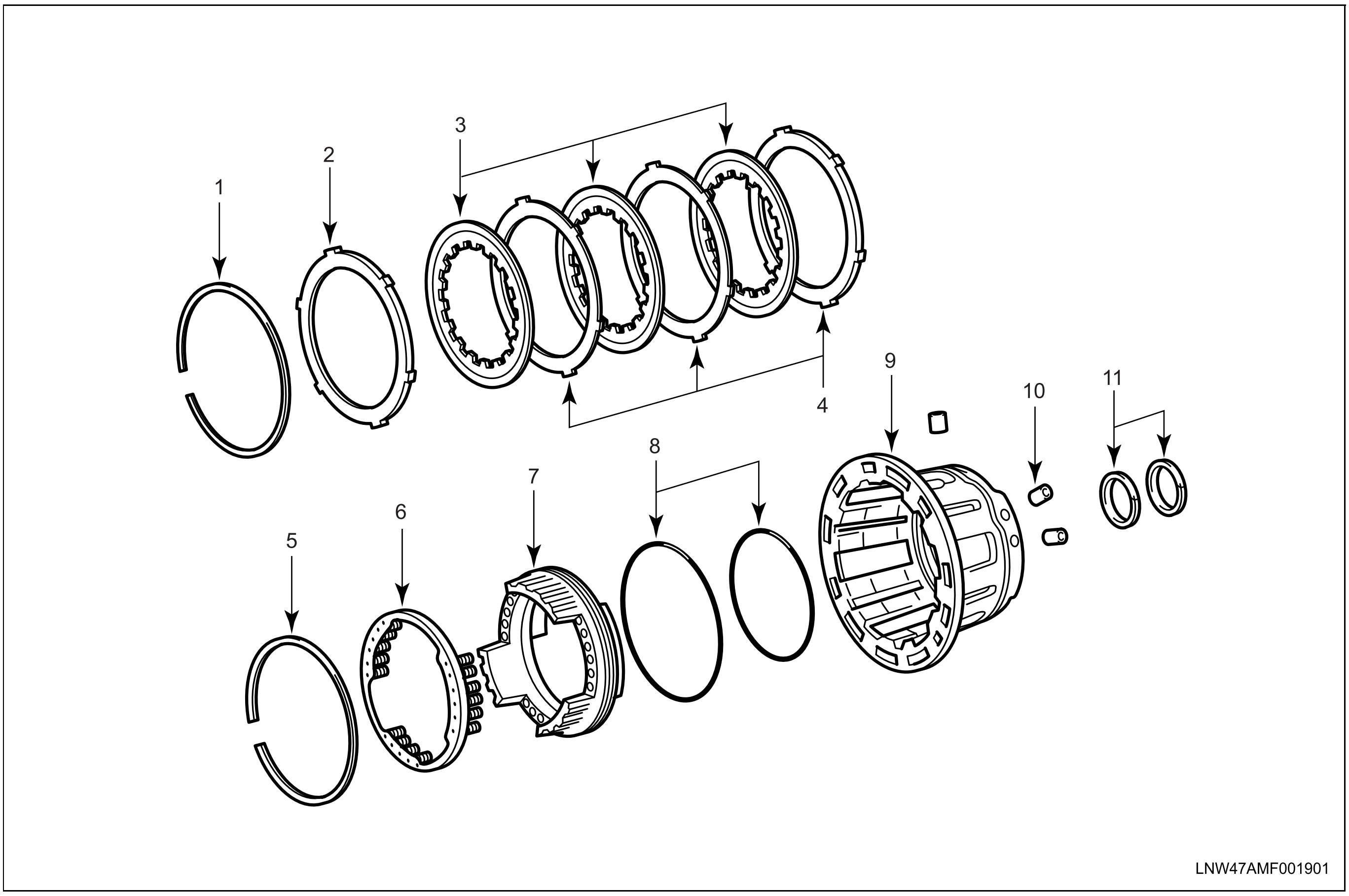
Overdrive (OD) Planetary Gear and Direct Clutch



Legend

1. OD Direct Clutch Drum
2. O-ring
3. OD Direct Clutch Piston
4. Piston Return Spring
5. Snap Ring
6. Plate
7. Disc
8. Flange
9. Snap Ring
10. Snap Ring
11. Thrust Washer
12. One-way Clutch Outer Race
13. Retainer
14. One-way Clutch
15. Thrust Washer
16. OD Planetary Gear
17. Thrust Washer
18. Planetary Ring Gear
19. Ring Gear Flange
20. Snap Ring
21. Oil Seal Ring

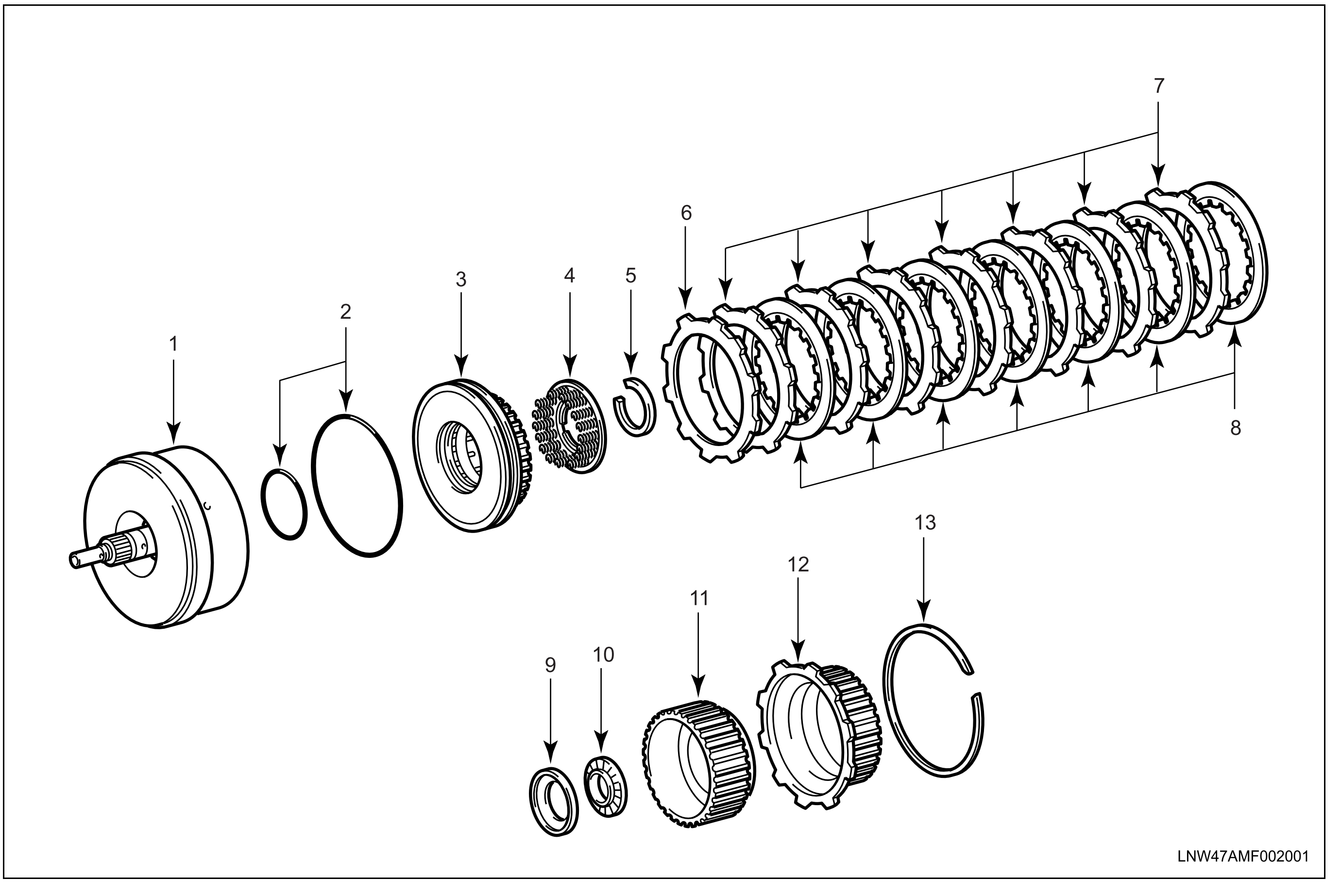
Overdrive (OD) Brake



Legend

1. Snap Ring
2. Flange
3. Disc
4. Plate
5. Snap Ring
6. Piston Return Spring
7. OD Brake Piston
8. O-ring
9. OD Case
10. Ring Retainer
11. Oil Seal Ring

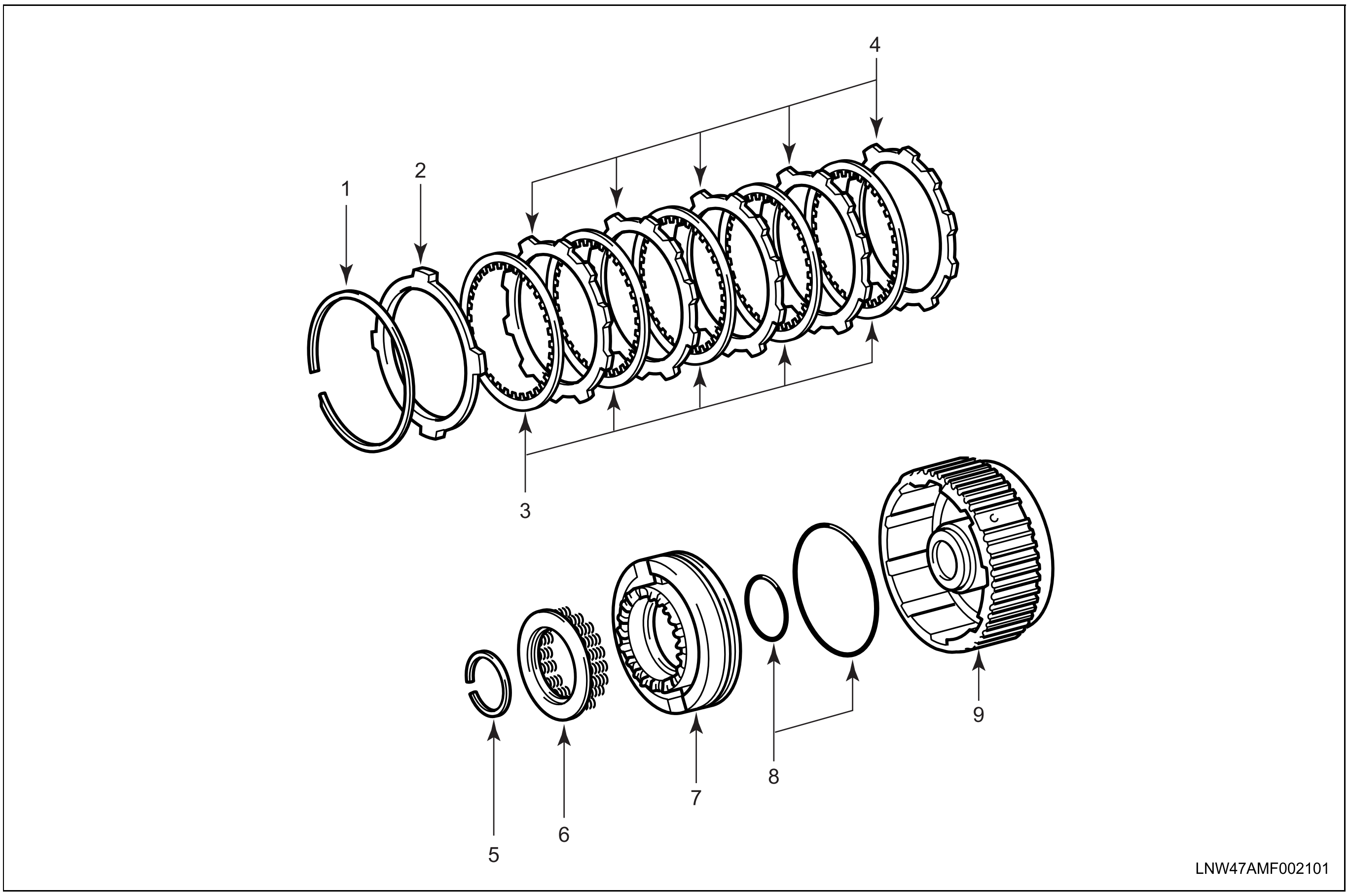
Front Clutch



Legend

1. Front Clutch Drum
2. O-ring
3. Front Clutch Piston
4. Piston Return Spring
5. Snap Ring
6. Cushion Plate
7. Plate
8. Disc
9. Race
10. Thrust Bearing
11. Front Clutch Hub
12. Rear Clutch Hub
13. Snap Ring

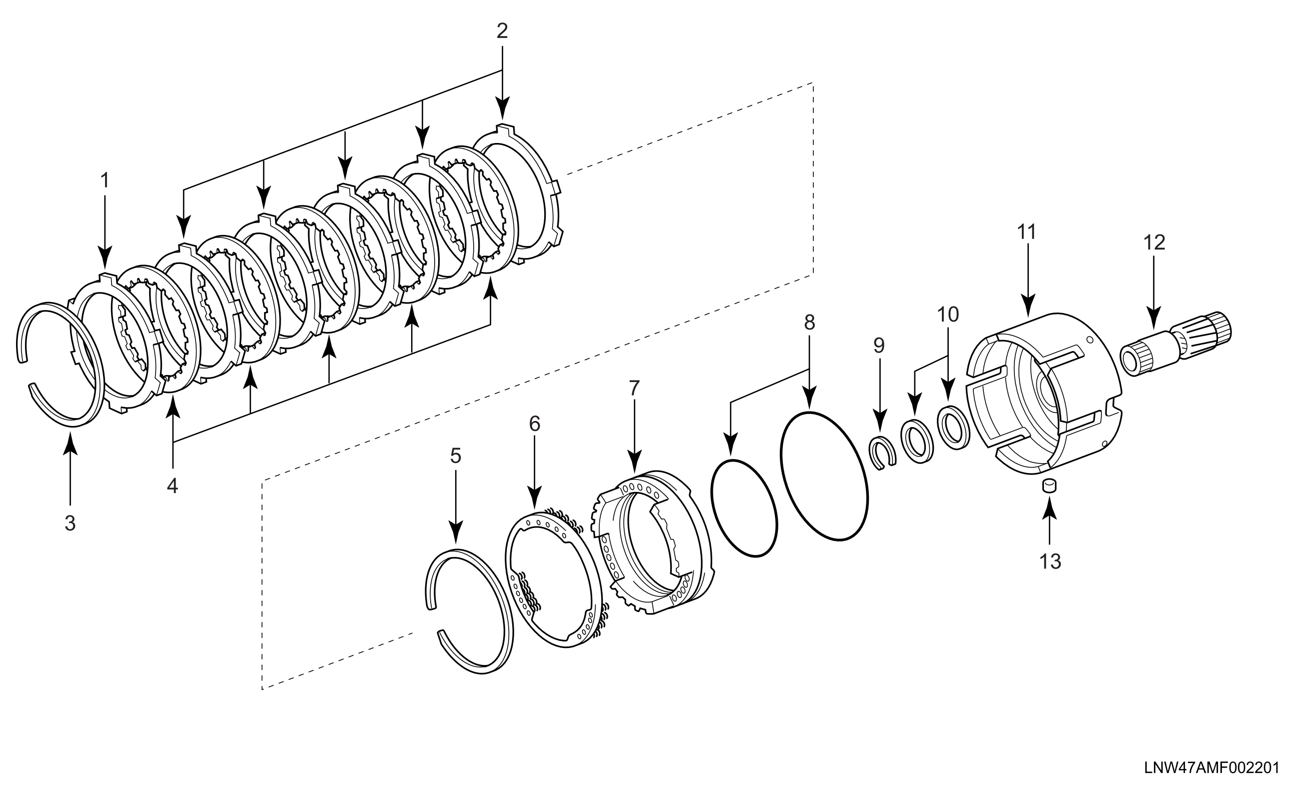
Rear Clutch



Legend

1. Snap Ring
2. Flange
3. Disc
4. Plate
5. Snap Ring
6. Piston Return Spring
7. Rear Clutch Piston
8. O-ring
9. Rear Clutch Drum

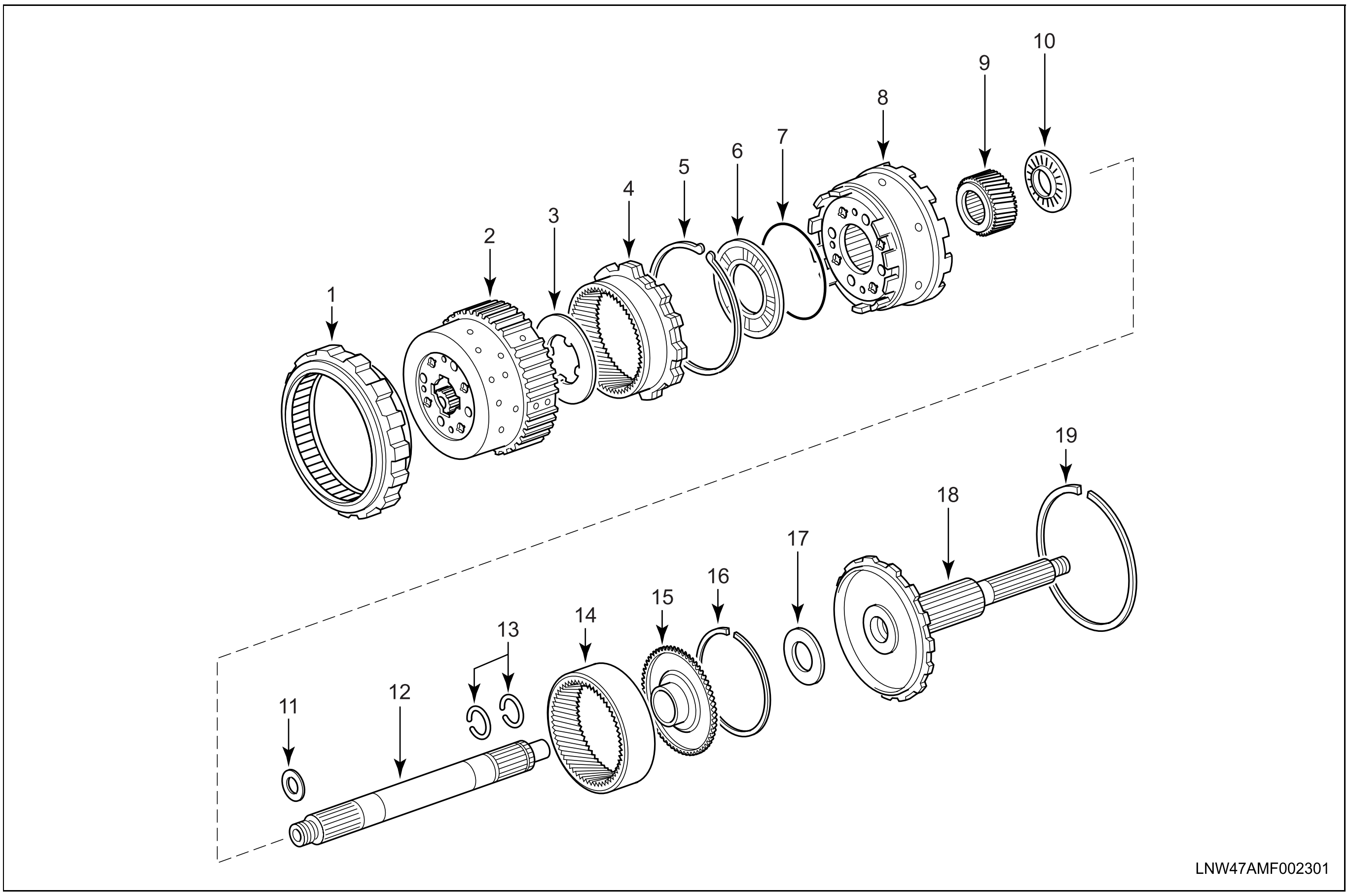
Second Brake



Legend

1. Flange
2. Plate
3. Snap Ring
4. Disc
5. Snap Ring
6. Piston Return Spring
7. Second Brake Piston
8. O-ring
9. Snap Ring
10. Oil Seal Ring
11. Center Support
12. Front Planetary Sun Gear
13. Retainer

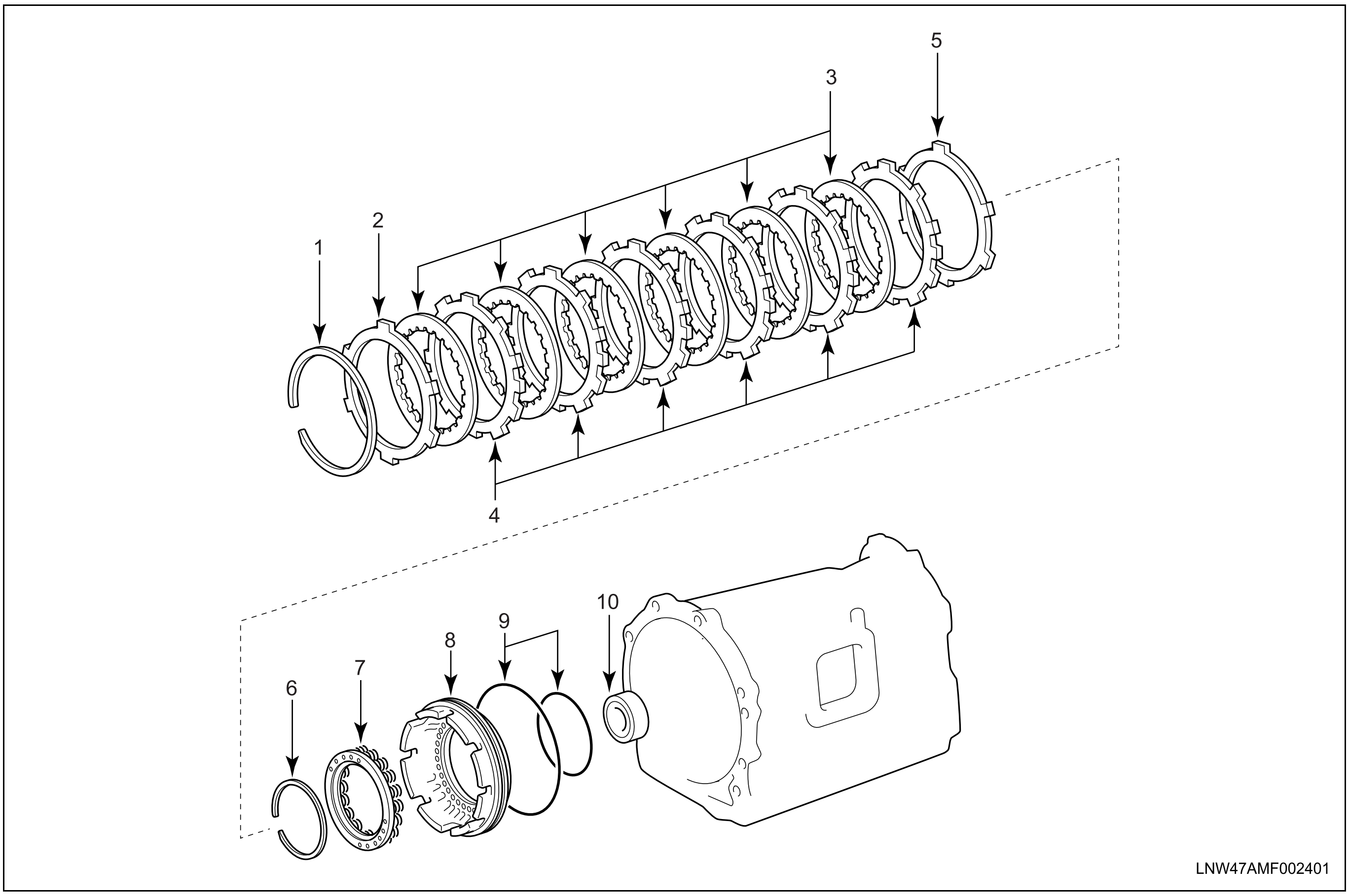
Planetary Gears, One-way Clutch and Output Shaft



Legend

1. One-way Clutch
2. Front Planetary Gear
3. No.1 Thrust Washer
4. Front Planetary Ring Gear
5. Snap Ring
6. No.2 Thrust Washer
7. O-ring
8. Rear Planetary Gear
9. Rear Planetary Sun Gear
10. Thrust Bearing
11. Oil Seal Ring
12. Intermediate Shaft
13. Snap Ring
14. Rear Planetary Ring Gear
15. Ring Gear Flange
16. Snap Ring
17. Thrust Bearing
18. Output Shaft
19. Snap Ring

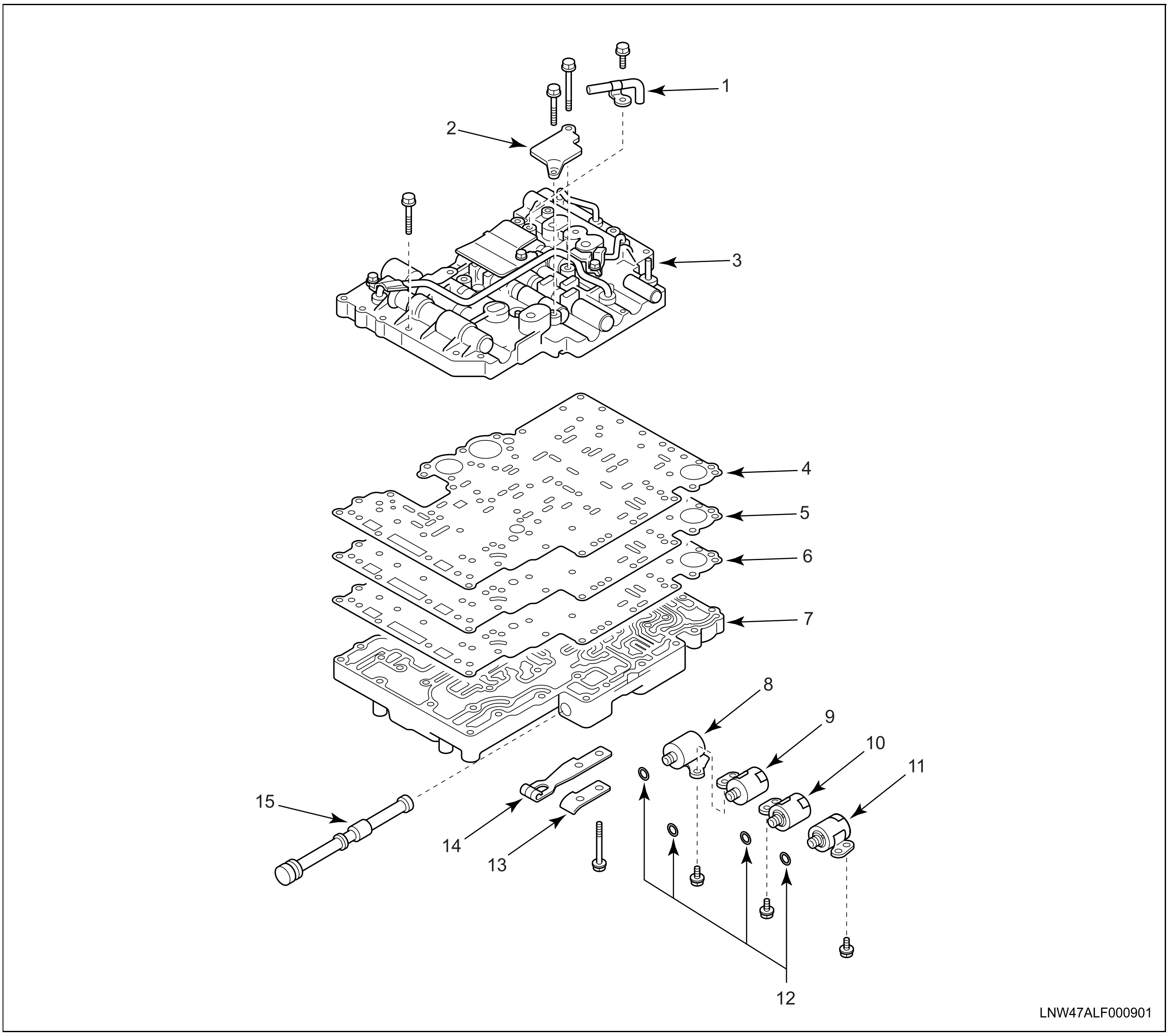
First and Reverse Brake



Legend

1. Snap Ring
2. Flange
3. Disc
4. Plate
5. Cushion Plate
6. Snap Ring
7. Piston Return Spring
8. First and Reverse Brake Piston
9. O-ring
10. Output Shaft Front Bearing

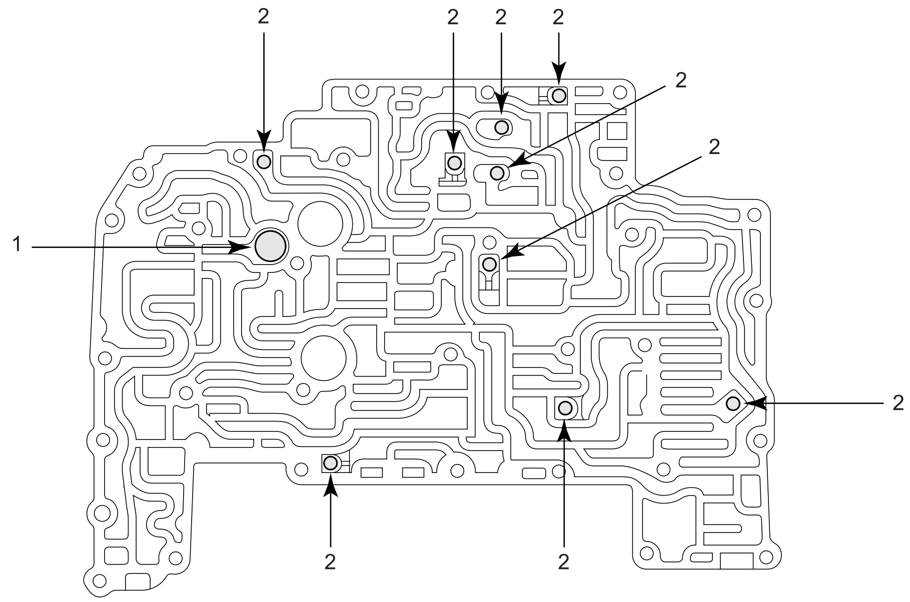
Valve Body



Legend

1. Drain Tube
2. Plate
3. Upper Valve Body
4. No.1 Gasket
5. Plate
6. No.2 Valve Body
7. Lower Valve Body
8. Torque Converter Clutch Pulse Width Modulation (TCC PWM) Solenoid Valve
9. Shift Timing Solenoid Valve
10. Shift Solenoid (S2) Valve
11. Shift Solenoid (S1) Valve
12. O-ring
13. Spring Cover
14. Manual Detent Spring
15. Manual Valve

Upper Valve Body Parts Location

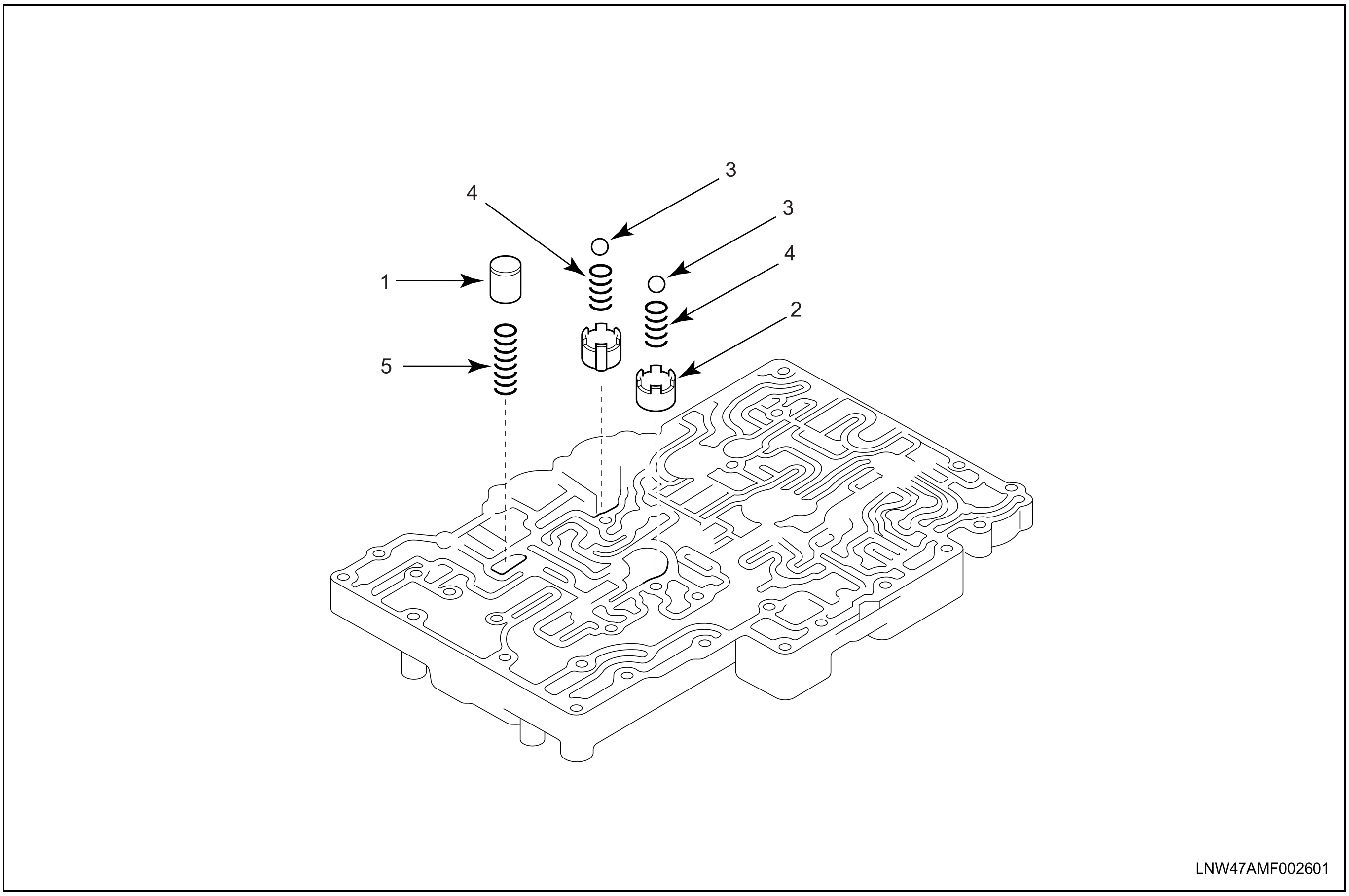


LNW47AMF002501

Legend

1. Strainer
2. Check Ball

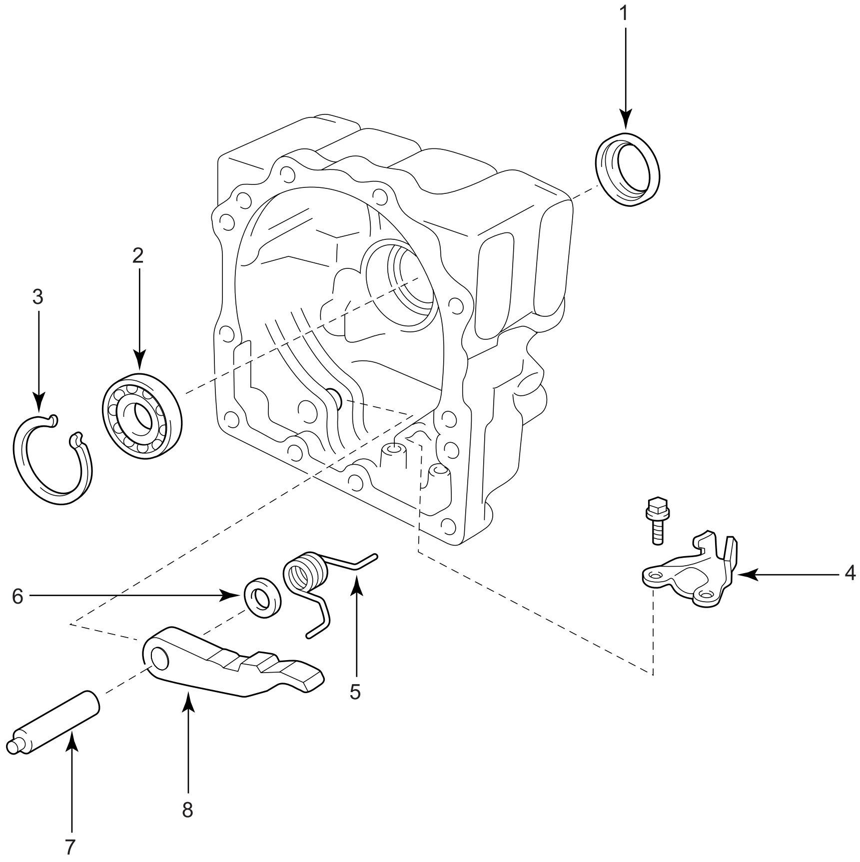
Lower Valve Body Parts Location



Legend

1. Pressure Relief Valve
2. Case
3. Check Ball
4. Check Valve (Pink)
5. Pressure Relief Valve (White)

Extension Housing



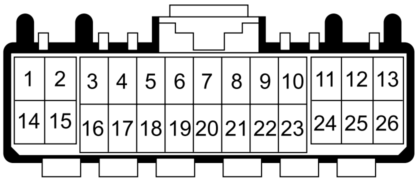
LNW47AMF002701

Legend

1. Oil Seal Ring
2. Bearing
3. Snap Ring
4. Bracket
5. Torsion Spring
6. Washer
7. Parking Lock Pawl Shaft
8. Parking Lock Pawl

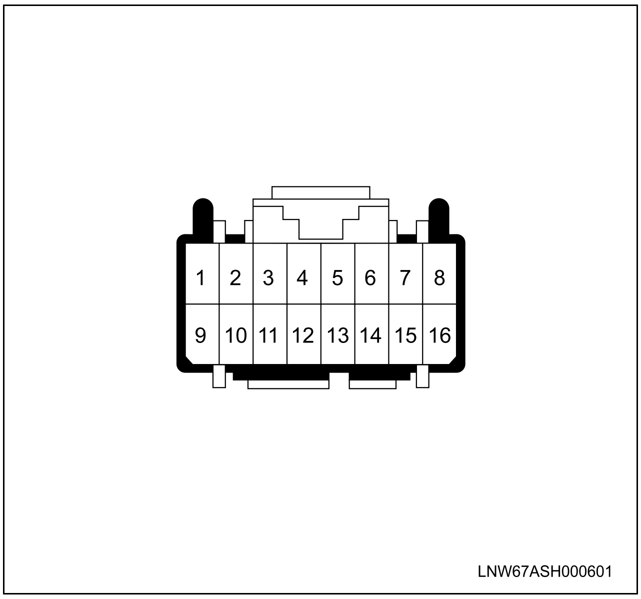
Transmission Control Module (TCM) Connector End Views

Transmission Control Module (TCM)

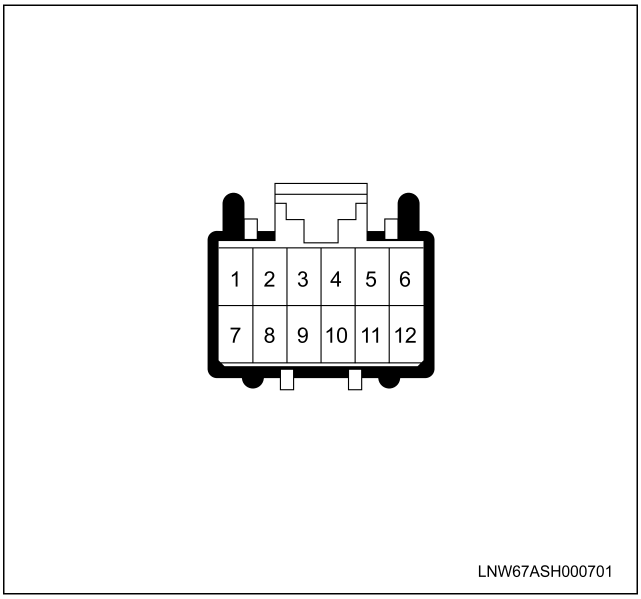


LNW67ASH000501

Connector No.		B-229
Connector Color		Gray
Test Adapter No.		J-35616-64A
Pin	Wire Color	Function
1	LT BLU	Engine Speed Signal Input
2	–	Not Used
3	YEL	Vehicle Speed Sensor (VSS) 1 (SP2) Signal
4	GRN	Input Shaft Speed Sensor (C0) Signal [12,000 lbs GVW]
5	GRY/BLK	CAN Low Signal
6	BLU/YEL	Automatic Transmission Fluid (ATF) Temperature Sensor Signal
7	–	Not Used
8	–	Not Used
9	ORN/BLK	Check Trans Lamp Control
10	–	Not Used
11	BRN/BLK	Shift Timing Solenoid Control
12	BRN/RED	Shift Solenoid (S2) Valve Control
13	BRN/YEL	Shift Solenoid (S1) Valve Control
14	–	Not Used
15	–	Not Used
16	BLU	Vehicle Speed Sensor (VSS) 1 (SP2) Low Reference
17	RED	Input Shaft Speed Sensor (C0) Low Reference [12,000 lbs GVW]
18	GRY	CAN High Signal
19	–	Not Used
20	YEL	Automatic Transmission Fluid (ATF) Temperature Sensor Low Reference
21	–	Not Used
22	BLU/WHT	MIL Turn ON Request Output [12,000 lbs GVW]
23	–	Not Used
24	BRN/WHT	Torque Converter Clutch Pulse Width Modulation (TCC PWM) Solenoid Valve Control
25	BRN/GRN	Line Pressure Solenoid Valve Low Control
26	BRN	Line Pressure Solenoid Valve High Control



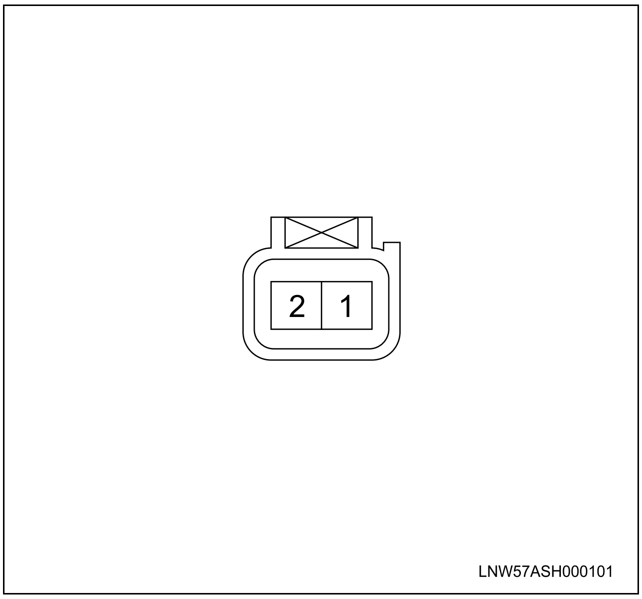
Connector No.		B-230
Connector Color		Gray
Test Adapter No.		J-35616-64A
Pin	Wire Color	Function
1	RED	Exhaust Brake Control Relay Signal
2	–	Not Used
3	–	Not Used
4	LT GRN	Exhaust Brake Cut Relay Signal
5	–	Not Used
6	ORN	Overdrive (OD) OFF Switch Input
7	YEL/GRN	Automatic Transmission Fluid (ATF) Temperature Switch Control
8	BLK/WHT	Diagnostic Switch Signal
9	WHT	Vehicle Speed Sensor (VSS) 2 (SP1) Signal
10	–	Not Used
11	–	Not Used
12	–	Not Used
13	–	Not Used
14	ORN	J1850 (Class 2) to DLC
15	–	Not Used
16	–	Not Used



Connector No.		B-231
Connector Color		Gray
Test Adapter No.		J-35616-64A
Pin	Wire Color	Function
1	BLK/YEL	Ignition Voltage Feed
2	BLK/BLU	TCM Ground
3	WHT/RED	P Range Signal Input
4	BLU	N Range Signal Input
5	–	Not Used
6	BLU/WHT	L Range Signal Input
7	–	Not Used
8	–	Not Used
9	RED/BLU	R Range Signal Input
10	BLU/ORN	D Range Signal Input
11	BLU/RED	2 Range Signal Input
12	GRN	Stop Lamp Pedal Switch (Brake Pedal 1 Switch)

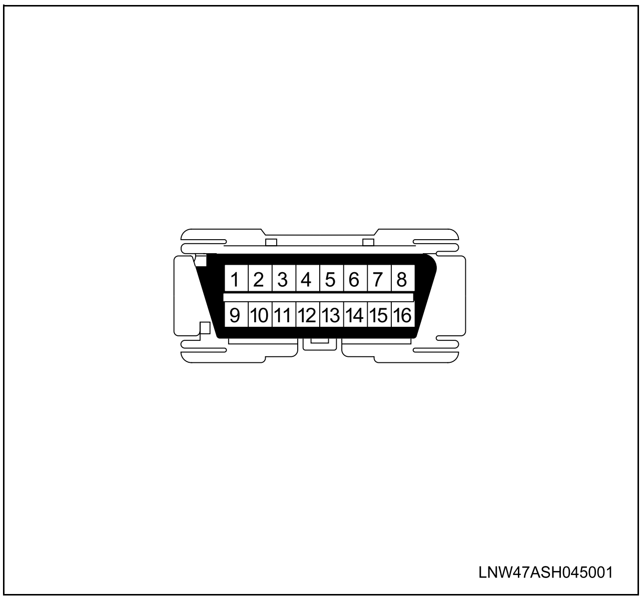
Transmission Controls Connector End Views

Automatic Transmission Fluid (ATF) Temperature Switch



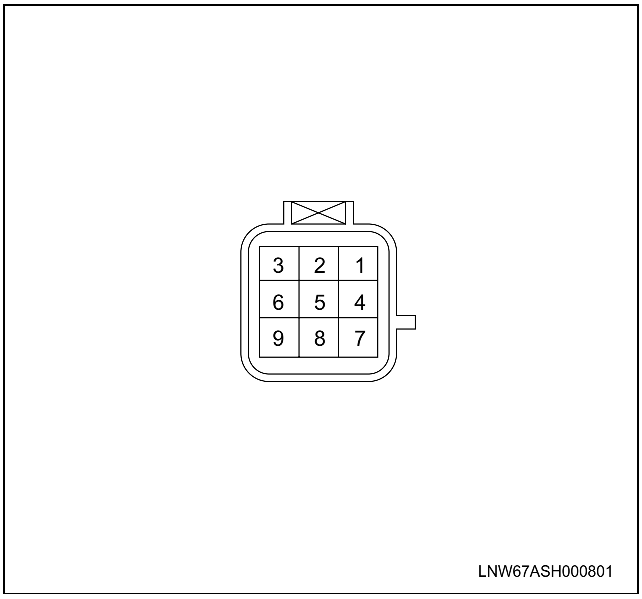
Connector No.		J-129
Connector Color		White
Test Adapter No.		J-35616-5
Pin	Wire Color	Function
1	—	Not Used
2	YEL/GRN	ATF Temperature Switch Signal

Data Link Connector (DLC)



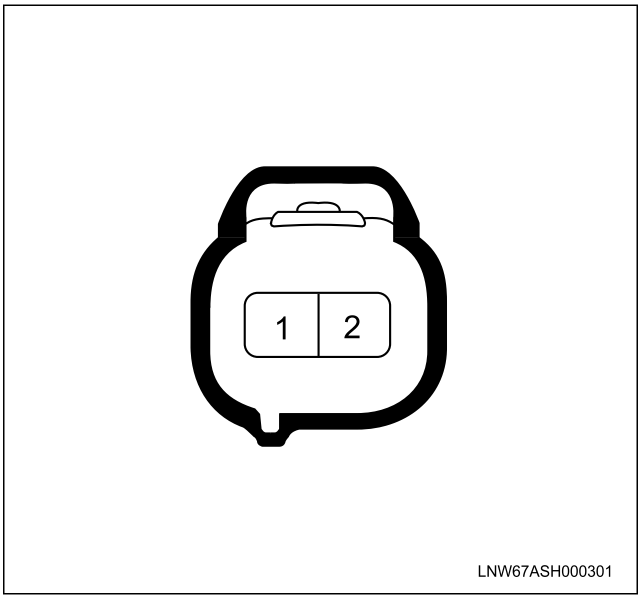
Connector No.		B-79
Connector Color		Black
Test Adapter No.		J-35616-2A
Pin	Wire Color	Function
1	—	Not Used
2	ORN	J-1850 (Class 2)
3	—	Not Used
4	BLK/BLU	Ground
5	BLK/BLU	Ground
6	—	Not Used
7	WHT	ISO 14230 (KWP2000) [Not Used]
8	—	Not Used
9	—	Not Used
10	—	Not Used
11	BLK/WHT	TCM Diagnostic Switch
12	WHT/BLU	EHCU [ABS Module] Diagnostic
13	—	Not Used
14	—	Not Used
15	—	Not Used
16	GRN	Battery Voltage Supply

Inhibitor Switch



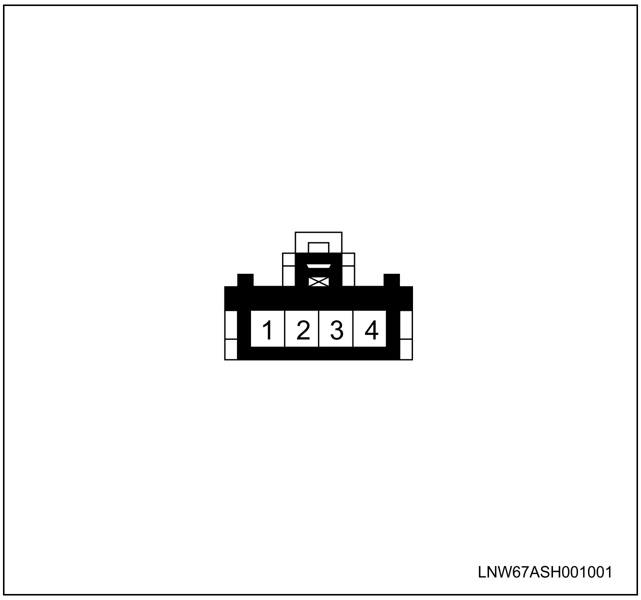
Connector No.		J-69
Connector Color		Black
Test Adapter No.		J-35616-5
Pin	Wire Color	Function
1	BLU/ORN	D Range Signal
2	BLU/RED	2 Range Signal
3	BLU/WHT	L Range Signal
4	RED/BLU	R Range Signal
5	BLU	N Range Signal
6	WHT/RED	P Range Signal
7	BLK/YEL	Ignition Voltage Feed
8	PNK	Starter Cut Control
9	BLK	Ground

Input Shaft Speed Sensor (C0) [12,000 lbs GVW]



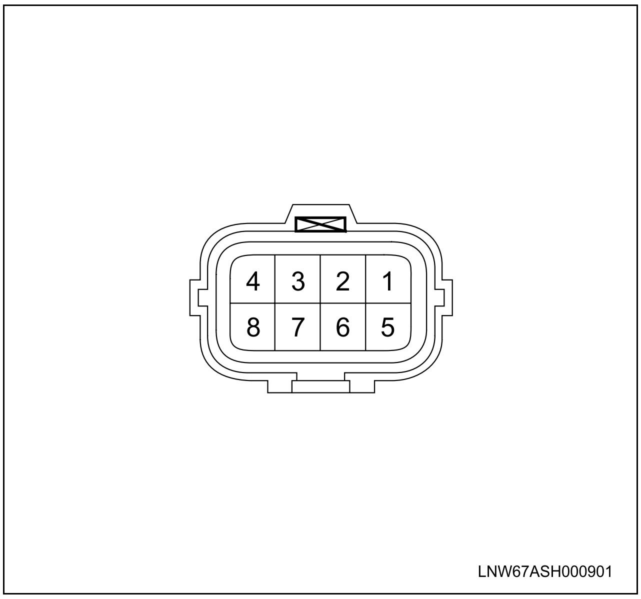
Connector No.		J-240
Connector Color		Gray
Test Adapter No.		J-35616-64A
Pin	Wire Color	Function
1	GRN	Sensor High Signal
2	RED	Sensor Low Signal

Overdrive (OD) OFF Switch



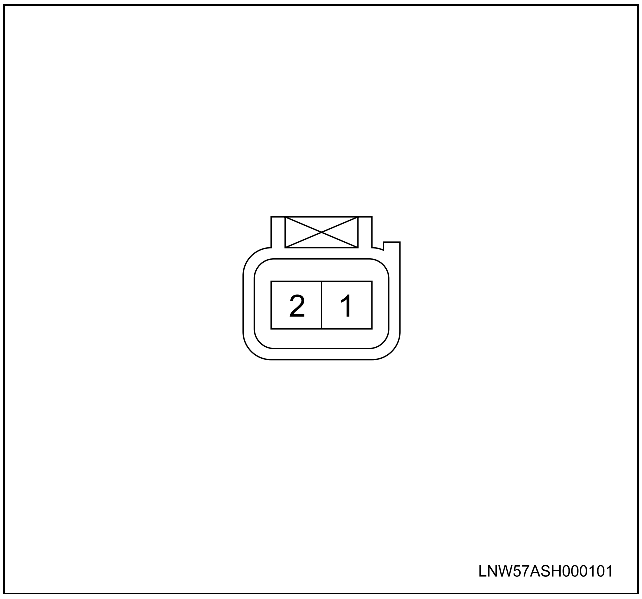
Connector No.		N-1
Connector Color		White
Test Adapter No.		J-35616-64A
Pin	Wire Color	Function
1	LT GRN/ RED	Illumination Lamp +12V Feed
2	LT GRN/ BLK	Illumination Lamp Ground
3	ORN	OD OFF Switch Signal
4	BLK	OD OFF Switch Ground

Solenoids and Automatic Transmission Fluid (ATF) Temperature Sensor in-line Connector



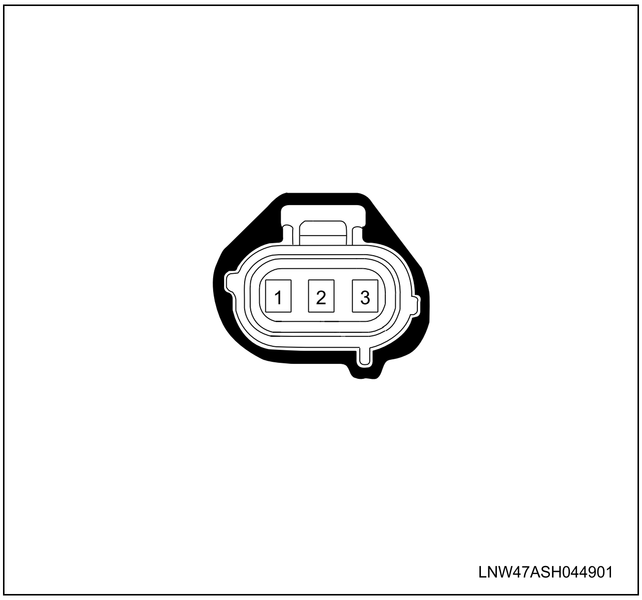
Connector No.		J-71
Connector Color		White
Test Adapter No.		J-35616-5
Pin	Wire Color	Function
1	BRN/YEL	Shift Solenoid (S1) Valve Control
2	BRN/RED	Shift Solenoid (S2) Valve Control
3	BRN/BLK	Shift Timing Solenoid Valve Control
4	BRN	Line Pressure Solenoid Valve High Control
5	BRN/WHT	Torque Converter Clutch Pulse Width Modulation (TCC PWM) Solenoid Valve Control
6	YEL	ATF Temperature Sensor Low Reference
7	BLU/YEL	ATF Temperature Sensor Signal
8	BRN/GRN	Line Pressure Solenoid Valve Low Control

Vehicle Speed Sensor (VSS) 1 (SP2) Connector



Connector No.		J-73
Connector Color		Black
Test Adapter No.		J-35616-5
Pin	Wire Color	Function
1	BLK	Sensor High Signal
2	YEL/RED	Sensor Low Signal

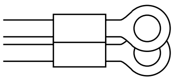
Vehicle Speed Sensor (VSS) 2 (SP1)



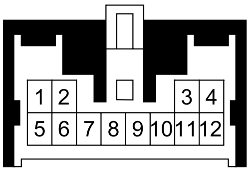
Connector No.		J-32
Connector Color		Gray
Test Adapter No.		J-35616-64A
Pin	Wire Color	Function
1	RED/GRN	Sensor +12V Feed
2	BLK	Sensor Low Reference
3	YEL/GRN	Sensor Signal

Harness Connector Views

B-1

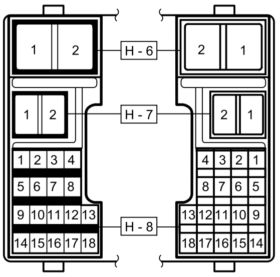


B-53(WHT)



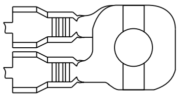
Test Adapter No. : J-35616-64A

H-6, H-7 H-8(GRY)

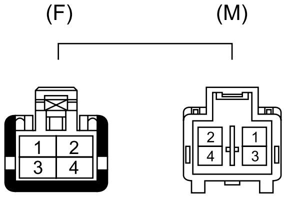


Test Adapter No. : H-7(F) J-35616-42
H-7(M) J-35616-43
H-8(F) J-35616-64A
H-8(M) J-35616-3

B-7

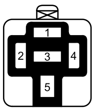


B-67(WHT)



Test Adapter No. : (F) J-35616-42
(M) J-35616-43

B-19,B-20,B-21,B-38(BLK)

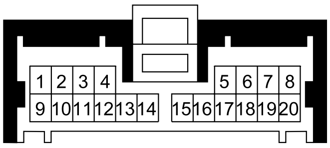


Test Adapter No. : J-35616-42

H-4(WHT)

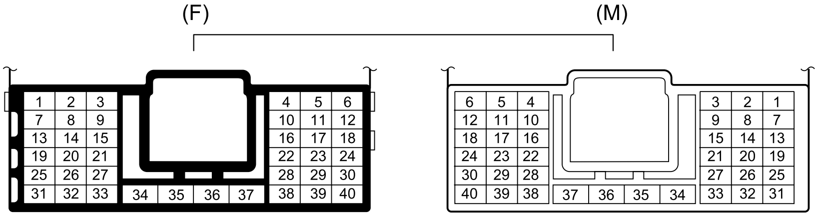
Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

B-51(GRY)



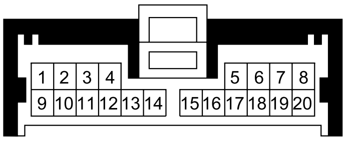
Test Adapter No. : J-35616-64A

H-5(GRY)



Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

B-52(WHT)



Test Adapter No. : J-35616-64A

H-12(WHT)

Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

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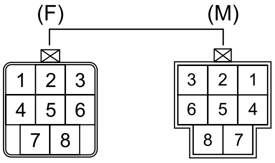
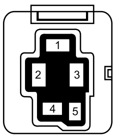
H-105(BLK)



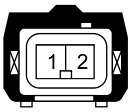
Test Adapter No. : (F) J-35616-64A[Pin 1-6]
(F) J-35616-42[Pin 7-8]
(M) J-35616-5[Pin 1-6]
(M) J-35616-43[Pin 7-8]

J-12(BLK)



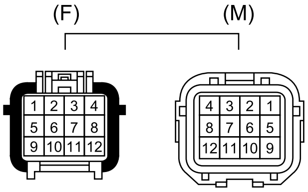
Test Adapter No. : J-35616-42

J-40(BRN)



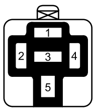
Test Adapter No. : J-35616-4A

H-124(BLK)



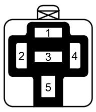
Test Adapter No. : (F) J-35616-64A
(M) J-35616-3

J-18(BLK)



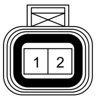
Test Adapter No. : J-35616-42

J-209,J-210(BLK)



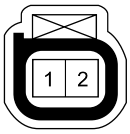
Test Adapter No. : J-35616-42

J-1(GRY)



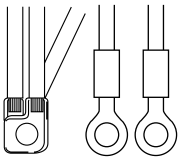
Test Adapter No. : J-35616-42

J-31(BLK)

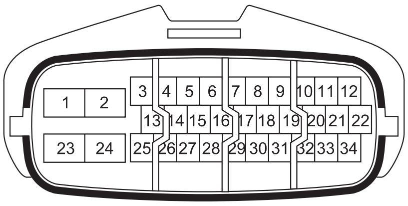


Test Adapter No. : J-35616-64A

J-9

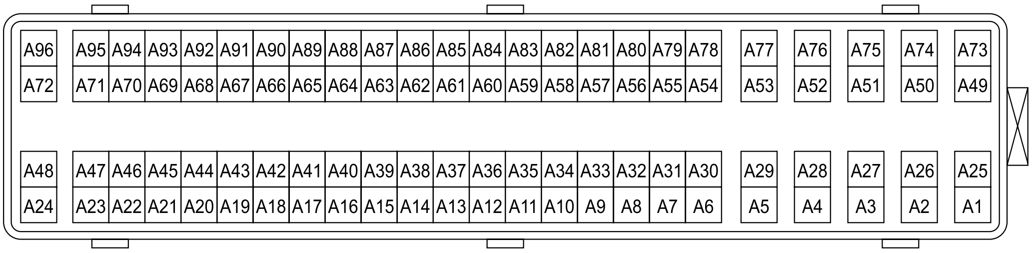


J-177(BLK)



Test Adapter No. : J-35616-40[Pin 1,2,23,24]
J-35616-64A[Pin 3-22,25-34]

J-218(BLK)



Test Adapter No. : J-35616-64A

LNW67AXF000301

Harness Connector Locations

Inlines

No.	Connection	Location
H-4	Body H. - Frame H.	Lower center of dash.
H-5	Body H. - Frame H.	Lower center of dash.
H-6	Body H. - Frame H.	Lower center of dash.
H-7	Body H. - Frame H.	Lower center of dash.
H-8	Body H. - Frame H.	Lower center of dash.
H-12	Body H. - Floor H. (LH)	Under the instrument panel lower cover of the driver side.
H-124	Body H. - Frame H.	Behind front cross member.

Joints

No.	Joint	Location
B-379	Joint Connection L1	Under the instrument panel lower cover of the driver side, near the terminal B-67.
B-380	Joint Connection M1	Lower center of dash.
B-381	Joint Connection M5	Back of the fuse box in the glove box.
	W/S-L2	Under the instrument panel lower cover of the driver side (This is not a connector. Harnesses are twisted and covered by a tube).
	W/S-M1	Lower center of dash (This is not a connector. Harnesses are twisted and covered by a tube).
	W/S-M2	Lower center of dash (This is not a connector. Harnesses are twisted and covered by a tube).
	W/S-M3	Lower center of dash (This is not a connector. Harnesses are twisted and covered by a tube).
	W/S-M4	Back of the fuse box in the glove box (This is not connector. Harnesses are twisted and covered by a tube).
	W/S Joint-1	Behind front cross member, near terminal H-124 (This is a not a connector. Harnesses is twisted and covered by a tube).
	W/S Joint-2	Inner side of left rear frame, near terminal H-122 (This is not a connector. Harnesses are twisted and covered by a tube).

Grounds

No.	Ground	Location
B-1	Frame-LH Front Ground	Bolted to front cross member, near in-line connector H-124.
B-7	Head Light Bracket-LH Ground	Bolted to the body under near the left turn signal light.
J-9	Frame-LH Center Ground	Bolted to the left frame, ahead of front tire.

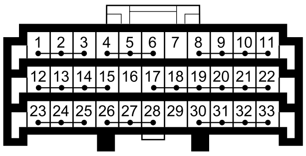
Others

No.	Connection	Location
B-19	Charge Relay	In the relay box behind the cab.
B-38	Exhaust Brake Relay	In the relay box at the dash.
B-51	IPC A	Instrument panel cluster (IPC).

No.	Connection	Location
B-52	IPC B	Instrument panel cluster (IPC).
B-53	IPC C	Instrument panel cluster (IPC).
B-66	Stop Light Switch	Above the brake pedal.
B-67	Ignition Switch	Behind the steering cowl.
B-69	Exhaust Brake Switch (Combination Switch)	Behind the steering cowl.
J-12	Starter Relay	In the relay box behind the cab.
J-18	Exhaust Brake Control Relay	In the relay box behind the cab.
J-31	Exhaust Brake Magnetic Valve	On the exhaust pipe, near the silencer.
J-40	Intake Throttle Solenoid Valve	On the frame the left side, near the intake throttle diaphragm.
J-177	Electronic Hydraulic Control Unit (EHCU) ABS Module	Behind the rear cross member.
J-209	Starter Cut Relay	In the relay box behind the cab.
J-210	Exhaust Brake Cut Relay	In the relay box behind the cab.
J-211	Diode	In the relay box behind the cab.
J-218	Engine Control Module (ECM)	Frame side (LH)
N-1	Overdrive Off Switch	In the AT shift lever.

Joint Connection Distribution

B-379 Joint Connection-L1

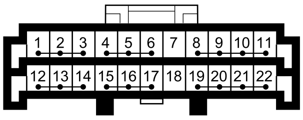


Test Adaptor No. :J-35616-64A

Joint Point	PIN No.	Connection
	1	W/S-L2
	2	A/T Lever Illumination(+)
	3	—
	4	Frame Ground
	5	Instrument Panel Cluster(IPC)(B) Ground
	6	Instrument Panel Cluster(IPC)(C) Ground
	7	—
	8	—
	9	—
	10	—
	11	—
	12	Frame Ground
	13	Data Link Connector(DLC) Ground
	14	Transmission Control Module(TCM) Ground
	15	—
	16	—

Joint Point	PIN No.	Connection
	17	Joint Connection M5
	18	OD OFF Ground(A/T)/Seat Belt Switch Ground(M/T)
	19	—
	20	Pressure Switch / Vacuum Pump
	21	Power Window Switch(DR) Ground
	22	—
	23	Brake Light
	24	Brake Light Switch
	25	Transmission Control Module(TCM) Brake Light Input
	26	EHCU(ABS Module) Class2
	27	Data Link Connector Class2
	28	Transmission Control Module(TCM) Class2
	29	—
	30	W/S-M3
	31	A/T Lever(Illumination(−))
	32	—
	33	—

B-380 Joint Connection-M1

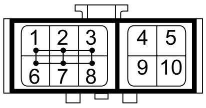


Test Adaptor No. :J-35616-64A

Joint Point	PIN No.	Connection
	1	Brake Fluid Level Switch
	2	Instrument Panel Cluster(IPC)(A) Parking Brake Inhibitor Light
	3	D.R.L / HBB Oil Level Sensor
	4	Charge Relay Voltage Feed
	5	Generator(L)
	6	—
	7	—
	8	W/S-M4
	9	Transmission Control Module(TCM) IGN Voltage Feed
	10	Power Window Relay Voltage Feed
	11	Vacuum Pump Relay Voltage Feed

Joint Point	PIN No.	Connection
	12	Fan Switch
	13	Electro Thermo
	14	Ceramic Heater
	15	Parking Brake Switch
	16	D.R.L
	17	Buzzer Cancel Relay
	18	—
	19	Fuse Box ECM(IGN)
	20	ECM Ignition Voltage Feed
	21	Clutch Switch
	22	PTO Switch

B-381 Joint Connection-M5



Test Adaptor No. :J-35616-42

Joint Point	PIN No.	Connection
	1	Headlight Bracket Ground
	2	W/S-L1
	3	W/S-M1
	4	—
	5	—
	6	Joint Connection L1
	7	W/S-R1
	8	—
	9	—
	10	—

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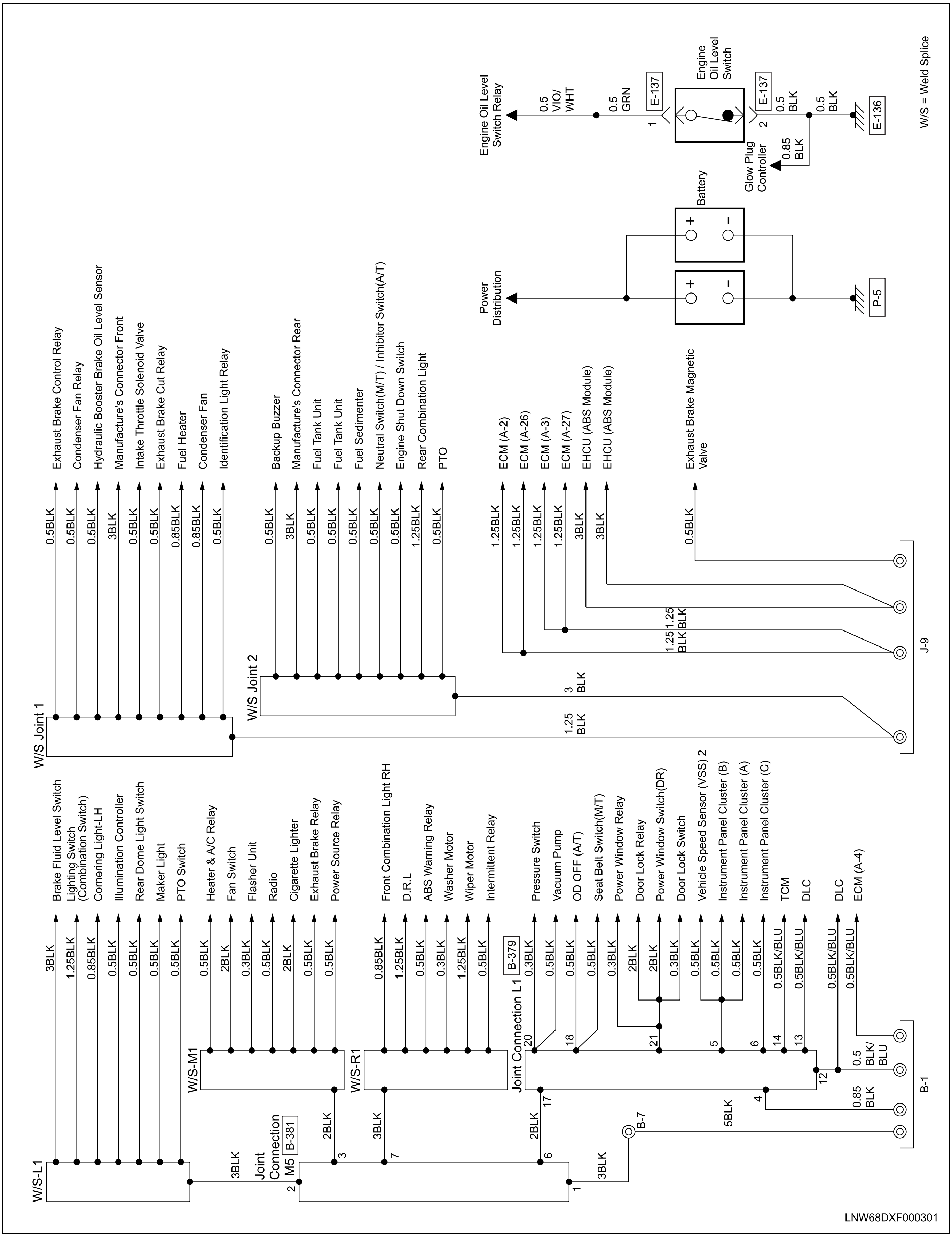
Weld Splice (W/S) Distribution

W/S-L1	Joint Connection M5
	Brake Fluid Level Switch Ground
	Cab Interior Light Switch Ground
	Dome Light Ground
	Front Turn Signal Light LH Ground
	Illumination Controller Ground
	PTO Switch Ground
	Rear Dome Light Switch Ground
W/S-L2	Joint Connection L1
	W/S-M2
	Cruise Resume Switch
	Front Turn Signal Light LH
	Illumination Controller
	Oil Level Check Switch
W/S-M1	Joint Connection M5
	Cigar Lighter Ground
	Fan Switch Ground
	Flasher Unit Ground
	Heater A/C Relay Ground
	Power Source Relay Ground
	Radio Ground
W/S-M2	W/S-L2
	Ashtray Illumination
	Cigar Lighter Illumination
	Cruise Main Switch
	Cruise Set Coast Switch
	Front Turn Signal Light RH
	Hazard Warning Switch
	Heater Bezel
	License Plate Light
	Instrument Panel Cluster (IPC) (A) Illumination (+)
	PTO Switch
	Radio
	Tail Relay Control

W/S-M3	Joint Connection L1
	Ashtray Illumination Ground
	Cigar Lighter Illumination Ground
	Cruise Main Switch Ground
	Cruise Resume Accel Switch Ground
	Cruise Set Coast Switch Ground
	Hazard Warning Switch Ground
	Heater Bezel Ground
	Illumination Controller
	Instrument Panel Cluster (IPC) (B) Illumination (-)
	Oil Level Check Switch Ground
	PTO Switch Ground
	Radio Ground
W/S-M4	Joint Connection M1
	ABS Relay Voltage Feed
	Buzzer Cancel Relay Voltage Feed
	Cornering Relay Voltage Feed
	Gauges(IDA) Fuse
	Inhibitor Switch
	Vehicle Speed Sensor Voltage Feed
	Instrument Panel Cluster (IPC) (A) Voltage Feed
W/S-R1	Joint Connection M5
	ABS Relay Ground
	D.R.L
	Front Turn Signal Light RH Ground
	Intermittent Relay Ground
	Washer Motor Ground
	Wiper Motor Ground

W/S-JOINT 1	Frame Ground
	Exhaust Brake Control Relay Ground
	Condenser Fan Relay Ground
	Hydraulic Booster Brake (HBB) Oil Level Sensor Ground
	Manufacture Connector Front Ground
	Intake Throttle Solenoid Valve
	Exhaust Brake Cut Relay Ground
	Fuel Heater Ground
	Condenser Fan Ground
	Identification Light Relay Ground
W/S-JOINT 2	Backup Buzzer Ground
	Manufacture Connector Rear Ground
	Fuel Tank Unit Ground
	Rear Combination Light Ground
	Fuel Sedimenter Ground
	Engine Shut Down Switch
	Frame Ground
	PTO Ground
	Fuel Tank Unit Ground
	Inhibitor Switch (A/T)
	Neutral Switch (M/T)

Ground Distribution



Diagnostic Information and Procedures

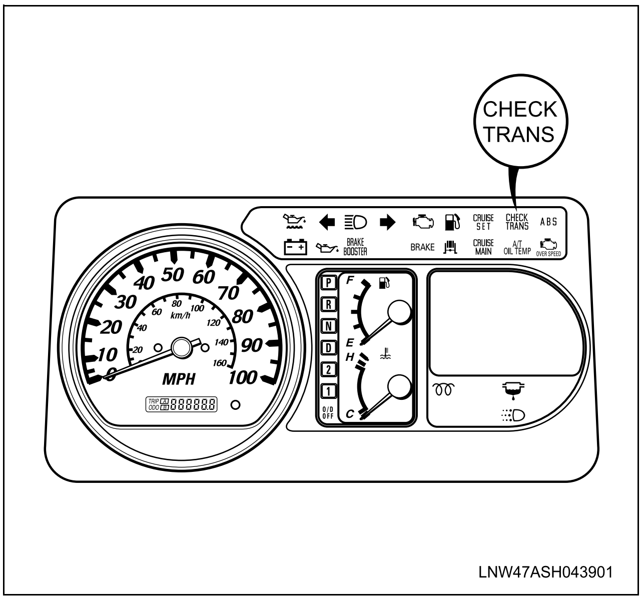
Diagnosis Procedure

When the automatic transmission is malfunctioning, something is wrong with the mechanical system, electrical system such as the hydraulic circuit, friction element or transmission control module (TCM). At the time of diagnosis, perform the self-diagnosis function, a stall test, a line pressure test or a road test to reproduce the malfunction so as to fully understand what is out of order before starting inspection, adjustment or overhaul.

Self Diagnosis Information

The transmission control module of this system has the function of self diagnosis. If any trouble occurs in this system, the check trans lamp functions to inform the operator of possible troubles related to the following 17 items.

1. Engine Speed Signal
2. Input Shaft Speed Sensor (C0) [12,000 lbs GVW]
3. Vehicle Speed Sensor (VSS) 1 (SP2) (Installed on the Transmission)
4. Vehicle Speed Sensor (VSS) 2 (SP1) (Fitted on the speedometer driven gear)
5. Shift Solenoid (S1) Valve
6. Shift Solenoid (S2) Valve
7. Torque Converter Clutch Pulse Width Modulation (TCC PWM) Solenoid Valve
8. Shift Timing Solenoid Valve
9. Line Pressure Solenoid Valve
10. Automatic Transmission Fluid (ATF) Temperature Sensor
11. Automatic Transmission Fluid (ATF) Temperature Switch [12,000 lbs GVW]
12. Inhibitor Switch
13. ABS operation signal (Exhaust brake cut signal)
14. Exhaust brake cut request
15. TCM Interface (ROM/RAM) [12,000 lbs GVW]
16. CAN Bus Communication
17. CAN Parameter

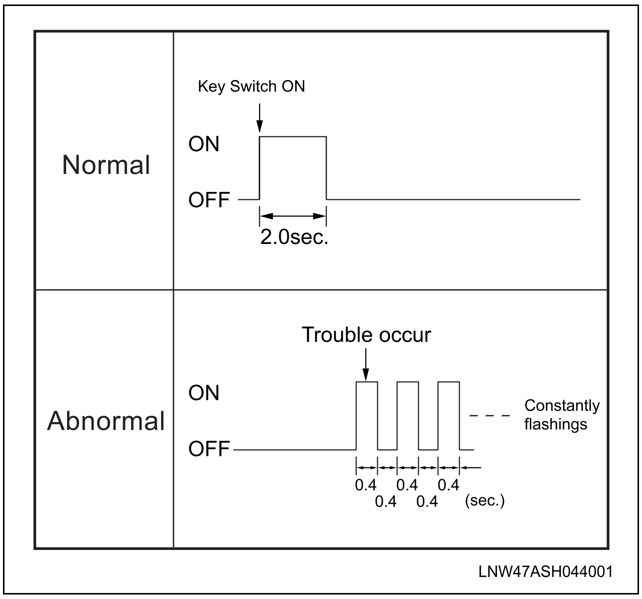


LNW47ASH043901

Indication of the Check Trans Lamp with the Ignition Turned On (User Mode)

When the throttle position sensor, vehicle speed sensor, solenoids, etc., begin to malfunction when the vehicle is running (the ignition turned on), the check trans lamp blinks to warn the driver.

- The check trans lamp begins to blink as soon as a problem occurs during driving, and keeps blinking until it is corrected.



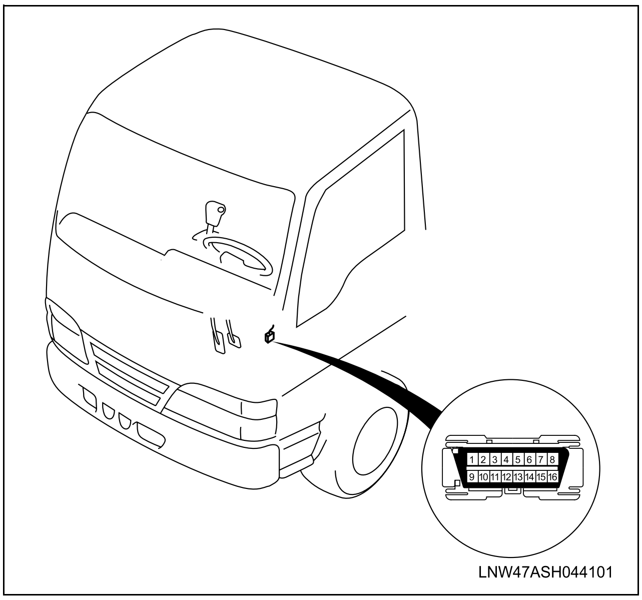
LNW47ASH044001

Indication of the Check Trans Lamp During Self-Diagnosis (Dealer Mode)

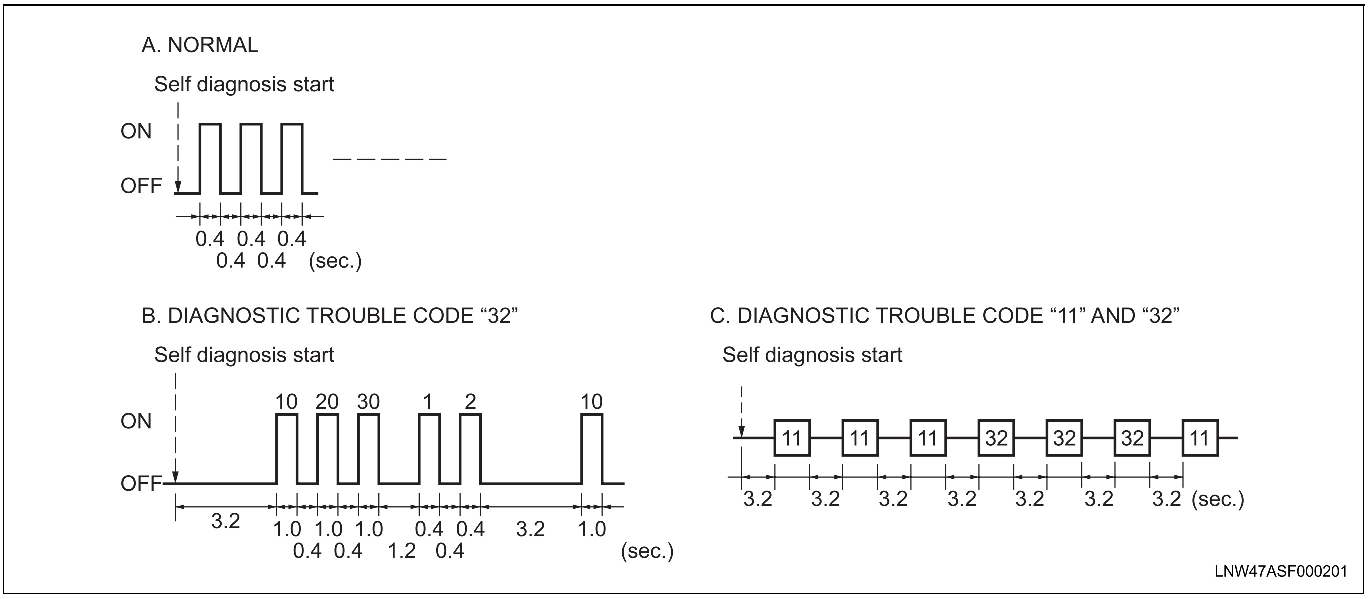
To help the technician locate the problem more easily, the check trans lamp blinks in different cycles. Each cycle represents one of the eleven possible sources of the problem.

Indication of Self-Diagnostic Results

A diagnostic trouble code (DTC) registered in memory can be displayed by the connection of terminal 11 and terminal 4 or 5 of the data link connector (DLC).
The DLC is the black 16 pin connector that is tied to the support bracket located to the left of the steering column.



- When no problem exists, the display flashes “1” repeatedly.
- When a malfunction exists, the appropriate DTC is displayed three times repeatedly.
- When two or more DTCs are registered, they are all displayed three times repeatedly, one at a time, starting with the lowest code number.



Cleaning Memory of The Diagnosis Trouble Code (DTC)

1. To clear the memory in TCM, use Scan Tool.
2. To clear the memory in TCM without Scan Tool, perform the overdrive (OD) OFF switch ON-OFF more than three times at 5 seconds at following conditions.

- Turn ON the ignition, with the engine OFF.
  (= No engine RPM/No vehicle speed)
- Connect terminal 11 and terminal 4 or 5 of the DLC.
  (= Self-diagnosis is started)
- Select “N”(Neutral) range.
  (= “N”range signal is sent)
- Depress brake pedal fully.
  (= Brake switch is ON)

If the memory is cleared using this procedure, the check trans lamp will flash quickly (“ON” for 0.2 sec, “OFF” for 0.2 sec) for 10 seconds.

Diagnostic System Check - Transmission Controls

Diagnostic Starting Point - Transmission Controls

Begin the system diagnosis with Diagnostic System Check - Transmission Controls. The Diagnostic System Check - Transmission Controls will provide the following information:

- The identification of the control modules which command the system.
- The ability of the control modules to communicate through the serial data circuit.
- The identification of any stored diagnostic trouble codes (DTCs).

The use of the Diagnostic System Check-Transmission Controls will identify the correct procedure for diagnosing the system and where the procedure is located.

Diagnostic System Check - Transmission Controls

Description

The Diagnostic System Check-Transmission Controls is an organized approach to identifying a condition that is created by a malfunction in the electronic transmission control system. The Diagnostic System Check must be the starting point for any driveability concern. The Diagnostic System Check directs the service technician to the next logical step in order to diagnose the concern. Understanding and correctly using the diagnostic table reduces diagnostic time, and prevents the replacement of good parts.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. Lack of communication may be because of a partial or a total malfunction of the class 2 serial data circuit. The specified procedure determines the particular condition.

6. The presence of DTCs which begin with U, indicate that some other module is not communicating. Following the specified procedure will gather all the available information before you perform the tests.

7. If there are other modules with DTCs set, refer to the DTC list. The DTC list directs you to the appropriate diagnostic procedure. If the control module stores multiple powertrain DTCs, diagnose the DTCs in the following order:

- Component level DTCs, such as sensor DTCs, solenoid DTCs, and relay DTCs. Diagnose the multiple DTCs within this category in numerical order. Begin with the lowest numbered DTC, unless the diagnostic table directs you otherwise.

Important:

- DO NOT perform this diagnostic if there is not a driveability concern, unless another procedure directs you to this diagnostic.
- Before you proceed with diagnosis, search for applicable service bulletins.
- Unless a diagnostic procedure instructs you, DO NOT clear the DTCs.
- If there is a condition with the starting system, refer to Diagnostic System Check - Engine Electrical in Engine Electrical.
- Ensure the battery has a full charge.
- Ensure the battery cables are clean and tight.
- Ensure the TCM grounds are clean, tight, and in the correct location.

Step	Action	Value(s)	Yes	No
1	Install a scan tool. Does the scan tool turn ON?	—	Go to Step 2	Go to Scan Tool Does Not Power Up

Step	Action	Value(s)	Yes	No
2	1. Turn ON the ignition, with the engine OFF. 2. Attempt to establish communication with the listed control modules. If you are using a scan tool, obtain the information using the Class 2 Message Monitor feature: • Engine control module (ECM) • Transmission control module (TCM) • Electronic hydraulic control unit (EHCU) ABS Module Does the scan tool communicate with all the listed control modules?	—	Go to Step 3	Go to Scan Tool Does Not Communicate with Class 2 Device
3	Attempt to start the engine. Does the engine start and idle?	—	Go to Step 4	Go to Engine Cranks But Does Not Run in Engine Control System
4	Select the DTC display function for the following control modules: • Engine control module (ECM) • Transmission control module (TCM) • Electronic hydraulic control unit (EHCU) ABS Module Does the scan tool display any DTCs?	—	Go to Step 5	Go to Step 8
5	With a scan tool, select Capture Info in order to store the TCM DTC information. Did you complete the action?	—	Go to Step 6	—
6	Does the scan tool display DTCs which begin with a U?	—	Go to Diagnostic Trouble Code (DTC) List	Go to Step 7
7	Does the scan tool display DTCs which begin with a P?	—	Go to Diagnostic Trouble Code (DTC) List	Go to Step 8
8	Is the custmer's concern with the engine?	—	Go to Diagnostic System Check - Engine Control	Go to Step 9
9	Is the customer's concern with the anti-lock brake system?	—	Go to Diagnostic System Check - Anti-lock Brake Control	Go to Step 10
10	Drive vehicle and verify if any engine or transmission related driveability concern exist. Does an engine or transmission driveability concern exist?	—	Go to Symptoms-Engine Controls in Engine Control System or Diagnosis based on vehicle condition for Transmission	System OK

Scan Tool Does Not Power Up

Circuit Description

The data link connector (DLC) is a standardized 16 cavity connector. Connector design and location is dictated by an industry wide standard, and is required to provide the following:

- Scan tool power battery positive voltage at terminal 16.
- Scan tool power ground at terminal 4.
- Common signal ground at terminal 5.

The scan tool will power up with the ignition OFF. Some modules however, will not communicate unless the ignition is ON.

Scan Tool Does Not Power Up

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views

Step	Action	Value(s)	Yes	No
1	**Important:** Make sure the scan tool works properly on another vehicle before using this chart. 1. Turn OFF the ignition. 2. Inspect the Hazard/Horn (20A) fuse in the glove fuse box. Is the Hazard/Hone (20A) fuse open?	—	Go to Step 2	Go to Step 3
2	Replace the Hazard/Horn (20A) fuse. If the fuse continues to open, repair the short to ground on one of the circuits that is fed by the Hazard/Horn (20A) fuse or replace the shorted attached component fed by the Hazard/Horn (20A) fuse. Did you complete the repair?	—	Go to Step 7	—
3	1. Check each circuit at the data link connector (DLC) for a backed out, spread or missing terminal. 2. Repair the terminal as necessary. Did you find and complete the repair?	—	Go to Step 7	Go to Step 4
4	Connect a test lamp between the B+ circuit (pin 16) at the DLC and ground. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 5
5	Repair the open in the battery voltage circuit to the DLC. Did you complete the repair?	—	Go to Step 7	—
6	1. Test each ground circuit at the DLC (pins 4 and 5) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Intermittent Conditions
7	1. Connect the scan tool to the DLC. 2. Attempt to turn ON the scan tool. Does the scan tool ON?	—	System OK	Go to Step 1

Scan Tool Does Not Communicate with Class 2 Device

Circuit Description

The engine control module (ECM), transmission control module (TCM) and electronic hydraulic control unit (EHCU) [ABS module] all communicate with the scan tool over the Class 2 serial data link. The EHCU receives transmission parameters necessary for correct ABS functions over the Class 2 link as well. However, the ECM and TCM communicate with each other over the controller area network (CAN) link. The CAN link is not used for communication with the scan tool and is shared only between the ECM and TCM (Except 12,000 lbs GVW) or between the ECM, TCM and glow plug controller (12,000 lbs GVW).

Diagnostic Aids

The following conditions will cause a loss of class 2 serial data communication between the scan tool and any control module:

- A class 2 serial data circuit open.
- A class 2 serial data circuit shorted to ground.
- A class 2 serial data circuit shorted to voltage.
- An internal condition within a module or connector on the class 2 serial data circuit, that causes a short to voltage or ground to the class 2 serial data circuit.
- Open ground circuit (pin 5) at the DLC.

The Class 2 Message Monitor may be used to determine if a control module is intermittently communicating over the Class 2 link. The scan tool will indicate INACTIVE if a module is not communicating with the ignition turned ON.

Notice:
If the control module does not communicate as soon as the ignition is turned ON, that module will not be appear on the scan tool until it initially communicates. Therefore, if the scan tool indicates INACTIVE for a module or does not display the module with the ignition ON, the module is not communicating on the Class 2 link.

Scan Tool Does Not Communicate with Class 2 Device

Schematic Reference: Transmission Controls Schematics
Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Attempt to communicate with each control module on the Class 2 serial data circuit (ECM, TCM and EHCU). If using a scan tool, obtain this information using the Class 2 Message Monitor, ping all modules feature. Does the scan tool communicate with any module on the Class 2 serial data circuit (If using a scan tool, the display must read ACTIVE for any controller)?	—	Go to Step 3	Go to Step 7
3	Does the scan tool communicate with the ECM?	—	Go to Step 4	Go to Lost Communication with the ECM
4	Does the scan tool communicate with the TCM?	—	Go to Step 5	Go to Lost Communication with the TCM
5	Does the scan tool communicate with the EHCU (ABS Module)?	—	Go to Step 6	Go to Lost Communication with the EHCU

Step	Action	Value(s)	Yes	No
6	1. Test the Class 2 serial data circuit for an intermittent short to ground or intermittent short to voltage Then test the class 2 serial data circuit for an intermittent open (based on which control module did not communicate) at the connection in the circuit. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	System OK
7	1. Test the data link connector (DLC) ground circuit at terminal 5 for an open circuit and for a poor connection. 2. Repair the circuit as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 8
8	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Turn ON the ignition leaving the engine OFF. 4. Attempt to communicate with the TCM and the EHCU (ABS Module). Does the scan tool communicate with the TCM and EHCU?	—	Go to Step 12	Go to Step 9
9	1. Turn OFF the ignition. 2. Reconnect the ECM harness connector. 3. Disconnect the TCM harness connector. 4. Turn ON the ignition leaving the engine OFF. 5. Attempt to communicate with the ECM and EHCU (ABS Module). Does the scan tool communicate with the ECM and EHCU?	—	Go to Step 13	Go to Step 10
10	1. Turn OFF the ignition. 2. Reconnect the TCM harness connector. 3. Disconnect the EHCU (ABS Module) harness connector. 4. Turn ON the ignition leaving the engine OFF. 5. Attempt to communicate with the ECM and TCM. Does the scan tool communicate with the ECM and TCM?	—	Go to Step 14	Go to Step 11
11	Repair the short to ground or short to voltage on the Class 2 serial data circuit between the DLC and ECM, TCM or EHCU (ABS Module). Did you complete the repair?	—	Go to Step 15	—

Step	Action	Value(s)	Yes	No
12	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in Engine Control System section. Did you complete the replacement?	—	Go to Step 15	—
13	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 15	—
14	Replace the EHCU (ABS Module). Refer to Electronic Hydraulic Control Unit (EHCU) Replacement in the Anti-Lock Brake section. Did you complete the replacement?	—	Go to Step 15	—
15	Attempt to communicate with the ECM, TCM and EHCU (ABS module). Does the scan tool communicate with the ECM, TCM and EHCU (ABS module)?	—	System OK	Go to Step 2

Lost Communications With The Transmission Control Module (TCM)

Circuit Description

The engine control module (ECM), transmission control module (TCM) and electronic hydraulic control unit (EHCU) [ABS module] all communicate with the scan tool over the Class 2 serial data link. The EHCU receives transmission parameters necessary for correct ABS functions over the Class 2 link as well. However, the ECM and TCM communicate with each other over the controller area network (CAN) link. The CAN link is not used for communication with the scan tool and is shared only between the ECM and TCM (Except 12,000 lbs GVW) or between the ECM, TCM and glow plug controller (12,000 lbs GVW).

Lost Communications With The Transmission Control Module (TCM)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	Attempt to establish TCM communications with the scan tool. Does the TCM communicate with the scan tool?	—	Go to Intermittent Conditions	Go to Step 3
3	Check the TCM connectors for a poor connection. Did you find and correct the condition?	—	Go to Step 11	Go to Step 4
4	1. Turn ON the ignition, with the engine OFF. 2. Check the Gauges (10A) fuse. If the fuse continues to open, check for a short to ground on each circuit fed by that fuse. 3. Turn OFF the ignition. 4. Disconnect the TCM B-231 harness connector. 5. Turn ON the ignition, with the engine OFF. 6. Connect a test lamp to ground and check for voltage at the ignition voltage supply circuit at the TCM. Does the test lamp illuminate?	—	Go to Step 5	Go to Step 8
5	Connect a test lamp between battery voltage and the TCM ground (pin 2 of B-231 connector) at the harness connector of the TCM. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 9

Step	Action	Value(s)	Yes	No
6	1. Turn OFF the ignition. 2. Connect a DMM between the Class 2 serial data circuit at the TCM and the data link connector (DLC). 3. Test the circuits for an open circuit or high resistance. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 7
7	1. Inspect for an intermittent and for poor connections on these ignition voltage, ground and Class 2 circuits at the harness connector of the TCM (pins 1 and 2 of B-231 connector and pin 14 of B-230 connector). 2. Repair the connection(s) as necessary Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
8	Repair the open in the ignition voltage circuit of the TCM. Did you complete the repair?	—	Go to Step 11	—
9	Repair the open in the ground circuit of the TCM. Did you complete the repair?	—	Go to Step 11	—
10	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 11	—
11	1. Turn OFF the ignition. 2. Reconnect all disconnected connectors. 3. Turn the ignition ON with the engine OFF. Does the scan tool communicate with the TCM?	—	System OK	Go to Step 2

Scan Tool Data Display

Transmission Scan Tool Data List

Scan Tool Parameter	Units
Delivered Engine Torque	%
Requested Torque	%
Accelerator Pedal Position	%
Engine Speed	RPM
Requested Engine Speed	RPM
Transmission ISS [12,000 lbs GVW]	RPM
Transmission OSS	RPM
Gear Ratio [12,000 lbs GVW]	0.000 : 1
Speed Meter Signal	km/h, mph
Vehicle Speed	km/h, mph
Commanded Gear	1, 2, 3, 4
Current Gear	Park/Neutral, 1st, 2nd, 3rd, 4th
Shift Solenoid 1	On/Off
Shift Solenoid 2	On/Off
Shift Timing Solenoid	On/Off
TR. Sw.	Park, Reverse, Neutral, Drive 4, Drive 2, Drive 1
Overdrive Switch	On/Off
Trans. Fluid Temp.	°C/°F
ECT	°C/°F
PC Sol. Ref. Current	amps
PC Sol. Actual Current	amps
TCC Duty Cycle	%
TCC Slip Speed [12,000 lbs GVW]	RPM
Ignition Voltage	Volts
PTO Enable	Yes/No
Diagnostic Switch	Open/Closed
Check Trans Light	On/Off
Exhaust Brake Cut Relay	On/Off
Exhaust Brake Cut Request	On/Off
ABS Signal	On/Off
Cruise Status	OFF, Hold, Decel/Coast, Accelerate
TCC Brake Switch	Applied/Released

Transmission Scan Tool Data Definitions

Delivered Engine Torque

This parameter indicates the calculated engine torque being commanded by the engine control module (ECM). This data is sent over the controller area network (CAN) serial data link from the ECM to the transmission control module (TCM).

Requested Engine Torque
This parameter indicates the calculated requested engine torque being commanded by the TCM. This data is sent over the CAN serial data link from the TCM to the ECM. Under normal conditions, the TCM will always request the maximum engine torque.

Accelerator Pedal Position
This parameter indicates the accelerator pedal position from the ECM as detected from the APP sensor. This data is sent over the CAN serial data link from the ECM to the TCM.

Engine Speed
This parameter indicates the crankshaft speed from the ECM as detected from the crankshaft position (CKP) sensor. This data is sent over the CAN serial data link from the ECM to the TCM. If the CKP sensor circuit contains a fault, the camshaft position sensor will be used to calculate engine speed and that information will be sent to the TCM.

Requested Engine Speed
This parameter indicates the engine speed requested by the TCM to the ECM. This requested engine speed will change from 8160 RPM if the vehicle is decelerating over 31 MPH (50 km/h), with the exhaust brake ON, TCC OFF and in 4th gear with the accelerator pedal at 0% throttle. This parameter is sent over the CAN serial data link from the TCM to the ECM.

Transmission ISS [12,000 lbs GVW]
This parameter indicates the overdrive direct clutch speed as detected by the input shaft speed sensor (C0). The input shaft speed sensor (C0) is on the top of the transmission front side. When the shift position is not any driving range or the gear position is 4th, the scan tool displays 0 RPM.

Transmission OSS
This parameter indicates the transmission output shaft speed as detected by the vehicle speed sensor 1. The vehicle speed sensor 1 is on the top left of the back of the transmission.

Gear Ratio [12,000 lbs GVW]
This parameter indicates the current gear ratio calculated by the TCM. The TCM calculates the gear ratio based on the input speed signal from the input shaft speed sensor (C0) and the output speed signal from the vehicle speed sensor (VSS) 1 (SP2). When the shift position is not in any driving range or the gear position is 4th, the scan tool displays 0.000:1.

Speed Meter Signal
This parameter indicates vehicle speed from the instrument panel cluster (IPC) based on the vehicle speed sensor 2 input to the IPC. The vehicle speed sensor 2 is on the right side of the transmission near the tail shaft.

Vehicle Speed
This parameter indicates vehicle speed based on the vehicle speed sensor 1 OR vehicle speed sensor 2 input to the TCM. The vehicle speed sensor 1 is on the top left of the back of the transmission. The vehicle speed sensor 2 is on the right side of the transmission near the tail shaft.

Commanded Gear
This parameter indicates the forward gear commanded by the TCM. There are four forward gears on the Asian automatic transmission not including TCC lockup.

Current Gear
This parameter indicates the forward gear calculated by the TCM based on the engine speed and transmission output shaft speed. There are four forward gears on the Asian automatic transmission not including TCC lockup.

Shift Solenoid 1
This parameter indicates the commanded ON/OFF electrical state of the shift solenoid (S1) valve. The combination of the shift solenoid (S1) valve and shift solenoid (S2) valve ON/OFF states produces gears 1 through 4.

Shift Solenoid 2
This parameter indicates the commanded ON/OFF electrical state of the shift solenoid (S2) valve. The combination of the shift solenoid (S1) valve and shift solenoid (S2) valve ON/OFF states produces gears 1 through 4.

Shift Timing Solenoid
This parameter indicates the commanded ON/OFF electrical state of the shift timing solenoid valve. The shift timing solenoid valve is used to reduce shift shock between the 2-3 upshift.

TR. Switch
This parameter indicates the transmission range selector position based on the inhibitor switch inputs at the TCM.

Overdrive Switch
This parameter indicates the Overdrive (O/D) off switch ON/OFF state based on the O/D off switch input at the TCM. When the O/D button is out, the O/D OFF light is illuminated in the I/P cluster and this parameter should read ON.

Trans. Fluid Temp.
This parameter indicates the temperature of the transmission fluid as detected by the TCM based on the signal from the automatic transmission fluid (ATF) temperature sensor. The ATF temperature sensor is located under the valve body assembly and can be accessed by removing the transmission oil pan.

ECT
This parameter indicates the engine coolant temperature (ECT) from the ECM as detected from the ECT sensor. This data is sent over the CAN serial data link from the ECM to the TCM.

PC Sol. Ref. Current
This parameter indicates the line pressure solenoid valve reference current as commanded by the TCM. Zero current to the line pressure solenoid valve equals full main line pressure and vice versa.

PC Sol. Actual Current
This parameter indicates the line pressure solenoid valve actual current as detected by the TCM. Zero current to the line pressure solenoid valve equals full main line pressure and vice versa.

TCC Brake Switch
This parameter indicates the ON (brake pedal depressed)/OFF (brake pedal released) state of the stop lamp switch as indicated at the input of the TCM. Battery voltage at the TCM input indicates the brake pedal is being depressed.

TCC Duty Cycle
This parameter indicates the percent ON-time the TCM is electrically commanding to the torque converter clutch pulse width modulation (TCC PWM) solenoid valve. 100% on time indicates the TCC is hydraulically OFF (locked up) and vice versa.

TCC Slip Speed [12,000 lbs GVW]
This parameter indicates the difference in RPM between engine speed and the transmission input shaft speed (overdrive direct clutch speed). If there is no slip speed, this parameter will indicate near 0 RPM indicating there in no loss of speed in the torque converter or the transmission clutch pack for that commanded gear.

Ignition Voltage
This parameter indicates the voltage level at the ignition voltage supply input of the TCM.

PTO Enable
This parameter indicates the PTO enable switch ON/OFF state based on the PTO enable switch input at the ECM. The parameter is sent by the ECM to the TCM over the CAN serial data link.

Diagnostic Switch
This parameter indicates the diagnostic switch open or closed (grounded) state based on the diagnostic switch input at the TCM. The diagnostic switch can be used to pull and clear diagnostic trouble codes without the use of a scan tool. There is a specific procedure listed in this section that describes how this is accomplished.

Check Trans Light
This parameter indicates the TCM commanded ON/OFF state of the check trans lamp.

Exhaust Brake Cut Relay
This parameter indicates the exhaust brake solenoid voltage feedback at the exhaust brake input of the TCM. Exhaust brake ON indicates a high voltage (battery voltage) at the solenoid and OFF indicates a low voltage at the solenoid.

Exhaust Brake Cut Request
This parameter indicates the states of the exhaust brake cut request from the TCM to the engine control module (ECM) over the controller area network (CAN) serial data link. The TCM requests to cut the exhaust brake according to the torque converter clutch (TCC) state and shift control state. If the TCM requests to cut the exhaust brake to the ECM, the scan tool displays ON.

ABS Signal
This parameter indicates the exhaust brake cut relay (switch side) voltage feed back. The electronic hydraulic control unit (EHCU) [ABS module] turns ON the exhaust brake cut relay when the ABS is active. When the exhaust brake cut relay is OFF the exhaust brake cut signal (ABS signal) voltage is ignition voltage (the relay is normally closed), and the scan tool displays OFF.

Cruise Status
This parameter indicates the commanded OFF, HOLD, DECEL/COAST or ACCELERATE status of the cruise control system. This parameter is sent from the ECM to the TCM over the CAN serial data link.

Scan Tool Output Controls

Following items are performed with the ignition ON with the engine OFF, and the shift position at the P range.

Scan Tool Output Control	Descriptions
Check Transmission Lamp	The purpose of this test is for checking whether the Check Trans lamp is operative when it is commanded ON. Faulty circuit(s) or an opened bulb could be considered when not operating with command.
TCC Control Solenoid	The purpose of this test is for checking whether the TCM operates the torque converter clutch pulse width modulation (TCC PWM) solenoid valve correctly with command. The TCC Duty Cycle parameter indicates 100% when commanded ON, and the TCC Duty Cycle parameter indicates 0% when commanded OFF.

Scan Tool Output Control	Descriptions
Shift Solenoid 1	The purpose of this test is for checking whether the TCM operates the shift solenoid (S1) valve correctly with command. The Shift Solenoid 1 parameter indicates ON when commanded ON, and the Shift Solenoid 1 parameter indicates OFF when commanded OFF.
Shift Solenoid 2	The purpose of this test is for checking whether the TCM operates the shift solenoid (S2) valve correctly with command. The Shift Solenoid 2 parameter indicates ON when commanded ON, and the Shift Solenoid 2 parameter indicates OFF when commanded OFF.
Shift Timing Solenoid	The purpose of this test is for checking whether the TCM operates the shift timing solenoid valve correctly with command. The Shift Timing Solenoid parameter indicates ON when commanded ON, and the Shift Timing Solenoid parameter indicates OFF when commanded OFF.
PC Solenoid	The purpose of this test is for checking whether the TCM operates the line pressure solenoid valve correctly with command. The PC Sol. Actual Current parameter increase when commanded Increase, and the PC Sol. Actual Current parameter decrease when commanded to Decrease.

Diagnostic Trouble Code (DTC) Type Definitions [12,000 lbs GVW]

Emissions Related DTCs

Action Taken When the DTC Sets - Type A

- The transmission control module (TCM) flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history at the time the diagnostic fails.

Action Taken When the DTC Sets - Type B

- The TCM flashes the Check Trans lamp and requests to illuminate the MIL on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.

Condition for Clearing the MIL/DTC - Type A or Type B

- The TCM turns OFF the Check Trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Non-Emissions Related DTCs

Action Taken When the DTC Sets - Type C

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM does not request to illuminate the MIL.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.

Action Taken When the DTC Sets - Type D

- The TCM does not flash the Check Trans lamp and does not request to illuminate the MIL.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.

Condition for Clearing the MIL/DTC - Type C

- The TCM turns OFF the check trans lamp after first driving cycle when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Condition for Clearing the DTC - Type D

- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

[12,000 lbs GVW]

Diagnostic Trouble Codes

Provided below is a list of all DTC's for the transmission control system. Choose and trace the appropriate flowchart by DTC (Flash code) to find fault and repair.

DTC	Flash Code	Description	Check Trans Lamp	DTC Type
P0475	37	Exhaust Brake Cut Relay Circuit	○	C
P0503	24	Vehicle Speed Sensor (VSS) 2 (SP1) Circuit Intermittent	○	A
P0560	25	System Voltage	–	D
P0602	63	Transmission Control Module (TCM) Not Programmed	○	C
P0705	17	Transmission Range (TR) Switch Circuit	○	A
P0711	18	Transmission Fluid Temperature (TFT) Sensor Performance	–	D
P0712	15	Transmission Fluid Temperature (TFT) Sensor Circuit Low Voltage	–	D
P0713	16	Transmission Fluid Temperature (TFT) Sensor Circuit High Voltage	–	D
P0717	14	Input Speed (C0) Sensor Circuit Low Voltage	○	B
P0722	11	Output Speed Sensor (SP2) Circuit Low Voltage [VSS1]	○	B
P0723	11	Output Speed Sensor (SP2) Circuit Intermittent	○	A
P0727	13	Engine Speed No Signal	○	B
P0741	54	Torque Converter Clutch (TCC) System-Stuck OFF	○	B
P0742	74	Torque Converter Clutch (TCC) System-Stuck ON	○	B
P0743	34	Torque Converter Clutch Enable Solenoid Control Circuit	○	A
P0748	35	Pressure Control (PC) Solenoid Control Circuit	○	C
P0751	51	Shift Solenoid (SS) 1 Valve Performance-Stuck OFF	○	B
P0752	71	Shift Solenoid (SS) 1 Valve Performance-Stuck ON	○	B
P0753	31	Shift Solenoid (SS) 1 Control Circuit	○	A
P0756	52	Shift Solenoid (SS) 2 Valve Performance-Stuck OFF	○	B
P0757	72	Shift Solenoid (SS) 2 Valve Performance-Stuck ON	○	B
P0758	32	Shift Solenoid (SS) 2 Control Circuit	○	A
P0785	33	Shift Timing Solenoid Control Circuit	○	C
P1382	19	ABS Communications Fault	○	C
P1790	61	Transmission Control Module (TCM) Read Only Memory (ROM)	○	B
P1791	62	Transmission Control Module (TCM) Random Access Memory (RAM)	○	B
P1813	42	Engine Torque Limit Fault	○	C
P1839	45	Transmission Fluid Temperature Switch Malfunction	○	B
U2104	41	CAN Bus Reset Counter Overrun	○	A
U2105	41	Lost CAN Communication With Engine Control System	○	A

[Except 12,000 lbs GVW]

DTC	Flash Code	Description	Check Trans Lamp
P0475	37	Exhaust Brake Cut Relay Circuit	○
P0500	24	Vehicle Speed Sensor (VSS) 2 (SP1) Circuit	○
P0602	63	Transmission Control Module (TCM) Not Programmed	○
P0705	17	Transmission Range (TR) Switch Circuit	○
P0710	15	Transmission Fluid Temperature (TFT) Sensor Circuit	–
P0722	11	Output Speed Sensor (SP2) Circuit [VSS1]	○
P0727	13	Engine Speed No Signal	○
P0743	34	Torque Converter Clutch Enable Solenoid Control Circuit	○
P0748	35	Pressure Control (PC) Solenoid Control Circuit	○
P0753	31	Shift Solenoid (SS) 1 Control Circuit	○
P0758	32	Shift Solenoid (SS) 2 Control Circuit	○
P0785	33	Shift Timing Solenoid Control Circuit	○
P1382	19	ABS Communications Fault	○
P1813	42	Engine Torque Limit Fault	○
U2100	41	Exhaust Brake Cut Relay Circuit	○

○ : ON (Flashing)
– : OFF

DTC P0475 (Flash Code 37)

Circuit Description

The exhaust brake magnetic valve is controlled by the engine control module (ECM) through the exhaust brake control relay. The transmission control module (TCM) has the ability to inhibit the exhaust brake during a torque converter clutch (TCC) OFF state or if the transmission selector position is moved to the Park or Neutral range. If any one of these two events occurs, the TCM will send a message over the controller area network (CAN) serial data link to the ECM to turn OFF the exhaust brake control relay. The TCM expects to see a low voltage exhaust brake signal after it sends the message to the ECM to turn OFF the exhaust brake control relay. If the TCM detects a high voltage exhaust brake signal for a certain amount of time through a certain amount of driving cycles when it is requesting the exhaust brake control relay to be turned OFF, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The TCM requested to the ECM over the CAN serial data link to turn ON the exhaust brake cut control.
- The TCM detects a high voltage exhaust brake control relay signal for longer than 1.5 seconds.
- The above conditions have been met once in a total of 15 driving cycles.

Action Taken When the DTC sets

12,000 lbs GVW

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM does not request to illuminate the malfunction indicator lamp (MIL).
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM changes the TCC lock-up control mapping. (The TCM inhibits the TCC lock-up control when the accelerator pedal position is 0-7%.)
- The TCM inhibits the lock-up duty control.
- When the Overdrive (OD) OFF switch is turned OFF, the TCM keeps 4th gear until the engine speed is less than 3250 RPM.

Except 12,000 lbs GVW

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM changes the TCC lock-up control mapping. (The TCM inhibits the TCC lock-up control when the accelerator pedal position is idle.)
- The TCM inhibits the lock-up duty control.
- When the OD OFF switch is turned OFF, the TCM keeps 4th gear until the engine speed is less than 3250 RPM.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

Diagnostic Aids

This DTC indicates there is a continuous voltage supply to the exhaust brake magnetic valve when the TCM is commanding the ECM to turn OFF the exhaust brake. Use the scan tool to perform the Exhaust Brake Control test in Special Functions - Engine Output Controls with the engine running in Park and ECT above 68°F (20°C). Turn the exhaust brake ON and OFF (a notable sound will be heard) several times. If a short to voltage or sticking exhaust brake control relay is occurring, the exhaust brake will not turn OFF.

DTC P0475 (Flash Code 37)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check – Transmission Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Start the engine and allow the engine coolant temperature (ECT) to reach at least 20°C (68°F). 3. Turn the exhaust brake ON and OFF by using the Special Function – Engine Output Controls - Exhaust Brake Control. Turn the exhaust brake ON and OFF 10 times while listening for the exhaust brake to turn ON and OFF. Does the exhaust brake consistently turn ON and OFF when commanded with a scan tool?	—	Go to Step 3	Go to Step 4
3	1. Leave the engine running. 2. Make sure the exhaust brake is turned OFF. 3. Monitor the Exhaust Brake Cut Relay parameter in the Transmission Data table for 10 seconds. Does the Exhaust Brake Cut Relay parameter consistently indicate OFF?	—	Go to Diagnostic Aids	Go to Step 10
4	1. Turn OFF the ignition. 2. Replace the exhaust brake control relay with the ID light relay or replace with a known good relay. 3. Start the engine. 4. Use a scan tool to turn the exhaust brake ON and OFF 10 times. Does the exhaust brake consistently turn ON and OFF when commanded with a scan tool?	—	Go to Step 9	Go to Step 5
5	1. Turn OFF the ignition. 2. Remove the exhaust brake control relay. 3. Turn ON the ignition with the engine OFF. 4. Connect a test light between the exhaust brake control relay (pin 2 of J-18 connector) and a known good ground. Does the test lamp illuminate?	—	Go to Step 7	Go to Step 6
6	1. Remove the test lamp. 2. Connect a DMM between the exhaust brake control relay switch circuit (pin 5 of J-18 connector) and a known good ground. Is the DMM voltage more than the specified value?	1 volt	Go to Step 8	Exhaust Brake Inoperative independent of this DTC. Refer to Exhaust Brake Diagnosis in Engine Controls

Step	Action	Value(s)	Yes	No
7	1. Test the exhaust brake control relay coil control circuit between the exhaust brake control relay (pin 2 of J-18 connector) and the engine control module (ECM) (pin A-77 of J-218 connector) for a short to battery or ignition voltage. 2. Repair the circuit as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
8	Repair the short to battery or ignition voltage on the exhaust brake magnetic valve circuit between the exhaust brake control relay (pin 5 of J-18 connector) and the following: • TCM (pin 1 of B-230 connector) • Exhaust brake magnetic valve (pin 1 of J-31 connector) • Intake throttle solenoid valve (pin 1 of J-40 connector) Did you complete the repair?	—	Go to Step 12	—
9	Replace the exhaust brake control relay. Did you complete the replacement?	—	Go to Step 12	—
10	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in engine control system section. Did you complete the replacement?	—	Go to Step 12	—
12	1. Reconnect all previously disconnected relay or harness connector(s). 2. Reinstall the exhaust brake control module relay if removed. 3. Clear the DTCs with a scan tool. 4. Turn OFF the ignition for 30 seconds. 5. Start the engine and allow the ECT to reach at least 20°C (68°F). 6. Operate the vehicle within the Conditions for Running the DTC. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 13
13	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0500 (Flash Code 24)

Circuit Description

Vehicle speed information is provided to the speedometer by vehicle speed sensor (VSS) 2 (SP1). VSS2 (SP1) is a hall effect type sensor, which creates a square wave as the rotor on the transmission output shaft spins. The speedometer in turn outputs a square wave that is read by the transmission control module (TCM) and shared with the engine control module (ECM). VSS2 (SP1) is used as a redundant vehicle speed input to the TCM if the vehicle speed sensor (VSS) 1 (SP2) signal is lost. The TCM continuously monitors the VSS2 (SP1) signal output from the speedometer during the driving cycle. If this signal is suddenly lost, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The VSS1 (SP2) signal is not generated.
- The VSS2 (SP1) signal is suddenly lost when the vehicle speed is between 13 MPH (21 km/h) and 106 MPH (171 km/h).

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM keeps the last gear position when the DTC was set.
- The TCM controls line pressure using a throttle position substitution of 100%.
- The TCM turns OFF the shift solenoid (S1) valve and shift solenoid (S2) valve when the engine speed becomes less than 1000 RPM.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
    - Turn ON the ignition, with the engine OFF.
    - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
    - Select "N" (neutral) range.
    - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

Diagnostic Aids

This DTC indicates that both vehicle speed sensor circuits contain a fault. VSS 1 can be read as Transmission OSS and VSS 2 can be read as Speed Meter Signal in the transmission data table.

Notice:
Vehicle Speed in the transmission data table will indicate VSS 1 OR VSS 2 based upon which signal is valid.

Notice:
The following chart only diagnoses the VSS 2 (SP1) circuit.

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections.
- Misrouted harness.
- Rubbed through wire insulation.
- Broken wire inside the insulation.

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Speed Meter Signal" and the “Transmission OSS” display on the scan tool while driving the vehicle. A change in the display to 0 km/h indicates a fault is occurring.

DTC P0500 (Flash Code 24)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Drive the vehicle. 3. Observe the Vehicle Speed Sensor parameter in the engine data with a scan tool. Does the Vehicle Speed Sensor parameter indicate correct vehicle speed?	—	Go to Step 3	Go to DTC P0500 in Engine Control Section
3	Observe the Speed Meter Signal parameter in the transmission data with a scan tool. Does the Speed Meter Signal parameter indicate correct vehicle speed?	—	Go to Diagnostic Aids	Go to Step 4
4	1. Turn OFF the ignition. 2. Remove the instrument panel cluster (IPC) bezel in order to disconnect the IPC harness connector. 3. Disconnect the IPC B-51 harness connector. 4. Connect a test lamp between the vehicle speed output circuit of the IPC harness (pin 16 of B-51 connector) and battery voltage. 5. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 7	Go to Step 5
5	1. Turn OFF the ignition. 2. Connect a test lamp between the vehicle speed output circuit of the IPC harness (pin 16 of B-51 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 8	Go to Step 6
6	1. Turn ON the ignition, with the engine OFF. 2. Momentarily jump the vehicle speed output circuit (pin 16 of B-51 connector) with a test lamp that is connected to a known good ground, while monitoring the Speed Meter Signal parameter with a scan tool. Does the scan tool indicate any vehicle speed when the circuit is momentarily pulled to ground?	—	Go to Step 10	Go to Step 9
7	1. Test the vehicle speed output circuit between the IPC (pin 16 of B-51 connector) and the transmission control module (TCM) (pin 9 of B-230 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14

Step	Action	Value(s)	Yes	No
8	1. Test the vehicle speed output circuit between the IPC (pin 16 of B-51 connector) and the TCM (pin 9 of B-230 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
9	1. Test the vehicle speed output circuit between the IPC (pin 16 of B-51 connector) and the TCM (pin 9 of B-230 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 12
10	1. Turn OFF the ignition. 2. Disconnect the IPC harness connector (B-52). 3. Test the vehicle speed sensor (VSS) 2 (SP1) signal circuit between the VSS 2 (pin 3 of J-32 connector) and IPC (pin 17 of B-52 connector) for an open. 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 11
11	1. Inspect for an intermittent and for poor connections at the harness connector of the IPC (pin 16 of B-51 connector and pin 17 of B-52 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 13
12	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for a poor connection on the vehicle speed input circuit at the harness connector of the TCM (pin 9 of B-230 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
13	Replace the IPC. Refer to Instrument Panel Replacement in the Body, Cab and Accessories section. Did you complete the replacement?	—	Go to Step 15	—
14	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 15	—

Step	Action	Value(s)	Yes	No
15	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Drive the vehicle. 5. Observe the Speed Meter Signal parameter with a scan tool. Does the Speed Meter Signal parameter indicate correct vehicle speed?	—	Go to Step 16	Go to Step 2
16	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0503 (Flash Code 24)

Circuit Description

Vehicle speed information is provided to the speedometer by vehicle speed sensor (VSS) 2 (SP1). VSS2 (SP1) is a hall effect type sensor, which creates a square wave as the rotor on the transmission output shaft spins. The speedometer in turn outputs a square wave that is read by the transmission control module (TCM) and shared with the engine control module (ECM). VSS2 (SP1) is used as a redundant vehicle speed input to the TCM if the vehicle speed sensor (VSS) 1 (SP2) signal is lost. The TCM continuously monitors the VSS2 (SP1) signal output from the speedometer during the driving cycle. If this signal is suddenly lost, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The VSS1 (SP2) signal is not generated.
- The VSS2 (SP1) signal is suddenly lost when the vehicle speed is between 13 MPH (21 km/h) and 106 MPH (171 km/h).

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history at the time the diagnostic fails.
- The TCM keeps the last gear position when the DTC was set.
- The TCM controls line pressure using a throttle position substitution of 100%.
- The TCM turns OFF the shift solenoid (S1) valve and shift solenoid (S2) valve when the engine speed becomes less than 1000 RPM.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

This DTC indicates that both vehicle speed sensor circuits contain a fault. VSS 1 can be read as Transmission OSS and VSS 2 can be read as Speed Meter Signal in the transmission data table.

Notice:
Vehicle Speed in the transmission data table will indicate VSS 1 OR VSS 2 based upon which signal is valid.

Notice:
The following chart only diagnoses the VSS 2 (SP1) circuit.

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Speed Meter Signal" and the “Transmission OSS” display on the scan tool while driving the vehicle. A change in the display to 0 km/h indicates a fault is occurring.

DTC P0503 (Flash Code 24)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Drive the vehicle. 3. Observe the Vehicle Speed Sensor parameter in the engine data with a scan tool. Does the Vehicle Speed Sensor parameter indicate correct vehicle speed?	—	Go to Step 3	Go to DTC P0500 in Engine Control Section
3	Observe the Speed Meter Signal parameter in the transmission data with a scan tool. Does the Speed Meter Signal parameter indicate correct vehicle speed?	—	Go to Diagnostic Aids	Go to Step 4
4	1. Turn OFF the ignition. 2. Remove the instrument panel cluster (IPC) bezel in order to disconnect the IPC harness connector. 3. Disconnect the IPC B-51 harness connector. 4. Connect a test lamp between the vehicle speed output circuit of the IPC harness (pin 16 of B-51 connector) and battery voltage. 5. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 7	Go to Step 5
5	1. Turn OFF the ignition. 2. Connect a test lamp between the vehicle speed output circuit of the IPC harness (pin 16 of B-51 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 8	Go to Step 6
6	1. Turn ON the ignition, with the engine OFF. 2. Momentarily jump the vehicle speed output circuit (pin 16 of B-51 connector) with a test lamp that is connected to a known good ground, while monitoring the Speed Meter Signal parameter with a scan tool. Does the scan tool indicate any vehicle speed when the circuit is momentarily pulled to ground?	—	Go to Step 10	Go to Step 9

Step	Action	Value(s)	Yes	No
7	1. Test the vehicle speed output circuit between the IPC (pin 16 of B-51 connector) and the transmission control module (TCM) (pin 9 of B-230 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
8	1. Test the vehicle speed output circuit between the IPC (pin 16 of B-51 connector) and the TCM (pin 9 of B-230 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
9	1. Test the vehicle speed output circuit between the IPC (pin 16 of B-51 connector) and the TCM (pin 9 of B-230 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 12
10	1. Turn OFF the ignition. 2. Disconnect the IPC harness connector (B-52). 3. Test the vehicle speed sensor (VSS) 2 (SP1) signal circuit between the VSS 2 (pin 3 of J-32 connector) and IPC (pin 17 of B-52 connector) for an open. 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 11
11	1. Inspect for an intermittent and for poor connections at the harness connector of the IPC (pin 16 of B-51 connector and pin 17 of B-52 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 13
12	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for a poor connection on the vehicle speed input circuit at the harness connector of the TCM (pin 9 of B-230 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14
13	Replace the IPC. Refer to Instrument Panel Replacement in the Body, Cab and Accessories section. Did you complete the replacement?	—	Go to Step 15	—

Step	Action	Value(s)	Yes	No
14	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 15	—
15	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Drive the vehicle. 5. Observe the Speed Meter Signal parameter with a scan tool. Does the Speed Meter Signal parameter indicate correct vehicle speed?	—	Go to Step 16	Go to Step 2
16	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0560 (Flash Code 25)

Circuit Description

The transmission control module (TCM) monitors the system voltage on the ignition voltage feed terminal to make sure that the voltage stays within the proper range. If the TCM detects an excessively low or high system voltage, this DTC will set. When the charging system detects a malfunction, the charge indicator will light.

Condition for Running the DTC

- The ignition switch is ON.

Condition for Setting the DTC

- The system voltage is less than 10 volts when the engine speed is more than 600 RPM for 2 seconds.

OR

- The system voltage is more than 16 volts when the engine speed is more than 600 RPM for 2 seconds.

Action Taken When the DTC Sets

- The TCM does not flash the Check Trans lamp and does not request to illuminate the malfunction indicator lamp (MIL).
- The TCM stores the DTC in TCM history at the time the diagnostic fails.

Condition for Clearing the MIL/DTC

- Clear the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

- If the ignition voltage feed to the TCM is open, the scan tool will not communicate with the TCM.
- A charging system problem may set this DTC.
- An intermittent or poor connection at the ignition voltage feed (pin 1 of B-231 connector) may set this DTC.
- Jump starting the vehicle or the use of a battery charger may have set this DTC.

DTC P0560 (Flash Code 25)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check – Transmission Controls
2	1. Install a scan tool. 2. Start the engine and let idle for 30 seconds. 3. Load the electrical system by turning ON the headlights, A/C, etc. 4. Observe the Ignition Voltage parameter with a scan tool. Is the Ignition Voltage parameter within specified value?	10 - 16 volts	Go to Diagnostic Aids	Go to Step 3
3	Is the Ignition Voltage parameter less than specified value at step 2?	10 volts	Go to Step 4	Go to Step 5

Step	Action	Value(s)	Yes	No
4	1. Turn OFF the ignition. 2. Disconnect the transmission control module (TCM) harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion of the ignition voltage feed circuit at the harness connector of the TCM (pin 1 of B-231 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 8	Go to Step 5
5	Test the charging system. Refer to Diagnosis of The Charging System in the Charging System Section. Did you find a charging system problem?	—	Go to Step 6	Go to Step 7
6	Repair the charging system. Refer to Diagnosis of The Charging System in the Charging System Section. Did you complete the repair?	—	Go to Step 8	—
7	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 8	—
8	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Load the electrical system by turning ON the headlights, A/C, etc. 6. Observe the Ignition Voltage parameter with a scan tool. Is the Ignition Voltage parameter within specified value?	10-16 volts	Go to Step 9	Go to Step 3
9	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0602 (Flash Code 63)

Circuit Description

The transmission control module (TCM) has the ability to set a diagnostic trouble code if it detects that there is no vehicle identification number (VIN) stored. In order for the software to be locked, the mechanization (MEC) counter used at time of production must be set to zero. If the counter is anything other than zero AND there is no VIN stored, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- VIN in TCM is not programmed (blank).

Action Taken When the DTC sets

- The TCM flashes the check trans lamp when the diagnostic runs and fails.

Condition for Clearing the DTC

- Not cleared

DTC P0602 (Flash Code 63)

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check – Transmission Controls
2	Program the TCM which will program the VIN also. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the programming?	—	Go to Step 3	—
3	1. Install the scan tool. 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition. Did the DTC fail this ignition?	—	Go to Step 4	Go to Step 5
4	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 5	—
5	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0705 (Flash Code 17)

Circuit Description

The inhibitor switch is connected to the transmission manual shaft and installed externally to the transmission case. The inhibitor switch relays a signal to the transmission control module (TCM) indicating transmission gearshift position by supplying ignition voltage through an internal switch. Only one of the six internal switches will close for each P, R, N, D, 2 and 1 gearshift position. Normally, the TCM expects to see one high voltage input for each position. If the TCM detects more than one high voltage input at the same time or does not detect any high voltage input for a certain length of time, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

Either of following condition is met:

Condition 1

- The TCM detects all low voltage inhibitor switch inputs indicating no gear shift position.
- The above condition exists for longer than 30 seconds.

Condition 2

- The TCM detects two or more high voltage inhibitor switch inputs indicating an invalid gear shift position.
- The above condition exists for longer than 30 seconds.

Action Taken When the DTC Sets

12,000 lbs GVW

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history at the time the diagnostic fails.
- The TCM uses a shift position substitution of D range. (Condition 1)
- The TCM inhibits the shift-up control from 3rd gear to 4th gear. (Condition 1)
- The TCM controls the selector switch priority according to the following: 1>R>2>D>N>P (Condition 2)

Except 12,000 lbs GVW

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM uses a shift position substitution of D range. (Condition 1)
- The TCM inhibits the shift-up control from 3rd gear to 4th gear. (Condition 1)
- The TCM controls the selector switch priority according to the following: 1>R>2>D>N>P (Condition 2)

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

12,000 lbs GVW

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

- Use the scan tool to check the TR. Sw. parameter in each gear position. A problem is occurring if the scan tool does not indicate the correct gear position or if no display shows on the screen.
- A misadjusted inhibitor switch or shift cable can set this DTC.
- A faulty connection, worn insulation or a wire breaking internally may cause a temporary failure. Check if any of the following conditions are evident in the TCM harness connector: Terminal positional shift, connector lock damage, improper terminal shape, faulty terminal connections or harness damage.

DTC P0705 (Flash Code 17)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the TR. Sw parameter with a scan tool. 4. Select the P, R, N, D, 2 and 1 range. Does each TR Sw. parameter display the correct position?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Place the transmission in Park. 2. Turn OFF the ignition. 3. Disconnect the inhibitor switch harness connector. 4. Connect a test lamp between the inhibitor switch ignition voltage supply (pin 7 of J-69 connector) and a known good ground. 5. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 4	Go to Step 7
4	Does the instrument panel cluster (IPC) indicate any gearshift position with the inhibitor switch harness connector disconnected?	—	Go to Step 8	Go to Step 5
5	1. Connect a jumper wire independently between the inhibitor switch ignition voltage supply circuit (pin 7 of J-69 connector) and each range signal circuits (pins 1, 2, 3, 4, 5 and 6 of J-69 connector). 2. Monitor the TR Sw. parameter with a scan tool each time a circuit is jumpered. When pins 1, 2, 3, 4, 5 and 6 are independently jumpered to pin 7, does the TR Sw. parameter on scan tool indicate Drive 4, Drive 2, Drive 1, Reverse, Neutral and Park respectively?	—	Go to Step 10	Go to Step 6

Step	Action	Value(s)	Yes	No
6	1. Test the inhibitor switch signal input circuit which the TR SW parameter did not indicate at step 5 for the following: • An open circuit • A short to ground • High resistance 2. If a blank was displayed for each circuit jumpered, test each inhibitor switch signal circuit for a short to another inhibitor switch circuit. 3. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go Step 11
7	1. Inspect the Gauges (10A) fuse (F-25) and replace if open. If the fuse continues to open, check for a short to ground on all circuits fed by that fuse or for a shorted attached component. 2. Replace the fuse and/or repair the circuits as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 9
8	1. Test each inhibitor switch signal input circuit for a short to battery or ignition voltage that was the indicated shift position at step 4. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
9	Repair the open in the inhibitor switch ignition voltage supply circuit between the Gauges (10A) fuse (F-25) and pin 7 of the J-69 connector. Did you complete the repair?	—	Go to Step 14	—
10	1. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the inhibitor switch (pins 1, 2, 3, 4, 5, 6 and 7 of J-69 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 12
11	1. Inspect for an intermittent and for poor connections on these inhibitor switch circuits at the harness connector of the TCM (pins 3, 4, 6, 9, 10 and 11 of B-231 connector). 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13

Step	Action	Value(s)	Yes	No
12	**Important:** The shift cable or the inhibitor switch may be out of adjustment. 1. Adjust the shift cable and inhibitor switch. Refer to Inhibitor Switch and Shift Cable Adjustment in the Transmission On-Vehicle Service section. 2. Recheck each gear position against the scan tool TR. Sw parameter. 3. If the all gear positions cannot be read correctly after the adjustments, replace and adjust the inhibitor switch. Refer to Inhibitor Switch Replacement and Adjustment in the Transmission On-Vehicle Service section. Did you complete the adjustment and/or replacement?	—	Go to Step 14	—
13	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 14	—
14	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. (12,000 lbs GVW only) 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition, with the engine OFF. 5. Observe the TR. Sw parameter with a scan tool. 6. Shift the gearshift through the entire P, R, N, D, 2 and 1 range. Does each TR Sw. parameter display match the actual gearshift position?	—	Go to Step 15	Go to Step 3
15	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code List	System OK

Table 1

⊖Terminal	⊕Terminal	Voltage (V)
B231-2 or B231-8	B231-3	10～16 : P range 1 or less : Other than P range
	B231-9	10～16 : R range 1 or less : Other than R range
	B231-4	10～16 : N range 1 or less : Other than N range
	B231-10	10～16 : D range 1 or less : Other than D range
	B231-11	10～16 : 2 range 1 or less : Other than 2 range
	B231-6	10～16 : 1 range 1 or less : Other than 1 range

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Table 2

Terminal / Range	J69								
	1	2	3	4	5	6	7	8	9
P						○—	—○	○—	—○
R				○—	—	—	—○		
N					○—	—	—○	○—	—○
D	○—	—	—	—	—	—	—○		
2		○—	—	—	—	—	—○		
1			○—	—	—	—	—○		

○—○ Continuity

LNW47ASH044501

DTC P0710 (Flash Code 15)

Circuit Description

The automatic transmission fluid (ATF) temperature sensor is installed in the transmission valve body. The ATF temperature sensor is a variable resistor. The ATF temperature sensor has a signal circuit and a low reference circuit. The ATF temperature sensor measures the temperature of the ATF in the transmission. The transmission control module (TCM) supplies 5 volts to the ATF temperature signal circuit and a ground for the ATF temperature low reference circuit. When the ATF temperature sensor is cold, the sensor resistance increases. With high sensor resistance, the TCM detects a high voltage on the ATF temperature signal circuit. With lower sensor resistance, the TCM detects a lower voltage on the ATF temperature signal circuit. If the TCM detects an excessively high or low ATF temperature signal voltage, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

When the TCM detects either of the following conditions for 0.5 seconds continuously:

- Resistance of sensor less than 83Ω.
  (The ATF temperature is more than about 279°F{137°C})
- Resistance of sensor more than 94kΩ.
  (The ATF temperature is less than about -112°F{-80°C})

Action Taken When the DTC Sets

- The TCM does not flashes the Check Trans lamp.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM uses the ATF temperature substitution of -40°F (-40°C) if the DTC set within 1 second after the ignition switch has been turned ON. The TCM uses the ATF temperature substitution of 212°F (100°C) when the ignition switch is being ON for 300 seconds.
- The TCM keeps the last ATF temperature if the DTC set within 1-300 seconds after the ignition switch has been turned ON. The TCM uses the ATF temperature substitution of 212°F (100°C) when the ignition switch has been ON for 300 seconds.
- The TCM uses the ATF temperature substitution of 212°F (100°C) if the DTC set after the ignition switch has been turned IN longer than 300 seconds.

Condition for Clearing the MIL/DTC

- Clear the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Trans. Fluid Temp." display on the scan tool while moving connectors and wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0710 (Flash Code 15)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the Trans. Fluid Temp. parameter with a scan tool. **Notice:** If the automatic transmission fluid (ATF) temperature sensor resistance is lower than 83ohms, the Trans. Fluid Temp. on scan tool will also indicate -40°F (-40°C) after the key is cycled when the ignition has been turned OFF for longer than 10 seconds. Does the Trans. Fluid Temp. parameter indicate less than the specified value?	-38°F (-39°C)	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (J-71). 3. Connect a DMM between the automatic transmission fluid (ATF) temperature sensor signal circuit (pin 7 of J-71 male side connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	5.5 volts	Go to Step 7	Go to Step 4
4	Is the DMM voltage more than the specified value at step 3?	4.5 volts	Go to Step 5	Go to Step 8
5	1. Turn OFF the ignition. 2. Connect a test lamp between the ATF temperature sensor signal circuit (pin 7 of J-71 male side connector) and a known good ground. 3. Connect a DMM between the probe of the test lamp and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 9	Go to Step 6
6	1. Turn OFF the ignition. 2. Connect a DMM across the ATF temperature sensor circuits (pins 6 and 7 of J-71 male side connector). 3. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 11	Go to Step 10

Step	Action	Value(s)	Yes	No
7	**Important:** The ATF temperature sensor may be damaged if the circuit is shorted to a voltage source. 1. Test the signal circuit between the transmission control module (TCM) (pin 6 of B-229 connector) and the in-line connector (pin 7 of J-71 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
8	1. Test the signal circuit between the TCM (pin 6 of B-229 connector) and the in-line connector (pin 7 of J-71 connector) for the following conditions: • An open circuit • A short to ground • A short to the low reference • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 13
9	1. Test the signal circuit between the TCM (pin 6 of B-229 connector) and the in-line connector (pin 7 of J-71 connector) for a short to any 5 volts reference. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
10	1. Test the low reference circuit between the TCM (pin 20 of B-229 connector) and the in-line connector (pin 6 of J-71 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 13
11	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor connections and corrosion on these ATF temperature sensor circuits at the in-line connector (pins 6 and 7 of J-71 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12

Step	Action	Value(s)	Yes	No
12	1. Test the signal circuit between the ATF temperature sensor and the in-line connector (pin 7 of J-71 connector) for the following conditions: • An open circuit • A short to ground • A short to the low reference • A short to battery or ignition voltage • High resistance 2. Test the low reference circuit between the ATF temperature sensor and the in-line connector (pin 6 of J-71 connector) for an open circuit or high resistance. 3. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 14
13	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for poor connections on these ATF temperature sensor circuits at the harness connector of the TCM (pins 6 and 20 of B-229 connector). 4. Repair the connection(s) as necessary Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
14	Replace the ATF temperature sensor. Refer to Repair Instructions (Overhaul) - Valve Body in this section Did you complete the repair or replacement?	—	Go to Step 16	—
15	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Observe the Trans. Fluid Temp. parameter with a scan tool. **Notice:** If the automatic transmission fluid (ATF) temperature sensor resistance is lower than 83ohms, the Trans. Fluid Temp. on scan tool will also indicate -40°F (-40°C) after the key is cycled when the ignition has been turned OFF for longer than 10 seconds. Does the Trans. Fluid Temp. parameter indicate less than the specified value?	-38°F (-39°C)	Go to Step 2	Go to Step 17

Step	Action	Value(s)	Yes	No
17	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0711 (Flash Code 18)

Circuit Description

The automatic transmission fluid (ATF) temperature sensor is installed in the transmission valve body. The ATF temperature sensor is a variable resistor. The ATF temperature sensor has a signal circuit and a low reference circuit. The ATF temperature sensor measures the temperature of the ATF in the transmission. The transmission control module (TCM) supplies 5 volts to the ATF temperature signal circuit and a ground for the ATF temperature low reference circuit. When the ATF temperature sensor is cold, the sensor resistance increases. With high sensor resistance, the TCM detects a high voltage on the ATF temperature signal circuit. With lower sensor resistance, the TCM detects a lower voltage on the ATF temperature signal circuit. If the TCM detects an excessively small or large deviation of the ATF temperature, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- DTC(s) related to the engine coolant temperature sensor are not set.
- DTC P0722 is not set.
- The output shaft speed is higher than 300 RPM for 410 seconds.

Condition for Setting the DTC

Condition 1

- The engine coolant temperature is higher than 158°F (70°C) and the temperature has changed by 122°F (50°C) since start up.
- The ATF temperature when the ignition is turned ON is between -40°F (-40°C) and 104°F (40°C).
- The ATF temperature does not change more than 3.6°F (2°C) since start up.

Condition 2

- The deviation of the ATF temperature changes more than 36°F (20°C) every 0.2 seconds sampling time.
- The ATF temperature is less than 158°F (70°C).
- Above conditions are met for 7 seconds.

Action Taken When the DTC Sets

- The TCM does not flash the Check Trans lamp and does not request to illuminate the malfunction indicator lamp (MIL).
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM uses the ATF temperature substitution of -40°F (-40°C) if the DTC set within 1 second after the ignition switch has been turned ON. The TCM uses the ATF temperature substitution of 212°F (100°C) when the ignition switch is being ON for 300 seconds.
- The TCM keeps the last ATF temperature if the DTC set within 1-300 seconds after the ignition switch has been turned ON. The TCM uses the ATF temperature substitution of 212°F (100°C) when the ignition switch has been ON for 300 seconds.
- The TCM uses the ATF temperature substitution of 212°F (100°C) if the DTC set after the ignition switch has been turned IN longer than 300 seconds.

Condition for Clearing the MIL/DTC

- Clear the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
    - Turn ON the ignition, with the engine OFF.
    - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
    - Select "N" (neutral) range.
    - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

- Use the Temperature vs. Resistance table to test the ATF temperature sensor at various temperature levels to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to Temperature vs. Resistance.

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Trans. Fluid Temp." display on the scan tool while moving connectors and wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0711 (Flash Code 18)

Schematic Reference: Transmission Controls Schematics
Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	**Important:** If DTC P0712 or P0713 also set, diagnose that DTC first. Inspect for correct transmission fluid level. Repair Instructions (On-Vehicle) - Automatic Transmission Fluid (ATF). Did you perform the fluid checking procedure?	—	Go to Step 3	Go to Instructions (On-Vehicle) - Automatic Transmission Fluid (ATF)
3	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Drive the vehicle and observe the Trans. Fluid Temp. parameter with a scan tool for either of the following conditions: • The parameter does not change more than 6°F (2°C) since start up. • The parameter changes more than 36°F (20°C) in 0.2 seconds. Did either of the conditions occur?	—	Go to Step 4	Go to Diagnostic Aids
4	Did the scan tool display a condition in which the Trans. Fluid Temp. parameter does not change by more than the specified value since start up at step 3?	3.6°F (2°C)	Go to Step 6	Go to Step 5
5	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (J-71). 3. Connect a test lamp across the ATF temperature sensor circuits (pins 6 and 7 of J-71 connector) on male side in-line connector. 4. Turn ON the ignition, with the engine OFF. 5. While the observing the scan tool display, move or wiggle the wiring harness from transmission control module (TCM) harness connector B-229 to the in-line harness connector J-71. Does the Trans. Fluid Temp. parameter change by more than the specified value?	36°F (20°C)	Go to Step 7	Go to Step 8

Step	Action	Value(s)	Yes	No
6	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (J-71). 3. Turn ON the ignition, with the engine OFF. Does the scan tool display the same as in Step 4?	—	Go to Step 10	Go to Step 9
7	1. Test the signal circuit of the ATF temperature sensor between the TCM (pin 6 of B-229 connector) and the AT in-line 8-way connector (pin 7 of J-71 connector) for an intermittent open or short condition. 2. Test the low reference circuit of the ATF temperature sensor between the TCM (pin 20 of B-229 connector) and the AT in-line 8-way connector (pin 6 of J-71 connector) for an intermittent open or short condition. 3. Repair the connection(s) as necessary Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
8	1. Test the signal circuit of the ATF temperature sensor between the AT in-line 8-way connector (pin 7 of J-71 connector) and the ATF temperature sensor for an intermittent open or short condition. 2. Test the low reference circuit of the ATF temperature sensor between the AT in-line 8-way connector (pin 6 of J-71 connector) and the ATF temperature sensor for an intermittent open or short condition. 3. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 11	Go to Step 9
9	Replace the ATF temperature sensor. Refer to Repair Instructions (Overhaul) - Valve Body in this section Did you complete the repair or replacement?	—	Go to Step 11	—
10	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 11	—

Step	Action	Value(s)	Yes	No
11	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Drive the vehicle and observe the Trans. Fluid Temp. parameter with a scan tool for either of the following conditions: • The parameter changes more than 6°F (2°C) since start up. • The parameter does not change more than 36°F (20°C) in 0.2 seconds. Did either of the conditions occur?	—	Go to Step 2	Go to Step 12
12	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0712 (Flash Code 15)

Circuit Description

The automatic transmission fluid (ATF) temperature sensor is installed in the transmission valve body. The ATF temperature sensor is a variable resistor. The ATF temperature sensor has a signal circuit and a low reference circuit. The ATF temperature sensor measures the temperature of the ATF in the transmission. The transmission control module (TCM) supplies 5 volts to the ATF temperature signal circuit and a ground for the ATF temperature low reference circuit. When the ATF temperature sensor is cold, the sensor resistance increases. With high sensor resistance, the TCM detects a high voltage on the ATF temperature signal circuit. With lower sensor resistance, the TCM detects a lower voltage on the ATF temperature signal circuit. If the TCM detects an excessively low ATF temperature signal voltage, indicating a high temperature, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- Resistance of sensor is less than 83Ω.
  (The ATF temperature is more than about 279°F{137°C})
- Above condition is met for 8 consecutive driving cycles.

Action Taken When the DTC Sets

- The TCM does not flash the Check Trans lamp and does not request to illuminate the malfunction indicator lamp (MIL).
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM uses the ATF temperature substitution of -40°F (-40°C) if the DTC set within 1 second after the ignition switch has been turned ON. The TCM uses the ATF temperature substitution of 212°F (100°C) when the ignition switch is being ON for 300 seconds.
- he TCM keeps the last ATF temperature if the DTC set within 1-300 seconds after the ignition switch has been turned ON. The TCM uses the ATF temperature substitution of 212°F (100°C) when the ignition switch has been ON for 300 seconds.
- The TCM uses the ATF temperature substitution of 212°F (100°C) if the DTC set after the ignition switch has been turned IN longer than 300 seconds.

Condition for Clearing the MIL/DTC

- Clear the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

- Use the Temperature vs. Resistance table to test the ATF temperature sensor at various temperature levels to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to Temperature vs. Resistance.

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Trans. Fluid Temp." display on the scan tool while moving connectors and wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0712 (Flash Code 15)

Schematic Reference: Transmission Controls Schematics
Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the Trans. Fluid Temp. parameter with a scan tool. **Notice:** If the automatic transmission fluid (ATF) temperature sensor resistance is lower than 83ohms, the Trans. Fluid Temp. on scan tool will indicate -40°F (-40°C) after the key is cycled when the ignition has been turned OFF for longer than 10 seconds. Does the Trans. Fluid Temp. parameter indicate less than the specified value?	-38°F (-39°C)	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (J-71). 3. Connect a DMM between the automatic transmission fluid (ATF) temperature sensor signal circuit (pin 7 of J-71 male side connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 5	Go to Step 4
4	1. Test the signal circuit between the transmission control module (TCM) (pin 6 of B-229 connector) and the in-line connector (pin 7 of J-71 connector) for the following conditions: • A short to ground • A short to the low reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 7
5	1. Turn OFF the ignition. 2. Inspect for an intermittent and for corrosion on the ATF temperature sensor circuits at the in-line connector (pins 6 and 7 of J-71 connector). 3. Repair or clean the corrosion as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 6

Step	Action	Value(s)	Yes	No
6	1. Test the signal circuit between the ATF temperature sensor and the in-line connector (pin 7 of J-71 connector) for the following conditions: • A short to ground • A short to the low reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 8
7	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for corrosion on the ATF temperature sensor signal circuit at the harness connector of the TCM (pins 6 of B-229 connector). 4. Repair or clean the corrosion as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 9
8	Replace the ATF temperature sensor. Refer to Repair Instructions (Overhaul) - Valve Body in this section Did you complete the repair or replacement?	—	Go to Step 10	—
9	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 10	—
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:**The engine control module (ECM) sets the DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Observe the Trans. Fluid Temp. parameter with a scan tool. **Notice:** If the automatic transmission fluid (ATF) temperature sensor resistance is lower than 83ohms, the Trans. Fluid Temp. on scan tool will indicate -40°F (-40°C) after the key is cycled when the ignition has been turned OFF for longer than 10 seconds. Does the Trans. Fluid Temp. parameter indicate less than the specified value?	-38°F (-39°C)	Go to Step 2	Go to Step 11
11	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0713 (Flash Code 16)

Circuit Description

The automatic transmission fluid (ATF) temperature sensor is installed in the transmission valve body. The ATF temperature sensor is a variable resistor. The ATF temperature sensor has a signal circuit and a low reference circuit. The ATF temperature sensor measures the temperature of the ATF in the transmission. The transmission control module (TCM) supplies 5 volts to the ATF temperature signal circuit and a ground for the ATF temperature low reference circuit. When the ATF temperature sensor is cold, the sensor resistance increases. With high sensor resistance, the TCM detects a high voltage on the ATF temperature signal circuit. With lower sensor resistance, the TCM detects a lower voltage on the ATF temperature signal circuit. If the TCM detects an excessively high ATF temperature signal voltage, indicating a low temperature, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- Resistance of sensor is more than 94kΩ. (The ATF temperature is less than about -112°{-80°C})
- Above condition is met for 8 consecutive driving cycles.

Action Taken When the DTC Sets

- The TCM does not flash the Check Trans lamp and does not request to illuminate the malfunction indicator lamp (MIL).
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM uses the ATF temperature substitution of -40°F (-40°C) if the DTC set within 1 second after the ignition switch has been turned ON. The TCM uses the ATF temperature substitution of 212°F (100°C) when the ignition switch is being ON for 300 seconds.
- The TCM keeps the last ATF temperature if the DTC set within 1-300 seconds after the ignition switch has been turned ON. The TCM uses the ATF temperature substitution of 212°F (100°C) when the ignition switch has been ON for 300 seconds.
- The TCM uses the ATF temperature substitution of 212°F (100°C) if the DTC set after the ignition switch has been turned IN longer than 300 seconds.

Clear the DTC with a scan tool.

- Clear the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

- Use the Temperature vs. Resistance table to test the ATF temperature sensor at various temperature levels to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to Temperature vs. Resistance.

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Trans. Fluid Temp." display on the scan tool while moving connectors and wiring harness related to the sensor. A change in the display will indicate the location of the fault.

DTC P0713 (Flash Code 16)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the Trans. Fluid Temp. parameter with a scan tool. Does the Trans. Fluid Temp. parameter indicate less than the specified value?	-38°F (-39°C)	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (J-71). 3. Connect a DMM between the automatic transmission fluid (ATF) temperature sensor signal circuit (pin 7 of J-71 male side connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	5.5 volts	Go to Step 7	Go to Step 4
4	Is the DMM voltage more than the specified value at step 3?	4.5 volts	Go to Step 5	Go to Step 8
5	1. Turn OFF the ignition. 2. Connect a test lamp between the ATF temperature sensor signal circuit (pin 7 of J-71 male side connector) and a known good ground. 3. Connect a DMM between the probe of the test lamp and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 9	Go to Step 6
6	1. Turn OFF the ignition. 2. Connect a DMM across the ATF temperature sensor circuits (pins 6 and 7 of J-71 male side connector). 3. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	4.5 volts	Go to Step 11	Go to Step 10

Step	Action	Value(s)	Yes	No
7	**Important:** The ATF temperature sensor may be damaged if the circuit is shorted to a voltage source. 1. Test the signal circuit between the transmission control module (TCM) (pin 6 of B-229 connector) and the in-line connector (pin 7 of J-71 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
8	1. Test the signal circuit between the TCM (pin 6 of B-229 connector) and the in-line connector (pin 7 of J-71 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 13
9	1. Test the signal circuit between the TCM (pin 6 of B-229 connector) and the in-line connector (pin 7 of J-71 connector) for a short to any 5 volts reference. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
10	1. Test the low reference circuit between the TCM (pin 20 of B-229 connector) and the in-line connector (pin 6 of J-71 connector) for an open circuit or high resistance. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 13
11	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor connections and corrosion on these ATF temperature sensor circuits at the in-line connector (pins 6 and 7 of J-71 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
12	1. Test the signal circuit between the ATF temperature sensor and the in-line connector (pin 7 of J-71 connector) for the following conditions: • An open circuit • A short to battery or ignition voltage • High resistance 2. Test the low reference circuit between the ATF temperature sensor and the in-line connector (pin 6 of J-71 connector) for an open circuit or high resistance. 3. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 14

Step	Action	Value(s)	Yes	No
13	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for poor connections on these ATF temperature sensor circuits at the harness connector of the TCM (pins 6 and 20 of B-229 connector). 4. Repair the connection(s) as necessary Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
14	Replace the ATF temperature sensor. Refer to Repair Instructions (Overhaul) - Valve Body in this section Did you complete the repair or replacement?	—	Go to Step 16	—
15	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:**The engine control module (ECM) sets the DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Observe the Trans. Fluid Temp. parameter with a scan tool. Does the Trans. Fluid Temp. parameter indicate less than the specified value?	-38°F (-39°C)	Go to Step 2	Go to Step 17
17	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0717 (Flash Code 14)

Circuit Description

The input shaft speed sensor (C0) is located on top of the transmission case. The input shaft speed sensor (C0) is an electromagnetic pulse pick up type sensor, which generates a speed signal based on the overdrive direct clutch rotational speed (18 pulses per rotation of the overdrive direct clutch). The transmission control module (TCM) calculates the overdrive direct clutch speed by the input shaft speed sensor (C0) signal, and uses it to calculate torque converter slip speed and gear ratio. If the TCM detects excessively low overdrive direct clutch speed in comparison to output shaft speed, This DTC will set

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

Following conditions are met twice:

- The gear shift position is in the D range.
- The commanded gear is 2nd.
- The output shaft speed is more than 400 RPM.
- The input shaft speed (overdrive direct clutch speed) is less than 100 RPM.
- Above conditions are met for 2 seconds.

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine contorol module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.
- The TCM inhibits diagnosis of DTCs P0751, P0752, P0756 and P0757.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the “Transmission ISS” display on the scan tool with driving the vehicle. A change in the display will indicate the location of the fault.

Notice:
The Transmission ISS parameter indicates 0 RPM when the shift position is in the D range and the commanded gear position is 4th. This is due to the overdrive direct clutch not rotating in 4th gear.

DTC P0717 (Flash Code 14)

Schematic Reference: Transmission Controls Schematics
Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Lift the driving wheels. 3. Start the engine. 4. Select the D range and release the park brake. 5. Observe the Transmission Input Shaft Speed (ISS) parameter with a scan tool while depressing the accelerator pedal. **Notice:** The Transmission ISS parameter indicates 0 RPM when the shift position is in the D range and the commanded gear position is 4th. This is due to the overdrive direct clutch not rotating in 4th gear. Does the Transmission ISS parameter increase in accordance with a vehicle speed increase?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the input shaft speed sensor (C0) harness connector. 3. Connect a DMM across the input shaft speed sensor (C0) terminals (pins 1 and 2 of J-240 connector) 4. Measure the resistance across the input shaft speed sensor (C0). Does the resistance measure within the specified value?	500-1000 Ω	Go to Step 4	Go to Step 14
4	1. Place the DMM on the AC volt scale. 2. Start the engine. 3. Select the D range and release the park brake 4. Monitor the DMM while depressing the accelerator pedal. Does the DMM indicate an AC voltage increase in accordance with a vehicle speed increase?	—	Go to Step 5	Go to Step 13
5	1. Turn OFF the ignition. 2. Connect a DMM between the input shaft speed sensor (C0) high signal circuit (pin 1 of J-240 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. Is the DMM voltage within the specified value?	0.4-1.2 volts	Go to Step 7	Go to Step 6
6	Is the DMM voltage more than the specified value at step 5?	4.5 volts	Go to Step 9	Go to Step 8

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Connect a test lamp between the input shaft speed sensor (C0) low signal circuit (pin 2 of J-240 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 11	Go to Step 10
8	1. Test the input shaft speed sensor (C0) high signal circuit between the transmission control module (TCM) (pin 4 of B-229 connector) and the input shaft speed sensor (C0) harness (pin 1 of J-240 connector) for the following conditions: • An open circuit • A short to ground • A short to each other • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
9	1. Test the input shaft speed sensor (C0) high signal circuit between the TCM (pin 4 of B-229 connector) and the input shaft speed sensor (C0) harness (pin 1 of J-240 connector) for the following conditions: • A short to battery or ignition voltage • A short to any 5 volts reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
10	1. Test the input shaft speed sensor (C0) low signal circuit between the TCM (pin 17 of B-229 connector) and the input shaft speed sensor (C0) harness (pin 2 of J-240 connector) for the following conditions: • An open circuit • A short to battery or ignition voltage • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
11	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the input shaft speed sensor (C0) (pins 1 and 2 of J-240 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15

Step	Action	Value(s)	Yes	No
12	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for poor connections on these input shaft speed sensor (C0) circuits at the harness connector of the TCM (pins 4 and 17 of B-229 connector). 4. Repair the connection(s) as necessary Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
13	1. Inspect the input shaft speed sensor (C0) tightness. Retest if the sensor was loose. 2. Remove the input shaft speed sensor (C0) and check for damage, metal particles on magnet and for overdrive (OD) planetary gear teeth damage. Did you find and correct the condition?	—	Go to Step 16	Go to Step 14
14	Replace the input shaft speed sensor (C0). Refer to Repair Instructions (Overhaul) - Input Shaft Speed Sensor (C0) in this section Did you complete the replacement?	—	Go to Step 16	—
15	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Select the D range and release the park brake. 6. Observe the Transmission ISS parameter with a scan tool while depressing the accelerator pedal. Does the Transmission ISS parameter increase in accordance with a vehicle speed increase?	—	Go to Step 2	Go to Step 17
17	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0722 (Flash Code 11) [12,000 lbs GVW]

Circuit Description

Vehicle speed information is sent from the vehicle speed sensor (VSS) 1 (SP2) to the Transmission Control Module (TCM). This sensor is provided in the transmission rear cover.

The VSS1 (SP2) is an electromagnetic pulse pickup type that generates a speed signal according to the revolution of the transmission output shaft (18 pulses at a single revolution of the output shaft). As a result, the sensor sends a sine wave signal to the TCM, which converts this sine wave signal (pulse voltage) into a MPH (km/h) signal. If this signal is not inputted, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The vehicle speed sensor (VSS) 2 (SP1) signal is normal.
- The VSS1 (SP2) signal is not inputted while the VSS2 (SP1) signal has inputted at least 4 pulses.
- The shift position is not P or N range.
- The output shaft speed is higher than 186 RPM for 4 seconds or more.

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.
- The TCM uses the VSS2 (SP1) signal instead of the VSS1 (SP2) signal.
- The TCM inhibits the shift-up control from 3rd gear range to 4th gear range.
- The TCM starts the diagnosis of DTC P0503.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Transmission OSS" display on the scan tool while driving the vehicle. A change in the display will indicate the location of the fault.

DTC P0722 (Flash Code 11) [12,000 lbs GVW]

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Lift the driving wheels. 3. Start the engine. 4. Select the D range and release the park brake. 5. Observe the Transmission OSS parameter with a scan tool while depressing the accelerator pedal. Does the Transmission OSS parameter increase in accordance with a vehicle speed increase?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the vehicle speed sensor (VSS) 1 (SP2) harness connector. 3. Connect a DMM across the VSS1 (SP2) terminals (pins 1 and 2 of J-73 connector) 4. Measure the resistance across the VSS1 (SP2). Does the resistance measure within the specified value?	500-1000 Ω	Go to Step 4	Go to Step 14
4	1. Place the DMM on the AC volt scale. 2. Start the engine. 3. Select the D range and release the park brake 4. Monitor the DMM while depressing the accelerator pedal. Does the DMM indicate an AC voltage increase in accordance with a vehicle speed increase?	—	Go to Step 5	Go to Step 13
5	1. Turn OFF the ignition. 2. Connect a DMM between the VSS1 (SP2) high signal circuit (pin 1 of J-73 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. Is the DMM voltage within the specified value?	0.4-1.2 volts	Go to Step 7	Go to Step 6
6	Is the DMM voltage more than the specified value at step 5 ?	4.5 volts	Go to Step 9	Go to Step 8

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Connect a test lamp between the VSS1 (SP2) low signal circuit (pin 2 of J-73 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 11	Go to Step 10
8	1. Test the VSS1 (SP2) high signal circuit between the transmission control module (TCM) (pin 3 of B-229 connector) and the VSS1 (SP2) harness (pin 1 of J-73 connector) for the following conditions: • An open circuit • A short to ground • A short to each other • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
9	1. Test the VSS1 (SP2) high signal circuit between the TCM (pin 3 of B-229 connector) and the VSS1 (SP2) harness (pin 1 of J-73 connector) for the following conditions: • A short to battery or ignition voltage • A short to any 5 volts reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
10	1. Test the VSS1 (SP2) low signal circuit between the TCM (pin 16 of B-229 connector) and the VSS1 (SP2) harness (pin 2 of J-73 connector) for the following conditions: • An open circuit • A short to battery or ignition voltage • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
11	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the VSS1 (SP2) (pins 1 and 2 of J-73 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15

Step	Action	Value(s)	Yes	No
12	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for poor connections on these VSS1 (SP2) circuits at the harness connector of the TCM (pins 3 and 16 of B-229 connector). 4. Repair the connection(s) as necessary Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
13	1. Inspect the VSS1 (SP2) for tightness. 2. Retest if the sensor was loose. 3. Remove the VSS1 (SP2) and check for damage, metal particles on magnet and for output shaft gear teeth damage. Did you find and correct the condition?	—	Go to Step 16	Go to Step 14
14	Replace the VSS1 (SP2). Refer to Repair Instructions (Overhaul) - Vehicle Speed Sensor 1 (SP2) in this section Did you complete the replacement?	—	Go to Step 16	—
15	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Select the D range and release the park brake. 6. Observe the Transmission OSS parameter with a scan tool while depressing the accelerator pedal. Does the Transmission OSS parameter increase in accordance with a vehicle speed increase?	—	Go to Step 2	Go to Step 17
17	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0722 (Flash Code 11) [Except 12,000 lbs GVW]

Circuit Description

Vehicle speed information is sent from the vehicle speed sensor (VSS) 1 (SP2) to the Transmission Control Module (TCM). This sensor is provided in the transmission rear cover.
The VSS1 (SP2) is an electromagnetic pulse pickup type that generates a speed signal according to the revolution of the transmission output shaft (18 pulses at a single revolution of the output shaft). As a result, the sensor sends a sine wave signal to the TCM, which converts this sine wave signal (pulse voltage) into a MPH (km/h) signal. If this signal is not inputted or suddenly lost, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

Condition 1

- The vehicle speed sensor (VSS) 2 (SP1) is normal.
- The VSS1 (SP2) signal has not inputted while the VSS2 (SP1) signal is inputted at least 4 pulses.
- The shift position is not P or N range.
- The output shaft speed is higher than 186 RPM for 4 seconds or more.

Condition 2

- The VSS 2 (SP1) signal is not generated.
- The VSS1 (SP2) signal is suddenly lost when the vehicle speed is between 13 MPH (21 km/h) and 106 MPH (171 km/h).

Action Taken When the DTC Sets

Condition 1

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The TCM uses the VSS2 (SP1) signal instead of the VSS1 (SP2) signal.
- The TCM inhibits the shift-up control from 3rd gear range to 4th gear range.

Condition 2

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The TCM keeps the last gear position when the DTC was set.
- The TCM controls line pressure using a throttle position substitution of 100%.
- The TCM turns OFF the shift solenoid (S1) valve and shift solenoid (S2) valve when the engine speed becomes less than 1000 RPM.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

Diagnostic Aids

This DTC indicates that both vehicle speed sensor circuits contain a fault. VSS 1 can be read as Transmission OSS and VSS 2 can be read as Speed Meter Signal in the transmission data table.

Notice:
Vehicle Speed in the transmission data table will indicate VSS 1 OR VSS 2 based upon which signal is valid.

Notice:
The following chart only diagnoses the VSS 1 (SP2) circuit.

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Transmission OSS" display on the scan tool while driving the vehicle. A change in the display will indicate the location of the fault.

DTC P0722 (Flash Code 11) [Except 12,000 lbs GVW]

Schematic Reference: Transmission Controls Schematics
Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Lift the driving wheels. 3. Start the engine. 4. Select the D range and release the park brake. 5. Observe the Transmission OSS parameter with a scan tool while depressing the accelerator pedal. Does the Transmission OSS parameter increase in accordance with a vehicle speed increase?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the vehicle speed sensor (VSS) 1 (SP2) harness connector. 3. Connect a DMM across the VSS1 (SP2) terminals (pins 1 and 2 of J-73 connector) 4. Measure the resistance across the VSS1 (SP2). Does the resistance measure within the specified value?	500-1000 Ω	Go to Step 4	Go to Step 14
4	1. Place the DMM on the AC volt scale. 2. Start the engine. 3. Select the D range and release the park brake 4. Monitor the DMM while depressing the accelerator pedal. Does the DMM indicate an AC voltage increase in accordance with a vehicle speed increase?	—	Go to Step 5	Go to Step 13
5	1. Turn OFF the ignition. 2. Connect a DMM between the VSS1 (SP2) high signal circuit (pin 1 of J-73 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. Is the DMM voltage within the specified value?	0.4-1.2 volts	Go to Step 7	Go to Step 6
6	Is the DMM voltage more than the specified value at step 5 ?	4.5 volts	Go to Step 9	Go to Step 8

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Connect a test lamp between the VSS1 (SP2) low signal circuit (pin 2 of J-73 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 11	Go to Step 10
8	1. Test the VSS1 (SP2) signal circuit between the transmission control module (TCM) (pin 3 of B-229 connector) and the VSS1 (SP2) high signal circuit (pin 1 of J-73 connector) for the following conditions: • An open circuit • A short to ground • A short to each other • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
9	1. Test the VSS1 (SP2) signal circuit between the TCM (pin 3 of B-229 connector) and the VSS1 (SP2) high signal circuit (pin 1 of J-73 connector) for the following conditions: • A short to battery or ignition voltage • A short to any 5 volts reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
10	1. Test the VSS1 (SP2) low signal circuit between the TCM (pin 16 of B-229 connector) and the VSS1 (SP2) harness (pin 2 of J-73 connector) for the following conditions: • An open circuit • A short to battery or ignition voltage • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
11	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the VSS1 (SP2) (pins 1 and 2 of J-73 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15

Step	Action	Value(s)	Yes	No
12	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for poor connections on these VSS1 (SP2) circuits at the harness connector of the TCM (pins 3 and 16 of B-229 connector). 4. Repair the connection(s) as necessary Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
13	1. Inspect the VSS1 (SP2) for tightness. 2. Retest if the sensor was loose. 3. Remove the VSS1 (SP2) and check for damage, metal particles on magnet and for output shaft gear teeth damage. Did you find and correct the condition?	—	Go to Step 16	Go to Step 14
14	Replace the VSS1 (SP2). Refer to Repair Instructions (Overhaul) - Vehicle Speed Sensor 1 (SP2) in this section Did you complete the replacement?	—	Go to Step 16	—
15	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Select the D range and release the park brake. 6. Observe the Transmission OSS parameter with a scan tool while depressing the accelerator pedal. Does the Transmission OSS parameter increase in accordance with a vehicle speed increase?	—	Go to Step 2	Go to Step 17
17	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0723 (Flash Code 11)

Circuit Description

Vehicle speed information is sent from the vehicle speed sensor (VSS) 1 (SP2) to the Transmission Control Module (TCM). This sensor is provided in the transmission rear cover.

The VSS1 (SP2) is an electromagnetic pulse pickup type that generates a speed signal according to the revolution of the transmission output shaft (18 pulses at a single revolution of the output shaft). As a result, the sensor sends a sine wave signal to the TCM, which converts this sine wave signal (pulse voltage) into a MPH (km/h) signal. If this signal is suddenly lost, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The VSS2 (SP1) signal is not generated.
- The VSS1 (SP2) signal is suddenly lost when the vehicle speed is between 13 MPH (21 km/h) and 106 MPH (171 km/h).

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history at the time the diagnostic fails.
- The TCM keeps the last gear position when the DTC was set.
- The TCM controls line pressure using a throttle position substitution of 100%.
- The TCM turns OFF the shift solenoid (S1) valve and shift solenoid (S2) valve when the engine speed becomes less than 1000 RPM.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the "Transmission OSS" and the “Speed Meter Signal” display on the scan tool while driving the vehicle. A change in the display will indicate the location of the fault.

DTC P0723 (Flash Code 11)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Lift the driving wheels. 3. Start the engine. 4. Select the D range and release the park brake. 5. Observe the Transmission OSS parameter with a scan tool while depressing the accelerator pedal. Does the Transmission OSS parameter increase in accordance with a vehicle speed increase?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the vehicle speed sensor (VSS) 1 (SP2) harness connector. 3. Connect a DMM across the VSS1 (SP2) terminals (pins 1 and 2 of J-73 connector) 4. Measure the resistance across the VSS1 (SP2). Does the resistance measure within the specified value?	500-1000 Ω	Go to Step 4	Go to Step 14
4	1. Place the DMM on the AC volt scale. 2. Start the engine. 3. Select the D range and release the park brake 4. Monitor the DMM while depressing the accelerator pedal. Does the DMM indicate an AC voltage increase in accordance with a vehicle speed increase?	—	Go to Step 5	Go to Step 13
5	1. Turn OFF the ignition. 2. Connect a DMM between the VSS1 (SP2) high signal circuit (pin 1 of J-73 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. Is the DMM voltage within the specified value?	0.4-1.2 volts	Go to Step 7	Go to Step 6
6	Is the DMM voltage more than the specified value at step 5 ?	4.5 volts	Go to Step 9	Go to Step 8
7	1. Turn OFF the ignition. 2. Connect a test lamp between the VSS1 (SP2) high signal circuit (pin 2 of J-73 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to Step 11	Go to Step 10

Step	Action	Value(s)	Yes	No
8	1. Test the VSS1 (SP2) high signal circuit between the transmission control module (TCM) (pin 3 of B-229 connector) and the VSS1 (SP2) harness (pin 1 of J-73 connector) for the following conditions: • An open circuit • A short to ground • A short to each other • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
9	1. Test the VSS1 (SP2) high signal circuit between the TCM (pin 3 of B-229 connector) and the VSS1 (SP2) harness (pin 1 of J-73 connector) for the following conditions: • A short to battery or ignition voltage • A short to any 5 volts reference 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
10	1. Test the VSS1 (SP2) low signal circuit circuit between the TCM (pin 16 of B-229 connector) and the VSS1 (SP2) harness (pin 2 of J-73 connector) for the following conditions: • An open circuit • A short to battery or ignition voltage • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
11	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor connections and corrosion at the harness connector of the VSS1 (SP2) (pins 1 and 2 of J-73 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
12	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for poor connections on these VSS1 (SP2) circuit at the harness connector of the TCM (pins 3 and 16 of B-229 connector). 4. Repair the connection(s) as necessary Did you find and correct the condition?	—	Go to Step 16	Go to Step 15

Step	Action	Value(s)	Yes	No
13	1. Inspect the VSS1 (SP2) for tightness. 2. Retest if the sensor was loose. 3. Remove the VSS1 (SP2) and check for damage, metal particles on magnet and for output shaft gear teeth damage. Did you find and correct the condition?	—	Go to Step 16	Go to Step 14
14	Replace the VSS1 (SP2). Refer to Repair Instructions (Overhaul) - Vehicle Speed Sensor 1 (SP2) in this section Did you complete the replacement?	—	Go to Step 16	—
15	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Select the D range and release the park brake. 6. Observe the Transmission OSS parameter with a scan tool while depressing the accelerator pedal. Does the Transmission OSS parameter increase in accordance with a vehicle speed increase?	—	Go to Step 2	Go to Step 17
17	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0727 (Flash Code 13)

Circuit Description

The engine speed signal to the transmission control module (TCM) is sent from the engine control module (ECM) based on inputs from the crankshaft position (CKP) sensor and camshaft position (CMP) sensor. If the TCM detects that the engine speed signal is not generated during vehicle running, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The shift position is not N range or P range.
- The output shaft speed is more than 1000 RPM.
- The engine speed is less than 100 RPM.
- Above conditions are met for 2 minutes.

Action Taken When the DTC Sets

12,000 lbs GVW

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.
- The TCM changes the TCC lock-up control mapping. (The TCM inhibits the TCC lock-up control when the throttle position is idle.)
- The TCM inhibits the lock-up duty control.
- The TCM inhibits the shift timing control from 2nd gear to 3rd gear
- The engine torque control outputs the demand value which becomes the new A/T permission torque.
- The TCM inhibits the current value compensation control of the line pressure solenoid valve.

Except 12,000 lbs GVW

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The TCM changes the TCC lock-up control mapping. (The TCM inhibits the TCC lock-up control when the throttle position is idle.)
- The TCM inhibits the lock-up duty control.
- The TCM inhibits the shift timing control from 2nd gear to 3rd gear.
- The engine torque control outputs the demand value which becomes the new A/T permission torque.
- The TCM inhibits the current value compensation control of the line pressure solenoid valve.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

12,000 lbs GVW

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM and ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the “Engine Speed” display on the scan tool while depressing the accelerator pedal. A change in the display will indicate the location of the fault.

Notice:
Engine Speed in the transmission data table will indicate CKP sensor OR CMP sensor based upon which signal is valid.

DTC P0727 (Flash Code 13)

Schematic Reference: Transmission Controls Schematics
Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check Engine Controls
2	1. Install a scan tool. 2. Start the engine and let engine idle. 3. Observe the Engine Speed parameter with a scan tool. Does the Engine Speed parameter indicate correct engine speed?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) harness connector. 3. Connect a DMM between the engine speed signal output circuit (pin A-82 of J-218 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Is the DMM voltage more than the specified value?	5.5 volts	Go to Step 5	Go to Step 4
4	Is the DMM voltage more than the specified value at step 3?	4.5 volts	Go to Step 7	Go to Step 6
5	1. Test the engine speed signal circuit between the transmission control module (TCM) (pin 1 of B-229 connector) and the ECM (pin A-82 of J-218 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10
6	1. Test the engine speed signal circuit between the TCM (pin 1 of B-229 connector) and the ECM (pin A-82 of J-218 connector) for the following conditions: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 8

Step	Action	Value(s)	Yes	No
7	1. Connect the J-35616-64A terminal test lead to the A-82 pin of the engine control module (ECM) J-218 harness connector. 2. Use the scan tool to monitor the Engine Speed parameter while momentarily jumping the Engine Speed signal (pin A-82 of J-218 connector) to a known good ground. Make sure to be quick when momentarily jumping the circuit to the known good ground. Does the Engine Speed change when the engine speed circuit is momentarily jumpered to ground?	—	Go toStep 11	Go toStep 10
8	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for a poor connection on the engine speed signal input circuit at the harness connector of the TCM (pin 1 of B-229 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 10
9	1. Turn OFF the ignition. 2. Disconnect the ECM harness connector. 3. Inspect for an intermittent, for a poor connection and corrosion on the engine speed signal output circuit at the harness connector of the ECM (pin A-82 of J-218 connector). 4. Repair the connection (s) as necessary. Did you find and correct the condition?	—	Go to Step 12	Go to Step 11
10	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 12	—
11	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 12	—

Step	Action	Value(s)	Yes	No
12	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets the DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Start the engine and let engine idle. 4. Observe the Engine Speed parameter with a scan tool. Does the Engine Speed parameter indicate correct engine speed?	—	Go to Step 13	Go to Step 3
13	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0741 (Flash Code 15)

Circuit Description

The torque converter clutch pulse width modulation (TCC PWM) solenoid valve is located in the lower part of the valve body. It controls the fluid supply to the lock-up control valve. The transmission control module (TCM) controls the TCC PWM solenoid valve by the duty signal based on shift position, gear position, accelerator pedal position, engine speed and vehicle speed. The TCM turns ON the TCC PWM solenoid valve when the gear shift control has completed and contain conditions have been met. Then the lock-up control valve is moved and the fluid that presses the lock-up clutch in the torque converter is released. At the same time, the lock-up clutch is pressed to the converter front cover and then the torque converter is locked. The TCM detects the actual state of the TCC PWM solenoid valve by the slip speed of the torque converter. The slip speed of the torque converter is low when the TCC PWM solenoid valve is ON, and is high when the TCC PWM solenoid valve is OFF. If the TCM detects a high slip speed when it commands the TCC PWM solenoid valve ON, this DTC will set.

Condition for Running the DTC

- The engine speed is between 600 RPM and 4800 RPM.
- The vehicle speed is greater than 0 MPH (0 km/h) .
- The shift position is D or 2.
- The TCM is commanding the TCC PWM solenoid valve ON.
- The commanded gear is constant.

When the following conditions are met while above conditions are met and passed for 10 - 200 seconds:

- DTC P0722, P0727, P0743, P0751, P0752, P0753, P0756, P0757, P0758, U2104 and U2105 are not set
- Either of the following conditions are met:
  - The automatic transmission fluid (ATF) temperature is more than 104°F (40°C) when DTC P0711, P0712 and P0713 are not set.
  - The engine coolant temperature is more than 158°F (70°C) for 10 minutes or more.

Condition for Setting the DTC

- {A - (B×C)} value is more than 100 RPM
  - A: Engine speed (RPM)
  - B: Output shaft speed (RPM)
  - C: Gear ratio

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores the DTC in ECM history during the second consecutive trip in which the diagnostic fails.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

- Residue or contamination of the fluid line may cause an intermittent TCC clutch slip.

DTC P0741 (Flash Code 15)

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Start the engine. 3. Drive the vehicle in the D range. 4. Raise the speed until the gear position shifts to 3rd. (Observe the Current Gear parameter with a scan tool.) 5. Observe the TCC Slip Speed parameter with a scan tool. Is the TCC Slip Speed parameter less than the specified value?	100 RPM	Go to Diagnostic Aids	Go to Step 3
3	1. Remove the valve body. Refer to Repair Instructions (Overhaul). 2. Inspect the transmission for the following conditions: • The torque converter clutch pulse width modulation (TCC PWM) solenoid valve for mechanically stuck OFF. • The lock-up control valve for stuck in the released position. • Valve body gaskets for damage. • Torque converter mechanically stuck. Refer to Repair Instructions (On-Vehicle) - Torque Converter 3. Repair any of the above conditions or replace the transmission assembly as necessary. Refer to Repair Instructions (On-Vehicle) - Transmission Assembly in this section. Did you find and correct the condition?	—	Go to Step 5	Go to Step 4
4	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 5	—

Step	Action	Value(s)	Yes	No
5	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Drive the vehicle in the D range. 6. Raise the speed until the gear position shifts to 3rd. (Observe the Current Gear parameter with a scan tool.) 7. Observe the TCC Slip Speed parameter with a scan tool. Is the TCC Slip Speed parameter less than the specified value?	100 RPM	Go to Step 6	Go to Step 2
6	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0742 (Flash Code 74)

Circuit Description

The torque converter clutch pulse width modulation (TCC PWM) solenoid valve is located in the lower part of the valve body. It controls the fluid supply to the lock-up control valve. The transmission control module (TCM) controls the TCC PWM solenoid valve by the duty signal based on shift position, gear position, accelerator pedal position, engine speed and vehicle speed. The TCM turns ON the TCC PWM solenoid valve when the gear shift control has completed and contain conditions have been met. Then the lock-up control valve is moved and the fluid that presses the lock-up clutch in the torque converter is released. At the same time, the lock-up clutch is pressed to the converter front cover and then the torque converter is locked. The TCM detects the actual state of the TCC PWM solenoid valve by the slip speed of the torque converter. The slip speed of the torque converter is low when the TCC PWM solenoid valve is ON, and is high when the TCC PWM solenoid valve is OFF. If the TCM detects a low slip speed when it commands to the TCC PWM solenoid valve ON, this DTC will set.

Condition for Running the DTC

- The engine speed is between 600 RPM and 4800 RPM.
- The vehicle speed is greater than 0 MPH (0 km/h).
- The shift position is D or 2.
- The TCM is commanding the TCC PWM solenoid valve OFF.

When the following conditions are met while above conditions are met and passed for 1-200 seconds:

- DTC P0722, P0727, P0743, P0748, P0751, P0752, P0756, P0757, P0785, U2104 and U2105 are not set.
- Either of the following conditions are met:
  - The automatic transmission fluid (ATF) temperature is more than 104°F (40°C) when DTC P0711, P0712 and P0713 are not set.
  - The engine coolant temperature is more than 158°F (70°C) for 10 minutes or more.

Condition for Setting the DTC

During the coast-down controlling when the following conditions are met for 2 seconds:

- The accelerator pedal position (APP) is idle (less than 7%).
- The output shaft speed is decreasing.
- The output shaft speed is more than 1200 RPM.
- |A - (B×C)| value is less than 20 RPM
  - A: Engine speed (RPM)
  - B: Output shaft speed (RPM)
  - C: Gear ratio
- The engine coolant temperature is more than 158°F (70°C).
- The gear position is the 4th.

During the up-shift controlling when the following conditions are met in 10 seconds, after the up-shift finished:

- The last up-shift was a Power on Up-shift.
- The APP is between 30% and 100%.
- The engine speed is increased.
- The output shaft speed is increased.
- |A - (B×C)| less than 20 RPM
  - A: Engine speed (RPM)
  - B: Output shaft speed (RPM)
  - C: Gear ratio
- Above conditions are met for 1 second.

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.

- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

- Any intermittently stuck TCC solenoid valve may cause the TCC to be stuck ON.

DTC P0742 (Flash Code 74)

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Start the engine and let idle until the engine coolant temperature (ECT) reaches 158°F (70°C). 3. Drive the vehicle. 4. Raise the speed until the gear position shifts to 4th and the output shaft speed reaches 1300 RPM. (Observe the Current Gear and the Transmission OSS parameters with a scan tool.) 5. Release your foot from the accelerator pedal. 6. Observe the TCC Slip Speed parameter with a scan tool. Is the TCC Slip Speed parameter within the specified value?	-100–100 RPM	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the valve body. Refer to Repair Instructions (Overhaul). 2. Inspect the transmission for the following conditions: • The torque converter clutch pulse width modulation (TCC PWM) solenoid valve for mechanically stuck ON. • The lock-up control for stuck in the applied position. • Valve body gaskets for damage. • Torque converter mechanically stuck. Refer to Repair Instructions (On-Vehicle) - Torque Converter 3. Repair any of the above conditions or replace the transmission assembly as necessary. Refer to Repair Instructions (On-Vehicle) - Transmission Assembly. Did you find and correct the condition?	—	Go to Step 5	Go to Step 4
4	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 5	—

Step	Action	Value(s)	Yes	No
5	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Drive the vehicle. 6. Raise the speed until the gear position shifts to 4th and the output shaft speed reaches 1300 RPM.(Observe the Current Gear and the Transmission OSS parameters with a scan tool.) 7. Release your foot from the accelerator pedal. 8. Observe the TCC Slip Speed parameter with a scan tool. Is the TCC Slip Speed parameter within the specified value?	-100–100 RPM	Go to Step 2	Go to Step 6
6	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0743 (Flash Code 34)

Circuit Description

The torque converter clutch pulse width modulation (TCC PWM) solenoid valve is located in the lower part of the valve body. It controls the fluid supply to the lock-up control valve. The transmission control module (TCM) controls the TCC PWM solenoid valve by the duty signal based on shift position, gear position, accelerator pedal position, engine speed and vehicle speed. The TCM turns ON the TCC PWM solenoid valve when the gear shift control has completed and contain conditions have been met. The TCM monitors the output voltage to the TCC PWM solenoid valve. If the TCM detects the inconsistency between the command to the TCC PWM solenoid valve and the output voltage to the TCC PWM solenoid valve, this DTC will set.

Condition for Setting the DTC

Either of the following conditions are met for 8 consecutive times:

- The output circuit voltage to the TCC PWM solenoid valve is 0 volts when the TCM commands the TCC PWM solenoid valve ON.
- The output circuit voltage to the TCC PWM solenoid valve is 12 volts when the TCM commands the TCC PWM solenoid valve OFF.

Action Taken When the DTC Sets

12,000 lbs GVW

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history at the time the diagnostic fails.
- The TCM turns the TCC PWM solenoid valve OFF.

Except 12,000 lbs GVW

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM turns the TCC PWM solenoid valve OFF.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
    - Turn ON the ignition, with the engine OFF.
    - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
    - Select "N" (neutral) range.
    - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

12,000 lbs GVW

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the DTC display on the scan tool while moving connectors and the wiring harness. A change in the display will indicate the location of the fault.

DTC P0743 (Flash Code 34)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle with the following conditions: • Select the D range • Accelerate the vehicle speed to 50 MPH (80 km/h), and decelerate the vehicle speed to 3 MPH (5 km/h). 5. Repeat the above conditions (action number 4) for 8 times. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (J-71). 3. Connect a test lamp between the torque converter clutch pulse width modulation (TCC PWM) solenoid valve control circuit (pin 5 of J-71 male side connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. 5. Command the TCC Solenoid ON with a scan tool. Does the test lamp continuously illuminate when commanded ON?	—	Go to Step 4	Go to Step 6
4	Command the TCC Solenoid OFF with a scan tool. Does the test lamp illuminate when commanded OFF?	—	Go to Step 5	Go to Step 7
5	1. Test the TCC PWM solenoid valve control circuit between the transmission control module (TCM) (pin 24 of B-229 connector) and the in-line harness connector (pin 5 of J-71 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary Did you find and correct the condition?	—	Go to Step 13	Go to Step 12

Step	Action	Value(s)	Yes	No
6	1. Test the TCC PWM solenoid valve control circuit between the TCM (pin 24 of B-229 connector) and the in-line harness connector (pin 5 of J-71 connector) for the following conditions: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary Did you find and correct the condition?	—	Go to Step 13	Go to Step 11
7	1. Turn OFF the ignition. 2. Inspect for an intermittent, for a poor connection and corrosion on the TCC PWM solenoid valve control circuit at the in-line connector (pin 5 of J-71 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 8
8	1. Test the TCC PWM solenoid valve control circuit between the TCC PWM solenoid valve and the in-line connector (pin 5 of J-71 connector) for the following conditions: • An open circuit • A short to ground • A short to battery or ignition voltage • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 9
9	1. Inspect for an intermittent and for a poor connection at the harness connector of the TCC PWM solenoid valve. 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 10
10	Replace the TCC PWM solenoid valve. Refer to Repair Instructions (Overhaul) - Valve Body in this section Did you complete the replacement?	—	Go to Step 13	—
11	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for a poor connection on the TCC PWM solenoid valve control circuit at the harness connector of the TCM (pin 24 of B-229 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12

Step	Action	Value(s)	Yes	No
12	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 13	—
13	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. (12,000 lbs GVW) 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle with the following conditions: • Select the D range • Accelerate the vehicle speed to 50 MPH (80 km/h), and decelerate the vehicle speed to 3 MPH (5 km/h). 6. Repeat the above conditions (action number 4) for 8 times. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 14
14	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

Table P0743

Final gear ratio	Lock-up point MPH (km/h) at throttle position angle 50%
5.571	28 (45)

DTC P0748 (Flash Code 35)

Circuit Description

The Transmission Control Module (TCM) outputs signals to the line pressure solenoid valve to control the line pressure of the transmission. With the operation of this solenoid, the operation and shift of the hydraulic circuit in the transmission can be performed smoothly. The line pressure solenoid valve is controlled according to the inhibitor switch, vehicle speed and accelerator position pedal signal.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

Condition 1:

The TCM detects a low voltage condition for 0.01 seconds at the voltage feedback high control circuit when the TCM is commanding the line pressure high control circuit driver ON.

Condition 2:

The TCM detects a high voltage condition for 0.01 seconds at the voltage feedback high control circuit when the TCM is commanding the line pressure high control circuit driver OFF.

Condition 3:

The TCM detects less than 0.05 amps for 0.5 seconds at the current feedback low control circuit when the TCM is commanding the line pressure low control driver ON.

Condition 4:

The TCM detects greater than 1.2 amps for 0.5 seconds at the current feedback low control circuit when the TCM is commanding the line pressure low control driver OFF.

Notice:
The P0748 diagnostic does not run until after the ignition has been turned ON for longer than 2 seconds.

Action Taken When the DTC Sets

12,000 lbs GVW

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM does not request to illuminate the malfunction indicator lamp (MIL).
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM turns the line pressure solenoid valve OFF.
- The TCM changes the TCC lock-up control mapping. (The TCM inhibits the TCC lock-up control when the accelerator pedal position is idle.)
- The TCM inhibits the lock-up duty control.

Except 12,000 lbs GVW

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM turns the line pressure solenoid valve OFF.
- The TCM changes the TCC lock-up control mapping. (The TCM inhibits the TCC lock-up control when the accelerator pedal position is idle.)
- The TCM inhibits the lock-up duty control.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

12,000 lbs GVW

- The TCM turns OFF the check trans lamp after the first driving cycle when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.

- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the DTC display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0748 (Flash Code 35)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Turn OFF the ignition for 30 seconds. 2. Install a scan tool. 3. Turn ON the ignition,with the engine OFF. 4. Observe the PC Sol. Actual Current parameter with a scan tool. Is the PC Sol. Actual Current parameter within specified value?	0.3-1.1 amps	Go to Diagnostic Aids	Go to Step 3
3	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (J-71). 3. Connect a test lamp between the line pressure solenoid valve high control circuit (pin 4 of J-71 connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate (the test lamp will turn ON then go out normally)?	—	Go to Step 4	Go to Step 7
4	Does the test lamp continuously illuminate?	—	Go to Step 8	Go to Step 5
5	1. Turn OFF the ignition. 2. Connect a test lamp between the line pressure solenoid valve low control circuit (pin 8 of J-71 connector) and battery voltage. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate (the test lamp will turn ON then go out normally)?	—	Go to Step 6	Go to Step 9
6	Does the test lamp continuously illuminate?	—	Go to Step 10	Go to Step 12
7	1. Test the line pressure solenoid high control circuit between the TCM (pin 26 of B-229 connector) and the in-line connector (pin 4 of J-71 connector) for the following conditions: • An open circuit • A short to ground • A short to the low control circuit • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 11

Step	Action	Value(s)	Yes	No
8	1. Test the line pressure solenoid high control circuit between the TCM (pin 26 of B-229 connector) and the in-line connector (pin 4 of J-71 connector) for a short to battery or ignition voltage. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
9	1. Test the line pressure solenoid low control circuit between the TCM (pin 25 of B-229 connector) and the in-line connector (pin 8 of J-71 connector) for the following conditions: • An open circuit • A short to battery or ignition voltage • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 11
10	1. Test the line pressure solenoid low control circuit between the TCM (pin 25 of B-229 connector) and the in-line connector (pin 8 of J-71 connector) for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
11	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for poor connections on these line pressure solenoid circuits at the harness connector of the TCM (pins 25 and 26 of B-229 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
12	1. Turn OFF the ignition. 2. Inspect for an intermittent, for poor connections and corrosion on these line pressure solenoid valve control circuit at the harness connector of the in-line connector (pins 4 and 8 of J-71 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 13

Step	Action	Value(s)	Yes	No
13	1. Test the control circuits of the line pressure solenoid valve between the in-line connector (pins 4 and 8 of J-71 connector) and the line pressure solenoid valve for the following conditions: • An open circuit • A short to ground • A short to battery or ignition voltage • A short to each other • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 14
14	1. Turn OFF the ignition. 2. Inspect for an intermittent and for poor connections at the harness connector of the line pressure solenoid valve. 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 15
15	Replace the line pressure solenoid valve. Refer to Repair Instructions (Overhaul) - Valve Body in this section. Did you complete the repair or replacement?	—	Go to Step 17	—
16	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 17	—
17	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Turn ON the ignition. 5. Observe the PC Sol. Actual Current parameter with a scan tool. Is the PC Sol. Actual Current parameter within specified value?	0.3-1.1 amps	Go to Step 18	Go to Step 3
18	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0751 (Flash Code 51)

Circuit Description

The shift solenoid (S1) valve is located in the lower part of the valve body. It controls the fluid supply to the 2-3 shift valve. The transmission control module (TCM) controls the shift solenoid (S1) valve based on shift position, gear position, accelerator pedal position, engine speed and vehicle speed. The TCM turns ON the shift solenoid (S1) valve when the commanded gear position is 1st and 2nd. If the TCM detects an inconsistency between the commanded gear position and the gear ratio, this DTC will set.

Condition for Running the DTC

- Either of following conditions are met:
  - The automatic transmission fluid (ATF) temperature is more than 10°F (40°C) when DTCs P0711, P0712 and P0713 are not set.
  - The engine coolant temperature is more than 158°F (70°C) for 10 minutes or more.
- The TCM detects the shift position at the D range for 20 seconds or more.
- The engine speed is more than 600 RPM.
- DTCs P0705, P0717, P0722, P0727, P0743, P0748 P0785, U2104 and U2105 are not set.

Condition for Setting the DTC

Both of the following conditions are met for 2 seconds after a shift has completed:

Condition 1

Following conditions are met for 2 consecutive times.

- The accelerator pedal position (APP) is between 12% and 100%.
- The vehicle speed is more than 3 MPH (5 km/h).
- The current gear position is 1st, but the overdrive direct clutch speed is less than 500 RPM.

Condition 2

Following conditions are met for 2 consecutive times.

- The accelerator pedal position (APP) is between 12% and 100%.
- The vehicle speed is more than 3 MPH (5 km/h).
- The current gear position is 2nd and the gear ratio equals 3rd (the gear ratio is between 0.889 and 1.125).
- The engine speed is more than overdrive direct clutch speed.

Gear Ratio Table

Gear Position	Gear Ratio
1st	2.794–3.269
2nd	1.406–1.706
3rd	0.889–1.125
4th	0

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

- Other internal transmission failures may cause this DTC intermittently.

DTC P0751 (Flash Code 51)

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Start the engine. 3. Drive the vehicle in the D range. 4. Accelerate the vehicle until 4th gear is reached while observing the Current Gear parameter with a scan tool. 5. Observe the change of the Current Gear parameter with a scan tool in each gear. Does the Current Gear parameter change correctly from the 1st to the 4th?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Remove the valve body. Refer to Repair Instructions (Overhaul). 2. Inspect the transmission for the following conditions: • The shift solenoid (S1) valve for mechanically stuck OFF. • The shift solenoid (S1) valve for leak. • The 2-3 shift valve for stuck in the released position. 3. Repair any of the above conditions or replace the transmission assembly as necessary. Refer to Repair Instructions (On-Vehicle) - Transmission Assembly. Did you find and correct the condition?	—	Go to Step 5	Go to Step 4
4	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 5	—

Step	Action	Value(s)	Yes	No
5	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Drive the vehicle in the D range. 6. Accelerate the vehicle until 4th gear is reached while observing the Current Gear parameter with a scan tool. 7. Observe the change of the Current Gear parameter with a scan tool in each gear. Does the Current Gear parameter change correctly from the 1st to the 4th?	—	Go to Step 6	Go to Step 2
6	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0752 (Flash Code 71)

Circuit Description

The shift solenoid (S1) valve is located in the lower part of the valve body. It controls the fluid supply to the 2-3 shift valve. The transmission control module (TCM) controls the shift solenoid (S1) valve based on shift position, gear position, accelerator pedal position, engine speed and vehicle speed. The TCM turns ON the shift solenoid (S1) valve when the commanded gear position is 1st and 2nd. If the TCM detects an inconsistency between the commanded gear position and the gear ratio, this DTC will set.

Condition for Running the DTC

- Either of the following conditions are met:
  - The automatic transmission fluid (ATF) temperature is more than 104°F (40°C) when DTCs P0711, P0712 and P0713 are not set.
  - The engine coolant temperature is more than 158°F (70°C) for 10 minutes or more.
- The TCM detects the shift position at the D range for 20 seconds or more.
- The engine speed is more than 600 RPM.
- DTCs P0705, P0717, P0722, P0727, P0753 P0758, U2104 and U2105 are not set.

Condition for Setting the DTC

Following conditions are met for 2 times.

- The accelerator pedal position (APP) is between 12% and 100%.
- The vehicle speed is more than 3 MPH (5 km/h).
- The current gear position is 3rd, but the gear ratio equals 2nd (the gear ratio is between 1.406 and 1.706).

Gear Ratio Table

Gear Position	Gear Ratio
1st	2.794–3.269
2nd	1.406–1.706
3rd	0.889–1.125
4th	0

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.
- The TCM inhibits the shift-up control from 3rd range to 4th range.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

- Other internal transmission failures may cause this DTC intermittently.

DTC P0752 (Flash Code 71)

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Start the engine. 3. Drive the vehicle in the D range. 4. Accelerate the vehicle until 4th gear is reached while observing the Current Gear parameter with a scan tool. 5. Observe the change of the Current Gear parameter with a scan tool in each gear. Does the Current Gear parameter change correctly from the 1st to the 4th?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Remove the valve body. Refer to Repair Instructions (Overhaul). 2. Inspect the transmission for the following conditions: • The shift solenoid (S1) valve for mechanically stuck ON. • Oil seals for damage. • The 2-3 shift valve for stuck in the applied position. 3. Repair any of the above conditions or replace the transmission assembly as necessary. Refer to Repair Instructions (On-Vehicle) - Transmission Assembly. Did you find and correct the condition?	—	Go to Step 5	Go to Step 4
4	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 5	—
5	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Drive the vehicle in the D range. 6. Accelerate the vehicle until 4th gear is readed while observing the Current Gear parameter with a scan tool. 7. Observe the change of the Current Gear parameter with a scan tool in each gear. Does the Current Gear parameter change correctly from the 1st to the 4th?	—	Go to Step 6	Go to Step 2
6	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0753 (Flash Code 31)

Circuit Description

The shift solenoid (S1) valve is located in the lower part of the valve body. It controls the fluid supply to the 2-3 shift valve. The transmission control module (TCM) controls the shift solenoid (S1) valve based on shift position, gear position, accelerator pedal position, engine speed and vehicle speed. The TCM turns ON the shift solenoid (S1) valve when the commanded gear position is the 1st and the 2nd. If the TCM detects an inconsistency between the command to the shift solenoid (S1) valve and the actual output voltage to the shift solenoid (S1) valve, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

Either of following conditions are met for 8 times:

- The output voltage to the shift solenoid (S1) valve is 0 volts when the TCM commands the shift solenoid (S1) valve ON.
- The output voltage to the shift solenoid (S1) valve is 12 volts when the TCM commands the shift solenoid (S1) valve OFF.

Action Taken When the DTC Sets

12,000 lbs GVW

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history at the time the diagnostic fails.
- The TCM turns the shift solenoid (S1) valve OFF.
- The TCM turns the torque converter clutch pulse width modulation (TCC PWM) solenoid valve and shift timing solenoid valve OFF.

Except 12,000 lbs GVW

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM turns the shift solenoid (S1) valve OFF.
- The TCM turns the TCC PWM solenoid valve and shift timing solenoid valve OFF.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

12,000 lbs GVW

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the DTC display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0753 (Flash Code 31)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle with the following conditions: • Select the D range • Accelerate the vehicle speed to 50 MPH (80 km/h), and decelerate the vehicle speed to 3 MPH (5 km/h). 5. Repeat the above conditions (action number 4) for 8 times. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (J-71). 3. Connect a test lamp between the shift solenoid (S1) valve control circuit (pin 1 of J-71 male side connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. 5. Command the Shift Solenoid 1 ON with a scan tool. Does the test lamp illuminate when commanded ON?	—	Go to Step 4	Go to Step 6
4	Command the Shift Solenoid 1 OFF with a scan tool. Does the test lamp continuously illuminate when commanded OFF?	—	Go to Step 5	Go to Step 7
5	1. Test the shift solenoid (S1) valve control circuit between the transmission control module (TCM) (pin 13 of B-229 connector) and the in-line harness connector (pin 1 of J-71 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary Did you find and correct the condition?	—	Go to Step 13	Go to Step 12

Step	Action	Value(s)	Yes	No
6	1. Test the shift solenoid (S1) valve control circuit between the TCM (pin 13 of B-229 connector) and the in-line harness connector (pin 1 of J-71 connector) for the following conditions: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary Did you find and correct the condition?	—	Go to Step 13	Go to Step 11
7	1. Turn OFF the ignition. 2. Inspect for an intermittent, for a poor connection and corrosion on the shift solenoid (S1) valve control circuit at the in-line connector (pin 1 of J-71 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 8
8	1. Test the shift solenoid (S1) valve control circuit between the shift solenoid (S1) valve and the in-line connector (pin 1 of J-71 connector) for the following conditions: • An open circuit • A short to ground • A short to battery or ignition voltage • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 9
9	1. Inspect for an intermittent and for a poor connection at the harness connector of the shift solenoid (S1) valve. 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 10
10	Replace the shift solenoid (S1) valve. Refer to Repair Instructions (Overhaul) - Valve Body in this section Did you complete the replacement?	—	Go to Step 13	—
11	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for a poor connection on the shift solenoid (S1) valve control circuit at the harness connector of the TCM (pin 13 of B-229 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12

Step	Action	Value(s)	Yes	No
12	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 13	—
13	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. (12,000 lbs GVW) 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle with the following conditions: • Select the D range • Accelerate the vehicle speed to 50 MPH (80 km/h), and decelerate the vehicle speed to 3 MPH (5 km/h). 6. Repeat the above conditions (action number 4) for 8 times. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 14
14	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

Reference

Operating Solenoid		
Gear	S1	S2
1st	ON	OFF
2nd	ON	ON
3rd	OFF	ON
4th	OFF	OFF

DTC P0756 (Flash Code 52)

Circuit Description

The shift solenoid (S2) valve is located in the lower part of the valve body. It controls the fluid supply to the 1-2 shift valve and the 3-4 shift valve. The transmission control module (TCM) controls the shift solenoid (S2) valve based on shift position, gear position, accelerator pedal position, engine speed and vehicle speed. The TCM turns ON the shift solenoid (S2) valve when the commanded gear position is 2nd and 3rd. If the TCM detects an inconsistency between the commanded gear position and the gear ratio, this DTC will set.

Condition for Running the DTC

- Either of following conditions are met:
  - The engine coolant temperature is more than 158°F (70°C) for 10 minutes or more.
  - The automatic transmission fluid (ATF) temperature is more than 104°F (40°C) when DTCs P0711, P0712 and P0713 are not set.
- The TCM detects the shift position at the D range for 20 seconds or more.
- The engine speed is more than 600 RPM.
- DTCs P0717, P0705, P0722, P0727 P0753, P0758, U2104 and U2105.

Condition for Setting the DTC

Both of the following conditions are met for 2 seconds after a shift has completed:

Condition 1

Following conditions are met for 2 consecutive times.

- The accelerator pedal position (APP) is between 12% and 100%.
- The vehicle speed is more than 3 MPH (5 km/h).
- The current gear position is 2nd, but gear ratio equals 1st (the gear ratio is between 2.794 and 3.269).

Condition 2

Following conditions are met for 2 consecutive times.

- The accelerator pedal position (APP) is between 12% and 100%.
- The vehicle speed is more than 3 MPH (5 km/h).
- The current gear position is 3rd, but overdrive direct clutch speed is less than 500 RPM.
- The engine speed is more than overdrive direct clutch speed.

Gear Ratio Table

Gear Position	Gear Ratio
1st	2.794–3.269
2nd	1.406–1.706
3rd	0.889–1.125
4th	0

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

- Other internal transmission failures may cause this DTC intermittently.

DTC P0756 (Flash Code 52)

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Start the engine. 3. Drive the vehicle in the D range. 4. Accelerate the vehicle until 4th gear is reached while observing the Current Gear parameter with a scan tool. 5. Observe the change of the Current Gear parameter with a scan tool in each gear. Does the Current Gear parameter change correctly from the 1st to the 4th?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Remove the valve body. Refer to Repair Instructions (Overhaul). 2. Inspect the transmission for the following conditions: • The shift solenoid (S2) valve for mechanically stuck OFF. • The shift solenoid (S2) valve for leak. • The 1-2 shift valve for stuck in the released position. • The 3-4 shift valve for stuck in the released position. 3. Repair any of the above conditions or replace the transmission assembly as necessary. Refer to Repair Instructions (On-Vehicle) - Transmission Assembly. Did you find and correct the condition?	—	Go to Step 5	Go to Step 4
4	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 5	—

Step	Action	Value(s)	Yes	No
5	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Drive the vehicle in the D range. 6. Accelerate the vehicle until 4th gear is reached while observing the Current Gear parameter with a scan tool. 7. Observe the change of the Current Gear parameter with a scan tool in each gear. Does the Current Gear parameter change correctly from the 1st to the 4th?	—	Go to Step 6	Go to Step 2
6	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0757 (Flash Code 72)

Circuit Description

The shift solenoid (S2) valve is located in the lower part of the valve body. It controls the fluid supply to the 1-2 shift valve and the 3-4 shift valve. The transmission control module (TCM) controls the shift solenoid (S2) valve based on shift position, gear position, accelerator pedal position, engine speed and vehicle speed. The TCM turns ON the shift solenoid (S2) valve when the commanded gear position is 2nd and 3rd. If the TCM detects an inconsistency between the commanded gear position and the gear ratio, this DTC will set.

Condition for Running the DTC

- Either of following conditions are met:
  - The automatic transmission fluid (ATF) temperature is more than 104°F (40°C) when DTCs P0711, P0712 and P0713 are not set.
  - The engine coolant temperature is more than 158°F (70°C) for 10 minutes or more.
- The TCM detects the shift position at the D range for 20 seconds or more.
- The engine speed is more than 600 RPM.
- DTCs P0705, P0717, P0722, P0727, P0753, P0758 U2104 and U2105 are not set.

Condition for Setting the DTC

Both of following conditions are met for 2 seconds after a shift has completed:

Condition 1

Following conditions are met for 2 consecutive times.

- The accelerator pedal position (APP) is between 12% and 100%.
- The vehicle speed is more than 3 MPH (5 km/h).
- The calculated gear position is 1st, but the gear ratio equals 2nd (the gear ratio is between 1.406 and 1.706).

Condition 2

Following conditions are met for 2 consecutive times.

- The accelerator pedal position (APP) is between 12% and 100%.
- The vehicle speed is more than 3 MPH (5 km/h).
- The calculated gear position is 4th, but gear ratio equals 3rd (the gear ratio is between 0.889 and 1.125).

Gear Ratio Table

Gear Position	Gear Ratio
1st	2.794–3.269
2nd	1.406–1.706
3rd	0.889–1.125
4th	0

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.
- The TCM inhibits the shift-up control from 3rd range to 4th range. (For Condition 1)

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

- Other internal transmission failures may cause this DTC intermittently.

DTC P0757 (Flash Code 72)

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Start the engine. 3. Drive the vehicle in the D range. 4. Accelerate the vehicle until 4th gear is reached while observing the Current Gear parameter with a scan tool. 5. Observe the change of the Current Gear parameter with a scan tool in each gear. Does the Current Gear parameter change correctly from the 1st to the 4th?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Remove the valve body. Refer to Repair Instructions (Overhaul). 2. Inspect the transmission for the following conditions: • The shift solenoid (S2) valve for mechanically stuck ON. • Oil seals for damage. • The 1-2 shift valve for stuck in the applied position. • The 3-4 shift valve for stuck in the applied position. 3. Repair any of the above conditions or replace the transmission assembly as necessary. Refer to Repair Instructions (On-Vehicle) - Transmission Assembly. Did you find and correct the condition?	—	Go to Step 8	Go to Step 7
4	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 8	—

Step	Action	Value(s)	Yes	No
5	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Drive the vehicle in the D range. 6. Accelerate the vehicle until 4th gear is reached while observing the Current Gear parameter with a scan tool. 7. Observe the change of the Current Gear parameter with a scan tool each gear. Does the Current Gear parameter change correctly from the 1st to the 4th?	—	Go to Step 6	Go to Step 2
6	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P0758 (Flash Code 32)

Circuit Description

The shift solenoid (S2) valve is located in the lower part of the valve body. It controls the fluid supply to the 1-2 shift valve and the 3-4 shift valve. The transmission control module (TCM) controls the shift solenoid (S2) valve based on shift position, gear position, accelerator pedal position, engine speed and vehicle speed. The TCM turns ON the shift solenoid (S2) valve when the commanded gear position is 2nd and 3rd. If the TCM detects an inconsistency between the command to the shift solenoid (S2) valve and the actual output voltage to the shift solenoid (S2) valve, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

Either of following conditions are met for 8 times.

- The output voltage to the shift solenoid (S2) valve is 0 volts when the TCM commands the shift solenoid (S2) valve ON.
- The output voltage to the shift solenoid (S2) valve is 12 volts when the TCM commands the shift solenoid (S2) valve OFF.

Action Taken When the DTC Sets

12,000 lbs GVW

- The TCM flashes the check trans lamp and requests to illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history at the time the diagnostic fails.
- The TCM turns the shift solenoid (S2) valve OFF.
- The TCM turns the torque converter clutch pulse width modulation (TCC PWM) solenoid valve and shift timing solenoid valve OFF.

Except 12,000 lbs GVW

- The TCM flashes the check trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM turns the shift solenoid (S2) valve OFF.
- The TCM turns the TCC PWM solenoid valve and shift timing solenoid valve OFF.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

12,000 lbs GVW

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the DTC display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0758 (Flash Code 32)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle with the following conditions: • Select the D range • Accelerate the vehicle speed to 50 MPH (80 km/h), and decelerate the vehicle speed to 3 MPH (5 km/h). 5. Repeat the above conditions (action number 4) for 8 times. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (J-71). 3. Connect a test lamp between the shift solenoid (S2) valve control circuit (pin 2 of J-71 male side connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. 5. Command the Shift Solenoid 2 ON with a scan tool. Does the test lamp illuminate when commanded ON?	—	Go to Step 4	Go to Step 6
4	Command the Shift Solenoid 2 OFF with a scan tool. Does the test lamp continuously illuminate when commanded OFF?	—	Go to Step 5	Go to Step 7
5	1. Test the shift solenoid (S2) valve control circuit between the transmission control module (TCM) (pin 12 of B-229 connector) and the in-line harness connector (pin 2 of J-71 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary Did you find and correct the condition?	—	Go to Step 13	Go to Step 12

Step	Action	Value(s)	Yes	No
6	1. Test the shift solenoid (S2) valve control circuit between the TCM (pin 12 of B-229 connector) and the in-line harness connector (pin 2 of J-71 connector) for the following conditions: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary Did you find and correct the condition?	—	Go to Step 13	Go to Step 11
7	1. Turn OFF the ignition. 2. Inspect for an intermittent, for a poor connection and corrosion on the shift solenoid (S2) valve control circuit at the in-line connector (pin 2 of J-71 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 8
8	1. Test the shift solenoid (S2) valve control circuit between the shift solenoid (S2) valve and the in-line connector (pin 2 of J-71 connector) for the following conditions: • An open circuit • A short to ground • A short to battery or ignition voltage • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 9
9	1. Inspect for an intermittent and for a poor connection at the harness connector of the shift solenoid (S2) valve. 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 10
10	Replace the shift solenoid (S2) valve. Refer to Repair Instructions (Overhaul) - Valve Body in this section Did you complete the replacement?	—	Go to Step 13	—
11	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for a poor connection on the shift solenoid (S2) valve control circuit at the harness connector of the TCM (pin 12 of B-229 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12

Step	Action	Value(s)	Yes	No
12	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 13	—
13	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. (12,000 lbs GVW) 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle with the following conditions: • Select the D range • Accelerate the vehicle speed to 50 MPH (80 km/h), and decelerate the vehicle speed to 3 MPH (5 km/h). 6. Repeat the above conditions (action number 4) for 8 times. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 14
14	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

Reference

Operating Solenoid		
Gear	S1	S2
1st	ON	OFF
2nd	ON	ON
3rd	OFF	ON
4th	OFF	OFF

DTC P0785 (Flash Code 33)

Circuit Description

The shift timing solenoid valve is located in the lower part of the valve body. It controls the fluid supply to the 2nd brake (B1). The transmission control module (TCM) controls the shift timing solenoid valve based on shift position, gear position, accelerator pedal position, engine speed and vehicle speed. The TCM turns ON the shift timing solenoid valve when changing gears 1st - 2nd, 2nd - 3rd or 3rd - 2nd. The TCM also turns ON the shift timing solenoid valve when the gear position is 3rd in L range. If the TCM detects an inconsistency between the command to the shift timing solenoid valve and the output voltage to the shift timing solenoid valve, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

Either of following conditions are met for 8 times.

- The output voltage to the shift timing solenoid valve is 0 volts when the TCM commands the shift timing solenoid valve ON.
- The output voltage to the shift timing solenoid valve is 12 volts when the TCM commands the shift timing solenoid valve OFF.

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM turns the shift timing solenoid valve OFF.

Condition for Clearing the MIL/DTC

- Clear the Check Trans lamp and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
    - Turn ON the ignition, with the engine OFF.
    - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
    - Select "N" (neutral) range.
    - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds

12,000 lbs GVW

- The TCM turns OFF the check trans lamp after the first driving cycle when the diagnostic runs and does not fail
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the DTC display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P0785 (Flash Code 33)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle with the following conditions: • Select the D range • Accelerate the vehicle speed to 50 MPH (80 km/h), and decelerate the vehicle speed to 3 MPH (5 km/h). 5. Repeat the above conditions (action number 4) for 8 times. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (J-71). 3. Connect a test lamp between the shift timing solenoid valve control circuit (pin 3 of J-71 male side connector) and a known good ground. 4. Turn ON the ignition, with the engine OFF. 5. Command the Shift Timing Solenoid ON with a scan tool. Does the test lamp illuminate when commanded ON?	—	Go to Step 4	Go to Step 6
4	Command the Shift Timing Solenoid OFF with a scan tool. Does the test lamp continuously illuminate when commanded OFF?	—	Go to Step 5	Go to Step 7
5	1. Test the shift timing solenoid valve control circuit between the transmission control module (TCM) (pin 11 of B-229 connector) and the in-line harness connector (pin 3 of J-71 connector) for a short to battery or ignition voltage. 2. Repair the circuit(s) as necessary Did you find and correct the condition?	—	Go to Step 13	Go to Step 12
6	1. Test the shift timing solenoid valve control circuit between the TCM (pin 11 of B-229 connector) and the in-line harness connector (pin 3 of J-71 connector) for the following conditions: • An open circuit • A short to ground • High resistance 2. Repair the circuit(s) as necessary Did you find and correct the condition?	—	Go to Step 13	Go to Step 11

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Inspect for an intermittent, for a poor connection and corrosion on the shift timing solenoid valve control circuit at the in-line connector (pin 3 of J-71 connector). 3. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 8
8	1. Test the shift timing solenoid valve control circuit between the shift timing solenoid valve and the in-line connector (pin 3 of J-71 connector) for the following conditions: • An open circuit • A short to ground • A short to battery or ignition voltage • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 9
9	1. Inspect for an intermittent and for a poor connection at the harness connector of the shift timing solenoid valve. 2. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 10
10	Replace the shift timing solenoid valve. Refer to Repair Instructions (Overhaul) - Valve Body in this section Did you complete the replacement?	—	Go to Step 13	—
11	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for a poor connection on the shift timing solenoid valve control circuit at the harness connector of the TCM (pin 11 of B-229 connector). 4. Repair the connection(s) as necessary. Did you find and correct the condition?	—	Go to Step 13	Go to Step 12
12	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 13	—

Step	Action	Value(s)	Yes	No
13	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Operate the vehicle with the following conditions: • Select the D range • Accelerate the vehicle speed to 50 MPH (80 km/h), and decelerate the vehicle speed to 3 MPH (5 km/h). 6. Repeat the above conditions (action number 4) for 8 times. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 14
14	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1382 (Flash Code 19)

Circuit Description

The transmission control module (TCM) receives the exhaust brake cut signal. The exhaust brake cut signal is voltage feed back of the exhaust brake cut relay (switch side). When the exhaust brake cut relay is OFF, the exhaust brake cut signal voltage is ignition voltage (the relay is normally closed). The electronic hydraulic control unit (EHCU) [ABS module] turns ON the exhaust brake cut relay when the ABS active. And then the exhaust brake cut signal to the TCM is not inputted. The TCM detects that the ABS operates when the exhaust brake cut signal is not inputted and inhibits the coast lock-up control. If the TCM detects that the exhaust brake cut signal is not inputted (the ABS operation signal is ON) when the engine speed is higher than specified value, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

The TCM detects the following condition continuously for 40 seconds:

- The engine speed is more than 470 RPM.
- The ABS operation signal is ON.

Action Taken When the DTC Sets

- The TCM flashes the check trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.

Condition for Clearing the MIL/DTC

- Clear the Check Trans lamp and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

12,000 lbs GVW

- The TCM turns OFF the check trans lamp and the MIL after the first driving cycle when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM and EHCU: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the “ABS Signal” display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P1382 (Flash Code 19)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Monitor the Diagnostic Trouble Code (DTC) Information of the ABS control system with a scan tool. Is DTC C0299 also set?	—	Refer to DTC C0299 in Anti-Lock Brake System (ABS) section	Go to Step 3

Step	Action	Value(s)	Yes	No
3	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Observe the ABS Signal parameter with a scan tool. Does the ABS Signal parameter indicate the specified value?	OFF	Go to Diagnostic Aids	Go to Step 4
4	1. Test the exhaust brake cut signal circuit between the TCM (pin 4 of B-230 connector) and exhaust brake cut relay (pin 5 of J-210 connector) for the following conditions: • An open circuit • High resistance 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 5
5	1. Turn OFF the ignition. 2. Disconnect the TCM harness connector. 3. Inspect for an intermittent and for a poor connection on the exhaust brake cut signal circuit at the harness connector of the TCM (pin 4 of B-230 connector). 4. Repair the connection(s) as necessary Did you find and correct the condition?	—	Go to Step 7	Go to Step 6
6	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 7	—
7	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Observe the ABS Signal parameter with a scan tool. Does the ABS Signal parameter indicate the specified value?	OFF	Go to Step 8	Go to Step 2
8	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1790 (Flash Code 61)

Circuit Description

This diagnostic applies the internal microprocessor integrity conditions within the transmission control module (TCM).

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The TCM detects that the total sum of the Read Only Memory (ROM) data is not equal to the registered value.

Action Taken When the DTC Sets

- The TCM flashes the check trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.
- The TCM turns OFF all solenoids (the Torque converter clutch pulse width modulation (TCC PWM) solenoid valve, the shift solenoid (S1) valve, the shift solenoid (S2) valve, the line pressure solenoid valve and the shift timing solenoid valve).

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by all diagnostic.

DTC P1790 (Flash Code 61)

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install the scan tool 2. Turn OFF the ignition for 30 seconds 3. Turn ON the ignition 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 5
3	**Important:** Replacement transmission control module (TCM) must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 4	—

Step	Action	Value(s)	Yes	No
4	1. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 5
5	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1791 (Flash Code 62)

Circuit Description

This diagnostic applies the internal microprocessor integrity conditions within the transmission control module (TCM).

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The TCM detects that the incorrect programmed data is read out from the internal Random Access Memory (RAM).

Action Taken When the DTC Sets

- The TCM flashes the check trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.
- The TCM turns OFF all solenoids (the torque converter clutch pulse width modulation (TCC PWM) solenoid valve, the shift solenoid (S1) valve, the shift solenoid (S2) valve, the line pressure solenoid valve and the shift timing solenoid valve).

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by all diagnostic.

DTC P1791 (Flash Code 62)

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install the scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Did the DTC fail this ignition?	—	Go to Step 3	Go to Step 5
3	**Important:** Replacement transmission control module (TCM) must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 4	—

Step	Action	Value(s)	Yes	No
4	1. Clear the DTCs with a scan tool. **Important:** The engine control module (ECM) sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 2. Turn OFF the ignition for 30 seconds. 3. Turn ON the ignition. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 5
5	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1813 (Flash Code 42)

Circuit Description

The transmission control module (TCM) commands the engine control module (ECM) to reduce the engine torque by the controller area network (CAN) communication if the engine speed is more than a specified value. The TCM outputs the engine torque control quantity to the ECM if the engine speed and accelerator pedal position are more than specified value when the shift position is D, 2 or L range (the engine torque limit control). If the TCM detects that after it performs an engine torque limit control request to the ECM, but the engine torque has not lowered, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The TCM performs the engine torque limit control.
- The TCM increases the engine torque control quantity.
- The actual engine torque is more than the value that added 10% to the engine torque control quantity within a certain amoount of time.

(The TCM runs this diagnostic just once when the TCM performs an engine torque limit control.)

Action Taken When the DTC Sets

12,000 lbs GVW

- The TCM flashes the check trans lamp when the diagnostic runs and fails.
- The TCM does not request to illuminate the malfunction indicator lamp (MIL).
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM continues the engine torque limit control.
- The TCM controls line pressure using a throttle position substitution of 100%.

Except 12,000 lbs GVW

- The TCM flashes the check trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM continues the engine torque limit control.
- The TCM controls line pressure using a throttle position substitution of 100%.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

12,000 lbs GVW

- The TCM turns OFF the check trans lamp and the MIL after the first driving cycle when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the DTC display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC P1813 (Flash Code 42)

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the Diagnostic Trouble Code (DTC) Information of with a scan tool. Does the DTC U2100, U2104 or U2105 set?	—	Go to Applicable DTC	Go to Step 3
3	Monitor the DTC Information of the engine control system with a scan tool. Are any U-type DTC(s) set?	—	Refer to Applicable U-type DTC in Engine Control System section	Go to Step 4
4	**Important:** Replacement engine control module (ECM) must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in engine control system section. Did you complete the replacement?	—	Go to Step 5	—
5	1. Clear the DTCs with a scan tool. **Important:** The ECM sets DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. (12,000 lbs GVW) 2. Turn OFF the ignition for 30 seconds. 3. Drive the vehicle. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 6
6	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC P1839 (Flash Code 45)

Circuit Description

The automatic transmission fluid (ATF) temperature switch is located in the right side of the transmission case. The ATF temperature switch turns ON if the ATF temperature rises to between 284°F (140°C) and 298°F (148°C), and it turns OFF if the ATF temperature falls to 248°F (120°C). The transmission control module (TCM) receives the signal from the ATF temperature switch and uses this input for shift control and lock-up control. The input voltage to the TCM is low when the ATF temperature switch is ON, and the input voltage to the TCM is high when the ATF temperature switch is OFF. If the TCM detects that the ATF temperature is low but the ATF temperature switch is ON for a certain length of time, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The ATF temperature is less than 140°F (60°C).
- The ATF temperature switch is ON.
- The engine speed is more than 600 RPM.
- Above conditions are met for 1 minute.

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) on the second consecutive driving cycle when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history during the second consecutive trip in which the diagnostic fails.
- The engine control module (ECM) records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history during the second consecutive trip in which the diagnostic fails.

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by any diagnostics.

Diagnostic Aids

The generator will supply a ground (through some resistance) to generator L-terminal when the ignition is ON and the engine is not running. As a result, the A/T Oil Temp lamp will illuminate. The voltage at the ATF temperature switch harness with the connector disconnected will read between 1.5-3.5 volts.

The TCM supplies a pull-up voltage of around 8-12 volts on the ATF Temp Switch Signal circuit. Therefore, the voltage at the ATF temperature switch harness with the connector disconnected AND the IPC B-51 harness disconnected will read between 8-12 volts.

If an intermittent condition is suspected, the following may cause an intermittent:

- Misrouted harness
- Rubbed through wire insulation

DTC P1839 (Flash Code 45)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check Engine Controls

Step	Action	Value(s)	Yes	No
2	1. Start the engine and let idle. 2. Observe the A/T Oil Temp. indicator lamp in the instrument panel cluster (IPC). Does the A/T Oil Temp. indicator lamp illuminate?	—	Go to Step 4	Go to Step 3
3	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine and let idle for 2 minutes. 4. Monitor the A/T Oil Temp indicator and the DTC status. Did DTC P1839 reset without illuminating the A/T Oil Temp indicator?	—	Go to Step 9	Go to Diagnostic Aids
4	1. Turn OFF the ignition. 2. Disconnect the in-line harness connector (J-129). 3. Start the engine and let idle. Does the A/T Oil Temp. indicator lamp illuminate?	—	Go to Step 5	Go to Step 7
5	1. Turn OFF the ignition. 2. Disconnect the transmission control module (TCM) harness connector. 3. Start the engine and let idle. Does the A/T Oil Temp. indicator lamp illuminate?	—	Go to Step 6	Go to Step 9
6	Repair the short to ground on the A/T Oil Temp. indicator lamp circuit among the TCM (pin 7 of B-230 connector), in-line connector (2 of J-129 connector), IPC (pin 20 of B-51 connector). Did you complete the repair?	—	Go to Step 10	—
7	1. Test the automatic transmission fluid (ATF) temperature switch circuit between the in-line connector (J-129) and the ATF temperature switch for a short to ground. 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 10	Go to Step 8
8	Replace the ATF temperature switch. Refer to Repair Instructions (On-Vehicle) - Automatic Transmission Fluid (ATF) Temperature Switch. Did you complete the replacement?	—	Go to Step 10	—
9	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 10	—

Step	Action	Value(s)	Yes	No
10	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Start the engine and let idle. 4. Observe the A/T Oil Temp. indicator lamp in the IPC. Does the A/T Oil Temp. indicator lamp illuminate?	—	Go to Step 3	Go to Step 11
11	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC U2100 (Flash Code 41)

Circuit Description

The transmission control module (TCM) and the engine control module (ECM) communicate control and diagnostic information via a controller area network (CAN) communication bus. The TCM monitors CAN operational status by expecting a constant flow of messages from the ECM. If the TCM detects abnormal data in the CAN BUS, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

Either of following conditions are met:

- The transmission control module (TCM) cannot detect the CAN High signal or CAN Low signal.
- The TCM fails to receive an expected message from the ECM or detects failure or abnormal data of the following items from the ECM.
  - Accelerator pedal position
  - Actual engine torque
  - Nominal friction torque
  - Engine coolant temperature
  - Cruise control state or PTO state

Action Taken When the DTC Sets

- The TCM flashes the check trans lamp when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The TCM uses the substitution of the following items and inhibits the controls using the following items.
  - Accelerator pedal position
  - Actual engine torque
  - Nominal friction torque
  - Engine coolant temperature
  - Cruise control state or PTO state

Condition for Clearing the MIL/DTC

- Clear the check trans lamp and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM and ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the DTC display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC U2100 (Flash Code 41)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids

Step	Action	Value(s)	Yes	No
3	Does the scan tool communicate with the engine control module (ECM)?	—	Go to Step 4	Go to Diagnostic System Check – Engine Controls
4	1. Turn OFF the ignition. 2. Measure the resistance across the controller area network (CAN) Low and High circuit by back probing the TCM (pins 5 and 18 of B-229 connector) (TCM is located near the base of the steering column). Does the resistance measure within the specified value (120 Ω will be read if an open circuit)?	50-70 Ω	Go to Step 5	Go to Step 9
5	1. Disconnect the TCM harness connector. 2. Connect a DMM between the CAN Low circuit harness (pin 5 of B-229 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. Is the DMM voltage within the specified value?	1.5-3.5 volts	Go to Step 6	Go to Step 10
6	1. Connect a DMM between the CAN High circuit harness (pin 18 of B-229 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Is the DMM voltage within the specified value?	1.5-3.5 volts	Go to Step 7	Go to Step 11
7	1. Turn OFF the ignition. 2. Reconnect the TCM harness connector. 3. Disconnect the engine control module (ECM) harness connector. 4. Connect a DMM between the CAN Low circuit by back probing the TCM (pin 5 of B-229 connector) and a known good ground. 5. Turn ON the ignition, with the engine OFF. Is the DMM voltage within the specified value?	1.5-3.5 volts	Go to Step 8	Go to Step 14
8	1. Connect a DMM between the CAN High circuit by back probing the TCM (pin 18 of B-229 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Is the DMM voltage within the specified value?	1.5-3.5 volts	Go to Step 13	Go to Step 14

Step	Action	Value(s)	Yes	No
9	1. Test the CAN Low and High circuit between the ECM (pins A-17 and A-18 of J-218 connector) and the TCM (pins 5 and 18 of B-229 connector) for an open circuit or high resistance. 2. Inspect for an intermittent and for poor connections on the CAN Low and High circuits at the ECM and TCM. 3. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 12
10	1. Test the CAN Low circuit between the ECM (pin A-18 of J-218 connector) and the TCM (pin 5 of B-229 connector) for the following conditions: • A short to ground • A short to battery or ignition voltage 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
11	1. Test the CAN High circuit between the ECM (pin A-17 of J-218 connector) and the TCM (pin 18 of B-229 connector) for the following conditions: • A short to ground • A short to battery or ignition voltage 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
12	1. Reconnect the ECM harness connectors. 2. Keep the ignition turned OFF. 3. Measure the resistance between the CAN High and CAN Low circuits at the harness connector of the TCM. Is the resistance within the specified value?	110-130 ohm	Go to Step 14	Go to Step 15
13	1. Clear the DTC. 2. Install a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 5	Go to Step 8
14	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did your complete the replacement?	—	Go to Step 16	—

Step	Action	Value(s)	Yes	No
15	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in engine control system section. Did you complete the replacement?	—	Go to Step 16	—
16	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 17
17	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC U2104 (Flash Code 41)

Circuit Description

The transmission control module (TCM) and the engine control module (ECM) communicate control and diagnostic information via a controller area network (CAN) communication bus. The TCM monitors CAN operational status by expecting a constant flow of messages from the ECM. If the TCM fails to receive an expected message from the ECM or fails to send an expected message to the ECM, this DTC will set.

Important:
When DTC U2104 is set, DTC U2105 must be set at the same time.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

- The transmission control module (TCM) cannot detect the CAN High signal or CAN Low signal for 5 seconds.

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history at the time the diagnostic fails.
- The TCM stops sending CAN data.
- The TCM performs the shift control using a throttle position substitution of 0%.
- The TCM controls line pressure using a throttle position substitution of 100%.
- The TCM inhibits the engine torque control.
- The TCM inhibits the 2-3 shift control.
- The TCM inhibits the lock-up duty control.
- The TCM inhibits the engine speed up control during coasting.
- The TCM inhibits the current revision control of the line pressure solenoid valve.
- The TCM uses an actual engine torque substitution of 125%.
- The TCM uses a nominal friction torque substitution of 0%.
- The TCM inhibits the orifice control.
- The TCM re-starts to send data. (If this operation is repeated 6 times during an driving cycle, the TCM stops sending CAN data).

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds.

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM and ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the DTC display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC U2104 (Flash Code 41)

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to Step 2	Go to Diagnostic System Check – Engine Controls
2	1. Install a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the Diagnostic Trouble Code (DTC) Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	Does the scan tool communicate with the engine control module (ECM)?	—	Go to Step 4	Go to Diagnostic System Check - Engine Controls in Engine Control System section
4	1. Turn OFF the ignition. 2. Measure the resistance across the controller area network (CAN) Low and High circuit by back probing the transmission control module (TCM) (pins 5 and 18 of B-229 connector) (TCM is located near the base of the steering column). Does the resistance measure within the specified value (120 Ω will be read if an open circuit)?	50-70 Ω	Go to Step 5	Go to Step 9
5	1. Disconnect the TCM harness connector. 2. Connect a DMM between the CAN Low circuit harness (pin 5 of B-229 connector) and a known good ground. 3. Turn ON the ignition, with the engine OFF. Is the voltage measure within the specified value?	1.5-3.5 volts	Go to Step 6	Go to Step 10
6	1. Connect a DMM between the CAN High circuit harness (pin 18 of B-229 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Is the voltage measure within the specified value?	1.5-3.5 volts	Go to Step 7	Go to Step 11

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Reconnect the TCM harness connector. 3. Disconnect the engine control module (ECM) harness connector. 4. Connect a DMM between the CAN Low circuit by back probing the TCM (pin 5 of B-229 connector) and a known goof ground. 5. Turn ON the ignition, with the engine OFF. Is the voltage measure within the specified value?	1.5-3.5 volts	Go to Step 8	Go to Step 15
8	1. Connect a DMM between the CAN High circuit by back probing the TCM (pin 18 of B-229 connector) and a known good ground. 2. Turn ON the ignition, with the engine OFF. Is the voltage measure within the specified value?	1.5-3.5 volts	Go to Step 13	Go to Step 15
9	1. Test the CAN Low and High circuit between the ECM (pins A-17 and A-18 of J-218 connector) and the TCM (pins 5 and 18 of B-229 connector) for an open circuit or high resistance. 2. Inspect for an intermittent and for poor connections on the CAN Low and High circuits at the ECM and TCM. 3. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 13
10	1. Test the CAN Low circuit between the ECM (pin A-18 of J-218 connector) and the TCM (pin 5 of B-229 connector) for the following conditions: • A short to ground • A short to battery or ignition voltage 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
11	1. Test the CAN High circuit between the ECM (pin A-17 of J-218 connector) and the TCM (pin 18 of B-229 connector) for the following conditions: • A short to ground • A short to battery or ignition voltage 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 17	Go to Step 16

Step	Action	Value(s)	Yes	No
12	1. Reconnect the ECM harness connectors. 2. Keep the ignition turned OFF. 3. Measure the resistance between the CAN High and CAN Low circuits at the harness connector of the TCM. Is the resistance within the specified value?	110-130 ohm	Go to Step 15	Go to Step 16
13	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Monitor the DTC Information with a scan tool. Does DTC U2104 and U2105 set?	—	Go to Step 15	Go to Step 14
14	Does only U2105 set at step 12?	—	Go to Step 16	Go to Diagnostic Aids
15	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 17	—
16	**Important:** Replacement ECM must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 17	—
17	1. Reconnect all previously disconnected harness connector(s). 2. Clear the DTCs with a scan tool. **Important:** The ECM sets the DTC P0700 when the TCM sets emissions related DTC(s). Clear the DTC in the ECM after DTCs in the TCM were cleared. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 18
18	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

DTC U2105 (Flash Code 41)

Circuit Description

The transmission control module (TCM) and the engine control module (ECM) communicate control and diagnostic information via a controller area network (CAN) communication bus. The TCM monitors CAN operational status by expecting a constant flow of messages from the ECM. If the TCM detects abnormal data in the CAN BUS, this DTC will set.

Condition for Running the DTC

- The battery voltage is between 10-16 volts.
- The ignition switch is ON.

Condition for Setting the DTC

The TCM fails to receive an expected message from the ECM or detects failure or abnormal data of the following items from the ECM:

- Accelerator pedal position
- Actual engine torque
- Nominal friction torque
- Engine coolant temperature
- Cruise control state or PTO state

Action Taken When the DTC Sets

- The TCM flashes the Check Trans lamp and requests to illuminate the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The TCM stores the DTC in TCM history at the time the diagnostic fails.
- The ECM records the operating conditions at the time the diagnostic fails. The ECM stores this information in the Freeze Frame/Failure Records.
- The ECM stores DTC P0700 in ECM history at the time the diagnostic fails.
- The TCM uses the substitution of the following items and inhibits the controls using the following items.
  - Accelerator pedal position
  - Actual engine torque
  - Nominal friction torque
  - Engine coolant temperature
  - Cruise control state or PTO state

Condition for Clearing the MIL/DTC

- Clear the check trans lamp, the MIL and the DTC with a scan tool.
- To clear the memory in the TCM without a scan tool, perform the overdrive (OD) OFF switch ON-OFF more than three times within 5 seconds after performing the following:
  - Turn ON the ignition, with the engine OFF.
  - Connect terminal 11 and terminal 4 or 5 (ground) at the data link connector (DLC).
  - Select "N" (neutral) range.
  - Depress the brake pedal.

If the DTC is cleared, the check trans lamp will flash quickly (ON for 0.2 seconds, and OFF for 0.2 seconds) for 10 seconds

- The TCM turns OFF the check trans lamp after 3 consecutive driving cycles when the diagnostic runs and does not fail.
- The TCM requests to turn OFF the MIL after 4 consecutive driving cycles when the diagnostic runs and does not fail.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any diagnostics.

Diagnostic Aids

If an intermittent condition is suspected, the following may cause an intermittent:

- Poor connections
- Misrouted harness
- Rubbed through wire insulation
- Broken wire inside the insulation

Check for the following conditions:

- Poor connection at TCM and ECM: Inspect harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal to wire connection.
- Damaged harness: Inspect the wiring harness for damage. If the harness appears to be OK, observe the DTC display on the scan tool while moving connectors and wiring harness. A change in the display will indicate the location of the fault.

DTC U2105 (Flash Code 41)

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls

Step	Action	Value(s)	Yes	No
2	1. Install the scan tool. 2. Clear the DTCs with a scan tool. 3. Turn OFF the ignition for 30 seconds. 4. Start the engine. 5. Monitor the DTC Information with a scan tool. Does the DTC fail this ignition?	—	Go to Step 3	Go to Diagnostic Aids
3	Does U2104 also set?	—	Go to U2104	Go to Step 4
4	**Important:** Replacement engine control module (ECM) must be programmed. Replace the ECM. Refer to Engine Control Module (ECM) Replacement/Fuel Injector Flow Rate Programming & Option Programming in this section. Did you complete the replacement?	—	Go to Step 5	—
5	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 6
6	Are there any DTCs that you have not diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

Check Trans Lamp Inoperative

Description

Battery positive voltage is supplied to the check trans lamp through the ignition switch. The transmission control module (TCM) turns the check trans lamp ON by grounding the check trans lamp control circuit. The check trans lamp should be turned OFF 2 seconds after the ignition switch is turned ON.

Check Trans Lamp Operation

The check trans lamp is located on the instrument panel cluster (IPC).

Check Trans Lamp Function

- The check trans lamp informs the driver that a malfunction has occurred and the vehicle should be taken in for service as soon as possible.
- The check trans lamp illuminates during a bulb test and a system test.
- A DTC will be stored if the check trans lamp is requested by the TCM.

Check Trans Lamp Illumination

- The check trans lamp will illuminate for 2 seconds after the ignition switch is turned ON.
- The check trans lamp will turn OFF when the engine is started.
- The check trans lamp should be turned OFF 2 seconds after the ignition switch is turned ON.
- The check trans lamp may turn OFF if the malfunction is not present.

Test Description

The number below refers to the step number on the diagnostic table.
4. This step tests for a short to voltage on the check trans lamp control circuit. With the fuse removed there should be no voltage on the check trans lamp control circuit.

Schematic Reference: Transmission Controls Schematics
Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Verify whether the instrument cluster is operational. 2. Install a scan tool. 3. Turn ON the ignition, with the engine OFF. 4. Command the check trans lamp ON and OFF with a scan tool. Does the check trans lamp turn ON and OFF when commanded with a scan tool?	—	Go to Intermittent Conditions	Go to Step 3
3	Inspect the Gauges (10 A) fuse that supplies ignition voltage to the check trans lamp. Is the fuse open?	—	Go to Step 10	Go to Step 4

Step	Action	Value(s)	Yes	No
4	1. Turn OFF the ignition. 2. Remove the Gauges (10 A) fuse that supplies voltage to the check trans lamp. 3. Disconnect the transmission control module (TCM) harness connector (B-229). 4. Turn ON the ignition, with the engine OFF. DO NOT start the engine. 5. Measure the voltage from the check trans lamp control circuit at the fuse to a known good ground. Is the voltage less than the specified value?	0.5 volts	Go to Step 5	Go to Step 11
5	1. Turn OFF the ignition. 2. Install the Gauges (10 A) fuse that supplies voltage to the check trans lamp. 3. Turn ON the ignition, with the engine OFF. 4. Connect a 3-amp fused jumper wire between the check trans lamp control circuit in the TCM harness connector and a known good ground. Is the check trans lamp illuminated?	—	Go to Step 9	Go to Step 6
6	1. Turn ON the ignition. 2. Operate the cruise main switch while observing the cruise main lamp in the instrument panel cluster (IPC). Does the Cruise Main lamp operate correctly?	—	Go to Step 7	Go to Step 12
7	1. Turn OFF the ignition. 2. Disconnect the IPC harness connector (B-51). 3. Test the check trans lamp control circuit for an open or high resistance. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 8
8	1. Test for an intermittent and for a poor connection at the IPC (pin 19 of B-51 connector). 2. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 13
9	1. Test for an intermittent and for a poor connection at the TCM harness connector (pin 9 of B-229 connector). 2. Repair the connector(s) as necessary. Did you find and correct the condition?	—	Go to Step 15	Go to Step 14

Step	Action	Value(s)	Yes	No
10	Replace the Gauges (10 A) fuse. If the fuse continues to open, repair the short to ground on the ignition voltage circuit or check for a shorted component. Did you complete the repair?	—	Go to Step 15	—
11	Repair the short to voltage circuit on the check trans lamp control circuit. Did you complete the repair?	—	Go to Step 15	—
12	Repair the open in the check trans lamp ignition voltage circuit. Did you complete the repair?	—	Go to Step 15	—
13	Repair or replace the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Body, Cab and Accessories section. Did you complete the repair or replacement?	—	Go to Step 15	—
14	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 15	—
15	1. Remove all test equipment. 2. Connect any disconnected components or any disconnected fuse. 3. Turn ON the ignition, with the engine OFF. 4. Command the check trans lamp ON and OFF with a scan tool. Does the check trans lamp turn ON and OFF when commanded with a scan tool?	—	Go to Step 16	Go to Step 2
16	1. Turn OFF the ignition for 30 seconds. 2. Start the engine and operate the vehicle checking for acceptable performance and driveability. 3. Observe the check trans lamp, the vehicle performance and the driveability. Does the vehicle operate correctly, without any check trans lamp illumination and without any stored DTCs?	—	System OK	Go to Diagnostic Trouble Code (DTC) List

Check Trans Lamp Always On

Description

Battery positive voltage is supplied to the check trans lamp through the ignition switch. The transmission control module (TCM) turns the check trans lamp ON by grounding the check trans lamp control circuit.

Check Trans Lamp Operation

The check trans lamp is located on the instrument panel cluster (IPC).

Check Trans Lamp Function

- The check trans lamp informs the driver that a malfunction has occurred and the vehicle should be taken in for service as soon as possible.
- The check trans lamp illuminates during a bulb test and a system test.
- A DTC will be stored if the check trans lamp is requested by the TCM.

Check Trans Lamp Illumination

- The check trans lamp will illuminate for 2 seconds after the ignition switch is turned ON.
- The check trans lamp will turn OFF when the engine is started.
- The check trans lamp should be turned OFF 2 seconds after the ignition switch is turned ON.
- The check trans lamp may turn OFF if the malfunction is not present.

Schematic Reference: Transmission Controls Schematics

Connector End View Reference: Transmission Controls Connector End Views or Transmission Control Module (TCM) Connector End Views

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check - Transmission Controls?	—	Go to Step 2	Go to Diagnostic System Check - Transmission Controls
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Command the check trans lamp ON and OFF with a scan tool. Does the check trans lamp always remain ON when commanded ON and OFF with a scan tool?	—	Go to Step 3	Check for DTCs and if none exist Go to Intermittent Conditions
3	1. Turn OFF the ignition. 2. Disconnect the transmission control module (TCM) harness connector. 3. Turn ON the ignition, with the engine OFF. DO NOT start the engine. 4. Observe the check trans lamp. Is the check trans lamp illuminated?	—	Go to Step 4	Go to Step 6
4	1. Remove the instrument panel cluster (IPC). 2. Disconnect the IPC harness connector. (B-51) 3. Test the check trans lamp control circuit for a short to ground. 4. Repair the circuit(s) as necessary. Did you find and correct the condition?	—	Go to Step 7	Go to Step 5
5	Replace the IPC. Refer to Instrument Panel Cluster (IPC) Replacement in the Body, Cab and Accessories section. Did you complete the replacement?	—	Go to Step 7	—

Step	Action	Value(s)	Yes	No
6	**Important:** Replacement TCM must be programmed. Replace the TCM. Refer to Repair Instructions (On-Vehicle) - Transmission Control Module (TCM) in this section. Did you complete the replacement?	—	Go to Step 7	—
7	1. Remove all test equipment. 2. Connect any disconnected components. 3. Turn ON the ignition, with the engine OFF. 4. Command the check trans lamp ON and OFF with a scan tool. Does the check trans lamp always remain ON when commanded ON and OFF with a scan tool?	—	Go to Step 2	Go to Step 8
8	1. Turn OFF the ignition for 30 seconds. 2. Start the engine and operate checking for acceptable performance and driveability. 3. Observe the check trans lamp, the vehicle performance, and the driveability. Does the vehicle operate correctly, without any check trans lamp illumination and without any stored DTCs?	—	System OK	Go to Diagnostic Trouble Code (DTC) List

Diagnosis based on vehicle condition

On-Vehicle Service Item

Check position Faulty symptom	ATF level and condition	Control linkage	Inhibitor switch	Accelerator position sensor	Vehicle speed sensor	Engine speed sensor	Engine idling revolution	Line pressure solenoid	No.1 shift solenoid (S1)	No.2 shift solenoid (S2)	Timing solenoid (ST)	Lock-up solenoid	Starter circuit	OD OFF switch	Exhaust brake switch	Idle signal	TCM	Torque converter
VEHICLE MOVEMENT																		
Vehicle does not run at “R”									1	1							2	
Vehicle does not move at every range	1	1						1										2
Vehicle moves at “P”		1																
Parking gear does not release when selector is moved from “P”		1																
Vehicle moves at “N”		1																
ABNORMAL GEAR CHANGE																		
Does not upshift from 1st to 2nd		1	1		3					2							3	
Does not upshift from 2nd to 3rd		1	1		3				2								3	
Does not upshift from 3rd to 4th			1		3					2					3		3	
Does not downshift from 4th to 3rd					2					1							2	
Does not downshift from 3rd to 2nd					2				1								2	
Does not downshift from 2nd to 1st					2					1							2	
Engine overruns when shifting from 2nd to 3rd				1		3					2						3	
All shift points extremly high or low				1													2	
Engine brake does not function at “L” range										1							2	
Engine brake does not function at “2” range									1	1							2	
Lock-up device does not function				1		3		1	2	2		2			3	3	3	4
Lock-up point extremly high or low				1	3							2					3	
EXCESSIVE SHOCK WHEN CHANGING GEARS																		
Excessive shock when selector is moved to “R” from “N”, or “D” from “N”				1			2	1			2					2		
Excessive shock when upshifting from 1st to 2nd				1							2					3	3	
Excessive shock when upshifting from 2nd to 3rd				1		3										3	3	
Excessive shock when upshifting from 3rd to 4th				1												2		
Excessive shock when upshifting (all gear)				1												2		
Excessive shock when downshift from 4th to 3rd				1												2		
Excessive shock when downshift from 3rd to 2nd				1							2					3	3	
When lock-up				1		2												3
SLIPPAGE																		
When going forward and backward	1			1				1										2
When in reverse gear				1														
When in 1st gear				1														
When in 2nd gear				1														
When in 3nd gear				1														
When in 4th gear				1														
OTHERS																		
Engine will not start in either “P” or “N”		1	1										2					
Engine can start in other than “P” or “N”		1	1															
Engine stalls when selector is moved from “P” or “N” to one of drive ranges							2					1						3
Automatic transmission unit overheating/ATF blows off from air breather pipe	1							1				3					3	4

Note: The numbers in the table denote the order of inspection.

1. Moveable parts that are dislocated easily or are hard to adjust.
2. Parts that are turned on and off
3. Other parts that are controlled by electrical circuit.
4. Others

TCM = Transmission Control Module
OD = Overdrive
ATF = Automatic Transmission Fluid

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Overhaul Item

Check position / Faulty symptom	ATF thermosensor	Oil pump	OD brake (B0)	2nd brake (B1)	1st & Rev. brake (B2)	OD direct clutch (C0)	Front Clutch (C1)	Rear clutch (C2)	OD one-way clutch (F0)	No.2 one-way clutch (F1)	Front planetary	Rear planetary	Parking linkage	Valve body assembly	B0 accumulator	C1 accumulator	B1 accumulator	C2 accumulator	Line pressure solenoid
VEHICLE MOVEMENT																			
Vehicle does not run at “D”, “2”, “L”							○												
Vehicle does not run at “R”					○			○											
Vehicle does not move at every range		○				○			○		○	○		○					
Vehicle moves at “P”													○						
Parking gear does not release when selector is moved from “P”													○						
Vehicle moves at “N”							○	○											
ABNORMAL GEAR CHANGE																			
Does not upshift from 1st to 2nd				○						○				○					
Does not upshift from 2nd to 3rd						○		○						○					
Does not upshift from 3rd to 4th	○		○											○					
Does not downshift from 4th to 3rd						○			○					○					
Does not downshift from 3rd to 2nd				○										○					
Does not downshift from 2nd to 1st						○				○				○					
Engine overruns when shifting from 2nd to 3rd								○						○					
All shift points extremely high or low																			
Engine brake does not function at “L” range					○									○					
Engine brake does not function at “2” range						○													
Lock-up device does not function	○													○					○
Lock-up point extremely high or low														○					
EXCESSIVE SHOCK WHEN CHANGING GEARS																			
Excessive shock when selector is moved to “R” from “N”					○			○						○				○	
Excessive shock when selector is moved to “D” from “N”							○			○				○		○			
Excessive shock when selector is moved to “R” from “N”, or “D” from “N”														○					○
Excessive shock when upshifting from 1st to 2nd				○										○			○		○
Excessive shock when upshifting from 2nd to 3rd						○		○						○				○	○
Excessive shock when upshifting from 3rd to 4th			○											○	○				○
Excessive shock when upshifting (all gear)	○						○							○					○
Excessive shock when downshift from 4th to 3rd						○			○					○					○
Excessive shock when downshift from 3rd to 2nd				○										○			○		○
When lock-up														○					○
SLIPPAGE																			
When going forward and backward		○							○										○
When in reverse gear					○			○											○
When in 1st gear							○			○									○
When in 2nd gear				○			○		○										○
When in 3nd gear							○	○											○
When in 4th gear			○				○	○											○
OTHERS																			
Engine will not srart in either “P” or “N”																			
Engine can start in other than “P” or “N”																			
Engine stalls when selector is moved from “P” or “N” to one of drive ranges														○					
Automatic transmission unit overheating/ATF blows off from air breather pipe		○	○	○			○	○						○					

OD = Overdrive
ATF = Automatic Transmission Fluid

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The vehicle does not move at every range

Checks	Cause
Automatic transmission fluid (ATF)	The ATF level is not sufficient.
Relevant DTC section	The control valve does not slide correctly.
Line pressure	The line pressure has dropped.
Parking mechanism	The parking mechanism is defective
Selector lever	The selector lever has not been assembled nor adjusted correctly.
Line pressure solenoid valve	The line pressure solenoid valve is defective
Accelerator pedal position (APP) sensor	The APP sensor is defective.
Supply voltage of the accelerator pedal sensor	The powertrain slippage.

The vehicle moves at the “N” range

Checks	Cause
Selector lever	The selector lever has not been assembled nor adjusted correctly.
The inside of the A/T	The front clutch or the rear clutch has seized.
The control linkage	The manual valve has malfunctioned (the linkage has come off).

The gear cannot be changed

Checks	Cause
Shift solenoid valves (S1,S2)	The shift solenoid valves (S1,S2) are defective.
Relevant DTC section	The control valve does not slide properly.
Shift solenoid valves (S1,S2) harness	Ground is not correct.
Vehicle speed sensor (VSS) 1 (SP2)	The VSS 1 (SP2) is defective.
Transmission Control Module (TCM)	The TCM is defective.

Does not upshift from the 3rd to 4th

Checks	Cause
Relevant DTC section	The control valve does not slide well.
Shift solenoid valves (S1,S2)	Shift solenoid valves (S1,S2) are defective.
Inhibitor switch	The inhibitor switch is defective or is not adjusted correctly.
Overdrive (OD) OFF switch	The OD OFF switch is defective.
TCM	The TCM is defective.
TCM grounding	Ground is not correct.
ATF temperature sensor	The ATF temperature sensor is defective.
VSS 1 (SP2)	The VSS 1 (SP2) is defective.

The gear change is abnormal

Checks	Cause
ATF	The ATF level is not sufficient.

Checks	Cause
Relevant DTC section	The control valve does not slide well.
Line pressure	The line pressure has dropped.
Selector lever	The selector lever has not been assembled nor adjusted correctly.
Line pressure solenoid valve	The line pressure solenoid valve is defective
VSS 1 (SP2)	The VSS 1 (SP2) is defective.
TCM	The TCM is defective.

At acceleration, the engine races and slippage occurs

Checks	Cause
ATF	The ATF level is not sufficient.
Relevant DTC section	The control valve does not slide well. The powertrain slips.
Line pressure	The line pressure has dropped.
Line pressure solenoid valve	The line pressure solenoid valve is defective.
Selector lever	The selector lever has not been assembled or adjusted correctly.
APP sensor	The APP sensor is defective.

The engine stalls when the selector lever is moved from the “P” or “N” to one of the drive ranges

Checks	Cause
Idling speed	The idling speed of the engine is slow.
Inhibitor switch	The inhibitor switch is defective or is not adjusted correctly.
VSS 1 (SP2)	The VSS 1 (SP2) is defective.
Engine speed sensor	The engine speed sensor is defective.
TCM	The TCM connector is fault. Ground is not correct.

The ATF blows off from the air breather pipe during driving

Checks	Cause
ATF	The ATF is too much. Water enters the A/T from the outside.

Engine brake does not function

Checks	Cause
ATF	The ATF is too much. Water enters the A/T from the outside.
Relevant DTC section	The control valve does not slide well.
Inhibitor switch	The inhibitor switch is defective or is not adjusted correctly.
VSS 1 (SP2)	The VSS 1 (SP2) is defective.
OD OFF switch	The OD OFF switch is defective.

Checks	Cause
Selector lever	The selector lever has not been assembled nor adjusted correctly.
APP sensor	The APP sensor is defective.

Control Signal Inspection

Control signal inspection is done to check for transmission and transmission control module (TCM) problems which cannot be detected by self diagnosis.

Additionally, it serves as a back-up check for self diagnosis.

Measure the voltage drop and make a continuity test for each of the sensors, solenoids, and switches.

If the voltage is within the specified range and continuity exists, that particular area of the TCM and automatic transmission assembly is normal.

If voltage deviation or lack of continuity is discovered, disconnect the applicable parts and check each of them individually.

This will allow you to determine the trouble location (TCM, automatic transmission unit, or another area of the vehicle).

Inspection Tool

Use a DMM to measure voltage and circuit continuity.

Refer to the following table for the specified voltage ranges.

TCM terminals are extremely small.

Use appropriate test adapter from the J-35616-C connector test adapter kit.

This will make measurement easier.

* : The terminal is used for vehicles of 12,000 lbs GVW.

TCM Terminal No. (Wire Color)		Standard Voltage	Inspection Condition	Signal Type	Circuit
Tester (-)	Tester (+)				
B231-2 (B/L)	B229-1 (LT B)	2.5 (Intermittent AC)	At an engine speed of approx. 1,000 RPM	Input	Engine speed signal
	B229-2	Not used	—	—	—
B229-16 (L)	B229-3 (Y)	More than 0.2 (AC)	Vehicle speed 15 MPH (24 km/h) (Voltage increases in proportion to the speed)	Input	Vehicle speed sensor (VSS) 1 (SP2) (Transmission)
		0	Vehicle stopped		
B229-17 (R)*	B229-4 (G)*	More than 0.4 (AC)	Vehicle speed 15 MPH (24 km/h) (Voltage increases in proportion to the speed)	Input	Input shaft speed sensor (C0)
		0	Vehicle stopped		
B231-2 (B/L)	B229-5 (GR/B)	1.5-2.5	CAN Low	Input/ Output	CAN
B229-20 (Y)	B229-6 (L/Y)	0.9	ATF temp. approx. 50°F (10°C)	Input	ATF temperature sensor
		0.3	ATF temp. approx. 104°F (40°C)		

TCM Terminal No. (Wire Color)		Standard Voltage	Inspection Condition	Signal Type	Circuit
Tester (-)	Tester (+)				
B231-2 (B/L)	B229-7	Not used	—	—	—
	B229-8	Not used	—	—	—
	B229-9 (O/B)	10-16	Normal state	Output	Check trans lamp
		Less than 3.0	At this voltage for 2 seconds when after the ignition is turned “ON”		
	B229-10	Not used	—	—	—
	B229-11 (BR/B)	10-16	Shift up to 2nd or 3rd kick down to 1st	Output	Shift timing solenoid valve
		Less than 1.0	Normal state		
	B229-12 (BR/R)	10-16	Driving at “D2” and “D3” (Shift solenoid (S2) valve “ON”)	Output	Shift solenoid (S2) valve
		Less than 1.0	Driving at “D1” and “D4” (Shift solenoid (S2) valve “OFF”)		
	B229-13 (BR/Y)	10-16	Driving at “D1” and “D2” (Shift solenoid (S1) valve “ON”)	Output	Shift solenoid (S1) valve
		Less than 1.0	Driving at “D3” and “D4” (Shift solenoid (S1) valve “OFF”)		—
	B229-14	Not used	—	—	—
	B229-15	Not used	—	—	—
	B229-17	Not used	—	—	—
	B229-18 (GR)	2.5-3.5	CAN High	Input/ Output	CAN
	B229-19	Not used	—	—	—
	B229-21	Not used	—	—	—
	B229-22 (L/W)*	10-16	Normal state	Output	Malfunction indicator lamp (MIL) signal
		Less than 3.0	Emission related DTCs are set		
	B229-23	Not used	—	—	—
	B229-24 (BR/W)	10-16	Lock-up “ON”	Output	Torque converter clutch pulse width modulation (TCC PWM) solenoid valve
		Less than 1.0	Lock-up “OFF”		
B229-25 (BR/G)	B229-26 (BR)	5.0-7.0 (AC)	Engine warmed up and stopped, Throttle fully closed, the ignition “ON”	Output	Line pressure solenoid valve
		4.6-6.0 (AC)	Engine warmed up and stopped, Throttle fully opened,the ignition “ON”		

TCM Terminal No. (Wire Color)		Standard Voltage	Inspection Condition	Signal Type	Circuit
Tester (-)	Tester (+)				
B231-2 (B/L)	B230-1 (R)	10-16	Exhaust brake M/V “ON”	Input	Exhaust brake
		Less than 1.0	Exhaust brake M/V “OFF”		
	B230-2	Not used	—	—	—
	B230-3	Not used	—	—	—
	B230-4 (LT G)	10-16	ABS “Inactive” at engine running	Input	ABS signal (Exhaust brake cut relay signal)
		Less than 1.0	ABS “Active”		

TCM Terminal No. (Wire Color)		Standard Voltage	Inspection Condition	Signal Type	Circuit
Tester (-)	Tester (+)				
B231-2 (B/L)	B230-5	Not used	—	—	—
	B230-6 (O)	10-16	OD OFF switch “OFF”	Input	OD OFF switch
		Less than 1.0	OD OFF switch “ON”		
	B230-7 (Y/G)	10-16	Normal state	Input	ATF temperature switch
		Less than 1.0	ATF temperature more than 147°C		
	B230-8 (B/W)	10-16	Self diagnosis “OFF”	Input	Data link connector
		Less than 1.0	Self diagnosis “ON”		
	B230-9 (W)	0-5	Vehicle moved at slowest possible speed at least 1 meter	Input	Vehicle speed sensor (VSS) 2 (SP1)
	B230-10	Not used	—	—	—
	B230-11	Not used	—	—	—
	B230-12	Not used	—	—	—
	B230-13	Not used	—	—	—
	B230-14 (O)	0-7(Varies)	Class 2 communication	Input/ Output	Class 2
	B230-15	Not used	—	—	—
	B230-16	Not used	—	—	—
	B231-1 (B/Y)	10-16	The ignition “ON”	Source	Battery voltage
	B231-3 (W/R)	10-16	Selector “P” range	Input	“P” range switch
		Less than 1.0	Selector other than except “P” range		
	B231-4 (L)	10-16	Selector “N” range	Input	“N” range switch
		Less than 1.0	Selector other than except “N” range		
	B231-5	Not used	—	—	—
	B231-6 (L/W)	10-16	Selector “1” range	Input	“1” range switch
		Less than 1.0	Selector other than except “1” range		
	B231-7	Not used	—	—	—
	B231-8	Not used	—	—	—
	B231-9 (R/L)	10-16	Selector “R” range	Input	“R” range switch
		Less than 1.0	Selector other than except “R” range		
	B231-10 (L/O)	10-16	Selector “D” range	Input	“D” range switch
		Less than 1.0	Selector other than except “D” range		

TCM Terminal No. (Wire Color)		Standard Voltage	Inspection Condition	Signal Type	Circuit
Tester (-)	Tester (+)				
B231-2 (B/L)	B231-11 (L/R)	10–16	Selector “2” range	Input	“2” range switch
		Less than 1.0	Selector other than except “2” range		
	B231-12 (G)	10–16	Stop light “ON”	Input	Stop lamp
		Less than 1.0	Stop light “OFF”		

AC: Alternating Current
OD: Overdrive
ATF: Automatic Transmission Fluid
M/V: Magnetic Valve
TCM: Transmission Control Module

Line Pressure Test

The line pressure test checks oil pump and control valve pressure regulator valve function. It will also detect oil leakage.

Caution:
The line pressure test always requires two persons with the first person checking the tire and tire stopper off the vehicle while the second person performs testing.

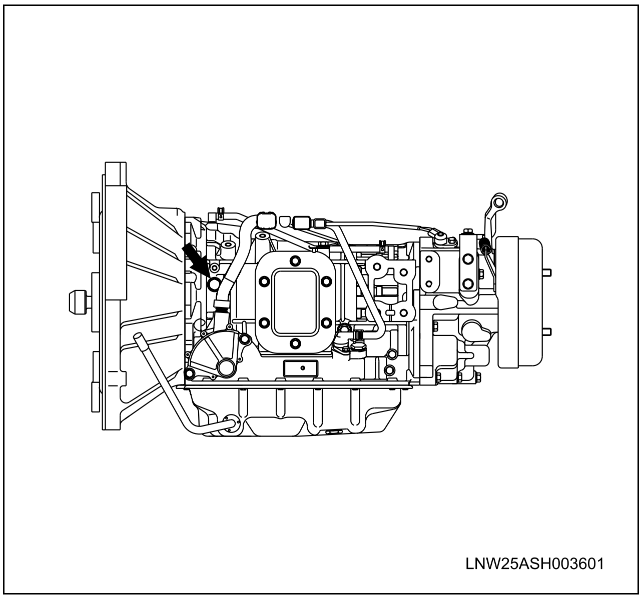
Line Pressure Test Procedure

1. Check the level of the engine coolant, the engine oil, and the automatic transmission fluid.
   Replenish if required.
2. Set the parking brake.
3. Place chocks at the front and rear of each tire.
4. Remove the pressure detection plug at the left side of the transmission.
5. Connect a pressure gauge to the pressure detection plug hole.

Tools Required:

J-29770-A Pressure Gauge

J-43407 Adapter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6. Start the engine and allow it to idle until the automatic transmission fluid (ATF) temperature reaches 122–176°F (50–80°C) and check the idling RPM.
7. Hold the brake pedal down as far as it will go.
8. Place the selector in the “D” range.
9. Note the pressure gauge reading with the engine idling.
10. While depressing the accelerator pedal to the floor, quickly read the oil pressure at stalling RPM.

Caution:
Release the accelerator pedal and stop the test if the rear wheels start to turn before the engine reaches the stalling RPM.

11. Repeat the test in the “R” range.

• Line Pressure		kPa (PSI)
Range	Engine Speed	
	Idling	Stalling
D	529–784 (77–114)	990–1480 (144–215)
R	755–1127 (110–164)	1401–2107 (203–306)

12. Install pressure detection plug to the transmission.
13. Tighten the pressure detection plug.

Tighten

- Detection Plug 27 N·m (20 lb in)

Line Pressure Test Results	Probable Trouble Area
Line pressure is above the specified limit in all ranges	• Accelerator pedal position (APP) sensor malfunction • Sticking or short line pressure solenoid valve • Sticking regulator valve
Line pressure is below the specified limit in all ranges	• APP sensor malfunction • Sticking or shorted line pressure solenoid valve • Sticking regulator valve • Worn oil pump • Defective overdrive (OD) direct clutch
Line pressure is below the specified limit in “D” ranges	• Oil leakage in “D” range line • Defective front clutch
Line pressure is below the specified limit in “R” ranges	• Oil leakage in “R” range line • Defective rear clutch • 1st and reverse brake malfunction

Stall Test

The stall test allows you to check the transmission for internal abrasion and the one-way clutch for slippage. Torque converter performance can also be evaluated.
The stall test results together with the road test results will identify transmission components requiring servicing or adjustment.

Caution:
When the clutch appears to be slipping in a road test, etc., or when the line pressure does not reach a preset value in a line pressure test, do not proceed to a stall test.

Stall Test Procedure

1. Set the parking brake.
2. Place chocks at the front and rear of each tire.
3. Check the level of the engine coolant, the engine oil, and the automatic transmission fluid. Replenish if required.
4. Start the engine and allow it to idle until the engine coolant temperature reaches 158–176°F (70–80°C).
5. Hold the brake pedal down as far as it will go.
6. Place the selector in the “D” range.
7. Gradually push the accelerator pedal to the floor. The throttle will fully open.
   Note the engine speed at which the tachometer needle stabilizes.

- Stall speed 1,900–2,000 RPM

8. Release the accelerator pedal.
9. Place the selector in the “N” range.
10. Run the engine at 1,200 RPM for one minute.
    This will cool the transmission fluid.
11. Repeat Steps 6–11 for the “2”, “1”, and “R” ranges.

Caution:
Do not continuously run this test longer than 5 seconds so the transmission does not become overheated.

Road Test

The road test should be performed by two people (one to drive and the other to note the required data) on a lightly traveled ordinary public road.

General Test Items

1. Compare the actual automatic shift speeds with the fixed shift schedule.
   a. Perform the diagnosis procedures.

   b. Note the actual shift up, shift down, and lock up speeds on the fixed shift schedule.

2. Check for shock or drag when the transmission shifts from one gear to another.
3. Check that the engine brake functions in the “2” and “1” ranges.
4. Check for abnormal noise or vibration.
   After completing the road test, make the necessary adjustments and repairs to the automatic transmission and related parts.

Shift Point Chart and Lock-up Point Chart

In the shift point chart and the lock-up point chart, indicate vehicle speeds for the final gear ratio of 5.571 and for the tire radius of 0.394m (225/70R19.5).
The tolerance to measured values is ± 2 MPH (3 km/h).

Shift Point Chart

D Range

1→2			2→3			3→4		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	345	6 (9)	0	621	10 (17)	0	1226	20 (33)
30	345	6 (9)	30	621	10 (17)	30	1226	20 (33)
40	552	9 (15)	40	1144	19 (31)	40	1794	30 (48)
60	794	13 (21)	60	1622	27 (43)	60	2519	42 (67)
80	863	14 (23)	80	1794	30 (48)	80	2760	46 (74)
100	966	16 (26)	100	1932	32 (52)	100	3006	50 (80)

2→1			3→2			4→3		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	276	5 (7)	0	552	9 (15)	0	1139	19 (30)
30	276	5 (7)	35	552	9 (15)	30	1139	19 (30)
70	276	5 (7)	60	1114	19 (30)	35	1139	19 (30)
100	794	13 (21)	80	1493	25 (40)	60	1875	31 (50)
			100	1760	29 (47)	80	2292	38 (61)
						100	2829	47 (75)

2 Range

1→2			2→1			3→2		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	345	6 (9)	0	276	5 (7)	0	2070	34 (55)
30	345	6 (9)	30	276	5 (7)	100	2070	34 (55)
40	552	9 (15)	70	276	5 (7)			

1→2			2→1			3→2		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
60	794	13 (21)	100	794	13 (21)			
80	863	14 (23)						
100	966	16 (26)						

1 Range

2→1		
Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)
0	831	14 (22)

2→1		
Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)
100	831	14 (22)

D Range OD Inhibit

1→2			2→3		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	345	6 (9)	0	621	10 (17)
30	345	6 (9)	30	621	10 (17)
40	552	9 (15)	40	1144	19 (31)
60	794	13 (21)	60	1622	27 (43)
80	863	14 (23)	80	1794	30 (48)
100	966	16 (26)	100	1932	32 (52)

2→1			3→2			4→3		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	276	5 (7)	0	552	9 (15)	0	3209	53 (86)
30	276	5 (7)	35	552	9 (15)	100	3209	53 (86)
70	276	5 (7)	60	1114	19 (30)			
100	794	13 (21)	80	1493	25 (40)			
			100	1760	29 (47)			

Bimetal temperature Switch (BTS) Mode

BTS Mode: This mode is the control mode when the automatic transmission fluid (ATF) temperature is high. The transmission control module (TCM) uses this mode when the ATF temperature switch is turned ON, and inhibits shift-up to 4th gear.

1→2			2→3		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	449	7 (12)	0	897	15 (24)
30	449	7 (12)	30	897	15 (24)
40	656	11 (17)	40	1346	22 (36)
60	1242	21 (33)	60	1932	32 (52)
80	1242	21 (33)	80	2243	37 (60)
100	1242	21 (33)	100	2243	37 (60)

2→1			3→2		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	276	5 (7)	0	725	12 (19)
30	276	5 (7)	30	725	12 (19)
70	483	8 (13)	40	1173	20 (31)
100	1070	18 (29)	60	1760	29 (47)
			70	2070	34 (55)
			100	2070	34 (55)

Lock-Up Point Chart

D Range

2nd ON			3rd ON			4th ON		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	1354	23 (36)	0	1702	28 (45)	0	1898	32 (51)
5	1354	23 (36)	3	1702	28 (45)	5	1898	32 (51)
40	1354	23 (36)	20	1702	28 (45)	5	2166	36 (58)
60	1354	23 (36)	40	1702	28 (45)	42	2166	36 (58)
80	1354	23 (36)	60	1702	28 (45)	60	2524	42 (67)
100	1354	23 (36)	80	1702	28 (45)	80	2760	46 (74)

2nd ON			3rd ON			4th ON		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
			100	1702	28 (45)	100	3002	50 (80)

2nd OFF			3rd OFF			4th OFF		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	1238	21 (33)	0	1605	27 (43)	0	1774	30 (47)
3	1238	21 (33)	4	1605	27 (43)	20	1774	30 (47)
40	1238	21 (33)	40	1605	27 (43)	20	2012	34 (54)
60	1238	21 (33)	60	1605	27 (43)	42	2012	34 (54)
80	1238	21 (33)	80	1605	27 (43)	65	2244	37 (60)
100	1238	21 (33)	100	1605	27 (43)	80	2244	37 (60)
					100	2244	37 (60)	

2 Range

2nd ON			2nd OFF		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	1354	23 (36)	0	1238	21 (33)
5	1354	23 (36)	3	1238	21 (33)
40	1354	23 (36)	40	1238	21 (33)
60	1354	23 (36)	60	1238	21 (33)
80	1354	23 (36)	80	1238	21 (33)
100	1354	23 (36)	100	1238	21 (33)

D Range OD Inhibit

2nd ON			3rd ON		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	1354	23 (36)	0	1702	28 (45)
5	1354	23 (36)	3	1702	28 (45)
40	1354	23 (36)	20	1702	28 (45)
60	1354	23 (36)	40	1702	28 (45)
80	1354	23 (36)	60	1702	28 (45)

2nd ON			3rd ON		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
100	1354	23 (36)	80	1702	28 (45)
			100	1702	28 (45)

2nd OFF			3rd OFF		
Throttle position	Output revolution	Vehicle speed	Throttle position	Output revolution	Vehicle speed
%	RPM	MPH (km/h)	%	RPM	MPH (km/h)
0	1238	21 (33)	0	1605	27 (43)
3	1238	21 (33)	4	1605	27 (43)
40	1238	21 (33)	40	1605	27 (43)
60	1238	21 (33)	60	1605	27 (43)
80	1238	21 (33)	80	1605	27 (43)
100	1238	21 (33)	100	1605	27 (43)

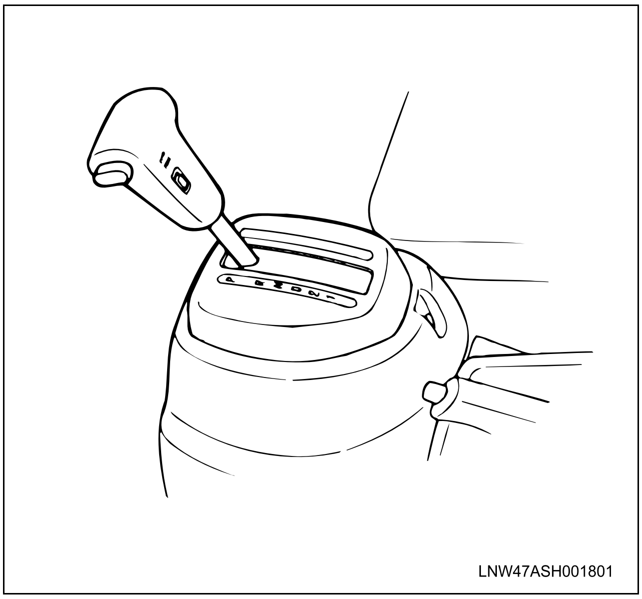
Repair Instructions (On-Vehicle)

Automatic Transmission Fluid (ATF)

Before performing on-vehicle service on the automatic transmission, check that the engine idling speed and general engine condition are normal.

Inspection Procedure

Remove the transmission dipstick (level guage) to check the condition of the ATF.
Clean the dipstick and look for gum or varnish.
Gum or varnish indicate scorching of the clutch and other parts.
The transmission control module, the transmission unit, and the vehicle must be carefully checked if gum or varnish is present.



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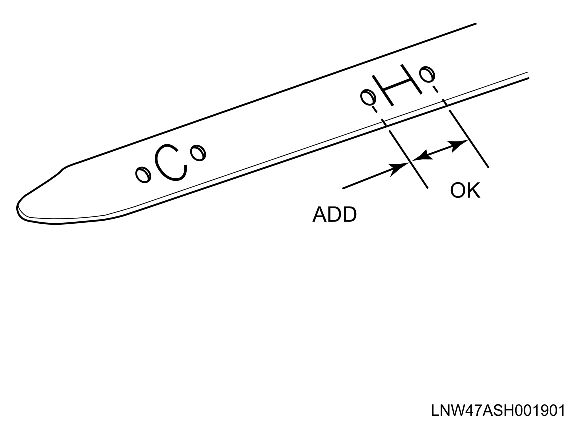
Automatic Transmission Fluid (ATF) Level

Inspection Procedure

Caution:
Steady the vehicle level on a flat road. Apply the parking brake and block the wheels.

- An improper oil level (too high or too low) can cause trouble.
- Check the idle RPM before starting the level check.
- Keep the transmission fully warmed (ATF temperature: 150–176°F/70–80°C) during the check.

1. Depress the brake pedal and start the engine.
2. With the engine idling, shift the gear slowly in every range from “P” to “L” ranges, and return to the “P” range.
3. With the engine idling, remove the level gauge and apply compressed air to remove threads or other foreign items. Insert the level gauge, remove it again, and confirm that the oil level is within the “HOT” range.



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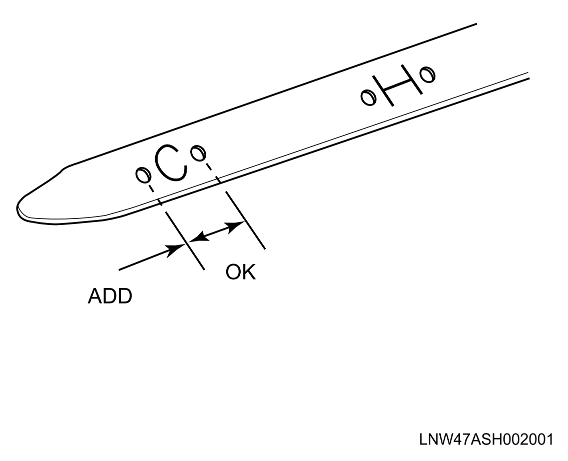
Caution:

- When checking the oil level at low ATF temperatures (68–86°F/20–30°C) during oil change, etc., adjust the oil level so that it is within the “COLD” range. Then, recheck the oil level in the fully warmed condition (150–176°F/70–80°C). “COLD” range is reference only for replacement of transmission assembly or transmission fluid.
- Use the lower level if the oil level varies between the front and back of the level gauge.



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4. If the oil level is low, suspect oil leakage.

Automatic Transmission Fluid (ATF) Change

1. Start the engine and allow it to idle until the ATF reaches a temperature of 104–122°F (40–50°C).
2. Park the vehicle on level ground and block the wheels.
3. Stop the engine.
4. Raise vehicle and support with suitable safety stands.
5. Remove the drain plug from the oil pan and drain the ATF (approximately 4 liters).
6. Remove the oil pan.
7. Inspect the oil pan (details written below).
8. Install the oil pan.

Notice:
Use new gasket. Clean the oil pan and magnet.

Tighten

- Oil pan bolts 7 N·m (61 lb in)

9. Replace the gasket and install the drain plug.

Tighten

- Drain plug 27 N·m (20 lb ft)

Notice:
Do not reuse old washer (gasket). Clean the drain plug (especially the threaded section).

10. Remove the ATF filter element.
11. Install new ATF filter element.
12. Pour about 5 liters of new ATF. Then, add more ATF carefully as necessary using the level gauge. Refer to “Automatic Transmission Fluid (ATF) Level” previously in this section.

Caution:
Keep the engine idle (do not stop it) during the oil level adjustment.

13. Remove the safety stands and wheel blocks.

Inspection Procedure

1. Check the drain plug tip for adhesion of foreign substances.
2. Check the drained ATF for color, smell and inclusion of foreign substances.
3. Check the oil pan bottom and magnet for adhesion of foreign substances.
   If a problem is discovered during those checks, the automatic transmission must be overhauled.

Transmission Control Module (TCM)

The TCM is located under the instrument panel cluster (IPC).

Removal Procedure

1. Turn OFF the ignition.
2. Disconnect the negative battery cable.
3. Disconnect the TCM harness connectors (26 pin, 16 pin and 12 pin connectors).
4. Loosen the TCM fixing nuts.
5. Remove the TCM.

Installation Procedure

1. Install the TCM.
2. Tighten the TCM fixing nuts.
3. Connect the TCM harness connectors.
4. Connect the negative battery cable.
5. Program software and the VIN into the new TCM.

Programming Software and VIN

Important:
The software and VIN will always be downloaded together when programming the TCM.

Important:
There is no data transfer from the old TCM needed; nor any learning procedures that need to be performed after programming the new TCM.

1. Make sure the hardware lock is installed on the TIS2000 terminal printer (LPT) port unless you are using a satellite-connected server.
2. Launch TIS2000 and click on Service Programming System.
3. Select the following from the Select Diagnostic Tool and Programming Process screen:
   - Select Diagnostic Tool - Tech 2
   - Select Programming Process - Reprogram ECU
   - Select ECU Location - Vehicle
4. Click Next.
5. Follow the instructions on the Preparing for Communication screen, which will Request Info. from the new (or controller being reflashed) TCM.
6. Turn ON the ignition, with the engine OFF.
7. Use the scan tool to Request Info. from the new (or controller being reflashed) TCM located under the Service Programming System option from the scan tool Main Menu. Follow the On-Screen instructions.
8. Turn OFF the ignition.
9. Take the scan tool to the TIS2000 terminal, connect the 110-volt power supply to the scan tool then turn it ON.

Important:
The ribbon cable cannot exceed 25 feet or programming errors may occur.

10. Connect the ribbon cable between the TIS2000 terminal RS-232 port and the scan tool side port.
11. Continue to follow the SPS On-Screen instructions to download the correct software to the scan tool.
12. Bring the scan tool to the vehicle then connect it to the data link connector (DLC) ensuring a robust connection.
13. Disconnect the ABS module harness connector (walk the connector out as to not damage the lock tab). The TCM may not program unless the ABS module Class 2 communications are disabled.
14. Turn ON the ignition with the engine OFF.
15. Before TCM programming, ensure the following are met:
    - Vehicle batteries are fully charged and there is no charging system concern. All charging system concerns must be repaired before programming the TCM.
    - Ensure NO battery charger is connected.
    - Turn OFF all accessories that may put a load on the batteries.
    - Do not change the ignition position unless instructed to do so.
    - Program only when the TCM is exposed to temperatures in the 0-50°C (32-122°F) range.

Caution:
An interruption of the tool harness connection during programming may cause TCM damage.

16. Use the scan tool to reprogram the TCM by choosing to Reprogram ECU under the Service Programming System option from the scan tool Main Menu.
17. Turn OFF the ignition and the scan tool.
18. Reconnect the ABS module harness connector.
19. Turn ON the ignition with the engine OFF.
20. Clear DTCs in the engine control module (ECM) as a CAN communication DTC may have set during the programming event.

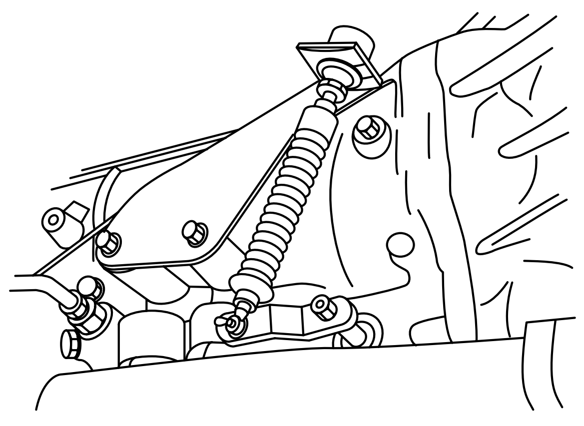
The programming is complete.

Inhibitor Switch

The inhibitor switch is attached to the left side of the transmission.

Inspection Procedure

1. Block the wheels.
2. Disconnect the negative battery cable.
3. Disconnect the control cable from the lever.
4. Remove the harness connector cover and disconnect the harness connectors.
5. Use a ohmmeter to check the inhibitor switch continuity between the following terminals.
6. Place the select lever in the "N" range.



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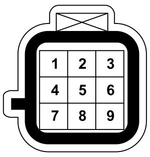
7. Move the select lever to either side.
   Check the inhibitor switch continuity between the terminals shown in Step 5.
   The continuity readings should remain fairly steady as the select lever is moved.
   If there is no continuity or the continuity is intermittent, the inhibitor switch must be reinstalled correctly.
   After reinstallation, if there is still a problem with the inhibitor switch continuity, the switch must be replaced.
8. Connect the control cable to the lever.
9. Connect the harness connector and install the cover.

Terminal / Range	J69								
	1	2	3	4	5	6	7	8	9
P						○	○	○	○
R				○	—	—	○		
N					○	—	○	○	○
D	○	—	—	—	—	—	○		
2		○	—	—	—	—	○		
1			○	—	—	—	○		

○–○ Continuity

LNW47ASH044501



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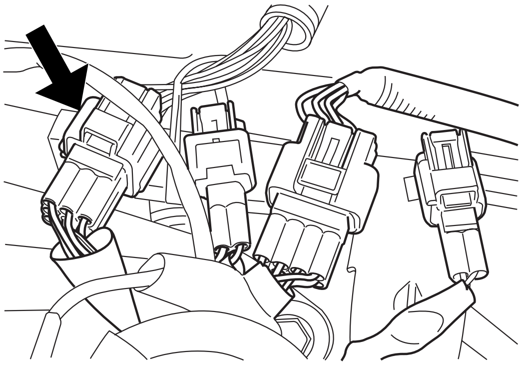
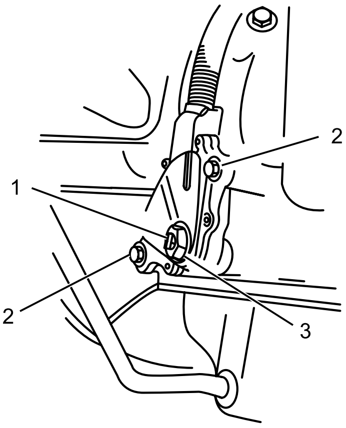


LNW25BSH004201

Removal Procedure

1. Remove the nut retainer.
2. Loosen the nut.
3. Remove the inhibitor switch bolts.
4. Remove the inhibitor switch from the transmission.



LNW47ASH003001

Legend

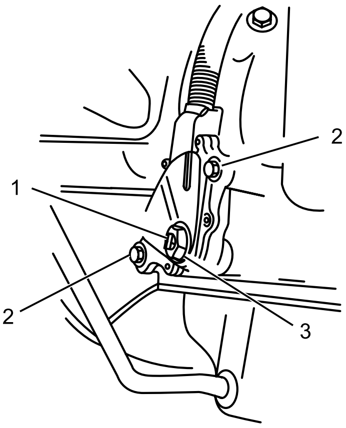
1. Shaft
2. Bolt
3. Nut

Installation Procedure

1. Place the select lever in the “N” range.
2. Assemble the inhibitor switch to the end of the shaft.
3. Temporarily tighten the inhibitor switch bolts.
4. Tighten the nut.

Tighten

- Inhibitor switch nut 7 N·m (61 lb in)

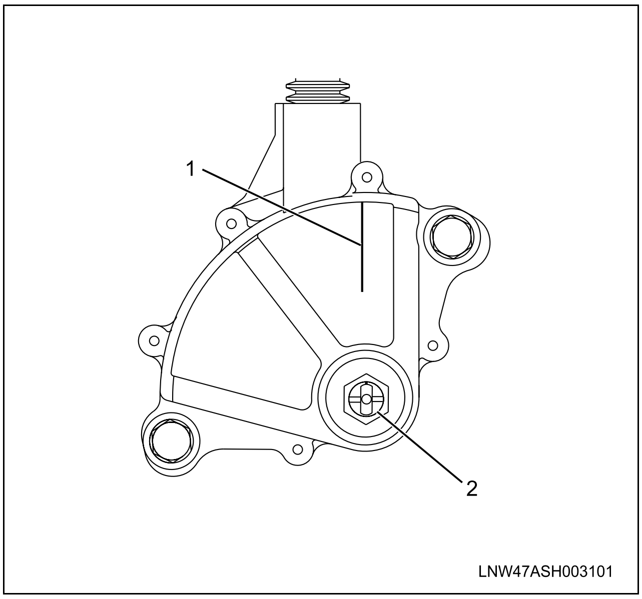


LNW47ASH003001

Legend

1. Shaft
2. Bolt
3. Nut

5. Loosen the two temporarily tightened bolts and move the inhibitor switch as necessary to align the reference line with the groove.



Legend

1. Reference Line
2. Groove

---

6. Steadying the inhibitor switch with one hand, tighten the two bolts.

Tighten

- Inhibitor switch bolts 12.5 N·m (109 lb in)

7. Bend the nut retainer of the inhibitor switch at two places.

Vehicle Speed Sensor 2 (SP1)

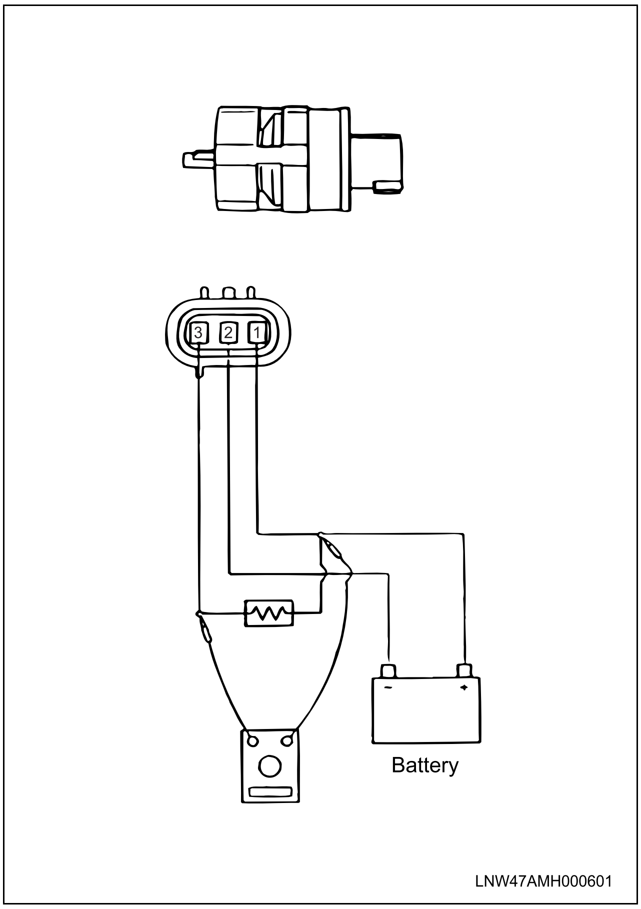
Vehicle speed sensor 2 (SP1) is attached on the speedometer driven gear assembly.

Inspection Procedure

1. Block the wheels.
2. Disconnect the negative battery cable.
3. Disconnect the harness connector from vehicle speed sensor 2 (SP1).
4. Connect the vehicle speed sensor connector terminal (1) to the battery (+) terminal and terminal (2) to the battery (-) terminal.
5. Connect a resistance of 1.3 k to 1.5 k (1.4 W or more) between terminals (1) and (3).

Caution:
Be extremely careful not to connect the battery (+) terminal to the vehicle speed sensor terminal(3).
This may damage the vehicle speed sensor.

6. Rotate the shaft of the vehicle speed sensor slowly and measure the voltage at both ends with a digital voltmeter.
   - The voltage, with one rotation of vehicle speed sensor shaft, fluctuates four times in the following range: 10 to 14 V ←→ 2 V or less.
7. Replace the sensor when the result of inspection is found abnormal.



Removal Procedure

1. Remove cover and clip.
2. Disconnect the vehicle speed sensor 2 harness connector.
3. Remove the vehicle speed sensor 2 with key rod.

Installation Procedure

1. Install the vehicle speed sensor 2 with key rod.

Tighten

- Vehicle speed sensor 27 N·m (20 lb ft)

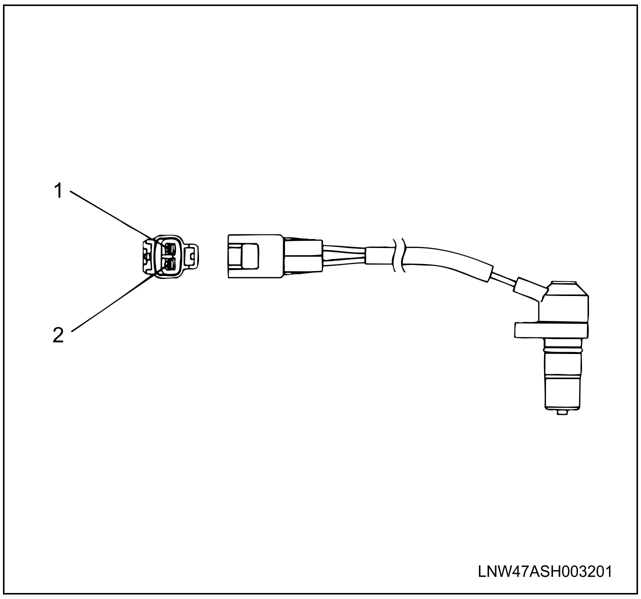
2. Connect the vehicle speed sensor 2 harness connector.
3. Install cover and clip.
4. Connect the negative battery cable.
5. Remove wheel blocks.

Vehicle Speed Sensor 1 (SP2)

The vehicle speed sensor1 (SP2) is attached on the transmission rear cover.

Inspection Procedure

1. Block the wheels.
2. Disconnect the negative battery cable.
3. Disconnect the harness connector.
4. Use a ohmmeter to measure the resistance between sensor signal terminal and sensor ground terminal.
   - Resistance 560–680 Ω at approx. 68°F (20°C)
5. If the measured value is outside the specified range, the vehicle speed sensor1 (SP2) must be replaced.

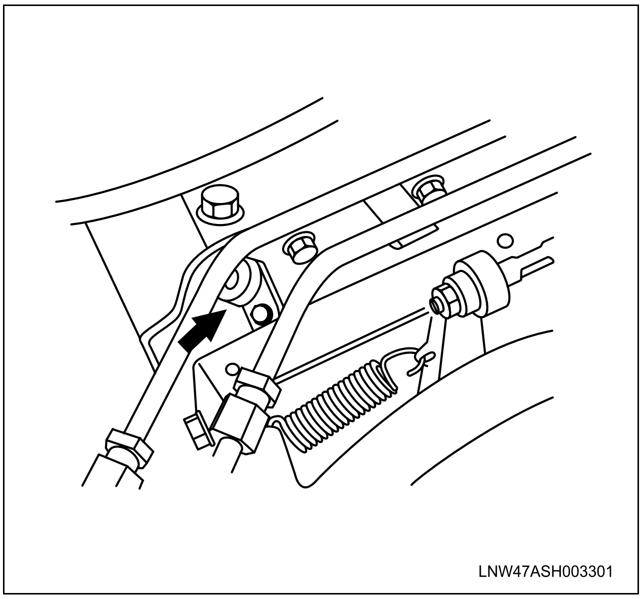


Legend

1. Sensor Signal Terminal
2. Sensor Ground Terminal

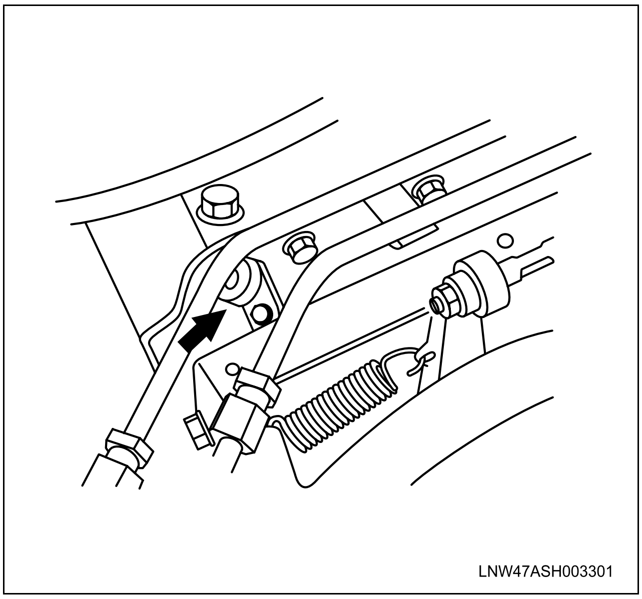
Removal Procedure

1. Support transmission with a transmission jack.
2. Remove the mount bolt (8 pcs) from the crossmember. Then lower the transmission assembly slightly.
3. Disconnect the vehicle speed sensor 1 harness connector.
4. Loosen the fixing screw.
5. Remove the vehicle speed sensor1 (SP2) from transmission rear cover.



Installation Procedure

1. Apply grease to the new O-ring then attach to the vehicle speed sensor.
2. Install the vehicle speed sensor to the rear cover.



3. Tighten the fixing screw.

Tighten

- Vehicle speed sensor screw 8 N·m (69 lb in)

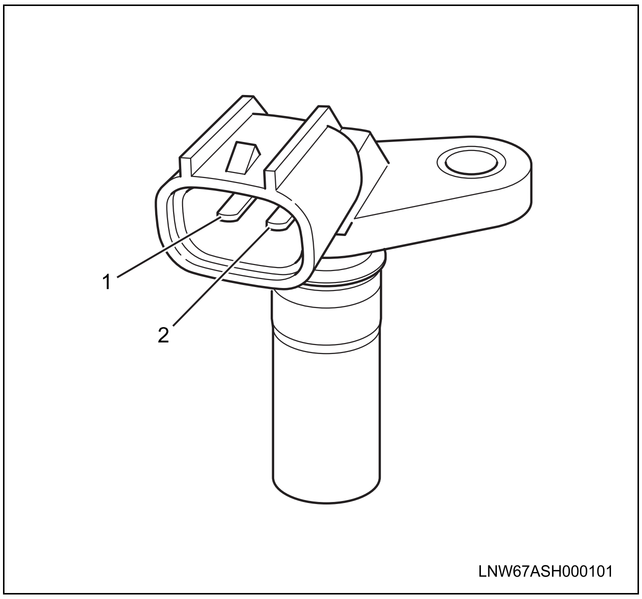
4. Connect the vehicle speed sensor 1 harness connector.
5. Raise the transmission jack and install mount bolt.
6. Connect the negative battery cable.
7. Remove the wheel blocks.

Input Shaft Speed Sensor (C0) [12,000 lbs GVW]

The Input shaft speed sensor (C0) is attached on the transmission case.

Inspection Procedure

1. Block the wheels.
2. Disconnect the negative battery cable.
3. Disconnect the harness connector.
4. Use a ohmmeter to measure the resistance between sensor signal terminal 1 and 2.
    - Resistance 560-680 Ω at approx. 68°F (20°C)
5. If the measured value is outside the specified range, the Input shaft speed sensor (C0) must be replaced.

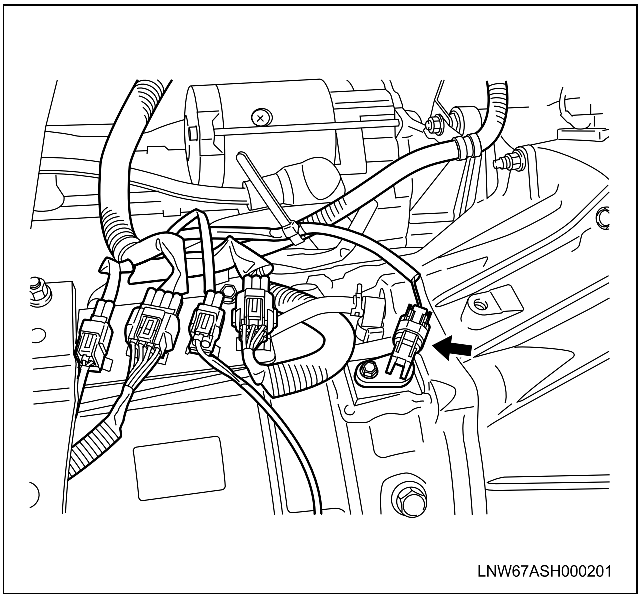


Legend

1. Sensor High Signal Terminal
2. Sensor Low Signal Terminal

Removal Procedure

1. Disconnect the Input shaft speed sensor (C0) harness connector.
2. Loosen the fixing bolt.
3. Remove the Input shaft speed sensor (C0) from transmission case.



Installation Procedure

1. Apply grease to the new O-ring then attach to the Input shaft speed sensor (C0).
2. Install the Input shaft speed sensor (C0) to the transmission case.
3. Tighten the fixing bolt.

Tighten

- Input shaft speed sensor (C0) bolt 8 N·m (69 lb in)

4. Connect the Input shaft speed sensor (C0) harness connector.
5. Connect the negative battery cable.

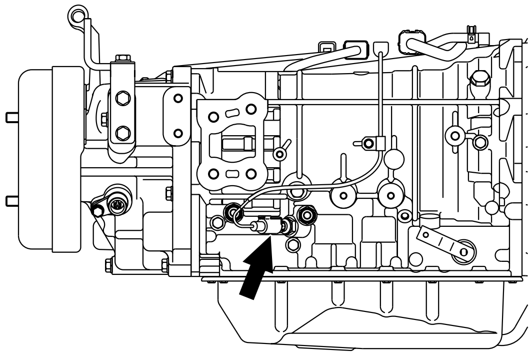
Automatic Transmission Fluid (ATF) Temperature Switch

The ATF temperature switch fitted to the right side of the transmission.

Removal Procedure

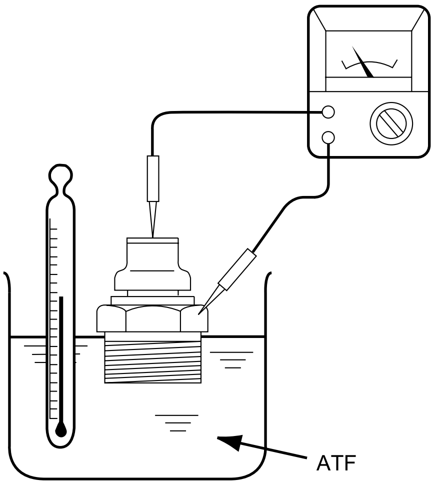
1. Turn OFF the ignition.
2. Disconnect the harness connector and harness clip.

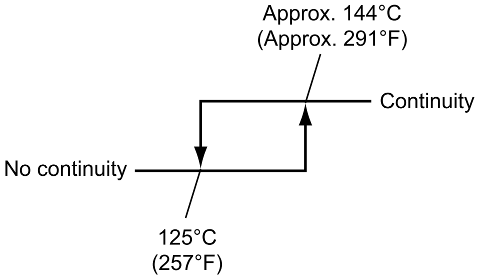
3. Remove the ATF temperature switch.



Inspection Procedure

1. Heat ATF in a container and place the ATF temperature switch.
2. Check the electrical continuity between the switch terminal and the switch body.





Installation Procedure

1. Install the ATF temperature switch.

Tighten

- ATF temperature switch 25 N·m (18 lb ft)

2. Connect the harness connector and harness clip.

Crank Position (CKP) Sensor

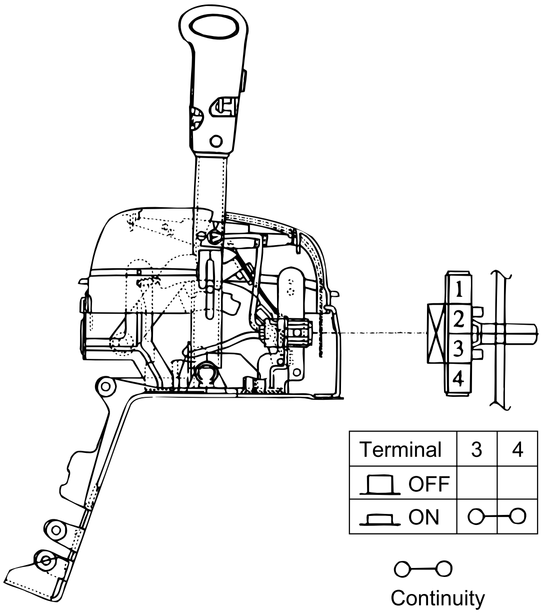
The CKP sensor attached to left side of the flywheel housing.
Refer to Crankshaft Position (CKP) Sensor Replacement in Engine Control System section.

Overdrive Off Switch

Inspection Procedure

1. Block the wheels.
2. Disconnect the negative battery cable.
3. Remove the select lever cover
4. Disconnect the harness connector
5. Check continuity between terminals (3) and (4).
6. Replace the control lever assembly when the result of inspection is found abnormal.
   Refer to “Control Lever Assembly” later in this section.
7. Connect the harness connector.
8. Connect negative battery cable.

9. Remove wheel blocks.



Terminal	3	4
OFF		
ON	○—○	

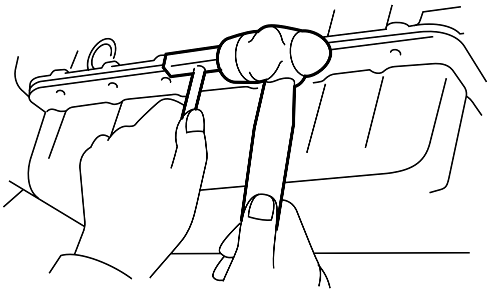
○—○ Continuity

Oil Pan

Removal Procedure

Tool Required: J-37228 Oil Pan Seal Cutter

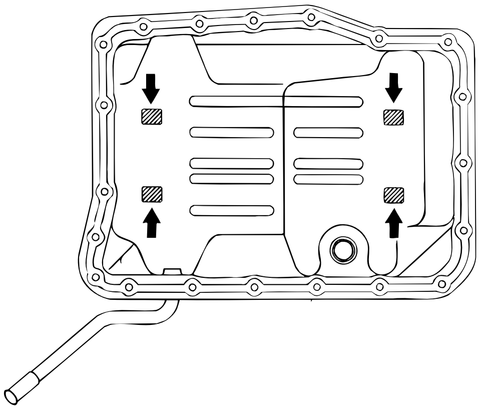
1. Block the wheels.
2. Disconnect the negative battery cable.
3. Raise the vehicle and support with suitable safety stands.
4. Drain the Automatic Transmission Fluid (ATF).
   Refer to “Automatic Transmission Fluid (ATF) Change” previously in this section.
5. Remove the oil pan bolts (20 pcs).
   Leave several bolts attached (2–3 pitch).
6. Insert an oil pan seal cutter from a corner of the oil pan and separate the oil pan.



Caution:
Drive the oil pan cutter carefully. Do not deform the oil pan.
The oil pan cannot be emptied completely. Do not tilt.

Installation Procedure

1. Clean the oil cleaner magnet and set it to the oil pan.

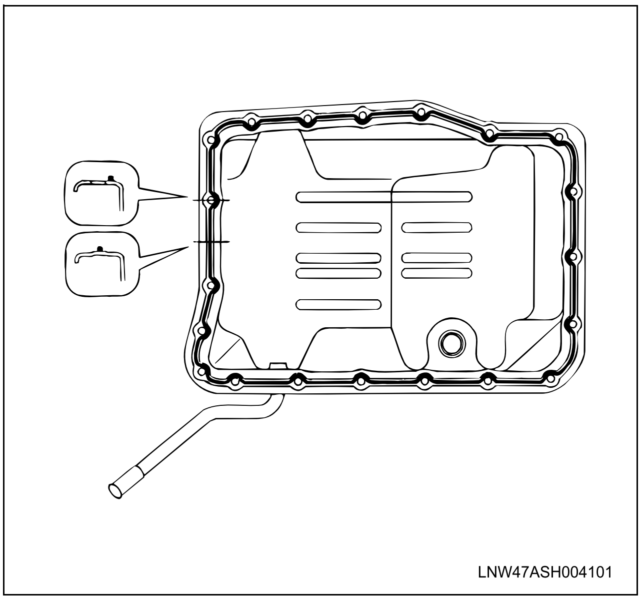


2. Remove the sealant in the contact surface between the transmission case and the oil pan.

Caution:
Work carefully to keep the contact surface between the transmission case and the oil pan free of ATF.

3. Apply sealant (ThreeBond 1281B or equivalent) and attach the oil pan to the transmission case.

Caution:
The sealant must be 2-3 mm (0.03-0.12 in.) diameter without interruption. Assemble the oil pan within 10 minutes after the sealant is applied.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4. Oil pan to the transmission case and tighten the oil pan bolts.

Tighten

- Oil pan bolts 7 N·m (61 lb in)
- Drain plug 27 N·m (20 lb ft)

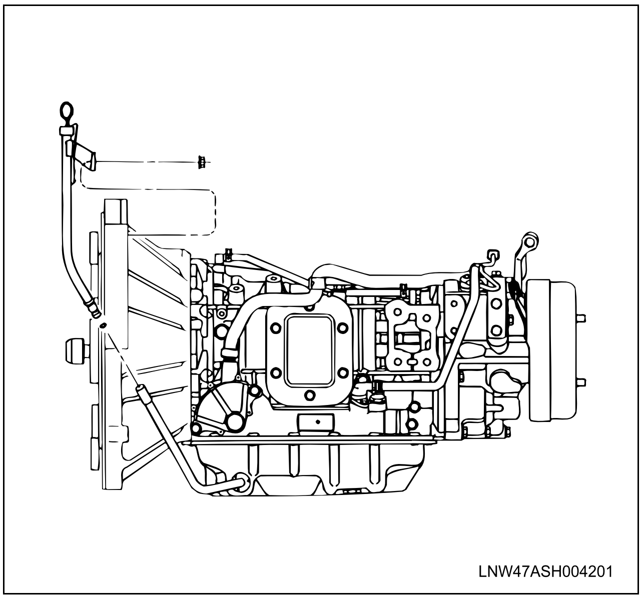
Caution:
Tighten the bolts evenly in several times.

5. Refill the transmission with new ATF.
   Refer to “Automatic Transmission Fluid (ATF) Change”.
6. Connect the negative battery cable.
7. Remove safety stands.
8. Remove wheel blocks.

Oil Filler Tube

Removal Procedure

1. Block the wheels.
2. Disconnect the negative battery cable.
3. Remove the oil level gauge.
4. Remove the nut from bracket, then remove the oil filler tube with O-ring.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Installation Procedure

1. Install the oil filler tube with O-ring.

Tighten

- Oil filler tube nut 47 N·m (35 lb ft)

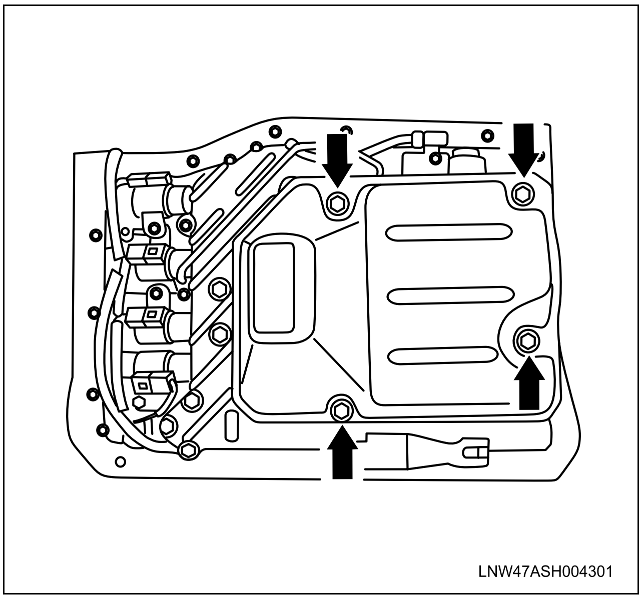
2. Install level gauge.
3. Connect the negative battery cable.
4. Remove wheel blocks.

Oil Strainer

Removal Procedure

1. Block the wheels.
2. Disconnect the negative battery cable.
3. Raise vehicle and support with suitable safety stands.
4. Remove the oil pan.
   Refer to “Oil Pan” previously in this section.

5. Remove the oil strainer bolts (4 pcs), and then oil strainer.



Inspection Procedure

Check oil pan bottom and oil strainer mesh for foreign substances (facing of clutches and metal flakes, etc.).

Installation Procedure

1. Install the oil strainer.

Tighten

- Oil strainer bolts 10 N·m (87 lb in)

2. Install the oil pan.
   Refer to “Oil Pan” previously in this section.
3. Connect the negative battery cable.
4. Remove safety stands.
5. Remove wheel blocks.

Solenoids

Inspection Procedure

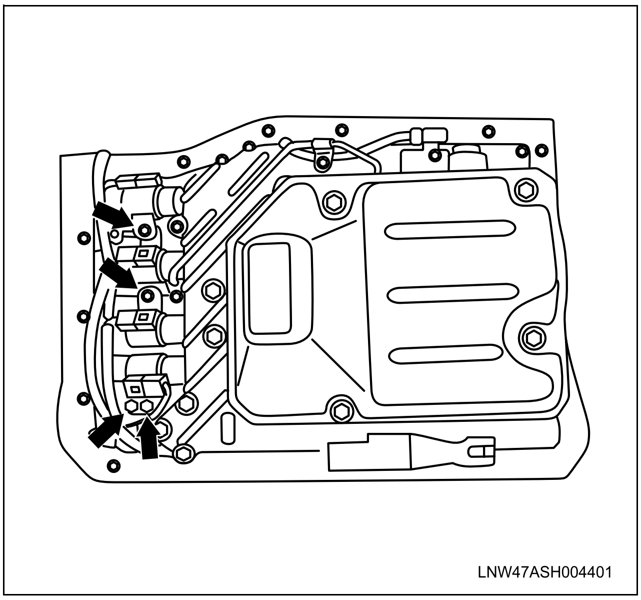
1. Block the wheels.
2. Disconnect the negative battery cable.
3. Remove oil pan.
   Refer to “Oil Pan” previously in this section.
4. Disconnect the connectors from the solenoids. Use the ohmmeter to measure the resistance of each solenoid valve.

Solenoid valve	Resistance (Ω) (at approx. 68°F/20°C)
Shift timing solenoid valve	10 – 20
Shift solenoid (S1) valve	
Shift solenoid (S2) valve	
TCC PWM solenoid valve	

Solenoid valve	Resistance (Ω) (at approx. 68°F/20°C)
Line pressure solenoid valve	6 – 9

Removal Procedure

1. Loosen the bolts and remove the solenoids.



Installation Procedure

1. Install solenoids and tighten the bolts.

Tighten

- Solenoid valve bolts 10 N·m (87 lb in)

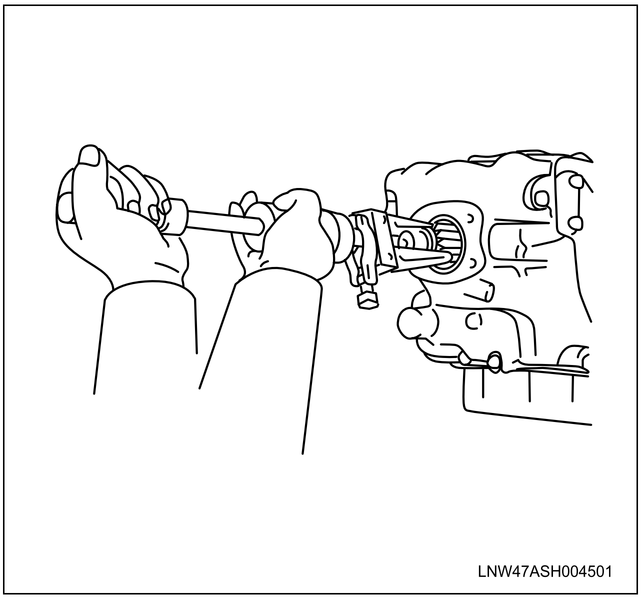
Rear Cover Oil Seal

Removal Procedure

Tool Required:
J-26941 Rear Oil Seal Remover
J-23907 Sliding Hammer

1. Block the wheels.
2. Disconnect the negative battery cable.
3. Raise vehicle and support with suitable safety stands.
4. Reference mark the flange yoke to the parking brake drum.
5. Remove the propeller shaft.
6. Remove the lock nut.
   Make sure to raise the caulking of the lock nut. Apply the parking brake or move the select lever to the P range to prevent the output shaft from turning.
7. Remove the O-ring using a screwdriver.
8. Release the parking brake and remove the parking brake drum.
9. Remove the drive coupling from output shaft.
10. Remove the parking brake assembly.

11. Remove the oil seal using oil seal remover.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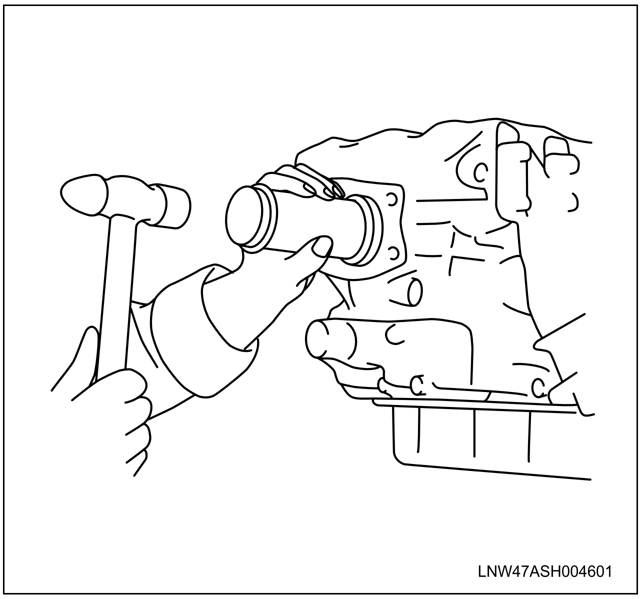
Installation Procedure

Tool Required: J-41736 Rear Oil Seal Installer

1. Apply grease to the new oil seal lip.
2. Drive the oil seal to the rear cover end surface using oil seal installer.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Caution:
Drive the oil seal evenly.
Take care not to damage or deform the oil seal.

3. Install the parking brake assembly.

Tighten

- Parking brake bolts 83 N·m (61 lb ft)

4. Install the drive coupling to the output shaft.

Caution:
Take care not to damage the oil seal lip.

5. Apply the parking brake or move the select lever to the “P” range to prevent the output shaft from turning.
6. Install the new O-ring and new lock nut.

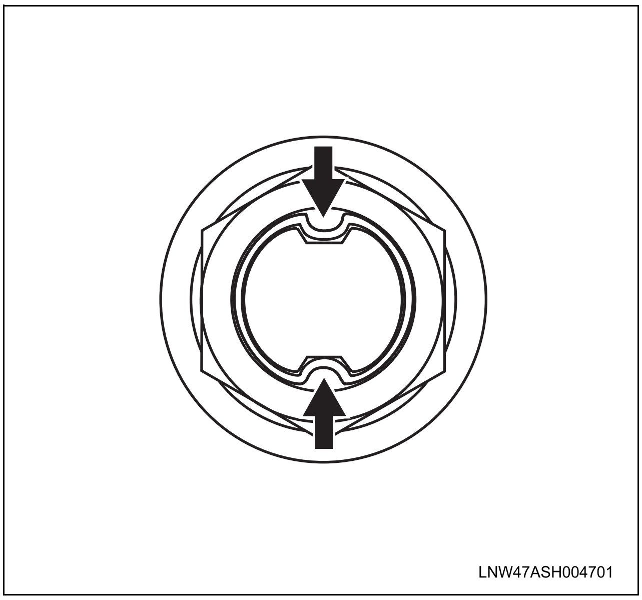
Tighten

- Driver coupling nut 170 N·m (125 lb ft)

Caution:

Always install a new lock nut. Never reuse the original coupling nut.

- Stake nut by chisel.


LNW47ASH004701

7. Install the parking brake drum.
8. Line up reference mark and install propeller shaft to the driver coupling.

Tighten

- Propeller shaft nuts 102 N·m (75 lb ft)

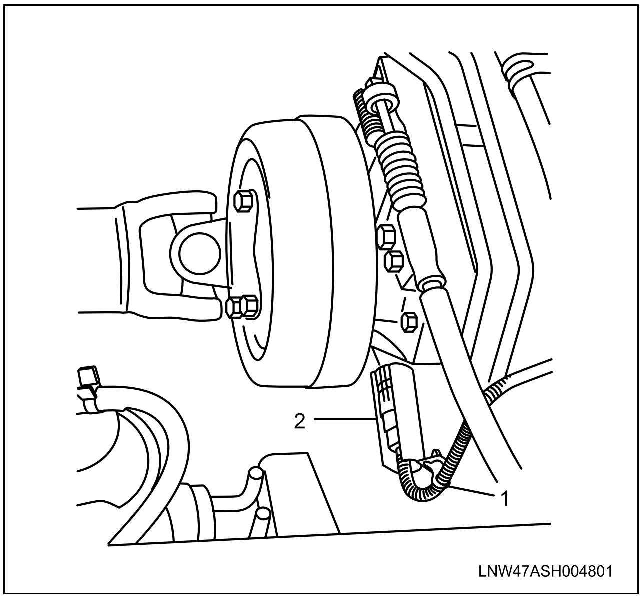
9. Connect the negative battery cable.
10. Remove safety stands.
11. Remove wheel blocks.

Vehicle Speed (Speedometer) Sensor Driven Gear

Removal Procedure

1. Block the wheels.
2. Disconnect the negative battery cable.
3. Raise vehicle and support with suitable safety stands.

4. Remove the harness clip and protector.

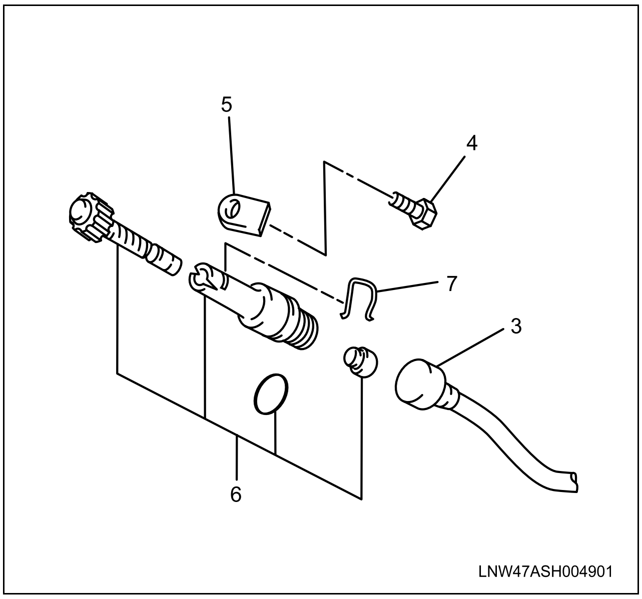


Legend

1. Clip
2. Protector

---

5. Disconnect the harness connector.
6. Remove the vehicle speed sensor with key rod.
7. Remove the fixing bolt and plate.
8. Remove the driven gear assembly.
9. Remove clip and disassemble driven gear assembly.



Legend

3. Vehicle Speed Sensor
4. Fixing Bolt
5. Plate
6. Driven Gear Assembly
7. Clip

Installation Procedure

1. Install the driven gear assembly.
2. Install clip.
3. Install the plate and fixing bolt.

Tighten

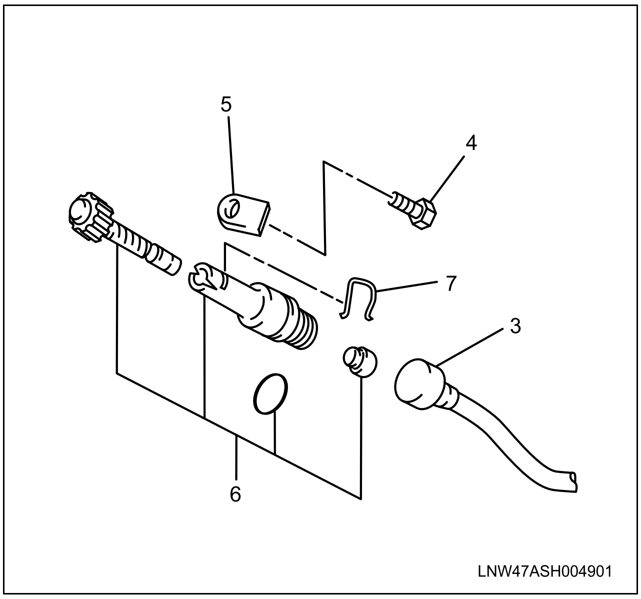
- Driven gear fixing bolt 12.5 N·m (109 lb in)

4. Install the vehicle speed sensor with key rod.

Tighten

- Vehicle speed sensor 27 N·m (20 lb ft)

5. Connect the harness connector.
6. Install the protector and harness clip.
7. Connect the negative battery cable.
8. Remove safety stands.
9. Remove wheel blocks.



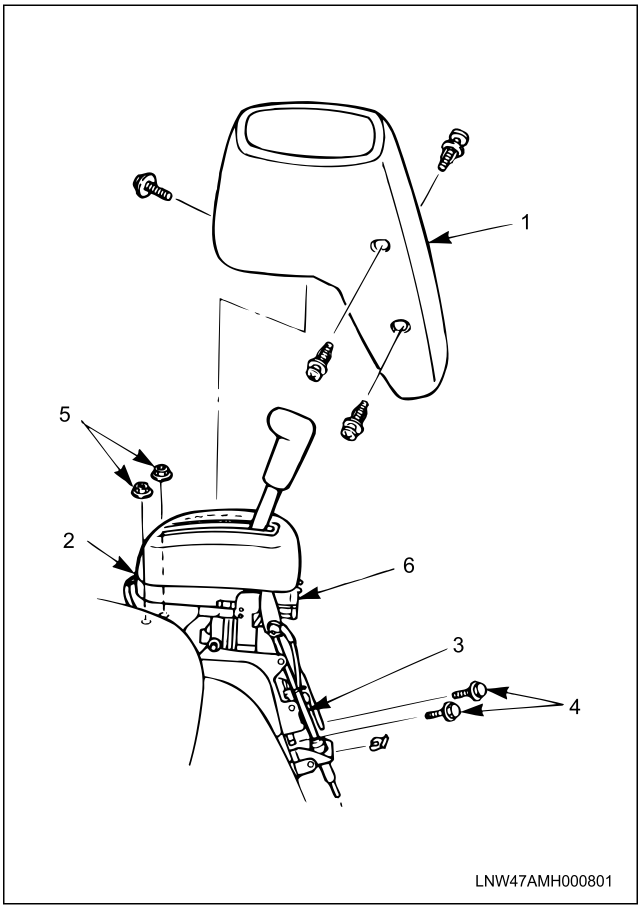
Legend

3. Vehicle Speed Sensor
4. Fixing Bolt
5. Plate
6. Driven Gear Assembly
7. Clip

Control Lever Assembly

Removal Procedure

1. Block the wheels.
2. Disconnect the negative battery cable.
3. Raise vehicle and support with suitable safety stands.
4. Remove the control lever cover.
5. Disconnect the harness connector.
6. Remove the control cable from control lever assembly.
7. Remove the bolts and nuts.
8. Remove the control lever assembly.

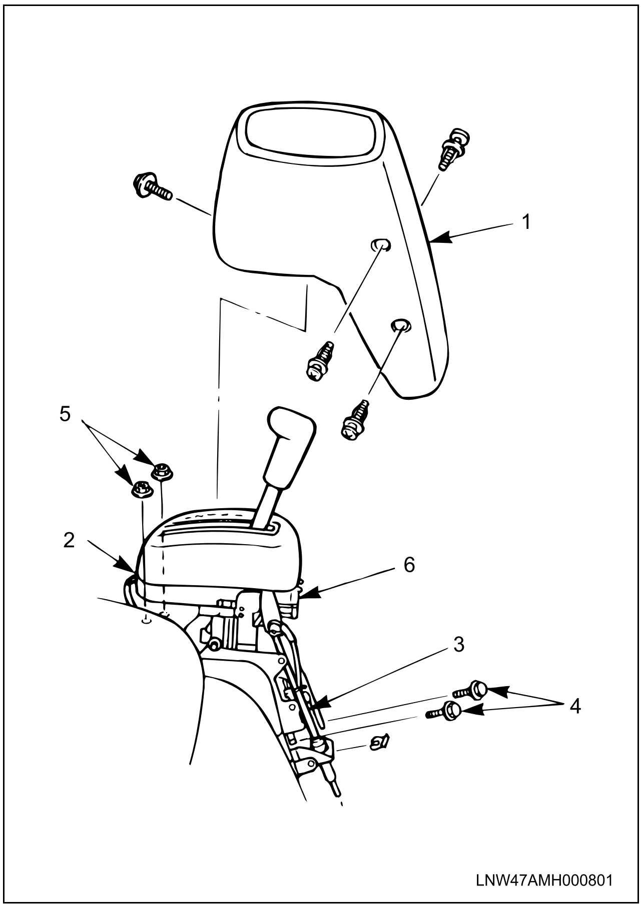


Legend

1. Control Lever Cover
2. Harness Connector
3. Control Cable
4. Bolt
5. Nut
6. Control Lever Assembly

Installation Procedure

1. Install the control lever assembly.



Legend

1. Control Lever Cover
2. Harness Connector
3. Control Cable
4. Bolt
5. Nut
6. Control Lever Assembly

2. Install the bolts and nut.
3. Install the control cable to the control lever assembly.
    - When connecting the control cable to the select lever, adjust the cable.
      Refer to “Control Cable” later in this section.
4. Connect the harness connector.
5. Install the control lever cover.
6. Connect the negative battery cable.
7. Remove safety stands.
8. Remove wheel blocks.

Control Cable

Check that each control lever position matches the corresponding shift indicators (“P”, “R”, “N”, “D”, “2” and “1”).

If the control lever positions and shift indicators do not match, the control cable must be adjusted.

Adjustment

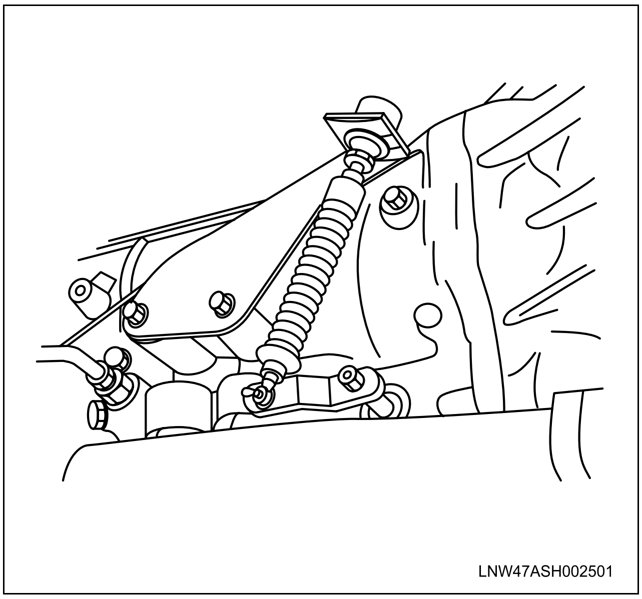
- Disconnect the negative battery cable.
- Apply parking brake.

1. Remove the retaining pin.
2. Remove the cable rod and washer.
3. Put the control lever in the “N” position.
4. Put the transmission in the “N” range.
5. Move the control lever towards the “R” position until a slight resistance is felt.
   Do not move the lever fully into the “R” position.
6. Loosen the cable lock nuts.
7. Adjust the cable rod length by rotating the turn buckle.
8. Tighten the lock nuts.
9. Install the cable rod and washer to the control lever.
10. Install the new retaining pin
    - Install the negative battery cable.

Removal Procedure

- Disconnect the negative battery cable.
- Apply parking brake.

1. Remove the retaining pin.
2. Remove the cable rod and washer.
3. Remove the cable from rear bracket.
4. Remove the control lever cover.
5. Remove the clip.
6. Remove the snap pin and washer.
7. Remove the cable rod.
8. Remove the grommet assembly.
9. Remove the cable from the bracket.
10. Remove the clip bands.
11. Remove the cable assembly.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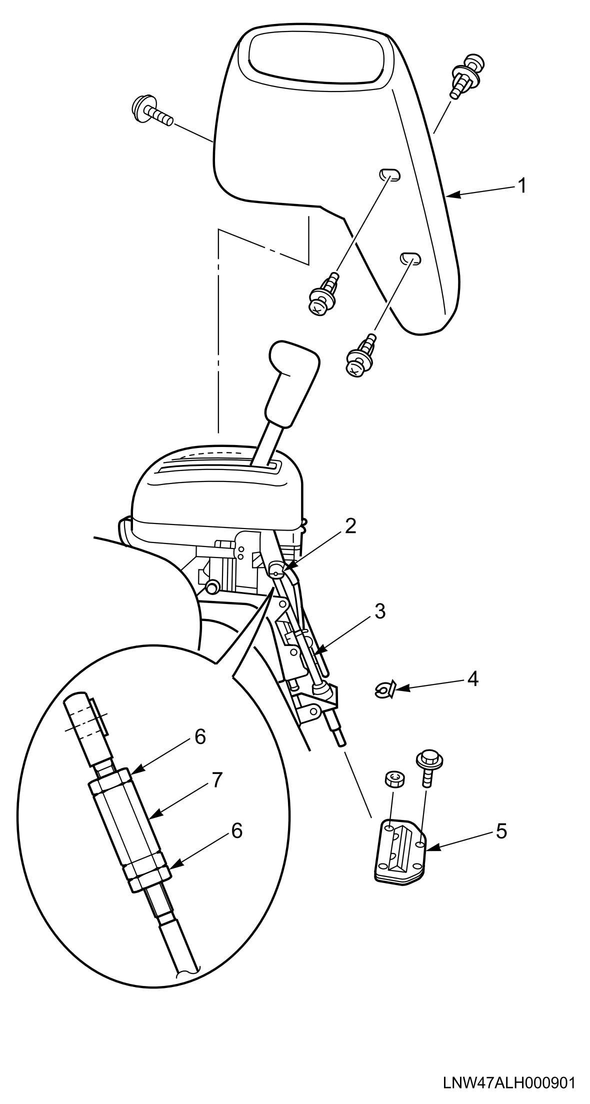

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Legend

1. Control Lever Cover
2. Retaining Pin
3. Control Cable
4. Clip
5. Grommet Assembly
6. Lock Nuts
7. Turn Buckle

Installation Procedure

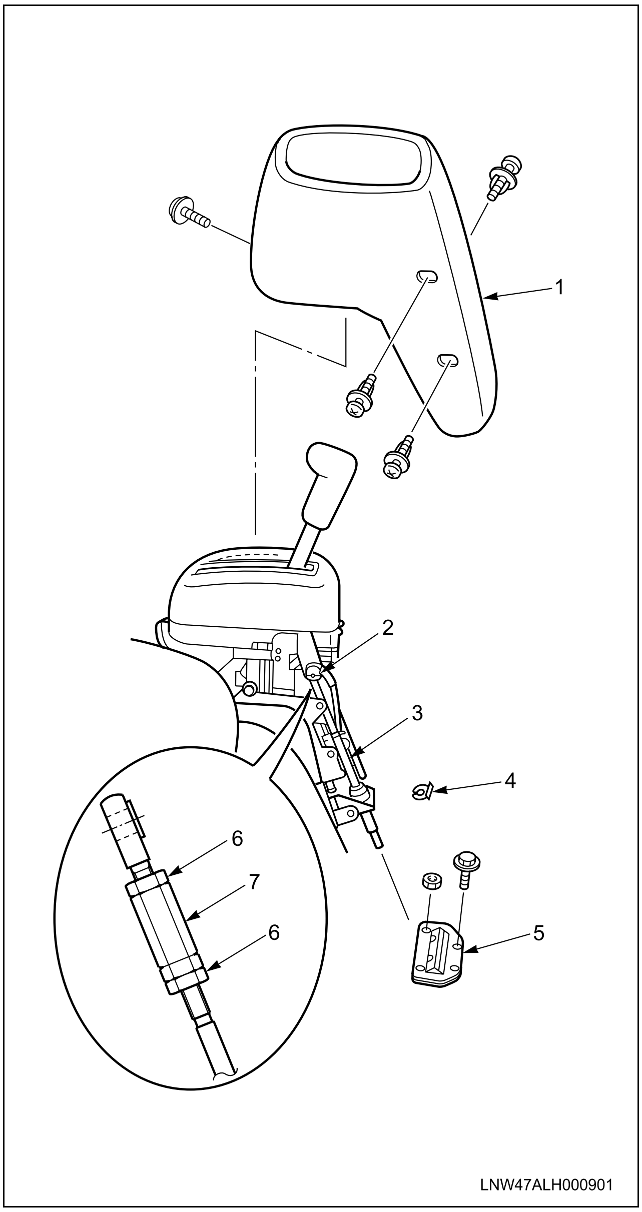
1. Install temporarily the control cable.

Important:

- Never bend the cable to radius less than 450 mm (18 in) unless it is necessary to do so for wiring purposes. And never bend the cable to radius less than 180 mm (7 in) even during wiring.
- Install the cable carefully without unnecessary twisting of the cable boots.

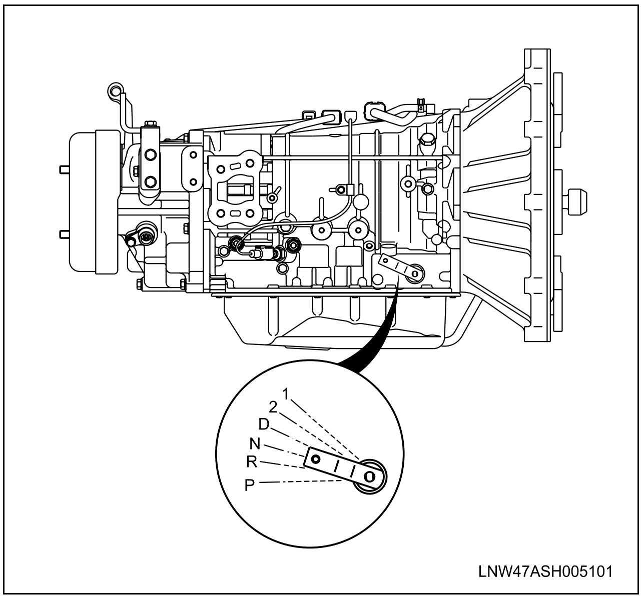
2. Install the cable rod and washer to control lever.

3. Install the new snap pin.
4. Install the cable to front bracket.
5. Install the clip.
6. Install the contro lever cover.
7. Install the grommet assembly.
8. Put the control lever in the “N” position.
9. Put the transmission in “N” range.
10. Cable to rear bracket.
11. Install the clip.
12. Install the cable rod and washer to shift lever.
13. Install the clip bands.
    - Adjust the control cable.
    - Negative battery cable.



Legend

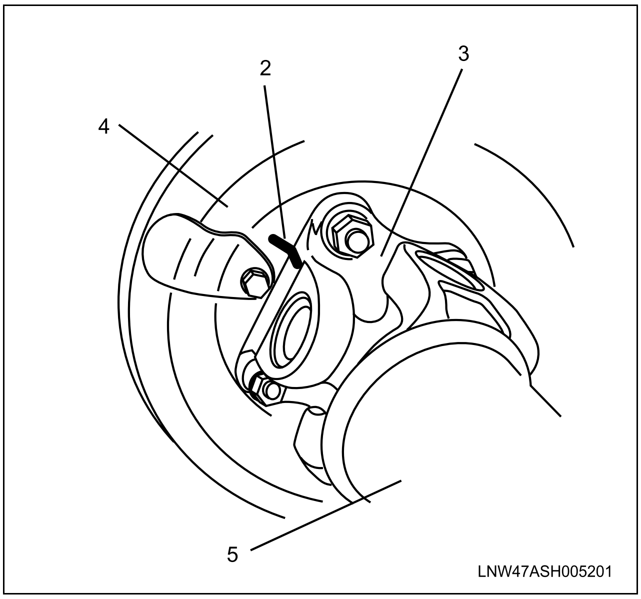
1. Control Lever Cover
2. Retaining Pin
3. Control Cable
4. Clip
5. Grommet Assembly
6. Lock Nuts
7. Turn Buckle



Transmission Assembly

Removal Procedure

1. Block the wheels.
2. Disconnect the negative battery cable.
3. Raise vehicle and support with suitable safety stands.
4. Tilt the cab.
5. Remove the oil filler tube with bracket.
6. Remove the propeller shaft guard.
7. Remove the center bearing bracket (If equipped).
8. Reference mark the flange yoke to the parking brake drum.
9. Remove the propeller shaft.

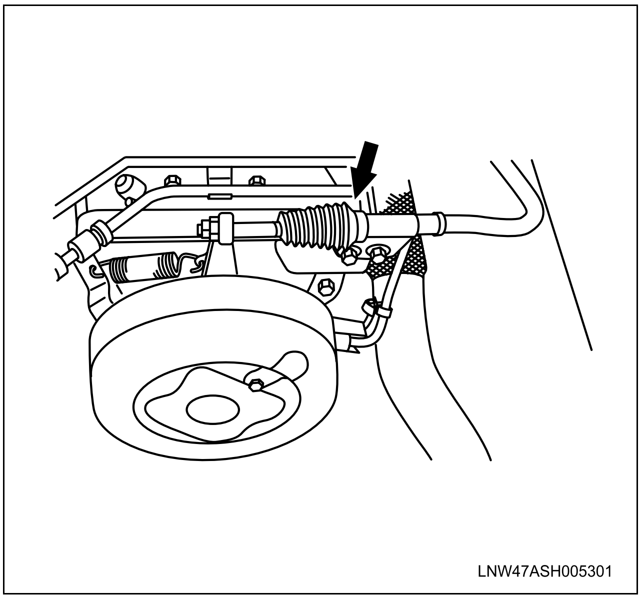


Legend

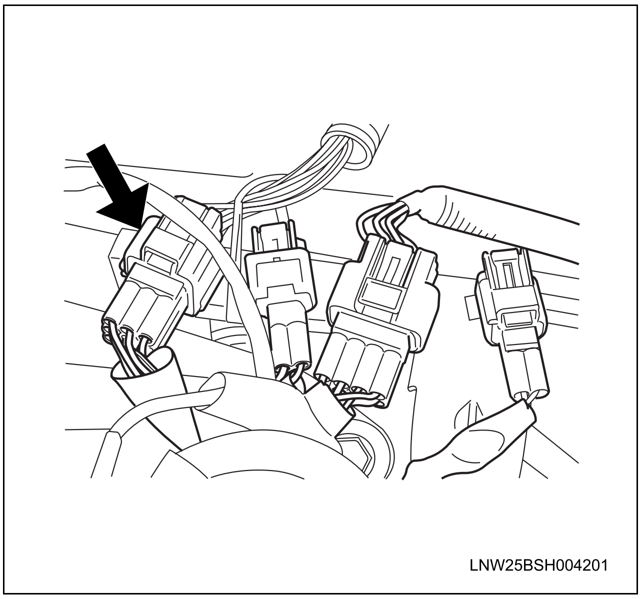
2. Reference Mark
3. Flange Yoke
4. Parking Brake Drum
5. Propeller Shaft

---

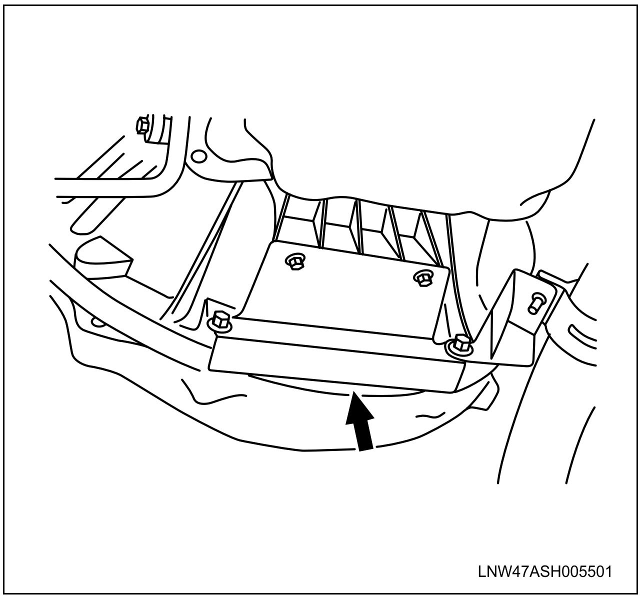
10. Remove the starter assembly. Wire the starter assembly to frame.
11. Remove the parking brake cable with bracket.



12. Disconnect the harness connectors.
    Remove the harness connector bracket on the transmission. Then disconnect four connectors (inhibitor switch, solenoid valves, vehicle speed sensor 2 and automatic transmission fluid (ATF) temperature switch).



13. Remove the vehicle speed sensor 1.
14. Disconnect transmission fluid cooler lines above the transmission.
15. Remove the control cable with bracket from transmission.
16. Remove the exhaust pipe bracket.
17. Remove the under cover from converter housing.
18. Remove the torque converter bolts (6 pcs).



19. Support the transmission with a transmission jack.
20. Attach a lifting cable/chain to the engine.
21. Operate the hoist to slightly raise the engine and support it.
22. Remove the torque converter housing to flywheel housing bolts.
23. Operate the hoist to slowly lower the engine.
    Hold the front end of the transmission higher than the rear end of the transmission.
    This will prevent the torque converter from falling from the transmission.
24. Lower the transmission jack.

Installation Procedure

1. Set the transmission assembly on a transmission jack.
    - Hold the front end of the transmission higher than the rear end of the transmission.
    - This will prevent the torque converter from falling from the transmission.
2. Install the transmission to the flywheel housing.

Tighten

- Torque converter housing to flywheel housing fixing bolts 40 N·m (30 lb ft).

3. Operate the hoist to slowly raise the engine and transmission assembly.
4. Install the torque converter to the flywheel.
    - By turning the flywheel.

Tighten

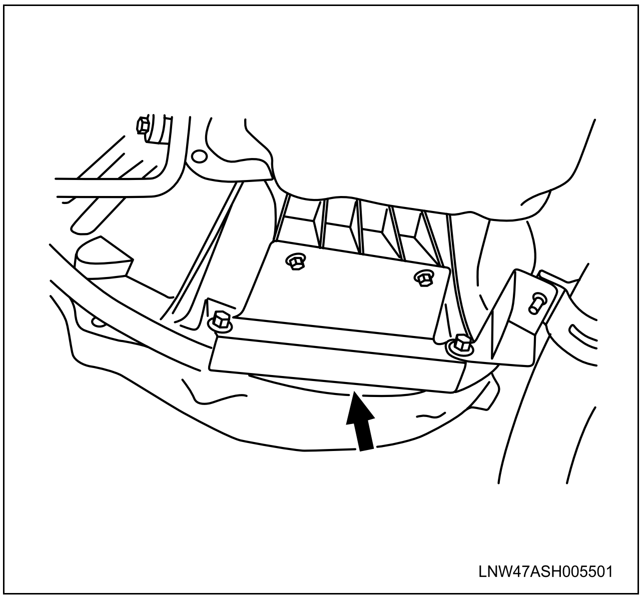
- Torque converter bolts 40 N·m (30 lb ft)

Notice:
Discard used bolts and install new ones.

5. Install the under cover.

Tighten

- Under cover bolt 9 N·m (78 lb in)



6. Install the exhaust pipe bracket.
7. Install the control cable and bracket to the transmission.
8. Adjust control cable.
    - Refer to “Control Cable” previously in this section.

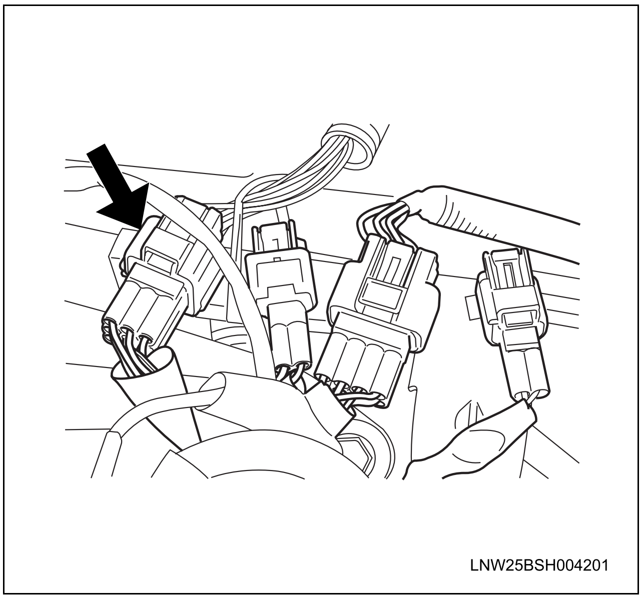
9. Connect the transmission fluid cooler line.

Important:
When constructing on automatic transmission fluid (ATF) hose, it warns against carrying out on incorrect group.

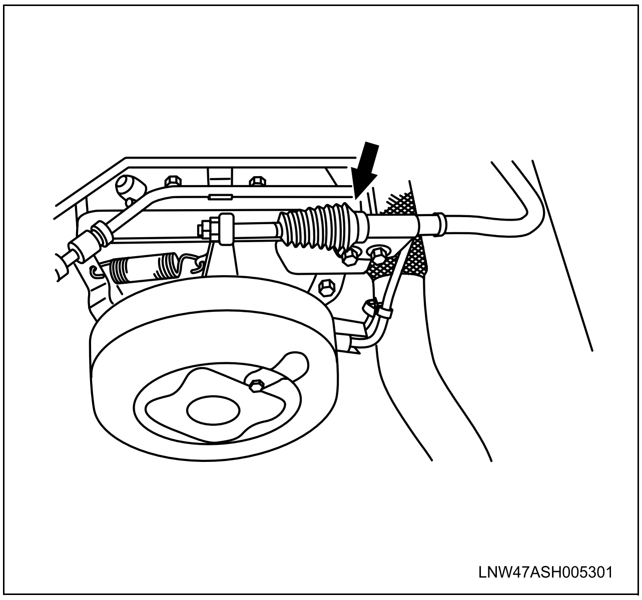
Tighten

- Cooler line joint connector 34 N·m (25 lb ft)

10. Install the vehicle speed sensor 1.
11. Connect the harness connectors and install the bracket.



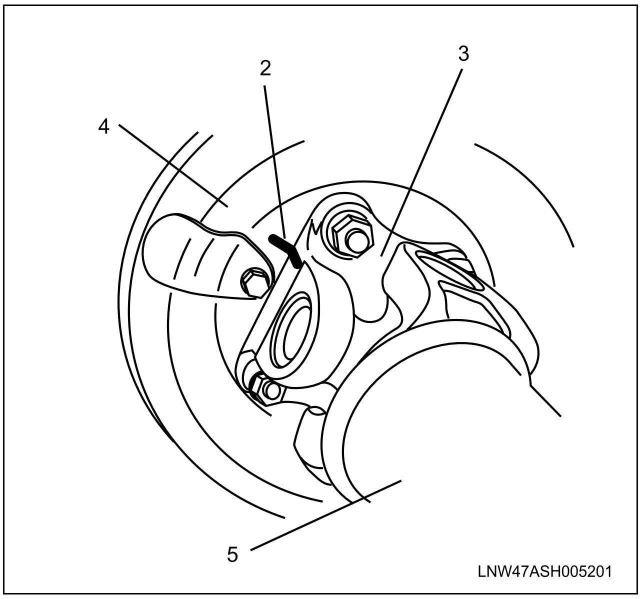
12. Install the parking brake cable.
    Adjust parking brake cable.



13. Install the starter assembly.
14. Install the propeller shaft to the driver coupling.
    - Line up reference mark.

Tighten

- Propeller shaft bolts 102 N·m (75 lb ft)



Legend

2. Reference Mark
3. Flange Yoke
4. Parking Brake Drum
5. Propeller Shaft

---

15. Install the center Bearing Bracket (If equipped).

Tighten

- Center bearing bracket bolts 40 N·m (30 lb ft)

16. Install the propeller shaft guard.
17. Install the oil filler tube with bracket.
18. Connect the negative battery cable.
19. Remove safety stands.
20. Remove wheel blocks.

Torque Converter

Removal Procedure

1. Remove the transmission assembly from the vehicle.
2. Remove the torque converter from the torque converter housing.

Inspection Procedure

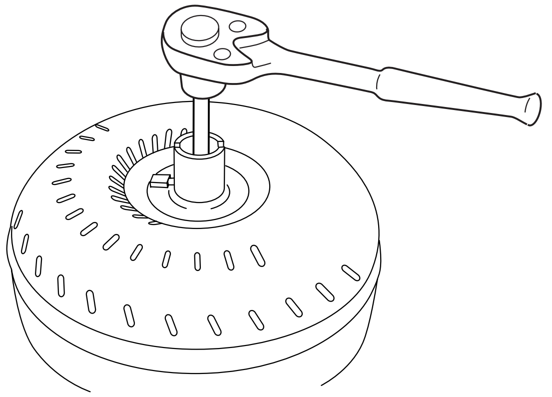
Whenever the transmission is replaced, inspect the torque converter and replace it if any of the following conditions exists:

- Line pressure is normal but a stalling test fails (idle in “D” or “R” range).
- Metallic sound is heard from the torque converter during a stall test or when in “N” range.
- The torque converter center piece is deformed.
- The extension sleeve is rusty, has a large vertical scratch, or is worn excessively.
- Debris of paper, bearing or foreign materials is found from the automatic transmission fluid (ATF) in the torque converter.

- Check the one-way clutch of the torque converter by using the special tools.

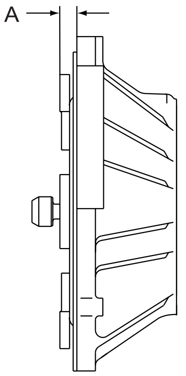
Tool Required: J-35467 One-way Clutch Test Tool

1. Set the pilot nut in the test tool to the wrench. Insert the wrench to stator shaft fitting face of the torque converter.
2. Insert stator stopper through the sleeve in converter and set it to cutaway portion of the sleeve.
3. If both direction of the one-way clutch are free, or turns counterclockwise and locks clockwise, torque converter should be replaced.
   The normal one-way clutch turns clockwise and locks counterclockwise.



Installation Procedure

1. Pour new automatic transmission fluid (ATF) (approximately 2 liters) if a new torque converter is being installed.
2. Install the torque converter to the oil pump.
3. Measure the dimension A from the torque converter housing to the torque converter set block and confirm that the torque converter is inserted to the correct position.
   - Dimension A: 23.0 mm (0.91 in) or less



Repair Instructions (Overhaul)

General Description

1. Before assembling, remove sand or mud etc. adhered to the outside of the transmission to prevent them from coming into the inside when disassembling or assembling.
2. Do not face the oil pan upward to avoid foreign particle coming in until oil pan is removed.
3. When disassembling the attaching the part made of light alloy such as a case, do not pry out with a screwdriver but tap with a plastic.
4. When disassembling or assembling, do it with bare hands or using vinyl grabs. To avoid lint coming in, do not use grabs or shop rug.
5. Ensure those disassembled parts are well organized and free from dust.
6. Before assembling, wash each disassembled part and all the water has evaporated, apply DEXRON®-III. Do not clean the aluminum or rubber part with alkaline agent. Never clean the rubber part of O-ring, gasket and oil seal, and clutch disc and brake disc with white gasoline.
7. Submerge the clutch disc and brake disc into DEXRON®-III before assembling. Especially a new disc should be submerged in for more than 15 minutes to pervade the oil into the lining.
8. Apply DEXRON®-III to the sliding and rotating surfaces and O-ring or oil seal ring, assemble them being carefully not to damage them.
9. Replace the damaged or deformed snap ring with a new one.
10. When placing a part in a vise,do not place it in a vise directly but use an aluminum mounting plate.
11. Take a caution not to damage the contact surface of case, otherwise it causes fluid leakage. If damaged, replace the case with a new one.
12. Before applying sealant, clean off the adhered sealant on the sealing part, clean the sealing part with white gasoline.
13. Right after applying sealant, do not pour the fluid or drive the vehicle. Leave it for more than 2 hours.
14. Pay due attention when assembling those similar parts such as O-ring, snap ring, bearing and bearing race and not to lose a part.
15. When assembling oil seal ring, do not spread the ring ends as thick as more than necessary.
16. When assembling the thrust bearing, race and thrust washer, to prevent dropping off, a little amount of petroleum jelly in over haul gasket kit should be applied. Unless there is petroleum jelly, a little amount of Vaseline can be used.
17. Use fluid is DEXRON®-III.
18. Non - reusable parts:
    Always replace cotter pin, gaskets, O-rings and oil seals etc. with new ones.
19. Precoated parts are bolts and nuts, etc. that are coated with a sealant at the factory.
    a. If a precoated parts is retightened, loosened or caused to move in any way, it must be recoated with the specified adhesive.
    b. When reusing precoated parts, clean off the old adhesive and dry with compressed air. Then apply the specified adhesive to the bolt, nut or threads.
20. When necessary, use a sealer on gaskets to prevent leaks.
21. Carefully observe all specifications for bolt tightening torques. Always use a torque wrench.
22. Use of special tools and sealants may be required, depending on the nature of the repair. Be sure to use special tools and sealant where specified and follow the proper work procedure. A list of special tools and sealant can be found at the preparation of automatic transmission section.

Transmission Wiring

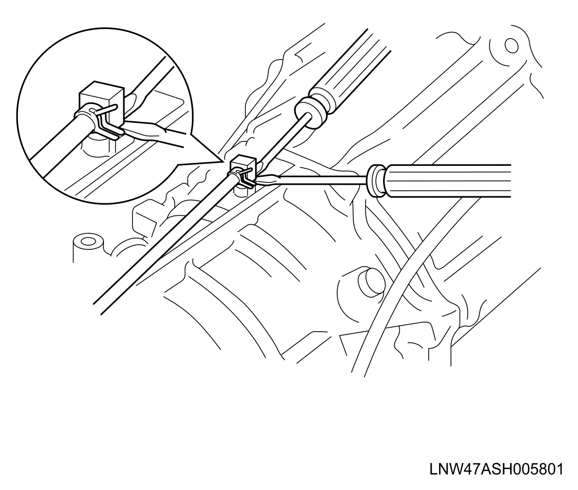
Removal Procedure

Disconnect the connectors, and remove the transmission wiring.

Breather Plug and Hose

Removal Procedure

1. Using 2 screwdrivers, pry out the breather plug and hose.

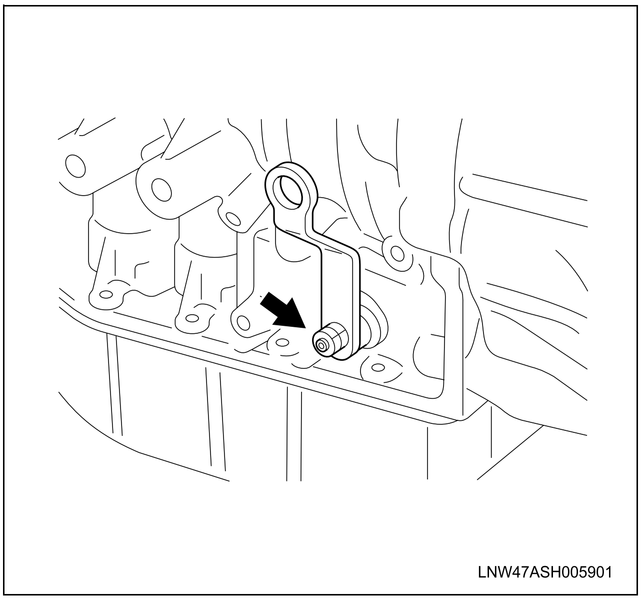


2. Remove the O-ring from the breather plug.

Control Shaft Lever

Removal Procedure

Remove the 2 nuts and the lever.

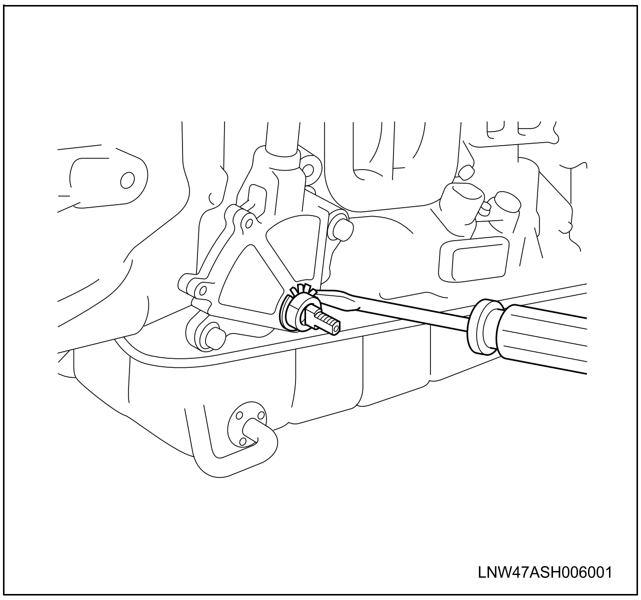


LNW47ASH005901

Inhibitor Switch

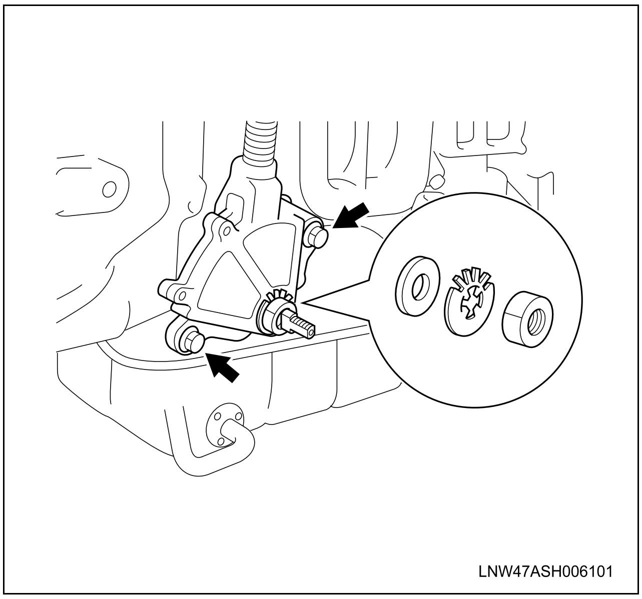
Removal Procedure

1. Unstake the lock washer.



LNW47ASH006001

2. Remove the nut, lock washer and grommet.
3. Remove the 2 bolts and inhibitor switch.

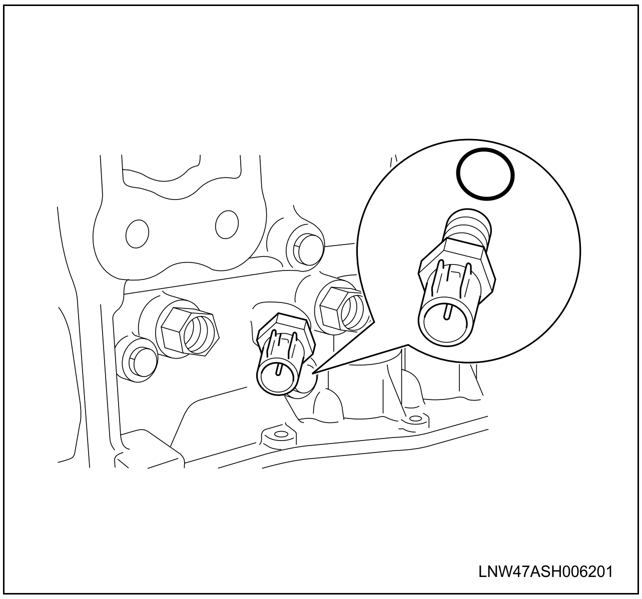


LNW47ASH006101

Automatic Transmission Fluid (ATF) Temperature Switch

Removal Procedure

1. Remove the switch.
2. Remove the O-ring from the switch.

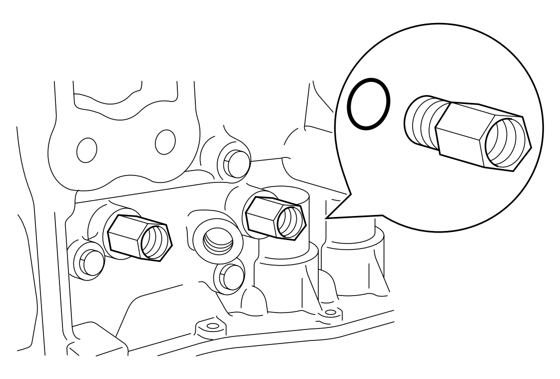


LNW47ASH006201

Oil Cooler Unions

Removal Procedure

1. Remove the 2 unions.
2. Remove the O-ring from both the unions.

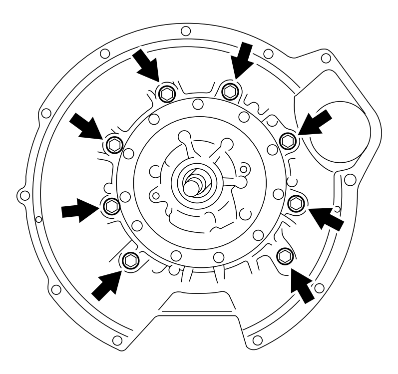


LNW47ASH006301

Torque Converter Housing

Removal Procedure

Remove the 8 bolts and torque converter housing.

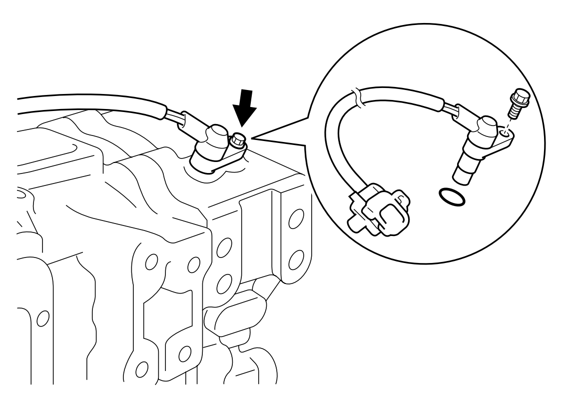


LNW47ASH006401

Vehicle Speed Sensor SP2

Removal Procedure

1. Remove the bolt and the sensor.
2. Remove the O-ring from sensor.

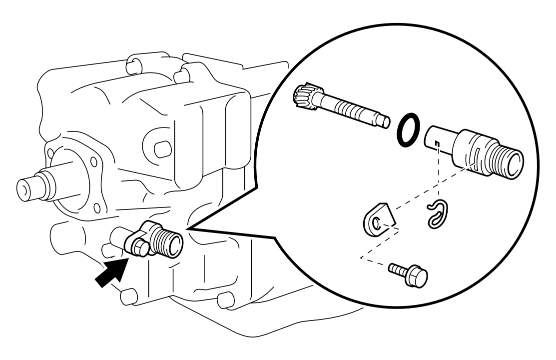


LNW47ASH006501

Speedometer Driven Gear Assembly

Removal Procedure

1. Remove the lock bolt and plate.
2. Remove speedometer driven gear assembly.
3. Remove the O-ring from the driven gear assembly.

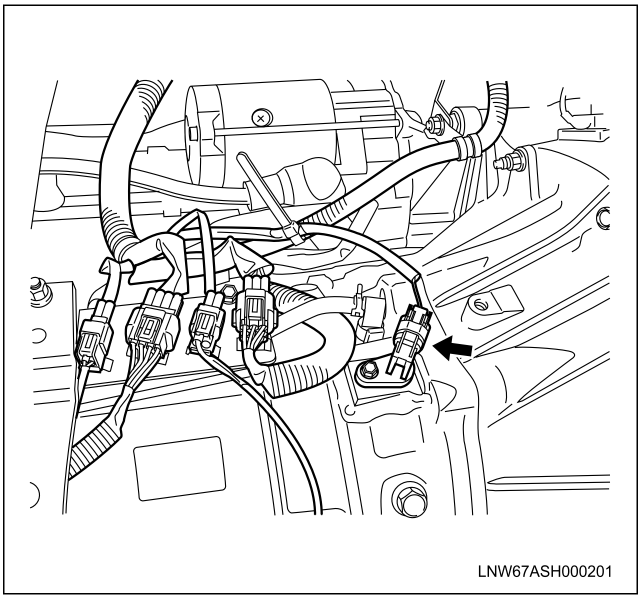


LNW47ASH006601

Input Shaft Speed Sensor (C0) [12,000 lbs GVW]

Removal Procedure

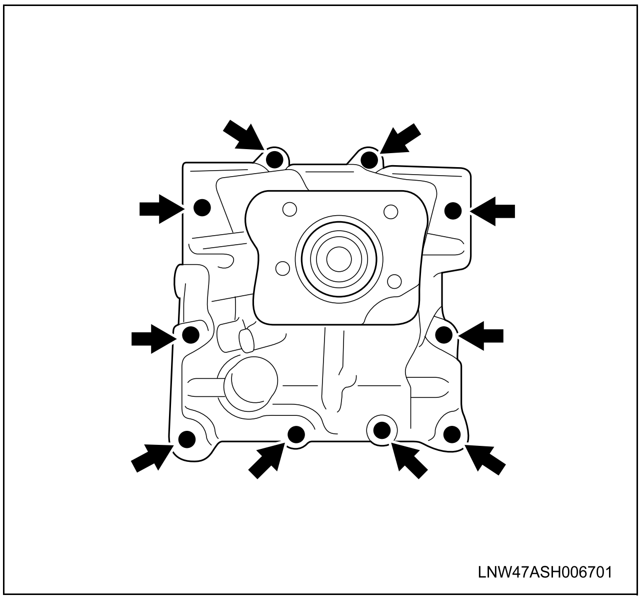
1. Remove the bolt and sensor.
2. Remove the O-ring from sensor.


LNW67ASH000201

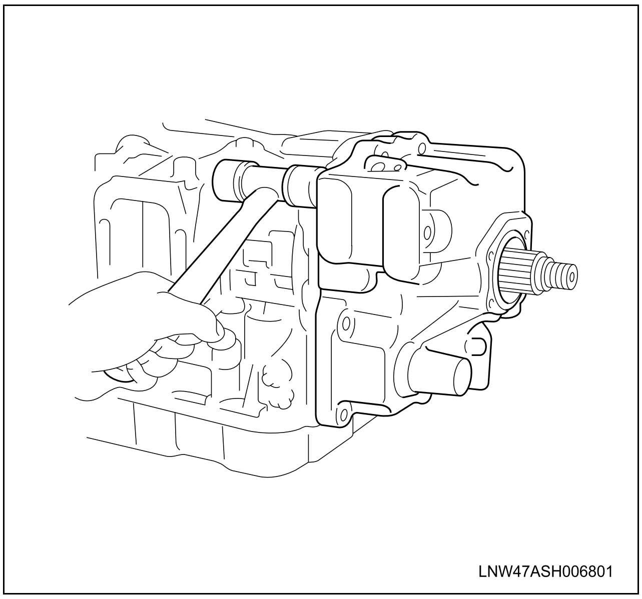
Extension Housing

Removal Procedure

1. Remove the 10 bolts.


LNW47ASH006701

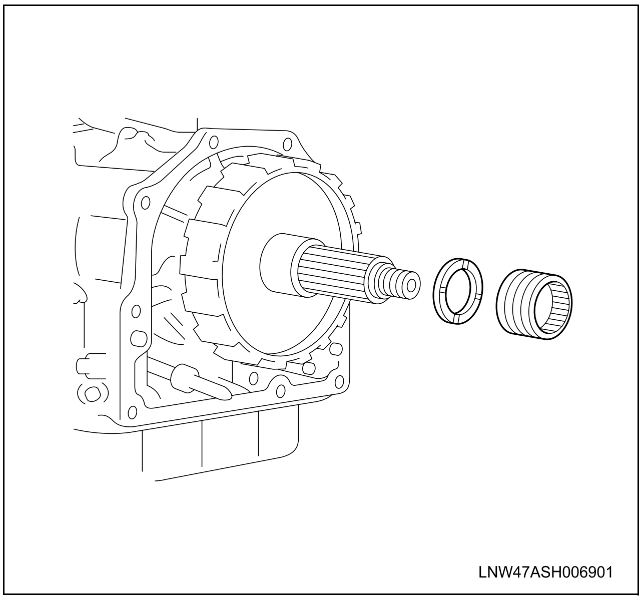
2. Using a plastic hammer, remove the extension housing and gasket.


LNW47ASH006801

Speedometer Drive Gear and Spacer

Removal Procedure

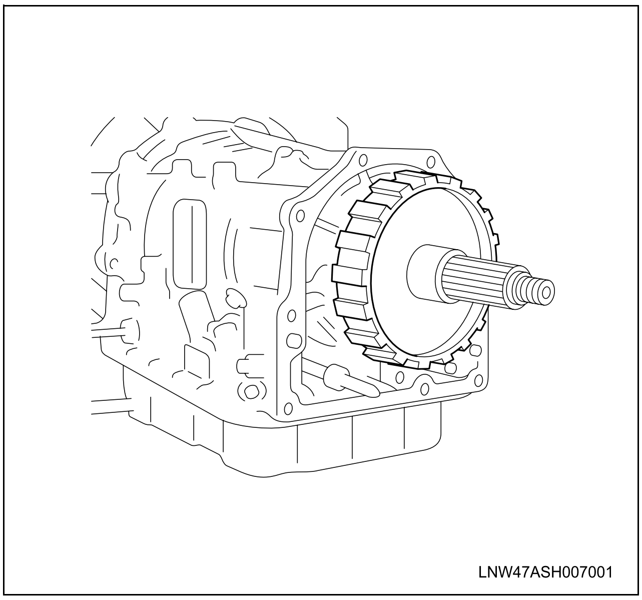
Remove the spacer and speedometer drive gear from the output shaft.


LNW47ASH006901

Parking Lock Gear

Removal Procedure

Remove the parking lock gear from the output shaft.



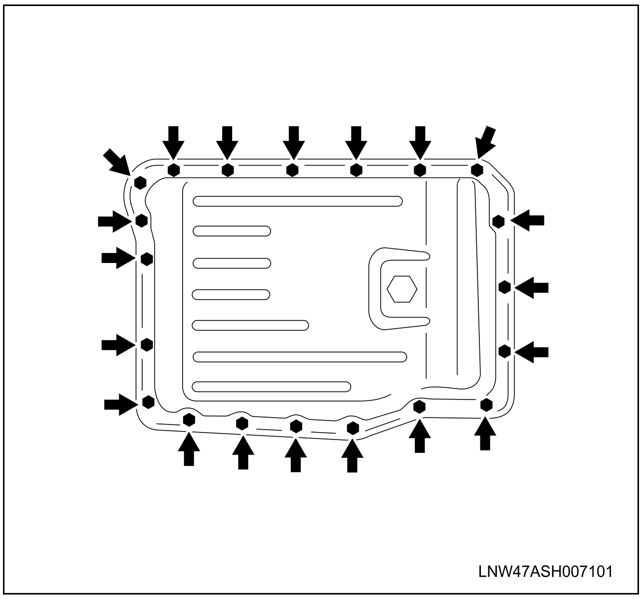
LNW47ASH007001

Oil Pan

Removal Procedure

Notice:
Do not turn the transmission over as this will contaminate the valve body with any foreign matter at the bottom of the pan.

1. Remove the 20 bolts.



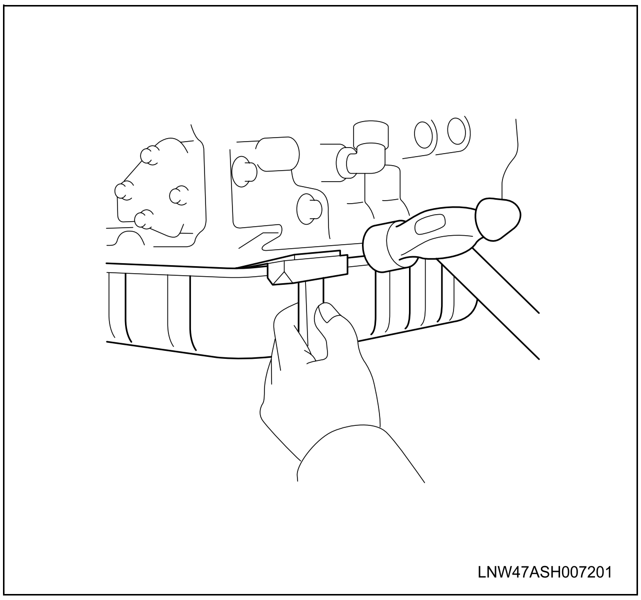
LNW47ASH007101

2. Insert the blade of oil pan seal cutter between the transmission and oil pan, cut off applied sealer.

Tool Required: J-37228 Oil Pan Seal Cutter

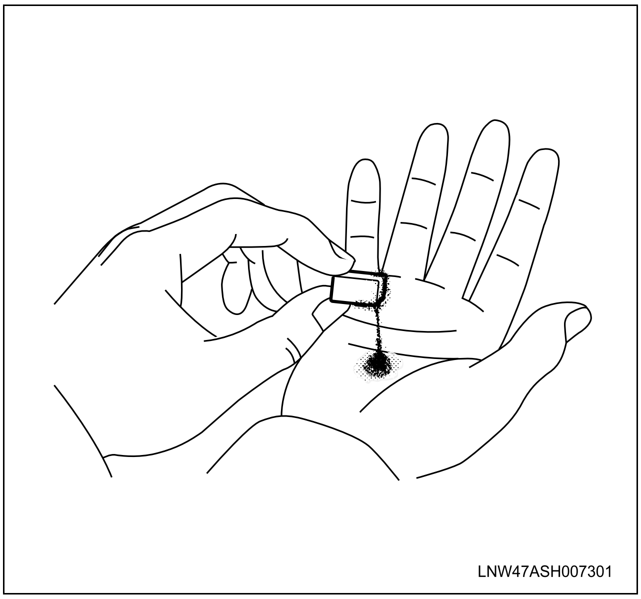
Notice:

- Be careful not to damage the oil pan flange.
- Install several mounting bolts by tightening 2 to 3 pitches.
- Do not tilt the oil pan as all the oil in the pan has not been drained.



LNW47ASH007201

3. Examine particles in pan.
   Remove the magnets and use them to collect any steel particles.
   Carefully look at the foreign matter and particles in the pan and on the magnets to anticipate the type of wear you will find in the transmission:
   - Steel (magnetic): Bearing, gear, and clutch
   - Brass (non-magnetic): Bushing wear

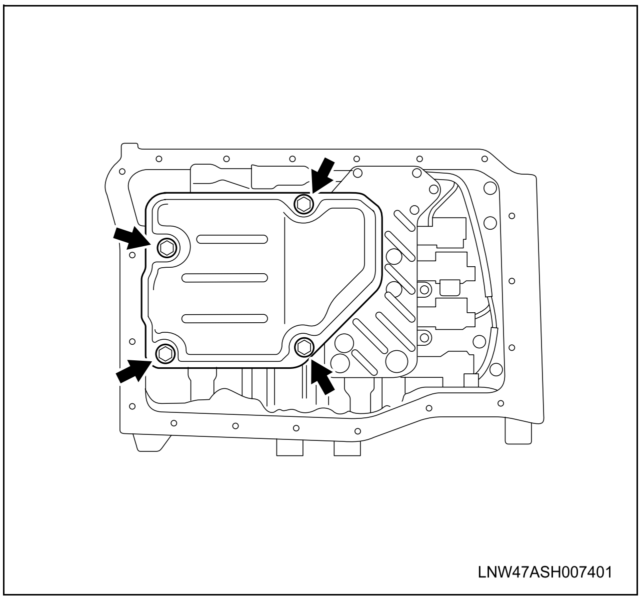


LNW47ASH007301

Oil Strainer

Removal Procedure

Remove the 4 bolts and oil strainer.

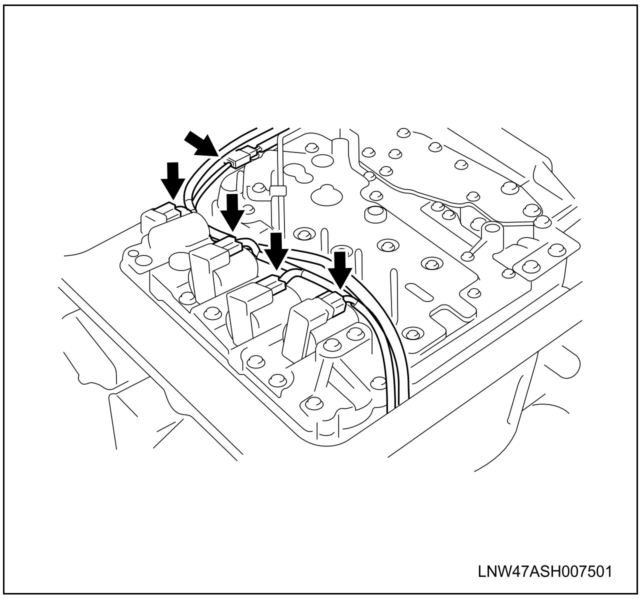


LNW47ASH007401

Solenoid Valve Connectors

Disconnect Procedure

1. Disconnect the 4 connectors from the solenoids.
2. Disconnect the connector from the automatic transmission fluid (ATF) temperature sensor.
3. Disconnect the connector from the line pressure solenoid valve.

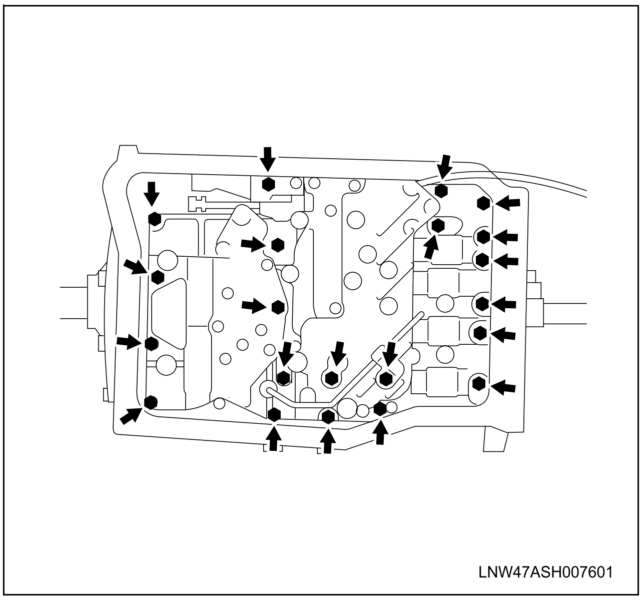


LNW47ASH007501

Valve Body

Removal Procedure

Remove the 21 bolts.



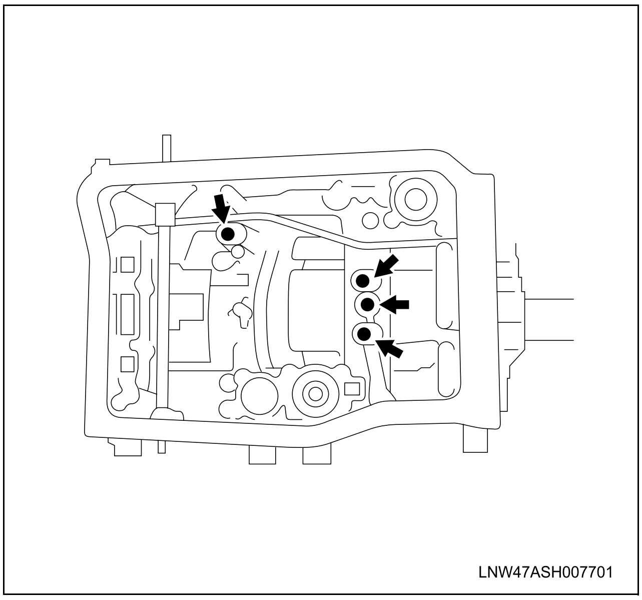
LNW47ASH007601

Center Support Apply Gaskets

Removal Procedure

Remove the 4 apply gaskets.

Notice:
Check the installation direction of apply gaskets.

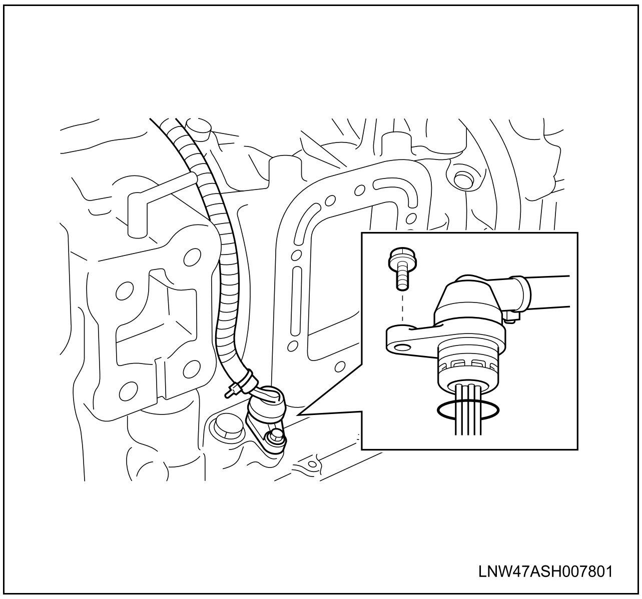


LNW47ASH007701

Solenoid Valve Wiring

Removal Procedure

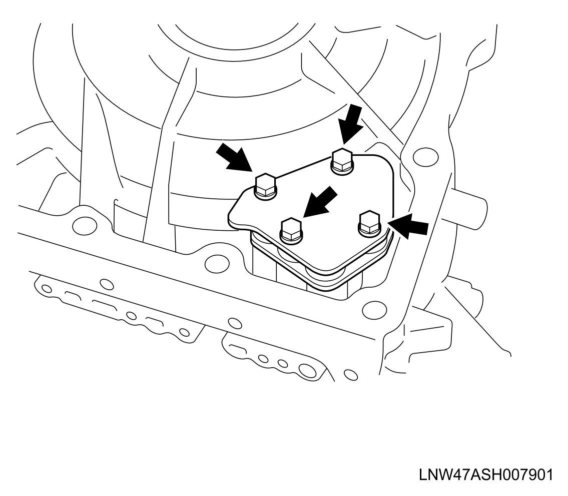
1. Remove the bolt and the solenoid valve wiring.
2. Remove the O-ring from it.


LNW47ASH007801

C_1 Accumulator Piston and Spring

Removal Procedure

1. Remove the 4 bolts, front clutch accumulator cover, 2 gaskets and plate.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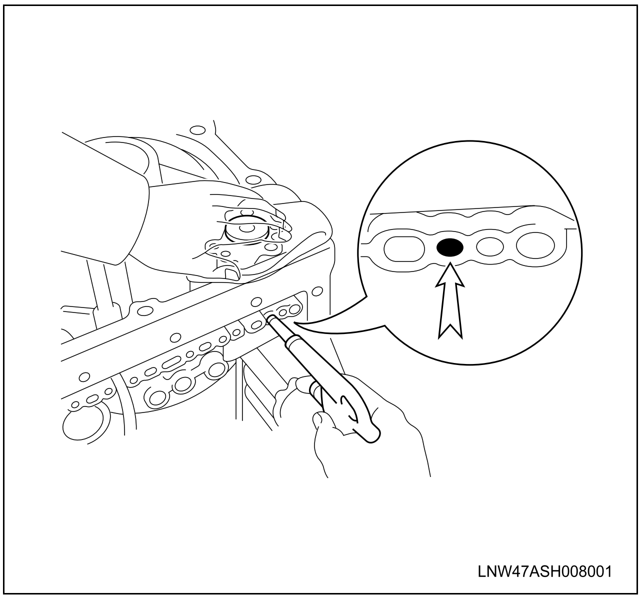
2. Remove the accumulator piston and spring by applying compressed air 392–785 kPa (4–8 kg/ cm^2, 57–114 psi) to the oil hole.

Notice:
Cover the area around the piston with a shop rag as the piston and oil gush out.

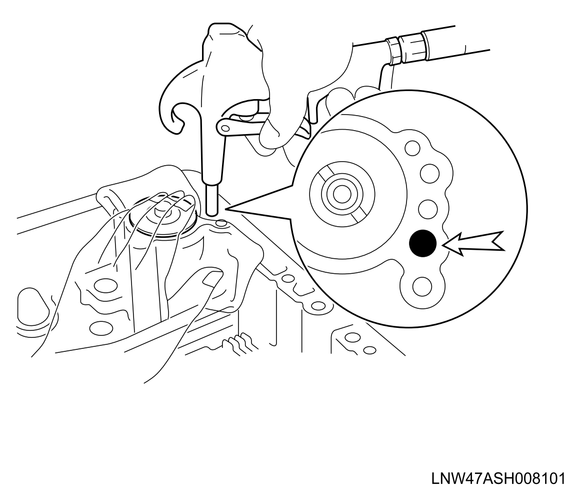

LNW47ASH008001

C_2 B_0 B_1 Accumulator Pistons And Springs

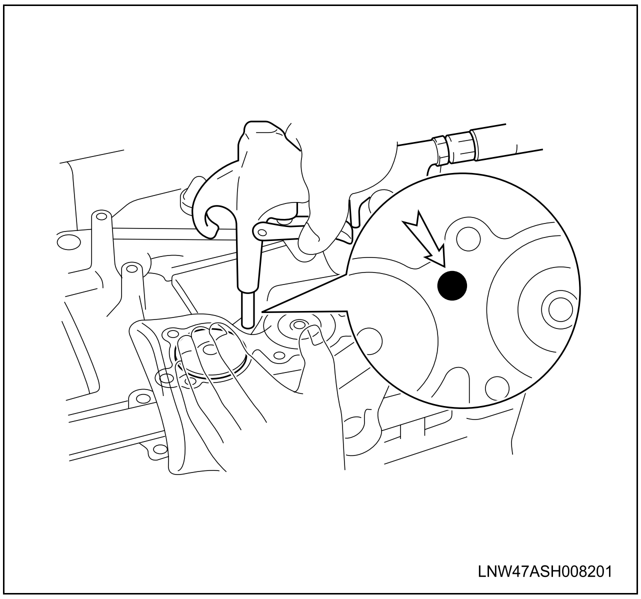
Removal Procedure

1. Remove the C_2 accumulator piston and spring by applying compressed air 392–785 kPa (4–8 kg/ cm^2, 57–114 psi) to the oil hole.

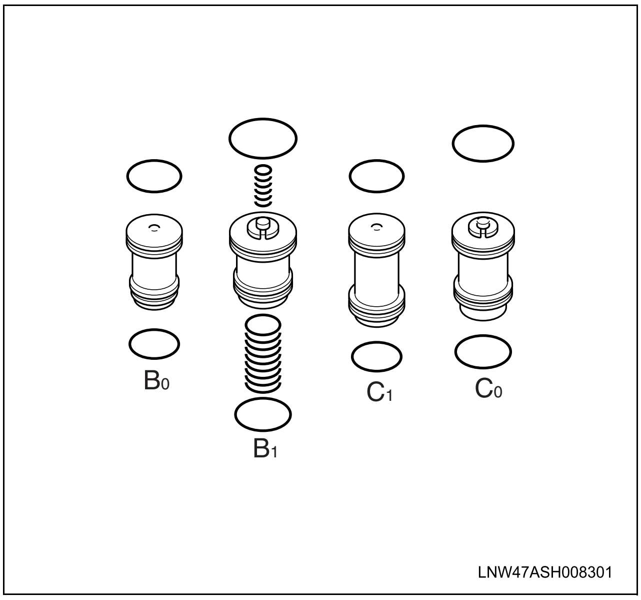
Notice:
Cover the area around the piston with a shop rag as the piston and oil gush out.


LNW47ASH008101

2. Remove the B_0 accumulator piston together with the B_1 accumulator piston by applying compressed air to the oil hole.



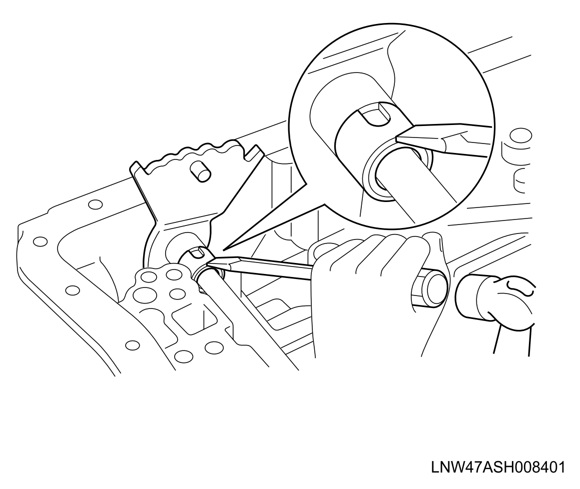
3. Remove the B_0 and B1 accumulator pistons.
4. Remove the O-ring from the accumulator pistons.



Manual Valve Lever, Shaft and Oil Seals

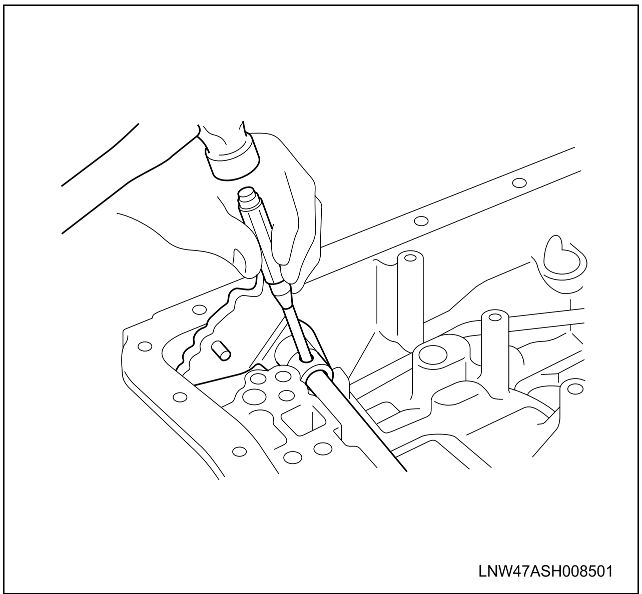
Removal Procedure

1. Using a screwdriver or chisel, cut off the spacer and remove it from the shaft.



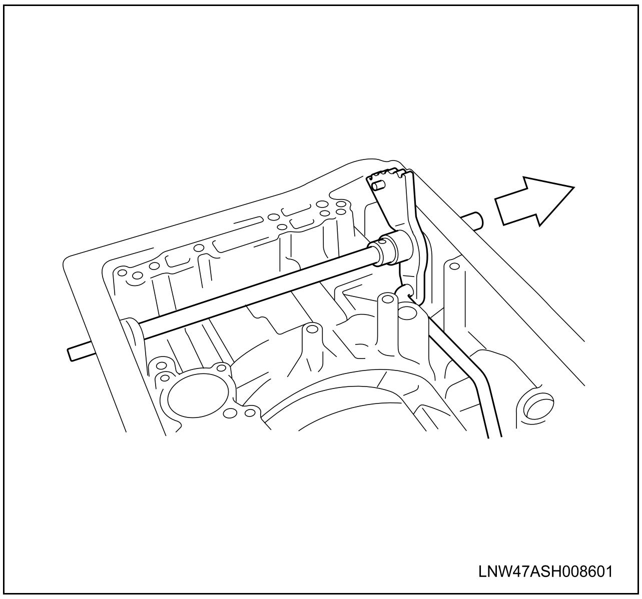
2. Using a pin punch, tap out the pin.

Notice:
Do not drop the pin into the transmission case.

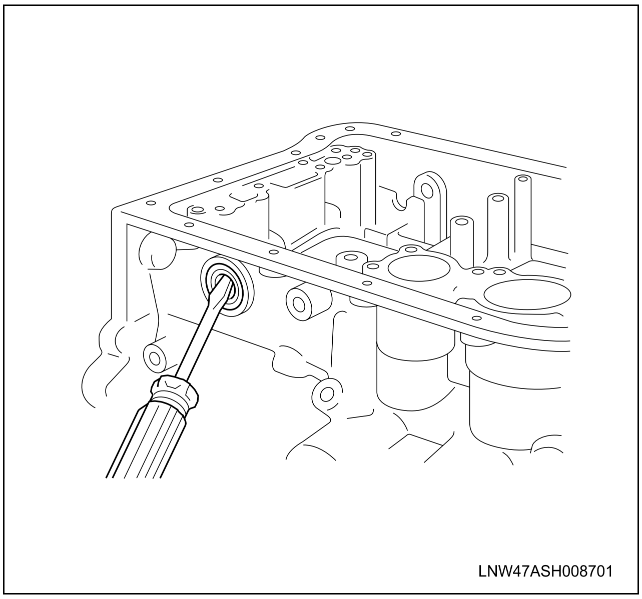


3. Pull the manual valve lever shaft out through the case, remove the manual valve lever, parking lock rod assembly, the 2 plate washers and wave washer.

4. Disconnect the parking lock rod from the manual valve lever.



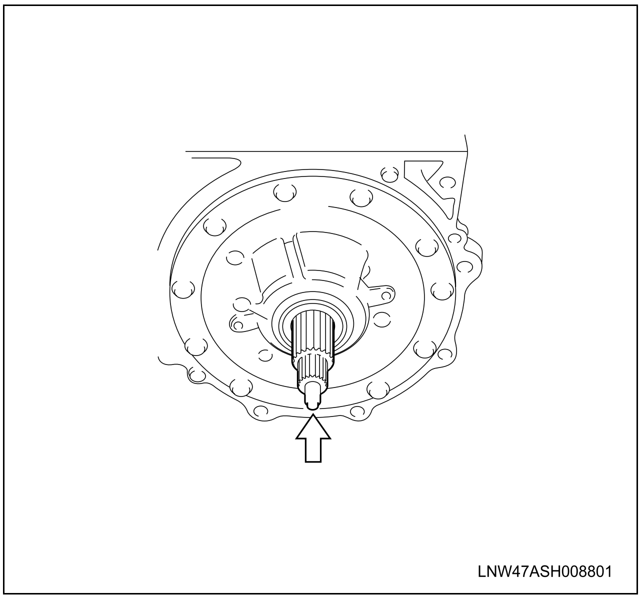
5. Using a screwdriver, pry out the 2 oil seals.



Thrust Clearance of Overdrive (OD) Input Shaft (Overdrive Planetary Gear)

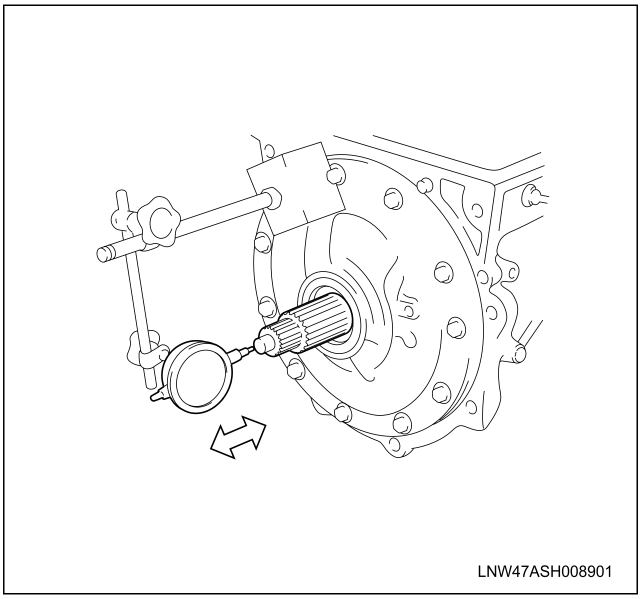
Inspection Procedure

1. Push the OD input shaft toward the rear of the transmission by applying a force of 49–98 N (11.0–22.0 lb).



2. Using dial indicator, measure the thrust clearance of the input shaft.

Standard thrust clearance:	0.40–0.90 mm (0.0157–0.0354 in.)
Maximum thrust clearance:	0.90 mm (0.0354 in.)

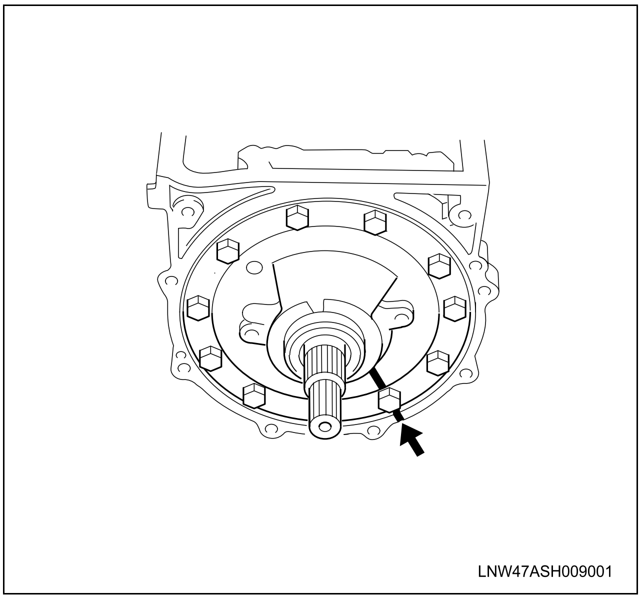


Oil Pump

Removal Procedure

1. Place matchmarks on the oil pump and transmission case.

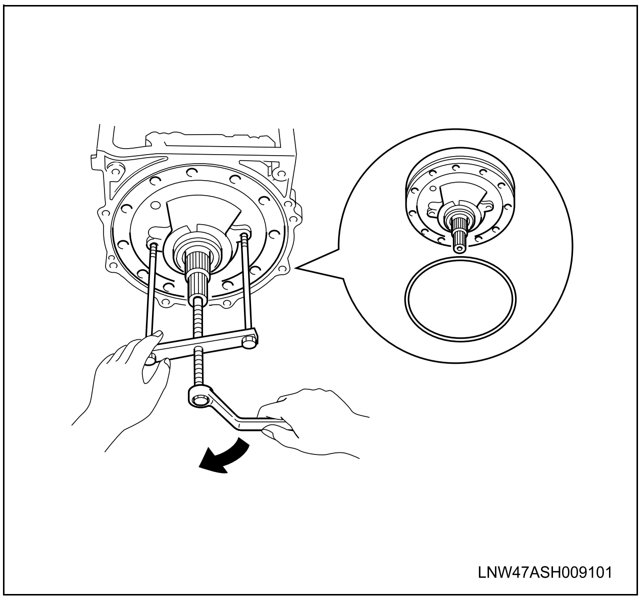
2. Remove the 11 bolts holding the oil pump to the transmission case.



3. Using oil pump remover, remove the oil pump and gasket.

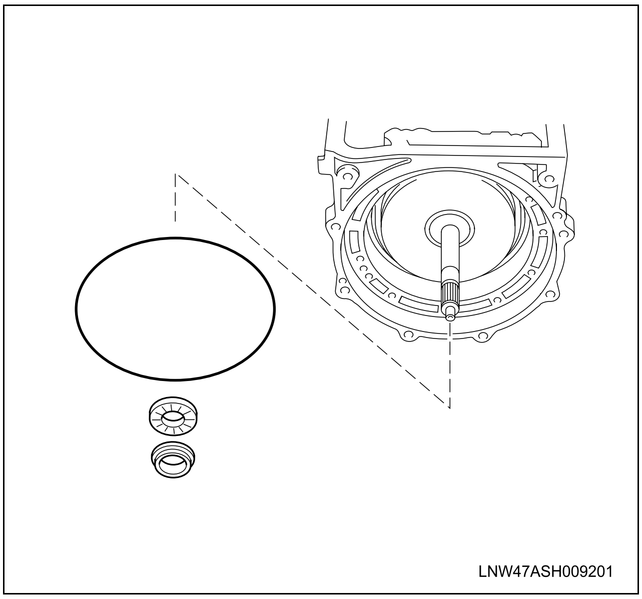
Tool Required: J-44170 Oil Pump Remover

4. Remove the O-ring from the oil pump.



5. Remove the race and thrust bearing from the OD direct clutch drum or oil pump.

6. Remove the O-ring from the transmission case.



Overdrive (OD) Planetary Gear, Overdrive Direct Clutch and One-Way Clutch Assembly

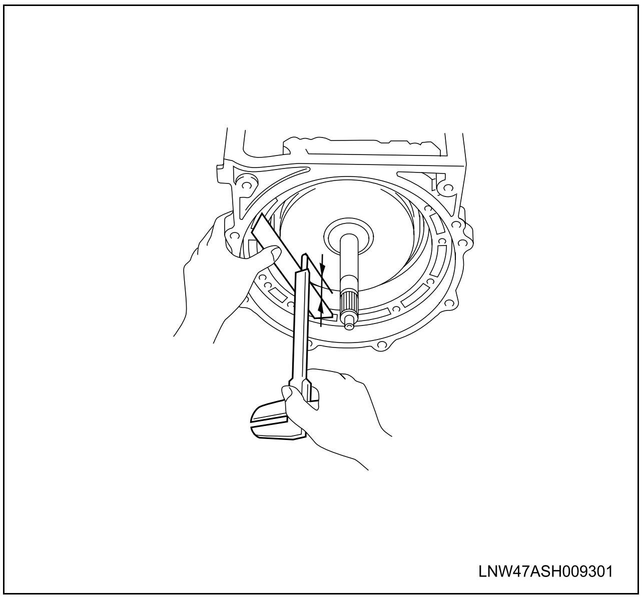
Removal Procedure

1. Place plate on the installation surface of the oil pump.

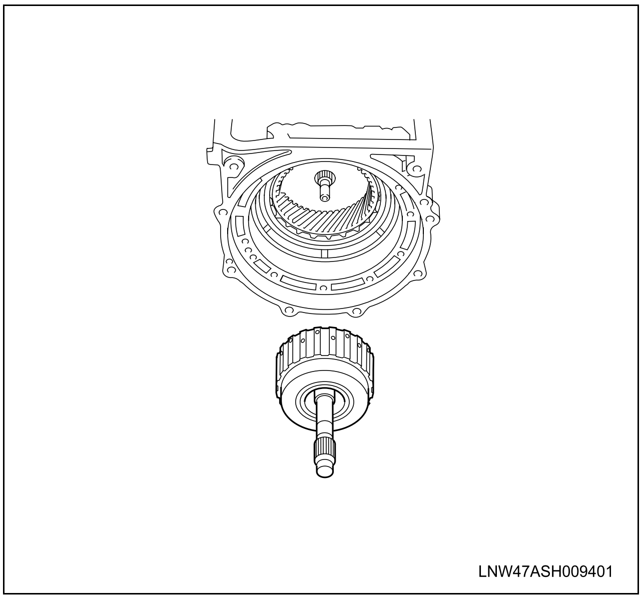
Tool Required: J-44166 Plate

2. Using calipers, measure the distance between the tops of plate and the clutch drum for assembly.

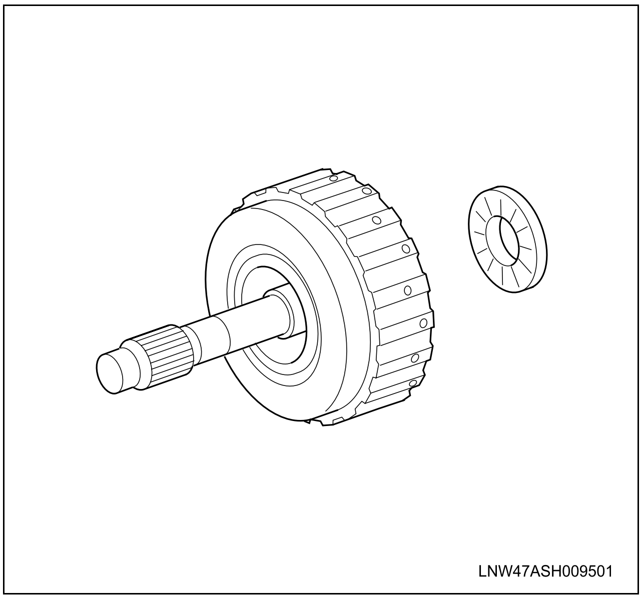
Notice:
Record the measured distance to keep it as a reference when assembling.



3. Remove the OD planetary gear, direct clutch and one-way clutch assembly.



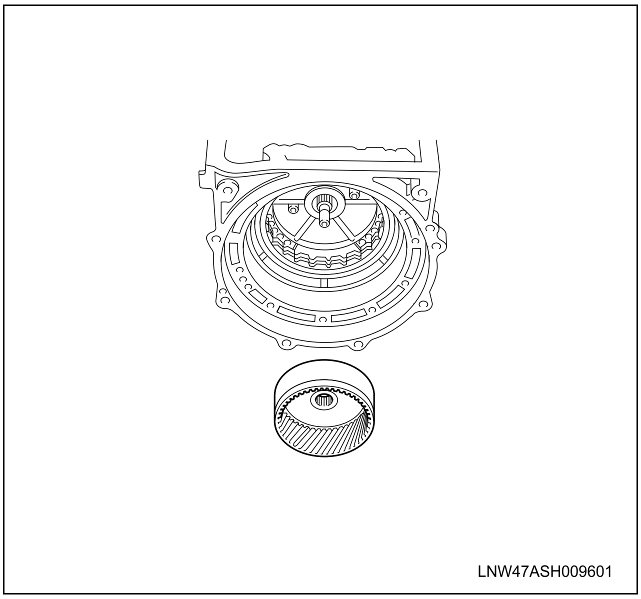
4. Remove the thrust bearing from the OD planetary gear.



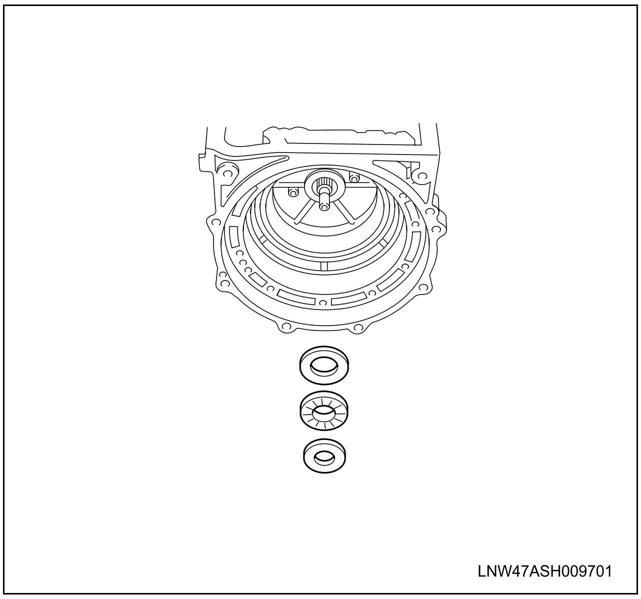
Overdrive (OD) Planetary Ring Gear Assembly

Removal Procedure

1. Remove the ring gear assembly from the OD case.



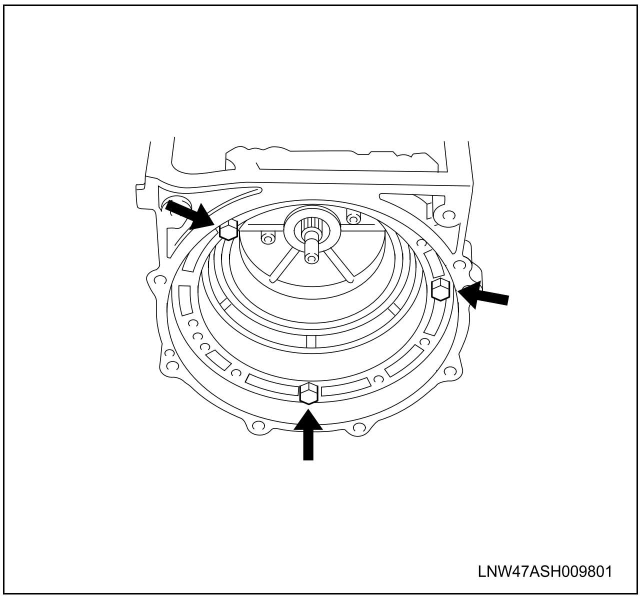
2. Remove the thrust bearing and the 2 races from the OD case.



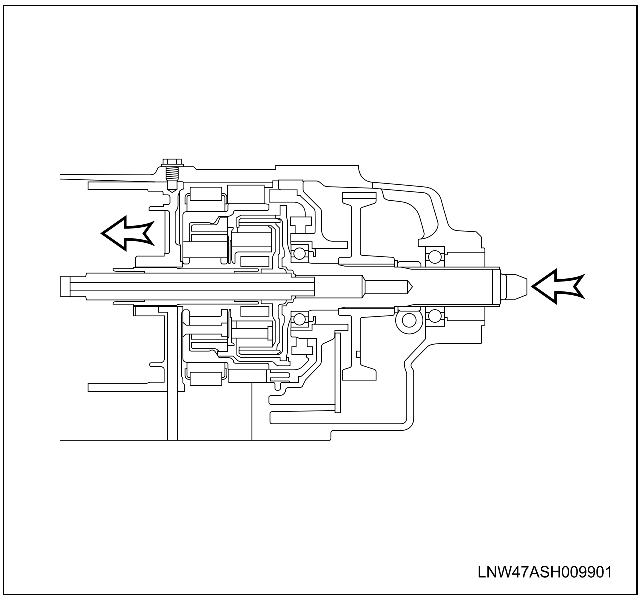
Thrust Clearance of Input Shaft (Front Clutch Drum)

Inspection Procedure

1. Temporarily install the 3 bolts.



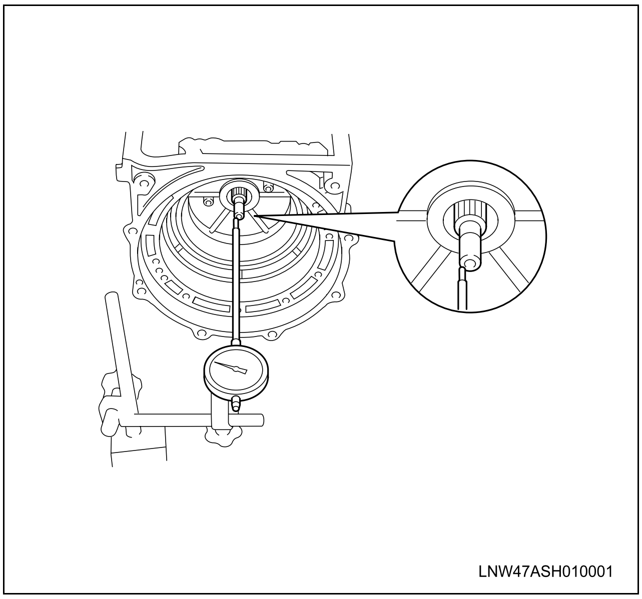
2. Push the transmission output shaft toward the front of the transmission by applying a force of 49–98 N (11.0–22.0 lb).
3. Push the OD case toward the rear of the transmission by applying a force of 49–98 N (11.0–22.0 lb).



4. Using the extension bar and dial indicator, measure the thrust clearance of the input shaft.

Tool Required: J-44169 Extension Bar

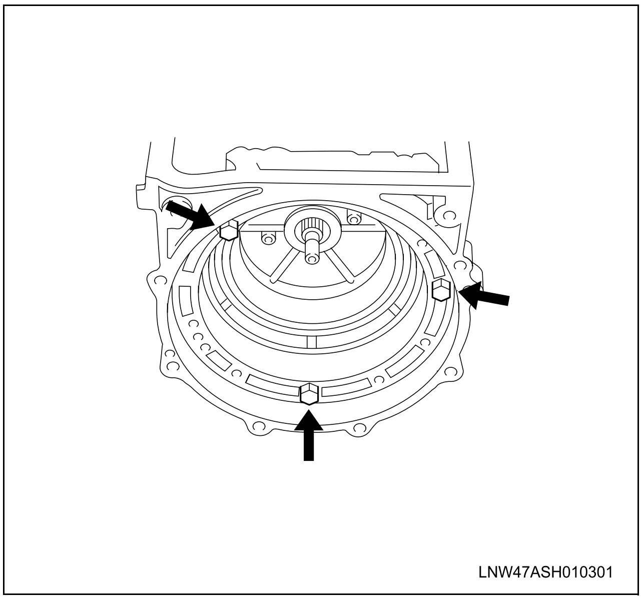
Standard thrust clearance:	0.30–0.70 mm (0.0118–0.0276 in.)
Maximum thrust clearance:	0.70 mm (0.0276 in.)



Overdrive (OD) Case Assembly

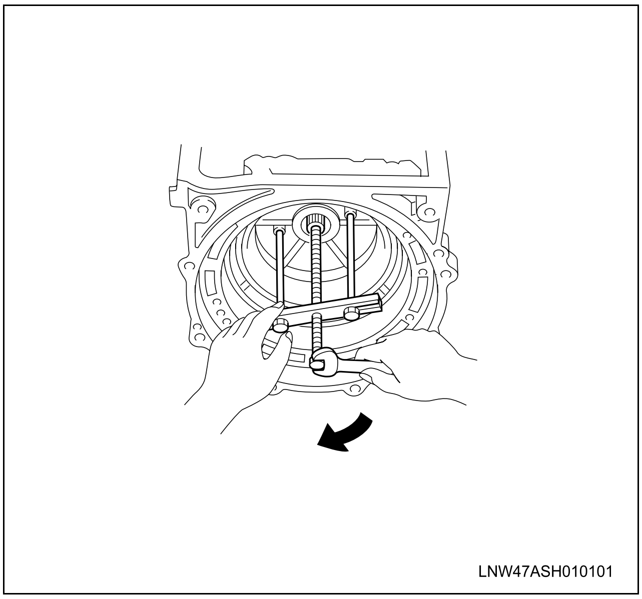
Removal Procedure

1. Remove 3 bolts.

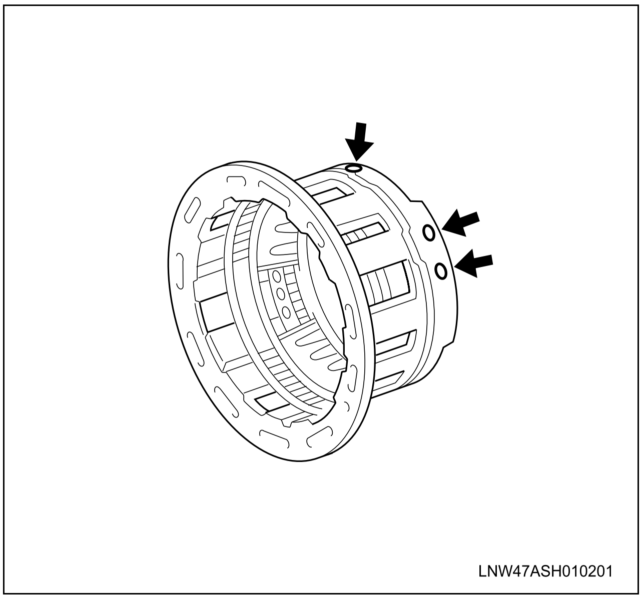


2. Using the oil pump remover, remove the OD case assembly.

Tool Required: J-44170 Oil Pump Remover



3. Remove the 3 O-rings from the oil holes of the OD case.



Front Clutch Assembly

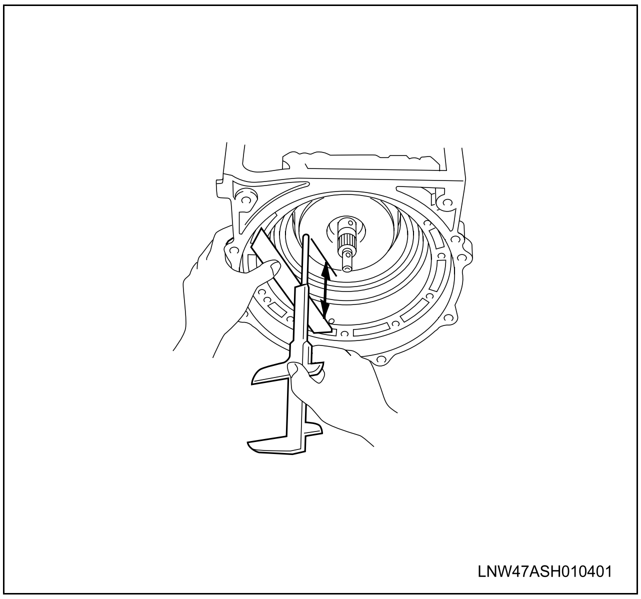
Removal Procedure

1. Place the plate, on the installation surface of the oil pump.

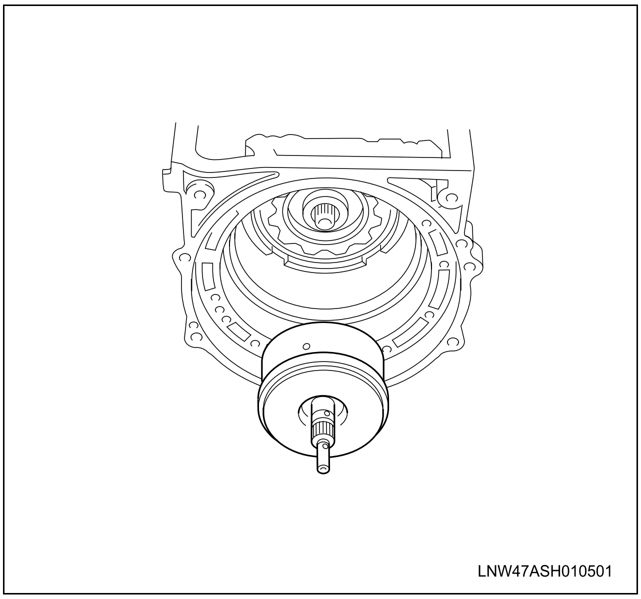
Tool Required: J-44166 Plate

2. Using calipers, measure the distance between the tops of the plate and the clutch drum for assembly.

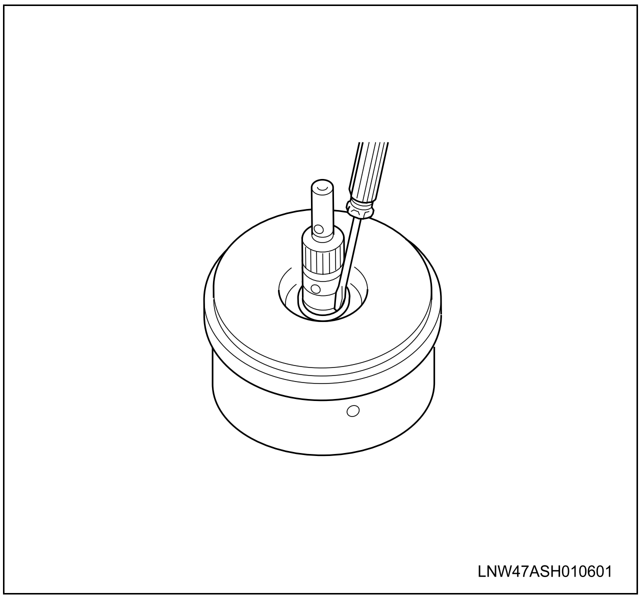
Notice:
Record the measured distance to keep it as a reference when assembling.



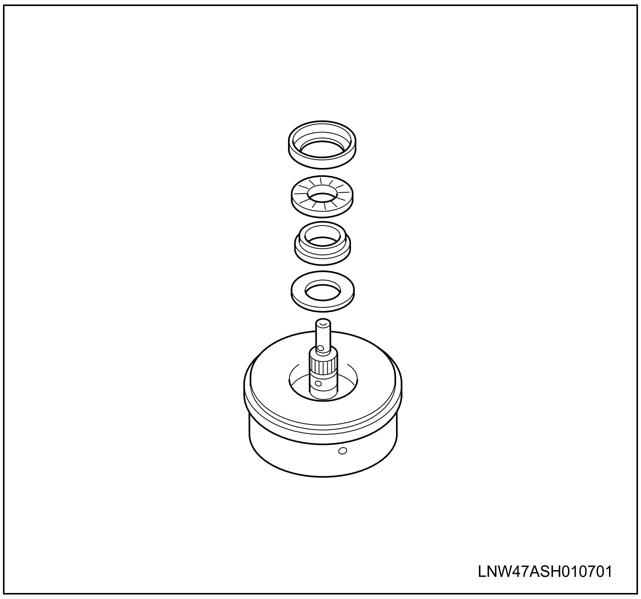
3. Remove the front clutch assembly.



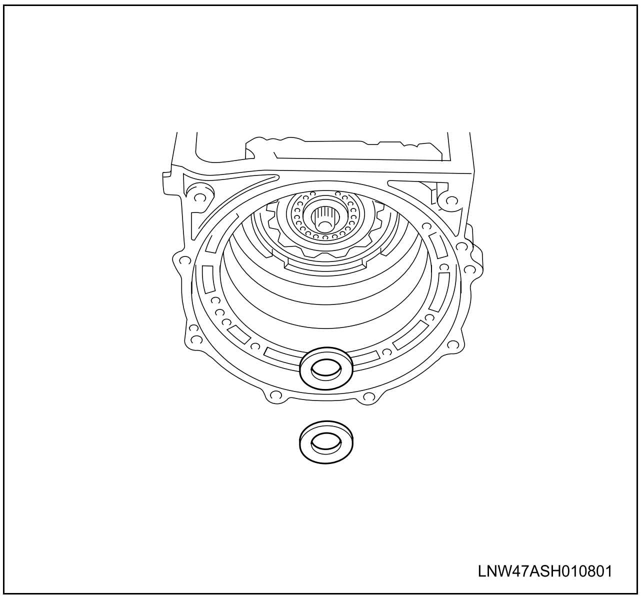
4. Using a screwdriver, remove the oil seal ring from the input shaft.



5. Remove the 2 races, thrust bearing and spacer from the front clutch drum.



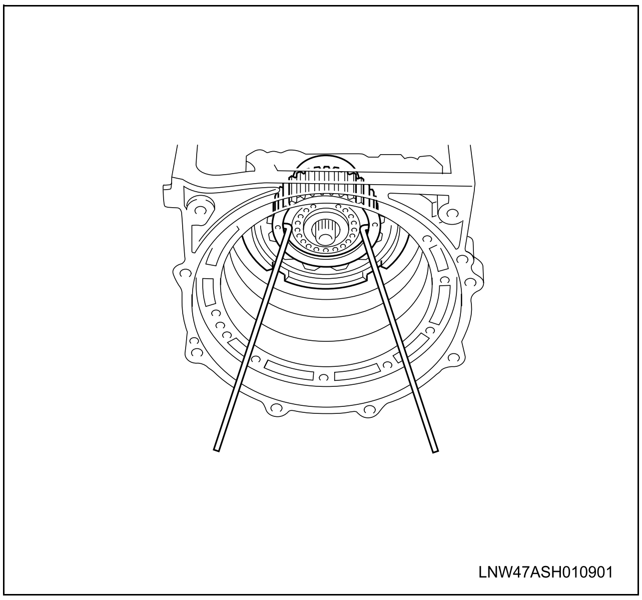
6. Remove the thrust bearing and race from the rear clutch drum.



Rear Clutch Assembly

Removal Procedure

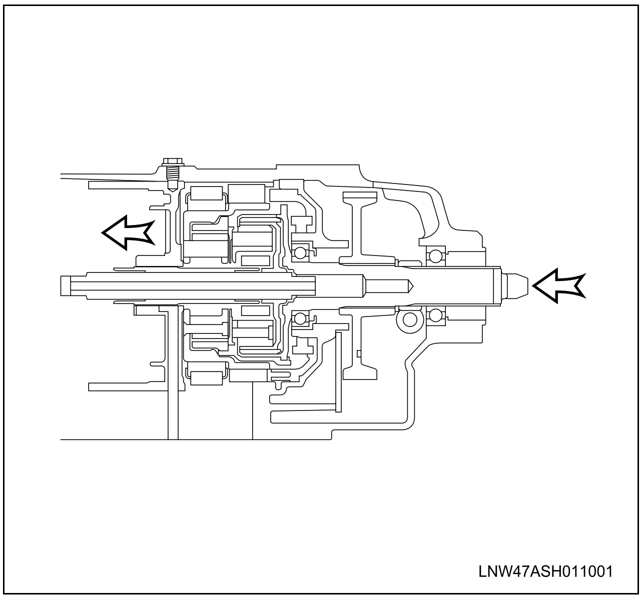
Install 2 wires into flukes of the clutch discs, and remove the rear clutch assembly.



Center Support Assembly

Removal Procedure

1. Push the transmission output shaft toward the front of the transmission by applying a force of 49–98 N (11.0–22.0 lb).
2. Push the center support toward the rear of the transmission by applying a force of 49-98 N (11.0–22.0 lb), then pull with the same amount of force.

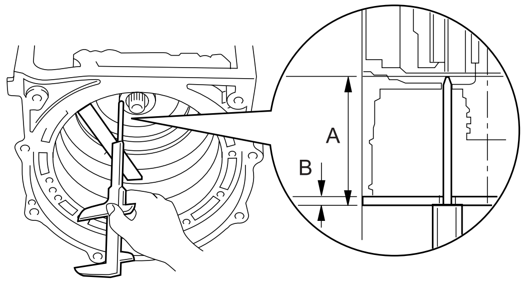


3. Place the plate on the center support.

Tool Required: J-44166 Plate

4. Using calipers, measure distance (A) between the tops of the plate and the thrust washer on the front planetary gear.

5. Using calipers, measure the thickness (B) of the plate.



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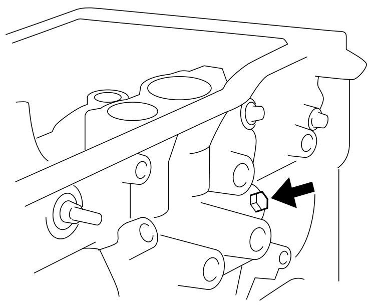
6. Remove the 3 center support set bolts.



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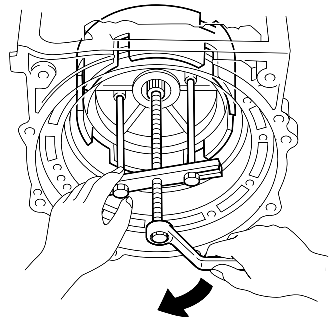
7. Using the oil pump remover, remove the center support assembly.

Tool Required: J-44170 Oil Pump Remover



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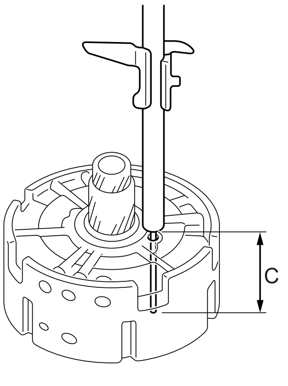
8. Turn over the center support together with the thrust washer, and place it on a flat surface.
9. Inserting the calipers into the thrust washer hole, measure the distance (C) between it and the flat surface.

Center support thrust clearance: A –(B + C)
(0.0118–0.0276 in.)

Standard thrust clearance: 0.30–0.70 mm
Maximum thrust clearance: 0.90 mm (0.0354 in.)



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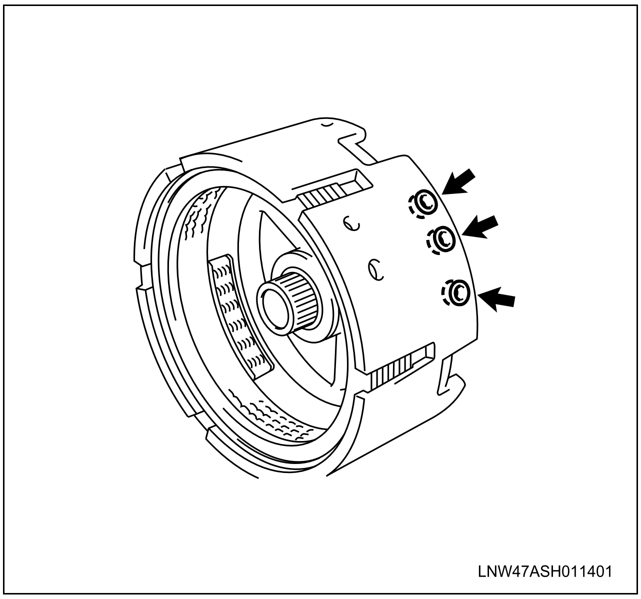
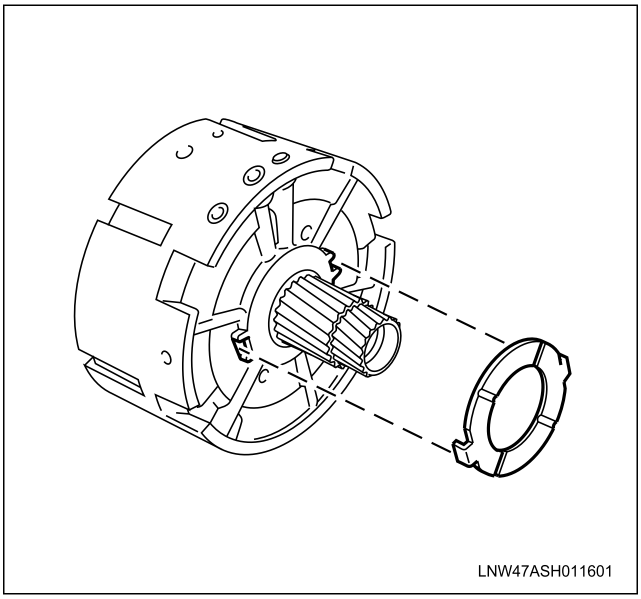
10. Remove the 3 O-rings from the center support.



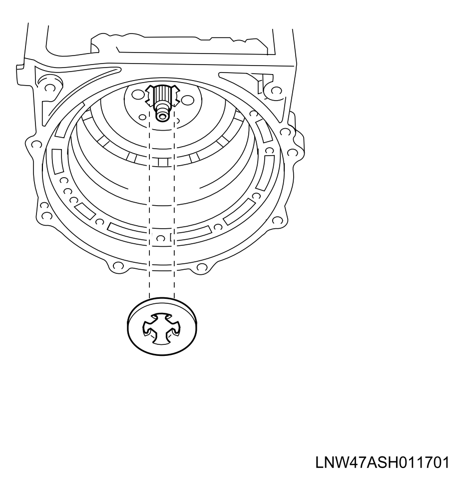
11. Remove the thrust washer from the center support.



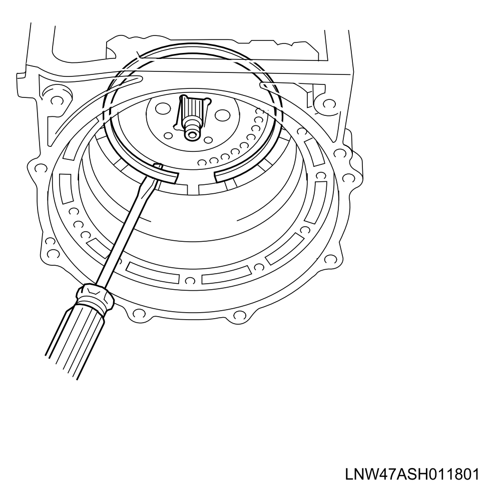
Planetary Gears, One-Way Clutch and Output Shaft Assembly

Removal Procedure

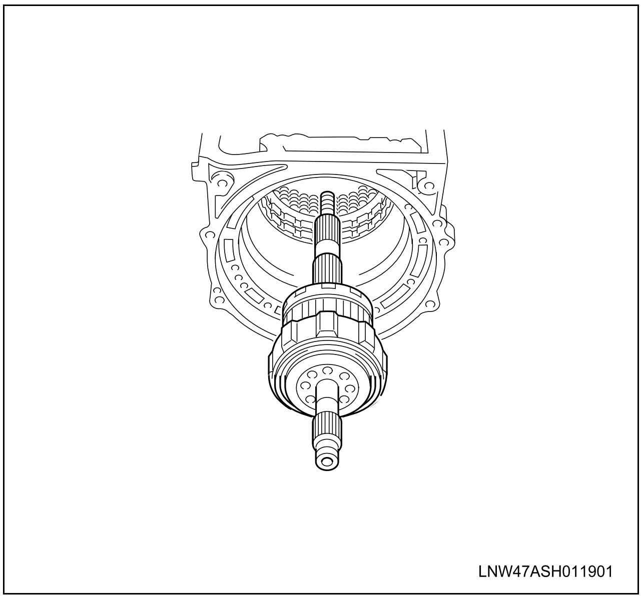
1. Remove the thrust washer from the planetary gear.



2. Using a screwdriver, remove the snap ring.



3. Remove the planetary gears, one-way clutch and output shaft assembly.



General Notes

The instructions here are organized so that you work on only one component group at a time.

This will help avoid confusion from similar-looking parts of different subassemblies being on your workbench at the same time.

The component groups are inspected and repaired from the converter housing side.

As much as possible, complete the inspection, repair and assembly before proceeding to the next component group. If a component group can not be assembled because parts are being ordered, be sure to keep all parts of that group in a separate container while proceeding with disassembly, inspection, repair and assembly of other component groups.

Recommended fluid of the automatic transmission is DEXRON®-III.

General Cleaning Notes:

1. All disassembled parts should be washed clean and any fluid passages and holes blown through with compressed air.
2. When using compressed air to dry parts, always aim away from yourself to prevent accidentally spraying automatic transmission fluid (ATF) or kerosene on your face.
3. The recommended ATF or kerosene should be used for cleaning.

Parts Arrangement:

1. After cleaning, the parts should be arranged in proper order to allow performing inspection, repairs, and reassembly with efficiency.
2. When disassembling a valve body, be sure to keep each valve together with the corresponding spring.
3. New disc for the brakes and clutches that are to be used for replacement must be soaked in ATF for at least 15 minutes before assembly.

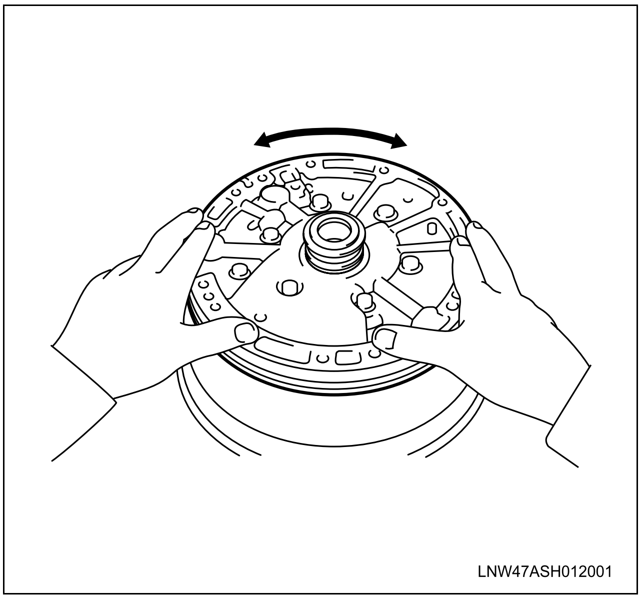
General Assembly:

1. All oil seal rings, clutch discs, clutch plates, rotating parts, and sliding surfaces should be coated with ATF prior to reassembly.
2. All gaskets and rubber O-rings should be replaced.
3. Make sure that the ends of a snap ring are not aligned with one of the cutouts and are installed in the groove correctly.
4. If a worn bushing is to be replaced, the subassembly containing that bushing must also be replaced.
5. Check thrust bearings and races for wear or damage. Replace if necessary.
6. Use petroleum jelly to keep parts in place.

Oil Pump Assembly

Disassembly

1. Use torque converter as work stand.
   Make sure the drive gear rotates smoothly when installed to the torque converter.

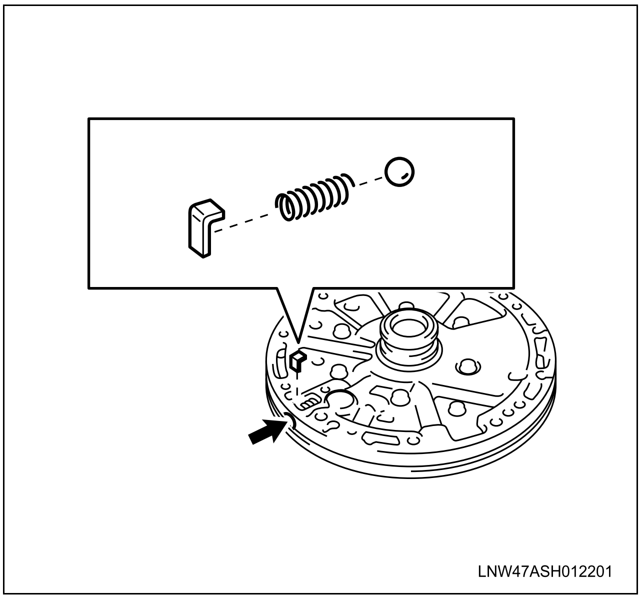


2. Remove the 2 oil seal rings.

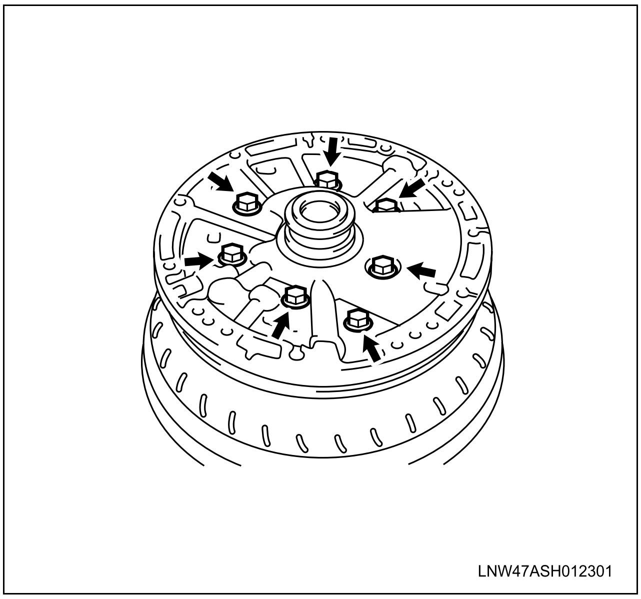
Caution:

- Do not damage the oil seal rings and do not deform them unless necessary.
- Do not damage the claws on the oil seal rings.

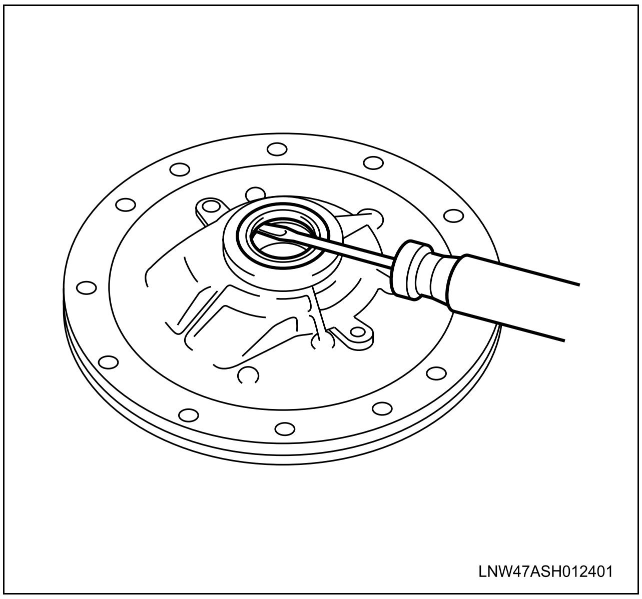
3. Using a screwdriver, compress the spring and remove the spring seat.
   Remove the spring and check ball.



4. Remove 7 bolts and pump cover.



5. Using a screwdriver, pry off the oil seal.



Oil Pump Body

Inspection Procedure

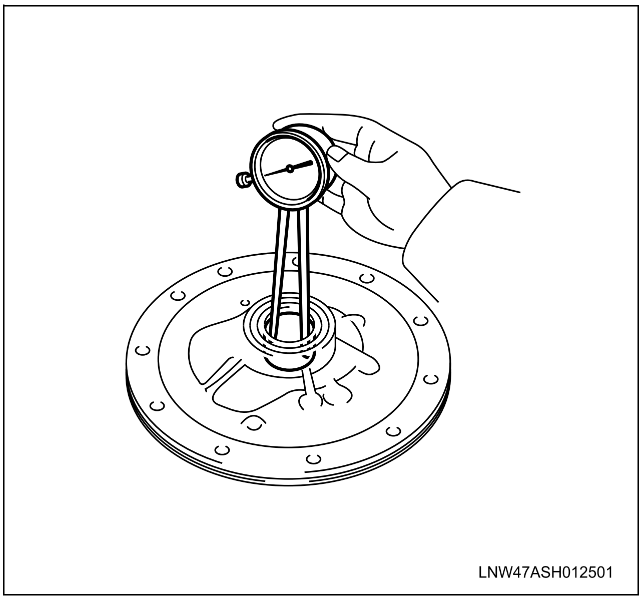
1. Inspect bushing of oil pump body.
   Using a dial indicator, measure the inside diameter.

Standard inside diameter:	42.050–42.075 mm (1.6555–1.6565 in.)
Maximum inside diameter:	42.13 mm (1.6587 in.)

Notice:

Measure at several points and take the average value.

If the inside diameter is greater than maximum, replace the oil pump assembly.

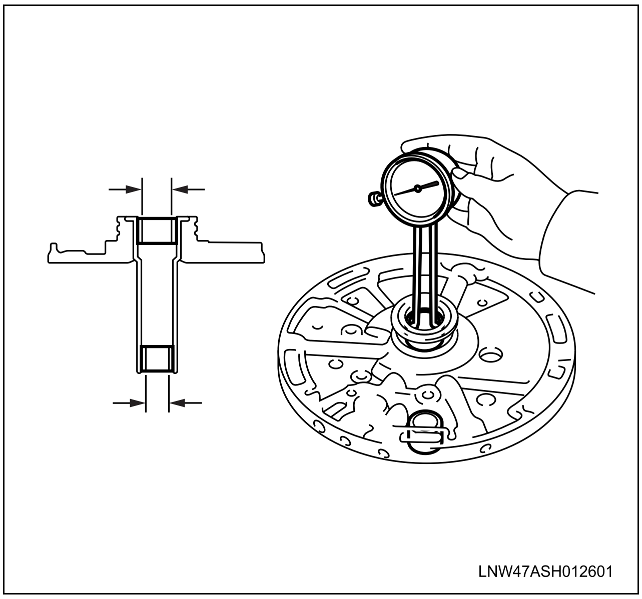


2. Inspect bushings of oil pump cover.
   Using a dial indicator, measure the inside diameter.

Front bushing standard inside diameter:
24.000–24.021 mm (0.9449–0.9457 in.)
Rear bushing standard inside diameter:
26.500–26.521 mm (1.0433–1.0441 in.)
Front bushing maximum inside diameter:
24.07 mm (0.9476 in.)
Rear bushing maximum inside diameter:
26.57 mm (1.0461 in.)

Notice:
Measure at several points and take the average value.

If the inside diameter is greater than the maximum, replace the oil pump assembly.



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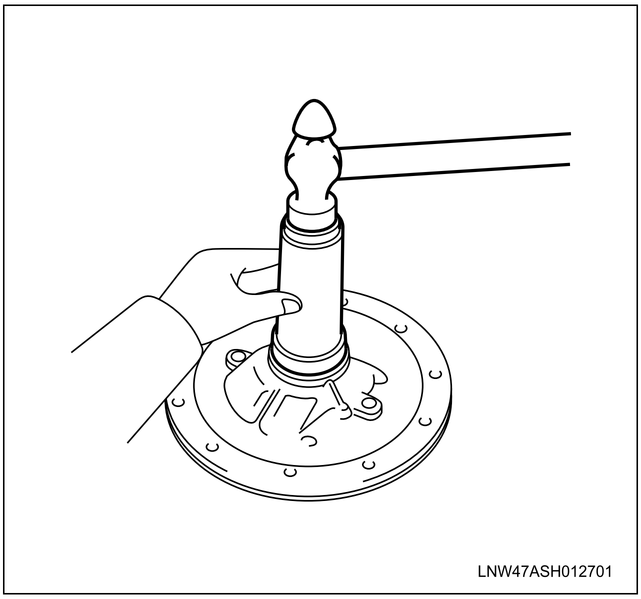
Reassembly

1. Install oil seal.
   Coat the new oil seal with DEXRON®-III.
   Using installer, tap in a new oil seal.

Tool Required: J-44163 Oil Seal Installer

The oil seal end should be flushed with the outer edge of the pump body.
Apply grease to the oil seal lip.



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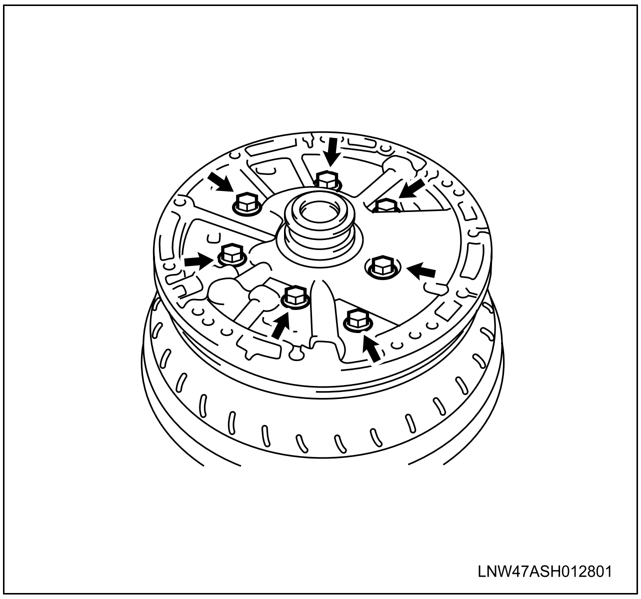
2. Install oil pump cover to oil pump body.
   Align the bolt holes of the oil pump body and cover.
   Install the pump cover with the 7 bolts.

Tighten

Torque: 21 N·m (15 lb ft)



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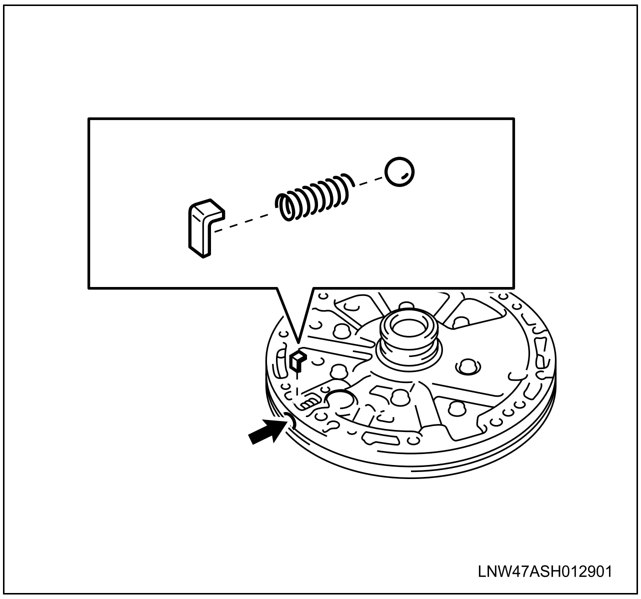
3. Install the check ball and spring.
   Using a screwdriver, compress the spring and install the spring seat.



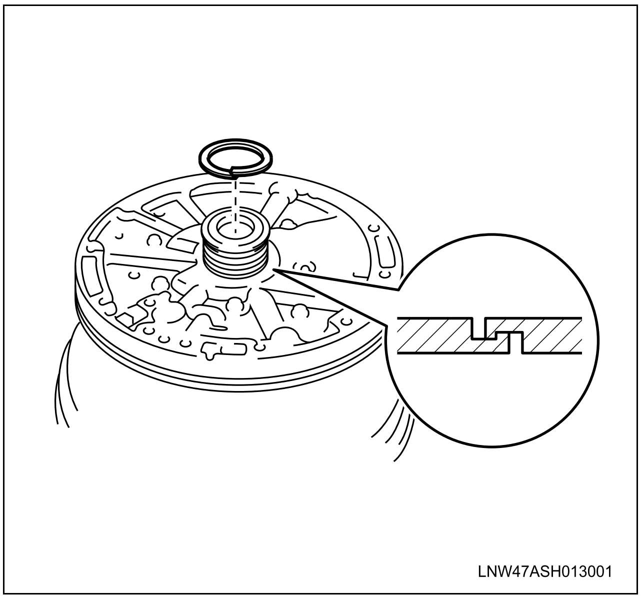
4. Coat the 2 oil seal rings with automatic transmission fluid (ATF).
   Contract the oil seal rings, and install them onto the stator shaft.

Caution:

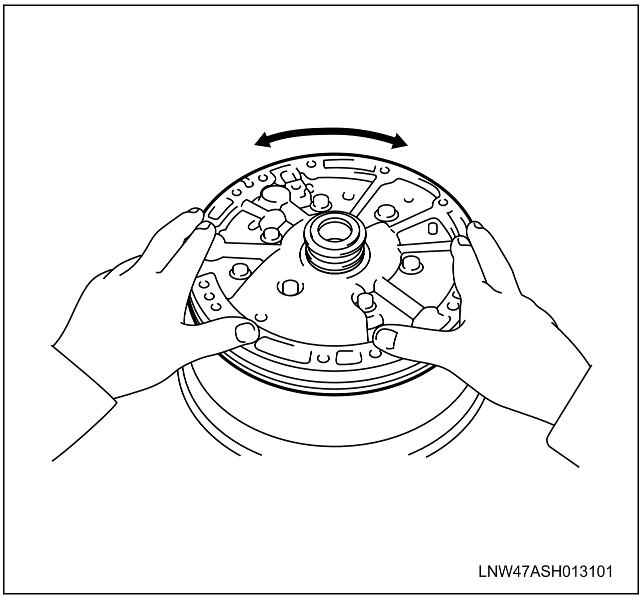
- Do not spread the ring ends too much.
- Do not damage the claws on the oil seal rings.

Notice:

- If the rings are damaged or deformed, replace them with new ones.
- After installing the oil seal rings, check that they rotate smoothly.



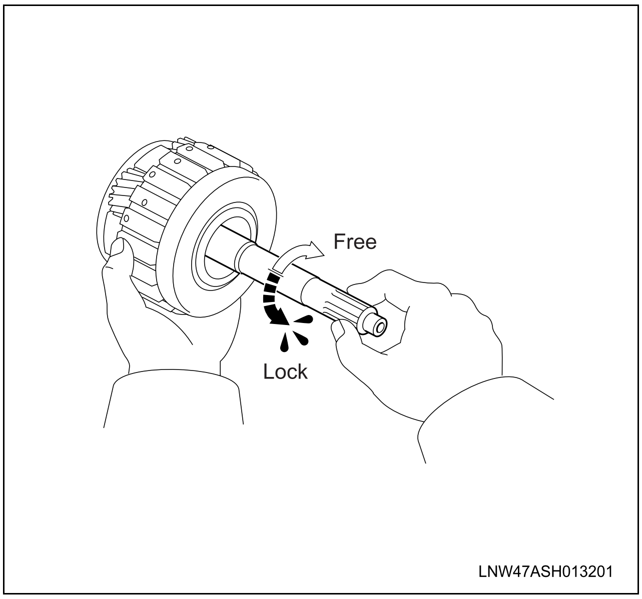
5. Check oil pump drive rotation.
   Make sure the drive gear rotates smoothly when installed to the torque converter.



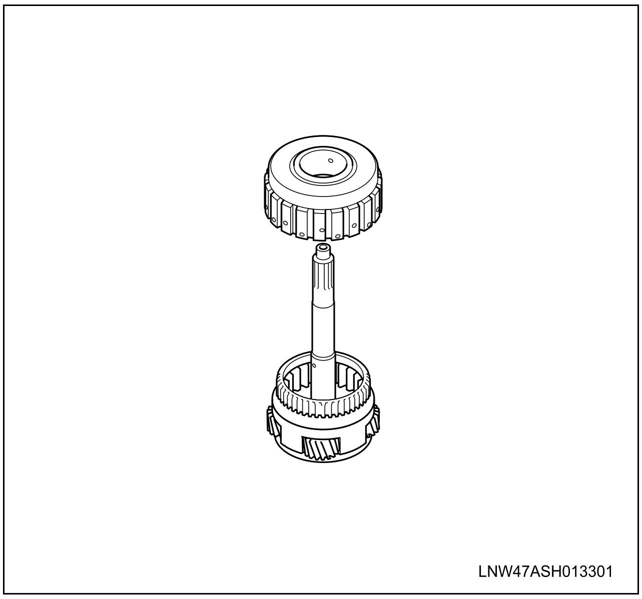
Overdrive (OD) Planetary Gear and Direct Clutch

Disassembly

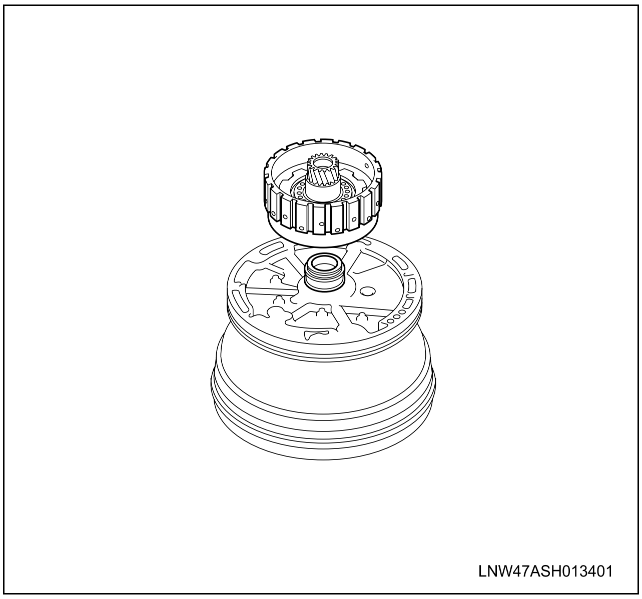
1. Check operation of one-way clutch.
   Hold the OD direct clutch drum and turn the input shaft.
   The input shaft should turn freely clockwise and should lock counterclockwise.



2. Remove overdrive direct clutch assembly from overdrive planetary gear.



3. Check piston stroke of overdrive direct clutch.
   Place the oil pump onto the torque converter, and then place the OD direct clutch assembly onto the oil pump.



   Using No.1 measure terminal and a dial indicator, measure the piston stroke by applying and releasing compressed air 392–785 kPa (4–8 kg/cm^2, 57–114 psi).

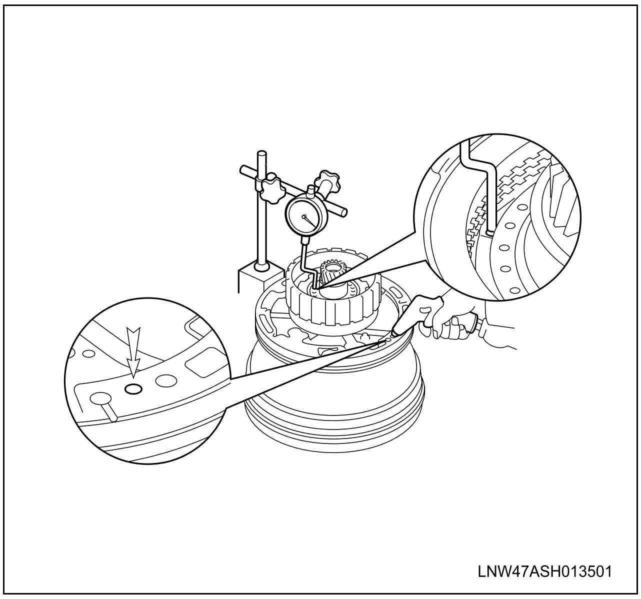
Tool Required: J-44167 No.1 measure terminal

Notice:

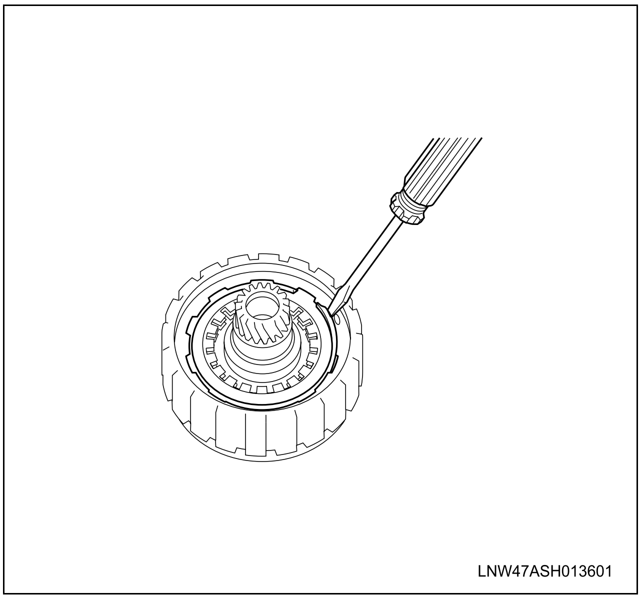
- Stand the measure terminal on the piston vertically.
- Ensure that the measure terminal does not touches other parts than the piston.
- Measure the stroke at more than 3 points.

Piston stroke: 1.80–2.07 mm (0.0709–0.0815 in.)

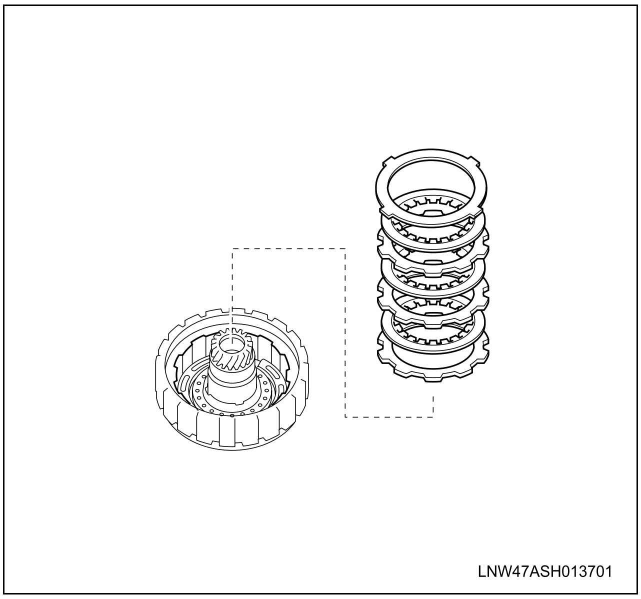
If the piston stroke is not as specified, inspect the discs and the plates.



4. Remove flange, plates and discs
   Using a screwdriver, remove the snap ring.



Remove the flange, 3 discs and 3 plates.

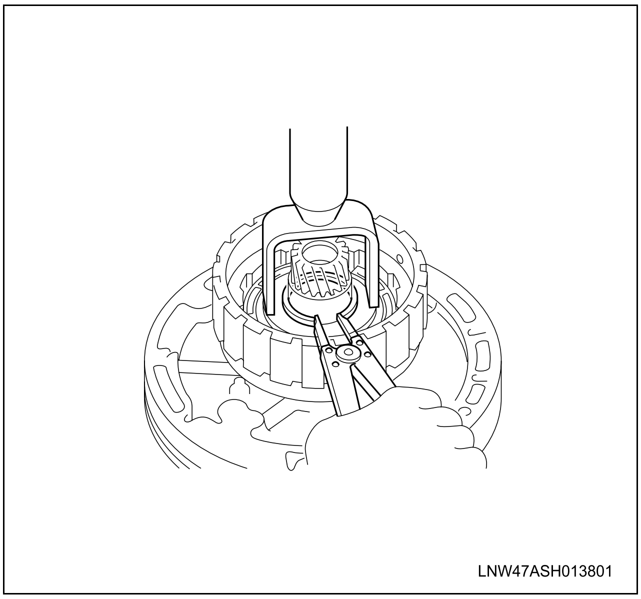


5. Remove piston return spring.
   Place No.2 piston spring compressor on the spring seat, and compress the return spring with a shop press.

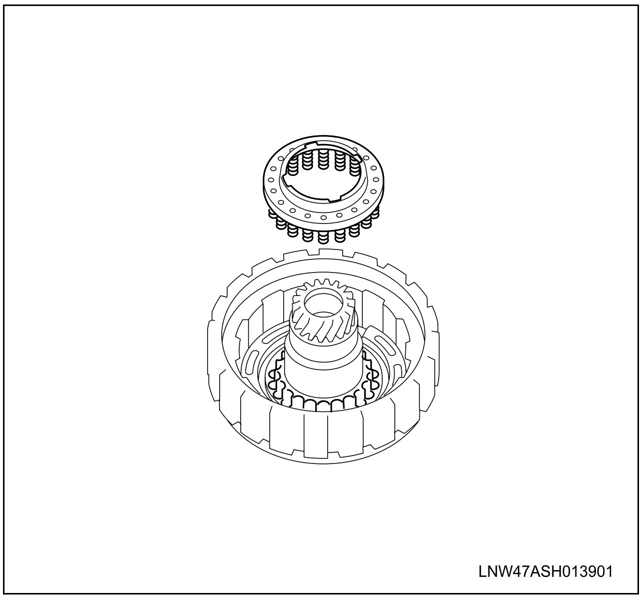
Tool Required: J-44160 No.2 Piston Spring Compressor

Notice:
Stop compressing the return spring at the position 1 to 2 mm away from the snap ring to prevent the spring sheet from being deformed.

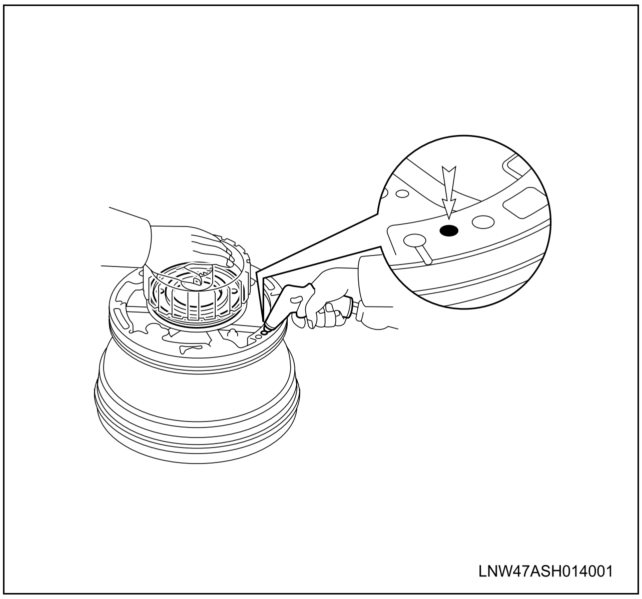
Using snap ring pliers, remove the snap ring.



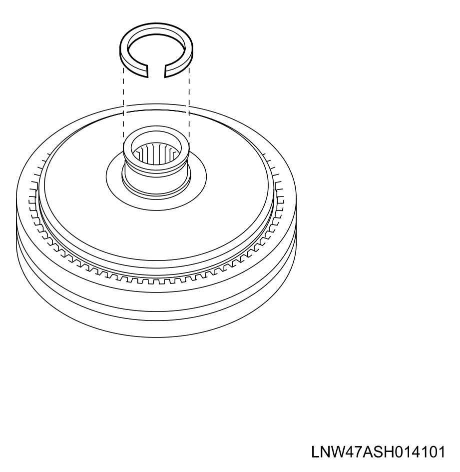
6. Remove the piston return spring.



7. Remove overdrive direct clutch piston.
   Place the oil pump onto the torque converter, and then place the OD direct clutch onto the oil pump.
   Hold the clutch piston with hand, apply compressed air into the oil hole of the oil pump to remove the clutch piston.
   Remove the 2 O-rings from the clutch piston.

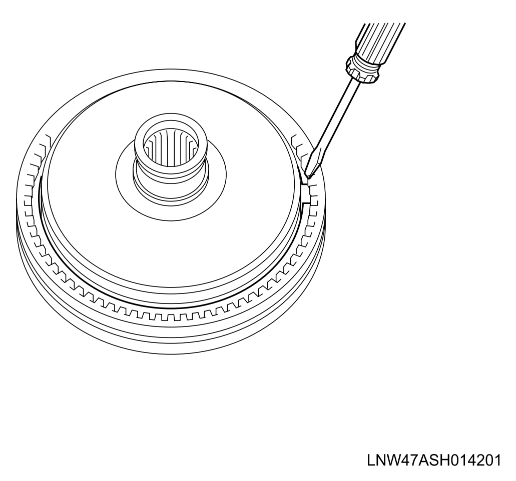


8. Remove oil seal ring from ring gear flange.



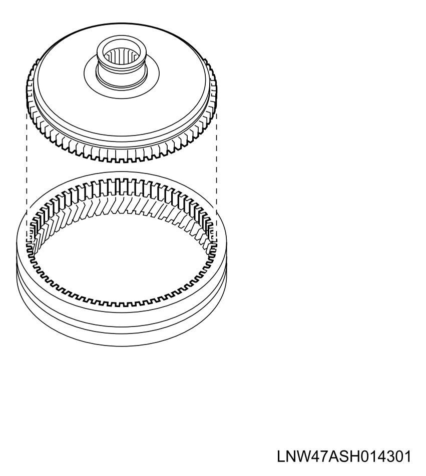
LNW47ASH014101

9. Remove ring gear flange.
   Using a small screwdriver, remove the snap ring.



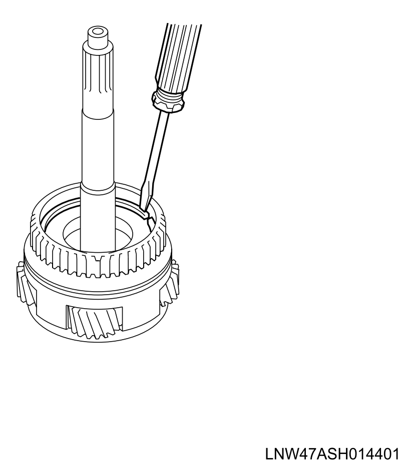
LNW47ASH014201

10. Remove the ring gear flange.



LNW47ASH014301

11. Remove one-way clutch from overdrive planetary gear.
    Using small screwdriver, remove the snap ring.



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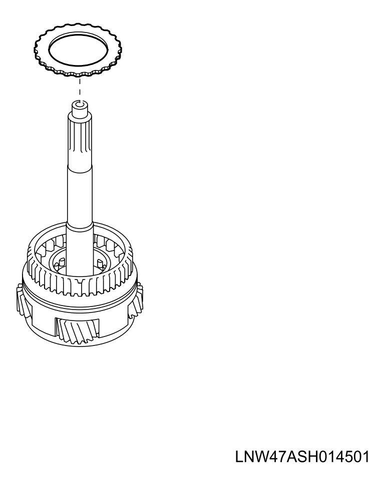
12. Remove the thrust washer.



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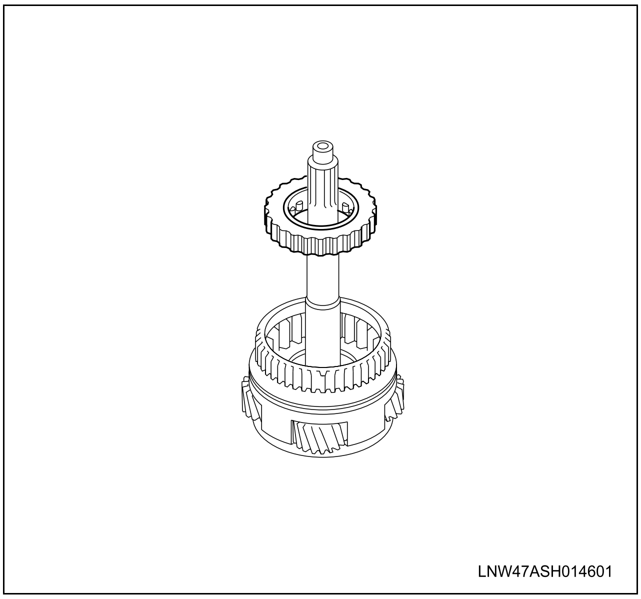
13. Remove the one-way clutch together with the outer race.

Notice:
Check the installation direction of the one-way clutch.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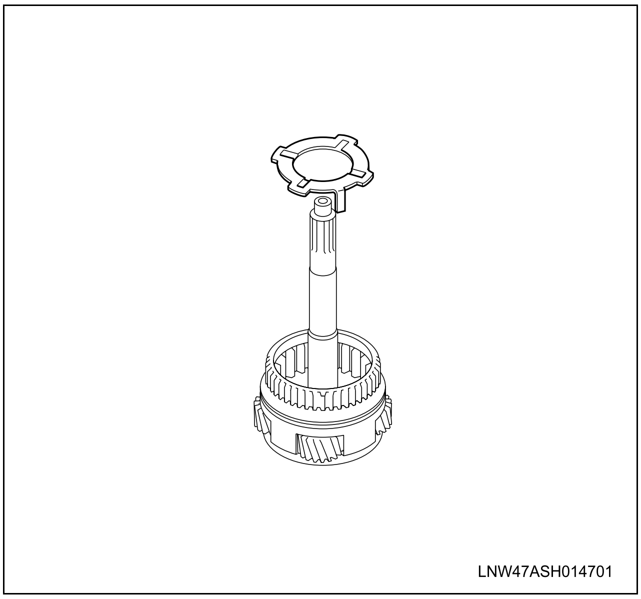
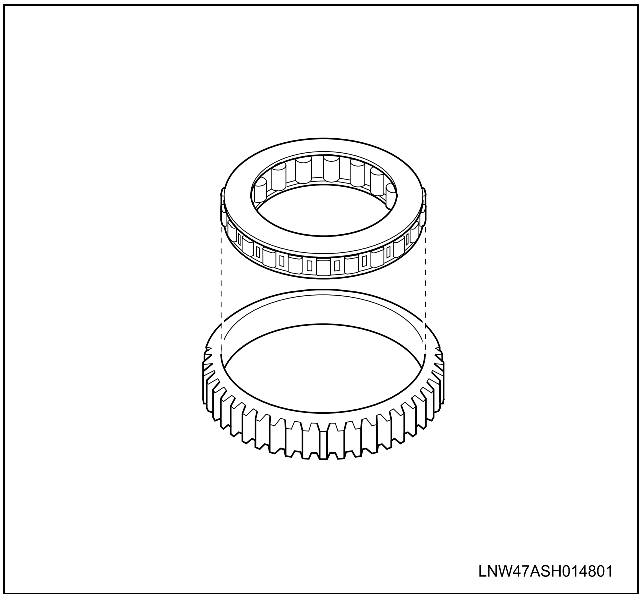
14. Remove the thrust washer.

Notice:
Check the installation direction of the thrust washer.


LNW47ASH014701

15. Remove the one-way clutch from the outer race.

Notice:
Do not remove the upper and lower plates of the one-way clutch.

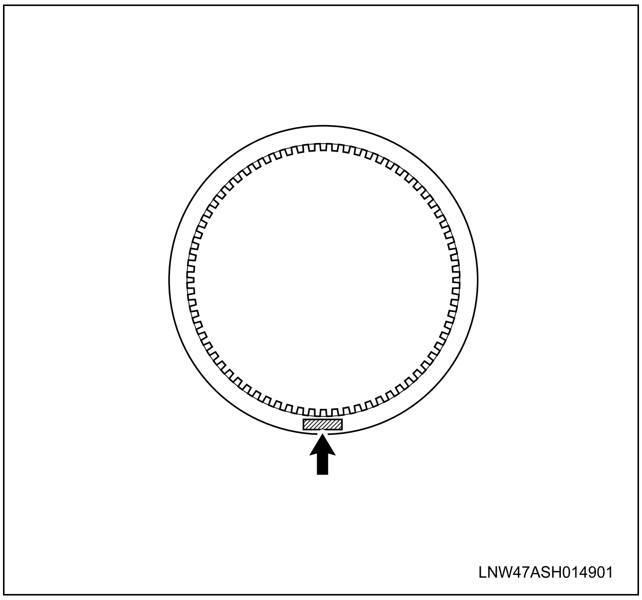

LNW47ASH014801

Inspection Procedure

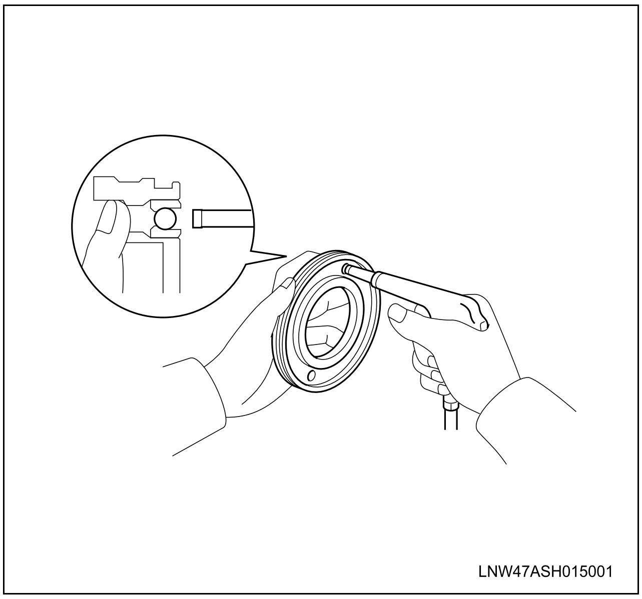
1. Inspect discs, plates and flange.
   Check to see if the sliding surface of the disc, plate and flange are worn or burnt. If necessary, replace them.

Notice:

- If the lining of the disc is peeling off or discolored, or even if a part of the printed numbers are defaced, replace all discs.
- Before assembling new discs, soak them in automatic transmission fluid (ATF) for at least 15 minutes.


LNW47ASH014901

2. Inspect overdrive direct clutch piston.
   Check that check ball is free by shaking the piston.
   Check that the valve does not leak by applying low pressure compressed air.

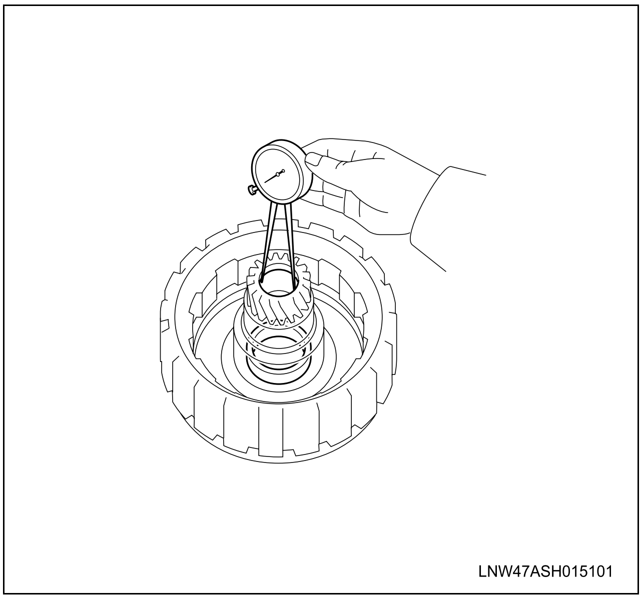


3. Inspect bushings of overdrive direct clutch drum.
   Using a dial indicator, measure the inside diameter.

Standard inside diameter:	26.500–26.521 mm (1.0433–1.0441 in.)
Maximum inside diameter:	26.57 mm (1.0461 in.)

Notice:
Measure at several points and take the average value.

If the inside diameter is greater than maximum, replace the clutch drum.
Inspect the bushing contacting surface of the planetary gear input shaft, when discoloration or damage on the surface is found, replace the planetary gear.

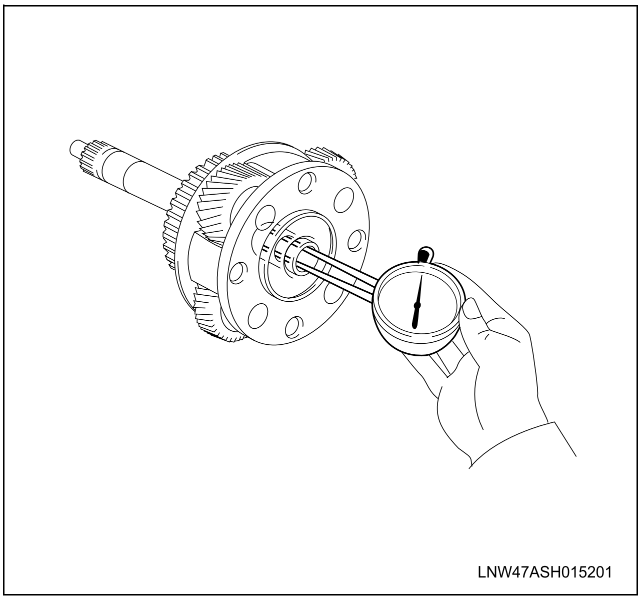


4. Inspect bushings of overdrive planetary gear.
   Using a dial indicator, measure the inside diameter.

Standard inside diameter:	12.000–12.018 mm (0.4724–0.4731 in.)
Maximum inside diameter:	12.070 mm (0.4752 in.)

Notice:
Measure at several points and take the average value.

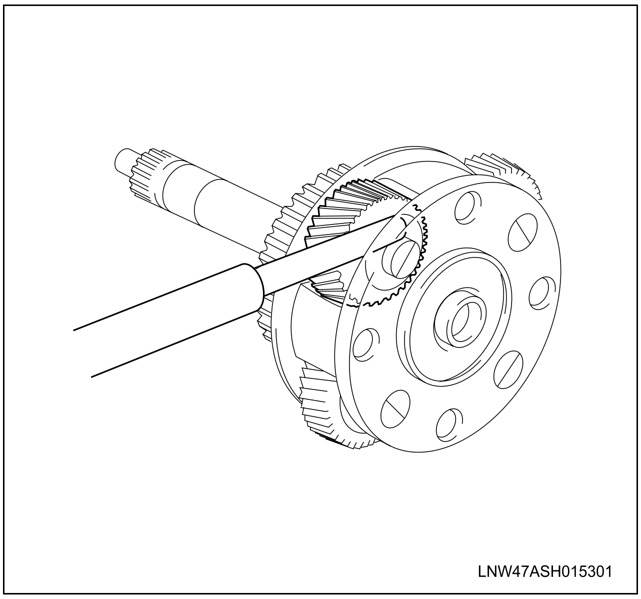
If the inside diameter is greater than maximum, replace the planetary gear.
Inspect the bushing contacting surface of the front clutch drum input shaft, when discoloration or damage on the surface is found, replace the front clutch drum.



5. Inspect planetary pinion gear thrust clearance.
   Using a feeler gauge, measure the clearance between the pinions and carrier.

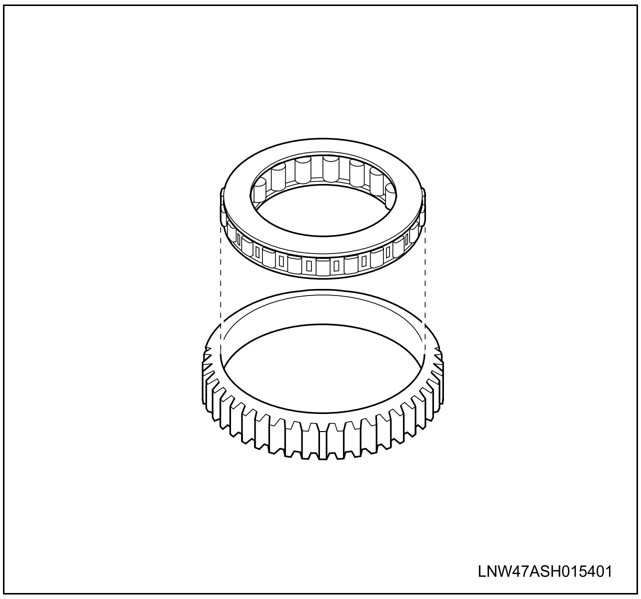
Standard clearance:	0.20–0.59 mm (0.0079–0.0232 in.)
Maximum clearance:	0.80 mm (0.0315 in.)

If the thrust clearance is greater than maximum, replace the planetary gear.



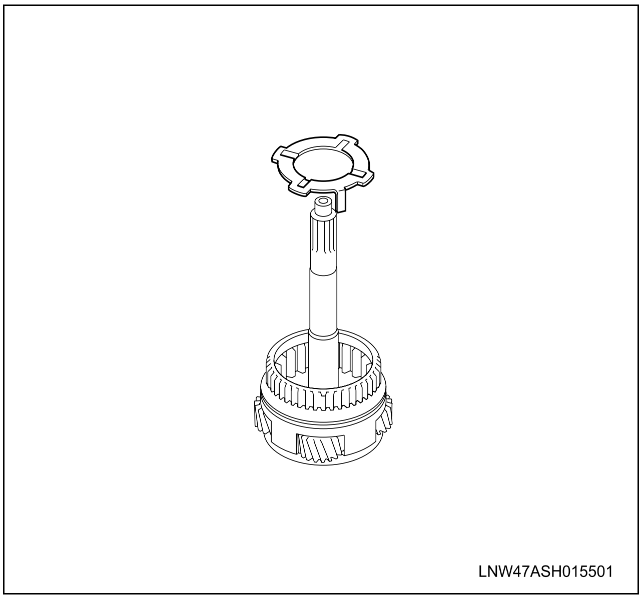
Reassembly

1. Install one-way clutch to overdrive (OD) planetary gear.
    a. Install the one-way clutch into the outer race.

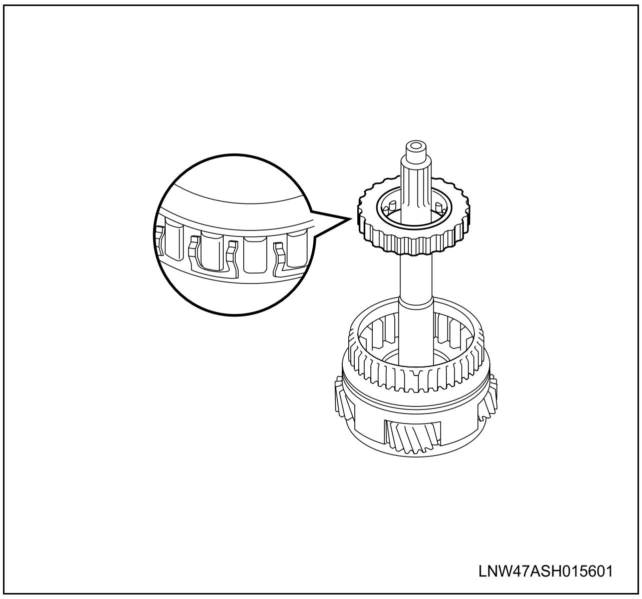


   b. Install the thrust washer, facing the grooved side upward.

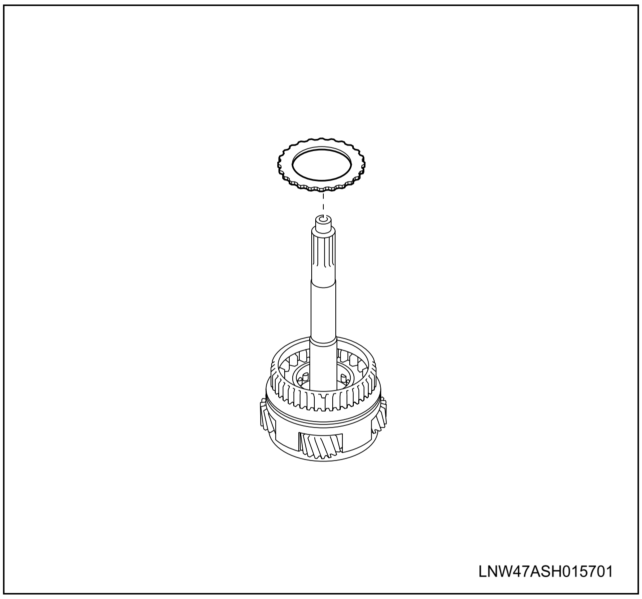
Notice:
Insert the pin of thrust washer into holes in the OD planetary gear.



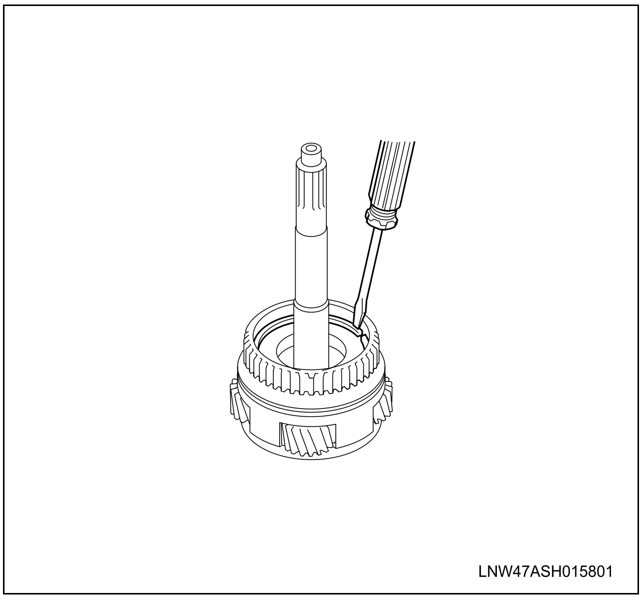
   c. Install the one-way clutch and outer race assembly, facing the flanged side of the one-way clutch upward.



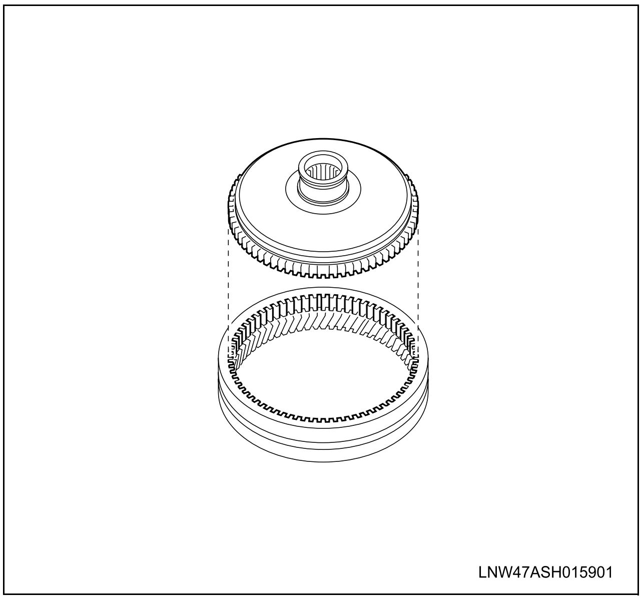
   d. Install the thrust washer.



e. Using a screwdriver, install the snap ring.


LNW47ASH015801

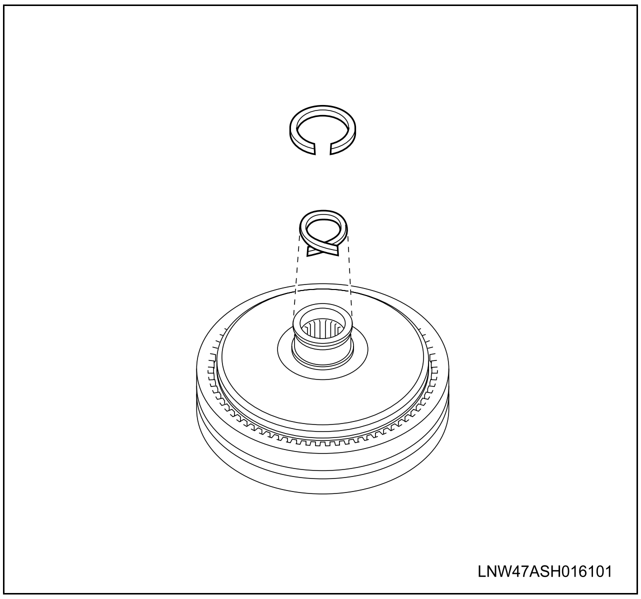
2. Install ring gear flange to overdrive planetary ring gear.
   a. Install the ring gear flange as shown.


LNW47ASH015901

   b. Using a screwdriver, install the snap ring.
3. Install oil seal ring.
   Coat the oil seal ring with ATF, and install it to the ring gear flange, then sank it down by squeezing their ends together.

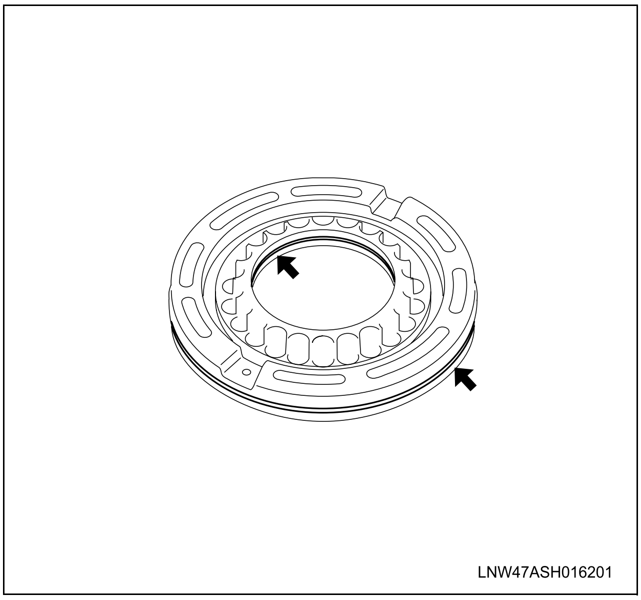
Caution:
Do not spread the ring ends more than necessary.

Notice:
After installing the oil seal ring, check that it moves smoothly.


LNW47ASH016101

4. Install overdrive direct clutch piston.
   a. Coat new O-rings with ATF, and install them on the clutch piston.

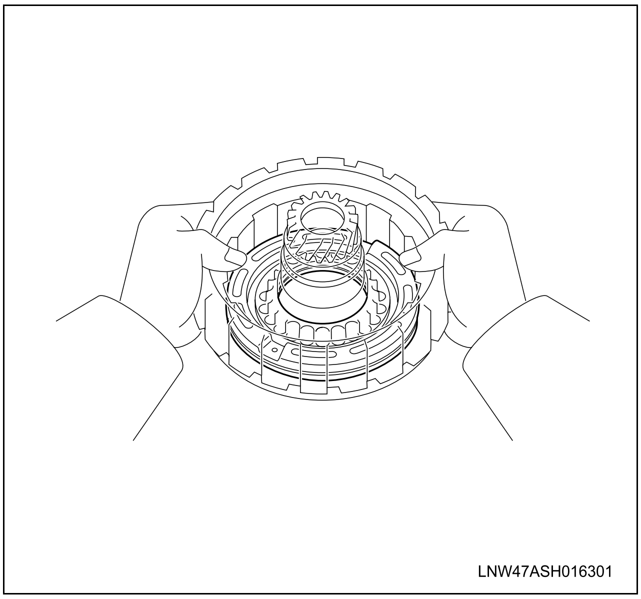
O-ring Diameter		mm (in.)
	Inside	Wire diameter
Inner side	64.1 (2.524)	2.6 (0.102)
Outer side	117.4 (4.6227)	3.1 (0.122)


LNW47ASH016201

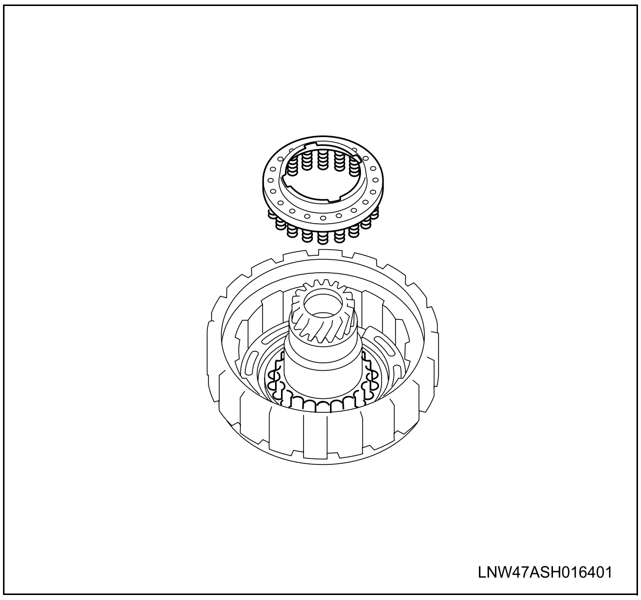
   b. Push in the clutch piston into the clutch drum with both hands.

Caution:
Be careful not to damage the O-rings.

Notice:
Push in the piston uniformly.



5. Install piston return spring.
   a. Place the piston return spring on the clutch piston.



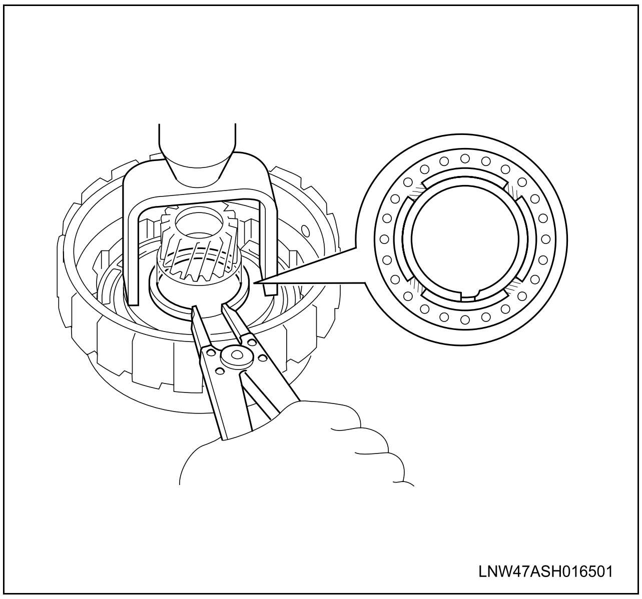
   b. Place No.2 piston spring compressor on the spring seat, and compress the return spring with a shop press.

Tool Required: J-44160 No.2 Piston Spring Compressor

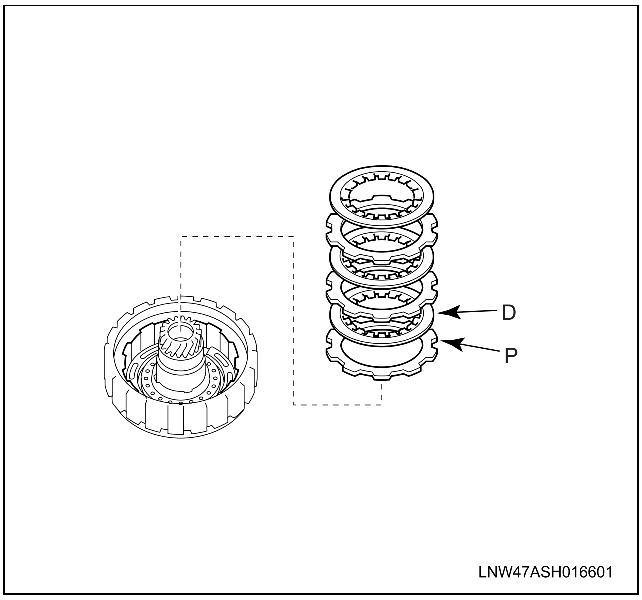
Notice:
Stop compressing the return spring at the position 1 to 2 mm away from the snap ring to prevent the spring sheet from being deformed.

   c. Using snap ring pliers, install the snap ring.

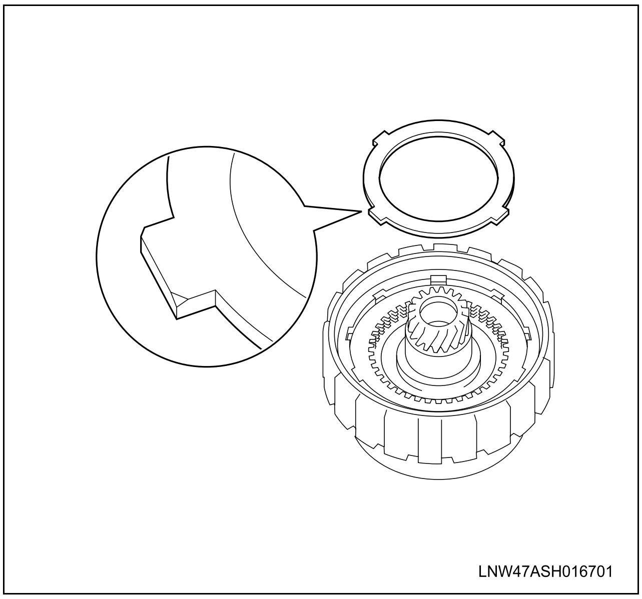
Notice:
Be sure the end gap of the snap ring is not aligned with the spring retainer claw.



6. Install plates, discs and flange.
   a. Install the 3 plates and 3 discs in order:
      P = Plate D = Disc
      P –D –P –D –P –D



b. Install the flange, facing the rounded edge upward.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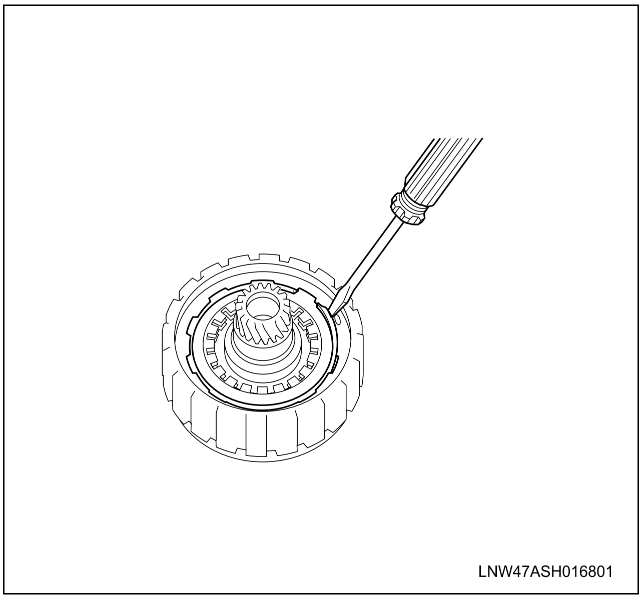
c. Using a screwdriver, install the snap ring.

Notice:
Be sure the end gap of the snap ring is not aligned with the cutout portion of the clutch drum.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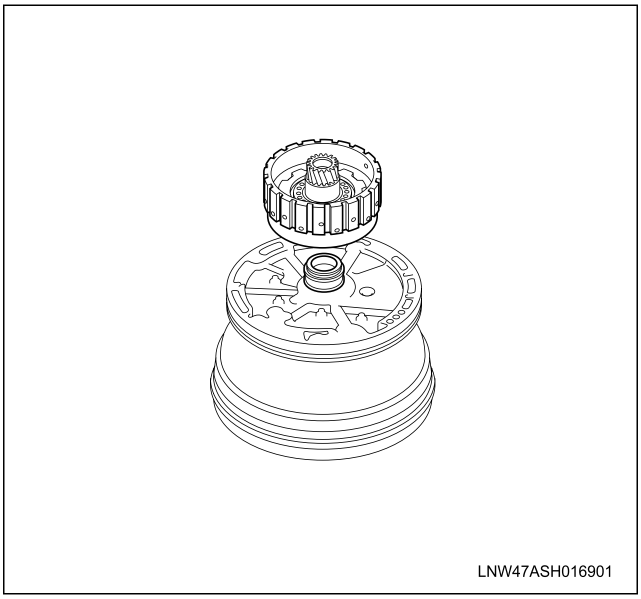
7. Check piston stroke of overdrive direct clutch.

a. Place the oil pump onto the torque converter, and then place the OD direct clutch assembly onto the oil pump.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b. Using No.1 measure terminal and a dial indicator, measure the piston stroke by applying and releasing compressed air 392–785 kPa (4–8 kg/cm^2, 57–114 psi).

Tool Required: J-44167 No.1 Measure Terminal

Notice:

- Stand the measure terminal on the piston vertically.
- Ensure that the measure terminal does not touches other parts than the piston.
- Measure the stroke at more than 3 points.

Piston stroke: 1.80–2.07 mm (0.0709–0.0815 in.)

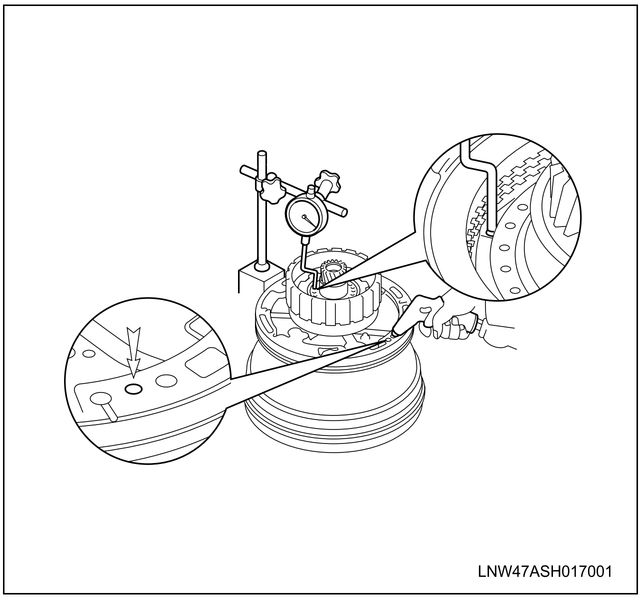
If the piston stroke is less than specified, parts may have been assembled incorrectly, check and reassemble again.

If the piston stroke is not as specified, select another flange.

Notice:
There are 4 different thicknesses for flange.

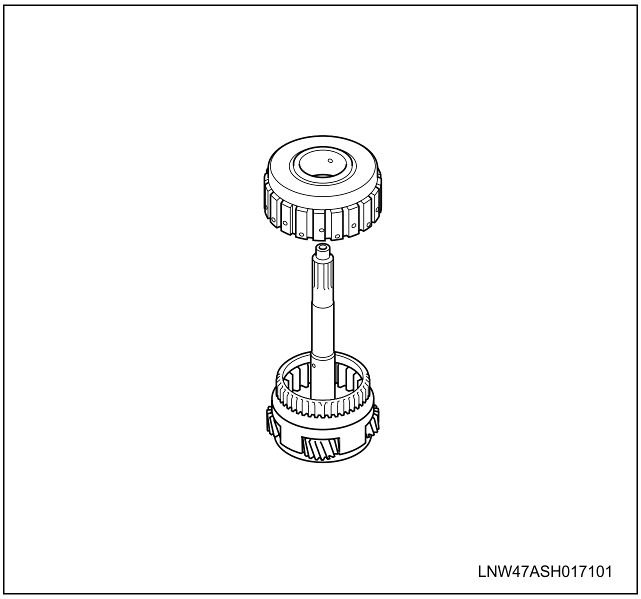
Flange Thicknesses

No.	Thickness mm (in.)
A	4.6 (0.181)
B	4.77 (0.188)
C	4.94 (0.194)
D	5.11 (0.201)

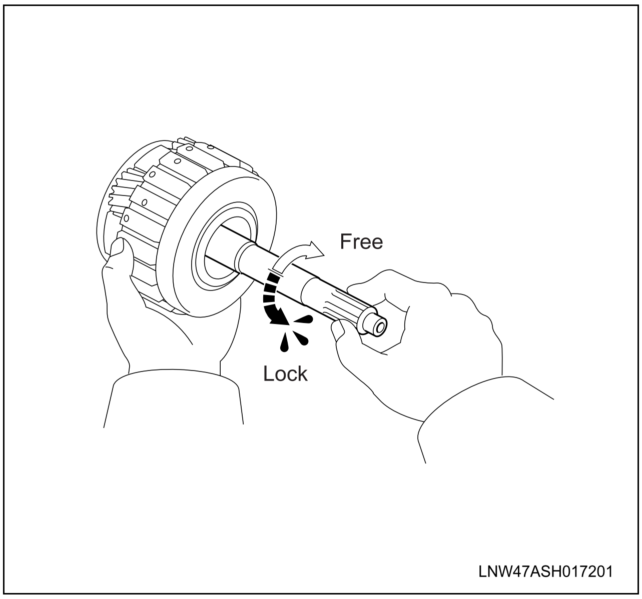


8. Install overdrive direct clutch assembly.
   Install the direct clutch assembly onto the OD planetary gear.

Notice:
Mesh the spline of the OD planetary gear with the flukes of the discs by rotating and pushing the OD direct clutch counterclockwise.



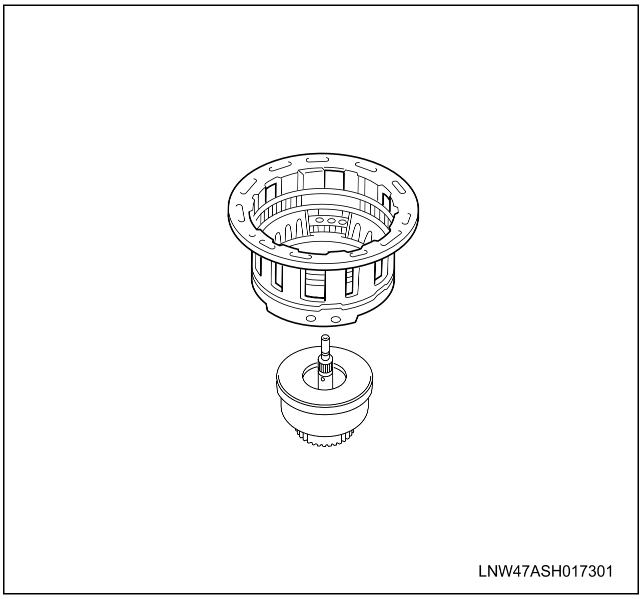
9. Check operation of one-way clutch
   Hold the OD direct clutch drum and turn the input shaft.
   The input shaft should turn freely clockwise and should lock counterclockwise.



Overdrive (OD) Brake

Disassembly

1. Check piston stroke of overdrive brake.
   a. Place the OD case assembly onto the front clutch assembly.



   b. Using No.2 measure terminal and a dial indicator, measure the piston stroke by applying and releasing compressed air 392–785 kPa (4–8 kg/cm^2, 57–114 psi).

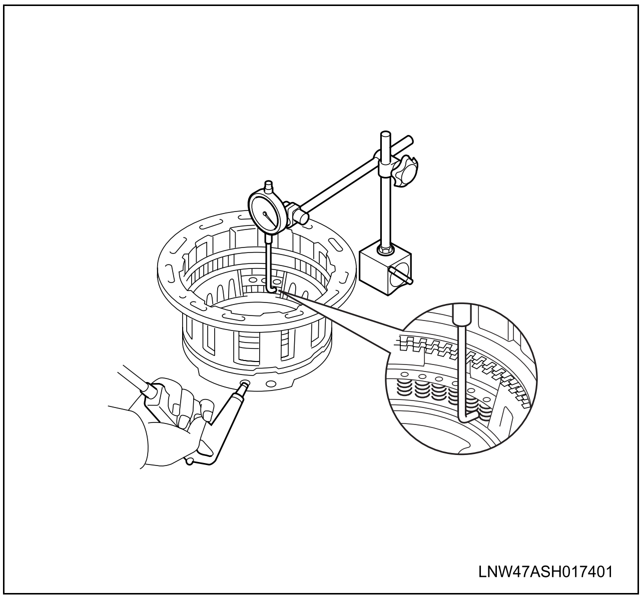
Tool Required: J-44168 No.2 Measure Terminal

Piston stroke: 1.25–1.85 mm

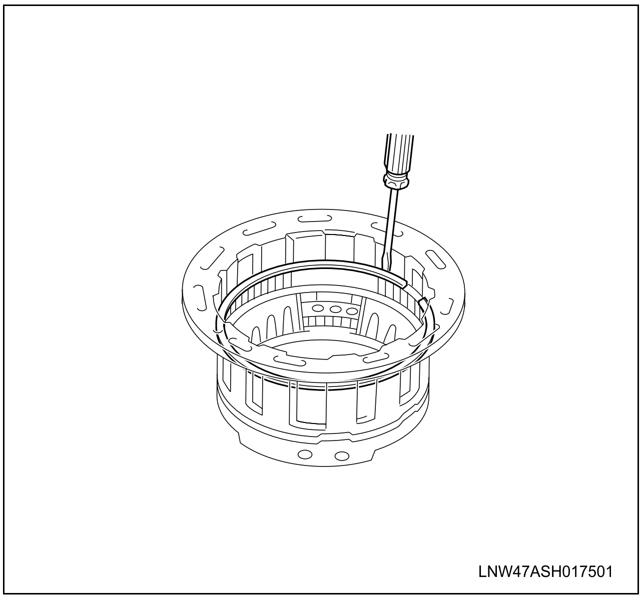
Notice:
- Stand the measure terminal on the piston vertically.

- Ensure that the measure terminal does not touches other parts than the piston.
- Measure the stroke at more than 3 points.

If the piston stroke is not as specified, inspect the discs and plates.



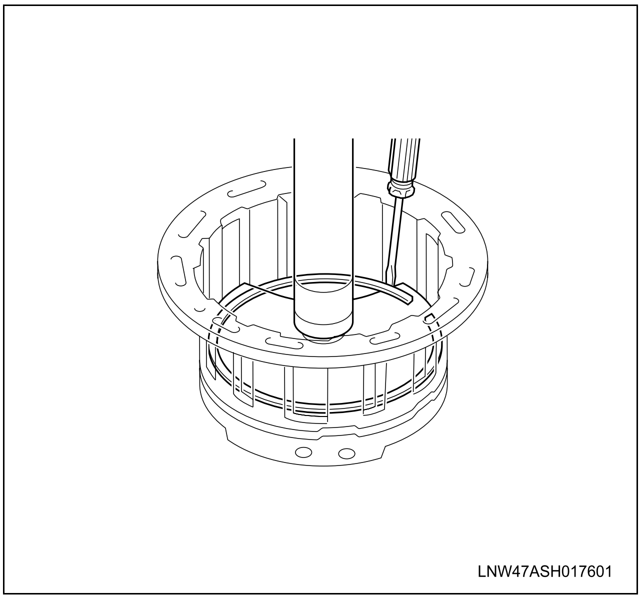
2. Remove flange, discs and plates.
   1. Using a screwdriver, remove the snap ring.
   2. Remove the flange, 3 discs and 3 plates.



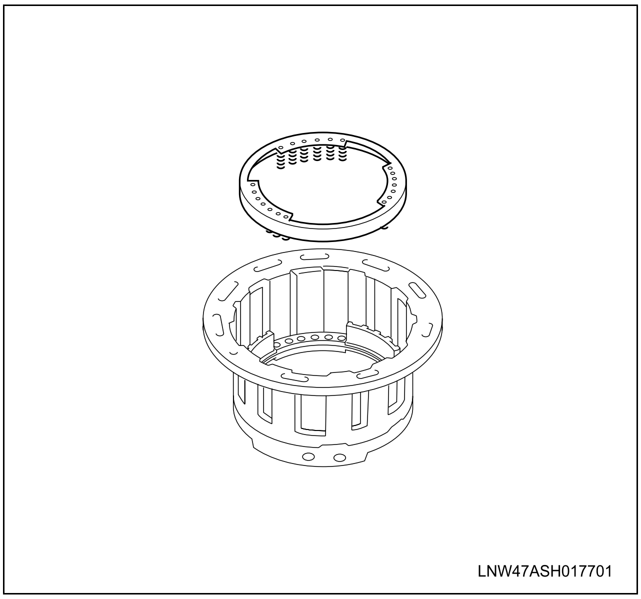
3. Remove piston return spring.
   1. Place No.3 piston spring compressor on the spring seat, and compress the return spring with a shop press.

Tool Required: J-44161 No.3 Piston Spring Compressor

b. Using screwdriver, remove the snap ring.

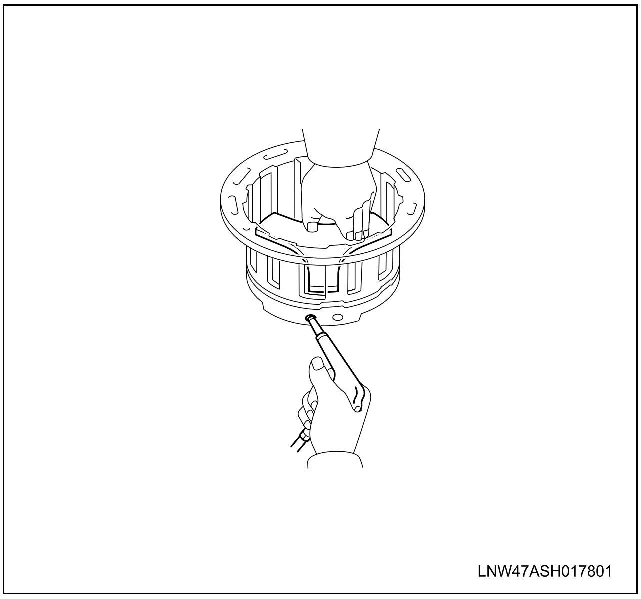


c. Remove the return spring.

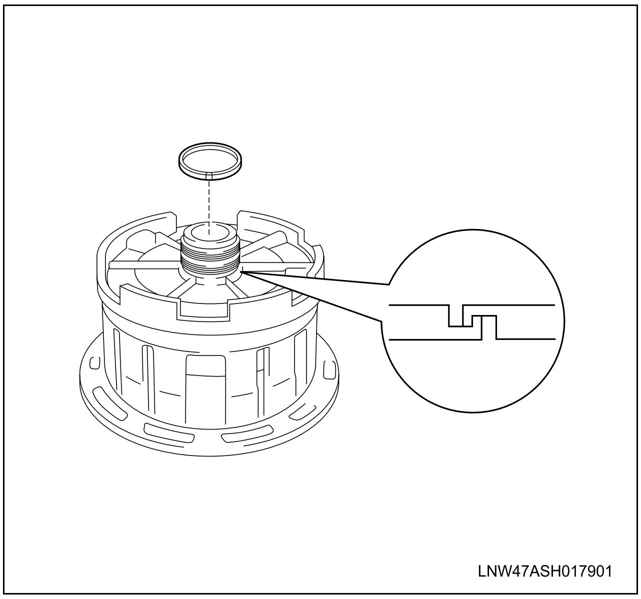


4. Remove overdrive brake piston
   Place the No.3 piston spring compressor on the brake piston.
   Hold piston spring compressor so it does not slant, and apply compressed air 392–785 kPa (4–8 kg/cm^2, 57–114 psi) into the oil hole of the OD case to remove the brake piston.
   Remove the 2 O-rings from the brake piston.

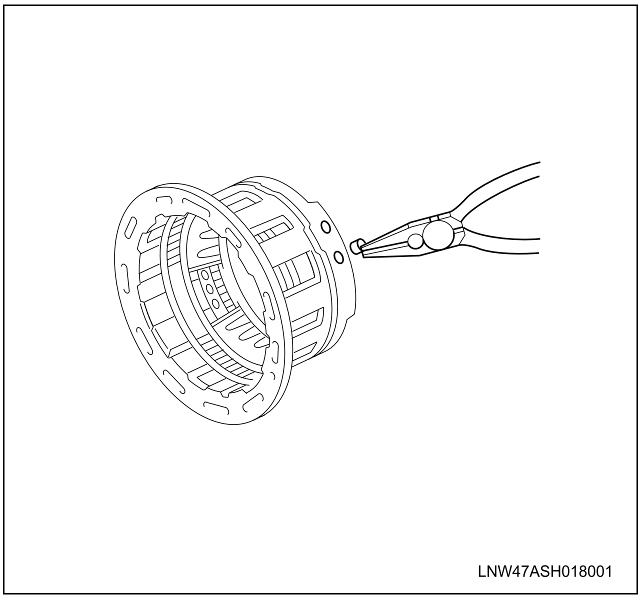
Notice:
Be careful not to slant the brake piston while applying compressed air. If the brake piston slants, it is difficult to remove.



5. Remove the 2 oil seal rings from the OD case.



6. Remove ring retainers.
   Using needle nose pliers, remove the 3 ring retainers from the oil holes of OD case.

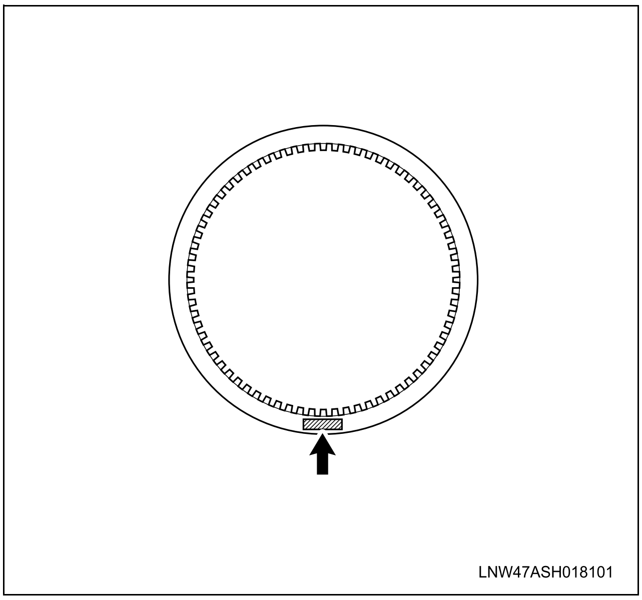


Inspection Procedure

1. Inspect discs, plates and flange.
   Check to see if the sliding surface of the disc, plate and flange are worn or burnt. If necessary, replace them.

Notice:

- If the lining of the disc is peeling off or discolored, or even if a part of the printed numbers are defaced, replace all discs.
- Before assembling new discs, soak them in automatic transmission fluid (ATF) for at least 15 minutes.



2. Inspect bushing of overdrive (OD) case.
   Using a dial indicator, measure the inside diameter.

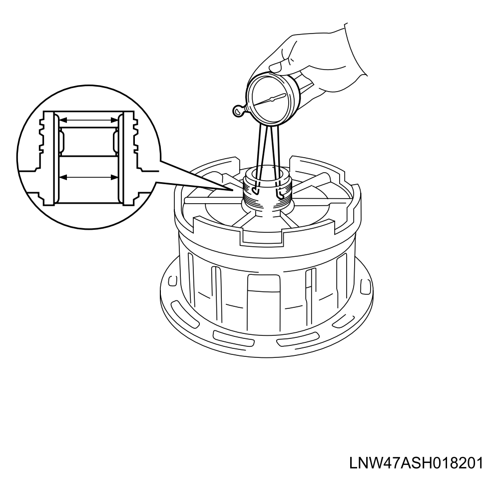
Standard inside diameter:	33.10–33.15 mm (1.3031–1.3051 in.)
Maximum inside diameter:	33.20 mm (1.3071 in.)

Notice:

Measure at several points and take the average value.

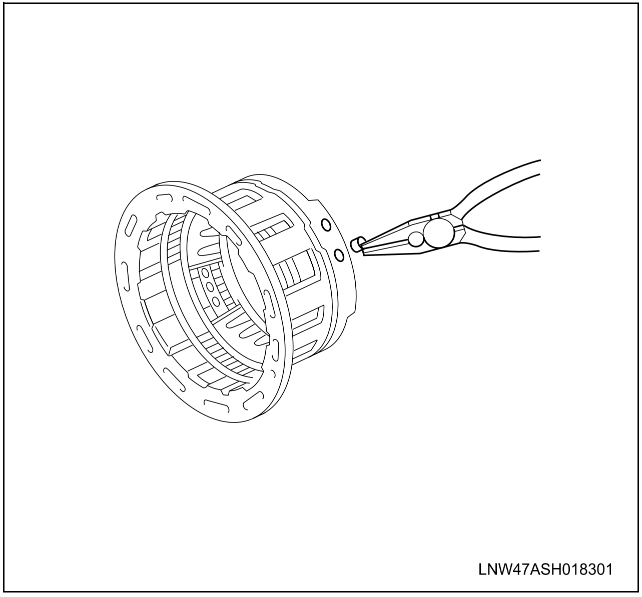
If the inside diameter is greater than maximum, replace the OD case.

Inspect the bushing contacting surface of the front clutch drum input shaft and the planetary ring gear flange, when discoloration or damage on the surface is found, replace the front clutch drum and planetary ring gear flange.



Reassembly

1. Install ring retainers.
   Coat the new 3 ring retainers with automatic transmission fluid (ATF).
   Using needle nose pliers, install the 3 ring retainers into the oil holes of the overdrive (OD) case.



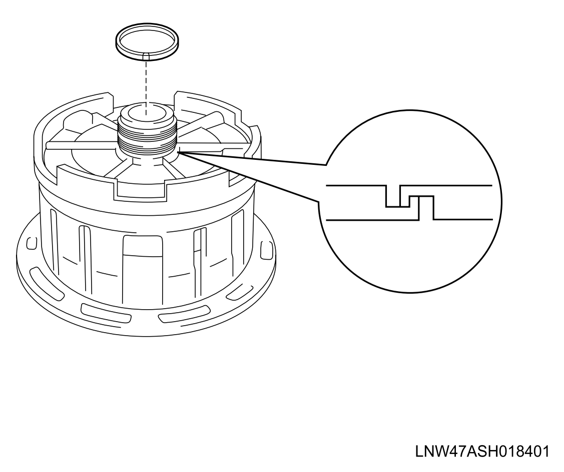
2. Install oil seal rings.
   Coat the new 2 oil seal rings with ATF.
   Contract the oil seals, and install them onto the OD case.

Caution:

- Do not damage the claws on the oil seal rings.
- Do not spread the ring ends more than necessary.

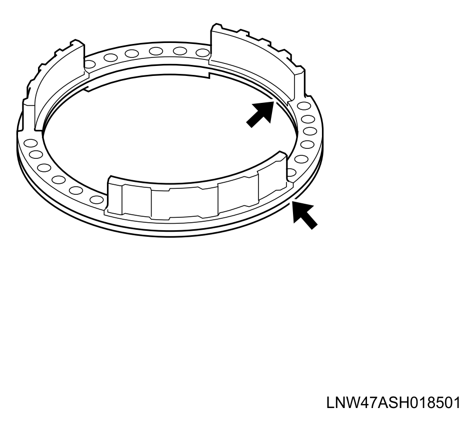
Notice:

After installing the oil seal rings, check that they rotate smoothly.



3. Install overdrive brake piston.
   a. Coat new 2 O-rings with ATF, and install them on the brake piston.

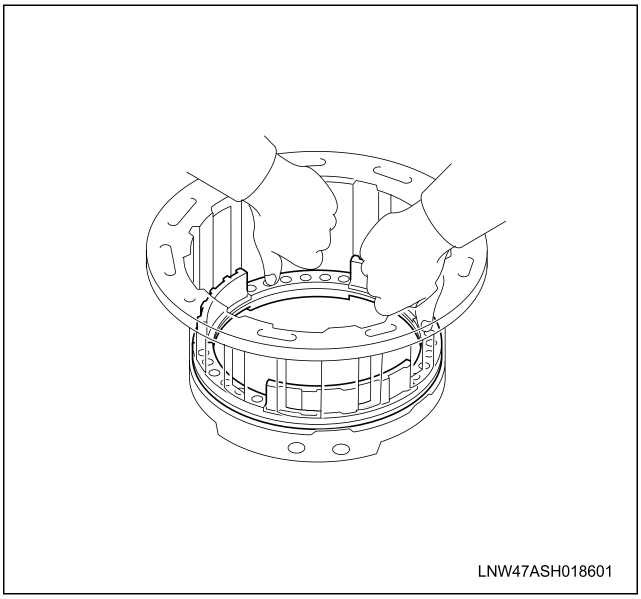
O-ring diameters		mm (in.)
	Inside	Wire diameter
Inner side	145.3 (5.7)	3.1 (0.1)
Outer side	163.7 (6.4)	3.1 (0.1)



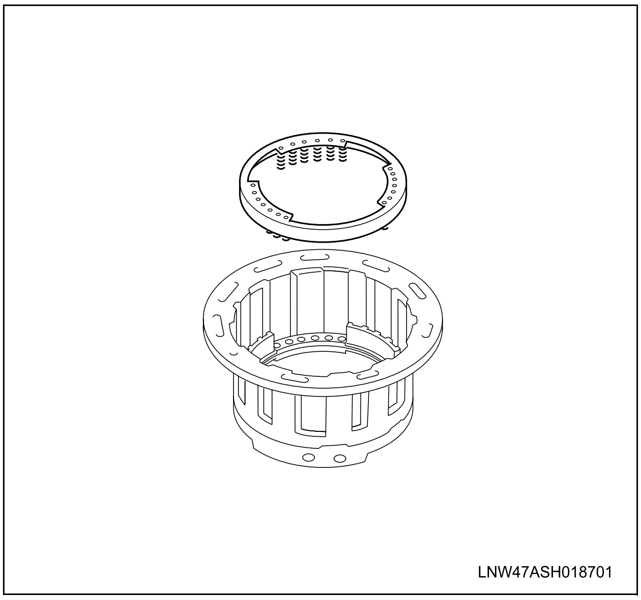
   b. Align the protrusions of the brake piston with the grooves of the OD case.
   c. Push in the brake piston into the OD case with both hands.

Caution:
Be careful not to damage the O-rings.

Notice:
Push in the piston uniformly.


LNW47ASH018601

4. Install piston return spring.
   a. Place the return spring on the brake piston.


LNW47ASH018701

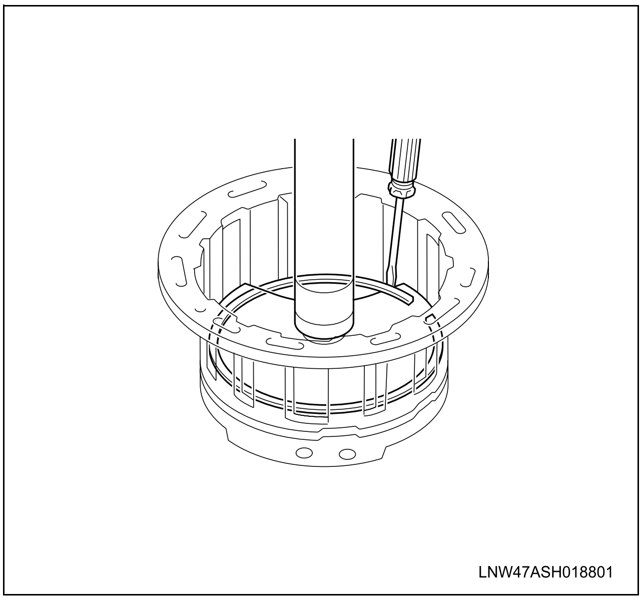
   b. Place No.3 piston spring compressor on the spring on the spring seat, and compress the return spring with a shop press.

Tool Required: J-44161 No.3 Piston Spring Compressor

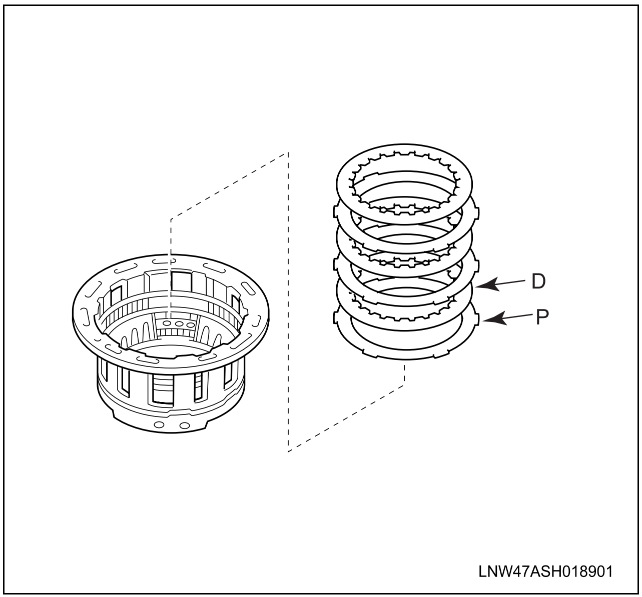
Notice:
Stop compressing the return spring at the position 1 to 2 mm away from the snap ring to prevent the spring sheet from being deformed.

   c. Using a screwdriver, install the snap ring.

Notice:
Be sure the end gap of the snap ring is not aligned with the cutout portion of the OD case.

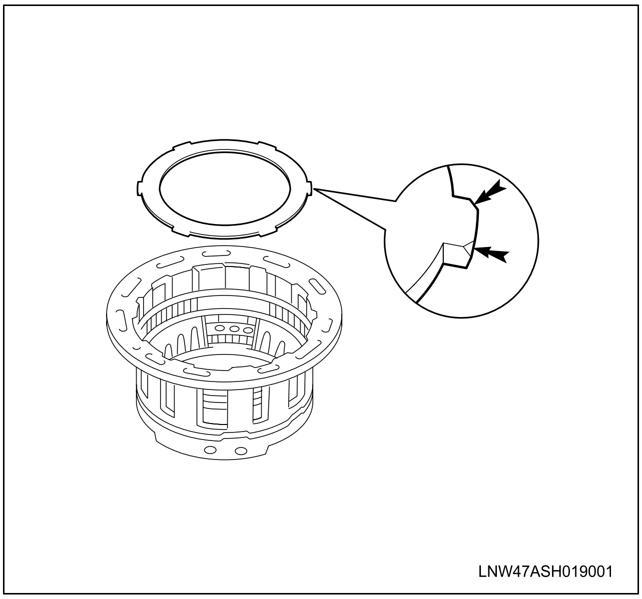

LNW47ASH018801

5. Install plates, discs and flange.
   a. Install the 3 plates and 3 discs in order:
      P = Plate D = Disc
      P – D – P – D – P – D



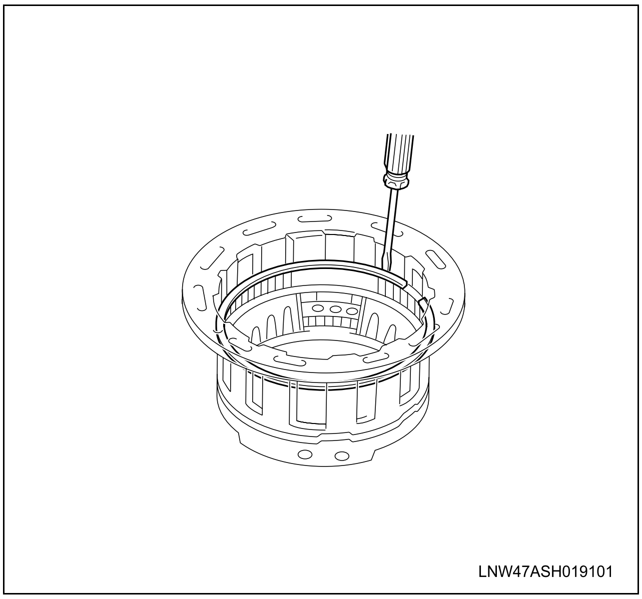
LNW47ASH018901

b. Install the flange, facing the rounded edge upward.



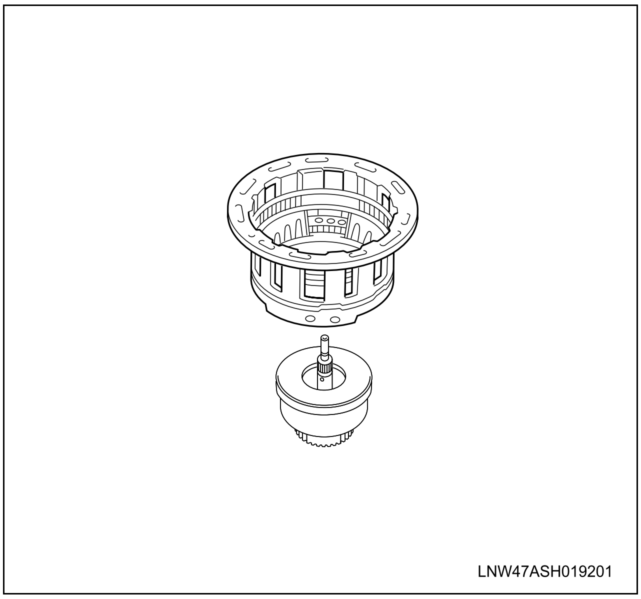
c. Using a screwdriver, install the snap ring.

Notice:
Be sure the end gap of the snap ring is not aligned with the cutout portion of the OD case.



6. Check piston stroke of overdrive brake.

a. Place the OD case assembly onto the front clutch assembly.



b. Using No.2 measure terminal and a dial indicator, measure the piston stroke by applying and releasing compressed air 392–785 kPa (4–8 kg/cm^2, 57–114 psi).

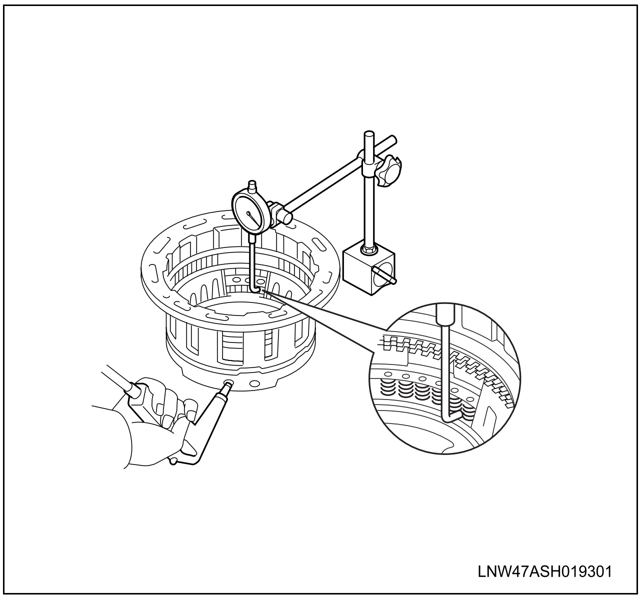
Tool Required: J-44168 No.2 Measure Terminal

Piston stroke: 1.25–1.85 mm (0.0492–0.0728 in.)

Notice:

- Stand the measure terminal on the piston vertically.
- Ensure that the measure terminal does not touches other parts than the piston.
- Measure the stroke at more than 3 points.

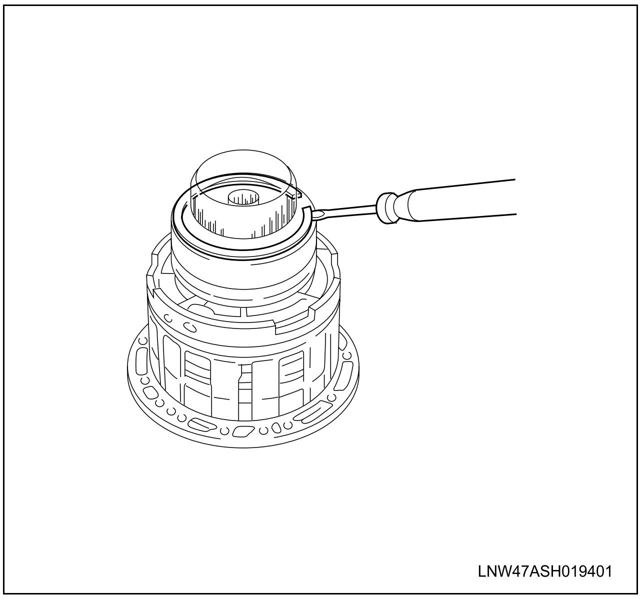
If the piston stroke is less than specified, parts may have been assembled incorrectly, check and reassemble again.



Front Clutch

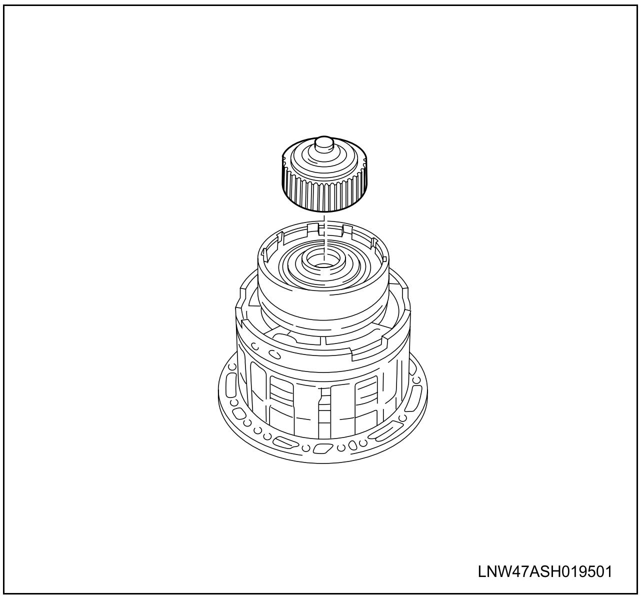
Disassembly

1. Remove rear and front clutch hubs.
   a. Place the front clutch assembly onto the OD case assembly.
   b. Using a screwdriver, remove the snap ring.
   c. Remove the rear clutch hub.



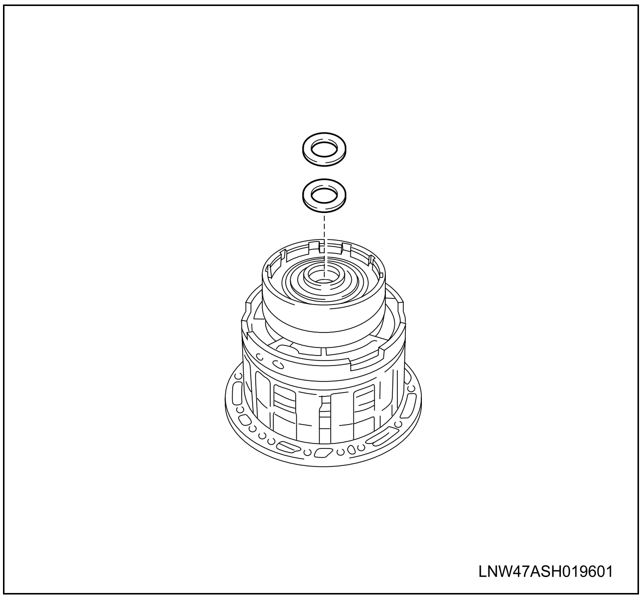
LNW47ASH019401

   d. Remove the front clutch hub.



LNW47ASH019501

   e. Remove the race and thrust bearing.



LNW47ASH019601

2. Check piston stroke of front clutch.
   a. Install No.1 measure terminal to a dial indicator.

Tool Required: J-44167 No.1 Measure Terminal

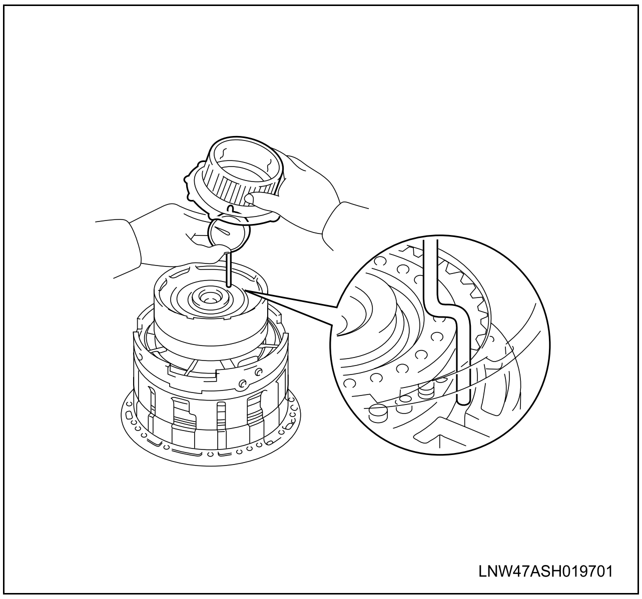
   b. Place the assembled measure terminal and a dial indicator on the clutch piston.

Notice:

- Stand the measure terminal on the piston vertically.
- Ensure that the measure terminal does not touches other parts than the piston.

   c. Install the rear clutch hub with the snap ring.

Notice:
Do not install the front clutch hub.

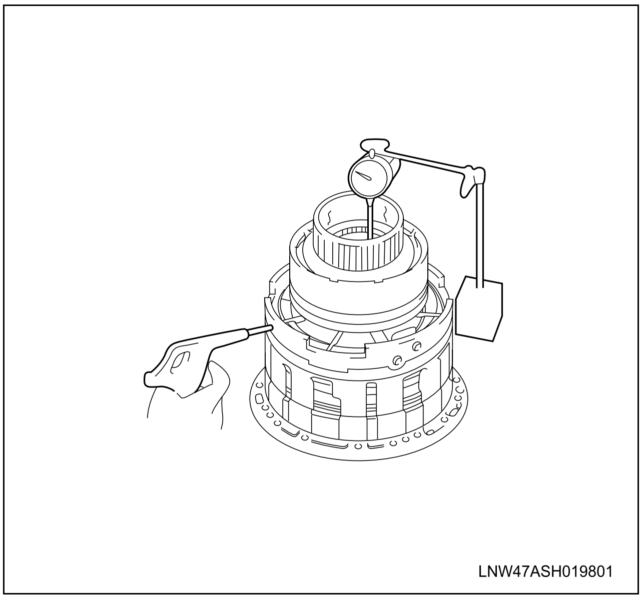


LNW47ASH019701

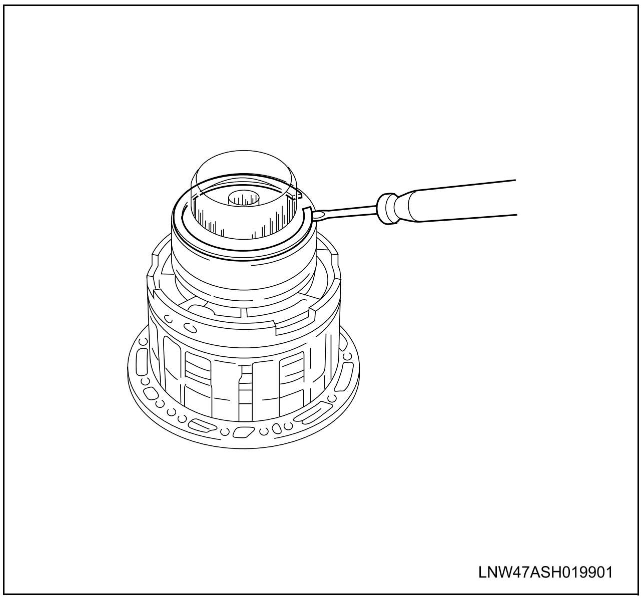
d. Using No.1 measure terminal and a dial indicator, measure the piston stroke by applying and releasing compressed air 392–785 kPa (4–8 kgf/cm^2, 57–114 psi).

Piston stroke: 3.93–4.23 mm (0.1547–0.1665 in.)

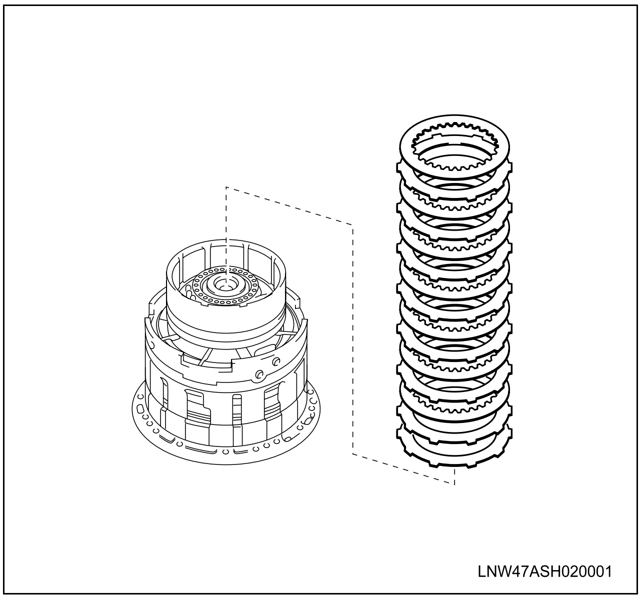
Notice:
Measure the stroke at more than 3 points. If the piston stroke is greater than specified, inspect the discs.


LNW47ASH019801

3. Remove discs, plates and cushion plate.
   a. Remove the snap ring and rear clutch hub.


LNW47ASH019901

b. Remove the 7 discs, 7 plates and cushion plate.


LNW47ASH020001

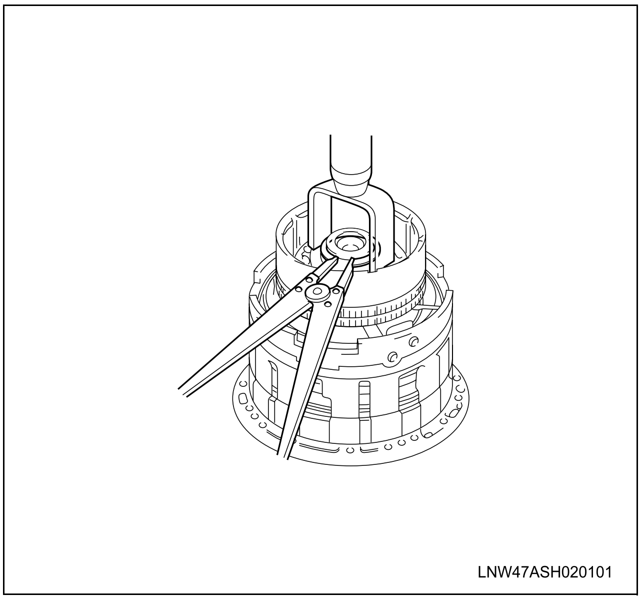
4. Remove piston return springs.
   a. Place No.2 piston spring compressor on the spring seat, and compress the return springs with a shop press.

Tool Required: J-44160 No.2 Piston Spring Compressor

Notice:
Stop compressing the return spring at the position 1 to 2 mm away from the snap ring to prevent the spring sheet from being deformed.

b. Using snap ring pliers, remove the snap ring.

Notice:
Do not damage the snap ring and do not deform them unless necessary.

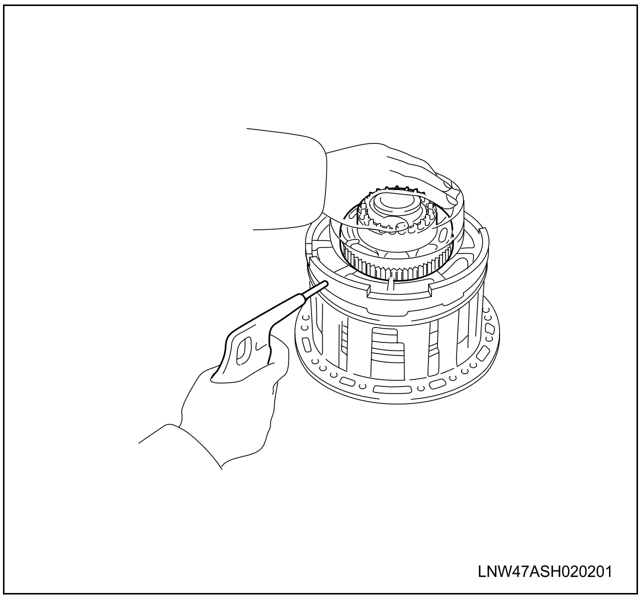

LNW47ASH020101

c. Remove the piston return spring.

5. Remove front clutch piston.

a. Holding the clutch piston by hand, apply compressed air 392–785 kPa (4–8 kgf/cm^2, 57–114 psi) into the oil hole of the overdrive (OD) case to remove the clutch piston.

b. Remove the 2 O-rings from the clutch piston.

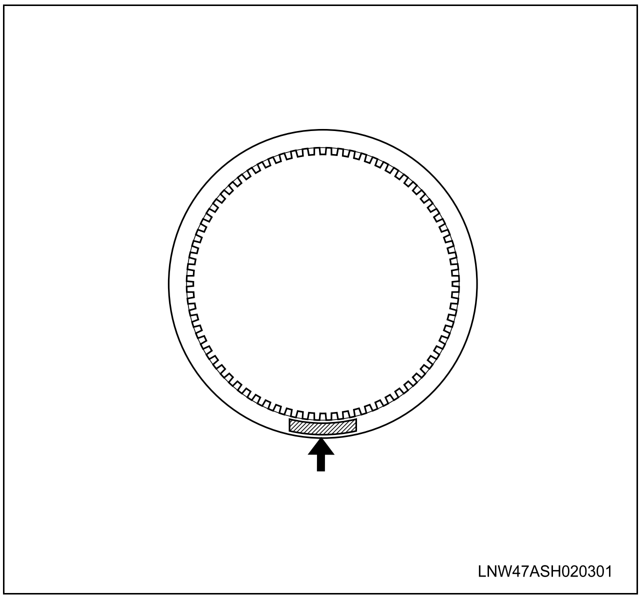

LNW47ASH020201

Inspection Procedure

1. Inspect discs, plates and cushion plate.
   Check to see if the contacting surface of the disc, plate and cushion plate are worn or burnt. If necessary, replace them.

Notice:

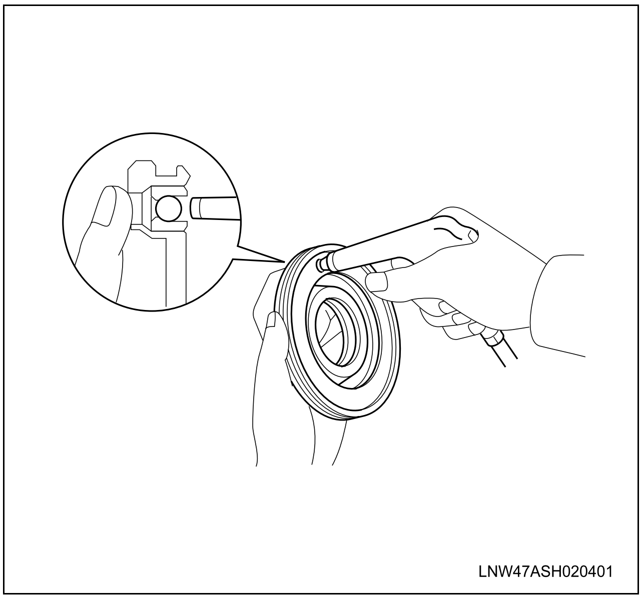
- If the lining of the disc is peeling off or discolored, or even if a parts of the printed numbers are defaced, replace all discs.
- Before assembling new discs, soak them in ATF for at least 15 minutes.


LNW47ASH020301

2. Inspect front clutch piston.

a. Check that the check ball is free by shaking the piston.

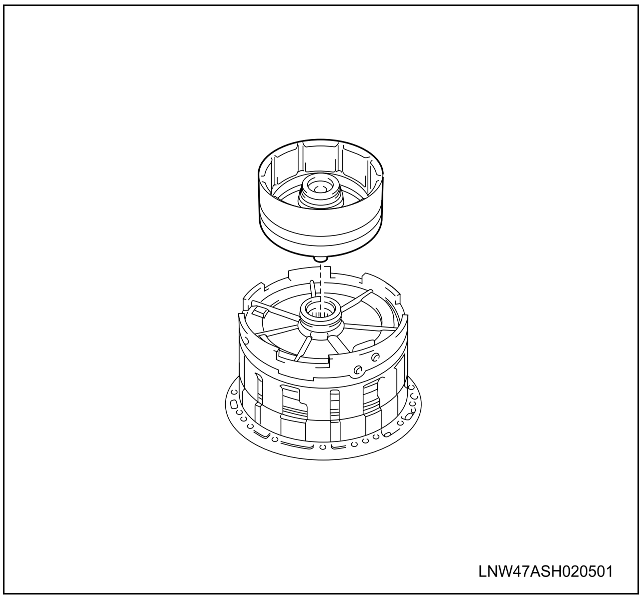
b. Check that the valve does not leak by applying compressed air 392–785 kPa (4–8 kgf/cm^2, 57–114 psi).


LNW47ASH020401

Reassembly

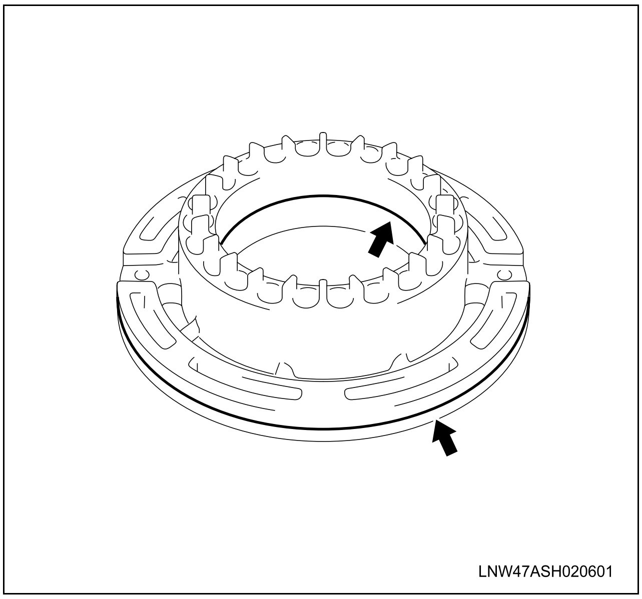
1. Install front clutch piston.

a. Place front clutch drum onto overdrive (OD) case assembly.


LNW47ASH020501

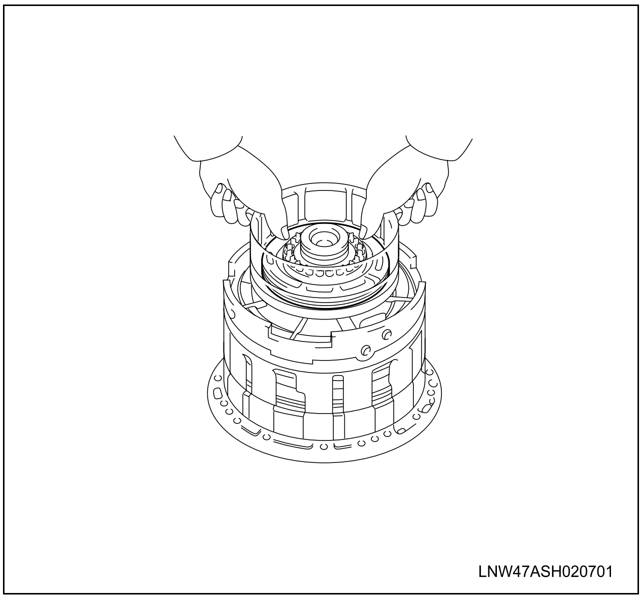
b. Coat new 2 O-rings with ATF, and install them on the clutch piston.

O-ring diameters		mm (in.)
	Inside	Wire diameter
Inner side	62.9 (2.476)	2.6 (0.102)
Outer side	117.4 (4.622)	3.1 (0.122)


LNW47ASH020601

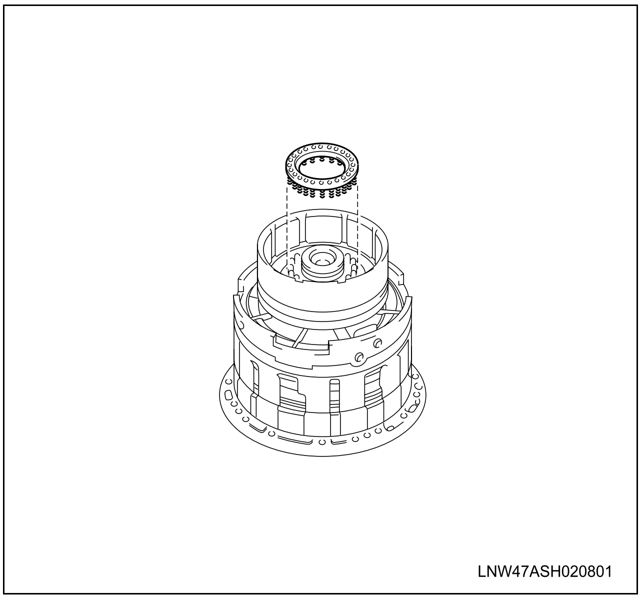
c. Push in the clutch piston into the clutch drum by both hands.

Caution:
Be careful not to damage the O-rings.


LNW47ASH020701

2. Install piston return springs.

a. Install the piston return spring on the clutch piston.


LNW47ASH020801

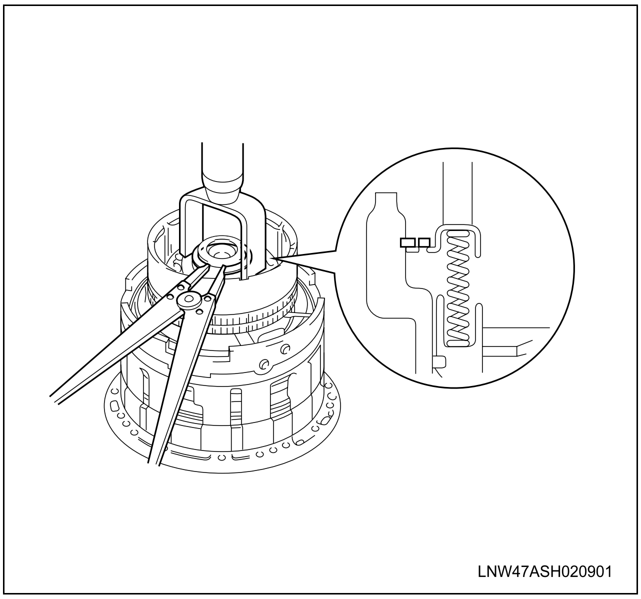
b. Place No.2 piston spring compressor on the spring seat, and compress the return springs with a shop press.

Tool Required: J-44160 No.2 Piston Spring Compressor

Notice:
Stop compressing the return spring at the position 1 to 2 mm away from the snap ring to prevent the spring sheet from being deformed.

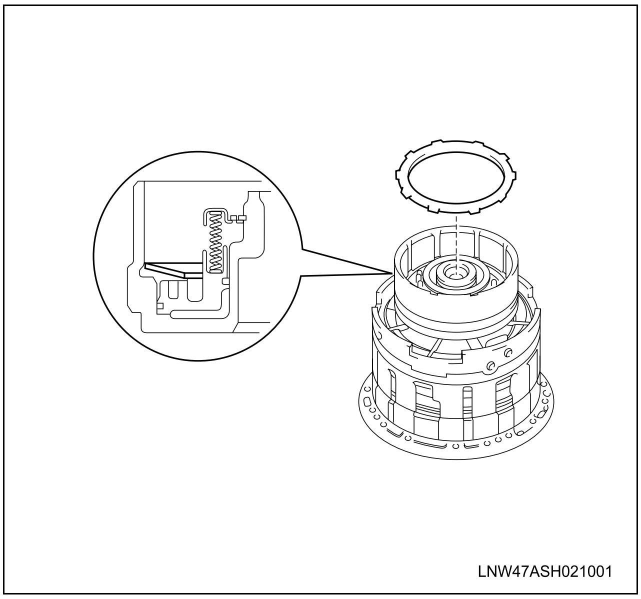
c. Using snap ring pliers, install the snap ring.

Notice:
Be sure the end gap of the ring is not aligned with the spring seat claw.


LNW47ASH020901

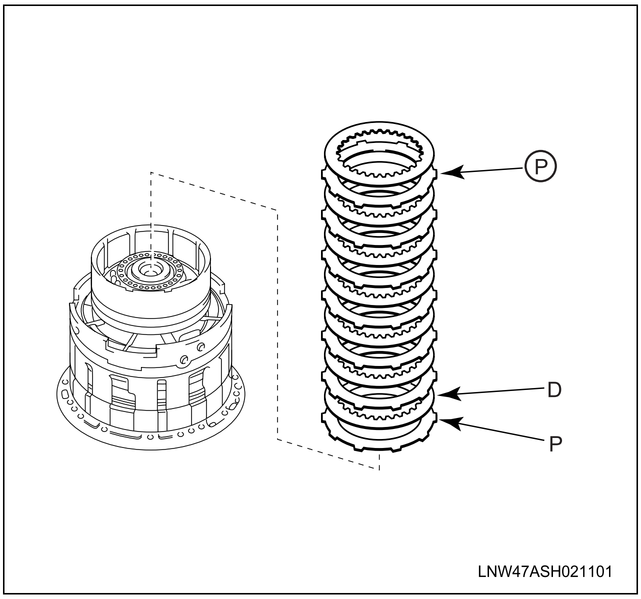
3. Install cushion plate, plates and discs.

a. Install the cushion plate, facing the rounded edge downward.



b. Install the 7 plates and 7 discs in order:
P = Plate D = Disc
P – D – P – D – P – D – P – D – P – D – P – D – P – D

Notice:
P = This plate is used to adjust piston stroke.



4. Check piston stroke of front clutch.
   a. Install No.1 measure terminal to a dial indicator.

Tool Required: J-44167 No.1 Measure Terminal

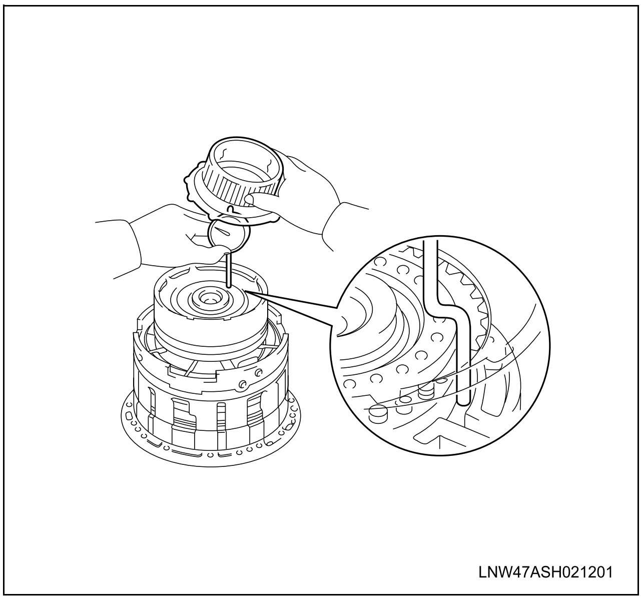
b. Place the assembled measure terminal and a dial indicator on the clutch piston.

Notice:

- Stand the measure terminal on the piston vertically.
- Ensure that the measure terminal does not touches other parts than the piston.

c. Install the rear clutch hub with the snap ring.

Notice:
Do not install the front clutch hub.



d. Using No.1 measure terminal and a dial indicator, measure the piston stroke by applying and releasing compressed air 392–785 kPa (4–8 kgf/cm^2, 57–114 psi).

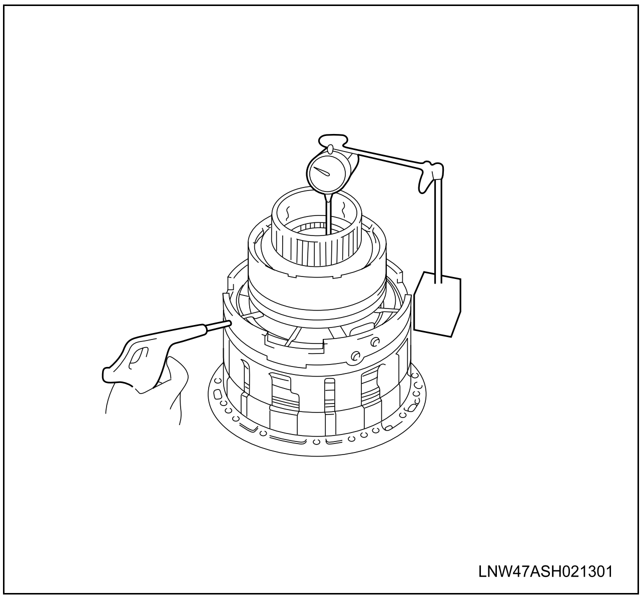
Piston stroke: 3.93–4.23 mm (0.1547–0.1665 in.)

Notice:
Measure the stroke at more than 3 points.

If the piston stroke is less than specified, parts may have been assembled incorrectly, check and reassemble again.
If the piston stroke is not as specified, select another plate.

Plate thicknesses mm (in.)
1.8 (0.071)
2.0 (0.079)
2.2 (0.087)
2.4 (0.094)

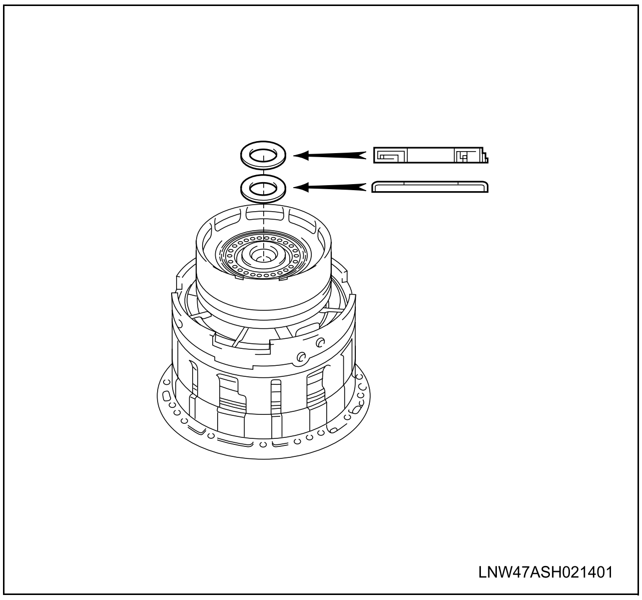
e. Remove the snap ring and rear clutch hub.



5. Install front and rear clutch hubs.
   a. Coat the race and thrust bearing with petroleum jelly, and install them onto the front clutch drum.

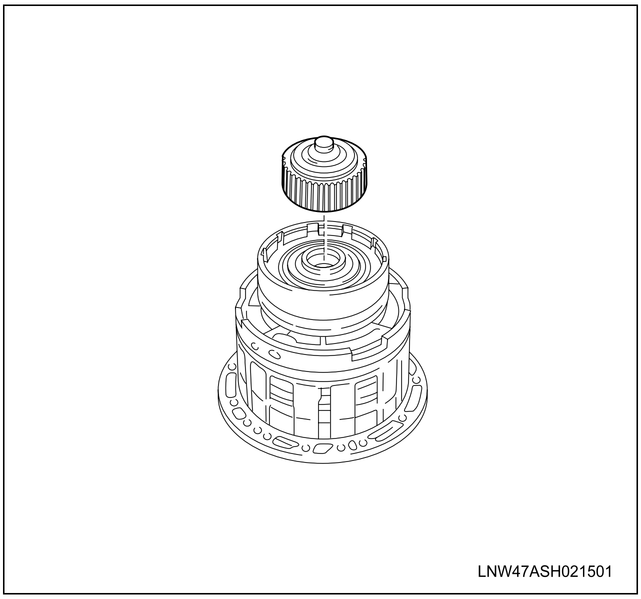
Race and bearing diameter

Diameter mm (in.)	Inside	Outside
Bearing	32.8 (1.291)	52.0 (2.047)
Race	37.0 (1.457)	52.0 (2.047)



b. Install the front clutch hub into the clutch drum.

Notice:
Mesh the spline of the front clutch hub with the flukes of the discs by rotating the front clutch hub clockwise or counterclockwise.

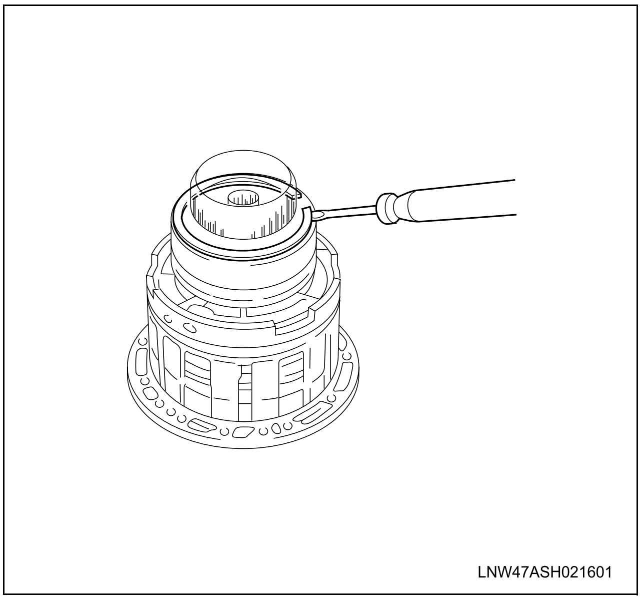


c. Install the rear clutch hub onto the clutch drum.

d. Using a screwdriver, install the snap ring.

Notice:
Be sure the end gap of the snap ring is not aligned with the cutout portion of the front clutch drum.

e. Remove the front clutch assembly from the overdrive (OD) case.



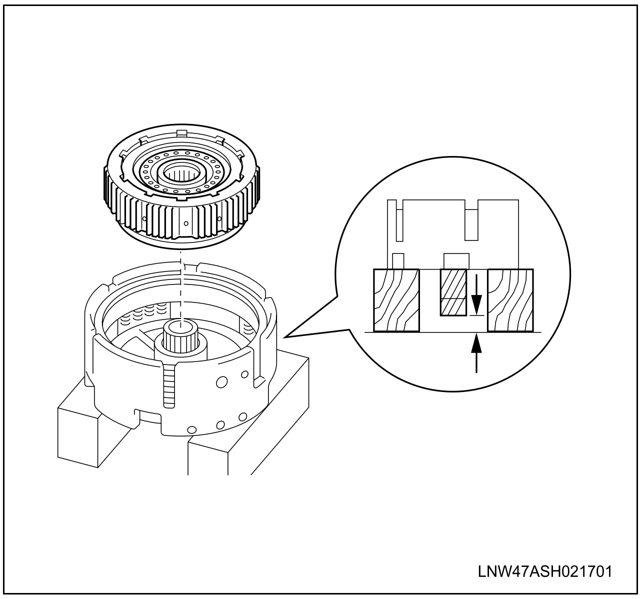
Rear Clutch

Disassembly

1. Check piston stroke of rear clutch.
   a. Place the center support assembly on wooden blocks.

Notice:
Provide clearance so that the sun gear does not touch the rear clutch drum.

b. Place the rear clutch assembly into the center support assembly.


LNW47ASH021701

Using No.1 measure terminal and a dial indicator, measure the piston stroke by applying and releasing the compressed air 392–785 kPa (4–8 kgf/cm^2, 57–114 psi).

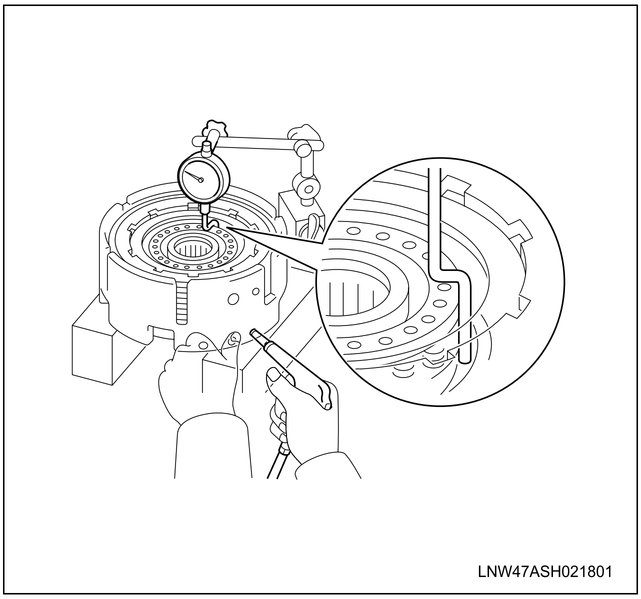
Tool Required: J-44167 No.1 Measure Terminal

Piston stroke: 2.00–2.20 mm (0.0787–0.0866 in.)

Notice:

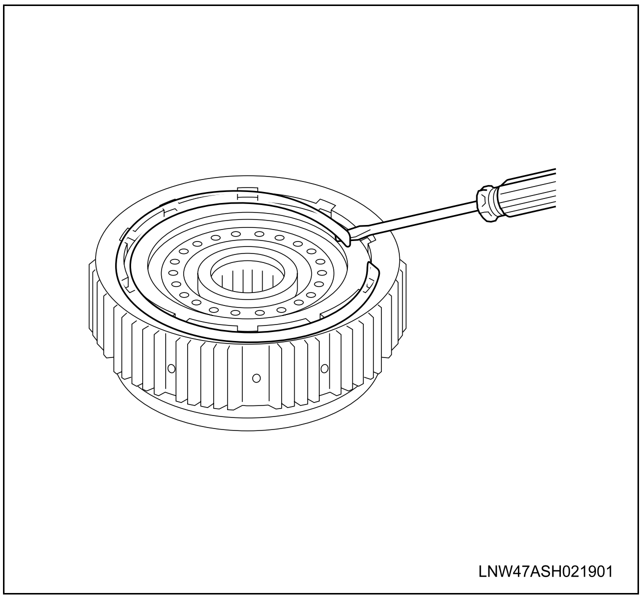
- Stand the measure terminal on the piston vertically.
- Ensure that the measure terminal does not touches other parts than the piston.
- Measure the stroke at more than 3 points.

If the piston stroke is greater than specified, inspect the discs.

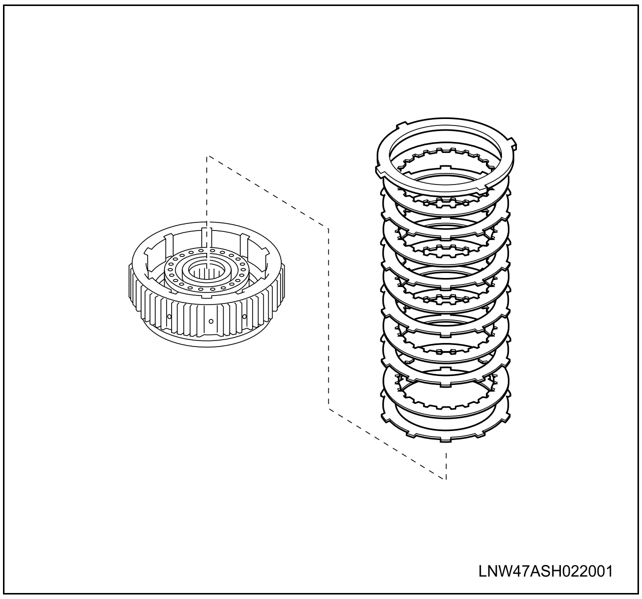

LNW47ASH021801

2. Remove flange, discs and plates.

a. Using a screwdriver, remove the snap ring.


LNW47ASH021901

b. Remove the flange, 5 discs and 5 plates.


LNW47ASH022001

3. Remove piston return spring.

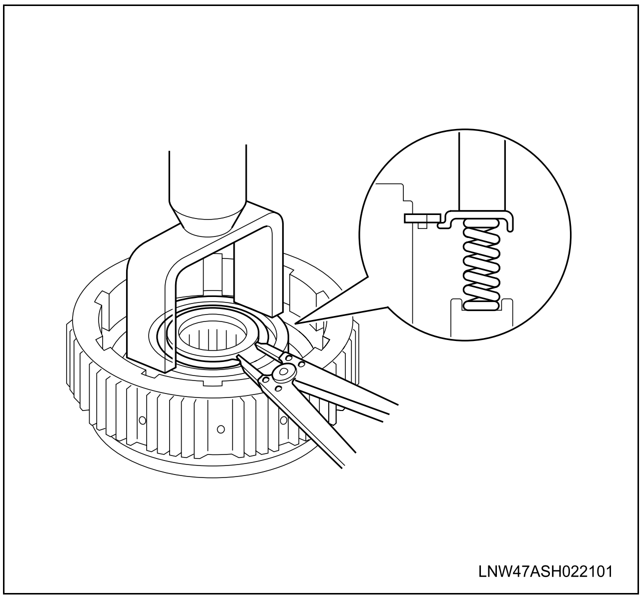
a. Place No.2 piston spring compressor on the spring seat, and compress the return spring with a shop press.

Tool Required: J-44160 No.2 Piston Spring Compressor

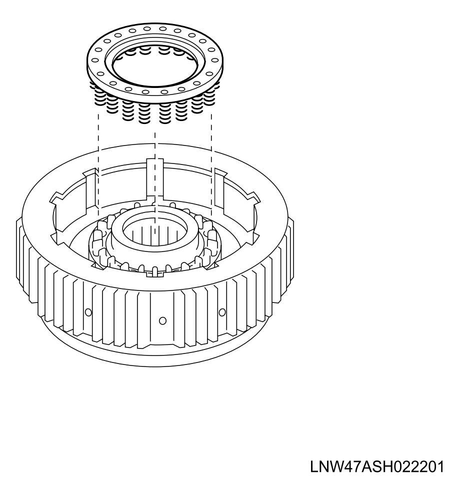
Notice:
Stop compressing the return spring at the position 1 to 2 mm away from the snap ring to prevent the spring sheet from being deformed.

b. Using snap ring pliers, remove the snap ring.

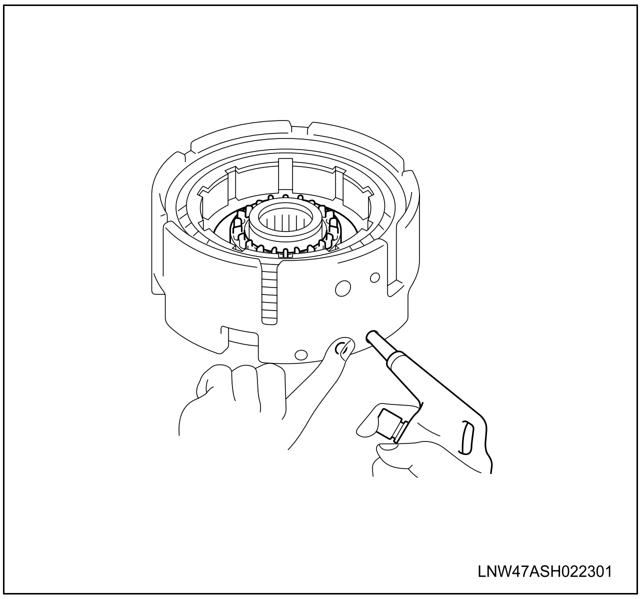
Notice:
Do not damage the snap ring and do not deform them unless necessary.



c. Remove the piston return spring.



4. Remove rear clutch piston.
   a. Place the center support assembly on wooden blocks.
   b. Place the rear clutch drum onto the center support assembly.
   c. Hold the piston with hand, apply compressed air 392–785 kPa (4–8 kgf/cm^2, 57–114 psi) into the oil hole of the center support to remove the clutch piston.
   d. Remove the 2 O-rings from the clutch piston.

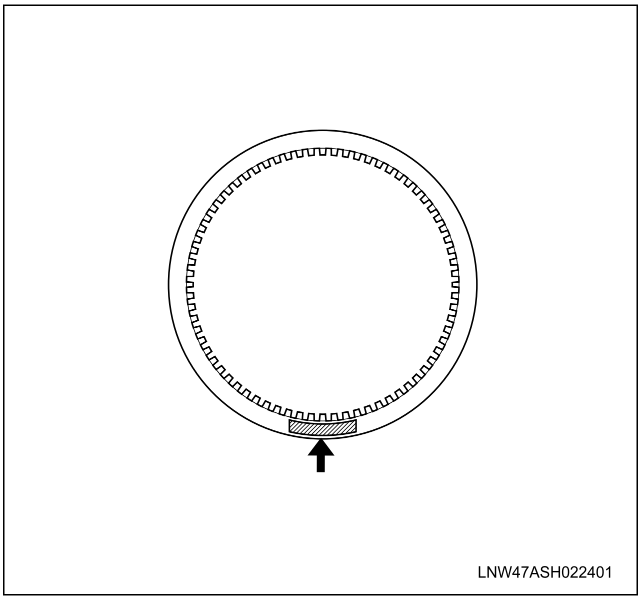


Inspection Procedure

1. Inspect discs, plates and flange.
   Check to see if the contacting surface of the disc, plate and flange are worn or burnt. If necessary, replace them.

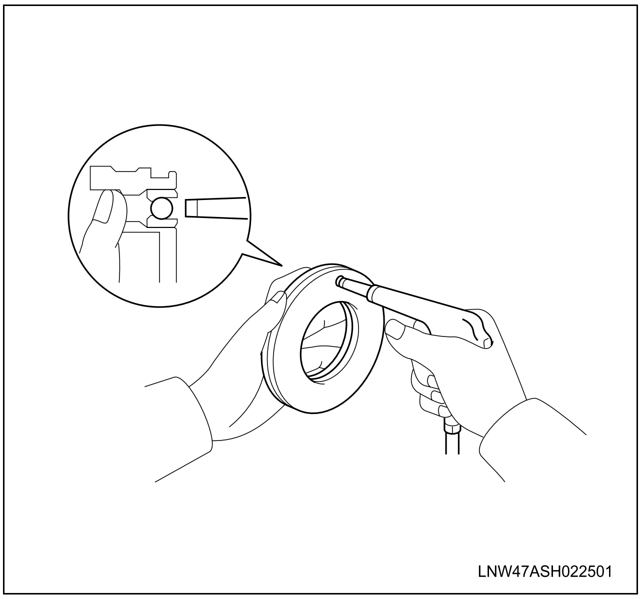
Notice:

- If the lining of the disc is peeling off or discolored, or even if a parts of the printed numbers are defaced, replace all discs.
- Before assembling new discs, soak them in automatic transmission fluid (ATF) for at least 15 minutes.



2. Inspect rear clutch piston.
   a. Check that check ball is free by shaking the piston.

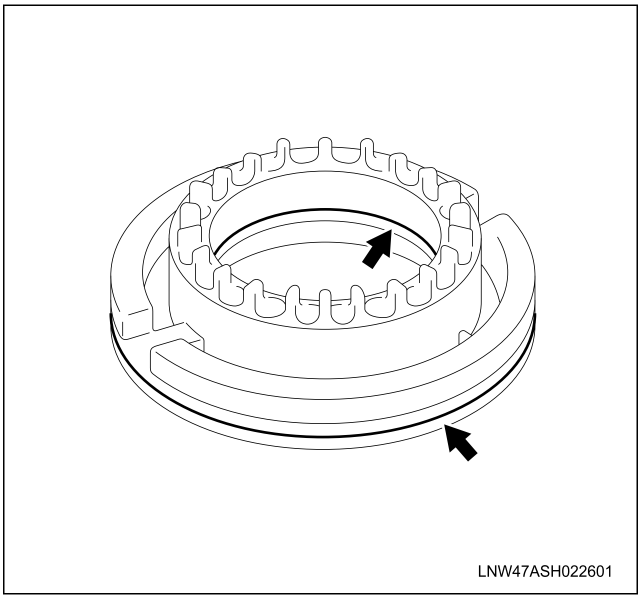
b. Check that the valve does not leak by applying low-pressure compressed air.



Reassembly

1. Install rear clutch piston.
   a. Coat new O-rings with automatic transmission fluid (ATF), and install them in the clutch drum.

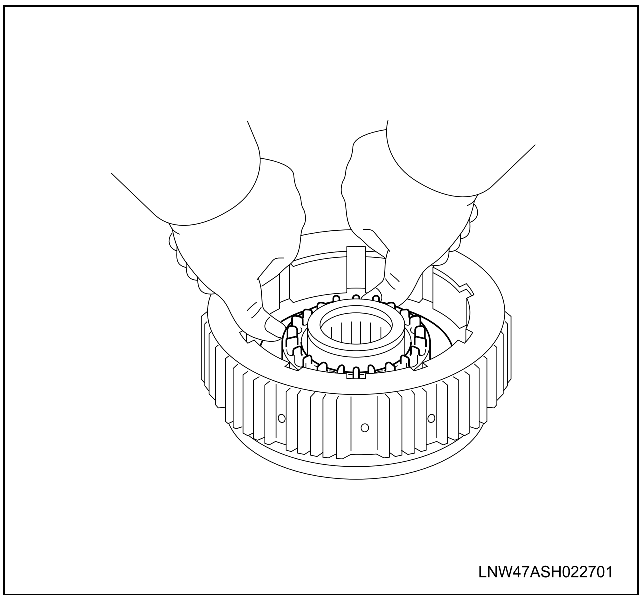
O-ring diameters		mm (in.)
	Inside	Wire diameter
Inner side	62.9 (2.4767)	2.6 (0.1024)
Outer side	109.7 (4.3189)	3.1 (0.1220)



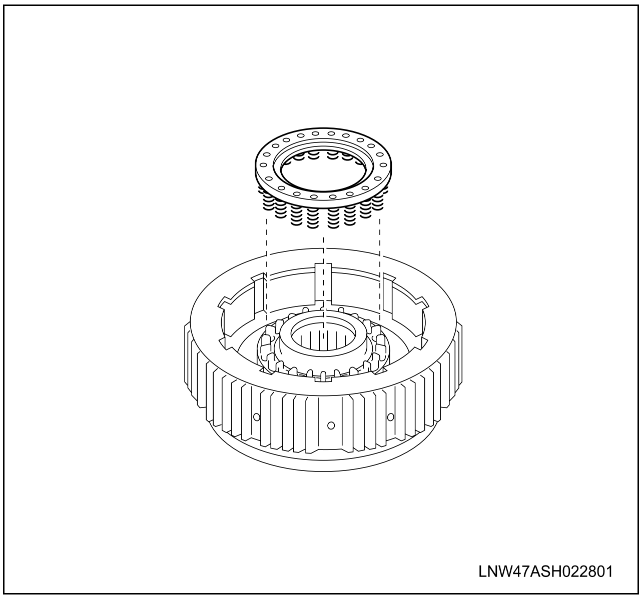
b. Push in the clutch piston into the clutch drum with both hands.

Caution:
Be careful not to damage the O-rings.

Notice:
Push in the piston uniformly.



2. Install piston return springs.
   a. Place the piston return spring on the clutch piston.



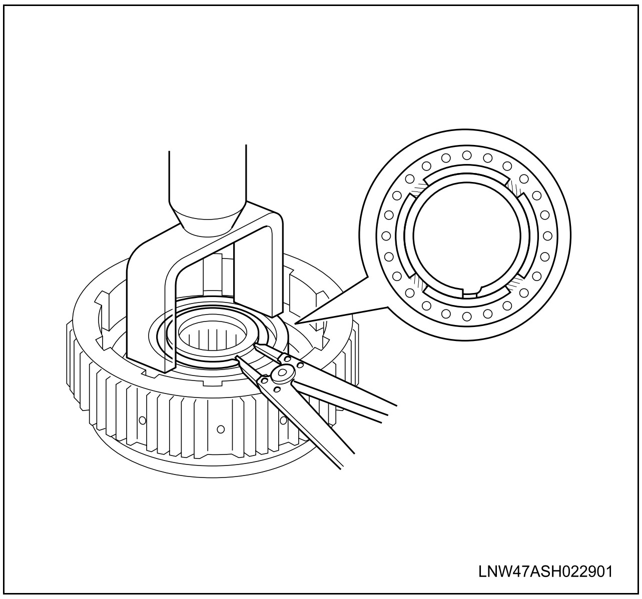
b. Place No.2 piston spring compressor on the spring seat, and compress the return spring with a shop press.

Tool Required: J-44160 No.2 Piston Spring Compressor

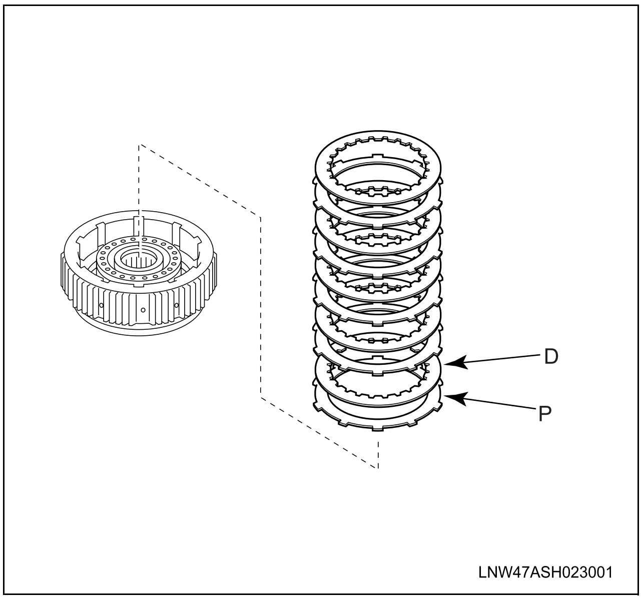
Notice:
Stop compressing the return spring at the position 1 to 2 mm away from the snap ring to prevent the spring sheet from being deformed.

c. Using snap ring pliers, install the snap ring.

Notice:
Be sure the end gap of the snap ring is not aligned with the spring retainer claw.

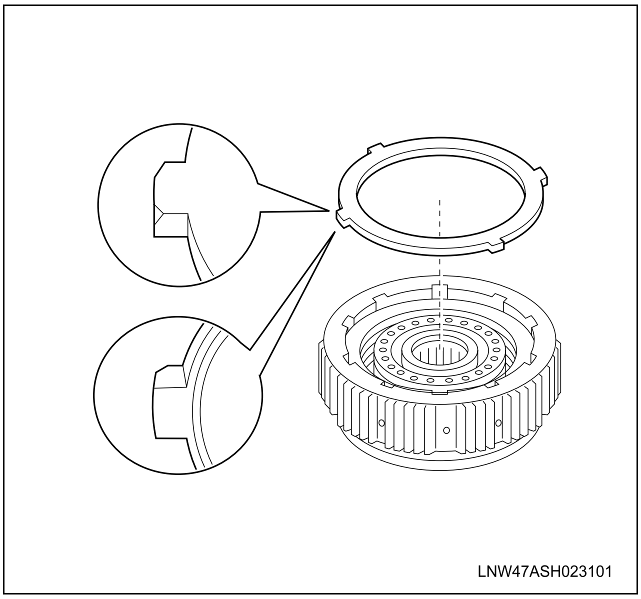


3. Install plates, discs and flange.
   a. Install the 5 plates and 5 discs in order:
      P = Plate D = Disc
      P – D – P – D – P – D – P – D – P – D



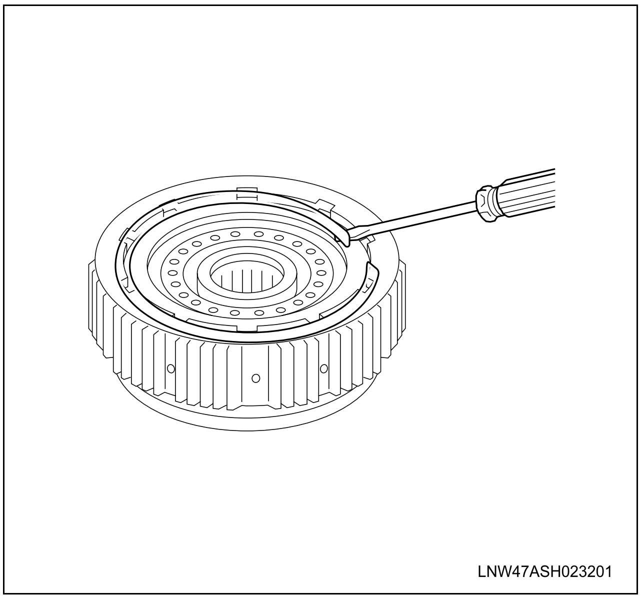
   b. Install the flange, facing the rounded edge upward.

Notice:
If the flange is step-edged, install the flange with the step-edge, facing downward.



   c. Using a screwdriver, install the snap ring.

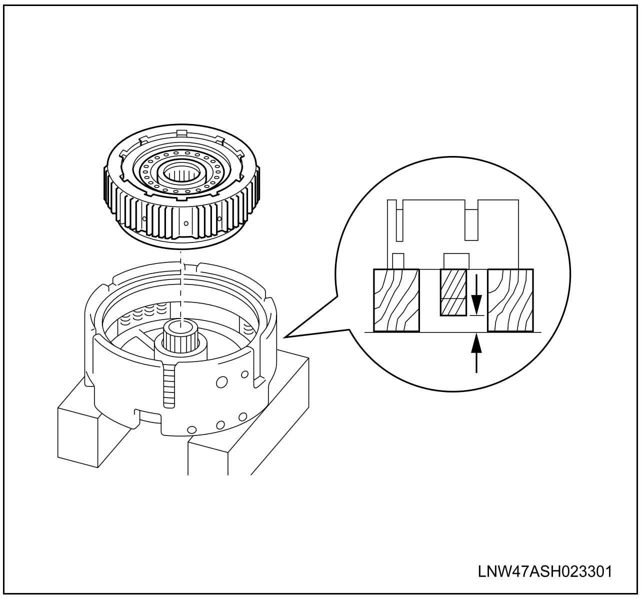
Notice:
Be sure the end gap of the snap ring is not aligned with the cutout portion of the rear clutch drum.



4. Check piston stroke of rear clutch.
   a. Place the center support assembly on wooden blocks.

Notice:
Provide clearance so that the sun gear does not touch the rear clutch drum.

b. Place the rear clutch assembly onto the center support assembly.


LNW47ASH023301

c. Using No.1 measure terminal and a dial indicator, measure the piston stroke while applying and releasing compressed air 392–785 kPa (4–8 kgf/cm^2, 57–114 psi).

Tool Required: J-44167 No.1 Measure Terminal

Piston stroke: 2.00–2.20 mm (0.0787–0.0866 in.)

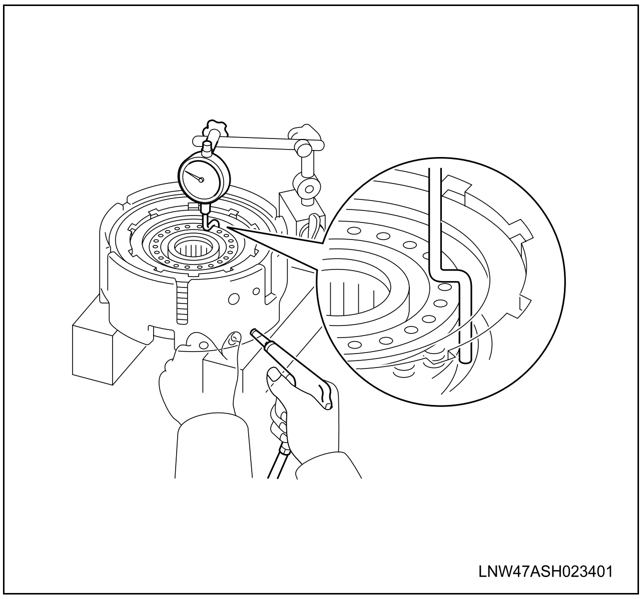
Notice:

- Stand the measure terminal on the piston vertically.
- Ensure that the measure terminal does not touches other parts than the piston.
- Measure the stroke at more than 3 points.

If the piston stroke is less than specified, parts may have been assembled incorrectly, check and reassemble again.
If the piston stroke is not as specified, select another flange.

Flange thicknesses

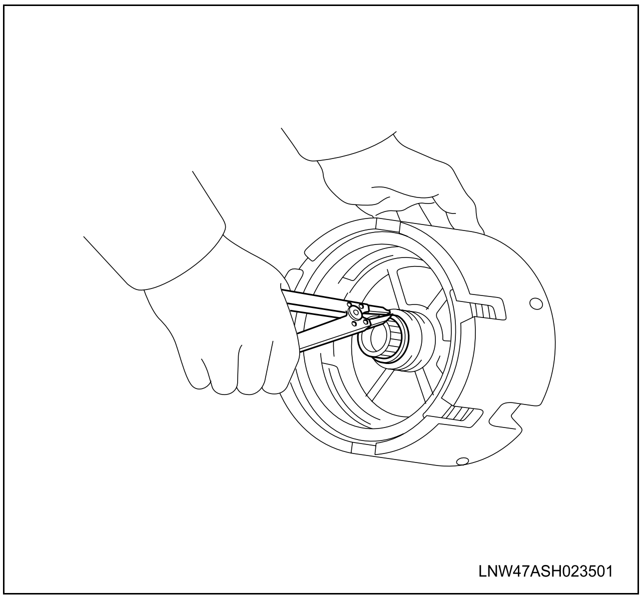
No.	Thickness mm (in.)
A	5.0 (0.197)
B	5.2 (0.205)
E	4.6 (0.181)
F	4.8 (0.189)


LNW47ASH023401

Second Brake

Disassembly

1. Remove front planetary sun gear.
   a. Using snap ring pliers, remove the snap ring.


LNW47ASH023501

   b. Remove the sun gear.
2. Check piston stroke of second brake.
   Using No.2 measure terminal and a dial indicator, measure the piston stroke by applying and releasing compressed air 392–785 kPa (4–8 kgf/cm^2, 57–114 psi).

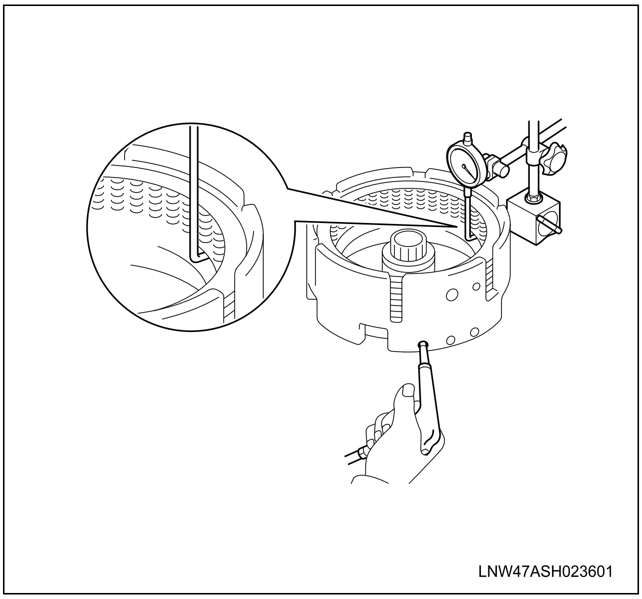
Tool Required: J-44168 No.2 Measure Terminal

Piston stroke: 1.86–2.06 mm (0.0732–0.0811 in.)

Notice:

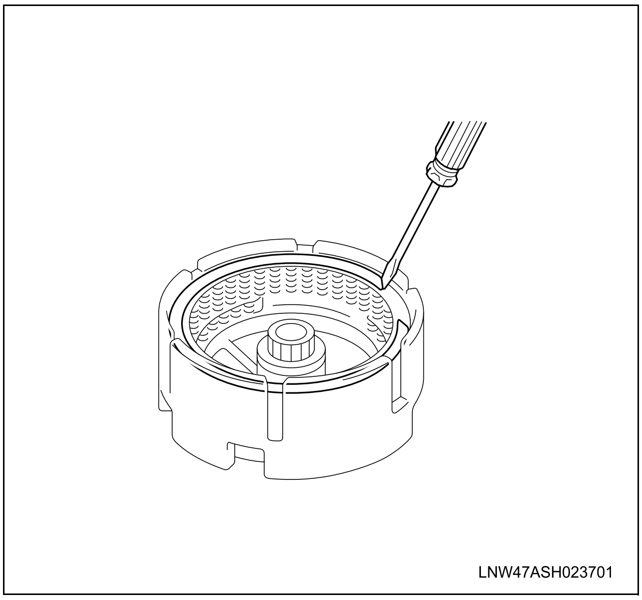
- Stand the measure terminal on the piston vertically.
- Ensure that the measure terminal does not touches other parts than the piston.
- Measure the stroke at more than 3 points.

If the piston stroke is greater than specified, inspect the discs.



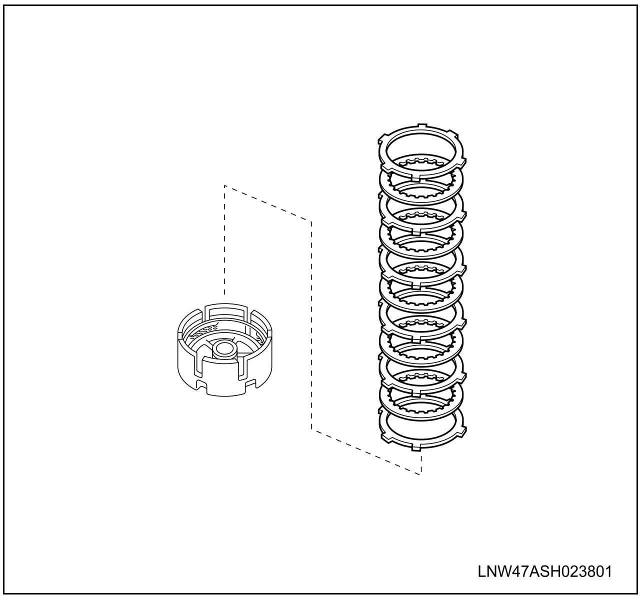
LNW47ASH023601

3. Remove flange, discs and plates.
   a. Using a screwdriver, remove the snap ring.



LNW47ASH023701

   b. Remove the flange, 5 discs and 5 plates.



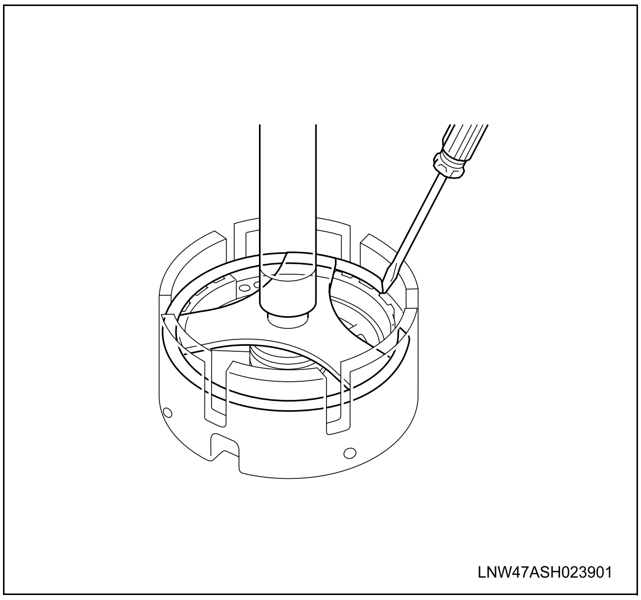
LNW47ASH023801

4. Remove piston return spring.
   a. Place No.3 piston spring compressor on the spring seat, and compress the return spring with a shop press.

Tool Required: J-44161 No.3 Piston Spring Compressor

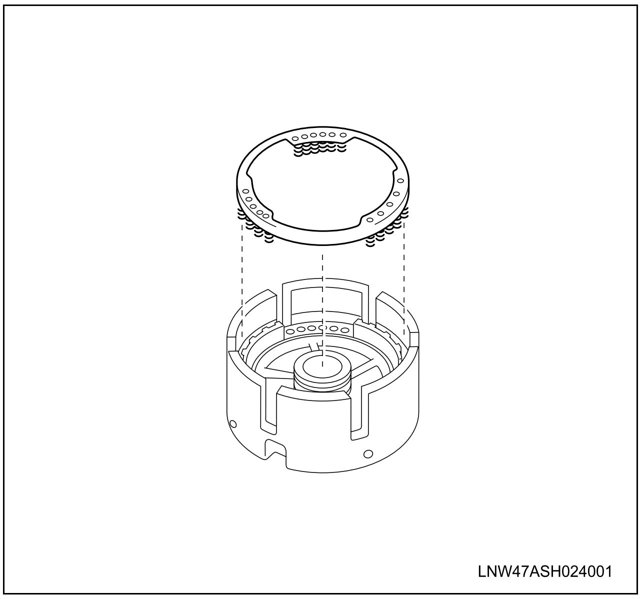
Notice:
Stop compressing the return spring at the position 1 to 2 mm away from the snap ring to prevent the spring sheet from being deformed.

   b. Using a screwdriver, remove the snap ring.



LNW47ASH023901

c. Remove the piston return spring.


LNW47ASH024001

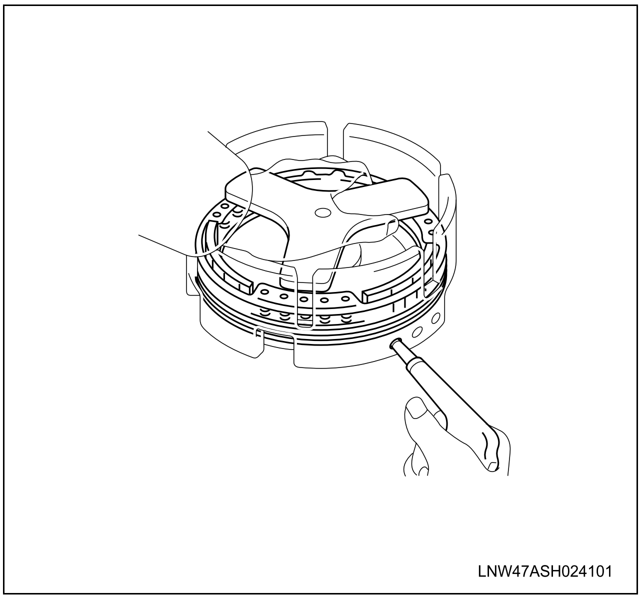
5. Remove second brake piston.
    a. Place the No.3 piston spring compressor on the brake piston.

Tool Required: J-44161 No.3 Piston Spring Compressor

b. Hold the spring compressor so it does not slant, and apply compressed air 392–785 kPa (4–8 kg/cm^2, 57–114 psi) into the oil hole of the center support to remove the brake piston.

Notice:
Be careful not to slant the brake piston while applying compressed air. If the brake piston slants, it is difficult to remove.

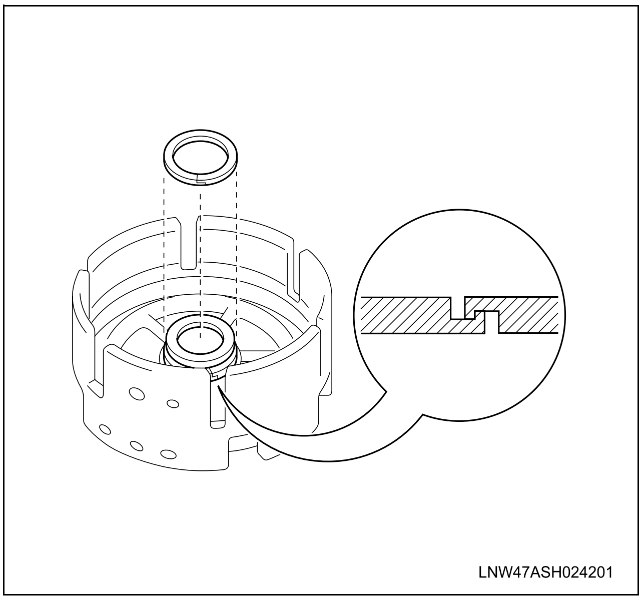
c. Remove the 2 O-rings from the brake piston.


LNW47ASH024101

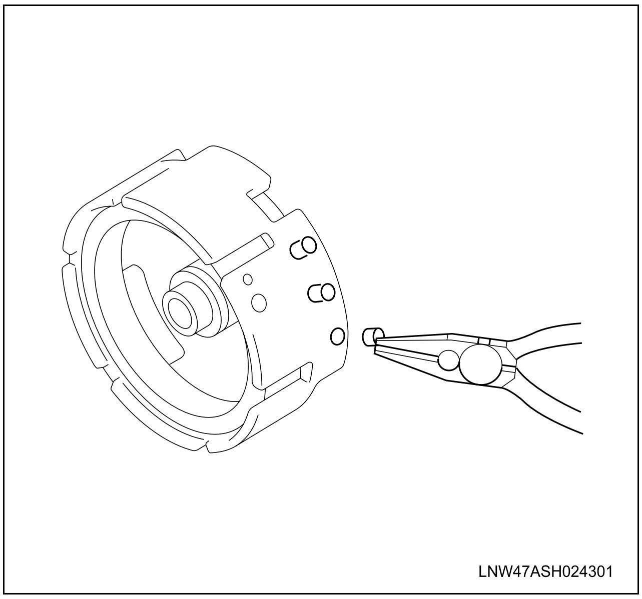
6. Remove oil seal rings.
   Remove the 2 oil seal rings from the center support.

Caution:

- Do not damage the oil seal rings and do not deform them unless necessary.
- Do not damage the claws on the oil seal rings.


LNW47ASH024201

7. Remove ring retainers.
   Using needle nose pliers, remove the 3 ring retainers from the oil holes of the center support.

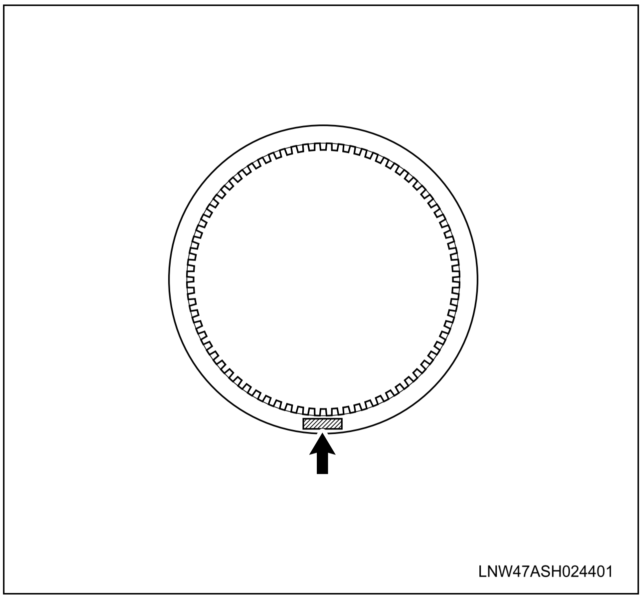

LNW47ASH024301

Inspection Procedure

1. Inspect discs, plates and flange.
   Check to see if the contacting surface of the disc, plate and flange are worn or burnt. If necessary, replace them.

Notice:

- If the lining of the disc is peeling off or discolored, or even if parts of the printed numbers are defaced, replace all discs.
- Before assembling new discs, soak them in ATF for at least 15 minutes.

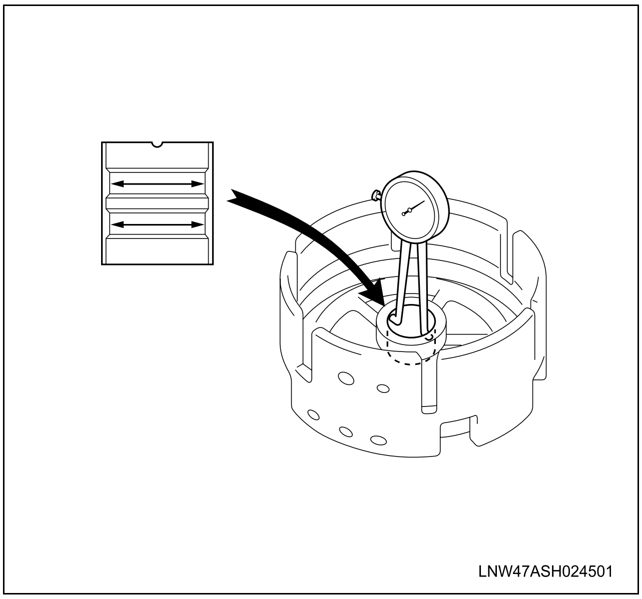

LNW47ASH024401

2. Inspect bushing of center support.
   Using a dial indicator, measure the inside diameter.

Standard inside diameter:	35.000–35.025 mm (1.3780–1.3789 in.)
Maximum inside diameter:	35.08 mm (1.3811 in.)

Notice:
Measure at several points and take the average value.

If the inside diameter is greater than the maximum, replace the center support.
Inspect the bushing contacting surface of the front planetary sun gear, when discoloration or damage on the surface is found, replace the front planetary sun gear with a new one.

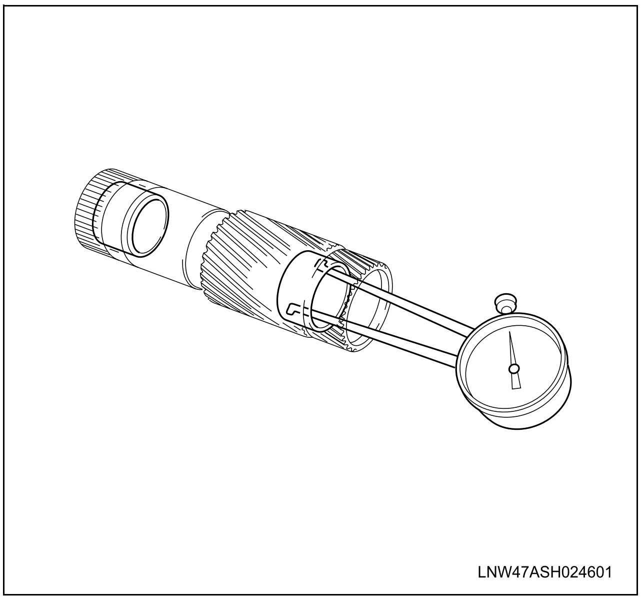

LNW47ASH024501

3. Inspect bushings of front planetary sun gear.
   Using a dial indicator, measure the inside diameter.

Standard inside diameter:	25.500–25.521 mm (1.0039–1.0048 in.)
Maximum inside diameter:	25.570 mm (1.0067 in.)

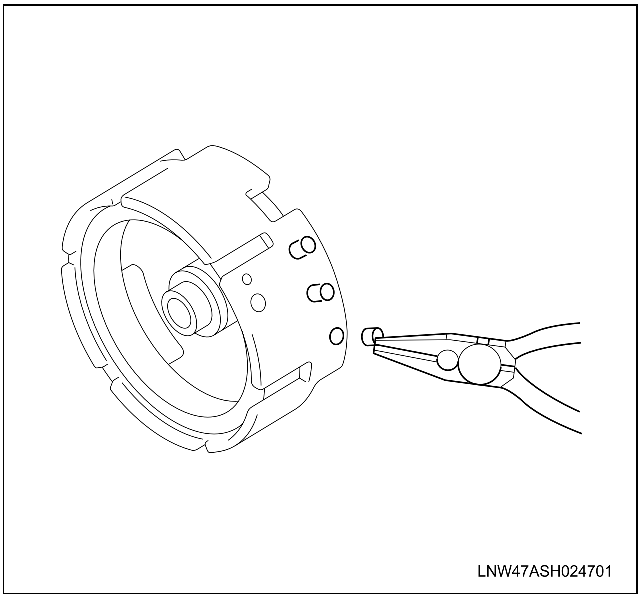
Notice:
Measure at several points and take the average value.

If the inside diameter is greater than the maximum, replace the front planetary sun gear.
Inspect the bushing contacting surface of the intermediate shaft, when discoloration or damage on the surface is found, replace the intermediate shaft with a new one.


LNW47ASH024601

Reassembly

1. Install ring retainers.
   Using needle nose pliers, install the 3 ring retainers into the oil holes of the center support.


LNW47ASH024701

2. Install oil seal rings.

a. Coat the new 2 oil seal rings with automatic transmission fluid (ATF).

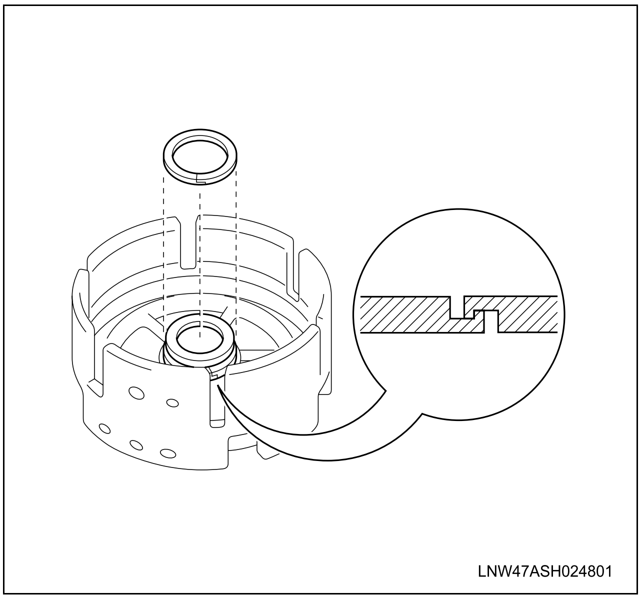
b. Contract the oil seal rings, and install them onto the center support.

Caution:

- Do not spread the ring ends more than necessary.
- Do not damage the claws on the oil seal rings.

Notice:

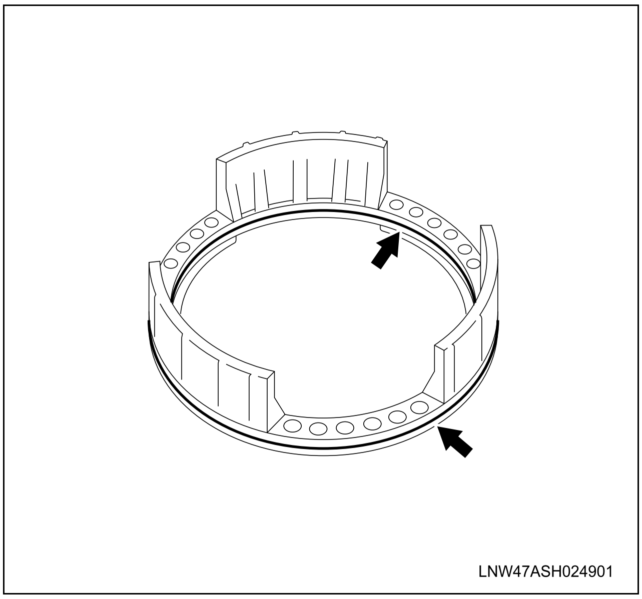
- If the oil seal rings are damaged or deformed, replace them with new ones.
- After installing the oil seal rings, check that they rotate smoothly.



3. Install second brake piston.

a. Coat the new 2 O-rings with ATF, and install them on the brake piston.

O-ring diameters		mm (in.)
	Inside	Wire diameter
Inner side	145.3 (5.72047)	3.1 (0.12208)
Outer side	163.7 (6.44489)	3.1 (0.12208)

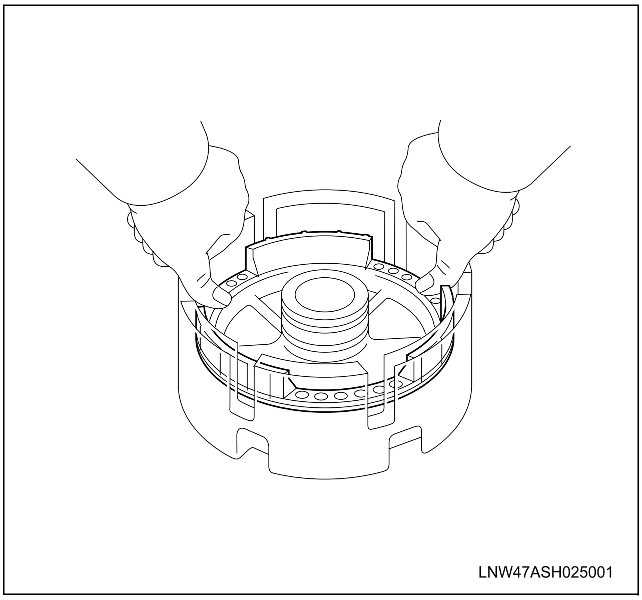


b. Align the protrusions of the brake piston with the grooves of the center support.

c. Push in the brake piston into the center support with both hands.

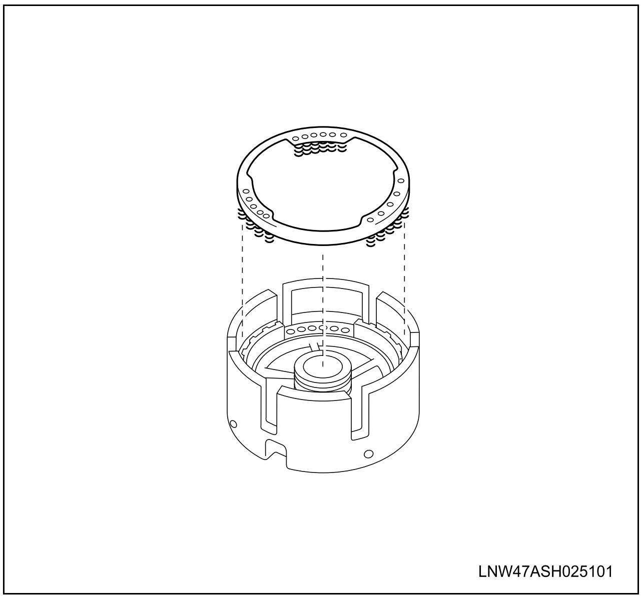
Caution:

- Be careful not to damage the O-rings.
- Push in the piston uniformly.



4. Install piston return spring.

a. Place the return spring on the brake piston.


LNW47ASH025101

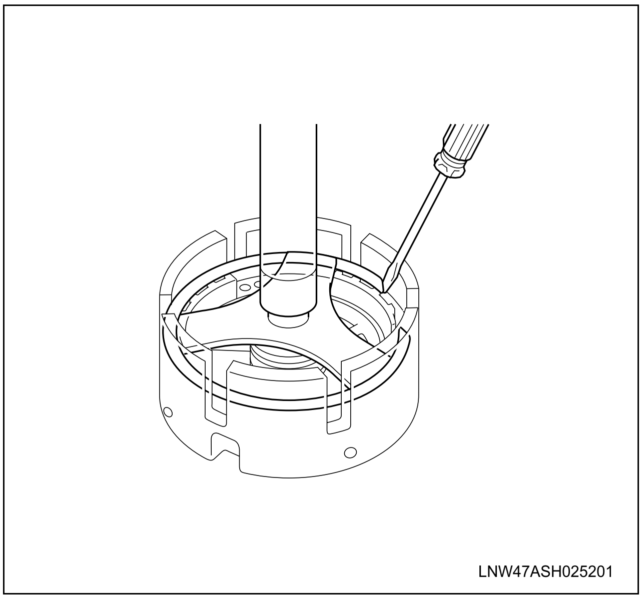
b. Place the No.3 piston spring compressor on the return spring, and compress the return spring with a shop press.

Tool Required: J-44161 No.3 Piston Spring Compressor

Notice:
Stop compressing the return spring at the position 1 to 2 mm away from the snap ring to prevent the spring sheet from being deformed.

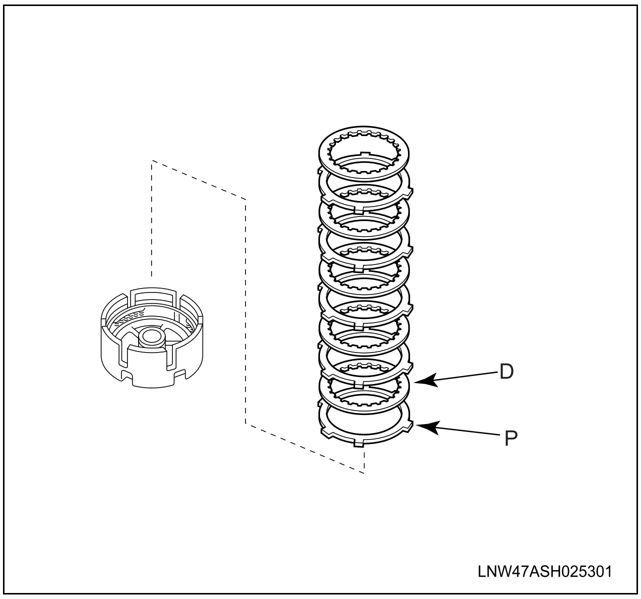
c. Using a screwdriver, install the new snap ring.

Notice:
Be sure the end gap of the snap ring is not aligned with the cutout portion of the center support.


LNW47ASH025201

5. Install plates, discs and flange.

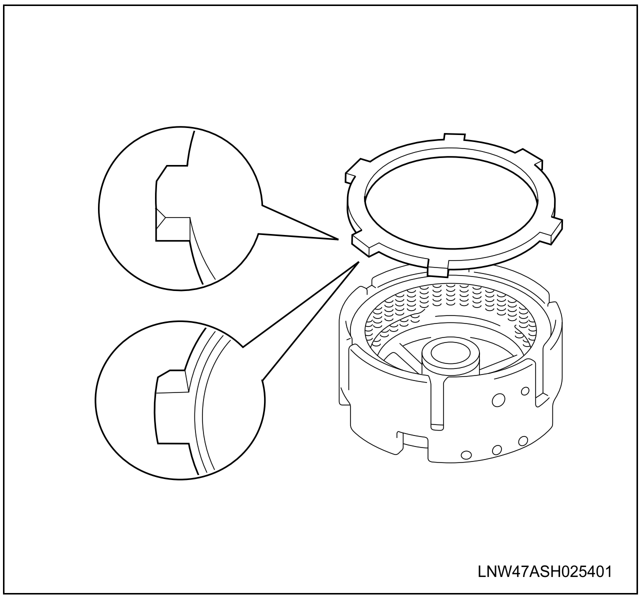
a. Install the 5 plates and 5 discs in order:
P = Plate D = Disc
P – D – P – D – P – D – P – D – P – D



LNW47ASH025301

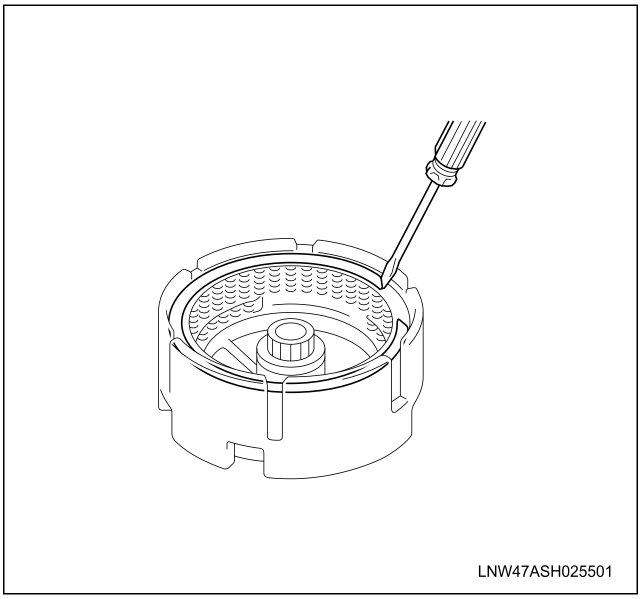
b. Install the flange, facing the rounded edge upward.

Notice:
If the flange is step-edged, install the flange with the step-edge, facing downward.


LNW47ASH025401

c. Using a screwdriver, install the snap ring.

Notice:
Be sure the end gap of the snap ring is not aligned the cutout portion of the center support.


LNW47ASH025501

6. Check piston stroke of second brake.
   Using the No.2 measure terminal and a dial indicator, measure the piston stroke by applying and releasing compressed air 392–785 kPa (4–8 kg/cm^2, 57–114 psi).

Piston stroke: 1.86–2.06 mm (0.0732–0.0811 in.)

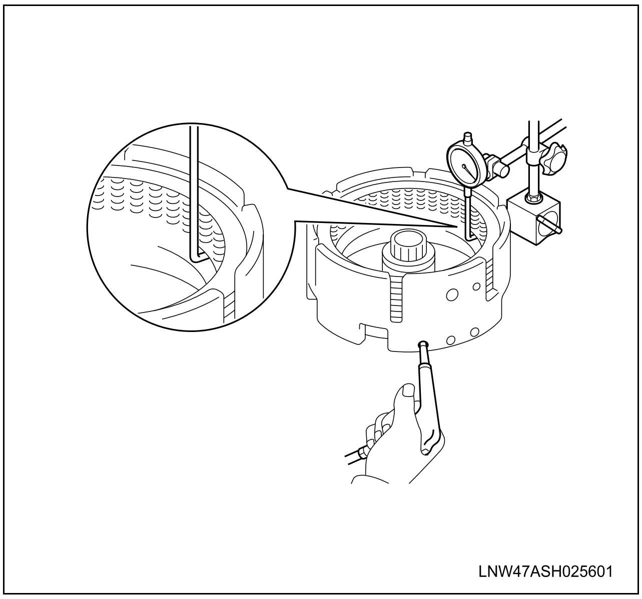
Notice:

- Stand the measure terminal on the piston vertically.
- Ensure that the measure terminal does not touches other parts than the piston.
- Measure the stroke at more than 3 points.

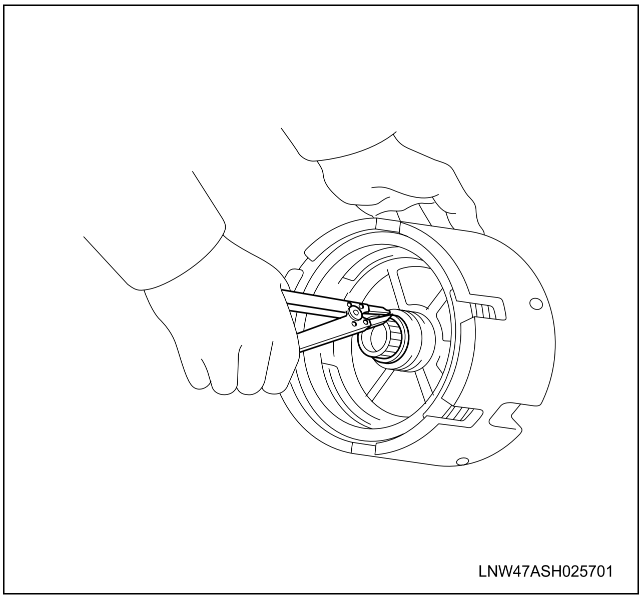
If the piston stroke is less than specified, parts may have been assembled incorrectly, check and reassemble again.
If the piston stroke is not as specified, select another flange.

Flange thicknesses

No.	Thickness mm (in.)
A	5.0 (0.197)
B	5.2 (0.205)
C	5.4 (0.213)
D	5.6 (0.220)


LNW47ASH025601

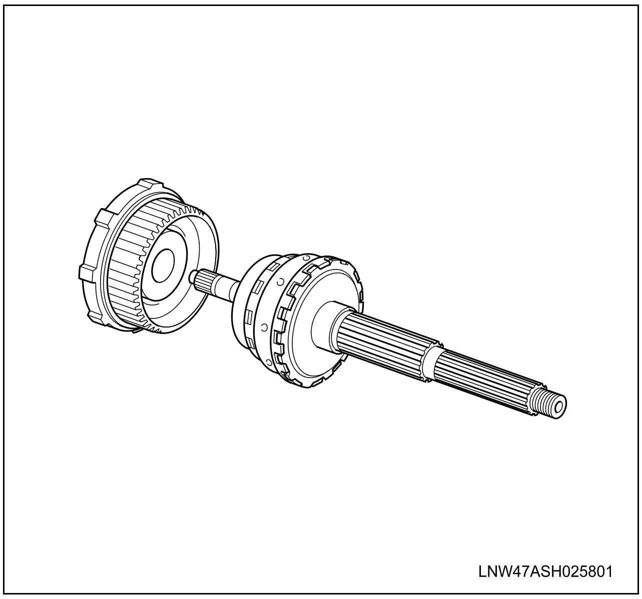
7. Install front planetary sun gear.
   a. Install the sun gear.
   b. Using snap ring pliers, install the snap ring.


LNW47ASH025701

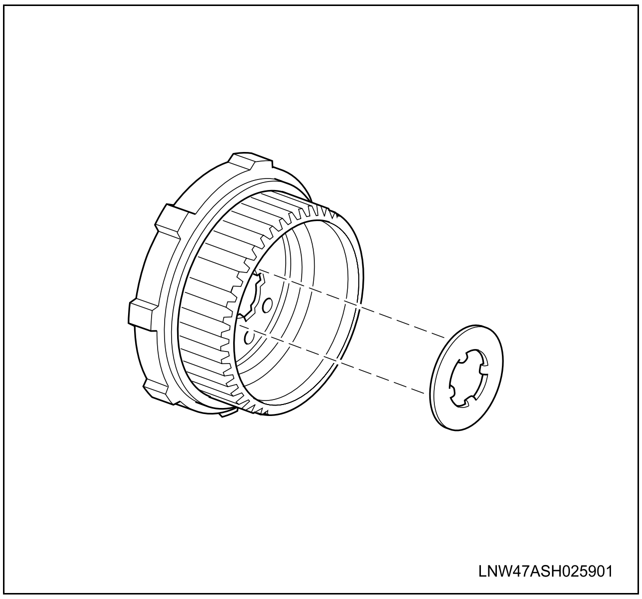
Planetary Gears, One-Way Clutch and Output Shaft

Disassembly

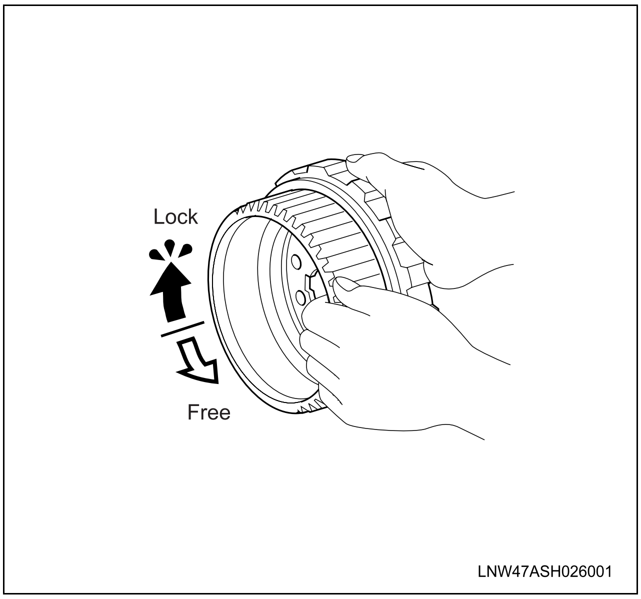
1. Remove the rear planetary gear and output shaft assembly from the front planetary gear.



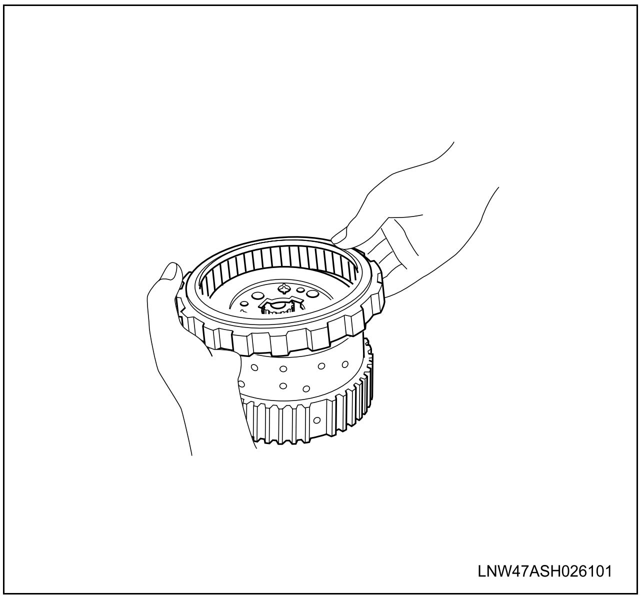
2. Remove No.1 rear thrust washer.
   Remove the thrust washer from the rear side of the front planetary gear.



3. Check operation of one-way clutch.
   Hold the one-way clutch outer race and turn the front planetary gear. The front planetary gear should turn freely counterclockwise and should lock clockwise.
   If operation is not as specified, replace the one-way clutch.

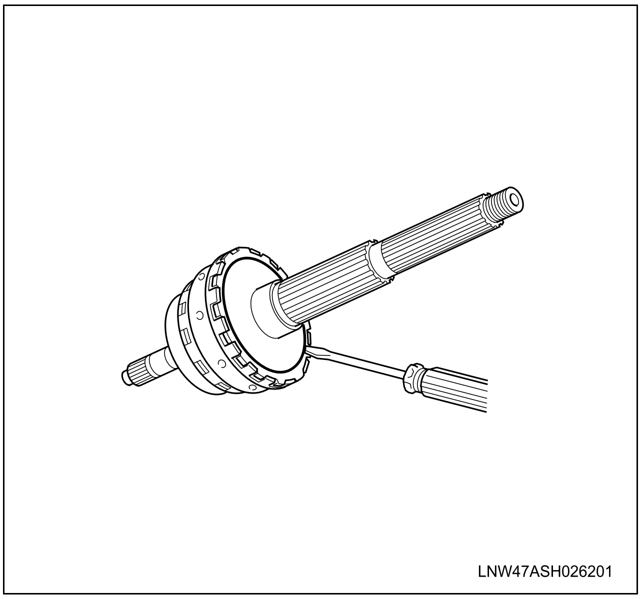


4. Remove the one-way clutch from the front planetary gear.

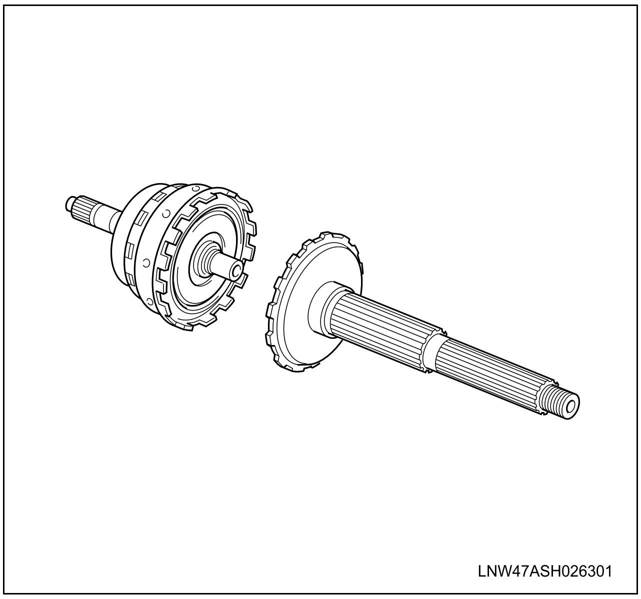


5. Remove output shaft.

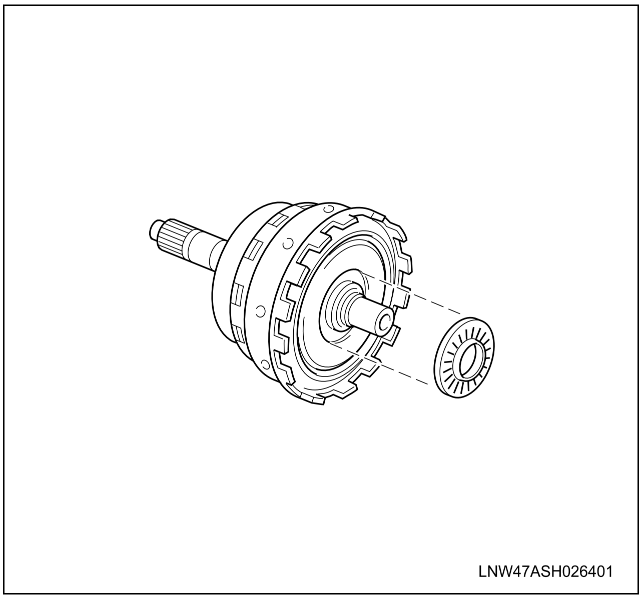
a. Using a screwdriver, remove the snap ring.



b. Remove the output shaft from the rear planetary gear.

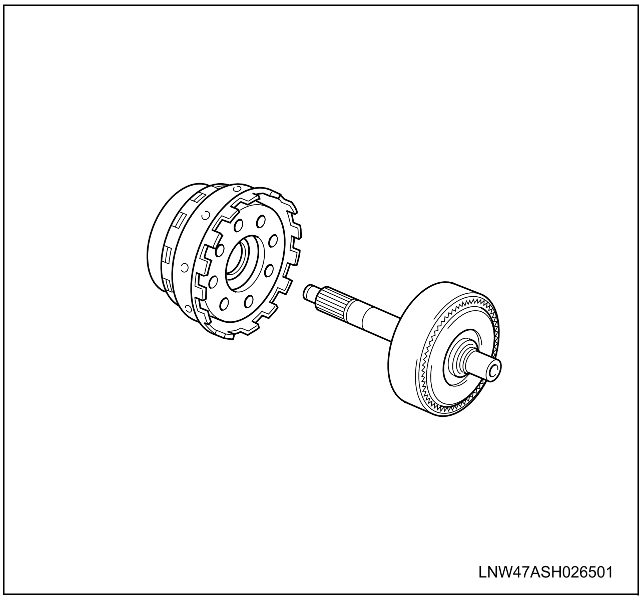


c. Remove the thrust bearing and race from the rear side of the ring gear flange.

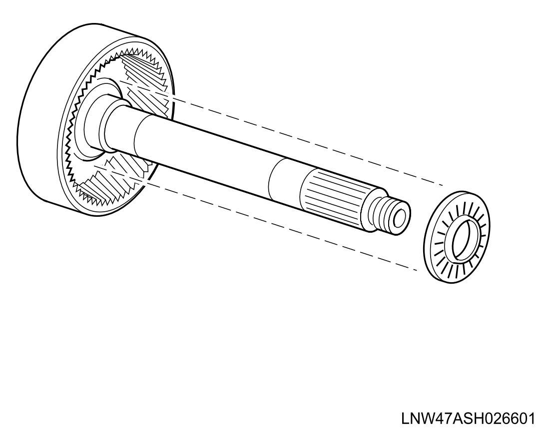


6. Remove rear planetary ring gear and intermediate shaft assembly.
   a. Remove the ring gear and intermediate shaft assembly from the rear planetary gear.

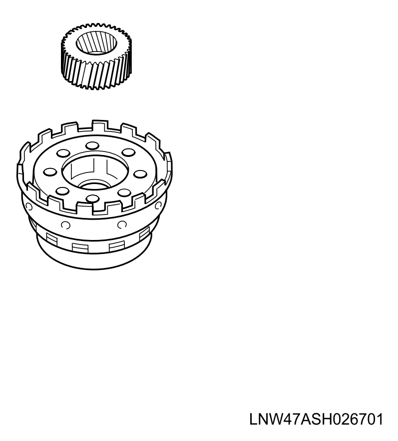
Notice:
Do not drop the planetary sun gear.



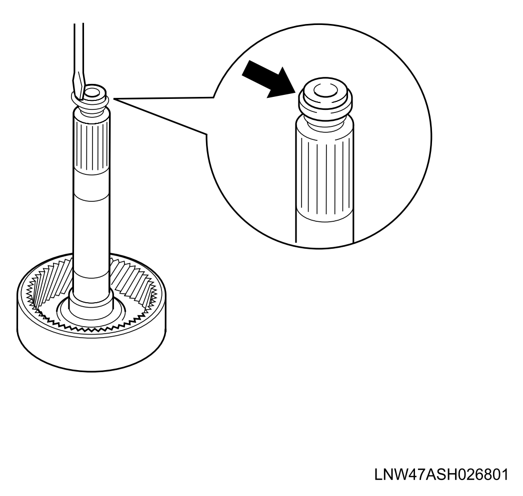
b. Remove the thrust bearing from the front side of the ring gear flange.



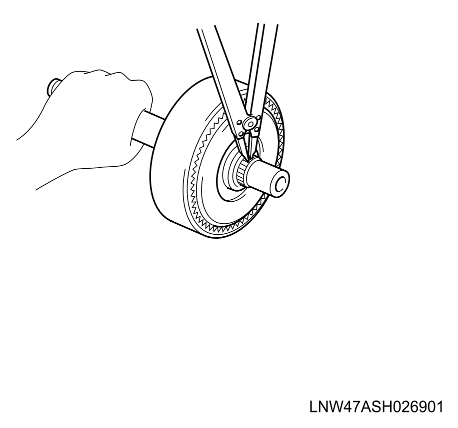
7. Remove the sun gear from the rear planetary gear.



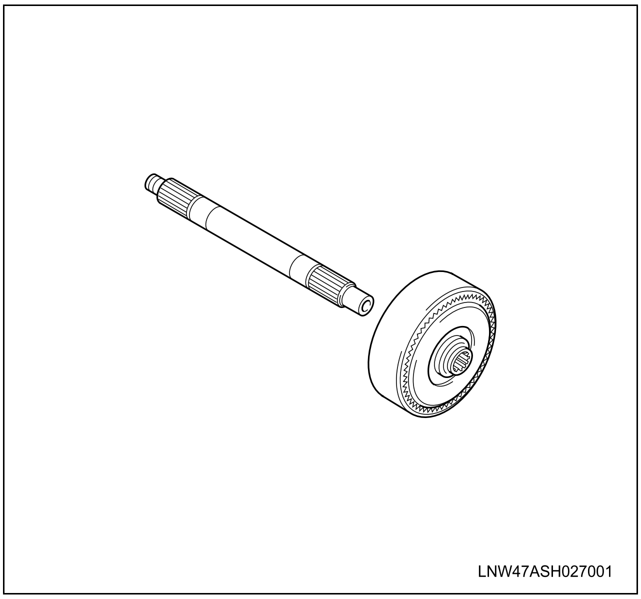
8. Remove oil seal ring.
   Using a small screwdriver, pry out the oil seal ring.



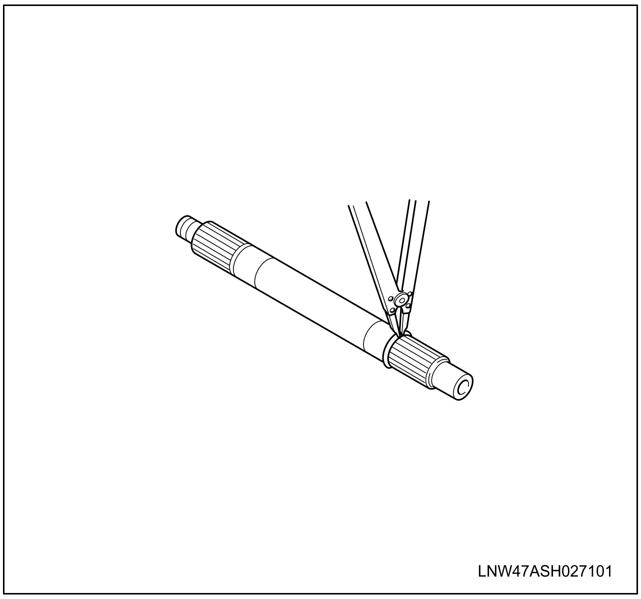
9. Remove rear planetary ring gear and flange assembly.
   a. Using snap ring pliers, remove the snap ring from the rear side of the intermediate shaft.



b. Remove the ring gear and flange assembly from the intermediate shaft.

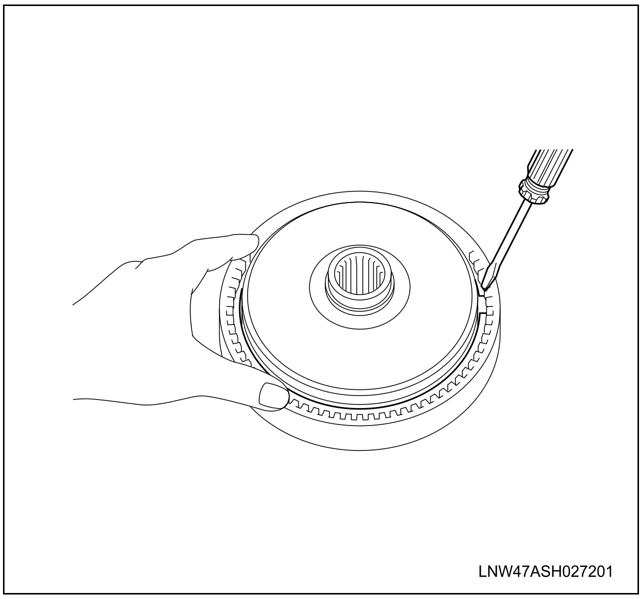


c. Using snap ring pliers, remove the snap ring from the front side of the intermediate shaft.

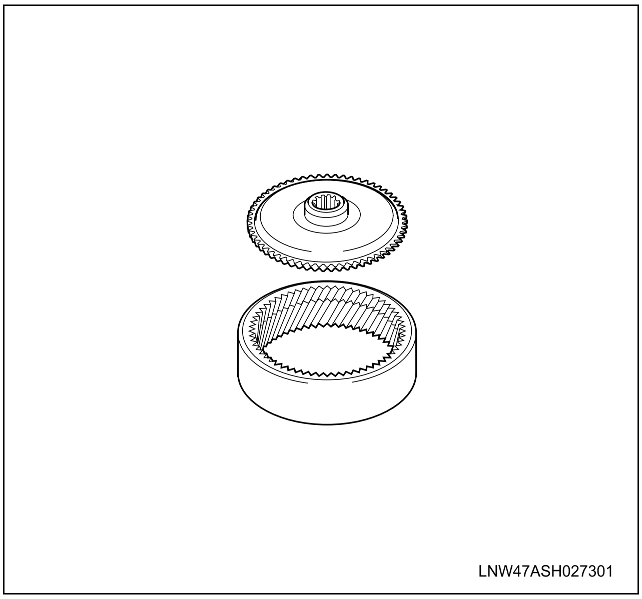


10. Remove rear planetary ring gear flange.

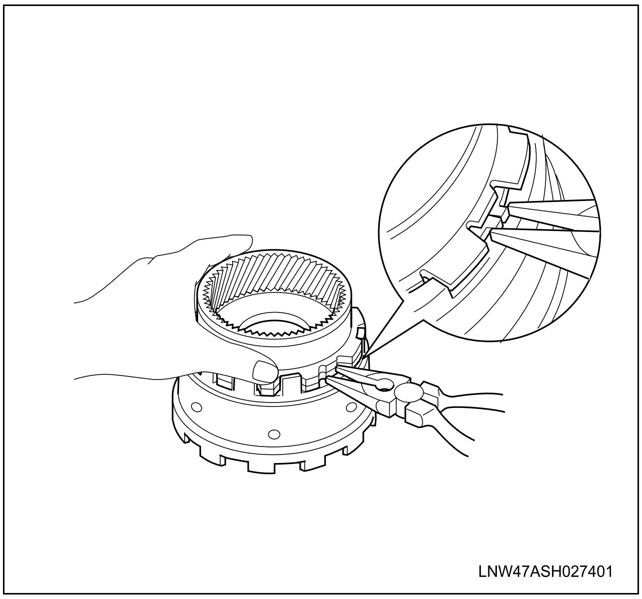
a. Using a small screwdriver or awls, remove the snap ring.



b. Remove the ring gear flange from the rear planetary ring gear.

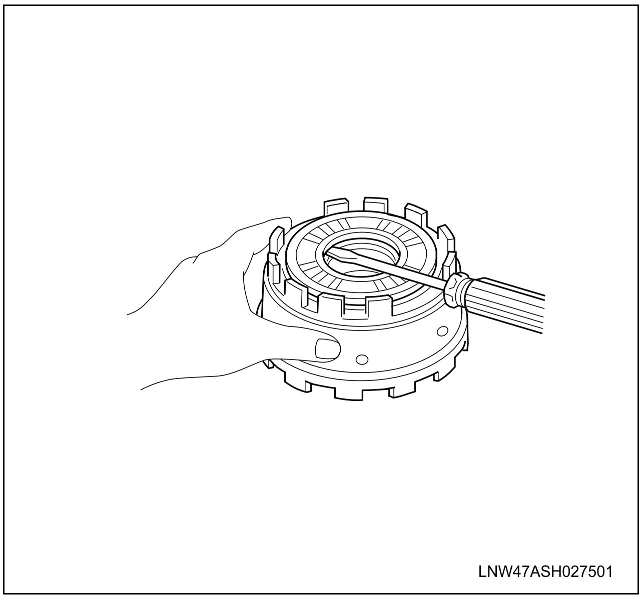


11. Remove front planetary ring gear.
    Using needle nose pliers, pry out the ring gear while compressing the snap ring.

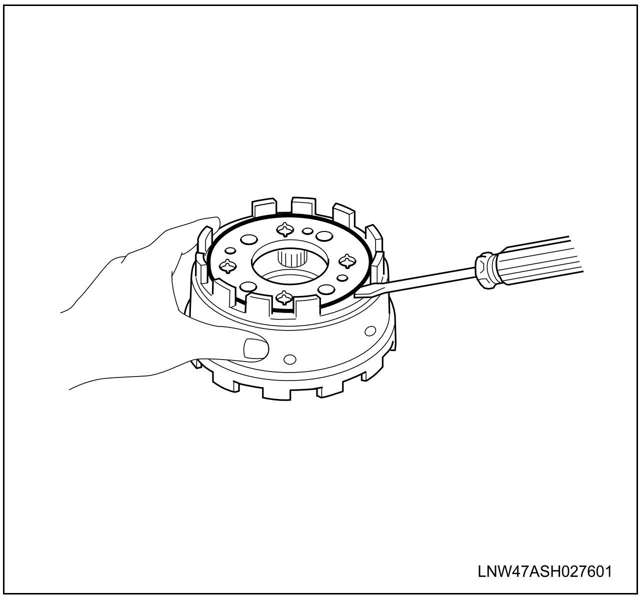


12. Using a screwdriver, remove the No.2 thrust washer from the rear planetary gear.

Caution:
Do not damage the No.2 thrust washer.



13. Using a small screwdriver, remove the O-ring from the rear planetary gear.

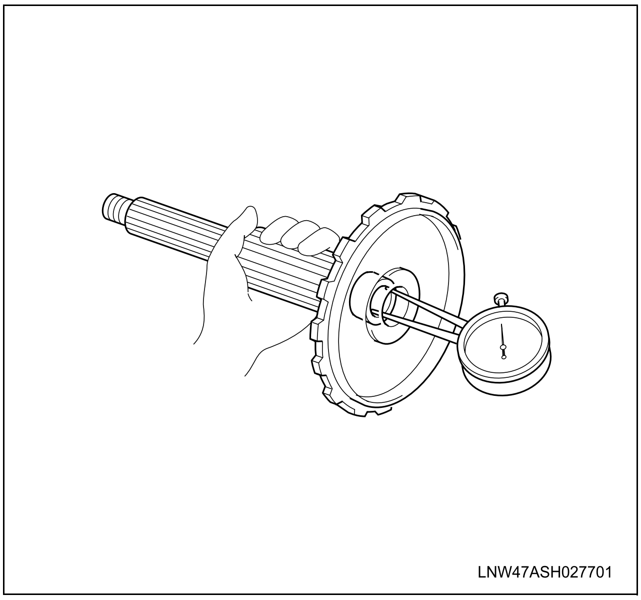


Inspection Procedure

1. Inspect bushing of output shaft.
   Using a dial indicator, measure the inside diameter.

Standard inside diameter:	17.000–17.021 mm (0.6693–0.6701 in.)
Maximum inside diameter:	17.07 mm (0.6720 in.)

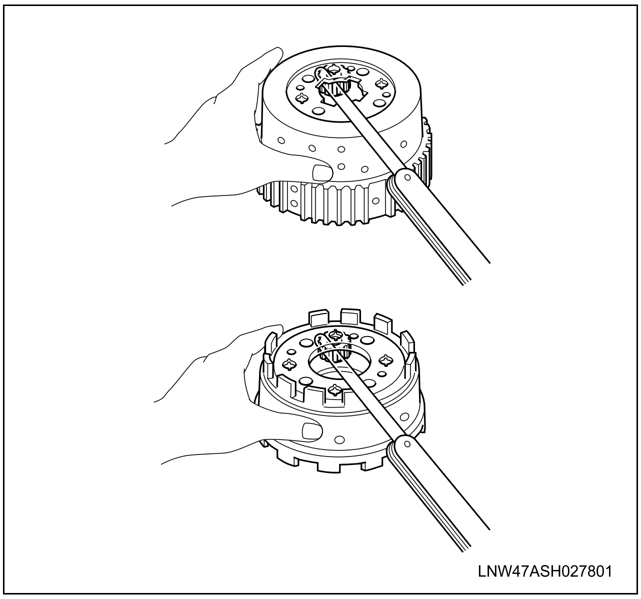
If the inside diameter is greater than maximum, replace the output shaft.
Inspect the bushing contact surface of the intermediate shaft, when discoloration or damage on the surface is found, replace the intermediate shaft with a new one.



2. Inspect planetary pinion gear thrust clearance.
   Using a feeler gauge, measure the thrust clearance between the pinions and carrier.

Standard clearance:	0.20–0.59 mm (0.0079–0.0232 in.)
Maximum clearance:	0.75 mm (0.0295 in.)

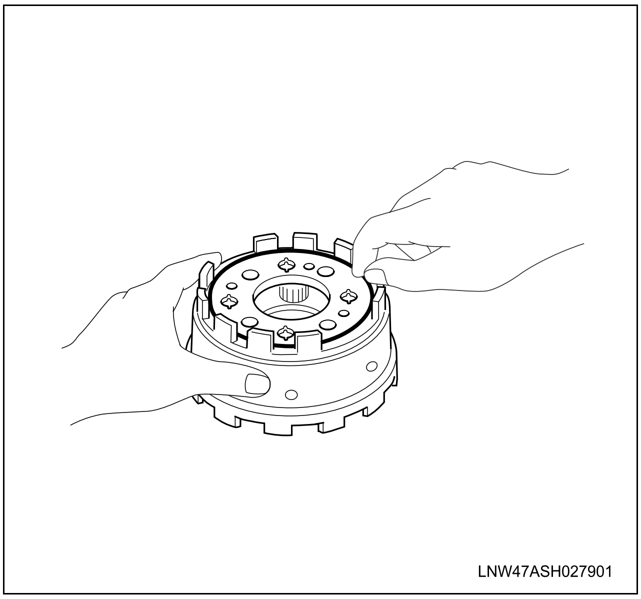
   If the thrust clearance is greater than maximum, replace the planetary gear.


LNW47ASH027801

Reassembly

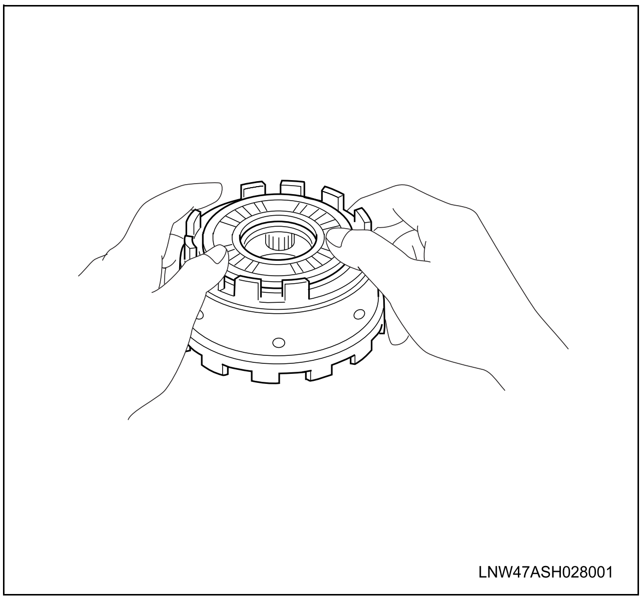
1. Install O-ring.
   Coat a new O-ring with automatic transmission fluid (ATF), and install it onto the rear planetary gear.

Caution:
Be careful not to damage the O-ring.

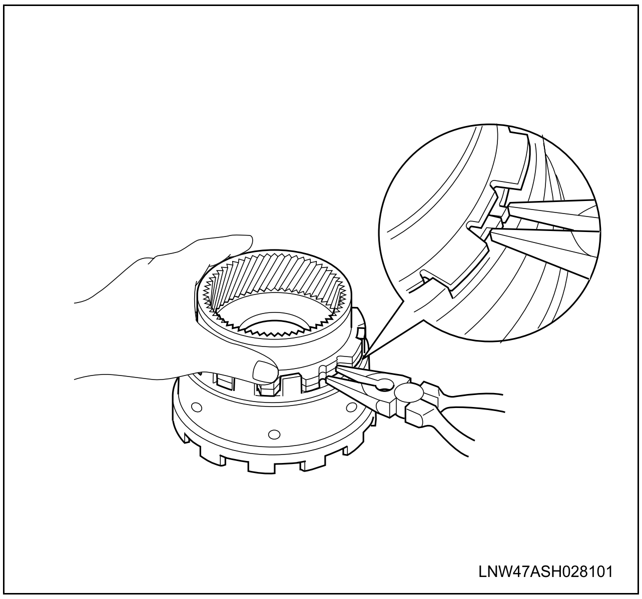

LNW47ASH027901

2. Install No.2 thrust washer.
   Coat the thrust washer with petroleum jelly, and install it onto the rear planetary gear.

Notice:
Securely fit the lips of the thrust washer into the holes of the rear planetary gear.

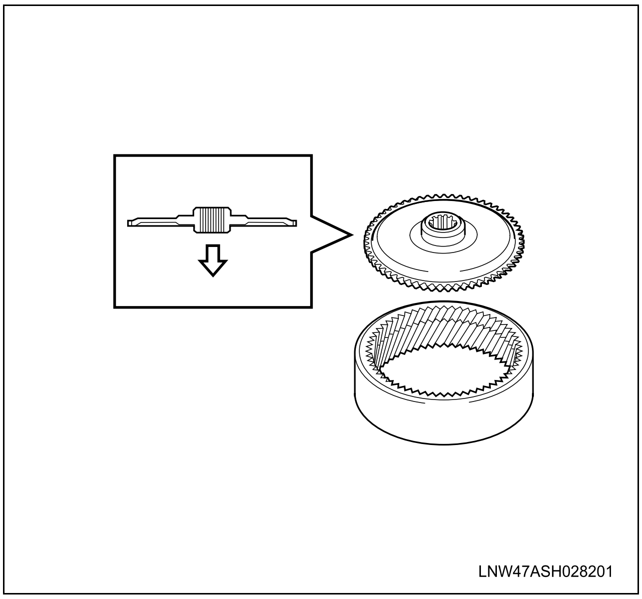

LNW47ASH028001

3. Install front planetary ring gear.
   a. Align the snap ring end with the wide cutout portion of the rear planetary gear.
   b. Using needle nose pliers, compress the snap ring and then install the ring gear.
   c. Check that the snap ring is installed into the groove of the rear planetary gear.

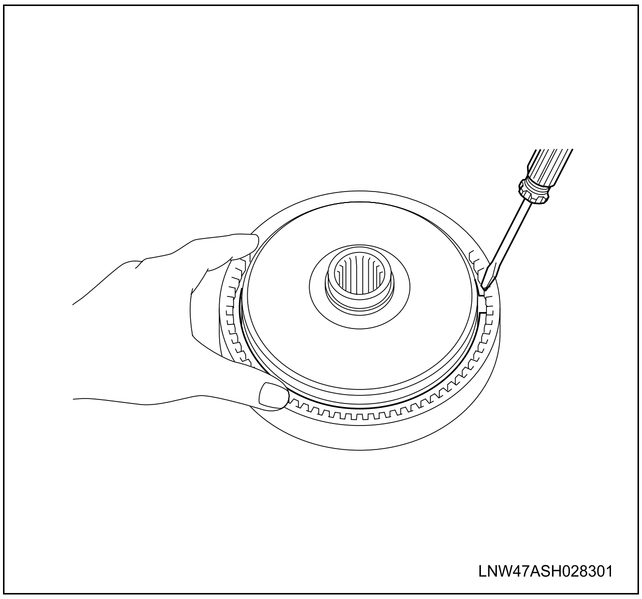

LNW47ASH028101

4. Install rear planetary ring gear flange.

a. Install the ring gear flange to the rear planetary ring gear.

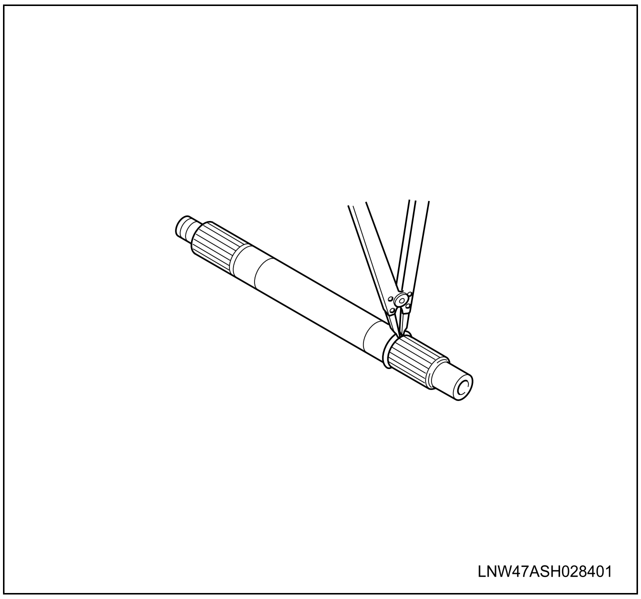


b. Using a small screwdriver, install the snap ring.



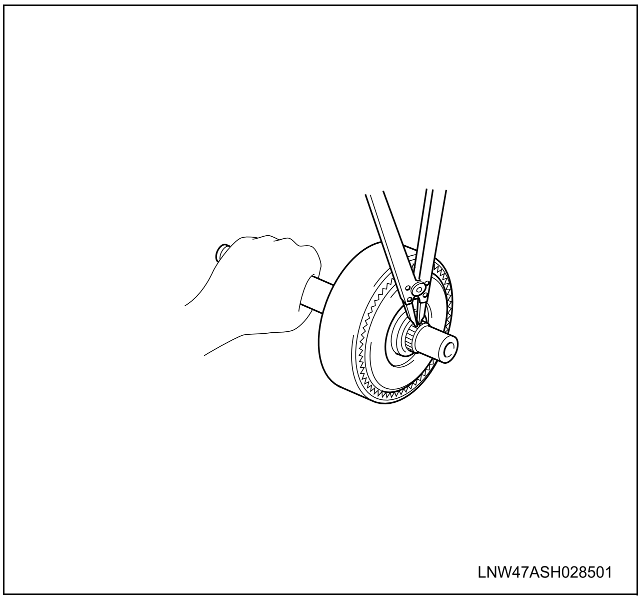
5. Install rear planetary ring gear and flange assembly.

a. Using snap ring pliers, install the snap ring on the front side of the intermediate shaft.

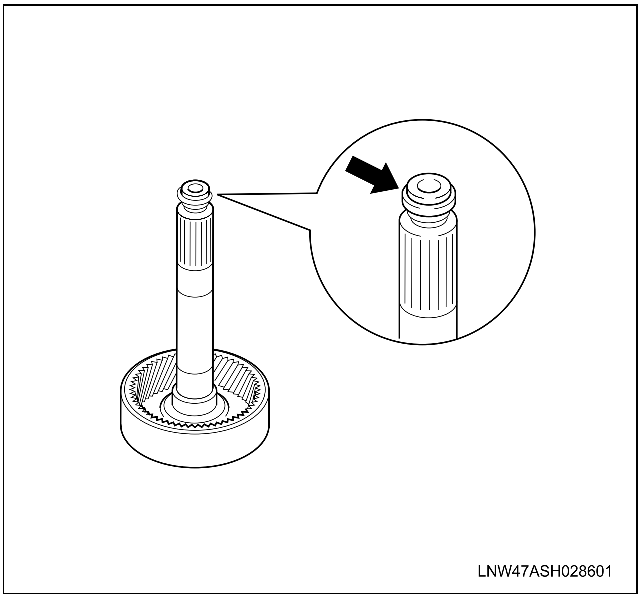


b. Install the ring gear and flange assembly.

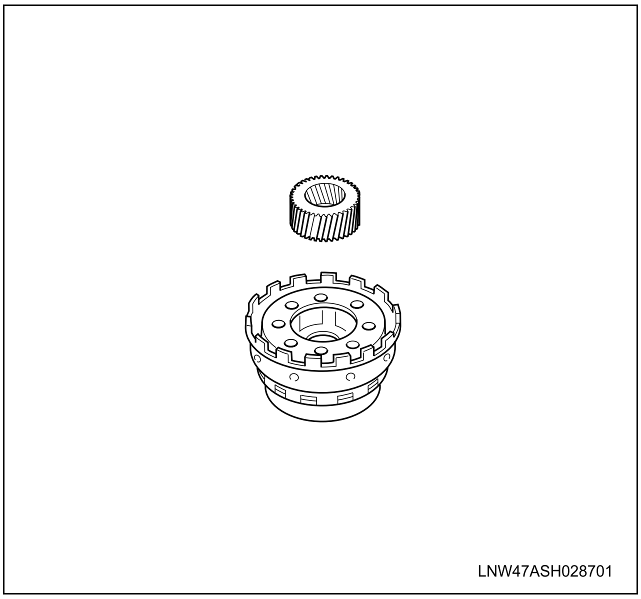
c. Using snap ring pliers, install the snap ring on the rear side of the intermediate shaft.



6. Install oil seal ring.
   Coat the new oil seal ring with ATF, and install it on the intermediate shaft.


LNW47ASH028601

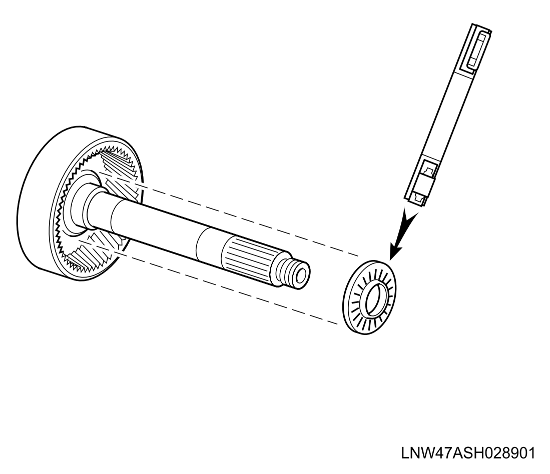
7. Install rear planetary sun gear.
   Install the sun gear to the rear planetary gear.


LNW47ASH028701

8. Install rear planetary ring gear and intermediate shaft assembly.
   a. Coat the thrust bearing with petroleum jelly.
   b. Install the thrust bearing onto the front side of the ring gear flange.

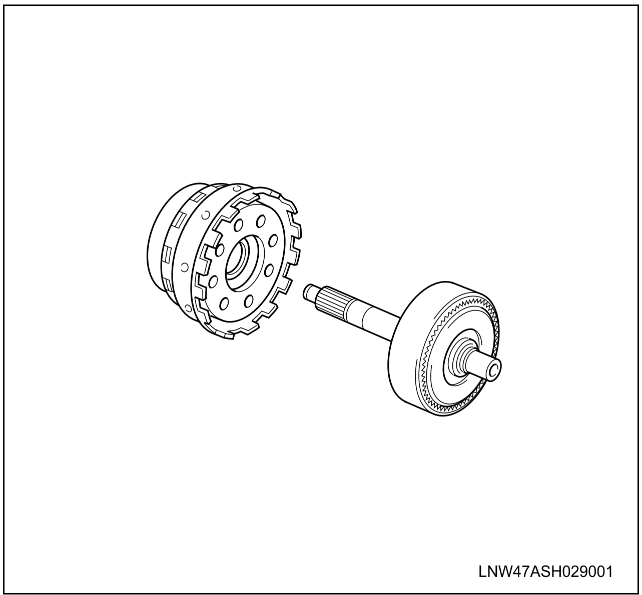
Thrust bearing diameter

Diameter mm (in.)	Inside	Outside
Bearing	32.8 (1.291)	53.2 (2.094)


LNW47ASH028901

   c. Install the ring gear and intermediate shaft assembly to the rear planetary gear.

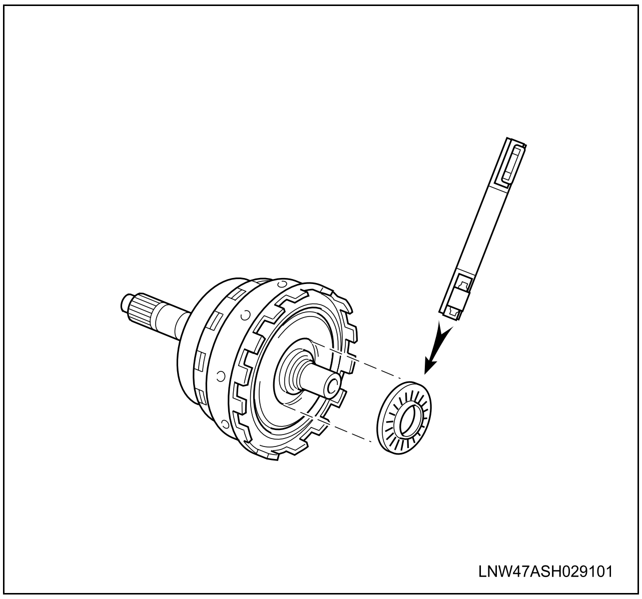
Notice:
Do not drop the planetary sun gear.


LNW47ASH029001

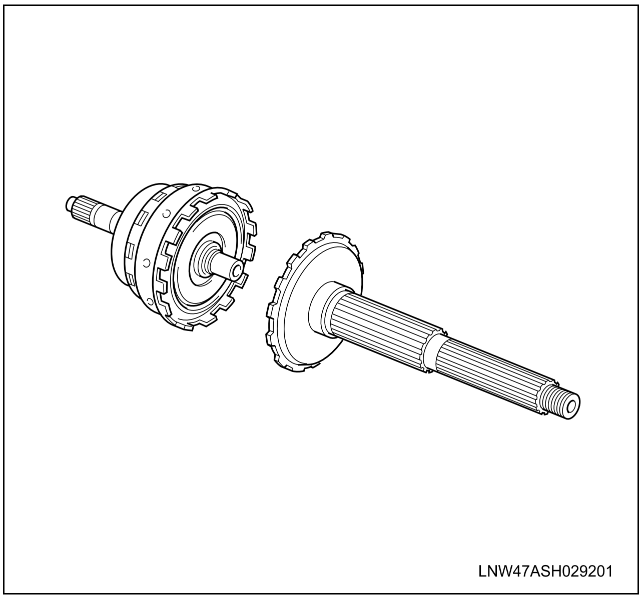
9. Install output shaft.
   a. Coat the thrust bearing with petroleum jelly.
   b. Install the thrust bearing onto the rear side of the ring gear flange.

Thrust bearing diameter

Diameter mm (in.)	Inside	Outside
Bearing	32.8 (1.291)	53.2 (2.094)

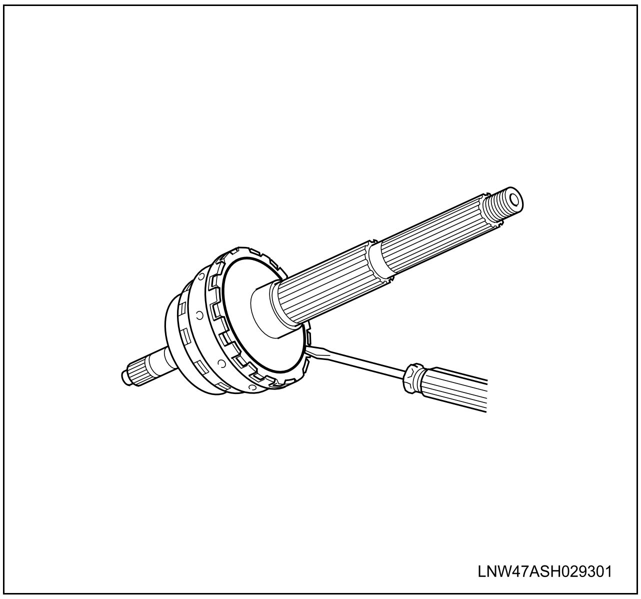


c. Install the output shaft to the rear planetary gear.

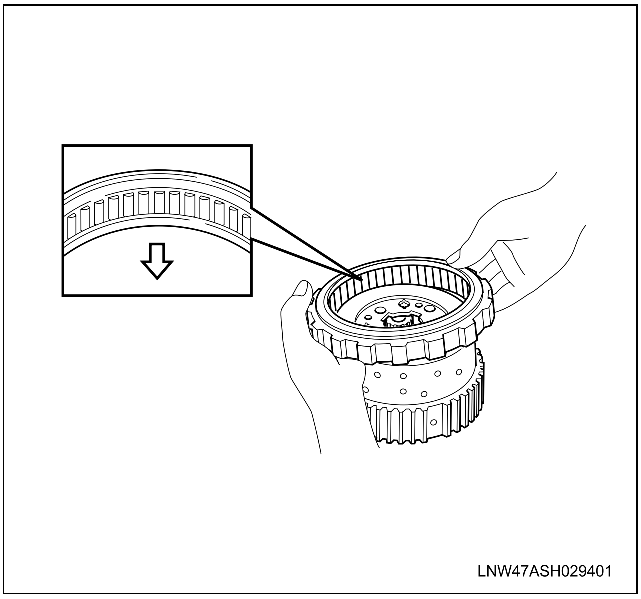


d. Using a screwdriver, install the snap ring.

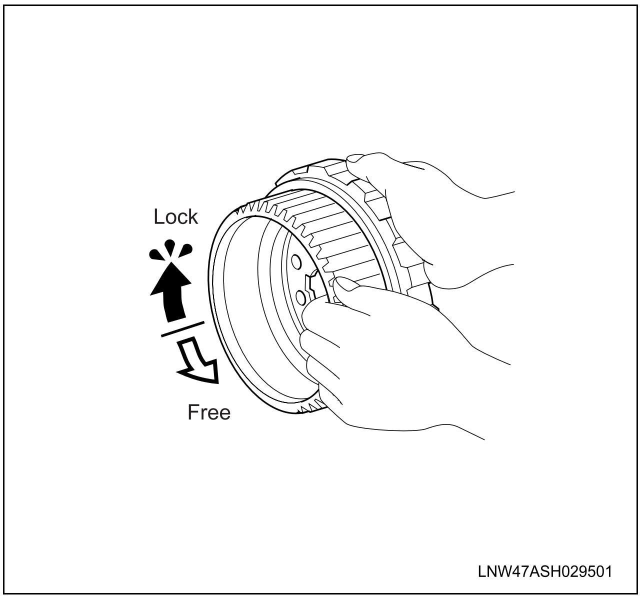
Notice:
Be sure the end gap of the snap ring is not aligned with the cutout portion of the rear planetary gear.



10. Install one-way clutch.
    a. Position the one-way clutch on the front planetary gear, facing the flanged side of the one-way clutch downward.
    b. Install the one-way clutch to the front planetary gear by rotating the one-way clutch counterclockwise.

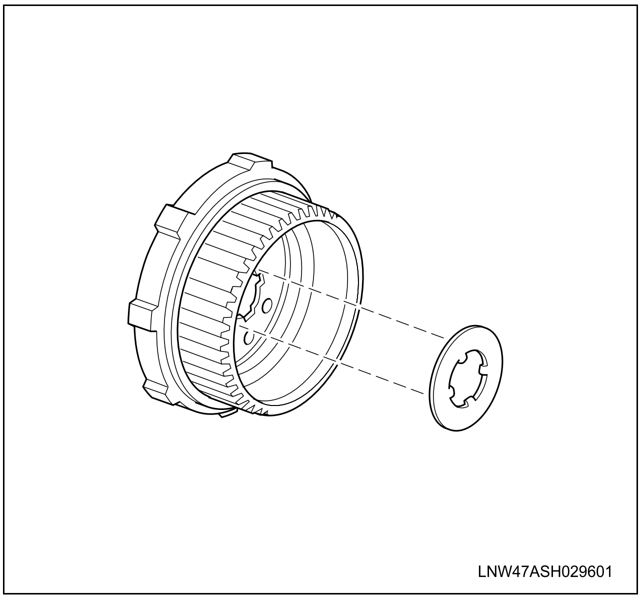


11. Check operation of one-way clutch.
    Hold the one-way clutch outer race and turn the front planetary gear. The front planetary gear should turn freely counterclockwise and should lock clockwise.
    If operation is not as specified, replace the one-way clutch.

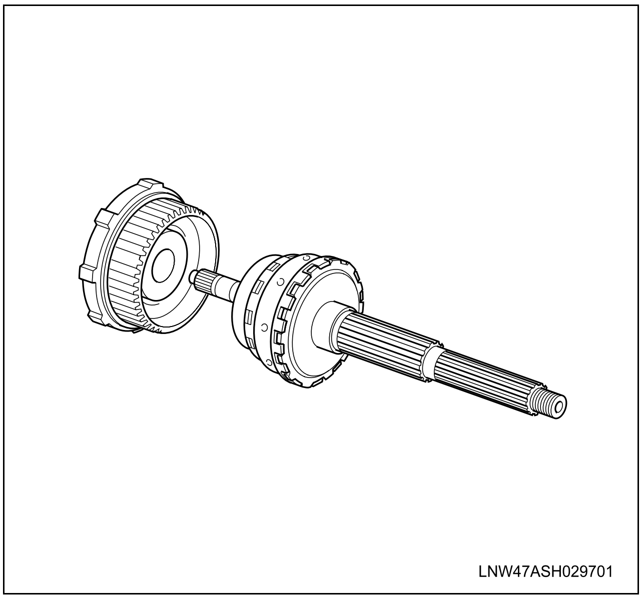


12. Install No.1 thrust washer.
    Coat the thrust washer with petroleum jelly, and install it onto the rear side of the front planetary gear.

Notice:
Securely fit the claws of the thrust washer into the grooves of the front planetary gear.



13. Install the rear planetary gear and output shaft assembly to the front planetary gear.



First and Reverse Brake

Disassembly

1. Check piston stroke of first and reverse brake piston.
    a. Using the No.2 measure terminal and a dial indicator, measure the piston stroke by applying and releasing the compressed air 392–785 kPa (4–8 kg/cm^2, 57–114 psi).

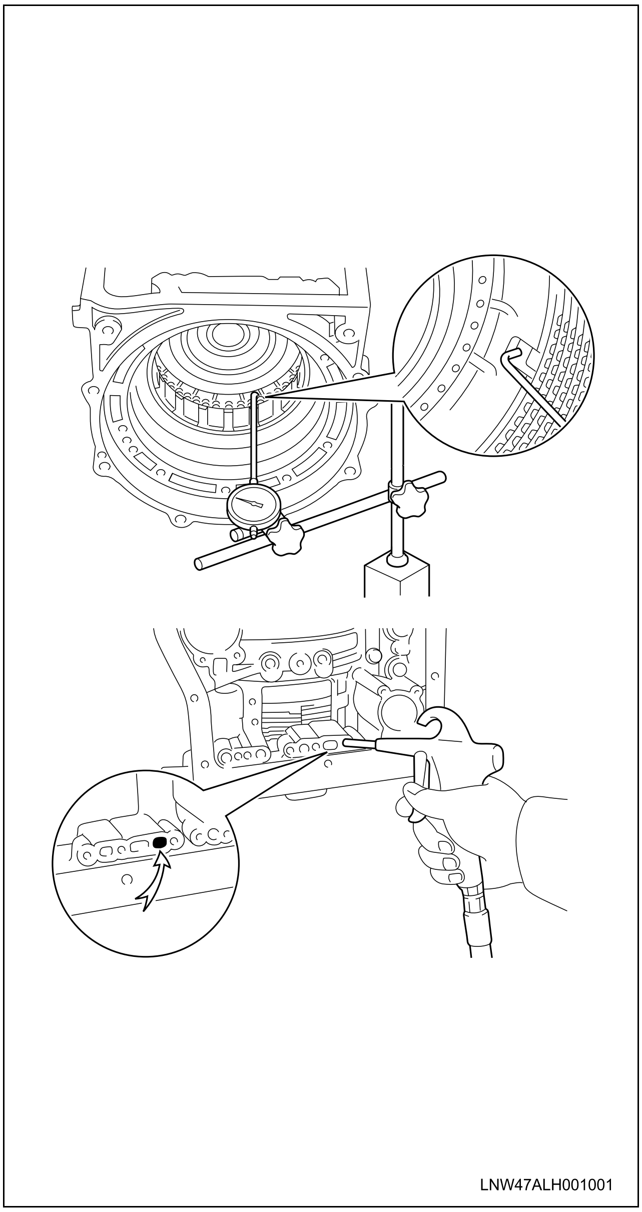
Tool Required: J-44168 No.2 Measure Terminal

Piston stroke: 3.30–3.80 mm (0.1299–0.1496 in.)

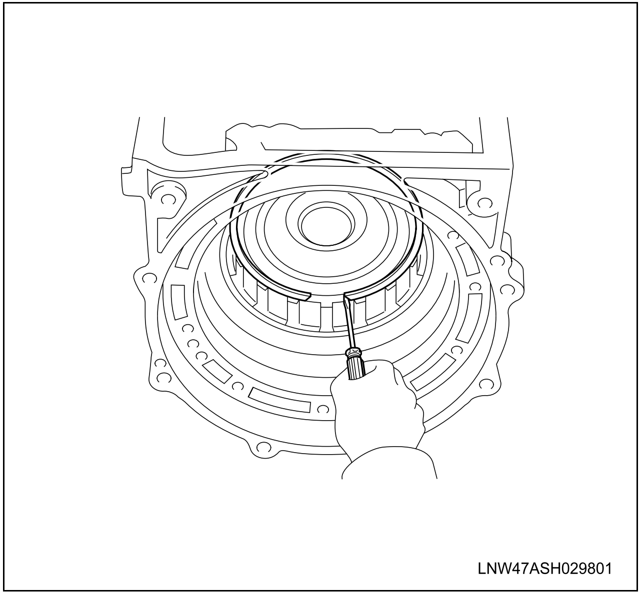
Notice:

- Stand the measure terminal on the piston vertically.
- Ensure that the measure terminal does not touches other parts than the piston.
- Measure the stroke at more than 3 points.

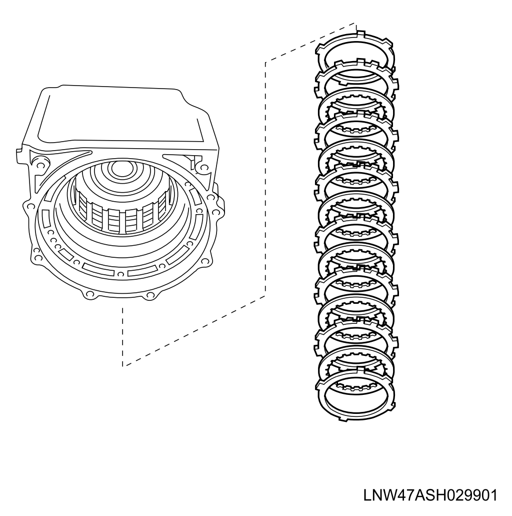
If the piston stroke is not as specified, inspect the discs.


LNW47ALH001001

2. Remove flange, discs, plates and cushion plate.
   a. Using screwdriver, remove the snap ring.


LNW47ASH029801

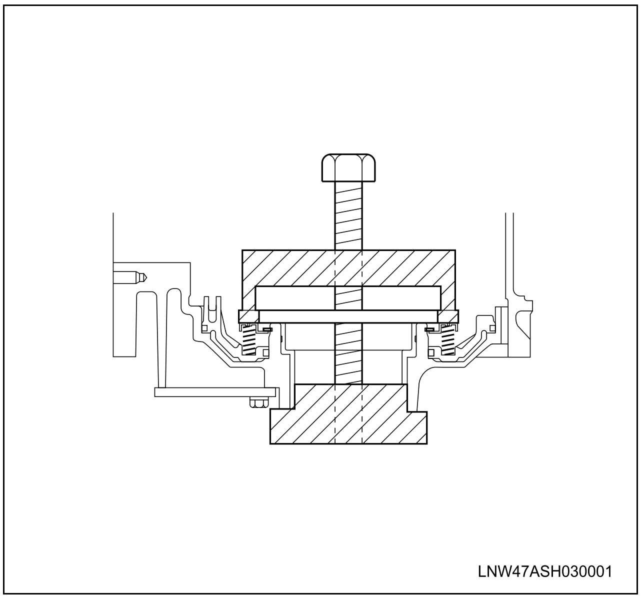
   b. Remove flange, 6 discs, 6 plates and cushion plate.


LNW47ASH029901

3. Remove piston return spring.
   a. Set the No.1 piston spring compressor on the spring retainer, and compress the return spring.

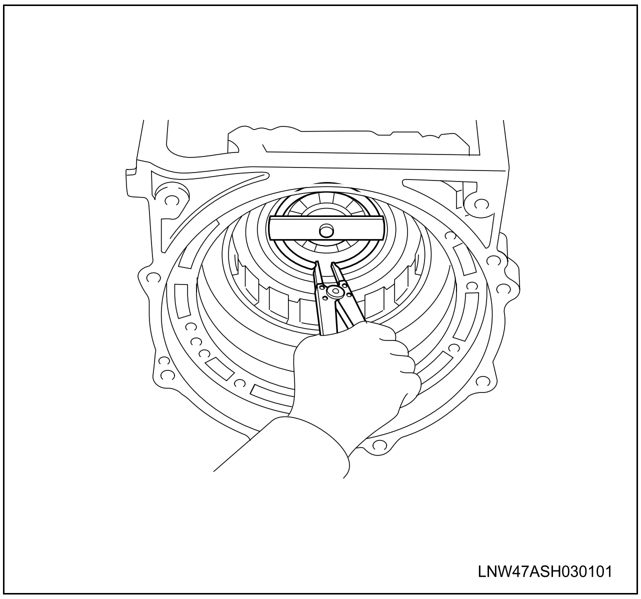
Tool Required: J-44162 No.1 Piston Spring Compressor

Notice:
Stop compressing the return spring at the position 1 to 2 mm away from the snap ring to prevent the spring sheet from being deformed.

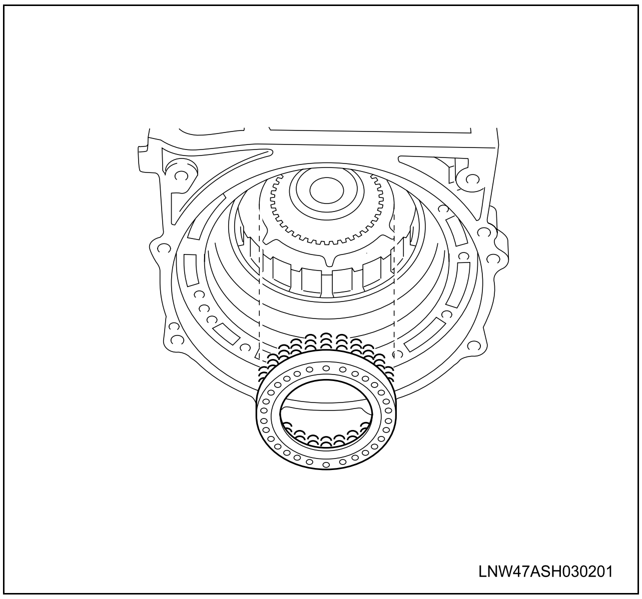

LNW47ASH030001

b. Using a snap ring pilers, remove the snap ring.

Caution:
Do not damage the snap ring and do not deform them unless necessary.


LNW47ASH030101

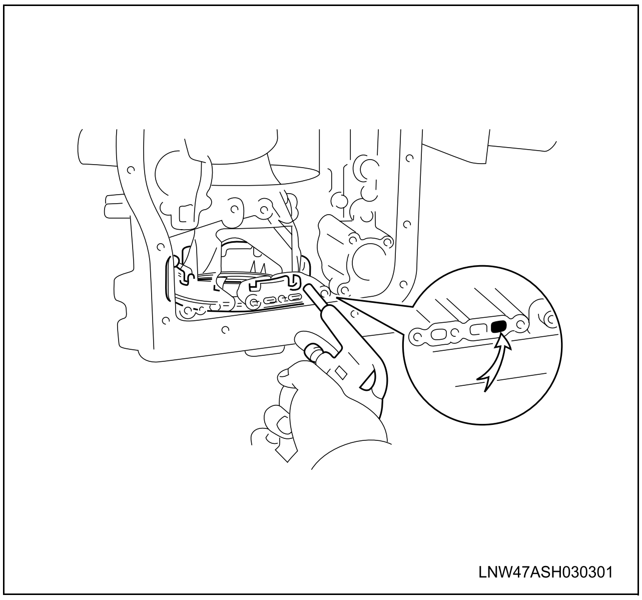
c. Remove the piston return spring.


LNW47ASH030201

4. Remove first and reverse brake piston.
   a. Hold first and reverse brake piston with hand or piston spring compressor with return spring, remove first and reverse brake piston by applying compressed air 392–785 kPa (4–8 kg/cm^2, 57–114 psi) into the oil hole of the transmission case.

Notice:
Be careful not to slant the brake piston while applying compressed air. If the brake piston slants, it is difficult to remove.

b. Remove the 2 O-rings from brake piston.

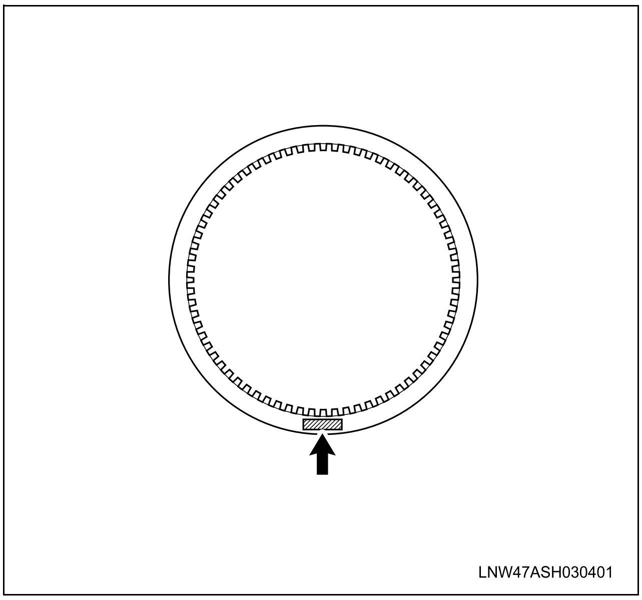

LNW47ASH030301

Inspection Procedure

Inspect discs, plates and cushion plate.
Check to see of the contacting surface of the disc, plate and flange are worn or burnt. If necessary, replace them.

Notice:

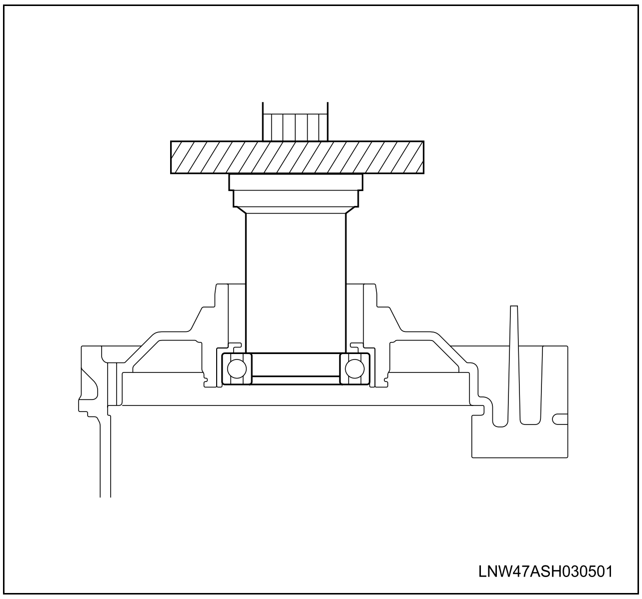
- If the lining of the disc is peeling off or discolored, or even if a part of the printed numbers are defaced, replace all discs.
- Before assembling new discs, soak them in ATF for at least 15 minutes.



Output shaft front bearing replacement

1. Remove output shaft front bearing.
   Using oil seal installer (for oil pump), steel plate and a shop press, press out the bearing.

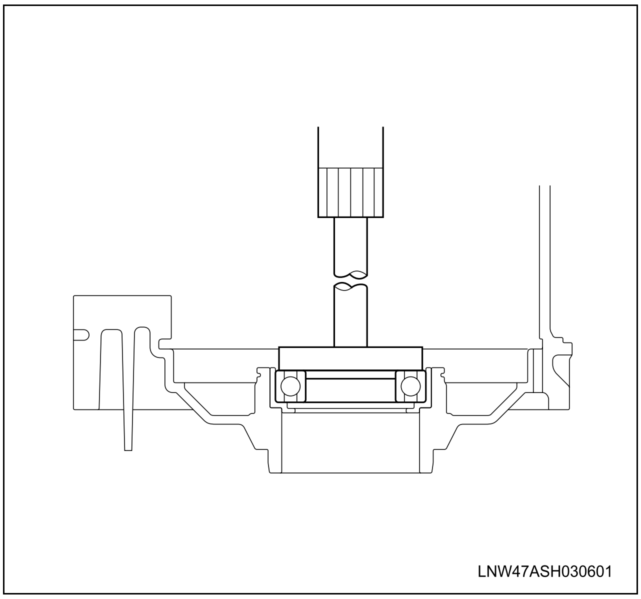
Tool Required: J-44163 Oil Seal Installer



2. Install output shaft front bearing.
   a. Using the bearing installer, handle and a shop press, press in the new bearing.

Tool Required: J-44164 Handle
J-44165 Bearing Installer

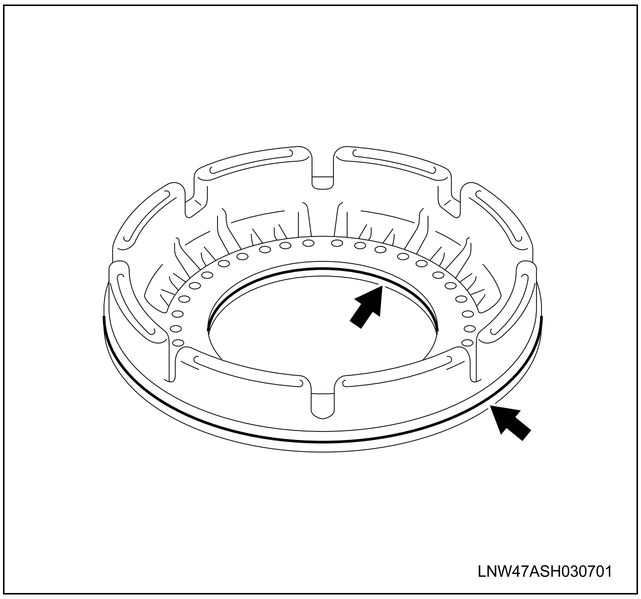
b. Check that the bearing rotates smoothly.



Reassembly

1. Install first and reverse brake piston.
   a. Coat the new 2 O-rings with automatic transmission fluid (ATF), and install them in the first and reverse brake piston.

O-ring diameters		mm (in.)
	Inside	Wire diameter
Inner side	94.4 (3.7165)	3.1 (0.1221)
Outer side	163.7 (6.4449)	3.1 (0.1221)

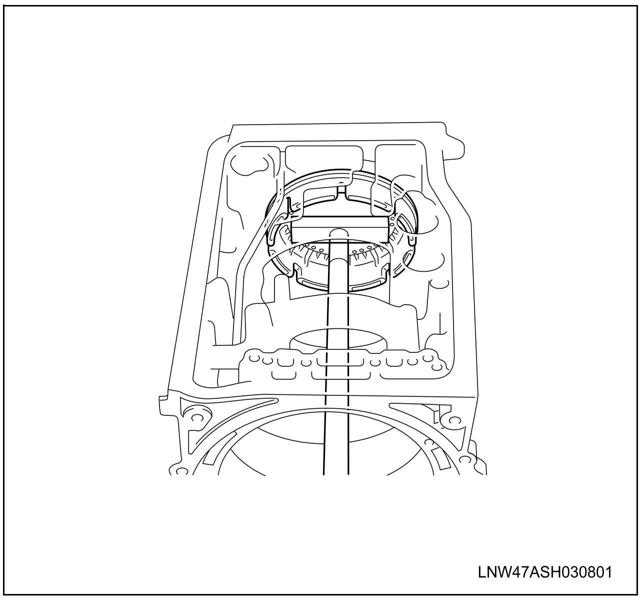


b. Using the No.1 piston spring compressor and the handle, push in the brake piston.

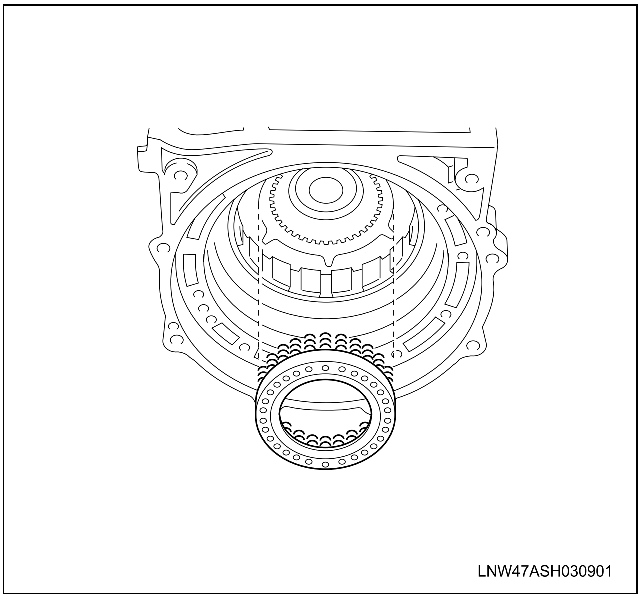
Tool Required: J-44162 No.1 Piston Spring Compressor
J-44164 Handle

Caution:

Be careful not to damage the O-ring.



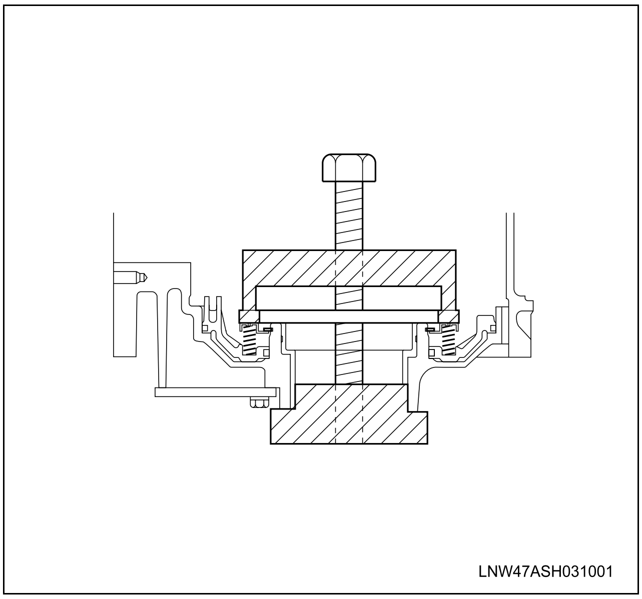
2. Install piston return spring.
   a. Place the return spring on the brake piston.



   b. Using No.1 piston spring compressor, compress the return spring.

Notice:

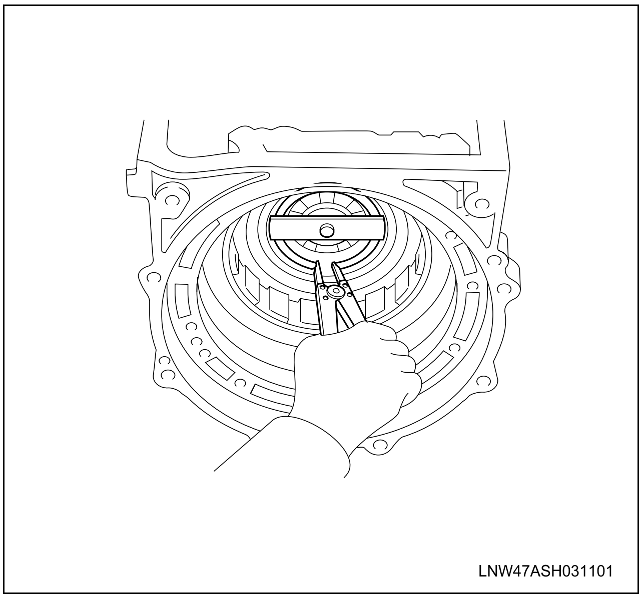
Stop compressing the return spring at the position 1 to 2 mm away from the snap ring to prevent the spring sheet from being deformed.



   c. Using snap ring pliers, install the snap ring.

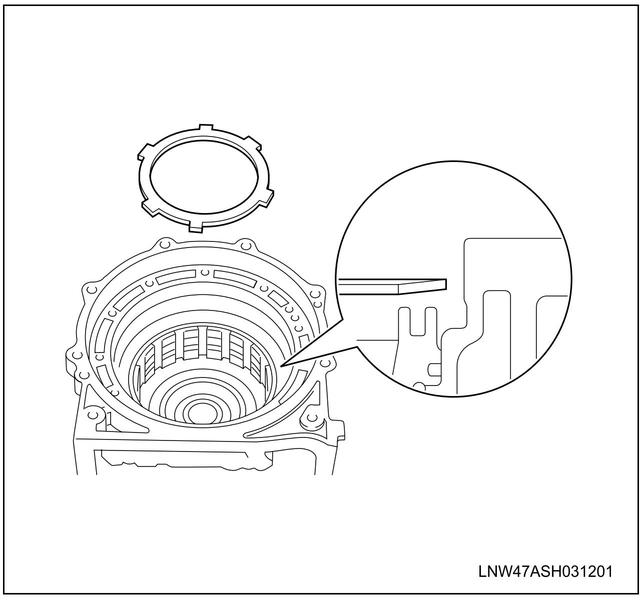
Notice:

If the snap ring are damaged or deformed, replace it with a new one.

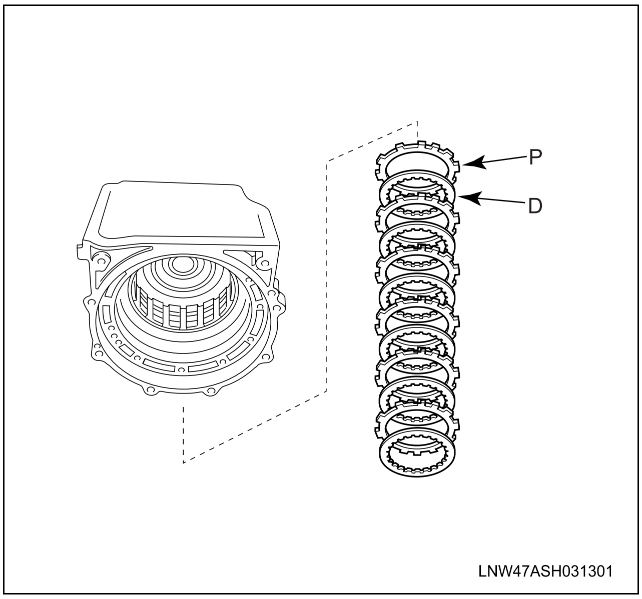


3. Install cushion plate, plates, discs and flange.

a. Install the cushion plate, facing the rounded edge inward.


LNW47ASH031201

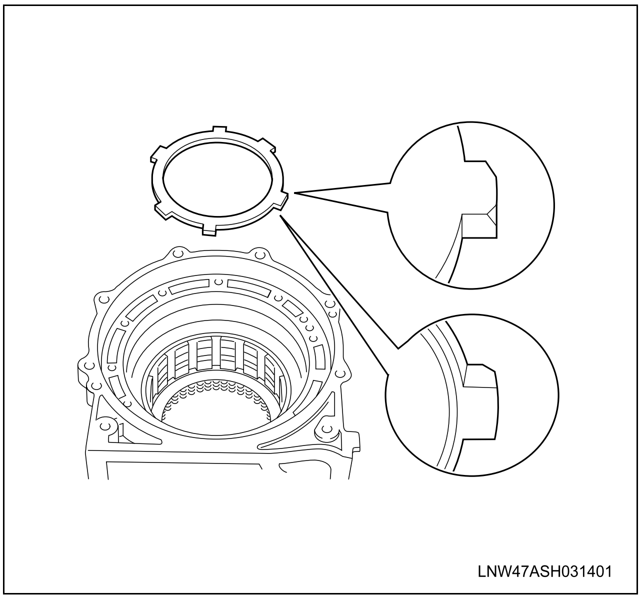
b. Install the 6 plates and 6 discs in order:
P = Plate D = Disc
P – D – P – D – P – D – P – D – P – D



LNW47ASH031301

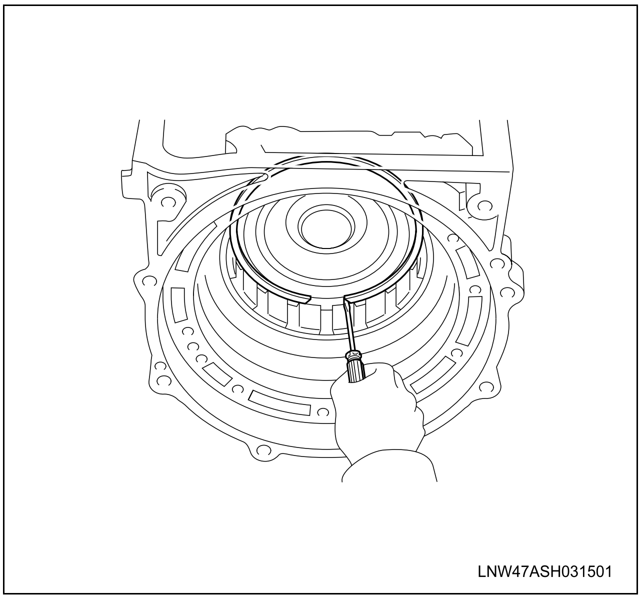
c. Install the flange, facing the rounded edge outward.

Notice:
If the flange is step-edged, install the flange with the step-edge, facing inward.


LNW47ASH031401

d. Using screwdriver, install the snap ring.

Notice:
Be sure the end of the snap ring is not aligned with the cutout portion of the transmission case.


LNW47ASH031501

4. Check piston stroke of first and reverse brake.
   a. Using No.2 measure terminal and a dial indicator, measure the piston stroke by applying and releasing the compressed air 392–785 kPa (4–8 kg/cm^2, 57–114 psi).

Tool Required: J-44168 No.2 Measure Terminal

Piston stroke: 3.3–3.8 mm (0.130–0.150 in.)

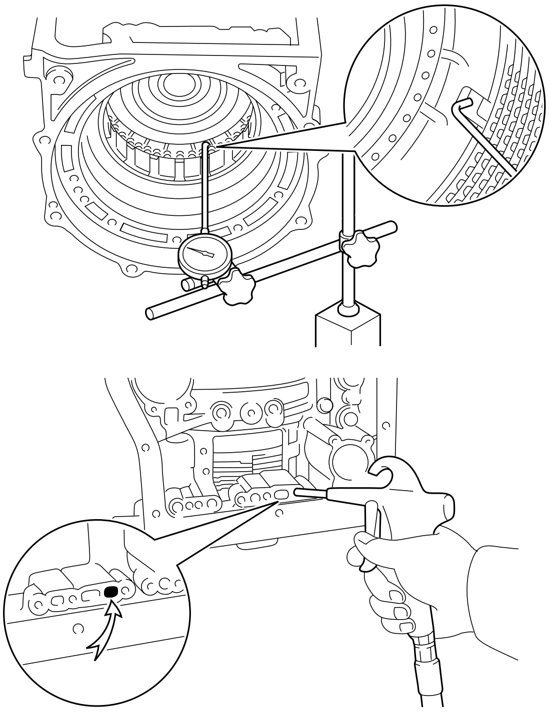
Notice:

- Stand the measure terminal on the piston vertically.
- Ensure that the measure terminal does not touches other parts than the piston.
- Measure the stroke at more than 3 points.

If the piston stroke is less than specified, parts may have been assembled incorrectly, check and reassemble again.
If the piston stroke is not as specified, select another flange.

Flange thicknesses

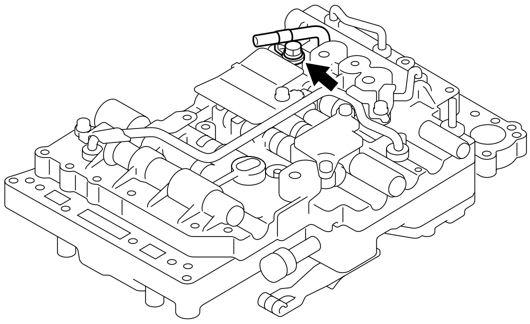
No.	Thickness mm (in.)
E	6.65 (0.2618)
F	7.05 (0.2776)
G	7.45 (0.2933)


LNW47ALH001101

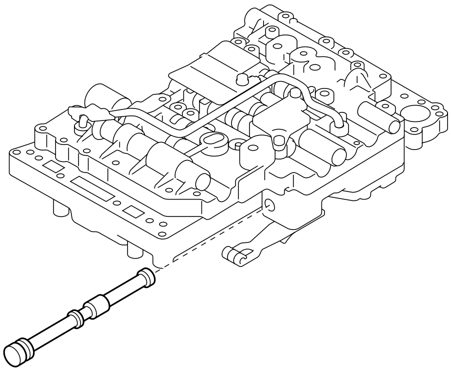
Valve Body

Disassembly

1. Remove the bolt and the drain tube.

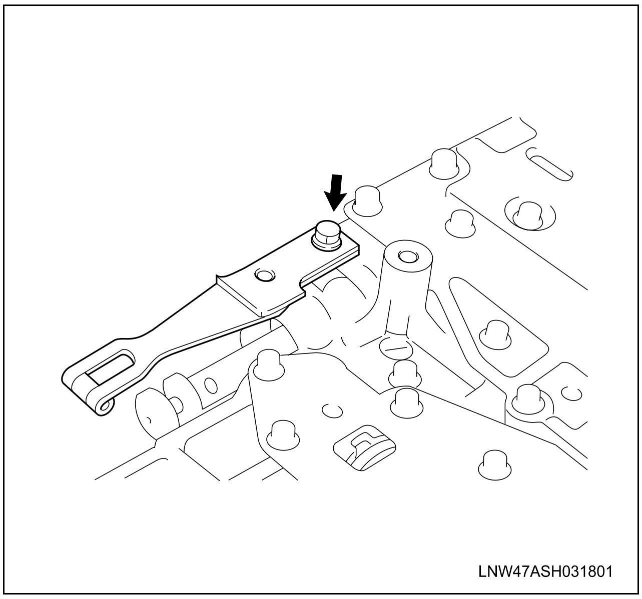

LNW47ASH031601

2. Remove the manual valve.


LNW47ASH031701

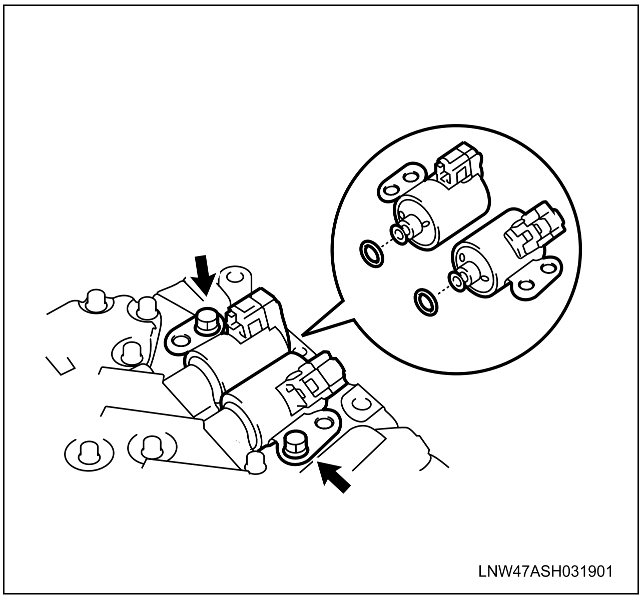
3. Remove manual detent spring.
    a. Turn over the valve body assembly.

b. Remove the bolt, spring cover and detent spring.



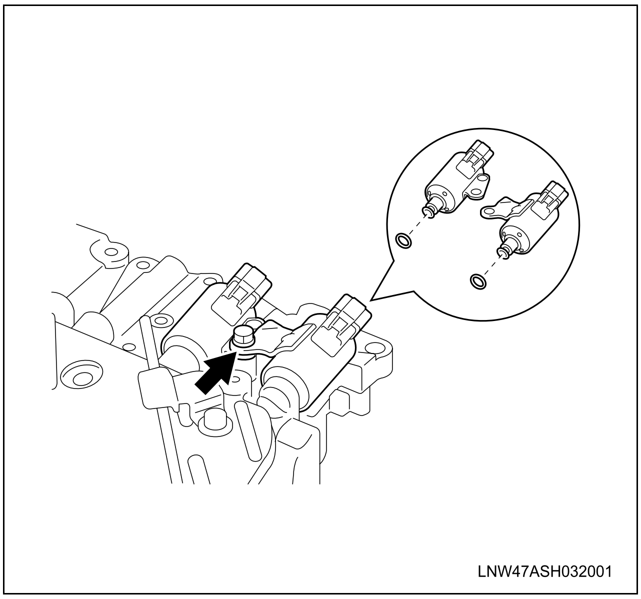
LNW47ASH031801

4. Remove 4 solenoid valves.
   a. Remove the 2 bolts, the No.1 and No.2 solenoids.
   b. Remove the 2 O-rings from them.



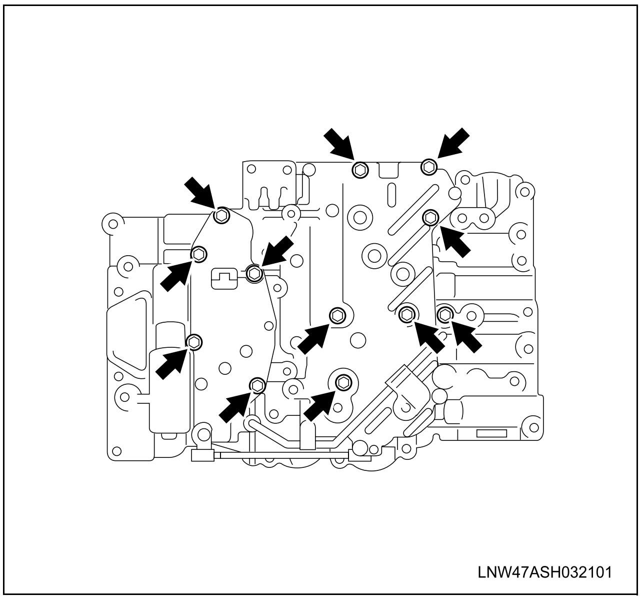
LNW47ASH031901

   c. Remove the bolt, the timing and lockup solenoids.
   d. Remove the 2 O-rings from them.



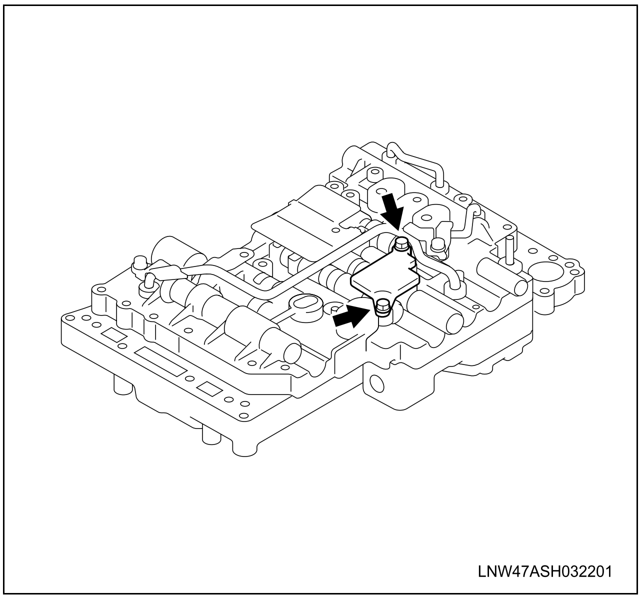
LNW47ASH032001

5. Separate upper and lower valve bodies.
   a. Remove the 12 bolts, and washers from the lower valve body.

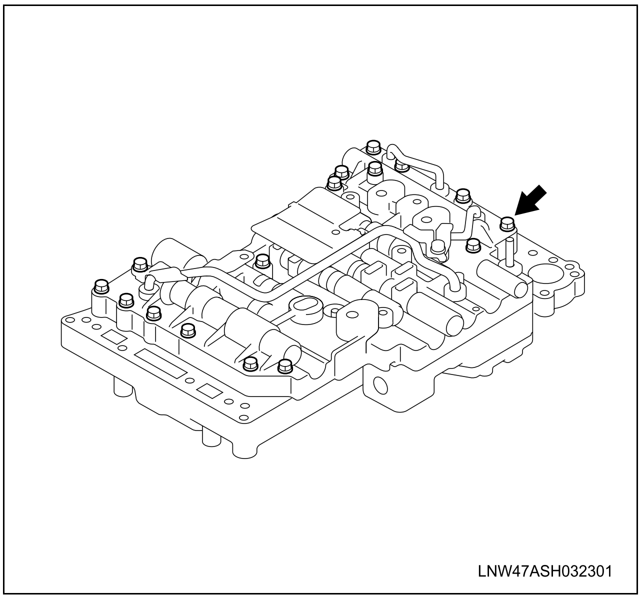


LNW47ASH032101

b. Remove 2 bolts and plates.



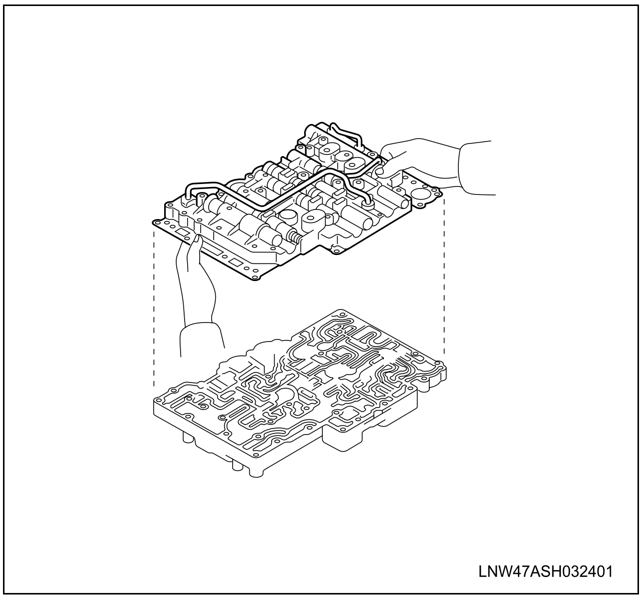
c. Remove the 16 bolts from the upper valve body.



d. Remove the upper valve body together with the 2 gaskets and plate.

e. Remove the 2 gaskets and plate from the upper valve body.

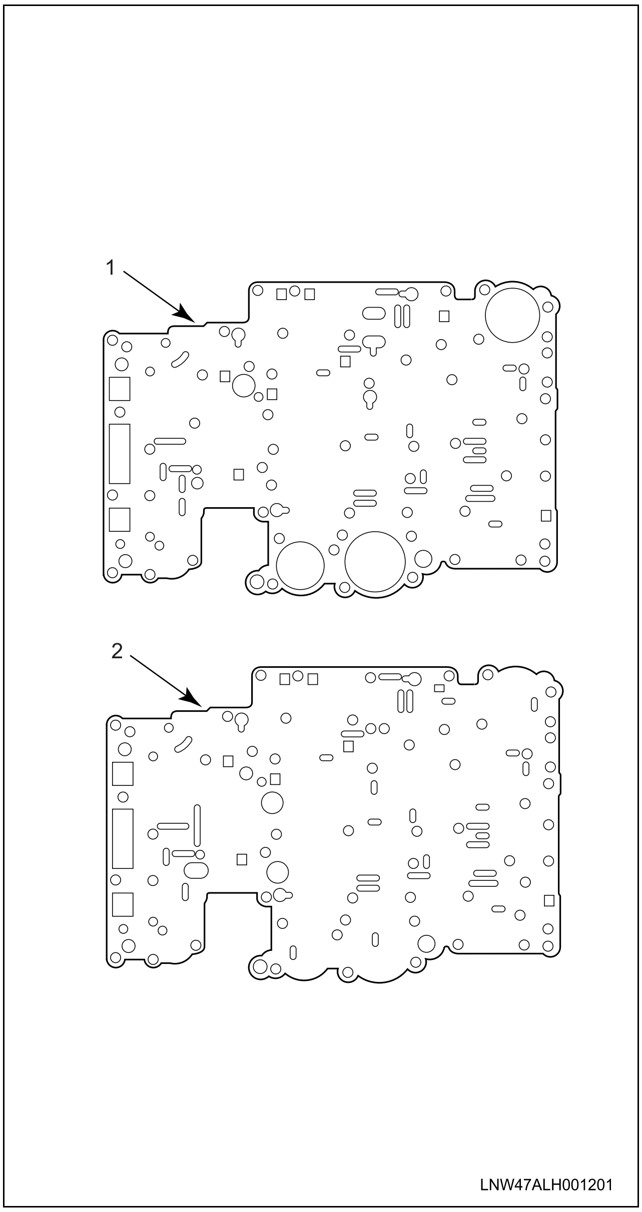
Notice:
Be careful that the check balls, springs and check valves do not fall out from the lower valve body.



Reassembly

1. Install valve body plate and gaskets.

Notice:
If there is dirt on the valve body, wash the valve body clean and install it.



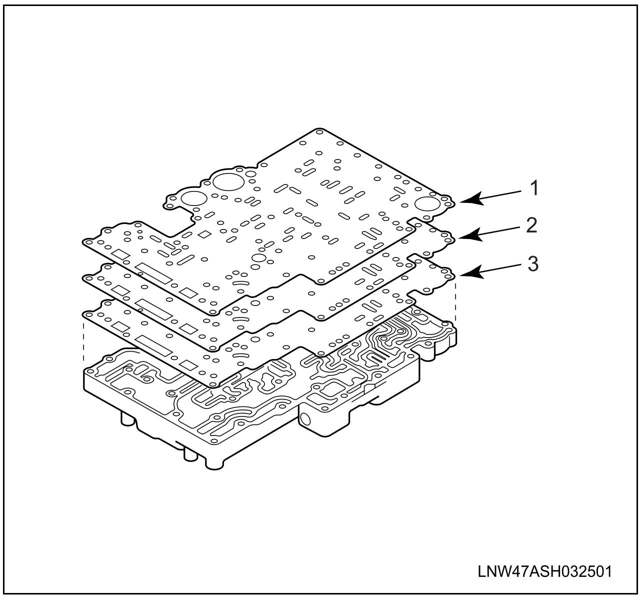
Legend

1. No.1 Gasket
2. No.2 Gasket

---

a. Place a new No.1 gasket, plate and a new No.2 gasket on the lower valve body.

Notice:
Since No.1 and No.2 gaskets look similar, use the illustrations above to differentiate between them.



Legend

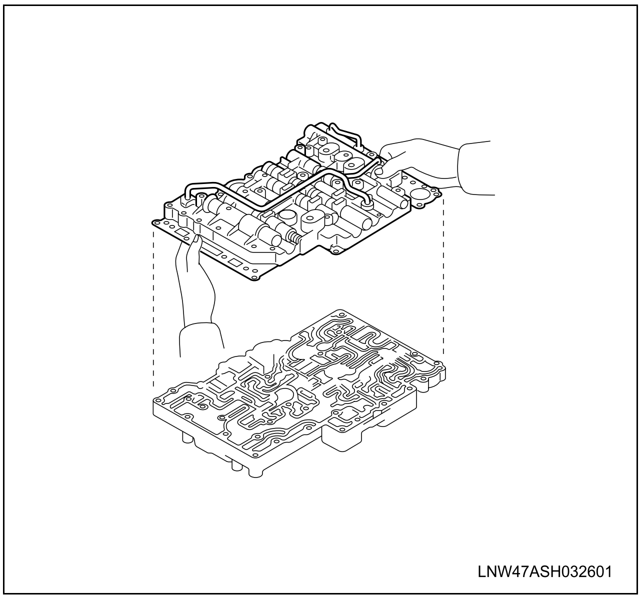
1. No.2 Gasket
2. Plate
3. No.1 Gasket

---

2. Install lower valve body.
   a. Turn over the valve body assembly together with the plate and 2 gaskets.

Notice:
Be careful that the check balls, check valve and spring do not fall out.

b. Place the lower valve body on the upper valve body.

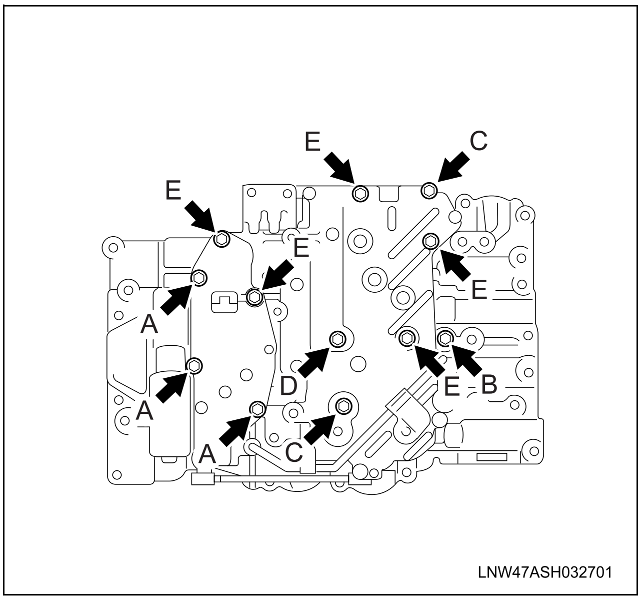


c. Install the 2 bolts and 2 washers indicated as “C” in the illustration and tighten them temporarily.

d. Install and tighten the rest of 10 bolts temporarily.

Notice:
Each bolt length (mm) is indicated in the illustration.

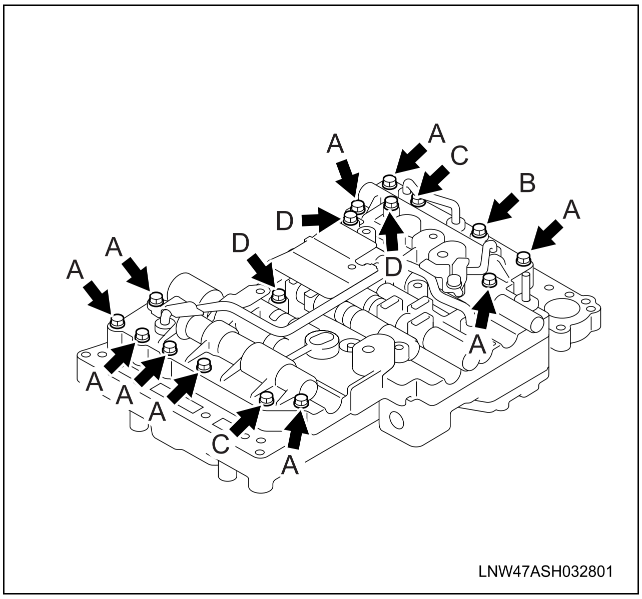
Bolt length: A 50 mm (1.97 in.)
B 42 mm (1.65 in.)
C 50 mm (1.97 in.) with washer
D 50 mm (1.97 in.)
E 53 mm (2.09 in.)



3. Install upper valve body.
   a. Turn over the valve body assembly.
   b. Install the 2 bolts and 2 washers indicated as “C” in the illustration and tighten them temporarily.
   c. Install and tighten the rest of 14 bolts temporarily.

Notice:
Each bolt length (mm) is indicated in the illustration.

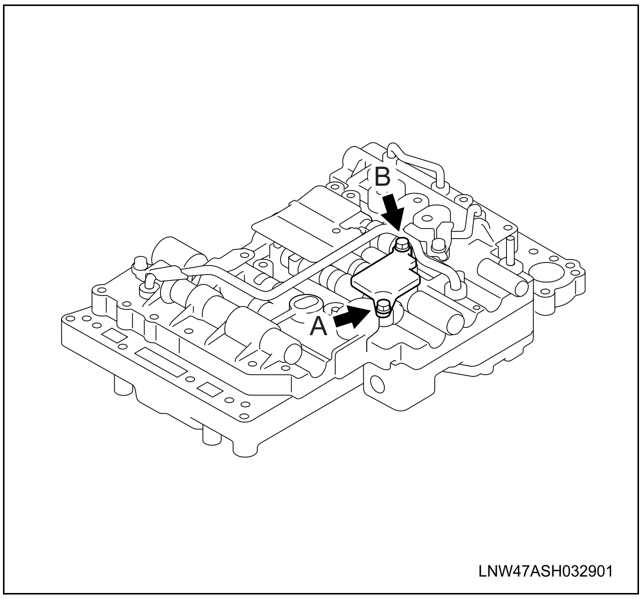
Bolt length: A 28 mm (1.10 in.)
B 32 mm (1.26 in.)
C 36 mm (1.42 in.) with washer
D 40 mm (1.57 in.)



4. Install the plate and tighten the 2 bolts temporarily.

Notice:
Each bolt length (mm) is indicated in the illustration.

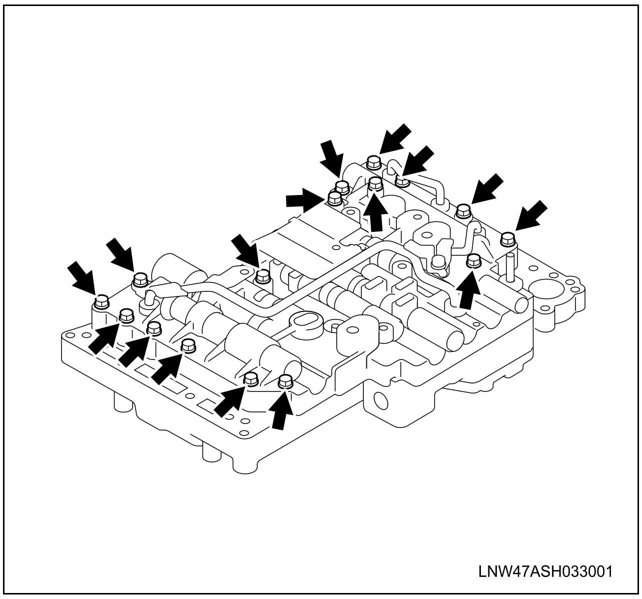
Bolt length: A 42 mm (1.65 in.)
B 50 mm (1.97 in.)



5. Tighten bolts of upper and lower valve bodies.
Upper side: Tighten the 16 bolts.

Tighten

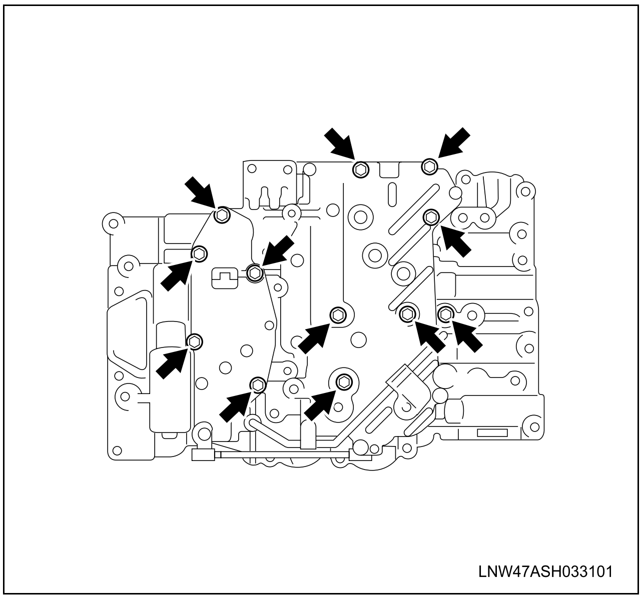
Torque: 5.5 N·m (48 lb in)



Lower side: Tighten the 12 bolts.

Tighten

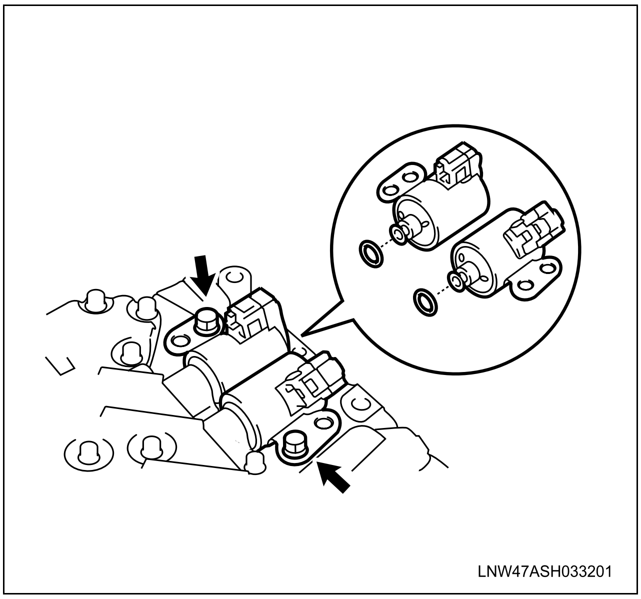
Torque: 5.5 N·m (48 lb in)



6. Install 4 solenoid valves.
   a. Coat the 2 O-rings with automatic transmission fluid (ATF), install them to the No.1 and No.2 solenoids.
   b. Install the No.1 and No.2 solenoids with the 2 bolts.

Tighten

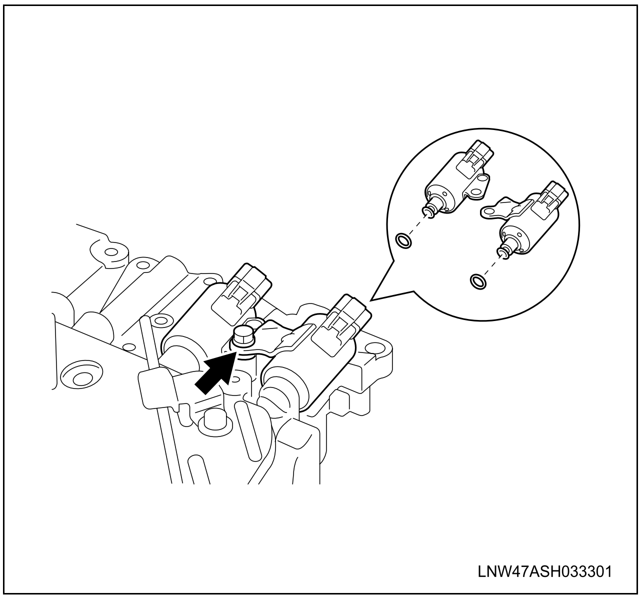
Torque: 10 N·m (87 lb in)



   c. Coat the 2 O-rings with ATF, install them to the timing and lockup solenoids.
   d. Install the timing and lockup solenoids.

Tighten

Torque: 10 N·m (87 lb in)

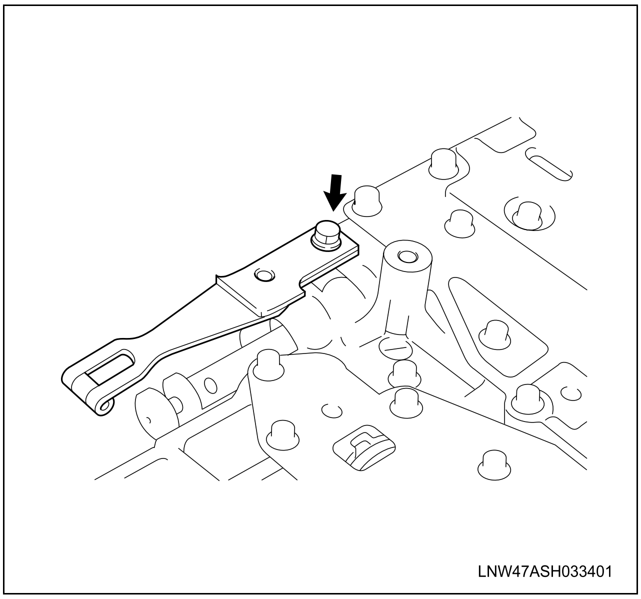


7. Install manual detent spring.
   Install the detent spring and cover with the bolt.

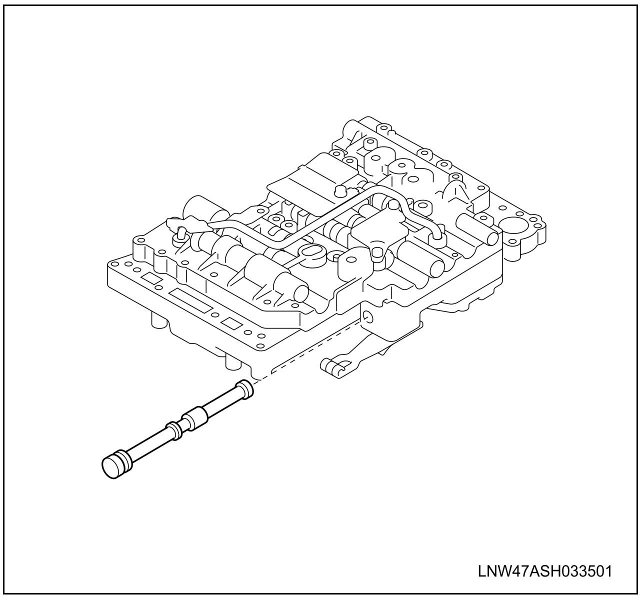
Tighten

Torque: 5.5 N·m (48 lb in)

Notice:
Use the bolt which is 43 mm (1.69 in.) in length.



8. Install manual valve into the valve body.

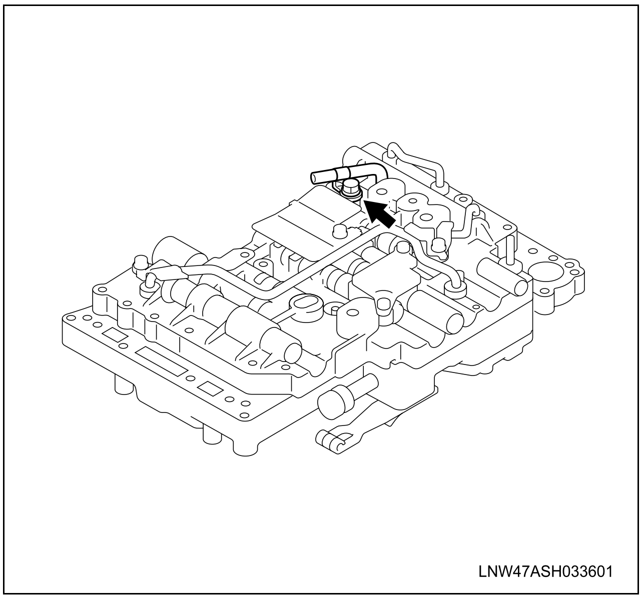


9. Install the drain tube.

Notice:
Use the bolt which is 10.5 mm (0.41 in.) in length.

Tighten

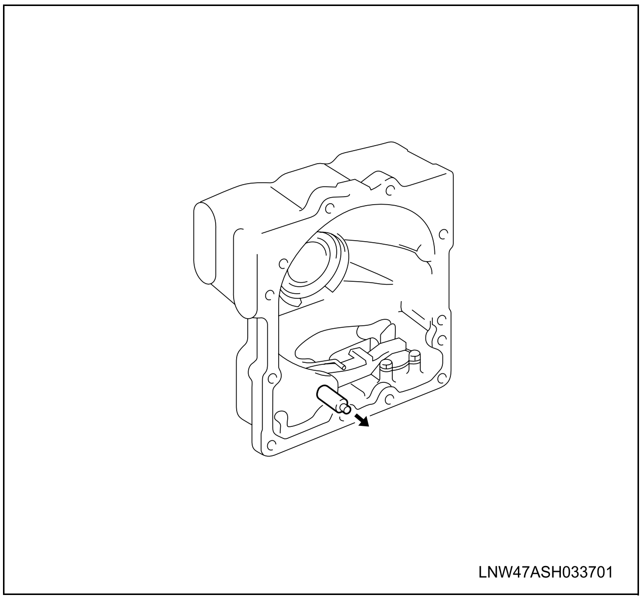
Torque: 5.5 N·m (48 lb in)



Extension Housing

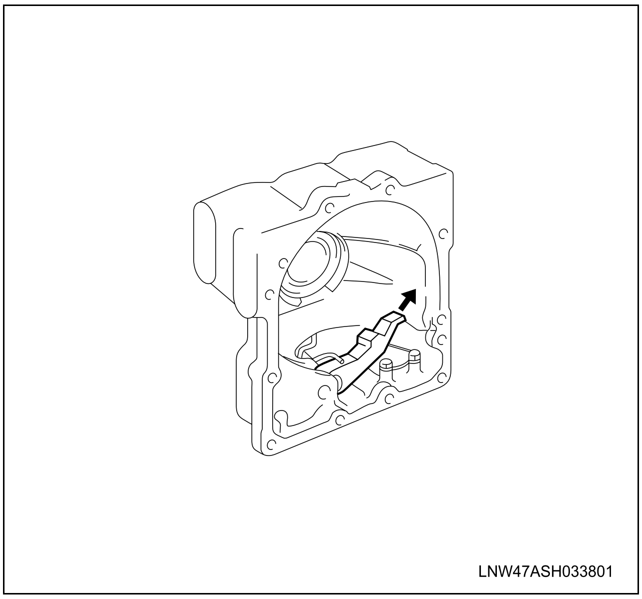
Disassembly

1. Remove the parking lock pawl shaft from the extension housing.

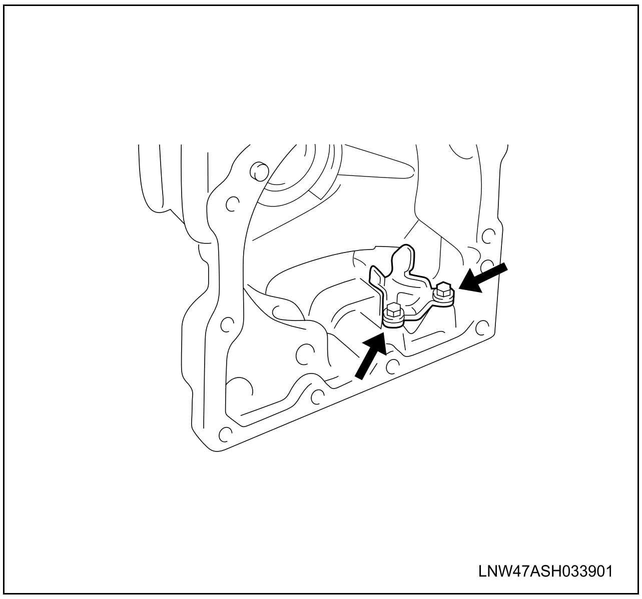


2. Remove parking lock pawl, torsion spring and plate washer.
   a. Remove the parking lock pawl.
   b. Remove the spring and plate washer.

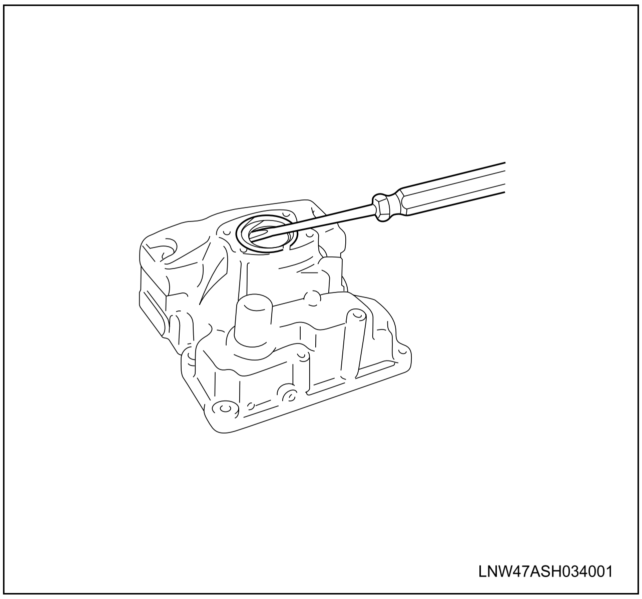
Caution:
Do not damage the spring and do not deform it unless necessary.



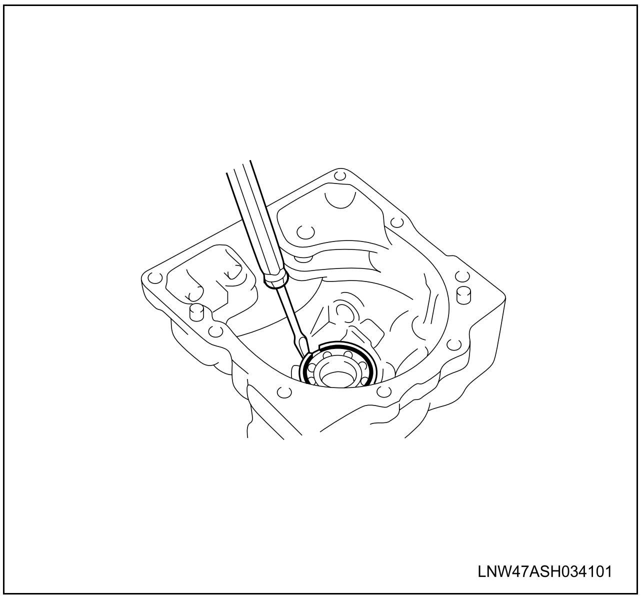
3. Remove the 2 bolts and parking lock pawl bracket.



4. Using a screwdriver, remove the oil seal.

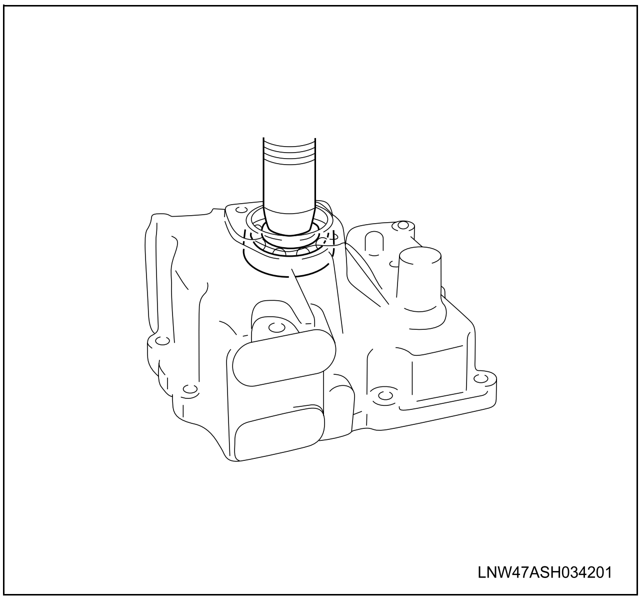


5. Remove bearing.
   a. Using a screwdriver, remove the snap ring.



   b. Using the rear bearing replacer and a shop press, press out the bearing.

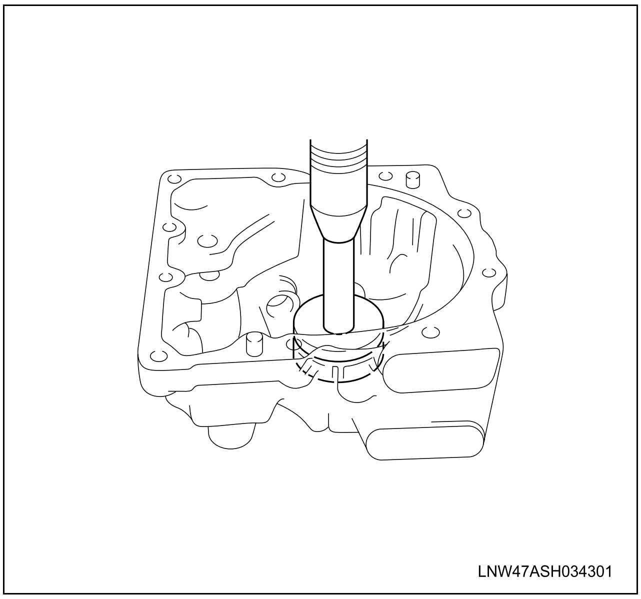
Tool Required: J-44165 Rear Bearing Replacer



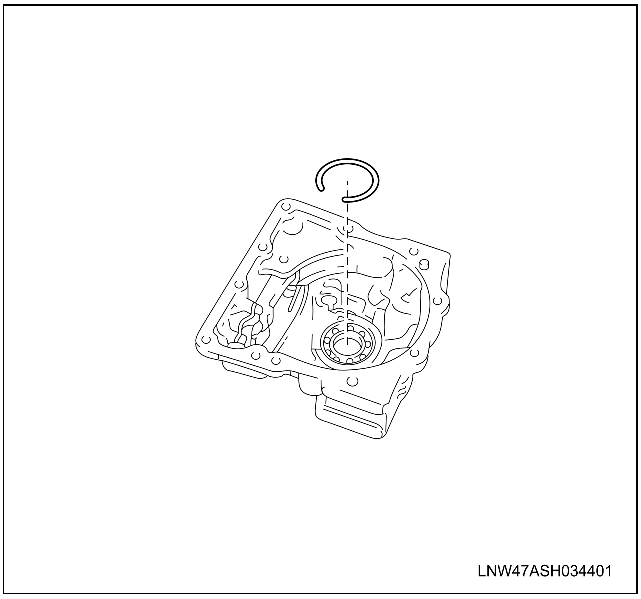
Reassembly

1. Install bearing.
   a. Using the rear bearing replacer, Oil seal (for lever shaft) installer and a shop press, press in the bearing.

Tool Required: J-44165 Rear Bearing Replacer
J-44171 Oil Seal (for lever shaft) Installer

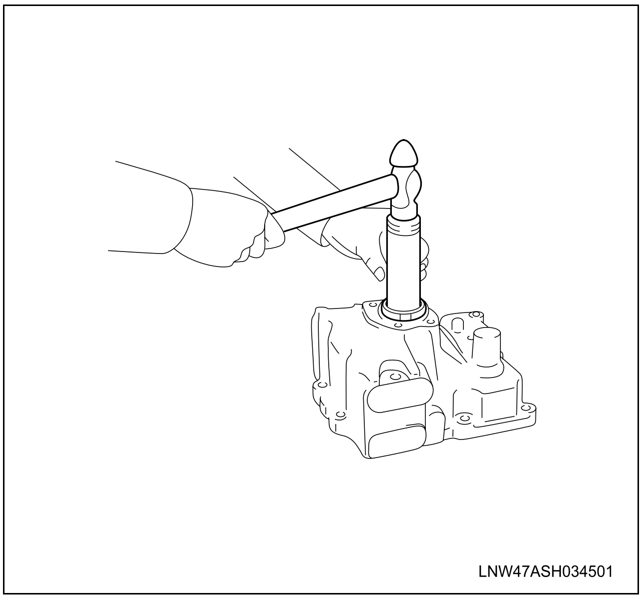


b. Install the snap ring.



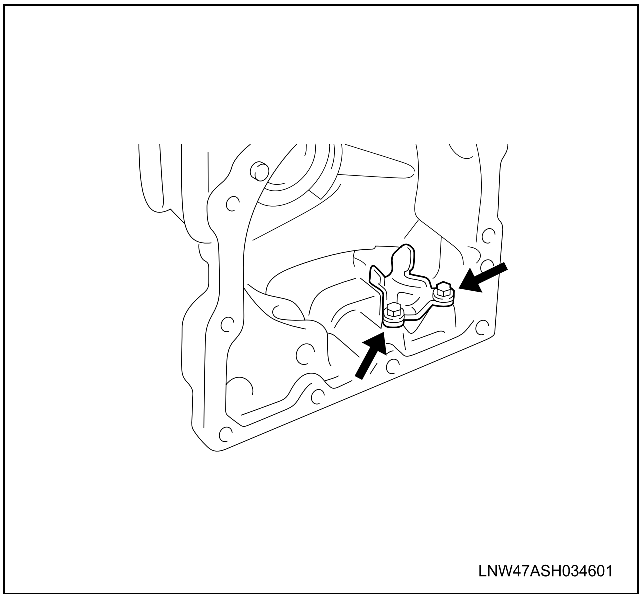
2. Using the oil seal installer and a hammer, install the oil seal.

Tool Required: J-44163 Oil Seal Installer



3. Install parking lock pawl bracket.
   a. Apply sealant (Three Bond 1344 or equivalent) to the threads of the 2 bolts.
   b. Temporarily install the bracket with the 2 bolts.

Notice:
These bolts are precoated bolt.



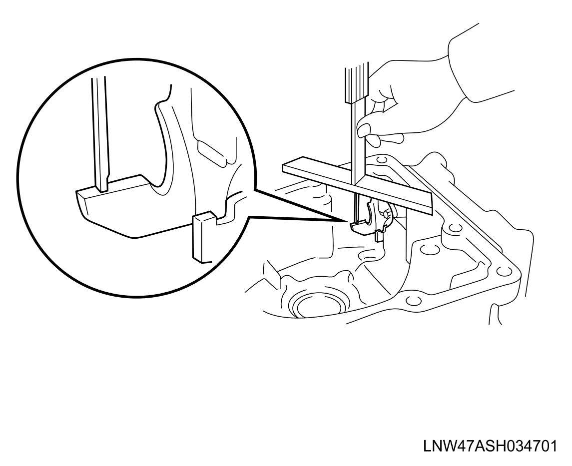
   c. Using the plate and a calipers, set the bracket so that the distance between the extension housing surface and the top of the bracket tab is the standard distance.
      Standard distance
      = Total distance – Plate thickness

Standard distance: 49.76–49.86 mm (1.959–1.963 in.)

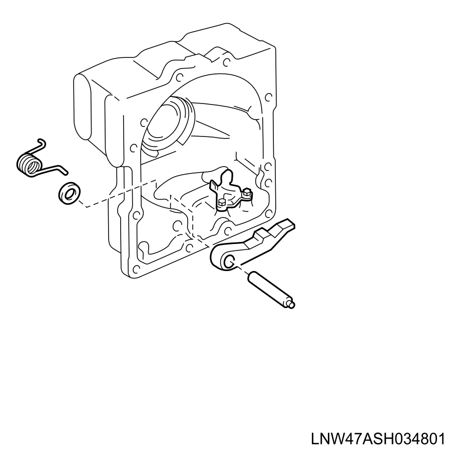
   d. Tighten the 2 bolts.

Tighten

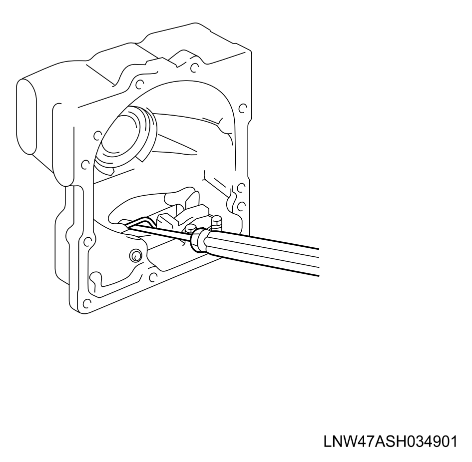
Torque: 19 N·m (14 lb ft)



4. Install parking lock pawl.
    a. Insert the torsion spring end to the hole of the extension housing.
    b. Install the parking lock pawl, shaft and plate washer.



    c. Hook another spring end to the parking lock pawl.
    d. Make sure the parking lock pawl moves smoothly.



Component Parts Installation

General Installation Description

Disassembly, inspection and assembly of each component group have been indicated in the preceding chapter. Before assembly, make sure again that all component groups are assembled correctly.
If something wrong is found in a certain component group during assembly, inspect and repair this group immediately.
Recommended automatic transmission fluid (ATF): DEXRON®-III

General Installation Notes:

1. The automatic transmission is composed of highly precision-finished parts, necessitating careful inspection before assembly because even a small nick could cause fluid leakage and affect performance.
2. Before assembling new clutch discs, soak them in ATF for at least 15 minutes.
   Apply ATF on sliding or rotating surfaces of parts before assembly.
3. Use petroleum jelly to keep small parts in their places.
4. Do not use adhesive cements on gaskets and similar parts.
5. When assembling the transmission, be sure to use new gaskets and O-rings.
6. Dry all parts with compressed air, never use shop rags.

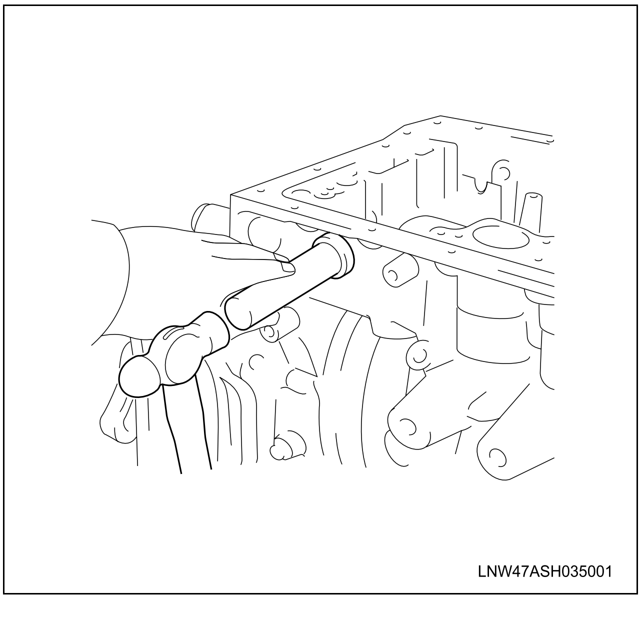
Manual Valve Lever, Shaft and Oil Seals

Installation Procedure

1. Using the oil seal installer, tap in new 2 oil seals.

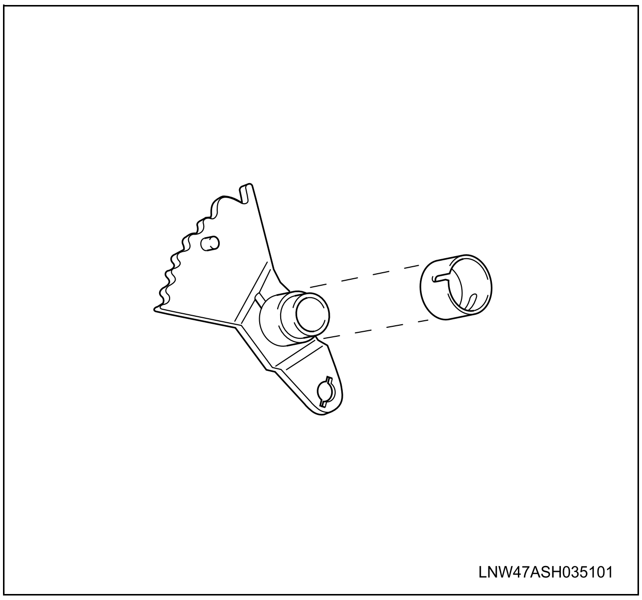
Tool Required: J-44171 Lever Shaft Oil Seal Installer

2. Apply multi purpose grease to the oil seal lip.



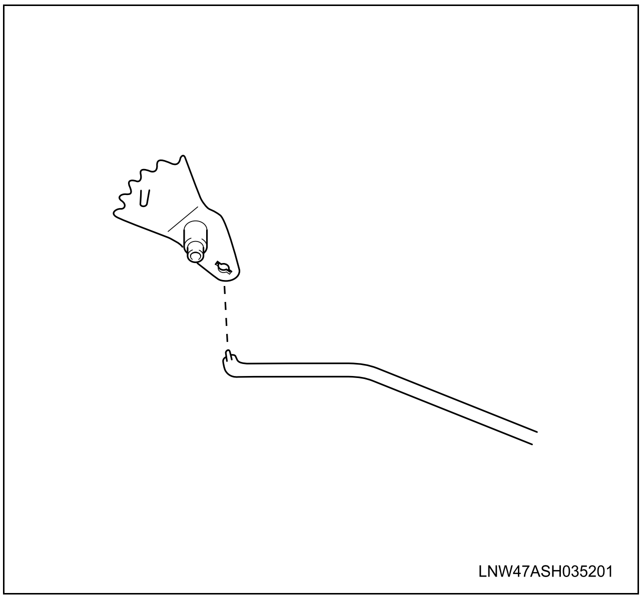
LNW47ASH035001

3. Install the new spacer to the manual valve lever.



LNW47ASH035101

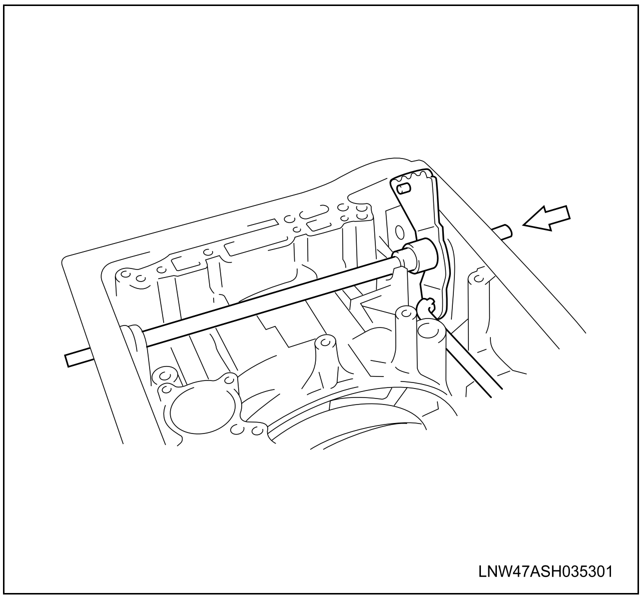
4. Connect the parking lock rod to the manual valve lever.



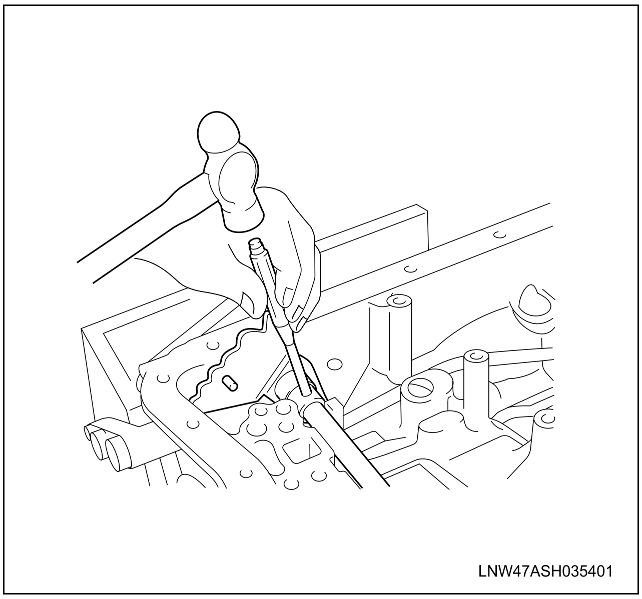
LNW47ASH035201

5. Install the manual valve lever shaft to the transmission case through the manual valve lever.

Caution:
Be careful not to damage the oil seals.

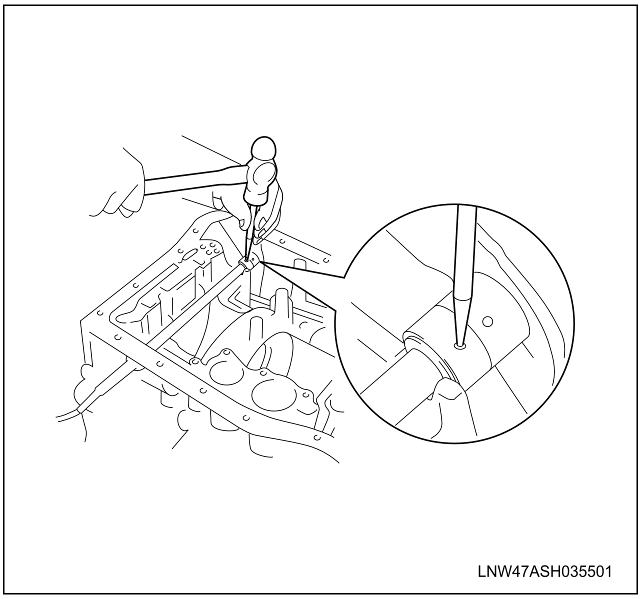


6. Using a punch and hammer, tap in the pin with the slot at right angle to the shaft.



7. Match the spacer hole to the lever calking hollow and calk the spacer to the lever.

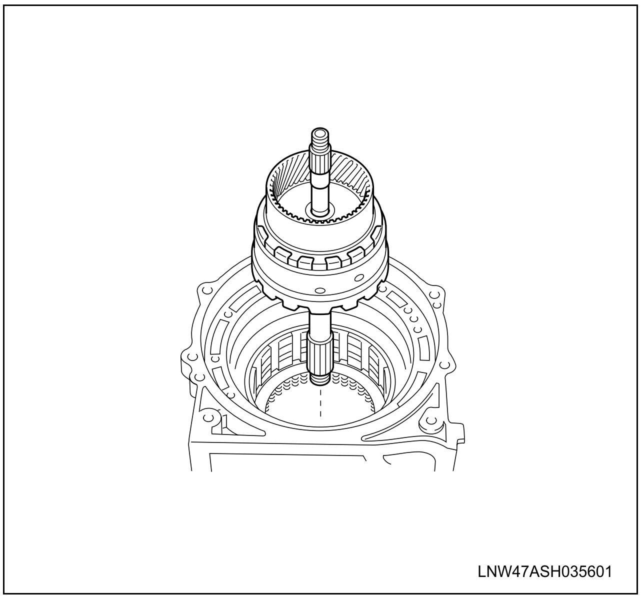
8. Make sure the manual valve lever shaft turns smoothly.



Planetary Gears, One-Way Clutch and Output Shaft Assembly

Installation Procedure

1. Place the transmission case on a cylinder.
2. Install the rear planetary gear and output shaft assembly to the transmission case.



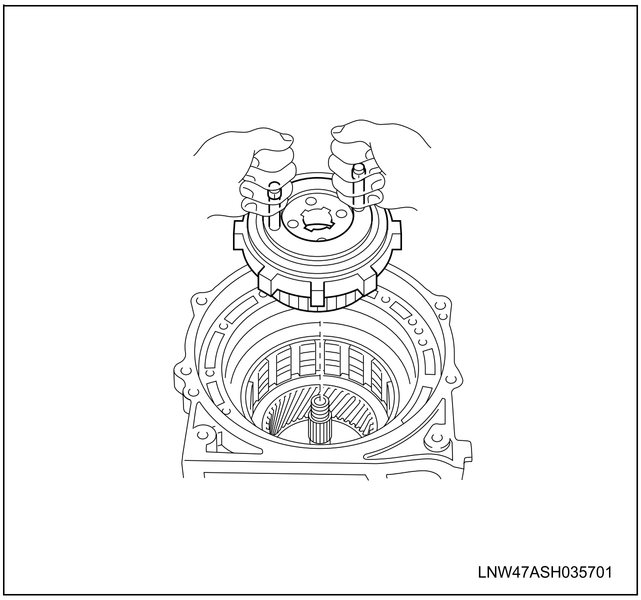
3. Temporarily install 2 bolts to the front planetary gear.

Notice:
Use two 6 mm (1 mm pitch) bolts. Do not screw more than 5 revolutions.

4. Align the spline of the one-way clutch assembly into the transmission case.
5. Install the front planetary gear and one-way clutch assembly into the transmission case.

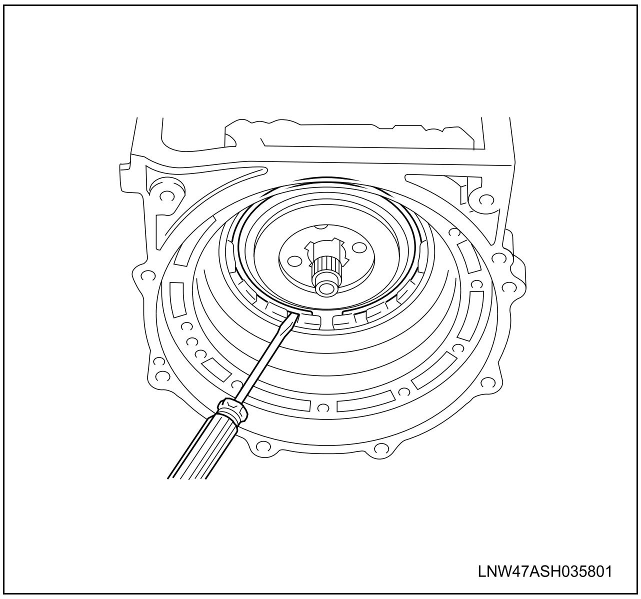
Notice:

- Mesh the spline of the front planetary gear with the flukes of the discs by rotating and pushing the front planetary gear clockwise.
- If the front planetary gear will not rotate clockwise, check the installation of the one-way clutch.


LNW47ASH035701

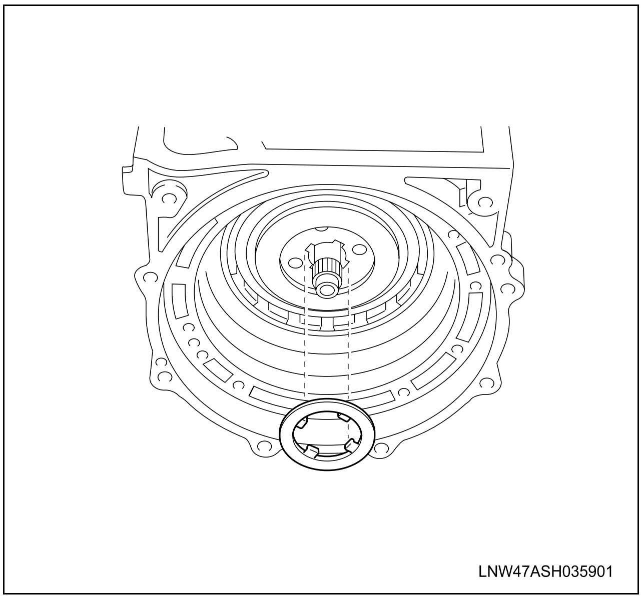
6. Remove the 2 bolts from the front planetary gear.
7. Using a screwdriver, install the snap ring.

Notice:
Be sure the end of the snap ring is not aligned with the cutout portion of the transmission case.


LNW47ASH035801

8. Coat the thrust washer with petroleum jelly, and install it onto the front planetary gear.

Notice:
Securely fit the claws of the thrust washer into the grooves of the front planetary gear.

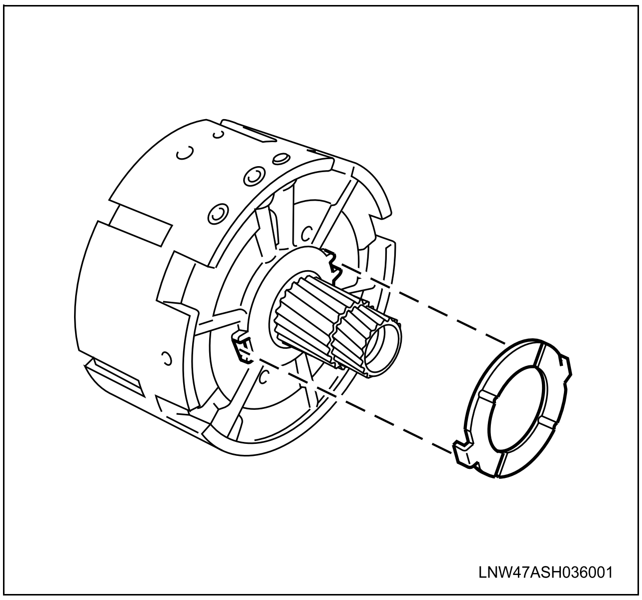

LNW47ASH035901

Temporarily Install Center Support Assembly

Installation Procedure

1. Coat the thrust washer with petroleum jelly, and install it onto the rear side of the center support.

Notice:
Securely fit the claws of the thrust washer into the grooves of the center support.

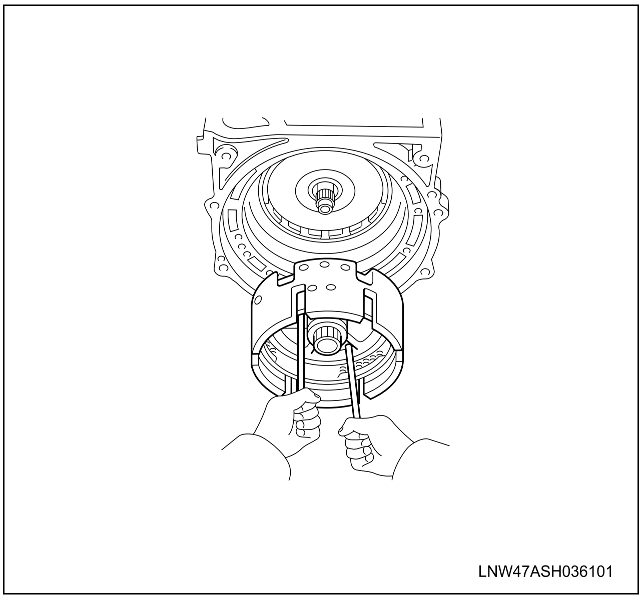

LNW47ASH036001

2. Install oil pump remover (2 bolts) to the center support.

Tool Required: J-44170 Oil Pump Remover

3. Align the oil holes and bolt holes of the center support and transmission case.

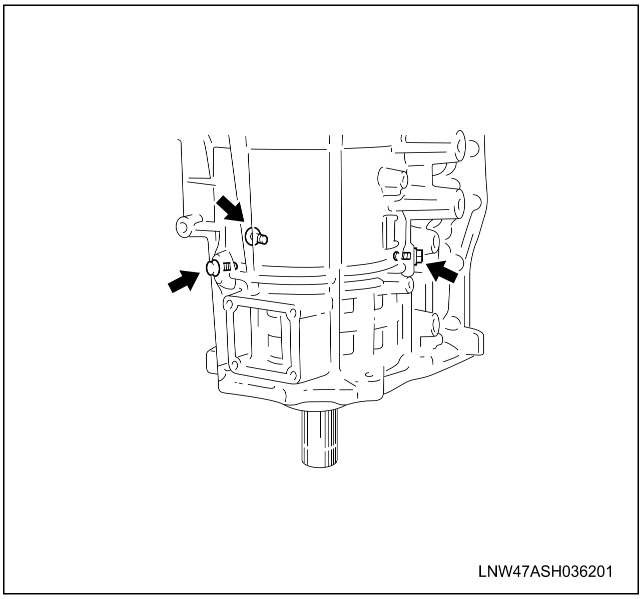
4. Install the center support assembly into the transmission case.



5. Install the 3 center support bolts.

Tighten

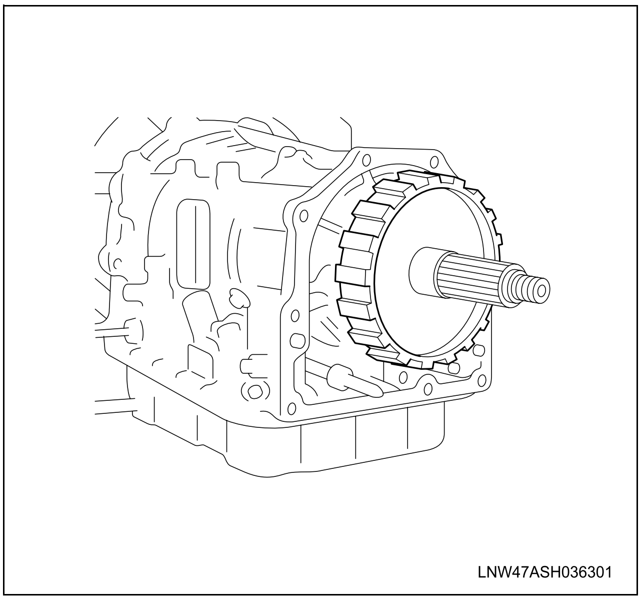
Torque: 25 N·m (18 lb ft)



Parking Lock Gear

Installation Procedure

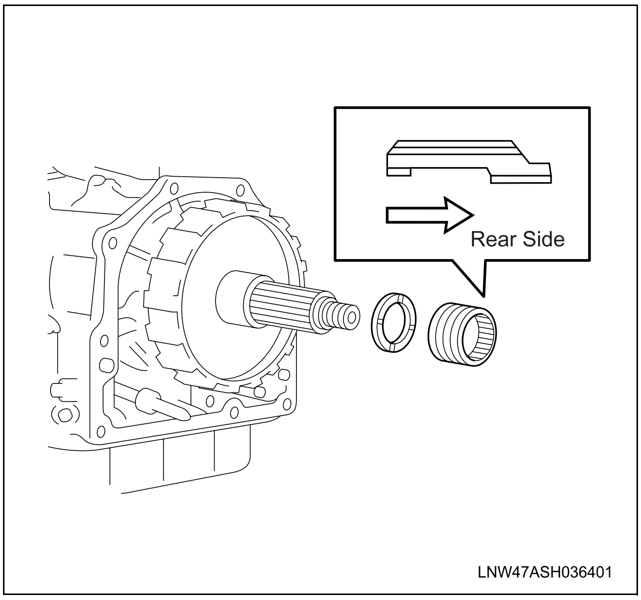
Install the parking lock gear onto the output shaft.



Output Shaft Spacer and Speedometer Drive Gear

Installation Procedure

Install the spacer and speedometer drive gear onto the output shaft.

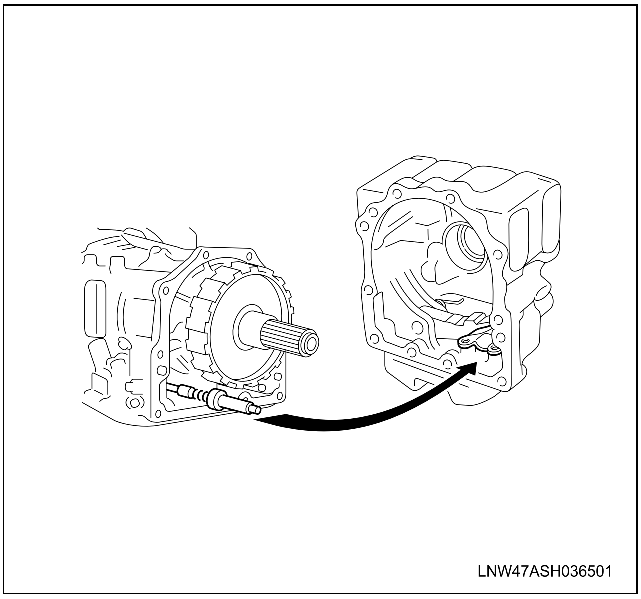


Extension Housing

Installation Procedure

1. Place the new gasket on the transmission case.

2. Install the parking lock rod between the parking lock pawl and bracket, and attach the extension housing on the transmission case.

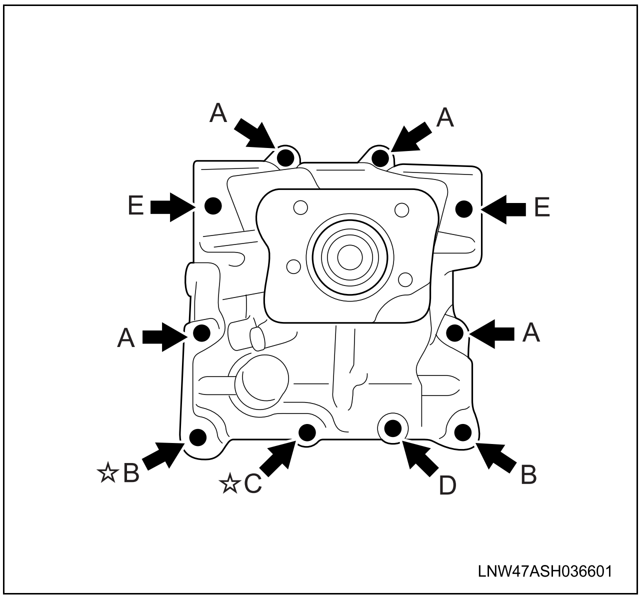


3. Apply sealant (Three Bond 1344, Loctite 572 or equivalent) to the thread of the 2 bolts.
4. Install the 2 bolts indicated by I marks in the illustration and tighten them.
5. Install and tighten the 7 bolts.

Bolt length: A 45 mm (1.77 in.)
B 50 mm (1.97 in.)
C 85 mm (3.35 in.)
D 117 mm (4.61 in.)
E 120 mm (4.72 in.)

Tighten

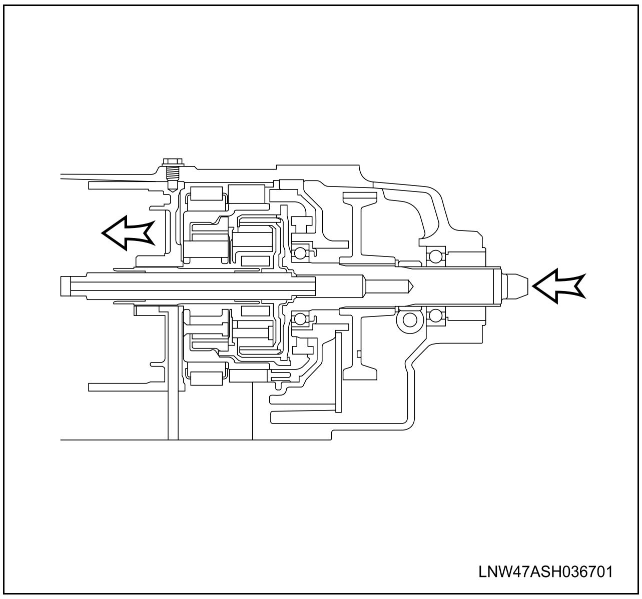
Torque: 37 N·m (27 lb ft)



Thrust Clearance of Center Support

Installation Procedure

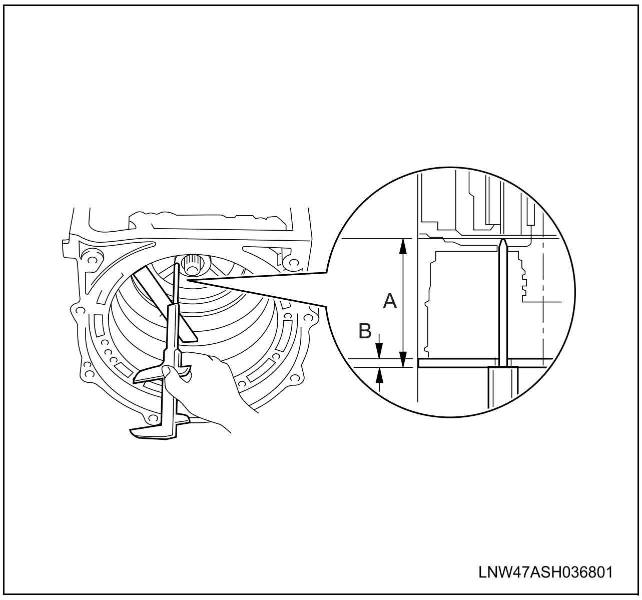
1. Push the transmission output shaft toward the front of the transmission by applying a force of 49–89 N (11.0–22.0 lb).
2. Push the center support toward the rear of the transmission by applying a force of 49–89 N (11.0–22.0 lb), then pull with the same amount of force.



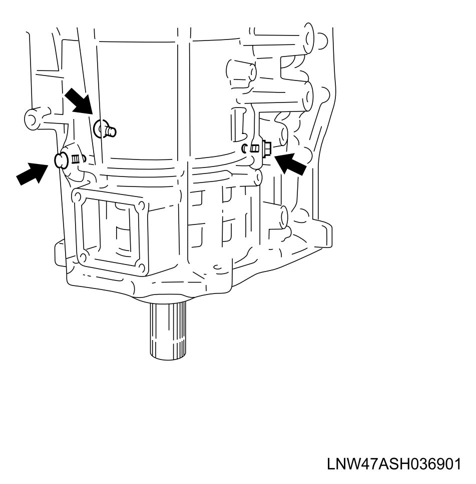
3. Place the plate on the center support.

Tool Required: J-44166 Plate

4. Using calipers, measure distance (A) between the tops of the plate and the thrust washer on the front planetary gear.
5. Using calipers, measure thickness (B) of the plate.

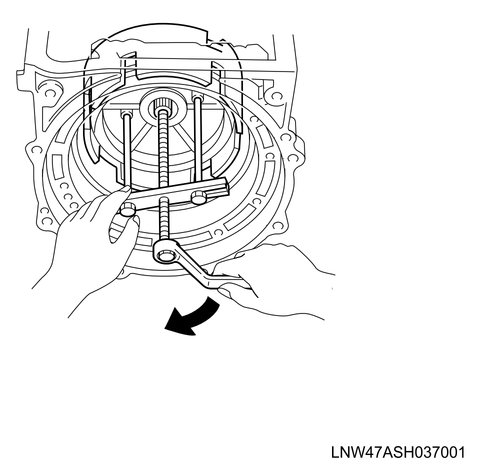


6. Remove the 3 center support set bolts.



7. Using the oil pump remover, remove the center support assembly from transmission case.

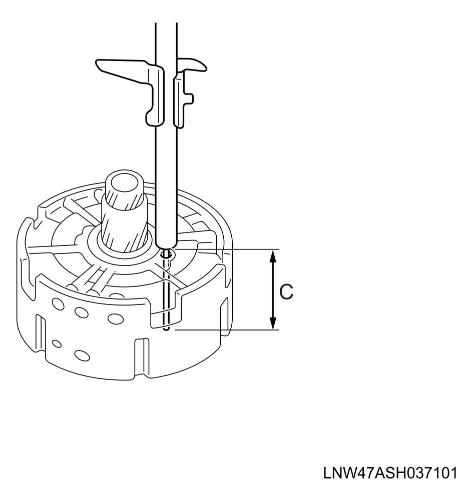
Tool Required: J-44170 Oil Pump Remover



8. Turn over the center support together with the thrust washer, and place it on a flat surface.
9. Inserting calipers into the thrust washer hole, measure the distance (C) between it and the flat surface.

Center support thrust clearance: A – (B + C)

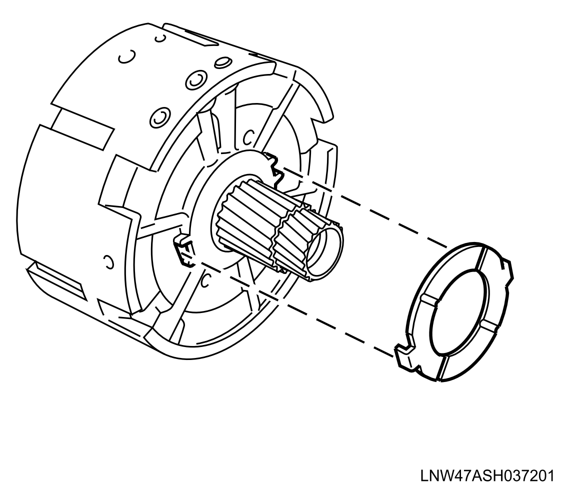
Standard thrust clearance:	0.30–0.70 mm (0.0118–0.0276 in.)
Maximum thrust clearance:	0.90 mm (0.0354 in.)



If the thrust clearance is greater than the maximum, select and install a thrust washer.

Thrust washer thicknesses

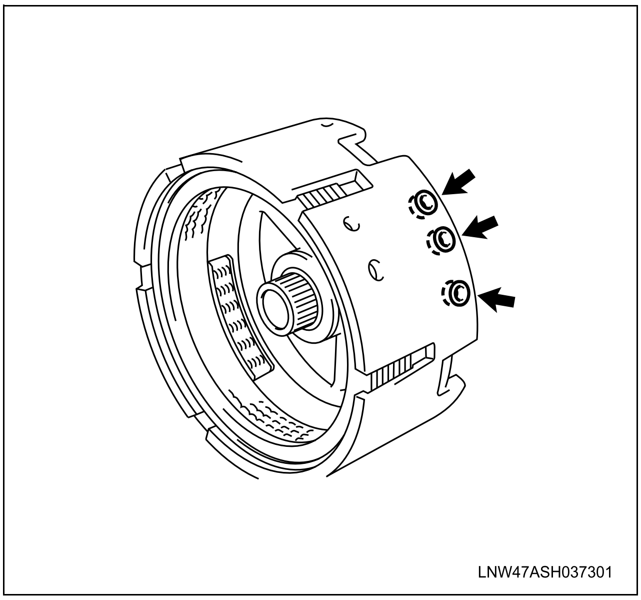
Thickness mm (in.)
1.5 (0.059)
1.8 (0.071)
2.1 (0.083)
2.4 (0.094)
2.7 (0.108)



Center Support Assembly

Installation Procedure

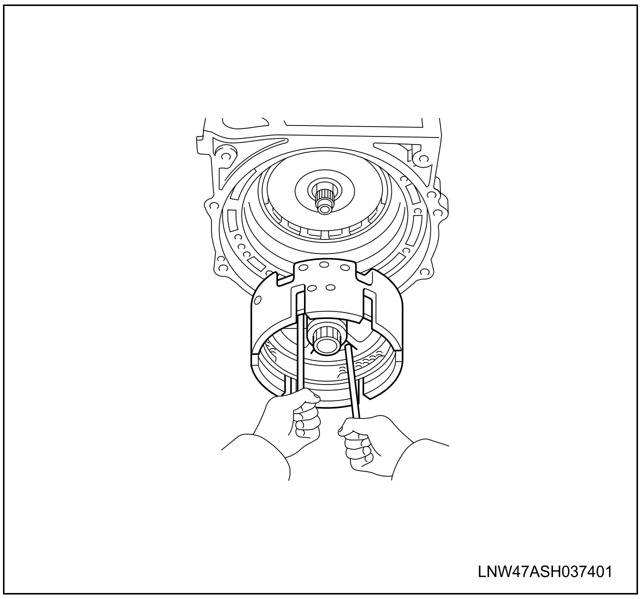
1. Coat new 3 O-rings with automatic transmission fluid (ATF) and install them to the oil holes of the center support.



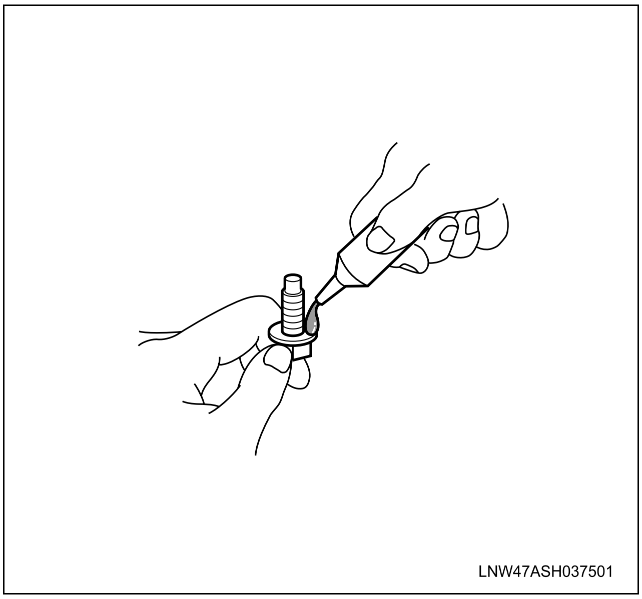
2. Install the oil pump remover (2 bolts) to the center support.

Tool Required: J-44170 Oil Pump Remover

3. Align the oil holes and bolt hole of the center support and transmission case.
4. Install the center support assembly into the transmission case.



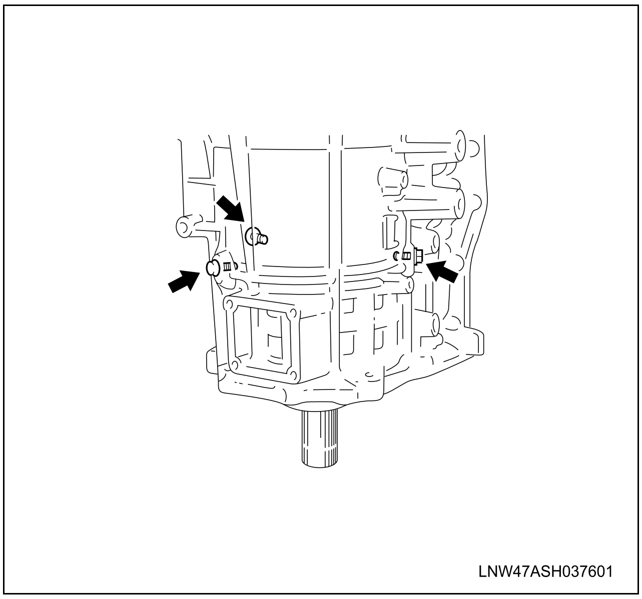
5. Apply sealant (Three Bond 1344, Loctite 572 or equivalent) to the threads of the center support set bolts.



6. Install the 3 center support set bolts.

Tighten

Torque: 25 N·m (19 lb ft)

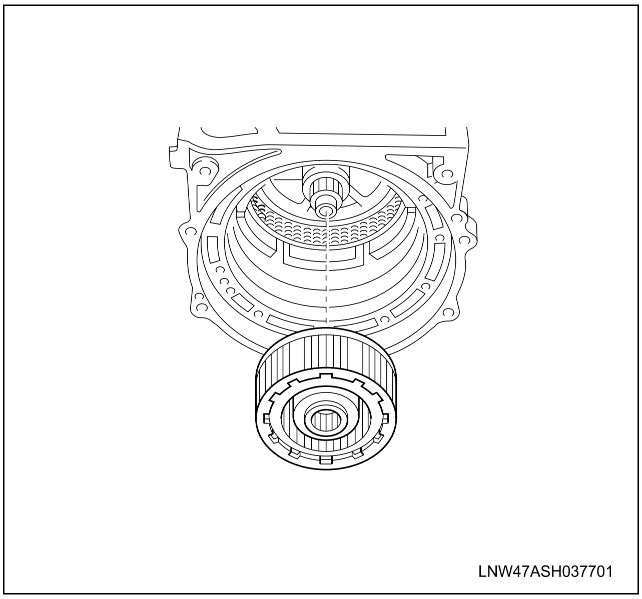


Rear Clutch Assembly

Installation Procedure

Install the rear clutch assembly into the transmission case.

Notice:
Mesh the spline of the rear clutch drum with the flukes of the discs by rotating and pushing the rear clutch drum clockwise or counterclockwise.



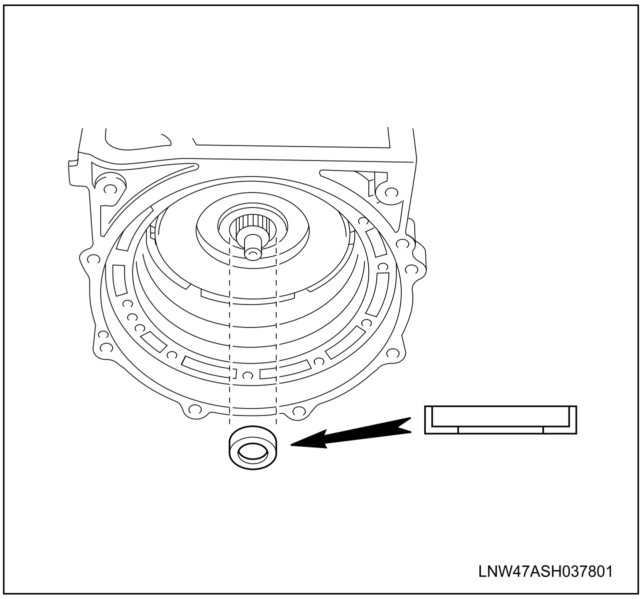
Front Clutch Assembly

Installation Procedure

1. Coat the race with petroleum jelly, and install it onto the rear clutch drum.

Race diameter

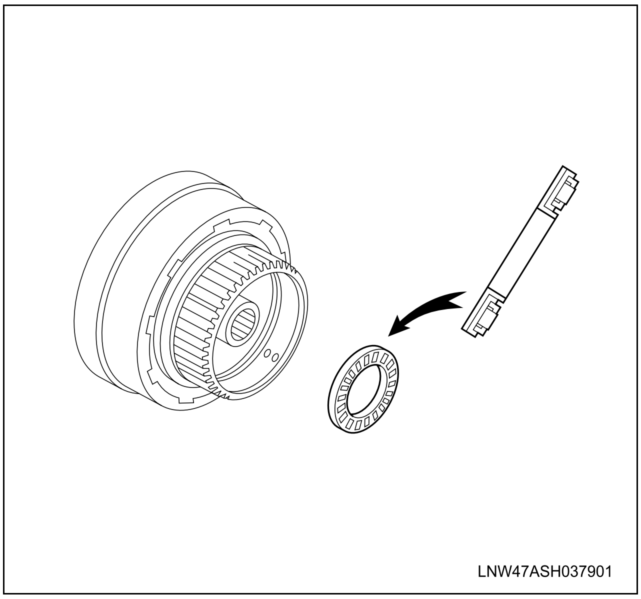
Diameter mm (in.)	Inside	Outside
Race	37.0 (1.457)	52.0 (2.047)



2. Coat the bearing with petroleum jelly, and install it onto the front clutch hub.

Bearing diameter

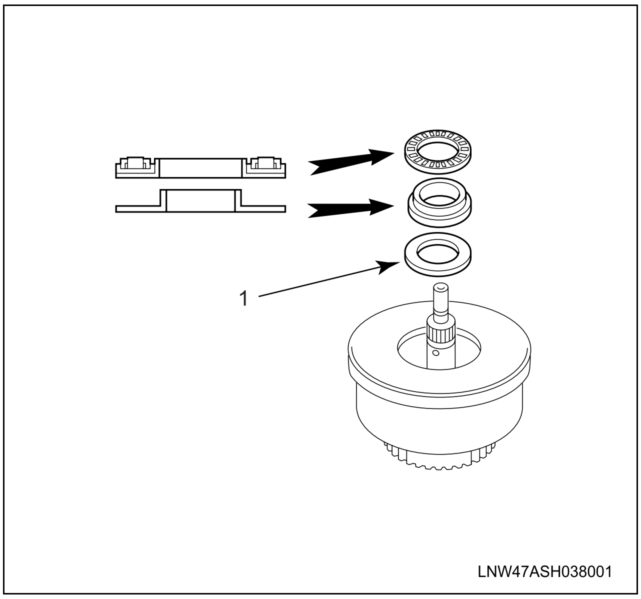
Diameter mm (in.)	Inside	Outside
Bearing	32.8 (1.291)	52.0 (2.047)



3. Coat the spacer, race and bearing with petroleum jelly, and install these parts onto the front clutch drum.

Bearing and race diameter

Diameter mm (in.)	Inside	Outside
Bearing	34.7 (1.366)	52.0 (2.047)
Race (Rear)	32.8 (1.291)	50.4 (1.984)

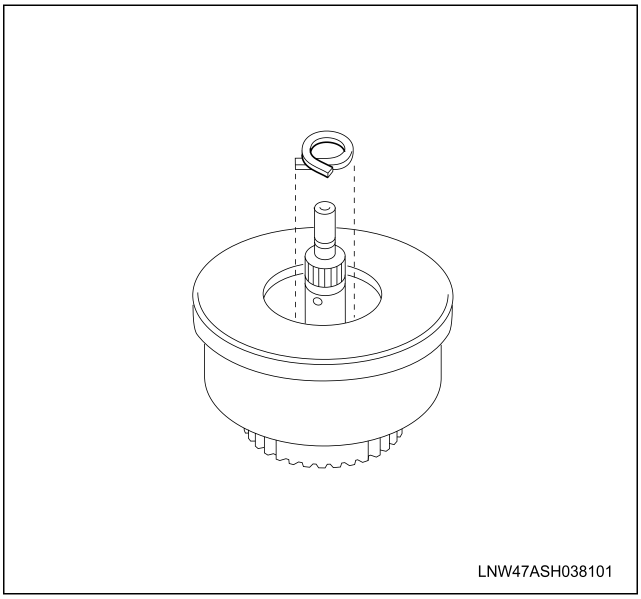


Legend

1. Spacer

4. Coat the new oil seal ring with automatic transmission fluid (ATF).
5. Install the oil seal ring to the clutch drum, then sank it down by squeezing their ends together.

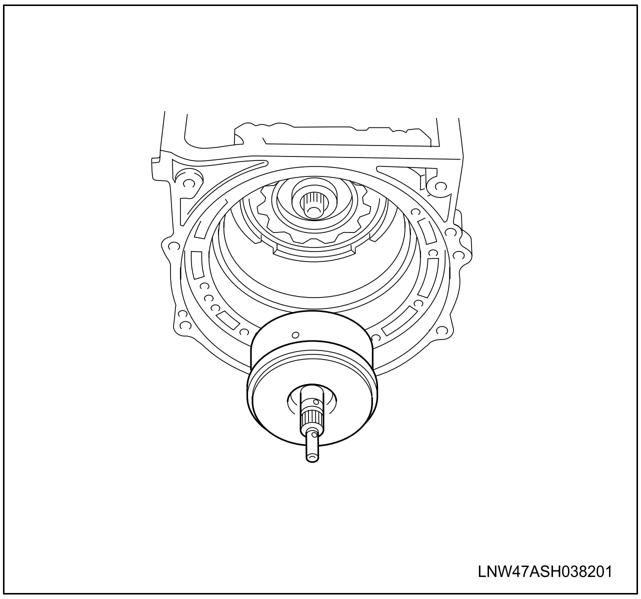
Caution:
Do not spread the ring seals more than necessary.



LNW47ASH038101

6. Install the front clutch assembly into the rear clutch assembly.

Notice:
Mesh the spline of the rear clutch drum with the flukes of the discs by rotating and pushing the rear clutch drum clockwise or counterclockwise.



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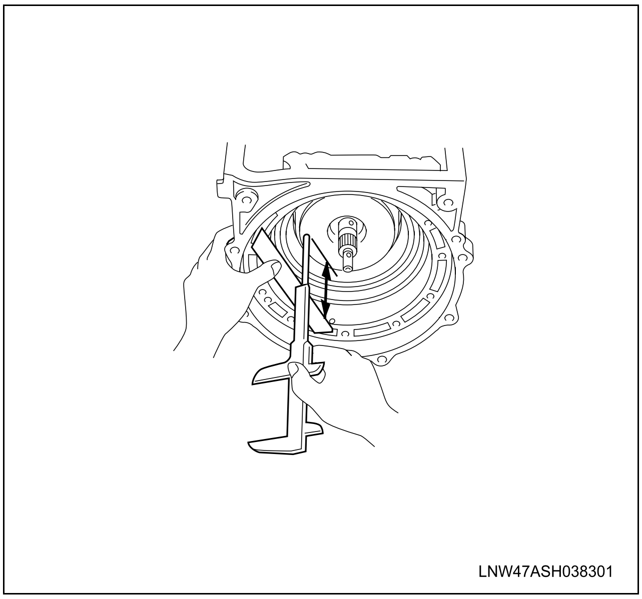
7. Place the plate on the installation surface of the oil pump.

Tool Required: J-44166 Plate

8. Using calipers, measure the distance between the tops of the plate and the clutch drum.
   If the distance corresponds to that during disassembly, the front clutch assembly is installed correctly.



LNW47ASH038301

Temporarily Install Overdrive (OD) Case Assembly

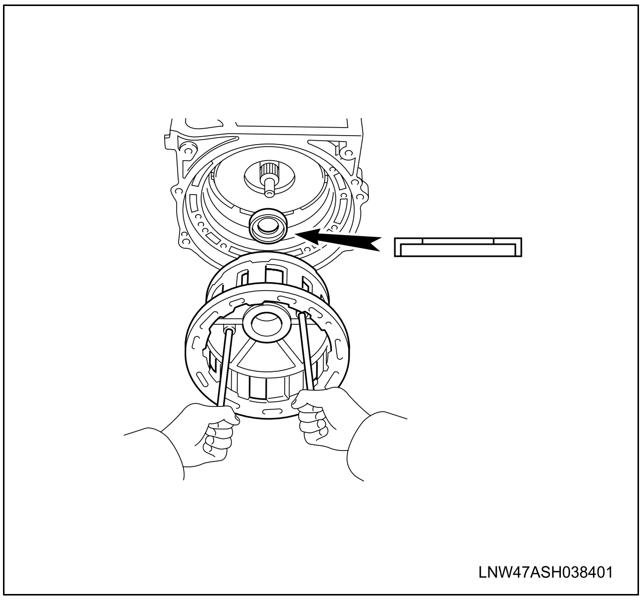
installation Procedure

1. Coat the race with petroleum jelly, and install it into the OD case.

Race diameter

Diameter mm (in.)	Inside	Outside
Race (Rear)	32.8 (1.291)	50.4 (1.984)

2. Install the oil pump remover (2 bolts) to the OD case.

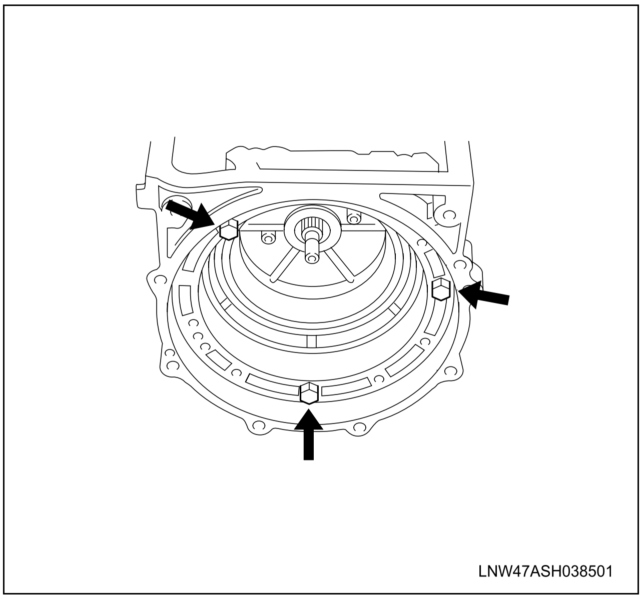


LNW47ASH038401

3. Align the oil holes and bolt holes of the OD case and transmission case.
4. Temporarily install the 3 bolts.

Tighten

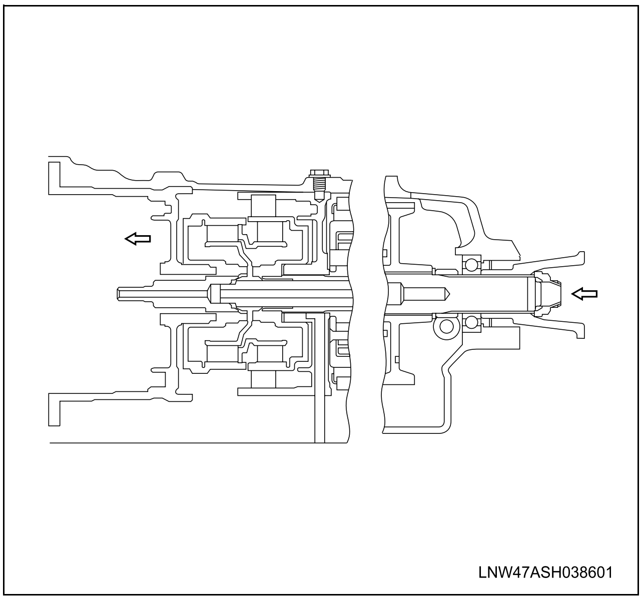
Torque: 25 N·m (18 lb ft)



Thrust Clearance of Input Shaft (Front Clutch Drum)

installation Procedure

1. Push the transmission output shaft toward the front of the transmission by applying a force of 49–98 N (11.0–22.0 lb).
2. Push the OD case toward the rear of the transmission by applying a force of 49–98 N (11.0–22.0 lb).

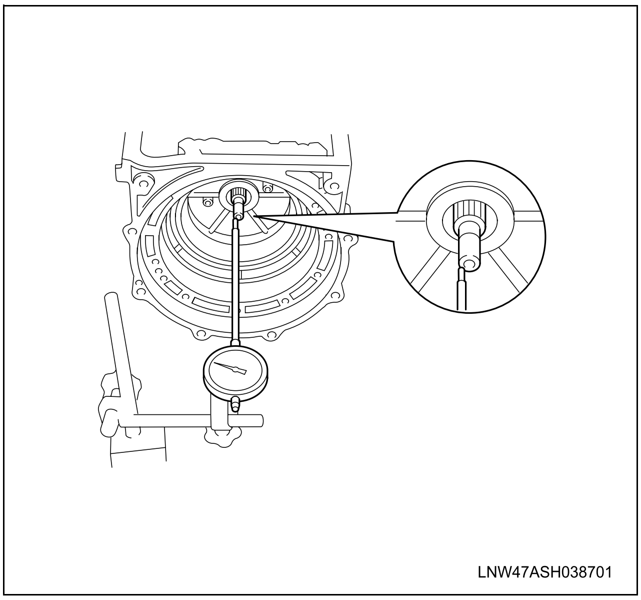


3. Using the extension bar and a dial indicator, measure the thrust clearance of the input shaft.

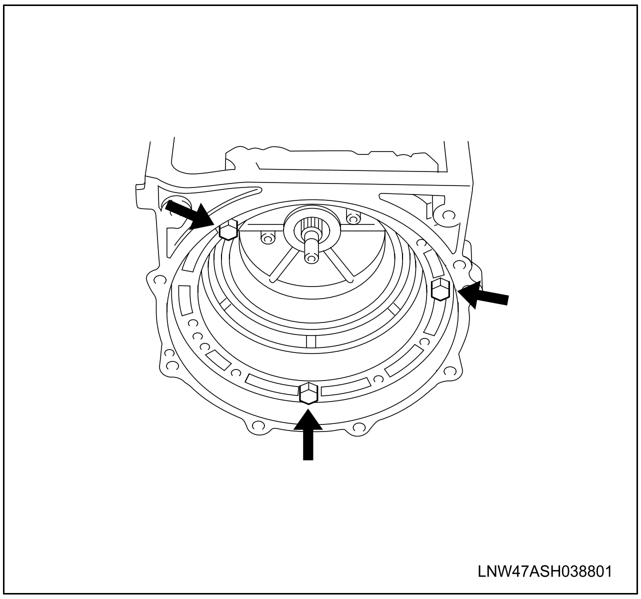
Tool Required: J-44169 Extension Bar

Standard thrust clearance:	0.30–0.70 mm (0.0118–0.0276 in.)
Maximum thrust clearance:	0.70 mm (0.0276 in.)

If the thrust clearance is greater than the maximum, adjust with a spacer.

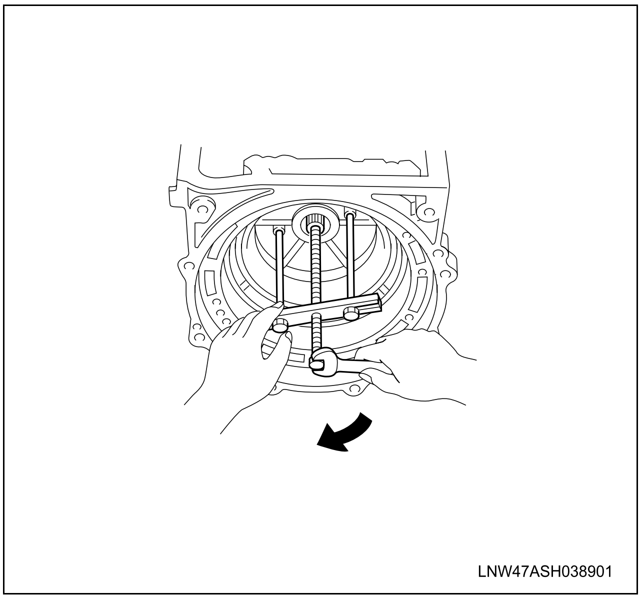


4. Remove the 3 OD case set bolts.



5. Using the oil pump remover, remove the OD case assembly.

Tool Required: J-44170 Oil Pump Remover

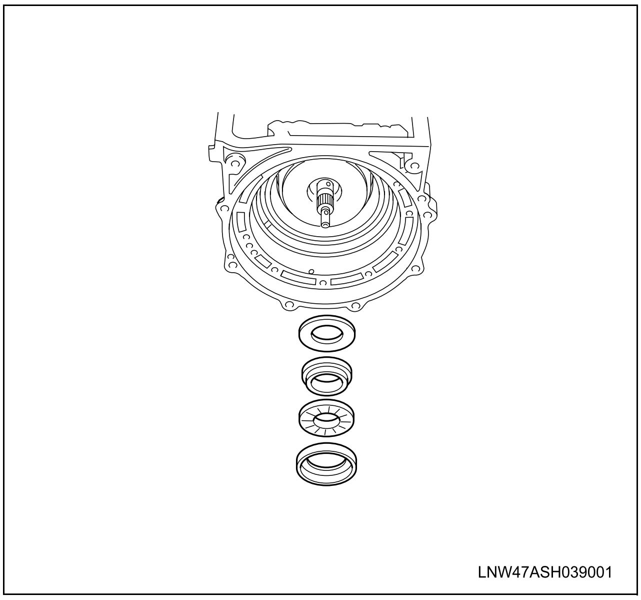


6. Remove the thrust bearing, two races, and spacer from the front clutch drum or OD case.
7. Select a spacer.

Spacer thicknesses

Thickness mm (in.)
0.9 (0.035)
1.2 (0.047)
1.5 (0.059)
1.8 (0.071)
2.1 (0.083)

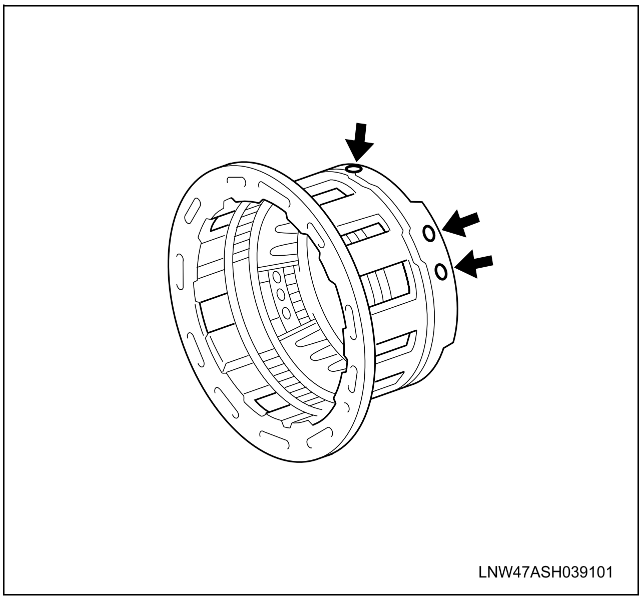
8. Install the spacer, 2 races and bearing onto the front clutch drum.



Overdrive (OD) Case Assembly

Installation Procedure

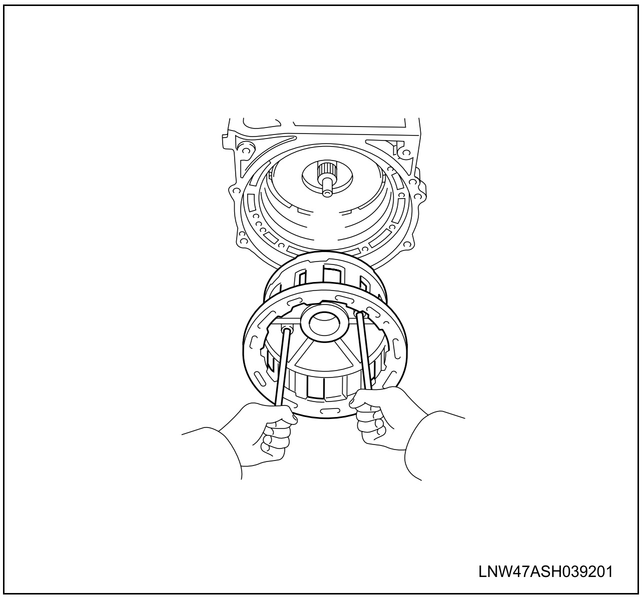
1. Coat the new 3 O-rings with ATF, and install them to the oil holes of the OD case.



2. Install the oil pump remover (2 bolts) to the OD case.

Tool Required: J-44170 Oil Pump Remover

3. Align the oil holes and bolt holes of the OD case and transmission case.



Overdrive (OD) Ring Gear Assembly

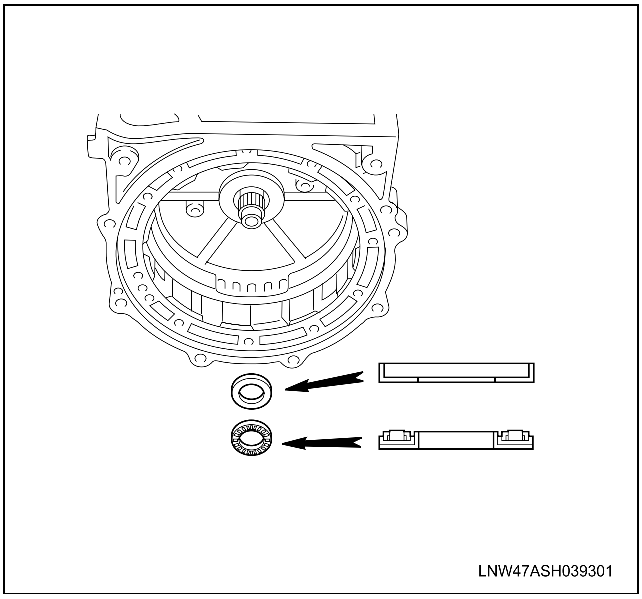
Installation Procedure

1. Coat the race and bearing with petroleum jelly, and install them onto the OD case.

Race and bearing diameter

Diameter mm (in.)	Inside	Outside
Race	37.0 (1.457)	60.5 (2.382)

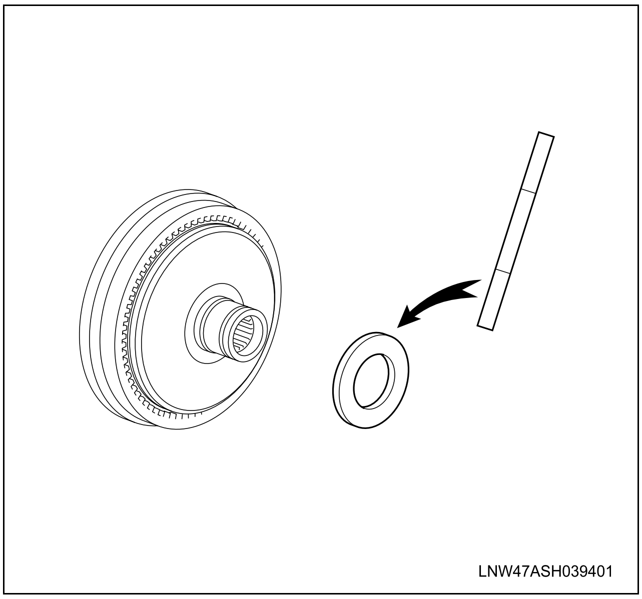
Diameter mm (in.)	Inside	Outside
Bearing	34.7 (1.366)	58.4 (2.299)



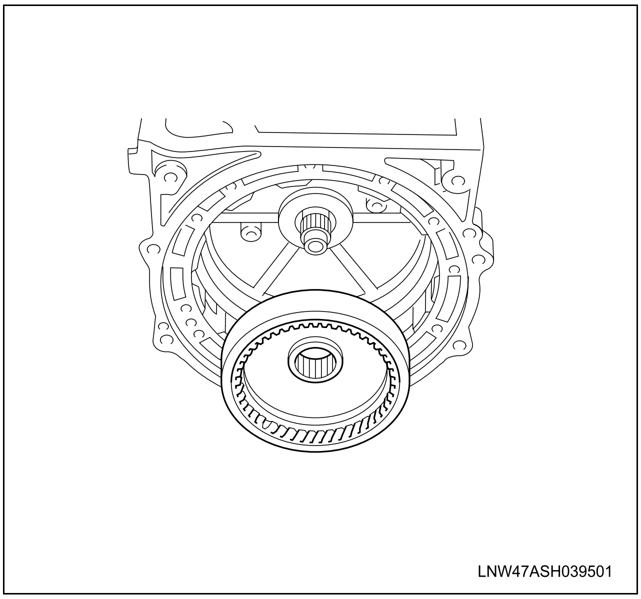
2. Coat the race with petroleum jelly, and install it onto the ring gear flange.

Race diameter

Diameter mm (in.)	Inside	Outside
Race	34.6 (1.362)	58.2 (2.291)



3. Install the ring gear assembly into the OD case.



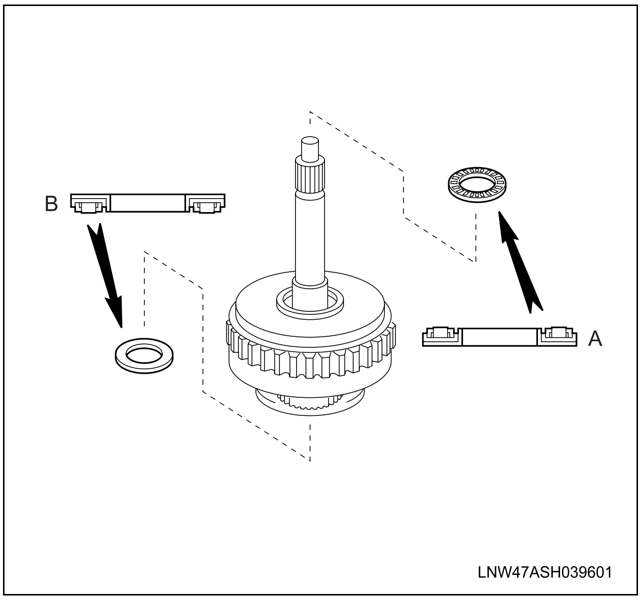
Overdrive Planetary Gear, Overdrive (OD) Direct Clutch and One-Way Clutch Assembly

Installation Procedure

1. Coat the 2 bearings with petroleum jelly, and install them onto the planetary gear.

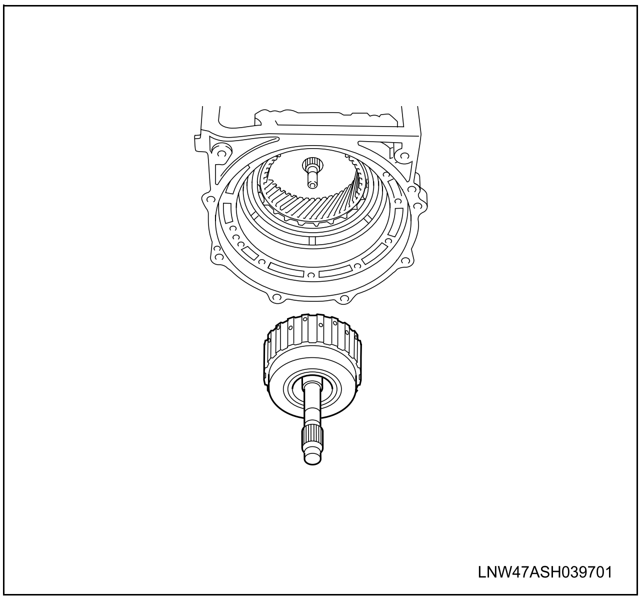
Bearing diameters

Diameter mm (in.)	Inside	Outside
Bearing (A)	28.5 (1.122)	48.0 (1.889)
Bearing (B)	23.2 (0.913)	42.0 (1.654)



2. Install the planetary gear, direct clutch and one-way clutch assembly into transmission case.

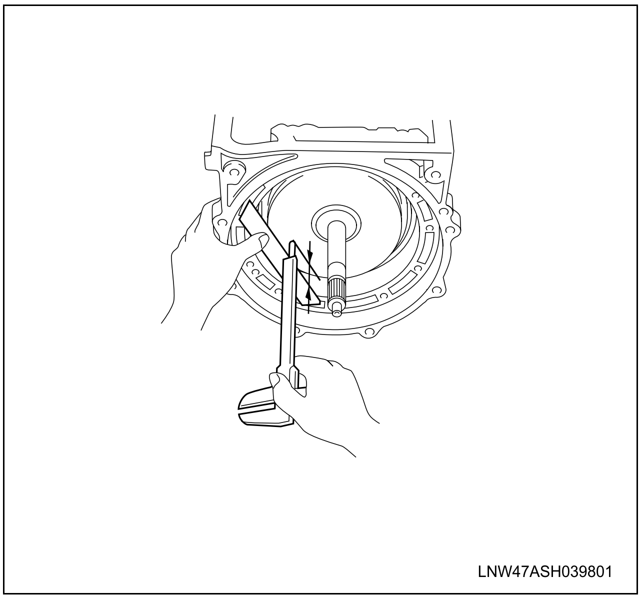
Notice:
Mesh the spline of the OD direct clutch drum with the flukes of the discs by rotating and pushing the OD direct clutch drum clockwise or counterclockwise.


LNW47ASH039701

3. Place the plate on the installation surface of the oil pump.

Tool Required: J-44166 Plate

4. Using calipers, measure the distance between the tops of the plate and the clutch drum.
   If the distance corresponds to that during disassembly, the OD planetary gear, OD direct clutch and one-way clutch assembly are installed correctly.


LNW47ASH039801

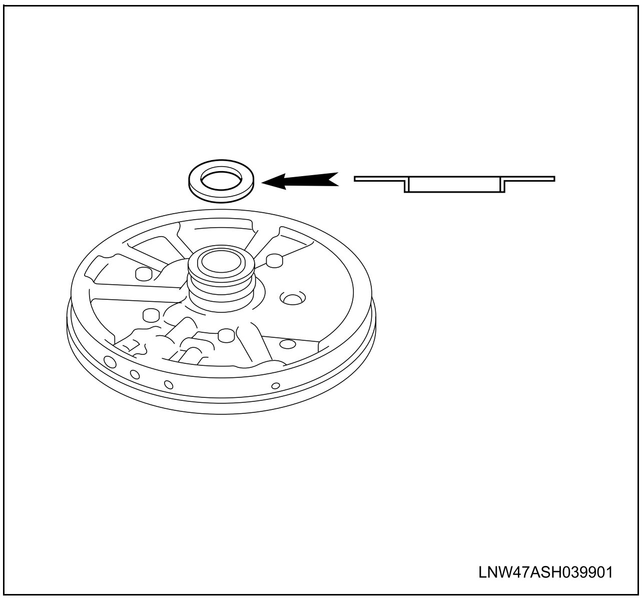
Temporarily Install Oil Pump

Installation Procedure

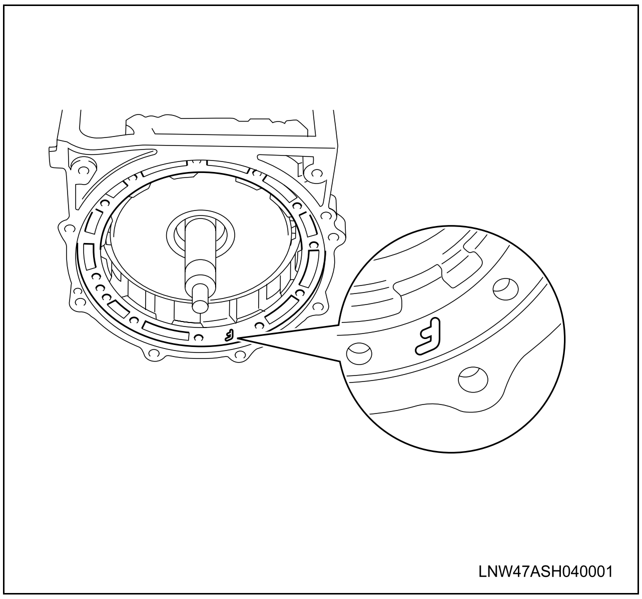
1. Coat the race with petroleum jelly, and install it onto the oil pump.

Race diameter (Reference)

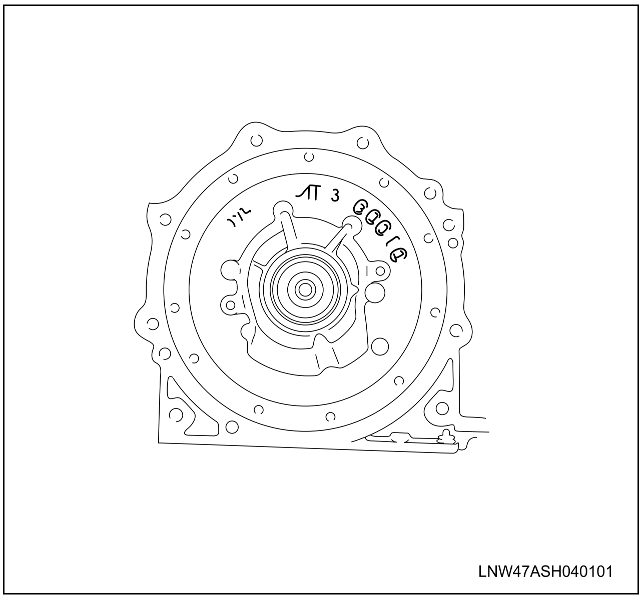
Diameter mm (in.)	Inside	Outside
Race	27.1 (1.067)	43.0 (1.693)
	27.9 (1.098)	43.0 (1.693)
	28.3 (1.114)	43.0 (1.693)


LNW47ASH039901

2. Place the gasket on the transmission case.


LNW47ASH040001

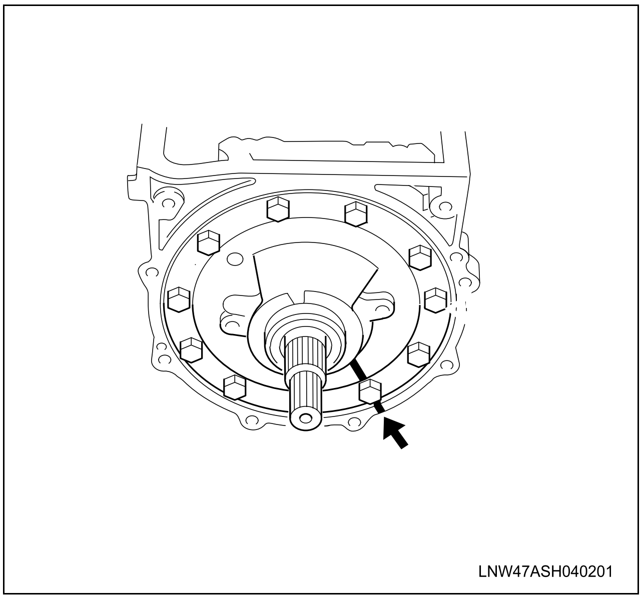
3. Align the bolt holes of the pump body and transmission case, and install it.



4. Install a bolt to the matchmarked position, tighten all the 11 bolts temporarily, then tighten them completely a little at a time.

Tighten

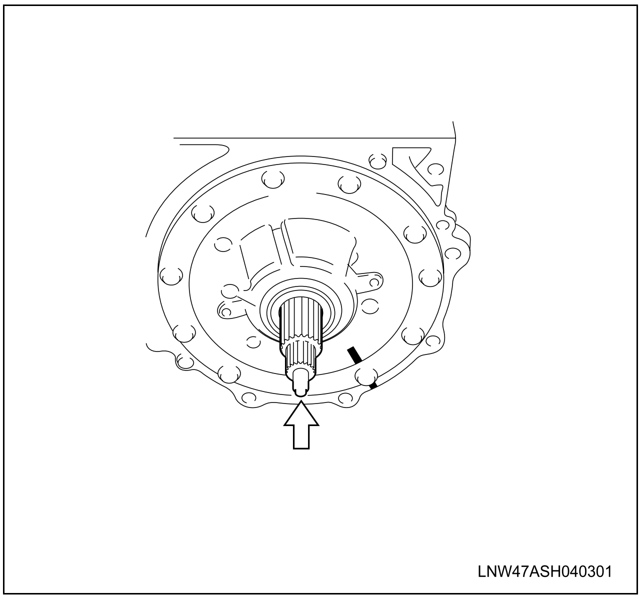
Torque: 21 N·m (15 lb ft)



Thrust Clearance of Overdrive (OD) Input Shaft (Overdrive Planetary Gear)

Installation Procedure

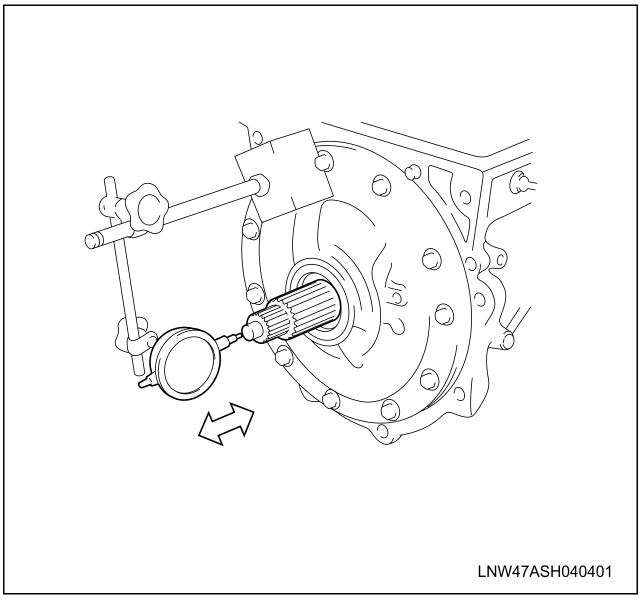
1. Push the OD input shaft toward the rear of the transmission by applying a force of 49–98 N (11.0–22.0 lb).



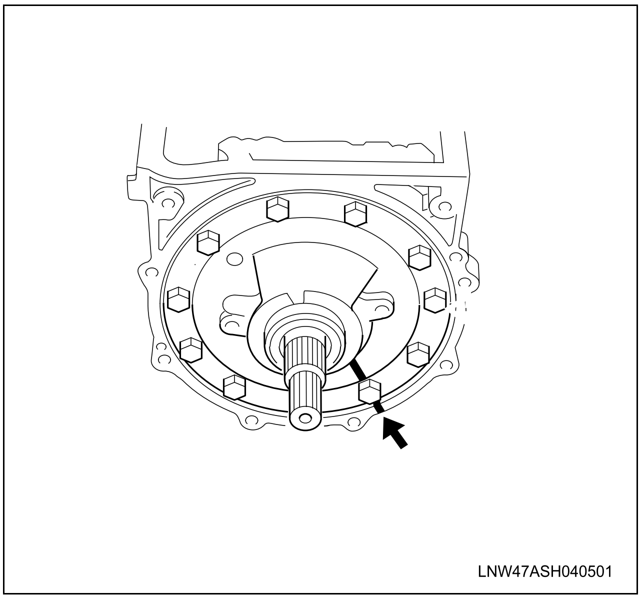
2. Using a dial indicator, measure the thrust clearance of the input shaft.

Standard thrust clearance:	0.40–0.90 mm (0.0157–0.0354 in.)
Maximum thrust clearance:	0.90 mm (0.0354 in.)

If the thrust clearance is greater than the maximum, adjust with a race.

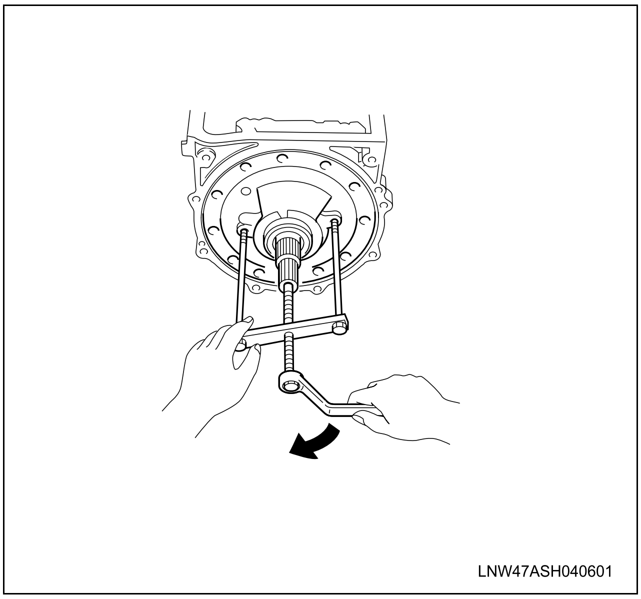


3. Remove the 11 oil pump set bolts.



4. Using the oil pump remover, remove the oil pump and gasket.

Tool Required: J-44170 Oil Pump Remover

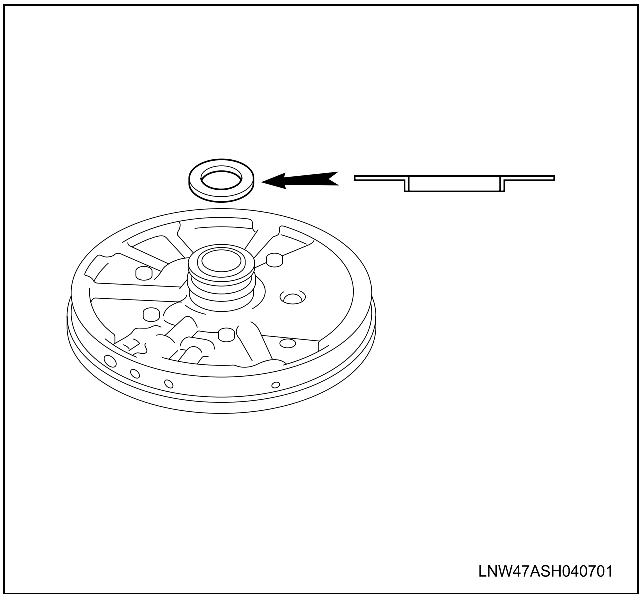


5. Remove the race from the oil pump cover.
6. Select a race.

Race thicknesses

Thickness mm (in.)
0.8 (0.031)
1.0 (0.039)
1.4 (0.055)

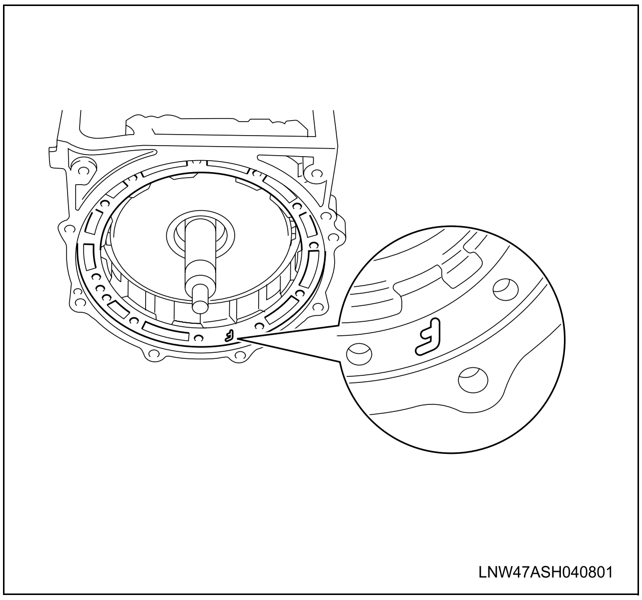
7. Coat the race with petroleum jelly, and install it onto the oil pump cover.



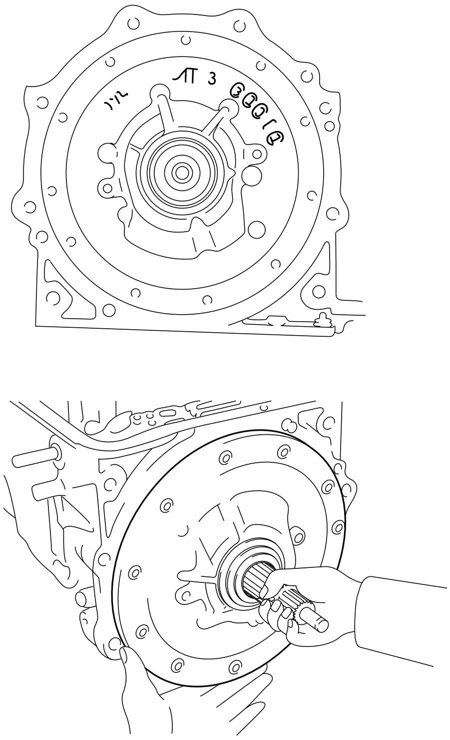
Oil Pump

Installation Procedure

1. Place a new gasket on the transmission case.



2. Align the bolt holes of the pump body and transmission case.



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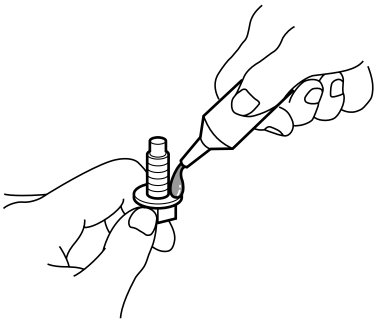
3. Apply sealant (Three Bond 1344, Loctite 572 or equivalent) to the threads of the oil pump set bolts.



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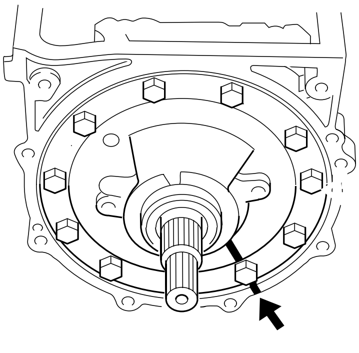
4. Install a bolt to the matchmarked position, tighten all the 11 bolts temporarily, then tighten them completely a little at a time.

Tighten

Torque: 21 N·m (15 lb ft)



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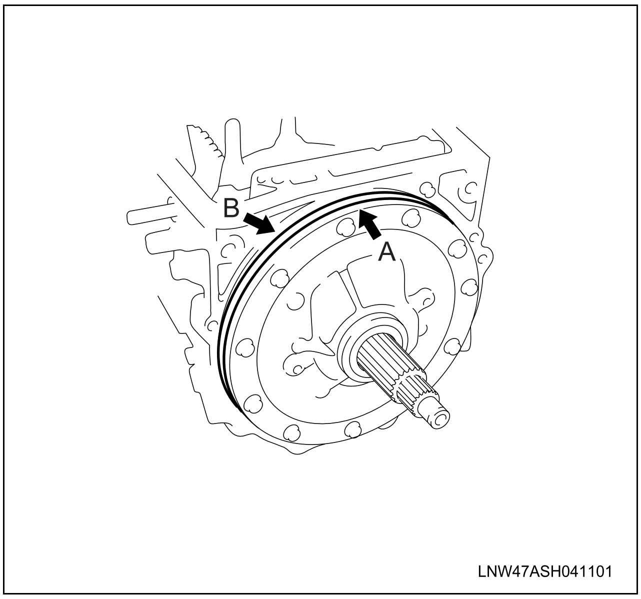
5. Coat the new 2 O-rings with automatic transmission fluid (ATF), and install them to the oil pump body.

Notice:
Be careful not to damage the O-rings.

O-ring diameters

Diameter mm (in.)	Inside	Thickness
O-ring (A)	241.6 (9.512)	3.1 (0.122)
O-ring (B)	250.0 (9.843)	2.7 (0.106)



Accumulator Springs and Pistons

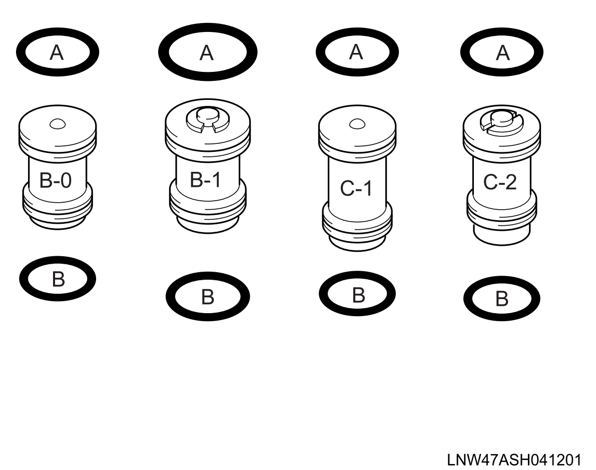
Installation Procedure

1. Coat the new 8 O-rings with automatic transmission fluid (ATF), and install them to the pistons.

Caution:
Be careful not to damage the O-rings.

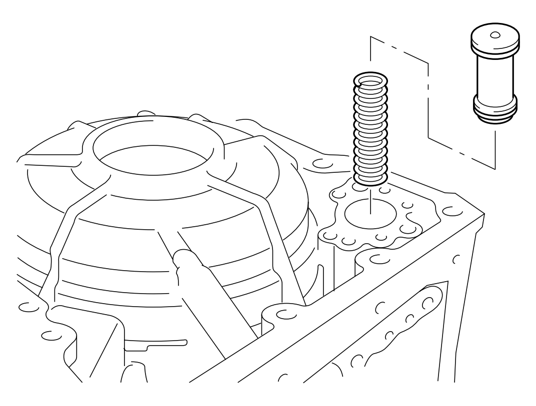
O-ring diameter

Diameter mm (in.)		Inside	Outside
B-0	A	29.9 (1.177)	2.6 (0.102)
	B	26.1 (1.028)	2.6 (0.102)
B-1	A	37.5 (1.476)	2.6 (0.102)
	B	29.9 (1.177)	2.6 (0.102)
C-1	A	28.5 (1.122)	2.6 (0.102)
	B	22.3 (0.878)	2.6 (0.102)
C-2	A	33.7 (1.327)	2.6 (0.102)
	B	28.5 (1.122)	2.6 (0.102)

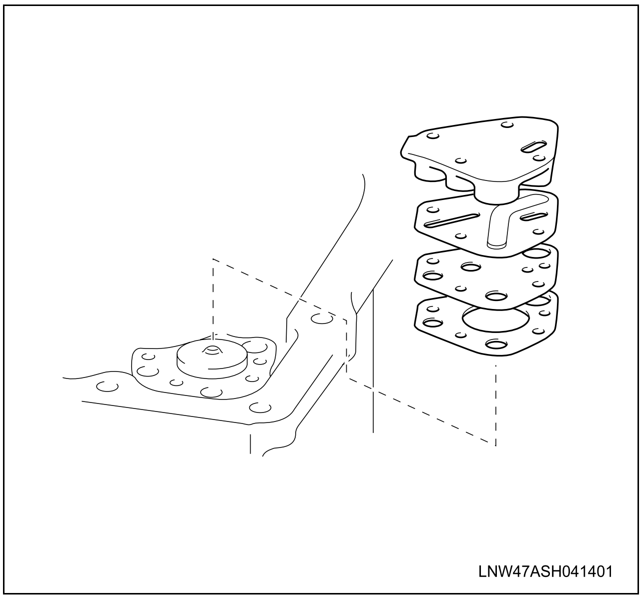


2. Install the spring and accumulator pistons into the bore of the transmission case.

Spring diameter	mm (in.)
	C-1
Free length	93.3 (3.673)
Diameter	17.7 (0.697)
Color	Red



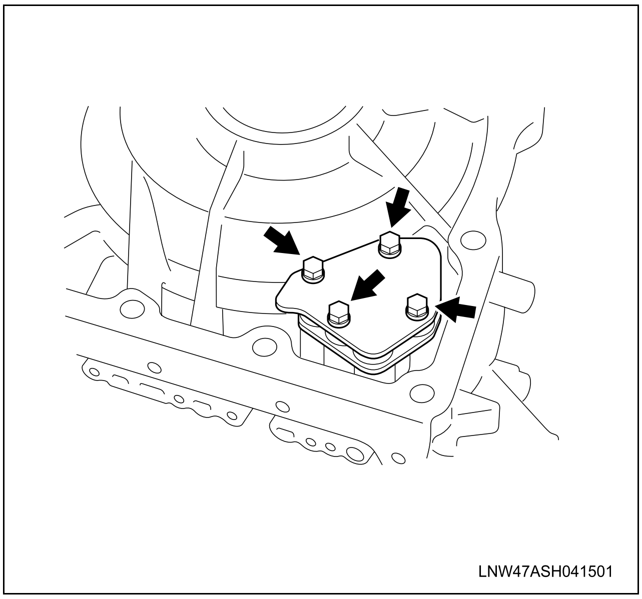
3. Place the new 2 gaskets, plate and accumulator on the transmission case.



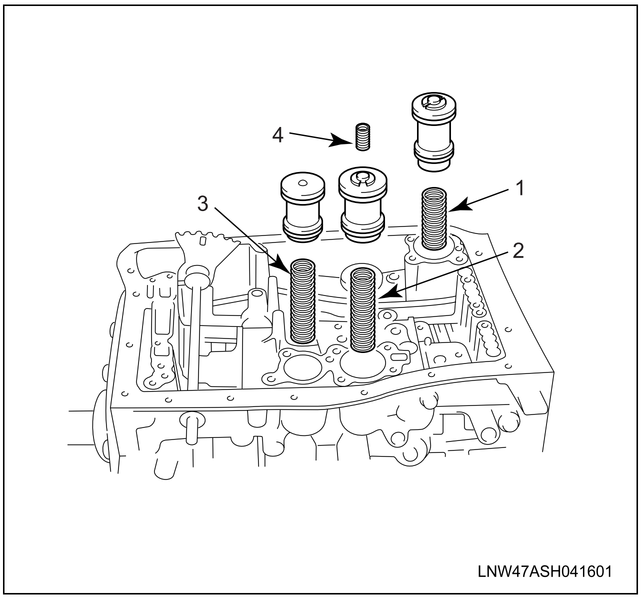
4. Install the 4 bolts.

Tighten

Torque: 8 N·m (69 lb in)



5. Install the 4 springs and accumulator pistons into the bore of the transmission case as shown.



Legend

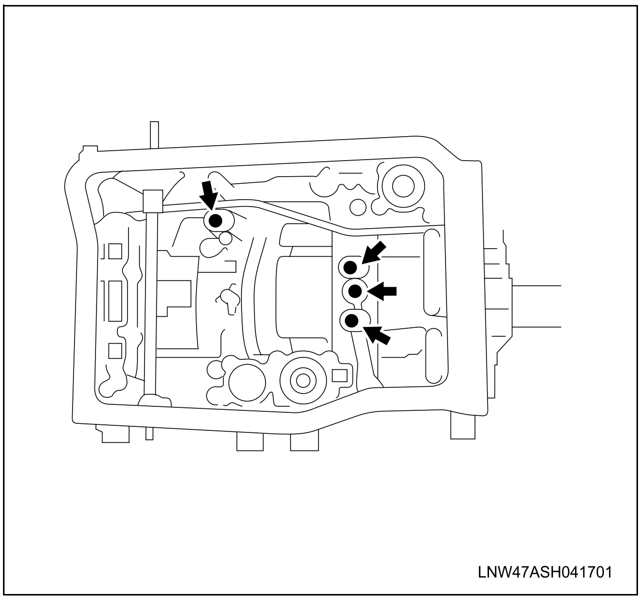
1. C-2
2. B-1
3. B-0
4. B-1

Spring diameter and free length			mm (in.)
	Free length	Diameter	Color
B-0	67.9 (2.673)	21.1 (0.831)	White
B-1 (Upper)	30.4 (1.197)	11.0 (0.433)	Yellow
B-1 (Low)	66.0 (2.598)	25.1 (0.988)	Yellow
C-2	81.8 (3.220)	22.4 (0.882)	Beige

Center Support Apply Gasket

Installation Procedure

Coat the new gaskets with automatic transmission fluid (ATF), and install them, facing the pitted side toward the transmission case.



Solenoid Valve Wiring

Installation Procedure

1. Coat a new O-ring with automatic transmission fluid (ATF), and install it to the wiring.

O-ring diameters		mm (in.)
	Inside diameter	Thickness
O-ring	17.8 (0.701)	2.4 (0.094)

Caution:
Be careful not to damage the O-ring.

2. Install the solenoid valve wiring to the transmission case.

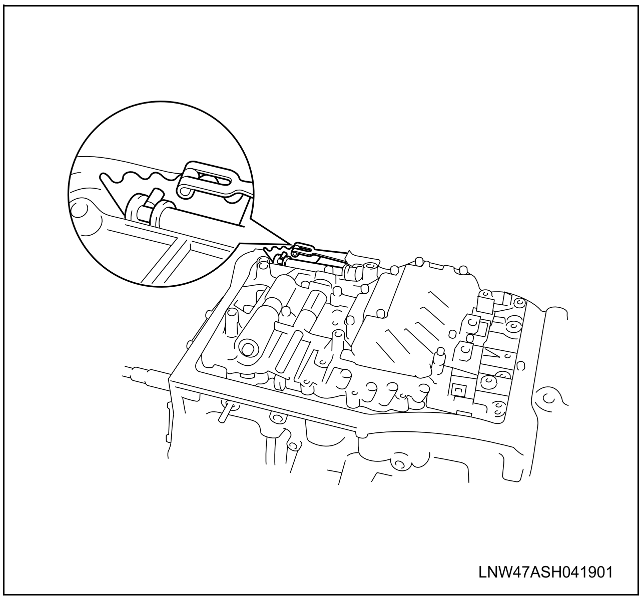
Tighten

Torque: 8 N·m (69 lb in)

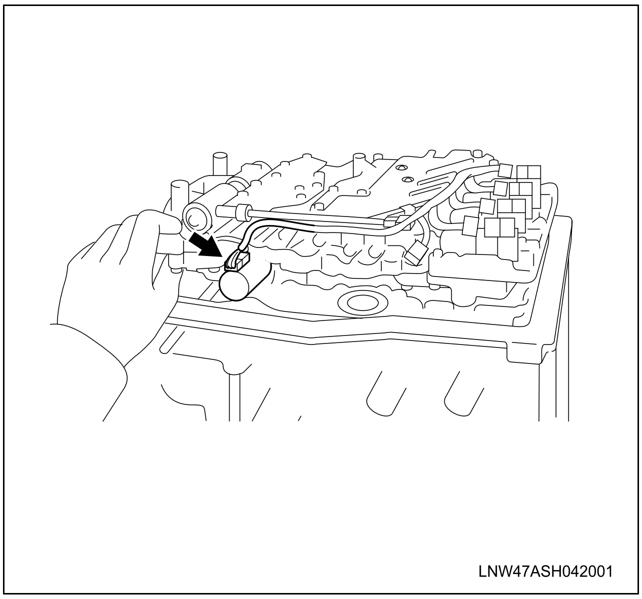
Valve Body

Installation Procedure

1. Align the groove of the manual valve with the pin of the manual valve lever.



2. Connect the line pressure solenoid valve connector.



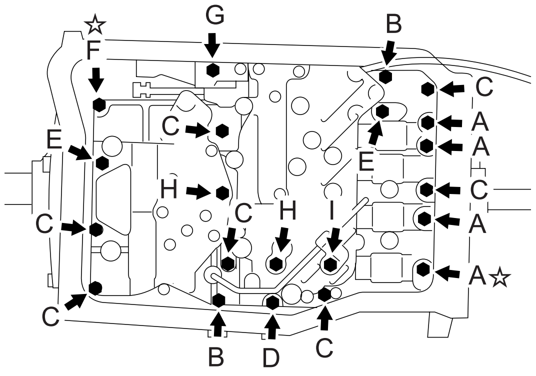
3. Install the 2 bolts indicated by I marks in the illustration and tighten them temporarily.
4. Install and tighten the rest of 19 bolts temporarily, then tighten all of them completely a little at a time.

Tighten

Torque: 10 N·m (87 lb in)

Notice:
Each bolt length is indicated in the illustration.

Bolt length: A 22 mm (0.87 in.)
B 28 mm (1.10 in.)
C 32 mm (1.26 in.)
D 37.5 mm (1.48 in.)
E 40 mm (1.57 in.)
F 41 mm (1.61 in.)
G 45 mm (1.77 in.)
H 52 mm (2.05 in.)
I 57 mm (2.24 in.)

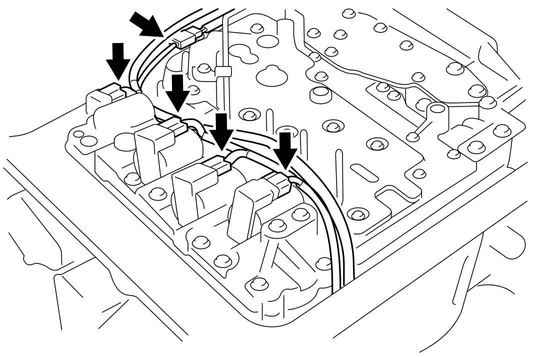


LNW47ASH042101

Solenoid Valve and Automatic Transmission Fluid (ATF) Temperature Sensor Connectors

Reconnect

1. Connect the 4 connectors to the solenoids.
2. Connect the connector to the ATF temperature sensor.



LNW47ASH042201

Oil Strainer

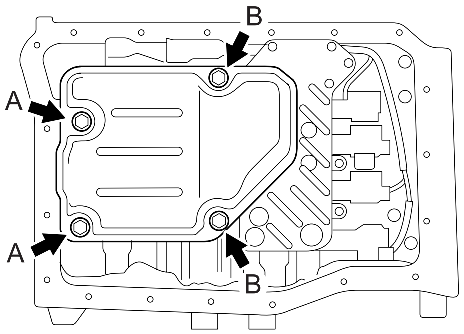
Installation Procedure

Install the oil strainer with the 4 bolts.

Tighten

Torque: 10 N·m (87 lb in)

Bolt length: A 16 mm (0.63 in.)
B 32.4 mm (1.28 in.)

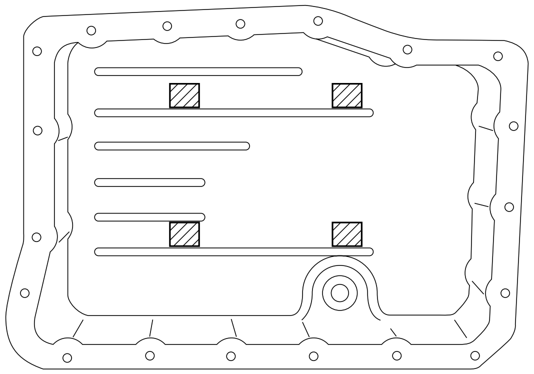


LNW47ASH042301

Magnet in Pan

Installation Procedure

Install the 4 magnets in the oil pan as shown in the illustration.

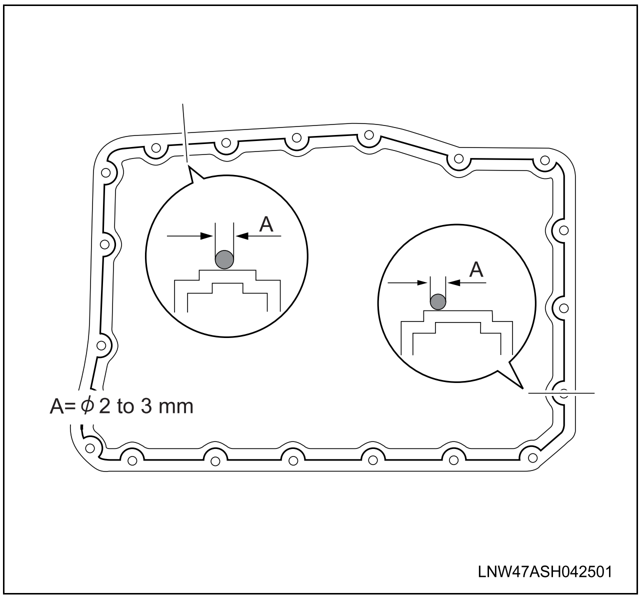


LNW47ASH042401

Oil Pan

Installation Procedure

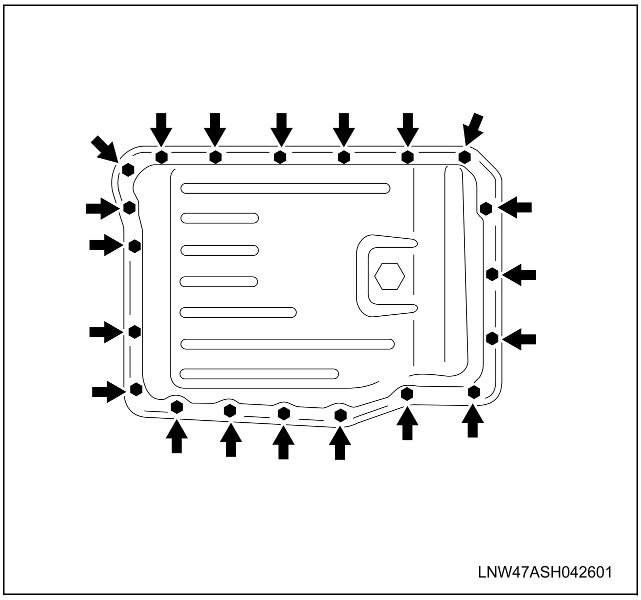
1. Remove any sealants and be careful not to drop oil on the contacting surface of the transmission case and oil pan.
2. Apply sealants (Three Bond 1281 or equivalent) to the oil pan.



3. Install and tighten the 20 bolts.

Tighten

Torque: 7 N·m (61 lb in)



Torque Converter Housing

Installation Procedure

1. Install the torque converter housing with the 8 bolts.

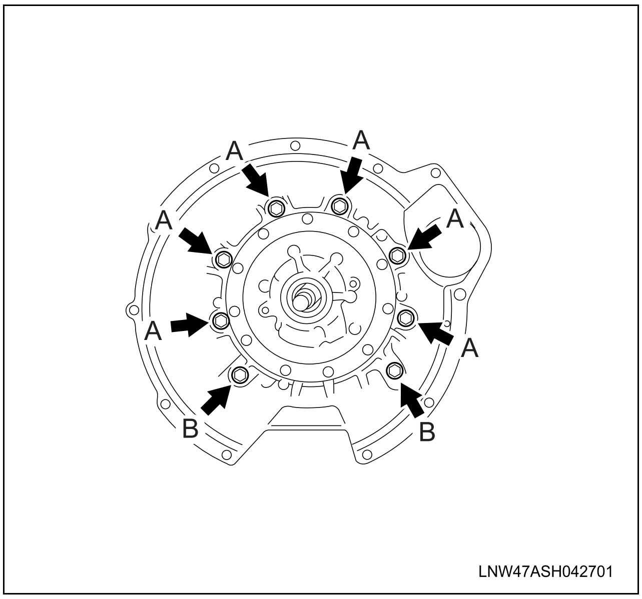
Caution:

Be careful do not damage the 2 O-rings around the oil pump body when installing the torque converter housing.

Tighten

Torque: 64 N·m (47 lb ft)

Bolt length: A 35 mm (1.38 in.)
B 45 mm (1.77 in.)



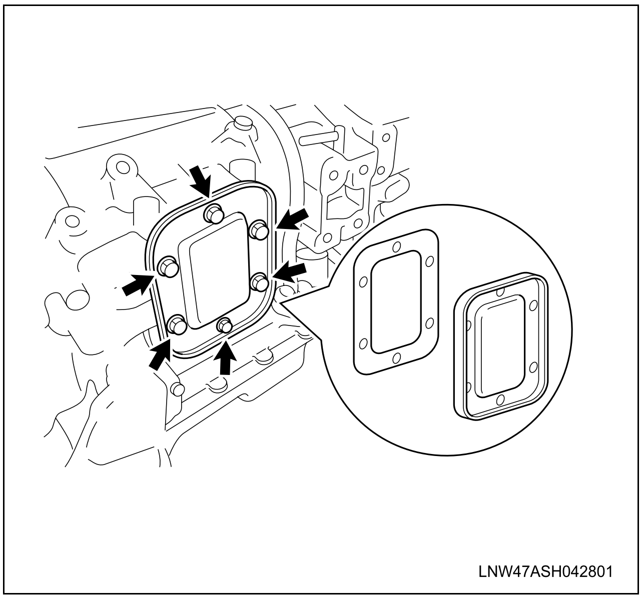
Transmission PTO Cover

Installation Procedure

1. Apply sealant (Three Bond 1344, Loctite 572 or equivalent) to the thread of the PTO cover fixing bolt.
2. Install the transmission PTO cover and new gasket with 6 bolts.

Tighten

Torque: 15 N·m (11 lb ft)



Vehicle Speed Sensor SP2

Installation Procedure

1. Coat the new O-ring with automatic transmission fluid (ATF), and install it to the sensor.

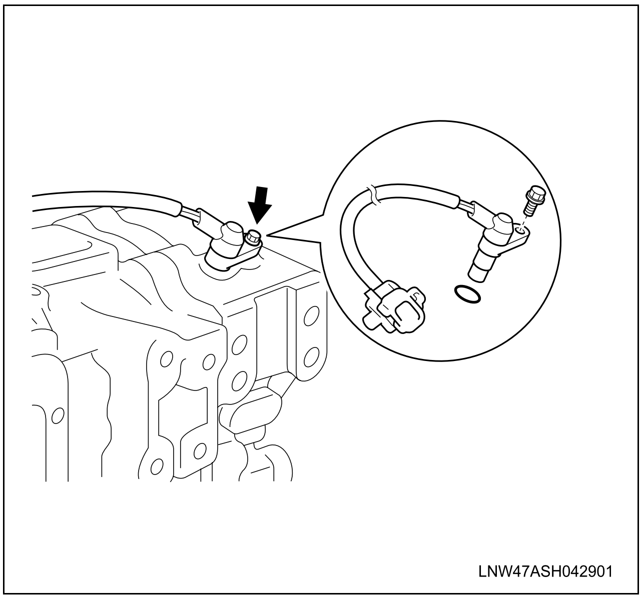
Caution:
Be careful not to damage the O-ring.

O-ring diameters		mm (in.)
	Inside	Thickness
O-ring	11.8 (0.465)	1.9 (0.075)

2. Install the speed sensor to the extension housing with the bolt.

Tighten

Torque: 8 N·m (69 lb in)


LNW47ASH042901

Transmission Oil Cooler Unions

Installation Procedure

1. Coat the new 2 O-rings with automatic transmission fluid (ATF), and install them to each union.

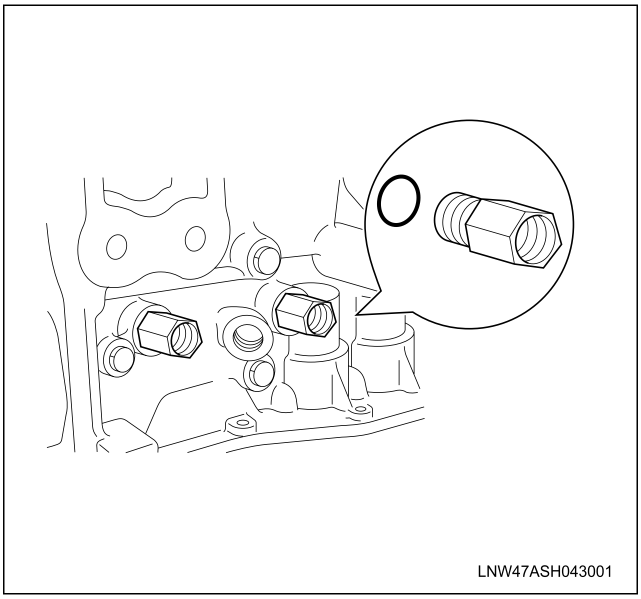
Caution:
Be careful not to damage to the O-rings.

O-ring diameters		mm (in.)
	Inside	Wire diameter
O-ring	11.6 (0.457)	2.0 (0.079)

2. Install the 2 unions.

Tighten

Torque: 32 N·m (24 lb ft)


LNW47ASH043001

Automatic Transmission Fluid (ATF) Temperature Switch

Installation Procedure

1. Coat the new O-ring with ATF, and install it to the switch.

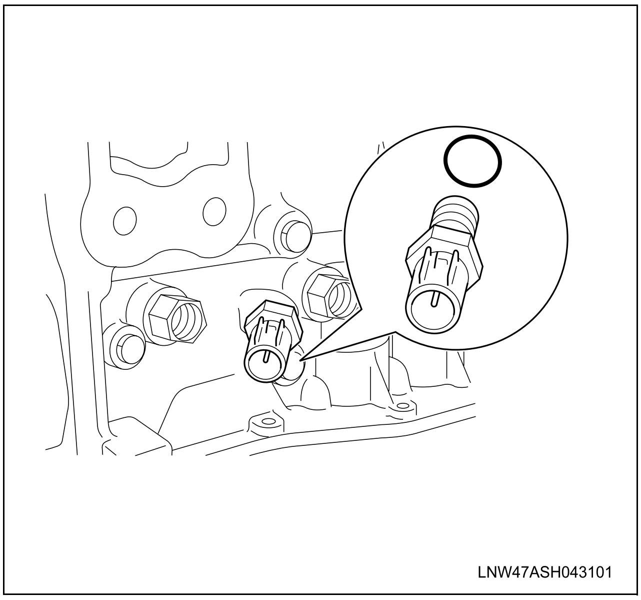
Caution:
Be careful not to damage to the O-ring.

O-ring diameters		mm (in.)
	Inside	Wire diameter
O-ring	13.8 (0.543)	1.9 (0.075)

2. Install the sensor to the transmission case.

Tighten

Torque: 25 N·m (18 lb ft)


LNW47ASH043101

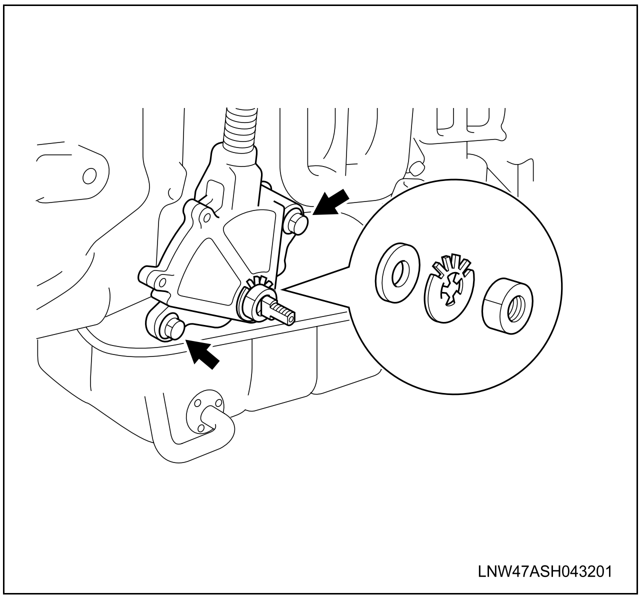
Inhibitor Switch

Installation Procedure

1. Temporarily install the inhibitor switch with the 2 bolts.
2. Install the gasket, a new lock washer and the nut.

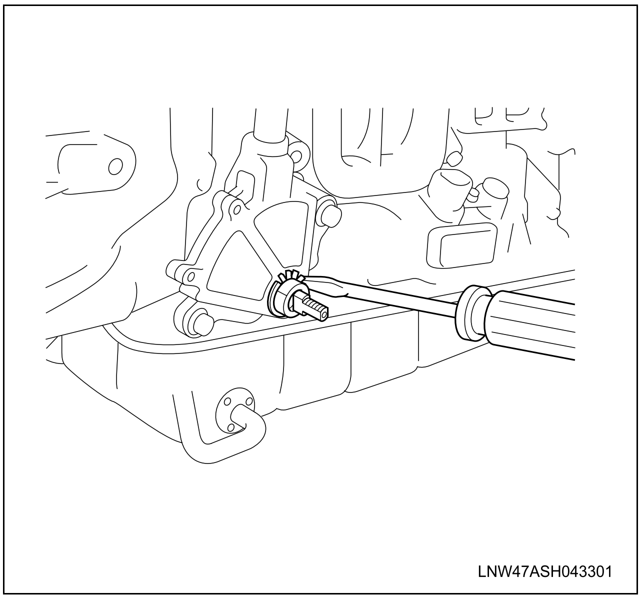
Tighten

Torque: 7 N·m (61 lb in)

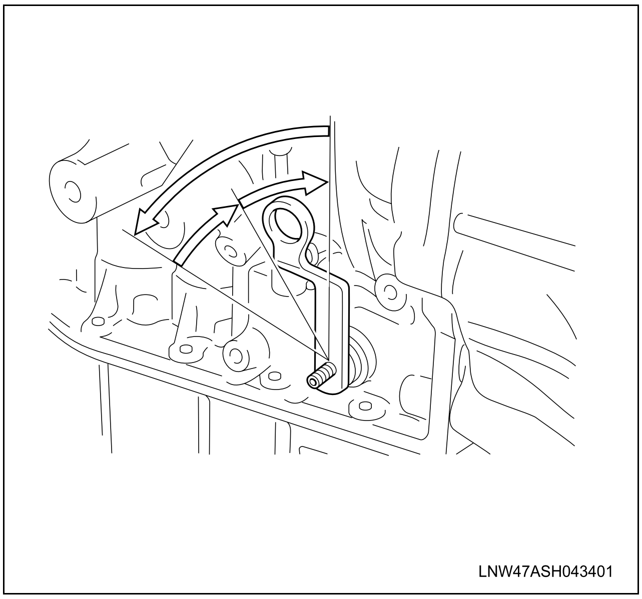

LNW47ASH043201

3. Using a screwdriver, bend the tabs of the lock washer.

Notice:
Bend at least 2 of the lock washer tabs.


LNW47ASH043301

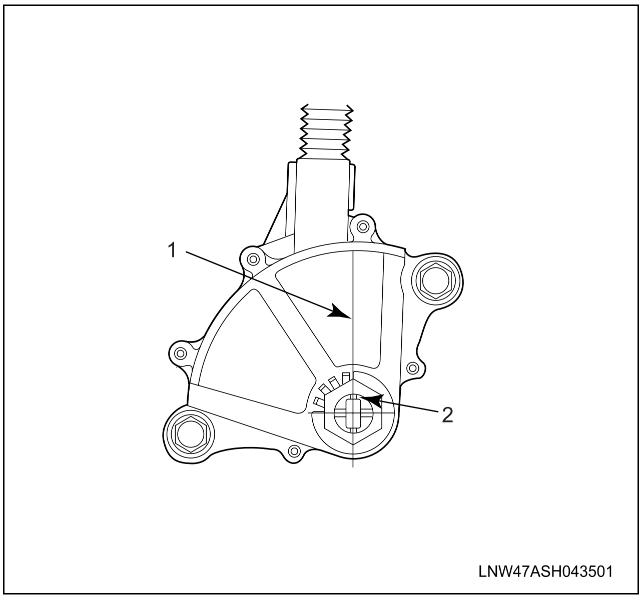
4. Using the control shaft lever, fully turn the control shaft lever back and return 2 notches, it is now in neutral position.
5. Remove the control shaft lever.


LNW47ASH043401

6. Align the neutral basic line with the switch groove and tighten the 2 bolts.

Tighten

Torque: 13 N·m (113 lb in)



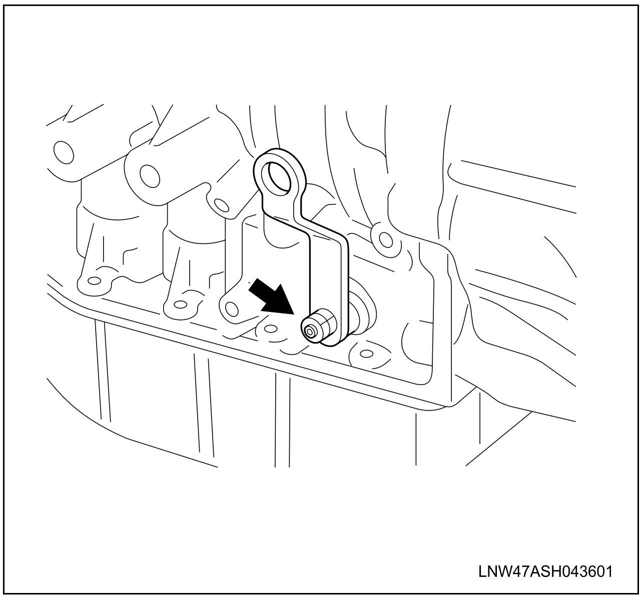
LNW47ASH043501

Legend
1. Neutral Basic Line
2. Switch Groove

Control Shaft Lever

Tighten

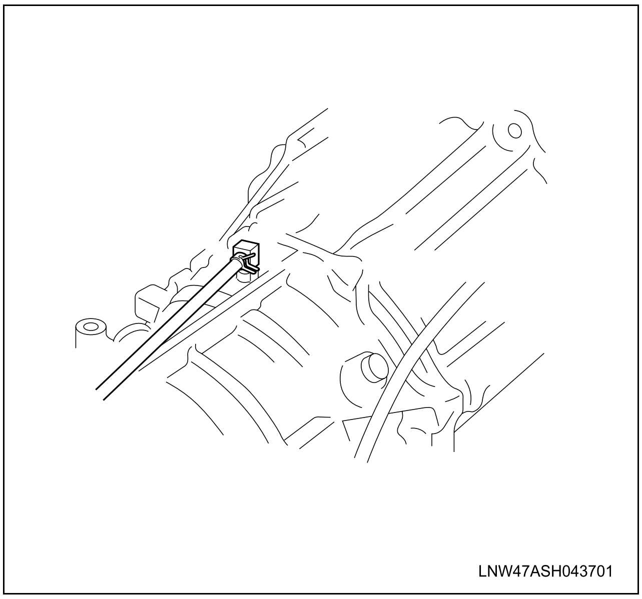
Torque: 13 N·m (113 lb in)



Breather Plug and Hose

Installation Procedure

1. Coat a new O-ring with automatic transmission fluid (ATF), and install it to breather plug.
2. Install the breather plug and hose.



Speedometer Driven Gear Assembly

Installation Procedure

1. Coat the new O-ring with automatic transmission fluid (ATF), and install it to the speedometer sleeve.

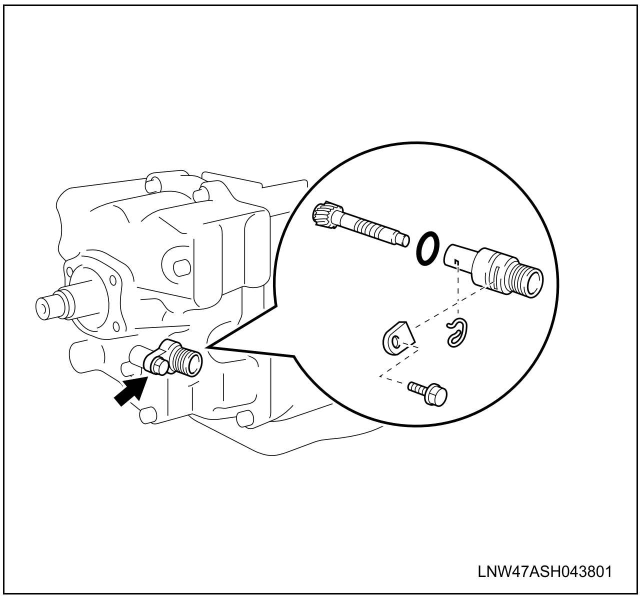
Caution:
Be careful not to damage the O-ring.

O-ring diameters		mm (in.)
	Inside	Wire diameter
O-ring	18.7 (0.736)	2.6 (0.102)

2. Install the speedometer driven gear to the speedometer sleeve with the clip.
3. Install the speedometer driven gear assembly to the extension housing with the bolt.

Tighten

Torque: 12 N·m (104 lb in)



Input Shaft Speed Sensor (C0) [12,000 lbs GVW]

Installation Procedure

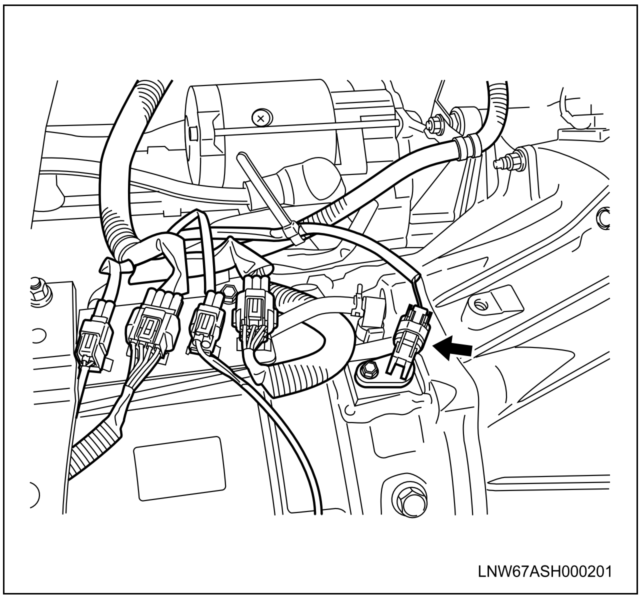
1. Coat the new O-ring with automatic transmission fluid (ATF), and install it to the sensor.

Caution:
Be careful not to damage the O-ring.

2. Install the speed sensor to the Transmission Case with the bolt.

Tighten

Torque: 8 N·m (69 lb in)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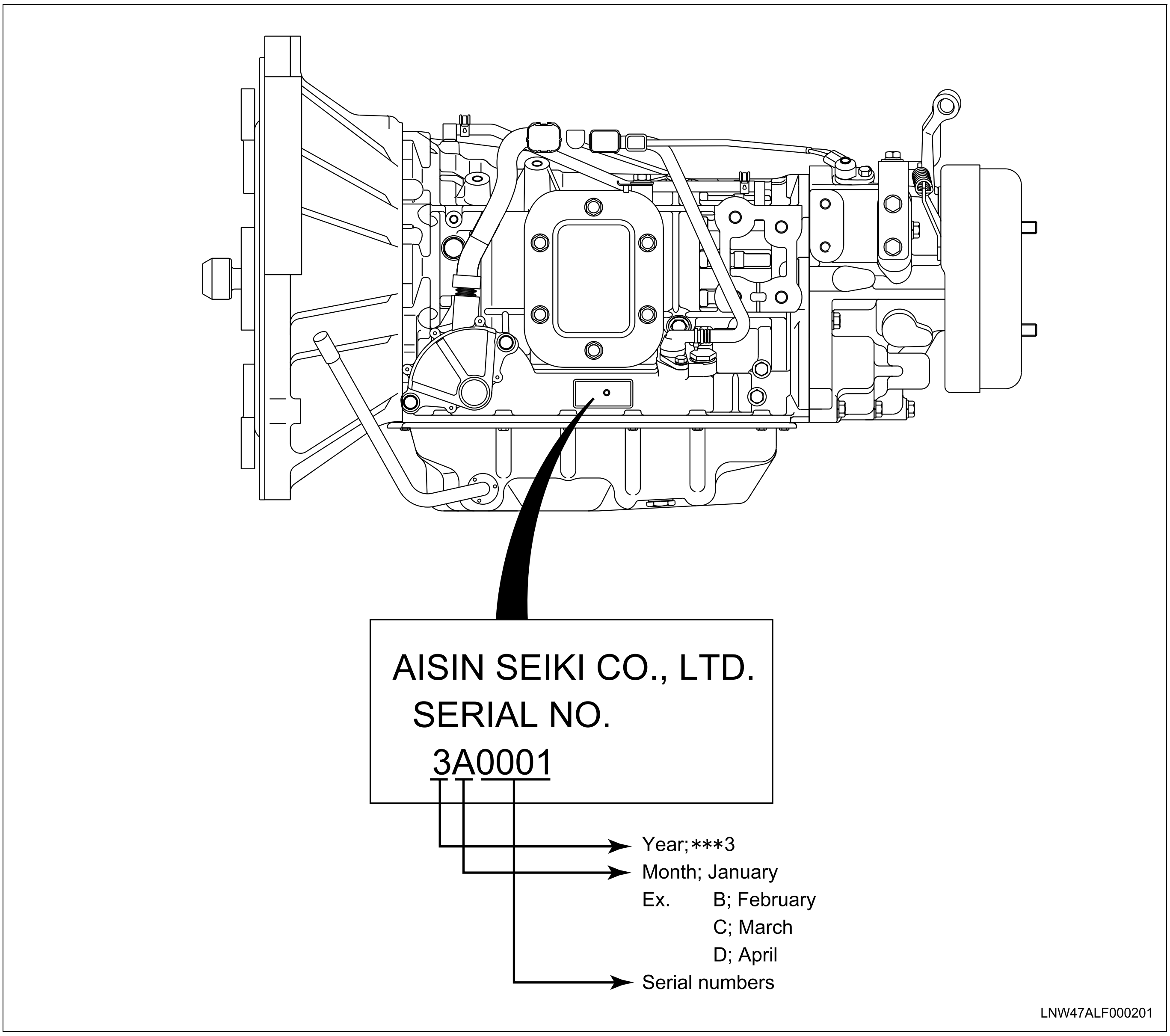
Description and Operation

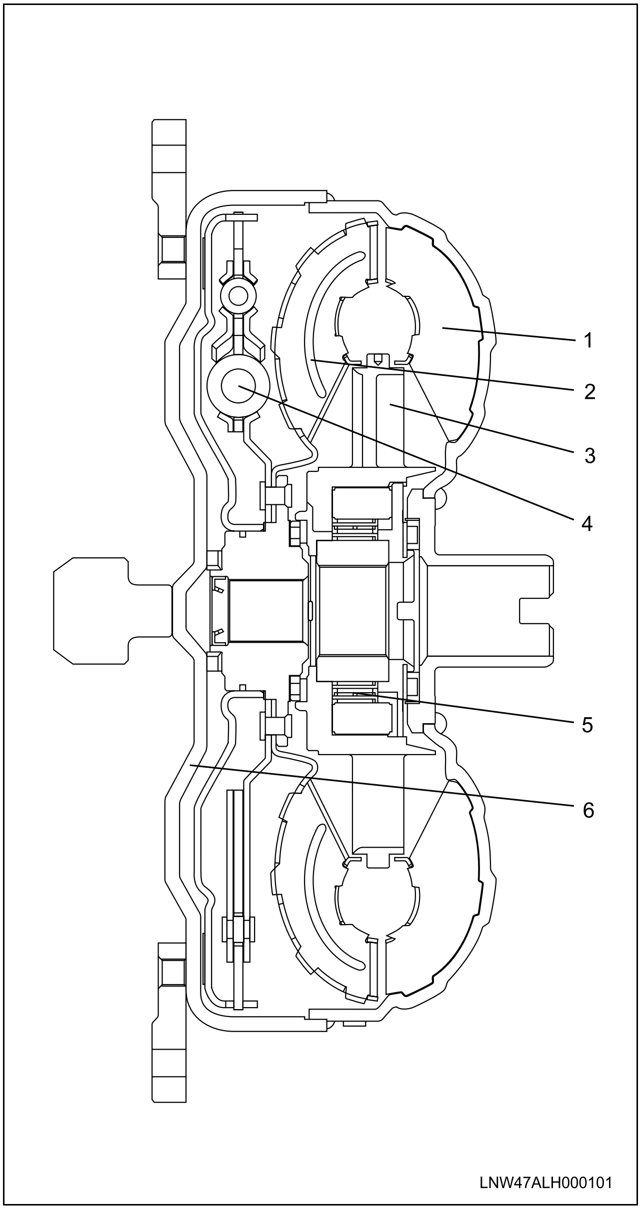
Transmission Identification Information



Torque Converter

- The torque converter transmits the engine torque to the transmission by way of oil (when the lock-up clutch is disengaged) or the lock-up piston (when the lock-up clutch is engaged).
- The torque converter is of the 3-element, 1-stage, and 2-phase type.
- “1-stage” means the output element consists of a single turbine runner.
  “2-phase” means the converter works as a torque converter against the pump impeller when the turbine runner speed is relatively low, and as a fluid coupling when the speed is high.

Torque Converter



Legend

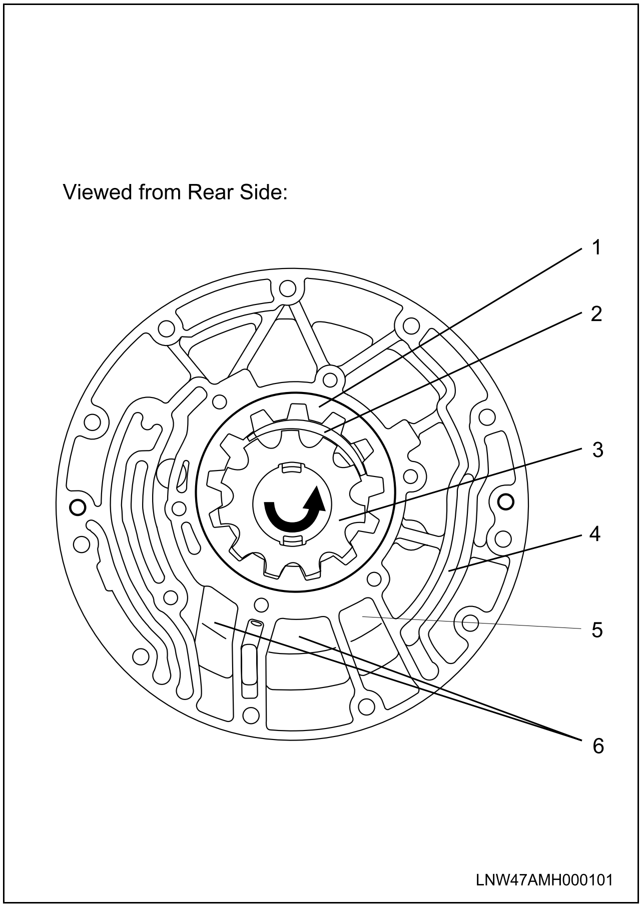
1. Pump Impeller
2. Turbine Runner
3. Stator
4. Lock-up Clutch
5. One-way Clutch
6. Converter Front Cover

Oil Pump

Construction

- The oil pump is a high performance geared oil pump with a small number of teeth of a special profile.

Oil Pump



Legend

1. Driven Gear
2. Crescent
3. Drive Gear
4. Oil Pump Body
5. Delivery Port
6. Suction Port

Operation

- The drive gear is engaged with the extension sleeve of the torque converter. As it rotates in the direction of the arrow at the engine speed, the oil is drawn in and compressed before exiting from the delivery port.

Shaft

Overdrive (OD) input shaft

- The OD input shaft (OD planetary gear) is engaged with the turbine runner and the lock-up piston inside the torque converter. Therefore, the driving force of the engine reaching the torque converter is transmitted to the OD planetary gear.
  The oil hole (A) inside the OD input shaft serves as the torque converter operating pressure supply passage when the lock-up clutch is disengaged. It also serves as the lubricant supply passage to all parts.

Input shaft

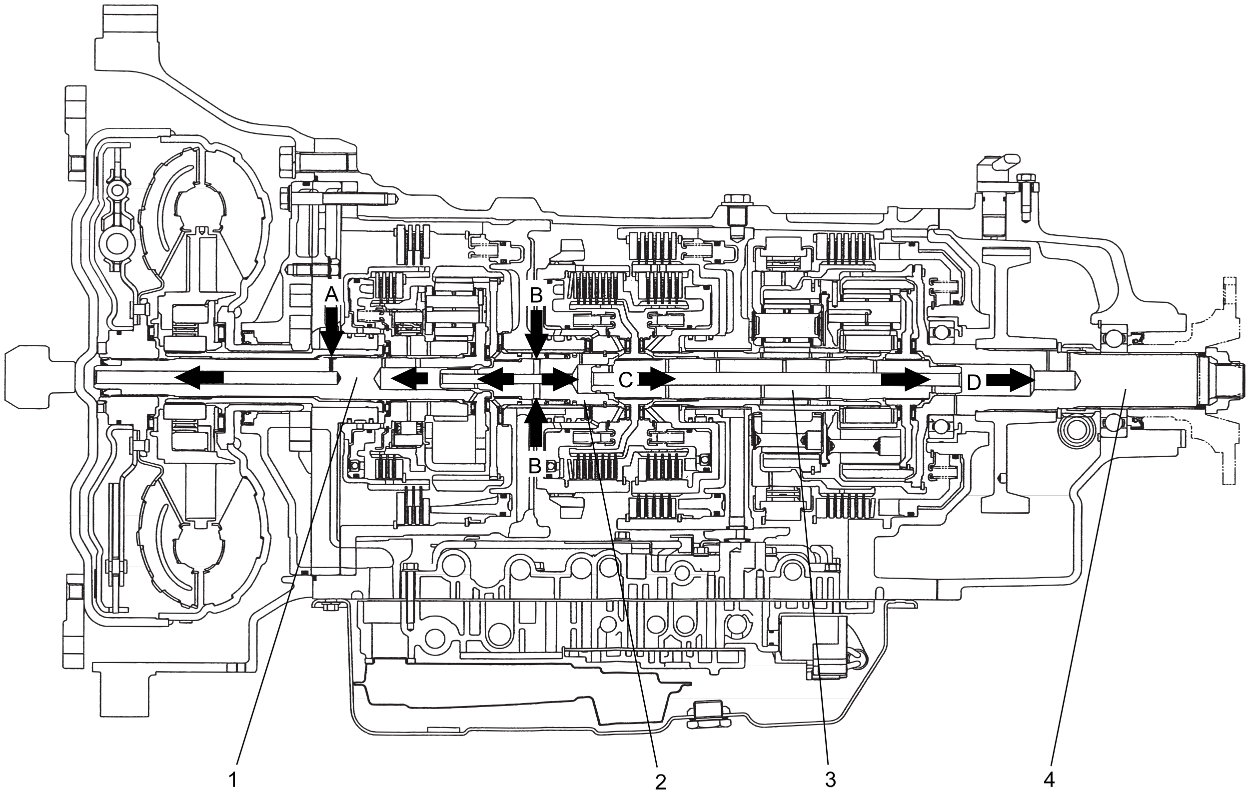
- The input shaft transmits the driving force from the overdrive (OD) planetary gear to the front clutch. The oil hole (B) inside the input shaft is used to supply the oil, cooled by the oil cooler, to all parts as the lubricant.

Intermediate shaft

- The intermediate shaft transmits the driving force from the front clutch to the rear planetary gear. The oil passage (C) inside the intermediate shaft is used to supply the oil to all parts as the lubricant.

Output shaft

- The output shaft transmits the driving force reaching the front and rear planetary gears to the propeller shaft. The output shaft is engaged with the front planetary ring gear and the rear planetary carrier. The parking gear, which is used to fix the output shaft and detect rotation, is also engaged by way of spline. The oil passage (D) inside the output shaft is used to supply the lubricant to all parts.



LNW47ALF000301

Legend

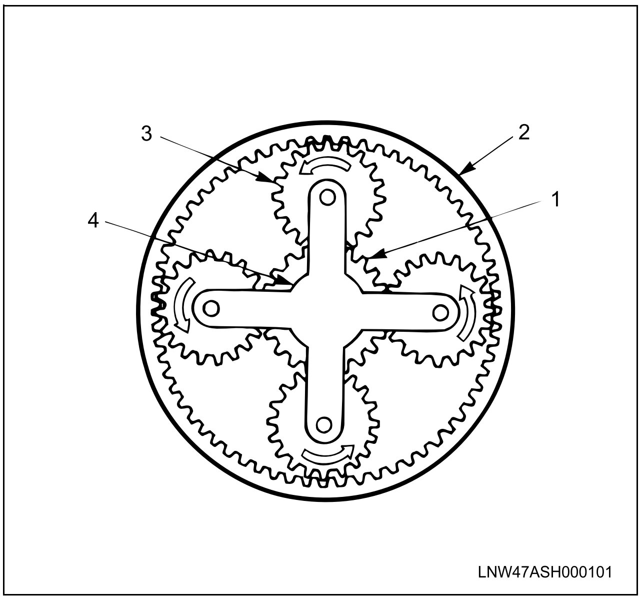
1. OD Input Shaft
2. Input Shaft
3. Intermediate Shaft
4. Output Shaft

Gear Shifting Mechanism

- The 450-43LE type transmission combines three sets of planetary gears, three sets of multi-plate clutches and multi-plate brakes, and two sets of one-way clutches to achieve forward (4 speeds) and backward (1 speed) gear shifting.

Principle of gear shifting

- The automatic transmission uses three sets of planetary gears unlike the parallel gears that are used in the manual transmission.
- Planetary gears have the advantage of a compact configuration because of the way they are constructed with a single central shaft (one axis).
- Also, unlike the manual transmission gears that require changing of gear mesh, the gear ratio of the planetary gears can be changed more easily by locking, releasing or rotating only some of their parts.
- A planetary gear is made up of a sun gear at its center and pinion gears each of which rotates about its own center and also along the sun gear.
- Also, since the pinion gears are further supported by the planetary carrier, they rotate as a unit in the same direction and at the same rate.
- As shown in the figure, each planetary gear is constructed of three elements; a sun gear, pinion gears, a ring gear, and a planetary carrier. Gear shifting is achieved by conditioning two of the three elements, namely the sun gear, internal gear, and the planetary carrier.
- The planetary gears are locked by the clutch, brake, and one-way clutch, according to the gear shifting.



Legend

1. Sun Gear
2. Pinion Gear
3. Ring Gear
4. Planetary Carrier

Overdrive (OD) Direct Clutch

When engaged

- The operating pressure, switched by the control valve, acts on the OD direct clutch piston to connect the clutch disk and clutch plate. This also connects the OD sun gear and OD planetary carrier. As the result, the entire OD planetary gear works as a unit to transmit the engine torque from the OD input shaft to the input shaft.

When disengaged

- Since the operating pressure is not sent to the OD direct clutch piston when disengaging it, the clutch piston is returned by the return spring.
- The clutch plate separates from the clutch disk cutting the power transmission.

Front Clutch

When engaged

- The operating pressure, switched by the control valve, acts on the front clutch piston to connect the clutch disk and clutch plate. As the result, the engine torque is transmitted from the input shaft to the front clutch hub.

When disengaged

- Since the operating pressure is not sent to the front clutch piston when disengaging it, the clutch piston is returned by the return spring.
- The clutch plate separates from the clutch disk cutting the power transmission.

Rear Clutch

When engaged

- The operating pressure, switched by the control valve, acts on the rear clutch piston to connect the clutch disk and clutch plate. As the result, the engine torque is transmitted from the front clutch hub to the front sun gear.

When disengaged

- Since the operating pressure is not sent to the rear clutch piston when disengaging it, the clutch piston is returned by the return spring.
- The clutch plate separates from the clutch disk cutting the power transmission.

Overdrive (OD) Brake

When engaged

- The operating pressure, switched by the control valve, acts on the OD brake piston to connect the clutch disk and brake plate. This also locks the OD direct clutch to the OD case. As the result, the OD planetary sun gear is locked in position.

When disengaged

- Since the operating pressure is not sent to the OD brake piston when disengaging it, the clutch piston is returned by the return spring.
- The brake plate separates from the clutch disk cutting the power transmission.

2nd Brake

When engaged

- The operating pressure, switched by the control valve, acts on the brake piston No. 1 to connect the clutch disk and brake plate. This also locks the rear clutch to the center support.

When disengaged

- Since the operating pressure is not sent to the brake piston No. 1 when disengaging it, the brake piston is returned by the return spring.
- The brake plate separates from the clutch disk cutting the power transmission.

1st and Reverse Brake

When engaged

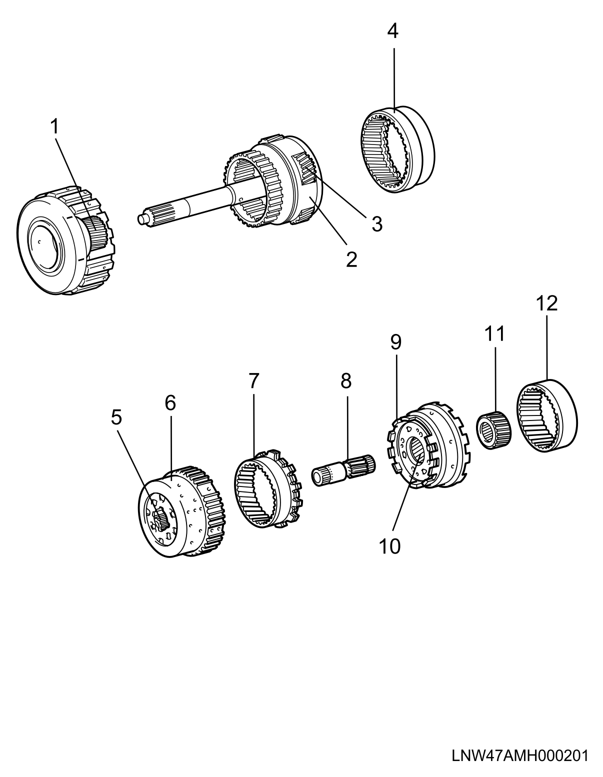
- The operating pressure, switched by the control valve, acts on the 1st and reverse brake piston to connect the clutch disk and brake plate. This also locks the 1st and reverse brake hub to the transmission case. As the result, the front planetary carrier is locked in position.

When disengaged

- Since the operating pressure is not sent to the 1st and reverse brake piston when disengaging it, the brake piston is returned by the return spring.
- The brake plate separates from the clutch disk cutting the power transmission.

Planetary Gear

- Three sets of Simpson type planetary gears are used to achieve the total of five gear ratios including 4 forward and 1 backward ratios.



Legend

1. Overdrive (OD) Sun Gear
2. OD Planetary Carrier
3. OD Pinion Gear
4. OD Ring Gear
5. Front Sun Gear
6. Front Planetary Carrier
7. Front Pinion Gear
8. Front Ring Gear
9. Rear Sun Gear
10. Rear Planetary Carrier
11. Rear Pinion Gear
12. Rear Ring Gear

Overdrive (OD) One-way clutch

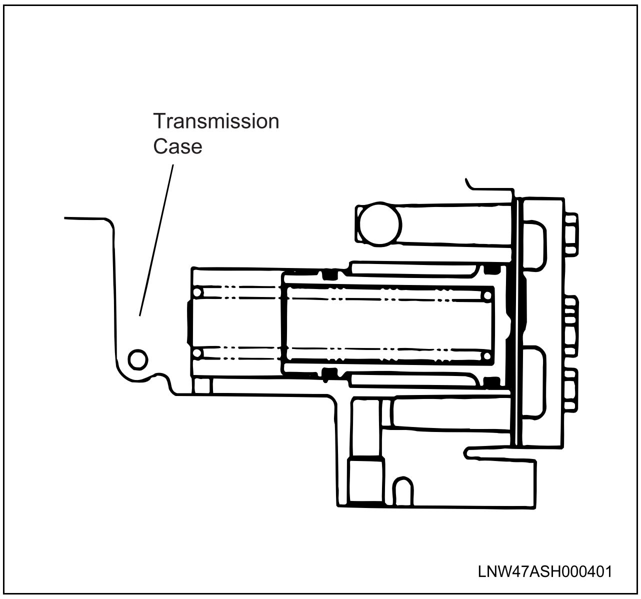
- The OD one-way clutch is locked during acceleration in 1st, 2nd or 3rd speed to maintain the OD sun gear fixed to the OD planetary carrier.
- The OD one-way clutch idles in 4th speed.

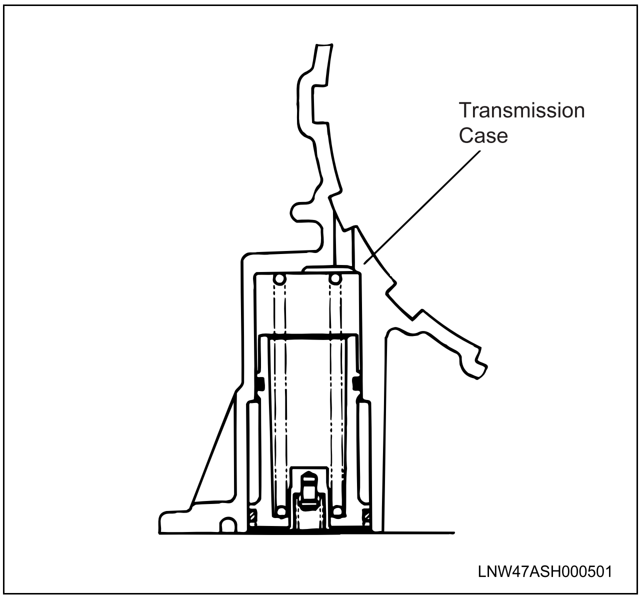
One-way Clutch No.2

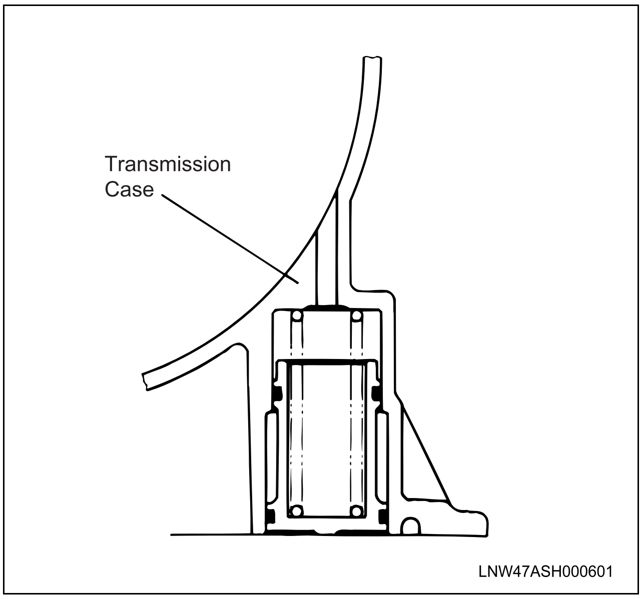
- The one-way clutch No.2 is locked during acceleration in 1st speed to fix the front planetary carrier.
- It idles in 2nd, 3rd and 4th speeds.

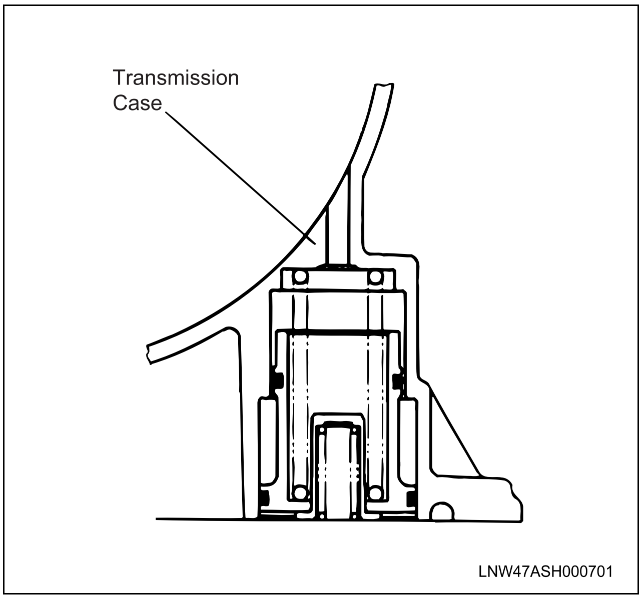
Accumulator

- The accumulator helps a smooth increase of the operating pressure in the respective friction element to ease the gear shifting shock.
- During a gear shift, the accumulator control pressure regulated by the respective accumulator control valve is applied to the back of the accumulator to ease the gear shifting shock.









Solenoid Valve

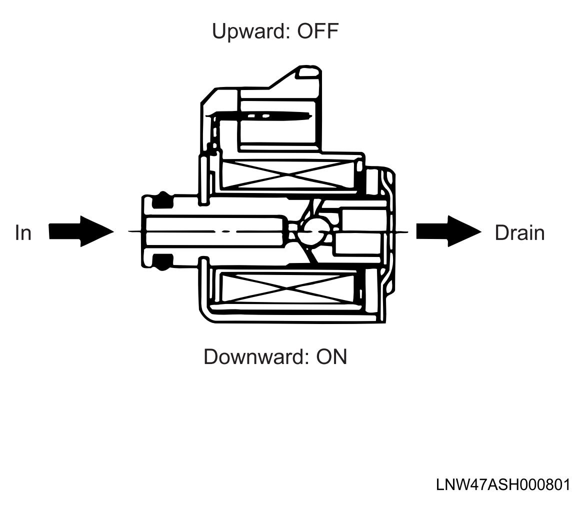
Shift Solenoid valves (S1, S2)

- These solenoid valves are fitted in the lower part of the valve body. They are turned ON or OFF by a signal from the Transmission Control Module (TCM) to control the gear shifting.
- The ON/OFF combinations of the two solenoid valves are used to control the gear position as shown below.

Solenoid valve	Gear Position			
	1st gear	2nd gear	3rd gear	4th gear
Shift solenoid (S1) valve	ON	ON	OFF	OFF
Shift solenoid (S2) valve	OFF	ON	ON	OFF

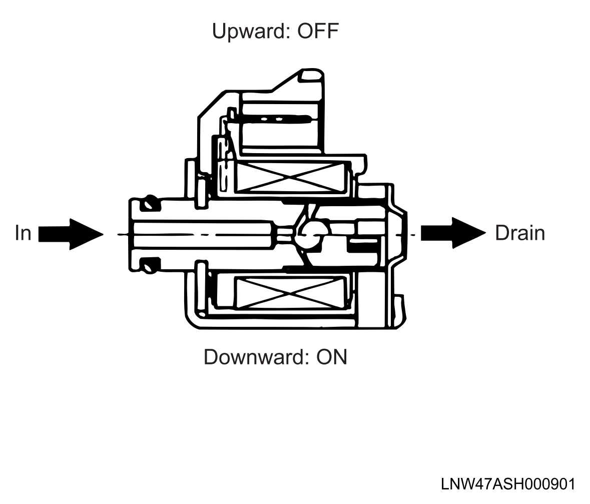
Shift Timing Solenoid valve

- This solenoid valve is fitted in the lower part of the valve body. It is turned on or off by a signal from the TCM to control the timing during 2nd and 3rd gear shifting.



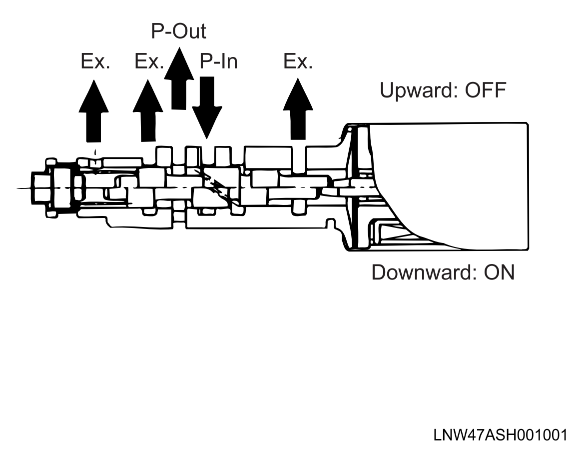
Torque Converter Clutch Pulse Width Modulation (TCC PWM) Solenoid Valve

- This solenoid valve is fitted in the lower part of the valve body. It controls the lock-up oil pressure by a signal from the TCM according to the duty cycle.



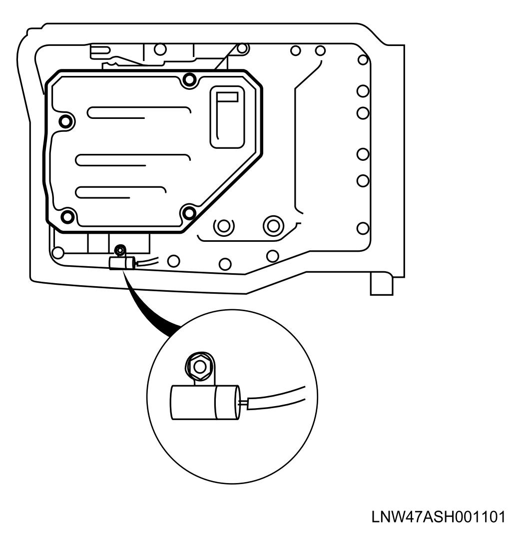
Line Pressure Solenoid Valve

- This solenoid valve is fitted in the upper part of the valve body and integrally consists of the electromagnetic component and the pressure regulating valve. It controls the line pressure by a signal from the TCM according to the electric current.



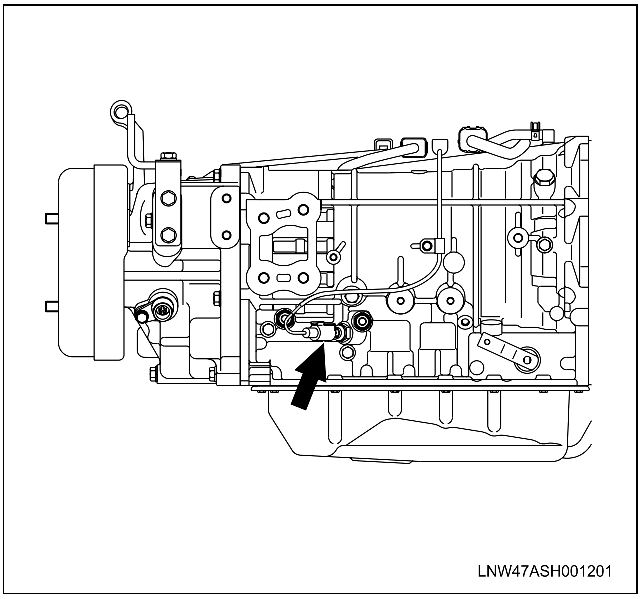
Automatic Transmission Fluid (ATF) Temperature Sensor

- The sensor is fitted to the valve body in the transmission. It converts a change in temperature into a continuous electrical signal, which is sent to the transmission control module (TCM).



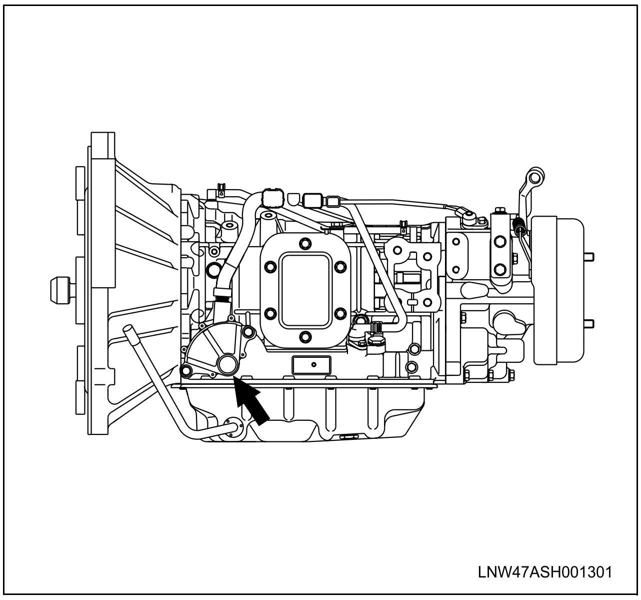
Automatic Transmission Fluid (ATF) Temperature Switch

- This switches fitted to the right side of the transmission case. It detects abnormal high temperature of the ATF to protect transmission.



Inhibitor Switch (Neutral/Start Switch)

- Inhibitor switch is attached to the right side of the transmission, and detects P, R, N, D, 2 and 1 range of selector lever.
- Inhibitor switch is set to be “ON” when selector lever is shifted to P, R, N, D, 2 and 1 range.
- Also, inhibitor switch is connected to starter switch circuit and makes engine-starting possible when selector lever is only P or N range.



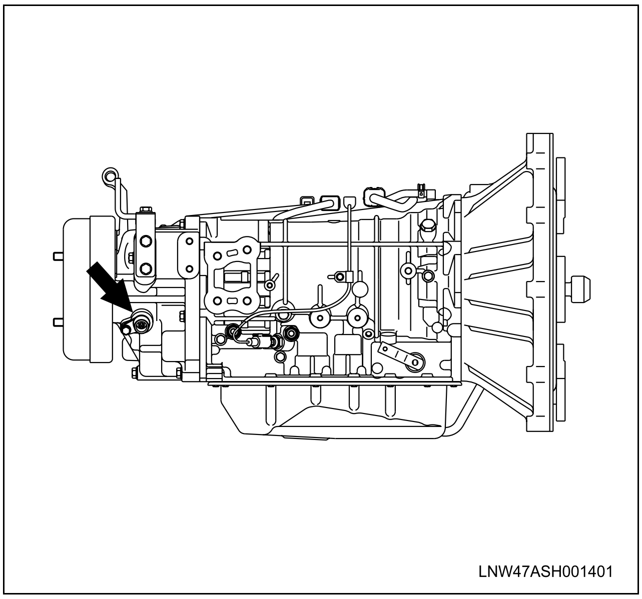
Accelerator Pedal Position Sensor

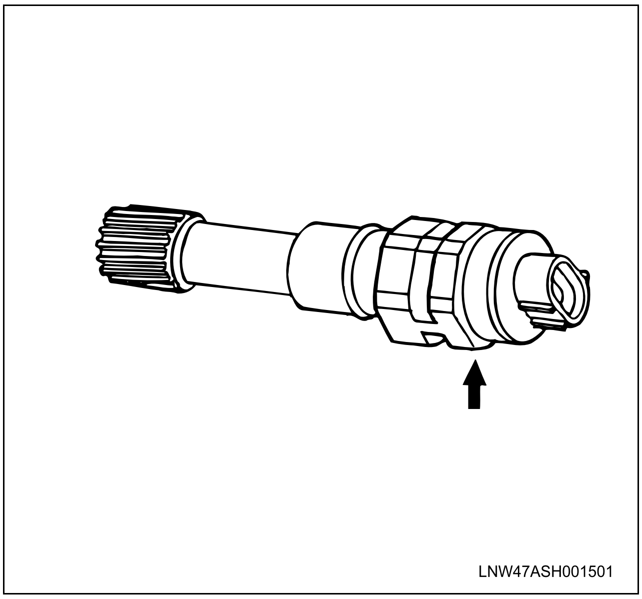
Refer to “Engine Control System”.

Vehicle Speed Sensor 2 (SP1)

(Fitted to the speedometer driven gear)

- The vehicle speed sensor 2 (SP1) is fitted on the speedometer driven gear assembly.
- The number of pulses generated is four pulses (AC) per one rotation of the pinion shaft.
- Should the vehicle speed sensor1 (SP2) malfunction for any reason, the vehicle speed sensor 2 (SP1) takes over control.

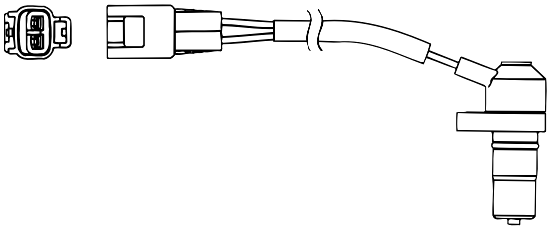




Vehicle Speed Sensor 1 (SP2)

(Fitted to the extension housing)

- This sensor detects the speed of revolution of the parking gear fitted to the output shaft, and generates a pulse (AC=Alternating Current) signal accordingly.
- The pulse signal is sent to the transmission control module (TCM) where it is converted into the vehicle speed.



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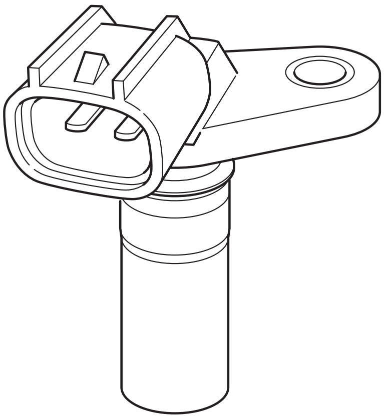
Crank Position (CKP) Sensor

Refer to “Engine Control System”.

Input shaft speed sensor (C0) [12,000 lbs GVW]

(Fitted to the transmission case)

- This sensor is an electromagnetic pulse pickup type that generates a speed signal according to the revolution of the transmission Overdrive direct clutch (C0) drum. As a result, the sensor sends a sine wave signal (AC) to the TCM, which converts this sine wave signal (pulse voltage) to a RPM signal.



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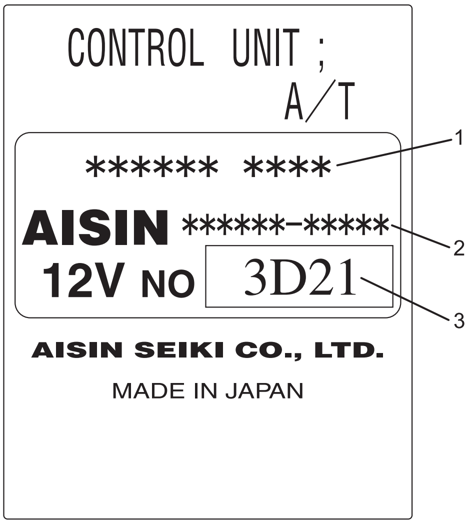
Transmission Control Module (TCM)

- The TCM is fitted under the instrument panel cluster (IPC) by means of four stud bolts. It receives signals from various sensors and judges the running condition of the vehicle accordingly. It compares the result with programmed gear shifting parameters, lock-up operating parameters, etc., and sends signals to solenoids and controls them accordingly.
- It controls seven different items:
  1. Line pressure
  2. Gear shifting (including overdrive control)
  3. Lock-up
  4. Exhaust brake
  5. “2-3” timing
  6. Self-diagnosis
  7. Fail-safe function

Identification Of Transmission Control Module (TCM)

1: ISUZU part No.
2: AISIN part No.
3: Manufactured date

Ex. : 3D21
3= Year; 2003
D= Month; April
A: January
B: February
L: December
21= Day



LNW47ASH044201

Automatic Transmission

The 450-43LE type automatic transmission is a four-speed automatic gear shift that is controlled electronically by the Transmission Control Module (TCM).

The TCM provides smooth and powerful driving performance by automatically selecting the optimum transmission characteristics and gear positions according to the accelerator (throttle) position, vehicle speed, and other conditions.

In an event of a malfunction of the vehicle speed sensor, throttle position sensor, solenoid valve or other components, it shifts to fail-safe control mode to maintain the driveability. In an event of a malfunction of the vehicle speed sensor, throttle position sensor, solenoid valve, engine RPM signal, etc., the TCM’s self-diagnosis function allows faster troubleshooting to enhance the vehicle’s serviceability.

The automatic transmission consists of the torque converter, oil pump, gear train, and valve bodies.

The torque converter is of the 3-element, 1-stage, and 2-phase type with a built-in lock-up clutch.

The gear train consists of 3 sets of multiple-plate clutches, 3 sets of multiple-plate brakes, 2 one-way clutches, and 3 sets of planetary gear each consisting of a sun gear, a pinion gear, and a ring gear.

Control Mechanism

Content of Function and Control

Item	Description
Line pressure control	• The line pressure solenoid valve is controlled by the TCM, based on signals from inhibitor switch and those regarding vehicle speed, throttle opening angle, etc., to automatically control the pressure regulator. This keeps oil pump delivery pressure at an optimal line pressure for driving condition. • Line pressure parameters including line pressure for continuous driving and that for gear shifting are stored in the TCM's microcomputer and appropriate parameters are selected from time to time.
Gear shift control	• No. 1 and No. 2 shift solenoids are controlled by the TCM, based on signals from inhibitor switch and those regarding vehicle speed, throttle opening angle, etc., to automatically shift gears to an optimal pattern.
OD up-shift inhibition control	• When OD OFF switch is turned off or when the transmission fluid temperature is low, upshifting to D4 speed (OD) is prohibited.
Lock-up control	• When driving in D4, D3 and D2 gear, TCM activates the torque converter clutch pulse width modulation (TCC PWM) solenoid valve based on vehicle speed, throttle opening angle and other signals to automatically control lock-up operation. • When transmission fluid temperature is low, the TCM prohibits lock-up operation. • When ABS operation signal is supplied to TCM, the TCM prohibits coast lock-up control.
Engine brake control	• The TCM activates the solenoid based on signals from inhibitor switch, and throttle position sensor to automatically control clutch operation. When exhaust brake is used, it increases line pressure to ensure sufficient clutch capacity.
Fail-safe function	• In case of malfunction of the vehicle speed sensor, throttle position sensor, all solenoids or inhibitor switch, TCM automatically begins fail-safe control to minimize effects on driving.
Self-diagnosis function	• In case of malfunction (with key switch turned on) in vehicle speed sensor, throttle position sensor, all solenoids, ATF temperature sensor or engine RPM signal, check trans lamp at instrument panel cluster (IPC) starts blinking to warn the driver. Malfunctioning system diagnostic trouble data is stored in the TCM and, when self-diagnosis start signal is received, the TCM causes the check trans lamp to blink in a special manner to indicate the diagnostic result.
Serial data control	• TCM data (such as the vehicle and engine speed) is checked and actuator test controlled by sending signals from "Scan Tool" to the communication program incorporated in the TCM.
Exhaust brake control	• When shifting or while lock-up operation, TCM require to the ECM cuts exhaust brake operation.

ATF: Automatic Transmission Fluid
ABS: Anti-lock Brake System
OD: Overdrive
ECM: Engine Control Module
TCM: Transmission Control Module

Control Item, Input and Output

* : 12,000 lbs GVW only

Item	Control Item								
	Shift control (Main)	Shift control (Excep-tion)	Lock-up control	Shift timing control	Line pressure control	EXH. Brake monitor	Fail-safe	Self-diagnosis	Engine stall prevention control
Input									
Vehicle speed sensor 1 (SP2)	○	○	○	○	○	○		○	○
Vehicle speed sensor 2 (SP1)	○	○	○	○	○	○		○	○
Input shaft speed sensor (C0)*								○	
Crank Position (CKP) sensor			○	○				○	
CAN									
Accelerator signal	○		○	○	○			○	○
Engine torque signal	○		○					○	
Cruise control signal								○	
PTO signal								○	
EXH. Brake monitor			○			○		○	
ATF temperature switch			○						
ATF temperature sensor	○				○			○	
Diag switch						○			
OD OFF switch	○		○					○	
Brake switch	○							○	○
ABS operation signal								○	
Inhibitor switch	○	○	○	○	○	○	○	○	○
Output									
Shift solenoid (S1) valve	○	○		○			○	○	

Item	Control Item								
	Shift control (Main)	Shift control (Exception)	Lock-up control	Shift timing control	Line pressure control	EXH. Brake monitor	Fail-safe	Self-diagnosis	Engine stall prevention control
Shift solenoid (S2) valve	○	○		○			○	○	
Shift timing solenoid valve	○			○				○	
TCC PWM solenoid valve			○					○	
CAN									
EXH. Brake cancel signal						○			
Engine torque limit request	○		○					○	
Engine speed up request			○						
Line pressure solenoid valve					○			○	
Diag lamp indicator								○	

Item	Control Item			
	ABS control	Engine torque control	Cruise control	Coast control
Input				
Vehicle speed sensor 1 (SP2)		○		○
Vehicle speed sensor 2 (SP1)		○		○
Crank Position (CKP) sensor		○		○
CAN				
Accelerator signal		○	○	○
Engine torque signal		○		
Cruise control signal			○	
PTO signal			○	
EXH. Brake monitor				
ATF temperature switch				
ATF temperature sensor				
Diag switch				
OD OFF switch				
Brake switch				
ABS operation signal	○			

Item	Control Item			
	ABS control	Engine torque control	Cruise control	Coast control
Inhibitor switch				
Output				
Shift solenoid (S1) valve				○
Shift solenoid (S2) valve				○
Shift timing solenoid valve				
TCC PWM solenoid valve	○			○
CAN				
EXH. Brake cancel signal				
Engine torque limit request		○		
Engine speed up request				○
Line pressure solenoid				
Check trans indicator				

Major Input/output Component Function

* : 12,000 lbs GVW only

Component	Function
Input	
Vehicle speed sensor 1 (Fitted to transmission)	Detects output shaft revolution and sends RPM signal to TCM.
Vehicle speed sensor 2 (Fitted to speedometer driven gear)	In case of malfunction of vehicle speed sensor 1 fitted to the transmission, a signal from this sensor (spare sensor) is used for continued control.
Engine Speed Signal	Detects engine revolution and sends signal to TCM from ECM.
CAN	
Accelerator signal	TCM receives accelerator opening signal from ECM.
Engine torque signal	TCM receives engine torque signal from ECM.
Cruise control signal	TCM receives cruise control signal from ECM.
PTO signal	TCM receives PTO signal from ECM.
EXH. Brake monitor	TCM receives exhaust brake operation signal.
ATF temperature switch	Detects abnormal ATF temperature and sends signal to TCM.
ATF temperature sensor	Detects ATF temperature and sends signal to TCM.
Diag switch	Detects failure condition and sends signal to TCM.
OD OFF switch	Detects OD prohibition signal and sends to TCM.
Brake switch	Detects foot brake operation and sends signal to TCM.
ABS operation signal	Detects ABS operation signal and sends to TCM.
Inhibitor switch	Detects select lever position and sends signal to TCM.
Input shaft speed sensor (C0)*	Detects Overdrive direct clutch (C0) drum revolution and sends signal to TCM.
Output	

Component			Function
	Shift solenoid (S1) valve		Selects appropriate gear shifting position for current driving condition based on signal from TCM.
	Shift solenoid (S2) valve		Selects appropriate gear shifting position for current driving condition based on signal from TCM.
	Shift timing solenoid valve		Controls the timing during 2nd and 3rd shifting based on signal from TCM.
	TCC PWM solenoid valve		Regulates (decreases) lock-up pressure to appropriate level for current driving condition based on signal from TCM.
	CAN		
		EXH. Brake cancel signal	TCM sends an exhaust brake release signal to ECM.
		Engine torque limit request	TCM sends an engine torque limit to ECM.
		Engine speed up request	TCM sends an engine speed increase request to ECM.
	Line pressure solenoid valve		Regulates (decreases) oil pump delivery pressure to the appropriate line pressure for current driving condition based on signal from TCM.
	Diag lamp indicator		Indicates transmission malfunction.
Input/ Output			
	Scan Tool		Self-diagnosis (such as check of vehicle input/output values and actuator test) is performed by connecting TCM and “Scan Tool”.

ATF: Automatic Transmission Fluid
ECM: Engine Control Module
TCM: Transmission Control Module
CAN: Control Area Network
OD: Overdrive

Valve Operation

Valve Function

Upper Valve Body

	Valve name	Function
(1)	• 2-3 shift valve	• Shifts between the 2nd and the 3rd gears.
(2)	• Reverse inhibitor valve	• When the gear is shifted to the R range when the vehicle is running forward at high speed, this valve provides the necessary solenoid output to prevent shifting to the reverse gear.
(3)	• Modulator valve	• Regulates the line pressure before it is supplied to the lock-up signal valve, orifice control valve, etc.
(4)	• Throttle valve	• Regulates the signal pressure (throttle pressure) to regulate the line pressure to the optimum level for the driving conditions.
(5)	• Secondary regulator valve	• Controls the oil pressure being sent from the primary regulator valve to the torque converter, and controls the pressure of the lubricant being supplied to all parts.
(6)	• Reducing valve	• Reduces the line pressure before it is supplied to the throttle valve.
(7)	• Lock-up signal valve	• Activates or deactivates the lock-up function.
(8)	• Accumulator control valve	• Lowers the back pressure of the accumulator to the low throttle opening angle, and acquires from line pressure the necessary accumulator control pressure for easing the gear shifting shock.
(9)	• Low coast modulator valve	• Regulates pressure from the line pressure to a low pressure to ease the gear shifting shock when shifting to the L range.

	Valve name	Function
(10)	• Orifice control valve	• Switches the orifices to reduce the shock.
(11)	• Low inhibitor valve	• When the gear is shifted to the L range when driving at high speed, this valve shifts to the 3rd gear at the shift timing solenoid valve output.
(12)	• Check valve	• Switches the oil passage to the rear clutch (C2) between the D range and the R range.

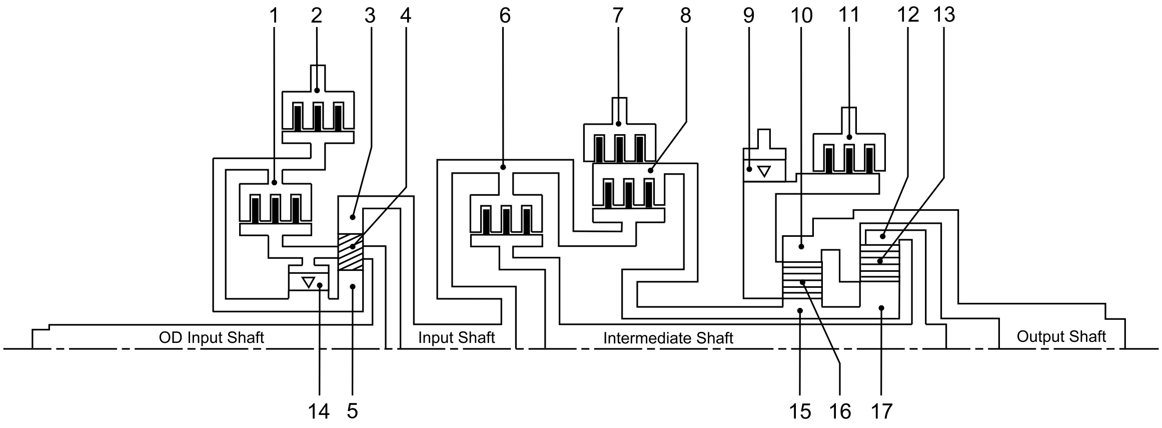
Lower Valve Body

	Valve name	Function
(1)	• Manual valve	• Switches the oil passage to the P, R, N, D, 2, or L range according to the select lever action.
(2)	• 1-2 shift valve	• Switches between the 1st and the 2nd gears.
(3)	• 3-4 shift valve	• Switches between the 3rd and the OD gears.
(4)	• Pressure relief valve	• Regulates the supply pressure to the cooler to the low pressure.
(5)	• Primary regulator valve	• Controls the oil pressure (line pressure) reaching respective elements.
(6)	• Lock-up control valve	• Switches the flow of fluid being sent to the torque converter.
(7)	• C0 exhaust valve	• Eases the gear shifting shock when shifting from the 3rd to 2nd gears.
(8)	• 2-3 timing valve	• Optimizes the oil pressure switching timing to ease the shock when shifting from 2nd to the 3rd gears.
(9)	• Cut-back valve	• Causes the cut-back pressure to act upon the throttle valve to lower the line pressure.

Gear Train (Transmission Mechanism) Operation

Construction and Operation

The gear train consists of three pairs of planetary gears, three pairs of multi-plate clutches, three pairs of multi-plate brakes and two pairs of one-way clutches.



OD = Overdrive

LNW47AMF000101

Legend

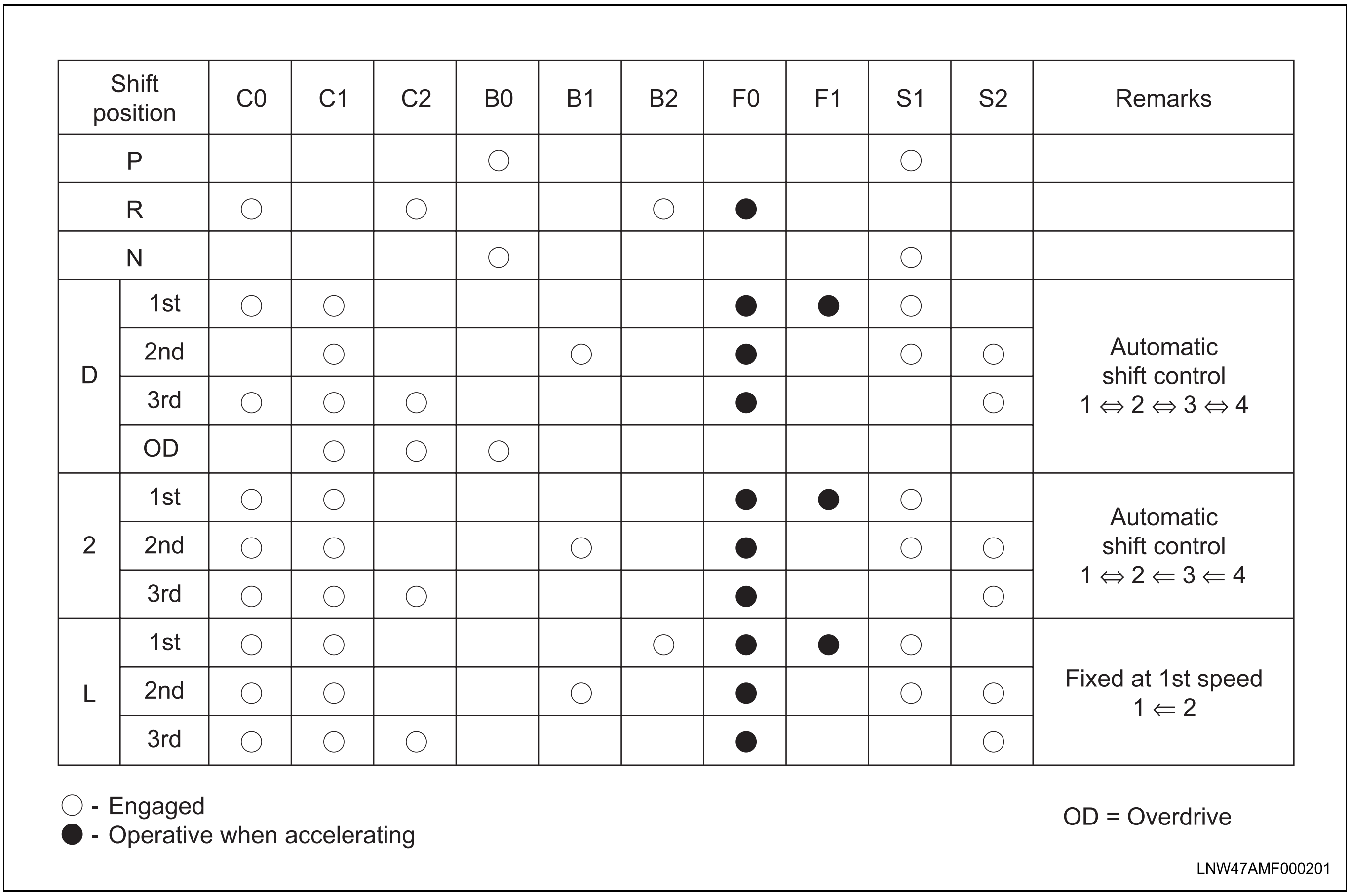
1. OD Direct Clutch (C0)
2. OD Brake (B0)
3. OD Ring Gear
4. OD Pinion Gear
5. OD Sun Gear
6. Front Clutch (C1)
7. 2nd Brake (B1)
8. Rear Clutch (C2)
9. No.2 One-way Clutch (F1)
10. Front Ring Gear
11. 1st and Reverse Gear
12. Rear Ring Gear
13. Rear Pinion Gear
14. OD One-way Clutch (F0)
15. Front Sun Gear
16. Front Pinion Gear
17. Rear Sun Gear

Component Name and Function

Component name	Symbol	Function
Overdrive (OD) direct clutch	C0	Connects OD sun gear and OD carrier.
Front clutch	C1	Transmit the engine torque from the input shaft to the intermediate shaft.
Rear clutch	C2	Transmit the engine torque from the front clutch hub to the front and rear planetary sun gear.
OD brake	B0	Locks the OD planetary sun gear.
2nd brake	B1	Locks the front and rear planetary sun gear.

Component name	Symbol	Function
1st & Rev. brake	B2	Locks the front planetary carrier.
OD one-way clutch	F0	Locks the OD sun gear and OD planetary carrier during acceleration in 1st, 2nd or 3rd gear.
One-way clutch No.2	F1	Locks the front planetary carrier during acceleration in 1st gear.
No.1 shift solenoid valve	S1	The ON/OFF combinations of the two solenoids are used to control the gear position.
No.2 shift solenoid valve	S2	

Component and Their Operating Condition



Shift position		C0	C1	C2	B0	B1	B2	F0	F1	S1	S2	Remarks
P					○					○		
R		○		○			○	●				
N					○					○		
D	1st	○	○					●	●	○		Automatic shift control 1 ⇔ 2 ⇔ 3 ⇔ 4
	2nd		○			○		●		○	○	
	3rd	○	○	○				●			○	
	OD		○	○	○							
2	1st	○	○					●	●	○		Automatic shift control 1 ⇔ 2 ⇐ 3 ⇐ 4
	2nd	○	○			○		●		○	○	
	3rd	○	○	○				●			○	
L	1st	○	○				○	●	●	○		Fixed at 1st speed 1 ⇐ 2
	2nd	○	○			○		●		○	○	
	3rd	○	○	○				●			○	

○ - Engaged
● - Operative when accelerating

OD = Overdrive

LNW47AMF000201

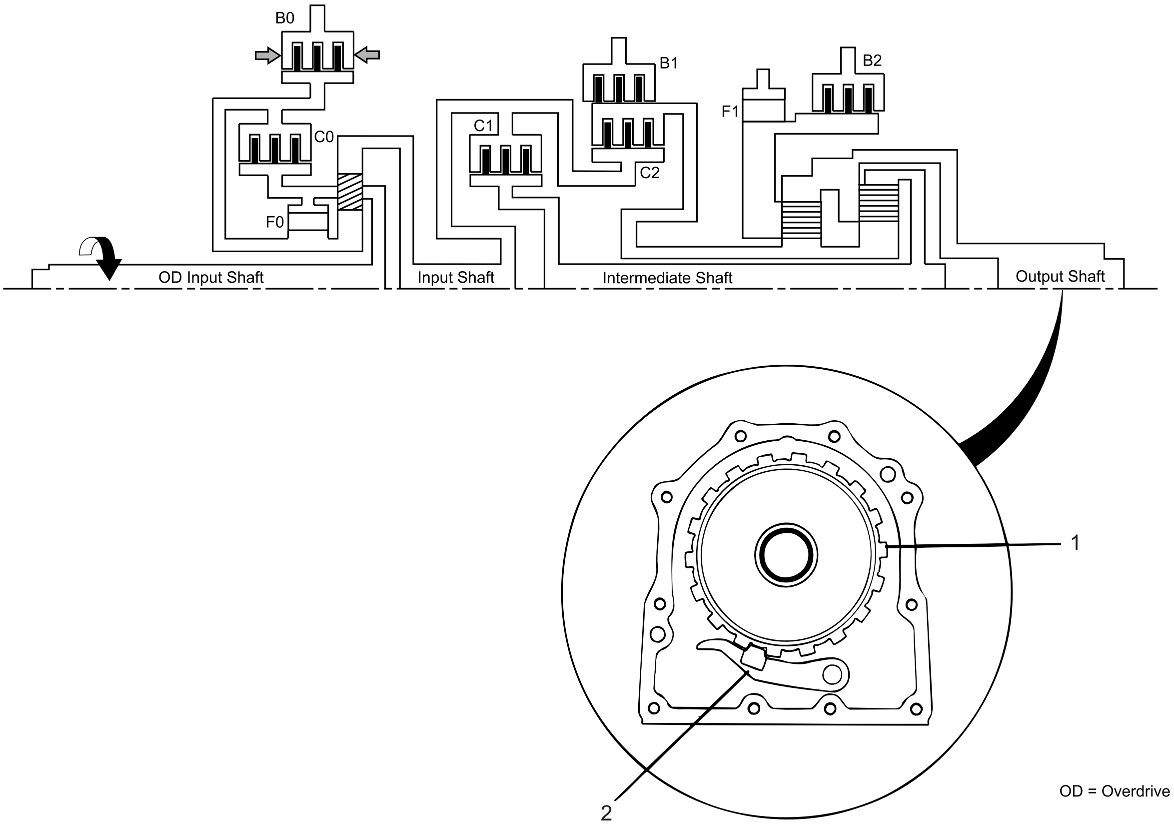
N and P ranges

N range

- The front clutch (C1) and the rear clutch (C2) are released. The torque from the input shaft is not transmitted to the output shaft.

P range

- As in the case of the N range above, the torque from the input shaft is not transmitted to the output shaft. The parking lock pawl, which is linked to the select lever, is engaged with the parking lock gear, which is directly coupled with the output shaft. The vehicle is locked as the result.



Legend

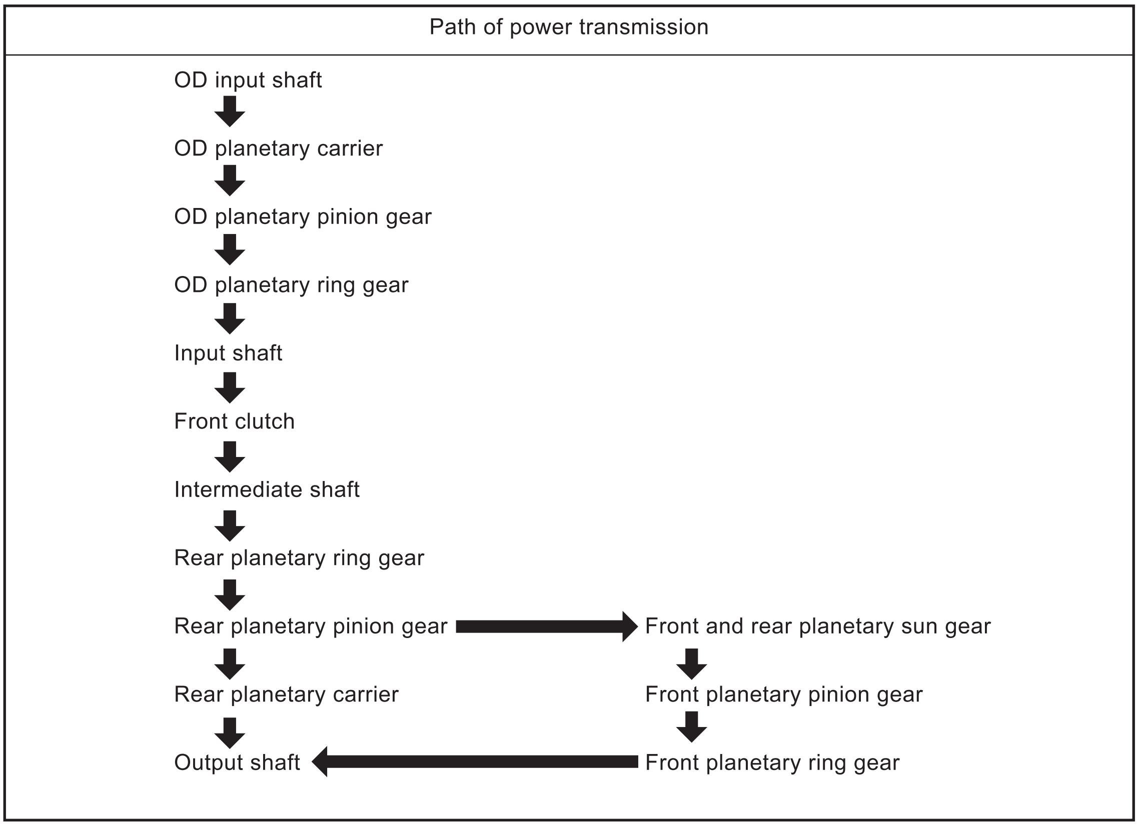
1. Parking Lock Gear
2. Parking Lock Pawl

First Gear in D or 2 Range

The overdrive (OD) direct clutch (C0), front clutch (C1), OD one-way clutch (F0) and No.2 one-way clutch (F1) are activated to form the 1st gear. In the OD planetary gear, the OD direct clutch (C0) connects the OD planetary carrier (OD input shaft) to the OD sun gear. This prevents the OD pinion gear from turning so that the OD planetary carrier transmits the driving force to the input shaft along with the OD ring gear as a unit (direct coupling). When the OD planetary carrier turns clockwise the OD pinion gear tends to turn counterclockwise causing the OD sun gear to turn clockwise. However, since it turns faster than the OD planetary carrier, the OD one-way clutch (F0) locks the OD planetary carrier with the OD sun gear. This prevents the OD pinion gear from turning, as in the case when the OD direct clutch (C0) is activated, so that the OD planetary carrier transmit the driving force to the input shaft along with the OD ring gear as a unit (direct coupling). The two-way transmission of the power helps to ease the load being applied to the OD direct clutch (C0).

The clockwise rotational force of the input shaft is transmitted, by the front clutch (C1), from the intermediate shaft to the rear planetary ring gear and to the rear planetary pinion gear. Since the rear planetary carrier is stopped at this time due to the vehicle load, the rear sun gear receives the counterclockwise rotational force and transmits it to the front planetary pinion gear. This causes the front planetary carrier to turn counterclockwise. However, since the front planetary carrier is prevented from turning counterclockwise by the one-way clutch No.2 (F1), the pinion gear causes the front ring gear and the rear planetary carrier to turn clockwise so that the driving force is transmitted to the output shaft.

(Rotational direction is viewed from torque converter side)



OD = Overdrive

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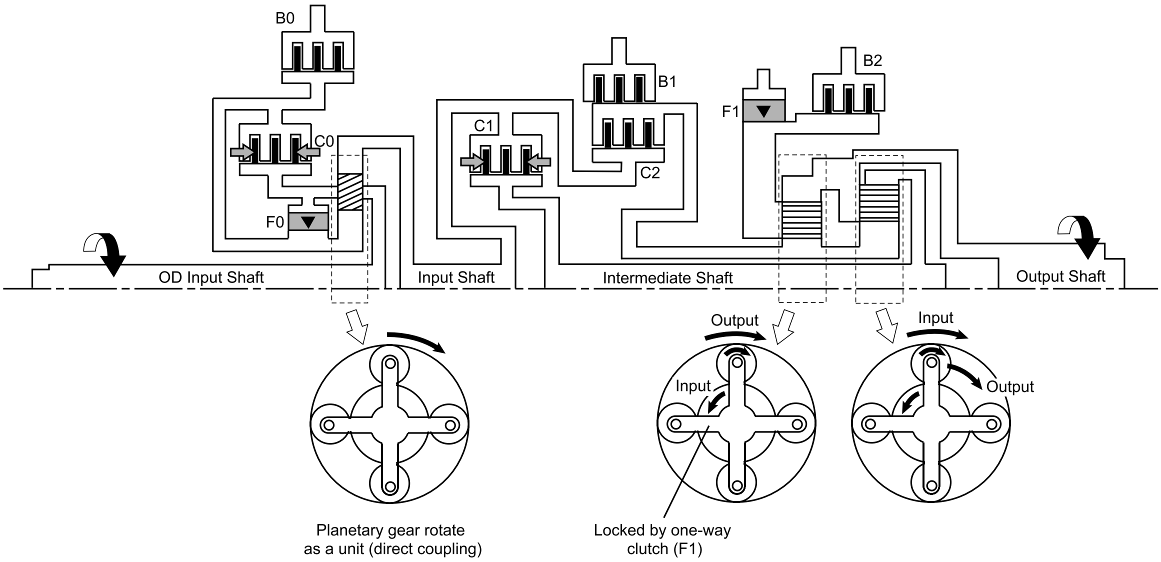
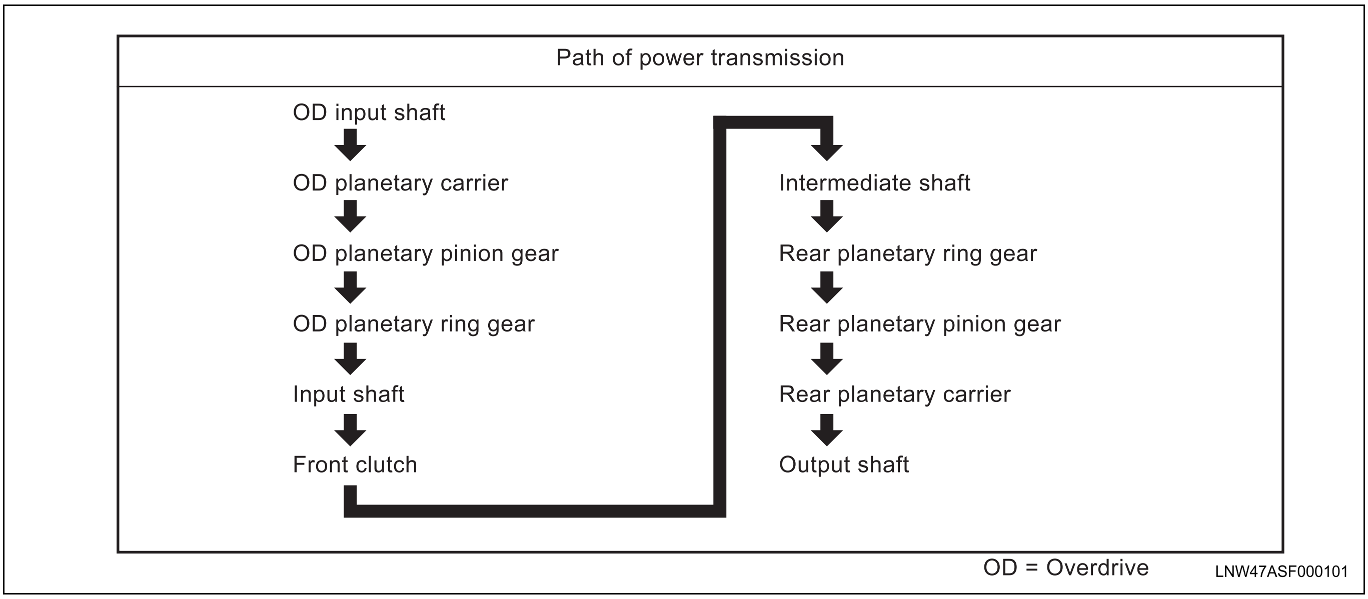


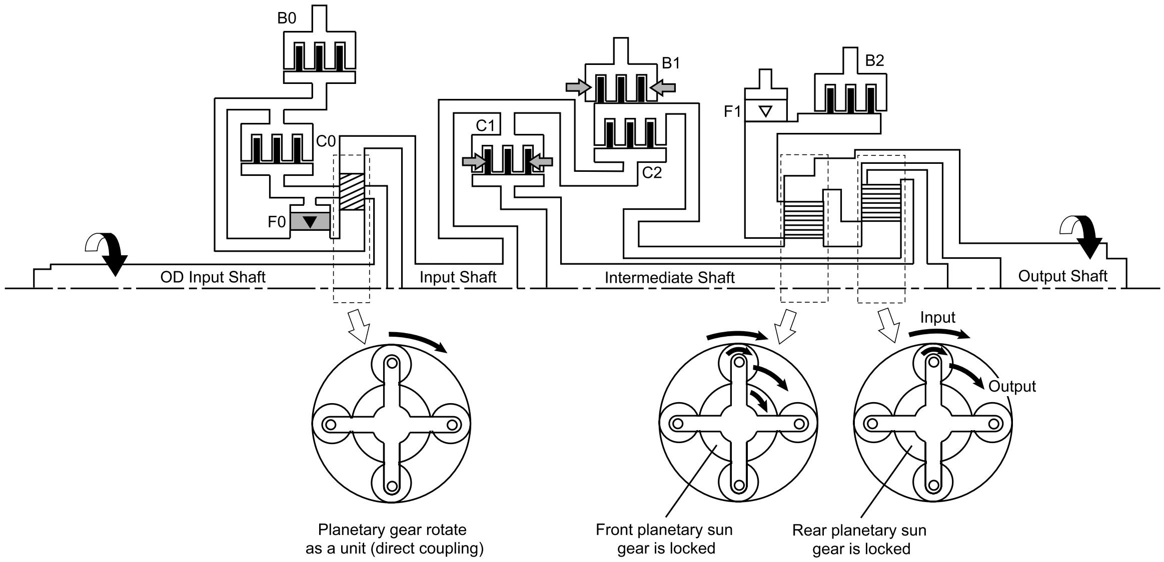
OD = Overdrive

LNW47AMF000501

Second Gear in D Range

The front clutch (C1), 2nd brake (B1), and OD one-way clutch (F0) are activated to form the 2nd gear. In the 2nd gear, the rotational force of the input shaft caused by the OD one-way clutch (F0) is transmitted from the intermediate shaft to the rear planetary ring gear and to the rear planetary pinion gear. At this time, the rear sun gear which is engaged with the pinion gear receives a counterclockwise rotational force. However, since it is prevented from turning by the 2nd brake (B1), the rotational force is not transmitted to the front planetary gear. It is transmitted via the rear pinion gear to the rear planetary carrier and to the output shaft.





OD = Overdrive

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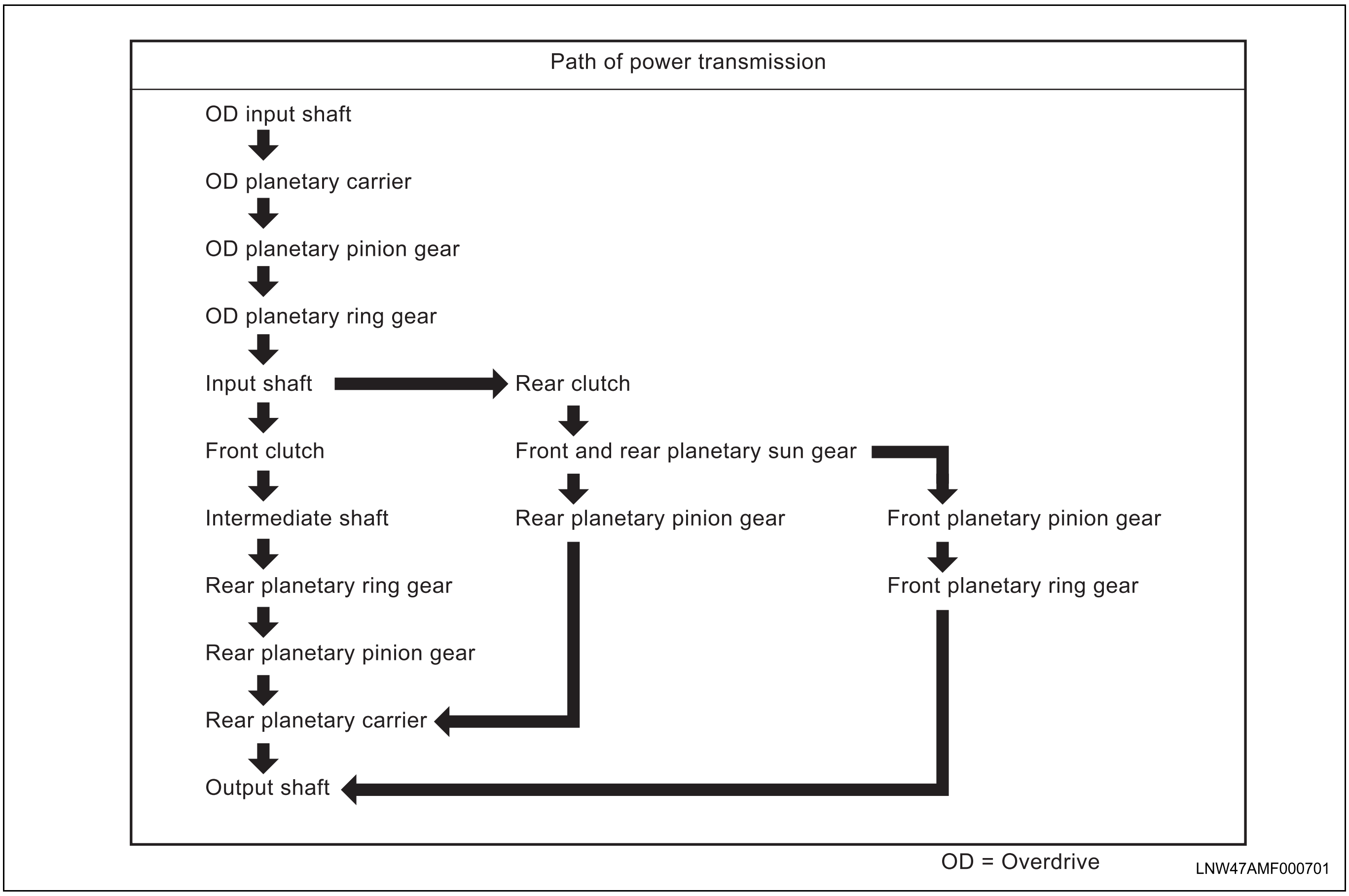
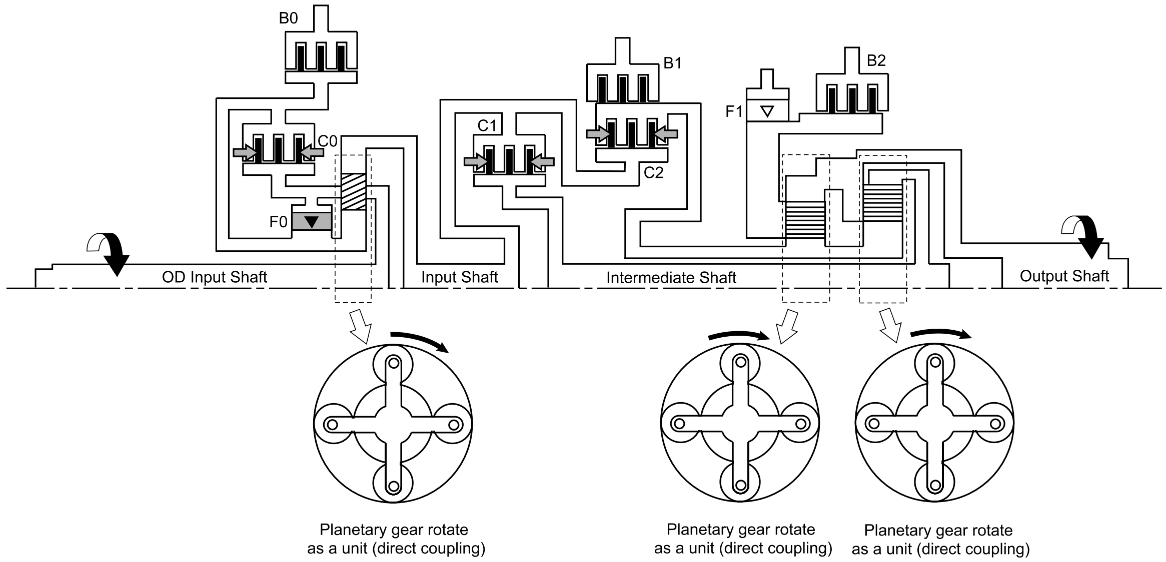
Third Gear in D, 2, L Range

The OD direct clutch (C0), front clutch (C1), rear clutch (C2), and OD one-way clutch (F0) are activated to form the 3rd gear. In the 3rd gear, the intermediate shat and the front and rear sun gears rotate in the same direction as a unit because of the front clutch (C1) and the rear clutch (C2). Therefore, the front and rear planetary pinion gears are locked so that the planetary gear turns as a unit. As the result, the rotational force of the input shaft is transmitted directly to the output shaft without being reduced.



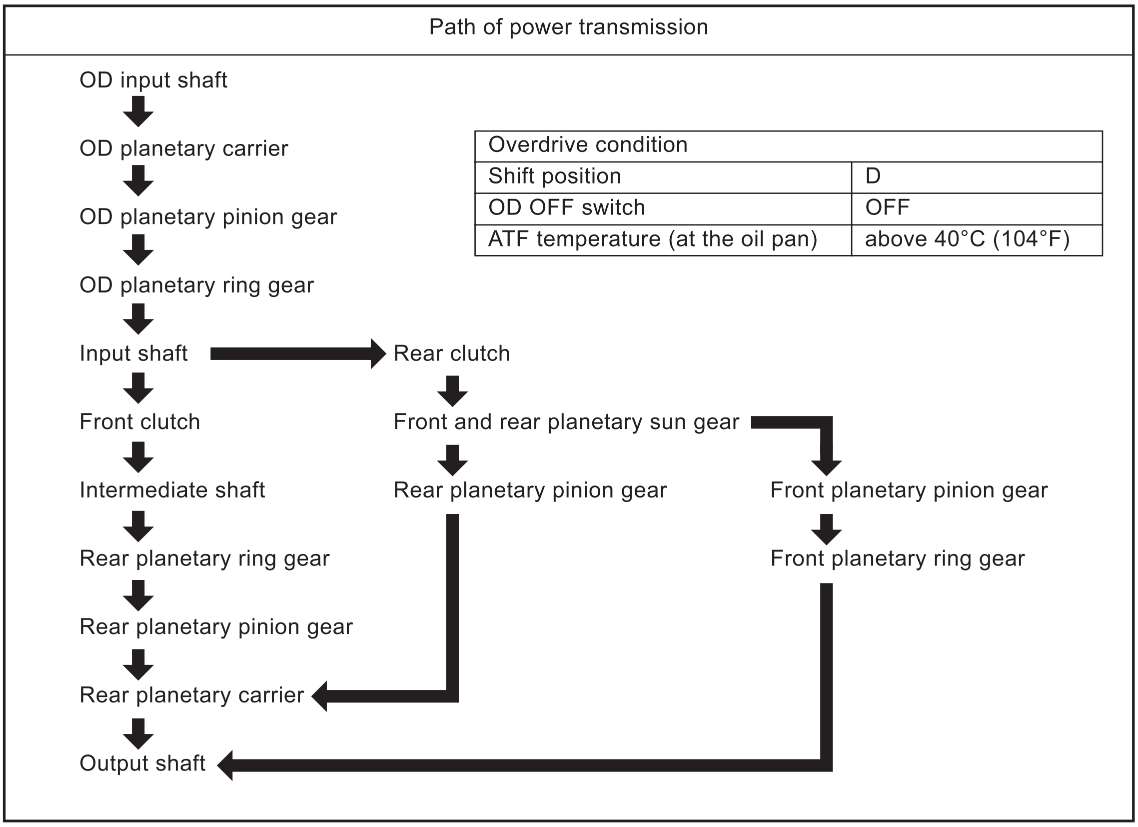


OD = Overdrive

LNW47AMF000801

Overdrive (OD) Gear in D Range

When the overdrive conditions (shown in the table below) are met in the 3rd gear condition, the OD direct clutch (C0) is released. At the same time, the OD brake (B0) is activated to form the overdrive gear. In the overdrive gear, the OD sun gear is locked by the OD brake (B0). Therefore, the rotational force which is transmitted from the OD input shaft to the OD planetary carrier causes the OD planetary pinion gear to turn about itself and revolve at the same time. This increases the speed of the OD planetary ring gear (input shaft) and, as in the case of the 3rd gear, the rotational force of the input shaft is transmitted directly to the output shaft.



Overdrive condition	
Shift position	D
OD OFF switch	OFF
ATF temperature (at the oil pan)	above 40°C (104°F)

ATF = Automatic Transmission Fluid OD = Overdrive

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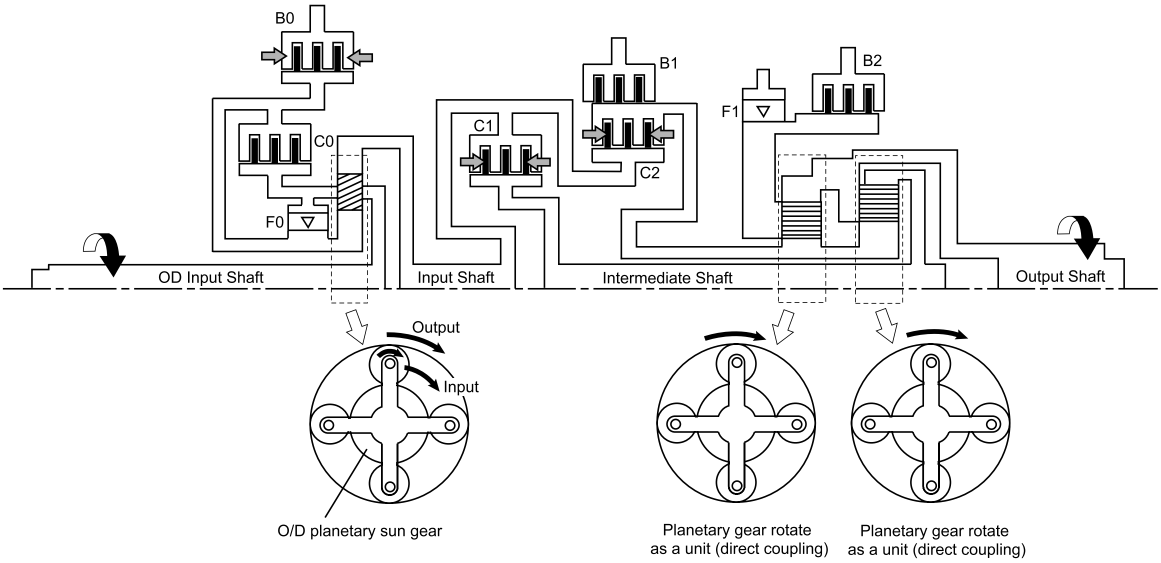

OD = Overdrive

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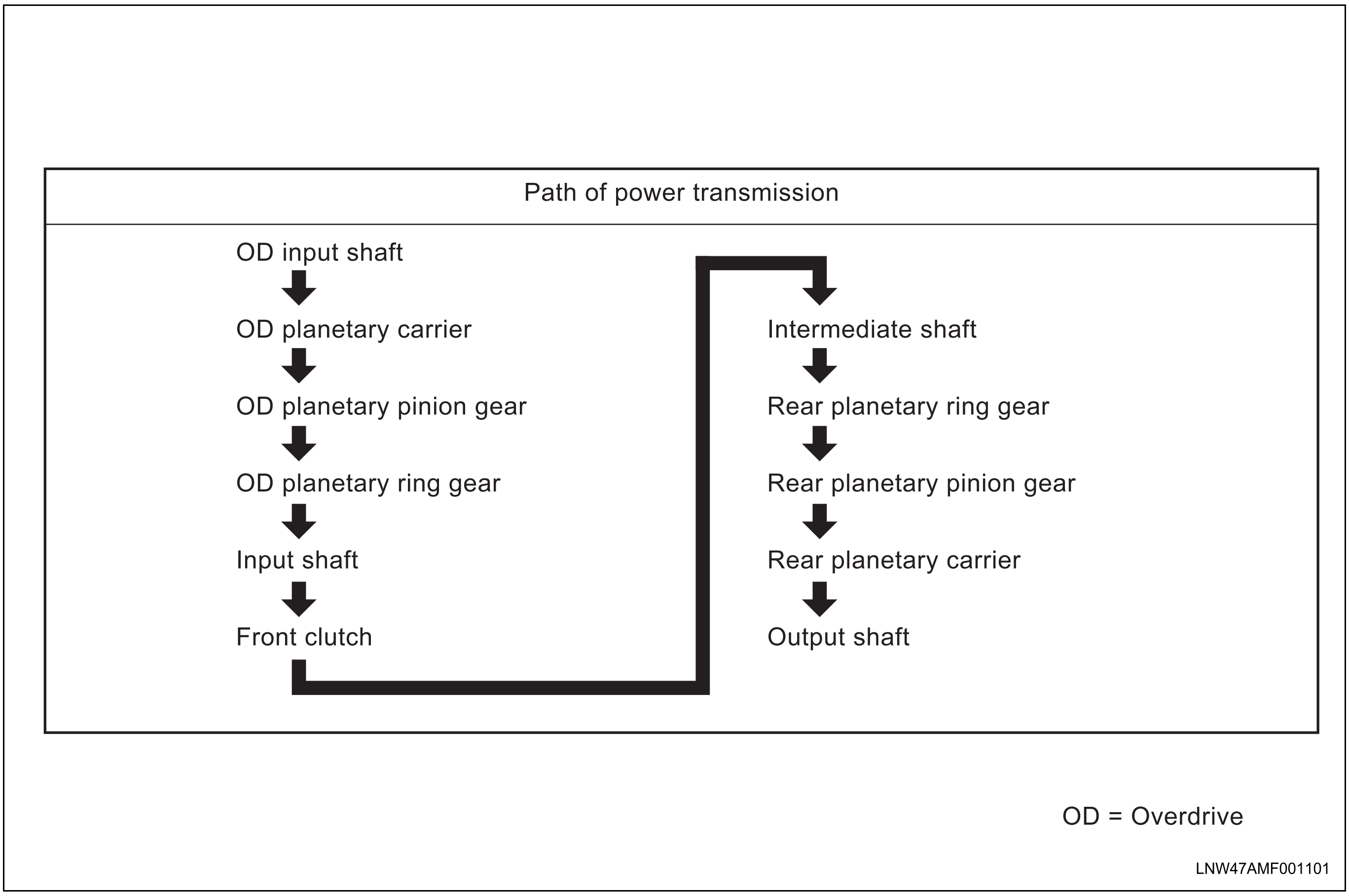
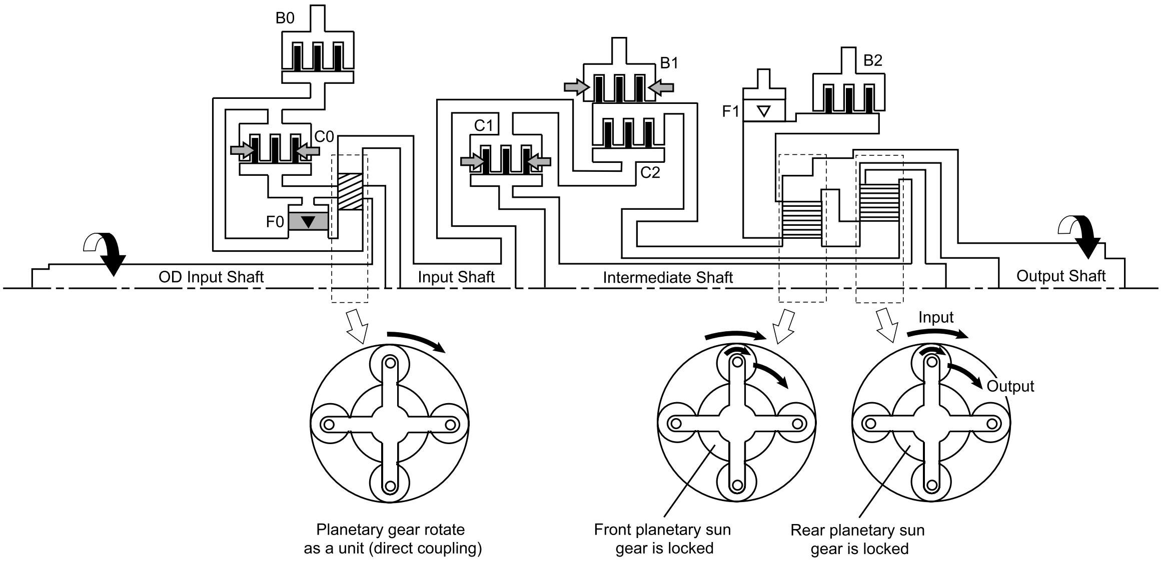
Second Gear in 2 Range

The rotational force is transmitted in the same way as in the case of the 2nd gear in the D range with a few exceptions. The clockwise rotation of the overdrive (OD) sun gear during the engine brake is prevented by the OD direct clutch (C0). In other words, the rotational force is transmitted to the input shaft by the OD one-way clutch (F0) when the vehicle is driven by the second gear in the D range. When the engine brake is applied, the counterclockwise rotational force of the OD sun gear deactivates the OD one-way clutch. The engine brake takes no effect as the OD sun gear idles in this condition. For this reason, the OD direct clutch (C0) is activated in the 2nd range to engage the OD sun gear and the OD planetary carrier so that the engine brake is effective.



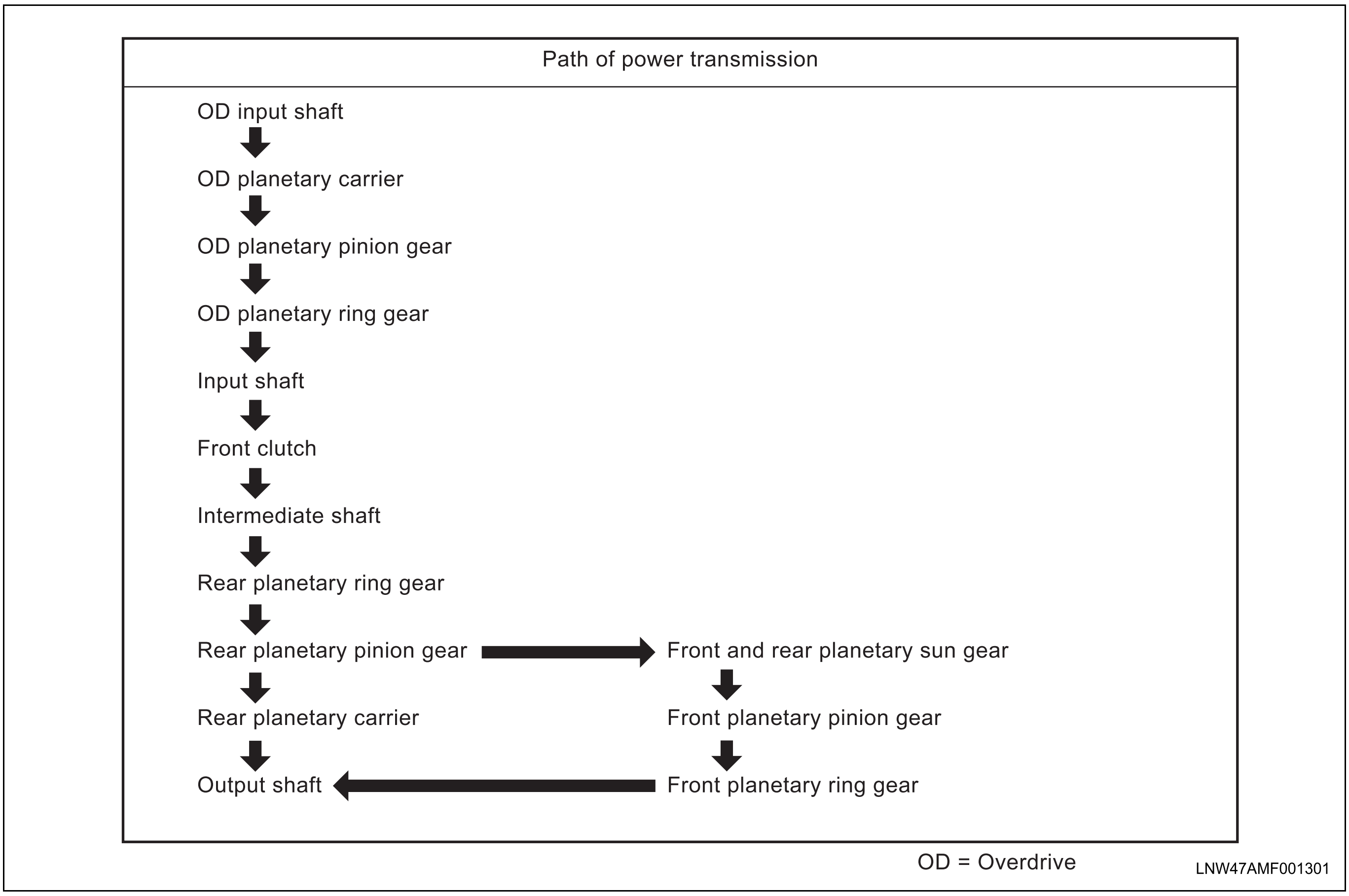


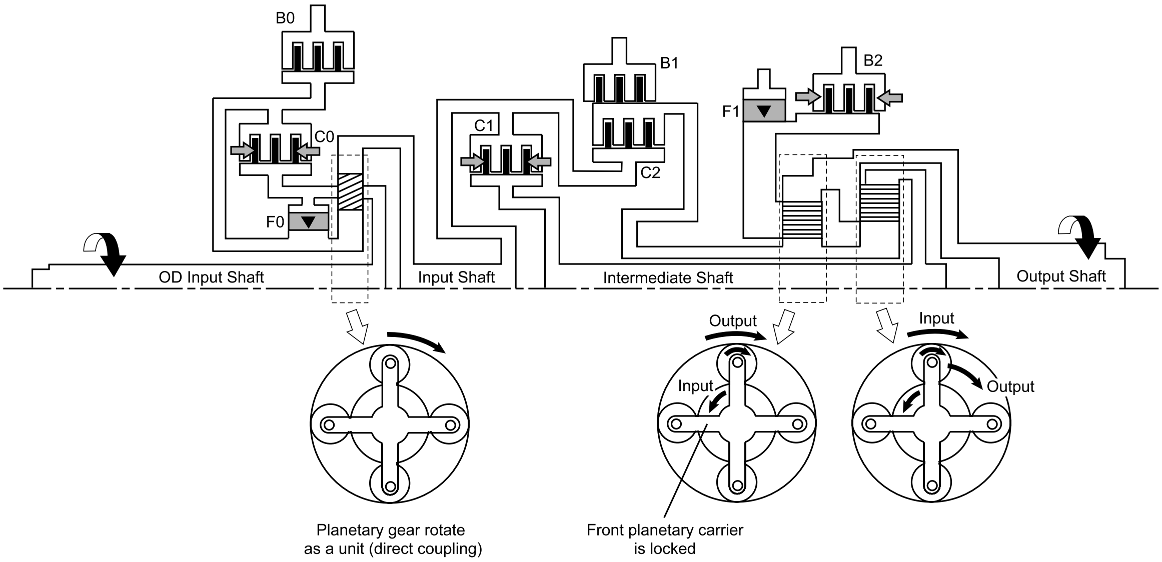
OD = Overdrive

LNW47AMF001201

First Gear in L Range

The rotational force is transmitted in the same way as in the case of the 1st gear in the D and 2nd ranges with a few exceptions. When the engine brake is applied, the clockwise rotation of the front planetary carrier is prevented by the 1st and reverse brake (B2). When the vehicle is driven by the 1st gear in the D or 2nd range, the counterclockwise rotation of the front planetary carrier is locked by the one-way clutch No.2 (F1) so that the rotational force is transmitted to the output shaft. When the engine brake is applied, however, a counter force deactivates the one-way clutch No.2 (F1). This causes the front planetary carrier to idle and the engine brake takes no effect. In the L range, the 1st and reverse brake (B2) is activated to lock the front planetary carrier so that the engine brake is effective.



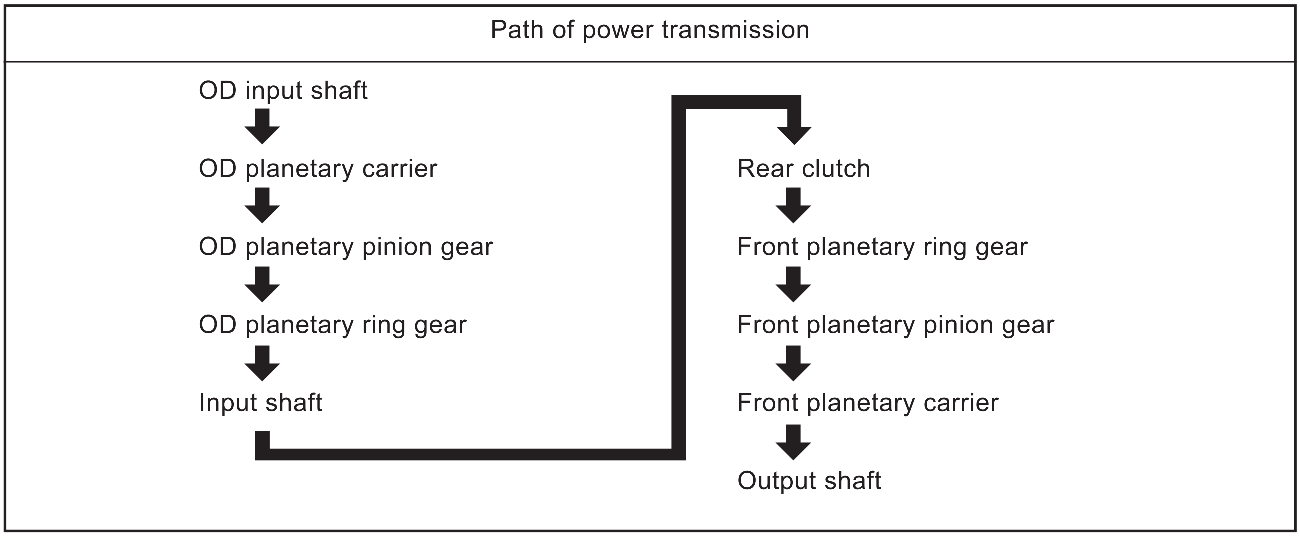


OD = Overdrive

LNW47AMF001401

R Range

In the R range, the overdrive (OD) direct clutch (C0), OD one-way clutch (F0), rear clutch (C2) and 1st and reverse brake (B2) are activated to form the reverse gear. The rotational force of the OD input shaft is transmitted directly to the input shaft as does the 1st gear in the D or 2nd range. The rotational force of the input shaft is transmitted to the pinion gear of the front planetary gear as the rear clutch (C2) is active. However, since the front planetary carrier is locked by the 1st and reverse brake (B2), the rotational force of the sun gear is transmitted to the ring gear via the pinion gear so that the counterclockwise rotational force is transmitted to the output shaft.



OD = Overdrive

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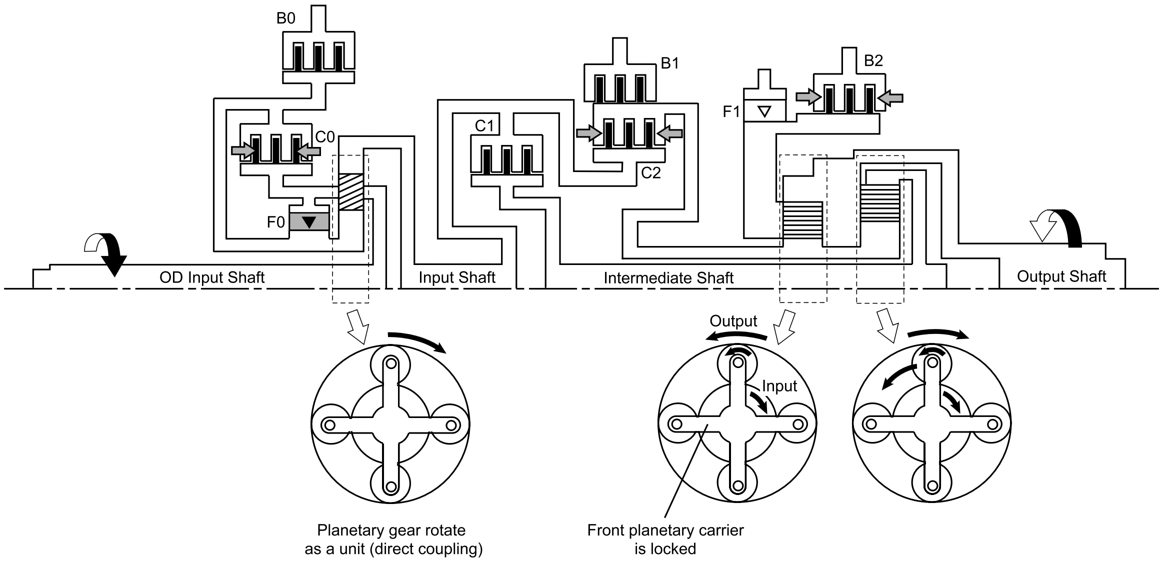


OD = Overdrive

LNW47AMF001601

Special Tools and Equipment

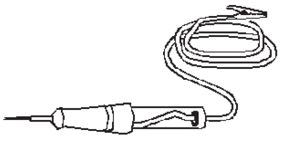
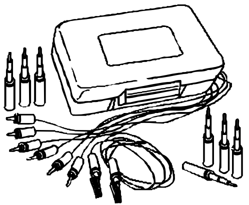
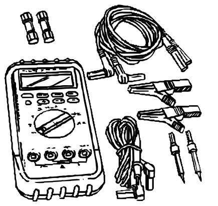
Illustration	Tool Number/ Description
 AAW0Z0SH013701	J-34142-B Test Lamp
 AAW0Z0SH014101	J-35616-C Connector Test Adapter Kit (With Test Lamp)
 AAW0Z0SH014701	J-39200 Digital Multimeter

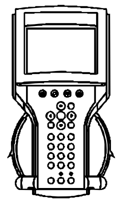
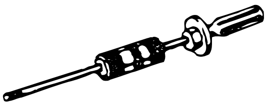
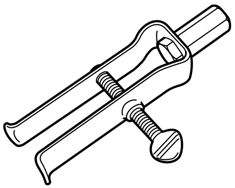
Illustration	Tool Number/ Description
 AAW0Z0SH015701	7000081 Tech2 Kit
 5884000190	J-23907 Sliding Hammer
 J26941	J-26941 Rear Oil Seal Remover

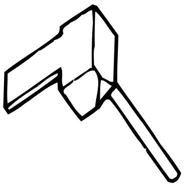
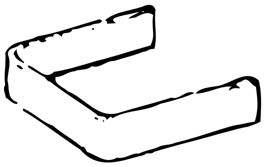
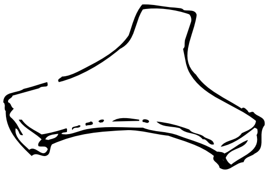
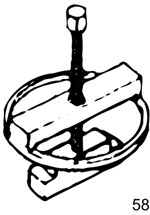
Illustration	Tool Number/ Description
	J-29770-A Pressure Gauge
	J-35467 One-way Clutch Test Tool
	J-37228 Oil Pan Seal Cutter
	J-44160 No.2 Piston Spring Compressor
	J-44161 No.3 Piston Spring Compressor
	J-44162 No.1 Piston Spring Compressor

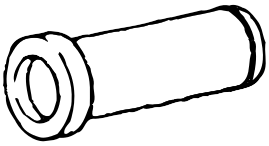
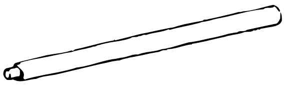
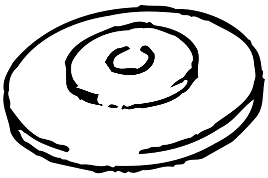
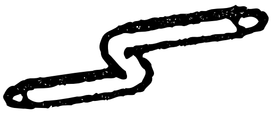
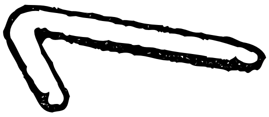
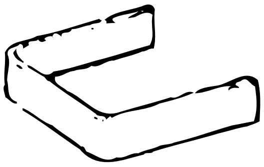
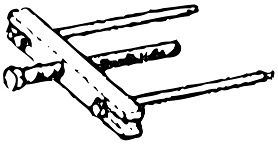
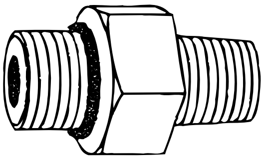
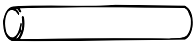
Illustration	Tool Number/ Description
	J-44163 Oil Pump Oil Seal Installer
	J-44164 Handle
	J-44165 Rear Bearing Installer
	J-44166 Plate
	J-44167 No.1 Measure Termial
	J-44168 No.2 Measure Termial

Illustration	Tool Number/ Description
 5884026410	J-44169 Extension Bar
 5884026520	J-44170 Oil Pump Remover
 5884026530	J-44171 Lever Shaft Oil Seal Installer
 5884026540	J-43407 Adapter
 J41736	J-41736 Rear Oil Seal Installer

TRANSMISSION/TRANSAXLE

Manual Transmission (MZZ)

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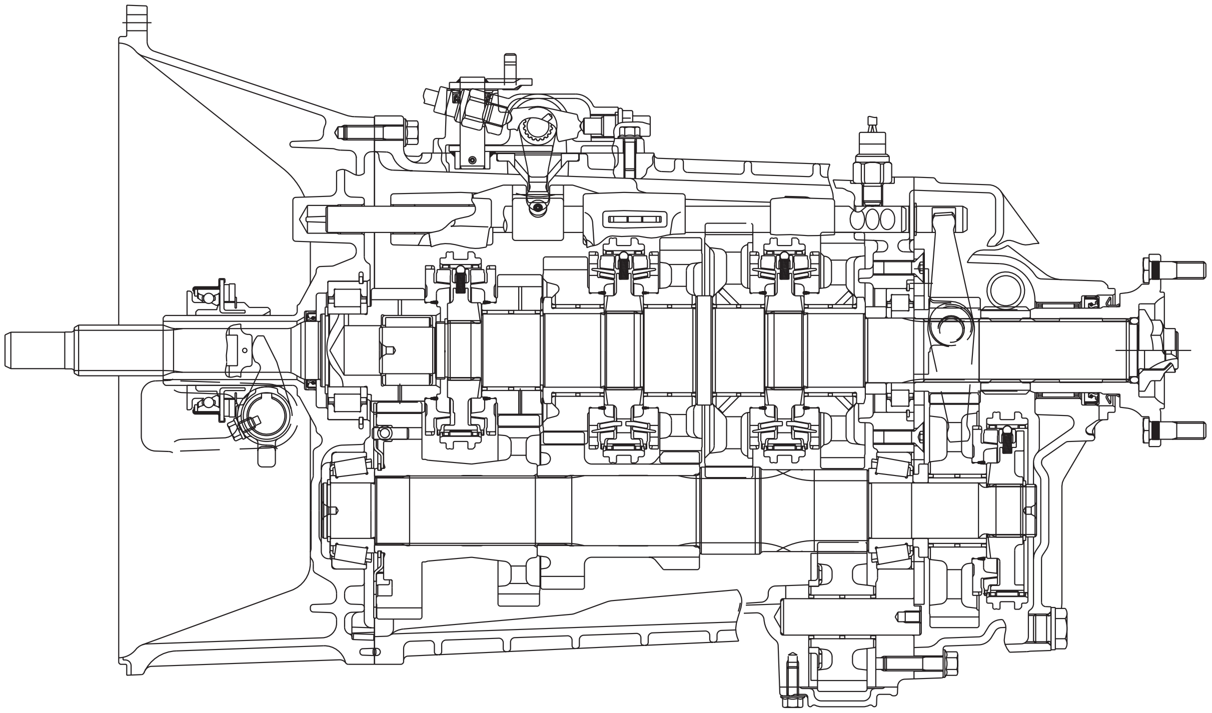
Description and Operation

Function and operation explanation



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MZZ transmission has a 3-piece aluminum case to greatly reduce weight.
Taper roller bearings are used for both ends of the counter shaft (front and rear).
The transmission features a twin-rod shift control.

Function check

Condition	Possible Cause	Correction
Abnormal noise	Flywheel pilot bearing wear.	Replace the bearing.
	Main shaft or counter shaft bearing wear or other damage.	Replace the bearing(s).
	Main shaft gear, counter shaft gear, and/or reverse idle gear wear or other damage.	Replace the gear(s).
	Main shaft spline and/or synchronizer hub spline wear.	Replace the spline(s).
	Gear or bearing thrust surface scoring.	Replace the gear(s) and/or bearing(s)
	Insufficient backlash between mating gears.	Replace the gears.

Condition	Possible Cause	Correction
Difficult shifting	Insufficient clutch pedal play.	Adjust the play.
	Change lever contact surface wear.	Repair or replace the change lever and apply grease.
	Shift block, shift rod, and/or control box contact surface wear.	Replace the worn components.
	Shift arm and/or synchronizer sleeve wear.	Replace the worn parts.
	Thrust washer and collar and/or gear thrust surface wear (Main shaft and counter shaft thrust play).	Replace the worn parts.
	Synchronizer wear	Replace the synchronizer.
Gear slippage	Detent ball wear.	Replace the detent ball.
	Shift rod and/or control box contact surface wear.	Replace the worn components.
	Shift arm and/or synchronizer sleeve wear.	Replace the worn parts.
	Thrust washer and collar and/or gear thrust surface wear (Main shaft and counter shaft thrust play).	Replace the worn parts.
	Bearing wear or other damage.	Replace the worn or damaged bearings.
	Main shaft spline and synchronizer hub spline wear.	Replace the worn parts.
	Synchronizer spring weak or broken.	Replace the spring.
Oil leakage	Drain plug and/or filler plug loose.	Tighten the plug(s).
	Broken gasket.	Replace the gasket.
	Oil seal wear or damage.	Replace the oil seal.

Transmission Oil Level Check

Measurement

- Block the vehicle so it cannot move.
- Disconnect the ground cable from the battery negative (-) post.

1. Remove the filler plug (2) from the transmission case (3).
2. Check oil level

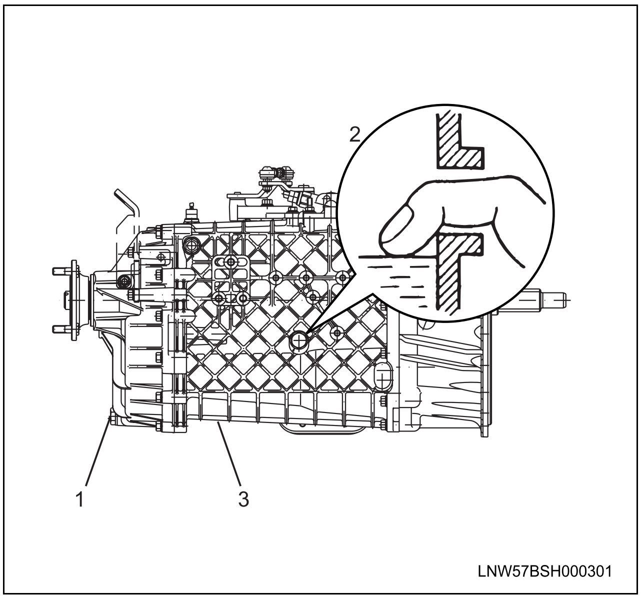
- Add lubricant to within 0 to 10 mm (0 to 0.4 in) of bottom edge of the filler hole if necessary.

Caution:
Use ENGINE OIL SAE 5W-30 for the transmission case.

3. Install the filler plug.

Tighten

- Filler plug to 39 N·m (29 lb ft)
- Connect the battery ground cable and remove the wheel blocks.



Legend

1. Drain Plug
2. Filler Plug
3. Transmission Case

Changing Transmission Oil

Drain the transmission oil after driving the vehicle. The oil will drain more completely.

- Block the vehicle so it cannot move.
- Disconnect the ground cable from the battery negative (-) post.

1. Remove the drain plug (1). Provide a pan to catch oil.
2. Install the drain plug and tighten.

Tighten

- Drain plug to 39 N·m (29 lb ft)

3. Remove the filler plug (2).
4. Fill the transmission case to level of the filler plug opening.

Caution:
Use ENGINE OIL SAE 5W-30 for the transmission case.

5. Install filler plug and tighten.

Tighten

- Filler plug to 39 N·m (29 lb ft)
- Connect the battery negative cable and remove the wheel blocks.

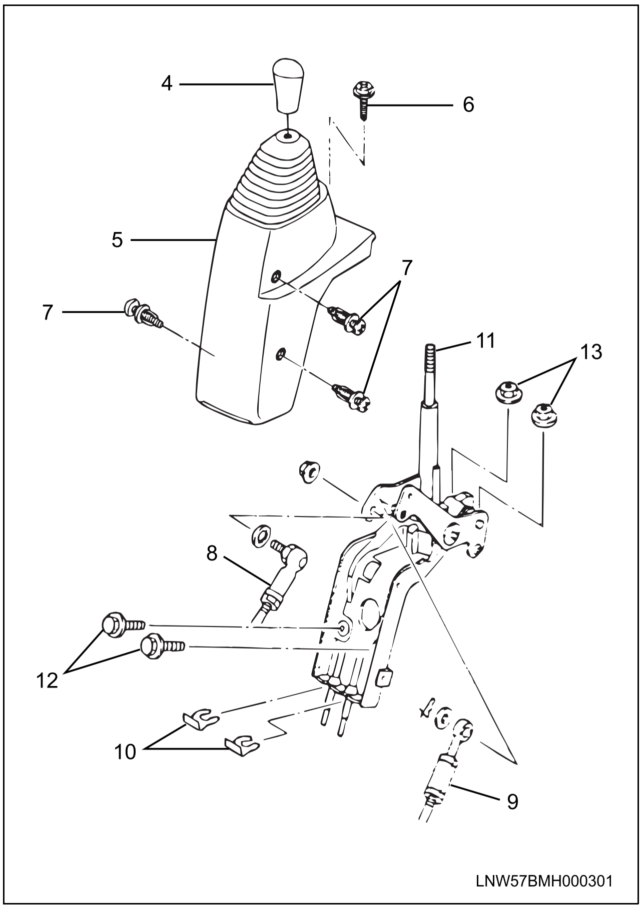
Repair Instructions

Gearshift Lever

Removal Procedure

- Block the vehicle so it cannot move.
- Disconnect the ground cable from the battery negative (-) post.

1. Gearshift lever knob (4).
2. Cover assembly (5).
    - Remove the fixing screw (6) and 3 clips (7).
3. Shift cable (8) and select cable (9).
    - Disconnect the cables from the gearshift lever.
    - Remove the C-clips (10) and disconnect the cables from bracket.
4. Gearshift lever assembly (11).
    - Remove 2 screws (12) and 2 nuts (13).



Legend

4. Gearshift Lever Knob
5. Cover Assembly
6. Screw
7. Clip
8. Shift Cable
9. Select Cable
10. C-clip
11. Gearshift Lever Assembly
12. Screw
13. Nut

Installation Procedure

1. Gearshift lever assembly (11).
2. Shift cable (8) and select cable (9).
    - Connect the cables to the gearshift lever.
    - Install the C-clips (10) to the bracket.

   Adjustment
    - When connecting the shift cable and select cable to the gearshift lever, adjust the cable. Refer to GEARSHIFT CABLE ADJUSTMENT in this section.
3. Cover assembly (5).
4. Gearshift lever knob (4).
    - Connect the battery negative cable and remove the wheel blocks.

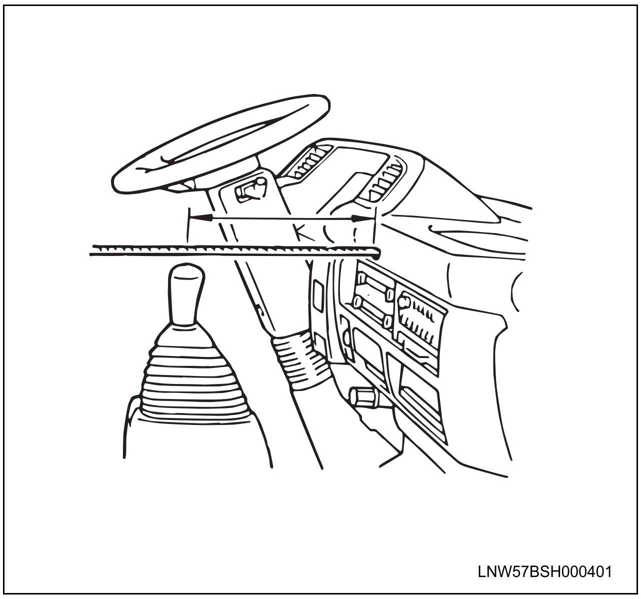
Gearshift Cable

Adjustment

After connection of the select cable and the shift cable, confirm if shift operation is performed smoothly. If any dragging or improper stroke is present, check and adjust in accordance with the procedures shown below.

Measurement

Set the transmission in the neutral position, then confirm if the dimension between the center of the shift lever play and the instrument center cluster is within the 283 ± 15 mm (11.1 ± 0.6 in) . If the dimension is out of the reference value, adjust as required.



- Block the vehicle so it cannot move.
- Disconnect the ground cable from the battery negative (-) post.

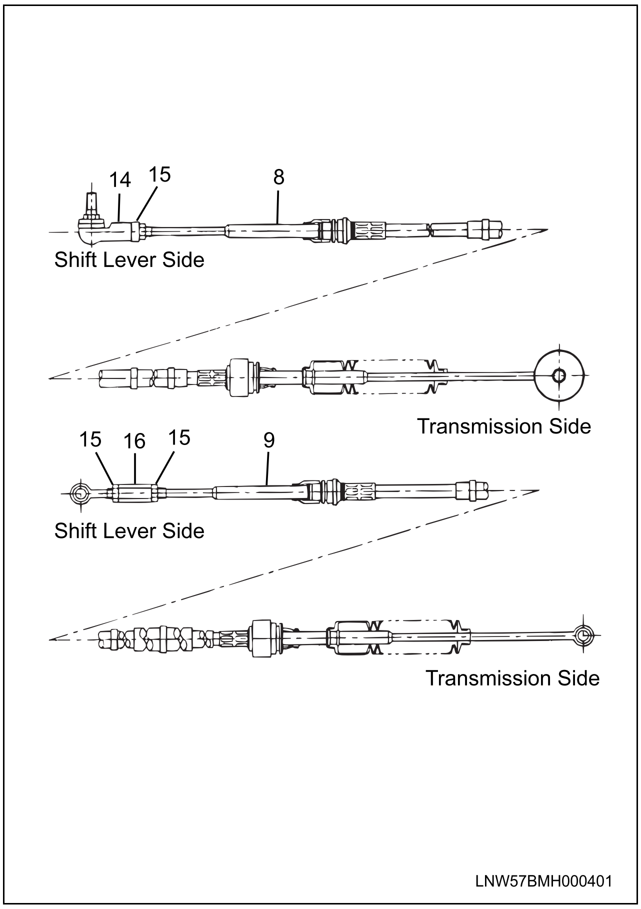
1. Remove the gearshift lever knob (4).
2. Remove the cover assembly (5).
3. Disconnect the shift cable (8) and the select cable (9) on the gearshift lever side.

4. Set the transmission in the neutral position, then adjust the dimension between the center of the shift lever play and the instrument center cluster to the 283 ± 15 mm (11.1 ± 0.6 in).
5. Loosen the lock nut (15) of the shift cable (8) and the select cable (9), then turn the ball joint (14) or turnbuckle (16) as necessary for respective pins.
6. Fasten the lock nut (15) with specific torque.

Tighten

- Lock nuts to 6 N·m (52 lb in)

7. Install the cover assembly (5).
8. Install the gearshift lever knob (4).
    - Connect the battery ground cable and remove the wheel blocks.



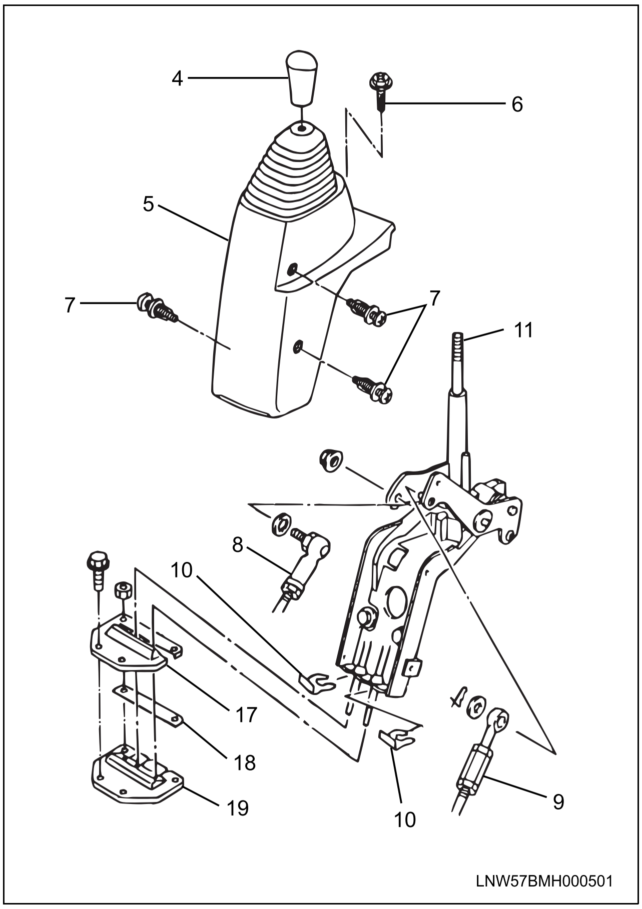
Legend

8. Shift Cable
9. Select Cable
14. Ball Joint
15. Lock Nut
16. Turnbuckle

Removal Procedure

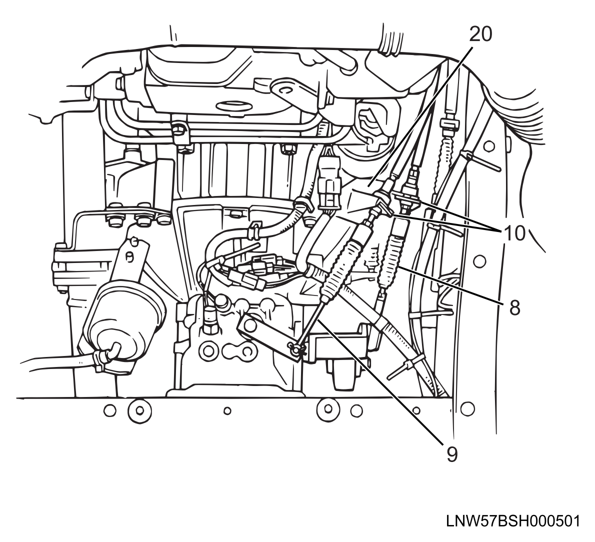
- Block the vehicle so it cannot move.
- Disconnect the ground cable from the battery negative (-) post.

1. Gearshift lever knob (4).
2. Cover assembly (5).
3. Shift cable (8) and select cable (9).
    - Disconnect the shift cable and select cable from gearshift lever.
    - Remove the C-clips (10) and disconnect the cables from gearshift lever bracket.
    - Remove the grommet retainer (17), grommet seal (18) and grommet (19).
    - Tilt the cab.
    - Disconnect the shift cable and the select cable on the transmission side.
    - Remove the C-clips (10) and disconnect the shift cable and the select cable from the bracket.(20).
    - Remove the clips that fix the cables to the frames or brackets.
    - Remove the shift and select cable assemblies.



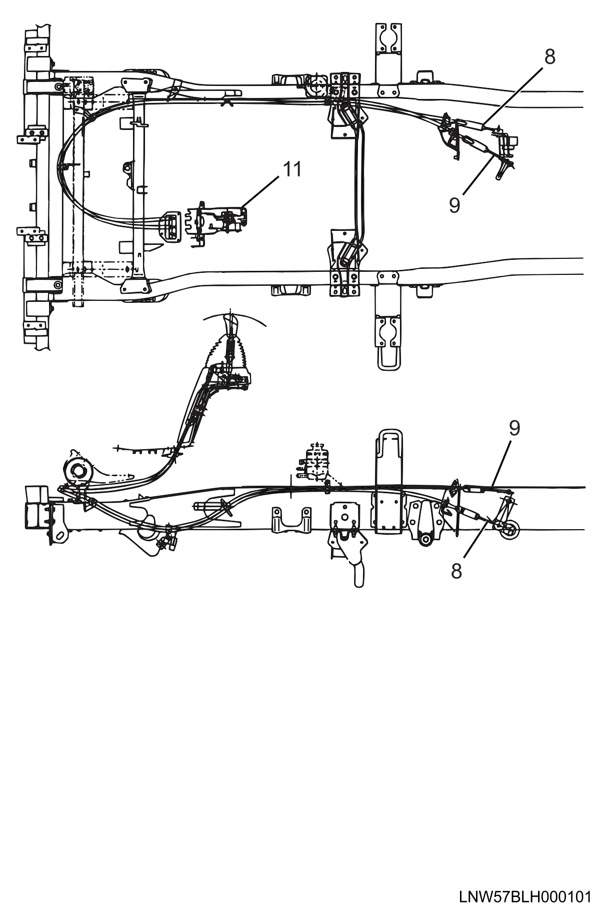
Legend

4. Gearshift Lever Knob
5. Cover Assembly
6. Screw
7. Clip
8. Shift Cable
9. Select Cable
10. C-clip
11. Gearshift Lever
17. Grommet Retainer
18. Grommet Seal
19. Grommet



Legend

8. Shift Cable
9. Select Cable
10. C-clip
20. Bracket



Legend

8. Shift Cable
9. Select Cable
11. Gearshift Lever

Inspection

Check the cables for any deformation, damage or rust, and also check the sliding portion for any abnormal condition.
When there is any abnormal condition found, replace it with new one.

Installation Procedure

1. Shift cable (8) and select cable(9).
   - Install temporarily that the shift cable and select cable.

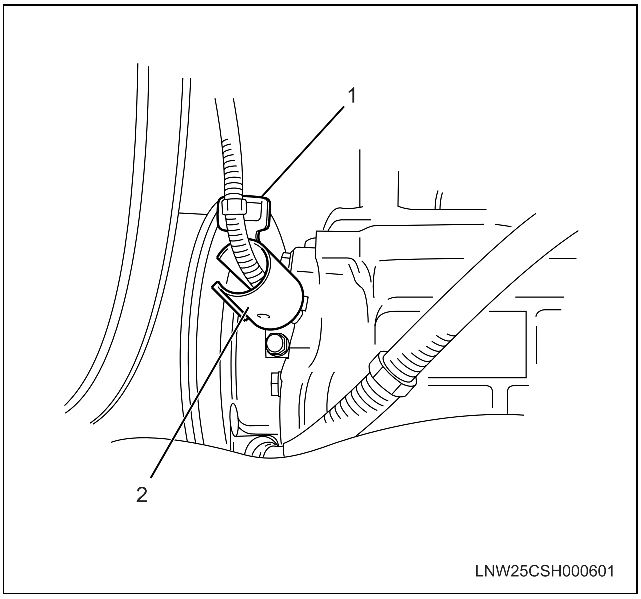
- Never bend the cables to radius less than 450 mm (18 in) unless it is necessary to do so for wiring purposes. And never bend the cables to radius less than 180 mm (7 in) even during wiring.
- Install the cables carefully without unnecessary twisting the cable boots.
- Fasten the cables with C-clips to the brackets on the transmission side.
- Fasten the cables with C-clips to the gearshift lever bracket.
- Fasten the cables with clips to the frames and brackets.
- Connect the cables to the transmission.
- Install the grommet (19), grommet seal (18) and grommet retainer(17).
- When connecting the shift cable (8) and the select cable (9) to the gearshift lever, adjust the cables.
  Refer to GEARSHIFT CABLE ADJUSTMENT given previously in this section.

2. Cover assembly (5).
3. Gearshift lever knob (4).
   - Connect the battery negative cable and remove the wheel blocks.

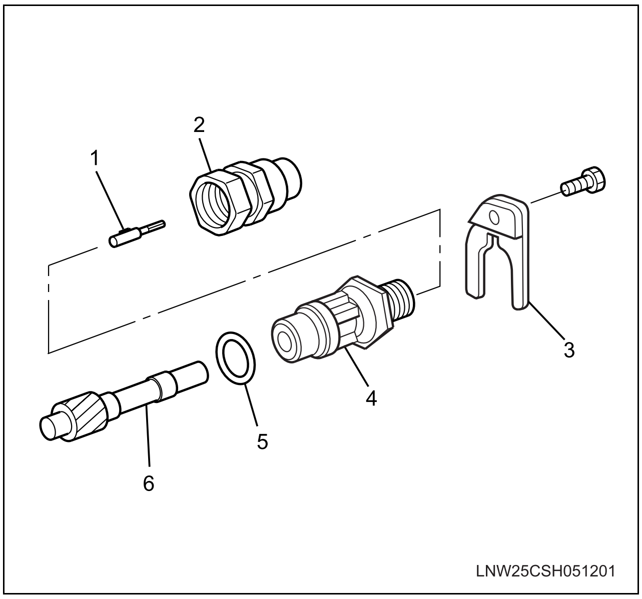
Vehicle Speed Sensor

Removal Procedure

1. Remove the clips (1) and the protector (2).
2. Remove the wiring connectors.



3. Loosen the fixing screw and remove the vehicle speed sensor.

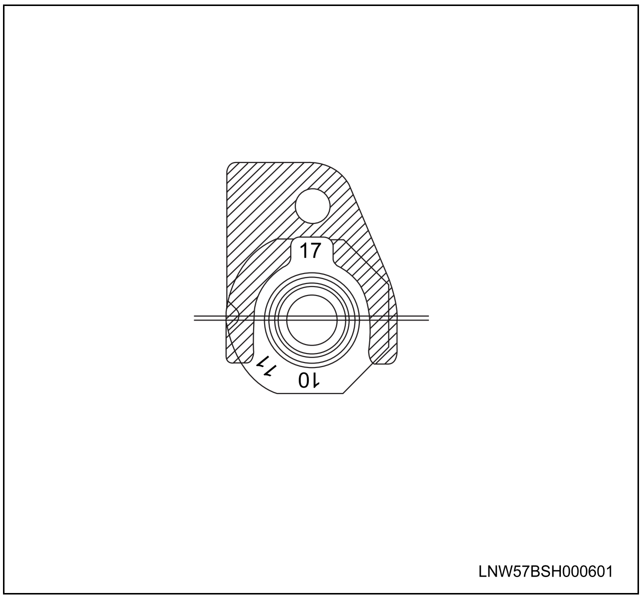


Legend

1. Sensor Insert
2. Vehicle Speed Sensor
3. Plate
4. Bush
5. O-ring
6. Driven Gear

Installation Procedure

1. Install the driven gear (with bush) and secure it with the fixing screw.
   - It attached so that the stamp mark which appears from the window of the plate and the number of driven gear teeth may be in agreement. (The following figure shows the case where driven gear teeth is 17.)



2. Tighten the fixing screw to the specified torque.

Torque : 20 N·m (2.0 lb ft)

3. Install the sensor insert and the vehicle speed sensor. Tighten the vehicle speed sensor to the specified torque.

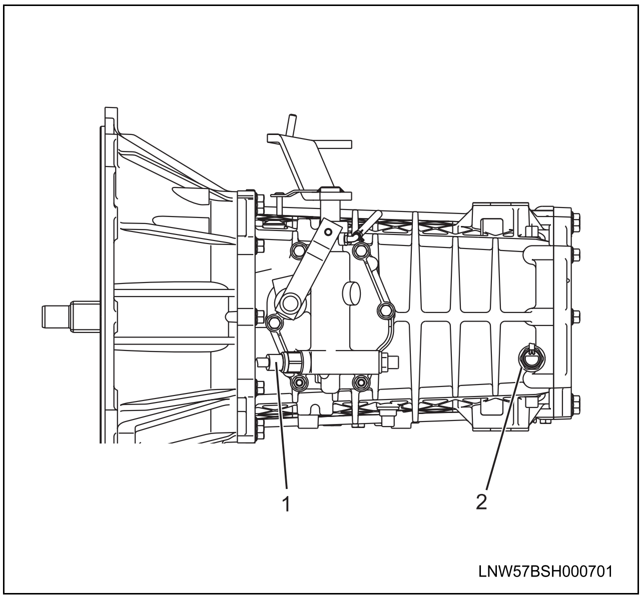
Torque : 25 N·m (18 lb ft)

4. Connect the wiring connectors.
5. Install the protector and secure it with the clips.

Reverse, Neutral, And Selector Switches

Removal Procedure

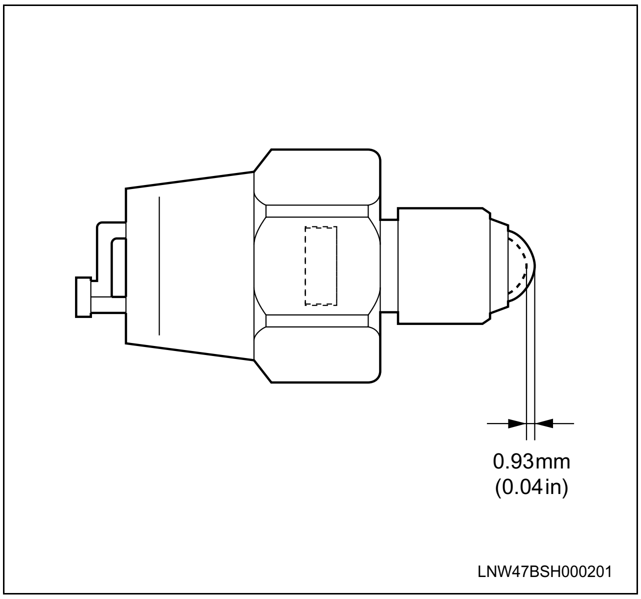
1. Remove the wiring connectors.
2. Remove the reverse switch (2). The switch has a black connector.
3. Remove the neutral switch (1). The switch has a black connector.



Inspection Procedure

1. Check for continuity between the switch terminals when the ball is pressed. If there is no continuity, the switch is bad.
2. Measure the switch travel.

Switch travel : 0.93 mm (0.04 in)



Installation Procedure

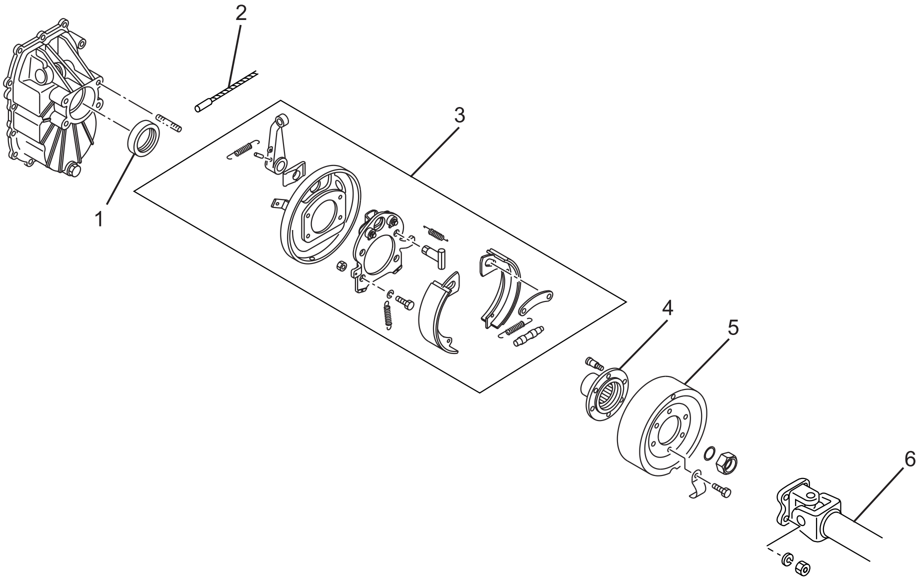
1. Apply liquid gasket (Loctite No.242) to the threaded portion of the neutral switch.
2. Install the neutral switch. Tighten the switch to the specified torque.

Torque : 34 N·m (25 lb ft)

3. Apply liquid gasket (Loctite No. 242) to the threaded portion of the reverse switch.
4. Install the reverse switch. Tighten the switch to the specified torque.

Torque : 39 N·m (29 lb ft)

Rear Oil Seal



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Legend

1. Oil Seal
2. Parking Brake Cable
3. Parking Brake Assembly
4. Coupling Driver
5. Parking Brake Drum
6. Rear Propeller Shaft Assembly

Removal Procedure

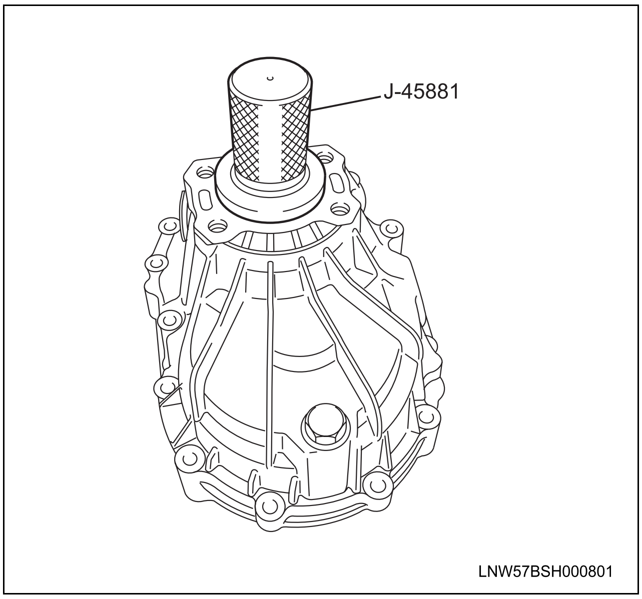
1. Remove the rear propeller shaft assembly.
   - Refer to PROPELLER SHAFT (SEC. 4B).
2. Remove the parking brake cable.
   - Refer to PARKING BRAKE (SEC. 5C).
3. Remove the parking brake drum.
   - Refer to PARKING BRAKE (SEC. 5C).
4. Use the special tool (J-35016) to break the coupler driver lock nut caulking (2 locations) and remove the nut.
5. Remove the coupling driver together with the O-ring.
6. Remove the parking brake assembly.
   - Refer to PARKING BRAKE (SEC. 5C).
7. Use an ordinary screwdriver to remove the rear oil seal.

Installation Procedure

1. Apply engine oil (5W-30) to the new oil seal outer circumference.
2. Apply multi-purpose type grease to the lipped portion of the oil seal.
3. Use the installer (J-45881) to press the oil seal into the rear cover.

Caution:

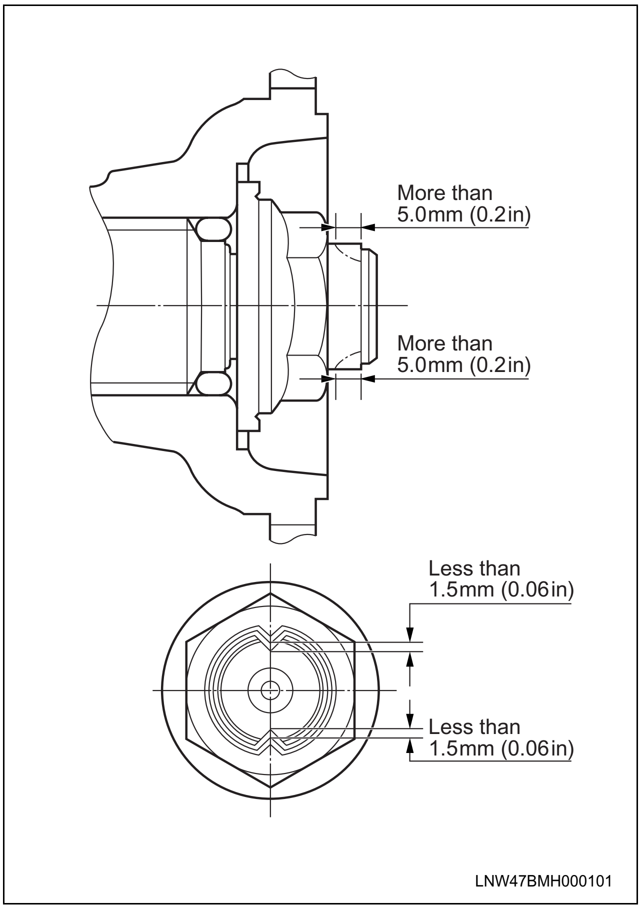
The lipped portion of the oil seal is easily broken. Exercise care during the installation procedure.



4. Install the parking brake assembly.
   - Refer to PARKING BRAKE (SEC. 5C).
5. Apply engine oil (5W-30) to the new O-ring.
6. Install the coupling driver together with the O-ring.
7. Use the special tool (J-35016) to tighten the lock nut to the specified torque.

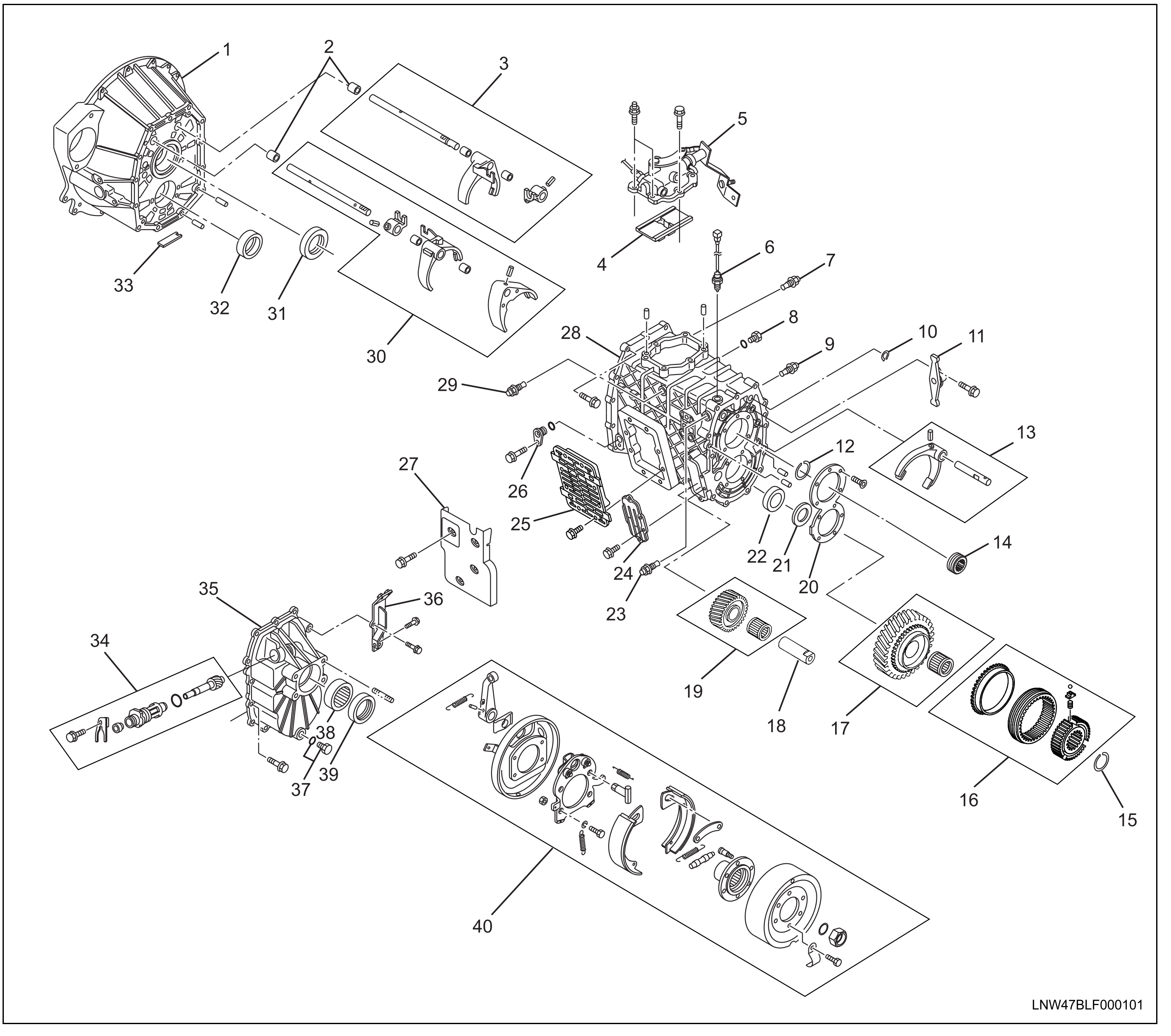
Torque : 382 N·m (282 lb ft)

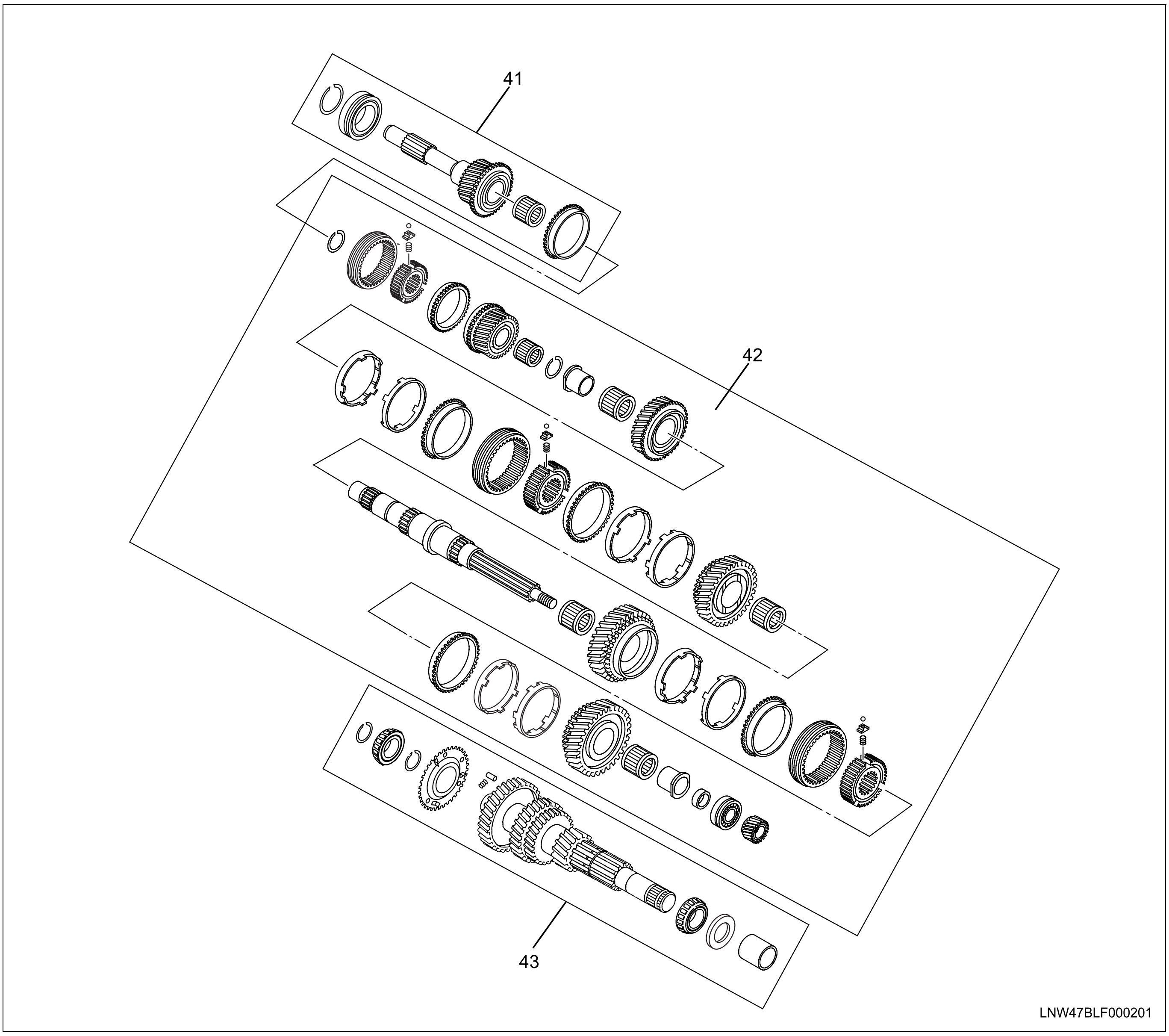
8. Align the lip portion of the lock nut with the V-groove at the end of the shaft (length must be at least 5 mm (0.2 in)). Wedge the lipped portion of the nut into the V-groove so that the gap between the nut and the bottom of the V-groove is less than 1.5 mm (0.06 in).
9. Caulk the lock nut at two places (radius approximately 1 mm (0.04 in) with caulking sites 60 degrees away form each other).



10. Install the parking brake drum.
    - Refer to PARKING BRAKE (SEC. 5C).
11. Install the parking brake cable.
    - Refer to PARKING BRAKE (SEC. 5C).
12. Install the rear propeller shaft assembly.
    - Refer to PROPELLER SHAFT (SEC. 4B).

Transmission





Legend

1. Clutch Housing
2. Bush (Clutch Housing)
3. 4th / 5th, 6th Shift Arm
4. Interlock Plate
5. Controller Box
6. Reverse Switch
7. Detent Assembly
8. Filler Plug
9. Detent Assembly
10. Snap Ring
11. 6th Relay Lever
12. Snap Ring
13. 6th Shift Arm and Shift Rod
14. Speedometer Gear
15. Snap Ring
16. 6th Clutch Hub Assembly and Sleeve
17. 6th Gear and Needle Bearing
18. Reverse Idle Shaft
19. Reverse Idle Gear and Needle Bearing
20. Retainer
21. Counter Shim
22. Counter Rear Bearing
23. Detent Assembly
24. Reverse Gear Idle Cover
25. PTO Cover
26. Sensor Dummy Plug
27. Noise Cover
28. Transmission Case
29. Detent Assembly
30. 1st / Reverse and 2nd/ 3rd Shift Arm
31. Front Oil Seal
32. Bearing Outer Race
33. Magnet
34. Speedometer Driven Gear
35. Rear Cover
36. Parking Brake Cable Bracket
37. Drain Plug
38. Needle Bearing (Main End)
39. Rear Oil Seal
40. Parking Brake Assembly

41. Top Gear Shaft Assembly
42. Main Shaft Assembly
43. Counter Shaft Assembly

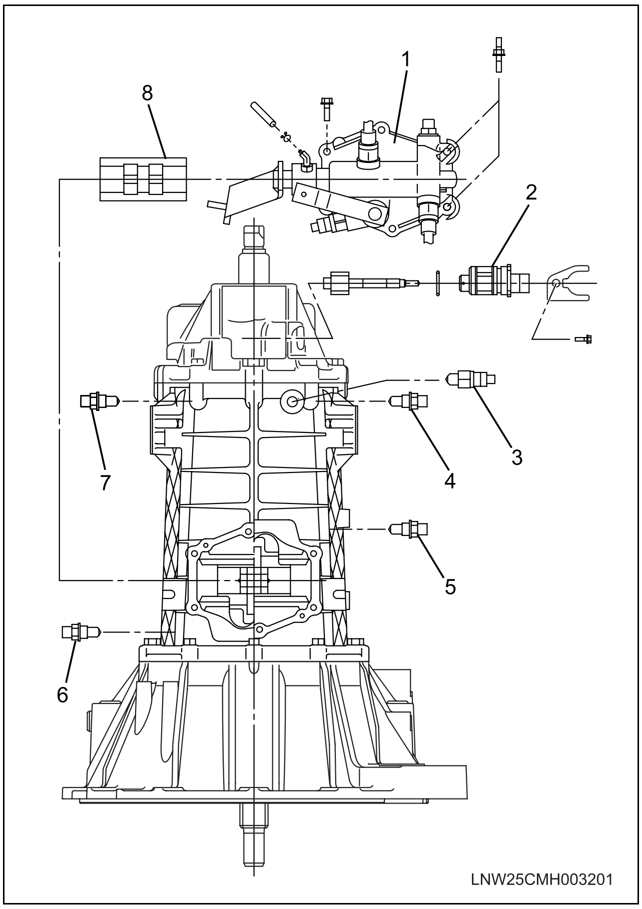
Disassembly Procedure

Caution:
The transmission case and clutch housing are made of aluminum. They are easily damaged. Exercise care during the disassembly and reassembly procedure.

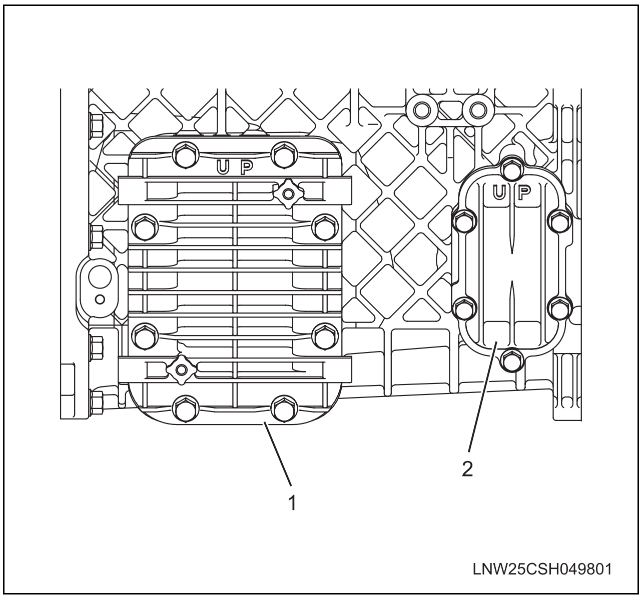
Caution:
Be especially careful not to damage the transmission case ribs. A damaged rib greatly weakens the case.

Caution:
Remember that transmission and clutch parts are heavy and must be handled with great care to avoid serious injury to yourself and others around you.

1. Remove the shift block together with the release bearing, the clutch shaft, and the shaft fork.
   - Refer to CLUTCH (SEC. 7C3).
2. Remove the parking brake drum.
   - Refer to PARKING BRAKE (SEC. 5C).
3. Use the special tool (J-35016) to break the coupler driver lock nut caulking (2 locations) and remove the nut.
4. Remove the coupling driver together with the O-ring.
5. Remove the parking brake assembly.
   - Refer to PARKING BRAKE (SEC. 5C).
6. Remove the parking brake cable bracket from the transmission case.
7. Remove the filler plug and O-ring.
8. Remove the drain plug and the O-ring.
   - Allow time for the transmission oil to drain into a suitable container. Check the oil volume. Look for metallic particles and other foreign material in the oil.
9. Remove the noise cover.
10. Remove the speedometer driven gear (2).
11. Remove the reverse switch (3).
12. Remove the 4 detente assemblies ((4), (5), (6), and (7)).
13. Remove the control box (1) together with the interlock plate (8).

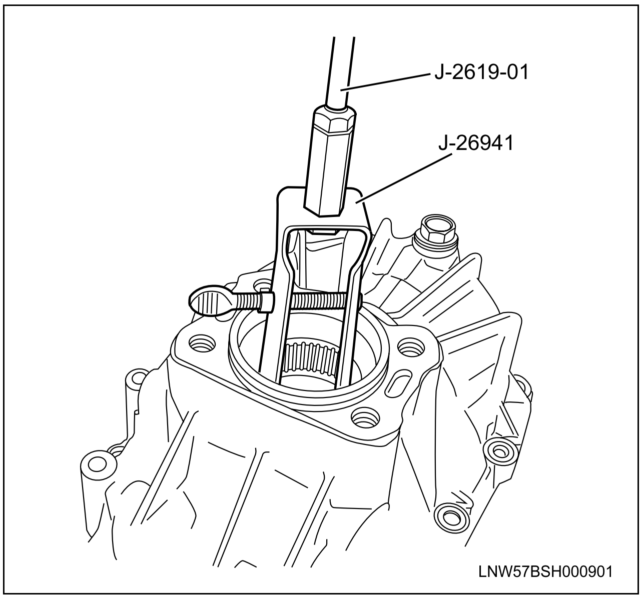


14. Remove the PTO cover (1).
15. Remove the reverse idle cover (2).

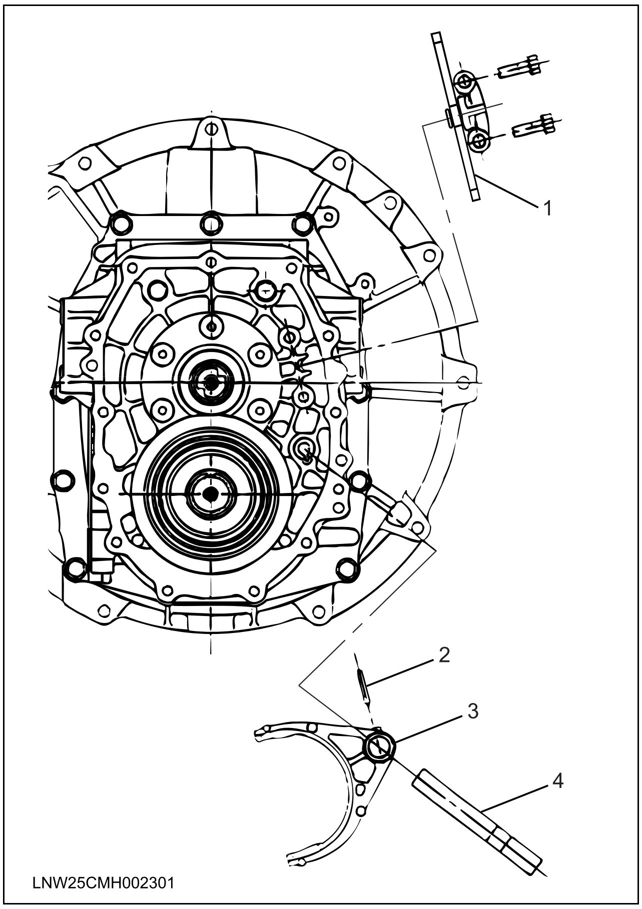


16. Remove the rear cover assembly.

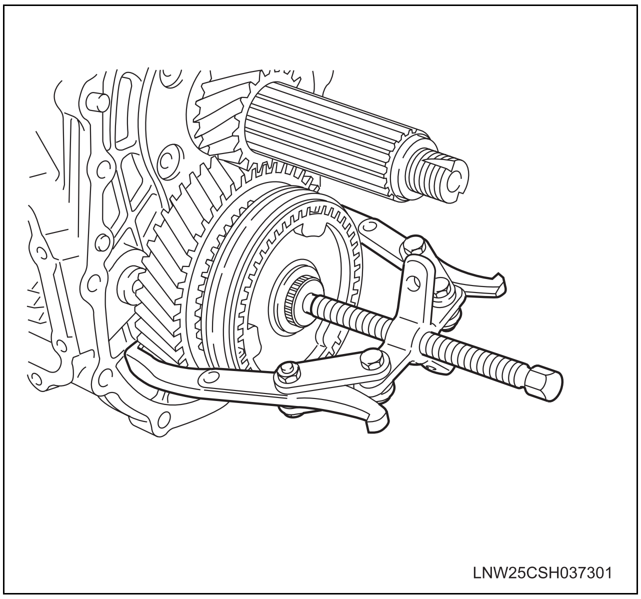
17. Inspect the rear cover oil seal for wear and other damage. If wear or damage is present, the oil seal must be replaced. Use an ordinary screwdriver to remove it from the rear cover.
18. Use the remover (J-26941) and the sliding hammer (J-2619-01) to remove the needle bearing (main end) from the rear cover.



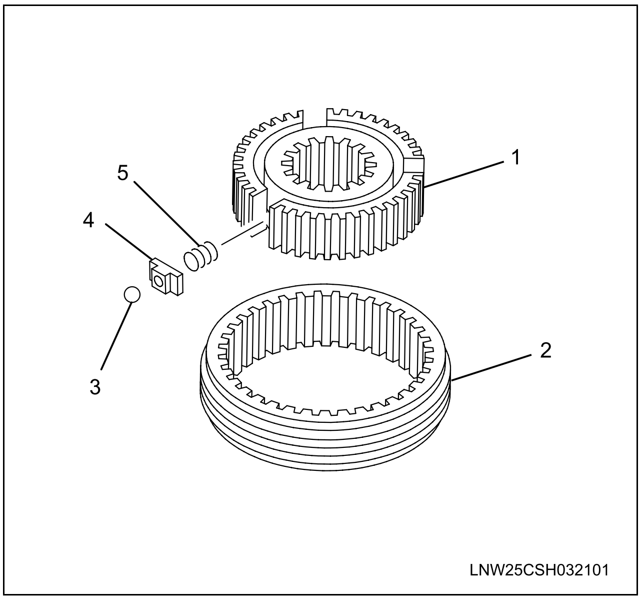
19. Remove the relay lever (6th gear (1)).
20. Use a spring remover to force out the spring pins (2) from the 6th shift arm (3) and the 6th shift rod (4).
21. Remove the 6th shift arm and the 6th shift rod.



22. Use a pair of snap ring pliers to remove the snap ring from the 6th clutch hub.
23. Use a puller to remove the 6th clutch hub assembly, the sleeve, the block ring, the gear, and the needle bearing from the counter shaft.



24. Disassemble the 6th clutch hub assembly and the sleeve.



Legend

1. Clutch Hub
2. Sleeve
3. Ball
4. Block
5. Spring

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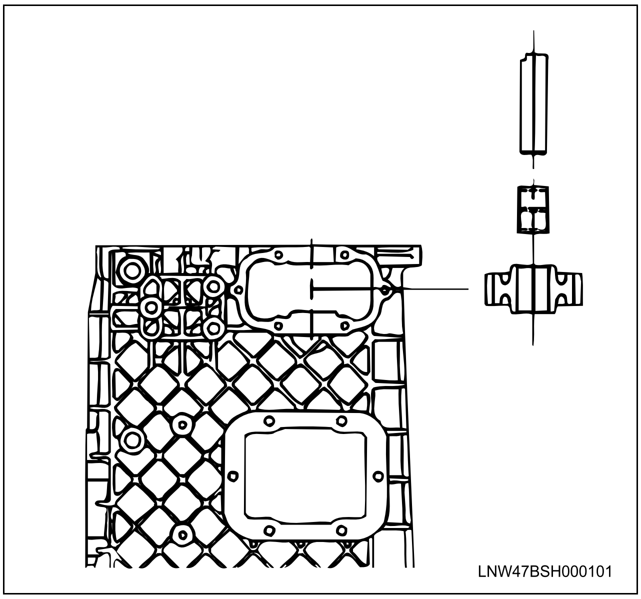
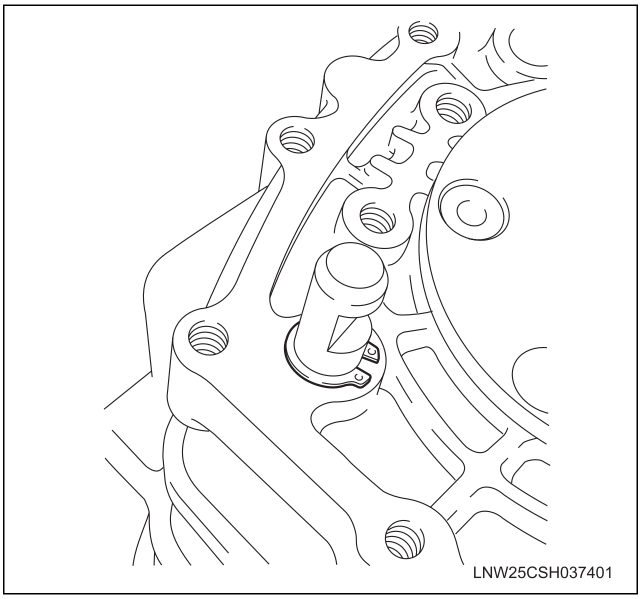
25. Remove the speedometer gear.
26. Remove the retainer from the transmission case.
27. Pull out the reverse idle shaft.

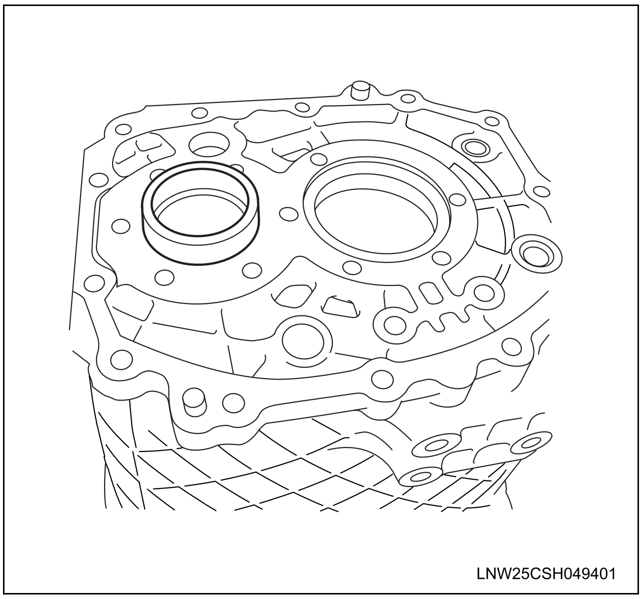
28. Remove the reverse idle gear together with the needle bearing.



29. Remove the snap ring (rear outer) from the main shaft rear bearing.
30. Remove the counter shims.
31. Remove the snap rings (4th / 5th and 6th shift rods).

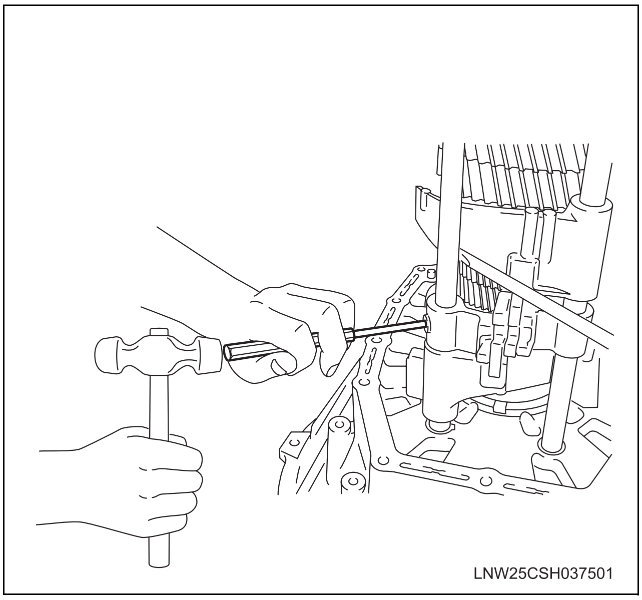


32. Remove the transmission case from the clutch housing.
33. Remove the bearing rear outer race from the transmission case.



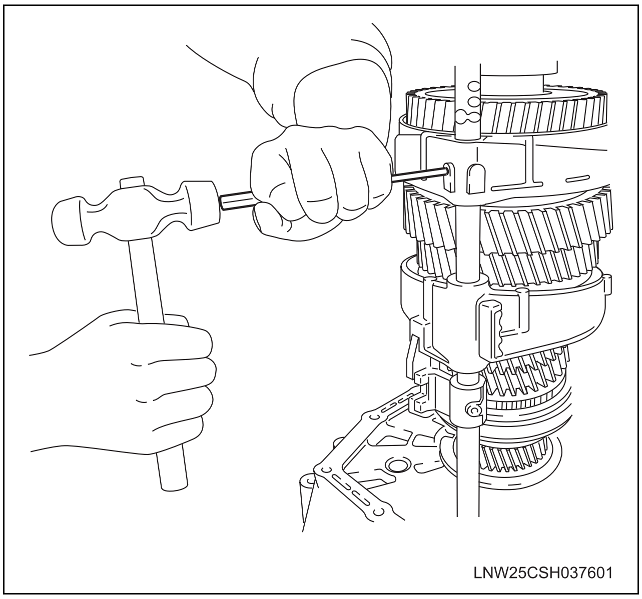
34. Use a spring pin remover to remove the spring pins from the 4th / 5th shift rod, the 1st / reverse shift block, the 6th shift block, and 4th / 5th shift arm.
35. Remove the 4th / 5th shift rod, the 1st / reverse shift block, the 6th shift block, and 4th / 5th shift arm.

Caution:
To avoid damaging other parts, place a round shaft at the opposite end of the shift rod when removing the spring pins.



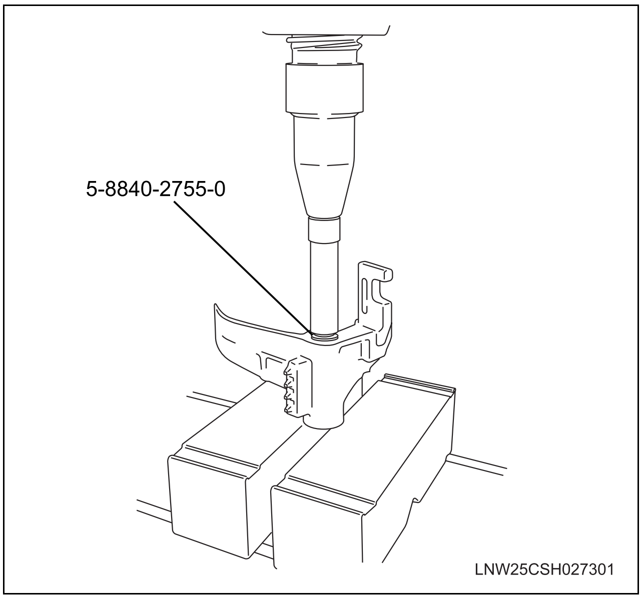
36. Remove the 1st / reverse and the 2nd / 3rd shift rod, the 1st / reverse shift arm, the 2nd (3rd shift arm, the 1st / reverse, and the 6th shift block.

Caution:
To avoid damaging other parts, place a round shaft at the opposite end of the shift rod when removing the spring pins.



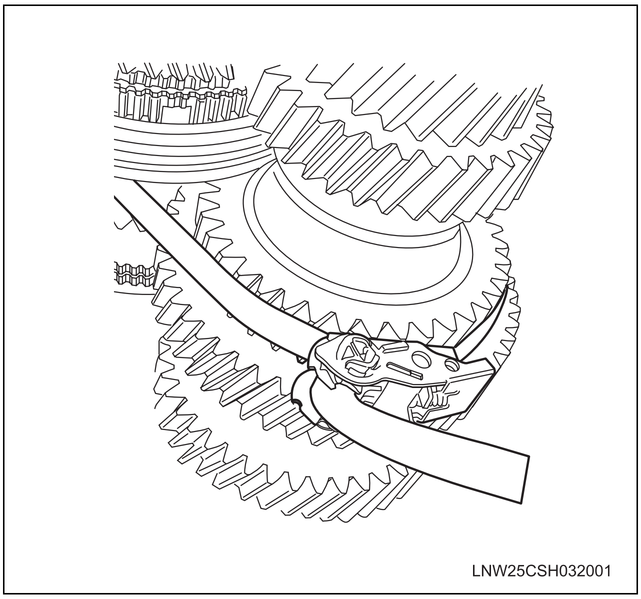
37. Use the remover (J-45883) to remove the bush from the 4th / 5th shift arm.
38. Use the remover (J-45883) to remove the bush from the 1st / reverse shift arm.
39. Use the remover (J-45883) to remove the bush from the 2nd / 3rd shift arm.

Caution:
To avoid damaging other parts, place a round shaft at the opposite end of the shift arm (same length as the remover) when removing the bushes.

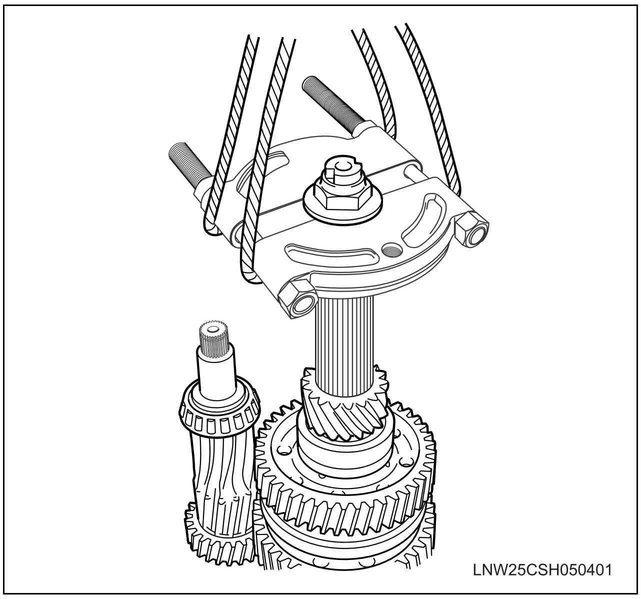


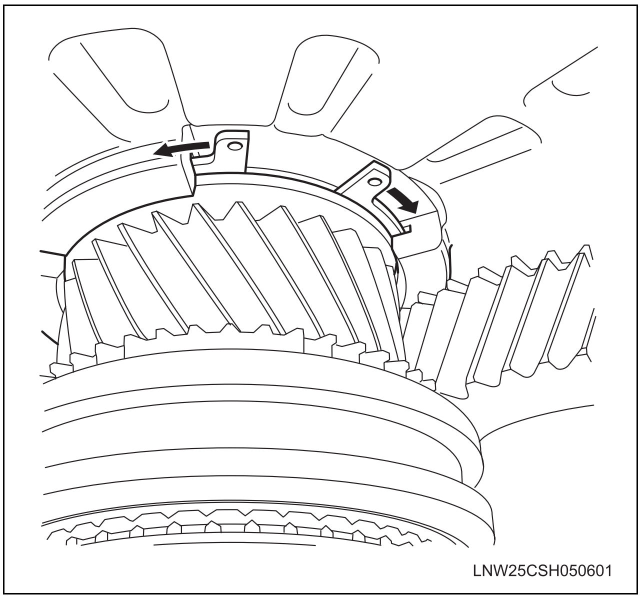
40. Remove the magnet from the clutch housing.
41. Remove the main shaft assembly, top gear shaft assembly, and the counter shaft assembly.

a. Tightly wrap belts such as lashing belts around the main shaft assembly, top gear shaft assembly, and the counter shaft assembly in two or more places to prevent the assemblies from separating.

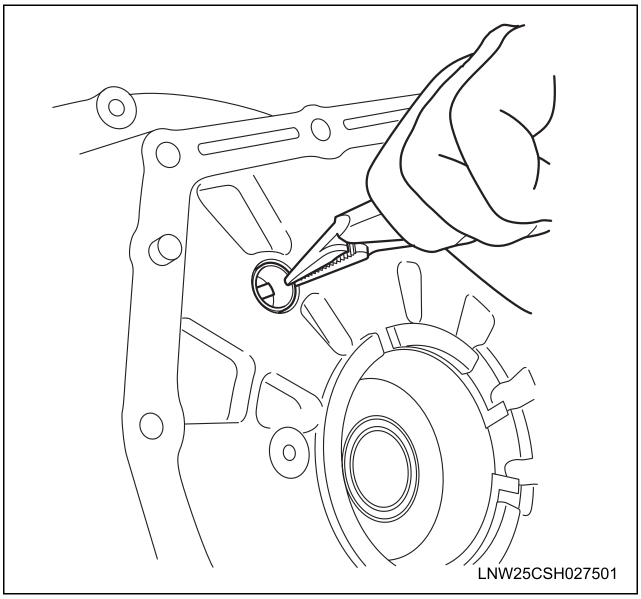


b. Secure the bearing remover to the main shaft with the lock nut, then raise it with a hoisting cable. Spread the outer snap ring of the top gear shaft bearing, which is attached to the clutch housing, and simultaneously remove top gear shaft assembly, main shaft assembly, and counter shaft assembly from the clutch housing.

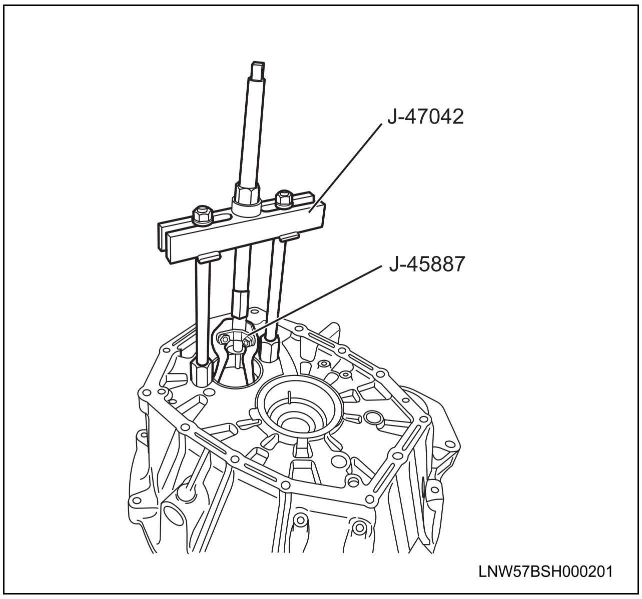




42. Inspect the clutch housing bush for wear and damage. If wear or damage is present, the bush must be replaced. Remove the old bush from the clutch housing with a pair of pliers.

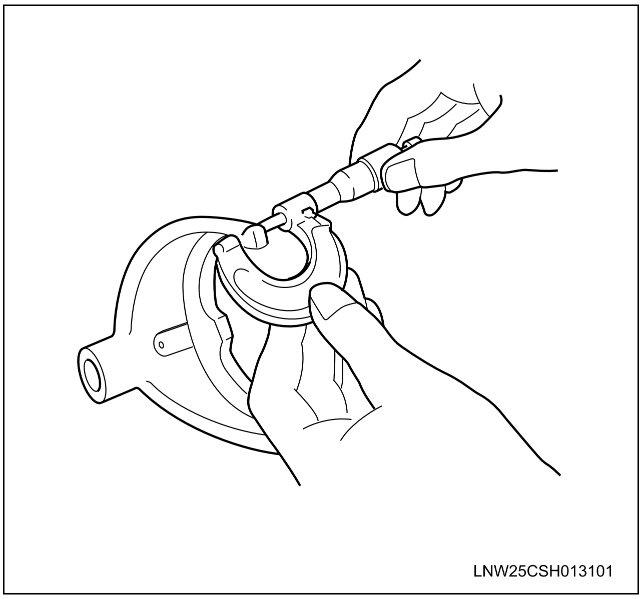


43. Inspect the counter shaft front bearing for wear and other damage. Replace the bearing if necessary. Use the bearing remover (J-45887) and the push puller (J-47042) to remove the bearing and race from the clutch housing.

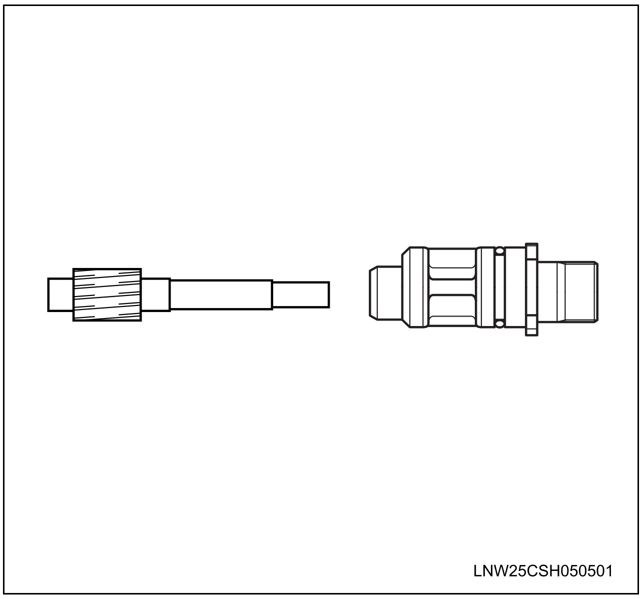


44. Inspect the front oil seal for wear and damage. If wear or damage is present, the race be replaced. Remove the old seal from the clutch housing with an ordinary screwdriver.
45. Inspect the other parts for wear and damage. If wear or damage is present, make the necessary repairs or replace the part(s).
46. Inspect the shift rod and the shift arm for bending, wear, and other damage. If minor wear or damage is present, make the necessary repairs. If major wear or damage is present, the part(s) must be replaced.
47. Use a micrometer to measure the shift arm end thickness. If the thickness exceeds the specified limit, the shift arm must be replaced.

Shift arm end thickness		mm (in)
Gear	Standard	Limit
1st / reverse 3rd / 2nd 5th / 4th	9.60 - 9.85 (0.378 - 0.388)	9.00 (0.354)
6th	9.60 - 9.85 (0.378 - 0.388)	9.30 (0.366)



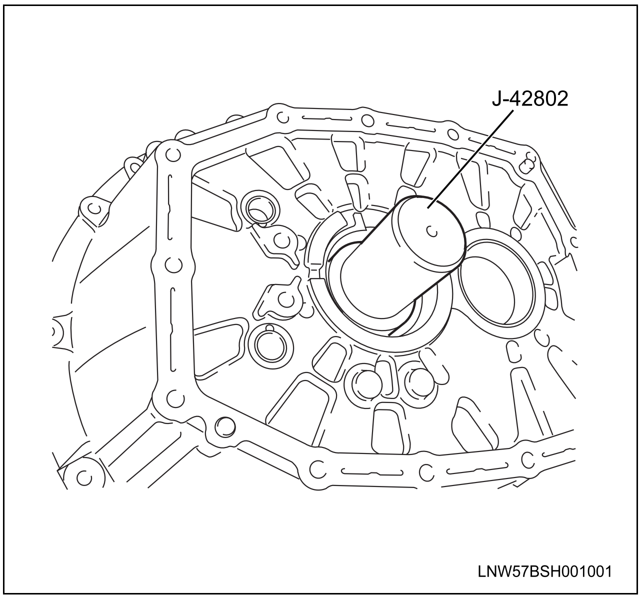
48. Inspect the speedometer driven gear and the driven gear bush for wear and other damage. Replace the driven gear and bush if significant wear is present.



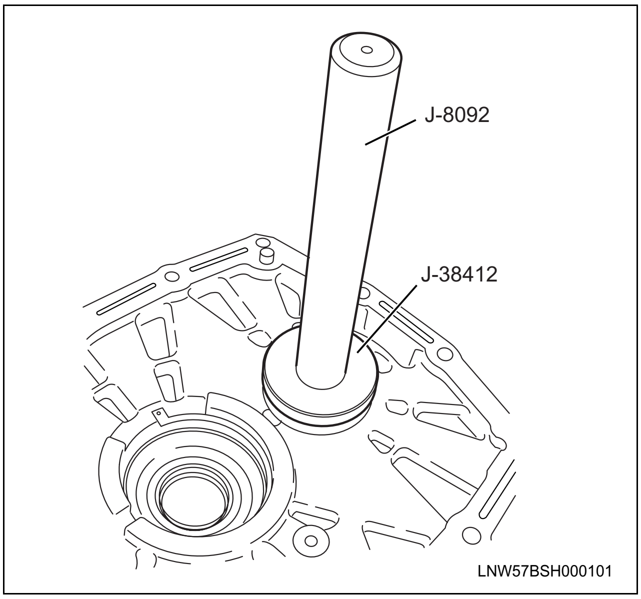
Reassembly Procedure

1. Inspect the oil seal for wear and damage. If damage or wear is present, the oil seal must be replaced.
2. Apply engine oil (5W-30) to the outside circumference of the oil seal.
3. Apply multi-purpose type grease to the lipped portion of the oil seal.
4. Use the installer (J-42802) to press the oil seal into the clutch housing.

Caution:
The lipped portion of the oil seal is easily broken. Exercise care during the installation procedure.

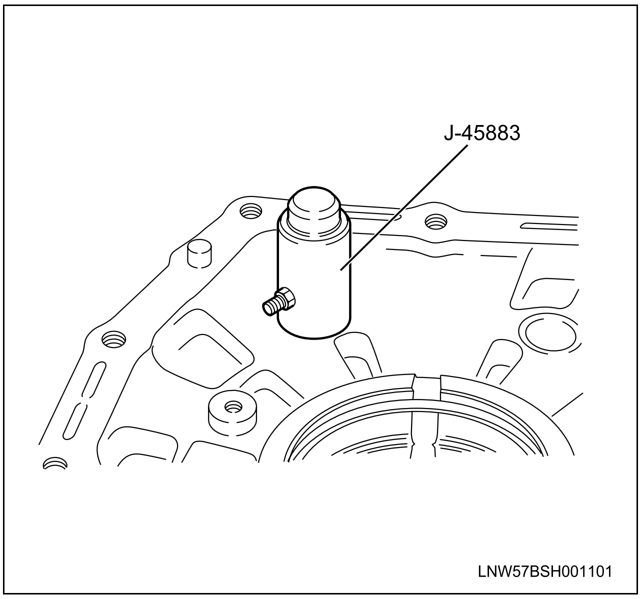


5. Use the grip (J-8092) and the installer (J-38412) to press the new counter shaft front bearing and race into position on the clutch housing.



6. Inspect the bearing outer race for wear and damage. If wear or damage is present, the race must be replaced.
7. Inspect the clutch housing bush for wear and damage. If wear or damage is present, the bush must be replaced.

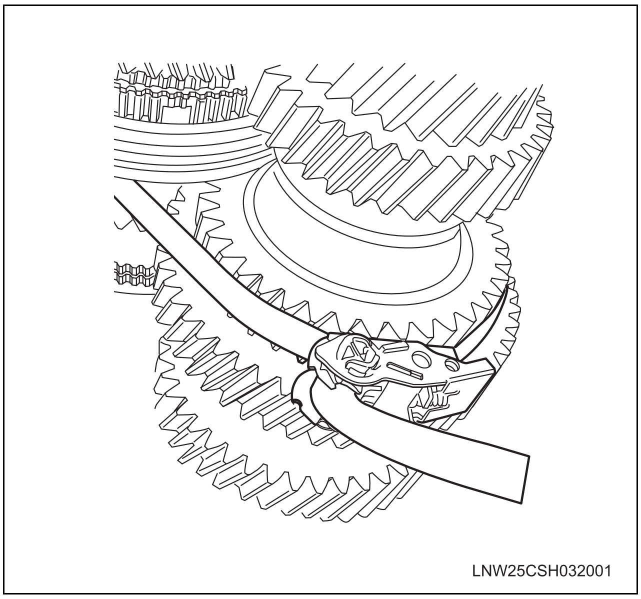
8. Use the installer (J-45883) to press the bush into the clutch housing. Pay close attention to the bush installation direction.



LNW57BSH001101

- Attach by crimping to secure at three points, but avoid the grooved area and previous crimping spots.
- Apply the second and subsequent bushing presses with the notch facing the clutch housing.

9. Attach the main shaft assembly, top gear shaft assembly, and counter shaft assembly
    a. Tightly wrap belts such as lashing belts around the main shaft assembly, counter shaft assembly, and top gear shaft assembly at two or more places to prevent the assemblies from separating. Make sure that the top gear shaft does not fall when the assembly is suspended.



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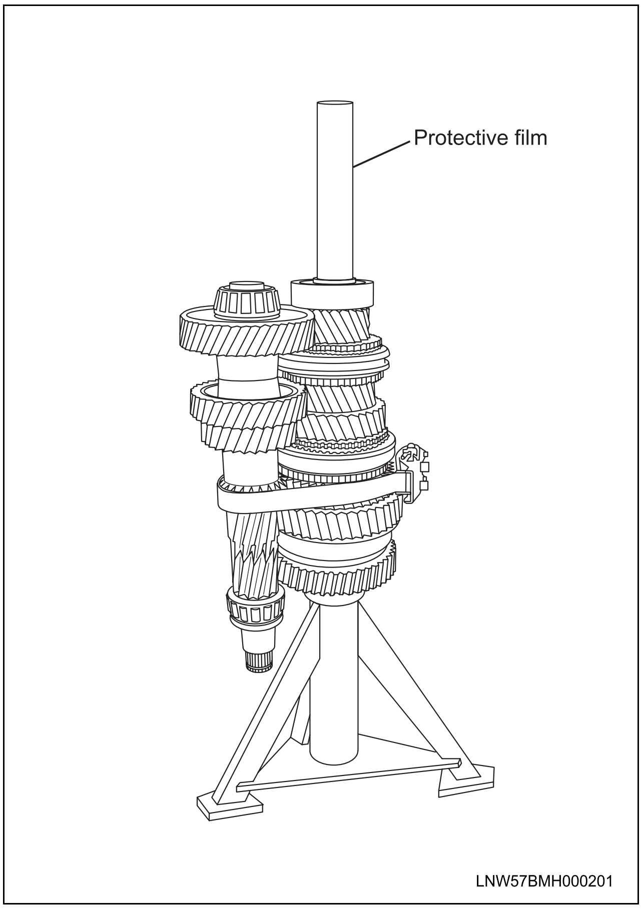
    b. Place the top gear shaft assembly, the main shaft assembly, and the counter shaft assembly on a support stand. The top gear shaft assembly must be at the top.
    c. Apply protective film to the main shaft.



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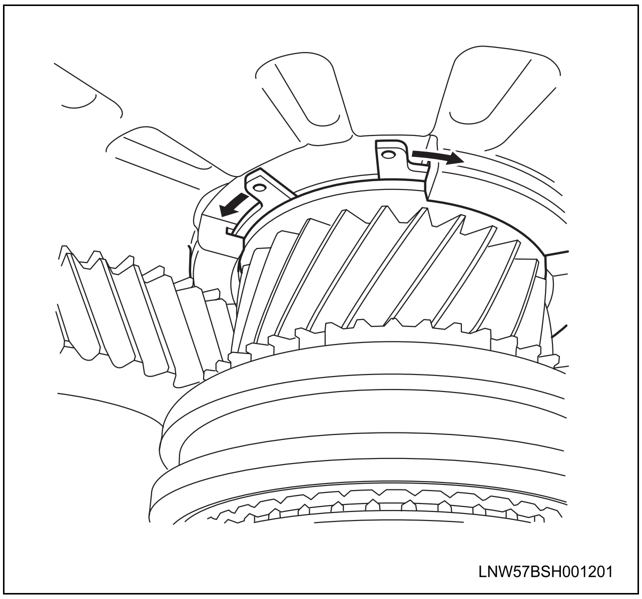
    d. Install the top gear shaft bearing outer snap ring to the clutch housing. Use a pair of snap ring pliers to hold the snap ring open. Align the top gear shaft, the counter shaft, and the shift rod. Press them into position on the clutch housing.



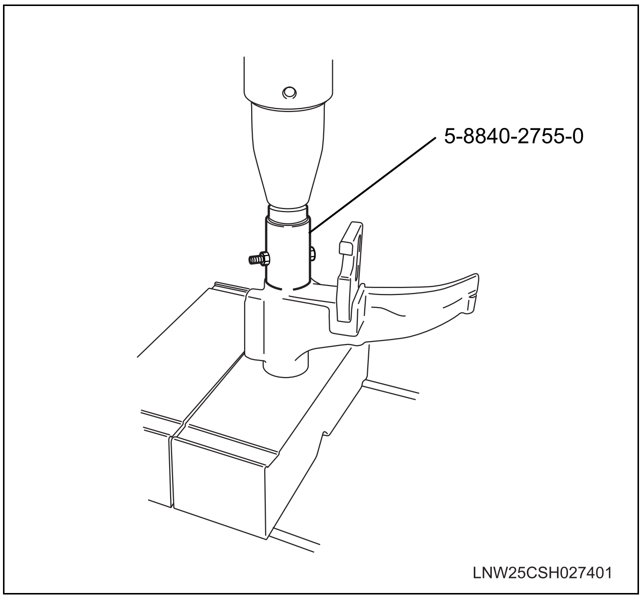
LNW57BSH001201

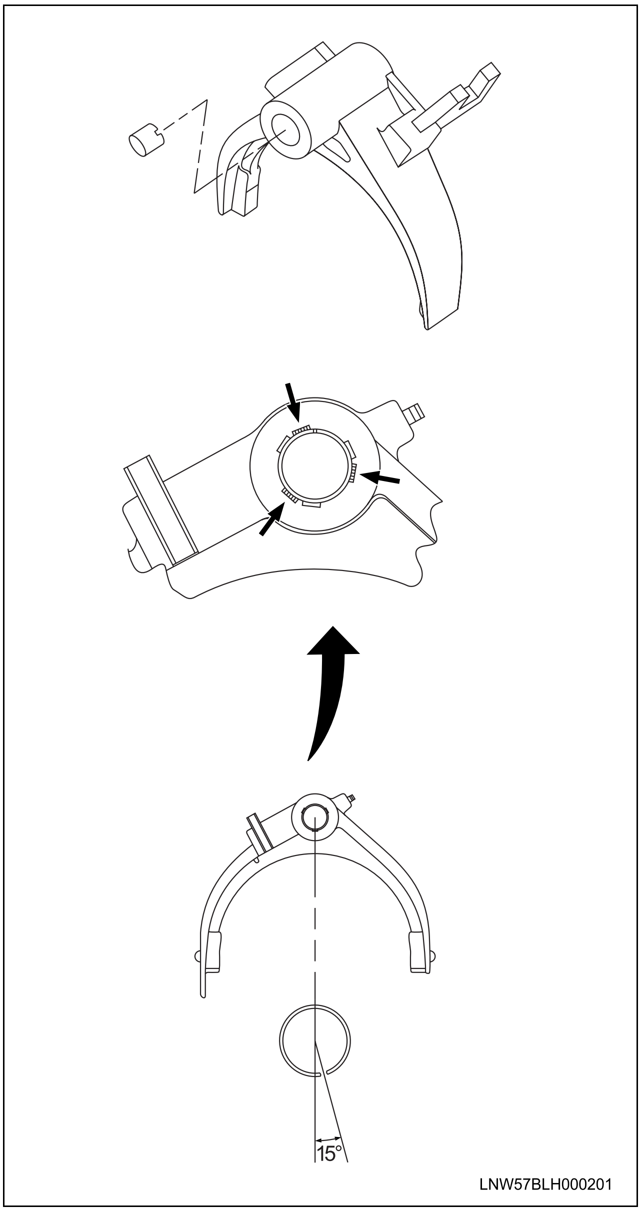
Notice:

- Be sure that the snap ring is securely installed.
- Take care not to damage the front oil seal during the installation procedure.

10. Install the magnet to the clutch housing.

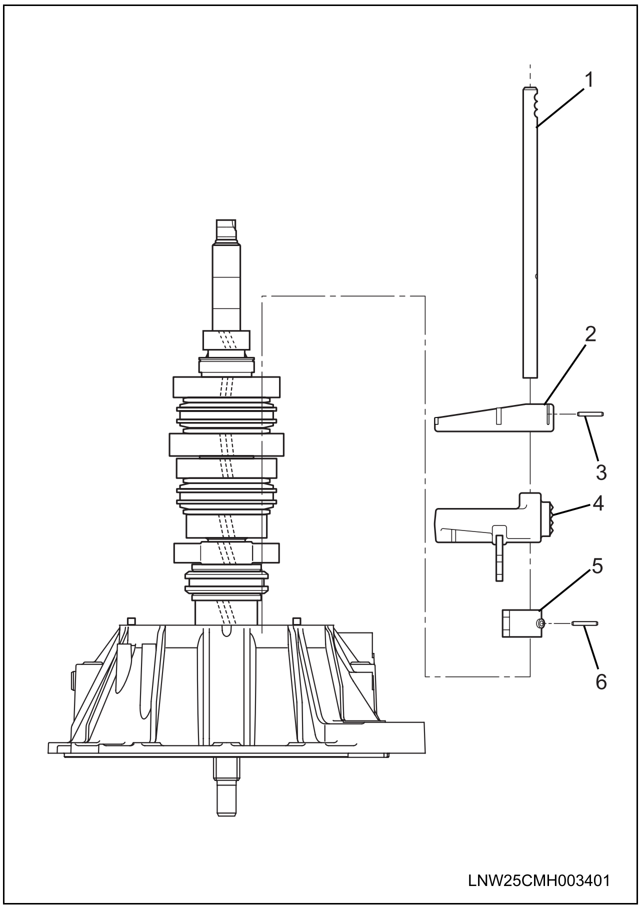
11. Inspect the 3rd / 2nd shift arm bush for wear and damage. If wear or damage is present, the bush must be replaced.
12. Use the installer (J-45883) to press the bush into the clutch housing. Pay careful attention to direction of installation and installation angle.
13. Caulk the bush at 3 locations (do not caulk near the bush grooves).
14. Inspect the 1st / reverse shift arm bush for wear and damage. If wear or damage is present, the bush must be replaced.
15. Use the installer (J-45883) to press the bush into the clutch housing. Pay careful attention to direction of installation and installation angle.
16. Caulk the bush at 3 locations (do not caulk near the bush grooves).
17. Inspect the 4th / 5th shift arm bush for wear and damage. If wear or damage is present, the bush must be replaced.
18. Use the installer (J-45883) to press the bush into the clutch housing.
19. Caulk the bush at 3 locations (do not caulk near the bush grooves). Pay careful attention to direction of installation and installation angle.





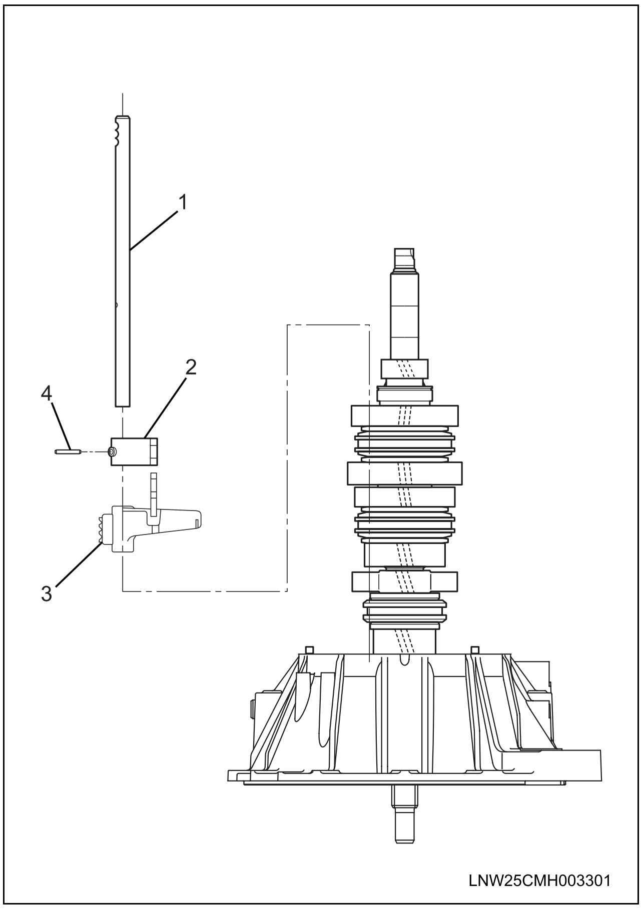
20. Align the spring pin holes.
21. Install the 1st / reverse and the 2nd / 3rd shift rod (1) to the 1st / reverse and the 6th shift block (5), the 2nd / 3rd shift arm (4), and the 1st / reverse shift arm (2).
22. Use a hammer to drive the spring pins (3) (6) into the holes.

Caution:
To avoid damaging other parts, place a round shaft at the opposite end of the shift rod when installing the spring pins.



23. Align the spring pin holes.
24. Install the 4th / 5th and the 6th shift rod (1) to the 4th / 5th shift arm (3), the 1st / reverse and the 6th shift block (2).
25. Use a hammer to drive the spring pins (4) into the holes.

Caution:
To avoid damaging other parts, place a round shaft at the opposite end of the shift rod when installing the spring pins.

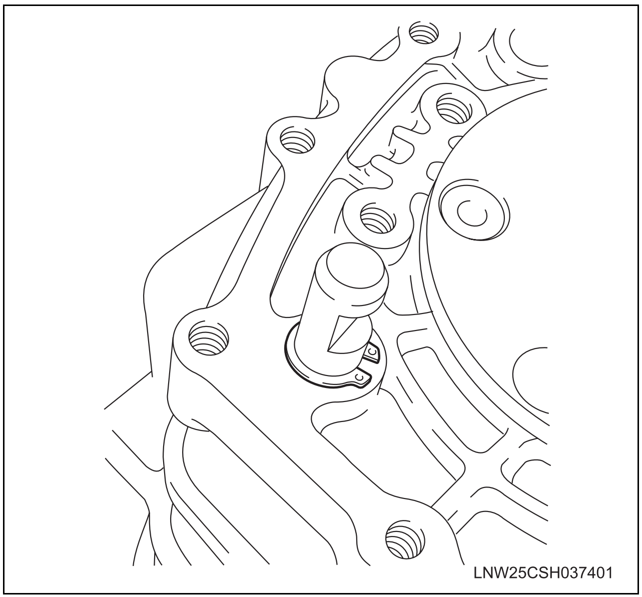


26. Apply ThreeBond TB1215 to the fitting surfaces of the transmission case and the clutch housing.
    - Remove moisture and oil from the fitting surface prior to application. Set the beat diameter to greater than 2 mm (0.078 in.) and make it even all around.
27. Install the clutch housing to the transmission case. Tighten the bolts to the specified torque.

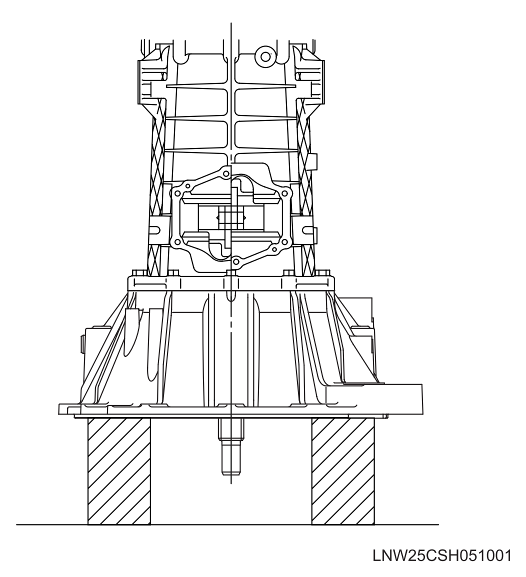
Torque : 46 N·m (34 lb ft)

28. Install the bearing rear outer race to the transmission case.
29. Install the snap ring to the 4th / 5th and the 6th gear shift rod.

Notice:
If a snap ring is deformed or damaged, replace it with a new one and verify that it is attached properly.



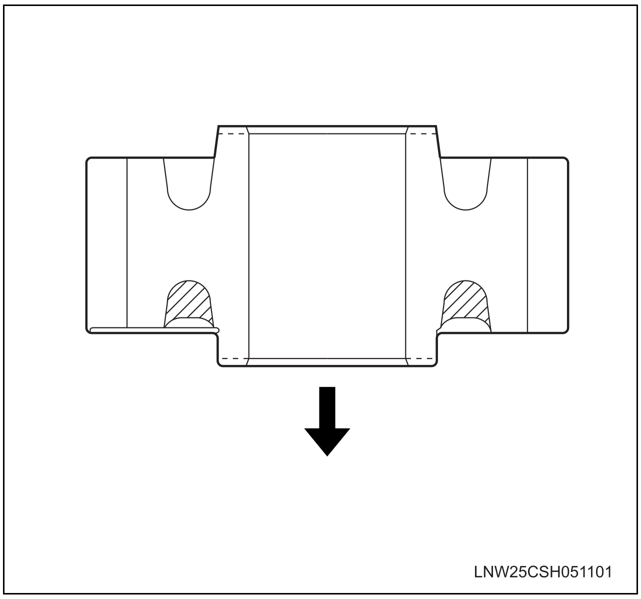
30. Attaching the counter shim
    a. Put the gear into neutral.
    b. Set the transmission assembly with the housing at the bottom.

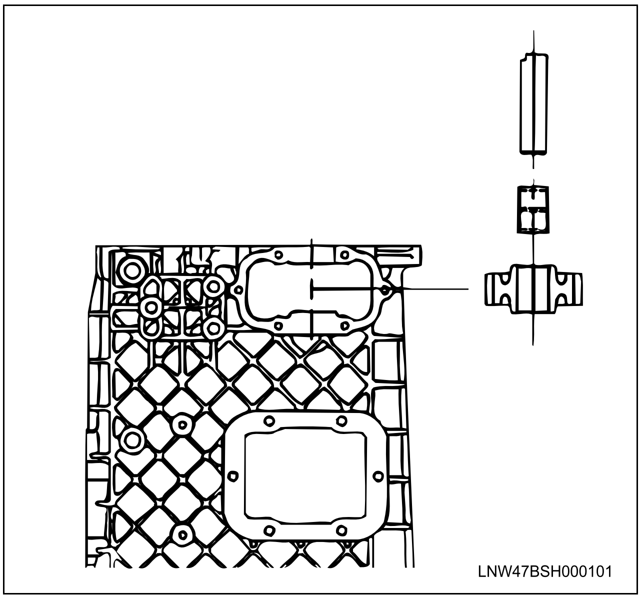


    c. Break in the taper roller bearing by rotating the counter shaft at least 30 times.
    d. Selecting a counter shim
        - Measure the depth between the rearmost surface of the transmission housing and the outer wheel surfaces of the counter shaft rear bearing. Take three measurements at 120-degree intervals, and calculate the average.
        - Select the shim with the appropriate thickness from the table below.

Measured depth mm (in)	Shim thickness mm (in)
2.13 - 2.19 (0.084 - 0.086)	1.98 (0.078)
2.07 - 2.13 (0.081 - 0.084)	1.92 (0.076)
2.01 - 2.07 (0.079 - 0.081)	1.88 (0.074)
1.95 - 2.01 (0.077 - 0.079)	1.80 (0.071)
1.89 - 1.95 (0.074 - 0.077)	1.74 (0.069)
1.83 - 1.89 (0.072 - 0.074)	1.68 (0.066)
1.77 - 1.83 (0.070 - 0.072)	1.62 (0.064)
1.71 - 1.77 (0.067 - 0.070)	1.58 (0.062)
1.65 - 1.71 (0.065 - 0.067)	1.50 (0.059)
1.59 - 1.65 (0.063 - 0.065)	1.44 (0.057)
1.53 - 1.59 (0.060 - 0.063)	1.38 (0.054)
1.47 - 1.53 (0.058 - 0.060)	1.32 (0.052)
1.41 - 1.47 (0.056 - 0.058)	1.26 (0.050)
1.35 - 1.41 (0.053 - 0.056)	1.20 (0.047)

31. Install the snap ring (rear outer) to the main shaft rear bearing.
32. Apply engine oil (5W-30) to the needle bearing.
33. Install the reverse idle gear together with the needle bearing.
34. Install the reverse idle shaft.
    - The arrow indicates the front of the transmission.



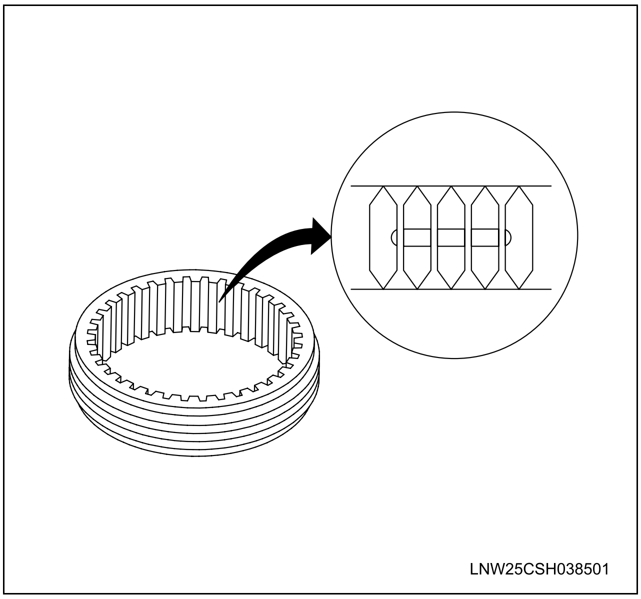


35. Install the retainer to the transmission case. Tighten the bolts to the specified torque.

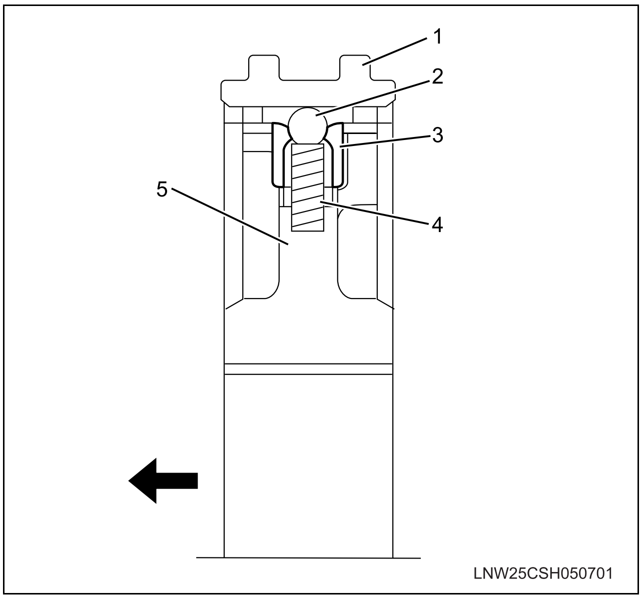
Torque : 26 N·m (20 lb ft)

Notice:
Be sure to thoroughly remove sealing material from the screw threads of the transmission housing, and to use a set of new screws.

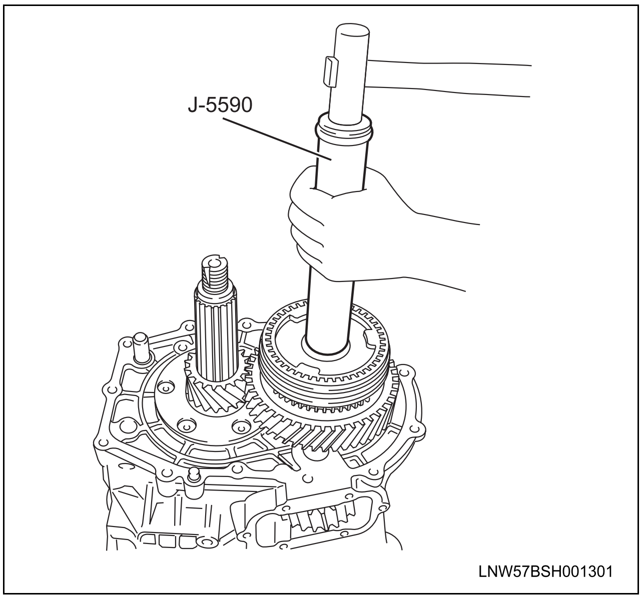
36. Install the speedometer gear.
37. Install the block and spring to the clutch hub.
38. Adjust the phase so that the three balls fit into the three ball grooves inside the sleeve.



39. Insert the sleeve (1) into the clutch hub (5) until resistance is felt.
40. Insert the ball (2), the block (3), and the spring (4) into the clutch hub. Be sure that the ball enters the ball groove.
    - The arrow indicates the front of the transmission.



41. Apply engine oil (5W-30) to the neutral bearing and the inside of the block ring.
42. Assemble the 6th gear, the needle bearing, and the 6th gear block ring.
43. Align the above assembly with the clutch hub block ring.
44. Assemble the 6th clutch hub assembly and the sleeve.
45. Use the installer (J-5590) and a hammer to install the assembled parts.



46. Use a pair of snap ring pliers to install the 6th clutch hub snap ring.
    - From the mountable snap rings, select the thickest one of the four types.

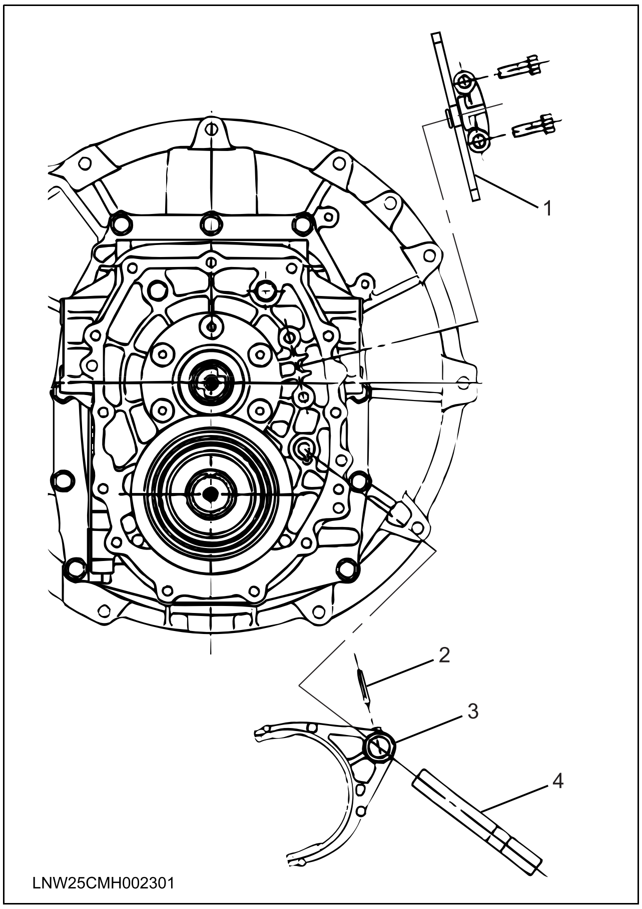
Shim thickness mm (in)	Discernment color
1.6 (0.063)	Pink

Shim thickness mm (in)	Discernment color
1.7 (0.067)	Light blue
1.8 (0.071)	Orange
1.9 (0.075)	Purple

Notice:
If a snap ring is deformed or damaged, replace it with a new one and verify that it is attached properly.

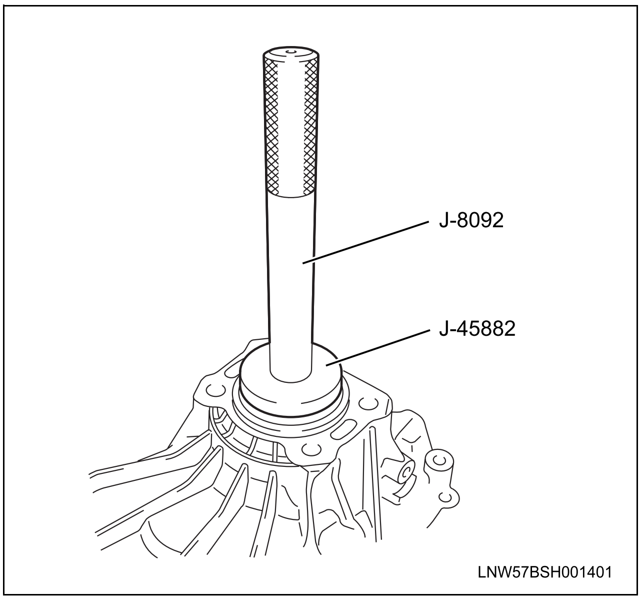
47. Apply engine oil (5W-30) to the shift rod holes in the transmission case.
48. Install the 6th shift arm (3) and the 6th shift rod (4).
49. Align the spring pin holes.
50. Insert the spring pins (2).
51. Install the 6th relay lever (1). Tighten the bolts to the specified torque.

Torque : 50 N·m (37 lb ft)

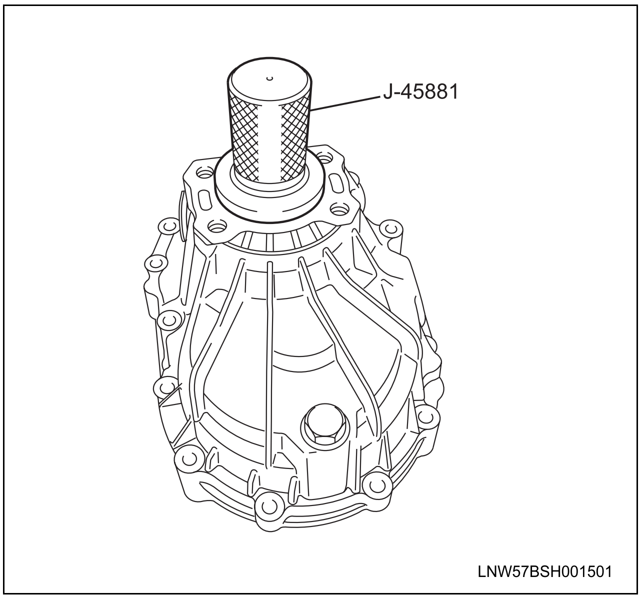


52. Apply multi-purpose type grease to the inside of the main end needle bearing.
53. Apply engine oil (5W-30) to the inside contact surfaces of the rear cover bearing.
54. Use the installer (J-45882) and the handle (J-8092) to press the needle bearing into the rear cover from the outside. The inscribed mark on the bearing must be facing out.

Caution:
The lipped portion of the oil seal is easily broken. Exercise care during the installation procedure.



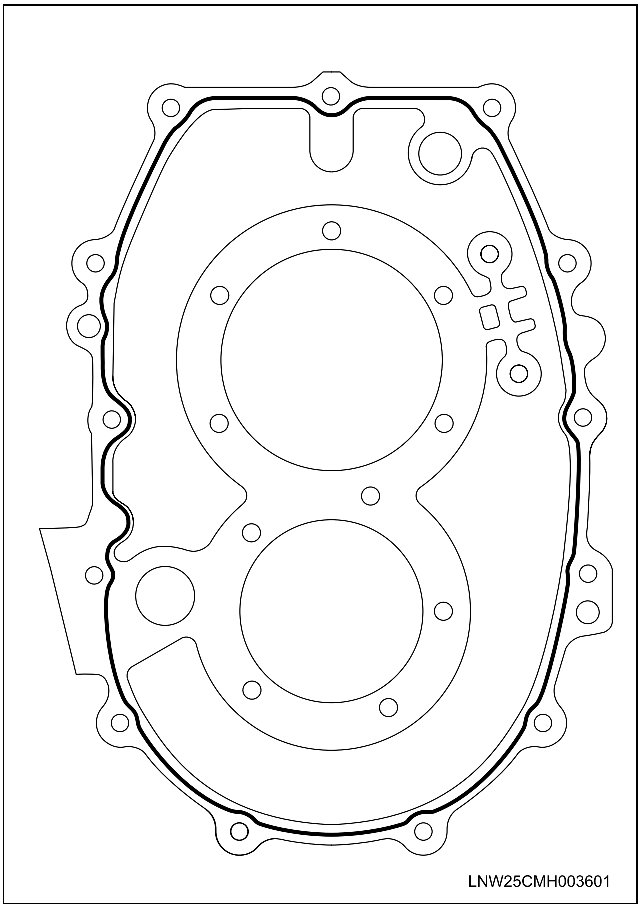
55. Inspect the rear cover oil seal for wear and damage. If wear or damage is present, the oil seal must be replaced.
56. Apply multi-purpose type grease to the lip portion of the oil seal.
57. Apply engine oil (5W-30) to the outer circumference of the oil seal.
58. Use the installer (J-45881) to press the oil seal into the rear cover.



59. Apply ThreeBond 1215 to the contact surfaces of the transmission case and the rear cover.
60. Install the rear cover to the transmission case. Tighten the bolts to the specified torque.

- Remove moisture and oil from the fitting surface prior to application. Set the beat diameter to greater than 2 mm (0.078 in.) and make it even all around.

Torque : 46 N·m (34 lb ft)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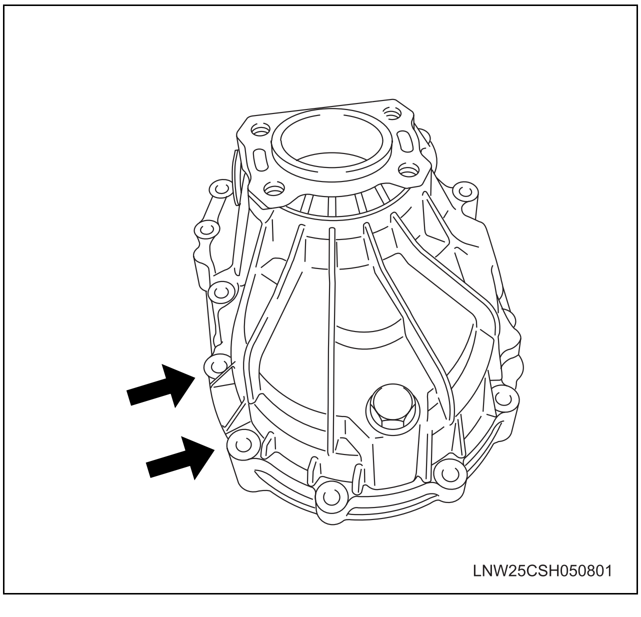
Notice:
The two bolts, indicated by the arrows, have lock-tight material applied to them. Be sure to thoroughly remove sealing material from the threads and to use new bolts with lock-tight material.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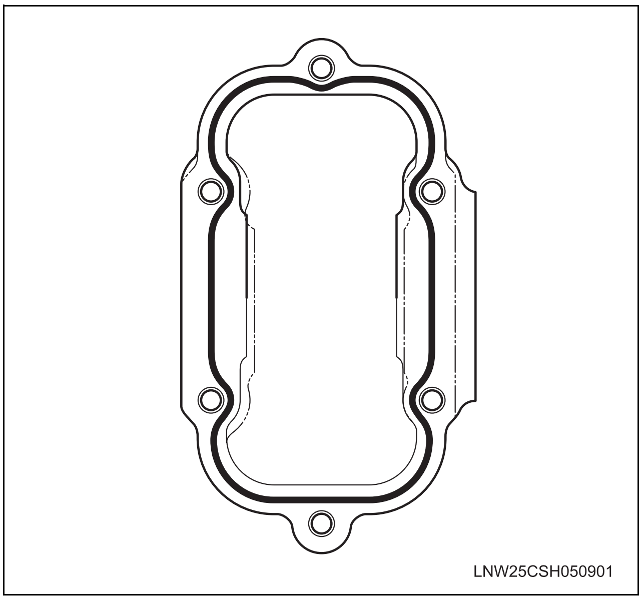
61. Align the contact surfaces of the transmission case reverse gear side cover.
62. Apply ThreeBond 1215 to the contact surfaces.
63. Install the reverse gear side cover. Tighten the bolts to the specified torque.

Torque : 23 N·m (17 lb ft)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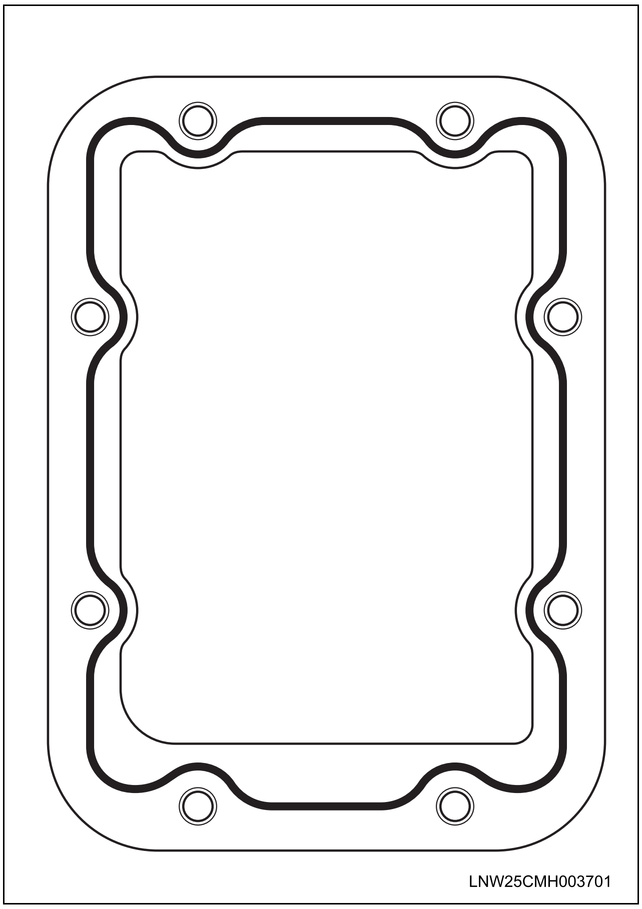
64. Align the contact surfaces of the transmission case PTO cover.
65. Apply ThreeBond 1215 to the contact surfaces.
66. Install the PTO cover. Tighten the bolts to the specified torque.

Torque : 37 N·m (27 lb ft)

Notice:
The bolts have lock-tight material applied to them. Be sure to thoroughly remove sealing material from the threads and to use new bolts with lock-tight material.



67. Place the transmission in the neutral position.
68. Align the contact surfaces of the transmission case control box (1).
69. Apply ThreeBond 1215 to the contact surfaces.
70. Install the interlock plate (8) and the control box. Tighten the bolts to the specified torque.

Torque : 27 N·m (20 lb ft)

Notice:
The bolts have lock-tight material applied to them. Be sure to thoroughly remove sealing material from the threads and to use new bolts with lock-tight material.

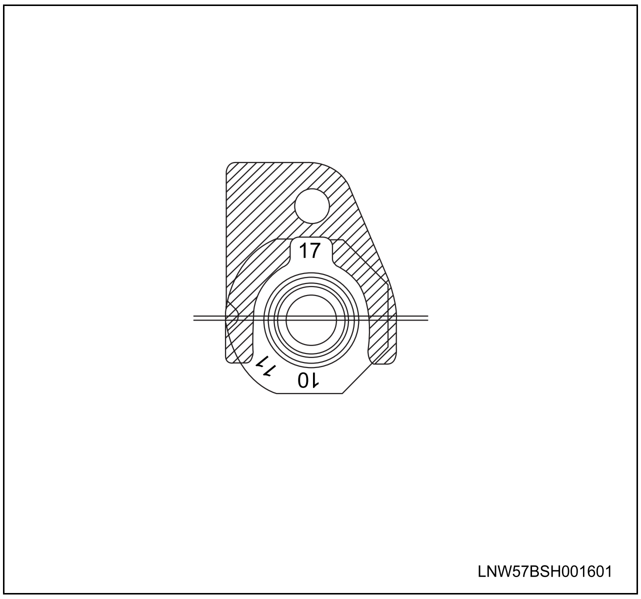
71. Install the 4 detente assemblies ((7), (6), (5), and (4)). Tighten the bolts to the specified torque.

Torque : 27 N·m (20 lb ft)

72. Apply liquid gasket (Loctite No. 242) to the threaded portion of the reverse switch.
73. Install the reverse switch (3). Tighten the bolt to the specified torque.

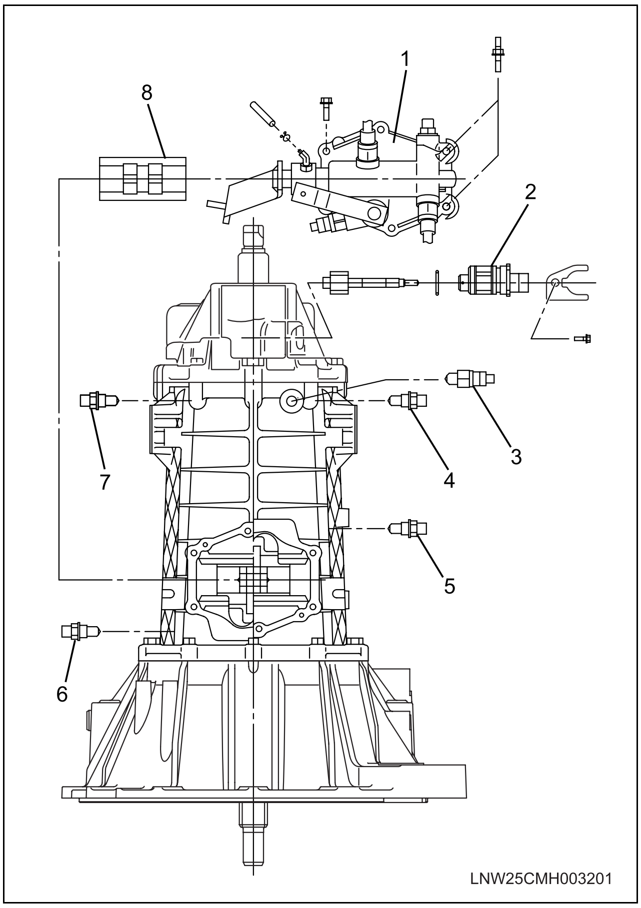
Torque : 39 N·m (29 lb ft)

74. Apply engine oil (5W-30) to the speedometer driven gear (2) and the O-ring.
    - It attached so that the stamp mark which appears from the window of the plate and the number of driven gear teeth may be in agreement. (The following figure shows the case where driven gear teeth is 17.)



75. Install the driven gear together with the O-ring. Tighten the bolts to the specified torque.

Torque : 20 N·m (2.0 lb ft)



76. Install the noise cover.
77. Apply engine oil (5W-30) to the drain plug O-ring.
78. Install the drain plug together with the O-ring. Tighten the bolts to the specified torque.

Torque : 39 N·m (29 lb ft)

79. Apply engine oil (5W-30) to the filler plug O-ring.

80. Install the filler plug together with the O-ring. Tighten the bolts to the specified torque.

Torque : 39 N·m (29 lb ft)

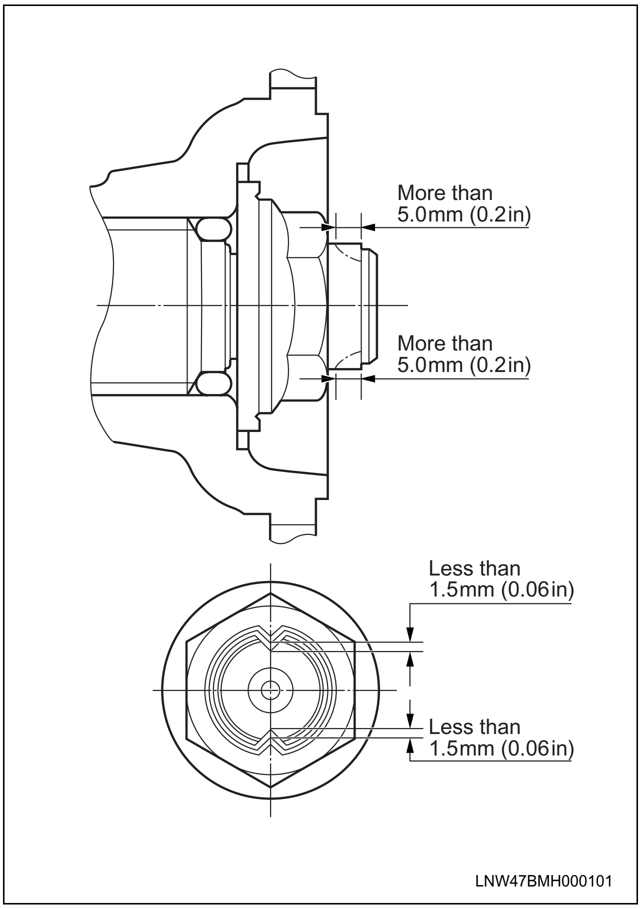
81. Install the parking brake assembly.
    - Refer to PARKING BRAKE (SEC. 5C).
82. Install the parking brake bracket to the transmission case. Tighten the bolts to the specified torque.

Torque : 48 N·m (35 lb ft)

83. Apply engine oil (5W-30) to the coupling driver O-ring.
84. Install the coupling driver together with the O-ring.
85. Use the special tool (J-35016) to tighten the lock nut to the specified torque.

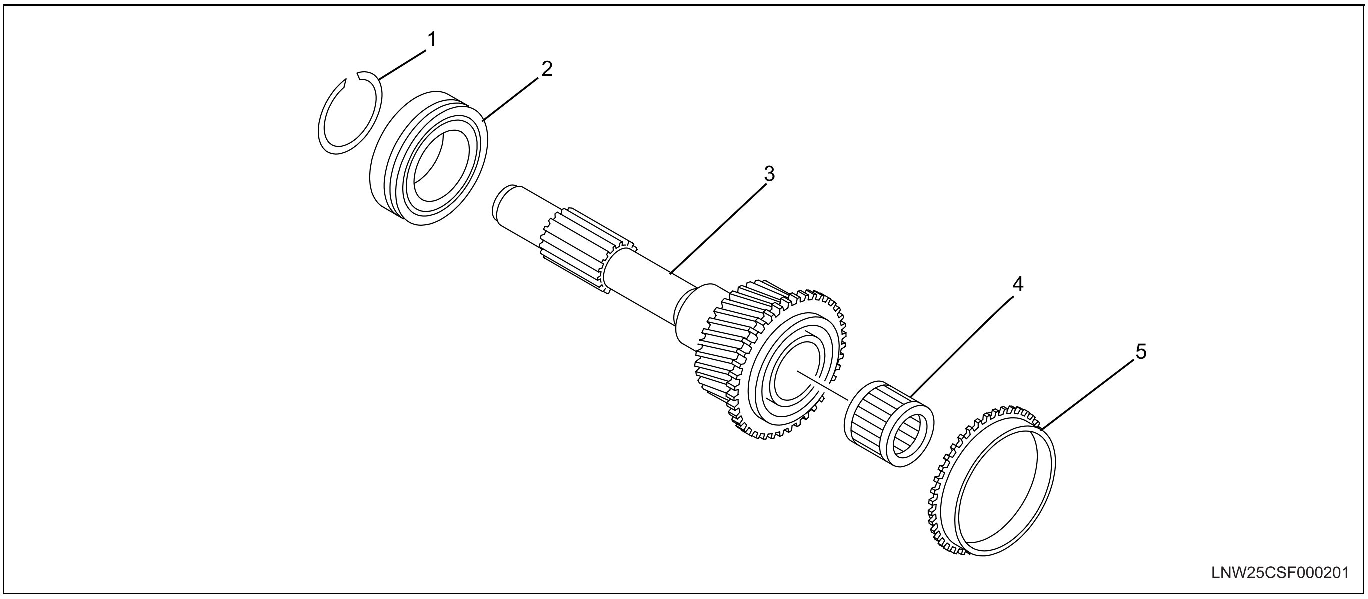
Torque : 382 N·m (282 lb ft)

86. Align the lip portion of the lock nut with the V-groove at the end of the shaft (length must be at least 5 mm (0.2 in)). Wedge the lipped portion of the nut into the V-groove so that the gap between the nut and the bottom of the V-groove is less than 1.5 mm (0.06 in).
87. Caulk the lock nut at two places (radius approximately 1 mm (0.04 in) with caulking sites 60 degrees away form each other).



88. Install the parking brake drum.
    - Refer to PARKING BRAKE (SEC. 5C).
89. Install the shift block together with the release bearing, the clutch shaft, and the shift fork.
    - Refer to CLUTCH (SEC. 7C3).

Top Gear Shaft



Legend

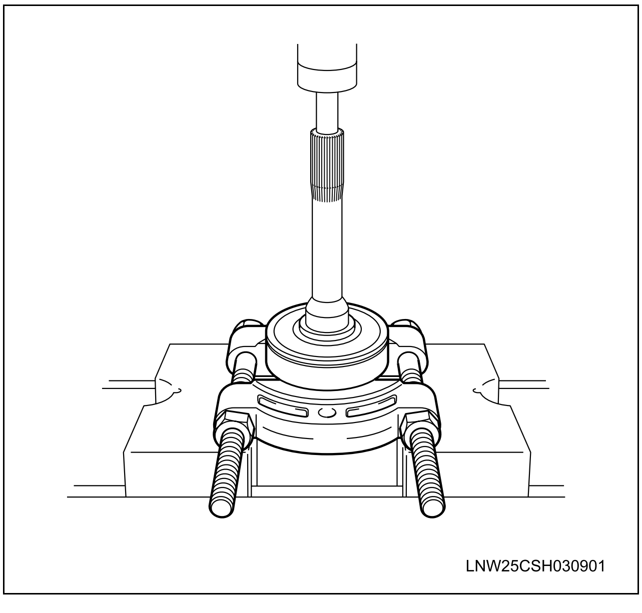
1. Snap Ring
2. Bearing
3. Top Gear Shaft
4. Needle Bearing
5. Block Ring

Disassembly

1. Remove the block ring from the top gear shaft.
2. Remove the needle bearing from the top gear shaft.

Notice:
The needle bearing is a separator type. Be careful not to drop the roller when disassembling.

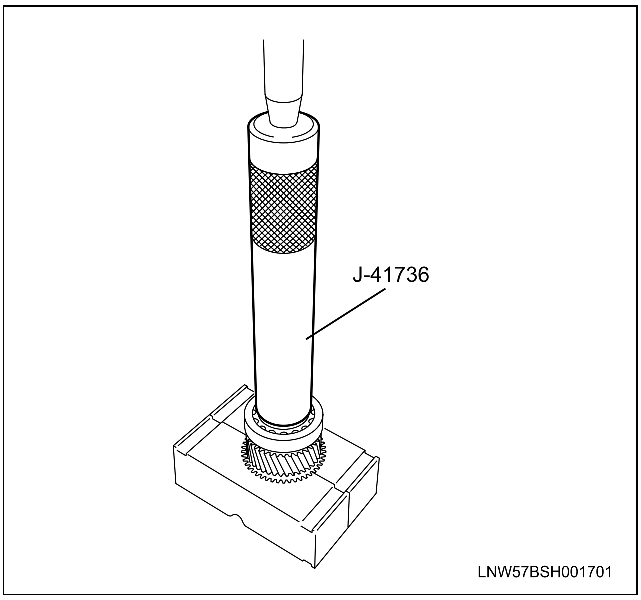
3. Use a pair of snap ring pliers to remove the snap ring from the top gear shaft.
4. Use a press and a bearing remover to remove the bearing from the top gear shaft.



5. Inspect each of the disassembled parts for wear and damage. If wear or damage is present, make the necessary repairs or replace the part(s).
6. Inspect the gear teeth, the spline, and the end contact surfaces for wear and damage. If wear or damage is present, the part(s) must be replaced.
7. Inspect each of the bearings. The bearings must rotate smoothly and quietly. There must be no corrosion. Play in the thrust direction must be normal. Replace the bearing(s) if these conditions are not met.
8. Inspect the needle bearing rolling surface and roller for discoloration, excessive wear, and pitching. Replace the bearing if any of these conditions are present.

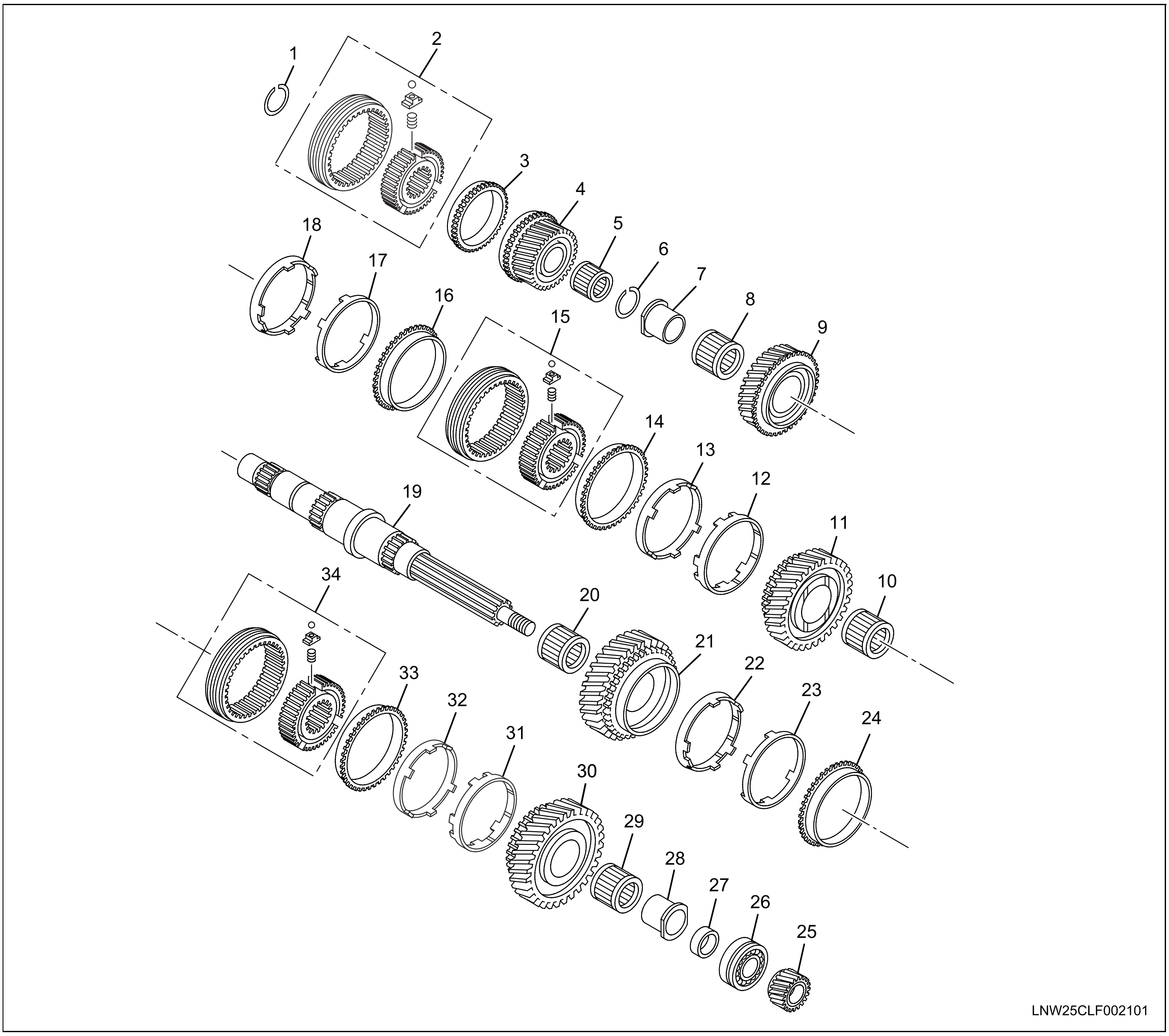
Reassembly

1. Use the installer (J-41736) and a press to install the bearing to the top gear shaft.



2. Use a pair of snap ring pliers to install the snap ring to the top gear shaft.
3. Install the needle bearing to the top gear shaft.
4. Thoroughly apply 5W-30 engine oil to the inner surface of the block ring, then attach the block ring to the top gear shaft.

Main Shaft

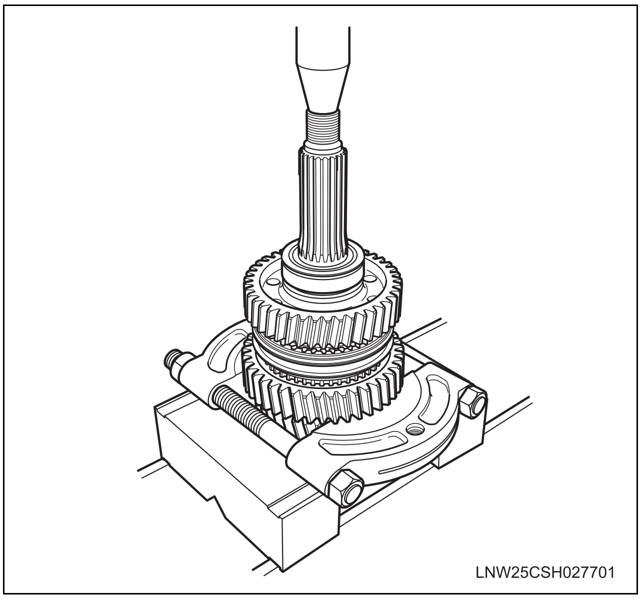


Legend

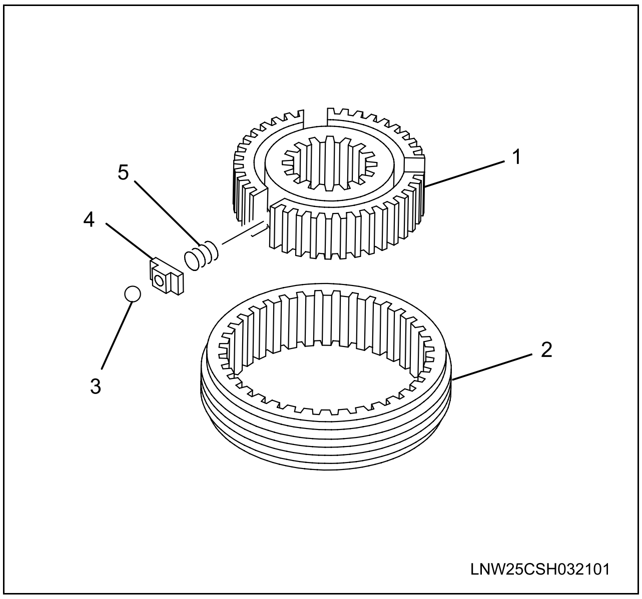
1. Snap Ring
2. 4th / 5th Clutch Hub Assembly and Sleeve
3. 4th Block Ring
4. 4th Gear
5. Needle Bearing
6. Snap Ring
7. Collar
8. Needle Bearing
9. 3rd Gear
10. Needle Bearing
11. 2nd Gear
12. 2nd Gear Inside Ring
13. 2nd Gear Outside Ring
14. 2nd Gear Block Ring
15. 2nd / 3rd Clutch Hub Assembly and Sleeve
16. 3rd Gear Block Ring
17. 3rd Gear Outside Ring
18. 3rd Gear Inside Ring
19. Main Shaft
20. Needle Bearing
21. 1st Gear
22. 1st Gear Inside Ring
23. 1st Gear Outside Ring
24. 1st Gear Block Ring
25. 6th Gear
26. Bearing
27. Spacer
28. Collar
29. Needle Bearing
30. Reverse Gear
31. Reverse Gear Inside Ring
32. Reverse Gear Outside Ring
33. Reverse Gear Block Ring
34. 1st / Reverse Clutch Assembly and Sleeve

Disassembly

1. Remove the 6th gear.
2. Use a bearing remover and a press to simultaneously remove the following parts.
   - Bearing
   - Spacer
   - Collar
   - Reverse gear
   - Needle bearing
   - Reverse gear inside ring
   - Reverse gear outside ring
   - Reverse gear block ring
   - 1st / reverse clutch hub assembly and sleeve
   - 1st gear block ring
   - 1st gear outside ring
   - 1st gear inside ring
   - 1st gear
   - Needle bearing



3. Disassemble the 1st / reverse clutch hub assembly and sleeve.

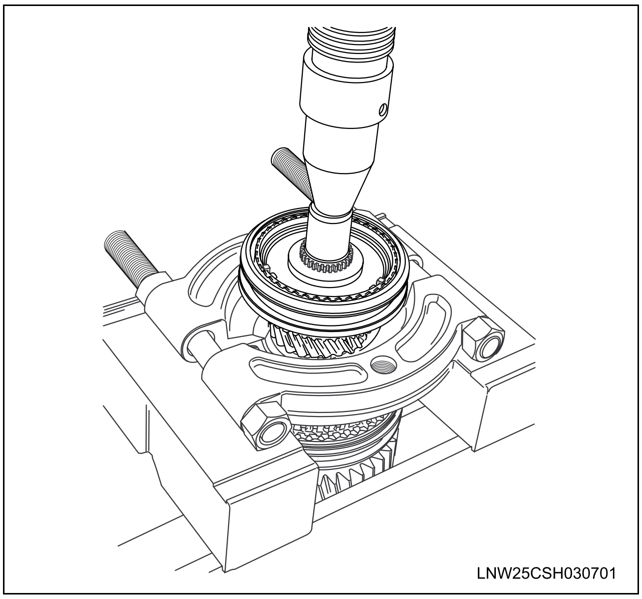


Legend

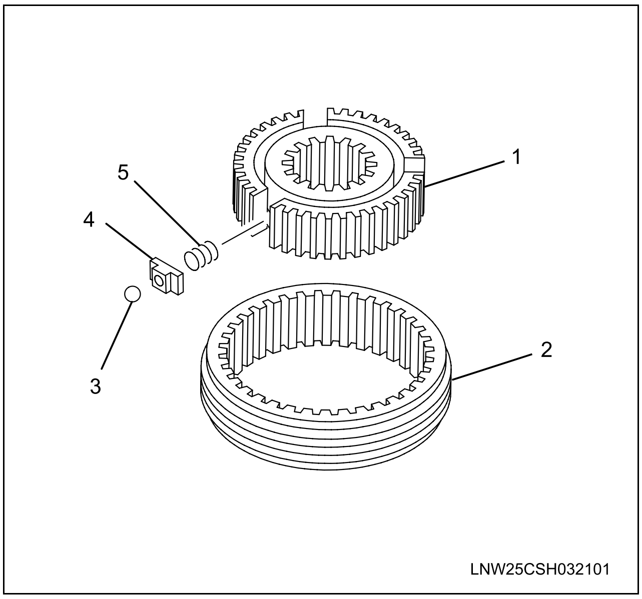
1. Clutch Hub
2. Sleeve
3. Ball
4. Block
5. Spring

---

4. Use a pair of snap ring pliers to remove the snap ring securing the 4th / 5th clutch hub assembly.
5. Use a bearing remover to simultaneously remove the 4th / 5th clutch hub assembly, the sleeve, the 4th / 5th block ring, and the 4th gear needle bearing.



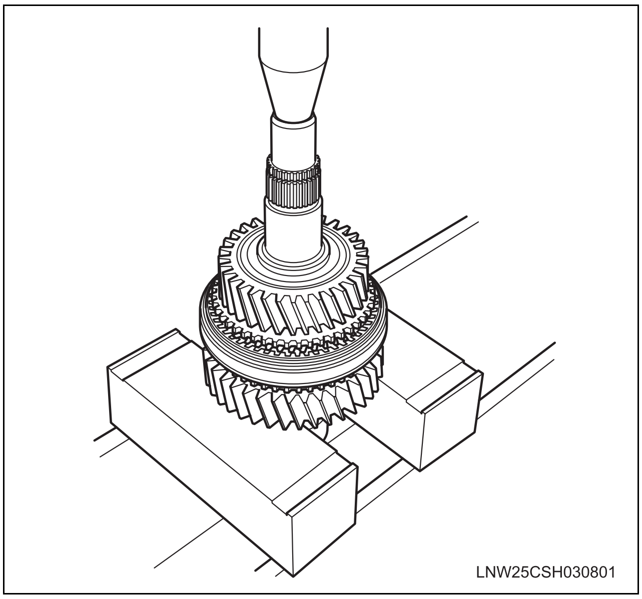
6. Disassemble the 4th / 5th clutch hub assembly and the sleeve.



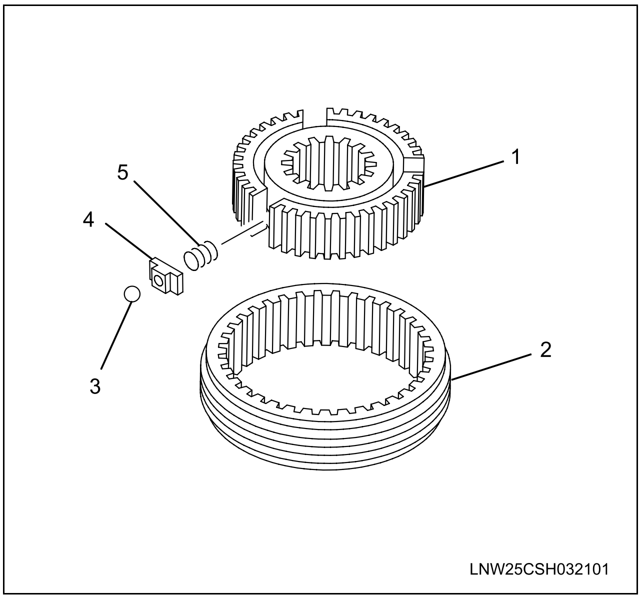
Legend

1. Clutch Hub
2. Sleeve
3. Ball
4. Block
5. Spring

7. Use a pair of snap ring pliers to remove the snap ring securing the 3rd gear collar.
8. Use a bearing remover to simultaneously remove the 3rd gear collar, the 3rd gear needle bearing, the 3rd gear inside ring, the 3rd gear outside ring, the 3rd gear block ring, the 2nd / 3rd clutch hub assembly, the sleeve, the 2nd gear block ring, the 2nd gear inside ring, the 2nd gear outside ring, and the 2nd gear needle bearing from the main shaft.



9. Disassemble the 2nd / 3rd clutch hub assembly and the sleeve.

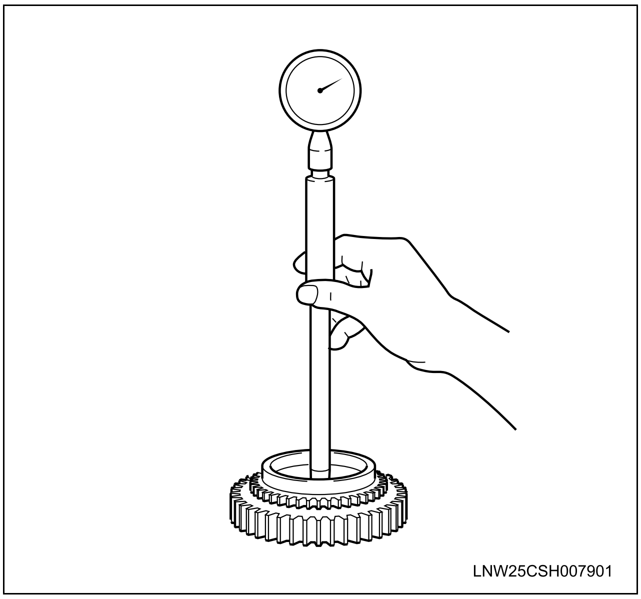


Legend

1. Clutch Hub
2. Sleeve
3. Ball
4. Block
5. Spring

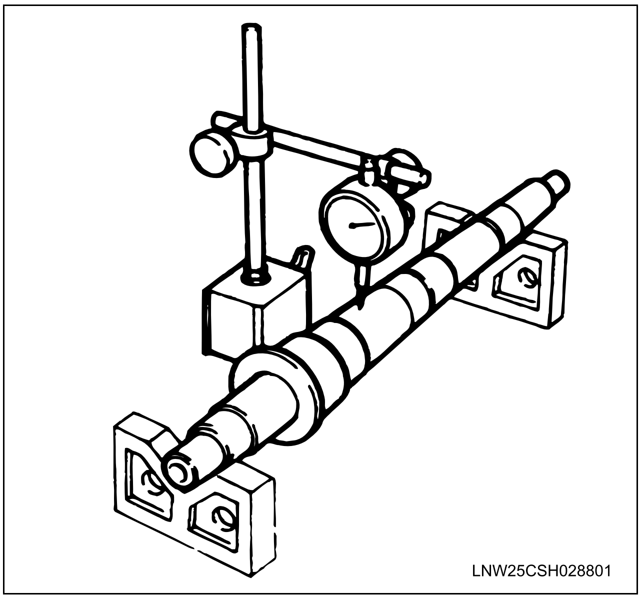
10. Inspect each of the bearings for roughness, abnormal operating noise, corrosion, internal and external damage, and excessive play (in the direction of the slide). Repair or replace the bearings as required.
11. Use and inside dial gauge to measure the inside diameter of each of the gears. If the measured diameter exceeds the specified limit, the gear must be replaced.

Gear inside diameter		mm (in)
Gear	Standard	Limit
6th	50.009 - 50.025 (1.968 - 1.969)	50.065 (1.971)
5th	48.009 - 48.025 (1.890 - 1.890)	48.065 (1.892)
4th	55.010 - 55.029 (2.165 - 2.166)	55.069 (2.168)
3rd	63.010 - 63.029 (2.480 - 2.481)	63.069 (2.483)
2nd	63.010 - 63.029 (2.480 - 2.481)	63.069 (2.483)
1st	63.010 - 63.029 (2.480 - 2.481)	63.069 (2.483)
Reverse	63.010 - 63.029 (2.480 - 2.481)	63.069 (2.483)

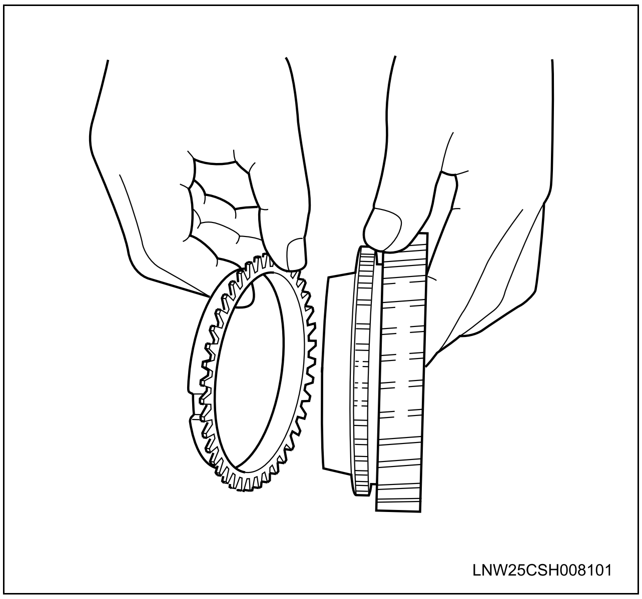


12. Use a dial gauge to measure the main shaft deflection (curvature). If the deflection exceeds the specified limit, the shaft must be replaced.

Main shaft deflection	mm (in)
Standard	Limit
0.015 (0.001)	0.1 (0.004)

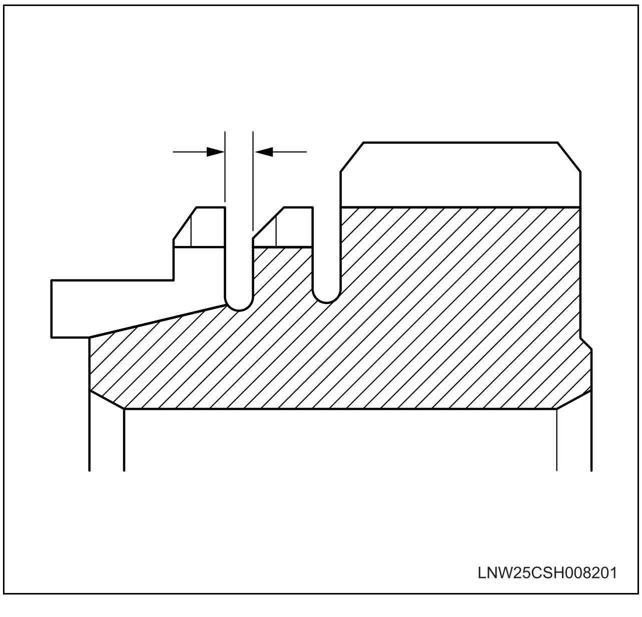


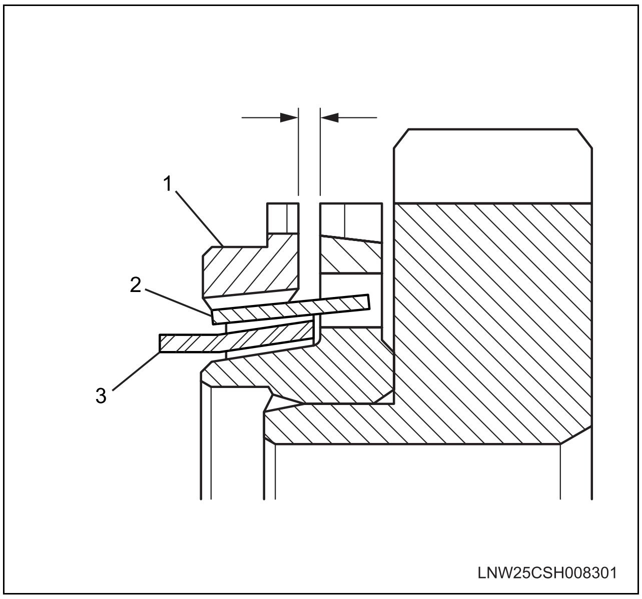
13. Inspect the synchromesh mechanism. Use an oil stone or a pencil grinder to correct light stepping and other minor imperfections.



14. Use a thickness gauge to measure the gaps between the block ring and the dog gear. If the gap exceeds the specified limit, the block ring must be replaced.

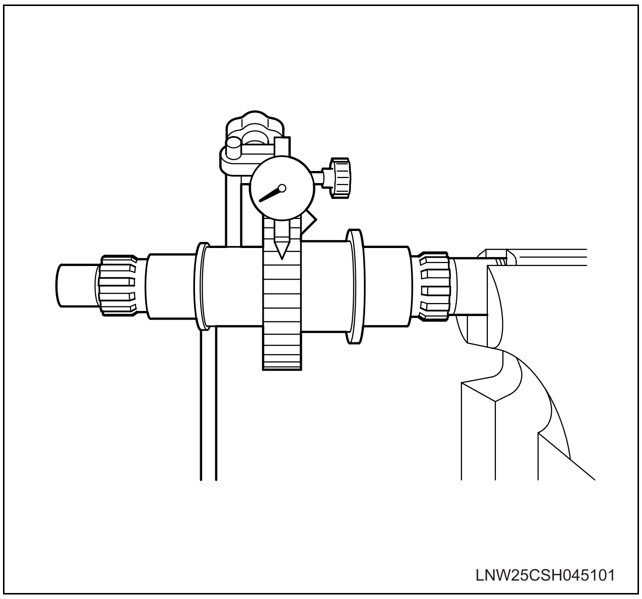
Block ring and dog gear gap		mm (in)
Gear	Standard	Limit
4th / 5th / 6th	1.03 - 2.60 (0.04 - 0.10)	0.50 (0.02)
2nd / 3rd	1.00 - 2.50 (0.04 - 0.10)	0.50 (0.02)
1st / Reverse	1.00 - 2.50 (0.04 - 0.10)	0.50 (0.02)





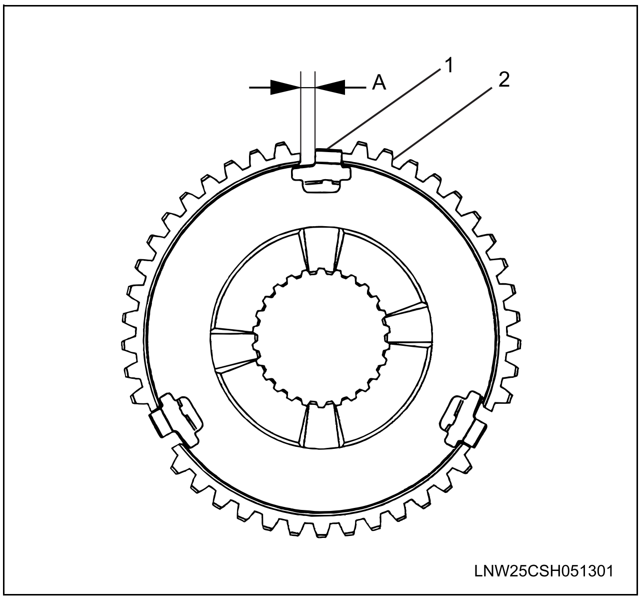
15. Inspect the clutch hub and sliding sleeve contact surfaces for wear and/or damage.
16. Inspect the spline interior and groove for wear and/or damage.
17. Measure the spline play in the direction of rotation (above the clutch hub outside circumference). If the play exceeds the specified limit, the spline must be replaced.

Spline play	mm (in)
Standard	
0 - 0.16 (0 - 0.01)	



18. Measure the gaps (A) at the clutch hub and the protrusion of the block ring using a thickness gauge.
    - If the measurements exceed the limits, replace the block and clutch hub.

Block and clutch hub gap	mm (in)
Gear	Limit
5th / 4th 6th	4.30 – 4.70 (0.17 – 0.19)
1st / Reverse 3rd / 2nd	3.30 - 3.70 (0.13 - 0.15)



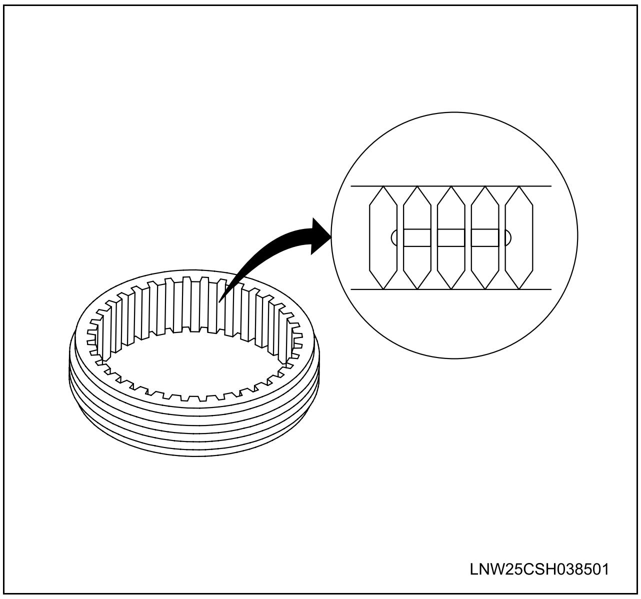
Legend

1. Block ring
2. Clutch hub

Reassembly Procedure

1. Clean all the parts.
2. Place the main shaft in a vise. The long end of the spline must be facing down.
3. Install the block and spring to the 2nd / 3rd clutch hub.

4. Insert the 3 balls into the 3 insert grooves inside the sleeve. Position the balls carefully to set the phase.



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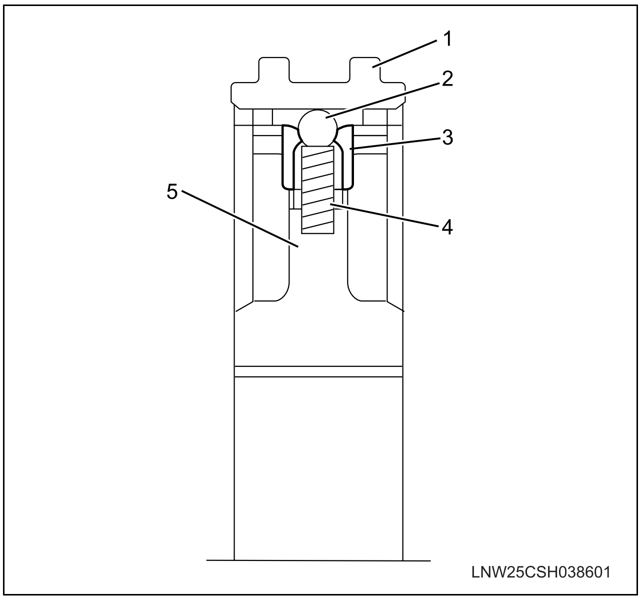
5. Install the sleeve (1) to the clutch hub (5). The sleeve should press slightly against the block.
6. Press on the ball (2), the block (3), and the spring (4). Insert the sleeve into the ball groove until it touches the ball.



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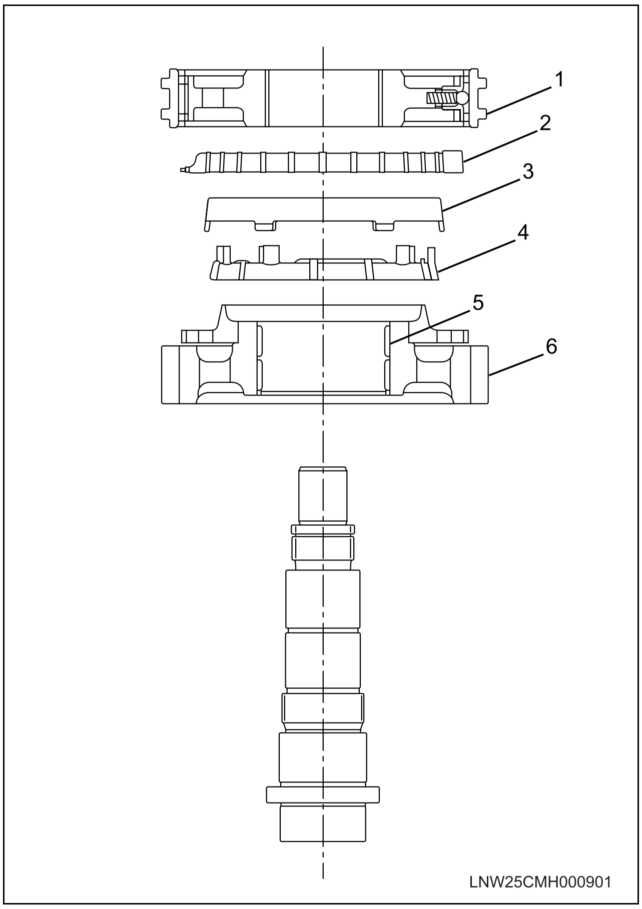
7. Apply 5W-30 motor oil to the needle bearing, 2nd gear thrust surface, and the tapered surface of the synchronization cone. Face the dog gear upward and attach the 2nd gear (6) and needle bearing (5) to the main shaft.
8. Attach the 2nd gear inside ring (4), 2nd gear outside ring (3), and 2nd gear block ring (2) so that the teeth of the outside ring mesh with those of the dog gear.
9. Insert the 6 pawls on the inside ring into the holes in the hub.
10. Use the installer (J-41736) to press the 2nd / 3rd clutch hub assembly and sleeve (1) into place.



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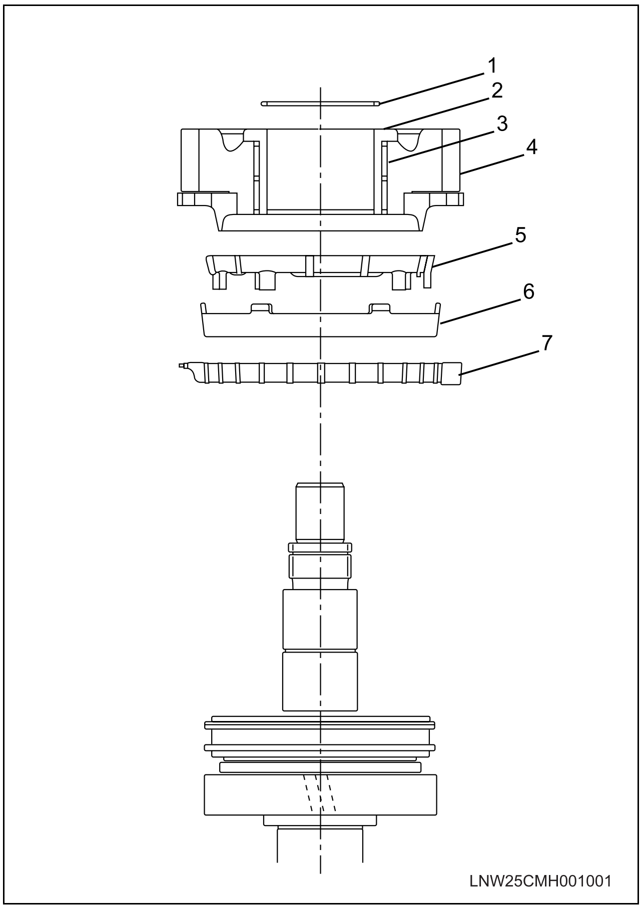
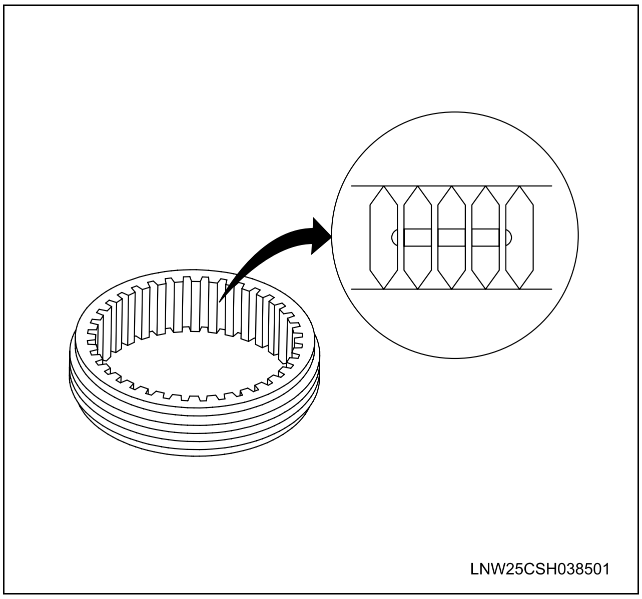
11. Attach the 3rd gear block ring (7), 3rd gear outside ring (6), 3rd gear inside ring (5) so that the six teeth mesh with those of the hub. Make sure to thoroughly apply 5W-30 engine oil to both sides of the inside ring and outside ring as well as the inside surface of the block ring.
12. Apply 5W-30 engine oil to the needle bearing, 3rd gear thrust surface, and the tapered surface of the synchronization cone. Face the dog gear downward and press-fit the 3rd gear (4), needle bearing (3), and collar (2) using the installer (J-41736) so that the teeth of the outer ring mesh with those of the dog gear of the 3rd gear.
13. Use a pair of pliers to install the snap ring (1).

Caution:

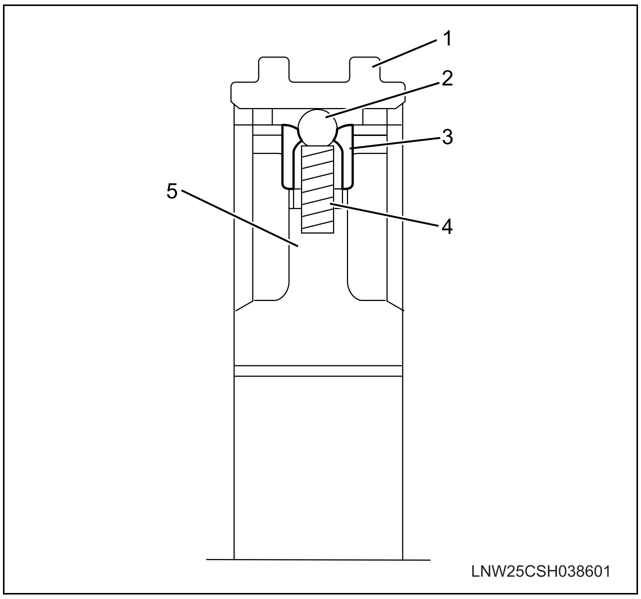
- If the snap ring is bent or otherwise damaged, it must be replaced with a new one.
- Be sure that the snap ring is completely installed to the snap ring groove.



14. Install the block and spring to the 4th / 5th clutch hub.
15. Insert the 3 balls into the 3 insert grooves inside the sleeve. Position the balls carefully to set the phase.



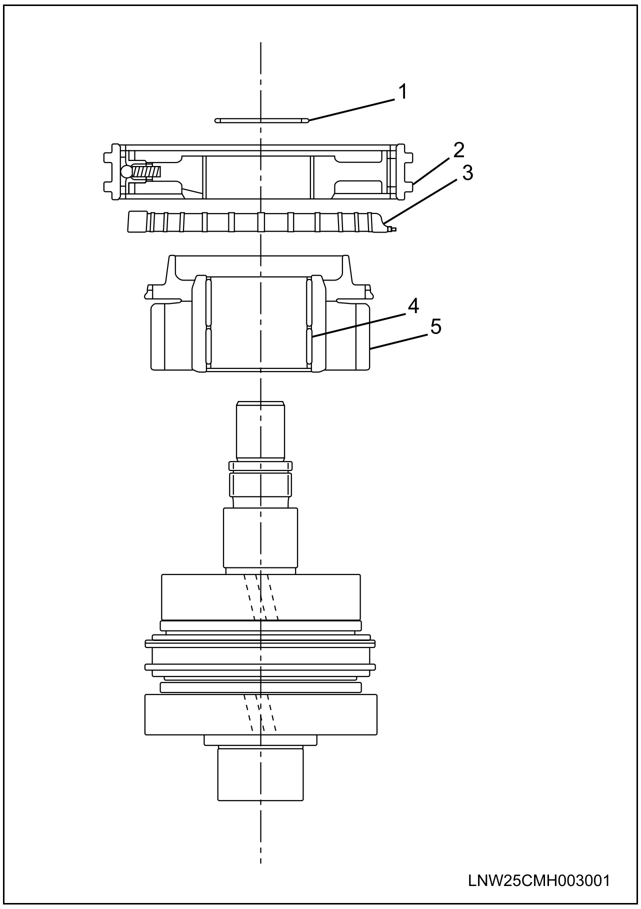
16. Install the sleeve (1) to the clutch hub (5). The sleeve should press slightly against the block.
17. Press on the ball (2), the block (3), and the spring (4). Insert the sleeve into the ball groove until it touches the ball.



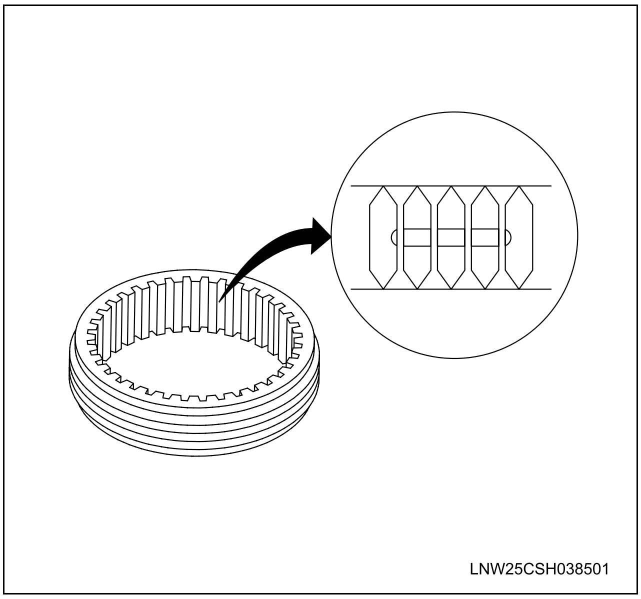
18. Apply engine oil (5W-30) to the needle bearing, the 4th gear thrust surfaces, and the synchrotron taper.
19. Install the 4th gear (5) and the needle bearing (4) to the main shaft. The dog gear must be facing up.
20. Apply engine oil (5W-30) to the 4th block ring. (3)
21. Use the installer (J-41736) to press the 4th / 5th clutch hub assembly and sleeve (2) into the groove in the 4th / 5th block ring.
22. Use a pair of pliers to install the snap ring (1).

Caution:

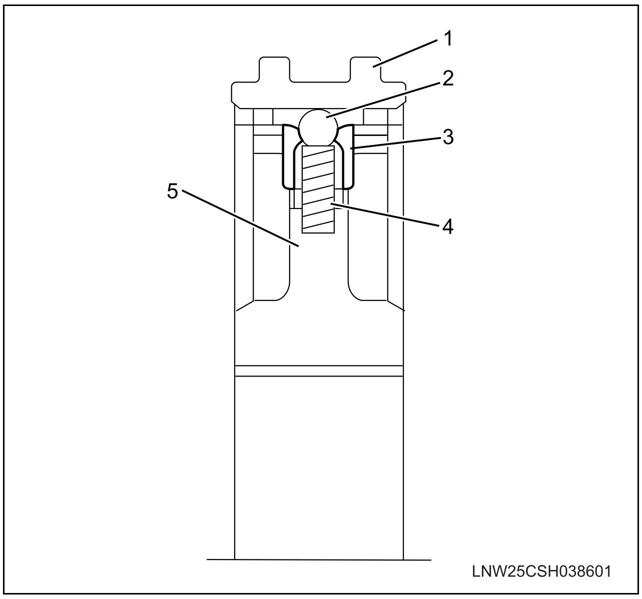
- If the snap ring is bent or otherwise damaged, it must be replaced with a new one.
- Be sure that the snap ring is completely installed to the snap ring groove.



23. Install the block and spring to the 1st / reverse clutch hub.
24. Insert the 3 balls into the 3 insert grooves inside the sleeve. Position the balls carefully to set the phase.

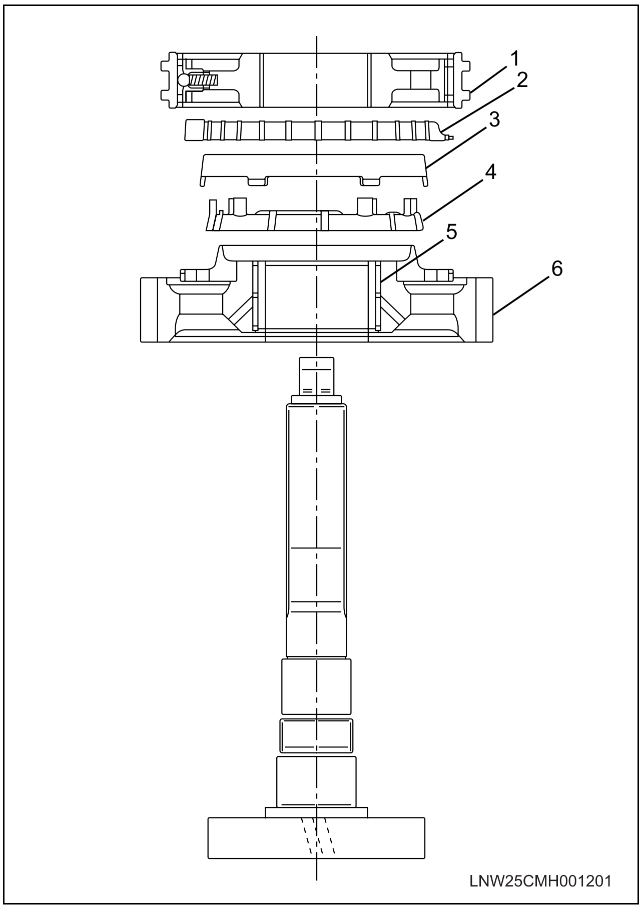


25. Install the sleeve (1) to the clutch hub (5). The sleeve should press slightly against the block.
26. Press on the ball (2), the block (3), and the spring (4). Insert the sleeve into the ball groove until it touches the ball.

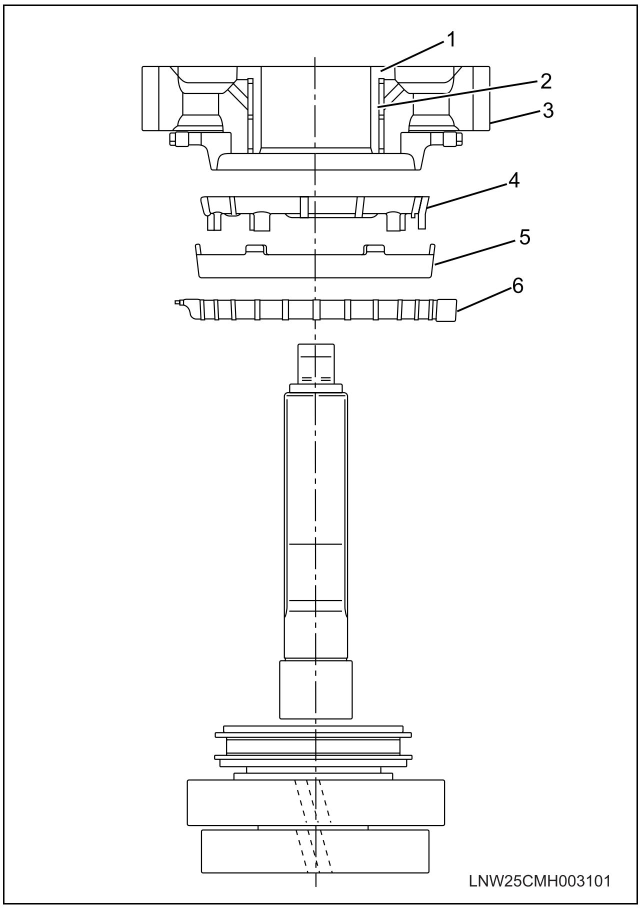


27. Apply engine oil (5W-30) to the needle bearing, the 1st gear thrust surfaces, and the synchrotron taper.
28. Install the 1st gear (6) and the needle bearing (5) to the main shaft. The dog gear must be facing up.
29. Assemble the 1st gear inside ring (4), 1st gear outside ring (3), and 1st gear block ring (2) in that order. Then attach them so that the teeth of the outer ring mesh with those of the dog gear of the 1st gear. Be sure to thoroughly apply 5W-30 engine oil to both sides of the inside ring and outside ring as well as the inside surface of the block ring.
30. Insert the 6 pawls on the 1st gear inside ring into the 6 hub holes.

31. Use the installer (J-41736) to press the 1st / reverse clutch hub assembly and sleeve (1) into place.

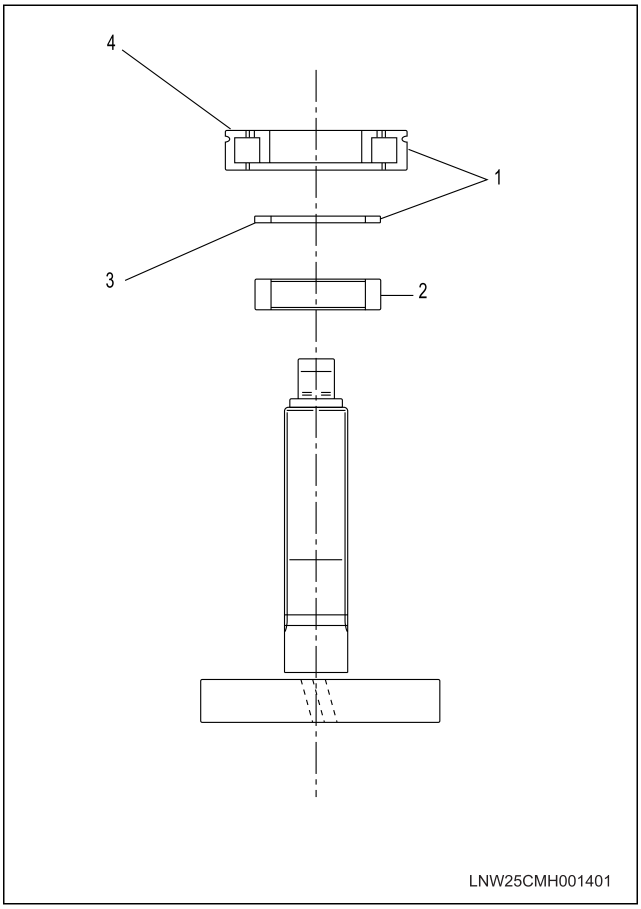


32. Apply engine oil (5W-30) to the reverse gear block ring (6), the reverse gear outside ring (5), and the reverse inside ring (4).
33. Align the block ring groove phase with the 1st / reverse clutch hub assembly and sleeve.
34. Install the block ring.
35. Apply engine oil (5W-30) to the needle bearing and the reverse gear thrust surfaces.
36. Align the reverse gear with the pawl on the outer ring to set the synchrotron phase.
37. Use the installer (J-41736) to press the reverse gear (3), the needle bearing (2), and the collar (1) into place.



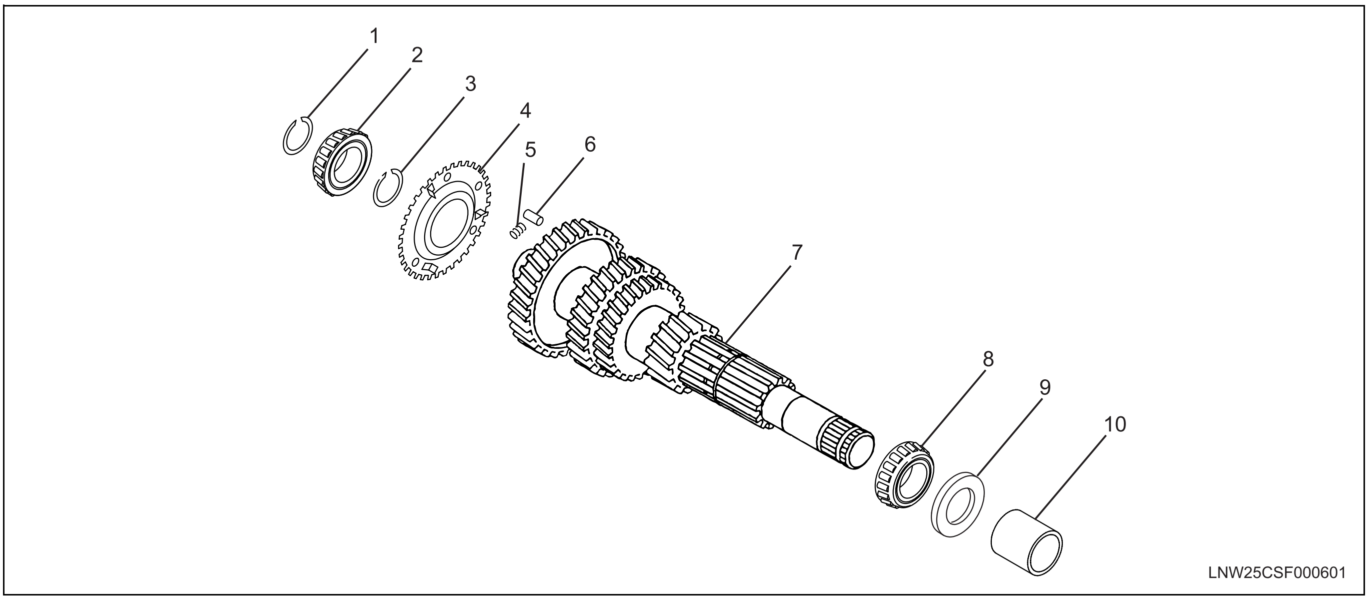
38. Install the spacer (2).

39. Use the installer (J-41736) to press the bearing (1) into place. The bearing surface 'A' mark (4) must be facing up. The bearing surface 'B' mark (3) must be facing down.



40. Install the 6th gear. The projecting portion of the gear must be facing down.

Counter Shaft



Legend

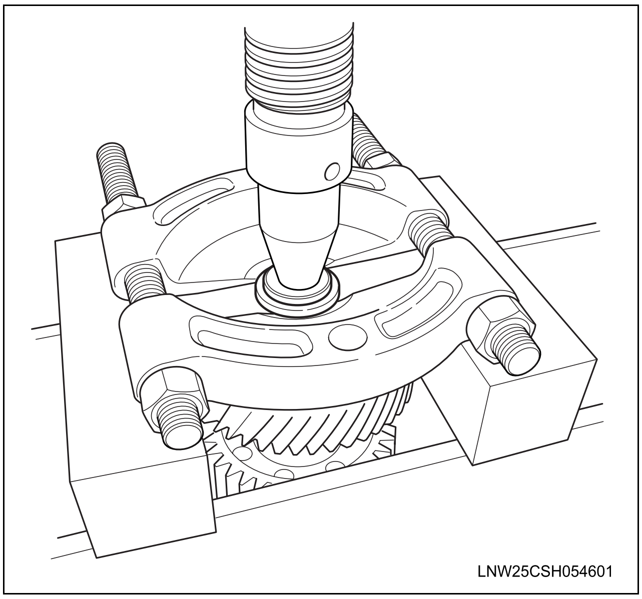
1. Snap Ring
2. Bearing (Front of Counter Shaft)
3. Snap Ring
4. Antilash Plate
5. Coil Spring
6. Straight Pin
7. Counter Shaft Assembly
8. Bearing (Back of Counter Shaft)

9. Thrust Washer

10. Collar

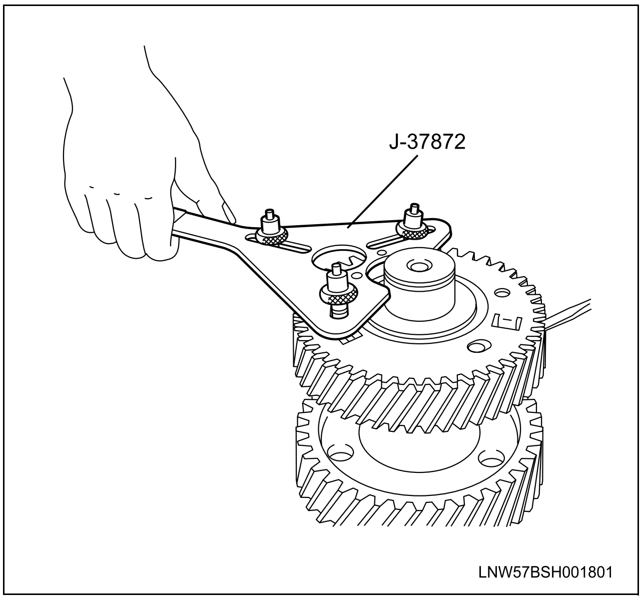
Disassembly

1. Use a pair of snap ring pliers to remove the snap ring holding the bearings in place.
2. Cage of bearing (front of counter shaft) is broken by chisel and inner race is removed using bearing separator..



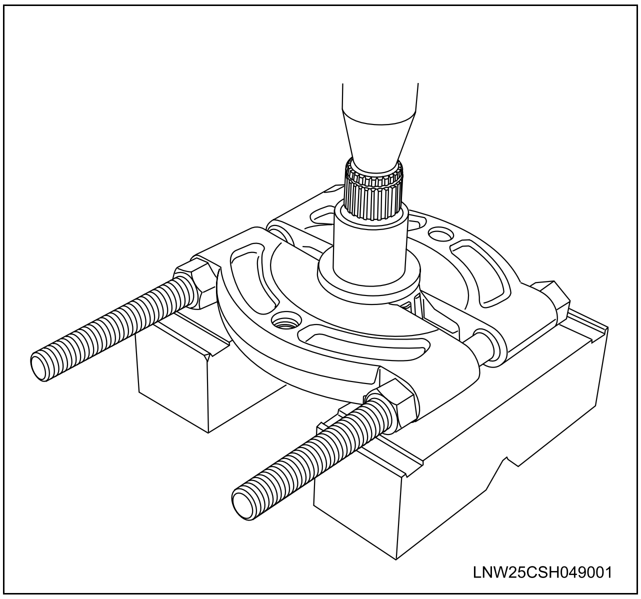
LNW25CSH054601

3. Use a pair of snap ring pliers to remove the snap ring holding the antilash plate in place.
4. Use the flange holder (J-37872) to remove the antilash plate.



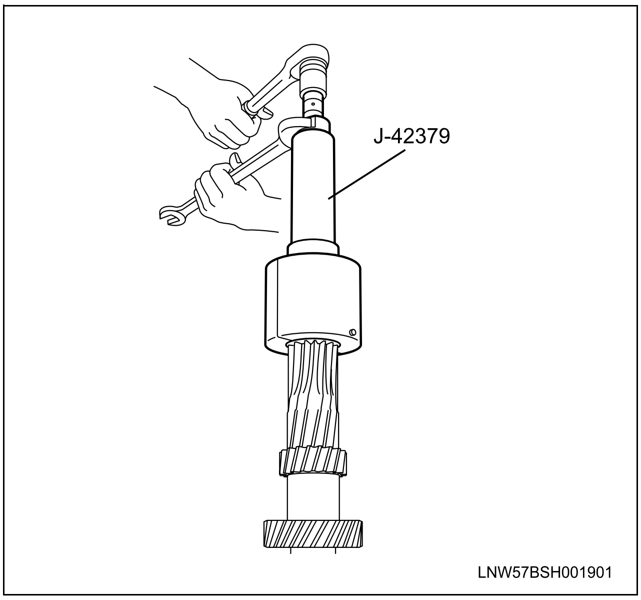
LNW57BSH001801

5. Remove the 3 coil springs from the 5th gear.
6. Remove the straight pin from the 5th gear.
7. Use a bearing remover and a press to remove the collar and the thrust washer.



LNW25CSH049001

8. Use the bearing remover (J-42379) to remove the bearing from the rear of the counter shaft.

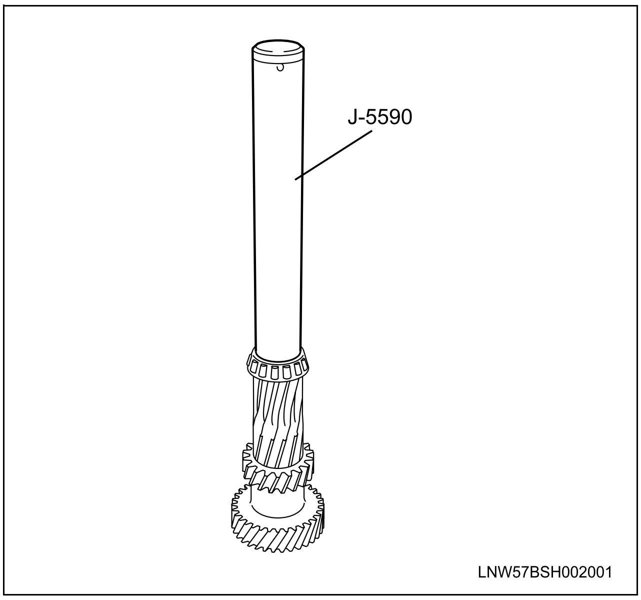


LNW57BSH001901

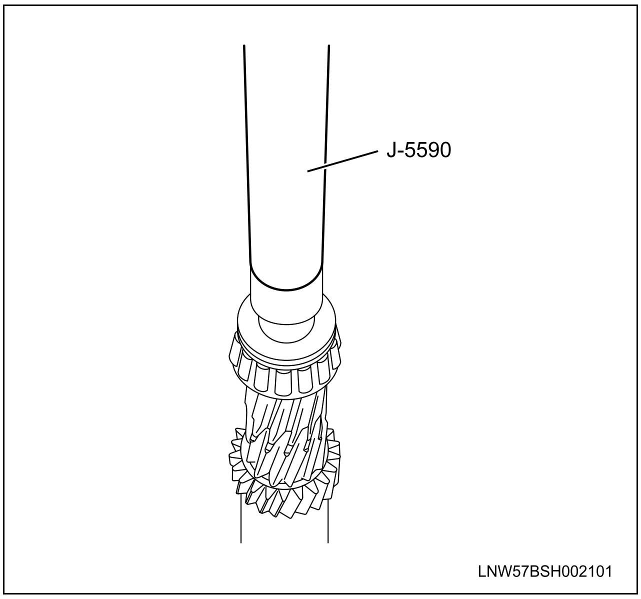
9. Inspect the disassembled parts for wear and/or other damage. Repair or replace damaged parts as required.
10. Check the cross-sectional area of each gear for significant wear and/or damage. If wear of damage is present, the gear must be replaced.
11. Inspect each of the bearings for roughness, abnormal operating noise, corrosion, internal and external damage, and excessive play (in the direction of the slide). Repair or replace the bearings as required.

Reassembly

1. Use the installer (J-5590) and a press to force the rear counter shaft bearing into place.

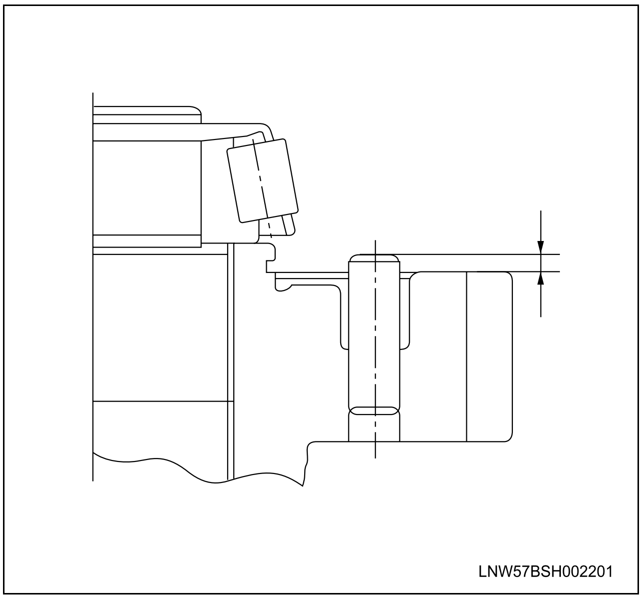


2. Use the installer (J-5590) and a press to force the collar and thrust washer into place.

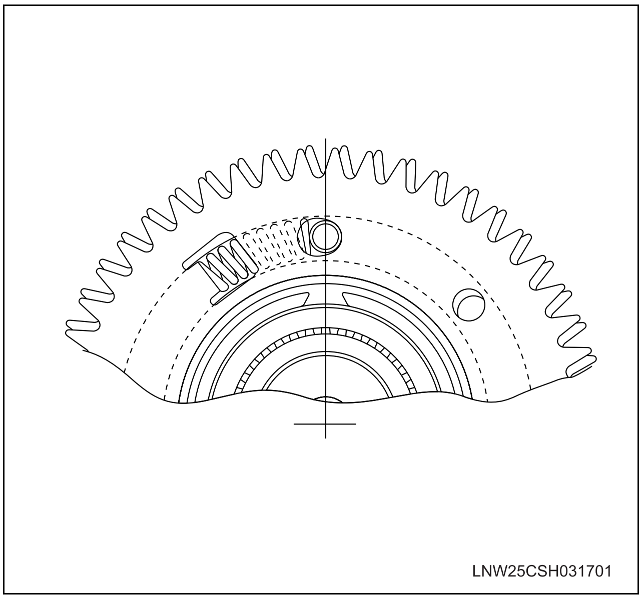


3. Install the straight pin. Pay attention to the pin projection area.

Pin projection area	mm (in)
Standard	
2.80 (0.11)	

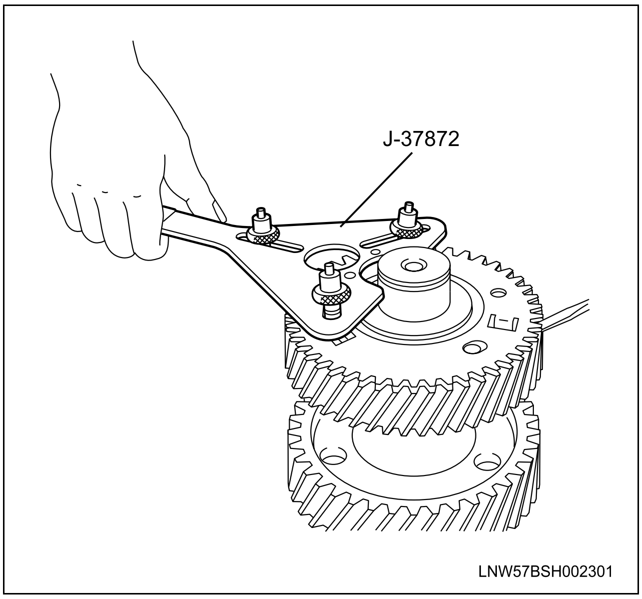


4. Install the 3 coil springs to the 5th gear grooves. When viewed from the center of the gear, the springs will touch the left side of the pin.

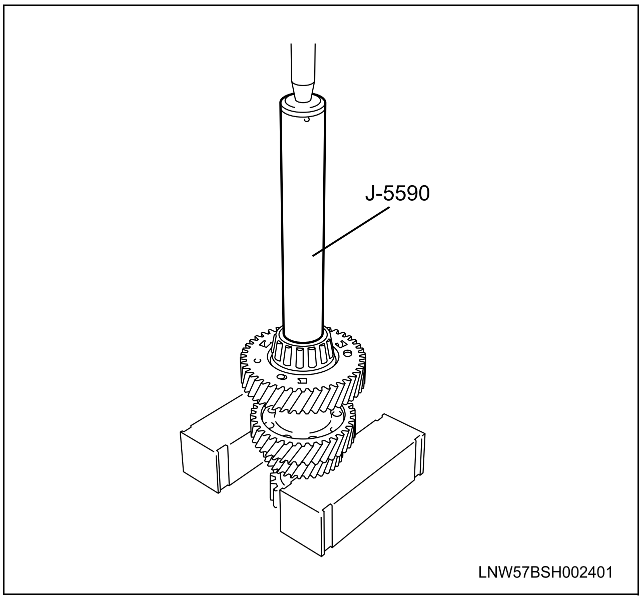


5. Compress the springs between the return portion of the antilash plate and the straight pin.

6. Use the flange holder (J-37872) to align the setting holes in the antilash plate and the 5th gear.



7. Use a pair of snap ring pliers to install the snap ring securing the antilash plate.
8. Use the installer (J-5590) and a press to force the bearing on to the front of the counter shaft.

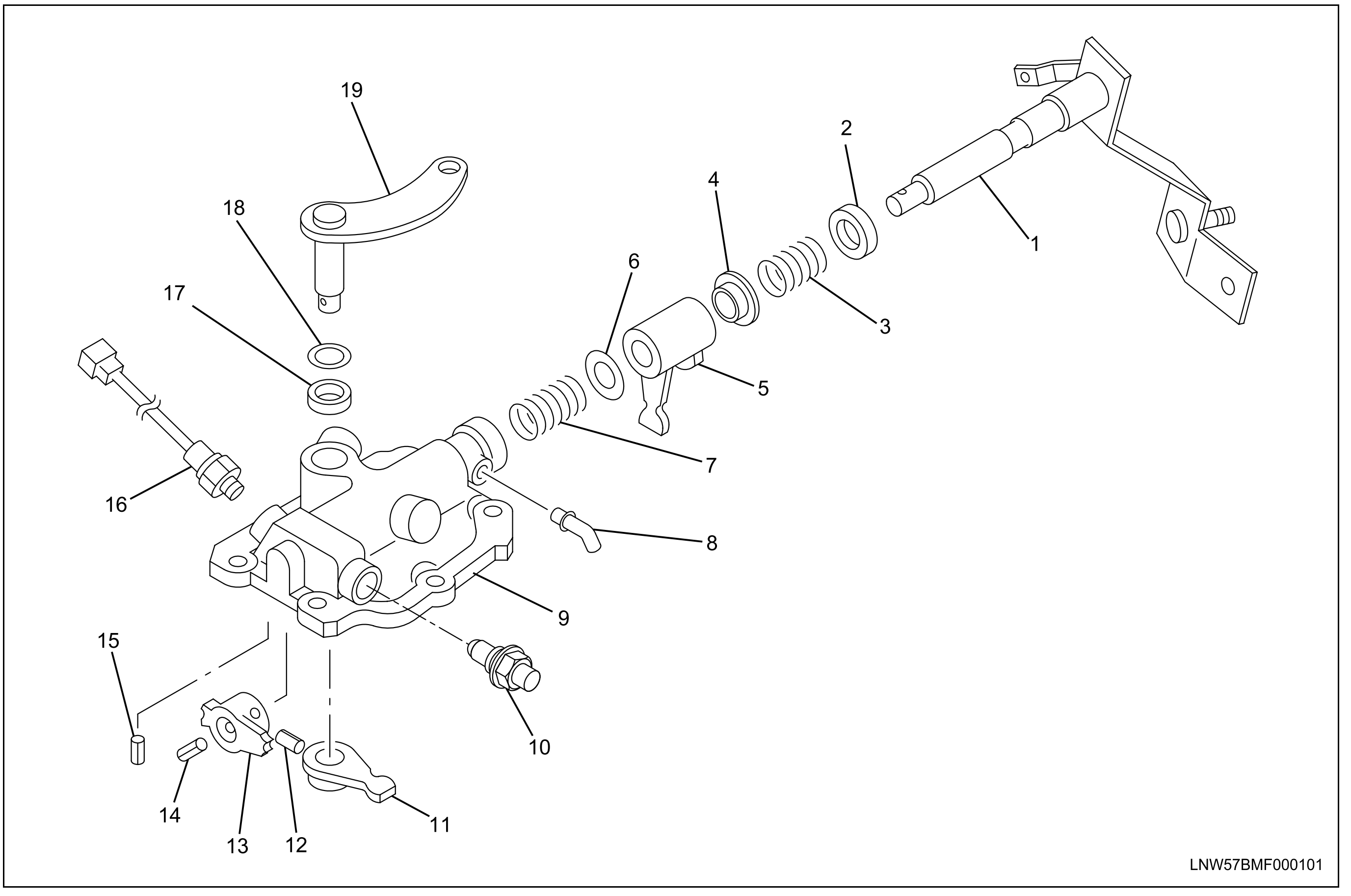


9. Use a pair of snap ring pliers to install the snap ring securing the front counter shaft bearing.
    - From the mountable snap rings, select the thickest one of the three types.

Shim thickness mm (in)	Discernment color
1.9 (0.075)	Colorlessness
2.1 (0.083)	Yellow
2.3 (0.091)	Pink

Notice:
If a snap ring is deformed or damaged, replace it with a new one and verify that it is attached properly.

Control Box

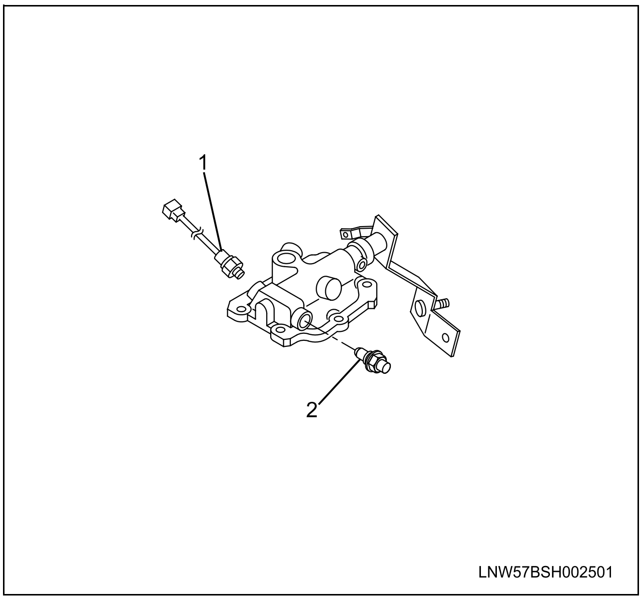


Legend

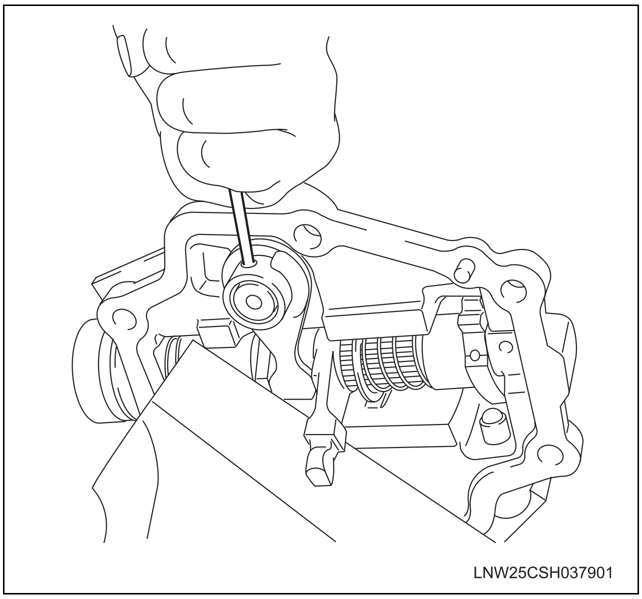
1. Shift Lever Shaft
2. Shift Lever Shaft Oil Seal
3. Spring
4. Washer
5. Shift Internal Lever
6. Spring Seat
7. Spring
8. Pipe
9. Control Box
10. Detent
11. Selector Internal Lever
12. Spring Pin (Selector Internal Lever)
13. Stopper Ring
14. Spring Pin (Stopper Ring)
15. Spring Pin (Shift Lever Shaft)
16. Neutral Switch
17. Selector Lever Shaft Oil Seal
18. Washer
19. Selector External Lever

Disassembly Procedure

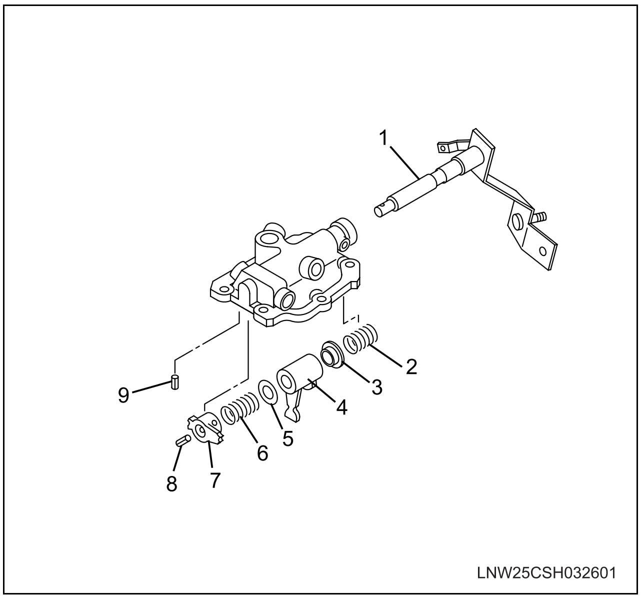
1. Remove the neutral switch (1), the detente (2).



2. Use a spring pin remover to remove the selector internal bar spring pin (4).
3. Remove the selector internal bar (3), the selector external bar (1), and the washer (2).



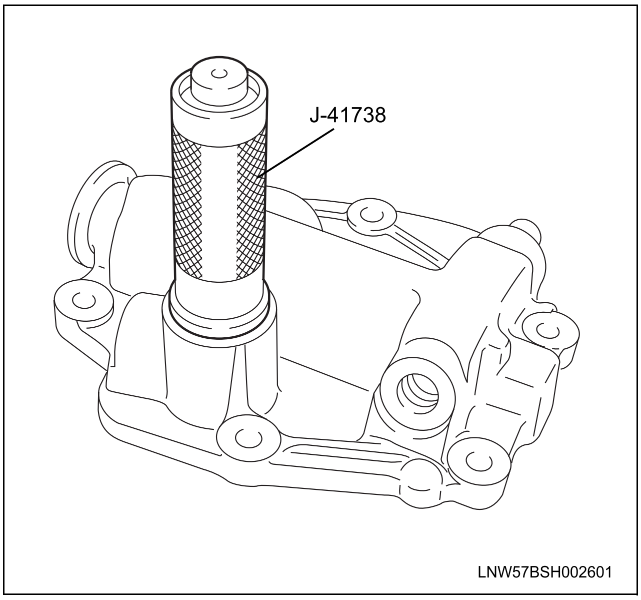
4. Use a pair of pliers to remove the stopper ring spring pin (8) and the shift lever shaft spring pin.
5. Pull the shift lever shaft from the assembly.
6. Remove the stopper ring (7), the spring (6), the spring seat (5), the shift internal bar (4), the washer (3), and the spring (2).



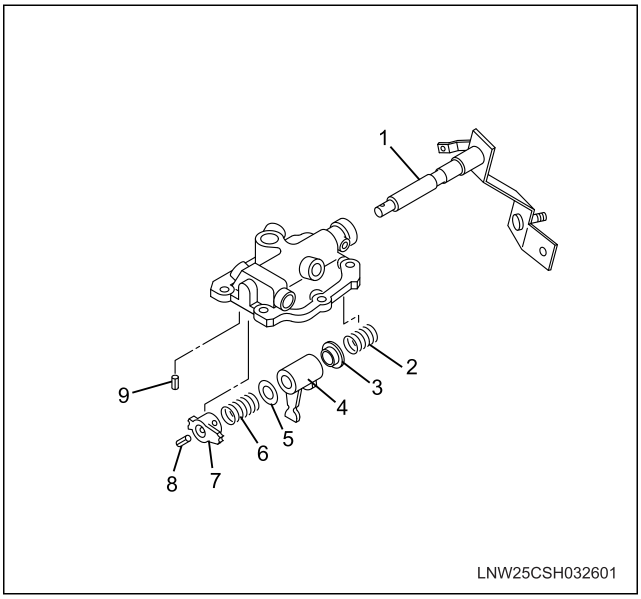
7. Use a screwdriver or similar prying tool to remove the selector lever shaft oil seal and the shift lever shaft oil seal from the control box.
8. Inspect the disassembled parts for wear and/or damage. Make the necessary repairs or replace the part as appropriate.
9. Inspect the shift lever shaft for significant wear. Replace the shaft if significant wear is present.
10. Inspect the control box for excessive play and rough or restricted movement. Replace the control box if either of these conditions is present.

Reassembly Procedure

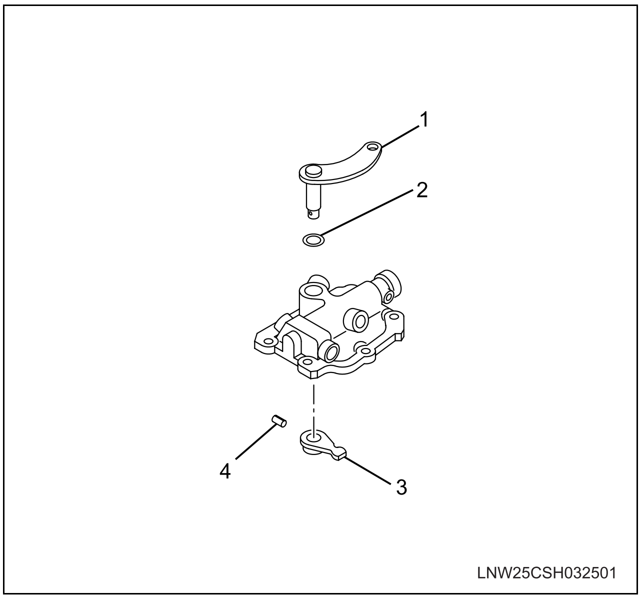
1. Use the installer (J-41738) to install the shift lever shaft oil seal and the selector lever shaft oil seal to the control box.



2. Install the spring (2), the washer (3), the shift internal lever (4), the spring seat (5), the spring (6), and the stopper ring (7) to the control box.
3. Insert the shift lever shaft (1).
4. Align the pin holes in the shift lever shaft and the stopper ring.
5. Drive the new stopper ring spring pin (8) and the new shift lever shaft spring pin (9) into place.



6. Install the selector external lever (1) and the washer (2) to the control box.
7. Install the selector internal lever (3).
8. Drive the new selector internal lever spring pin into place.



9. Install the detente (2).

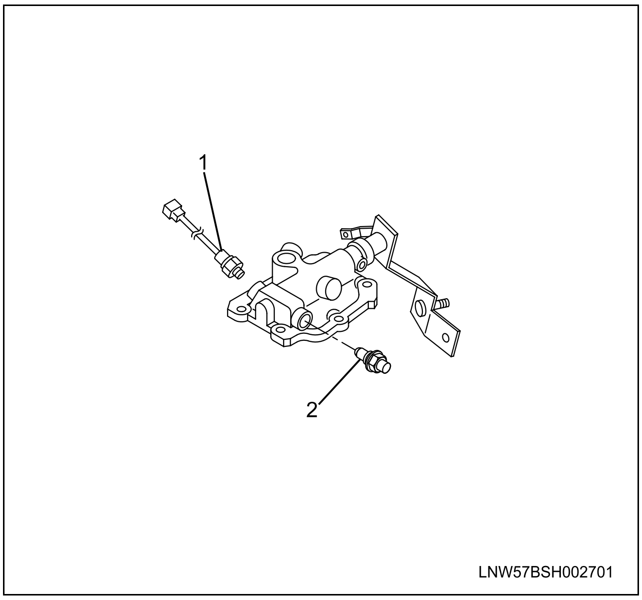
Torque : 28 N·m (21 lb ft)

- Detents are precoated. Be sure to thoroughly remove sealing material around the threads of the case, and use new detents.

10. Tighten the neutral switch (1) to the specified torque.

- Thoroughly remove sealing material from the threads, apply Loctite 242 to them, and then assemble.

Torque : 34 N·m (25 lb ft)



Specifications

Specifications

Transmission Type	MZZ6U Direct Drive 6-Speed
Gear Mesh Type	1st, 2nd, 3rd, Reverse: Synchro-mesh
Gear Ratio	1st 6.369
	2nd 3.767
	3rd 2.234
	4th 1.442
	5th 1.000
	6th 0.782
	Reverse 6.369
Lubricating Oil	Engine Oil SAE 5W-30
Oil Capacity	Approx. 4.4 Liters (9.30 pints)
Weight without Lubricating Oil	100 kg (221 lb)
Distance between Center of Shift Lever Play and Center Cluster	283 ± 15 mm (11.1 ± 0.6 in)
Spline Play between Clutch Hub and Main shaft	0–0.16 mm (0–0.01 in)
Shift Arm Thickness	More than 9.0 mm (0.354 in)
	6th 9.3 mm (0.366 in)
Gear Inside Diameter	1st, 2nd, 3rd, Reverse 63.1 mm (2.483 in)
	4th 55.1 mm (2.168 in)
	5th 48.0 mm (1.892 in)
	6th 50.1 mm (1.971 in)
Main Shaft Deflection	0.1 mm (0.004 in)
Block Ring and Dog Gear Gap	0.5 mm (0.020 in)
Block and Clutch Hub Gap	1st / Reverse, 3rd / 2nd 3.3–3.7 mm (0.130–0.150 in)

Fastener Torques

Clutch Housing to Transmission Case Bolt	46 N·m (34 lb ft)
Rear Cover Bolt	46 N·m (34 lb ft)
Control Box Bolt	27 N·m (20 lb ft)
Filler Plug	39 N·m (29 lb ft)
Drain Plug	39 N·m (29 lb ft)
Drive Coupling Lock Nut	382 N·m (282 lb ft)
Reverse Switch	39 N·m (29 lb ft)
Neutral Switch	34 N·m (25 lb ft)
Vehicle Speed Sensor Driven Gear Mounting Bolt	20 N·m (2.0 lb ft)
Vehicle Speed Sensor	25 N·m (18 lb ft)
Retainer Bolt	26 N·m (20 lb ft)
6th Relay Lever Bolt	50 N·m (37 lb ft)
Reverse Gear Side cover Bolt	23 N·m (17 lb ft)
PTO Cover Bolt	46 N·m (34 lb ft)
Detente Plug	27 N·m (20 lb ft)
Parking Brake Bracket Bolt	48 N·m (35 lb ft)

Special Tools

Special Tools

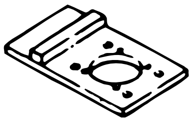
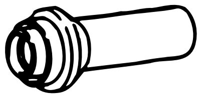
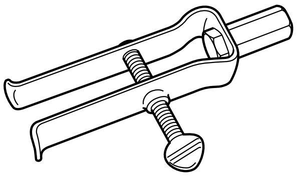
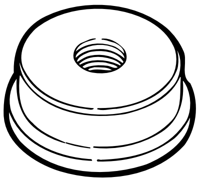
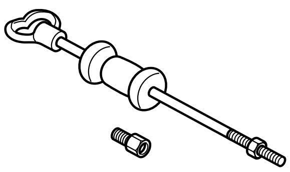
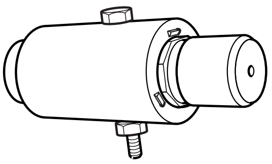
Illustration	Tool Number/ Description
	J-35016 Drive Pinion Flange Bracket
	J-45881 Oil Seal Installer
	J-26941 Bearing Remover
	J-38412 Bearing Installer
	J-2619-01 Sliding Hammer
	J-45883 Bush Remover & Installer

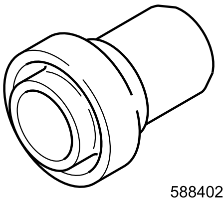
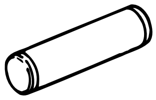
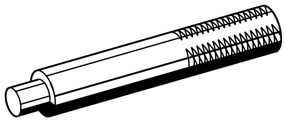
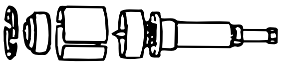
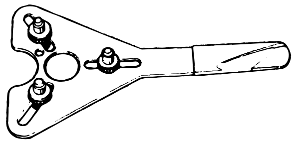
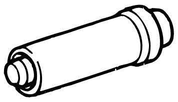
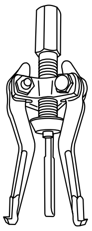
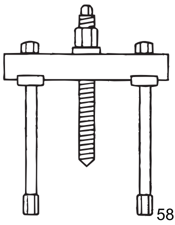
Illustration	Tool Number/ Description
	J-42802 Oil Seal Installer
	J-5590 Bearing Installer
	J-8092 Driver Handle
	J-45882 Bearing Installer
	J-41736 Clutch Hub & Collar Installer
	J-42379 Bearing Remover

Illustration	Tool Number/ Description
 5884040560	J-37872 Flange Holder
 5884022450	J-41738 Oil Seal Installer
 5884027570	J-45887 Bearing Remover
 5884028020	J-47042 Push Puller

TRANSMISSION/TRANSAXLE

CLUTCH

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Description and Operation

Clutch System

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Driving Members

The driving members of a clutch usually consist of two flat surfaces machined to a smooth finish.
One of these surfaces is usually the rear face of the engine flywheel, and the other is a comparatively heavy flat ring with one side machined. This part is known as the pressure plate. It is fitted into a steel cover, which also contains some of the operating members, and is bolted to the flywheel.

Driven Member

The driven member is a clutch disc with a splined hub which is free to slide lengthwise along the splines of the clutch shaft, but which drives the shaft through these same splines. Suitable frictional facings are attached to each side of the clutch disc by means of rivets. These facings must be heat resistant since friction produces heat.

Operating Members

The driving and driven members are held in contact by spring pressure.
The throwout (clutch release) bearing is a ballthrust bearing contained in the clutch housing, mounted on a sleeve attached to the front of the transmission case. The throwout bearing is moved by the clutch release yoke to contact the release levers and move the pressure plate to the rear, thus separating the clutch driving members from the driven member when the clutch pedal is depressed by the driver.

Clutch Controls

This system utilizes hydraulic pressure as a means of transmitting clutch pedal movement to the clutch release mechanism. The system consists of a pedal-operated master cylinder and a slave cylinder, interconnected with hydraulic lines. The clutch pedal is connected to the master cylinder pushrod, and the slave cylinder pushrod is connected to the clutch release fork.

Diagnostic Information and Procedures

Diagnosis of Clutch

Condition	Possible Cause	Correction
Clutch Slips	Binding of release levers in the pressure plate and cover assembly.	Replace the clutch cover assembly.
	Clutch release levers improperly adjusted.	If levers are in place, adjust free pedal.
	Facings loose on the clutch disc.	Replace the driven disc assembly.
	Improper clutch release bearing adjustment.	Adjust for proper clearance (free pedal).
	Binding or sticking clutch pedal assembly.	Repair or replace faulty parts. Check linkage for proper adjustment.
	Weak or broken clutch pressure springs.	Replace the clutch cover assembly.
	Burned clutch facings.	Replace clutch driven disc assembly and check flywheel and pressure plate friction surfaces for damage replace parts as necessary.
	Binding or sticking of the clutch disc hub on the transmission drive gear.	Lubricate splines with high temperature grease (if dry). Replace driven discs if splined hubs are worn.
	Release bearing binding on bearing retainer.	Replace release bearing or lubricate.
	Warped pressure plate or engine flywheel.	Replace defective parts. Check transmission, clutch, and engine alignment.
	No free pedal	Adjust for free pedal, check clutch driven disc wear and replace parts as required.

Condition	Possible Cause	Correction
Clutch Chatters During Engagement	Loose engine mounts.	Tighten engine mount bolts to specifications.
	Grease or oil on facings.	Replace driven disc assembly and repair oil leak.
	Slight binding in linkage during engagement.	Check linkage for wear or damage. Replace parts as required.
	Weak pressure springs.	Replace clutch cover assembly.
	Clutch release levers binding during engagement.	Repair or replace clutch cover assembly.
	Worn or broken pilot bearing.	Replace and lubricate pilot bearing.
	Rough engine idle.	Tune engine to manufacturer's specifications.
	Bent or out of plane pressure plate fingers.	Replace clutch cover assembly if release fingers are more than 2 mm (0.079 in) out of plane.
	Driven disc warped, cracked, or loose friction material.	Replace driven disc assembly.
	Pressure plate warped or hot spots.	Replace pressure plate or clutch cover assembly.
	Flywheel warpage or discoloration.	Replace flywheel.
	Flywheel housing bore and face not aligned.	Correct per alignment procedure.

Condition	Possible Cause	Correction
Clutch Drags When Disengaged	Pedal cannot disengage clutch because of excessive free pedal travel.	Check pedal and linkage for wear, replace parts as required. Adjust clutch and linkage for proper free travel.
	Clutch release levers need adjustment.	Replace clutch cover assembly.
	High spots on clutch facings.	Replace driven disc assembly.
	Loose rivet in facings.	Replace driven disc assembly. Check for damaged flywheel and pressure plate, replace as necessary.
	Clutch disc wobbles because of broken springs in hub.	Replace driven disc assembly.
	Flange of clutch cover not in alignment with flywheel because of loose bolts or bent flange.	Torque bolts to specifications or replace cover assembly.
	Deteriorated or broken engine mounts.	Replace engine mountings.
	Worn clutch release bearing.	Replace release bearing and adjust clutch free pedal.
	Worn linkage components.	Check pedal and linkage for wear; replace parts as required.
	Clutch disc warped.	Replace driven disc assembly, also check flywheel for deep heat checks. Replace flywheel as necessary.
	Broken or loose facings.	Replace driven disc assembly.
	Misalignment of transmission.	Check engine mounts, wear on flywheel housing, and bolt torque.
	Main drive gear misaligned because of worn bearings.	Repair transmission if required and check flywheel pilot bearing; replace pilot bearing as required.
	Clutch pressure plate warped.	Replace clutch cover assembly; also check flywheel surface for dished out wear pattern. Replace flywheel as required.
	Loose flywheel housing bolts.	Torque bolts to specifications.

Condition	Possible Cause	Correction
Clutch Grabs	Grease or oil on clutch facings.	Replace driven disc assembly and repair oil leak.
	Exposed rivet heads due to excessively worn facings or loose rivets.	Replace driven disc assembly and check for flywheel and pressure plate damage. Replace damaged parts.
	Loose engine mounts.	Tighten engine mount bolts to specifications.
	Clutch pressure springs too stiff.	Replace clutch cover assembly.
	Momentary binding in linkage while clutch is being engaged.	Check pedal and linkage for wear or damage. Replace parts as required.
	Warped pressure plate, or flywheel.	Replace damaged parts. Check alignment.

Condition	Possible Cause	Correction
Clutch Noisy When Engaged	Improper clutch release bearing adjustment.	Adjust clutch linkage for pedal free play.
	Clutch disc damper springs weak or broken.	Replace driven disc assembly.
	Linkage binds.	Check pedal and linkage. Replace or repair as required.
	Clutch release bearing binding.	Check for alignment and release bearing lubricant. Replace bearing as required.
	Loose flywheel or clutch cover bolts.	Torque bolts to specifications.
	Misalignment of transmission.	Check engine mountings, wear on flywheel housing, and fastener torque.
	Worn splines on clutch disc or transmission main drive gear.	Replace parts as required. Lubricate with high temperature grease.
	Weak or missing clutch return springs.	Replace clutch cover assembly.
	Clutch pedal assembly binding.	Check pedal and linkage for wear or damage. Repair or replace parts as required.

Condition	Possible Cause	Correction
Clutch Pedal Pulsates During Engagement	Misalignment of transmission.	Check engine mountings, wear on flywheel housing, and fastener torque.
	Loose or improperly installed engine mounts.	Refer to ENGINE (SEC. 6A) for proper engine mount installation.
	Clutch release levers not adjusted to uniform height.	Replace clutch cover assembly.

Condition	Possible Cause	Correction
Clutch Rattles When Disengaged With Engine Idling	Wear or looseness in linkage.	Check linkage for wear or damage. Replace parts as required.
	Retractor springs on release lever weak, broken, or disconnected.	Replace clutch cover assembly.
	Loose flywheel or clutch cover bolts.	Torque bolts to specifications.
	Rough engine idle.	Tune engine to manufacturer's specifications.

Condition	Possible Cause	Correction
Clutch Noisy When Disengaged	Pilot bearing or bushing in crankshaft worn, damaged, broken, or inadequately lubricated.	Replace parts as required. Lubricate with high temperature grease.
	Release bearing worn, dirty, damaged, broken, or inadequately lubricated.	Replace release bearing. Lubricate with high temperature grease.
	Transmission main drive gear bearing worn, dirty or lacks lubricant.	Repair transmission. Check for rear bearing cap oil hole for restriction clearance.

On-Vehicle Service

Clutch System Inspection

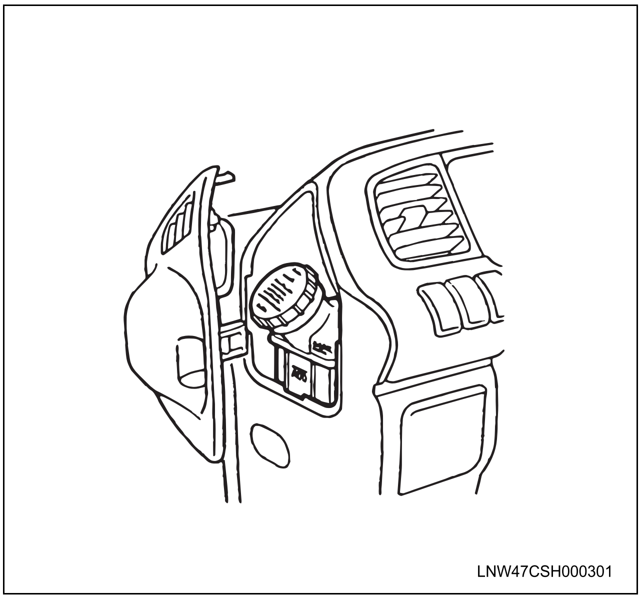
The system should be checked and serviced periodically as stated below.

- Maintain the proper level of hydraulic fluid in the master cylinder reservoir. Refer to MAINTENANCE AND LUBRICATION (SEC. 0B) for recommended fluid and checking intervals.
- Inspect the entire clutch system regularly for fluid leakage. Leakage must be corrected immediately.
- Adjust the clutch linkage if necessary.
- If the clutch pedal action is springy or spongy, it is an indication that air needs to be bled from the hydraulic system.

A specified clearance in the hydraulic control linkage must exist between the end of the push rod and master cylinder piston. This clearance is measured as pedal free travel.

Before making the adjustment, make sure that the level of fluid in the master cylinder reservoir is 13 mm (1/2 in) below the top of the reservoir. The fluid system must be free of air.

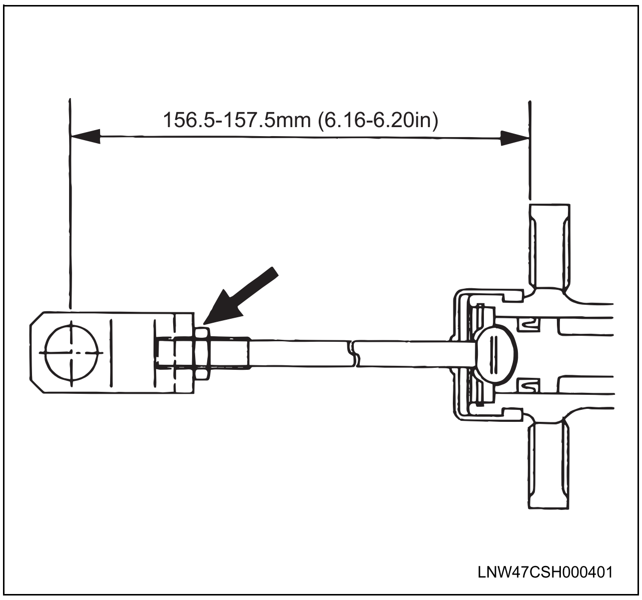
The dual brake/clutch master cylinder reservoir is in the left-upper portion of the dash panel. It can be accessed by opening the driver door.



Clutch Pedal Free Play, Height and Travel Adjustment

Adjust

1. Loosen the jam nut (5) on the clutch switch (6).
2. Remove the master cylinder from the clutch pedal assembly.
3. Loosen the jam nut on the master cylinder push rod.
4. Turn the push rod until the distance from the centre of clevis pin hole to mounting surface of clutch pedal bracket should be set at 157.0-157.5 mm (6.18-6.20 in).
   When fixed under this condition, there is no need to adjust the clutch pedal height and free play.



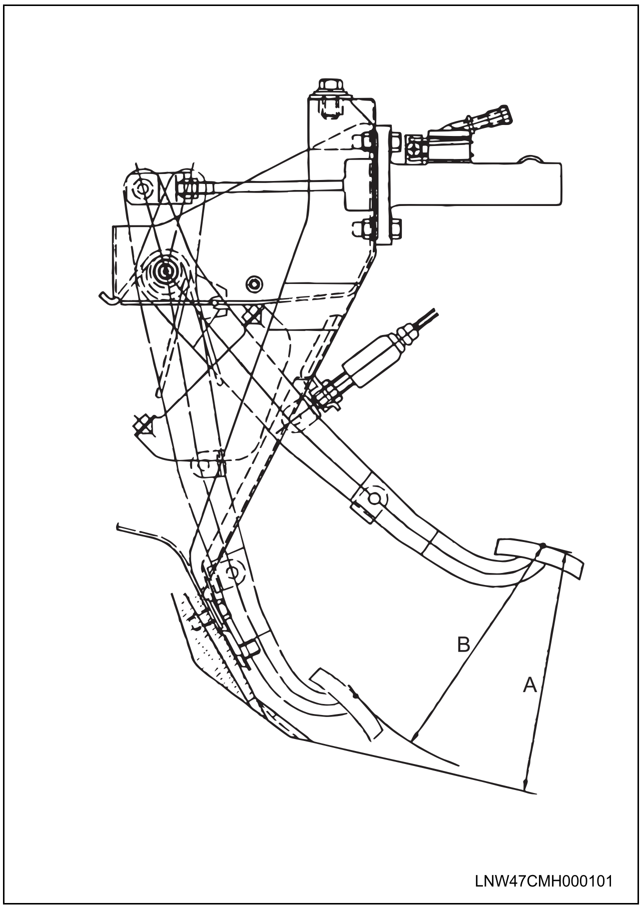
5. Tighten the master cylinder push rod jam nut .

Tighten

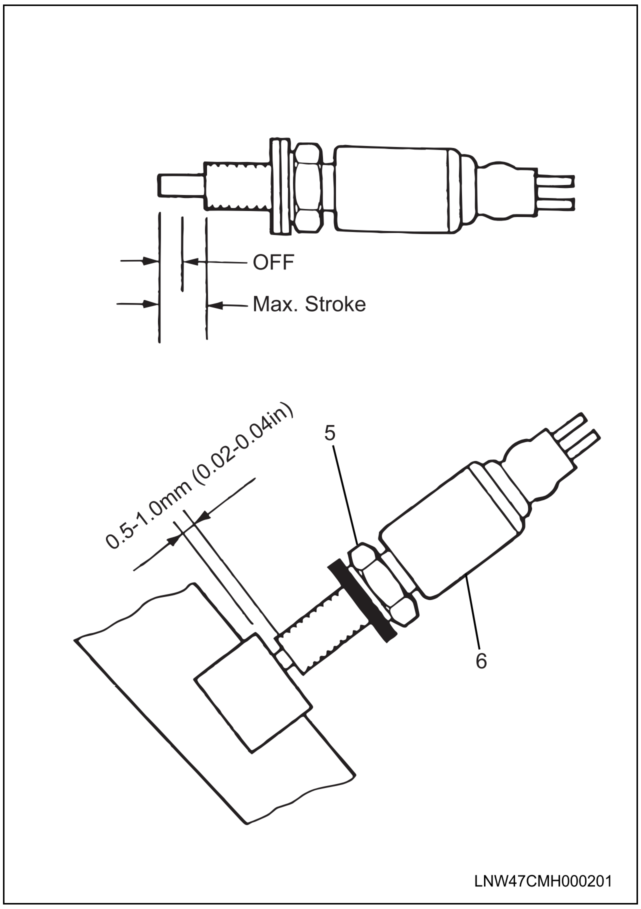
- Jam nut to 13 N·m (113 lb in).

6. Install the master cylinder to the clutch pedal assembly.
   Measurement
   - Clutch pedal normal play is between 15-25 mm (0.6-1.0 in) (reference).
   - Clutch pedal height “A” is between 160-170 mm (6.3-6.7 in) (reference).

- Clutch pedal travel “B” is between 159-169 mm (6.2-6.7 in) (reference).



7. Check clearance at the clutch switch. Turn the switch in its bracket until the clearance between the fully depressed plunger and the clutch pedal is 0.5-1.0 mm (0.02-0.04 in) .



Legend

5. Jam Nut
6. Clutch Switch

Caution:
Clutch switch must be adjusted so that when the clutch pedal is released, it closes the switch but does not completely depress the switch plunger (max stroke see figure). If the plunger is completely depressed by the pedal, switch damage may result.

8. Tighten the jam nut (5) at the clutch switch.

Tighten

- Jam nut to 13 N·m (113 lb in).

9. Recheck the clutch switch clearance.

Bleeding the Clutch Hydraulic Circuits

If air enters the clutch circuit, it will cause the clutch to drag. It will be necessary to bleed the clutch fluid circuit if the reservoir has been emptied or the hydraulic circuit has been disassembled. To bleed the clutch circuit properly, an assistant will be needed.

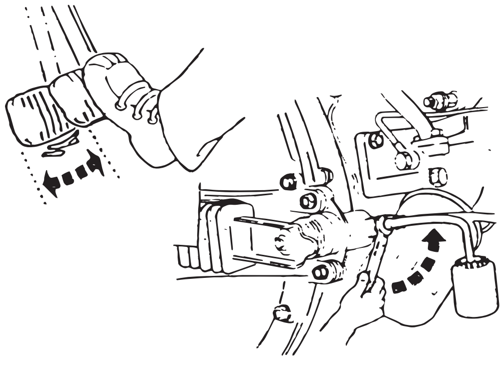
Bleeding Procedure

1. Check the level of the clutch fluid in the clutch reservoir and add clutch fluid if necessary.
2. Remove the rubber cap from the bleeder screw and wipe the bleeder screw clean. Connect a vinyl tube to the bleeder screw and insert the other end of the vinyl tube into a transparent container. Pump the clutch pedal repeatedly and hold the pedal in the depressed position.
3. Loosen the bleeder screw on the clutch slave cylinder to discharge clutch fluid and air bubbles into a container then tighten the bleeder screw immediately.
4. Release the clutch pedal slowly. Repeat step 3 until all air bubbles disappear from the clutch fluid being discharged into the container. During the bleeding operation, keep the clutch fluid reservoir filled to 13 mm (1/2 in) below the top of the reservoir.
5. Install the rubber cap onto the bleeder screw.

Optional Bleeding Method

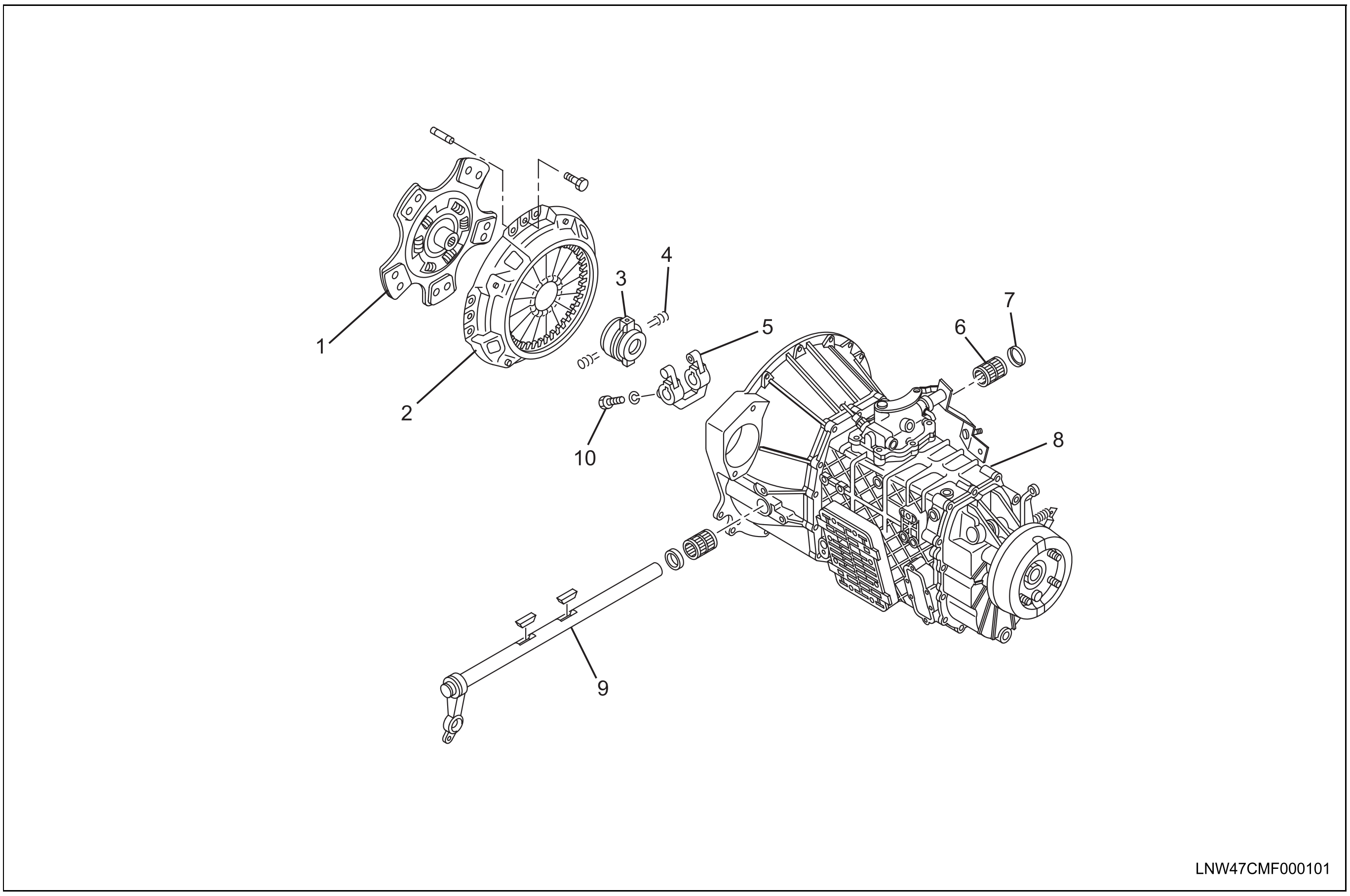
Tool Required:
J-35854 Power Bleeder Adapter or Equivalent

- Connect a power bleeding machine to the master cylinder with the use of adapter J-35854 or equivalent. Bleed until all air bubbles are out of the system and a solid pedal is obtained.



Repair Instructions

Clutch Assembly

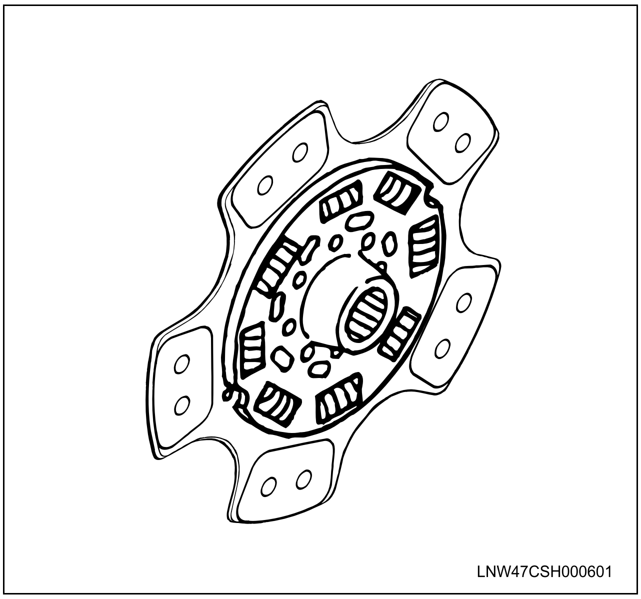


Legend

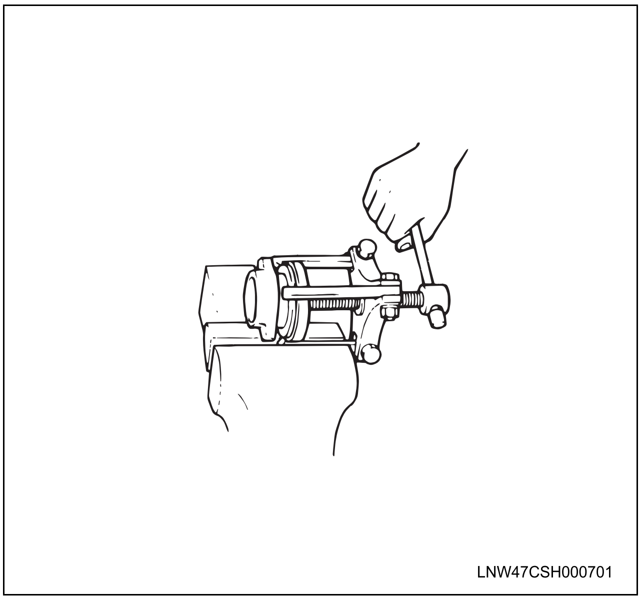
1. Clutch Disc Assembly
2. Pressure Plate Assembly
3. Release Bearing
4. Return Spring
5. Shift Fork
6. Needle Bearing
7. Dust Cover
8. Transmission Assembly
9. Clutch Shaft
10. Set Bolt

Removal Procedure

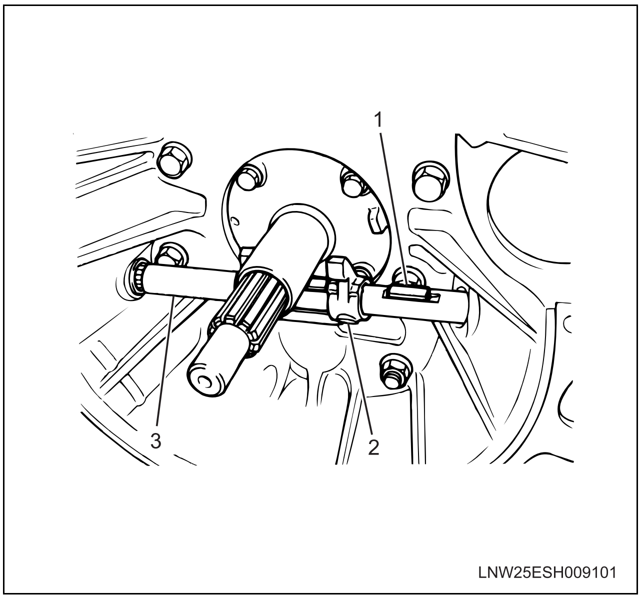
1. Transmission assembly. (8)
   Refer to MANUAL TRANSMISSION (SEC. 7B3).
2. Pressure plate assembly. (2)
3. Clutch Disc assembly. (1)



4. Return spring.
5. Release bearing.
   - Use suitable puller to remove the release bearing.



6. Set bolt.
7. Clutch shaft.
   - Remove the clutch shaft. Clutch shaft with a brass bar to remove it.
8. Shift fork.



Legend

1. Key
2. Shift Fork
3. Clutch Shaft

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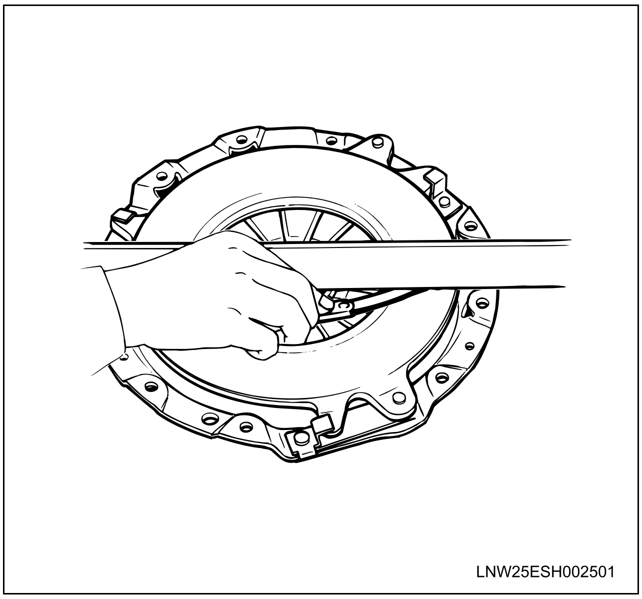
9. Dust cover.
10. Needle bearing.

Inspection

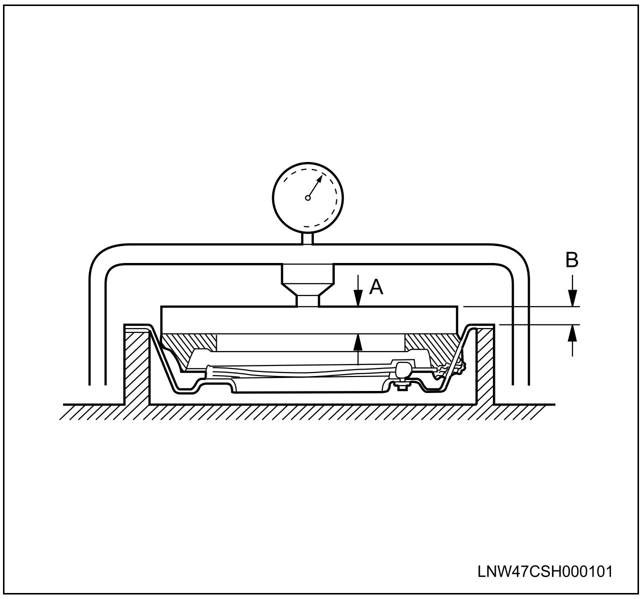
- Pressure plate cover for cracks or distortion.
- Diaphragm spring for heat distortion.
- For loose or bent rivets.
- Release bearing for roughness or noise by rotating the bearing race under light pressure.
- Shift fork for wear or damage.
- Pilot bearing on the crankshaft for roughness by rotating the bearing race under light pressure.
- Replace all parts that would effect proper operation of the clutch release assembly.
- Replace the flywheel, pressure plate assembly, or driven plate if found to be scored, burned, warped, or worn. Do not machine the flywheel or the pressure plate to eliminate these conditions.

Measurement

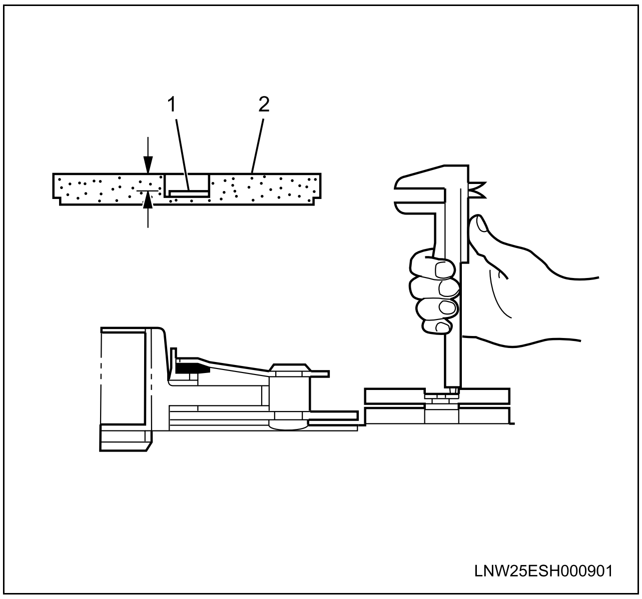
- Pressure plate wear.
  If the wear exceeds the limit 0.3 mm (0.012 in), the pressure plate assembly must be replaced.



- Pressure plate clamping force. Invert the pressure plate and position an 9.2 mm (0.36 in) thick plate A over the pressure plate with hydraulic press. Then observe the load gage reading when the dimension B becomes 19 mm (0.75 in) as indicated in figure. Replace the pressure plate assembly if the clamping force is less than 970 kg (2,139 lb).

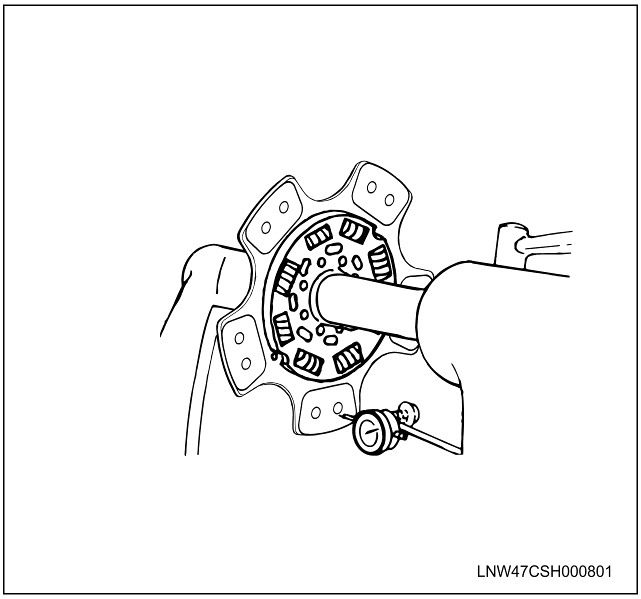


- The depression of the rivet head (1) on the driven plate (2). Replace the Clutch Disc assembly if the thickness of the friction material is less than 0.2 mm (0.008 in).

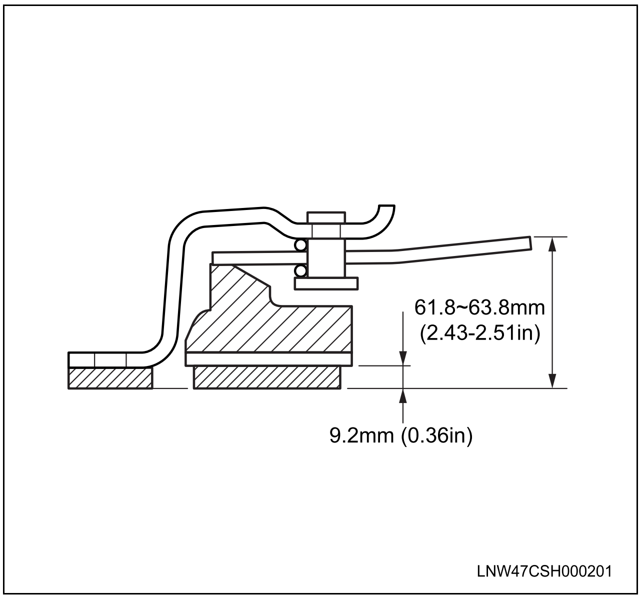


- Clutch Disc warpage

Limit	: 0.6 mm (0.024 in).
Clutch Size	: 325 mm (12.80 in).

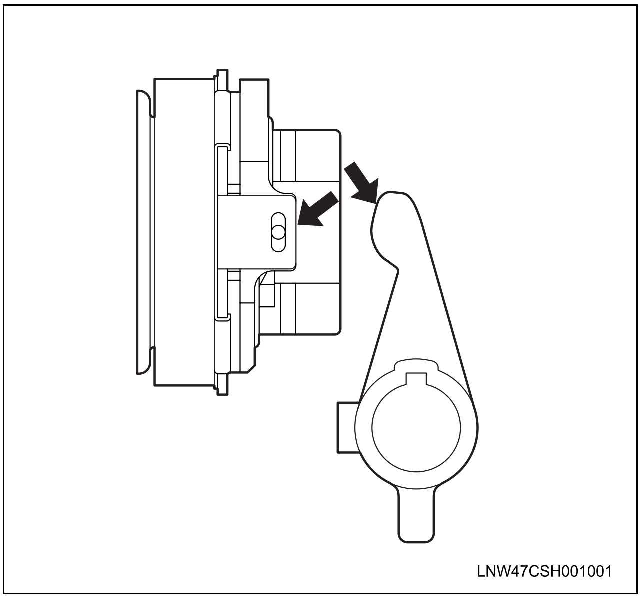


- Height of the diaphragm spring fingers. Position an 9.2 mm (0.36 in) thick plate under the pressure plate. Compress the diaphragm spring until the spring touches the table. Measure the height of the diaphragm spring fingers. They must be 61.8-63.8 mm (2.43-2.51 in) high.

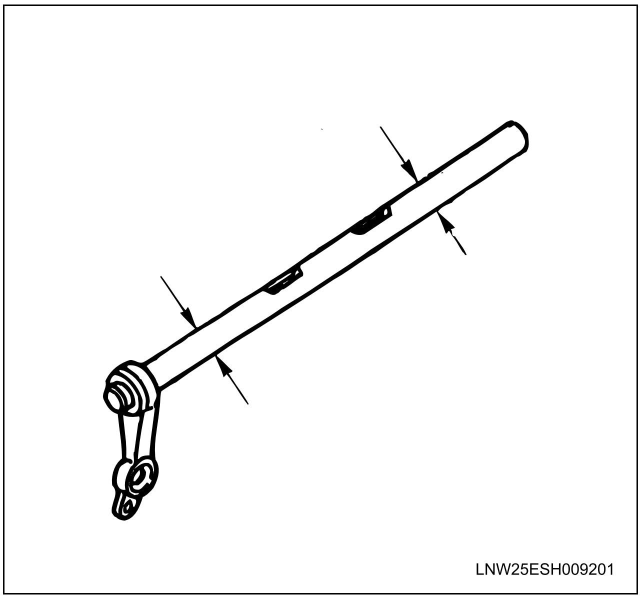


- Check the surface of the release bearing for wear or damage.

- Check the surface of the shift fork for wear or damage.


LNW47CSH001001

- Clutch shaft diameters as shown in figure. If the diameter is less than 24.5 mm (0.96 in), replace the clutch shaft and needle bearing.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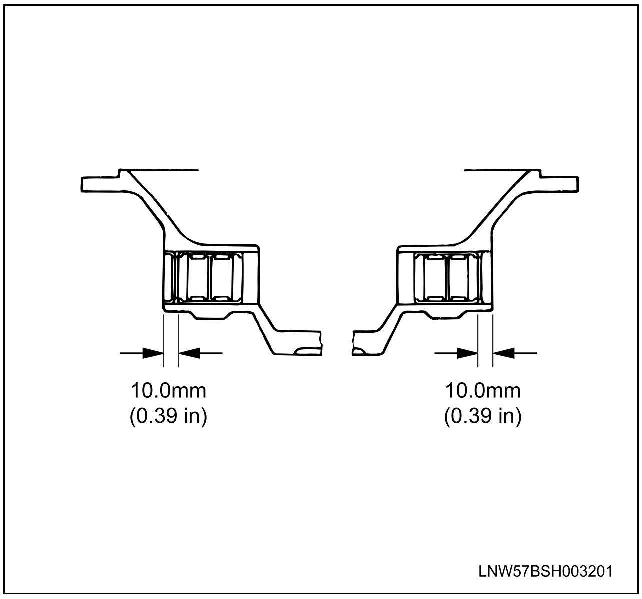
Installation Procedure

1. Needle bearing.
   - Use a 32 mm (1.26 in) diameter bar to drive the Needle bearing from the marked side of bearing and install it specified depth as shows in illustration.



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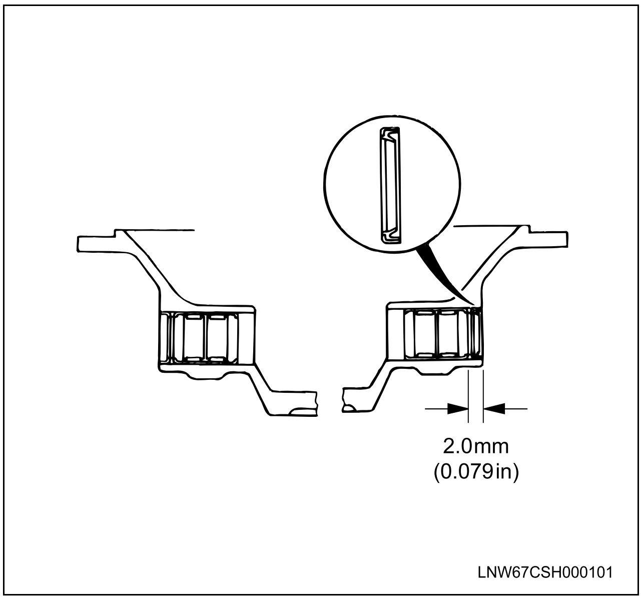
2. Dust seal.
   - Before installing the new bearing, apply MoS2 contained type grease to the bearing surfaces and the clearance area between the bearing and the dust seal.

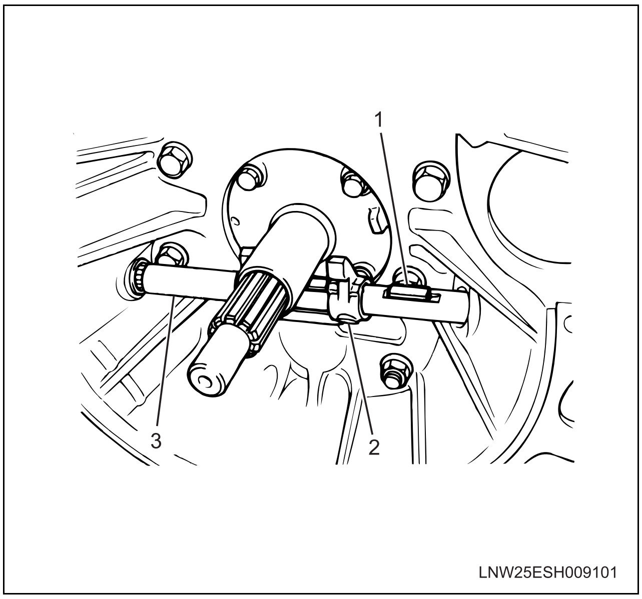


LNW67CSH000101

3. Shift fork.
4. Clutch shaft and key.
5. Set bolt.
   - Install the clutch shaft to the clutch housing.
   - Key and shift fork onto the clutch shaft assembly.
   - Tighten the set bolt

Tighten

- Set bolt to 13 N·m (113 lb in)



Legend

1. Key
2. Shift Fork
3. Clutch Shaft

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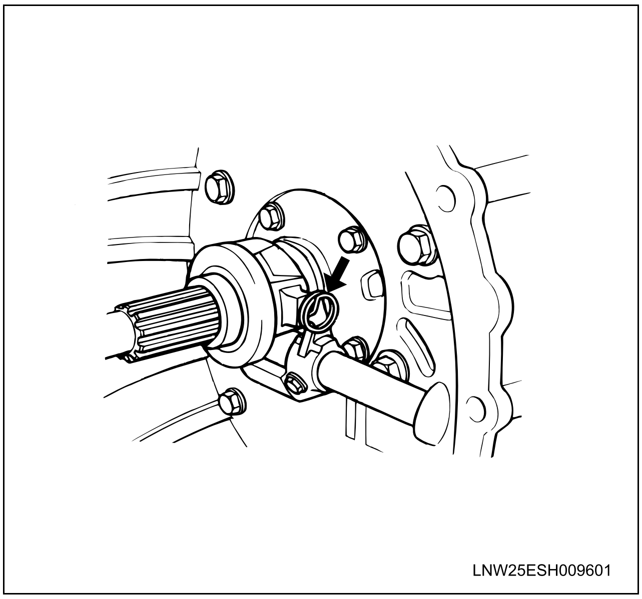
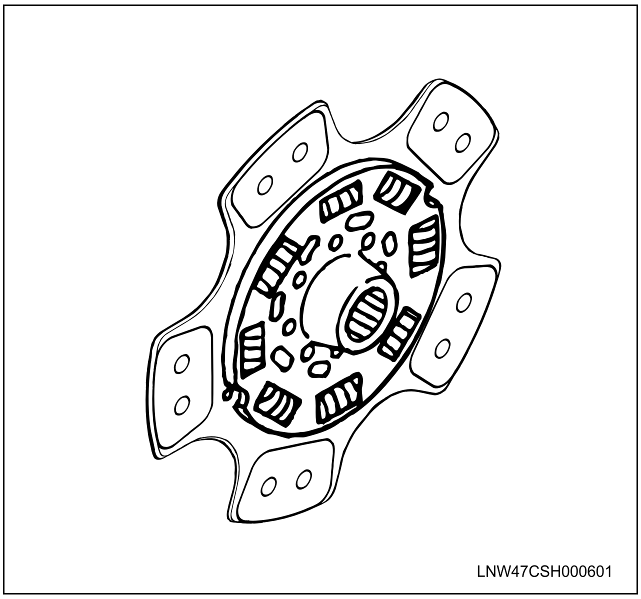
6. Release bearing
7. Return spring.
    - Apply the MoS2 contained type grease to shift fork and surfaces.
    - Install the return spring.



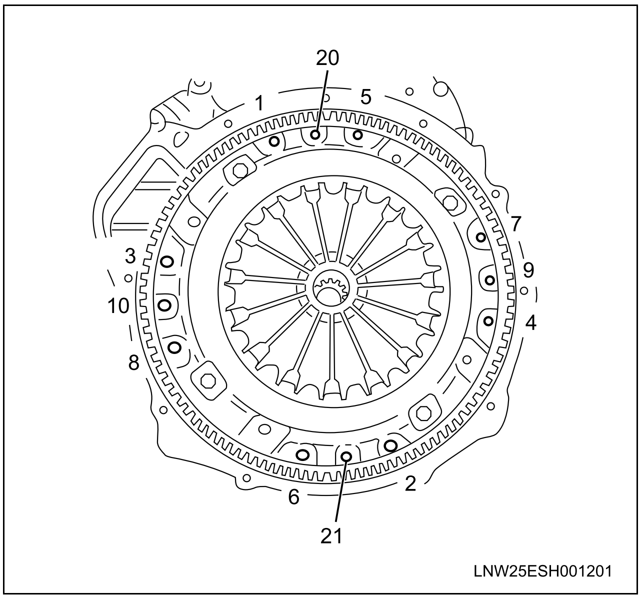
8. Clutch Disc assembly.
    - Clutch pilot aligner J-45991 into the center of the Clutch Disc assembly.



9. Pressure plate assembly.
    - Install the pressure plate assembly to the flywheel.
      If the pressure plate was replaced to new parts, be sure to remove the ring which is installed to the diaphragm spring.

Tighten

- Pressure plate bolt to 40 N·m (30 lb ft) in the sequence shown in the figure.



Legend

20. Dowel Pin
21. Dowel Pin

- Remove the pilot aligner.

10. Transmission assembly.

Clutch Controls

Removal Procedure

- Drain the clutch fluid from the clutch hydraulic line.

Notice:
Do not let clutch fluid remain on a painted surface. Wash it off immediately.

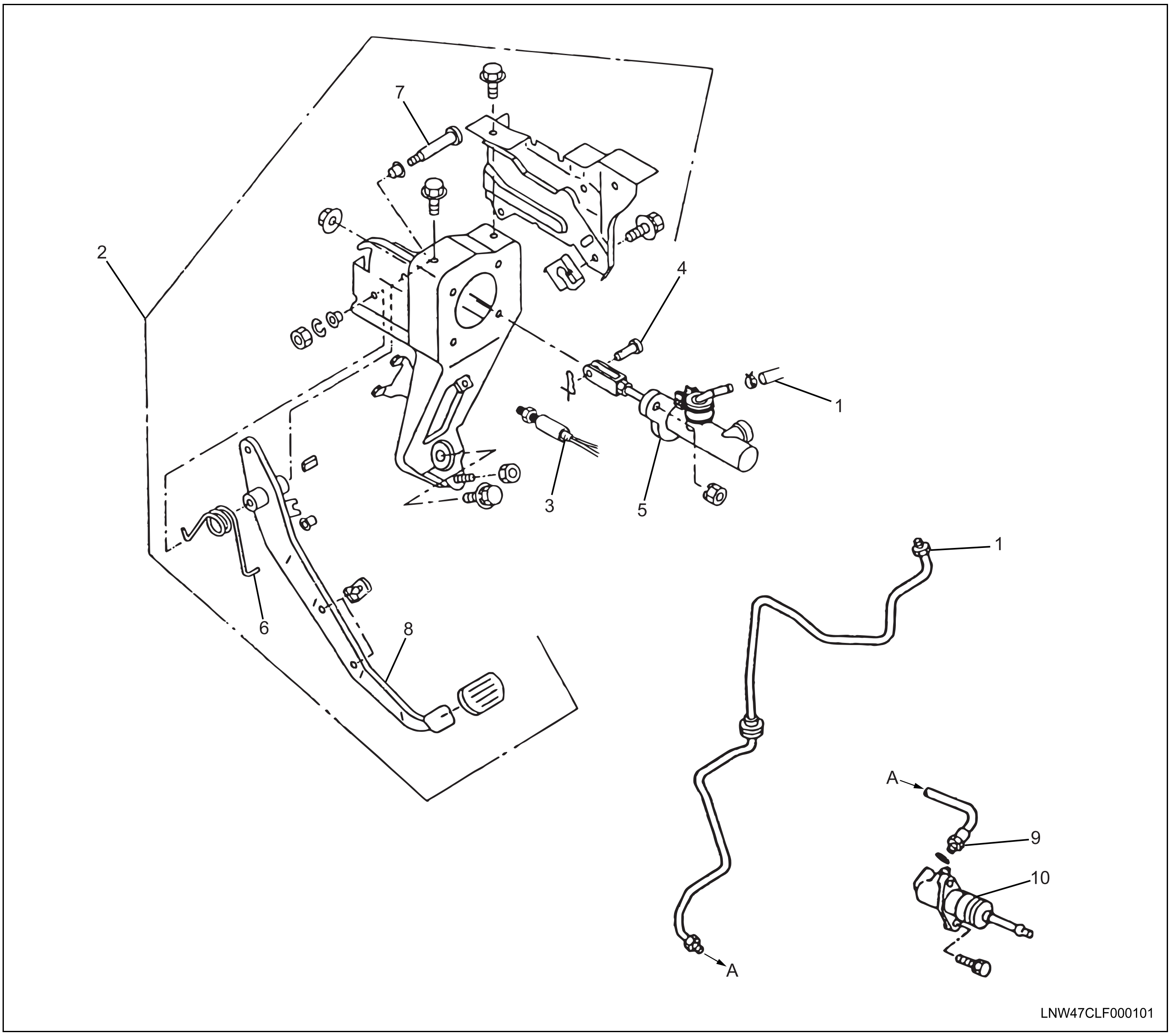
1. Meter cluster and meter assembly.
   - Pull out the meter cluster and disconnect harness connectors.
     Refer to INSTRUMENTAL PANEL (SEC.10D).
2. Electric vacuum pump
   - Remove the electric vacuum pump.
     Refer to ELECTRIC VACUUM PUMP (SEC. 8).
3. Hose and pipe (1).
4. Clutch pedal and bracket assembly (2).
5. Clutch switch (3).
6. Clevis pin (4).
7. Master cylinder (5).
8. Return spring (6).
9. Fulcrum pin (7).
10. Clutch pedal (8).
11. Flexible hose (9).
12. Slave cylinder (10).

Inspection

- All parts for damage or wear.
- The clearance between the pedal shaft and bushings.
- Replace the clutch pedal assembly if the clearance is excessive.

Installation Procedure

Notice:
For steps 1, 6 and 8 see “NOTICE” on page 7C3-2 of this section.



Legend

1. Hose and Pipe
2. Clutch Pedal and Bracket Assembly

3. Clutch Switch
4. Clevis Pin
5. Master Cylinder
6. Return Spring
7. Fulcrum Pin
8. Clutch Pedal
9. Flexible Hose
10. Slave Cylinder

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1. Slave cylinder.

Tighten

- Slave cylinder bolt to 19 N·m (14 lb ft).

2. Flexible hose.
3. Clutch pedal.
4. Fulcrum pin
5. Return spring.
6. Master cylinder.

Adjust

- Loosen the jam nut on the master cylinder push rod.
- Adjust push rod length to156.5mm - 157.5mm (6.16 - 6.20 in.), and tighten the jam nut.

Tighten

- Master cylinder jam nut to 13 N·m (113 lb in).

7. Clutch switch.
8. Clutch pedal and bracket assembly.

Tighten

- Clutch pedal and bracket bolt to 37 N·m (27 lb ft).

9. Hose and pipe
10. Electric vacuum pump.
    - Refer to ELECTRIC VACUUM PUMP (SEC. 8).
11. Meter cluster and meter assembly.
    - Refer to INSTRUMENTAL PANEL (SEC. 10D).
12. Bleed the clutch hydraulic circuit. Refer to "Bleeding Clutch Hydraulic Circuits" previously in this section.

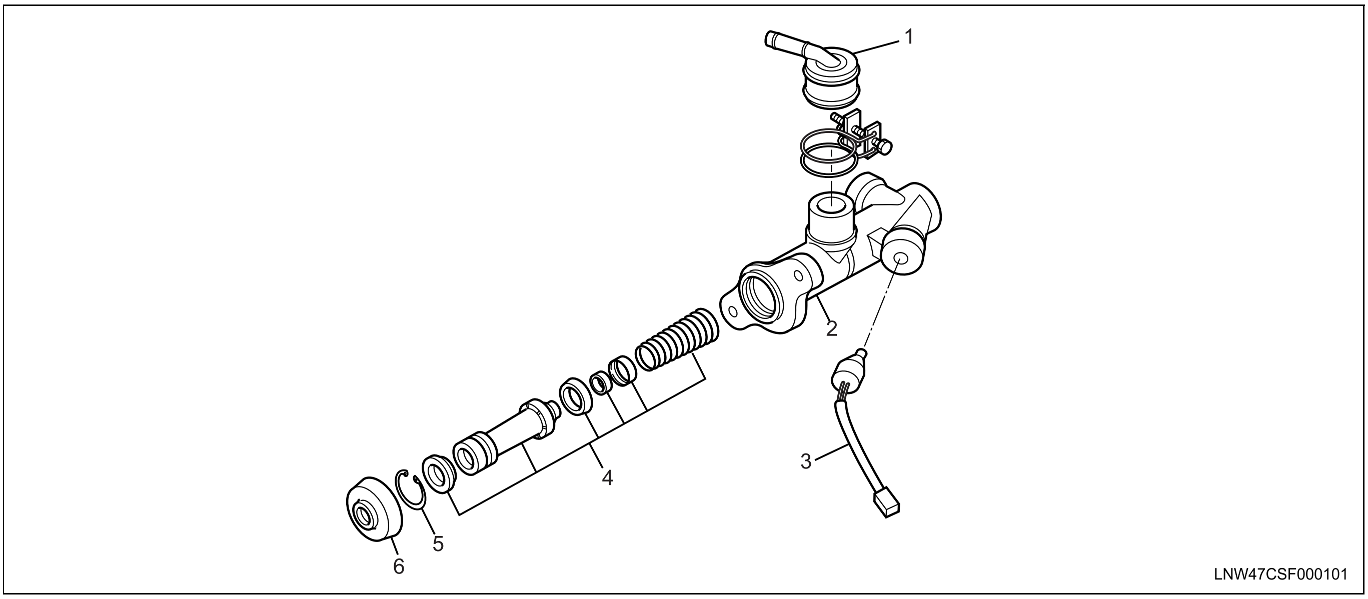
Master Cylinder

Disassembly Procedure

1. Hose joint (1).
2. Pressure switch (3).
3. Dust cover (6).
4. Snap ring (5).
5. Piston assembly (4).
6. Cylinder body (2).

Clean

- All disassembled parts in brake fluid. Be sure to check the ports for restrictions. Use a metal wire to loosen the dirt.



Legend

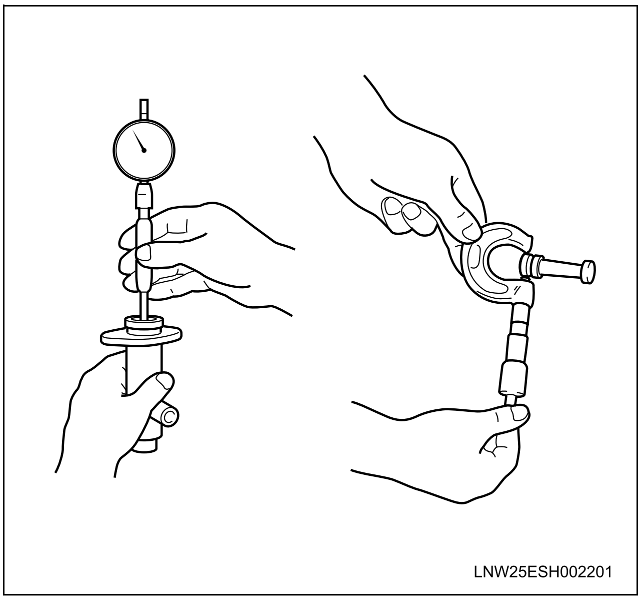
1. Hose Joint
2. Cylinder Body
3. Pressure Switch
4. Piston Assembly
5. Snap Ring
6. Dust Cover

Inspection Procedure

- Cylinder bore and piston for wear and rust formation.
- Spring for weakening.
- Replace any parts if wear, damage, or any other abnormal conditions are found during inspection.

Measure

- The bore inside the master cylinder body with a dial indicator. Use a micrometer to check the thickness of the piston. Replace the master cylinder body or piston if the clearance is less than 0.12 mm (0.0047 in).



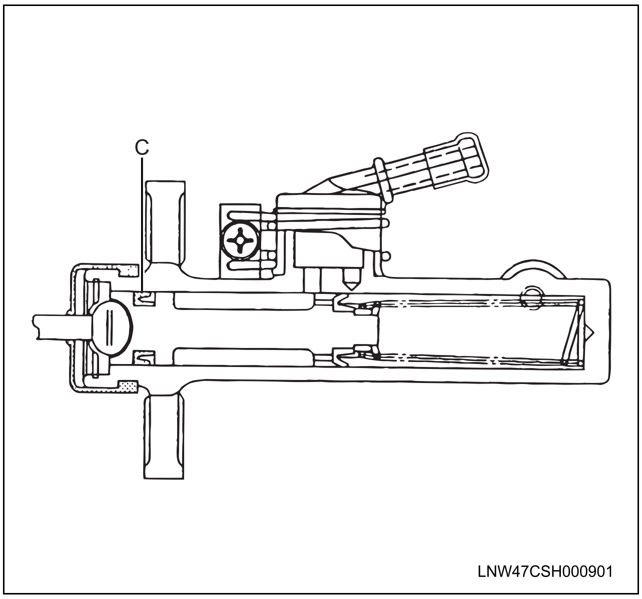
Reassembly

1. Cylinder body (2).

Important:

- Before installing the parts, apply a thin coat of brake fluid.

2. Piston assembly (4). Install new cup (C) in groove in piston with the lip turned toward the front of the cylinder body. Use care so as not to scratch the lipped portion of the cup.
3. Dust cover (4), with snap ring (5).
4. Snap ring (5) to the cylinder body groove.
5. Dust cover (6).
6. Hose joint (1).



Legend

1. Piston Cup

Slave Cylinder

Disassembly Procedure

1. Push rod (1).
2. Boot (2).
3. Piston assembly (3).
4. Adjuster spring (4).
5. Slave cylinder body (5).
6. Bleeder screw and cap (6).

Clean

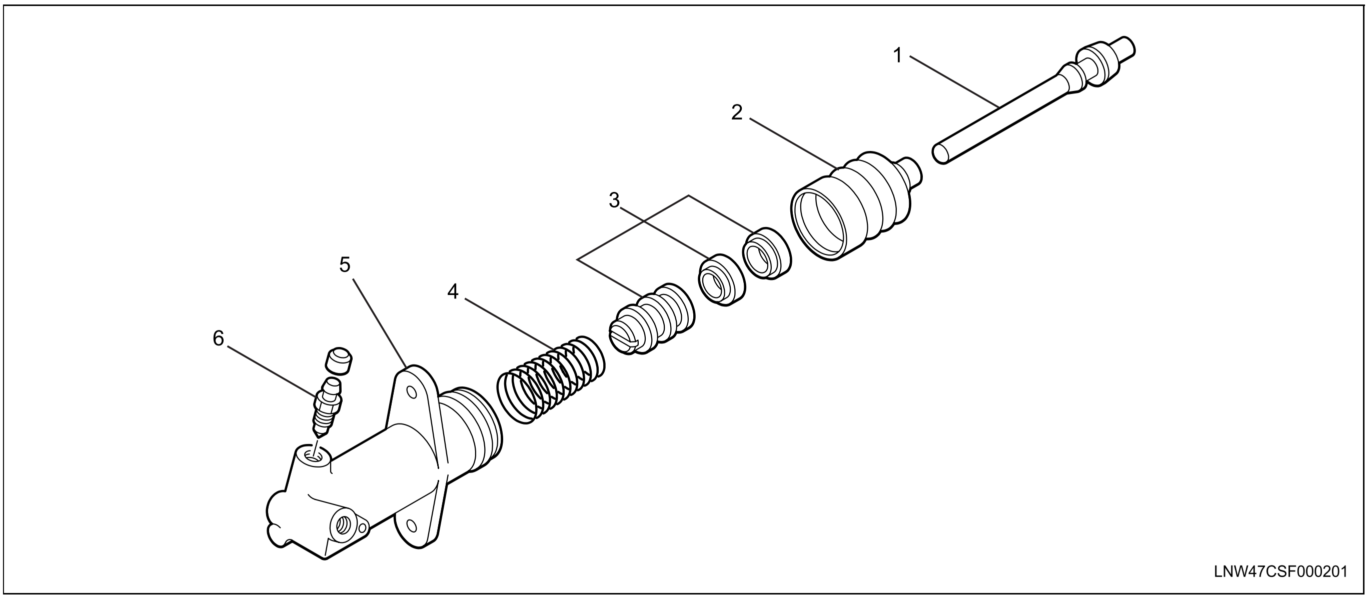
- All disassembled parts in brake fluid. Be sure to wipe excess brake fluid from the components.

Inspection

- Cylinder bore and piston for wear and rust formation.
- Spring for weakening.
- Piston cups for wear, deterioration and scratches.
- Replace any parts if wear, damage, or any other abnormal conditions are found during inspection.

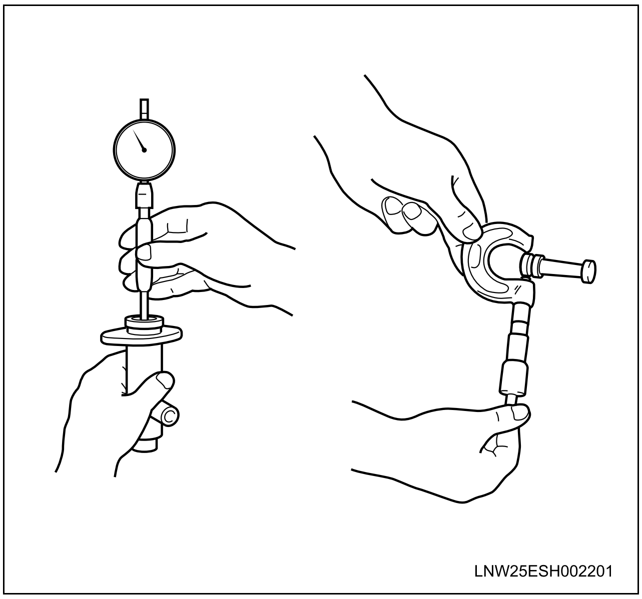
Measure

- The clearance inside the slave cylinder body with a dial indicator. Use a micrometer to check the thickness of the piston. Replace the slave cylinder body or piston if the clearance is less than 0.11 mm (0.0043 in).



Legend

1. Pushrod
2. Boot
3. Piston Assembly
4. Adjuster Spring
5. Slave Cylinder Body
6. Bleeder Screw and Cap



Reassembly Procedure

1. Slave cylinder body (5).

Notice:
See “NOTICE” on page 7C3-2 of this section.

2. Bleeder screw and cap (6).

Tighten

- Bleeder screw to 8 N·m (69 lb in).

Important:

- Before installing the parts, apply a thin coat of brake fluid.
- Be sure to install the piston cup in the piston groove with the lip turned toward the front of the cylinder body. Use care so as not to scratch the lip portion of the piston cup.

3. Adjuster spring (4).
4. Piston assembly (3).
5. Boot (2).
6. Push rod (1).

Specifications

Specifications

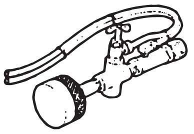
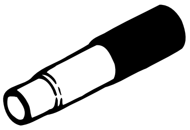
Pressure Plate Types	Dry Single Plate w/Cushioning Spring
Clearance Between Master Cylinder Body and Piston	0.12 mm (0.0047 in)
Clearance Between Slave Cylinder Body and Piston	0.11 mm (0.0043 in)
Driven Plate Warpage Maximum Limit	0.6 mm (0.024 in)
Clutch Size	325 mm (12.80 in)
Depression of Rivet Head Maximum Limit	0.2 mm (0.008 in)
Pressure Plate Clamping Force Maximum Limit	970 kg (2,139 lb)
Pressure Plate Finger Height	61.8-63.8 mm (2.43-2.51 in)
Master Cylinder Push Rod Length (From Centre of Crevis Pin Hole to Mounting Surface)	156.5-157.5 mm (6.16-6.20 in)
Pedal Height (Reference)	160-170 mm (6.3-6.7 in)
Pedal Travel (Reference)	159-169 mm (6.2-6.7 in)
Free Play (Reference)	15-25 mm (0.6-1.0 in)
Clutch Switch Clearance	0.5-1.0 mm (0.020-0.039 in)

Fastener Torques

Master Cylinder Push Rod Jam Nut	13 N·m (113 lb in)
Clutch Switch Jam Nut	20 N·m (14 lb ft)
Pressure Plate Bolts	40 N·m (30 lb ft)
Master Cylinder Bolts	13 N·m (113 lb in)
Slave Cylinder Bolts	19 N·m (14 lb ft)
Flexible Hose Tube Nuts	20 N·m (14 lb ft)
Slave Cylinder Bleeder Screw	8 N·m (69 lb in)
Clutch Pedal and Bracket Assembly Mounting Bolt	37 N·m (27 lb ft)

Special Tools

Special Tools

Illustration	Tool Number/ Description
 J35854	J-35854 Power Bleeder Adapter
 J45991	J-45991 Clutch Pilot Aligner

BODY, CAB, AND ACCESSORIES

Cab and Chassis Electrical

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  Connector Test Adapter List. 8-343

General Information

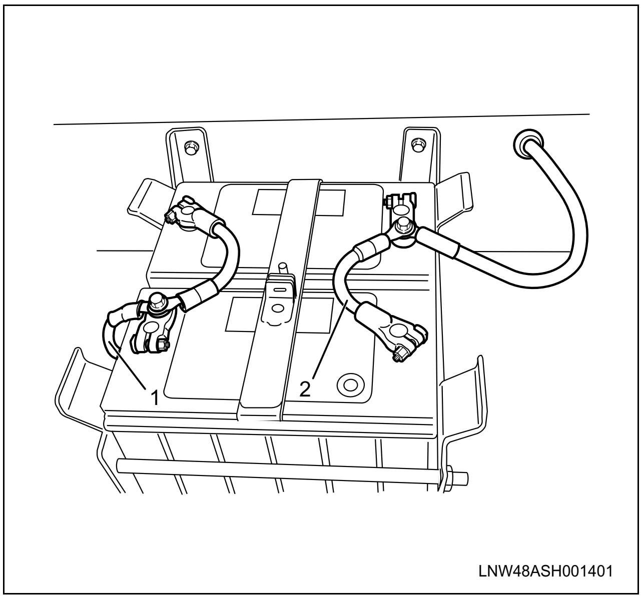
General Information

Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound, will be called out. The correct torque values must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

The chassis electrical system is of 12-volt specifications with a negative ground polarity.
Wire sizes are appropriate to respective circuits, and classified by color. (The classification of harnesses by color is shown on the circuit diagram for ease of harness identification.)
The wire size is determined by load capacity and the length of wire required.
The vehicle harnesses are: body harness, floor harness, engine harness, frame front harness, frame rear harness, rear body harness, dome light harness, door harness and battery cable.
The harnesses are protected either by tape or corrugated tube, depending on harness location.
The circuit for each system consists of the power source, wire, fuse, relay switch, load parts and ground, all of which are shown on the circuit diagram.
In this manual, each electrical device is classified by system. For major parts shown on the circuit based on the circuit diagram for each system, a summary, diagnosis of troubles, inspection and removal and installation procedures are detailed.

Notes for Working on Electrical Items

BATTERY CABLE



Disconnecting the Battery Cable

1. All switches should be in the "LOCK" position.
2. Disconnect the battery ground cable (1).
3. Disconnect the battery positive cable (2).

Caution:
It is important that the battery ground cable be disconnected first.
Disconnecting the battery positive cable first can result in a short circuit.

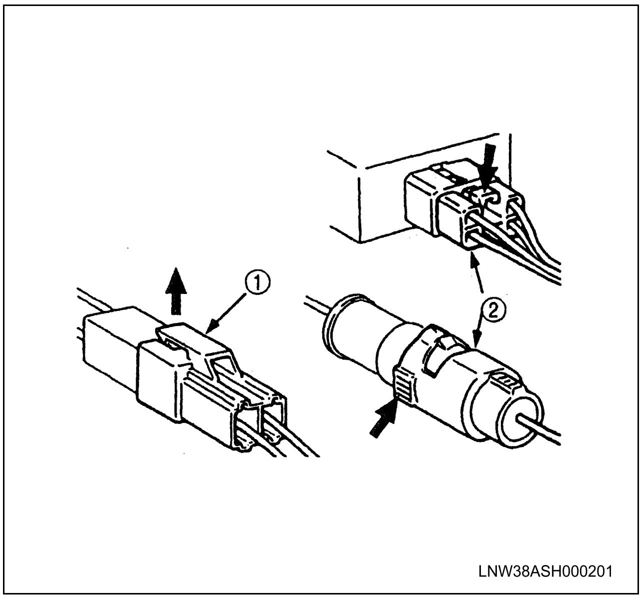
Connecting the Battery Cable

Follow the disconnecting procedure in the reverse order.

Caution:
Clean the battery terminal and apply a light coat of grease to prevent terminal corrosion.

Connector Handling

Disconnecting The Connectors



LNW38ASH000201

Some connectors have a tang lock to hold the connectors together during vehicle operation.

Some tang locks are released by pulling them towards you (1).

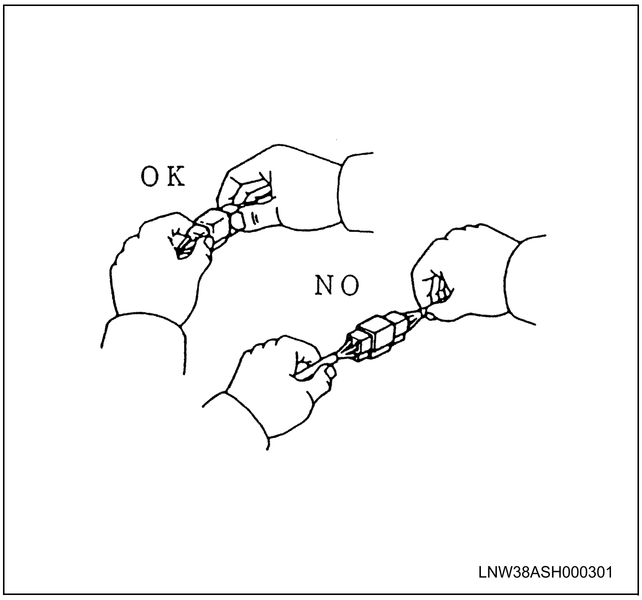
Other tang locks are released by pressing them forward (2).

Determine which type of tang lock is on the connector being handled.

Firmly grasp both sides (male and female) of the connector.

Release the tang lock and carefully pull the two halves of the connector apart.

Never pull on the wires to separate the connectors. This will result in wire breakage.



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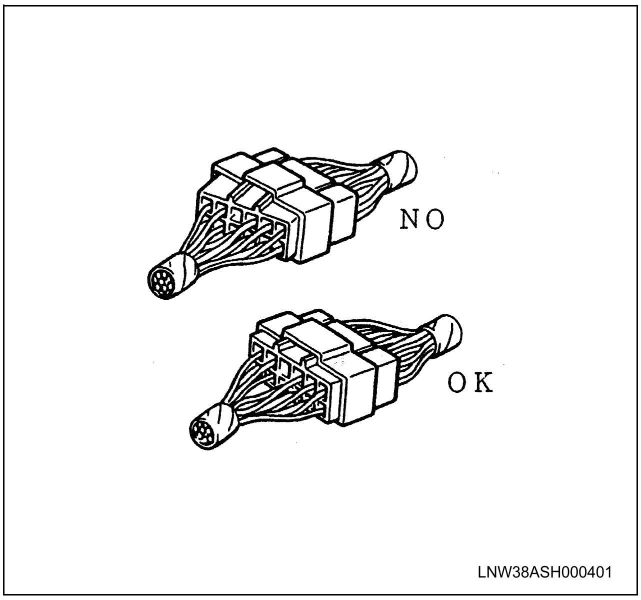
Connecting the Connector

Firmly grasp both sides (male and female) of the connector. Be sure that the connector pins and pin holes match. Be sure that both sides of the connector are aligned with each other. Firmly but carefully push the two sides of the connector together until a distinct click is heard.



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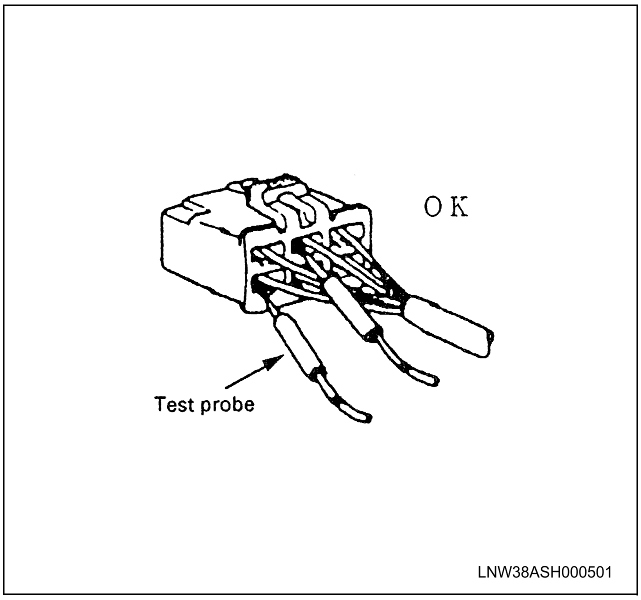
Connector Inspection

Use a circuit tester to check the connector for continuity. Insert the test probes from the connector wire side.



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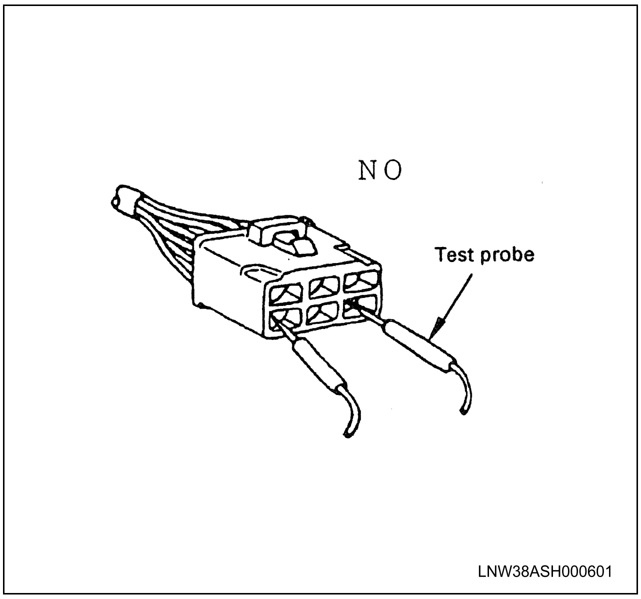
Never insert the circuit tester test probes into the connector open end to test the continuity. Broken or open connector terminals will result.



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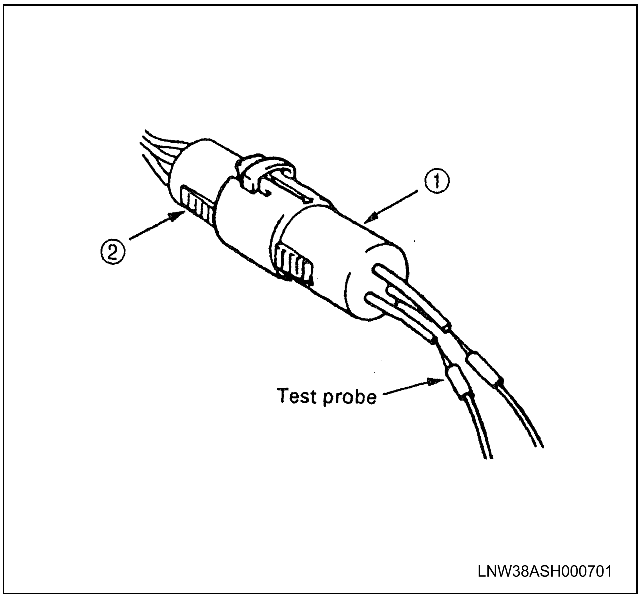
Waterproof Connector Inspection

It is not possible to insert the test probes into the connector wire side of a waterproof connector.
Use one side of a connector (1) with its wires cut to make the test. Connect the test connector (2) to the connector to be tested. Connect the test probes to the cut wires to check the connector continuity.



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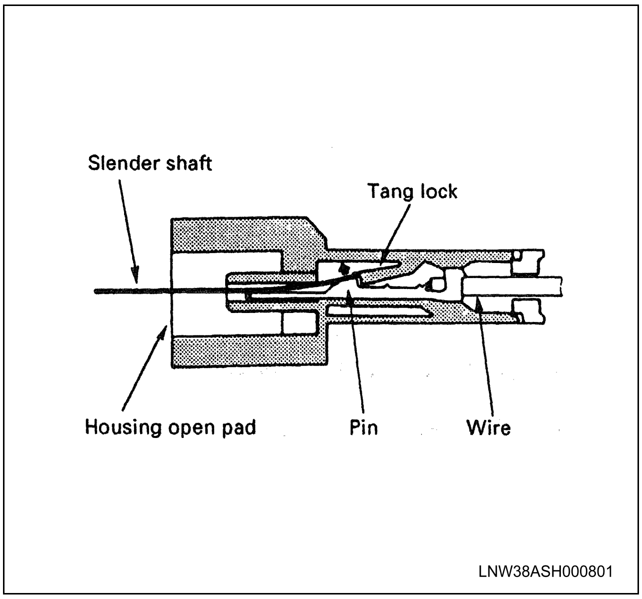
Connector Pin Removal

Connector Housing Tang Lock Type

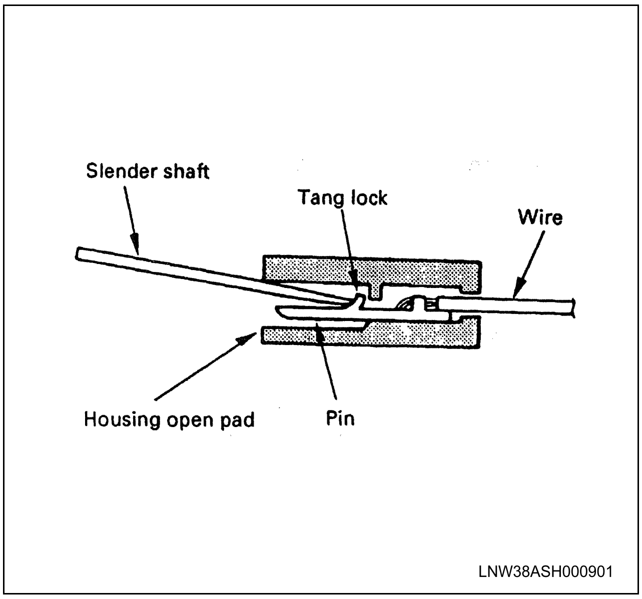
1. Insert a slender shaft into the connector housing open end.
2. Push the tang lock up (in the direction of the arrow in the illustration). Pull the wire with pin free from the wire side of the connector.



LNW38ASH000801

Pin Tang Lock Type

1. Insert a slender shaft into the connector housing open end.
2. Push the tang lock flat (toward the wire side of the connector). Pull the wire with pin free from the wire side of the connector.



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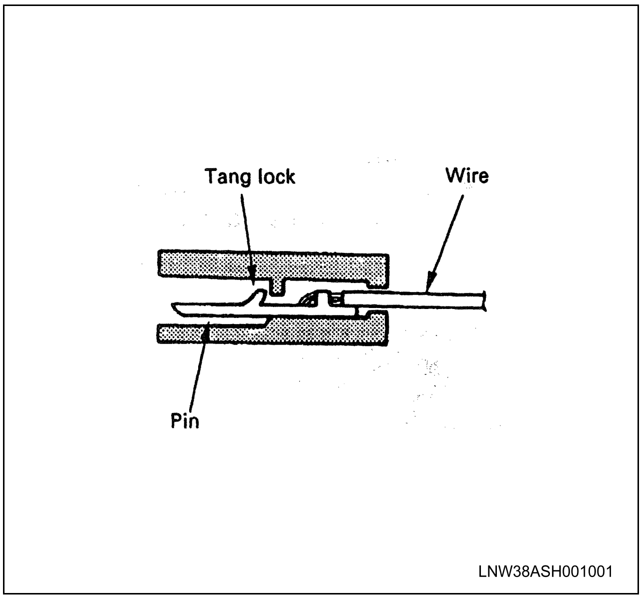
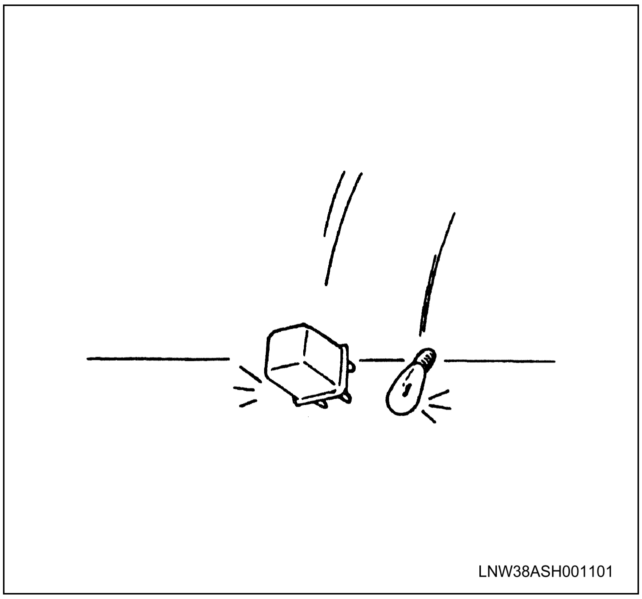
Connector Pin Insertion

1. Check that the tang lock is fully up.
2. Insert the pin from the connector wire side Push the pin in until the tang lock closes firmly.
3. Gently pull on the wires to make sure that the connector pin is firmly set in place.



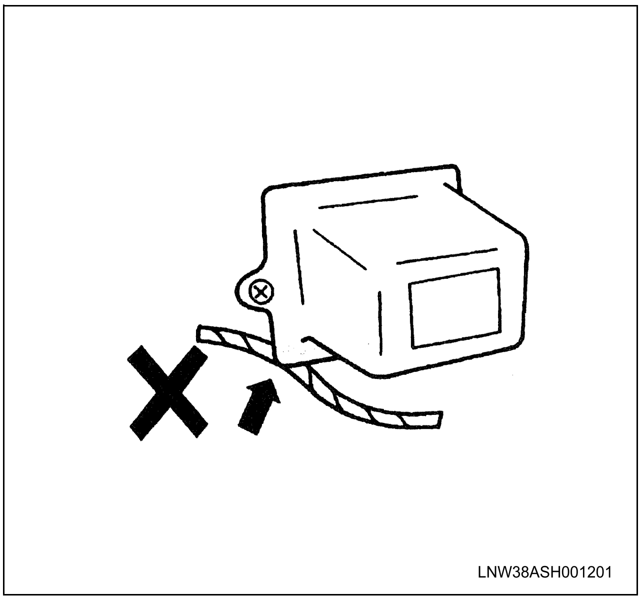
Parts Handling

Be careful when handling electrical parts. They should not be dropped or thrown, because short circuit or other damage may result.

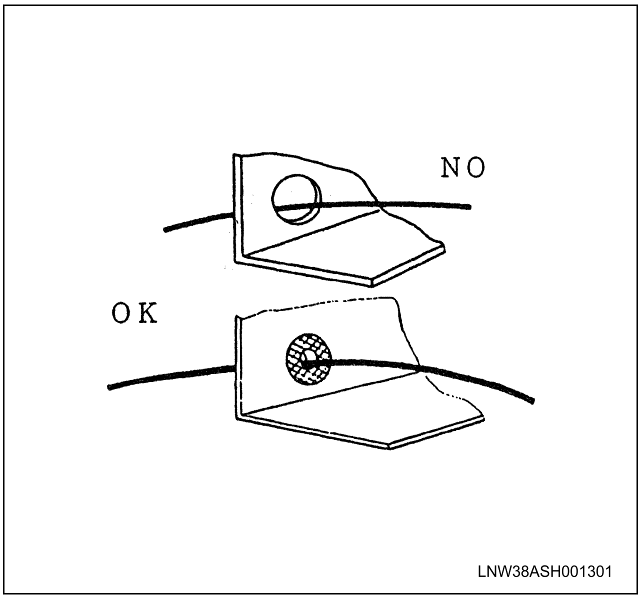


Cable Harness

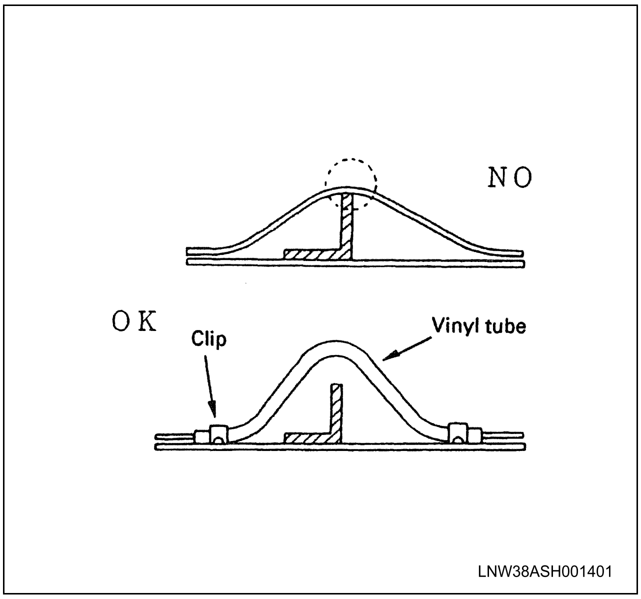
When installing the parts, be careful not to pinch or wedge the wiring harness.
All electrical connections must be kept clean and tight.



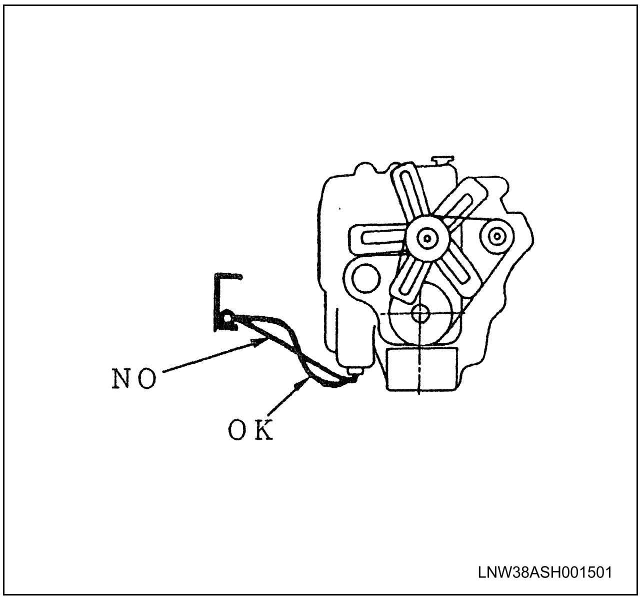
Use a grommet or guard tube to protect the wiring harness from contacting a sharp edge or surface.



Position the wiring harness with a enough clearance from the other parts and guard the wiring harness with a vinyl tube and clips to avoid direct contact.



The wiring harness between engine and chassis should be long enough to prevent chafing or damage due to various vibrations.



SPLICING WIRE

1. Open the Harness

If the harness is taped, remove the tape. To avoid wire insulation damage, use a sewing "seam ripper" (available from sewing supply stores) to cut open the harness.
If the harness has a block plastic conduit, simply pull out the desired wire.

2. Cut the wire

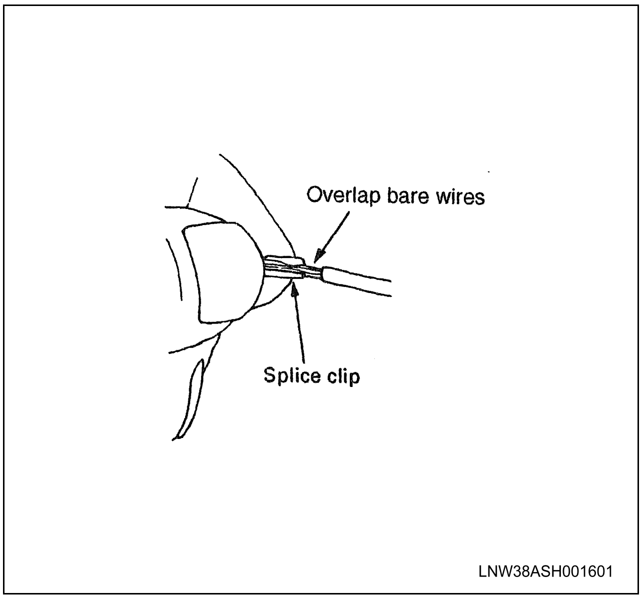
Begin by cutting as little wire off the harness as possible. You may need the extra length of wire later if you decide to cut more wire off to change the location of a splice. You may have to adjust splice locations to make certain that each splice is at least $1^1/_2$" (40 mm) away from other splices, harness branches, or connectors.

3. Strip the Insulation

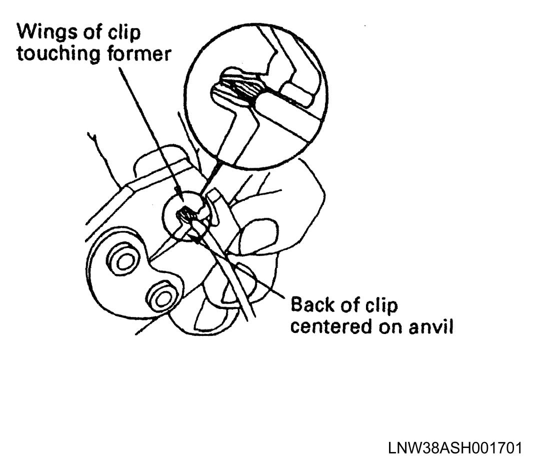
When replacing a wire, use a wire of the same size as the original wire. Check the stripped wire for nicks or cut stands. If the wire is damaged, repeat the procedure on a new section of wire. The two stripped wire ends should be equal in length.

4. Crimp the Wires

Select the proper clip to secure the splice. To determine the proper clip size for the wire being spliced, follow the directions included with your clips. Select the correct anvil on the crimper. (On most crimpers your choice is limited to either a small or large anvil.) Overlap the two stripped wire ends and hold them between your thumb and forefinger.
Then, center the splice clip under the stripped wires and hold it in place.



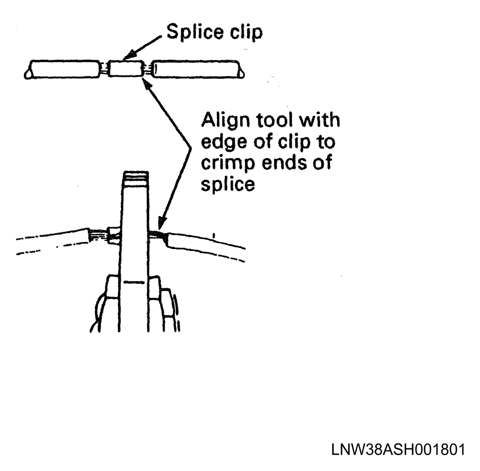
- Open the crimping tool to its full width and rest one handle on a firm flat surface.
- Center the back of the splice clip on the proper anvil and close the crimping tool to the point where the back of the splice clip touches the wings of the clip.
- Make sure that the clip and wires are still in the correct position. Then, apply steady pressure until the crimping tool closes.



Before crimping the ends of the clip, be sure that:

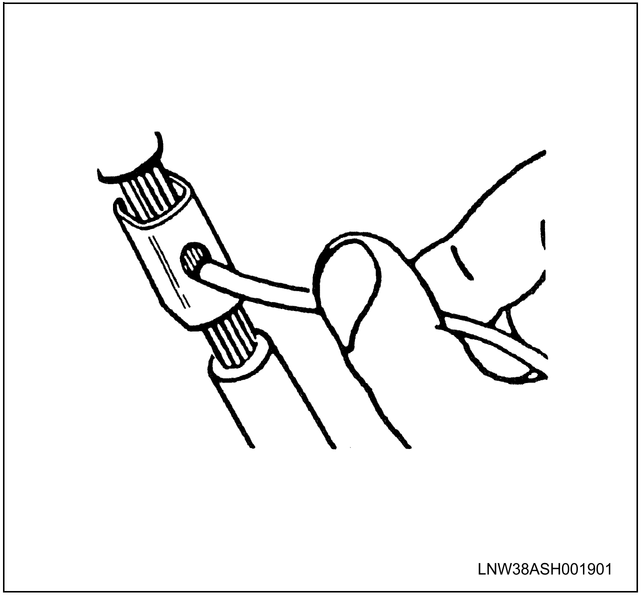
- The wires extend beyond the clip in each direction.
- No strands of wire are cut loose, and
- No insulation is caught under the clip.

Crimp the splice again, once on each end. Do not let the crimping tool extend beyond the edge of the clip or you may damage or nick the wires.



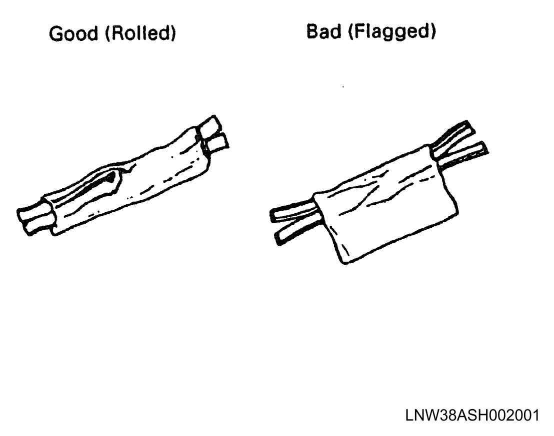
5. Solder

Apply 60/40 rosin core solder to the opening in the back of the clip. Follow the manufacturer's instructions for the solder equipment you are using.

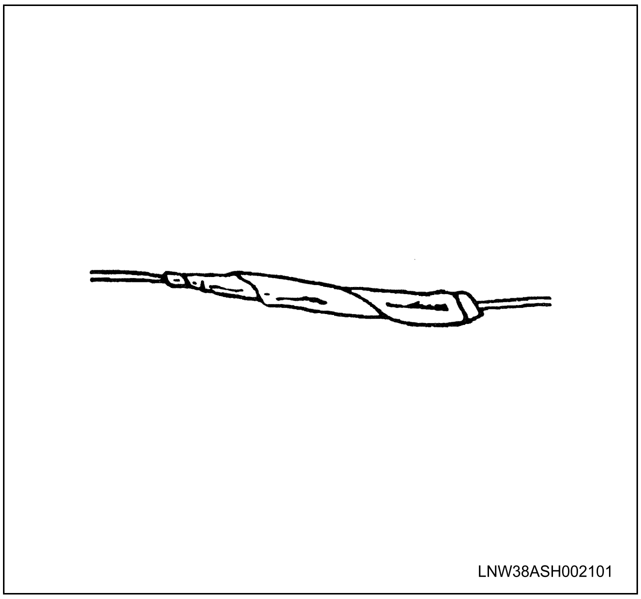


6. Tape the Splice

Center and roll the splicing tape. The tape should cover the entire splice. Roll on enough tape to duplicate the thickness of the insulation on the existing wires. Do not flag the tape. Flagged tape may not provide enough insulation, and the flagged ends will tangle with the other wires in the harness.

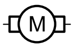
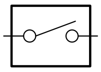
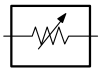
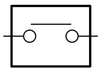
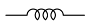
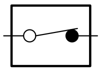
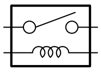
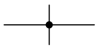
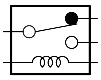
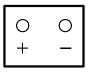
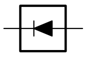
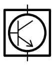
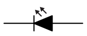
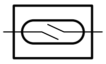
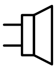
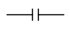
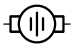
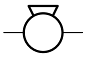
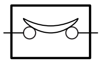
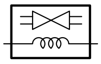


If the wire does not belong in a conduit or other harness covering, tape the wire again. Use a winding motion to cover the first piece of tape.



Symbols and Abbreviations

SYMBOLS

Symbol	Meaning of Symbol	Symbol	Meaning of Symbol
	Fuse		Bulb
	Slow blow fuse		Double filament bulb
	Fusible link wire		Motor
	Switch (Normal open type)		Variable register Rheostat
	Switch		Coil (inductor), solenoid, magnetic bvalve
	Switch (Normal close type)		Relay (Normal open type)
	Contact wiring		Relay (Normal close type)
	Battery		
	Diode		Connector
	Electronic Parts		Light emitting diode
	Resistor		Reed switch
	Speaker		Condenser
	Buzzer		Horn
	Circuit breaker		Vacuum switching valve

LNW68DLF001601

ABBREVIATIONS

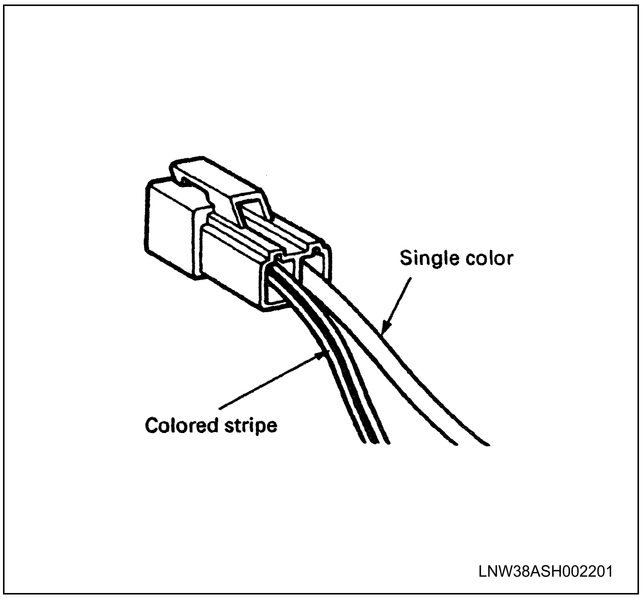
Abbreviation	Meaning of Abbreviation
3A/T	3-speed automatic transmission
4×4	Four-wheel drive
4A/T	4-speed automatic transmission
A/C	Air conditioner
A/T	Automatic transmission
ABS	Anti-lock brake system
AC	Alternating current
ACC	Accessories
ACCEL	Accelerator
APP	Accelerator pedal position
ASM	Assembly
ATF	Automatic Transmission Fluid
AUTO	Automatic
BRKT	Bracket
C/B	Circuit breaker
CKP	Crankshaft position
CMP	Camshaft position
COMB	Combination
CONT	Control
D.R.L	Day time running light
DC	Direct current
ECM	Electronic control module
ECT	Engine coolant temperature

Abbreviation	Meaning of Abbreviation
ECU	Electronic control unit
EGR	Exhaust gas recirculation
EHCU	Electronic and hydraulic control unit
FL	Fusible link
FRP	Fuel rail pressure
FRT	Front
FT	Fuel temperature
H/L	Headlight
HI	High
IAT	Intake air temperature
IC	Integrated circuit
IG	Ignition
kW	kilowatt
LH	Left hand
LO	Low
LWB	Long wheel base
M/T	Manual transmission
M/V	Magnetic valve
MAF	Mass air flow
MIL	Check engine light
OD	Over drive
OPT	Option
PTO	Power Take Off
RH	Right hand
RR	Rear
ST	Start
STD	Standard
SVS	Service vehicle soon
SW	Switch
SWB	Short wheel base
TCM	Transmission control module
V	Volt
VSV	Vacuum switching valve
W	Watt (S)
W/	With
W/O	Without
W/S	Weld splice
WOT	Wide open throttle

Parts for Electrical Circuit

WIRING

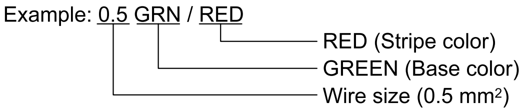
Wire Color



LNW38ASH002201

All wires have color-coded insulation.

Wires belonging to a system's main harness will have a single color. Wires belonging to a system's sub-circuits will have a colored stripe. Striped wires use the following code to show wire size and colors.



HCW480SH000101

Abbreviations are used to indicate wire color within a circuit diagram.

Refer to the following table.

Wire Color Coding

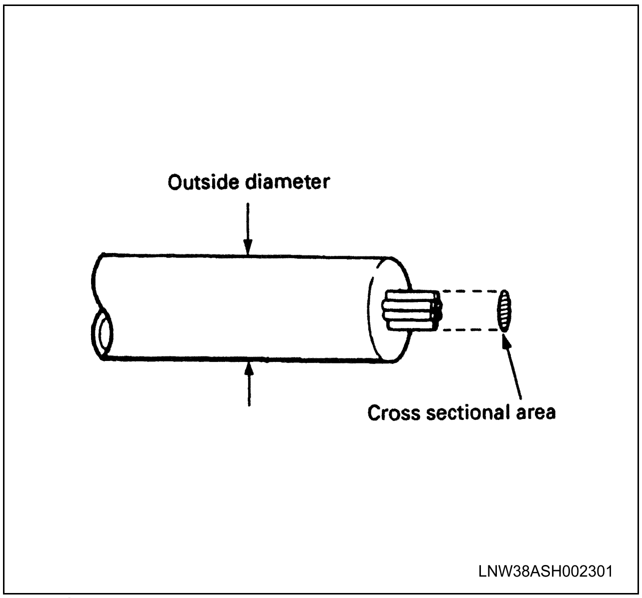
Color-coding	Meaning	Color-coding	Meaning
BLK	Black	BRN	Brown
WHT	White	LT GRN	Light green
RED	Red	GRY	Gray
GRN	Green	PNK	Pink
YEL	Yellow	LT BLU	Light blue
BLU	Blue	VIO	Violet
ORN	Orange		

Distinction of Circuit by Wire Base Color

Base color	Circuits	Base color	Circuits
BLK	Starter circuit	YEL	Instrument circuit
WHT	Charging circuit	BLU, ORN, BRN, LT GRN, GRY, PNK, LT BLU, VIO	Other circuit
RED	Lighting circuit		
GRN	Signal circuits		

Wire Size

The size of wire used in a circuit is determined by the amount of current (amperage), the length of the circuit, and the voltage drop allowed. The following wire size and load capacity, shown below, are specified by AWG (American Wire Gauge) (Nominal size means approximate cross sectional area).



Wire Size Table

Nominal size	Cross sectional area (mm^2)	Outside diameter (mm)	Allowable current (A)	AWG size (cross reference)
0.3	0.372	1.8	9	22
0.5	0.563	2.0	12	20
0.85	0.885	2.2	16	18
1.25	1.287	2.5	21	16

Nominal size	Cross sectional area (mm^2)	Outside diameter (mm)	Allowable current (A)	AWG size (cross reference)
2	2.091	2.9	28	14
3	3.296	3.6	37.5	12
5	5.227	4.4	53	10
8	7.952	5.5	67	8
15	13.36	7.0	75	6
20	20.61	8.2	97	4

Fuse, Fusible Link And Circuit Breaker

FUSE

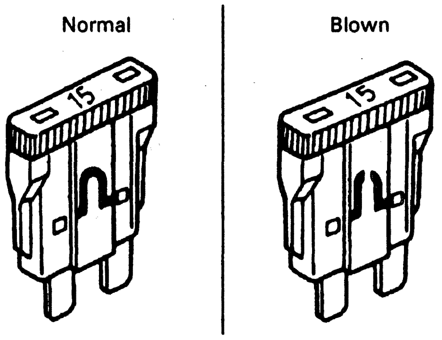
Fuses are the most common form of circuit protection used in vehicle wiring. A fuse is a thin piece of wire or strip of metal encases in a glass or plastic housing. It is wired in series with the circuit it protects. When there is an overload of current in a circuit, such as a short of a ground, the wire or metal strip is designed to burn out and interrupt the flow of current. This prevents a surge of high current from reaching and damaging other components in the circuit.

Determine the cause of the overloaded before replacing the fuse.

The replacement fuse must have the same amperage specifications as the original fuse.

Never replace a blown fuse with a fuse of a different amperage specification.

Doing so can result in an electrical fire or other serious circuit damage. A blown fuse is easily identified.



LNW38ASH002401

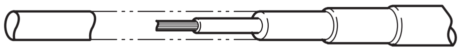
FUSIBLE LINK

The fusible link is primarily used to protect circuits where high amounts of current flow and where it would not be practical to use a fuse. For example, the starter circuit. When a current overload occurs, the fusible link melts open and interrupts the flow of current so as to prevent the rest of the wiring harness from burning.

Determine the cause of the overload before replacing the fusible link. The replacement fusible link must have the same amperage specification as the original fusible link.

Never replace a blown fusible link with fusible link of a different amperage specification. Doing so can result in an electrical fire or other serious circuit damage.

A blown fusible link is easily identified.



LNW48ASH004001

SLOW-BLOW FUSE

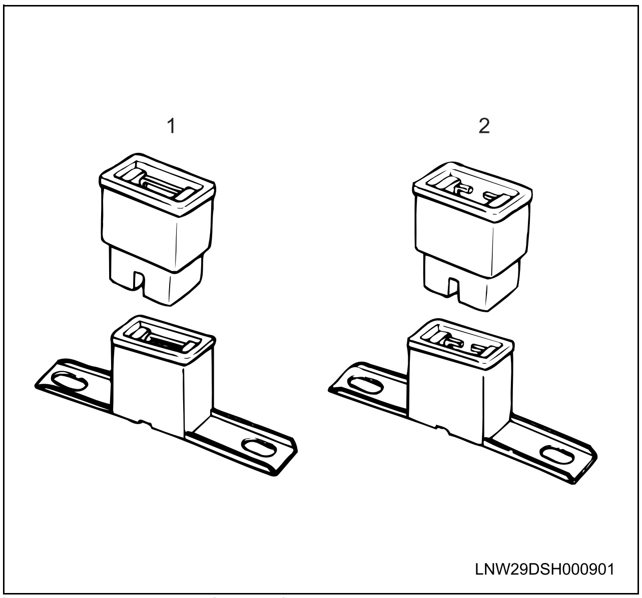
A slow-blow fuse is used in a circuit having a very high current flow (starter) or in an area where an ordinary fuse would be impractical.

Excessive current flow causes the fusible link inside the fuse to melt. Current flow is interrupted. Circuit damage caused by fire or heat is prevented.

Before replacing a fuse, determine the cause of the excessive current.

Always replace the burnt-out fuse with a new fuse of the same amperage rating. Replacing the fuse with one having a higher rating can result in a serious and expensive electrical fire.

Figure 1 shows a normal slow-blow fuse. Figure 2 shows a burnt-out fuse. it is easy to distinguish between the 2 fuses.



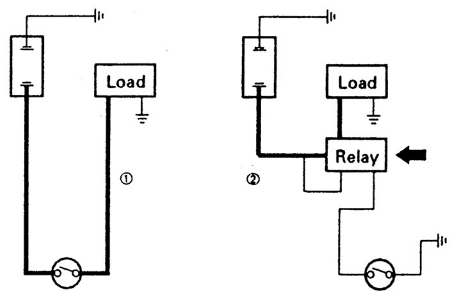
Slow Blow Fuse Specifications

Type	Rating	Case Color	Maximum Circuit Current (A)
Connector	30A	Pink	15
Connector	40A	Green	20
Connector	50A	Red	25
Connector	60A	Yellow	30
Bolted	80A	Black	40
Connector	100A	Blue	40

Relay

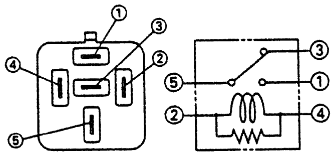
Battery and load location may require that a switch be placed some distance from either component. This means a longer wire and a higher voltage drop (1). The installation the battery and the load reduces the voltage drop (2).

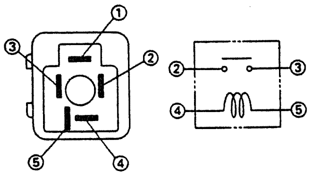
Because the switch controls the relay, amperage through the switch can be reduced.



LNW38ASH002701

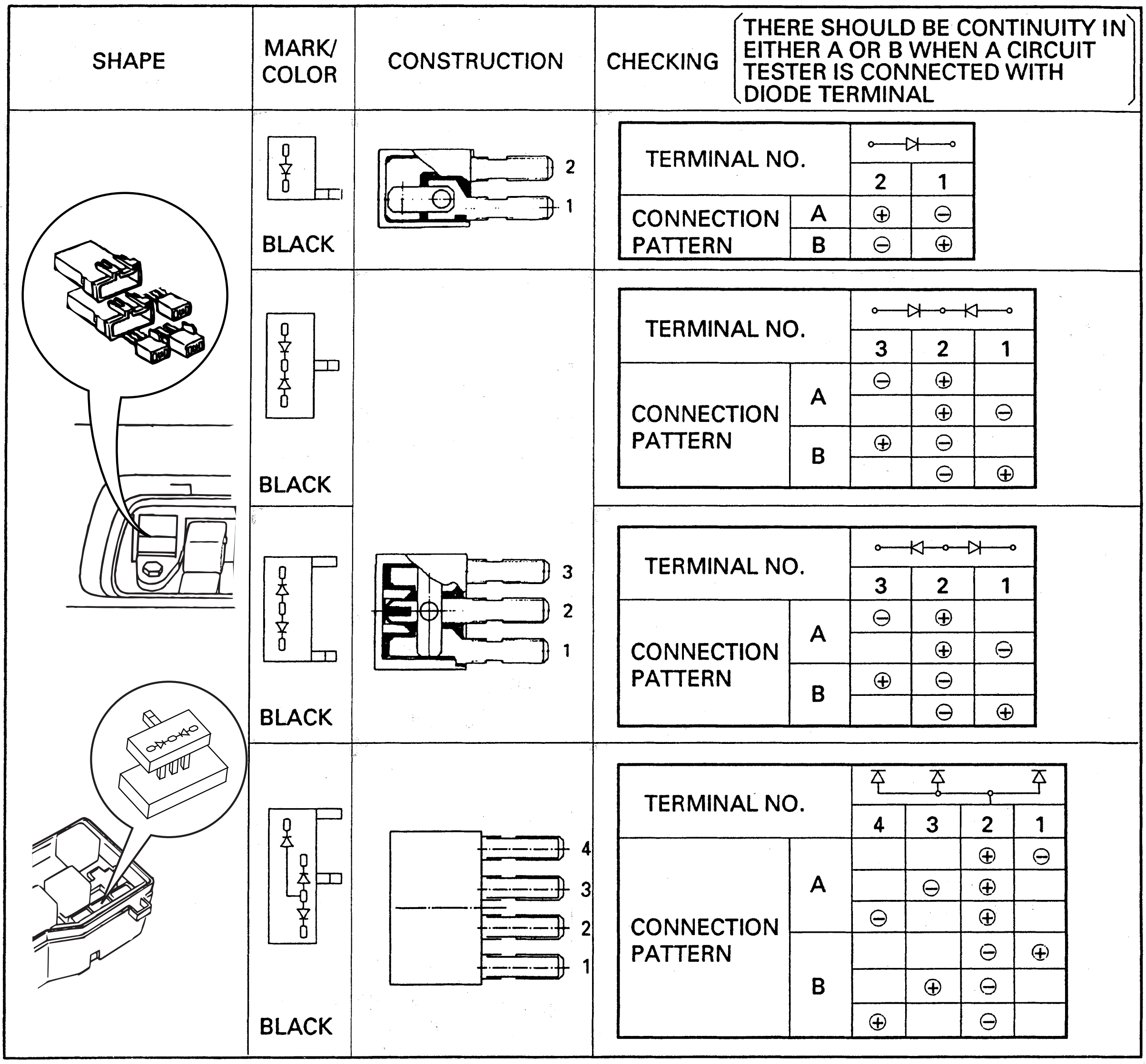
RELAY SPECIFICATION AND CONFIGURATION

Name/Color	Rated voltage/Coil resistance	Internal circuit
MR5C (1T)/ Black	12V/ Approx. 90Ω Minimum operating voltage: 7V at 25°C (77°F)	 LNW38ASH002801
MR5C (1T)/ Brown	12V/ Approx. 90Ω Minimum operating voltage: 10.5V at 25°C (77°F)	

Name/Color	Rated voltage/Coil resistance	Internal circuit
12V/ Approx. 23Ω Minimum operating voltage: 7V at 20°C (68°F)	MR82C/ White label	 LNW38ASH002901

Diode

DIODE SPECIFICATIONS AND CONFIGURATIONS



THERE SHOULD BE CONTINUITY IN EITHER A OR B WHEN A CIRCUIT TESTER IS CONNECTED WITH DIODE TERMINAL

TERMINAL NO.		2	1
CONNECTION PATTERN	A	⊕	⊖
	B	⊖	⊕

TERMINAL NO.		3	2	1
CONNECTION PATTERN	A	⊖	⊕	
			⊕	⊖
	B	⊕	⊖	
			⊖	⊕

TERMINAL NO.		3	2	1
CONNECTION PATTERN	A	⊖	⊕	
			⊕	⊖
	B	⊕	⊖	
			⊖	⊕

TERMINAL NO.		4	3	2	1
CONNECTION PATTERN	A			⊕	⊖
			⊖	⊕	
		⊖		⊕	
	B			⊖	⊕
			⊕	⊖	
		⊕		⊖	

LNW48ALF006501

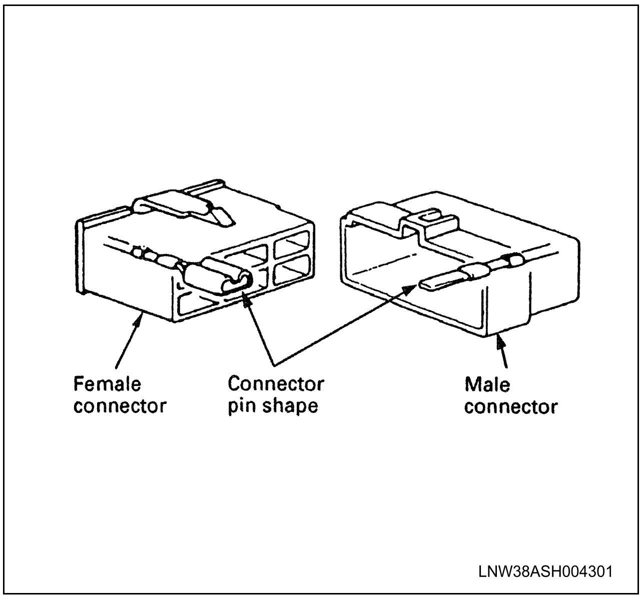
MAXIMUM RATING (Temp. = 25°C {77°K})

Items	Rating	Remarks
Peak reverse voltage	400V	
Transient peak reverse voltage	500V	
Average output current	1.5A	Temp. = 40°C (104°F)
Working ambient temperature	-30°C ~ 80°C (-86°F~176°F)	
Storage temperature	-40°C ~ 100°C (-104°F~212°F)	

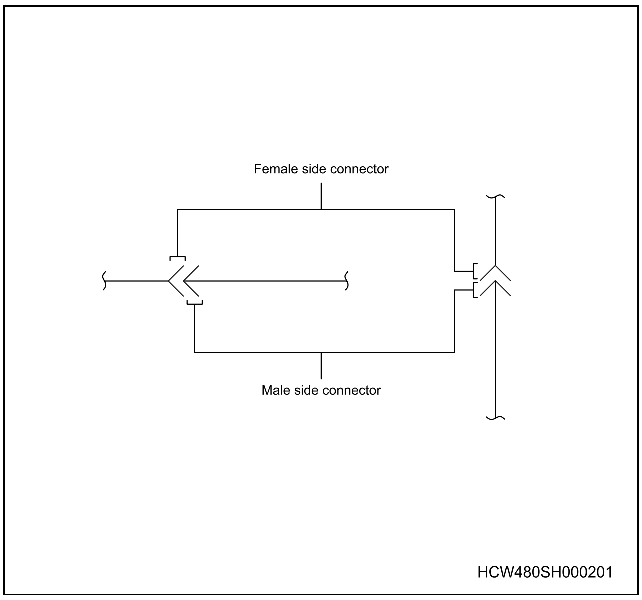
Connector

The connector pin shape determines whether the connector is male or female.

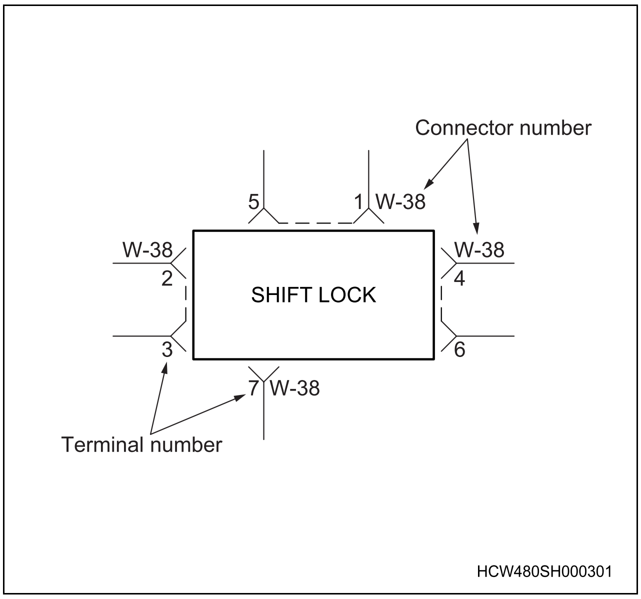
The connector housing configuration does not determine whether a connector is male or female.



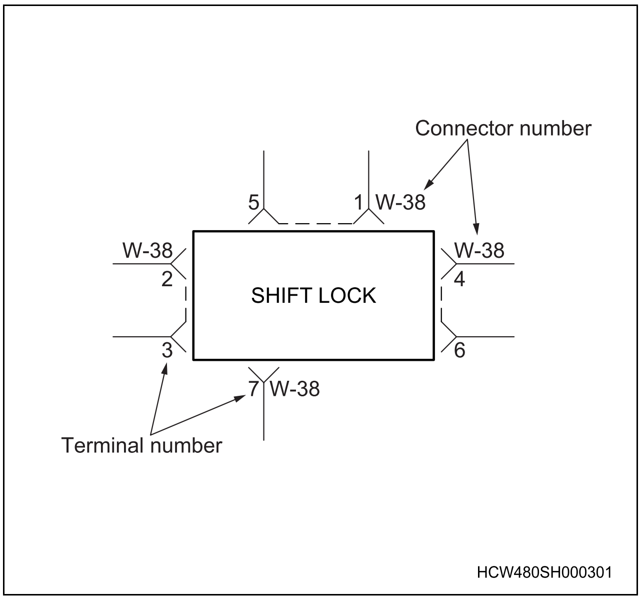
The symbol illustrated in the figure is used as connector, In the circuit of this section.



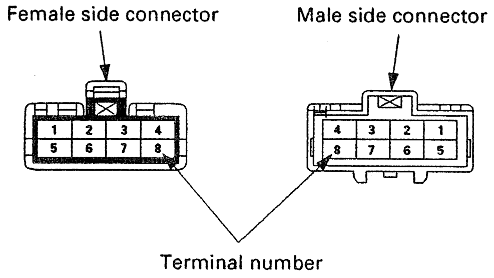
Connector is identified with a number.



The applicable terminal number is shown for each connector.

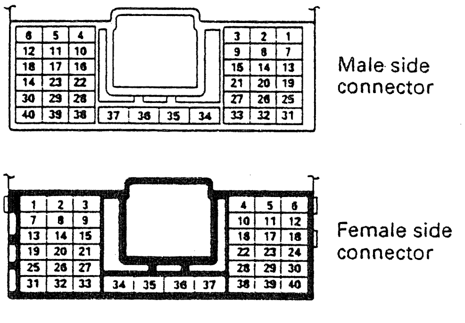


Connector terminal numbers are clearly shown.
Male side connector terminal numbers are in sequence from upper right to lower left.
Female side connector terminal numbers are in sequence from upper left to lower right.



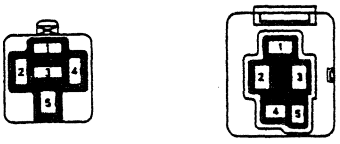
LNW38ASH004701

Notice:
For those connectors on which specific terminal numbers or symbols are shown (such as ECM), the terminal numbers or symbols are used in the circuit diagram, irrespective of the above rule.



LNW38ASH004801

The connectors used for relays have their own terminal number assignment, irrespective of the above rule.



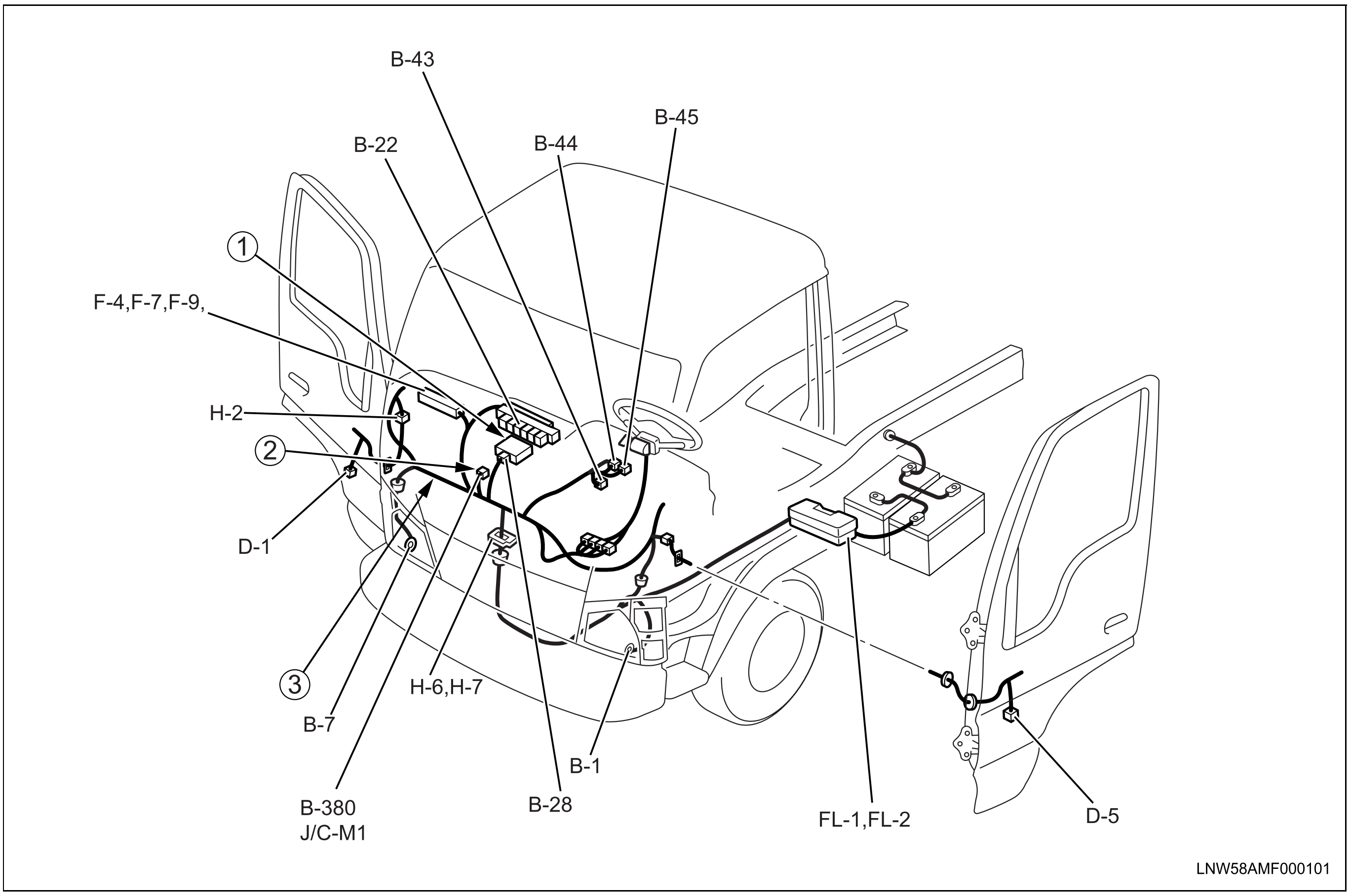
LNW38ASH004901

Reading the Circuit Diagram

In this manual, each system has its own parts location illustration, circuit diagram and connector configuration used in the circuit diagram.

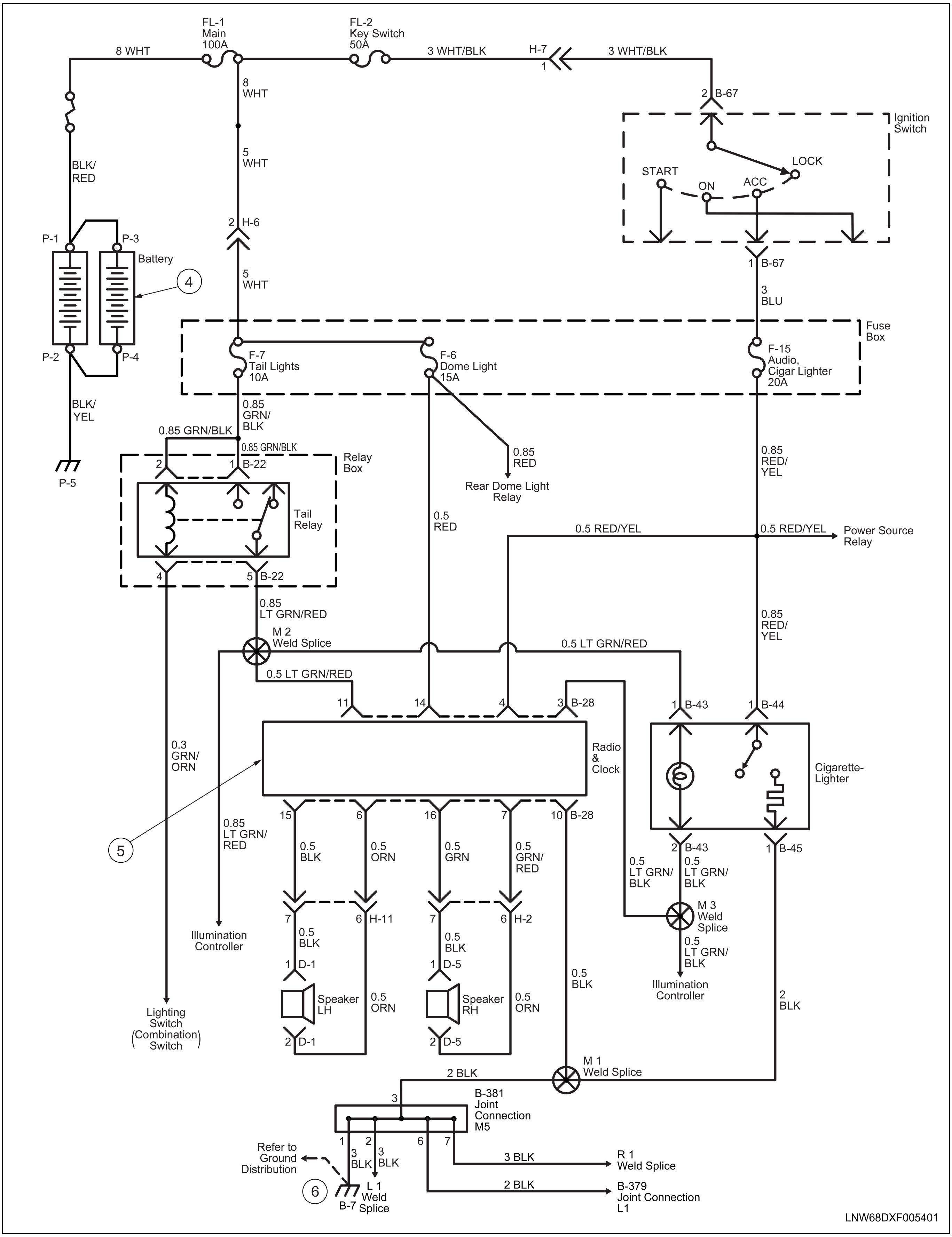
PARTS LOCATION

The parts location shows the location of the parts (1) and the connector (2) used in each harness routing (3).



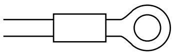
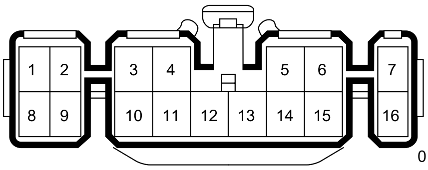
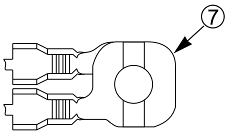
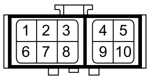
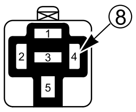
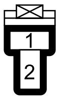
CIRCUIT DIAGRAM

The circuit diagram shows the power supply (4) the load or loads (5) and the grounding point(s) (6).



CONNECTOR LIST

The connector list shows each connectors' configuration (7) and the pin number (8).

No.	Connector Face	No.	Connector Face
B-1	 Ground:Frame-LH (Front)	B-28 (White)	 Radio
B-7	 Ground: Headlight Bracket-RH	B-381 (White)	 Joint Connection-M5
B-22 (Black)	 Tail Relay	B-43 (White)	 Cigarette lighter Illumination

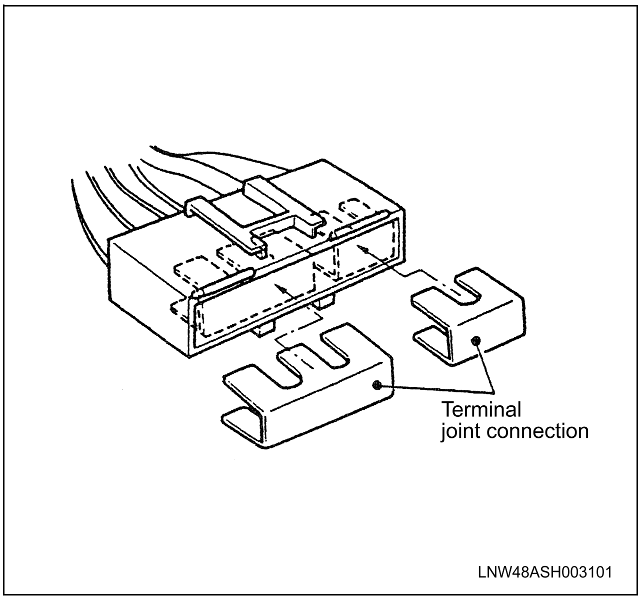
LNW68DMF001201

CONNECTOR SYMBOL

Connector Symbol	Harness name	Connector Symbol	Harness name
B	Body Harness	L	Dome Light Harness
D	Door Harness	N	Floor Harness (LH & RH)
E	Engine Harness	P	Battery Harness
H	For joint between harnesses	R	Rear Body Harness
J	Frame front & frame rear harness		

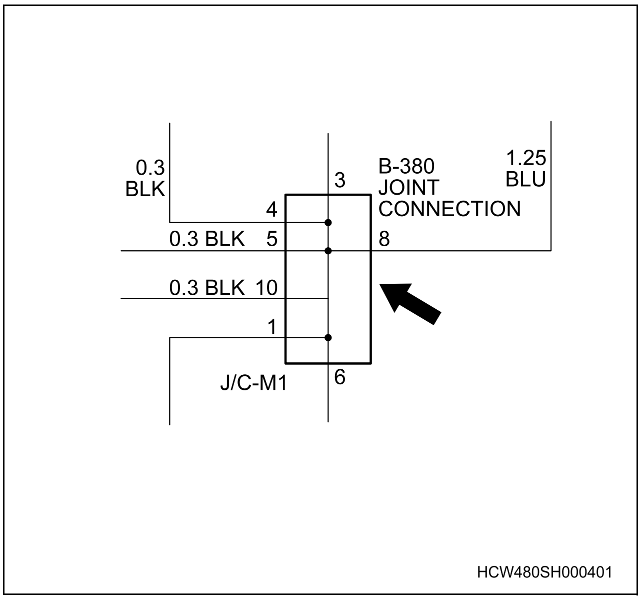
JOINT CONNECTION

This connector has the structure of plural number of terminals collectively connected inside the connector.



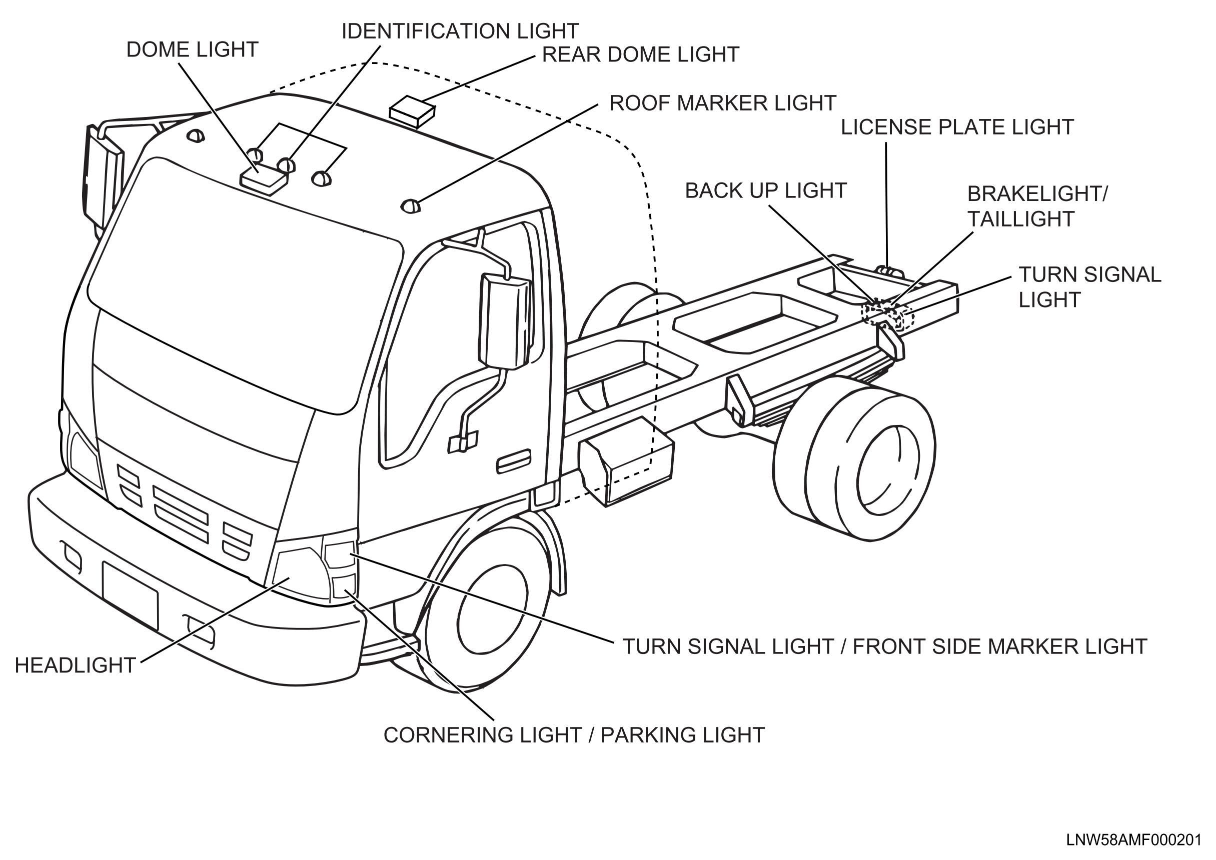
How to show joint connection in the circuit diagram

1. When joint connection can be shown as actual circuit diagram.



Main Data and Specifications

Bulb Specifications (Under Creation)



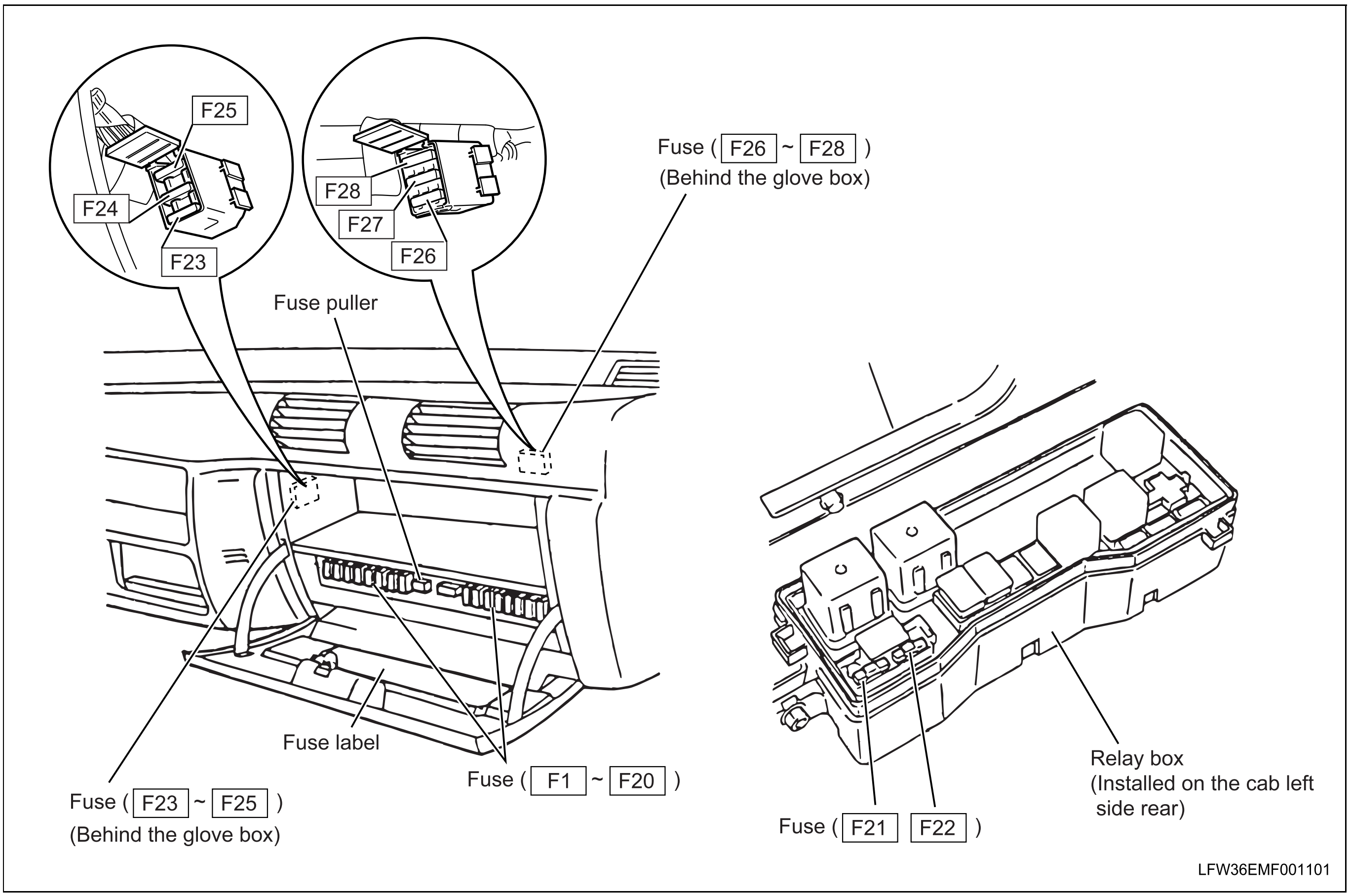
NOTE: Do not grip the roof marker lights to prevent damage or water leakage.

Light Name		Rated Power	Number of Bulb	Lens Color
Headlight	Rectangular Type	65W/55W	2	Clear
Front Combination Light	Turn Signal Light / Front Side Marker Light	27W/8W	2 Bulb (Amber)	Clear
	Cornering Light / Parking Light	27W/8W	2	Clear
Rear Combination Light	Brakelight, Turn Signal Light / Taillight, License Plate Light	27W/8W	4	Red
	Back up Light	27W	2	Clear
Roof Marker Light		5W	2	Amber
Identification Light		5W	3	Amber
Dome Light		10W	1	White
Rear Dome Light		10W	1	White

Light Name		Rated Power	Number of Bulb	Lens Color
Indicator/Warning light (In the Instrument Panel Cluster)	Engine Oil Pressure	2W	1	Red
	Brake Booster	2W	1	Red
	Charge	2W	1	Red
	High Beam	2W	1	Blue
	Turn Signal / Hazard Warning	2W	2	Green
	Check Engine	2W	1	Orange
	D.R.L	2W	1	Green
	ABS	2W	1	Orange
	Check Trans	2W	1	Red
	Sedimenter	2W	1	Red
	Oil Level	2W	1	Green
	Fuel	2W	1	Orange
	Glow	2W	1	Orange
	A/T Oil Temp	2W	1	Red
	Cruise Main	2W	1	Green
	Cruise Set	2W	1	Green
	SVS	2W	1	Orange
Illumination & Indicator light	Illumination light for instrument panel cluster	3.4W	5	
	Hazard warning switch	2W	1	
	Cab interior switch	1.2W	1	
	A/C switch	60mA	1	
	Cruise main switch	60mA	1	
	Cruise set coast switch	60mA	1	
	Cruise resume accel switch	60mA	1	
	Oil level check and Miles check switch	60mA	2	
	Cigarette lighter	1.4W	1	
	Heater bezel	1.4W	1	
	Ashtray	1.4W	1	

Fuse, Fusible Link and Slow Blow Fuse Location

FUSE



FUSE LABEL

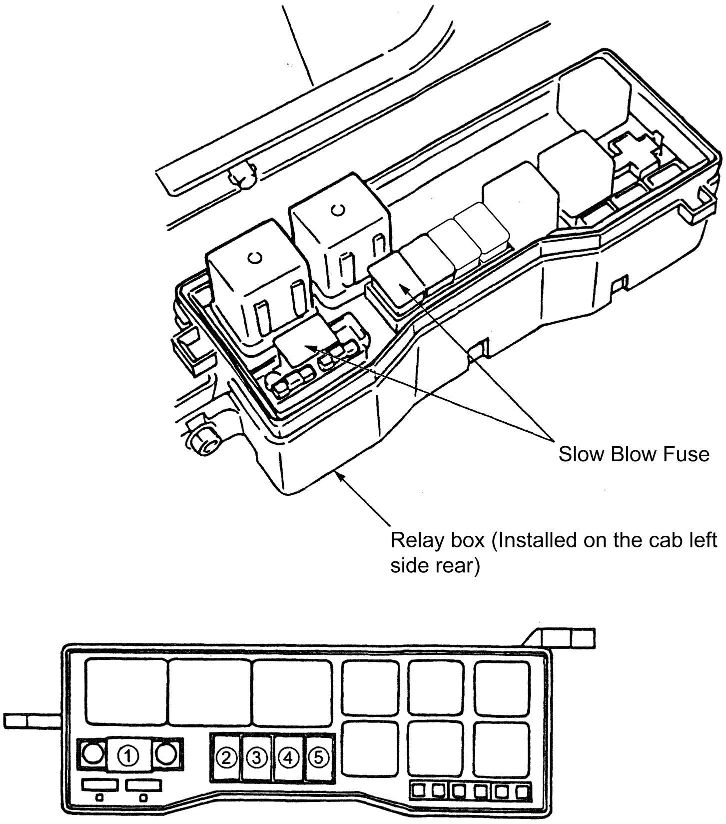
25A (1)	HEATER
10A (2)	AIR CONDITIONER
10A (3)	EXHAUST BRAKE
10A (4)	D. R. L.
20A (5)	RR DOME LIGHT
15A (6)	DOME LIGHT
10A (7)	TAIL LIGHTS
10A (8)	BRAKE LIGHTS
20A (9)	HEAD LIGHT (RH)
20A (10)	HEAD LIGHT (LH)
20A (11)	WIPER, WASHER
20A (12)	GENERATOR
10A (13)	TURN SIGNAL LIGHTS
10A (14)	ECM (IGN)
20A (15)	AUDIO, CIGAR LIGHTER
15A (16)	FUEL HEATER
20A (17)	POWER SOURCE 1
20A (18)	HAZARD, HORN
20A (19)	MARKER LIGHT
10A (20)	STARTER
20A F-21	ECM (BATTERY)
15A F-22	CONDENSER FAN

15A F-23	POWER SOURCE 2
20A F-24	Not Used
10A F-25	GAUGES
25A F-26	POWER WINDOW

15A F-27	POWER DOOR LOCK
15A F-28	REAR HEATER

Notice:
The fuse numbers (1)-(20) indicated on the fuse labels are expressed as [F-1] ~ [F-20] in the circuit diagrams of this manual.

SLOW BLOW FUSE

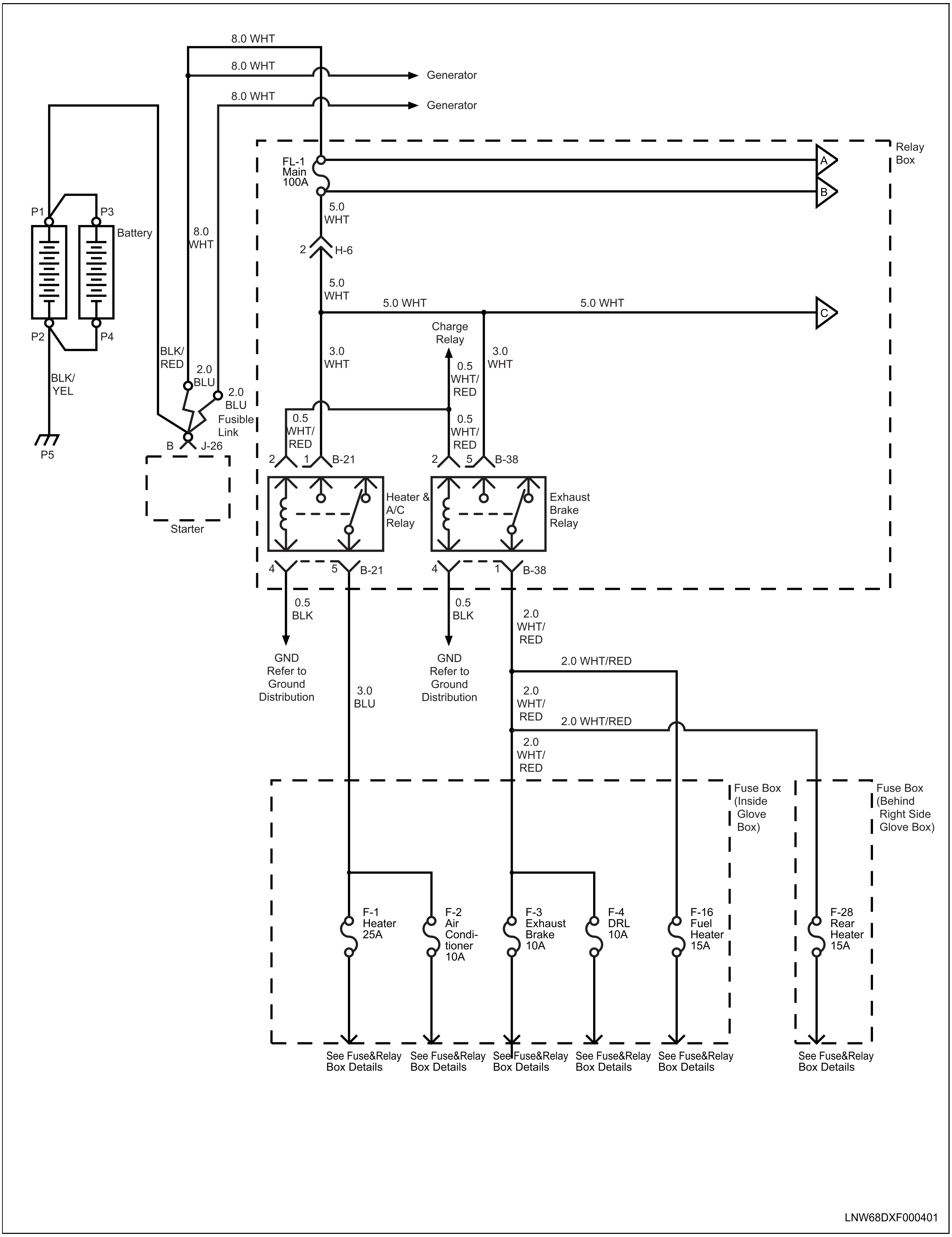


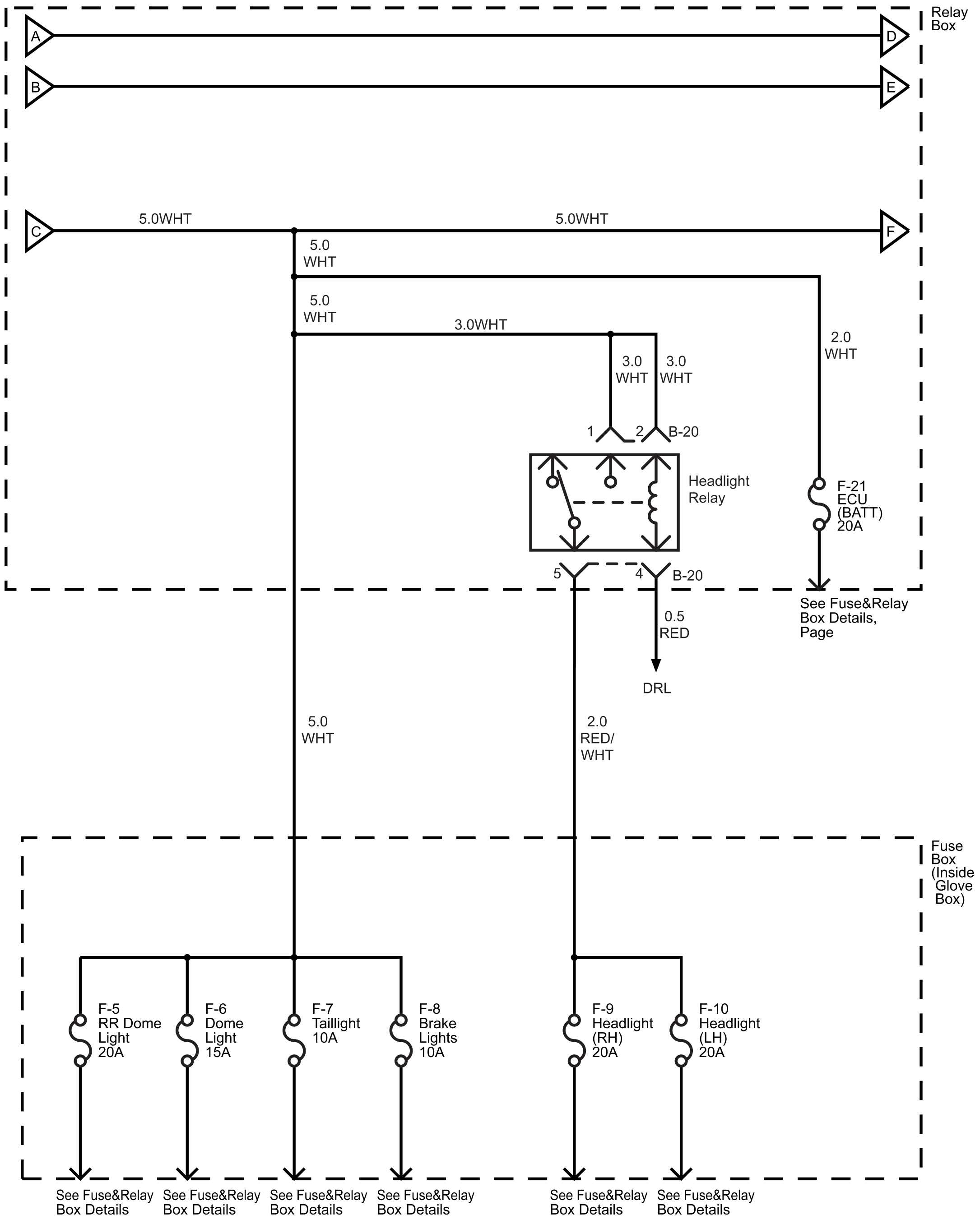
LNW48AMF001301

No.	Name	Capacity
(1)	MAIN	100A
(2)	KEY SW	50A
(3)	GLOW	60A
(4)	ABS	60A
(5)	CERAMIC HEATER	60A

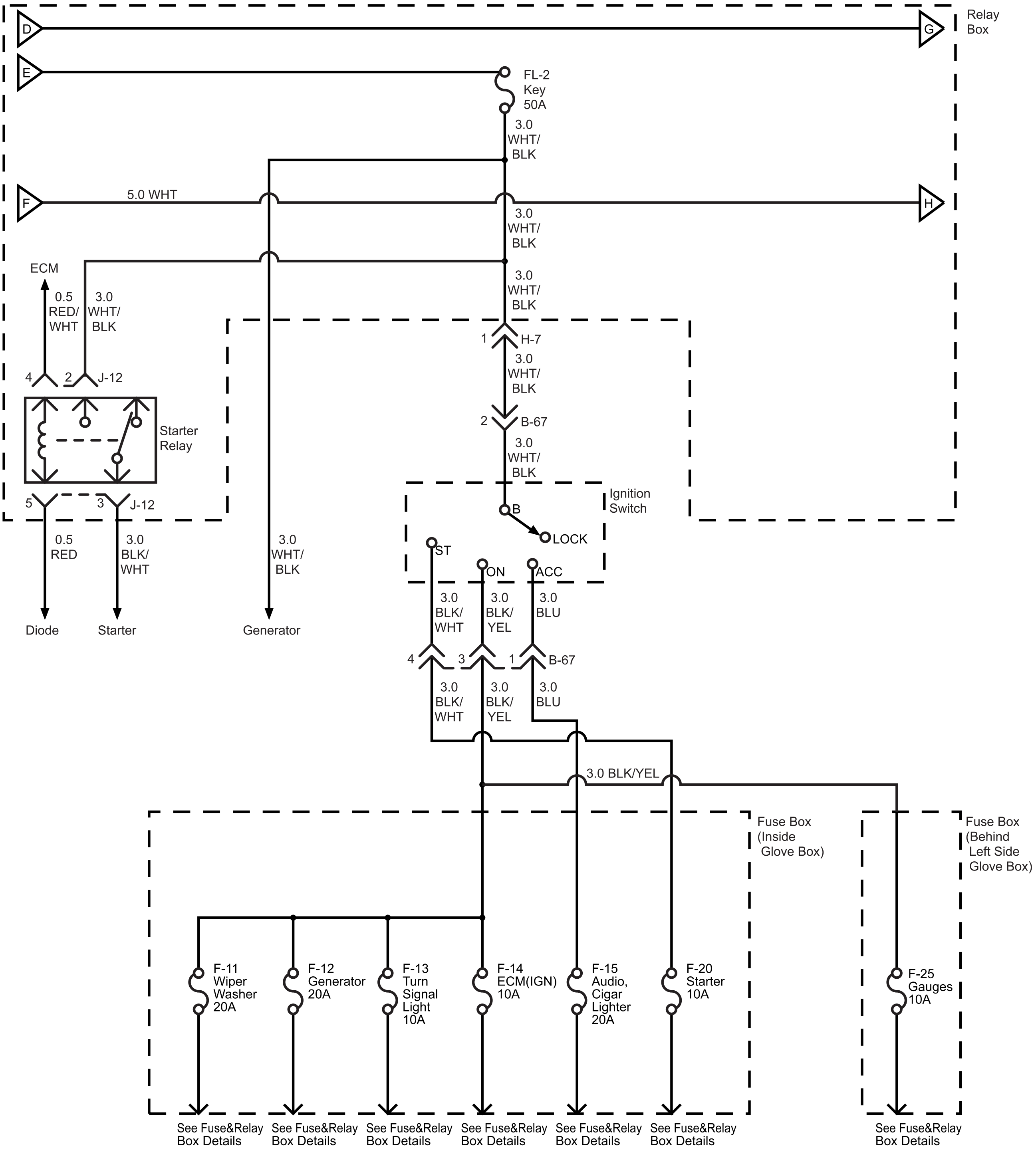
Notice:
The slow blow fuse numbers (1)-(5) indicated on the fuse labels are expressed as [FL-1] ~ [FL-5] in the circuit diagrams of this manual.

Power Distribution

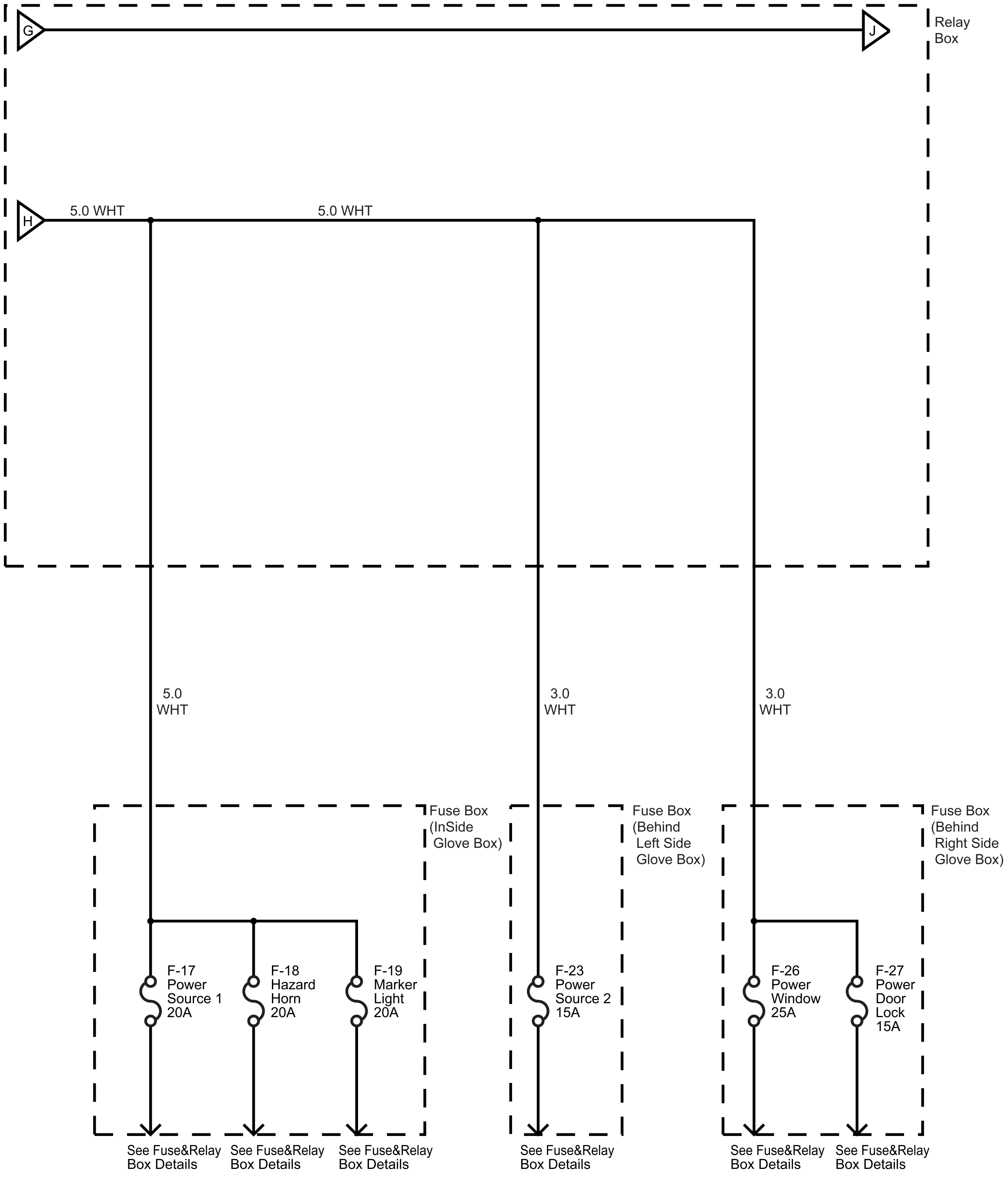




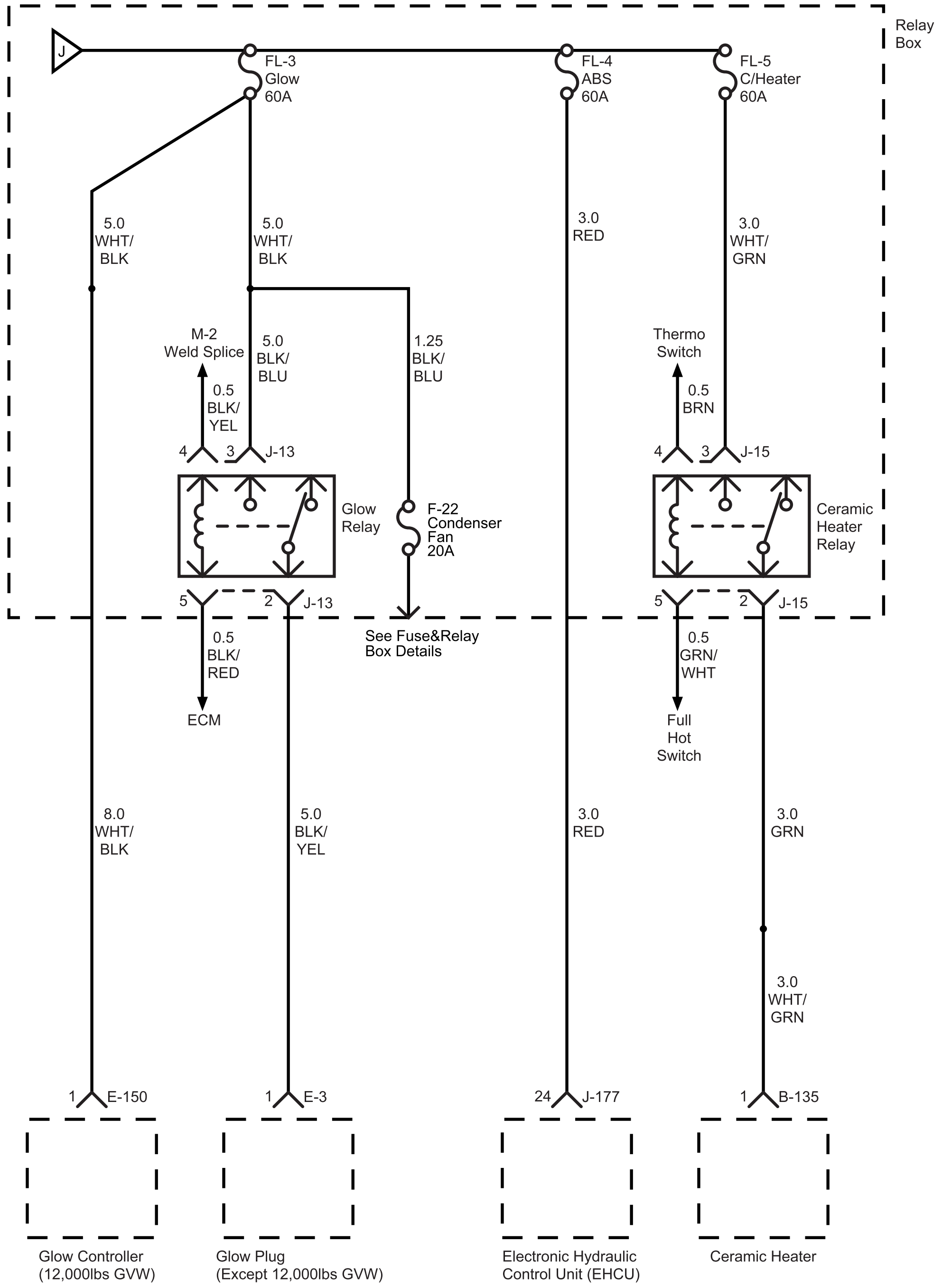
LNW68DXF000501



LNW68DXF000601

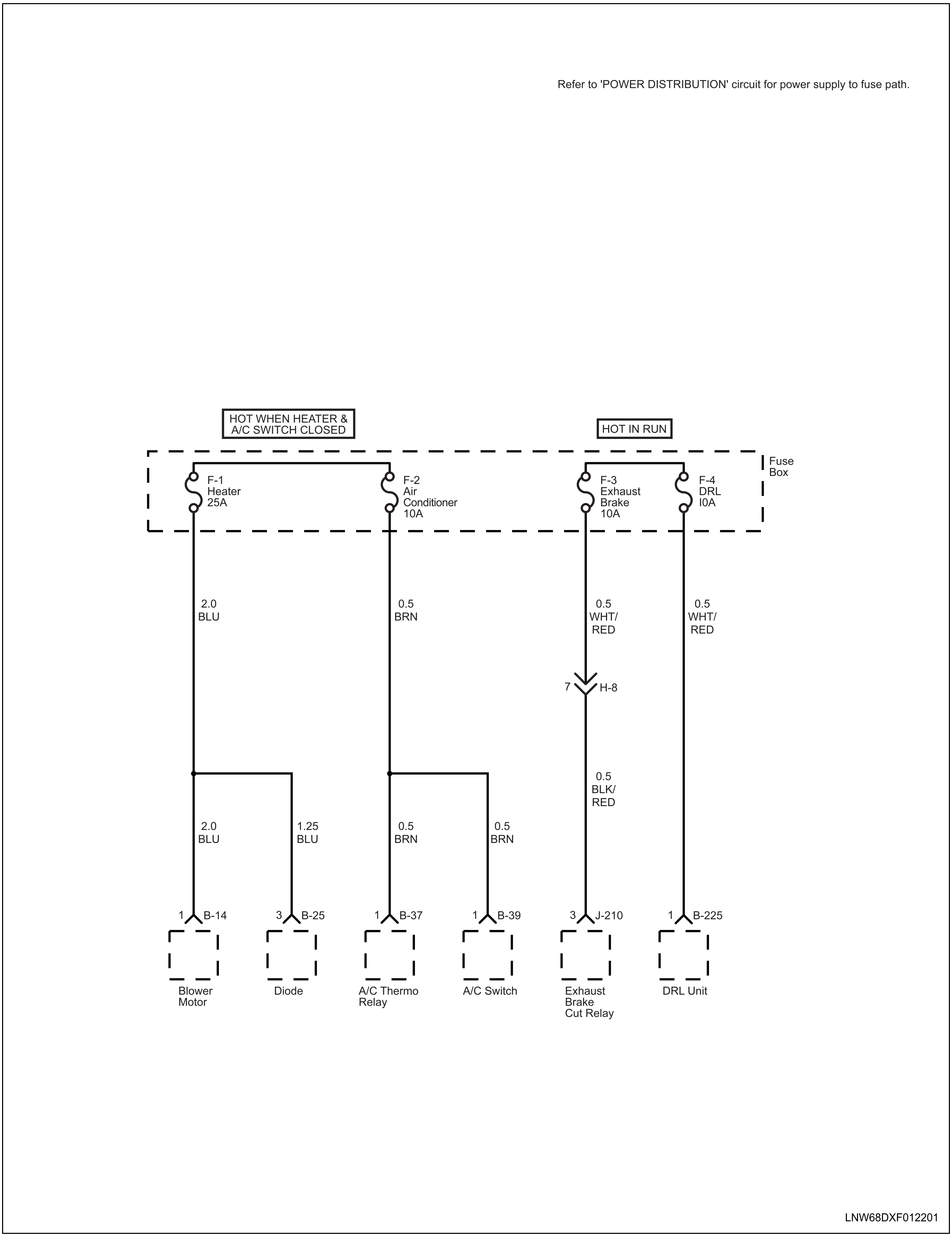


LNW68DXF000701

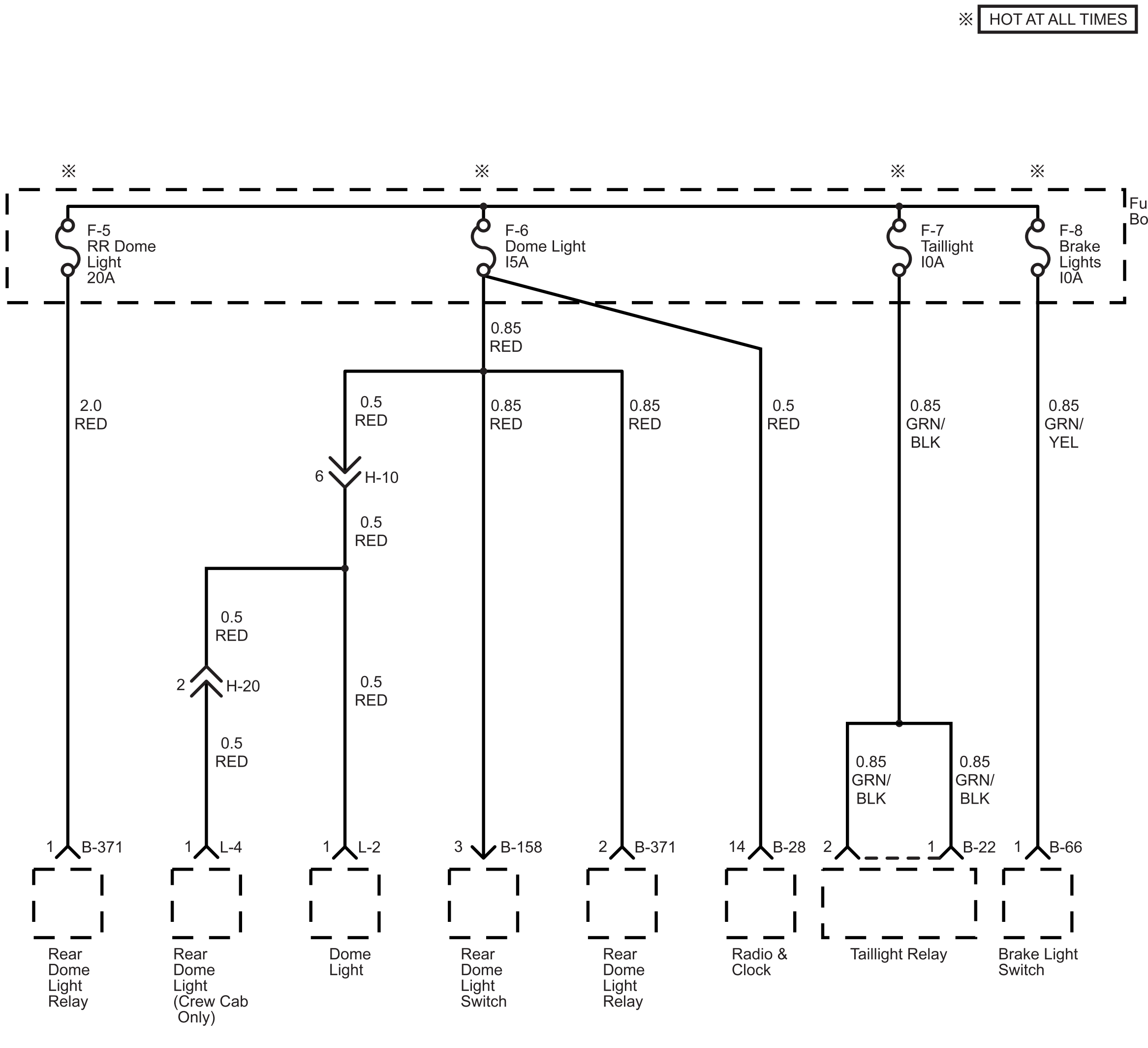


LNW68DXF000801

Fuse and Relay Box Details

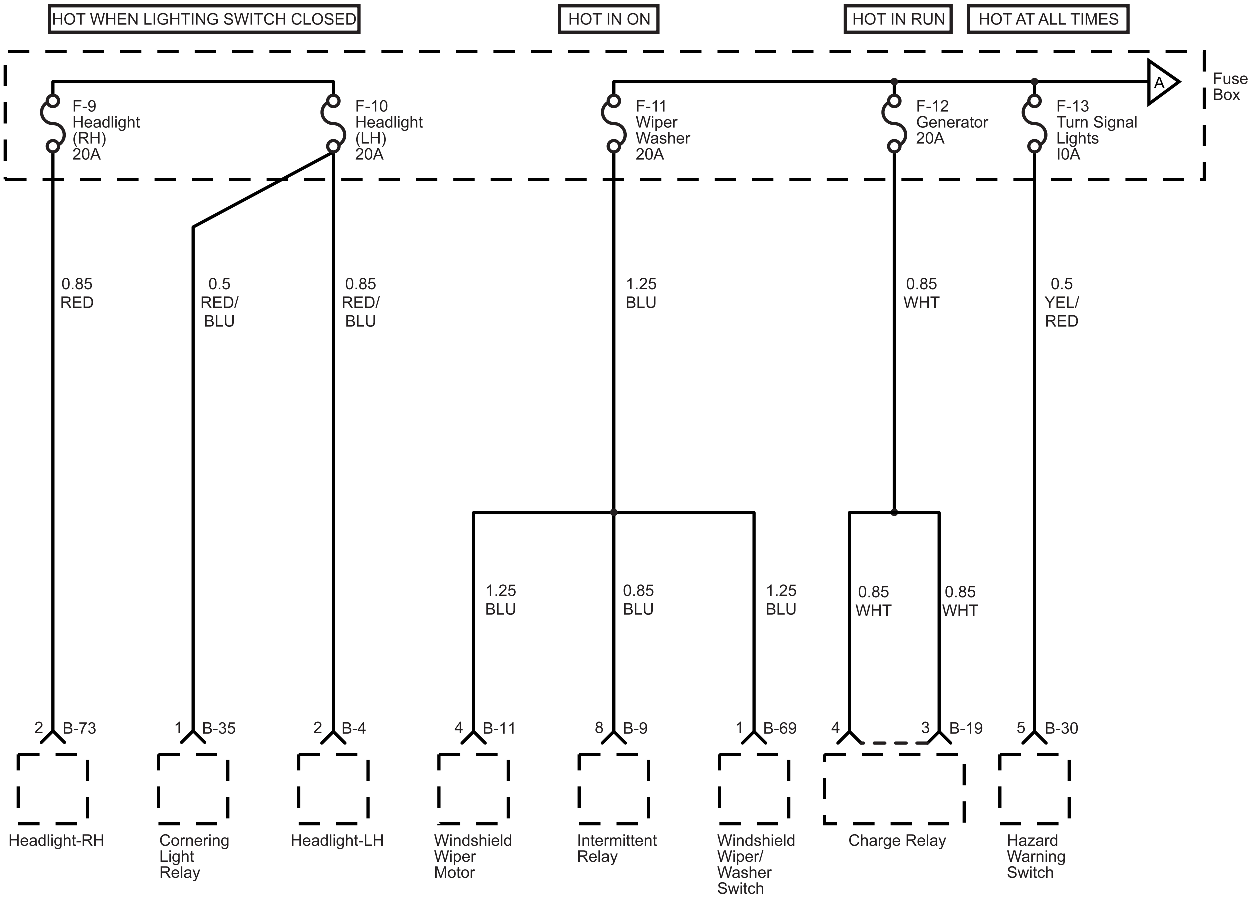


Refer to 'POWER DISTRIBUTION' circuit for power supply to fuse path.



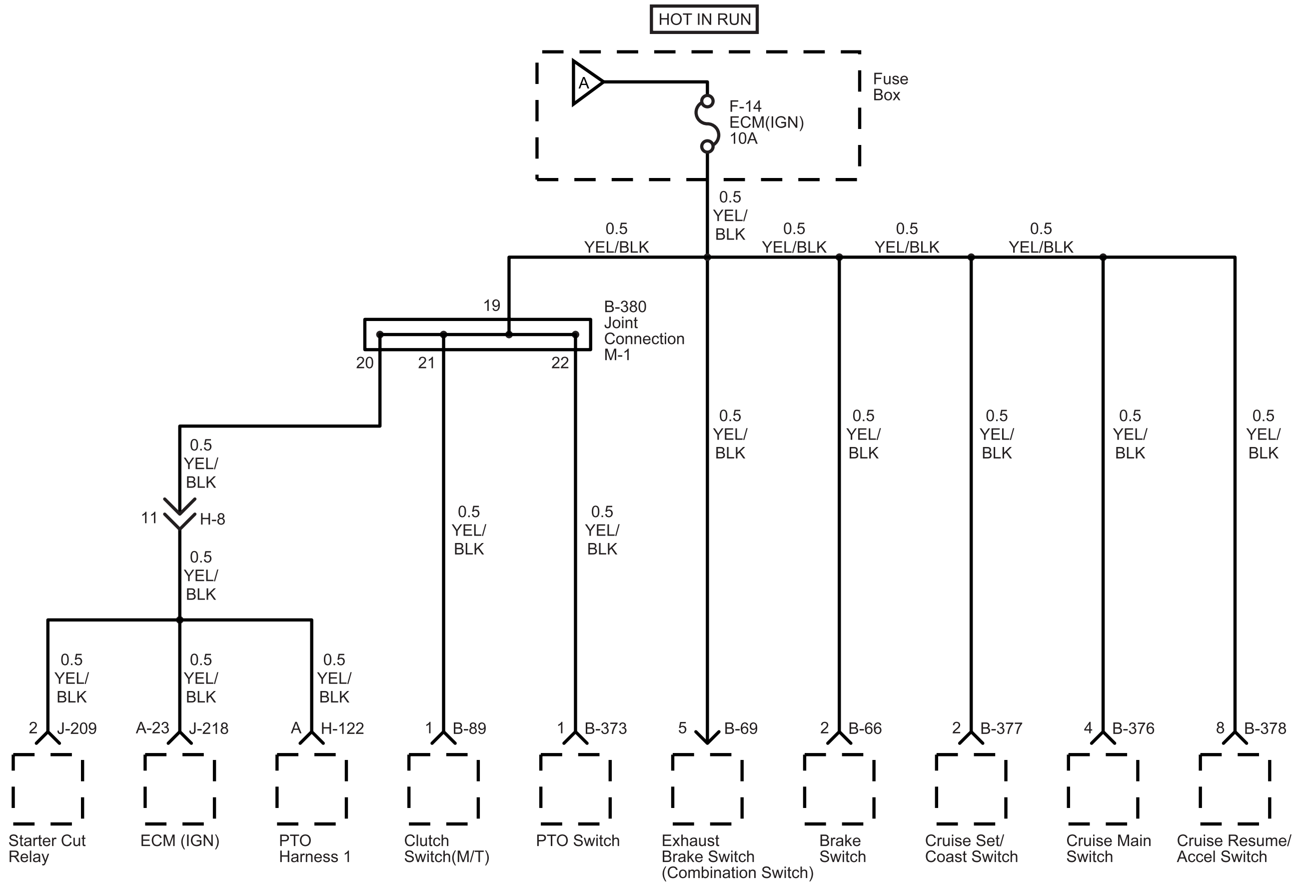
LNW68DXF012301

Refer to 'POWER DISTRIBUTION' circuit for power supply to fuse path.



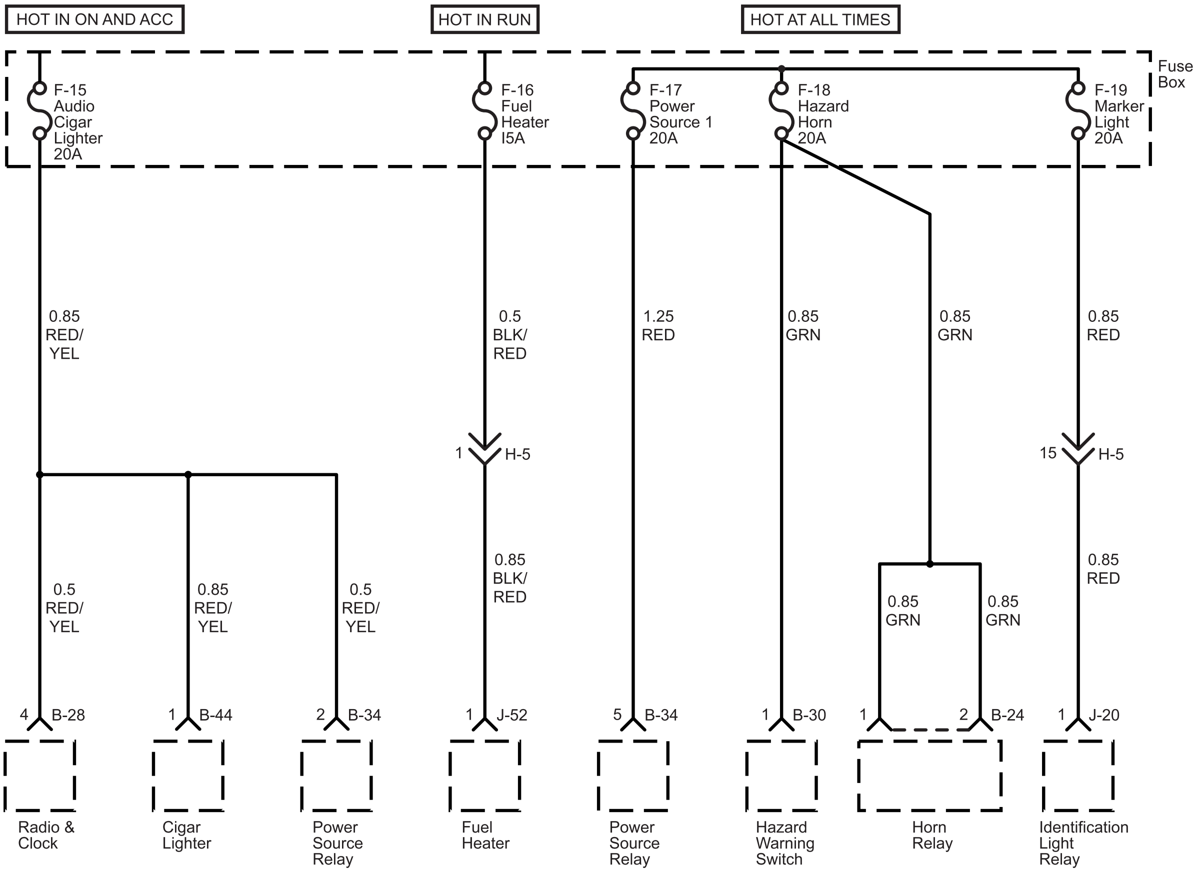
LNW68DXF012401

Refer to 'POWER DISTRIBUTION' circuit for power supply to fuse path.



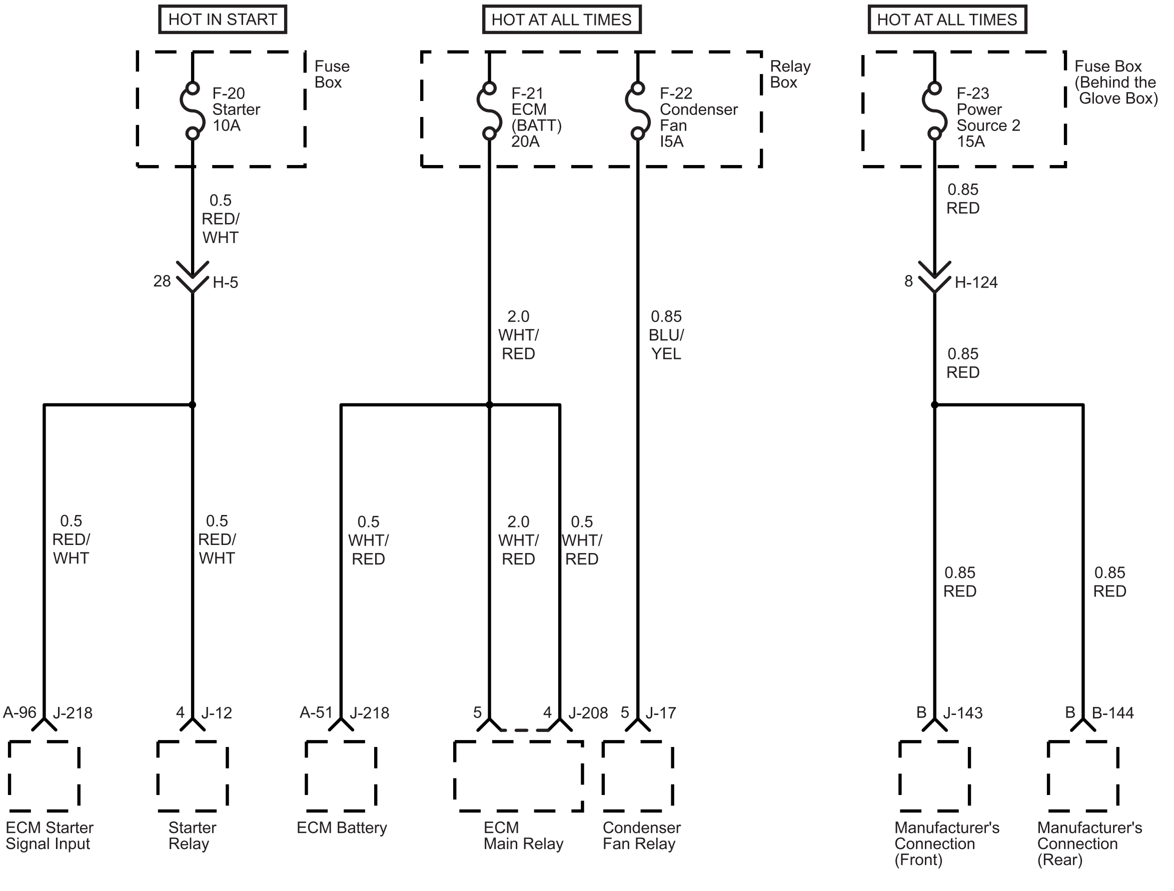
LNW68DXF012501

Refer to 'POWER DISTRIBUTION' circuit for power supply to fuse path.



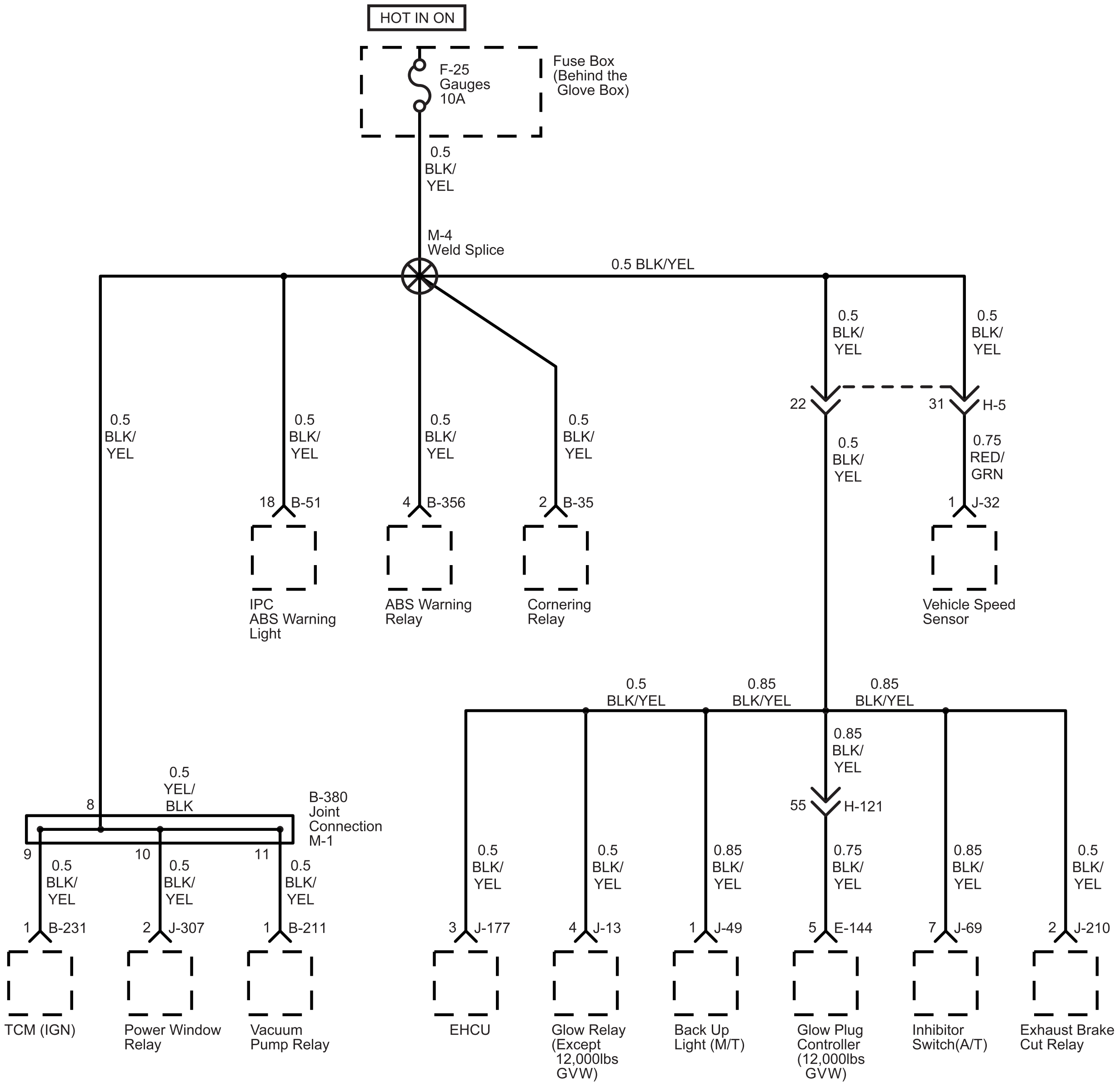
LNW68DXF012601

Refer to 'POWER DISTRIBUTION' circuit for power supply to fuse path.



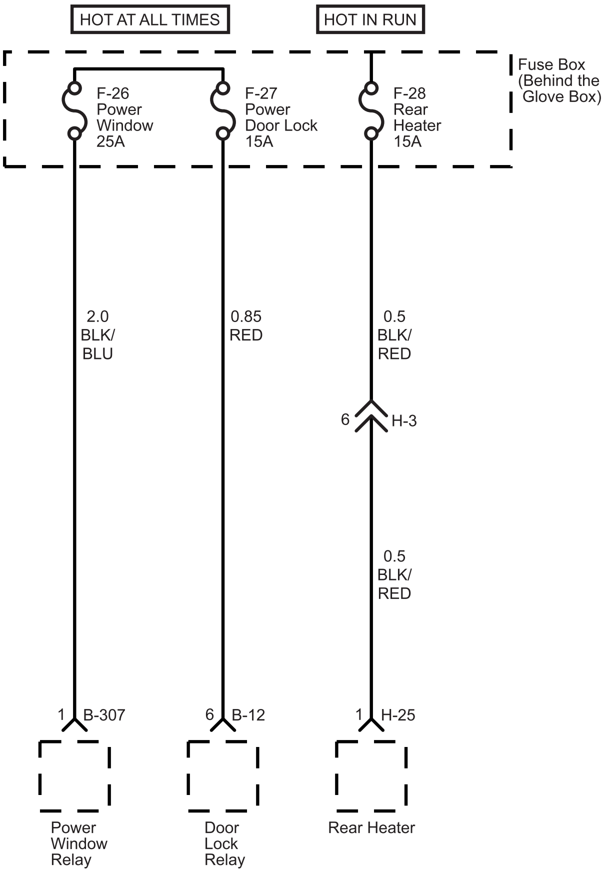
LNW68DXF012701

Refer to 'POWER DISTRIBUTION' circuit for power supply to fuse path.



LNW68DXF012801

Refer to 'POWER DISTRIBUTION' circuit for power supply to fuse path.



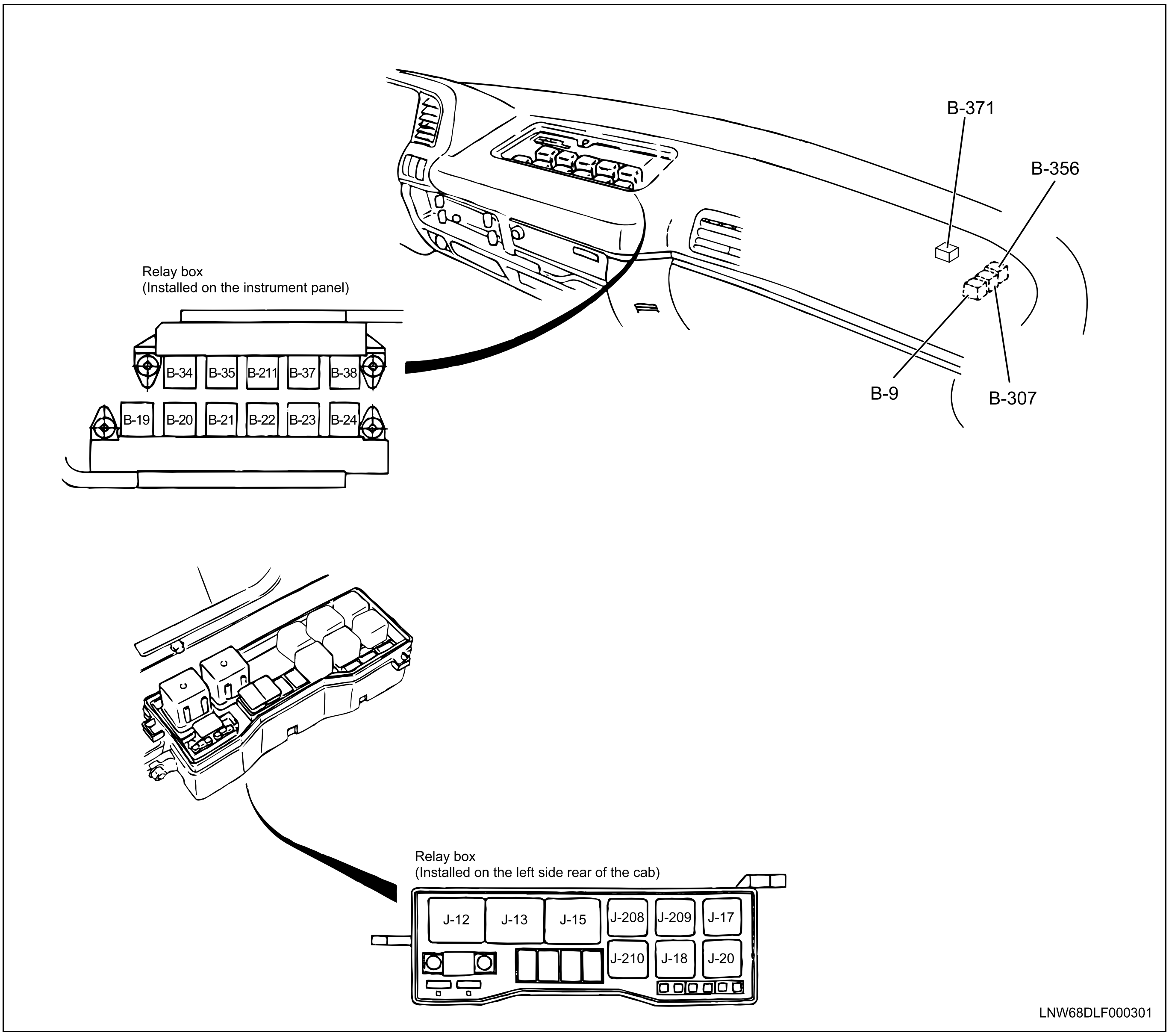
LNW68DXF012901

Reference Table of Fuse

Fuse No.	Capacity	Indication on Label	Main Parts (Load)
[F-1]	25A	HEATER	Blower Motor, Blower Resistor, Fan Switch, A/C Thermo Relay, Electronic Thermostat
[F-2]	10A	AIR CONDITIONER	A/C Switch, A/C Thermo Relay, Pressure Switch, Magnetic Clutch, Electronic Thermostat
[F-3]	10A	EXHAUST BRAKE	Exhaust Brake Cut Relay, Exhaust Brake Control Relay
[F-4]	10A	D. R. L	D. R. L Unit
[F-5]	20A	RR DOME LIGHT	Rear Dome Light Relay, Manufacturer’s Connection
[F-6]	15A	DOME LIGHT	Radio & Clock, Rear Dome Light Switch, Dome Light, Rear Dome Light, Door Switch (LH), Rear Dome Light Relay, Manufacturer’s Connection
[F-7]	10A	TAIL LIGHTS	Tail Relay, Illumination Light(s), Lighting Switch, Tail light(s), Illumination Controller, Identification Light Relay, Cigarette Lighter, Radio&Clock
[F-8]	10A	BRAKE LIGHTS	Brake Switch, Rear Combination Light, TCM
[F-9]	20A	HEAD LIGHT (RH)	Headlight (RH), High Beam Indicator Light, D.R.L Unit
[F-10]	20A	HEAD LIGHT (LH)	Headlight (LH), Cornering Light Relay, Cornering Light, Cornering Light Switch, D.R.L Unit
[F-11]	20A	WIPER, WASHER	Wiper & Washer Switch, Wiper motor, Washer Motor, Intermittent Relay
[F-12]	20A	GENERATOR	Generator, Charge Relay, Heater & A/C relay, Exhaust Brake Relay
[F-13]	10A	TURN SIGNAL LIGHTS	Hazard Warning Switch, Flasher Unit, Turn signal Light Switch
[F-14]	10A	ECM (IGN)	ECM, Starter Cut Relay, Exhaust Brake Switch, Cruise Main Switch, Clutch Switch, Cruise Resume Accel Switch, Cruise Set Coast Switch, PTO Switch, Brake Switch
[F-15]	20A	AUDIO, CIGAR LIGHTER	Cigarette Lighter, Radio&Clock, Power Source Relay
[F-16]	15A	FUEL HEATER	Fuel Heater
[F-17]	20A	POWER SOURCE 1	Power Source Relay (Service Terminal)
[F-18]	20A	HAZARD, HORN	Hazard Warning Switch, Horn, Horn Relay, Horn Switch, Flasher Unit
[F-19]	20A	MARKER LIGHT	Identification Light relay, Identification Light, Roof Marker Light
[F-20]	10A	STARTER	Starter Relay, Inhibitor Switch(A/T), Neutral Switch (M/T) ECM
[F-21]	20A	ECU (BATT)	ECM Main Relay, ECM
[F-22]	15A	CONDENSER FAN	Condenser Fan Relay, Condenser Fan
[F-23]	15A	POWER SOUCE 2	Manufacturer’s Connection
[F-25]	10A	GAUGES	Glow Relay, Power Window Relay, EHCU, Backup Light, Inhibitor Switch, Meter Assembly, Cornering Light Relay, Ignition Relay, Vacuum Pump Relay, TCM, Back Buzzer, Exhaust Brake Cut Relay, Glow Plug Controller

Fuse No.	Capacity	Indication on Label	Main Parts (Load)
[F-26]	25A	POWER WINDOW	Power Window Relay, Power Window Motor, Power Window Switch
[F-27]	15A	POWER DOOR LOCK	Door Lock Relay, Door Lock Controller, Door Lock Switch
[F-28]	15A	REAR HEATER	Rear Heater

Relay Location



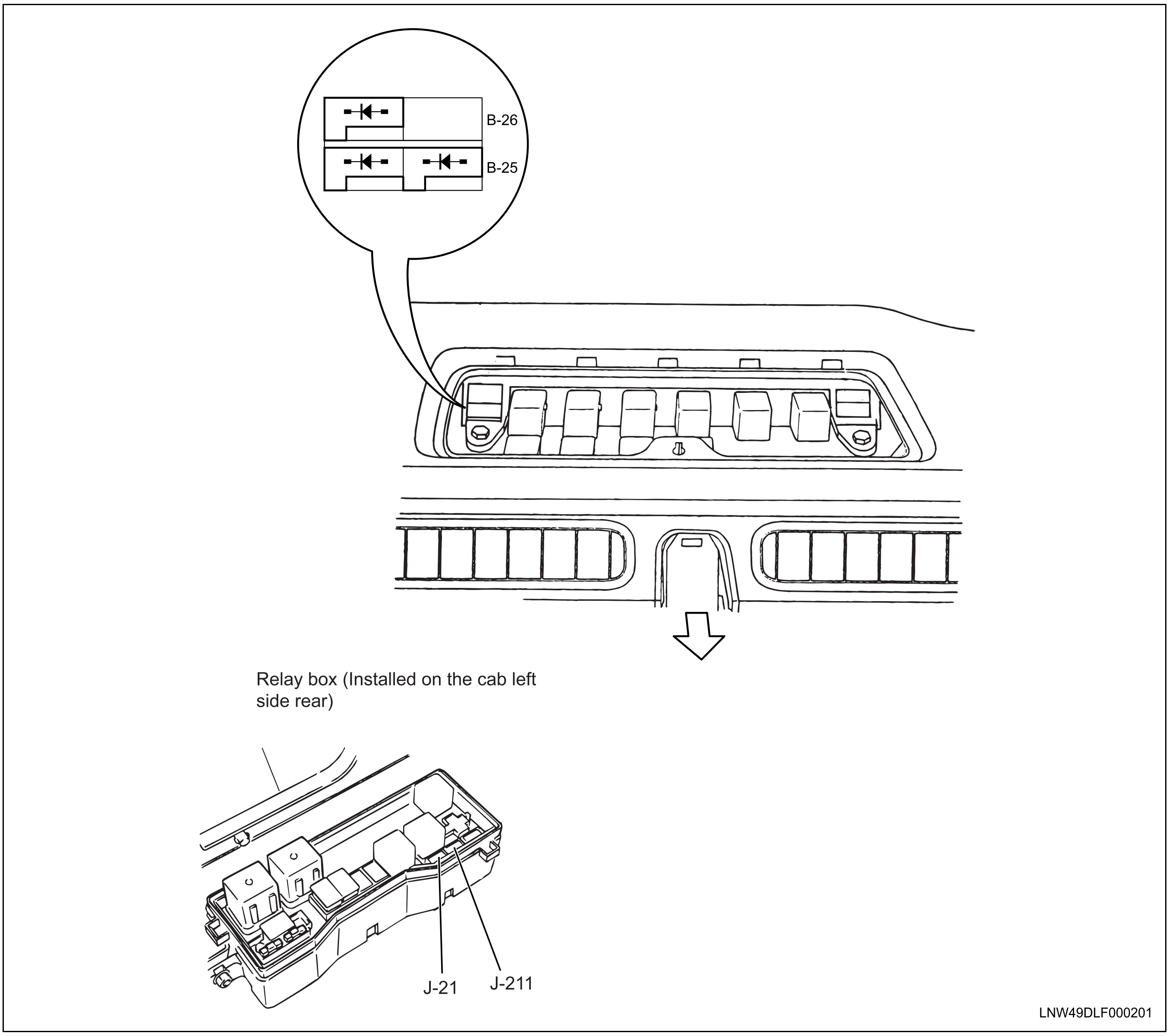
Relay List

Connector No.	Relay Name
B-9	Intermittent
B-19	Charge
B-20	Headlight
B-21	Heater & A/C
B-22	Tail
B-23	Buzzer Cancel
B-24	Horn
B-34	Power Source
B-35	Cornering Light
B-37	A/C Thermo

Connector No.	Relay Name
B-38	Exhaust Brake
B-211	Vacuum Pump
B-307	Power Window
B-356	ABS Indicator
B-371	Rear Dome Light
J-12	Starter
J-13	Glow
J-15	Ceramic Heater
J-17	Condenser Fan
J-18	Exhaust Brake Control
J-20	Identification Light

Connector No.	Relay Name
J-208	ECM Main
J-209	Starter Cut
J-210	Exhaust Brake Cut

Diode Location

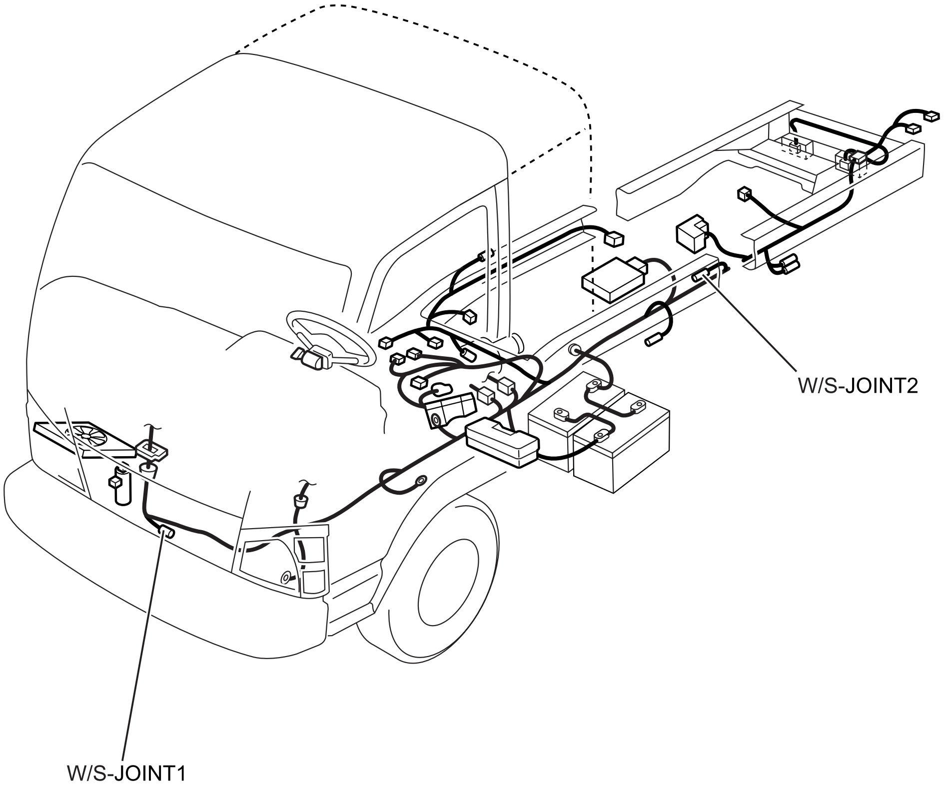


Diode List

Connector No.	Usage
B-25	A/C, A/T
B-26	Meter (Indicator)
J-21	Starter
J-211	Tap (PTO)

Joint Connection and Weld Splice Location

Frame Cable Harness



W/S=WELD SPLICE

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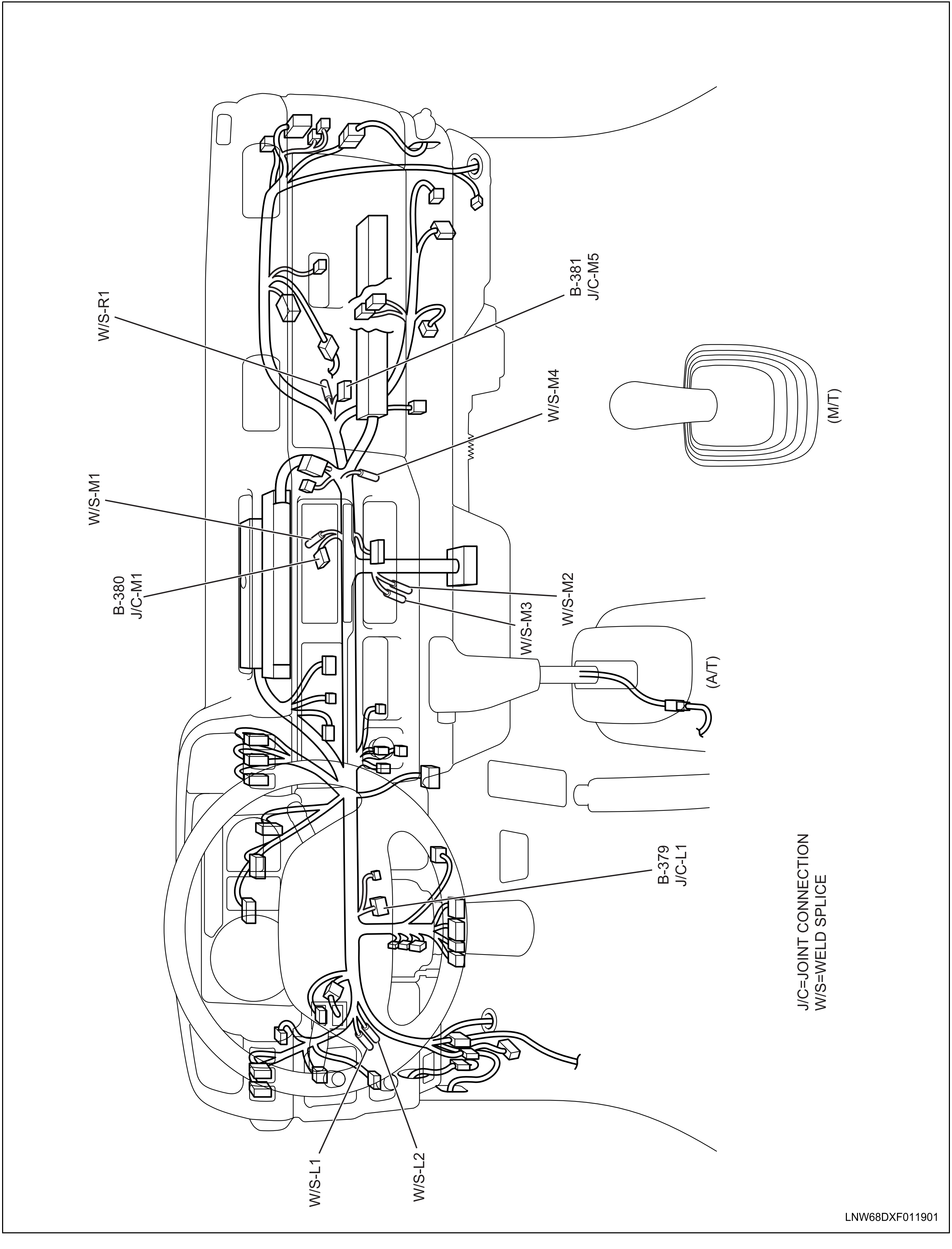
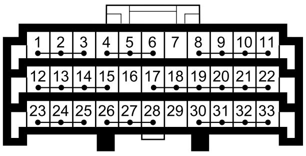
Body Cable Harness



Joint Connection Circuit

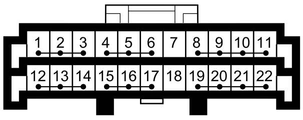
B-379 Joint Connection-L1



Joint Point	Terminal No.	Connection
●	1	W/S-L2
●	2	A/T Lever Illumination(+)
●	3	—
●	4	Frame Ground
●	5	Meter(B) Ground
●	6	Meter(C) Ground
	7	—
●	8	—
●	9	—
●	10	—
●	11	—
	12	Frame Ground
●	13	Data Link Connector(DLC) Ground
●	14	Transmission Control Module(TCM) Ground
●	15	—
●	16	—

Joint Point	Terminal No.	Connection
●	17	Joint Connection-M5
●	18	OD OFF Ground(A/T)/Seat Belt Switch Ground(M/T)
●	19	—
●	20	Pressure Switch / Vacuum Pump
●	21	Power Window Switch(DR) Ground
●	22	—
●	23	Brake Light
●	24	Brake Light Switch
●	25	Transmission Control Module(TCM) Brake Light
●	26	EHCU(ABS Module) Class2
●	27	Data Link Connector(DLC) Class2
●	28	Transmission Control Module(TCM) Class2
	29	—
●	30	W/S-M3
●	31	A/T Lever Illumination(-)
●	32	—
●	33	—

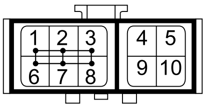
B-380 Joint Connection-M1



Joint Point	Terminal No.	Connection
●	1	Brake Fluid Level Switch
●	2	Meter(A) Parking Brake Indicator Light
●	3	D.R.L(Brake Fluid Level Switch Input) / HBB Oil Level Sensor
●	4	Charge Relay Voltage Feed
●	5	Generator(L)
●	6	—
	7	—
●	8	W/S-M4
●	9	Transmission Control Module(TCM)IGN Voltage Feed
●	10	Power Window Relay Voltage Feed
●	11	Vacuum Pump Relay Voltage Feed

Joint Point	Terminal No.	Connection
●	12	Fan Switch
●	13	Electro Thermo
●	14	Ceramic Heater
●	15	Parking Brake Switch
●	16	D.R.L (Parking Brake Switch Input)
●	17	Buzzer Cansel Relay Voltage Feed
	18	—
●	19	Fuse Box ECM(IGN)
●	20	ECM Ignition voltage feed
●	21	Clutch Switch
●	22	PTO Main Switch

B-381 Joint Connection-M5



Joint Point	Terminal No.	Connection
●	1	Headlight Bracket Ground
●	2	W/S-L1
●	3	W/S-M1
	4	—
	5	—
●	6	Joint Connection-L1
●	7	W/S-R1
●	8	—
	9	—
	10	—

W/S = Weld Splice

LNW68DXF000101

Reference Table of Weld Splice

Connector No	Usage
W/S-L1	J/C-M5
	Breke Fluid Level Switch Ground
	Cab Interior Light Switch Ground
	Doom Light Ground
	Front Turn Signal Light LH Ground
	Illumination Controller Ground
	PTO Switch Ground
	Turn Signal Light Switch Ground
W/S-L2	J/C-L1
	W/S-M2
	Cruise Resume Switch
	Front Turn Signal Light LH
	Illumination Controller
	Oil Level Check Switch
W/S-M1	J/C-M5
	Cigar Lighter Ground
	Fan Switch Ground
	Flasher Unit Ground
	Heater A/C Relay Control
	Power Source Relay Control
	Radio Ground
W/S-M2	W/S-L2
	Ashtray Illumi
	Cigar Lighter Illumi
	Cruise Main Switch
	Cruise Set Coast Switch
	Front Turn Signal Light RH
	Hazzard Warning Switch
	Heater Bezel
	License Plate Light
	Meter(A) Tail Relay
	PTO Switch
	Radio
	Tail Relay Control

Connector No	Usage
W/S-M3	J/C-L1
	Ashtray Illumi Ground
	Cigar Lighter Illumi Ground
	Cruise Main Switch Ground
	Cruise Resume Switch Ground
	Cruise Set Coast Switch Ground
	Hazzard Warning Switch Ground
	Heater Bezel Ground
	Illimination Controller
	Meter(B)Ground
	Oil Level Check Switch Ground
	PTO Switch Ground
	Radio Ground
W/S-M4	J/C-M1
	ABS Relay Voltage Feed
	Buzzer Cansel Relay Voltage Feed
	Cornering Relay Voltage Feed
	Fuse Box Gauge
	Inhibitor Switch
	Meter(A) Voltage Feed
W/S-R1	J/C-M5
	ABS Relay Ground
	D.R.L Unit
	Front Turn Signal Light RH Ground
	Intermittent Relay Ground
	Washer Moter Ground
	Wiper Moter Ground
W/S-JOINT1	Back Buzzer
	Manufacture Connector Rear
	Fuel Tank Unit
	Fuel Sedimenter
	Manufacture Connector Front
	Intake Throttle Solenoid Valve
	Frame Ground
	PTO Harness 1, Neutral Switch(M/T)
	Fuel Heater, Inhibitor Switch(A/T)
W/S-JOINT2	Frame Ground
	Exhaust Brake Control Relay
	Condenser Fan Relay
	HBB. Oil Level Sensor
	Rear Combination Light
	Engine Shut Down Switch
	Exhaust Brake Cut Relay
	Fuel Tank Unit
	Condenser Fan
	Identification Light Relay

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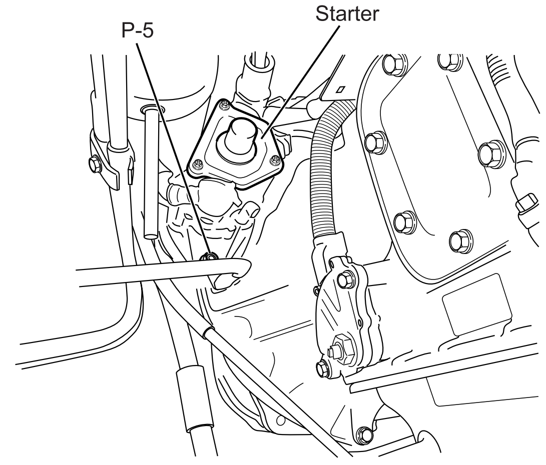
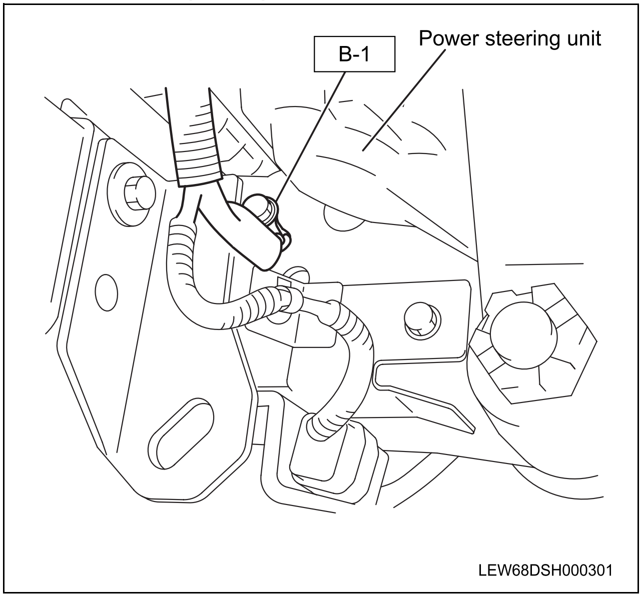
Ground Point Location

P-5 Frame

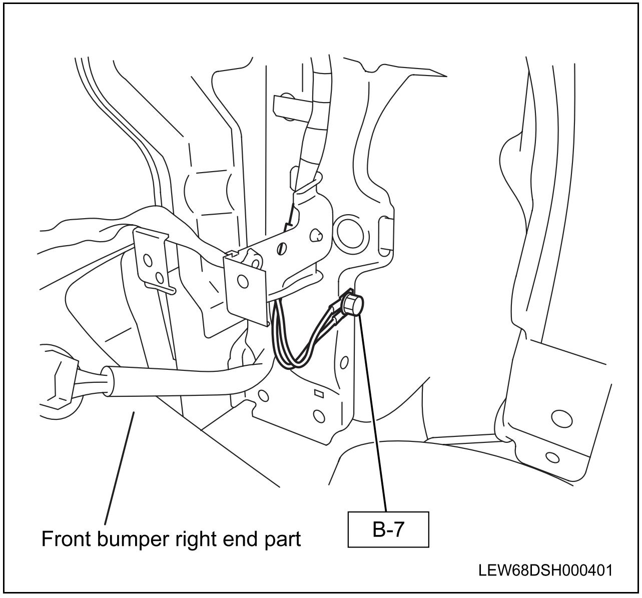


LNW48ASH002101

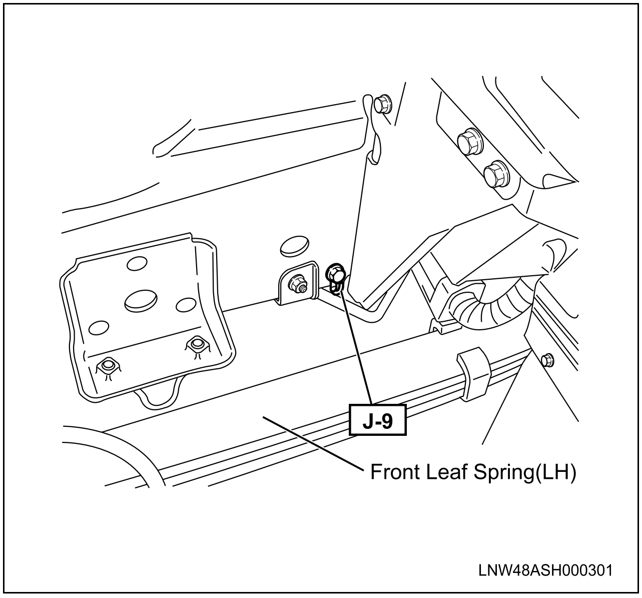
B-1 Frame–LH (Front)



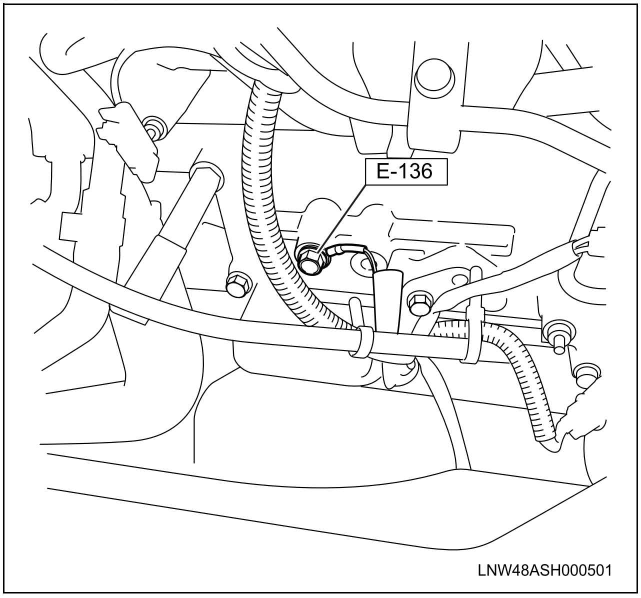
B-7 Headlight Bracket–RH



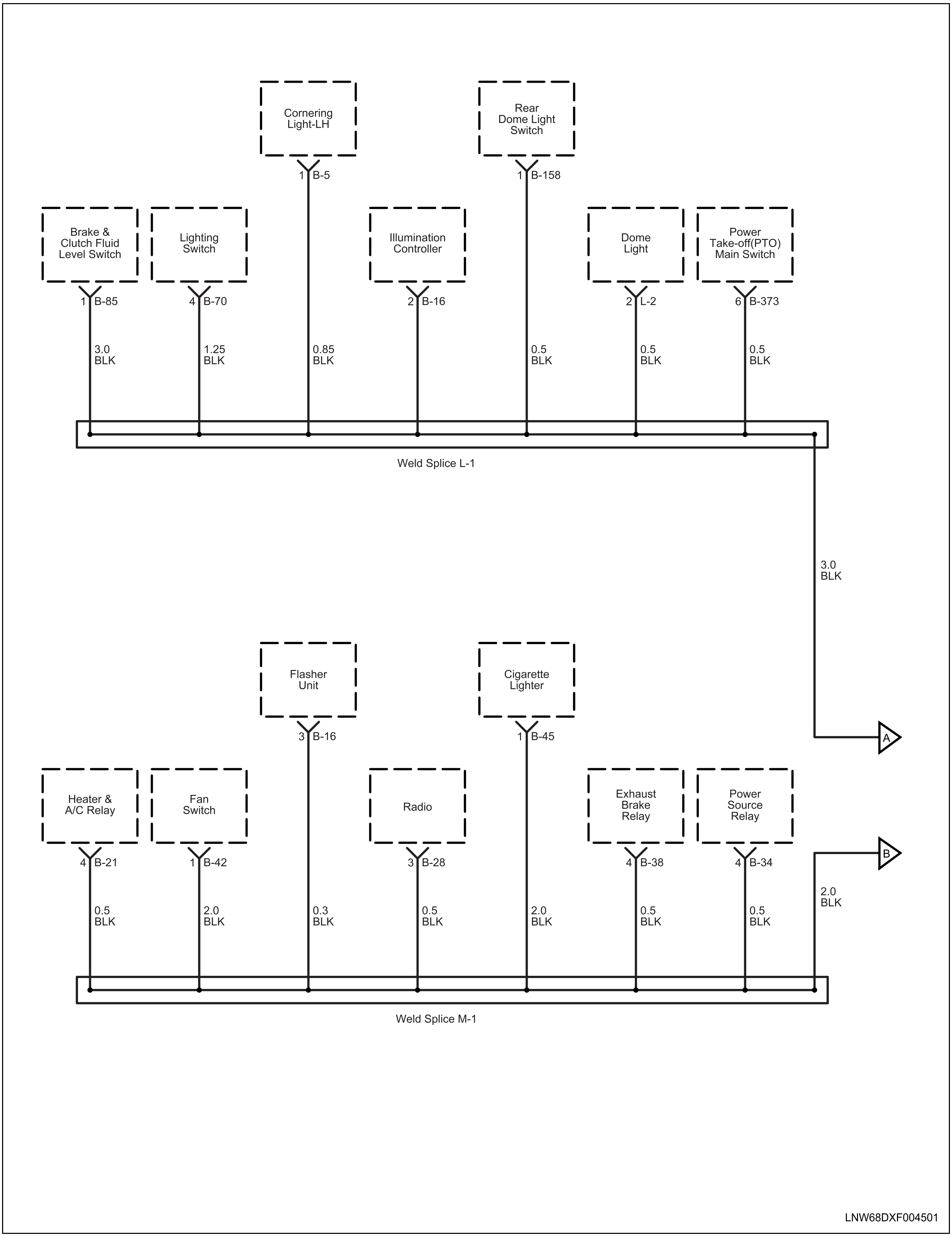
J-9 Frame–LH (Center)

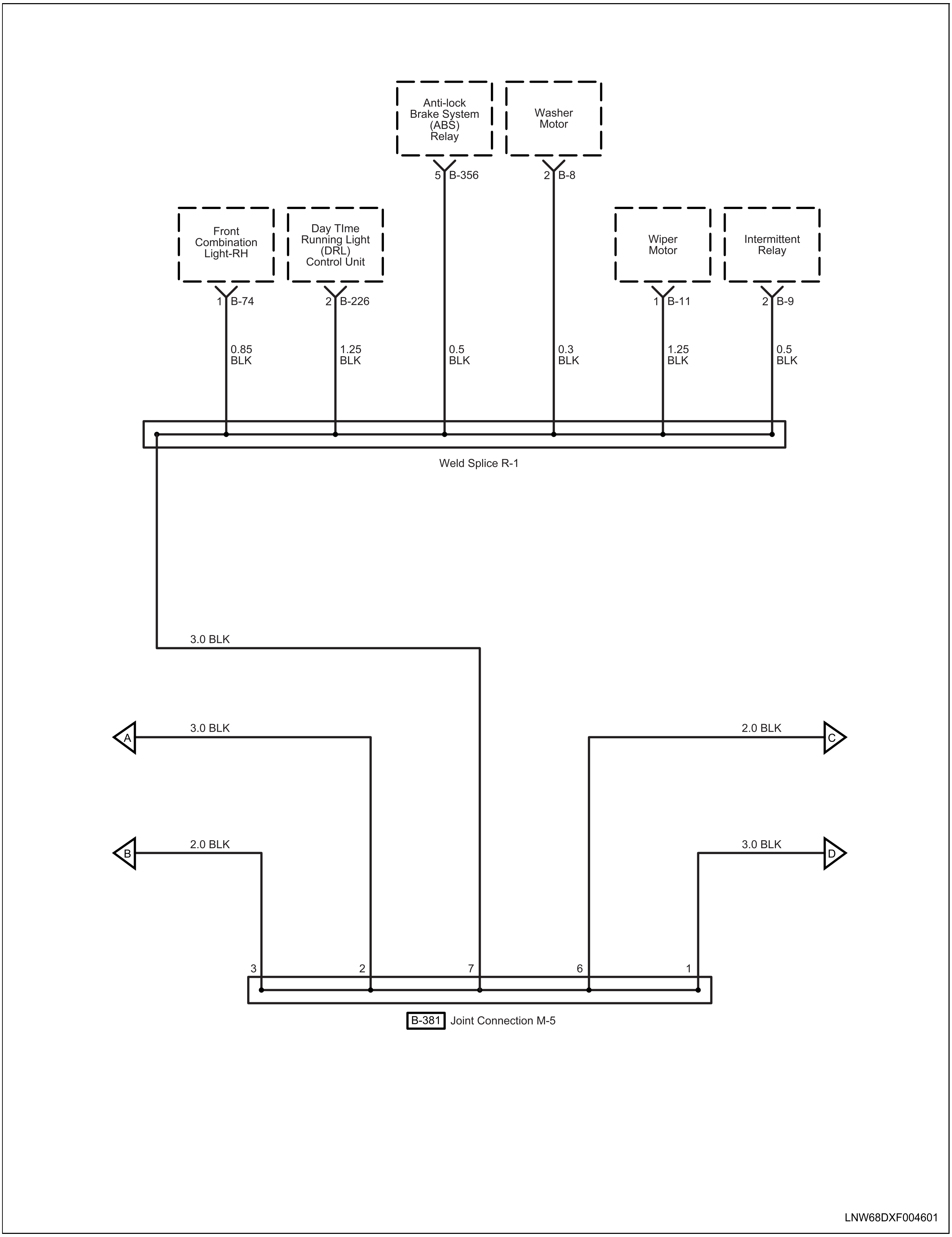


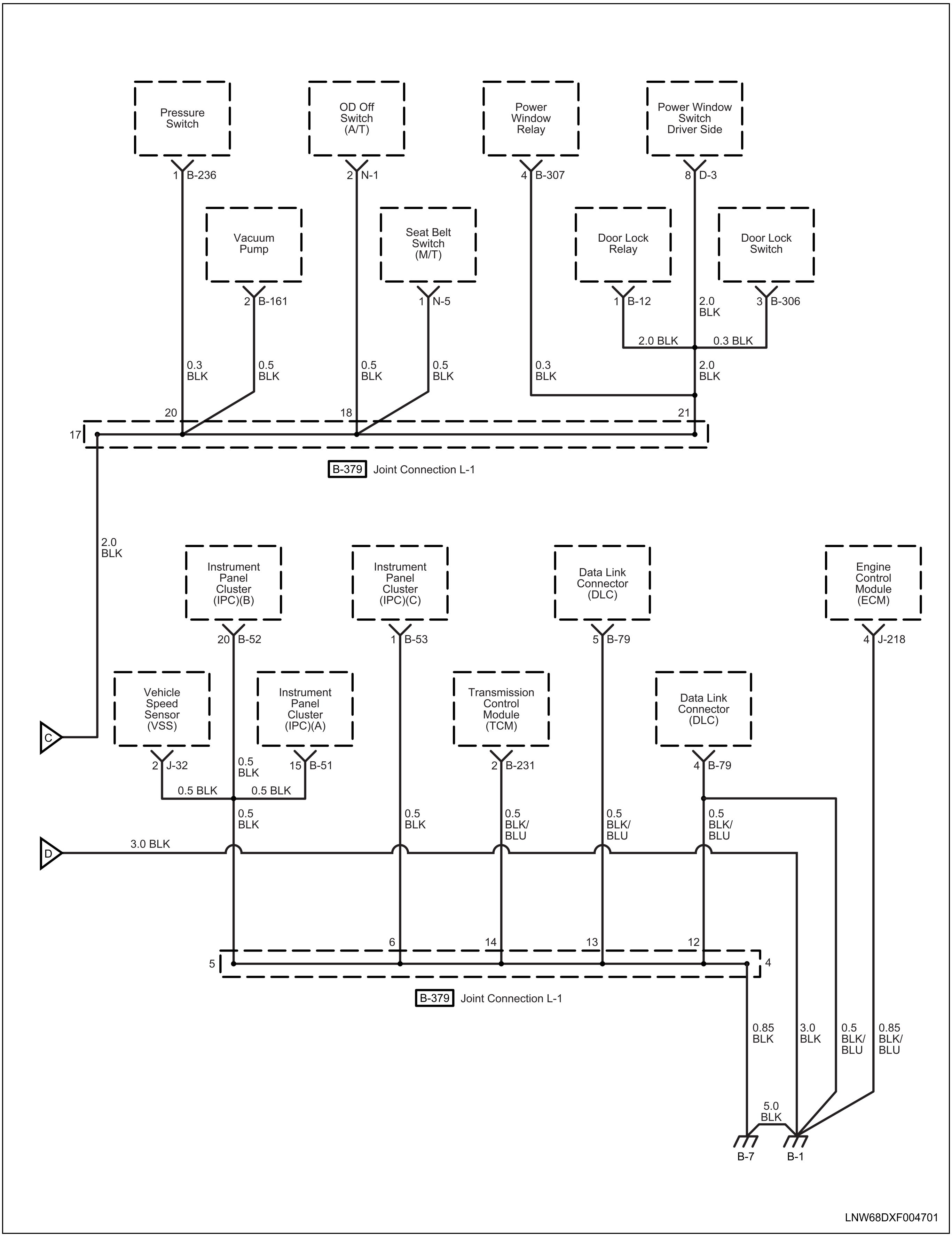
E-136 Engine Block–LH

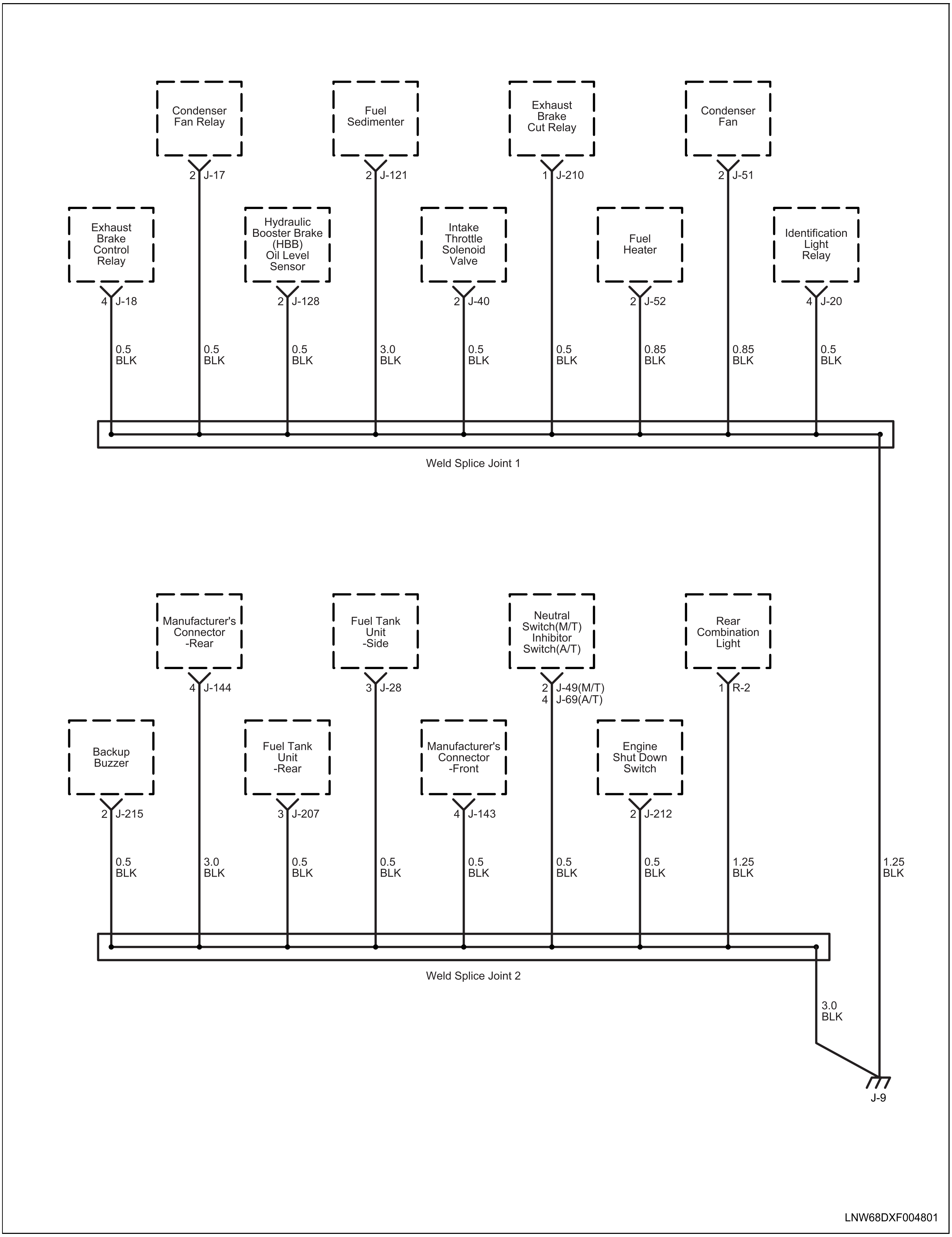


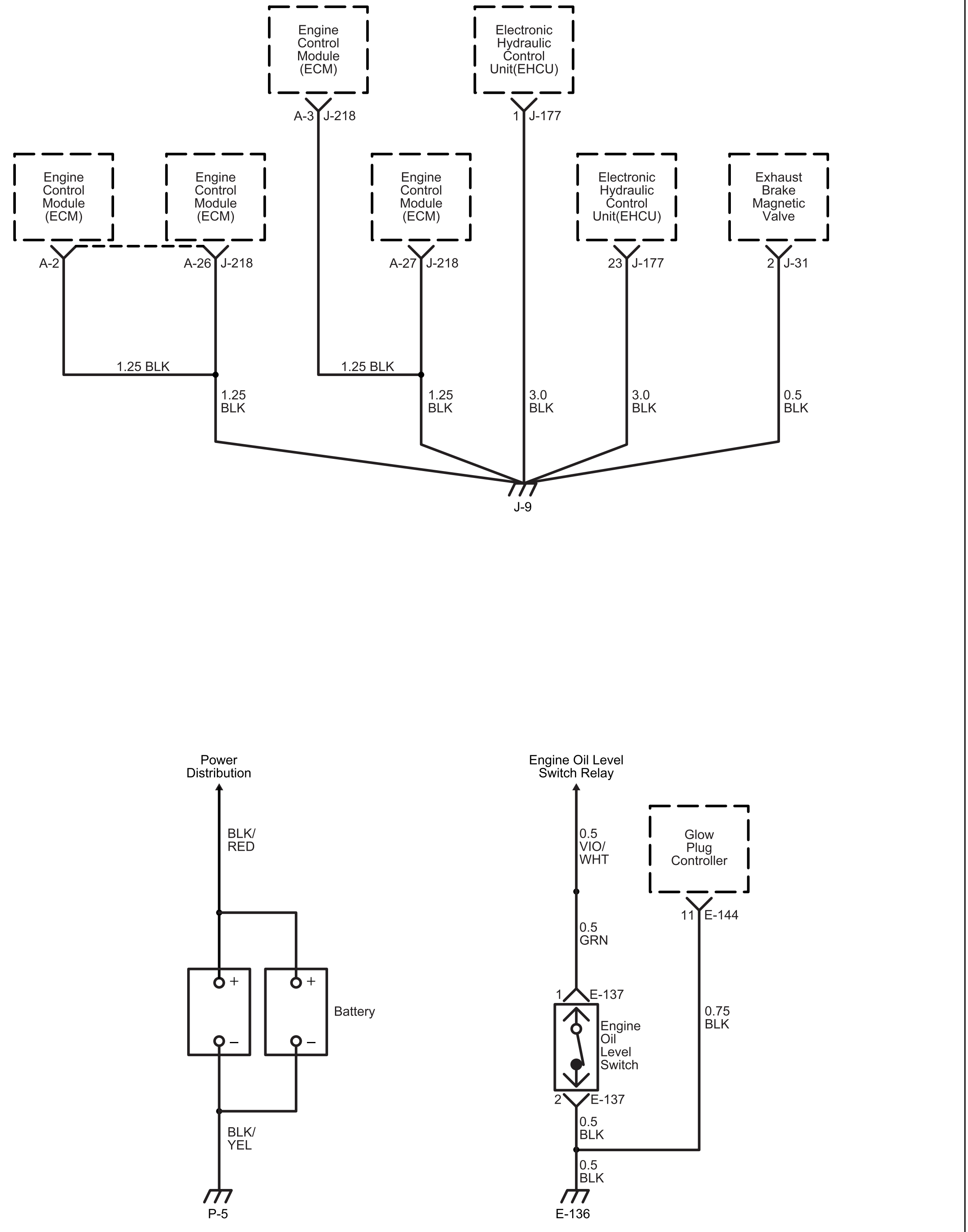
Grounding Point Circuit




Anti-lock Brake System (ABS) Relay
5 B-356
Washer Motor
2 B-8
Front Combination Light-RH
1 B-74
Day TIme Running Light (DRL) Control Unit
2 B-226
Wiper Motor
1 B-11
Intermittent Relay
2 B-9
0.85 BLK
1.25 BLK
0.5 BLK
0.3 BLK
1.25 BLK
0.5 BLK
Weld Splice R-1
3.0 BLK
A
3.0 BLK
2.0 BLK
C
B
2.0 BLK
3.0 BLK
D
3
2
7
6
1
B-381 Joint Connection M-5
LNW68DXF004601


Pressure Switch
1 B-236
OD Off Switch (A/T)
2 N-1
Power Window Relay
4 B-307
Power Window Switch Driver Side
8 D-3
Vacuum Pump
2 B-161
Seat Belt Switch (M/T)
1 N-5
Door Lock Relay
1 B-12
Door Lock Switch
3 B-306
2.0 BLK
2.0 BLK
0.3 BLK
0.3 BLK
0.5 BLK
0.5 BLK
0.5 BLK
0.3 BLK
2.0 BLK
20
18
21
17
B-379 Joint Connection L-1
2.0 BLK
Instrument Panel Cluster (IPC)(B)
20 B-52
Instrument Panel Cluster (IPC)(C)
1 B-53
Data Link Connector (DLC)
5 B-79
Engine Control Module (ECM)
4 J-218
Vehicle Speed Sensor (VSS)
2 J-32
Instrument Panel Cluster (IPC)(A)
15 B-51
Transmission Control Module (TCM)
2 B-231
Data Link Connector (DLC)
4 B-79
C
D
0.5 BLK
0.5 BLK
0.5 BLK
3.0 BLK
0.5 BLK
0.5 BLK
0.5 BLK/BLU
0.5 BLK/BLU
0.5 BLK/BLU
5
6
14
13
12
4
B-379 Joint Connection L-1
0.85 BLK
3.0 BLK
0.5 BLK/BLU
0.85 BLK/BLU
5.0 BLK
B-7
B-1
LNW68DXF004701

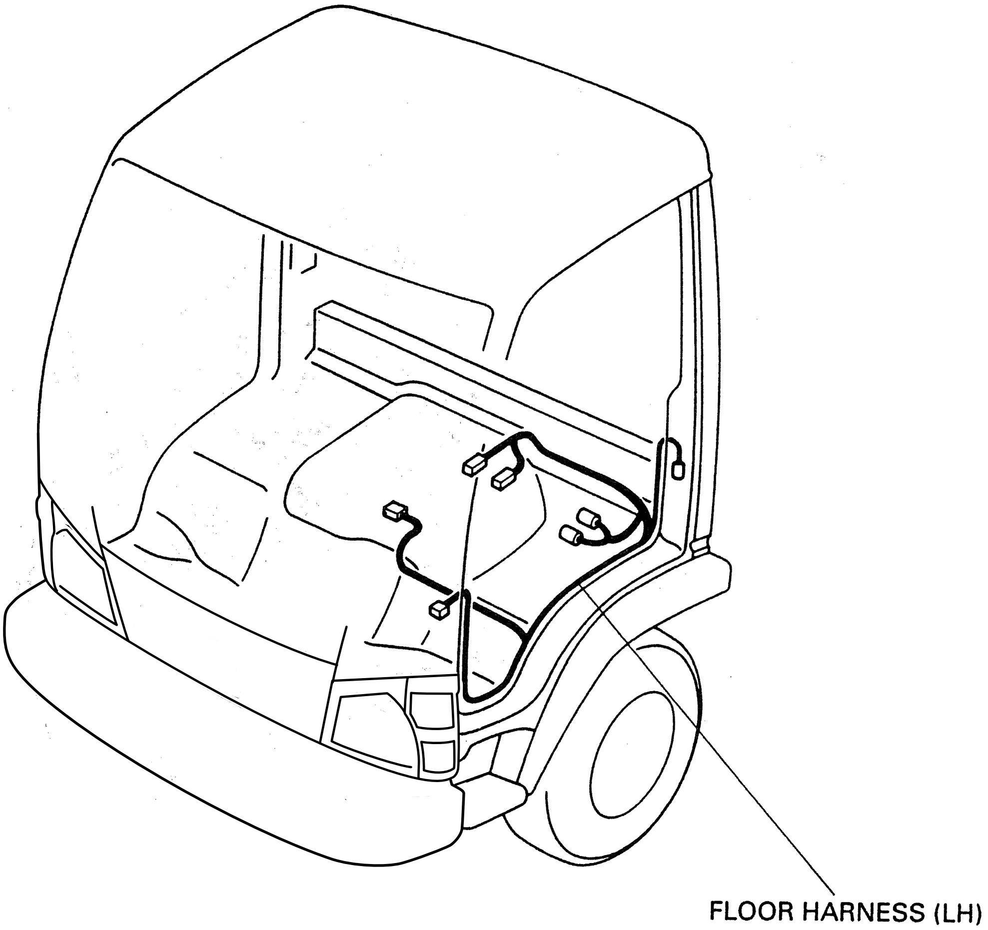

Condenser Fan Relay
2 J-17
Fuel Sedimenter
2 J-121
Exhaust Brake Cut Relay
1 J-210
Condenser Fan
2 J-51
Exhaust Brake Control Relay
4 J-18
Hydraulic Booster Brake (HBB) Oil Level Sensor
2 J-128
Intake Throttle Solenoid Valve
2 J-40
Fuel Heater
2 J-52
Identification Light Relay
4 J-20
0.5 BLK
0.5 BLK
0.5 BLK
3.0 BLK
0.5 BLK
0.5 BLK
0.85 BLK
0.85 BLK
0.5 BLK
Weld Splice Joint 1
Manufacturer's Connector -Rear
4 J-144
Fuel Tank Unit -Side
3 J-28
Neutral Switch(M/T) Inhibitor Switch(A/T)
2 J-49(M/T)
4 J-69(A/T)
Rear Combination Light
1 R-2
Backup Buzzer
2 J-215
Fuel Tank Unit -Rear
3 J-207
Manufacturer's Connector -Front
4 J-143
Engine Shut Down Switch
2 J-212
0.5 BLK
3.0 BLK
0.5 BLK
0.5 BLK
0.5 BLK
0.5 BLK
0.5 BLK
1.25 BLK
1.25 BLK
Weld Splice Joint 2
3.0 BLK
J-9
LNW68DXF004801



LNW68DXF004901

Cable Harness Routing

CABLE HARNESS ROUTING (1)



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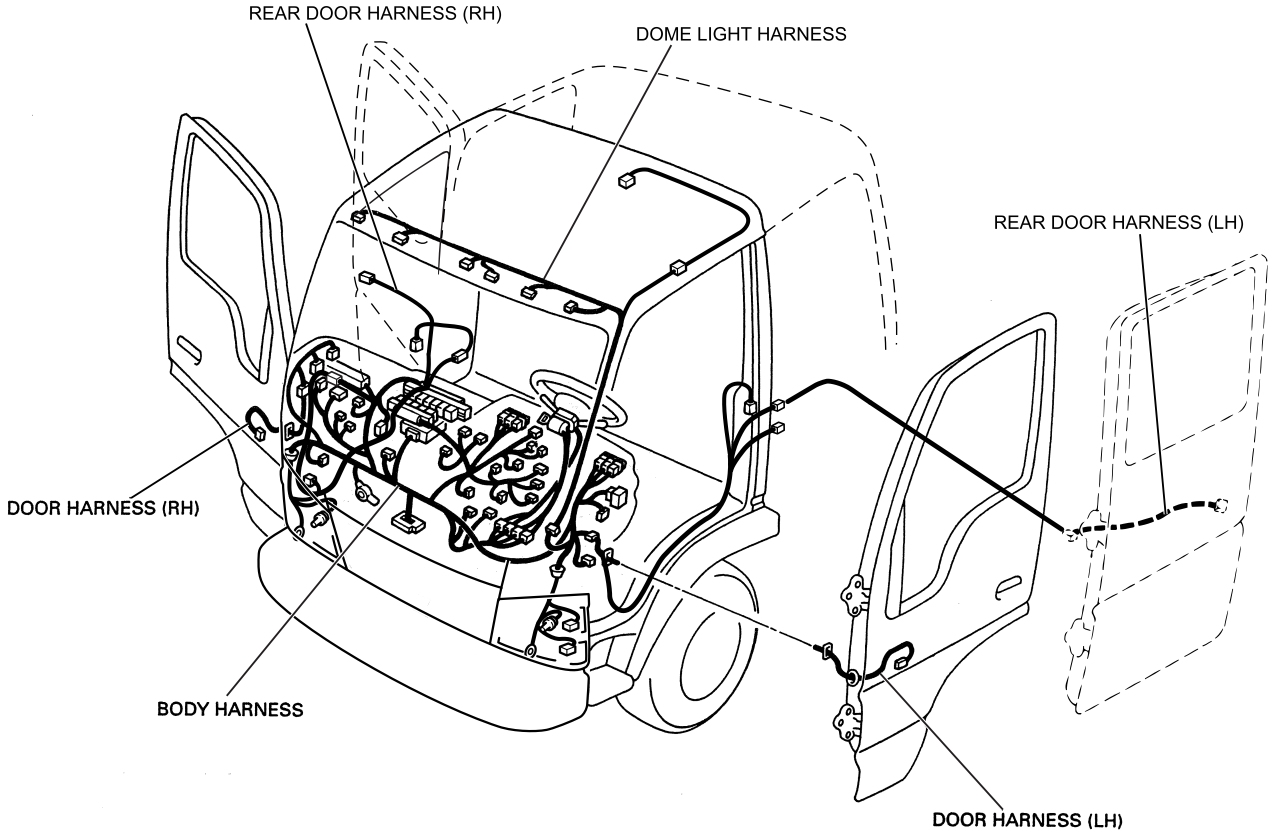
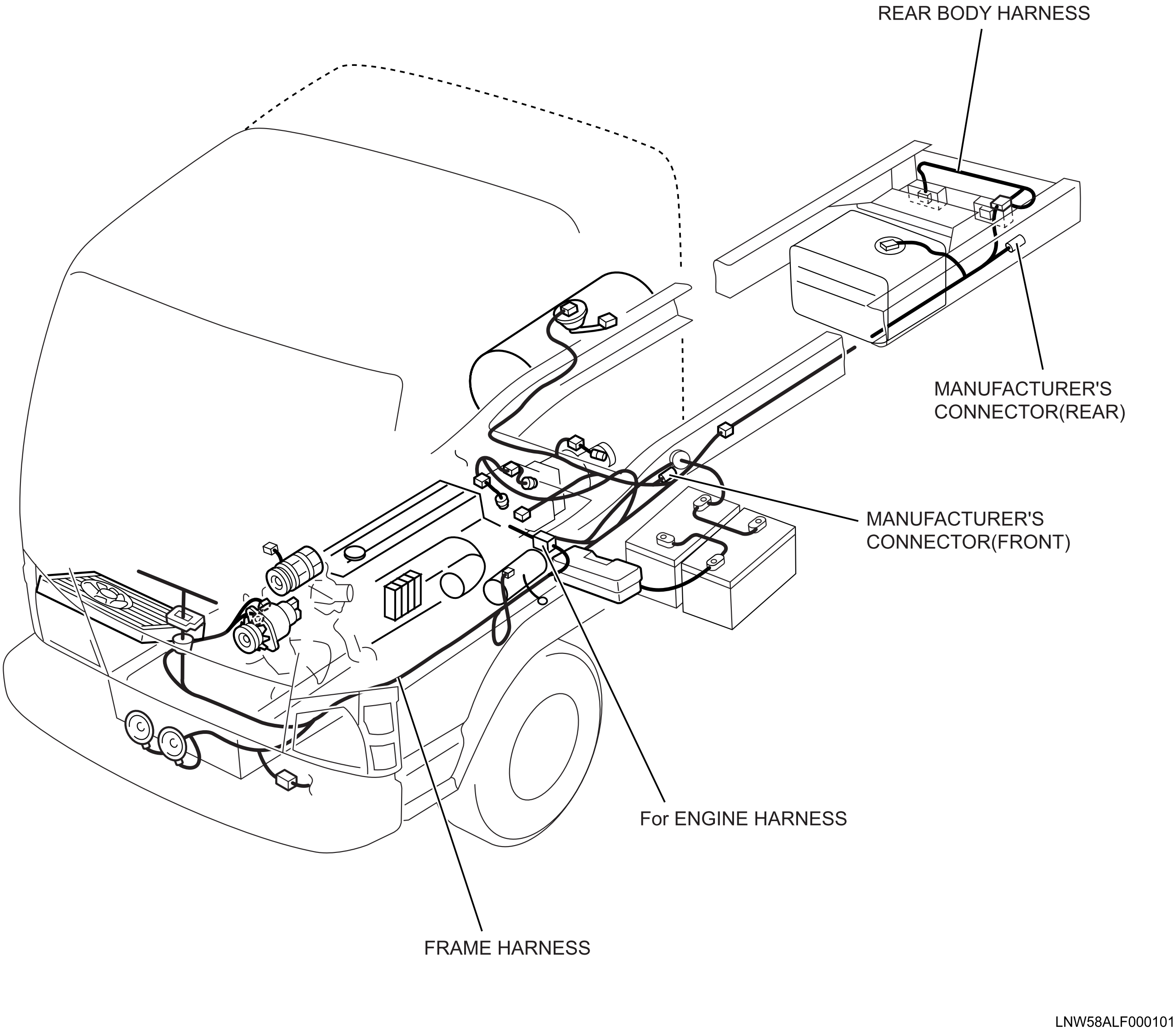
CABLE HARNESS ROUTING (2)



LNW58ALF002001

CABLE HARNESS ROUTING (3)



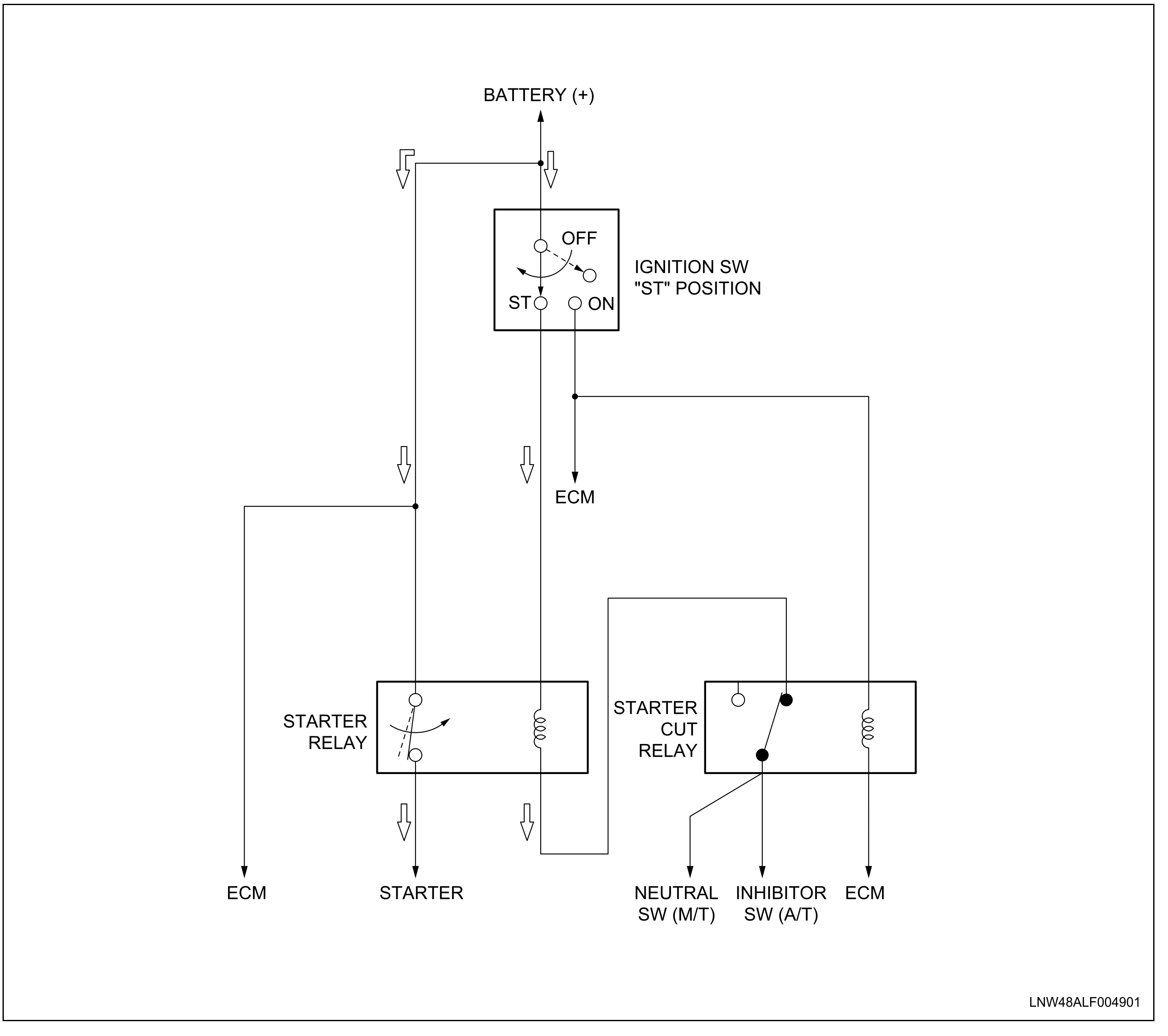
System Repair

Start and Charging

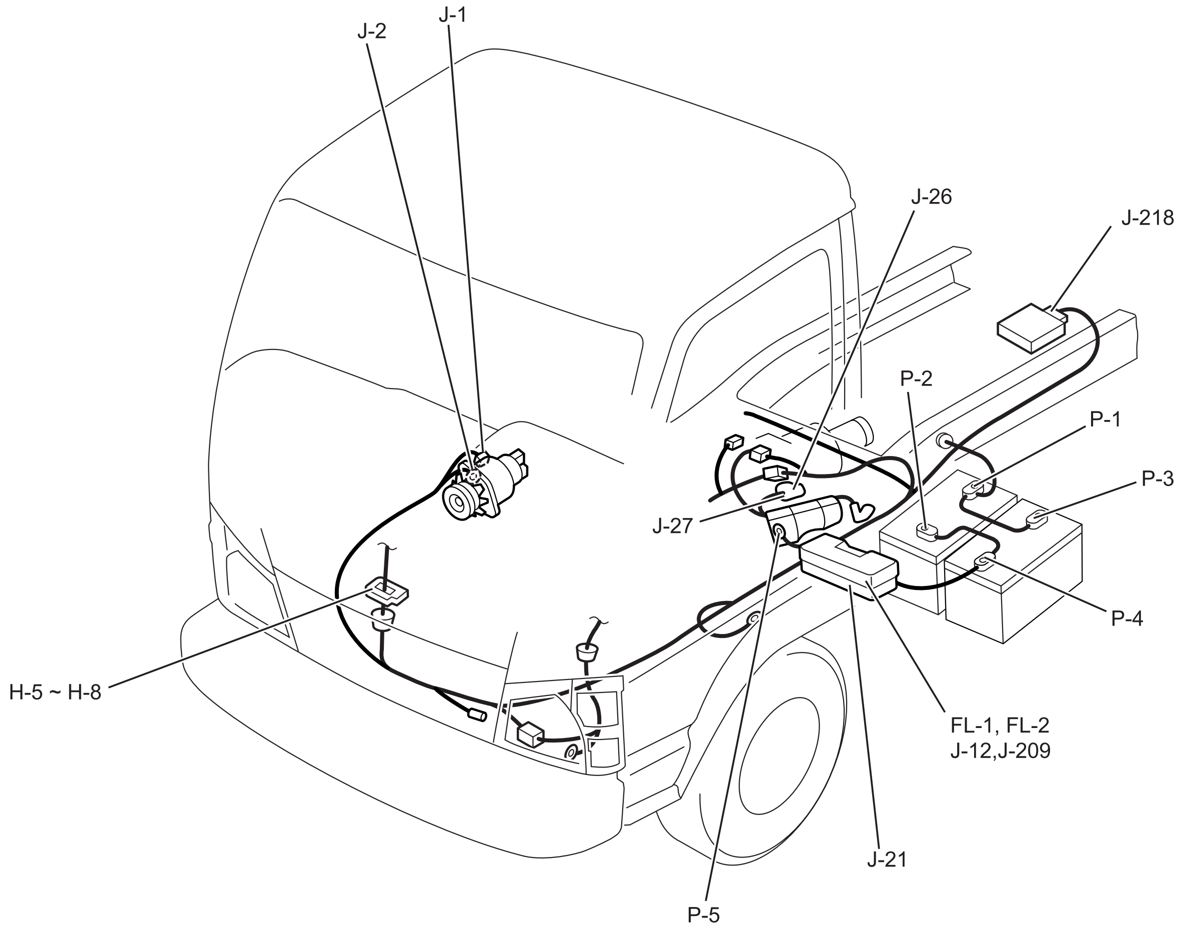
General Description

The system consists of the ignition switch, starter, AC generator, starter relay and charge relay. When the ignition SW is set to the "ST" position, the battery voltage is applied to the starter solenoid coil through the starter relay to start the starter.

STARTING CIRCUIT

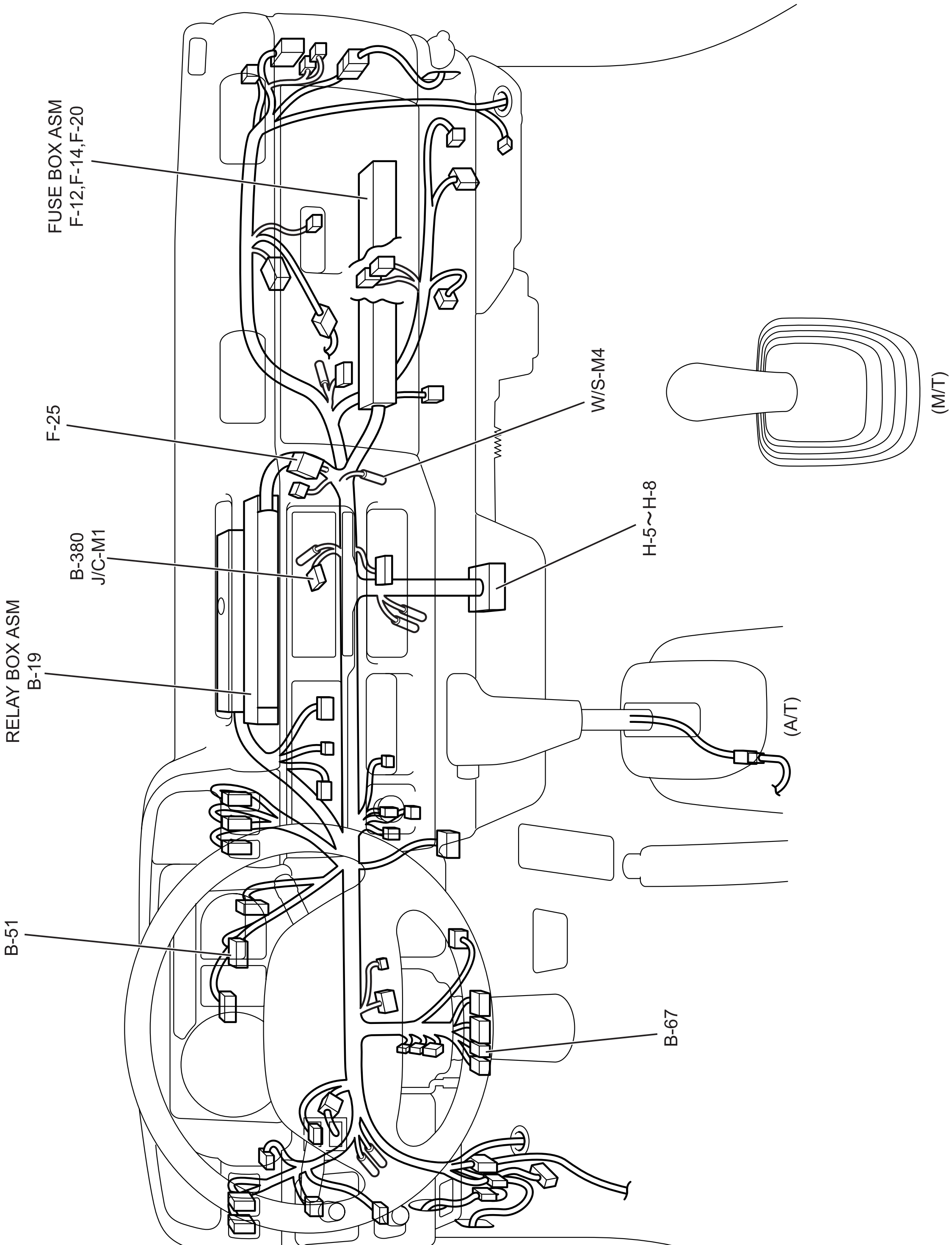


PARTS LOCATION (1)



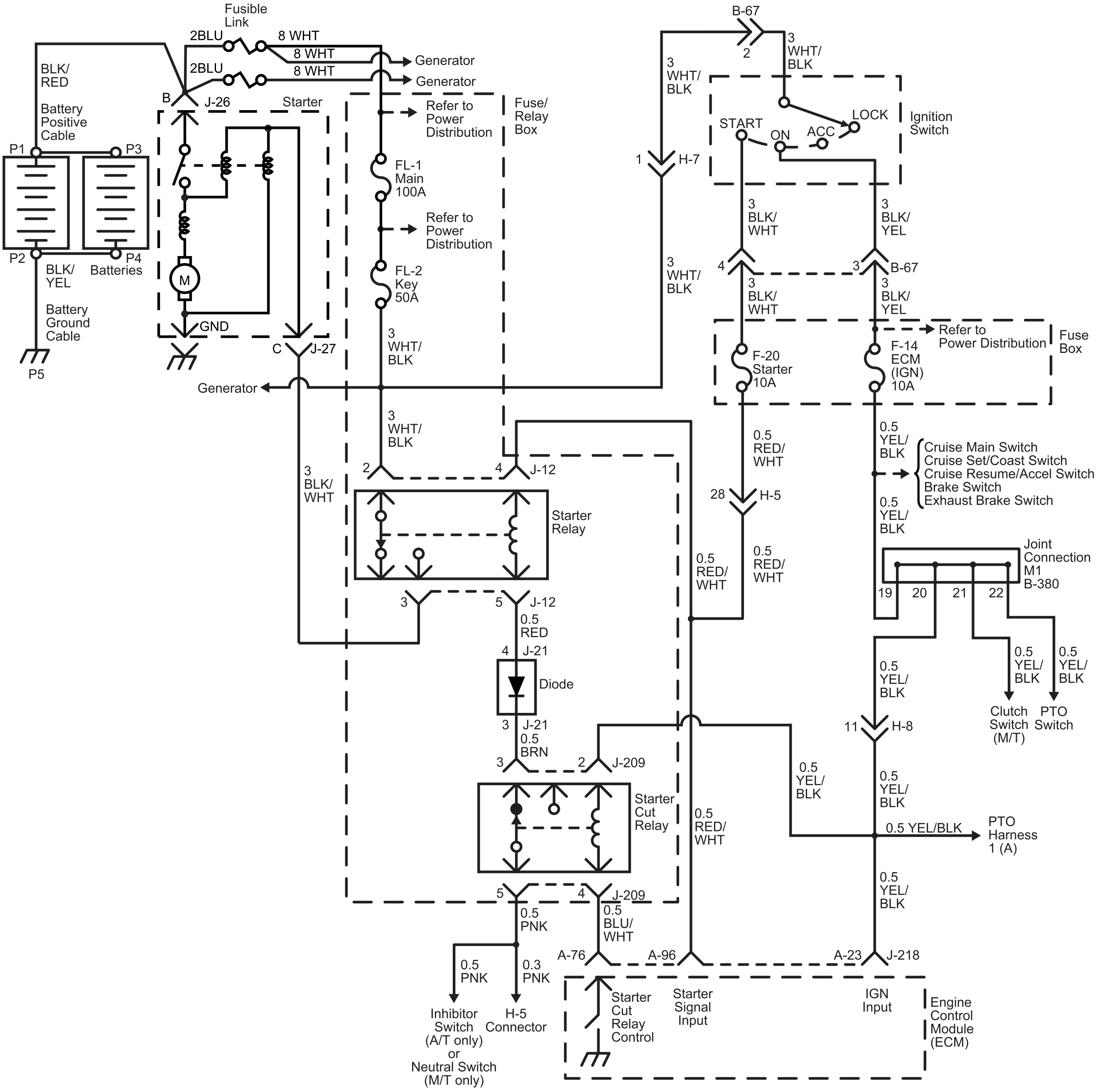
LNW58ALF000501

PARTS LOCATION (2)

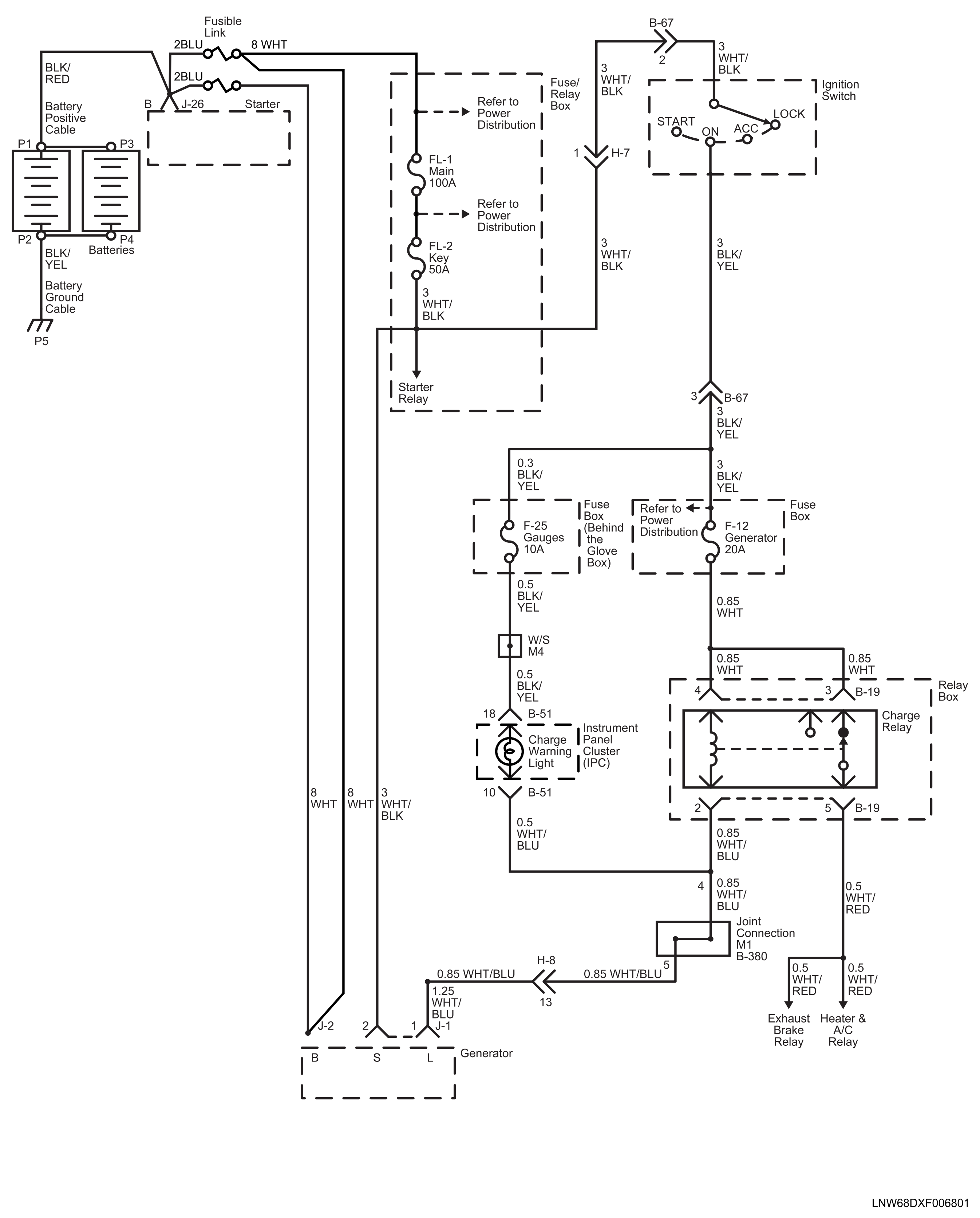


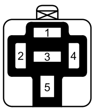
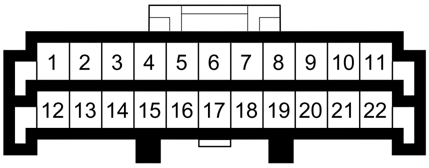
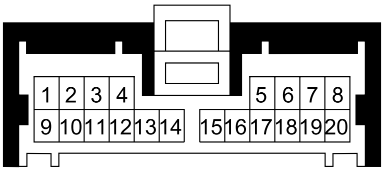
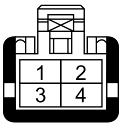
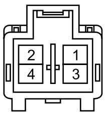
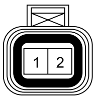
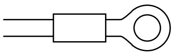
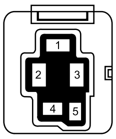
LNW68DXF010301

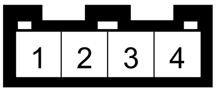
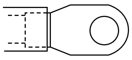
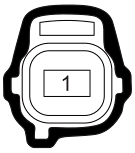
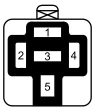
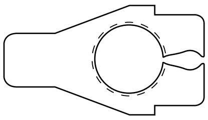
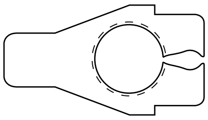
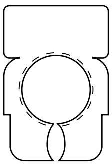
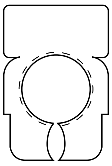
CIRCUIT DIAGRAM

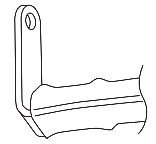


LNW68DXF006701

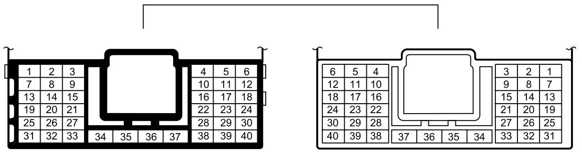

Fusible Link
2BLU
8 WHT
2BLU
BLK/ RED
Battery Positive Cable
B
J-26
Starter
P1
P3
P2
P4
BLK/ YEL
Batteries
Battery Ground Cable
P5
Fuse/ Relay Box
Refer to Power Distribution
FL-1 Main 100A
Refer to Power Distribution
FL-2 Key 50A
3 WHT/ BLK
Starter Relay
B-67
2
3 WHT/ BLK
3 WHT/ BLK
1
H-7
3 WHT/ BLK
Ignition Switch
START
ON
ACC
LOCK
3 BLK/ YEL
3
B-67
3 BLK/ YEL
0.3 BLK/ YEL
3 BLK/ YEL
F-25 Gauges 10A
Fuse Box (Behind the Glove Box)
Refer to Power Distribution
F-12 Generator 20A
Fuse Box
0.5 BLK/ YEL
0.85 WHT
W/S M4
0.5 BLK/ YEL
0.85 WHT
0.85 WHT
4
3
B-19
Relay Box
Charge Relay
18
B-51
Charge Warning Light
Instrument Panel Cluster (IPC)
10
B-51
2
5
B-19
8 WHT
8 WHT
3 WHT/ BLK
0.5 WHT/ BLU
0.85 WHT/ BLU
4
0.85 WHT/ BLU
0.5 WHT/ RED
Joint Connection M1 B-380
H-8
0.85 WHT/BLU
0.85 WHT/BLU
5
1.25 WHT/ BLU
13
0.5 WHT/ RED
0.5 WHT/ RED
J-2
2
1
J-1
B
S
L
Generator
Exhaust Brake Relay
Heater & A/C Relay
LNW68DXF006801

No.	Connector Face
B-19 (Black)	 005-012 Charge Relay
B-380 (White)	 022-005 Joint Connection-M1
B-51 (Gray)	 020-024 Instrument Panel Cluster(A)
B-67 (White)	 004-015 Ignition Switch
B-67 (Black)	 004-035 Ignition Switch
J-1 (Green)	 002-001 Generator
J-2	 000-012 AC Generator (B)
J-12 (Black)	 005-013 Starter Relay

No.	Connector Face
J-21 (Black)	 004-077 Diode
J-26	 000-021 Starter (B)
J-27 (Gray)	 001-082 Starter (C)
J-209 (Black)	 005-012 Starter Cut Relay
P-1	 000-029 Battery (+)
P-2	 000-029 Battery (–)
P-3	 000-028 Battery (+)
P-4	 000-028 Battery (–)

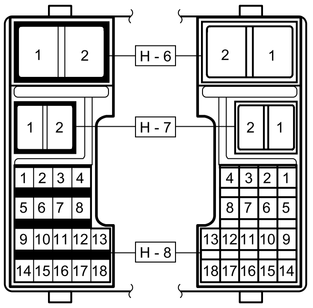
No.	Connector Face
P-5	 000-044 Ground; Frame

H-5 Body H. – Frame H. (Gray)



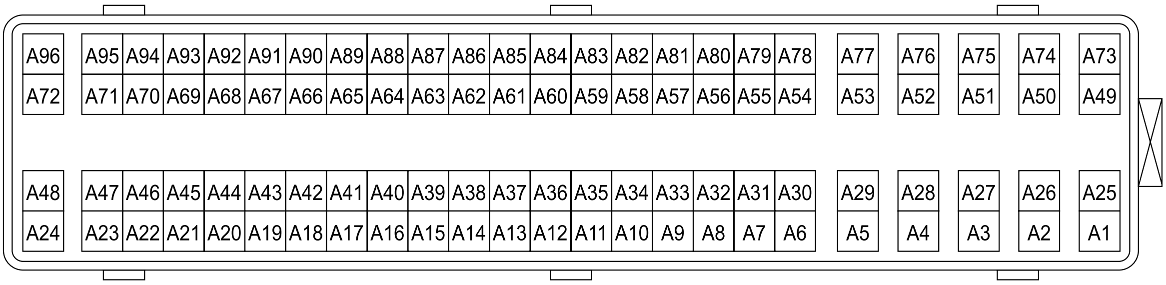
LNW38ASH018701

H-7, H-8 Body H. – Frame H. (Gray)



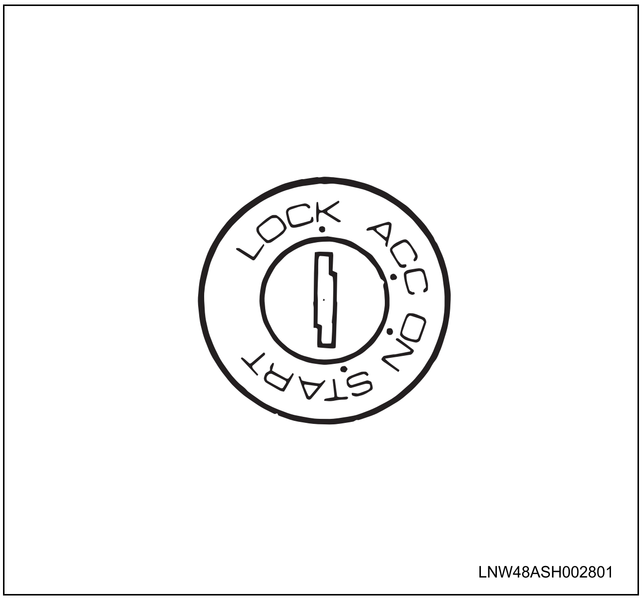
LNW38ASH018801

J-218 ECM (Black)



LNW48ASF000101

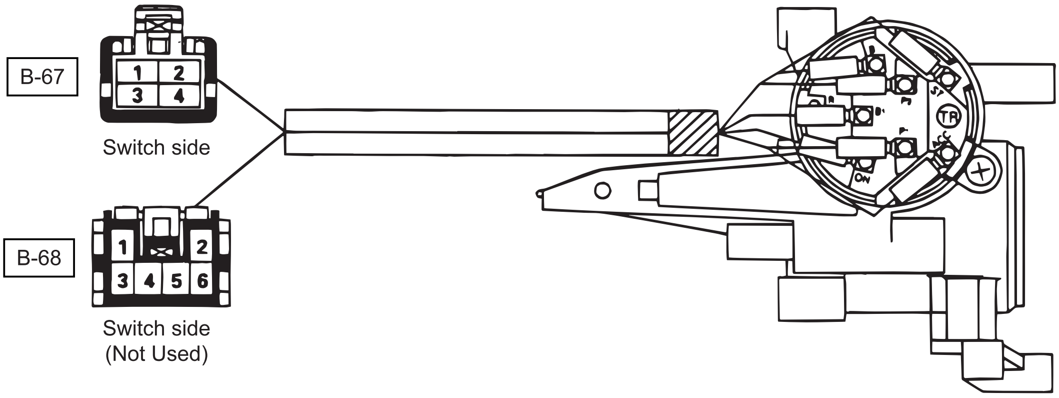
IGNITION SWITCH



The ignition switch positions are LOCK, ACC, ON and START. Turning the starter key to these positions a circuit for starting the engine, the operation of accessories, or stop the engine.

Inspect

Check the continuity between the ignition connector terminals.
Repair or replace the switch when the result of inspection is found abnormal.



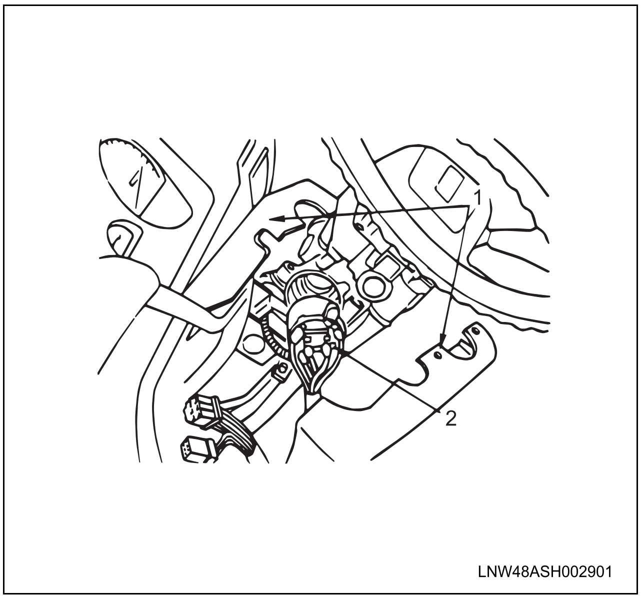
Ignition Switch Key Position		B-67				B-68				
Connector No. / Terminal No.		1	2	3	4	1	2	4	5	6
		ACC	B	ON	ST	B1	P1	P2	W	W
Removed	LOCK					○—	—○			
Inserted									○—	—○
	ACC	○—	—○			○—	—○			
	ON	○—	—○—	—○		○—	——	—○		
	START		○—	—○—	—○	○—	——	—○		

LNW68DLF001501

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Steering cowl
   Remove four screws and take off the steering cowl.
2. Ignition switch
   - Disconnect the connector.
   - Remove the screw.



Legend

1. Steering Cowl
2. Ignition Switch

INSTALL OR CONNECT

To install, follow the removal steps in the reverse order.

Engine Control Module (ECM)

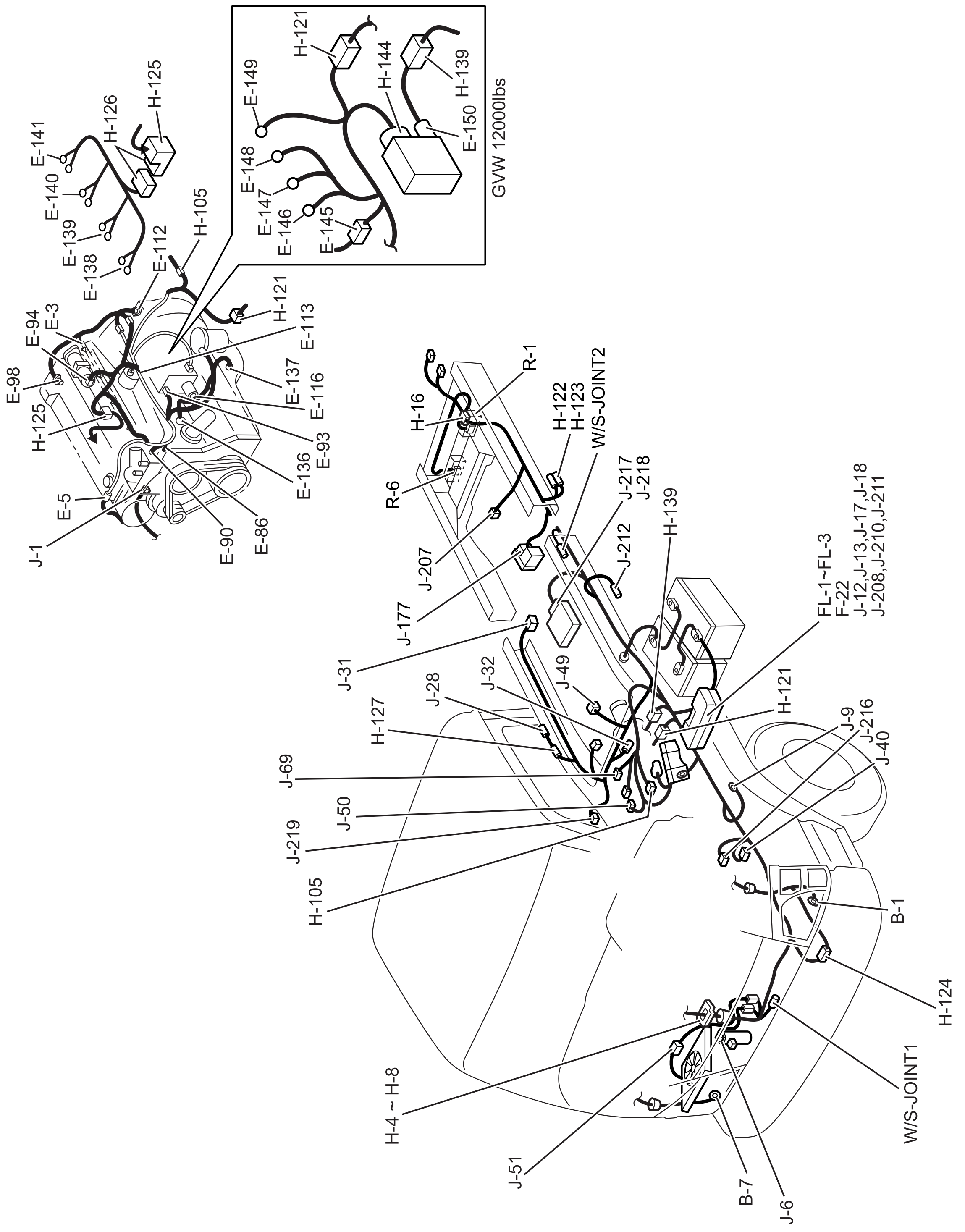
The engine control module (ECM) is located on the chassis frame side near the transmission. The ECM controls the following:

- The fuel supply control
- The fuel injection timing control
- The exhaust gas recirculation (EGR) control
- The preheating control
- The on-board diagnostics for engine control
- The cruise control

The ECM constantly observes the information from various sensors. The ECM controls the systems that affect vehicle performance. The ECM performs the diagnostic function of the system. The ECM can recognize operational problems, alert the driver through the malfunction indicator lamp (MIL), and store diagnostic trouble codes (DTCs). DTCs identify the system faults to aid the technician in making repairs.

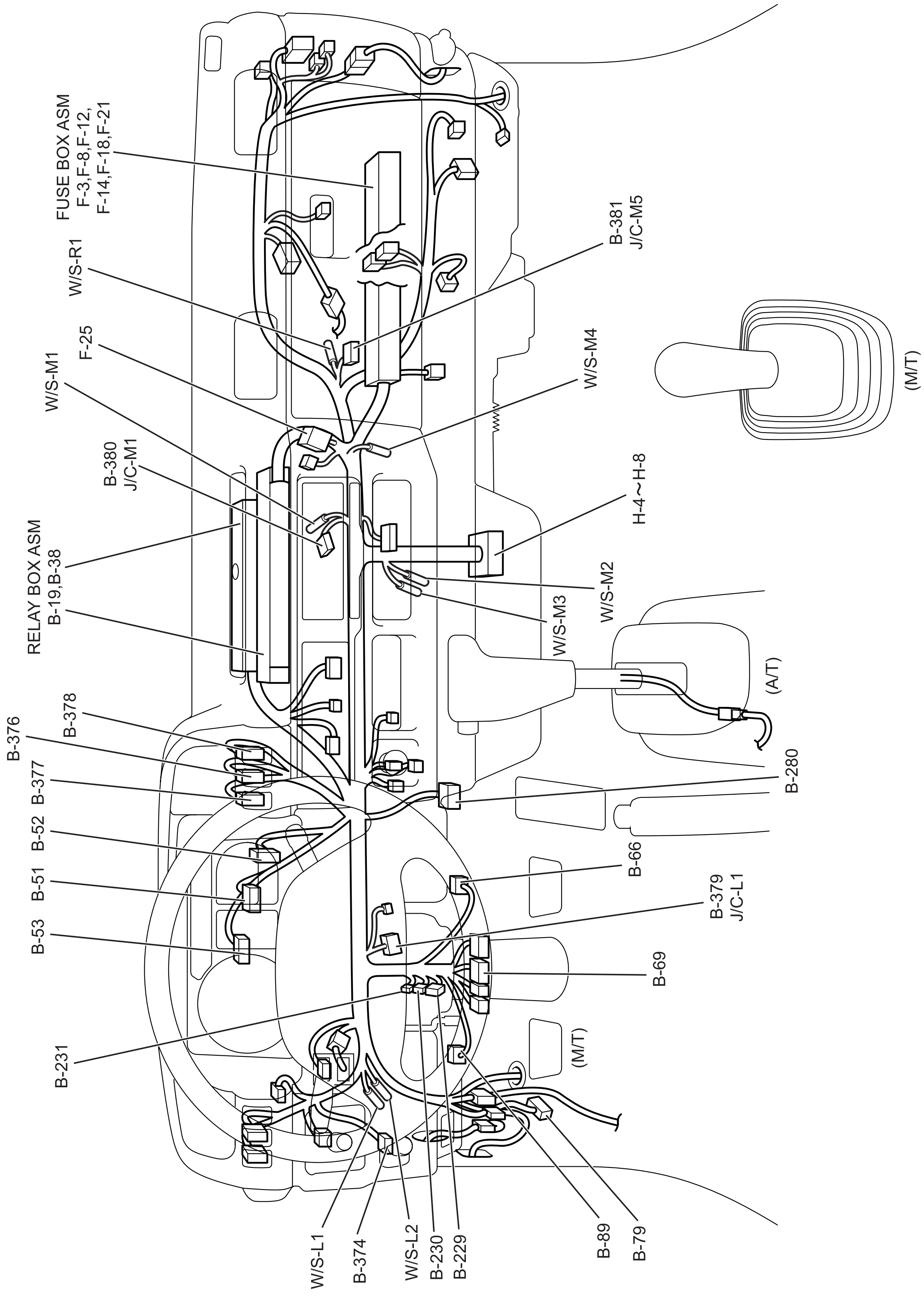
Refer to Engine Control System section.

PARTS LOCATION (1)

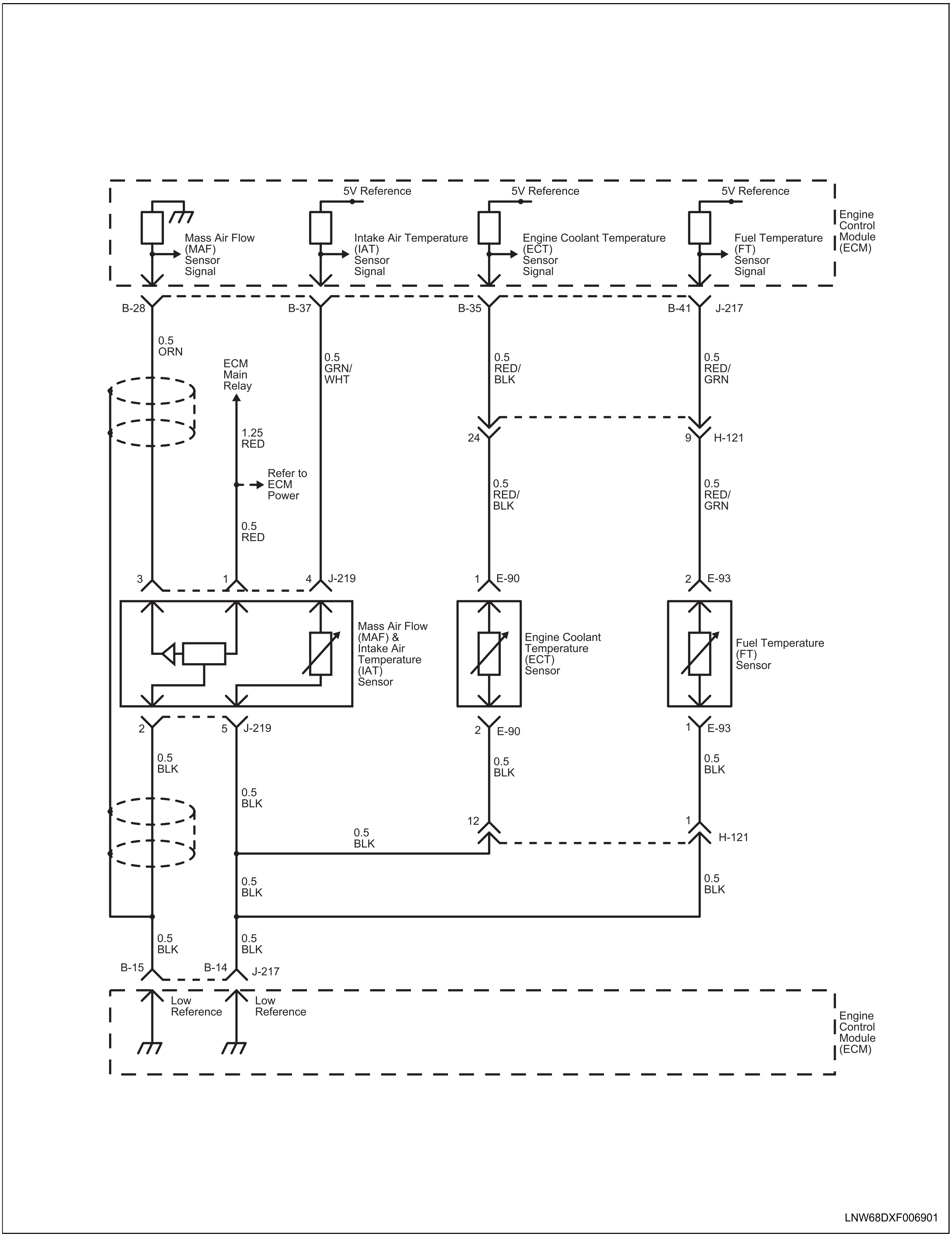


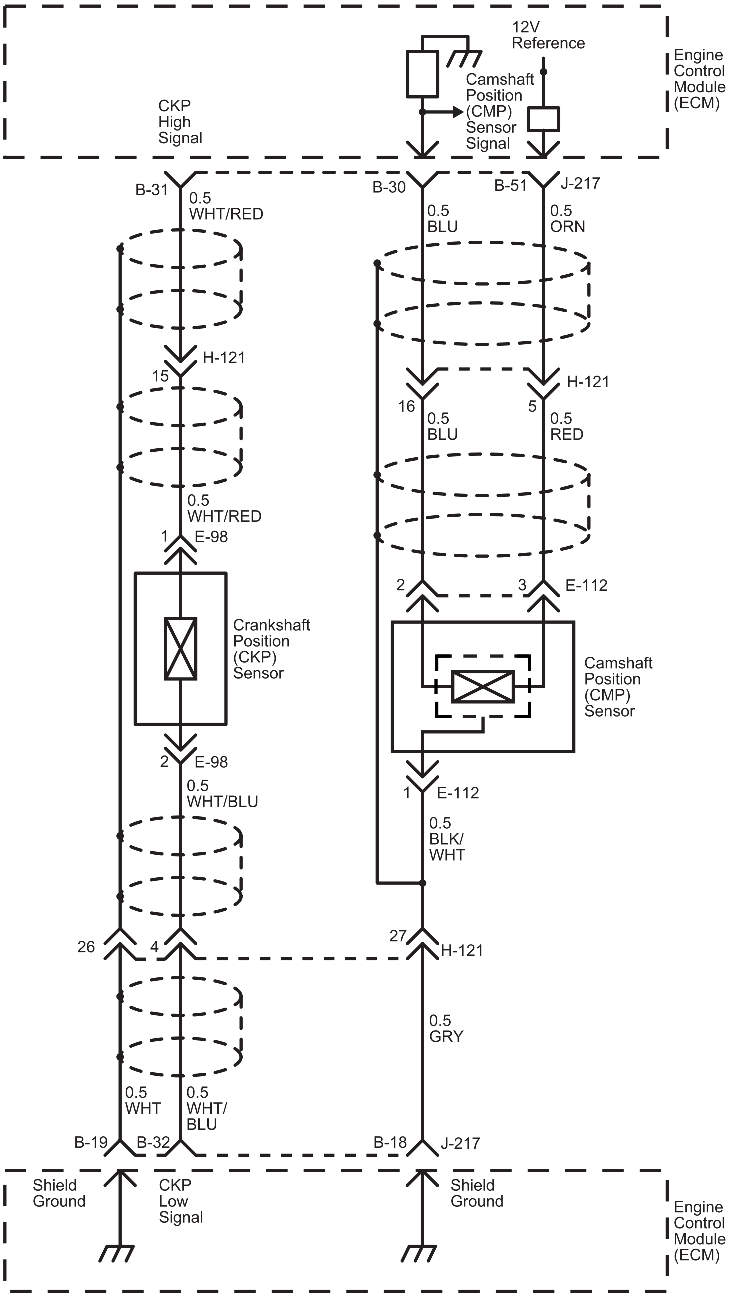
LNW58AXF000101

PARTS LOCATION (2)

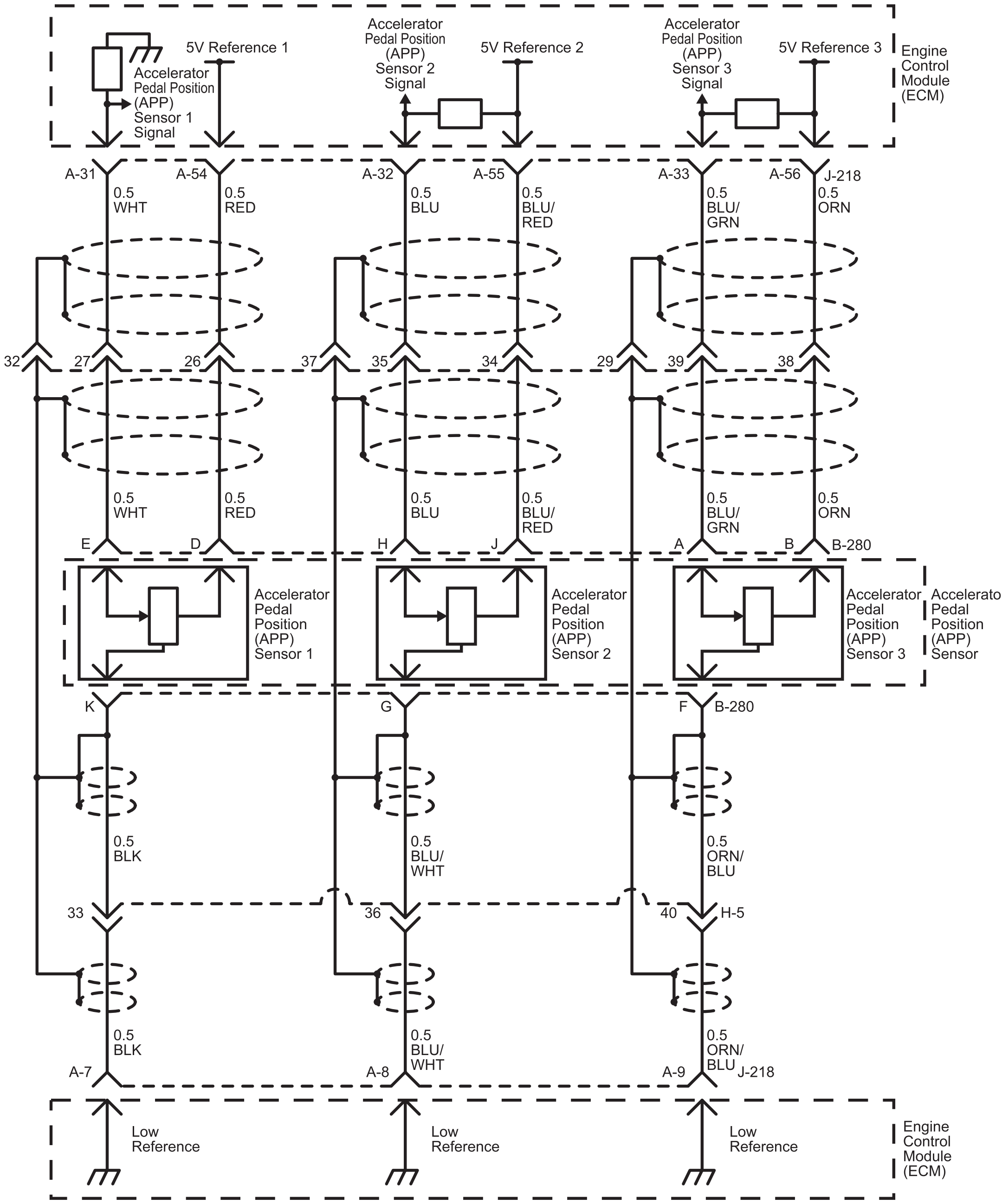


CIRCUIT DIAGRAM





LNW68DXF007001



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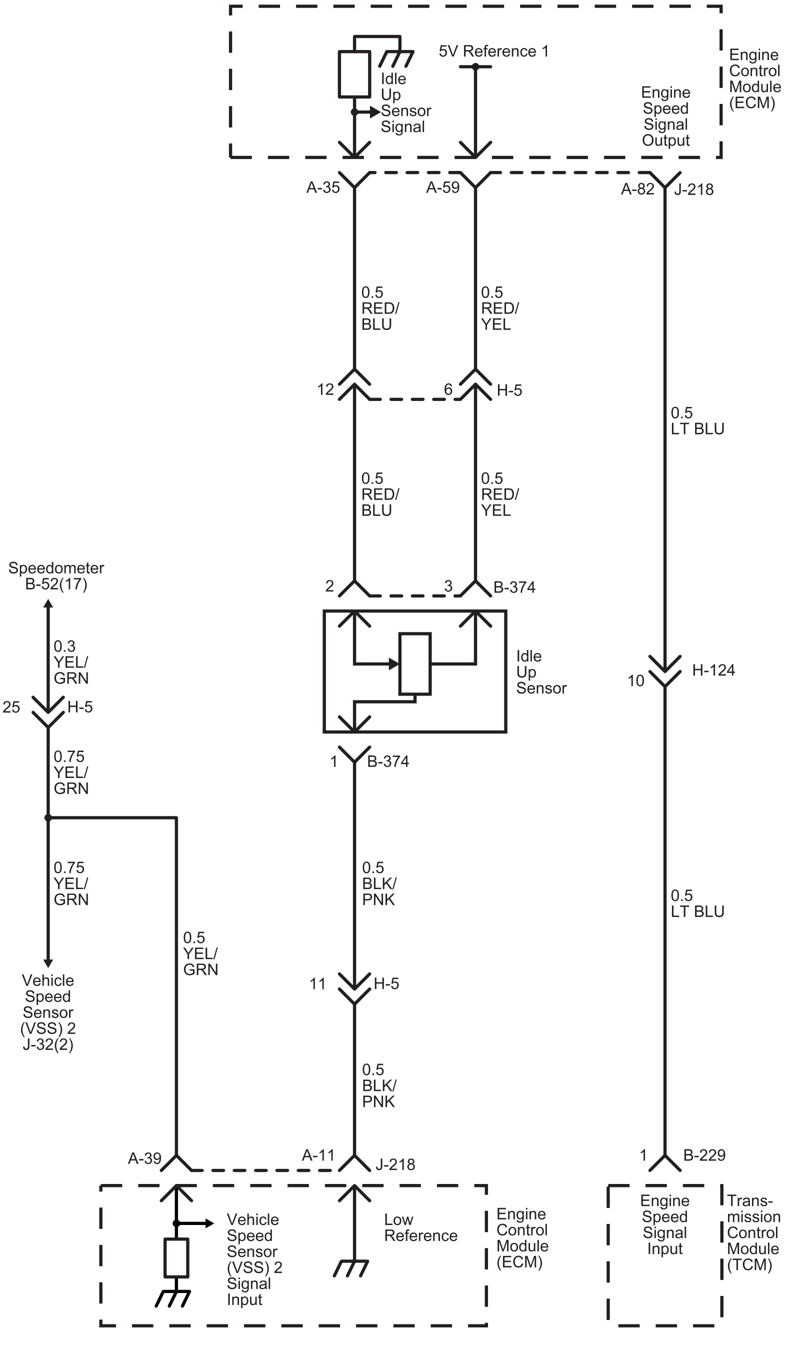
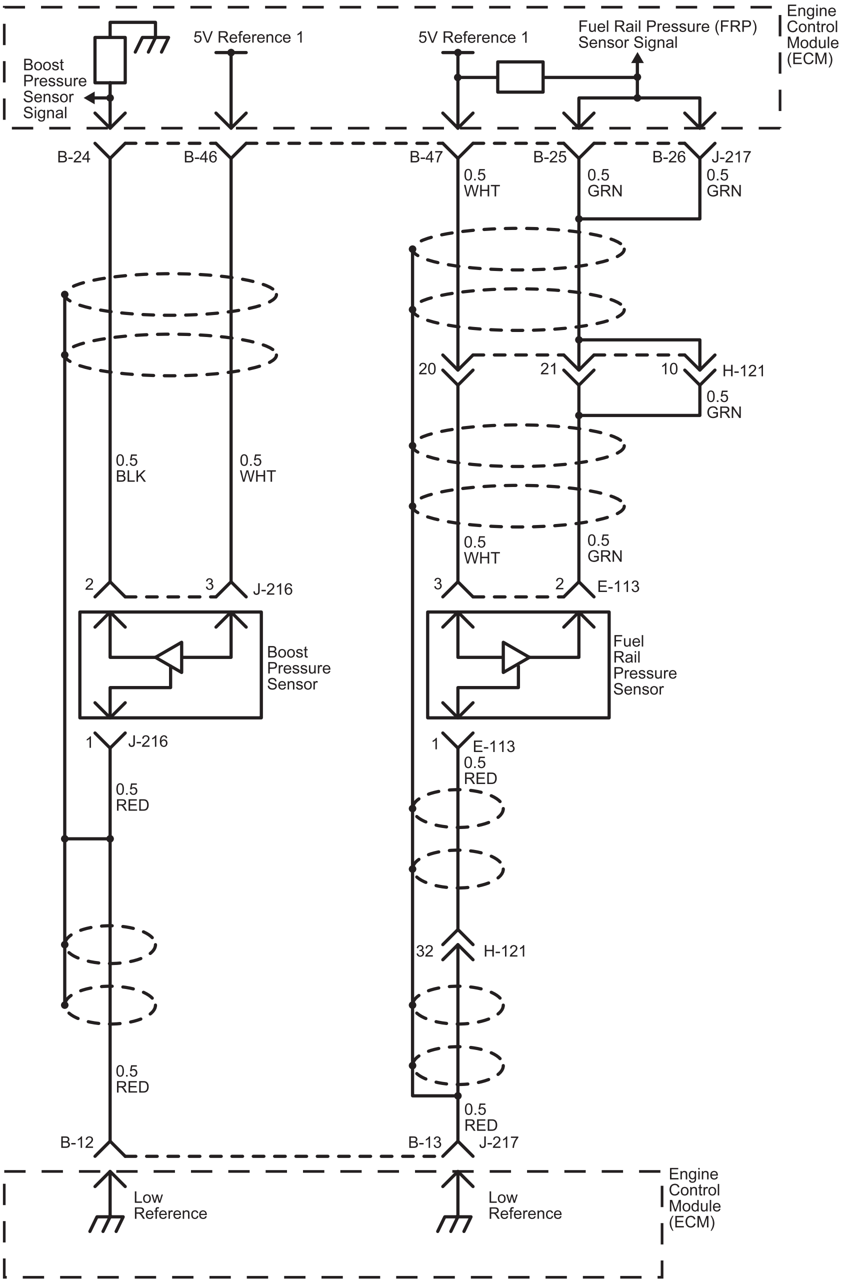
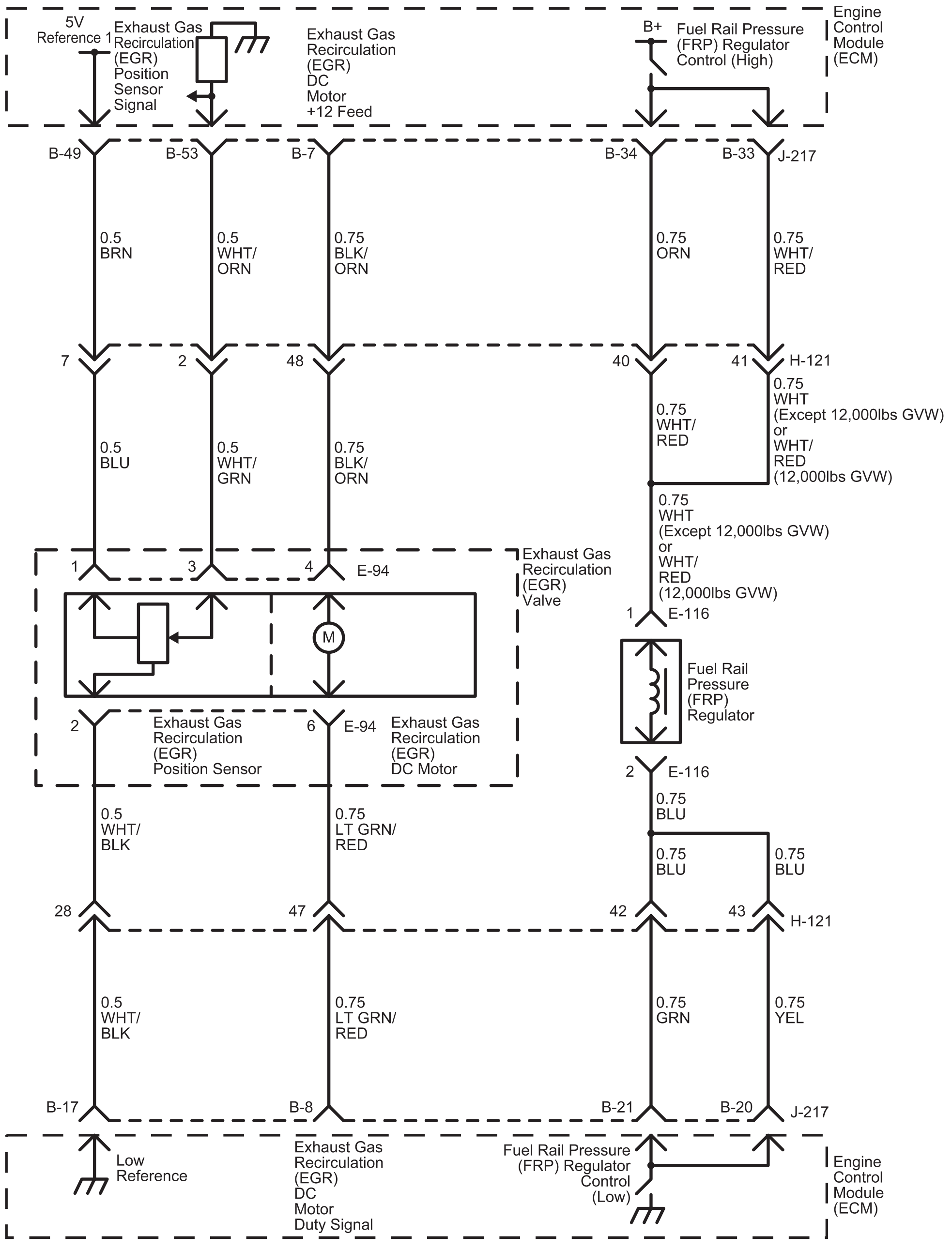


LNW68DXF007201



LNW68DXF007301



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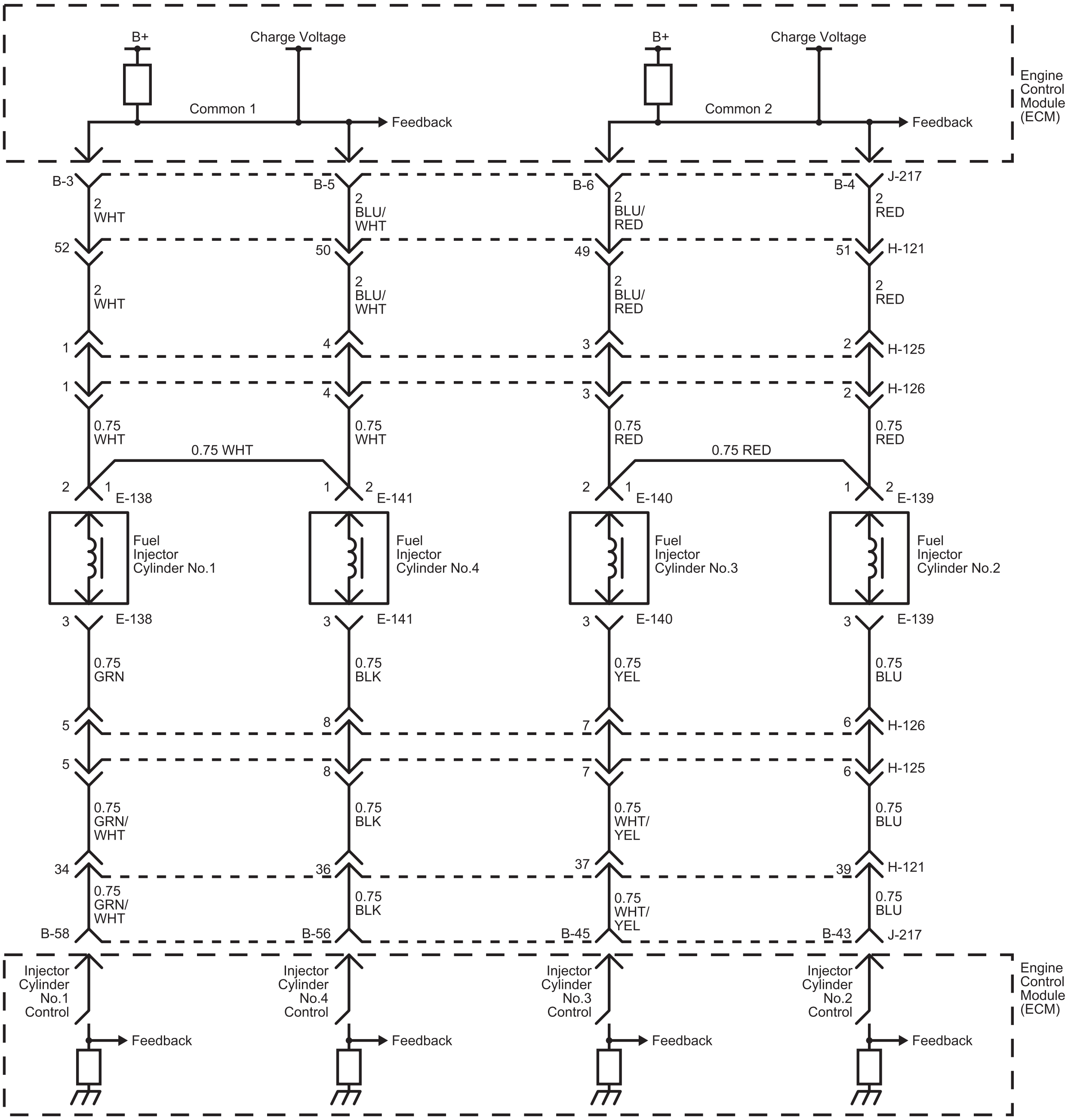
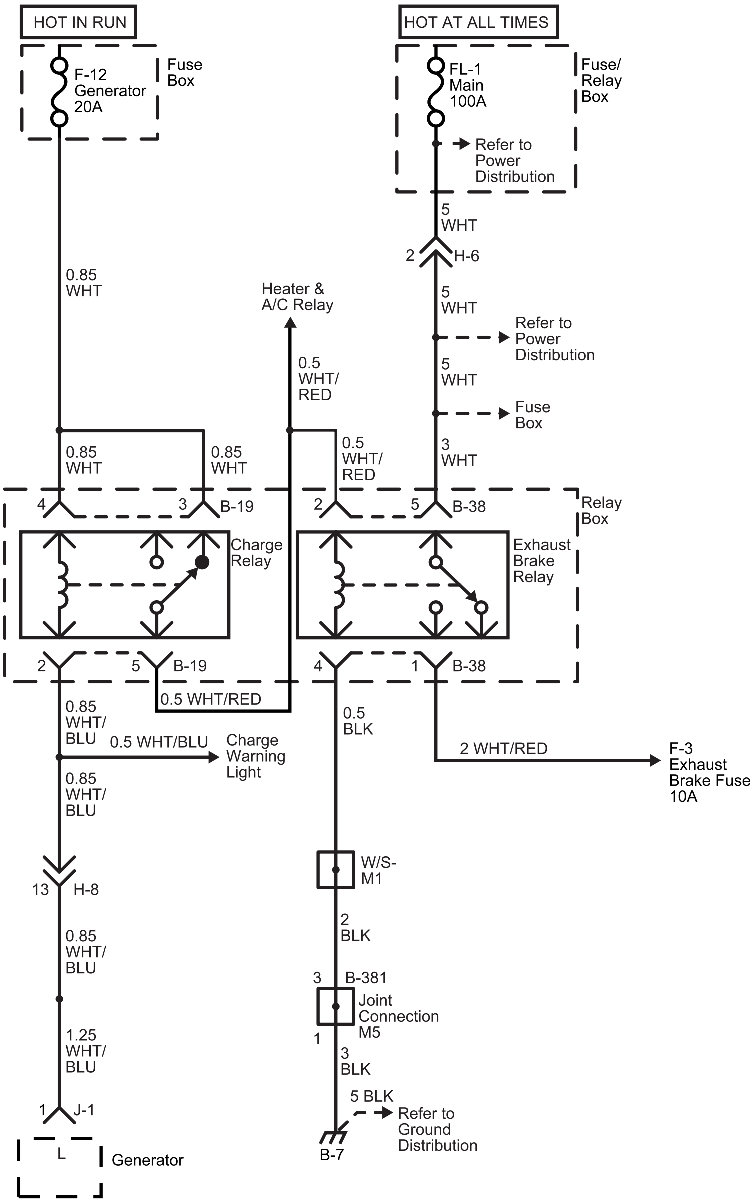
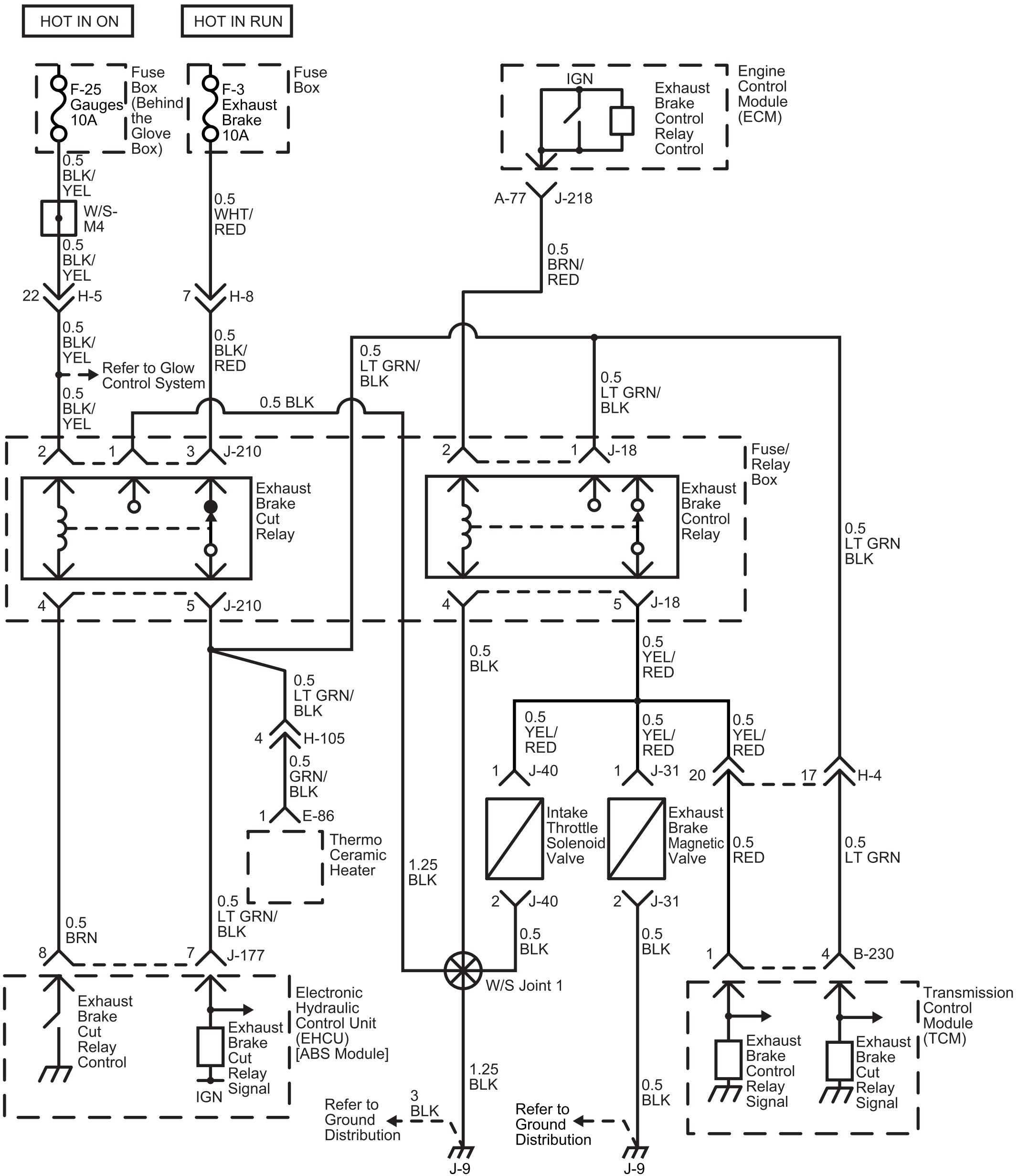


LNW66EXF001301



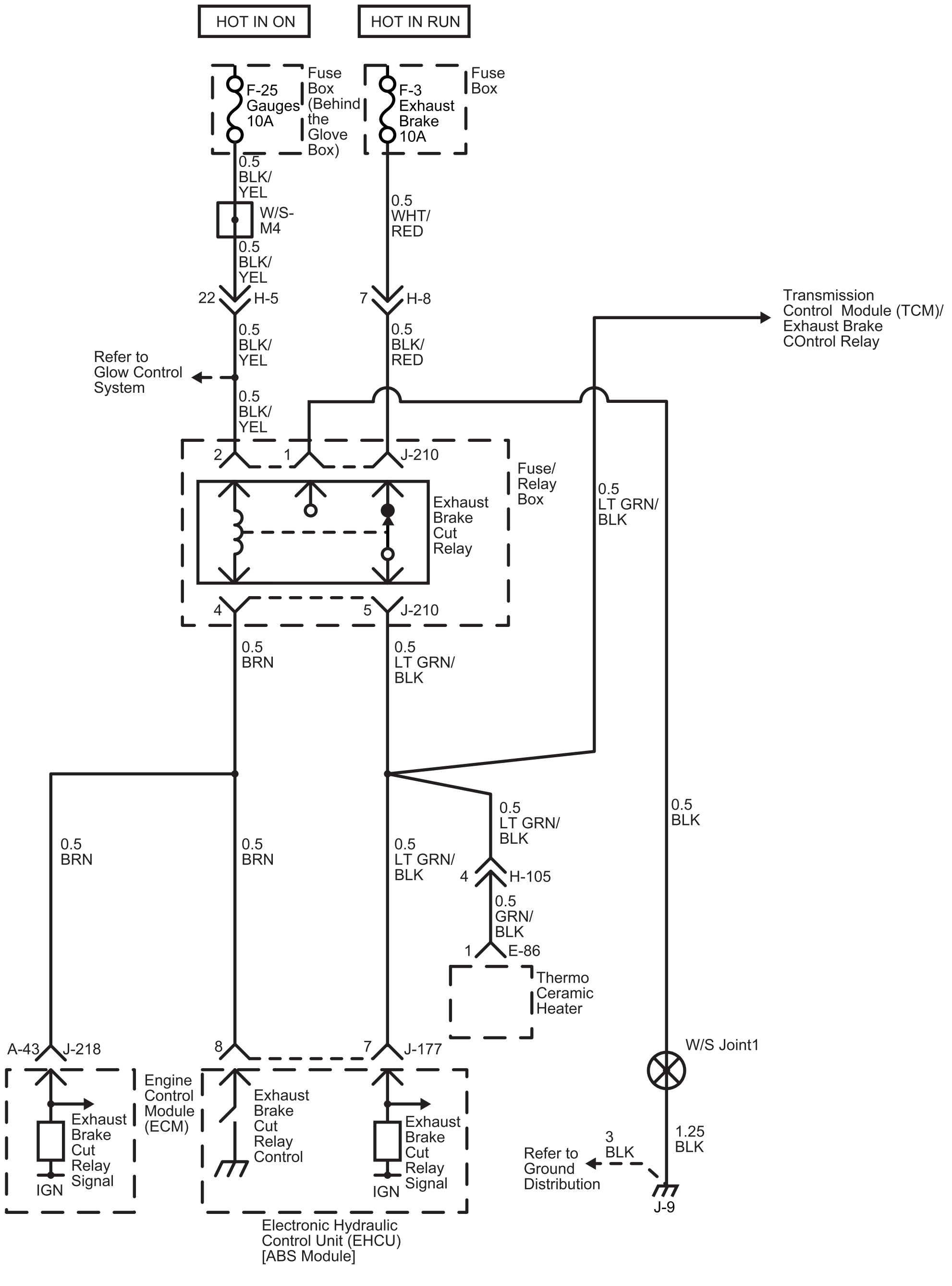
LNW68DXF007501

Except 12,000lbs GVW



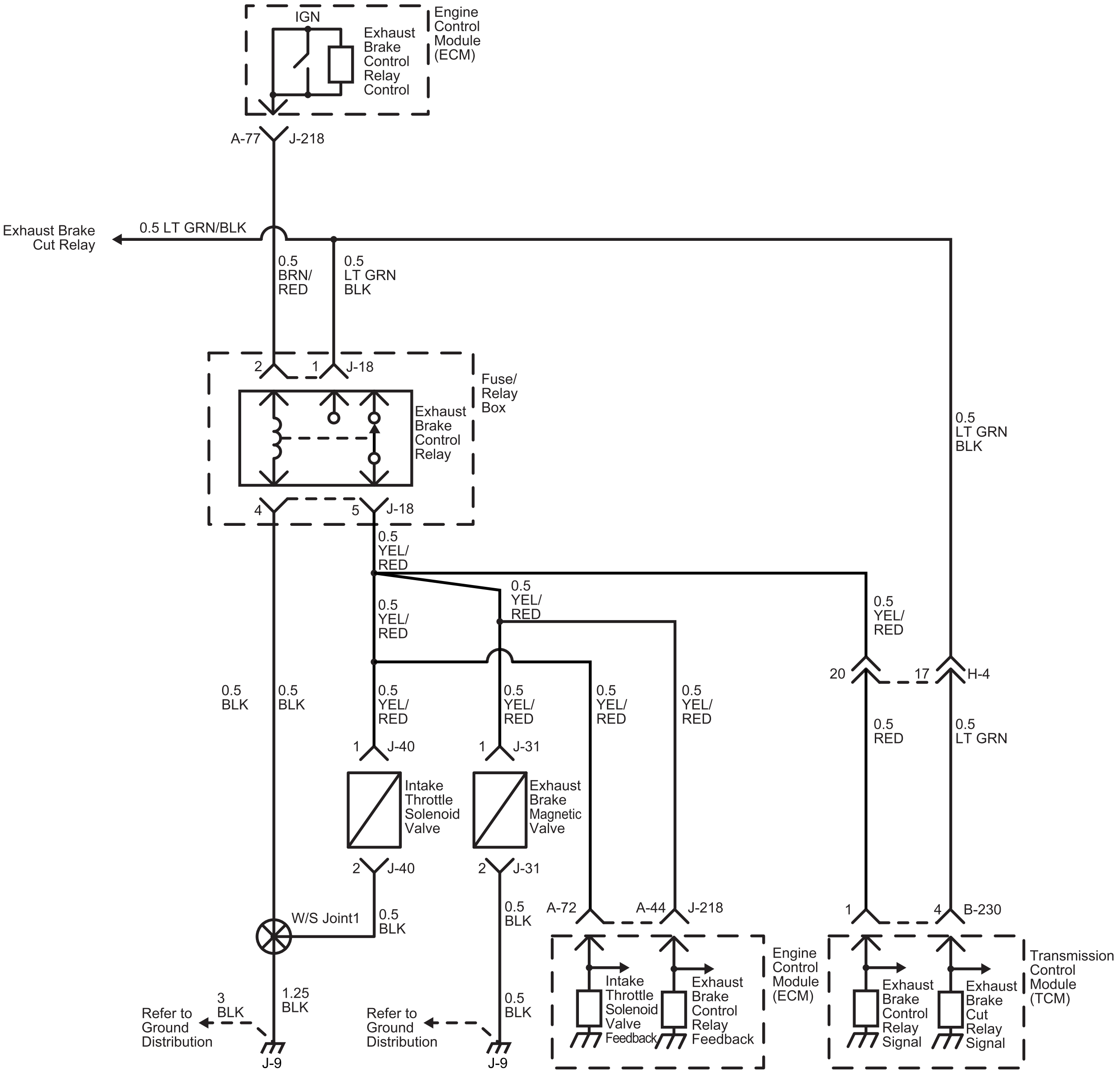
LNW68DXF007601

12,000lbs GVW



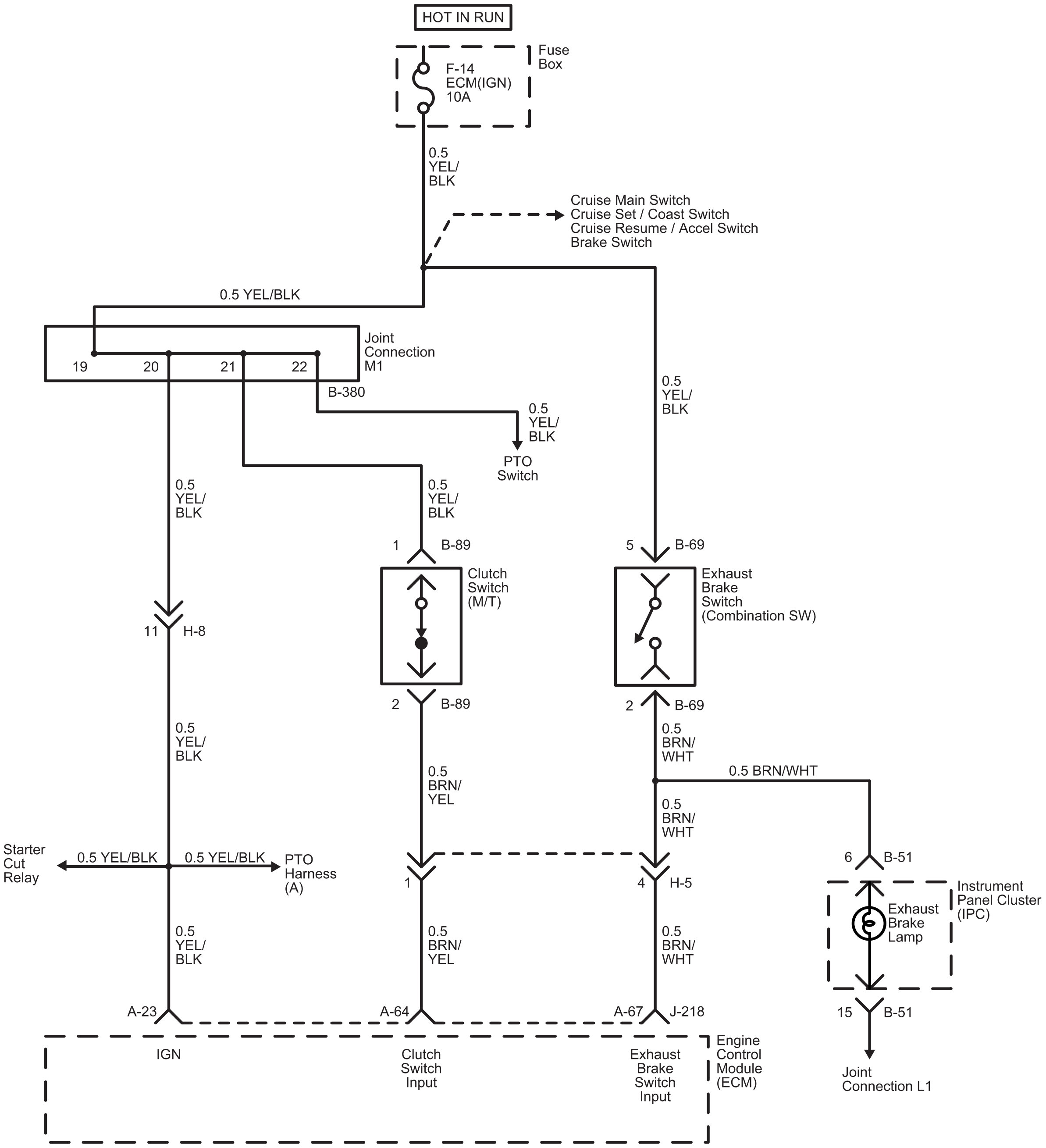
LNW68DXF007701

12,000lbs GVW

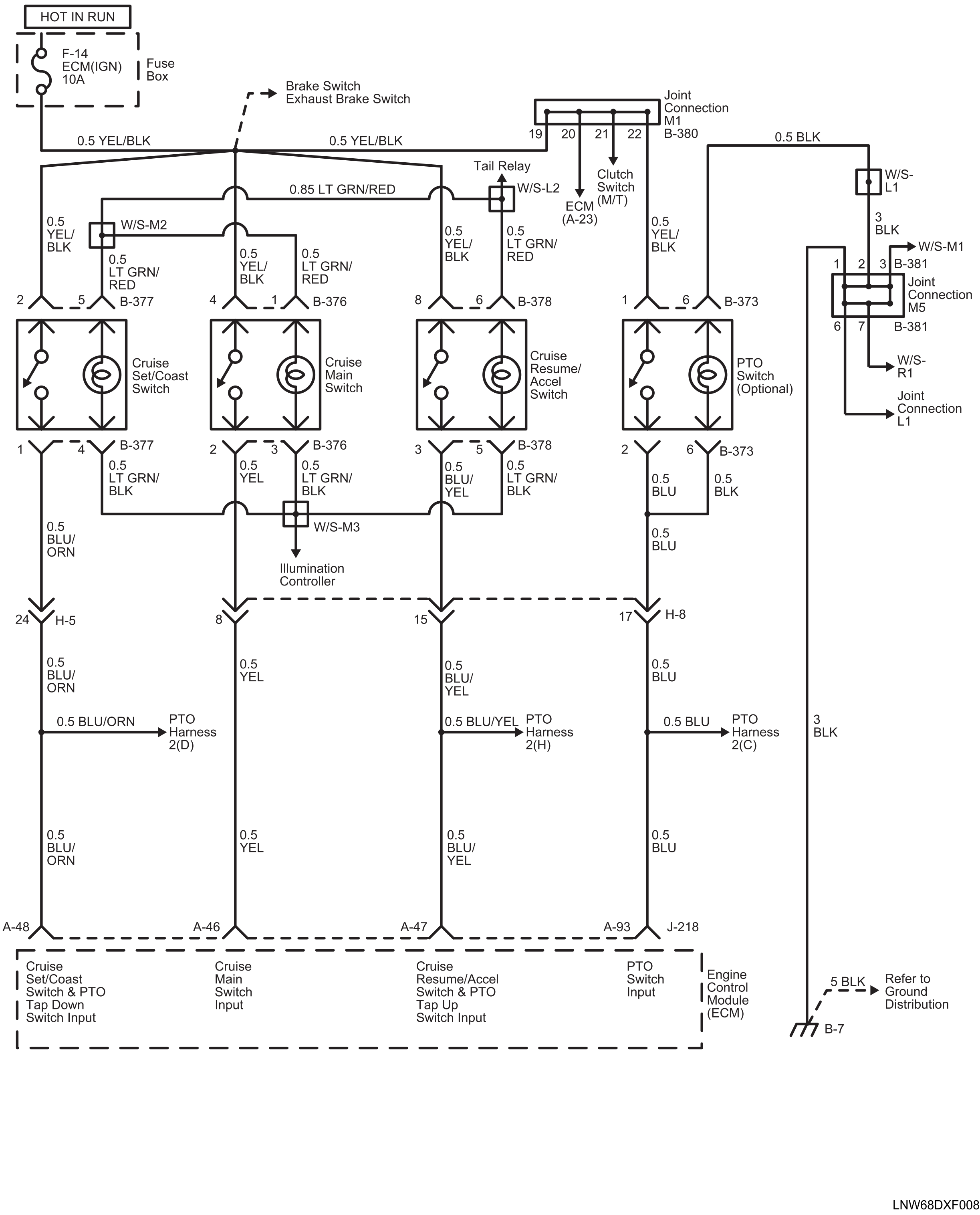


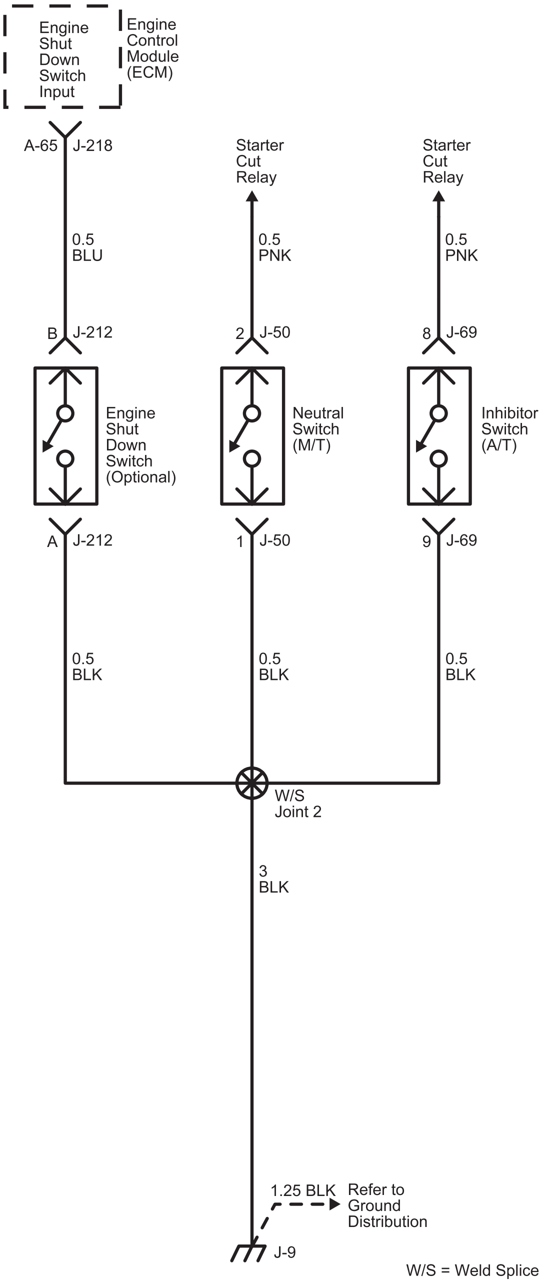
W/S = Weld Splice

LNW68DXF007801



LNW68DXF007901


HOT IN RUN
F-14
ECM(IGN)
10A
Fuse
Box
Brake Switch
Exhaust Brake Switch
Joint
Connection
M1
B-380
19
20
21
22
0.5 YEL/BLK
0.5 YEL/BLK
0.5 BLK
Tail Relay
0.85 LT GRN/RED
W/S-L2
Clutch
Switch
(M/T)
ECM
(A-23)
W/S-
L1
3
BLK
W/S-M1
1
2
3
B-381
Joint
Connection
M5
6
7
B-381
W/S-
R1
Joint
Connection
L1
0.5
YEL/
BLK
W/S-M2
0.5
LT GRN/
RED
0.5
YEL/
BLK
0.5
LT GRN/
RED
0.5
YEL/
BLK
0.5
LT GRN/
RED
0.5
YEL/
BLK
2
5
B-377
4
1
B-376
8
6
B-378
1
6
B-373
Cruise
Set/Coast
Switch
Cruise
Main
Switch
Cruise
Resume/
Accel
Switch
PTO
Switch
(Optional)
1
4
B-377
2
3
B-376
3
5
B-378
2
6
B-373
0.5
LT GRN/
BLK
0.5
YEL
0.5
LT GRN/
BLK
0.5
BLU/
YEL
0.5
LT GRN/
BLK
0.5
BLU
0.5
BLK
0.5
BLU/
ORN
W/S-M3
Illumination
Controller
0.5
BLU
24
H-5
8
15
17
H-8
0.5
BLU/
ORN
0.5
YEL
0.5
BLU/
YEL
0.5
BLU
0.5 BLU/ORN
PTO
Harness
2(D)
0.5 BLU/YEL
PTO
Harness
2(H)
0.5 BLU
PTO
Harness
2(C)
3
BLK
0.5
BLU/
ORN
0.5
YEL
0.5
BLU/
YEL
0.5
BLU
A-48
A-46
A-47
A-93
J-218
Cruise
Set/Coast
Switch & PTO
Tap Down
Switch Input
Cruise
Main
Switch
Input
Cruise
Resume/Accel
Switch & PTO
Tap Up
Switch Input
PTO
Switch
Input
Engine
Control
Module
(ECM)
5 BLK
Refer to
Ground
Distribution
B-7
LNW68DXF008001



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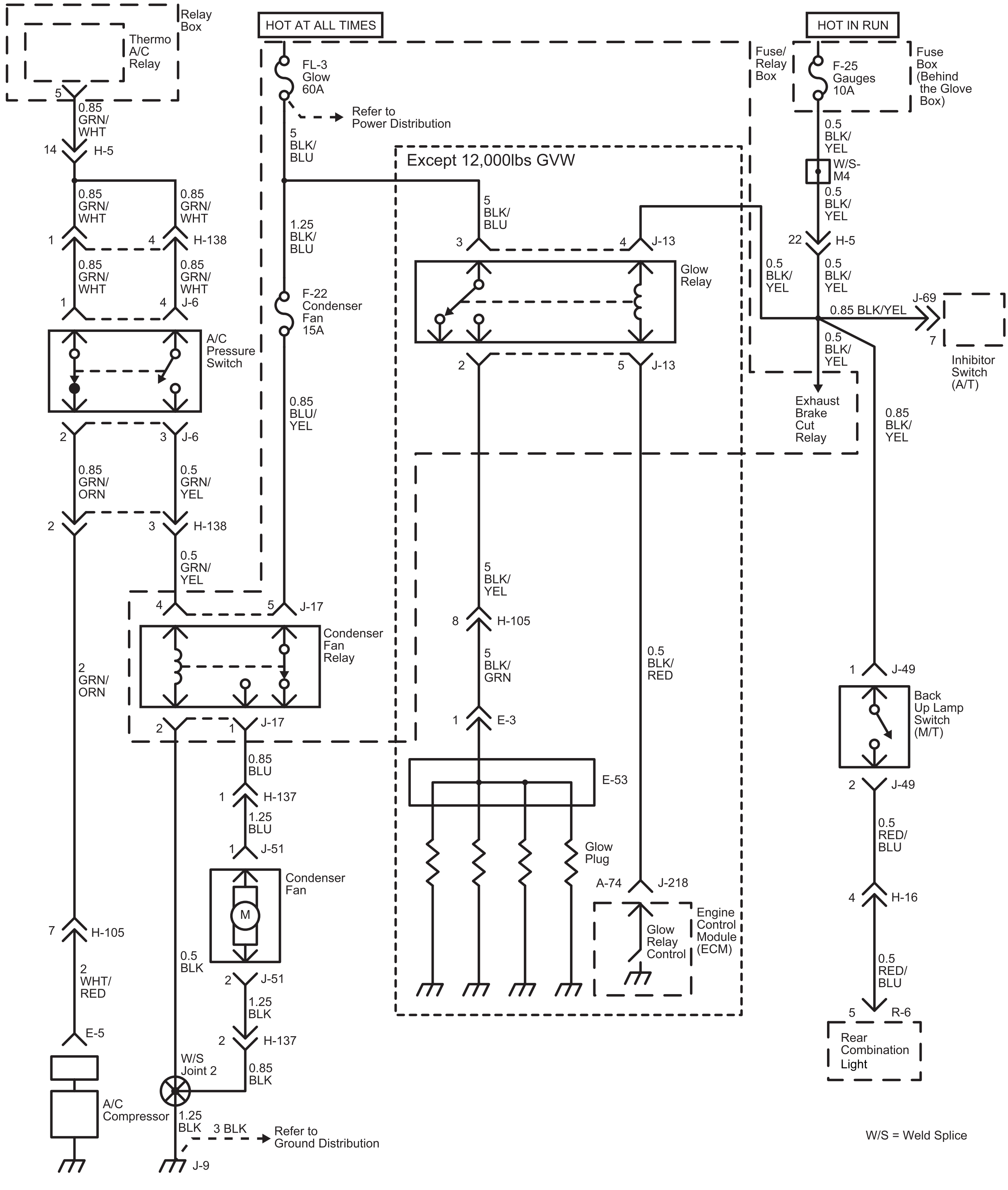
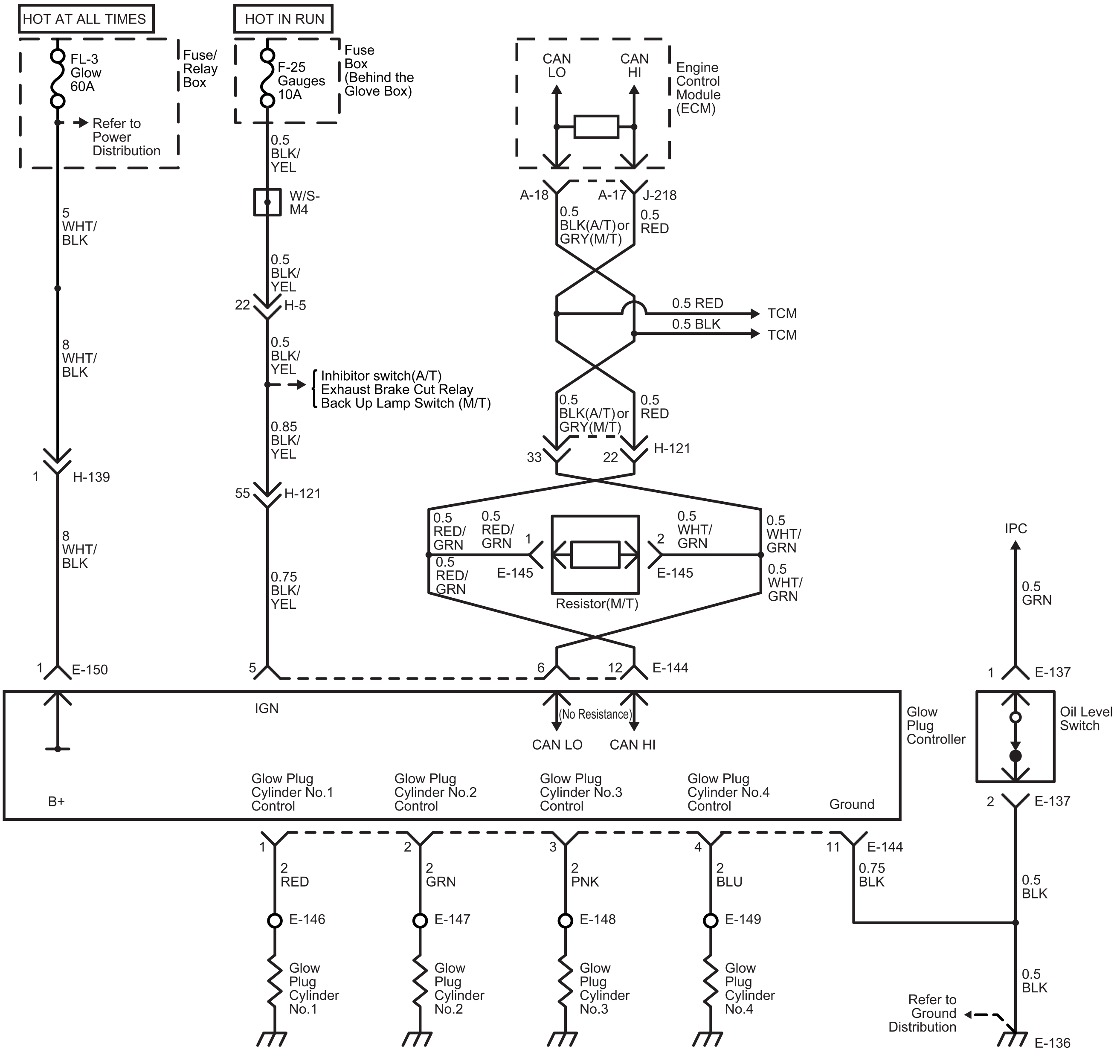


W/S = Weld Splice

LNW68DXF008201

12,000lbs GVW



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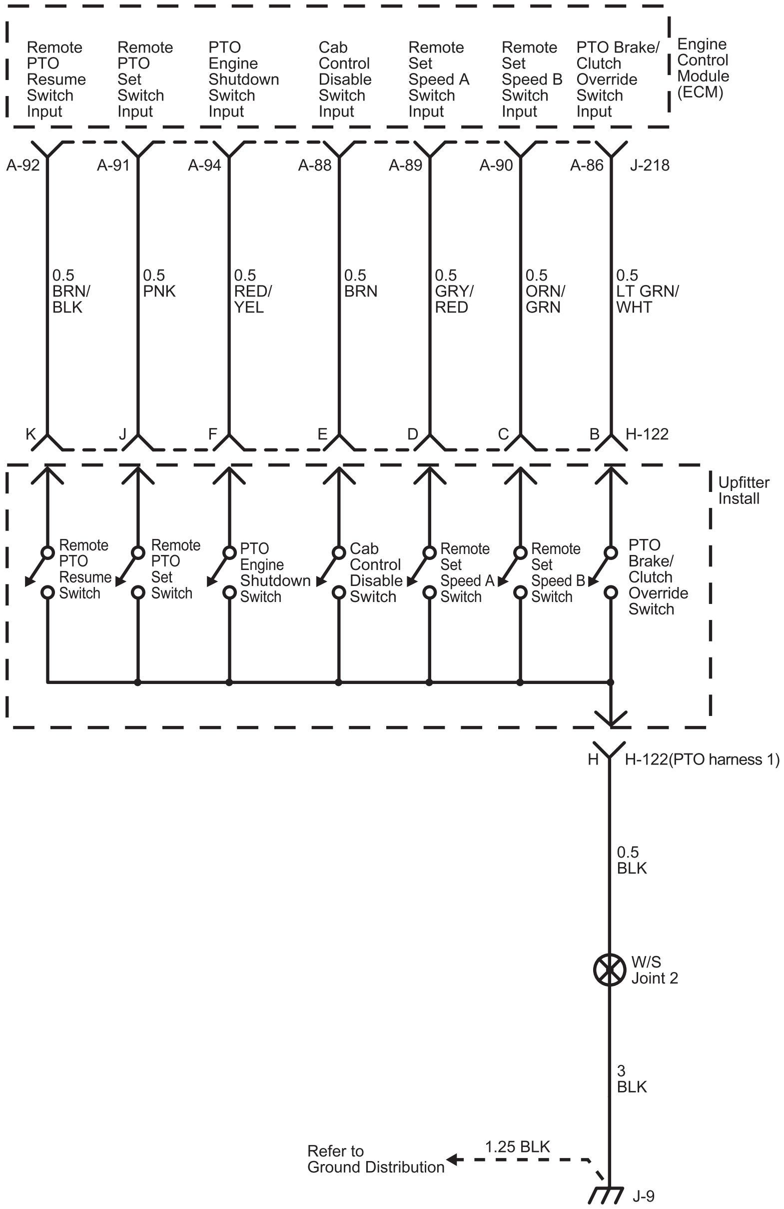

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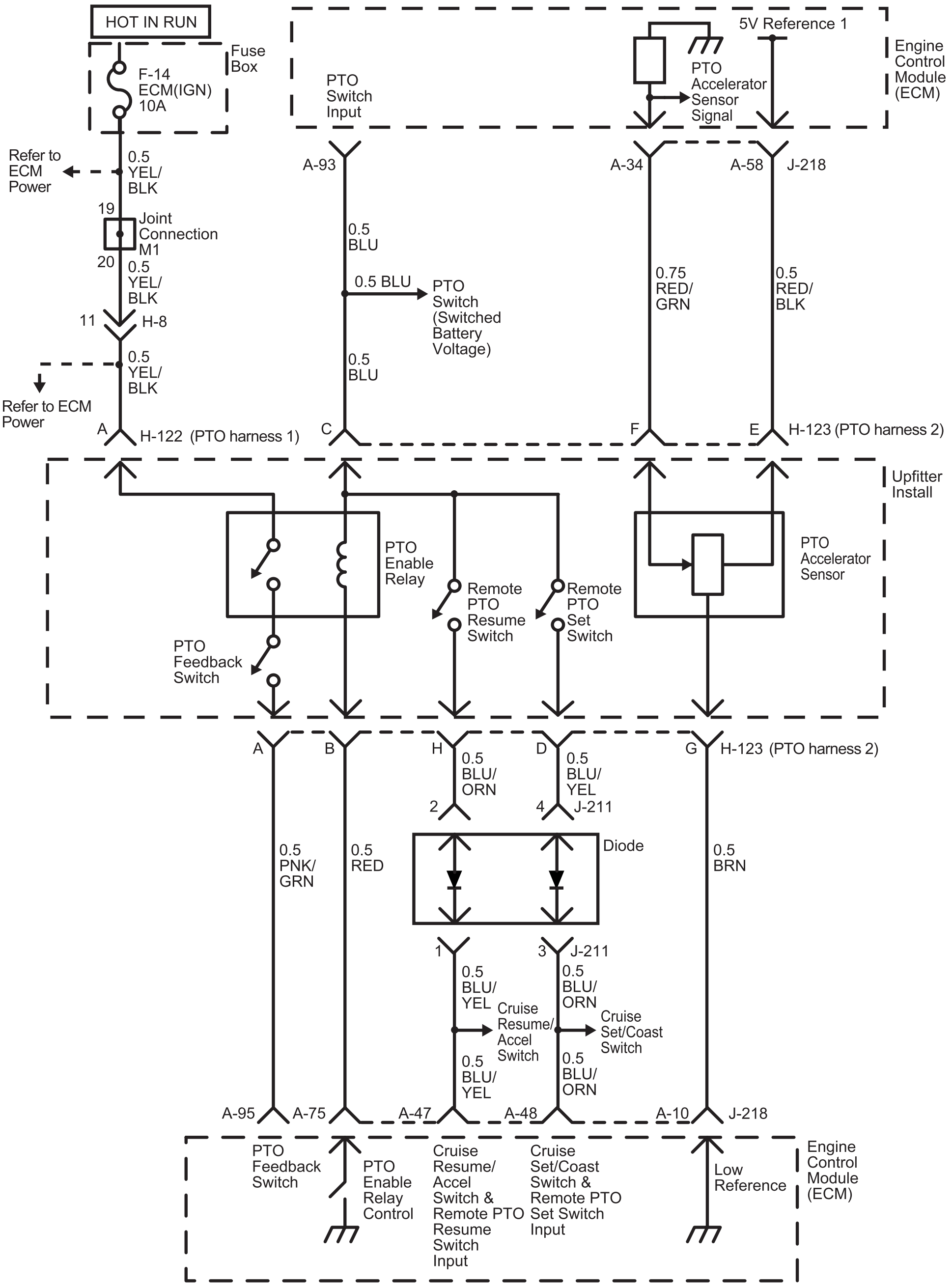

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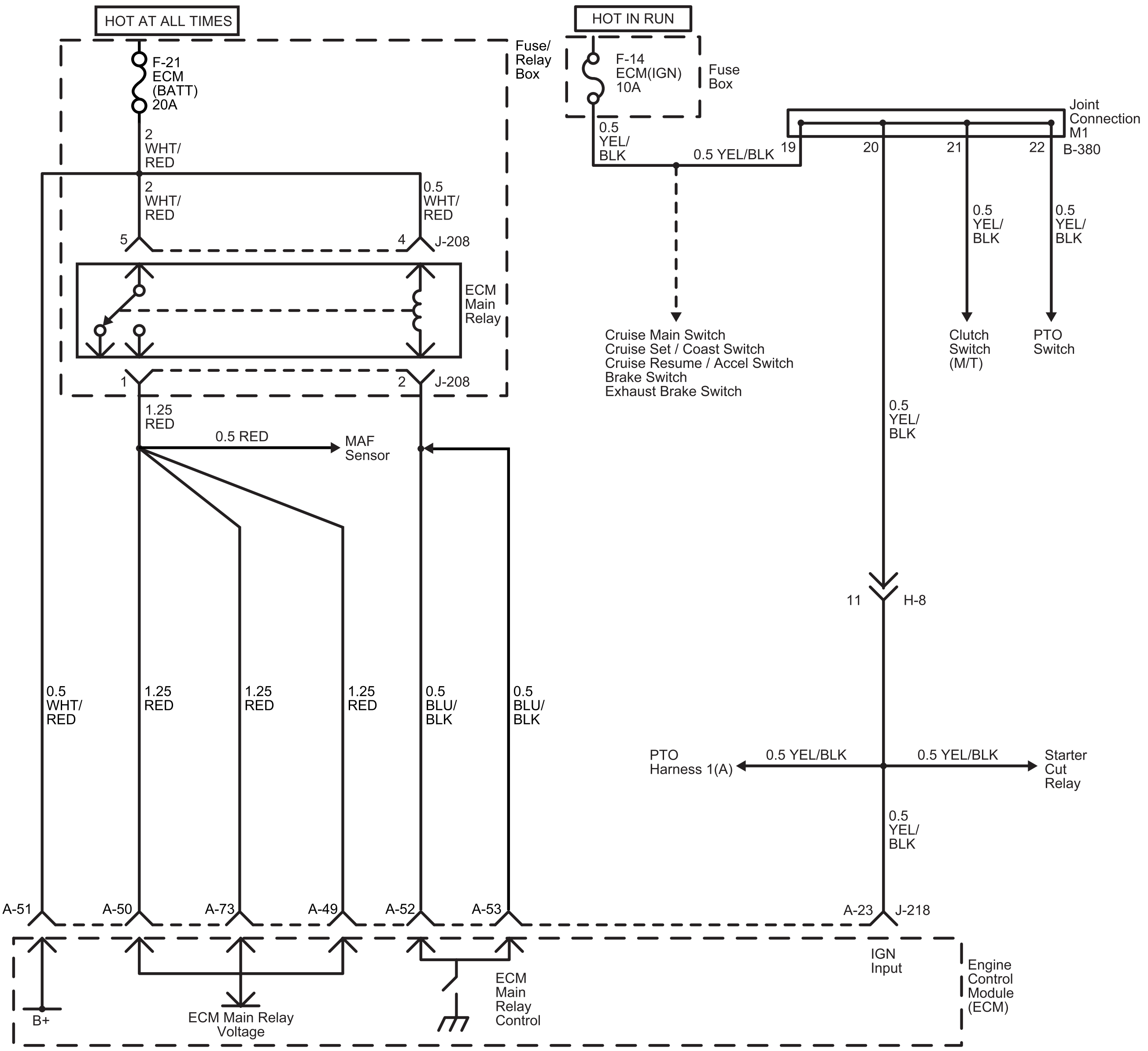
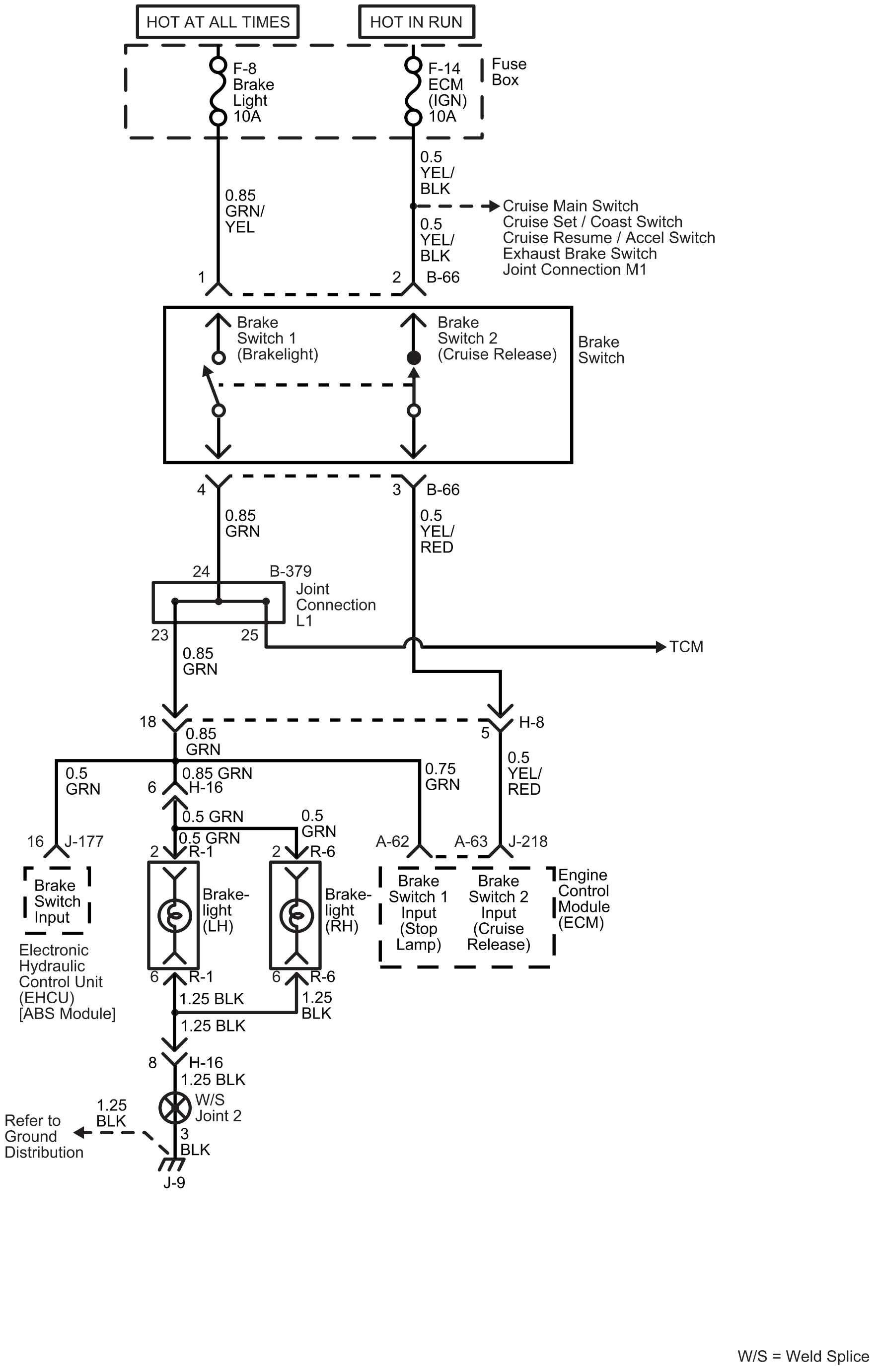
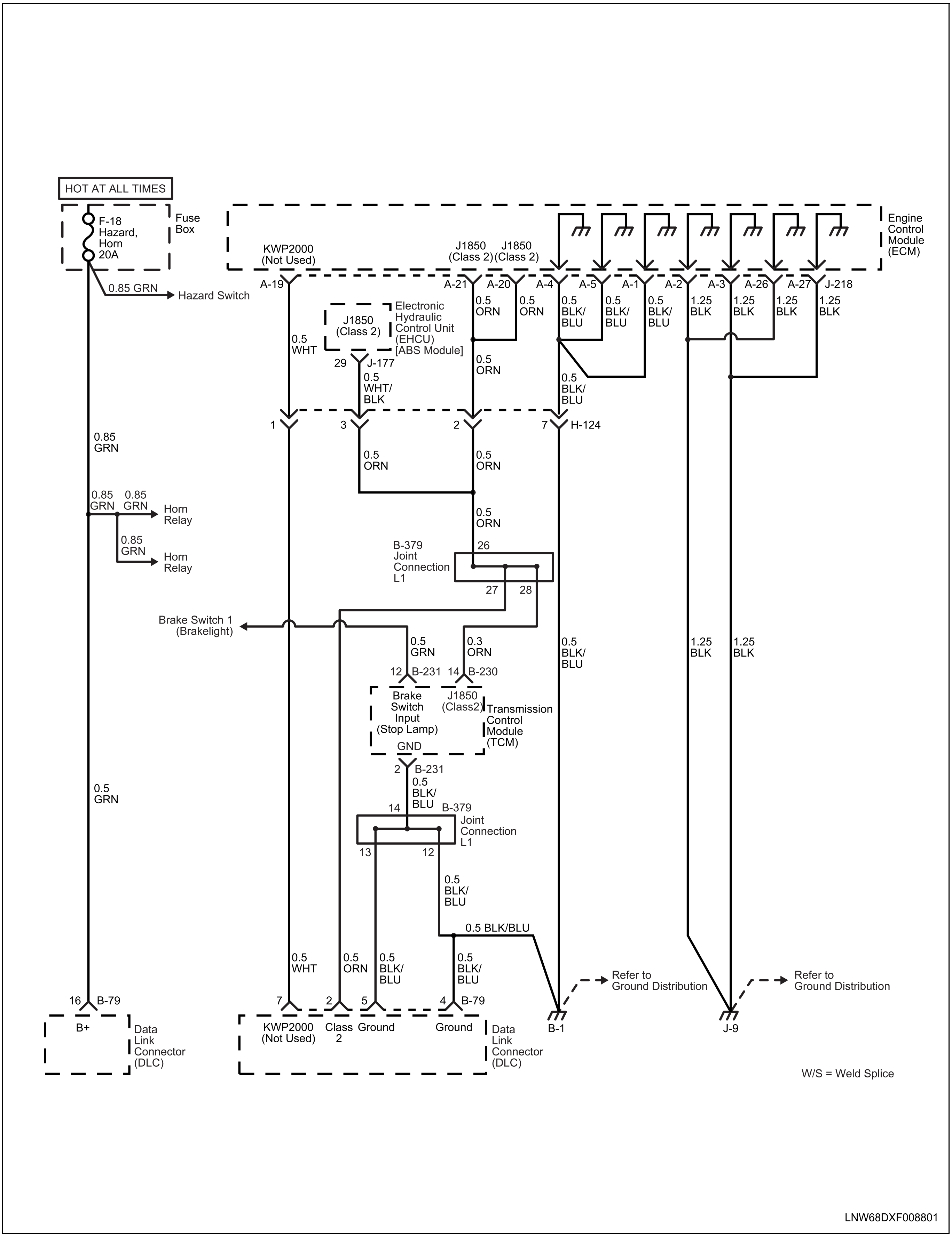
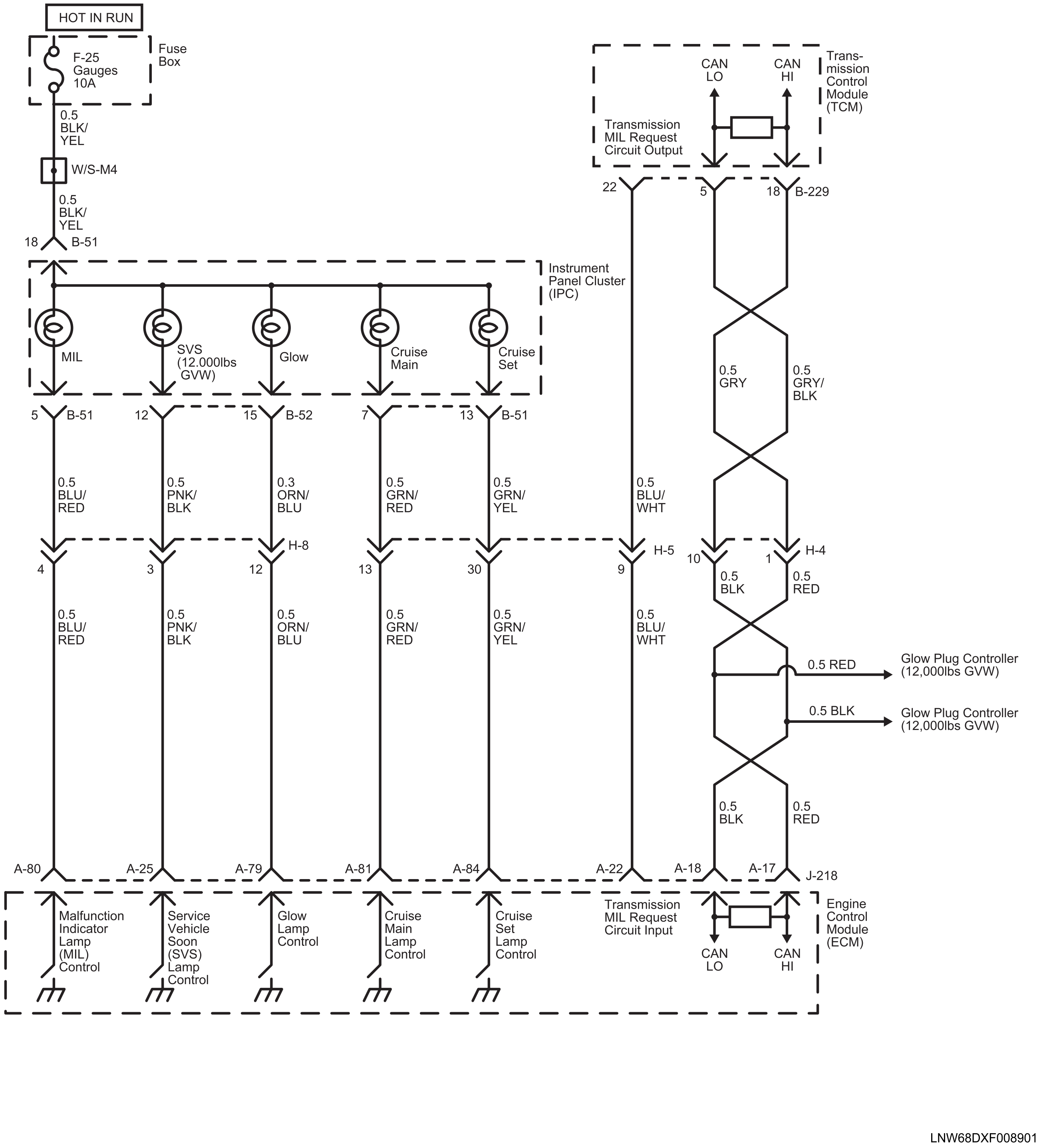


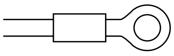
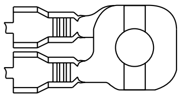
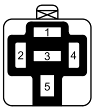
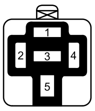
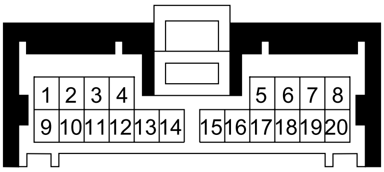
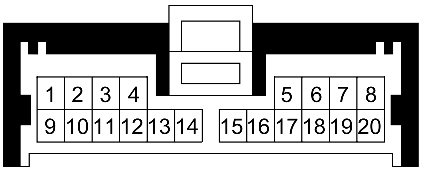
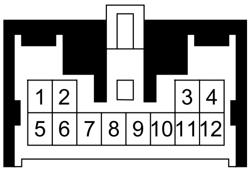
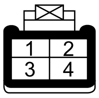
LNW68DXF008601

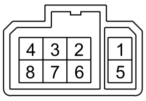
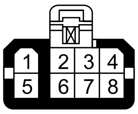
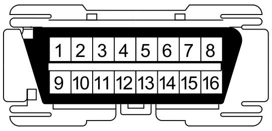
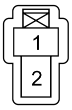
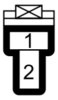
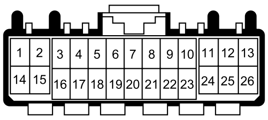
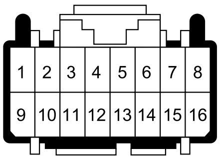
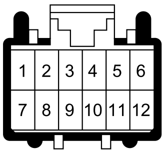


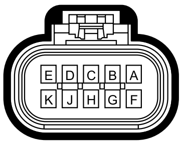
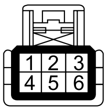
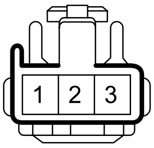
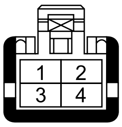
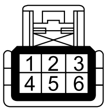
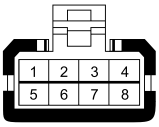
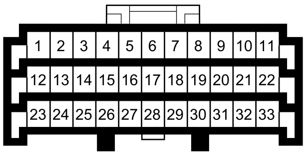
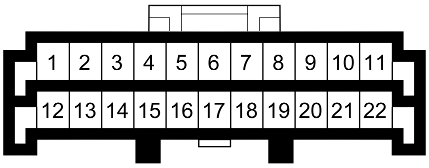
LNW68DXF008701

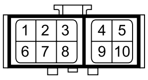
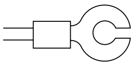
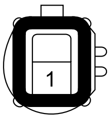
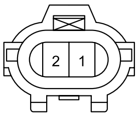
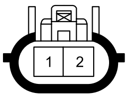
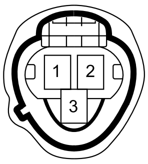
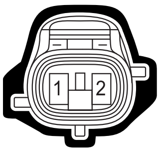
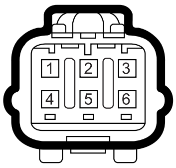

HOT AT ALL TIMES
F-18
Hazard,
Horn
20A
Fuse
Box
0.85 GRN
Hazard Switch
KWP2000
(Not Used)
J1850
(Class 2)
J1850
(Class 2)
Engine
Control
Module
(ECM)
A-19
A-21
A-20
A-4
A-5
A-1
A-2
A-3
A-26
A-27
J-218
0.5
ORN
0.5
ORN
0.5
BLK/
BLU
0.5
BLK/
BLU
0.5
BLK/
BLU
1.25
BLK
1.25
BLK
1.25
BLK
1.25
BLK
J1850
(Class 2)
Electronic
Hydraulic
Control Unit
(EHCU)
[ABS Module]
0.5
WHT
29
J-177
0.5
WHT/
BLK
0.5
ORN
0.5
BLK/
BLU
1
3
2
7
H-124
0.85
GRN
0.5
ORN
0.5
ORN
0.85
GRN
0.85
GRN
Horn
Relay
0.85
GRN
Horn
Relay
0.5
ORN
B-379
Joint
Connection
L1
26
27
28
Brake Switch 1
(Brakelight)
0.5
GRN
0.3
ORN
0.5
BLK/
BLU
1.25
BLK
1.25
BLK
12
B-231
14
B-230
Brake
Switch
Input
(Stop Lamp)
J1850
(Class2)
Transmission
Control
Module
(TCM)
GND
2
B-231
0.5
BLK/
BLU
0.5
GRN
14
B-379
Joint
Connection
L1
13
12
0.5
BLK/
BLU
0.5 BLK/BLU
0.5
WHT
0.5
ORN
0.5
BLK/
BLU
0.5
BLK/
BLU
Refer to
Ground Distribution
Refer to
Ground Distribution
16
B-79
7
2
5
4
B-79
B+
Data
Link
Connector
(DLC)
KWP2000
(Not Used)
Class
2
Ground
Ground
Data
Link
Connector
(DLC)
B-1
J-9
W/S = Weld Splice
LNW68DXF008801

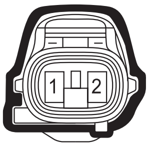
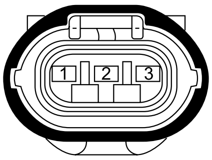
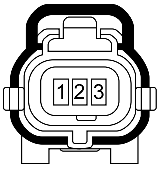
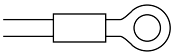
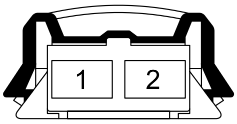
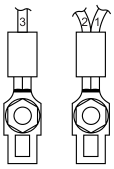
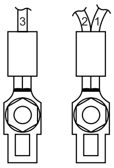

HOT IN RUN
F-25
Gauges
10A
Fuse
Box
0.5
BLK/
YEL
W/S-M4
0.5
BLK/
YEL
18
B-51
Instrument
Panel Cluster
(IPC)
MIL
SVS
(12.000lbs
GVW)
Glow
Cruise
Main
Cruise
Set
5
B-51
12
15
B-52
7
13
B-51
0.5
BLU/
RED
0.5
PNK/
BLK
0.3
ORN/
BLU
0.5
GRN/
RED
0.5
GRN/
YEL
0.5
BLU/
WHT
H-8
H-5
H-4
4
3
12
13
30
9
10
1
0.5
BLU/
RED
0.5
PNK/
BLK
0.5
ORN/
BLU
0.5
GRN/
RED
0.5
GRN/
YEL
0.5
BLU/
WHT
CAN
LO
CAN
HI
Trans-
mission
Control
Module
(TCM)
Transmission
MIL Request
Circuit Output
22
5
18
B-229
0.5
GRY
0.5
GRY/
BLK
0.5
BLK
0.5
RED
0.5 RED
Glow Plug Controller
(12,000lbs GVW)
0.5 BLK
Glow Plug Controller
(12,000lbs GVW)
0.5
BLK
0.5
RED
A-80
A-25
A-79
A-81
A-84
A-22
A-18
A-17
J-218
Malfunction
Indicator
Lamp
(MIL)
Control
Service
Vehicle
Soon
(SVS)
Lamp
Control
Glow
Lamp
Control
Cruise
Main
Lamp
Control
Cruise
Set
Lamp
Control
Transmission
MIL Request
Circuit Input
CAN
LO
CAN
HI
Engine
Control
Module
(ECM)
LNW68DXF008901

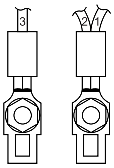
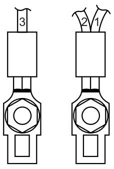
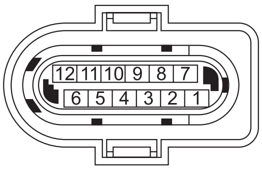
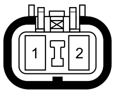
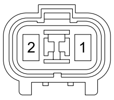
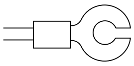
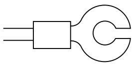
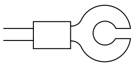
No.	Connector Face
B-1	 000-012 Ground; Frame–LH (Front)
B-7	 000-007 Ground; Headlight Bracket–RH
B-19 (Black)	 005-012 Charge Relay
B-38 (Black)	 005-012 Exhaust Brake Relay
B-51 (Gray)	 020-024 Instrument Panel Cluster(A)
B-52 (White)	 020-025 Instrument Panel Cluster (B)
B-53 (White)	 012-038 Instrument Panel Cluster (C)
B-66 (Brown)	 004-004 Brake Switch

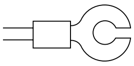
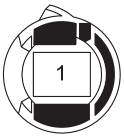
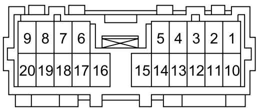
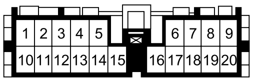
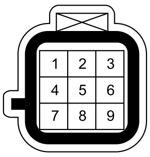
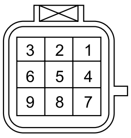
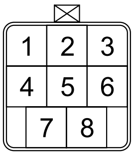
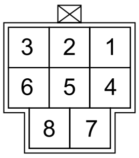
No.	Connector Face
B-69 (Black)	 008-028 Combination Switch (A)
B-69 (Blue)	 008-021 Combination Switch (A)
B-79 (Black)	 016-033 DLC Connector
B-89 (White)	 002-011 Clutch Switch
B-89 (White)	 002-012 Clutch Switch
B-229 (Gray)	 026-002 TCM
B-230 (Gray)	 016-034 TCM
B-231 (Gray)	 012-026 TCM

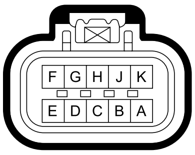
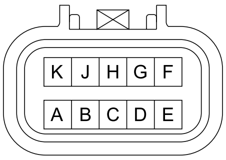
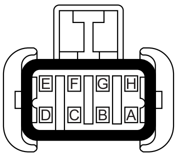
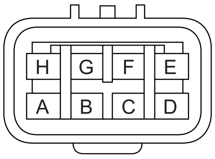
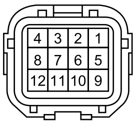
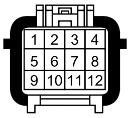
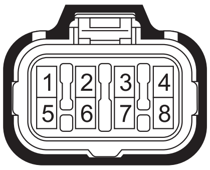
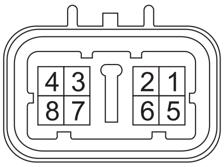
No.	Connector Face
B-280 (Black)	 010-053 APP Sensor
B-373 (White)	 006-004 PTO Switch
B-374 (White)	 003-064 Idle Up Volume
B-376 (White)	 004-015 Cruise Main Switch
B-377 (White)	 006-004 Cruise Set Coast Switch
B-378 (White)	 008-016 Cruise Resume Accel Switch
B-379 (White)	 033-001 Joint Connection – L1
B-380 (White)	 022-005 Joint Connection – M1

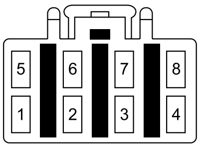
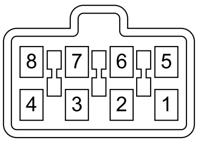
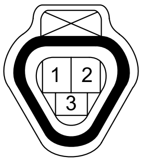
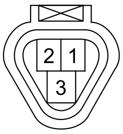
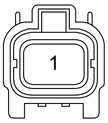
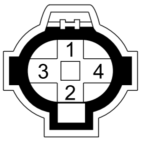
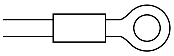
No.	Connector Face
B-381 (White)	 010-015 Joint Connection – M5
E-3	 000-020 Glow Plug
E-5 (Black)	 001-037 A/C Compressor
E-86 (White)	 002-005 Thermo Ceramic Heater
E-86 (White)	 002-006 Thermo Ceramic Heater
E-90 (Gray)	 003-095 Engine Coolant Temperature Sensor
E-93 (Green)	 002-232 Fuel Temperature Sensor
E-94 (Gray)	 006-067 EGR Valve

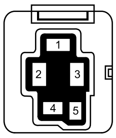
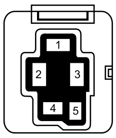
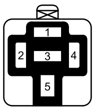
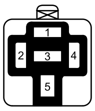
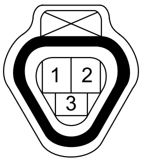
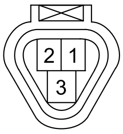
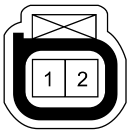
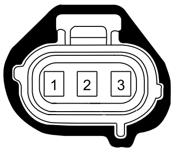
No.	Connector Face
E-98 (Gray)	 002-233 CKP Sensor
E-112 (Black)	 003-097 CMP Sensor
E-113 (Black)	 003-067 Rail Pressure Sensor
E-116 (Gray)	 002-178 Fuel Rail Pressure (FRP) Regulator
E-136	 000-012 Ground; Engine
E-137 (White)	 002-231 Oil Level Switch
E-138	 003-125 Cylinder No.1 (Injector No.1)
E-139	 003-125 Cylinder No.2 (Injector No.4)

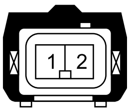
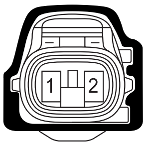
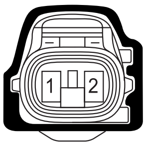
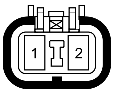
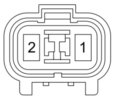
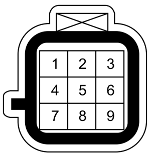
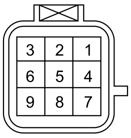
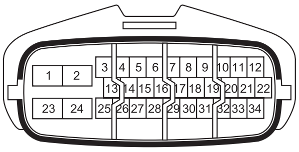
No.	Connector Face
E-140	 003-125 Cylinder No.3 (Injector No.2)
E-141	 003-125 Cylinder No.4 (Injector No.3)
E-144 (Black)	 012-064 Glow Plug Controller
E-145 (White)	 002-053 Resistor (M/T)
E-145 (White)	 002-054 Resistor (M/T)
E-146	 000-020 Glow Plug (Cylinder No.1)
E-147	 000-020 Glow Plug (Cylinder No.2)
E-148	 000-020 Glow Plug (Cylinder No.3)

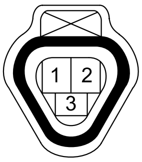
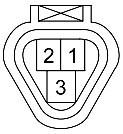
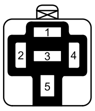
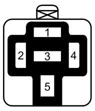
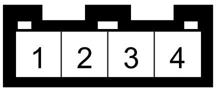
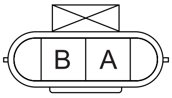
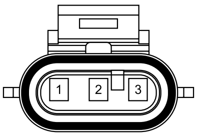
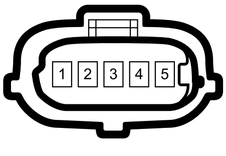
No.	Connector Face
E-149	 Glow Plug (Cylinder No.4)
E-150 (White)	 Glow Plug Controller
H-4 (White)	 Body H. – Frame H.
H-4 (White)	 Body H. – Frame H.
H-16 (Black)	 Rear Frame – Rear Body
H-16 (Black)	 Rear Frame – Rear Body
H-105 (Black)	 Frame. H – Engine H.
H-105 (Black)	 Frame. H – Engine H

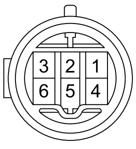
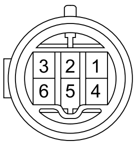
No.	Connector Face
H-122 (Black)	 PTO Harness Connector
H-122 (Black)	 PTO Harness Connector
H-123 (Black)	 PTO Harness Connector
H-123 (Black)	 PTO Harness Connector
H-124 (Black)	 Frame – Body
H-124 (Black)	 Frame – Body
H-125 (Gray)	 Engine – Injector
H-125 (Gray)	 Engine – Injector

No.	Connector Face
H-126 (Gray)	 008-062 Engine – Injector
H-126 (Gray)	 008-063 Engine – Injector
H-127 (Black)	 003-006 Frame H. – Fuel Tank H.
H-127 (Black)	 003-007 Frame H. – Fuel Tank H.
H-139 (Gray)	 001-042 Frame H. – Engine H.
J-1 (Green)	 002-001 Generator
J-6 (White)	 004-029 A/C Pressure Switch
J-9	 000-012 Ground; Frame–LH (Center)

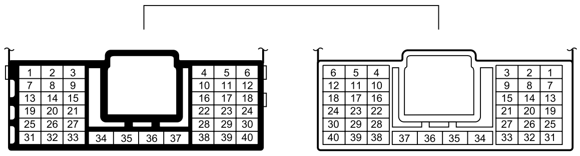
No.	Connector Face
J-12 (Black)	 005-013 Starter Relay
J-13 (Black)	 005-013 Glow Relay
J-17 (Black)	 005-012 Condenser Fan Relay
J-18 (Black)	 005-012 Exhaust Brake Control Relay
J-28 (Black)	 003-006 Fuel Tank Unit (Side)
J-28 (Black)	 003-007 Fuel Tank Unit (Side)
J-31 (Black)	 002-008 Exhaust Brake Magnetic Valve
J-32 (Gray)	 003-048 Vehicle Speed Sensor

No.	Connector Face
J-40 (Brown)	 002-024 Intake Throttle Solenoide Valve
J-49 (Brack)	 002-210 Back Up Light Switch
J-50 (Black)	 002-210 Neutral Switch
J-51 (Black)	 002-053 Condenser Fan
J-51 (Black)	 002-054 Condenser Fan
J-69 (Black)	 009-001 Inhibitor Switch
J-69 (Black)	 009-002 Inhibitor Switch
J-177 (White)	 034-001 Electronic Hydraulic Control Unit (EHCU)

No.	Connector Face
J-207 (Black)	 003-006 Fuel Tank Unit (Rear)
J-207 (Black)	 003-007 Fuel Tank Unit (Rear)
J-208 (Black)	 005-012 ECM Main Relay
J-210 (Black)	 005-012 Exhaust Brake Cut Relay
J-211 (Black)	 004-077 Diode
J-212 (Black)	 002-228 Engine Shut Down Switch
J-216 (Gray)	 003-126 Boost Pressure Sensor
J-219 (Black)	 005-035 MAF·IAT Sensor

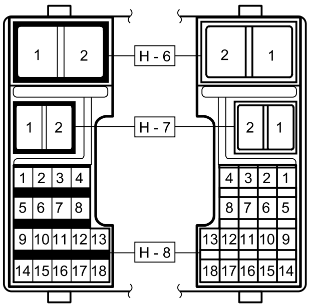
No.	Connector Face
R-1 (White)	 006-036 Rear Combination Light (LH)
R-6 (White)	 006-036 Rear Combination Light (RH)

H-5 Body H. – Frame H. (Gray)



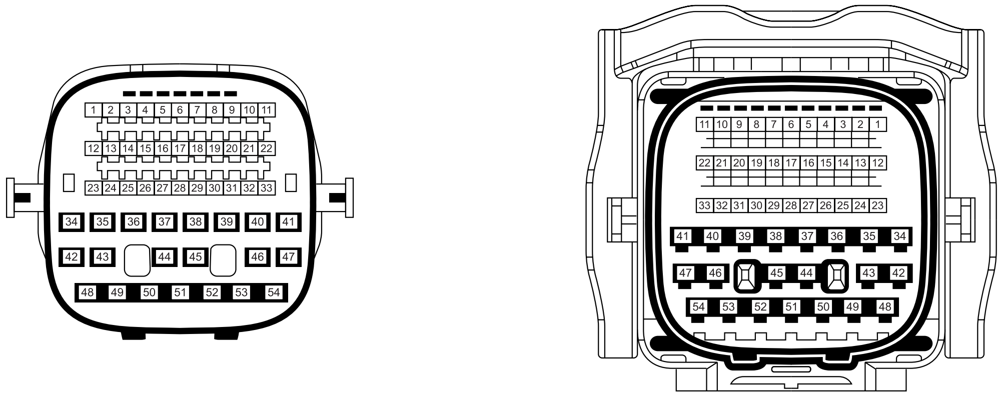
LNW38ASH018701

H-6, H-8 Body H. – Frame H. (Gray)



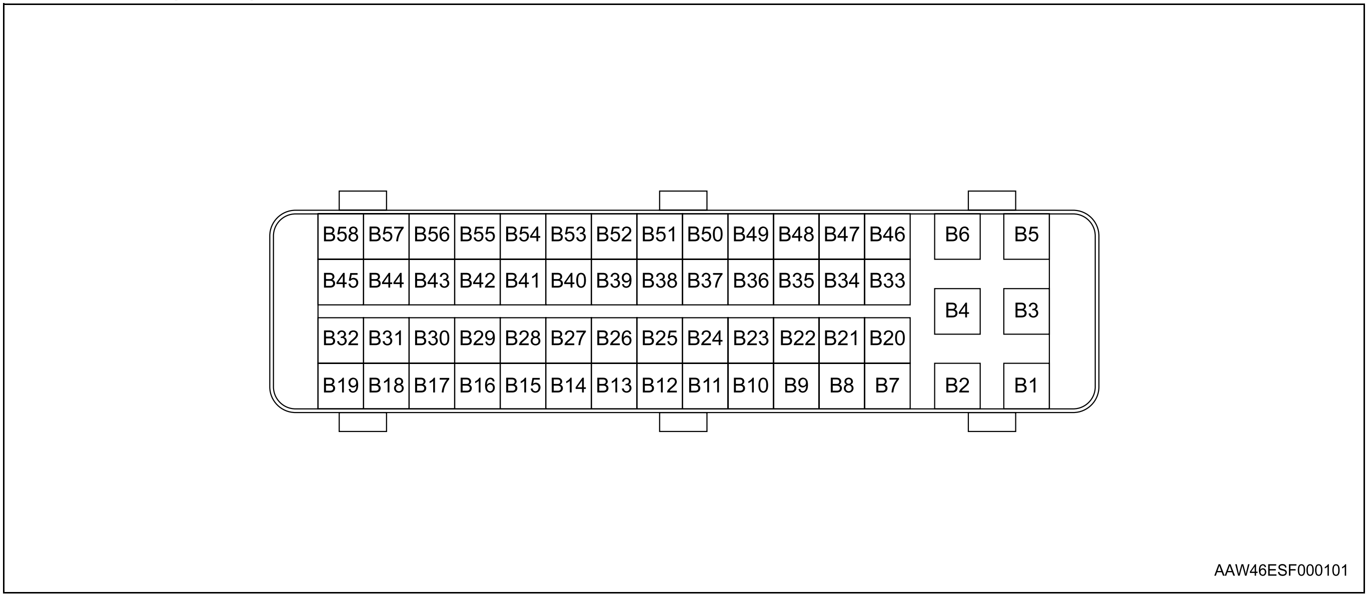
LNW38ASH018801

H-121 Engine H. – Frame H. (Black)

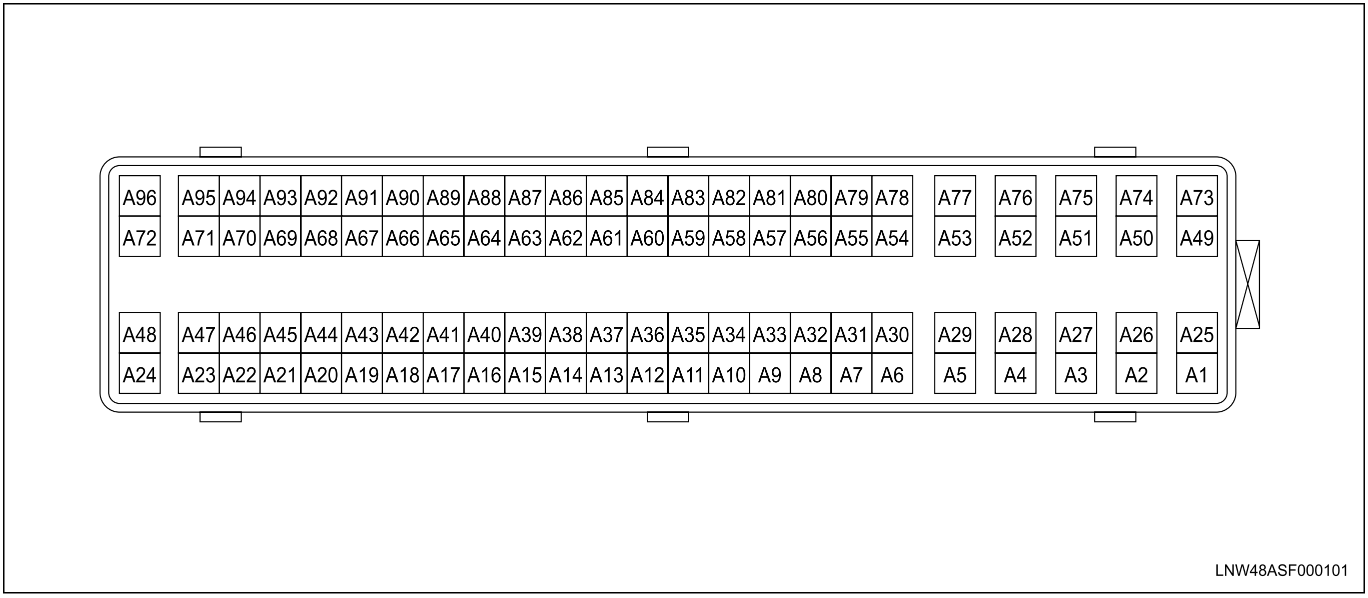


LNW48ASF000201

J-217 ECM-1 (Black)



J-218 ECM-2 (Black)



IGNITION SWITCH

Refer to “Start and Charging” in this section.

GLOW INDICATOR LIGHT

Refer to “Instrument Panel Cluster and Warning/ Indicator Light” in this section.

Engine Control Module (ECM) Replacement

Removal Procedure

Refer to “Engine Control Module (ECM) Replacement/ Fuel Injector Flow Rate Programming & Option Programming” of section 6E “Engine Control System”.

Installation Procedure

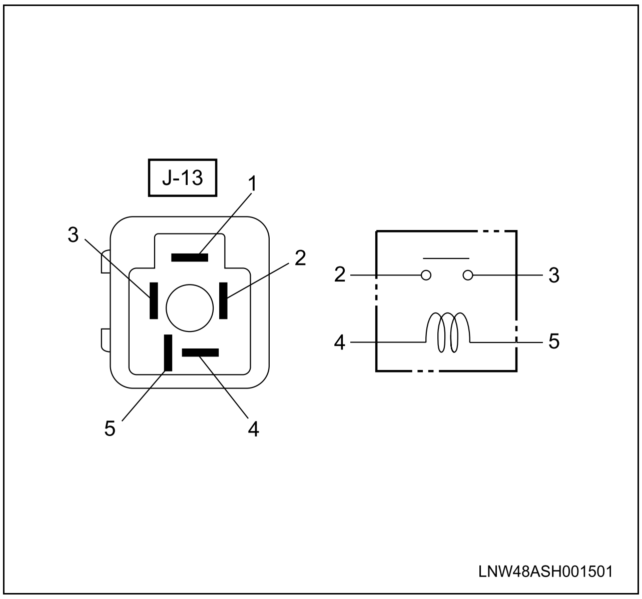
Refer to “Engine Control Module (ECM) Replacement/ Fuel Injector Flow Rate Programming & Option Programming” of section 6E “Engine Control System”.

GLOW RELAY

Inspect

Check to see if there is any continuity between the relay terminals.
Replace the relay when the result of inspection is found abnormal.

(2) – (3)	No continuity
(When battery voltage is applied between (4) – (5))	
(2) – (3)	Continuity



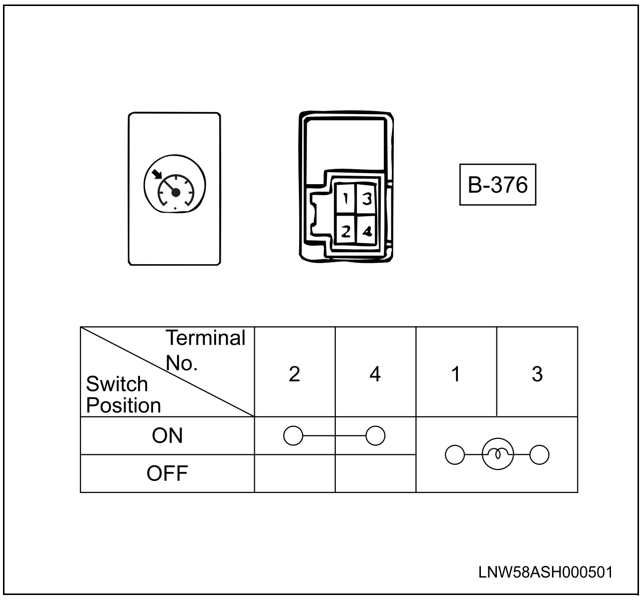
STARTER RELAY, CHARGE RELAY, IGNITION SWITCH

Refer to “Start and Charging” in this section.

CRUISE MAIN SWITCH

Inspect

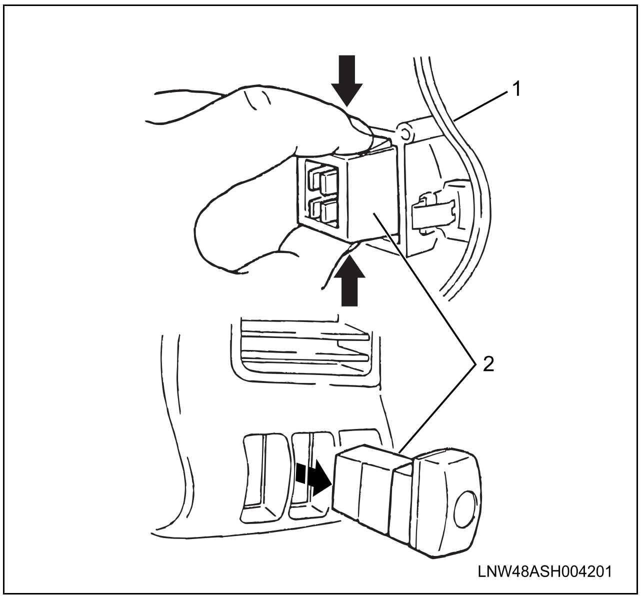
Check the continuity between the cruise main switch connector terminals.
Repair or replace the switch when the result of inspection is found abnormal.



Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Instrument Panel Cluster Bezel
   Refer to the “Instrument Panel Cluster and Warning/Indicator Light” in this section.
2. Cruise Main switch
   Release the lock pushing the switch from the back side of the meter cluster.



Legend

1. Instrument Panel Cluster Bezel
2. Cruise Main Switch

Install or Connect

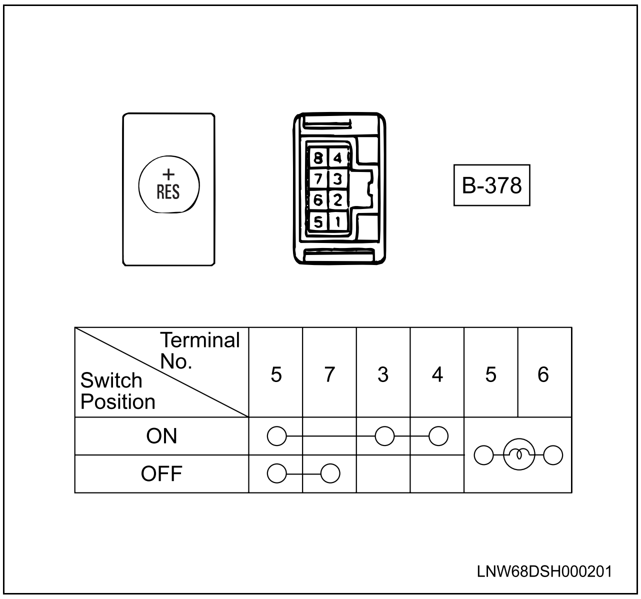
To install, follow the removal steps in the reverse order noting the following point:

- Push the switch with your fingers until locks securely.

CRUISE RESUME ACCEL SWITCH

Inspect

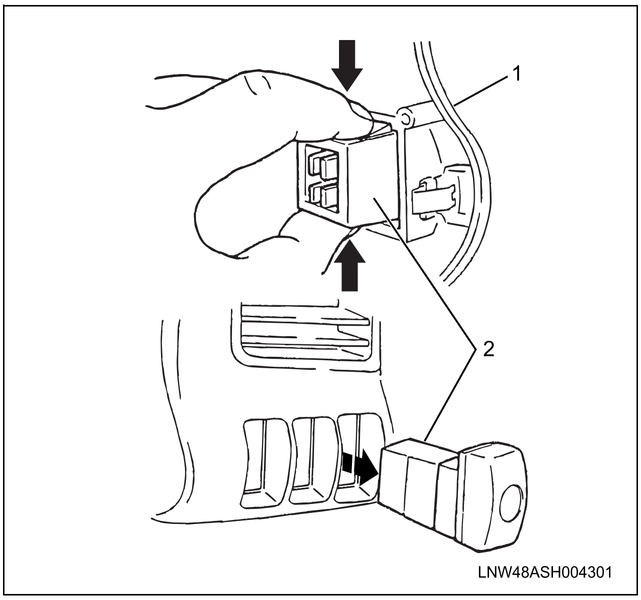
Check the continuity between the terminals of the cruise resume accel switch.
Repair or replace the switch when the result of inspection is found abnormal.



Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Instrument Panel Cluster Bezel
   Refer to the “Instrument Panel Cluster and Warning/Indicator Light” in this section.
2. Cruise Resume Accel Switch
   Release the lock pushing the switch from the back side of the meter cluster.



Legend

1. Instrument Panel Cluster Bezel
2. Cruise Resume Accel Switch

This illustration is based on the dome light switch

Install or Connect

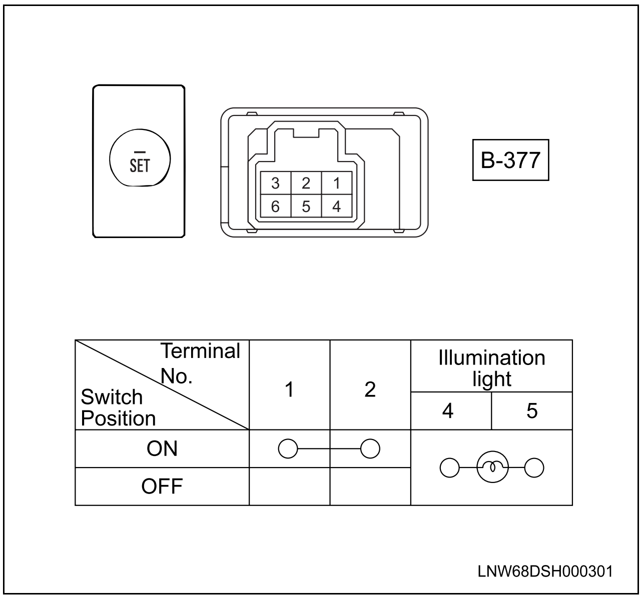
To install, follow the removal steps in the reverse order noting the following point:

1. Push the switch with your fingers until locks securely.

CRUISE SET COAST SWITCH

Inspect

Check the continuity between the terminals of the cruise set coast switch.
Repair or replace the switch when the result of inspection is found abnormal.

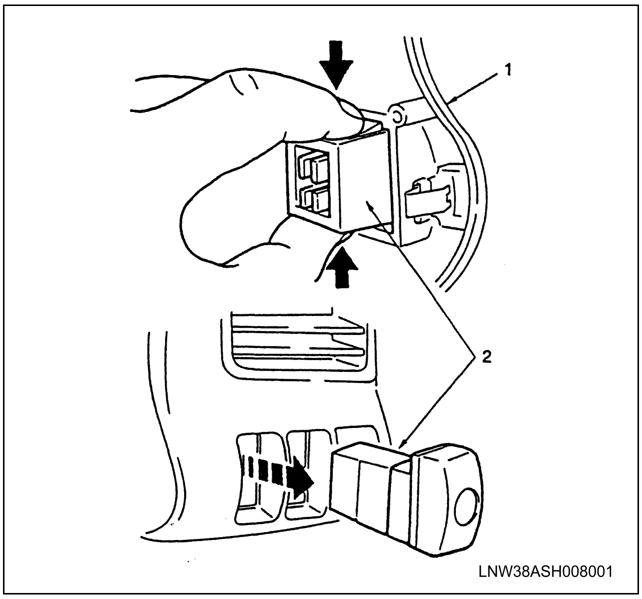


Terminal No. / Switch Position	1	2	Illumination light	
			4	5
ON	○—	—○	○—⊗—○	
OFF				

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Instrument Panel Cluster Bezel
   Refer to the “Instrument Panel Cluster and Warning/Indicator Light” in this section.
2. Cruise set coast switch
   Release the lock pushing the switch from the back side of the meter cluster.



Legend

1. Instrument Panel Cluster Bezel
2. Cruise Set Coast Switch

This illustration is based on the dome light switch

Install or Connect

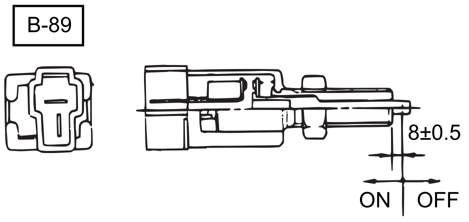
To install, follow the removal steps in the reverse order noting the following point:

1. Push the switch with your fingers until locks securely.

CLUTCH SWITCH (M/T)

Inspect

1. Check the continuity between the switch connector terminals.
2. Check to see if switch push rod operate smoothly. Repair or replace the switch when result of inspection is found abnormal.

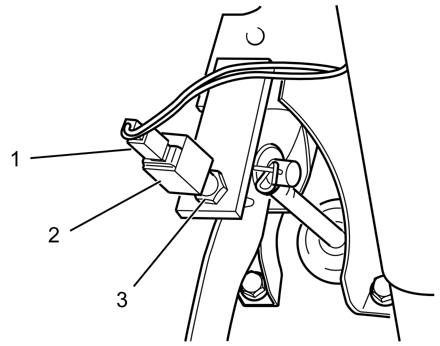


Terminal No. / SW position	1	2
Release clutch pedal (Push rod in)	○—	—○

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Clutch switch
   - Disconnect the connector (1).
   - Loosen the lock nut of the switch (3).
   - Remove the switch (2) by turning it.

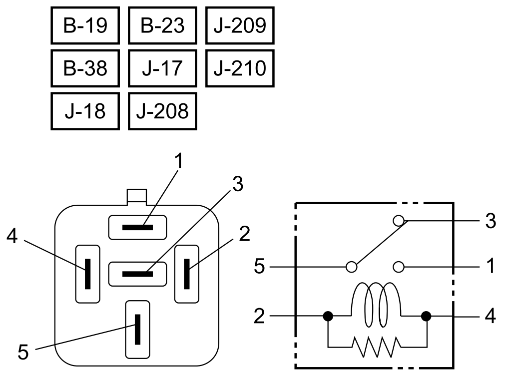


EXHAUST BRAKE RELAY, EXHAUST BRAKE CONTROL RELAY, EXHAUST BRAKE CUT RELAY, ECM MAIN RELAY, CHARGE RELAY, STARTER CUT RELAY, BUZZER CANCEL RELAY, CONDENSER FAN RELAY

Inspect

Check to see if there is any continuity between the relay terminals.
Replace the relay when the result of inspection is found abnormal.

(3) – (5)	Continuity
(1) – (5)	No continuity
(When battery voltage is applied between (2) – (4))	
(3) – (5)	No continuity
(1) – (5)	Continuity

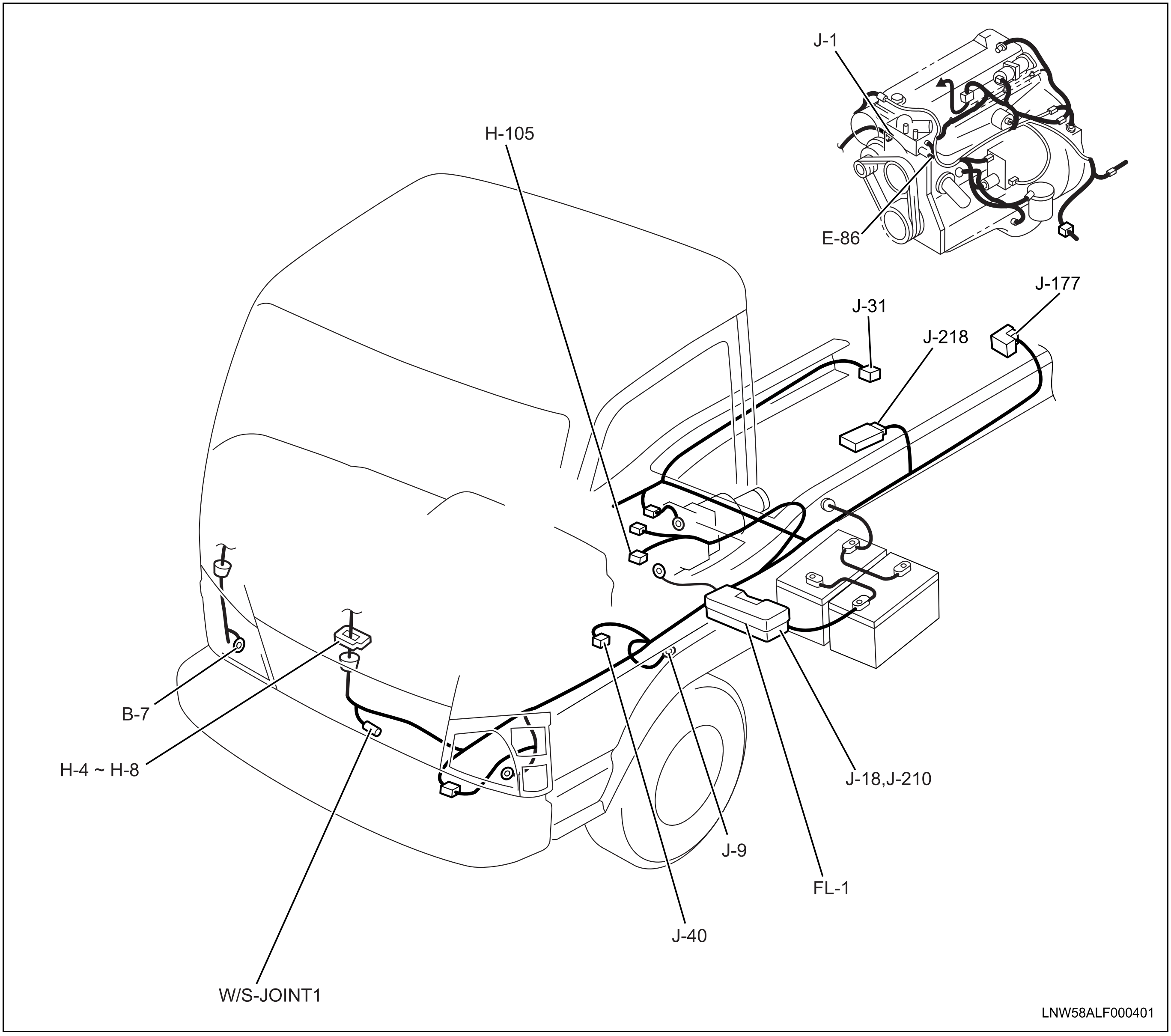


Exhaust Brake

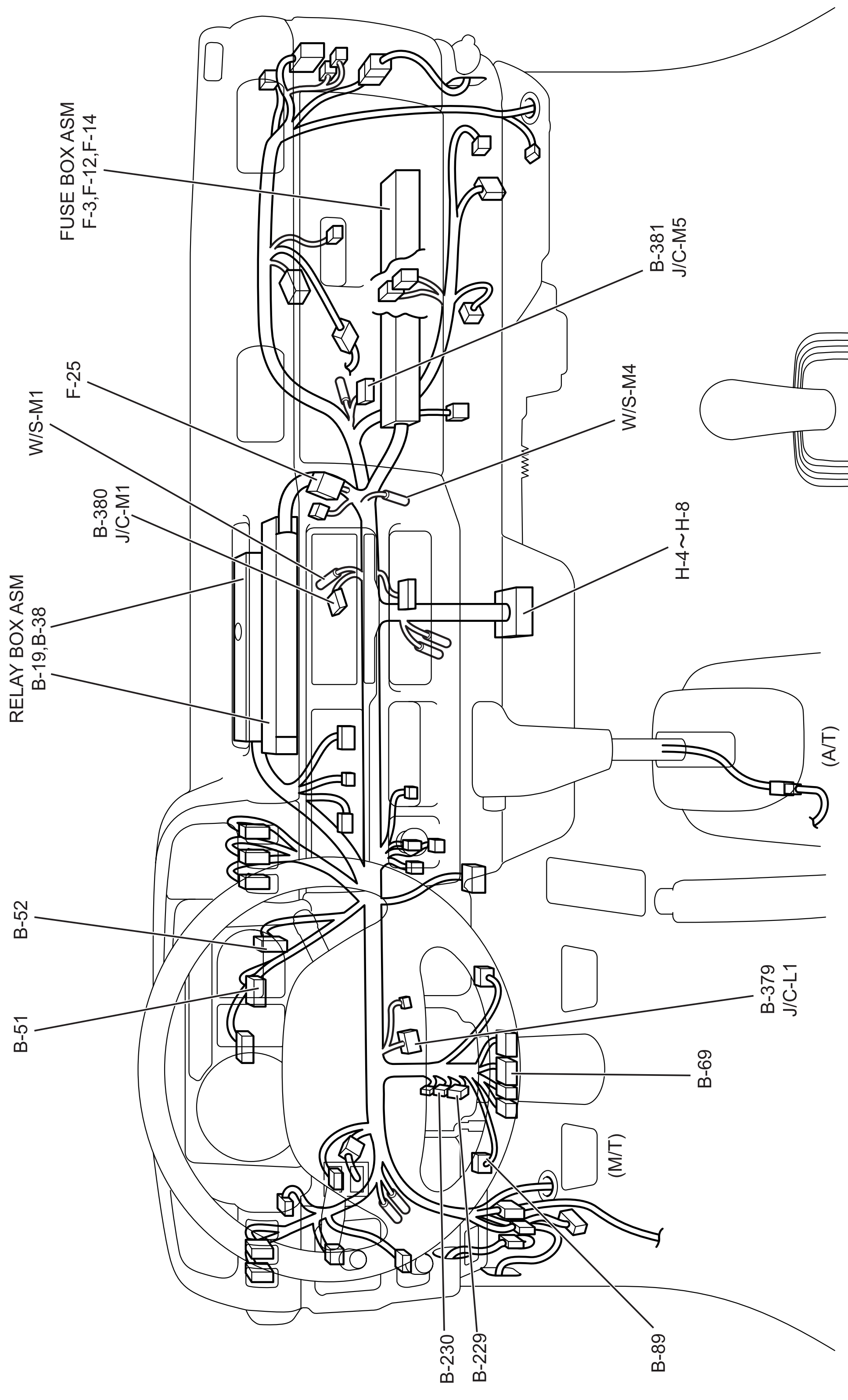
General Description

The exhaust brake system consists the exhaust brake valve, exhaust brake magnetic valve, the exhaust brake switch, relays and ECM. The exhaust brake valve is opened or closed by the exhaust brake magnetic valve. If exhaust brake switch is turned ON and conditions of the vehicle are satisfied, the ECM turn ON the exhaust brake control relay and the exhaust brake magnetic valve. And then the vacuum is supplied to the exhaust brake valve, and it is closed. If the ABS system operate, the EHCU (ABS) turn ON the exhaust brake cut relay (normally closed) and the exhaust brake magnetic valve is turned OFF.
Refer to “Exhaust System Check” of section 6F “Exhaust System”.

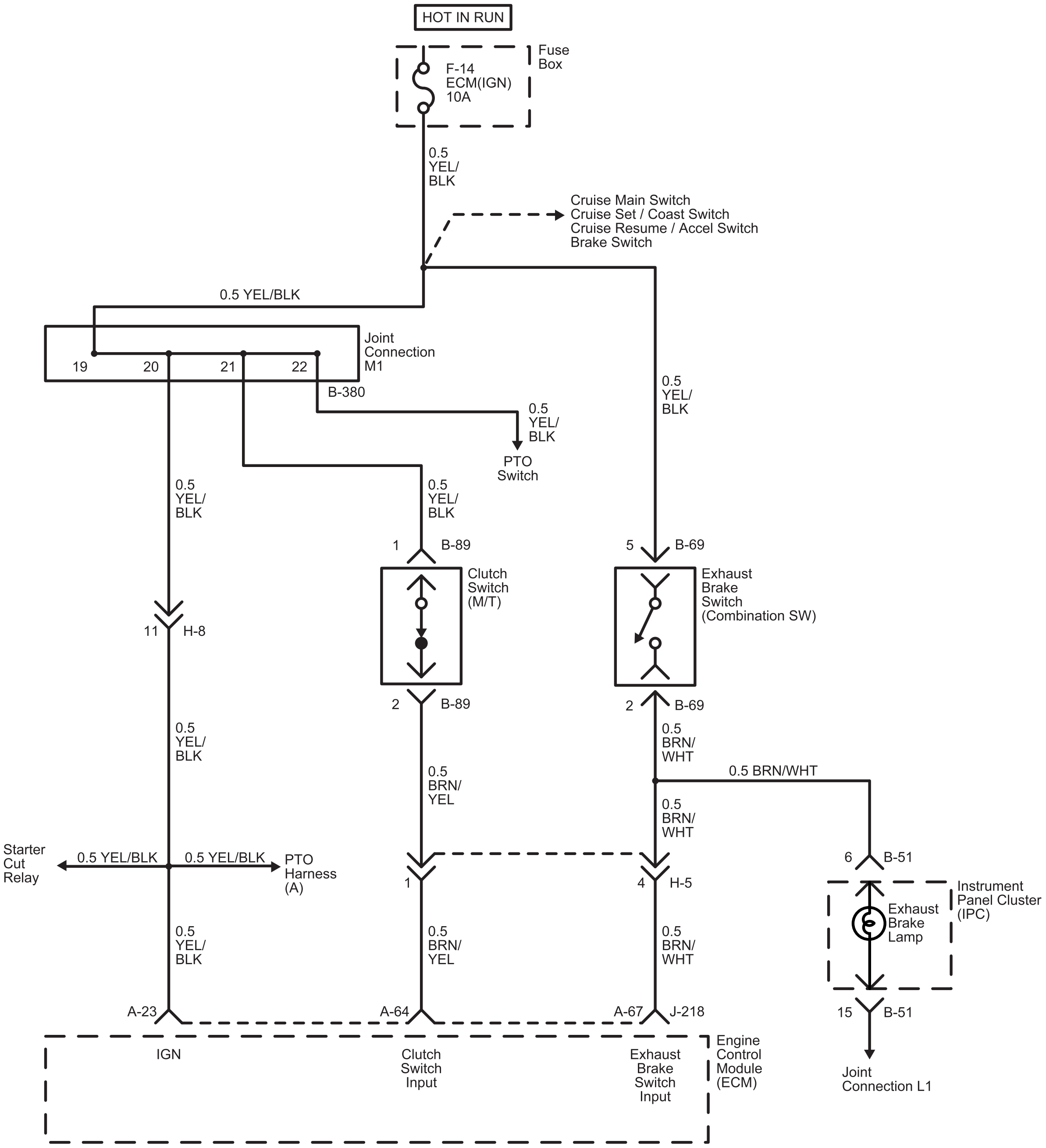
PARTS LOCATION (1)



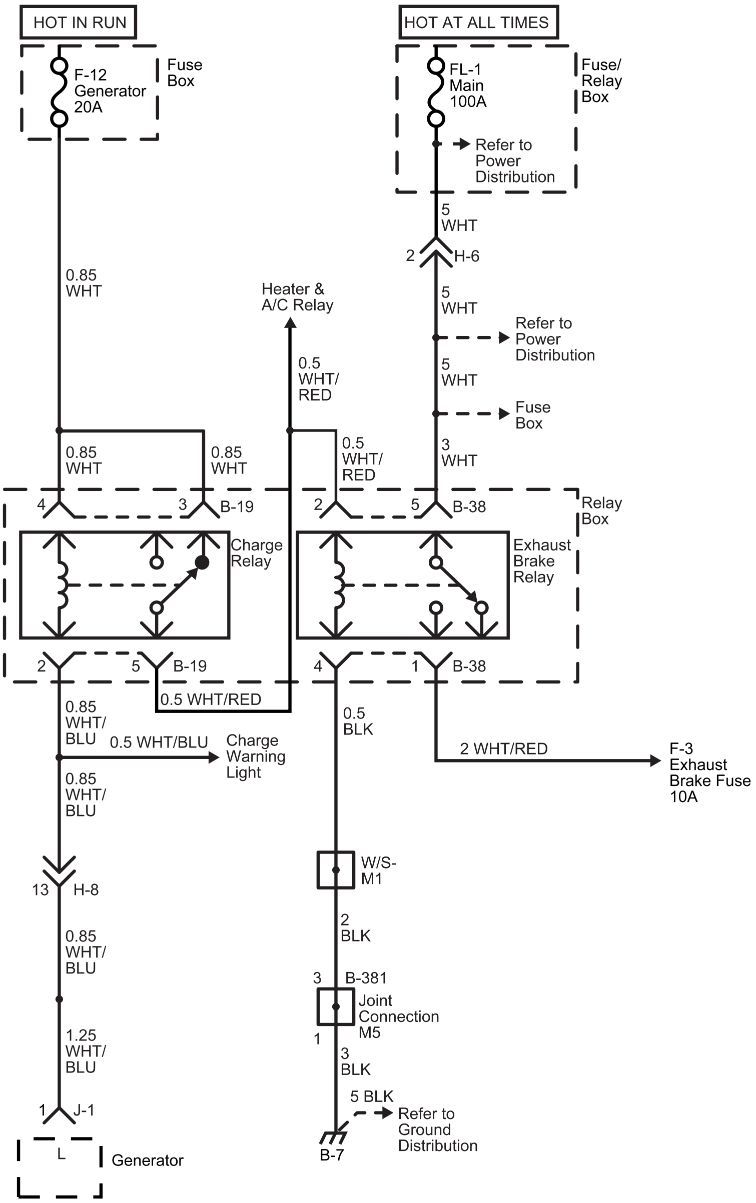
PARTS LOCATION (2)



LNW68DXF010501

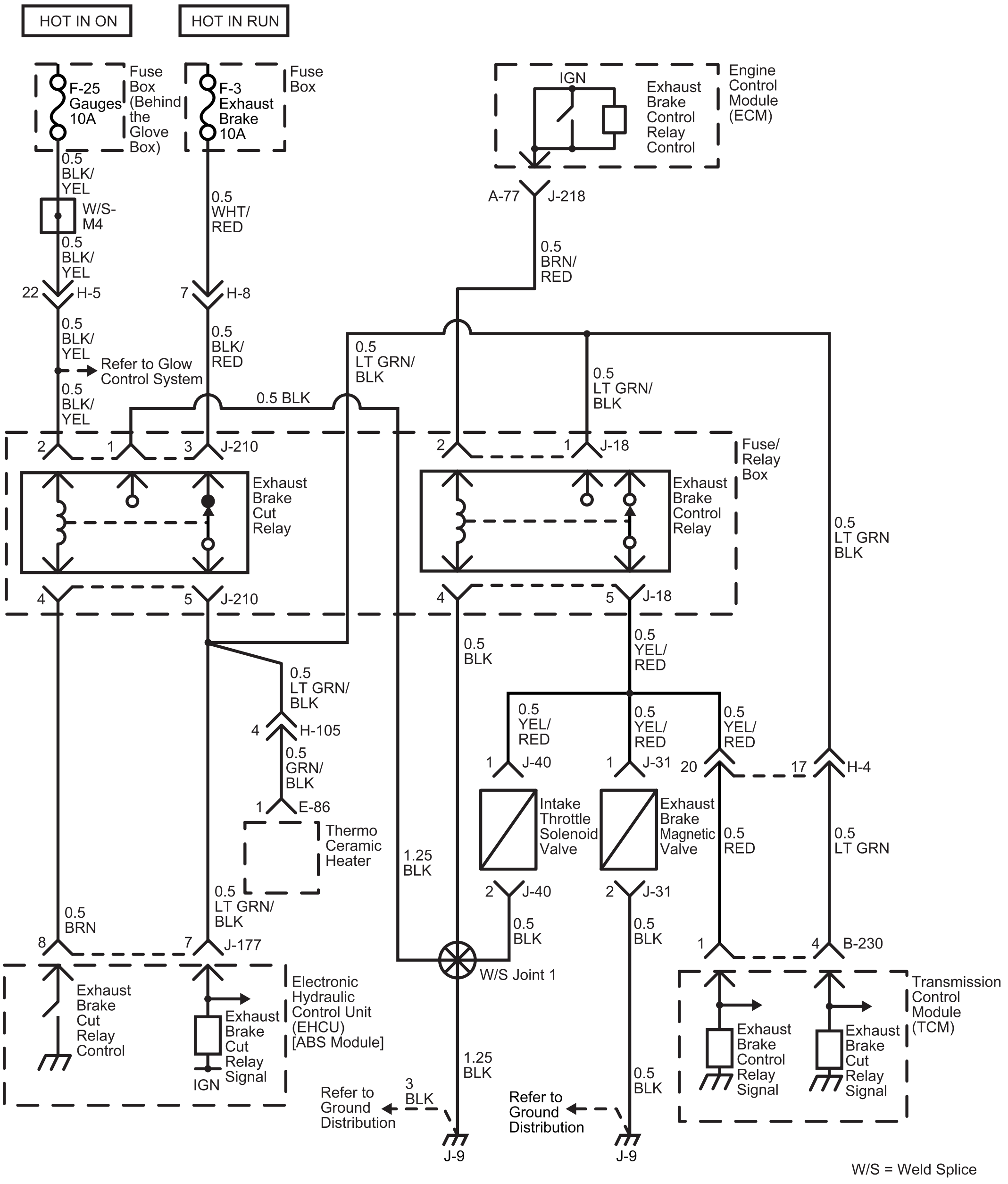


LNW68DXF007901



LNW68DXF007501

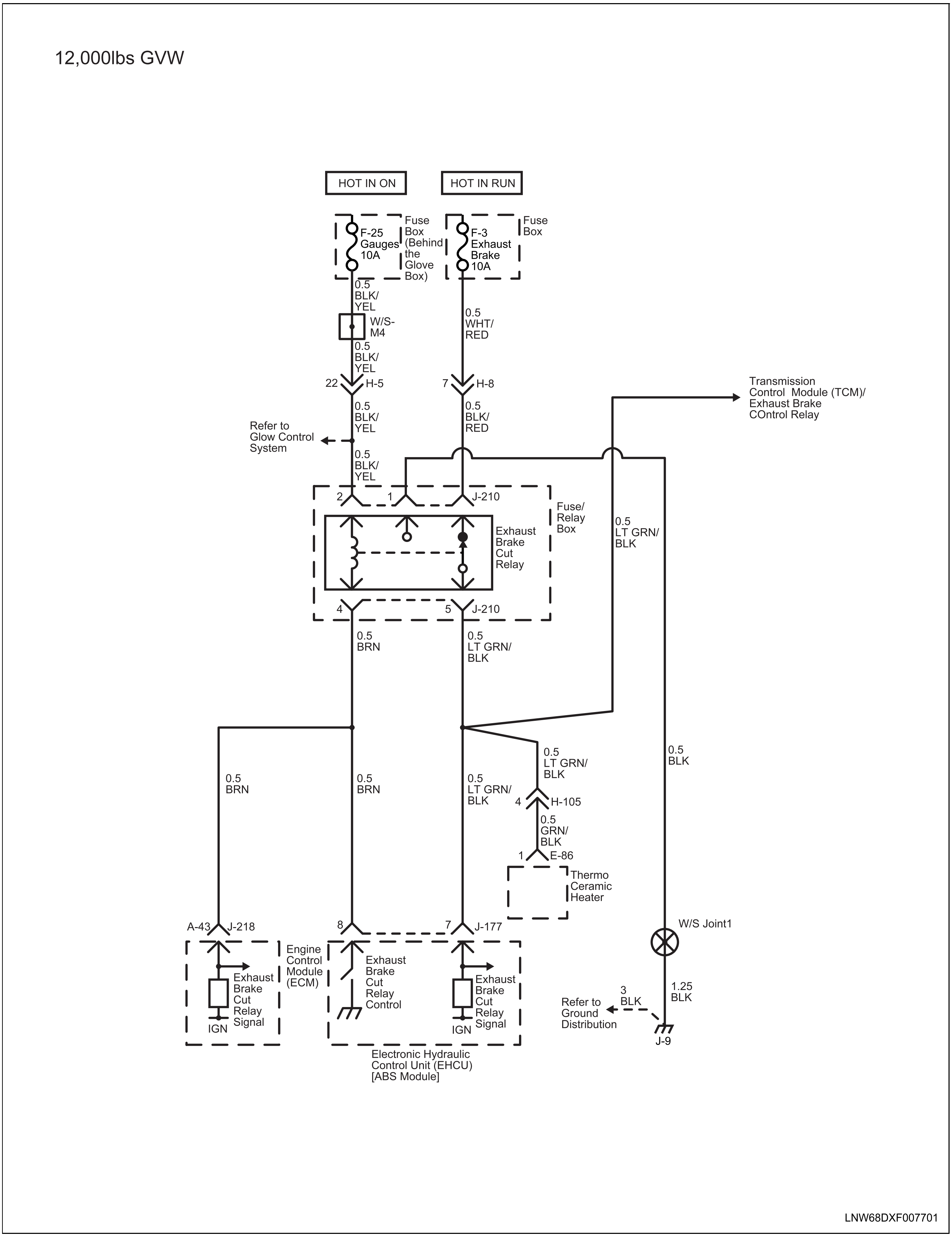
Except 12,000lbs GVW



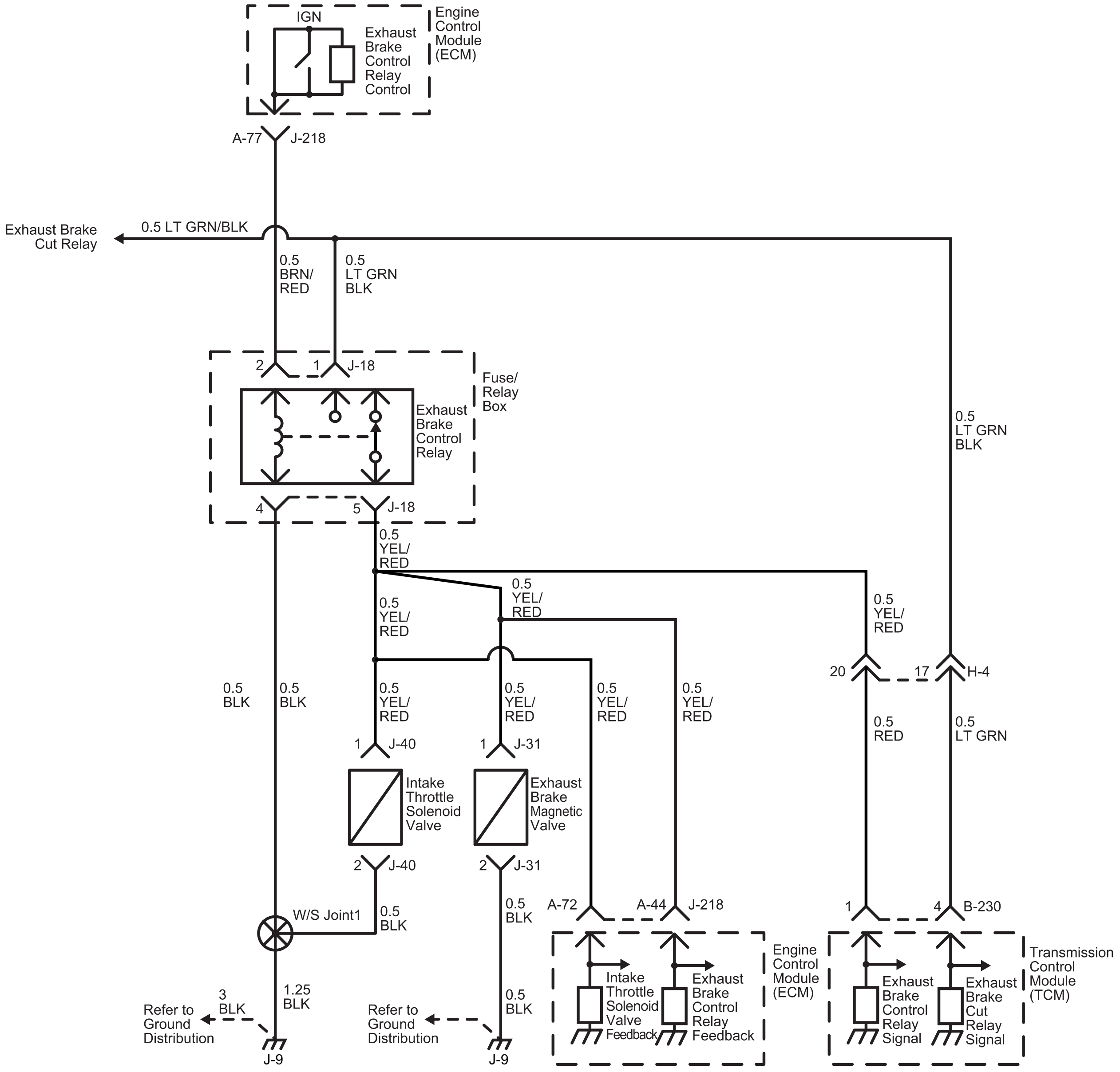
W/S = Weld Splice

LNW68DXF007601

CIRCUIT DIAGRAM

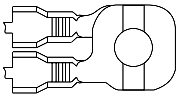
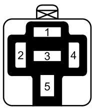
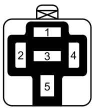
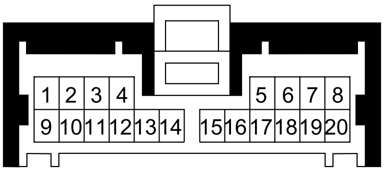
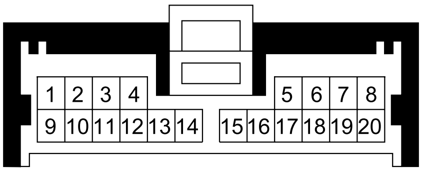
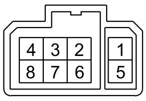
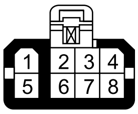
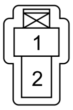


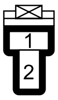
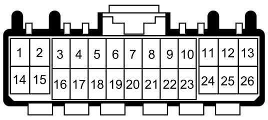
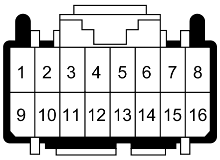
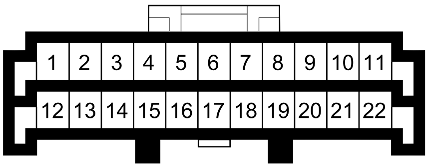
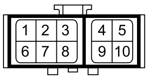
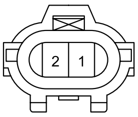
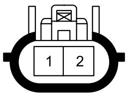
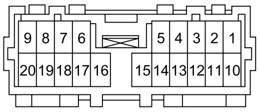
12,000lbs GVW

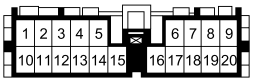
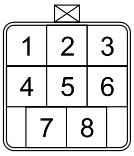
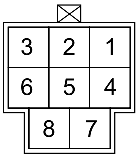
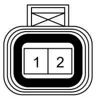
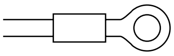
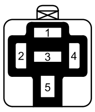
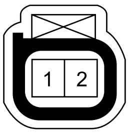
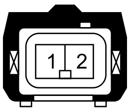


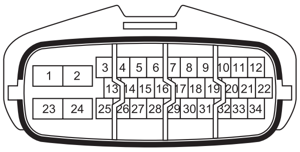
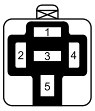
W/S = Weld Splice

LNW68DXF007801

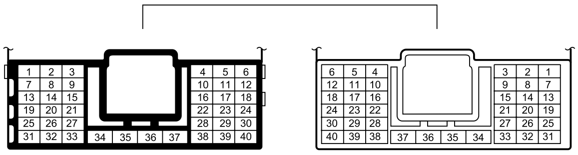
No.	Connector Face
B-7	 000-007 Ground; Headlight Bracket–RH
B-19 (Black)	 005-012 Charge Relay
B-38 (Black)	 005-012 Exhaust Brake Relay
B-51 (Gray)	 020-024 Instrument Panel Cluster (A)
B-52 (White)	 020-025 Instrument Panel Cluster (B)
B-69 (Black)	 008-028 Combination Switch (A)
B-69 (Blue)	 008-021 Combination Switch (A)
B-89 (White)	 002-011 Clutch Switch

No.	Connector Face
B-89 (White)	 002-012 Clutch Switch
B-229 (Gray)	 026-002 TCM
B-230 (Gray)	 016-034 TCM
B-380 (White)	 022-005 Joint Connection – M1
B-381 (White)	 010-015 Joint Connection – M5
E-86 (White)	 002-005 Thermo Ceramic Heater
E-86 (White)	 002-006 Thermo Ceramic Heater
H-4 (White)	 020-002 Body H. – Frame H.

No.	Connector Face
H-4 (White)	 020-001 Body H. – Frame H.
H-105 (Black)	 008-060 Frame H. – Engine H.
H-105 (Black)	 008-061 Frame H. – Engine H.
J-1 (Green)	 002-001 Generator
J-9	 000-012 Ground; Frame–LH (Center)
J-18 (Black)	 005-012 Exhaust Brake Control Relay
J-31 (Black)	 002-008 Exhaust Brake Magnetic Valve
J-40 (Brown)	 002-024 VSV Intake Throttle

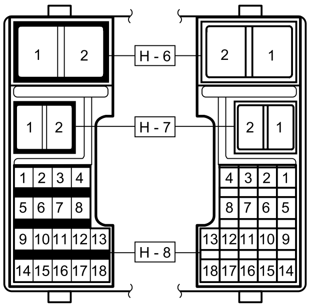
No.	Connector Face
J-177 (White)	 034-001 Electronic Hydraulic Control Unit (EHCU) [ABS Module]
J-210 (Black)	 005-012 Exhaust Brake Cut Relay

H-5 Body H. – Frame H. (Gray)



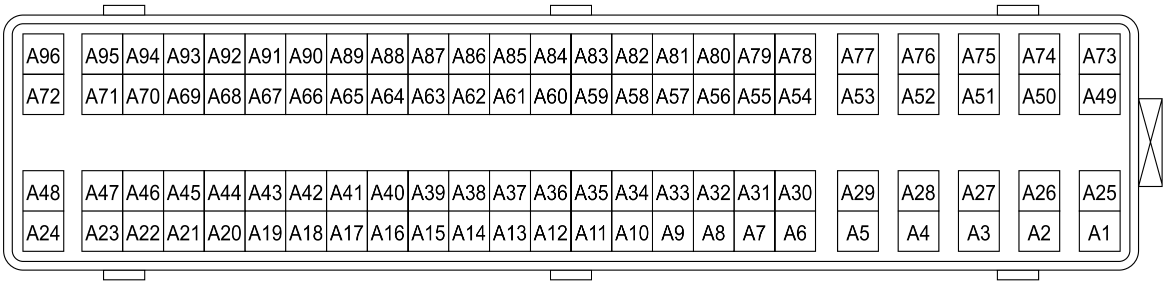
LNW38ASH018701

H-6, H-8 Body H. – Frame H. (Gray)



LNW38ASH018801

J-218 ECM-2 (Black)



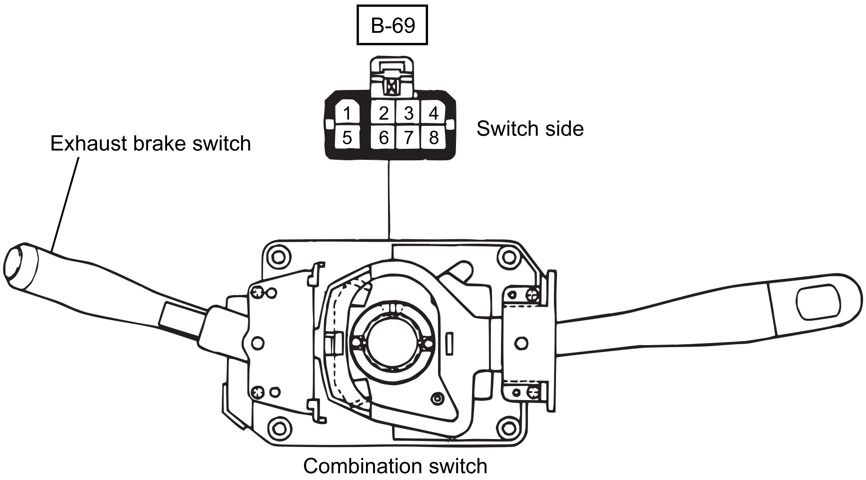
LNW48ASF000101

EXHAUST BRAKE SWITCH

Inspect

Check the continuity between the terminals of the exhaust brake switch.

Repair or replace the switch when result of inspection is found abnormal.



SW position \ Terminal No.	2	5
ON	○—	—○
OFF		

LNW48AMF001201

INSTALL OR CONNECT

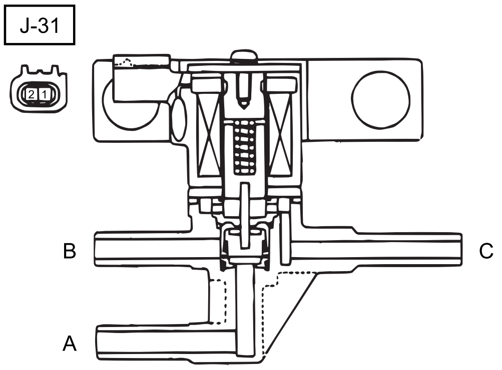
Refer to “Headlight and Cornering Light” in this section.

EXHAUST BRAKE MAGNETIC VALVE

Inspect

Connect the magnetic valve connector terminal No. 1 to the battery (+) terminal and terminal No. 2 to the (–) terminal and then check the continuity among each port.

Repair or replace the magnetic valve when the result of inspection is found abnormal.



Port Operation	A	B	C
When battery voltage applied	○—	○	
When battery voltage not applied		○—	○

LNW48AMH000201

Headlight and Cornering Light

General Description

The circuit consists of headlight, Cornering light, ignition switch, Combination switch (Lighting switch, dimmer passing switch, cornering light switch), high beam indicator light, relay and D.R.L unit.

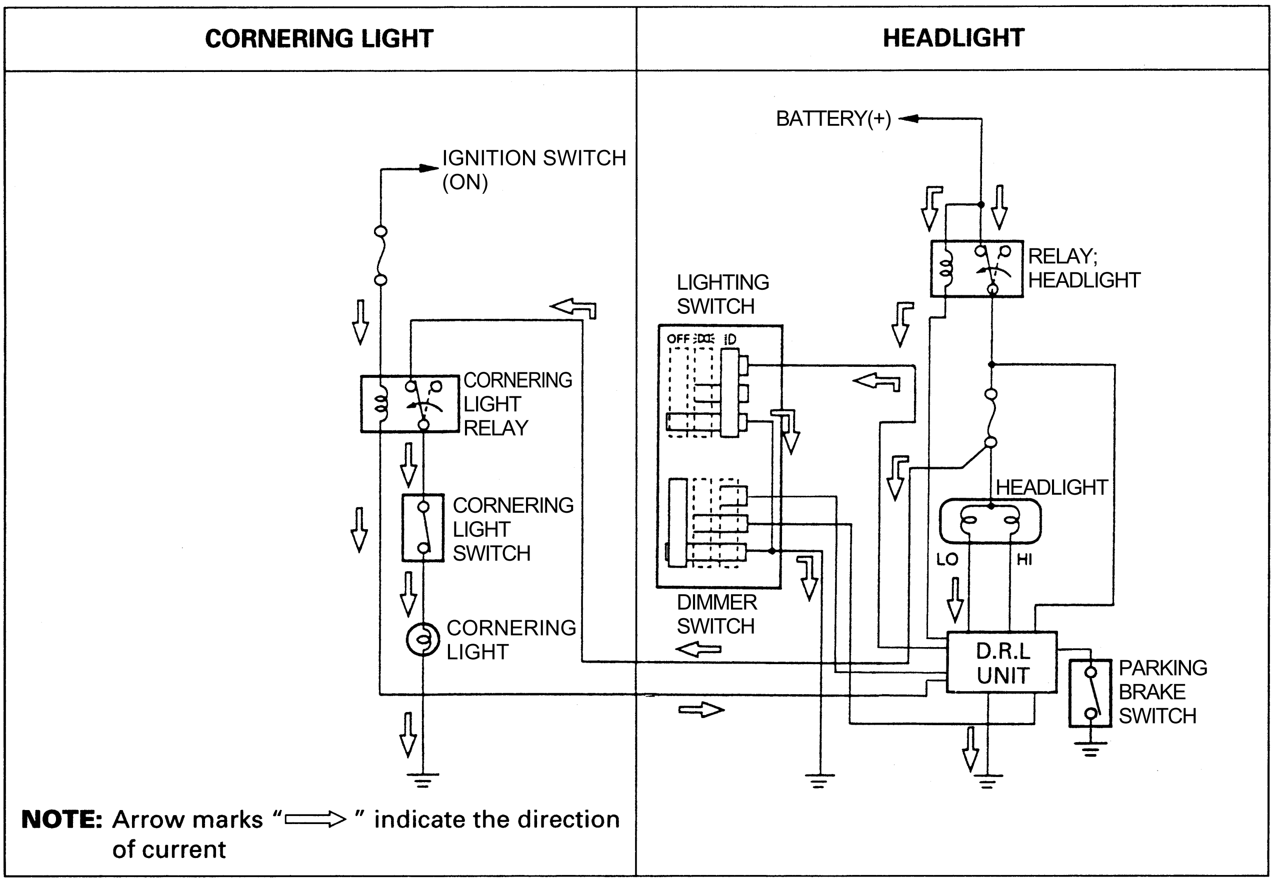
With the engine running, and the parking brake released, the D.R.L function lights up the headlight automatically.

When the lighting switch is turned on by setting it at headlight position, the D.R.L function is cancelled. The optical axis of the headlight can be turned up or down by operating the dimmer switch while headlight switch on.

The passing switch is independent of the lighting switch, and the optical axis of the passing light can be turned up only while the switch lever is pulled up and held in this state.

When the headlight is on, turn the turn-signal switch left or right, and then the cornering switch built in the combination switch turns on, followed by the cornering light turning on.

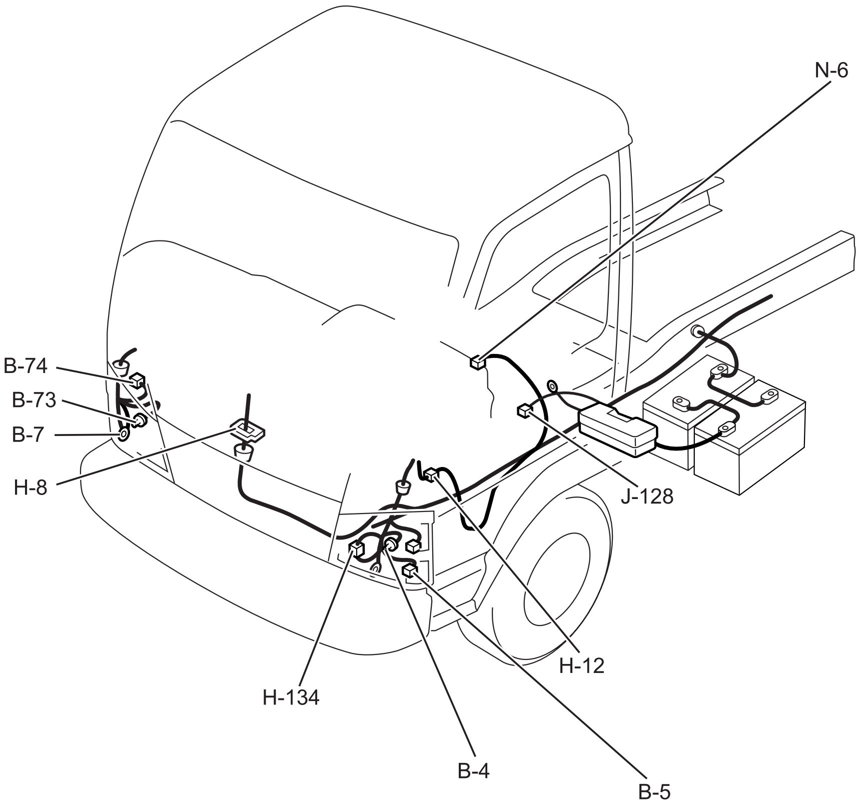
LIGHTING CIRCUIT



NOTE: Arrow marks "⟹" indicate the direction of current

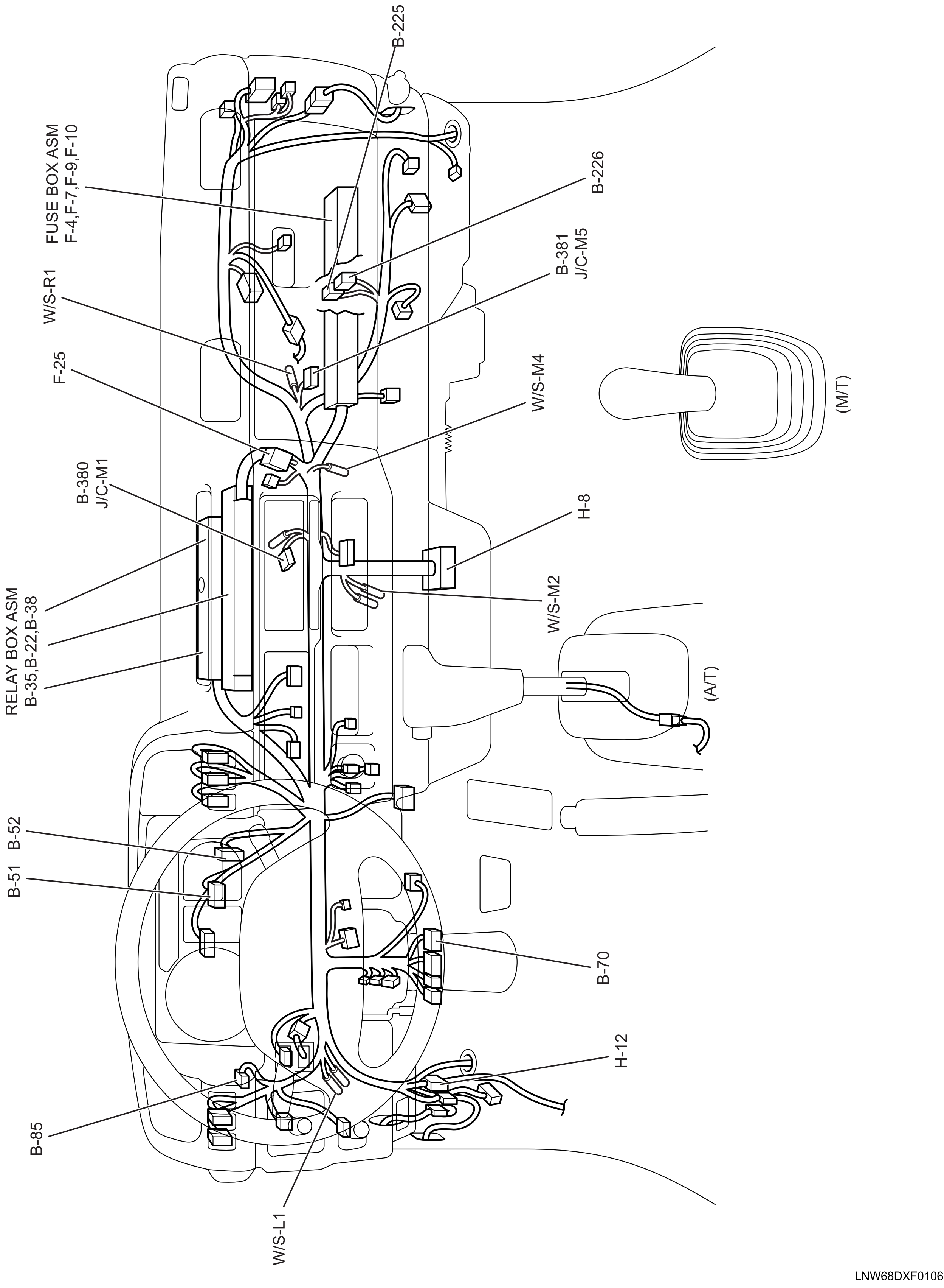
LNW48ALF005001

PARTS LOCATION (1)



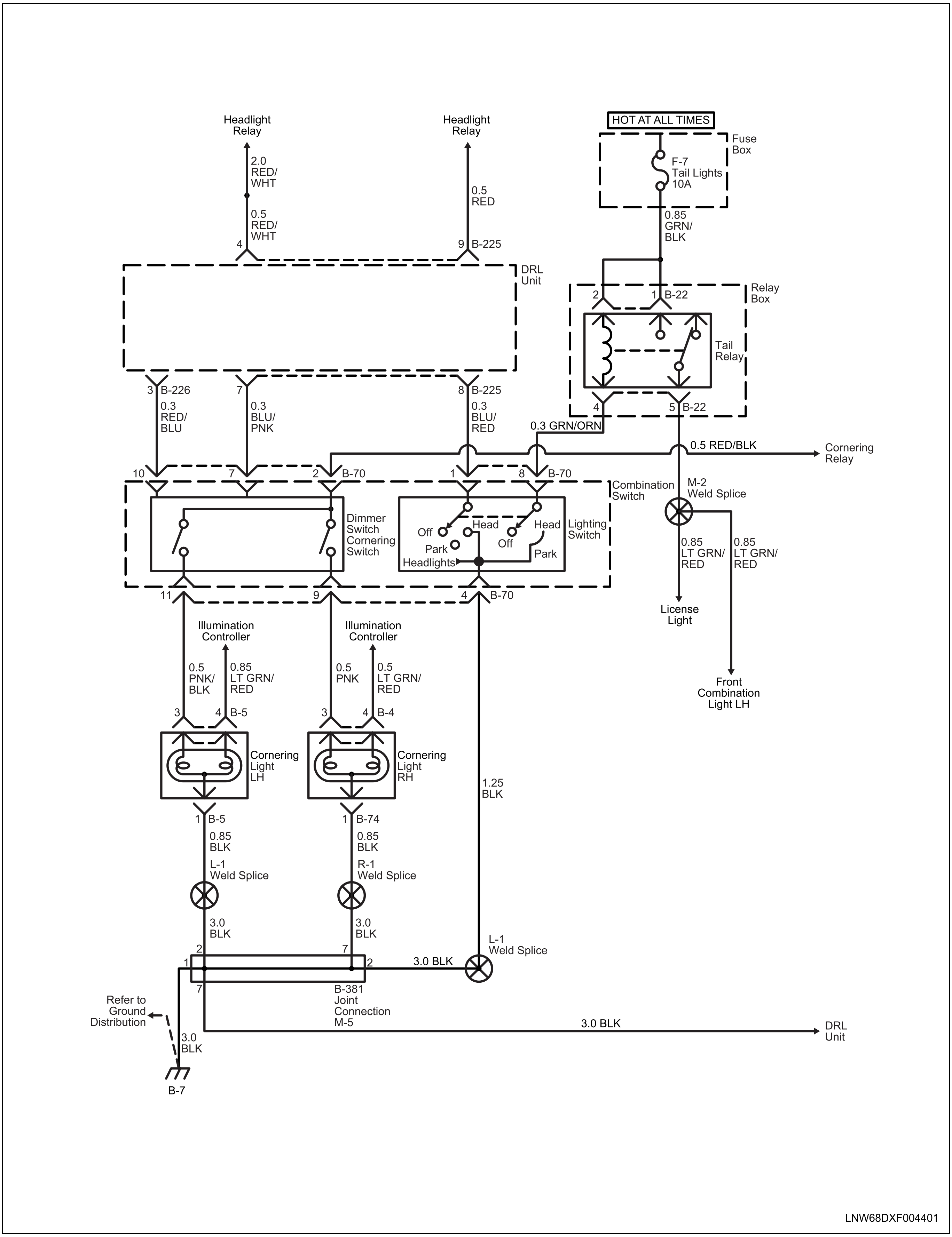
LNW58ALF000301

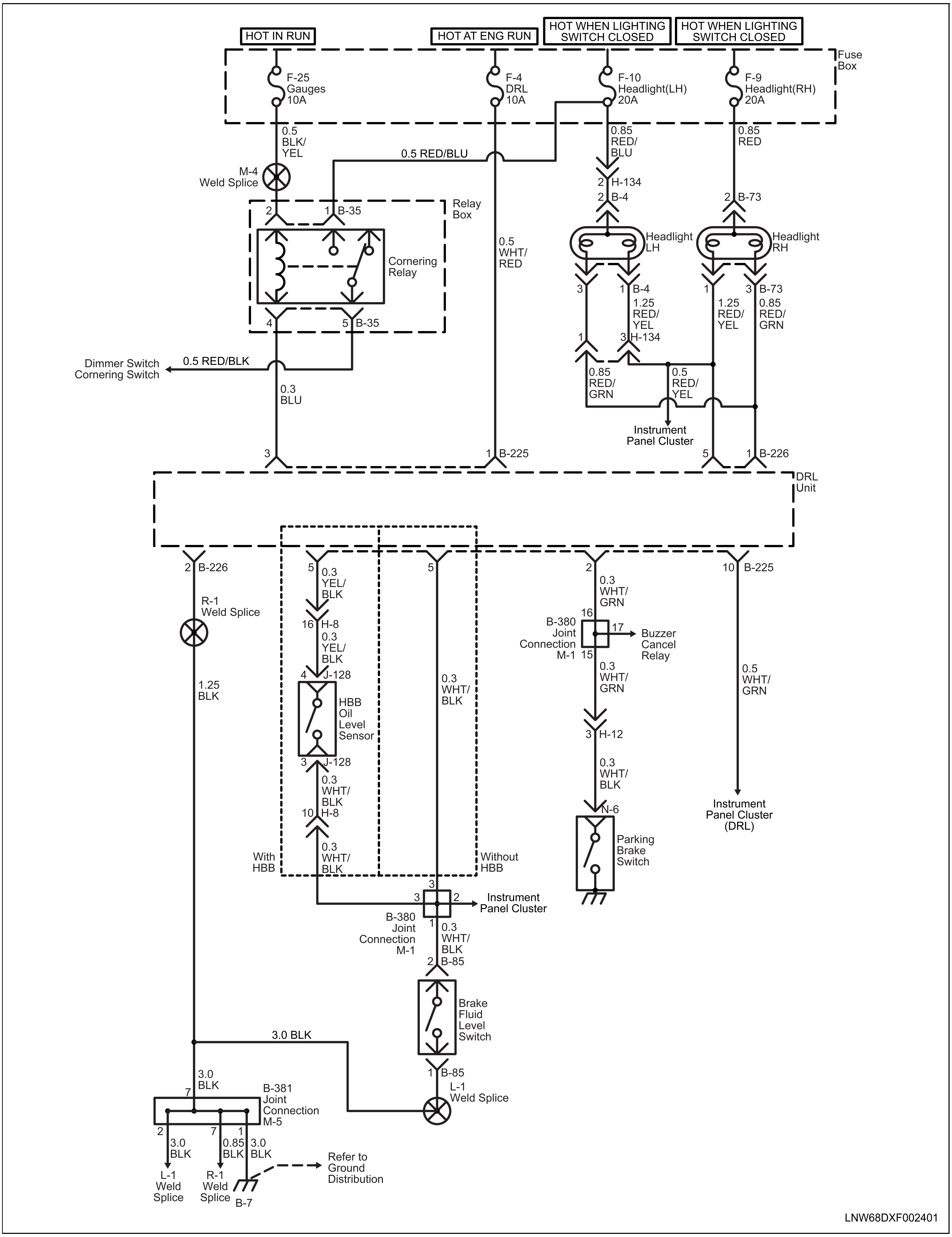
PARTS LOCATION (2)

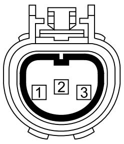
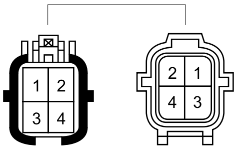
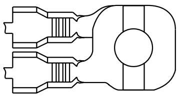
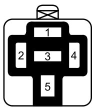
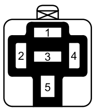
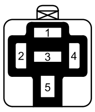
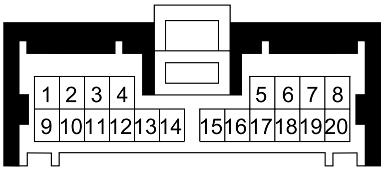
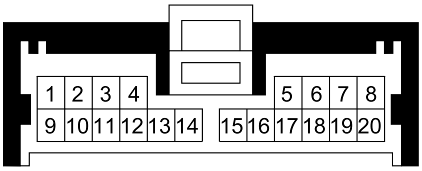


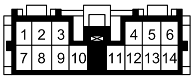
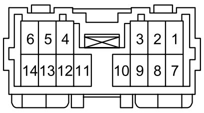
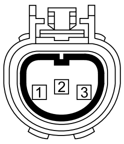
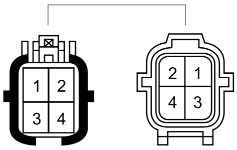
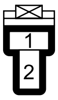
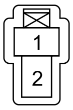
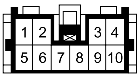
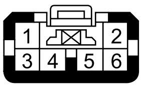
LNW68DXF010601

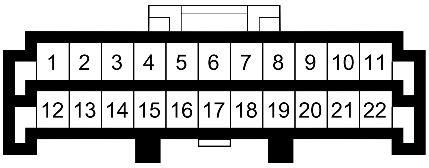
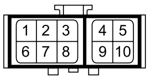
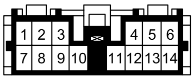
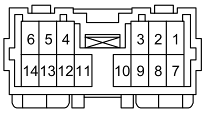
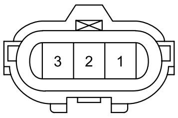
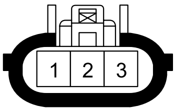
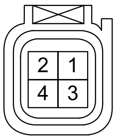
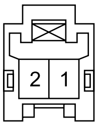
CIRCUIT DIAGRAM

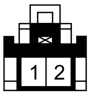



HOT IN RUN
HOT AT ENG RUN
HOT WHEN LIGHTING SWITCH CLOSED
HOT WHEN LIGHTING SWITCH CLOSED
Fuse Box
F-25 Gauges 10A
F-4 DRL 10A
F-10 Headlight(LH) 20A
F-9 Headlight(RH) 20A
0.5 BLK/ YEL
0.5 RED/BLU
0.85 RED/ BLU
0.85 RED
M-4 Weld Splice
2 H-134
2 B-4
2 B-73
2 1 B-35
Relay Box
Cornering Relay
0.5 WHT/ RED
Headlight LH
Headlight RH
3 1 B-4
1 3 B-73
1.25 RED/ YEL
1.25 RED/ YEL
0.85 RED/ GRN
4 5 B-35
1 3 H-134
Dimmer Switch Cornering Switch
0.5 RED/BLK
0.3 BLU
0.85 RED/ GRN
0.5 RED/ YEL
Instrument Panel Cluster
3
1 B-225
5 1 B-226
DRL Unit
2 B-226
5
5
2
10 B-225
R-1 Weld Splice
0.3 YEL/ BLK
16 H-8
0.3 YEL/ BLK
4 J-128
HBB Oil Level Sensor
3 J-128
0.3 WHT/ BLK
10 H-8
0.3 WHT/ BLK
With HBB
Without HBB
0.3 WHT/ BLK
1.25 BLK
0.3 WHT/ GRN
16
B-380 Joint Connection M-1
17
15
Buzzer Cancel Relay
0.3 WHT/ GRN
3 H-12
0.3 WHT/ BLK
N-6
Parking Brake Switch
0.5 WHT/ GRN
Instrument Panel Cluster (DRL)
3
3 2
Instrument Panel Cluster
B-380 Joint Connection M-1
1
0.3 WHT/ BLK
2 B-85
Brake Fluid Level Switch
1 B-85
L-1 Weld Splice
3.0 BLK
3.0 BLK
7
B-381 Joint Connection M-5
2 7 1
3.0 BLK
0.85 BLK
3.0 BLK
L-1 Weld Splice
R-1 Weld Splice
B-7
Refer to Ground Distribution
LNW68DXF002401

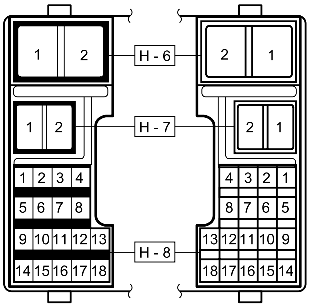
No.	Connector Face
B-4 (Black)	 003-031 Headlight (LH)
B-5 (Gray)	 004-016 Front Combination Light (LH)
B-7	 000-007 Ground; Headlight Bracket–RH
B-22 (Black)	 005-012 Tail Relay
B-35 (Black)	 005-012 Cornering Relay
B-38 (Black)	 005-012 Exhaust Brake Relay
B-51 (Gray)	 020-024 Instrument Panel Cluster (A)
B-52 (White)	 020-025 Instrument Panel Cluster (B)

No.	Connector Face
B-70 (Black)	 014-003 Combination Switch (B)
B-70 (Black)	 014-004 Combination Switch (B)
B-73 (Black)	 003-031 Headlight (RH)
B-74 (Gray)	 004-016 Combination Light (RH)
B-85 (White)	 002-012 Brake Fluid Level Switch
B-85 (White)	 002-011 Brake Fluid Level Switch
B-225 (Black)	 010-002 D.R.L Unit (A)
B-226 (White)	 006-005 D.R.L Unit (B)

No.	Connector Face
B-380 (White)	 022-005 Joint Connector–M1
B-381 (White)	 010-015 Joint Connection – M5
H-12 (White)	 014-003 Body H. – Floor H. (RH)
H-12 (White)	 014-004 Body H. – Floor H. (RH)
H-134 (Gray)	 003-003 EXT Headlight LH. – Body
H-134 (Gray)	 003-030 EXT Headlight LH. – Body
J-128 (Black)	 004-002 HBB Oil Level Sensor
N-6 (Black)	 002-021 Parking Brake Switch

No.	Connector Face
N-6 (Black)	 002-022 Parking Brake Switch

H-8 Body H. – Frame H. (Gray)



LNW38ASH018801

Diagnosis

QUICK CHART FOR CHECK POINT

1. HEADLIGHT

Check Point	Fuse		Headlight Relay	Lighting Switch	Dimmer Passing Switch	D.R.L Unit	Headlight Bulb		Cable Harness
Trouble Mode	F-9 (20A)	F-10 (20A)					LH	RH	
1-1. Both Headlights inoperative			○ (1)	○ (3)		○ (4)			○ (2)
1-2. Headlight on the left (or right) side inoperative	○ (1)	○ ((1))					○ (2)	○ (2)	○ (3)
1-3. Headlight in low-beam inoperative						○ (1)			○ (2)
1-4. Headlight in high-beam inoperative						○ (1)			○ (2)

NOTE: Figure in parenthesis "( )" indicates the order of inspection.

2. D.R.L (Daytime running light)

Check Point	Fuse		Headlight Relay	Lighting and Dimmer Switch	Parking Brake Switch	D.R.L Unit	Headlight Bulb		CHG Warning Light	Cable Harness
Trouble Mode	F-9 (20A)	F-10 (20A)					LH	RH		
2-1. D.R.L inoperative	○ (1)	○ ((1))	○ (3)	○ (4)	○ (6)	○ (8)	○ (2)	○ (2)	○ (7)	○ (5)
2-2. D.R.L remain on when the parking lever is pulled					○ (1)	○ (2)				○ (3)
2-3. D.R.L remain on when the lighting switch turned on				○ (1)		○ (3)				○ (2)

NOTE: Figure in parenthesis "( )" indicates the order of inspection.

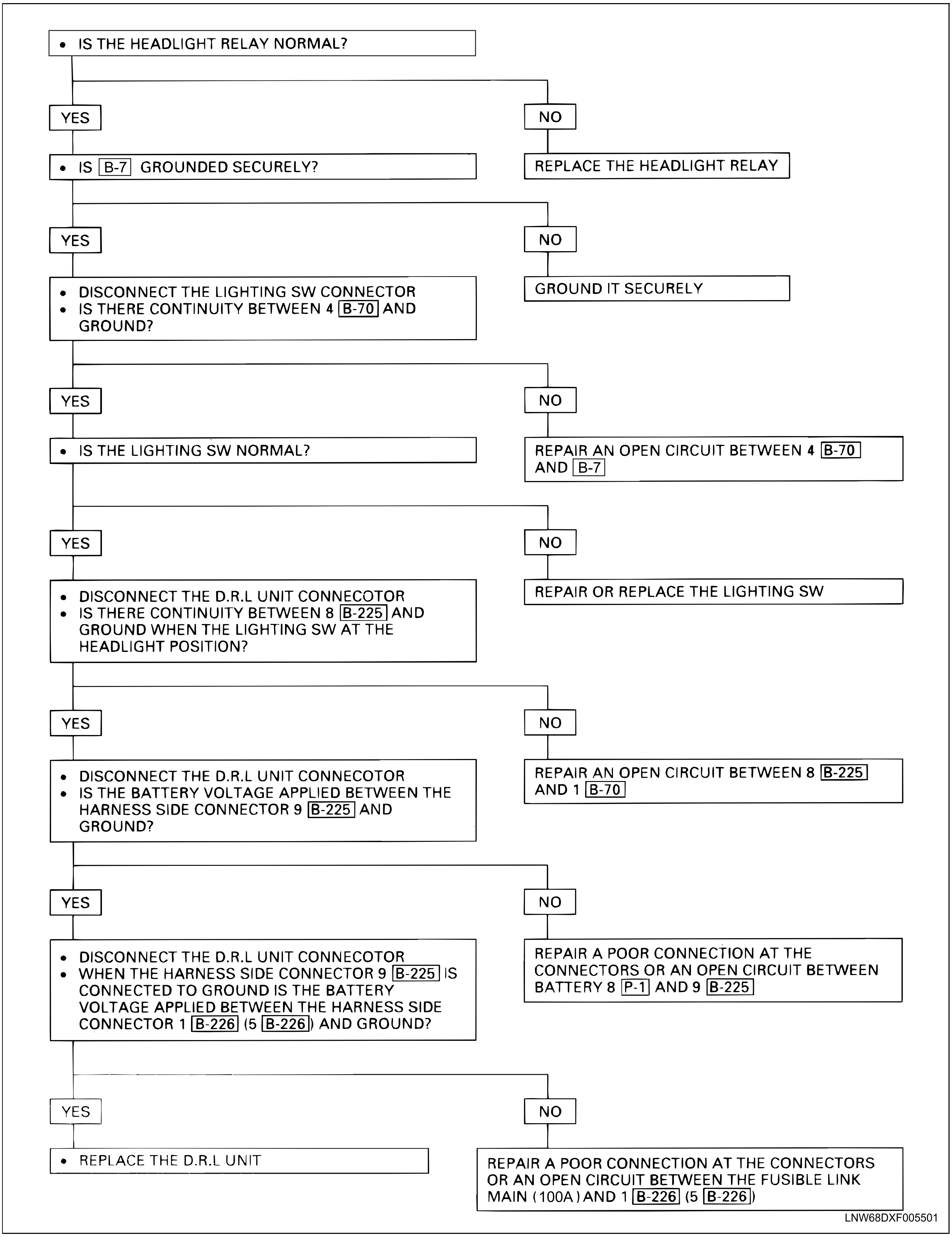
3. CORNERING LIGHT

Check Point	Fuse		Cornering Light Switch	Cornering Light Bulb	Cornering Light Relay	Cable Harness	D.R.L Unit
Trouble Mode	F-10 (20A)	F-25 (10A)					
3-1. Both cornering lights inoperative	○ (2)	○ (1)	○ (5)		○ (3)	○ (4)	○ (6)
3-2. Cornering light on the left (or right) side inoperative			○ (2)	○ (1)		○ (3)	
3-3. Cornering light remains on even when steering wheel is in the straight ahead position.			○ (1)				

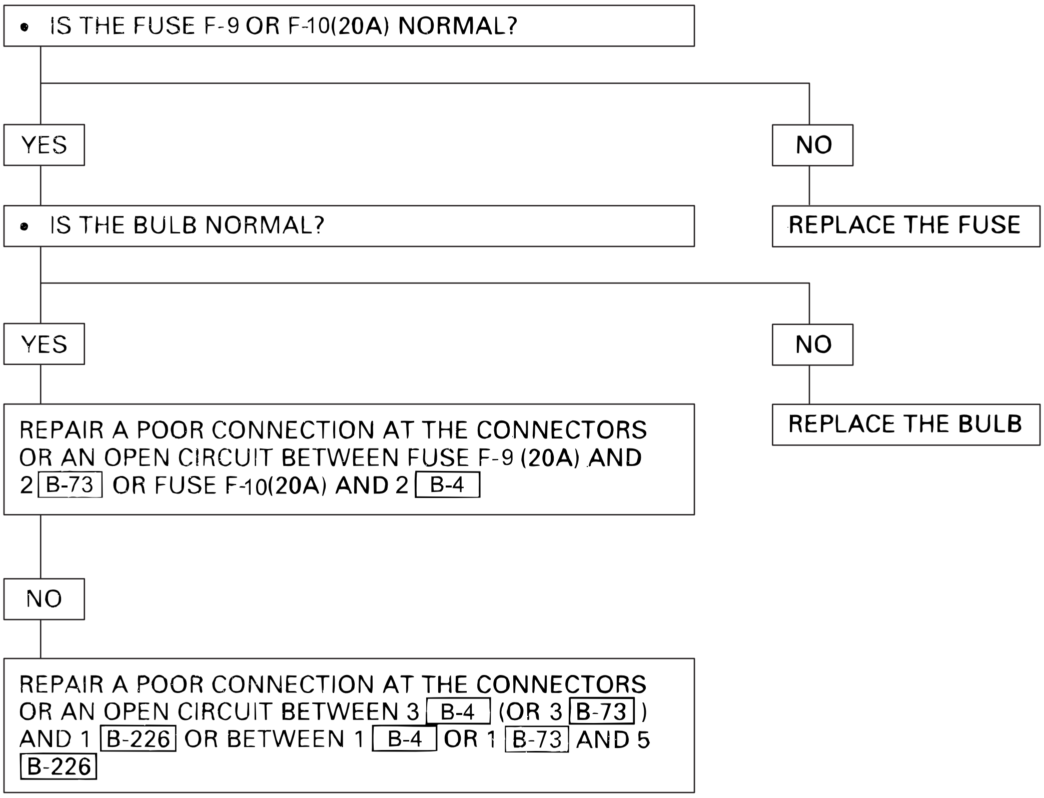
NOTE: Figure in parenthesis "( )" indicates the order of inspection.

1. Headlight

1-1. BOTH HEADLIGHTS INOPERATIVE

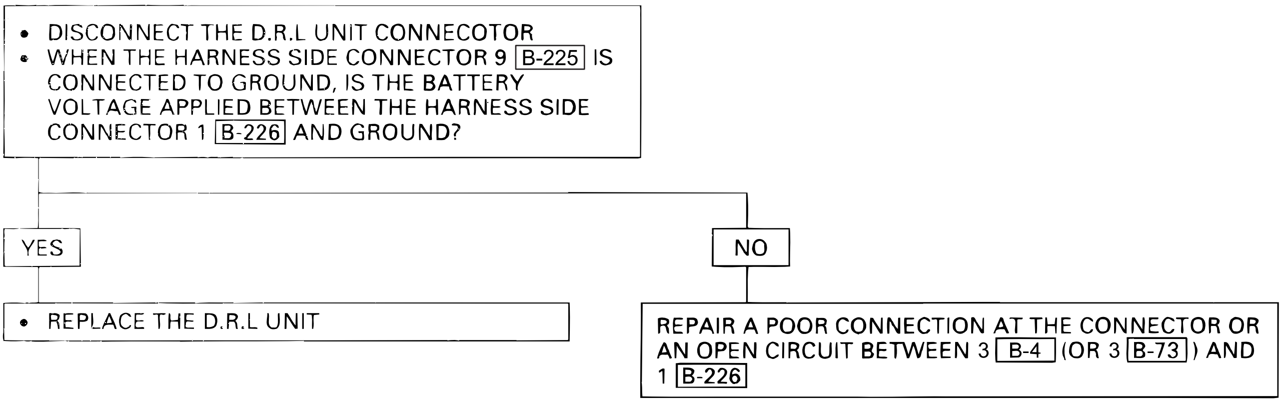


1-2. HEADLIGHT ON THE LEFT (OR RIGHT) SIDE INOPERATIVE



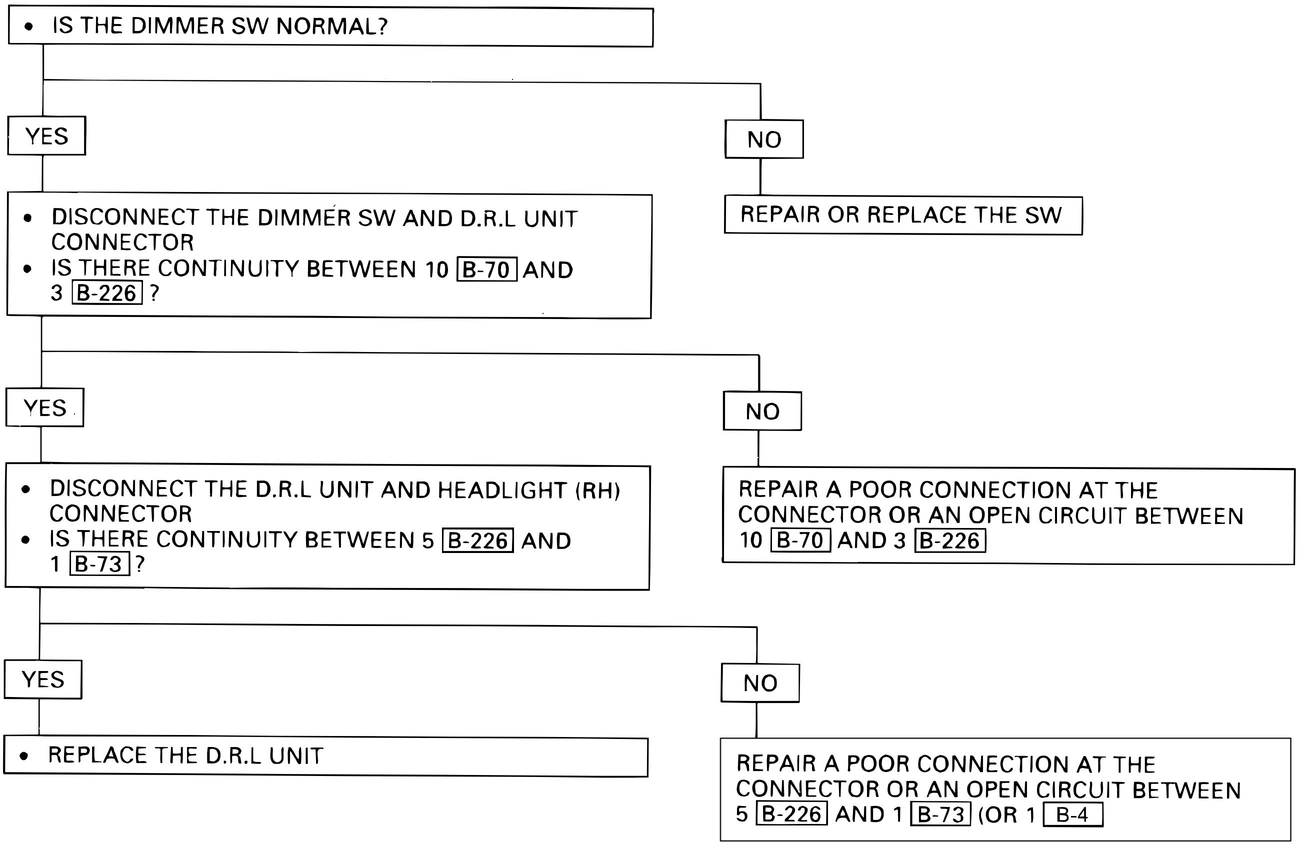
LNW68DLF000401

1-3. HEADLIGHTS IN LOW-BEAM INOPERATIVE



LNW68DSF000101

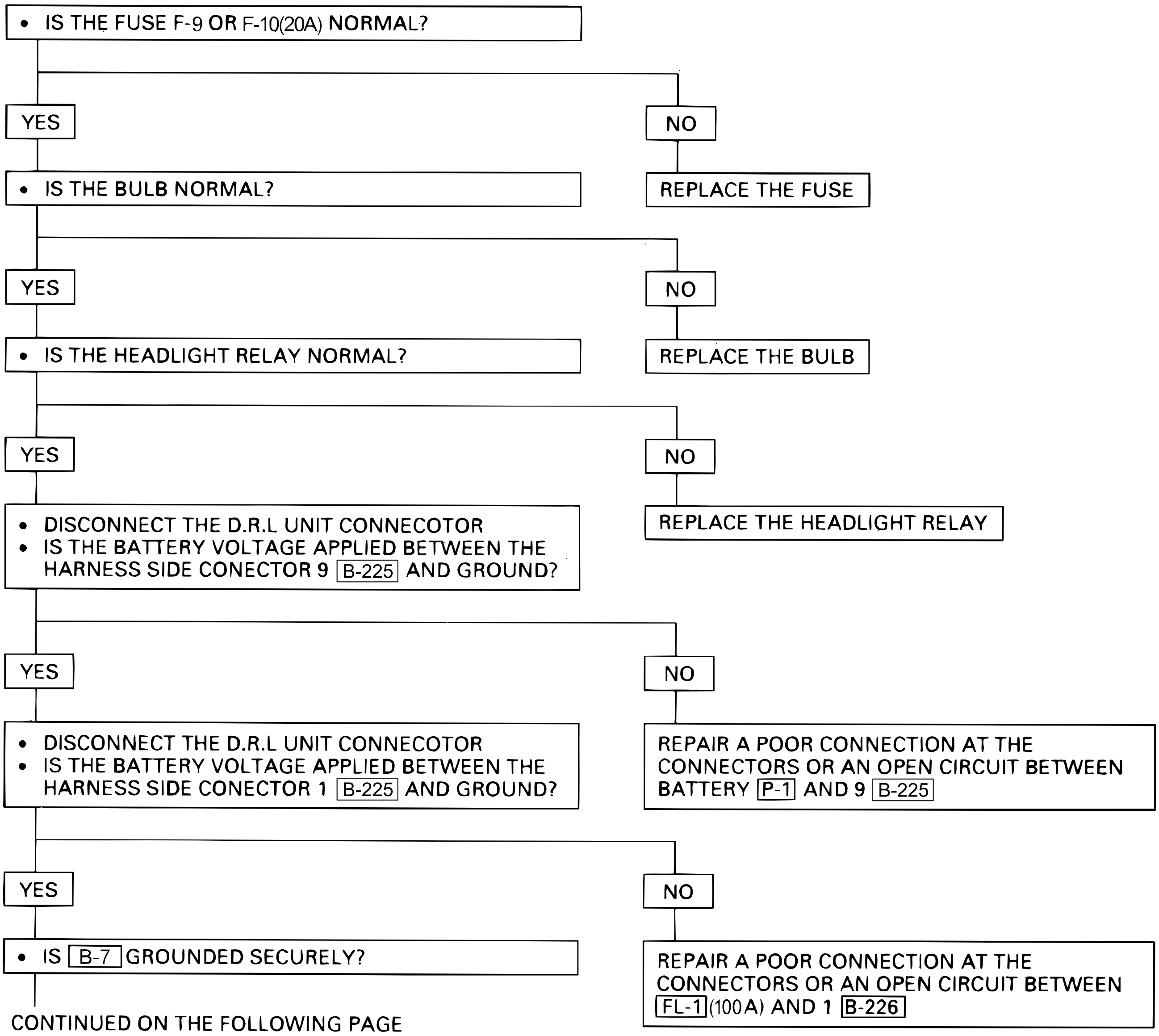
1-4. HEADLIGHT IN HIGH-BEAM INOPERATIVE



LNW68DLF000501

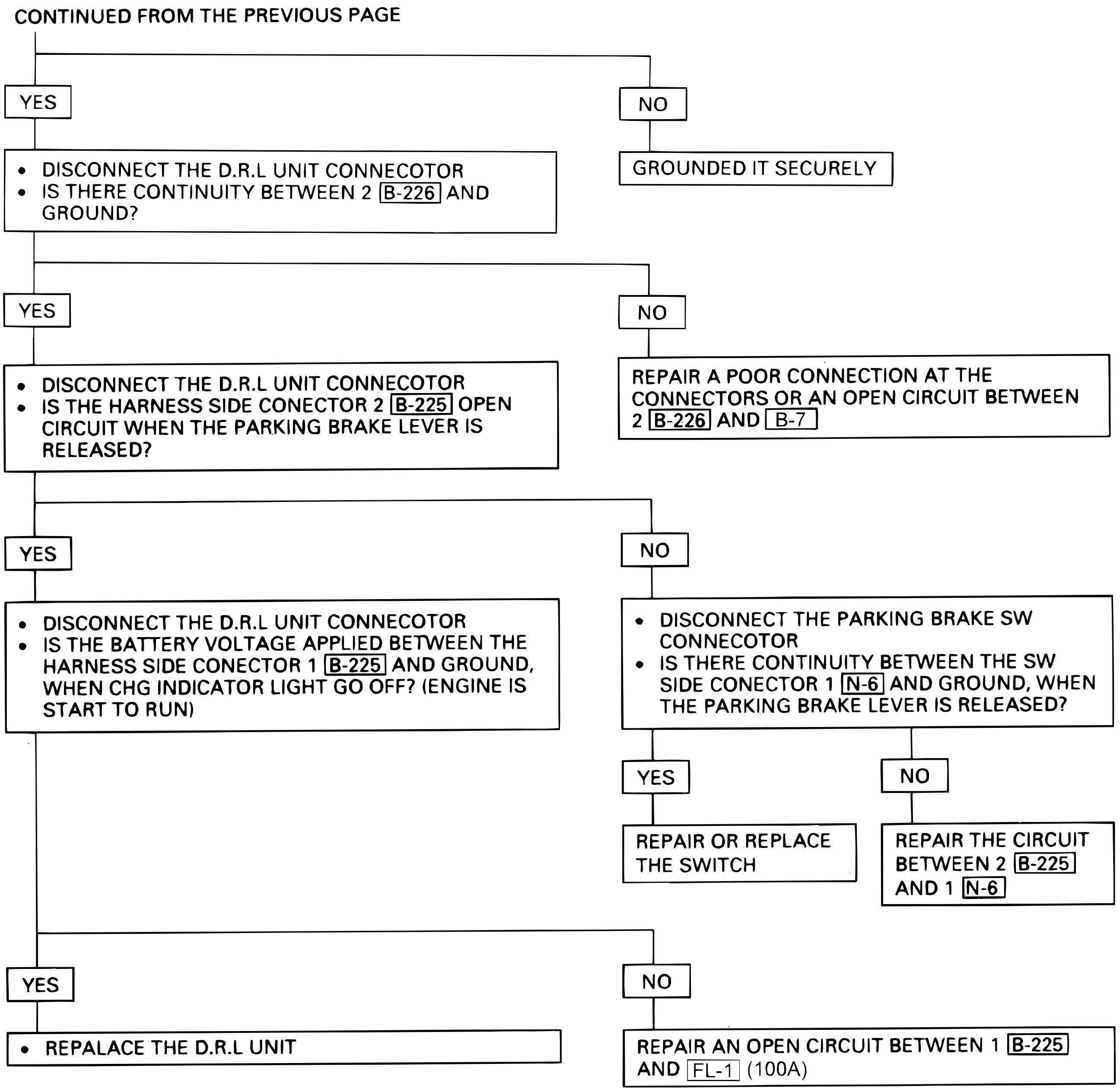
2. D.R.L (Day Time Running Light)

2-1. D.R.L INOPERATIVE



CONTINUED ON THE FOLLOWING PAGE

LNW68DXF005601



CONTINUED FROM THE PREVIOUS PAGE

YES

- DISCONNECT THE D.R.L UNIT CONNECOTOR
- IS THERE CONTINUITY BETWEEN 2 B-226 AND GROUND?

NO

GROUNDED IT SECURELY

YES

- DISCONNECT THE D.R.L UNIT CONNECOTOR
- IS THE HARNESS SIDE CONECTOR 2 B-225 OPEN CIRCUIT WHEN THE PARKING BRAKE LEVER IS RELEASED?

NO

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN 2 B-226 AND B-7

YES

- DISCONNECT THE D.R.L UNIT CONNECOTOR
- IS THE BATTERY VOLTAGE APPLIED BETWEEN THE HARNESS SIDE CONECTOR 1 B-225 AND GROUND, WHEN CHG INDICATOR LIGHT GO OFF? (ENGINE IS START TO RUN)

NO

- DISCONNECT THE PARKING BRAKE SW CONNECOTOR
- IS THERE CONTINUITY BETWEEN THE SW SIDE CONECTOR 1 N-6 AND GROUND, WHEN THE PARKING BRAKE LEVER IS RELEASED?

YES

REPAIR OR REPLACE THE SWITCH

NO

REPAIR THE CIRCUIT BETWEEN 2 B-225 AND 1 N-6

YES

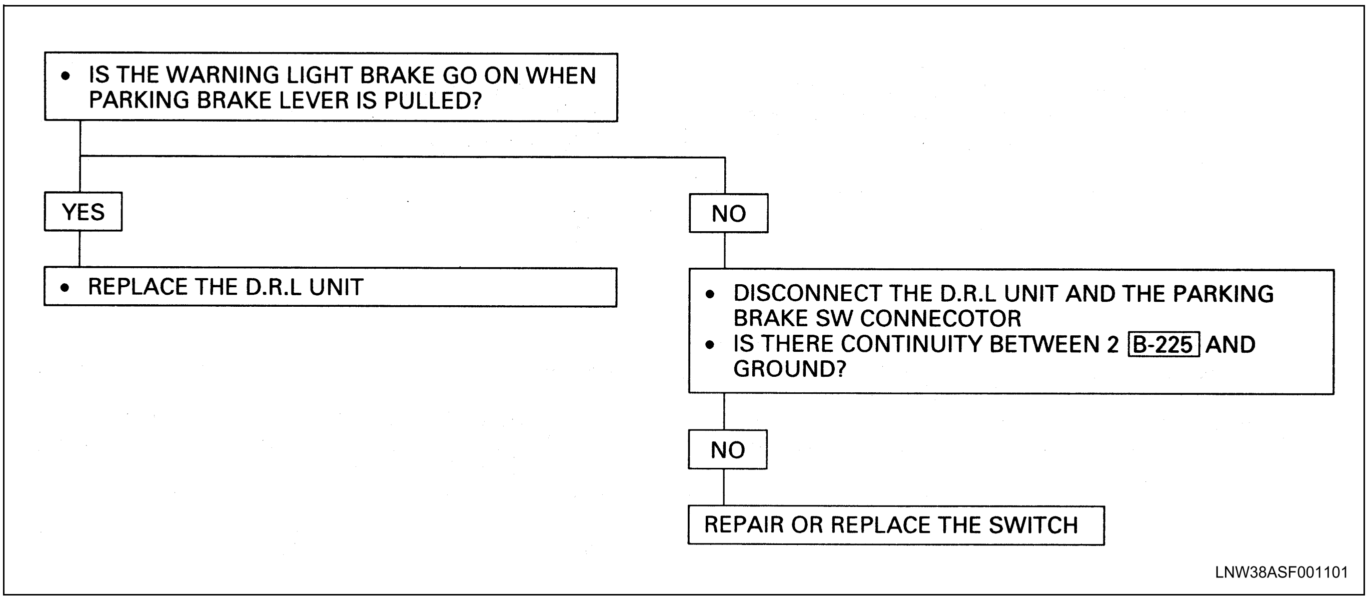
- REPALACE THE D.R.L UNIT

NO

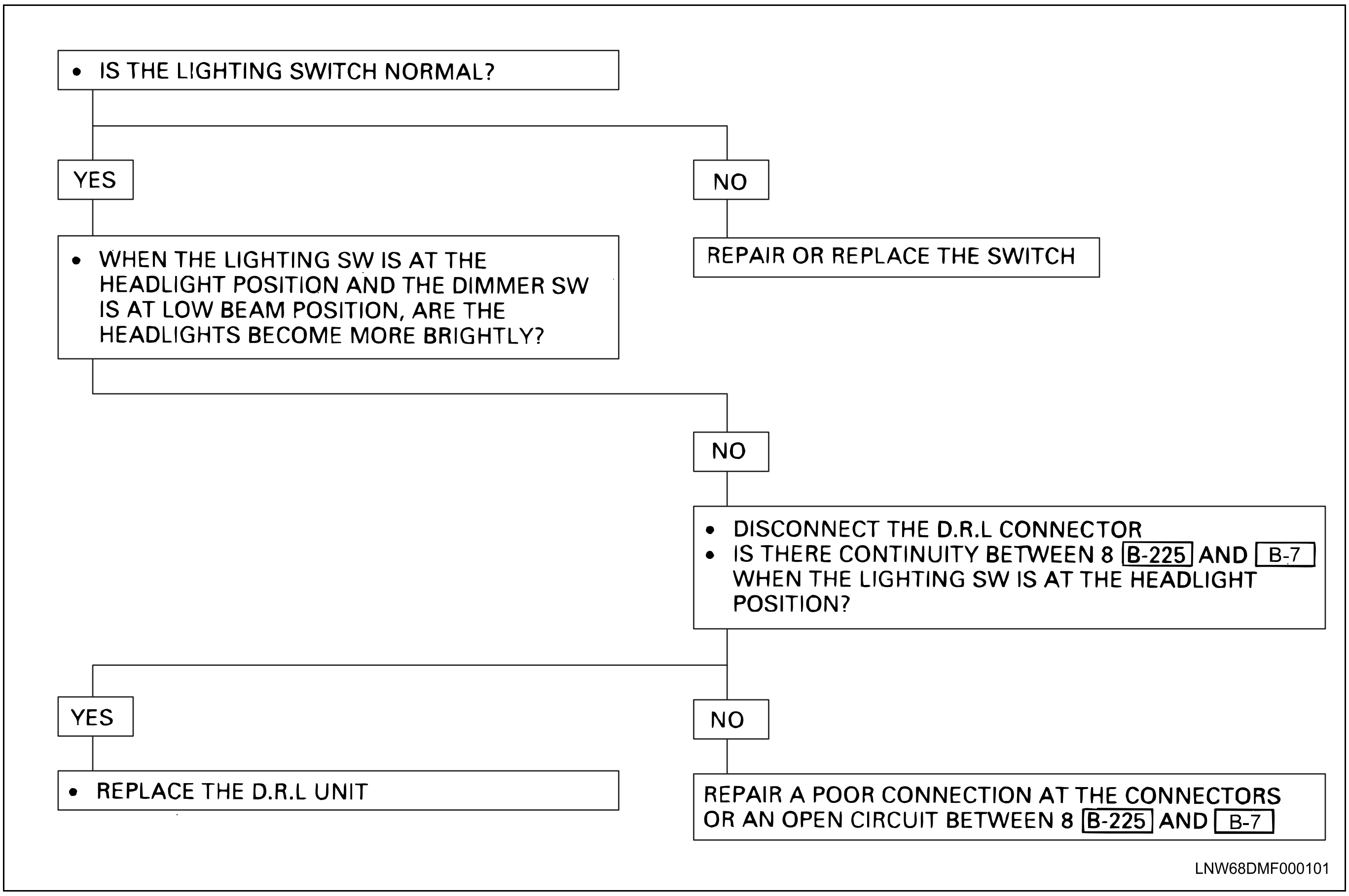
REPAIR AN OPEN CIRCUIT BETWEEN 1 B-225 AND FL-1 (100A)

LNW68DXF005701

2-2. D.R.L REMAIN ON WHEN THE PARKING LEVER IS PULLED

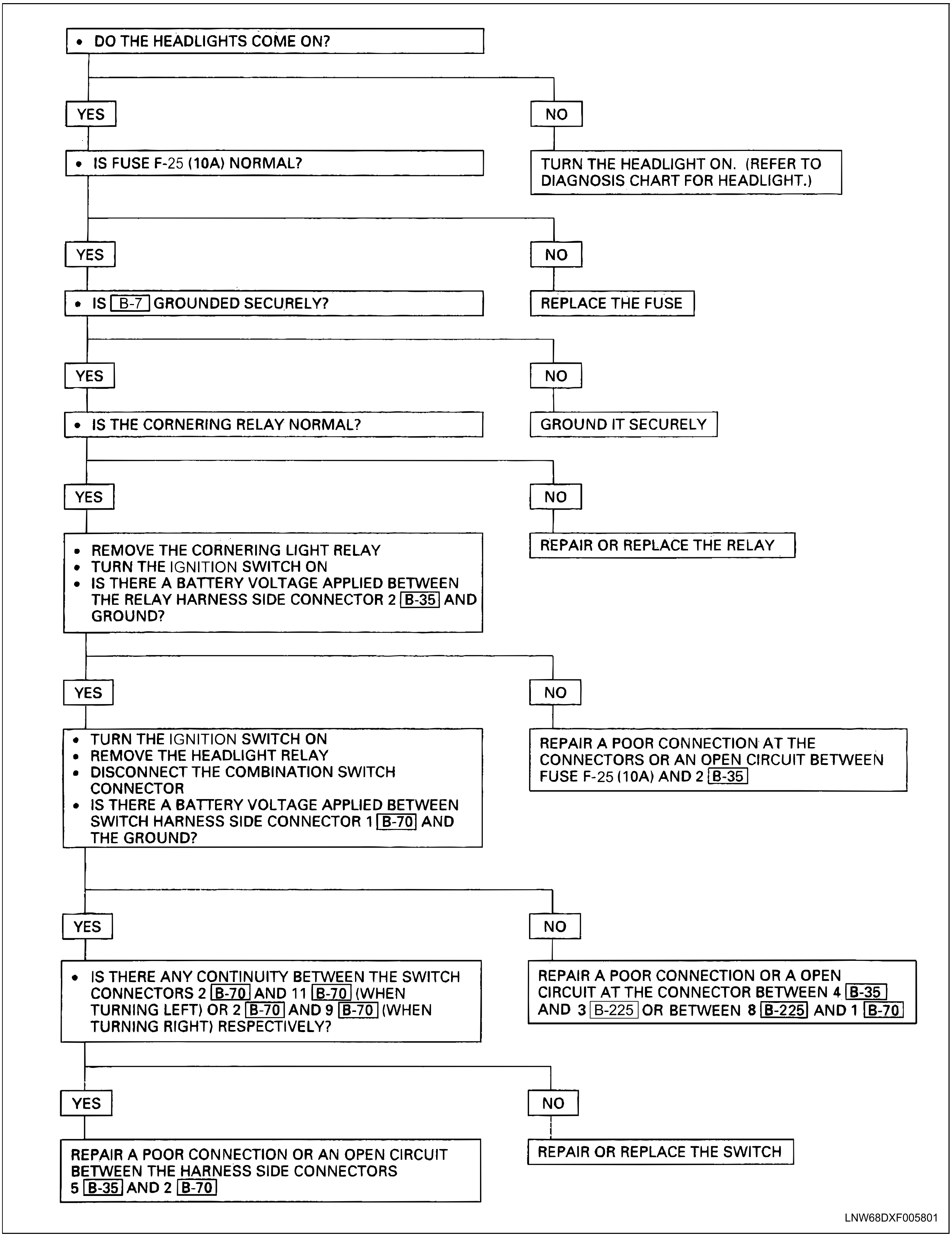


2-3. D.R.L REMAIN ON WHEN THE LIGHTING SWITCH IS TURNED ON



3. Cornering Light

3-1. BOTH CORNERING LIGHTS INOPERATIVE



- DO THE HEADLIGHTS COME ON?

YES

- IS FUSE F-25 (10A) NORMAL?

NO

TURN THE HEADLIGHT ON. (REFER TO DIAGNOSIS CHART FOR HEADLIGHT.)

YES

- IS B-7 GROUNDED SECURELY?

NO

REPLACE THE FUSE

YES

- IS THE CORNERING RELAY NORMAL?

NO

GROUND IT SECURELY

YES

- REMOVE THE CORNERING LIGHT RELAY
- TURN THE IGNITION SWITCH ON
- IS THERE A BATTERY VOLTAGE APPLIED BETWEEN THE RELAY HARNESS SIDE CONNECTOR 2 B-35 AND GROUND?

NO

REPAIR OR REPLACE THE RELAY

YES

- TURN THE IGNITION SWITCH ON
- REMOVE THE HEADLIGHT RELAY
- DISCONNECT THE COMBINATION SWITCH CONNECTOR
- IS THERE A BATTERY VOLTAGE APPLIED BETWEEN SWITCH HARNESS SIDE CONNECTOR 1 B-70 AND THE GROUND?

NO

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN FUSE F-25 (10A) AND 2 B-35

YES

- IS THERE ANY CONTINUITY BETWEEN THE SWITCH CONNECTORS 2 B-70 AND 11 B-70 (WHEN TURNING LEFT) OR 2 B-70 AND 9 B-70 (WHEN TURNING RIGHT) RESPECTIVELY?

NO

REPAIR A POOR CONNECTION OR A OPEN CIRCUIT AT THE CONNECTOR BETWEEN 4 B-35 AND 3 B-225 OR BETWEEN 8 B-225 AND 1 B-70

YES

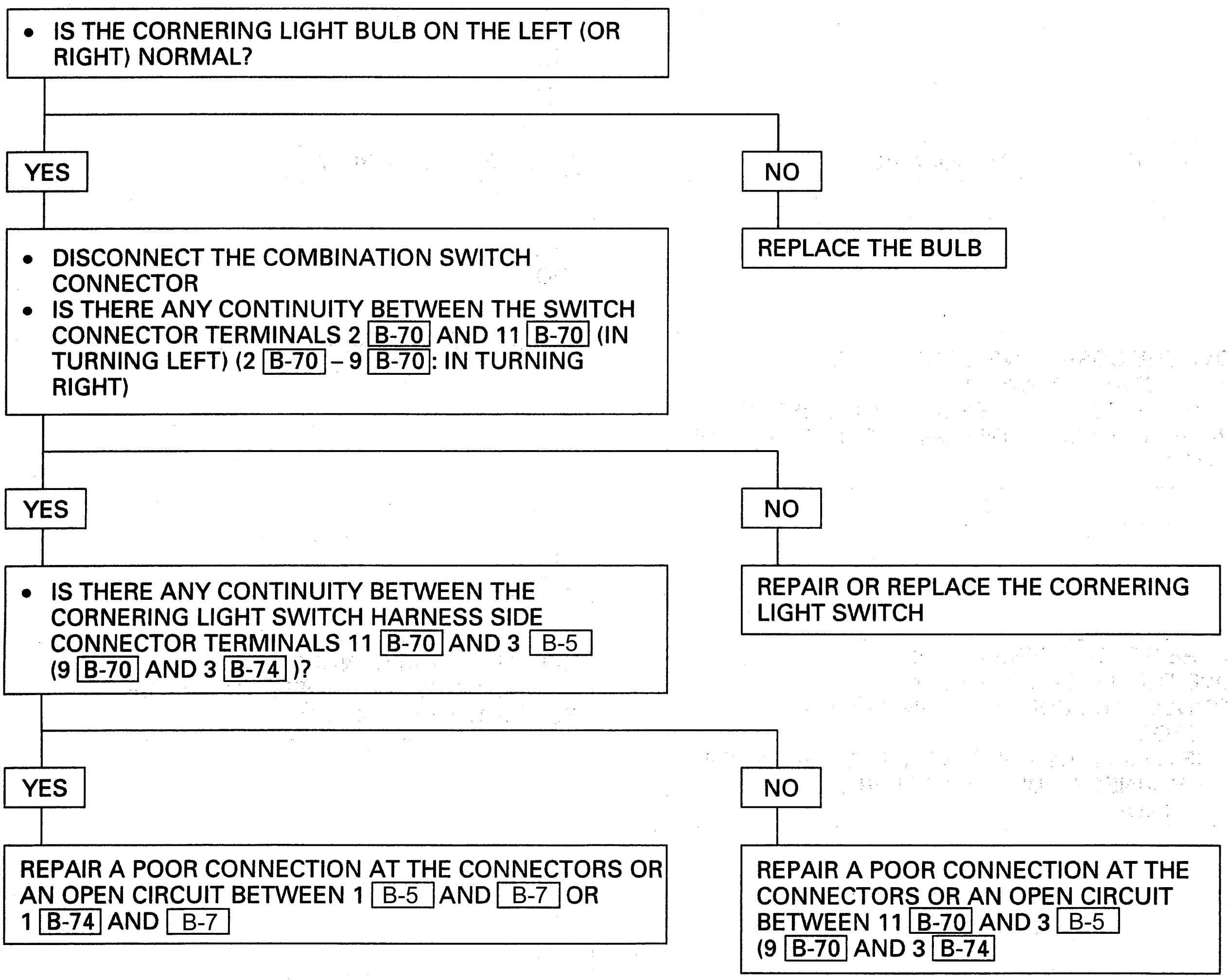
REPAIR A POOR CONNECTION OR AN OPEN CIRCUIT BETWEEN THE HARNESS SIDE CONNECTORS 5 B-35 AND 2 B-70

NO

REPAIR OR REPLACE THE SWITCH

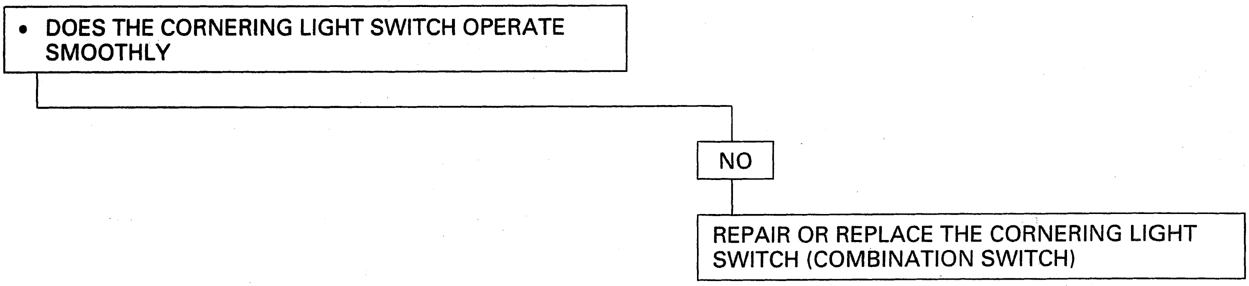
NOTE: Figures in Parenthesis "( )" indicate place of inspection for the cornering light on the right.

3-2. CORNERING LIGHT ON THE LEFT (OR RIGHT) SIDE INOPERATIVE



LNW48ALF003801

3-3. CORNERING LIGHT REMAINS ON EVEN WHEN STEERING WHEEL IS IN STRAIGHT AHEAD POSITION

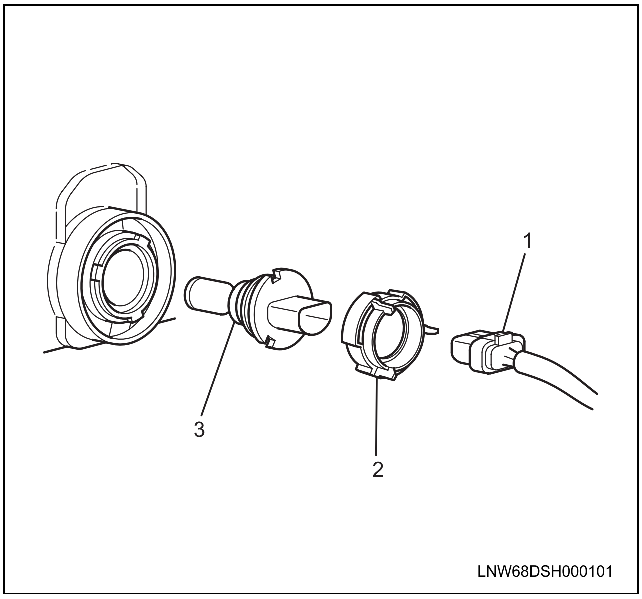


LNW38ASF001301

Headlight bulb replacement

Removal

1. Remove the battery ground cable at the battery.
2. Remove the headlight assembly (refer to 'Headlight replacement' below).
3. Remove the headlight bulb.
    - Remove the headlight connector (1).
    - Turn the locking ring (2) counterclockwise to remove it.
    - Remove the headlight bulb (3).

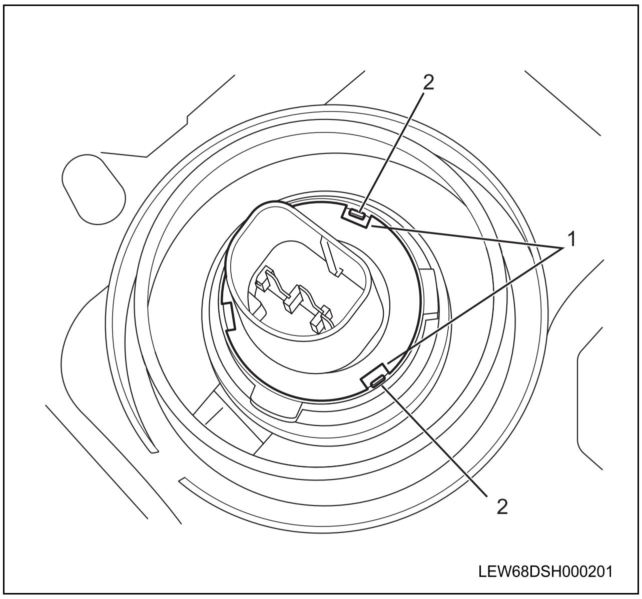


LNW68DSH000101

Installation

Follow the removal procedure in the reverse order.
To install the new bulb, align the grooves (1) with the bosses (2).

Caution:
Do not touch the glass portion of the new bulb with your fingers.



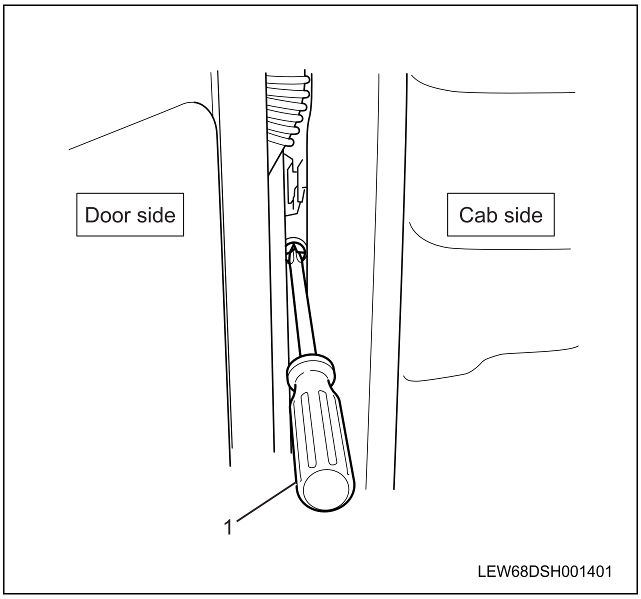
LEW68DSH000201

Headlight replacement

Removal

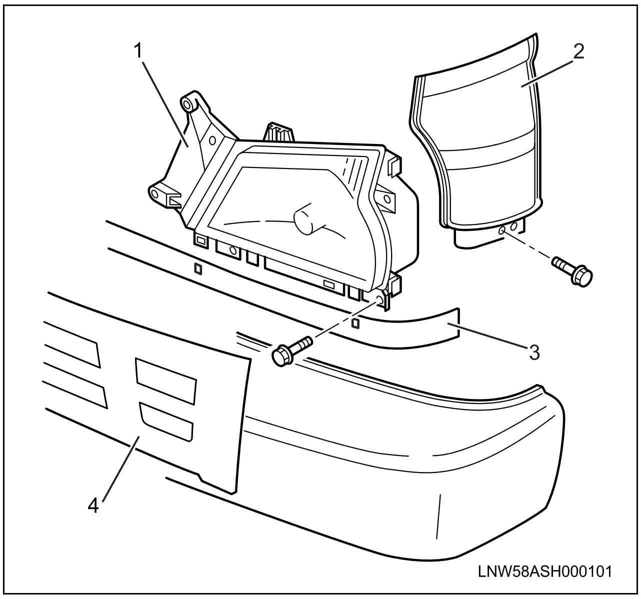
Preparation: Disconnect the battery ground cable.

1. Remove the battery ground cable at the battery.
2. Remove the front combination light (2).
    - Open the cab door. Insert a screwdriver (1) into the space between the cab and the cab door. Use the screwdriver to force out the stud pin at the center of the grommet (the pin securing the front combination light).



LEW68DSH001401

    - Remove the fixing screw.
    - Remove the two catches.
    - Remove the front combination light connector.
3. Remove the front grille (4).
    - Remove the bolt at the center of the front grille.
    - Remove the four clips securing the front grille.
    - The grille is secured by 4 clips (2 clips at the inside of each headlamp). Pull the grille toward you to remove it.
4. Remove the seal rubber (3).
    - Remove the seal rubber from beneath the headlight.
5. Remove the front corner panel.
   Refer to “door” of section 8F “Steel Tilt Cab”.
6. Remove the headlight (1).
    - Remove the four bolts securing the headlight (loosen the fixing bolts at the bottom of the front side panel to create working space).
    - Remove the headlight clips.
    - Remove the headlight connector.



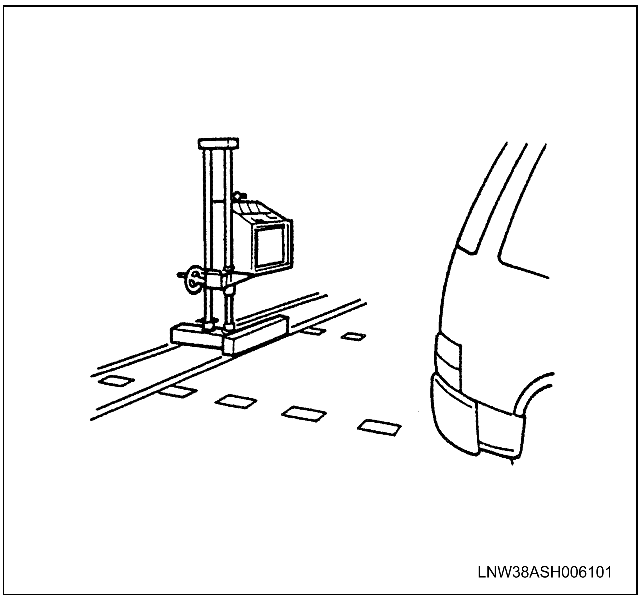
LNW58ASH000101

Installation

Follow the removal procedure in the reverse order.

Aiming of Headlight

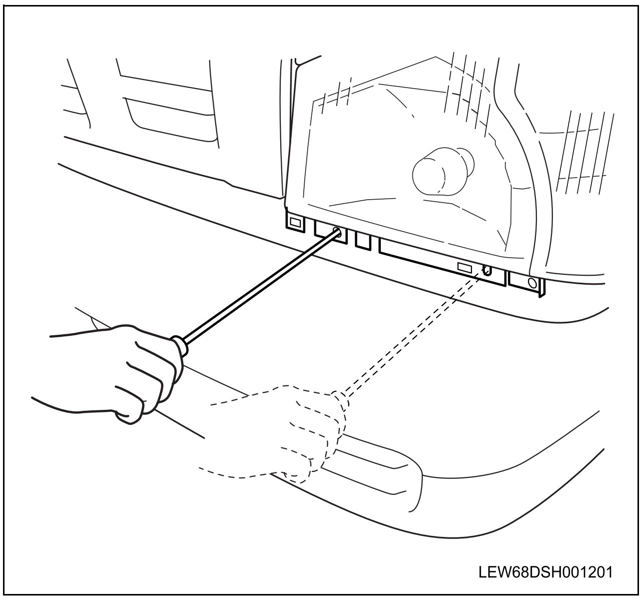
Preparation: Place the unloaded vehicle on a level surface and check to see if the inflation pressure of the tires is correct, the lenses are clean, and the battery is sufficiently charged. Adjust the aim with the headlight tester.
When adjusting, follow the procedure of the tester manufacturer's.



LNW38ASH006101

Vertical adjustment

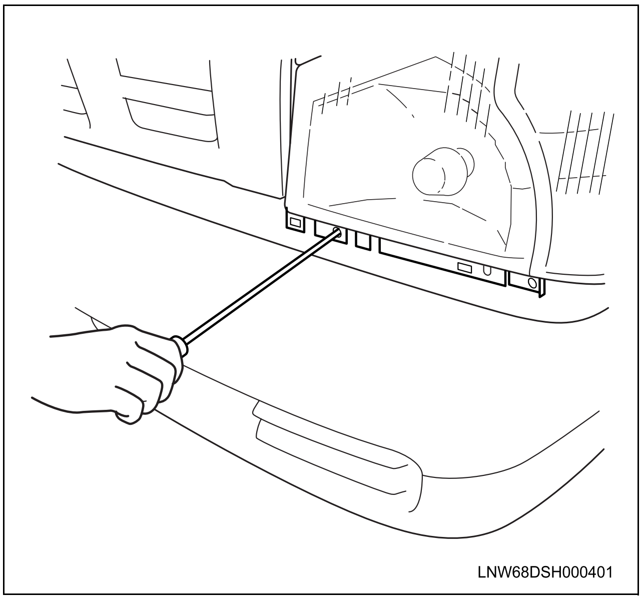
Insert the tip of a screwdriver into the hole beneath the headlight (the shaft of the screwdriver must be slanted up) until contact is made with the head of the adjusting screw. Turn the screw to adjust headlight focus up or down.
Two vertical aim screws should be turned in the same direction at the same time to adjust aiming.



LEW68DSH001201

Horizontal adjustment

Insert the tip of a screwdriver into the hole beneath the headlight (the shaft of the screwdriver must be slanted up) until contact is made with the head of the adjusting screw. Turn the screw to adjust headlight focus to the left or right.



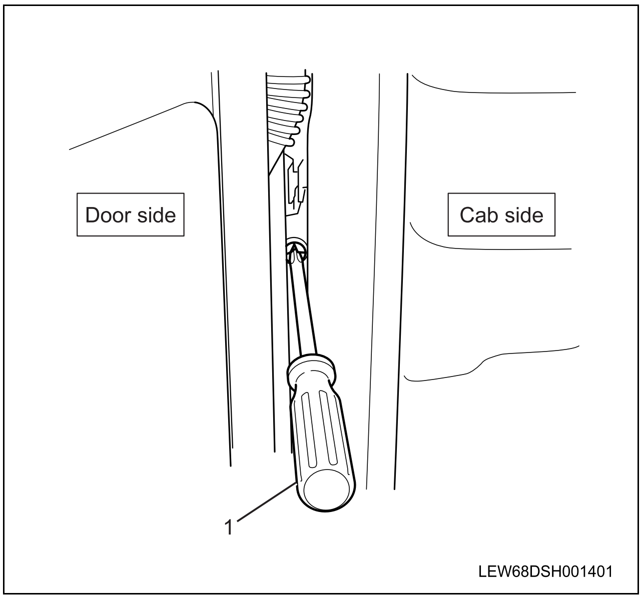
LNW68DSH000401

Cornering light bulb replacement

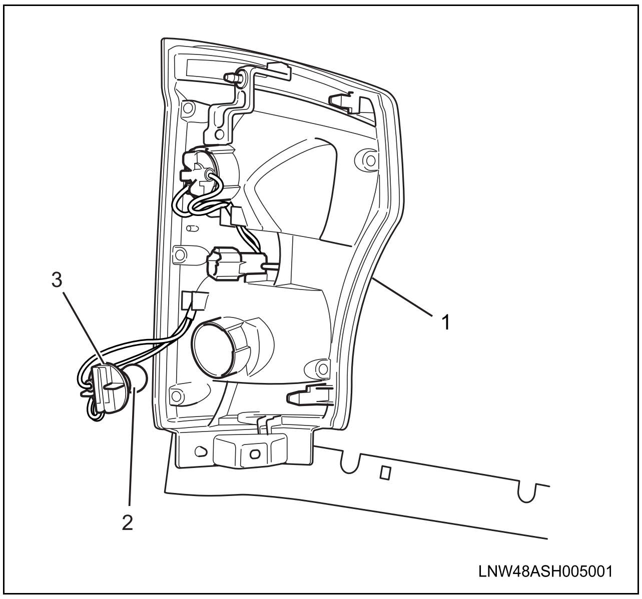
Removal

1. Remove the battery ground cable at the battery.
2. Remove the front combination light.

- Open the cab door. Insert a screwdriver (1) into the space between the cab and the cab door. Use the screwdriver to force out the stud pin at the center of the grommet (the pin securing the front combination light).



- Remove the fixing screw.
- Remove the two catches.
- Remove the front combination light connector.



3. Remove the cornering light bulb.
    - Turn the parking bulb socket (3) to the left to remove it.
    - Press the bulb (2) in and turn it to the left to remove it from the socket.

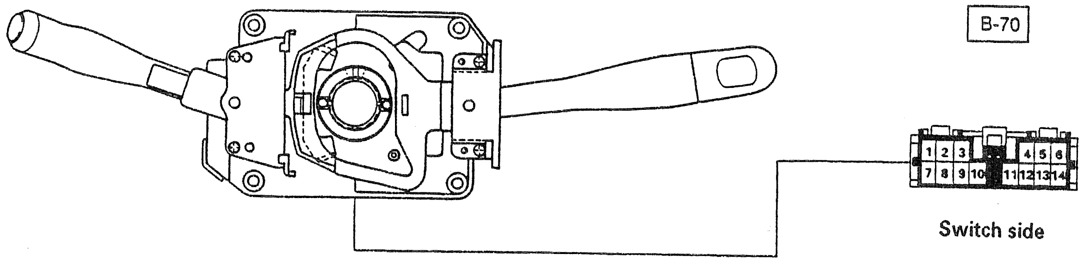
Installation

Follow the removal procedure in the reverse order.

COMBINATION SWITCH (Lighting Switch, Dimmer Passing Cornering Light Switch)

Inspect

Check the continuity between the connector terminals while operating the switch.
Replace the switch when the result of inspection is found abnormal.



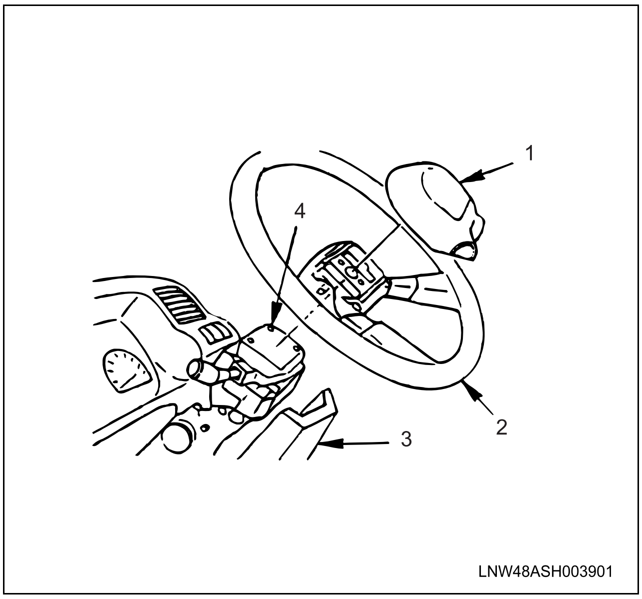
SW position \ Terminal No.		1	2	4	5	7	8	9	10	11	12	13
Lighting SW	≣D	○	—	○	—	—	○					
	≶D◁≶			○	—	—	○					
	OFF											
Dimmer·passing SW	High beam			○	—	—	—	—	○			
	Passing			○	—	○	—	—	○			
Cornering light SW	Turning left		○	—	—	—	—	—	—	○		
	Neutral											
	Turning right		○	—	—	—	—	○				

LNW38AMF000501

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Horn pad
   - Hold the horn pad and pull it upward.
2. Steering wheel
   - Remove the steering shaft nut.
   - Remove the steering wheel by using steering wheel remover.
     (Refer to “Steering Wheel” of section 3B4 “Steering Column”.)
3. Steering cowl
   Remove four screws.
4. Combination switch
   - Remove four screws.
   - Disconnect the connector.



Legend

1. Horn Pad
2. Steering Wheel
3. Steering Cowl
4. Combination Switch

Install or Connect

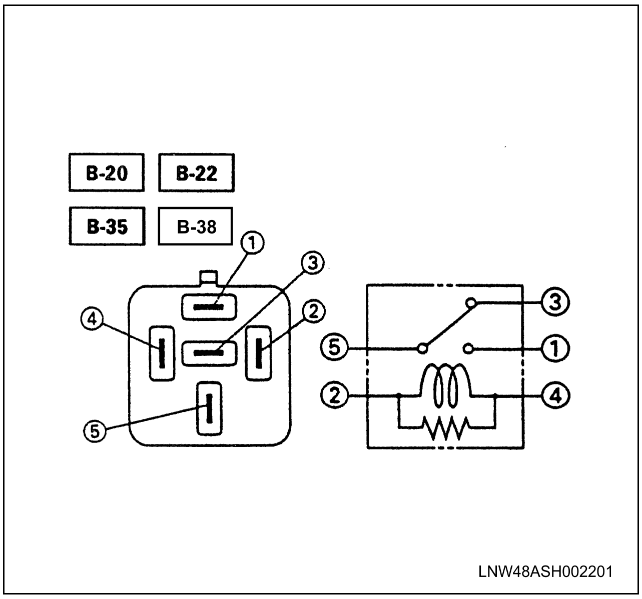
To install, follow the removal steps in the reverse order, noting the following point.

1. Tighten the steering shaft nut to the specified torque.

Shaft nut torque	N·m (lb ft)
49 (36)	

HEADLIGHT RELAY, TAIL RELAY, CORNERING LIGHT RELAY, EXHAUST BRAKE RELAY

Inspect



Check to see if there is any continuity between the relay terminals.
Replace the relay when the result of inspection is found abnormal.

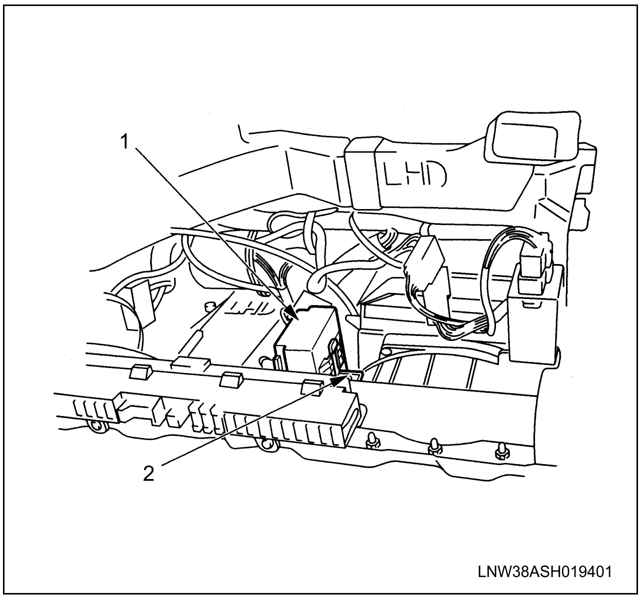
(3) – (5)	Continuity
(1) – (5)	No continuity
(When battery voltage is applied between (2) – (4))	
(3) – (5)	No continuity
(1) – (5)	Continuity

D.R.L UNIT

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Glove box
   Open the lid and remove four screws.
2. D.R.L UNIT
   - Press upward the unit with your hand.



Legend

1. D.R.L Unit
2. D.R.L Unit Bracket

Install or Connect

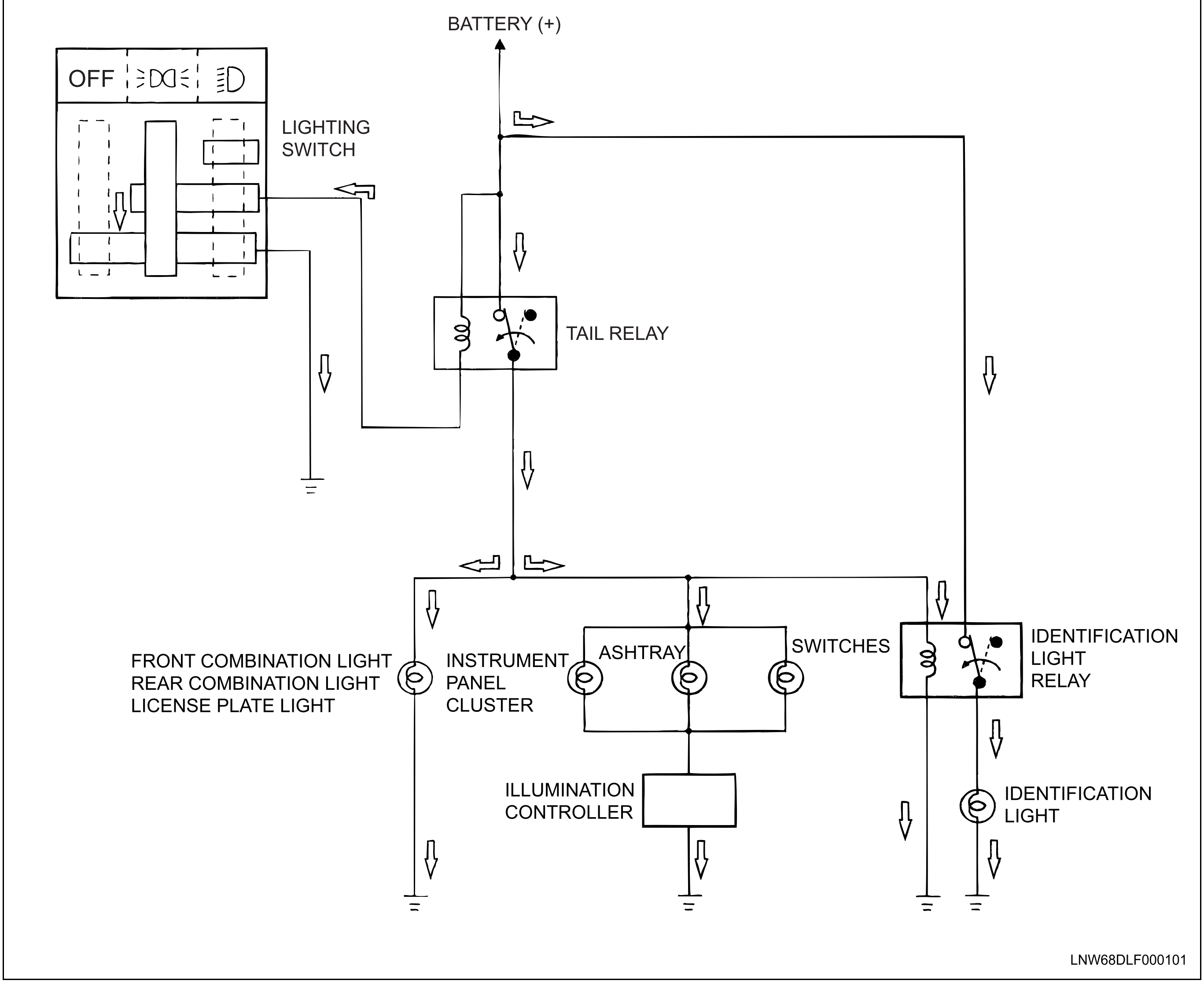
To install, follow the removal steps in the reverse order.

Identification Light, Illumination Light and Horn

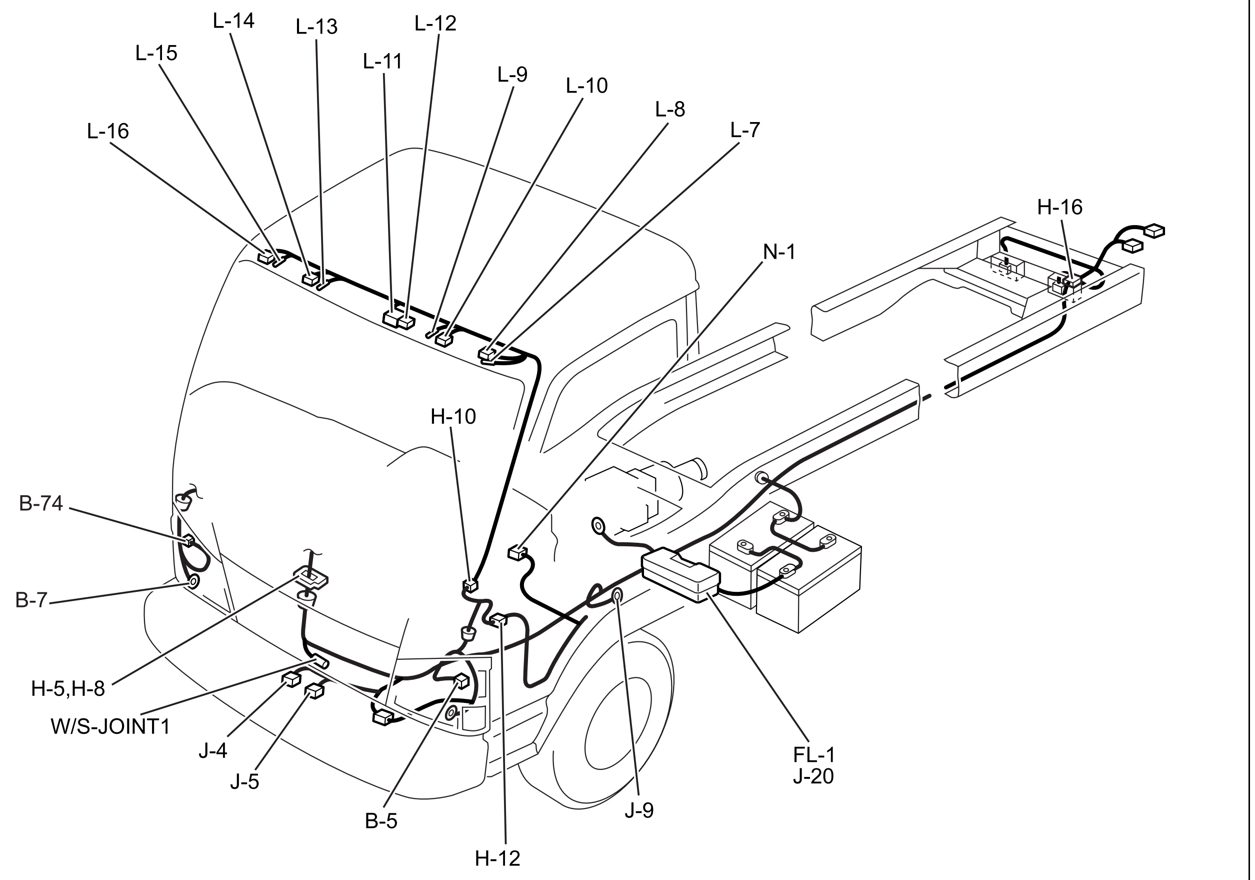
General Description

The circuit consists of the lighting switch, clearance light, taillight, license plate light and the illumination light for each of switch, instrument panel cluster and ashtray.
All these lights come on when the lighting switch are turned on with the switch to either clearance or headlight position.

LIGHTING CIRCUIT

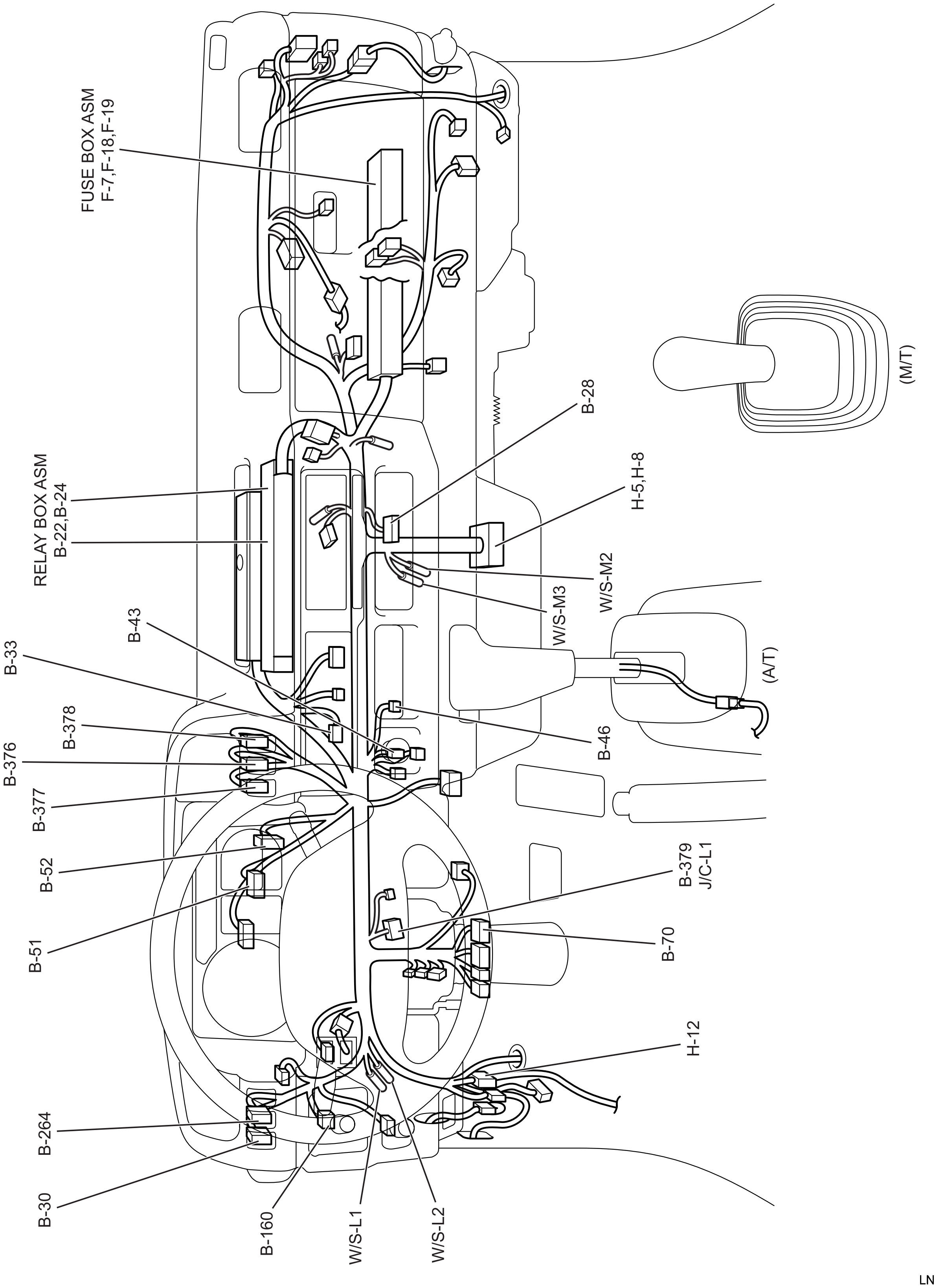


PARTS LOCATION (1)



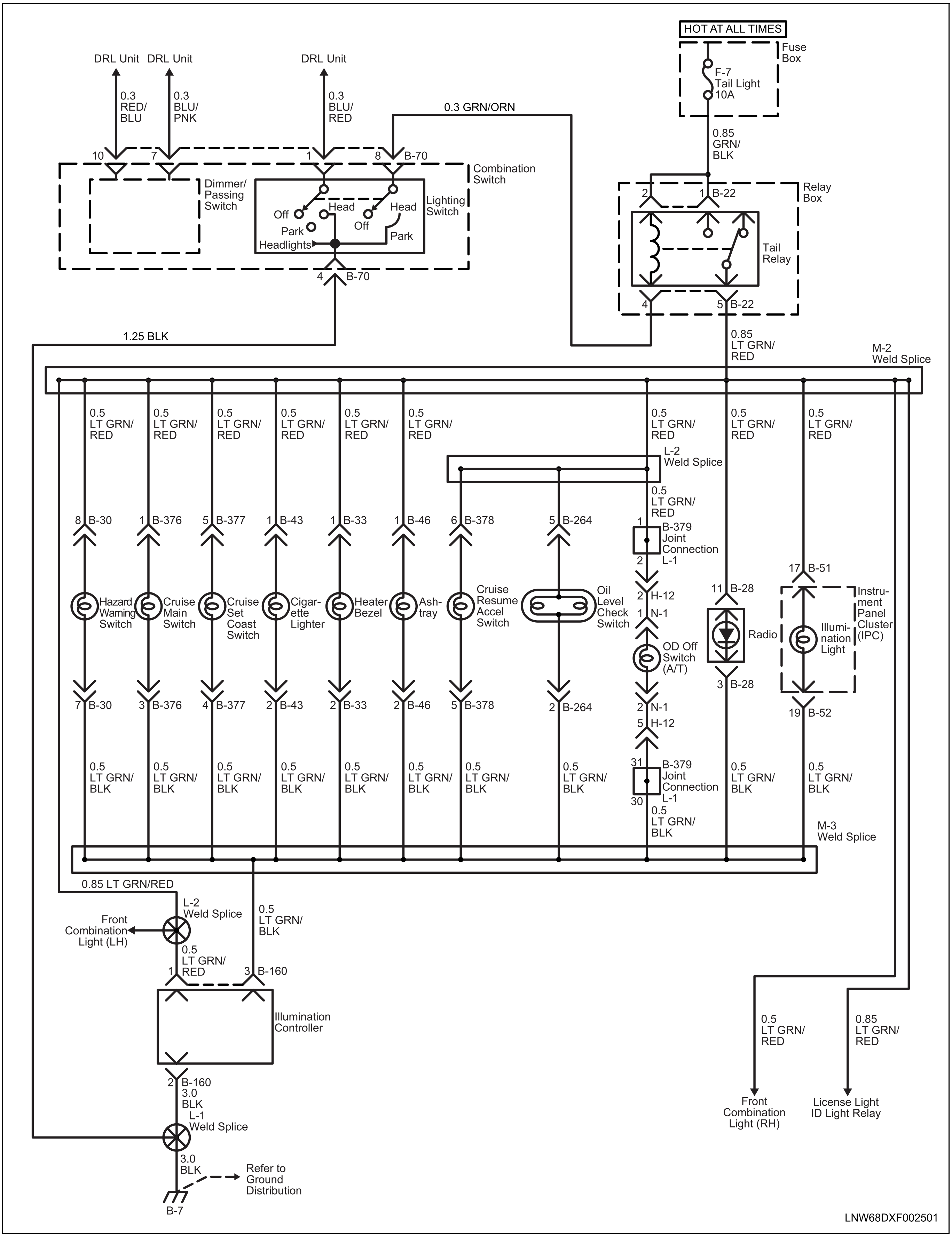
NOTE: Do not grip the roof marker lights to prevent damage or water leakage.

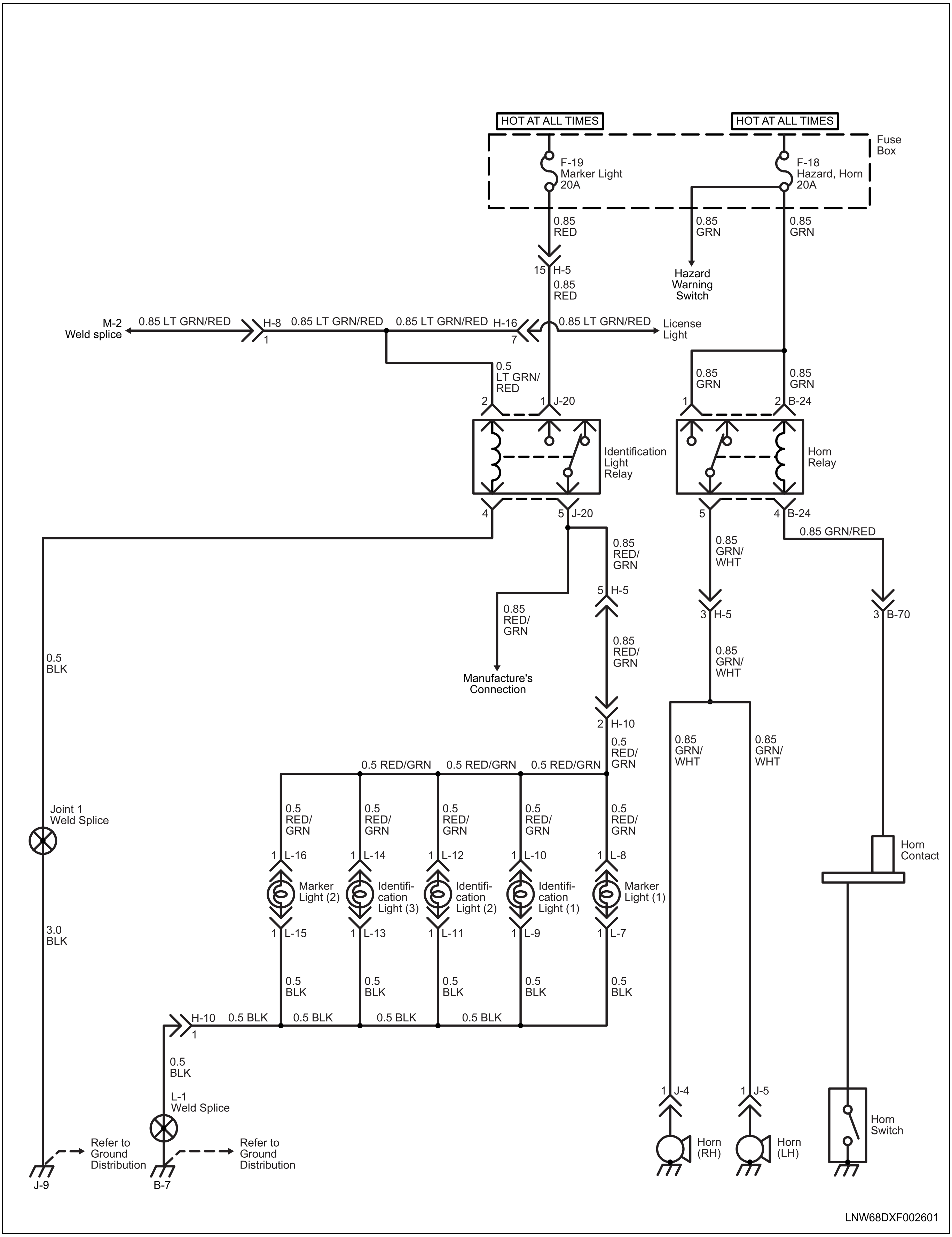
PARTS LOCATION (2)

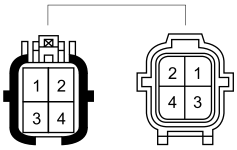
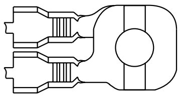
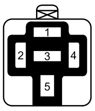
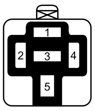
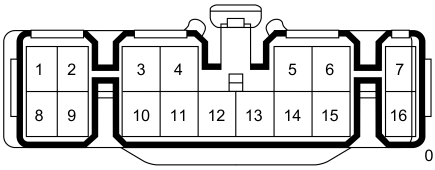
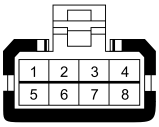
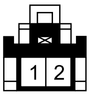
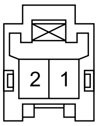


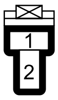
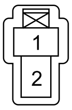
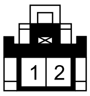
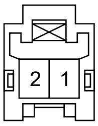
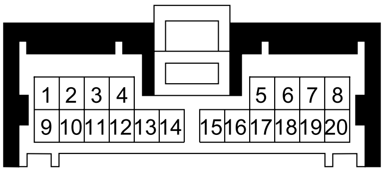
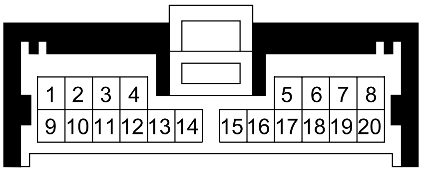
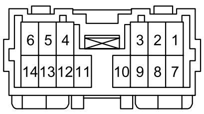
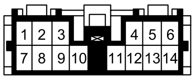
LNW68DXF010701

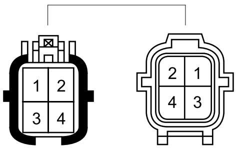
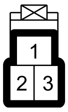
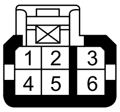
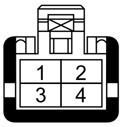
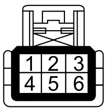
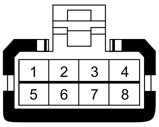
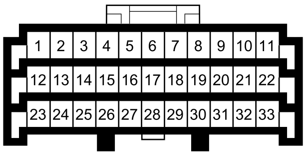
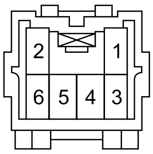
CIRCUIT DIAGRAM

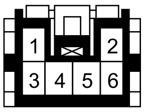
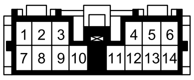
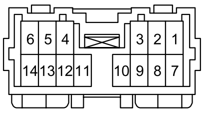
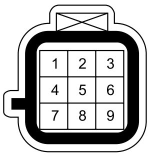
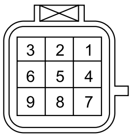
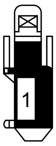
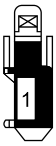
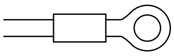


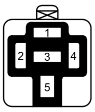
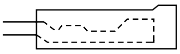
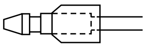
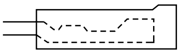
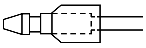
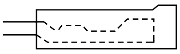
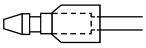
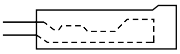

HOT AT ALL TIMES
HOT AT ALL TIMES
Fuse Box
F-19 Marker Light 20A
F-18 Hazard, Horn 20A
0.85 RED
0.85 GRN
0.85 GRN
15 H-5
0.85 RED
Hazard Warning Switch
M-2 Weld splice
0.85 LT GRN/RED
H-8 1
0.85 LT GRN/RED
0.85 LT GRN/RED
H-16 7
0.85 LT GRN/RED
License Light
0.5 LT GRN/ RED
0.85 GRN
0.85 GRN
2
1 J-20
1
2 B-24
Identification Light Relay
Horn Relay
4
5 J-20
5
4 B-24
0.85 GRN/RED
0.85 RED/ GRN
5 H-5
0.85 GRN/ WHT
3 H-5
3 B-70
0.85 RED/ GRN
Manufacture's Connection
0.85 RED/ GRN
0.85 GRN/ WHT
0.5 BLK
2 H-10
0.5 RED/ GRN
0.5 RED/GRN
0.5 RED/GRN
0.5 RED/GRN
0.85 GRN/ WHT
0.85 GRN/ WHT
Joint 1 Weld Splice
0.5 RED/ GRN
0.5 RED/ GRN
0.5 RED/ GRN
0.5 RED/ GRN
0.5 RED/ GRN
Horn Contact
1 L-16
1 L-14
1 L-12
1 L-10
1 L-8
Marker Light (2)
Identifi- cation Light (3)
Identifi- cation Light (2)
Identifi- cation Light (1)
Marker Light (1)
1 L-15
1 L-13
1 L-11
1 L-9
1 L-7
3.0 BLK
0.5 BLK
0.5 BLK
0.5 BLK
0.5 BLK
0.5 BLK
H-10 1
0.5 BLK
0.5 BLK
0.5 BLK
0.5 BLK
0.5 BLK
L-1 Weld Splice
1 J-4
1 J-5
Horn Switch
Refer to Ground Distribution
Refer to Ground Distribution
Horn (RH)
Horn (LH)
J-9
B-7
LNW68DXF002601

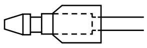
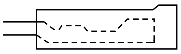
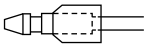
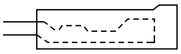
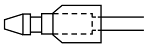
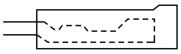
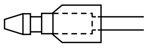
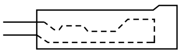
No.	Connector Face
B-5 (Gray)	 004-016 Front Combination Light (LH)
B-7	 000-007 Ground; Headlight Bracket (RH)
B-22 (Black)	 005-012 Tail Relay
B-24 (White)	 005-012 Horn Relay
B-28 (White)	 016-043 Radio
B-30 (White)	 008-016 Hazard Switch
B-33 (Black)	 002-022 Heater Bezel Illumination
B-33 (Black)	 002-021 Heater Bezel Illumination

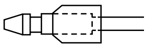
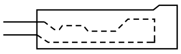
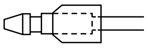
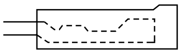
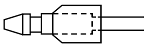
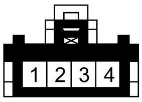
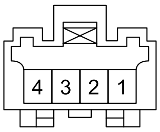
No.	Connector Face
B-43 (White)	 002-012 Cigarette Lighter Illumination
B-43 (White)	 002-011 Cigarette Lighter Illumination
B-46 (White)	 002-022 Ashtray Illumination
B-46 (White)	 002-021 Ashtray Illumination
B-51 (Gray)	 020-024 Instrument Panel Cluster (A)
B-52 (White)	 020-025 Instrument Panel Cluster (B)
B-70 (Black)	 014-004 Combination Switch (B)
B-70 (Black)	 014-003 Combination Switch (B)

No.	Connector Face
B-74 (Gray)	 004-016 Front Combination Light (RH)
B-160 (White)	 003-008 Illumination Controller
B-264 (Blue))	 006-006 Oil Level Check and Miles Check Switch
B-376 (White)	 004-015 Cruise Main Switch
B-377 (White)	 006-004 Cruise Set Coast Switch
B-378 (White)	 008-016 Cruise Resume Accel Switch
B-379 (White)	 033-001 Joint Connection – L1
H-10 (White)	 006-010 Body H. – Room Light H.

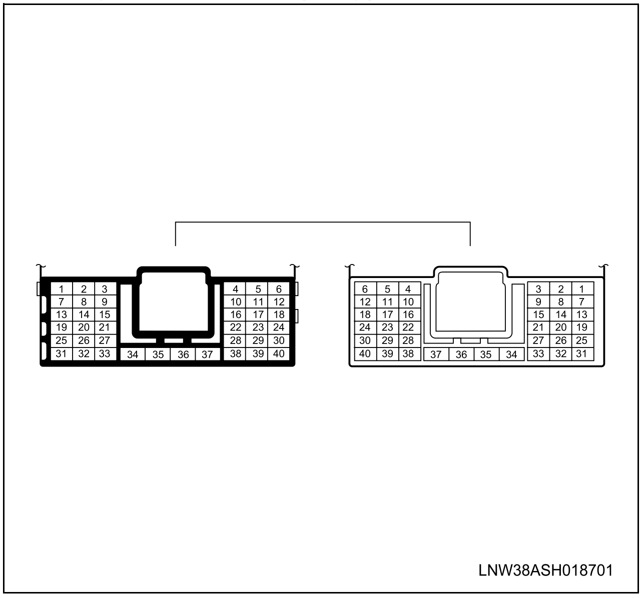
No.	Connector Face
H-10 (White)	 006-009 Body H. – Room Light H.
H-12 (White)	 014-003 Body H. – Floor H. (RH)
H-12 (White)	 014-004 Body H. – Floor H. (RH)
H-16 (Black)	 009-001 Rear Frame H. – Rear Body H.
H-16 (Black)	 009-002 Rear Frame H. – Rear Body H.
J-4 (Black)	 001-018 Horn (RH)
J-5 (Black)	 001-018 Horn (LH)
J-9	 000-012 Ground; Frame – LH (Center)

No.	Connector Face
J-20 (Black)	 005-012 Identification Light Relay
L-7	 000-013 Marker Light (1)
L-7	 000-014 Marker Light (1)
L-8	 000-013 Marker Light (1)
L-8	 000-014 Marker Light (1)
L-9	 000-013 Identification Light (2)
L-9	 000-014 Identification Light (2)
L-10	 000-013 Identification Light (2)

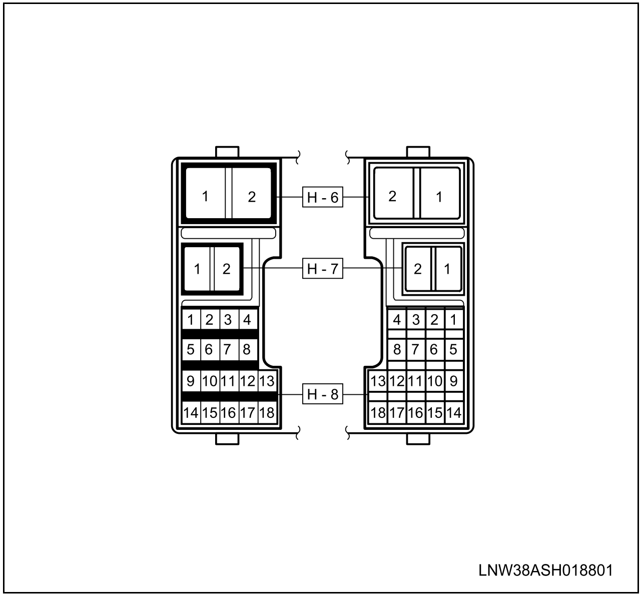
No.	Connector Face
L-10	 000-014 Identification Light (2)
L-11	 000-013 Identification Light (3)
L-11	 000-014 Identification Light (3)
L-12	 000-013 Identification Light (3)
L-12	 000-014 Identification Light (3)
L-13	 000-013 Identification Light (4)
L-13	 000-014 Identification Light (4)
L-14	 000-013 Identification Light (4)

No.	Connector Face
L-14	 000-014 Identification Light (4)
L-15	 000-013 Marker Light (5)
L-15	 000-014 Marker Light (5)
L-16	 000-013 Marker Light (5)
L-16	 000-014 Marker Light (5)
N-1 (White)	 004-008 A/T Lever
N-1 (White)	 004-007 A/T Lever

H-5 Body H. – Frame H. (Gray)



H-8 Body H. – Frame H. (Gray)



Diagnosis

1. IDENTIFICATION LIGHT

Check Point Trouble Mode	Fuse F-6 (15A)	ID Light Bulb	ID Light Relay	Cable Harness
1-1. Identification lights inoperative	○ (1)	○ (2)	○ (3)	○ (4)

Check Point Trouble Mode	Fuse F-6 (15A)	ID Light Bulb	ID Light Relay	Cable Harness
1-2. Identification lights (1, 2 or 3) inoperative		○ (1)		○ (2)

ID: Identification

NOTE: Figure in parenthesis “( )” indicates the order of inspection.

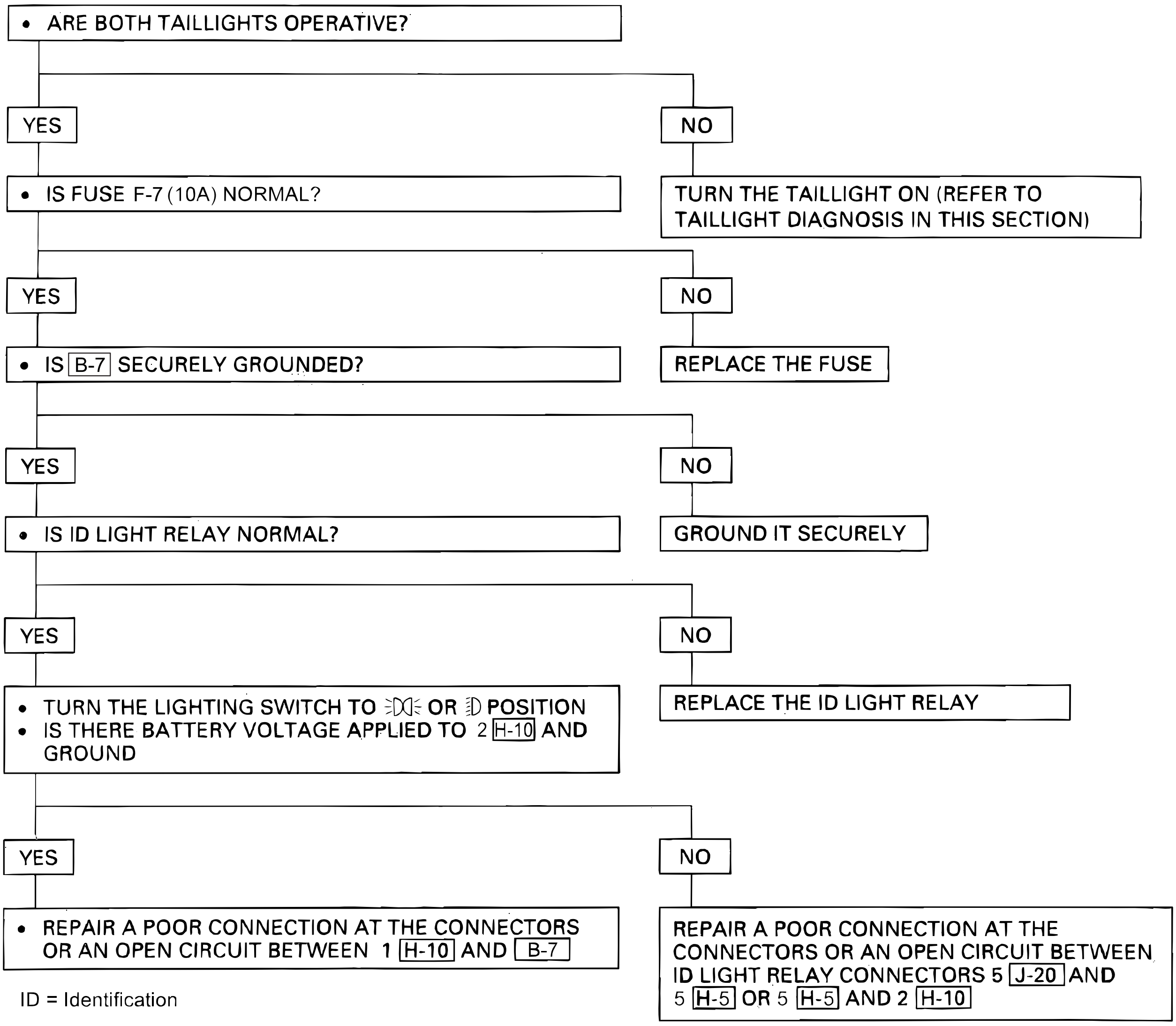
2. HORN

Check Point Trouble Mode	Fuse F-18 (20A)	Horn	Horn Switch	Horn Relay	Horn Contact	Cable Harness
2-1. Horn does not sound	○ (1)	○ (4)	○ (6)	○ (2)	○ (5)	○ (3)
2-2. Horn does not shut off			○ (2)	○ (1)		○ (3)

NOTE: Figure in parenthesis “( )” indicates the order of inspection.

1. Identification Lights.

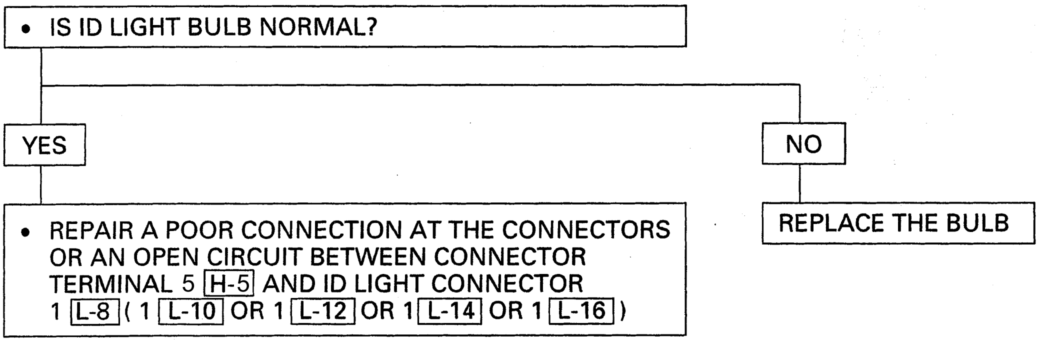
1-1. IDENTIFICATION LIGHT INOPERATIVE



ID = Identification

LNW68DLF000601

1-2. IDENTIFICATION LIGHT INOPERATIVE

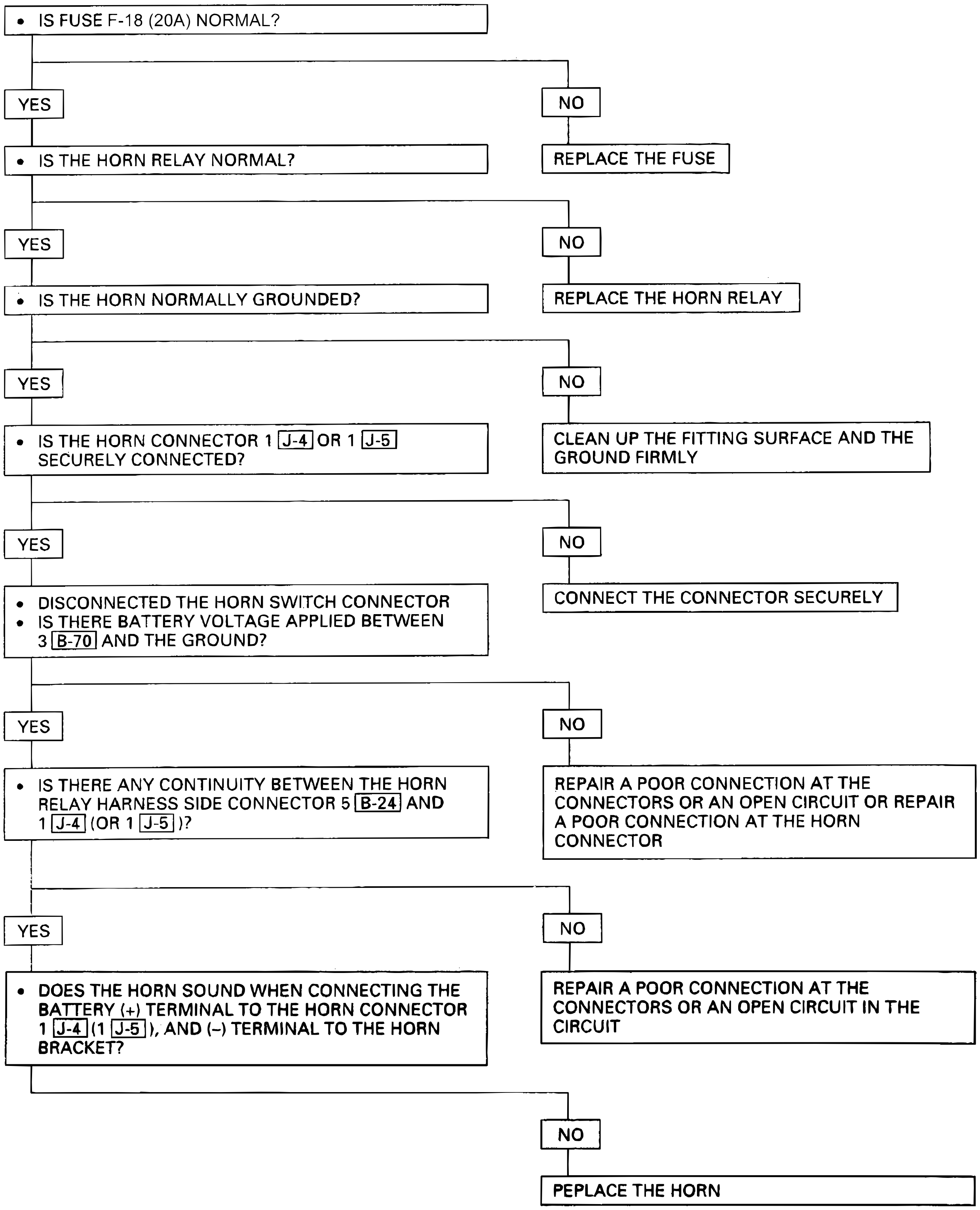


ID = Identification

LNW48ASF000701

2. Horn

2-1. HORN DOES NOT SOUND



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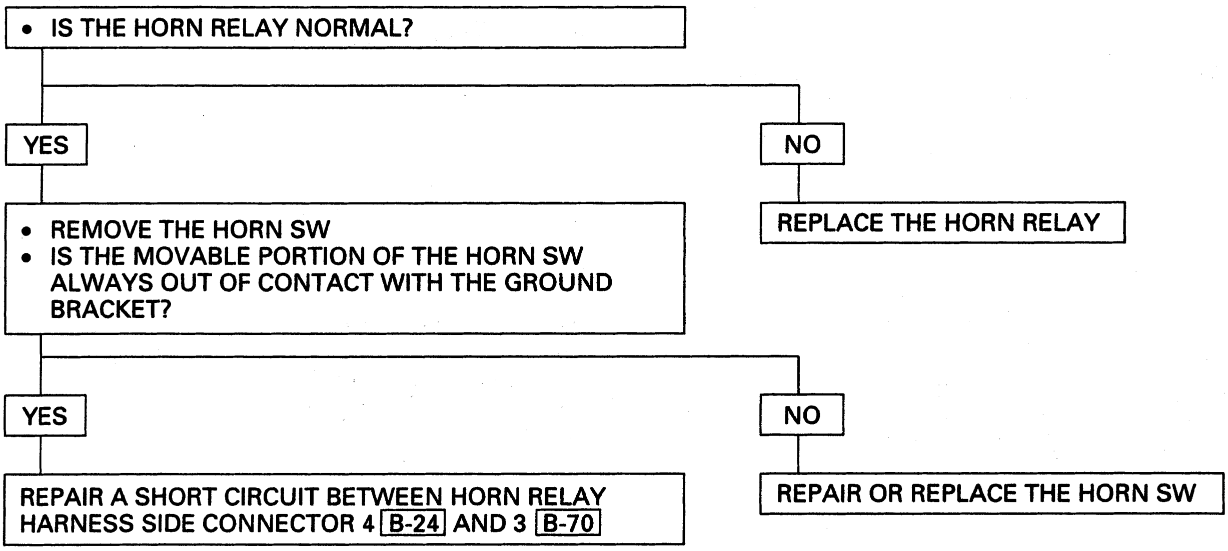
2-2. HORN DOES NOT SHUT OFF



LNW38AMF001501

LIGHTING SWITCH

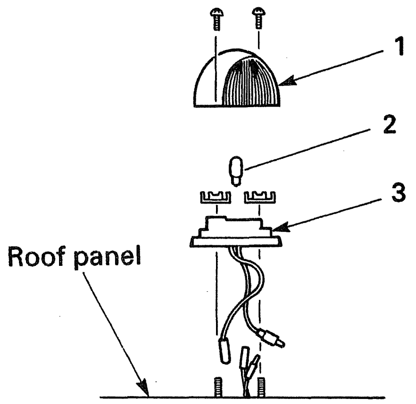
Refer to “Headlight and Cornering Light” in this section.

ROOF MARKER LIGHT, IDENTIFICATION LIGHT

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Lens
   - Remove two screws.
2. Bulb
   - Pull out the bulb.
3. Base
   - Remove two nuts.
   - Disconnect the connectors.



LNW38ASH007001

Legend

1. Lens
2. Bulb
3. Base with Gasket

Install or Connect

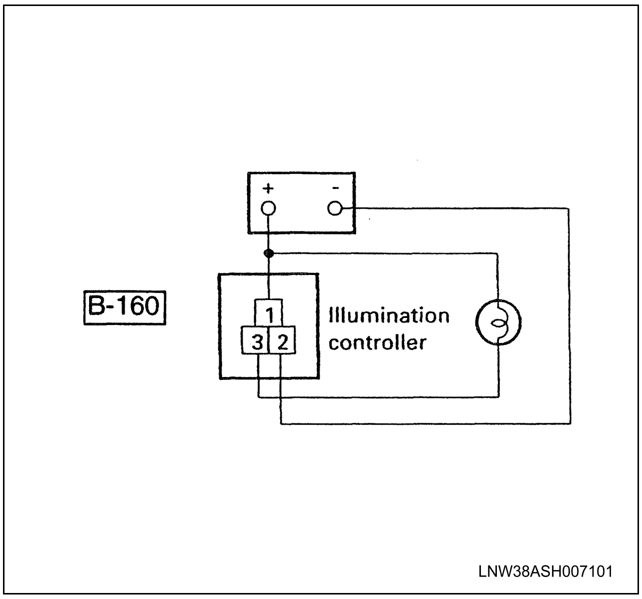
1. Assemble the light.
2. Install the light in the vehicle.
   - Make connections.
   - Push onto studs.

Notice:
To prevent water leakage, apply adequate force when pushing the light onto the studs without breaking the lens. Make sure that the nut is in place correctly.

ILLUMINATION CONTROLLER

Inspect

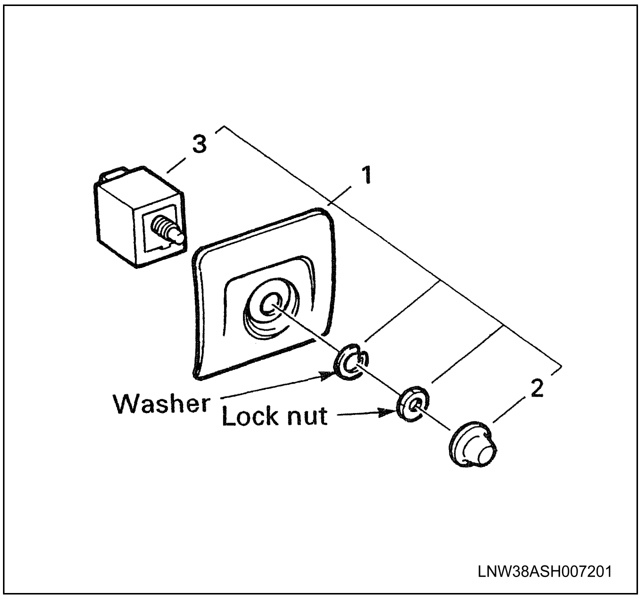
1. Connect the illumination controller connector terminal No.1 to the battery (+) terminal and No.2 to the (–) terminal.
2. Connect a test bulb of 1.4 W or 3.4 W between terminal No.1 and No.3.



Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Bezel with illumination controller
   - Pull the controller bezel to release the locks.
2. Controller knob
   - Pull out the knob.
3. Illumination controller
   - Loosen the lock nut then remove the washer and controller.



Legend

1. Bezel with Illumination Controller
2. Controller Knob
3. Illumination Controller

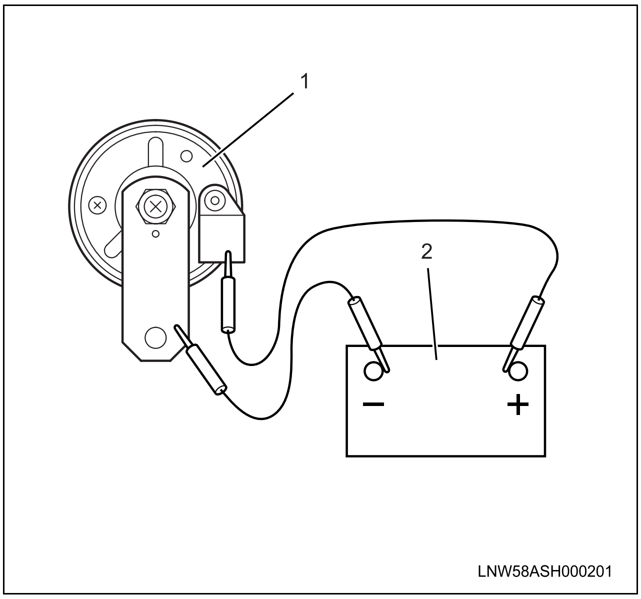
Install or Connect

To install, follow the removal steps in the reverse order.

HORN

Inspect

Check to see if horn sounds when a battery voltage is applied between horn terminal and the fixing bracket. Repair or replace the horn when the result of inspection is found abnormal.



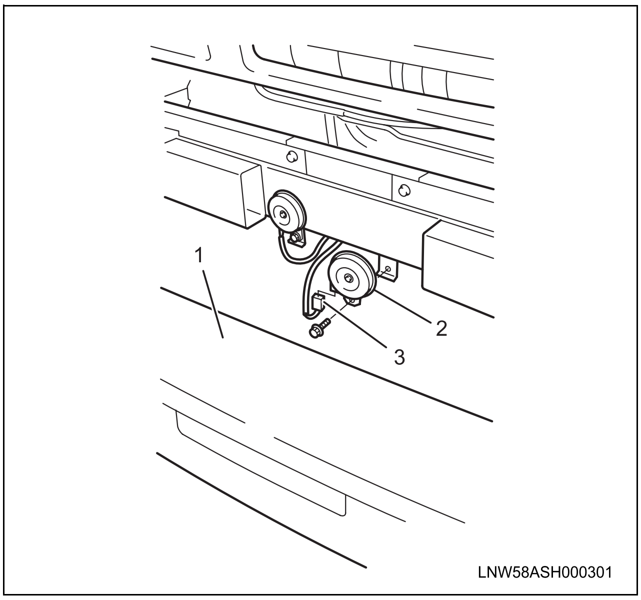
Legend

1. Horn
2. Battery

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Bumper
   Refer to “Bumper and Brackets Replacement” of section 2C “Sheet Metal”.
2. Horn
   Disconnect the connector.
   Remove the horn.



Legend

1. Bumper
2. Horn
3. Connector

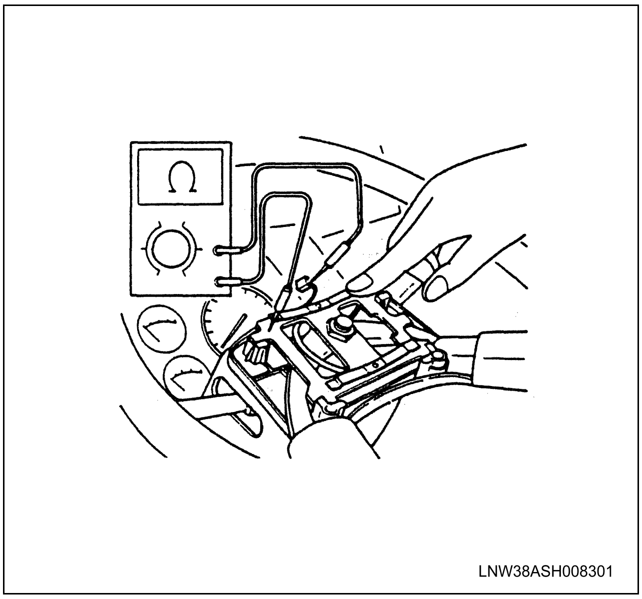
Install or Connect

To install, follow the removal steps in the reverse order.

Horn Switch

Inspect

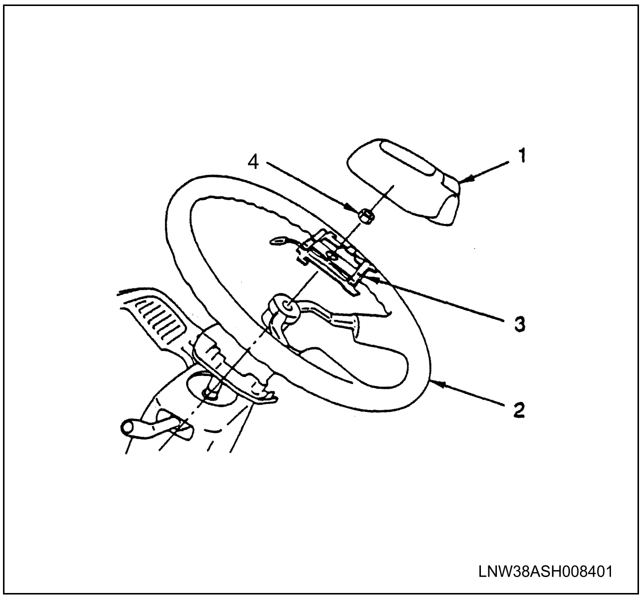
With the contact point of the horn switch pressed to the switch bracket, check the continuity between the connector terminal and the bracket of the switch.
Check the contact condition between horn contact of the combination switch and contact plate of steering wheel.
Repair or replace the switch when the result of inspection is found abnormal.



Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Horn pad
   - Hold the horn pad and pull it upward.
2. Steering wheel
   - Remove the steering shaft nut.
   - Remove the steering wheel by using steering wheel remover.
     (Refer to “Steering Wheel” of section 3B4 “Steering Column”.)
3. Horn switch



Legend

1. Horn Pad
2. Steering Wheel
3. Horn Switch
4. Shaft Nut

Install or Connect

To install, follow the removal steps in the reverse order, noting the following point:

- Tighten the steering shaft nut to the specified torque

Shaft nut torque	N·m (lb ft)
49 (36)	

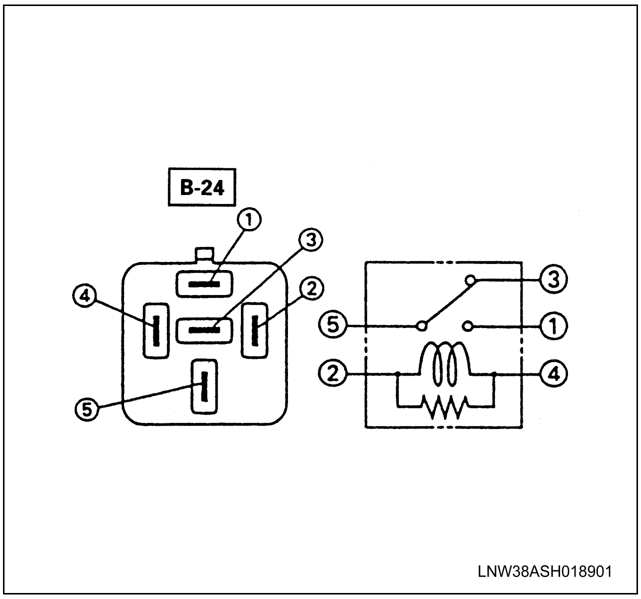
HORN RELAY

Inspect

Check to see if there is any continuity between the relay terminals.

Replace the relay when the result of inspection is found abnormal.

(3) – (5)	Continuity
(1) – (5)	No continuity
(When battery voltage is applied between (2) – (4))	
(3) – (5)	No continuity
(1) – (5)	Continuity



Front Combination Light, Rear Combination Light and License Plate Light

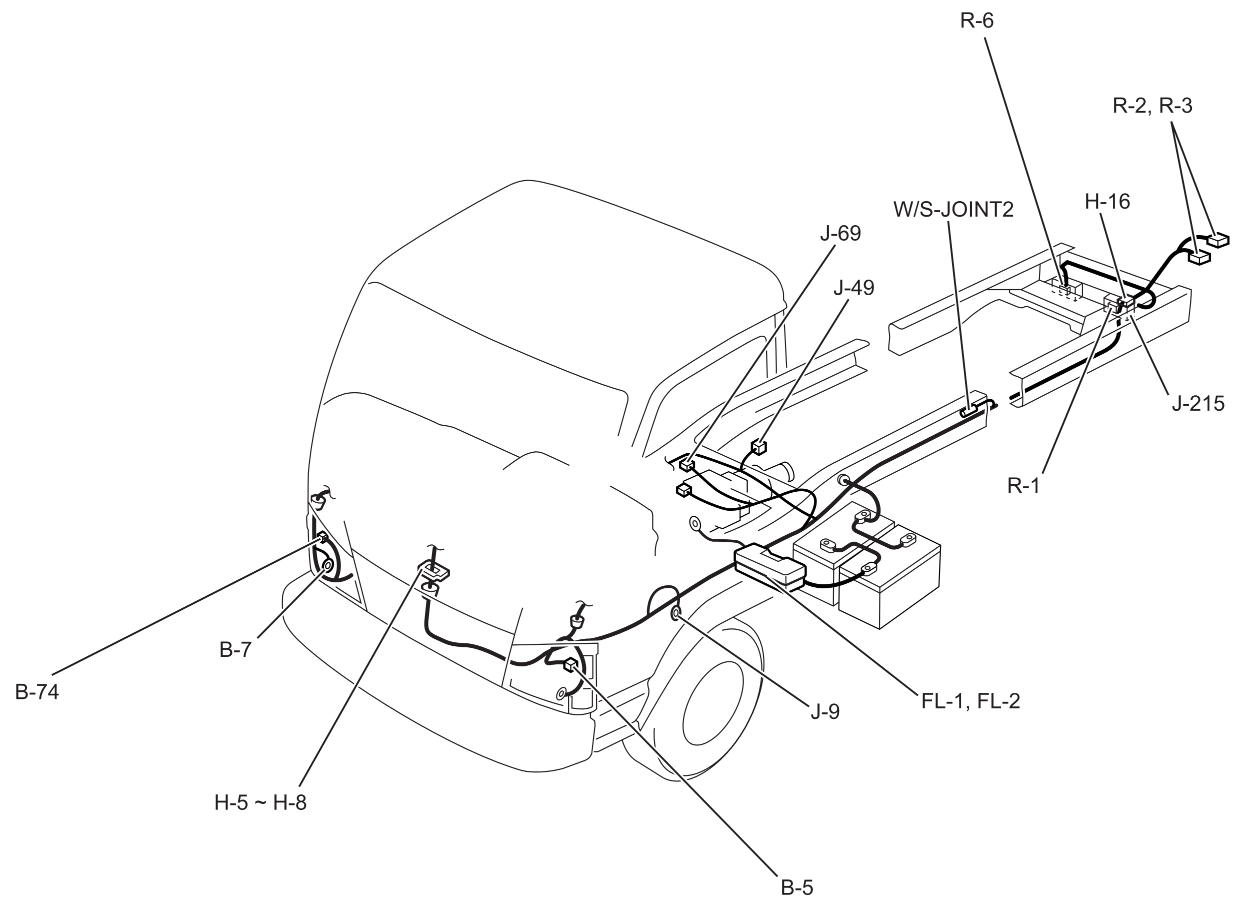
General Description

The circuit consists of the ignition switch, turn signal light (front and rear), turn signal light switch, hazard warning light, flasher unit, brakelight and brake switch.

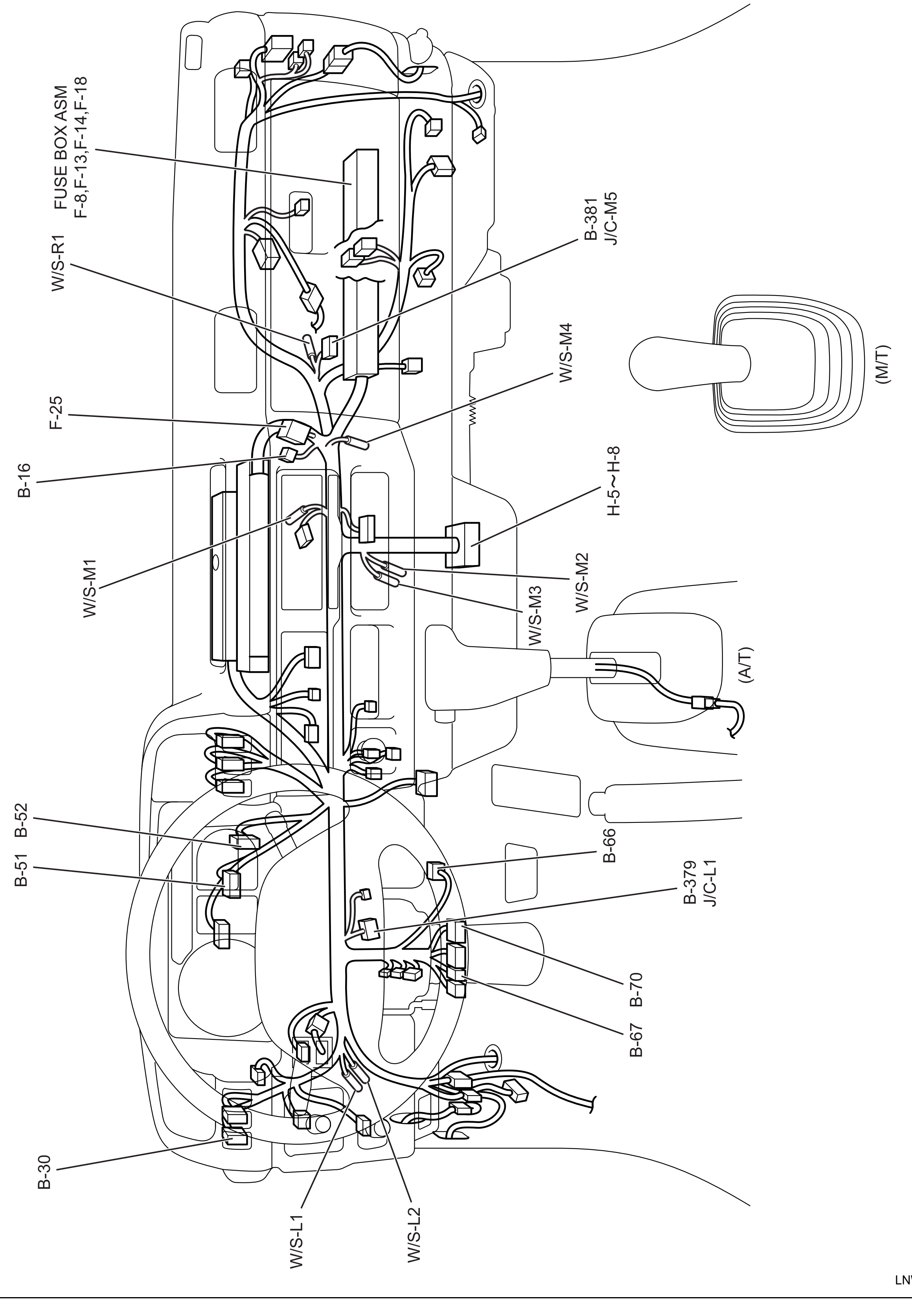
When turning on the respective switches with the ignition switch on, the turn signal light will operate. When the turn signal light is flashing, the indicator light in the instrument panel cluster also start flashing. When the hazard warning switch is turned on, the current flows to the flasher unit through the hazard warning switch to cause the hazard warning light to flash, independent of the position of the ignition switch. At the same time, the indicator lights in the instrument panel cluster also start flashing.

The brake switch will turn on and the light comes on once the brake pedal is depressed, independent of the position of the ignition switch.

PARTS LOCATION (1)



PARTS LOCATION (2)



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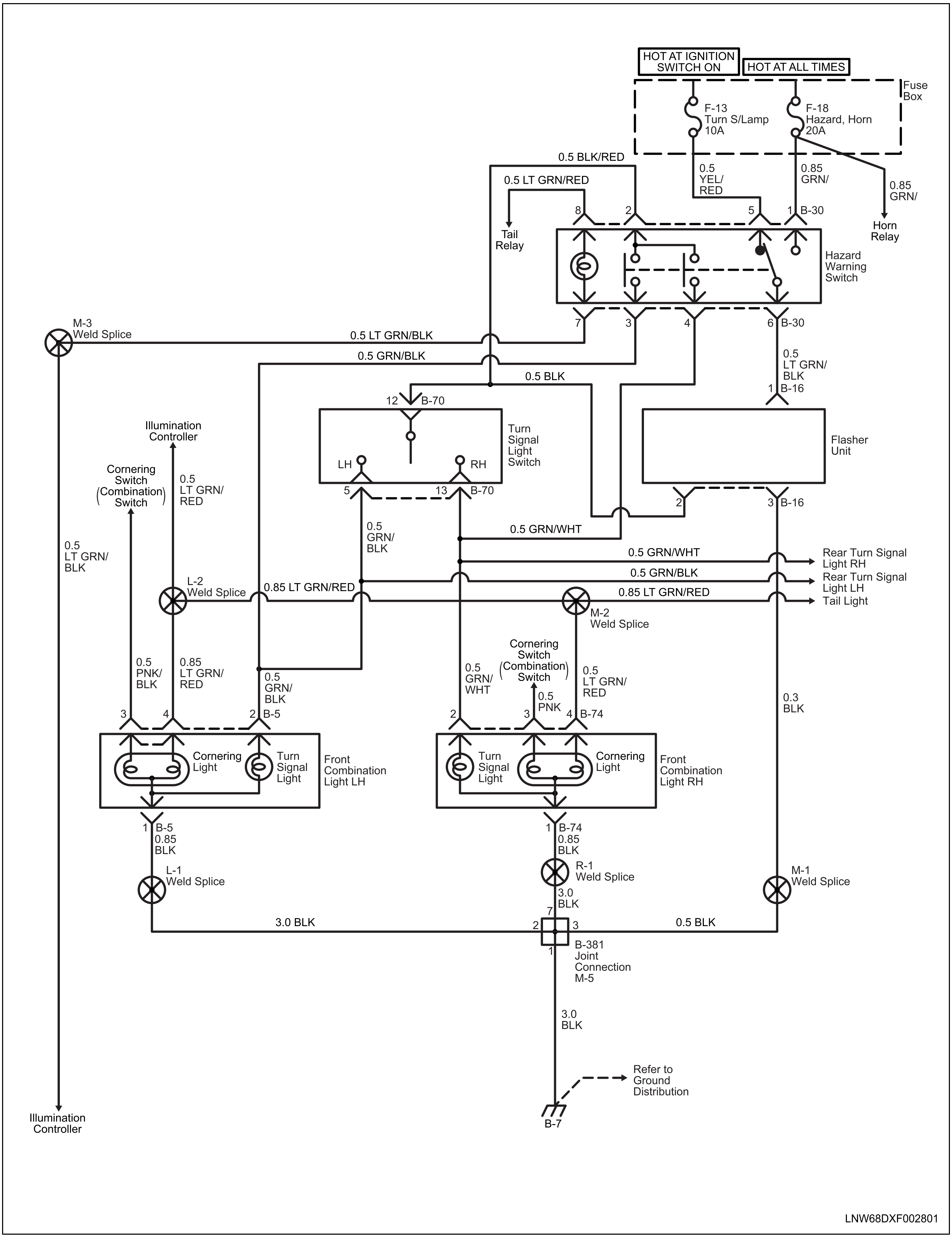
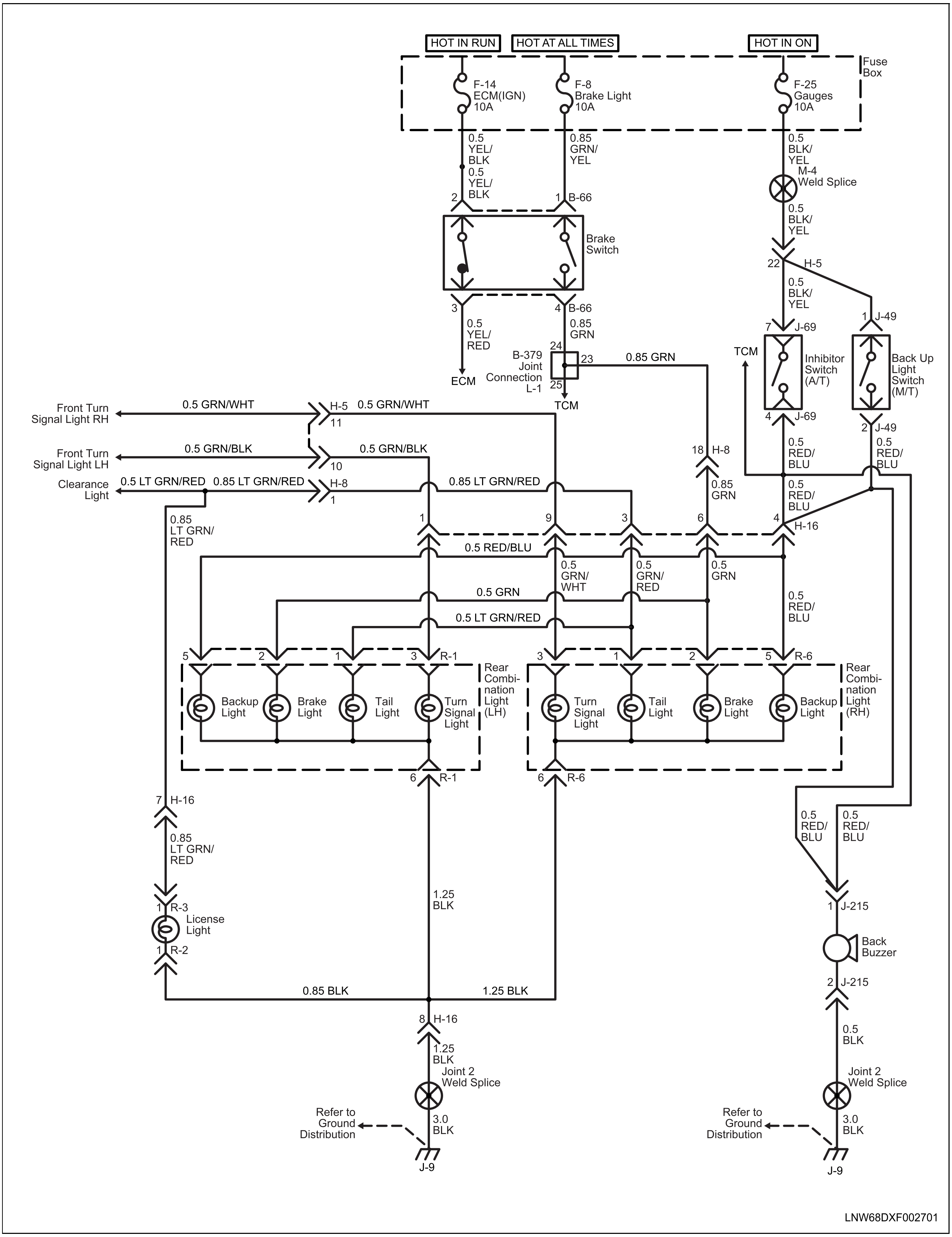
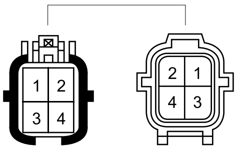
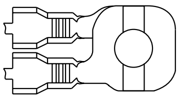
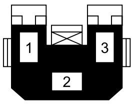
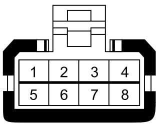
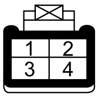
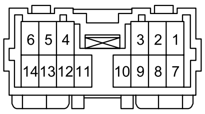
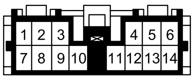
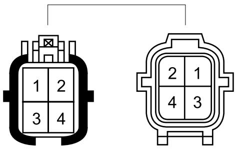
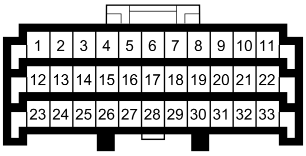
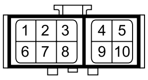
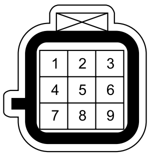
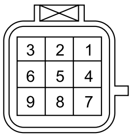
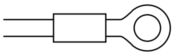
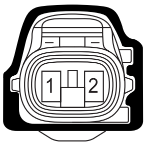
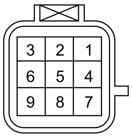
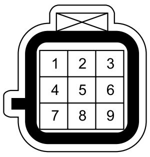
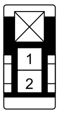
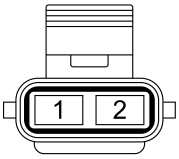
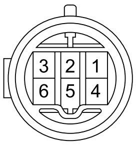
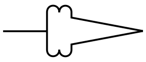
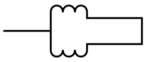
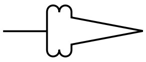
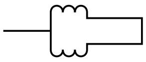
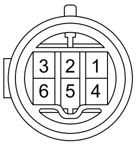
CIRCUIT DIAGRAM



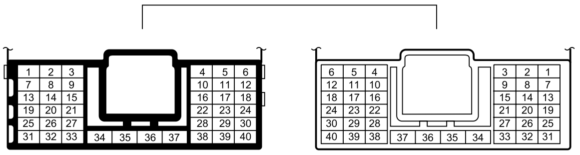

HOT IN RUN
HOT AT ALL TIMES
HOT IN ON
Fuse Box
F-14 ECM(IGN) 10A
F-8 Brake Light 10A
F-25 Gauges 10A
0.5 YEL/ BLK
0.5 YEL/ BLK
0.85 GRN/ YEL
0.5 BLK/ YEL
M-4 Weld Splice
0.5 BLK/ YEL
2
1 B-66
Brake Switch
3
4 B-66
0.5 YEL/ RED
ECM
0.85 GRN
B-379 Joint Connection L-1
24
23
25
TCM
0.85 GRN
22 H-5
0.5 BLK/ YEL
1 J-49
7 J-69
TCM
Inhibitor Switch (A/T)
Back Up Light Switch (M/T)
4 J-69
2 J-49
0.5 RED/ BLU
0.5 RED/ BLU
0.5 RED/ BLU
Front Turn Signal Light RH
0.5 GRN/WHT
H-5 11
0.5 GRN/WHT
Front Turn Signal Light LH
0.5 GRN/BLK
10
0.5 GRN/BLK
Clearance Light
0.5 LT GRN/RED
0.85 LT GRN/RED
H-8 1
0.85 LT GRN/RED
18 H-8
0.85 GRN
0.85 LT GRN/ RED
1
9
3
6
4 H-16
0.5 RED/BLU
0.5 GRN/ WHT
0.5 GRN/ RED
0.5 GRN
0.5 GRN
0.5 LT GRN/RED
0.5 RED/ BLU
5
2
1
3 R-1
3
1
2
5 R-6
Backup Light
Brake Light
Tail Light
Turn Signal Light
Rear Combination Light (LH)
Turn Signal Light
Tail Light
Brake Light
Backup Light
Rear Combination Light (RH)
6 R-1
6 R-6
7 H-16
0.85 LT GRN/ RED
1 R-3
License Light
1 R-2
1.25 BLK
0.85 BLK
1.25 BLK
8 H-16
1.25 BLK
Joint 2 Weld Splice
Refer to Ground Distribution
3.0 BLK
J-9
0.5 RED/ BLU
0.5 RED/ BLU
1 J-215
Back Buzzer
2 J-215
0.5 BLK
Joint 2 Weld Splice
Refer to Ground Distribution
3.0 BLK
J-9
LNW68DXF002701

No.	Connector Face
B-5 (Gray)	 004-016 Front Combination Light (LH)
B-7	 000-007 Ground; Headlight Bracket–RH
B-16 (Black)	 003-020 Flasher Unit
B-30 (White)	 008-016 Hazard Switch
B-66 (Brown)	 004-004 Brake Switch
B-70 (Black)	 014-004 Combination Switch (B)
B-70 (Black)	 014-003 Combination Switch (B)
B-74 (Gray)	 004-016 Front Combination Light (RH)

No.	Connector Face
B-379 (White)	 033-001 Joint Connection – L1
B-381 (White)	 010-015 Joint Connection – M5
H-16 (Black)	 009-001 Frame H. – Rear Body H.
H-16 (Black)	 009-002 Frame H. – Rear Body H.
J-9	 000-012 Ground; Frame–LH (Center)
J-49 (Black)	 002-210 Back Up Light Switch (M/T)
J-69 (Black)	 009-002 Inhibitor Switch (A/T)
J-69 (Black)	 009-001 Inhibitor Switch (A/T)

No.	Connector Face
J-215 (Black)	 002-048 Back Buzzer
J-215 (Black)	 002-163 Back Buzzer
R-1 (White)	 006-036 Rear Combination Light (LH)
R-2	 000-026 License Plate Light
R-2	 000-025 License Plate Light
R-3	 000-026 License Plate Light
R-3	 000-025 License Plate Light
R-6 (White)	 006-036 Rear Combination Light (RH)

H-5 Body H. – Frame H. (Gray)



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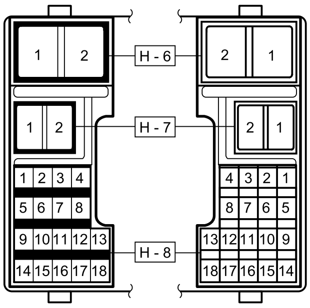
H-8 Body H. – Frame H. (Gray)



LNW38ASH018801

Diagnosis

1. TURN SIGNAL LIGHT, HAZARD WARNING LIGHT

Check Point Trouble Mode	Fuse		Turn Signal Light Switch	Hazard Warning Light Switch	Flasher Unit	Turn signal Light Bulb	Cable Harness
	F-18 (20A)	F-13 (10A)					
1-1. Turn signal lights inoperative		○ (1)	○ (3)		○ (2)		○ (4)
1-2. Turn signal lights flashes too quickly						○ (1)	○ (2)
1-3. Hazard warning lights inoperative	○ (1)			○ (2)			

NOTE: Figure in parenthesis "( )" indicates the order of inspection.

2. BRAKELIGHT

Check Point Trouble Mode	Fuse F-8 (10A)	Brake Switch	Brakelight Bulb	Cable Harness
2-1. Both brakelights inoperative	○ (1)	○ (2)		○ (3)
2-2. Brakelight on the left (or right) side inoperative			○ (1)	○ (2)

NOTE: Figure in parenthesis "( )" indicates the order of inspection.

3. CLEARANCE LIGHT, TAIL LIGHT, LICENSE PLATE LIGHT

Check Point Trouble Mode	Fuse	Lighting Switch	Taillight Bulb	Clearance Light Bulb	License Plate Light Bulb	Cable Harness
	F-7 (10A)					
3-1. Both clearance lights inoperative	○ (1)	○ (3)		○ (2)		○ (4)
3-2. Clearance light on the left (or right) side inoperative				○ (1)		○ (2)
3-3. Both taillights inoperative	○ (1)	○ (2)				○ (3)
3-4. Taillight on the left (or right) side inoperative			○ (1)			○ (2)
3-5. License plate light inoperative					○ (1)	○ (2)

ID: Identification
NOTE: Figure in parenthesis “( )” indicates the order of inspection.

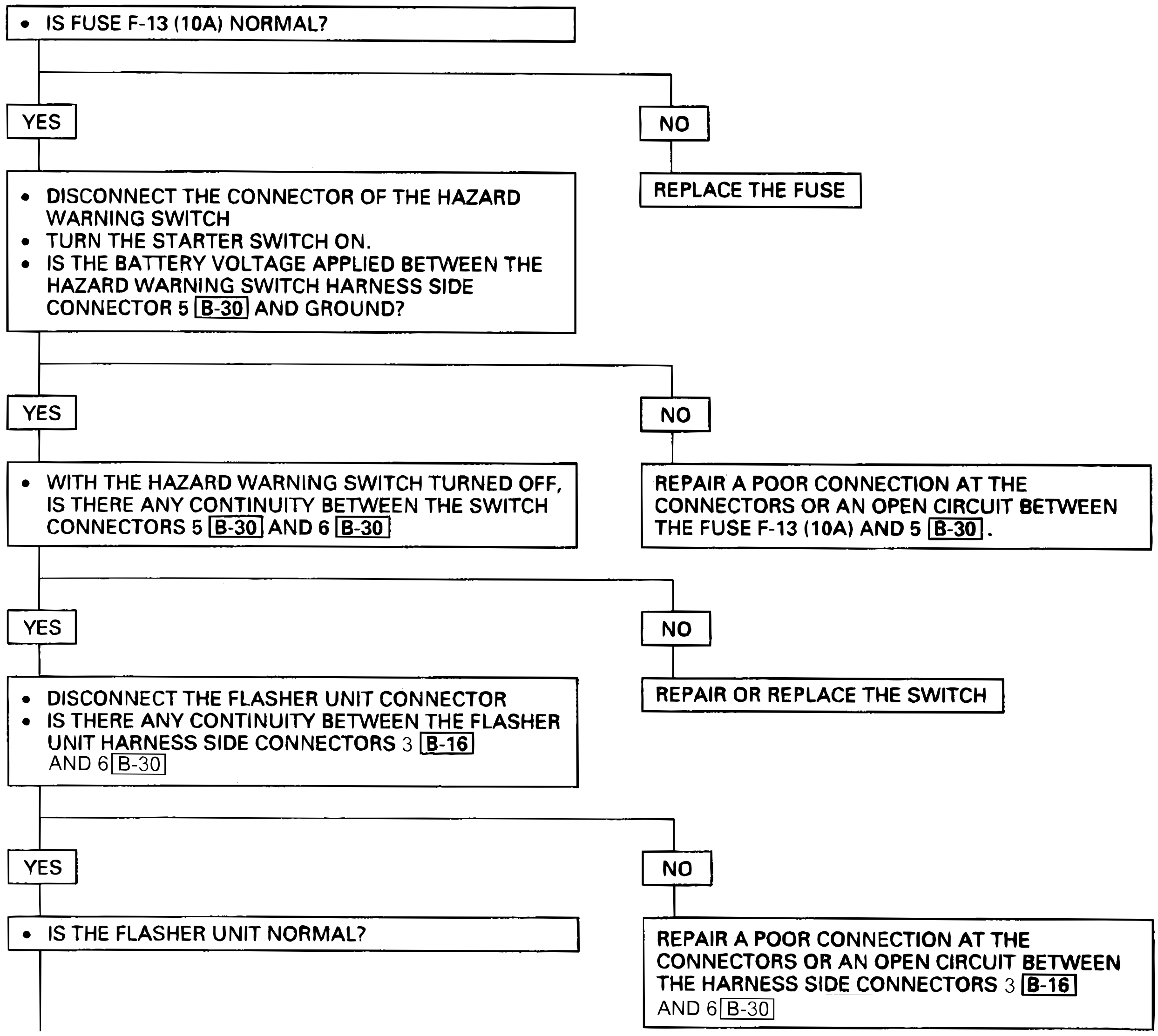
4. BACK UP LIGHT

Check Point / Trouble Mode	Fuse F-25 (10A)	Back up Light Switch (Inhibitor Switch)	Back up Light Bulb	Cable Harness
4-1. Both back up lights inoperative	○ (1)	○ (3)		○ (2)
4-2. Back up light on the left (or right) side inoperative			○ (1)	○ (2)
4-3. Back up light remains on		○ (1)		

NOTE: Figure in parenthesis “( )” indicates the order of inspection.

1. Turn Signal Light, Hazard Warning Light

1-1. TURN SIGNAL LIGHTS INOPERATIVE



- IS FUSE F-13 (10A) NORMAL?

YES

- DISCONNECT THE CONNECTOR OF THE HAZARD WARNING SWITCH
- TURN THE STARTER SWITCH ON.
- IS THE BATTERY VOLTAGE APPLIED BETWEEN THE HAZARD WARNING SWITCH HARNESS SIDE CONNECTOR 5 B-30 AND GROUND?

NO

REPLACE THE FUSE

YES

- WITH THE HAZARD WARNING SWITCH TURNED OFF, IS THERE ANY CONTINUITY BETWEEN THE SWITCH CONNECTORS 5 B-30 AND 6 B-30

NO

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN THE FUSE F-13 (10A) AND 5 B-30.

YES

- DISCONNECT THE FLASHER UNIT CONNECTOR
- IS THERE ANY CONTINUITY BETWEEN THE FLASHER UNIT HARNESS SIDE CONNECTORS 3 B-16 AND 6 B-30

NO

REPAIR OR REPLACE THE SWITCH

YES

- IS THE FLASHER UNIT NORMAL?

NO

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN THE HARNESS SIDE CONNECTORS 3 B-16 AND 6 B-30

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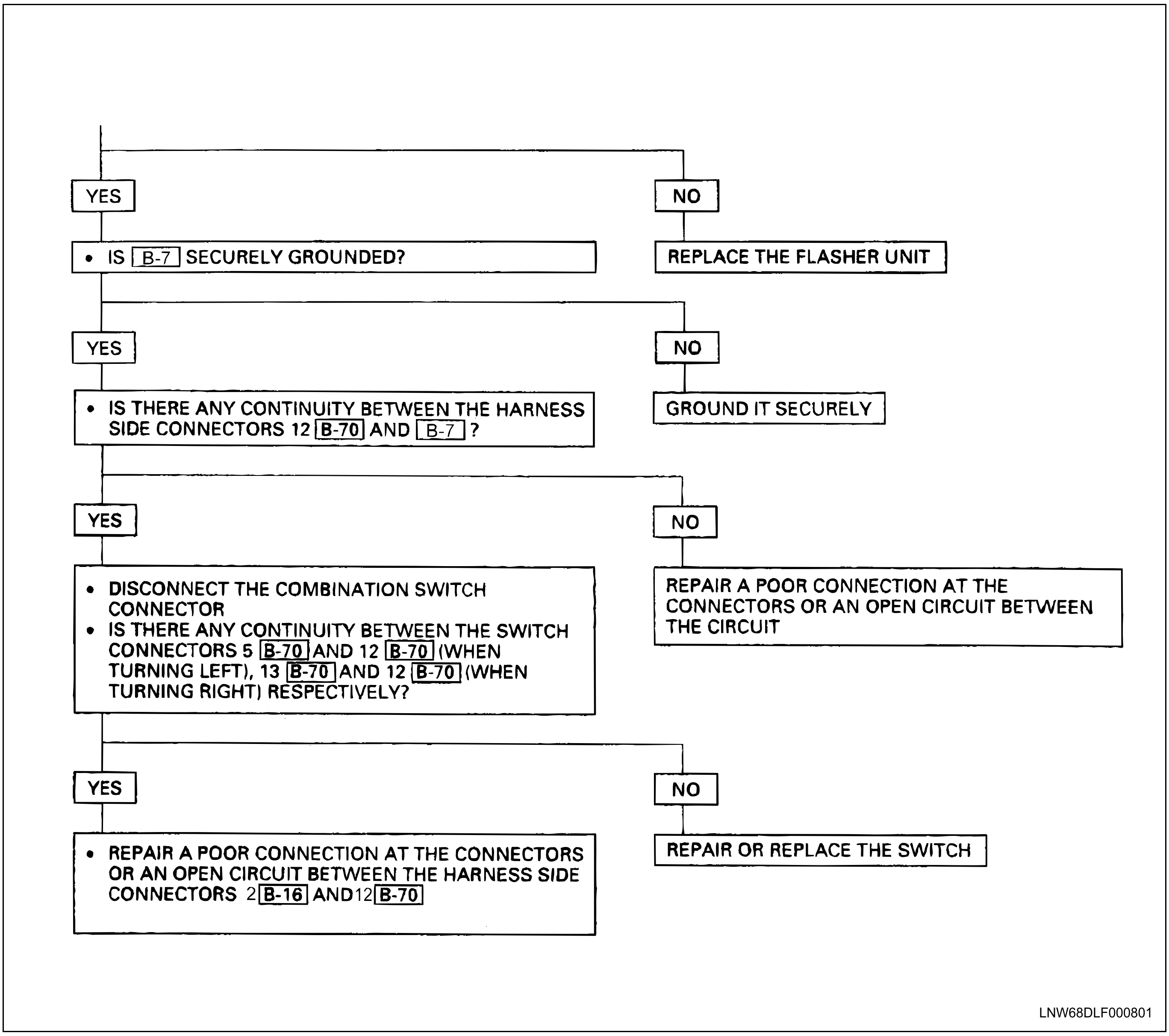
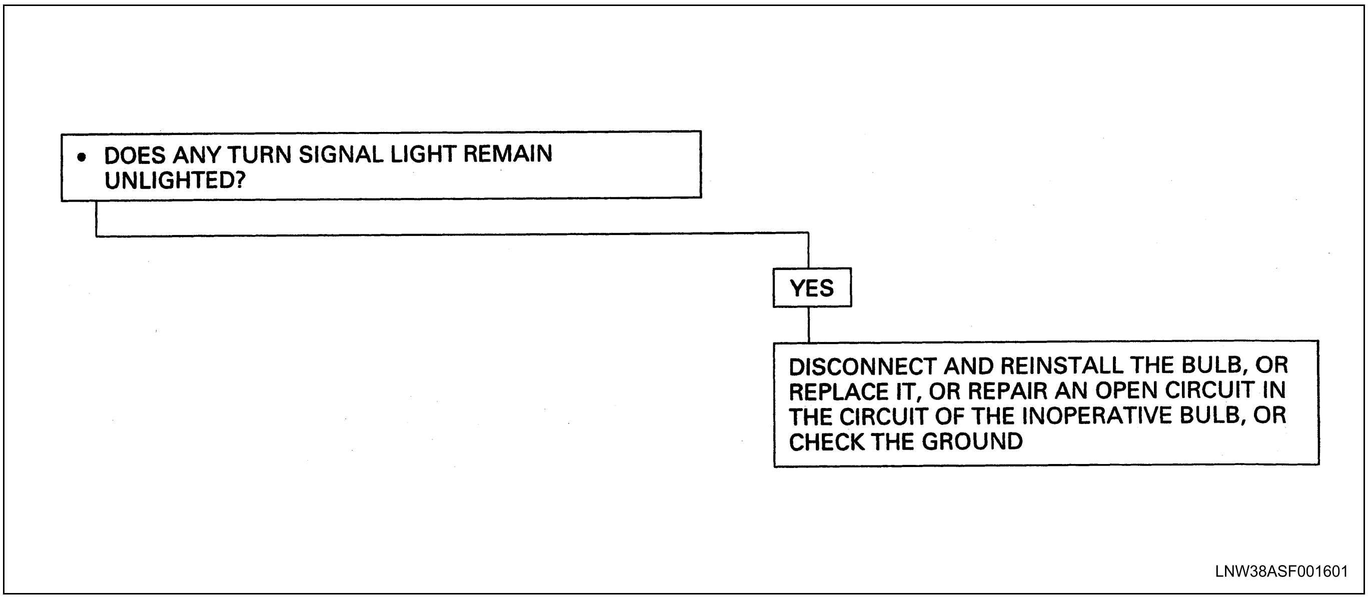
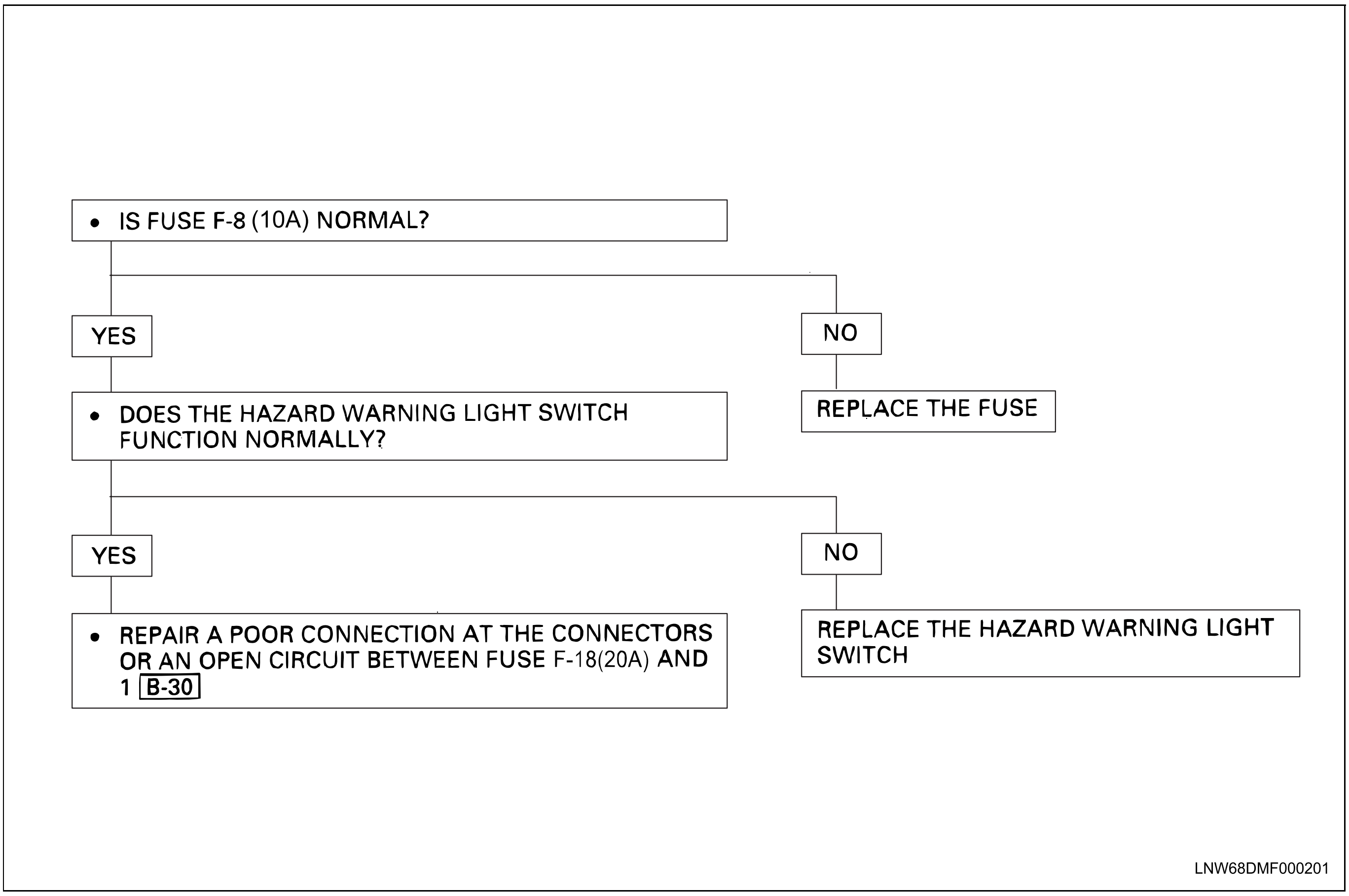


1-2. TURN SIGNAL LIGHTS FLASHES TOO QUICKLY

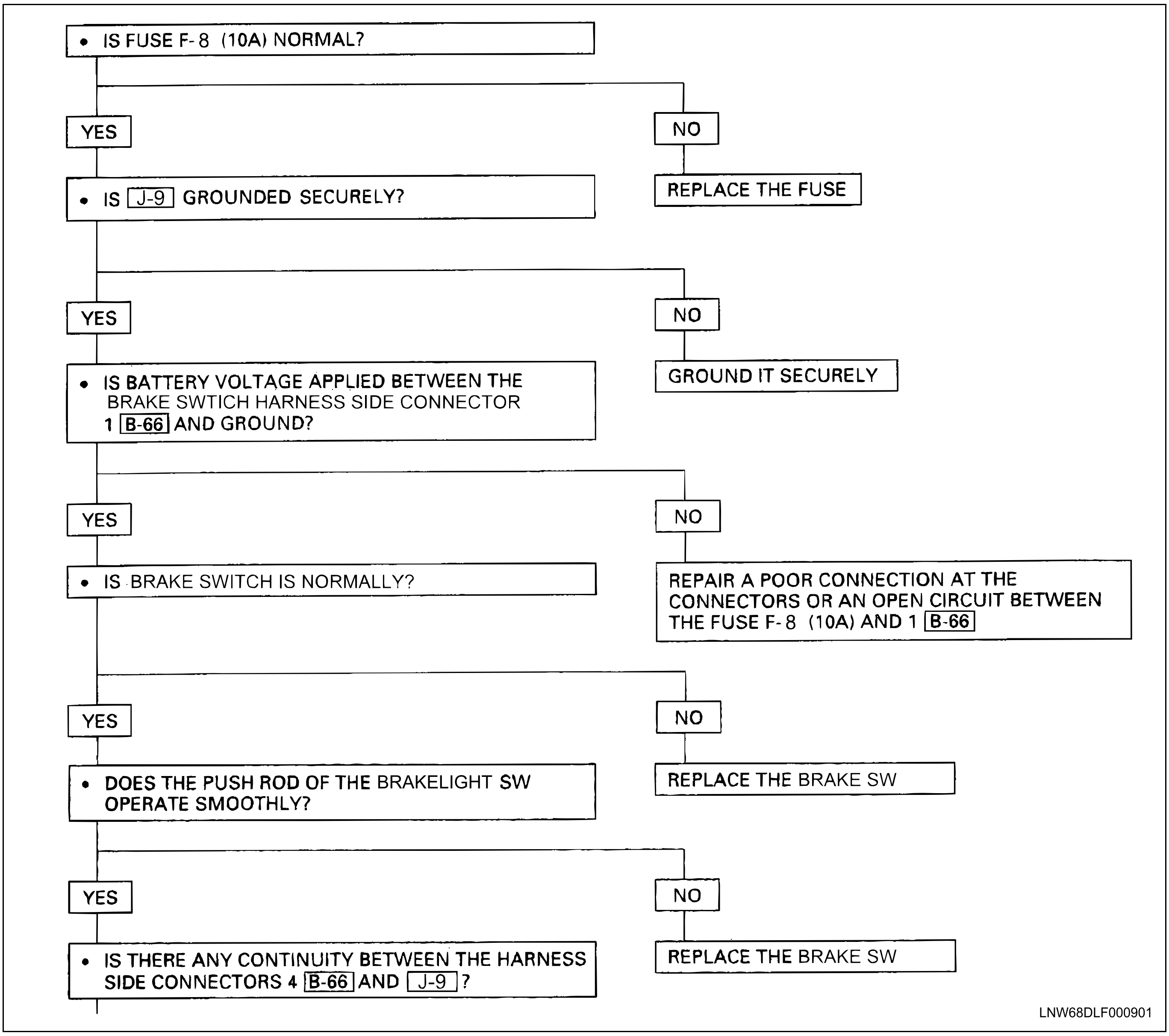


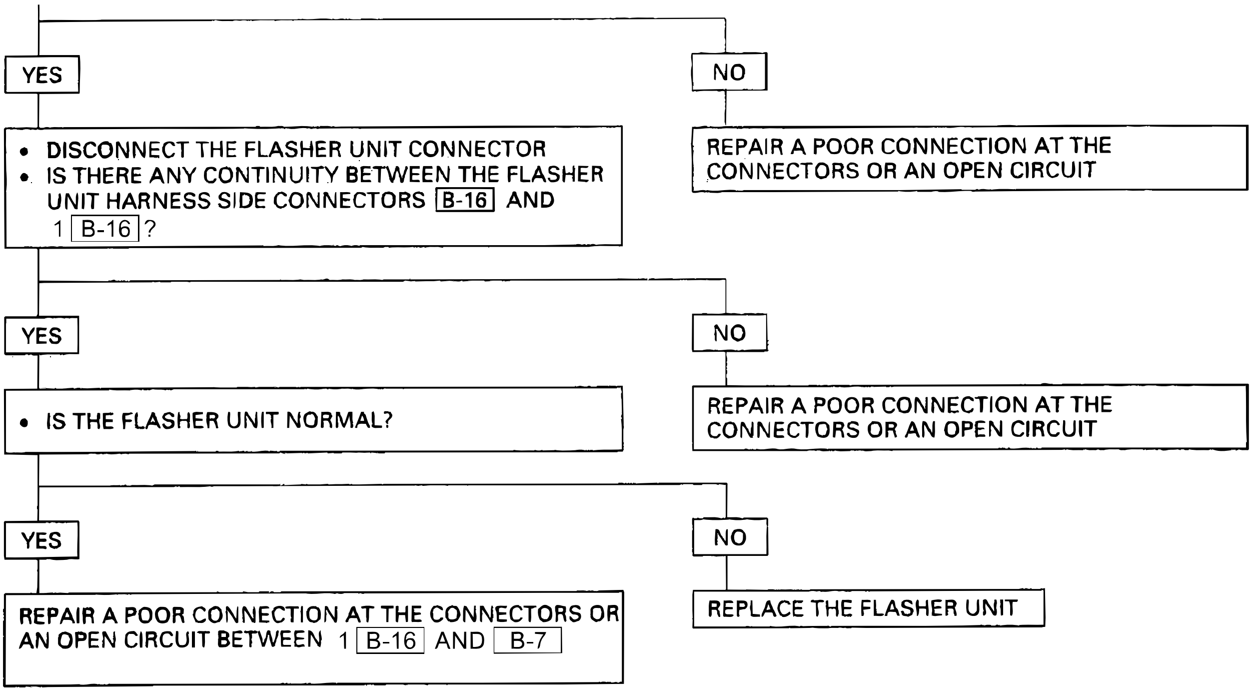
1-3. HAZARD WARNING LIGHTS INOPERATIVE



2. Brakelight

2-1. BOTH BRAKELIGHTS INOPERATIVE





- DISCONNECT THE FLASHER UNIT CONNECTOR
- IS THERE ANY CONTINUITY BETWEEN THE FLASHER UNIT HARNESS SIDE CONNECTORS B-16 AND 1 B-16 ?

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT

- IS THE FLASHER UNIT NORMAL?

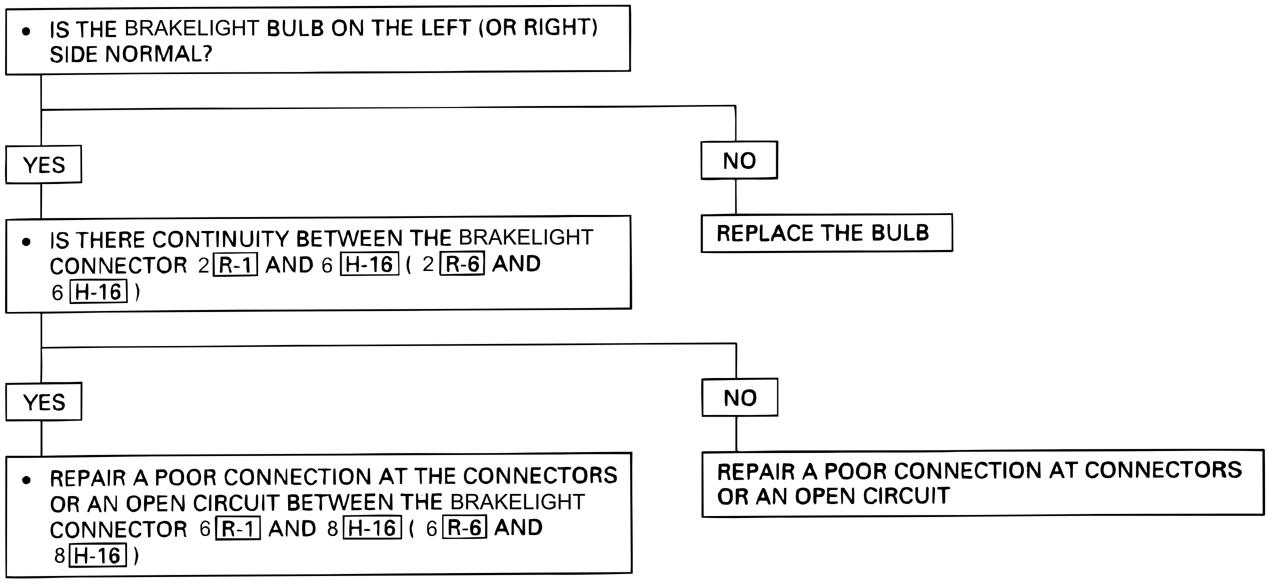
REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN 1 B-16 AND B-7

REPLACE THE FLASHER UNIT

LNW68DLF001001

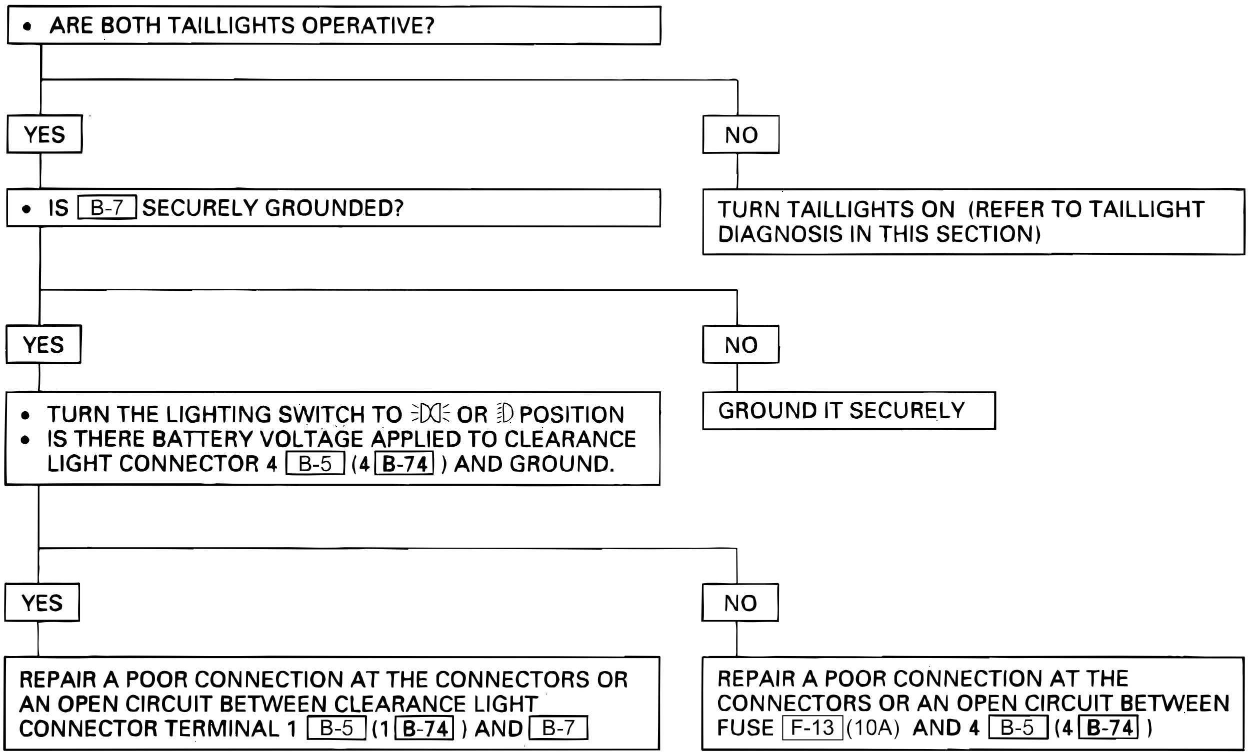
2-2. BRAKELIGHT ON THE LEFT (OR RIGHT) SIDE INOPERATIVE



LNW68DMF000301

NOTE: Figure in parenthesis "( )" indicate the place of inspection for the right side brakelight.

3-1. BOTH CLEARANCE LIGHTS INOPERATIVE



- ARE BOTH TAILLIGHTS OPERATIVE?

YES

- IS B-7 SECURELY GROUNDED?

NO

TURN TAILLIGHTS ON (REFER TO TAILLIGHT DIAGNOSIS IN THIS SECTION)

YES

- TURN THE LIGHTING SWITCH TO ≡DC≡ OR ≡D POSITION
- IS THERE BATTERY VOLTAGE APPLIED TO CLEARANCE LIGHT CONNECTOR 4 B-5 (4 B-74) AND GROUND.

NO

GROUND IT SECURELY

YES

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN CLEARANCE LIGHT CONNECTOR TERMINAL 1 B-5 (1 B-74) AND B-7

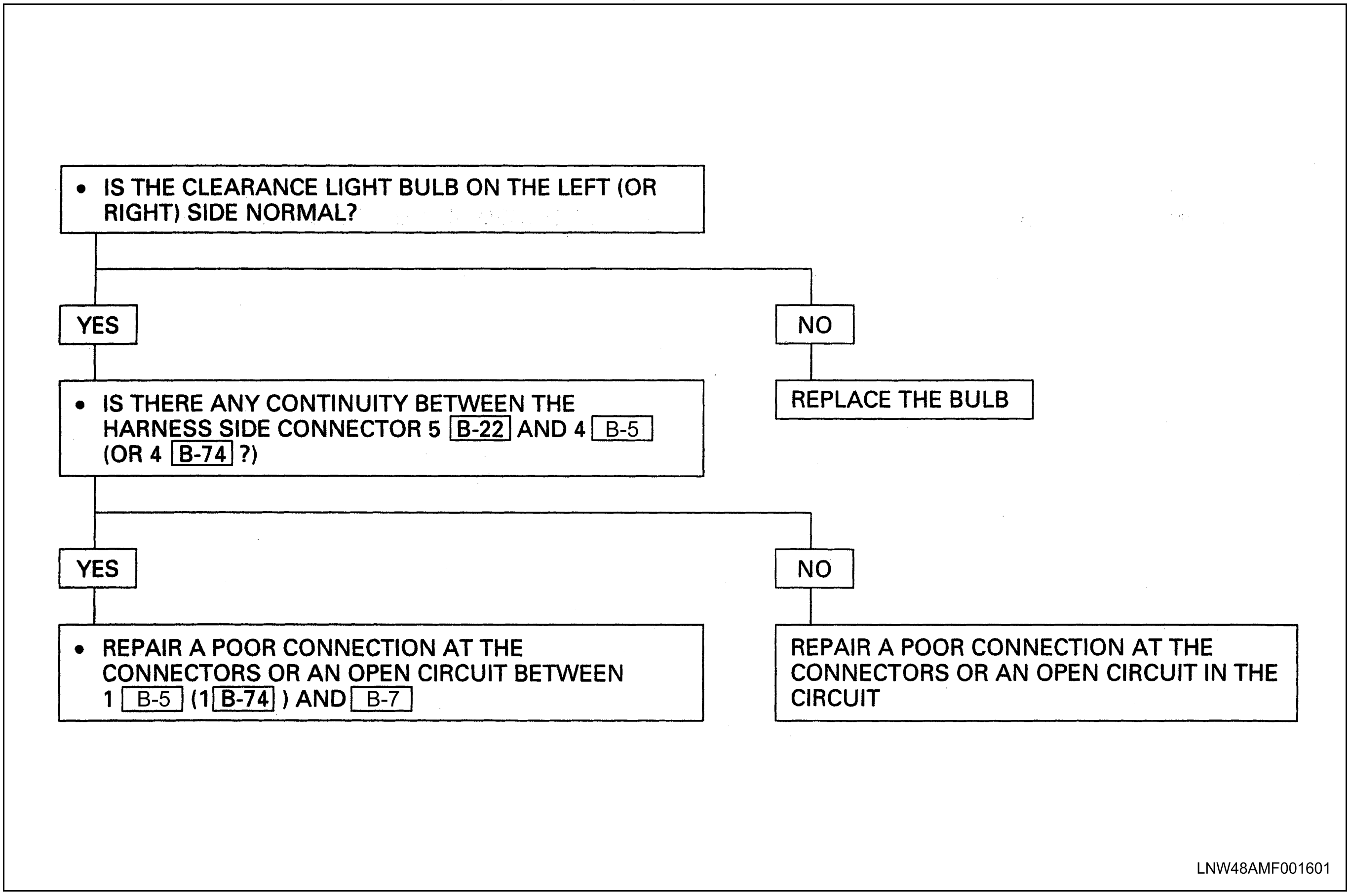
NO

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN FUSE F-13 (10A) AND 4 B-5 (4 B-74)

LNW68DMF000401

NOTE: Figure in parenthesis “( )” indicates place of inspection for clearance light the right side.

3-2. CLEARANCE LIGHT ON THE LEFT (OR RIGHT) SIDE INOPERATIVE



- IS THE CLEARANCE LIGHT BULB ON THE LEFT (OR RIGHT) SIDE NORMAL?

YES

- IS THERE ANY CONTINUITY BETWEEN THE HARNESS SIDE CONNECTOR 5 B-22 AND 4 B-5 (OR 4 B-74 ?)

YES

- REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN 1 B-5 (1 B-74) AND B-7

NO

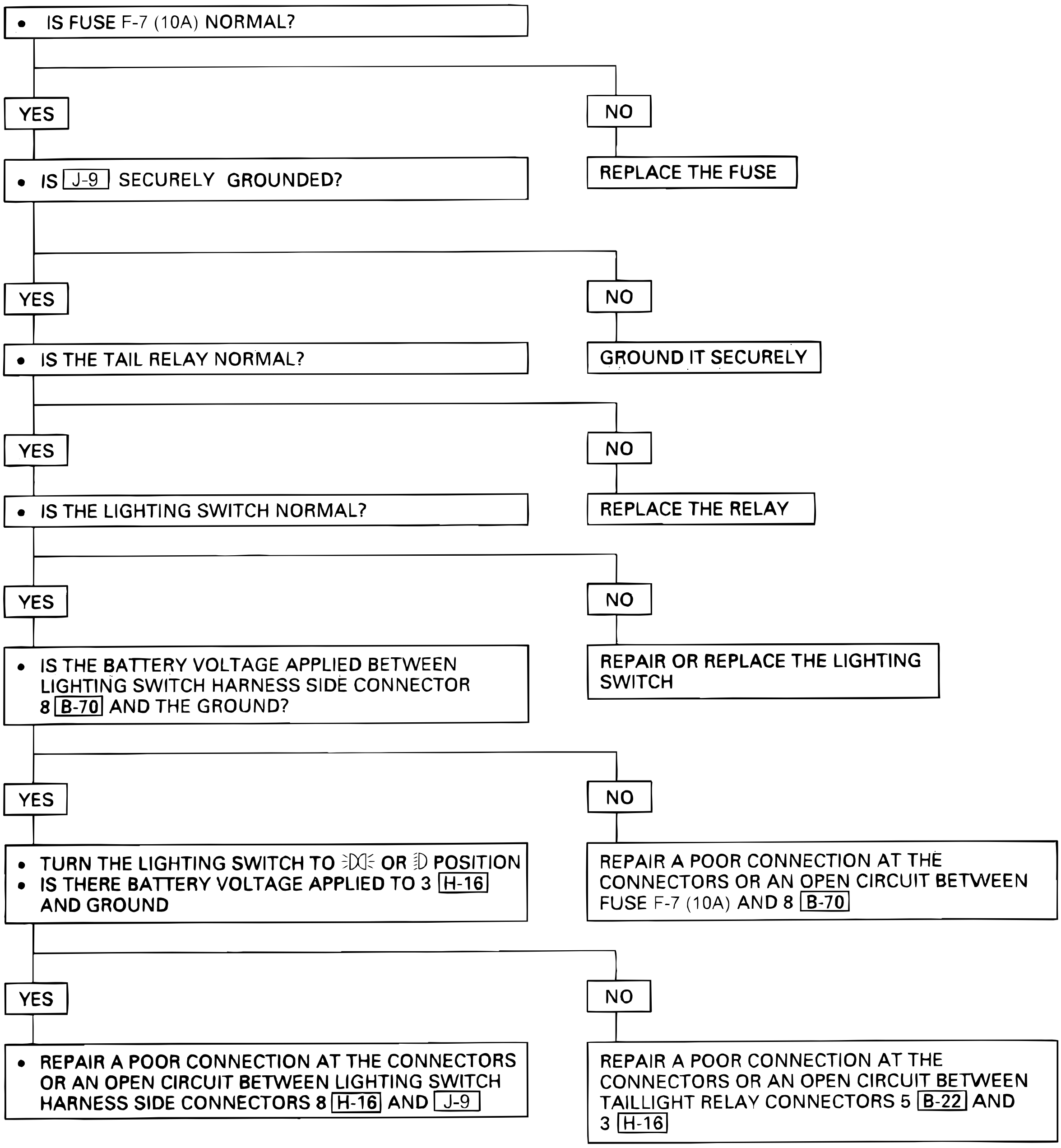
REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT IN THE CIRCUIT

NO

REPLACE THE BULB

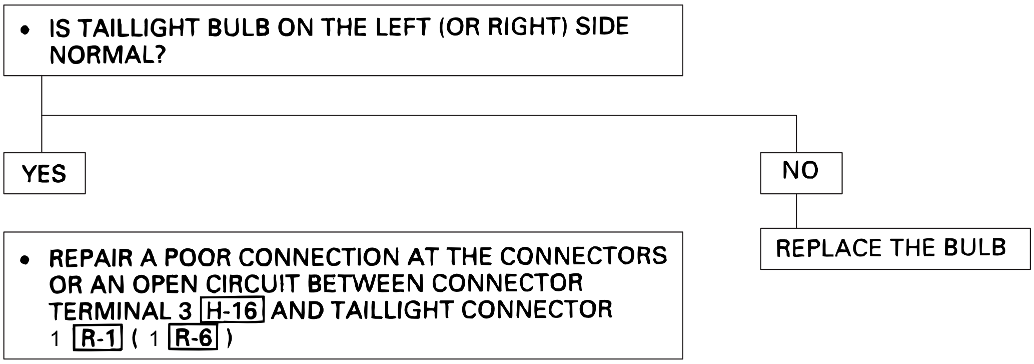
NOTE: Figure in parenthesis "( )" indicates place of inspection for clearance light the right side.

3-3. BOTH TAILLIGHTS INOPERATIVE



LNW68DXF006001

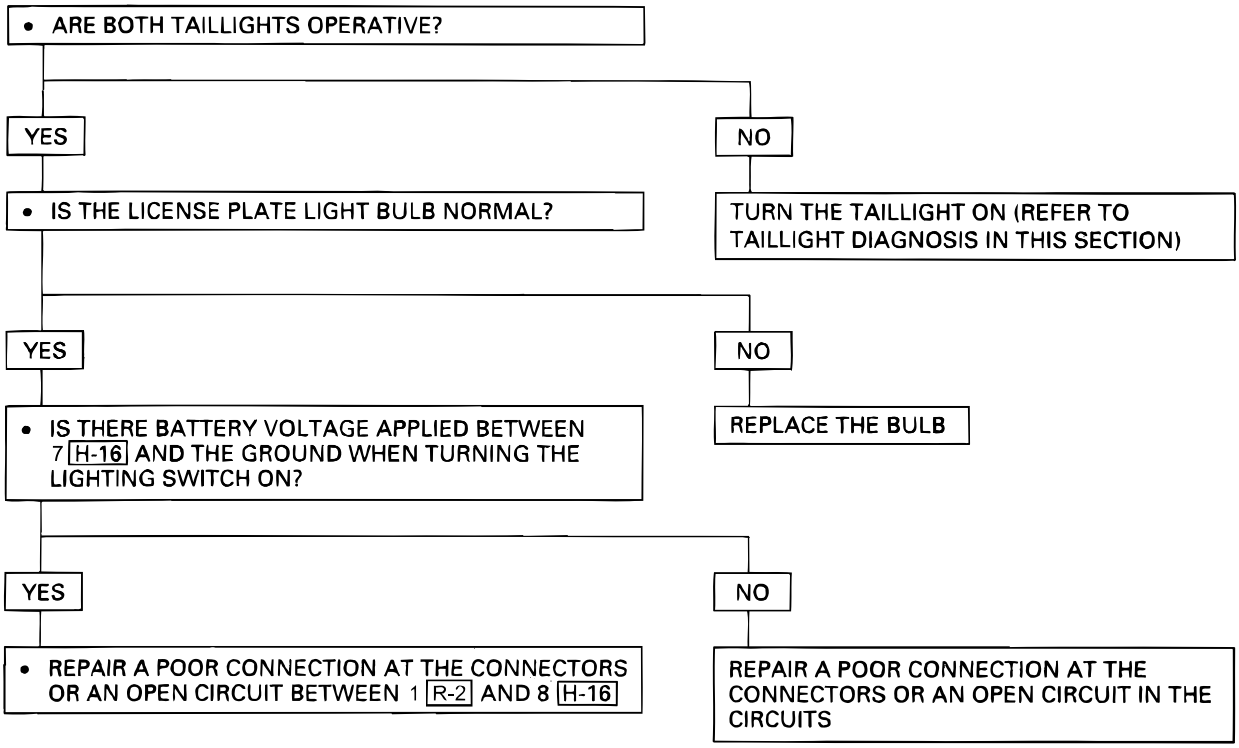
3-4. TAILLIGHT ON THE LEFT (OR RIGHT) SIDE INOPERATIVE



LNW68DSF000201

NOTE: Figure in parenthesis "( )" indicates place of inspection for taillight the right side.

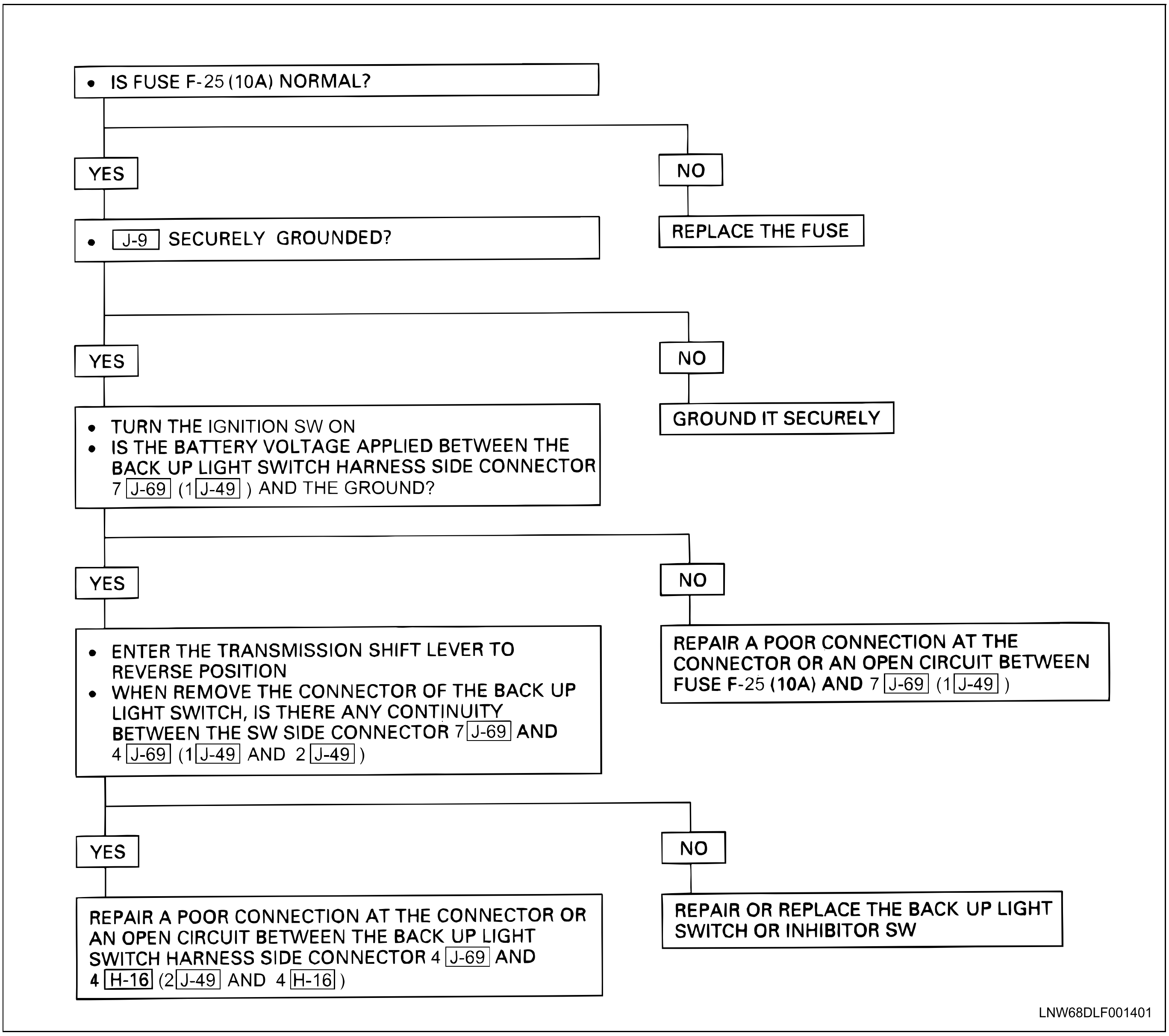
3-5. LICENSE PLATE LIGHT INOPERATIVE



LNW68DMF000501

4. Back up Light

4-1. BACK UP LIGHTS INOPERATIVE



- IS FUSE F-25 (10A) NORMAL?

NO: REPLACE THE FUSE

YES:

- J-9 SECURELY GROUNDED?

NO: GROUND IT SECURELY

YES:

- TURN THE IGNITION SW ON
- IS THE BATTERY VOLTAGE APPLIED BETWEEN THE BACK UP LIGHT SWITCH HARNESS SIDE CONNECTOR 7 J-69 (1 J-49) AND THE GROUND?

NO: REPAIR A POOR CONNECTION AT THE CONNECTOR OR AN OPEN CIRCUIT BETWEEN FUSE F-25 (10A) AND 7 J-69 (1 J-49)

YES:

- ENTER THE TRANSMISSION SHIFT LEVER TO REVERSE POSITION
- WHEN REMOVE THE CONNECTOR OF THE BACK UP LIGHT SWITCH, IS THERE ANY CONTINUITY BETWEEN THE SW SIDE CONNECTOR 7 J-69 AND 4 J-69 (1 J-49 AND 2 J-49)

NO: REPAIR OR REPLACE THE BACK UP LIGHT SWITCH OR INHIBITOR SW

YES: REPAIR A POOR CONNECTION AT THE CONNECTOR OR AN OPEN CIRCUIT BETWEEN THE BACK UP LIGHT SWITCH HARNESS SIDE CONNECTOR 4 J-69 AND 4 H-16 (2 J-49 AND 4 H-16)

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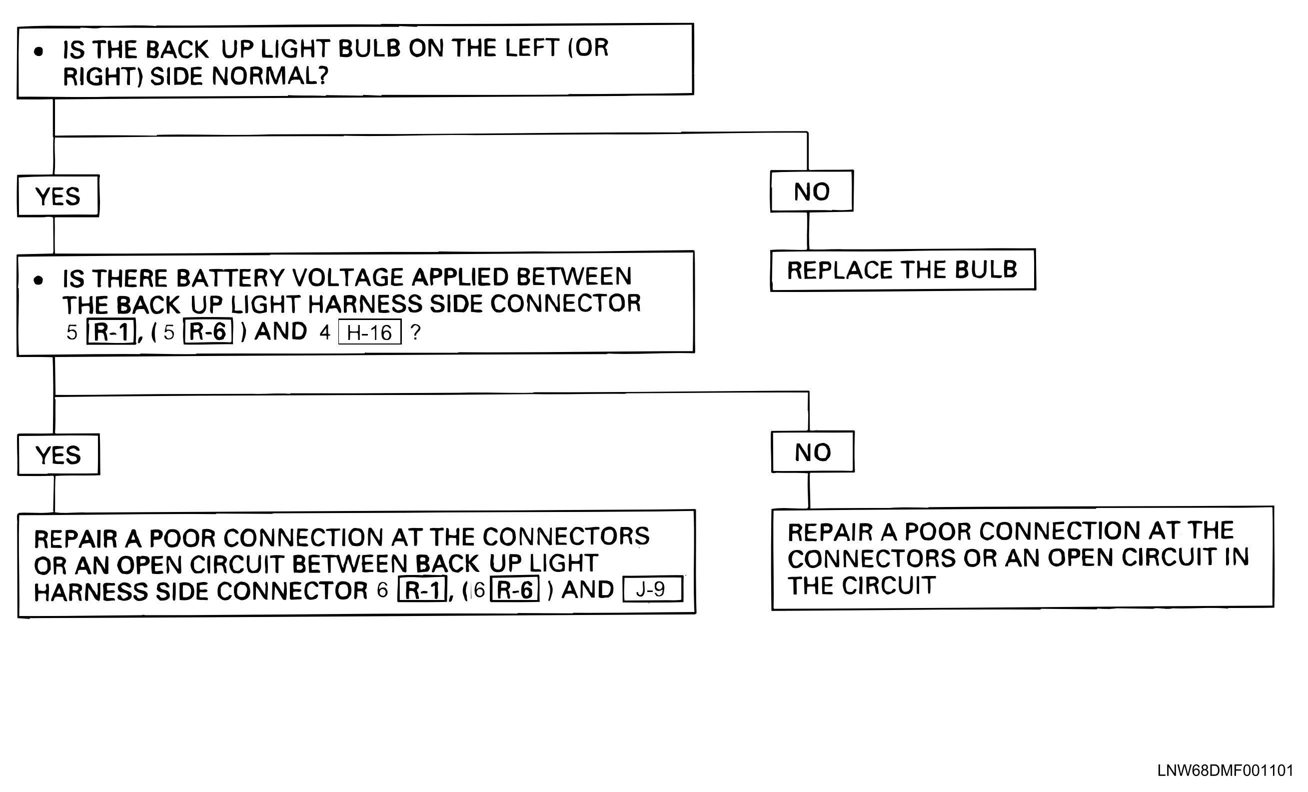
4-2. BACK UP LIGHT ON THE LEFT (OR RIGHT) SIDE INOPERATIVE



4-3. BACK UP LIGHT REMAINS ON

REPAIR OR REPLACE THE BACK UP LIGHT Switch OR INHIBITOR Switch

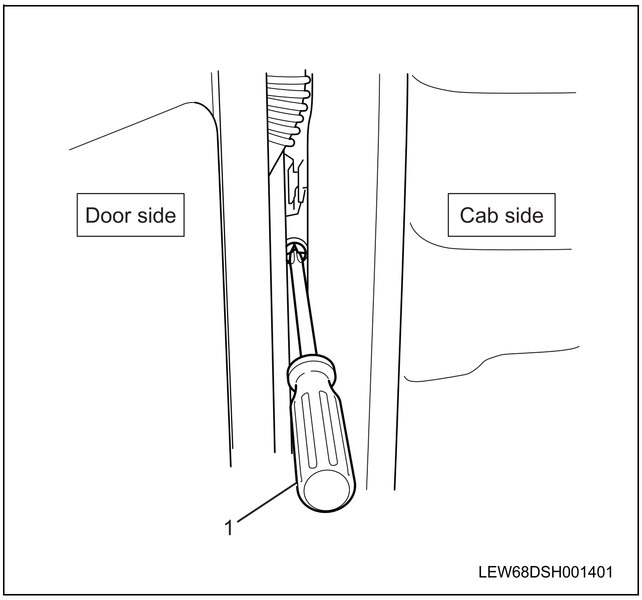
IGNITION SWITCH

Refer to “Start and Charging” in this section.

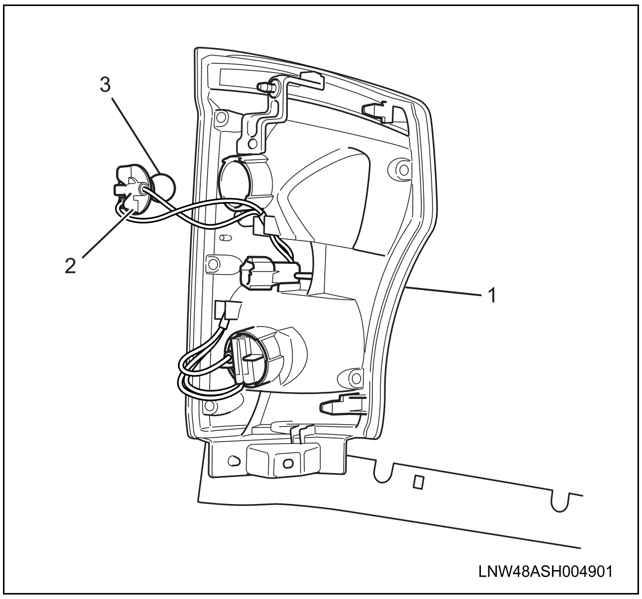
Front Turn Signal Light/bulb

Removal

1. Remove the battery ground cable at the battery.
2. Remove the front combination light.
   - Open the cab door. Insert a screwdriver (1) into the space between the cab and the cab door. Use the screwdriver to force out the stud pin at the center of the grommet (the pin securing the front combination light).



   - Remove the fixing screw.
   - Remove the two catches.
   - Remove the front combination light (1) connector.



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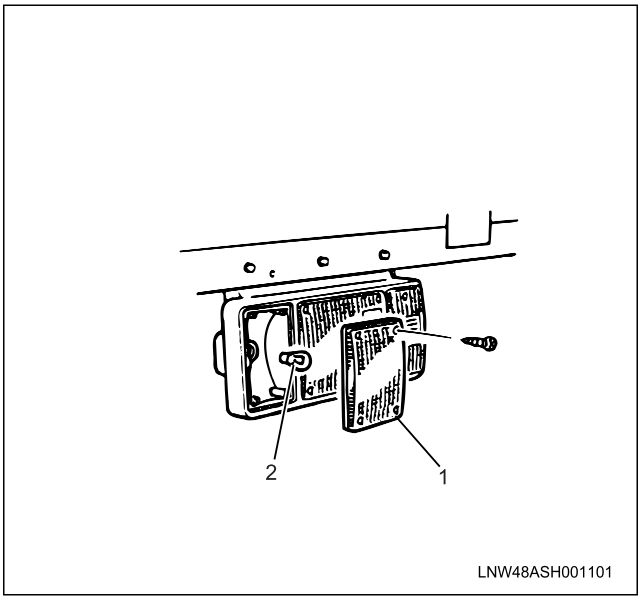
3. Remove the front turn signal light bulb.
    - Turn the bulb socket (2) to the left to remove it.
    - Press the bulb (3) in and turn it to the left to remove it from the socket.

Installation

Follow the removal procedure in the reverse order.

2. Bulb



LNW48ASH001101

Legend

1. Lens
2. Bulb

Install or Connect

To install, follow the removal steps in the reverse order.

Rear Turn Signal Light/bulb

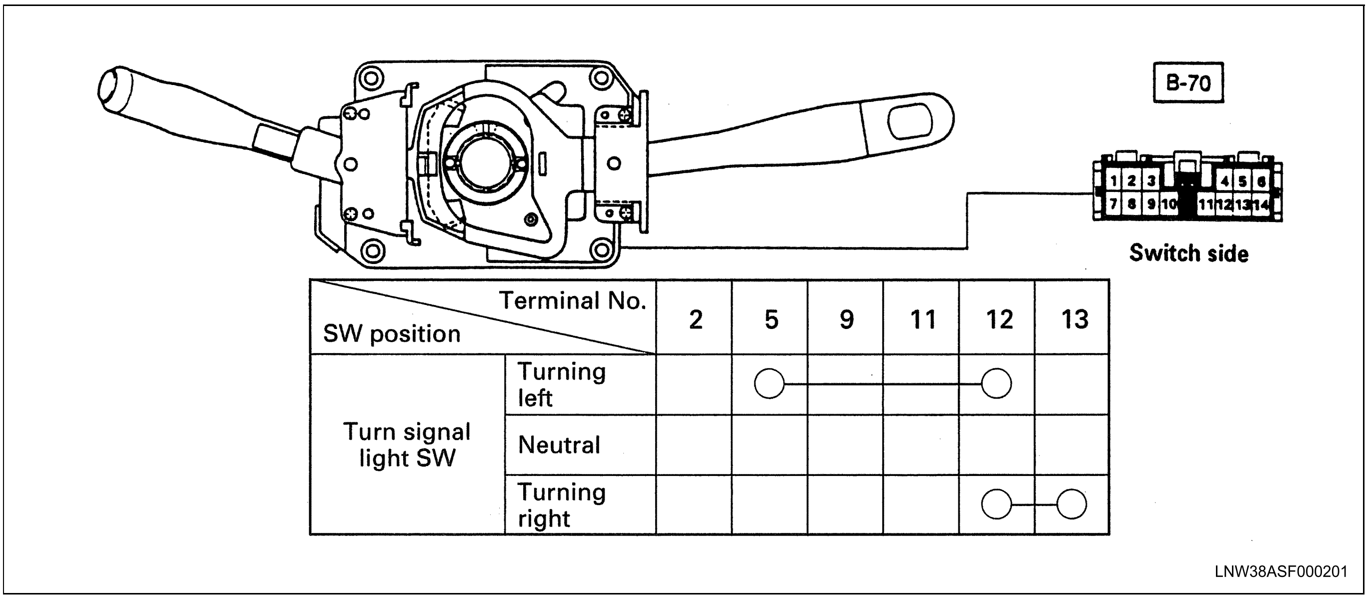
Preparation: Disconnect the battery ground cable.

1. Lens
2. Bulb

TURN SIGNAL LIGHT SWITCH (COMBINATION SWITCH)

Inspect

Check the continuity between the terminals of the turn signal light switch.
Repair or replace the switch when the result of inspection is found abnormal.



SW position \ Terminal No.		2	5	9	11	12	13
Turn signal light SW	Turning left		○	—	—	○	
	Neutral						
	Turning right					○	○

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Remove or Disconnect

Refer to “Headlight and Cornering Light” in this section.

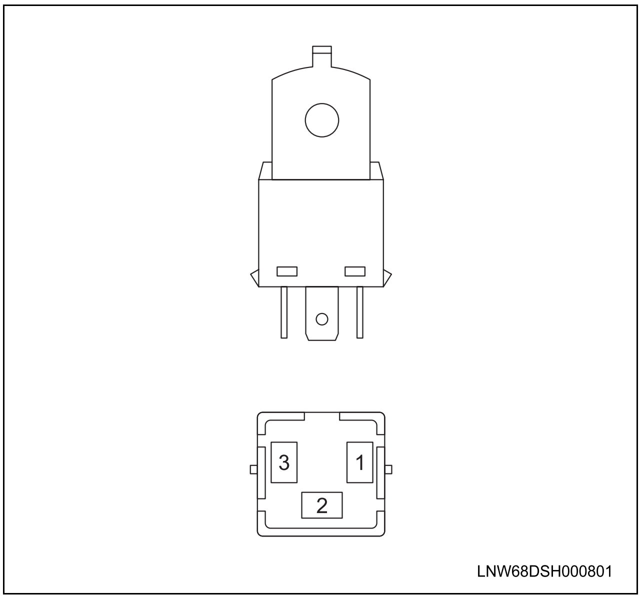
Install or Connect

Refer to “Headlight and Cornering Light” in this section.

FLASHER UNIT

Inspect

It is check whether the current intermittently flows to terminal 2 when voltage (12V) of the battery is applied to terminal 1.
Replace the unit when the result of inspection is found abnormal.



BRAKELIGHT BULB

Remove or Disconnect

Refer to “Front Combination Light, Rear Combination Light and License Plate Light” for TAILLIGHT BULB removal and installation steps in this section.

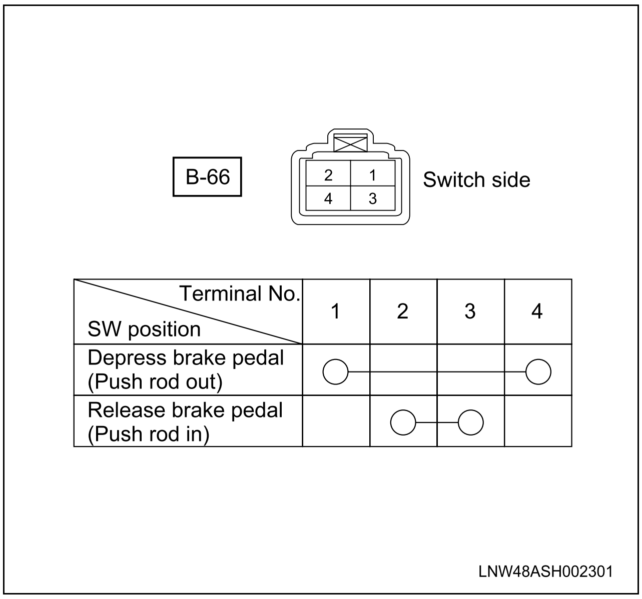
Install or Connect

Refer to “Front Combination Light, Rear Combination Light and License Plate Light” for TAILLIGHT BULB removal and installation steps in this section.

BRAKE SWITCH

Inspect

- Check to see if the brake switch is installed correctly to the specified position. Adjust the position when the result of the inspection is found abnormal.
- Check to see if there is any continuity between the terminals of the brakelight switch. Replace the switch when the result of inspection is found abnormal.

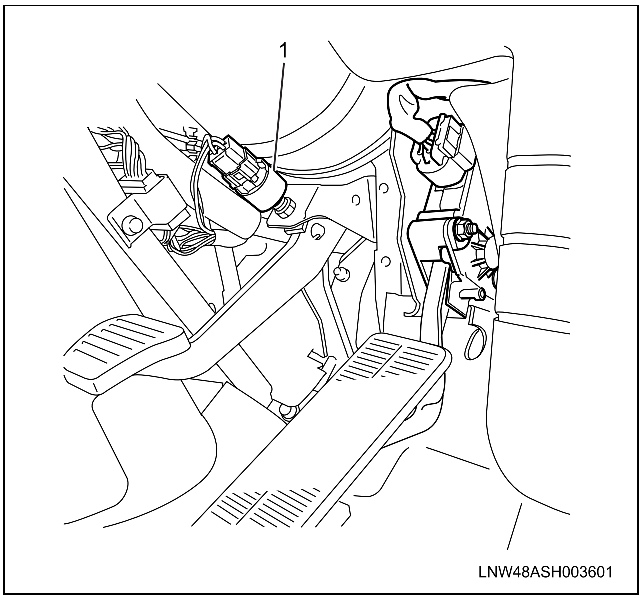


Terminal No. SW position	1	2	3	4
Depress brake pedal (Push rod out)	○	─	─	○
Release brake pedal (Push rod in)		○	○	

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Brake switch
   - Disconnect the connector.
   - Loosen the lock nut of the switch.
   - Remove the switch by turning it.



Legend

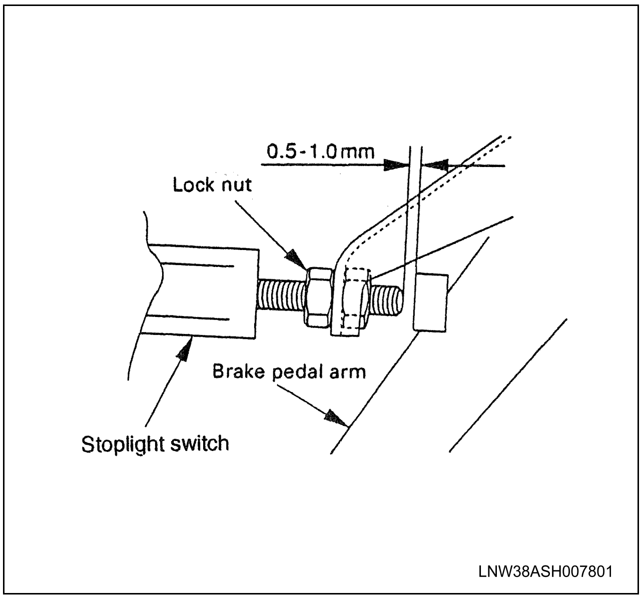
1. Brake Switch

Install or Connect

To install, follow the removal steps in the reverse order, noting the following points:
Check Brake Switch

- Check to see if the brake pedal has been returned by the return spring to the specified position.
- Turn the brake switch clockwise until the tip of the threaded portion of the switch contacts the pedal arm.

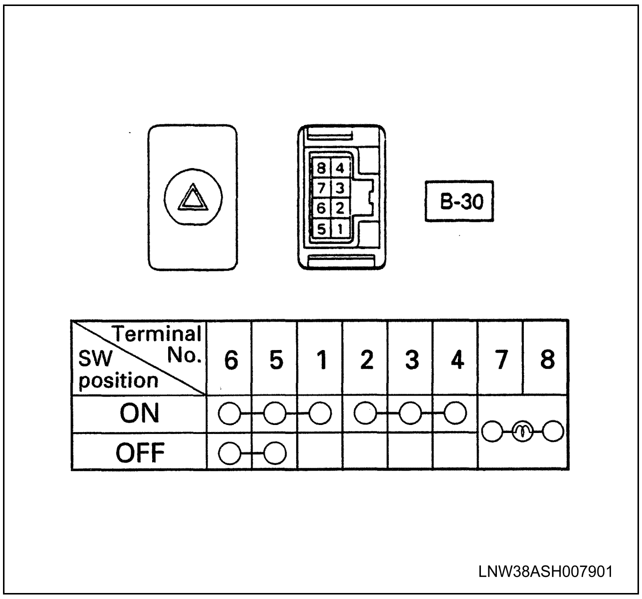
- Turn the switch counterclockwise until the space between the tip of the threaded portion and the pedal arm is 0.5 to 1.0 mm (0.02 – 0.04in.)



HAZARD WARNING SWITCH

Inspect

Check the continuity between the terminals of the hazard warning switch.
Repair or replace the switch when the result of inspection is found abnormal.

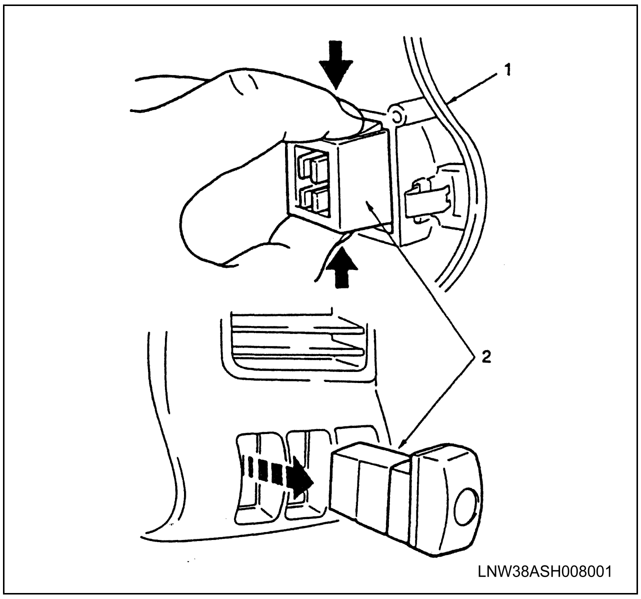


Terminal No. / SW position	6	5	1	2	3	4	7	8
ON	○—	—○—	—○	○—	—○—	—○	○—Ⓡ—	—○
OFF	○—	—○						

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Instrument Panel Cluster Bezel
   Refer to the “Instrument Panel Cluster and Warning/Indicator Light” in this section.
2. Hazard warning switch
   Release the lock pushing the switch from the back side of the meter cluster.



Legend

1. Instrument Panel Cluster Bezel
2. Hazard Warning Switch

This illustration is based on the dome light switch

Install or Connect

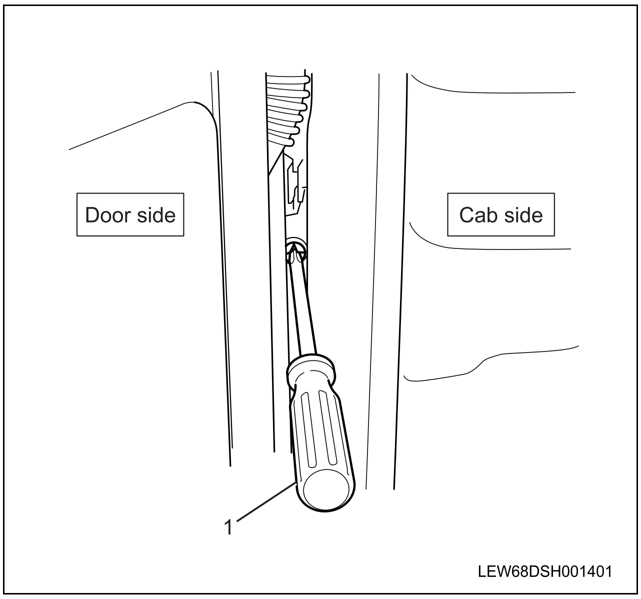
To install, follow the removal steps in the reverse order noting the following point:

1. Push the switch with your fingers until locks securely.

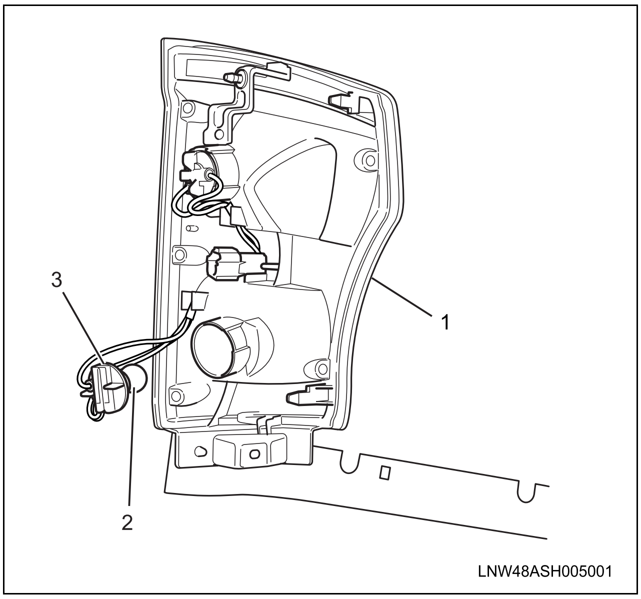
CLEARANCE LIGHT/BULB

Removal

1. Remove the battery ground cable at the battery.
2. Remove the front combination light.
   - Open the cab door. Insert a screwdriver (1) into the space between the cab and the cab door. Use the screwdriver to force out the stud pin at the center of the grommet (the pin securing the front combination light).



- Remove the fixing screw.
- Remove the two catches.
- Remove the front combination light (1) connector.



3. Remove the clearance light bulb.
   - Turn the bulb socket (3) to the left to remove it.
   - Press the bulb (2) in and turn it to the left to remove it from the socket.

Installation

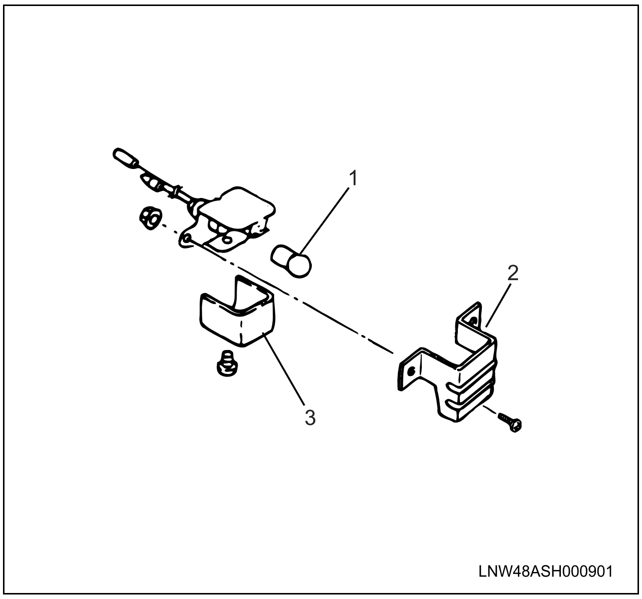
Follow the removal procedure in the reverse order.

Install or Connect

To install, follow the removal steps in the reverse order.

TAILLIGHT BULB, LICENSE PLATE LIGHT BULB (LH)

Remove or Disconnect



Legend

1. Bulb
2. Cover
3. Lens

Install or Connect

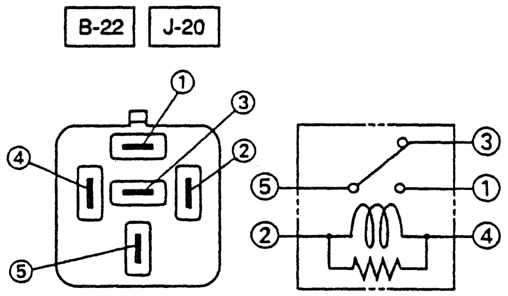
To install, follow the removal steps in the reverse order.

TAIL RELAY, IDENTIFICATION LIGHT RELAY

Install or Connect

Check to see if there is any continuity between the relay terminals.
Replace the relay when the result of inspection is found abnormal.

(3) – (5)	Continuity
(1) – (5)	No continuity
(When battery voltage is applied between (2) – (4))	
(3) – (5)	No continuity
(1) – (5)	Continuity



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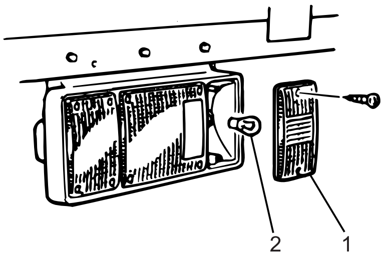
BACK UP LIGHT BULB

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Lens
2. Bulb



LNW48ASH001201

Legend

1. Lens
2. Bulb

Install or Connect

To install, follow the removal steps in the reverse order.

BACK UP LIGHT SWITCH

Inspection Procedure

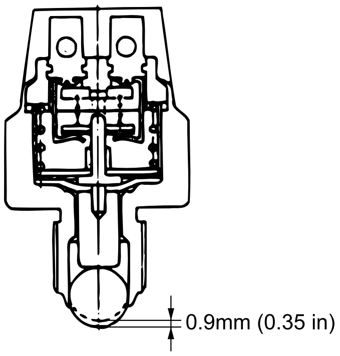
With the switch installed to the transmission, check the continuity between the terminals of the switch connectors.

When the continuity is found between the terminals only with the switch shifted to the reverse position, the switch is normal.

When the result of the above inspection is found abnormal, remove the switch from the transmission and conduct a test on the switch alone.

If the continuity appears between the connector terminals when the ball of the switch is pushed, the switch is not normal. (When the ball is released, the continuity appears.)

If there is no continuity with the switch installed to the transmission, even though the switch is found to be normal, then adjust the stroke of the switch by changing the thickness of the switch gasket.



LNW48ASH001301

Removal Procedure

Preparation: Disconnect the battery ground cable.

- Disconnect the connectors.
- Remove the switch by turning it counter clockwise.

Installation Procedure

Apply liquid gasket to the screw portion of the switch to prevent oil leak.

INHIBITOR SWITCH

Inspection Procedure

Refer to “Inhibitor Switch” of section 7A “Automatic Transmission 450-43LE”.

Removal Procedure

Refer to “Inhibitor Switch” of section 7A “Automatic Transmission 450-43LE”.

Installation Procedure

Refer to “Inhibitor Switch” of section 7A “Automatic Transmission 450-43LE”.

Dome Light and Rear Dome Light

General Description

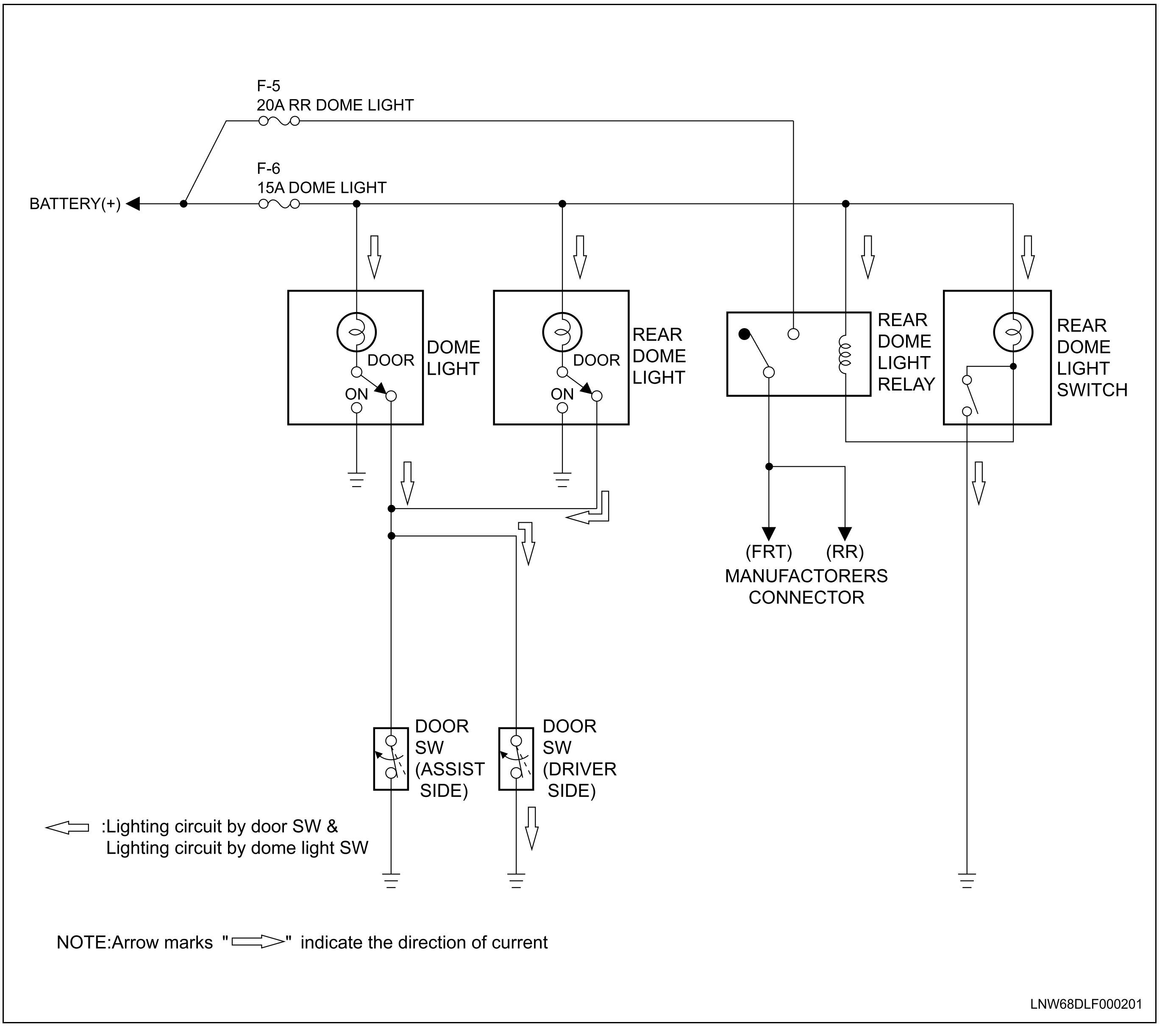
The circuit consists of the dome light, dome light switch, door switch and rear dome light switch.

The dome light lights up when the door is opened with the switch set at the door mode. It can be lit by operating ON or OFF of the dome light switch.

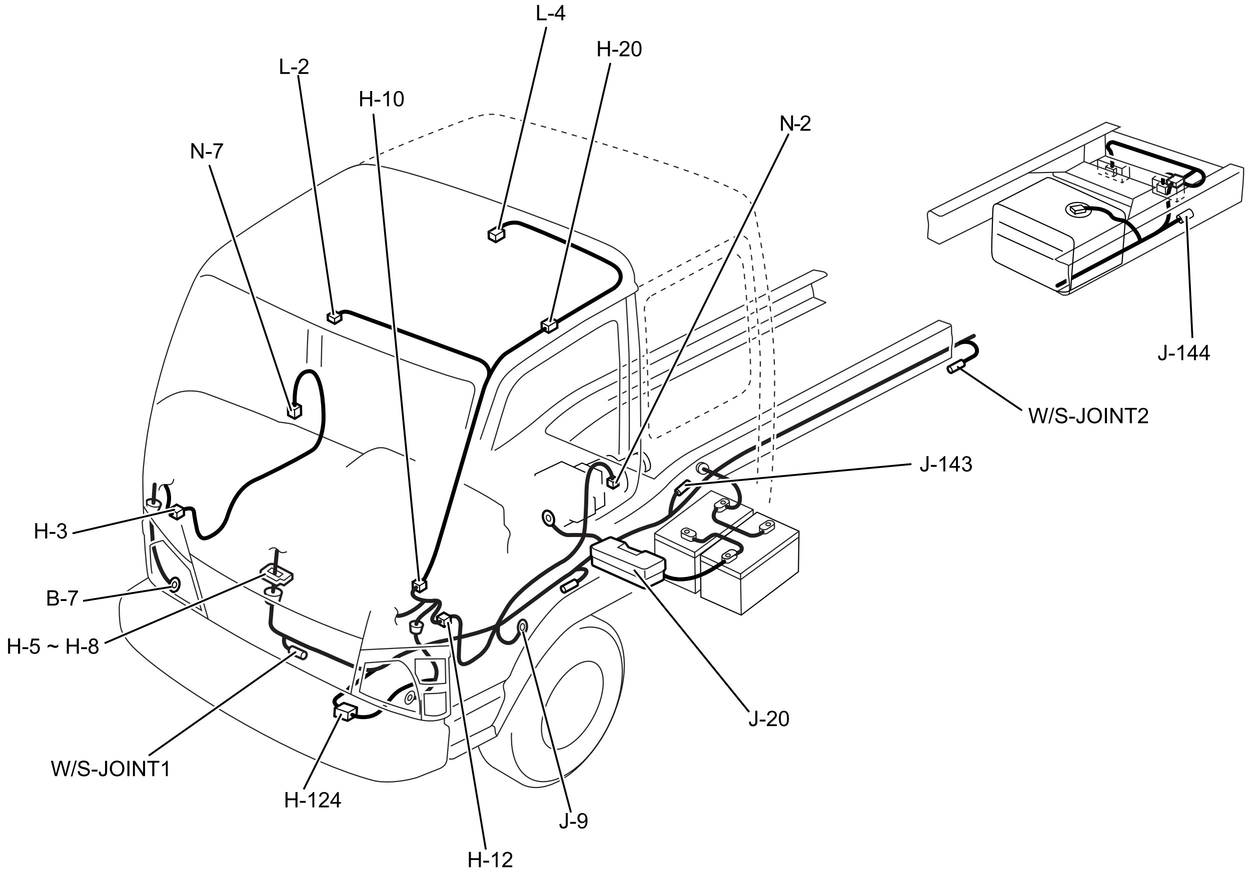
The dome light can be lit by respective switch independent of the position of the ignition switch.

By operating the dome light switch fitted on the instrument panel, the dome light can be lit independent of the switch position of dome light.

LIGHTING CIRCUIT



PARTS LOCATION (1)



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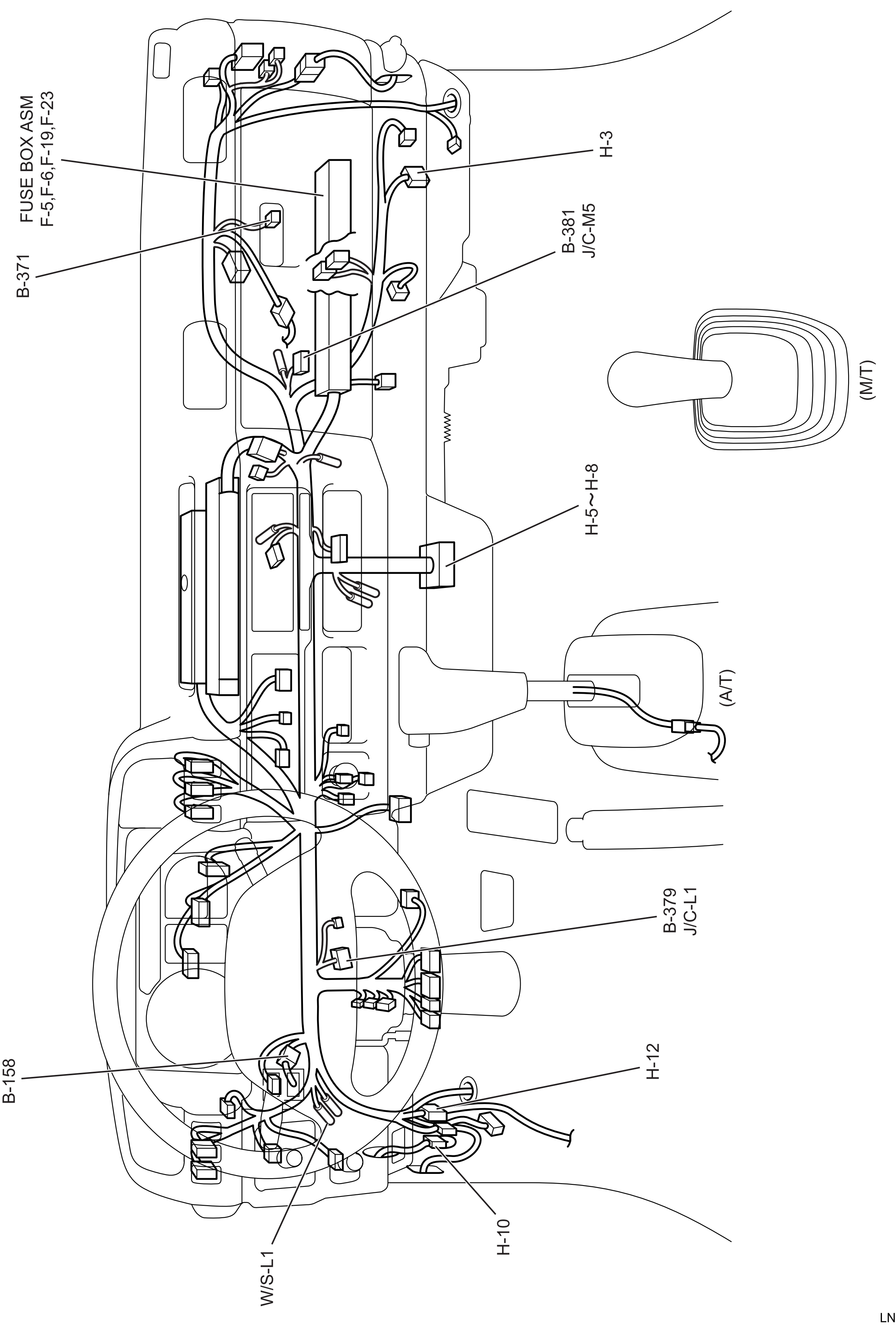
PARTS LOCATION (2)



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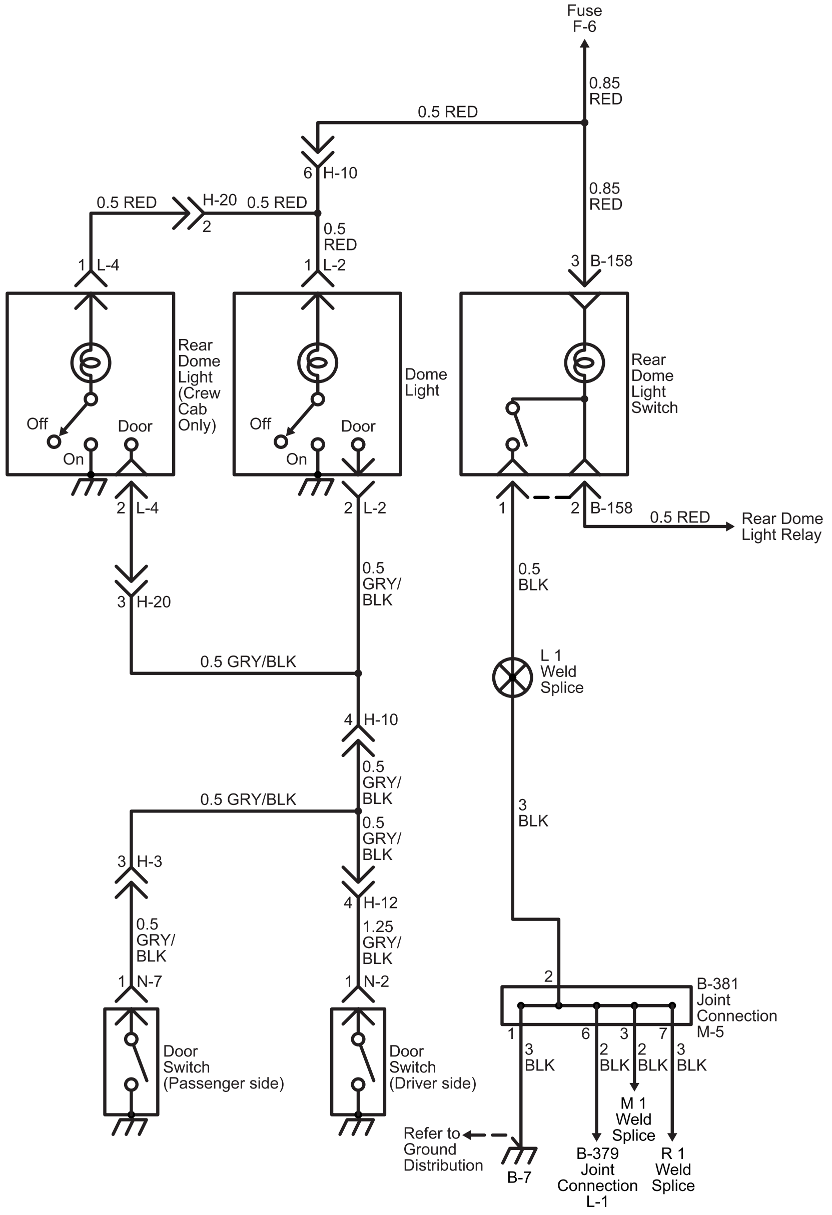
CIRCUIT DIAGRAM



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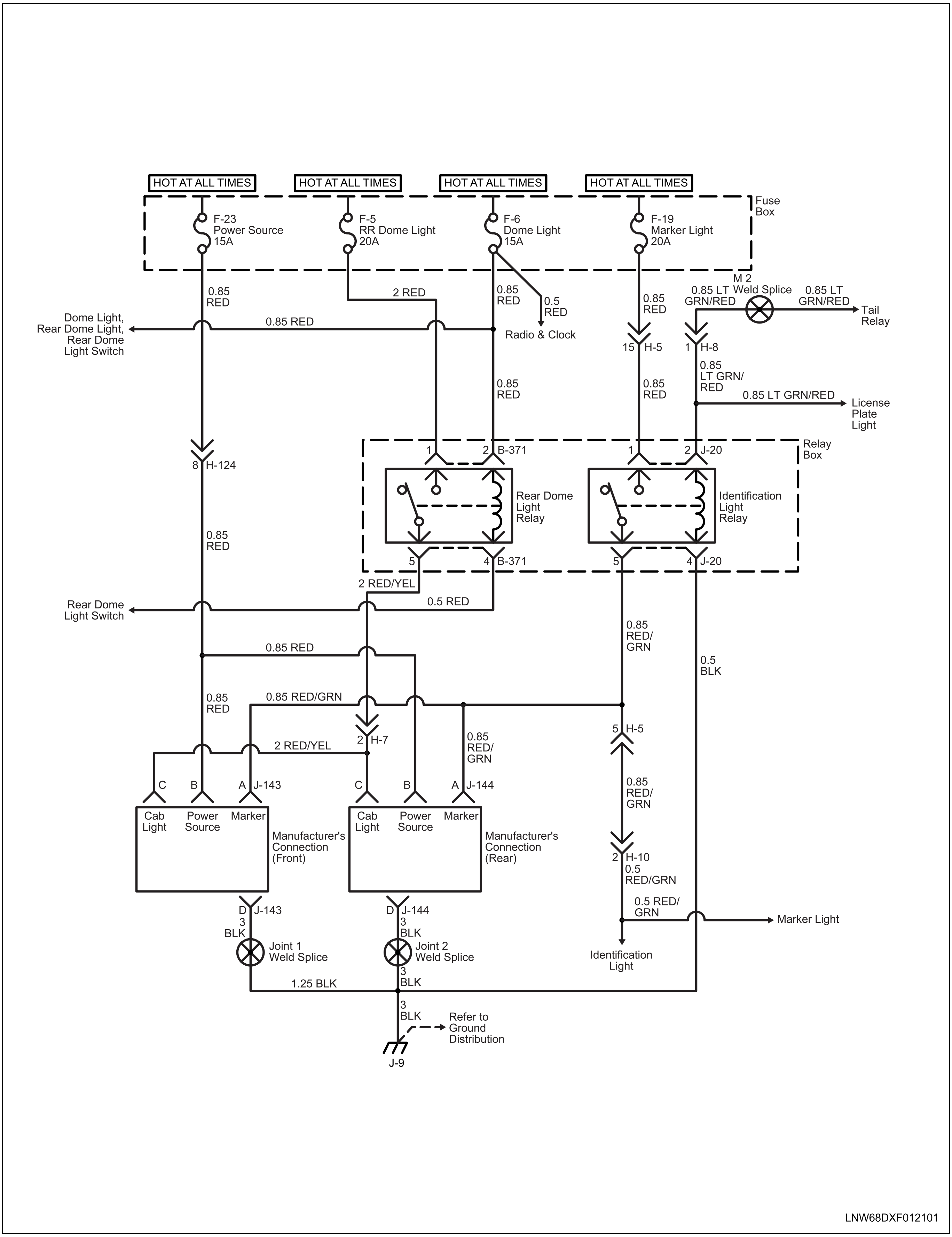
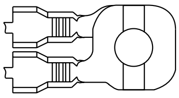
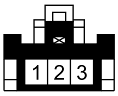
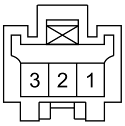
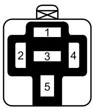
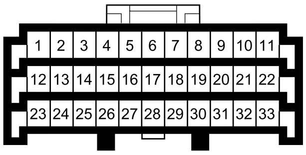
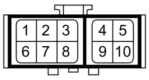
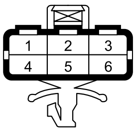
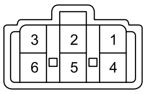
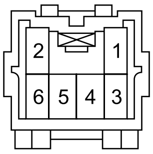
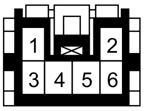
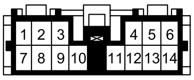
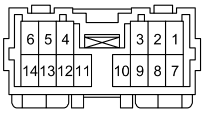
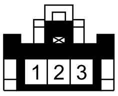
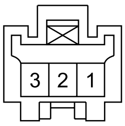
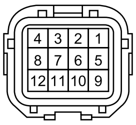
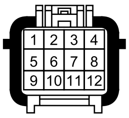
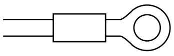
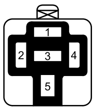
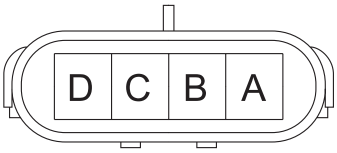
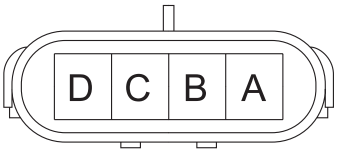
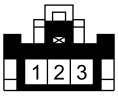
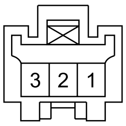
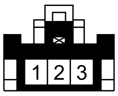
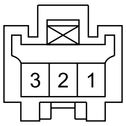
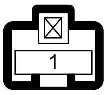
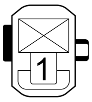
CIRCUIT DIAGRAM



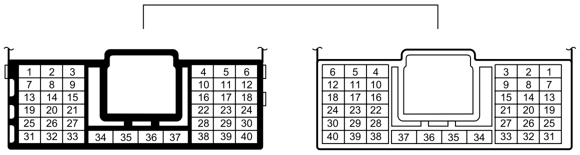
No.	Connector Face
B-7	 000-007 Ground; Headlight Bracket (RH)
B-158 (White)	 003-015 Rear Dome Light Switch
B-158 (White)	 003-014 Rear Dome Light Switch
B-371 (Black)	 005-012 Rear Dome light Relay
B-379 (White)	 033-001 Joint Connection (L1)
B-381 (White)	 010-015 Joint Connection – M5
H-3 (White)	 006-017 Body H. – Floor H. (LH)
H-3 (White)	 006-018 Body H. – Floor H. (LH)

No.	Connector Face
H-10 (White)	 006-010 Body H. – Dome Light H.
H-10 (White)	 006-009 Body H. – Dome Light H.
H-12 (White)	 014-003 Body H. – Floor H. (RH)
H-12 (White)	 014-004 Body H. – Floor H. (RH)
H-20 (White)	 003-015 Dome Light H. – Rear Dome light H.
H-20 (White)	 003-014 Dome Light H. – Rear Dome Light H.
H-124 (Black)	 012-014 Frame H. – Body H.
H-124 (Black)	 012-013 Frame H. – Body H.

No.	Connector Face
J-9	 000-012 Ground; Frame – LH (Center)
J-20 (Black)	 005-012 Identification Light Relay
J-143 (Black)	 004-119 Manufacturer's Connection (FRT)
J-144 (Black)	 004-119 Manufacturer's Connection (RR)
L-2 (Black)	 003-015 Dome Light
L-2 (White)	 003-014 Dome Light
L-4 (White)	 003-015 Rear Dome Light
L-4 (White)	 003-014 Rear Dome Light

No.	Connector Face
N-2 (White)	 001-006 Door Switch (Driver Side)
N-7 (White)	 001-050 Door Switch (Passenger Side)

H-5 Body H. – Frame H. (Gray)



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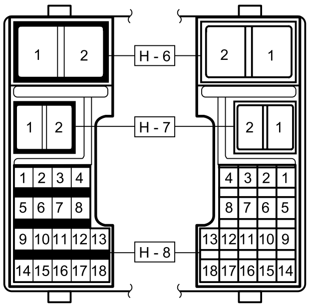
H-7, H-8 Body H. – Frame H. (Gray)



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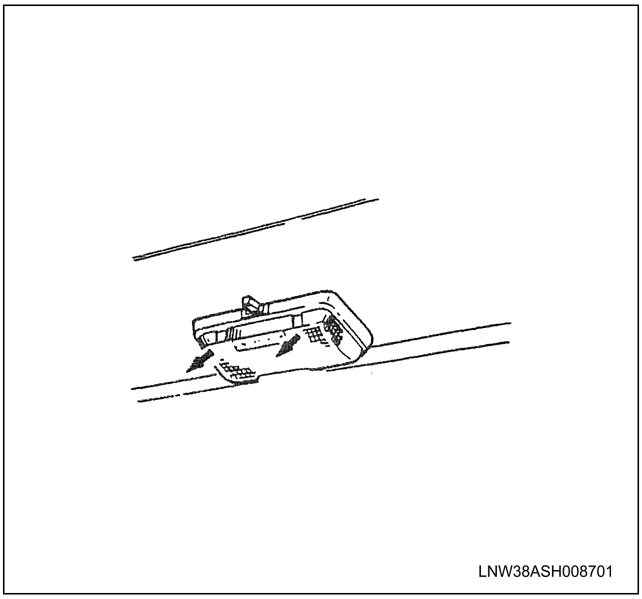
DOME LIGHT BULB and REAR DOME LIGHT BULB

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Lens
   Hold the lens and pull it downward.
2. Bulb



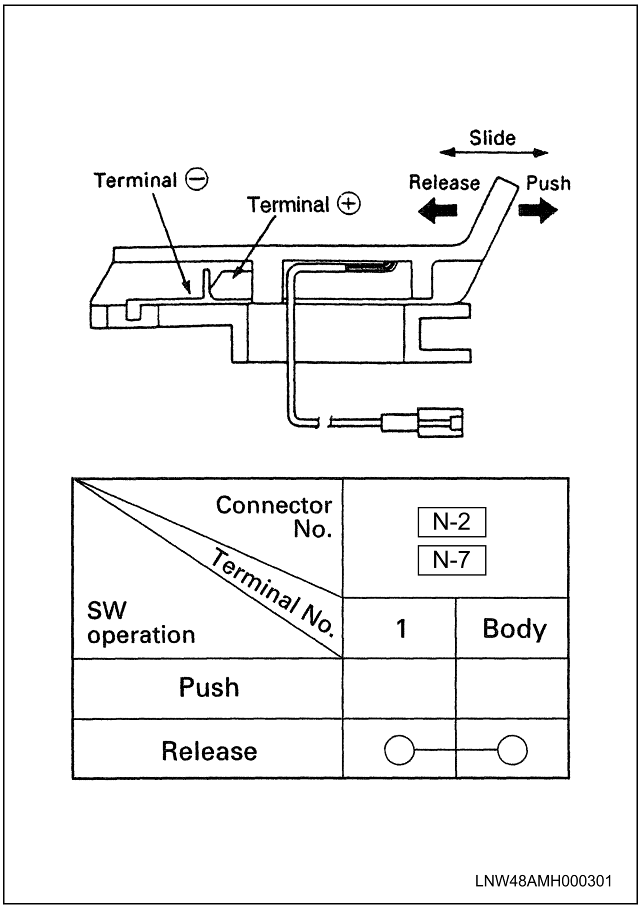
Install or Connect

To install, follow the removal steps in the reverse order.

Door Switch

Inspect

Check to see if there is any continuity between the terminals and the body while operating the door switch. Repair or replace the switch, when the result of inspection is found abnormal.

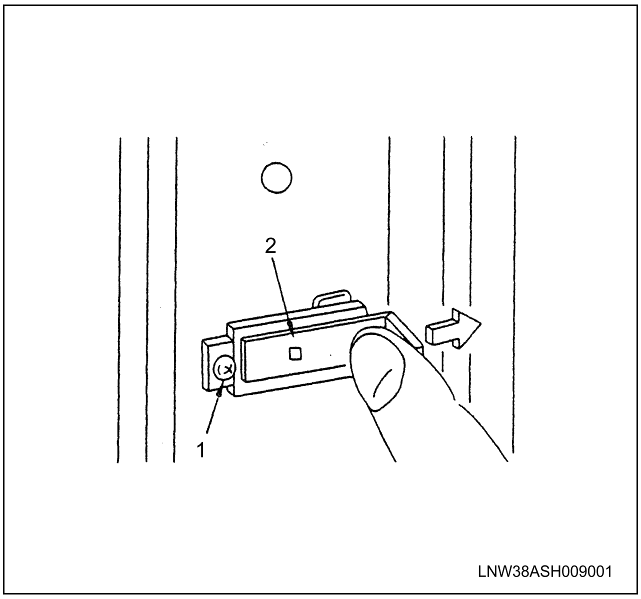


Connector No.	N-2 N-7	
SW operation / Terminal No.	1	Body
Push		
Release	○—	—○

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Door switch
   - Remove the screw.
   - Disconnect the connector of the switch.



Legend

1. Screw
2. Slide Part

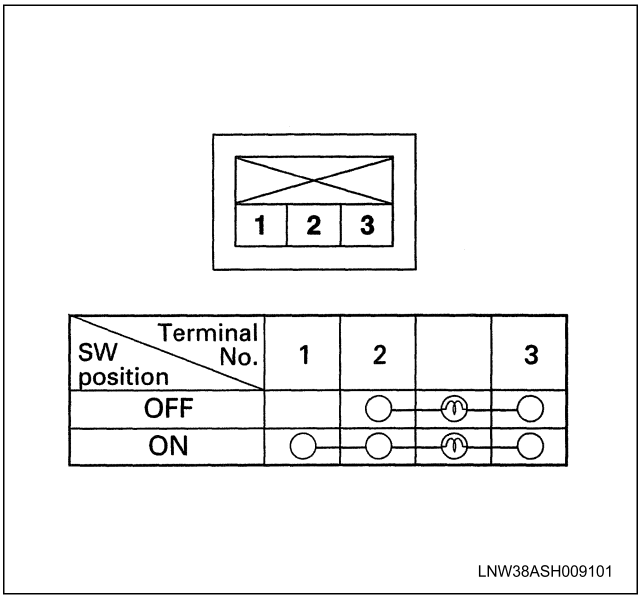
Install or Connect

To install, follow the removal steps in the reverse order.

REAR DOME LIGHT SWITCH

Inspect

Check the continuity when the switch is "ON" position.

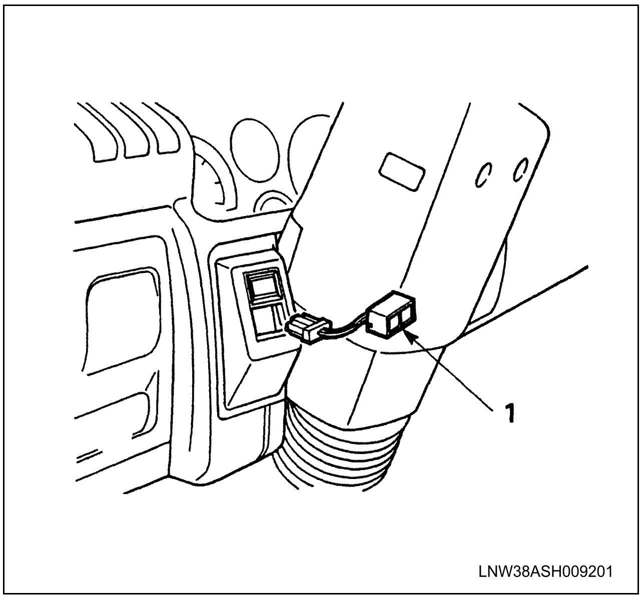


SW position \ Terminal No.	1	2		3
OFF		○	—⊗—	○
ON	○—	○	—⊗—	○

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Rear dome light switch
   - For release the lock, pushing the switch from back side of switch panel.
   - Disconnect the connector.



Legend

1. Rear dome Light Switch

Install or Connect

To install, follow the removal steps in the reverse order.

Windshield Wiper and Washer

General Description

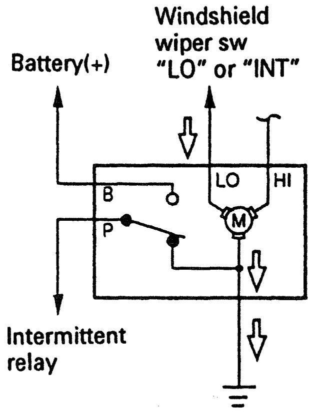
The circuit consists of the ignition switch, windshield wiper & washer switch, wiper motor, washer motor and the intermittent relay.

When the wiper & washer switch is turned on with starter switch on, the battery voltage is applied to the wiper motor to activate the wiper.

The washer motor squirts glass cleaning fluid while the washer switch is being pushed. The intermittent relay is used to control motion of the wiper.

Operation of Windshield Wiper Motor (When Wiper “LO” or “INT” Position)

1. Condition of wiper switch is “LO” or “INT” position (Wiper motor is starting to operate)



NOTE: Arrow marks " ⇨ " indicate the direction of current.

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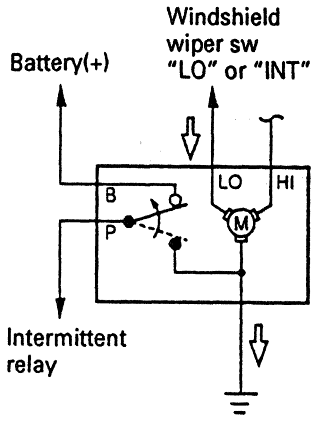
2. Condition of wiper motor is operating



NOTE: Arrow marks " ⇨ " indicate the direction of current.

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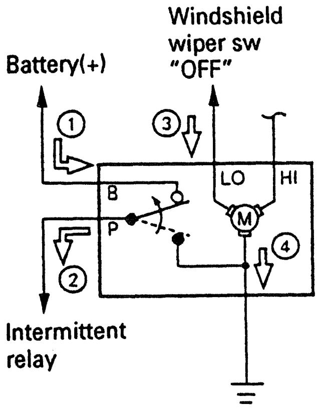
3. Condition of wiper switch is just "OFF" (Wiper motor is still operating until auto-stop position)



NOTE: Arrow marks " ⇨ " indicate the direction of current.

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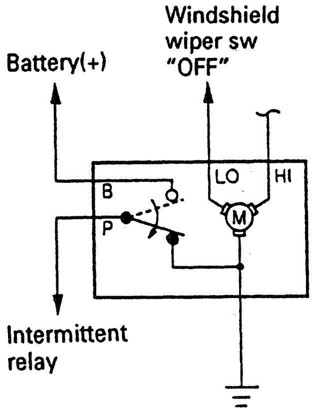
4. Wiper motor stops at auto-stop position



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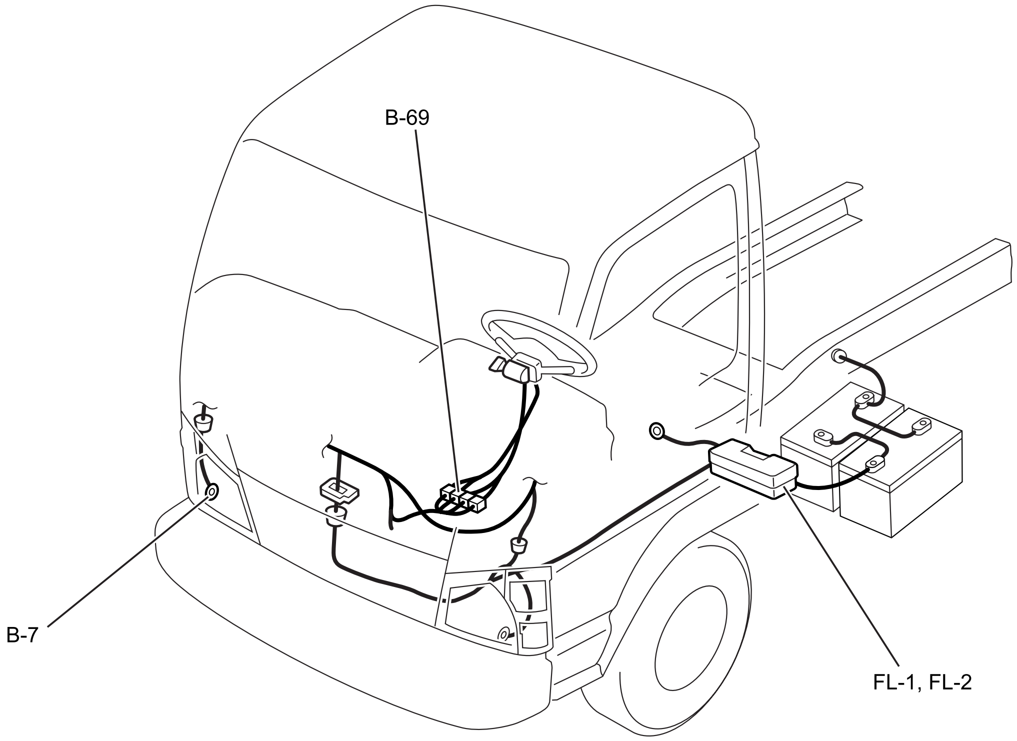
PARTS LOCATION (1)



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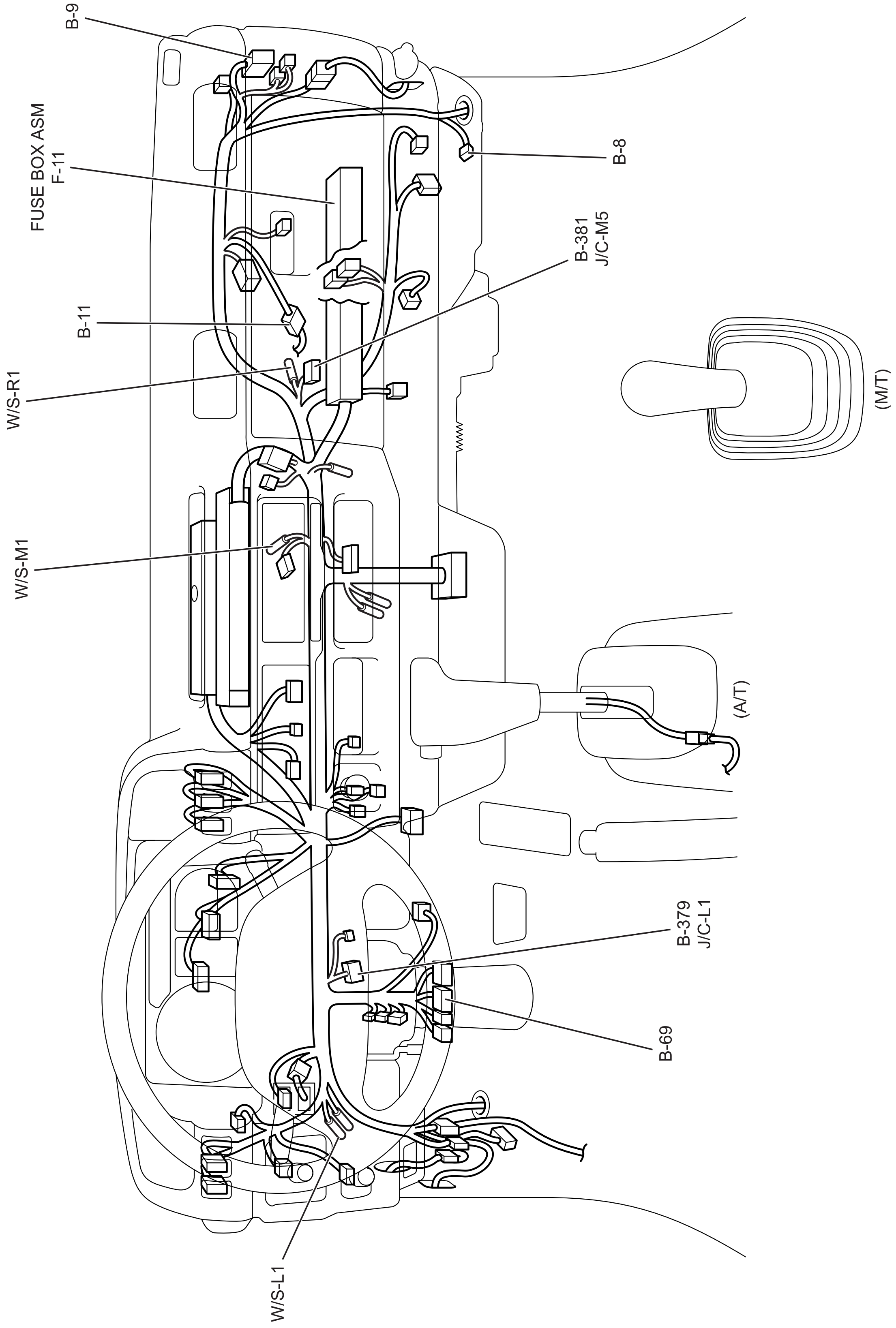
PARTS LOCATION (2)



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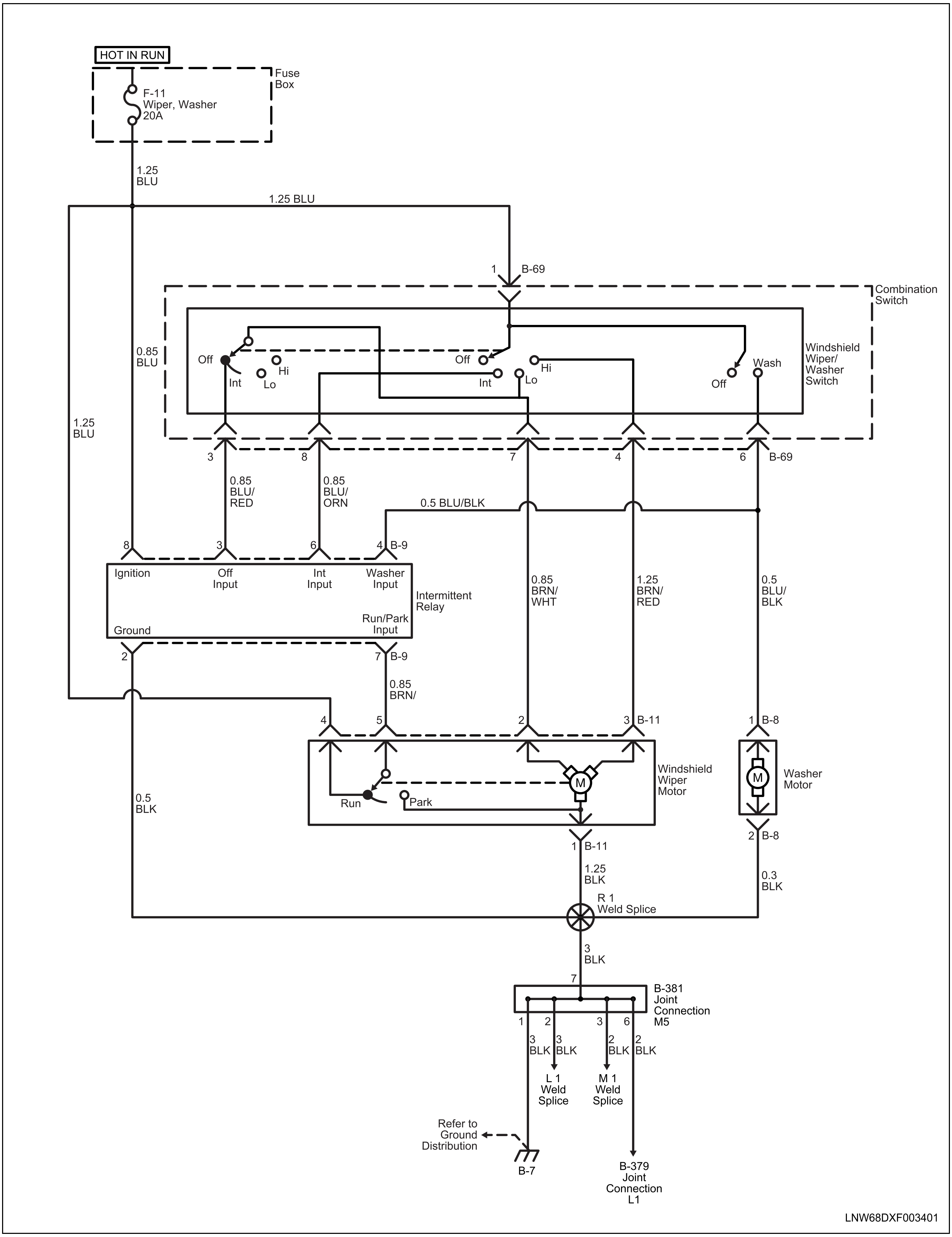
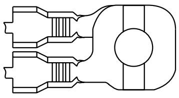
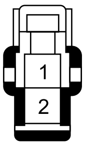
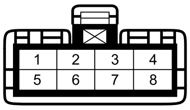
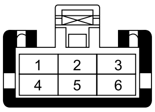
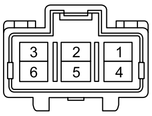
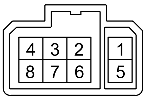
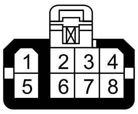
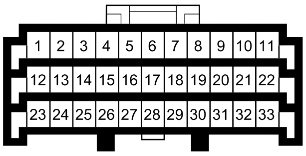
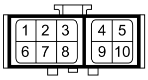
CIRCUIT DIAGRAM



No.	Connector Face
B-7	 000-007 Ground; Headlight Bracket–RH
B-8 (White)	 002-020 Washer Motor
B-9 (Brown)	 008-007 Intermittent Relay
B-11 (White)	 006-024 Wiper Motor
B-11 (White)	 006-025 Wiper Motor

No.	Connector Face
B-69 (Black)	 008-028 Combination Switch (A)
B-69 (Blue)	 008-021 Combination Switch (A)
B-379 (White)	 033-001 Joint Connection–L1
B-381 (White)	 010-015 Joint Connection–M5

Diagnosis

Quick Chart for Check Point

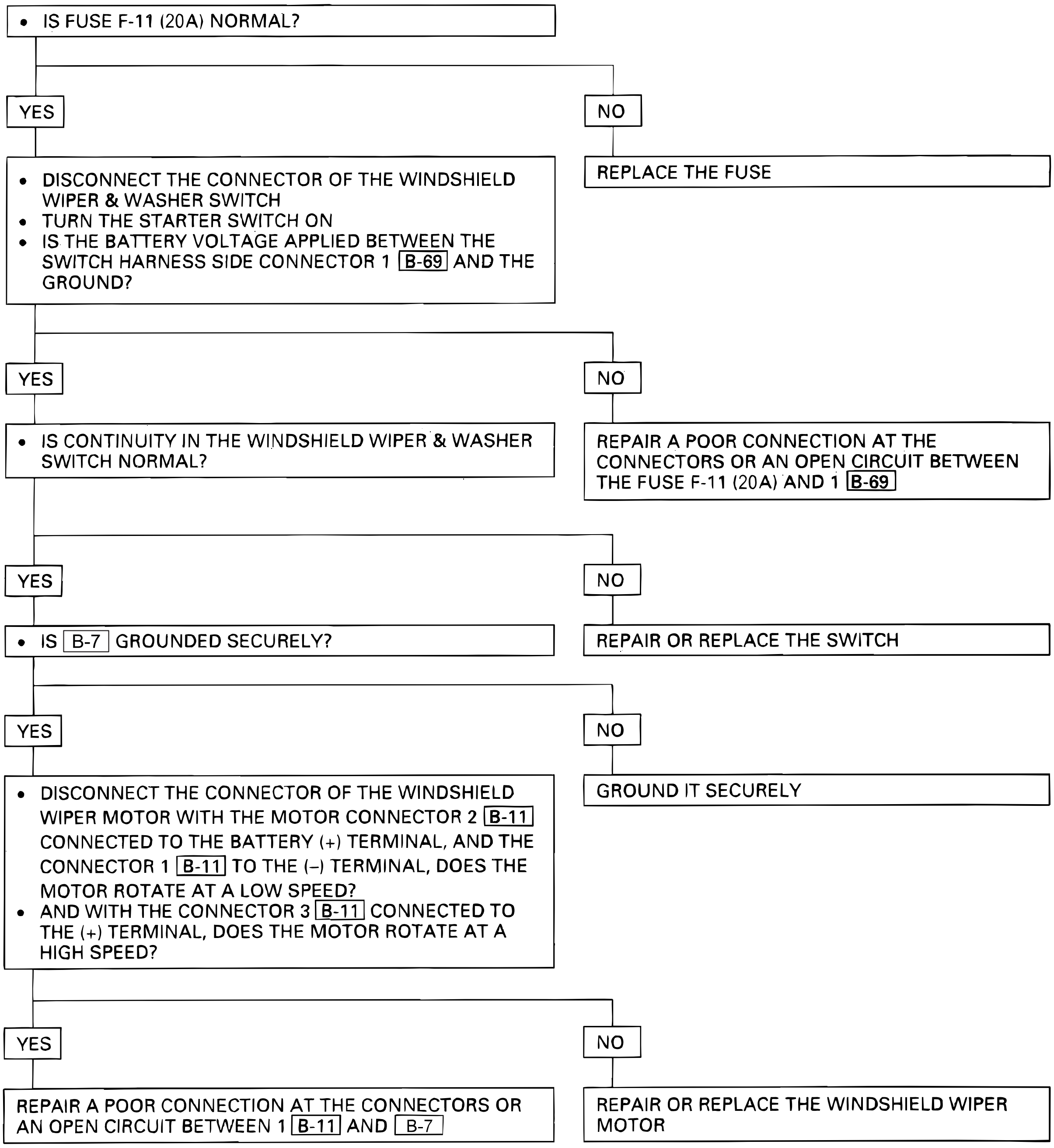
1. WINDSHEILD WIPER AND WASHER

Check Point Trouble Mode	Fuse F-11 (20A)	Wiper & Washer Switch	Inter-mittent Relay	Wiper Motor	Washer Motor	Cable Harness
1. Windshield wiper does not operate at any switch position	○ (1)	○ (3)		○ (4)		○ (2)
2. Windshield wiper does not operate at “INT” position		○ (1)	○ (3)			○ (2)
3. Windshield wiper does not operate at “LO” position		○ (1)		○ (3)		○ (2)
4. Windshield wiper does not operate at “HI” position		○ (1)		○ (2)		○ (3)

Check Point Trouble Mode	Fuse F-11 (20A)	Wiper & Washer Switch	Inter-mittent Relay	Wiper Motor	Washer Motor	Cable Harness
5. Auto-stop function of the windshield wiper motor does not operate		○ (1)	○ (4)	○ (2)		○ (3)
6. Rotation of the windshield wiper motor does not stop		○ (1)		○ (2)		
7. Windshield washer motor does not operate		○ (1)			○ (3)	○ (2)

NOTE: Figure in parenthesis “( )” indicates the order of inspection.

1. WINDSHIELD WIPER DOES NOT OPERATE AT ANY SWITCH POSITION



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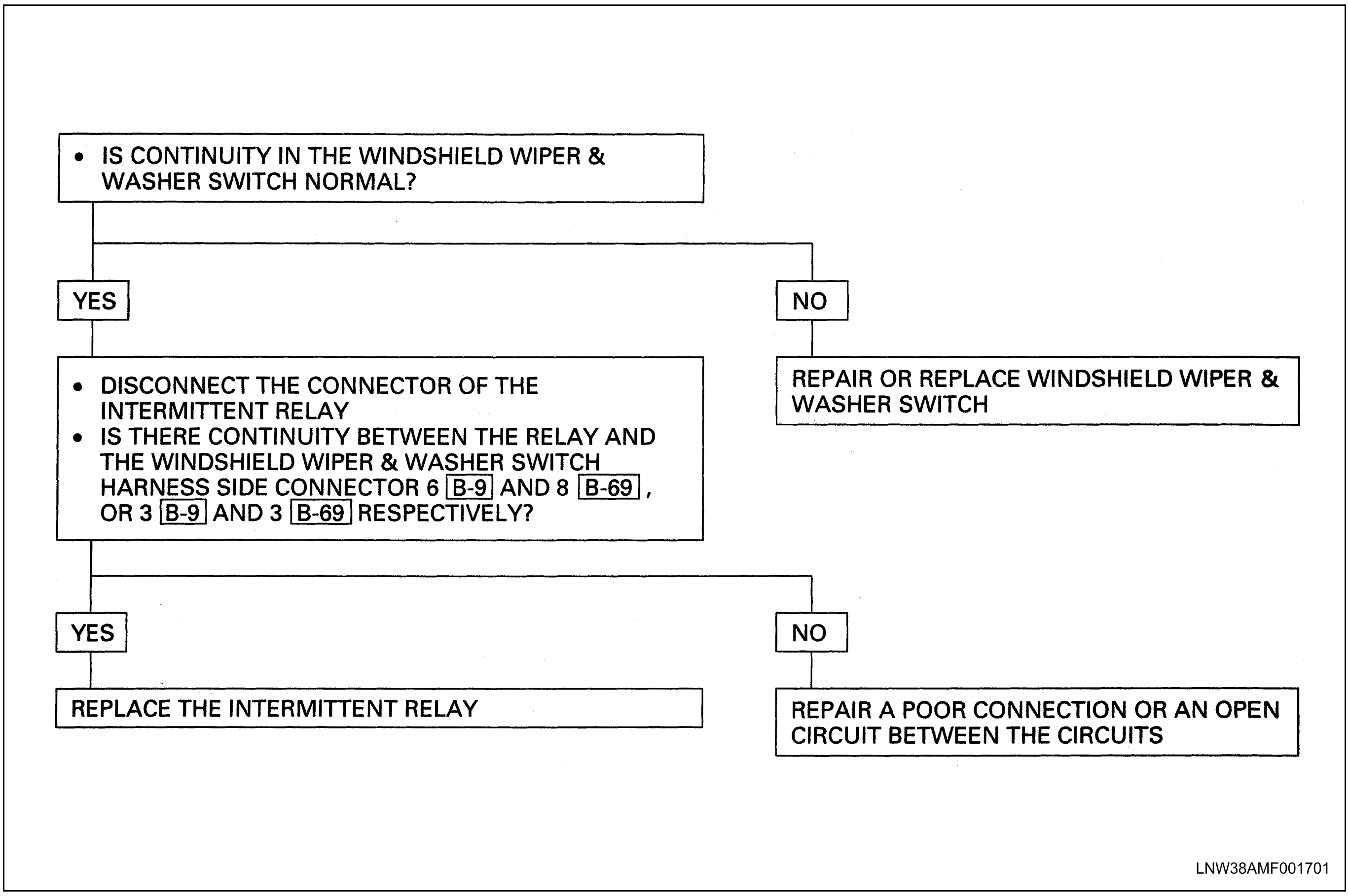
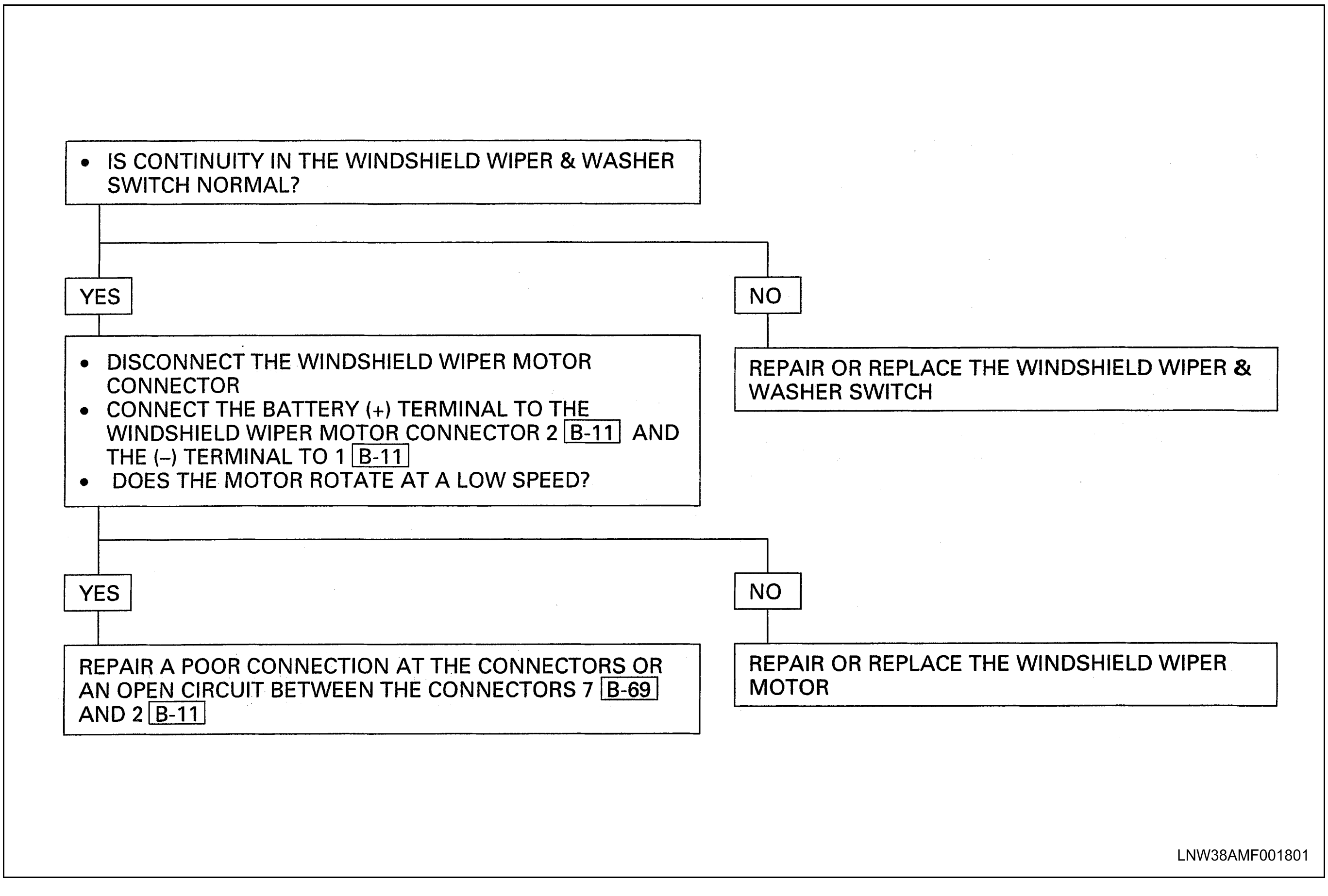
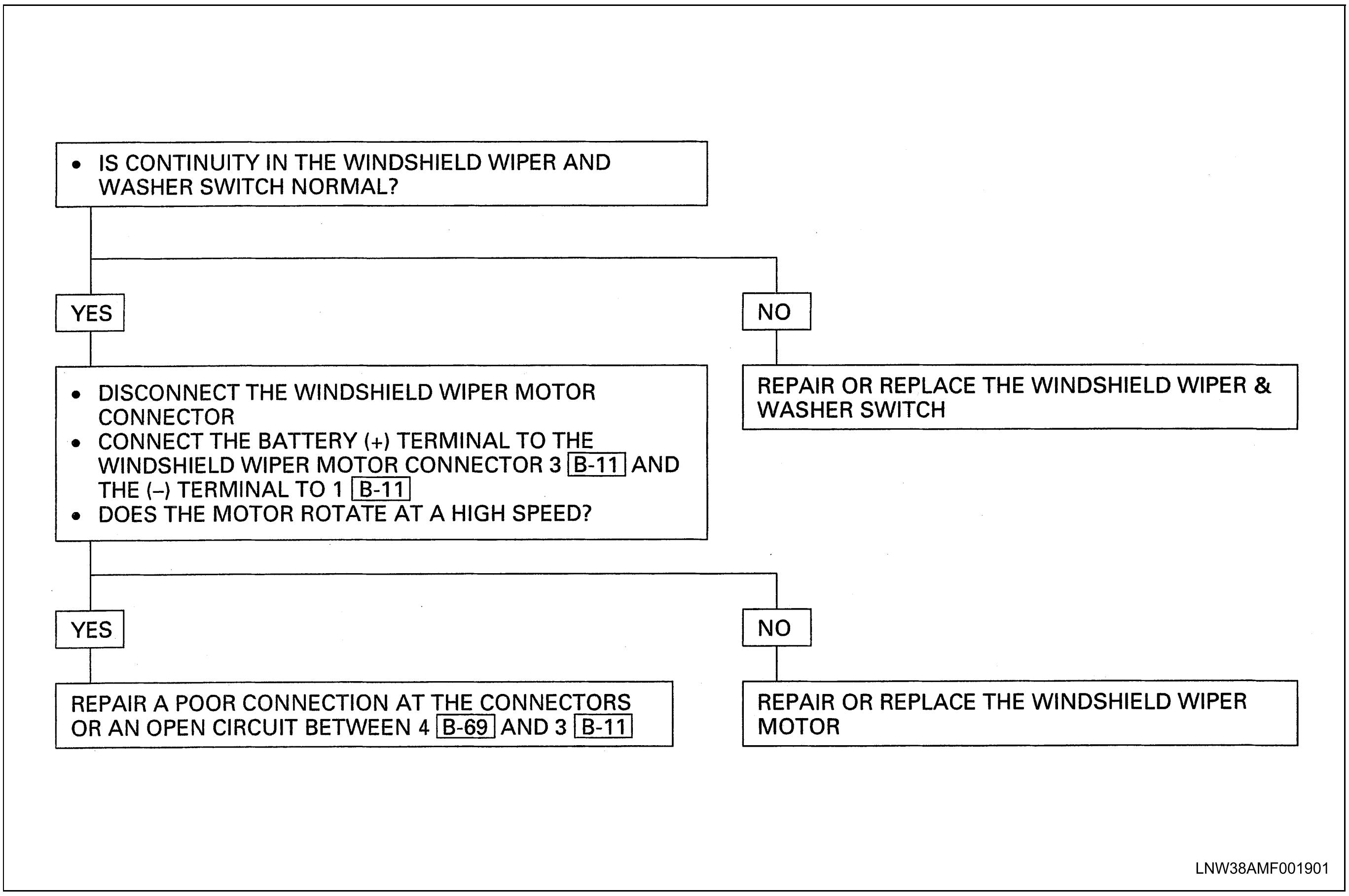
2. WINDSHIELD WIPER DOES NOT OPERATE AT “INT” POSITION



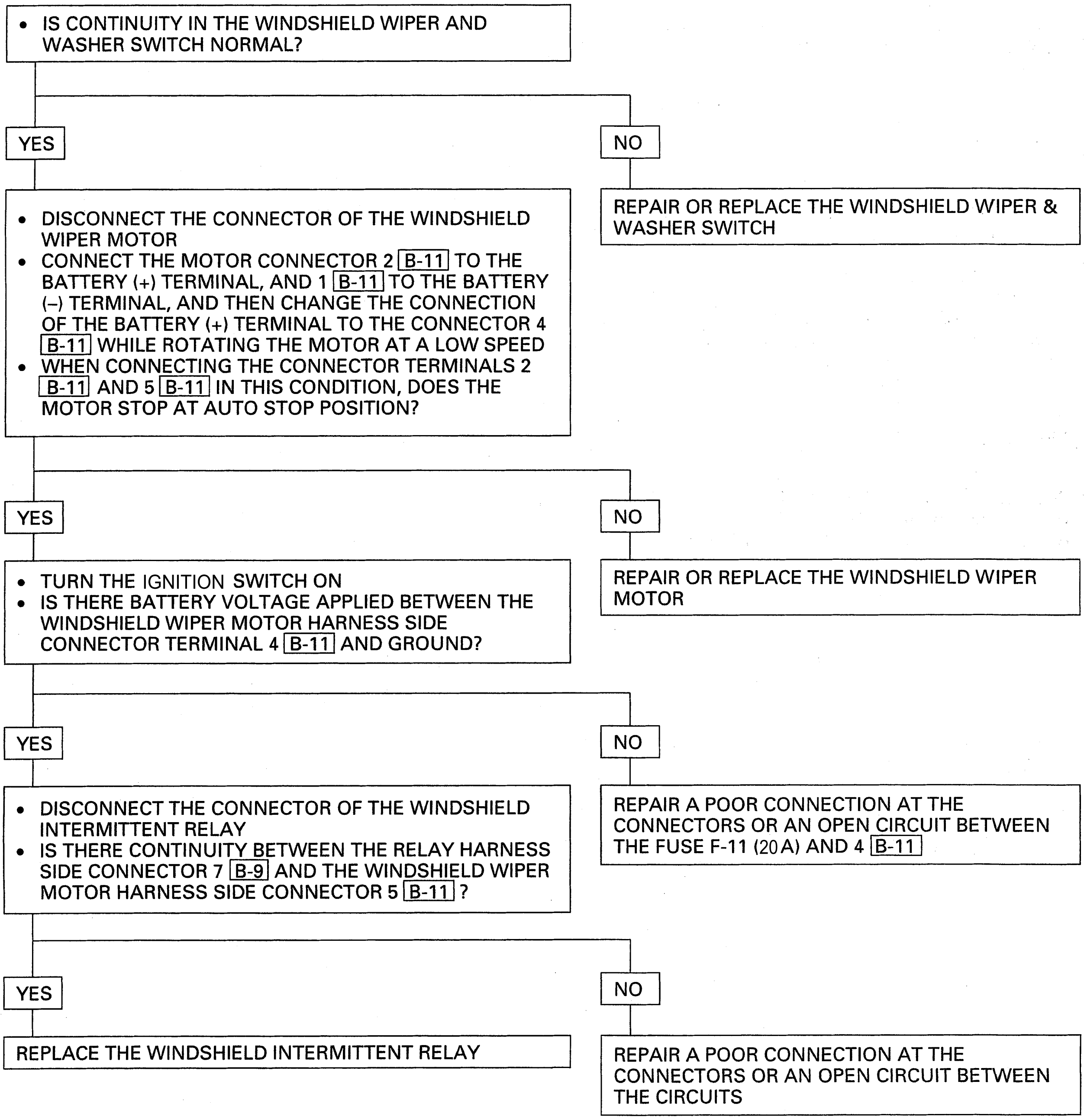
3. WINDSHIELD WIPER DOES NOT OPERATE AT “LO” POSITION



4. WINDSHIELD WIPER DOES NOT OPERATE AT "HI" POSITION



5. AUTO-STOP FUNCTION OF THE WINDSHIELD WIPER MOTOR DOES NOT OPERATE



- IS CONTINUITY IN THE WINDSHIELD WIPER AND WASHER SWITCH NORMAL?

YES

- DISCONNECT THE CONNECTOR OF THE WINDSHIELD WIPER MOTOR
- CONNECT THE MOTOR CONNECTOR 2 B-11 TO THE BATTERY (+) TERMINAL, AND 1 B-11 TO THE BATTERY (–) TERMINAL, AND THEN CHANGE THE CONNECTION OF THE BATTERY (+) TERMINAL TO THE CONNECTOR 4 B-11 WHILE ROTATING THE MOTOR AT A LOW SPEED
- WHEN CONNECTING THE CONNECTOR TERMINALS 2 B-11 AND 5 B-11 IN THIS CONDITION, DOES THE MOTOR STOP AT AUTO STOP POSITION?

NO

REPAIR OR REPLACE THE WINDSHIELD WIPER & WASHER SWITCH

YES

- TURN THE IGNITION SWITCH ON
- IS THERE BATTERY VOLTAGE APPLIED BETWEEN THE WINDSHIELD WIPER MOTOR HARNESS SIDE CONNECTOR TERMINAL 4 B-11 AND GROUND?

NO

REPAIR OR REPLACE THE WINDSHIELD WIPER MOTOR

YES

- DISCONNECT THE CONNECTOR OF THE WINDSHIELD INTERMITTENT RELAY
- IS THERE CONTINUITY BETWEEN THE RELAY HARNESS SIDE CONNECTOR 7 B-9 AND THE WINDSHIELD WIPER MOTOR HARNESS SIDE CONNECTOR 5 B-11 ?

NO

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN THE FUSE F-11 (20A) AND 4 B-11

YES

REPLACE THE WINDSHIELD INTERMITTENT RELAY

NO

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN THE CIRCUITS

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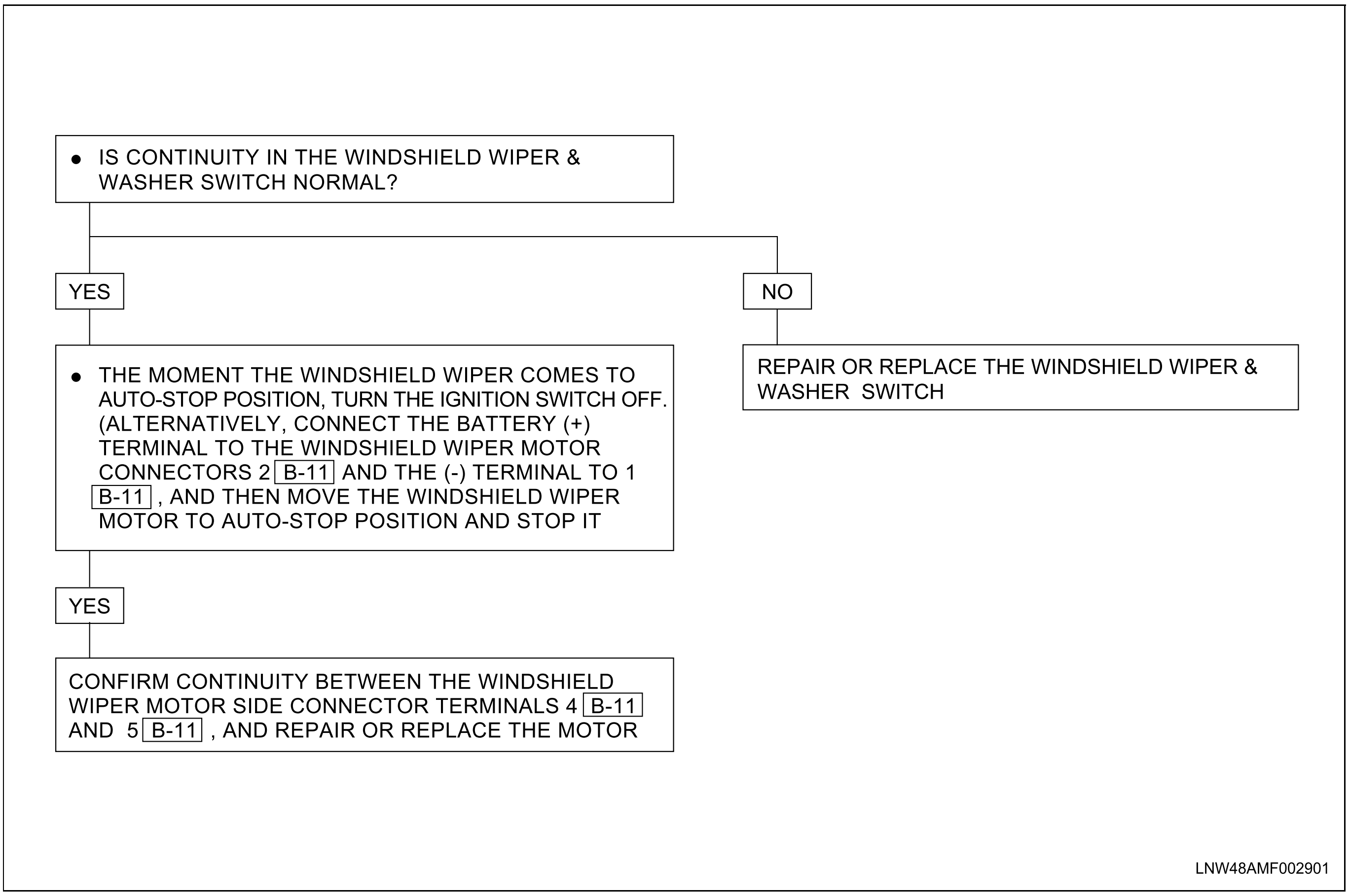
6. ROTATION OF THE WINDSHIELD WIPER MOTOR DOES NOT STOP



- IS CONTINUITY IN THE WINDSHIELD WIPER & WASHER SWITCH NORMAL?

YES:

- THE MOMENT THE WINDSHIELD WIPER COMES TO AUTO-STOP POSITION, TURN THE IGNITION SWITCH OFF. (ALTERNATIVELY, CONNECT THE BATTERY (+) TERMINAL TO THE WINDSHIELD WIPER MOTOR CONNECTORS 2 B-11 AND THE (-) TERMINAL TO 1 B-11 , AND THEN MOVE THE WINDSHIELD WIPER MOTOR TO AUTO-STOP POSITION AND STOP IT

YES:

CONFIRM CONTINUITY BETWEEN THE WINDSHIELD WIPER MOTOR SIDE CONNECTOR TERMINALS 4 B-11 AND 5 B-11 , AND REPAIR OR REPLACE THE MOTOR

NO:

REPAIR OR REPLACE THE WINDSHIELD WIPER & WASHER SWITCH

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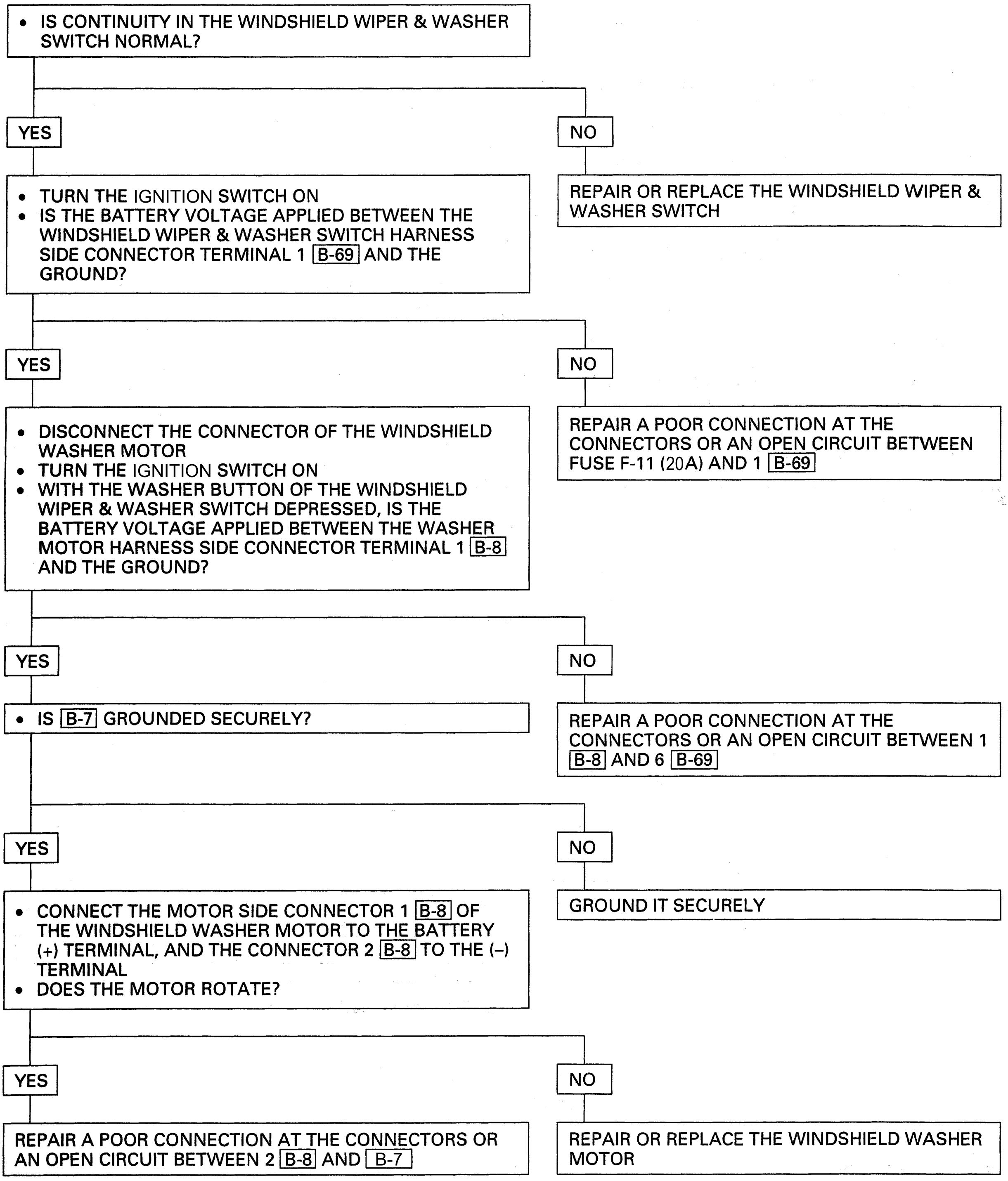
7. WINDSHIELD WASHER MOTOR DOES NOT OPERATE



- IS CONTINUITY IN THE WINDSHIELD WIPER & WASHER SWITCH NORMAL?

NO: REPAIR OR REPLACE THE WINDSHIELD WIPER & WASHER SWITCH

YES:

- TURN THE IGNITION SWITCH ON
- IS THE BATTERY VOLTAGE APPLIED BETWEEN THE WINDSHIELD WIPER & WASHER SWITCH HARNESS SIDE CONNECTOR TERMINAL 1 B-69 AND THE GROUND?

NO: REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN FUSE F-11 (20A) AND 1 B-69

YES:

- DISCONNECT THE CONNECTOR OF THE WINDSHIELD WASHER MOTOR
- TURN THE IGNITION SWITCH ON
- WITH THE WASHER BUTTON OF THE WINDSHIELD WIPER & WASHER SWITCH DEPRESSED, IS THE BATTERY VOLTAGE APPLIED BETWEEN THE WASHER MOTOR HARNESS SIDE CONNECTOR TERMINAL 1 B-8 AND THE GROUND?

NO: REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN 1 B-8 AND 6 B-69

YES:

- IS B-7 GROUNDED SECURELY?

NO: GROUND IT SECURELY

YES:

- CONNECT THE MOTOR SIDE CONNECTOR 1 B-8 OF THE WINDSHIELD WASHER MOTOR TO THE BATTERY (+) TERMINAL, AND THE CONNECTOR 2 B-8 TO THE (–) TERMINAL
- DOES THE MOTOR ROTATE?

YES: REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN 2 B-8 AND B-7

NO: REPAIR OR REPLACE THE WINDSHIELD WASHER MOTOR

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IGNITION SWITCH

Refer to “Start and Charging” in this section.

WINDSHIELD WIPER & WASHER SWITCH

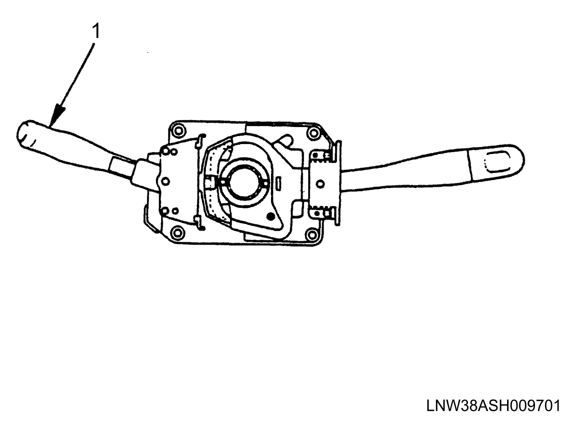
With the ignition swtch on, the windshield wiper and washer switch controls the start and stop operation as well as the change of operating speeds.

Both the windshield washer motor and the wiper motor jointly operate while the washer button is pushed.

Inspect

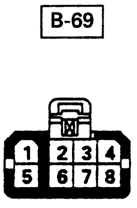
Check the continuity between the connector terminals of the switch.

Repair or replace the switch when the result of inspection is found abnormal.



Legend

1. Windshield Wiper & Washer Switch



Switch side

Washer SW	Wiper SW	Terminal No.					
		3	7	1	4	8	6
OFF	OFF	○	○				
	INT	○	○	○	—	○	
	LO		○	○			
	HI			○	○		
ON	OFF,INT,LO,HI			○	—	—	○

LNW48AMF002201

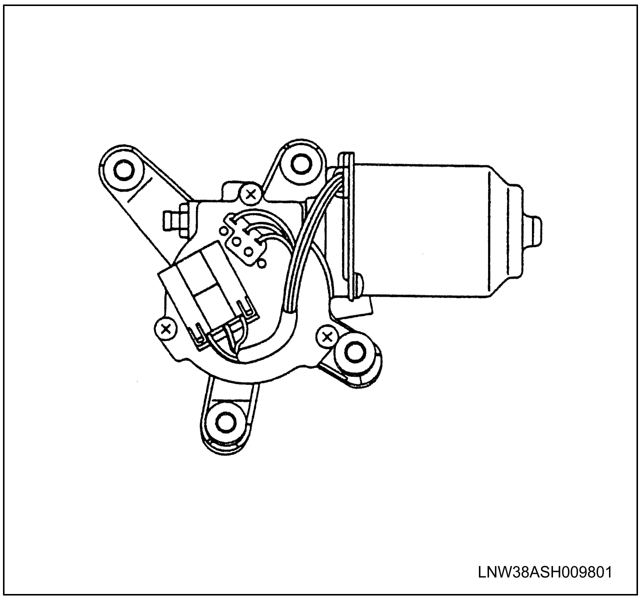
Remove or Disconnect

Refer to “Headlight and Cornering Light” in this section.

Install or Connect

Refer to “Headlight and Cornering Light” in this section.

WINDSHIELD WIPER MOTOR



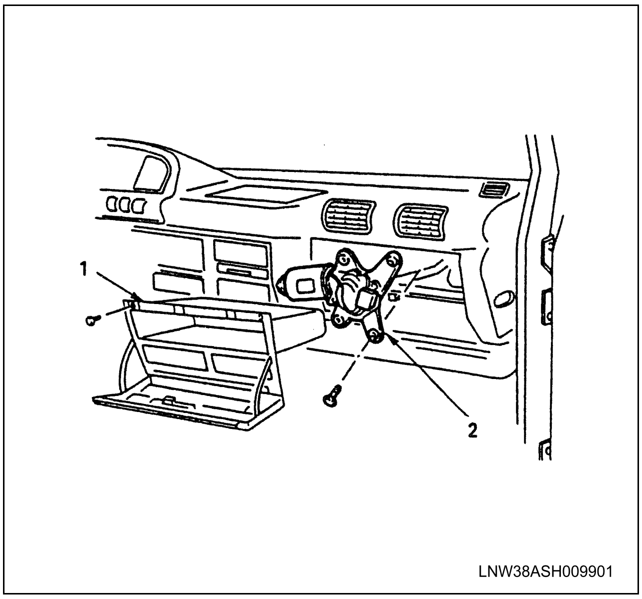
Inspect

1. Operation in low speed
   With the motor connector terminal 2 [B-11] connected to the battery (+) terminal and the connector 1 [B-11] to the (–) terminal, check to see if the motor rotates in low speed.
2. Operation in high speed
   With the motor connector terminal 3 [B-11] connected to the battery (+) terminal and the connector 1 [B-11] to the (–) terminal, check to see if the motor rotates in low speed.
3. Stop operation
   After stopping the windshield wiper in the position on the way by confirming the operation at the low speed in item No. 1.
   When the connectors 2 [B-11] and 5 [B-11] are connected, while connecting the motor connector terminal 4 [B-11] to the battery (+) terminal, check to see, if the motor rotates at low speed and stops at the auto-stop position.
   Repair or replace the motor when the results of the above inspections are found abnormal.

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Glove box
   Refer to “Instrument Panel” of section 8F “Steel Tilt Cab”.
2. Windshield wiper motor
   - Disconnect the connector.
   - Remove four screws.
   - Remove the ball joint between crank arm and wiper link.



Legend

1. Glove Box
2. Windshield Wiper Motor

Install or Connect

To install, follow the removal steps in the reverse order, noting the following points:

- Windshield Wiper Motor
  When the crank arm is removed from the windshield wiper motor, tighten the motor shaft nut with the specified torque.

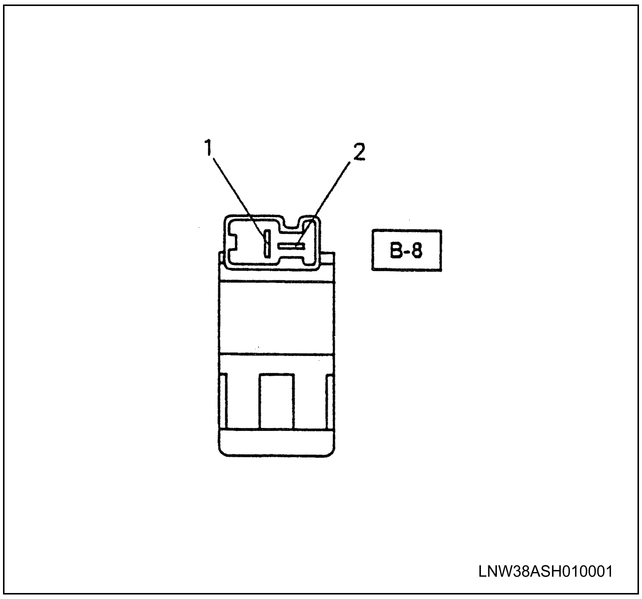
Shaft nut torque	N·m (lb in)
17 (147)	

- Temporarily fit the motor by using one of the four wiper motor fixing screws.
- Put the crank arm ball joint in the wiper link hole and fix them together while pulling the wiper link.

WINDSHIELD WASHER MOTOR

Inspect

With the battery (+) terminal connected to the washer motor connector terminal 1 [B-8] and the (–) terminal to the connector 2 [B-8], check to see if the cleaning fluid pushes out.
Replace the tank/motor when the result of inspection is found abnormal.

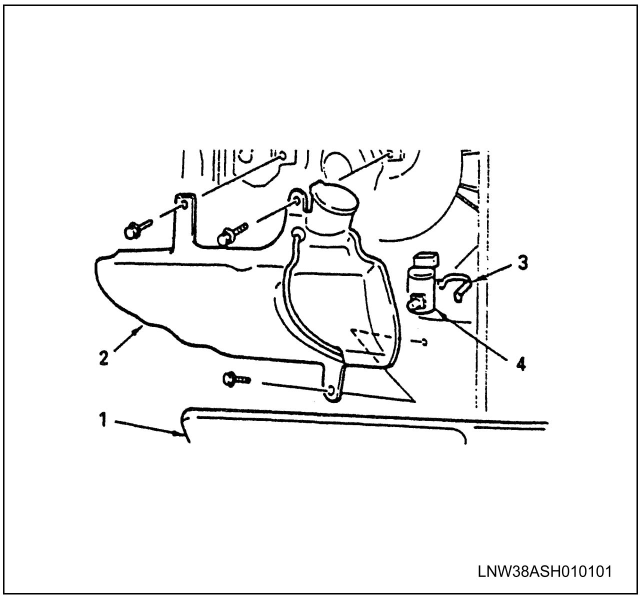


LNW38ASH010001

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Instrument panel under cover
   Refer to “Instrument Panel” of section 8F “Steel Tilt Cab”.
2. Washer tank
   - Disconnect the washer motor connector.
   - Disconnect the washer hose.
   - Remove three fixing screws.
3. Clip band
4. Windshield washer motor
   Hold the motor and pull it out from the washer tank.



LNW38ASH010101

Legend

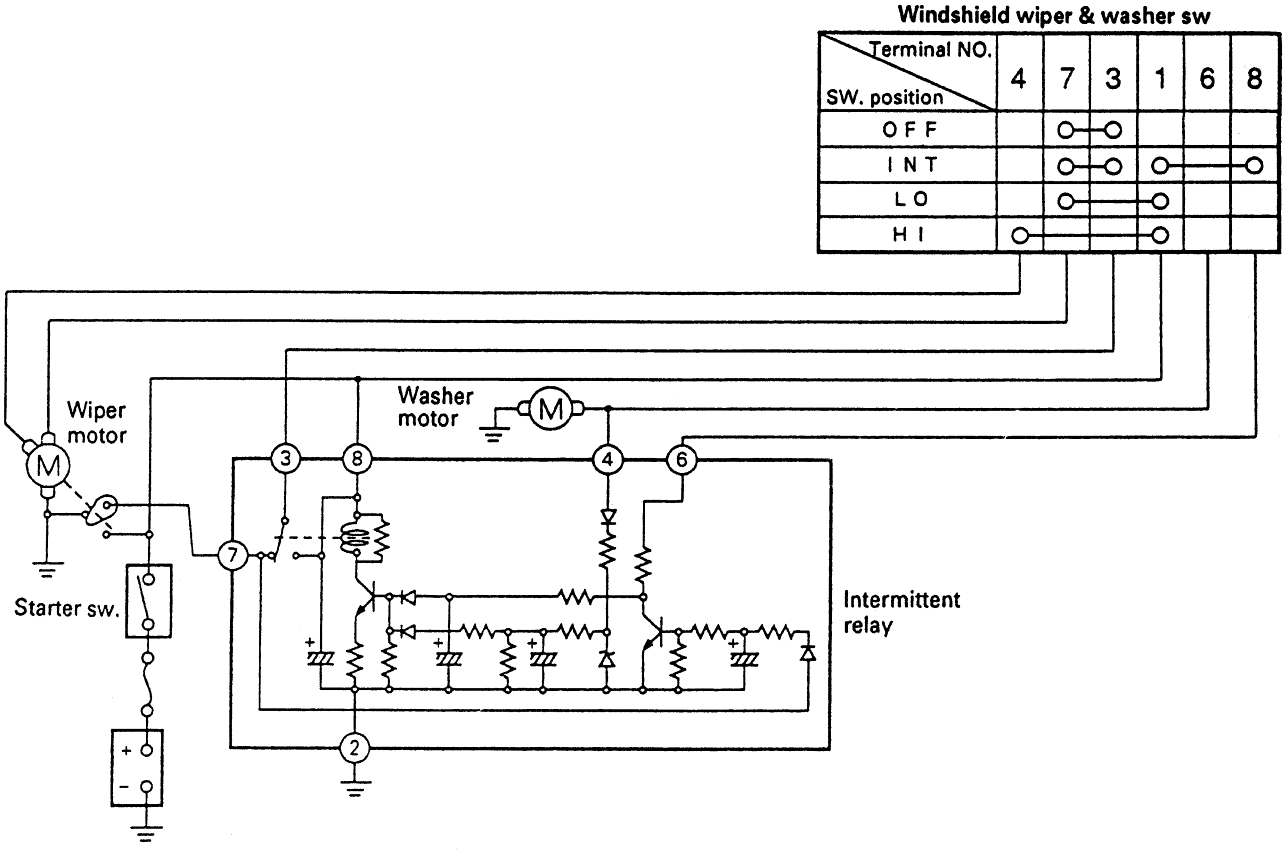
1. Instrument Panel Under Cover
2. Washer Tank
3. Clip Band
4. Windshield Washer Motor

Install or Connect

To install, follow the removal steps in the reverse order.

INTERMITTENT RELAY

CIRCUIT DIAGRAM



Windshield wiper & washer sw

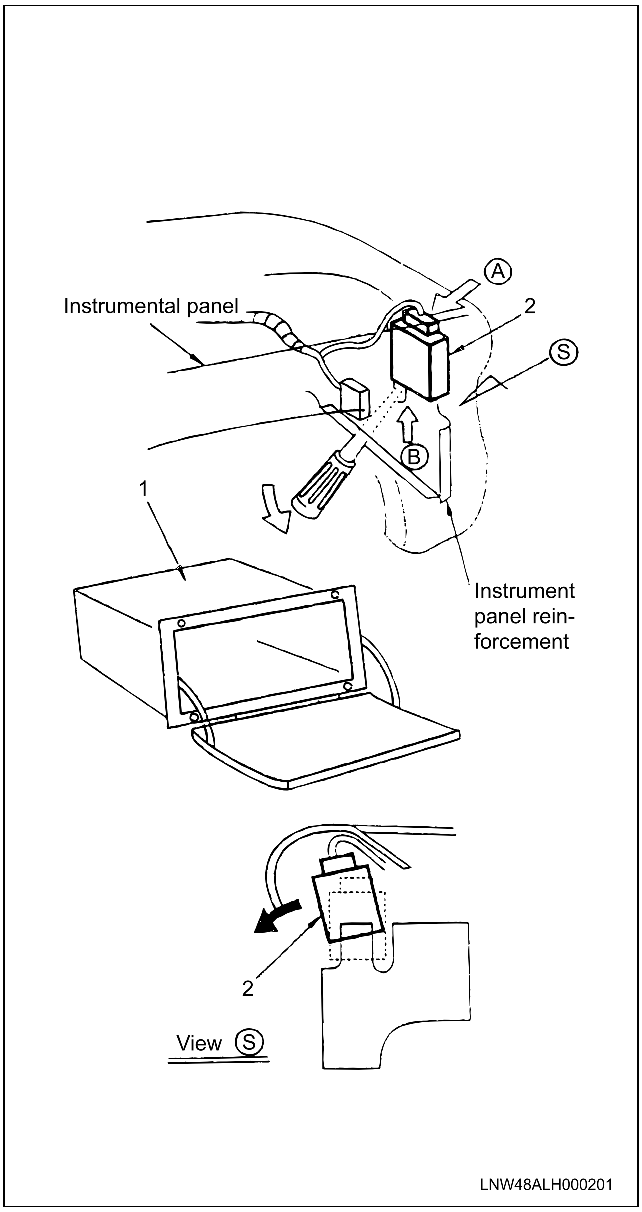
Terminal NO. / SW. position	4	7	3	1	6	8
OFF		○—	—○			
INT		○—	—○	○—	—	—○
LO		○—	—	—○		
HI	○—	—	—	—○		

LNW48ALF005501

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Glove box
   Open the lid and remove the four screws.
2. Intermittent relay
   - Press (A) position with your finger and pry up (B) position with the tip of a screw-driver.
   - When the relay moves up by about 2/3 of its size, tilt and take off the relay to avoid interference with the instrument panel.
   - Disconnect the connector.



Legend

1. Glove Box
2. Intermittent Relay

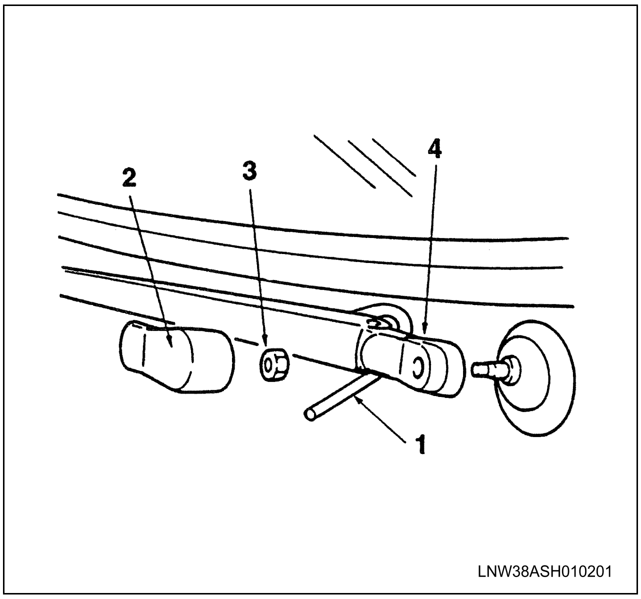
Install or Connect

To install, follow the removal steps in the reverse order.

WINDSHIELD WIPER ARM/BLADE

Remove or Disconnect

1. Rubber hose
2. Cover
3. Wiper arm nut
4. Wiper arm/Blade



Legend

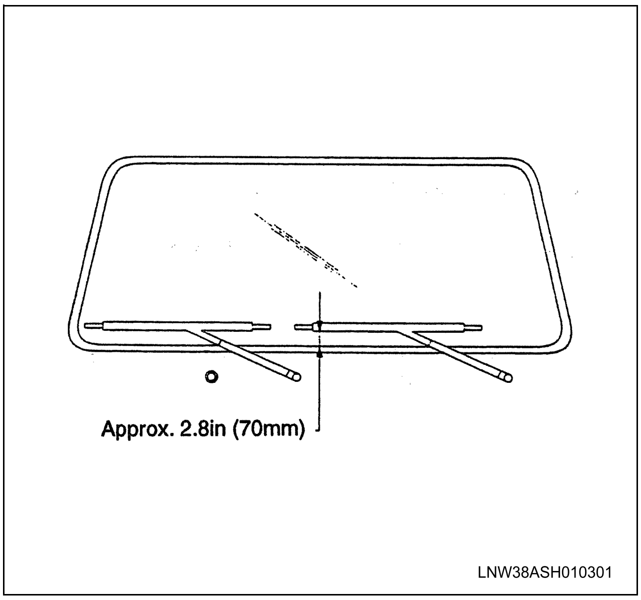
1. Rubber Hose
2. Cover
3. Wiper Arm Nut
4. Wiper Arm/Blade

Install or Connect

To install, follow the removal steps in the reverse order, noting the following points.

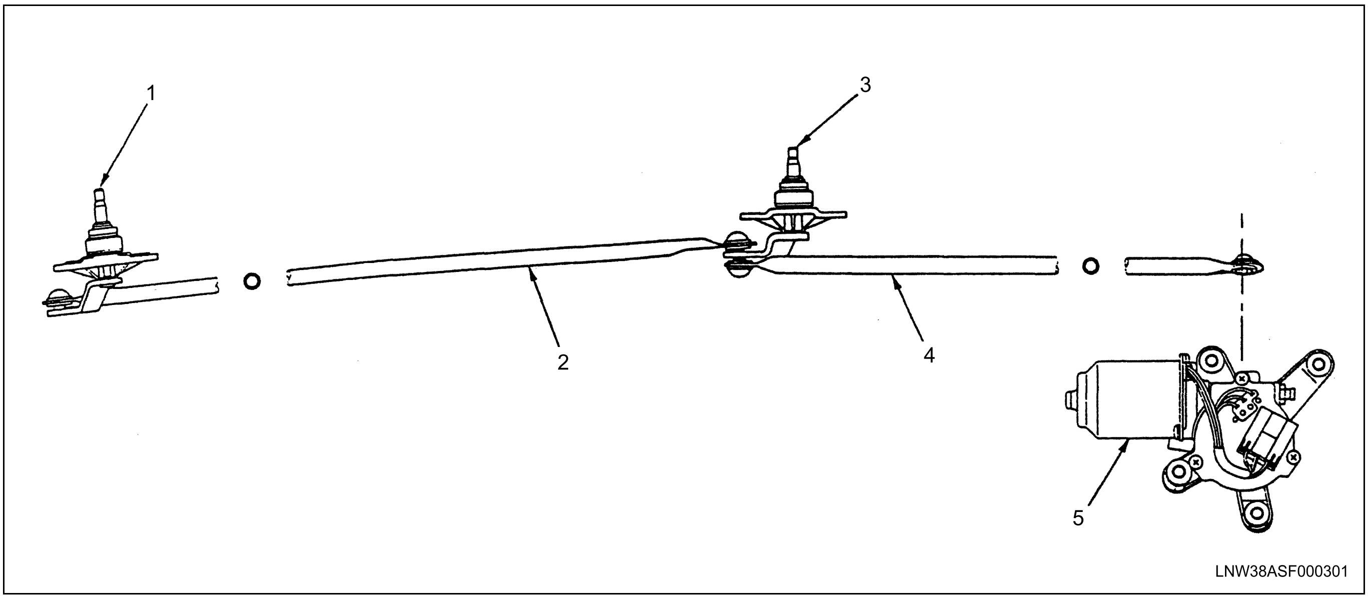
- Before installing the wiper arm/blade to the shaft, confirm that the motor stops at the auto-stop position.
- Set the wiper arm/blade so that the tips of both blades are positioned as shown in the illustration.
- Tighten the wiper arm nut to the specified torque.

Wiper arm nut torque	N·m (lb in)
17 (147)	



WINDSHIELD WIPER LINKAGE

LOCATION OF ROD AND PIVOT



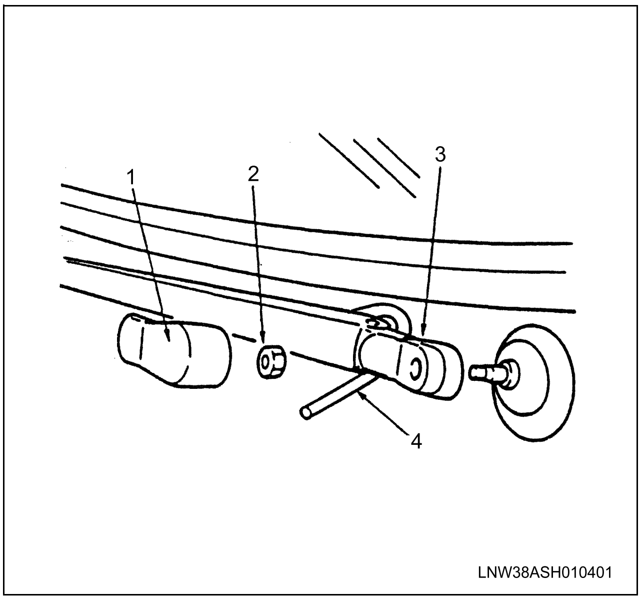
Legend

1. Pivot (Wiper: LH)
2. Rod
3. Pivot (Wiper: RH)
4. Rod
5. Wiper Motor

Remove or Disconnect

Preparation: Disconnect the battery ground cable

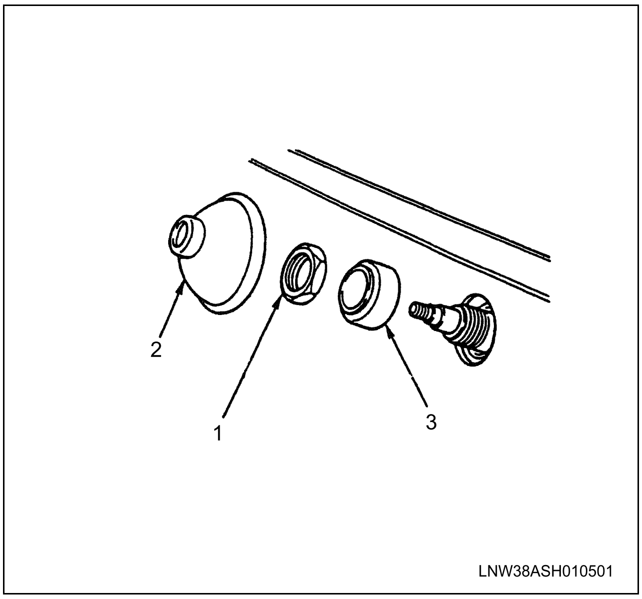
1. Wiper arm & blade
   Remove the rubber hose, cover, nut and wiper arm & blade.



Legend

1. Cover
2. Nut
3. Wiper Arm & Blade
4. Rubber Hose

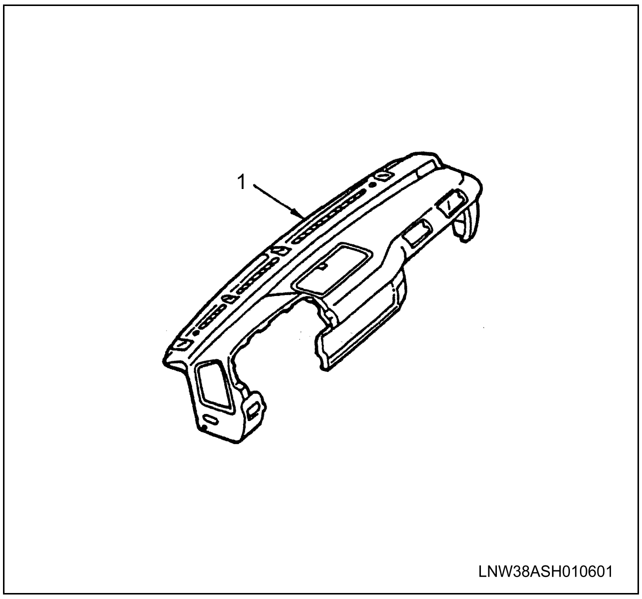
2. Pivot nut
   Remove the rubber seal, nut and retaining rubber.



Legend

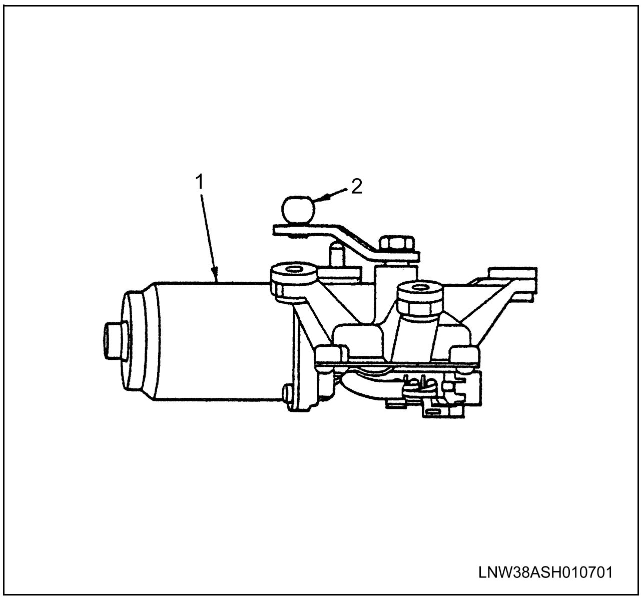
1. Pivot Nut
2. Rubber Seal
3. Retaining Rubber

3. Instrument panel assembly
   Refer to “Instrument Panel” of section 8F “Steel Tilt Cab”.



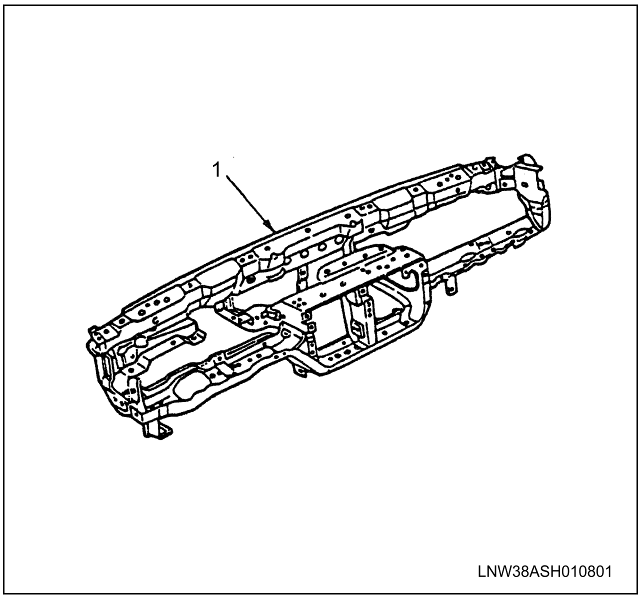
Legend
1. Instrument Panel Assembly

4. Wiper motor
   - Remove four screws.
   - Disconnect the ball joint between the crank arm and the wiper link.



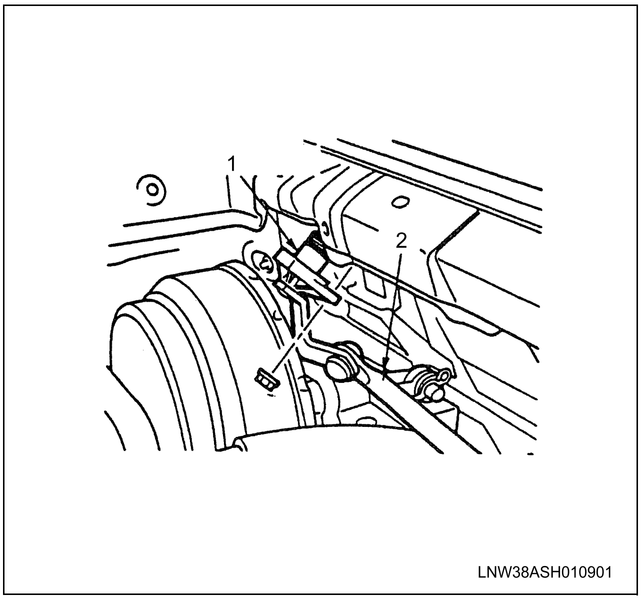
Legend
1. Wiper Motor
2. Ball Joint

5. Instrument panel reinforcement
   Refer to “Instrument Panel” of section 8F “Steel Tilt Cab”.



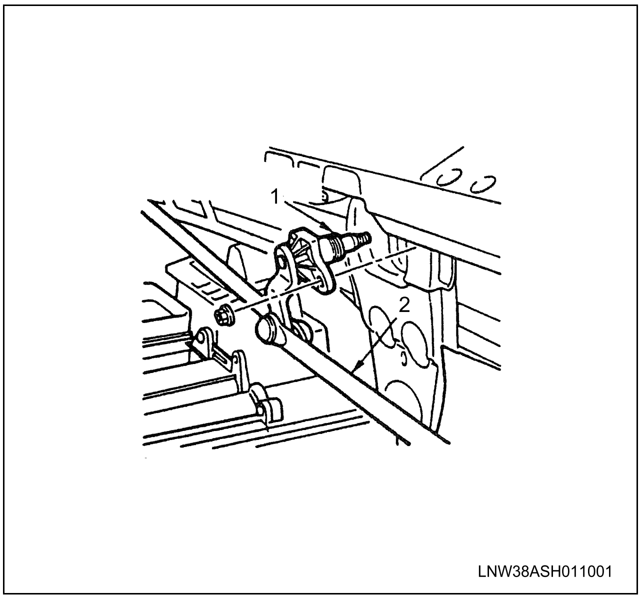
Legend
1. Instrument Panel Reinforcement

6. Wiper link assembly
   Remove two retaining nut from left hand side of pivot.



Legend
1. Pivot (Wiper: LH)
2. Wiper Link Assembly

Remove two retaining nut from right hand side of pivot.



Legend

1. Pivot (Wiper: RH)
2. Wiper Link Assembly

Install or Connect

To install, follow the removal steps in the reverse order, noting the following points:

- Temporarily fit the wiper motor by using one of the four wiper motor fixing screw.
- Put the crank arm ball joint in the wiper link hole and fix them together while pulling the wiper link.
- Fit the motor with four screws.
- Tighten the pivot nut with the specified torque.

Pivot nut torque	N·m (lb in)
8 (70)	

- Tighten the wiper arm nut with the specified torque

Wiper arm nut torque	N·m (lb in)
17 (147)	

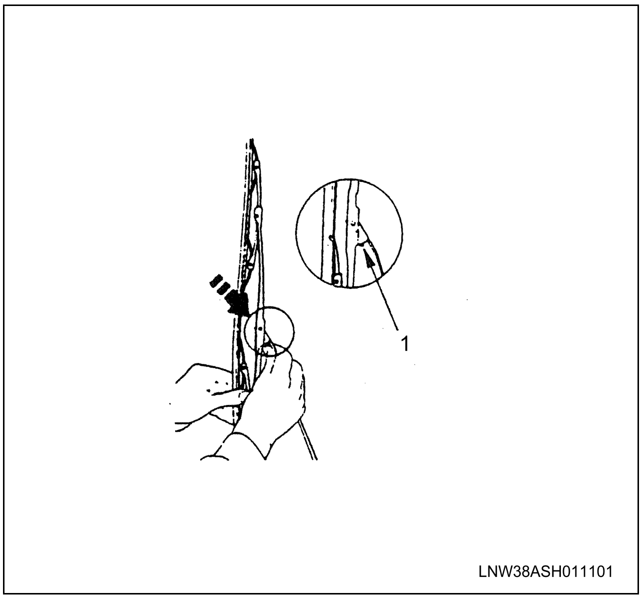
WIPER BLADE RUBBER

Remove or Disconnect

1. Wiper blade
   Push the wiper blade lock while pulling the wiper blade in the arrow direction.

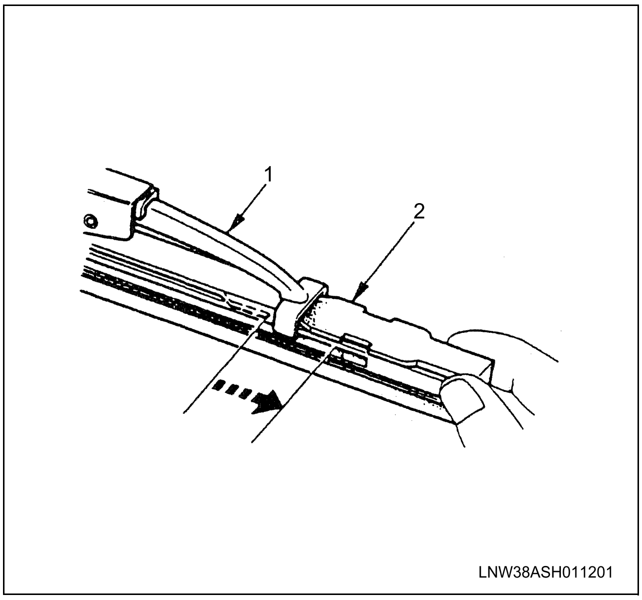
Notice:
When the wiper blade has been removed, wrap the tip of the wiper arm with cloth, to avoid damaging the glass.

2. Wiper blade rubber
   - Pull the end of rubber and remove the projection from the click of the blade stay.
   - Pull the rubber out in the same direction.



Legend

1. Blade Lock

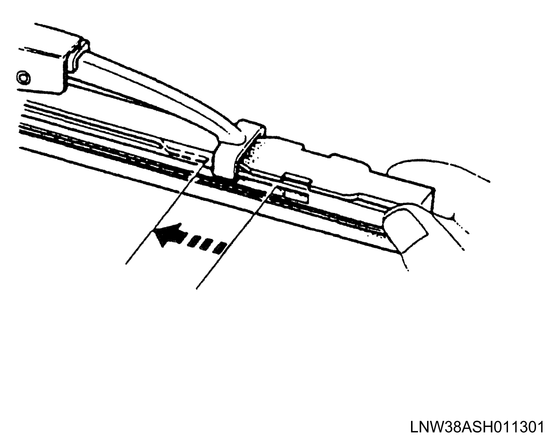


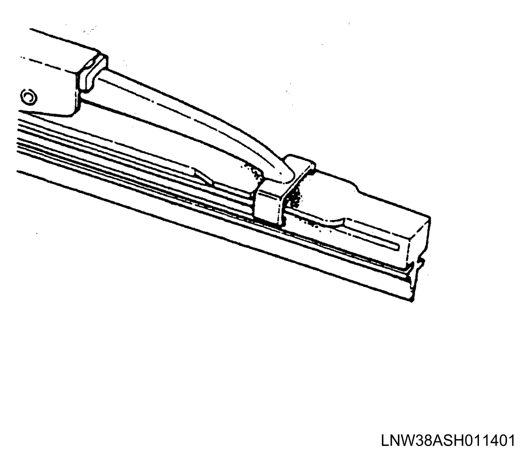
Legend

1. Blade Stay
2. Projection

Install or Connect

1. Wiper blade rubber
   Install the click of the blade stay in the groove of the new rubber and slide it in. Complete Installation by pushing the click. Finally, check that the click of the stay has caught in the hole of the rubber.
2. Wiper blade


LNW38ASH011301


LNW38ASH011401

Audio and Cigarette Lighter

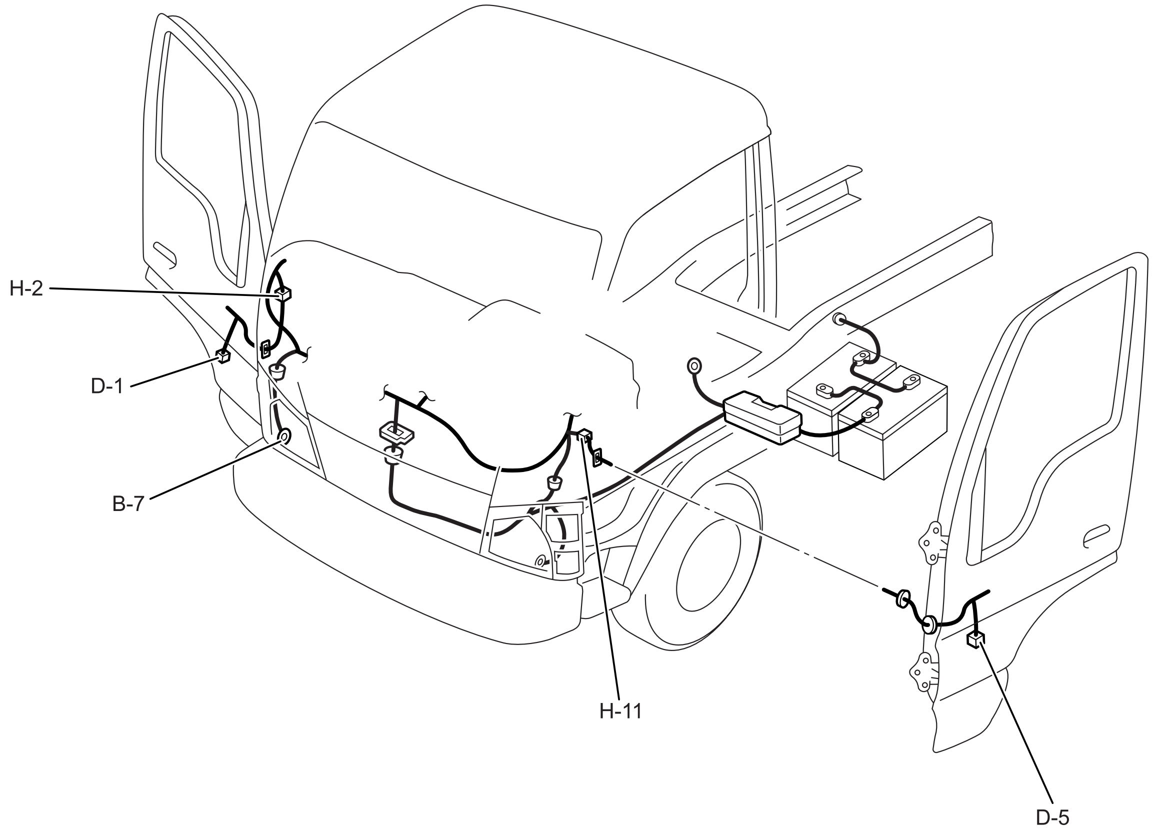
General Description

The circuit consists of the ignition switch, audio, cigarette lighter and the relay.

The audio circuit is designed for the current to flow through the receiver circuit when the audio switch is turned on with the ignition switch in “ACC” or “ON”. Current runs through the memory circuit of the audio regardless of the position of the ignition switch.

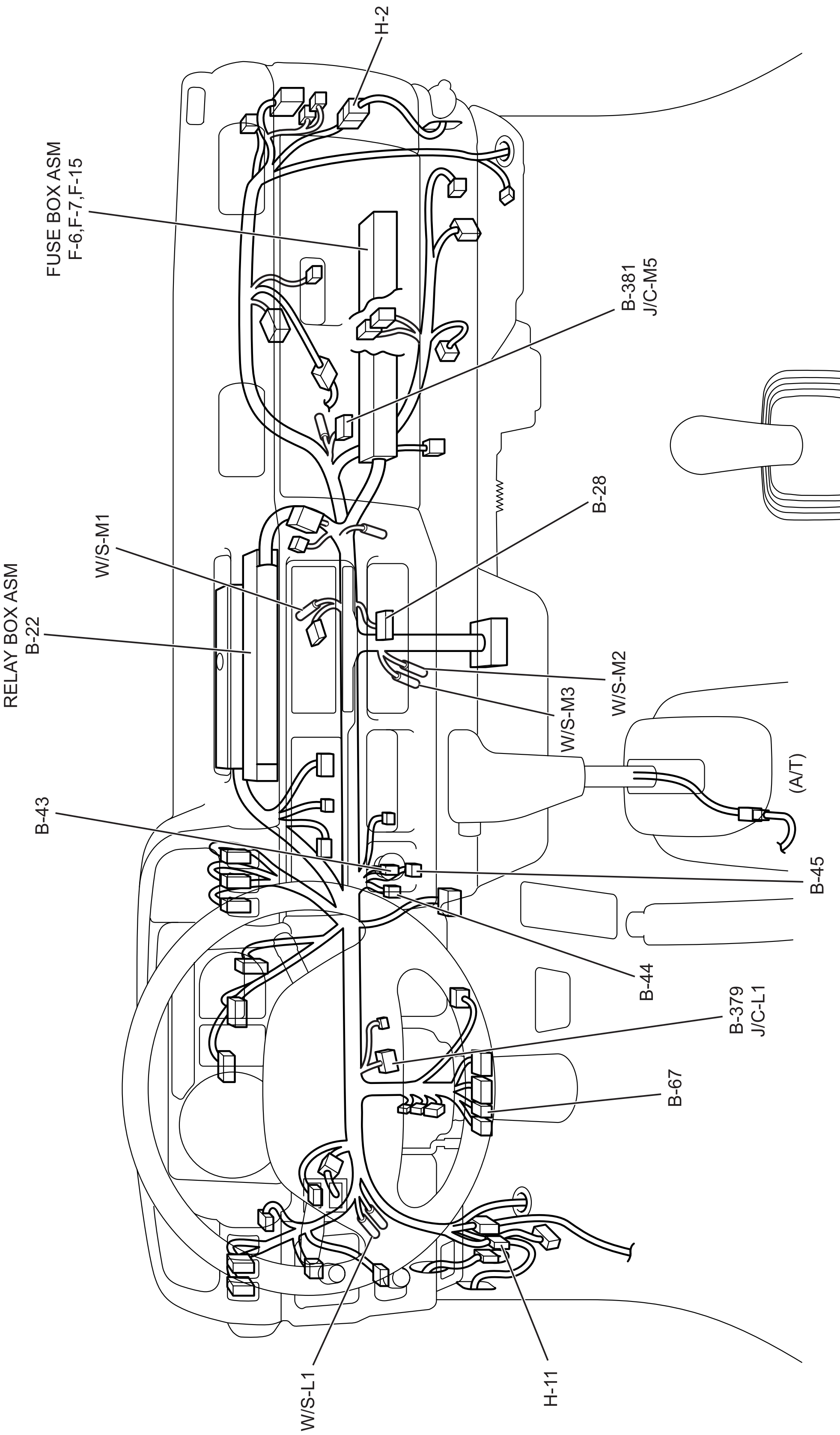
When the cigarette lighter is pushed in with the ignition switch at either “ACC” or “ON” position, a circuit is formed in the cigarette lighter case to heat the lighter coil. The cigarette lighter is spring back to its original position after the lighter coil is heated.

PARTS LOCATION (1)



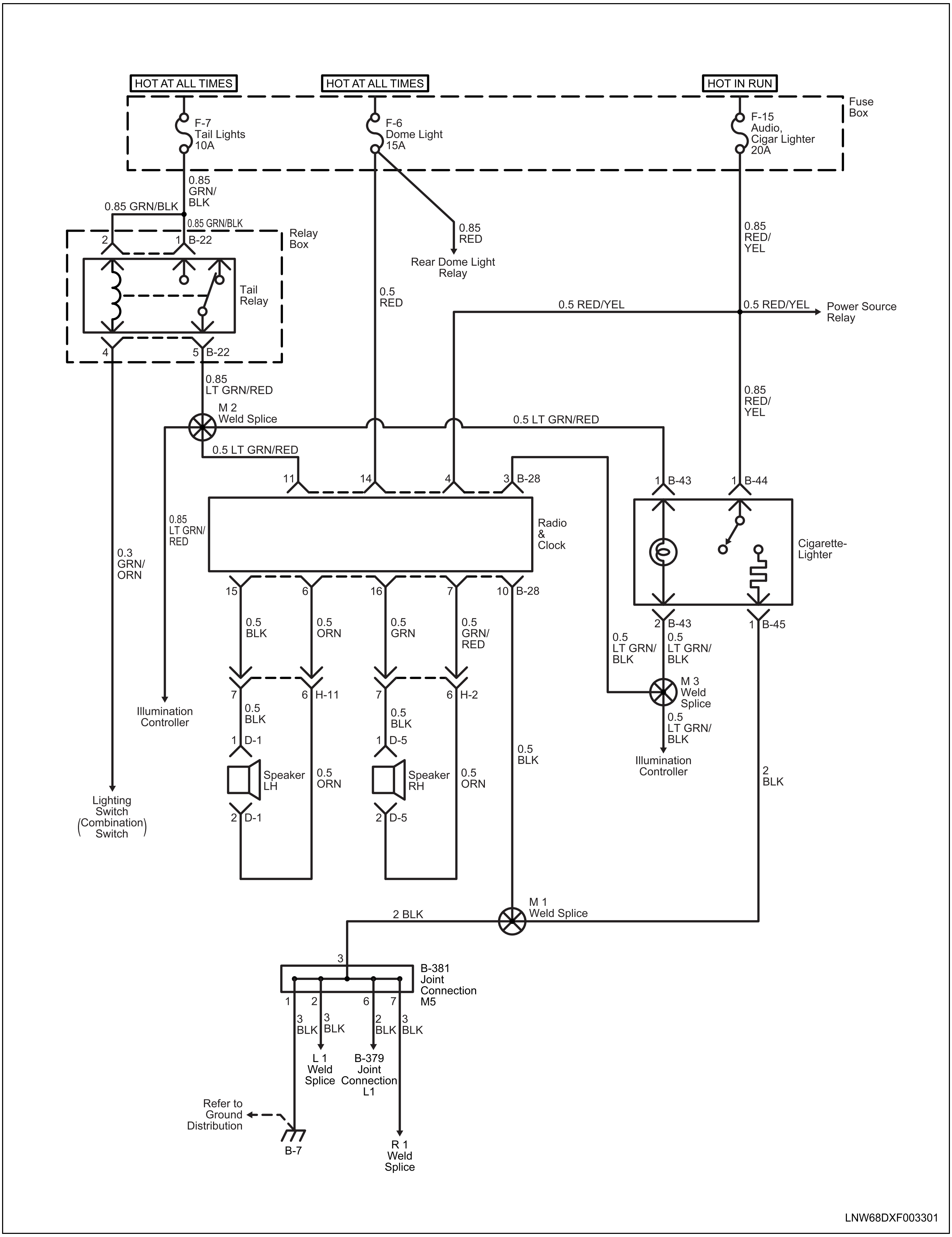
LNW58ALF001201

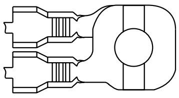
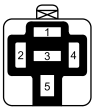
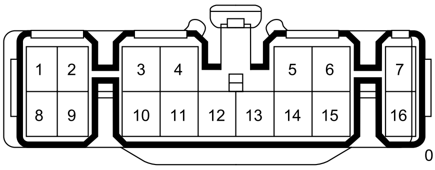
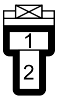
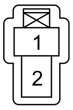
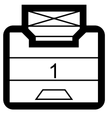
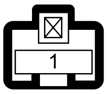
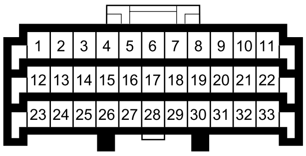
PARTS LOCATION (2)

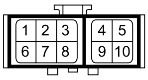
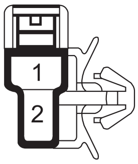
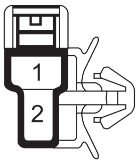
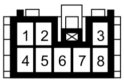
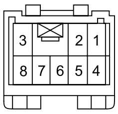
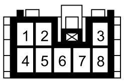
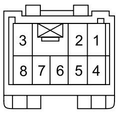


LNW68DXF011101

CIRCUIT DIAGRAM

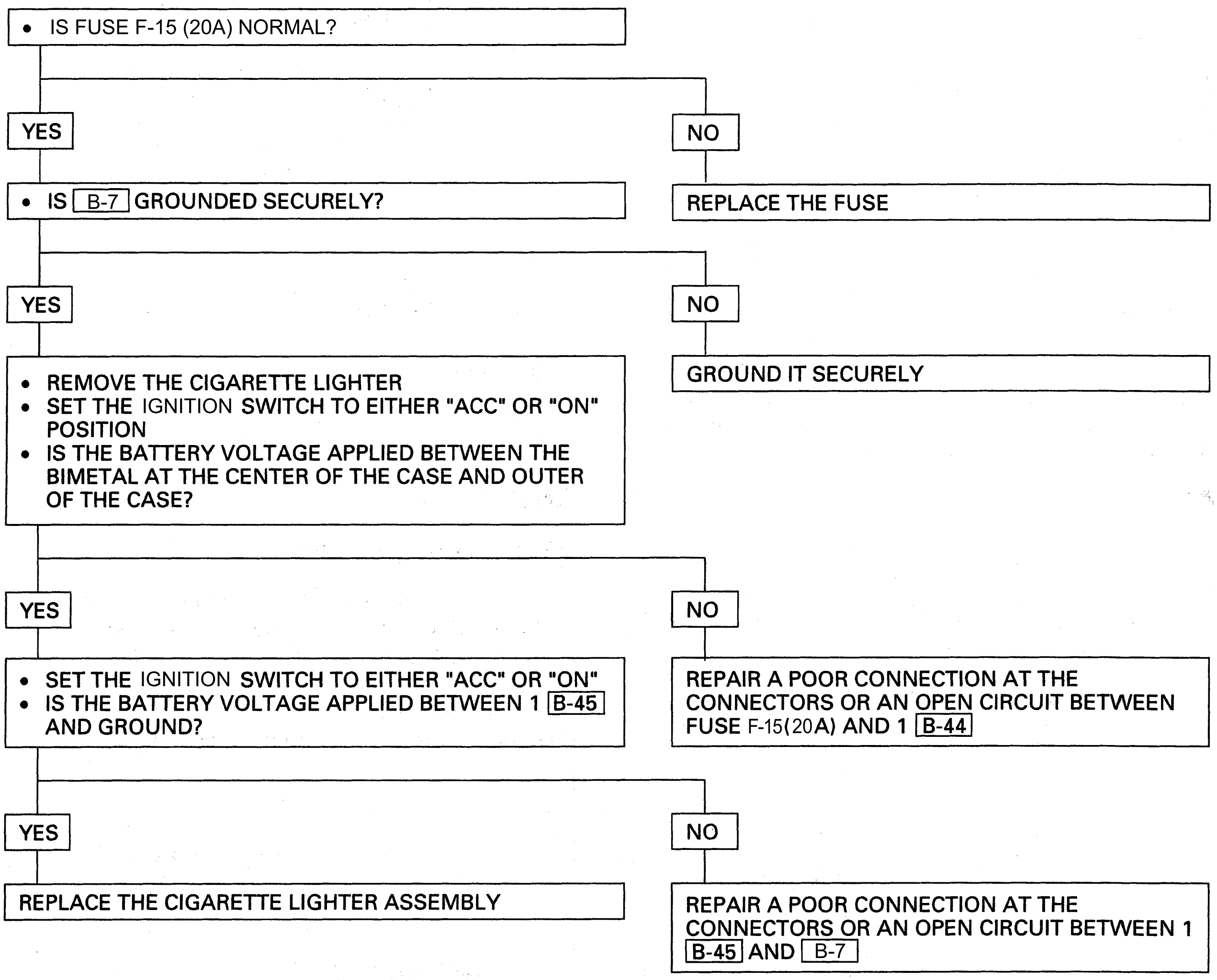


No.	Connector Face
B-7	 000-007 Ground; Headlight Bracket– RH
B-22 (Black)	 005-012 Tail Relay
B-28 (White)	 016-043 Radio
B-43 (White)	 002-012 Cigarette Lighter Illumination
B-43 (White)	 002-011 Cigarette Lighter Illumination
B-44 (White)	 001-013 Cigarette Lighter (B)
B-45 (Black)	 001-006 Cigarette Lighter
B-379 (White)	 033-001 Joint Connection – L1

No.	Connector Face
B-381 (White)	 010-015 Joint Connection – M5
D-1 (White)	 002-171 Speaker (RH)
D-5 (White)	 002-171 Speaker (LH)
H-2 (Yellow)	 008-001 Body H. – Door H. (RH)
H-2 (Yellow)	 008-002 Body H. – Door H. (RH)
H-11 (White)	 008-001 Body H. – Door H. (LH)
H-11 (White)	 008-002 Body H. – Door H. (LH)

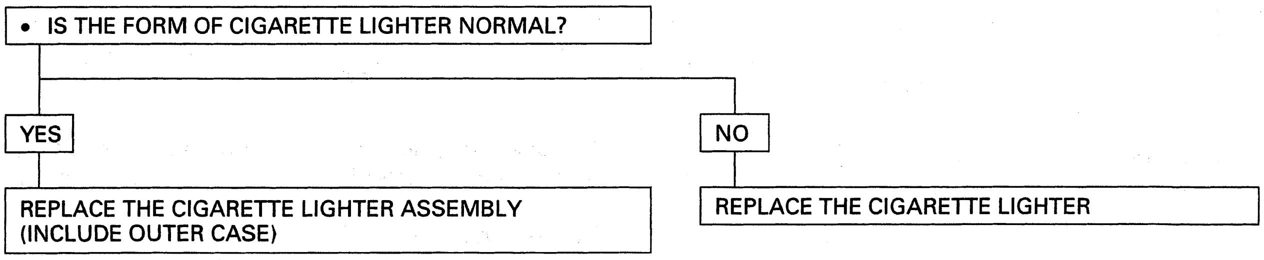
Diagnosis

1. CIGARETTE LIGHTER DOES NOT HEAT SUFFICIENTLY



LNW48ALF004601

2. THE CIGARETTE LIGHTER DOES NOT SPRING OUT AFTER BEING HEATED



LNW38ASF001701

IGNITION SWITCH

Refer to “Start and Charging” in this section.

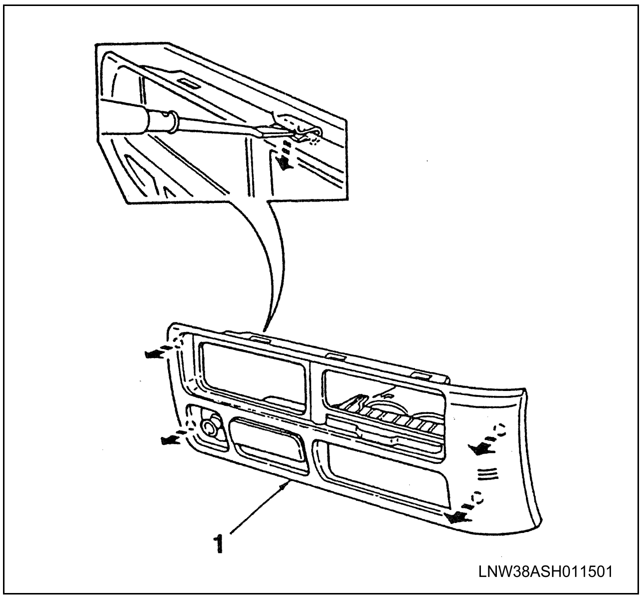
AUDIO

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Center cluster
    - Pull it to remove. Pry off three clips by the tip of screwdriver.
    - Remove the cigarette lighter power source and its illumination connector.

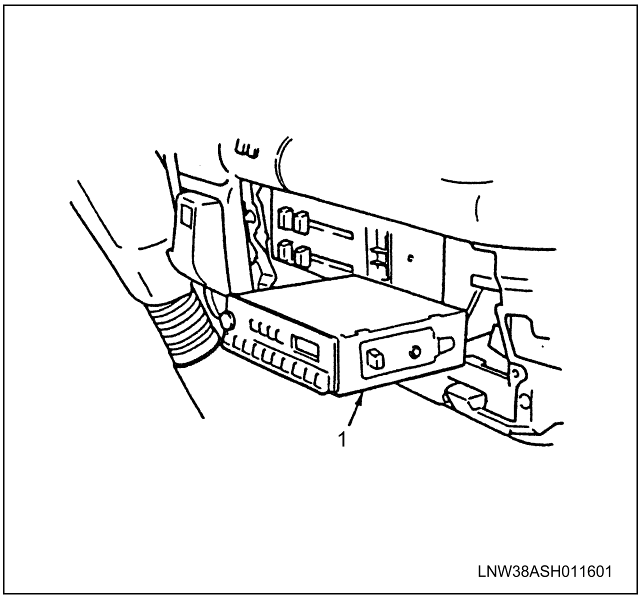
Notice:
To remove the center cluster, do not force to pry off three clips at upper portion of the center cluster.



Legend
1. Center Cluster

---

2. Radio
    - Remove two radio fixing screws.
    - Disconnect the connector and feeder plug.



Legend
1. Radio

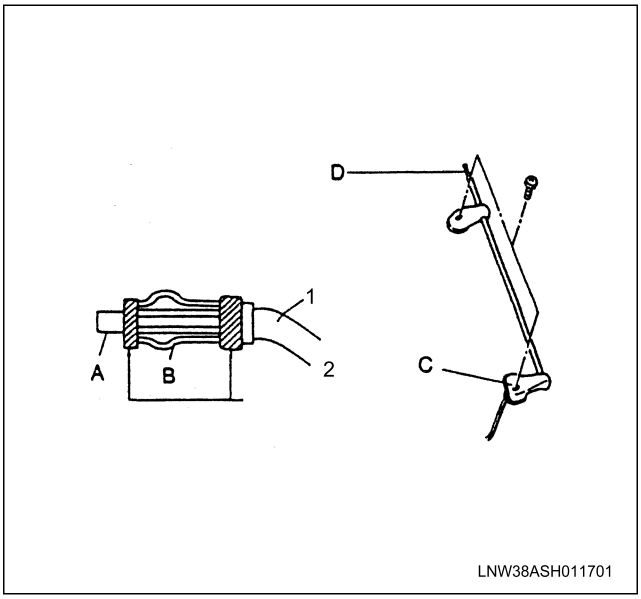
Install or Connect

To install, follow the removal steps in the reverse order.

ANTENNA

Inspect

The metal A is connected to the pole D at the top of the antenna through the core of the feeder.
The metal B is fitted in the feeder shielding the core, and grounded at the screw C to avoid the core hampered by noise.
Defective grounding would cause noise.



Legend
1. Feeder
2. Resin Made Parts

In checking, measure the following three points with the circuit tester in the range of "resistance × 1 (Ω)":

Between A and B

- No continuity (No reading at the indicator) → Normal
- Continuity (A bite in the feeder. The core grounded) → Lower reception

Between B and C

- Continuity (Indicator reading: 0Ω) → Normal.
- No continuity (Shielded core disconnected or defective grounding at the screw → Hampered by noise)

Between A and D

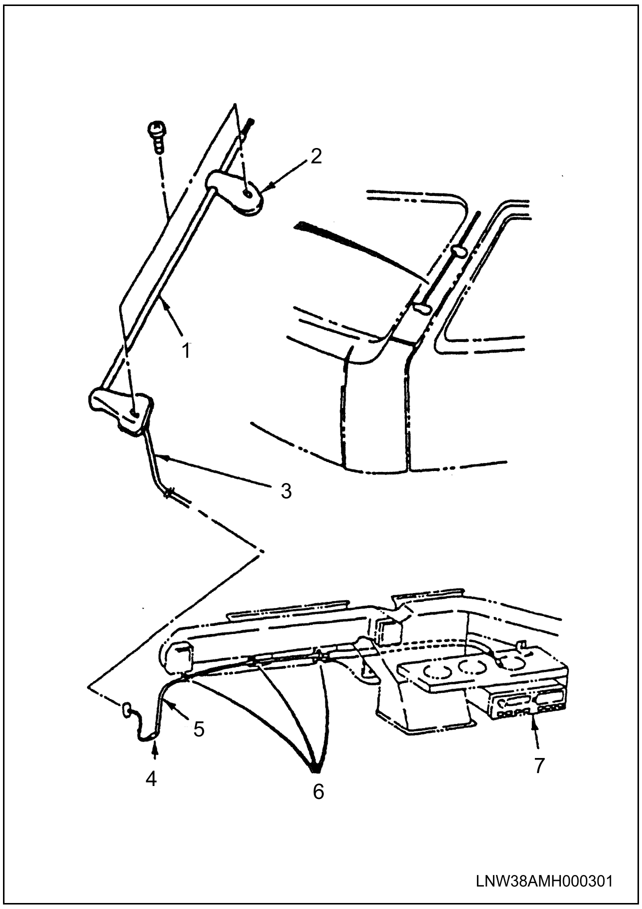
- Continuity or no continuity
  There are some antenna feeders and relay feeders with a condenser built in their connections. Measuring resistance between the two points does not result in correct Judgment. Connect temporarily another normal antenna to the radio and check to see if its reception is audible. Most antenna now available are slide type. Rust at the screw C and the cab panel where grounded would lead no continuity, followed by lower reception.
  Keep this portion clean to avoid rust.

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Antenna
   - Disconnect the joint connection.
   - Remove the upper and lower side antenna bracket.
   - Pull out the antenna feeder.

Notice:
For easier fitting, tie the lead wire to the end of the antenna feeder in advance.



Legend

1. Antenna
2. Antenna Bracket
3. Feeder
4. Joint Connection
5. Feeder
6. Clip
7. Radio

Install or Connect

To install, follow the removal steps in the reverse order.

SPEAKER

Inspect

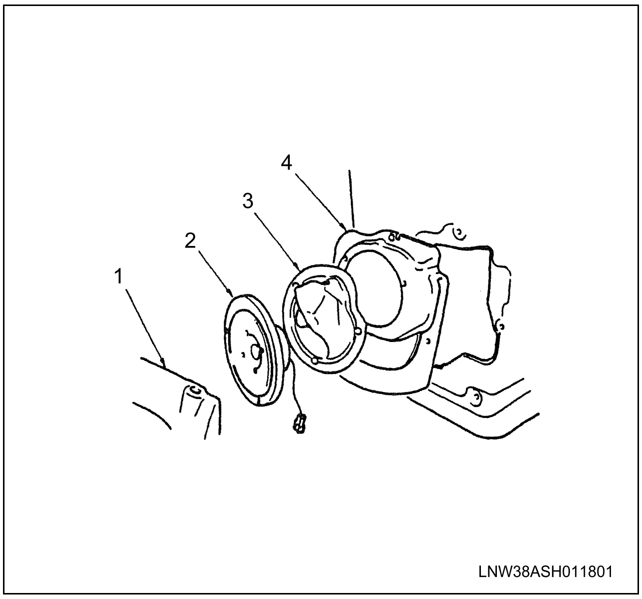
1. With the circuit tester set to the range of × 1 (Ω), connect the circuit tester probes (red and black) to the (+) and (–) terminals of the speaker.
2. When the speaker is normal, a low buzzing sound is heard.
3. When the speaker is defective, no sound is heard. However, the distortion or chattering of the sound cannot be identified.
   When the speaker is installed to the vehicle, disconnect the connectors before checking. When no sound is heard, the following are considered as the cause.
   - The speaker wiring is disconnected at the speaker terminals.
   - The speaker body is defective.

- There is an open circuit somewhere in the speaker harness on the vehicle side.
- The speaker harness on the vehicle side is grounded or caught up.

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Trim Panel
   Refer to “Trim Panel” of section 8F “Steel Tilt Cab”.
2. Speaker panel
   Disconnect the speaker connector.
3. Speaker
4. Waterproof sheet



Legend

1. Trim Panel
2. Speaker
3. Waterproof Sheet
4. Speaker Panel

Install or Connect

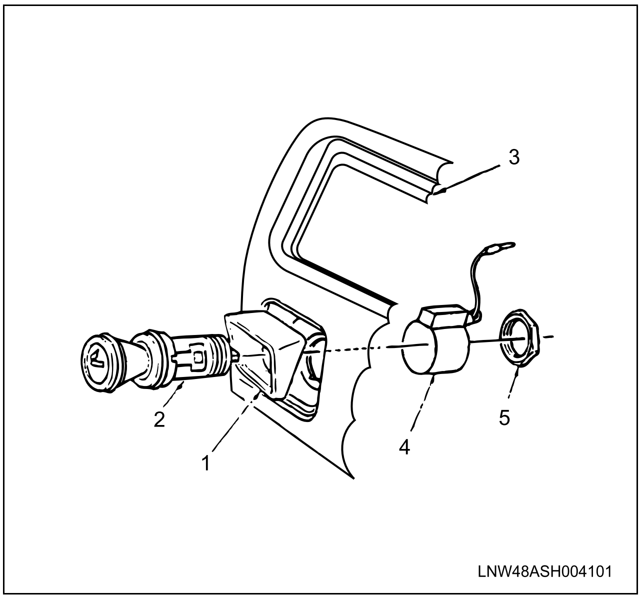
To install, follow the removal steps in the reverse order.

CIGARETTE LIGHTER

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Center cluster
   Refer to Radio in this section.
2. Cigarette lighter assembly
   Remove the nut, then remove cigarette lighter assembly, bezel and outer case.



Legend

1. Bezel
2. Cigarette Lighter Assembly
3. Center Cluster
4. Outer Case
5. Nut

Install or Connect

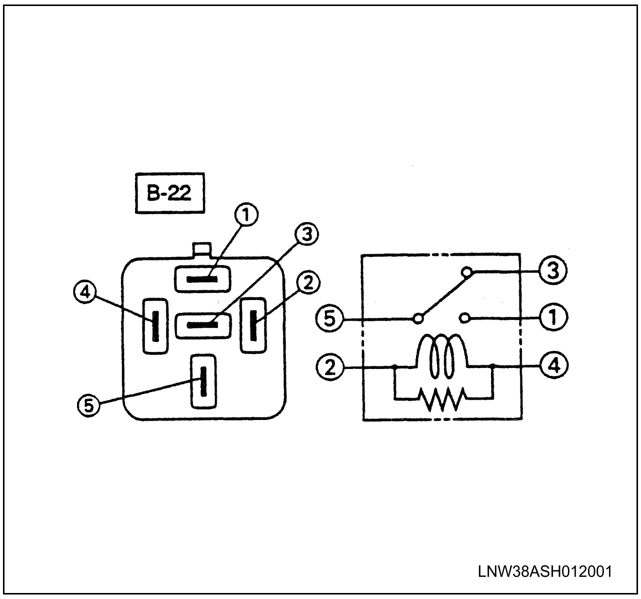
To install, follow the removal steps in the reverse order.

TAIL RELAY

Inspect

Check to see if there is any continuity between the relay terminals.
Replace the relay when the result of inspection is found abnormal.

(3) – (5)	Continuity
(1) – (5)	No continuity
(When battery voltage is applied between (2) – (4))	
(3) – (5)	No continuity
(1) – (5)	Continuity



Instrument Panel Cluster (IPC) and Warning / Indicator Light

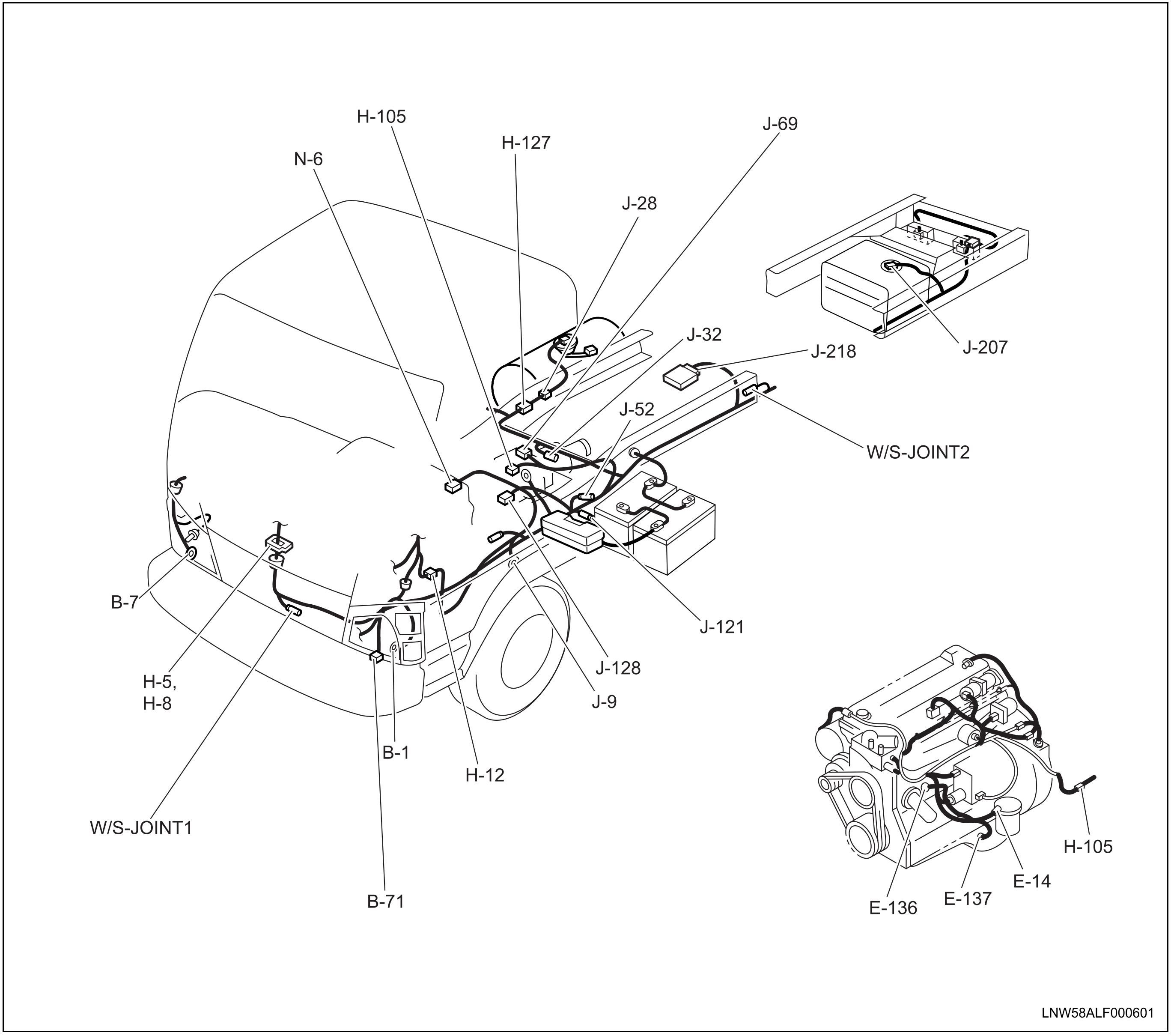
General Description

The circuit consists of the ignition switch, instrument panel cluster, vacuum tank switch, oil pressure switch, brake fluid level switch, parking brake switch, vehicle speed sensor, fuel tank unit, A/T shift indicator and thermo unit.

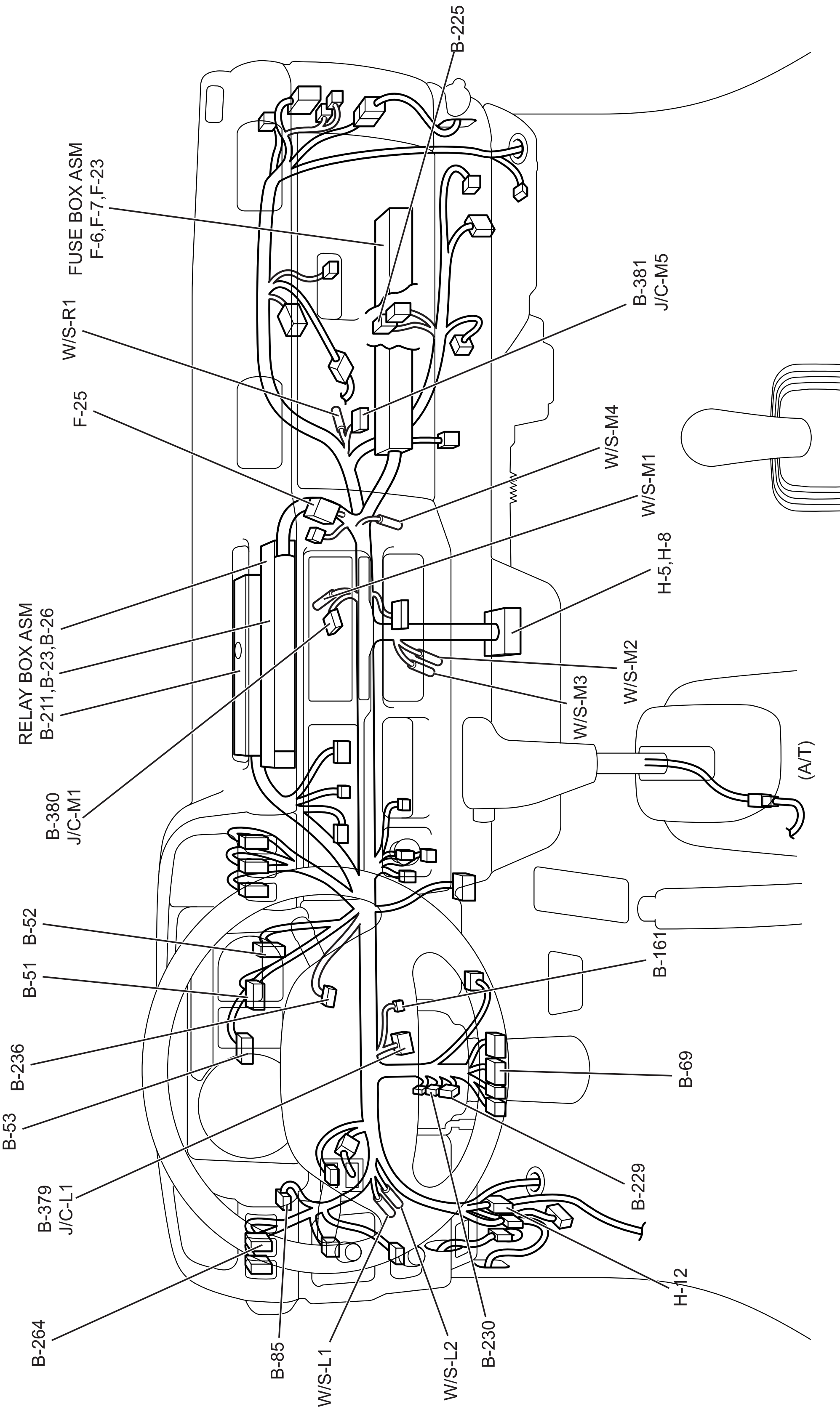
The instrument panel cluster contains the speedometer, fuel gauge, engine coolant temperature gauge and the warning/indicator light.

The instrument panel cluster warning/indicator lights and their bulb sockets are a unit, they are installed from the back of the speedometer assembly.

PARTS LOCATION (1)

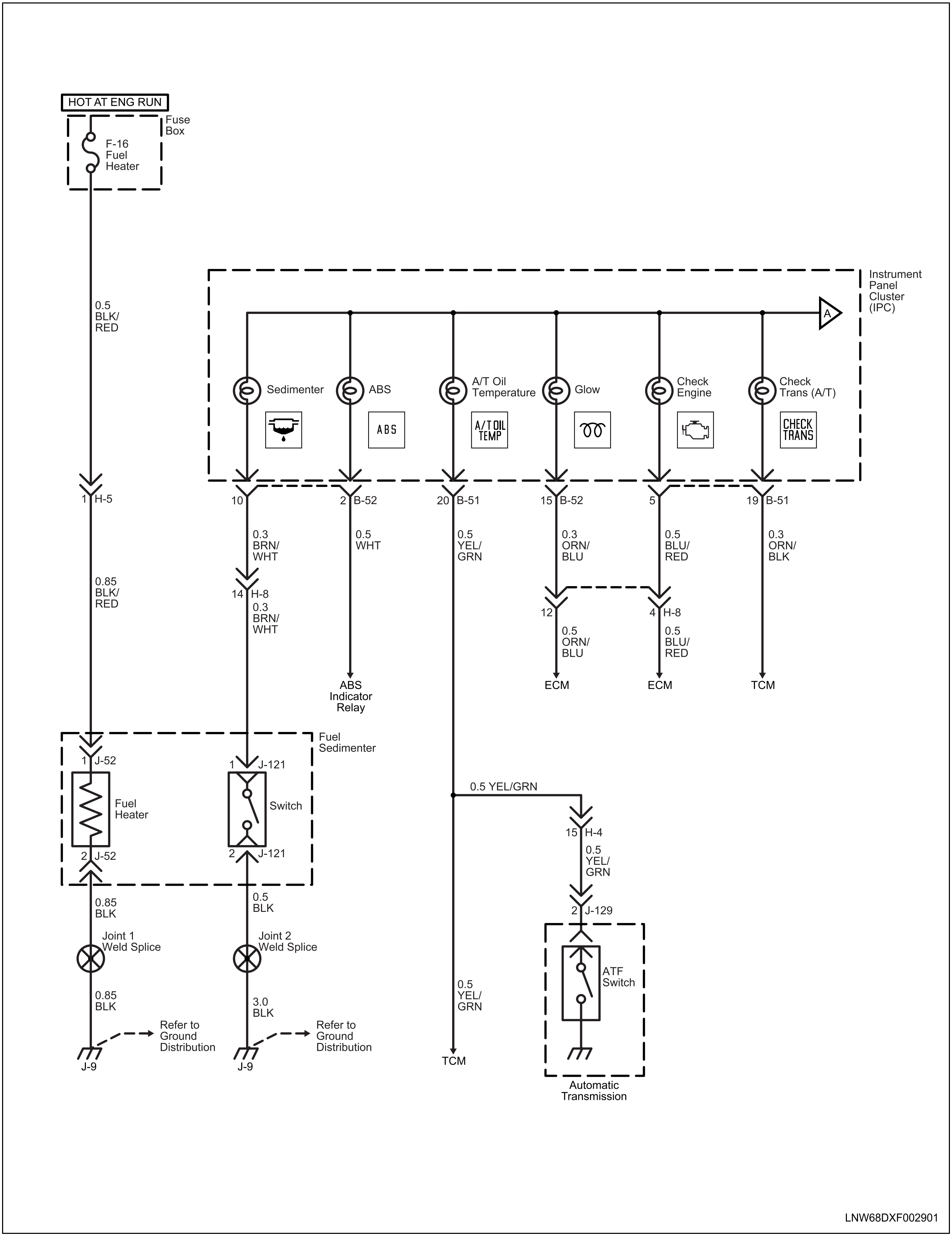


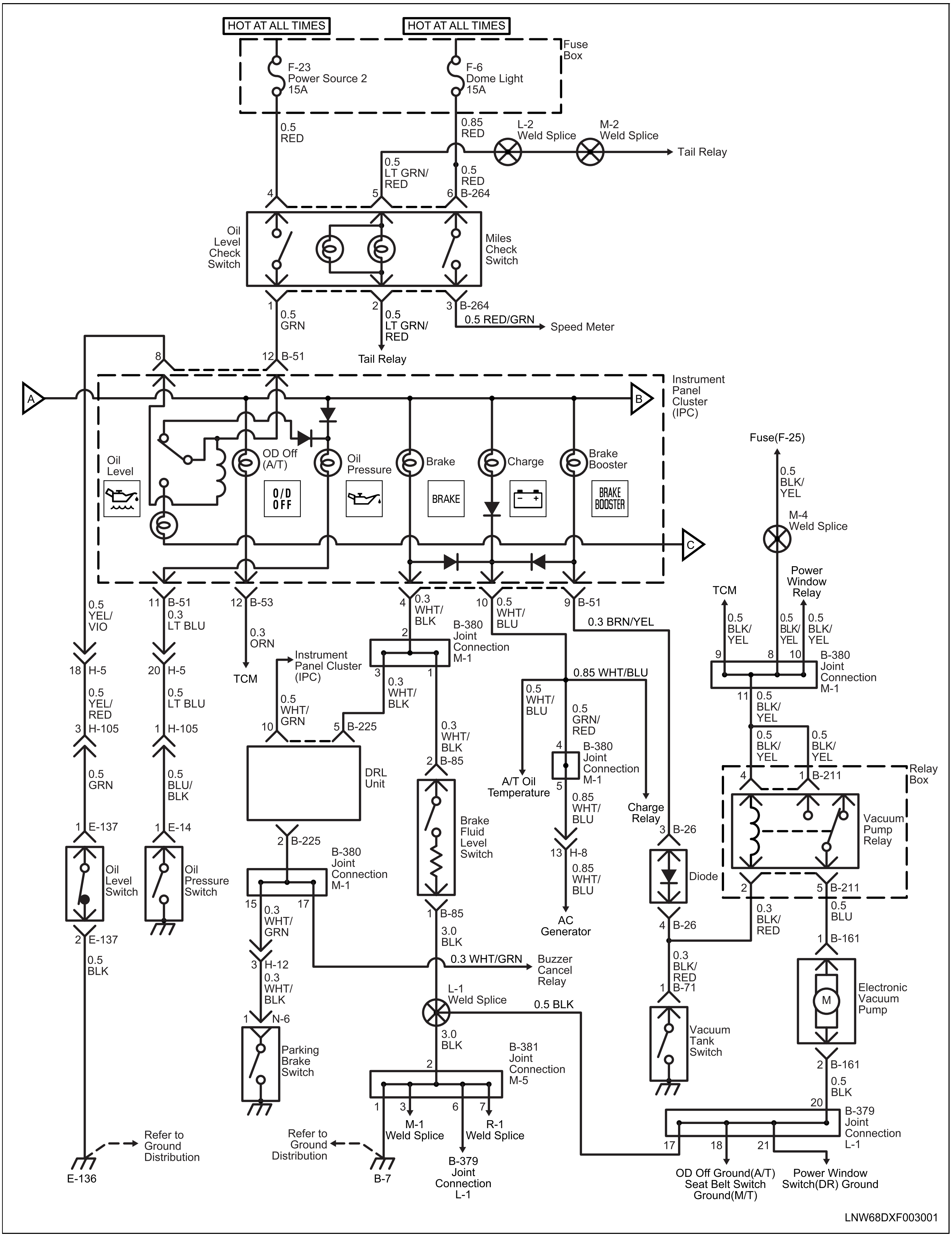
PARTS LOCATION (2)

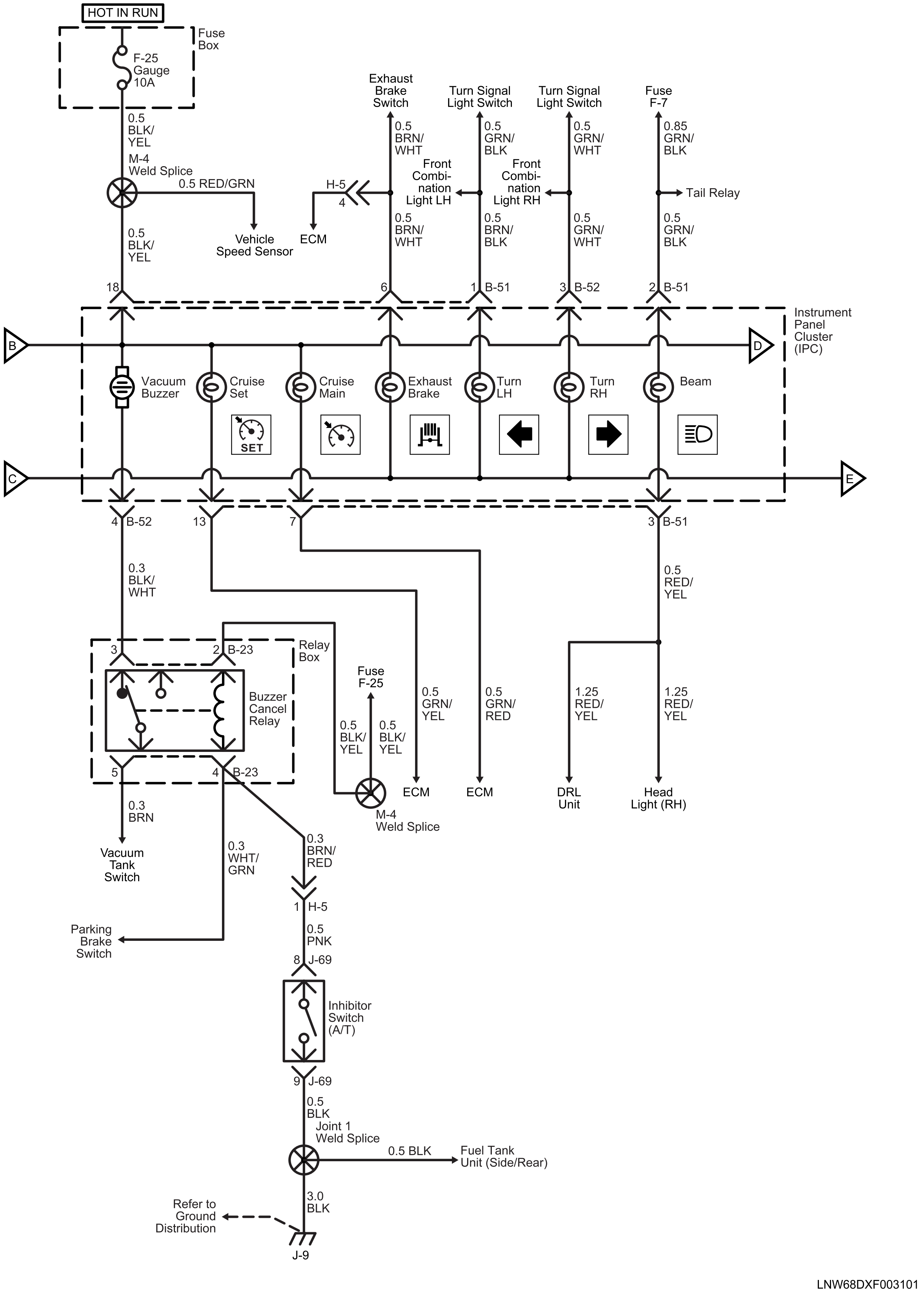


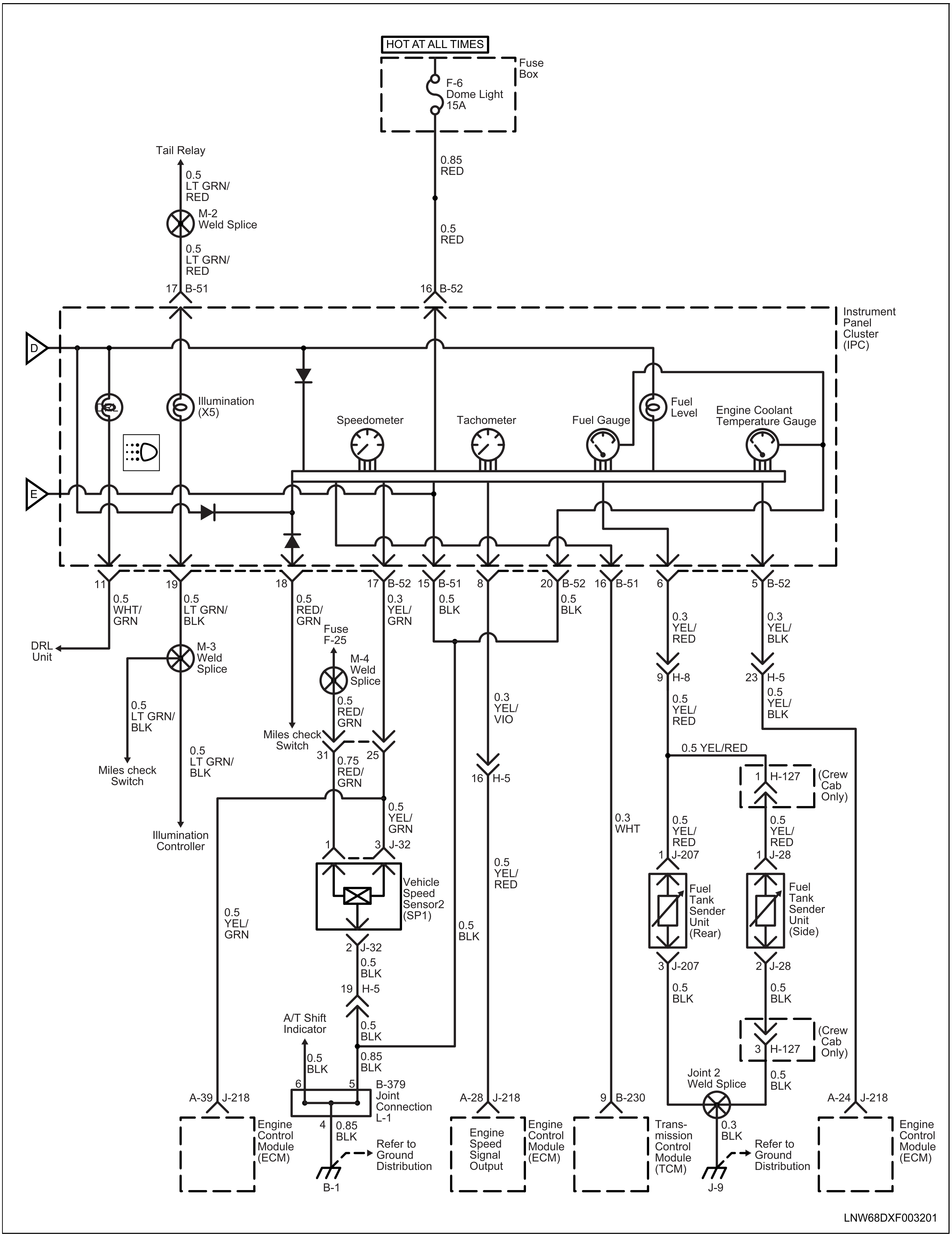
LNW68DXF011201

CIRCUIT DIAGRAM (WITHOUT HBB)

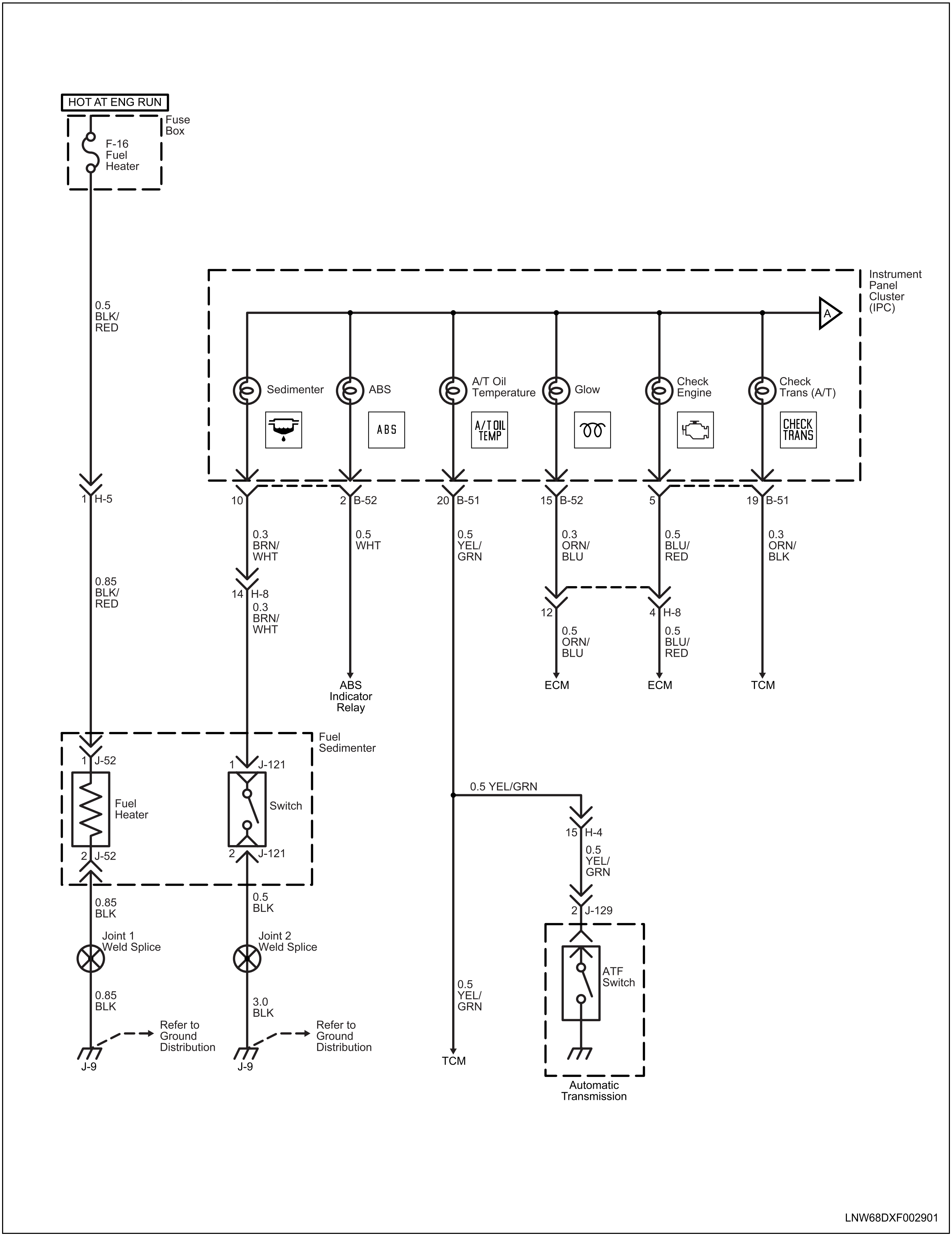


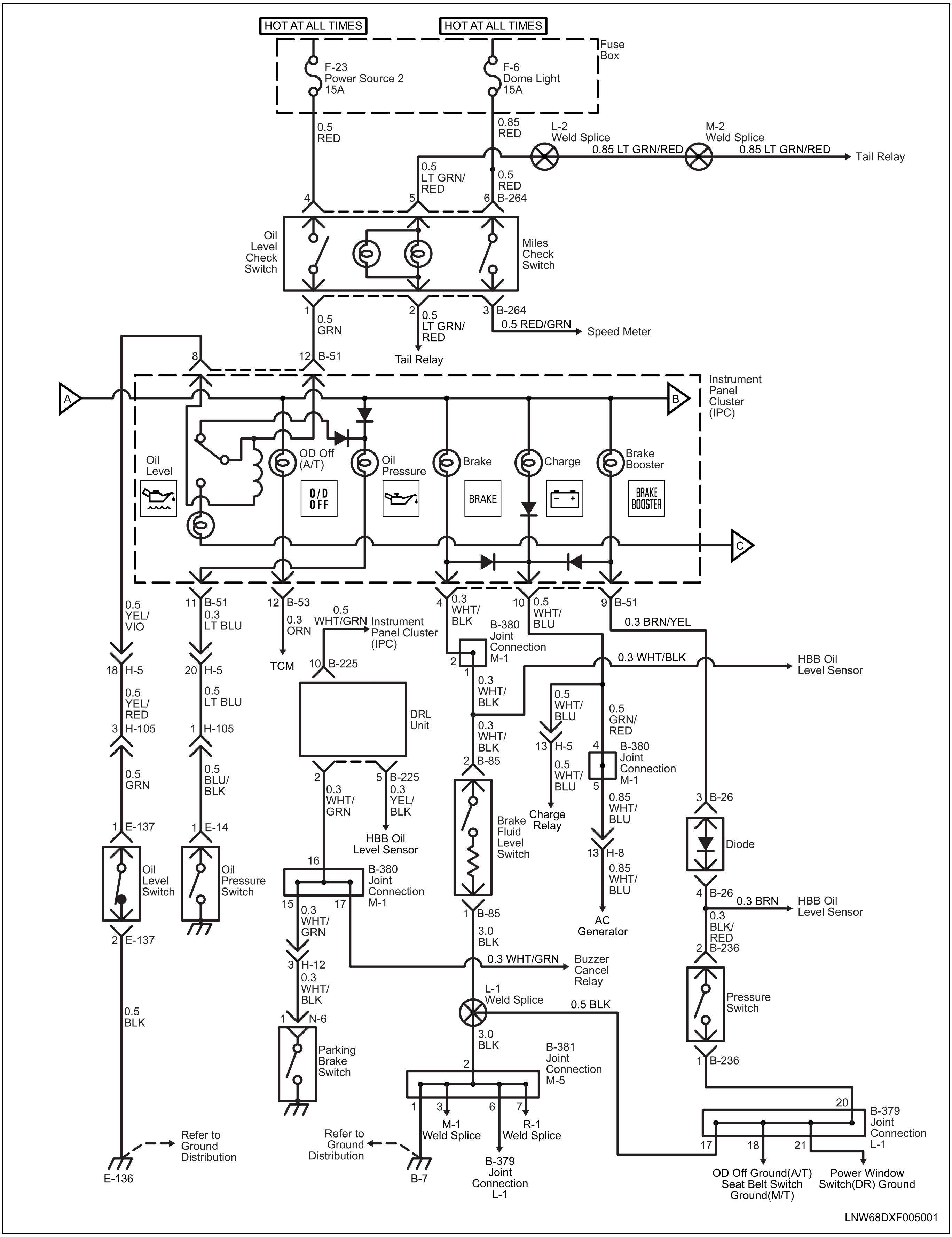

HOT AT ALL TIMES
HOT AT ALL TIMES
Fuse Box
F-23 Power Source 2 15A
F-6 Dome Light 15A
0.5 RED
0.85 RED
L-2 Weld Splice
M-2 Weld Splice
Tail Relay
0.5 LT GRN/ RED
0.5 RED
B-264
4
5
6
Oil Level Check Switch
Miles Check Switch
1
2
3
B-264
0.5 GRN
0.5 LT GRN/ RED
0.5 RED/GRN
Speed Meter
Tail Relay
8
12
B-51
A
B
C
Instrument Panel Cluster (IPC)
Oil Level
OD Off (A/T)
O/D OFF
Oil Pressure
Brake
BRAKE
Charge
Brake Booster
BRAKE BOOSTER
Fuse(F-25)
0.5 BLK/ YEL
M-4 Weld Splice
Power Window Relay
TCM
0.5 YEL/ VIO
11
B-51
0.3 LT BLU
12
B-53
0.3 ORN
TCM
4
0.3 WHT/ BLK
10
0.5 WHT/ BLU
9
B-51
0.3 BRN/YEL
B-380 Joint Connection M-1
2
3
1
Instrument Panel Cluster (IPC)
0.5 WHT/ GRN
10
5
B-225
0.3 WHT/ BLK
DRL Unit
0.3 WHT/ BLK
2
B-85
Brake Fluid Level Switch
1
B-85
3.0 BLK
0.3 WHT/GRN
Buzzer Cancel Relay
2
B-225
B-380 Joint Connection M-1
15
17
0.3 WHT/ GRN
3
H-12
0.3 WHT/ BLK
1
N-6
Parking Brake Switch
L-1 Weld Splice
0.5 BLK
3.0 BLK
2
B-381 Joint Connection M-5
1
3
6
7
M-1 Weld Splice
R-1 Weld Splice
B-379 Joint Connection L-1
Refer to Ground Distribution
B-7
Refer to Ground Distribution
E-136
18
H-5
0.5 YEL/ RED
3
H-105
0.5 GRN
1
E-137
Oil Level Switch
2
E-137
0.5 BLK
20
H-5
0.5 LT BLU
1
H-105
0.5 BLU/ BLK
1
E-14
Oil Pressure Switch
0.85 WHT/BLU
0.5 WHT/ BLU
A/T Oil Temperature
0.5 GRN/ RED
4
B-380 Joint Connection M-1
5
0.85 WHT/ BLU
13
H-8
0.85 WHT/ BLU
AC Generator
Charge Relay
3
B-26
Diode
4
B-26
0.3 BLK/ RED
1
B-71
Vacuum Tank Switch
0.5 BLK/ YEL
0.5 BLK/ YEL
0.5 BLK/ YEL
9
8
10
B-380 Joint Connection M-1
11
0.5 BLK/ YEL
0.5 BLK/ YEL
0.5 BLK/ YEL
4
1
B-211
Relay Box
Vacuum Pump Relay
2
5
B-211
0.3 BLK/ RED
0.5 BLU
1
B-161
Electronic Vacuum Pump
M
2
B-161
0.5 BLK
20
B-379 Joint Connection L-1
17
18
21
OD Off Ground(A/T) Seat Belt Switch Ground(M/T)
Power Window Switch(DR) Ground
LNW68DXF003001

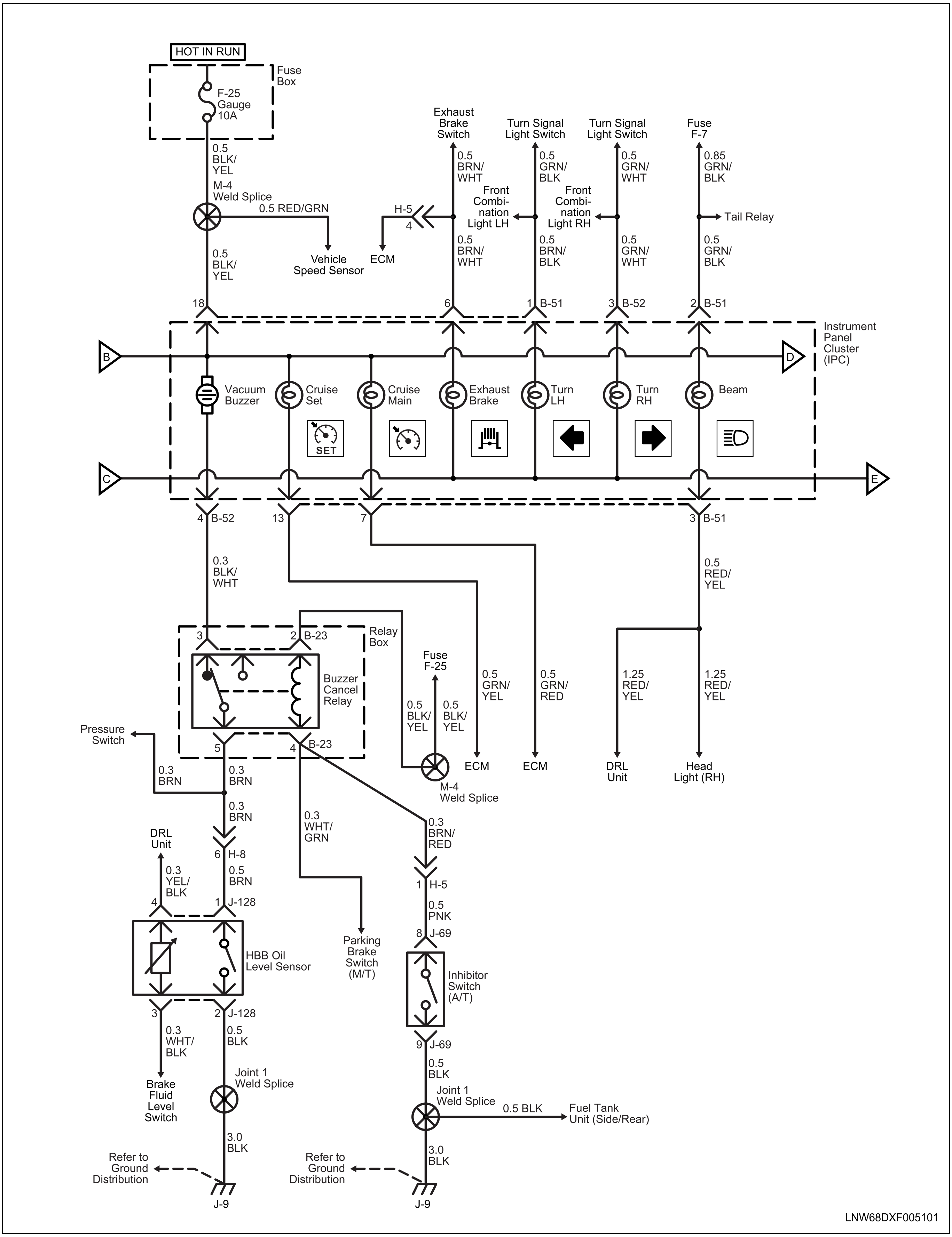

HOT IN RUN
Fuse Box
F-25 Gauge 10A
0.5 BLK/YEL
M-4 Weld Splice
0.5 RED/GRN
Vehicle Speed Sensor
0.5 BLK/YEL
H-5
4
ECM
Exhaust Brake Switch
0.5 BRN/WHT
Turn Signal Light Switch
0.5 GRN/BLK
Turn Signal Light Switch
0.5 GRN/WHT
Fuse F-7
0.85 GRN/BLK
Front Combi-nation Light LH
Front Combi-nation Light RH
Tail Relay
0.5 BRN/WHT
0.5 BRN/BLK
0.5 GRN/WHT
0.5 GRN/BLK
18
6
1 B-51
3 B-52
2 B-51
Instrument Panel Cluster (IPC)
B
D
C
E
Vacuum Buzzer
Cruise Set
SET
Cruise Main
Exhaust Brake
Turn LH
Turn RH
Beam
4 B-52
13
7
3 B-51
0.3 BLK/WHT
0.5 RED/YEL
3
2 B-23
Relay Box
Buzzer Cancel Relay
5
4 B-23
Fuse F-25
0.5 BLK/YEL
0.5 BLK/YEL
0.5 GRN/YEL
0.5 GRN/RED
1.25 RED/YEL
1.25 RED/YEL
ECM
ECM
DRL Unit
Head Light (RH)
M-4 Weld Splice
0.3 BRN
Vacuum Tank Switch
0.3 WHT/GRN
0.3 BRN/RED
1 H-5
0.5 PNK
8 J-69
Parking Brake Switch
Inhibitor Switch (A/T)
9 J-69
0.5 BLK
Joint 1 Weld Splice
0.5 BLK
Fuel Tank Unit (Side/Rear)
3.0 BLK
Refer to Ground Distribution
J-9
LNW68DXF003101

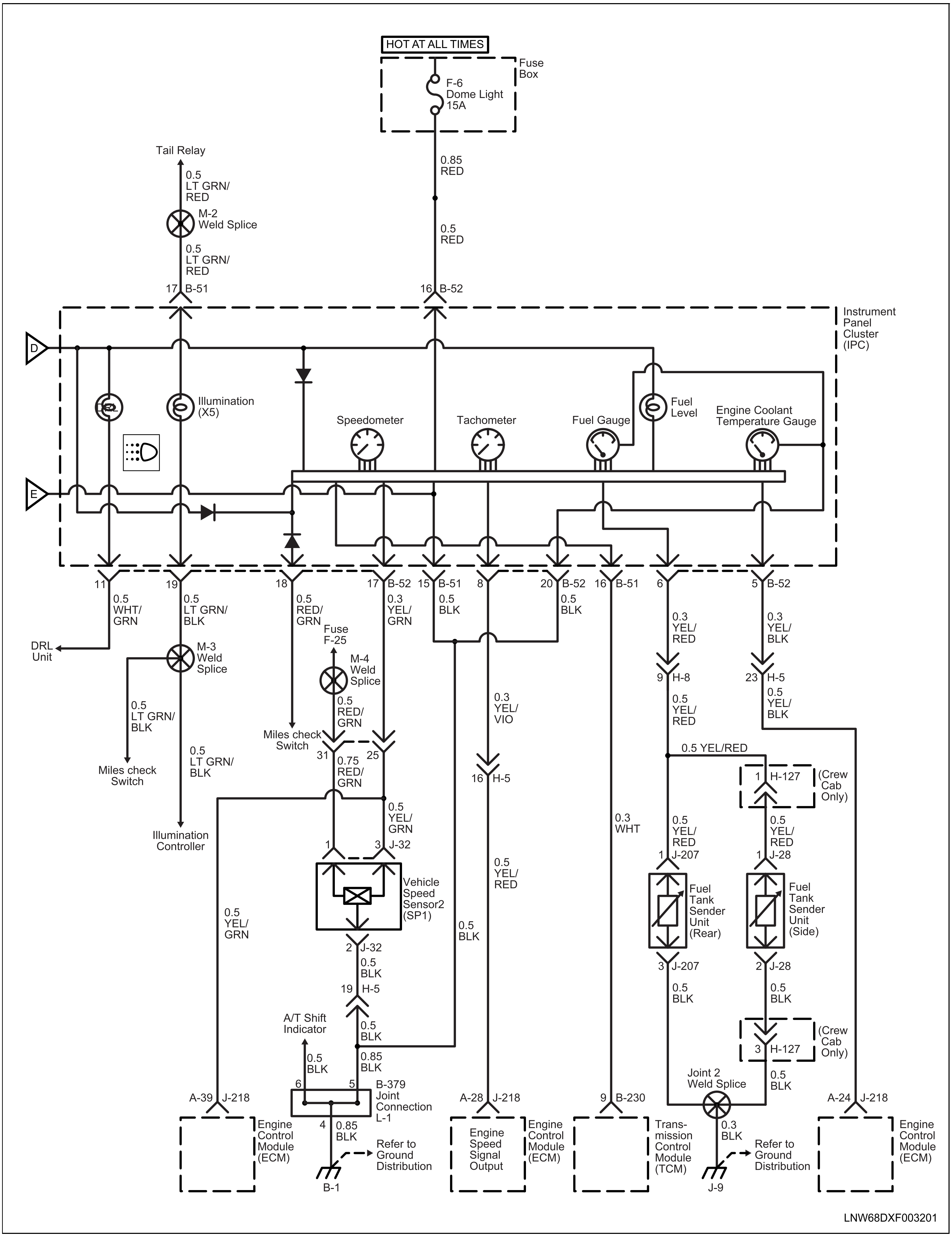

HOT AT ALL TIMES
Fuse Box
F-6 Dome Light 15A
0.85 RED
0.5 RED
16 B-52
Tail Relay
0.5 LT GRN/ RED
M-2 Weld Splice
0.5 LT GRN/ RED
17 B-51
Instrument Panel Cluster (IPC)
D
E
DRL
Illumination (X5)
Speedometer
Tachometer
Fuel Gauge
Fuel Level
Engine Coolant Temperature Gauge
11
0.5 WHT/ GRN
DRL Unit
19
0.5 LT GRN/ BLK
M-3 Weld Splice
0.5 LT GRN/ BLK
Miles check Switch
0.5 LT GRN/ BLK
Illumination Controller
18
0.5 RED/ GRN
Miles check Switch
Fuse F-25
M-4 Weld Splice
0.5 RED/ GRN
31
0.75 RED/ GRN
25
17 B-52
0.3 YEL/ GRN
0.5 YEL/ GRN
1
3 J-32
Vehicle Speed Sensor2 (SP1)
2 J-32
0.5 BLK
19 H-5
0.5 BLK
0.85 BLK
A/T Shift Indicator
0.5 BLK
6
5
B-379 Joint Connection L-1
4
0.85 BLK
Refer to Ground Distribution
B-1
0.5 YEL/ GRN
A-39 J-218
Engine Control Module (ECM)
15 B-51
0.5 BLK
0.5 BLK
8
0.3 YEL/ VIO
16 H-5
0.5 YEL/ RED
A-28 J-218
Engine Speed Signal Output
Engine Control Module (ECM)
20 B-52
0.5 BLK
16 B-51
0.3 WHT
9 B-230
Trans- mission Control Module (TCM)
6
0.3 YEL/ RED
9 H-8
0.5 YEL/ RED
0.5 YEL/RED
0.5 YEL/ RED
1 J-207
Fuel Tank Sender Unit (Rear)
3 J-207
0.5 BLK
Joint 2 Weld Splice
0.3 BLK
Refer to Ground Distribution
J-9
5 B-52
0.3 YEL/ BLK
23 H-5
0.5 YEL/ BLK
1 H-127
(Crew Cab Only)
0.5 YEL/ RED
1 J-28
Fuel Tank Sender Unit (Side)
2 J-28
0.5 BLK
3 H-127
(Crew Cab Only)
0.5 BLK
A-24 J-218
Engine Control Module (ECM)
LNW68DXF003201

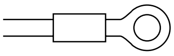
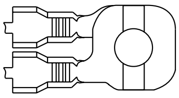
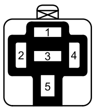
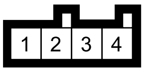
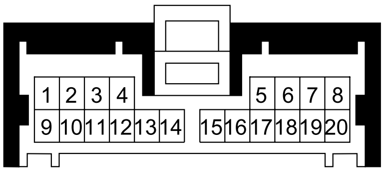
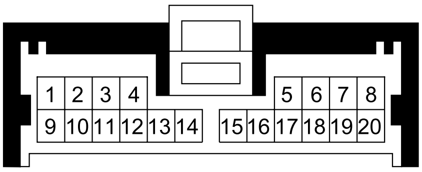
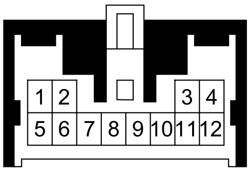
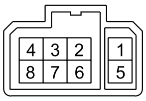
CIRCUIT DIAGRAM (WITH HBB)

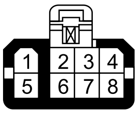
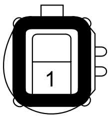
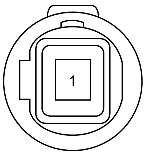
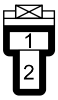
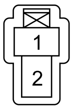
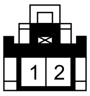
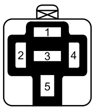
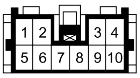


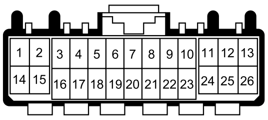
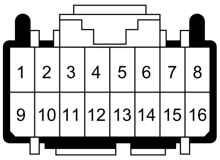
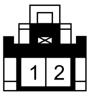
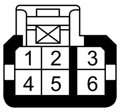
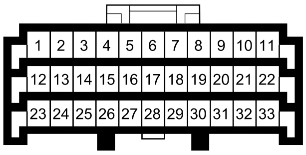
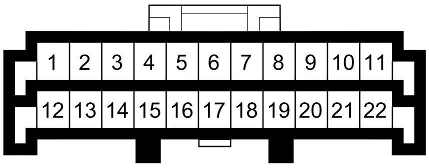
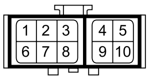
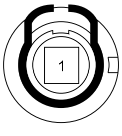

HOT AT ALL TIMES
HOT AT ALL TIMES
Fuse Box
F-23 Power Source 2 15A
F-6 Dome Light 15A
0.5 RED
0.85 RED
L-2 Weld Splice
0.85 LT GRN/RED
M-2 Weld Splice
0.85 LT GRN/RED
Tail Relay
0.5 LT GRN/ RED
0.5 RED
B-264
4
5
6
Oil Level Check Switch
Miles Check Switch
1
2
3
B-264
0.5 GRN
0.5 LT GRN/ RED
0.5 RED/GRN
Speed Meter
Tail Relay
8
12
B-51
Instrument Panel Cluster (IPC)
A
B
C
Oil Level
OD Off (A/T)
Oil Pressure
Brake
Charge
Brake Booster
O/D OFF
BRAKE
BRAKE BOOSTER
11
B-51
12
B-53
4
10
9
B-51
0.5 YEL/ VIO
0.3 LT BLU
0.3 ORN
0.5 WHT/GRN
Instrument Panel Cluster (IPC)
0.3 WHT/ BLK
B-380 Joint Connection M-1
0.5 WHT/ BLU
0.3 BRN/YEL
TCM
10
B-225
2
1
0.3 WHT/BLK
HBB Oil Level Sensor
18
H-5
20
H-5
0.5 YEL/ RED
0.5 LT BLU
3
H-105
1
H-105
DRL Unit
0.3 WHT/ BLK
0.5 WHT/ BLU
0.5 GRN/ RED
0.3 WHT/ BLK
13
H-5
4
B-380 Joint Connection M-1
2
B-85
0.5 WHT/ BLU
5
0.5 GRN
0.5 BLU/ BLK
2
5
B-225
0.3 WHT/ GRN
0.3 YEL/ BLK
Charge Relay
0.85 WHT/ BLU
3
B-26
1
E-137
1
E-14
HBB Oil Level Sensor
Brake Fluid Level Switch
Diode
13
H-8
Oil Level Switch
Oil Pressure Switch
16
B-380 Joint Connection M-1
0.85 WHT/ BLU
15
17
4
B-26
0.3 BRN
HBB Oil Level Sensor
1
B-85
AC Generator
0.3 WHT/ GRN
3.0 BLK
0.3 BLK/ RED
2
E-137
2
B-236
0.3 WHT/GRN
Buzzer Cancel Relay
3
H-12
0.3 WHT/ BLK
L-1 Weld Splice
0.5 BLK
Pressure Switch
0.5 BLK
1
N-6
3.0 BLK
Parking Brake Switch
B-381 Joint Connection M-5
2
1
B-236
20
B-379 Joint Connection L-1
1
3
6
7
M-1 Weld Splice
R-1 Weld Splice
17
18
21
Refer to Ground Distribution
Refer to Ground Distribution
B-379 Joint Connection L-1
OD Off Ground(A/T) Seat Belt Switch Ground(M/T)
Power Window Switch(DR) Ground
E-136
B-7
LNW68DXF005001

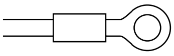
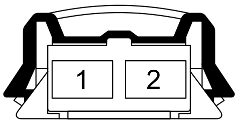
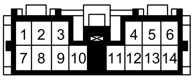
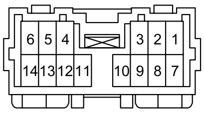
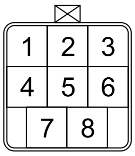
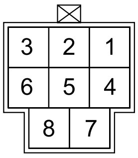
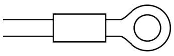
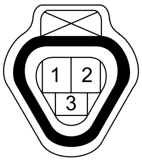

HOT IN RUN
Fuse Box
F-25 Gauge 10A
0.5 BLK/YEL
M-4 Weld Splice
0.5 RED/GRN
Vehicle Speed Sensor
0.5 BLK/YEL
H-5
4
ECM
Exhaust Brake Switch
0.5 BRN/WHT
Turn Signal Light Switch
0.5 GRN/BLK
Turn Signal Light Switch
0.5 GRN/WHT
Fuse F-7
0.85 GRN/BLK
Front Combination Light LH
Front Combination Light RH
Tail Relay
0.5 BRN/WHT
0.5 BRN/BLK
0.5 GRN/WHT
0.5 GRN/BLK
18
6
1 B-51
3 B-52
2 B-51
Instrument Panel Cluster (IPC)
B
D
C
E
Vacuum Buzzer
Cruise Set
SET
Cruise Main
Exhaust Brake
Turn LH
Turn RH
Beam
4 B-52
13
7
3 B-51
0.3 BLK/WHT
0.5 RED/YEL
Relay Box
3
2 B-23
Buzzer Cancel Relay
Fuse F-25
0.5 GRN/YEL
0.5 GRN/RED
1.25 RED/YEL
1.25 RED/YEL
0.5 BLK/YEL
0.5 BLK/YEL
Pressure Switch
5
4 B-23
ECM
ECM
DRL Unit
Head Light (RH)
M-4 Weld Splice
0.3 BRN
0.3 BRN
0.3 BRN
0.3 WHT/GRN
0.3 BRN/RED
DRL Unit
6 H-8
0.3 YEL/BLK
0.5 BRN
4
1 J-128
1 H-5
0.5 PNK
8 J-69
HBB Oil Level Sensor
Parking Brake Switch (M/T)
Inhibitor Switch (A/T)
3
2 J-128
9 J-69
0.3 WHT/BLK
0.5 BLK
0.5 BLK
Brake Fluid Level Switch
Joint 1 Weld Splice
Joint 1 Weld Splice
0.5 BLK
Fuel Tank Unit (Side/Rear)
3.0 BLK
3.0 BLK
Refer to Ground Distribution
Refer to Ground Distribution
J-9
J-9
LNW68DXF005101

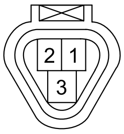
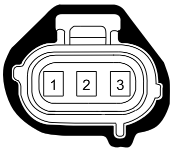
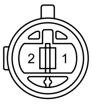
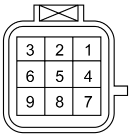
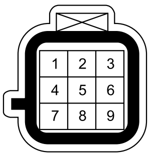
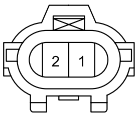
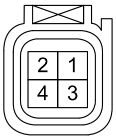
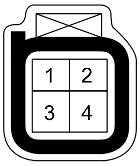

HOT AT ALL TIMES
Fuse Box
F-6 Dome Light 15A
0.85 RED
0.5 RED
16 B-52
Tail Relay
0.5 LT GRN/ RED
M-2 Weld Splice
0.5 LT GRN/ RED
17 B-51
Instrument Panel Cluster (IPC)
D
E
DRL
Illumination (X5)
Speedometer
Tachometer
Fuel Gauge
Fuel Level
Engine Coolant Temperature Gauge
11
0.5 WHT/ GRN
DRL Unit
19
0.5 LT GRN/ BLK
M-3 Weld Splice
0.5 LT GRN/ BLK
Miles check Switch
0.5 LT GRN/ BLK
Illumination Controller
18
0.5 RED/ GRN
Miles check Switch
Fuse F-25
M-4 Weld Splice
0.5 RED/ GRN
17 B-52
0.3 YEL/ GRN
31
25
0.75 RED/ GRN
0.5 YEL/ GRN
1
3 J-32
Vehicle Speed Sensor2 (SP1)
2 J-32
0.5 BLK
19 H-5
0.5 BLK
A/T Shift Indicator
0.5 BLK
0.85 BLK
6
5
B-379 Joint Connection L-1
4
0.85 BLK
Refer to Ground Distribution
B-1
0.5 YEL/ GRN
A-39 J-218
Engine Control Module (ECM)
15 B-51
0.5 BLK
8
20 B-52
0.5 BLK
0.5 BLK
0.3 YEL/ VIO
16 H-5
0.5 YEL/ RED
A-28 J-218
Engine Speed Signal Output
Engine Control Module (ECM)
16 B-51
0.3 WHT
9 B-230
Trans- mission Control Module (TCM)
6
0.3 YEL/ RED
9 H-8
0.5 YEL/ RED
0.5 YEL/RED
0.5 YEL/ RED
1 J-207
Fuel Tank Sender Unit (Rear)
3 J-207
0.5 BLK
Joint 2 Weld Splice
0.3 BLK
Refer to Ground Distribution
J-9
5 B-52
0.3 YEL/ BLK
23 H-5
0.5 YEL/ BLK
1 H-127
(Crew Cab Only)
0.5 YEL/ RED
1 J-28
Fuel Tank Sender Unit (Side)
2 J-28
0.5 BLK
3 H-127
(Crew Cab Only)
0.5 BLK
A-24 J-218
Engine Control Module (ECM)
LNW68DXF003201

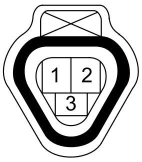
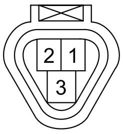
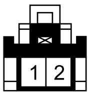
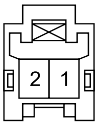
No.	Connector Face
B-1	 000-012 Ground; Frame–LH (Front)
B-7	 000-007 Ground; Headlight Bracket–RH
B-23 (Black)	 005-012 Buzzer Cancel Relay
B-26 (Black)	 004-021 Diode
B-51 (Gray)	 020-024 Instrument Panel Cluster (A)
B-52 (White)	 020-025 Instrument Panel Cluster (B)
B-53 (White)	 012-038 Instrument Panel Cluster (C)
B-69 (Black)	 008-028 Combination Switch (A)

No.	Connector Face
B-69 (Blue)	 008-021 Combination Switch (A)
B-71 (Black)	 001-037 Vacuum Tank Switch
B-71 (Black)	 001-038 Vacuum Tank Switch
B-85 (White)	 002-012 Brake Fluid Level Switch
B-85 (White)	 002-011 Brake Fluid Level Switch
B-161 (White)	 002-022 Electronic; Vacuum Pump
B-211 (Black)	 005-012 Vacuum Pump Relay
B-225 (Black)	 010-002 D.R.L Unit (A)

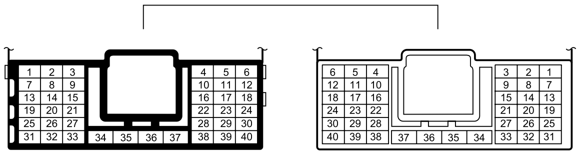
No.	Connector Face
B-229 (Gray)	 026-002 TCM
B-230 (Gray)	 016-034 TCM
B-236 (White)	 002-022 Pressure Switch
B-264 (Blue)	 006-006 Oil Level Check and Miles Check Switch
B-379 (White)	 033-001 Joint Connection-L1
B-380 (White)	 022-005 Joint Connection-M1
B-381 (White)	 010-015 Joint Connection – M5
E-14 (Gray)	 001-001 Oil Pressure Switch

No.	Connector Face
E-136	 000-012 Ground; Engine
E-137 (Black)	 002-231 Oil Level Switch
H-12 (White)	 014-003 Body H. – Foor H. (LH)
H-12 (White)	 014-004 Body H. – Foor H. (LH)
H-105 (Black)	 008-060 Body H. – Engine H.
H-105 (Black)	 008-061 Body H. – Engine H.
J-9	 000-012 Ground; Frame – LH (Center)
J-28 (Black)	 003-006 Fuel Tank Unit (Side)

No.	Connector Face
J-28 (Black)	 003-007 Fuel Tank Unit (Side)
J-32 (Gray)	 003-048 Vehicle Speed Sensor
J-52 (Black)	 002-097 Fuel Heater
J-69 (Black)	 009-002 Inhibitor Switch
J-69 (Black)	 009-001 Inhibitor Switch
J-121 (Gray)	 002-005 Fuel Sedimenter
J-128 (Black)	 004-002 HBB Oil Level Sensor
J-128 (Black)	 004-001 HBB Oil Level Sensor

No.	Connector Face
J-207 (Black)	 003-006 Fuel Tank Unit (Rear)
J-207 (Black)	 003-007 Fuel Tank Unit (Rear)
N-6 (White)	 002-022 Parking Brake Switch
N-6 (White)	 002-021 Parking Brake Switch

H-5 Body H. – Frame H. (Gray)



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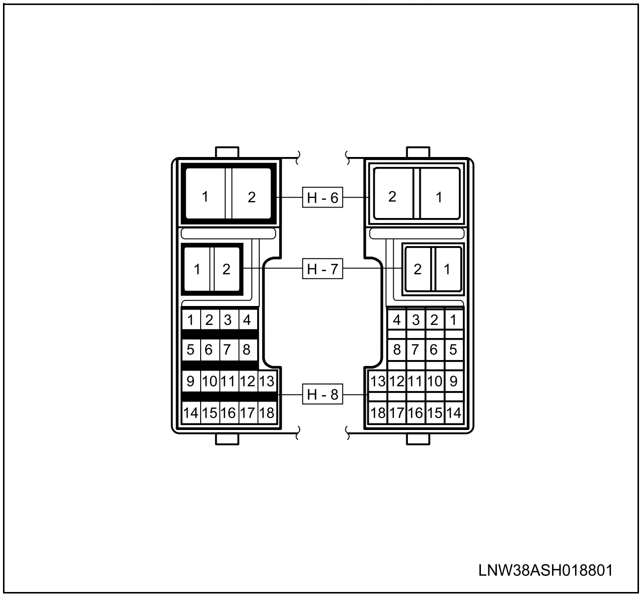
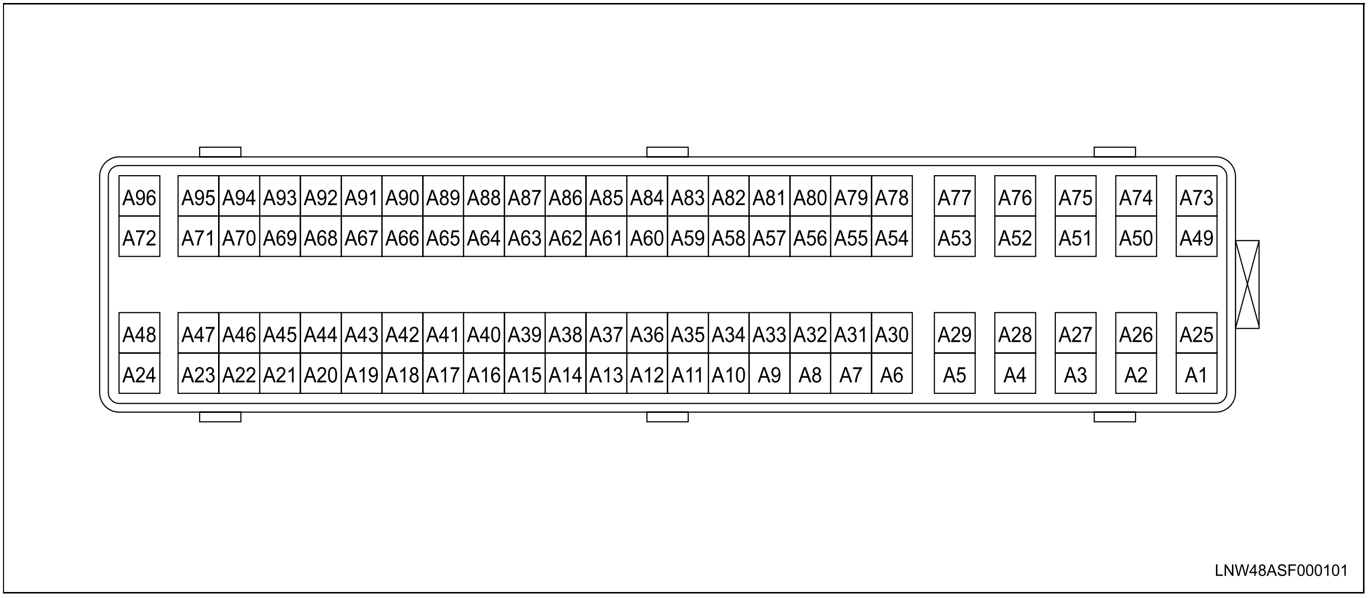
H-7, H-8 Body H. – Frame H. (Gray)



J-218 ECM-2 (Black)



Diagnosis

Quick Chart for Check Point

1. SPEEDOMETER

Check Point Trouble Mode	Speedometer	Vehicle Speed Sensor	Cable Harness
1-1. Speedometer and odometer do not function	○ (3)	○ (1)	○ (2)
1-2. Speedometer does not function (odometer is normal)	○ (1)		
1-3. Odometer does not function (Speedometer is normal)	○ (1)		
1-4. Speedometer needle fluctuates (May be wide fluctuation)	○ (3)	○ (1)	○ (2)
1-5. Speedometer needle jumps erratically	○ (3)	○ (1)	○ (2)

NOTE: Figure in parenthesis "( )" indicates the order of inspection.

2. ENGINE COOLANT TEMPERATURE (ECT) GAUGE

Check Point Trouble Mode	Meter ASM	ECU	ECT Gauge Sensor	Thermo stat	Cable Harness
2-1. Engine coolant temperature gauge needle does not move	○ (3)	○ (4)	○ (2)		○ (1)
2-2. Engine coolant temperature gauge reading is too low (or high)	○ (4)	○ (5)	○ (3)	○ (1)	○ (2)
2-3. Needle overshoots (or goes up to the "H" range)	○ (3)	○ (4)	○ (1)		○ (2)

NOTE: Figure in parenthesis "( )" indicates the order of inspection.

3. FUEL GAUGE

Check Point Trouble Mode	Meter ASM	Fuel Gauge	Fuel Pump & Gauge	Cable Harness
3-1. Fuel gauge needle does not move	○ (3)	○ (4)	○ (2)	○ (1)
3-2. Even when the tank is filled up with fuel, the needle does not reach "F"	○ (3)	○ (4)	○ (2)	○ (1)
3-3. When the tank is not full of fuel, the needle overshoots (or goes to "F")	○ (3)	○ (4)	○ (2)	○ (1)

NOTE: Figure in parenthesis "( )" indicates the order of inspection.

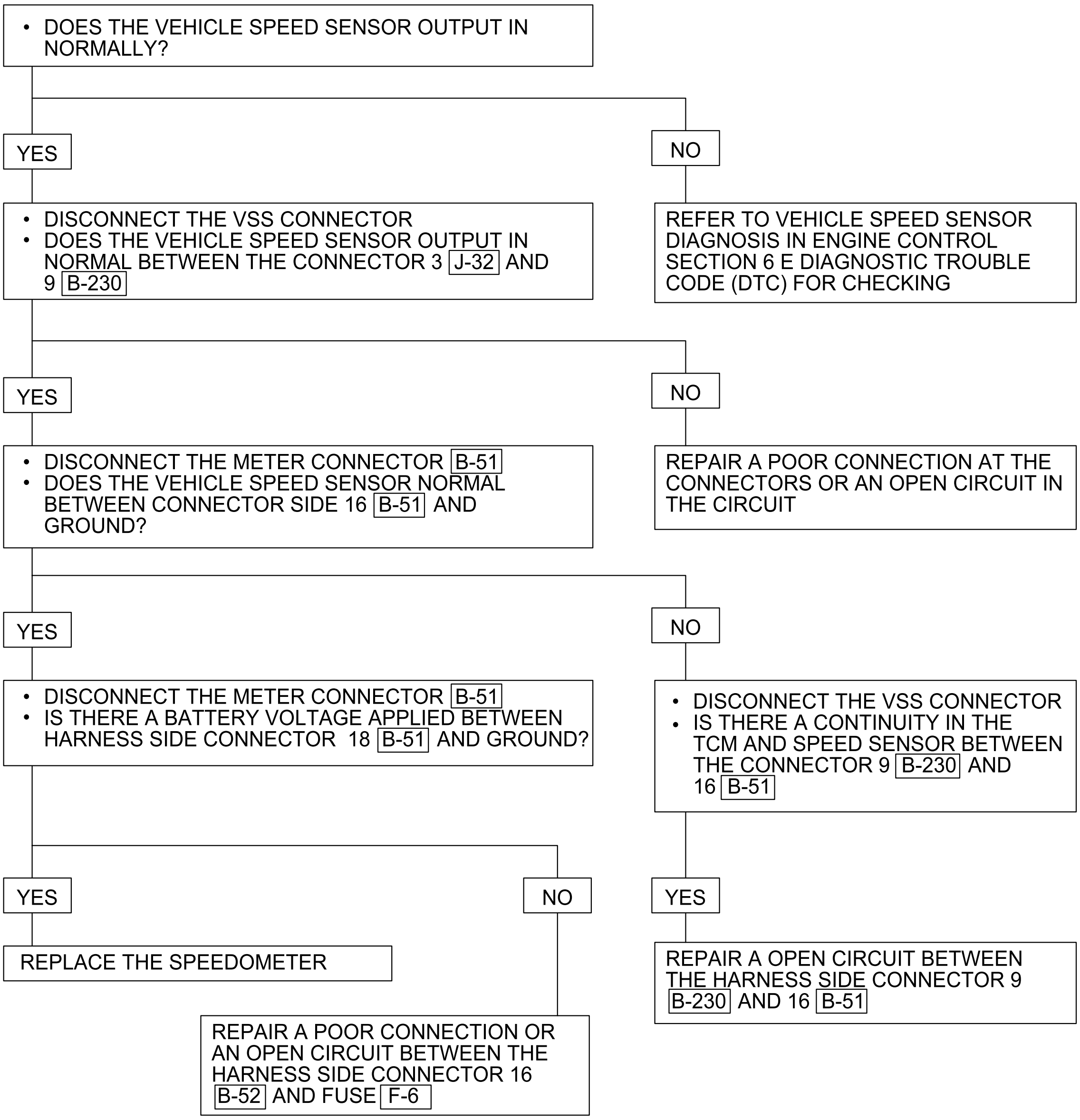
4. WARNING/INDICATOR LIGHT

Check Point Trouble Mode	Light Bulb	Parking Brake Switch	Brake Fluid Level Switch	Oil pressure Switch	Fuel Tank Unit	Vacuum Switch	Cable Harness	Vacuum Buzzer
4-1. When the parking brake lever is pulled, the indicator light does not light up.	○ (2)	○ (1)					○ (3)	
4-2. Even when the parking brake lever is released, the indicator light does not go off.		○ (1)					○ (2)	
4-3. While the engine operating, the oil pressure warning light does not go off.				○ (2)			○ (1)	
4-4. Even when the brake fluid is lower than specified level, the level warning light does not light up.	○ (1)		○ (2)				○ (3)	
4-5. Even when the vacuum tank is empty vacuum warning buzzer does not sound.						○ (1)	○ (2)	○ (4)

NOTE: Figure in parenthesis "( )" indicates the order of inspection.

1. Speedometer

1-1. SPEEDOMETER AND ODOMETER DO NOT FUNCTION



- DOES THE VEHICLE SPEED SENSOR OUTPUT IN NORMALLY?

YES

- DISCONNECT THE VSS CONNECTOR
- DOES THE VEHICLE SPEED SENSOR OUTPUT IN NORMAL BETWEEN THE CONNECTOR 3 J-32 AND 9 B-230

NO

REFER TO VEHICLE SPEED SENSOR DIAGNOSIS IN ENGINE CONTROL SECTION 6 E DIAGNOSTIC TROUBLE CODE (DTC) FOR CHECKING

YES

- DISCONNECT THE METER CONNECTOR B-51
- DOES THE VEHICLE SPEED SENSOR NORMAL BETWEEN CONNECTOR SIDE 16 B-51 AND GROUND?

NO

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT IN THE CIRCUIT

YES

- DISCONNECT THE METER CONNECTOR B-51
- IS THERE A BATTERY VOLTAGE APPLIED BETWEEN HARNESS SIDE CONNECTOR 18 B-51 AND GROUND?

NO

- DISCONNECT THE VSS CONNECTOR
- IS THERE A CONTINUITY IN THE TCM AND SPEED SENSOR BETWEEN THE CONNECTOR 9 B-230 AND 16 B-51

YES

REPLACE THE SPEEDOMETER

NO

REPAIR A POOR CONNECTION OR AN OPEN CIRCUIT BETWEEN THE HARNESS SIDE CONNECTOR 16 B-52 AND FUSE F-6

YES

REPAIR A OPEN CIRCUIT BETWEEN THE HARNESS SIDE CONNECTOR 9 B-230 AND 16 B-51

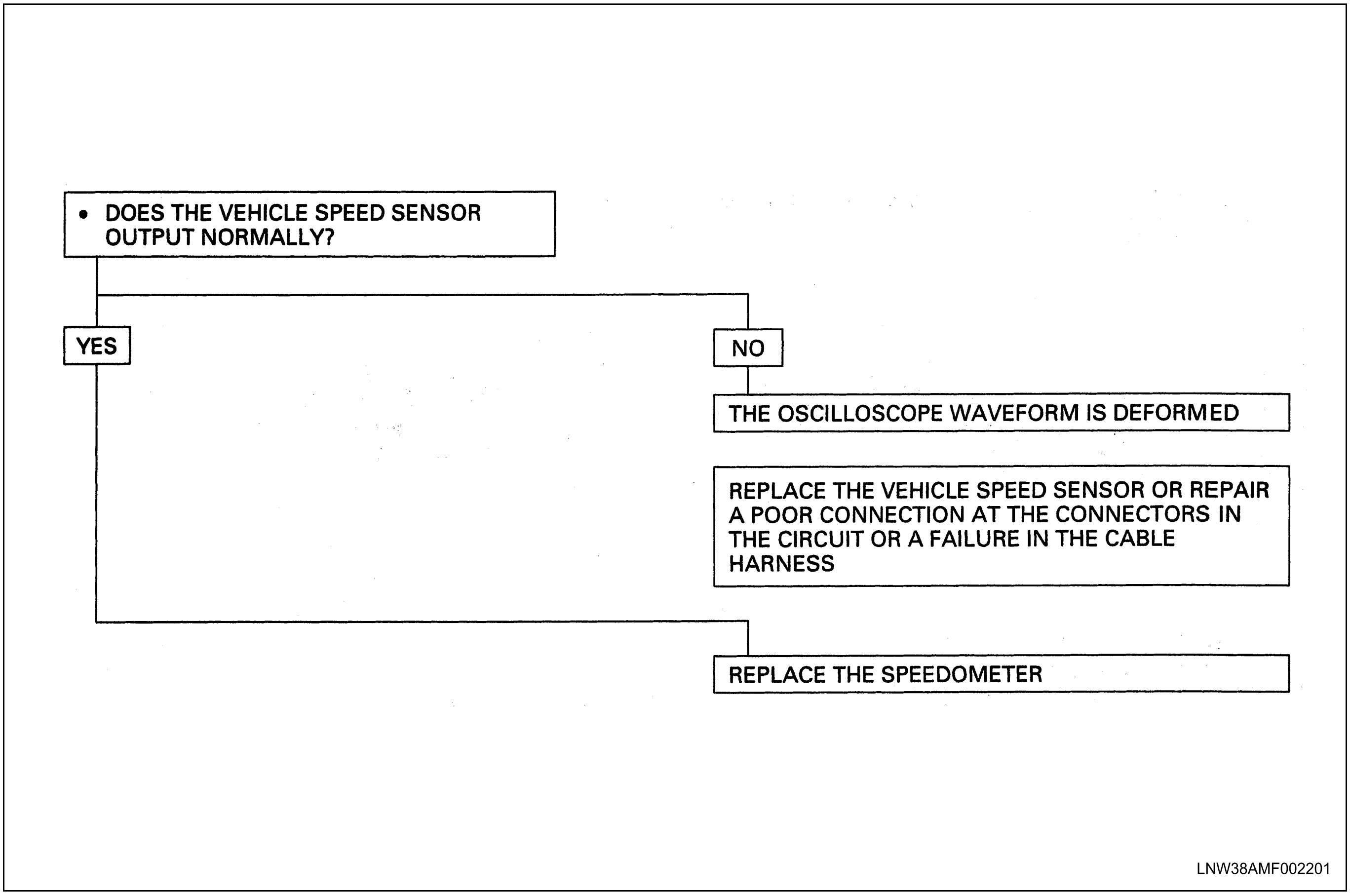
1-2. SPEEDOMETER DOES NOT FUNCTION (ODOMETER IS NORMAL)

REPLACE THE SPEEDOMETER ASSEMBLY

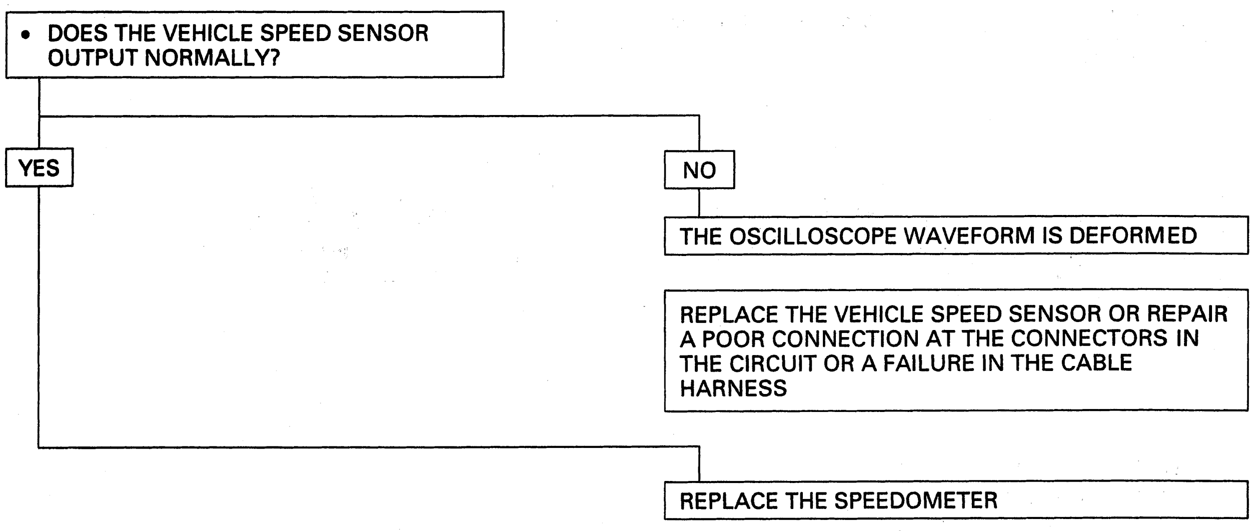
1-3. ODOMETER DOES NOT FUNOTION (SPEEDOMETER IS NORMAL)

REPLACE THE SPEEDOMETER ASSEMBLY

1-4. SPEEDOMETER NEEDLE FLUCTUATES (MAY BE WIDE FLUCTUATION)



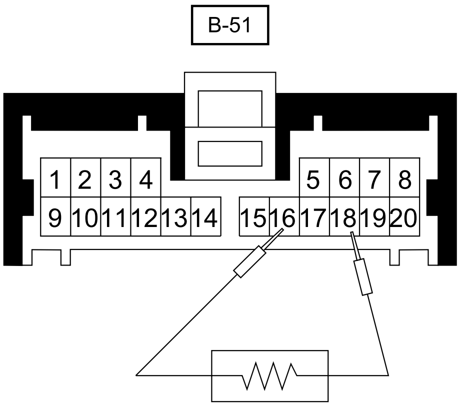
1-5. SPEEDOMETER NEEDLE JUMPS ERRATICALLY



LNW38AMF002201

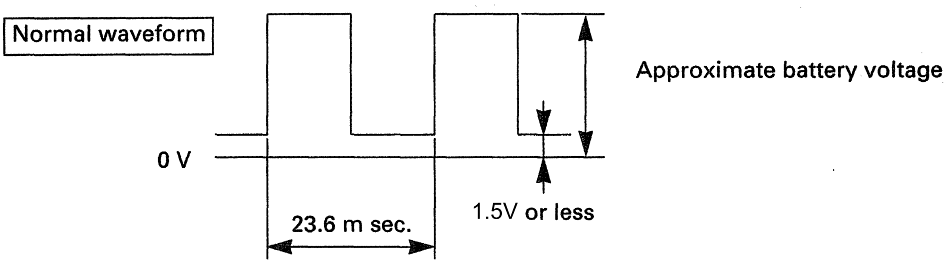
Inspection of waveform by oscilloscope

1. Connect a resistance of 1.3 to 5 kΩ (1.4W or more) between the harness side connectors 16 [B-51] and 18 [B-51] of the meter.



LNW48ASF000401

2. Install a speedometer tester.
3. Turn on the ignition switch.
4. Check the waveform at the time when the vehicle speed is at 60 km (37 mph).



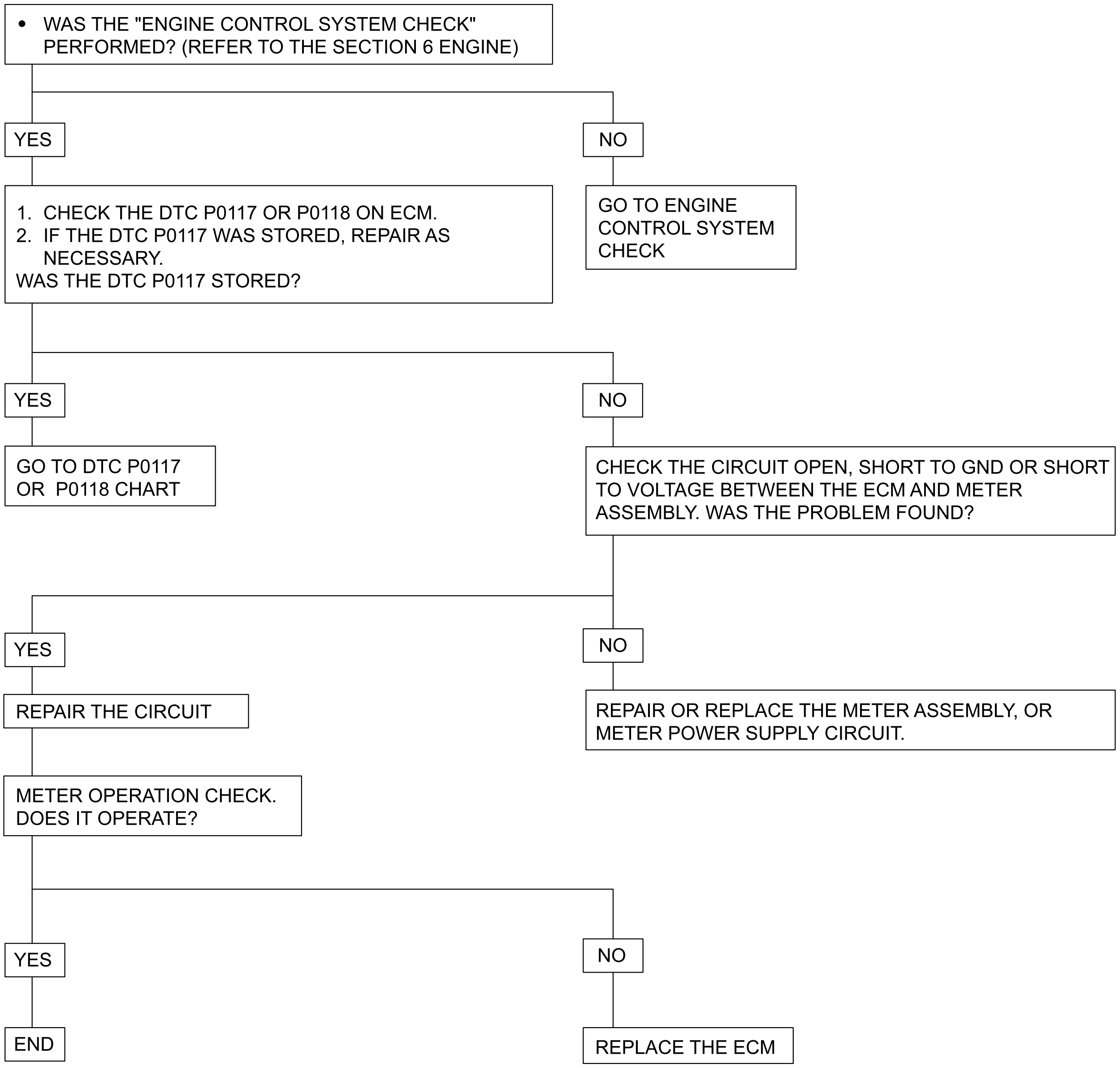
LNW48ASF000801

Inspection of waveform by oscilloscope

1. When fuel gauge is normal, turn on the ignition switch "ON" position.
2. Check the waveform [B-52] (6) connector connected with meter assembly.

2. Engine Coolant Temperature (ECT) Gauge

2.1 ENGINE COOLANT TEMPERATURE METER CONTROL DIAGNOSTIC CHECK



- WAS THE "ENGINE CONTROL SYSTEM CHECK" PERFORMED? (REFER TO THE SECTION 6 ENGINE)

1. CHECK THE DTC P0117 OR P0118 ON ECM.
2. IF THE DTC P0117 WAS STORED, REPAIR AS NECESSARY.

WAS THE DTC P0117 STORED?

GO TO ENGINE CONTROL SYSTEM CHECK

GO TO DTC P0117 OR P0118 CHART

CHECK THE CIRCUIT OPEN, SHORT TO GND OR SHORT TO VOLTAGE BETWEEN THE ECM AND METER ASSEMBLY. WAS THE PROBLEM FOUND?

REPAIR THE CIRCUIT

REPAIR OR REPLACE THE METER ASSEMBLY, OR METER POWER SUPPLY CIRCUIT.

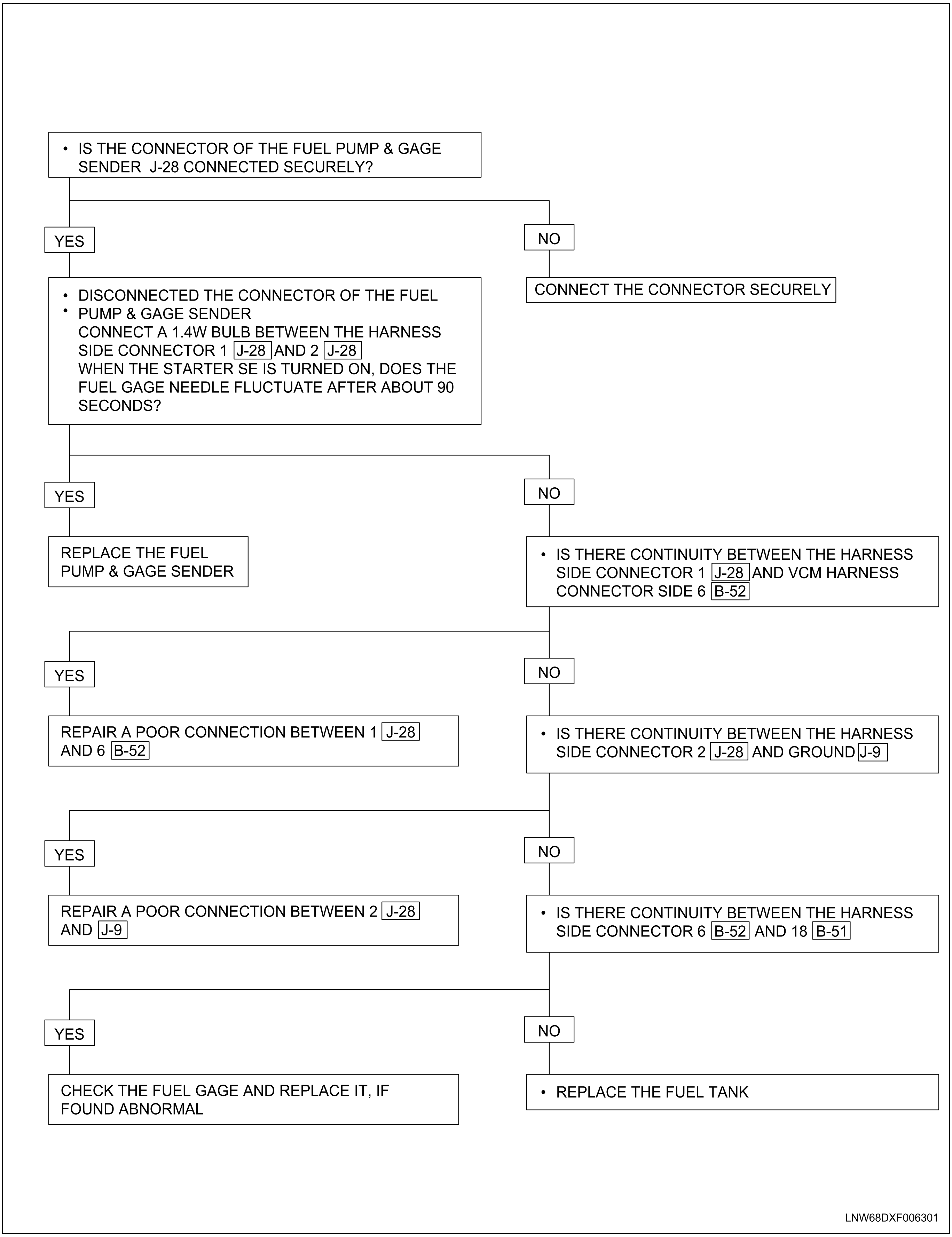
METER OPERATION CHECK. DOES IT OPERATE?

REPLACE THE ECM

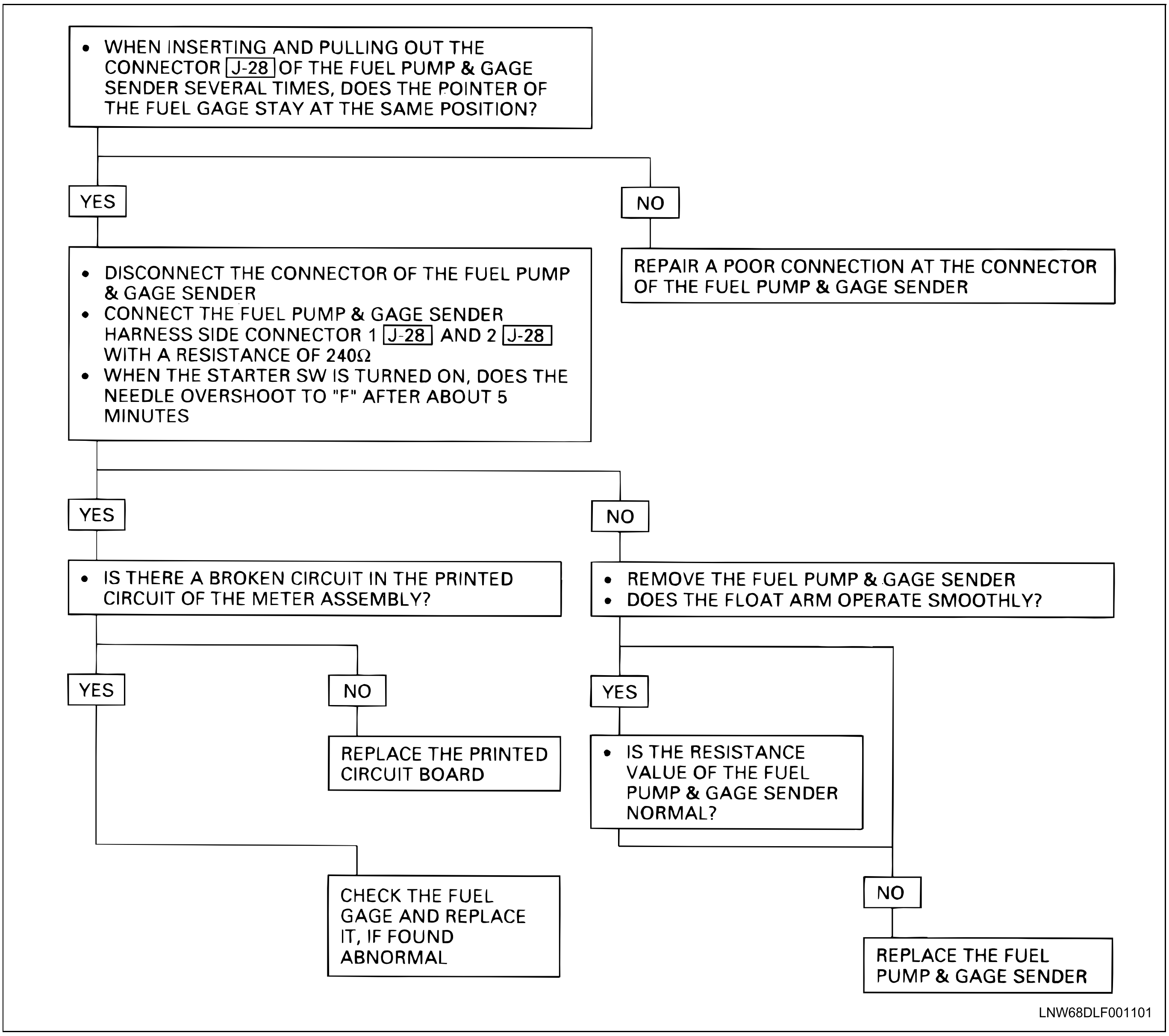
LNW68DXF006501

3. Fuel Gauge

3-1 FUEL GAUGE NEEDLE DOES NOT MOVE



3-2 EVEN WHEN THE TANK IS FILLED UP WITH FUEL, THE NEEDLE DOES NOT REACH “F”



- WHEN INSERTING AND PULLING OUT THE CONNECTOR J-28 OF THE FUEL PUMP & GAGE SENDER SEVERAL TIMES, DOES THE POINTER OF THE FUEL GAGE STAY AT THE SAME POSITION?

REPAIR A POOR CONNECTION AT THE CONNECTOR OF THE FUEL PUMP & GAGE SENDER

- DISCONNECT THE CONNECTOR OF THE FUEL PUMP & GAGE SENDER
- CONNECT THE FUEL PUMP & GAGE SENDER HARNESS SIDE CONNECTOR 1 J-28 AND 2 J-28 WITH A RESISTANCE OF 240Ω
- WHEN THE STARTER SW IS TURNED ON, DOES THE NEEDLE OVERSHOOT TO "F" AFTER ABOUT 5 MINUTES

- IS THERE A BROKEN CIRCUIT IN THE PRINTED CIRCUIT OF THE METER ASSEMBLY?

- REMOVE THE FUEL PUMP & GAGE SENDER
- DOES THE FLOAT ARM OPERATE SMOOTHLY?

REPLACE THE PRINTED CIRCUIT BOARD

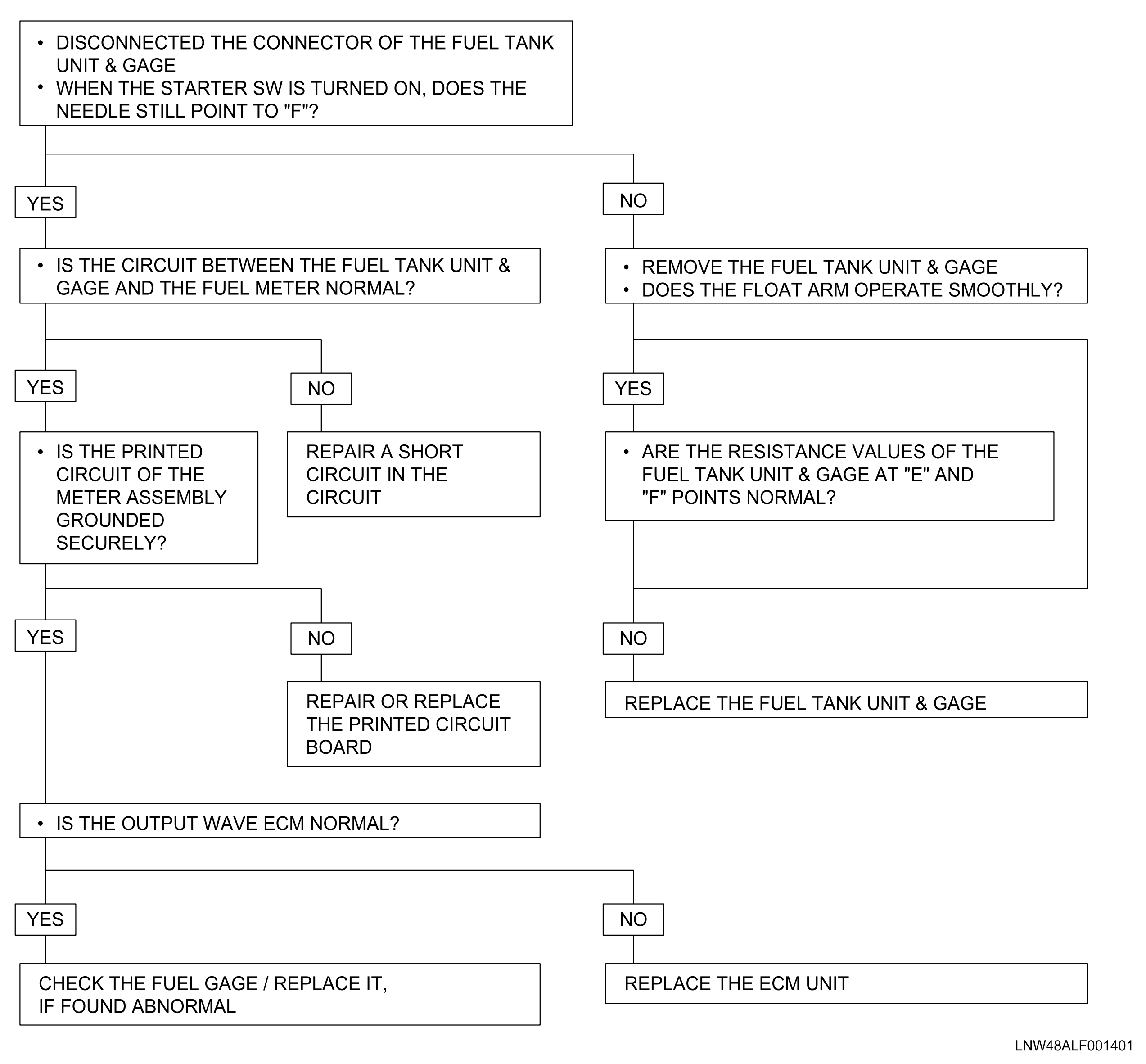
- IS THE RESISTANCE VALUE OF THE FUEL PUMP & GAGE SENDER NORMAL?

CHECK THE FUEL GAGE AND REPLACE IT, IF FOUND ABNORMAL

REPLACE THE FUEL PUMP & GAGE SENDER

LNW68DLF001101

3-3 WHEN THE TANK IS NOT FULL OF FUEL, THE NEEDLE OVERSHOOTS (OR GOES UP TO “F”)



- DISCONNECTED THE CONNECTOR OF THE FUEL TANK UNIT & GAGE
- WHEN THE STARTER SW IS TURNED ON, DOES THE NEEDLE STILL POINT TO "F"?

- IS THE CIRCUIT BETWEEN THE FUEL TANK UNIT & GAGE AND THE FUEL METER NORMAL?

- REMOVE THE FUEL TANK UNIT & GAGE
- DOES THE FLOAT ARM OPERATE SMOOTHLY?

- IS THE PRINTED CIRCUIT OF THE METER ASSEMBLY GROUNDED SECURELY?

REPAIR A SHORT CIRCUIT IN THE CIRCUIT

- ARE THE RESISTANCE VALUES OF THE FUEL TANK UNIT & GAGE AT "E" AND "F" POINTS NORMAL?

REPAIR OR REPLACE THE PRINTED CIRCUIT BOARD

REPLACE THE FUEL TANK UNIT & GAGE

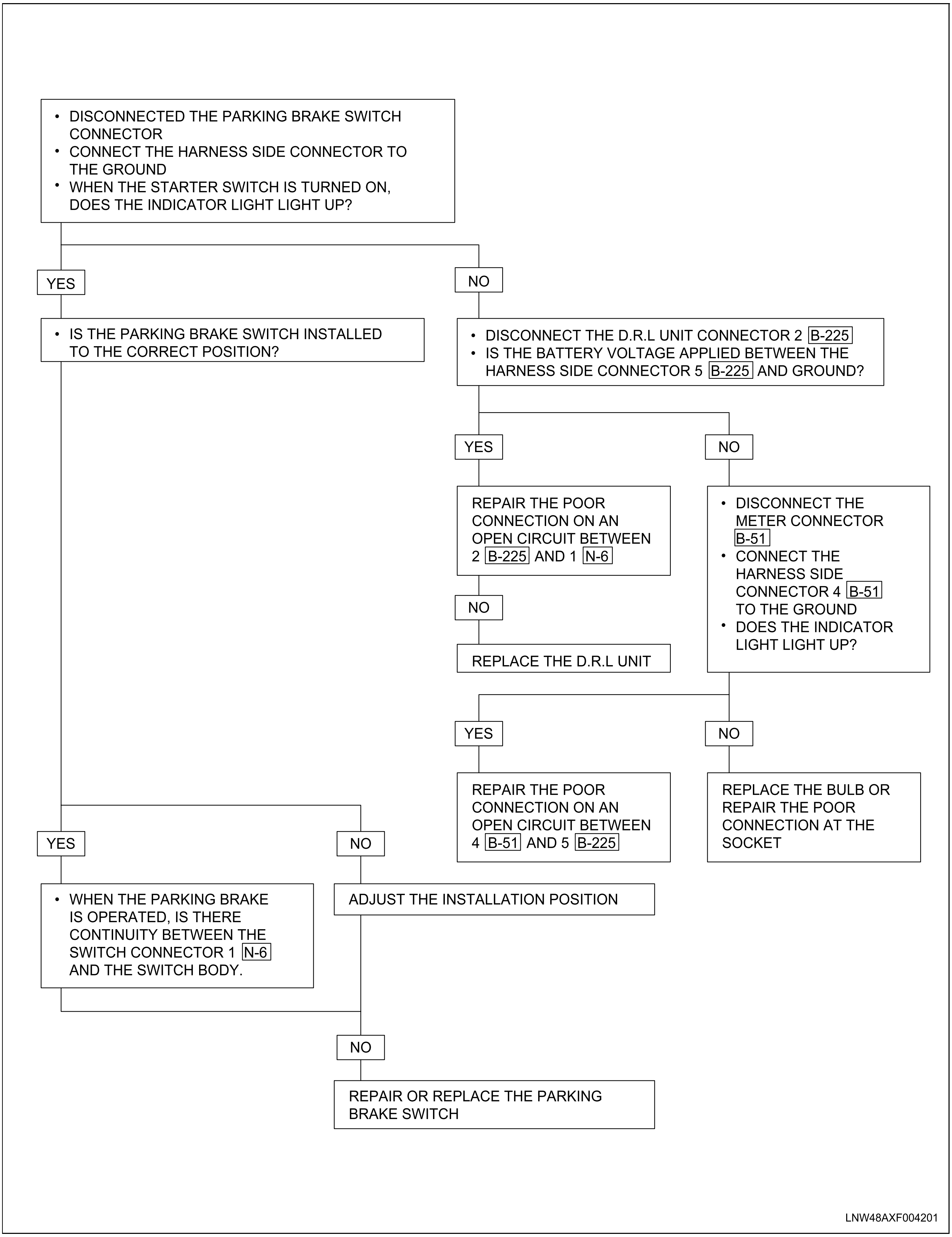
- IS THE OUTPUT WAVE ECM NORMAL?

CHECK THE FUEL GAGE / REPLACE IT, IF FOUND ABNORMAL

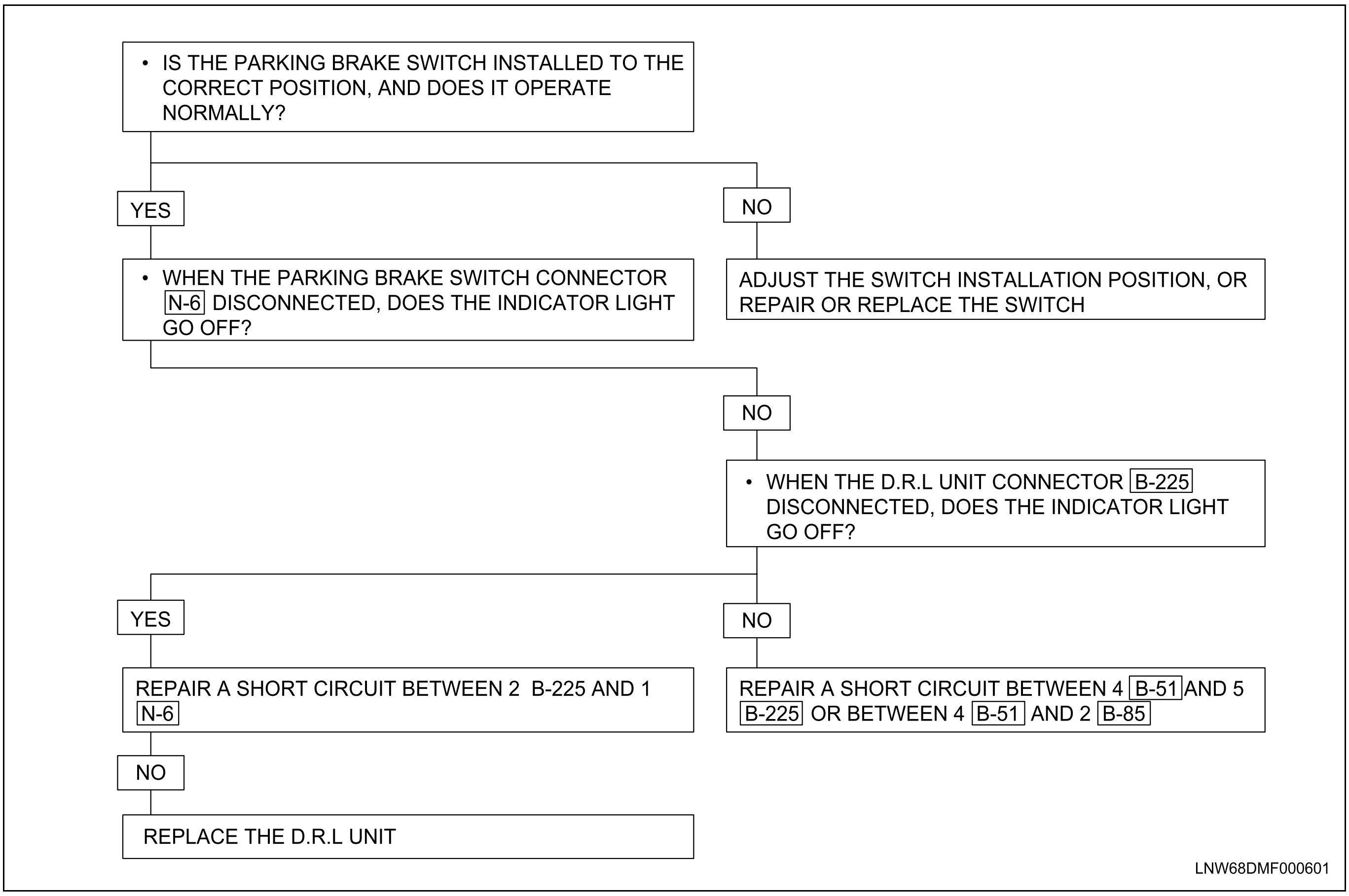
REPLACE THE ECM UNIT

4. Warning/Indicator Light

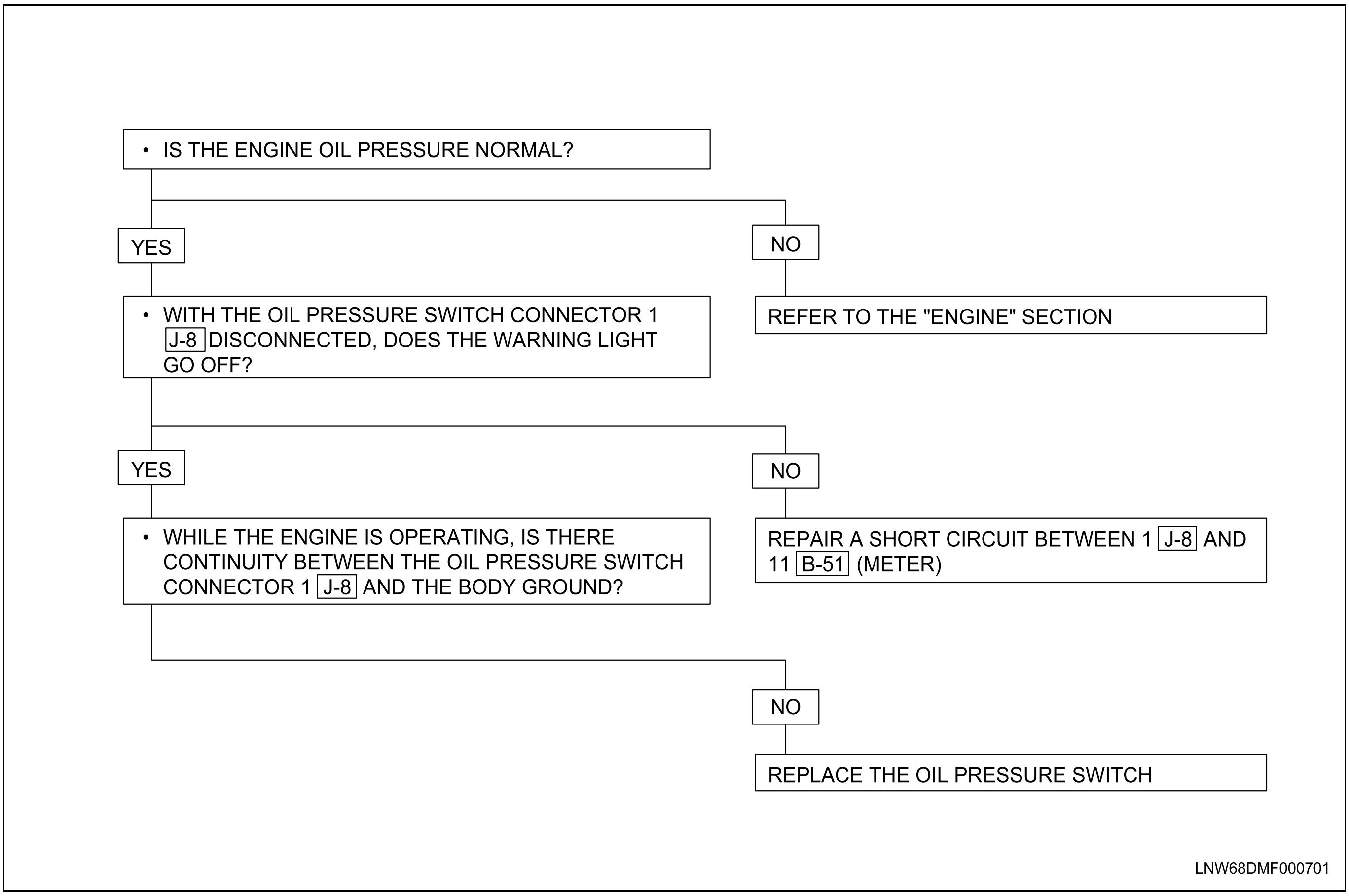
4-1 WHEN THE PARKING BRAKE LEVER IS PULLED, THE INDICATOR LIGHT DOES NOT LIGHT UP



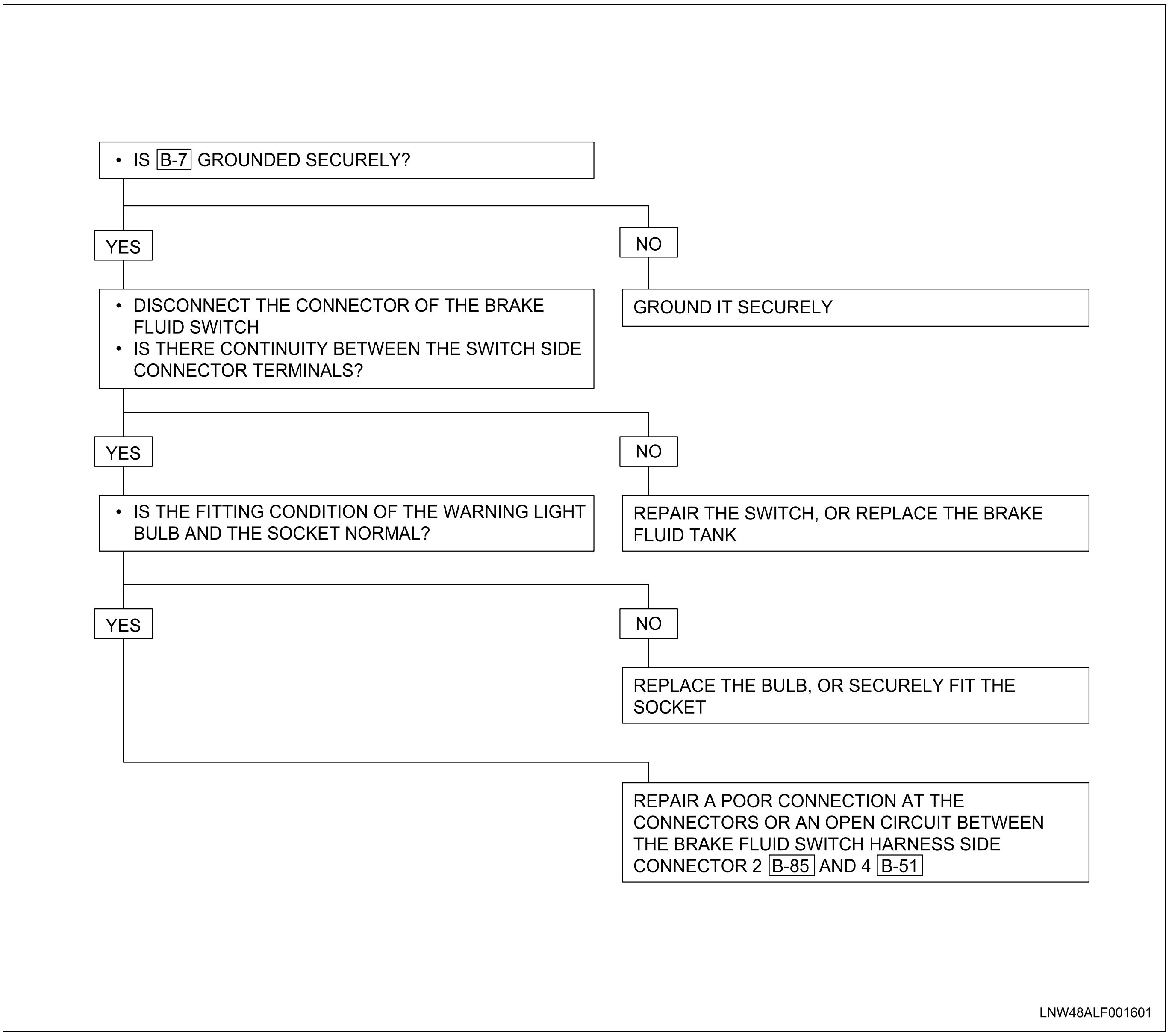
4-2 EVEN WHEN THE PARKING BRAKE LEVER IS RELEASED, THE INDICATOR LIGHT DOES NOT GO OFF



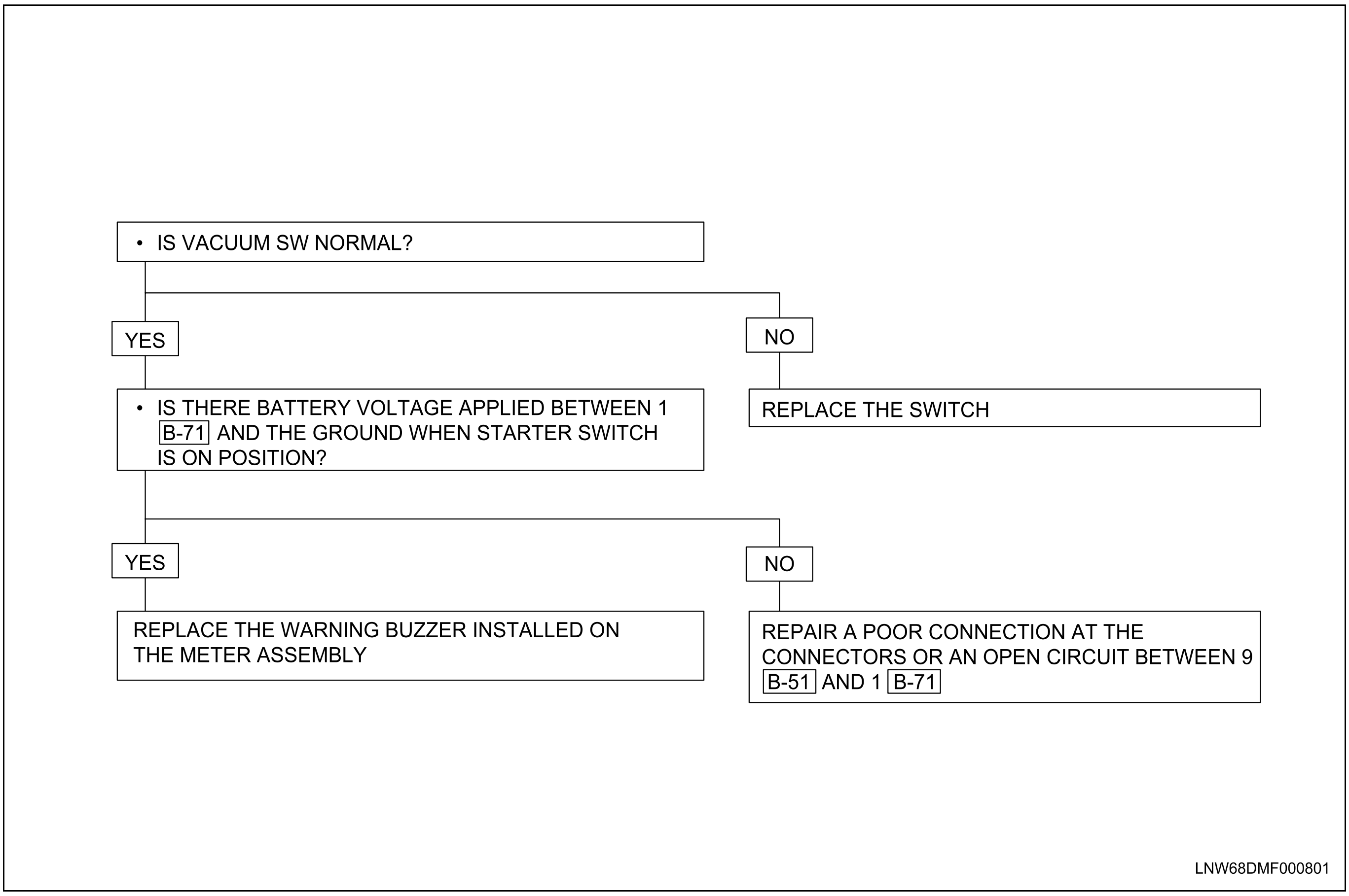
4-3 WHILE THE ENGINE IS OPERATING, THE OIL PRESSURE WARNING LIGHT DOES NOT GO OFF



4-4 EVEN WHEN THE BRAKE FLUID IS LOWER THAN SPECIFIED LEVEL, THE LEVEL WARNING LIGHT DOES NOT LIGHT UP



4-5 EVEN WHEN THE VACUUM TANK IS EMPTY, VACUUM WARNING BUZZER DOES NOT SOUND



- IS VACUUM SW NORMAL?

YES

- IS THERE BATTERY VOLTAGE APPLIED BETWEEN 1 B-71 AND THE GROUND WHEN STARTER SWITCH IS ON POSITION?

YES

REPLACE THE WARNING BUZZER INSTALLED ON THE METER ASSEMBLY

NO

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN 9 B-51 AND 1 B-71

NO

REPLACE THE SWITCH

IGNITION SWITCH

Refer to “Start and Charging” in this section.

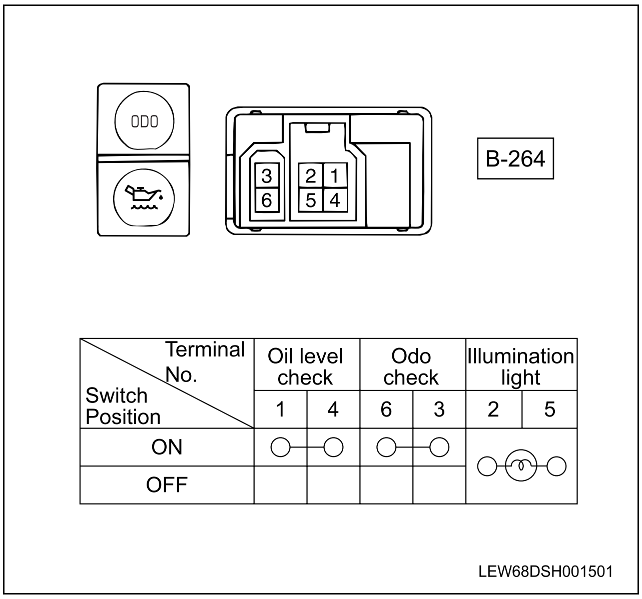
TURN SIGNAL LIGHT SWITCH

Refer to “Front Combination Light, Rear Combination Light and License Plate Light” in this section.

OIL LEVEL CHECK AND MILES CHECK SWITCH

Inspect

Check the continuity between the terminals of the oil level check and miles check switch.
Repair or replace the switch when the result of inspection is found abnormal.

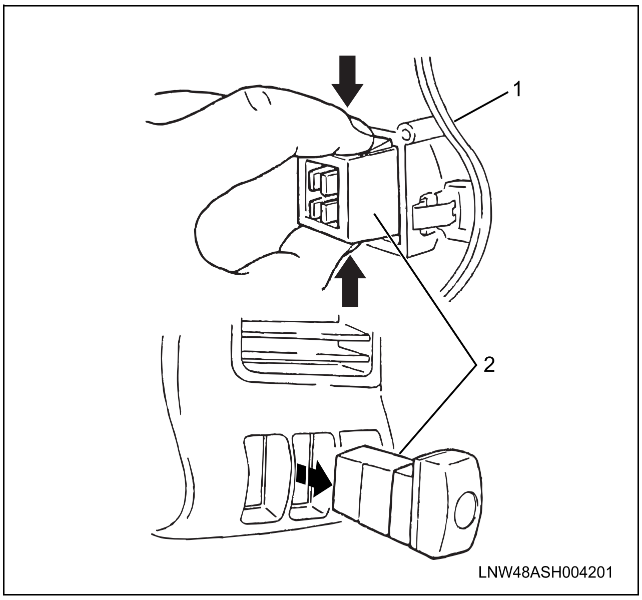


Terminal No. / Switch Position	Oil level check		Odo check		Illumination light	
	1	4	6	3	2	5
ON	○—	—○	○—	—○	○—⊗—○	
OFF						

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Instrument Panel Cluster Bezel
   Refer to the “Instrument Panel Cluster and Warning/Indicator Light” in this section.
2. Oil level check and miles check switch
   Release the lock pushing the switch from the back side of the meter cluster.



Legend

1. Instrument Panel Cluster Bezel
2. Oil Level Check and Miles Check Switch

This illustration is based on the dome light switch

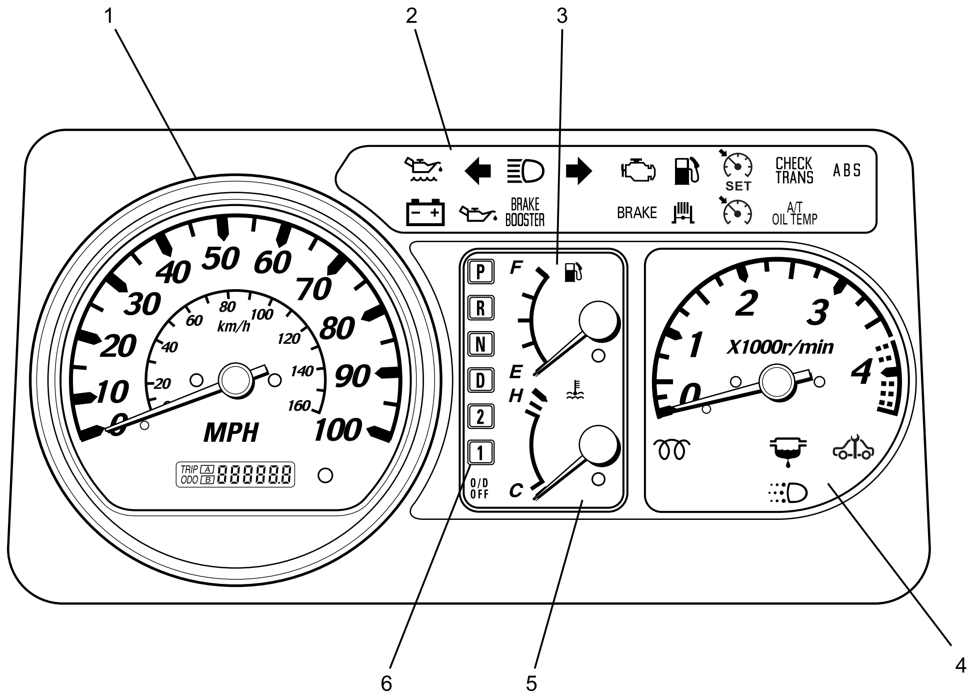
Install or Connect

To install, follow the removal steps in the reverse order noting the following point:

1. Push the switch with your fingers until locks securely.

INSTRUMENT PANEL CLUSTER

LAYOUT FOR GAUGES, WARNING, INDICATOR AND ILLUMINATION LIGHTS

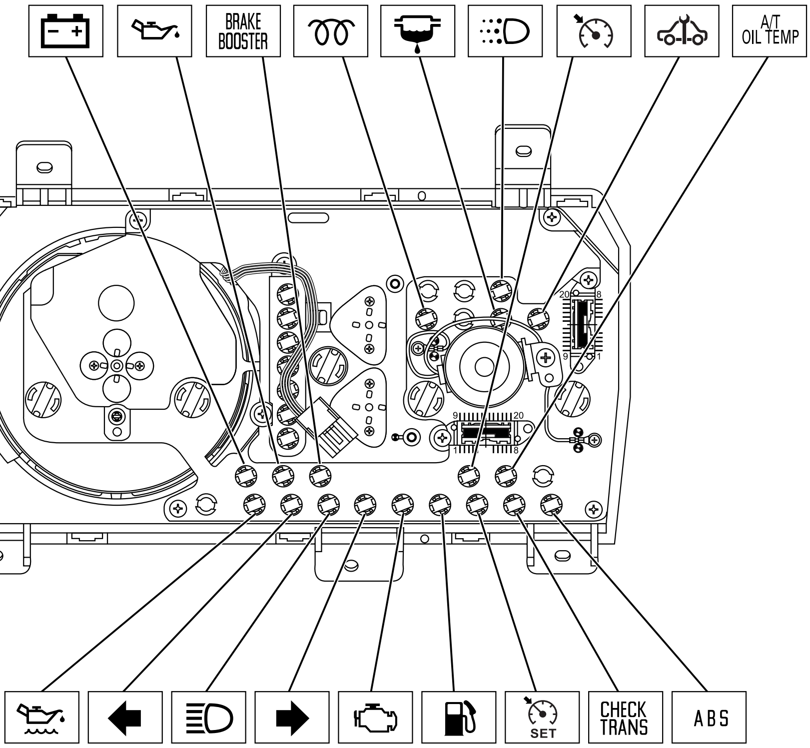


LNW58AMF000301

Legend

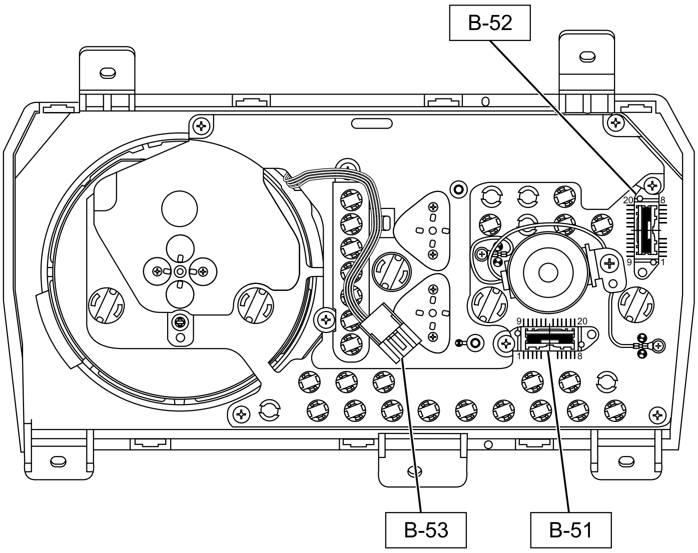
1. Speedometer
2. Warning/Indicator
3. Fuel Gauge
4. Tachometer
5. Coolant Temperature Gauge
6. A/T Shift Indicator

BULB LOCATION FOR WARNING LENS



LNW58AMF000401

TABLE FOR INSTRUMENT PANEL CLUSTER CONNECTOR TERMINAL CONNECTIONS



LNW58ASF000101

[B-53]

Terminal No.	Connected to
1	Ground
2	–
3	–
4	Light Switch
5	–
6	A/T Shift Indicator P
7	A/T Shift Indicator R
8	A/T Shift Indicator N
9	A/T Shift Indicator D
10	A/T Shift Indicator 2
11	A/T Shift Indicator 1
12	OD OFF

[B-51]

Terminal No.	Connected to
1	Turn LH
2	Beam (+)
3	Beam (–)
4	Brake
5	Check Engine
6	Exhaust Brake
7	Cruise Main
8	Oil Level Switch
9	Brake Booster
10	Charge
11	Oil Pressure Switch
12	Oil Level Check Switch
13	Cruise Set
14	Coolant Level
15	Ground
16	Speed Signal Output
17	Illumination (+)
18	Ignition
19	Check Trans
20	A/T Oil Temp

[B-52]

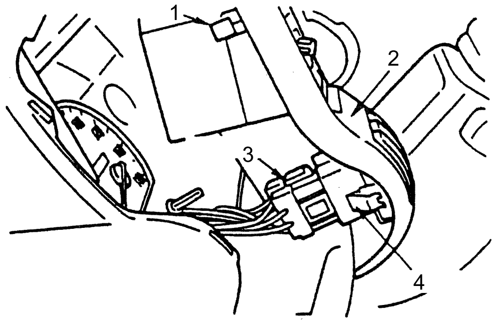
Terminal No.	Connected to
1	Over Speed
2	ABS
3	Turn RH
4	Buzzer
5	Thermal
6	Fuel
7	–
8	Tachometer Signal
9	Seat Belt
10	Sedimenter
11	D.R.L Unit
12	SVS
13	P.T.O
14	Cab Tilt
15	Glow
16	Battery
17	Speed Sensor
18	Miles Check Switch (Battery)
19	Illumination (–)
20	GND (for Control Circuit)

ECT - Engine Coolant Temperature

Remove or Disconnect

Preparation: Disconnect the battery ground cable

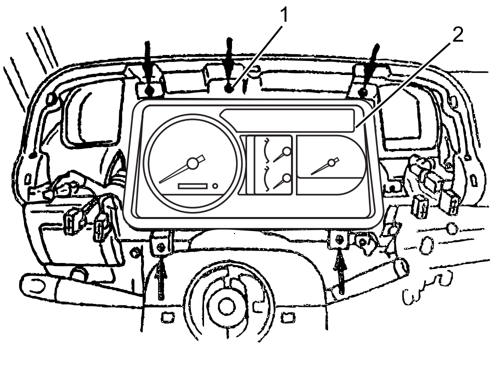
1. Instrument Panel Cluster Bezel
2. Instrument Panel Cluster
   Remove the five screws.
   Disconnect the instrument panel cluster connectors.



LNW38ASH012101

Legend

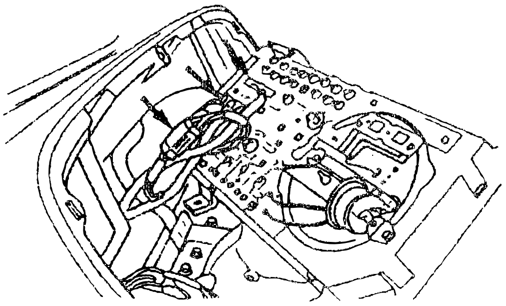
1. Clip
2. Instrument Panel Cluster Bezel
3. Connector
4. Clip



LNW68DSH001101

Legend

1. Screw
2. Instrument Panel Cluster

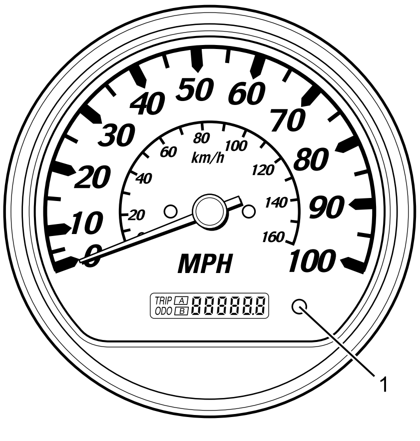


LNW68DSH001201

Install or Connect

To install, follow the removal steps in the reverse order.

Speedometer



LNW48ASH002501

Legend

1. Trip and Odometer Knob

The speedometer is made up of the cross coil type ammeter (movement) that displays indications, the stepper motor that drives and adds up the odometer and trip meter, and the driving circuit (printed circuit board) that makes exchanges between the pulse signals and the current.
Odometer alternates with trip meter by pushing knob.

On-vehicle Service

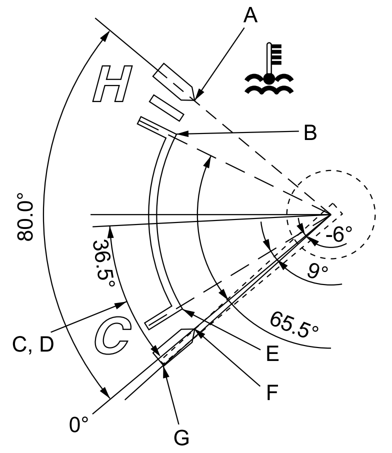
Check the meter display accuracy and the operation of the odometer with the speedometer tester.

Tester display speed	Instrument Panel Cluster display permissible level
20 MPH	17.5 – 20.5 MPH
40	38.0 – 41.0
60	59.0 – 62.0
80	79.0 – 83.0

Notice:
Inappropriate tire inflation may affect the accuracy of the odometer.
(To conduct this test, refer to the tester manufacturer's instruction manual.)
Since the meter display permissible levels above are specifications solely for the instrument panel cluster, they are to be used as reference values when conducting on-vehicle service.

COOLANT TEMPERATURE GAUGE

Check the coolant temperature gauge.

INDICATION SCALE (°C / F)	DUTY (%)	ANGLE (°)	INDICATION ERROR (°)	TEST CONDITION	ARRANGED SCALE
A (125 / 257)	90	(90)			
B (115 / 239)	75.5	65.5	+0.5 -5.8	Going	
C (100 / 212)	62	36.5	+3.5 -7.5	Going	
D (78 / 172.4)	41	36.5	+3.5 -7.5	Going	
E (55 / 131)	21	9			
F (50 / 122)	14.5	0	±5.4	Going	
G (45 / 113)	10	-6			

LNW68DMF001301

WARNING LENS

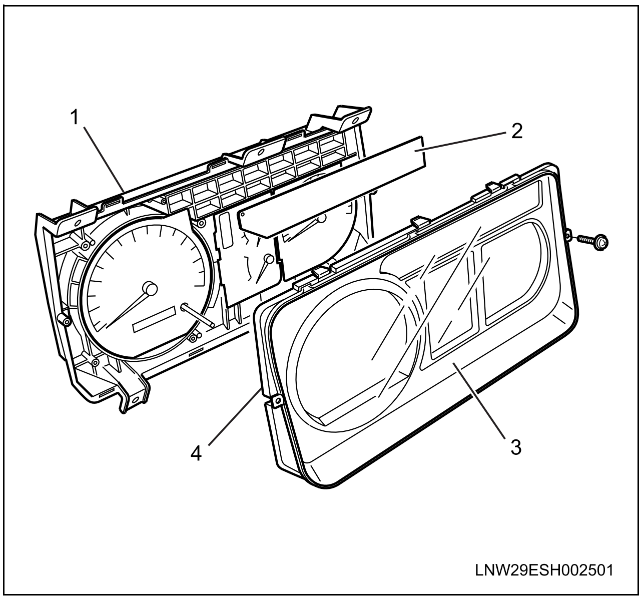
Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Instrument Panel Cluster
   Refer to “Instrument Panel Cluster” in this section.
2. Meter glass
   Remove it by pushing the catches with your finger.
3. Meter plate
   Remove it by pushing the catches with your finger.
4. Warning lens

Install or Connect

To install, follow the removal steps in the reverse order.



LNW29ESH002501

Legend

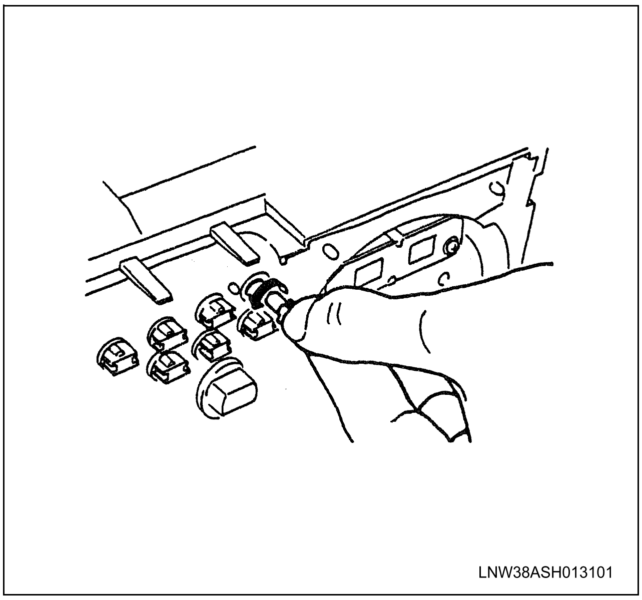
1. Instrument Panel Cluster
2. Warning Lens
3. Meter Glass
4. Meter Plate

WARNING LIGHT BULB, INDICATOR LIGHT BULB AND ILLUMINATION LIGHT BULB

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Instrument Panel Cluster
   Refer to “Instrument Panel Cluster” in this section.
2. Socket and bulb
   Hold the bulb socket by hand and rotate it counterclockwise to remove it from the instrument panel cluster body.
3. Bulb
   Pull out the bulb from the socket.



LNW38ASH013101

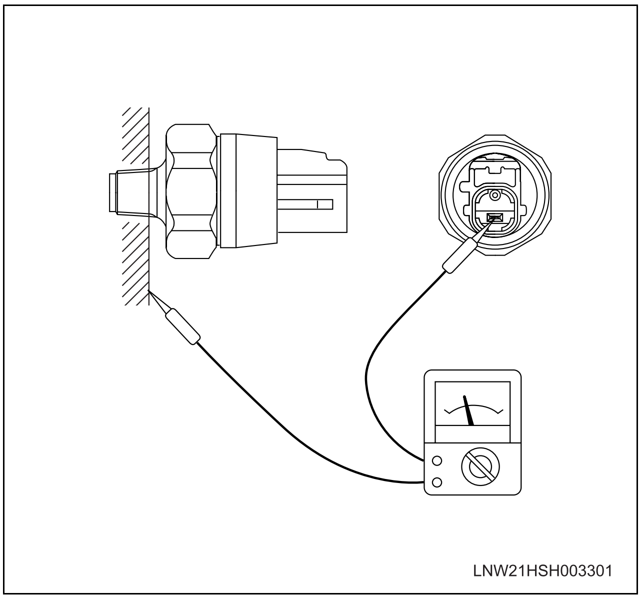
Install or Connect

To install, follow the removal steps in the reverse order.

OIL PRESSURE SWITCH

Inspect

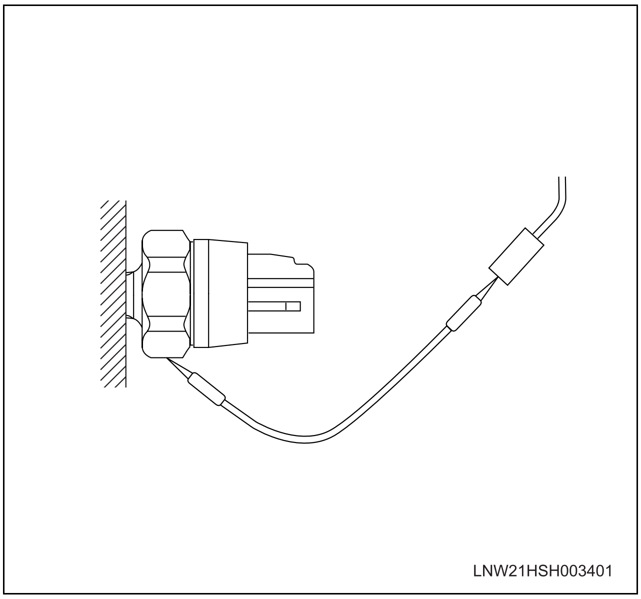
Check the continuity between the switch terminal and the body grounding in the no-load condition.
If there is no connectivity, replace with normal parts.



LNW21HSH003301

Circuit check

1. Turn the ignition switch to ON.
2. Disconnect the oil pressure switch connector, and confirm that the oil pressure-warning lamp lights when the connector on the harness side is grounded.
   If the warning lamp does not light up, check the circuit between the instrument panel cluster and the oil pressure switch, and repair the disconnected locations.



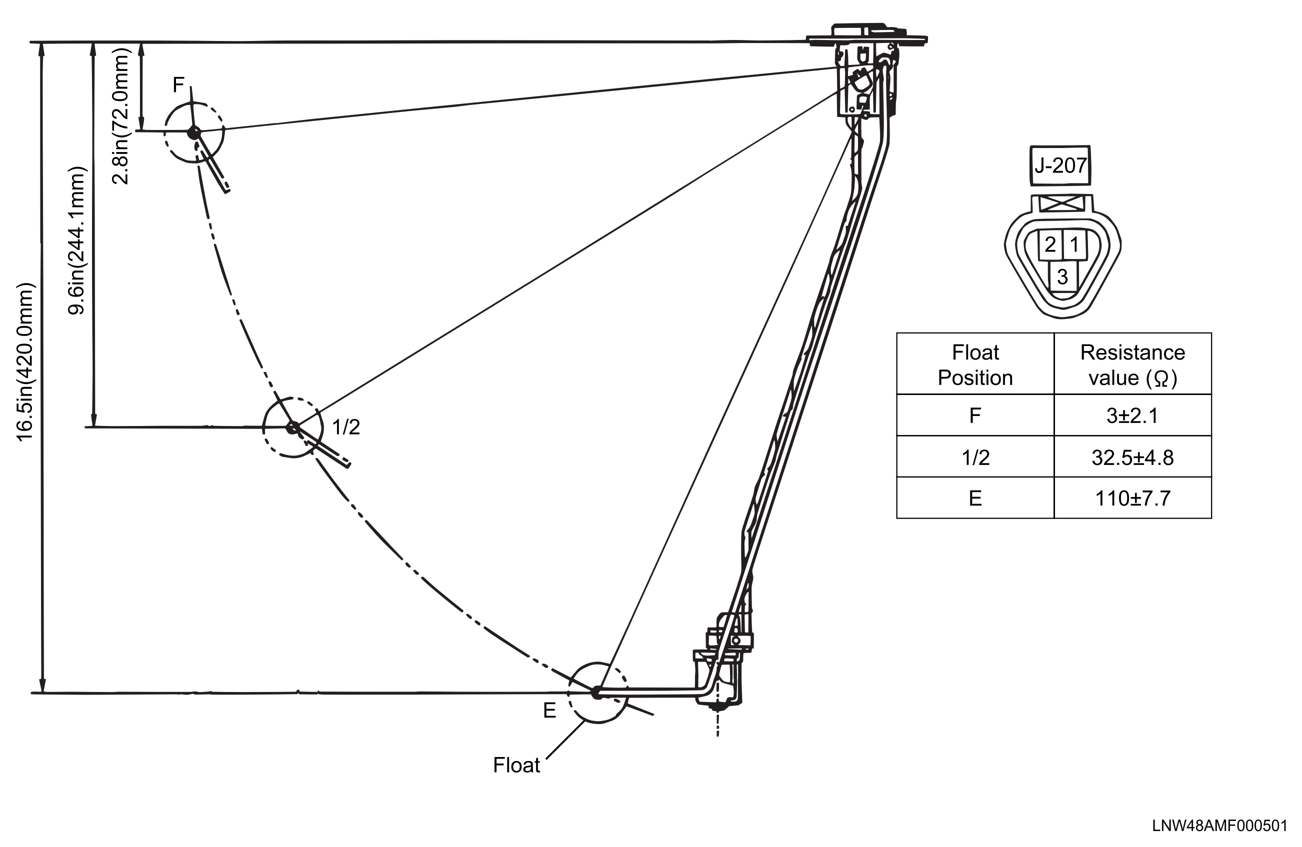
LNW21HSH003401

FUEL PUMP & FUEL LEVEL SENSOR

Inspect

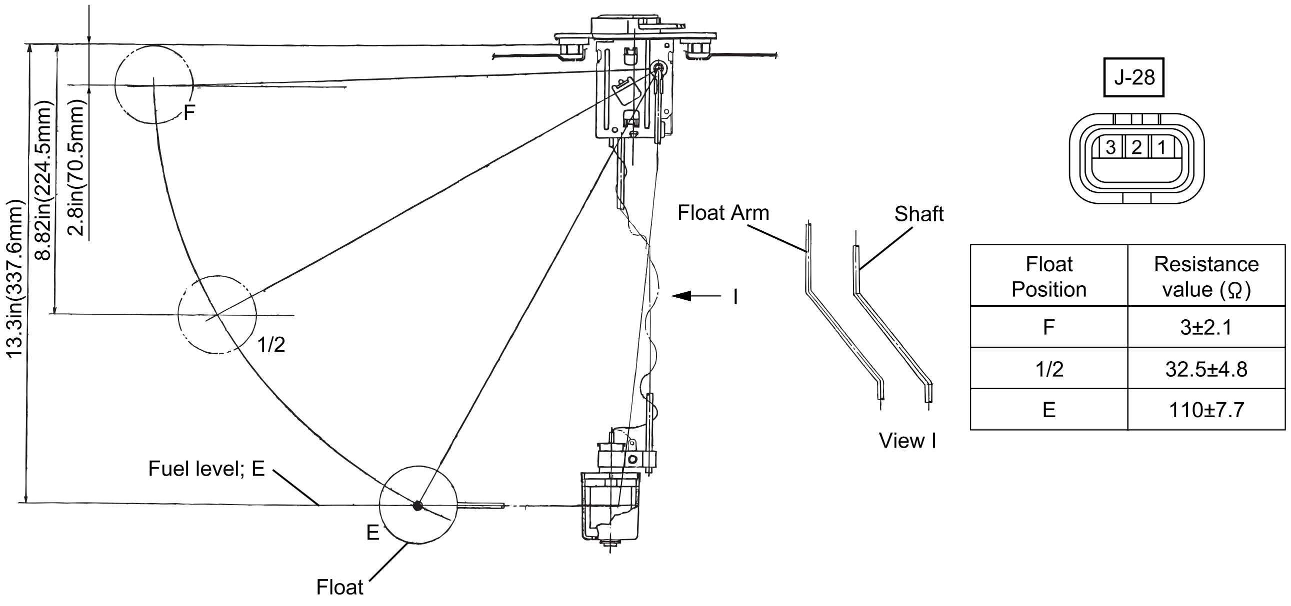
Measure the fuel tank unit resistance between terminal [J-28](2) and [J-28](3) with the float positioned at the two points shown in the illustration.

Fuel Tank (Frame Rear)



Float Position	Resistance value (Ω)
F	3±2.1
1/2	32.5±4.8
E	110±7.7

Fuel Tank (Frame Side)



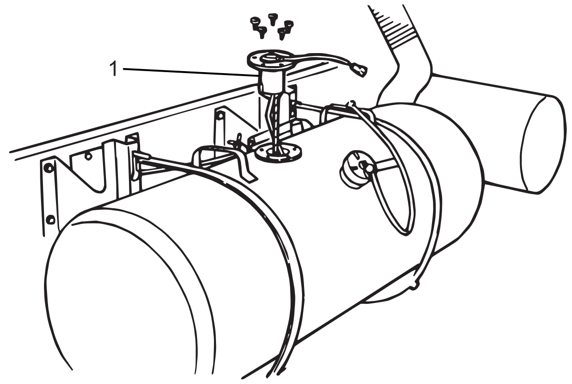
Float Position	Resistance value (Ω)
F	3±2.1
1/2	32.5±4.8
E	110±7.7

LNW48AMF002101

Remove or Disconnect

Preparation: Disconnect the battery ground cable

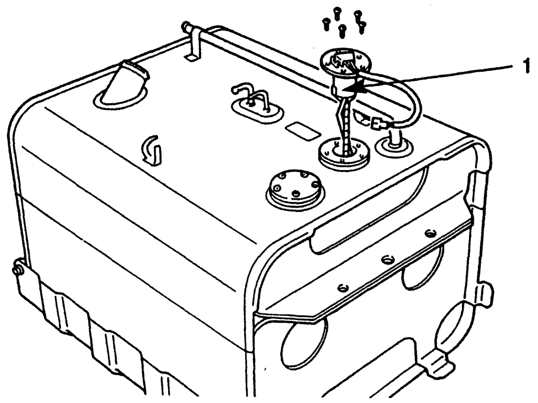
1. Fuel pump & level sensor
   - Disconnect the connector.
   - Remove screws.



LNW48ASH000601

Legend

1. Fuel Level Sensor



LNW38ASH013301

Legend

1. Fuel Level Sensor

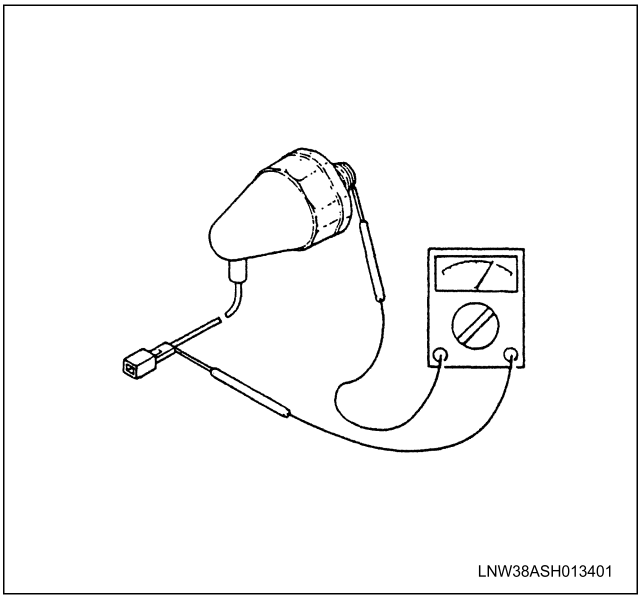
Install or Connect

To install, follow the removal steps in the reverse order.

VACUUM SWITCH

Install or Connect

When the pressure value is below 250 ± 30mmHg (33.3 ± 4.0 kPa), check to see if there is continuity between the terminal and the ground. If no continuity, replace the switch with a normal one.



Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Vacuum switch
   - Disconnect the connector.
   - Remove the vacuum switch.

Install or Connect

Apply liquid gasket to the screw portion of the switch to prevent vacuum leak.

VACUUM WARNING BUZZER

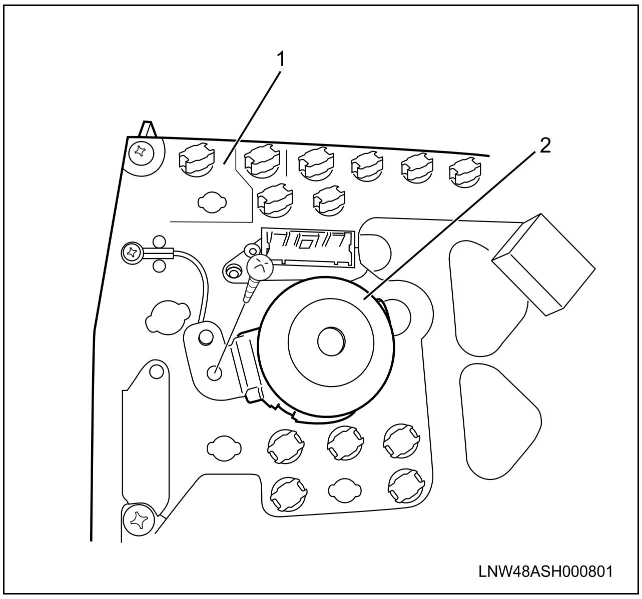
Inspect

Apply battery voltage to the buzzer connector terminals to check the buzzer sound.
Replace the buzzer when the result of inspection is found abnormal.

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Instrument Panel Cluster
   Refer to “Instrument Panel Cluster” in this section.
2. Vacuum warning buzzer
   - Disconnect the connector.
   - Remove the buzzer fixing screw.



Legend

1. Instrument Panel Cluster
2. Vacuum Warning Buzzer

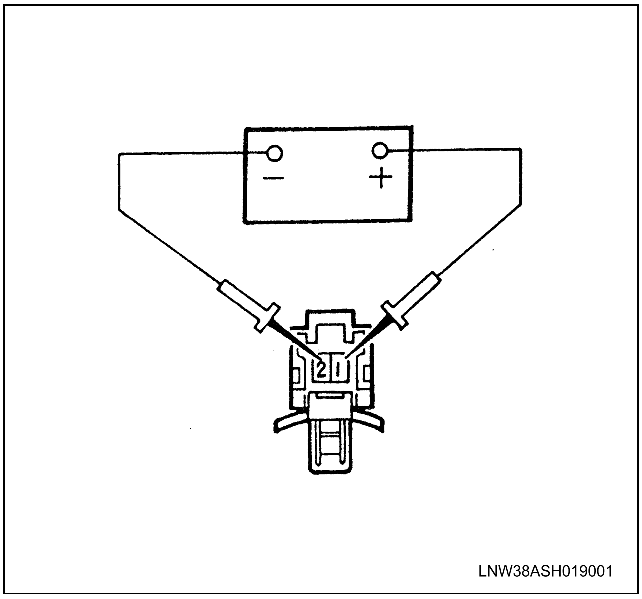
Install or Connect

To install, follow the removal steps in the reverse order.

VACUUM PUMP

Inspect

Connect the vacuum pump connector terminal No.1 to the battery (+) terminal and No.2 to the (–) terminal and then check vacuum pump function.

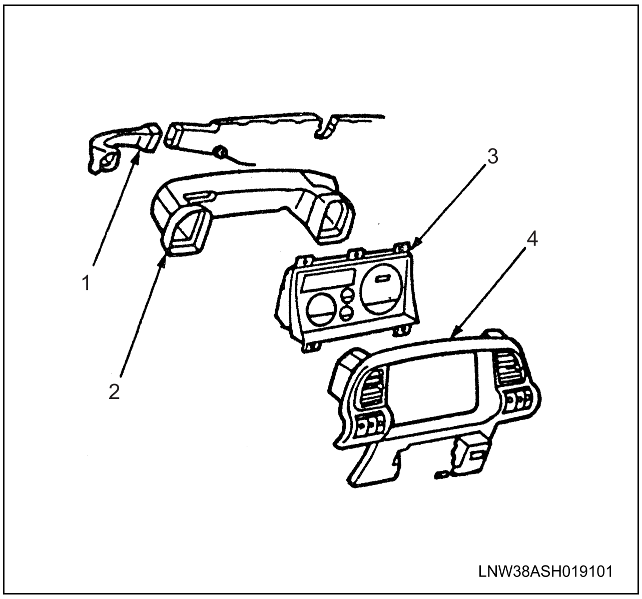


Remove or Disconnect

Preparation: Disconnect the battery ground cable

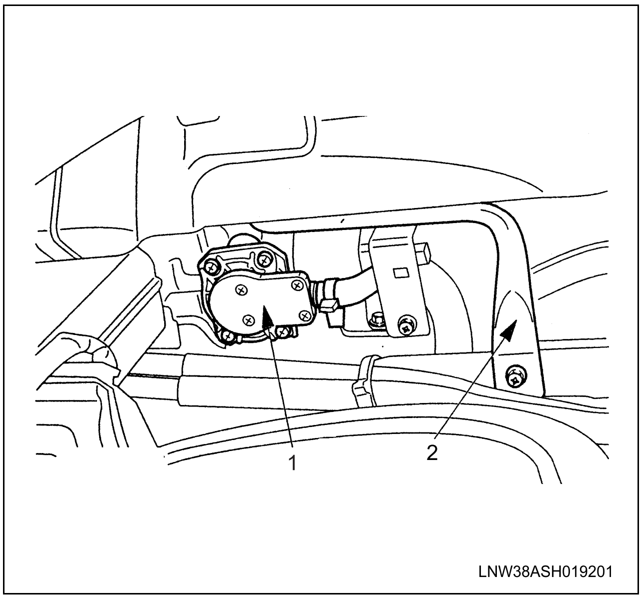
1. Instrument Panel Cluster Bezel
   - Release seven locks at back side of the instrument panel cluster bezel.
2. Instrument Panel Cluster
   - Remove five screws.

3. Vent duct
    - Remove antenna cable from the clips.
4. Side defroster nozzle
5. Stiffener
6. Vacuum pump with bracket
    - Disconnect the connector and vacuum pipe.
    - Remove three bolts.
7. Vacuum pump



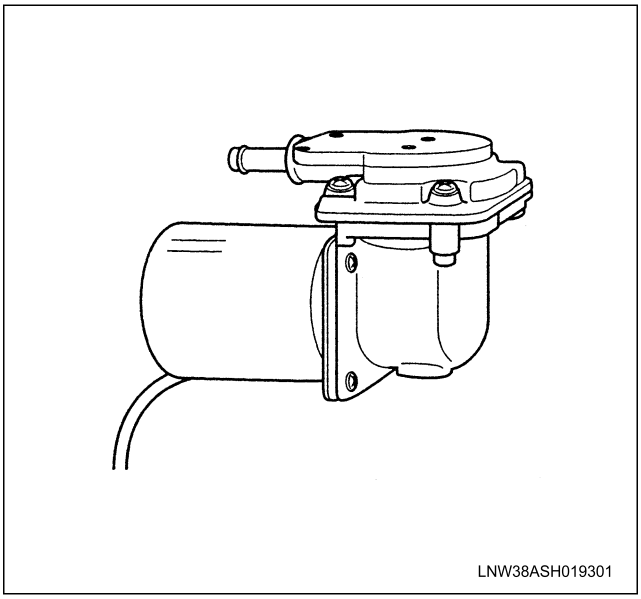
Legend

1. Side Defroster Nozzle
2. Vent Duct
3. Instrument Panel Cluster
4. Instrument Panel Cluster Bezel

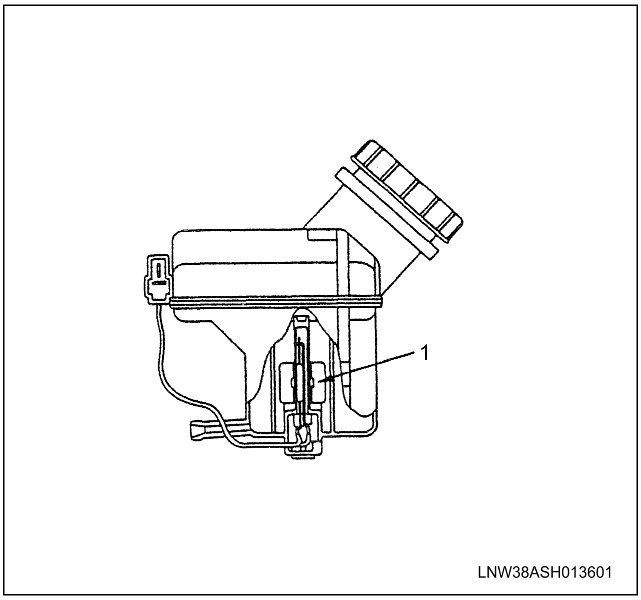


Legend

1. Vacuum Pump
2. Stiffener



BRAKE FLUID LEVEL SWITCH



Legend

1. Brake Fluid Level Switch

Inspect

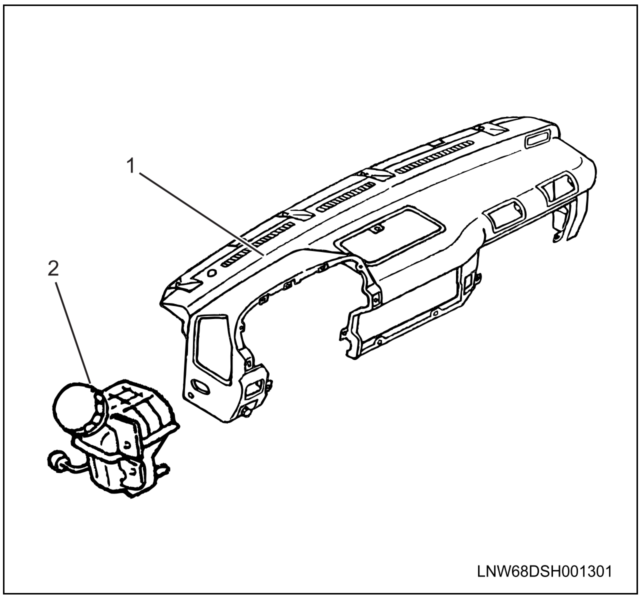
1. Confirm there is continuity between the switch connector terminals when the brake fluid in the tank is between 60 – 75 cc level.
2. Turn the switch on, disconnect the brake fluid level switch connector and connect the harness side connector terminals.
   Then confirm that brake warning light turns on. If found defective, replace the tank, or repair a poor connection or an open circuit between the connector terminals.

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Instrument panel assembly
   Refer to “Instrument Panel” of section 8F “Steel Tilt Cab”.
2. Brake fluid tank (Brake fluid level switch)
   - Disconnect the switch connector.
   - Remove four fixing nuts.
   - Drain brake fluid in the tank.
   - Disconnect the tubes.

Caution:
Be very careful not to allow the brake fluid to come in contact with painted surfaces or resin parts surfaces.



Legend

1. Instrument Panel Assembly
2. Brake Fluid Tank (Brake Fluid Level Switch)

Install or Connect

To install, follow the removal steps in the reverse order, noting the following points:

1. Bleed the air from brake and clutch fluid pipe line.
2. Check to see if the brake fluid level in the tank is within specified level.
3. Check to see if brake warning light comes on when ignition switch is turned on and then warning light goes off after the engine is running.

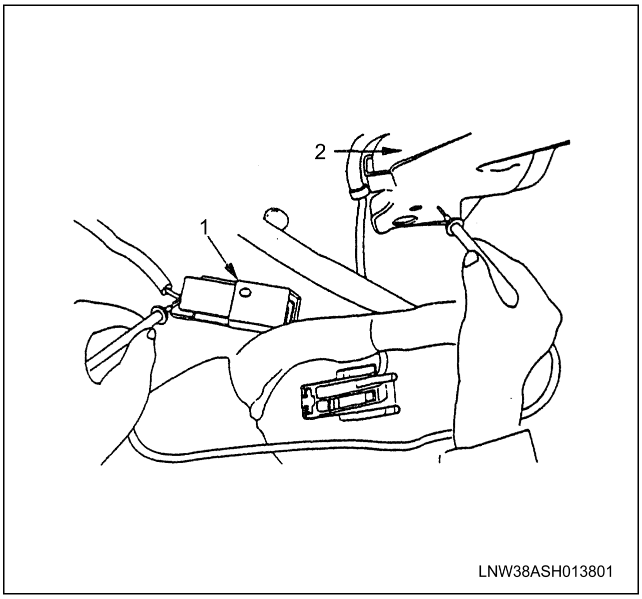
PARKING BRAKE INDICATOR LIGHT

The parking brake indicator light is connected in series with the parking brake switch installed to the parking brake lever bracket.
The light comes on when the parking brake lever is pulled, and goes out when the parking brake lever is fully released.

Notice:
The parking brake indicator light illuminates to warn the driver that the parking brake is on. This light does not indicate the condition of the operability of the parking brake.

Circuit inspect

1. Disconnect the parking brake switch connector.
2. Connect the harness side connector terminal to the ground.
3. Check to see if the indicator light comes on with the ignition switch “ON”.
   Check the bulb or the harness when the result of inspection is found abnormal.



Legend

1. Harness Side Connector
2. Parking Brake Lever

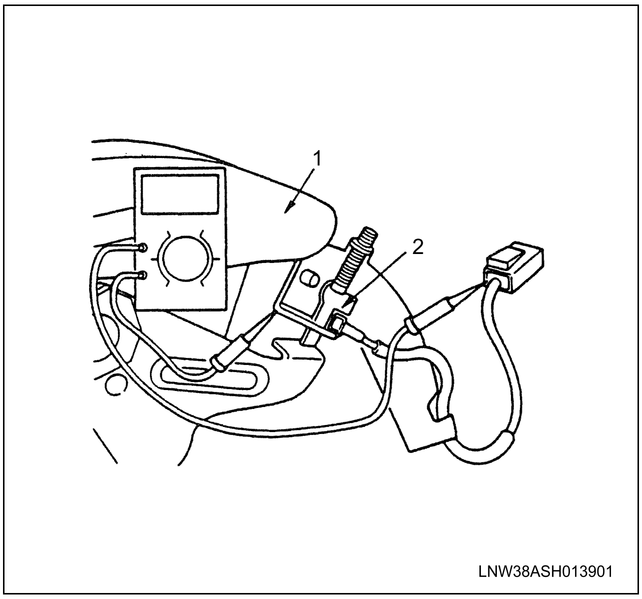
PARKING BRAKE SWITCH

Inspect

1. Disconnect the parking brake switch connector.
2. Check to see if there is any continuity between the switch terminal and the body ground with the circuit tester connected between them.

When parking brake applied	Continuity
When parking brake released	No continuity

Repair the parking brake switch or replace it when the result of inspection is found abnormal.



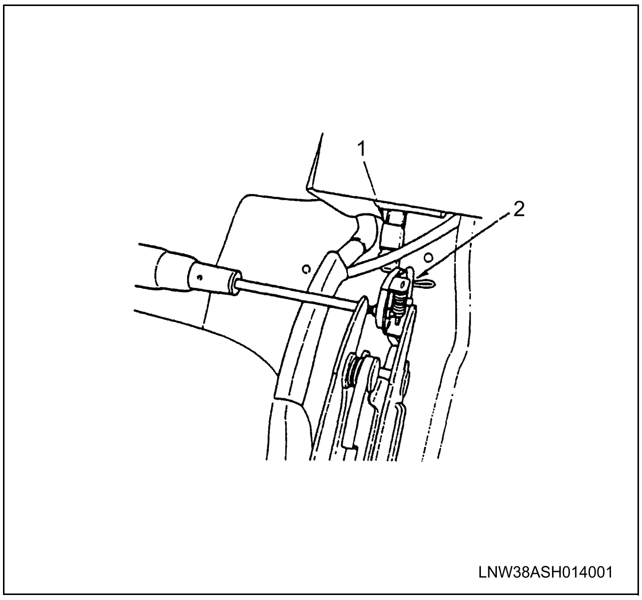
Legend

1. Parking Brake Lever
2. Parking Brake Switch

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Parking brake switch
   - Disconnect the connector.
   - Remove the fixing screw.



Legend

1. Connector
2. Parking Brake Switch

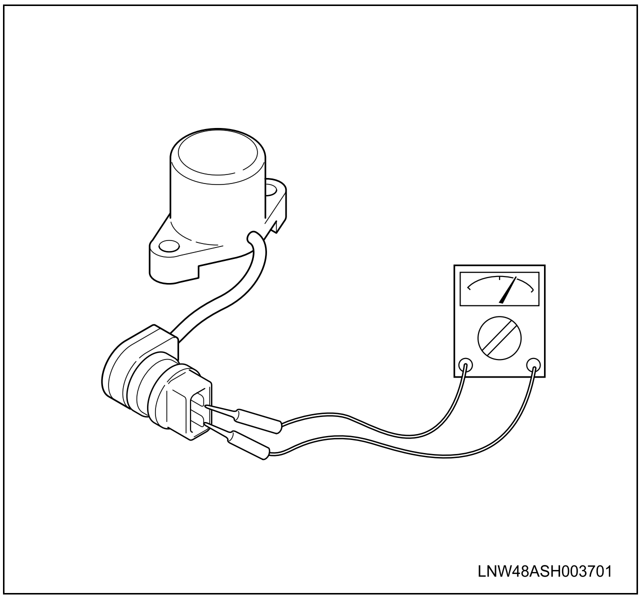
Install or Connect

To install, follow the removal steps in the reverse order.

OIL LEVEL SWITCH

Install or Connect

When the oil level switch is below 250 mmHg (33.3 kPa), check to see if there is continuity between the terminal and the ground. If no continuity, replace the switch with a normal one.



Remove or Disconnect

Notice:
Disconnect the battery ground cabel. Refer to “Oil Pan” of section 6A “ENGINE MECHANICAL (4HK1-TC).

Install or Connect

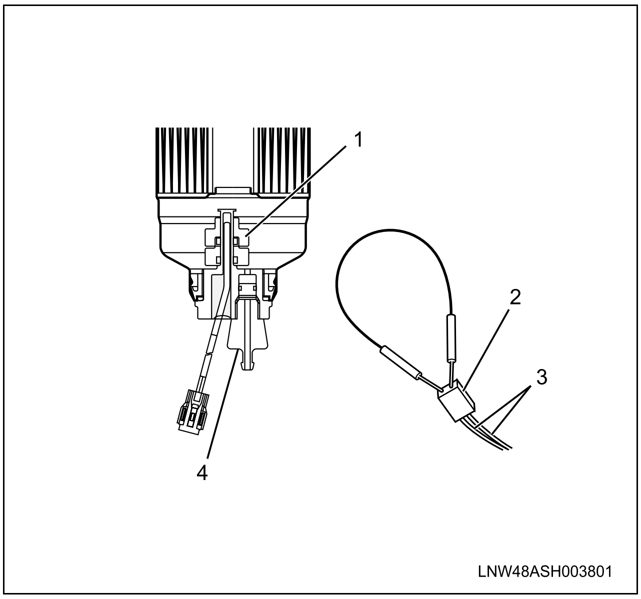
Refer to "Oil Pan" of section 6A "ENGINE MECHANICAL (4HK1-TC).

FUEL SEDIMENTER SWITCH

Inspection

1. Check for continuity between the connector terminals when the fuel sedimenter float is above the water drain line.
2. Turn the ignition switch to the ON position.
3. Remove the fuel sedimenter connector.
4. Check that the fuel sedimenter warning light turns on when the harness side connectors are joined.

If abnormal conditions are discovered during inspection, replace the fuel sedimenter switch and/or repair any broken connections and open circuit areas.



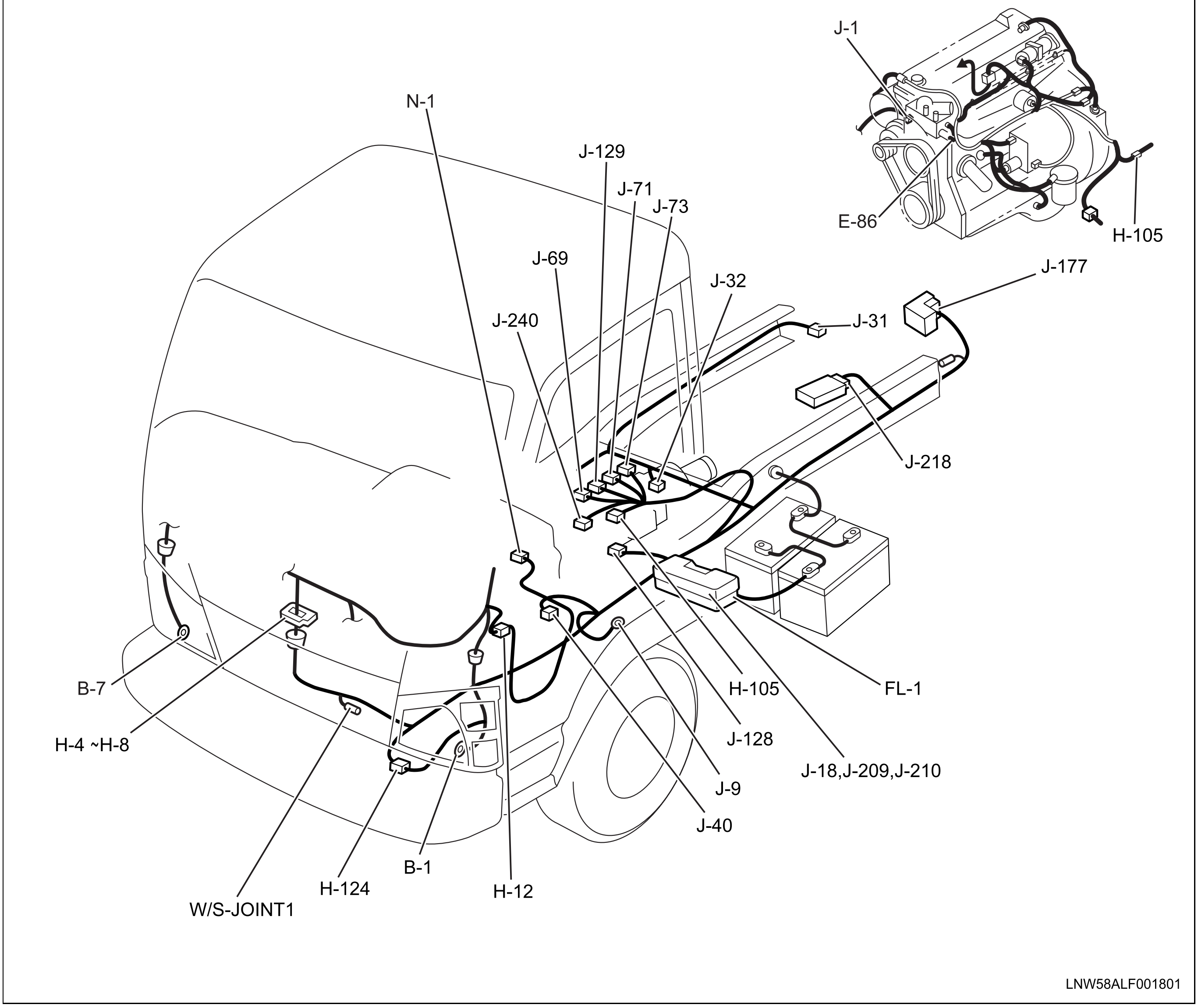
Legend

1. Fuel Sedimenter Switch
2. Connector
3. Harness
4. Drain plug

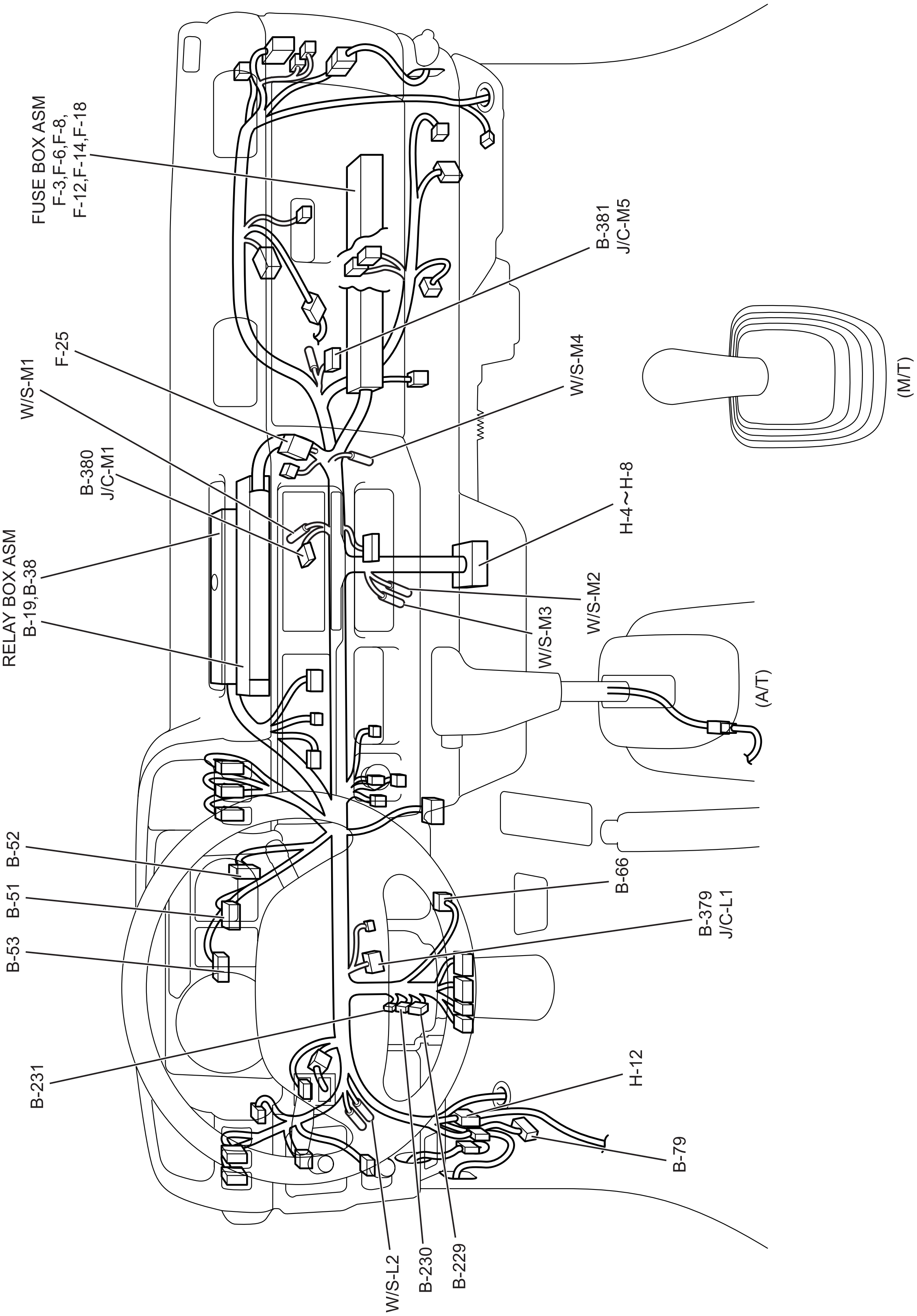
Transmission Control Module (TCM)

- The Transmission Control Module (TCM) is filled under the instrument panel cluster bezel by means of four stud bolts. It receives signals from various sensors and judges the running condition of the vehicle accordingly. It compares the result with programmed gear shifting parameters, lock-up operating parameters, etc., and sends signals to solenoids and controls them accordingly.
- It controls seven different items:

PARTS LOCATION (1)

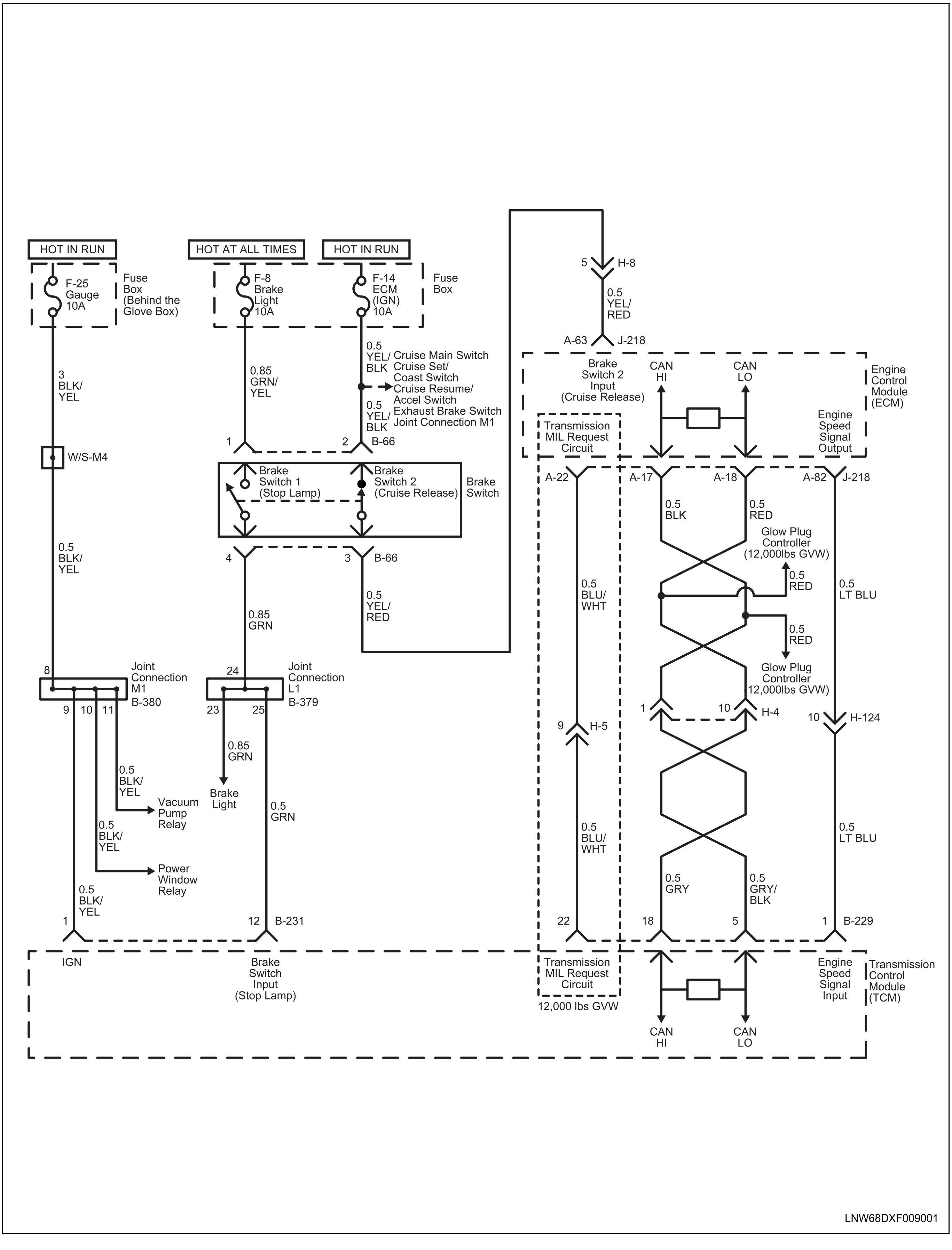


PARTS LOCATION (2)

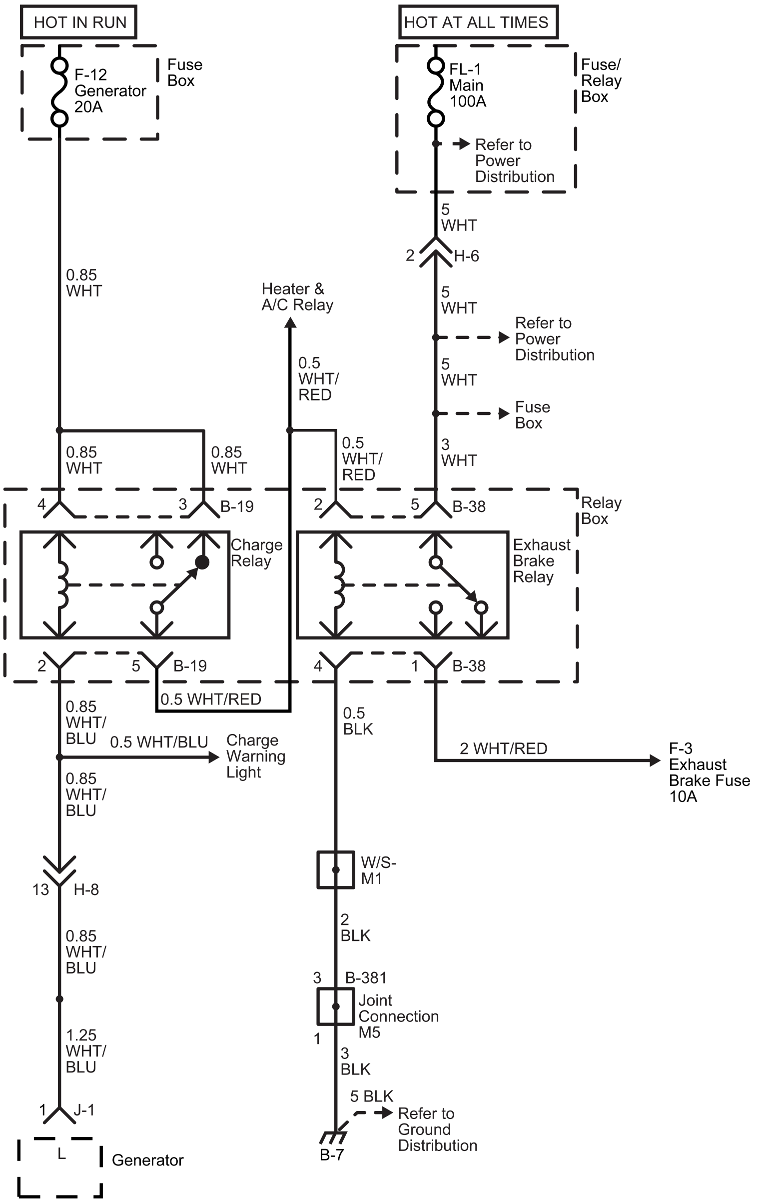


LNW68DXF011301

CIRCUIT DIAGRAM

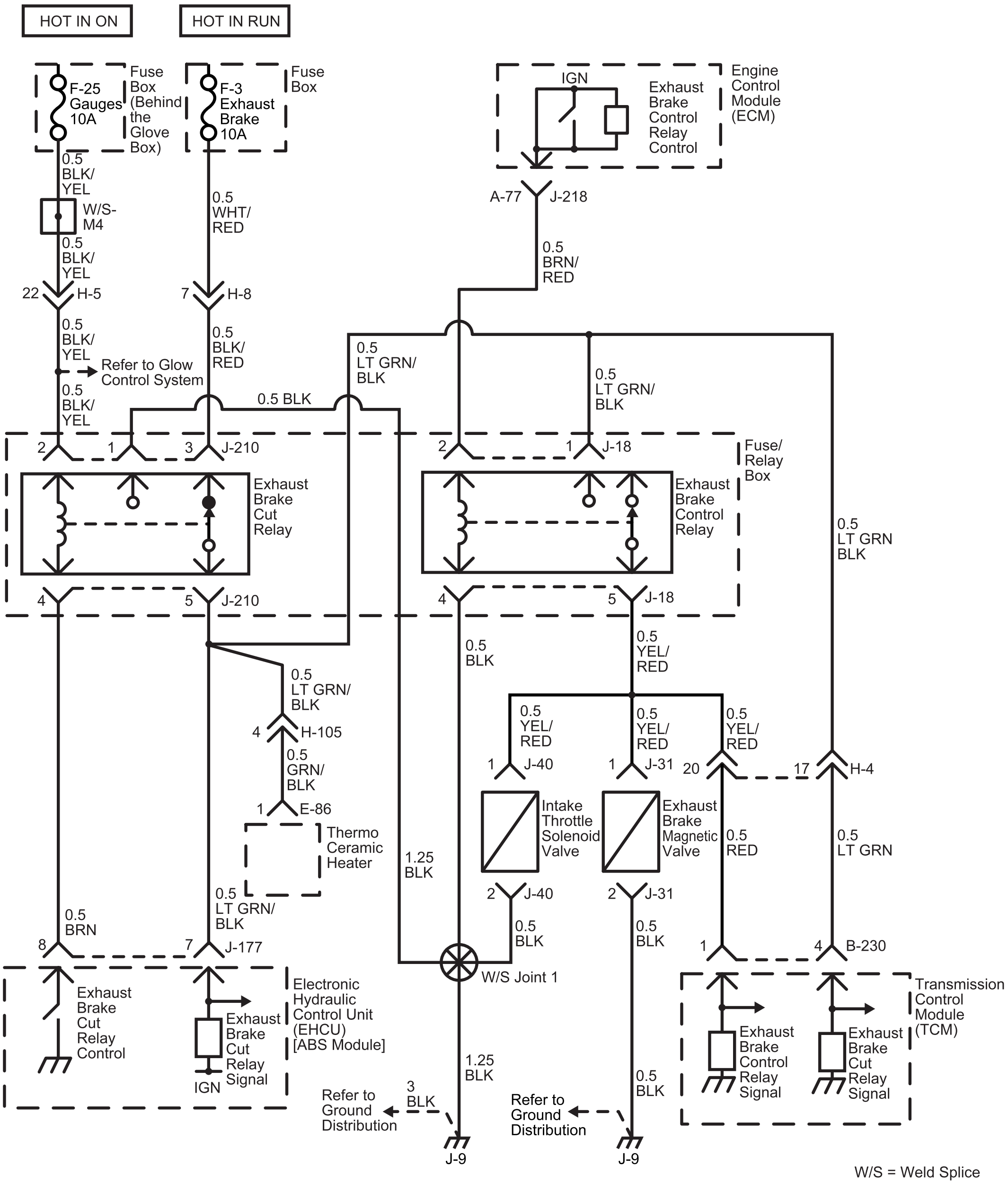


CIRCUIT DIAGRAM



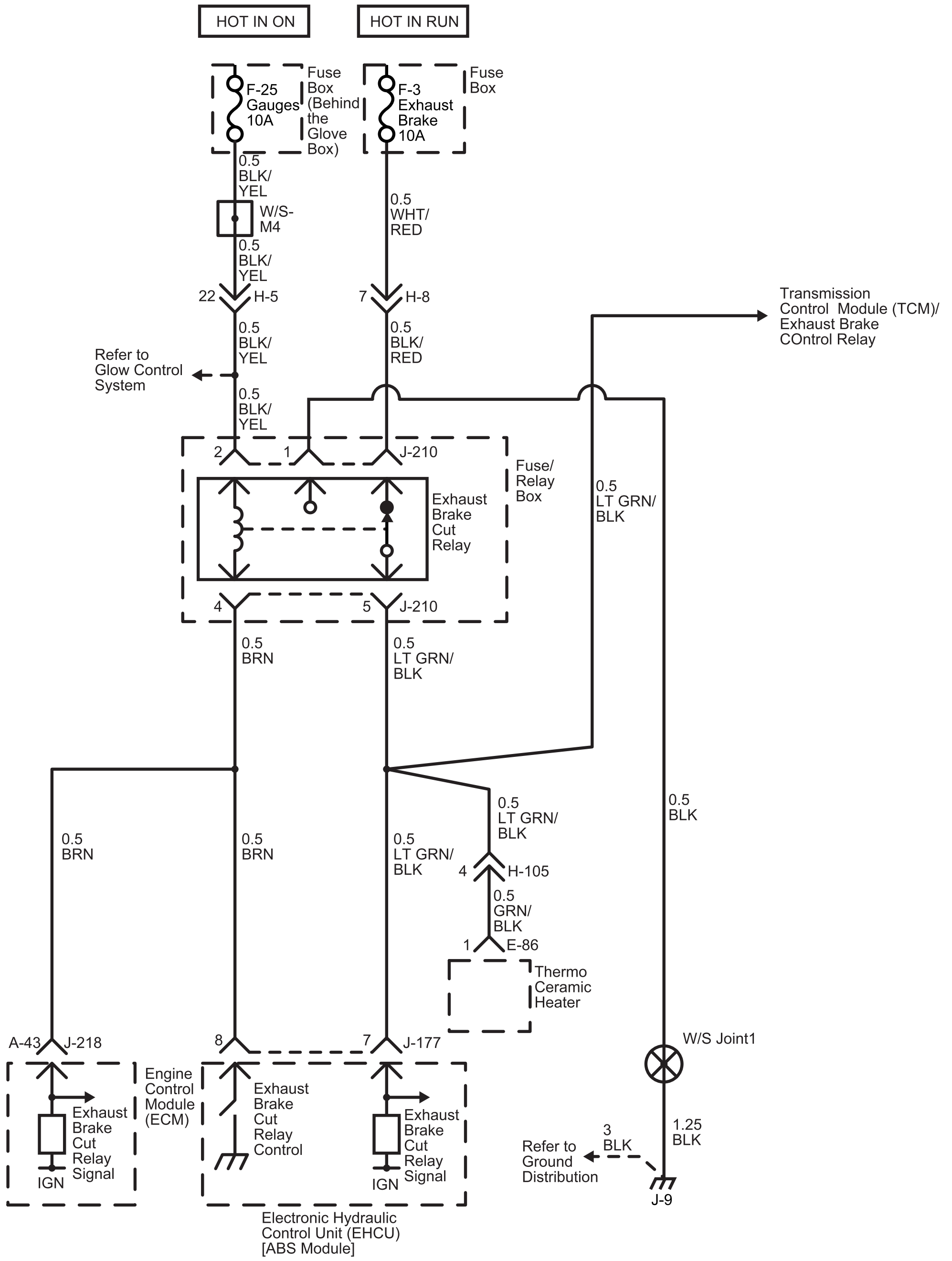
LNW68DXF007501

Except 12,000lbs GVW



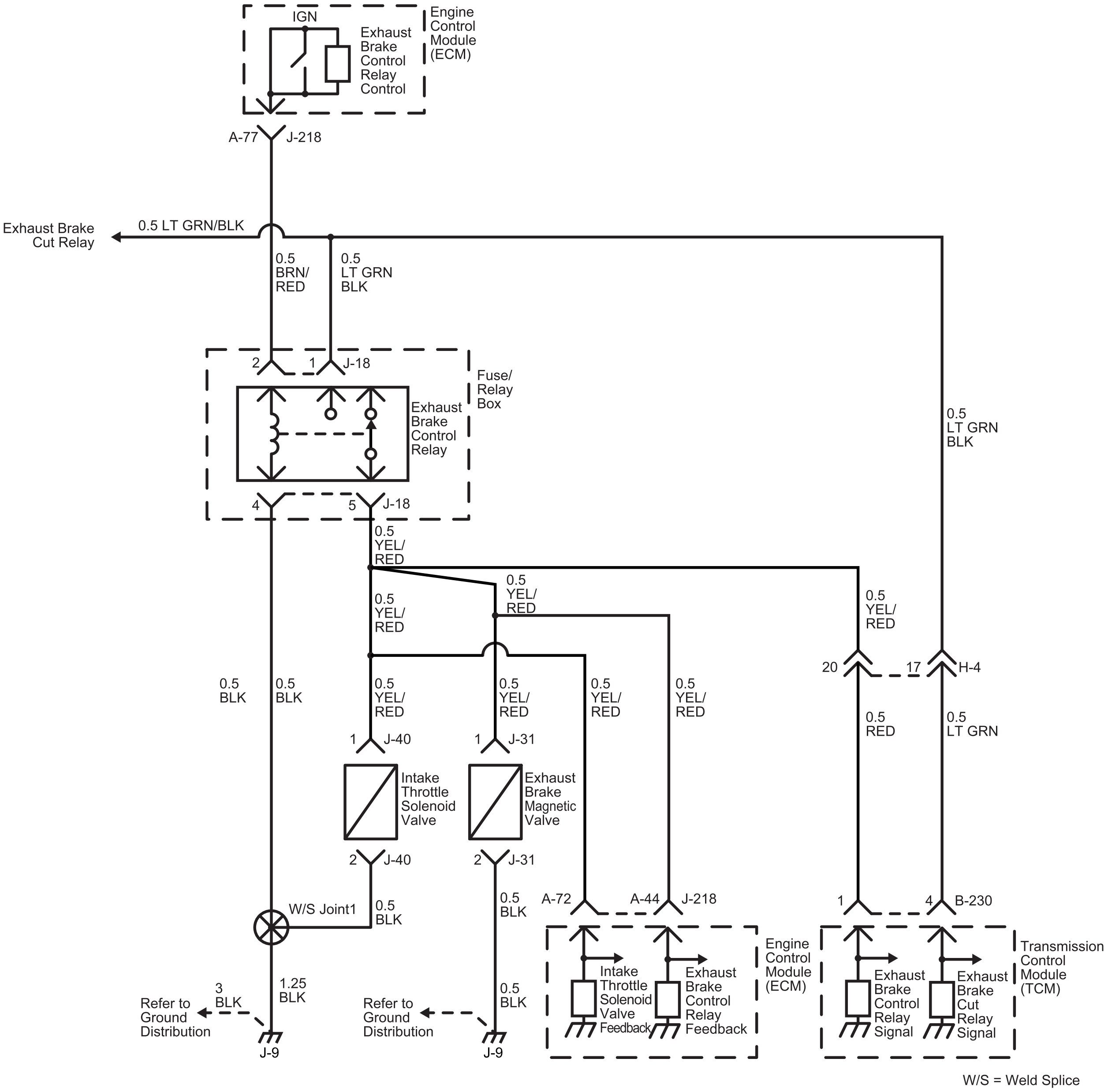
LNW68DXF007601

12,000lbs GVW



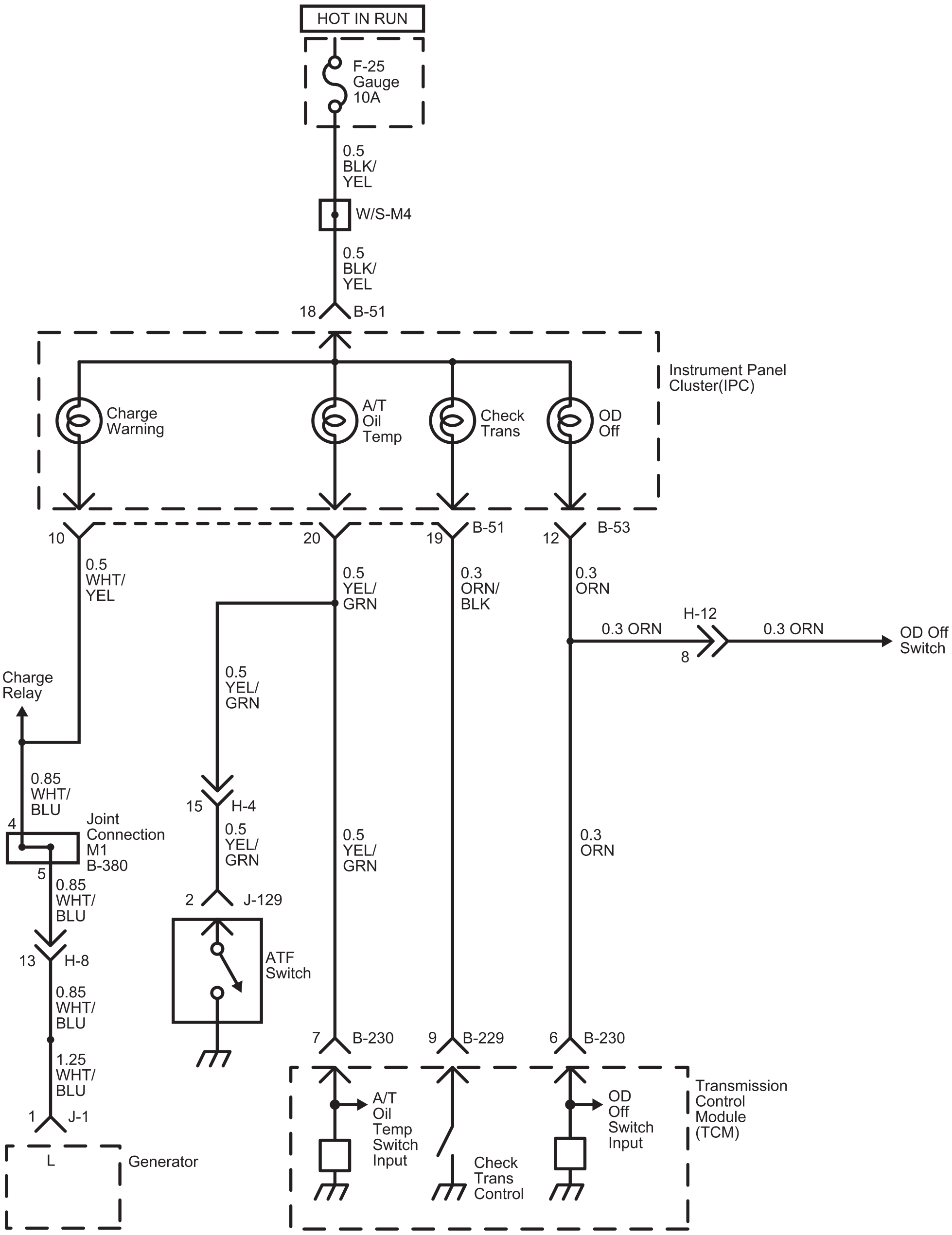
LNW68DXF007701

12,000lbs GVW

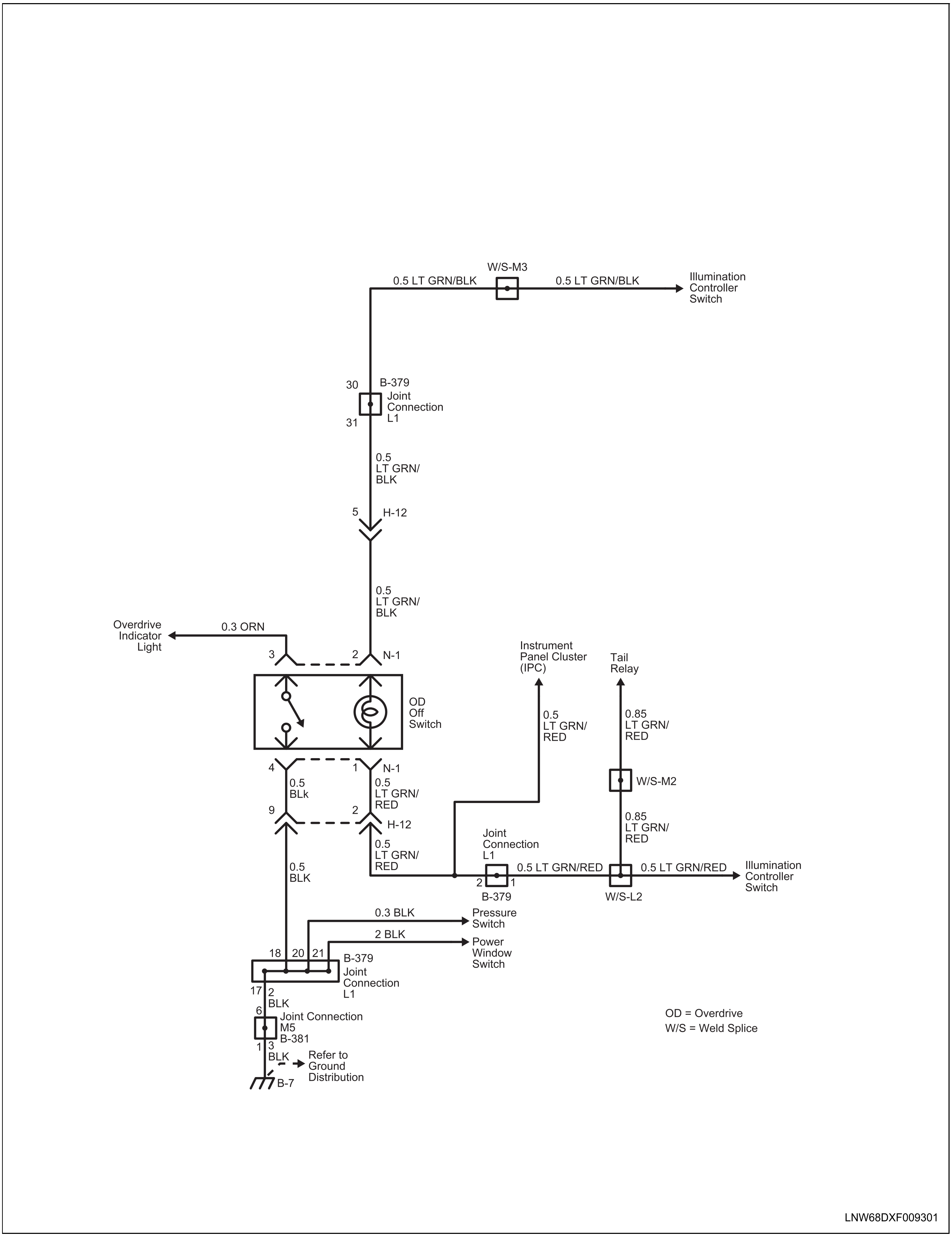


LNW68DXF007801

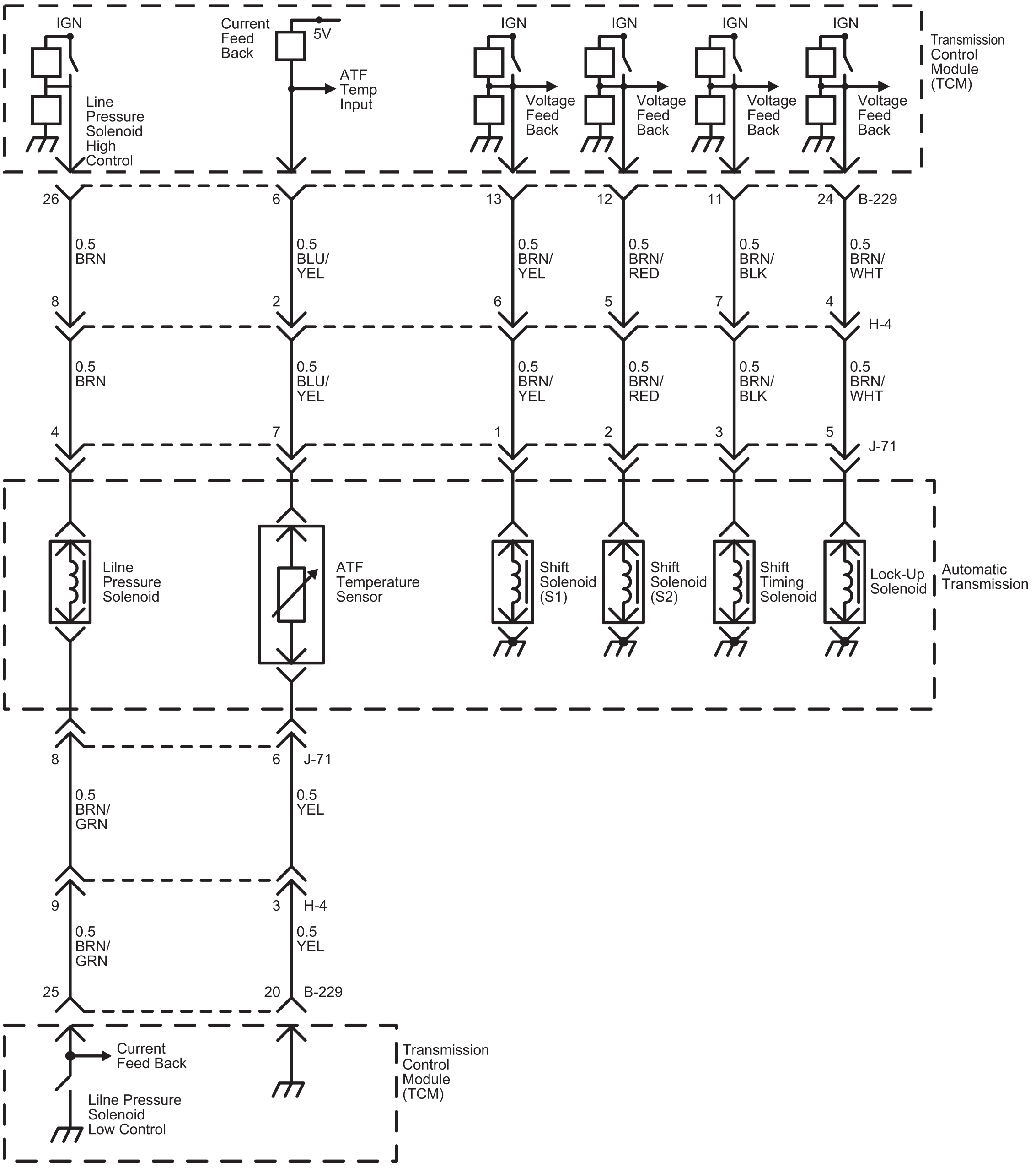
CIRCUIT DIAGRAM



LNW68DXF009201

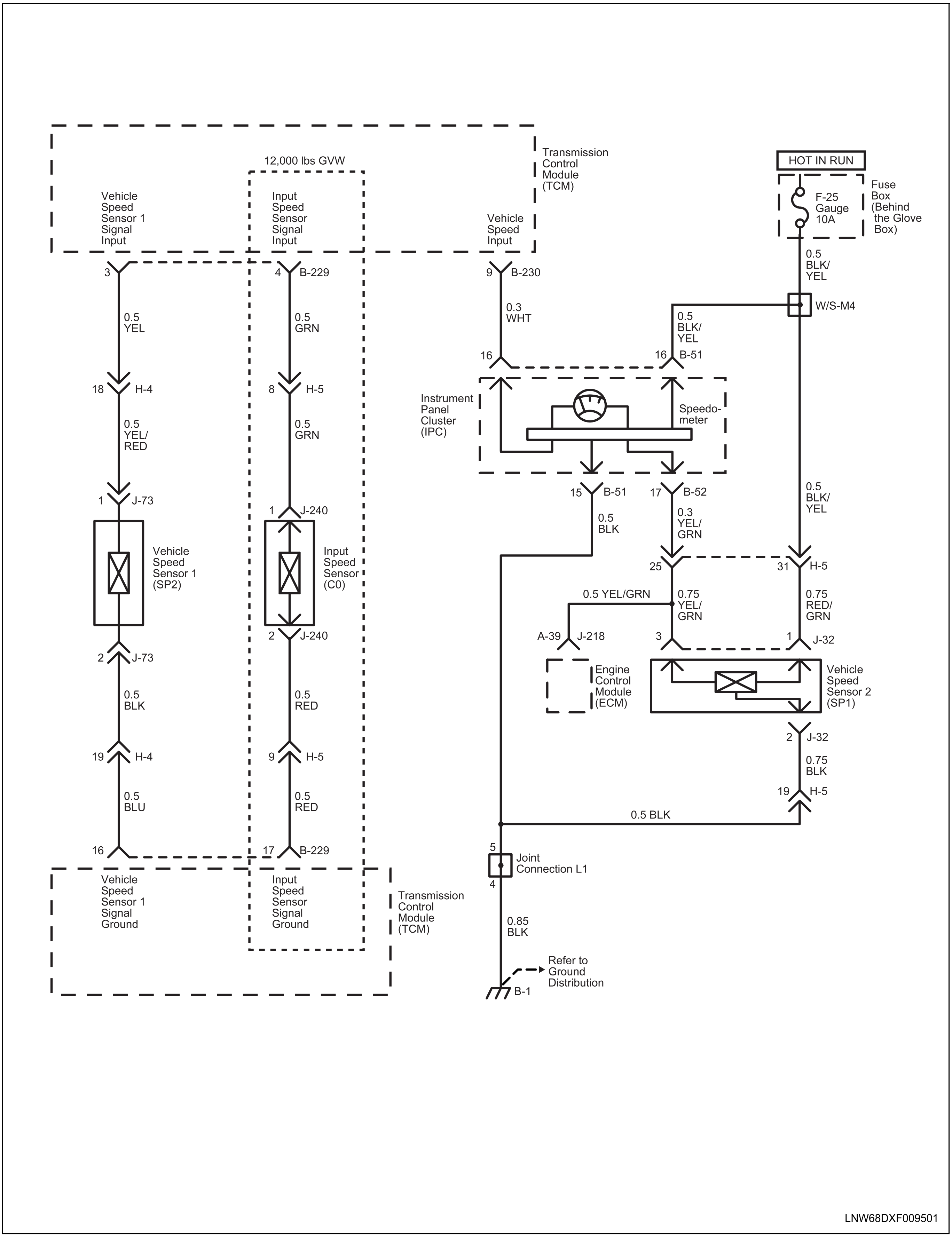

W/S-M3
0.5 LT GRN/BLK
0.5 LT GRN/BLK
Illumination Controller Switch
30
B-379
Joint Connection L1
31
0.5 LT GRN/BLK
5
H-12
0.5 LT GRN/BLK
Overdrive Indicator Light
0.3 ORN
3
2
N-1
OD Off Switch
Instrument Panel Cluster (IPC)
Tail Relay
0.5 LT GRN/RED
0.85 LT GRN/RED
W/S-M2
4
1
N-1
0.5 BLk
0.5 LT GRN/RED
9
2
H-12
0.85 LT GRN/RED
0.5 LT GRN/RED
0.5 BLK
Joint Connection L1
2
1
B-379
0.5 LT GRN/RED
W/S-L2
0.5 LT GRN/RED
Illumination Controller Switch
0.3 BLK
Pressure Switch
2 BLK
Power Window Switch
18
20
21
B-379
Joint Connection L1
17
2
BLK
6
Joint Connection M5
B-381
1
3
BLK
Refer to Ground Distribution
B-7
OD = Overdrive
W/S = Weld Splice
LNW68DXF009301

CIRCUIT DIAGRAM

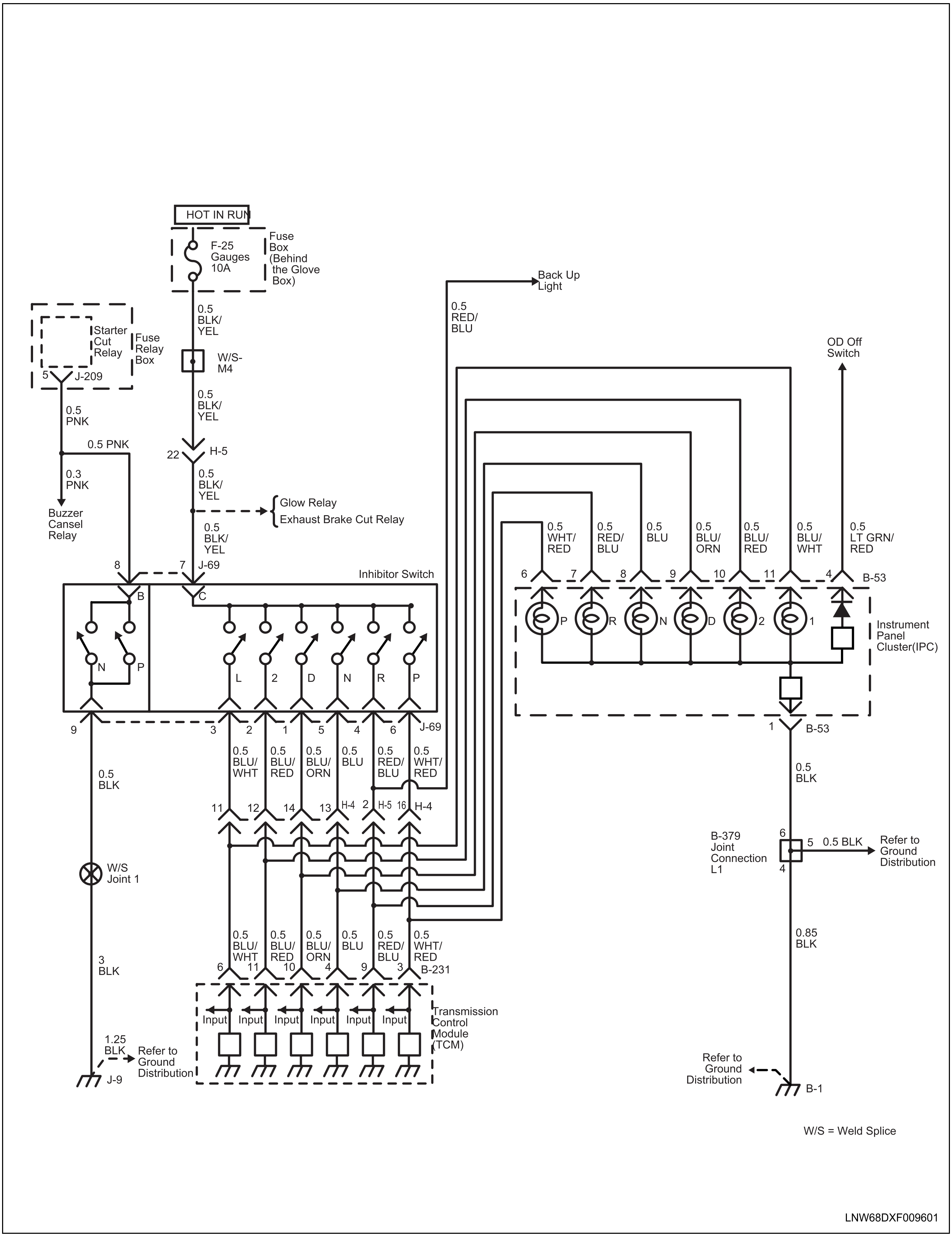


LNW68DXF009401

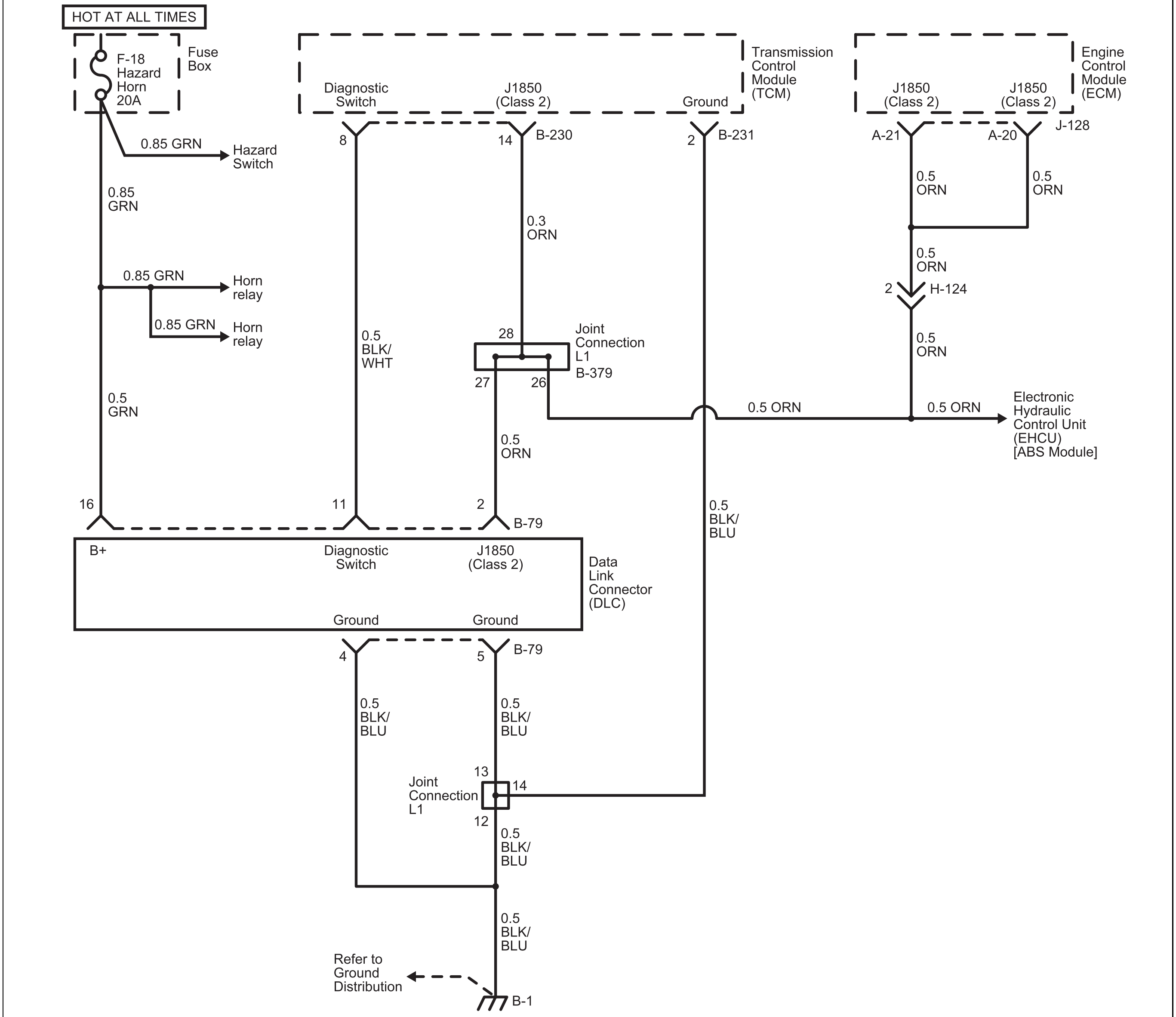
CIRCUIT DIAGRAM



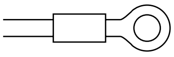
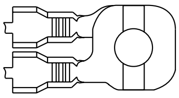
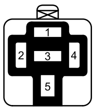
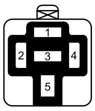
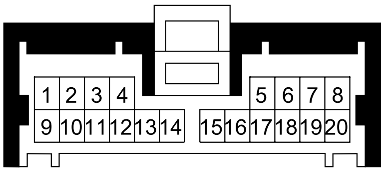
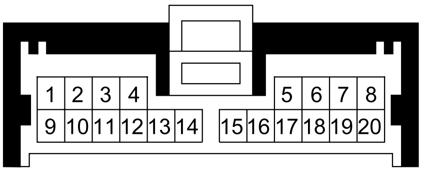
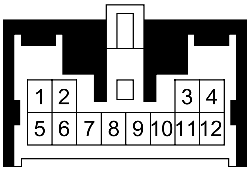
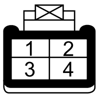
CIRCUIT DIAGRAM

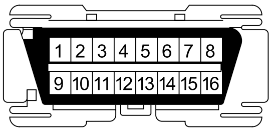
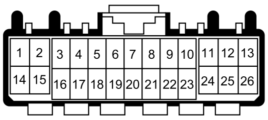
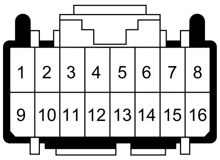
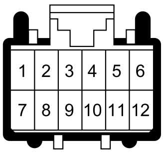
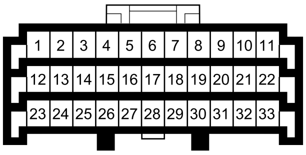
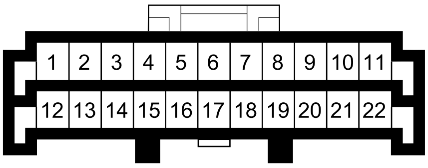
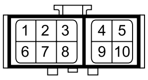
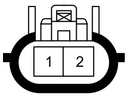


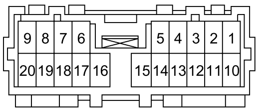
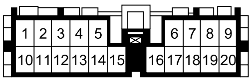
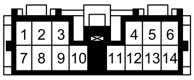
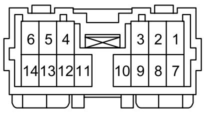
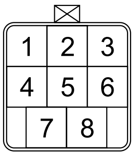
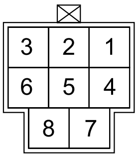
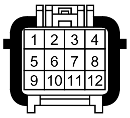
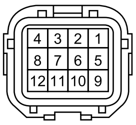
CIRCUIT DIAGRAM

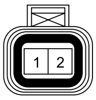
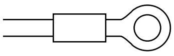
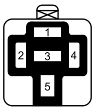
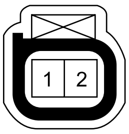
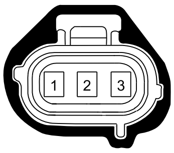
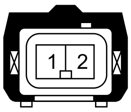
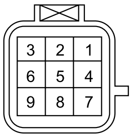
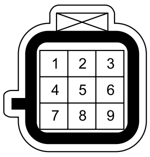


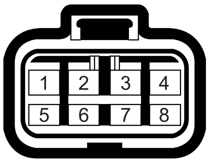
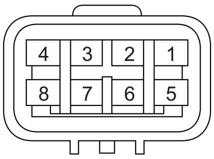
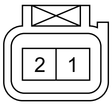
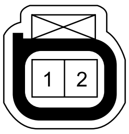
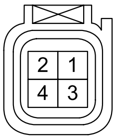
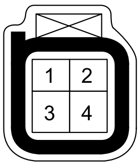
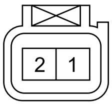
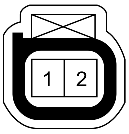
LNW68DXF009701

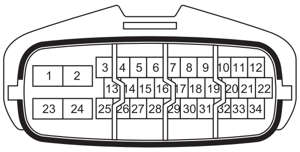
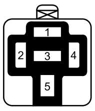
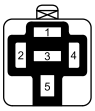
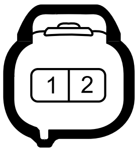
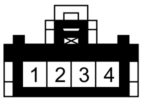
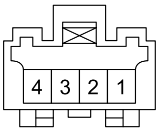
No.	Connector Face
B-1	 000-012 Ground; Frame–LH (Front)
B-7	 000-007 Ground; Headlight Bracket–RH
B-19 (Black)	 005-012 Charge Relay
B-38 (Black)	 005-012 Exhaust Brake Relay
B-51 (Gray)	 020-024 Instrument Panel Cluster (A)
B-52 (White)	 020-025 Instrument Panel Cluster (B)
B-53 (White)	 012-038 Instrument Panel Cluster (C)
B-66 (Brown)	 004-004 Brake Switch

No.	Connector Face
B-79 (Black)	 016-033 DLC connector
B-229 (Gray)	 026-002 TCM
B-230 (Gray)	 016-034 TCM
B-231 (Gray)	 012-026 TCM
B-379 (White)	 033-001 Joint Connection–L1
B-380 (White)	 022-005 Joint Connection–M1
B-381 (White)	 010-015 Joint Connection–M5
E-86 (White)	 002-006 Thermo Ceramic Heater

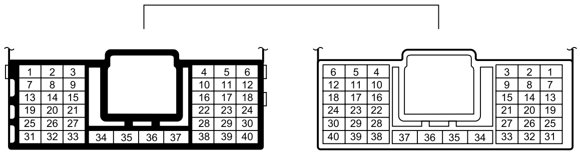
No.	Connector Face
H-4 (White)	 020-002 Body H. – Frame H.
H-4 (White)	 020-001 Body H. – Frame H.
H-12 (White)	 014-003 Body H. – Floor H. (RH)
H-12 (White)	 014-004 Body H. – Floor H. (RH)
H-105 (Black)	 008-060 Frame H. – Engien H.
H-105 (Black)	 008-061 Frame H. – Engien H.
H-124 (Black)	 012-013 Body H. – Frame H.
H-124 (Black)	 012-014 Body H. – Frame H.

No.	Connector Face
J-1 (Green)	 002-001 Generator
J-9	 000-012 Ground: Frame LH. – Center
J-18 (Black)	 005-012 Exhaust Brake Control Relay
J-31 (Black)	 002-008 Exhaust Brake Magnetic Valve
J-32 (Gray)	 003-048 Vehicle speed sensor
J-40 (Brown)	 002-024 Intake Throttle Solenoid Valve
J-69 (Black)	 009-002 Inhibitor Switch
J-69 (Black)	 009-001 Inhibitor Switch

No.	Connector Face
J-71 (Black)	 008-043 A/T Mission
J-71 (White)	 008-044 A/T Mission
J-73 (Black)	 002-007 Vehicle Speed Sensor
J-73 (Black)	 002-008 Vehicle Speed Sensor
J-128 (Black)	 004-002 HBB Oil Level Sensor
J-128 (Black)	 004-001 HBB Oil Level Sensor
J-129 (White)	 002-007 ATF Switch
J-129 (White)	 002-008 ATF Switch

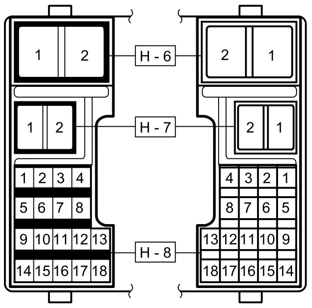
No.	Connector Face
J-177 (White)	 034-001 Electronic Hydraulic Control Unit (EHCU) [ABS Module]
J-209 (Black)	 005-012 Starter Cut Relay
J-210 (Black)	 005-012 Exhaust Brake Cut Relay
J-240 (Gray)	 002-087 Turbine Speed Sensor
N-1 (White)	 004-008 OD Off Switch
N-1 (White)	 004-007 OD Off Switch

H-5 Body H. – Frame H. (Gray)



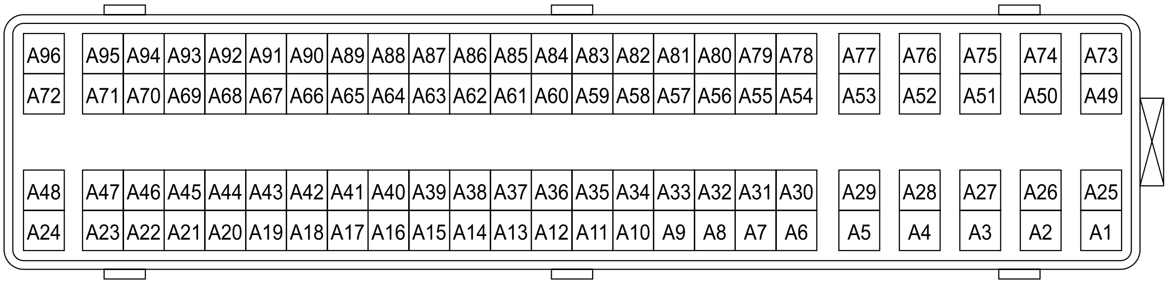
LNW38ASH018701

H-6, H-7, H-8 Body H. – Frame H. (Gray)



LNW38ASH018801

J-218 (Black)



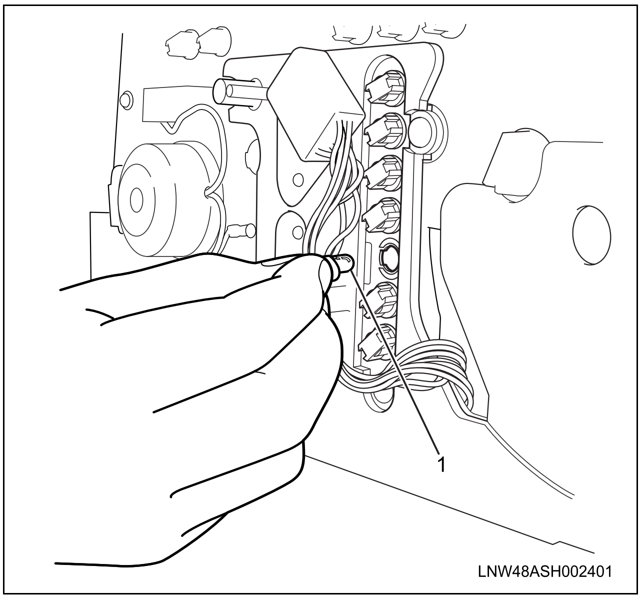
LNW48ASF000101

A/T SHIFT INDICATOR LIGHT BULB

Remove or Disconnect

Preparation: Disconnect the battery ground cable

1. Instrument Panel Cluster
   - Refer to “Instrument Panel Cluster” in this section.
2. Socket and bulb
   - Hold the bulb socket by hand and rotate it counterclockwise to remove it from the meter body.
3. Bulb
   - Pull out the bulb from the socket.



Legend

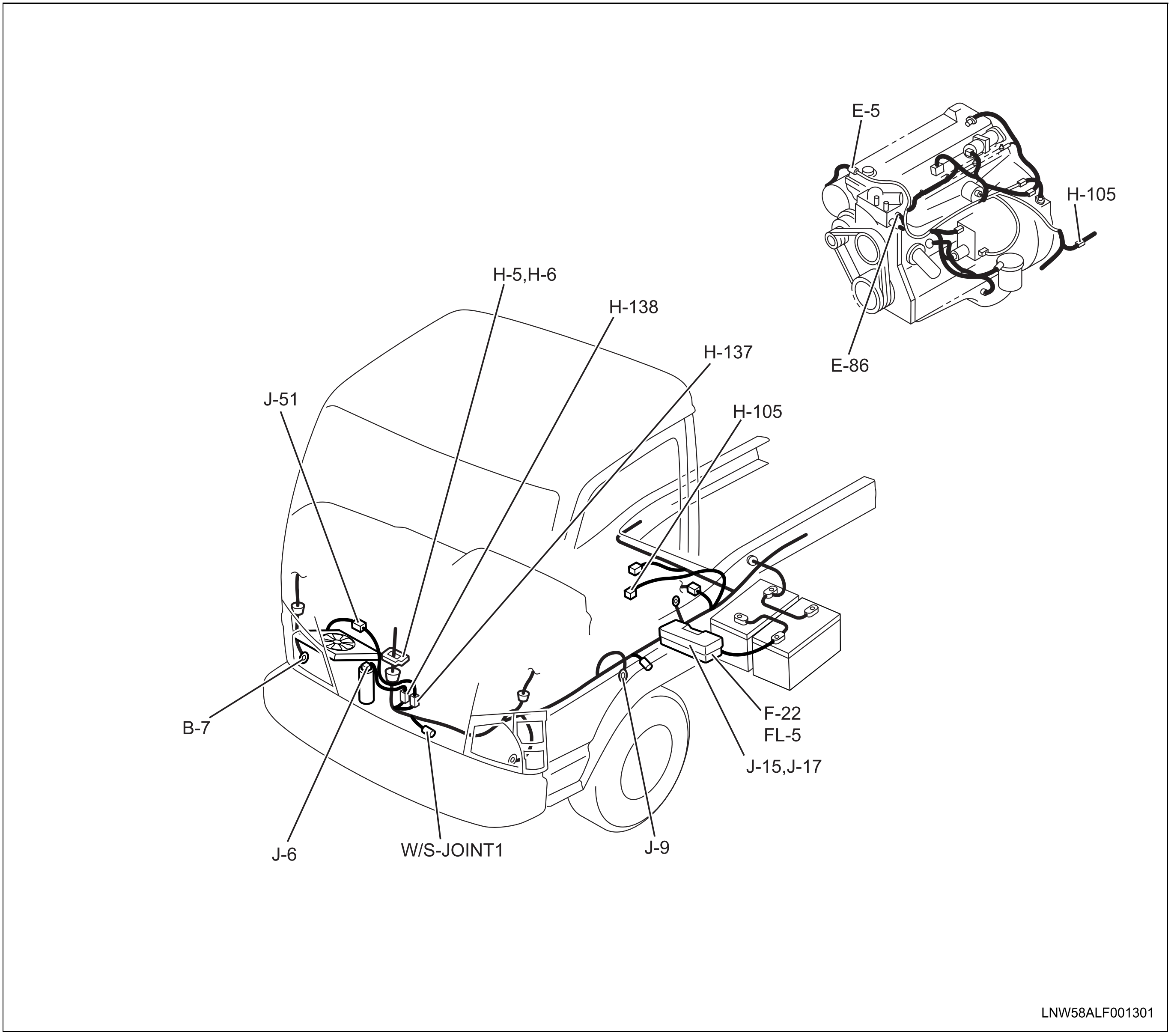
1. Bulb Assembly

Heater and Air Conditioning

General Description

The air conditioning circuit consists of compressor, A/C switch, fan switch, etc. When the engine is rotating, the A/C starts to work with both the A/C and fan switches "ON", followed by the engagement of the magnetic clutch. It stops to work when either the fan switch or the A/C switch turns "OFF". In addition, the A/C has the function of temporary stop of its operation by function of the pressure switch when sensing abnormal rise of the refrigerant pressure.

PARTS LOCATION (1)



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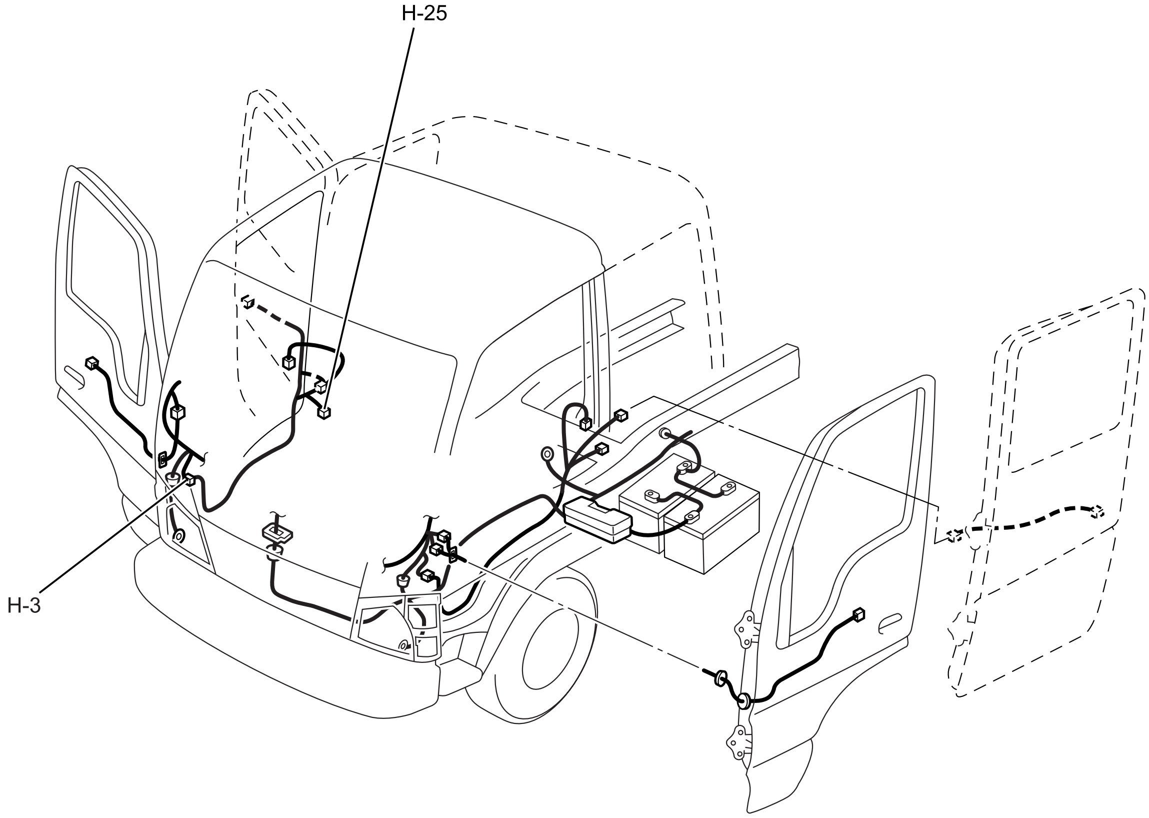
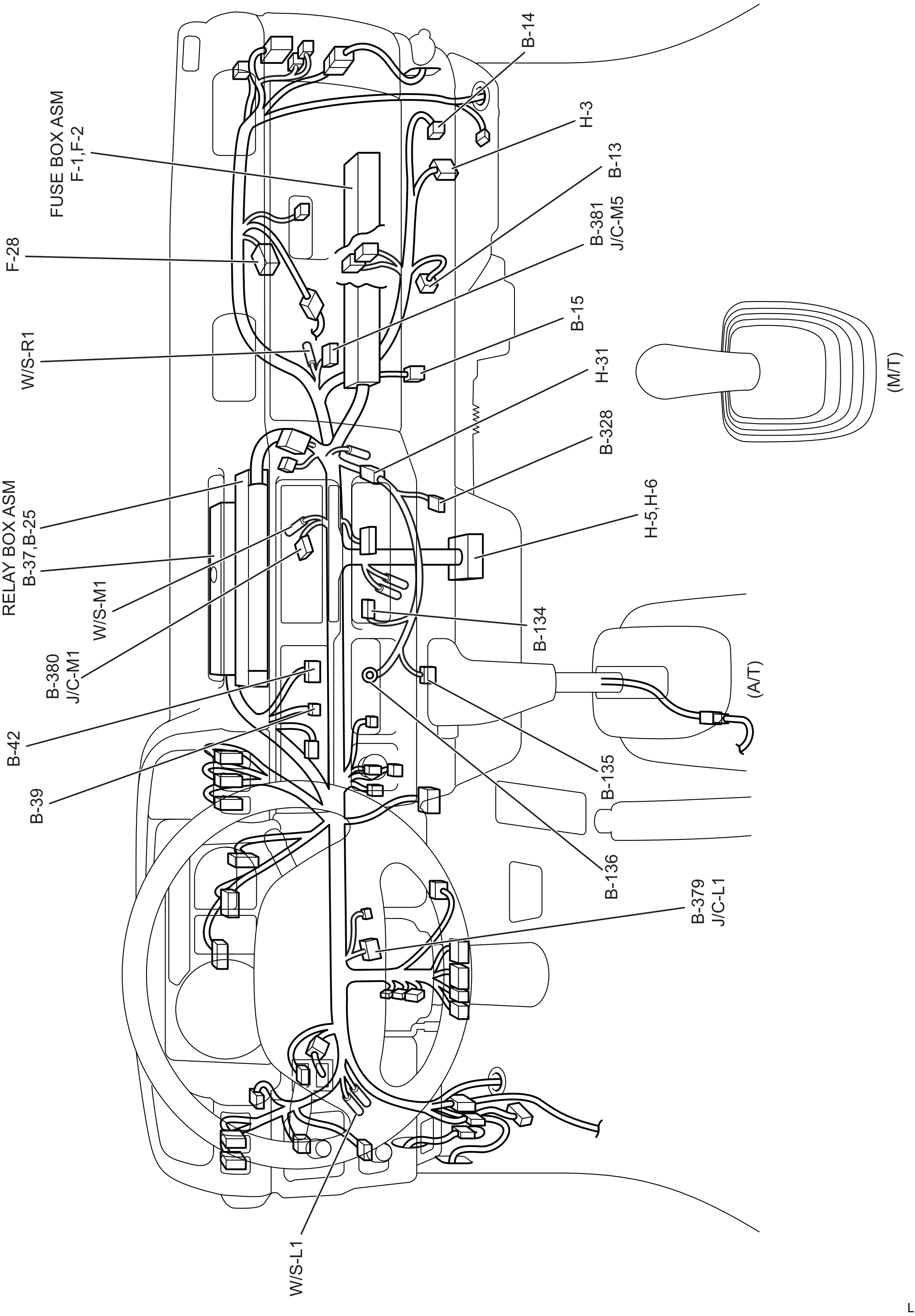


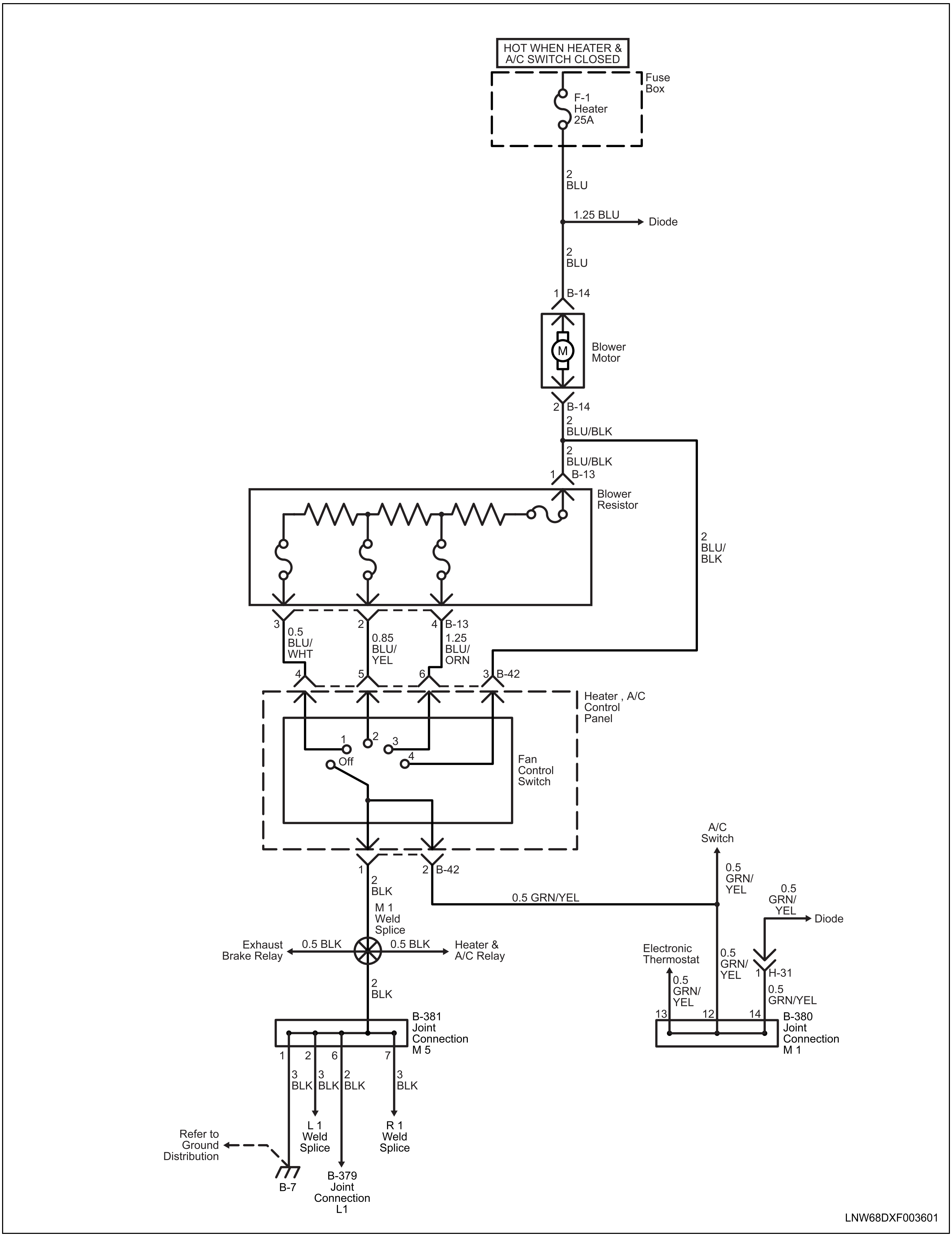
LNW58ALF004501

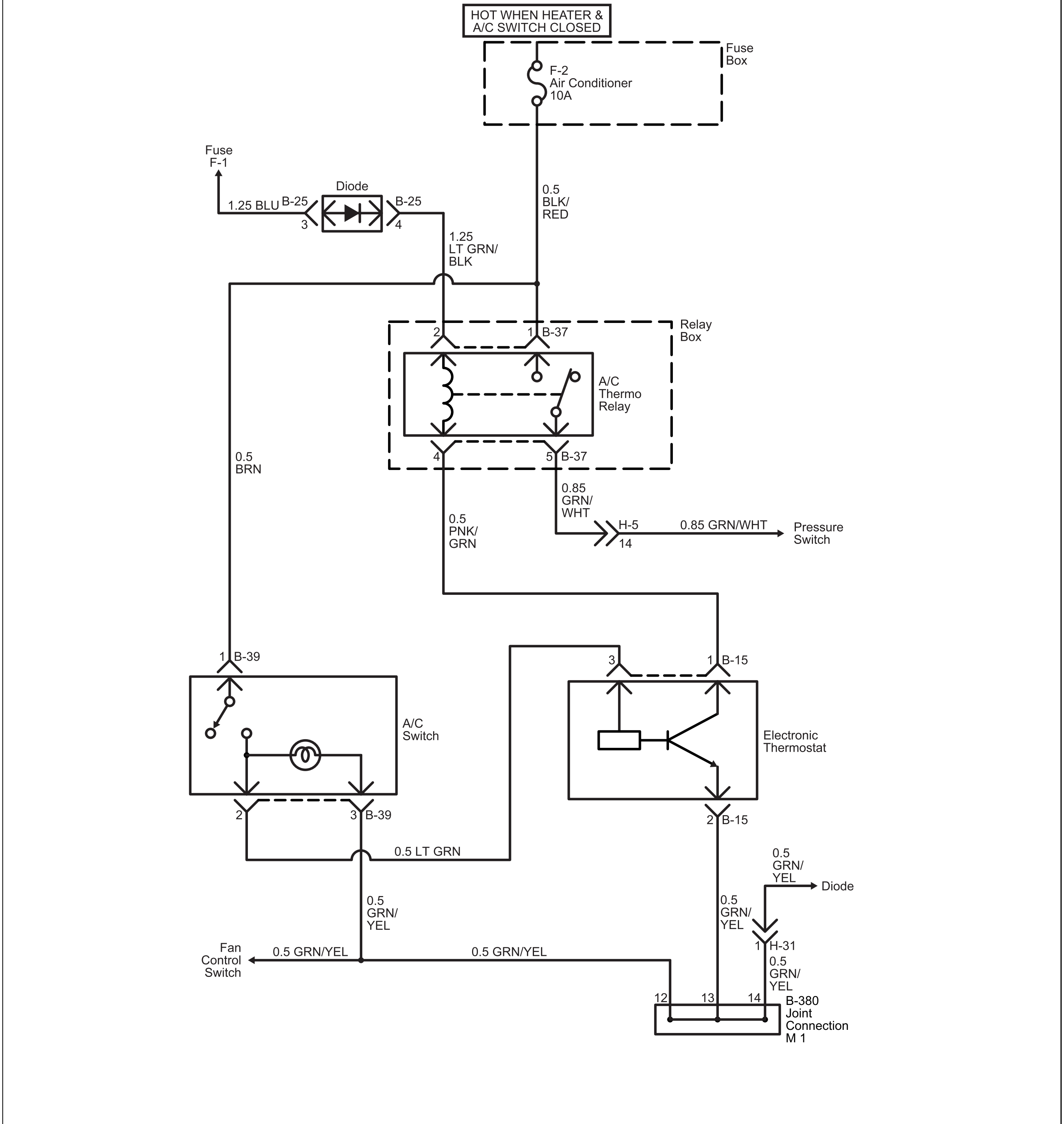
PARTS LOCATION (3)



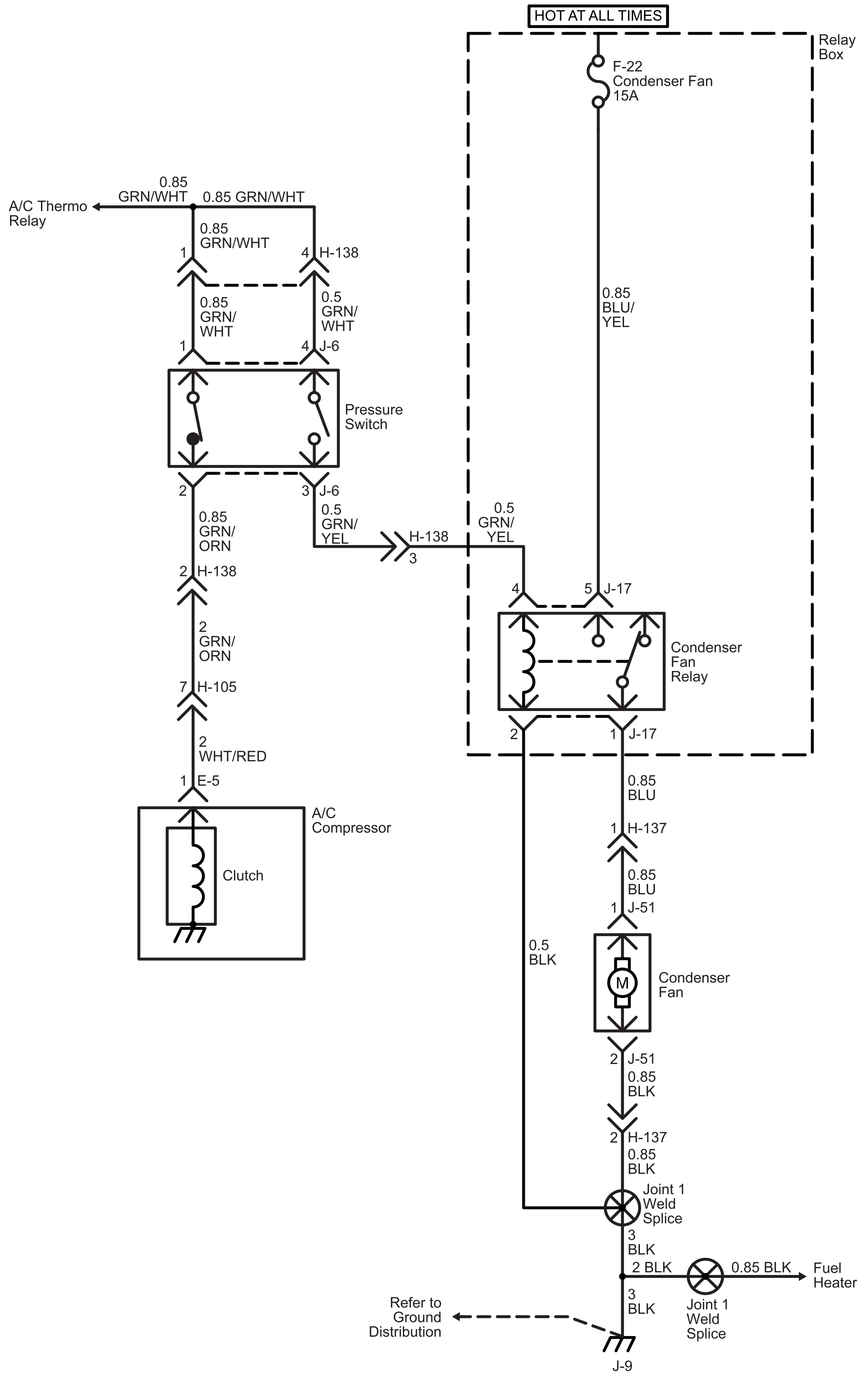
LNW68DXF011401

CIRCUIT DIAGRAM

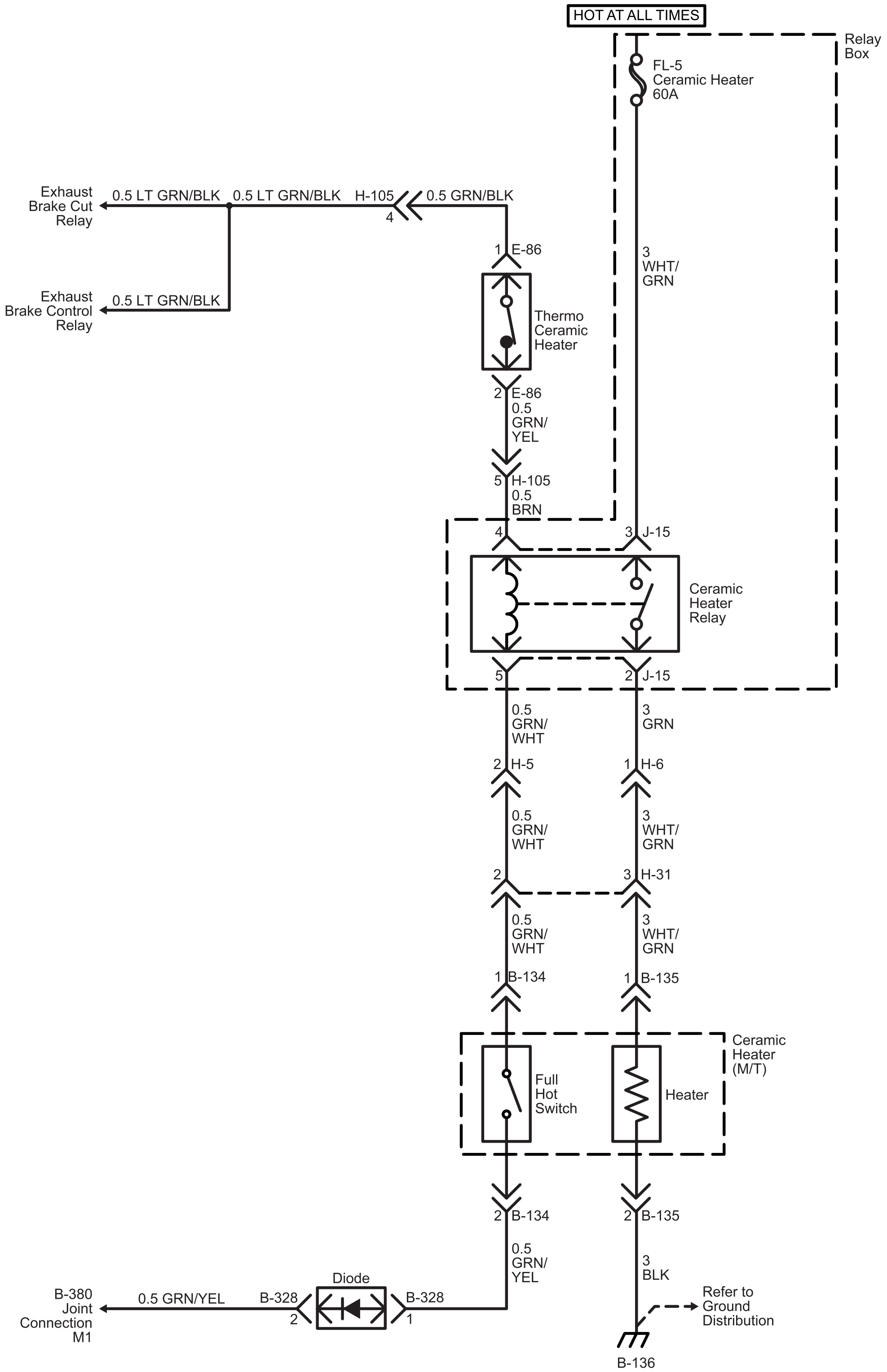




LNW68DXF003701

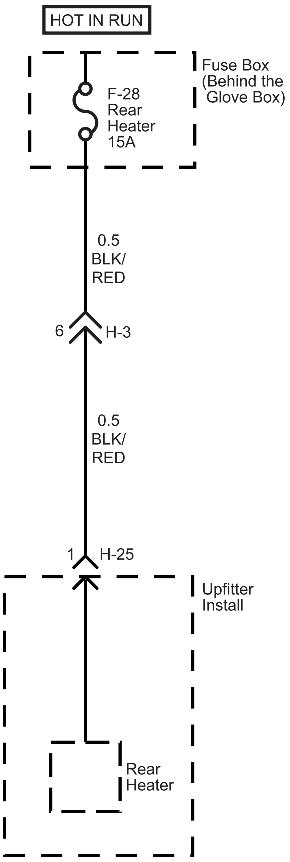


LNW68DXF003801

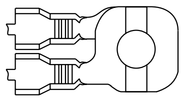
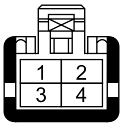
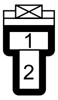
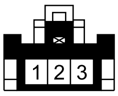
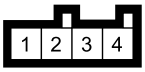
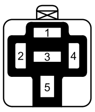
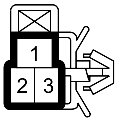
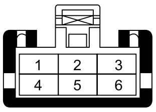


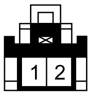
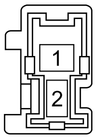
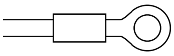
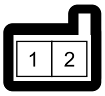
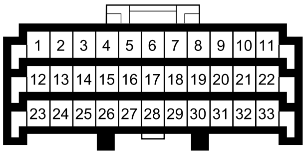
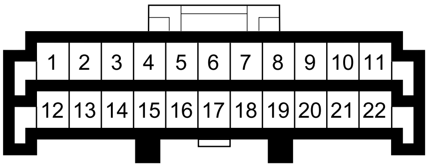
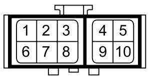
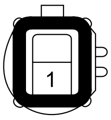
LNW68DXF003901

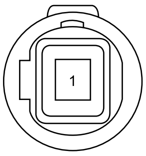
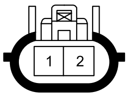
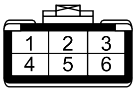
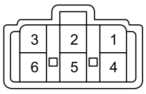
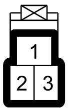
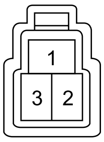
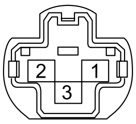
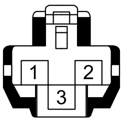
CIRCUIT DIAGRAM (REAR HEATER)

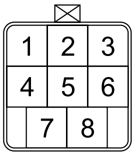
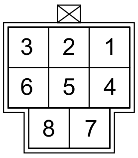
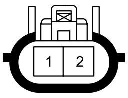
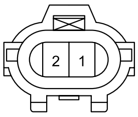
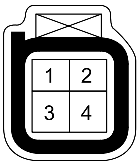
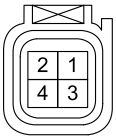
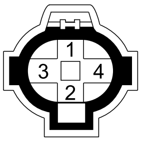
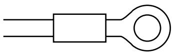


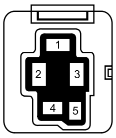
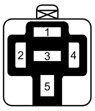
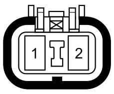
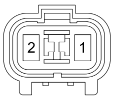
LNW68DXF012001

No.	Connector Face
B-7	 000-007 Ground; Headlight Bracket–RH
B-13 (Brown)	 004-015 Blower Resistor
B-14 (White)	 002-012 Blower Motor
B-15 (White)	 003-015 Electro Thermo
B-25 (White)	 004-021 Diode
B-37 (Black)	 005-012 A/C Thermo Relay
B-39 (White)	 003-009 A/C Switch
B-42 (White)	 006-024 Fan Switch

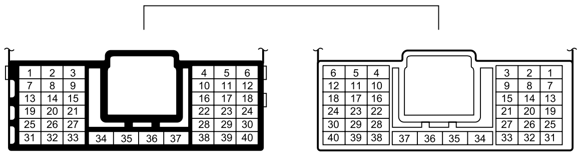
No.	Connector Face
B-134 (White)	 002-022 Full Hot Switch
B-135 (White)	 002-019 Ceramic Heater
B-136	 000-012 Ground; Ceramic H
B-328 (Black)	 002-043 Diode
B-379 (White)	 033-001 Joint Connection – L1
B-380 (White)	 022-005 Joint Connection – M1
B-381 (White)	 010-015 Joint Connection – M5
E-5 (Black)	 001-037 A/C Compressor

No.	Connector Face
E-5 (Black)	 001-038 A/C Compressor
E-86 (White)	 002-006 Thermo Ceramic Heater
H-3 (White)	 006-002 Body H. – Floor H. (RH)
H-3 (White)	 006-018 Body H. – Floor H. (RH)
H-25 (White)	 003-008 Floor H. – Heater H.
H-25 (White)	 003-034 Floor H. – Heater H.
H-31 (Blue)	 003-050 Body H. – Ceramic Heater H.
H-31 (Blue)	 003-049 Body H. – Ceramic Heater H.

No.	Connector Face
H-105 (Black)	 008-060 Frame H.– Engine H.
H-105 (Black)	 008-061 Frame H.– Engine H.
H-137 (Black)	 002-006 Frame – Condenser Fan
H-137 (Black)	 002-005 Frame – Condenser Fan
H-138 (Black)	 004-001 Frame – Pressure Switch
H-138 (Black)	 004-002 Frame – Pressure Switch
J-6 (White)	 004-029 A/C Pressure Switch
J-9	 000-012 Ground; Frame–LH (Center)

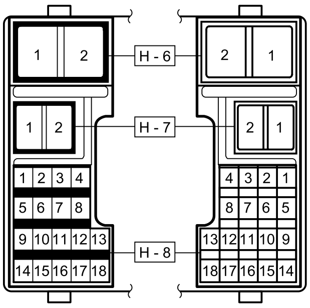
No.	Connector Face
J-15 (Black)	 005-013 Ceramic Heater
J-17 (Black)	 005-012 Condenser Fan Relay
J-51 (Black)	 002-053 Condenser Fan Motor
J-51 (Black)	 002-054 Condenser Fan Motor

H-5 Body H. – Frame H. (Gray)



LNW38ASH018701

H-6 Body H. – Frame H. (Gray)

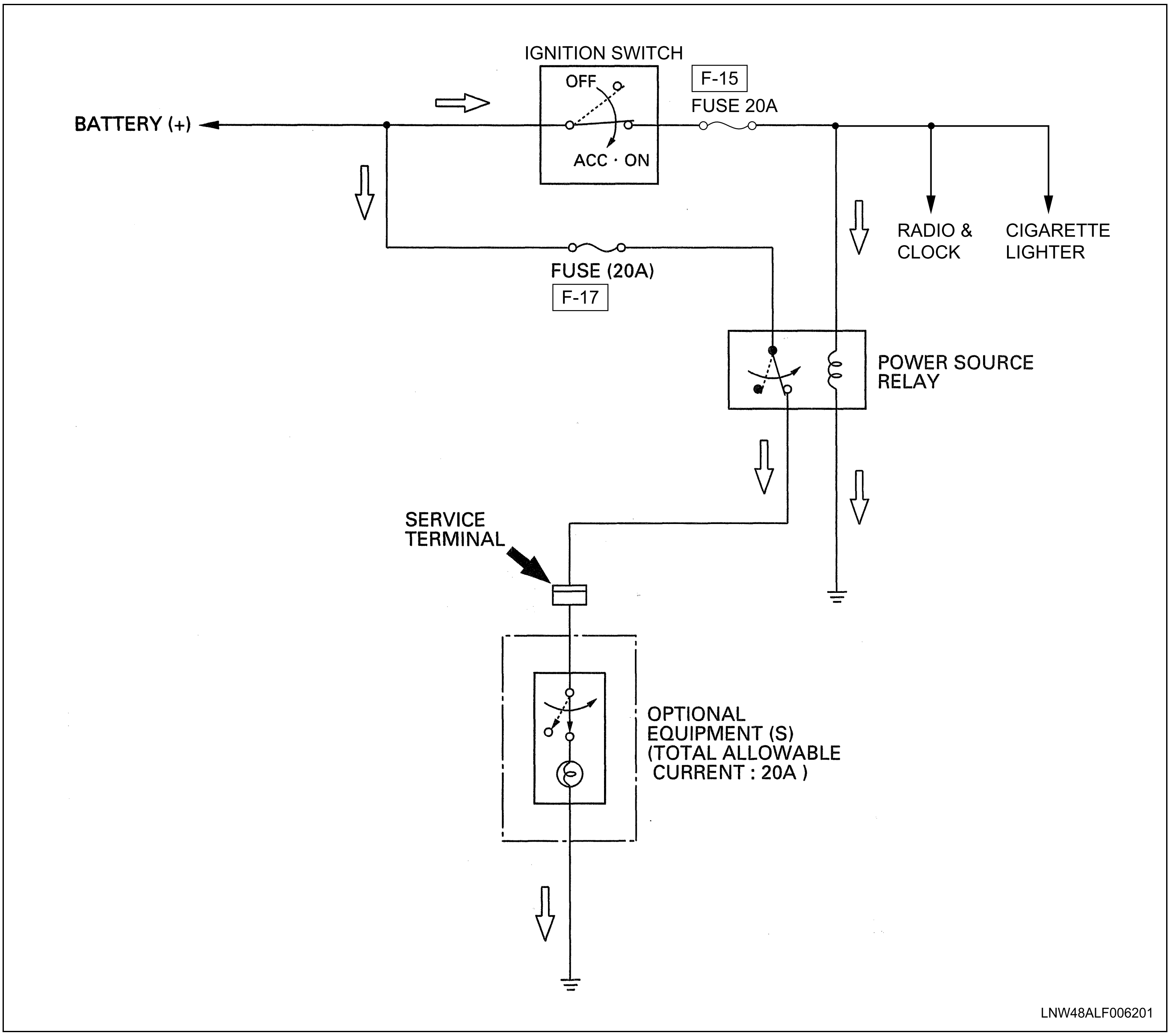


LNW38ASH018801

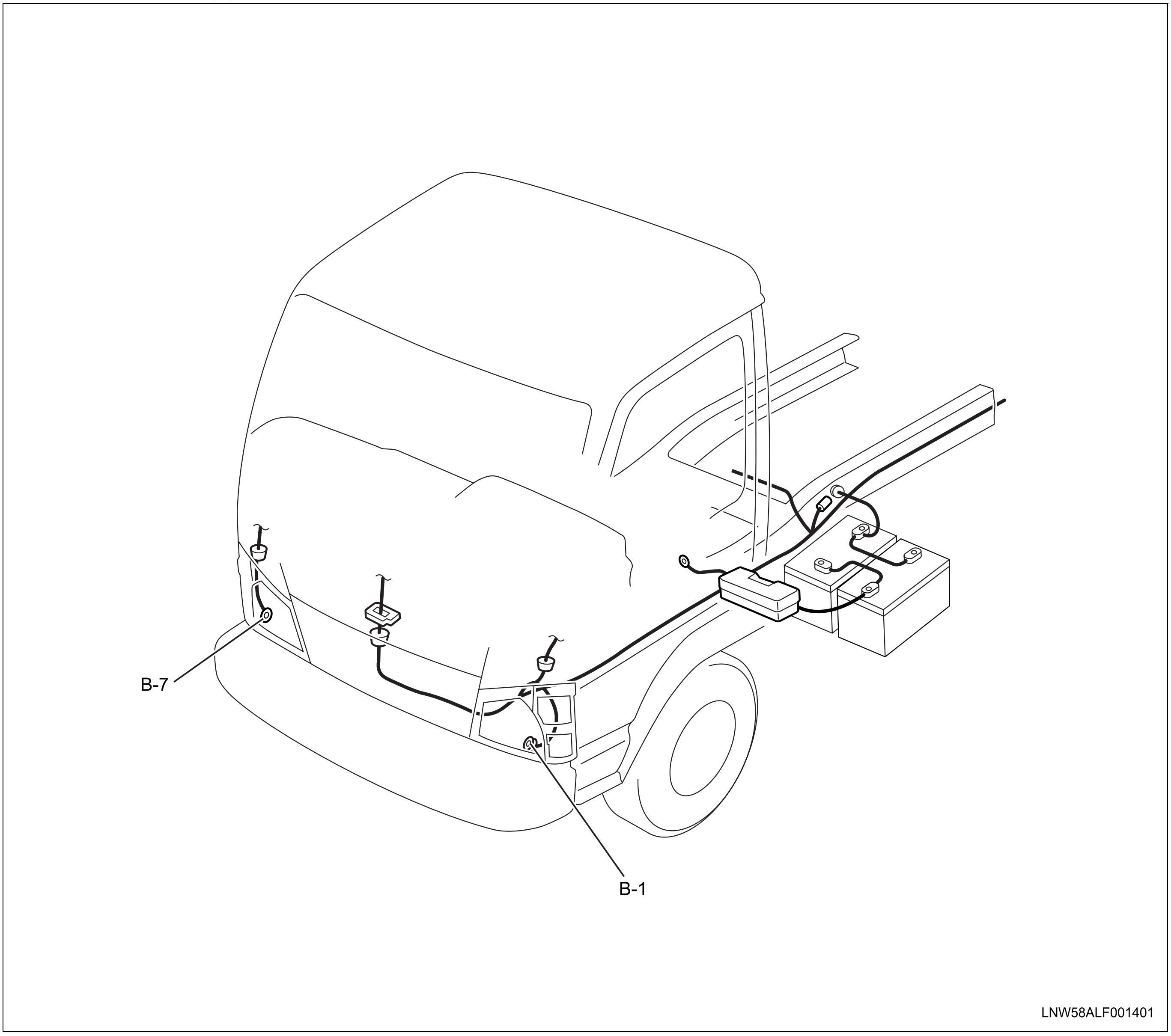
Service Terminal

General Description

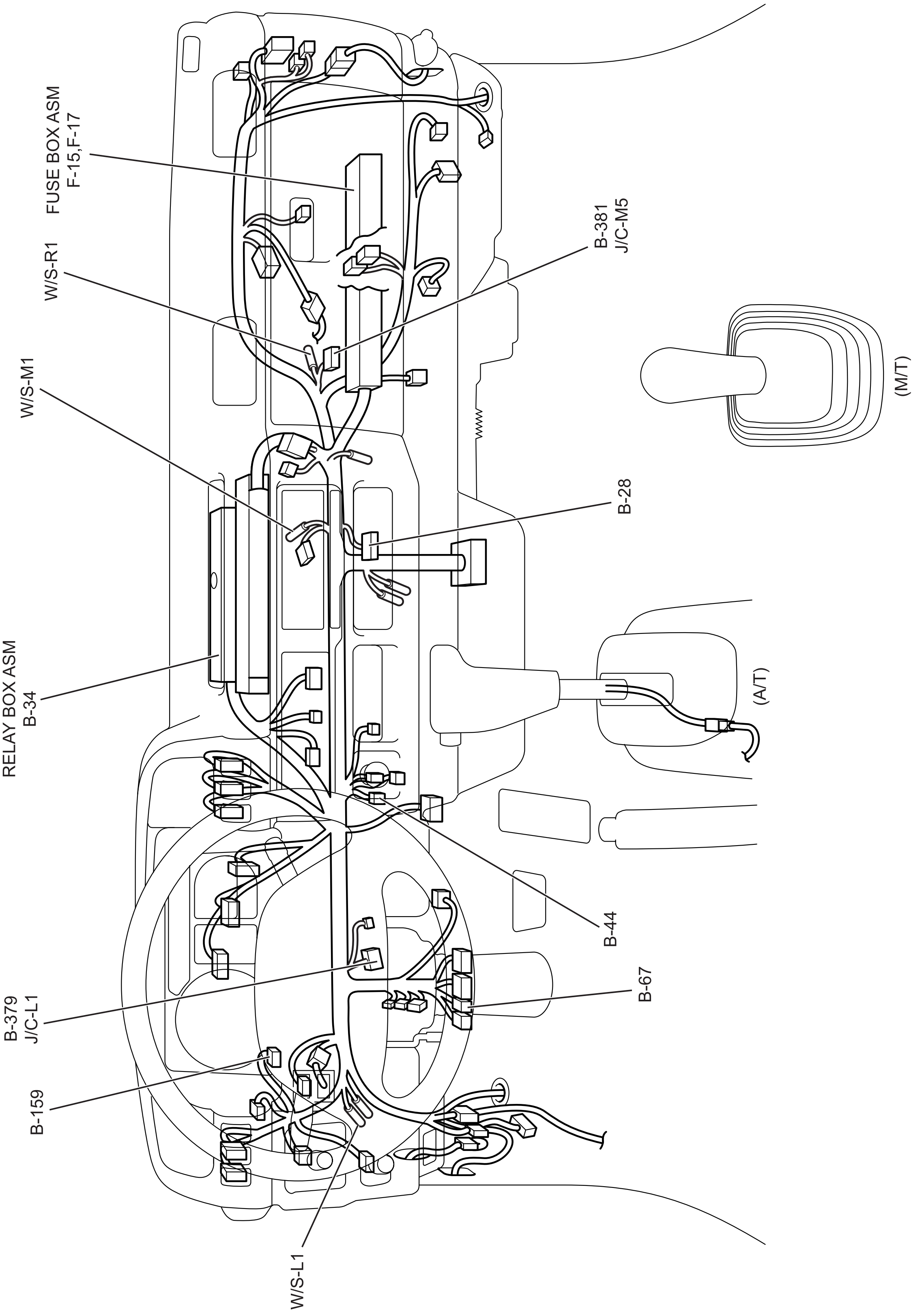
The circuit consists of the ignition switch, power source relay and the connector for the service terminal.
The service terminal connector is provided for Installation of optional equipment (S). This circuit incorporates a 20A fuse. Make sure that the total current of all installed parts does not exceed 20A.



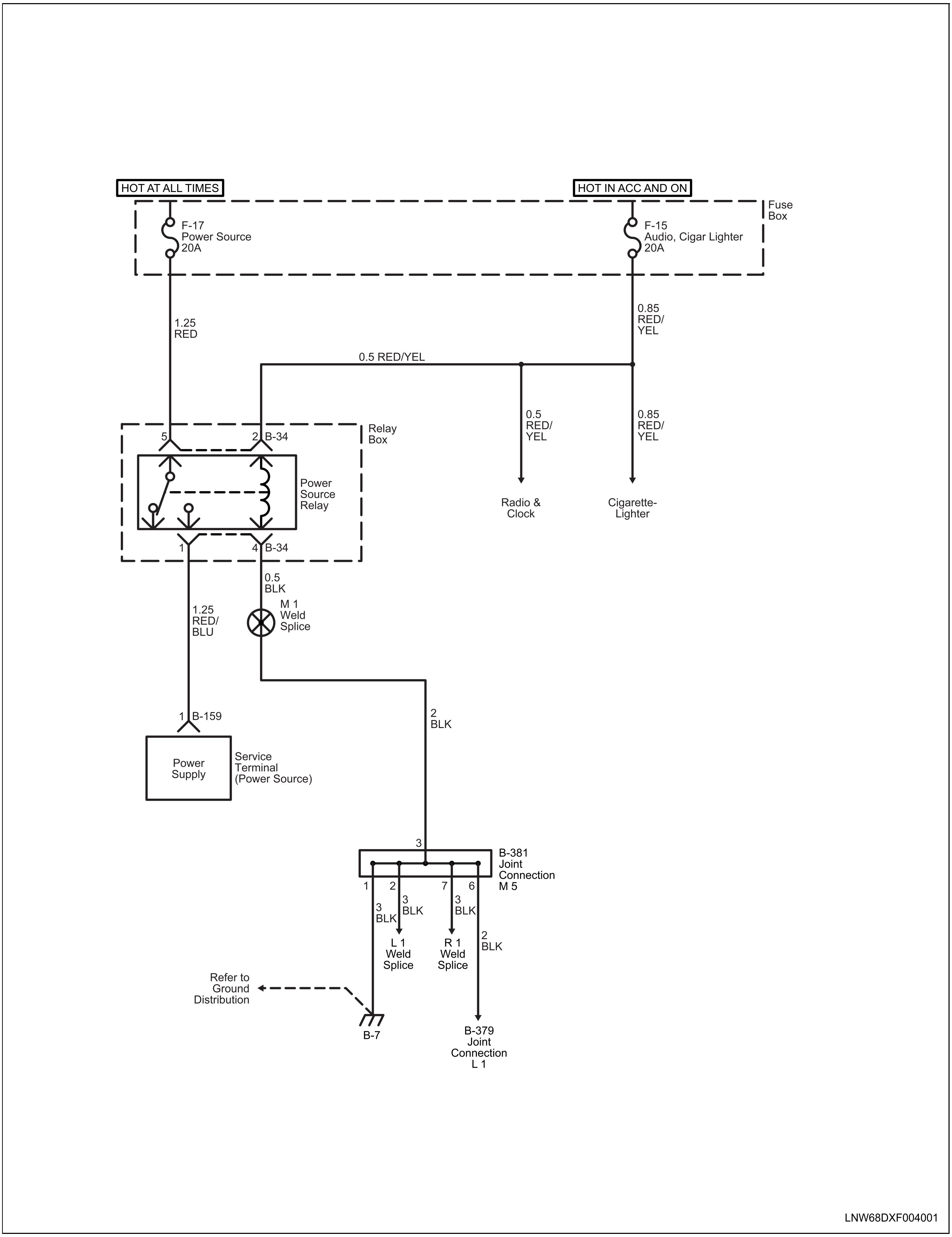
PARTS LOCATION (1)

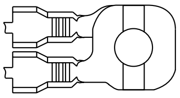
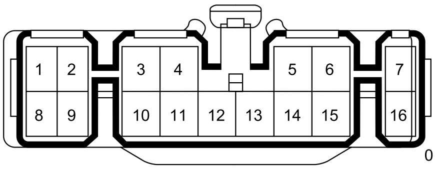
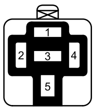
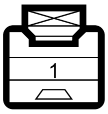
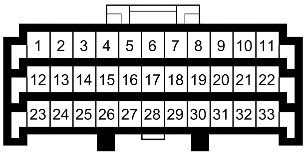
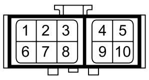


PARTS LOCATION (2)



CIRCUIT DIAGRAM



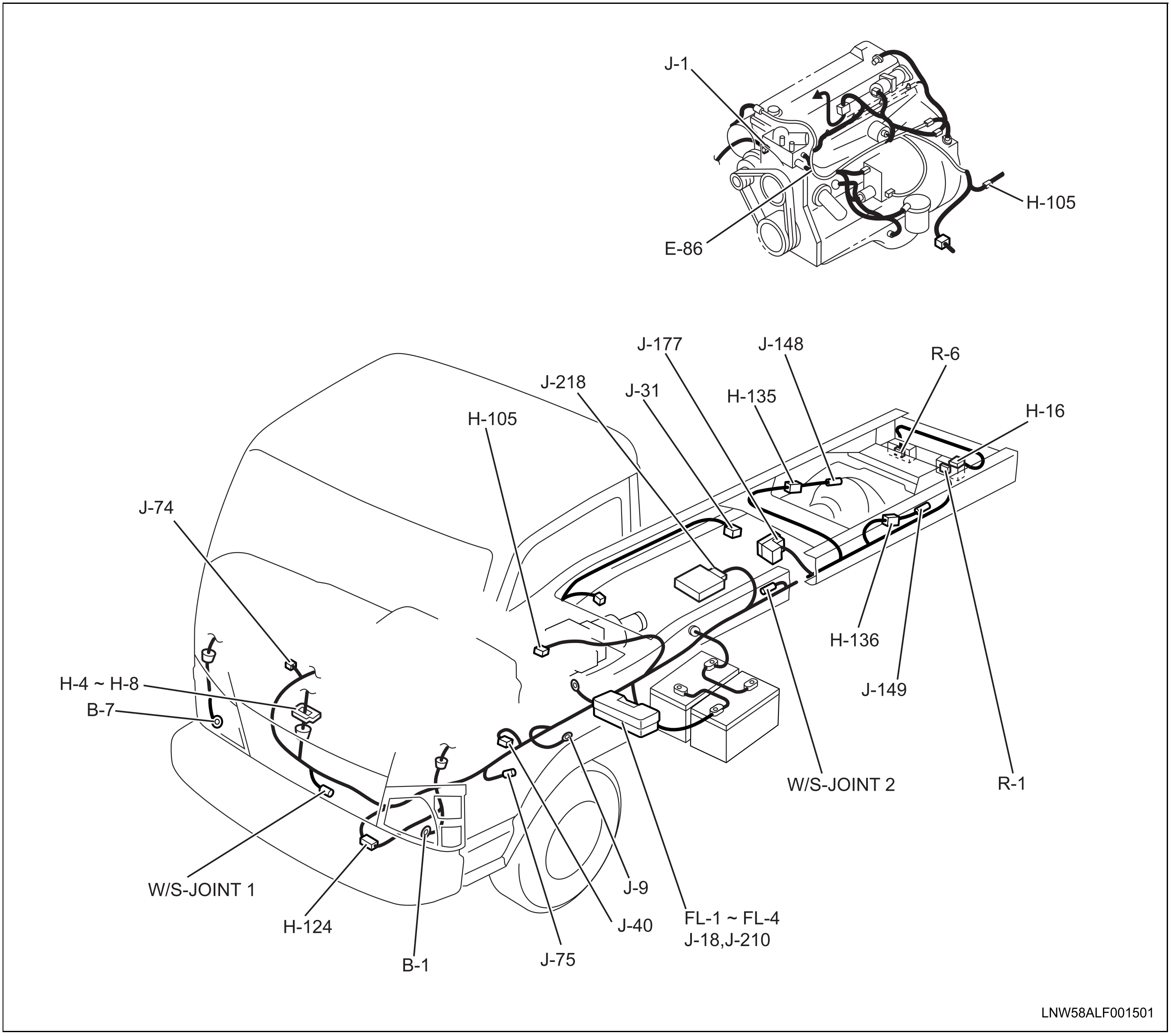
No.	Connector Face
B-7	 000-007 Ground; Headlight Bracket–RH
B-28 (White)	 016-043 Radio
B-34 (Black)	 005-012 Power Source Relay
B-44 (White)	 001-013 Cigarette Lighter
B-159 (White)	 001-004 Power Source
B-379 (White)	 033-001 Joint Connection – L1
B-381 (White)	 010-015 Joint Connection – M5

Anti-lock Brake System (ABS)

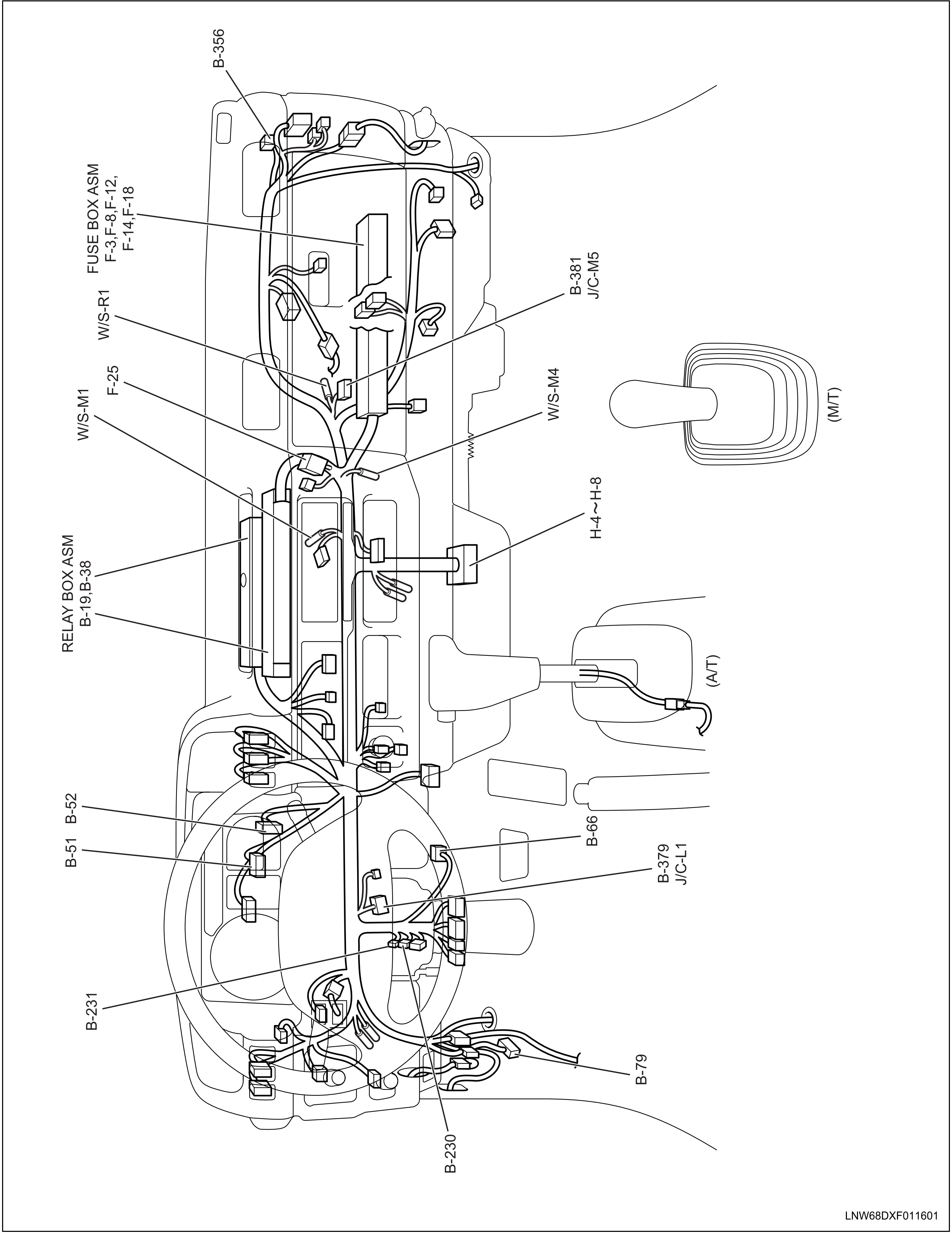
General Description

The Anti-lock Brake System (ABS) works on all four wheels. A combination of wheel speed sensor and Electronic and Hydraulic Control Unit (EHCU) can determine when a wheel is about to stop turning and adjust brake pressure to maintain best braking.
This system helps the driver main greater control of the vehicle under heavy braking conditions.

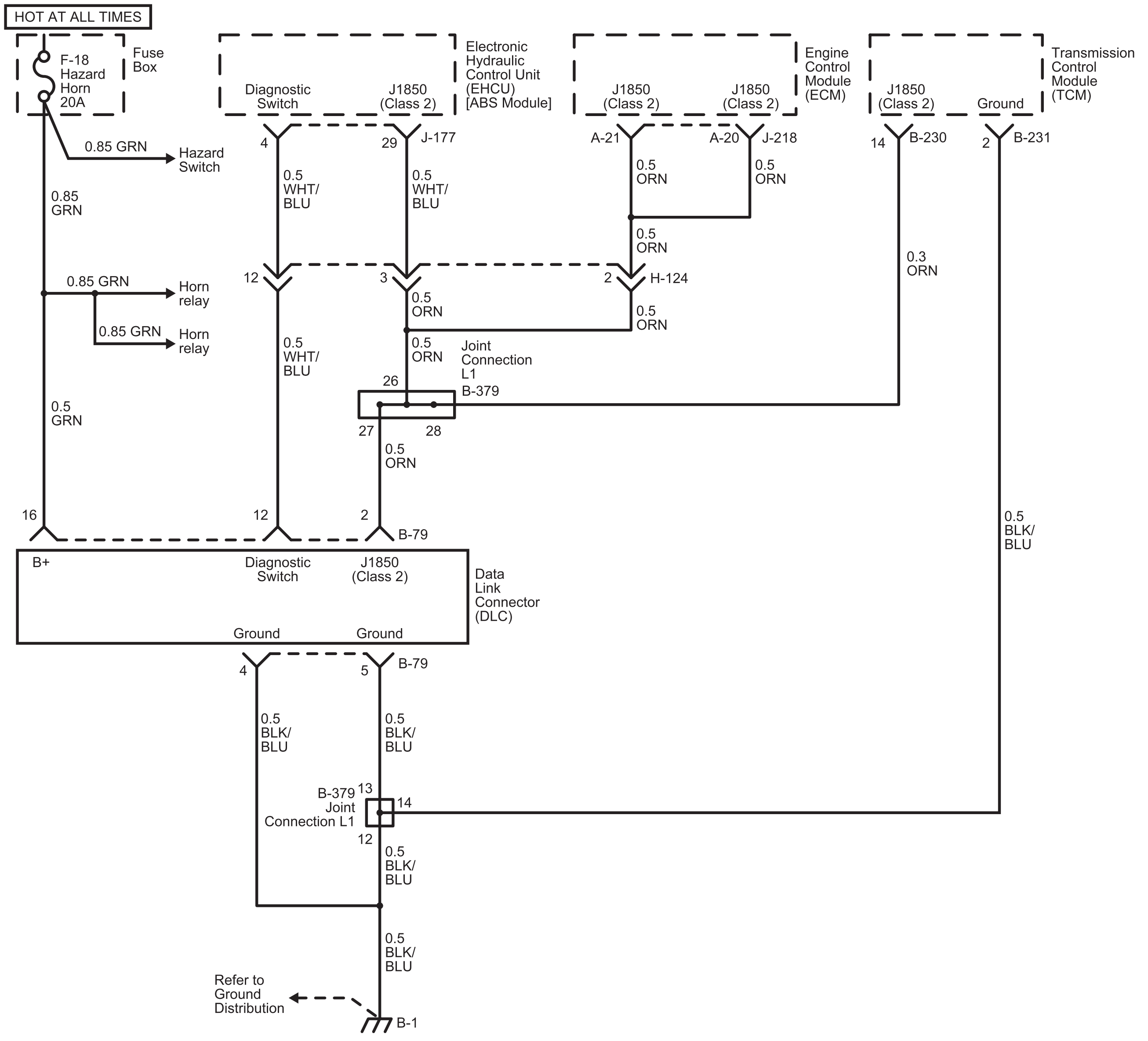
PARTS LOCATION (1)



PARTS LOCATION (2)



CIRCUIT DIAGRAM



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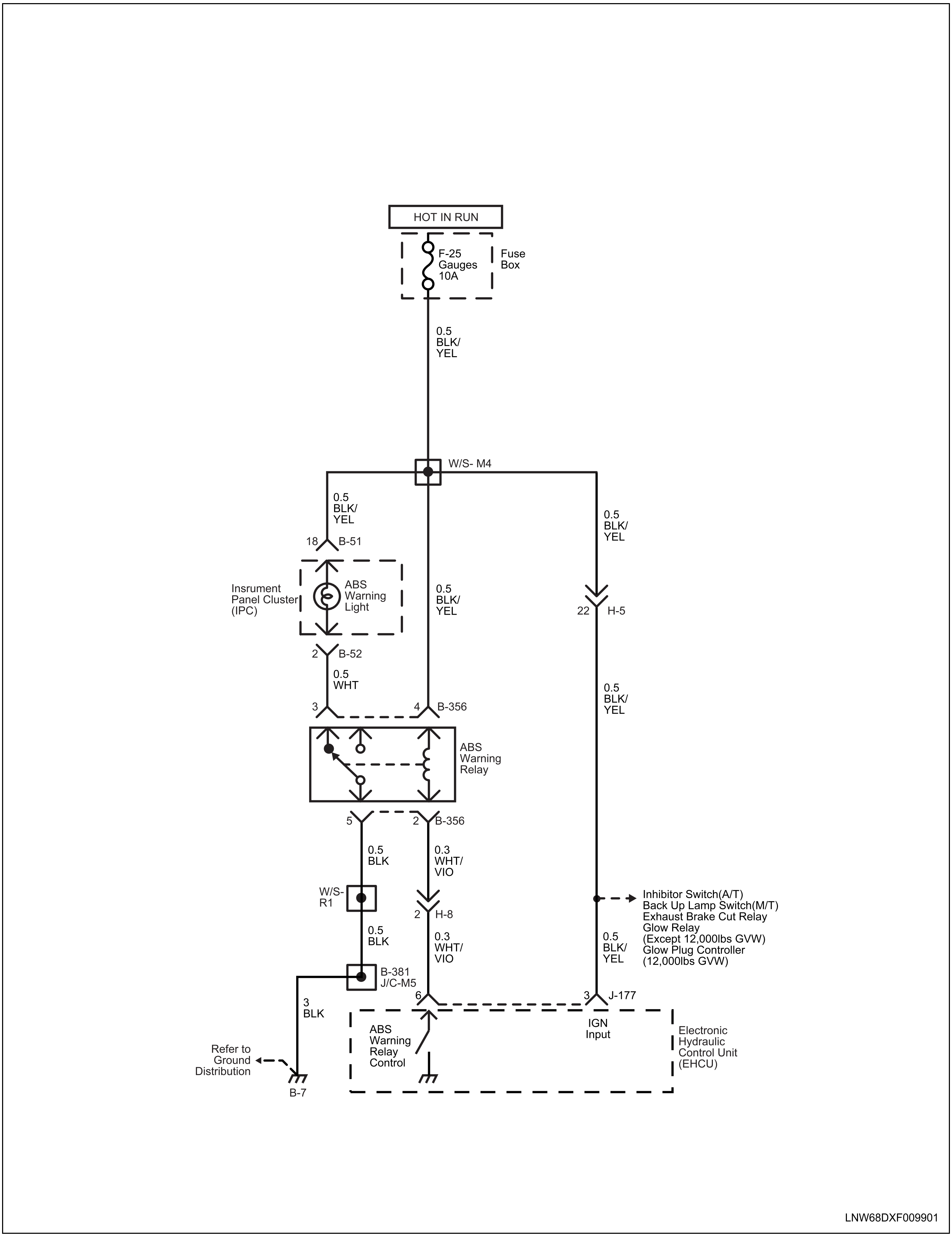
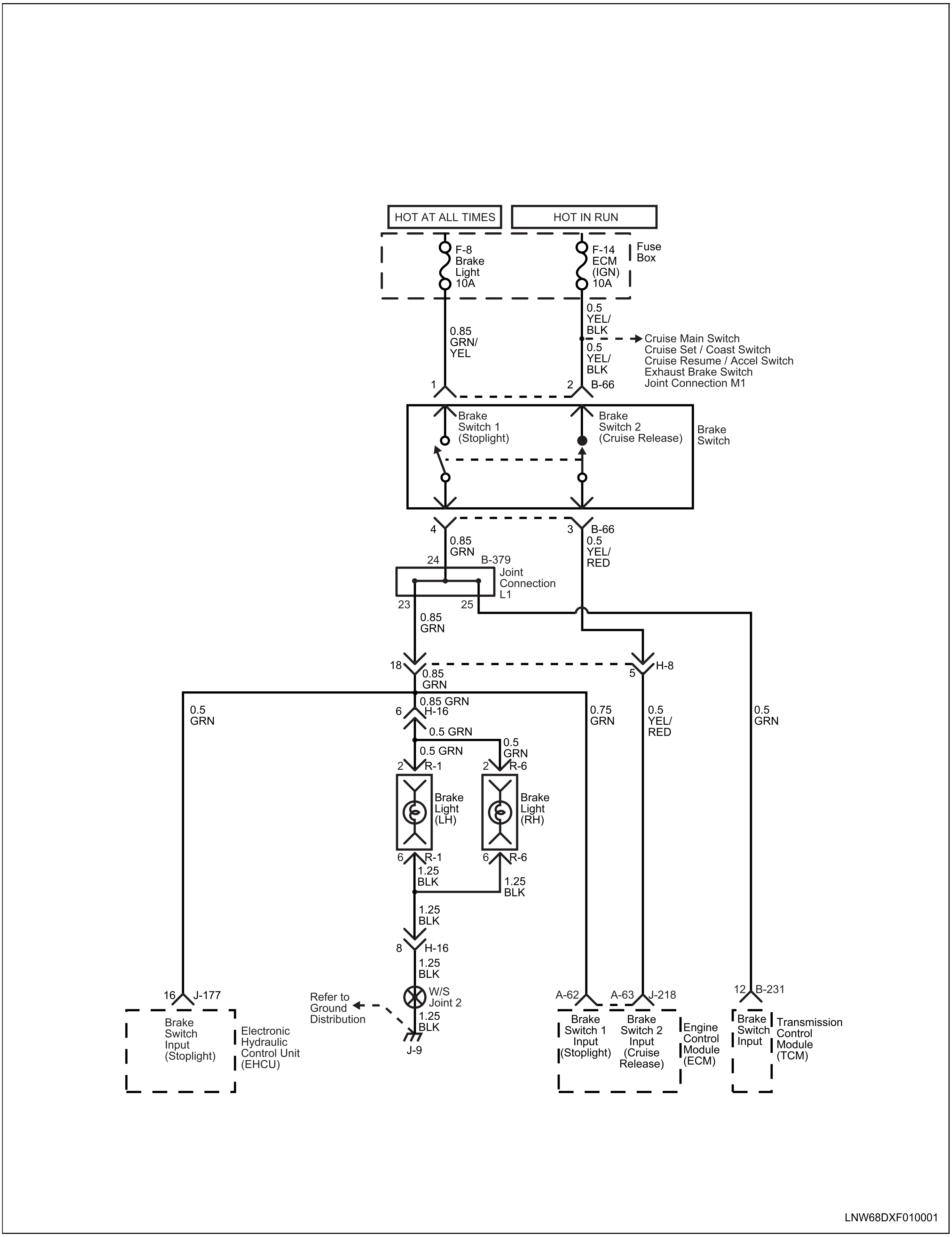
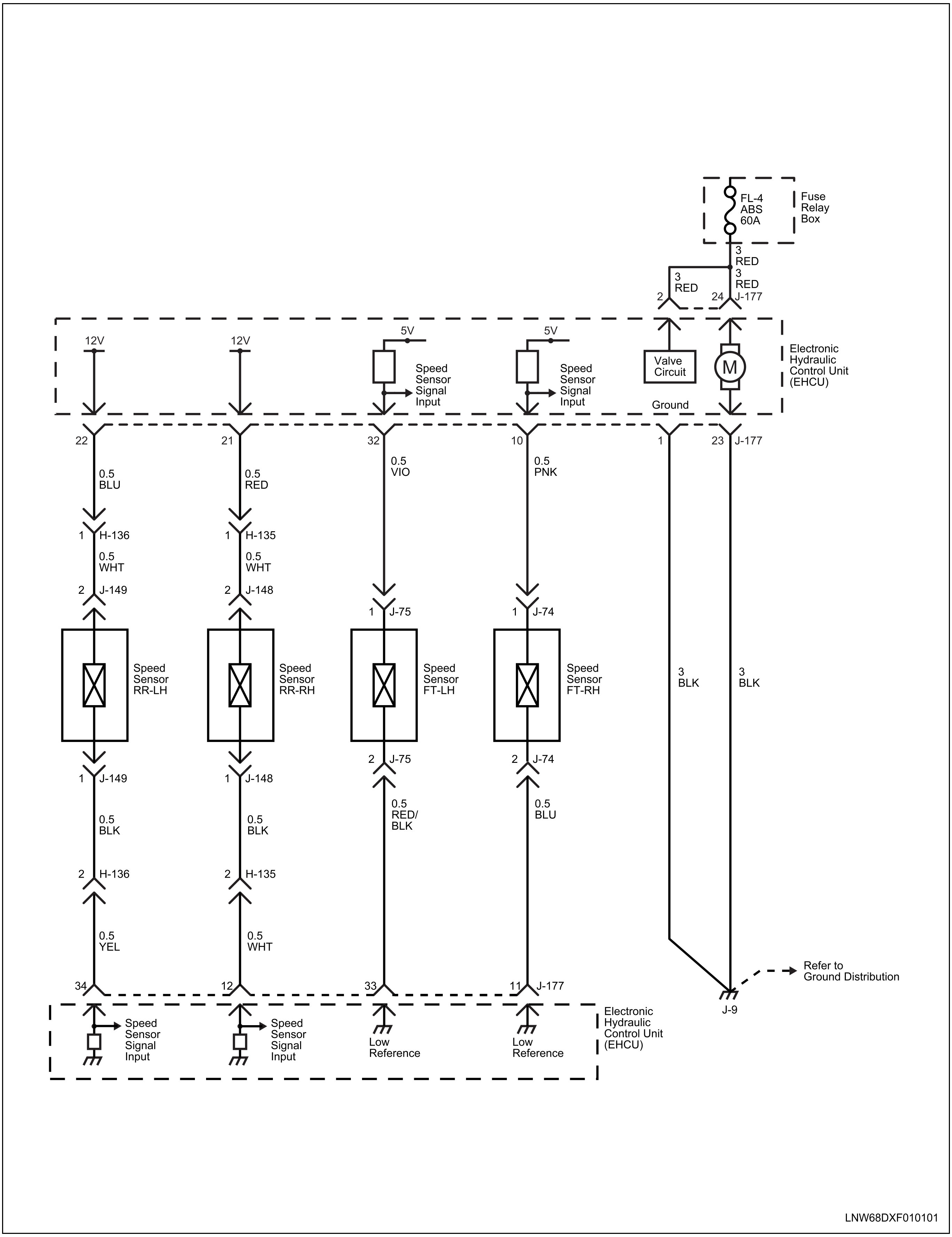
CIRCUIT DIAGRAM

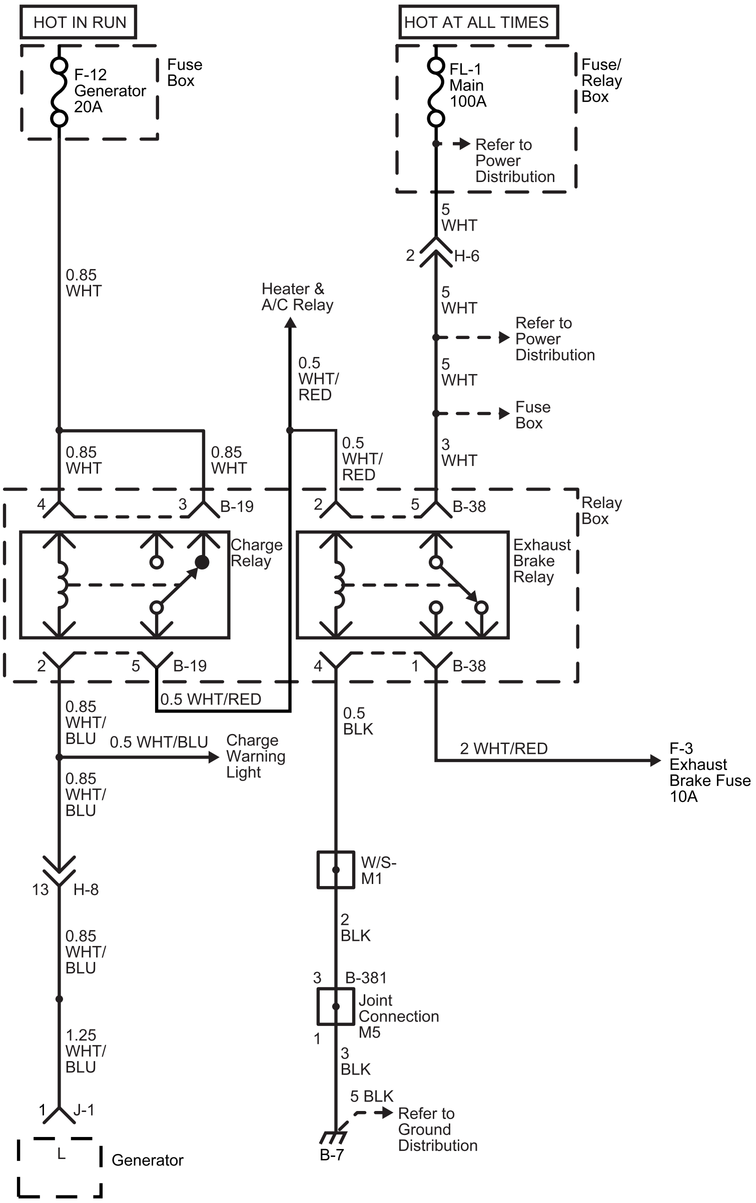



HOT AT ALL TIMES
HOT IN RUN
F-8
Brake
Light
10A
F-14
ECM
(IGN)
10A
Fuse
Box
0.5
YEL/
BLK
0.85
GRN/
YEL
Cruise Main Switch
Cruise Set / Coast Switch
Cruise Resume / Accel Switch
Exhaust Brake Switch
Joint Connection M1
0.5
YEL/
BLK
1
2
B-66
Brake
Switch 1
(Stoplight)
Brake
Switch 2
(Cruise Release)
Brake
Switch
4
3
B-66
0.85
GRN
0.5
YEL/
RED
24
B-379
Joint
Connection
L1
23
25
0.85
GRN
18
H-8
5
0.85
GRN
0.85 GRN
6
H-16
0.5
GRN
0.75
GRN
0.5
YEL/
RED
0.5
GRN
0.5 GRN
0.5 GRN
0.5
GRN
2
R-1
2
R-6
Brake
Light
(LH)
Brake
Light
(RH)
6
R-1
6
R-6
1.25
BLK
1.25
BLK
1.25
BLK
8
H-16
1.25
BLK
16
J-177
Refer to
Ground
Distribution
W/S
Joint 2
1.25
BLK
J-9
A-62
A-63
J-218
12
B-231
Brake
Switch
Input
(Stoplight)
Electronic
Hydraulic
Control Unit
(EHCU)
Brake
Switch 1
Input
(Stoplight)
Brake
Switch 2
Input
(Cruise
Release)
Engine
Control
Module
(ECM)
Brake
Switch
Input
Transmission
Control
Module
(TCM)
LNW68DXF010001

CIRCUIT DIAGRAM

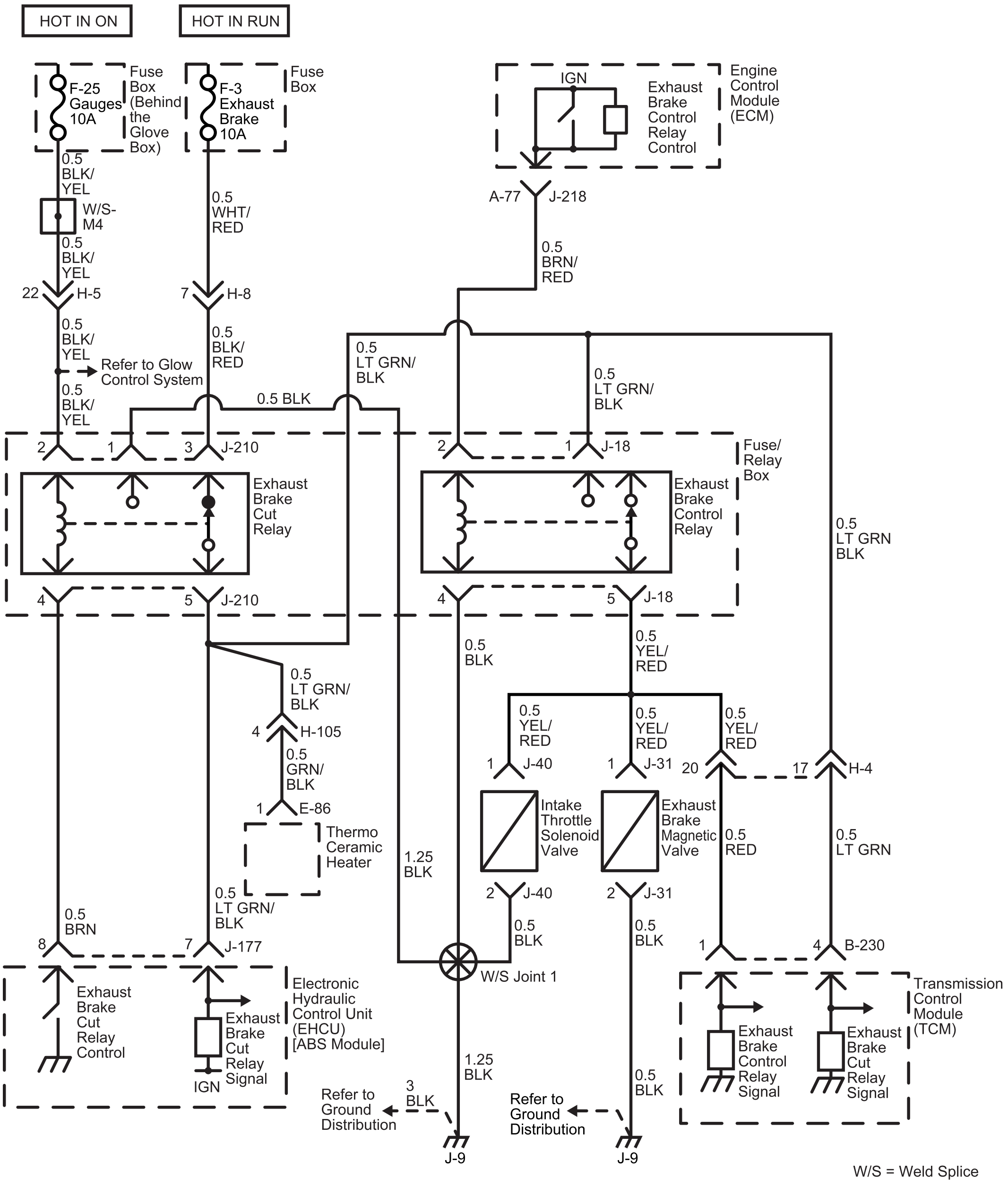


CIRCUIT DIAGRAM



LNW68DXF007501

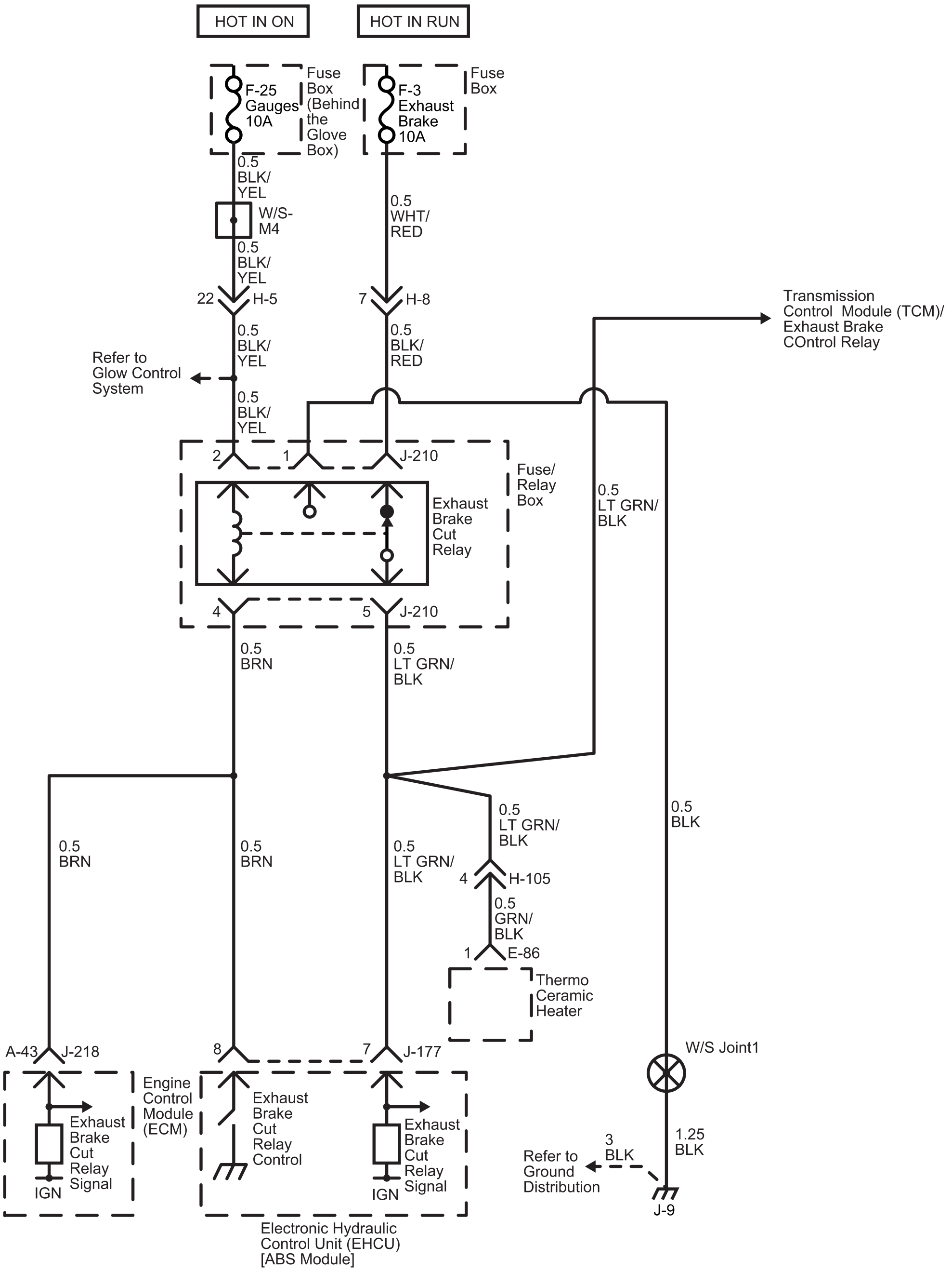
Except 12,000lbs GVW



LNW68DXF007601

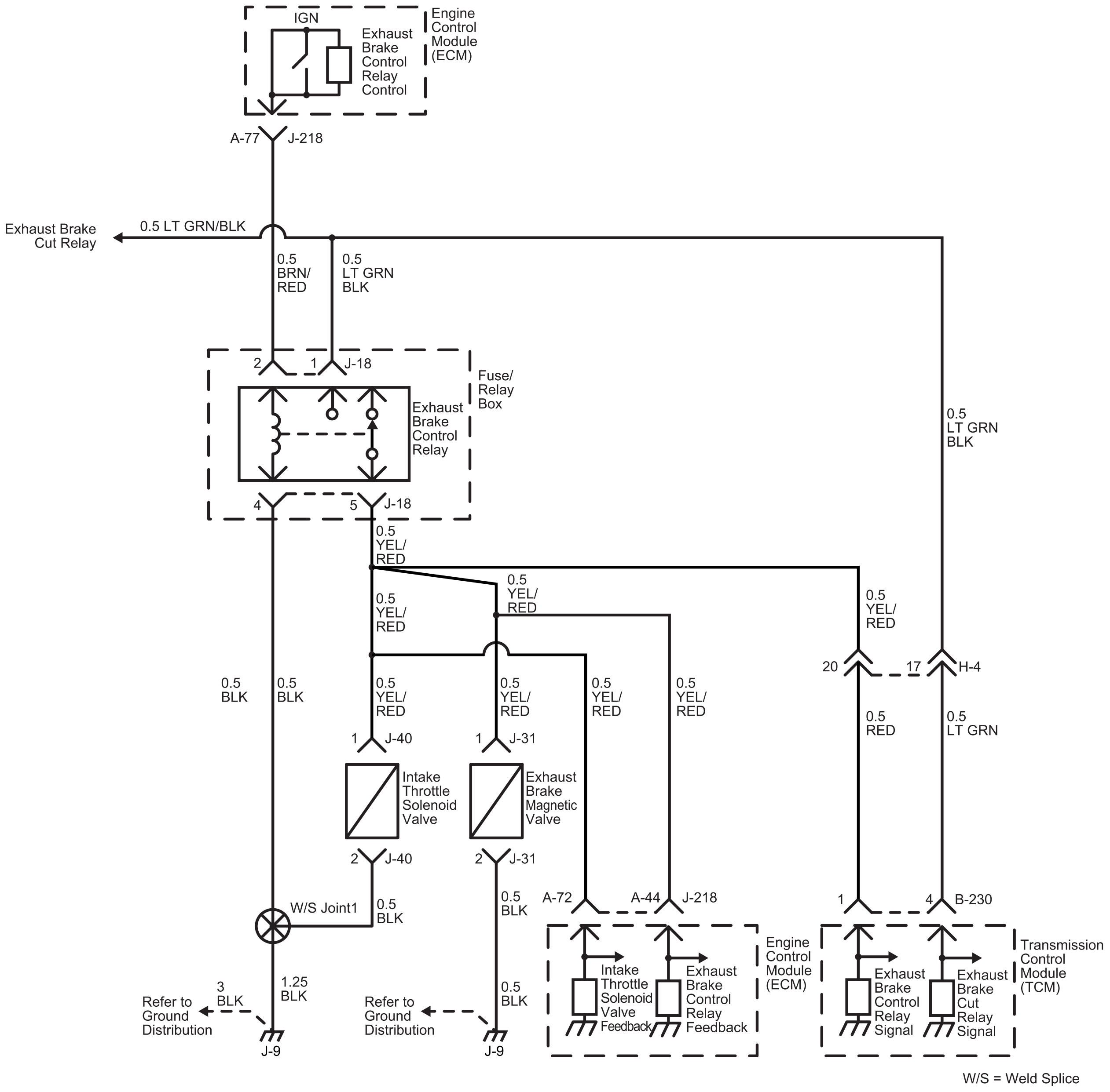
CIRCUIT DIAGRAM

12,000lbs GVW



LNW68DXF007701

12,000lbs GVW



LNW68DXF007801

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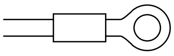
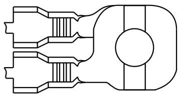
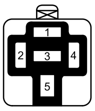
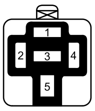
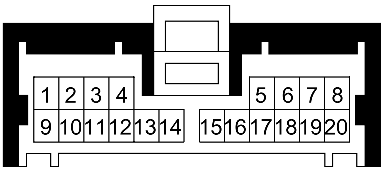
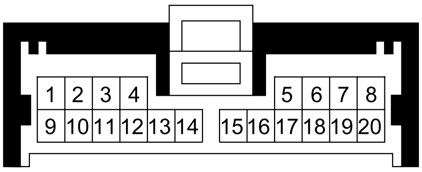
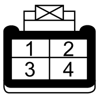
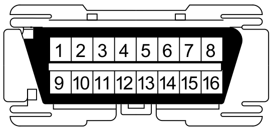
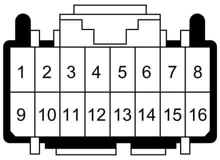
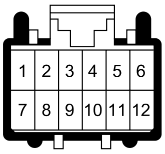
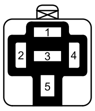
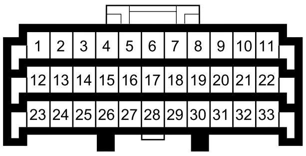
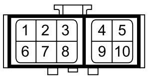
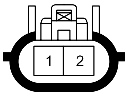
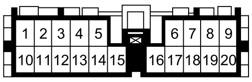
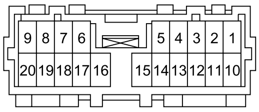
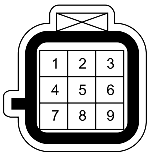
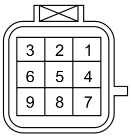
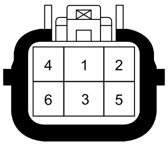
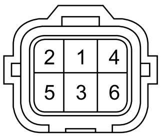
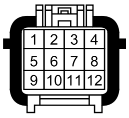
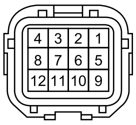
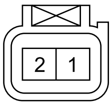
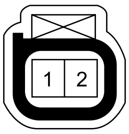
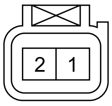
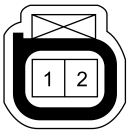
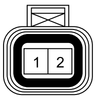
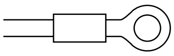
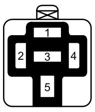
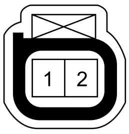
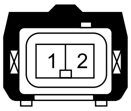
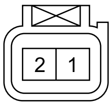
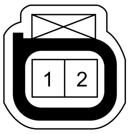
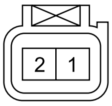
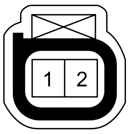
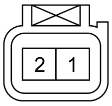
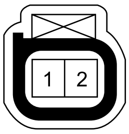
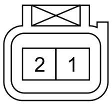
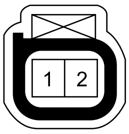
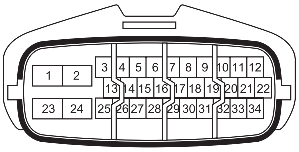
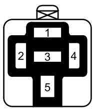
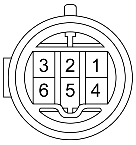
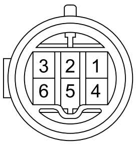
B-1	 Ground; Frame–LH (Front)
B-7	 Ground; Headlight Bracket–RH
B-19 (Black)	 Charge Relay
B-38 (Black)	 Exhaust Brake Relay
B-51 (Gray)	 Instrument Panel Cluster (A)
B-52 (White)	 Instrument Panel Cluster (B)
B-66 (Brown)	 Brake Switch
B-79 (Black)	 DLC Connector

No.	Connector Face
B-230 (Gray)	 TCM
B-231 (Gray)	 TCM
B-356 (Black)	 ABS Indicator Relay
B-379 (White)	 Joint Connection - L1
B-381 (White)	 Joint Connection – M5
E-86 (White)	 Thermo Ceramic Heater
H-4 (White)	 Body H. – Frame H.
H-4 (White)	 Body H. – Frame H.

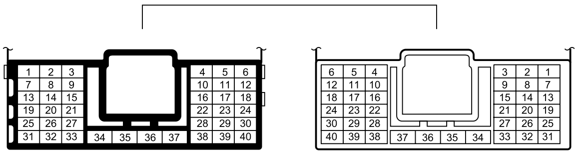
No.	Connector Face
H-16 (White)	 009-001 Frame H. – Rear Body H.
H-16 (White)	 009-002 Frame H. – Rear Body H.
H-105 (Black)	 006-060 Frame H. – Engine H.
H-105 (Black)	 006-061 Frame H. – Engine H.
H-124 (Black)	 012-013 Body H. – Frame H.
H-124 (Black)	 012-014 Body H. – Frame H.
H-135 (White)	 002-007 ABS Speed Sensor– Extension H (RH)
H-135 (White)	 002-008 ABS Speed Sensor– Extension H (RH)

No.	Connector Face
H-136 (Black)	 002-007 ABS Speed Sensor– Extension H (LH)
H-136 (Black)	 002-008 ABS Speed Sensor– Extension H (LH)
J-1 (Green)	 002-001 Generator
J-9	 000-012 Ground; Frame–LH (Center)
J-18 (Black)	 005-012 Exhaust Brake Control Relay
J-31 (Black)	 002-008 Exhaust Brake Magnetic Valve
J-40 (Brown)	 002-024 Intake Throttle Solenoid Valve
J-74 (White)	 002-007 Front Speed Sensor (RH)

No.	Connector Face
J-74 (White)	 002-008 Front Speed Sensor (RH)
J-75 (Black)	 002-007 Front Speed Sensor (LH)
J-75 (Black)	 002-008 Front Speed Sensor (LH)
J-148 (Wihte)	 002-007 Rear Speed Sensor (RH)
J-148 (White)	 002-008 Rear Speed Sensor (RH)
J-149 (White)	 002-007 Rear Speed Sensor (LH)
J-149 (Black)	 002-008 Rear Speed Sensor (LH)
J-177 (Black)	 034-001 Electronic Hydraulic Control Unit (EHCU) [ABS Module]

No.	Connector Face
J-210 (Black)	 005-012 Exhaust Brake Cut Relay
R-1 (White)	 006-036 Brake Light (LH)
R-6 (White)	 006-036 Brake Light (RH)

H-5 Body H. – Frame H. (Gray)



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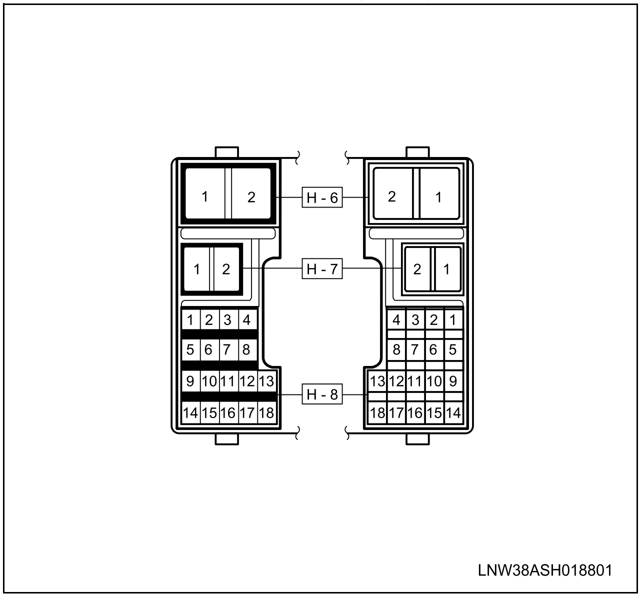
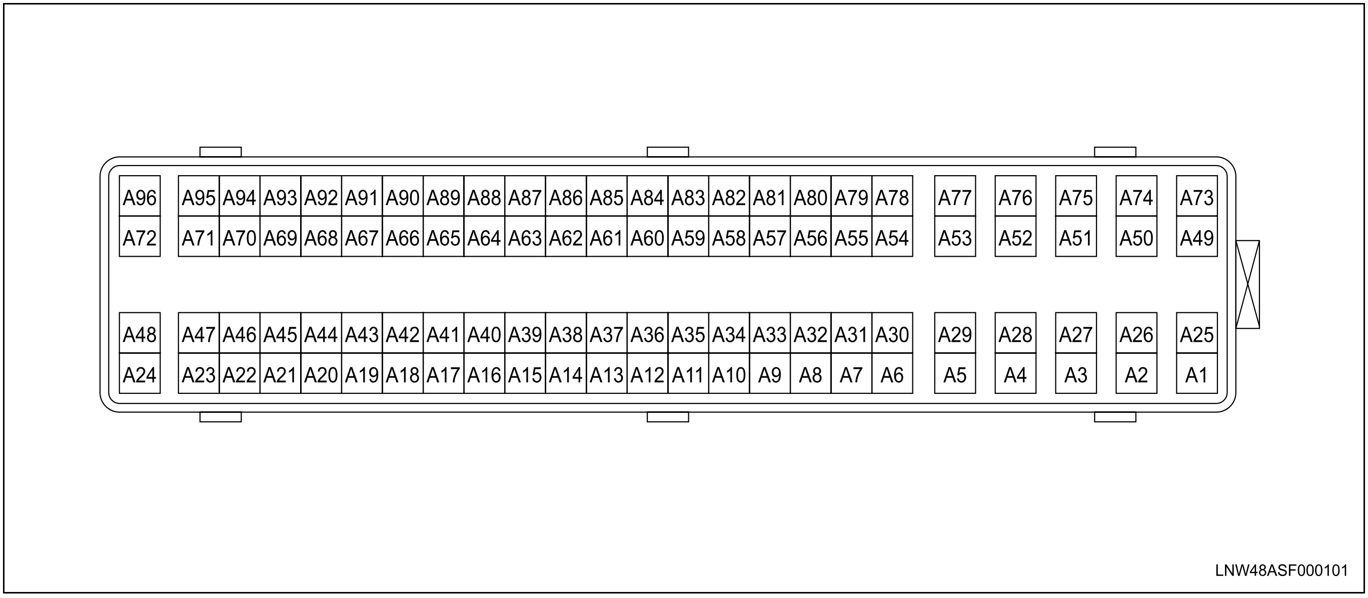
H-6, H-8 Body H. – Frame H. (Gray)



J-218 ECM-2 (Black)



Power Window

General Description

The circuit consist of the ignition switch, power window switch for each of the windows and power window motor.

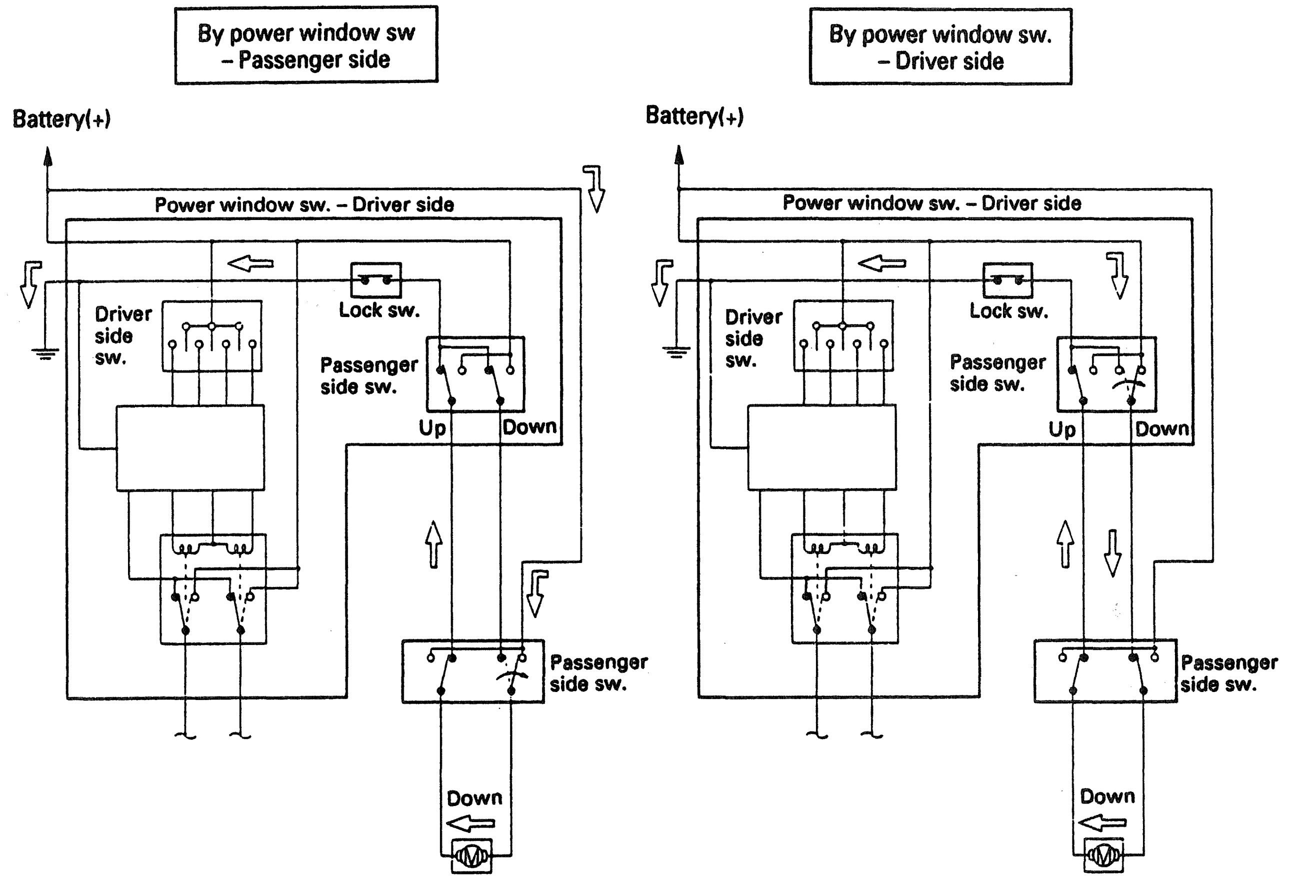
When the ignition switch is turned on, the battery voltage is applied to each of the power window switches through the circuit breaker and the power window relay on the circuit.

By operating the switches of each window to select “UP” or “DOWN”, the revolving direction of the power window motor changes to open or close the window.

The driver's power window switch has a built-in one-touch operating circuit which allows to automatically open the window by operating the switch to the AUTO position.

When the driver's power lock switch at the driver side is depressed, the power source to the passenger's power window switches will be shut off and passenger's side power window motor will not operate if the switch is operated.

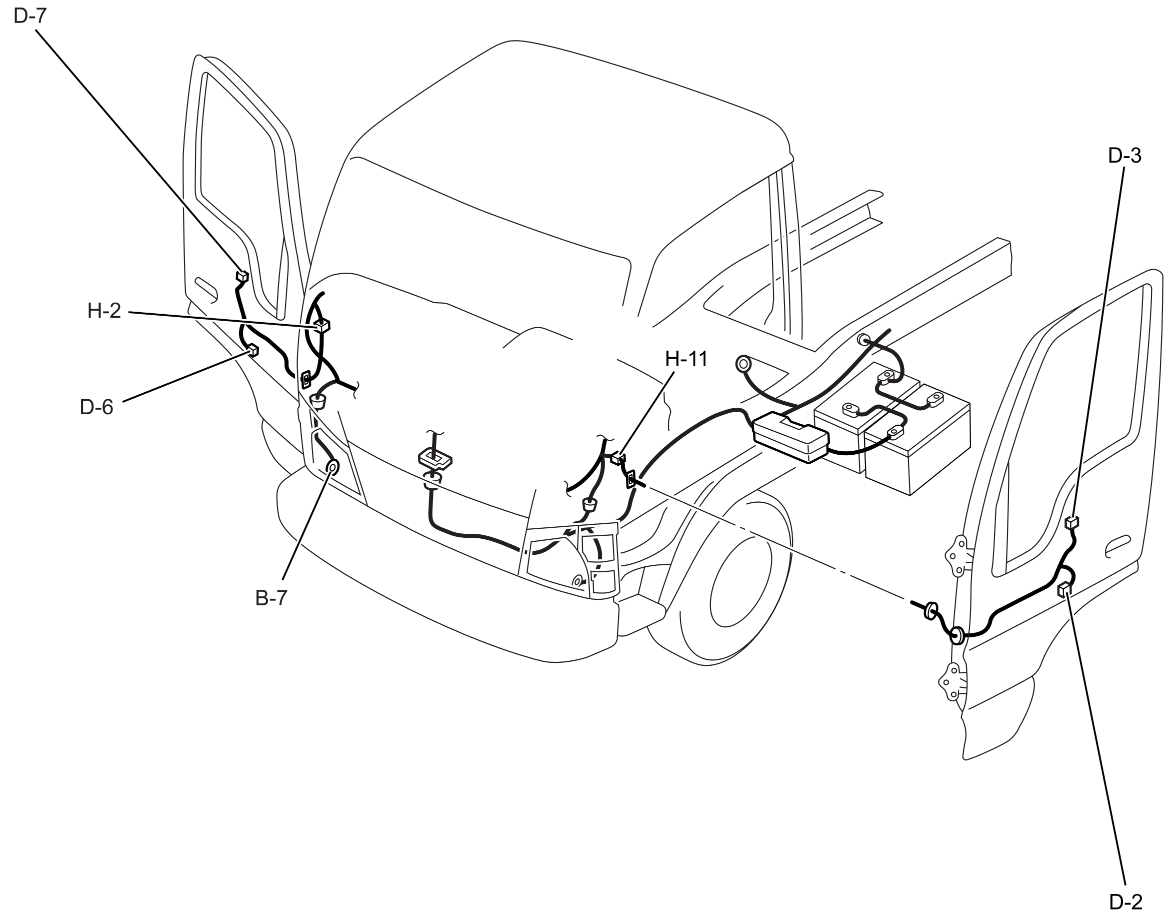
OPERATION OF PASSENGER SIDE WINDOW



NOTE: Arrow marks "⟹" indicate the direction of current

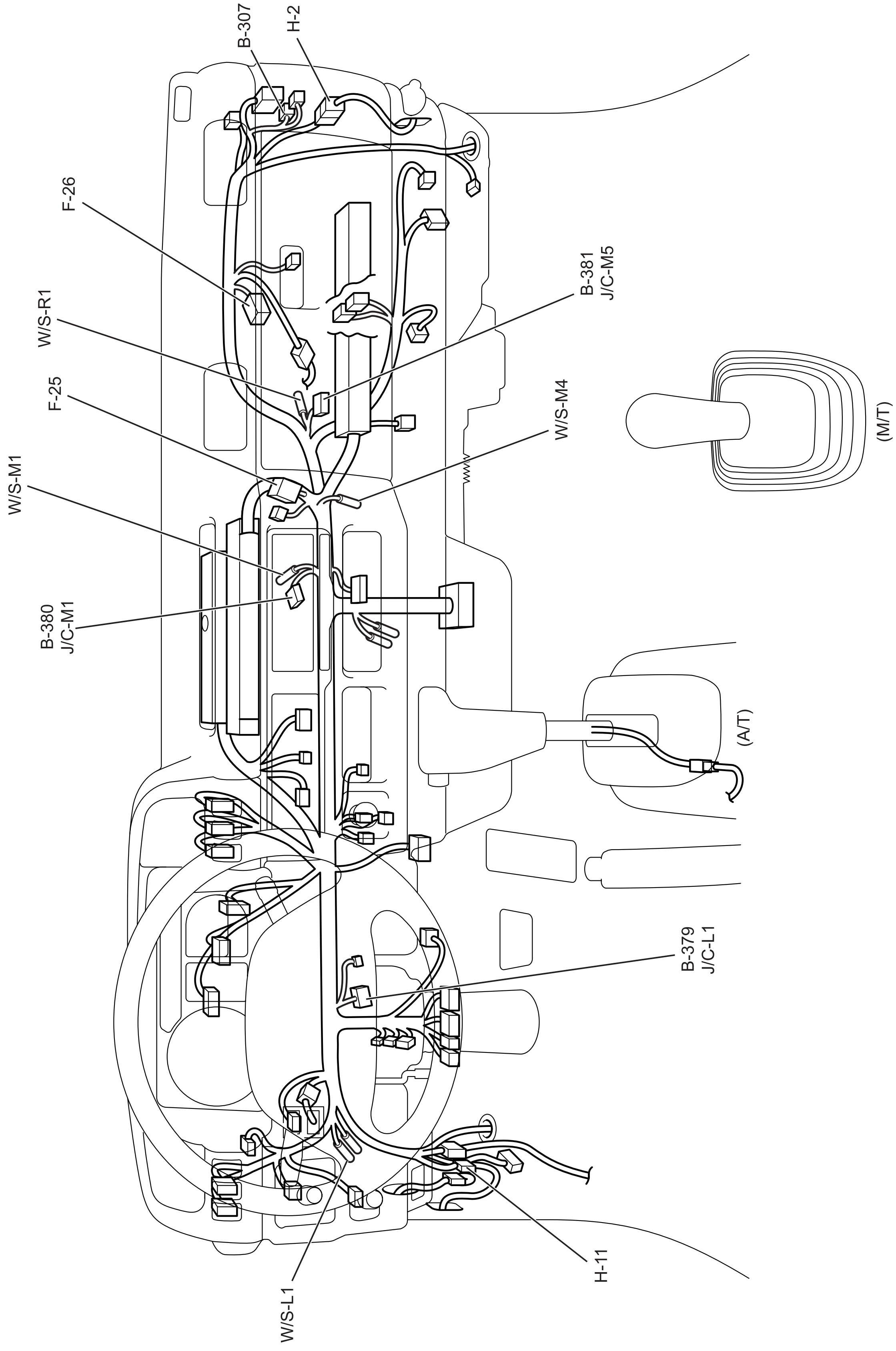
LNW38ALF005301

PARTS LOCATION (1)



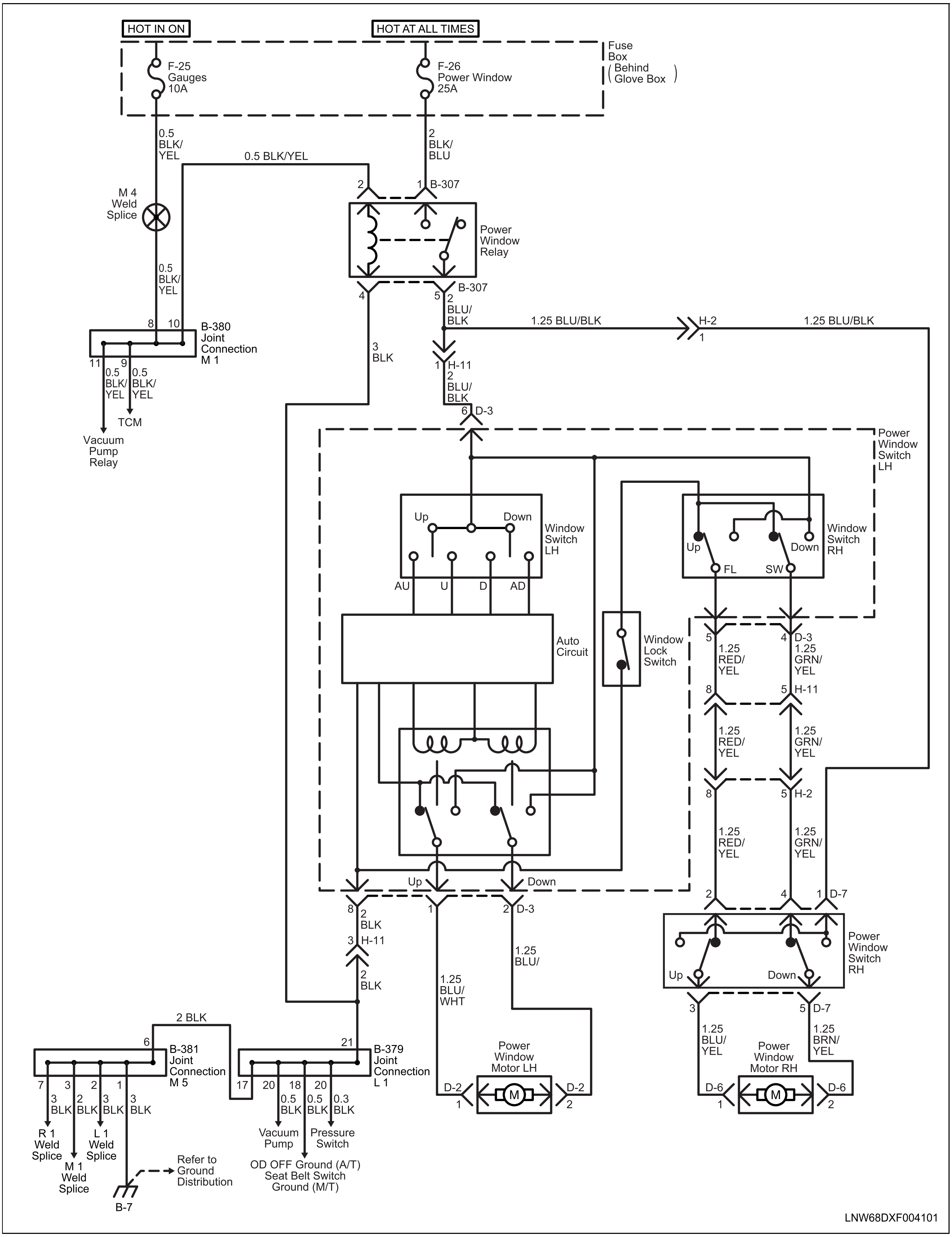
LNW58ALF001601

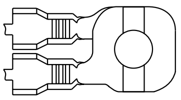
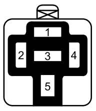
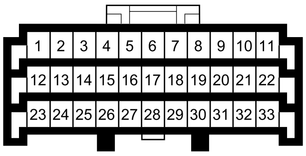
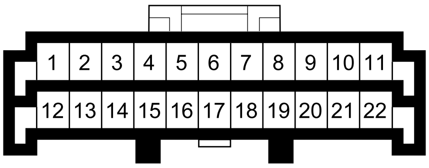
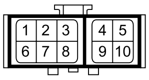
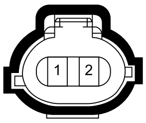
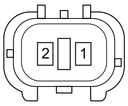
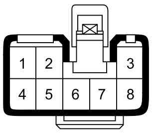
PARTS LOCATION (2)

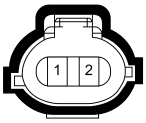
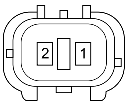
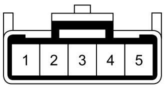
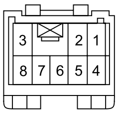
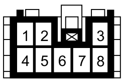
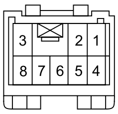
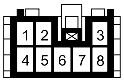


LNW68DXF011701

CIRCUIT DIAGRAM



No.	Connector Face
B-7	 000-007 Ground; Headlight Bracket–RH
B-307 (Black)	 005-012 Power Window Relay
B-379 (White)	 033-001 Joint Connection - L1
B-380 (White)	 022-005 Joint Connection - M1
B-381 (White)	 010-015 Joint Connection – M5
D-2 (Black)	 002-058 Power Window Motor (LH)
D-2 (Black)	 002-060 Power Window Motor (LH)
D-3 (Black)	 008-011 Power Window Switch (LH)

No.	Connector Face
D-6 (Black)	 002-058 Power Window Motor (RH)
D-6 (Black)	 002-060 Power Window Motor (RH)
D-7 (White)	 005-002 Power Window Switch (RH)
H-2 (Yellow)	 008-002 Body H. – Door H. (RH)
H-2 (Yellow)	 008-001 Body H. – Door H. (RH)
H-11 (White)	 008-002 Body H. – Door H. (LH)
H-11 (White)	 008-001 Body H. – Door H. (LH)

DIAGNOSIS

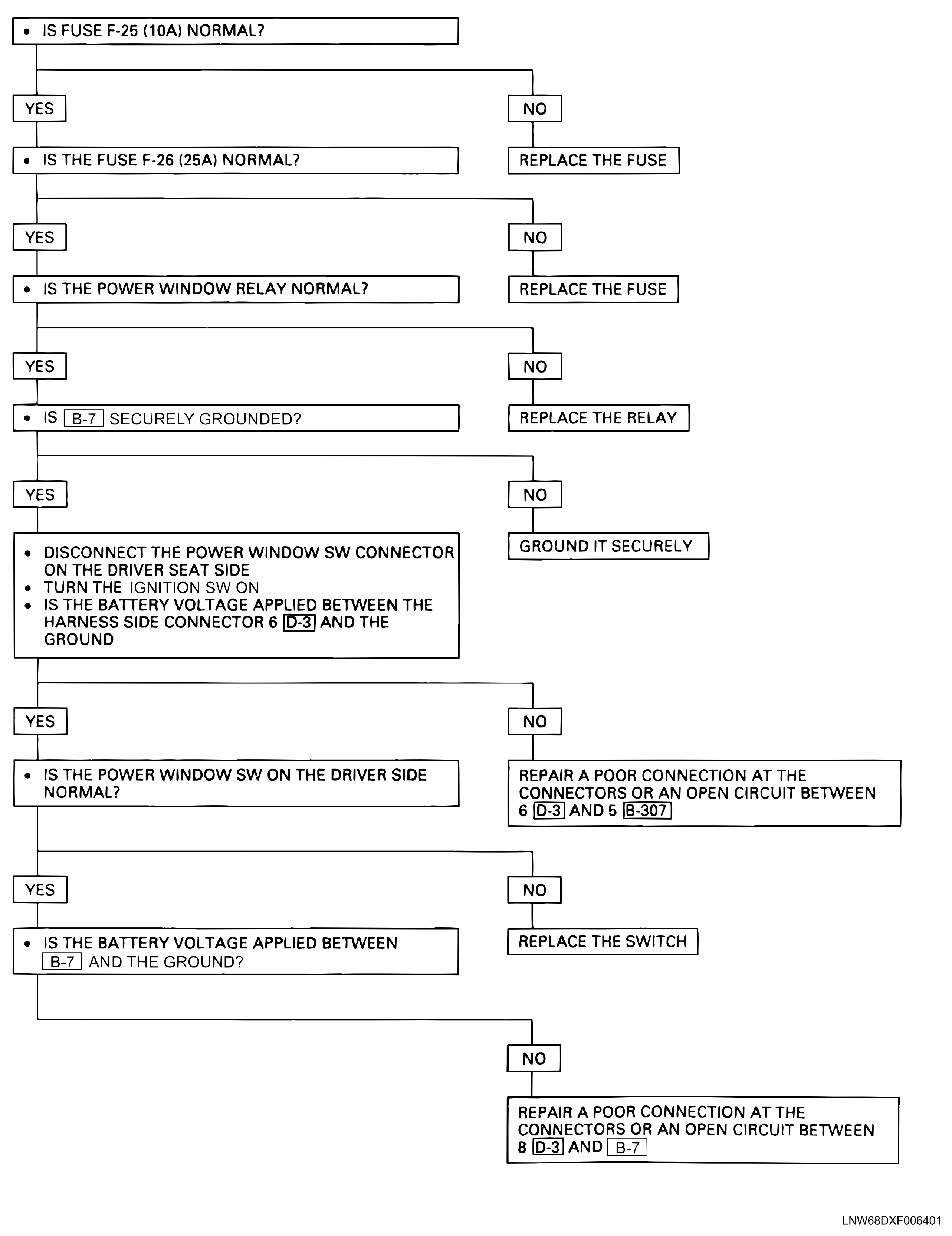
QUICK CHART FOR CHECK POINT

Check Point / Trouble Mode	Fuse F-25 (10A)	Fuse F-26 (25A)	Power Window Relay	Power Window Switch		Power Window Motor		Cable Harness
				Driver Side	Passenger Side	Driver Side	Passenger Side	
All Windows Do Not Operate	○ (1)	○ (2)	○ (3)	○ (5)				○ (4)
Lock Switch Does Not Functioin				○ (1)				
Driver Side Window								
Window Does Not Operate				○ (1)		○ (2)		○ (3)
One-touch Operation Does Not Operate				○ (1)				
Window Operates In Only One Directioin				○ (1)				
Front Passenger Side Window								
Window Does Not Operate				○ (2)	○ (1)		○ (3)	○ (4)
Window Does Not Operate When Operating The Driver Side Switch				○ (1)				○ (2)
Window Does Not Operate When Operating The Passenger Side Switch					○ (1)			○ (2)
Window Operates In Only One Directioin When Operating The Driver Side Switch				○ (1)				○ (2)
Window Operates In Only One Directioin When Operating The Passenger Side Switch				○ (2)	○ (1)			

LNW48ALF006001

NOTE: Figure in parenthesis "( )" indicates the order of inspection.

1. ALL WINDOWS DO NOT OPERATE



- IS FUSE F-25 (10A) NORMAL?

YES

- IS THE FUSE F-26 (25A) NORMAL?

NO

REPLACE THE FUSE

YES

- IS THE POWER WINDOW RELAY NORMAL?

NO

REPLACE THE FUSE

YES

- IS B-7 SECURELY GROUNDED?

NO

REPLACE THE RELAY

YES

- DISCONNECT THE POWER WINDOW SW CONNECTOR ON THE DRIVER SEAT SIDE
- TURN THE IGNITION SW ON
- IS THE BATTERY VOLTAGE APPLIED BETWEEN THE HARNESS SIDE CONNECTOR 6 D-3 AND THE GROUND

NO

GROUND IT SECURELY

YES

- IS THE POWER WINDOW SW ON THE DRIVER SIDE NORMAL?

NO

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN 6 D-3 AND 5 B-307

YES

- IS THE BATTERY VOLTAGE APPLIED BETWEEN B-7 AND THE GROUND?

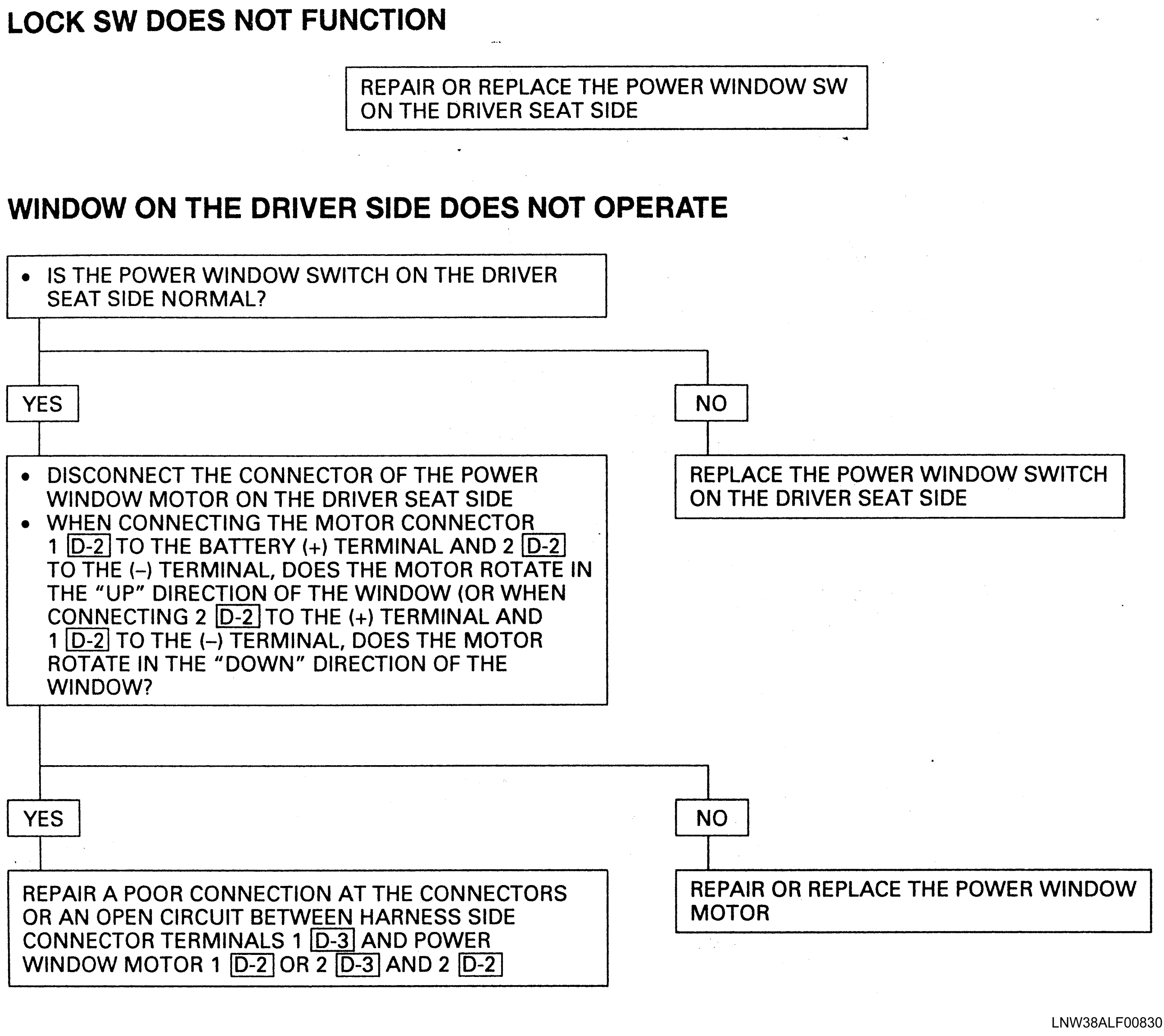
NO

REPLACE THE SWITCH

NO

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN 8 D-3 AND B-7

2. LOCK SW DOES NOT FUNCTION



LOCK SW DOES NOT FUNCTION

REPAIR OR REPLACE THE POWER WINDOW SW ON THE DRIVER SEAT SIDE

WINDOW ON THE DRIVER SIDE DOES NOT OPERATE

- IS THE POWER WINDOW SWITCH ON THE DRIVER SEAT SIDE NORMAL?

YES

- DISCONNECT THE CONNECTOR OF THE POWER WINDOW MOTOR ON THE DRIVER SEAT SIDE
- WHEN CONNECTING THE MOTOR CONNECTOR 1 D-2 TO THE BATTERY (+) TERMINAL AND 2 D-2 TO THE (–) TERMINAL, DOES THE MOTOR ROTATE IN THE "UP" DIRECTION OF THE WINDOW (OR WHEN CONNECTING 2 D-2 TO THE (+) TERMINAL AND 1 D-2 TO THE (–) TERMINAL, DOES THE MOTOR ROTATE IN THE "DOWN" DIRECTION OF THE WINDOW?

YES

REPAIR A POOR CONNECTION AT THE CONNECTORS OR AN OPEN CIRCUIT BETWEEN HARNESS SIDE CONNECTOR TERMINALS 1 D-3 AND POWER WINDOW MOTOR 1 D-2 OR 2 D-3 AND 2 D-2

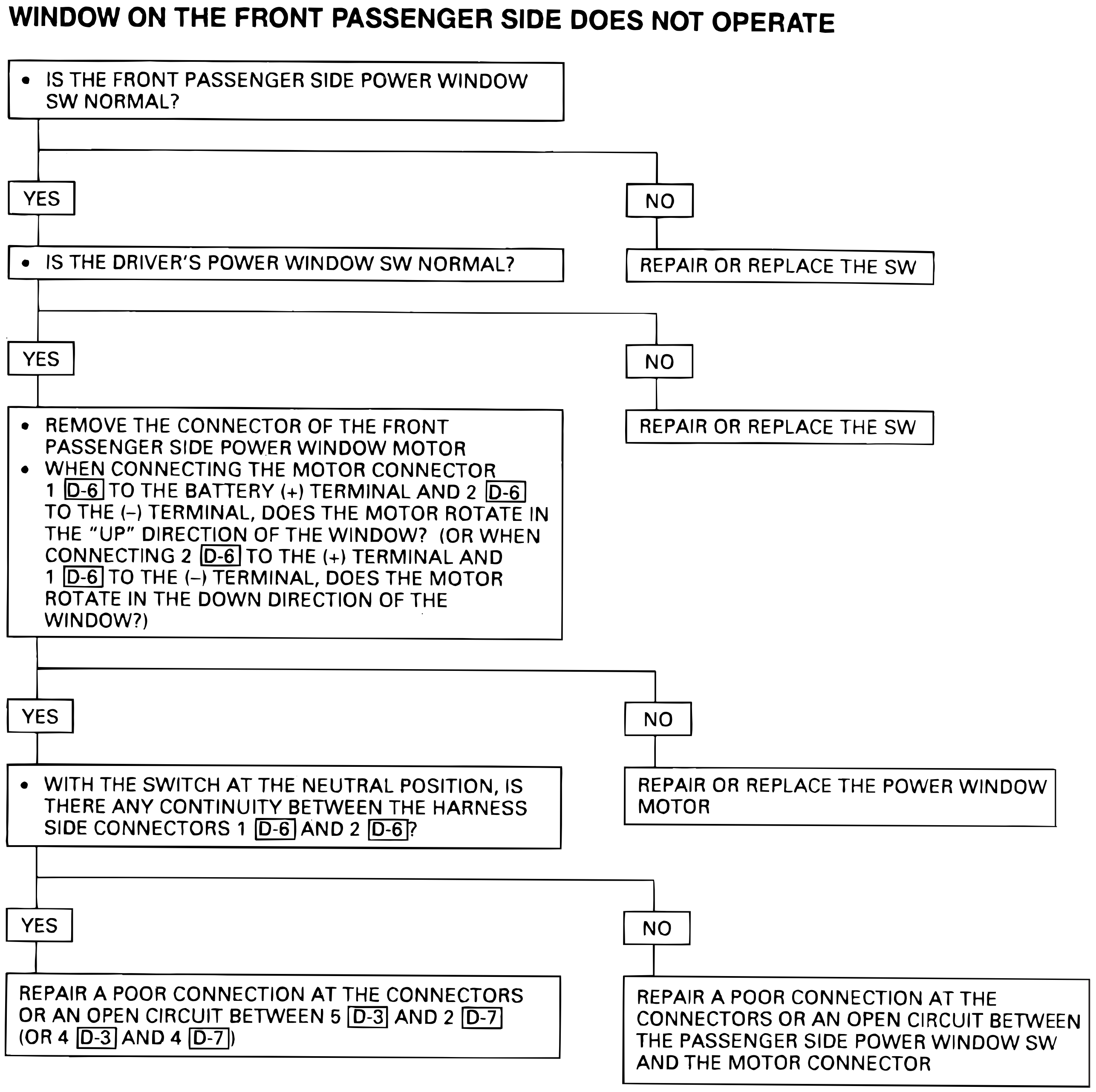
NO

REPAIR OR REPLACE THE POWER WINDOW MOTOR

NO

REPLACE THE POWER WINDOW SWITCH ON THE DRIVER SEAT SIDE

3. WINDOW ON THE FRONT PASSENGER SIDE DOES NOT OPERATE



LNW68DXF006601

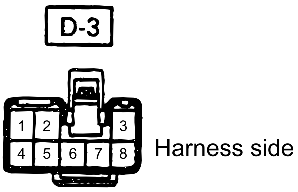
IGNITION SWITCH

Refer to "Start and Charging" in this section.

POWER WINDOW SWITCH-DRIVER SIDE

Circuit Inspect

Disconnect the switch connectors to check the voltage and the continuity between the harness side connector terminals.

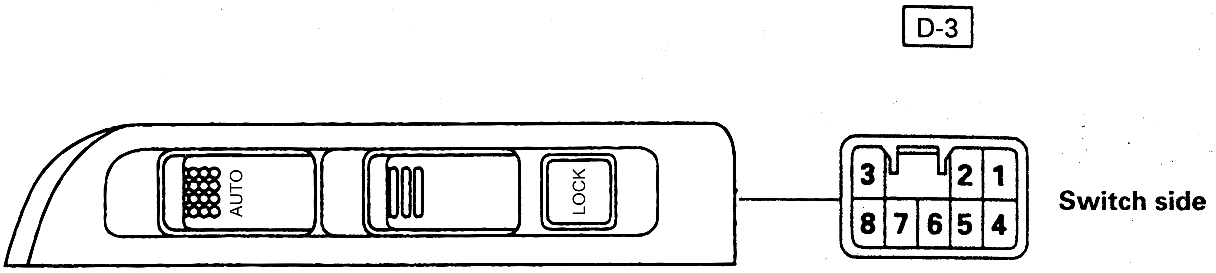


Terminal No.	Wire color	Connected to	Item to be checked	Connecting terminal	Checking conditions	Standard
1	BLU/ WHT	Driver seat side motor	Continuity (resistance)	1-2	–	Continuity
2	BLU					
4	GRN/ YEL	Passenger side power window SW		4-5		
5	RED/ YEL			5-4		
6	BLU/ BLK	Power window relay	Voltage	6-Ground	Starter SW "ON"	Battery voltage
8	BLK	Ground	Continuity (resistance)	8-Ground	–	Continuity

LNW68DMF000901

Inspect

Check the continuity between the connector terminals of the switch.
Repair or replace the switch when the result of inspection is found abnormal.



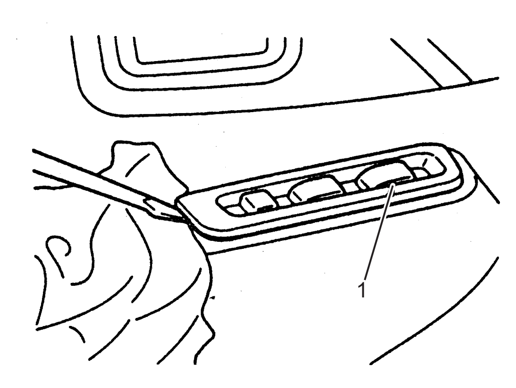
Window		Driver side				Passenger side			
SW position	Terminal No.	6	1	2	8	6	5	4	8
UP		○	○	○	○	○	○	○	○
OFF			○	—	○		○	—	○
				○	○			○	○
DOWN		○	—	○		○	—	○	
			○	—	○		○	—	○
LOCK	UP	○	○	○	○	○	○		
	OFF		○	—	○		○	○	
				○	○				
	DOWN	○	—	○		○	—	○	
			○	—	○				

LNW68DLF001701

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Switch
   - Insert the screw driver to the cut off portion to remove the switch.
   - Disconnect the connector.



LNW68DSH000901

Legend

1. Power Window Switch

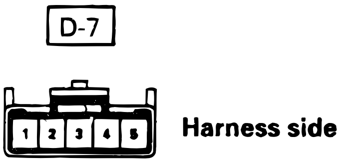
Install or Connect

To install, follow the removal steps in the reverse order.

POWER WINDOW SWITCH PASSENGER SIDE

Circuit Inspection

Disconnect the switch connectors to check the voltage and the continuity between the harness side connector terminals.



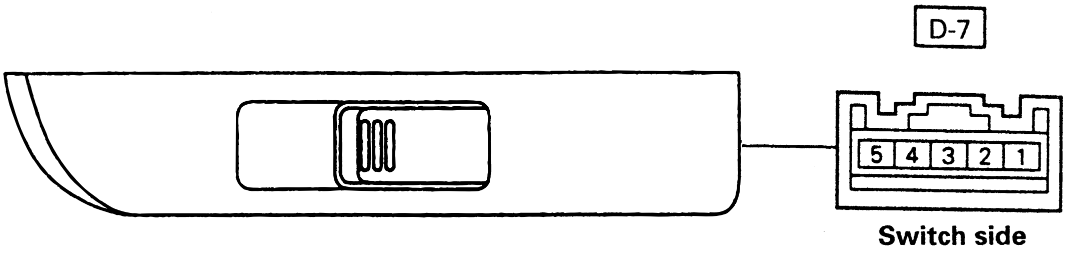
ermi-nal No.	Wire color	Connected to	Item to be checked	Connect-ing terminal	Checking conditions	Standard
1	BLU/ BLK	Power window relay	Voltage	1-Ground	· Turn "ON" the starter SW	Battery voltage
2	RED/ YEL	Driver side SW	Continuity (Resistance)	2-Ground	· Turn "OFF" the passenger side SW at the driver side SW	Continuity
			Voltage	2-Ground	· Turn "ON" the starter SW · Turn to "UP" the passenger side SW at the driver side SW	Battery voltage
3	BLU/ YEL	Passenge side motor	Continuity (Resistance)	3-5	–	Continuity
4	GRN/ YEL	Driver side SW	Continuity (Resistance)	4-Ground	· Turn "OFF" the passenger side SW at the driver side SW	Continuity
			Voltage	4-Ground	· Turn "ON" the starter SW · Turn to "DOWN" the passenger side SW at the driver side SW	Battery voltage
5	BRN/ YEL	Passenger side motor	Continuity (Resistance)	5-3		Continuity

LNW68DLF001201

Inspect

Check the continuity between the connector terminals of the switch.

Repair or replace the switch when the result of inspection is found abnormal.



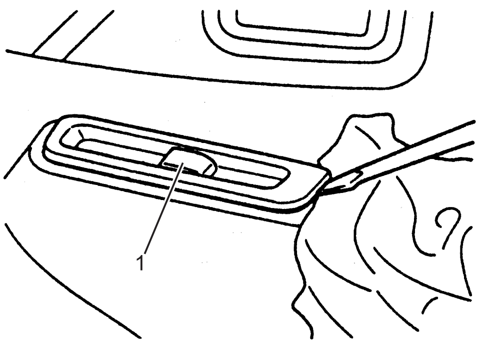
SW position \ Terminal No.	1	2	4	3	5
UP	○—	—	—	○	
			○—	—	○
OFF		○—	—	○	
			○—	—	○
DOWN		○—	—	○	
	○—	—	—	—	○

LNW68DMF001401

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Switch
   - Insert the screw driver to the cut off portion to remove the switch.
   - Disconnect the connector.



LNW68DSH001001

Legend

1. Power Window Switch

Install or Connect

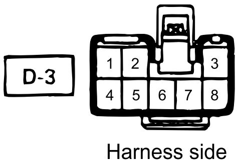
To install, follow the removal steps in the reverse order.

DRIVER SEAT SIDE POWER WINDOW MOTOR

Inspect

Before checking to see if the motor functions correctly, be sure to check the circuit through the connector [D-3] of the driver's power window switch.
If the motor does not operate smoothly, either the motor or the circuit between the switch and the motor is defective.

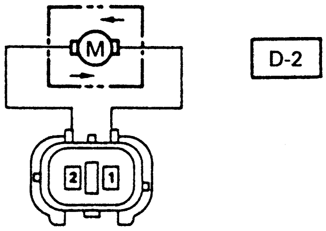
1. Circuit inspection of the driver side window switch
   Disconnect the switch connector and apply battery voltage to the harness side connector terminals to check its function.



Connecting terminal		Operation
1(BLU/WHT)	2(BLU)	
⊖	⊕	DOWN
⊕	⊖	UP

LNW68DSH000501

2. Inspection of the driver seat side motor
   Remove the motor connector and apply battery voltage to the motor side connector terminals to check its function.
   Replace the motor when the result of inspection is found abnormal.



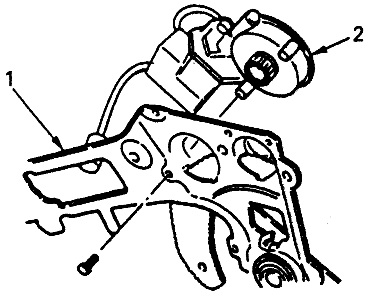
Terminal No. / Direction of operation	1	2
DOWN	⊖	⊕
UP	⊕	⊖

LNW38ASH019801

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

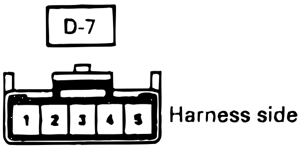
1. Window Regulator Assembly
   Refer to “Window / Rear Window Regulator Assembly” of sectiion 8F “Steel Tilt Cab” & 8G “Crew Cab”.
2. Power Window Motor
   Remove three screws.



LNW38ASH020001

Legend

1. Window Regulator Assembly
2. Power Window Motor



Connecting terminal		Direction of operation
3(BLU/YEL)	5(BRN/YEL)	
⊖	⊕	DOWN
⊕	⊖	UP

LNW68DSH000601

Install or Connect

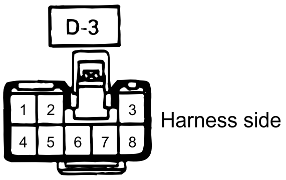
To install, follow the removal steps in the reverse order.

FRONT PASSENGER SEAT SIDE POWER WINDOW MOTOR

Inspect

Before checking to see if the motor functions correctly, be sure to check the circuit through the front passenger’s switch connector [D-7] and the driver’s power window switch connector [D-3].
If the motor does not operate smoothly, either the motor or the circuit between the switch and the motor is defective.

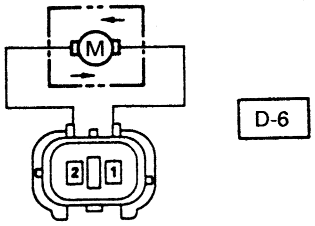
1. Circuit inspection of the front passenger seat side window
   Disconnect the switch connector and apply battery voltage to the harness side connector terminals to check its function.
2. Circuit inspection of the driver seat side switch
   Disconnect the switch connector and apply battery voltage to the harness side connector terminals to check its function.



Connecting terminal		Direction of operation
4(GRN/YEL)	5(RED/YEL)	
⊕	⊖	DOWN
⊖	⊕	UP

LNW68DSH000701

3. Inspection of the front passenger window motor
   Disconnect the motor connector and apply battery voltage to the motor side connector terminals to check its function.
   Refer or replace the motor when the result of inspection is found abnormal.



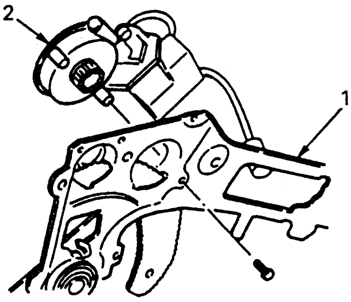
Terminal No. / Direction of operation	1	2
DOWN	⊖	⊕
UP	⊕	⊖

LNW38ASH020201

Remove or Disconnect

Preparation: Disconnect the battery ground cable.

1. Window Regulator Assembly
   Refer to "Window / Rear Window Regulator Assembly" of sectiion 8F "Steel Tilt Cab" & 8G "Crew Cab".
2. Power Window Motor
   Remove three screws.



LNW38ASH020301

Legend

1. Window Regulator Assembly
2. Power Window Motor

Install or Connect

To install, follow the removal steps in the reverse order.

Power Door Lock

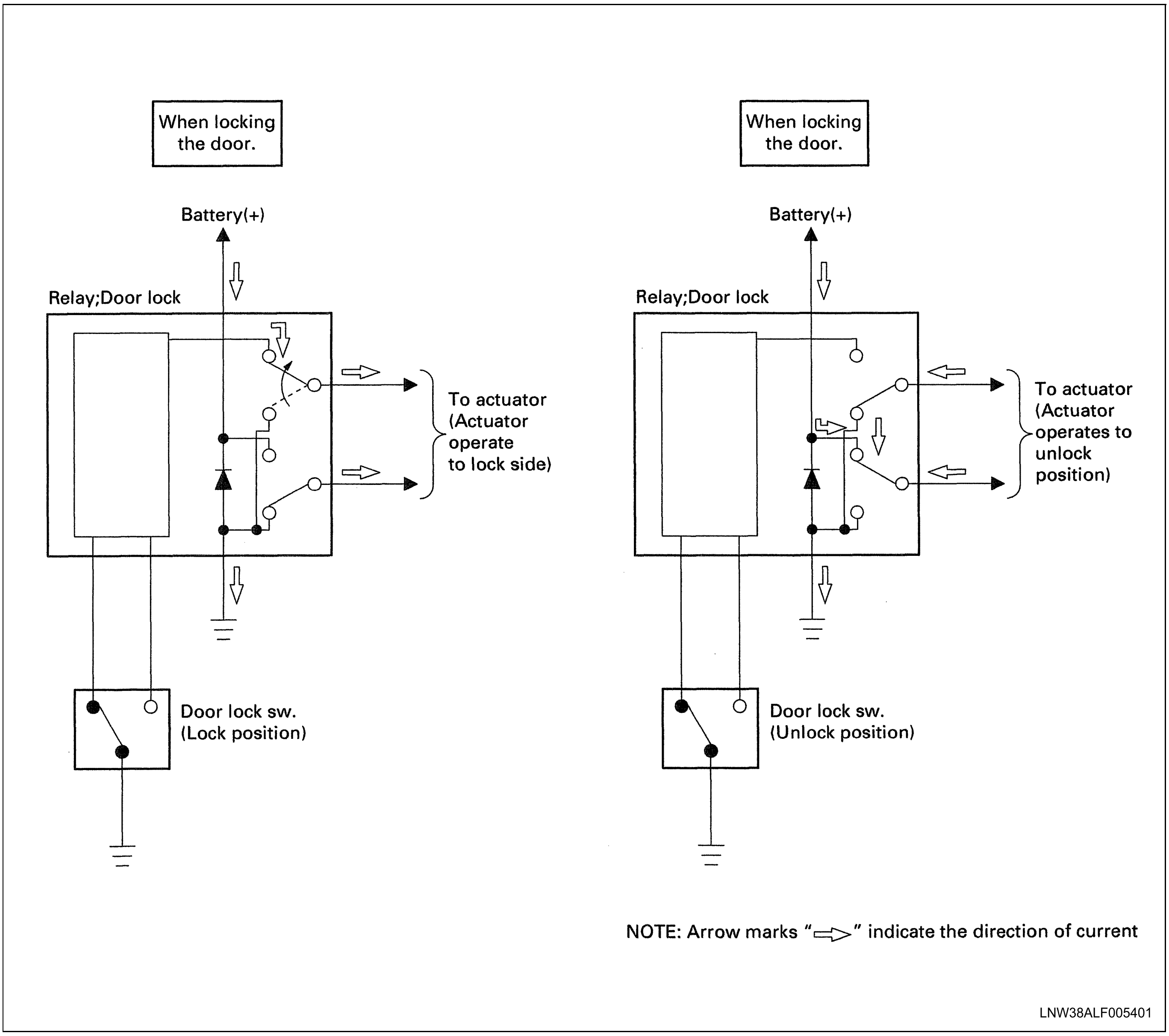
General Description

The circuit consists of the door lock switch, actuator for the front passenger door, rear doors and the door lock controller.

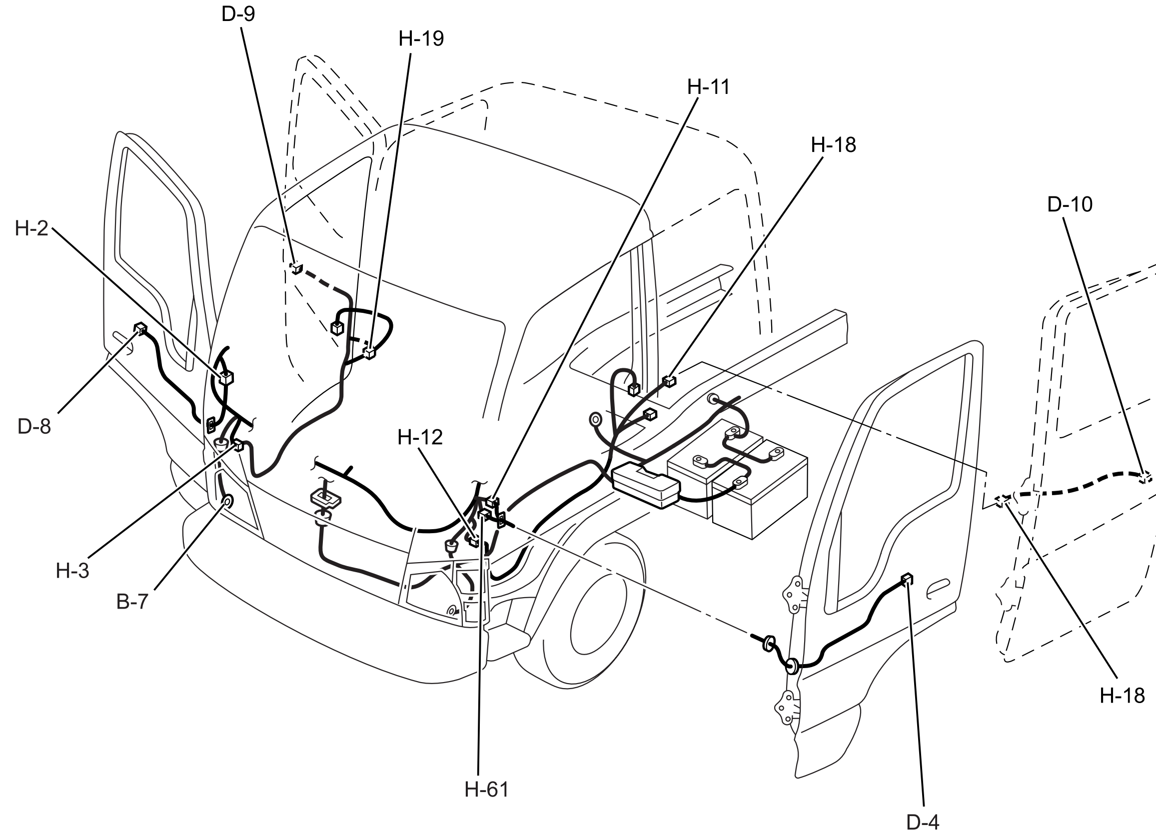
The door lock controller is always provided with battery voltage. The key or the inside lock knob on the driver's door can activate the lock mechanism of all the doors.

When the driver's door lock switch is turned on, current flows for about one second to the door lock actuator of each door connected in parallel with the controller to activates the actuator to lock and unlock the doors.

OPERATION OF DOOR LOCK CONTROLLER

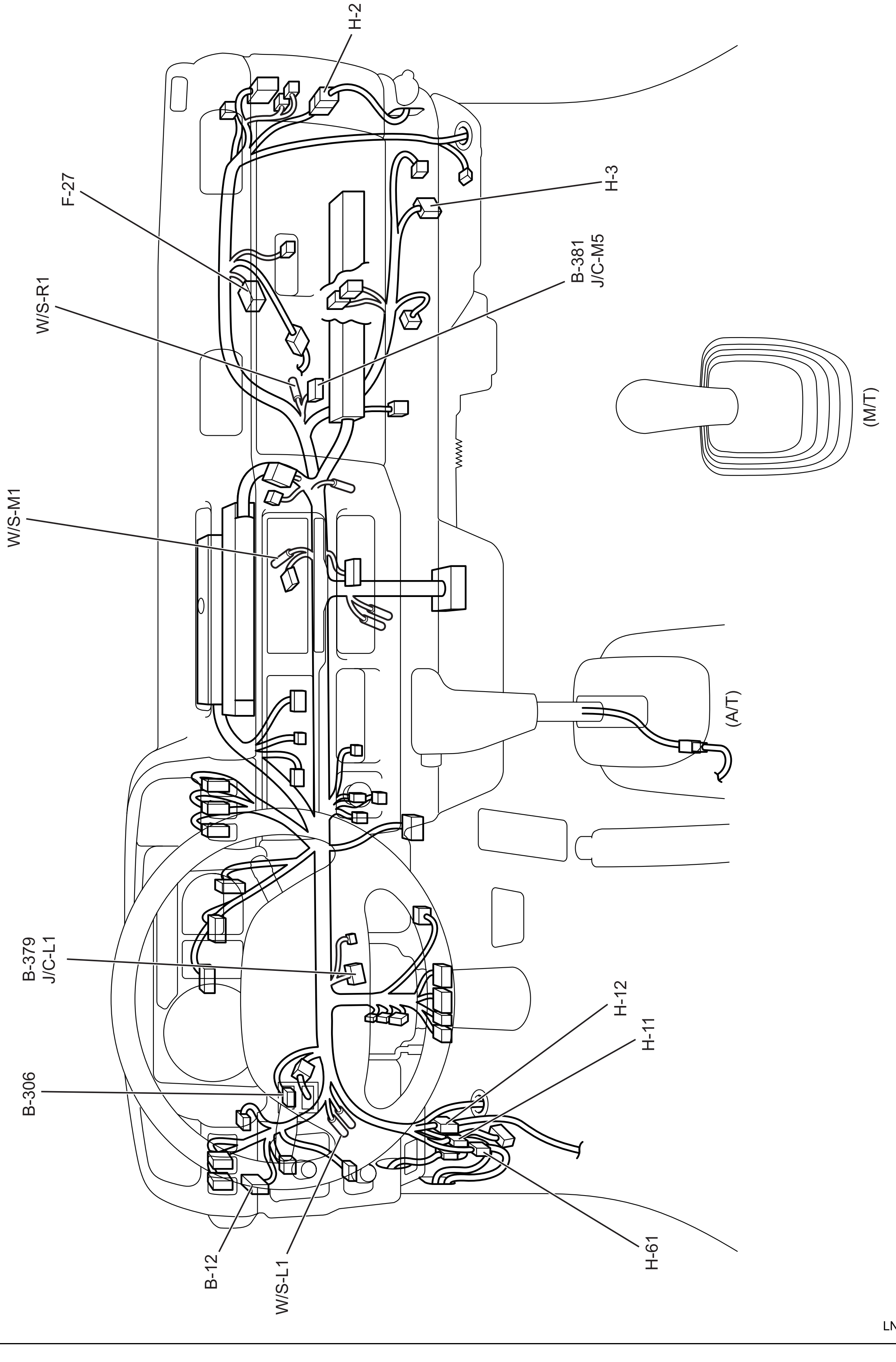


PARTS LOCATION (1)



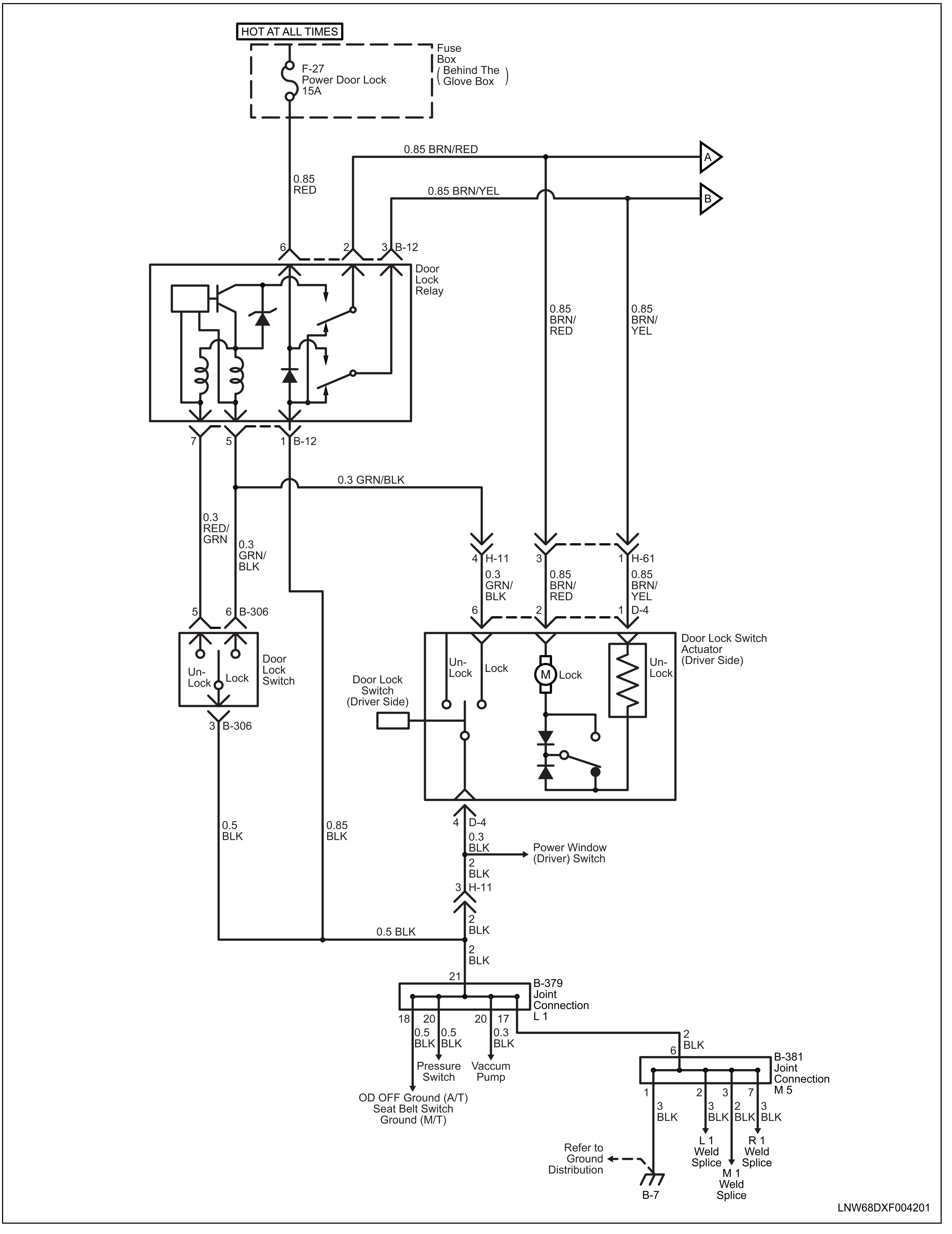
LNW58ALF001701

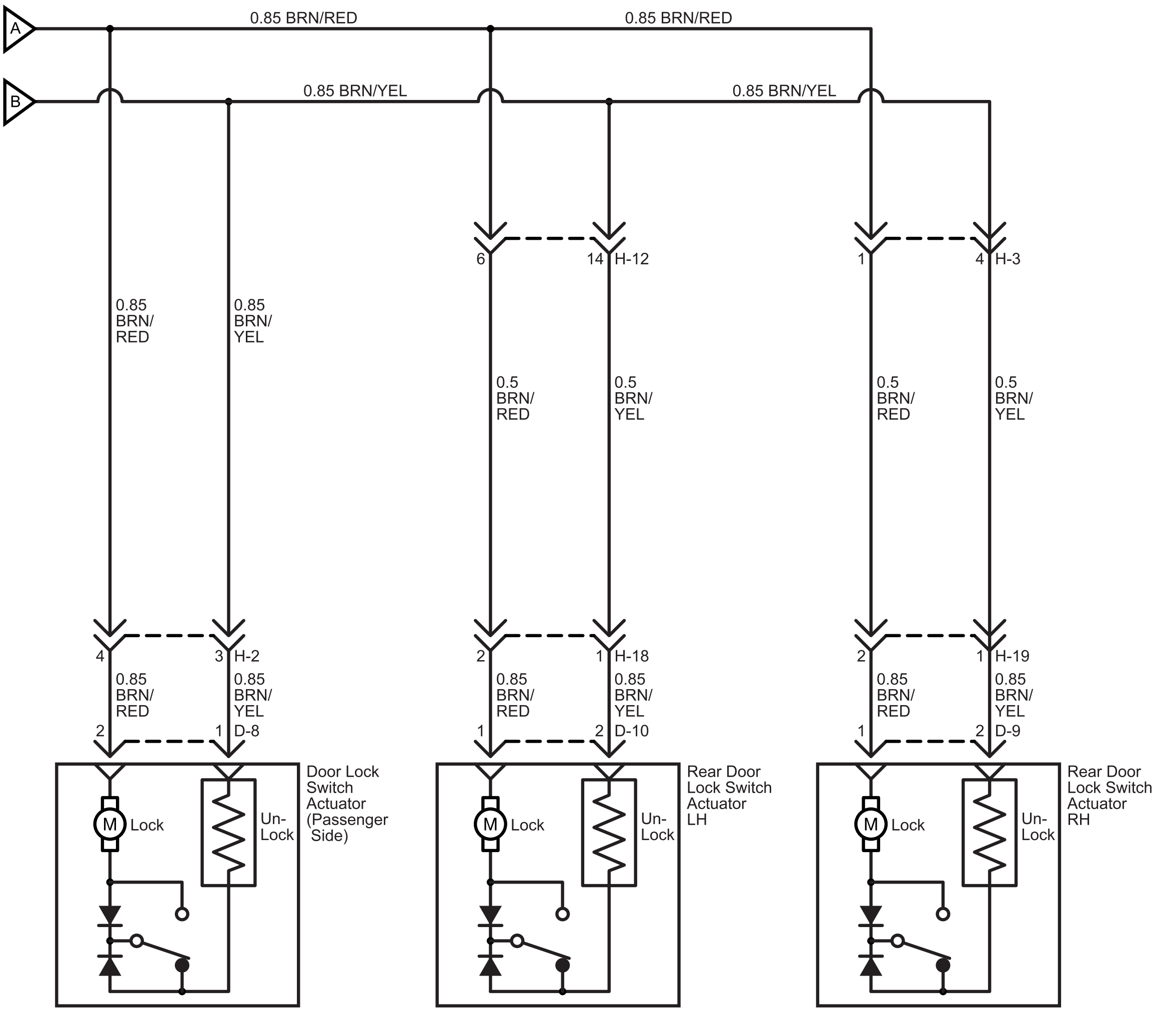
PARTS LOCATION (2)



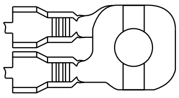
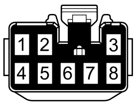
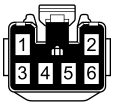
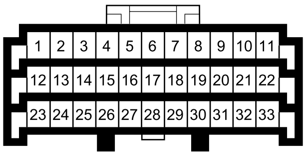
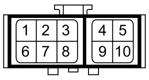
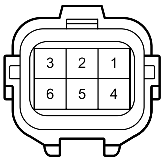
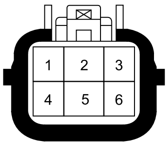
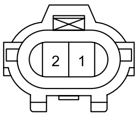
LNW68DXF011801

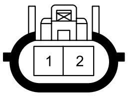
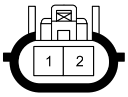
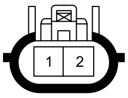
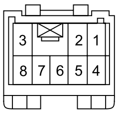
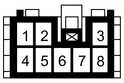
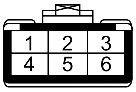
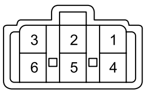
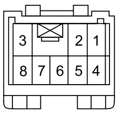
CIRCUIT DIAGRAM

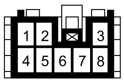
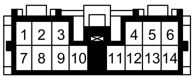
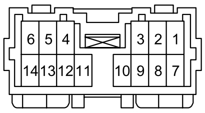
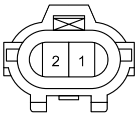
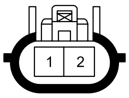
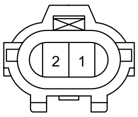
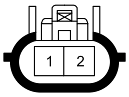
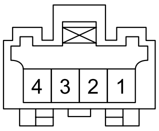


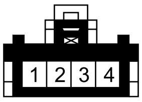


LNW68DXF004301

No.	Connector Face
B-7	 000-007 Ground; Headlight Bracket–RH
B-12 (White)	 008-030 Door Lock Relay
B-306 (White)	 006-040 Door Lock Switch
B-379 (White)	 033-001 Joint Connection - L1
B-381 (White)	 010-015 Joint Connection – M5
D-4 (Gray)	 006-048 Door Lock Switch & Actuator (LH)
D-4 (Gray)	 006-001 Door Lock Switch & Actuator (LH)
D-8 (Gray)	 002-005 Door Lock Switch & Actuator (RH)

No.	Connector Face
D-8 (Gray)	 002-006 Door Lock Switch & Actuator (RH)
D-9 (Gray)	 002-006 Door Lock Switch – Rear Actuator (RH)
D-10 (Gray)	 002-006 Door Lock Switch – Rear Actuator (LH)
H-2 (Yellow)	 008-002 Body H. – Door H. (RH)
H-2 (Yellow)	 008-001 Body H. – Door H. (RH)
H-3 (White)	 006-002 Body H. – Floor H. (RH)
H-3 (White)	 006-018 Body H. – Floor H. (RH)
H-11 (White)	 008-002 Body H. – Door H. (LH)

No.	Connector Face
H-11 (White)	 008-001 Body H. – Door H. (LH)
H-12 (White)	 014-003 Body H. – Floor H. (RH)
H-12 (White)	 014-004 Body H. – Floor H. (RH)
H-18 (Black)	 002-005 Floor H. (LH) – Rear Door H. (LH)
H-18 (Black)	 002-006 Floor H. (LH) – Rear Door H. (LH)
H-19 (Black)	 002-005 Floor H. (RH) – Rear Door H. (RH)
H-19 (Black)	 002-006 Floor H. (RH) – Rear Door H. (RH)
H-61 (White)	 004-007 Body H. – Door H. – LH

No.	Connector Face
H-61 (White)	 004-008 Body H. – Door H. – LH

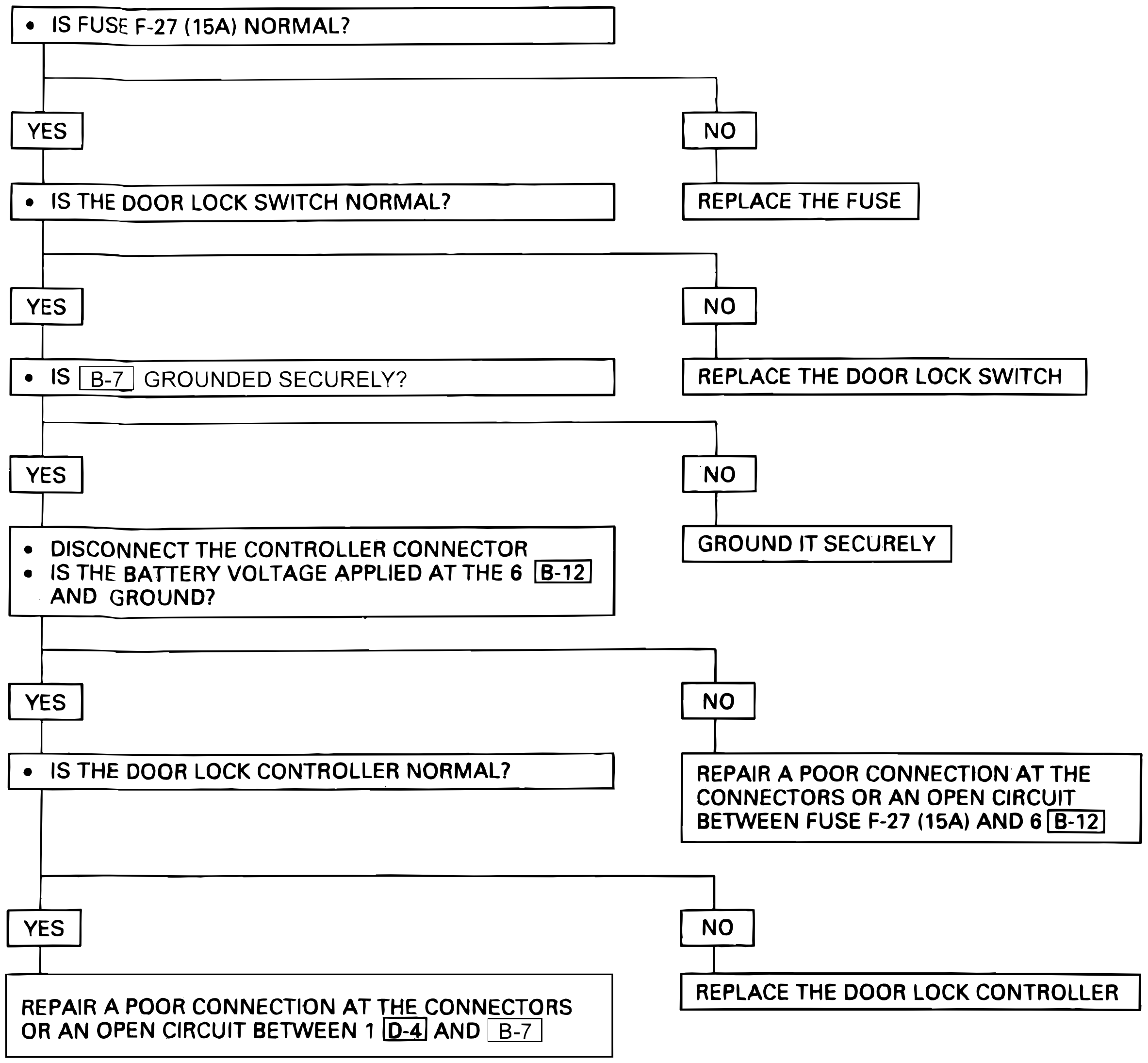
DIAGNOSIS

Check point / Trouble mode	Fuse F-27 (15A)	Door lock controller	Door lock sw (Driver side)	Door lock actuator			
				Front (Passenger side)	Rear (RH)	Rear (LH)	Cable harness
1. All the doors do not lock and unlock	○ (1)	○ (2)					○ (3)
2. All the doors do not get locked (or unlocked)		○ (1)					○ (2)
3. Driver side door does not get locked (or unlocked)			○ (1)				○ (2)
4. Front passenger side door does not get locked (or unlocked)				○ (1)			○ (2)
5. Rear door-RH side does not get locked (or unlocked)					○ (1)		○ (2)
6. Rear door-LH side does not get locked (or unlocked)						○ (1)	○ (2)

LNW48AMF002601

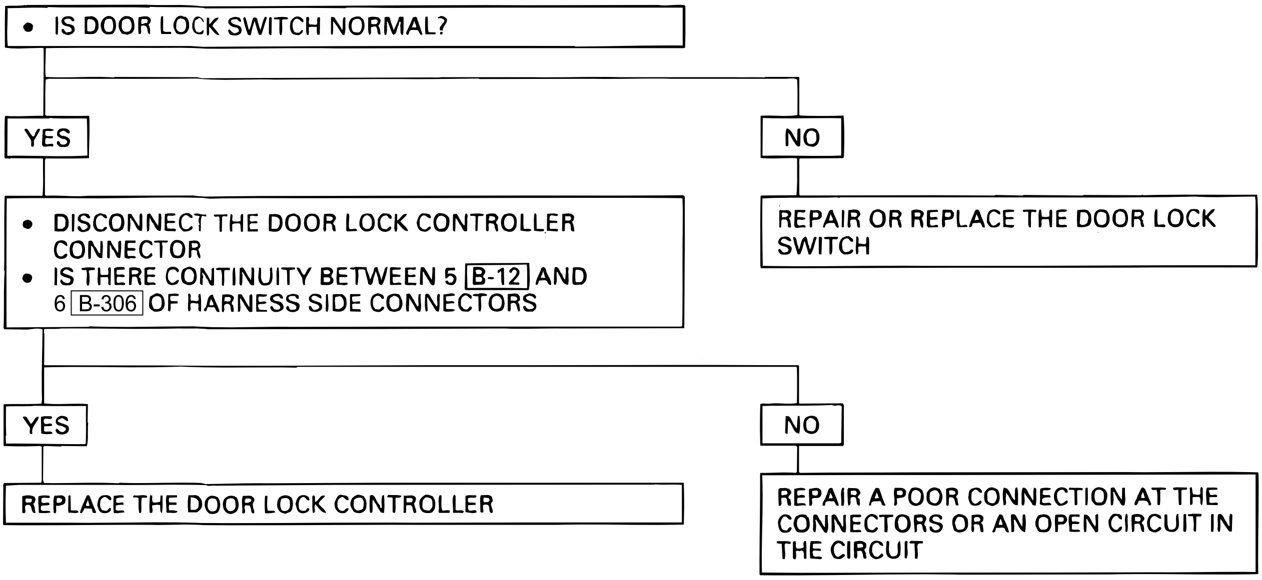
NOTE: Figure in parenthesis "( )" indicates the order of inspection.

1. ALL THE DOORS DO NOT LOCK AND UNLOCK



LNW68DLF001301

2. ALL THE DOORS DO NOT GET LOCKED (OR UNLOCKED)



LNW68DMF001001

3. DRIVER SIDE DOOR DOES NOT GET LOCKED (OR UNLOCKED)

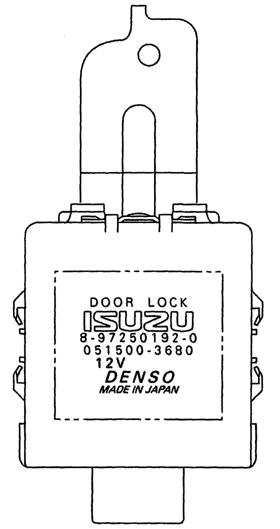
REPLACE THE DOOR LOCK SWITCH

4. FRT PASSENGER SIDE DOOR DOES NOT GET LOCKED (OR UNLOCKED)

REPLACE THE DOOR LOCK ACTUATOR

DOOR LOCK RELAY

The door lock controller sends out to each door lock actuator the lock/unlock signals received from door lock switch from the driver seat side.



LNW38ASH014801

Circuit Inspection

Check the voltage and the continuity between the controller harness side connector terminals.

LNW38ASH015801

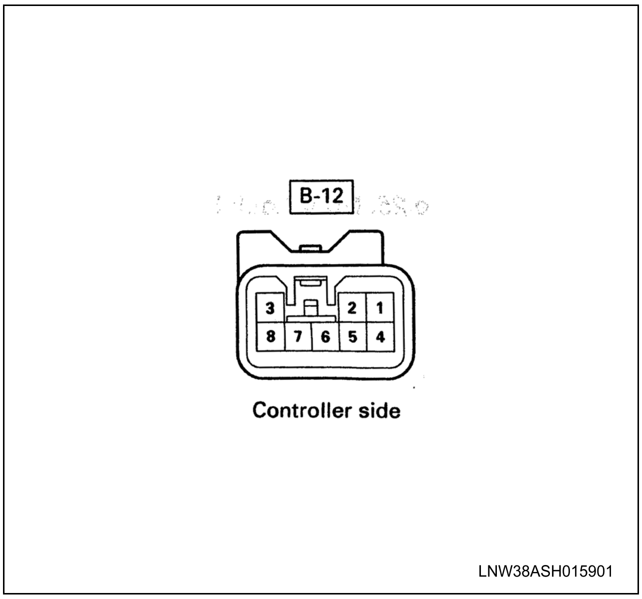
Terminal No.	Wire color	Connected to	Item to be checked	Connecting terminal	Checking conditions		Standard
7	RED/ GRN	Door lock SW (Unlock)	Continuity (Resistance)	7-Ground	Driver seat side door	Unlock	Continuity
						Lock	No continuity
5	GRN/ BLK	Door lock SW (Lock)		5-Ground	Driver seat side door	Unlock	No continuity
						Lock	Continuity
1	BLK	Ground		1-Ground	–		Continuity
3	BRN/ YEL	Actuator (Unlock)		3-2	–		Continuity (There is sore resistance)
2	BRN/ RED	Actuator (Lock)		2-3	–		Continuity (There is some resistance)
6	RED	Fuse F-27 (15A)	Voltage	6-G round	–		Battery voltage

Inspect

Remove the connector of the door lock controller, and check the continuity and the voltage between the controller side connector terminals.

(Connect the (+) terminal of the battery to 6 [B-12] and the (–) terminal to 1 [B-12])	
1 [B-12]– 2 [B-12]	Continuity
1 [B-12]– 3 [B-12]	Continuity
(Then, ground 5 [B-12])	
2 [B-12]	Voltage for approx. 1 second
(Disconnect the ground of 5 [B-12], and ground 7 [B-12].)	
3 [B-12]	Voltage for approx.1 second

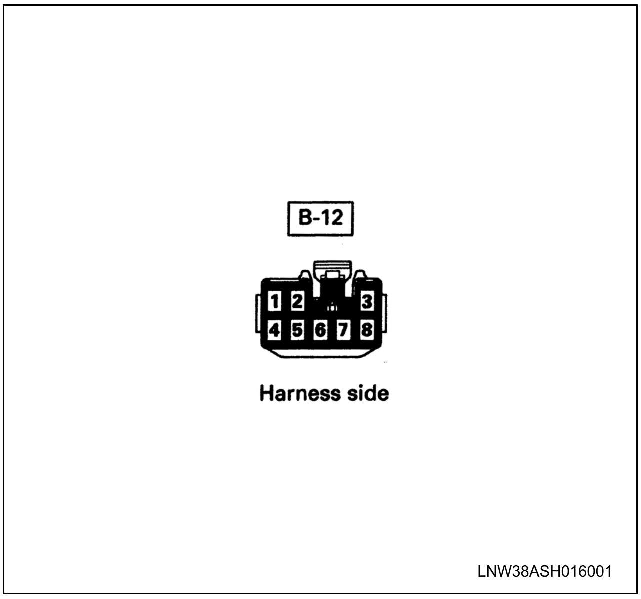
Replace the controller if the result of the inspection is found abnormal.



Inspect

After confirming that there is continuity between the harness side connector terminals 3 [B-12] and 2 [B-12] of the door lock controller, apply battery voltage to each of the terminals to conduct the operation test.

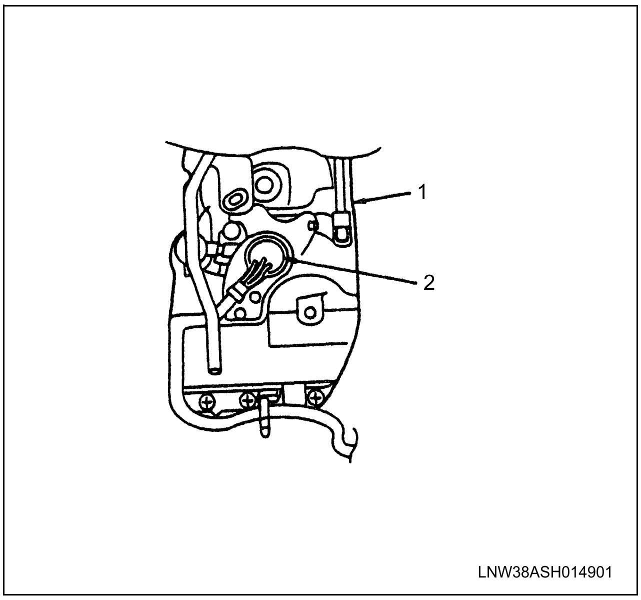
If the door lock will not operate, check the door lock actuator for functionality.



Connecting terminal		Operation
3 (BRN/YEL)	2 (BRN/YEL)	
(+)	(-)	Unlock
(-)	(+)	Lock

DOOR LOOK SWITCH (DRIVER SEAT SIDE)

The door lock switch on the driver's door is connected with the door lock cylinder and the inside lock knob with a rod. The switch sends lock/unlock signals to the door lock controller.

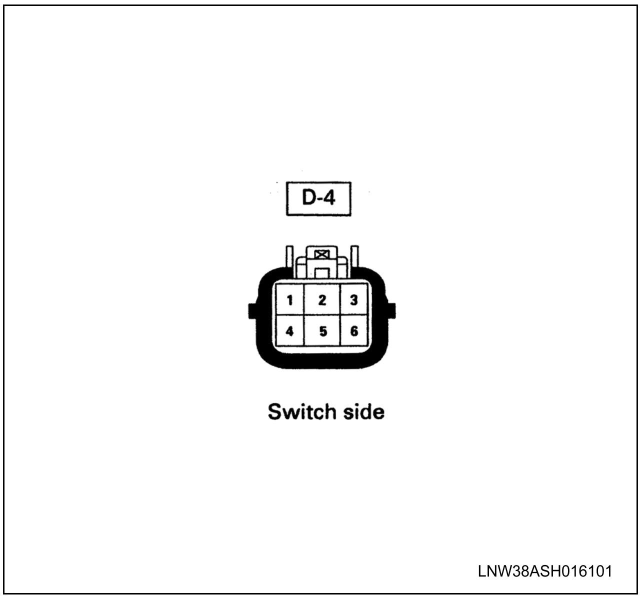


Legend

1. Door Lock ASM
2. Door Lock SW

Inspection

Check to see if there is any continuity between the connector terminals of the door lock switch.
Replace the switch if the result of the inspection is found abnormal.



Terminal No. Operation	1	2
Lock	(-)	(+)
Unlock	(+)	(-)

Remove or Disconnect

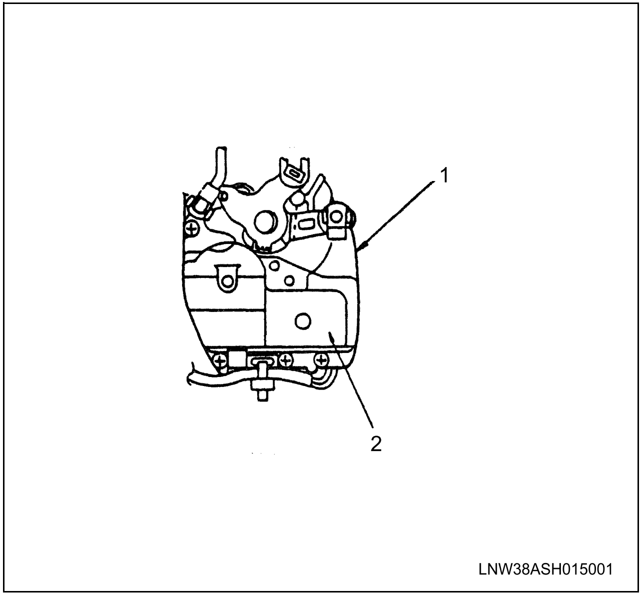
Refer to “Door / Rear Door Lock Mechanism” of section 8F “Steel Tilt Cab” & 8G “Crew Cab”.

Install or Connect

Refer to “Door / Rear Door Lock Mechanism” of section 8F “Steel Tilt Cab” & 8G “Crew Cab”.

DOOR LOCK ACTUATOR

Receiving forward or reverse current from the door lock controller, the door lock actuator locks or unlocks the door with the rod connected to the door lock mechanism.

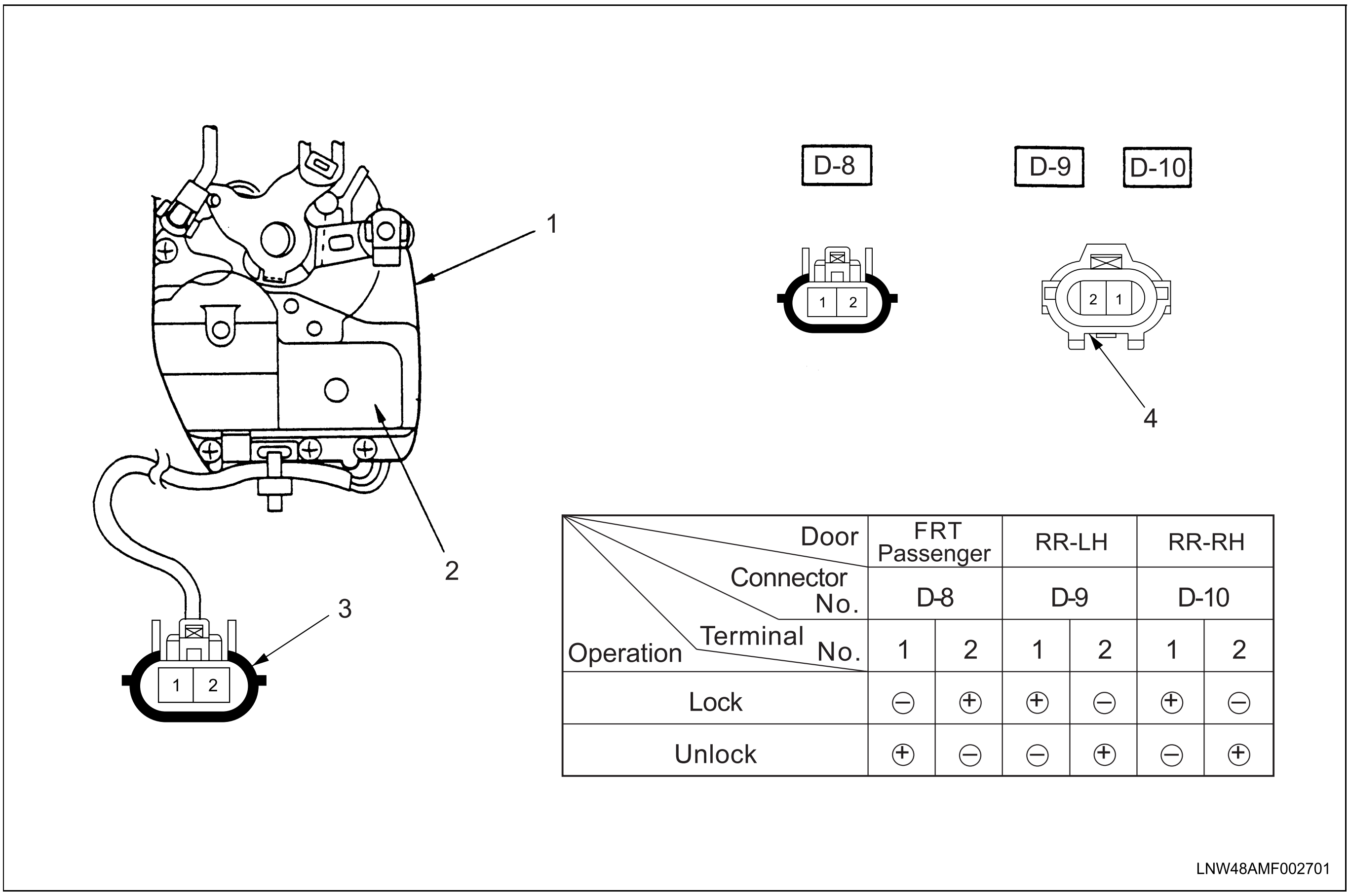


Legend

1. Door Lock ASM
2. Actuator

Inspection

Apply the battery voltage to the connector terminals of the door lock actuator to check the operation.
When the door lock actuator is checked on the vehicle and there is no continuity, and when the door lock actuator itself is checked and no trouble is found, check the circuit between the door lock actuator and the door lock controller for any failure.



Door	FRT Passenger		RR-LH		RR-RH	
Connector No.	D-8		D-9		D-10	
Operation / Terminal No.	1	2	1	2	1	2
Lock	⊖	⊕	⊕	⊖	⊕	⊖
Unlock	⊕	⊖	⊖	⊕	⊖	⊕

Legend

1. Door Lock ASM
2. Actuator
3. Actuator Side
4. Harness Side

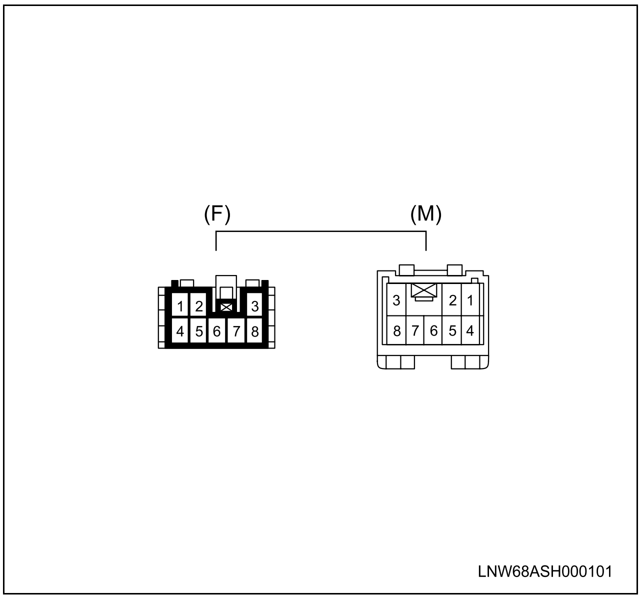
Remove or Disconnect

Refer to “Door / Rear Door Lock Mechanism” of section 8F “Steel Tilt Cab” & 8G “Crew Cab”.

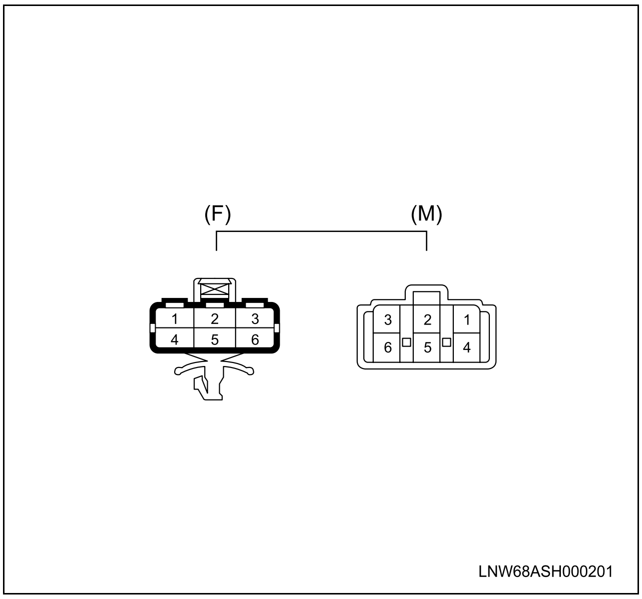
Install or Connect

Refer to “Door / Rear Door Lock Mechanism” of section 8F “Steel Tilt Cab” & 8G “Crew Cab”.

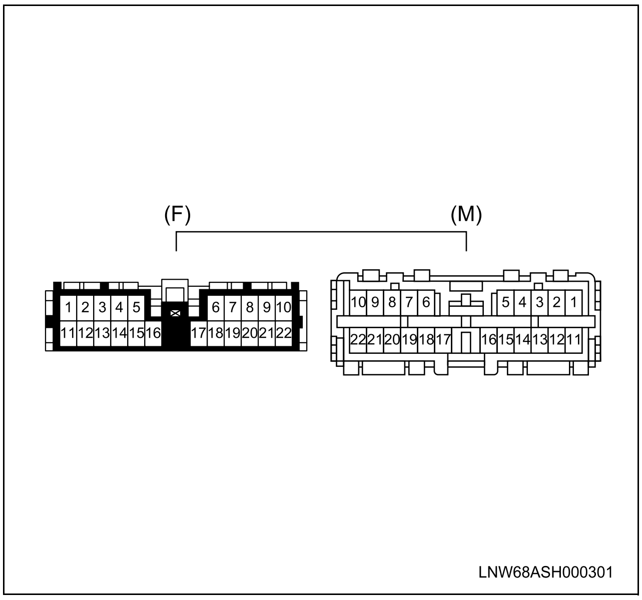
In-Line Harness Connector End of Views



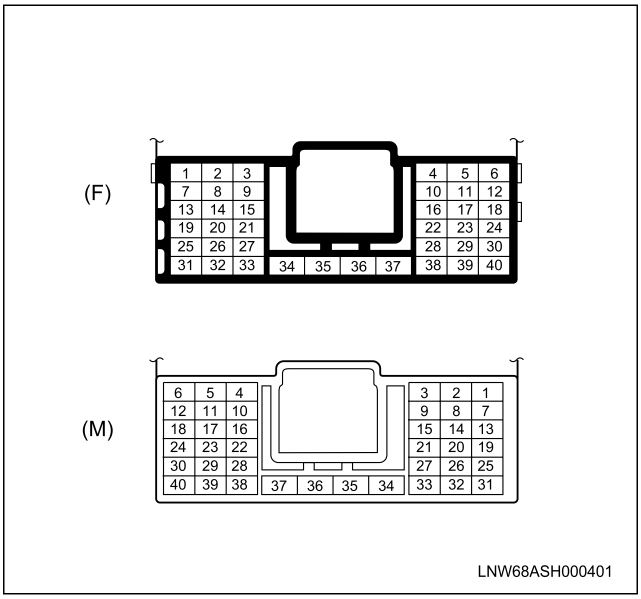
Connector No.		H-2
Connector Color		Yellow
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
1	BLU/BLK	Window Switch RH Voltage Feed
2	—	Not Used
3	BRN/YEL	Door Lock Switch Actuator Control (Passenger Side)
4	BRN/RED	Door Lock Switch Actuator Control (Passenger Side)
5	GRN/YEL	Window Switch RH Control
6	(F)ORN (M)GRN/RED	Speaker RH +
7	(F)BLK (M)GRN	Speaker RH -
8	RED/YEL	Window Switch RH Control



Connector No.		H-3
Connector Color		White
Test Adapter No.		(F) J-35616-40 (M) J-35616-41
Pin	Wire Color	Pin Function
1	BRN/RED	Rear Door Lock Switch Actuator Control (RH)
2	—	Not Used
3	GRY/BLK	Door Switch (Passenger Side) Voltage Feed
4	BRN/YEL	Rear Door Lock Switch Actuator Control (RH)
5	—	Not Used
6	BLK/RED	Rear Heater Voltage Feed via Rear Heater (15A) Fuse

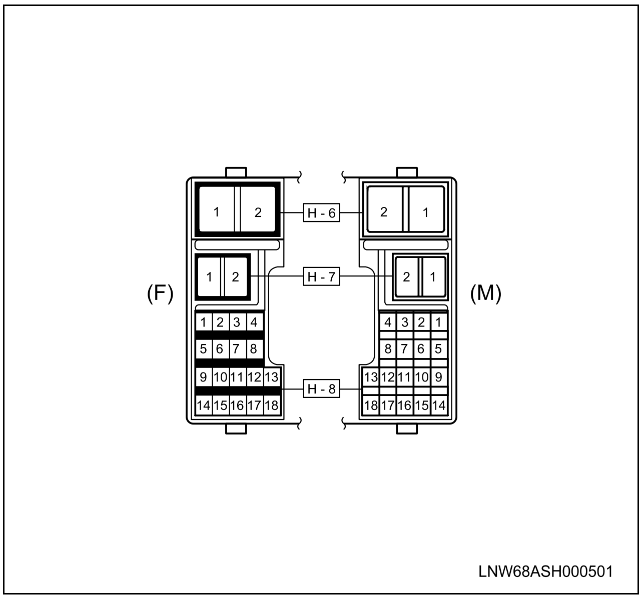


Connector No.		H-4
Connector Color		White
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
1	(F)RED(M) GRY	CAN High Signal
2	BLU/YEL	ATF Temperature Sensor Signal
3	YEL	ATF Temperature Sensor Ground
4	BRN/WHT	Lock-Up Solenoid Control
5	BRN/RED	Shift Solenoid (S2) Control
6	BRN/YEL	Shift Solenoid (S1) Control
7	BRN/BLK	Shift Timing Solenoid Control
8	BRN	Line Pressure Solenoid High Control
9	BRN/GRN	Line Pressure Solenoid Low Control
10	(F)BLK(M) GRY/BLK	CAN Low Signal
11	BLU/WHT	Inhibitor Switch L Range Signal
12	BLU/RED	Inhibitor Switch 2 Range Signal
13	BLU	Inhibitor Switch N Range Signal
14	BLU/ORN	Inhibitor Switch D Range Signal
15	YEL/GRN	ATF Switch
16	WHT/RED	Inhibitor Switch P Range Signal
17	(F)LT GRN/ BLK (M) LT GRN	Exhaust Brake Cut Relay Signal
18	(F)YEL/ RED (M)YEL	VSS 1 Signal
19	(F)BLK (M)BLU	VSS 1 Signal Ground
20	(F)YEL/ RED (M)RED	Exhaust Brake Control Relay Signal

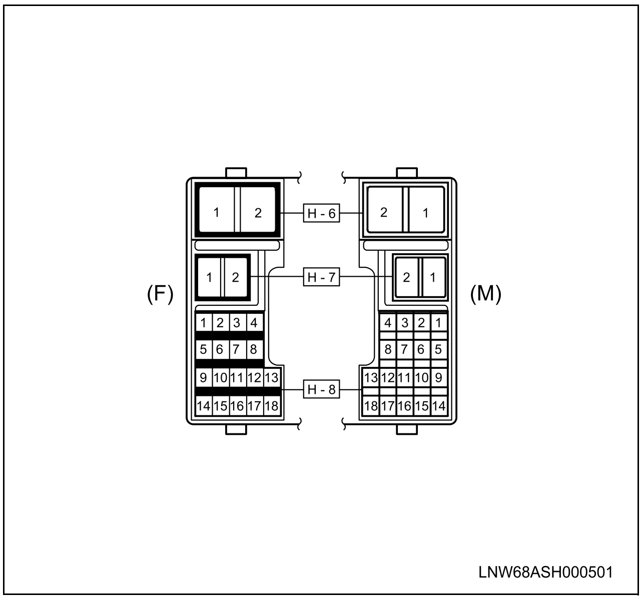


Connector No.		H-5
Connector Color		Gray
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
1	BRN/YEL	Clutch Switch (M/T) Buzzer Cancel Relay Control to Inhibitor Switch (A/T)
2	GRN/WHT	Ceramic Heater Relay Control to Full Hot Switch (M/T)
	RED/BLU	Inhibitor Switch R Range Signal , Backup Light Signal (A/T)
3	GRN/WHT	Horn Voltage Feed From Horn Relay
4	BRN/WHT	Exhaust Brake Switch Signal
5	RED/GRN	Marker Light, ID Light Voltage Feed from ID Light Relay
6	RED/YEL	Idle Up Sensor 5 V Reference
7	RED	Input Speed Sensor (C0) Signal Ground [12,000 lbs GVW]
8	GRN	Input Speed Sensor (C0) Signal [12,000 lbs GVW]
9	BLU/WHT	Transmissiion MIL Request Signal
10	GRN/BLK	Turn Signal Light LH Voltage Feed
11	BLK/PNK	Idle Up Sensor Low Reference
12	RED/BLU	Idle Up Sensor Signal
13	GRN/RED	Cruise Main Lamp Control
14	GRN/WHT	A/C Pressure Switch Voltage Feed

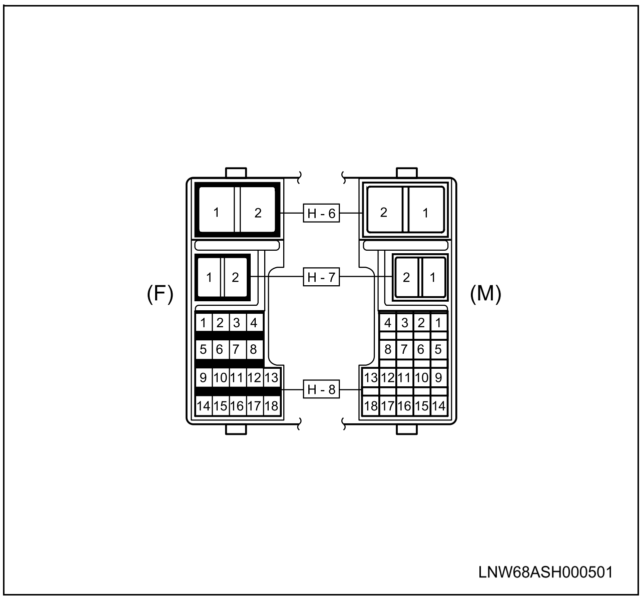
Connector No.		H-5
Connector Color		Gray
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
15	RED	ID Light Relay Voltage Feed via Marker Light (20A) Fuse
16	YEL/VIO	Engine Speed Signal Output to IPC
17	GRN/BLK	Turn Signal Light RH Voltage Feed
18	(F)YEL/ RED (M)YEL/VIO	Oil Level Switch Signal
19	BLK	VSS 2 Low Reference
20	LT BLU	Oil Pressure Switch Signal
21	BLK/RED	Fuel Heater Voltage Feed via Fuel Heater (15) Fuse
22	BLK/YEL	Ignition Voltage Feed via Gauges (10A) Fuse
23	YEL/BLK	Engine Coolant Temperature Gauge Signal
24	BLU/ORN	Cruise Set/Coast Switch & PTO Tap Down Switch Signal
25	YEL/GRN	VSS 2 Signal
26	RED	APP Sensor 1 5 V Reference
27	WHT	APP Sensor 1 Signal
28	RED/WHT	Starter Signal
29	—	APP Sensor 3 Shield
30	GRN/YEL	Cruise Set Lamp Control
31	(F)RED/ GRN (M)BLK/ YEL	VSS 2 +12V Feed
32	—	APP Sensor 1 Shield
33	BLK	APP Sensor 1 Low Reference
34	BLU/RED	APP Sensor 2 5 V Reference
35	BLU	APP Sensor 2 Signal
36	BLU/WHT	APP Sensor 2 Low Reference
37	—	APP Sensor 2 Shield
38	ORN	APP Sensor 3 5 V Reference
39	BLU/GRN	APP Sensor 3 Signal
40	ORN/BLU	APP Sensor 3 Low Reference



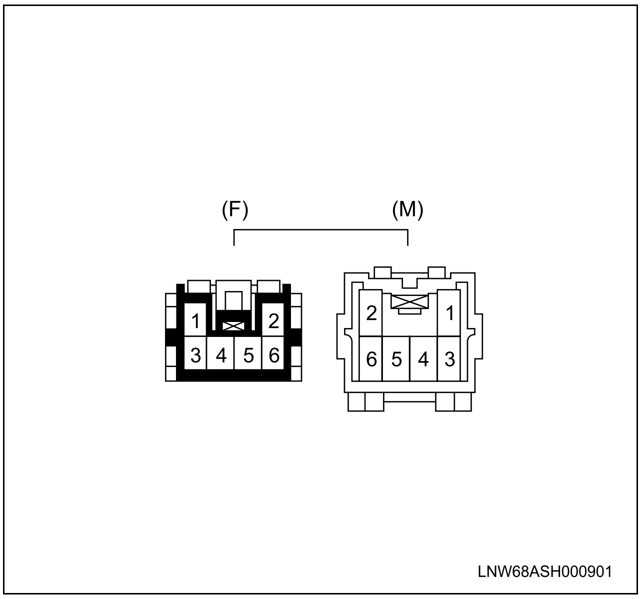
Connector No.		H-6
Connector Color		Gray
Test Adapter No.		—
Pin	Wire Color	Pin Function
1	(F)GRN (M)WHT/ GRN	Ceramic Heater Voltage Feed from Ceramic Heater Relay
2	WHT	Battery Voltage Feed via Main (100A) Slow Blow Fuse



Connector No.		H-7
Connector Color		Gray
Test Adapter No.		(F) J-35616-42 (M) J-35616-43
Pin	Wire Color	Pin Function
1	WHT/BLK	Ignition Switch Battery Voltage Feed via Key (50A) Slow Blow Fuse
2	RED/YEL	Manufacture's Connection Voltage Feed from Rear Dome Light Relay

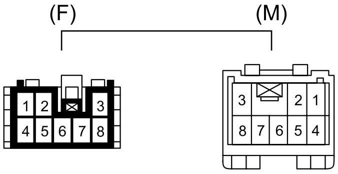


Connector No.		H-8
Connector Color		Gray
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
1	LT GRN/ RED	License Light, Tail Light, ID Relay Voltage Feed fom Tail Relay
2	WHT/VIO	ABS Warning Relay Control
3	PNK/BLK	Service Vehicle Soon (SVS) Lamp Control [12,000 lbs GVW]
4	BLU/RED	Malfunction Indicator Lamp (MIL) Control
5	YEL/RED	Brake Switch 2(Cruise Release) Signal
6	BRN	HBB Oil Level Sensor Voltage Feed from Buzzer Cancel Relay
7	(F)BLK/ RED (M)WHT/ RED	Ignition Voltage Feed via Exhaust Brake (10A) Fuse
8	YEL	Cruise Main Switch Signal
9	YEL/RED	Fuel Level Sensor Signal
10	WHT/BLK	HBB Oil Level Sensor Ground
11	YEL/BLK	Ignition Voltage via ECM(IGN) (10A) Fuse
12	ORN/BLU	Glow Lamp Control
13	YEL/BLU	Generator L Terminal
14	BRN/WHT	Fuel Sedimenter Signal
15	BLU/YEL	Cruise Resume/Accel Switch & PTO Tap Up Switch Signal
16	YEL/BLK	HBB Oil Level Sensor Signal
17	BLU	PTO Switch Signal
18	GRN	Brake Light (Stop Light) Voltage feed



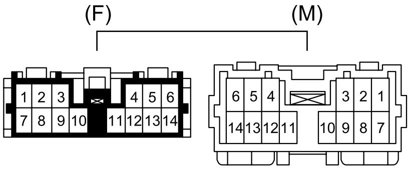
Connector No.		H-10
Connector Color		White
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
1	BLK	Marker Light, ID Light Ground
2	RED/GRN	Marker Light, ID Light Voltage Feed from ID Light Relay
3	—	Not Used

Connector No.		H-10
Connector Color		White
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
4	GRY/BLK	Dome Light Ground to Door Switch
5	—	Not Used
6	RED	Dome Light Voltage Feed via Dome Light (15A) Fuse



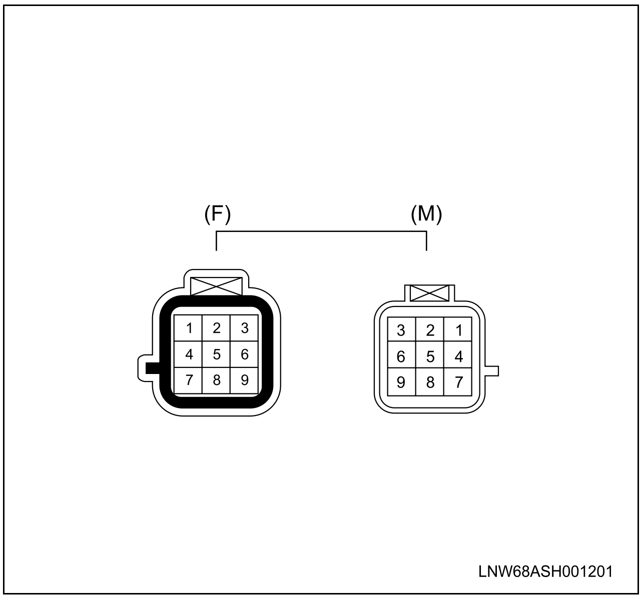
LNW68ASH001001

Connector No.		H-11
Connector Color		White
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
1	BLU/BLK	Power Window Switch Voltage Feed from Power Window Relay
2	—	Not Used
3	BLK	Door Lock Switch (Driver Side) Ground
4	GRN/BLK	Door Lock Switch (Driver Side) Voltage Feed
5	GRN/YEL	Window Switch RH Control
6	ORN	Speaker LH +
7	BLK	Speaker LH -
8	RED/YEL	Window Switch RH Control

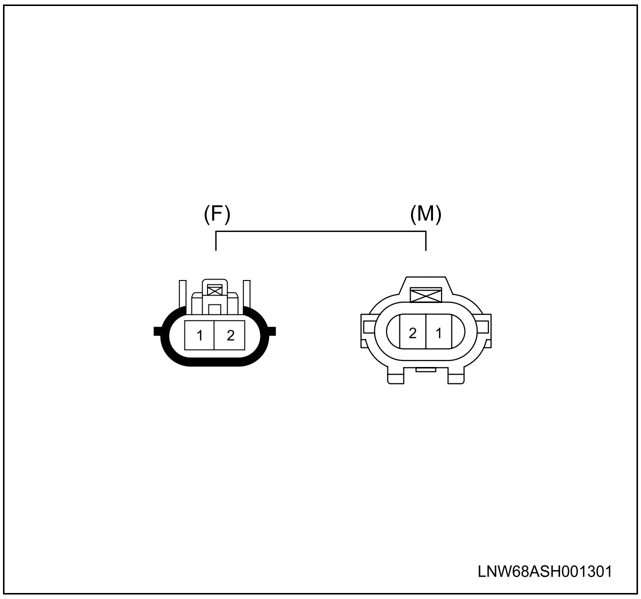


LNW68ASH001101

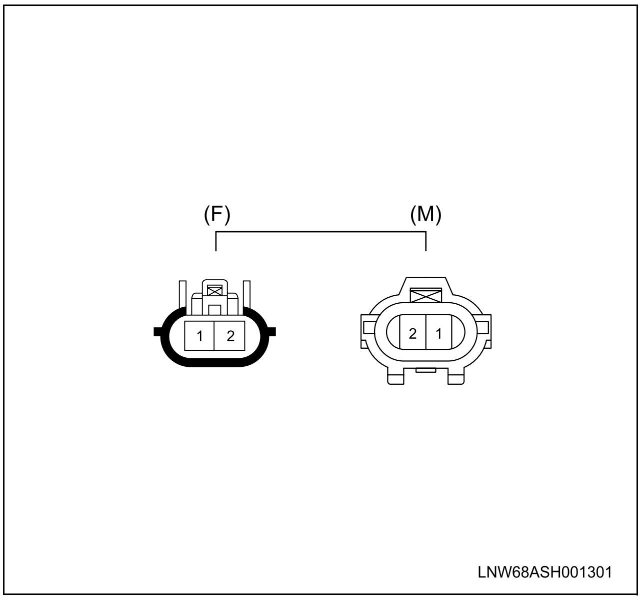
Connector No.		H-12
Connector Color		White
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
1	—	Not Used
2	LT GRN/ RED	OD OFF Switch Illumination +
3	(F)WHT/ BLK (M)WHT/ GRN	Parking BrakeSwitch Signal
4	GRY/BLK	Door Switch (Driver Side) Voltage Feed
5	LT GRN/ BLK	OD OFF Switch Illumination -
6	BRN/RED	Rear Door Lock Switch Actuator Control (LH)
7	—	Not Used
8	ORN	OD Switch Voltage Feed
9	BLK	OD OFF Switch Ground
10	—	Not Used
11	—	Not Used
12	—	Not Used
13	—	Not Used
14	BRN/YEL	Rear Door Lock Switch Actuator Control (LH)



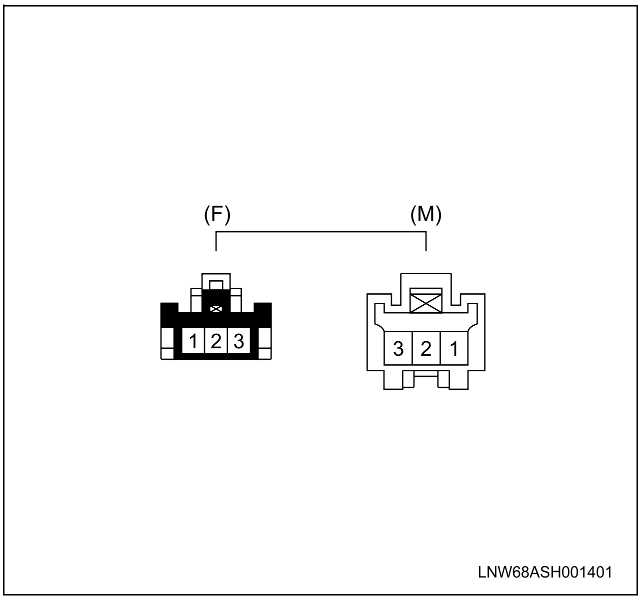
Connector No.		H-16
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-5
Pin	Wire Color	Pin Function
1	GRN/BLK	Turn Signal (LH) Light Voltage Feed
2	—	Not Used
3	LT GRN/ RED	Tail Light Voltage Feed
4	RED/BLU	Backup Light Voltage Feed
5	—	Not Used
6	GRN	Brake Light (Stop Light) Voltage Feed
7	LT GRN/ RED	Lisence Light Voltage Feed
8	BLK	Turn Signal Light, Tail Light, Brake Light (Stop Light), Backup Light, LisenceLight Ground
9	GRN/WHT	Turn Signal (RH) Light Voltage Feed



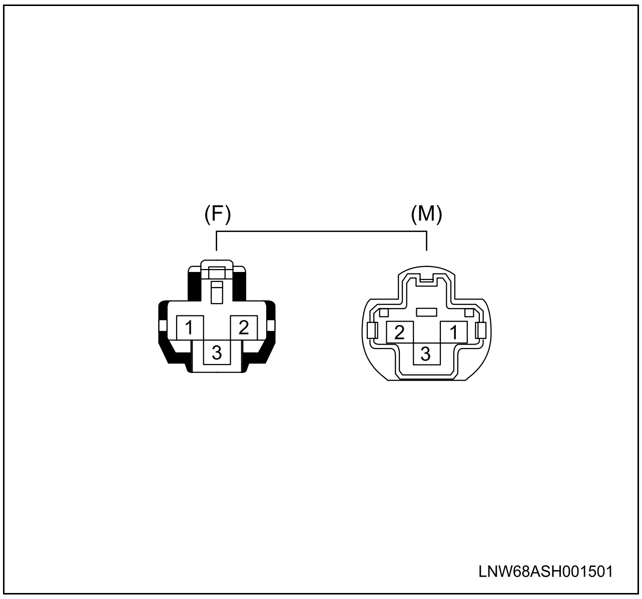
Connector No.		H-18
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-5
Pin	Wire Color	Pin Function
1	BRN/YEL	Rear Door Lock Switch Actuator Control (LH)
2	BRN/RED	Rear Door Lock Switch Actuator Control (LH)



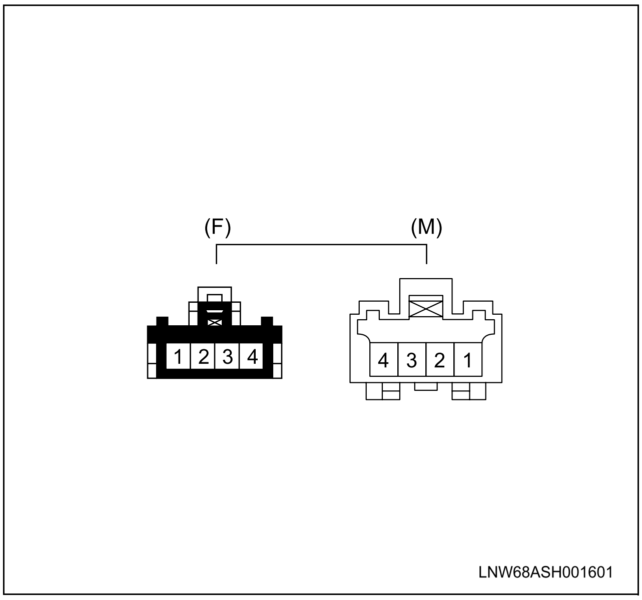
Connector No.		H-19
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-5
Pin	Wire Color	Pin Function
1	BRN/YEL	Rear Door Lock Switch Actuator Control (RH)
2	BRN/RED	Rear Door Lock Switch Actuator Control (RH)



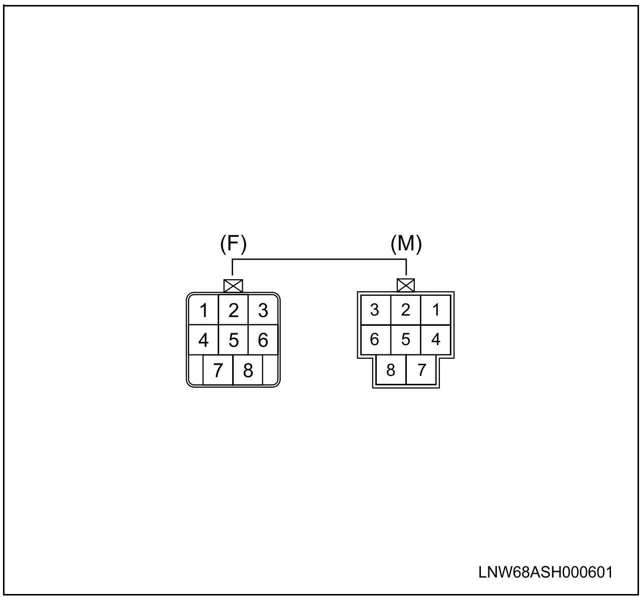
Connector No.		H-20
Connector Color		White
Test Adapter No.		(F) J-35616-64A (M) J-35616-5
Pin	Wire Color	Pin Function
1	—	Not Used
2	RED	Rear Dome Light Voltage Feed via Dome Light (15A) Fuse (Crew Cab Only)
3	GRY/BLK	Rear Dome Light Ground to Door Switch (Crew Cab Only)



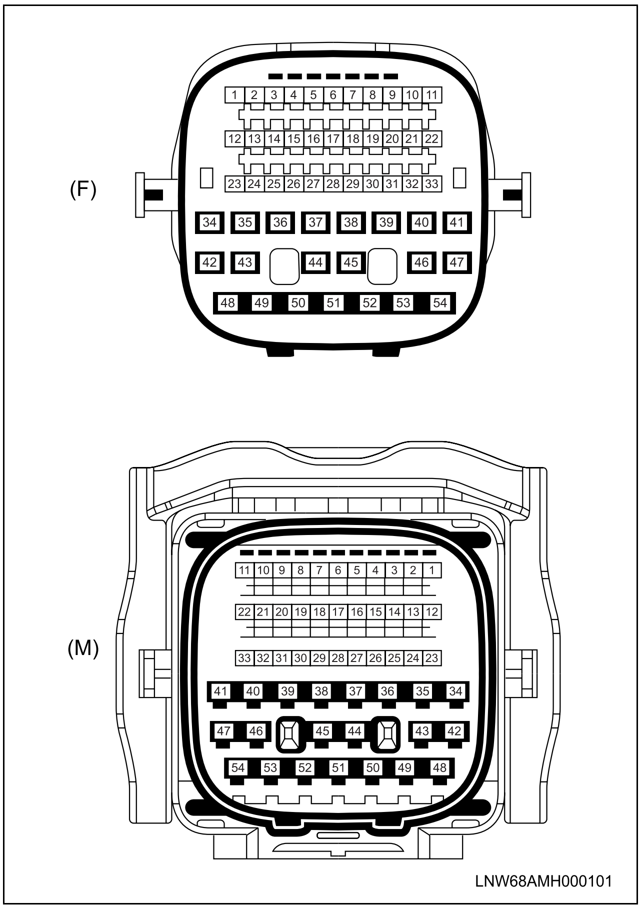
Connector No.		H-31
Connector Color		Blue
Test Adapter No.		(F) J-35616-42 (M) J-35616-43
Pin	Wire Color	Pin Function
1	GRN/YEL	Ceramic Heater Relay Control to Blower Motor Switch (Fan Switch)
2	GRN/WHT	Ceramic Heater Relay Control to Full Hot Switch
3	WHT/GRN	Ceramic Heater Voltage Feed from Ceramic Heater Relay



Connector No.		H-61
Connector Color		White
Test Adapter No.		(F) J-35616-64A (M) J-35616-5
Pin	Wire Color	Pin Function
1	BRN/YEL	Door Lock Switch Actuator Control (Driver Side)
2	—	Not Used
3	BRN/RED	Door Lock Switch Actuator Control (Driver Side)
4	—	Not Used

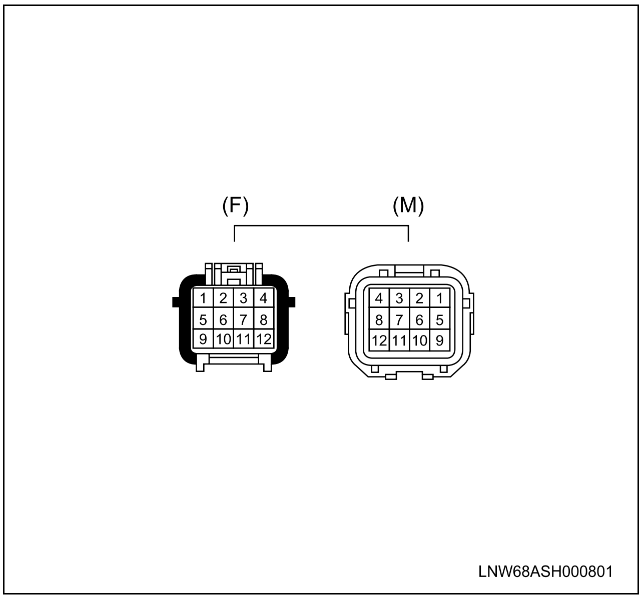


Connector No.		H-105
Connector Color		Black
Test Adapter No.		(F) J-35616-64A[Pin 1-6] (F) J-35616-42[Pin 7-8] (M) J-35616-5[Pin 1-6] (M) J-35616-43[Pin 7-8]
Pin	Wire Color	Pin Function
1	(F)LT BLU (M)BLU/ BLK	Oil Pressure Switch Signal
2	—	Not Used
3	(F)YEL/ RED (M)GRN	Oil Level Switch Signal
4	(F)LT GRN/ BLK (M)GRN/ BLK	Thermo Switch Voltage feed from Exhaust Brake Cut Relay
5	(F)BRN (M)GRN/ YEL	Ceramic Heater Relay Voltage feed from Thermo Switch
6	—	Not Used
7	(F)GRN/ ORN (M)WHT/ RED	A/C Compressor Voltage feed
8	(F)BLK/YEL (M)BLK/ GRN	Glow Plug Voltage Feed [Except 12,000 lbs GVW]



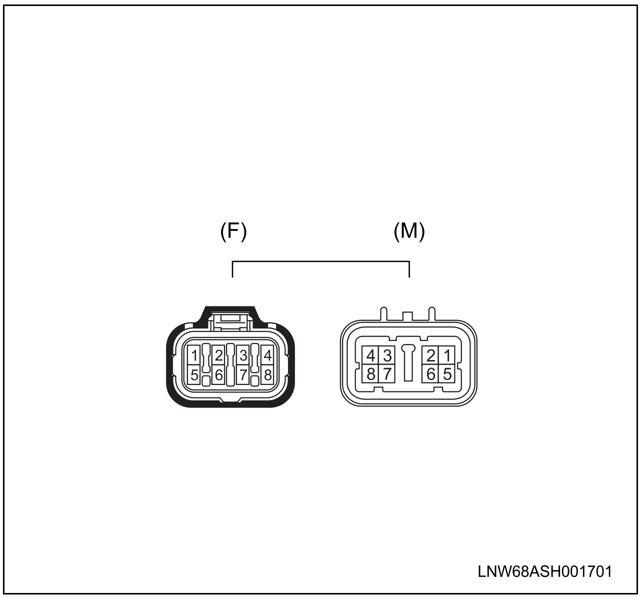
Connector No.		H-121
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-3[Pin 1-33] (M) J-35616-5[Pin 34-54]
Pin	Wire Color	Pin Function
1	BLK	FT Sensor Low Reference
2	(F)WHT/ ORN (M)WHT/ GRN	EGR Position Sensor Signal
3	—	Not Used
4	WHT/BLU	CKP Sensor Low Signal
5	(F)RED (M)ORN	CMP Sensor 12 V Reference
6	—	Not Used
7	(F)BLU (M)BRN	EGR Position Sensor 5 V Reference
8	—	Not Used
9	RED/GRN	FT Sensor Signal
10	GRN	FRP Sensor Signal
11	—	Not Used
12	BLK	ECT Sensor Low Reference
13	—	Not Used
14	—	Not Used
15	WHT/RED	CKP Sensor High Signal
16	BLU	CMP Sensor Signal
17	—	Not Used
18	—	Not Used
19	—	Not Used
20	WHT	FRP Sensor 5V Reference
21	GRN	FRP Sensor Signal
22	(F)RED/ GRN (M)RED	CAN High Signal
23	—	Not Used
24	RED/BLK	ECT Sensor Signal
25	—	Not Used
26	WHT	CKP Sensor Shield
27	(F)BLK/ WHT (M)GRY	CMP Sensor Shield
28	WHT/BLK	EGR Position Sensor Low Reference
29	—	Not Used
30	—	Not Used
31	—	Not Used
32	RED	FRP Sensor Low Reference
33	(F)WHT/ GRN (M)BLK	CAN Low Signal(A/T)
	(F)WHT/ GRN (M)GRY	CAN Low Signal (M/T)
34	GRN/WHT	Cylinder #1 Injector Control
35	—	Not Used
36	BLK	Cylinder #4 Injector Control
37	WHT/YEL	Cylinder #3 Injector Control
38	—	Not Used
39	BLU	Cylinder #2 Injector Control
40	(F)WHT/ RED (M)ORN	Fuel Rail Pressure (FRP) Regulator High Control
41	(F) WHT or WHT/RED (M) WHT/ RED	Fuel Rail Pressure (FRP) Regulator High Control
42	(F)BLU (M)GRN	Fuel Rail Pressure (FRP) Regulator Low Control
43	(F)BLU (M)YEL	Fuel Rail Pressure (FRP) Regulator Low Control
44	—	Not Used
45	BLK/YEL	Glow Plug Controller Ignition Voltage Feed
46	—	Not Used
47	LT GRN/ RED	EGR DC Motor Duty Signal
48	BLK/ORN	EGR DC Motor +12 V Feed
49	BLU/RED	Cylinder #2, #3 Injector Power Supply
50	BLU/WHT	Cylinder #1, #4 Injector Power Supply

Connector No.		H-121
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-3[Pin 1-33] (M) J-35616-5[Pin 34-54]
Pin	Wire Color	Pin Function
51	RED	Cylinder #2, #3 Injector Power Supply
52	WHT	Cylinder #1, #4 Injector Power Supply
53	—	Not Used
54	—	Not Used

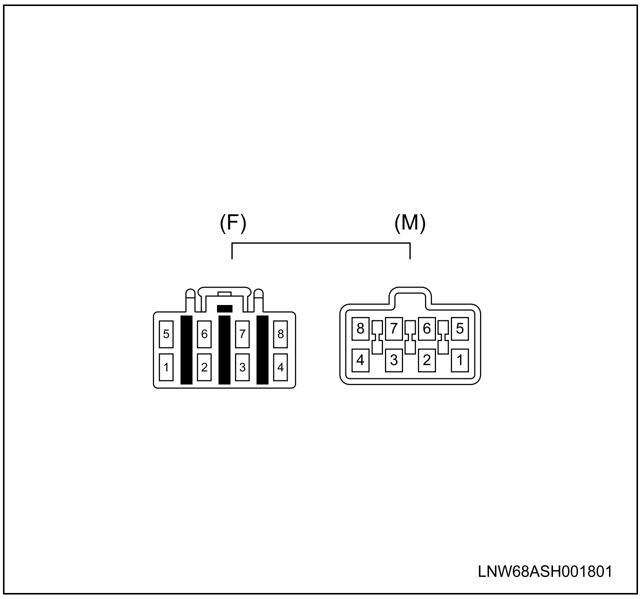


Connector No.		H-124
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
1	WHT	KWP2000 (Not Used)
2	ORN	Class 2 ECM
3	WHT/BLK	Class 2 EHCU
4	—	Not Used
5	—	Not Used
6	—	Not Used
7	BLK/BLU	ECM Ground
8	RED	Battery Voltage Feed via Power Source (15A) Fuse
9	—	Not Used
10	LT BLU	Engine Speed Signal Output to TCM (A/T Only)

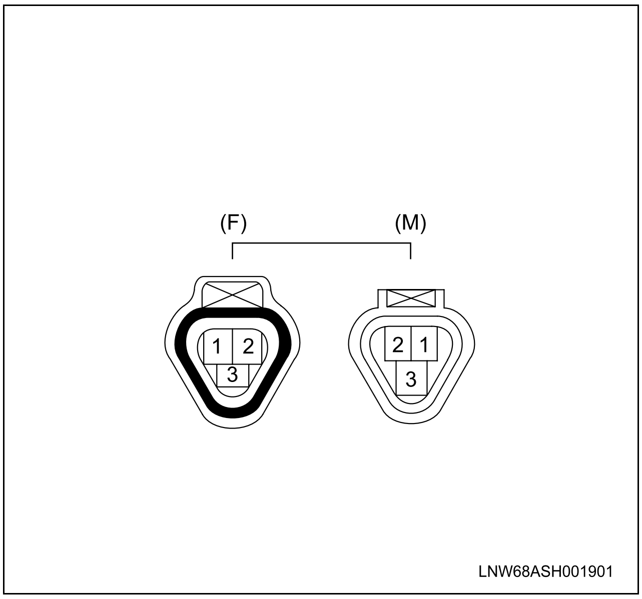
Connector No.		H-124
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
11	—	Not Used
12	WHT/BLU	ABS Diagnostic Switch



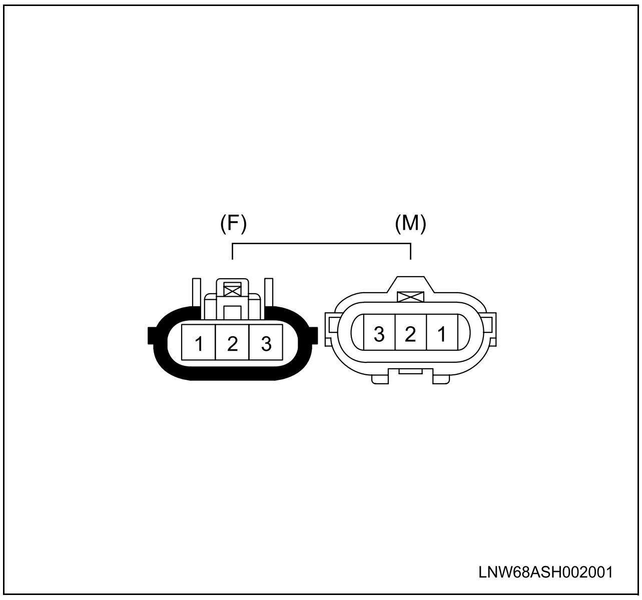
Connector No.		H-125
Connector Color		Gray
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
1	(F)WHT	Cylinder #1, #4 Injector Power Supply
2	(F)RED	Cylinder #2, #3 Injector Power Supply
3	(F)BLU/ RED	Cylinder #2, #3 Injector Power Supply
4	(F)BLU/ WHT	Cylinder #1, #4 Injector Power Supply
5	(F)GRN/ WHT	Cylinder #1 Injector Control
6	(F)BLU	Cylinder #2 Injector Control
7	(F)WHT/ YEL	Cylinder #3 Injector Control
8	(F)BLK	Cylinder #4 Injector Control



Connector No.		H-126
Connector Color		Gray
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
1	(F)WHT	Cylinder #1, #4 Injector Power Supply
2	(F)RED	Cylinder #2, #3 Injector Power Supply
3	(F)RED	Cylinder #2, #3 Injector Power Supply
4	(F)WHT	Cylinder #1, #4 Injector Power Supply
5	(F)GRN	Cylinder #1 Injector Control
6	(F)BLU	Cylinder #2 Injector Control
7	(F)YEL	Cylinder #3 Injector Control
8	(F)BLK	Cylinder #4 Injector Control

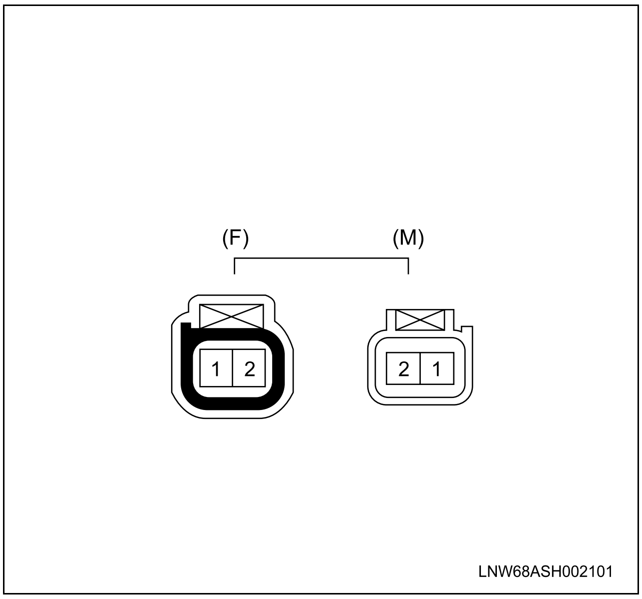


Connector No.		H-127
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-5
Pin	Wire Color	Pin Function
1	YEL	Fuel Level Sensor Signal
2	—	Not Used
3	BLK	Fuel Level Sensor Ground

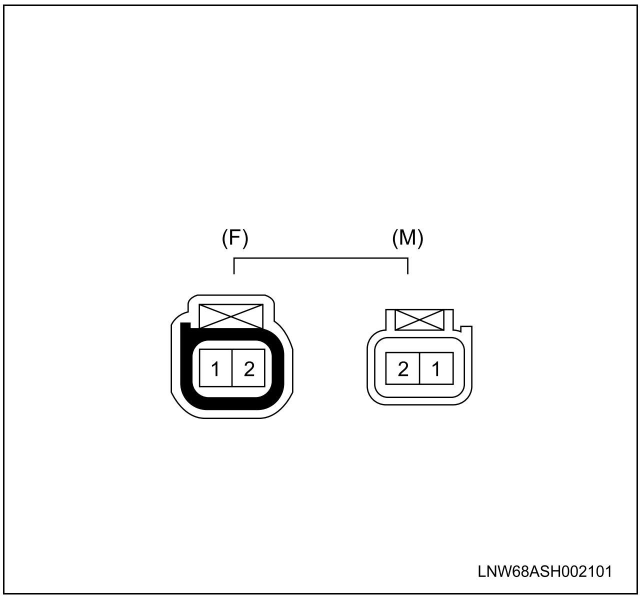


Connector No.		H-134
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-5
Pin	Wire Color	Pin Function
1	RED/GRN	Headlight(LH) Low Control

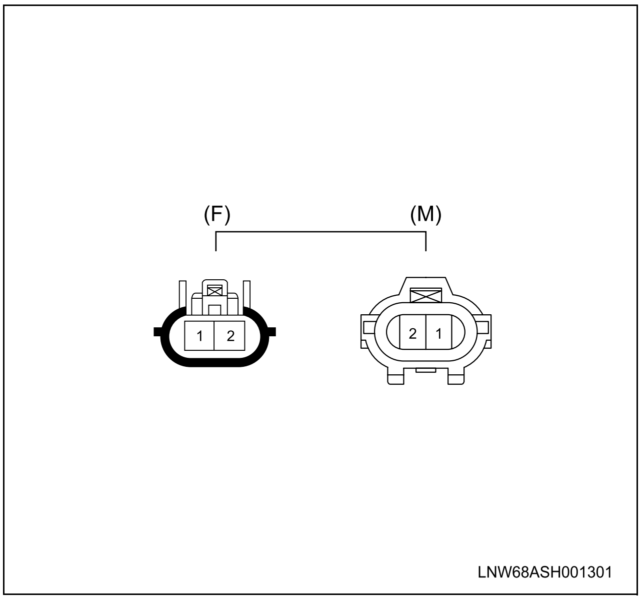
Connector No.		H-134
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-5
Pin	Wire Color	Pin Function
2	RED/BLU	Headlight Left side Voltage Feed via Headlight(LH)(20A) Fuse
3	RED/YEL	Headlight(LH) High Control



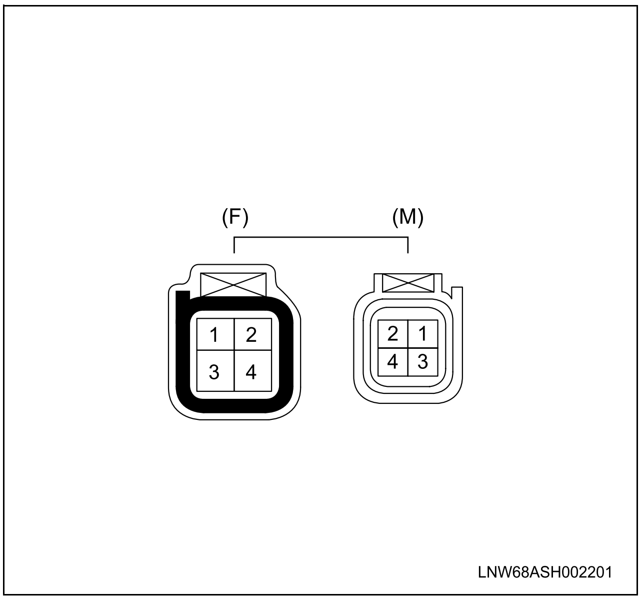
Connector No.		H-135
Connector Color		White
Test Adapter No.		(F) J-35616-64A (M) J-35616-5
Pin	Wire Color	Pin Function
1	(F) WHT (M) RED	Wheel Speed Sensor Rear Right 12V Reference
2	(F) BLK (M) WHT	Wheel Speed Sensor Rear Right Signal



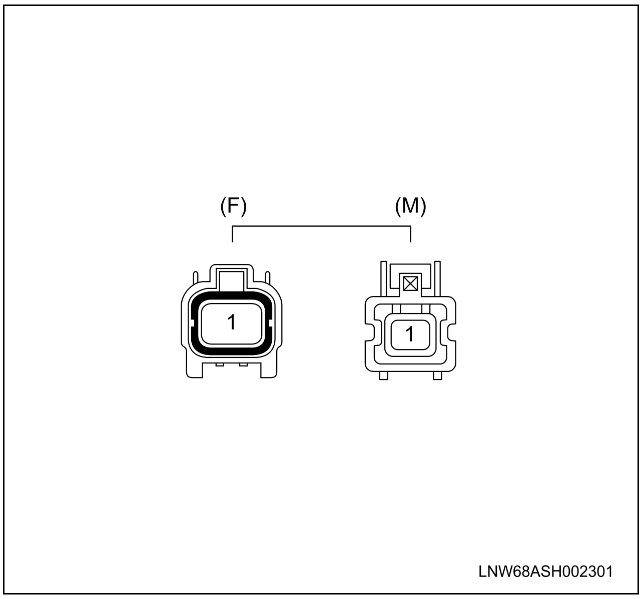
Connector No.		H-136
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-5
Pin	Wire Color	Pin Function
1	(F) WHT (M) BLU	Wheel Speed Sensor Rear Left 12V Reference
2	(F) BLK (M) YEL	Wheel Speed Sensor Rear Left Signal



Connector No.		H-137
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-3
Pin	Wire Color	Pin Function
1	BLU	Condenser Fan Voltage Feed from Condenser Fan Relay
2	BLK	Condenser Fan Ground



Connector No.		H-138
Connector Color		Black
Test Adapter No.		(F) J-35616-64A (M) J-35616-5
Pin	Wire Color	Pin Function
1	GRN/WHT	Pressure Switch Voltage Feed from A/C Thermo Relay
2	GRN/ORN	A/C Compressor Voltage Feed from Pressoer Switch
3	GRN/YEL	Condenser Fan Relay Voltage Feed from Pressure Switch
4	GRN/WHT	Pressure Switch Voltage Feed from A/C Thermo Relay



Connector No.		H-139
Connector Color		Black
Test Adapter No.		—
Pin	Wire Color	Pin Function
1	WHT/BLK	Glow Plug Controller Battery Voltage Feed

Connector Test Adapter List

Connector Test Adapter List

Connector No.	Test Adapter No.
B-5	J-35616-64A
B-8	J-35616-42
B-9	J-35616-42
B-11	J-35616-42
B-12	J-35616-64A
B-13	J-35616-42
B-14	J-35616-42
B-15	J-35616-64A
B-16	J-35616-42
B-19	J-35616-42
B-20	J-35616-42
B-21	J-35616-42
B-22	J-35616-42
B-23	J-35616-42
B-24	J-35616-42
B-25	J-35616-64A
B-26	J-35616-64A
B-28	J-35616-64A
B-30	J-35616-4A
B-33	J-35616-64A
B-34	J-35616-42
B-35	J-35616-42
B-37	J-35616-42
B-38	J-35616-42
B-39	J-35616-42
B-42	J-35616-42
B-43	J-35616-42
B-44	J-35616-40
B-45	J-35616-42
B-46	J-35616-64A
B-51	J-35616-64A
B-52	J-35616-64A
B-53	J-35616-64A
B-66	J-35616-42
B-67(F)	J-35616-42
B-67(M)	J-35616-43

Connector No.	Test Adapter No.
B-69(F)	J-35616-4A
B-69(M)	J-35616-5
B-70	J-35616-3
B-71	J-35616-64A
B-73	J-35616-4A
B-74	J-35616-64A
B-79	J-35616-2A
B-85	J-35616-42
B-89	J-35616-42
B-158	J-35616-3
B-159	J-35616-42
B-160	J-35616-42
B-161	J-35616-64A
B-211	J-35616-42
B-225	J-35616-40
B-226	J-35616-64A
B-229	J-35616-64A
B-230	J-35616-64A
B-231	J-35616-64A
B-236	J-35616-64A
B-264	J-35616-4A
B-280	J-35616-64A
B-306	J-35616-64A
B-307	J-35616-42
B-356	J-35616-42
B-371	J-35616-42
B-373	J-35616-4A
B-374	J-35616-64A
B-376	J-35616-44
B-377	J-35616-4A
B-378	J-35616-4A
D-1	J-35616-40
D-2	J-35616-4A
D-3	J-35616-64A
D-4	J-35616-64A
D-5	J-35616-40
D-6	J-35616-4A

Connector No.	Test Adapter No.
D-7	J-35616-4A
D-8	J-35616-5
D-9	J-35616-64A
D-10	J-35616-64A
E-5	J-35616-64A
E-14	J-35616-64A
E-86	J-35616-64A
E-90	J-35616-64A
E-93	J-35616-64A
E-94	J-35616-64A
E-98	J-35616-64A
E-112	J-35616-64A
E-113	J-35616-64A
E-116	J-35616-64A
E-137	J-35616-4A
E-144	J-35616-2A
E-145	J-35616-42
H-2(F)	J-35616-64A
H-2(M)	J-35616-3
H-3(F)	J-35616-40
H-3(M)	J-35616-41
H-4(F)	J-35616-64A
H-4(M)	J-35616-3
H-5(F)	J-35616-64A
H-5(M)	J-35616-3
H-6(F)	—
H-6(M)	—
H-7(F)	J-35616-42
H-7(M)	J-35616-43
H-8(F)	J-35616-64A
H-8(M)	J-35616-3
H-10(F)	J-35616-64A
H-10(M)	J-35616-3
H-11(F)	J-35616-64A
H-11(M)	J-35616-3
H-12(F)	J-35616-64A
H-12(M)	J-35616-3
H-16(F)	J-35616-64A
H-16(M)	J-35616-5

Connector No.	Test Adapter No.
H-18(F)	J-35616-64A
H-18(M)	J-35616-5
H-19(F)	J-35616-64A
H-19(M)	J-35616-5
H-20(F)	J-35616-64A
H-20(M)	J-35616-5
H-25(F)	J-35616-40
H-31(F)	J-35616-42
H-31(M)	J-35616-43
H-61(F)	J-35616-64A
H-61(M)	J-35616-5
H-105(F)	J-35616-64A
H-105(M)	J-35616-42
H-105(F)	J-35616-5
H-105(M)	J-35616-43
H-121(F)	J-35616-64A
H-121(M)	J-35616-3, 5
H-122(F)	J-35616-64A
H-123(F)	J-35616-64A
H-124(F)	J-35616-64A
H-124(M)	J-35616-3
H-125(F)	J-35616-64A
H-125(M)	J-35616-3
H-134(F)	J-35616-64A
H-134(M)	J-35616-5
H-135(F)	J-35616-64A
H-135(M)	J-35616-5
H-136(F)	J-35616-64A
H-136(M)	J-35616-5
H-137(F)	J-35616-64A
H-137(M)	J-35616-3
H-138(F)	J-35616-64A
H-138(M)	J-35616-5
H-139(F)	—
H-139(M)	—
J-1	J-35616-42
J-4	J-35616-42
J-5	J-35616-42
J-6	J-35616-64A

Connector No.	Test Adapter No.
J-12	J-35616-42
J-13	J-35616-42
J-15	J-35616-42
J-17	J-35616-42
J-18	J-35616-42
J-20	J-35616-42
J-21	J-35616-64A
J-27	J-35616-44
J-28	J-35616-64A
J-31	J-35616-64A
J-32	J-35616-64A
J-40	J-35616-4A
J-49	J-35616-64A
J-50	J-35616-64A
J-51	J-35616-42
J-52	J-35616-5
J-69	J-35616-64A
J-71	J-35616-5
J-73	J-35616-5
J-74	J-35616-64A
J-75	J-35616-64A
J-121	J-35616-3
J-128	J-35616-5
J-129	J-35616-5
J-143	J-35616-9
J-144	J-35616-9
J-148	J-35616-64A
J-149	J-35616-64A
J-177(F)	J-35616-40
J-177(M)	J-35616-64A
J-207	J-35616-64A
J-208	J-35616-42
J-209	J-35616-42
J-210	J-35616-42
J-211	J-35616-64A
J-212	J-35616-5
J-215	J-35616-5
J-216	J-35616-64A
J-217	J-35616-64A
J-218	J-35616-64A
J-219	J-35616-64A
J-240	J-35616-64A
L-2	J-35616-64A
L-4	J-35616-64A
L-5	J-35616-64A
L-31	J-35616-64A
L-32	J-35616-64A
N-1	J-35616-64A
N-2	J-35616-64A
N-5	J-35616-40
N-6	J-35616-3
N-7	J-35616-64A

BODY, CAB, AND ACCESSORIES

Steel Tilt Cab

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Description and Operation

Cab Description

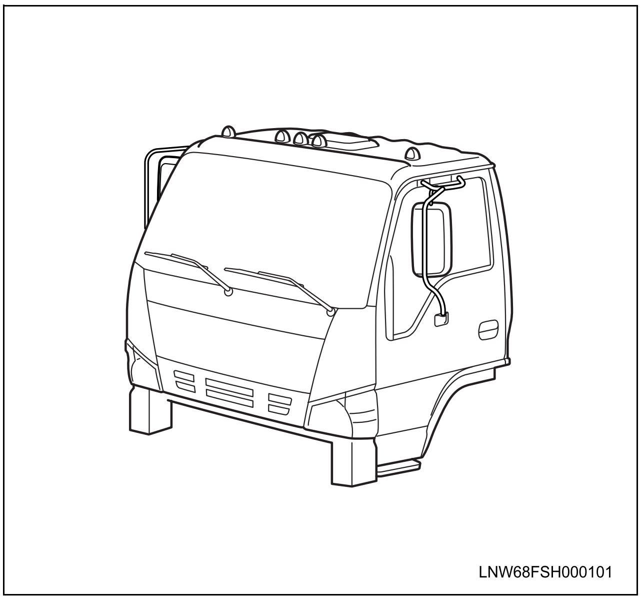
Notice:
When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

Design and Construction

The Steel Tilt Cab Model is all steel welded construction. The cab fully surrounds the engine and can be tilted 45 degrees to expose the engine for servicing. Cab tilting is aided by a torsion spring and lever that extended across the front frame rails. For more details, see “Torsion Spring and Lever Replacement”, later in this section.The rear of the cab rests on two mount brackets which are bolted to the frame rail on both sides of the truck. The brackets contain rubber cushions which act as shock-absorbers. A latch-type hold-down mechanism locks the cab firmly on both brackets.
The combination brake fluid/clutch fluid reservoir is located inside the cab, on the left side of the dash.

Windows

Door windows are covered in this section under “Doors”. All other windows are covered in Cab Maintenance under “Stationary Glass”.



Diagnostic Information and Procedures

Cab Tilts with Difficulty.

POSSIBLE CAUSE	CORRECTION
1. Broken torsion bar lever.	1. Replace the lever.
2. Broken torsion bar.	2. Replace the torsion bar.

Cab will not Tilt.

POSSIBLE CAUSE	CORRECTION
1. Safety catch is not released.	1. Lower the cab completely; release the safety catch, and then release the hold-down catch.
2. Hold-down mechanism is not released.	2. Release the hold-down mechanism (It may be necessary to adjust the mechanism.)
3. Torsion spring is broken.	3. Replace the torsion spring.
4. Broken support bracket.	4. Replace the bracket.
5. Broken torsion bar lever.	5. Replace torsion bar lever.

Cab does not Stay Firmly in the Driving Position; It Jiggles Up and down

POSSIBLE CAUSE	CORRECTION
1. Hold-down mechanism is not latched. (Cab is held only by the safetycatch.)	1. Lower the cab completely.
2. Worn or missing cushion(s) at the rear cab support.	2. Install new cushion(s).

Seat will not move

POSSIBLE CAUSE	CORRECTION
1. Obstructed adjustment mechanism	1. Remove the obstruction.
2. Frozen or obstructed guide rails	2. Replace obstruction and/or remove the seat and the adjustment mechanism. Clean the guide rails and lubricate.
3. Broken adjustment lever.	3. Replace the adjustment mechanism.

Seat moves only on One Side

POSSIBLE CAUSE	CORRECTION
1. Broken or disconnected control wire from the adjustment lever to the opposite side of the seat.	1. Replace or connect the wire.
2. Obstructed guide rail.	2. Remove the obstruction.
3. Obstructed adjustment mechanism.	3. Remove the obstruction.

Seat is Hard to Move

POSSIBLE CAUSE	CORRECTION
1. Tension spring is broken or disconnected.	1. Remove or connect the spring.
2. Rusty or obstructed guide rails.	2. Remove the obstruction and/or lubricate.

Seat will not Stay in Desired Position

POSSIBLE CAUSE	CORRECTION
1. Missing or disconnected adjustment springs.	1. Remove or connect the spring (s).
2. Broken adjustment lever.	2. Replace the adjustment mechanism.

Door will not Latch or Latches with Difficulty

POSSIBLE CAUSE	CORRECTION
1. Door is out of alignment.	1. Align the door.
2. Striker is out of alignment.	2. Align the striker.
3. Cam of the locking mechanism is in the closed position.	3. Unlock the door, pull the outside handle, and manually rotate the cam.
4. Locking mechanism is not attached securely to the door.	4. Tighten the attaching screws of the locking mechanism.
5. Cam of the locking mechanism is bent or broken.	5. Straighten the cam or replace the locking mechanism.

Door will not Lock

POSSIBLE CAUSE	CORRECTION
1. Disconnected lock rod between the outside handle and locking mechanism.	1. Connect rod Use a new clip.
2. Arm of the lock cylinder has not properly engaged the lug of the locking mechanism.	2. Remove the lock cylinder and install as directed later in this section.
3. Lug of the locking mechanism is broken.	3. Replace the locking mechanism.
4. Frozen lock cylinder.	4. Lubricate the lock cylinder or replace.

Door will not Open but It is Unlocked (Door Handles do not Work Freely)

POSSIBLE CAUSE	CORRECTION
1. Door out of alignment	1. Align the door.
2. Striker bolt out of alignment	2. Adjust the striker bolt.
3. Frozen locking mechanism	3. Remove the locking mechanism and lubricate or replace it.

Door will not Open, It is Unlocked, but Release Handle/Lever Works Freely

POSSIBLE CAUSE	CORRECTION
Disconnected rod from the door release mechanism to the locking mechanism.	If disconnected from the release mechanism, remove the mechanism and connect the rod to it. If disconnected from the locking mechanism, connect the rod.

Door is Hard to Open

POSSIBLE CAUSE	CORRECTION
1. Frozen hinge-dirty or incorrect lubricant.	1. Clean the hinge and lubricate
2. Door is out of alignment.	2. Align the door.

Door Window is Difficult to Move

POSSIBLE CAUSE	CORRECTION
1. Rusty or dirty regulator.	1. Remove the regulator, clean and lubricate.
2. Obstructed run channel.	2. Remove obstruction.

Door Window will not Close Nor will Regulator Handle Work

POSSIBLE CAUSE	CORRECTION
1. Obstructed or frozen regulator.	1. Remove the regulator, clean and lubricate.
2. Obstructed regulator guide channel.	2. Remove obstruction.
3. Obstructed run channel.	3. Remove obstruction.
4. Misaligned run channel.	4. Reposition run channel bracket and/or division channel.

Door Window will not Move but Regulator Handle Moves Freely

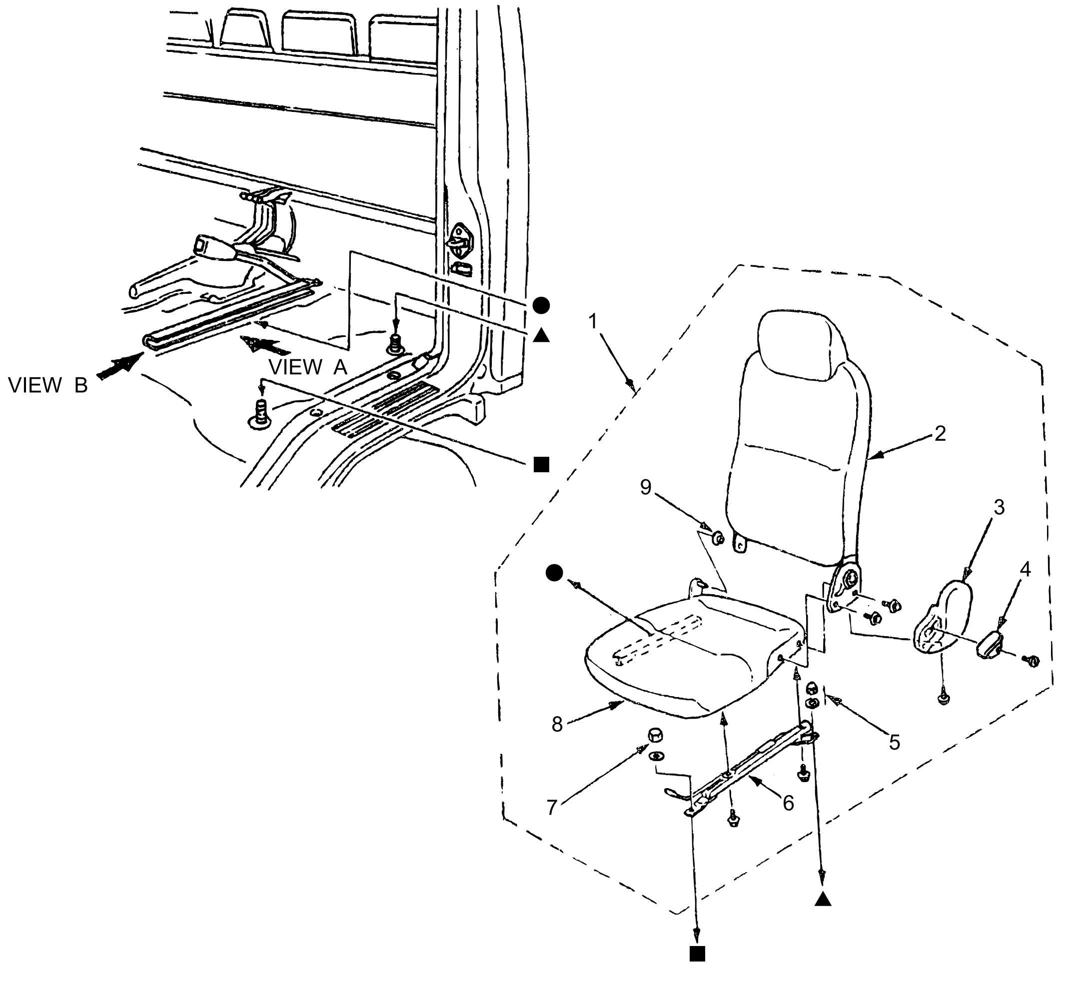
POSSIBLE CAUSE	CORRECTION
1. Stripped window regulator handle.	1. Replace handle.
2. Stripped window regulator shaft.	2. Replace regulator.
3. Regulator roller is not in the guide channel.	3. Remove regulator and install as outlined in this section.
4. The teeth of the regulator gear are broken.	4. Replace regulator.

Repair Instructions

Cab Interior

Adjustment mechanism should be kept clear and lubricated with Lubriplate or equivalent. Cleaning procedures are covered in Cab Maintenance 2B).

Driver's Seat



LNW68FLF000101

Legend

1. Seat Assembly
2. Seat Back Assembly
3. Reclining Cover
4. Reclining Lever
5. Cap Nut and Plain Washer (Rear Side)
6. Seat Rail
7. Cap Nut and Plain Washer (Front Side)
8. Seat Cushion
9. Bush

Removal Procedure

1. Cap nut and plain washer (Rear side)
    - Slide the seat forward and remove the cap nut.
2. Slide the seat backward and remove the cap nut.
3. Remove the seat assembly.
4. Remove the one screw and remove the reclining lever.

5. Remove the one screw and remove the reclining cover.
6. Remove the seat back assembly
7. Remove the 2 bolts.

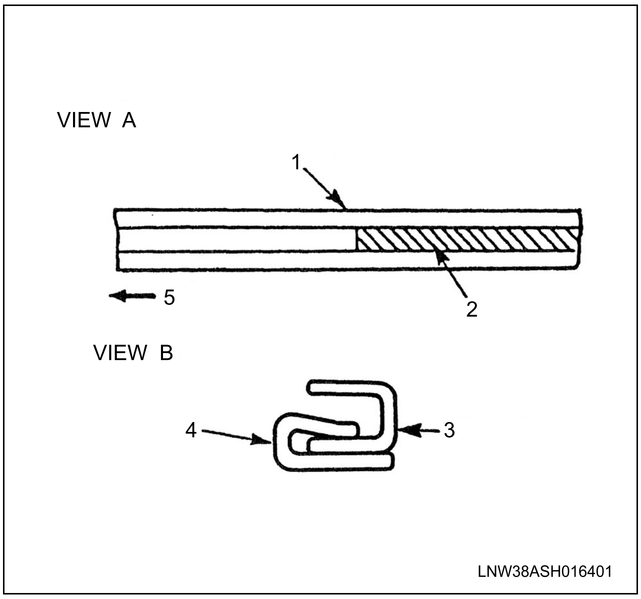
Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. Before installing the seat ASM, apply grease to the backward half of the cab-side seat rail (view at A) and set the claw on the seat frame side (view at B). After that, tighten the cap nut with plain washer.
2. Tighten the cap nut to the specified torque.

Tighten

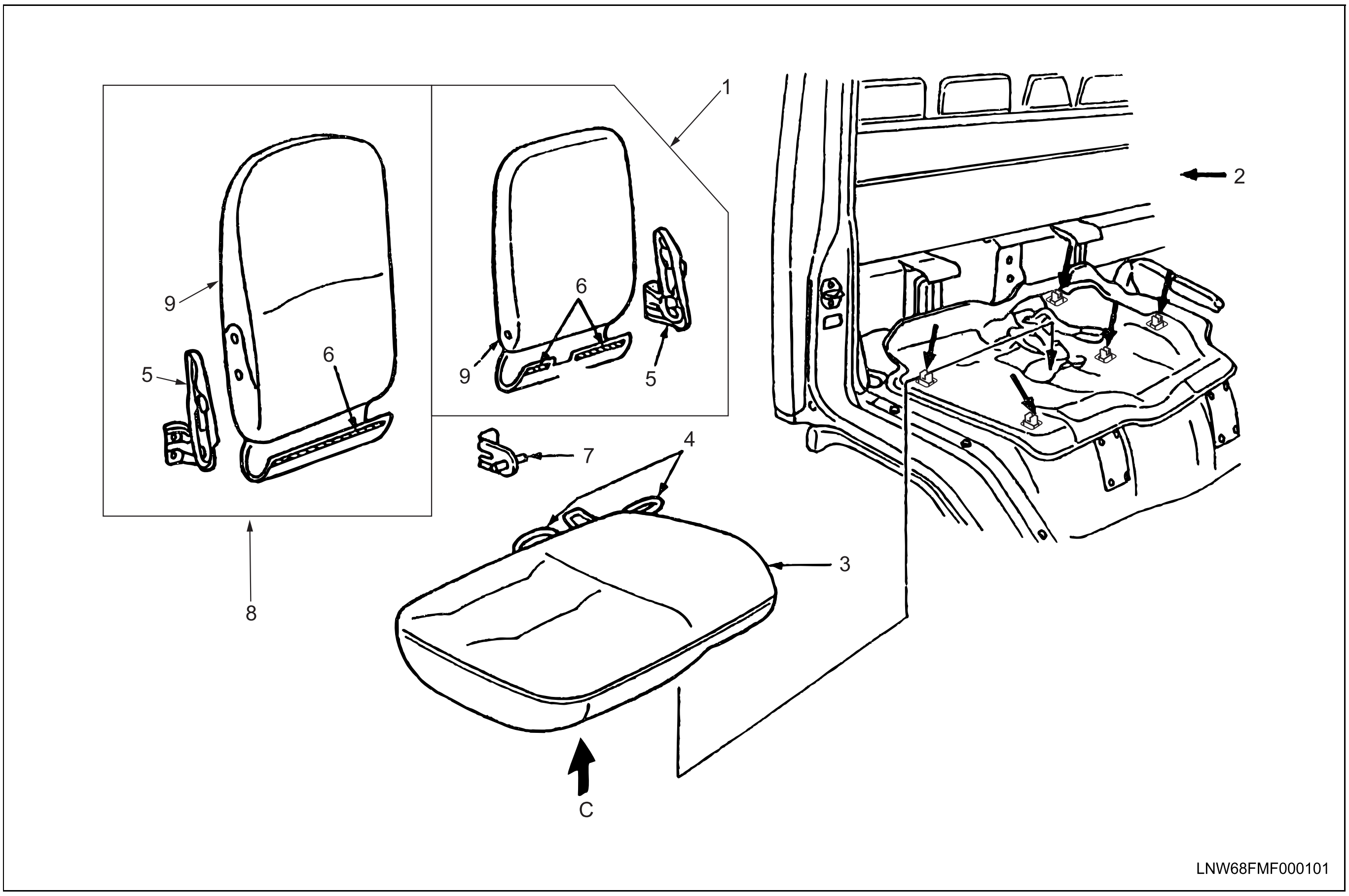
- Cap nut to 25 N·m (18 lb ft).



Legend

1. Seat Rail
2. Grease
3. Seat Frame
4. Cab-Side
5. Forward

Passenger Seat



Legend

1. Center Seat Back Assembly
2. Clip Position

3. Seat Cushion Assembly
4. Band
5. Hinge ASM
6. Fastener
7. Hinge Bracket
8. Passenger Seat Back Assembly
9. Seat Back

Removal Procedure

1. Raise the cushion and remove the clips and peel off the fasteners at 5 positions and pull out the seat belt from the band.
2. Remove the 2 hinge fixing bolts.
3. Remove the 2 fixing bolts and remove the hinge assembly.
4. Remove the 2 hinge fixing bolts.
5. Remove the 2 fixing bolts and remove the hinge assembly.
6. Remove the fixing screws and remove the seat back tray.
7. Remove 2 fixing bolts.

Installation Procedure

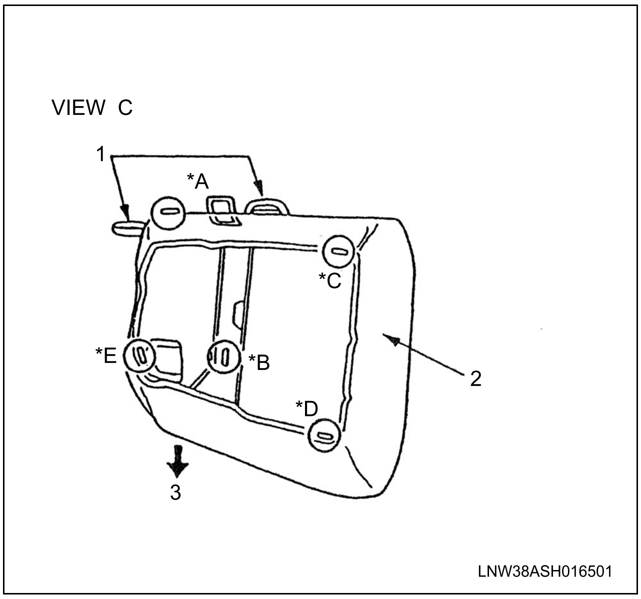
To install, follow the removal steps in the reverse order, noting the following points;

1. Tighten each hinge of the seat back with the specified bolts securely and specified torque

Tighten

- Each hinge bolts to 13 N·m (9 lb ft).

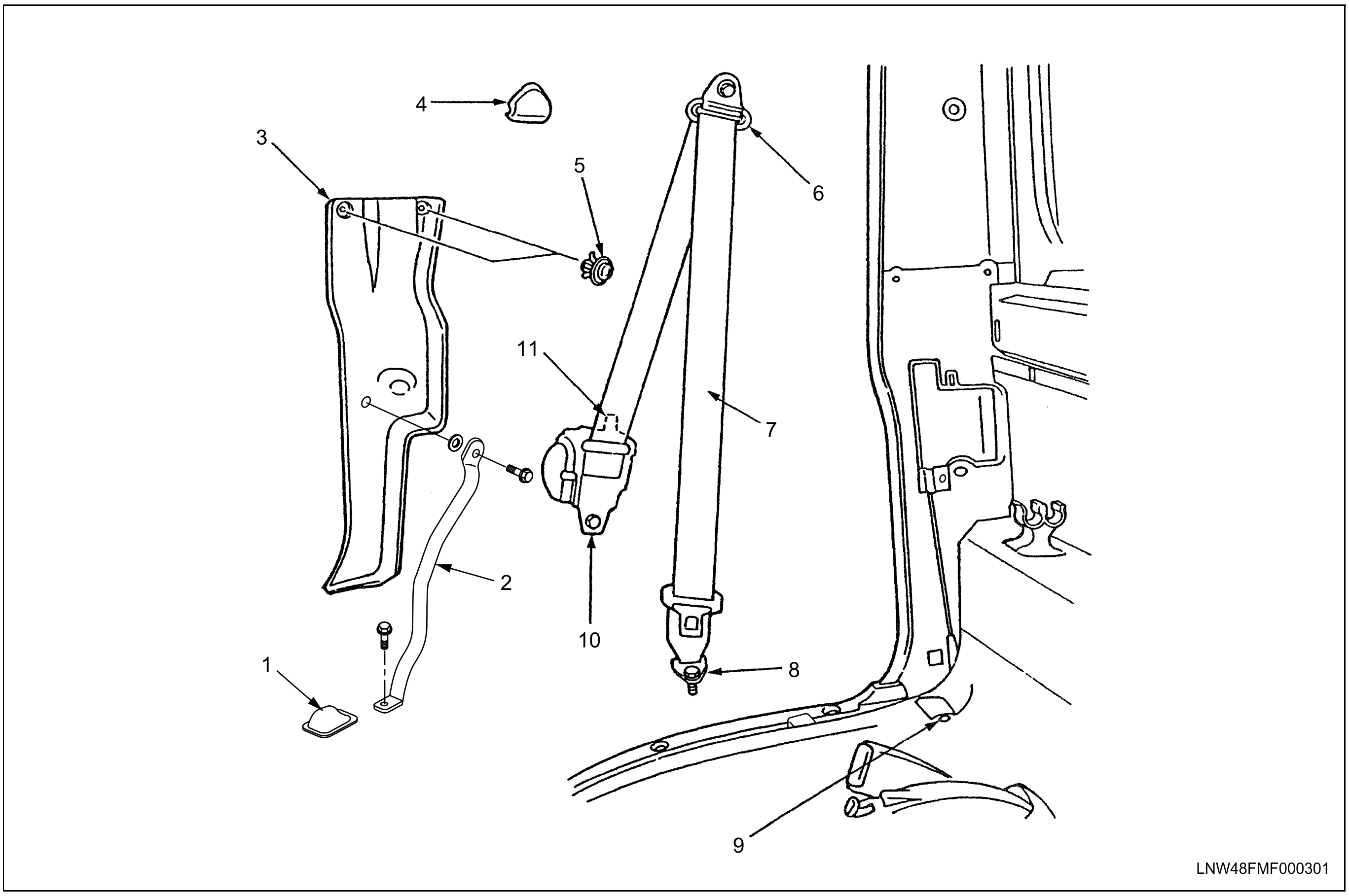
2. Check the direction of seat cushion fixing clip.
3. Pass the seat belt through the seat cushion band.
4. Install the seat cushion in the following order.
   *A→*B→*C→*D→*E



Legend

1. Band
2. Seat Cushion
3. Vehicle Front Side

Seat Belts: Side Seat Belt Tongue



Legend

1. Cap
2. Assist Grip
3. Rear Pillar Lower Trim Cover
4. Through Bolt Anchor Cover
5. Clip
6. Seat Belt Upper Anchor Bolt
7. Seat Belt Tongue Side Assembly
8. Seat Belt Lower Anchor Bolt
9. Seat Belt Lower Anchor Bolt Mounting Hole
10. Retractor Fixing Bolt
11. Bracket

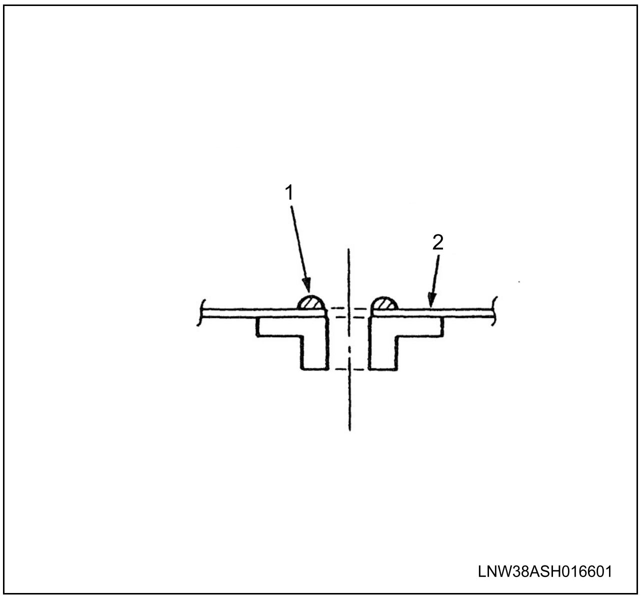
Removal Procedure

1. Remove the assist grip.
    - Remove the cap and assist grip bolt.
2. Remove the seat belt lower anchor bolt.
3. Remove the rear pillar lower trim cover.
    - Remove the 2 clips and pull up the cover.
4. Remove the through bolt anchor cover.
5. Remove the seat belt upper anchor bolt.
6. Remove the bolt and pull out the upper bracket of the retract from the panel.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. Apply the sealant around the seat belt lower anchor bolt mounting hole.



Legend

1. All Periphery Sealing Along the Floor Surface Mounting Hole
2. Floor Panel

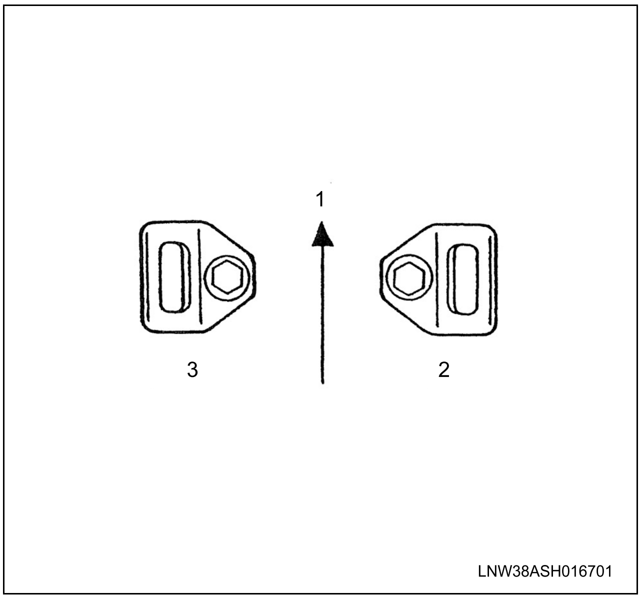
---

2. Install the lower anchor in the specified direction and tighten it to the specified torque.

Tighten

- Anchor bolt and Retractor fixing bolt to 45 N·m (33 lb ft)

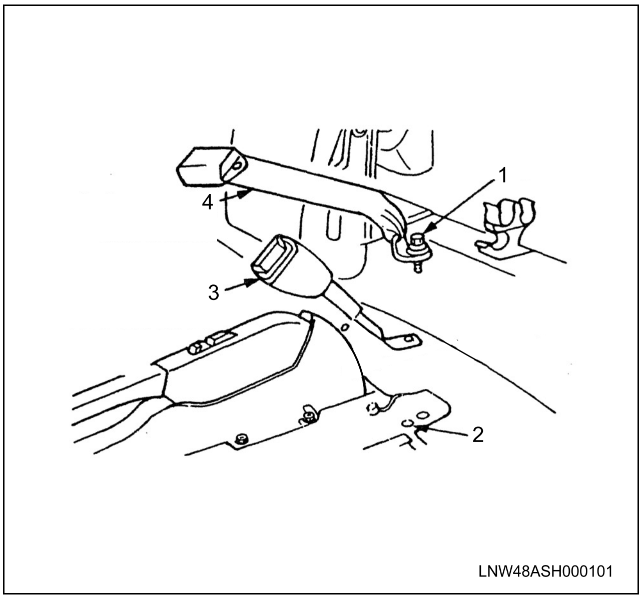
Notice:
Install the seat belt lower anchor so that it may not run on the anchor detent bead.



Legend

1. Vehicle Front Side
2. Right Side
3. Left Side

Front Center and Driver Side Seat Belt Buckle



Legend

1. Fixing Bolt
2. Detent
3. Driver Side Seat Belt Buckle
4. Center Seat Belt Buckle

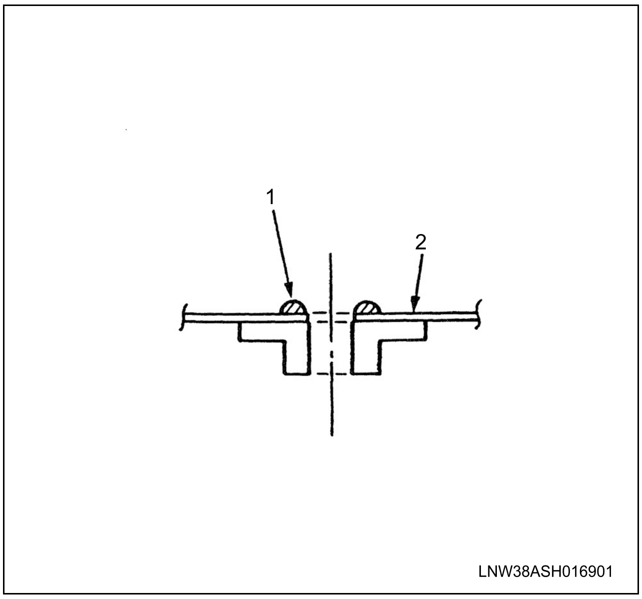
Removal Procedure

1. Remove the fixing bolt.
2. Remove the center seat belt buckle.
3. Remove the driver side seat belt buckle.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. Apply the sealant around the seat belt lower anchor bolt mounting hole.



Legend

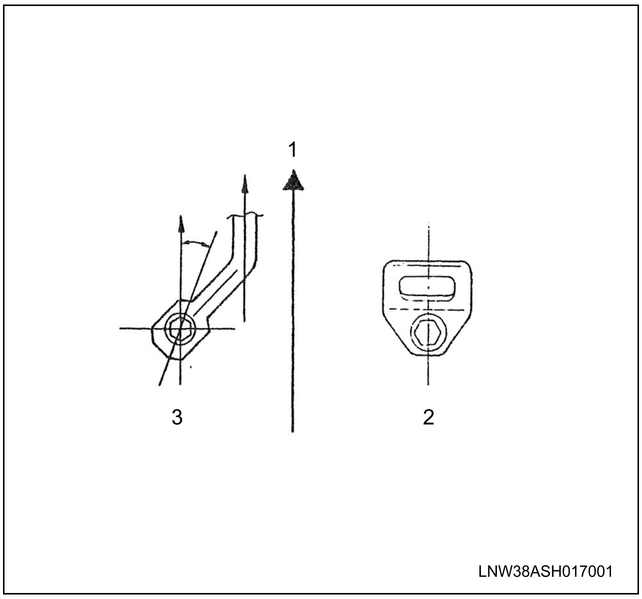
1. All-Periphery Sealing Along the Floor Surface Mounting Hole
2. Floor Panel

---

2. Install the anchor in the specified direction and tighten it to the specified torque.

Tighten

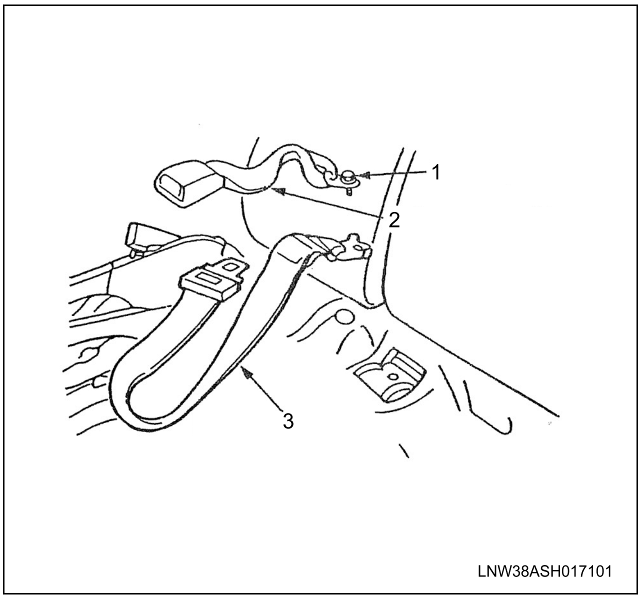
- Anchor bolt to 45 N·m (33 lb ft)



Legend

1. Vehicle Front Side
2. Center Seat Belt Buckle
3. Drive Side Seat Belt Buckle

Front Center Seat Belt Tongue and Passenger Side Seat Belt Buckle



Legend

1. Fixing Bolt
2. Passenger Side Seat Belt Buckle
3. Center Seat Belt Tongue

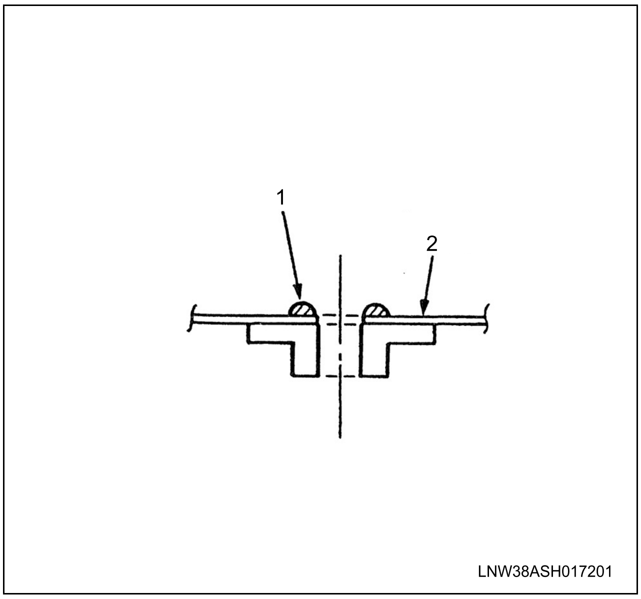
Removal Procedure

1. Remove the fixing bolt.
2. Remove the passenger seat belt buckle.
3. Remove the center seat belt tongue.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. Apply the sealant around the seat belt lower anchor bolt mounting hole.



Legend

1. All-Periphery Sealing Along the Floor Surface Mounting Hole
2. Floor Panel

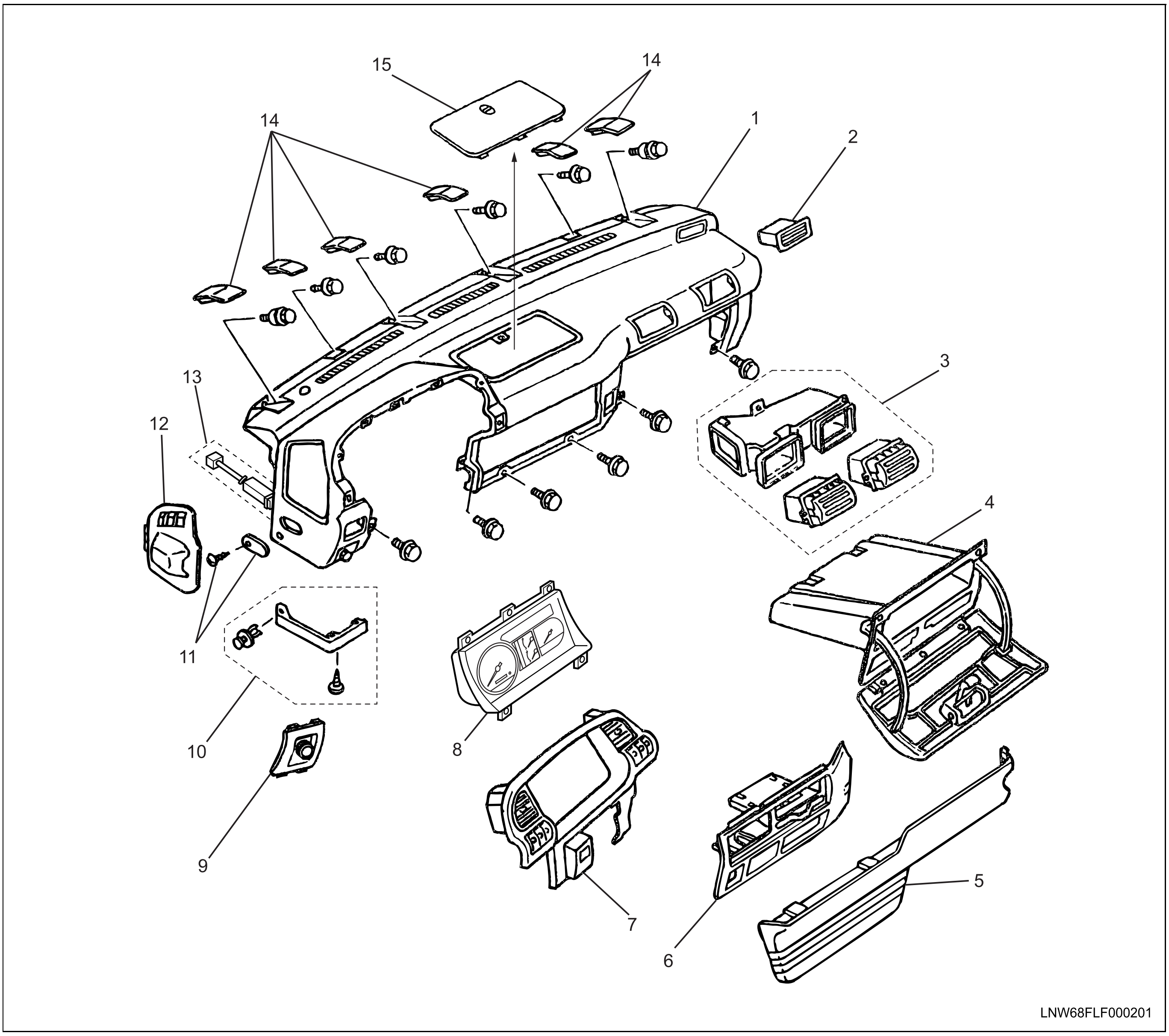
---

2. Install the anchor in parallel to the running direction of the vehicle and tighten the mounting bolt to the specified torque.

Tighten

- Anchor bolt to 45 N·m (33 lb ft)

Instrument Panel



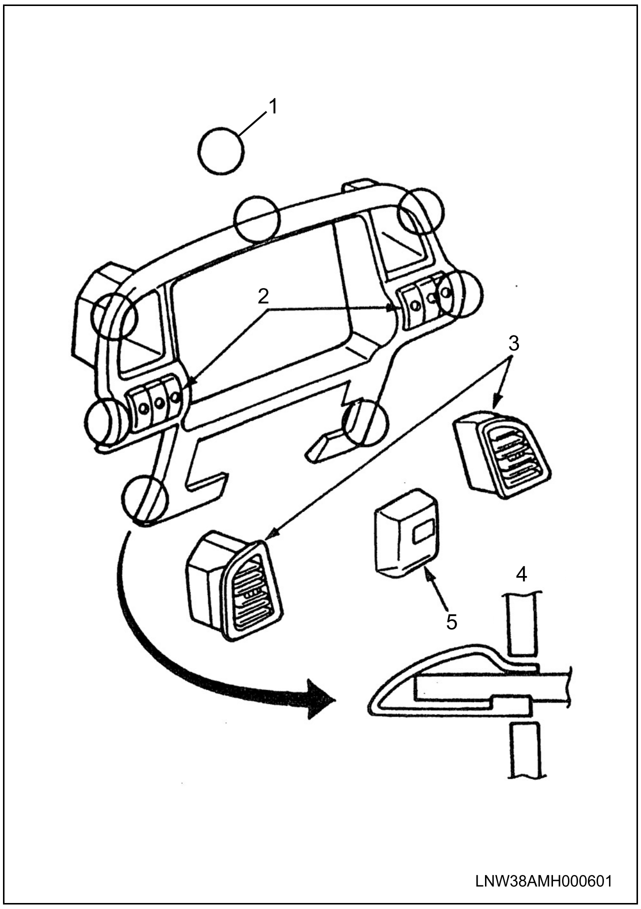
Legend

1. Instrument Panel Assembly
2. Side Defroster Nozzle
3. Vent Duct
4. Grove Box
5. Under Cover
6. Center Cluster
7. Instrument Panel Cluster Bezel
8. Instrument Panel Cluster (IPC)
9. Illumination Control Knob
10. Instrument Panel Extension
11. Instrument Side Grommet
12. Fluid Tank Cover
13. Idle Up Volume
14. Front Cover
15. Relay Lid

Removal Procedure

1. Pull the main unit toward you and remove the clips at 7 positions. Remove each switch connector. When switches are mounted on the switch cover, remove the connectors.

2. Remove the vent grille, switch cover and each switch from the instrument panel cluster bezel proper.



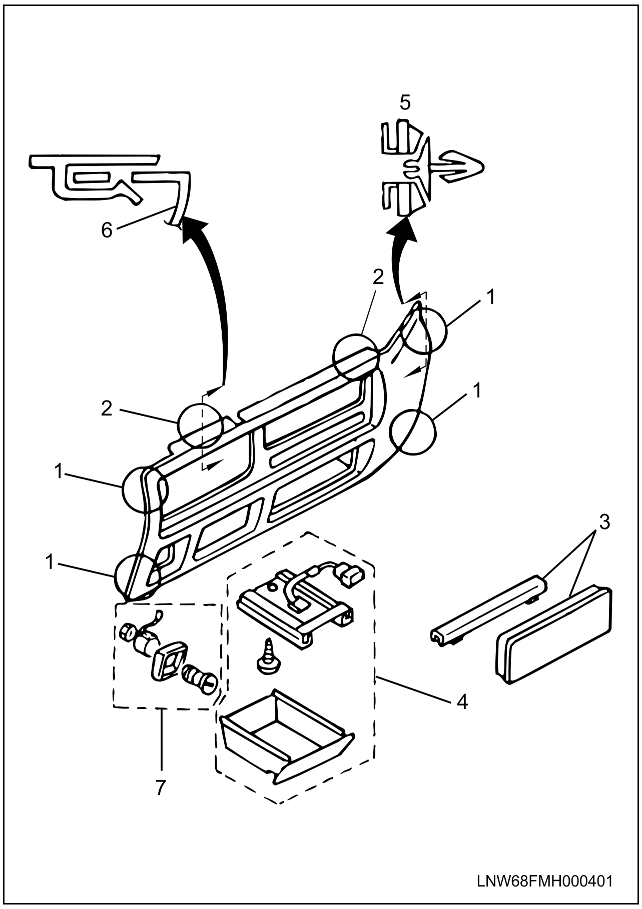
Legend

1. Clip Position
2. Switch
3. Vent Grille
4. Clip Section
5. Switch Cover

---

3. Center cluster
   - Pull the main unit toward you and remove the clips [1] at 4 positions, clips [2] at 2 positions, cigarette lighter power source and ashtray lighting connector.
   - Remove the hole cover, ashtray and cigarette lighter from the center cluster proper.

Notice:
Remove the clips with a bladed screwdriver.



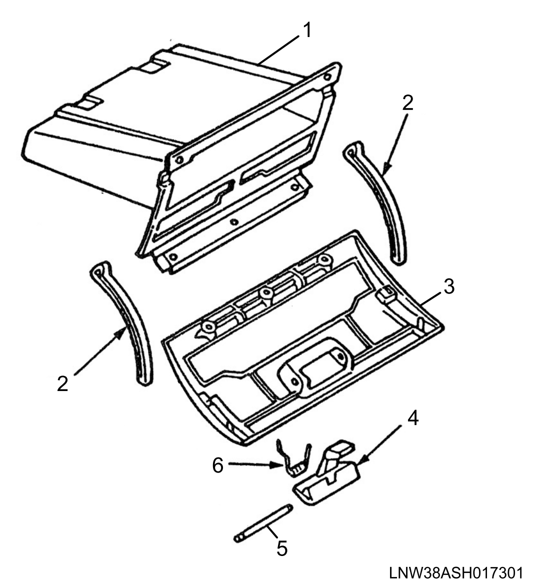
Legend

1. Clip Position (1)
2. Clip Position (2)
3. Hole Cover
4. Ashtray
5. Clip Section
6. Center Cluster
7. Cigarette Lighter

---

4. Open the lid and remove the 4 mounting screws. Then, remove the main unit.
5. Remove the left and right stays, and remove the 3 mounting screws, and remove the lid.
6. Pull out the pin from the lid and remove the spring and lever.

Notice:
The instrument panel assembly of this item can be removed without disassembling each of the parts of above items 1 to 3.



Legend

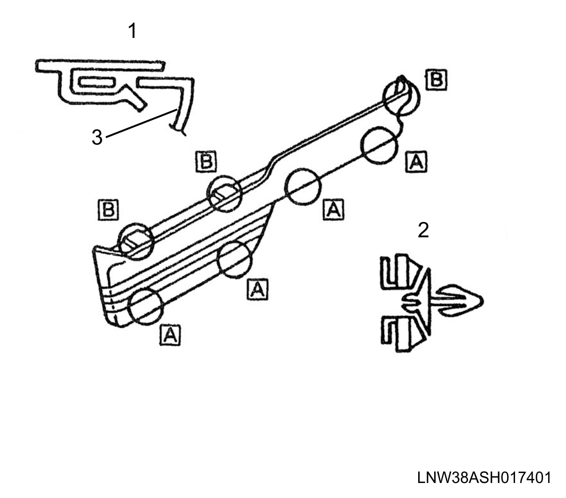
1. Glove Box
2. Stay
3. Glove Box Lid
4. Lever
5. Pin
6. Spring

---

7. Pull the main unit toward you and remove the clips [A] at 4 positions and clips [B] at 2 positions. First remove the clips [B].

Notice:

The above parts of 1 to 4 can be removed in any order, or each of them can be removed independently.



Legend

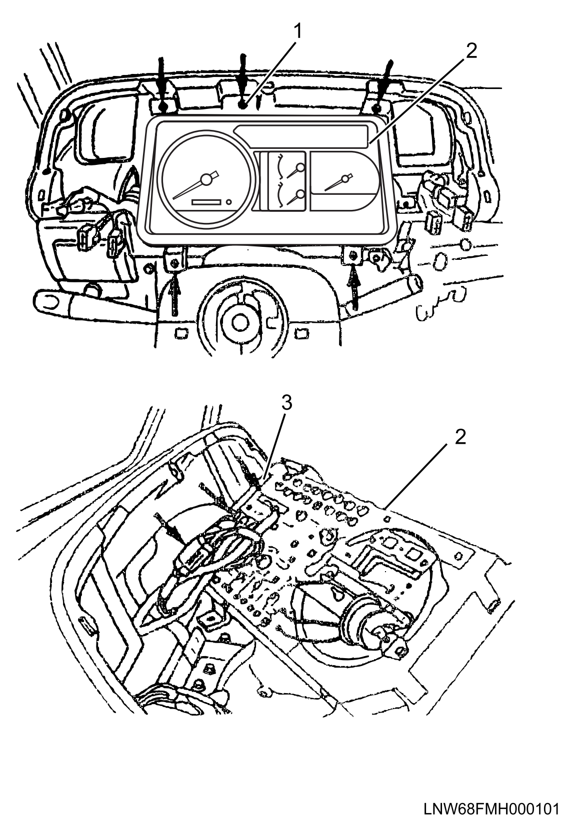
1. Clip Section B
2. Clip Section A
3. Center Cluster

---

8. Remove the 5 mounting screws.
9. Remove the 3 connector 5 and remove the instrument panel cluster (IPC).

Notice:

To remove only the IPC, it can be attained by removing the instrument panel cluster bezel.



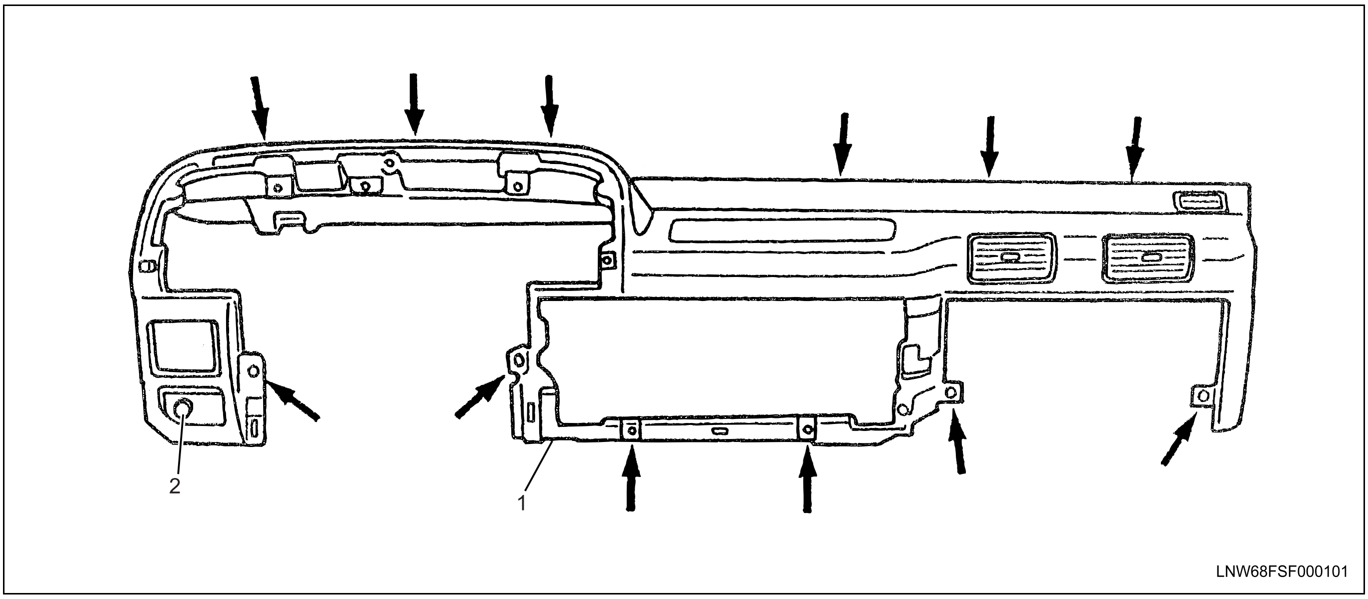
Legend

1. Screws
2. Instrument Panel Cluster (IPC)
3. Connectors

---

10. Front cover
11. Remove the screws and pull out the instrument side grommet.
12. Remove the clip on the accelerator pedal side.

13. Remove the 12 mounting bolts.



Legend

1. Instrument Panel
2. Idle Up Volume

---

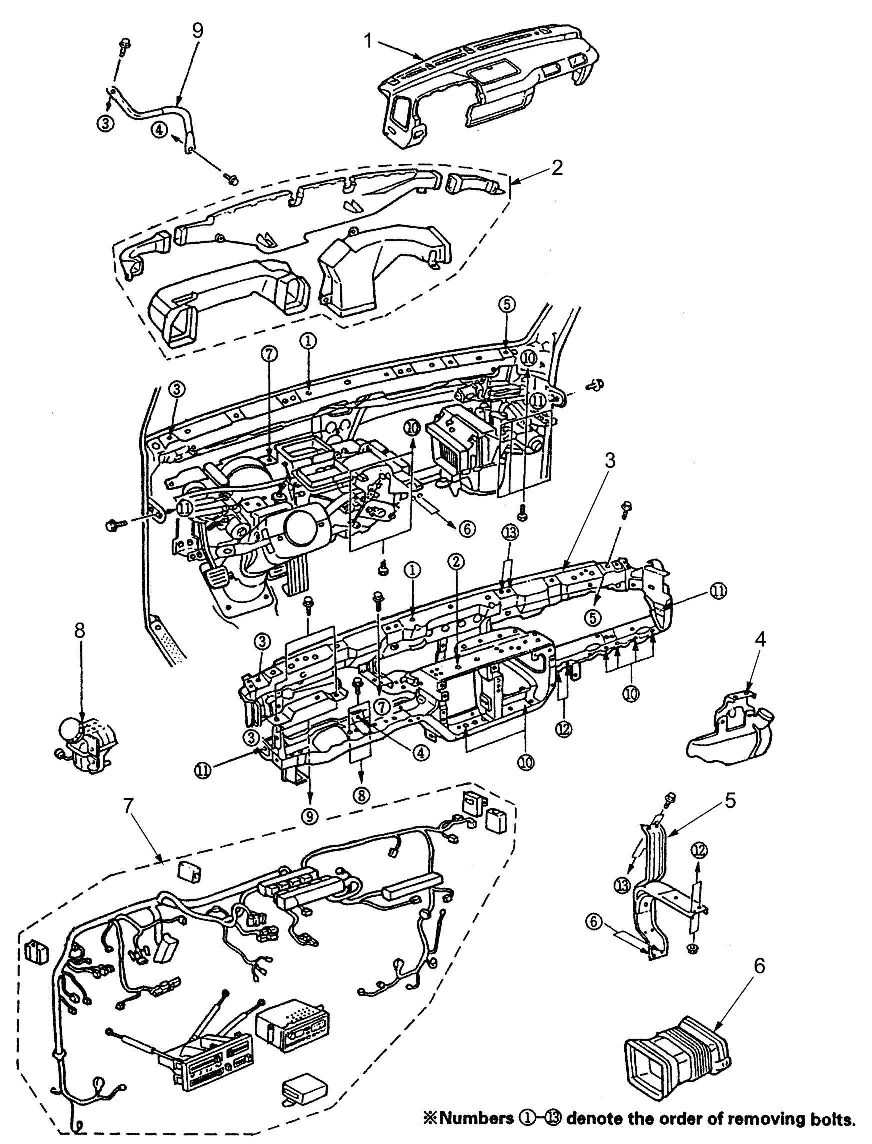
14. Remove the mounting screws and remove the vent duct.
15. Remove the mounting screws and clips and remove the instrument panel extension.
    Refer to idle up volume replacement in section 6E.
16. Pull the controller bezel to release the locks and disconnect the connector.
17. Push out the side defroster nozzle from the rear side of the instrument panel assembly.
18. Pull out the fluid tank cover.
19. Relay lid

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. After installing each connector, check the operation of each equipment.

Instrument Panel Reinforcement



Legend

1. Instrument Panel Assembly
2. Defroster Nozzle/Ventilation Duct
3. Instrument Reinforcement Assembly
4. Washer Tank/Bracket
5. Instrument Support Bracket
6. Intermediate Duct
7. Body Harness/Controller/Radio
8. Brake/Clutch Fluid Reserve Tank
9. Instrument Side Stay

Removal Procedure

1. Remove the instrument panel assembly.
   Refer to “Instrument panel assembly” in this Section.
2. Remove the mounting bolts.
3. Remove the defroster nozzle/ventilation duct.
   Refer to “Heater/Air Conditioner Workshop Manual”.
4. Remove the intermediate duct.
5. Remove the level switch connector and remove the 4 nuts.
6. Extract the fluid and remove each tube.

Caution:
Don't apply the brake/clutch fluid to the resin portions and painted portions in any case.

7. Remove the washer motor connector and washer tube and remove the two bolts fixing the bracket and the one bolt in the lower part of the tank.

8. Remove all the connectors of electrical equipments included in the body harness and the connectors. For connector numbers and positions, refer to Cab and Chassis Electrical.
9. Remove the mounting bolts.
10. Remove each air conditioner control cable, for removal, refer to Heating and Air Conditioning.
11. Remove the bolts and remove the instrument support bracket from the instrument reinforcement assembly.
12. Remove the body harness/controller/radio from the instrument reinforcement assembly. Refer to Cab and Chassis Electrical.

Installation Procedure

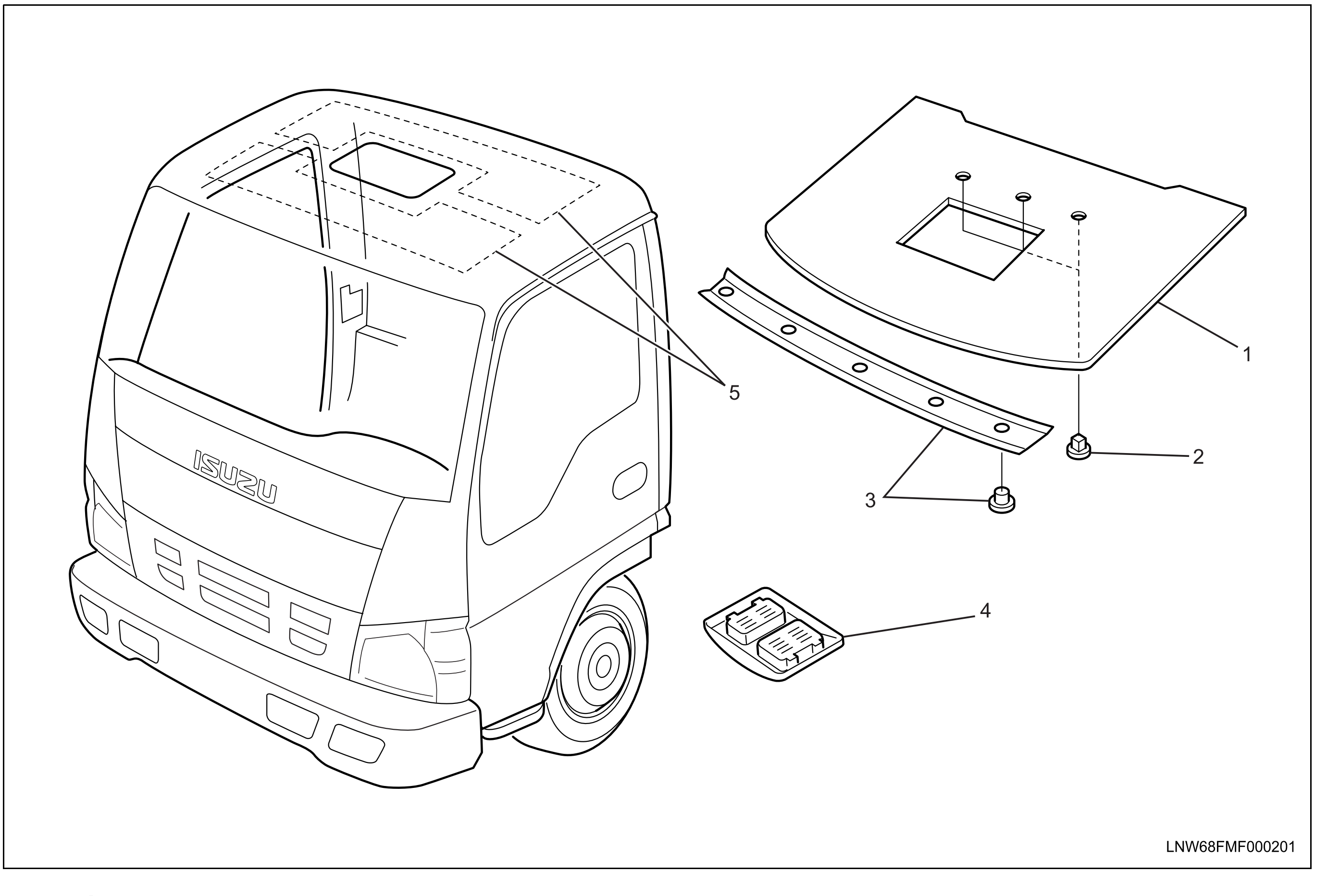
To install, follow the removal steps in the reverse order, noting the following points:

1. Perform air bleeding for the brake and clutch.
2. Tighten each bolts to the specified torque.

Tighten

- Clutch pedal bracket upper bolt to 37 N·m (27 lb ft).
- Steering column bracket bolt to 20 N·m (14 lb ft).
- Brake pedal bracket upper bolt to 42 N·m (31 lb ft).

Headlining

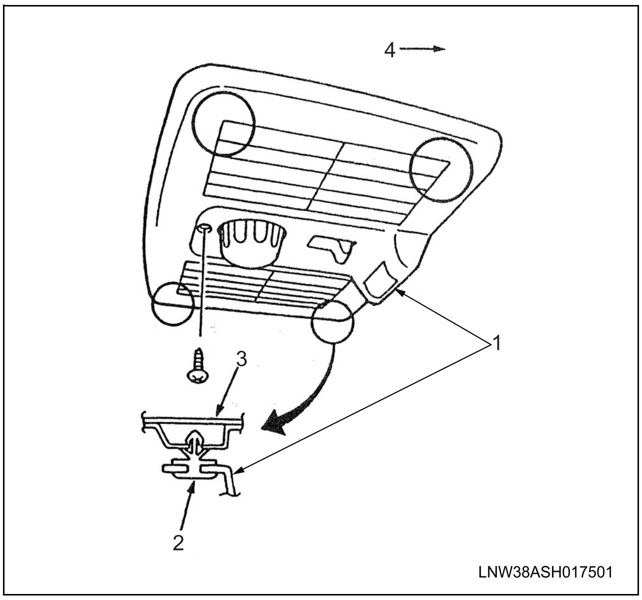


Legend

1. Head Lining
2. Clip
3. Front Retainer/Clip
4. Roof Ventilator Grille
5. Insulator

Removal Procedure

1. Remove the one mounting screw and pull out the clips at 4 positions.



Legend

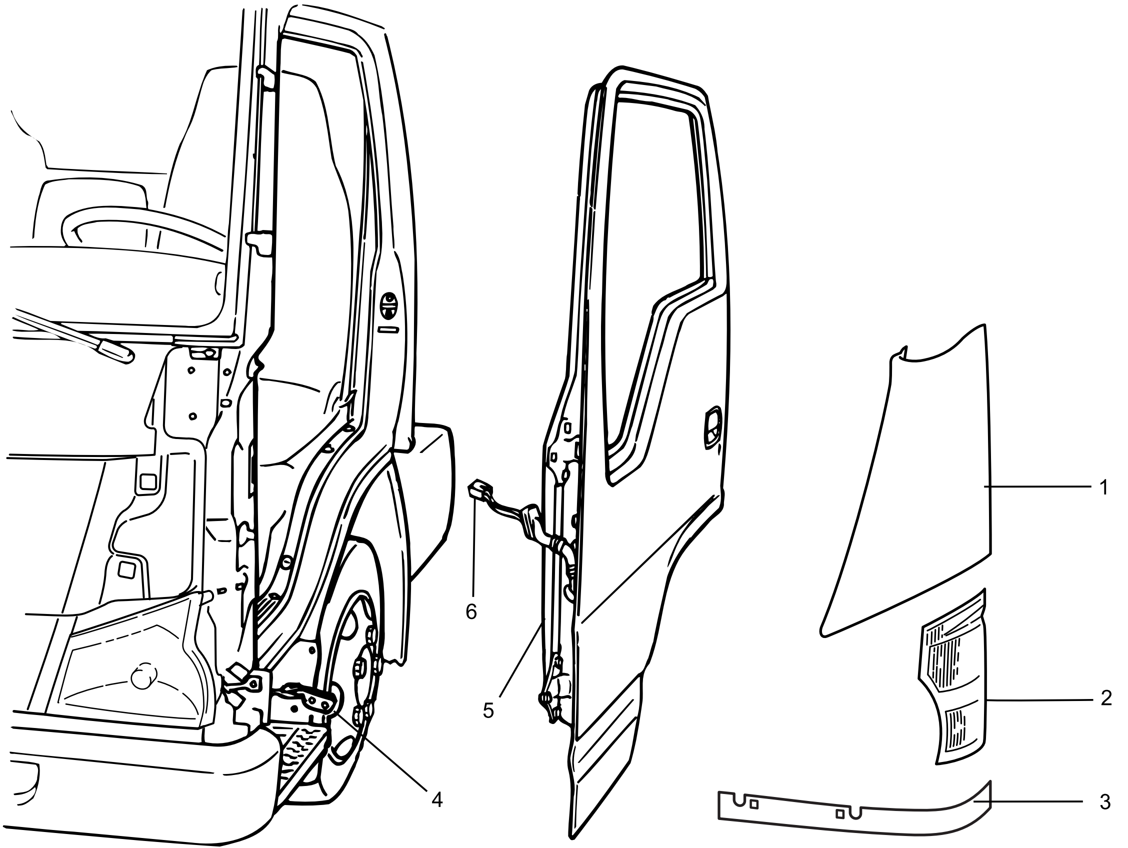
1. Roof Ventilator Grille
2. Clip
3. Roof Panel
4. Front Side

2. Remove the clip.
3. Remove the clips at 5 positions and remove the retainer.
4. Remove the head lining.
5. Remove the insulator.

Installation Procedure

To install, follow the removal steps in the reverse order.

Door



Legend

1. Front Corner Panel
2. Front Combination Lamp
3. Head Lamp Lower Cover
4. Door Check Arm
5. Front Door Assembly
6. Door Harness Connection

Description

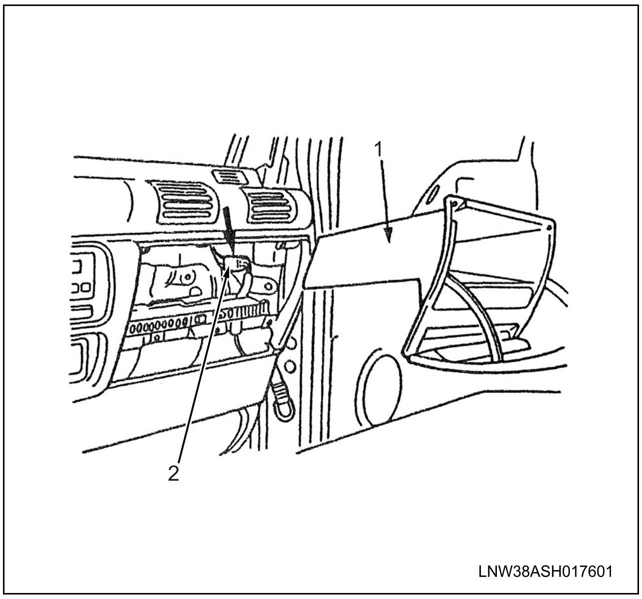
Doors on these vehicles are mounted to the cab by a pair of hinges. The cab's door frame has floating cage plates that allow forward up and down, and in and out adjustment of the door. An adjustable striker plate in the rear of the frame allows the door's rear alignment.

Most of the door components, such as window regulator, window, lock, handles and trim panel can be serviced with the door on the vehicle.

Removal Procedure

1. Pull out the head lamp lower cover toward you.
2. Remove the 1 mounting screw 1 mounting clip and connectors, and remove the front combination lamp.
3. Remove the 1 bolt securing the front corner panel. Pull the panel from the 2 clips to remove it.

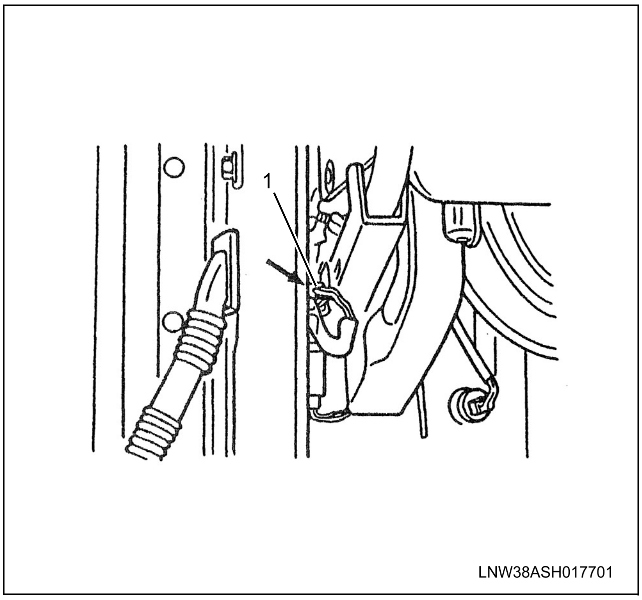
4. To remove the door on the passenger's seat side, remove the glove box and disconnect the connector.



Legend
1. Glove Box
2. Connector

---

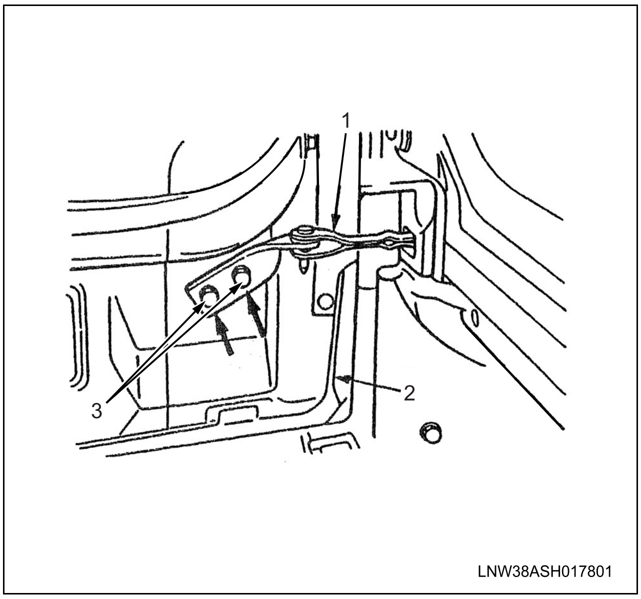
5. To remove the door on the driver's seat side, disconnect the connector from the bottom side of the instrument panel.



Legend
1. Connector

---

6. Remove the 2 mounting bolts on the door side.

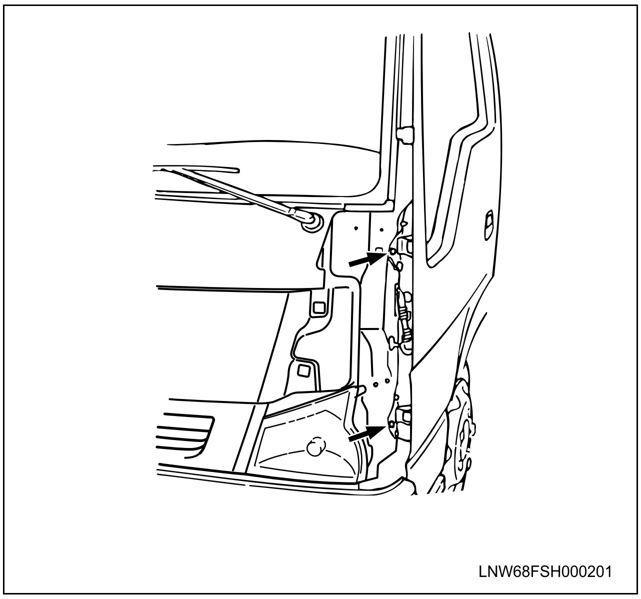


Legend
1. Check Arm
2. Front Door Assembly
3. Bolt

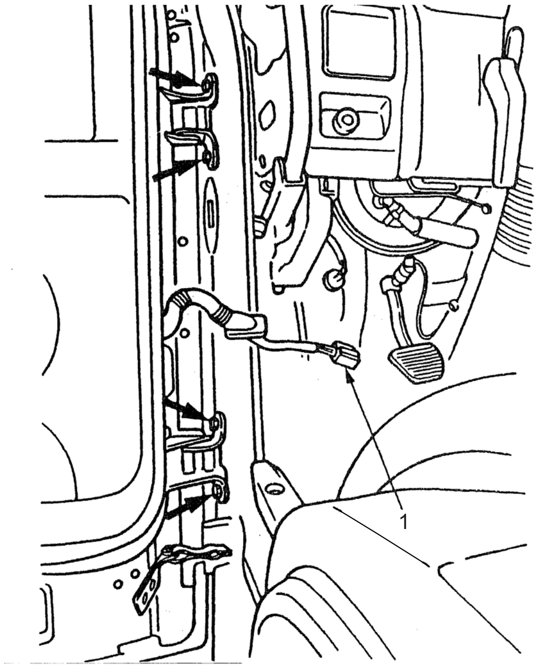
---

7. Remove the front side of the 3 mounting bolts for each hinge while the door is closed.

Notice:
To prevent scratches, support the door with a waste cloth or wooden piece.



8. Remove the 2 mounting bolts for each hinge on the rear side while the door is open.



Legend

1. Door Harness Connector

Installation Procedure

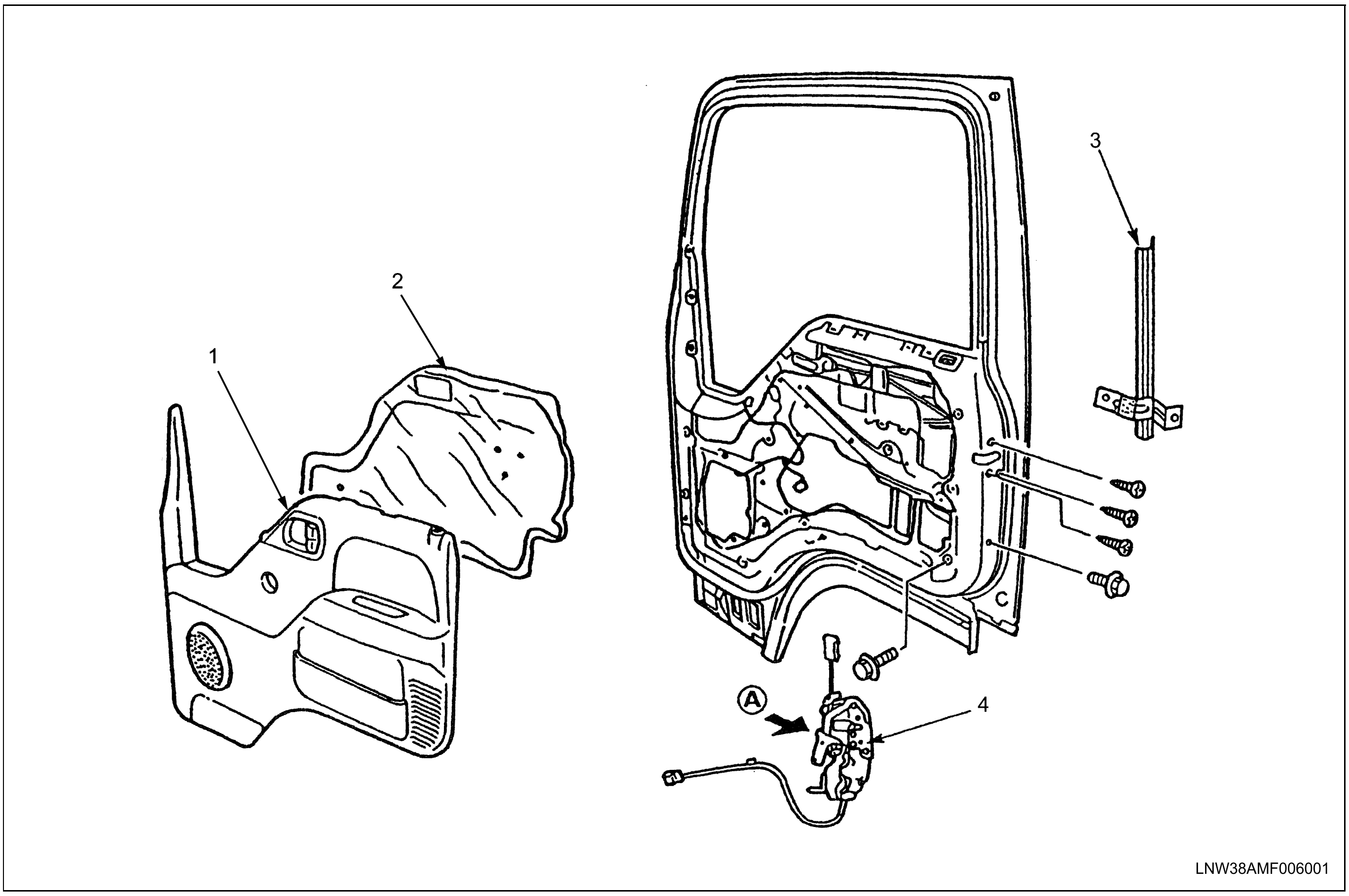
To install, follow the removal steps in the reverse order, noting the following points:

1. Tighten the mounting bolt to the specified torque.

Tighten

- Door hinge mounting bolts to 25 N·m (18 lb ft).

Door Lock Mechanism

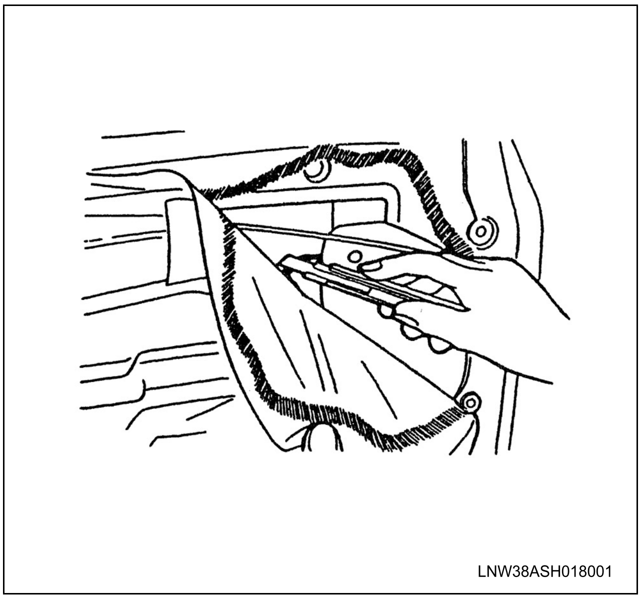


Legend

1. Trim Panel
2. Water-Proof Sheet
3. Glass Run Rear Channel
4. Lock Mechanism

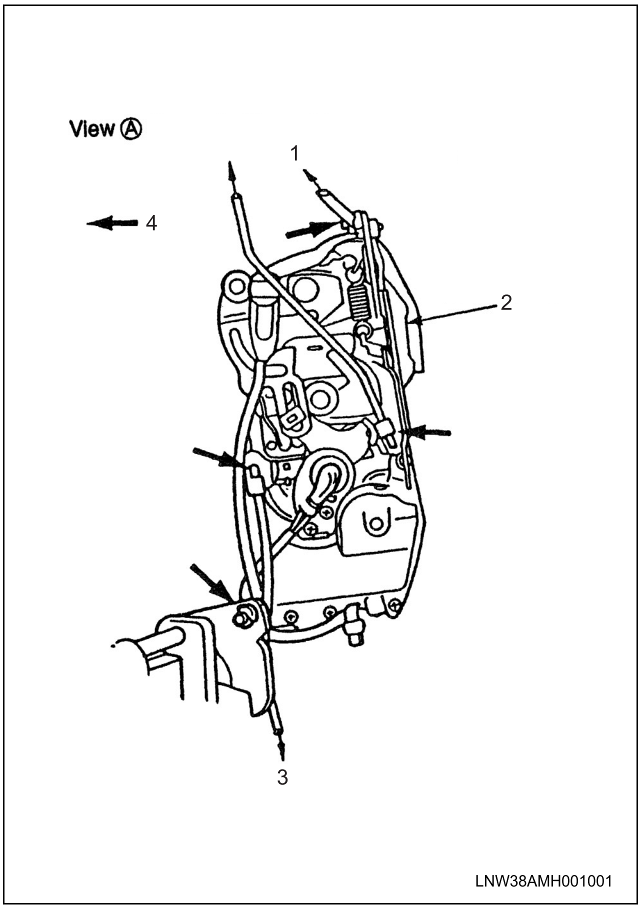
Removal Procedure

1. Remove the trim panel.
   Refer to trim panel in this section.
2. Peel off the water-proof sheet carefully with a cutter or knife. Take care not to damage it when peeling it off.



3. Pull out the 2 mounting screws.

4. Disconnect each link and remove the 3 mounting screws.



Legend

1. Door Inside Handle
2. Door Lock Assembly
3. Door Lock Cylinder
4. Link Remove Position

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

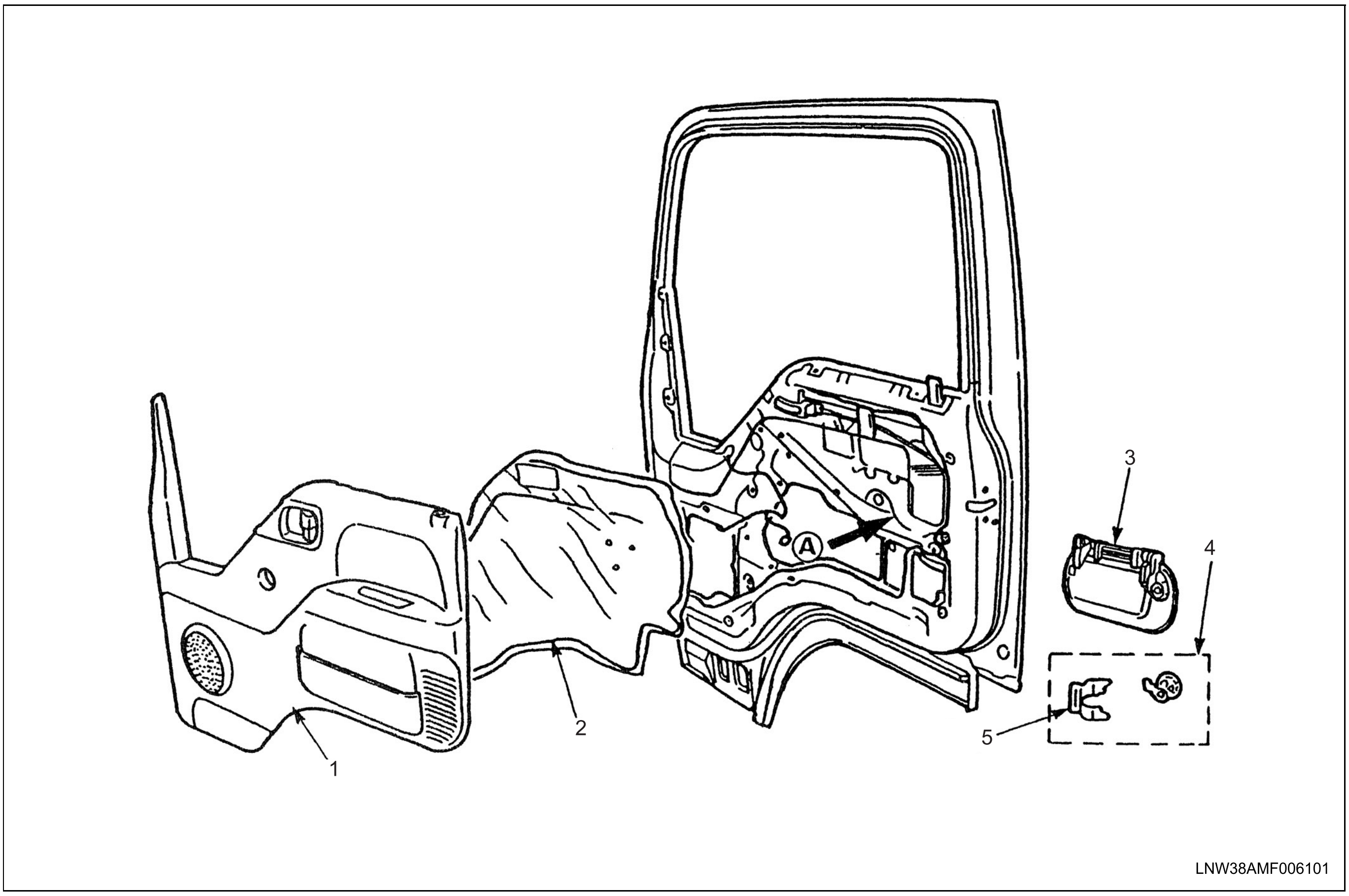
1. Tighten the Fixing bolt to the specified torque.

Tighten

- Door lock mechanism fixing bolts to 13 N·m (113 lb in) – 18 N·m (13 lb ft)

2. After installation, check the operation.

Door Lock Cylinder and Outside Door Release Handle

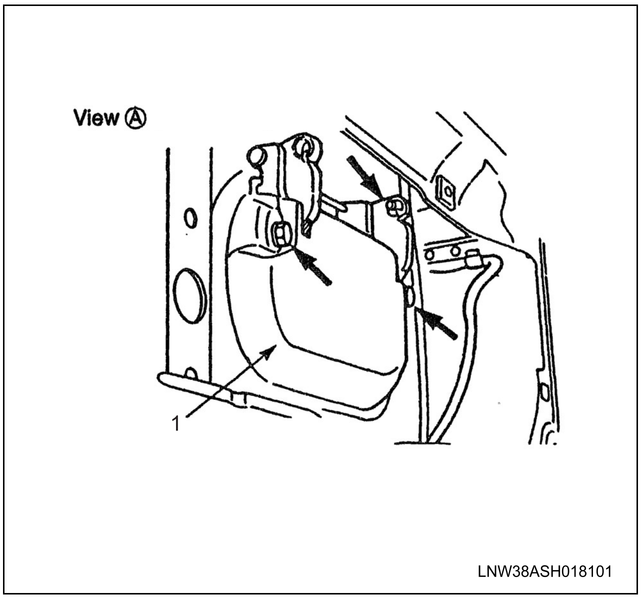


Legend

1. Trim Panel
2. Water-Proof Sheet
3. Outside Door Release Handle
4. Lock Cylinder
5. Clip

Removal Procedure

1. Remove the trim panel.
   Refer to Trim panel in this Section.
2. Remove the water-proof sheet.
   Refer to Lock mechanism in this Section.
3. Disconnect the link and remove the 2 mounting bolts.



Legend

1. Outside Door Release Handle

4. Disconnect the link and pull out the clip.

Installation Procedure

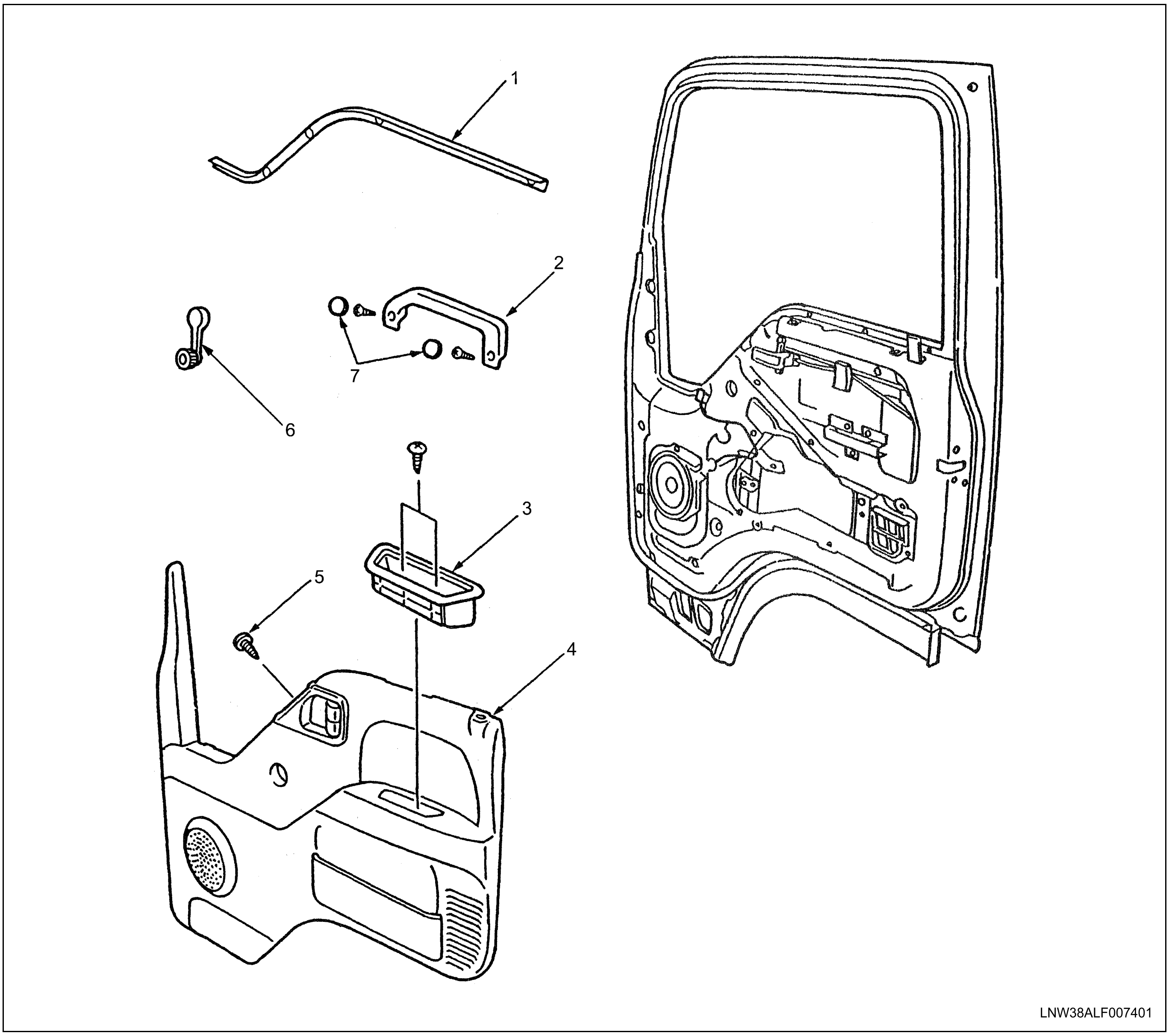
To install, follow the removal steps in the reverse order, noting the following points:

1. Tighten the mounting bolt to the specified torque.

Tighten

- Outside door release handle mounting bolts to 13 N·m (113 lb in) – 18 N·m (13 lb ft)

Trim Panel



Legend

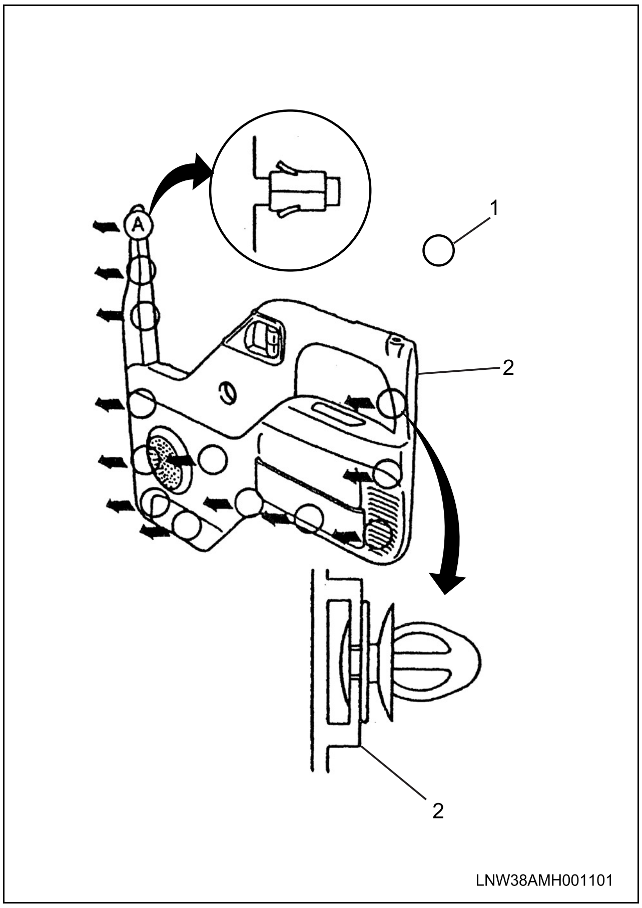
1. Inner Waist Seal
2. Guard Bar
3. Door Pull Case
4. Trim Panel
5. Screw
6. Regulator Handle
7. Grommet

Removal Procedure

1. Open the grommet and remove the 2 screws.
2. Remove the regulator handle.
3. Remove each clip from the rear side with a bladed screwdriver. Note that excessive force will cause deformation.
4. Remove the screw.
5. Remove the 2 mounting screws.

Notice:
The above parts 2 - 5 can be removed in any order or each of them can be removed independently.

6. Remove the clips at 13 positions.



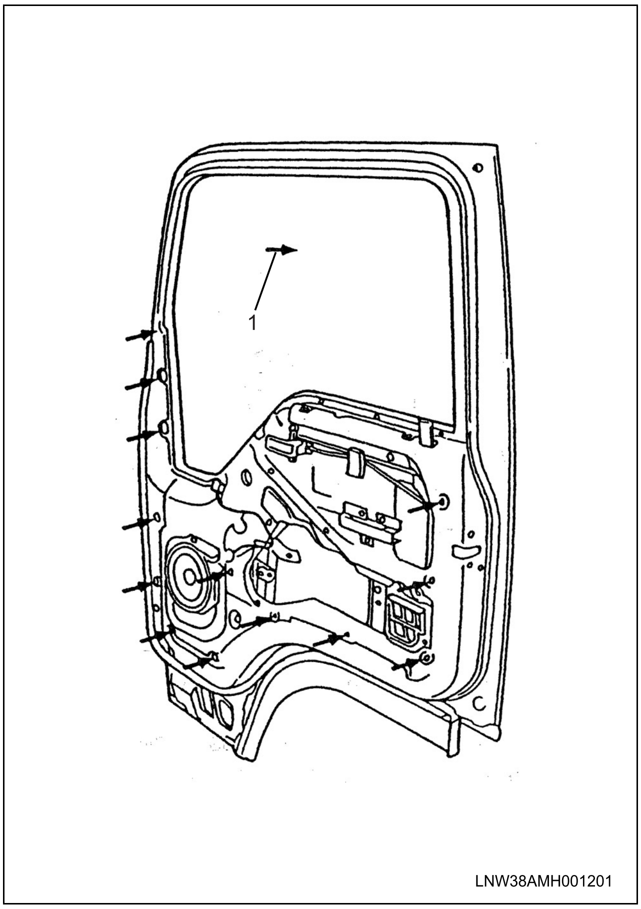
Legend

1. Clip Position
2. Trim Panel

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

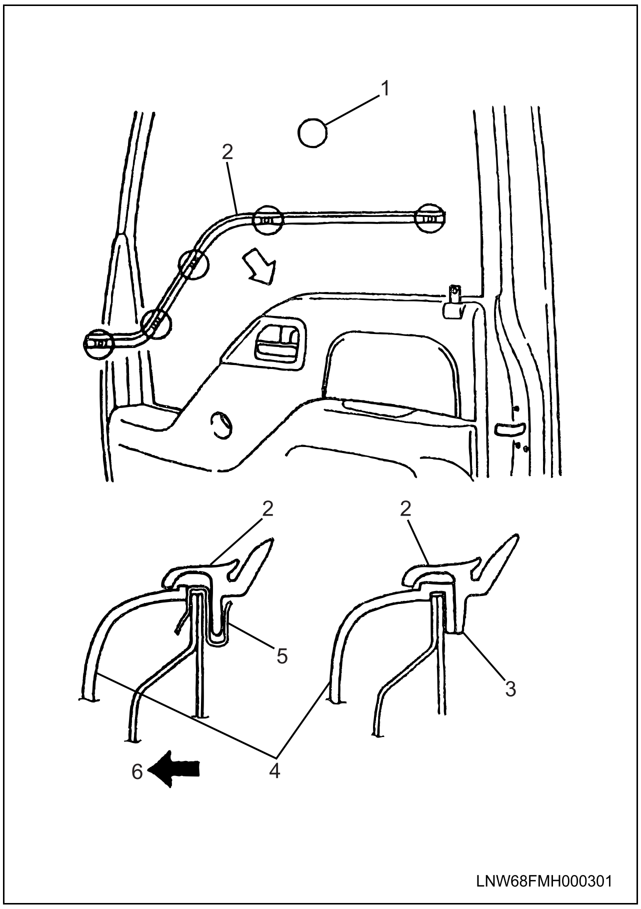
1. Adjust the trim panel clip to the mounting hole on the door panel side and install the trim pad so as to provide any float, skewness or door harness bite.



Legend

1. Clip Mounting Hole

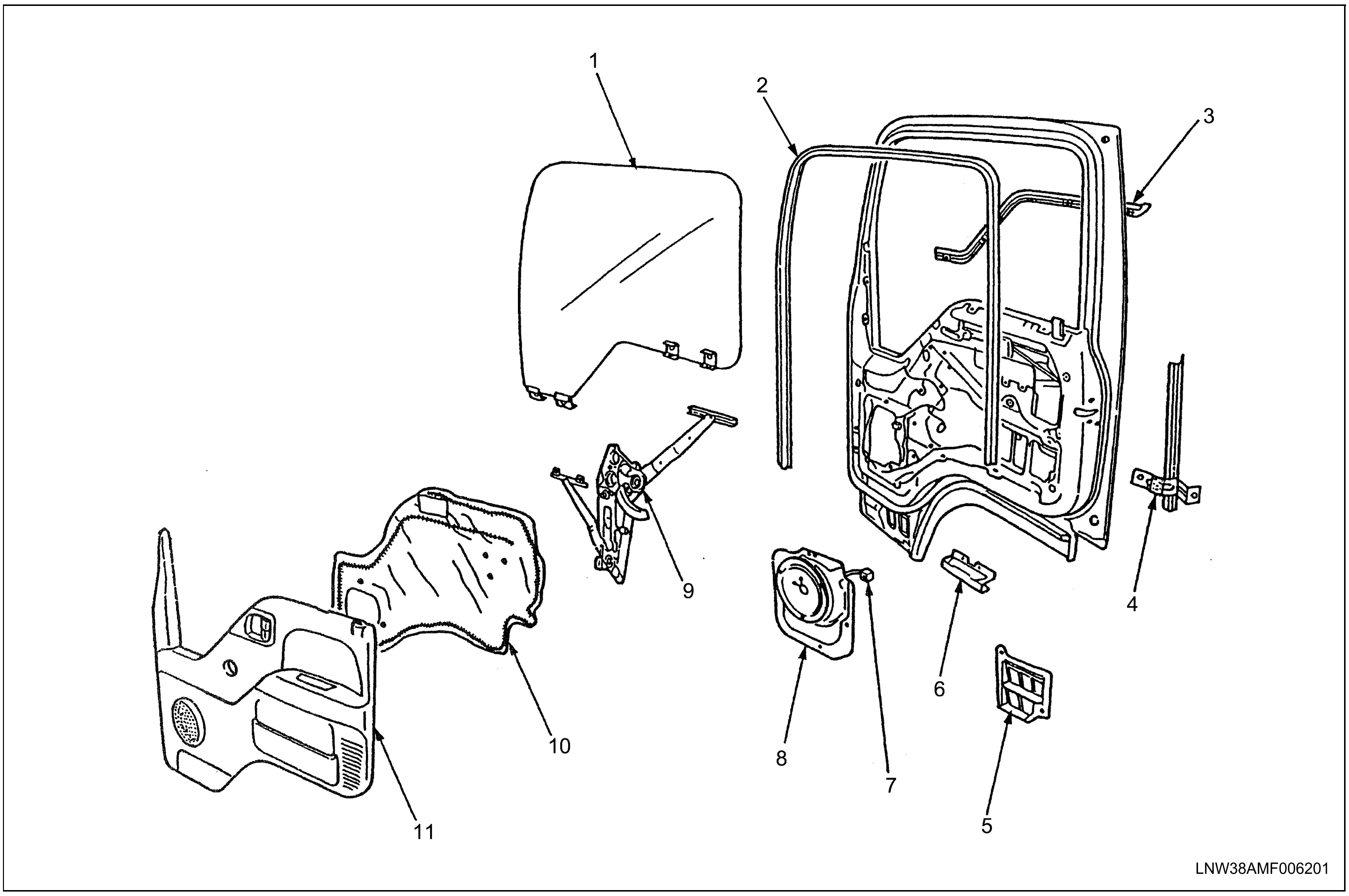
2. Align the front end together with the 4 claws in the upper part of the trim panel and insert the clips in sequence starting from the front end clip. Note that applying force in transverse direction will cause deformation.



Legend

1. Clip Position
2. Inner Waist Seal
3. Door Trim Pad Claw
4. Trim Panel
5. Clip
6. Room Side

Window and Window Regulator Assembly



Legend

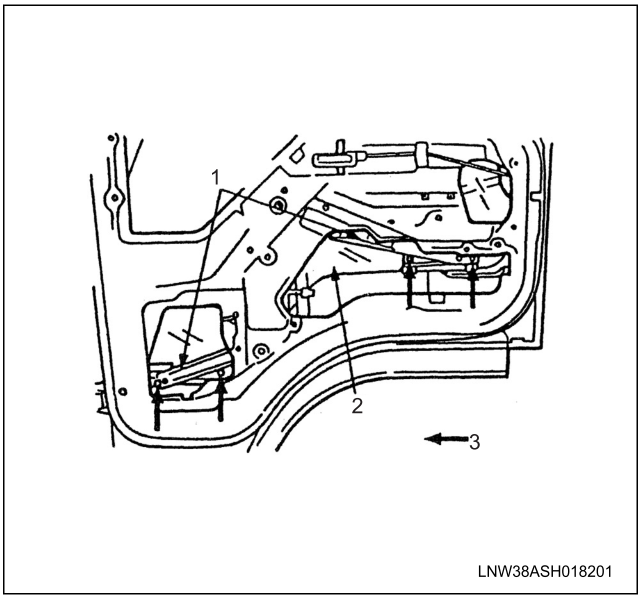
1. Glass
2. Glass Run
3. Outer Waist Seal
4. Glass Run Rear Channel
5. Door-Out one-Way Valve
6. Door pull Case Bracket
7. Speaker Connector
8. Speaker
9. Window Regulator
10. Water-Proof Sheet
11. Trim Panel

Notice:
It is a good practice to crisscross cracked glass with strips of masking tape before removing it ; this will help hold the glass together.

Removal Procedure

1. Remove the trim panel.
   Refer to Trim panel in this section.
2. Remove the 3 screws and 1 clip and disconnect the connector.
3. Remove the door pull case bracket.
4. Remove the door-out one-way valve.
5. Remove the water-proof sheet.
   Refer to Lock mechanism in this section.
6. Remove the outer waist seal.
7. Remove the glass.

8. Lower the glass to a position where the mounting screw can be seen, and remove the 4 screws.

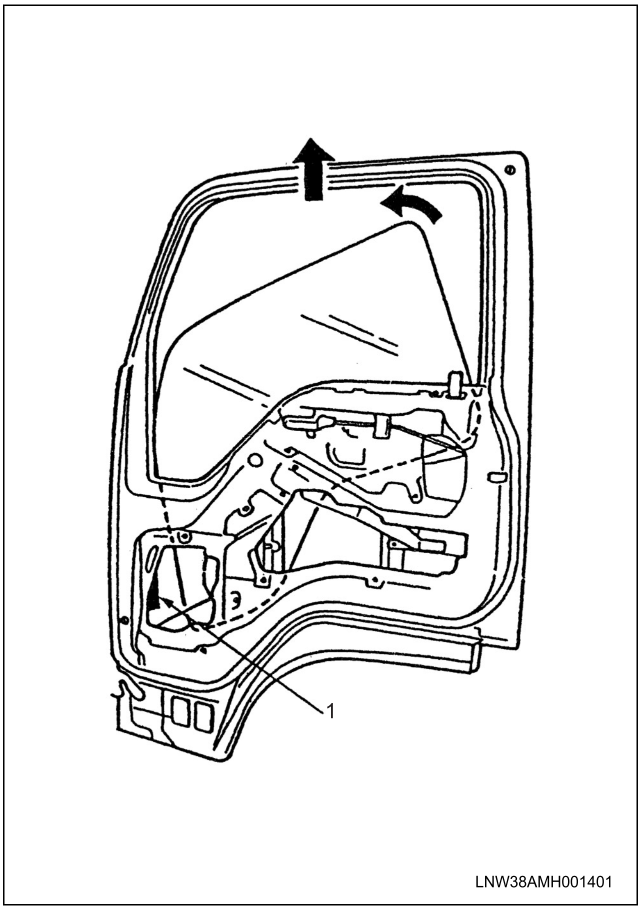


Legend

1. Window Regulator
2. Glass
3. Screw

---

9. Lower the front side of the glass. After the front side of the glass comes off from the glass run, pull up the rear side of the glass.

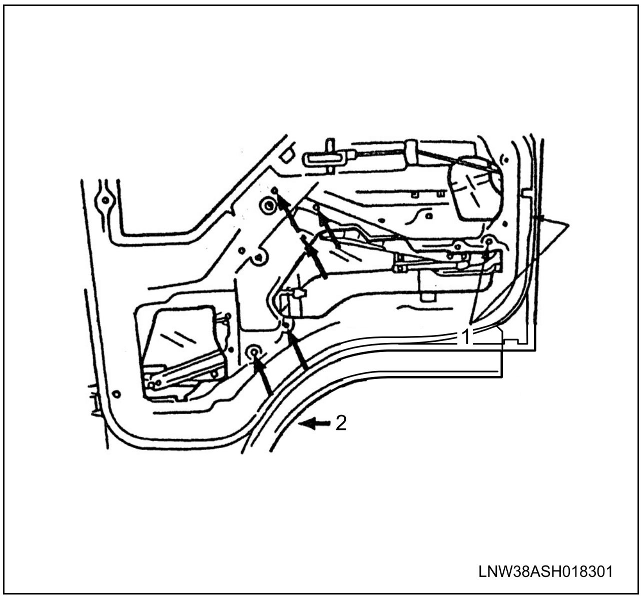


Legend

1. Glass Run

---

10. Window regulator
    - Remove the 5 mounting screws.



Legend

1. Glass Run Rear Channel Mounting Screw
2. Window Regulator Mounting Screw Position

---

11. Pull out the glass run from the door frame groove
12. Pull out the 2 mounting screws.

Caution:
Always wear heavy gloves when handling glass to minimize the risk of injury.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

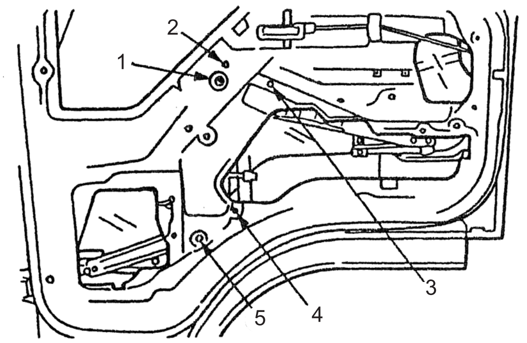
1. Align the notch (a) of the glass run lip with the door outer waist line (A). Align the glass run slit (b) with the door (B) and fit the glass run between (A) and (B). Next, align the notch (c) of the glass run lip with the door outer waist line (C) and fit the glass run between (B) and (C). Fit the glass run in the channel within the door.
    - Fit the glass run with the lip toward of the vehicle.
2. While the front side of the glass is lowered, insert the glass into the door panel. First, insert the rear side of the glass into the glass run, then insert the front side into the glass run. Raise the front side gradually along the glass run.

Notice:
When reusing the glass run, apply the sealant to the range.

3. Temporarily tighten the window regulator mounting screw (3) (basic hole) and tighten (1) to (5) firmly. Lastly, tighten (3) (basic hole) firmly and tighten it to the specified torque.

Tighten

- Window regulator fixing bolts to 7 N·m (61 lb in)

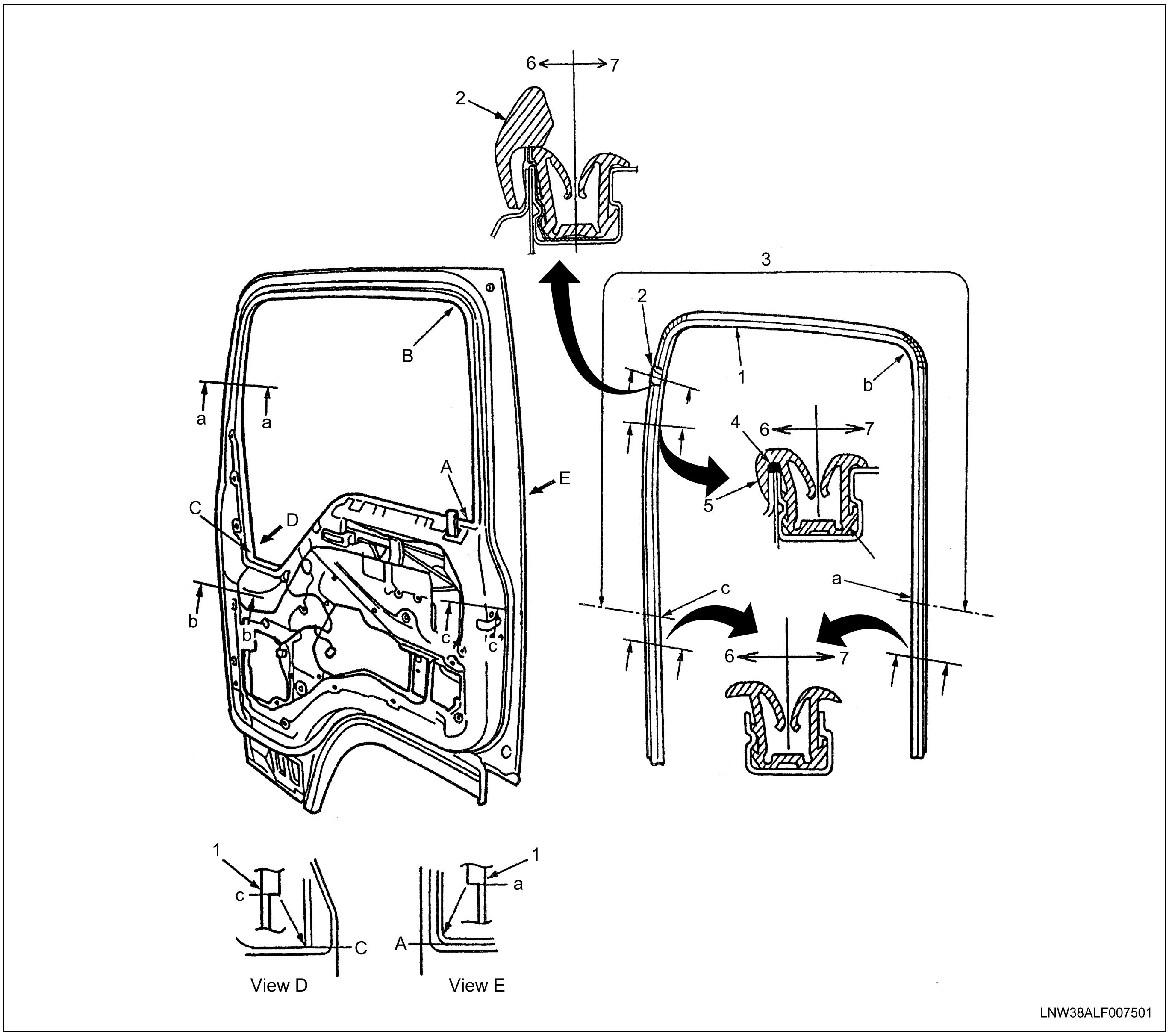


LNW38ASH018401

Legend

1. Screw (4)
2. Screw (1)
3. Screw (3) (Basic Hole)
4. Screw (5)
5. Screw (2)

4. Check the water-proof sheet for breakage.



Legend

1. Glass Run
2. Glass Guide
3. Sealant Application Range
4. Sealant
5. Lip
6. Outside
7. Inside

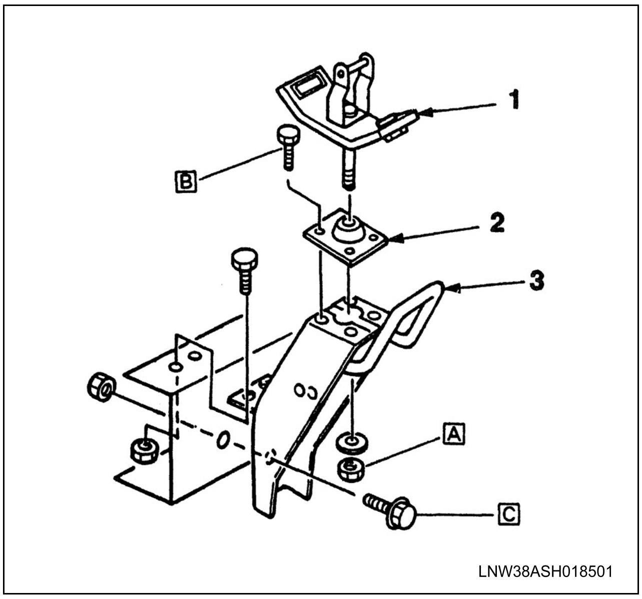
Cab Mounts

The cab is mounted to the frame at four points with two pivot brackets on the front and a pair of fastening brackets at the rear. Rubber cushions are mounted on the rear brackets to help absorb road shock.

The attaching bolts of all mount brackets should be checked for tightness at regular intervals. A loose bracket will allow the cab to shift and eventually cause the failure of other cab mounting components.

Rear Mount Brackets and Cushions

Periodically check for worn or broken mount cushions. Replace the cushions as necessary. Shims can be added or removed to adjust bracket height and keep the cab level and securely mounted.



Legend

1. Cab Mounting Rear Bracket
2. Mounting Rubber
3. Cab Mounting Bracket

Removal and Installation

Remove or Disconnect

1. Remove the nut and pull up the bracket.
   Cab mounting rear bracket
2. Remove the bolt from the cab-side bracket.
3. Remove the 4 bolts.
4. Remove the 2 bolts and the 4 nuts.

Installation Procedure

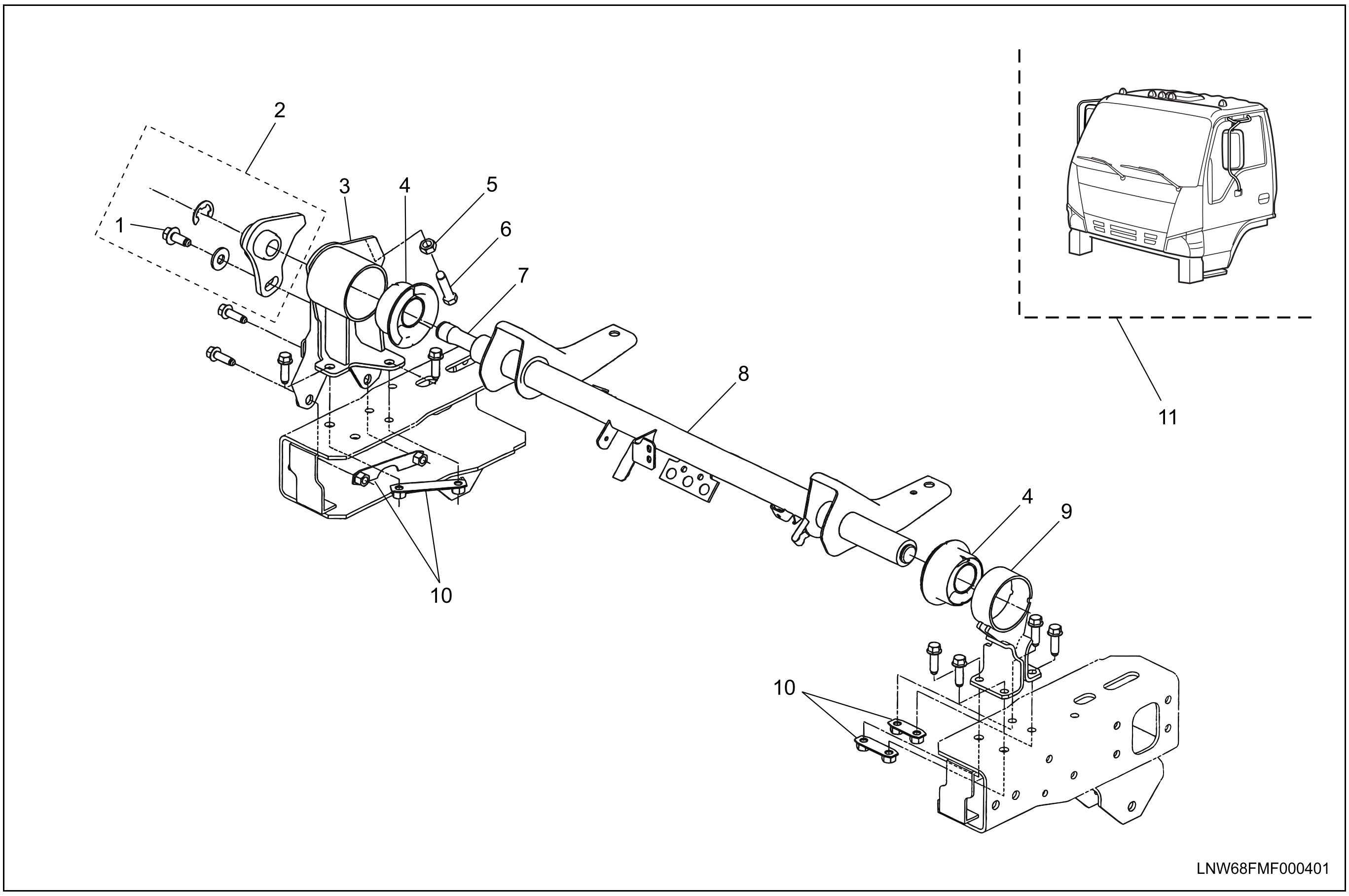
To install, follow the removal steps in the reverse order, noting the following points:

1. Tighten the mounting bolts to the specified torque.

Tighten

- Cab mounting bolts [A] to 88 N·m (65 lb ft).
- Cab mounting bolts [B] to 50 N·m (37 lb ft).
- Cab mounting bolts [C] to 81 N·m (60 lb ft).

Cab Mounting Lever



Legend

1. Anchor Bolt
2. Anchor Arm
3. Font Cab Mounting Bracket (RH)
4. Rubber Bush
5. Lock Nut
6. Adjusting Bolt
7. Torsion Bar
8. Cab Mounting Lever Assembly
9. Front Cab Mounting Bracket (LH)
10. Plate Nut
11. Cab Assembly

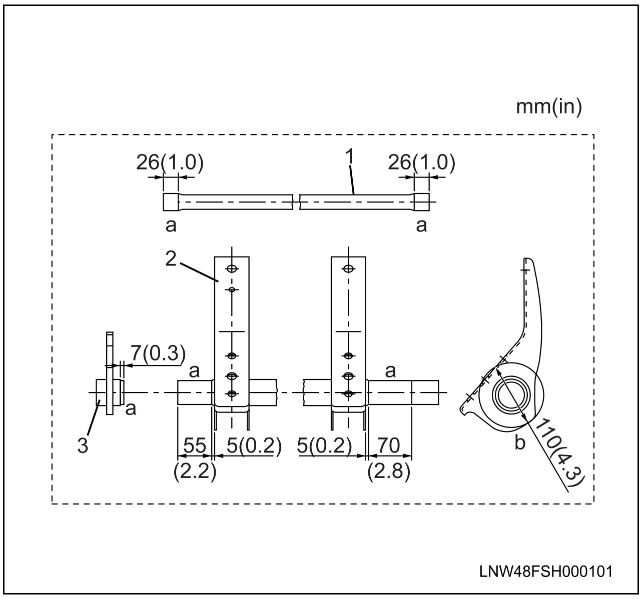
Removal Procedure

1. Remove the cab assembly.
   - Refer to “Cab assembly” in this section.
2. Remove the anchor bolt.
   - Anchor bolt is loosened, Adjusting bolt is removed and anchor bolt is removed after that.
3. Remove the 4 fixing bolts from the front mounting bracket (all bolts at the top of the bracket) and remove the front cab mounting bracket LH.
4. Remove the 4 fixing bolts from the front mounting bracket (2 bolts at the top of the bracket and 2 bolts at the side) and remove the front mounting bracket RH.
5. Remove the snap ring from the end of the torsion bar and remove the anchor arm.
6. Remove the cab mounting lever assembly.

Installation Procedure

Install the cab mounting following the removal steps in the reverse order. Pay careful attention to the following.

1. Apply Besco L-2 grease to the parts marked with an (a) in the illustrations below.
2. Apply Besco rubber grease to the parts marked with a (b) in the illustrations below.
   - Apply grease to the side portions of the mounting rubber facing the outside of the vehicle.

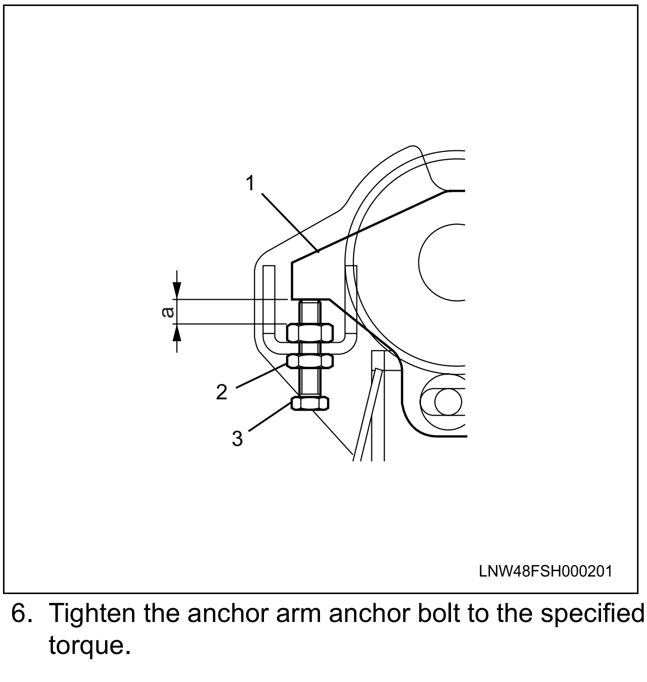


Legend

1. Torsion Bar
2. Cab Mounting Lever Assembly
3. Anchor Arm

3. Tighten the fixing bolts securing the cab mounting brackets to the specified torque.
4. Align the anchor arm I-mark with the torsion bar slot to install the anchor arm.
5. Use the adjusting bolt (3) to adjust the anchor arm assembly (1). Tighten the lock nut (2) to the specified torque after adjustment is complete.
   (Refer to the item below if "Step 7. Cab tilt control force adjustment" is required.)

Dimensions	Adjustment valve
a	13.5 ± 2.5 mm (0.5 ± 0.1 in)



6. Tighten the anchor arm anchor bolt to the specified torque.
7. Cab tilt control force adjustment
   - Heavy objects secured to the cab (racks etc.) may make cab tilt operational force adjustment necessary.

   a. Tilt the cab up.

Caution:
Do not attempt to adjust the cab tilt operational force with the cab in the down position. Because torque from the torsion bar is applied to the anchor arm and lock nut, damage will result.

   b. Loosen the anchor bolt until it can be turned by hand.

   c. Turn the adjusting bolt clockwise to decrease the cab tilt operational force.
   - Clockwise rotation: Cab tilt control force becomes light.
   - Counterclockwise rotation: Cab tilt control force becomes heavy.

   Reference: A single turn of the bolt will increase or decrease the required force approximately 4 kg.

   d. Check that the tip of the adjusting bolt is touching the outside surface of the anchor arm.

   e. Tighten the anchor bolt and the lock nut to the specified torque.

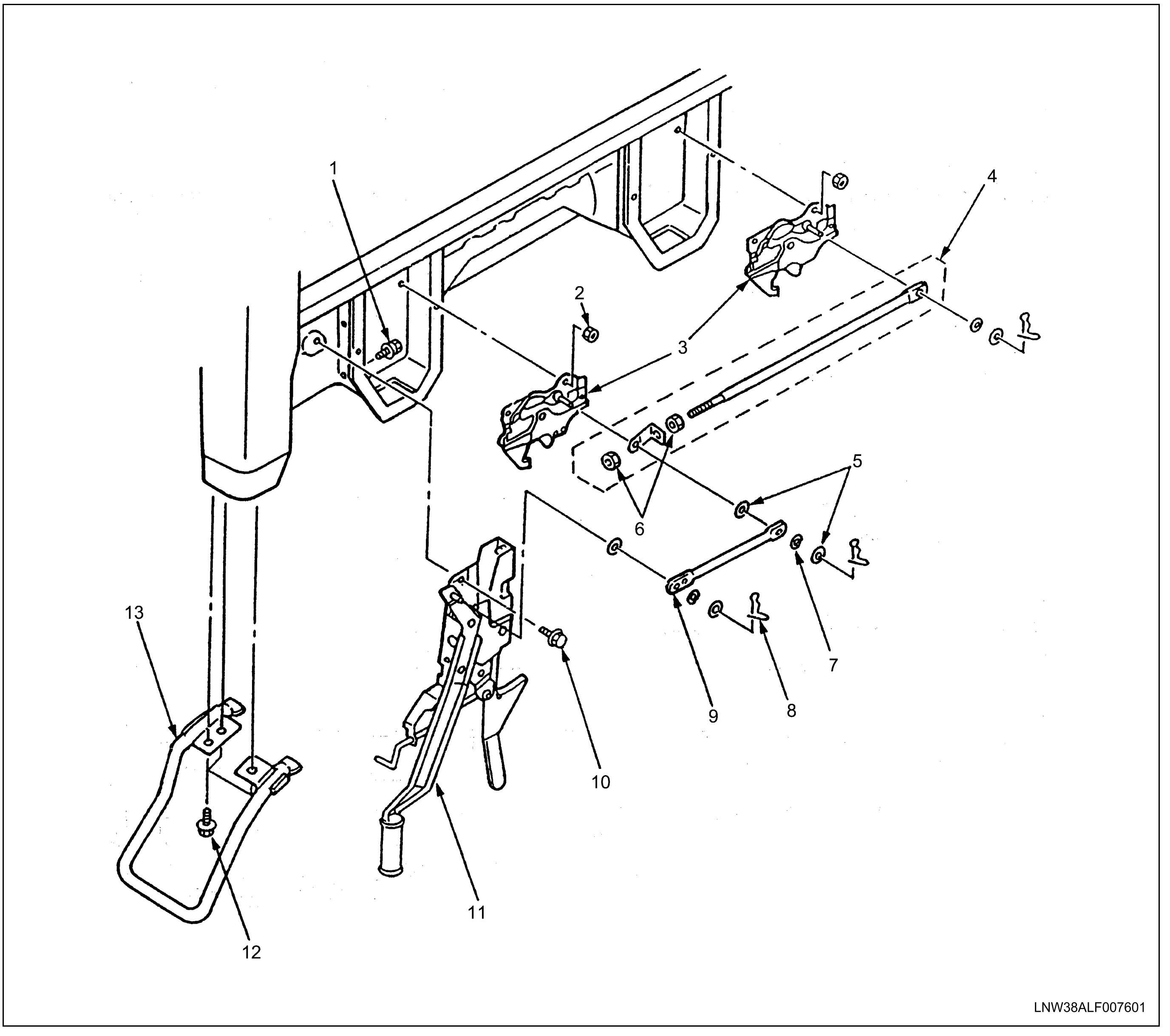
   f. Raise and lower the cab several times to confirm that it is well balanced and easy to operate. If it is not, repeat Steps (a) through (f).

8. Install the cab assembly.
   - Refer to "Cab assembly" in this section.

Tighten

- Mounting brackets fixing bolts to 117 N·m (88 lb ft)
- Lock nut to 76 N·m (56 lb ft)
- Anchor arm anchor bolt to 95 N·m (70 lb ft)

Lock Assembly



Legend

1. Cab Lock Control Unit Fixing Bolt
2. Cab Lock Assembly
3. Cab Lock Assembly
4. Hook Rod Assembly
5. Washer
6. Adjust Nut
7. Wave Washer
8. Snap Pin
9. Hand Lever Hook Rod
10. Cab Lock Control Unit Fixing Bolt
11. Cab Lock Control Unit Assembly
12. Title Handle Fixing Bolt
13. Tilt Handle Assembly

The torsion spring is loaded when the cab is in the operating position. To prevent the cab from tilting forward, hold-down hooks and secondary catch are mounted to the back of the cab.

Instructions for cab tilting are in the Owner's and Driver's Manual.

Removal Procedure

Preparation:

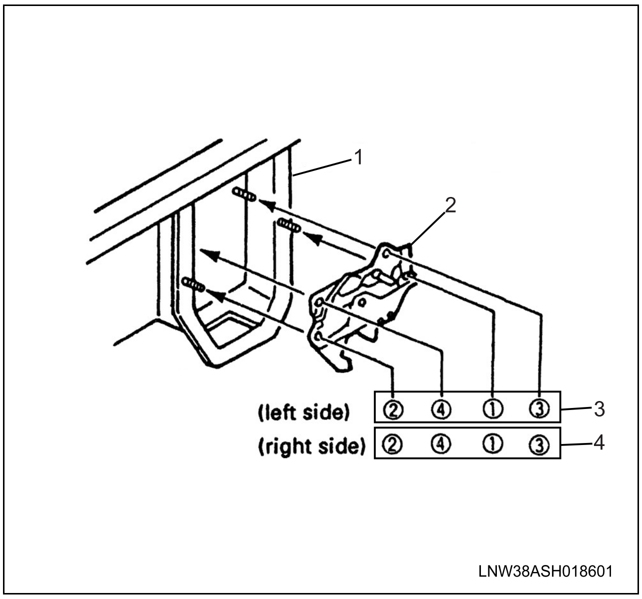
- Unlock the tilt lever.
- Mark the position of the lock assemblies on both sides of the cab.

1. Pull out the snap pins and remove the washers and wave washers.
2. Remove the hook rod assembly.
3. Remove the 3 fixing nuts and remove the hook rod assembly.
4. Remove the 3 fixing bolts and remove the cab lock control unit assembly.

5. Remove the 3 tilt handle fixing bolts.

Installation Procedure

1. Install the tilt handle assembly.
2. Install the cab lock control unit assembly.
3. When installing the cab lock assembly, temporarily tighten the rear mounting (1) with the left and right cab lock assembly mounting nuts in the order shown in the figure, tighten (2) to (4) to the specified torque, and lastly tighten (1) firmly.



Legend

1. Rear Mounting
2. Cab Lock Assembly
3. Left Side
4. Right Side

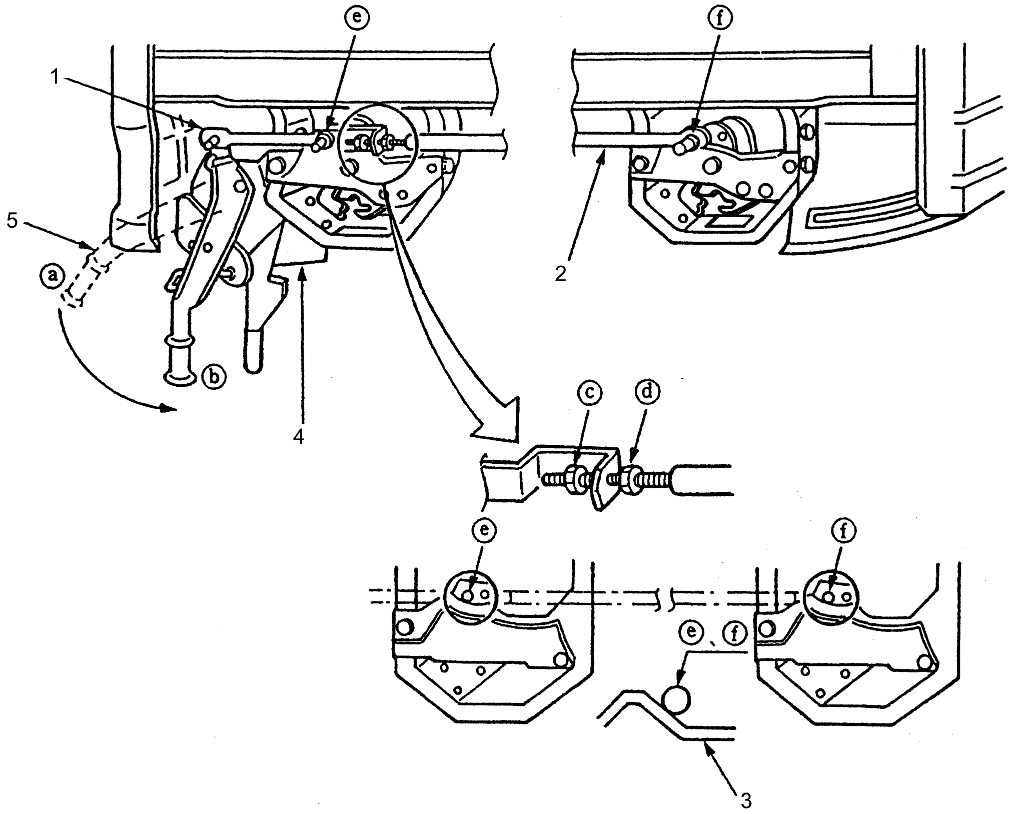
Tighten

- Cab Lock Assembly Fixing Nuts to 19 N·m (14 lb ft).
- Cab Lock Control Unit Assembly Fixing Bolts to 19 N·m (14 lb ft).

4. Install the hook rod assembly.
5. Change the control lever position from (a) to (b) and hold the control lever so that (e) may touch the bracket. At that time, adjust the lock nuts (c) and (d) and tighten them to the specified torque so that both (e) and (f) may touch the bracket.

Tighten

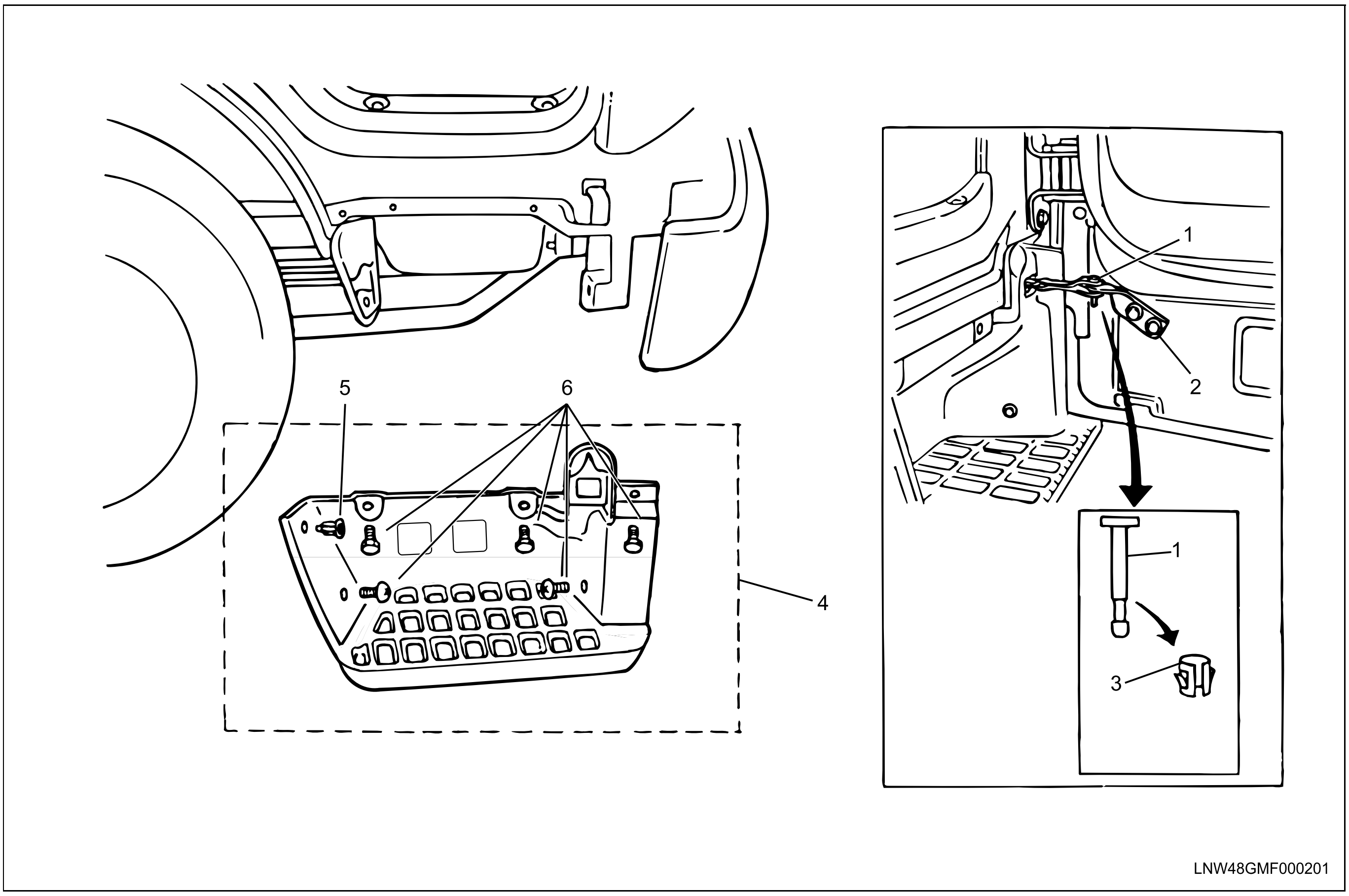
- Adjust Nut to 13 N·m (113 lb in).



Legend

1. Hand Lever Hook Rod
2. Hook Rod Assembly
3. Bracket
4. Cab Lock Control Unit Assembly
5. Control Lever

Front Step Assembly



Legend

1. Front Door Check Arm Pin
2. Check Arm Bracket
3. Clip
4. Front Step Assembly
5. Clip
6. Bolt/Screw (Used to Secure the Front Step Assembly)

Remove Procedure

1. Force open the clip notch at the tip of the pin. Remove the clip.
   Use a plastic hammer to drive the pin down and out and remove the front door check arm pin.
2. Remove the 2 mounting bolts on the door side and remove the check arm bracket.
3. Remove the 3 bolts, 2 screws, and 1 clip securing the front step assembly and remove the front step assembly.

Installation Procedure

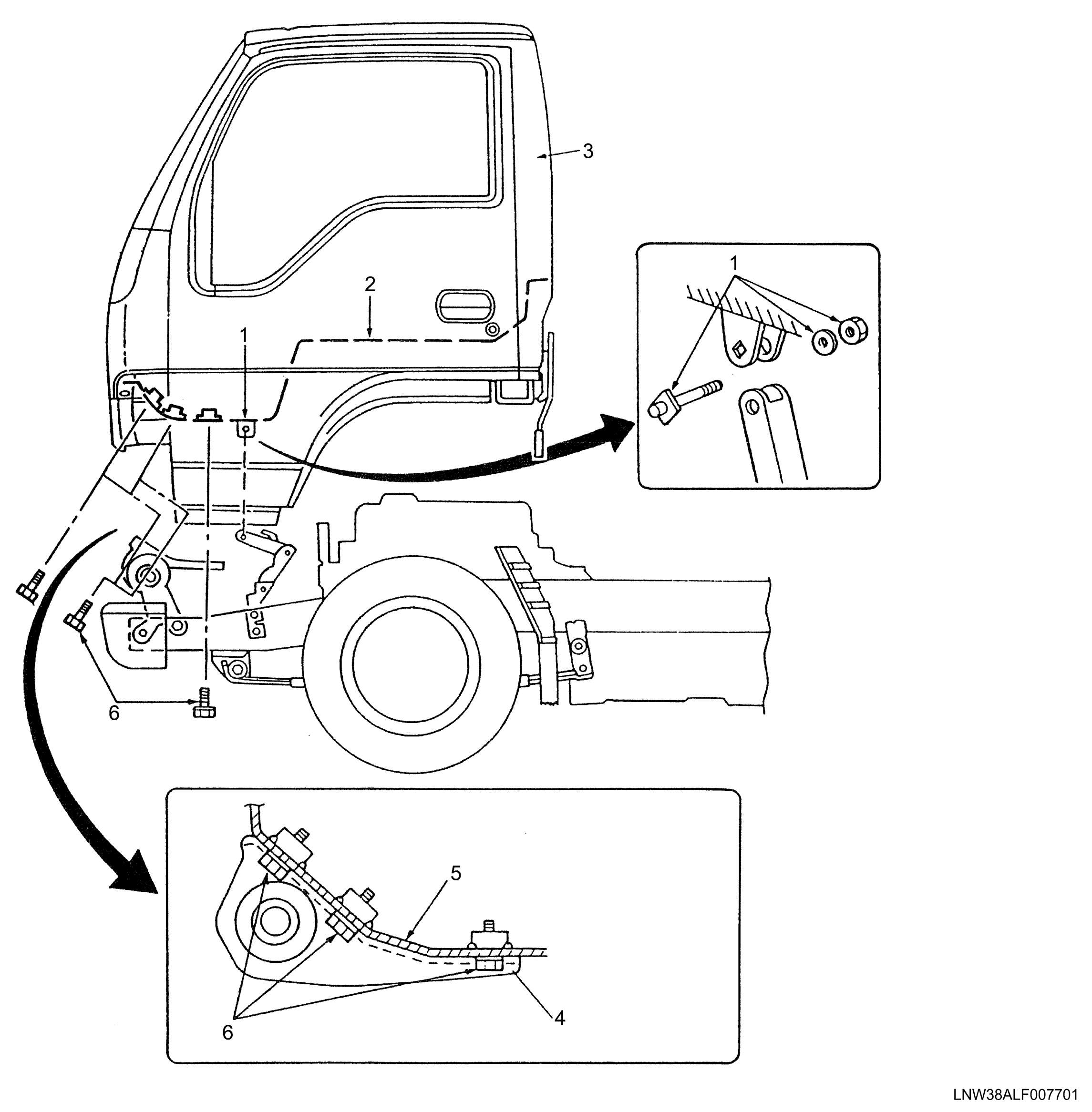
Install the front step following the removal steps in the reverse order. Pay careful attention to the following.

1. Tighten the front step bolt to the specified torque.
2. Tighten the 2 mounting bolts to the specified torque.
3. Be sure that the clip securing the end of the check arm pin is set correctly.

Tighten

- Front step fixing bolts to 15 N·m(11 lb ft)
- Door hinge mounting bolts to 25 N·m(18 lb ft)

Cab Replacement



Legend

1. Cab Stay Pin and Nut
2. Floor
3. Cab Assembly
4. Frame-Side Mounting Lever
5. Cab-Side Front Mounting Rail
6. Cab Mounting Bolt

Removal Procedure

Preparations;

- Before removal or installation of the cab ASM, remove the following connections. The removal order is free. However, perform each step surely referring to each workshop manual.

1. Remove the heater hose/air conditioner piping
   Refer to Heating and Air Conditioning.
2. Remove the brake fluid piping.
   Refer to Hydraulic Brakes.
3. Remove the hydraulic clutch piping.
   Refer to Clutch.
4. Disconnect the transmission control cable/linkage. Perform the work surely according to the procedure fit for the mounted engine.
5. Disconnect the parking brake control cable.
   Refer to Parking Brake.
6. Remove the steering linkage
   Refer to Steering Linkage.
7. Disconnect the harness connector and remove the frame earth bolt.
   Refer to Cab and Chassis Electrical.

- After disconnecting all the above connections, tilt the cab for a tilt cab vehicle or remove the rear mounting connection for a non-tilt vehicle. For removal of the rear mounting, refer to Cab mounts.

8. Remove the cab stay pin and nut.
9. Remove the cab mounting bolt.
10. Remove the cab ASM.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following point.

Tighten

- Cab mounting bolts to 82 N·m (61 lb ft).

Specifications

Fastener Torques

Seat Rail Cap Nut	25 N·m (18 lb ft)
Each Hinge Bolts	13 N·m (113 lb in)
Seat Belt Anchor Bolts	45 N·m (33 lb ft)
Retractor Mounting Bolt	45 N·m (33 lb ft)
Clutch Pedal Bracket Upper Bolt	37 N·m (27 lb ft)
Steering Column Bracket Bolt	20 N·m (14 lb ft)
Brake Pedal Bracket Upper Bolt	42 N·m (31 lb ft)
Door Hinge Mounting Bolts	25 N·m (18 lb ft)
Door Lock Mechanism Fixing Bolts	13 – 18 N·m (113 lb in – 13 lb ft)
Outside Door Release Handle Mounting Bolts	13 – 18 N·m (113 lb in – 13 lb ft)
Window Regulator Mounting Bolts	7 N·m (61 lb in)
Cab Mounting Bracket	A: 88 N·m (65 lb ft) B: 50 N·m (37 lb ft) C: 81 N·m (60 lb ft)
Cab Mounting Brackets Fixing Bolts	117 N·m (88 lb ft)
Cab Mounting Lock Nut	76 N·m (56 lb ft)
Anchor Arm Anchor Bolt	95 N·m (70 lb ft)
Cab Lock Assembly Fixing Nut	19 N·m (14 lb ft)
Cab Lock Adjust Nut	13 N·m (113 lb in)
Front Step Fixing Bolts	15 N·m (11 lb ft)
Cab Mounting Bolt	82 N·m (61 lb ft)

BODY, CAB, AND ACCESSORIES

Crew Cab

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Description and Operation

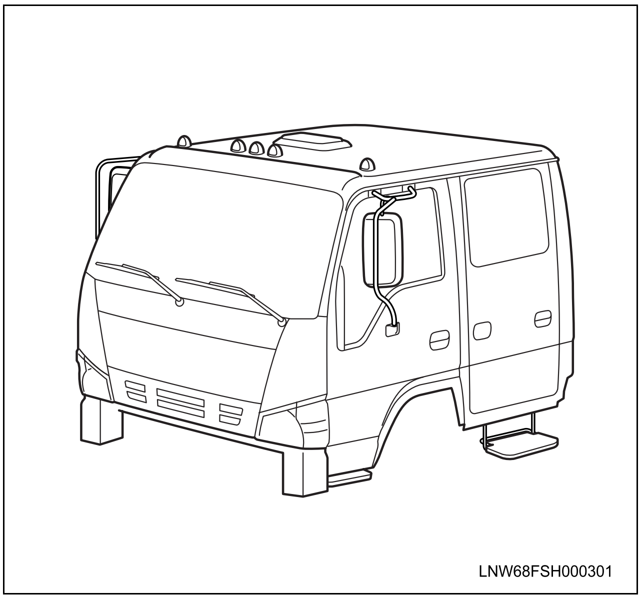
Cab Description

The Steel Crew Cab Model is all steel welded construction. The cab fully surrounds the engine. The cab rests on three mount brackets which are bolted to the frame rail on both sides of the truck.

The combination brake fluid/clutch fluid reservoir is located inside the cab, on the left side of the dash.

Windows

Door windows are covered in this section under “Doors”. All other windows are covered in CAB MAINTENANCE under “Stationary Glass”.



Diagnostic Information and Procedures

Seat will not move

POSSIBLE CAUSE	CORRECTION
1 Obstructed adjustment mechanism.	1 Remove the obstruction.
2 Frozen or obstructed guide rails.	2 Replace obstruction and/or remove the seat and the adjustment mechanism . Clean the guide rails and lubricate.
3 Broken adjustment lever.	3 Replace the adjustment mechanism.

Seat moves only on One Side

POSSIBLE CAUSE	CORRECTION
1 Obstructed guide rail.	1 Remove the obstruction.
2 Obstructed adjustment mechanism.	2 Remove the obstruction.

Seat is Hard to Move

POSSIBLE CAUSE	CORRECTION
1 Tension spring is broken or disconnected.	1 Remove or connect the spring.
2 Rusty or obstructed guide rails.	2 Remove the obstruction and/or lubricate.

Seat will not Stay in Desired Position

POSSIBLE CAUSE	CORRECTION
1 Missing or disconnected adjustment springs.	1 Remove or connect the spring(s).
2 Broken adjustment lever.	2 Replace the adjustment mechanism.

Door will not Latch or Latches with Difficulty

POSSIBLE CAUSE	CORRECTION
1 Door is out of alignment.	1 Align the door.
2 Striker is out of alignment.	2 Align the striker.
3 Cam of the locking mechanism is in the closed position.	3 Unlock the door, pull the outside handle, and manually rotate the cam.
4 Locking mechanism is not attached securely to the door.	4 Tighten the attaching screws of the locking mechanism.
5 Cam of the locking mechanism is bent or broken.	5 Straighten the cam or replace the locking mechanism.

Door will not Lock

POSSIBLE CAUSE	CORRECTION
1 Disconnected lock rod between the outside handle and locking mechanism.	1 Connect rod. Use a new clip.
2 Arm of the lock cylinder has not properly engaged the lug of the locking mechanism.	2 Remove the lock cylinder and install as directed later in this section.
3 Lug of the locking mechanism is broken.	3 Replace the locking mechanism.
4 Frozen lock cylinder.	4 Lubricate the lock cylinder or replace.

Door will not Open but It is Unlocked (Door Handles do not Work Freely)

POSSIBLE CAUSE	CORRECTION
1 Door out of alignment.	1 Align the door.
2 Striker bolt out of alignment.	2 Adjust the striker bolt.
3 Frozen locking mechanism.	3 Remove the locking mechanism and lubricate or replace it.

Door will not Open, It is Unlocked, but Release Handle/Lever Works Freely

POSSIBLE CAUSE	CORRECTION
Disconnected rod from the door release mechanism to the locking mechanism.	If disconnected from the release mechanism, remove the mechanism and connect the rod to it. If disconnected from the locking mechanism, connect the rod.

Door is Hard to Open

POSSIBLE CAUSE	CORRECTION
1 Frozen hinge-dirty or incorrect lubricant.	1 Clean the hinge and lubricate.
2 Door is out of alignment.	2 Align the door.

Door Window is Difficult to Move

POSSIBLE CAUSE	CORRECTION
1 Rusty or dirty regulator.	1 Remove the regulator, clean and lubricate.
2 Obstructed run channel.	2 Remove obstruction.

Door Window will not Close or Regulator Handle will not Work

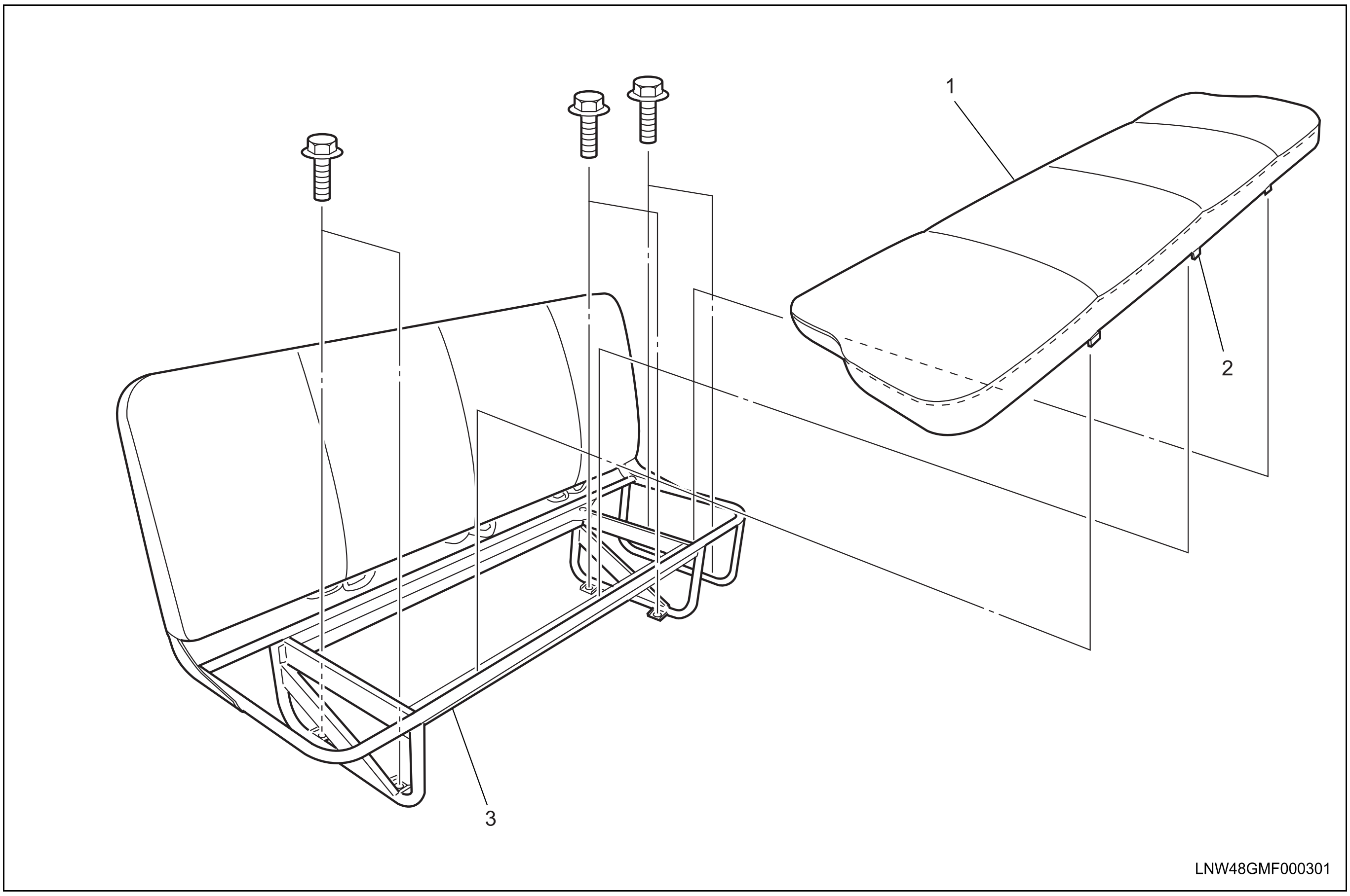
POSSIBLE CAUSE	CORRECTION
1 Obstructed or frozen regulator.	1 Remove the regulator, clean and lubricate.
2 Obstructed regulator guide channel.	2 Remove obstruction.
3 Obstructed run channel.	3 Remove obstruction.
4 Misaligned run channel.	4 Reposition run channel bracket and/or division channel.

Door Window will not Move but Regulator Handle Moves Freely

POSSIBLE CAUSE	CORRECTION
1 Stripped window regulator handle.	1 Replace handle.
2 Stripped window regulator shaft.	2 Replace regulator.
3 Regulator roller is not in the guide channel.	3 Remove regulator and install as outlined in this section.
4 The teeth of the regulator gear are broken.	4 Replace regulator.

Repair Instructions

Rear Seat



Legend

1. Rear Seat Cushion
2. Clip
3. Rear Seat Frame

Removal Procedure

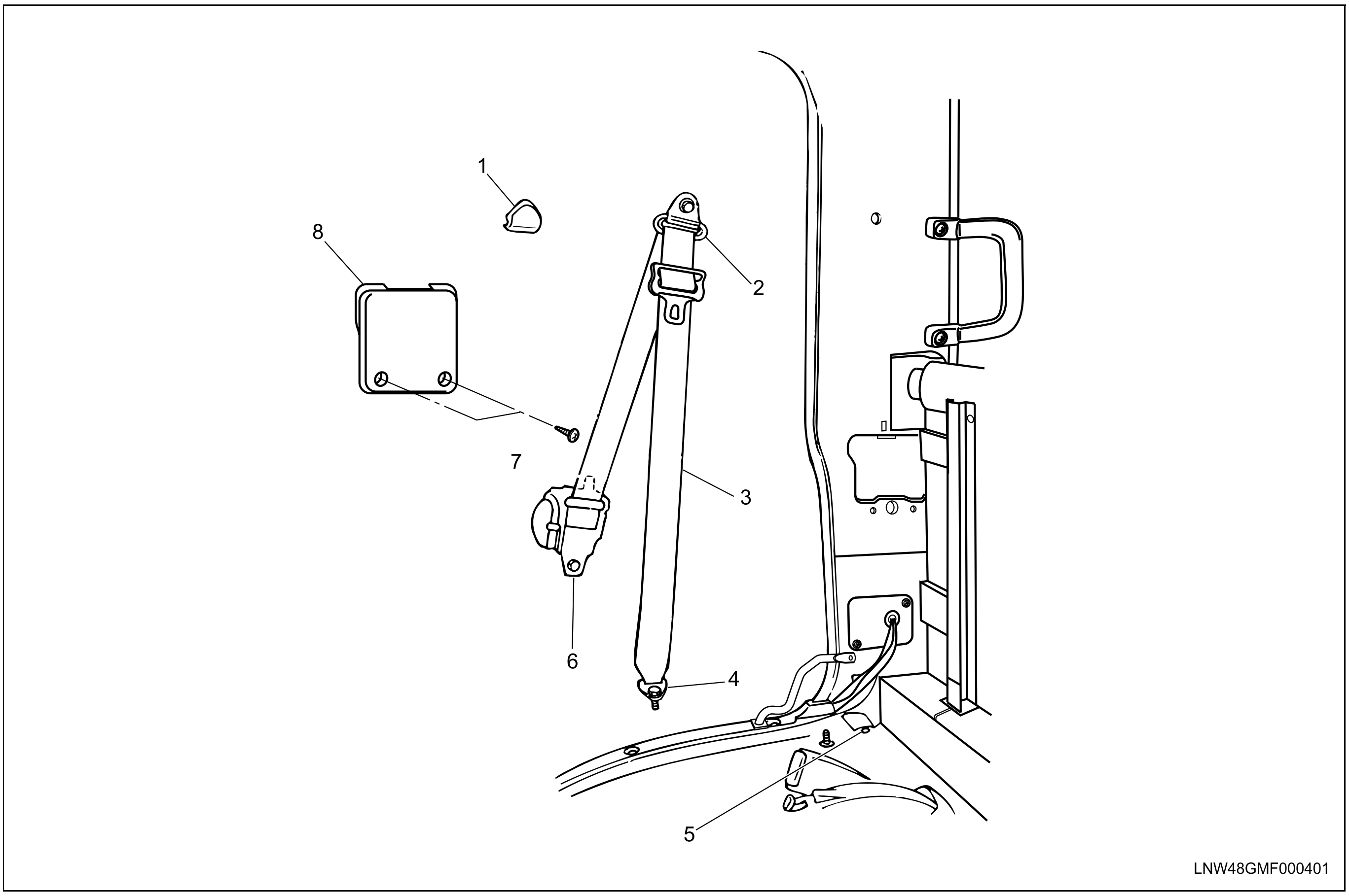
1. Pull the seat cushion at the three clip positions from the seat frame and remove the rear seat cushion.
2. Remove the 6 bolts and remove the rear seat frame.

Installation Procedure

To install, follow removal steps in the reverse order, noting the following point.

1. Tighten the rear seat frame mounting bolts to the specified torque.
   - Rear seat frame bolts to 13 N·m (113 lb in).

Front Seat Belts:Side Seat Belt Tongue



Legend

1. Through Bolt Anchor Cover
2. Seat Belt Upper Anchor Bolt
3. Seat Belt Tongue Side Assembly
4. Seat Belt Lower Anchor Bolt
5. Seat Belt Lower Anchor Bolt Mounting Hole
6. Retractor Mounting Bolt
7. Bracket
8. Retractor Cover

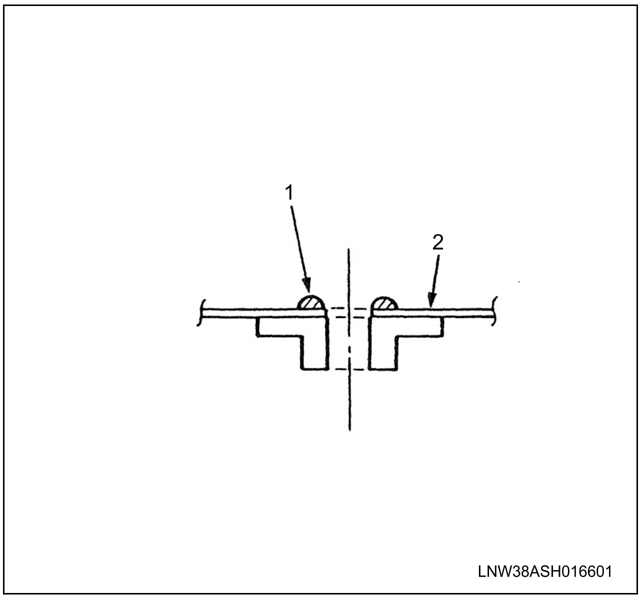
Removal Procedure

1. Remove the seat belt lower anchor bolt.
2. Remove the 2 mounting screws and remove the retractor cover.
3. Remove the through bolt anchor cover.
4. Remove the seat belt upper anchor bolt.
5. Remove the bolt and pull out the upper bracket of the retractor from the panel and remove the retractor mounting bolt.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. Apply the sealant around the seat belt lower anchor bolt mounting hole.



Legend

1. All Periphery Sealing Along the Floor Surface Mounting Hole
2. Floor Panel

---

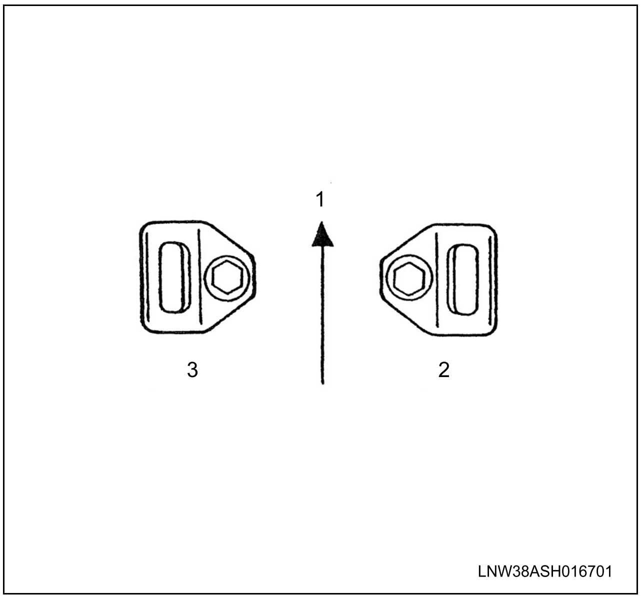
2. Install the lower anchor in the specified direction and tighten it to the specified torque.

Tighten

- Anchor bolt and Retractor fixing bolt to 45 N·m (33 lb ft)

Notice:

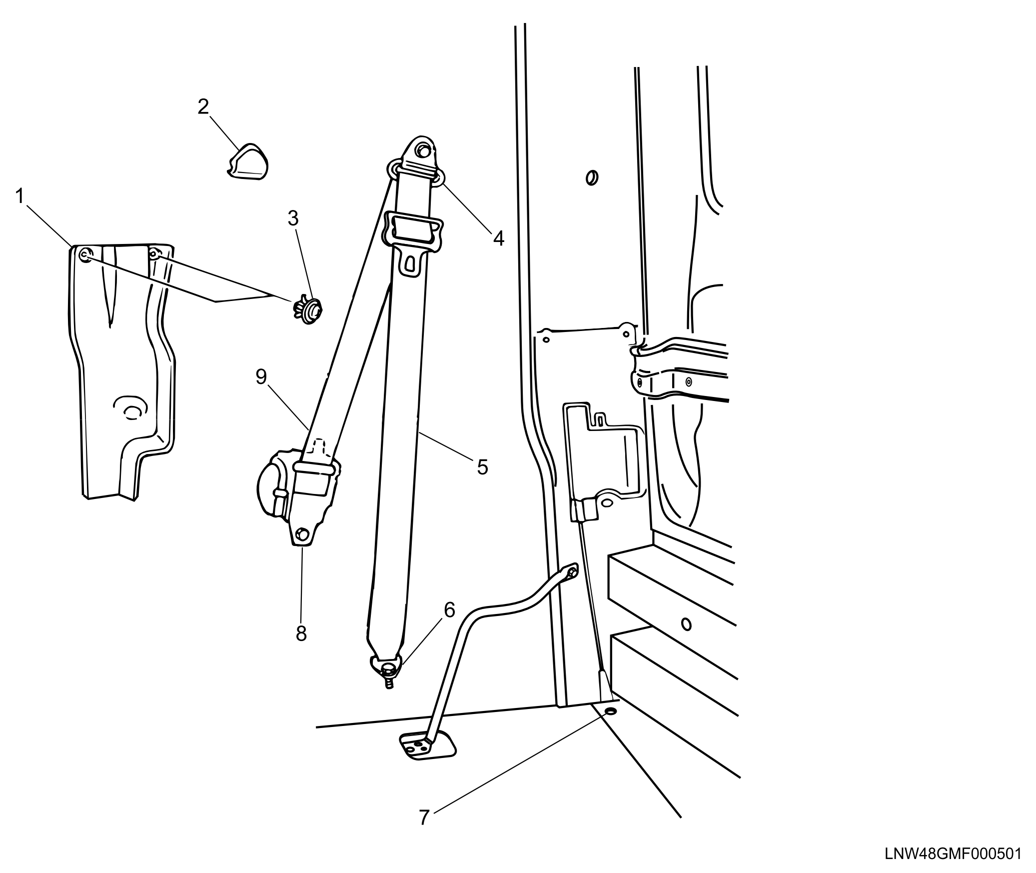
Install the seat belt lower anchor so that it may not run on the anchor detent bead.



Legend

1. Vehicle Front Side
2. Right Side
3. Left Side

Rear Seat Belts: Side Seat Belt Tongue



Legend

1. Rear Pillar Lower Trim Cover
2. Through Bolt Anchor Cover
3. Clip
4. Seat Belt Upper Anchor Bolt
5. Seat Belt Tongue Side Assembly
6. Seat Belt Lower Anchor Bolt
7. Seat Belt Lower Anchor Bolt Mounting Hole
8. Retractor Mounting Bolt
9. Bracket

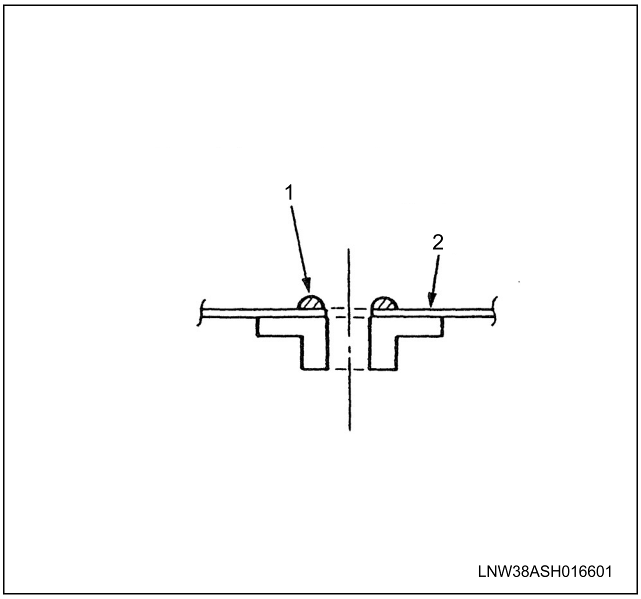
Removal Procedure

1. Remove the seat belt lower anchor bolt.
2. Remove the two clips and pull the cover upwards and remove the rear pillar lower trim cover.
3. Remove the through bolt anchor cover.
4. Remove the seat belt upper anchor bolt.
5. Remove the bolt and pull out the upper bracket of the retractor from the panel and remove the retractor mounting bolt.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. Apply the sealant around the seat belt lower anchor bolt mounting hole.



Legend

1. All Periphery Sealing Along the Floor Surface Mounting Hole
2. Floor Panel

---

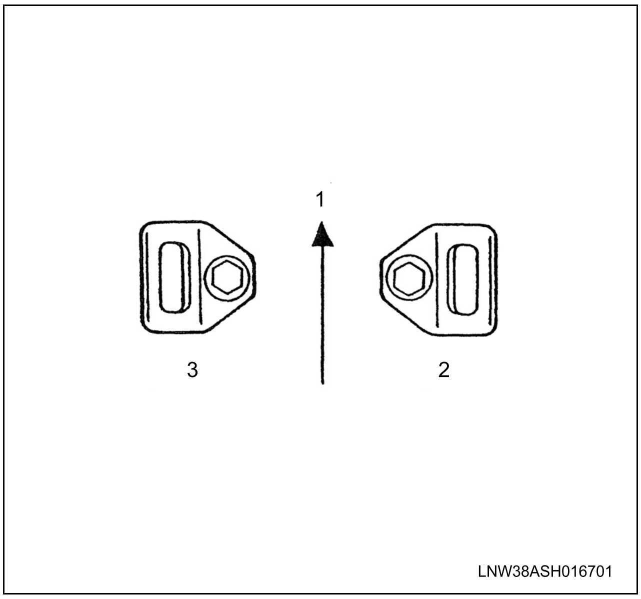
2. Install the lower anchor in the specified direction and tighten it to the specified torque.

Tighten

- Anchor bolt to 45 N·m (33 lb ft)

Notice:

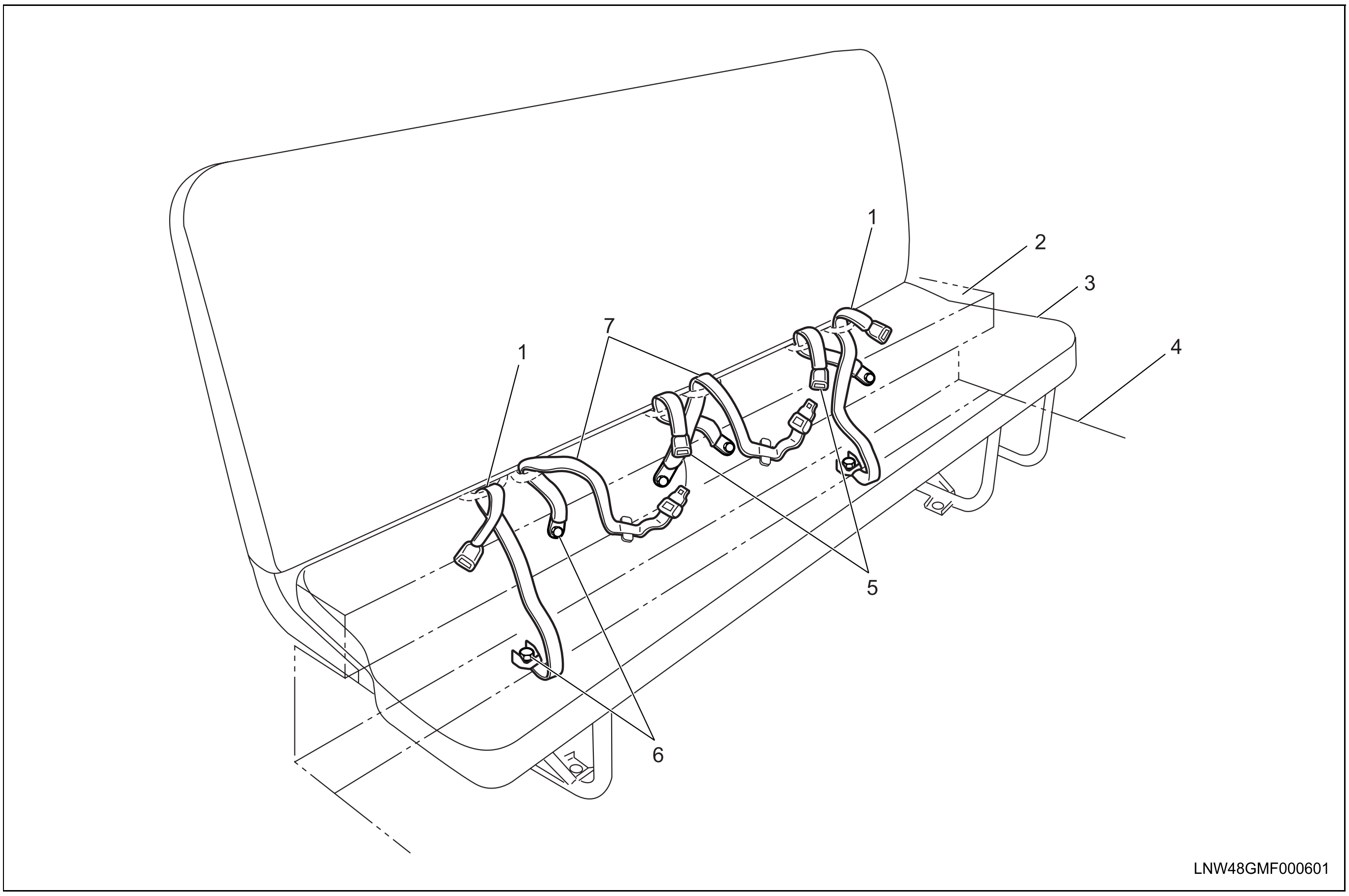
Install the seat belt lower anchor so that it may not run on the anchor detent bead.



Legend

1. Vehicle Front Side
2. Right Side
3. Left Side

Rear Door-Side Seat Belt Buckle And Rear Center Seat Belt/Buckle



Legend

1. Door-Side Seat Belt Buckle
2. Rear Seat Belt Reinforcement
3. Rear Seat Cushion
4. Rear Floor Panel
5. Center Seat Belt Buckle
6. Lower Anchor Bolt
7. Center Seat Belt Tongue

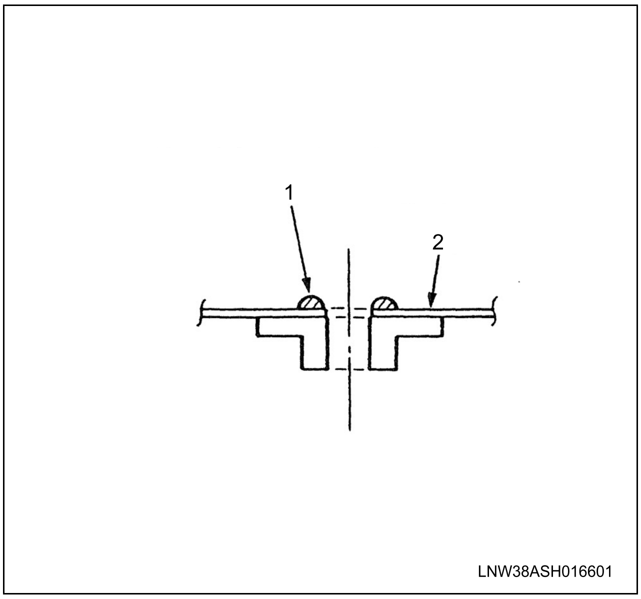
Removal Procedure

1. Remove the rear seat cushion.
   - Refer to “Rear seat” in this section
2. Remove the lower anchor bolt.
3. Remove the door-side seat belt buckle.
4. Remove the center seat belt tongue.
5. Remove the center seat belt buckle.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. Apply the sealant around the door-side seat belt buckle lower anchor bolt mounting hole.



Legend

1. All Periphery Sealing Along the Floor Surface Mounting Hole
2. Floor Panel

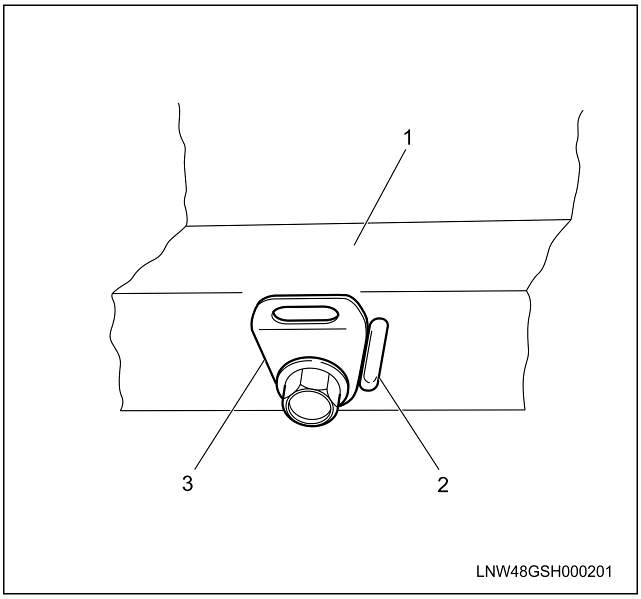
---

2. Install the anchor in the specified direction and tighten it to the specified torque.

Tighten

- Anchor bolt to 45 N·m (33 lb ft)

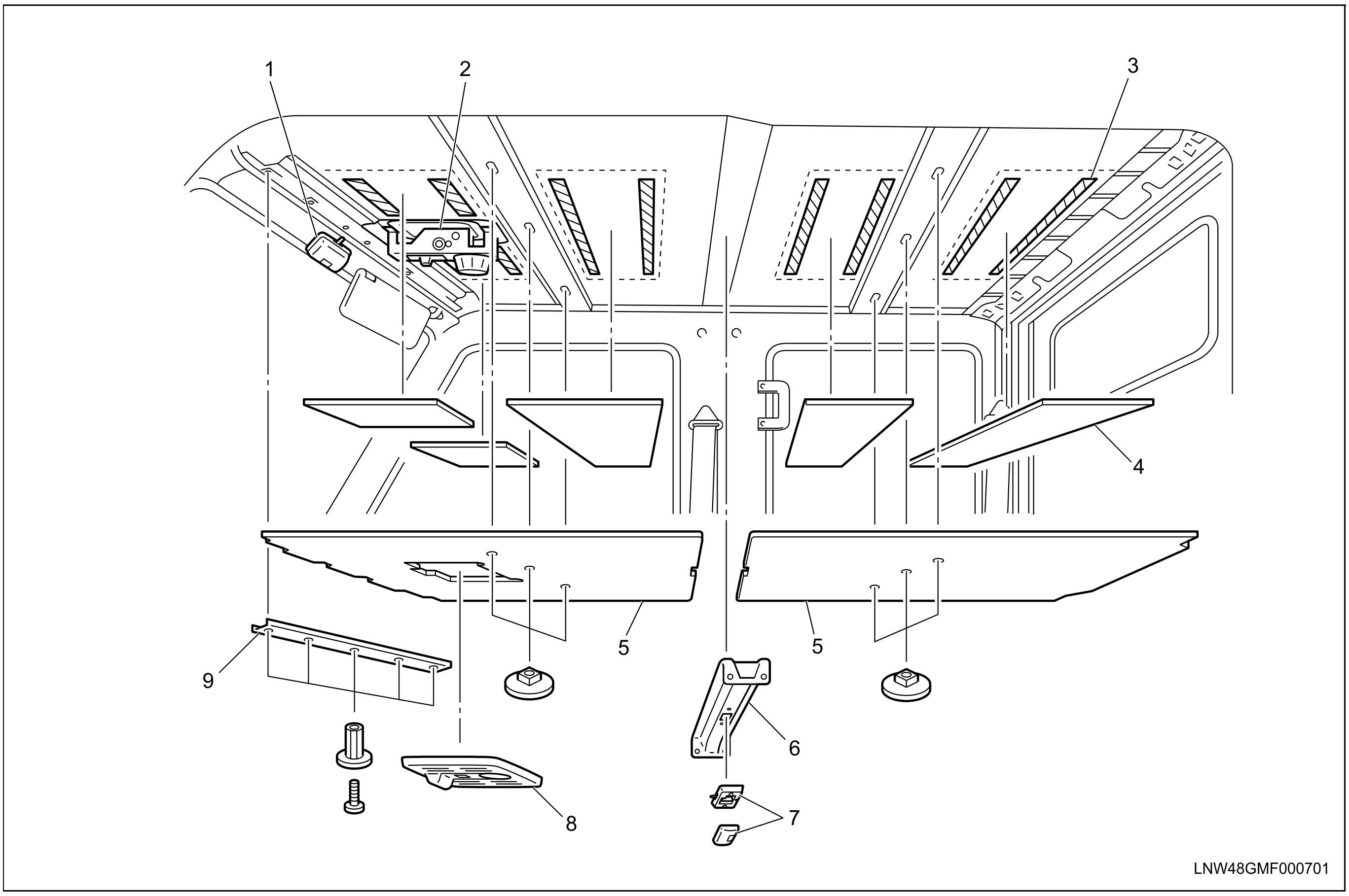
3. Install the anchor bracket to match the detent bead.



Legend

1. Rear Seat Belt Reinforcement
2. Detent Bead
3. Anchor Bracket

Headlining



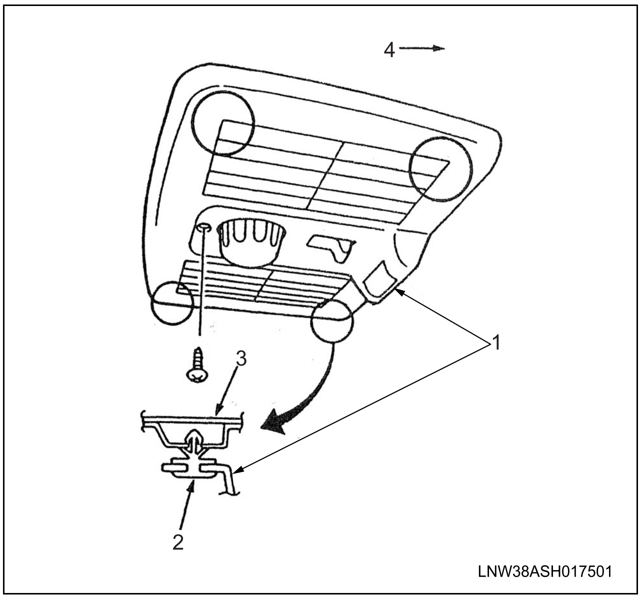
Legend

1. Dome Light
2. Roof Ventilator
3. Adhesive Tape
4. Insulator
5. Headlining
6. Roof Reinforcement
7. Interior Light
8. Roof Ventilator Grille
9. Front Retainer

Removal Procedure

Preparation:Disconnect the battery ground cable.

1. Remove one mounting screw and pull the four mounting clips and remove the roof ventilator grille.

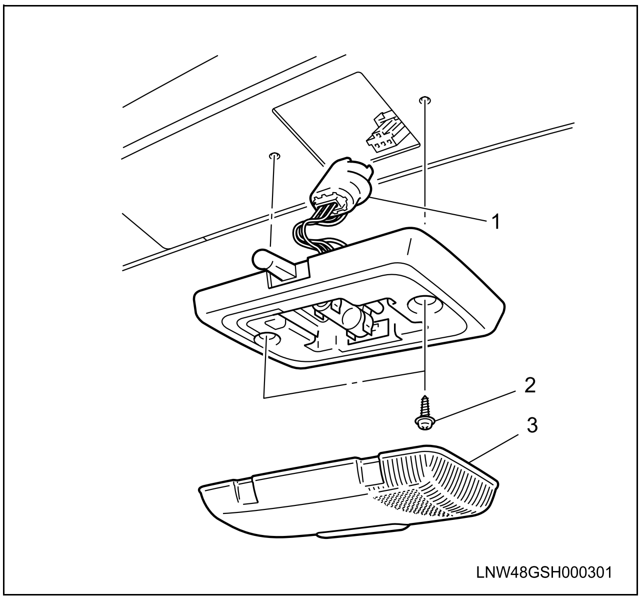


Legend

1. Roof Ventilator Grille
2. Clip
3. Roof Panel
4. Front Side

---

2. Remove the 5 clips and remove the front retainer.
3. After removing the lens, remove the 2 screws.
   - Disconnect the connector and remove the interior light.



Legend

1. Connector
2. Screw
3. Lens

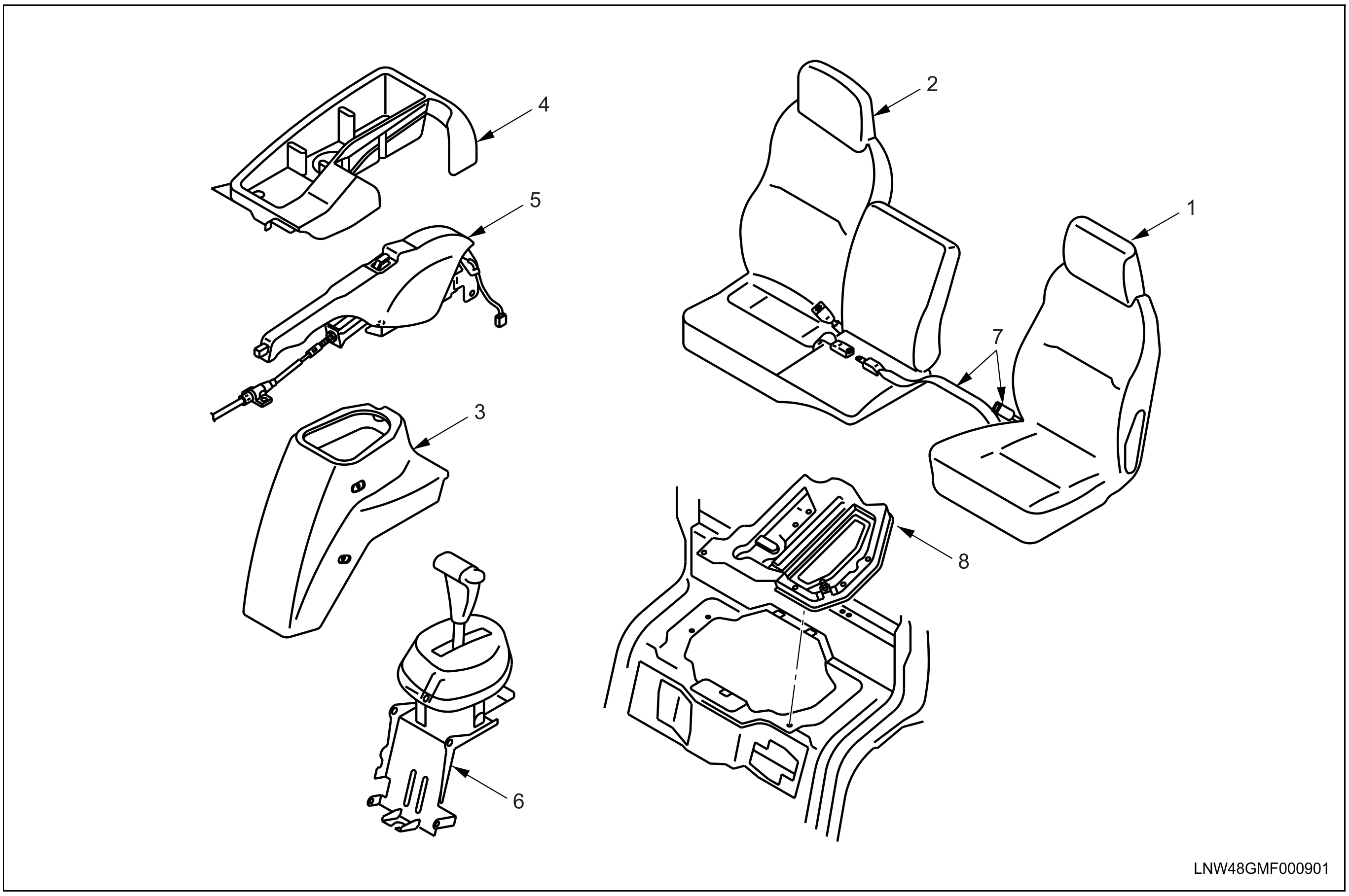
---

4. Remove the 4 screws and remove the roof reinforcement.
5. Remove the headlining.
6. Remove the insulator.

Installation Procedure

To install, follow the removal steps in the reverse order.

Cab Floor Cover



Legend

1. Driver’s Seat.
2. Passenger Seat with Engine Cover.
3. Automatic Transmission (A/T) Control Lever Cover.
4. Center Console.
5. Parking Brake Lever with Cable.
6. Automatic Transmission (A/T) with Shift Cable.
7. Driver and Center Seat Belt Buckle.
8. Cab Floor Cover.

Removal Procedure

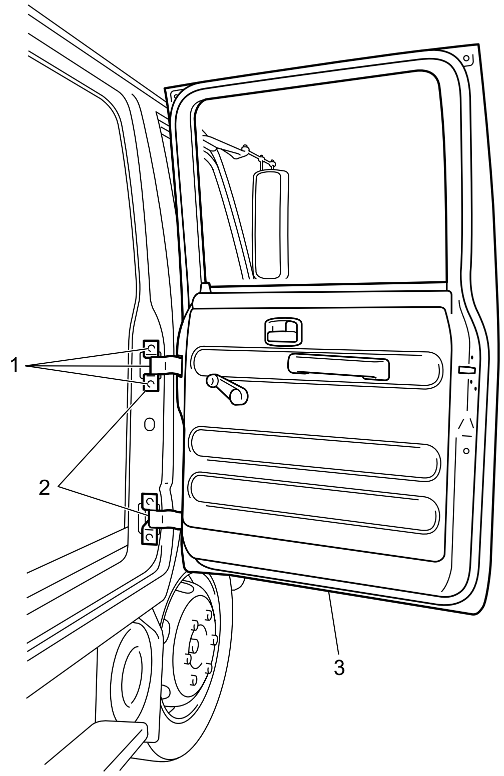
1. Remove the driver’s seat.
   - Refer to “Driver’s seat” in section 8F.
2. Remove the passenger seat with engine cover.
3. Remove the automatic transmission (A/T) control lever cover.
   - Refer to AUTOMATIC TRANSMISSION.
4. Remove the center console.
5. Remove the parking brake lever with cable.
6. Remove the automatic transmission (A/T) with shift cable.
   - Refer to AUTOMATIC TRANSMISSION.
7. Remove the driver and center seat belt buckle.
8. Remove the cab floor cover.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following point:

1. Before installing the cab floor cover, apply the sealant to the contact surface of the cab floor cover.

Rear Door



Legend

1. Mounting Bolt
2. Hinge
3. Rear Door Assembly

Removal Procedure

1. Remove the 3 mounting bolts for each hinge and remove the mounting bolt.
2. Remove the rear door assembly.

Installation Procedure

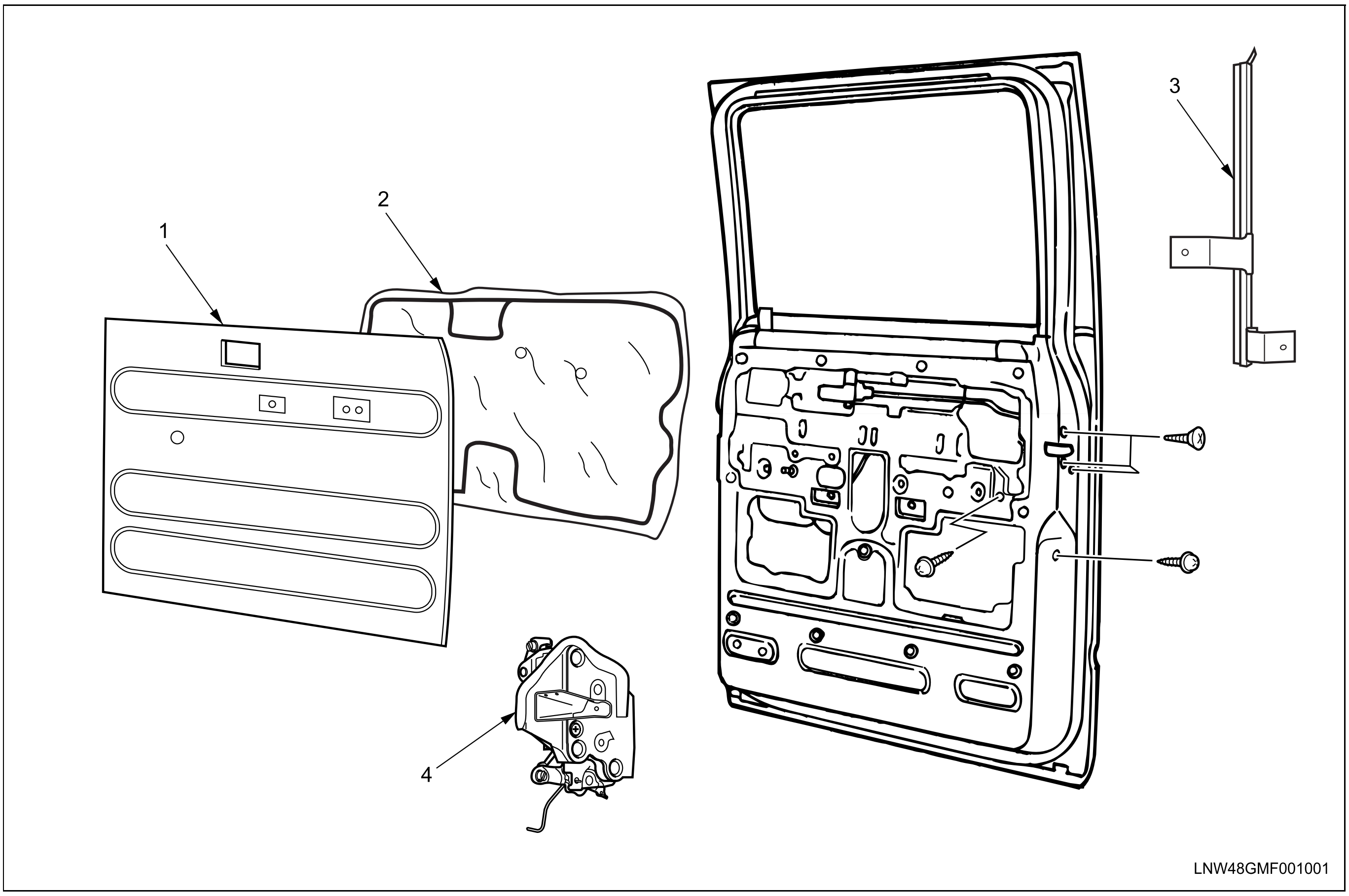
To install, follow the removal steps in the reverse order, noting the following point:

1. Tighten the mounting bolt to the specified torque.

Tighten

- Rear door hinge mounting bolts to 25 N·m (18 lb ft).

Rear Door Lock Mechanism

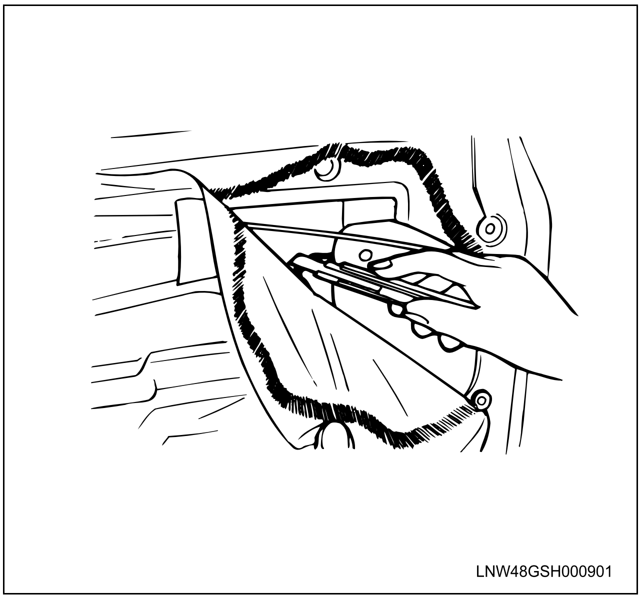


Legend

1. Rear Door Trim Panel
2. Water-proof Sheet
3. Glass Run Rear Channel
4. Lock Mechanism

Removal Procedure

1. Remove the Rear door trim panel.
   - Refer to “Rear door trim panel” in this section.
2. Peel off the water-proof sheet carefully with a cutter or knife. Take care not to damage it when peeling it off and remove the water-proof sheet.



3. Remove the 2 mounting screws and pull the rear channel out and remove the glass run rear channel.

4. Remove the 3 mounting screws and disconnect the locking links and remove the lock mechanism.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

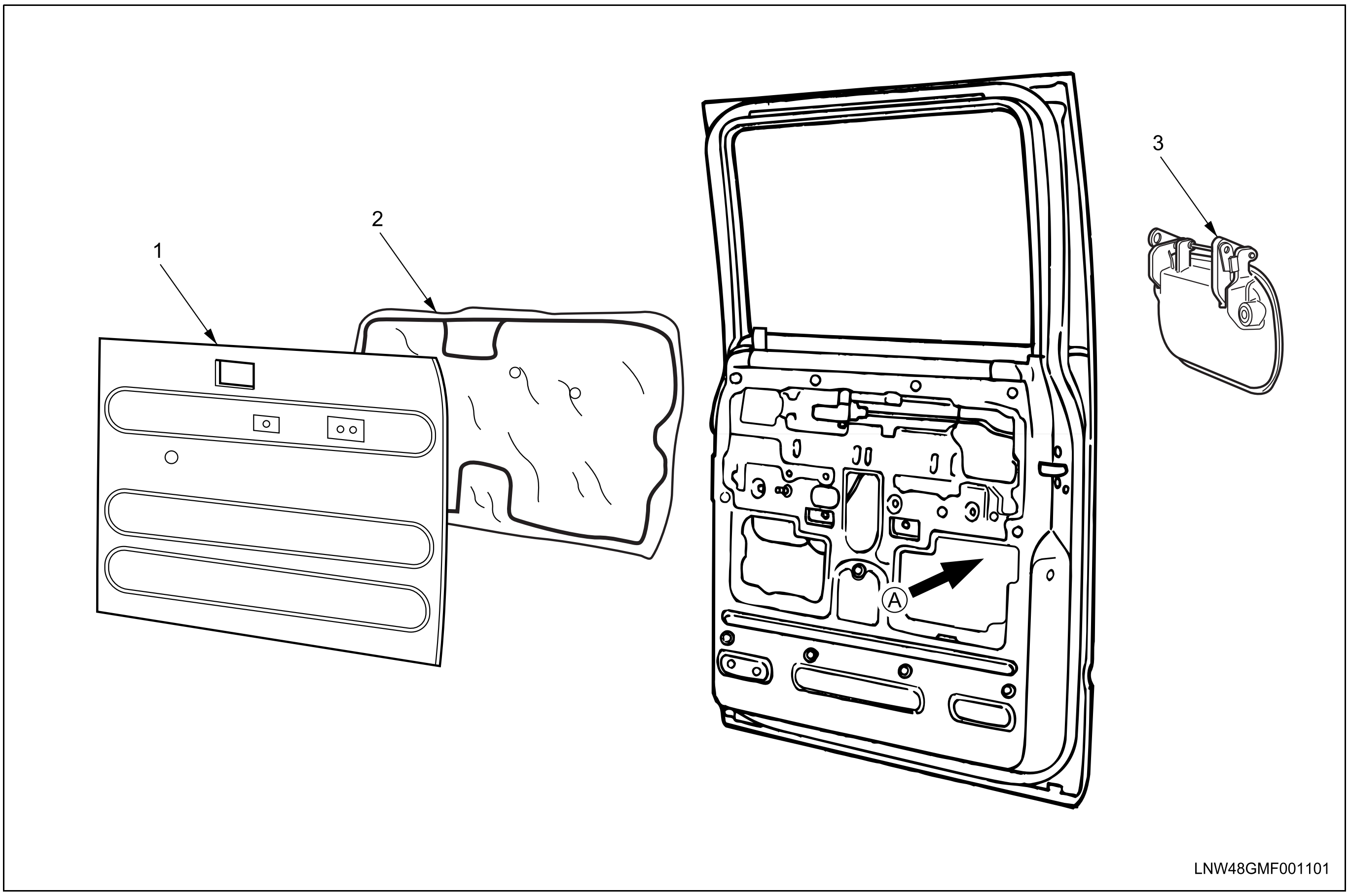
1. Tighten the mounting screw to the specified torque.

Tighten

- Rear door lock mechanism mounting screws to 6 N·m (52 lb in)

2. After installation, check the operation.

Rear Door Outside Door Release Handle



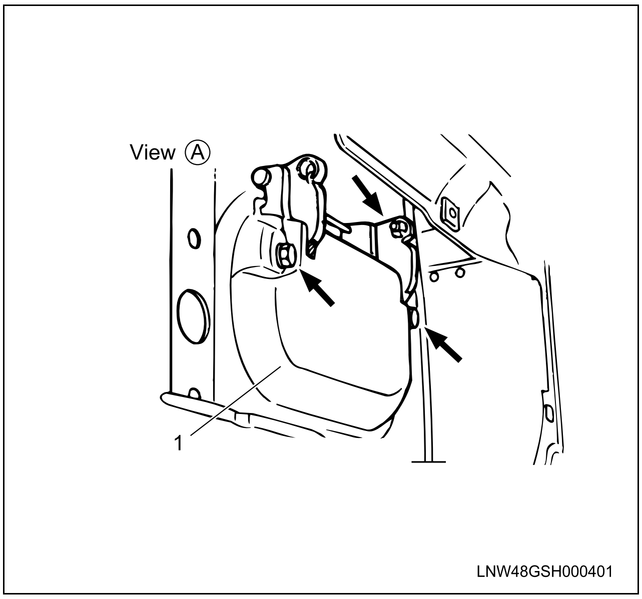
Legend

1. Rear Door Trim Panel
2. Water-proof Sheet
3. Outside Door Release Handle

Removal Procedure

1. Remove the rear door trim panel.
   - Refer to “Rear door trim panel” in this section.
2. Remove the water-proof sheet.
   - Refer to “Rear door lock mechanism” in this section.

3. Disconnect the link and remove the 2 mounting bolts and remove the Outside door release handle.



Legend

1. Outside Door Release Handle

Installation Procedure

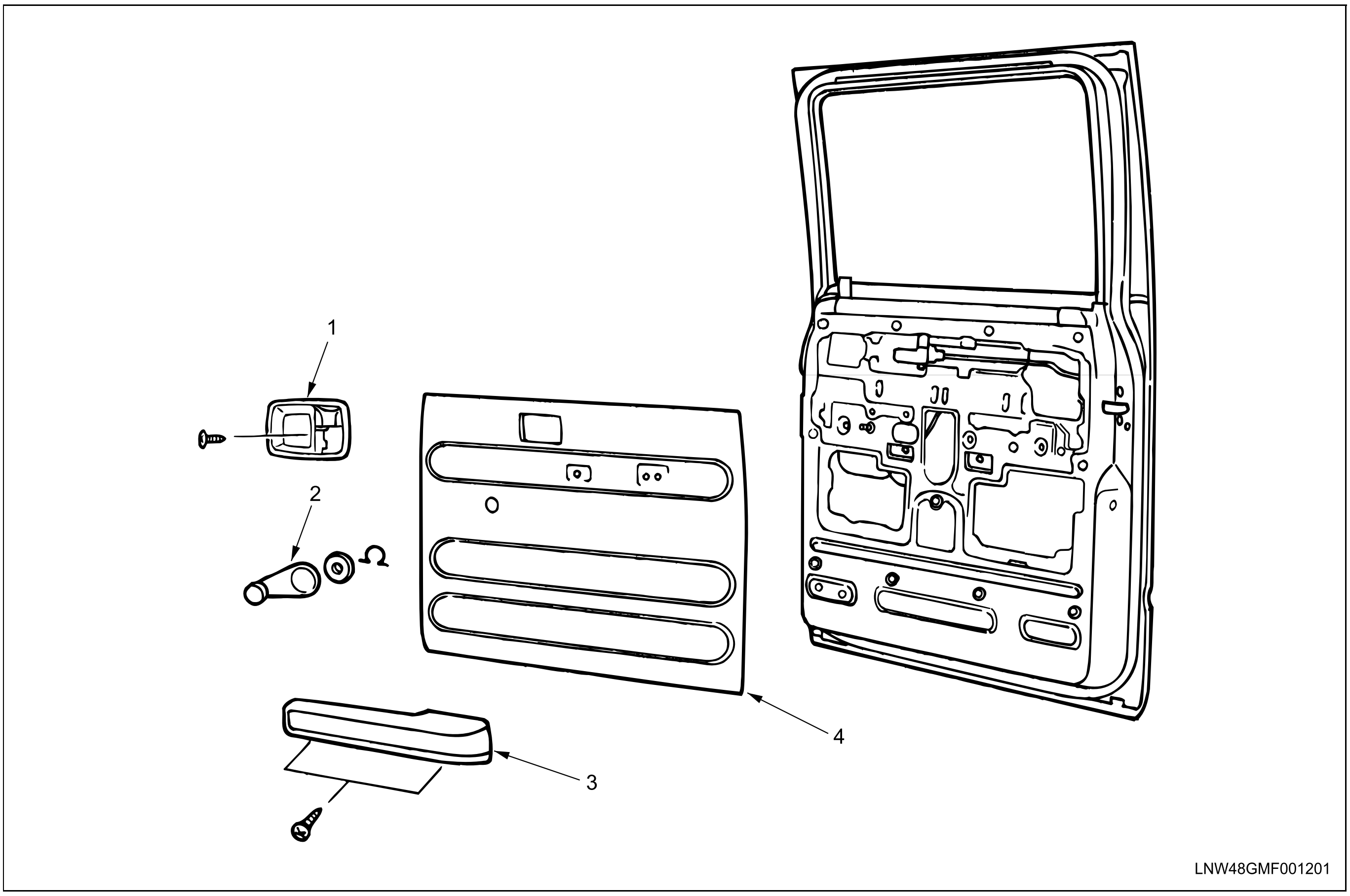
To install, follow the removal steps in the reverse order, noting the following point:

1. Tighten the mounting bolt to the specified torque.

Tighten

- Outside door release handle mounting bolts to 13 N·m (113 lb in) – 18 N·m (13 lb ft)

Rear Door Trim Panel

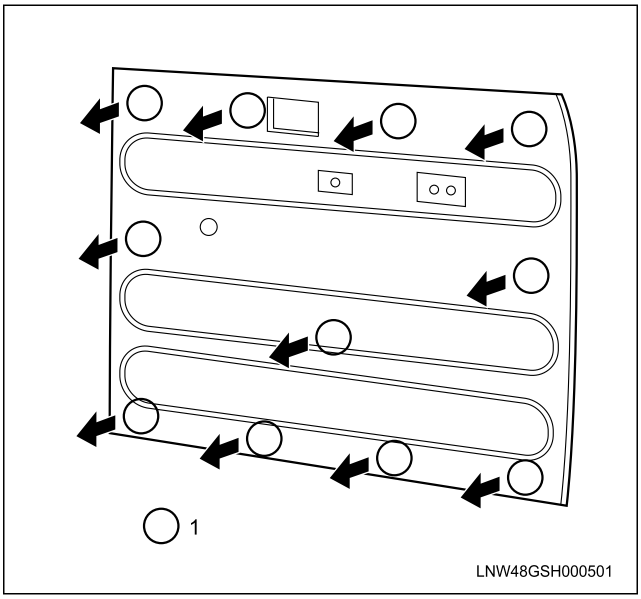


Legend

1. Inside Lever Garnish
2. Regulator Handle
3. Arm Rest
4. Rear Door Trim Panel

Removal Procedure

1. Remove the mounting screw and pull the bezel out toward you while pulling and holding the inside lever and remove the inside lever garnish.
2. Remove the clip on the rear side of the regulator handle using a wire and remove the regulator handle.
3. Remove the arm rest.
4. Remove the clip at 11 positions and remove the rear door trim panel.



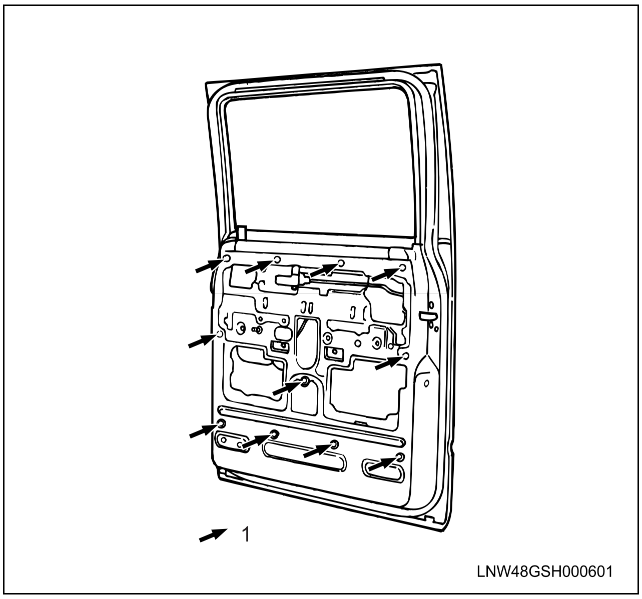
Legend

1. Clip Position

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. Adjust the trim panel clip to the mounting hole on the door panel side and install the trim pad.



Legend

1. Clip Mounting Hole

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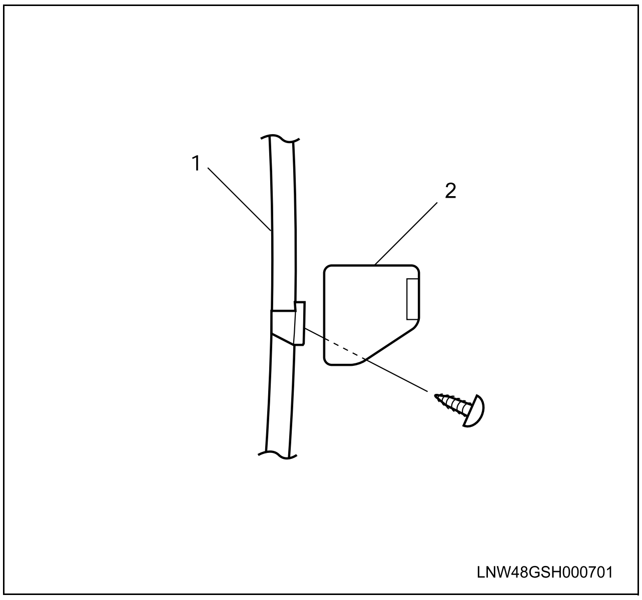
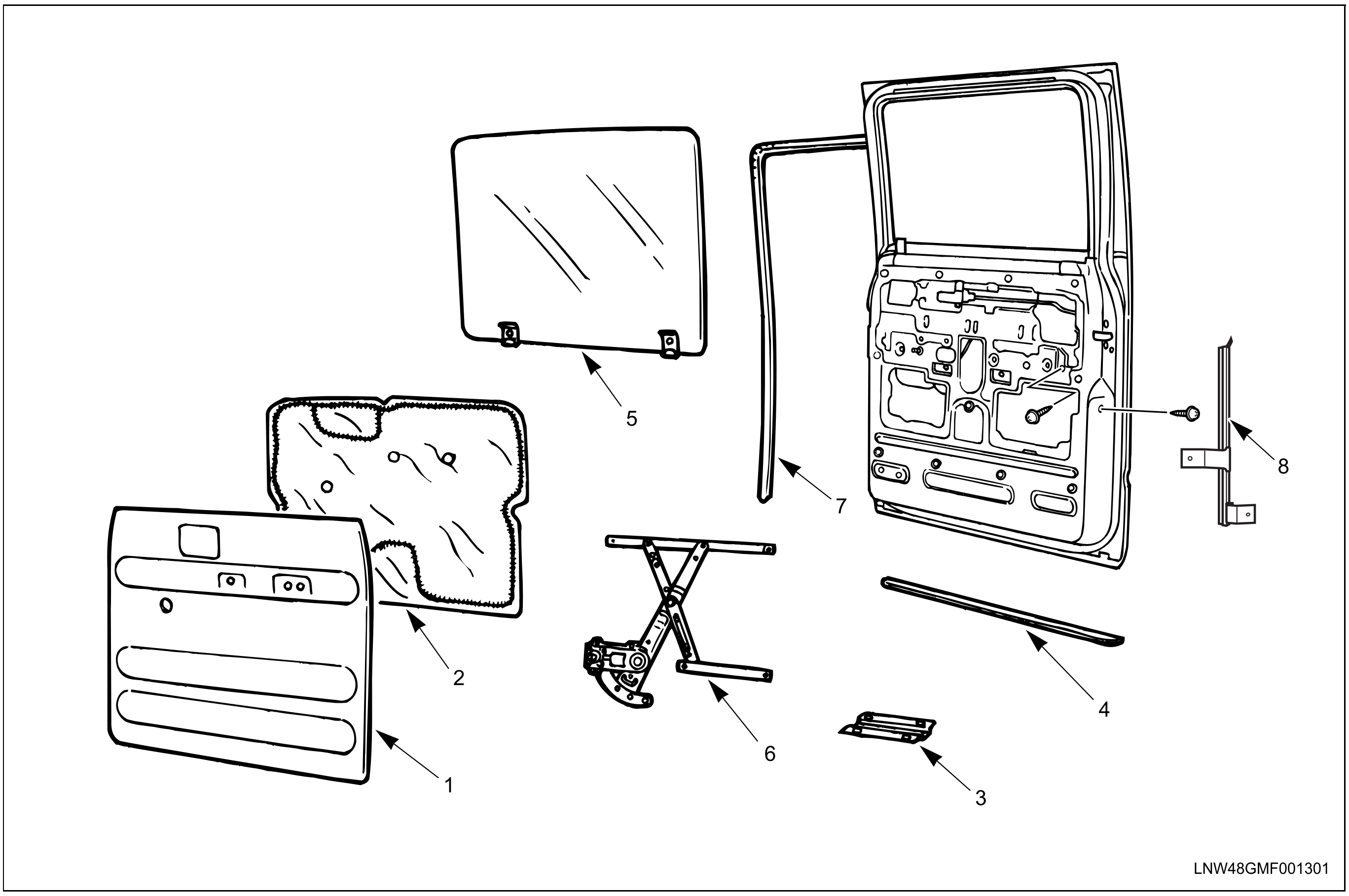
2. Carefully install the arm rest and tighten the mounting screws.



Legend

1. Rear Door Trim Panel
2. Arm Rest

Rear Window and Window Regulator Assembly



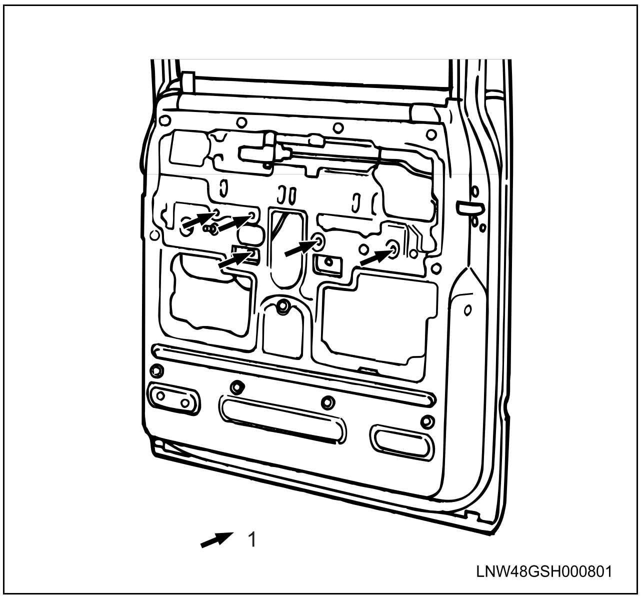
Legend

1. Rear Door Trim Panel
2. Water-proof Sheet
3. Door Bottom Bracket
4. Rear Door Glass Plug
5. Rear Window Glass
6. Window Regulator
7. Glass Run
8. Glass Run Rear Channel

Removal Procedure

1. Remove the rear door trim panel.
    - Refer to “Rear door trim panel” in this section.
2. Remove the water-proof sheet.
    - Refer to “Rear door lock mechanism” in this section.
3. Remove the 4 mounting screws and remove the door bottom bracket.
4. Remove the rear door glass plug.
5. Operate the regulator to adjust the glass height and expose the access hole. Remove the 2 bolts mounting the bottom channel and the regulator. Remove the glass from the bottom access hole and remove the rear window glass.

6. Remove the 5 mounting screws, and remove it through the access hole and remove the window regulator.



Legend

1. Window Regulator Mounting Screws

---

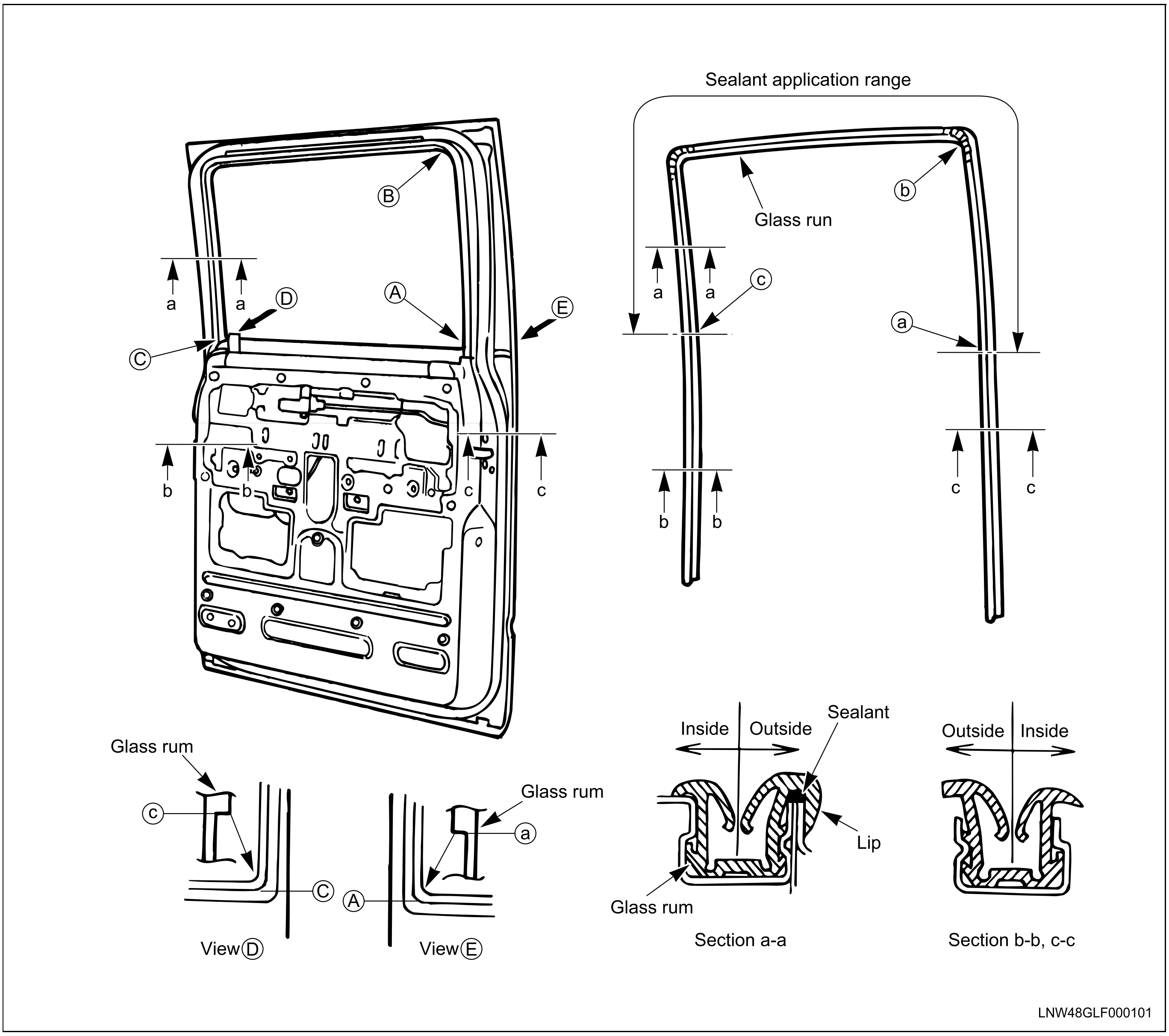
7. Pull the glass run out from the channel and remove the glass run.
8. Remove the 2 mounting screws and remove the glass run rear channel.

Installation Procedure

To install, follow the removal steps in the reverse order, noting the following points:

1. Align the notch (a) of the glass run lip with the door outer waist line (A). Align the glass run slit (b) with the door (B) and fit the glass run between (A) and (B). Next, align the notch (c) of the glass run lip with the door outer waist line (C) and fit the glass run between (B) and (C). Fit the glass run in the channel within the door.
   - Fit the glass run with the lip toward the outside of the vehicle.

Notice:
When reusing the glass run, apply the sealant to the range shown in the figure.



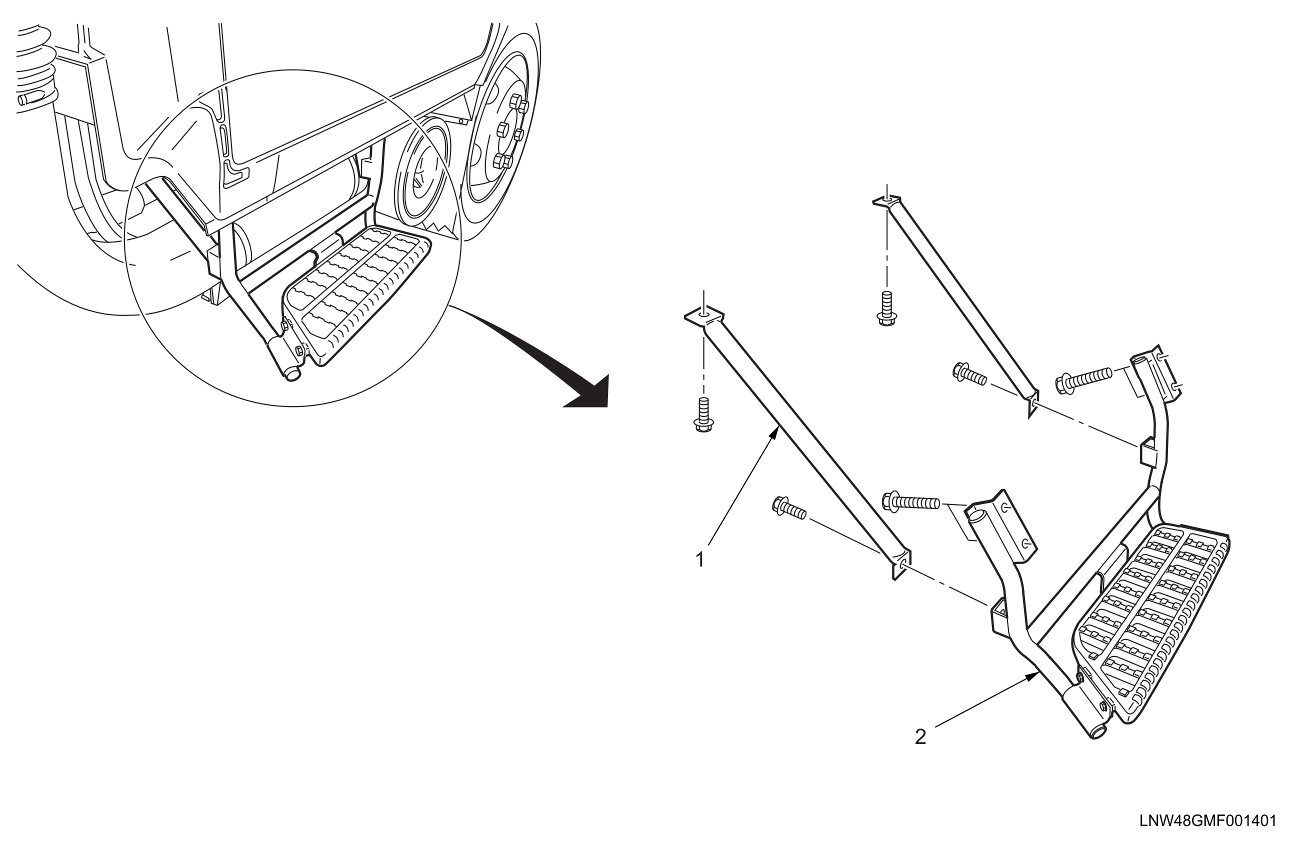
2. Tighten the mounting screw to the specified torque.

Tighten

- Rear window regulator mounting bolts to 7 N·m (61 lb in)

3. Check the water-proof sheet for breakage.

Rear Step Assembly



Legend

1. Rear Step Stay
2. Rear Step Assembly

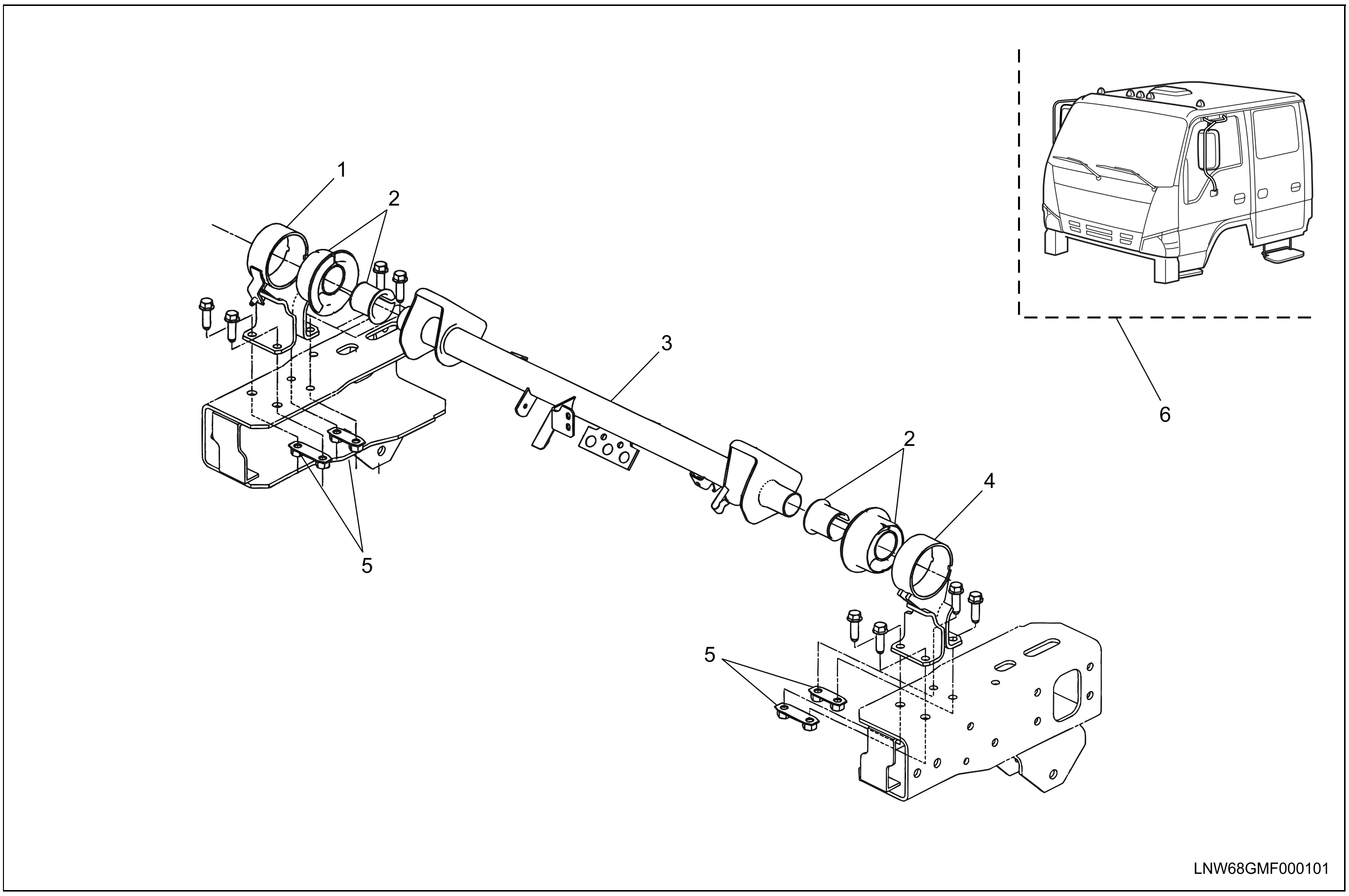
Removal Procedure

1. Remove the 2 bolts from each side and remove the rear step stay.
2. Remove the 4 bolts and remove the rear step assembly.

Installation Procedure

To install, follow the removal steps in the reverse order.

Cab Mounting Lever



Legend

1. Front Cab Mounting Bracket (RH)
2. Rubber Bush
3. Cab Mounting Lever Assembly
4. Front Cab Mounting Bracket (LH)
5. Plate Nut
6. Cab Assembly

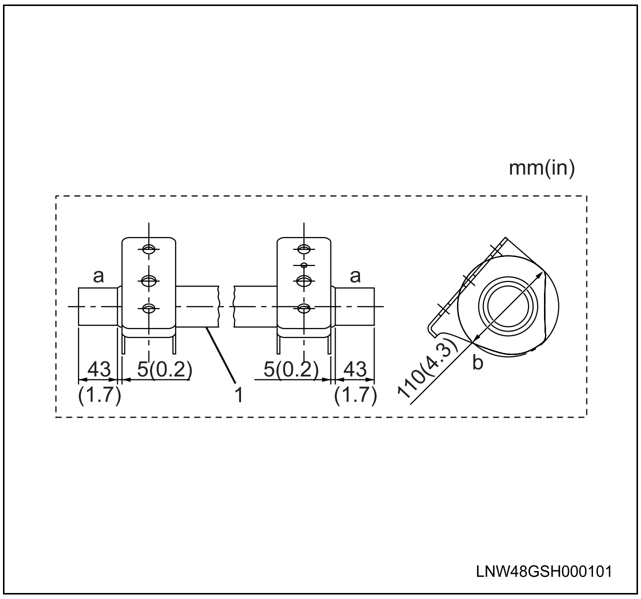
Removal Procedure

1. Remove the cab assembly.
   - Refer to “Cab assembly” in this section.
2. Remove the 4 fixing bolts from the front mounting bracket (all bolts at the top of the bracket) and remove the front cab mounting bracket RH,LH.
3. Remove the cab mounting lever assembly.

Installation Procedure

Install the cab mounting following the removal steps in the reverse order. Pay careful attention to the following.

1. Apply Besco L-2 grease to the parts marked with an (a) in the illustrations below.
2. Apply Besco rubber grease to the parts marked with a (b) in the illustrations below.
   - Apply grease to the side portions of the mounting rubber facing the outside of the vehicle.



Legend

1. Cab mounting lever assembly

3. Tighten the fixing bolts securing the cab mounting brackets to the specified torque.

4. Install the cab assembly.
    - Refer to “Cab assembly” in this section.

Tighten

- Mounting brackets fixing bolts to 117 N·m (88 lb ft)

Specifications

Fastener Torques

Seat Belt Anchor Bolts	45 N·m (33 lb ft)
Retractor Mounting Bolt	45 N·m (33 lb ft)
Rear Door Hinge Mounting Bolts	25 N·m (18 lb ft)
Rear Door Lock Mechanism Mounting Screws	6 N·m (52 lb in)
Outside Door Release Handle Mounting Bolts	13 – 18 N·m (113 lb in – 13 lb ft)
Rear Window Regulator Mounting Bolts	7 N·m (61 lb in)
Cab Mounting Brackets Fixing Bolts	117 N·m (88 lb ft)