ISUZU

ISUZU COMMERCIAL TRUCK

FSR, FTR, FVR
Equipped with 6 HK1 engine

SERVICE MANUAL (1998)

BOOK 3 OF 3

CAUTION

In order to reduce the chance of personal injury and/or property damage, carefully observe the instructions that follow:

The service manuals of Isuzu Motors America Inc. are intended for use by professional, qualified technicians. Attempting repairs or service without the appropriate training, tools, and equipment could cause injury to you or others. This could also damage the vehicle, or cause the vehicle to operate improperly.

Proper vehicle service and repair are important to the safety of the service technician and to the safe, reliable operation of all motor vehicles. If you need to replace a part, use the same part number or an equivalent part. Do not use a replacement part of lesser quality.

The service procedures we recommend and describe in this service manual are effective methods of performing service and repair. Some of the procedures require the use of tools that are designed for specific purposes.

Accordingly, any person who intends to use a replacement part, a service procedure, or a tool that is not recommended by Isuzu, must first establish that there is no jeopardy to personal safety or the safe operation of the vehicle.

This manual contains various *CAUTIONS* and *NOTICES* that you must observe carefully in order to reduce the risk of personal injury during service or repair. Improper service or repair may damage the vehicle or render the vehicle unsafe. These *CAUTIONS* and *NOTICES* are not exhaustive. Isuzu can not possibly warn of all the potentially hazardous consequences of your failure to follow these instructions.

This manual covers service procedures to vehicles that are equipped with a Supplemental Inflatable Restraint (SIR). Refer to the *CAUTIONS* in Cautions and Notices and in Restraints. Refer to SIR component and wiring location views in Restraints before performing a service on or around SIR components or wiring. Failure to follow these *CAUTIONS* could cause air bag deployment, personal injury, or otherwise unneeded SIR repairs.

In order to help avoid accidental air bag deployment and personal injury, whenever you service a vehicle that requires repair of the SIR and another vehicle system, we recommend that you first repair the SIR, then go on to the other system.

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New Style Service Manual Structure

This new style service manual is constructed with the following 10 sections:

0. General Information
1. Heating, Ventilation, and Air Conditioning (HVAC)
2. Steering
3. Suspension
4. Driveline and Axle
5. Brakes
6. Engine
7. Transmission
8. Body and Accessories
9. Restraints

The following table gives the previous service manual sub-sections with the name of the new section and sub-section. Almost all of the diagnosis that was in section 8A is now located in its applicable sub-section.

Truck Service Manual Sub-Section to Section and Sub-Section Conversion Table

Old Sub-Section	Old Sub-Section	New Section	Section Name	Sub-Section Name
0A	General Information	0	General Information	General Information
0B	Maintenance and Lubrication	0	General Information	Maintenance and Lubrication
0C	Vibration Diagnosis	0	General Information	Vibration Diagnosis
1A	Heating and Ventilation	1	HVAC	Heating and Ventilation (Non A/C)
1B	Heating, Ventilation, and Air Conditioning	1	HVAC	HVAC systems with Air Conditioning
1D	A/C Compressors	1	HVAC	HVAC systems with Air Conditioning
2A	Frame and Bumpers	8	Body and Accessories	Frame and Underbody, and Bumpers
3A	Front Wheel Alignment	3	Suspension	Wheel Alignment
3B, 3B1A, 3B1B	Power Steering Gear and Pump	2	Steering	Power Steering System
3B3	Steering Linkage	2	Steering	Steering Linkage
3C	Front Suspension	3	Suspension	Front Suspension
3D	Rear Suspension	3	Suspension	Rear Suspension
3E	Tires and Wheels	3	Suspension	Tires and Wheels
3F	Steering Columns	2	Steering	Steering Wheel and Column
4A	Propeller Shaft	4	Driveline/Axle	Propeller Shaft
4B	Rear Axle and Differential	4	Driveline/Axle	Rear Drive Axle
4C	Front Drive Axles and Differential	4	Driveline/Axle	Front Wheel Drive Shafts and Front Drive Axle
5	Hydraulic Brakes	5	Brakes	Hydraulic Brakes
5A	Master Cylinder	5	Brakes	Hydraulic Brakes
5B	Front Disc Brakes	5	Brakes	Disc Brakes
5C	Drum Brakes	5	Brakes	Drum Brakes
5D	Hydraulic or Vacuum Booster	5	Brakes	Hydraulic Brakes
5E	Antilock Brakes	5	Brakes	Antilock Brakes
5F	Parking Brake	5	Brakes	Parking Brake
6, 6A	Engine Mechanical	6	Engine	Engine Mechanical
6B	Engine Cooling and Radiator	6	Engine	Engine Cooling
6C	Engine Fuel	6	Engine	Engine Controls
6D	Engine Electrical	6	Engine	Engine Electrical
—	Driveability and Emissions	6	—	Engine Controls
6F	Exhaust System	6	—	Exhaust System
6H	Vacuum Pump	6	Engine	Vacuum Pump
6J	Turbocharger	6	Engine	Turbocharger
7A	Automatic Transmission	7	Transmission/Transaxle	Automatic Transmission and Transmission/Transfer Case Unit Repair Manual

Truck Service Manual Sub-Section to Section and Sub-Section Conversion Table (cont'd)

Old Sub-Section	Old Sub-Section	New Section	Section Name	Sub-Section Name
7B	Manual Transmission	7	Transmission/Transaxle	Manual Transmission and Transmission/Transfer Case Unit Repair Manual
7C	Clutch	7	Transmission/Transaxle	Clutch
7D	Transfer Case	4	Driveline/Axle	Transfer Case and Transmission/Transfer Case Unit Repair Manual
8B	Lighting Systems	8	Body and Accessories	Lighting Systems
8C	Instrument Panel and Gages	8	Body and Accessories	Instrument Panel, Gages and Console
8D	Chassis Electrical	8	—	Refer to the Index at the end of the manual
8E	Wipers and Washers	8	Body and Accessories	Wiper/Washer Systems
9A	Audio Systems	8	Body and Accessories	Entertainment
9B	Cruise Control	8	Body and Accessories	Cruise Control
9E	Engine Coolant Heater	6	Engine	Engine Cooling
9F	Luggage Carrier	8	Body and Accessories	Roof
9J	Supplemental Inflatable Restraint	9	Restraints	Supplemental Inflatable Restraints
9K	Remote Keyless Entry	8	Body and Accessories	Keyless Entry
10A1	Doors	8	Body and Accessories	Doors
10A2	Seats	8	Body and Accessories	Seats
		9	Restraints	Seat Belts
10A3	Stationary Windows	8	Body and Accessories	Stationary Glass
10A4	Interior Trim	8	Body and Accessories	Exterior/Interior Trim
10A5	Endgate	8	Body and Accessories	Body Rear End
10B	Cab and Body Maintenance	—	—	Refer to the Index at the end of the manual

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1998 Medium Duty Truck
FSR, FTR, FVR
Service Manual

Volume 3

This manual provides information on the diagnosis, the service procedures, the adjustments, and the specifications for the 1998 Isuzu Medium Duty Truck.

The technicians who understand the material in this manual and in the appropriate Dealer Service Bulletins better service the vehicle owners.

When this manual refers to a brand name, a part number, or a specific tool, you may use an equivalent product in place of the recommended item. All information, illustrations and specifications in this manual are based on the latest product information available at the time of publication approval. Isuzu reserves the right to make changes at any time without notice.

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Cautions and Notices

Definition of Caution, Notice, and Important

The diagnosis and repair procedures in the Isuzu Service Manual contain both general and specific Cautions, Notices, and Importants. Isuzu is dedicated to the presentation of service information that helps the technician to diagnose and repair the systems necessary for the proper operation of the vehicle, however, certain procedures may present a hazard to the technician if they are not followed in the recommended manner. Cautions, Notices, and Importants are elements designed to prevent these hazards, however, not all hazards can be foreseen. This information is placed at strategic locations within the service manual. This information is designed to prevent the following from occurring:

- Serious bodily injury to the technician
- Damage to the vehicle
- Unnecessary vehicle repairs
- Unnecessary component replacement
- Improper repair or replacement of vehicle components. Any caution or notice that appears in general information is referenced from the individual service categories.

CAUTION Defined
When encountering a CAUTION, you will be asked to take a necessary action or not to take a prohibited action. If a CAUTION is not heeded, the following consequences may occur:

- Serious bodily injury to the technician
- Serious bodily injury to other technicians in the workplace area
- Serious bodily injury to the driver and/or passenger(s) of the vehicle, if the vehicle has been improperly repaired

NOTICE Defined
Notices call special attention to a necessary action or to a prohibited action. If a NOTICE is not heeded, the following consequences may occur:

- Damage to the vehicle
- Unnecessary vehicle repairs
- Unnecessary component replacement
- Improper operation or performance of the system or component under repair
- Damage to any systems or components which are dependent upon the proper operation of the system or component under repair
- Improper operation or performance of any systems or components which are dependent upon the proper operation or performance of the system or component under repair
- Damage to fasteners, basic tools, or special tools
- The leakage of coolant, lubricant, or other vital fluids

IMPORTANT Defined
IMPORTANT statements emphasize a necessary characteristic of a diagnostic or repair procedure. IMPORTANT statements are designed to do the following:

- Clarify a procedure
- Present additional information for accomplishing a procedure
- Give insight into the reason or reasons for performing a procedure in the manner recommended
- Present information that will help to accomplish a procedure in a more effective manner
- Present information that gives the technician the benefit of past experience in accomplishing a procedure with greater ease

ABS Handling Caution

Caution: Certain components in the Antilock Brake System (ABS) are not intended to be serviced individually. Attempting to remove or disconnect certain system components may result in personal injury and/or improper system operation. Only those component with approved removal and installation procedures should be serviced.

Battery Disconnect Caution

Caution: Before servicing any electrical component, the ignition key must be in the OFF or 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.

Brake Dust Caution

Caution: Avoid taking the following actions when you service wheel brake parts:

- ***Do not grind brake linings.***
- ***Do not sand brake linings.***
- ***Do not clean wheel brake parts with a dry brush or with compressed air.***

Some models or aftermarket brake parts may contain asbestos fibers which can become airborne in dust. Breathing dust with asbestos fibers may cause serious bodily harm. Use a water-dampened cloth in order to remove any dust on brake parts. Equipment is available commercially in order to perform this washing function. These wet methods prevent fibers from becoming airborne.

Brake Fluid Caution

Caution: Brake fluid may be irritating to the skin or eyes. In case of contact, take the following actions:

- *Eye contact—rinse eyes thoroughly with water.*
- *Skin contact—wash skin with soap and water.*

Clutch Dust Caution

Caution: When servicing clutch parts, do not create dust by grinding or sanding the clutch disc or by cleaning parts with a dry brush or with compressed air. A water-dampened cloth—NOT SOAKED—should be used. The clutch disc contains asbestos fibers which can become airborne if dust is created during servicing. Breathing dust containing asbestos fibers may cause serious bodily harm.

Fuel and EVAP Pipe Caution

Caution: In order to Reduce the Risk of Fire and Personal Injury observe the following items:

- *Replace all nylon fuel pipes 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 pipes 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.)*

Fuel Gauge Leak Caution

Caution: Wrap a shop towel around the fuel pressure connection in order to reduce the risk of fire and personal injury. The towel will absorb any fuel leakage that occurs during the connection of the fuel pressure gauge. Place the towel in an approved container when the connection of the fuel pressure gauge is complete.

Fuel Pipe Fitting Caution

Caution: Always apply a few drops of clean engine oil to the male pipe ends before connecting fuel pipe fittings in order to reduce the risk of fire and personal injury.

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.

Fuel Storage Caution

Caution: Do not drain the fuel into an open container. Never store the fuel in an open container due to the possibility of a fire or an explosion.

Gasoline/Gasoline Vapors Caution

Caution: Gasoline or gasoline vapors are highly flammable. A fire could occur if an ignition source is present. Never drain or store gasoline or diesel fuel in an open container, due to the possibility of fire or explosion. Have a dry chemical (Class B) fire extinguisher nearby.

Moving Parts and Hot Surfaces Caution

Caution: While working around a running engine, avoid contact with moving parts and hot surfaces to prevent possible bodily injury.

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.

Safety Glasses and Compressed Air Caution

Caution: Wear safety glasses when using compressed air in order to prevent eye injury.

Safety Goggles and Fuel Caution

Caution: Always wear safety goggles when working with fuel in order to protect the eyes from fuel splash.

Vehicle Lifting Caution

Caution: To help avoid personal injury, when a vehicle is on a hoist, provide additional support for the vehicle at the opposite end from which you are removing components. The additional support will reduce the possibility of the vehicle falling off the hoist. When you are removing major components from the vehicle while the vehicle is on a hoist, chain the vehicle frame to the hoist pads at the same end from which you are removing the major components to prevent tip-off. If you fail to follow these precautionary measures, vehicle damage, serious personal injury, or death may result.

Window Removal Caution

Caution: When working with any type of glass, use approved safety glasses and gloves to reduce the chance of personal injury.

Work Stall Test Caution

Caution: One or more of the following guidelines may apply when performing specific required tests in the work stall:

- ***When a test requires spinning the drive wheels with the vehicle jacked up, adhere to the following precautions:***
  - ***Do not exceed 56 km/h (35 mph) when spinning one drive wheel with the other drive wheel stopped. This limit is necessary because the speedometer indicates only one-half the actual vehicle speed under these conditions. Personal injury may result from excessive wheel spinning.***
  - ***If all of the drive wheels are spinning at the same speed, do not exceed 112 km/h (70 mph). Personal injury may result from excessive wheel spinning.***
  - ***All persons should stay clear of the rotating components and the balance weight areas in order to avoid possible personal injury.***
  - ***When running an engine in the repair stall for an extended period of time, use care not to overheat the engine and the transmission.***
- ***When a test requires jacking up the vehicle and running with the wheels and brake rotors removed, adhere to the following precautions:***
  - ***Do not apply the brake with the brake rotors removed.***
  - ***Do not place the transmission in PARK with the drive wheels still spinning.***
  - ***Turn Off the ignition in order to stop the powertrain components from spinning.***

Defective Scan Tool Notice

Notice: Do not use a scan tool that displays faulty data. Report the scan tool problem to the manufacturer. Use of a faulty scan tool can result in misdiagnosis and unnecessary parts replacement.

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 Pressure Notice

Notice: Do not allow the fuel pressure to exceed the specified value because damage to the fuel pressure regulator or the fuel pressure gauge may result.

Handling ESD Sensitive Parts Notice

Notice: Electrostatic discharge (ESD) can damage many solid-state electrical components. ESD susceptible components may or may not be labeled with the ESD symbol. Handle all electrical components carefully. Use the following precautions in order to avoid ESD damage:

Touch a metal ground point in order to remove your body's static charge before servicing any electronic component; especially after sliding across the vehicle seat.

Do not touch exposed terminals. Terminals may connect to circuits susceptible the ESD damage.

Do not allow tools to contact exposed terminals when servicing connectors.

Do not remove components from their protective packaging until required to do so.

Avoid the following actions unless required by the diagnostic procedure:

Jumpering or grounding of the components or connectors.

Connecting test equipment probes to components or connectors. Connect the ground lead first when using test probes.

Ground the protective packaging of any component before opening. Do not rest solid-state components on metal workbenches, or on top of TVs, radios, or other electrical devices.

Ignition OFF When Disconnecting Battery Notice

Notice: Always turn the ignition OFF when connecting or disconnecting battery cables, battery chargers, or jumper cables. Failing to do so may damage the Powertrain Control Module (PCM) or other electronic components.

Nylon Fuel Lines Notice

Notice: Do not attempt to straighten the kinked nylon fuel lines. Replace any kinked nylon fuel feed or return pipes in order to prevent damage to the vehicle.

PCM and ESD Notice

Notice: Do not touch the connector pins or soldered components on the circuit board in order to prevent possible electrostatic discharge (ESD) damage to the PCM.

Single Cylinder Flooding Notice

Notice: In order to prevent flooding of a single cylinder and possible engine damage, relieve the fuel pressure before performing the fuel injector coil test procedure.

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Engine Cooling

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Coolant Outlet Bolt	19 N.m	14 lb ft
Coolant Recovery Pipe Mounting Bolt	14 N.m	124 lb in
Coolant Recovery Reservoir Mounting Bolt	6 N.m	53 lb in
Coolant Recovery Tank Mounting Bracket Bolt	30 N.m	22 lb ft
Fan Adapter to Water Pump Bolt	68 N.m	50 lb ft
Fan Shroud Bolt	6 N.m	53 lb in
Fan Clutch Nut	145 N.m	107 lb ft
Fan to Fan Clutch Bolt	21 N.m	16 lb ft
Radiator Hose Clamp	5 N.m	44 lb in
Radiator Support Brace Nut	55 N.m	41 lb ft
Radiator Support Side Mounting Bolt	65 N.m	48 lb ft
Radiator Support Top Cover Bolt	25 N.m	18 lb ft
Surge Tank Bolt	6 N.m	53 lb in
Tensioner Lock Nut	63 N.m	46 lb ft
Water Duct Bolt (M8)	19 N.m	14 lb ft
Water Duct Bolt (M16)	125 N.m	92 lb ft
Water Pump Bolt	19 N.m	14 lb ft

Engine Cooling System Specifications

Application	Specification	
	Metric	English
Pump Spindle Interferences		
Shaft to Pulley Center	0.048–0.078 mm	0.0019–0.0031 in
Shaft to Impeller	0.027–0.120 mm	0.0011–0.0047 in
Seal Height	11.0—11.6 N.m	0.433—0.457 in

Diagnostic Information and Procedures

Engine Overheating

Problem	Action
The engine temperature gauge is faulty.	Replace the engine temperature gauge. Refer to Body and Accessories.
The engine temperature gauge sensor is faulty.	Replace the engine temperature gauge sensor. Refer to *Engine Coolant Temperature Sensor Replacement* in Body and Accessories.
The operator exhibits poor driving habits.	Refer to the owner's manual.
The engine idling is prolonged.	Refer to the owner's manual.
The engine is lugging.	Refer to the owner's manual.
The brakes are dragging.	Adjust the brakes as needed. Refer to Brakes.
The engine coolant is frozen.	Allow the coolant to thaw.
The belt tension is incorrect.	Adjust the belt tension. Refer to Engine Mechanical.
The radiator is restricted.	Repair the restriction as needed. Refer to *Radiator Cleaning.*
The cooling fan is incorrect.	Install the correct fan. Refer to *Fan Replacement (Fan Blade).*
The exhaust is restricted.	Repair the restriction as needed. Refer to *Restricted Exhaust.*
The thermostat is incorrect.	Install the correct thermostat. Refer to *Thermostat Replacement.*
The water pump is faulty.	Replace the water pump. Refer to *Water Pump Replacement.*
The ignition timing is incorrect.	Adjust the ignition timing. Refer to Engine Mechanical.
The engine oil level is low.	Fill the engine oil to the correct level. Refer to *Approximate Fluid Capacities* in General Information.
The radiator grille is blocked.	Repair the grille as needed. Refer to *Radiator Cleaning.*
The radiator shroud or the baffles are missing.	Install the correct radiator shroud or the baffles. Refer to *Fan Shroud Replacement* or *Radiator Lower Mounting Panel Replacement.*
The thermostatic fan is faulty.	Replace the thermostatic fan clutch. Refer to Engine Mechanical.
The cooling fan is faulty.	Replace the fan. Refer to *Fan Replacement (Fan Blade).*
The engine thermostat is faulty.	Replace the thermostat. Refer to *Thermostat Replacement.*
The cooling system is plugged.	1. Repair the system as needed. 2. Drain the system. Refer to *Draining and Filling Cooling System (Draining).* 3. Flush the system. Refer to *Flushing.*

Loss of Coolant

Problem	Action
The coolant hoses are faulty.	Replace the hoses, as necessary. Refer to *Radiator Hose Replacement (Upper)* or *Radiator Hose Replacement (Lower).*
The drive belts are faulty.	1. Replace the belts. 2. Adjust the belt tension. Refer to Engine Mechanical.
The coolant hose clamps are faulty.	Replace the clamps, as necessary. Refer to *Radiator Hose Replacement (Upper)* or *Radiator Hose Replacement (Lower).*
The coolant drain plugs are loose.	Tighten the coolant drain plugs.
The radiator drain cock is loose.	Tighten the radiator drain cock as needed.
The radiator core is leaking.	Repair the radiator core as needed. Refer to *Radiator Replacement.*
The gaskets are leaking.	Repair or replace the gaskets as needed.
The radiator cap is faulty.	Replace the radiator cap.
The belt tension is incorrect.	Adjust the belt tension. Refer to Engine Mechanical.
The radiator is restricted.	Repair the restriction as needed. Refer to *Radiator Cleaning.*
The radiator grille is blocked.	Repair the grille as needed. Refer to *Radiator Cleaning.*
The radiator shroud or the baffles are missing.	Install the correct radiator shroud or baffles. Refer to *Fan Shroud Replacement* or *Radiator Lower Mounting Panel Replacement.*
The water pump is faulty.	Replace the water pump. Refer to *Water Pump Replacement.*
The cooling fan is faulty.	Replace the fan. Refer to *Fan Replacement (Fan Blade).*
The thermostatic fan clutch is faulty.	Replace the thermostatic fan clutch. Refer to Engine Mechanical.
The cooling system is plugged.	1. Repair the cooling system as needed. 2. Drain the system. Refer to *Draining and Filling Cooling System (Draining).* 3. Flush the system. Refer to *Flushing.*
The engine thermostat is faulty.	Replace the thermostat. Refer to *Thermostat Replacement.*
The engine thermostat is incorrect.	Install the correct thermostat. Refer to *Thermostat Replacement.*
The surge tank is faulty.	Repair or replace the surge tank. Refer to *Surge Tank (Diesel) Replacement.*
The heater hoses or the heater core is plugged.	Repair or replace the heater hoses of the heater core, as necessary.
The head gasket is leaking.	Repair or replace the head gasket, as necessary.
The engine temperature gauge sensor is faulty.	Replace the engine temperature gauge sensor. Refer to *Engine Coolant Temperature Sensor Replacement* in Body and Accessories.

Thermostat Diagnosis

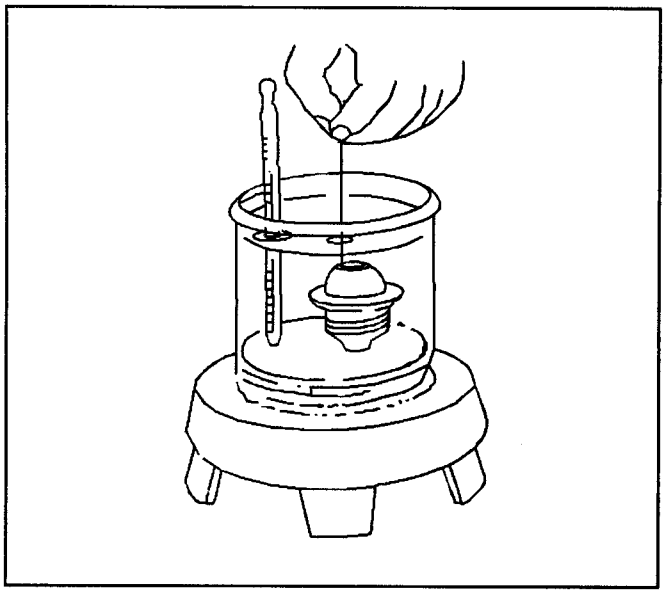
A thermostat that remains closed or only partially open restricts the flow of coolant in the system.

A faulty thermostat may cause the engine to overheat.

A thermostat that sticks in the full open position prevents the engine from reaching the normal operating temperature. Cold engine operation may cause a buildup of excess carbon deposits on the following components:

- The pistons
- The rings
- The valves

1. Remove the thermostat assembly.
   Refer to *Thermostat Replacement.*



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2. Suspend the thermostat and a thermometer in water. Place the thermostat near the thermometer.
3. Heat the water.
4. Record the temperature at which the thermostat begins to open.
5. Record the temperature at which the thermostat is open.
6. Compare the temperature readings with the Engine Thermostats.
7. Replace the thermostat and the gasket as needed.
   Refer to *Thermostat Replacement.*
8. Fill the cooling system.
9. Run the engine until the engine reaches normal operating temperature.
10. Inspect for coolant leaks around the thermostat housing and the gasket.
11. Inspect the coolant level. Add additional coolant as necessary.
12. Install the radiator cap.

Fan Clutch Diagnosis (Noise)

Fan noise may occur when the following normal conditions exist:

- The clutch is engaged for maximum cooling
- The fan has been running for 15–60 seconds.
  The clutch cannot redistribute the silicone fluid back to the normal disengaged operating condition (after overnight settling) for the first 15 seconds.

Fan noise or an excessive roar may occur continuously when the following conditions exist:

- The engine is operating at a high speed.
  A high speed is 2,500 RPM or more.
- The clutch assembly locks up due to an internal failure.

Replace the clutch if the following conditions exist:

- Rotating the fan by hand is impossible.
- A rough grating feeling exists while turning the fan.

Refer to *Fan Replacement (Fan Blade).*

Fan Clutch Diagnosis (Looseness)

Inspect a loose fan assembly for wear. Replace the fan assembly as necessary.

A visible lateral movement at the tip of the fan blade under is visible at various temperature conditions. Approximately 6.5 mm (1/4 in) maximum lateral movement, measured at the fan tip, is allowed. This movement is not cause for replacement.

Fan Clutch Diagnosis (Silicone Fluid Leaks)

The fan clutch operation is not affected by small fluid leaks which may occur around the bearing assembly. If the leakage appears excessive, replace the fan clutch.

Refer to *Fan Replacement (Fan Clutch).*

Fan Clutch Diagnosis (Engine Oveheating)

1. Verify that the engine is cool. A cool engine will ensure complete disengagement of the fan clutch.
2. Spin the clutch assembly by hand. The clutch assembly free-wheels if the assembly rotates more than five times.
3. If the fan and the clutch assembly free-wheel with no drag, replace the clutch.
4. If the clutch performs correctly with a slight drag, continue with the following procedure.
   Notice: Check for adequate clearance between the fan blades and the thermometer sensor before starting the engine, as damage could occur.
5. Place a thermometer between the fan blades and the radiator.

6. Insert the thermometer sensor through one of the existing holes in the fan shroud or place the thermometer between the radiator and the shroud.

   On some models, you may have to drill a 5 mm (3/16 in) hole in the fan shroud in order to insert the thermometer.
7. Cover the radiator grille in order to induce a high engine temperature.
8. Start the engine.
9. Turn on the air conditioning.
10. Operate the engine at 2,000 RPM.
11. Wait for 5–10 minutes for the clutch to engage.

    Observe the thermometer reading when the clutch engages.

    The following conditions indicate fan clutch engagement:
    - An increase or roar in the fan noise
    - A drop of 3–10 °C (5–15 °F) in the thermometer reading

    Important: Do not continue the test past a thermometer reading of 88 °C (190 °F). This action will prevent engine overheating.
12. Replace the unit if the following conditions exist:
    - The clutch does not engage between 65–90 °C (150–195 °F).

      Ensure that the fan clutch was disengaged at the start of the test.
    - No sharp increase in noise or no temperature drop was evident.
    - The fan noise level remained constantly high from the start of the test to 88 °C (190 °F).
13. As soon as the clutch engages, complete the following steps in order to assist in engine cooling:
    - Remove the radiator grille cover.
    - Turn off the air conditioning.
    - Run the engine at approximately 1,500 RPM.
14. Verify that the fan clutch disengages after several minutes.

    A reduction in fan speed and roar indicates disengagement.
15. Replace the fan clutch if the fan clutch fails to operate as described above.

Coolant Concentration Testing

Tools Required

- *J 26568* Coolant Tester (Centigrade)
- *J 23688* Coolant Tester (Fahrenheit)

Inspect the coolant for freeze protection and contamination.

The following fluids may cause contamination:

- Engine oil
- Automatic transmission fluid, if equipped

Inspect the following qualities of the coolant in order to detect contamination:

- The color
- The smell
- The feel

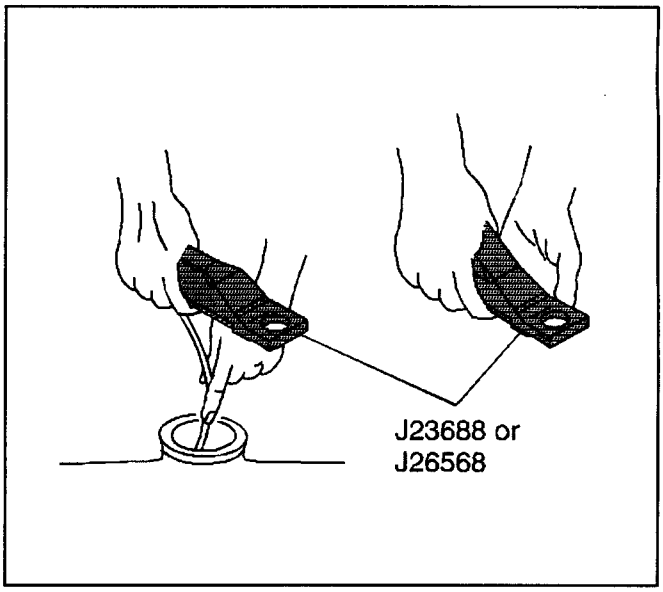
Diagnose and repair the cause of the contamination in order to prevent engine damage.

Use the *J 26568* or the *J 23688* in order to inspect the antifreeze protection of the coolant.

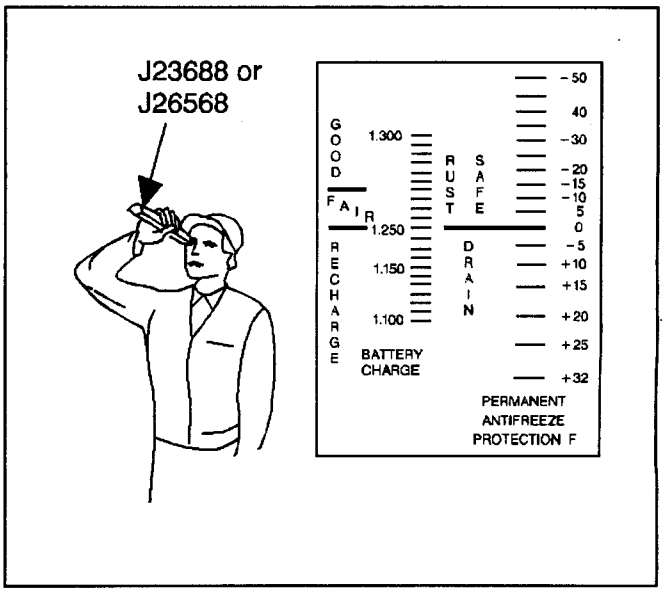
Ensure that the hydrometer markings are correct.

Unless the *J 26568* or the *J 23688* has a provision for temperature correction, test the temperature at which the *J 26568* or the *J 23688* calibrates. If the coolant is warmer or cooler, the reading may be incorrect.

Follow the manufacturer's directions for using the *J 26568* or the *J 23688*.



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Important:

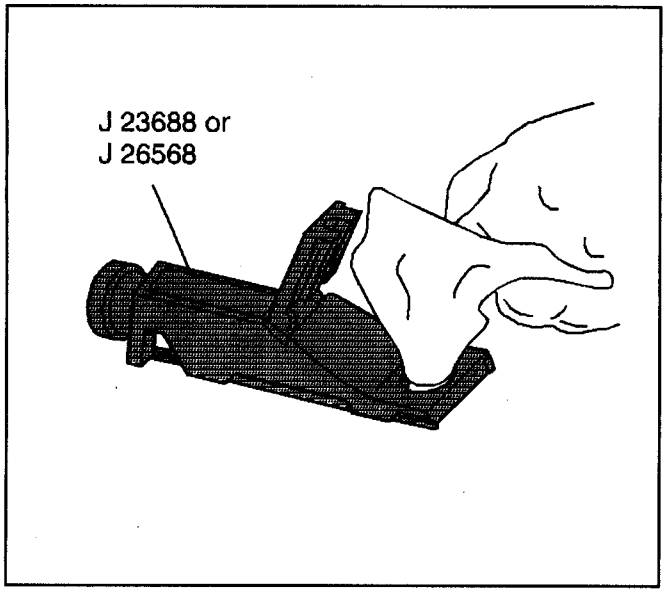
- Do not open the plastic cover when taking the readings.

  The coolant may evaporate. The evaporation may change the readings.
- If the readings are unclear, determine if the measuring surfaces were cleaned and dried.

  Wipe the measuring surfaces dry. Repeat the test.

Use the following procedure in order to clean the coolant tester:

1. Before each use, swing the plastic cover at the end of *J 26568* or *J 23688* in order to expose the measuring window at the bottom of the plastic cover.



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2. Wipe the measuring window dry with a tissue or a clean soft cloth.
3. Close the plastic cover.

Cooling System Leak Testing

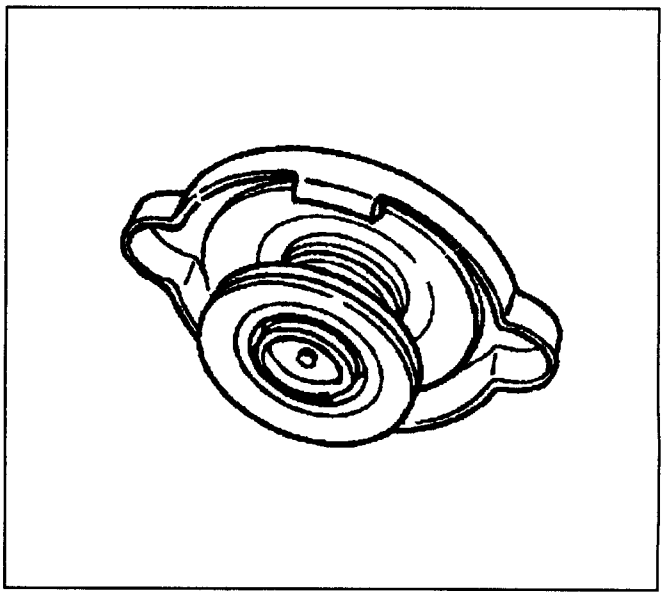
Tools Required

J 24460-01 Cooling System Tester

Caution: To avoid being burned, do not remove the radiator cap while the engine is at normal operating temperature. The cooling system will relieve scalding fluid and steam under pressure if the cap is removed while the engine and radiator are still hot, causing serious injury.

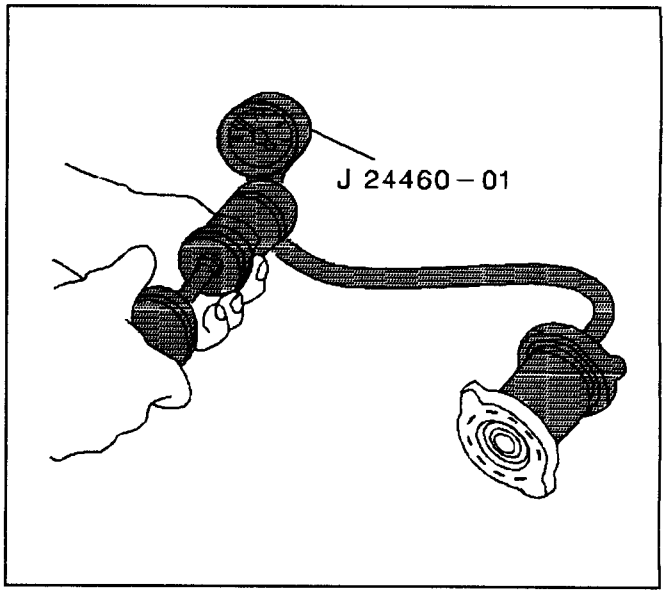
1. Test the radiator cap for correct opening and closing pressures.

   Correct opening and closing pressures ensure the safe, efficient operation of the cooling system. A pressure cap that cannot maintain pressure lowers the boiling point of the engine coolant. A lower boiling point causes the engine cooling system to operate at a higher than normal temperature.
2. Replace any faulty caps.



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3. Remove the radiator cap.
4. Wash off any sediment on the sealing surfaces of the radiator cap.
5. Wet the radiator cap gasket with coolant.



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6. Install the cap to the *J 24460-01*.
7. Operate the plunger handle of the *J 24460-01*.

   Pump up the pressure to the pressure that is stamped on the cap.
8. Note the rate of the decrease in pressure.

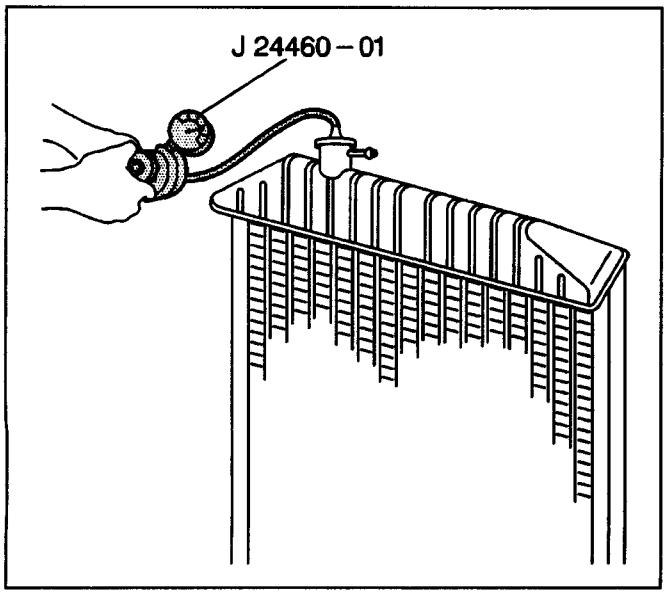
   Verify that the pressure reading remains within the corresponding pressure segment of the scale for about 10 seconds.
9. Replace the cap if the cap does not hold the pressure for 10 seconds.

Cooling System

Tools Required

J 24460-01 Cooling System Tester

1. Tighten the following components:
   - The radiator hose clamps
   - The heater hose clamps
2. Inspect the connections for leaks at the following locations:
   - The surge tank
   - The expansion tank
   - The air compressor coolant lines
3. Remove the filler cap.
4. Fill the cooling system to the level of the filler cap seat.



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5. Attach the *J 24460-01* to the filler neck.
6. Follow the instructions that are supplied with the *J 24460-01*.
7. Increase the pressure to 138 kPa (20 psi).

   Do not exceed 138 kPa (20 psi). The system should hold the pressure for about 2 minutes.

Off-Vehicle Pressure Testing

Notice: Do not use boil-out tanks or vats or other tanks that have been used for copper or brass radiators. The flux, acid, and caustic cleaners remaining in these tanks and will attack the aluminum and cause radiator failure. Use a separate test tank containing clean water for servicing aluminum/plastic radiators.

1. Install test fittings or rubber test caps in the inlet and the outlet necks.
2. Seal the oil cooler fittings with metal plugs.

   Sealing the fittings will protect the cooler and prevent fluid loss.
3. Attach the pressure tester.
4. Gradually apply air pressure until 138 kPa (20 psi) is attained.

   Do not exceed 138 kPa (20 psi).
5. Inspect the gauge in order to see if a pressure leak exists.
6. Run a mixture of water and mild detergent over the radiator.

   Inspect for bubbles in order to ensure that no leaks exist. Bubbles indicate leaks.

Repair Instructions

Draining and Filling Cooling System (Cooling System)

Notice: Two sealant pellets must be added to the radiator whenever the coolant system is drained and refilled with fresh coolant. Failure to use the correct sealant pellets may result in premature water pump leakage. Do not add pellets to the coolant recovery bottle since this may prevent the coolant system from operating properly.

Draining and Filling Cooling System (Draining)

Caution: To avoid being burned, do not remove the radiator cap while the engine is at normal operating temperature. The cooling system will relieve scalding fluid and steam under pressure if the cap is removed while the engine and radiator are still hot, causing serious injury.

1. Tilt the cab.

   Refer to *Cab Tilting* in General Information.
2. Place a drain pan under the radiator drain cock.

   Ensure that the capacity of the drain pan is at least 30 liters (32 quarts).
3. Ensure that the cooling system is cool.
4. Remove the radiator cap.
5. Open the drain cock. The drain cock is located at the bottom of the radiator. Allow the cooling system to drain until the coolant flow stops.
6. Open the following components:
   - The cylinder block
   - The accessory drain cocks
   - The plugs

   Allow the engine block to drain until the coolant flow stops.

   The radiator may drain more while the engine block drains.
7. Disconnect the coolant hose from the air compressor, if equipped.
8. Close the engine block drain plugs.
9. Close the radiator drain cock.

Draining and Filling Cooling System (Filling)

Do not use more than 70 percent antifreeze coolant solution or the coolant freeze point will begine to rise and the coolant will not be as effective. In order to avoid coolant loss, do not overfill the radiator.

1. Ensure that the radiator drain cock is closed.
2. Ensure that the engine drain plugs are tight.
3. Fill the cooling system with cooling solution.
4. Start the engine.
5. Run the engine for a few minutes in order to vent the air.
6. Add more coolant, if necessary.
7. Ensure that the engine is at normal operating temperature.
8. Fill coolant to the HOT LEVEL of the coolant recovery bottle, if equipped.
9. Fill the surge tank to the appropriate level.

   The system should hold approximately 30 liters (32 quarts).
   - If the engine is cold, fill the surge tank to the sight glass,
   - If the engine is warm, fill the surge tank to the filler neck.
10. Run the engine in order to remove air from the system.
11. Fill coolant to the HOT LEVEL of the coolant recovery bottle, if equipped.
12. Ensure that the coolant is sufficiently cool.
13. Ensure that pressure is off the system.
14. Remove the radiator cap.
15. Install the radiator cap.
16. Lower the cab.

Flushing

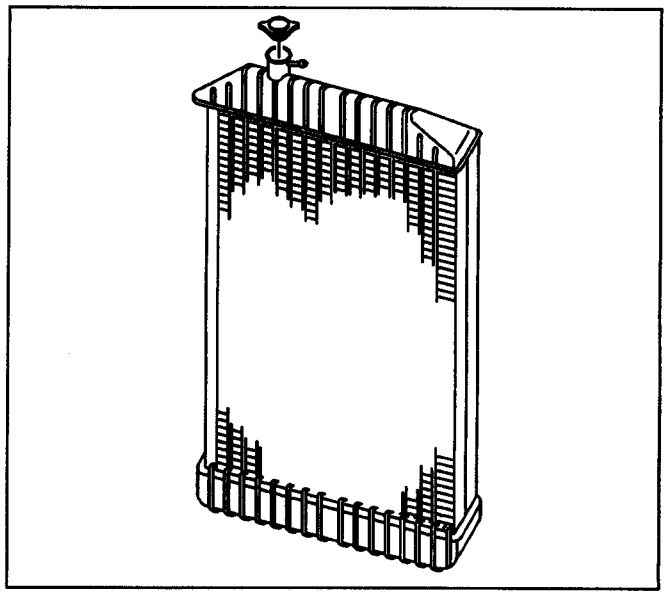
You can use various methods and equipment to flush the cooling system. If special equipment is used (such as a back flusher) follow the manufacturer's instructions. However, always remove the thermostat before flushing the system.

Radiator Cleaning

An engine may overheat when the following conditions exist:

1. The radiator core is dirty.
2. The radiator core is obstructed.
3. The radiator leaks.
4. Use any of the following materials in order to clean the outside of the radiator:
   - A soft bristle brush and clean hot water (or a mild detergent such as car wash or dishwashing liquid)
   - A common city water hose without the nozzle (in order to avoid damage to the fins)
5. Pressure flush the core tubes with clean hot water or a mild detergent in order to clean the inside of the tubes.
6. Use the following procedure in order to test for restrictions in the radiator:
   6.1. Turn on the engine in order to warm the engine.
   6.2. Turn off the engine.
   6.3. Feel the radiator.
   Verify that the following conditions exist:
   - The radiator is hot on the top.
   - The radiator is warm on the bottom.
   - The temperature rises evenly from the top to the bottom of the radiator.

   Cold spots in the radiator indicate clogged sections.

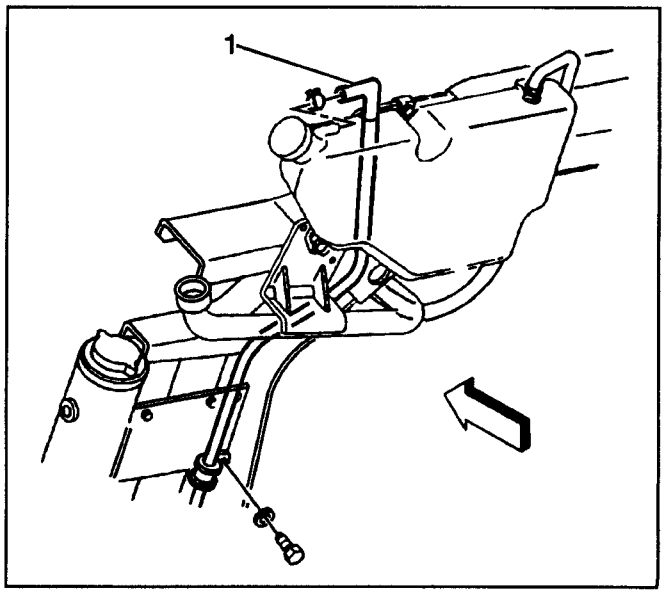


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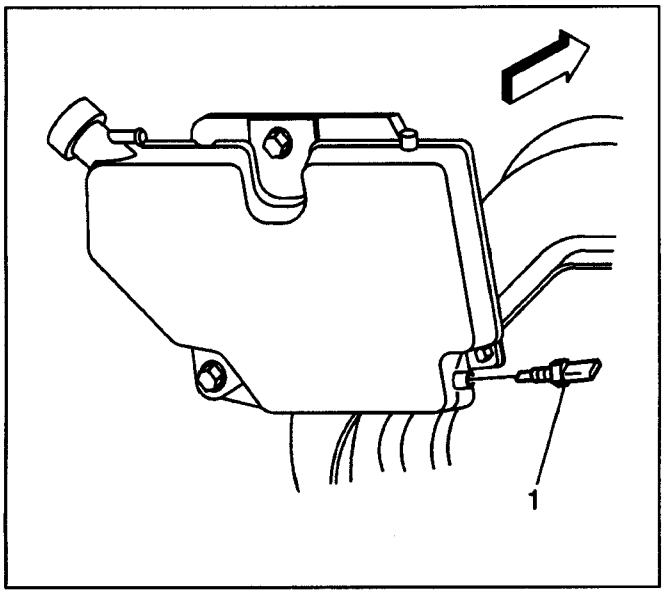
Surge Tank (Diesel) Replacement

Removal Procedure

1. Tilt the cab.
   Refer to *Cab Tilting* in General Information.
   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Partially drain the cooling system.
   Refer to *Draining and Filling Cooling System (Draining)*.
4. Remove the following components:
   - The radiator surge tank inlet hose
   - The clamps
5. Remove the following components:
   - The radiator surge tank outlet hose (1)
   - The clamps
6. Remove the following components:
   - The surge tank overflow hose
   - The clamp

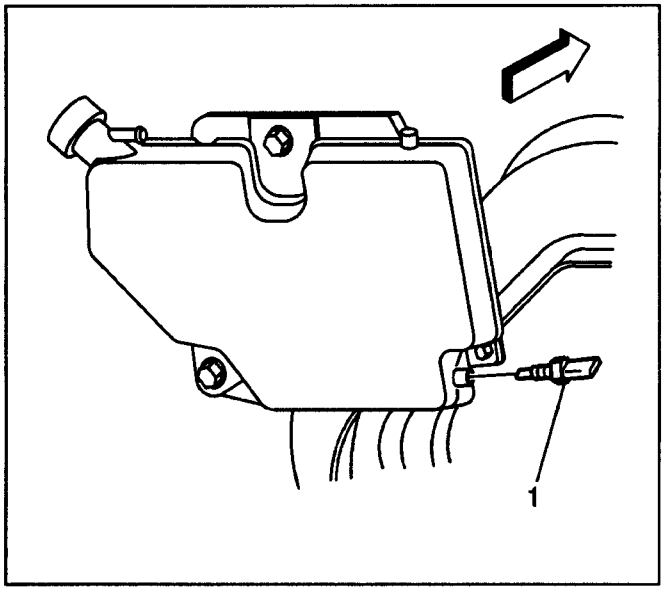


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7. Remove the low coolant sensor (1).
8. Remove the radiator surge tank cap.
9. Remove the radiator surge tank bolts.
10. Remove the radiator surge tank from the mount.
11. Inspect the radiator surge tank for cracks.
12. Replace the surge tank if the surge tank is damaged.



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Installation Procedure

1. Install the radiator surge tank to the mount.

   Notice: Refer to *Fastener Notice* in Caution and Notices.
2. Install the radiator surge tank bolts.

   Tighten

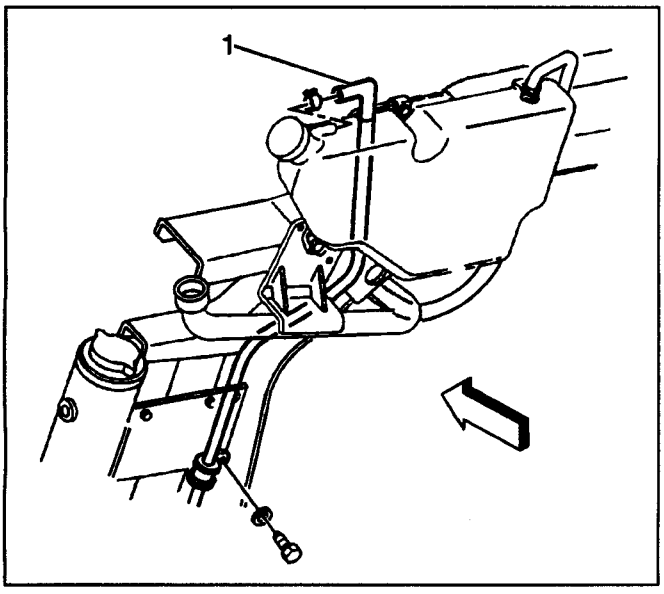
   Tighten the radiator surge tank bolts to 6 N·m (53 lb in).
3. Install the low coolant sensor (1).
4. Install the radiator surge tank inlet hose and the clamps.

   Tighten

   Tighten the clamps to 3 N·m (27 lb in).
5. Install the radiator surge tank outlet hose and the clamps.

   Tighten

   Tighten the clamps to 3 N·m (27 lb in).



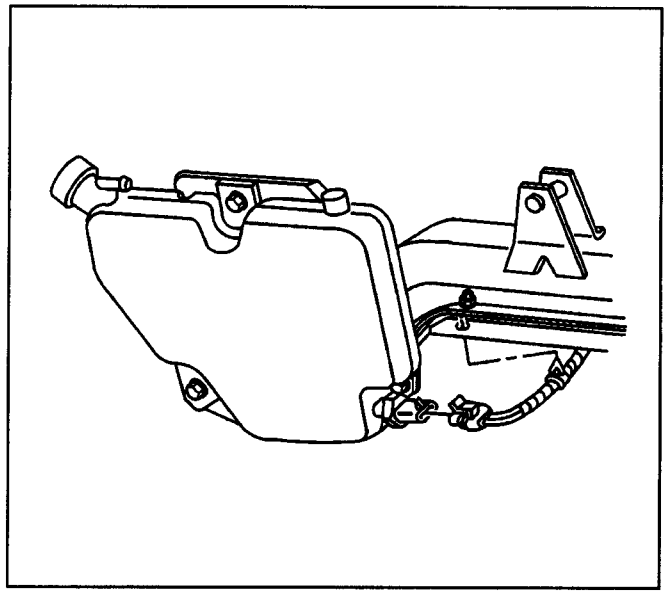
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6. Install the surge tank overflow hose (1) and the clamp.
7. Connect the negative battery cable.
8. Fill the cooling system.
9. Inspect the system for leaks.
10. Install the surge tank pressure cap.
11. Lower the cab.

Coolant Recovery Reservoir Replacement

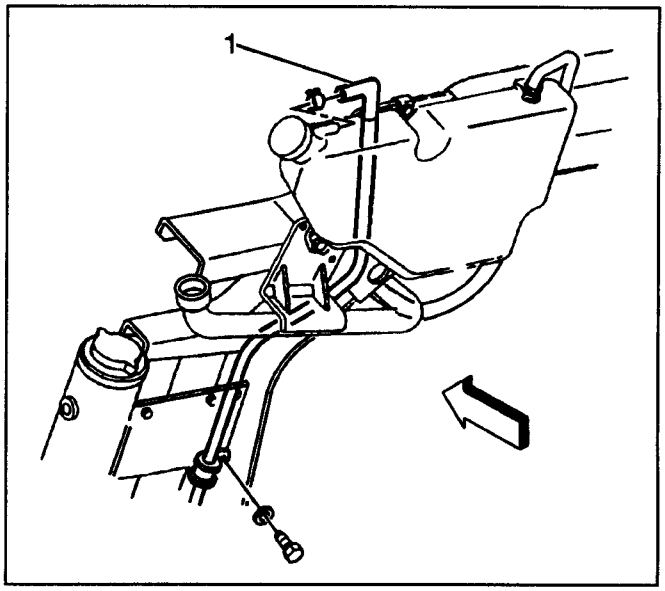
Removal Procedure

1. Tilt the cab.
   Refer to *Cab Tilting* in General Information.
   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Partially drain the cooling system.
   Refer to *Draining and Filling Cooling System (Draining).*
4. Remove the following components:
   - The coolant recovery reservoir hose
   - The clamps



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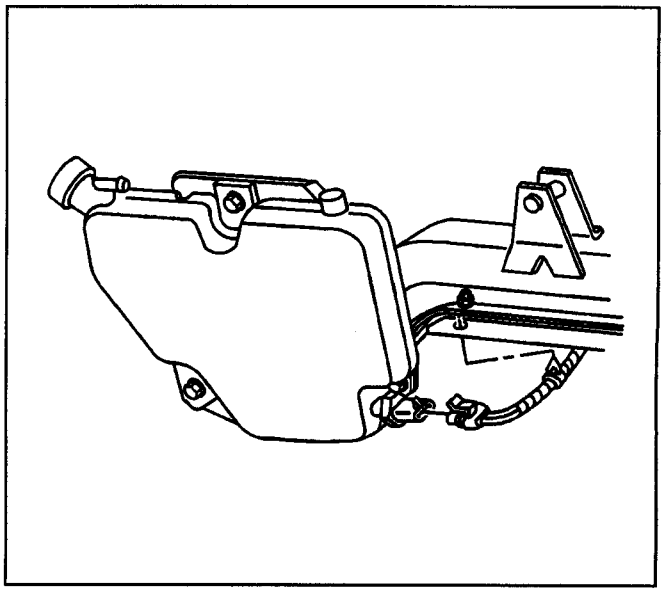
5. Remove the following components:
   - The recovery reservoir overflow hose (1)
   - The clamp
6. Remove the coolant recovery reservoir bolts.
7. Remove the coolant recovery reservoir.
8. Inspect the coolant recovery reservoir for the following conditions:
   - Cracks
   - Weak points
9. Replace the reservoir if the reservoir is damaged.
10. Inspect the recovery tank mounting bracket for cracks.
11. Replace the mounting bracket if necessary.



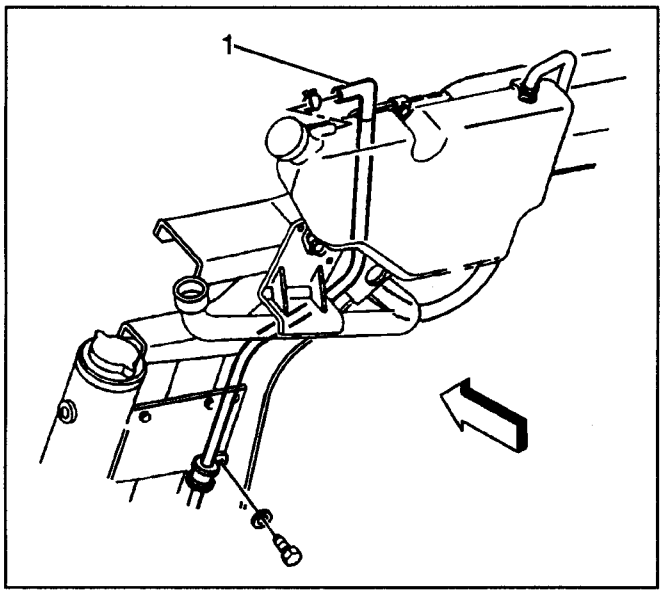
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Installation Procedure

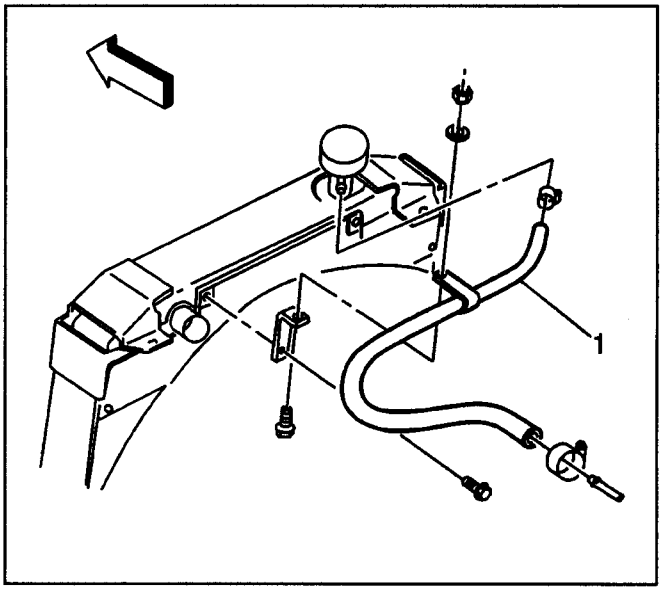
1. Install the coolant recovery reservoir to the mount.
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the coolant recovery reservoir bolts.
   Tighten
   Tighten the recovery reservoir bolts to 6 N·m (53 lb in).



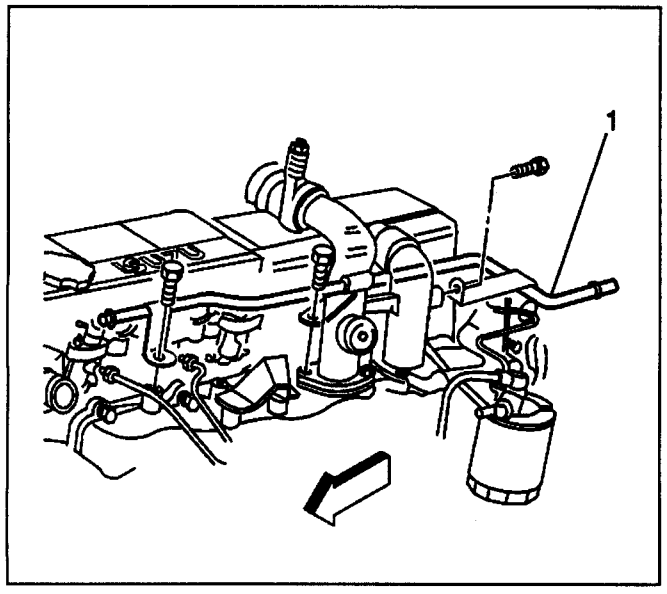
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3. Install the following components:
   - The recovery reservoir overflow hose (1)
   - The clamp

   Tighten

   Tighten the clamp to 3 N·m (27 lb in).
4. Install the following components:
   - The coolant recovery reservoir hose
   - The clamps

   Tighten

   Tighten the clamp to 3 N·m (27 lb in).
5. Connect the negative battery cable.
6. Fill the cooling system.
7. Inspect the system for leaks.
8. Lower the cab.

Coolant Recovery Pipe Replacement

Removal Procedure

1. Tilt the cab.

   Refer to *Cab Tilting* in General Information.

   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Partially drain the cooling system.

   Refer to *Draining and Filling Cooling System (Draining).*
4. Remove the following components:
   - The radiator recovery hose (1)
   - The clamp
5. Remove the following components:
   - The coolant recovery reservoir hose
   - The clamp
6. Remove the following components from the mounting brackets:
   - The bolts
   - The washers
7. Remove the radiator recovery pipe (1).
8. Inspect the following components for cracks, leakage and faulty conditions:
   - The radiator
   - The recovery reservoir
   - The hoses

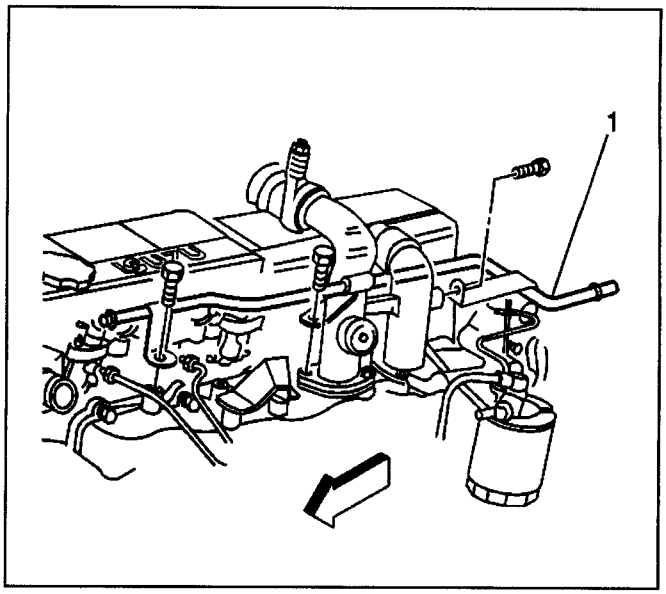
Installation Procedure

1. Install the radiator recovery pipe (1).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the following components to the mounting brackets.
   - The bolts

     Tighten

     Tighten the mounting bolts to 14 N.m (124 lb in).
   - The washers



228193

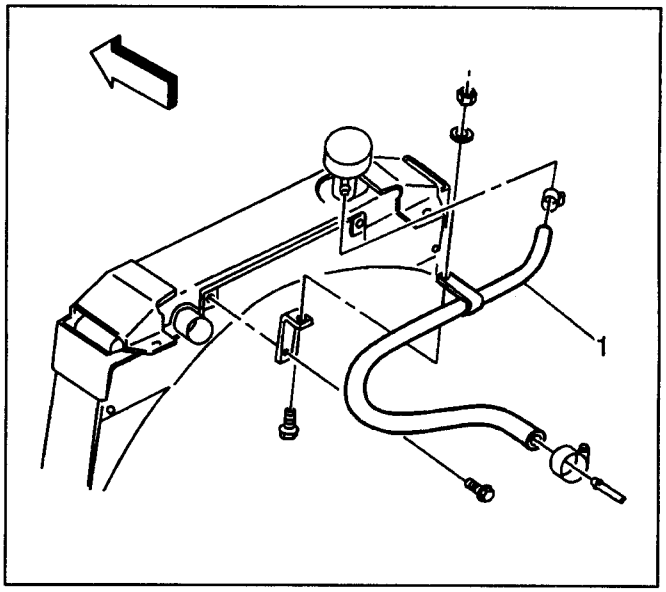
3. Install the following components:
   - The radiator recovery hose (1)
   - The clamp

     Tighten

     Tighten the clamps to 3 N.m (27 lb in).
4. Install the following components:
   - The coolant recovery reservoir hose
   - The clamp

     Tighten

     Tighten the clamp to 3 N.m (27 lb in).
5. Connect the negative battery cable.
6. Fill the cooling system.
7. Inspect the system for leaks.
8. Lower the cab.



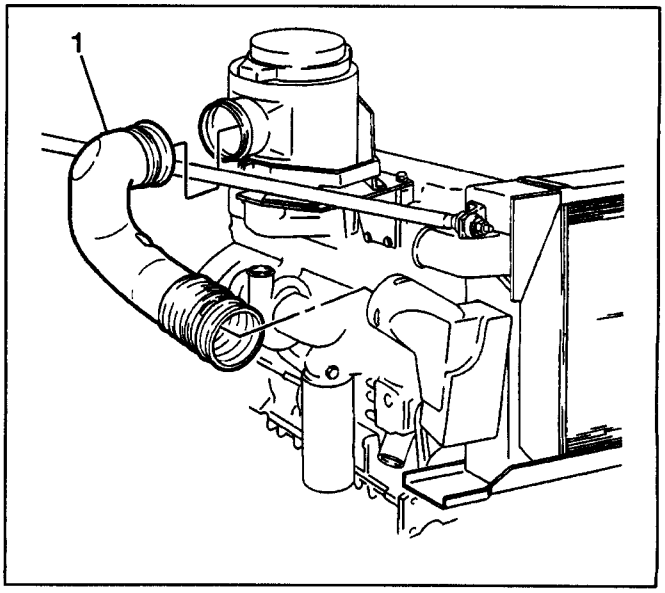
209213

Surge Tank Pipe Replacement - Inlet

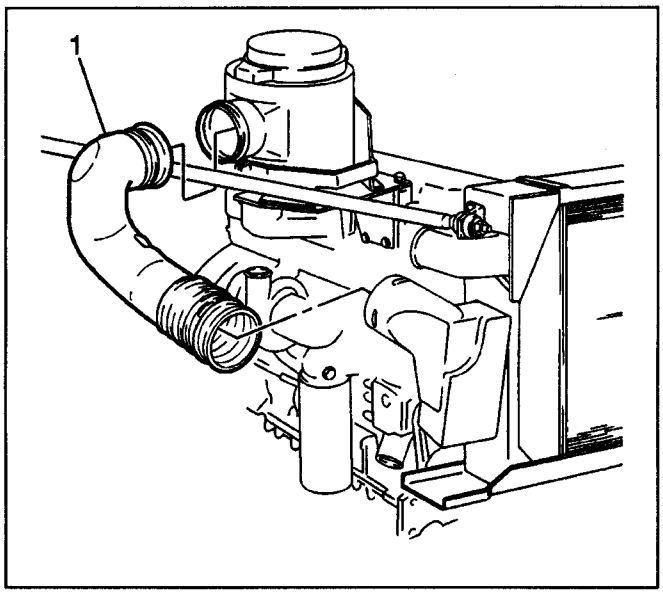
Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.

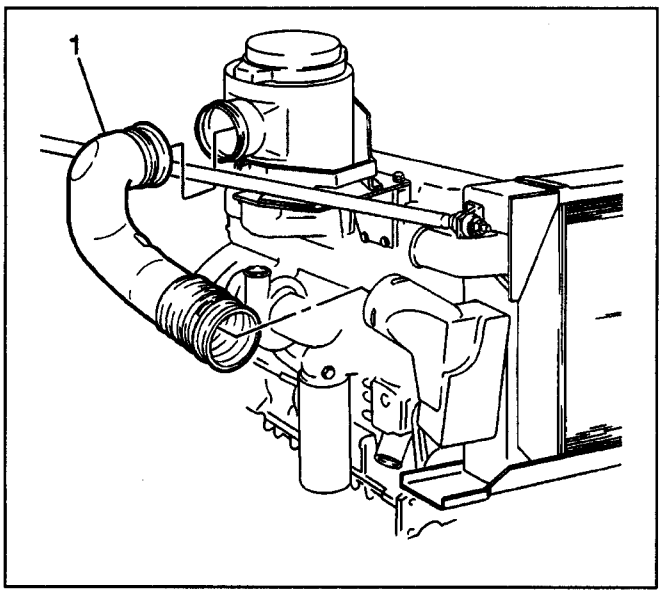
   Refer to *Battery Cable Replacement* in Engine Electrical.
2. Remove the front wheelhouse panel.
3. Remove the front intake air duct (1) from the air filter housing.
4. Drain the coolant. Refer to *Draining and Filling Cooling System (Draining).*
5. Remove the radiator surge tank inlet hose and the clamp.
6. Remove the surge tank inlet pipe.



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7. Inspect the following components for cracks or leaks:
   - The radiator
   - The surge tank
   - The pipes
   - The hoses

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the surge tank inlet pipe.
   Tighten
   Tighten the flare nut on the 6.6L engine only to 35 N·m (26 lb ft).
2. Install the radiator surge tank inlet hose and the clamp.
   Tighten
   Tighten the radiator surge tank hose clamp to 3 N·m (27 lb in).
3. Install the front intake air duct (1) to the air filter housing.
4. Install the front wheelhouse panel.
5. Connect the negative battery cable.
6. Fill the cooling system. Refer to *Draining and Filling Cooling System (Draining).*
7. Check the system for leaks.

Surge Tank Pipe Replacement - Outlet

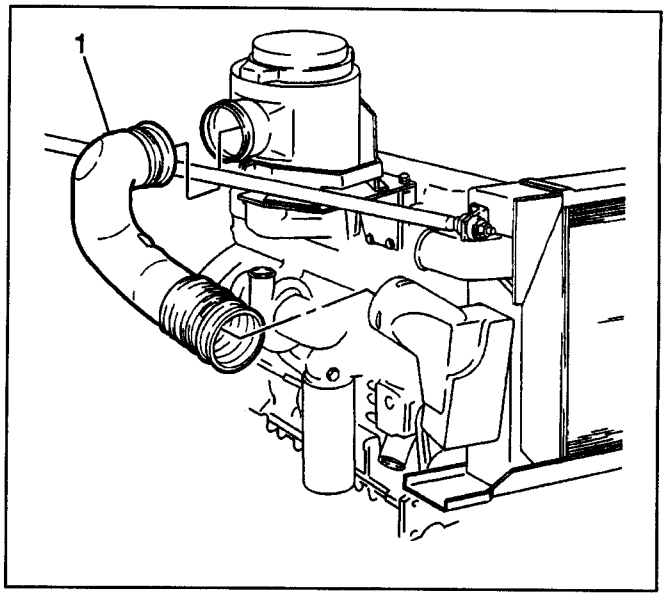
Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.
   Refer to *Battery Cable Replacement* in Engine Electrical.
2. Remove the front wheelhouse panel.
3. Remove the front intake air duct (1) from the air filter housing.
4. Drain the coolant. Refer to *Draining and Filling Cooling System (Draining).*
5. Remove the radiator surge tank outlet hose and the clamp.
6. Remove the surge tank outlet pipe.
7. Inspect the following components for cracks or leaks:
   - The radiator
   - The surge tank
   - The pipes
   - The hoses

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the surge tankoutlet pipe.
   Tighten
   Tighten the flare nut on the 7.2L engine only to 35 N·m (26 lb ft).
2. Install the radiator surge tank outlet hose and the clamp.
   Tighten
   Tighten the radiator surge tank hose clamp to 3 N·m (27 lb in).
3. Install the front intake air duct (1) to the air filter housing.
4. Install the front wheelhouse panel.
5. Connect the negative battery cable.
6. Fill the cooling system. Refer to *Draining and Filling Cooling System (Draining).*
7. Check the system for leaks.

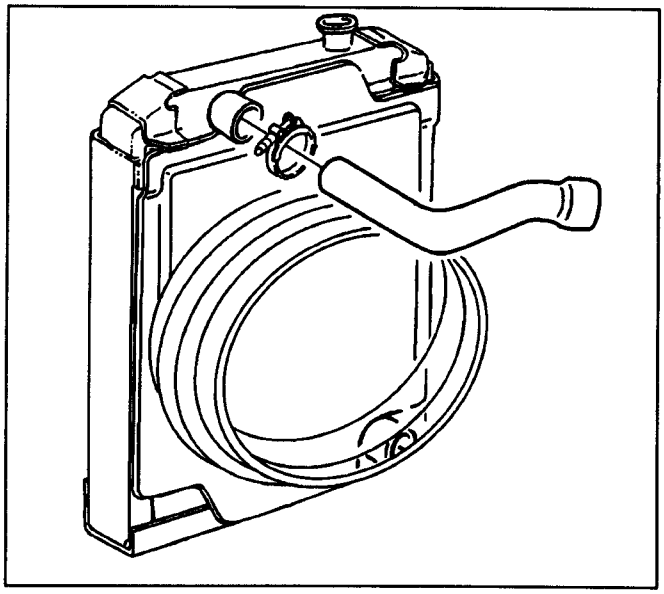


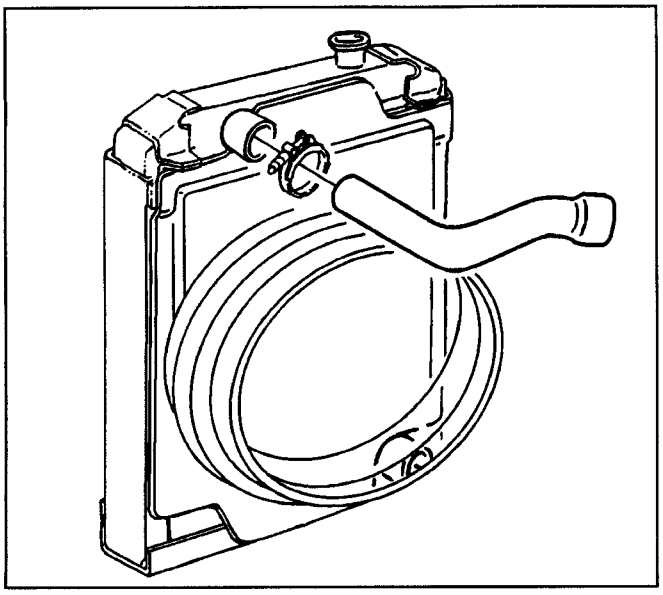
198949

Radiator Hose Replacement (Upper)

Removal Procedure

1. Tilt the cab.
   Refer to *Cab Tilting* in General Information.
   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Drain the coolant.
   Refer to *Draining and Filling Cooling System (Draining).*
4. Remove the upper radiator hose.


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Installation Procedure

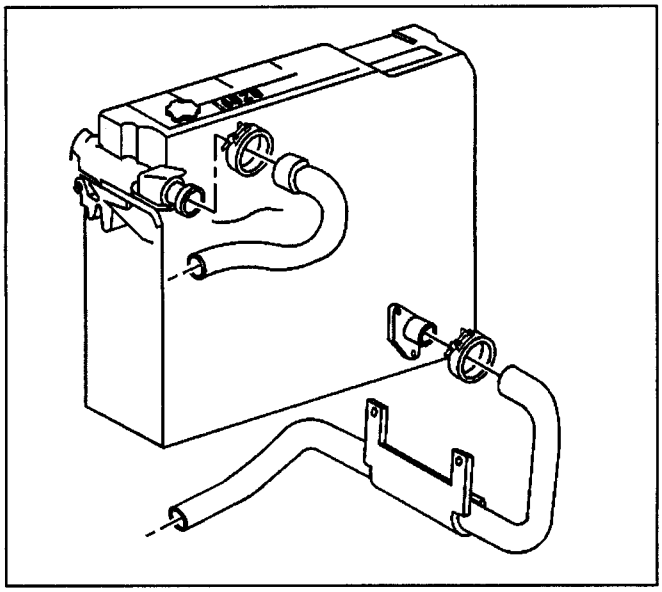
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the upper radiator hose.
   Tighten
   Tighten the clamps to 5 N·m (44 lb in).
2. Connect the negative battery cable.
3. Fill the cooling system.
4. Inspect the system for leaks.
5. Lower the cab.

Radiator Hose Replacement (Lower)

Removal Procedure

1. Tilt the cab.
   Refer to *Cab Tilting* in General Information.
   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Drain the coolant.
   Refer to *Draining and Filling Cooling System (Draining).*
4. Remove the lower radiator hose.

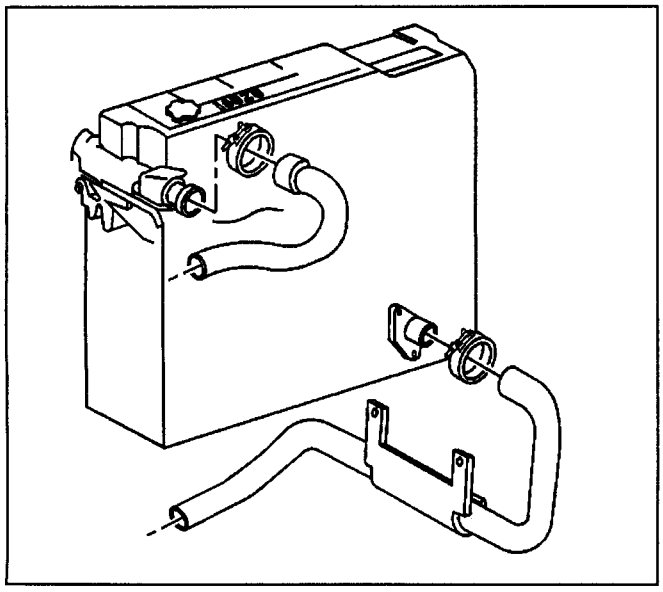


228186

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the lower radiator hose.
   Tighten
   Tighten the clamp to 5 N·m (44 lb in).
2. Connect the negative battery cable.
3. Fill the cooling system.
4. Inspect the system for leaks.
5. Lower the cab.



228186

Fan Replacement (Fan Blade)

Removal Procedure

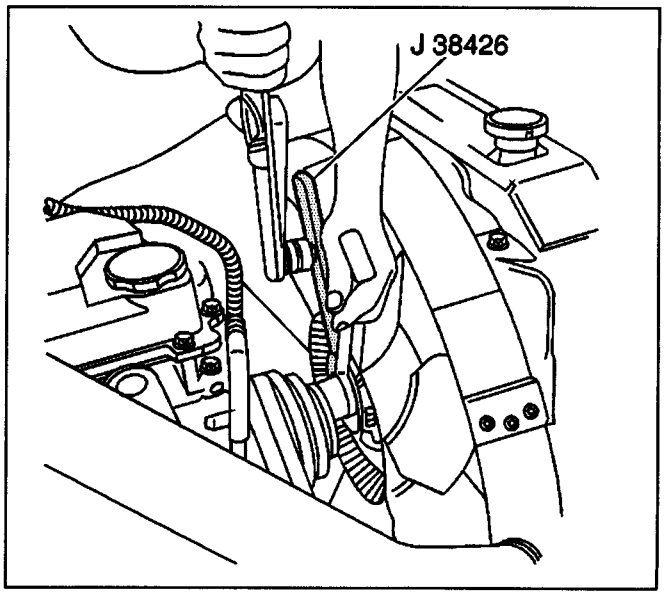
Tools Required
J 38425 Fan Hub Wrench

Notice: If a fan blade is bent or damaged, do not repair and use the damaged part. Replace a bent or damaged fan assembly with a new fan assembly. Using a fan with a different diameter, pitch, number of blades, or type of blade material may effect the cooling efficiency, performance and engine noise level.

Inspect the hub and the drive components if a fan assembly fails.

A fan assembly may fail due to an imbalance in the hub. The blades may not be the cause.

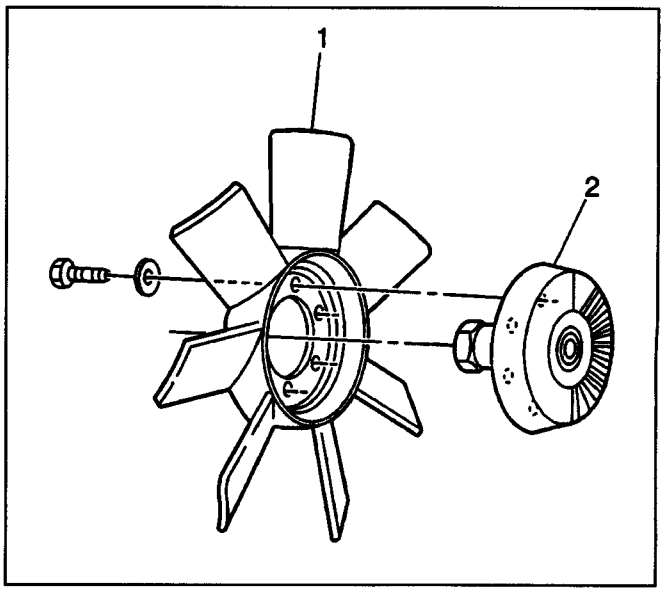
1. Tilt the cab.
   Refer to *Cab Tilting* in General Information.
   Caution: Refer to Battery Disconnect Caution in Cautions and Notices
2. Disconnect the negative battery cable.
   Important: The fan clutch (2) has a left hand thread and must be rotated clockwise for removal.
3. Position wrench on shaft flats.
4. Insert the *J 38425* onto the fan hub.
5. Remove the fan (1) and the fan clutch (2).
6. Remove the following components:
   - The fan blade (1) to fan clutch bolts
   - The washers
7. Remove the fan blade (1) from the fan clutch (2).
8. Inspect the belts and the pulley for the following conditions:
   - Cracks
   - Distortion
   - Other damage
9. Replace the above components as necessary.



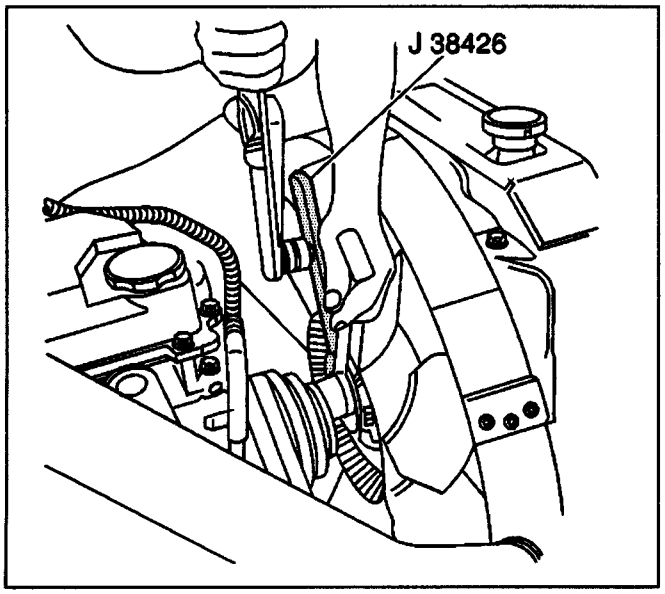
300348

Installation Procedure

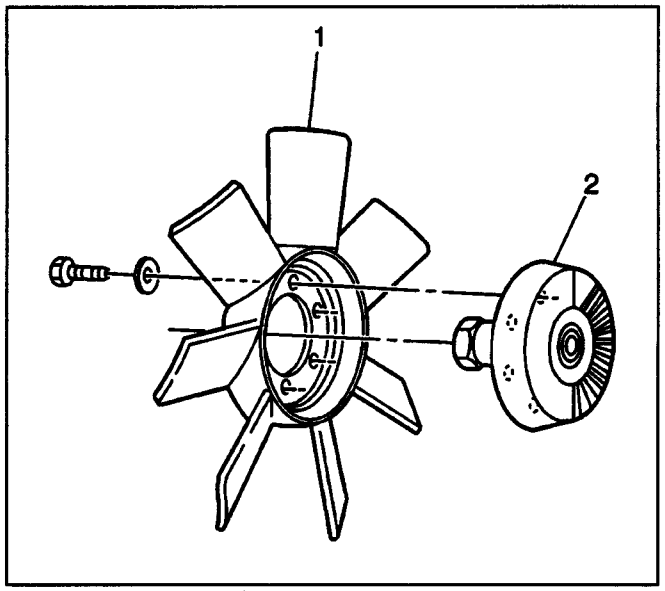
1. Install the fan (1) to the fan clutch (2).
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the fan blade to fan clutch bolts and the washers.
   Tighten
   Tighten the fan to fan clutch bolts to 21 N·m (16 lb ft).
3. Install the fan (1) and the fan clutch (2).
   Tighten
   Tighten the fan clutch nut to 145 N·m (107 lb ft).
4. Connect the negative battery cable.
5. Lower the cab.



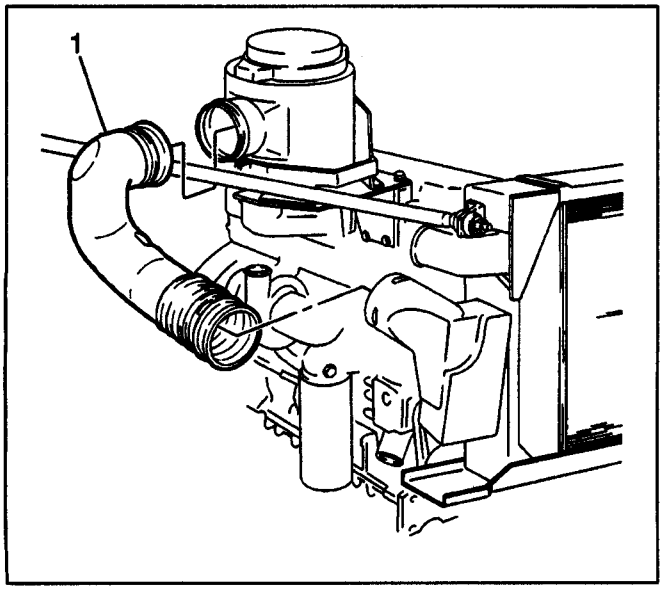
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300348



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Fan Replacement (Fan Clutch)

Tools Required

J 38425 Fan Hub Wrench

1. Tilt the cab.

   Refer to *Cab Tilting* in General Information.

   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Remove the fan and the fan clutch.

   Refer to *Fan Replacement (Fan Blade).*
4. Remove the following components:
   - The fan blade to fan clutch bolts
   - The washers
5. Remove the fan blade (1) from the fan clutch (2).
6. Inspect all of the components for smooth surfaces.

Installation Procedure

1. Install the fan (1) to the fan clutch (2).

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the following components:
   - The fan blade to fan clutch bolts

     Tighten

     Tighten the fan to fan clutch bolts to 21 N·m (16 lb ft).
   - The washers
3. Install the following components:
   - The fan (1)
   - The fan clutch (2)
4. Connect the negative battery cable.
5. Lower the cab.

Thermostat Housing Replacement

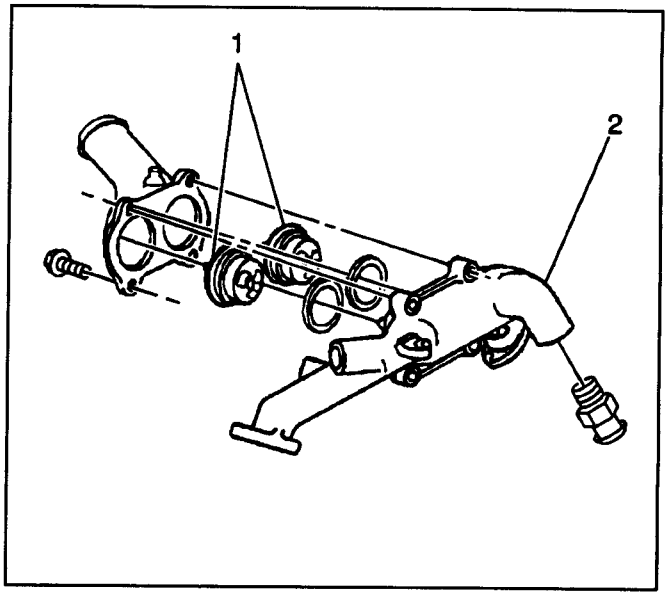
Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.

   Refer to *Battery Cable Replacement* in Engine Electrical.
2. Remove the front wheelhouse panel.
3. Remove the front intake air duct (1) from the air filter housing.
4. Drain the coolant. Refer to *Draining and Filling Cooling System (Draining).*
5. Remove the upper radiator hose from the coolant outlet.
6. Remove the coolant outlet bolts.

7. Remove the coolant outlet.
8. Remove the thermostat housing.
9. Remove the coolant outlet gasket.
10. Clean the following components:
    - The surface of the coolant crossover manifold (2)
    - The coolant outlet
11. Inspect the coolant crossover manifold and the coolant outlet mating surfaces for the following conditions:
    - Pits
    - Cracks
    - Other damage that could cause leaks



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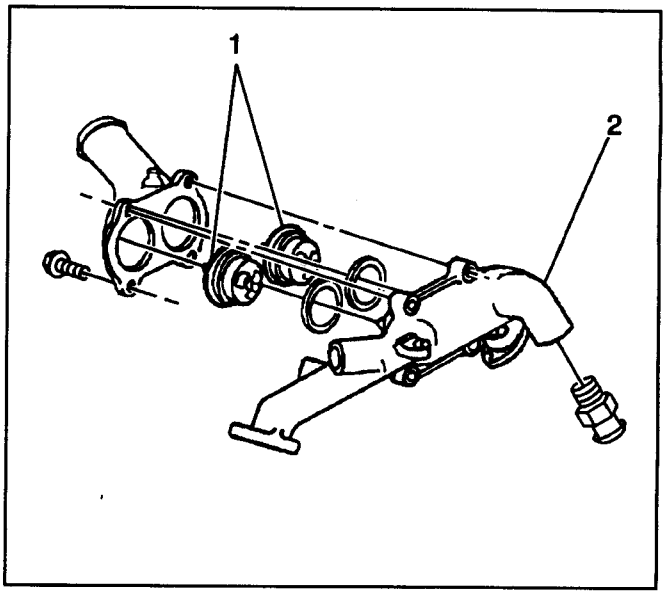
Installation Procedure

1. Install the thermostat housing (2).
2. Install the coolant outlet gasket.
3. Install the coolant outlet.

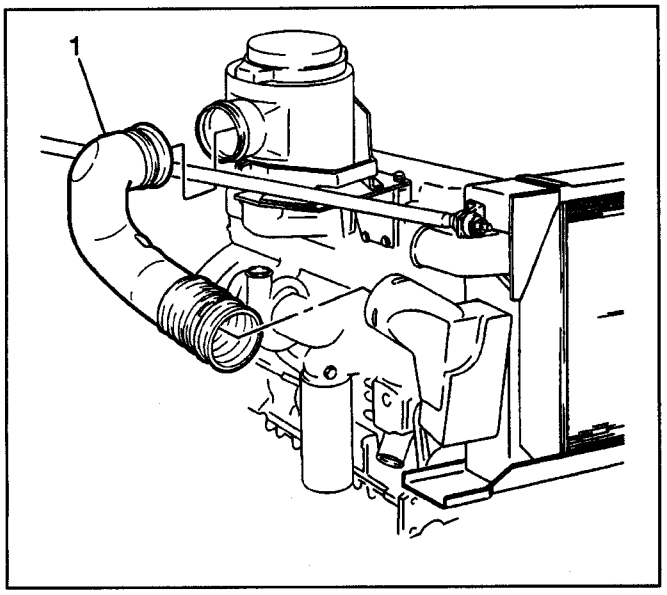
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
4. Install the coolant outlet bolts.

   Tighten

   Tighten the coolant outlet bolts to 42 N·m (31 lb ft).
5. Install the upper radiator hose to the coolant outlet.



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6. Install the front intake air duct (1) to the air filter housing.
7. Install the front wheelhouse panel.
8. Connect the negative battery cable.
9. Fill the cooling system. Refer to *Draining and Filling Cooling System (Draining).*
10. Inspect the system for leaks.

Thermostat Replacement

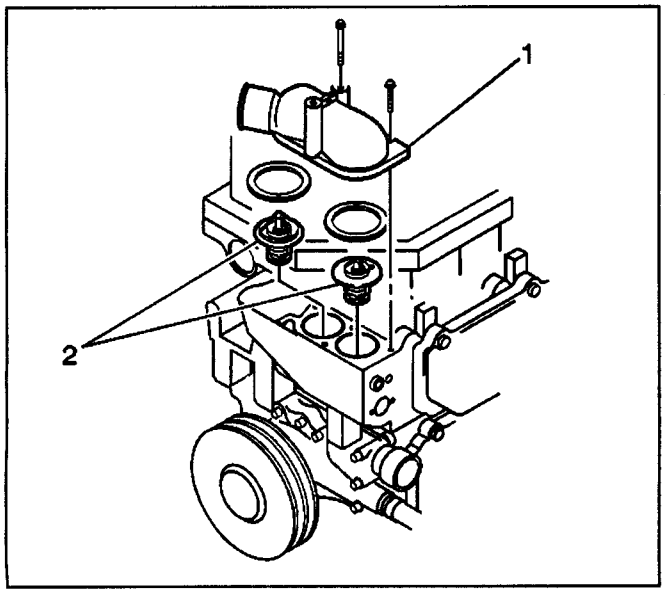
Removal Procedure

1. Tilt the cab.

   Refer to *Cab Tilting* in General Information.

   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Drain the coolant.

   Refer to *Draining and Filling Cooling System (Draining).*
4. Remove the upper radiator hose from the coolant outlet.
5. Remove the coolant outlet bolts.
6. Remove the coolant outlet (1).
7. Remove the thermostats (2).
8. Clean the following surfaces:
   - The inlet manifold
   - The coolant outlet
9. Inspect the coolant outlet for the following conditions:
   - Flat mating surfaces
   - Pits
   - Cracks
   - Other damage

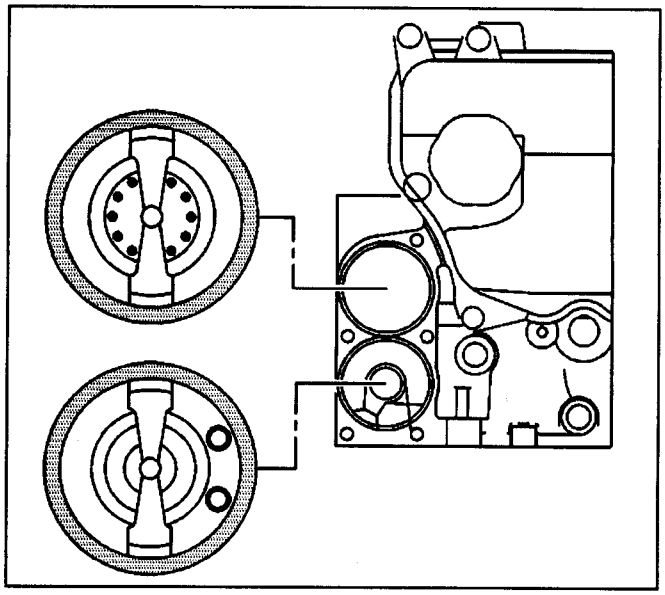


228201

Installation Procedure

Important: Place the thermostat with the jiggle valves on the left side.

1. Install the thermostats (2).



228198

2. Install the coolant outlet (1).

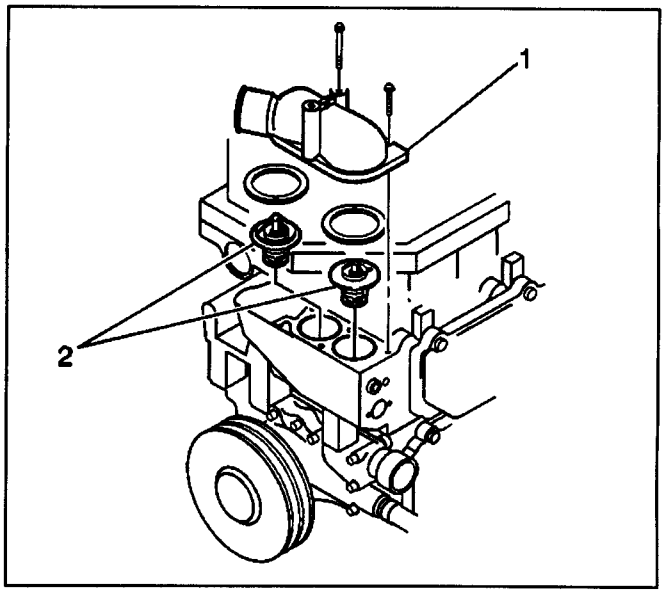
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the coolant outlet bolts.

   Tighten

   Tighten the coolant outlet bolts to 19 N·m (14 lb ft).
4. Install the upper radiator hose to the coolant outlet.

   Tighten

   Tighten the clamp to 5 N·m (44 lb in).
5. Connect the negative battery cable.
6. Fill the cooling system.
7. Inspect the system for leaks.
8. Lower the cab.



228201

Water Pump Replacement

Removal Procedure

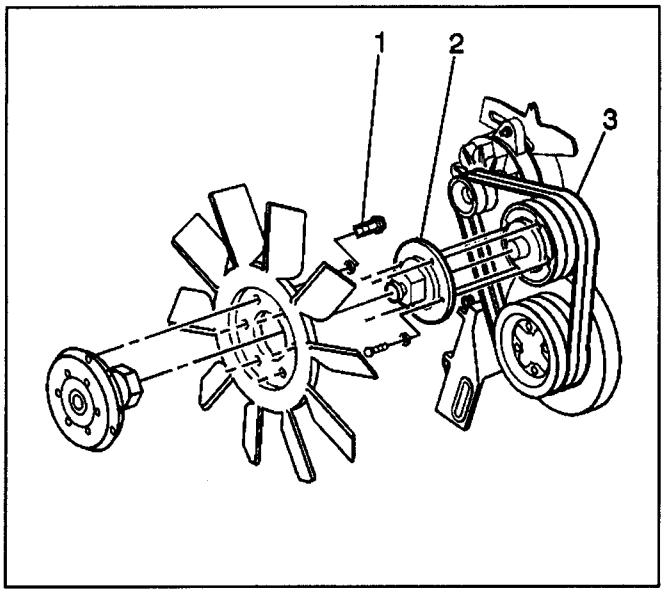
1. Tilt the cab.

   Refer to *Cab Tilting* in General Information.

   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Drain the coolant.

   Refer to *Draining and Filling Cooling System (Draining).*
4. Remove the drive belts.

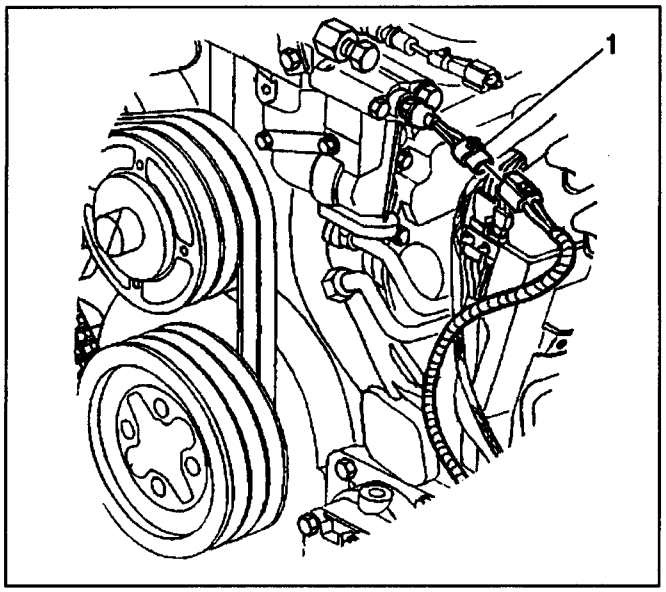
   Refer to Engine Mechanical.



228234

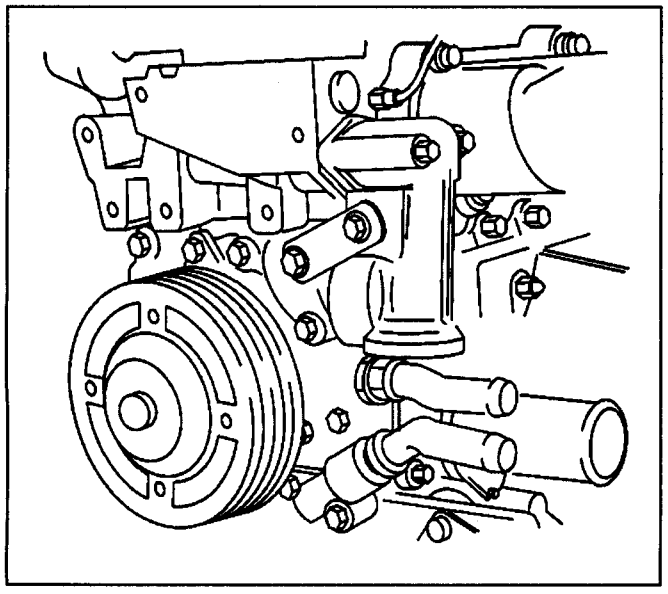
5. Remove the following components from the pump:
   - The fan clutch
   - The adapter (2)

   Refer to Fan Adapter.
6. Remove the following components from the water pump:
   - The clamp
   - The heater hose



228214

7. Remove the temperature sensor connector (1).

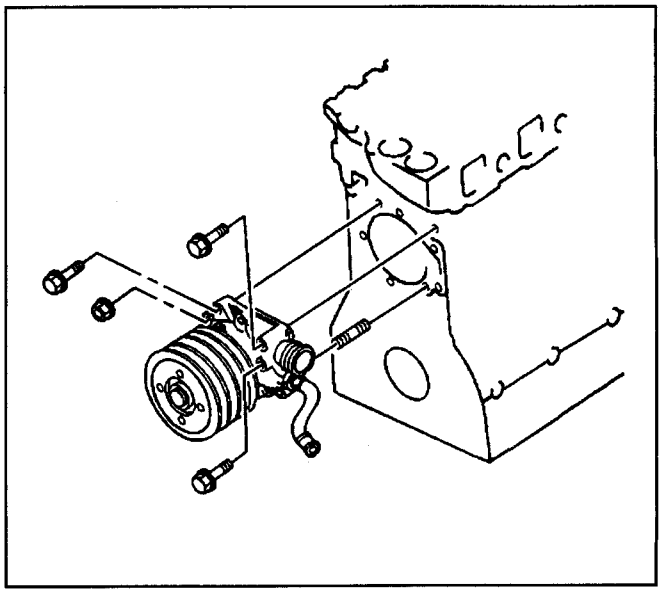


228206

8. Remove the bolts from the water duct.
9. Remove the following components:
   - The water duct
   - The O-ring

10. Remove the water pump bolts.
11. Remove the following components:
    - The water pump
    - The gaskets
12. Clean the following components:
    - The surface of the water pump
    - The surface of the engine block
    - The bolt threads
    - The water duct sealing surfaces
13. Inspect the following components for wear, deterioration or corrosion.

    Replace the components as necessary:
    - The clamps
    - The hoses
    - The water pump



228210

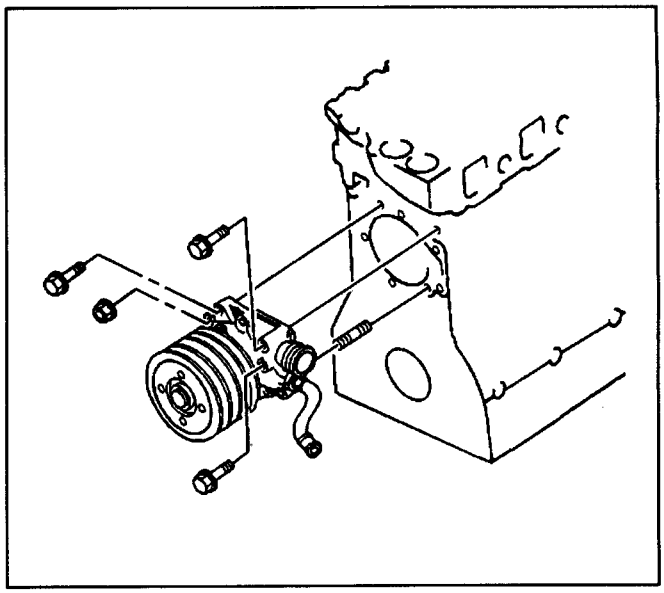
Installation Procedure

1. Install new gaskets to the water pump.
2. Install the water pump to the engine block.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the water pump bolts.

   Tighten

   Tighten the water pump bolts to 19 N.m (14 lb ft).



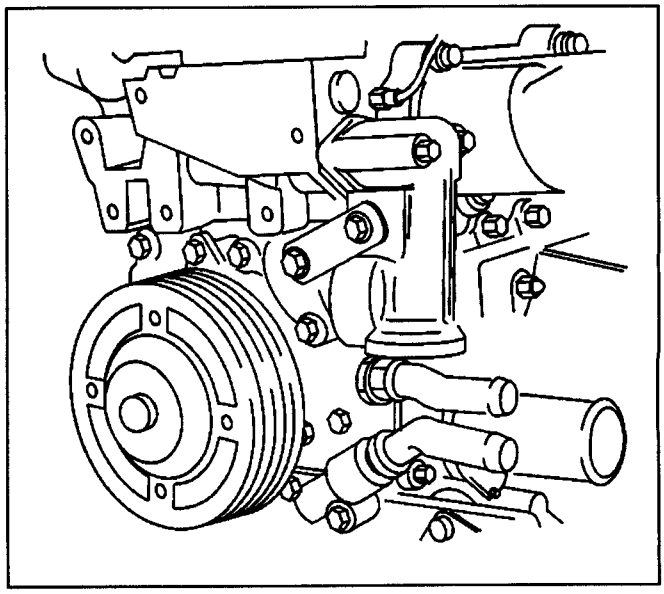
228210

4. Lube the O-ring with soap suds.
5. Install the following components:
   - The water duct
   - The O-ring
6. Install the water duct bolts.

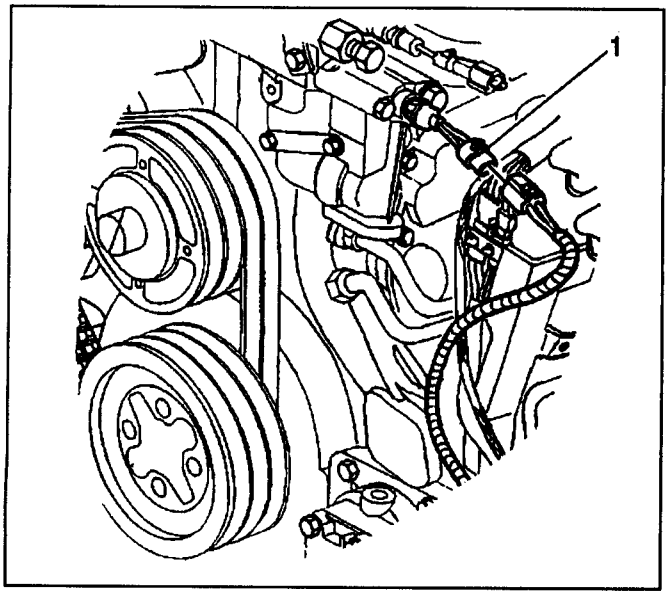
   Tighten

   6.1. Tighten the M8 bolt to 19 N.m (14 lb ft).

   6.2. Tighten the M16 bolt to 125 N.m (92 lb ft).



228206

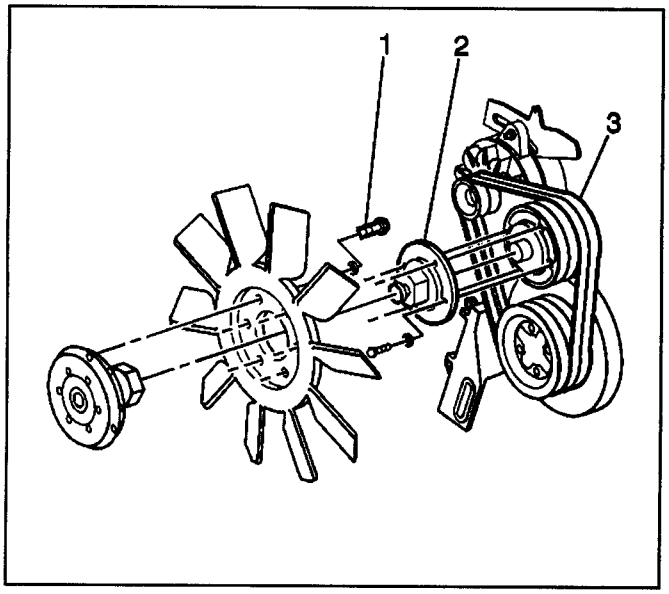


228214

7. Install the temperature sensor connector (1).
8. Install the following components to the water pump:
   - The heater hose
   - The clamp

   Tighten

   Tighten the clamp to 5 N.m (44 lb in).

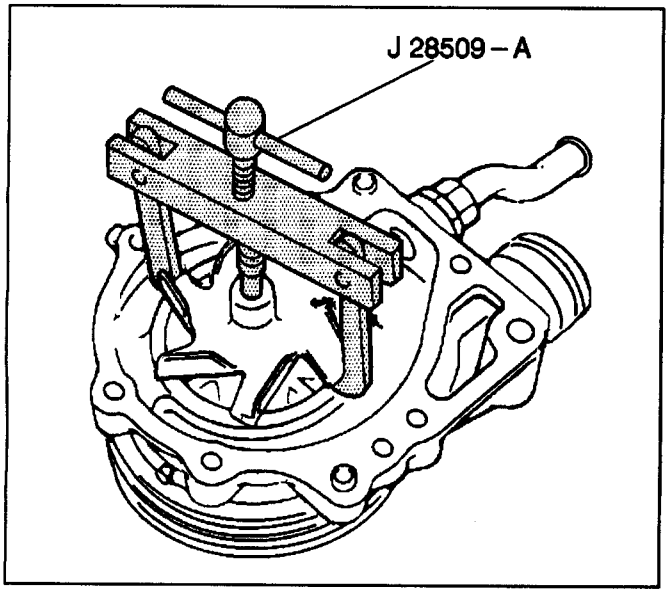


228234

9. Install the following components to the pump:
   - The adapter (2)

   Tighten

   Tighten the adapter bolts to 68 N.m (50 lb ft).
   - The fan clutch
10. Install the drive belts.
11. Connect the negative battery cable.
12. Fill the cooling system.
13. Inspect the system for leaks.
14. Lower the cab.



228725

Water Pump Overhaul

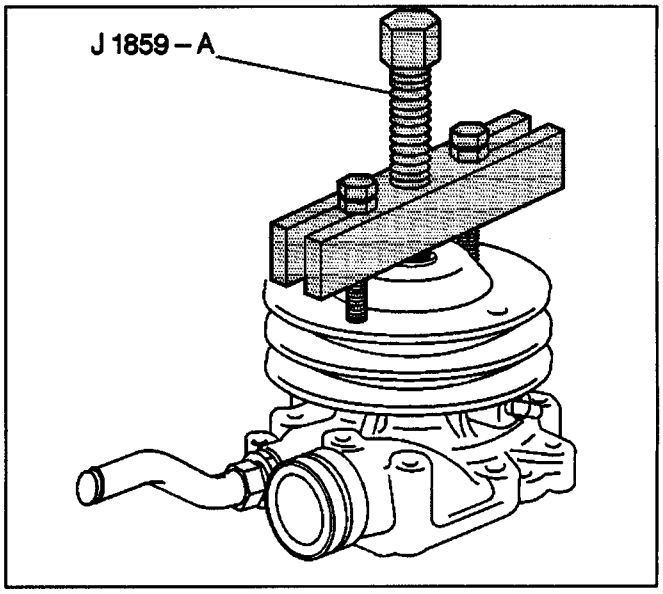
Disassembly Procedure

Tools Required

- *J 1859-A* Puller
- *J 28509-A* Bearing Remover

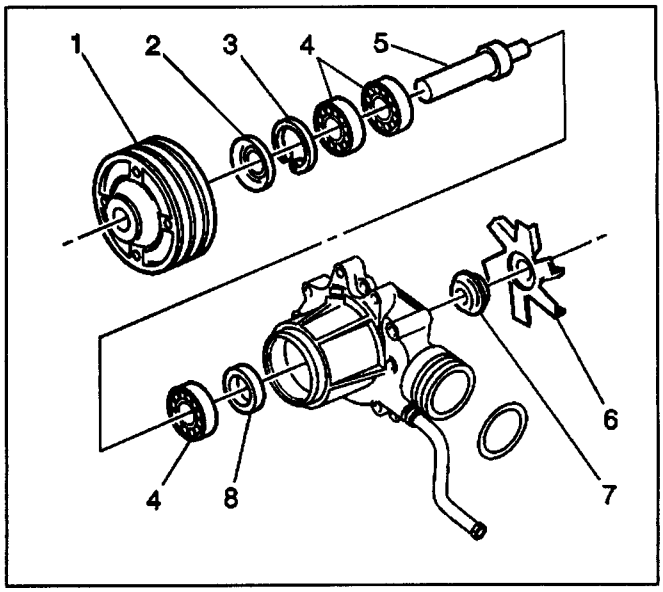
1. Use the *J 1859-A* in order to remove the impeller.

2. Use the *J 1859-A* in order to remove the pulley.



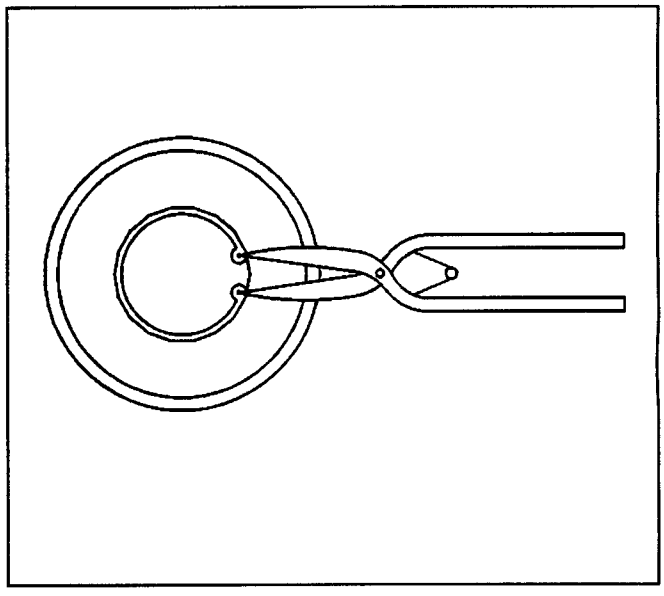
228727

3. Remove the dust thrower (2).

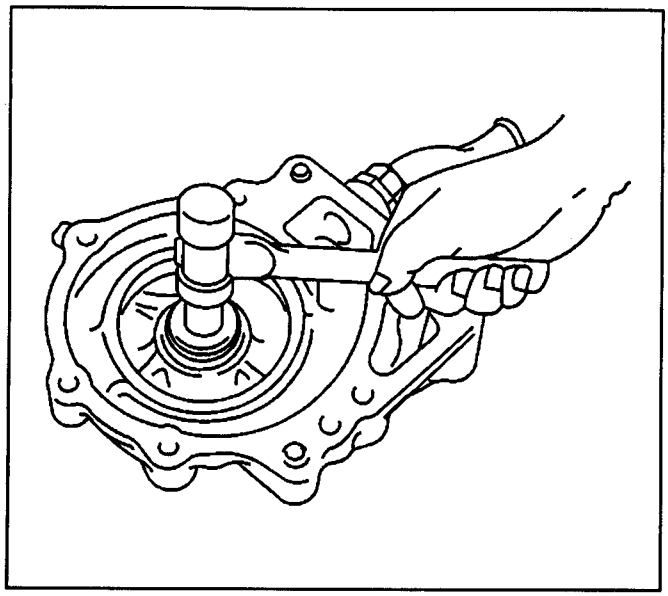


228730

4. Use snap ring pliers in order to remove the snap ring.

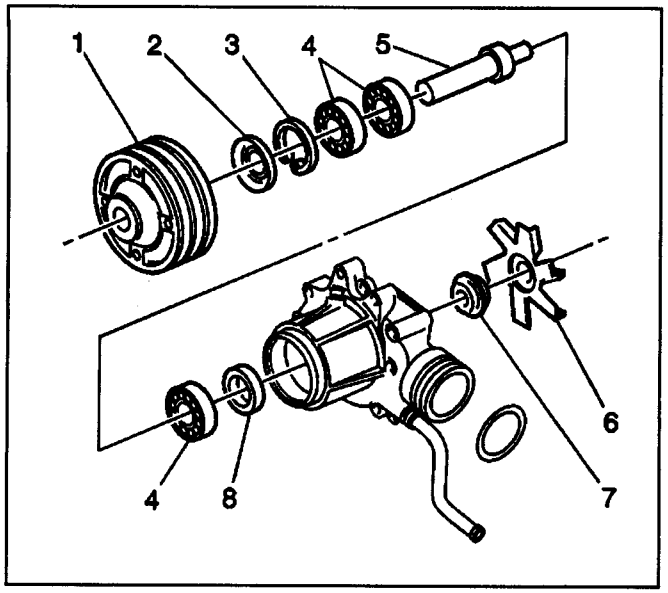


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228708

5. Remove the spindle. Use a plastic hammer in order to lightly tap the spindle free.
6. Remove the bearing.
7. Remove the spacer.



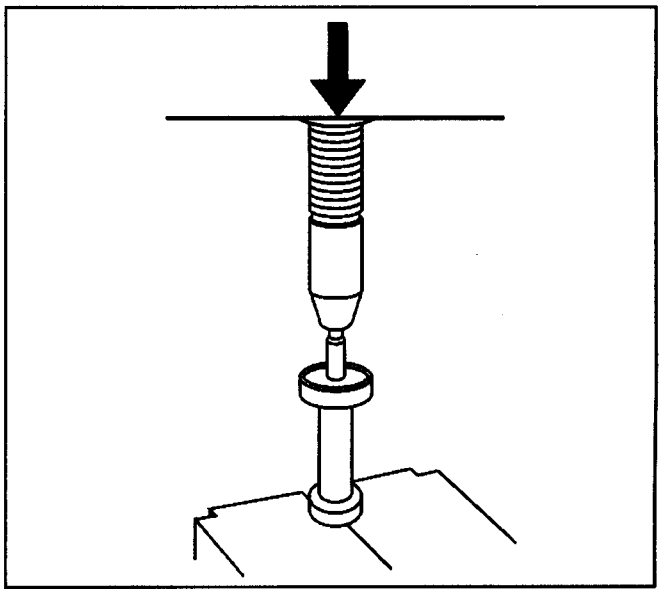
228730

8. Remove the front seal (8).
9. Use an arbor press and the *J 28509-A* in order to remove the seal unit (7).
10. Use an arbor press in order to remove the following components from the spindle (5):
    - The bearings
    - The spacer (4)
11. Inspect the above components for wear or damage.
12. Replace or repair the above components as necessary.
13. Inspect for proper fit of the shaft to the pulley center.
14. Inspect for proper fit of the impeller (6) and the pulley center to the pulley (1).
15. Inspect the housing for cracks or burrs.
16. Inspect the shaft for the following conditions:
    - Cracks
    - Burrs
    - Pitting

    Replace the shaft as necessary.

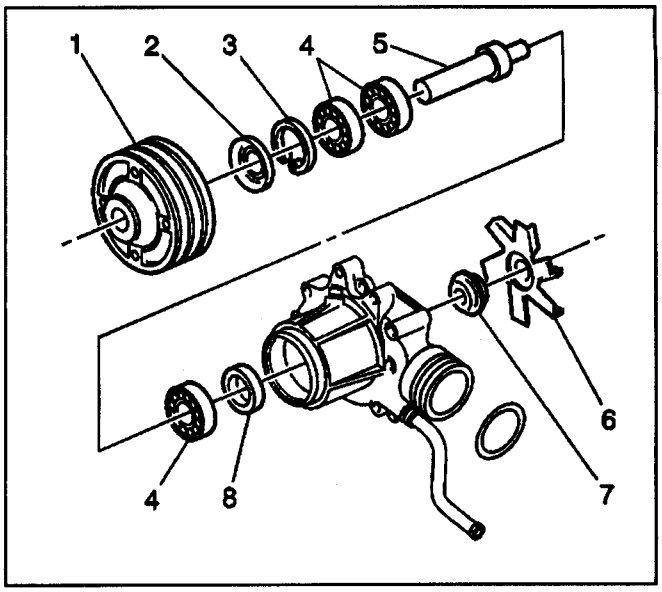
Assembly Procedure

1. Install the following components onto the spindle (5).
   - The bearings
   - The spacer (4)



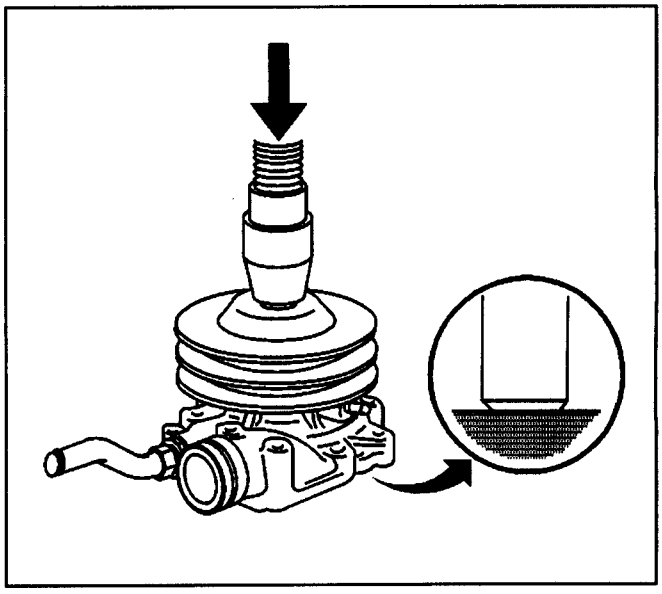
228705

2. Use an arbor press in order to install the following components onto the housing:
   - The spindle (5)
   - The bearings and spacer (4)
3. Apply multipurpose type grease to the lip seal.
4. Apply engine oil to the outer circumference of the lip seal.
5. Position the seal so that the lip of the seal faces forward.
6. Install the front seal (8).
7. Use snap ring pliers in order to install the snap ring (3).
8. Install the dust thrower (2).

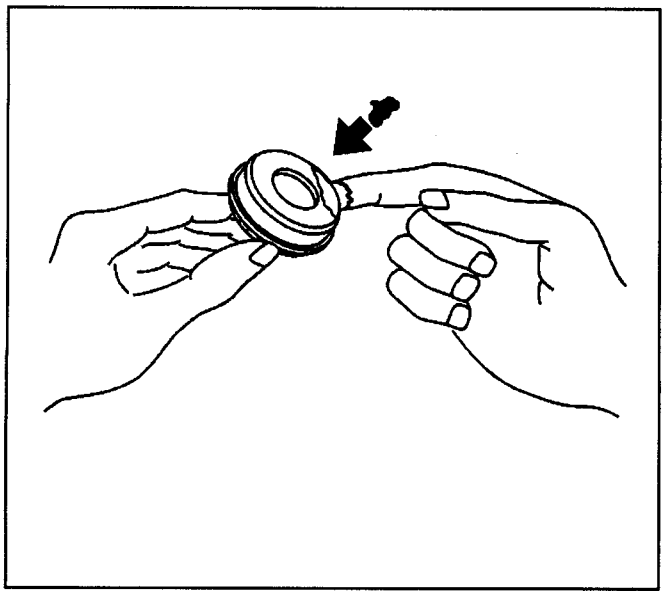


228730

9. Use a bench press in order to install the pulley.



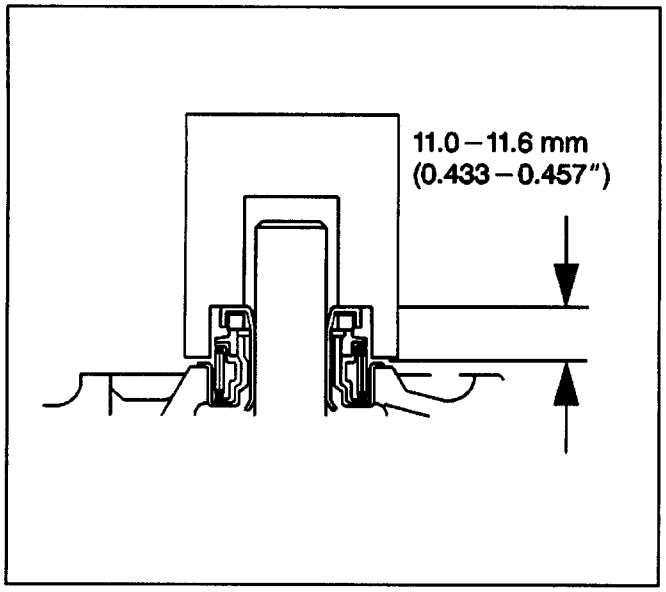
228720



228716

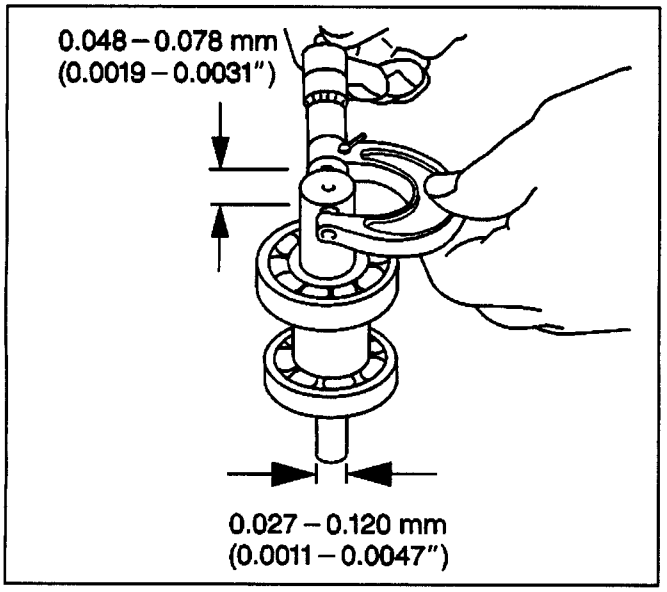
Caution: To protect the bearings and housing during this procedure, the press must contact the impeller side of the pump shaft and the pulley.

10. Apply a thin coat of liquid gasket (Three Bond 1104 or equivalent) to the seal.



228718

11. Use a bench press and an installer in order to install the seal unit to the housing.

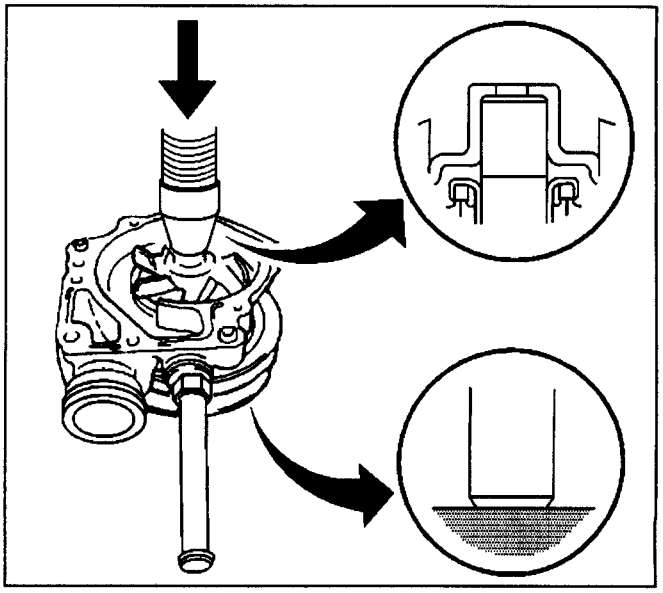


228688

12. Ensure that the seal height is between 11.0–11.6 mm (0.433–0.457 in).

Caution: To protect the bearings and housing during this procedure, the press must contact the impeller and the pulley.

13. Use a bench press in order to install the impeller to the shaft until the impeller bottoms out against the shaft.



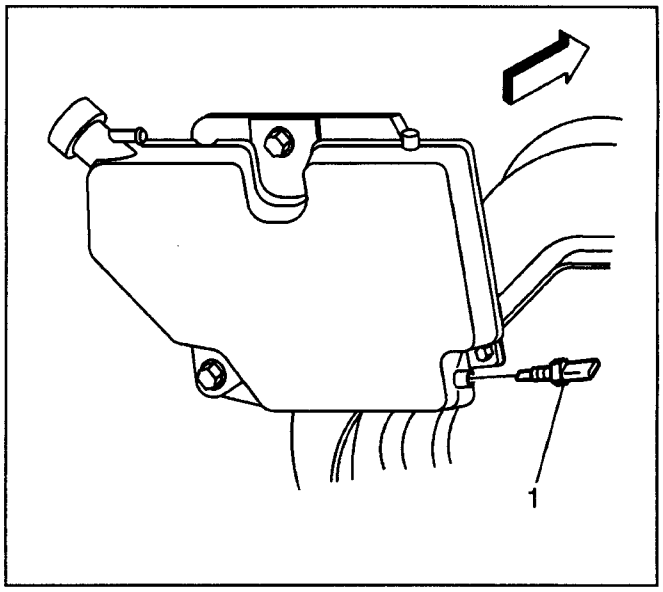
228712

Coolant Level Sensor Replacement

Removal Procedure

1. Disconnect the electrical connector from the probe.

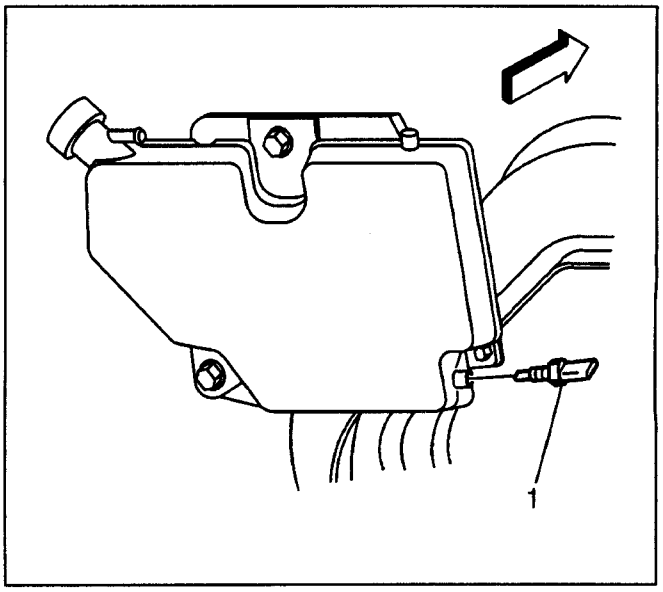
   Important: Catch any spilled coolant in a suitable container.
2. Remove the low coolant probe from the surge tank (1).



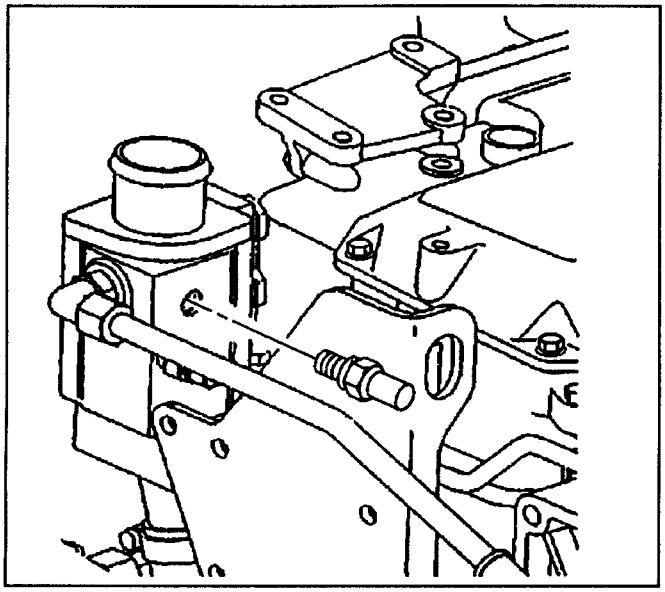
209252

Installation Procedure

1. Install the coolant probe into the surge tank (1).
2. Connect the electrical connector onto the probe.
3. Fill the engine coolant to the proper level.



209252

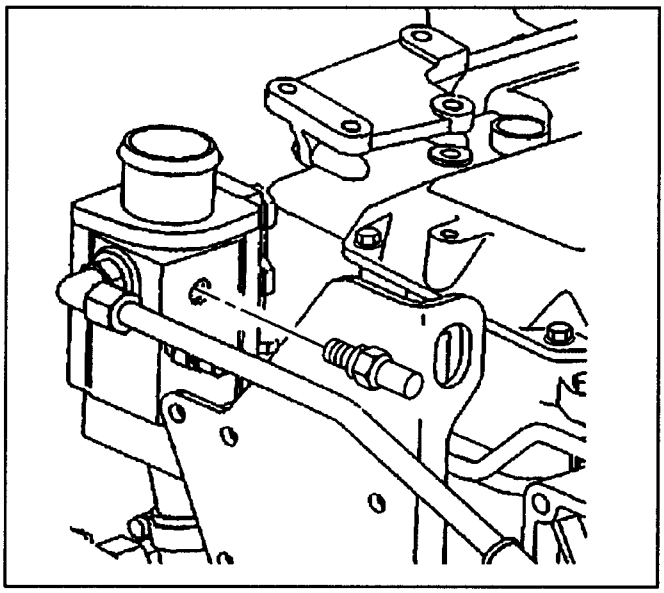


215566

Engine Coolant Temperature Sensor Replacement

Removal Procedure

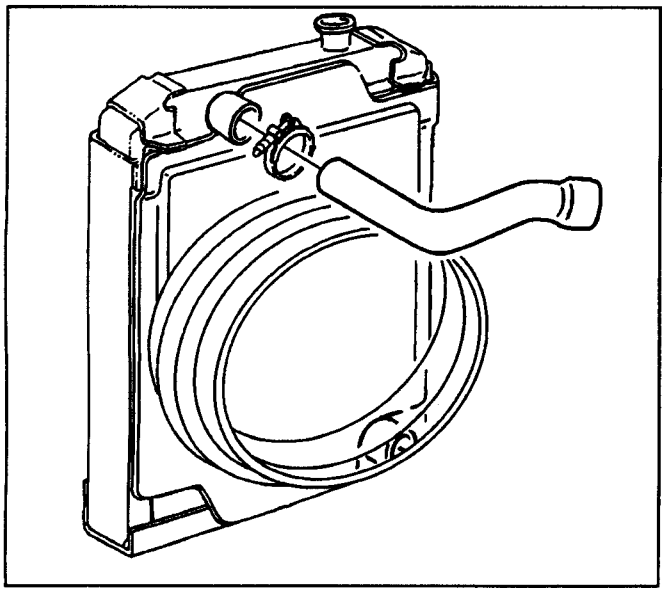
1. Drain the coolant.
2. Disconnect the electrical connector from the sensor.
3. Remove the sensor from the engine.



215566

Installation Procedure

1. Install the sensor to the engine.
2. Connect the electrical connector to the sensor.
3. Refill the coolant.



209225

Fan Shroud Replacement

Removal Procedure

1. Tilt the cab.

   Refer to *Cab Tilting* in General Information.

   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Remove the cooling fan.

   Refer to *Fan Replacement (Fan Blade).*
4. Partially drain the cooling system.

   Refer to *Draining and Filling Cooling System (Draining).*
5. Remove the upper radiator hose.
6. Remove the coolant recovery reservoir hose.
7. Remove the fan shroud bolts.
8. Remove the fan shroud.

9. Clean the fan shroud with a cloth in order to remove dirt and grease.
10. Inspect the fan shroud for cracks and warping.
11. Replace the fan shroud if the fan shroud is damaged.

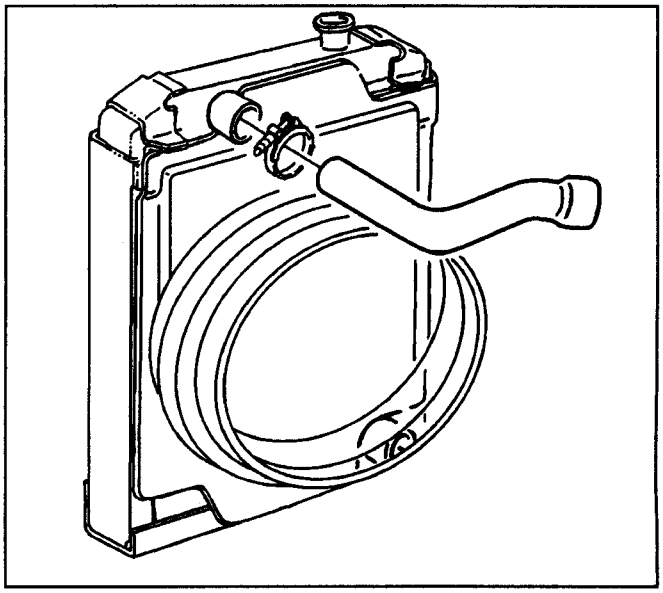
Installation Procedure

1. Install the fan shroud.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the fan shroud bolts.

   Tighten

   Tighten the fan shroud bolts to 6 N·m (53 lb in).
3. Install the coolant recovery reservoir hose.
4. Install the upper radiator hose.
5. Install the cooling fan.
6. Connect the negative battery cable.
7. Fill the cooling system.
8. Lower the cab.



209225

Radiator Replacement

Removal Procedure

Some assemblies may be equipped with an automatic transmission oil cooler in the bottom core tank. Before removing the automatic transmission oil cooler lines, provide a container in order to catch the oil that is drained from the automatic transmission cooler and the lines. Do not reuse the drained fluid. Fill the automatic transmission to the recommended level using clean, new fluid after completing the radiator installation.

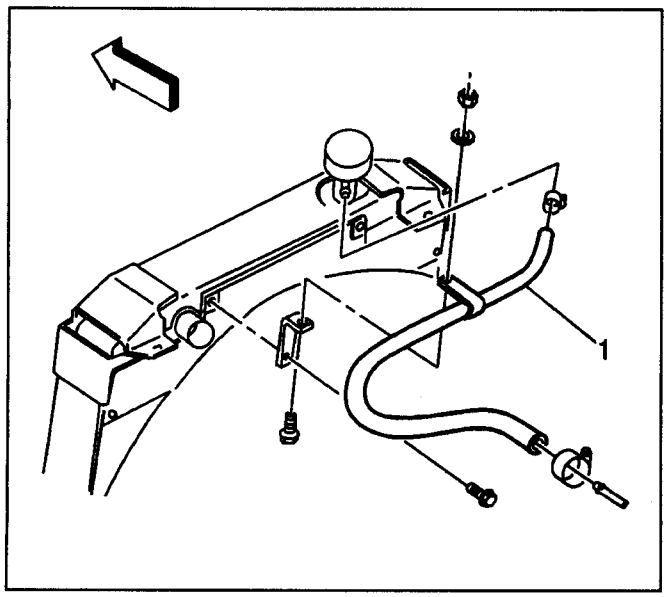
Refer to *Approximate Fluid Capacities* in General Information.

1. Tilt the cab.

   Refer to *Cab Tilting* in General Information.

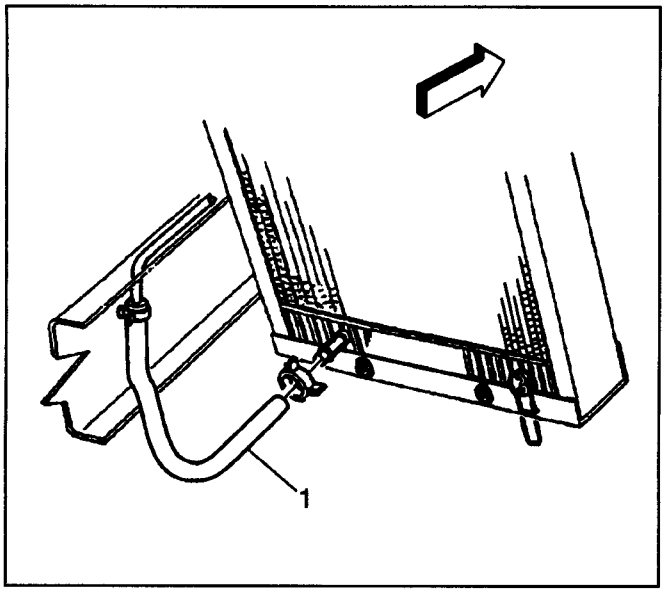
   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Drain the coolant into a suitable container.

   Refer to *Draining and Filling Cooling System (Draining).*
4. Remove the upper radiator hose.



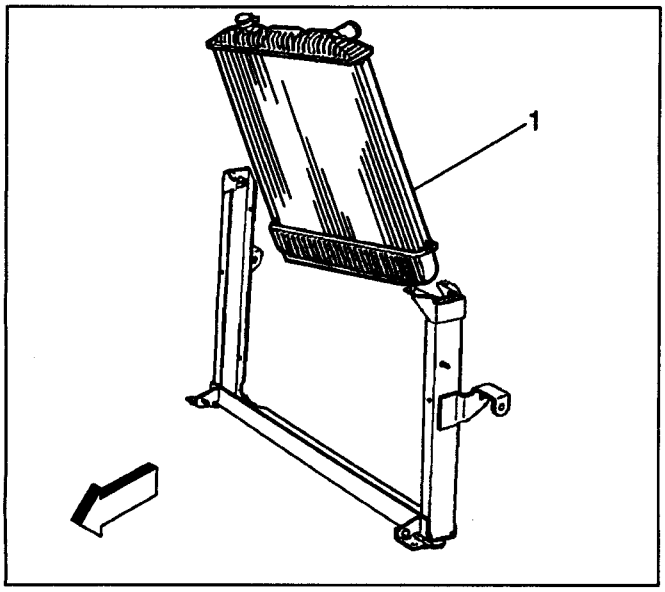
209213

5. Remove the coolant recovery hose (1) from the radiator.
6. Remove the automatic transmission oil cooler lines, if equipped.
7. Remove the lower radiator hose.



209207

8. Remove the heater hose (1).
9. Remove the radiator support top cover bolts.
10. Remove the radiator support top cover.



209210

11. Remove the radiator (1) from the support.
    Tilt the radiator in order to remove the radiator from the support.
12. Remove the radiator insulators.
13. Clean the radiator.
    Refer to *Radiator Cleaning*.
14. Inspect the following components:
    - The radiator
    - The hoses
    - The mounting hardware

    Replace the above components as necessary.

Installation Procedure

Important: Always install a new set of insulators when replacing the radiator.

Used insulators may wear out too large for the new radiator, which may cause the radiator to be loose.

1. Install the radiator insulators.
2. Install the radiator (1) to the support.
3. Install the radiator support top cover.

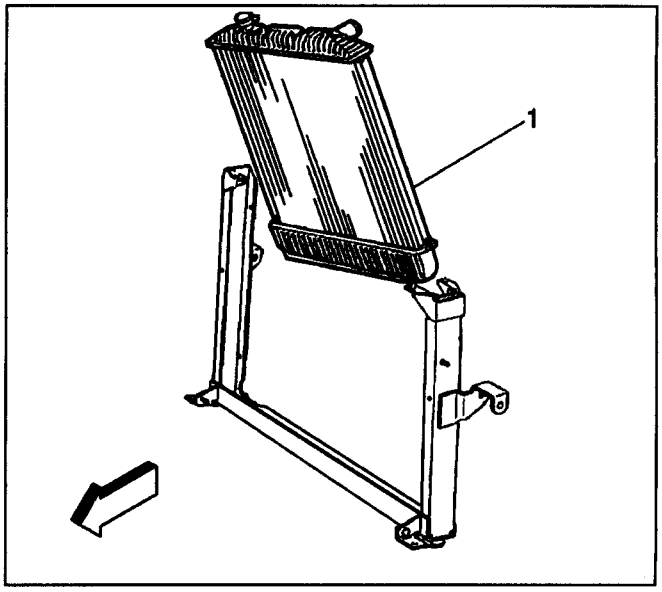
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
4. Install the radiator support top cover bolts.

   Tighten

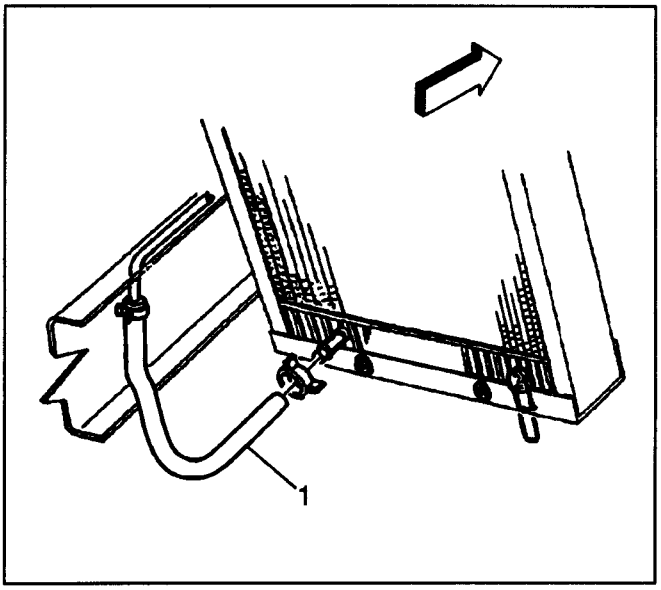
   Tighten the radiator support top cover bolts to 25 N·m (18 lb ft).
5. Install the automatic transmission oil cooler lines, if equipped.
6. Install the lower radiator hose.
7. Install the heater hose (1).

   Tighten

   Tighten the clamp to 5 N·m (44 lb in).



209210



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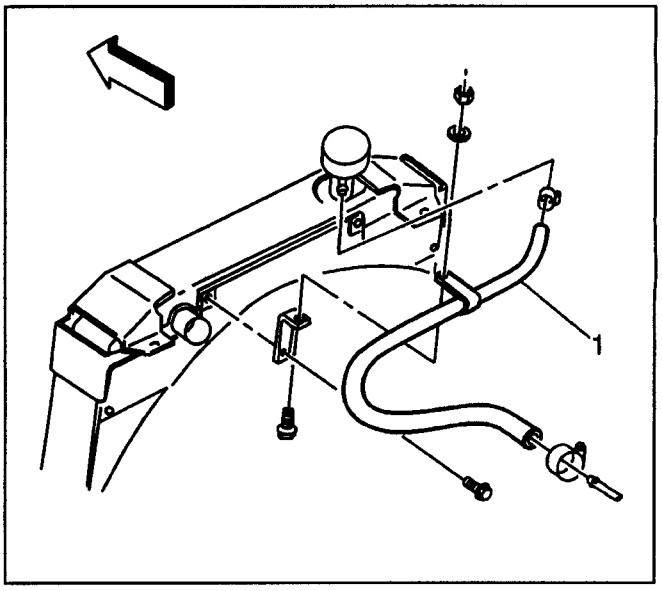
8. Install the coolant recovery hose (1) to the radiator.

   Tighten

   Tighten the clamp to 3 N·m (27 lb in).
9. Install the upper radiator hose clamp.

   Tighten

   Tighten the clamp to 5 N·m (44 lb in).
10. Connect the negative battery cable.
11. Fill the cooling system.
12. Fill the automatic transmission to the proper capacity, if equipped.
13. Inspect the system for leaks.
14. Lower the cab.

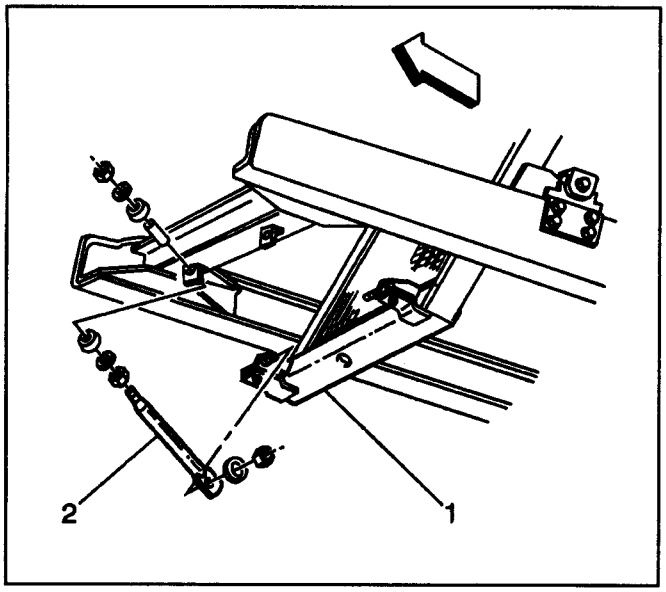


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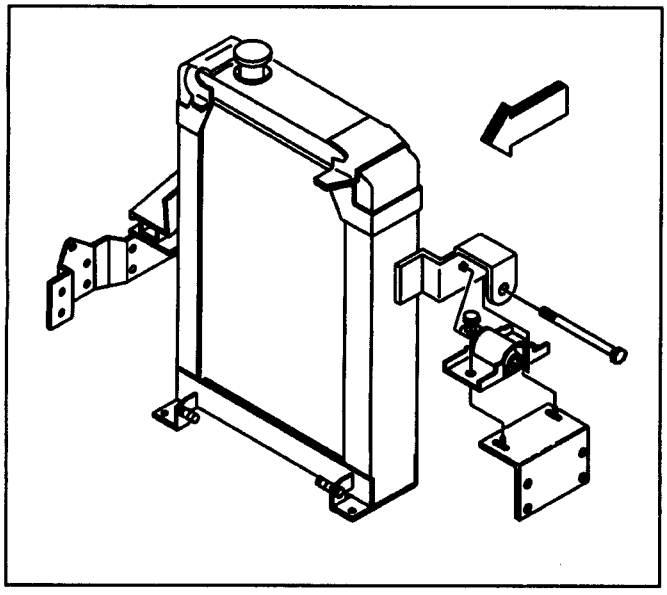
Radiator Lower Mounting Panel Replacement

Removal Procedure

1. Tilt the cab.
   Refer to *Cab Tilting* in General Information.
   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Drain the coolant.
   Refer to *Draining and Filling Cooling System (Draining).*
4. Remove the radiator.
   Refer to *Radiator Replacement.*
5. Remove the charge air cooler.
   Refer to Turbocharger.
6. Remove the radiator support brace nuts and the washers.
7. Disconnect the braces (2) from the radiator support (1).



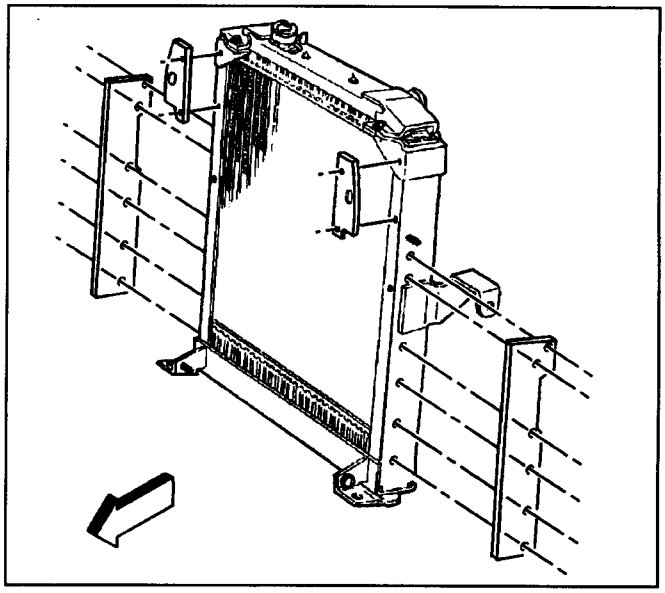
209230



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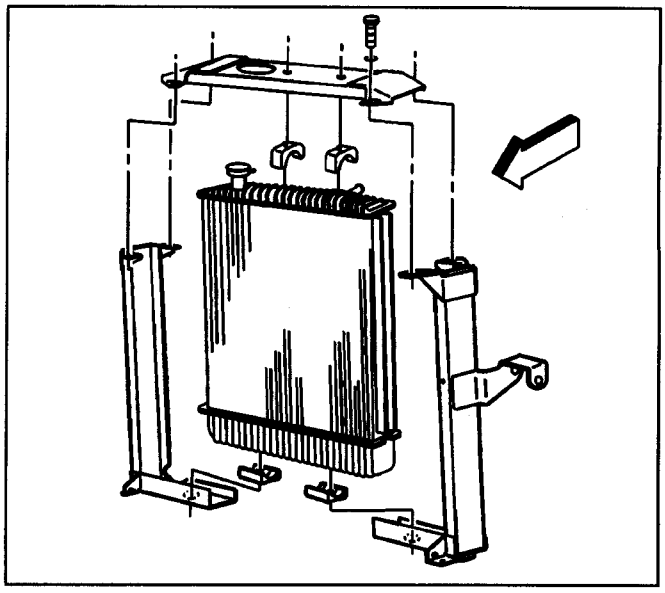
8. Remove the two side mounting bolts.
9. Remove the support from the vehicle.

10. Drill out the rivets for the radiator support side baffles.



209189

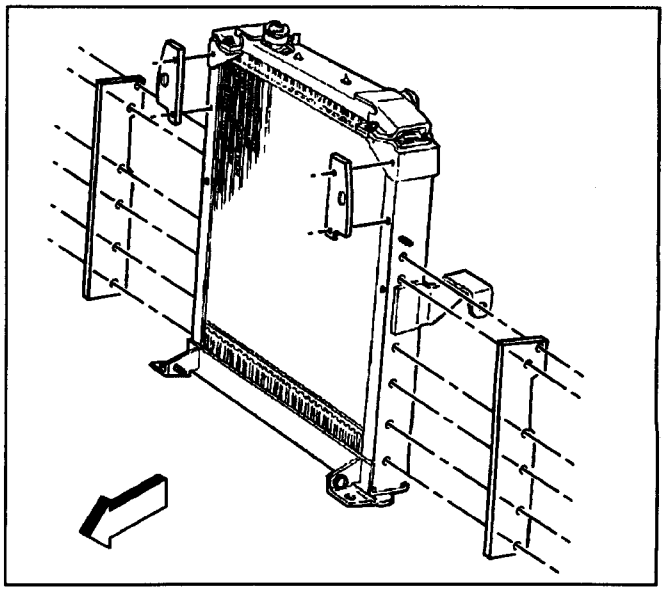
11. Remove the lower insulators from the radiator support.



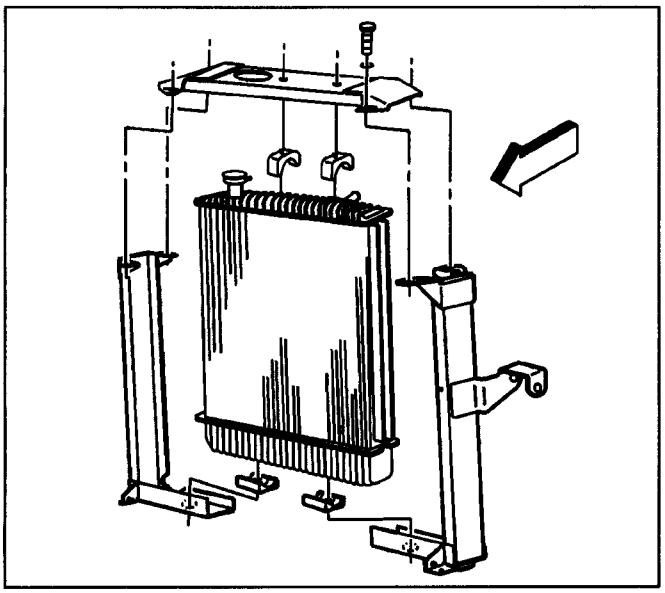
209216

Installation Procedure

1. Rivet the baffles to the radiator support.

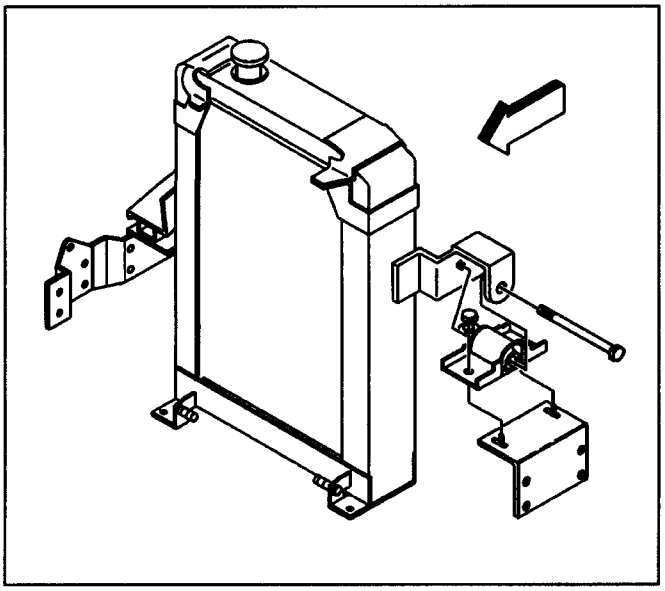


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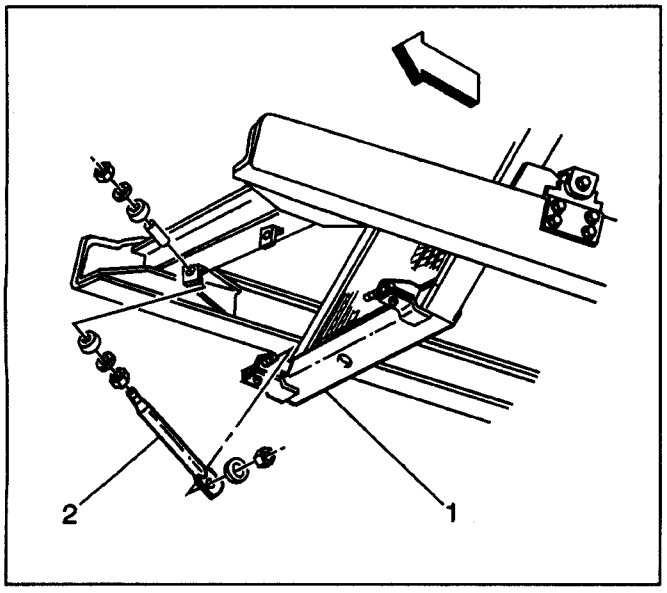
2. Install a new set of insulators.
3. Install the radiator support into the vehicle.



209239

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the two side mounting bolts.
   Tighten
   Tighten the radiator support side mounting bolts to 65 N·m (48 lb ft).



209230

5. Connect the braces (2) to the radiator support (1).
6. Install the radiator support brace nuts and the washers.
   Tighten
   Tighten the radiator support brace nuts to 55 N·m (41 lb ft).
7. Install the charge air cooler.
8. Install the radiator.
9. Fill the cooling system.
10. Lower the cab.

Description and Operation

Cooling System Description

The engine cooling system uses a coolant solution of DEX-COOL™ and clean, drinkable water. The system carries excess heat away from the engine block and the air compressor, if equipped. A belt driven water pump moves the solution through the engine cooling system. The heated coolant flows through the radiator, where heat is transferred to the outside air. The cooled fluid then flows back to the engine block.

The coolant dissipates heat as the coolant passes through the radiator tubes and the radiator. Radiators transfer heat from the coolant to the outside air. The engine cooling fan pulls outside air past the radiator fins and the tubes.

The fan draws the air through the radiator fins in order to cool the radiator and the coolant. A fan shroud and rubber baffles direct air flow. The rubber baffles are mounted to the under side of the cab. The fan shroud and the rubber baffles form a seal at the top of the radiator. Together the fan shroud and the baffles prevent air from re-circulating around the radiator. Missing or misaligned baffles may cause overheating.

A thermostatic fan clutch from the engine crankshaft belt drives the fan. The thermostatic fan clutch controls the torque that transmits from the engine crankshaft to the fan blades. The clutch allows more torque to engage on the fan when the following conditions exist:

- Increasing engine temperature
- Low driving speeds

The fan turns faster and draws more air through the radiator with more torque. The thermostatic fan clutch disengages when the following conditions exist:

- Decreasing engine temperature
- Higher driving speeds

Thermostats regulate the engine operating temperature. The thermostats are located in the coolant outlet at the front of the engine. When the engine reaches a predetermined temperature, the thermostats open and allow the coolant to flow through to the radiator. The thermostats close as the engine cools down in order to restrict coolant flow. The thermostats also control the amount of coolant that flows through the engine.

The cooling system operates under pressure in order to increase the efficiency of the cooling system. Operating the system under pressure causes the following actions:

- Reduces boiling at high engine coolant temperatures
- Reduces boiling at high altitudes
- Prevents cavitation
- Raises the boiling point of the coolant

The pressure cap on the radiator or on the surge tank regulates the cooling system pressure. The pressure cap is designed with two normally closed valves. The pressure relief valve opens when the coolant temperature and the pressure exceed the pressure valve spring tension. The pressure relief valve allows coolant or air to escape. The pressure relief valve is set for 62 kPa (9 psi). The vacuum valve opens when the coolant is cooling and when ambient pressure overcomes the vacuum valve spring. The vacuum valve allows the coolant in the recovery reservoir or the surge tank to re-enter the system. The vacuum valve also prevents the collapse of the hoses or other components that are not internally supported.

The coolant recovery reservoir or the surge tank is mounted behind the cab. Coolant recovery reservoirs or surge tanks compensate for coolant fluid expansion. Coolant recovery reservoirs or surge tanks also help remove air from the cooling system.

Radiator Assembly Description (Radiator)

This radiator uses an aluminum core with plastic core tanks. The lower core tank houses the transmission oil cooler, if equipped. The drain cock is located in the lower tank. The drain cock is serviceable.

Radiator Assembly Description (Core)

The core is made of aluminum. The core is the downflow design. The core uses large tubes that resist plugging. The core attaches to the side tanks by clinched tabs on the core. Replace the core under the following conditions:

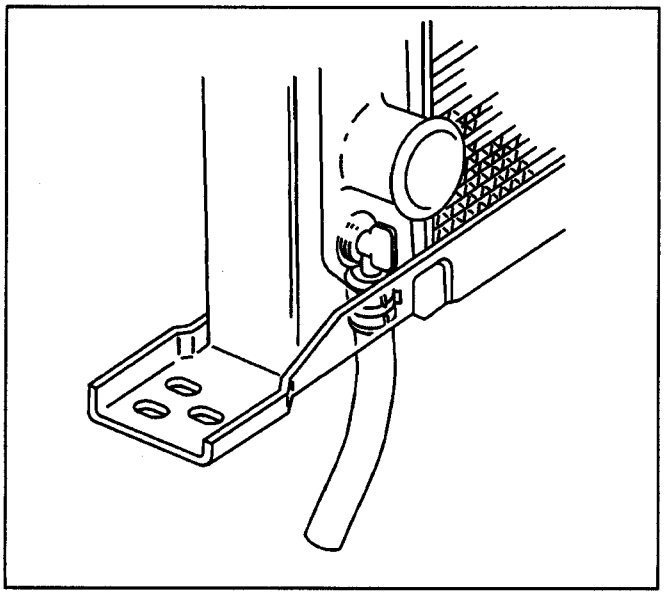
- More than three tabs are broken on one side.
- Two adjacent tabs are broken.

Radiator Assembly Description (Tanks)

The tanks are fastened to the core by clinched tabs. Clinched tabs attach to the sides of the core. The clinched tabs may bend backward in order to remove the tank from the core if necessary. Bend back the tabs only enough in order to remove the tank. Overbending weakens the tabs.

A high temperature rubber gasket seals the mating surface between the core and the tank. Replace the gasket when removing a tank from the core.

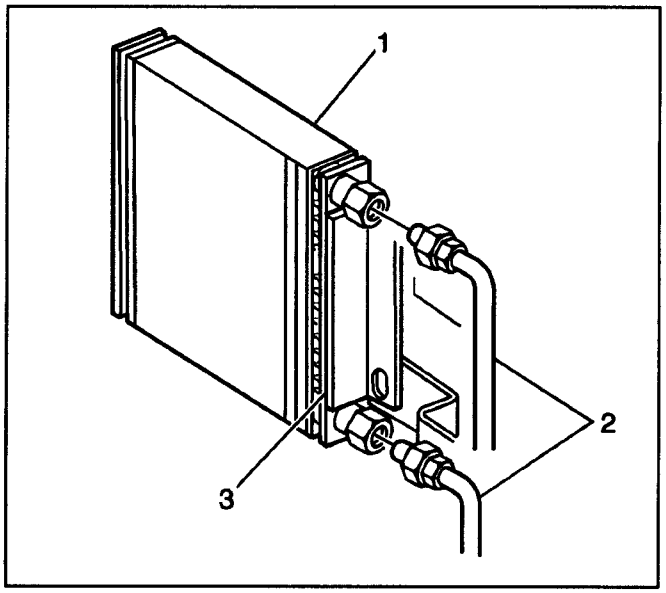
Radiator Assembly Description (Drain-Cock)



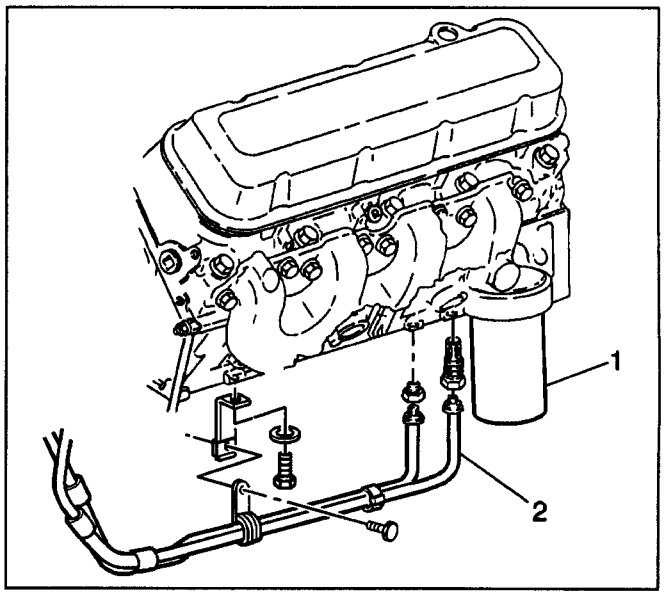
198896

The aluminum/plastic radiator uses a two-piece plastic drain cock and a rubber seal. The drain cock is serviceable.

Engine Oil Cooler Description



198899



198903

The engine oil cooler on all of the other models is located in the left radiator side tank.

Oil circulates through the following components in the system:

1. The engine oil pump
2. The engine oil cooler lines (2)
3. The engine oil cooler
4. The oil filter
5. The engine main oil passage

Flush the oil cooler and replace the oil filter in order to prevent premature engine wear under the following conditions:

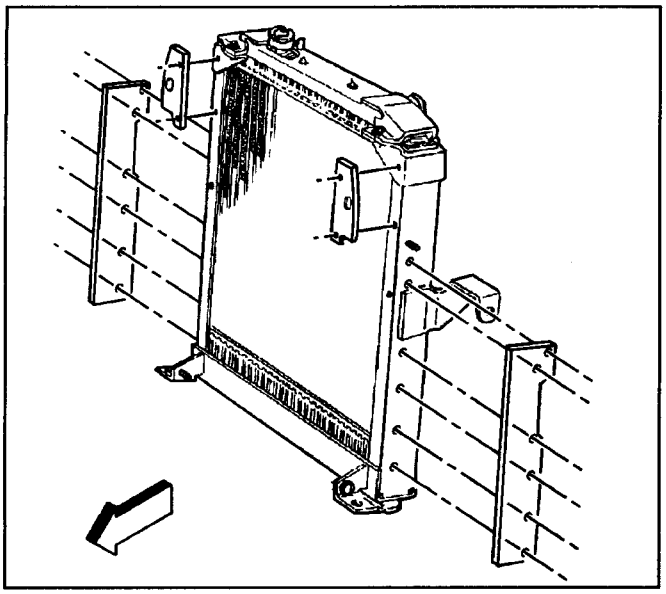
- Foreign material is present in the oil cooler.
- The engine is damaged internally.

Transmission Oil Cooler Description

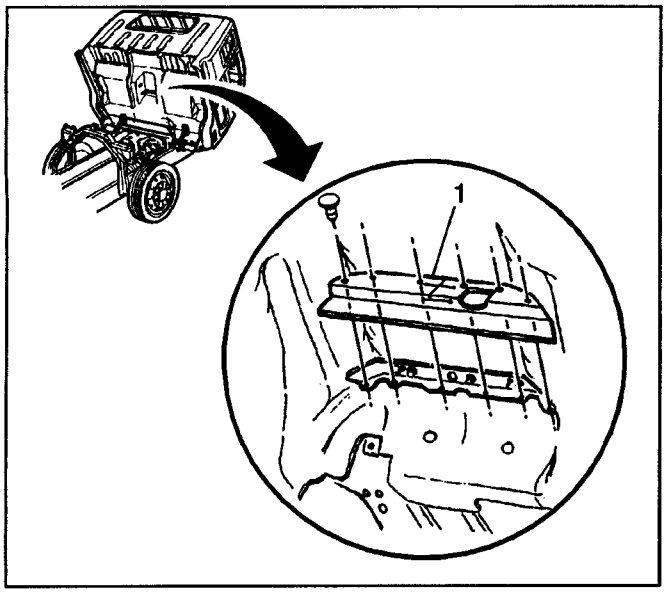
Remove the tank from the core in order to replace the transmission oil cooler.

Removing the tank from the core is not necessary when replacing a leaking transmission oil cooler gasket.

Air Baffles and Seals Description



209189



209184

Inspect for missing or misaligned baffles. Baffles that are missing or misaligned allow air to re-circulate around the radiator. Re-circulation causes the engine to overheat. Repair the baffles as needed.

Coolant Description

Newly developed engine coolant DEX-COOL™ was developed to last for 241 350 km (150,000 miles) or 5 years, whichever occurs first. Follow the instructions in *Draining and Filling Cooling System (Draining)*. Ensure that only DEX-COOL™ is added when coolant is added or changed.

A 50/50 mixture of DEX-COOL™ and clean, drinkable water provides the following conditions:

- Freezing protection to -37°C (-34°F)
- Boiling protection to 129°C (265°F)
- Rust and corrosion protection
- Helps keep the proper engine temperature
- Allows the warning lights and the gauges to operate as designed

Special Tools and Equipment

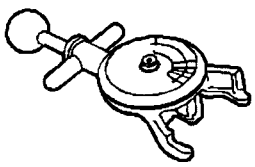
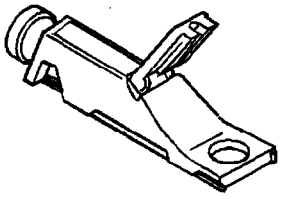
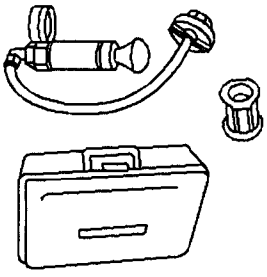
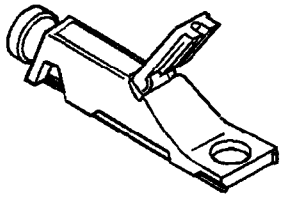
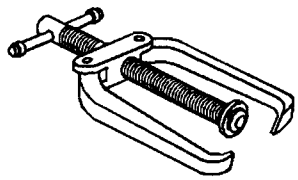
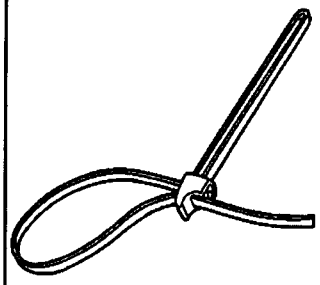
Illustration	Tool Number/ Description
 802	J 1859 Steering Wheel Puller
 48868	J 23600-B Belt Tension Gauge
 1409	J 23688 Coolant Tester Fahrenheit
 1405	J 24460-01 Cooling System Tester

Illustration	Tool Number/ Description
 12869	J 26568 Coolant Tester Centigrade
 48445	J 28509-A Counter Gear Bearing Remover
 199544	J 38425 Fan Hub Wrench
 340773	J 38426 Pulley Strap Wrench

Engine Electrical

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accessory Mounting Bracket to Engine Bolt	50 N.m	37 lb ft
Air Conditioning Compressor Mounting Bolt	39 N.m	29 lb ft
Battery Top Bar Nut	17 N.m	13 lb ft
Battery Top Post Terminal Nut	17 N.m	13 lb ft
Buss Bar to Glow Plug Nut	2 N.m	18 lb in
Generator Ground Strap to Frame Bolt	30 N.m	22 lb ft
Generator Ground Strap to Generator Bolt	6 N.m	53 lb in
Generator Ground Strap to Generator Bolt	11 N.m	97 lb in
Generator Indicator Terminal Nut	2 N.m	18 lb in
Generator Mounting Bolt	88 N.m	65 lb ft
Generator Output Terminal Nut	12 N.m	100 lb in
Generator Relay Terminal Nut	2 N.m	18 lb in
Generator Shaft Nut	100 N.m	75 lb ft
Generator Top Mounting Bracket to Engine Bottom Bolt	19 N.m	14 lb ft
Generator Top Mounting Bracket to Engine Top Bolt	38 N.m	28 lb ft
Glow Plug to Cylinder Head	25 N.m	18 lb ft
Negative Battery Cable to Frame Bolt	30 N.m	22 lb ft
Negative Cable to Engine, Engine Side Bolt	18 N.m	13 lb ft
Negative Cable to Engine Cable, Frame Side Bolt	28 N.m	21 lb ft
Positive Cable to Maxi-Fuse® Block Bolt	9 N.m	80 lb in
Positive Battery Cable to Starter Nut	21 N.m	16 lb ft
Starter Motor Mounting Nut	82 N.m	60 lb ft
Starter Relay Mounting Bolt	23 N.m	17 lb ft
Starter Solenoid Bolt	4 N.m	35 lb in

General Specifications

Battery Temperature and Minimum Voltage

Estimated Temperature (Metric)	Estimated Temperature (English)	Minimum Voltage
21°C	70°F	9.6 V
10°C	50°F	9.4 V
0°C	32°F	9.1 V
-10°C	15°F	8.8 V
-18°C	0°F	8.5 V
Below -18°C	Below 0°F	8.0 V

Generator Output

Rated Output Amps	Cold Output Amps	Cold Output RPM
160	45	1600
160	150	5000
100	60	1600
100	100	6500
130	57	1600
130	130	6500

Battery Usage

A battery has the following two ratings:

- Reserve capacity
- Cold cranking amperage

Reserve Capacity

The reserve capacity estimates how long the vehicle can drive without generator output under the following conditions:

- With the headlamps turned on.
- With minimum electrical load (most of the accessories are turned off).

Reserve capacity is the maximum amount of time (in minutes) necessary for a charged battery to reach a terminal voltage of 10.5 volts. The battery must have been discharged at a constant rate of 25 amperes and a constant temperature of 27°C (80° F). The following factors affect the life of a battery when the vehicle drives without generator output:

- Other temperatures or current draws
- The state of charge
- The condition of the battery

Cold Cranking Amperage

The Cold Cranking Amperage (CCA) indicates the battery's ability to crank the engine at cold temperatures. The battery must maintain the minimum amperage rating for 30 seconds at -18°C (0°F) at 7.2 V. A battery's performance will vary depending on the actual temperature.

Battery Specifications

Catalogue Number	Cold Cranking Amperes Rating	Reserve Capacity (Minutes)	Load Test Amperes
1110	750	160	370
1150	625	180	310
31-900CT	900	160	450

Generator Usage

21-SI 200 Generator Specifications

Part Number	Field-Ohms 27°C (80°F)	Field Current 27°C (80°F) AMPS	Field Current 27°C (80°F) VOLTS	Cold Output AMPS	Cold Output RPM	Rated Output AMPS
19010110	1.7–1.8	6.7–7.1	12	45	1600	160
19010110	1.7–1.8	6.7–7.1	12	150	5000	160
19010112	1.7–1.8	6.7–7.1	12	60	1600	100
19010112	1.7–1.8	6.7–7.1	12	100	6500	100
19010113	1.7–1.8	6.7–7.1	12	57	1600	130
19010113	1.7–1.8	6.7–7.1	12	130	6500	130

Generator Output Specifications

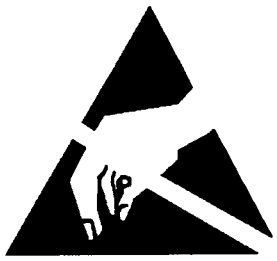
Engine	Option Code	Generator Model	Rated Output	Load Test
Diesel Engines	KW1	21SI	160 A	112 A
Diesel Engines	KG8	21SI	130 A	91 A
Diesel Engines	K60	21SI	100 A	70 A

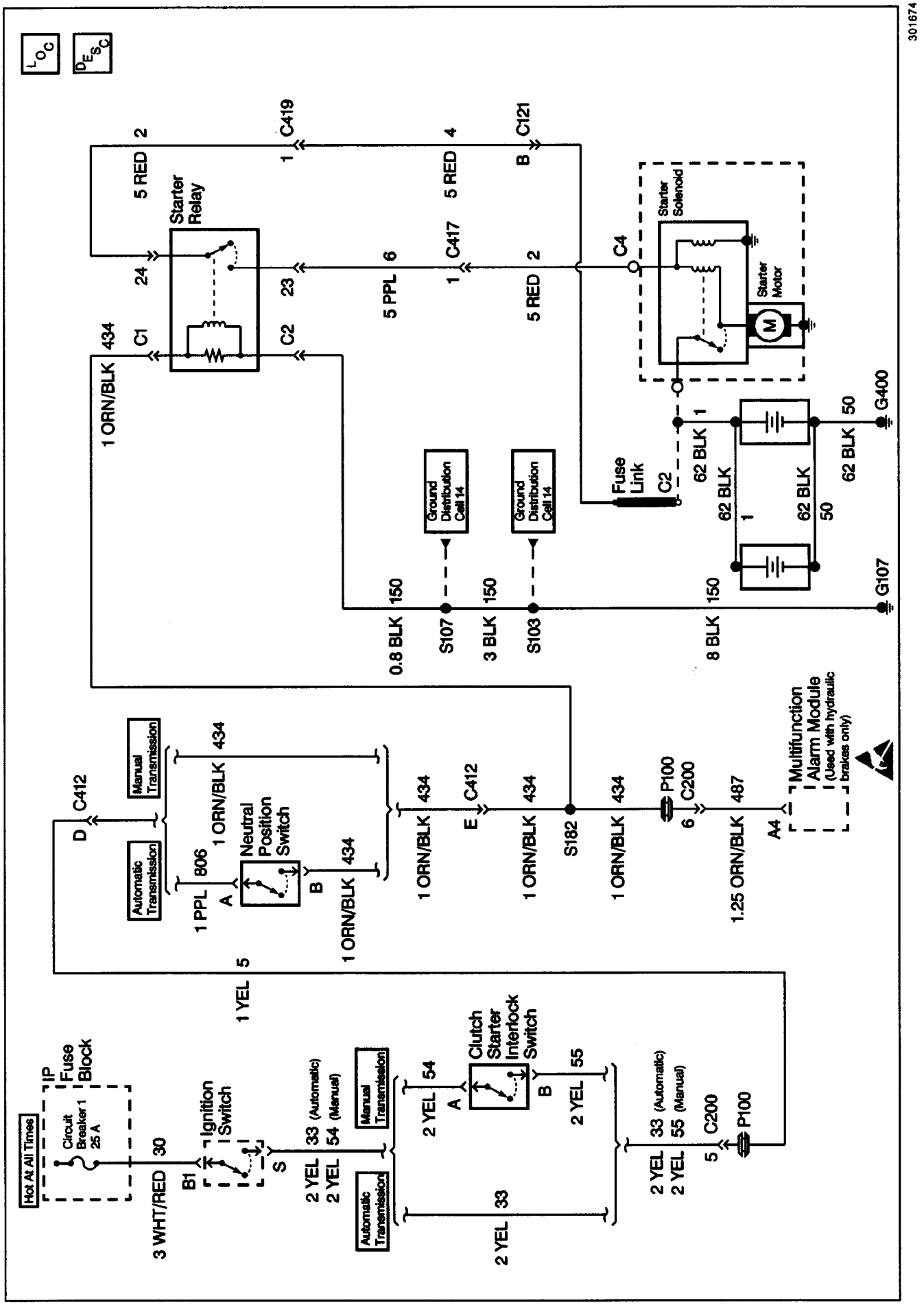
Schematic and Routing Diagrams

Starting and Charging Schematic References

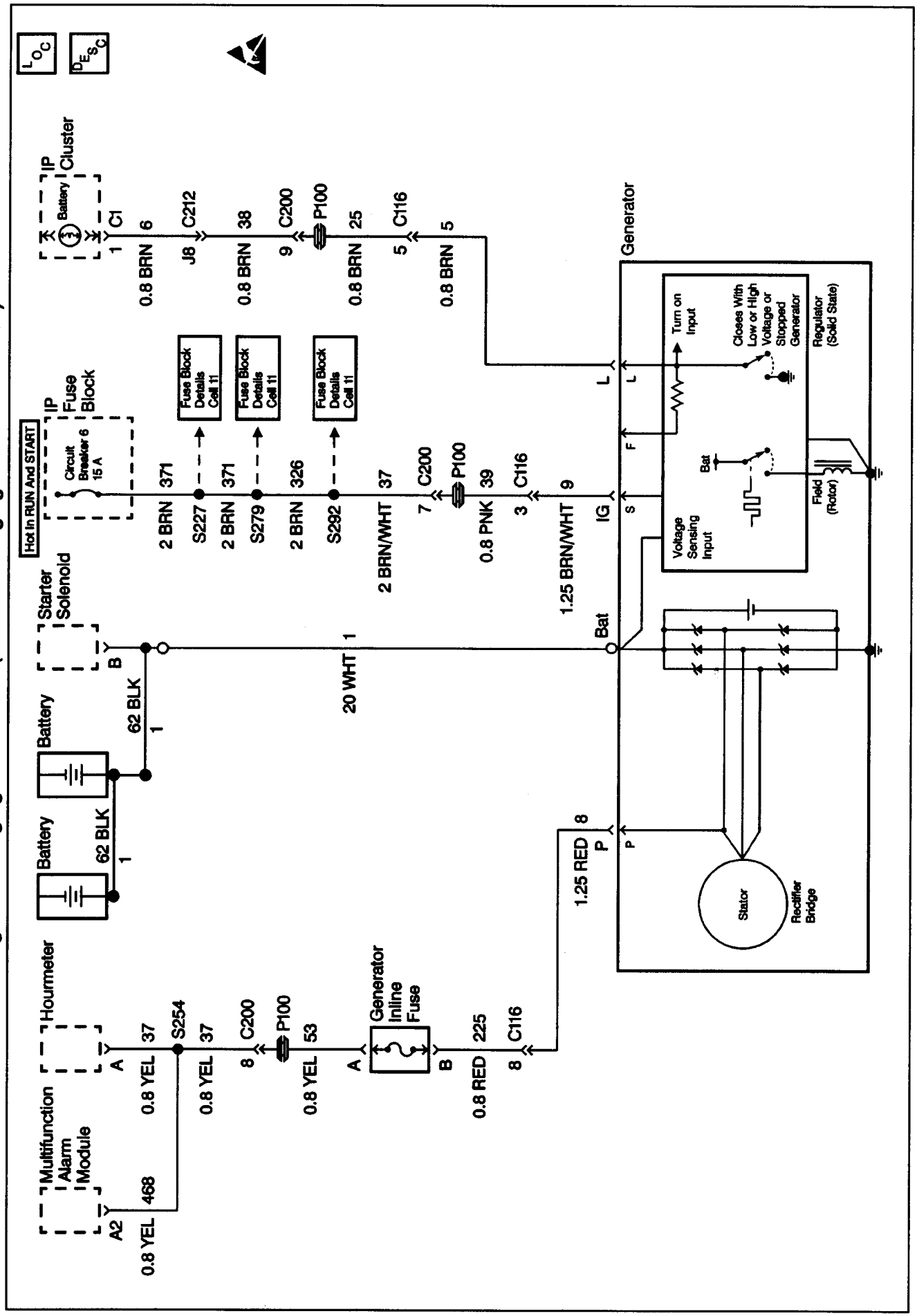
Reference on Schematic	Section Number - Subsection Name
Audible Warning Cell 76	8—Instrument Panel and Console
Fuse Block Details Cell 11	8—Wiring Systems
Ground Distribution Cell 14	8—Wiring Systems
Headlights: Daytime Running Lights Cell 102	8—Lighting Systems
Power Distribution Cell 10	8—Wiring Systems

Starting and Charging Schematic Icons

Icon	Icon Definition
 19384	Refer to *ESD Notice* in Cautions and Notices.


Starting and Charging Schematics (Cell 30: Starter Circuit Schematic)
LOC
DESC
301674
Hot At All Times
Circuit Breaker 1 25 A
IP Fuse Block
3 WHT/RED 30
B1
Ignition Switch
S
2 YEL 33 (Automatic)
2 YEL 54 (Manual)
Automatic Transmission
Manual Transmission
2 YEL 54
A
Clutch Starter Interlock Switch
B
2 YEL 55
2 YEL 33
2 YEL 33 (Automatic)
2 YEL 55 (Manual)
5 C200
P100
1 YEL 5
D C412
Automatic Transmission
Manual Transmission
1 PPL 806
A
1 ORN/BLK 434
Neutral Position Switch
B
1 ORN/BLK 434
1 ORN/BLK 434
E C412
1 ORN/BLK 434
S182
1 ORN/BLK 434
P100
6 C200
1.25 ORN/BLK 487
A4
Multifunction Alarm Module
(Used with hydraulic brakes only)
1 ORN/BLK 434
C1 24
C2 23
Starter Relay
5 RED 2
1 C419
5 PPL 6
1 C417
5 RED 4
B C121
5 RED 2
C4
Starter Solenoid
Starter Motor
M
Fuse Link
C2
1
62 BLK
1
62 BLK
50
62 BLK
50
G400
0.8 BLK 150
S107
Ground Distribution Cell 14
3 BLK 150
S103
Ground Distribution Cell 14
8 BLK 150
G107

Starting and Charging Schematics (Cell 30: Charging Circuit Schematic)

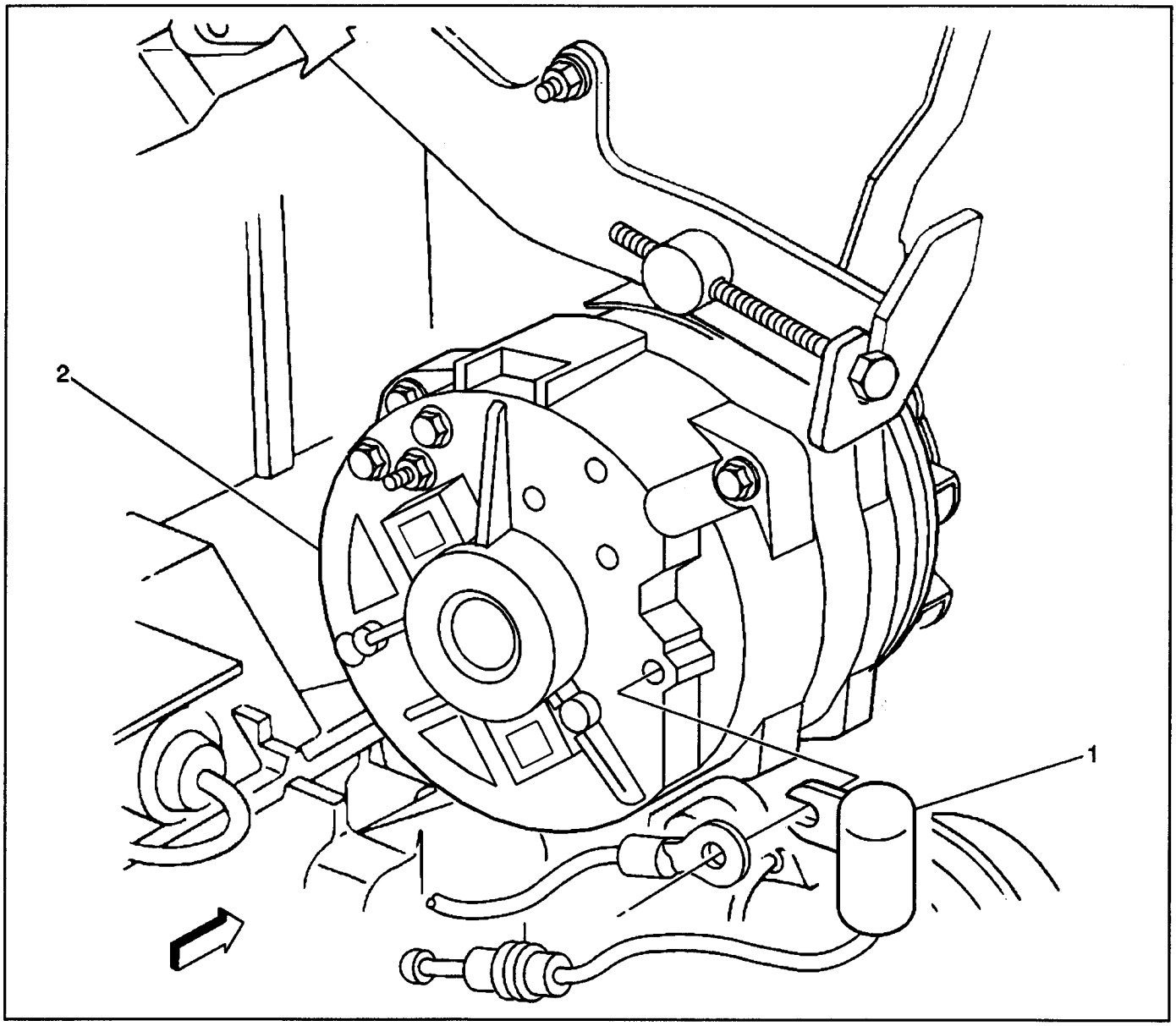


301675

Component Locator

Starting and Charging Component Views

Generator, Rear View

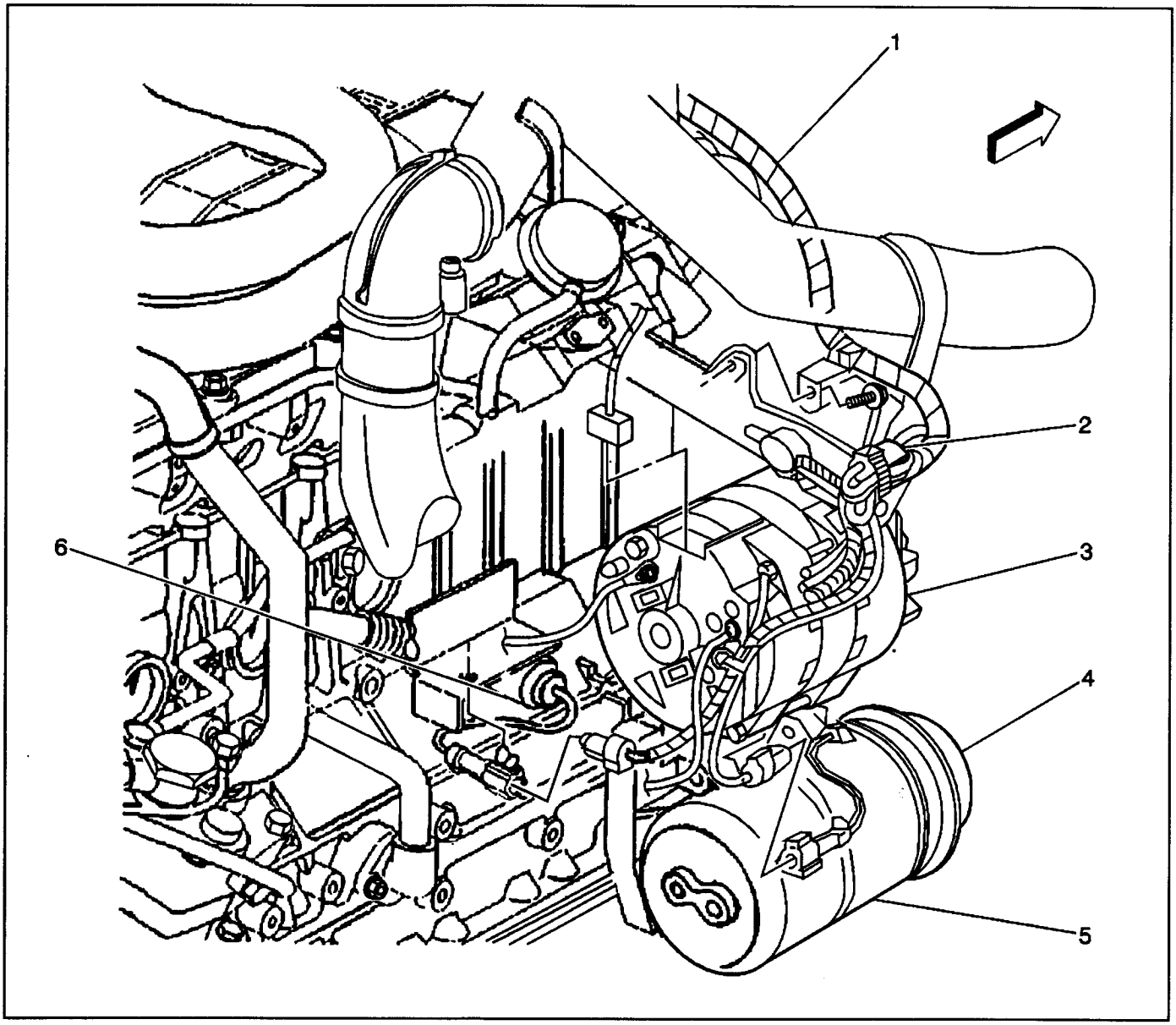


228810

Legend

(1) Generator Capacitor
(2) Generator

Engine Harness to RH Side of Engine, RH Rear View

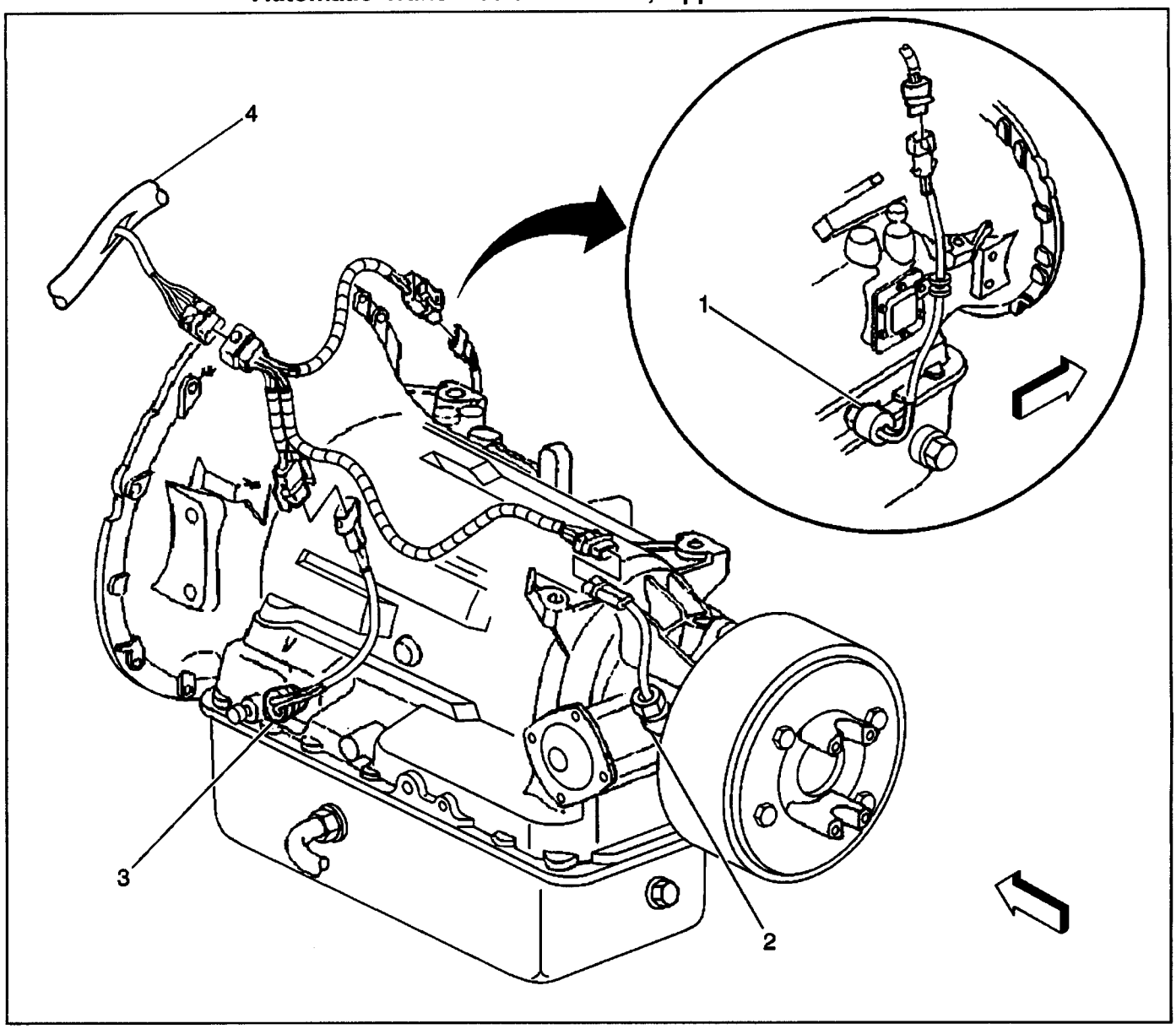


228805

Legend

(1) Engine Harness
(2) Generator Fuse
(3) Generator
(4) A/C Compressor Clutch
(5) A/C Compressor
(6) Engine Oil Pressure Gauge Sensor

Automatic Transmission Harness, Upper Left Rear View

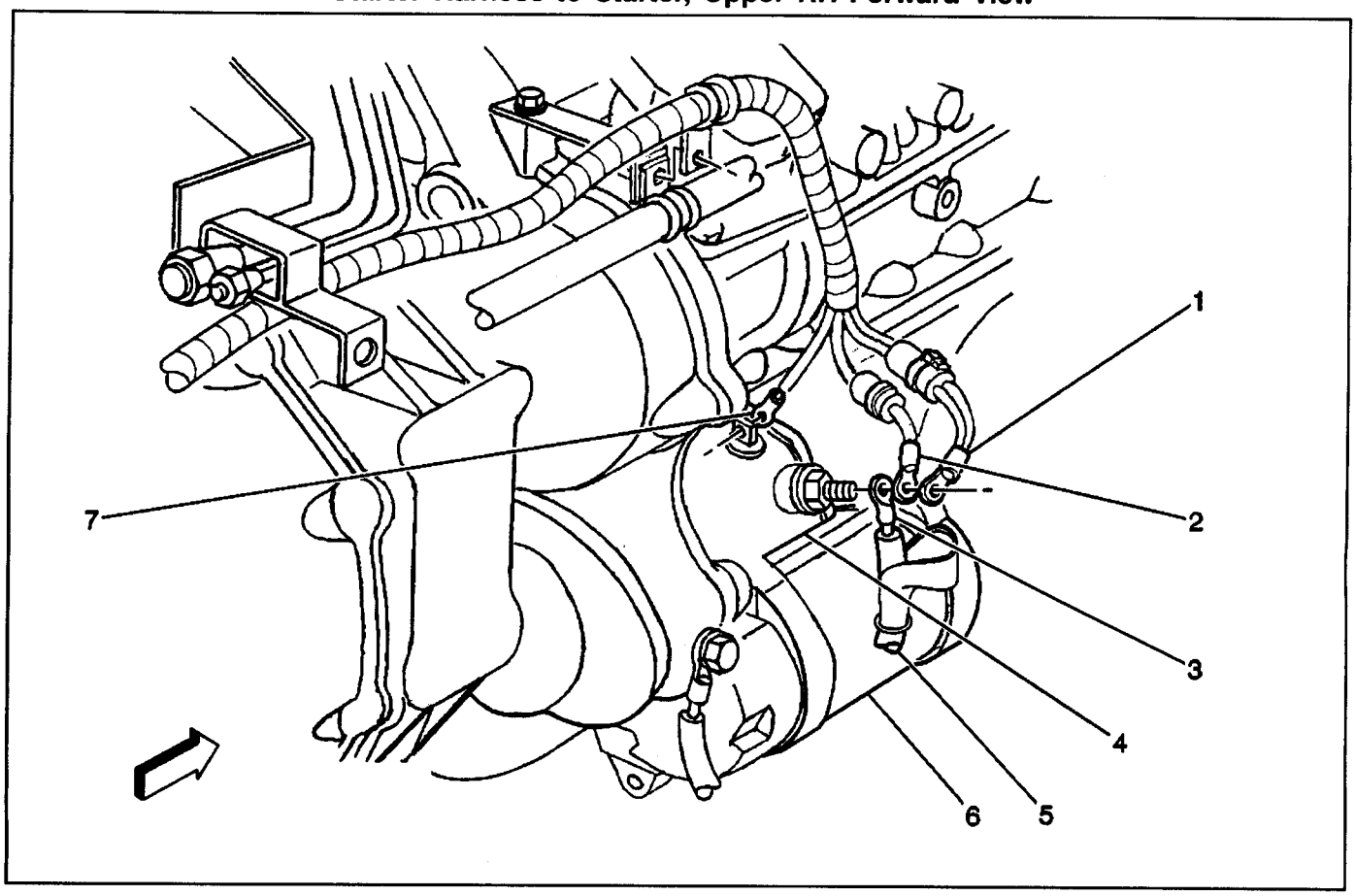


228797

Legend

(1) Backup Lamps Switch
(2) Vehicle Speed Sensor (VSS)
(3) Neutral Switch
(4) Front Chassis Harness

Starter Harness to Starter, Upper RH Forward View

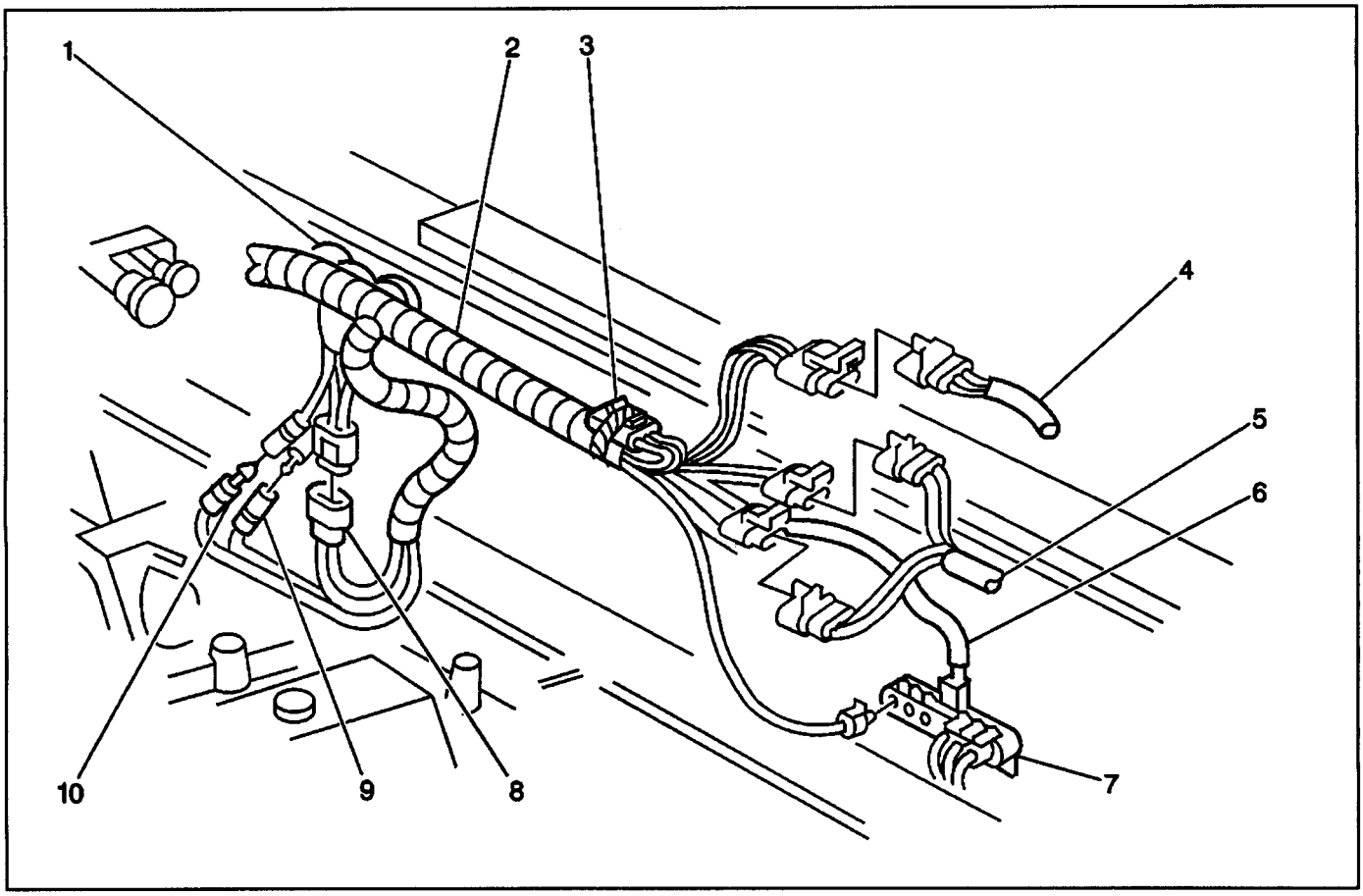


228771

Legend

(1) Engine Harness to Starter Solenoid Connector C3 (Ring Terminal)
(2) Engine Harness to Starter Solenoid Connector C2 (Ring Terminal)
(3) Positive Battery Cable to Starter Solenoid Connector C1 (Ring Terminal)
(4) Starter Solenoid
(5) Positive Battery Cable
(6) Starter Motor
(7) Engine Harness to Starter Solenoid Connector C4 (Ring Terminal)

Front Chassis Harness to RH Frame, LH Forward View



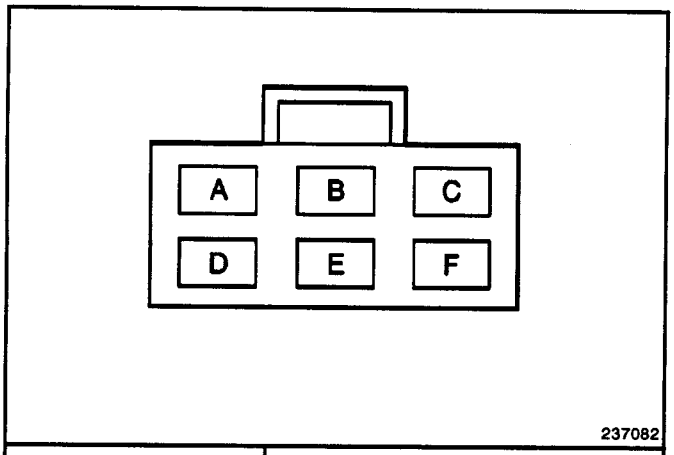
228778

Legend

(1) Starter Relay
(2) Front Chassis Harness
(3) Body Builder Connector(s)
(4) Trailer Harness
(5) Rear Chassis Harness
(6) Negative Battery Cable
(7) Ground Block (Part of Negative Battery Cable, 6 cavities)
(8) Starter Relay Connector C3 (2 cavities)
(9) Starter Relay Connector C2 (1 cavity)
(10) Starter Relay Connector C1 (1 cavity)

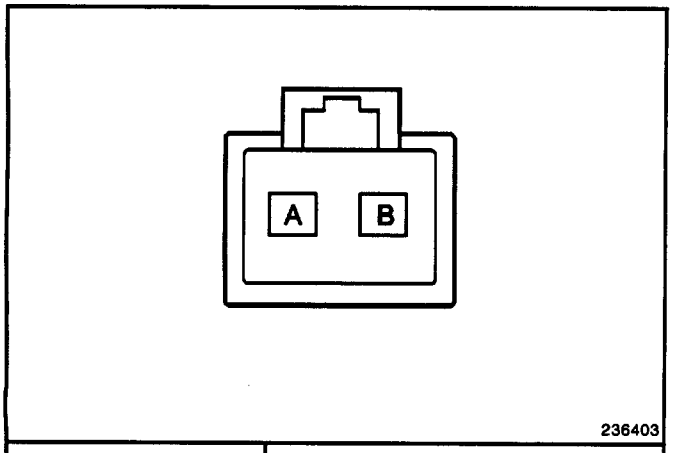
Starting and Charging Connector End Views

Automatic Transmission Selector Control (AT Transmission)



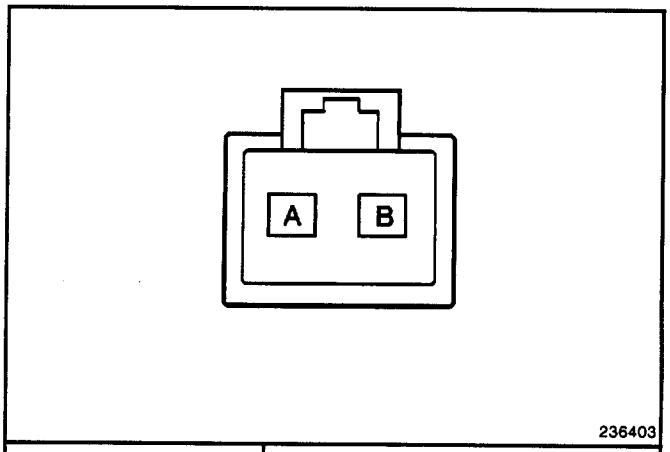
Connector Part Information	• 6 Way F • (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	RED/GRN	41	Illumination
B	RED	37	Fuse Output Ignition
C	BLK/WHT	40	Transmission Park/Neutral Signal
D	BLK/RED	46	Interior Lamp Dimming Buss
E	RED/BLU	38	Select Lever Back Lamp
F	BLK/RED	39	Neutral Signal

Clutch Switch



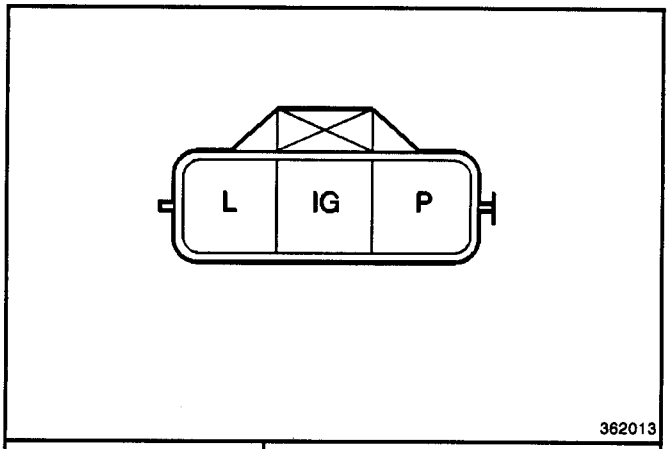
Connector Part Information	• 2 Way • Female		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PNK	276	Fuse Output-Ignition
B	BLU/YEL	277	ECM Pin-7

Clutch Starter Interlock Switch (Manual)



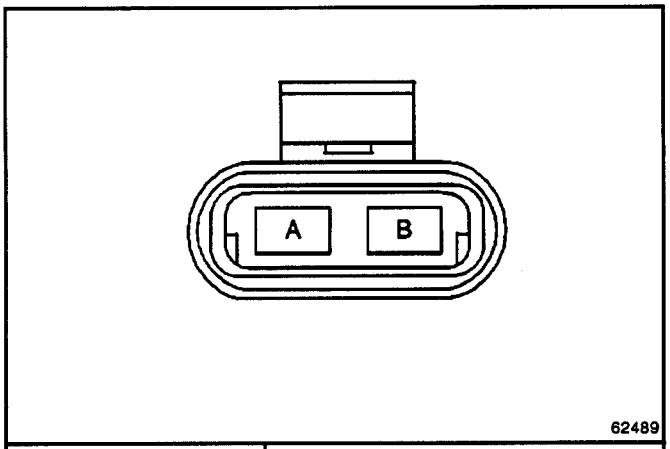
Connector Part Information	• 2 Way • Female		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	YEL	54	Ignition Switch
B	YEL	55	Starter Relay

Generator



Connector Part Information	• 3 Way • Female		
Pin	**Wire Color**	**Circuit No.**	**Function**
L	BRN	5	Generator (Charge Indicator Lamp Output)
IG	BRN/WHT	9	Generator
P	RED	8	Generator Output-Regulator Refence Voltage

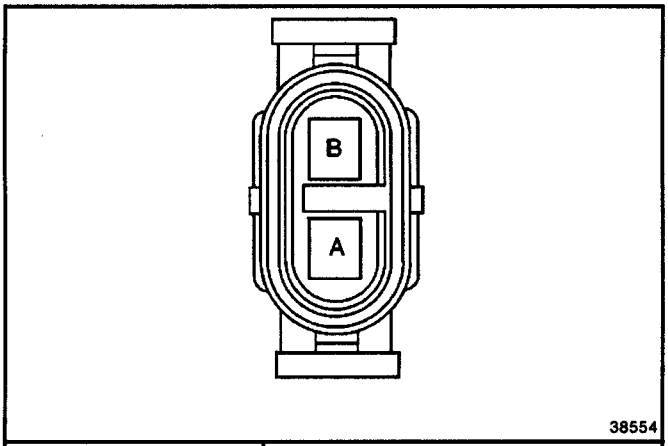
Generator In-Line Fuse



62489

Connector Part Information		• 12066681 • 2 Way F Metri-Pack 630 Series, Pull to Seat (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	YEL	53	Fuse Output-Generator-Tachometer Pulse
B	RED	225	Alternator Output-Regulator Reference Voltage

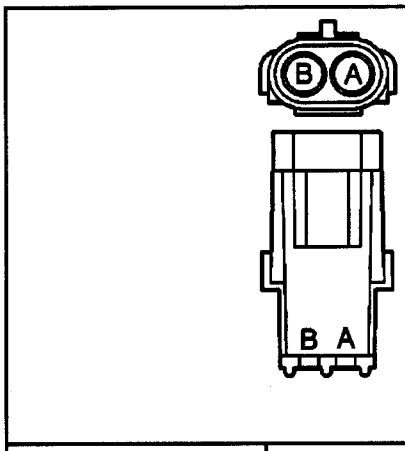
Neutral Position Switch



38554

Connector Part Information		• 12124819 • 2 Way F Metri-Pack 280 Series, Sealed (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PPL	806	Fuse Output-Crank
B	ORN/BLK	434	Transmission Mounted Neutral Safety Switch Signal

Starter Relay



258174

Connector Part Information		• 12162878 • 2 Way M 305 Series (NAT)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PPL	6	Starter Solenoid Feed
B	RED	2	Fuse Output-Battery

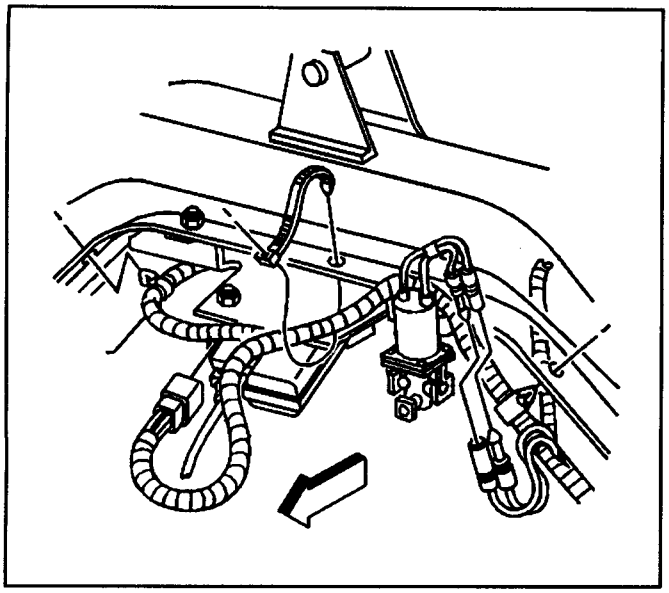
Diagnostic Information and Procedures

Starting System Check

Notice: Do not operate the starter motor continuously for more than 30 seconds without pausing to allow it to cool at least 2 minutes. Overheating from excessive cranking will seriously damage the starting motor.

Tools Required

- *J 39200* Digital Multimeter
- *J 35590* Inductive Current Clamp



240794

Disconnect the fuel stop control actuator in order to prevent the engine from starting which could cause serious injury while performing the following inspection procedures.

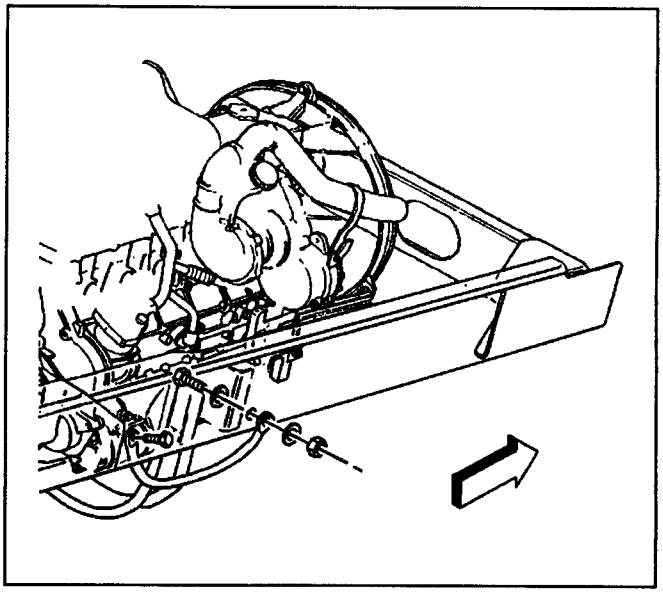
Testing the starter motor against the specifications while the starter motor is on the vehicle is impossible.

Use the following procedure in order to test for excessive resistance in the starting circuit:

1. Ensure that the vehicle is at room temperature. Colder weather causes higher resistance in the circuit.
2. Ensure that the battery is fully charged.
3. Remove the surface charge if the battery was recently charged.
4. Perform a load test. Refer to *Charging System Check (Battery Testing).*
5. Connect *J 39200* across the battery. The *J 39200* should show at least 12 volts.
6. Crank the engine.
7. Measure the voltage.

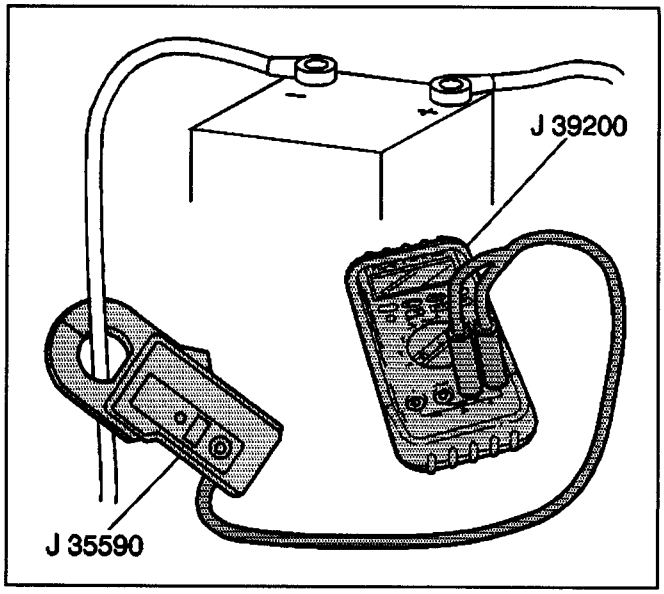
   Excessive resistance exists in the circuit if the voltage drops more than 2 volts.

8. Inspect the ground circuit for the following conditions:
   - Loose connections
   - Corroded connections
   - Dirty connections
   - Frayed cables



240793

9. Inspect the starter ground.



105066

10. Connect *J 39200* from the negative terminal of the battery to the ground stud on the engine block near the starter motor.
11. Crank the engine.
12. Measure the voltage.

    J 39200 should read about 0.2 volt.

    Excessive resistance exists in the ground circuit if the reading is 0.5 volt or higher.

13. Remove the starter motor for repair if excessive resistance exist but the following components are in proper condition:
    - The circuit wires
    - The connections
    - The ground circuit

Charging System Check

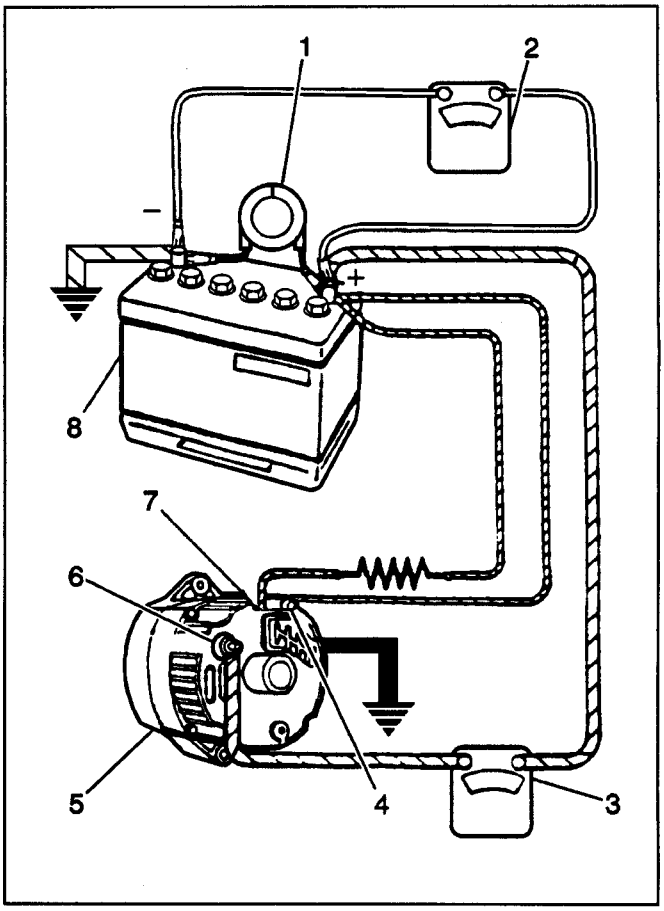
Tools Required

- *J 39200* Digital Multimeter
- *J 35590* Inductive Current Clamp

Using the Digital Multimeter:

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable. Refer to Negative Battery Cable Removal in *Battery Cable Replacement.*
2. Connect an ammeter in series between the BAT terminal of the generator and the output lead.
3. Connect the negative battery cable. Refer to Negative Battery Cable Installation in *Battery Cable Replacement.*
4. Start the engine.
5. Turn ON the following components:
    - The radio
    - The windshield wipers
    - The headlamps (high beam)
    - The blower motor (high speed)



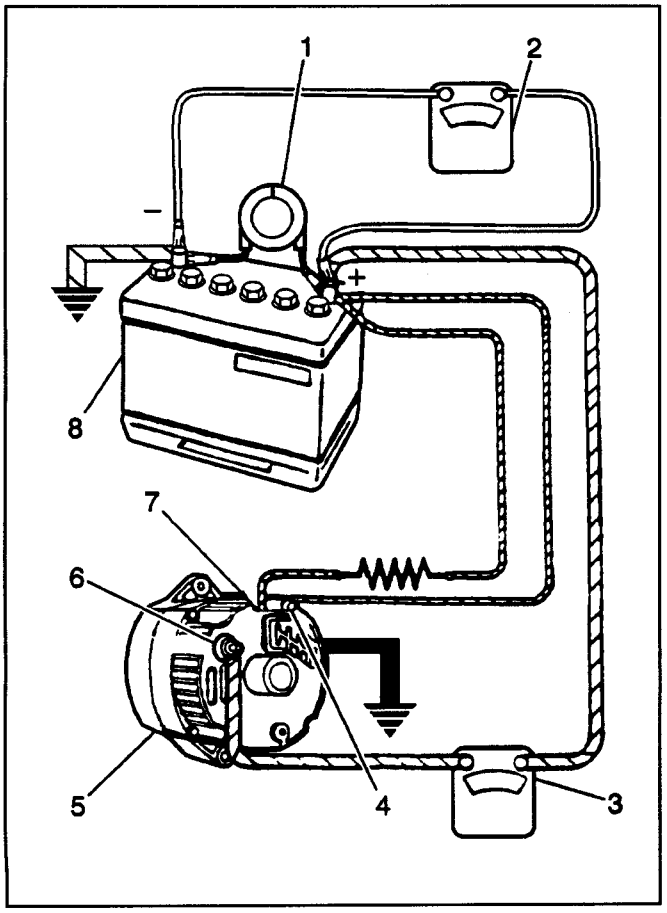
203666

6. Connect a carbon pile across the battery.
7. Operate the engine at 2500 RPM.

   Important: Residual magnetism in the rotor causes the initial voltage buildup. Increase the engine speed as necessary in order to obtain the maximum current output.
8. Adjust the carbon pile as necessary in order to obtain the maximum current output.
9. If the ampere output is within 10 amperes of the rated output stamped on the generator frame, the generator functions properly.
10. If the ampere output is not within 10 amperes of the rated output stamped on the generator frame, repair the generator. Refer to *Generator Replacement.*

Using the Inductive Current Clamp:

1. Install the *J 35590.*
2. Start the engine.
3. Turn ON the following components:
    - The radio
    - The windshield wipers
    - The headlamps (high beam)
    - The blower motor (high speed)



203666

4. Connect a carbon pile across the battery.
5. Operate the engine at 2500 RPM.

   Important: Residual magnetism in the rotor causes the initial voltage buildup. Increase the engine speed as necessary in order to obtain the maximum current output.
6. Adjust the carbon pile as necessary in order to obtain the maximum current output.
7. If the ampere output is within 10 amperes of the rated output stamped on the generator frame, the generator functions properly.
8. If the ampere output is not within 10 amperes of the rated output stamped on the generator frame, repair the generator. Refer to *Generator Replacement.*

Charging System Check (Battery Testing)

Tools Required

- Battery Terminal Adapters
- *J 39200* Digital Multimeter

Perform the following procedures in order to test batteries.

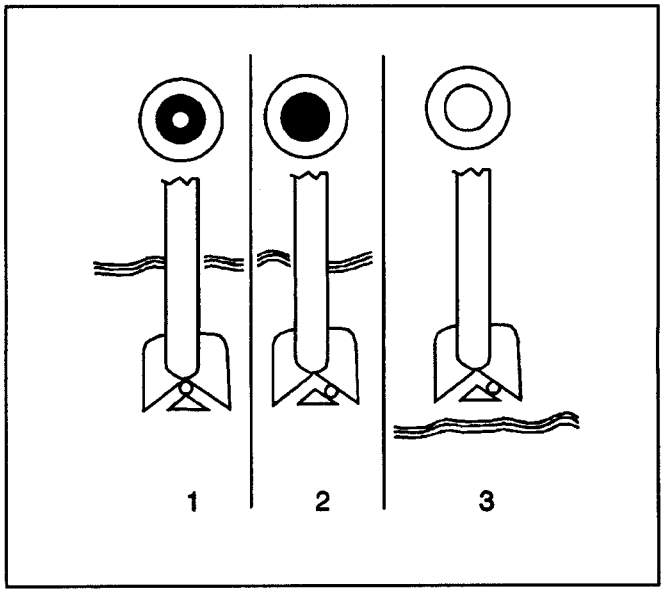
Visual Inspection Procedure

1. Inspect for obvious damage that may permit the loss of electrolyte.

   A cracked or broken battery case is an example of the above damage.
2. Determine the cause of the damage.
3. Correct the damage as necessary.

   If no obvious damage exists, proceed to the Hydrometer Inspection.

Hydrometer Inspection



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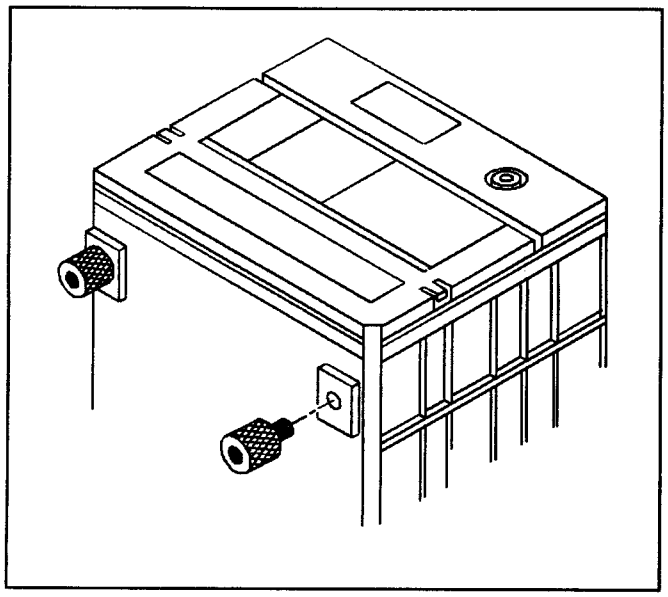
1. Inspect for green dot visibility (1).

   If the green dot is visible (1), proceed to Battery Load Testing.
2. Inspect for darkness (2). (The green dot is not visible.)

   If the hydrometer is dark (2), charge the battery. Refer to *Battery Charging.* Proceed to Battery Load Testing.
3. Inspect for a clear or yellow color (3).

   If a clear or yellow color exists (3), replace the battery.

Battery Load Testing



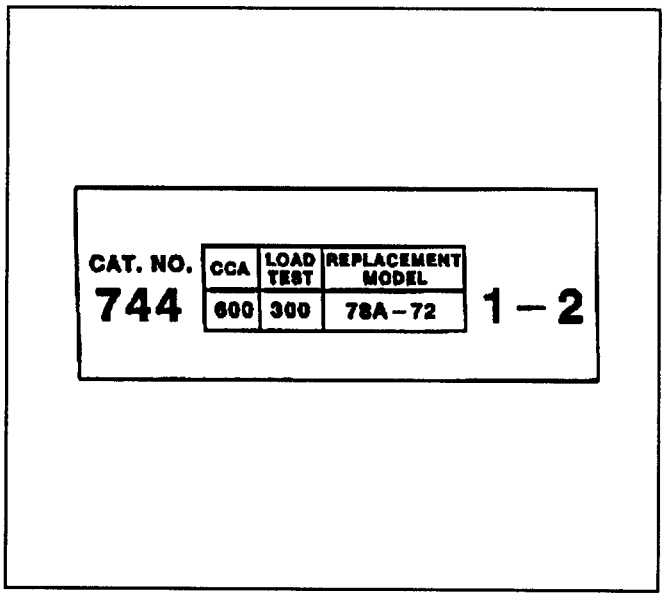
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1. Use battery side terminal adapters in order to ensure a proper connection during battery load testing.
2. Inspect the battery in order to ensure that the battery is not frozen.

   If the battery is frozen do not load test the battery. Replace the battery.
3. Turn all of the electrical loads off.
4. Use the *J 39200* in order to measure the voltage across the battery terminals.

   When the green dot appears in the hydrometer, the voltage should equal or exceed 12 volts. Replace the battery if the voltage is less than 12 volts, unless the battery has just been discharged (such as by load testing or cranking the engine).
5. With the *J 39200* attached, connect a battery load tester across the battery terminals.

   Important: Do not perform this step if the battery has not been recently charged.
6. Apply a 300 ampere load for 15 seconds to the battery in order to remove the surface charge from the battery.
7. Wait 15 seconds in order to allow the battery to recover.



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8. Apply the specified amperage load to the battery. The battery specification label determines the appropriate voltage.
9. Load the battery for 15 seconds. Read the voltage and remove the load.
10. If the voltage remains above the minimum value, the battery is good and should be returned to service. Refer to Battery Temperature and Minimum Voltage in *General Specifications*. Estimate the battery temperature by feel, and the temperature that the battery has been exposed to for the preceding few hours.
11. Replace the battery if the voltage drops below the listed minimum value.

Starter Solenoid Does Not Click

Step	Action	Value(s)	Yes	No
1	1. Ensure that the battery voltage is appropriate for the temperature. Refer to *General Specifications*. 2. Connect a test lamp from CKT 2 (RED) at starter solenoid terminal S to chassis ground. 3. Place the transmission in the PARK position. 4. Place the ignition switch in the START position. Does the test lamp light?	—	Go to *Step 2*	Go to *Step 4*
2	1. Clean the following components: • The starter mounting bolts • The starter motor • The starter motor ground • The mounting surface 2. Connect a test lamp from CKT 2 (RED) at starter solenoid terminal S to chassis ground. 3. Place the transmission in the PARK position. 4. Place the ignition switch in the START position. Does the test lamp light?	—	Go to *Step 3*	Go to *Step 4*
3	Replace the starter motor. Does the engine still not crank and does the starter solenoid still not click?	—	Go to *Step 4*	System OK
4	1. Connect a test lamp from starter relay terminal 23 to chassis ground. 2. Place the ignition switch in the START position. Does the test lamp light?	—	Go to *Step 5*	Go to *Step 6*
5	Locate and repair the open in CKT 6 (PPL) or CKT 2 (RED) between the starter relay and the starter solenoid. Does the engine still not crank and does the starter solenoid still not click?	—	Go to *Step 6*	System OK
6	Connect a test lamp from starter relay terminal 24 to chassis ground. Does the test lamp light?	—	Go to *Step 8*	Go to *Step 7*
7	Locate and repair the open in CKT 2 (RED) between the starter relay and the fusible link at the starter motor. Does the engine still not crank and does the starter solenoid still not click?	—	Go to *Step 8*	System OK
8	1. Connect a test lamp from CKT 434 (ORN/BLK) at starter relay connector C1 to chassis ground. 2. Place the ignition switch in the START position. Does the test lamp light?	—	Go to *Step 10*	Go to *Step 9*
9	Is the vehicle equipped with an automatic transmission?	—	Go to *Step 13*	Go to *Step 19*
10	1. Connect a jumper wire from CKT 150 (BLK) at starter relay connector C2 to chassis ground. 2. Place the ignition in the START position. Does the engine crank?	—	Go to *Step 11*	Go to *Step 12*
11	Locate and repair the open in CKT 150 (BLK) between the starter relay and G107. Does the engine still not crank and does the starter solenoid still not click?	—	Go to *Step 13*	System OK

Starter Solenoid Does Not Click (cont'd)

Step	Action	Value(s)	Yes	No
12	Replace the starter relay. Does the engine still not crank and does the starter solenoid still not click?	—	Go to *Step 13*	System OK
13	1. Connect a test lamp from neutral switch terminal B to chassis ground. 2. Place the ignition switch in the START position and hold. Does the test lamp light?	—	Go to *Step 14*	Go to *Step 15*
14	Locate and repair the open in CKT 434 (ORN/BLK) between the neutral switch and the starter relay. Does the engine still not crank and does the starter solenoid still not click?	—	Go to *Step 15*	System OK
15	1. Connect a test lamp from neutral switch terminal A to chassis ground. 2. Place the ignition switch in the START position and hold. Does the test lamp light?	—	Go to *Step 16*	Go to *Step 19*
16	Inspect the neutral switch for proper adjustment. Is an adjustment necessary?	—	Go to *Step 17*	Go to *Step 18*
17	Adjust the neutral switch as necessary. Does the engine still not crank and does the starter solenoid still not click?	—	Go to *Step 18*	System OK
18	Replace the neutral switch. Does the engine still not crank and does the starter solenoid still not click?	—	Go to *Step 19*	System OK
19	1. Connect a test lamp from transmission harness connector C412 terminal D to chassis ground. 2. Place the ignition switch in the START position. Does the test lamp light?	—	Go to *Step 20*	Go to *Step 23*
20	Is the vehicle equipped with a manual transmission?	—	Go to *Step 21*	Go to *Step 22*
21	Locate and repair the open in CKT 5 (YEL) or CKT 434 (ORN/BLK) between C412 and the starter relay. Does the engine still not crank and does the starter solenoid still not click?	—	Go to *Step 23*	System OK
22	Locate and repair the open in CKT 5 (YEL) or CKT 806 (PPL) between C412 and the neutral position switch. Does the engine still not crank and does the starter solenoid still not click?	—	Go to *Step 23*	System OK
23	1. Connect a test lamp from CKT 33 (YEL) at terminal S of the ignition switch to chassis ground. 2. Place the ignition switch in the START position and hold. Does the test lamp light?	—	Go to *Step 24*	Go to *Step 25*
24	Locate and repair the open in CKT 33 (YEL) or CKT 5 (YEL) between the ignition switch and transmission harness connector C412. Does the engine still not crank and does the starter solenoid still not click?	—	Go to *Step 25*	System OK

Starter Solenoid Does Not Click (cont'd)

Step	Action	Value(s)	Yes	No
25	Connect a test lamp from CKT 30 (WHT/RED) at terminal B1 of the ignition switch to chassis ground. Does the test lamp light?	—	Go to *Step 26*	Go to *Step 27*
26	Replace the ignition switch. Does the engine still not crank and does the starter solenoid still not click?	—	—	System OK
27	Locate and repair the open in CKT 30 (WHT/RED) between the ignition switch and the IP fuse block. Does the engine still not crank and does the starter solenoid still not click?	—	—	System OK

Starter Solenoid Clicks, Engine Does Not Crank

Step	Action	Value(s)	Yes	No
1	1. Disconnect the connector at the engine shutoff solenoid. 2. Connect a voltmeter to one of the battery's positive and negative terminals. 3. Place the ignition switch in the START position and hold for 15 seconds. 4. Observe the voltmeter indication. 5. Place the ignition switch in the OFF position. Does the voltage exceed the specified value?	9.6 V	Go to*Step 2*	Go to *Step 3*
2	1. Connect a voltmeter to the other battery's positive and negative terminals. 2. Place the ignition switch in the START position and hold for 15 seconds. 3. Observe the voltmeter indication. 4. Place the ignition switch in the OFF position. Does the voltage exceed the specified value?	9.6 V	Go to *Step 5*	Go to *Step 3*
3	Perform the battery load test.[1] Refer to *Charging System Check (Battery Testing)* Does the battery pass the load test?	—	Go to *Step 5*	Go to *Step 4*
4	Replace the battery and/or the auxiliary battery. Does the starter solenoid still click and does the engine still not crank or crank slowly?	—	Go to *Step 5*	System OK
5	1. Connect a voltmeter between the battery negative terminal and the engine block. 2. Place the ignition switch in the START position. 3. Observe the voltage. Does the voltage exceed the specified value?	0.5 V	Go to *Step 6*	Go to *Step 7*
6	Locate and repair the high resistance in negative cable 50 (BLK) between the battery and G400. Does the starter solenoid still click and does the engine still not crank or crank slowly?	—	Go to *Step 7*	System OK
7	1. Connect a voltmeter between the positive battery terminal and starter solenoid terminal S. 2. Place the ignition switch in the START position. 3. Observe the voltage. Does the voltage exceed the specified value?	0.5 V	Go to *Step 8*	Go to *Step 9*

Starter Solenoid Clicks, Engine Does Not Crank (cont'd)

Step	Action	Value(s)	Yes	No
8	Locate and repair the high resistance in positive cable 1 (BLK) between the battery and the starter. Does the starter solenoid still click and does the engine still not crank or crank slowly?	—	—	System OK
9	Repair or replace the starter motor. Does the starter solenoid still click and does the engine still not crank or crank slowly?	—	—	System OK
[1]This vehicle is equipped with dual batteries. Test the batteries individually.				

Starter Motor Noise Diagnosis

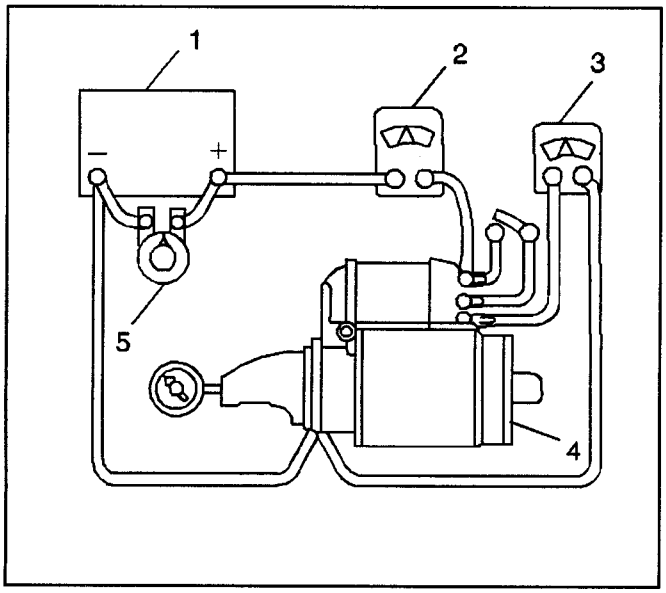
Loud Cranking Noise

Problem	Action
DEFINITION: A loud noise occurs while cranking the engine after the engine fires but while the starter remains engaged.	
The starter motor clutch is worn.	Remove the starter motor for repair.

Rumble, Growl or Knock

Problem	Action
DEFINITION: After starting the engine, a rumble, growl or (in severe cases) a knock is heard as the starter coasts down to a stop.	
A starter armature may be bent or unbalanced.	Remove the starter motor for repair. Refer to Unit Repair.

Starter No Load Test



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1. Connect a voltmeter from the motor terminal to the motor frame.

   On starter motors with ground terminals, connect the voltmeter to the ground terminals rather than the frame.
2. Use an RPM indicator in order to measure pinion speed.
3. Connect the motor and an ammeter in series with the following components:
   - A fully charged battery of the specified voltage
   - A switch in the open position from the solenoid battery terminal to the solenoid switch terminal.
4. Close the switch.
5. Compare the following measurements with the no load test specified values. Refer to Starter Motor Usage.
   - RPM
   - Current
   - Voltage
6. Evaluate the measurements by understanding that it is not necessary to obtain the exact voltage specified. A good reading may be made by understanding that if the voltage is slightly higher, the RPM will be slightly higher and the current will remain basically unchanged
7. Use the following procedure in order to obtain the exact specified voltage (if desired):
   7.1. Connect a carbon pile across the battery.
   7.2. Compare the reduced voltage with the no load test specified values. Refer to Starter Motor Usage.
8. Disconnect the circuit only with the switch open.

9. Use the following information in order to interpret the test results:
   - Rated current draw and no-load speed indicate normal condition of the starter motor.
   - Low free speed and high current draw indicate the following conditions:
     - Excessive friction

       Tight, dirty, or worn bearings, a bent armature shaft or loose pole shoes allow the armature to drag.
     - A shorted armature

       Inspect a shorted armature on a growler after disassembly.
     - Grounded armature fields

       Verify the grounded armature after disassembly.
   - Failure to operate with high current draw indicates the following conditions:
     - A direct ground

       A direct ground exists in the terminal or fields.
     - Seized bearings

       Seized bearings should have been noted by hand turning the armature by hand.
   - Failure to operate with no current draw indicates the following conditions:
     - An open field circuit

       An open field circuit can be checked after disassembly by inspecting the internal connections and tracing the circuit with a self-powered test lamp.
     - Open armature coils

       Inspect the commutator for badly burned bars.
     - Broken brush springs, worn brushes

       High insulation between the commutator bars or other causes which would prevent proper contact between the brushes and the commutator.
   - Low no-load speed and low current draw indicate a higher internal resistance due to the following conditions:
     - Poor connections
     - Defective leads
     - A dirty commutator
     - An open field circuit
     - Open armature coils
     - Broken brush springs, worn brushes
   - High free speed and high current draw indicate shorted fields. If shorted fields are suspected, replace the field coil assembly and inspect for improved performance.

Starter Motor Relay Test

Tools Required

J 39200 Digital Multimeter

The starter relay is located near the battery box on the inner side of the right frame rail.

Refer to *Starting System Circuit Description* and *Starting System Check*.

1. Disconnect the engine stop control actuator in order to prevent the engine from starting while performing these checks.
2. Place the transmission in the NEUTRAL position.
3. Block the wheels.

Battery Common Causes of Failure (Common Causes)

With the proper care, the battery will provide many years of service.

The following factors may reduce the battery performance level:

- Vehicle accessories remain ON overnight.
- Insufficient driving time in order to recharge the battery.

  Short trips may cause insufficient charging time.
- Insufficient driving speed.

  Slow average driving speeds for long periods of time may cause insufficient charging.
- The vehicle's electrical load is greater than generator output.

  The addition of aftermarket equipment often causes the above condition.
- The following charging system conditions:
  - Poor ground circuits
  - Electrical shorts
  - A slipping drive belt
  - A faulty generator
- The following methods of improper installation of aftermarket equipment affect the generator:
  - Structural failure of aftermarket mounting brackets.
  - Misaligned pulleys.
  - Loose belts.
- Failure to keep the battery cable terminals clean and tight.
- Operating the battery with a loose battery hold-down.
- Pinched wires or a cracked battery case resulting from a collision may cause improper mechanical conditions in the electrical system.

  Inspect the outside of the battery periodically for damage, such as a cracked cover or case.

Battery Common Causes of Failure (Electrolyte Freezing)

The freezing point of electrolyte depends on the specific gravity of the electrolyte. Maintaining the battery in a fully charged condition can protect the electrolyte against freezing. If the green dot appears in the built-in hydrometer, the battery will not freeze unless the temperature drops below -32 °C (-25 °F). A fully charged battery will not freeze unless the temperature drops below -54 °C (-65 °F).

Battery Common Causes of Failure (Carrier and Hold-Down)

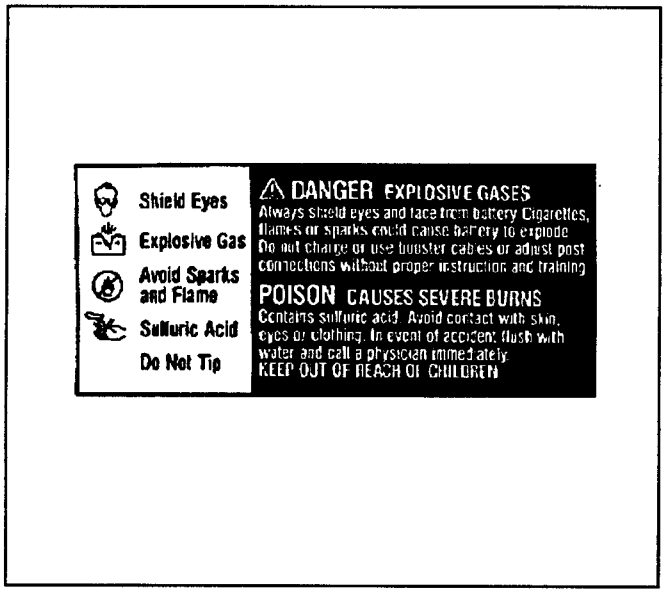
Ensure that the battery carrier and the battery hold-down(s) are in the following condition before installing the battery:

- Clean
- Free from corrosion

Ensure that the carrier is in proper condition because the carrier will hold the battery securely and keep the battery level. Ensure that no loose items are in the carrier before installing the battery.

Tighten the hold-down bolts to the specified values in order to prevent the battery from shaking in its carrier. Refer to *Fastener Tightening Specifications*.

Battery Common Causes of Failure (Battery Protect During Storage)



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Caution: Follow all safety precautions on the battery. Failure to do so may result in personal injury.

Some electronic devices on the vehicle impose small continuous current drains on the battery. This condition is commonly called parasitic current drain. If the vehicle is not used for an extended time, these parasitic loads can discharge and eventually cause permanent damage to the battery. Discharged batteries can also freeze in cold weather. Refer to *Battery Common Causes of Failure (Electrolyte Freezing)*.

Notice: Always turn off the engine control switch when connecting or disconnecting battery cables, battery chargers, or jumper cables. Failure to do so may damage the Powertrain Control Module (PCM) or other electronic components.

Perform the following actions if the vehicle is likely to be stored for over 30 days:

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

- Verify that the built-in hydrometer's green dot is visible, then disconnect the negative battery cable from the battery. This action will protect the battery from being discharged by parasitic current drain from the vehicle's electrical system.
- If the battery cable cannot be disconnected, establish a regular schedule of recharging the battery every 20–45 days in order to maintain a high state of charge. Any time a battery is found with the green dot not visible in the hydrometer, promptly recharge the battery.
- Use a battery charger that is capable of providing a charging voltage of at least 16 volts in order to maintain a low charge time. Charge rates of 50 amps or more will not damage original equipment maintenance free batteries if the battery does not exhibit the following conditions:
  - Excessive gassing of electrolyte from the vents
  - Excessive battery temperature

    Any temperature over 52 °C (125 °F) is excessive.
- Inspect the battery being charged every 45–60 minutes. Stop or reduce the charge rate as necessary. Stop charging within one hour after the green dot appears in the hydrometer in order to avoid overcharging the battery.
- Allow ample charging time. Refer to *Battery Charging*.

  A battery that remains in a discharged state for a long period of time will be difficult to recharge. The battery may even be permanently damaged if the battery remains discharged.

Use the following procedure when reconnecting the battery:

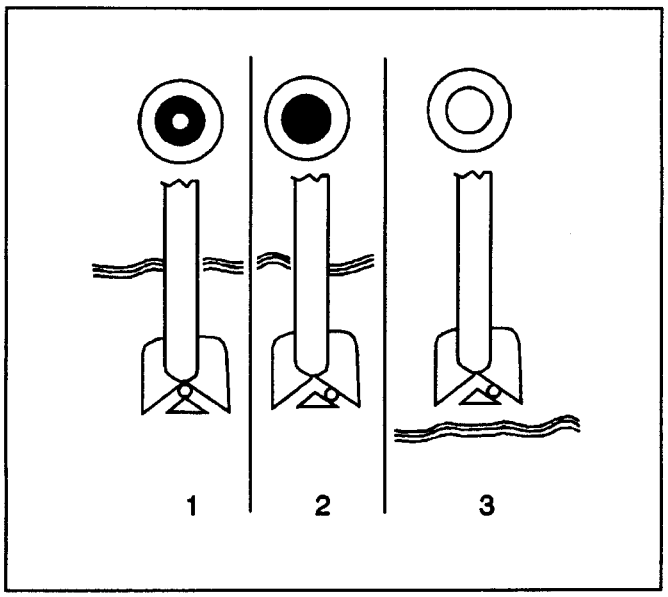
1. Use a wire brush in order to lightly clean any oxidation from the contact face of the battery terminal before reattaching the cable.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Tighten the battery cable.

   Tighten

   Tighten the top post terminal nut to 17 N.m (13 lb ft).
3. Reset the clock, push-button radio tuning, etc., before the vehicle returns to service.

Battery Common Causes of Failure (Built-In Hydrometer)



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A built-in temperature compensated hydrometer is molded into the top of the maintenance-free battery. The hydrometer is an indicator of the battery's state of charge. Use this hydrometer with the following diagnostic procedure.

When observing the hydrometer, ensure that the battery has a clean top. A light may be required in some poorly-lit areas.

Under normal operation one of the following three indications can be observed:

Green Dot Visibility

Any green appearance in the hydrometer is interpreted as a green dot (1). The presence of a green dot indicates that the battery's state of charge is 65 percent or more. The battery is ready for testing.

Dark Dot or Lack of Green Dot Visibility

Lack of green dot visibility (dark dot) (2) indicates that the battery's state of charge is below 65 percent. Test the charging system output and the electrical system for excessive draws.

Yellow Dot or Clear Dot Visibility

A yellow or clear dot (3) indicates that the electrolyte level is low. This electrolyte level is also too low for diagnosis. The following conditions may have caused the reduced electrolyte levels:

- Excessive or prolonged charging
- A broken case
- Excessive tipping of the battery

  Batteries having the above conditions may indicate excessive charging voltages, caused by a faulty charging system. Inspect the charging and the electrical systems. Replace the battery.

Battery Electrical Drain/Parasitic Load (Battery Electrical Drain)

Inspect the electrical system for excessive electrical drain (parasitic current drain) if the vehicle battery meets one of the following conditions:

- The battery is low or dead after an overnight period.
- The battery discharges over a period of 2–3 days.

Inspect the vehicle for excessive parasitic current drain if a battery needs recharging and no obvious cause exists.

Failure of one or more of the on-board solid state control modules, such as the PCM, may cause a high parasitic drain on the vehicle's battery. After the circuit continuity is restored, disconnecting the battery in order to install an ammeter or in order to test for excessive current drain may not continue. Cycling the engine control switch to the ON position and then to the LOCK position may cause such a drain to recur. Unless the vehicle's systems are reactivated in a road test, some drains will not recur.

Do not rotate the engine control switch to the following positions with an ammeter installed between the battery terminal and the battery cable:

- The ACCY position
- The ON position
- The START position

Use a current drain test tool in order to test the battery for parasitic current drain. Refer to *Battery Electrical Drain/Parasitic Load (Current Drain Test).*

Battery Electrical Drain/Parasitic Load (Current Drain Test)

Tools Required

- Terminal Adapters
- *J 38758* Parasitic Draw Test Switch
- *J 39200* Digital Multimeter

Perform the following procedure before starting the battery electrical drain/parasitic load test:

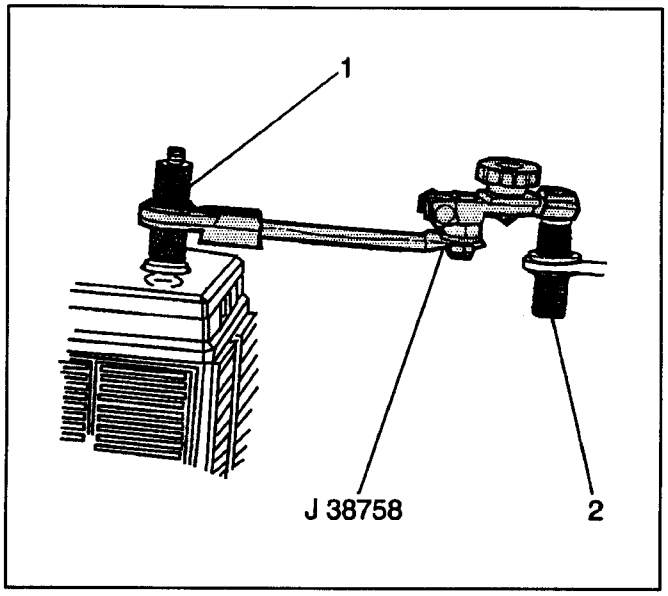
1. Turn the engine control switch to the LOCK position.
2. Turn off all electrical accessories.
3. Close the vehicle's doors.

Notice: J 38758 should never be turned to the OFF position, with the engine running or damage could occur to the vehicle's electrical system.

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Remove the negative battery cable at the main battery. Refer to Negative Battery Cable in *Battery Cable Replacement.*

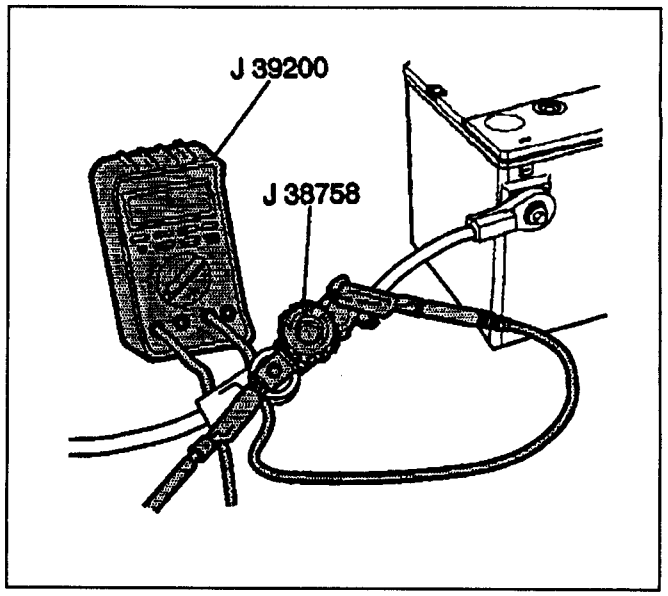
   The main battery will be wired from the positive battery terminal to the starter motor.



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Important: Ensure that the bottom of the adapter firmly contacts the pad or base of the battery post.

2. Use the following procedure in order to install the male end of *J 38758* to the negative battery terminal:
   2.1. Remove the terminal bolt from the battery cable end of the test switch.
   2.2. Thread a terminal adapter (1) onto the negative terminal post of the battery.
   2.3. Place the battery cable end of *J 38758* over the threaded end of the terminal adapter.
   2.4. Thread a second terminal adapter over the first terminal adapter.
   2.5. Turn the knob of the *J 38758* to the OFF position.
   2.6. Use a set of terminal adapters in order to install the negative battery cable to the female end of the *J 38758.*
3. Turn the knob on the *J 38758* to the OFF position.
4. Install the negative battery cable to the female end of *J 38758.*
5. Turn the test switch to the ON position.
6. Road test the vehicle and activate all accessories including the radio and air conditioning.
7. Turn the ignition switch to the OFF position and remove the key.



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Important: Electrical continuity in the ground circuit to the battery must be maintained from this point forward. Use the *J 38758* (in the ON position) or the ammeter in order to maintain electrical continuity.

8. Some components, including PCMs, have timers that draw several amps of current when the components cycle down. This condition may cause an incorrect parasitic current drain reading. Wait 15 minutes in order to allow the above components to power down before continuing the test.

   Important: If using a digital multimeter other than the *J 39200* , ensure that the vehicle does not have excessive current drain. Excessive current drain may damage the multimeter when the multimeter is installed.

9. Use the following procedure in order to test the current drain level:
   9.1. Connect a jumper wire with an in-line 10 amp fuse to the *J 38758* terminals.
   9.2. Turn the *J 38758* to the OFF position.
   9.3. Wait 10 seconds.
   9.4. Inspect for a blown fuse.
   If the fuse does not blow, the current draw is less than 10 amps and the *J 39200* may operate safely.
   9.5. Turn the *J 38758* to the ON position.
   Turning the *J 38758* to the ON position before installing the *J 39200* maintains continuity in the electrical system.
   9.6. Remove the fused jumper wire.
   9.7. Install the *J 39200.*

10. Set the *J 39200* to the 10 amp scale and connect the multimeter to the *J 38758*.
11. Turn the *J 38758* to the OFF position. Current now flows through the *J 39200* only.
12. Wait at least 60 seconds in order to observe the current reading.

    If the current reading is at or below 2 amps, turn the test switch to the ON position (in order to maintain continuity in the electrical system) and switch the *J 39200* to the 2 amp scale for a more accurate reading.
13. Turn the *J 38758* to the ON position.
14. Measure the reading in milliamps, if necessary.
15. Refer to Battery Specifications in *Battery Usage* in order to determine the reserve capacity of the battery.
16. Divide the reserve capacity value by 4 and compare the result to the *J 39200* reading.

    The current drain reading should not exceed the value determined above. Example: If a battery has a reserve capacity of 100 minutes, the current drain should not exceed 25 milliamps.

    Notice: Always turn the test switch knob to the ON position before removing each fuse in order to maintain continuity in the electrical system and to avoid damaging the digital multimeter due to accidental overloading, such as opening a door to change a fuse.
17. If the current draw is excessive, remove the system fuses one at a time until the draw returns to a value less than or equal to the specified value.

    In order to protect the *J 39200* without disrupting electrical continuity, turn the test switch to the ON position before opening the door.
18. Start with fuses that are hot at all times. Refer to Fuse Block Details Schematics in Wiring Systems.
19. Remove the courtesy lamp fuse and observe the *J 39200* reading.
20. If the parasitic load remains excessive perform the following steps:
    - 20.1. Removing the other fuses, one at a time.
    - 20.2. Leave the courtesy lamp fuse out during diagnosis so the vehicle door can be left open.
    - 20.3. Observe the *J 39200* reading each time a fuse is removed.
21. The PCM fuse should cause a drop of less than 10 milliamps when removed.
22. If the drop is more than 10 milliamps, inspect the PCM wiring for a short to ground. Also, inspect the components connected to the wires. Refer to the related schematics for the system being worked on.
23. Repeat the parasitic current drain test after the condition has been located and repaired. The vehicle could have more than one parasitic current drain.
24. When the cause of the excessive current draw has been located and repaired, remove the *J 39200*, the *J 38758* and the terminal adapters.
25. Reconnect the negative battery cable.

Battery Is Undercharged or Overcharged

Step	Action	Value(s)	Yes	No
1	1. Disconnect the generator connector. 2. Place the ignition switch in the RUN position. 3. Connect a voltmeter from CKT 5 (BRN) at the generator connector to chassis ground. 4. Observe the reading on the voltmeter. Does a battery voltage exist?	—	Go to *Step 5*	Go to *Step 2*
2	Inspect the condition of the indicator bulb. Is the indicator bulb in proper condition?	—	Go to *Step 4*	Go to *Step 3*
3	Replace the indicator bulb. Is the battery still undercharged or overcharged?	—	Go to *Step 4*	System OK
4	Locate and repair the open in the BRN wire between the instrument cluster and the generator. Is the battery still undercharged or overcharged?	—	Go to *Step 5*	System OK

Battery Is Undercharged or Overcharged (cont'd)

Step	Action	Value(s)	Yes	No
5	*Connect a voltmeter* from battery terminal 1 (RED) at the generator connector to chassis ground. Does the voltmeter read a battery voltage?	—	Go to *Step 7*	Go to *Step 6*
6	Locate and repair the open in CKT 1 (RED) between the generator and the MaxiFuse® Block. Is the battery still undercharged or overcharged?	—	Go to *Step 7*	System OK
7	1. Reconnect the generator connector. 2. Turn off all accessories. 3. Run the engine at a fast idle. 4. Connect a voltmeter from battery terminal 1 (RED) at the generator to chassis ground. Does the voltmeter give a reading within the specified range?	13–16 V	Go to *Step 8*	Go to *Step 9*
8	Perform a battery load test. Refer to *Charging System Check (Battery Testing).* Is the battery still undercharged or overcharged?	—	Go to *Step 9*	System OK
9	Perform a generator bench test. Refer to *Charging System Check (Battery Testing)* Is the generator in need of repair or replacement?	—	Go to *Step 10*	Go to *Step 11*
10	Repair or replace the generator. Is the battery still undercharged or overcharged?	—	—	System OK
11	Perform a battery load test. Refer to *Charging System Check (Battery Testing)* Is the battery still undercharged or overcharged?	—	—	System OK

Indicator - Charge Always On

Step	Action	Value(s)	Yes	No
1	1. Stop the engine. 2. Disconnect CKT 5 (BRN) to the generator. Does the BAT indicator lamp remain illuminated?	—	Go to *Step 3*	Go to *Step 2*
2	Replace the generator. Does the BAT indicator lamp remain illuminated with the engine running?	—	Go to *Step 3*	System OK
3	1. Disconnect the connector at the instrument cluster. 2. Connect a self-powered test lamp between generator connector terminal A1 and chassis ground. Does the test lamp light?	—	Go to *Step 4*	Go to *Step 5*
4	Locate and repair the short to ground in the BRN wire between the instrument cluster and the generator. Does the BAT indicator lamp remain illuminated with the engine running?	—	—	System OK
5	Replace the instrument cluster. Does the BAT indicator lamp remain illuminated with the engine running?	—	—	System OK

Indicator - Charge Inoperative

Step	Action	Value(s)	Yes	No
1	1. Ensure that the battery is charged. 2. Disconnect CKT 5 (BRN) at the generator. 3. Connect a fused wire between generator harness connector terminal C and chassis ground. 4. Place the ignition switch in the RUN position. Does the battery indicator light?	—	Go to *Step 2*	Go to *Step 5*
2	Inspect the generator mechanical grounding. Are the grounding connections in need of repair?	—	Go to *Step 3*	Go to *Step 4*
3	Repair the grounding connections. Does the BAT indicator lamp still not light with the ignition switch in the RUN position and the engine stopped?	—	Go to *Step 4*	System OK
4	Replace the generator. Does the BAT indicator lamp still not light with the ignition switch in the RUN position and the engine stopped?	—	Go to *Step 5*	System OK
5	1. Ensure that the jumper is still connected. 2. Disconnect the 15 way IP harness connector at the instrument cluster. 3. Connect a test lamp from CKT 6 (BRN) at instrument cluster connector terminal A1 to chassis ground. Does the test lamp light?	—	Go to *Step 7*	Go to *Step 6*
6	Locate and repair the open in CKT 6 (BRN) between the instrument cluster and the generator. Does the BAT indicator lamp still not light with the ignition switch in the RUN position and the engine stopped?	—	Go to *Step 7*	System OK
7	Connect a test lamp from CKT 1 (BRN) at instrument cluster connector terminal A6 to chassis ground. Does the test lamp light?	—	Go to *Step 9*	Go to *Step 8*
8	Locate and repair the open in CKT 1 (BRN) between the instrument cluster and S243. Does the BAT indicator lamp still not light with the ignition switch in the RUN position and the engine stopped?	—	Go to *Step 9*	System OK
9	Inspect for an open filament in the BAT indicator lamp. Is the filament good?	—	Go to *Step 11*	Go to *Step 10*
10	Replace the BAT indicator lamp. Does the BAT indicator lamp still not light with the ignition switch in the RUN position and the engine stopped?	—	—	System OK
11	Replace the instrument cluster. Does the BAT indicator lamp still not light with the ignition switch in the RUN position and the engine stopped?	—	—	System OK

Noisy Generator

The following conditions may cause the generator to emit noise:

- Insufficient fan clearance to bolts or structures
- Dirty or worn bearings
- A worn diode or stator

If the pulley and mounting bolts are snug and the noise continues, remove the generator for inspection and repair. Refer to *Generator Replacement.*

A loose drive pulley or loose generator mounting bolts may also cause a generator to emit noise. In some cases, the generator has been relocated in order to mount aftermarket equipment. Inspect the generator brackets for structural failure or misaligned pulleys. Observe the generator with the engine running in order to ensure that the following conditions do not exist:

- Excessive vibration
- Excessive motion
- Squealing or other abnormal noises

Verify the following conditions before performing the diagnostic procedures on the vehicle:

- The system wiring is in the proper condition.
- The generator belt is not slipping.
- The battery must be fully charged for a valid test of the charging system.

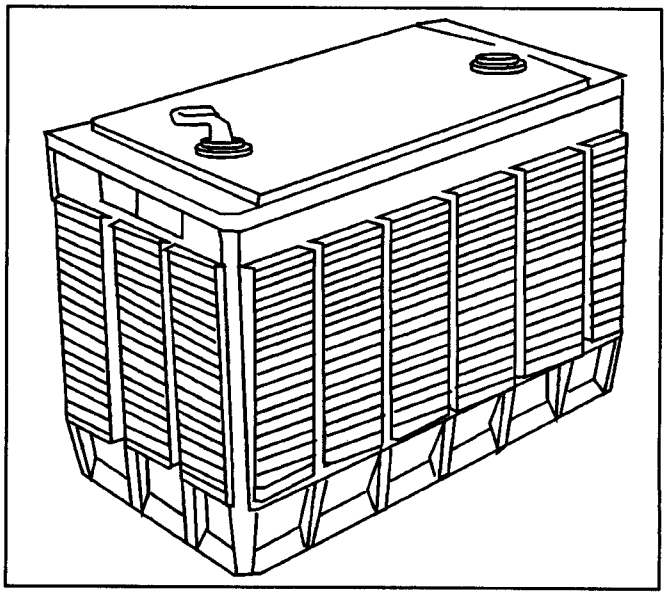
  Refer to *Charging System Check (Battery Testing)* for detailed diagnosis and repair.

Notice: To avoid damaging the vehicle's electrical system, 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.
- Make sure the generator and battery have the same ground polarity.
- When a connecting charger or booster battery to the vehicle's battery, connect the negative to negative and the positive to positive.

Faulty operation of the charging system will appear as one or more of the following conditions:

- Unusual operation of the charging indicator lamp on vehicles without gauges



181055

- An undercharged battery

  Slow cranking or a dark battery hydrometer indicates an undercharged battery. Refer to *Battery Is Undercharged or Overcharged.*
- An overcharged battery

  Excessive gassing of electrolyte from the battery vents indicates an overcharged battery. Refer to *Battery Is Undercharged or Overcharged.*

Charging System Indicator Lamp Operation

Generator Electrical Test

Step	Action	Value(s)	Yes	No
1	1. Turn the ignition to the ON position. Do not start the engine. 2. Observe the charging system indicator lamp. Does the indicator lamp turn ON?	—	System OK	*Go to Step 3*
2	1. Turn the ignition to the ON position. 2. Start the engine. 3. Observe the charging system indicator lamp. Does the indicator lamp turn OFF?	—	System OK	*Go to Step 3*
3	Perform the Charging System Check in order to identify the malfunction. Refer to *Charging System Check (Charging System Check).* Perform any necessary repairs. Is the system operating properly?	—	System OK	—

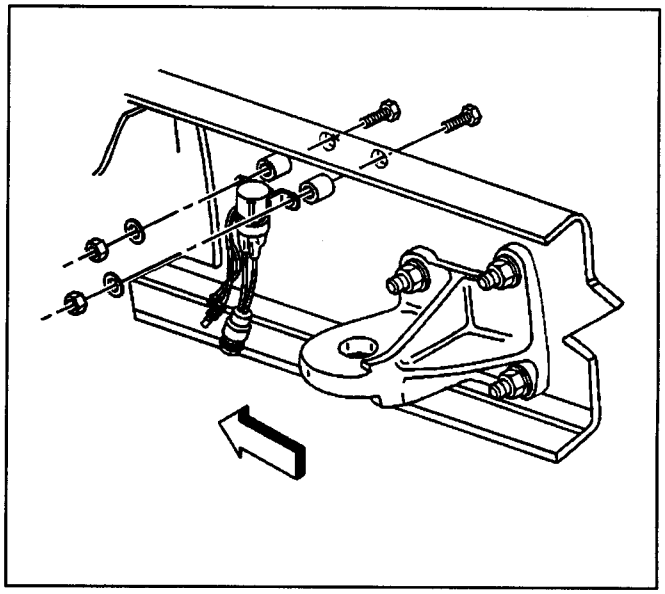
Repair Instructions

Starter Motor Relay Replacement

Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

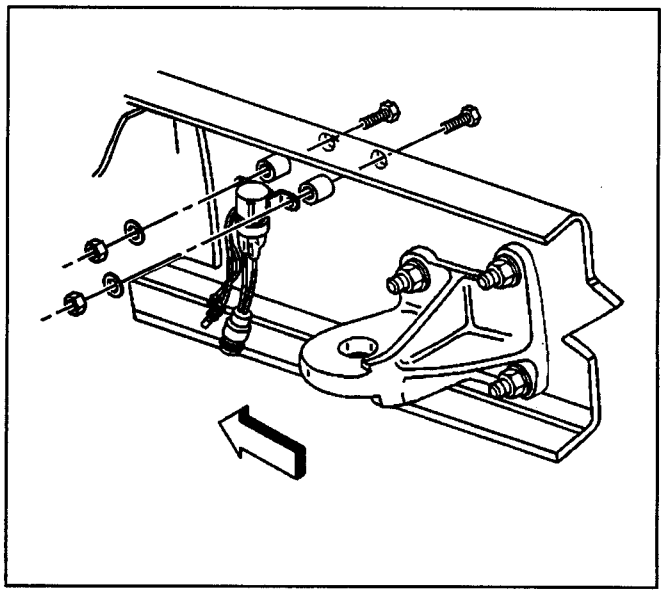
1. Disconnect the negative battery cable.
2. Tilt the cab.
   Refer to *Cab Tilting* in General Information.
3. Disconnect the electrical connectors to the starter relay.
4. Remove the starter relay mounting bolts.
5. Remove the starter relay from the frame.



240820

Installation Procedure

1. Connect the starter relay to the frame.
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the starter relay mounting bolts.
   Tighten
   Tighten the starter relay mounting bolts to 23 N·m (17 lb ft).
3. Connect the electrical connectors to the starter relay.
4. Connect the negative battery cable.
5. Lower the cab.



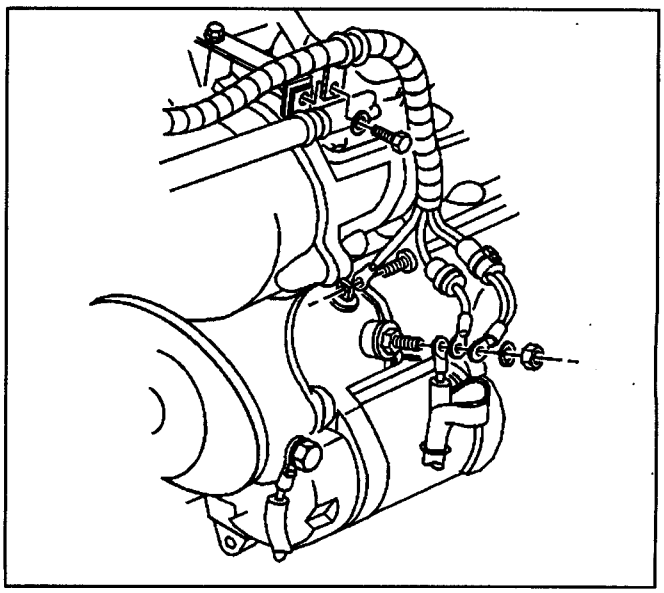
240820

Starter Motor Replacement

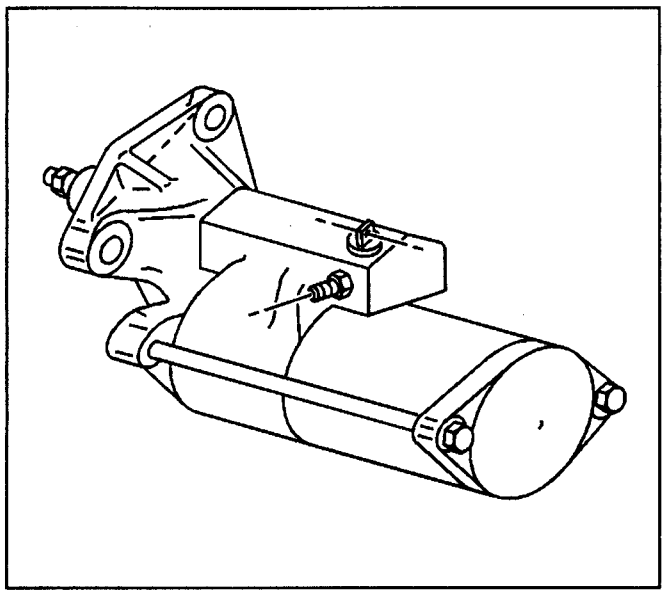
Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Tilt the cab.
   Refer to *Cab Tilting* in General Information.
3. Disconnect the electrical connectors from the starter motor.
4. Remove the nuts and the washers that attach the starter motor to the engine.

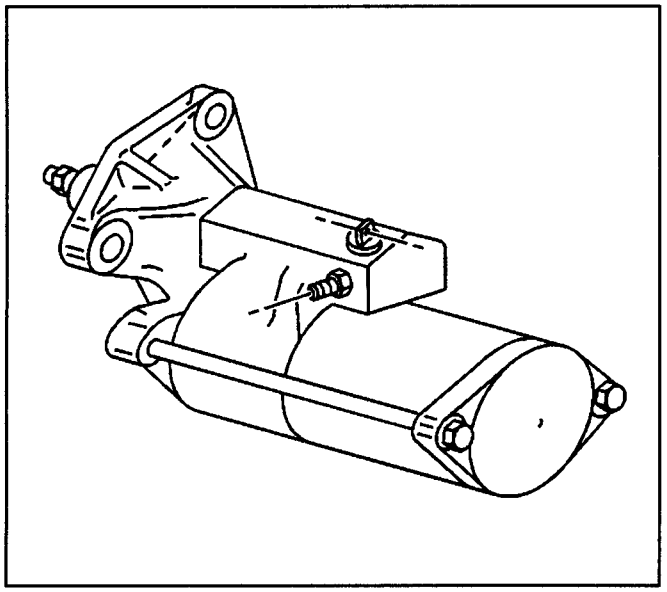


240818



240816

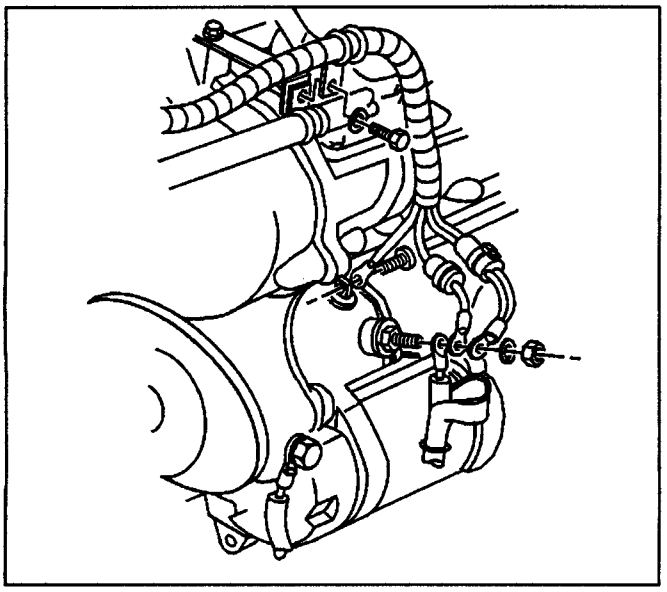
5. Remove the starter motor from the engine.
6. Clean the following components:
   - The starter motor terminals
   - The electrical connectors
7. Inspect the pinion gear teeth for wear and damage.



240816

Installation Procedure

1. Connect the starter motor to the engine.



240818

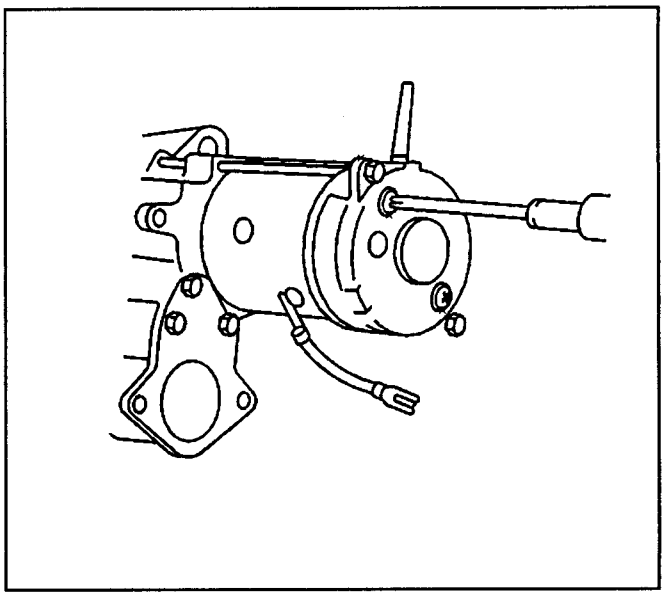
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the nuts and the washers that attach the starter motor to the engine.
   Tighten
   Tighten the starter motor mounting nuts to 82 N·m (60 lb ft).
3. Connect the electrical connectors to the starter motor.
4. Hold the hex-shaped base of the stud while tightening the positive battery cable nut.
   Tighten
   4.1. Tighten the positive battery cable nut to 21 N·m (16 lb ft).
   4.2. Tighten the solenoid bolt to 4.0 N·m (35 lb ft).
5. Lower the cab.
6. Connect the negative battery cable.

Starter Motor Overhaul

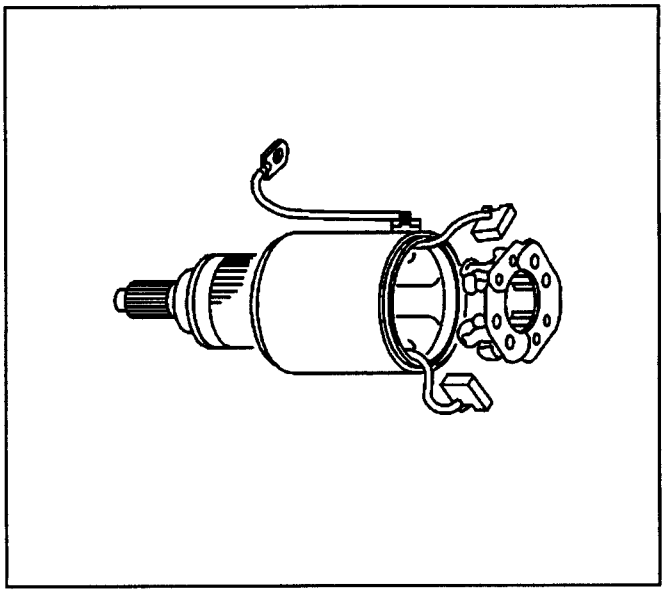
Disassembly Procedure

1. Disconnect the lead wire.
2. Remove the magnetic switch assembly and gasket.
3. Loosen the brush holder screws at the rear bracket.



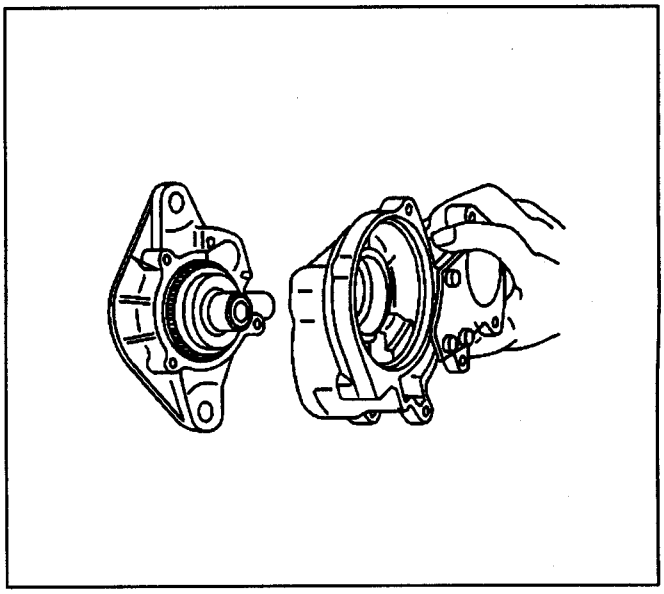
316329

4. Remove the through bolt.
5. Remove the rear bracket.
6. Remove the brush.
7. Remove the brush holder and spring.
8. Remove the yoke assembly
9. Disassemble the armature using the following procedure:
   - 9.1. the brush holder
   - 9.2. the yoke assembly
   - 9.3. the armature assembly

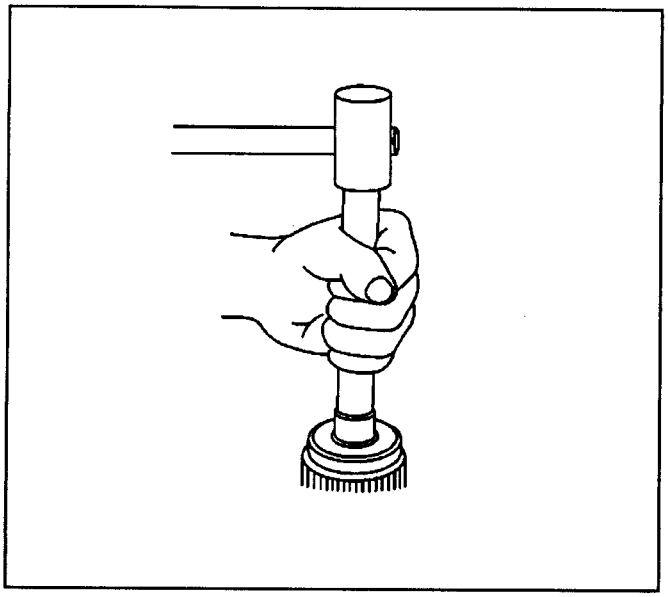


316338

10. Remove the front bracket.
11. Remove the center bracket using the following procedure.
    - 11.1. Loosen the bolts holding the front bracket to the center bracket.
    - 11.2. Remove the front bracket from the center bracket.

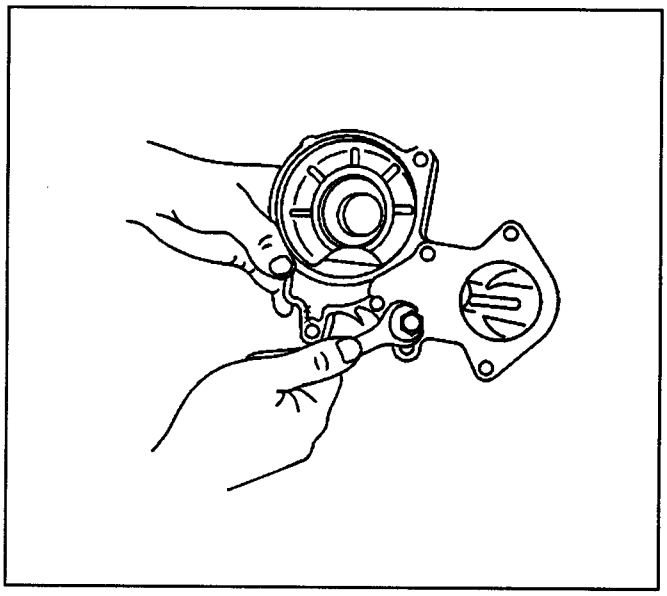


316341



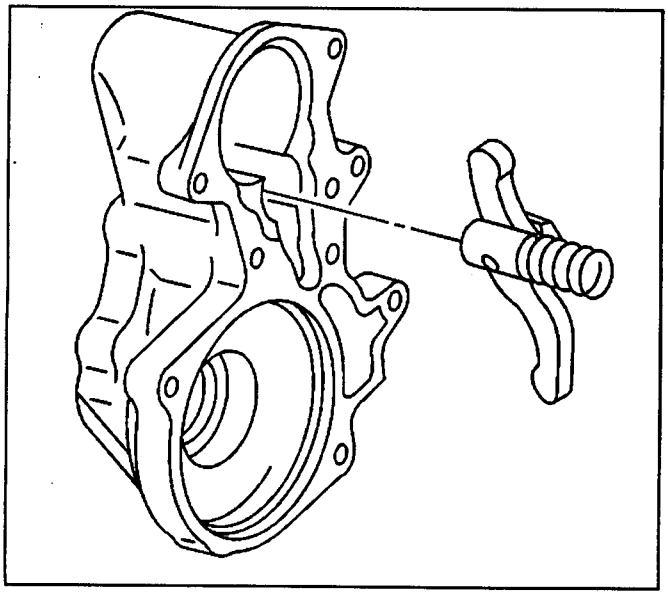
316344

12. Remove the pinion stopper clip.
13. Remove the cup ring from the right end of the over running clutch.
14. Remove the return spring.
15. Remove the pinion stopper from the right end of the over running clutch.
16. Drive out the pinion.



316348

17. Remove the over running clutch
18. Remove the plate and gasket.
19. Remove the shift lever using the following procedure:
    19.1. Loosen the plate bolts.
    19.2. Remove the shift lever from the center bracket.



316406

Reassembly Procedure

1. Install the center bracket.
2. Install the shift lever.
    2.1. Apply molybdenum disulfide grease to the shift lever pin.
    2.2. When installing the shift lever, pay attention to its installing direction as illustrated.

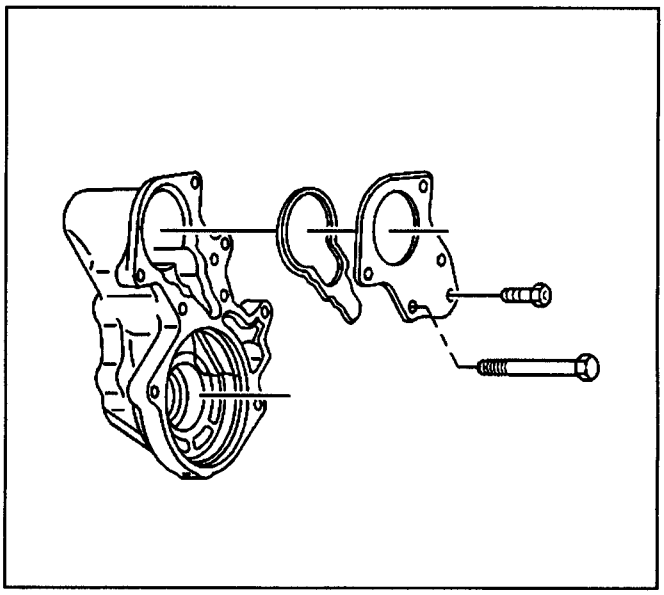
3. Install the plate and gasket using the following procedure:
   3.1. Install the plate and gasket to the center cover.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

   3.2. Install the plate bolts.

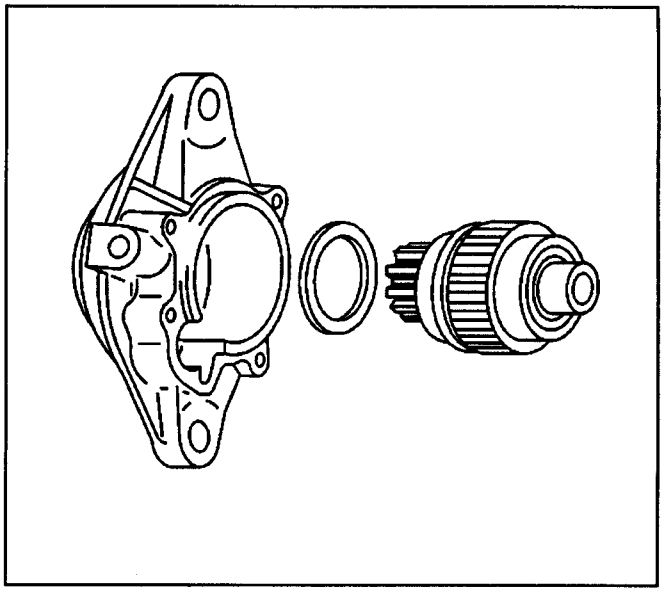
   Tighten

   Tighten the bolts to 9 N.m (78 lb in).



316410

4. Install the over running clutch.
5. Install the pinion.
6. Install the pinion stopper.
7. Install the return spring.
8. Install the cup ring.
9. Install the pinion stopper clip.



316415

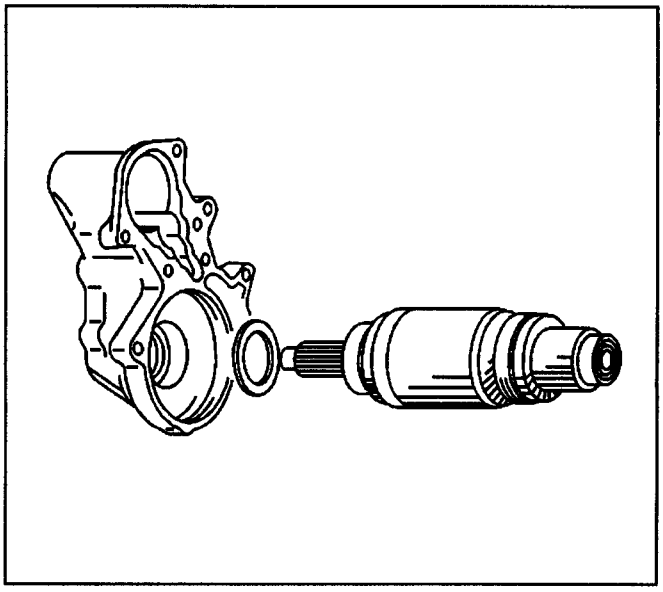
10. Adjust the over running clutch front bracket and bearing clearance with the adjusting washer so that the clearance may become as specified.

    Front Bracket and Bearing Clearance

    The clearance should be 0.2–0.8 mm (0.008–0.031 in).
11. Install the yoke assembly.
12. Install the brush holder and spring.
13. Adjust the armature center bracket and bearing clearance with the adjusting washer so that the clearance may become as specified:

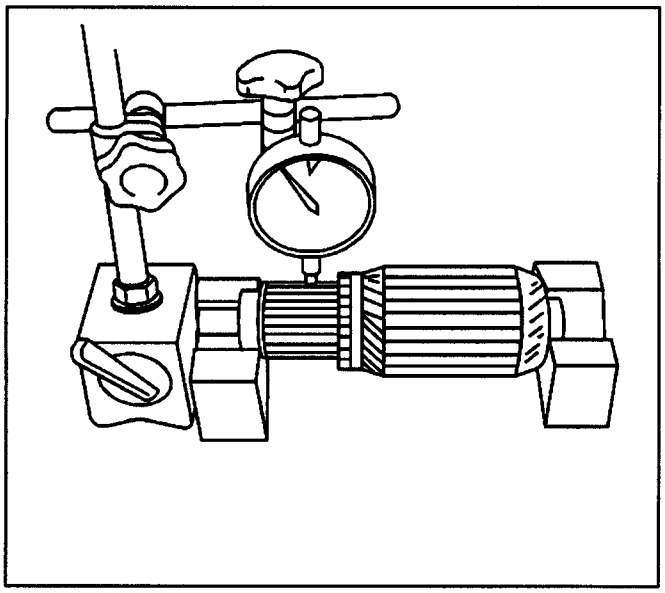
    Center Bracket and Bearing Clearance

    The clearance should be 0.2–0.8 mm (0.008–0.031 in).
14. Install the brushes.
15. Install the rear bracket.
16. Install the brush holder screw.

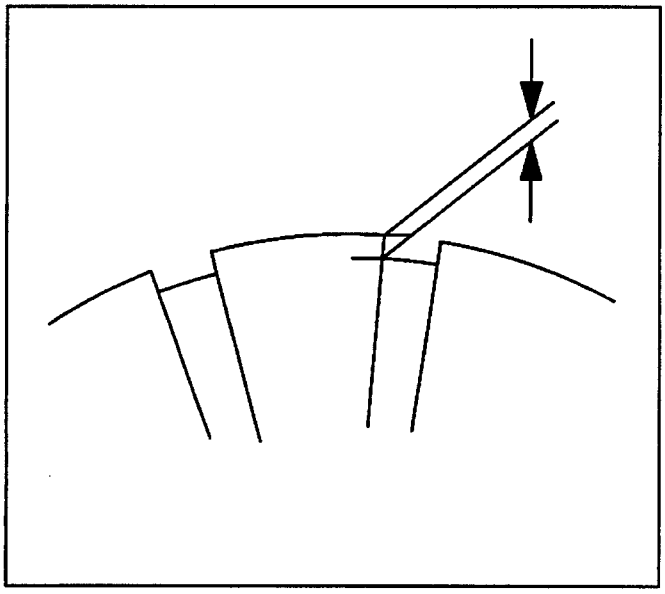


316420

17. Install the through bolt.
    Tighten
    Tighten the bolt to 9 N·m (78 lb in).
18. Install the magnetic switch assembly using the following procedure:
    18.1. Install the magnetic switch assembly to the center bracket.
    18.2. Install the magnetic switch assembly bolts.
    Tighten
    Tighten the bolt to 9 N·m (78 lb in).
19. Connect the lead wire.



316357



316360

Starter Motor Inspection

Inspection and Repair

Perform the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

It is important that electrical components be kept clean and dry at all times.

Always visibly check the fusible links, the fuses, and the indicator lights for damage as the first step in the inspection and repair procedure.

Armature

Commutator Face

1. Check the commutator face for roughness.
2. If necessary, dress the commutator face with fine sandpaper (#500 or #600).
3. Be absolutely sure that there are no metal filings in the segment gaps.

Commutator Run-Out

1. Mount the armature assembly on V-blocks.
2. Use a dial indicator to measure the commutator run-out. If the run-out is greater than the specified limit, the commutator may be turned on a lathe to correct it. If the run-out exceeds the specified limit, the armature assembly must be replaced.
   Commutator Run-Out
   The standard is 0.06 mm (0.002 in) or less. The limit is 0.1 mm (0.004 in).

Commutator Segment Groove Depth

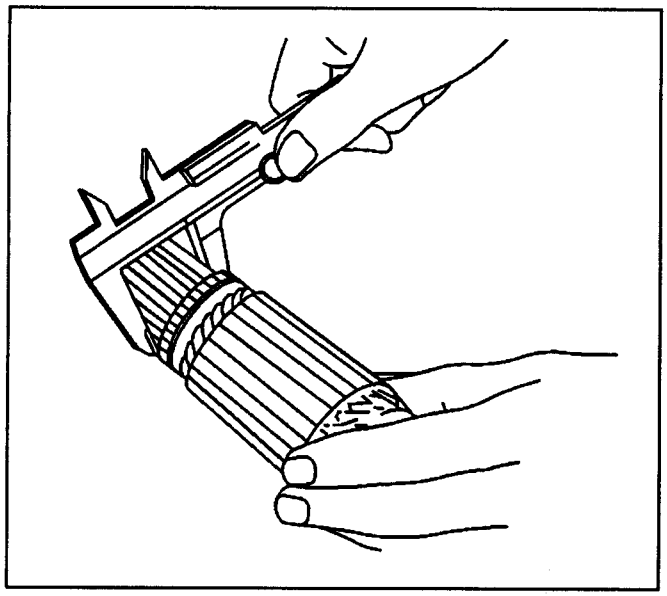
1. Use the V-blocks and the dial indicator to measure the depth of each of the commutator segment grooves.
2. Replace the armature assembly if the commutator segment groove depth is less than the specified limit.
   Commutator Segment Groove Depth
   The standard is 0.5–0.8 mm (0.020–0.031 in) or less. The limit is 0.2 mm (0.008 in).

Commutator Outside Diameter

1. Use a vernier caliper to measure the commutator outside diameter.
2. If the commutator outside diameter is less than the specified standard but greater than the specified limit, the commutator may be turned on a lathe to correct it.
3. Replace the armature assembly if the commutator outside diameter is less than the specified limit.

   Commutator Outside Diameter

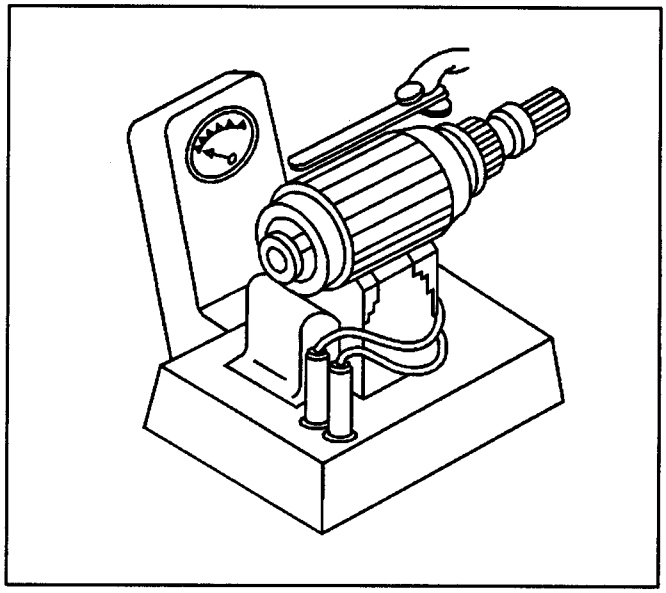
   The standard is 36 mm (1.42 in) or less. The limit is 35 mm (1.38 in).



316363

Armature Coil

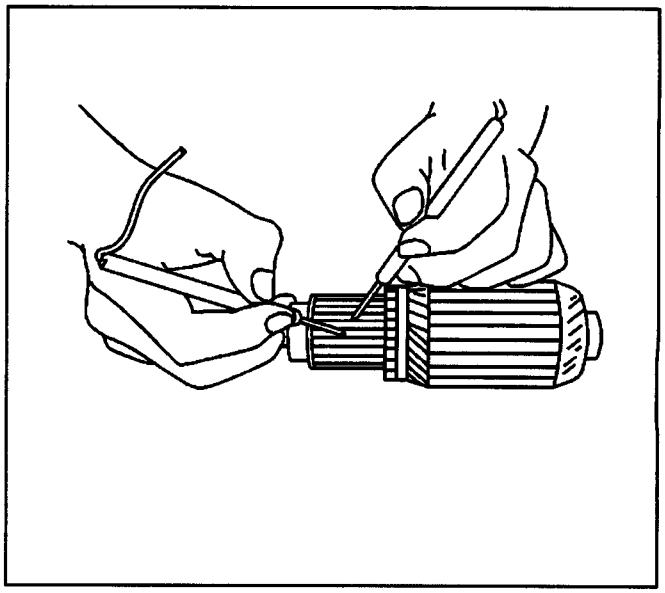
1. Place the armature in a growler tester.
2. Hold a hacksaw blade against the armature core. Slowly rotate the armature. If the armature is shorted, the hacksaw blade will vibrate. Replace the armature assembly if it is shorted.



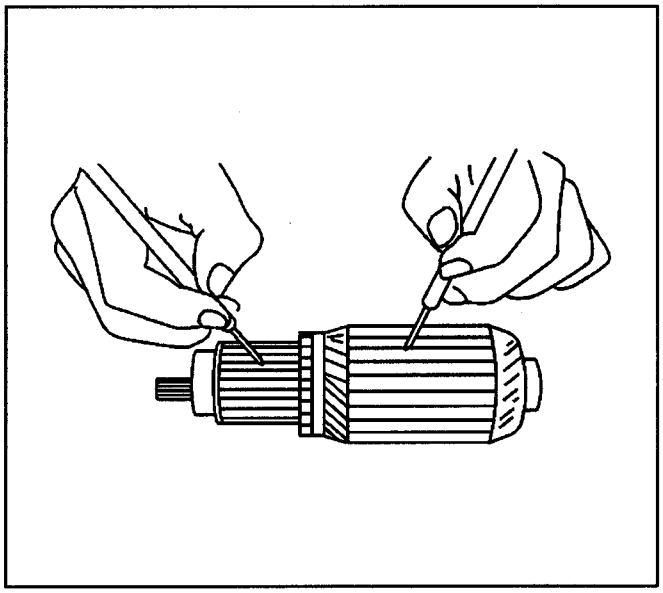
316364

Armature Continuity

1. Use a circuit tester to check for continuity between the commutator segments.
2. If there is no continuity between any two points on the commutator, the armature assembly must be replaced.



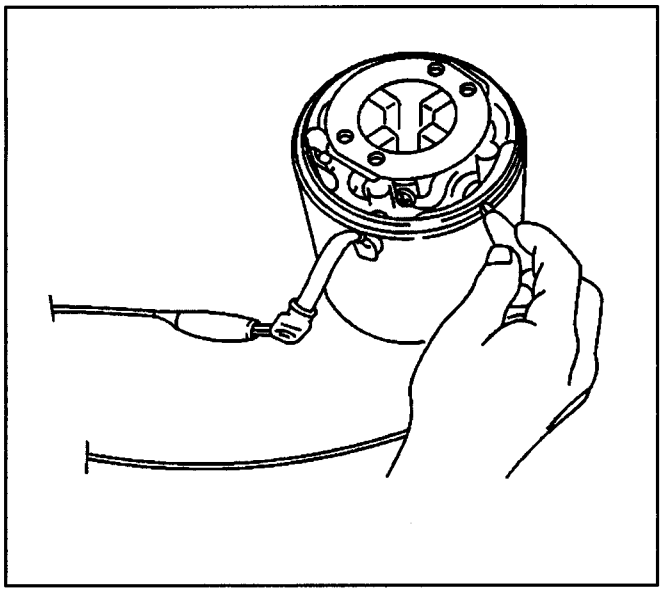
316369



316372

Armature Insulation

1. Use a circuit tester to check that there is no continuity between the commutator segments and the coil core.
2. If there is continuity between the commutator segments and the coil core, the armature assembly is defective and must be replaced.

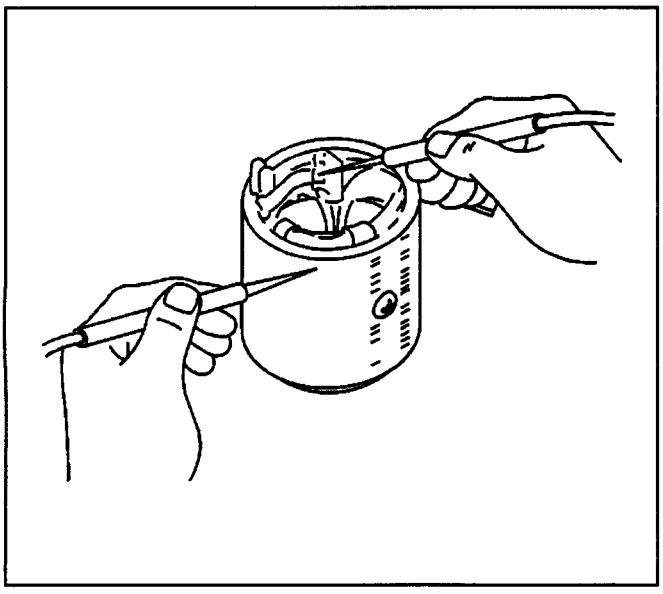


316376

Yoke

Field Coil Continuity

1. Use a circuit tester to check for continuity between the connecting leads and the brushes.
2. Replace the yoke assembly if there is no continuity at any point.



316377

Yoke Insulation

1. Use a circuit tester to check that there is no continuity between the field coil and the yoke body.
2. If there is continuity between the field coil and the yoke body, the yoke assembly is defective and must be replaced.

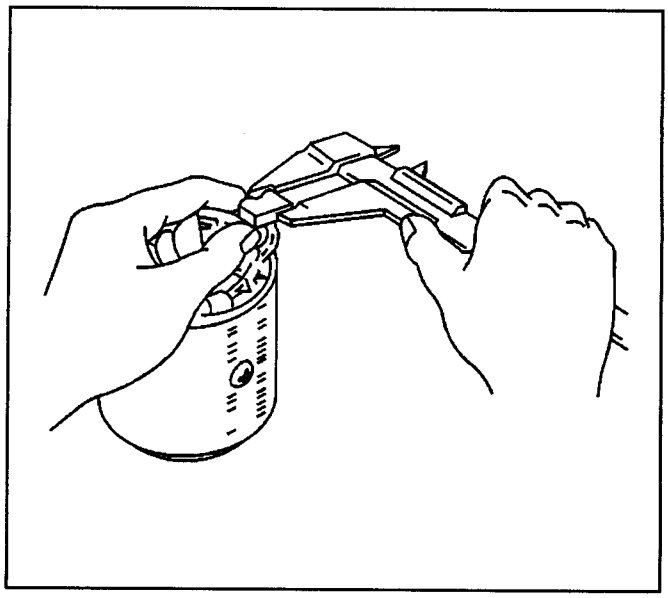
Brush and Brush Holder

Brushes

1. Use a vernier caliper to measure the brush lengths (four brushes).
2. Replace the brushes as a set if one or more of the brush lengths is less than the specified limit.

   Brush Length

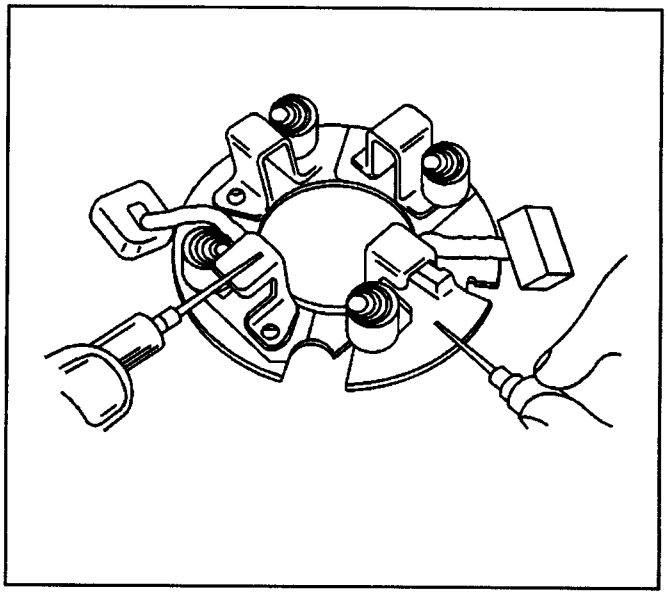
   The specified length limit is 12 mm (0.47 in).



316381

Brush Holder Insulation

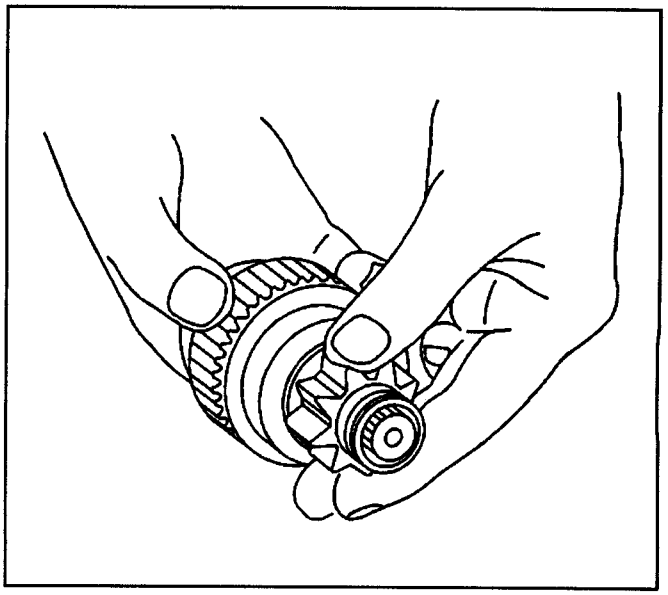
1. Use a circuit tester to check that there is no continuity between the battery side brush cages and the holder plate.
2. If there is continuity between the battery side brush cages and the holder plate, the brush holder assembly is defective and must be replaced.



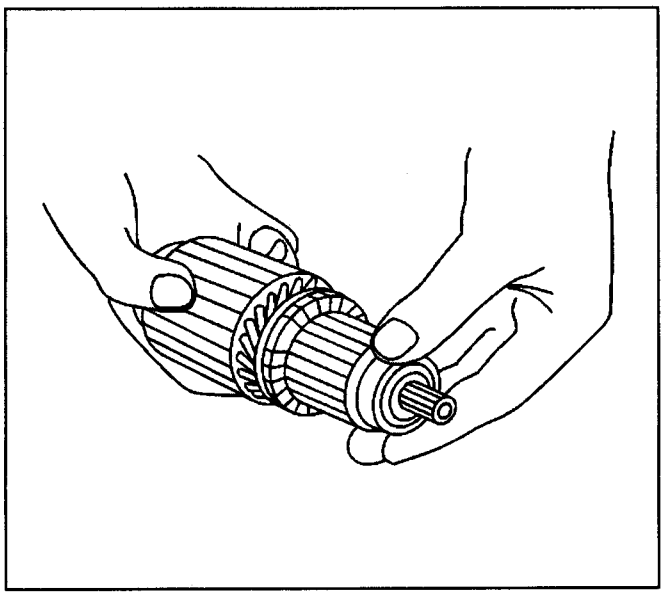
316387

Pinion Clutch

1. Clean the pinion clutch with a clean rag.
2. Check the pinion clutch and pinion gear for excessive wear and damage.
3. Turn the pinion gear clockwise. The gear should turn smoothly with no resistance. If the gear does not turn smoothly, the pinion clutch assembly must be replaced.
4. Turn the pinion gear counterclockwise. The gear should lock up firmly. If the gear does not lock firmly, the pinion clutch assembly must be replaced.

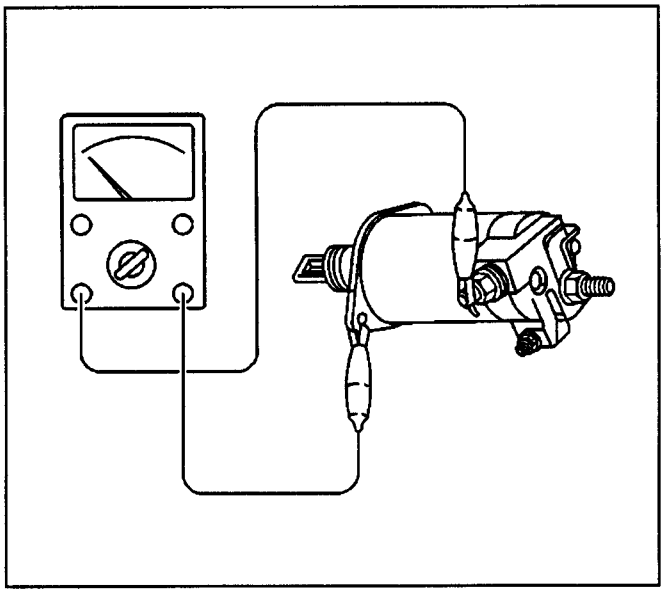


316390



316393

Bearing
Inspect the bearings for excessive wear and damage. Replace the bearings if necessary.

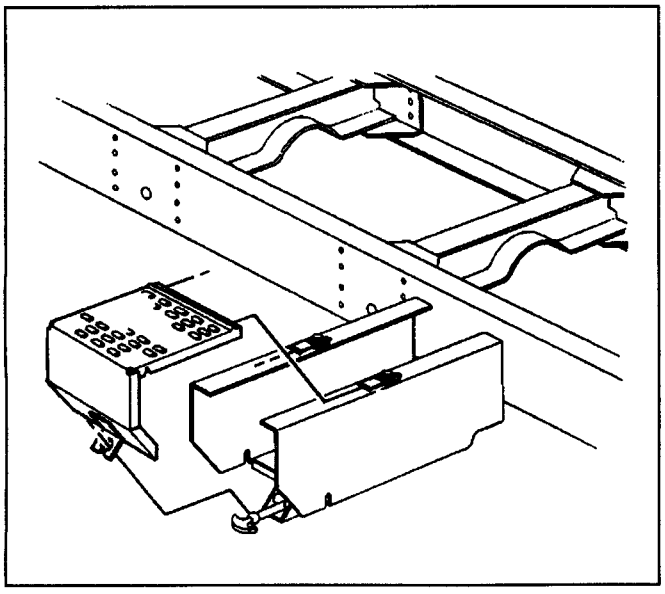


316395

Magnetic Switch

Caution: Do not apply the operating test to the magnetic switch as a single unit.

Inspect the continuity between the M terminal and the case of the magnetic switch using a circuit tester.



215008

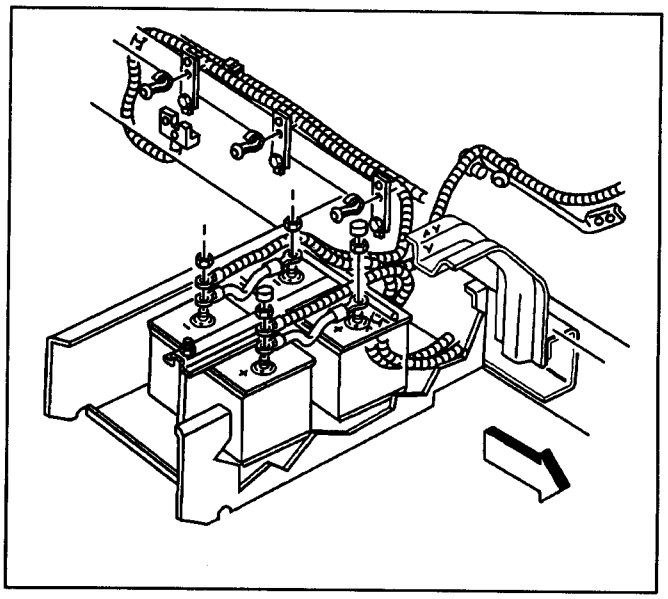
Battery Replacement

Removal Procedure

1. Remove the battery carrier cover.

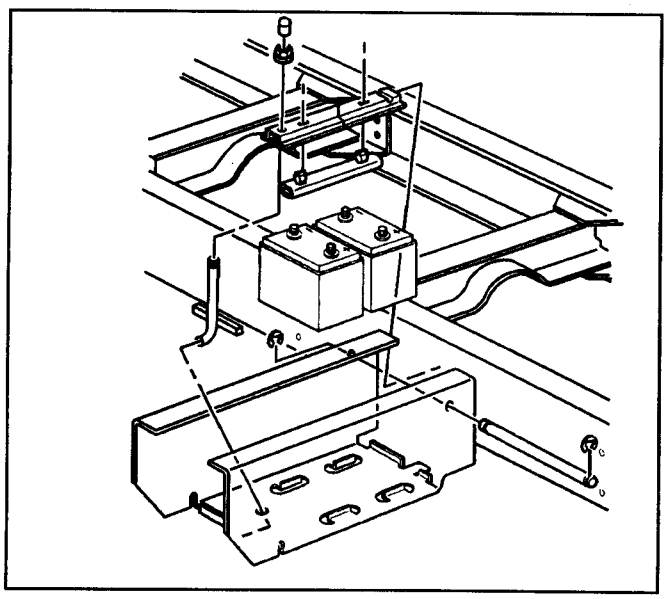
Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

2. Remove the negative cable from the negative battery terminal
3. Remove the positive cable from the positive battery terminal.



204729

4. Remove the battery hold-down retainer.
5. Remove the battery from the carrier.
6. Inspect the following components for damage:
   6.1. The battery
   6.2. The cables and the connectors
   6.3. The carrier
7. Clean the components as necessary.
   Correct any evident damage.



204720

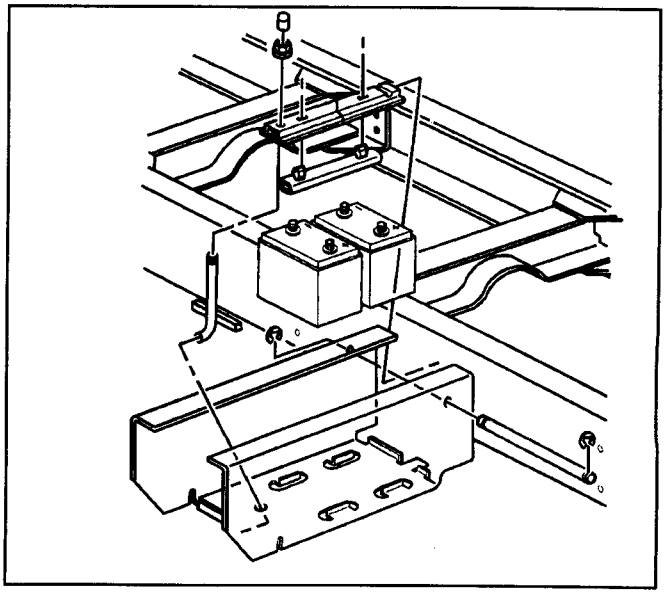
Installation Procedure

1. Install the battery into the cleaned carrier.

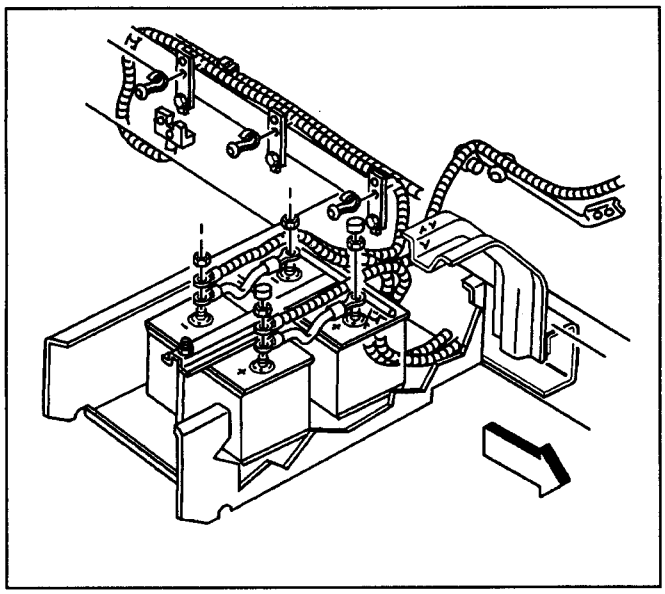
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the battery hold-down retainer or top bar and nut.

   Tighten

   Tighten the top bar nut to 17 N.m (13 lb ft).



204720

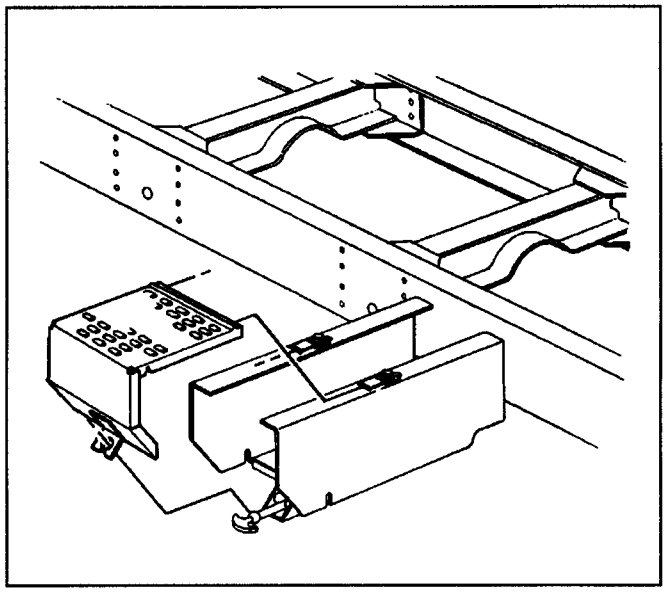


204729

3. Connect the positive cable to the positive battery terminal.
4. Connect the negative cable to the negative battery terminal.

   Tighten

   Tighten the top post terminal nut to 17 N.m (13 lb ft).



215008

5. Install the battery carrier cover.

Battery Charging

Follow these rules when charging the battery:

- Use a charger with an end charge voltage of 16 volts and a charger that is equipped with a voltmeter that is accurate within 1 percent.
- The surrounding temperature should be 15–38 °C (60–100 °F). A battery that is extremely cold may not accept measurable current for several hours after starting the charger.
- The charging area should be well ventilated.
- Do not charge the battery if the built-in hydrometer has a clear or yellow light.
- Do not charge a frozen battery. Replace the battery.
- Do not charge a battery with a green dot showing in the hydrometer unless the battery has just been discharged (such as by cranking the engine).

Caution: Always turn off the engine control switch when connecting or disconnecting battery cables, battery chargers, or jumper cables. Failure to do so may result in personal injury and damage to the Powertrain Control Module or other electronic components.

Tighten the adapters against the lead terminals of the battery in order to keep resistance between the adapter and the battery terminals to a minimum.

1. Clean and tighten all charger connections.
2. Use the 12 volt setting that gives the highest charging rate in order to charge the battery. Charge the battery until the green dot appears. Do not use the charger settings for jump starting a vehicle in order to charge the battery. Refer to the charger manufacturer's instructions. Inspect the battery periodically while charging. Tap the hydrometer lightly on the top in order to dislodge any air bubbles that may prevent a correct indication.
3. Discontinue charging the battery or reduce the charging rate if one of the following conditions occurs:
   - The battery feels hot, over 52 °C (125 °F).
   - Violent gassing of electrolyte through the vent holes occurs.
4. Test the battery after charging. Refer to *Charging System Check (Battery Testing)*.

The time required to change a battery depends on the following factors:

- Size of the battery

  A completely discharged heavy duty battery requires more than twice the recharging time than a completely discharged light duty battery.
- Temperature

  Recharging a cold battery takes more time. When a fast charger connects to a cold battery, the current accepted by the battery will be very low at first. The battery will accept a higher charging rate as the battery warms up.
- Charger capacity

  It takes less time to charge the battery that has a higher charger amperage.
- State of charge

  More than twice as much charge is required in order to charge a completely discharged battery than is needed to charge a one-half charged battery. The battery's current is low at first because the electrolyte is nearly pure water and is a poor conductor in a completely discharged battery. As the charging current causes the electrolyte acid content to increase, charging current will also increase.

  A battery that is discharged by parasitic current drain, and then allowed to stand in this condition for a period of time, may not accept a charge readily. However, if recharged long enough, many batteries will return to a usable condition.

  The battery can become permanently damaged if the battery remains in an extremely discharged condition for a prolonged period. Changes in temperature may accelerate this damage. Batteries that are extremely discharged can freeze at temperatures as high as -7 °C (20 °F) and be permanently damaged.

  Disconnect the negative battery cable in order to remove the constant drain on the battery if the vehicle will not operate within a 30 day period. This will prevent battery damage and recharging problems. If performing the above precaution is not possible, recharge the battery periodically (every 30–45 days) until the green dot is visible.

Charging Low or Completely Discharged Battery

Use the following procedure in order to recharge a very low or completely discharged battery. Unless the procedure is properly followed, a perfectly good battery may be needlessly replaced.

Tools Required:
J 39200 Digital Multimeter

1. Use the *J 39200* in order to measure the voltage at the battery terminals. If voltage is below 11 volts, the charge current will be very low and the battery may take longer to accept current in excess of a few milliamps.
2. Set the battery charger on the high setting.
3. Connect the charger leads to the battery terminals correctly because some chargers feature polarity protection circuitry that prevents charging. A completely discharged battery may not have enough voltage to activate this circuitry, even though the leads are connected properly. It will appear that the battery will not accept charging current. Follow the charger manufacturer's instructions in order to bypass or override the circuitry. This action will turn on the charger and charge a low-voltage battery.

4. Battery chargers vary in the amount of voltage and current the chargers provide. The following times are required for the battery in order to accept measurable charger current at various voltages:
   - 16.0 volts or more up to 4 hours
   - 14.0–15.9 volts up to 8 hours
   - 13.9 volts or less up to 16 hours

   Important: If the charge current is not measurable at the end of the above charging times, replace the battery.

   If the charge current is measurable during the charging time, the battery is good. Complete the charging in the normal manner.
5. Recharge a completely discharged battery for a sufficient number of ampere hours (AH) in order to restore the battery to a useable state. Use the reserve capacity rating of the battery in order to determine the amount of time necessary in order to completely recharge the battery. For capacity ratings, refer to Battery Specifications in *Battery Usage*. Divide the reserve capacity rating by the amount of ampere charge in order to determine how many hours of charging are needed. (Rating divided by amps = hours).

   For example: A battery with a reserve capacity rating of 75, charged at a rate of 10 amperes, will take 7.5 hours to fully recharge (75 divided by 10 = 7.5). The same battery, charged at a rate of 25 amperes, will take 3 hours to fully recharge (75 divided by 25 = 3).
6. Batteries recharged by this procedure should be load tested in order to determine serviceability. Refer to *Charging System Check (Battery Testing)*.

Jump Starting in Case of Emergency

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

- ***Always shield your eyes.***
- ***Avoid leaning over the battery whenever possible.***
- ***Do not expose the battery to open flames or sparks.***
- ***Do not allow battery acid to contact the eyes or the skin.***
    1. ***Flush any contacted areas with water immediately and thoroughly.***
    2. ***Get medical help.***
- ***Follow each step in the jump starting instructions, exactly.***

Notice: Do not push or tow the vehicle to start it. Under some conditions this may damage the catalytic converter or other parts of the vehicle. Also, since this vehicle has a 12–volt negative ground electrical system, make sure the vehicle or equipment used to jump start the engine has a 12–volt negative ground electrical system. Use of any other type system may damage the vehicle's electrical components.

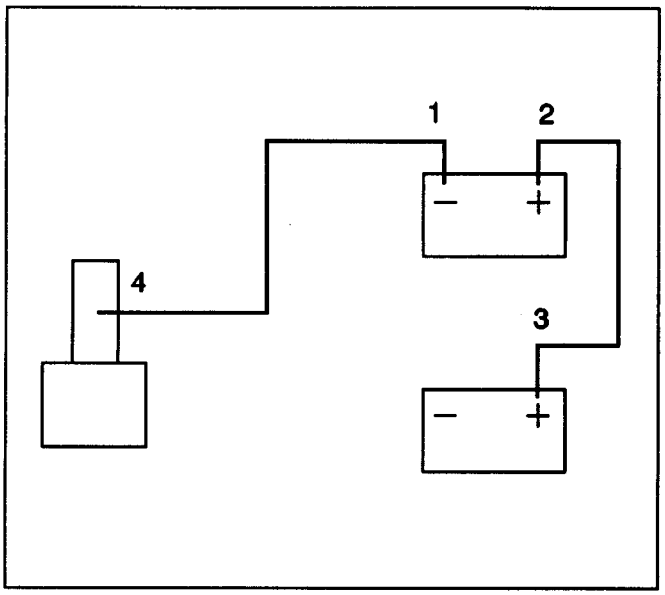
Do not jump start a vehicle under the following conditions:

- You do not know the voltage or ground of the other vehicle.
- The voltage or ground of the other vehicle are different than the voltage or ground of your vehicle.

Follow the procedure outlined below when using jumper cables. Treat the booster battery and the discharged battery carefully when using jumper cables. Do not cause sparks.

1. Position the vehicle equipped with the charged battery so that the jumper cables will reach the discharged battery.

   DO NOT allow the vehicles to touch.
2. Turn OFF the following components:
    - The engine control switch
    - The lights
    - Any other unnecessary electrical loads
3. Apply the parking brake.
4. Place the transmission in the NEUTRAL position.
5. Block the wheels.
6. Do not use the jumper cables if the insulation is loose or missing.
7. Inspect the built-in battery hydrometer of the vehicle equipped with the dead battery. If the hydrometer is clear or light yellow, do not jump start the battery. Replace the battery.



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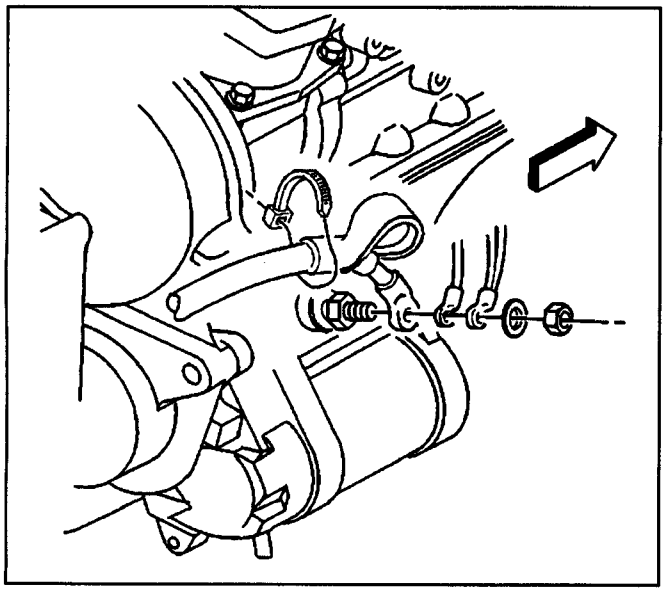
8. Attach one jumper cable end to the positive terminal (2) of the booster battery.
9. Attach the other end of the same cable to the positive terminal (3) of the discharged battery.
10. Attach one negative jumper cable end to the negative terminal (1) of the booster battery.
11. Connect the jumper negative cable end to a solid ground (4) (such as an A/C compressor bracket), at least 450 mm (18 in) from the battery of the vehicle being started.
12. Start the engine of the vehicle that provides the jump start.
13. Start the engine of the vehicle with the discharged battery.
14. Perform the following steps in order to remove the jumper cables:
    14.1. Remove the negative cable from the metal ground (4).
    14.2. Remove the negative cable from the booster battery (1).
    14.3. Remove the positive cable from the booster battery (2).
    14.4. Remove the positive cable from the jumped battery (3).

Battery Cable Replacement

When you replace a battery cable, use a replacement cable that has the following specifications that are equal to the specifications of the original cable:

- Type
- Diameter
- Length

Additional feed wires sometimes attach to positive cables. Additional ground leads sometimes attach to negative cables. Route the replacement cable in the same manner as the original cable was routed.

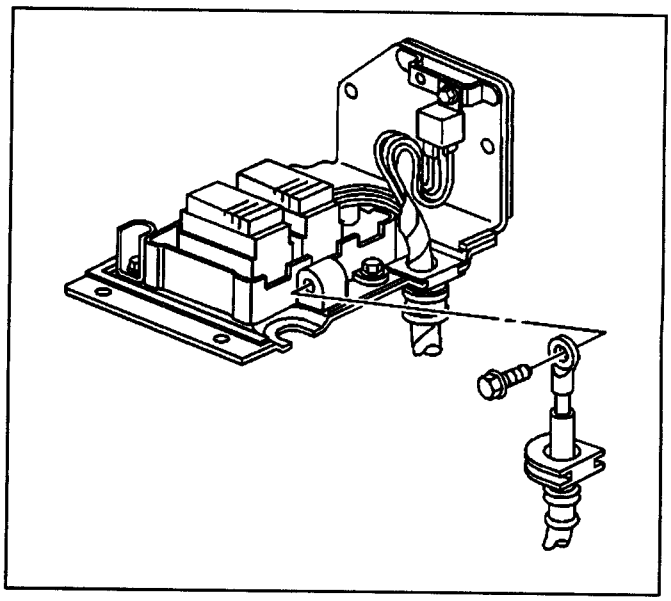

227242

Positive Cable Removal Procedure

1. Tilt the cab. Refer to *Cab Tilting* in General Information.

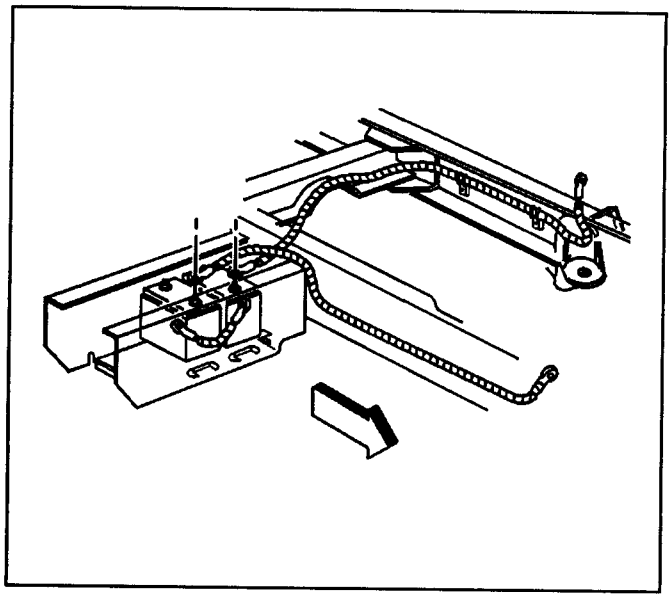
   Caution: Refer to Battery Disconnect Caution in Cautions and Notices.
2. Disconnect the negative battery cable.
3. Disconnect the positive cable from the starter solenoid.

4. Disconnect the positive cable from the Maxi-Fuse® block.



215054

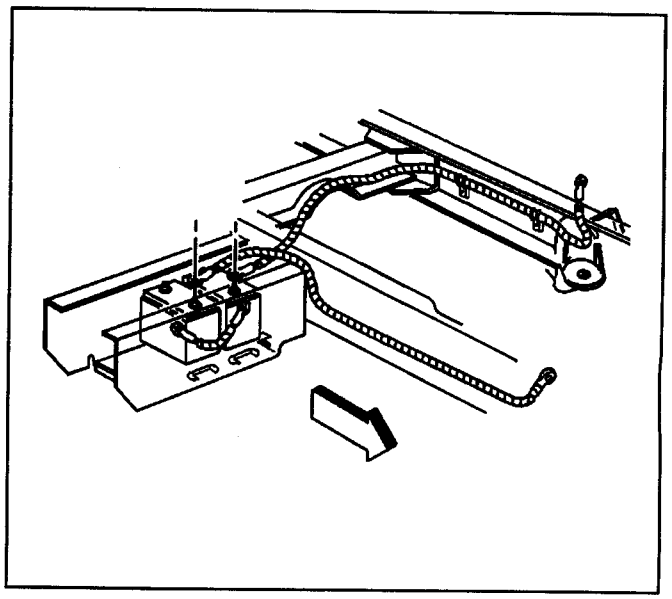
5. Remove the following components:
   - The positive cable clamps
   - The tie downs
6. Remove the positive cable.



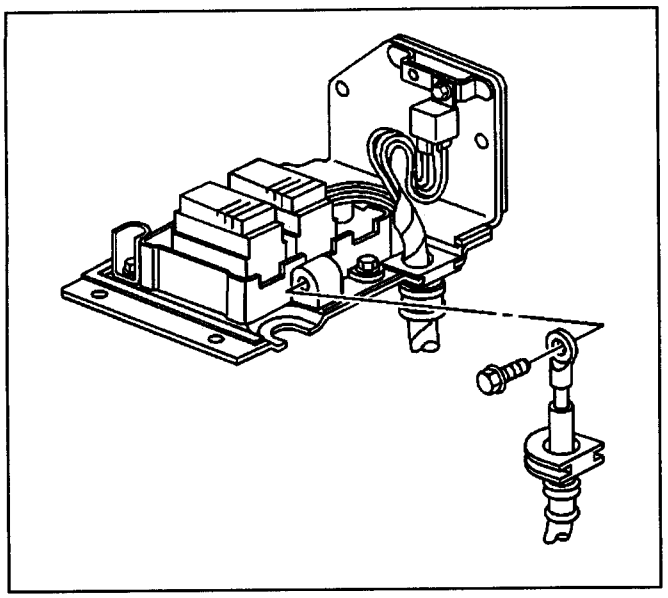
215049

Positive Cable Installation Procedure

1. Install the positive cable.
   Ensure that the positive cable is installed to the original positive cable routing.
2. Install the following components:
   - The positive cable clamps
   - The tie downs



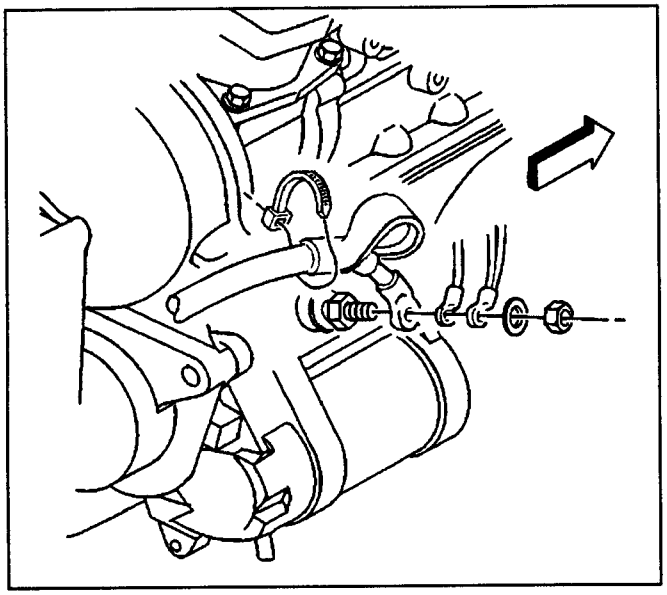
215049



215054

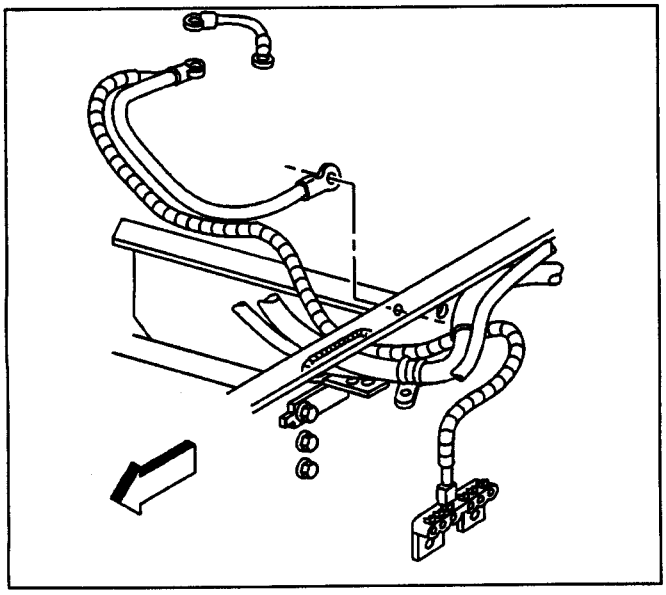
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Connect the positive cable to the Maxi-Fuse® block.
   Tighten
   Tighten the positive cable to Maxi-Fuse® block bolt to 9 N.m (80 lb in).



227242

4. Connect the positive cable to the starter solenoid.
   Tighten
   Tighten the positive cable starter nut to 21 N.m (16 lb ft).
5. Connect the negative battery cable.
   Tighten
   Tighten the top post terminal nut to 17 N.m (13 lb ft).
6. Lower the cab.



204733

Negative Cable to Frame Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable from the battery.
2. Connect the negative battery cable from the frame.
3. Disconnect the wires from the negative junction block.
4. Remove the negative junction from the frame.

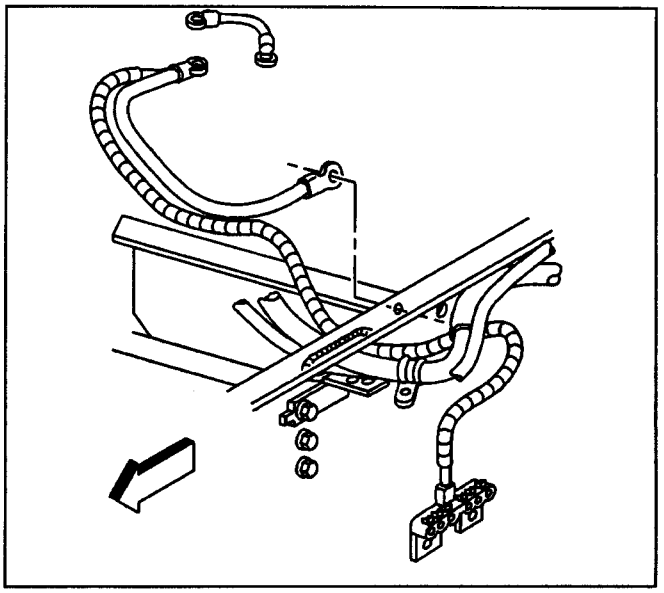
Negative Cable to Frame Installation Procedure

1. Install the negative junction to the frame.
2. Connect the wires to the negative junction block.
3. Connect the negative battery cable to the frame.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
4. Connect the negative battery cable to the battery.

   Tighten

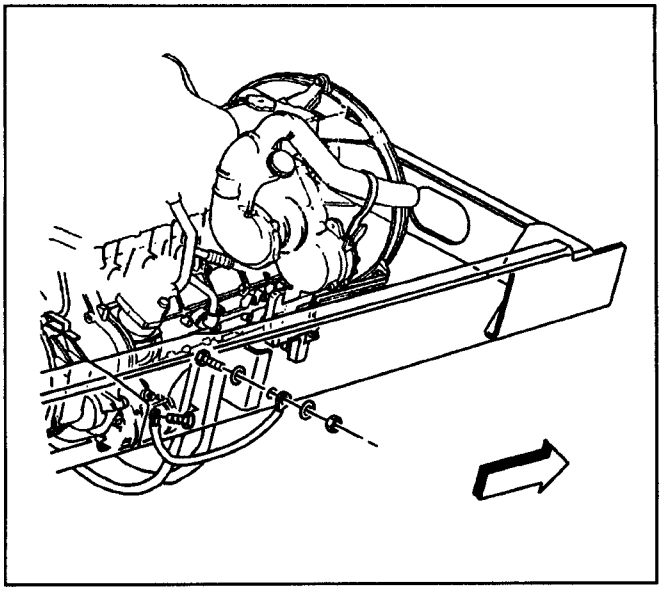
   - Tighten the top post terminal nut to 17 N.m (13 lb ft).
   - Tighten the negative cable bolt to frame to 30 N.m (22 lb ft).



204733

Negative Cable to Engine Removal Procedure

1. Disconnect the negative cable from the frame.
2. Disconnect the negative cable from the engine.



204739

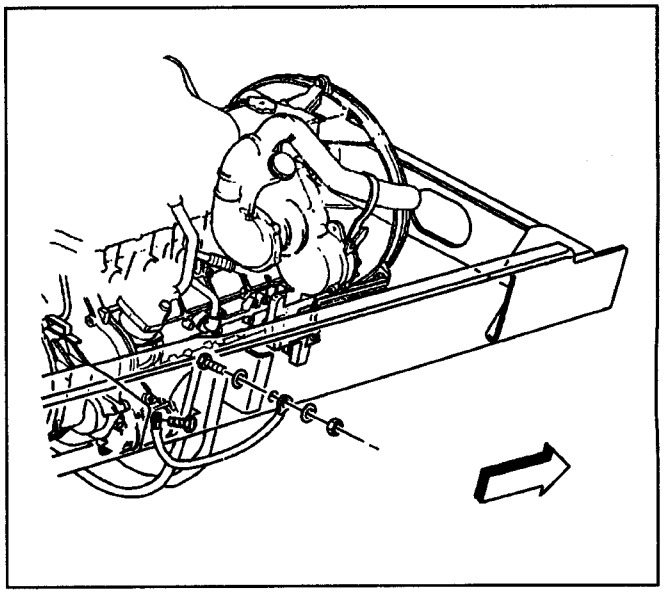
Negative Cable to Engine Installation Procedure

1. Connect the negative cable to the engine.

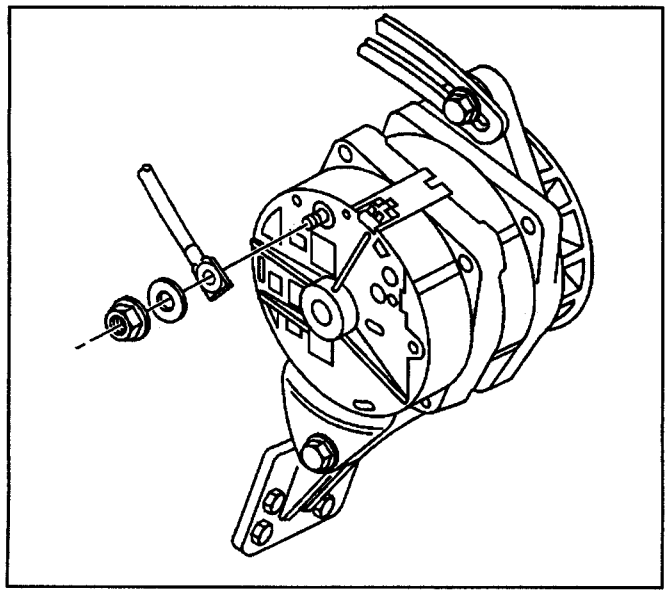
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Connect the negative cable to the frame.

   Tighten

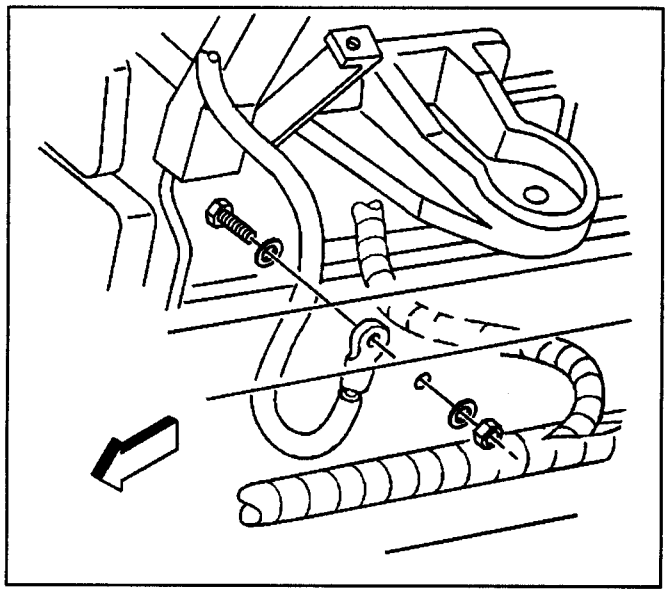
   - Tighten the negative cable to frame bolt to 28 N.m (21 lb ft).
   - Tighten the negative cable to engine bolt to 18 N.m (13 lb ft).



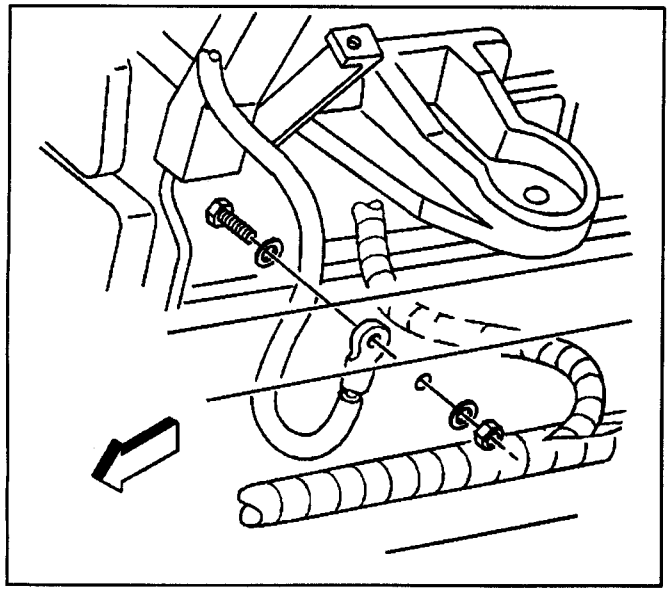
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227237



227251



227251

Ground Strap Replacement

Removal Procedure

1. Tilt the cab. Refer to *Cab Tilting* in General Information.
2. Disconnect the ground strap from the generator.
3. Disconnect the ground strap from the front engine harness.
4. Remove the ground strap from the left side frame rail.
5. Remove the ground strap from the front engine harness.

Installation Procedure

1. Install the ground strap.

   Route the ground strap to the original routing in the front engine harness.
2. Connect the ground strap to the left side frame rail.

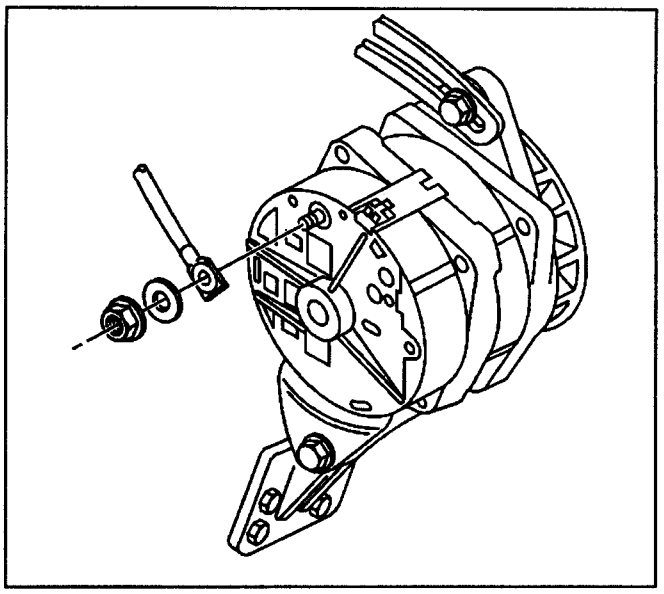
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Connect the ground strap to the generator.

   Use additional ground straps in order to connect the body and the frame to the engine and the transmission. Connect all of the ground straps in order to ensure a proper ground path to the battery from all of the electrical components.

   Tighten

   - Tighten the ground strap bolt to generator to 11 N·m (97 lb in).
   - Tighten the ground strap bolt to frame rail to 30 N·m (22 lb ft).
4. Lower the cab.



227237

Generator Bracket Replacement (Top Mounting Bracket)

Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable. Refer to *Battery Cable Replacement.*
2. Tilt the cab. Refer to *Cab Tilting* in General Information.
3. Remove the belts. Refer to Belt Tension Adjustment in Engine Mechanical.
4. Remove the generator top mounting bolt.
5. Remove the wire harness clamp.
6. Remove the mounting bracket bolts.
7. Remove the mounting bracket.

Installation Procedure

1. Install the mounting bracket.

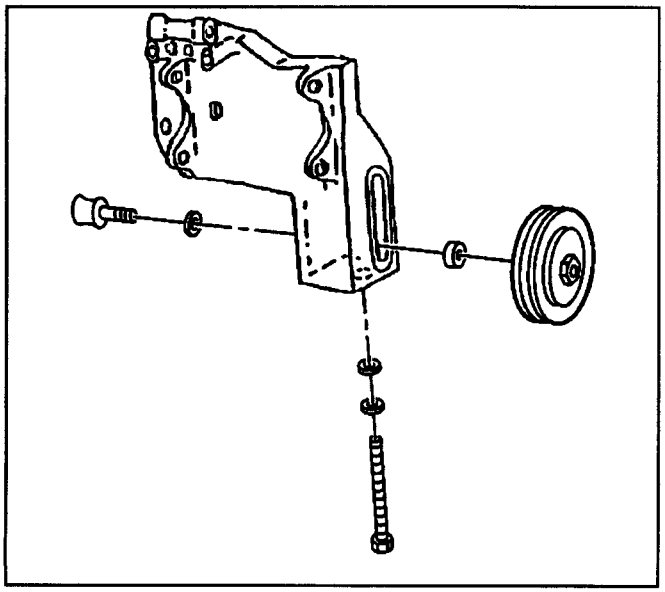
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the mounting bracket bolts.

   Tighten

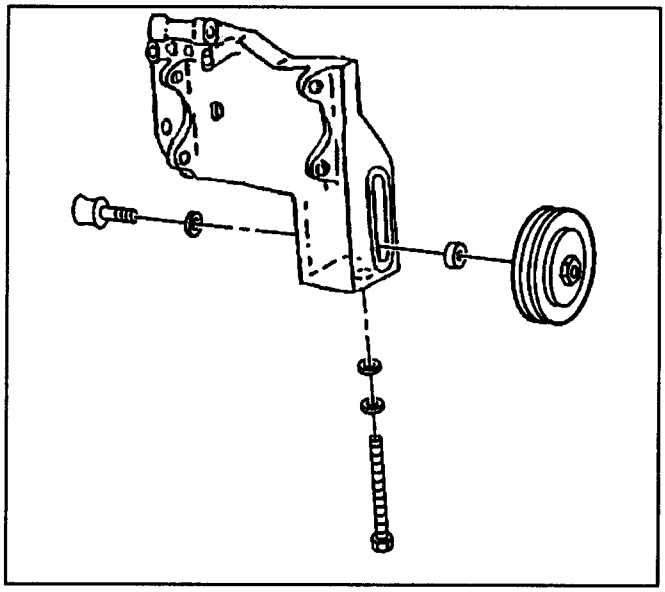
   - Tighten the mounting bracket to engine top bolt to 38 N·m (28 lb ft).
   - Tighten the mounting bracket to engine bottom bolts to 19 N·m (14 lb ft).
3. Install the wire harness clamp.
4. Install the belts.
5. Install the generator mounting bolts.

   Tighten

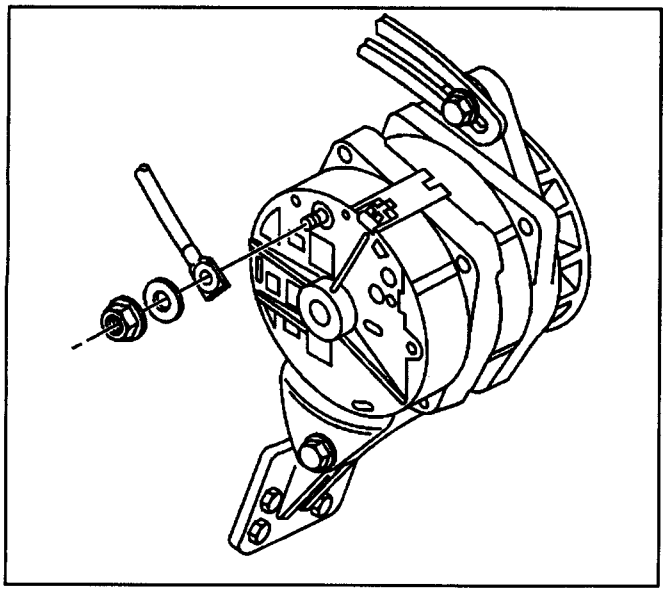
   Tighten the generator mounting bolts to 88 N·m (65 lb ft).
6. Lower the cab.
7. Connect the negative battery cable.



227233



227233



227237

Generator Bracket Replacement (Accessory Mounting Bracket)

Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable. Refer to *Battery Cable Replacement* .
2. Tilt the cab. Refer to *Cab Tilting* in General Information.
3. Remove the generator. Refer to *Generator Replacement.*
4. Remove the air conditioning belt, if equipped. Refer to Belt Tension Adjustment in Engine Mechanical.
5. Remove the air conditioning compressor mounting bolts, if equipped.
6. Remove the accessory mounting bracket bolts.
7. Remove the accessory mounting bracket.

Installation Procedure

1. Install the accessory mounting bracket.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the accessory mounting bracket bolts.

   Tighten

   Tighten the accessory mounting bracket bolts to 50 N.m (37 lb ft).
3. Install the air conditioning compressor mounting bolts, if equipped.

   Tighten

   Tighten the air conditioning compressor mounting bolts to 39 N.m (29 lb ft).
4. Install the air conditioning belt, if equipped.
5. Install the generator.
6. Lower the cab.
7. Connect the negative battery cable.

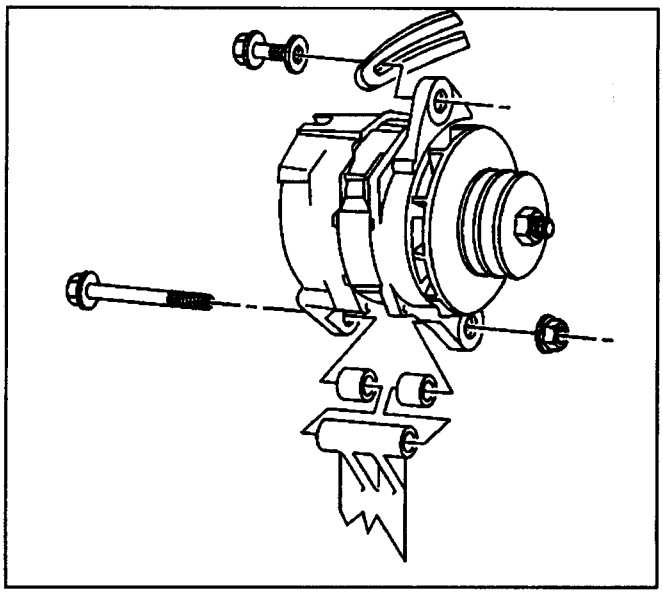
Generator Replacement

Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

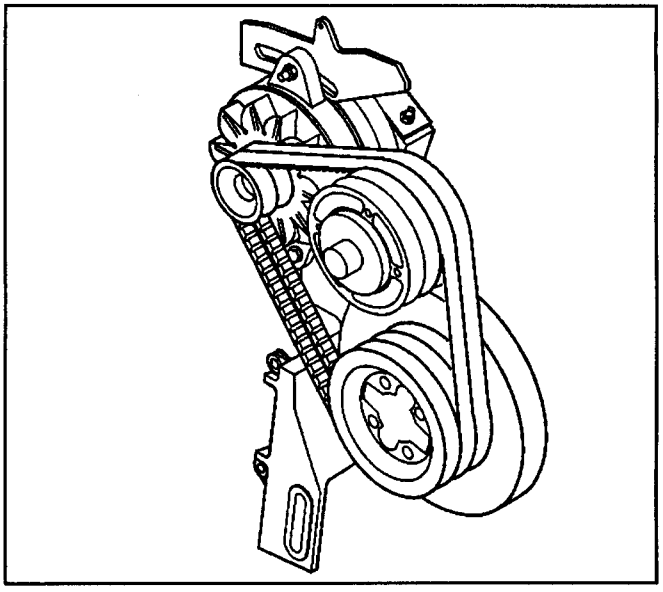
1. Disconnect the negative battery cable. Refer to *Battery Cable Replacement.*
2. Tilt the cab. Refer to *Cab Tilting* in General Information.
3. Disconnect the wiring connectors from the back of the generator.
4. Remove the ground strap.
5. Remove the drive belt. Refer to Belt Tension Adjustment in Engine Mechanical.

6. Remove the generator mounting bolts.
7. Remove the generator.



227236

8. Remove the generator pulley.



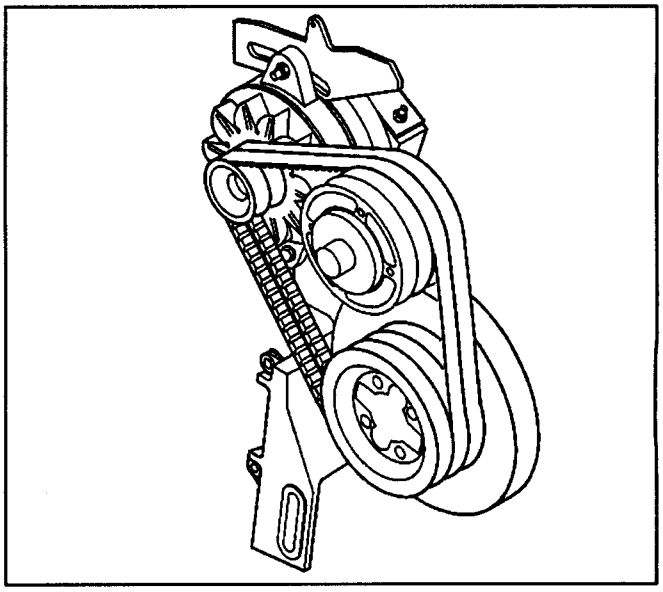
227240

Installation Procedure

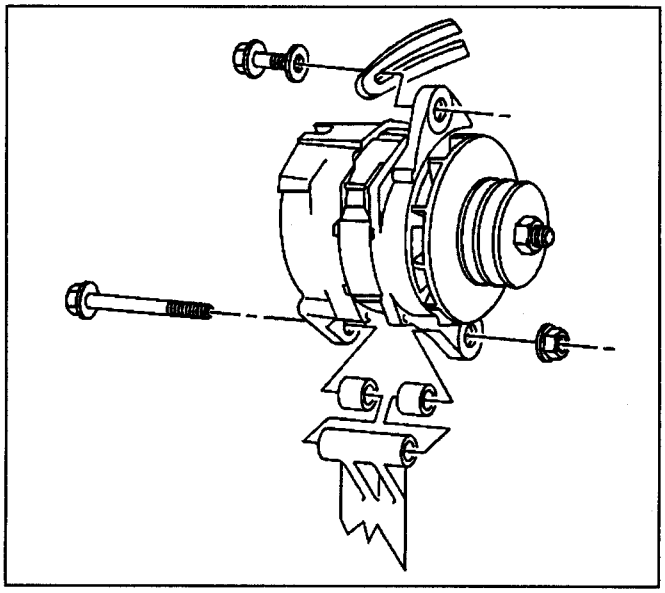
Important: Replace the pulley of the new generator, if the pulley diameter of the new pulley is not exactly equal to the diameter of the old pulley.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the generator pulley.
   Tighten
   Tighten the generator shaft nut to 100 N·m (75 lb ft).

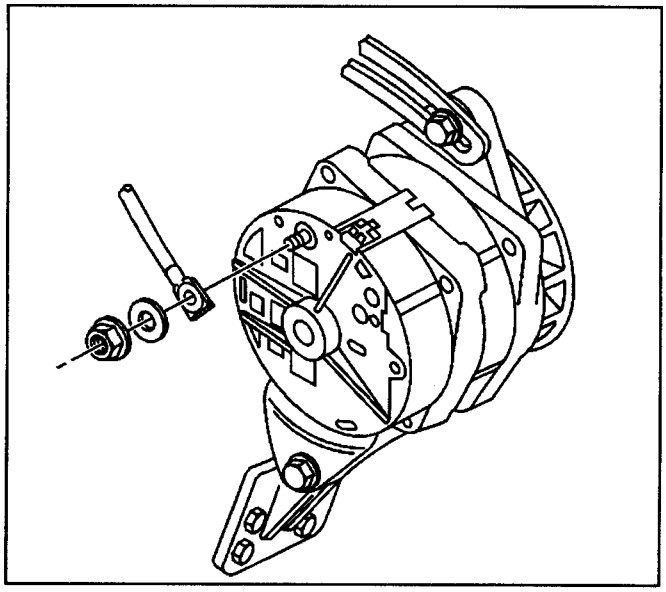


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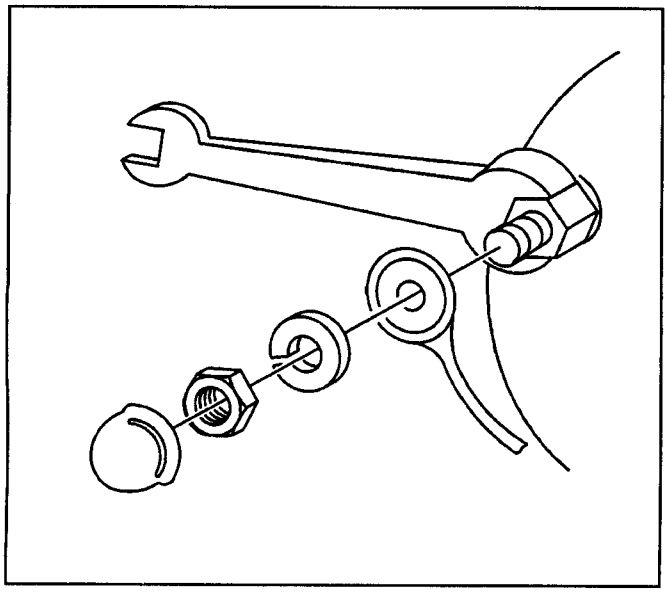
227236

2. Install the generator to the mounting bracket.
   Use mounting bolts in order to secure the generator.



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3. Install the ground strap.
   Tighten
   Tighten the ground strap bolt to 6 N·m (50 lb ft).
4. Install the drive belt.



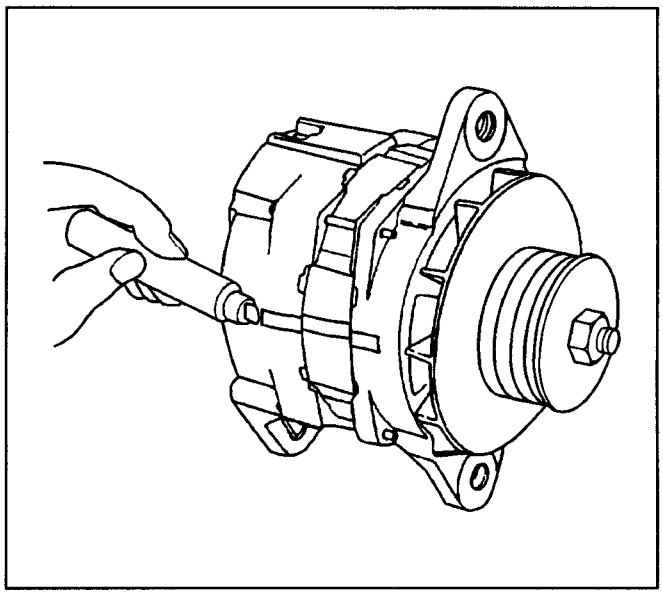
206221

5. Tighten the generator mounting bolts.
   Tighten
   - Tighten the top mounting bolts to 88 N·m (65 lb ft).
   - Tighten the mounting bolts to 88 N·m (65 lb ft).
6. Connect the wiring connectors to the back of the generator.
   Hold the hex-shaped base on the output terminal when you tighten the nuts.
   Tighten
   - Tighten the generator output terminal nut to 12N·m (100 lb in).
   - Tighten the relay terminal nut to 2 N·m (20 lb in).
   - Tighten the indicator terminal nut to 2 N·m (20 lb in).
7. Lower the cab.
8. Connect the negative battery cable.

Generator Overhaul

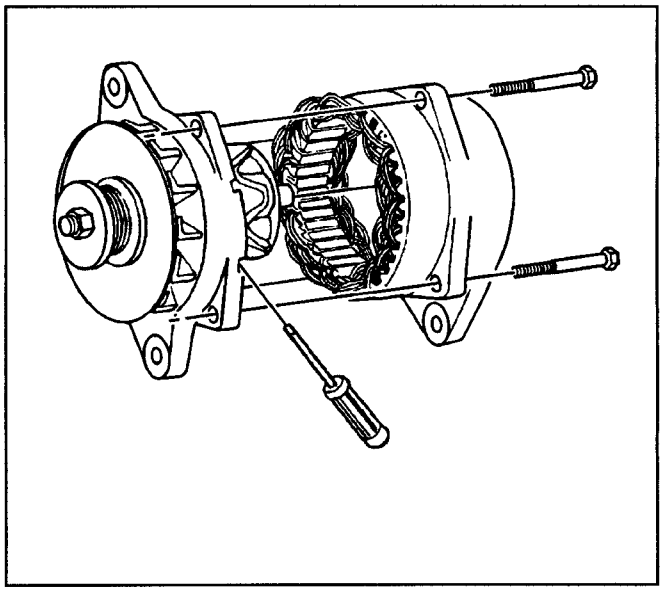
Slip Ring End Frame Disassembly

1. Hold the generator in a vise.
2. Clamp the generator lengthwise onto one mounting lug.
3. Scribe a mark onto the generator frame end parts in order to ensure correct assembly.



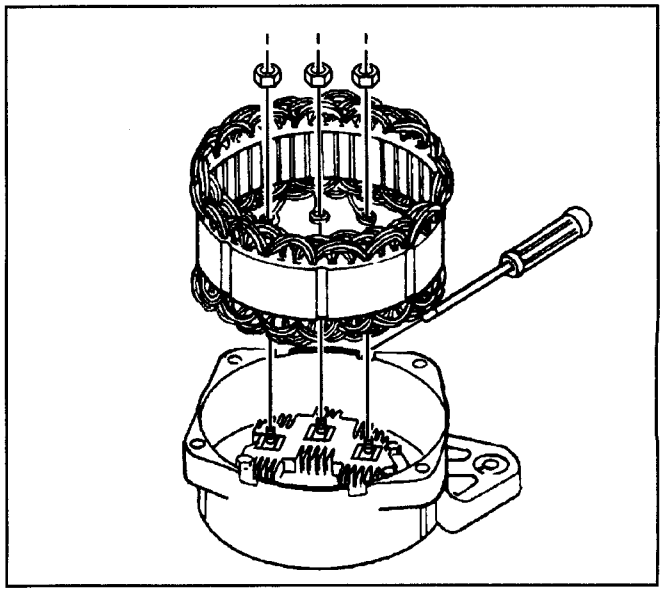
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4. Remove the four through-bolts.
5. Use a screwdriver at the stator slots, if necessary, in order to remove the slip ring end frame from the following components:
   - The drive end frame
   - The rotor assembly

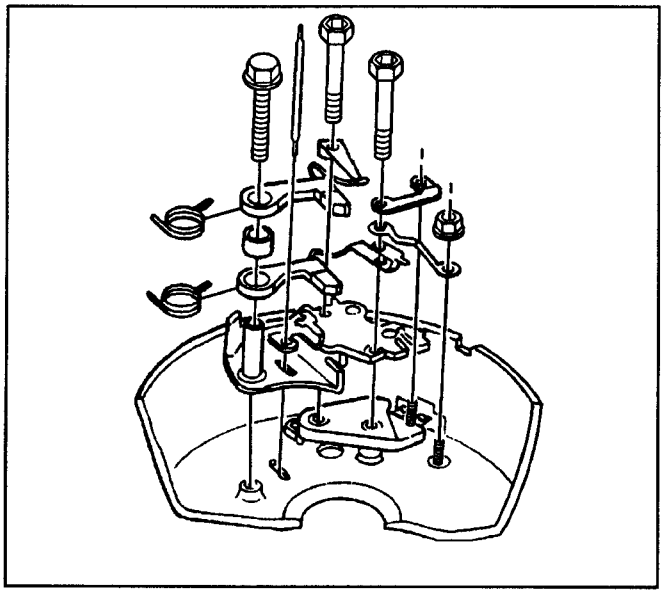


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6. Remove the three rectifier bridge nuts in order to disconnect the stator.
7. Carefully use a screwdriver, if necessary, in order to remove the stator from the slip ring end frame.
8. Remove the nut from the relay terminal connecting strap.
9. Remove the following components from the inside of the frame:
   - The connecting strap
   - The washer
10. Remove the threaded relay terminal from the outside of the frame.
11. Remove the following parts from the regulator:
    - The two insulated screws
    - The one ground screw

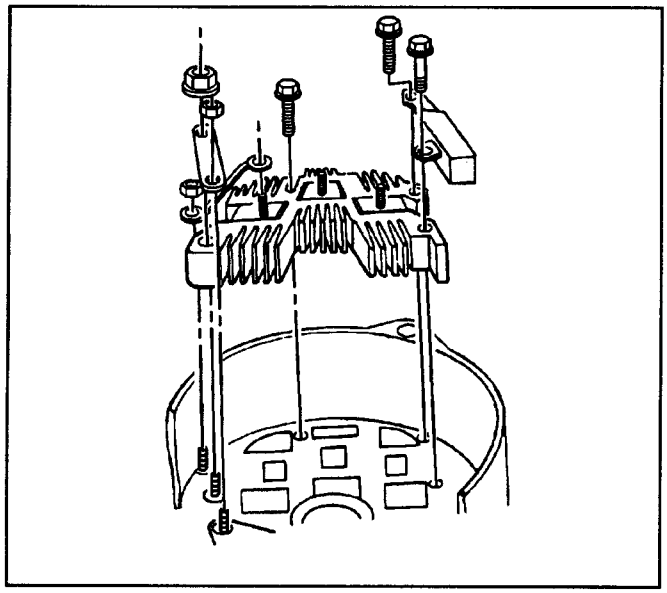


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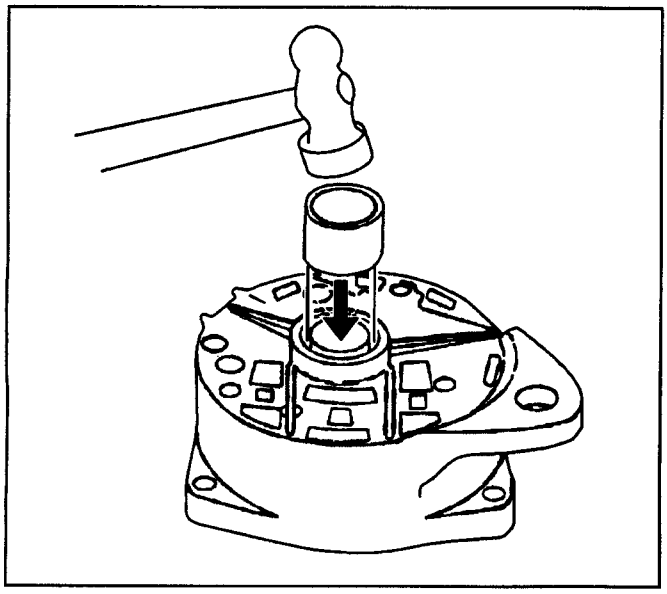
203713

12. Remove the following components from the brush holder.
    - The screw
    - The washer
13. Remove the following parts from the end frame:
    - The regulator
    - The brush holder
    - The diode trio



203711

14. Remove the screws holding the capacitor to the following components:
    - The slip ring end frame
    - The rectifier bridge
15. Remove the following parts on the BAT terminal from the rectifier bridge:
    - The ground screw
    - The ground screw washer
    - The ground screw nut
16. Remove the rectifier bridge from the end frame.
17. Remove the following parts from the outside of the frame.
    - The BAT terminal
    - The BAT terminal shield



203716

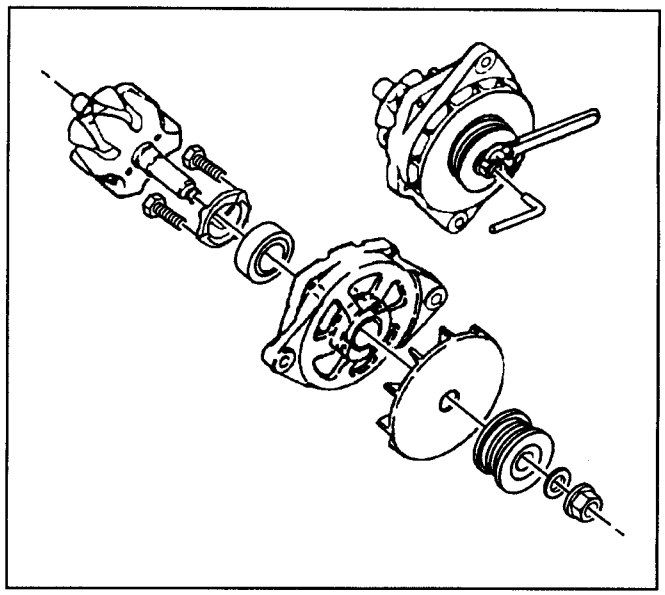
18. Use the following procedure in order to remove the bearing from the slip ring end frame:
    18.1. Support the slip ring end frame from the inside.
    18.2. Obtain a tube that has an outside diameter slightly smaller than the bearing.
    18.3. Use the tube from outside the frame in order to press the bearing in.

Drive End Frame Disassembly

1. Use the following procedure in order to remove the pulley nut:
   1.1. Use the 5/16 inch hex-head wrench in order to hold the end of the shaft.
   1.2. Turn the wrench to the left in order to remove the pulley nut.
   1.3. If a 5/16 inch hex-head wrench is not available, take the following steps:
      1.3.1. Wrap the rotor in a shop cloth.

      Notice: The rotor may be distorted if the vise is overtightened.

      1.3.2. Place the rotor in a vise.
      1.3.3. Tighten the vise in order to hold the rotor while removing the pulley nut.
2. Remove the washer.
3. Remove the pulley.
4. Remove the fan.
5. Use a puller, if necessary, in order to remove the drive end frame from the rotor shaft.
6. Remove the rotor from the vise.
7. Remove the three retainer bolts.
8. Remove the retainer.
9. Use the following procedure in order to remove the bearing from the drive end frame:
   9.1. Use a metal tube that has an inside diameter slightly larger than the outside diameter of the bearing in order to support the drive end frame from the inside.
   9.2. Use a second metal tube against the inner race of the bearing in order to press the bearing from the drive end frame.

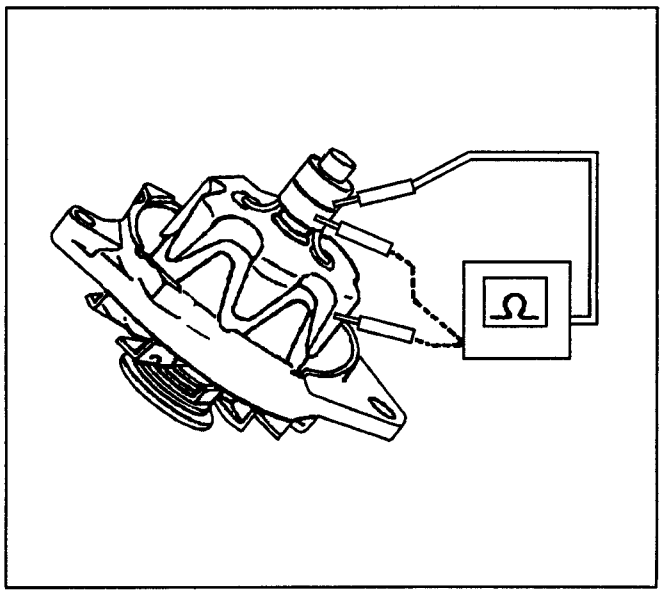


203718

Cleaning and Inspection Procedure

1. Clean all of the metal components except for the following components in a suitable solvent:
   - The voltage regulator
   - The rectifier bridge
   - The stator
   - The rotor
   - The bearing assemblies
2. Use one of the following methods in order to dry the components:
   - Wipe the components.
   - Blow the components.
3. Inspect the brush holder.
4. Inspect the insulating sleeves on the brush holder retaining screws.
5. Inspect the brushes.

   If the brushes are worn more than halfway, replace the brush assembly.



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6. Inspect the brush springs for the following conditions:
   - Discoloration
   - Weakness
7. Inspect the bearing seals.

   If the felt seal in the drive end bearing retainer plate exhibits one of the following conditions, replace the retainer assembly:
   - Hardness
   - Wear
8. Inspect the bearings for grease.

   Use the following standard in order to replace the bearing:
   - If the slip ring end bearing grease supply is exhausted, replace the bearing.
   - If the slip ring end bearing grease supply is not exhausted, relubricate the bearing. Refer to Lubrication in order to use the correct type of lubricant.
9. Replace the rotor and the stator windings if any of the following conditions exist:
   - Burnt insulation
   - Cracked insulation
   - Broken wires
   - Broken connectors
10. Inspect the rotor slip rings.

    Notice: The rotor must be rotated so that the slip rings will be cleaned evenly. Cleaning the slip rings by hand without spinning the rotor may result in flat spots on the slip rings, causing brush noise.

    10.1. If the slip rings are dirty, use the following procedure in order to clean the slip rings:
        10.1.1. Obtain a polishing cloth with a grain of 400 or finer.
        10.1.2. Spin the rotor.
        10.1.3. Hold the polishing cloth against the slip rings until the slip rings are clean.

    10.2. If the slip rings are rough or out of round, use the following procedure in order to true the rings:
        10.2.1. Use a lathe in order to true the slip rings to 0.05 mm (0.002 in) maximum indicator reading.
        10.2.2. Remove only enough material in order to make the rings smooth and round.
        10.2.3. Use a polishing cloth with a grain of 400 or finer in order to finish the rings.
        10.2.4. Blow away all of the dust.

11. Perform electrical tests on the following components.
    - The rotor
      Refer to Rotor Field Winding Tests.
    - The stator windings
      Refer to Stator Tests.
12. Inspect the drive end housing for damage.
13. Inspect the slip ring end housing for damage.

Rotor Field Winding Tests

Use a self-powered test lamp or an ohmmeter on the low range scale in order to perform an electrical test the rotor.

Open Circuit Test

1. Connect the test lamp or the ohmmeter to each slip ring in order to test for opens.
2. The winding is open if the lamp fails to light or if the ohmmeter reading is high (infinite).

Short Circuit or Resistance Test

1. Use one of the following two methods in order to test the winding for short-circuits or excessive resistance:

   Using an Ammeter

   1.1. Connect a 12 volt battery and an ammeter in series with the edges of the two slip rings.

   1.2. Compare the reading on the ammeter to the specified values for 21-SI 200 generators. Refer to *Generator Usage*.

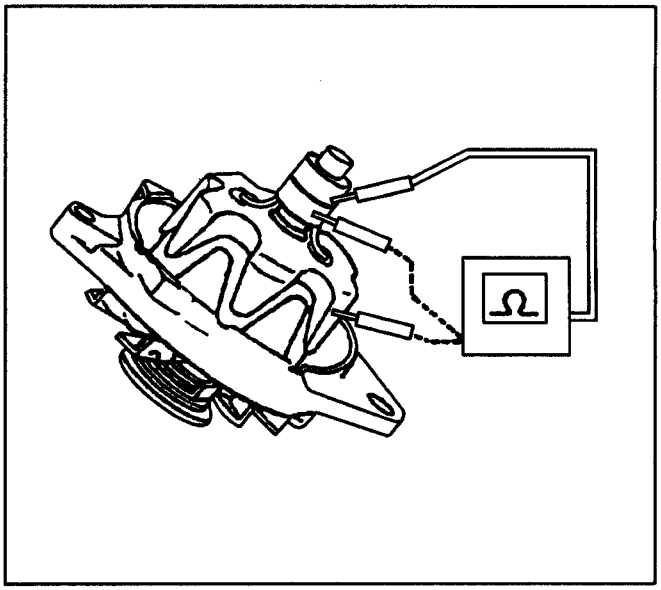
   1.3. Use the following procedure in order to identify a short circuit or excessive resistance.
   - If the ammeter reading is above the specified value, then the windings are shorted.
   - If the ammeter reading is below the specified value, then the resistance is excessive.

   Using an Ohmmeter

   1.1. Connect an ohmmeter to the two slip rings.

   1.2. Compare the reading on the ohmmeter to the specified values for 21-SI 200 generators. Refer to *Generator Usage*.

   1.3. If the resistance reading is below the value specified value, then the resistance is excessive.

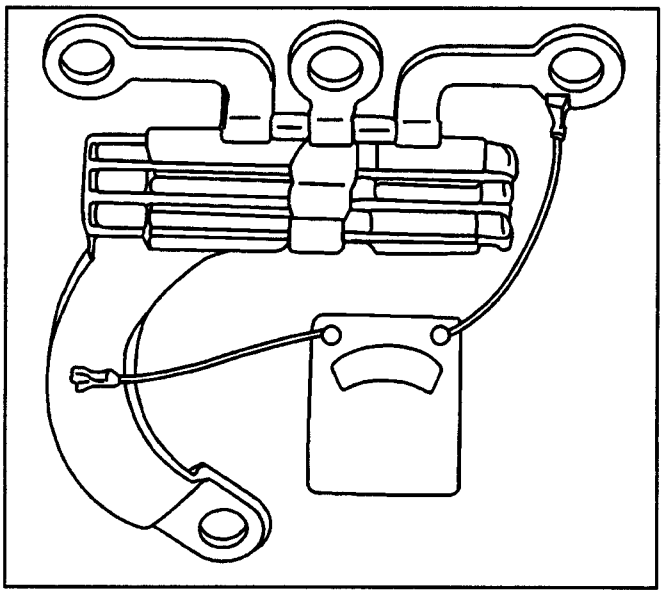


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2. Use the following guides in order to diagnose winding malfunctions:
   - The winding resistance and ammeter readings will vary slightly according to temperature changes in the winding.
   - If the rotor is good but the generator fails to supply the rated output, then the problem is in one of the following components:
     - The diode trio
     - The rectifier bridge
     - The stator
     - The regulator
   - Use the following procedure in order to test for grounds:
     2.3.1. Connect the ohmmeter as shown.
     2.3.2. Replace the rotor if the reading is less than infinite.
3. Replace the rotor if the results of the rotor tests are not within specifications.

Diode Trio Test

Use an ohmmeter with a 1.5 volt cell set to the lowest range scale in order to test the diode trio. Use the following procedure:



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1. Place the negative lead of the ohmmeter on the regulator strap.
2. Use the positive lead of the ohmmeter in order to test for continuity between each of the three rectifier bridge straps.
3. Ensure that all three readings indicate continuity.
4. Reverse the ohmmeter leads.
5. Perform the test again.
6. Ensure that all three readings indicate open circuits.
7. Replace the diode trio if any of the readings are wrong.

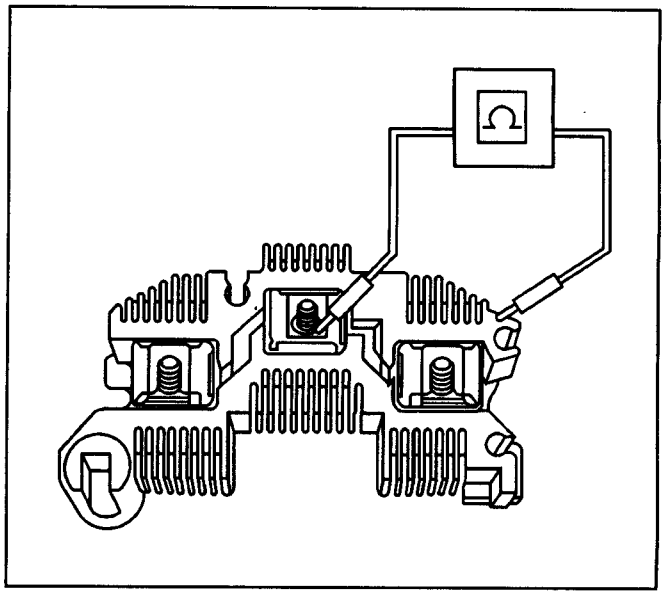
The ohmmeter test of the diode trio is a valid and accurate test. Do not replace the diode trio unless at least one pair of readings is the same.

Rectifier Bridge Test

Use an ohmmeter with a 1.5 volt cell set to the lowest range scale in order to test the rectifier bridge. Use the following procedure:

1. Connect an ohmmeter to the following components in order to test the rectifier bridge:
   - The grounded heat sink
   - One of the three flat metal connectors

   Do not bend the flat metal clips.
2. Observe the ohmmeter reading.
3. Reverse the lead connections to the grounded heat sink and the same flat metal connector.
4. A good rectifier bridge will show one high reading and one low reading. If both readings are the same, then replace the rectifier bridge.
5. Repeat the above test procedure between the grounded heat sink and the other two connectors.
6. Repeat the above test procedure between the insulated heat sink and each of the three connectors.
7. Complete a total of six tests using two readings for each test.



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The ohmmeter test of the rectifier bridge is a valid and accurate test. Do not replace the rectifier bridge unless at least one pair of readings is the same.

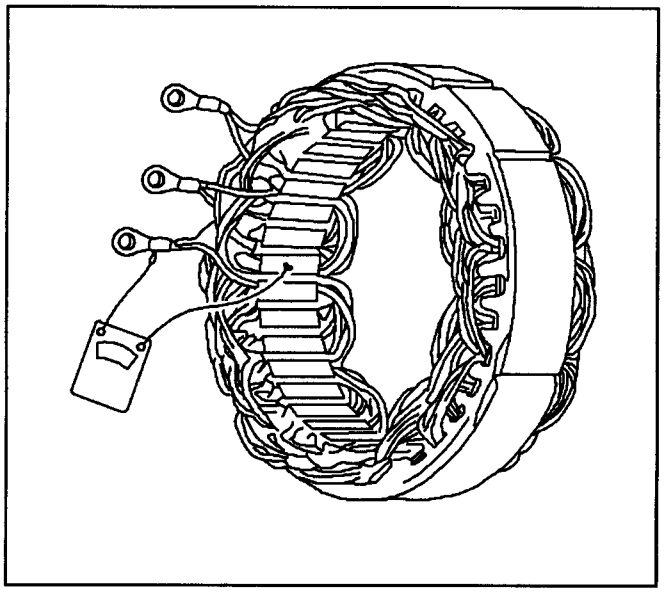
Stator Tests

1. Use a self-powered test lamp or an ohmmeter in order to test the stator windings.
2. If the test lamp lights or if the meter reading is low when connected from any stator lead to the frame, then the windings are grounded. Refer to *Generator Usage*.
3. If the windings are grounded, replace the stator.

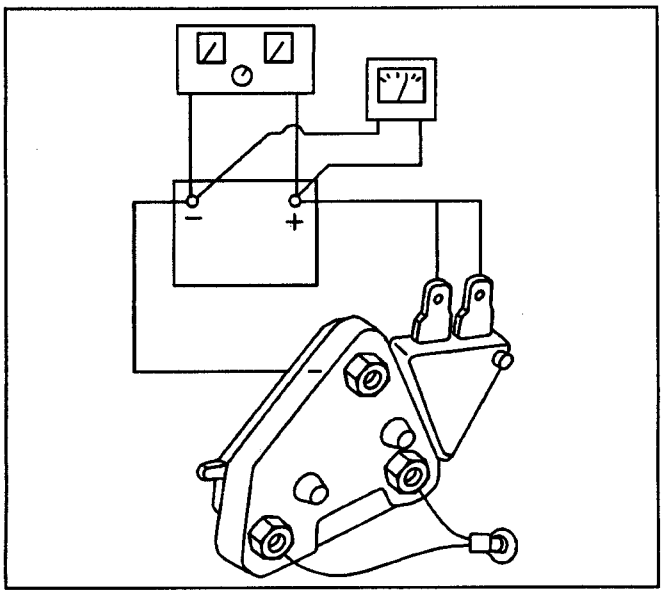
Locating an open or a short circuit in the delta stator windings is difficult without using laboratory test equipment. Locating an open or a short circuit in the delta stator windings is difficult because of the low resistance of the windings. The following conditions indicate shorted or open delta windings:

- All other electrical test are normal.
- The generator does not produce within 15 amps of the rated output.

If the above conditions exist, replace the stator.



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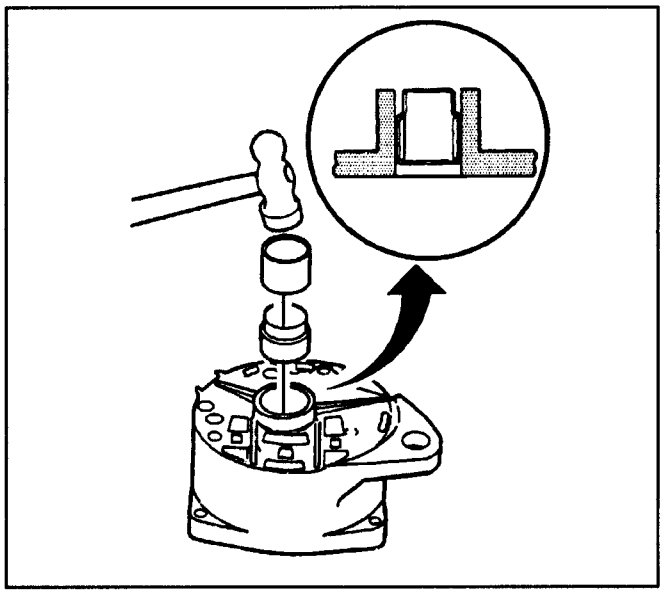
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Testing the Regulator

1. Connect the following items to the 12 volt battery
   - The voltmeter
   - The fast charger
2. Connect the following components:
   - The regulator
   - The test lamp
3. Observe the polarity of the battery.
4. Verify that the test lamp is ON.
5. Turn ON the fast charger.
6. Slowly increase the charge rate.
7. Observe the voltmeter.
8. Verify that the lamp turns OFF at the voltage regulator setting.
9. Verify that the voltage regulator setting is a minimum of 13.5 volts and a maximum of 15.5 volts.

The test lamp connects into the circuit exactly as the rotor is when the regulator is inside the generator. The regulator shuts off the current to the test lamp when the voltage reaches the regulator setting.

If you cannot test the regulator, and the regulator is questionable after testing the other components, replace the regulator with a new or a known good regulator.



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Generator Assembly

1. Use the following procedure in order to install the bearing into the slip ring end frame:
   1.1. Support the inside of the frame.
   1.2. Use a thin wall tube in the space between the grease cup and the housing in order to push the bearing in flush with the housing.
2. Use the following procedure in order to install the bearing into the drive end frame:
   2.1. Support the drive end frame on a flat surface.
   2.2. Use a tube against the outer race of the bearing in order to press the bearing in.
3. Install the retainer.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
4. Install the three retainer screws.

   Tighten

   Tighten the three retainer screws to 3 N.m (26 lb in).

5. Install the drive end frame onto the rotor shaft.
6. Install the fan.
7. Install the pulley.
8. Install the washer.
9. Install the pulley nut.

   Notice: Too much pressure applied against the rotor will distort it.
10. Place the rotor in a vise.

    Tighten the vise only enough to tighten the pulley nut.

    Tighten

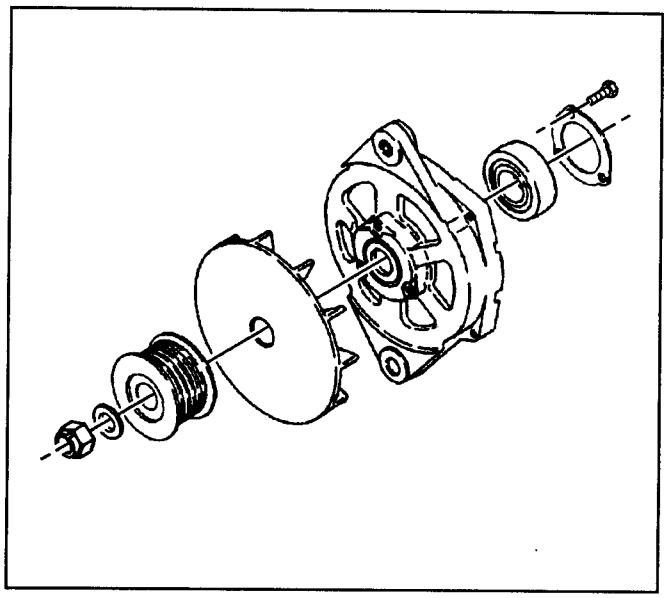
    Tighten the pulley nut to 100 N·m (74 lb ft).
11. Remove the assembly from the vise.
12. Install the following components onto the slip ring end frame:
    - The rectifier bridge
    - The capacitor
13. Use the following components in order to secure the rectifier bridge and the capacitor to the slip ring end frame:
    - Two ground screws
    - One insulated screw

    Tighten

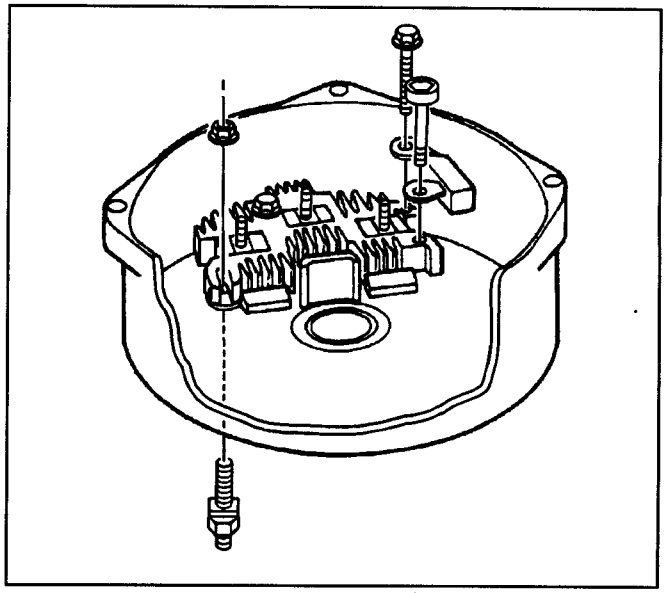
    - Tighten the ground screws to 3 N·m (25 lb in).
    - Tighten the insulated screw to 2.5 N·m (22 lb in).
14. Install the BAT terminal from the outside of the slip ring end frame.
15. Install the nut onto the BAT terminal stud.

    Tighten

    Tighten the nut to 5.5 N·m (50 lb in).



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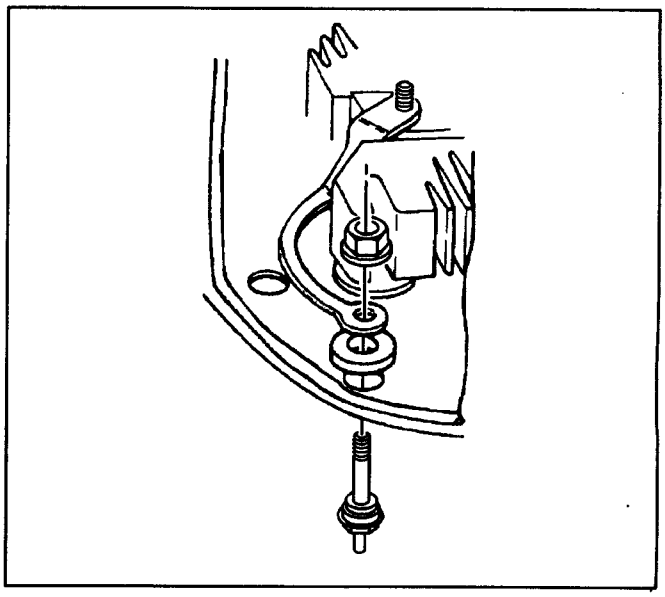


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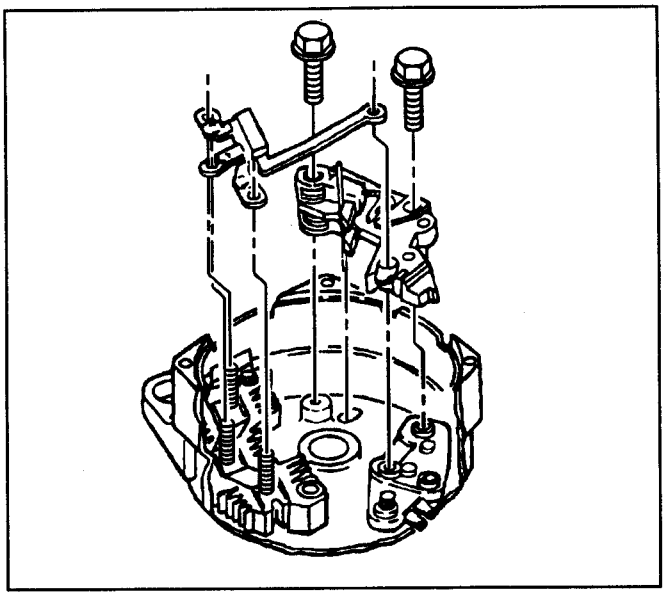
16. Install the relay terminal from the outside of the slip ring end frame.
17. Use the copper nut in order to secure the insulated washer and the attaching strap from the rectifier bridge to the relay terminal.

    Tighten

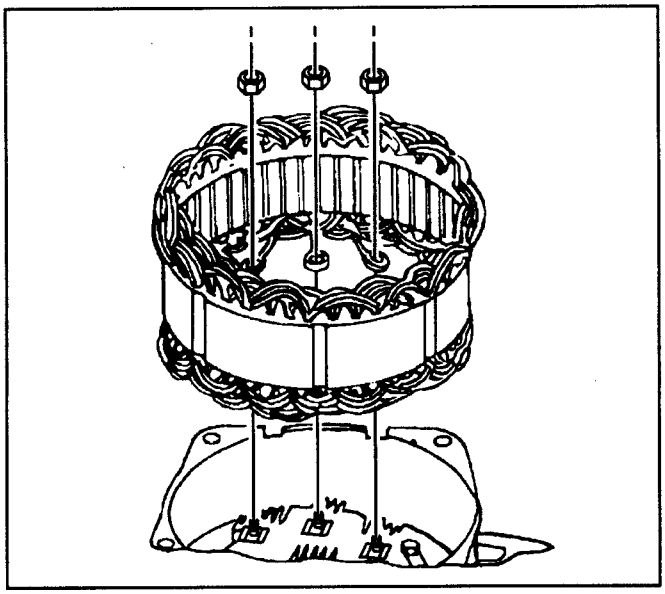
    Tighten the copper nut to 2.5 N·m (22 lb in).
18. Install the brushes into the brush holder assembly.
19. Use a retainer in order to retain the brushes.
20. Ensure that the long end of the retainer extends through the end frame in order that you are able to remove the retainer after you install the rotor and the drive end frame.



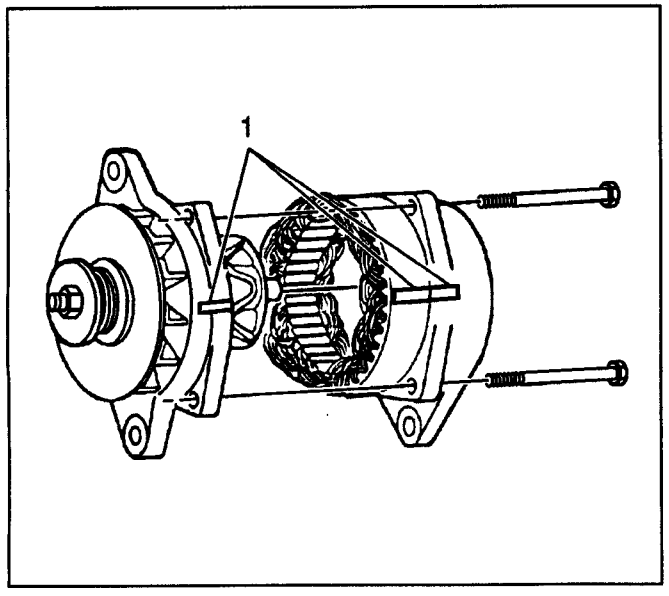
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21. Install the following components to the end frame:
    - The regulator
    - The brush holder assembly
    - The diode trio
22. Use the following components in order to secure the regulator, the brush holder assembly and the diode trio to the end frame:
    - The ground screw
    - The insulated screws
23. Install the nut onto the stud on the regulator:
    Tighten
    Tighten the nut to 2.5 N·m (22 lb in).
24. Install the stator to the following components:
    - The slip ring end frame
    - The three rectifier bridge terminals
25. Use the three terminal nuts in order to secure the following components to the rectifier bridge:
    - The stator leads
    - The diode trio leads

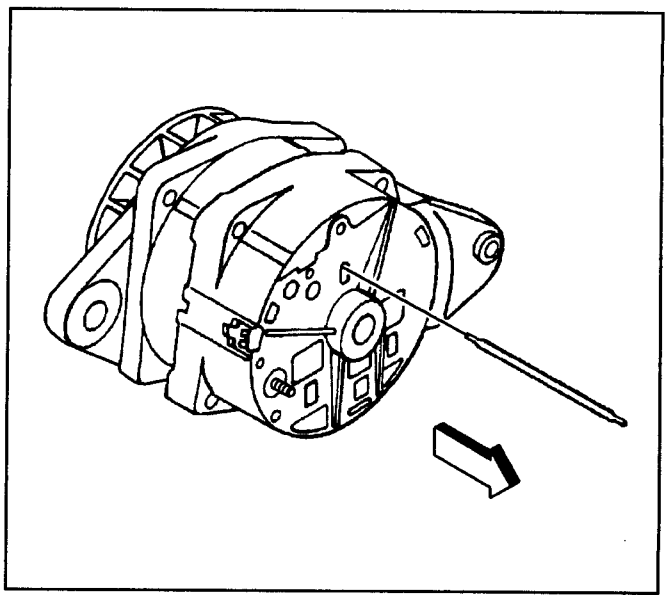
    Tighten

    Tighten the nuts to 2.5 N·m (22 lb in).
26. Use the scribe mark in order to line up the following components to the slip ring end frame:
    - The drive end frame
    - The rotor assembly
27. Use the four through-bolts in order to secure the following components to the slip ring end frame:
    - The drive end frame
    - The rotor assembly

    Tighten

    Tighten the through-bolts to 5.5 N·m (50 lb in).

28. Remove the brush retainer from the end frame.
29. Test the generator output. Refer to *Charging System Check*.



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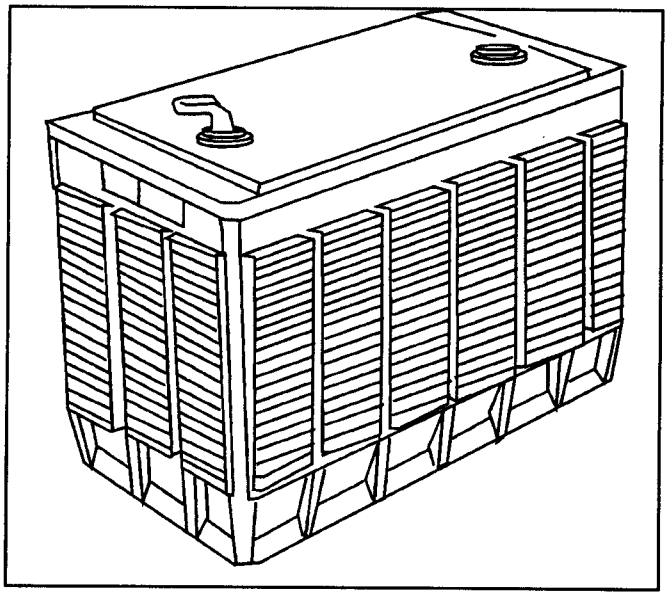
Description and Operation

Battery

The battery performs the following operations in the electrical system:

- Provides a source of energy in order to crank the engine
- Acts as a voltage stabilizer for the electrical charging system
- Provides energy when the vehicle's electrical load exceeds the output of the generator.

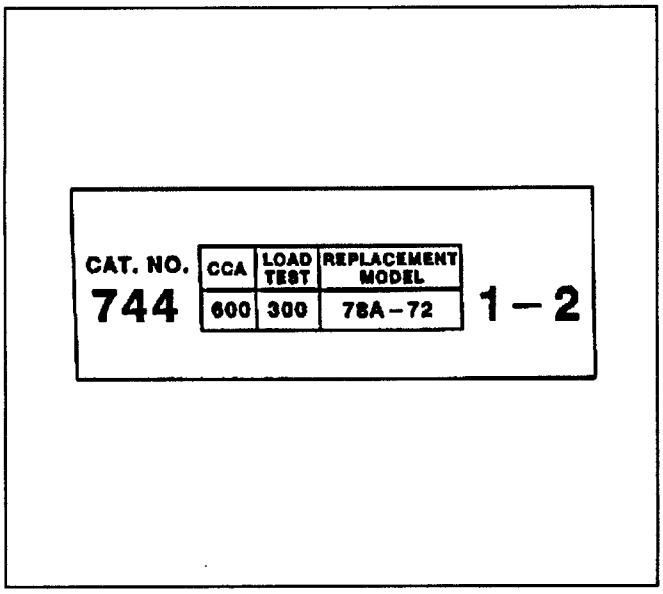
  The battery can only provide this energy for a limited amount of time.



181055

The maintenance-free battery is standard on all vehicles with top terminals. The battery is completely sealed except for two small vent holes. The vent holes are located near the top of the battery on two sides. The vent holes allow the release of a small amount of electrolyte gassing that is produced in the battery.

The battery carrier mounts on the outboard side of the right frame rail under the cab. The two 12-volt batteries are installed into the battery carrier.



106519

The battery specification label contains the following information that is pertinent to servicing the battery:

- Cold cranking amps
- Load test ratings
- Original equipment
- Recommended replacement part numbers

Refer to *General Specifications* for the above information.

Starting System Description

The cranking circuit consists of the following components:

- The battery
- The starter motor
- The engine control switch
- The starter relay
- Related electrical wiring

Vehicles that are equipped with automatic transmissions have a neutral start switch in the circuit.

Some vehicles are equipped with electronically-controlled automatic transmissions. Electronically-controlled automatic transmission vehicles do not have a separate neutral start switch in the cranking circuit. The switch is built into the Vehicle Interface Module (VIM).

Refer to component location.

Refer to *Starting System Circuit Description* for a detailed circuit description.

The starter is a reduction gear drive model with a direct acting solenoid. The solenoid works through the overrunning clutch. The gear housing and the armature end bearing housing are aluminum. The bearings on the armature are sealed ball bearings. The brush assembly brushes are replaceable. The ball bearings on the clutch assembly are serviced as part of the entire clutch assembly. The commutator bars are mica insulated and are undercut.

The shift lever mechanism and the solenoid plunger are within the drive housing. The drive housing protects the shift lever mechanism and the solenoid plunger from exposure to the following conditions:

- Dirt
- Ice
- Splash

The solenoid operates when the engine control switch is turned to the START position (the automatic transmission is in neutral). When the solenoid energizes the main contacts close, completing the electrical circuit between the battery and the starter motor. Energizing the solenoid also shifts the plunger and the shift lever. The pinion gear then engages in order to mesh with the engine flywheel ring. Engine cranking then takes place.

The pinion overriding clutch protects the armature from excessive speed when the engine starts. Releasing the engine control switch enables the following actions:

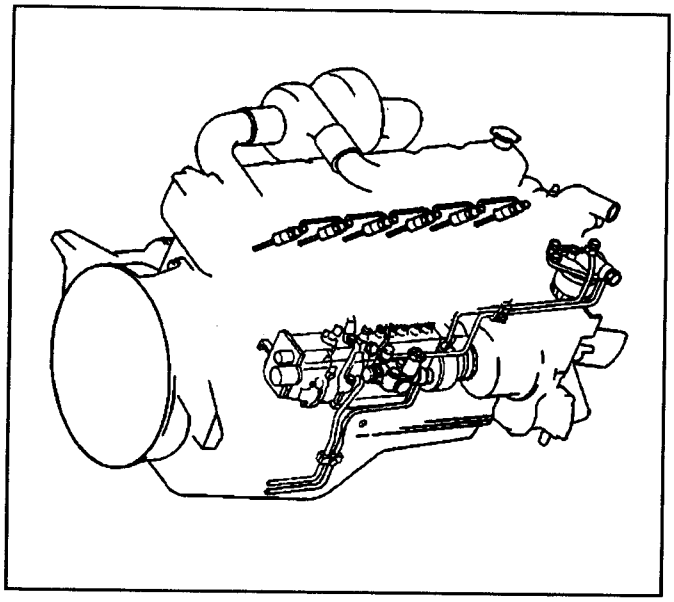
- The solenoid main contacts open
- The plunger return spring disengages the pinion

Release the key immediately after engine starts in order to prevent damage to the starter.

Starting System Operation (Glow Plugs)

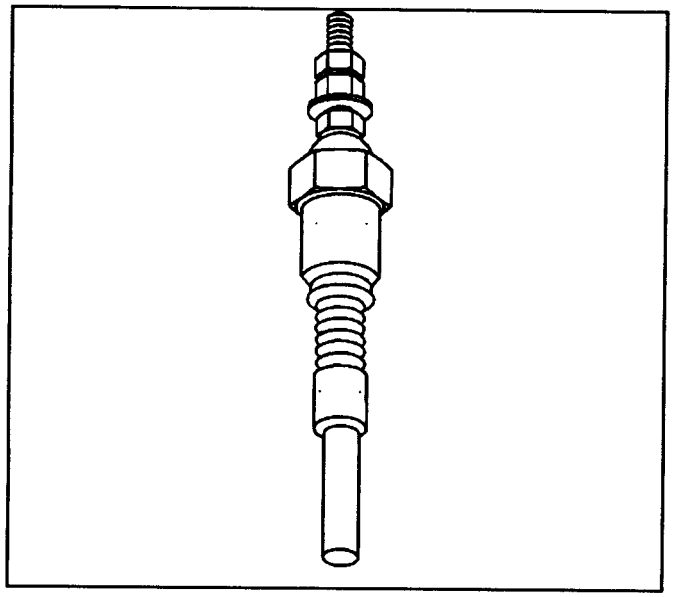
Notice: Never manually spray starting aid fluids into the air intake where the fluid may come in contact with the heater element. This could result in an explosion and/or fire.

Diesel engines rely on the heat of compression in order to initiate combustion. Cold engine start-ups may require extra engine cranking time in order to create the necessary heat needed in order to ignite the diesel fuel.



227701

Glow plugs are one of the devices available in order to aid in cold starting the diesel engine. Six glow plugs are used in order to preheat the combustion chambers as an aid to starting.



227706

The glow plugs are 10.5 volt heaters that are operated at 12 volts when the engine control switch turns to the H position. The glow plugs provide a pre-heat feature to the combustion chamber. The glow plugs also improve cold weather engine start ups.

Starting System Operation (Starting Procedure)

Use the following procedure in order to initiate glow plug operation:

1. Turn the engine control switch to the H position.
2. Wait until the glow plug indicator glows.
3. Crank the engine.
4. Fully depress the accelerator pedal.
5. Release the accelerator pedal.
6. Turn the engine control switch to the START position.

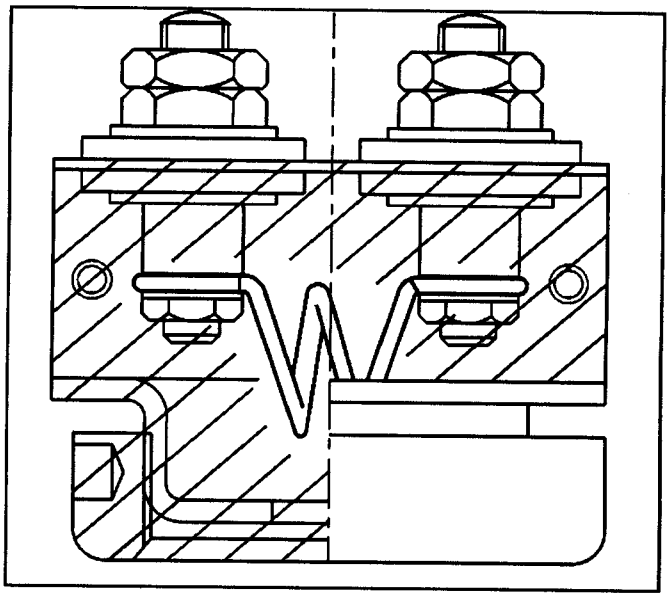
   Release the switch when the engine starts.
7. If the engine does not start after 15 seconds of cranking, repeat the procedure until the engine starts.

Starting System Operation (Glow Plug Operation)

Current flows through the following components when the engine control switch turns to the H position:

- The glow plug relay
- The thermal resistor
- The glow plugs

The current heats the glow plugs to 800°C (1472°F). The glow plugs take 20–25 seconds to heat when the ambient temperature is about 0°C (32°F).



227717

The temperature of the control resistor heats at the same rate as the glow plugs. As the resistor temperature reaches 1000°C (1832°F) the resistor glows red. A glowing red resistor indicates the following conditions:

- The glow plugs are hot.
- The engine control switch can turn to the START position.

Inspect the components and the connections under the following conditions:

- The resistor does not light
- The glow plugs do not heat

Refer to Control Resistor Check.

Starting System Circuit Description

CKT 30 (WHT/RED) from the 25 Amp circuit breaker in the IP fuse block provides battery voltage at the ignition switch at all times. CKT 2 (RED) from the fusible link on the starter provides battery voltage to the starter relay contacts at all times.

When you turn the ignition to the START position, the contacts close in order to apply voltage on CKT 5 (YEL) to the neutral switch (automatic transmission). If the automatic transmission is in the NEUTRAL position, voltage applies to CKT 434 (ORN/BLK) to the starter relay coil. CKT 150 (BLK) grounds the starter relay coil at ground G107.

When voltage applies to the coil, the starter relay energizes. CKT 6 (PPL) then applies voltage to the starter solenoid winding terminal S. CKT 1 (BLK) at starter solenoid terminal B also provides battery voltage at all times.

When battery voltage applies at starter solenoid terminal S, current flows through the hold-in winding to the mechanical ground at the solenoid. Simultaneously, current flows through the pull-in winding and the starter motor to the starter motor's mechanical ground. The combined force of these windings overcomes the force of the return spring. This force pulls the starter's plunger in order to engage the starter with the flywheel drive assembly through the shift lever. The engine turns over. The actuation of the plunger also operates a contact in the starter solenoid. This contact closes in order to apply battery voltage directly to the starter motor. With battery voltage applied directly to the starter motor, the pull-in winding no longer has a voltage drop across the coil. Current ceases to flow. The current flow through the hold-in winding enables the starter solenoid to remain engaged.

The starter motor operates until the ignition switch returns to the RUN position. With the ignition switch in the RUN position, voltage exits through starter solenoid terminal S. However, voltage remains at terminal B. CKT 1 (BLK) energizes both the hold-in winding and the pull-in winding. The forces from these windings now oppose one another. The operation of the return spring returns the plunger to the disengaged position. This action operates the contact in order to remove battery voltage from the starter motor. This action stops the motor. Both windings also de-energize. This plunger operation also retracts the starter from the flywheel drive assembly. The engine operates on the engine's own power.

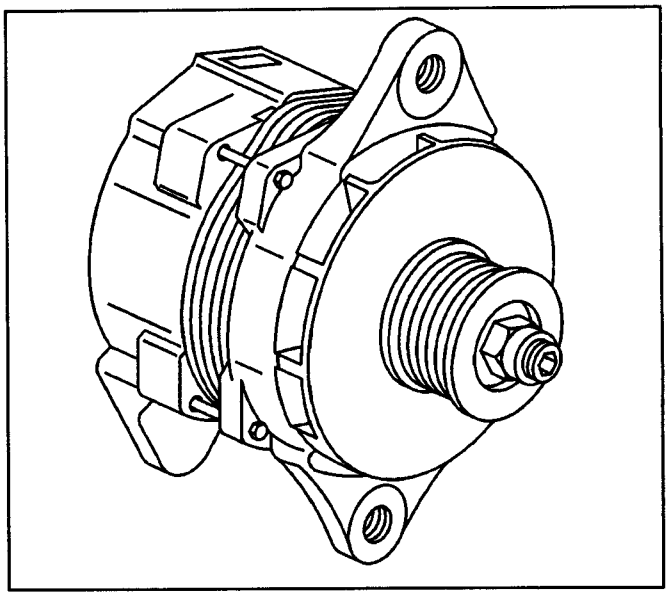
Charging System Description

The charging system consists of the following components:

- The battery
- The generator
- The regulator
- The voltmeter and charging system indicator lamp circitry

The generator supplies electrical power in order to charge the battery and operate the accessories. This vehicle uses the 21-SI 200 generator.

These generators are of the SI (Systems Integral) series. SI generators have a built-in regulator.



203654

The solid state regulator and the brush holder assembly attach to the slip ring end frame. The regulator voltage setting is not adjustable.

The regulator is equipped with the following terminals:

- The R (Relay) terminal.

  The R terminal operates auxiliary equipment in some circuits, such as the tachometer.
- The I (Indicator) terminal.

  The I terminal feeds an indicator lamp or a gauge.

The rotor bearings contain enough grease in order to eliminate the need for periodic lubrication. Two brushes carry current through the two slip rings to the field coil. The field coil mounts on the rotor. Under normal operating conditions, the field coil provides long periods of attention-free service.

The stator windings are assembled on the inside of a laminated core that forms part of the generator frame. A rectifier bridge that connects to the stator windings contains six diodes. The rectifier bridge electrically changes the stator AC voltages to DC voltage. This DC voltage appears at the generator output BAT terminal. A diode trio that connects to the stator windings supplies the generator field current. A capacitor or a condenser mounted to the end frame protects the rectifier bridge and diode trio from high voltages. The capacitor or the condenser also suppresses radio noise.

Charging System Description

The generator provides voltage in order to operate the vehicle's electrical system. The generator also provides voltage in order to charge the battery. The generator operates as an alternator in order to generate Alternating Current (AC) electricity which rectifies to Direct Current (DC) electricity.

A belt drives the generator. The generator rotates as the engine runs. The regulator induces an excitation magnetic field in the generator's rotor. The generator's rotation causes the excitation field to move through the stator windings. The motion of the field through the stator conductors induces an alternating magnetic field to be generated in the stator. Diodes in the rectifier bridge allow stator current to flow as a result of this alternating magnetic field. Stator current only flows in the one direction that charges the battery. The generator's internal solid state voltage regulator regulates the pulse width of the excitation field in order to regulate the voltage generated at the BAT terminal at 14 V, nominally.

The excitation field is present in the generator only when the ignition switch is in the RUN position or the START position. The generator does not contain permanent magnetism of sufficient strength in order to produce a useable excitation magnetic field. The generator's Turn On input is present from CKT 25 (BRN). CKT 25 (BRN) connects the generator to the instrument cluster. Voltage is present to the instrument cluster from circuit breaker 25 in the IP fuse block. The BAT indicator lamp only illuminates when sufficient current flow exists in order to cause the lamp filament to emit light. The resistor allows the slight current flow used by the generator in normal operations. The resistor bypasses the indicator lamp. Thus, an open filament in the lamp does not prevent generator operations.

The generator controls the BAT indicator lamp in the instrument cluster. Internal logic at the generator closes an internal contact to ground the indicator lamp circuit when the generator is not rotating or when the sensed generator output voltage is either too high or too low. The indicator lamp circuit is only powered when the ignition switch is in the RUN or START position.

Special Tools and Equipment

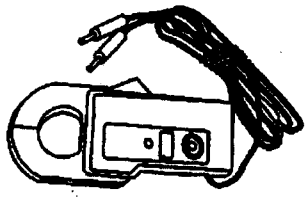
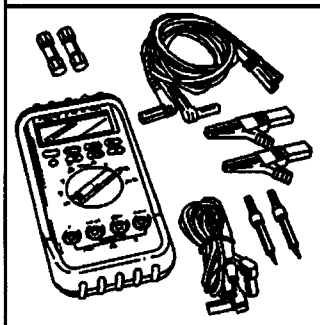
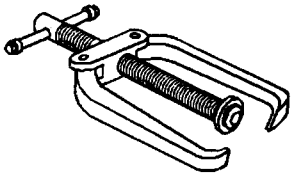
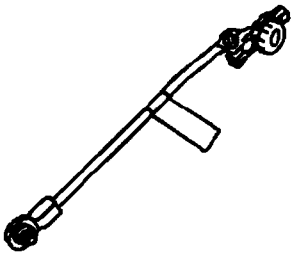
Illustration	Tool Number/ Description
 95591	J 35590 Current Clamp
 3430	J 39200 Digital Multimeter
 48445	J 28509-A Bearing Remover

Illustration	Tool Number/ Description
 3429	J 24642-F Module Tester
 3432	J 38758 Parasitic Draw Test Switch

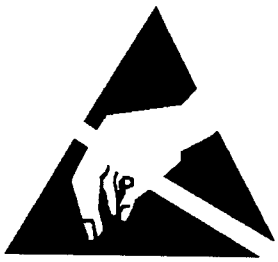
Engine Controls - 7.8L

Schematic and Routing Diagrams

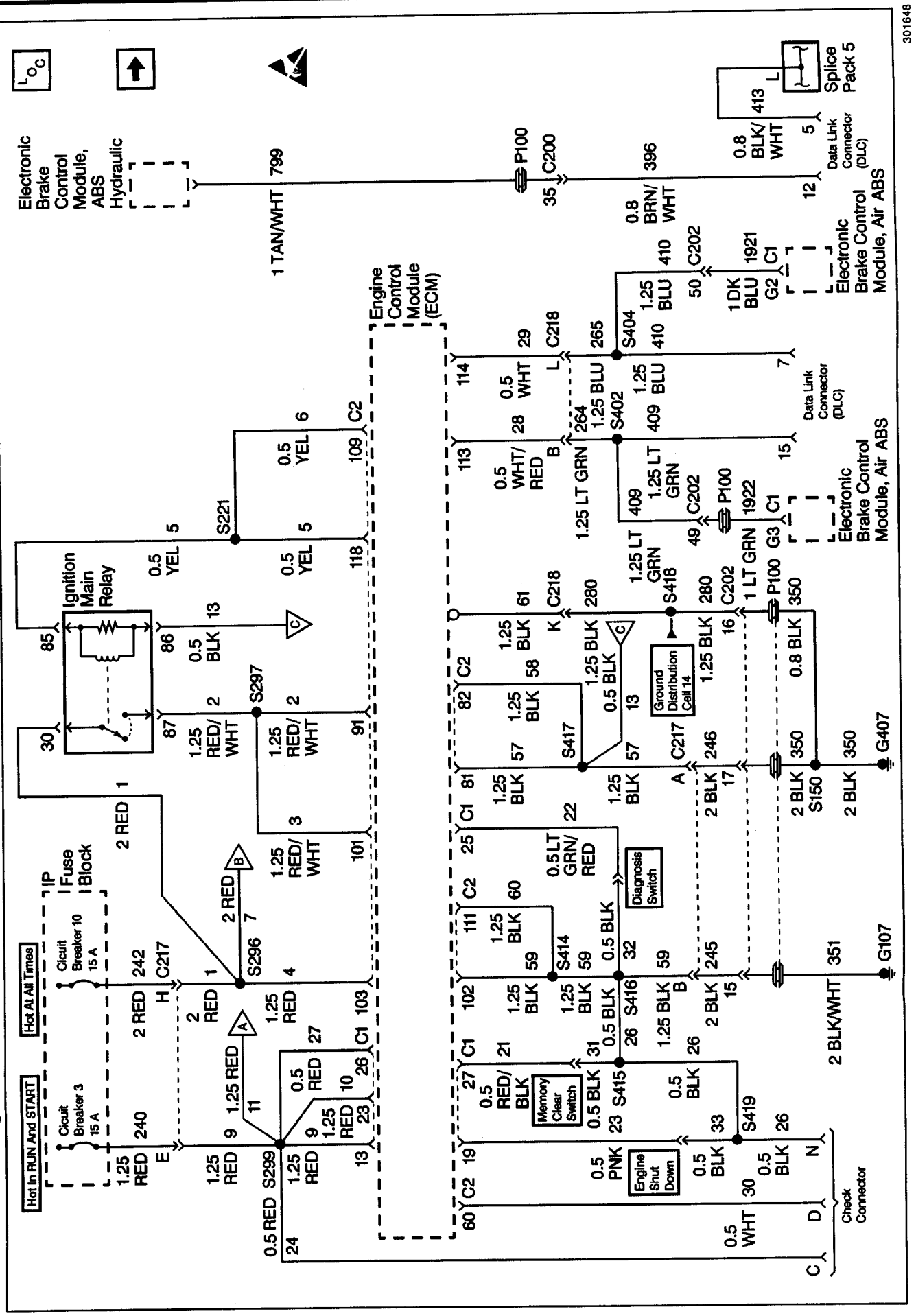
Engine Controls Schematic References

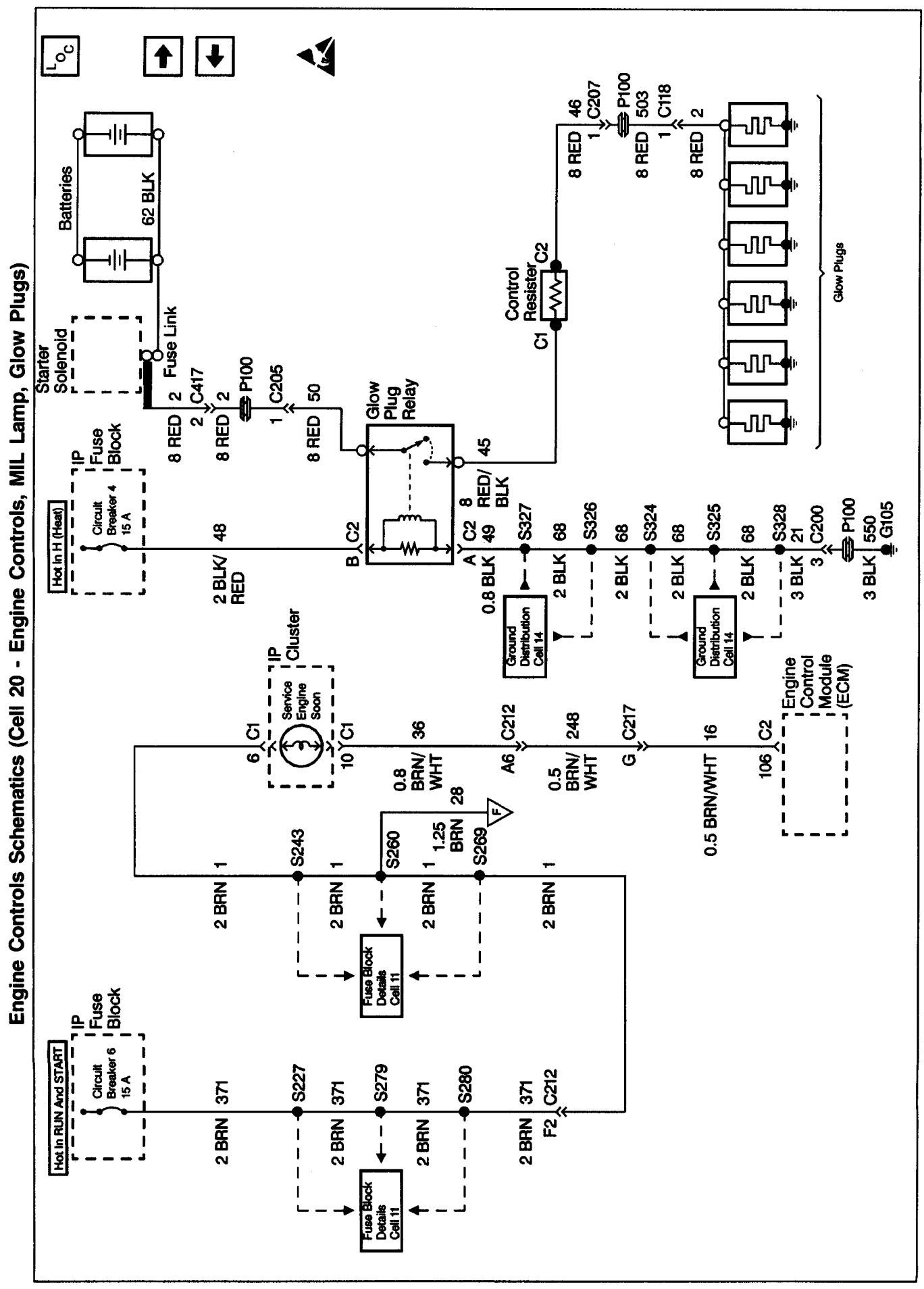
Reference on Schematic	Section Number - Subsection Name
Fuse Block Details Cell 11	8—Wiring Systems
Ground Distribution Cell 14	8—Wiring Systems

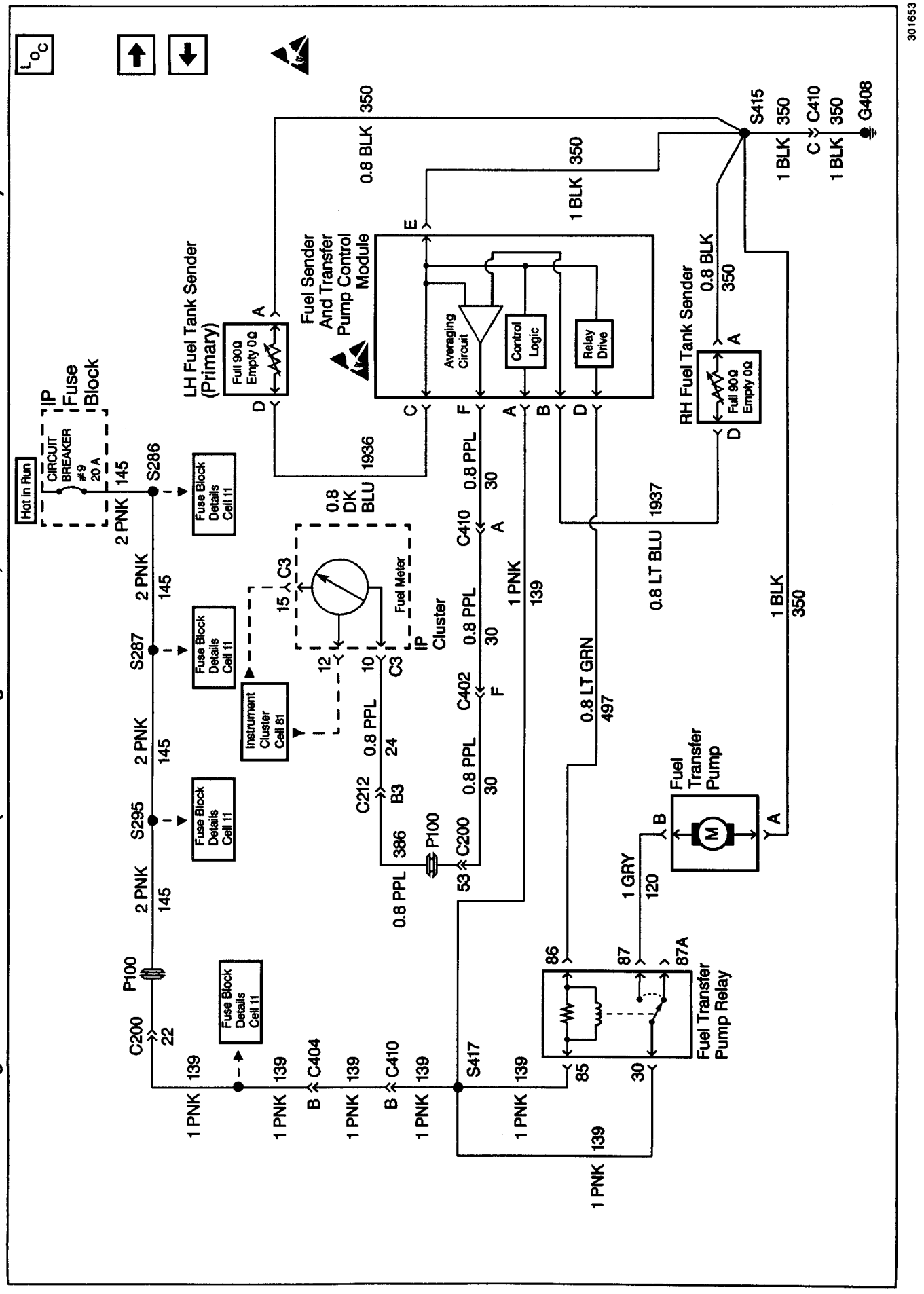
Engine Controls Schematic Icons

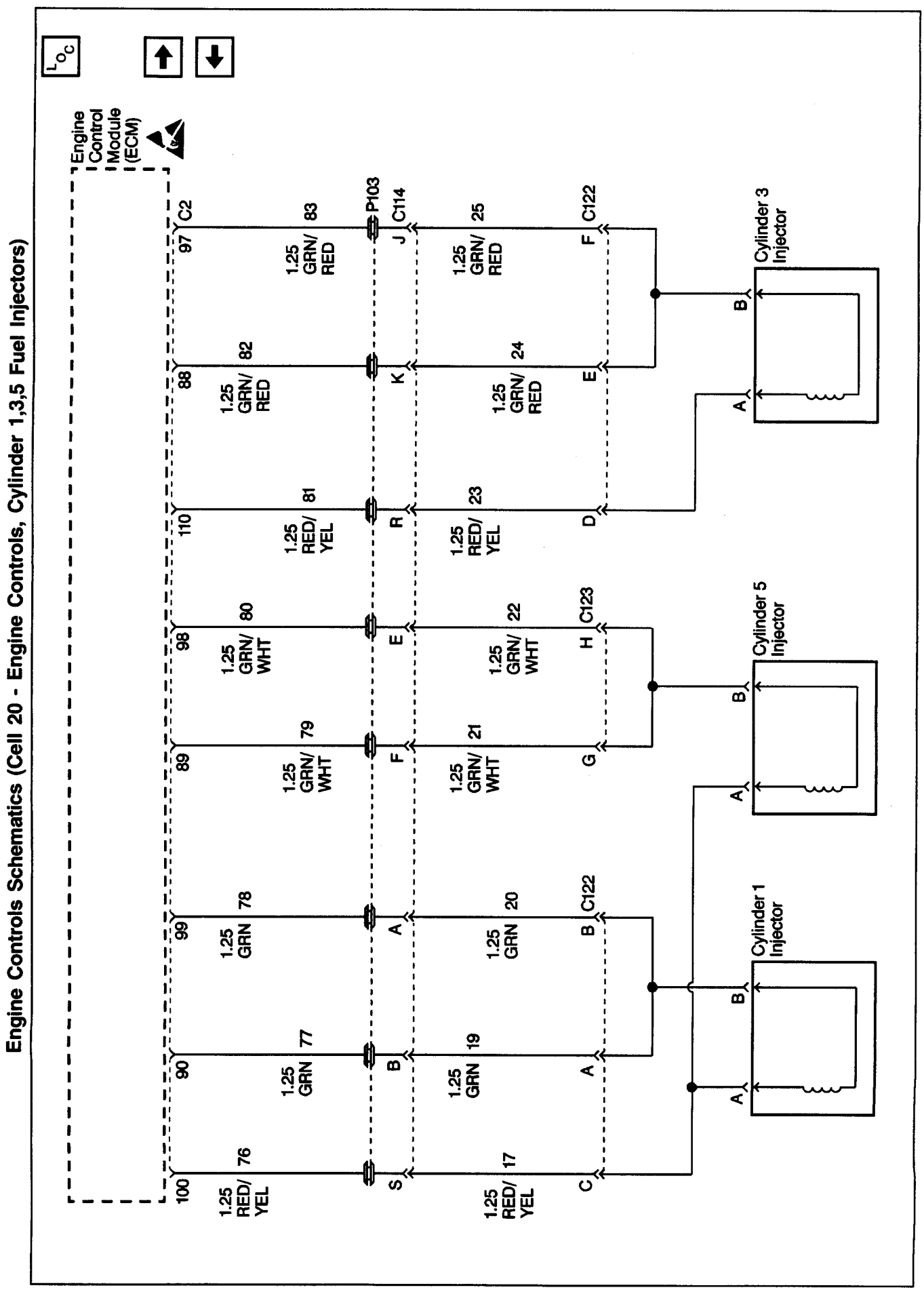
Icon	Icon Definition
 19384	Refer to *ESD Notice* in Cautions and Notices.

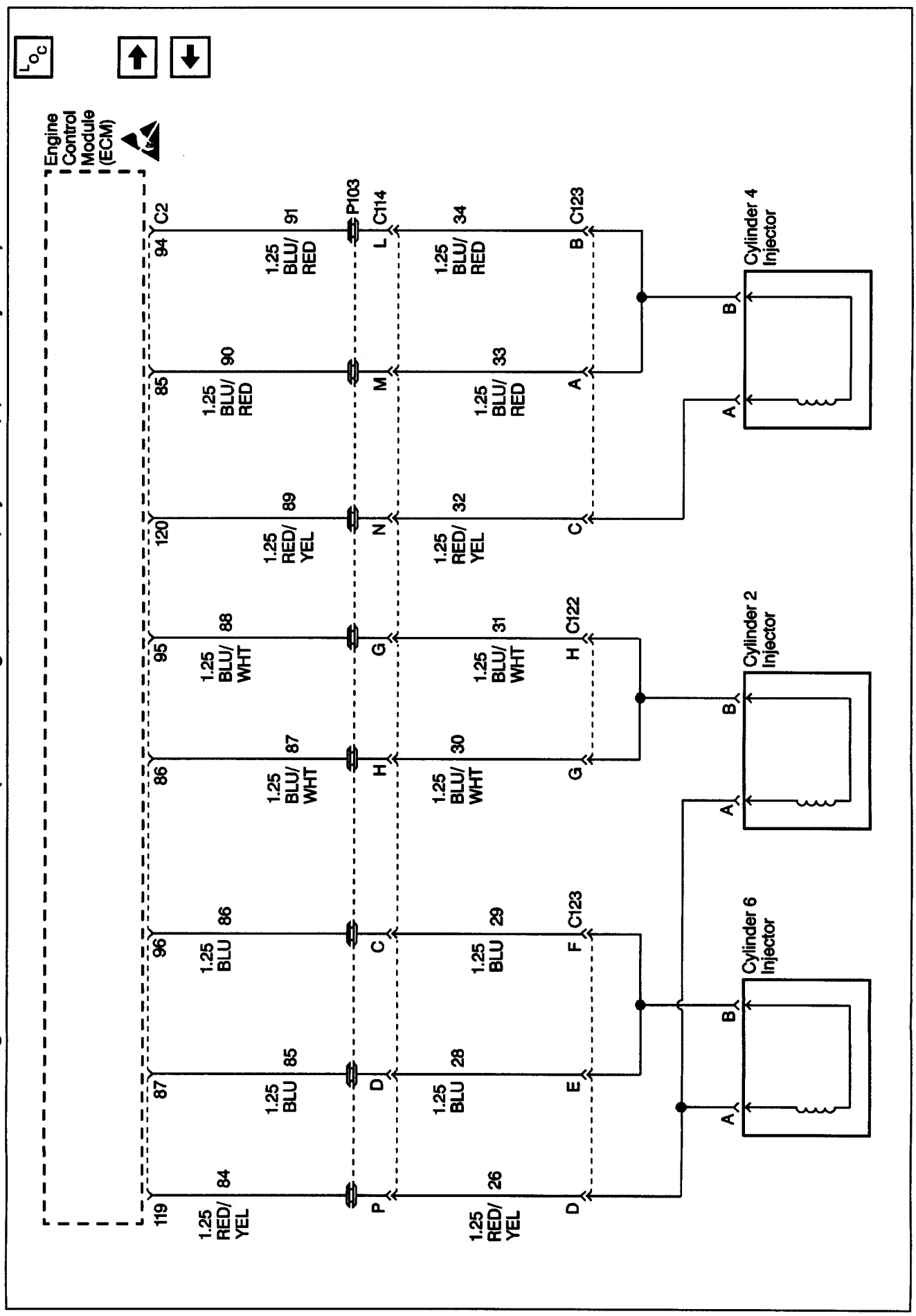
Engine Controls Schematics (Cell 20 - Engine Controls, Power and Ground, DLC, Check Connector)

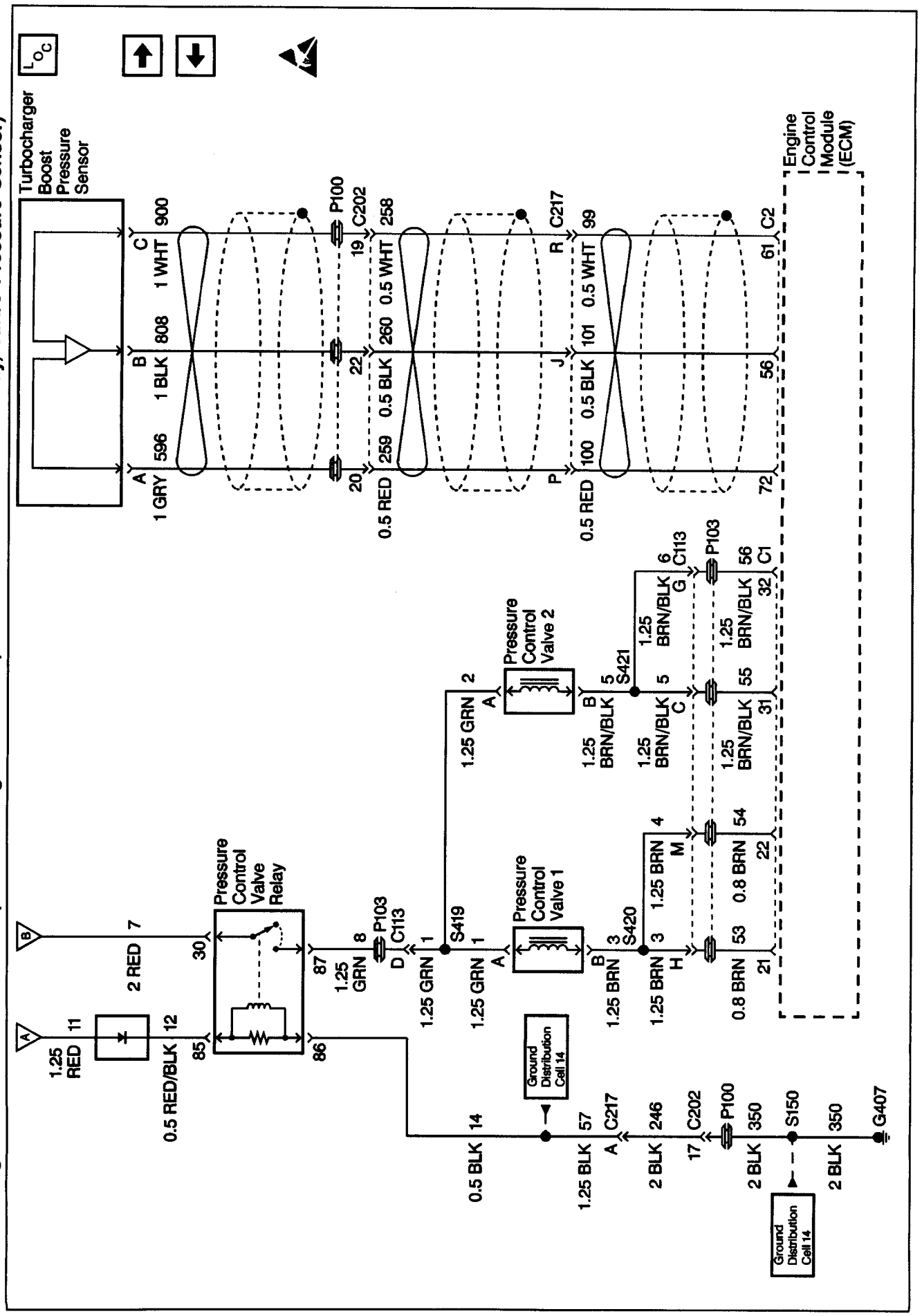


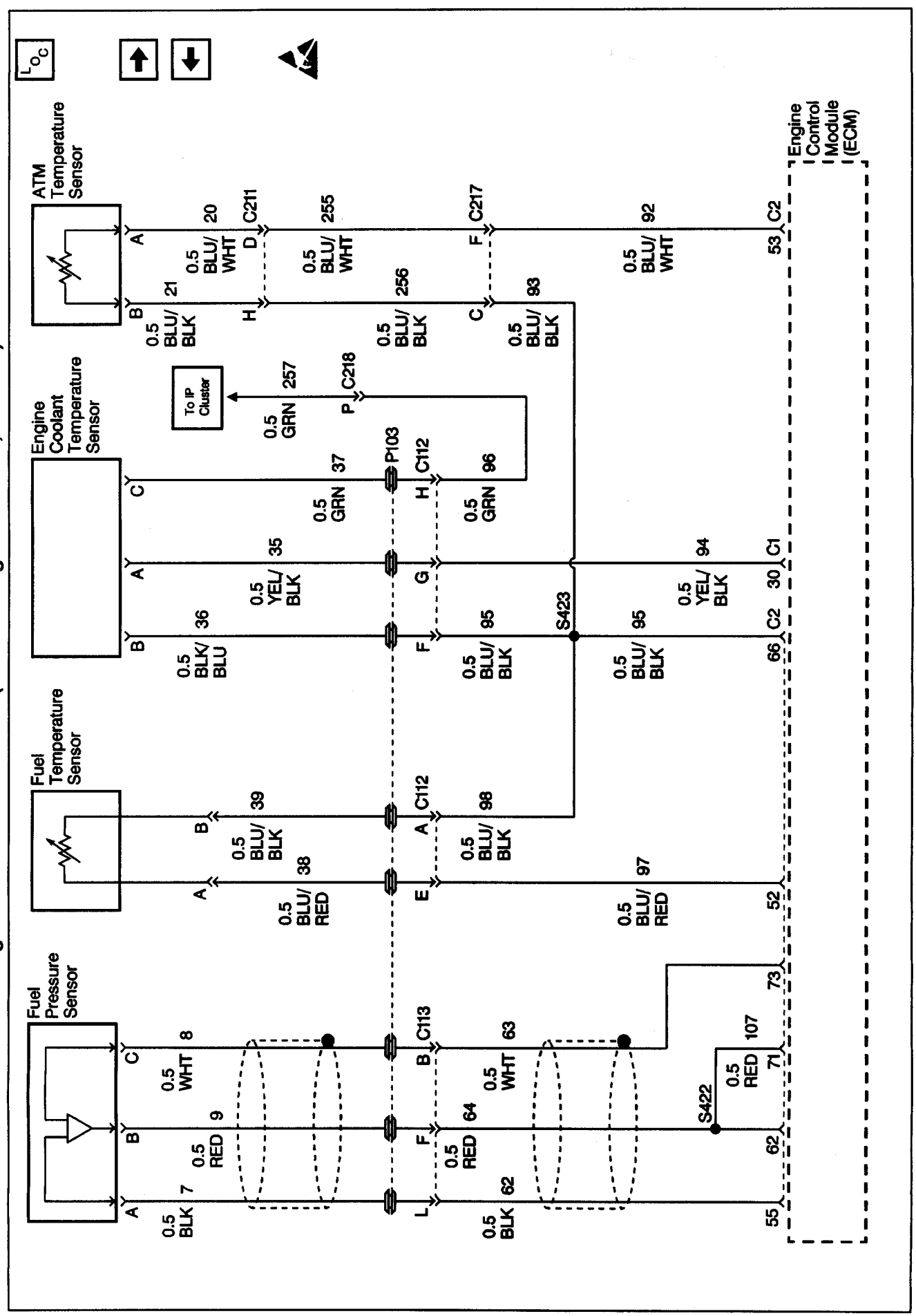

Engine Controls Schematics (Cell 20 - Engine Controls, MIL Lamp, Glow Plugs)
301651
Batteries
62 BLK
Starter Solenoid
Fuse Link
2 RED
C417
P100
C205
1
50
8 RED
Glow Plug Relay
45
Control Resister
C1
C2
46
C207
503
C118
Glow Plugs
IP Fuse Block
Circuit Breaker 4 15 A
Hot In H (Heat)
48
2 BLK/ RED
B
A
49
0.8 BLK/ RED
S327
S326
S324
S325
S328
68
21
C200
550
G105
3 BLK
2 BLK
Ground Distribution Cell 14
IP Cluster
Service Engine Soon
6
10
36
0.8 BRN/ WHT
C212
A6
248
0.5 BRN/ WHT
C217
G
16
0.5 BRN/WHT
106
Engine Control Module (ECM)
Hot In RUN And START
Circuit Breaker 6 15 A
371
S227
S279
S280
F2
2 BRN
1
S243
S260
S269
28
1.25 BRN
F
Fuse Block Details Cell 11


Engine Controls Schematics (Cell 20 - Engine Controls, Fuel Tank Sensor — Diesel Dual Tank)
301653
Hot in Run
IP Fuse Block
CIRCUIT BREAKER #9 20 A
2 PNK 145
S286
Fuse Block Details Cell 11
S287
S295
P100
C200 22
1 PNK 139
C404
C410
S417
LH Fuel Tank Sender (Primary)
Full 90Ω Empty 0Ω
Fuel Sender And Transfer Pump Control Module
Averaging Circuit
Control Logic
Relay Drive
0.8 BLK 350
1 BLK 350
0.8 DK BLU 1936
0.8 PPL 30
C410
C402
C212
C3
Fuel Meter
IP Cluster
Instrument Cluster Cell 81
0.8 PPL 24
0.8 PPL 386
P100
C200 53
1 PNK 139
0.8 LT GRN 497
0.8 LT BLU 1937
RH Fuel Tank Sender
Full 90Ω Empty 0Ω
S415
C410
G408
Fuel Transfer Pump
1 GRY 120
Fuel Transfer Pump Relay
86
87
87A
85
30

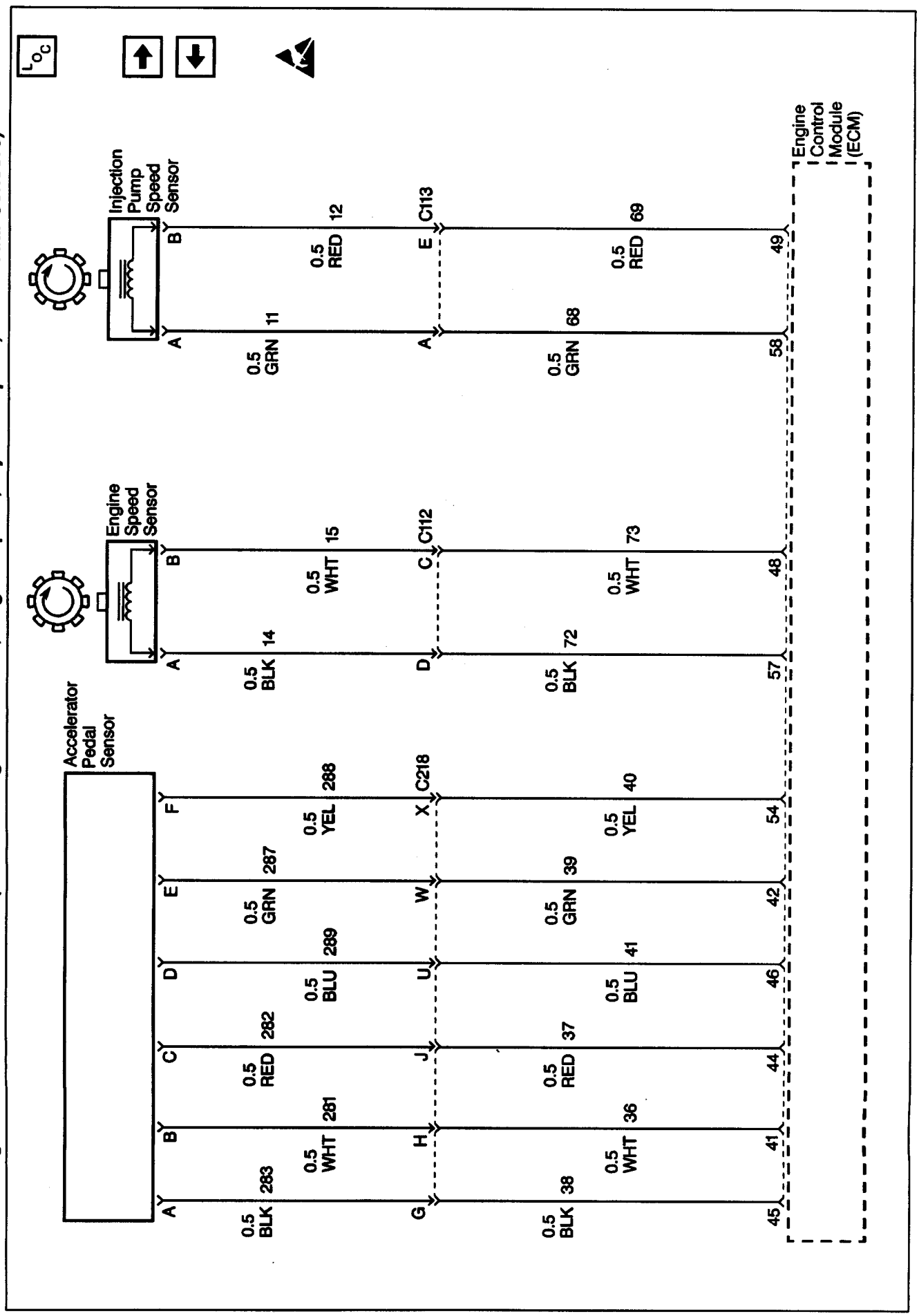

Engine Controls Schematics (Cell 20 - Engine Controls, Cylinder 1,3,5 Fuel Injectors)
301656
Engine Control Module (ECM)
C2
P103
C114
C122
C123
Cylinder 3 Injector
Cylinder 5 Injector
Cylinder 1 Injector
1.25 GRN/RED
1.25 RED/YEL
1.25 GRN/WHT
1.25 GRN

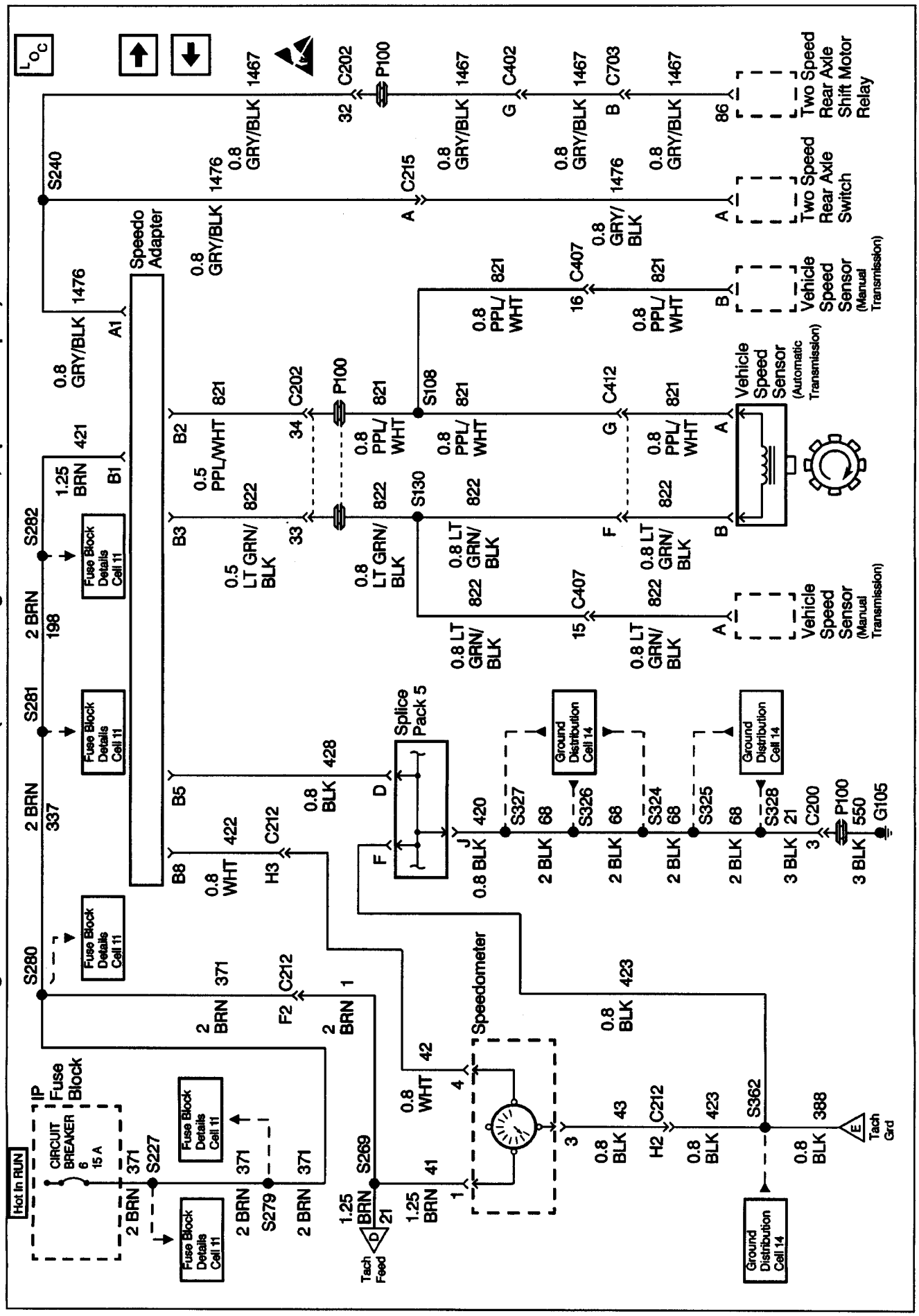

Engine Controls Schematics (Cell 20 - Engine Controls, Cylinder 2,4,6 Fuel Injectors)
Engine Control Module (ECM)
C2
P103
C114
C123
C122
Cylinder 4 Injector
Cylinder 2 Injector
Cylinder 6 Injector
1.25 BLU/RED
1.25 RED/YEL
1.25 BLU/WHT
1.25 BLU
301657

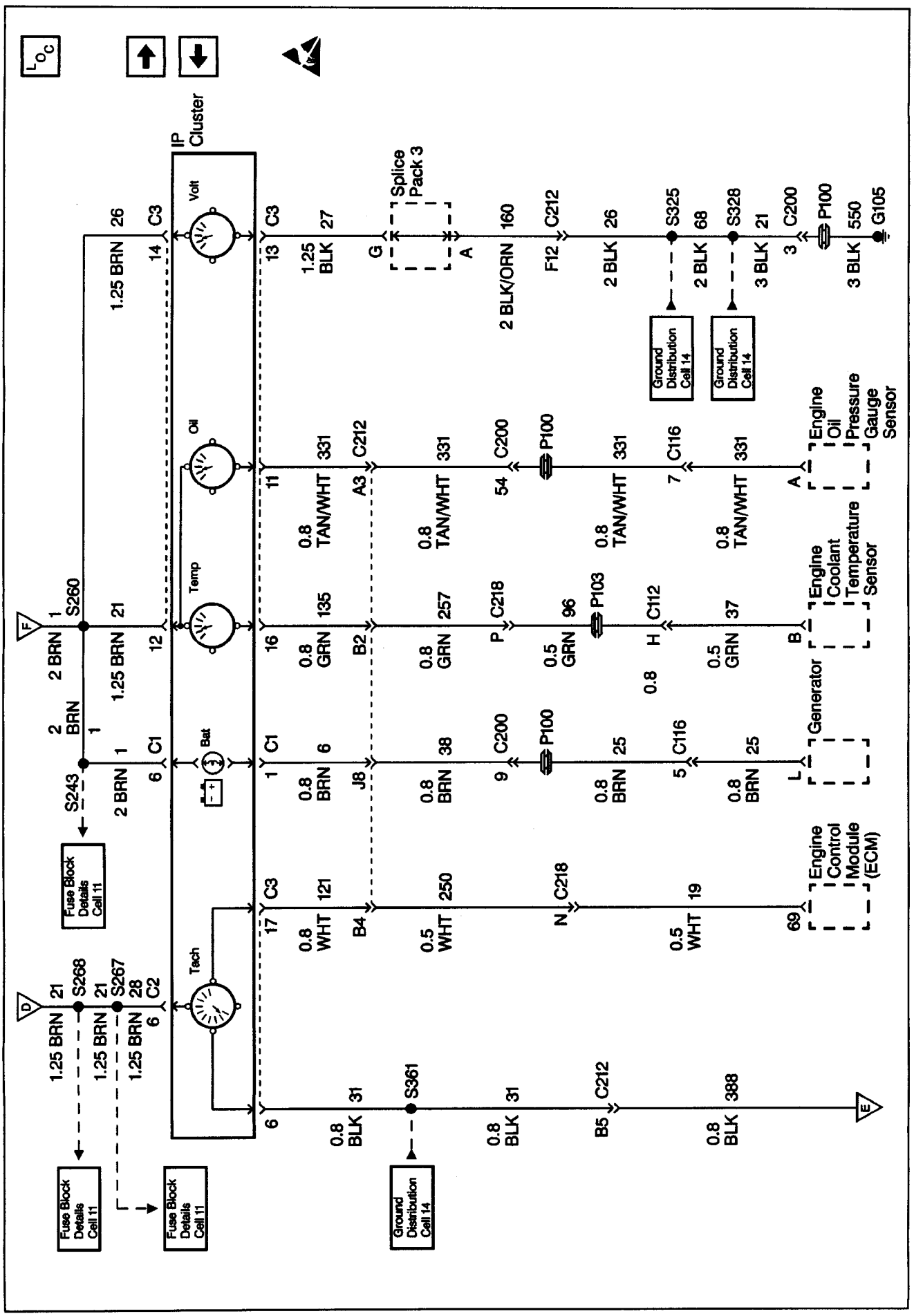

Engine Controls Schematics (Cell 20 - Engine Controls, Pressure Control Valve Relay, Turbo Pressure Sensor)
301660
Turbocharger Boost Pressure Sensor
Engine Control Module (ECM)
Pressure Control Valve Relay
Pressure Control Valve 1
Pressure Control Valve 2
Ground Distribution Cell 14
Ground Distribution Cell 14
1.25 RED
0.5 RED/BLK
2 RED
1.25 GRN
1.25 GRN
1.25 GRN
1.25 BRN
1.25 BRN
0.8 BRN
1.25 BRN/BLK
1.25 BRN/BLK
1.25 BRN/BLK
1.25 BRN/BLK
0.5 BLK
1.25 BLK
2 BLK
2 BLK
2 BLK
1 GRY
1 BLK
1 WHT
0.5 RED
0.5 BLK
0.5 WHT
0.5 RED
0.5 BLK
0.5 WHT
S419
S420
S421
P103
C113
P100
C202
C217
C2
S150
G407

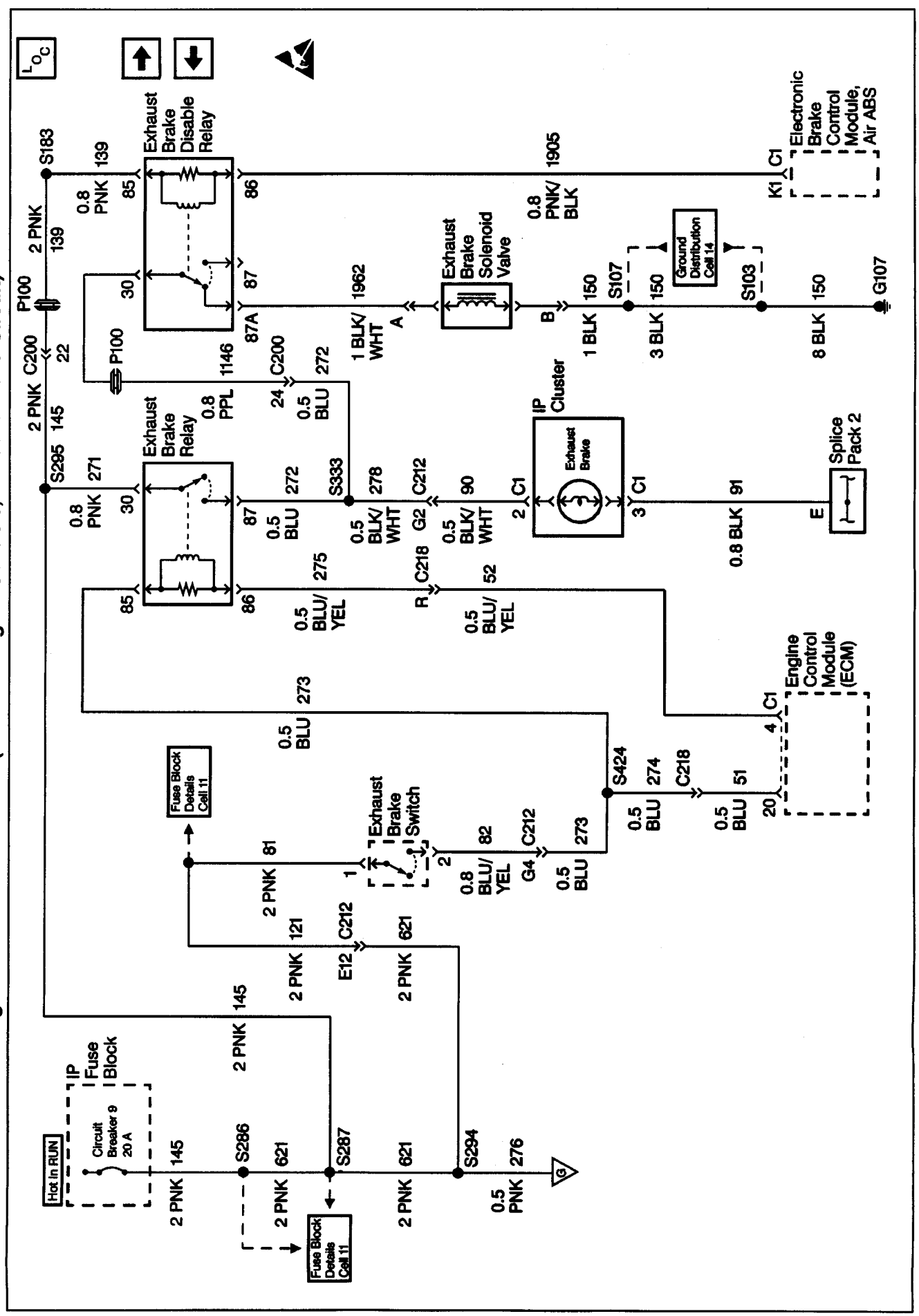

Engine Controls Schematics (Cell 20 - Engine Controls, Sensors)
301663
ATM Temperature Sensor
Engine Coolant Temperature Sensor
Fuel Temperature Sensor
Fuel Pressure Sensor
To IP Cluster
Engine Control Module (ECM)
C211
C217
C218
P103
C112
C113
S423
S422
C1
C2

Engine Controls Schematics (Cell 20 - Engine Controls, Engine Speed, Injector Speed, Acc. Pedal Sensors)

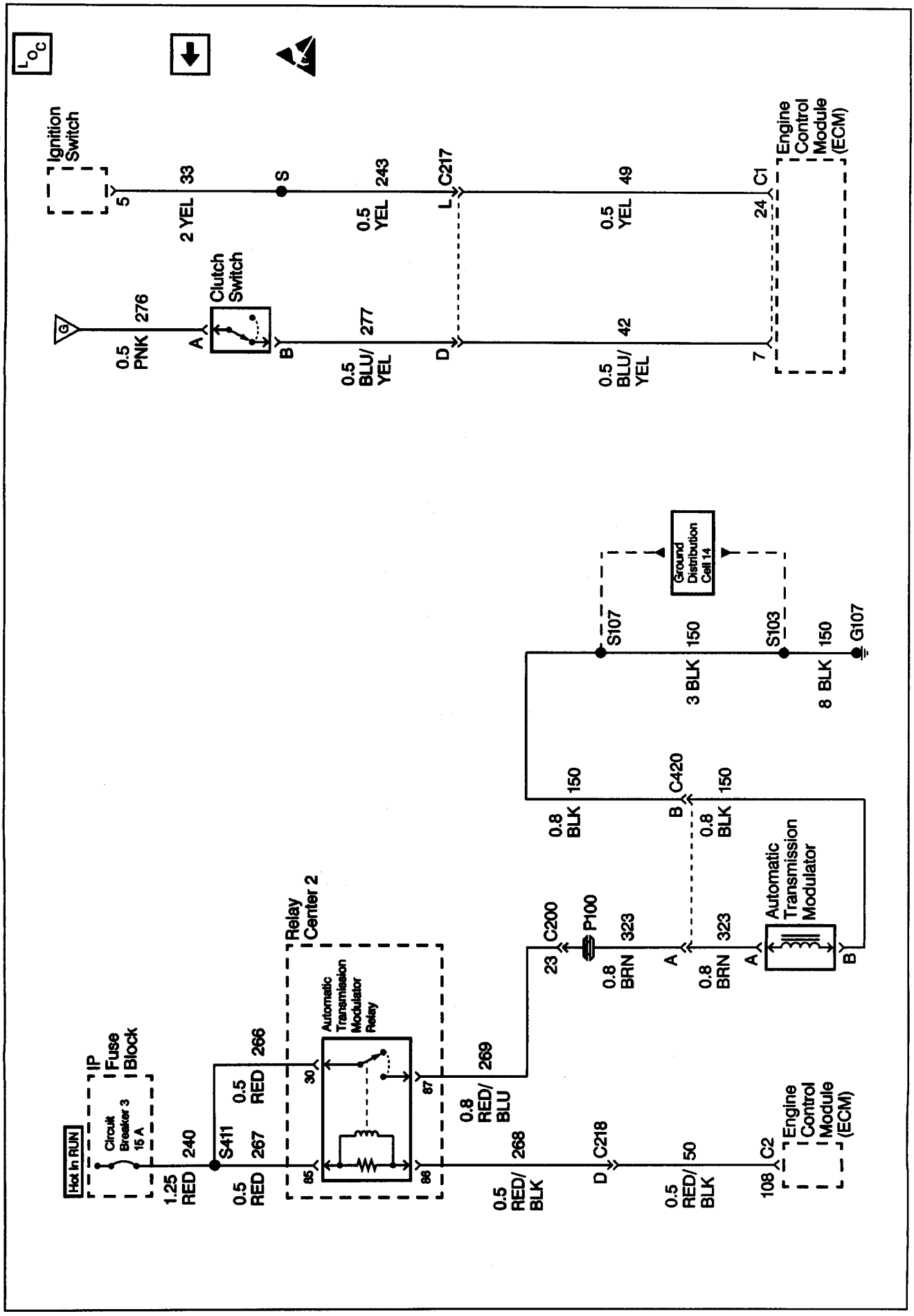



Engine Controls Schematics (Cell 20 - Engine Controls, Speedo Adapter)
301666
Hot In RUN
IP Fuse Block
CIRCUIT BREAKER 6 15 A
Fuse Block Details Cell 11
Ground Distribution Cell 14
Splice Pack 5
Speedometer
Speedo Adapter
Tach Feed
Tach Grd
Vehicle Speed Sensor (Automatic Transmission)
Vehicle Speed Sensor (Manual Transmission)
Two Speed Rear Axle Switch
Two Speed Rear Axle Shift Motor Relay
S280
S281
S282
S227
S279
S269
S362
S327
S326
S324
S325
S328
S130
S108
S240
C212
C202
C215
C407
C412
C402
C703
C200
P100
G105
H2
H3
F2
2 BRN 371
2 BRN 337
2 BRN 198
1.25 BRN 421
0.5 PPL/WHT 821
0.5 LT GRN/BLK 822
0.8 GRY/BLK 1476
0.8 GRY/BLK 1467
0.8 PPL/WHT 821
0.8 LT GRN/BLK 822
0.8 WHT 422
0.8 BLK 428
0.8 BLK 423
0.8 BLK 43
0.8 BLK 388
0.8 WHT 42
1.25 BRN 41
2 BRN 1
0.8 BLK 420
2 BLK 68
3 BLK 550
3 BLK 21
0.8 GRY/BLK 1467
0.8 GRY/BLK 1476
0.8 GRY/BLK 1467
0.8 GRY/BLK 1467
0.8 GRY/BLK 1467
0.8 PPL/WHT 821
0.8 PPL/WHT 821
0.8 GRY/BLK 1476
0.8 PPL/WHT 821
0.8 PPL/WHT 821
0.8 LT GRN/BLK 822
0.8 LT GRN/BLK 822
0.8 LT GRN/BLK 822
0.8 LT GRN/BLK 822


Engine Controls Schematics (Cell 20 - Engine Controls, IP Cluster)
301667
IP Cluster
Volt
Temp
Oil
Bat
Tach
Fuse Block Details Cell 11
Ground Distribution Cell 14
Splice Pack 3
Engine Control Module (ECM)
Generator
Engine Coolant Temperature Sensor
Engine Oil Pressure Gauge Sensor
S243
S260
S268
S267
S361
S325
S328
C1
C2
C3
C200
C212
C116
C112
C218
P100
P103
G105
1.25 BRN
2 BRN
0.8 BRN
0.8 WHT
0.8 BLK
0.8 TAN/WHT
0.8 GRN
0.5 GRN
0.5 WHT
1.25 BLK
2 BLK/ORN
2 BLK
3 BLK
3 BLK 550


Engine Controls Schematics (Cell 20 - Engine Controls, Exhaust Brake Circuit)
301669
Hot in RUN
IP Fuse Block
Circuit Breaker 9 20 A
Fuse Block Details Cell 11
Exhaust Brake Disable Relay
Exhaust Brake Relay
Exhaust Brake Switch
Exhaust Brake Solenoid Valve
IP Cluster
Exhaust Brake
Ground Distribution Cell 14
Electronic Brake Control Module, Air ABS
Splice Pack 2
Engine Control Module (ECM)
S183
S295
S333
S424
P100
C200
C212
C218
S107
S103
G107
S286
S287
S294
K1
E12
G4
G2
R
E
2 PNK 145
2 PNK 139
0.8 PNK 139
0.8 PNK 271
0.8 PPL 1146
0.5 BLU 272
0.5 BLU 273
0.5 BLU/YEL 275
0.5 BLK/WHT 278
0.5 BLK/WHT 90
0.5 BLU/YEL 52
0.8 BLK 91
0.8 PNK/BLK 1905
1 BLK/WHT 1962
1 BLK 150
3 BLK 150
8 BLK 150
2 PNK 145
2 PNK 621
2 PNK 276
0.5 PNK 276
2 PNK 121
0.8 BLU/YEL 82
0.5 BLU 273
0.5 BLU 274
0.5 BLU 51

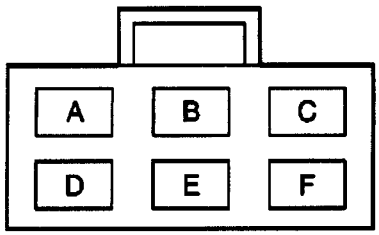
Engine Controls Schematics (Cell 20 - Engine Controls, Automatic Transmission Modulator, Clutch Switch)



Component Locator

Engine Controls Connector End Views

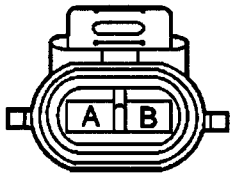
Accel Sensor



237082

Connector Part Information	• 6 Way • Female		
Pin	Wire Color	Circuit No.	Function
A	BLK	283	ECM Pin-45
B	WHT	281	ECM Pin-41
C	RED	282	ECM Pin-44
D	BLU	289	ECM Pin-46
E	GRN	287	ECM Pin-42
F	YEL	288	ECM Pin-54

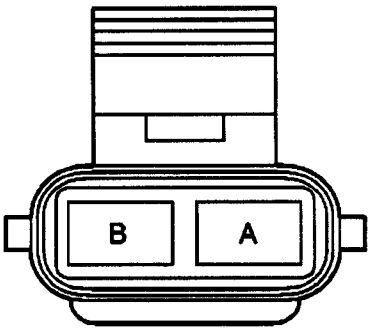
ATM Temp Sensor



236598

Connector Part Information	• 2 Way F • (GRY)		
Pin	Wire Color	Circuit No.	Function
A	BLU/WHT	20	ECM Pin 53
B	BLU/BLK	21	ECM Pin 66

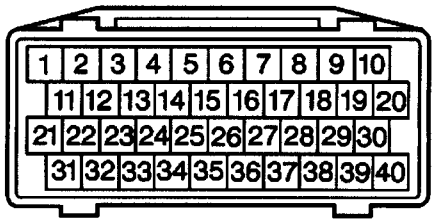
Automatic Transmission Modulator



68721

Connector Part Information	• 15300027 • 2 Way F Metri-Pack 280 Series, Sealed (BLK)		
Pin	Wire Color	Circuit No.	Function
A	BRN	323	Shift Solenoid Feed
B	BLK	150	Ground

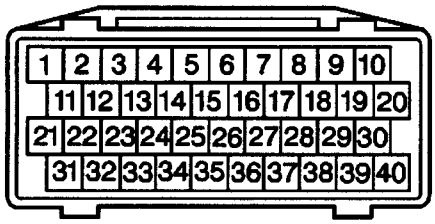
Engine Control Module C1



339162

Connector Part Information	• 40 Way • Female		
Pin	Wire Color	Circuit No.	Function
1–3	—	—	Not Used
4	BLU/YEL	52	Exhaust Brake Relay
5–6	—	—	Not Used
7	BLU/YEL	42	Clutch Switch
8–9	—	—	Not Used
10	PNK/GRN	34	Fast Idle-Up
11–12	—	—	Not Used
13	RED	9	Fuse Output-Ignition
14–18	—	—	Not Used
19	PNK	23	Ground
20	BLU	51	Exhaust Brake Relay
21	BRN	53	Pressure Control Valve 1

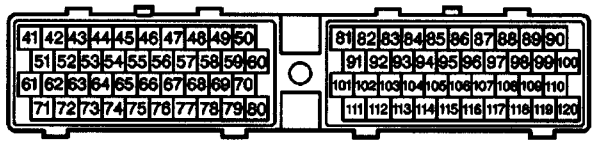
Engine Control Module C1 (cont'd)



339162

Connector Part Information		• 40 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
22	BRN	54	Pressure Control Valve 1
23	RED	10	Fuse Output-Ignition
24	YEL	49	Ignition Switch
25	LT GRN/RED	22	Ground
26	RED	27	Fuse Output-Ignition
27	RED/BLK	21	Ground
28	—	—	Not Used
29	PNK/BLK	35	Fast Idle-Down
30	YEL/BLK	94	Engine Coolant Temperature Sensor
31	BRN/BLK	55	Pressure Control Valve 2
32	BRN/BLK	56	Pressure Control Valve 2
33–38	—	—	Not Used
39	LT BLU	20	Multifunction Alarm Module
40	—	—	Not Used

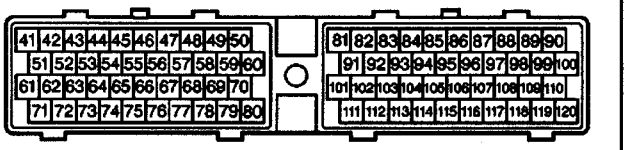
Electronic Control Module C2



339160

Connector Part Information		• 80 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
41	WHT	36	Accelerator Pedal Sensor
42	GRN	39	Accelerator Pedal Sensor
43	—	—	Not Used
44	RED	37	Accelerator Pedal Sensor
45	BLK	38	Accelerator Pedal Sensor
46	BLU	41	Accelerator Pedal Sensor
47	—	—	Not Used
48	WHT	73	Engine Speed Sensor
49	RED	69	Injection Pump Speed Sensor
50–51	—	—	Not Used
52	BLU/RED	97	Fuel Temperature Sensor
53	BLU/WHT	92	ATM Temperature Sensor
54	YEL	40	Accelerator Pedal Sensor
55	BLK	106	Fuel Pressure Sensor
56	BLK	108	Turbocharger Boost Pressure Sensor
57	BLK	72	Engine Speed Sensor
58	GRN	68	Injection Pump Speed Sensor
59	—	—	Not Used
60	WHT	30	Check Connector Pin-D
61	WHT	99	Turbocharger Boost Pressure Sensor
62	RED	65	Fuel Pressure Sensor
63–65	—	—	Not Used
66	BLU/BLK	95	Engine Coolant Temperature Sensor
67–68	—	—	Not Used

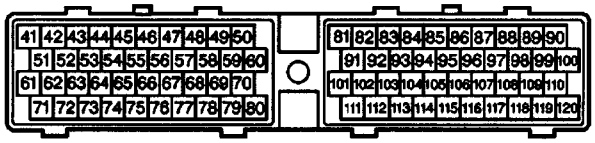
Electronic Control Module C2 (cont'd)



339160

Connector Part Information		• 80 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
69	WHT	19	IP Cluster (Tach.)
70	—	—	Not Used
71	RED	107	Fuel Pressure Sensor
72	RED	100	Turbocharger Boost Pressure Sensor
73	WHT	63	Fuel Pressure Sensor
74–75	—	—	Not Used
76	—	74	Shield
77	—	70	Shield
78–80	—	—	Not Used
81	BLK	57	Ground
82	BLK	58	Ground
83–84	—	—	Not Used
85	BLU/RED	90	Cylinder 4 Injector
86	BLU/WHT	87	Cylinder 2 Injector
87	BLU	85	Cylinder 6 Injector
88	GRN/RED	82	Cylinder 3 Injector
89	GRN/WHT	79	Cylinder 5 Injector
90	GRN	77	Cylinder 1 Injector
91	RED/WHT	2	Ignition Main Relay Contact
92–93	—	—	Not Used
94	BLU/RED	91	Cylinder 4 Injector
95	BLU/WHT	88	Cylinder 2 Injector
96	BLU	86	Cylinder 6 Injector
97	GRN/RED	83	Cylinder 3 Injector
98	GRN/WHT	80	Cylinder 5 Injector

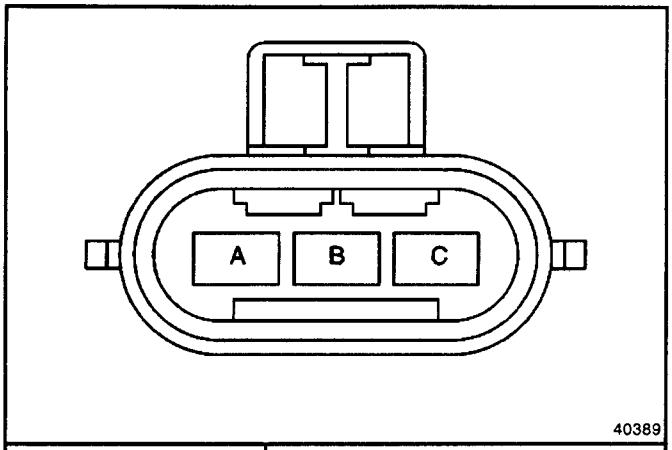
Electronic Control Module C2 (cont'd)



339160

Connector Part Information		• 80 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
99	GRN	78	Cylinder 1 Injector
100	RED/YEL	76	Cylinder 5 Injector and Cylinder 1 Injector
101	RED/WHT	3	Ignition Main Relay Contact
102	BLK	59	Ground
103	RED	4	Fuse Output-Battery
104-105	—	—	Not Used
106	BRN/WHT	16	IP Cluster (Service Engine Soon)
107	—	—	Not Used
108	RED/BLK	50	Automatic Transmission Modulator Relay (Located in Relay Center 2)
109	YEL	6	Ignition Main Relay Coil
110	RED/YEL	81	Cylinder 3 Injector
111	BLK	60	Ground
112	—	—	Not Used
113	WHT/RED	28	Data Link Connector
114	WHT	29	Data Link Connector
115–117	—	—	Not Used
118	YEL	5	Ignition Main Relay Coil
119	REDYEL	84	Cylinder 6 Injector and Cylinder 2 Injector
120	RED/BLU	89	Cylinder 4 Injector

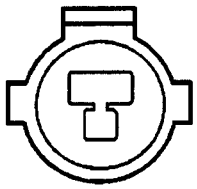
Engine Coolant Temperature Sensor



40389

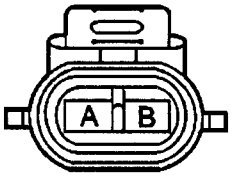
Connector Part Information		• 3 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	YEL/BLK	35	ECM Pin-30
B	GRN	37	IP Cluster (Temp.)
C	BLU/BLK	36	ECM Pin-66

Engine Oil Pressure Gauge Sender (Isuzu)


246685

Connector Part Information		• 1 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BRN/WHT	7	Oil Pressure Switch Signal

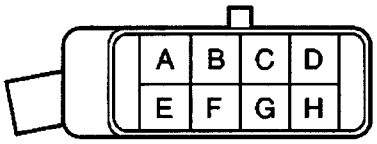
Engine Speed Sensor



236598

Connector Part Information		• 2 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	14	ECM Pin-57
B	WHT	15	ECM Pin-48

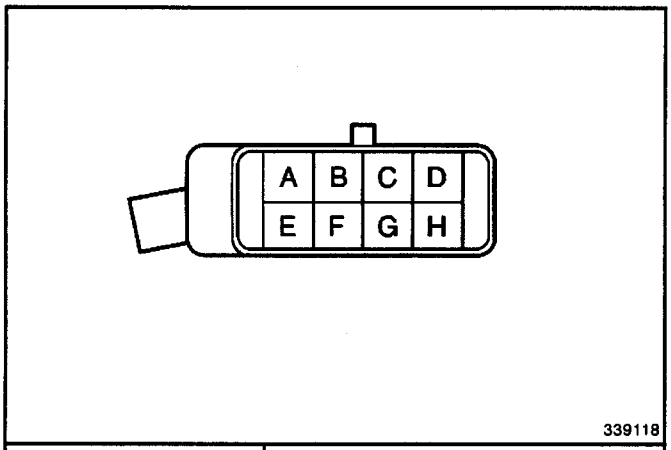
Fuel Injection-to-Engine Assembly (C122)



339118

Connector Part Information		8 Way F	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	GRN	19	Cylinder 1 Injector
B	GRN	20	Cylinder 1 Injector
C	RED/YEL	17	Cylinder 1 Injector
D	RED/YEL	23	Cylinder 3 Injector
E	BLU	24	Cylinder 3 Injector
F	BLU	25	Cylinder 3 Injector
G	GRN/WHT	30	Cylinder 2 Injector
H	GRN/WHT	31	Cylinder 2 Injector

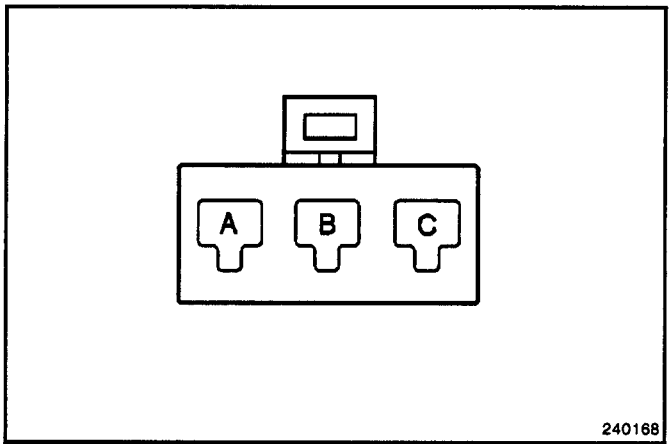
Fuel Injection-to-Engine Assembly (C123)



339118

Connector Part Information		8 Way F	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLU/RED	33	Cylinder 4 Injector
B	BLU/RED	34	Cylinder 4 Injector
C	RED/YEL	32	Cylinder 4 Injector
D	RED/YEL	27	Cylinder 6 Injector
E	BLU	28	Cylinder 6 Injector
F	BLU	29	Cylinder 6 Injector
G	GRN/WHT	21	Cylinder 5 Injector
H	GRN/WHT	22	Cylinder 5 Injector

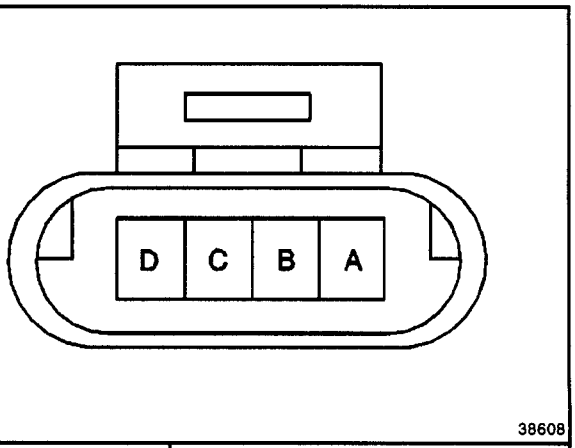
Fuel Pressure Sensor



240168

Connector Part Information		• 3 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	7	ECM Pin-55
B	RED	9	ECM Pin-62
C	WHT	8	ECM Pin-73

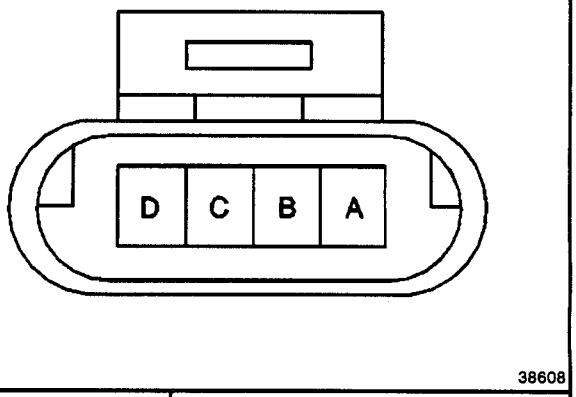
Fuel Sender (Single Fuel Tank)



38608

Connector Part Information		• 12162189 • 4 Way F Metri-Pack 150.2 Series Pull To Seat, Sealed (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	350	Ground
B–C	—	—	Not Used
D	PPL	30	Fuel Gauge Sensor Signal

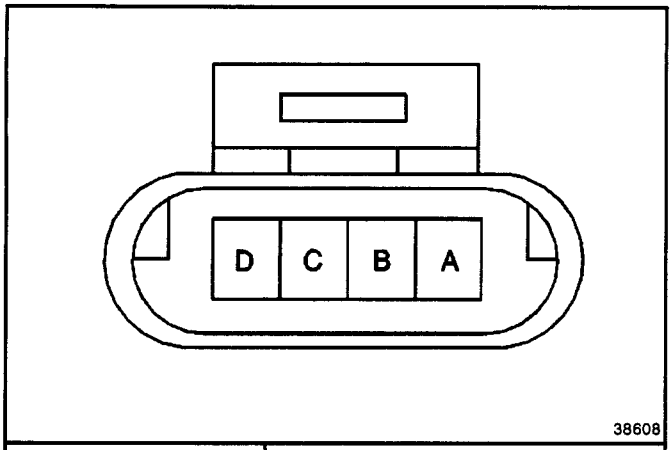
Fuel Sender (Duel Fuel Tank-Left Hand)



38608

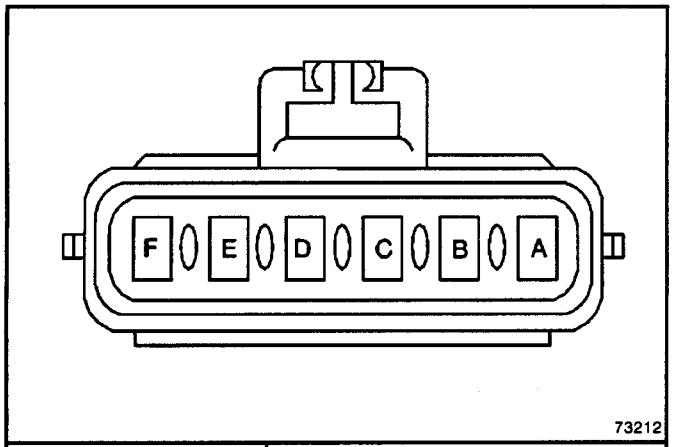
Connector Part Information		• 12162189 • 4 Way F Metri-Pack 150.2 Series Pull To Seat, Sealed (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	350	Ground
B–C	—	—	Not Used
D	DK BLU	1936	Fuel Gauge Sensor Signal-Left

Fuel Sender (Duel Fuel Tank-Right Hand)



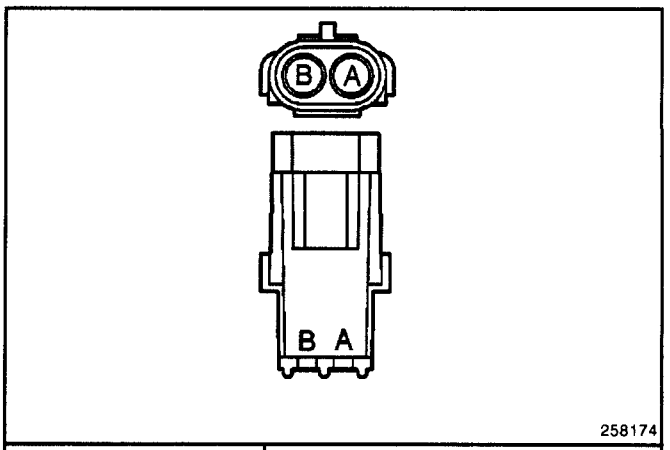
Connector Part Information		• 12162189 • 4 Way F Metri-Pack 150.2 P2S, Sealed (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	350	Ground
B–C	—	—	Not Used
D	DK BLU	1937	Fuel Gauge Sensor Signal-Right

Fuel Sender and Transfer Pump Control Module



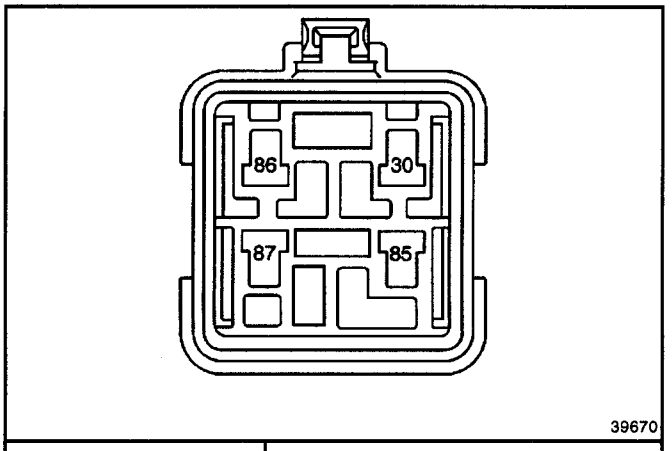
Connector Part Information		• 12059573 • 6 Way F Metri-Pack 280 Series, Sealed (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PNK	139	Fuse Output-Ignition
B	LT BLU	1937	Fuel Gauge Sensor Signal-Right
C	DK BLU	1936	Fuel Gauge Sensor Signal-Left
D	LT GRN	497	Fuel Pump Relay Output-Coil-Secondary
E	BLK	350	Ground
F	PPL	30	Fuel Gauge Sensor Signal

Fuel Transfer Pump



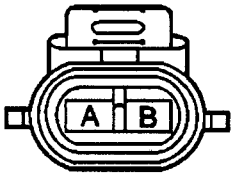
Connector Part Information		• 12010973 • 2 Way M Weather Pack (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	350	Ground
B	GRA	120	Fuel Pump,Motor Feed

Fuel Transfer Pump Relay



Connector Part Information		• 12129716 • 4 Way F Metri-Pack 280 Series, Flexlock, Sealed (GRA)	
Pin	**Wire Color**	**Circuit No.**	**Function**
30	PNK	139	Fuse Output-Ignition
85	PNK	139	Fuse Output-Ignition
86	LT GRN	497	Fuel Pump Relay Output-Coil-Secondary
87	GRA	120	Fuel Pump Motor Feed

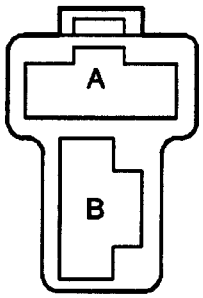
Fuel Temperature Sensor



236598

Connector Part Information		• 2Way • Female	
Pin	Wire Color	Circuit No.	Function
A	BLU/RED	38	ECM Pin-52
B	BLU/BLK	39	ECM Pin-66

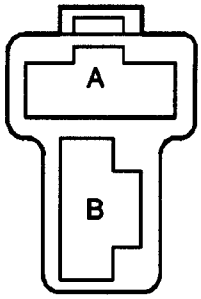
Glow Plug Relay C1



236009

Connector Part Information		• 2 Way • Female	
Pin	Wire Color	Circuit No.	Function
A	RED	50	Fuse Output-Battery
B	RED/BLK	45	Control Resistor

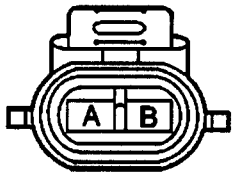
Glow Plug Relay C2



236009

Connector Part Information		• 2 Way • Female	
Pin	Wire Color	Circuit No.	Function
A	BLK	49	Ground
B	BLK/RED	48	Fuse Output-Ignition (Hot in Heat Switch Position)

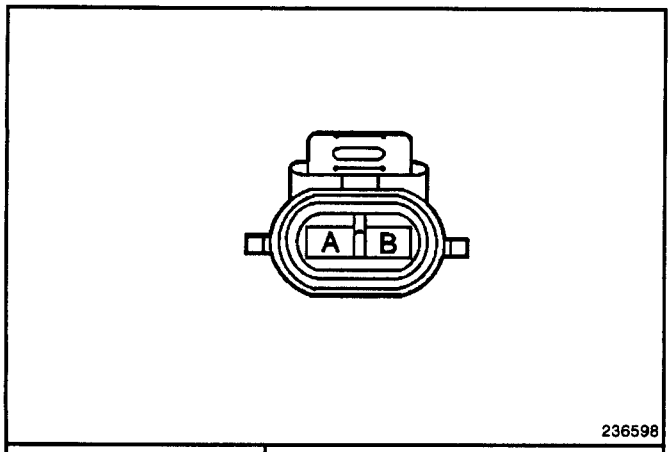
Injection Pump Speed Sensor



236598

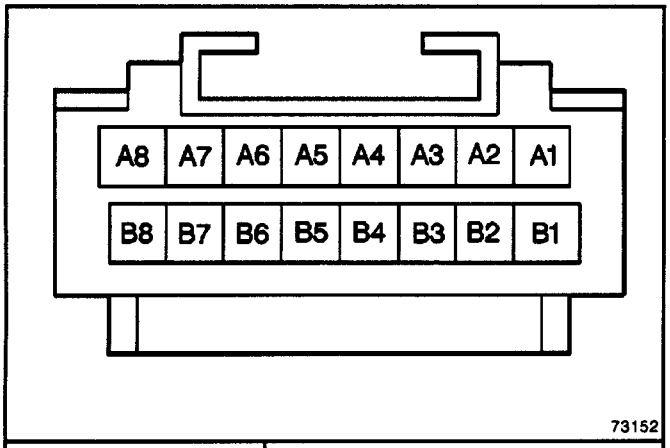
Connector Part Information		• 2 Way • Female	
Pin	Wire Color	Circuit No.	Function
A	GRN	11	ECM Pin-58
B	RED	12	ECM Pin-49

Low Coolant Level Indicator Switch



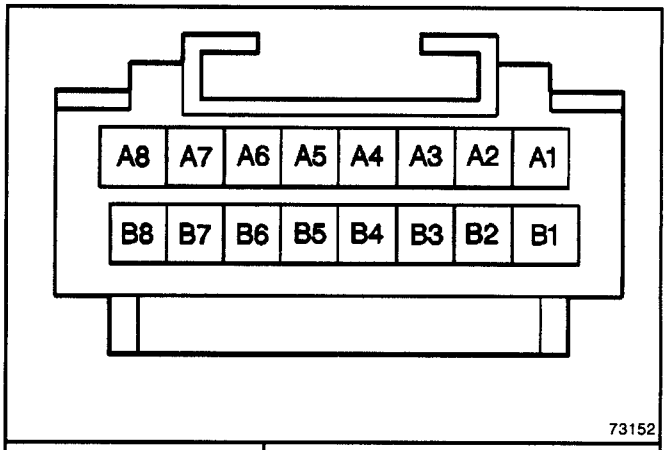
Connector Part Information	• 12052641 • ASM 2F M/P 150 (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	LT GRN	1478	Low Coolant Sensor Signal
B	BLK	150	Ground

Multifunction Alarm Module (MFAM) (Air Brakes)



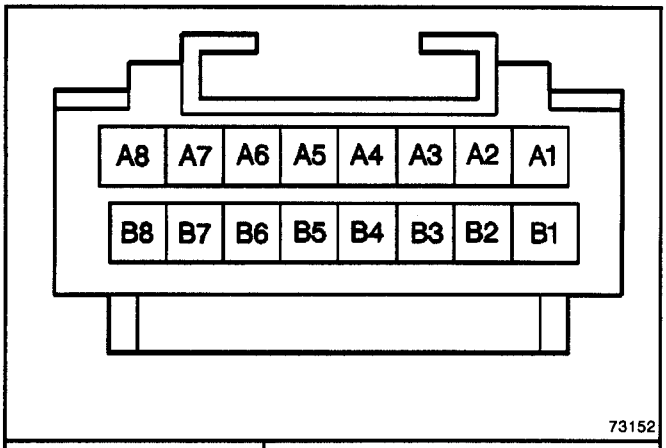
Connector Part Information	• 12084944 • ASM 16F MIC/P 100 (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A1–A4	—	—	Not Used
A5	PNK	611	Fused Output Ignition
A6	—	—	Not Used
A7	BRN/BLK	610	Low Oil Pressure Switch
A8	BLK	605	Ground
B1	LT GRN	601	Low Coolant Probe
B2	YEL/RED	603	Low Coolant Indicator Lamp
B3–B4	—	—	Not used
B5	BRN/WHT	602	Low Air Switch
B6	BLU/YEL	607	Check Gauges Indicator Lamp

Multifunction Alarm Module (MFAM) (Air Brakes) (cont'd)



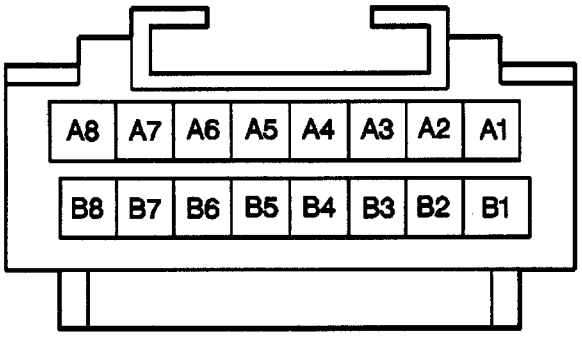
Connector Part Information	• 12084944 • ASM 16F MIC/P 100 (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
B7	BRN	609	Coolant Temperature Switch
B8	—	—	Not Used

Multifunction Alarm Module (MFAM) (Hydraulic)



Connector Part Information	• 12084944 • ASM 16F MIC/P 100 (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A1	LT BLU	475	Brake (Hydraulic)
A2	YEL	468	M.F.A.M. Pin-A2
A3	WHT	478	Stoplamp Switch Input
A4	ORN/BLK	487	Starter Input
A5	PNK	480	Fused Output Ignition
A6	BRN/WHT	482	Primary Brake Indicator Lamp Output
A7	BRN/BLK	466	Low Oil Pressure Switch
A8	BLK	485	Ground Buss
B1	LT GRN	481	Low Coolant Probe

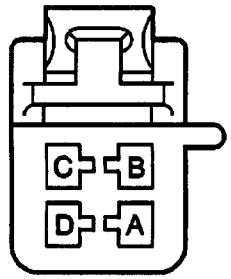
Multifunction Alarm Module (MFAM) (Hydraulic) (cont'd)



73152

Connector Part Information	• 12084944 • ASM 16F MIC/P 100 (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
B2	YEL/RED	483	Low Coolant Indicator Lamp
B3	YEL/BLK	484	Auxiliary Brake Indicator Lamp
B4	WHT	477	Stoplamp Switch Input
B5	—	—	Not Used
B6	BLU/YEL	488	Check Gauges Indicator Lamp
B7	BRN	465	Coolant Temperature Switch
B8	ORN/BLUL	476	Fuse Output Battery

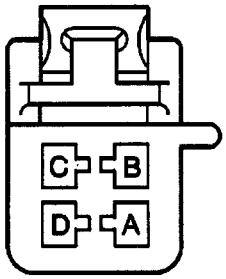
Multifunction Alarm Module (MFAM) C2 w/ Auto Engine Shutdown



280782

Connector Part Information	• 12064760 • 4 Way F Metri-Pack 150 Series (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	LT BLU	252	Engine Stop
B–C	—	—	Not Used

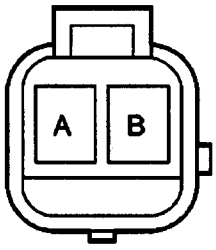
Multifunction Alarm Module (MFAM) C2 w/ Auto Engine Shutdown (cont'd)



280782

Connector Part Information	• 12064760 • 4 Way F Metri-Pack 150 Series (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
D	GRN	65	Engine Coolant Temperature Switch (Engine Shutdown)

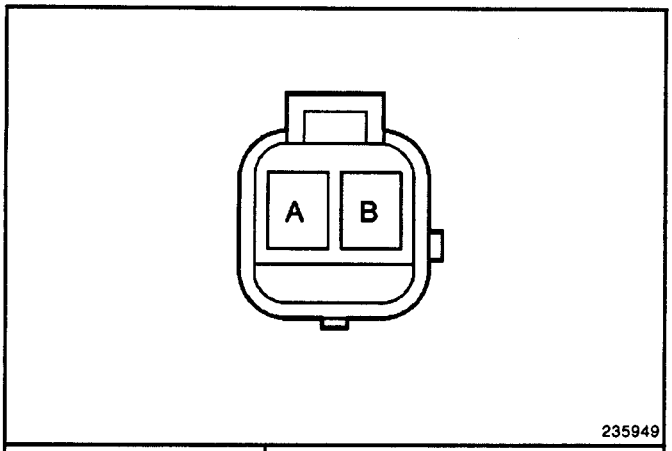
Pressure Control Valve 1



235949

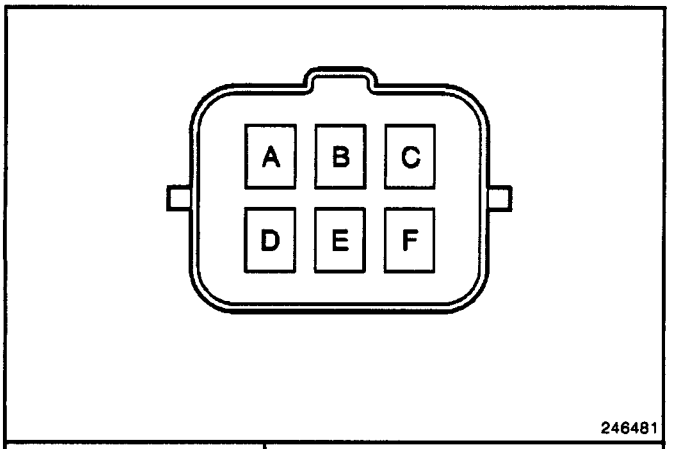
Connector Part Information	• 2 Way • Female		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	GRN	1	Pressure Control Valve Relay
B	BRN	3	ECM Pin-21

Pressure Control Valve 2



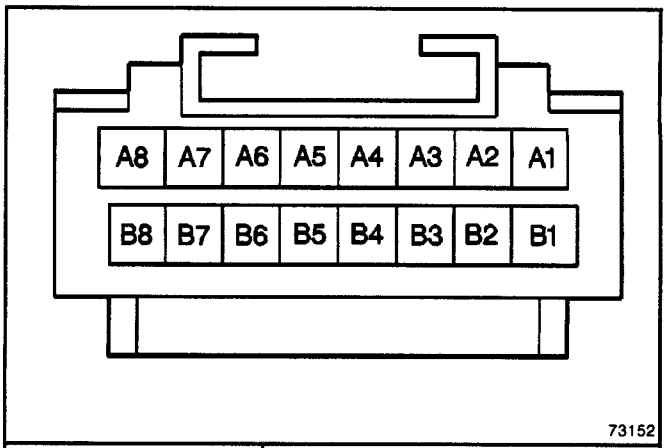
Connector Part Information		• 2 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	GRN	2	Pressure Control Valve Relay
B	BRN/BLK	5	ECM Pin-31

Pre-Stroke Actuator and Pressure Sensor



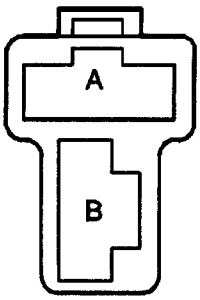
Connector Part Information		6 Way (GRA)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	267	Ground
B	BLK	261	TICS Module ( )
C	RED/BLK	260	TICS Module (+)
D	WHT	266	TICs Module (OSC)
E	GRY	292	(Shield)
F	BLK	270	TICS Module (MID)

Speedo Adaptor



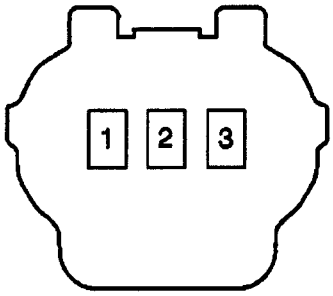
Connector Part Information		• 16 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
A1	GRA/BLK	418	Two Speed Rear Axle Switch and Two Speed Rear Axle Shift Motor Relay
A2–A8	—	—	Not Used
B1	BRN	421	Fuse Output-Ignition
B2	PPL/WHT	425	Vehicle Speed Sensor
B2	PPL/WHT	432	Vehicle Speed Sensor
B3	LT GRN/BLK	426	Vehicle Speed Sensor
B3	LT GRN/BLK	431	Vehicle Speed Sensor
B4	—	—	Not Used
B5	BLK	428	Splice Pack 5
B6–B7	—	—	Not Used
B8	WHT	422	Speedometer

Stop Lamp Switch (Hydraulic)



Connector Part Information		• 2 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	WHT	471	Stop Lamp Switch
B	GRN/WHT	470	Stop Lamp Switch

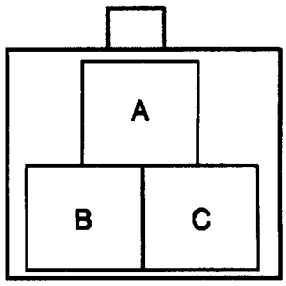
Turbo Boost Pressure Sensor



339127

Connector Part Information		• 12186893 • 3 Way F	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	GRA	596	Reference Voltage Feed-5 volt Reference
2	BLK	808	Sensor Return
3	WHT	900	Turbo Boost Pressure Signal

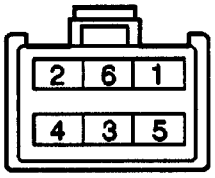
Two Speed Rear Axle Switch (Manual)



339122

Connector Part Information		• 3 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	GRA/BLK	21	Two Speed Rear Axle Input
B	BLK	22	Two Speed Rear Axle Input
C	—	—	Not Used

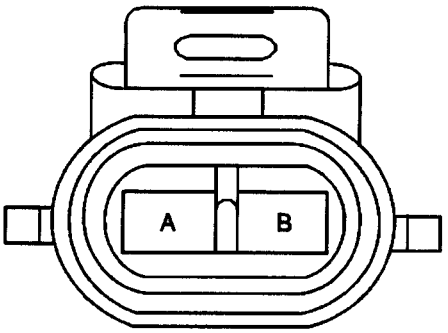
Two Speed Axle Switch (Auto)



237080

Connector Part Information		• 6 Way • Female	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	BLK	152	Two Speed Axle Switch
2	GRA/BLK	151	Two Speed Axle Switch
3	—	—	Not Used
4	BLK/RED	154	Rheostatt
5	BRN	153	Ilumination
6	—	—	Not Used

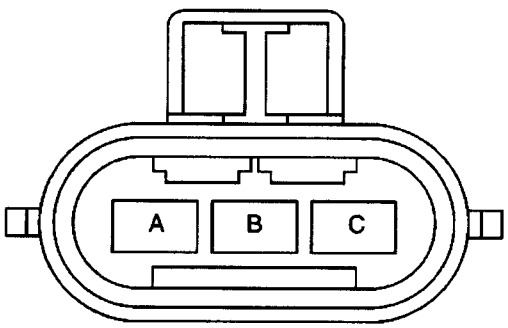
Vehicle Speed Sensor (Automatic)



35437

Connector Part Information		• 12052644 • 2 Way F Metri-Pack 150 Series (GRA)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PPL/WHT	821	Vehicle Speed Sensor Signal
B	LT GRN/BLK	822	Vehicle Speed Sensor Return

Vehicle Speed Sensor (Manual)



40389

Connector Part Information		• 3 Way F • (GRN)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	LT GRN/BLK	24	Vehicle Speed Sensor Signal
B	PPL/WHT	25	Vehicle Speed Sensor Return
C	PNK	26	Fuse Output-Ignition

BLANK

Engine Exhaust

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Exhaust Clamp Nut	24 N·m	18 lb ft
Exhaust Hanger Nut	24 N·m	18 lb ft
Front Exhaust Pipe Nut	29 N·m	21 lb ft
Wide Band Clamp	10 N·m	89 lb in

Diagnostic Information and Procedures

Vibration or Rattling

Problem	Action
The components are loose.	1. Tighten the connections. 2. Inspect the following components for damage: • The hangers • The mounting brackets • The clamps
The components are misaligned.	1. Align the components. 2. Inspect the following components for damage: • The hangers • The mounting brackets • The clamps

Restricted Exhaust

Problem	Action
The exhaust tubing is kinked.	Repair or replace the damaged tubing.
The muffler is restricted.	1. Remove the muffler. 2. Inspect the muffler for a restriction. 3. Replace the muffler if the condition of the muffler is doubtful. Refer to *Muffler Replacement.*
The tail pipe is obstructed.	1. Remove the obstruction. 2. If the end of the tail pipe is crimped, straighten the outlet. Refer to *Tail Pipe Replacement.*
The inner layer of the double layer pipe is separating.	Replace the pipe. Refer to *Exhaust Pipe Replacement (Front)* and *Exhaust Pipe Replacement (Rear).*

Exhaust Noise

Problem	Action
The exhaust components leak.	Tighten the clamps or the couplings.
The components are improperly installed or misaligned.	• Align the components. • Tighten the connections.
The following conditions are present in the tubing or the muffler: • Ruptures • Burn-outs	Replace the damaged components. Refer to *Muffler Replacement.*
Flaws are present in the following components: • The clamps • The pipes • The muffler	Replace the components. Refer to *Exhaust Pipe Replacement (Front)*, *Exhaust Pipe Replacement (Rear)* or *Muffler Replacement.*
Some of the exhaust system components are missing.	Install the missing components.

Exhaust Brake (Continuously On)

Problem	Action
The clutch pedal or the accelerator pedal switches are maladjusted.	Adjust the switches. Refer to Accelerator Pedal Switch and Clutch Pedal Switch.
The switches are improperly wired.	• Inspect the wiring. • Repair the wiring as needed.
A short is present in the wiring harness.	Repair the wiring.

Exhaust Brake (Engine Overheats/Loses Power)

Problem	Action
The exhaust manifold valve is stuck partially closed.	Loosen and lubricate the exhaust manifold valve or replace the exhaust manifold valve.
The exhaust manifold valve is adjusted so that it is partially closed.	Adjust the exhaust manifold valve.

Exhaust Brake (Does Not Operate)

Problem	Action
A fuse is blown.	Replace the fuse.
The accelerator pedal or the clutch pedal switches are improperly adjusted or faulty.	Adjust or replace the clutch pedal switch or the accelerator pedal switch. Refer to Clutch Pedal Switch or Accelerator Pedal Switch.
The following conditions exist at the switches or the control valves: • Poor connections • Corroded terminals	Clean or replace the switches or the control valves. Refer to Control Valves.
The air lines exhibit any of the following conditions: • Kinks • Restrictions • Ice	Repair the lines. In freezing weather, ensure that the air tanks are drained.
The relay crank is seized.	Repair the relay crank.

Exhaust Brake (Does Not Operate) (cont'd)

Problem	Action
The relay rod is broken or missing.	Repair or replace the relay rod.
The air cylinder or the control valve is jammed with ice.	Melt the ice. In freezing weather, ensure that the air tanks are drained.
The control valve is faulty. (The valve should open when 12 volts is applied.)	Replace the control valve. Refer to Control Valve.
The air cylinder is faulty.	Replace the air cylinder.
A broken wire is present in the harness.	Repair the wire.

Exhaust Brake (Slow To Operate)

Problem	Action
The exhaust manifold valve or the relay crank is tight.	1. Loosen the exhaust manifold valve or the relay crank. 2. Lubricate the exhaust manifold valve or the relay crank.
The accelerator pedal or clutch pedal switches are improperly adjusted.	Adjust the accelerator pedal switch or the clutch pedal switch.

Exhaust Brake (Weak Braking Action)

Problem	Action
The exhaust manifold valve is improperly adjusted or tight.	1. Loosen and/or adjust the exhaust manifold valve. 2. Lubricate the exhaust manifold valve, as necessary.
The relay crank is tight.	1. Loosen the relay crank. 2. Lubricate the relay crank.
The air lines are kinked or partially plugged with ice.	Repair the air lines. In freezing weather, ensure that the air tanks are drained.
The fittings at the air lines leak.	Tighten the fittings.
Leaking air cylinder	Replace the air cylinder.

Exhaust Brake (Will Not Turn Off)

Problem	Action
The relay crank or exhaust manifold valve is seized.	1. Loosen the relay crank or the exhaust manifold valve. 2. Lubricate the relay crank or the exhaust manifold valve.
The control valve or the air cylinder is jammed with ice.	1. Melt the ice. 2. Drain the lines. In freezing weather, ensure that the air tanks are drained.
A short is present in the wiring harness. (The wiring harness has 12 volts at the control solenoid in every control switch position.)	Repair the wiring.
The control switch is faulty.	Replace the control switch.

Repair Instructions

Exhaust System Replacement

Inspection Procedure

Inspect the exhaust pipes, the catalytic converter (if equipped), the muffler, and the tailpipe for the following conditions:

- Cracked joints
- Broken welds
- Corrosion damage

  These conditions may result in a leaking exhaust system.

Inspect the clamps, the brackets, and the insulators for the following conditions:

- Cracks
- Stripped bolt threads
- Corroded bolt threads

Verify that the exhaust system (including the heat shield) does not exhibit the following conditions:

- Leaks
- Binding
- Grounding
- Excessive vibration

The above conditions may occur if any of the following components are loose or damaged:

- The flange bolts
- The heat shields
- The brackets
- The pipes

Inspect the exhaust system components and the alignment if any of these conditions exist. Align and replace the components as necessary.

Exhaust Components Removal

Caution: Always wear protective goggles and gloves when removing exhaust parts as falling rust and sharp edges from worn exhaust components could result in serious personal injury.

An accumulation of dirt and corrosion can make the removal of the exhaust components difficult. Use a penetrating oil on the threads in order to assist in removing the exhaust components.

Exhaust Components Installation

Important: Replace the exhaust system parts with original equipment manufacturer (OEM) standard components. This action ensures that the vehicle operates as designed.

Important:

- Replace the tailpipe when the muffler is replaced.
- Use new packings and nuts when installing the exhaust pipe to the engine manifold.

  Clean the engine manifold stud threads with a wire brush before installing the new nuts.

Ensure that the components are correctly aligned when installing a new exhaust pipe or a new muffler or tailpipe. Incorrectly aligned components may cause rattles and noise vibrations in the exhaust.

Use the following steps when aligning the exhaust system:

1. Leave all of the bolts and the nuts loose.
2. Properly align all of the components.
3. Tighten the bolts and the nut, working from the front to the rear.

Replace the following components, if the components are damaged, in order to maintain the exhaust system alignment:

- The exhaust system hangers
- The hanger brackets
- The clamps

Exhaust Clamps Replacement (Wide Band Clamp)

1. Inspect all of the components for the following damage. Replace the damaged components as necessary:
   - Cracks
   - Bends
   - Stripped threads
   - Corrosion damage
   - Leaks
2. Insert a small pipe into the small end of the sleeve. Slide the sleeve back onto the pipe.
3. Install the pipes. Insert the small pipe into the large pipe.
4. Slide the sleeve over the pipe joint.
5. Install the block and the spacer bars.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
6. Install the bolts.

   Tighten

   Tighten the bolts until the spacer bars and the sleeve are clamped to the block. Do not exceed 80 N.m (59 lb ft).

Exhaust Clamps Replacement (U-Bolt Clamp)

1. Inspect all of the components for the following damage. Replace the damaged components as necessary:
   - Cracks
   - Bends
   - Stripped threads
   - Corrosion
2. Insert the exhaust clamp through the muffler hanger assembly.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
3. Install the nut on the exhaust clamp.

   Tighten

   Tighten the nuts to 60 N.m (44 lb ft).

Exhaust Clamps Replacement (Slip Joint)

Inspect all of the components for the following damage. Replace the damaged components as necessary:

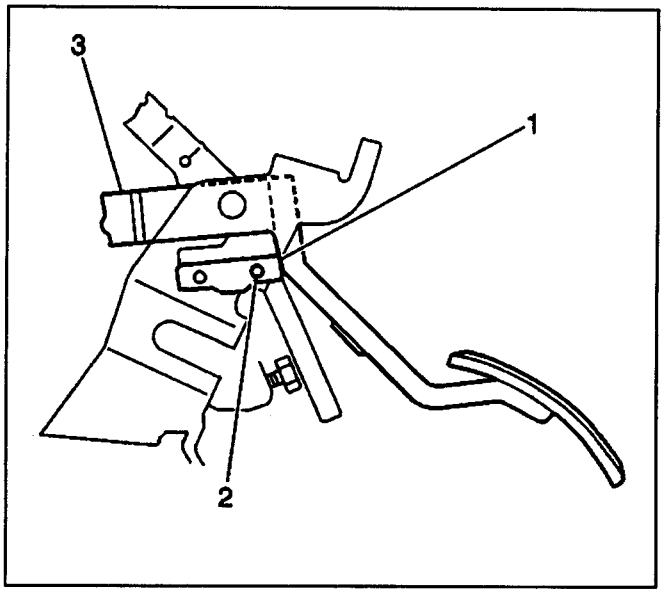
- Cracks
- Bends
- Stripped threads
- Corrosion damage
- Leaks

Accelerator Pedal Switch Replacement

Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Remove the pedal switch connector.
3. Remove the bolts (2).
4. Remove the accelerator pedal switch (1).



236567

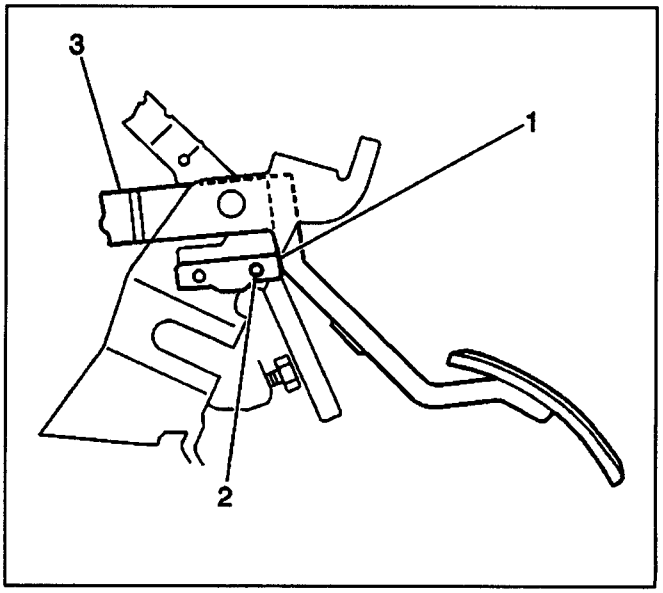
Installation Procedure

1. Install the accelerator pedal switch (1) to the bracket.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts.

   Tighten

   Tighten the bolts finger tight.
3. Ensure that the fast idle control is fully backed off.
4. Ensure that the accelerator linkage is properly adjusted.
5. Move the accelerator pedal switch (1) toward the actuating lever (3) until you hear a click.
6. Check the adjustment. The adjustment is correct when you hear the switch click immediately after you push in the accelerator pedal from the idle position.
7. Tighten the bolts.
8. Install the pedal switch connector.
9. Connect the negative battery cable.



236567

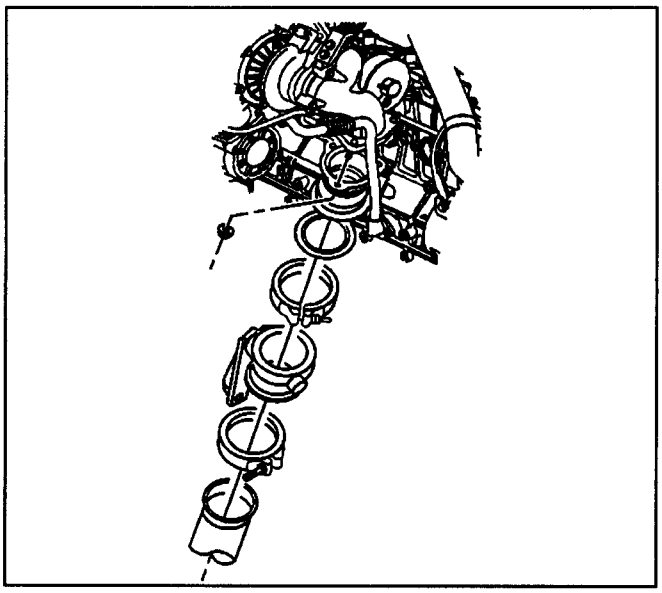
Clutch Pedal Switch Replacement

Removal Procedure

1. Release all of the compressed air from the air tanks.
2. Remove the control valve connector.
3. Remove the air lines.
4. Remove the bolts.
5. Remove the nuts.
6. Remove the washer.
7. Remove the control valve.

Installation Procedure

1. Connect the control valve to the frame.
2. Install the bolts.
3. Install the washers.
4. Install the nuts.
5. Install the air lines.
6. Install the control valve connector.



236570

Exhaust Brake Actuator Control Valve Replacement (Valve)

Removal Procedure

Caution: Make sure actuator is not pressurized before performing any service procedures. The actuator assembly, when pressurized, exerts sufficient force to cause personal injury. Refer to Air Brakes to depressurize the system before performing any service procedures.

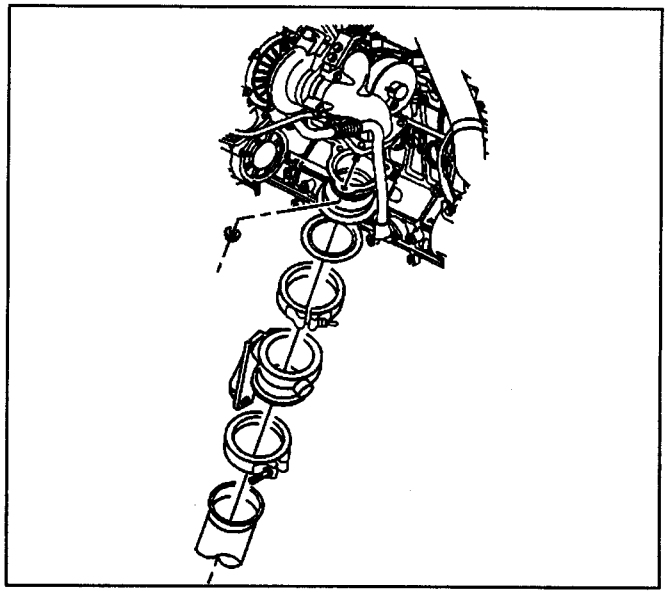
1. Inspect the exhaust brake for foreign objects that are trapped between the following components:
   - The lever and the stop peg
   - The actuator and the bracket
2. Inspect the following components for tightness:
   - The two mounting bracket bolts
   - The stop peg
   - The clamp rings
3. Inspect the following components for dirt:
   - The actuator push rod end
   - The lip seal
   - The breather
   - The pivot
4. Perform the following actions simultaneously:
   - Hold the actuator rod across the flats.
   - Slacken the locknut.
5. Remove the inlet hose elbow.

6. Remove the following components:
   - The circlip
   - The washer
7. Remove the actuator from the fixed pivot.
8. Unthread the actuator rod from the ball joint in order to remove the actuator rod.
9. Inspect the condition of the actuator sleeve.
   Replace the actuator sleeve, if necessary.

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Thread the locknut onto the actuator rod.
   Tighten
   Tighten the actuator rod locknut to 14 N·m (10 lb ft).
2. Install the end of the actuator rod into the ball joint.
3. Slide the actuator over the pivot pin.
4. Install the washer and the circlip.
   Ensure that the circlip is properly seated.
5. Install the inlet hose elbow.
   Tighten
   Tighten the inlet hose elbow to 20 N·m (14 lb ft).
6. Verify that the following conditions exist:
   - The actuator rod is properly adjusted.
   - The butterfly valve lever contacts the stop peg when the butterfly valve lever is in the fully open position.
   - The butterfly valve lever contacts the stop peg when the butterfly valve lever is in the fully closed position.



236570

Exhaust Brake Actuator Control Valve Replacement (Actuator Sleeve)

Removal Procedure

1. Remove the circlip and the washer.
2. Slide the actuator off of the following components:
   - The actuator sleeve
   - The pivot pin
3. Remove the actuator sleeve.
4. Remove the washer.

Installation Procedure

1. Install the washer over the pivot pin.
2. Install a new actuator sleeve into the actuator.
3. Slide the actuator and the sleeve onto the pivot pin.
4. Install the washer and the circlip. Ensure that the washer is properly seated.

Exhaust Brake Actuator Stop Peg Replacement

Removal Procedure

1. Close the butterfly valve.
2. Remove the stop peg.
3. Remove the washer.

Installation Procedure

1. Install a new washer.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install a new stop peg.

   Tighten

   Tighten the stop peg to 24 N·m (18 lb ft).
3. Verify that the following conditions exist:
   - The actuator rod is properly adjusted.
   - The butterfly valve lever contacts the stop peg when the butterfly valve lever is in the fully open position.
   - The butterfly valve lever contacts the stop peg when the butterfly valve lever is in the fully closed position.

Exhaust Brake Ball Joint Replacement

Removal Procedure

1. Remove the exhaust brake actuator.

   Refer to *Exhaust Brake Actuator Control Valve Replacement (Valve)*.
2. Remove the wire retaining clip from the ball joint.
3. Detach the ball joint from the assembly.

Installation Procedure

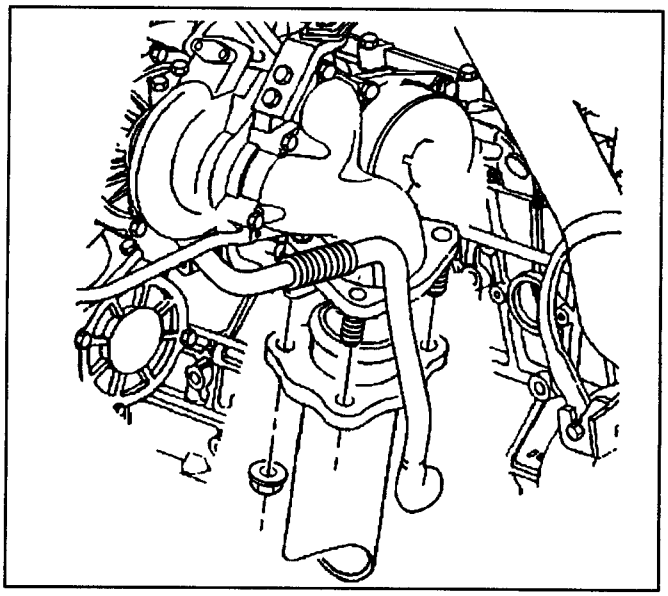
1. Install a new ball joint cap.
2. Install a new wire retaining clip.
3. Install the exhaust brake actuator.

   Refer to *Exhaust Brake Actuator Control Valve Replacement (Valve)*.

Exhaust Pipe Replacement (Front)

Removal Procedure

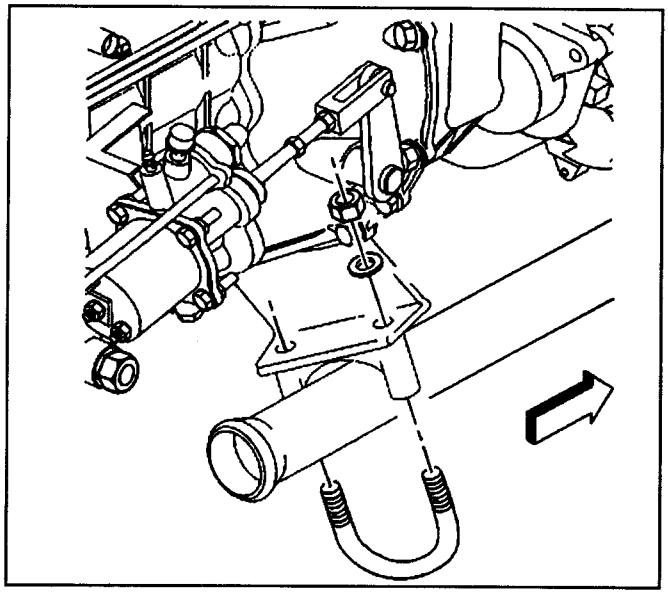
1. Remove the nuts from the turbocharger.
2. Remove the clamp from the flexible pipe.



236579

3. Remove the clamp from the transmission bracket.
4. Remove the front exhaust pipe.
5. Inspect all of the components for the following conditions:
   - Cracks
   - Bends
   - Stripped threads
   - Corrosion
   - Leaks

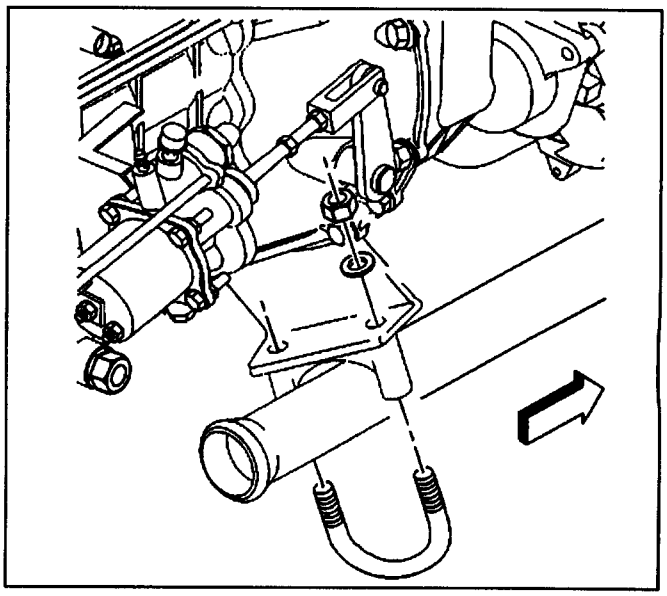
   Replace the components as necessary.



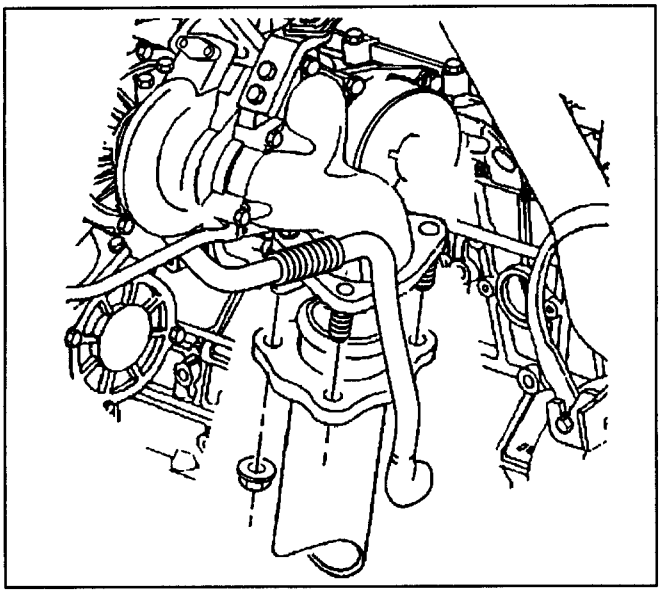
236578

Installation Procedure

1. Place the front exhaust pipe into position.
2. Install the clamp to the transmission bracket.



236578



236579

3. Install the clamp at the flexible pipe.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

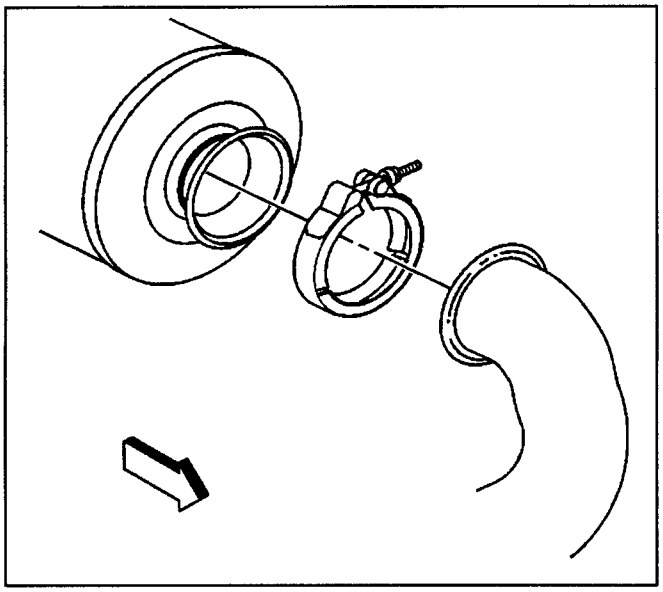
4. Install the nuts to the turbocharger.

   Tighten

   4.1. Tighten the front exhaust pipe nuts to 29 N·m (21 lb ft).

   4.2. Tighten the bolts on the wide band clamp to 10 N·m (89 lb in).

   4.3. Tighten the nuts on the exhaust clamps to 24 N·m (18 lb ft).

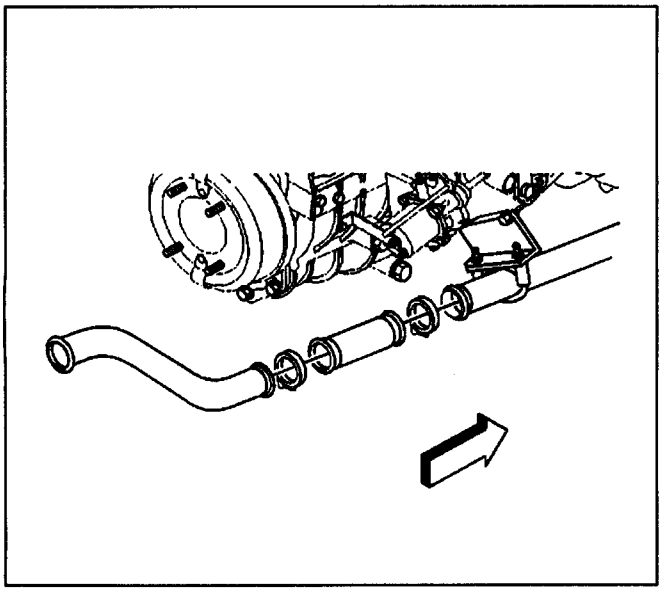


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Exhaust Pipe Replacement (Rear)

Removal Procedure

1. Loosen the clamps on the flexible pipe.
2. Remove the clamps at the muffler.



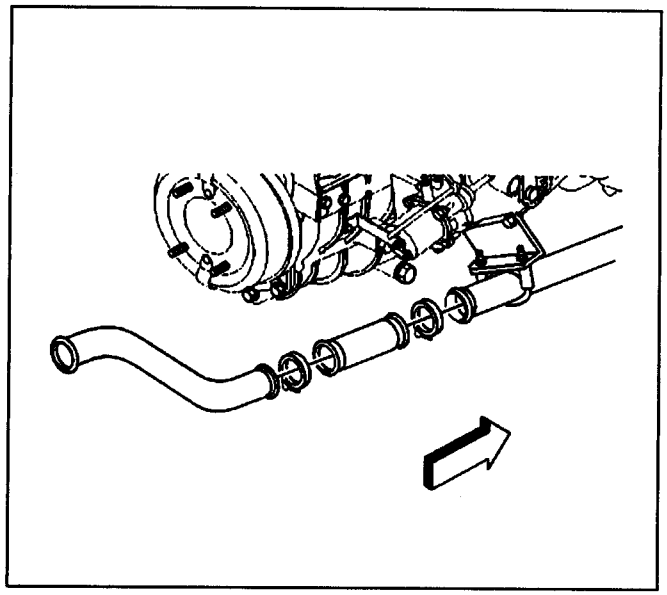
236576

3. Remove the rear exhaust pipe.
4. Inspect all of the components for the following conditions:
   - Cracks
   - Bends
   - Stripped threads
   - Corrosion
   - Leaks

   Replace the components as necessary.

Installation Procedure

1. Put the rear exhaust pipe into position.



236576

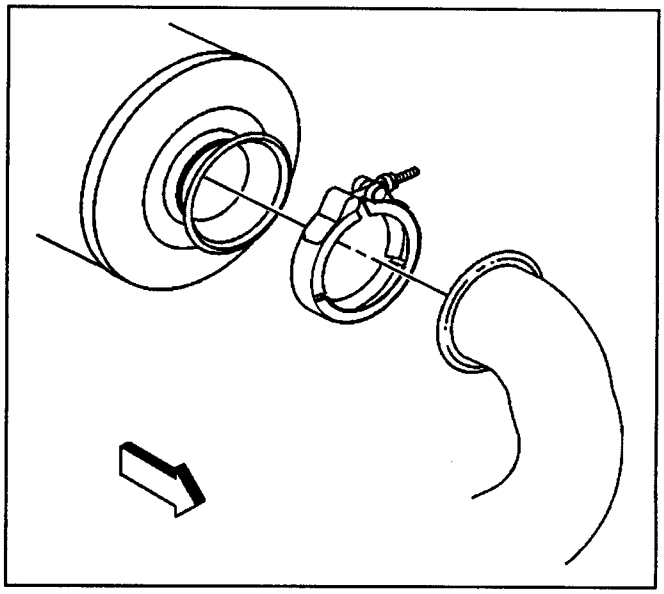
2. Install the clamp at the muffler.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the clamp at the flexible pipe.

   Tighten

   Tighten the clamp to 10 N.m (89 lb in).

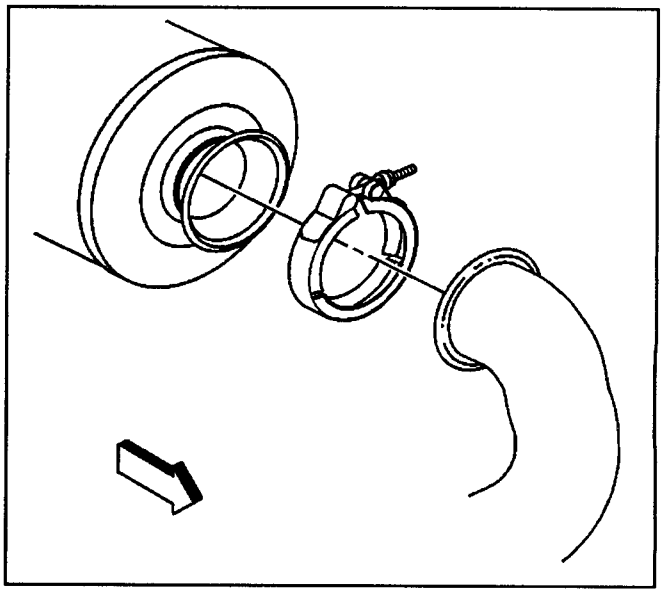


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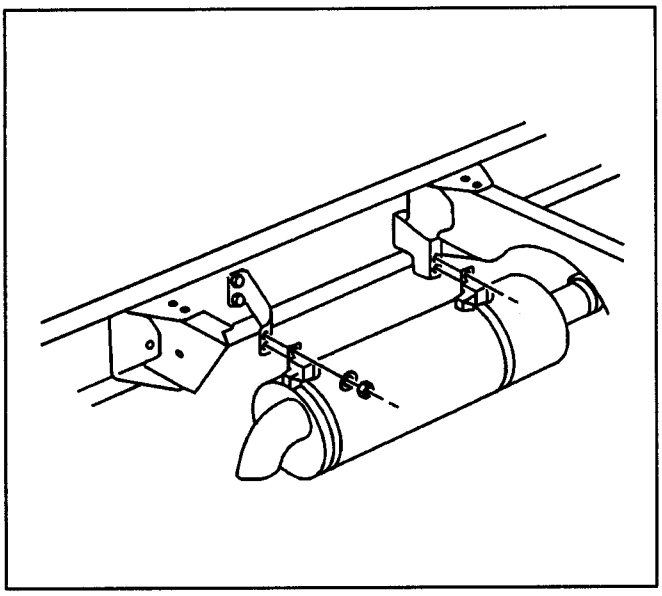
Muffler Replacement

Removal Procedure

1. Remove the clamp from the rear exhaust pipe to the muffler.



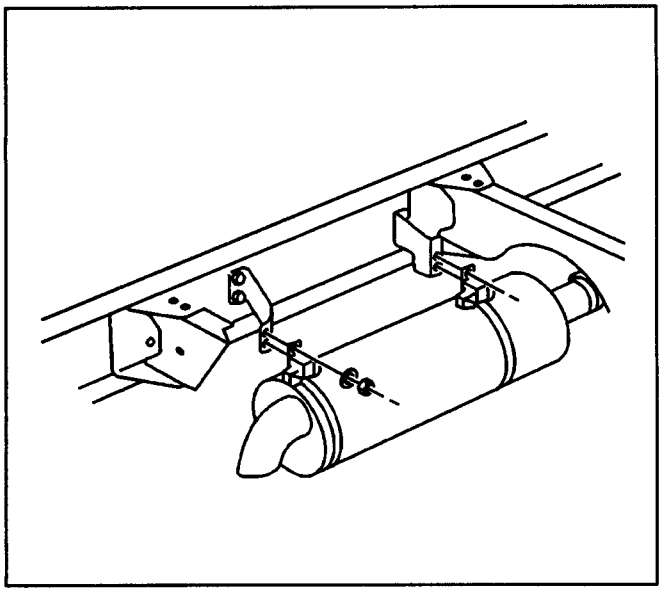
236575



206335

2. Remove the nuts from the muffler hanger.
3. Remove the muffler.
4. Inspect all of the components for the following conditions:
   - Cracks
   - Bends
   - Stripped threads
   - Corrosion
   - Leaks

   Repair or replace the components as necessary.

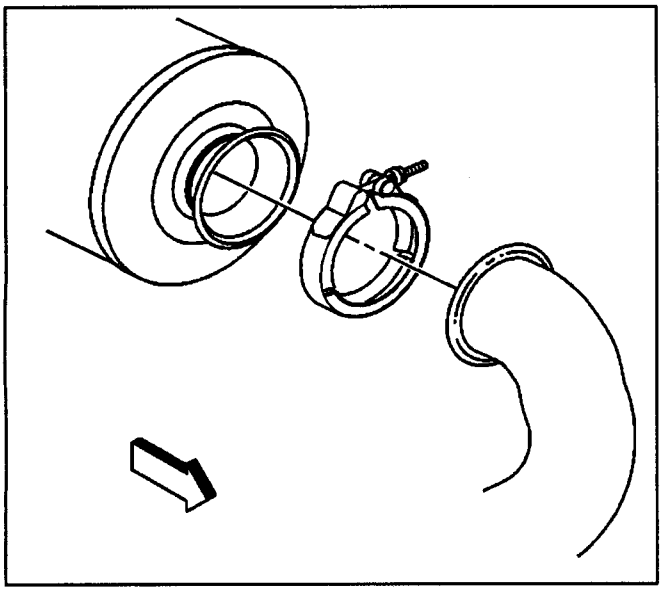


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Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the muffler hanger to the muffler.
   Tighten
   Tighten the muffler clamp nuts to 29 N·m (21 lb ft).
2. Install the nuts to the muffler hanger.
   Tighten
   Tighten the exhaust hanger nuts to 24 N·m (18 lb ft).



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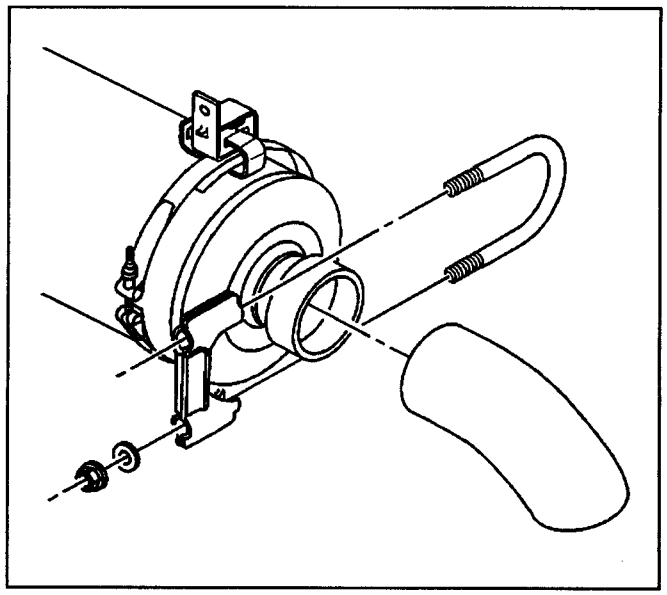
3. Install the clamp to the rear exhaust pipe.
   Important: Install a new tail pipe when the muffler is replaced.
4. Install a new tailpipe to the muffler.
   Tighten
   Tighten the tailpipe clamp nuts to 24 N·m (18 lb ft).

Tail Pipe Replacement

Removal Procedure

1. Remove the clamp.
2. Remove the tailpipe.
3. Inspect all of the components for the following conditions:
   - Cracks
   - Bends
   - Stripped threads
   - Corrosion
   - Leaks

   Repair or replace the components, as necessary.



236572

Installation Procedure

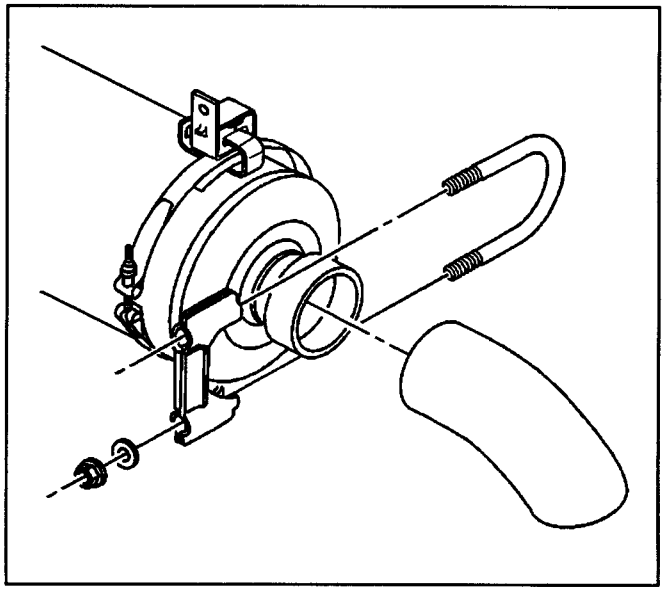
Important: Install a new tail pipe when you replace the muffler.

1. Install the tailpipe into the muffler.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the clamp.

   Tighten

   Tighten the nuts alternately and uniformly to 24 N·m (18 lb ft).



236572

Description and Operation

Exhaust System Description

Exhaust system designs vary according to the following items:

- The model destination
- The intended use of the vehicle

The exhaust system is suspended by hangers. The hangers are attached to the frame members. The hangers allow some movement of the exhaust system. The hangers prevent the transfer of noise and vibration into the vehicle.

Heat shields protect the vehicle and the environment from high temperatures. The high temperatures may develop from the exhaust system.

Inspect the following components:

- The exhaust pipes
- The muffler
- The tailpipe

Inspect the above components for the following conditions:

- Cracked joints
- Broken welds
- Corrosion

  The above conditions could result in a leaky exhaust system.

Inspect the following components for cracks or stripped or corroded thread bolts:

- The clamps
- The brackets
- The insulators

Inspect the exhaust system (including the heat shields) for the following conditions:

- Leaks
- Binding
- Grounding
- Excessive vibration

The conditions that are mentioned above are usually caused when the following components are damaged or loose:

- The flange bolts
- The heat shields
- The brackets
- The pipes

If any of the mentioned conditions exist, inspect the components and the alignment of the exhaust system. Align or replace the components as necessary.

Installing Exhaust Components

Important:

- Ensure that any exhaust system parts that you replace meet the original equipment manufacturer (OEM) standard. This action will ensure that the vehicle operates as designed.
- When you replace the muffler, you should also replace the tail pipe.
- When you install the exhaust pipe to the engine manifold, use new packings and new nuts. Clean the engine manifold stud threads with a wire brush before installing the new nuts.

Inspect for correct alignment whenever the following new components are installed onto any model:

- A new exhaust pipe
- A muffler
- A tail pipe

Misaligned parts may cause rattles and noise vibration in the exhaust.

When aligning the system, leave all of the bolts and the nuts loose until all of the components are properly aligned. Then tighten the bolts and the nuts, working from the front to the rear.

If any of the following components are damaged, replace the components. This action will maintain the correct exhaust system alignment.

- The exhaust system hangers
- The hanger brackets
- The clamps

Exhaust Brake Operation

The exhaust brake system increases the amount of power that is absorbed by the engine when the following conditions exist:

1. The exhaust brake system is turned on.
2. The vehicle is coasting.
3. The clutch is engaged.

The exhaust brake system consists of the following components:

- The exhaust manifold valve
- The air cylinder
- The control valve
- The control switches

Current flows through the fuse to the clutch pedal switch when the ignition switch is in the ON position. The clutch pedal switch and the accelerator switch are normally closed.

Current flows to the control switch when the clutch and the accelerator pedals are in the released position. When the clutch and the accelerator pedals are in the released position, the engine is at idle and the clutch is fully engaged.

Current flows to the control valve and to the indicator lamp when the control switch is turned ON.

The following actions occur when the control valve is energized:

1. The control valve opens.
2. The open control valve allows air to flow from the brake system air line to the air cylinder.
3. When the air cylinder is supplied with compressed air, the air cylinder pushes the exhaust manifold valve shut.
4. The exhaust pressure allows the engine to become a more effective brake.

The following actions occur when the clutch or the accelerator pedal is pushed in:

1. The accelerator pedal switch or the clutch pedal opens.
2. The power supply to the control valve is interrupted.
3. The control valve closes. This action removes air pressure from the air cylinder.
4. The air cylinder pulls the exhaust manifold open.
5. Normal engine operation resumes.

BLANK

SECTION 6A6

DIESEL ENGINE ON-VEHICLE SERVICE

NOTICE: *Always use the correct fastener in the correct location. When you replace a fastener, use ONLY the exact part number for that application. ISUZU will call out those fasteners that require a replacement after removal. ISUZU will also call out the fasteners that require thread lockers or thread sealant. UNLESS OTHERWISE SPECIFIED, do not use supplemental coatings (paints, greases, or other corrosion inhibitors) on threaded fasteners or fastener joint interfaces. Generally, such coatings adversely affect the fastener torque and the joint clamping force, and may damage the fastener. When you install fasteners, use the correct tightening sequence and specifications. Following these instructions can help you avoid damage to parts and systems.*

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GENERAL DESCRIPTION

The ISUZU model 6HK1-TC engine is used in the vehicle covered in this manual. The engine is an in-line six cylinder, four stroke, water cooled, direct fuel injection, turbocharged diesel. The charge air cooler is the air to air heat exchange system using a corrugated-fin heat exchanger installed in front of the radiator.

The forged crankshaft is supported by seven precision insert main bearings. The crankshaft thrust washer is located at the number seven crankshaft main bearing.

The connecting rods have precision insert type crankshaft (big end) bearings. The piston pins are retained by snap rings. The pistons have three compression rings and one oil

control ring. The pistons are cooled by oil jets. Dry liners are used. The liners have been phosphated (P-Mn method), both inside and outside for long life.

The camshaft is supported by four plain bearings, and is gear driven. Motion is transferred to the overhead valves by shaft type roller valve rocker arms.

The cylinder head may be rebuilt with new valve guides and seats. Refer to "Engine Overhaul" in SECTION 6A6B.

For further information on engine overhaul of the 7.8L, refer to SECTION 6A6B.

For information about the turbocharger, refer to SECTION 6J.

ENGINE IDENTIFICATION

The engine used in this vehicle is the 7.8L (475 CID).

The engine identification number is on the front right hand side (passenger) of the cylinder block. For further information, refer to SECTION 0A.

ENGINE LUBRICATION

A gear type oil pump is used. The engine is equipped with both full flow and bypass filters. An oil cooler is provided to help control oil temperatures. Major moving parts are supplied with oil from a large oil gallery in the cylinder block.

ON-VEHICLE SERVICE

VALVE ROCKER ARM COVER

Remover or Disconnect (Figure 1)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Air inlet pipes. Refer to SECTION 6J.
4. Valve rocker arm cover with gasket.

NOTICE: Do not pry on the valve rocker arm cover. Damage to the sealing surfaces may result.

Clean

- Oil and grease from the sealing surfaces on the cylinder head and the valve rocker arm cover.

Install or Connect (Figure 1)

1. Valve rocker arm cover and the gasket to the cylinder head.
2. Valve rocker arm bolts.

Tighten

- Valve rocker arm cover bolts to 13.N·m (113 lb. in.).

3. Air inlet pipes.
4. Negative battery cables.
5. Lower the cab.

VALVE ROCKER ARM AND CAMSHAFT

Remove or Disconnect (Figure 2)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Air inlet pipes. Refer to SECTION 6J.
4. Valve rocker arm cover. Refer to "Valve Rocker Arm Cover" in this section.
5. Connector both on the top of injectors and from engine harness.
6. Harness assembly.
7. Loosen all the valve adjusters, but do not remove.
8. Loosen the valve rocker arm shaft bracket bolts evenly, starting from the outer bolts moving to the inner bolts.

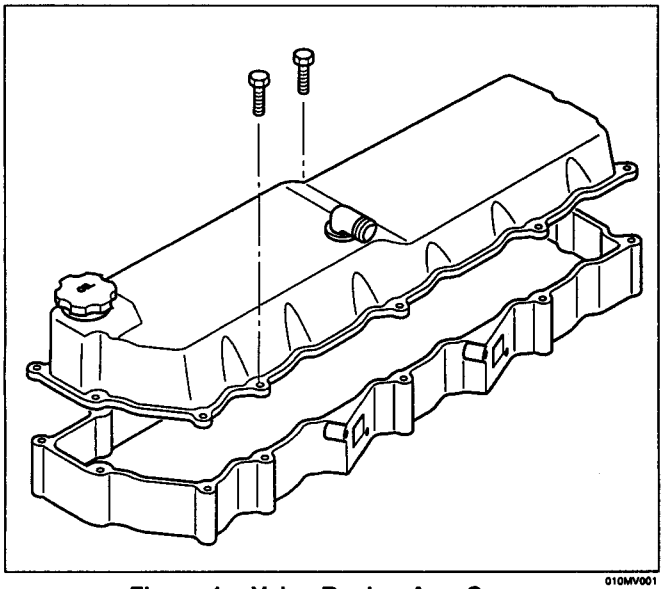


Figure 1 – Valve Rocker Arm Cover

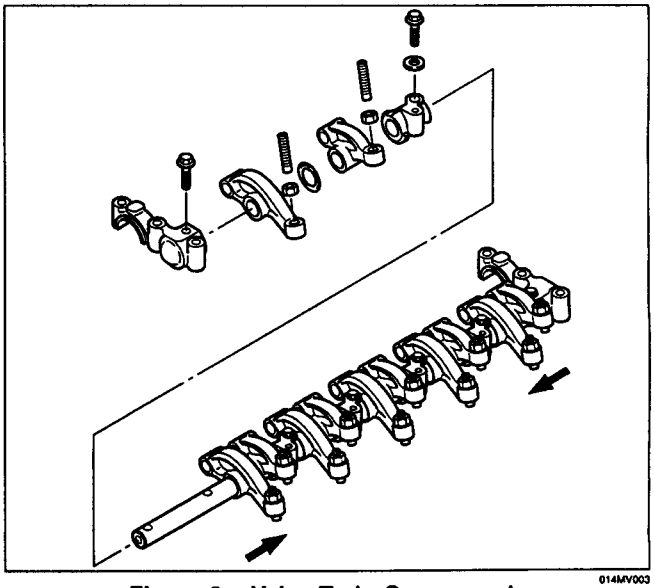


Figure 2 – Valve Train Components

Important

- Do not remove the rocker arm shaft bracket bolts from the valve rocker arm shaft assembly until the assembly is removed from the vehicle. Place on a work bench before disassembling.

9. Valve rocker arm shaft assembly.
10. Loosen camshaft bearing cap nuts evenly, starting from the outer nut moving to the inner nut.
11. Camshaft assembly.

Important

- Store used components in order so they can be reassembled in the same location.

Disassemble

- Rocker arm shaft bracket bolts, front camshaft bracket, valve rocker arm, valve rocker arm spring, valve rocker arm shaft bracket, and the rear camshaft bracket from the valve rocker arm shaft.

Clean

- Oil and dirt from the valve rocker arm assembly with approved cleaners.

Inspect

- All the valve rocker arm components for excessive scoring and wear. Replace if necessary.

Measure

- Valve rocker arm. Refer to SECTION 6A6B for valve rocker arm specifications.

Install or Connect (Figures 3 and 6)

1. Camshaft to the cylinder head.
2. Camshaft bearing caps to the cylinder head.

Important

- Camshaft bearing caps must be installed in facing front mark to engine front.

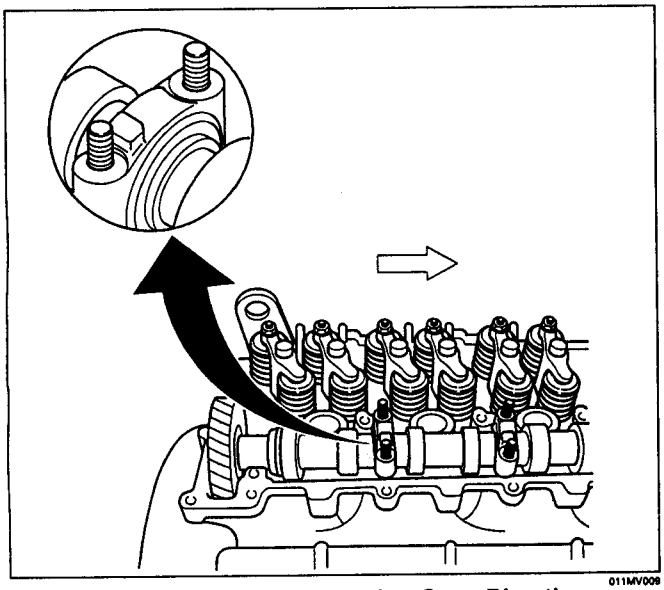


Figure 3 – Camshaft Bearing Caps Direction

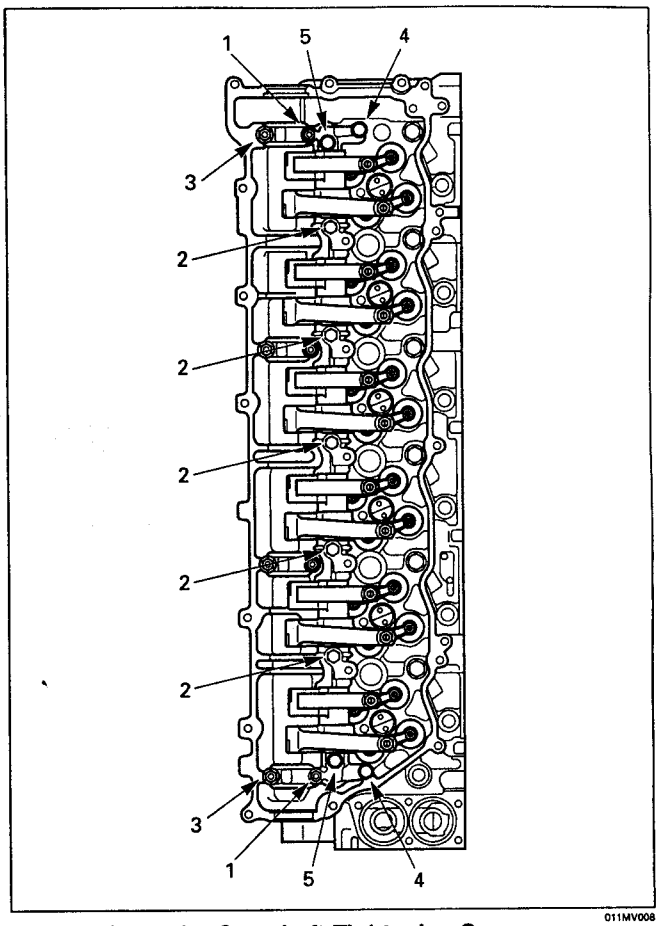


Figure 4 – Camshaft Tightening Sequence

3. Camshaft bearing cap nuts

Tighten

- Bolts to 27.5 N·m (20 lb. ft.).

4. Valve rocker arm assembly to the cylinder head.

Tighten

- Valve rocker arm shaft bracket bolts. Refer to Figure 5 for tightening sequence.
  — M8 Bolts to 27.5 N·m (20 lb. ft.).
  — M10 Bolts to 56 N·m (41 lb. ft.).

Adjust

- Refer to SECTION 6A6B for the "Valve Rocker Arm Adjustment" procedure.

5. Apply the sealant to lower surface of lower case and put on the cylinder head.

Tighten

- Bolts 19 N·m (14 lb·ft)

6. Harness assembly.

Tighten

- Bolt 21 N·m (16 lb.ft)

7. Tighten connector nuts to injector
   - Nut 1.4 N·m (12 lb.in)
8. Connect harness connector.
9. Valve rocker arm cover and the gasket to the cylinder head.
10. Valve rocker arm cover bolts.

Tighten

- Valve rocker arm cover bolts to 13 N·m (113 lb.in.).

11. Air inlet pipes.
12. Negative battery cables.
13. Lower the cab.

VALVE STEM SEAL AND VALVE SPRING

Tools Required:
J36022 Air Adapter
J43267 Valve Stem Seal Installer
J43263 Valve Spring Compressor.

Remove or Disconnect (Figures 5 through 7)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Air inlet pipes. Refer to SECTION 6J.
4. Valve rocker arm cover. Refer to "Valve Rocker Arm Cover" in this section.
5. Valve rocker arm shaft assembly. Refer to "Valve Rocker Arm" in this section.
6 Valve bridge.
7. Glow plugs.
8. Valve keys.
   A. Install J36022 adapter into the cylinder head.
   B. Apply compressed air to hold the valves in place.
   C. Install J43263 to the cylinder head and compress the valve spring.
   D. Remove the valve keys.
   E. Carefully release the valve spring tension.
9. Valve spring retainers.
10. Inner and outer valve springs.
11. Valve spring seats.
12. Valve stem seals.

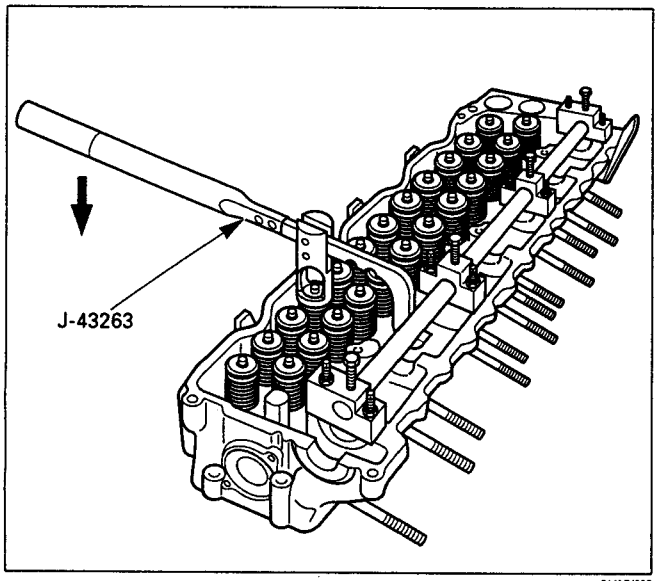


Figure 5 – Compressing the Valve Spring

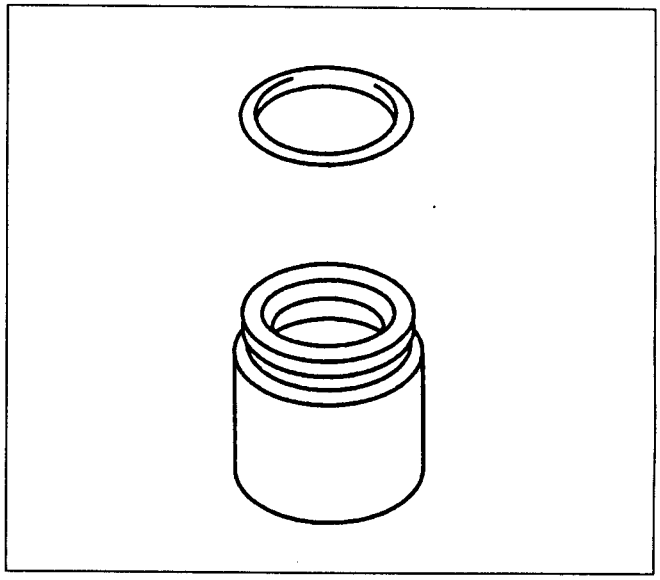


Figure 6 – Valve Seal

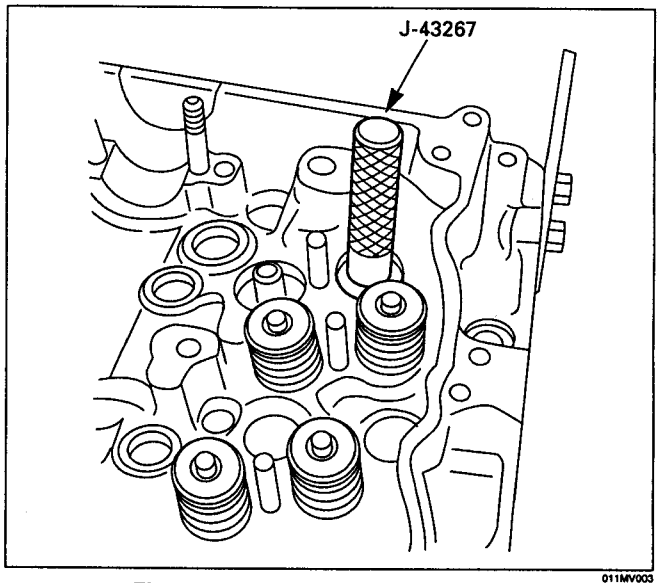


Figure 7 – Installing the Valve Seal

Install or Connect (Figures 5 through 7)

- Lubricate the new valve stem seals with clean engine oil.
- Valve stem seals using J43267.

1. Valve stem seals.
2. Valve spring seats.
3. Inner and outer valve springs.
4. Valve spring retainers.
   A. With compressed air applied to the cylinder, compress the valve spring using J43263.
   B. Install the valve keys.
   C. Carefully release the valve spring tension. Make sure the valve keys stay in place.
   D. Remove J43263.
   E. Remove J36022.
5. Valve bridge.
6. Glow plugs.
7. Valve rocker arm assembly. Refer to "Valve Rocker Arm" in this section.
8. Valve rocker arm cover.

9. Air inlet pipes.
10. Negative battery cables.
11. Lower the cab.

INTAKE MANIFOLD

Remove or Disconnect (Figures 8 and 9)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Air inlet pipes and brackets. Refer to SECTION 6J.
4. Coolant over flow hose bracket from the intake manifold. Refer to SECTION 6B.

Important

- Do not bend the fuel injector lines in any shape or form to ease the removal of the intake manifold.

5. Fuel lines from the fuel common rail to the fuel injector. Refer to SECTION 6C2.
6. Fuel lines from injection pump to fuel common rail.

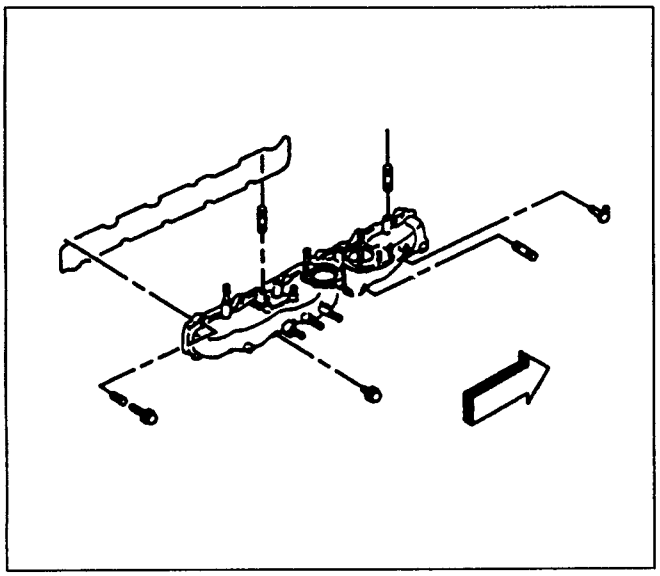


Figure 8 – Intake Manifold and Gasket

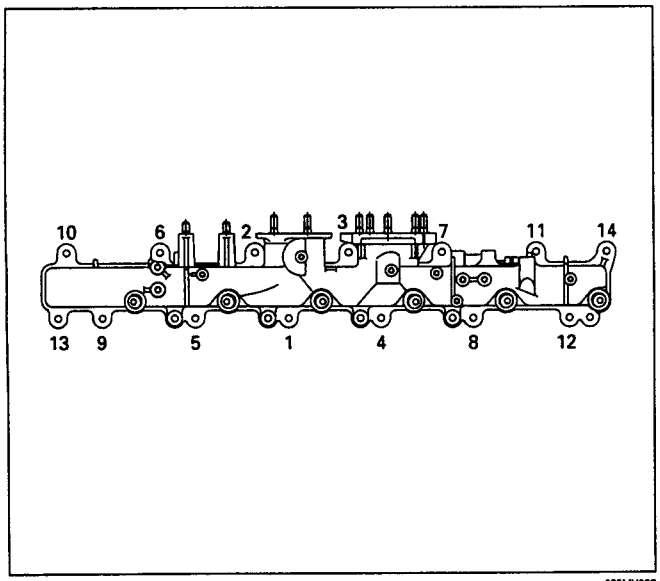


Figure 9 – Intake Manifold Tightening Sequence

7. Fuel injector return line from the fuel injector, fuel common rail and the fuel supply pump. Refer to SECTION 6C2.
8. Fuel filter and the bracket from the intake manifold. Refer to SECTION 6C2.
9. Intake manifold bolts.
10. Intake manifold and the gasket.

Inspect

- Intake manifold for cracks or damage to the gasket mating surfaces.

Install or Connect (Figures 8 and 9)

1. Intake manifold and gasket to the cylinder head.
2. Intake manifold bolts and nuts.
3. Fuel common rail.

Tighten

- Intake manifold bolts to 15 N·m (130 lb. in.).

4. Fuel lines from the supply pump to the fuel common rail.
5. Fuel lines from the common rail the fuel injector.
6. Fuel injector return line from fuel injector, fuel common rail and the fuel supply pump.
7. Fuel filter and the bracket to the intake manifold.
8. Fuel lines to the fuel filter and to the fuel supply pump.
9. Negative battery cables.
10. Lower the cab.

EXHAUST MANIFOLD

Remove or Disconnect (Figure 10)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Turbocharger assembly. Refer to SECTION 6J.
4. Exhaust heat shield.
5. Exhaust manifold nuts, bolts, washers, and the spacers.
6. Exhaust manifold and the gasket.

Inspect

- Exhaust manifold for cracks or damage.

Measure

- Use a straight edge to check the flatness of the exhaust manifold. If a gap of 0.4 mm (0.015 in.) or more exists, replace the exhaust manifold.

Install or Connect (Figure)

1. Exhaust gasket and the exhaust manifold.
2. Exhaust manifold bolts, washers, spacers and the nuts.

Tighten

- Exhaust manifold bolts and nuts to 34 N·m (25 lb. ft).

3. Exhaust manifold heat shield.
4. Turbocharger assembly.
5. Negative battery cables.
6. Lower the cab.

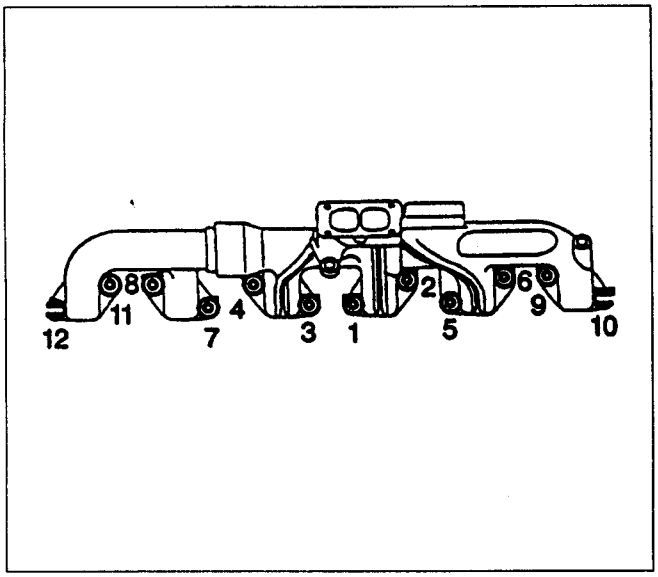


Figure 10 – Exhaust Manifold

CYLINDER HEAD

Remove or Disconnect (Figures 11 through 14)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Drain the cooling system. Refer to SECTION 6B.
4. Air inlet pipes. Refer to SECTION 6J.
5. Turbocharger assembly. Refer to SECTION 6J.
6. Intake manifold assembly. Refer to "Intake Manifold" in this section.
7. Exhaust manifold assembly. Refer to "Exhaust Manifold" in this section.
8. Heat shield and bracket.
9. Valve rocker arm cover. Refer to "Valve Rocker Arm Cover" in this section.
10. Valve rocker arm and camshaft from the cylinder head. Refer to "Valve rocker arm and camshaft" in this section.
11. Fuel injector nozzles. Refer to SECTION 6C2.
12. Coolant line from the air compressor to the cylinder head.
13. Glow plugs. Refer to SECTION 6D6.
14. Air compressor line bracket from the rear of the cylinder head. Refer to SECTION 5J.
15. Cylinder head bolts from the cylinder head.
16. Cylinder head and the gasket from the engine.

Clean

- Carbon deposits from the combustion chambers.
- All traces of the old cylinder head gasket from the cylinder head and the engine block.
- Cylinder head bolt threads using a wire brush
- Metal chips and dirt from the threads in the cylinder block.

Inspect

- Cylinder head for cracks or damaged parts.
- Threaded parts for wear or damage.

Measure

- Use a straight edge to check the flatness of the cylinder head. If the cylinder head has more than 0.2 mm (0.0078 in.) gap between the straight edge and the surface of the cylinder head, replace the cylinder head. Refer to SECTION 6A6B.

Install or Connect (Figures 10 through 14)

1. Cylinder head and the gasket to the engine block.
   - Apply sealant to the rear corners of the cylinder block.
   - Install the cylinder head gasket with the part number facing up.
2. Cylinder head bolts to the cylinder head.

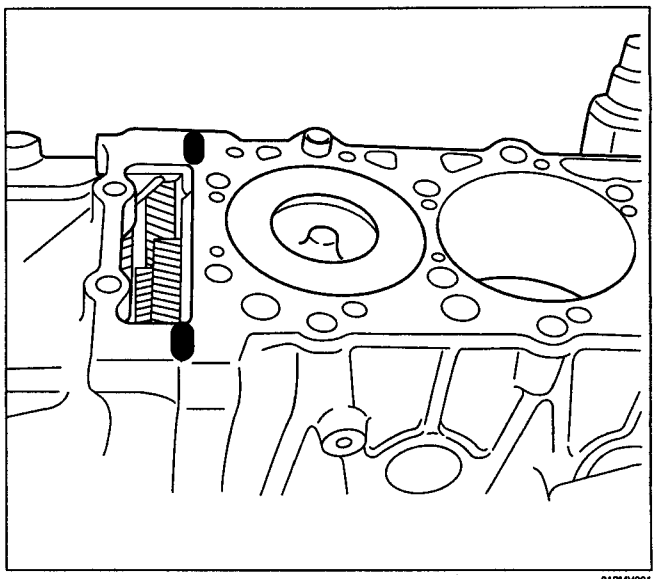


Figure 11 – Apply the Sealant

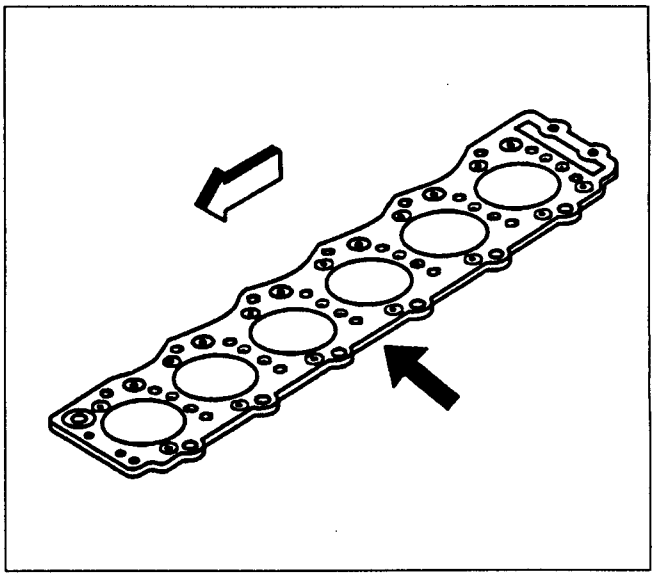


Figure 12 – Installing the Cylinder Head Gasket

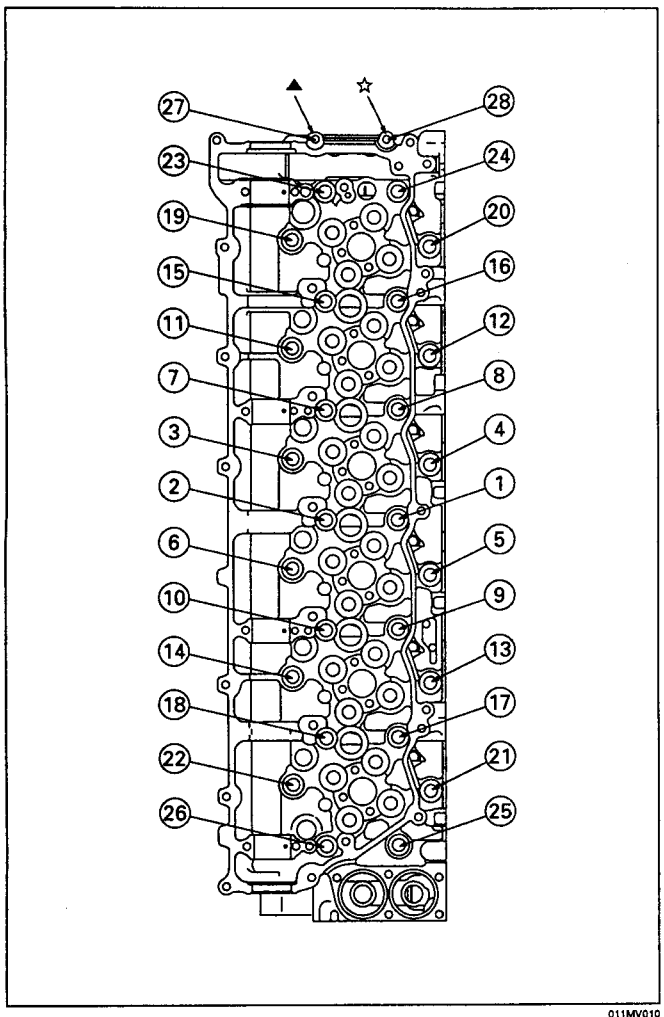


Figure 13 – Cylinder Head Torque Sequence

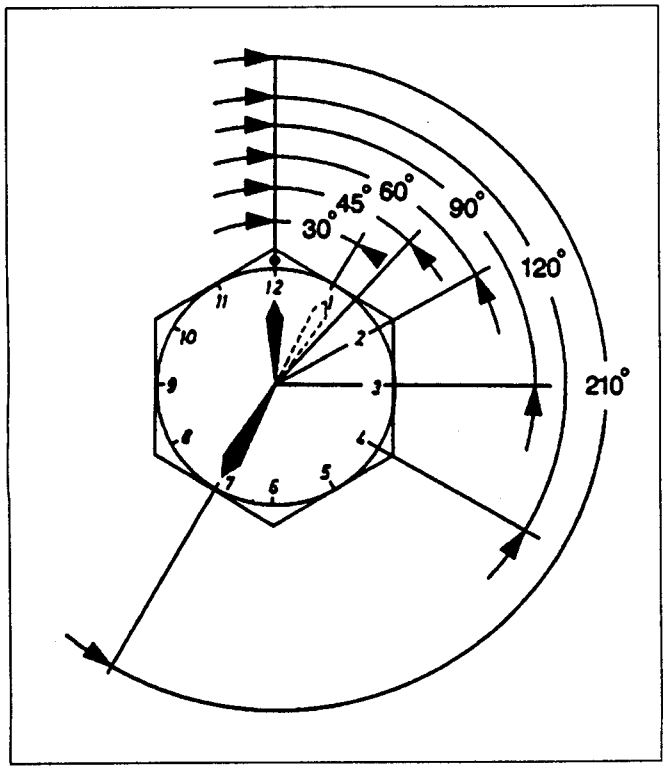


Figure 14 – Final Torque Step

Tighten

- Cylinder head bolts in the following steps.

For M14 Bolts

- Apply molybdenum disulfide grease to thread and contact surface of washer.
- Tighten cylinder head bolt and follow the tightening order 1 to 26.
  - — 98 N·m (72 lb. ft.).
  - — 147 N·m (108 lb. ft.).
  - — Turn all the cylinder head bolts an additional 30 to 60 degree.

For M10 Bolts

- Apply engine oil to threads and follow the tightening order number 27 to 28.
  - — 39 N·m (28 lb. ft.)

3. Camshaft and valve rocker arm to the cylinder head. Refer to "Valve rocker arm and Camshaft" in this section.
4. Valve rocker arm cover.
5. Coolant line from the air compressor to the cylinder head.
6. Air compressor lines and the bracket to the rear of the cylinder head.
7. Glow plugs.
8. Fuel injector nozzles.
9. Valve rocker arm cover.
10. Exhaust manifold. Refer to "Exhaust Manifold" in this section.
11. Intake manifold. Refer to "Intake Manifold'" in this section.
12. Turbocharger assembly. Refer to SECTION 6J.
13. Air inlet pipes.
14. Negative battery cables.
15. Lower the cab.

CYLINDER HEAD REPAIR

- Refer to SECTION 6A6B for cylinder head repair.

CRANKSHAFT BALANCER (EXTERNAL) FRONT COVER AND FRONT COVER OIL SEAL

Tools Required:
J.39046 Crankshaft Balancer (External) Remover and Installer
J41220 Oil Slinger Remover
J41221 Oil Seal Installer

Remove or Disconnect (Figures 15 through 16)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Drive belts. Refer to SECTION 6B.
4. Crankshaft balancer bolts and washers from the crankshaft balancer.
5. Crankshaft balancer bolt and the washer.
6. Crankshaft balancer from the crankshaft.
7. Front cover seal.
   - Carefully pry out the seal with a screw driver. Do not damage the front cover.
8. Front cover bolts.
9. Front cover.

Important

- Oil slinger must be replaced if the front cover oil seal has been removed.
- Install J41220 and remove the oil slinger.

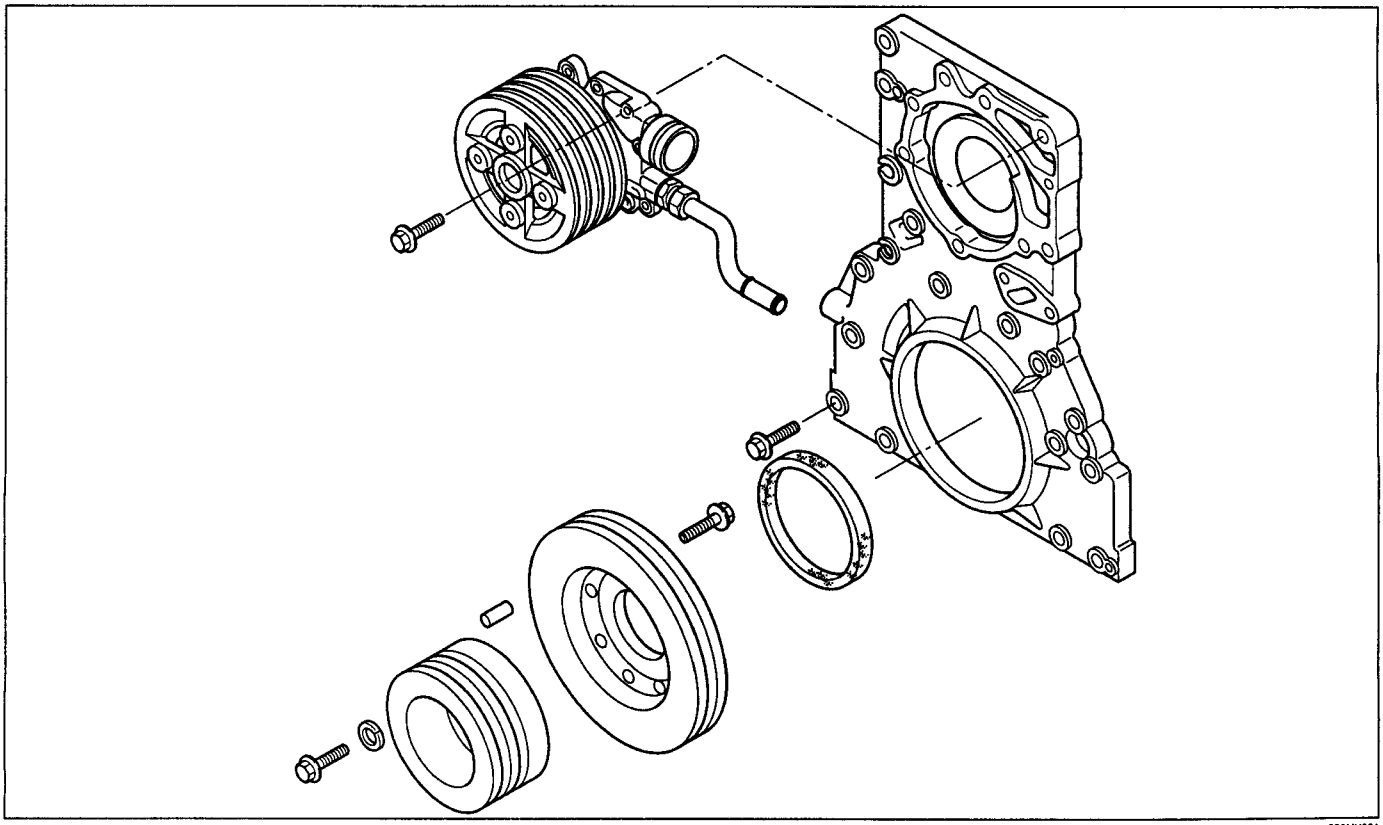
Install or Connect (Figures 17 through 20)

1. Oil slinger.
   - Install J41221.
     A. Apply clean engine oil to the oil slinger.
     B. Insert the oil slinger into the adapter.
     C. Install the oil slinger sleeve to the adapter, and tighten the center bolt until the sleeve comes in contact with the adapter and stops.
     D. After pressing in the oil slinger, make sure that the distance between the crankshaft end surface and the oil slinger is, 11.5 ± 0.15 mm (0.453 ± 0.006 in.).
        - Check the measurement at several different points.
2. Apply the sealant on the cylinder block then install the front cover.
3. Front cover bolts.

Tighjten

- Bolts to 19 N·m (14 lb. ft.).

4. Front cover seal.
   - Install J41221.
     A. Apply clean engine oil to the oil seal.
     B. Insert the oil seal into the adapter.
     C. Install the oil seal to the adapter, and tighten the center bolt until the sleeve comes in contact with the adapter and stops.
     D. After pressing in the oil seal, make sure that the distance between the crankshaft end surface and the oil seal is 8.5 ± 0.15 mm (0.335 ± 0.005 in.).
        - Check the measurement at several different points.



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Figure 15 – Crankshaft Balancer and Front Cover Components

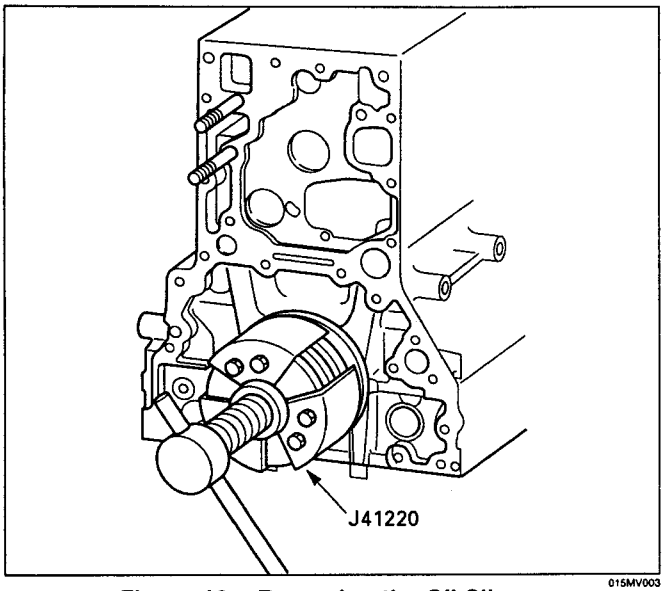


Figure 16 – Removing the Oil Slinger

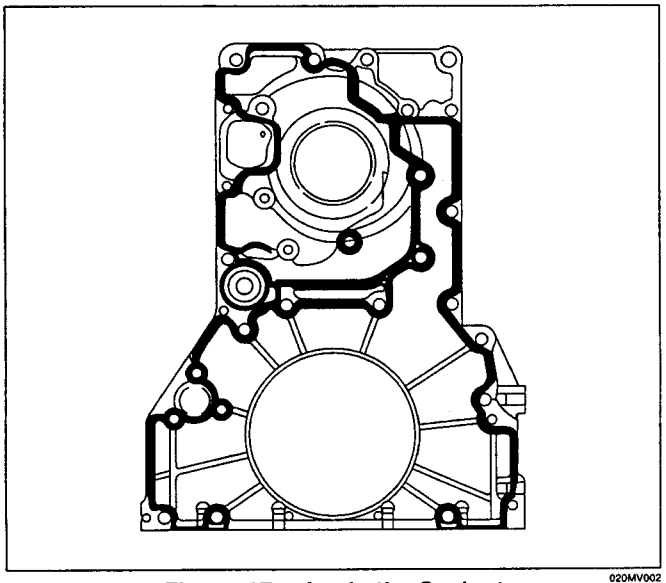


Figure 17 – Apply the Sealant

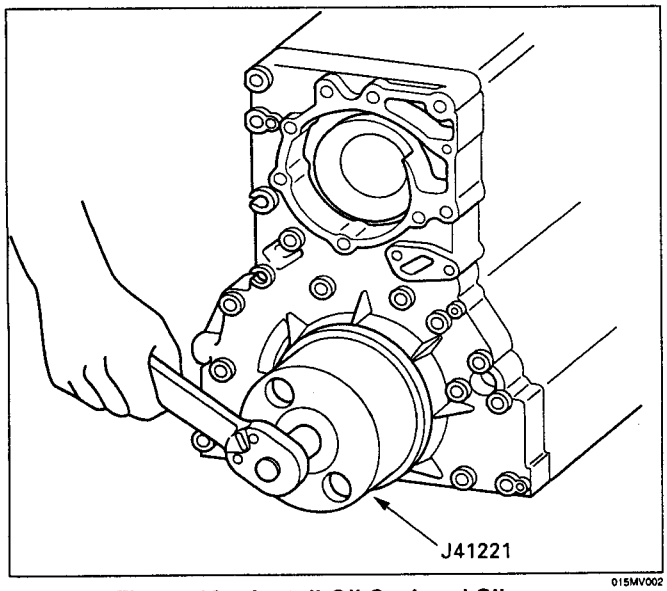


Figure 18 – Install Oil Seal and Slinger

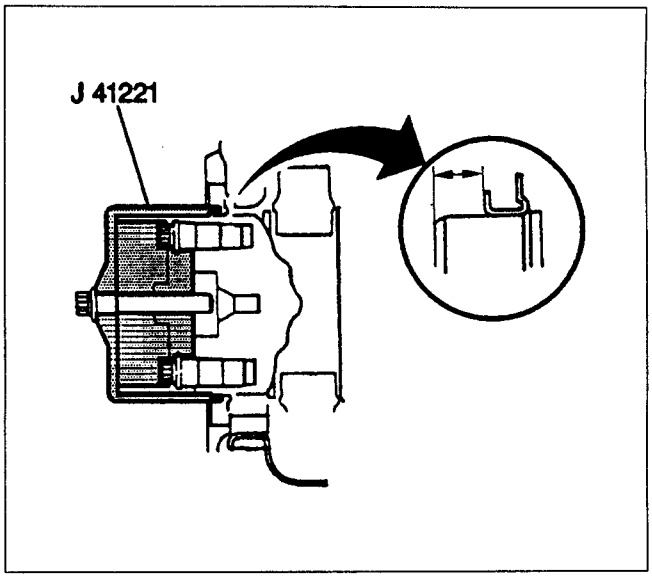


Figure 19 – Checking the Slinger Clearance

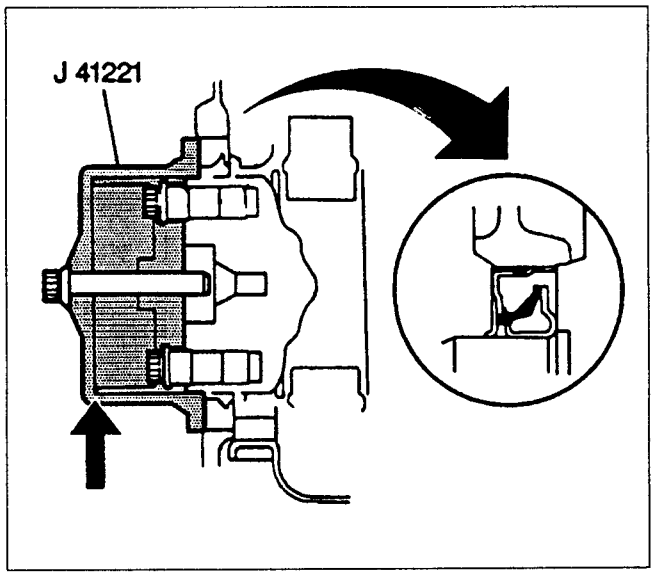


Figure 20 – Checking the Seal Clearance

Inspect

- Crankshaft balancer for excessive wear or damage.
- Crankshaft balancer for silicone leakage. If leakage appears, replace the crankshaft balancer.

5. Crankshaft balancer, bolts and washers.

Tighten

- Crankshaft balancer bolts and nuts to 48 N·m (35 lb. ft.).

6. Crankshaft balancer to the crankshaft.
7. Crankshaft balancer bolt and washer to the crankshaft.

Tighten

- Crankshaft balancer bolt and washer to 200 N·m (148 lb. ft.).

8. Drive belts.
9. Negative battery cables.
10. Lower the cab.

OIL PAN

Remove or Disconnect

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
   - Drain the crankcase.
3. Engine oil level indicator.
4. Bolts from the oil pan.
5. Oil pan.

Clean

- Sealant from the oil pan and the engine block.
- Sludge and dirt from the inside of the oil pan.
- All mating surfaces must be free of oil and dirt.

Install or Connect (Figures 21 through 23)

1. Apply sealant to the oil pan.
2. Apply sealant to the four corners of the cylinder block.
   - Apply a bead of silicone sealant approx. 2 mm (0.08 in.) thick and approx. 3 mm (0.12 in.) wide.
3. Bolts to the oil pan.

Tighten

- Oil pan bolts to 24 N·m (17 lb. ft.).

4. Engine oil level indicator.
5. Negative battery cables.
6. Lower the cab.
   - Fill the crankcase with the proper grade and quantity of engine oil. Refer to SECTION 0B.

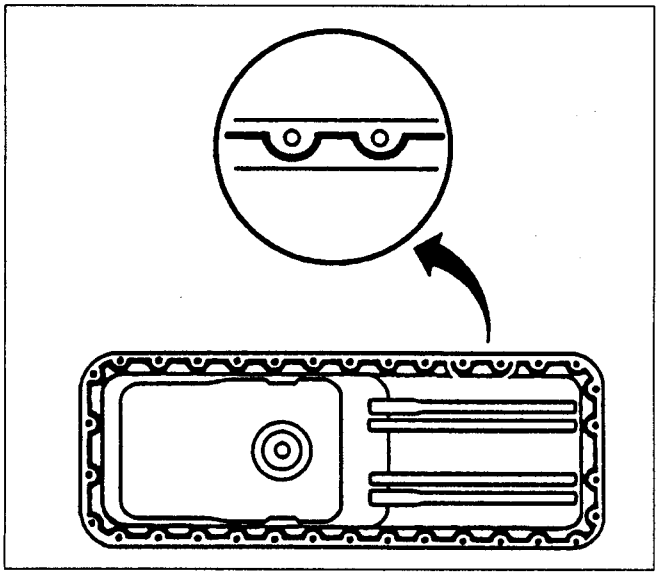
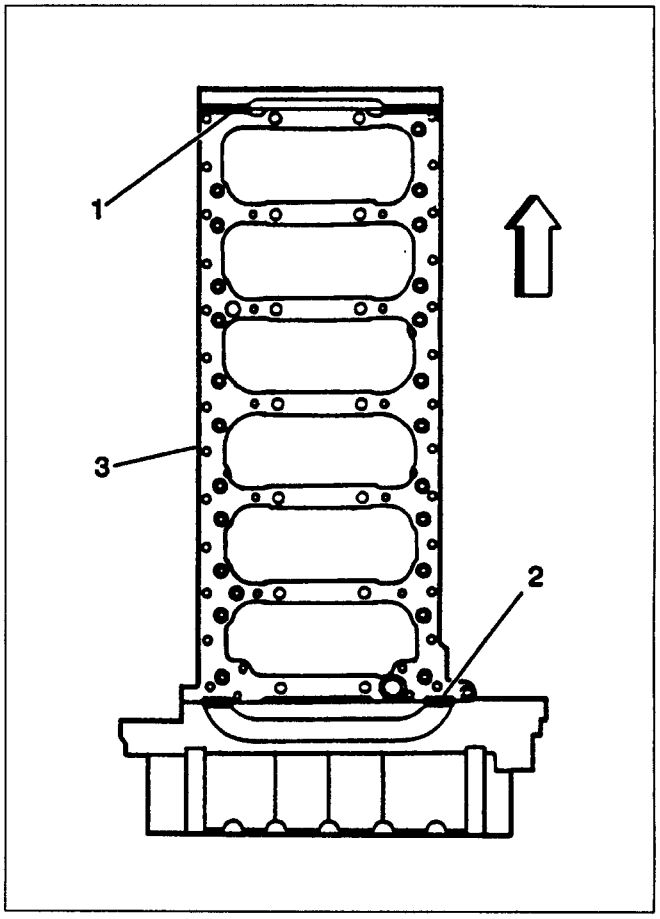


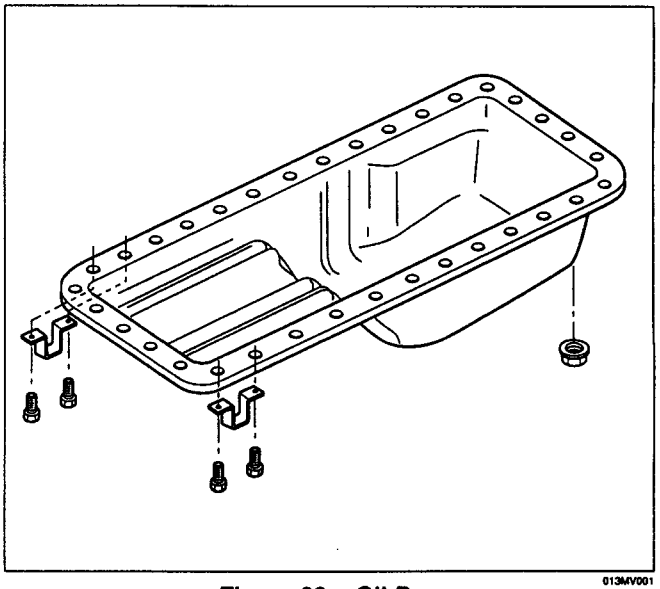
Figure 21 – Apply the Sealant



Legend

(1) Applying the Sealant at the Front Corners
(2) Applying the Sealant at the Rear Corners
(3) Cylinder Block

Figure 22 – Applying the Sealant



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Figure 23 – Oil Pan

OIL PUMP

- For further information, refer to SECTION 6A6B.

OIL PUMP REPAIR

- For further information, refer to SECTION 6A6B.

CRANKSHAFT REAR OIL SEAL

Tools Required:
J41220 Oil Slinger Remover
J41221 Oil Seal Installer

Remove or Disconnect (Figure 24)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Raise the vehicle.
   - Support the engine with a suitable stand.
4. Transmission assembly. Refer to SECTION 7A6 for automatic transmission, or SECTION 7B for manual transmission.
5. Flywheel or clutch. Refer to SECTION 7C.
6. Oil slinger and the rear crankshaft oil seal.
   - Install J41220 and remove the oil slinger and oil seal.

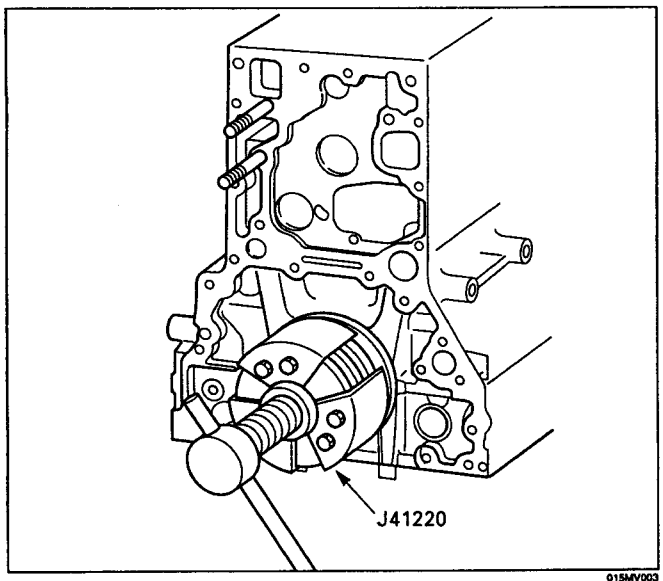


Figure 24 – Removing the Oil Slinger

Important

- Crankshaft rear oil slinger is gray. Front cover oil slinger is black.

Install or Connect (Figure 25 through 28)

1. Oil slinger.
   - Install J41221.
     A. Do not apply engine oil to the oil slinger inside surface.
     B. Insert the oil slinger into the adapter.
     C. Install the oil slinger sleeve to the adapter, and tighten the center bolt until the sleeve comes in contact with the adapter and stops.
     D. After pressing in the oil slinger, make sure that the distance between the crankshaft end surface and the oil slinger is (1) 10.5 ± 0.15 mm (0.413 ± 0.006 in.).
   - Check the measurement at several different points.

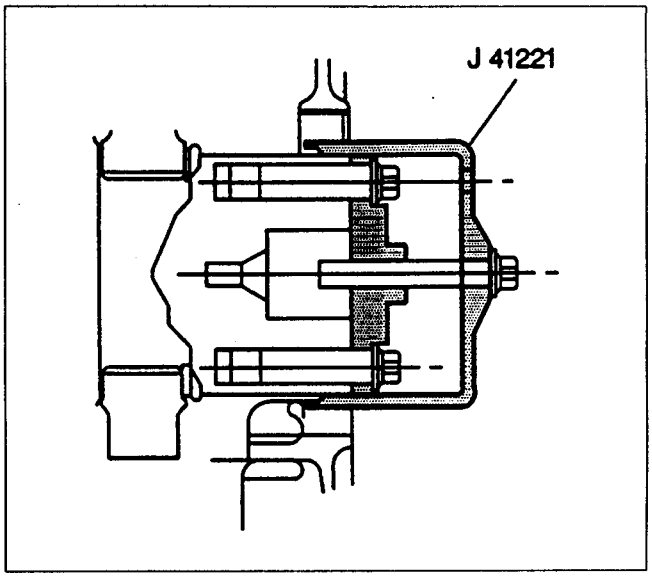
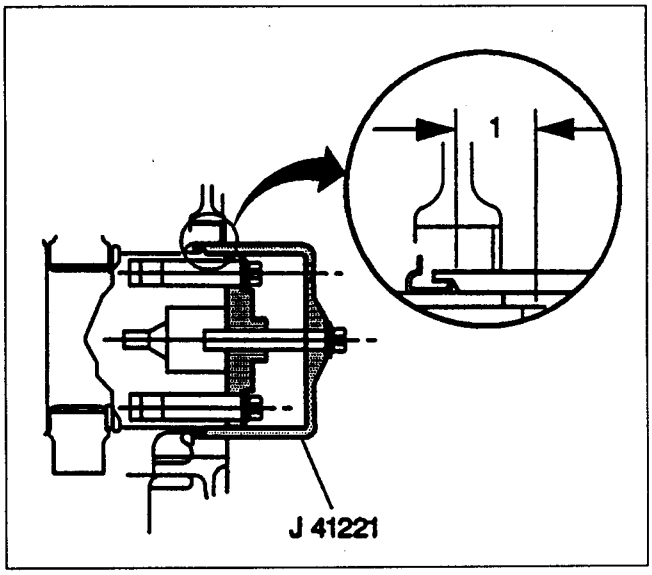


Figure 25 – Installing the Oil Slinger



Legend
(1) Measuring the Depth

Figure 26 – Measuring the Installed Depth

2. Crankshaft rear seal.
   - Install J41221.
     A. Apply clean engine oil to the oil seal lip. Do not apply engine oil to outside surface.
     B. Insert the oil seal adapter.
     C. Install the oil seal to the adapter, and tighten the center bolt until the sleeve comes in contact with the adapter and stops.

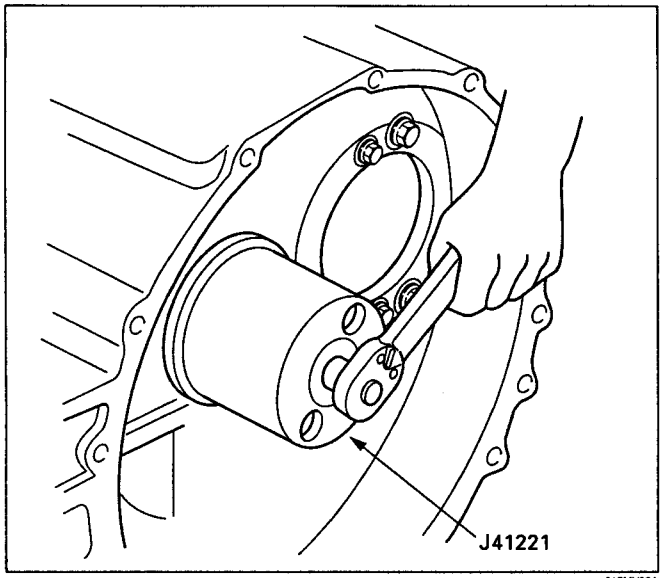


Figure 27 – Installing the Oil Seal

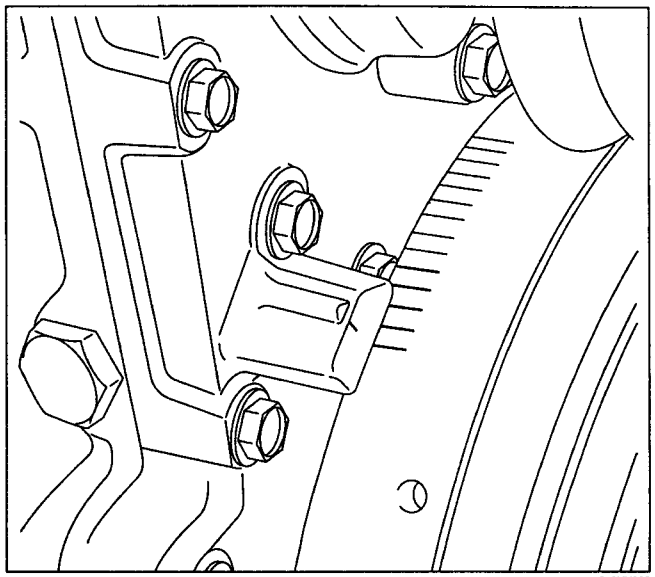
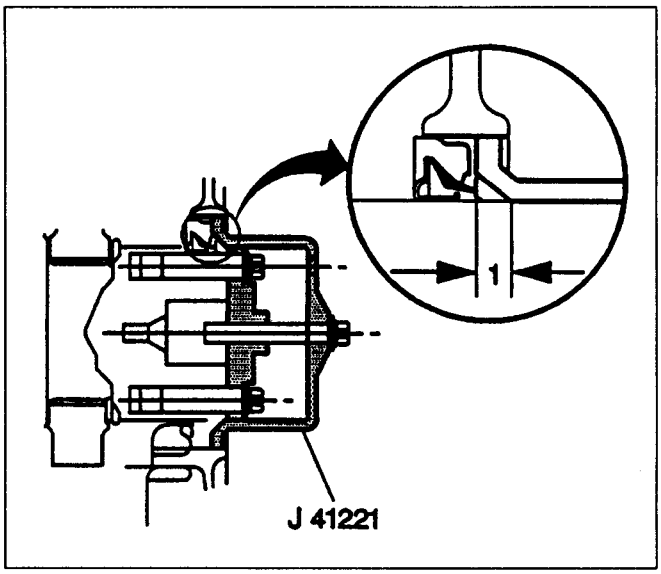


Figure 29 – Timing Marks



Legend

(1) Measuring the Depth

Figure 28 – Measuring the Installed Depth

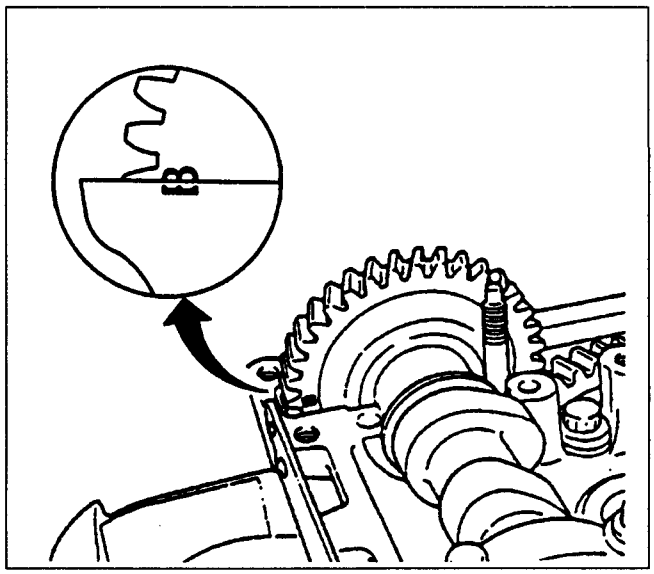


Figure 30 – Camshaft Timing Marks

D. After pressing in the oil seal, make sure that the distance between the crankshaft end surface and the oil seal is (1) 7.5 ± 0.15 mm (0.295 ± 0.006 in.).
   - Check the measurement at several different points.

3. Flywheel or clutch. Refer to SECTION 7C.
4. Transmission assembly.
   - Remove engine support.
5. Lower the vehicle.
6. Negative battery cables.
7. Lower the cab.

CAMSHAFT

Tools Required:

J 22888-D Crankshaft Sprocket Puller

Remove or Disconnect (Figures 29 through 34)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Glow plugs. Refer to SECTION 6D6.
4. Valve rocker arm cover. Refer to "Valve Rocker Arm Cover" in this section.
5. Rotate the engine to top dead center and align the timing marks on the camshaft (B).
6. Both connector on the injector and from engine harness.
7. Harness assembly.
8. Loosen the valve rocker arm adjusters, but do not remove them.
9. Loosen the valve rocker arm shaft bracket bolts evenly, starting from the outside bolts moving to the inner bolts.
10. Valve rocker arm assembly.
11. Loosen camshaft bearing cap nuts evenly starting from the outer nut moving to the inner nut.
12. Camshaft assembly with gear.

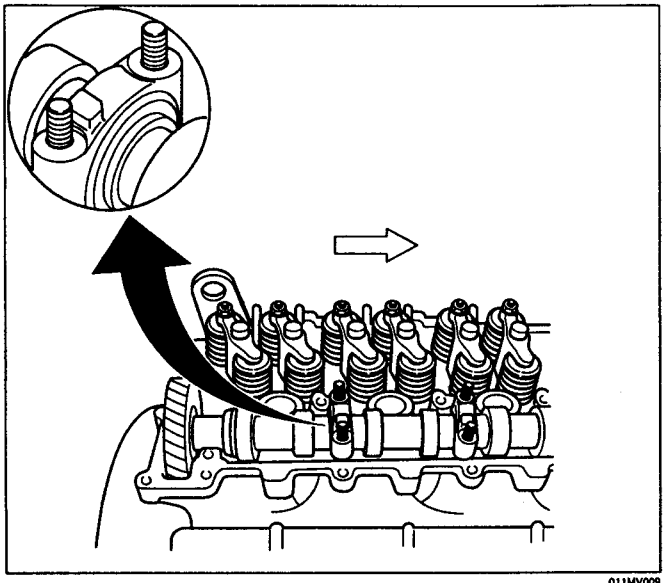


Figure 31 – Camshaft Bearing Caps Direction

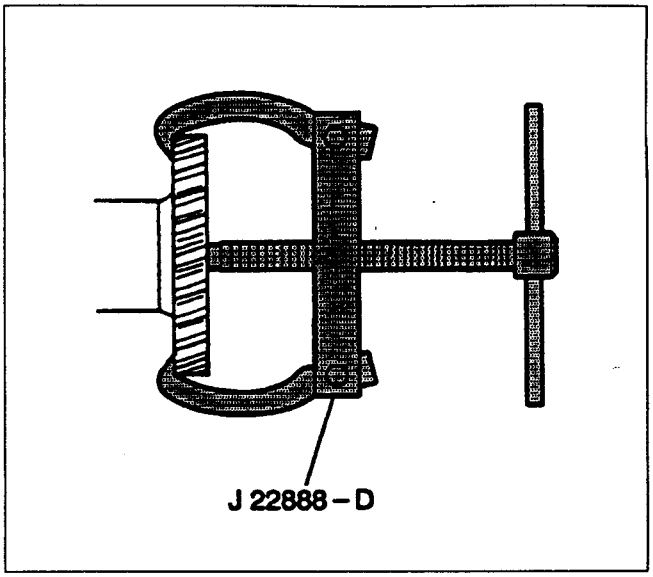


Figure 33 – Removing the Camshaft Gear

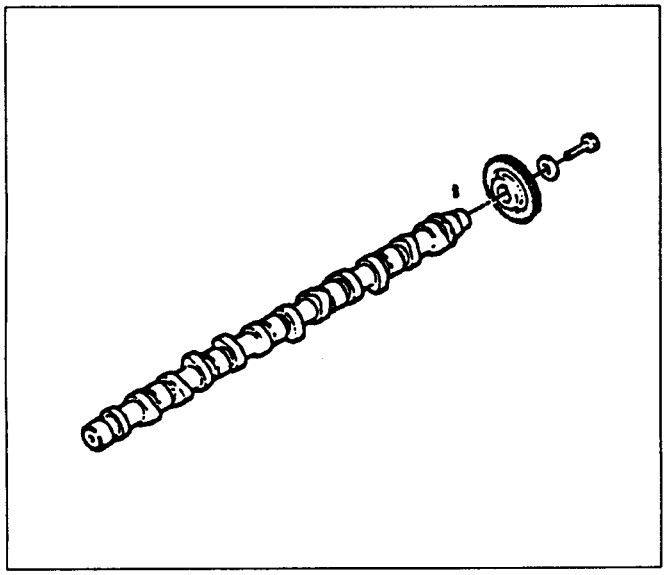


Figure 32 – Camshaft and Components

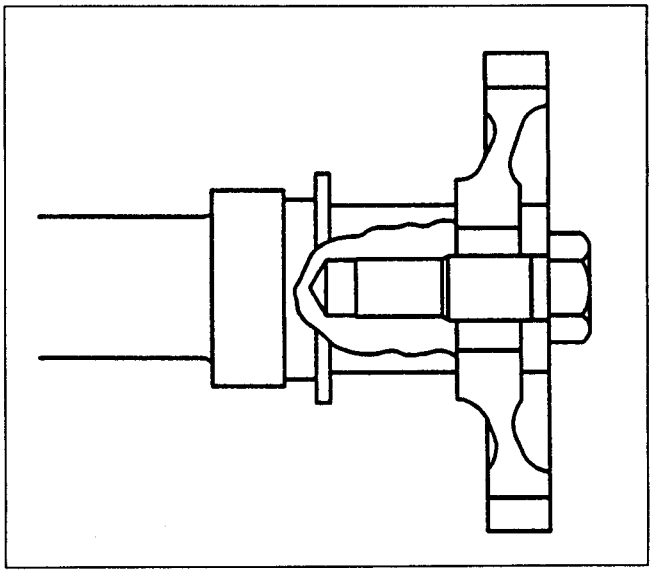


Figure 34 – Installing the Camshaft Gear

Important

- Do not remove the rocker arm shaft bracket bolts from the valve rocker arm shaft assembly.

13. Gear from the camshaft.
    - Install J22888-D on gear.
    - Remove the gear.

Clean

- Camshaft gear bore and keyway.

Inspect

- Camshaft for excessive wear on the lobes and the bearing surfaces.
- Camshaft gear for chips or broken teeth.

Measure

- Camshaft
- Refer to SECTION 6A6B in this manual for the camshaft specifications.

Install or Connect (Figures 31 and 34)

1. Gear to the camshaft.
2. Bolt to the camshaft.

Tighten

- Camshaft gear bolt to 142 N·m (105 lb. ft.).

3. Camshaft and bearing cap to the cylinder head. Refer to "Valve Rocker Arm and Camshaft" in this section.
4. Valve rocker arm assembly to the cylinder head. Refer to "Valve Rocker Arm and Camshaft" in this section.

Adjust

- Valve Rocker Arms.
- Refer to SECTION 6A6B, for the valve rocker arm adjustment procedure.

5. Valve rocker arm cover and gasket to the cylinder head.
6. Valve rocker arm cover bolts.

Tighten

- Valve rocker arm cover bolts to 13 N·m (113 lb. in.).

7. Glow plugs.
8. Negative battery cables.
9. Lower the cab.

CONNECTING ROD AND PISTON

1. Remove the engine assembly. Refer to "Engine" in this section.
2. Refer to "Engine Overhaul" in SECTION 6A6B.

CRANKSHAFT MAIN BEARING

1. Remove the engine. Refer to "Engine" in this section.
2. Refer to "Engine Overhaul" in SECTION 6A6B.

CRANKSHAFT

1. Remove the engine. Refer to "Engine" in this section.
2. Refer to "Engine Overhaul" in SECTION 6A6B.

FLYWHEEL

Remove or Disconnect (Figure 35)

1. Negative battery cables. Refer to SECTION 6D1.
2. Raise the vehicle.
3. Transmission assembly. Refer to SECTION 7A6 for automatic transmission, or SECTION 7B for manual transmission.
4. Clutch assembly, (if equipped). Refer to SECTION 7C.
5. Bolts and spacer.
6. Flywheel assembly. Refer to SECTION 7A.

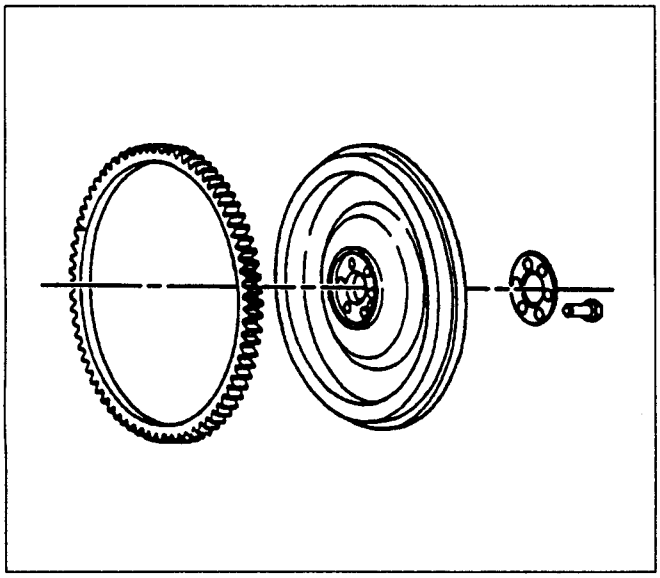


Figure 35 – Flywheel and components

Inspect

- Flywheel for burning, scoring, warping or excessive wear.
- Flywheel ring gear for worn or broken teeth.

FLYWHEEL RING GEAR

Remove or Disconnect (Figure 35)

1. Use a torch to heat the flywheel ring gear evenly.

NOTICE: ***Never heat the flywheel ring gear to red hot. This will change its metal structure and could cause damage to the ring gear or flywheel***

2. Drive the flywheel ring gear off with a hammer and a drift.
3. Heat the flywheel ring gear evenly to allow the ring gear fit on the flywheel. Do not allow the temperature exceed 120 deg C (250 deg F).
4. Ring gear to the flywheel, as soon as it is heated (Figure 36).

Install or Connect (Figure 35)

1. Flywheel to the crankshaft.
2. Bolts and spacer to the flywheel, (apply a small amount of molybdenum to the bolts). Refer to SECTION 7A, for the proper bolt tightening sequence.
3. Clutch to the flywheel.
4. Transmission assembly to the engine.
5. Lower the vehicle.
6. Negative battery cables.

ENGINE MOUNTS

Cushion-type mountings are used at both the front and the rear of the engine.

INSPECTING ENGINE MOUNTS

NOTICE: ***Broken or deteriorated mounts can cause misalignment and eventually destroy certain drive train components. Also, when a single mount breaks, the remaining mountings are subjected to abnormally high stresses, which may lead to early wear and breakage.***

Engine mounts should be inspected periodically and replaced if any damaged or deteriorated mounts are found.

Check the engine mounting brackets for cracks or elongated bolt holes. Replace the brackets if necessary. Check the mounting fasteners for the correct torque. Refer to "Specifications" at the end of this section. Inspect the rubber parts for deterioration and replace if needed.

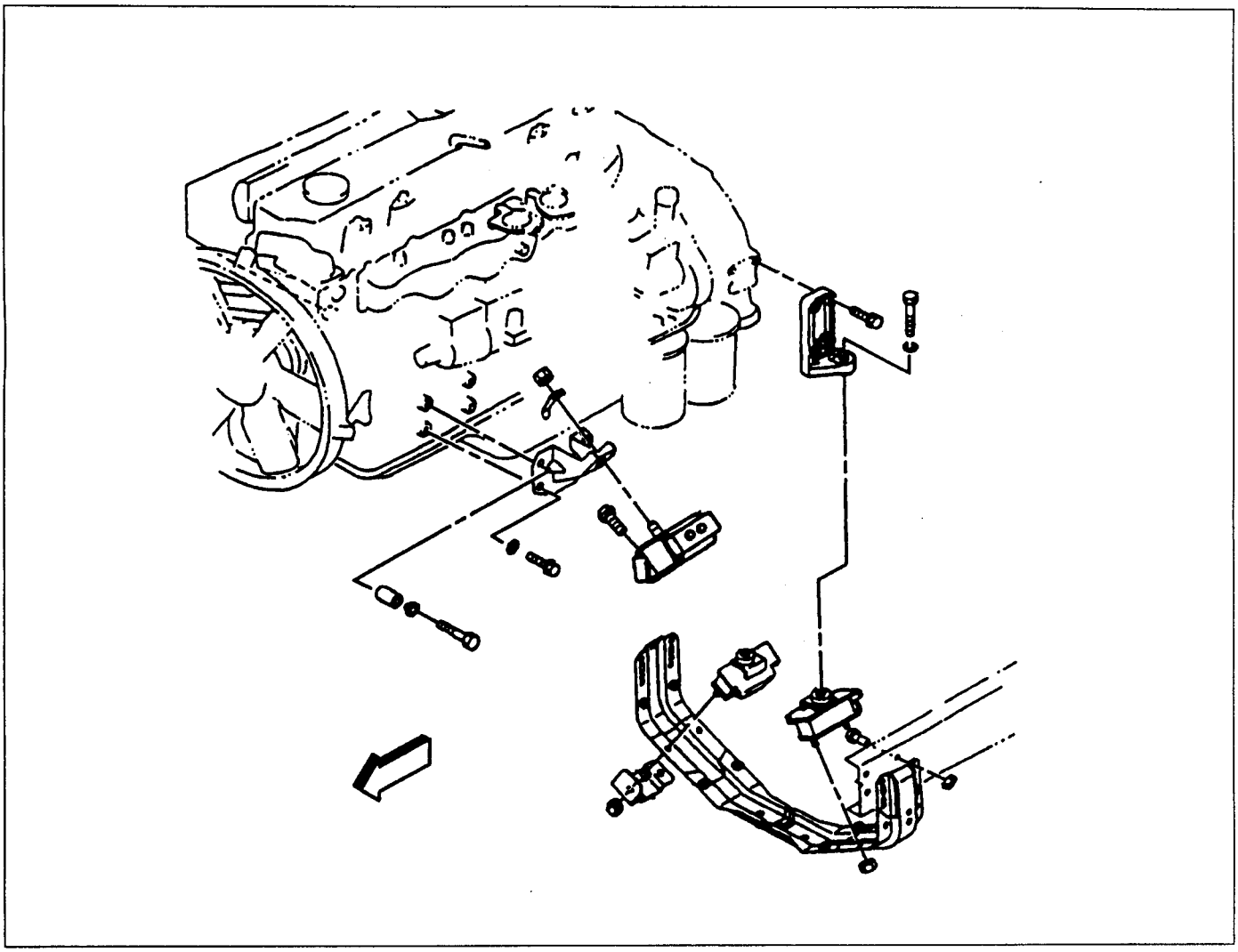


Figure 36 – Engine Mounts

FRONT ENGINE MOUNT

Remove or Disconnect (Figure 36)

NOTICE: ***When the raising or supporting the engine, do not use a jack under the oil pan, any sheet metal, or crankshaft pulley. Jacking against these parts may cause damage.***

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Engine mounting nuts and washers from the mounting bracket to the front mount.

NOTICE: ***When supporting the engine to replace a mount, raise the engine only to the height required to provide clearance for the mount removal. It may be necessary to drain the cooling system and disconnect hoses to avoid damage when the engine is raised. Be careful that control linkage and wiring are not damaged from raising the engine. When replacing a single front mount, both mounts should be detached before attempting to raise the engine. Failure to do this will place excessive stress on the attached mounts when the engine is raised.***

4. Bolts and nuts from the frame to the front mounts.
5. Raise the front of the engine.
   - Provide lifting equipment to safely support and raise the front of engine as required.
   - Raise the engine enough to permit removal of the mounting cushions.
6. Remove the front mounting cushion, spacers, washers as required.
7. Mounting bracket bolts and washers (if used).
8. Mount the front bracket to the engine, (if necessary).

Important

- Any vehicle components held in place by the engine mounting fasteners must be supported before the fasteners are removed.

Install or Connect

1. Mounting bracket to the engine, (if necessary).

Tighten

- Mount bracket bolt to 78.5 N·m (58 lb. ft.).

2. Mounting bracket bolts and washers.

Tighten

- Mounting bolts and nuts to 64 N·m (47 lb. ft.).

3. Front engine mounts to the bracket, (install nuts and washers to hold them in place).
4. Lower the engine.
5. Mounting bolts to the frame.

Tighten

- Mounting nuts to 83 N·m (61 lb. ft.).
- Mounting bolts to 36 N·m (26 lb. ft.).

6. Negative battery cables.
7. Lower the cab.

REAR ENGINE MOUNT

Remove or Disconnect (Figure 36)

1. Through bolts and the washers from both of the rear engine mount brackets.

NOTICE: ***When supporting the engine to replace a mount, raise the engine only to the height required to provide clearance for the mount removal. It may be necessary to drain the cooling system and disconnect hoses to avoid damage when the engine is raised. Be careful that control linkage and wiring are not damaged from raising the engine. When replacing a single front mount, both mounts should be detached before attempting to raise the engine. Failure to do this will place excessive stress on the attached mounts when the engine is raised.***

2. Raise the engine.
3. Rear mounting bolts and nuts.
4. Rear engine mounts from the mounting brackets.
5. Nuts and washers from the rear mounts.
6. Rear mounts from the frame rail.

Install or Connect

1. Rear mounts to the frame rail.
2. Nuts, bolts, and washers to the rear mounts and tighten.

Tighten

- Bolts and nuts to 108 N·m (80 lb. ft.).

3. Rear mounting brackets to the engine.

Tighten

- Rear mount bracket bolt to 75.5 N·m (56 lb. ft.).

4. Lower the engine.
5. Through bolts to the rear mounts.
6. Tighten through bolts.

Tighten

- Bolts to 294 N·m (217 lb. ft.).

ENGINE

NOTICE: ***If the engine is damaged internally and a new engine assembly is installed in the vehicle, make sure all foreign material is completely flushed out of the cooling system. The oil cooler system should also be flushed out (if equipped). Failure to rid the oil or cooler system of debris can result in engine damage to the replacement engine.***

The procedure required to replace an engine varies according to the optional equipment, and available shop facilities. The following procedure is intended only as a guide for performing the work. The technician must determine what additional work is needed.

It is important to note "CAUTIONS" and "NOTICES" against the use of some specific service methods that can harm personnel, damage the vehicle or make it unsafe. A technician who uses a service procedure or tools which are not recommended must be thoroughly satisfied that neither the safety of personnel, nor safety of the vehicle will be jeopardized by the service method selected.

NOTICE: ***On some vehicles it may be necessary to support the transmission as the engine is removed to prevent the transmission from falling, causing damage to the unit.***

Remove or Disconnect (Figure 36)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Drain the cooling system. Refer to SECTION 6B.

CAUTION: If the vehicle is equipped with air conditioning, removal of refrigerant line must be done by trained personnel. Injuries can result from improper procedures.

4. Air conditioning compressor. Refer to SECTION 1B.
5. Air inlet pipes. Refer to SECTION 6J.
6. Air intake housing from the cab bridge.
7. Coolant reservoir, hose and bracket. Refer to SECTION 6B.
8. Cab bridge support. Refer to SECTION 10B.
9. Engine oil level indicator tube.
10. Power steering pump from the engine, (lay to the side). Refer to SECTION 3B.
11. Air compressor and lines, (if equipped). Refer to SECTION 5J.
12. Radiator and charge air cooler assemblies. Refer to SECTION 6B.
13. Radiator and heater hoses. Refer to SECTION 6B.
14. Engine electrical harness from the retainers and the brackets.
15. Engine electrical harness from all the electrical connectors.
16. All ground straps from the engine to the frame.
17. Engine stop and throttle cables. Refer to SECTION 6C2.
18. Fuel line and connectors from the fuel injection pump. Refer to SECTION 6C2.

Important

- Cap the fuel line and the fittings to prevent the fuel from leaking and dirt from entering the fuel system.

19. Engine tachometer drive cable.
20. Engine brake rod, (if equipped).
21. Raise the vehicle.
22. Exhaust pipe from the turbocharger. Refer to SECTION 6J.
23. Exhaust pipe from the muffler. Refer to SECTION 6F.
24. Starter assembly. Refer to SECTION 6D2C.
25. Torque converter bolts from the torque converter, (if equipped). Refer to SECTION 7A.
26. Lower the vehicle.
27. Support the transmission.
    - Use a suitable support.
28. Attach suitable overhead hoist.
29. Front engine mounting bolts.
30. Bolts from the transmission to the engine.
31. Engine from the transmission assembly. Refer to SECTION 7A6 for automatic transmission, or SECTION 7B for manual transmission.
32. Engine from the vehicle.

Install or Connect (Figure 36)

1. Engine to the transmission assembly.
2. Engine to the engine mounts.
3. Bolts from the transmission to the engine.
4. Engine mount through bolts.

Tighten

- Through bolts to 245 N·m (180 lb. ft.).

5. Front engine mount bolts.

Tighten

- Mount bolts to 36 N·m (26 lb. ft.).

6. Remove the overhead hoist.
7. Raise the vehicle.
8. Torque converter bolts to the torque converter.
9. Starter assembly.
10. Exhaust from the muffler to the turbocharger.
11. Turbocharger to the exhaust.
12. Lower the vehicle.
13. Engine stop and throttle cables.
14. Engine brake rod.
15. Engine tachometer drive cable.
16. Fuels line and connectors to the fuel injection pump.
17. Ground straps to the frame and the engine.
18. Engine electrical harness to all the connectors.
19. Engine electrical harness to the retainers and the brackets.
20. Radiator, charge air cooler and the air conditioning condenser assembly.
21. Radiator and heater hoses to the engine.
22. Air compressor and the lines.
23. Power steering pump.
24. Air conditioning compressor to the mounting bracket.
25. Engine oil level indicator tube.
26. Cab bridge.
27. Coolant reservoir, hose and the bracket.
28. Air intake housing to the cab bridge.
29. Air inlet pipes.
30. Negative battery cables.
31. Lower the cab.
32. Fill the engine cooling system with the proper type and quantity of coolant. Refer to SECTION 6B and 0B.
33. Fill the engine crankcase with the proper grade and quantity of engine oil. Refer to SECTION 0B.
34. Charge the A/C system, refer to SECTION 1B.

Important

- **Check all fluid levels before starting engine.**

THREAD REPAIR

General purpose thread repair kits are available commercially. Damaged threads may be reconditioned by drilling out, rethreading, and installing a suitable thread insert. Refer to "Engine Overhaul" in SECTION 6A6B for further information.

SPECIFICATIONS

GENERAL ENGINE SPECIFICATIONS

MODEL	6HK1-TC
Type	Inline 6, 4 stroke
Induction	Turbocharged Combustion
Combustion	Direct Injection
Bore	115 mm (4.5276 in.)
Stroke	125 mm (4.9213 in.)
Displacement	7.8L (475.1 Cu. In.)
Compression Ratio	16.8:1
Firing Order	1-5-3-6-2-4
Valve Clearance, Cold (Intake and Exhaust)	0.4 mm (0.16 in.)
Full Flow Oil Filter	Cartridge Type
Oil Capacity	14.0L (14.79 Qts) *
Oil Pressure (Minimum at an Idle)	100 kPa (14 psi)
Compression at 200 RPM (Production)	3240 kPa (469 psi)
Compression at 200 RPM (Service Limit)	2157 kPa (313 psi)
Difference between each cylinder	Less than 196 kPa (28 psi)
* Includes full flow filter, which should be changed at each oil change.	

FASTENER TIGHTENING SPECIFICATIONS

Application	N·m	Lb Ft	Lb In.
Camshaft Bearing Cap Nut	27.5	20	—
Camshaft Gear Bolt	142	105	—
Camshaft Thrust Bracket Bolt (No. 1, and No. 7)	27.5	20	—
Charge Air Pipe Bolt	37	7	—
Connecting Rod Bolt (Apply Molybdenum disulfide grease)			
First Stage	39	29	—
Second Stage	plus 60 deg	plus 45 deg	—
Third Stage	plus 30 deg	plus 30 deg	—
Crankshaft Balancer Bolt and Washer	200	148	—
Crankshaft Pulley Bolt and Washer	48	35	—
Cylinder Body Lower Crankcase (M10)	37	27	—
Cylinder Body Lower Crankcase (M14) (Apply Molybdenum disulfide grease)			
First Stage	98	72	—
Second Stage	132	98	—
Third Stage	plus 45 deg	plus 45 deg	—
Cylinder Head Bolt (M14) (Apply Molybdenum disulfide grease)			
First Stage	98	72	—
Second Stage	147	108	—
Third Stage	plus 30 deg	plus 30 deg	—
Cylinder Head Bolt (M10)	39	29	—
Engine Mounting Bolt to the Frame	36	26	—
Engine Mounting Nut to the Frame	83	61	—
Engine Mount Through Bolt	294	217	—
Exhaust Manifold Nut and Bolt	34	25	—
Exhaust Pipe Adapter to the Exhaust Manifold	52	38	—

Application	N·m	Lb Ft	Lb In.
Flywheel Bolt			
First Stage	78	58	—
Second Stage	plus 60 deg	plus 60 deg	—
Third Stage	plus 75 deg	plus 75 deg	—
Front Cover Bolt	19	14	—
Front Engine Mount Bolt	64	47	—
Glow Plug	25	18	—
Idle Gear A Bolt (Apply Molybdenum disulfide grease)	29 + 75 deg	21 + 75 deg	—
Idle Gear A Shaft Bolt	26.5	20	—
Idle Gear B Bolt	95	70	—
Idle Gear B Shaft Bolt	31.4	23	—
Idle Gear C Bolt	95	70	—
Intake Manifold Bolt	15	—	130
Oil Cooler Bolt	19	14	—
Oil Jet Bolt	21	15	—
Oil Pan Bolt	24	17	—
Oil Pump Body Bolt	24	17	—
Oil Strainer Tube Bolt (M8)	24	17	—
Oil Strainer Tube Bolt (M10)	48	5	—
Rear Engine Mounting Nut and Bolt to the Frame	108	80	—
Thermostat Housing Bolt to the Cylinder Head	19	14	—
Turbocharger Drain Line Bolt (to Block)	8	13	—
Turbocharger Drain Line Bolt (to Turbocharger)	27	20	—
Turbocharger Feed Line Bolt (to Block)	18	13	—
Turbocharger Feed Line Bolt (to Turbocharger)	18	13	—
Turbocharger to Exhaust Manifold Nut	52	38	—
Valve Rocker Arm Cover Bolt	13	—	113
Valve Rocker Arm Shaft Support Bolt (M8)	27	20	—
Valve Rocker Arm Shaft Support Bolt (M10)	56	41	—
Water Outlet Bolt (M8)	19	14	—
Water Pump Bolt and Nut	19	14	—
Water by Pass Duct Bolt (M16)	103	76	—

SPECIAL TOOLS

J22888-D Gear Puller
J36022 Air Line Adapter
J41220 Slinger Replacer
J41221 Oil Seal Remover and Installer
J41222 Crankshaft Gear Installer
J43267 Valve Stem Seal Installer
J43263 Valve Spring Compressor

BLANK

SECTION 6A6B

DIESEL ENGINE OVERHAUL

NOTICE: *Always use the correct fastener in the correct location. When you replace a fastener, use ONLY the exact part number for that application. ISUZU will call out those fasteners that require a replacement after removal. ISUZU will also call out the fasteners that require thread lockers or thread sealant. UNLESS OTHERWISE SPECIFIED, do not use supplemental coatings (paints, greases, or other corrosion inhibitors) on threaded fasteners or fastener joint interfaces. Generally, such coatings adversely affect the fastener torque and the joint clamping force, and may damage the fastener. When you install fasteners, use the correct tightening sequence and specifications. Following these instructions can help you avoid damage to parts and systems.*

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GENERAL DESCRIPTION

The ISUZU model 6HK1-TC engine is used in vehicles covered by this manual. The engine is an in line six cylinder, four stroke, water cooled, direct fuel injection, turbocharged diesel. The charge air cooler is the air to air heat exchange system using a corrugated-fin heat exchanger installed in front of the radiator.

The forged crankshaft is supported by seven precision insert main bearings. The crankshaft thrust washer is located at the number seven crankshaft main bearing.

The connecting rods have precision insert type crankshaft (big end) bearings. The piston pins are retained by snap rings. The pistons have three compression rings and one oil control ring. The pistons are cooled by oil jets. The 6HK1-TC diesel uses dry cylinder liners. The liners have been phosphated (P- Mn method), both inside and outside for long life.

The camshaft is supported by seven plain bearings. The camshaft is gear driven. Motion is transferred to the overhead valves by shaft type roller valve rocker arms.

The cylinder head may be rebuilt, with new valve guides and seats.

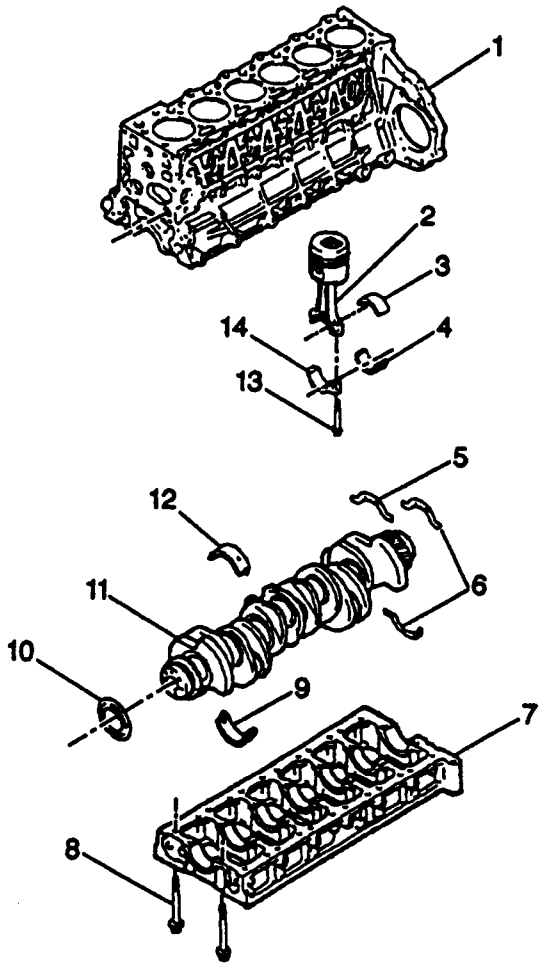
ENGINE IDENTIFICATION

The engine used in this vehicle is a 7.8L (475 CID).

The engine identification number is on the front right hand side (passenger) of the cylinder block. For further information, refer to "GENERAL INFORMATION" in SECTION 0A.

ENGINE LUBRICATION

A gear type oil pump is used. The engine is equipped with both full flow filter. An oil cooler is provided to help control oil temperatures. Major moving parts are supplied with oil from a larger oil gallery in the cylinder block.



(1) Cylinder Block
(2) Piston and Connecting Rod
(3) Upper Connecting Rod Bearing
(4) Lower Connecting Rod Bearing
(5) Thrust Washer
(6) Thrust Washer
(7) Lower Crankcase
(8) Crankshaft Bolt
(9) Lower Crankshaft Main Bearing
(10) Oil Slinger
(11) Crankshaft
(12) Upper Crankshaft Main Bearing
(13) Connecting Rod Bolt
(14) Connecting Rod Cap

Figure 1 — Cylinder Block and Components

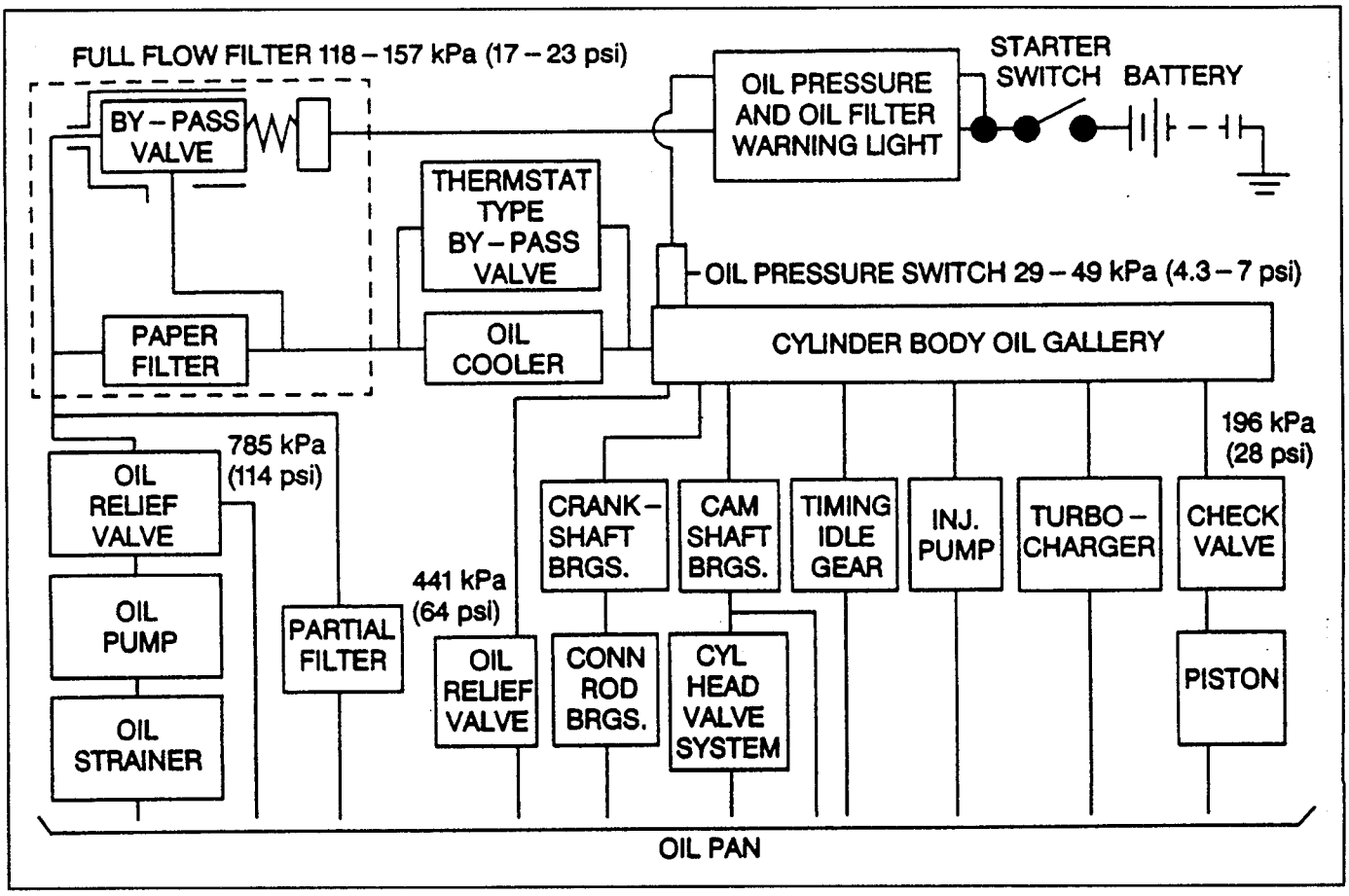


Figure 2 — Lubrication System

DISASSEMBLY OF THE ENGINE

TOOLS AND SHOP EQUIPMENT

A clean well-lit work area should be available. Other necessary equipment includes: a suitable parts cleaning tank, compressed air supply, trays to keep parts and fasteners organized, and an adequate set of hand tools.

An approved engine repair stand will aid the technician and help to prevent personal injury or damage to the engine components.

Special tools are listed and illustrated throughout this section. A complete listing is at the end of this section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these tools will also minimize possible damage to engine components.

Some precision measuring tools are required for inspection of certain critical components. Torque wrenches are necessary for the correct assembly of various parts.

ACCESSORY REMOVAL

This manual takes into consideration that the engine accessories have been removed. These accessories may include one or more of the following:

- Power Steering Pump
- Air Conditioning Compressor
- Generator
- Air Compressor (for air brakes)
- Starter Motor
- Hydraulic Pump (for hydraulic brakes)
- Drive Belts
- Engine Cooling Fans and Clutch

Diagrams of emissions and vacuum hose routings, wiring harness routing, accessory drive belts layout, etc., should be made before removing accessories.

CLEANING

NOTICE: ***Clean the engine only when it is cold, and never when the engine is running. Spraying or pouring water or other fluids on the engine when it is warm or hot, or when it is running, can cause serious damage to the engine and its components.***

Remove the engine accessories before cleaning to provide better access to the engine exterior surfaces. Cover all openings to the engine, after any engine control units such as, air inlet pipes, glow plugs, turbocharger etc., have been removed. Methods used to clean the engine will depend on what is available. Steam cleaning, pressure washing, or solvent cleaning are some of the acceptable methods. Allow the engine to dry before beginning any of the repair work. It is important that the engine be as clean as possible to prevent dirt from entering critical areas during disassembly.

DRAINING THE ENGINE

Remove or Disconnect

1. Oil pan drain plug.
2. Oil filter.
   - Allow the oil to drain into the proper container.
3. Coolant drain plugs from the engine block.
   - Allow the coolant to drain into the proper container.

Install or Connect

1. Oil drain plug to the oil pan.
2. Coolant drain plugs to the engine block.

FLYWHEEL REMOVAL

For service of the flywheel, refer to SECTION 7A6.

INTAKE MANIFOLD REMOVAL

Remove or Disconnect

1. Fuel injection lines from the fuel injectors.
2. Fuel lines from the fuel filter to the fuel injection pump.
3. Fuel injector return lines from fuel injectors.
4. Coolant pipe and bracket.
5. Fuel line from fuel injection pump to fuel common rail.
6. Fuel common rail.
7. Intake manifold bolts
8. Intake manifold with the gasket.

EXHAUST MANIFOLD REMOVAL

Remove or Disconnect

1. Turbocharger drain pipe with gasket.
2. Oil feed pipe.
3. Turbocharger assembly. Refer to SECTION 6J.
4. Front exhaust pipe.
5. Exhaust manifold nuts, bolts, washers and the spacers.
6. Exhaust manifold with the gasket.

GLOW PLUG REMOVAL

Remove or Disconnect

1. Glow plugs from the cylinder head. Refer to SECTION 6D6.

FUEL INJECTION PUMP REMOVAL

Remove or Disconnect

1. Fuel injection pump from the engine. Refer to SECTION 6C2.

THERMOSTAT HOUSING/THERMOSTAT REMOVAL

Remove or Disconnect

1. Bolts from the thermostat housing.
2. Thermostat housing from the cylinder head.
3. Both thermostats and the gasket from the cylinder head.

VALVE ROCKER ARM COVER REMOVAL

Remove or Disconnect

1. Bolts from the valve rocker arm cover.
2. Valve cover and gasket from the cylinder head.

NOTICE: Do not pry on the valve rocker arm cover. Damage to the sealing surfaces may result.

VALVE ROCKER ARM ASSEMBLY AND CAMSHAFT ASSEMBLY REMOVAL

Remove or Disconnect

1. Both connector on the top of injectors and from engine harness.
2. Harness assembly.
3. Lower case.
4. Loosen all the valve adjusters, but do not remove.
5. Loosen the valve rocker arm shaft bracket bolts evenly, starting from the outer bolts moving to the inner bolts.

Important

- Do not remove the rocker arm shaft bracket bolts from the valve rocker arm shaft assembly until the assembly has been removed from the engine.

6. Valve rocker arm assembly.
7. Loosen camshaft bearing cap nuts evenly, starting from the outer nut moving to the inner nut.
8. Camshaft assembly.

CYLINDER HEAD ASSEMBLY REMOVAL

Remove or Disconnect

1. Cylinder head from the cylinder block.

WATER PUMP REMOVAL

Remove or Disconnect

1. Bolts from the water duct.
2. Water duct and O-ring from the water pump.
3. Bolts from the water pump.
4. Water pump assembly with the gaskets.

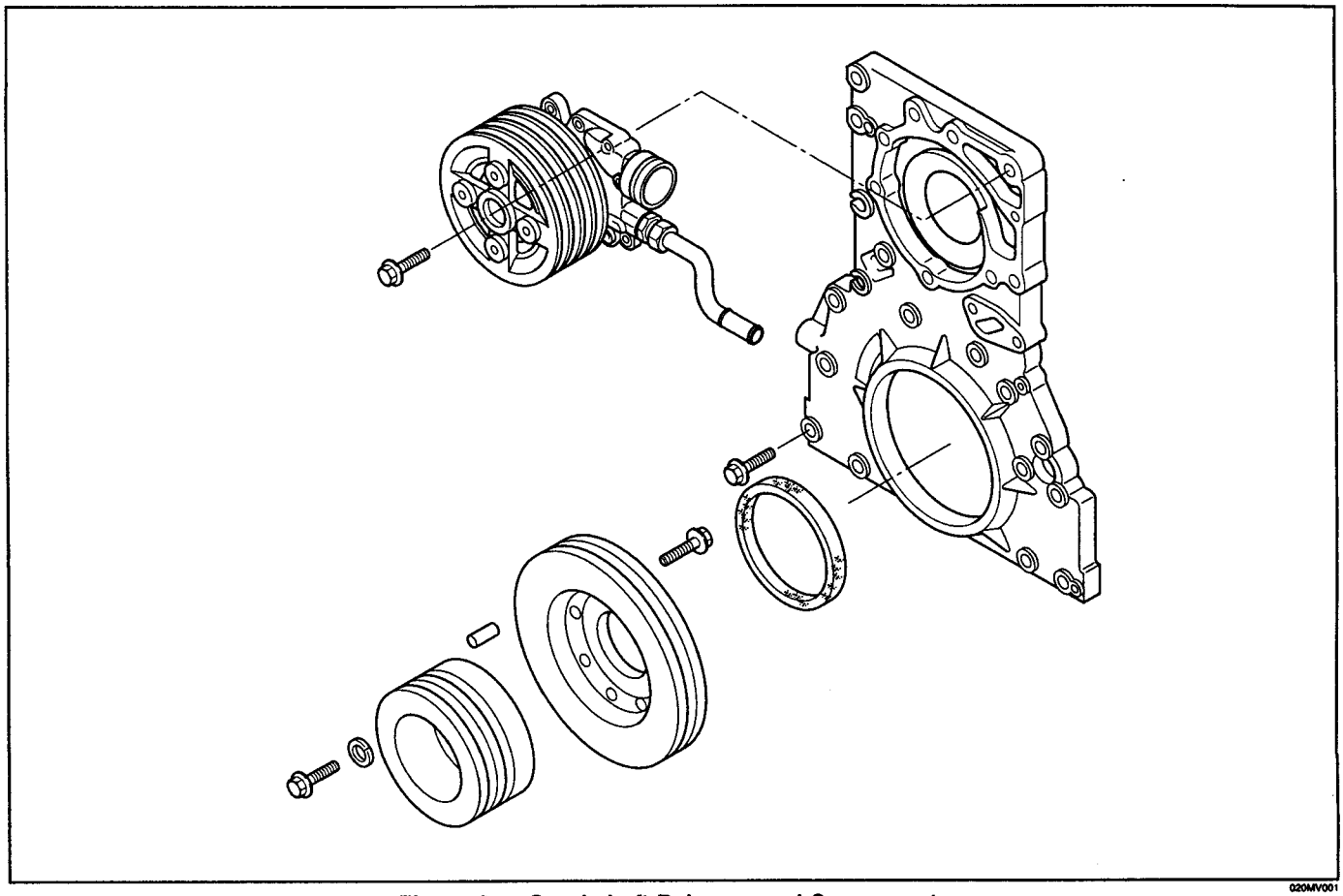

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Figure 3 — Crankshaft Balancer and Components

CRANKSHAFT BALANCER REMOVAL

Remove or Disconnect (Figure 3)

1. Bolts and washers from the crankshaft pulley.
2. Crankshaft pulley from the crankshaft.
3. Bolt and washer from the crankshaft.
4. Crankshaft balancer from the crankshaft.

FRONT COVER REMOVAL

Remove or Disconnect (Figure 3)

1. Bolts and washers from the front cover.
2. Front cover from the engine.
3. Seal and gasket from the front cover.

OIL PAN REMOVAL

Remove or Disconnect (Figure 4)

1. Engine oil level indicator.
2. Bolts, nuts and the washers from the oil pan.
3. Oil pan and the gasket from the engine block.

FLYWHEEL HOUSING REMOVAL

Remove or Disconnect

1. NE sensor.
2. Flywheel
3. Cover drive gear power steering pump.
4. Drive gear power steering pump.
5. Bolts from the flywheel housing.
6. Flywheel housing from the engine.

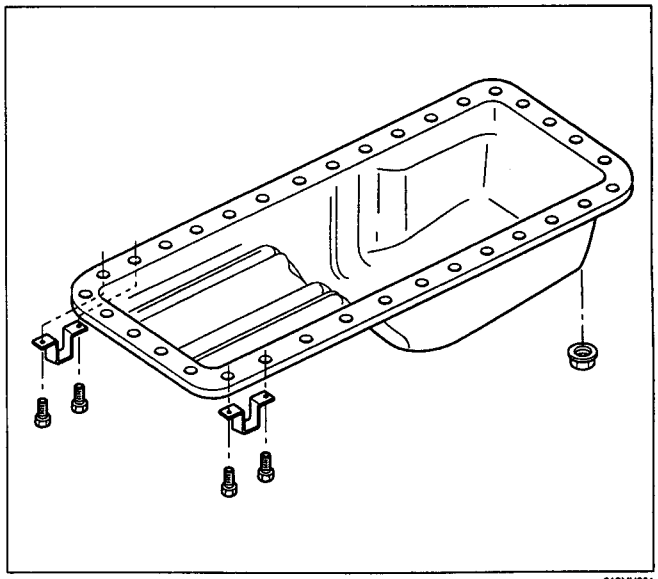

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Figure 4 — Oil Pan Removal

OIL PUMP REMOVAL

Remove or Disconnect

1. Oil pick up tube and the O-ring.
2. Oil slinger from the crankshaft. Refer to "CRANKSHAFT REAR SEAL" in SECTION 6A6.

Important

- Do not damage the crankshaft when removing the oil slinger.

3. Idler gears with the shafts from the cylinder block.
4. Oil pump with the drive gear from the cylinder block.

PISTON AND CONNECTING ROD REMOVAL

Remove or Disconnect (Figure 5)

1. Bolts from the connecting rod.
2. Piston and connecting rod from the cylinder.

Important

- The connecting rods and caps are marked from the factory so they can be returned to the proper cylinder. Replacement connecting rods and caps are not marked. They must be marked after installation.

CYLINDER LINER REMOVAL

Remove or Disconnect (Figure 6)

1. Rotate the crankshaft so the journal is just below TDC.
2. Cylinder liner from the block, using wooden or plastic hammer.

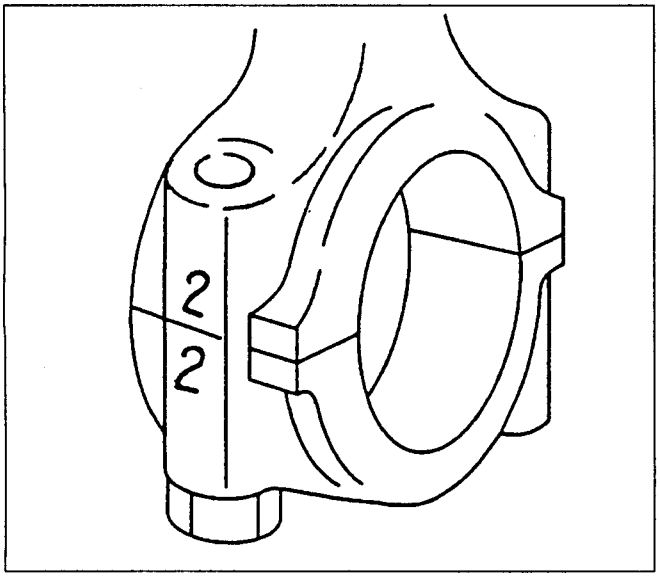


Figure 5 — Connecting Rod Markings

CRANKSHAFT REMOVAL

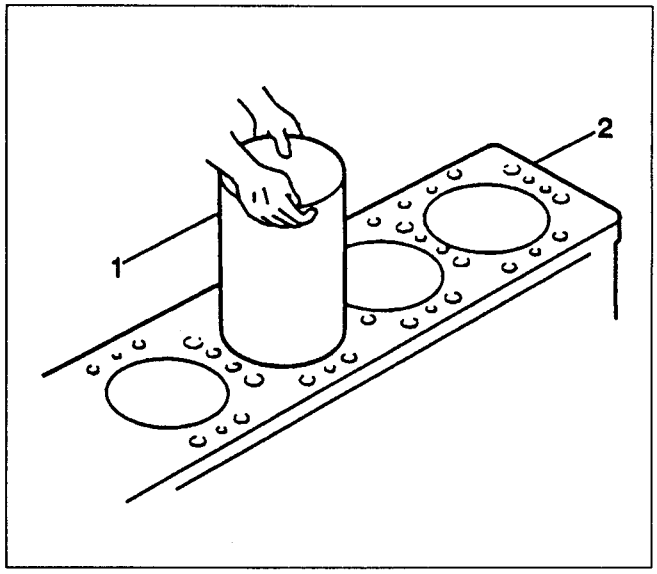
Remove or Disconnect (Figure 1)

1. Loosen the lower crankcase body bolts (marked M14) evenly.
2. Loosen the lower crankcase bolts (marked M10) evenly from the outer bolts to the inner.
3. Crankshaft from the lower crankcase cylinder block.
4. Crankshaft main bearings and thrust washers from the lower crankcase.

OIL JET REMOVAL

Remove or Disconnect (Figure 7)

1. Bolt from the cylinder block.
2. Oil jet and washers from the cylinder block.



Legend
(1) Cylinder Liner
(2) Cylinder Block

Figure 6 — Cylinder Liner Removal

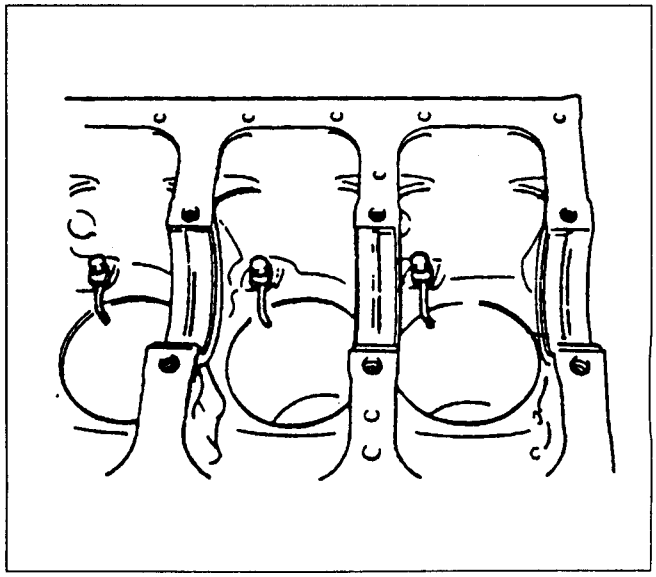


Figure 7 – Oil Jet Removal

CLEANING, INSPECTION, AND REPAIR

You will need a solvent tank large enough to hold the larger engine parts, along with various bristle brushes and a gasket scraper. A source of compressed air will be helpful in the cleaning operations.

Precision measuring tools will be required for the inspection procedure. These include: micrometers, cylinder bore gauge, feeler gauge, dial indicators sets, etc. It is very important that the inspection work be performed with the proper method and tools. The rebuilt engine cannot be expected to perform properly, if any of the parts are worn beyond their serviceable limits.

ENGINE BLOCK

The cylinder block needs to be inspected thoroughly to determine if it is reusable. Before the cylinder block inspection can be performed, it should be stripped of all coolant plugs and oil gallery plugs. To prevent dirt from being stuck into the oil bypass valves, they must be removed before the cylinder block can be cleaned.

OIL FILTER AND CYLINDER BLOCK PLUG REMOVAL

Remove or Disconnect (Figure 8)

1. Oil pipe.
2. Oil filter assembly.
3. Cup plugs and the block heater (if equipped).
4. Oil gallery plugs (if equipped).

CYLINDER BLOCK CLEANING

Clean

1. Block into the solvent.
2. Gasket from the sealing surfaces.
   - Use only the proper cleaning solvent when removing old gasket material.
3. Blow compressed air through all oil passages. Wear protective safety glasses and gloves.
4. Scale deposits from the coolant passages.
5. Crankshaft.

CYLINDER BLOCK INSPECTION

Inspect

1. Cylinder block for cracks and wear.
   - Coolant jackets
   - Crankshaft bearing webs
   - Engine mounting bosses
   - Thrust washer mating surfaces on cylinder block and lower crankcase.

Measure (Figure 9 through 11)

2. Cylinder block for warpage.
   - Use a straight edge and a feeler gauge to measure the four sides and the two diagonals of the cylinder block. If the measured values exceed the 0.2 mm (0.008 in.)., the cylinder block must be replaced.
3. Crankshaft bearing bores (cylinder block and lower crankcase).
4. Use an inside micrometer and measure the crankshaft bearing inside diameter.
   - Subtract the crankshaft main bearing journal diameter from the crankshaft main bearing inside diameter to obtain the proper clearances.
   - No. 4 crankshaft main bearing journal: 81.875 to 81.895 mm.(3.2234 to 3.2242 in.).
     — Production: 0.093 to 0.124 mm (0.0037 to 0.0049 in.).
     — Service Limit: 0.14 mm (0.0055 in.).
   - All other crankshaft main bearing journals:
     — Production: 0.063 to 0.094 mm (0.0025 to 0.0037 in.).
     — Service Limit: 0.14 mm (0.0055 in.).

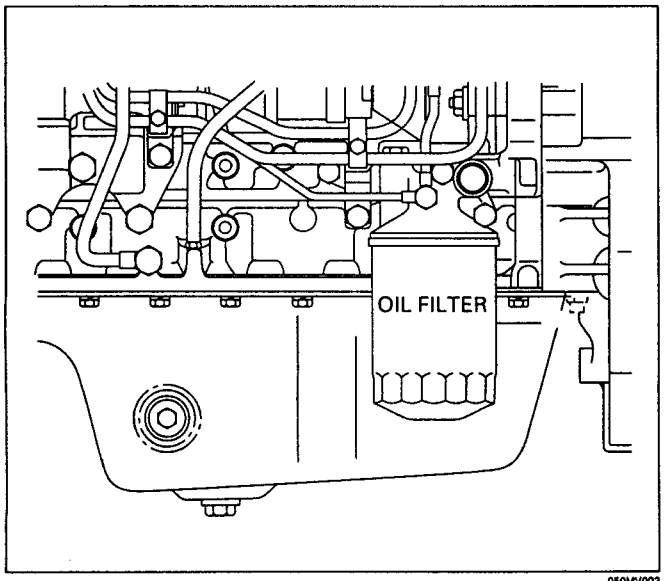


Figure 8 – Oil Filter

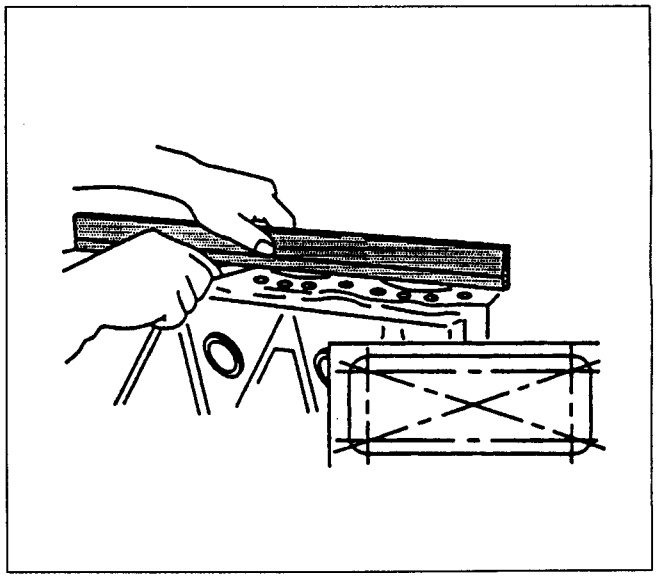


Figure 9 – Checking Cylinder Block for Warpage

CRANKSHAFT INSPECTION

Tools Required:
J22888-D Gear Puller
J41222 Timing Gear Installer

Inspect

1. Crankshaft.
   - Crankshaft for cracks
   - Crankshaft main bearing surfaces
   - Crankshaft thrust washer surfaces for excessive wear
   - Crankshaft timing gear for chipped or broken teeth

Measure (Figures 11 through 14)

1. Crankshaft main bearing journals.
   - No. 4 crankshaft main bearing journal: 81.875 to 81.895 mm.(3.2234 to 3.2242 in.).
   - All other crankshaft main bearing journals: 81.905 to 81.925 mm.(3.2246 to 3.2254 in.).
2. Crankshaft for run out.
   - Mount the crankshaft between centers or on V blocks and check.
   - Run out should not exceed 0.45 mm (0.0177 in.).
3. Crankshaft connecting rod journals at two different points on the journal.
   - Connecting rod bearings journals should be: 72.902 to 72.922 mm (2.8702 to 2.8709 in.).
   - If the crankshaft does not meet specifications, it should be replaced.

Important

- Replace the crankshaft or the main bearing inserts or both, to obtain the proper clearances.

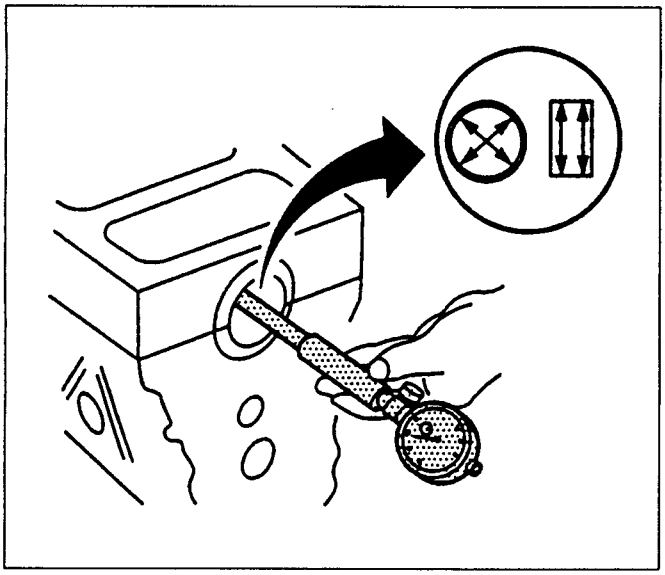


Figure 10 – Measuring Crankshaft Journal Inside Diameter

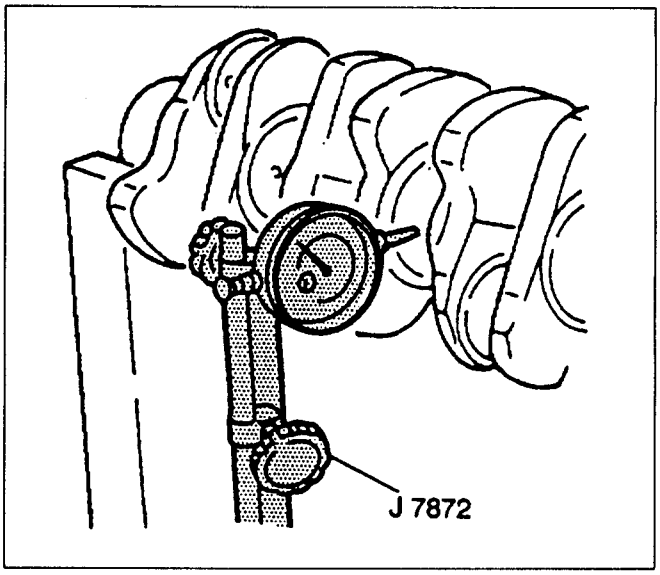


Figure 12 Measuring Crankshaft Run Out

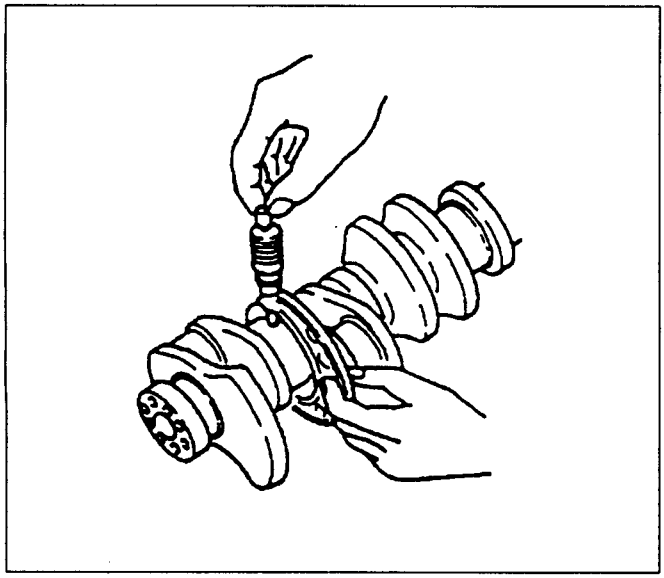


Figure 11 – Measuring Crankshaft Main Journal

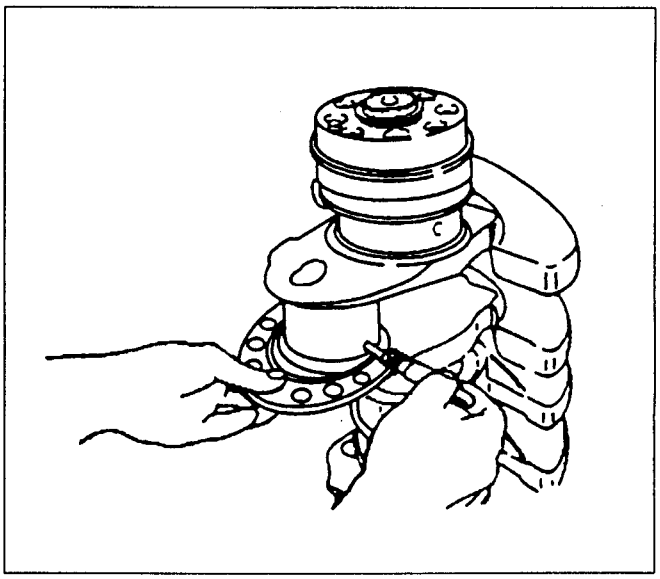


Figure 13 – Measuring Connecting Rod Journal

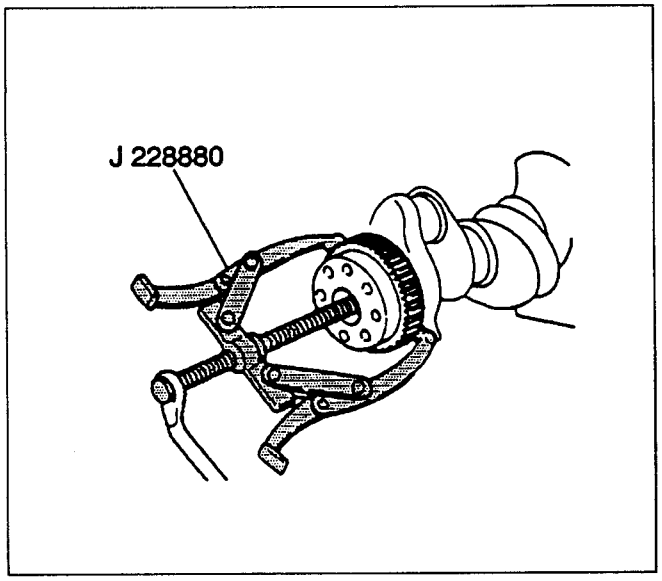


Figure 14 – Crankshaft Timing Gear Removal

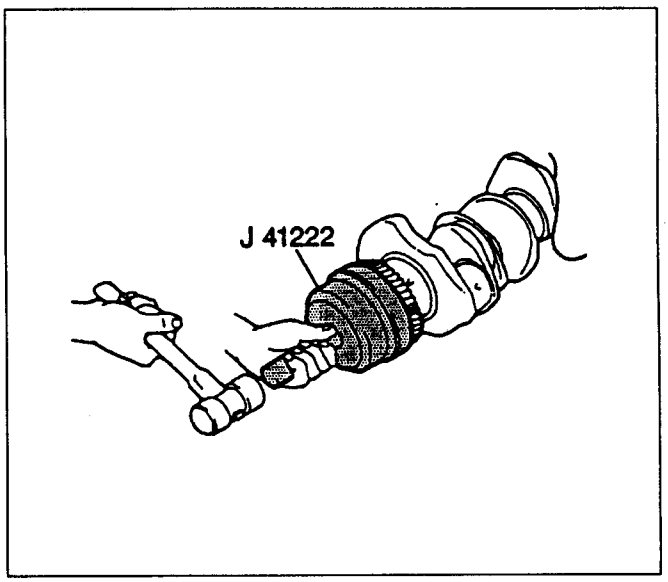


Figure 15 – Crankshaft Timing Gear Installation

CRANKSHAFT TIMING GEAR INSPECTION AND REPLACEMENT

Tools Required:
J22880 Gear Puller
J41222 Gear Installer

Remove or Disconnect (Figure 14)

1. Install tool J22880 on the crankshaft timing gear.
2. Crankshaft timing gear from the crankshaft.

Install or Connect (Figure 15)

1. Crankshaft timing gear to the crankshaft.
2. With tool J41222, install crankshaft timing gear on the crankshaft.

Important

- When installing crankshaft timing gear, make sure that the timing mark is facing away from the cylinder block.

OIL PUMP INSPECTION AND REPAIR

Disassembly and Inspection (Figure 16 through 20)

1. Driven gear and shaft (6) from the oil pump body (2).
2. Cotter pin (4) from the oil pump (4).
3. Oil relief valve (3) from the oil pump (3).
4. Oil pump drive gear (1).
   - Use a gear puller to remove the oil pump drive gear.
5. Drive gear (5).

Clean

- Clean all parts in solvent.
- Blow the parts dry with compressed air. Wear protective safety glasses and gloves.

Inspect

- Oil pump body (2) for cracks or damage.
- Gears (5 and 6) for pitting and wear.

Measure

- Gear tooth to wall clearance.
- Clearance must not exceed 0.3 mm (0.012 in.).
- Gear end clearance.
- Clearance must not exceed 0.2 mm (0.08 in.).

Important

- If the clearances are excessive, replace the oil pump as an assembly.

Measure

- For drive gear shaft (1) and oil pump body clearance.
- Use a micrometer to measure the drive gear shafts.
- The measurement should be: 15.9 mm (0.626 in.).
- Use an inside micrometer to measure the oil pump body inside diameter (2).
- Use an inside micrometer to measure the cylinder block body bushing (1) for the oil pump.
- If the clearance between the gear shaft and the oil pump body or the cylinder block bushing exceeds. 0.2 mm (0.008 in.)., both the oil pump and or the cylinder block bushing may have to be replaced.

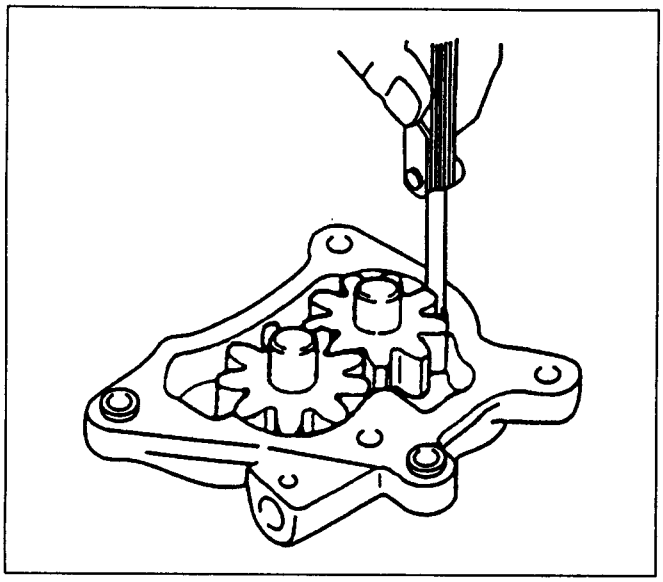


Figure 16 – Measuring Gear to Wall Clearance

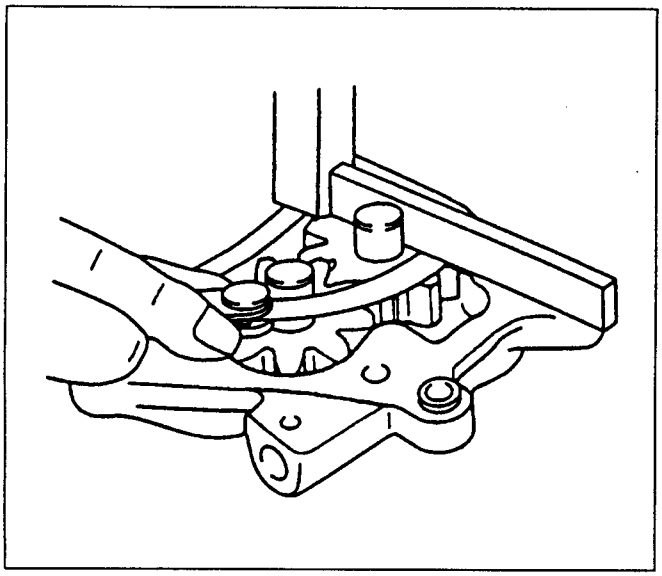
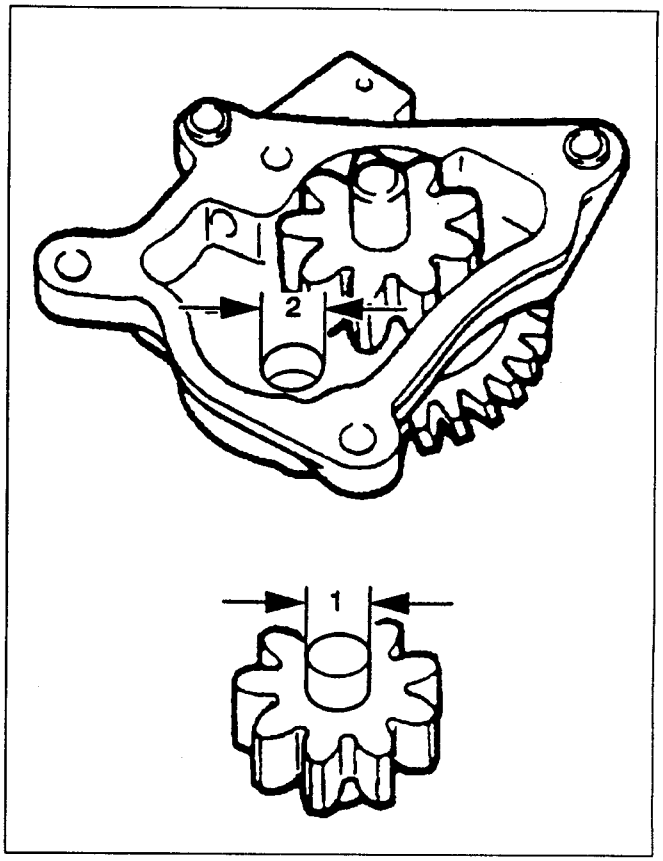
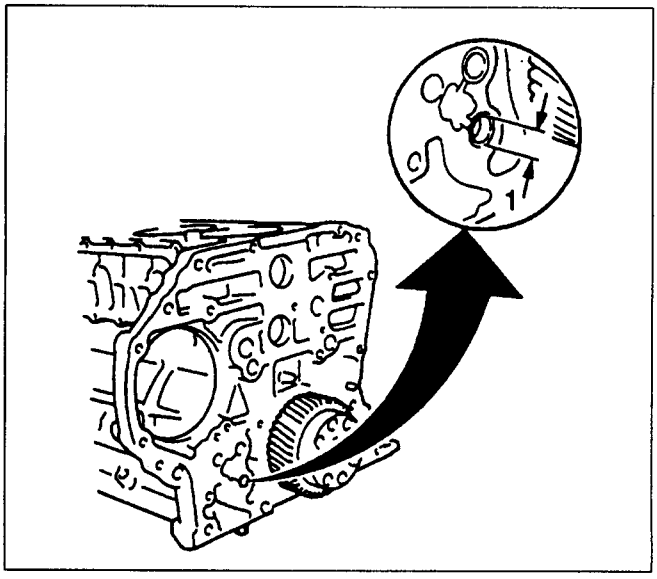


Figure 17 – Measuring Gear End Clearance



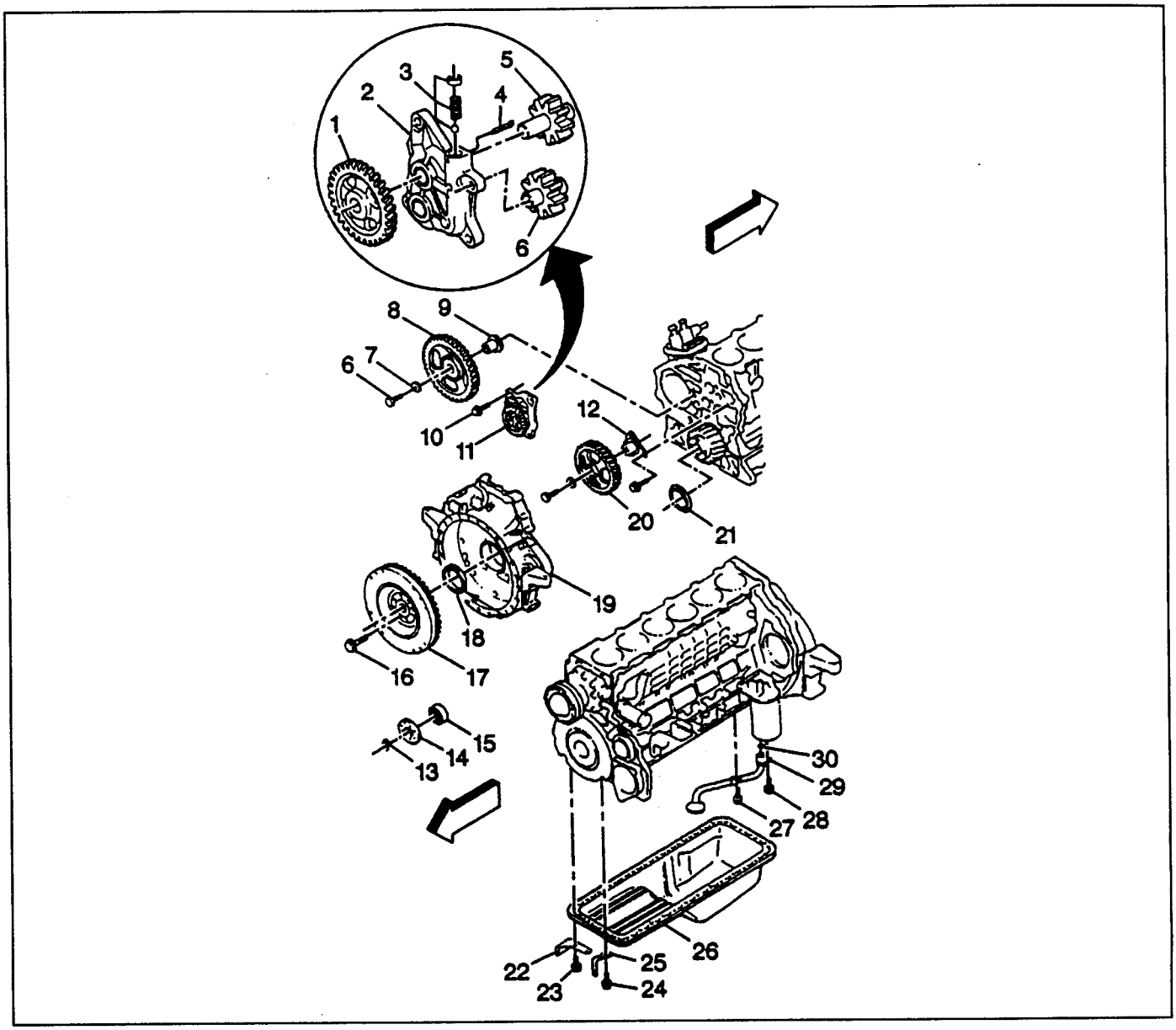
Legend
(1) Drive Gear Shaft
(2) Driven Gear Bushing

Figure 18 — Oil Pump Body Clearance



Legend
(1) Oil Pump Cylinder Block Bushing

Figure 19 — Cylinder Block Oil Pump Bushing Clearance



Legend

(1) Oil Pump Drive Gear
(2) Oil Pump Body
(3) Oil Pump Relief Valve Assembly
(4) Cotter Pin
(5) Drive Gear
(6) Driven Gear and Shaft
(7) Washer
(8) Idler Gear A
(9) Idler Gear Shaft
(10) Oil Pump Mounting Bolt
(11) Oil Pump Assembly
(12) Idler Gear B Shaft
(13) Snap Ring for Pilot Bearing
(14) Spacer
(15) Pilot Bearing
(16) Crankshaft Bolt
(17) Flywheel
(18) Crankshaft Rear Oil Seal
(19) Flywheel Housing
(20) Idler Gear B
(21) Oil Slinger
(22) Bracket
(23) Bolt
(24) Bolt
(25) Bracket
(26) Oil Pan
(27) Bolt for Oil Pick Up Tube
(28) Bolt for Oil Pick Up Tube
(29) Oil Pick Up Tube
(30) O-ring for Oil Pick Up Tube

Figure 20 — Oil Pump and Components

Reassemble (Figure 20)

1. Apply clean engine oil to the drive gear (5).
2. Install the oil pump drive gear to the drive gear (5).
   - When installing the drive gear (1), make sure that the large hub side of the gear is facing away from the oil pump body (2).
   - Use a bench press to press the drive gear on to the drive gear shaft.
3. Oil relief valve assembly (3) into the oil pump body (2).
4. Cotter pin (4) to the oil pump body (2).
5. Apply clean engine oil to the drive gear and drive gear shaft.
6. Driven gear and shaft (6) to the oil pump body (2).

IDLER GEAR INSPECTION AND REPLACEMENT

Tools Required:
J7872 Dial Indicator With Magnetic Base
J26900 Micrometer

Measure (Figures 21 and 22)

1. Idler gear end play.
   - If the measurement is greater than 0.2 mm (0.008 in.)., the idler gear and or hub should be replaced.
2. Idler gear backlash.
   - With dial indicator J7872, rest the plunger on the teeth of the idler gear. Zero the gauge and rock the idler gear back and forth to read the gear backlash. If the reading is more than 0.3 mm (0.012 in.)., replace the worn gear or gears.

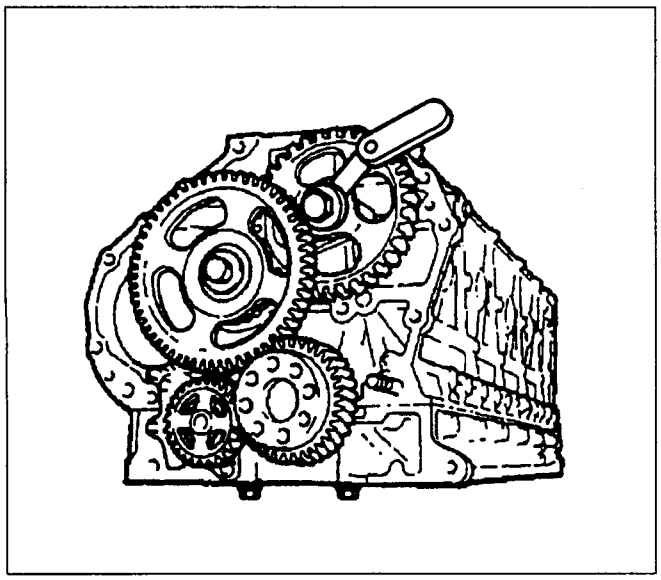


Figure 21 – Measuring the Idler Gear End Play

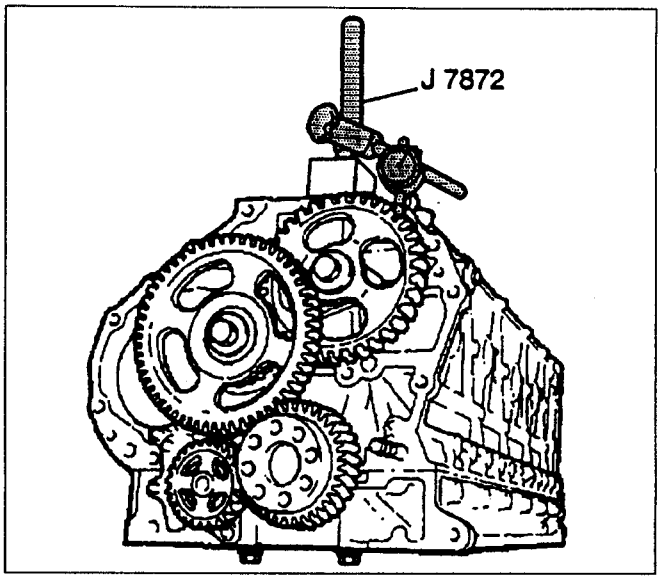


Figure 22 – Measuring the Idler Gear Backlash

Disassemble (Figures 23 and 24)

1. Rotate the crankshaft until the timing marks are aligned.
2. Bolt and washer from the idler gear.
3. Idler gear from the hub.
4. Mounting bolts from the hub.
5. Hub from the cylinder block.

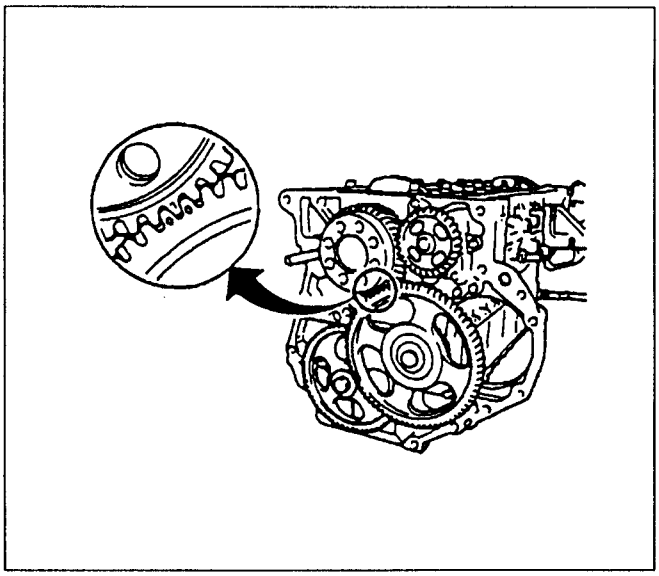


Figure 23 – Alignment of Timing Marks

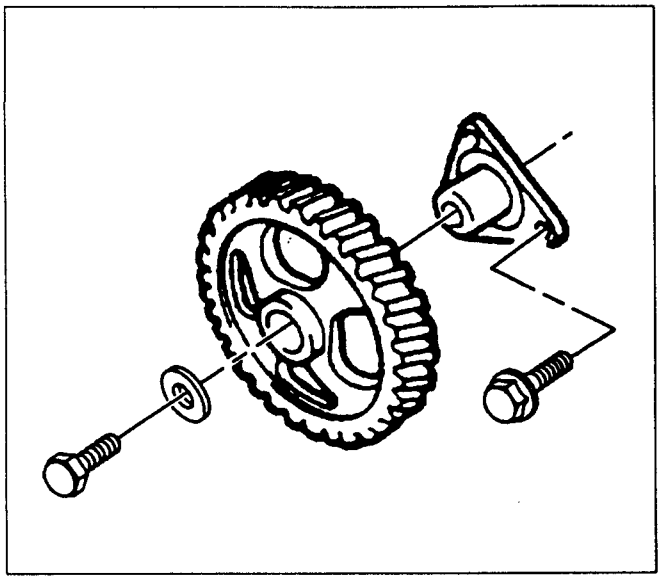


Figure 24 – Idler Gear and Hub

Inspect

- Gear teeth for chips or excessive wear.
- Gear bushing for scoring or damage.
- Hub for scoring or damage.

Measure (Figures 25 and 26)

- Measure the idler gear hub with tool J26900 .
- Measure the idler gear bushing inside diameter, using an inside diameter micrometer.
- Subtract the hub outside diameter from the idler gear bushing inside diameter to obtain the hub to idler gear bushing clearance.
  - — Production clearance is: 0.02 to 0.062 mm (0.00078 to 0.0024 in.).
  - — Service limit: 0.2 mm (0.0079 in.).
- If the clearance is excessive, replace the hub or gear as required. The bushing is not available separately.

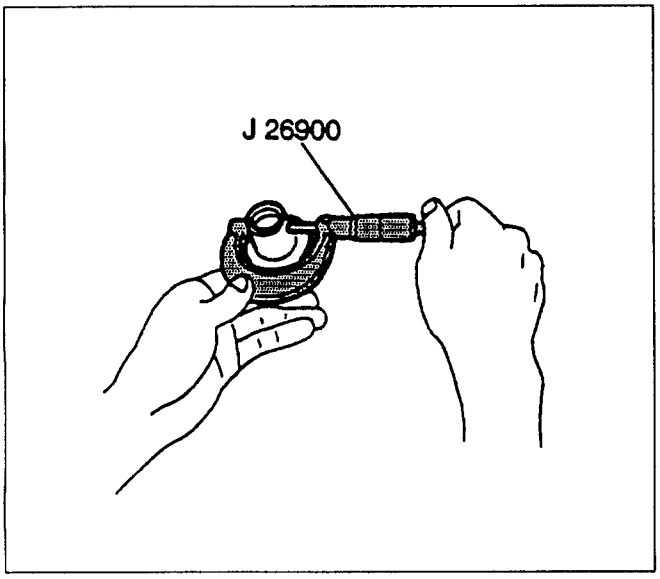


Figure 25 – Measuring the Hub Outside Diameter

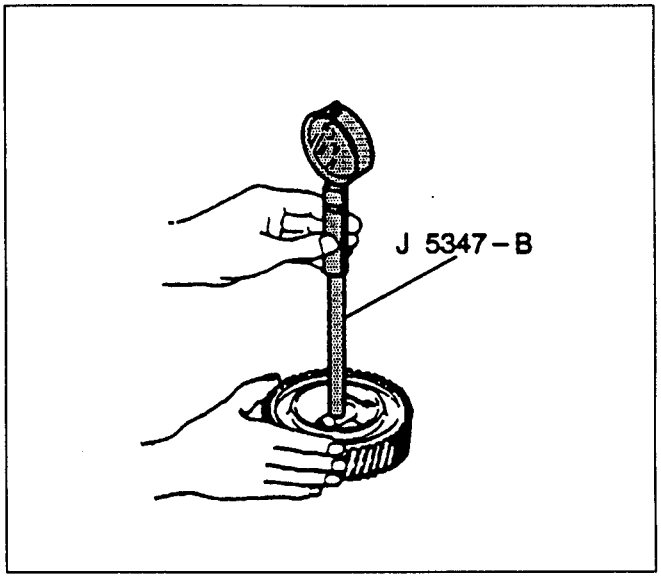


Figure 26 – Measuring Idler Gear Inside Diameter

PISTON, CONNECTING ROD AND CYLINDER LINER ASSEMBLIES

Remove or Disconnect (Figures 27 through 32)

1. Piston rings from the piston.
2. Snap rings from the piston pin.
3. Piston pin from the piston.
   - Heat the piston if necessary to aid in the piston pin removal. Do not drive the piston pin out.

Clean

- Piston and rings in cleaning solvent. Do not use a wire brush on the piston, damage may occur.
- Piston ring grooves with a ring groove cleaning tool.

Inspect

- Pistons for cracks and scoring.
- Liner for scratches, cracks, and scoring.

Measure

- Piston ring groove clearance.
  - — First groove: 0.080 to 0.115 mm (0.0031 to 0.0045 in.).
  - — Service limit: 0.2 mm (0.0787 in.).
  - — Second and third grooves: 0.05 mm to 0.08 mm (0.0019 to 0.0031 in.).
  - — Service limit: 0.15 mm (0.0059 in.).
  - — Oil control ring: 0.030 to 0.07 mm (0.0012 to 0.0028 in.).
  - — Service limit: 0.15 mm (0.0059 in.).
- Piston ring end gap (Figure 29).
- Insert piston assembly into the cylinder liner, 195 mm (7.67 in.). below the top of the cylinder liner.
- Piston ring gap:
  - — First compression ring 0.18 to 0.28 mm (0.0071 to 0.0110 in.).
  - — Service limit 1.2 mm (0.0472 in.).

— Second and third compression rings 0.35 to 0.5 mm (0.01378 to 0.01958 in.).
— Service limit 1.2 mm (0.0472 in.).
— Oil control ring 0.15 to 0.35 mm (0.0059 to 0.0138 in.).
— Service limit 1.2 mm (0.0472 in.).

- Piston pin bore inside diameter measurement.
  — 40.004 to 40.012 mm (1.5750 to 1.5752 in.).
- Piston pin to the piston clearance. Measure the piston pin at three different points.
  — 39.995 to 40.000 mm (1.5746 to 1.5748 in.).
- Replace piston pin, if it is less than the specification.
- Subtract the piston pin diameter from the piston pin bore reading.
- Proper clearance 0.004 to 0.017 mm (0.0002 to 0.0007 in.).

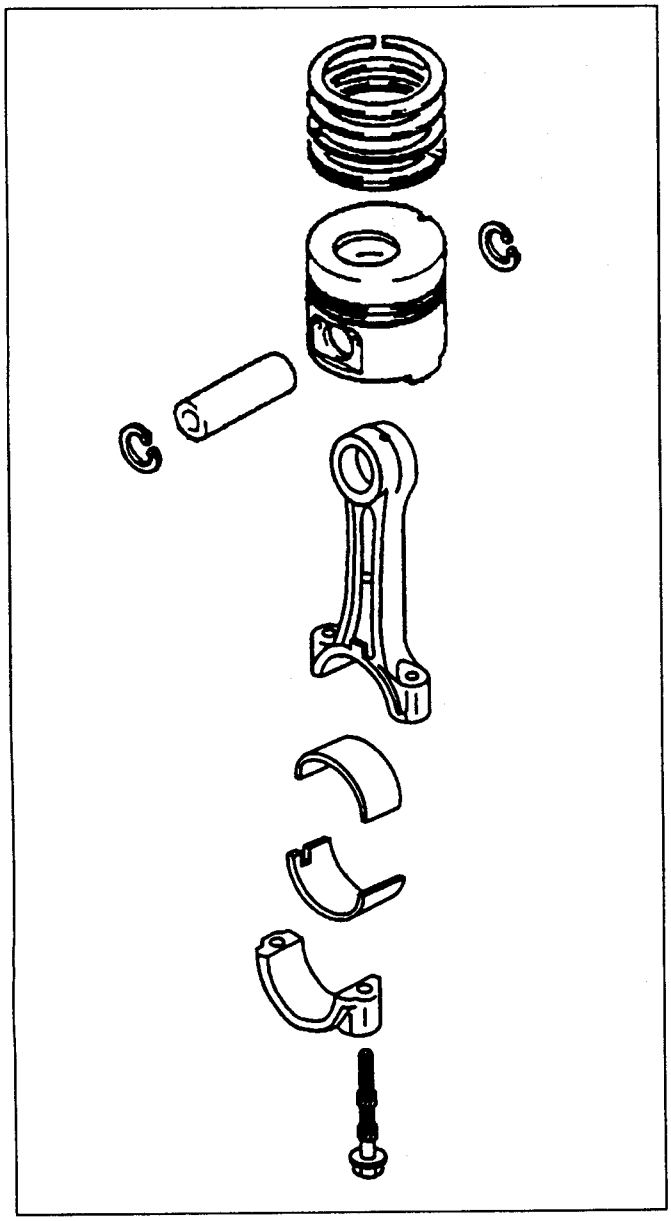


Figure 27 – Piston and Connecting Rod Components

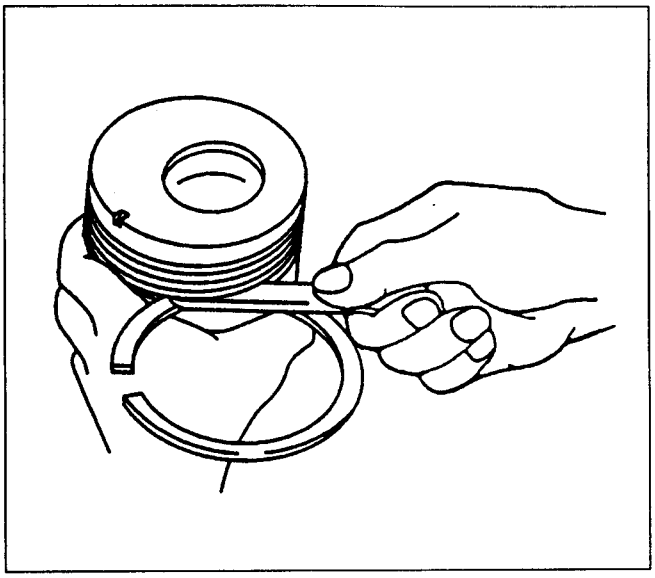


Figure 28 – Measuring Piston Ring Groove Clearance

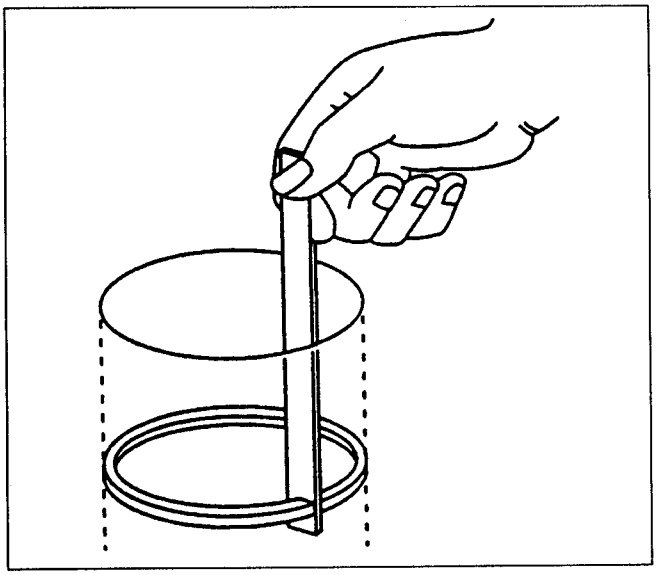


Figure 29 – Measuring Piston Ring End Gap

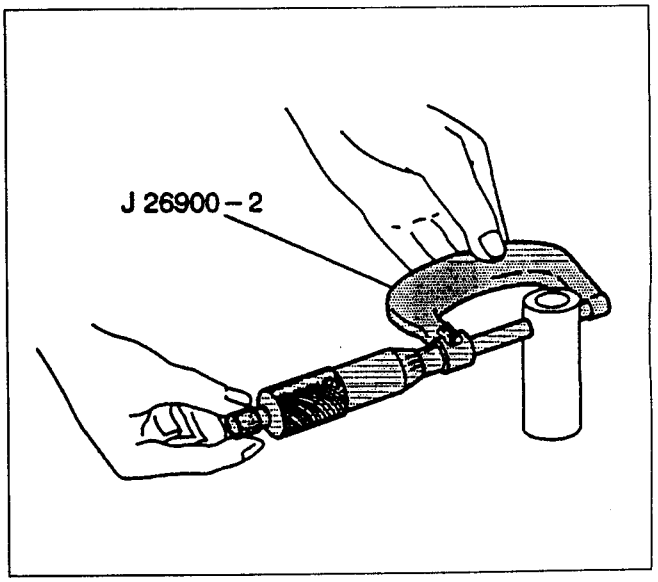
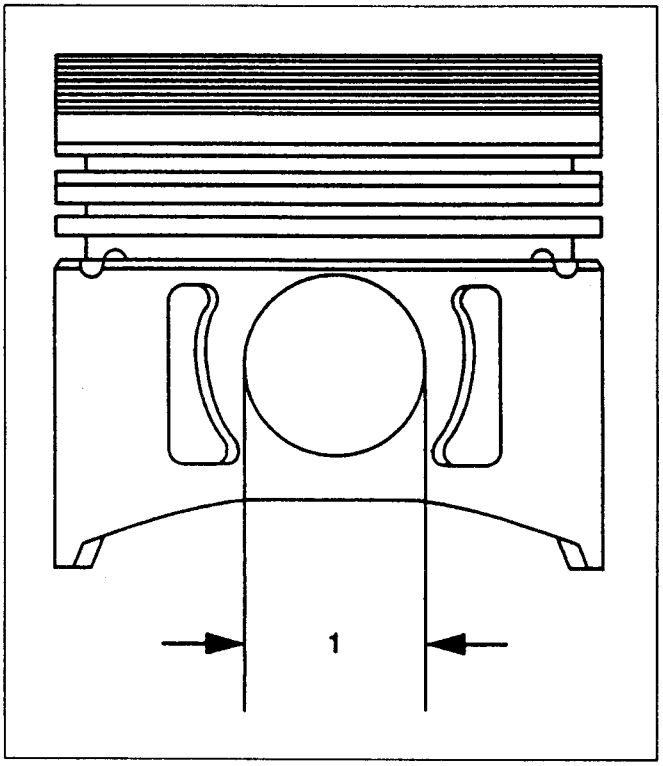


Figure 30 – Piston Pin Measurement



Legend
(1) Piston Pin Bore Measurement

Figure 31 — Measuring the Piston Pin Bore

PISTON SELECTION

Measure (Figures 32 and 33)

1. Cylinder liner outside diamete.
   - Place the bore gauge 20 mm (0.79 in.)., below the gasket surface.
   - Replace the cylinder liner if not with in specifications.
     - — Grade 1: 117.981 to 117.990 mm (4.6449 to 4.6453 in.).
     - — Grade 2: 117.991 to 118.000 mm (4.6453 to 4.6457 in.).
     - — Grade 3: 118.001 to 118.010 mm (4.6457 to 4.64619 in.).
   - When replace the cylinder liner from service part liner, select liner grade 1X for factory liner grade 1 and 2, liner grade 3X for factory liner grade 3.
     The cylinder liner bore diameter grade have not grade for service part liner.
2. Piston diameter.
   - Place the micrometer 82 mm (3.23 in.). below the piston crown, at a right angle to the piston pin bore.
     - — Grade A: 114.970 to 114.979 mm (4.5264 to 4.5267 in.).
     - — Grade B: 114.980 to 114.989 mm (4.5268 to 4.5271 in.).
     - — Grade C: 114.990 to 115.000 mm (4.5272 to 4.5276 in.).
   - There are three different sizes of pistons to be installed from factory. The size grades are referred to as: "A", "B" and "C".
   - The size grade letter is stamped on the piston crown. The engine may come with any combination of piston sizes.
   - Replace the piston, the piston grade have not stamped for service part piston.
   - Pistons are supplied either as part of the cylinder liner set, or separately.
   - When replacing the cylinder liner, also replace the piston. When replacing a piston separately, be sure that the piston to cylinder liner clearance is within factory specifications.
   - Separately supplied pistons have a not stamp grade mark.
   - For cylinder liners inside grade have not grade, mark it mean any service part pistons are installed to replaced service part liners.
3. Piston to cylinder liner clearance.
   - Subtract the piston diameter from the cylinder liner bore diameter.
   - Correct clearance is 0.122 to 0.159 mm (0.0048 to 0.0063 in.).
   - If the clearance is correct, the piston and the cylinder liner are acceptable for further use.
   - If the clearance is incorrect, try a new piston.

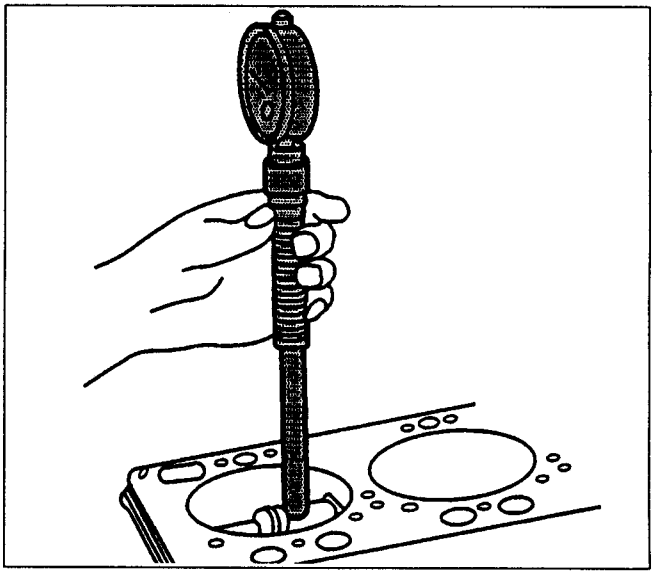


Figure 32 – Measuring the Cylinder Liner Bore

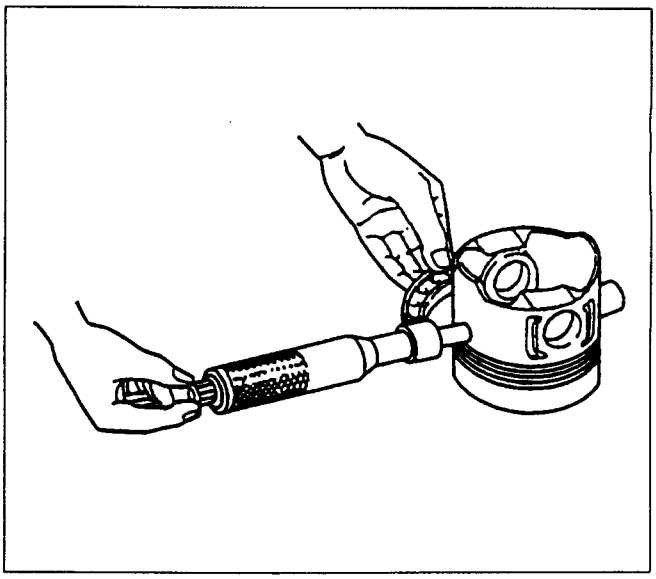


Figure 33 – Measuring the Piston

- If the clearance cannot be brought within factory specifications by the use of new piston, the cylinder liner must be replaced. There are no "oversize" pistons available.

Important

- Never attempt to hone the cylinder liner. Honing may damage the chrome finish on the liners surface.

INSPECTING THE CONNECTING ROD

Clean

- Clean all parts in solvent.
- Blow the parts dry with compressed air. Wear protective safety glasses and gloves.

Inspect (Figure 34)

- Connecting rods and connecting rod caps for cracks, damage, etc.
- Piston pin bushing for scoring.
- Connecting rod bearing insert for scoring.
- Connecting rod bearing insert tension. Moderate finger pressure should be needed to push the bearing insert into place.
- Connecting rod journal on the crankshaft for scoring or other damage.

Measure (Figures 31, 34 and 36)

- Piston pin to the piston clearance. Measure the piston pin at three different points.
- Replace the piston pin if the piston pin is less than 39.95 mm (1.5728 in.).
- Piston pin bushing inside diamete.
- The correct diameter is: 40.012 to 40.022 mm (1.5753 to 1.5767 in.).

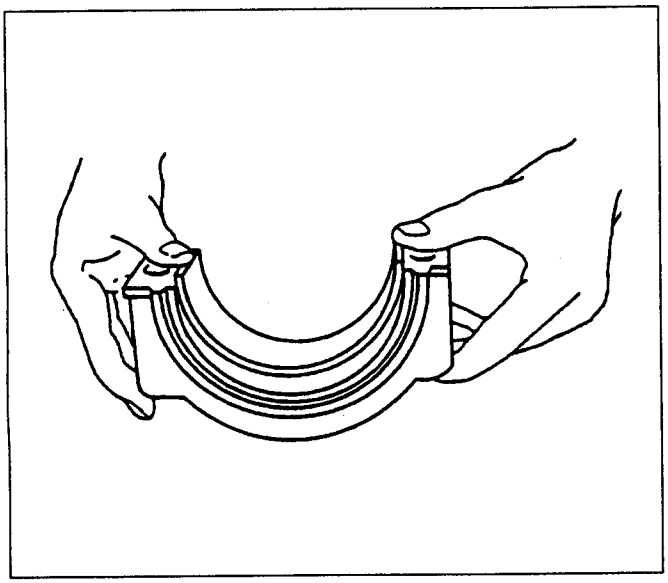


Figure 34 – Connecting Rod Bearing Tension

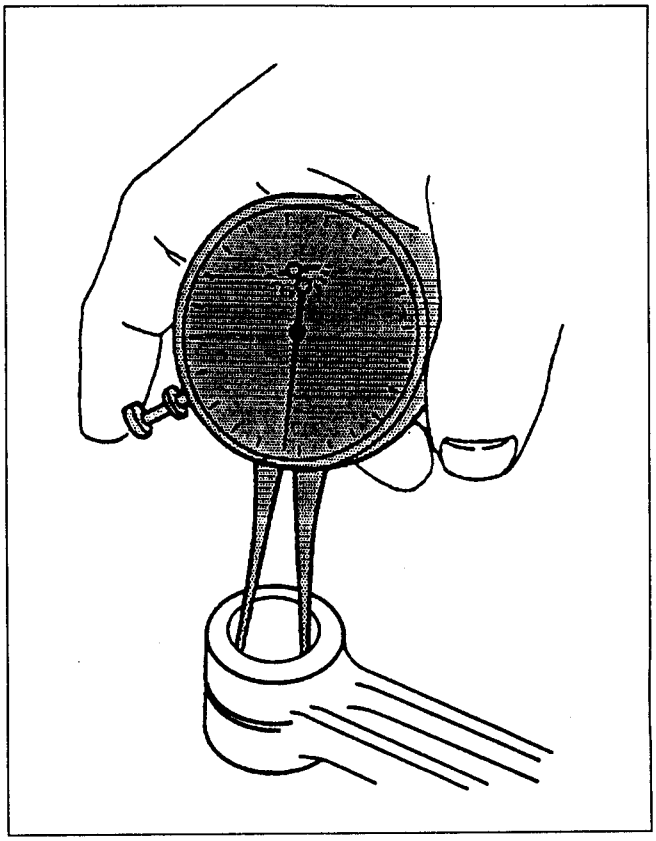


Figure 35 – Measuring Piston Pin Bushing Inside Diameter

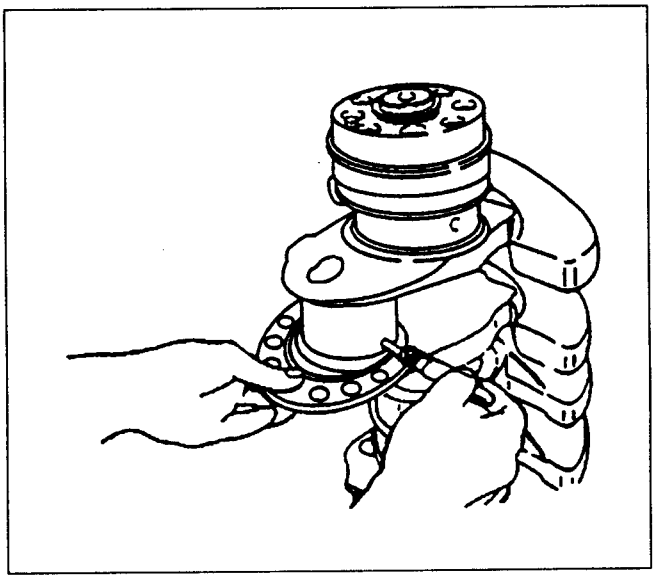


Figure 36 – Measuring the Connecting Rod Journal

- Piston pin to piston pin bushing clearance is as follows.
  - — Clearance: 0.012 to 0.027 mm (0.0005 to 0.0011 in.).
  - — Service limit: 0.05 mm (0.002 in.).
- Subtract the piston pin diameter from the piston pin bushing inside diameter.
- Connecting rod journal diameter, measure at two different points.
  - — Measurements should be: 72.902 to 72.922 mm (2.8701 to 2.8709 in.).

Important

- Undersize bearing are not available. If the crankshaft is worn, replaced it.

Measure

- Connecting rod bearing clearances can be measured by using the plastic gauge method.

Install or Connect (Figures 37 and 38)

1. Apply a piece of plastic gauge the width of the connecting rod bearing journal.
2. Connecting rod bearing inserts to the connecting rod and the connecting rod cap.
   - Apply a small amount of molybdenum grease to the bolts.

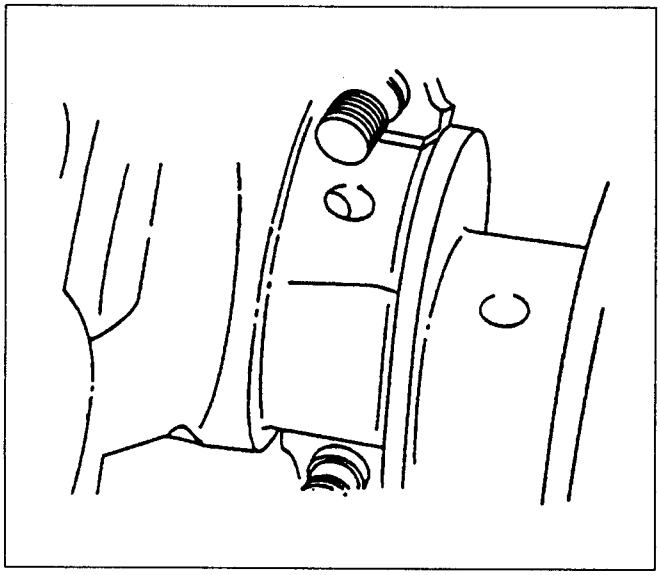


Figure 37 – Installing the Plastic Gauge

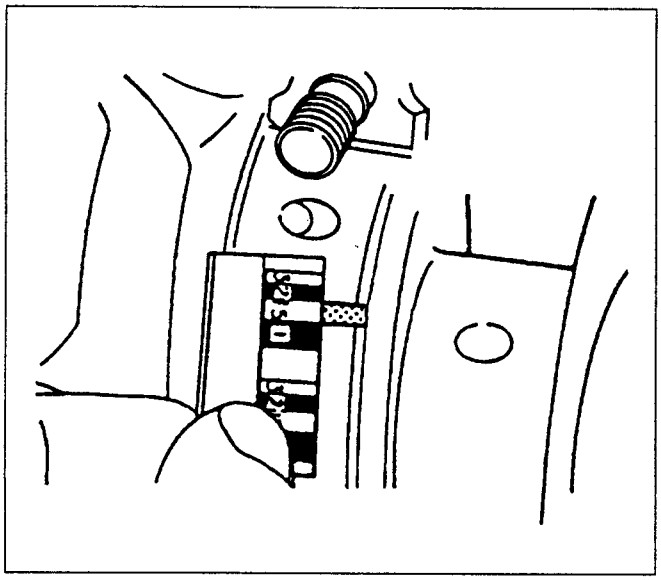


Figure 38 – Measuring the Plastic Gauge

3. Tighten the connecting rod bolts.

Tighten

- Bolts to 39 N·m (29 lb. ft.). Then tighten an additional 60 degrees and then 30 degrees.

Remove or Disconnect (Figure 38)

1. Remove the connecting rod cap from the crankshaft.
2. Measure the plastic gauge.

Important

- **Do not remove the plastic gauge from the crankshaft journal until the clearance measurement is finished.**

Measure

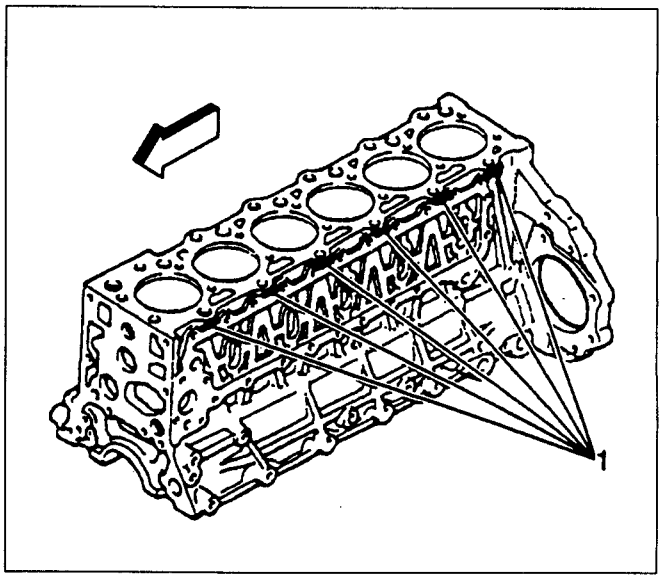
- Check the connecting rod bearing clearances.
- If the clearances are within factory specifications, the connecting rod bearings are satisfaction.
- Remove the plastic gauge.
- If the clearances are not within factory specifications, replace the connecting rod bearing inserts as a set (upper and lower inserts).
- Repeat the procedure.
- If connecting rod bearings still are not within factory specifications, replace the crankshaft.

CYLINDER LINER SELECTION

The cylinder liner body upper left side has been stamped during production to indicate the correct cylinder liner. The cylinder liner grade (1, 2, or 3) is indicated by this stamp.

Replacement cylinder liners have their grade (1X or 3X) stamped on the outside of the cylinder liner.

Select the 1X grade of replacement cylinder liners as marked 1 and 2 on the upper left side of the cylinder body, or 3X grade of replacement cylinder liners as marked 3 on the upper left side of the cylinder body.



Legend
(1) Cylinder Liner Grades

Figure 39 — Cylinder Liner Grademark

Measure

- Cylinder body bore to cylinder liner outside diameter clearance.
- Standard clearance: 0.011 to 0.029 mm (0.0004 to 0.0011 in.).

Important

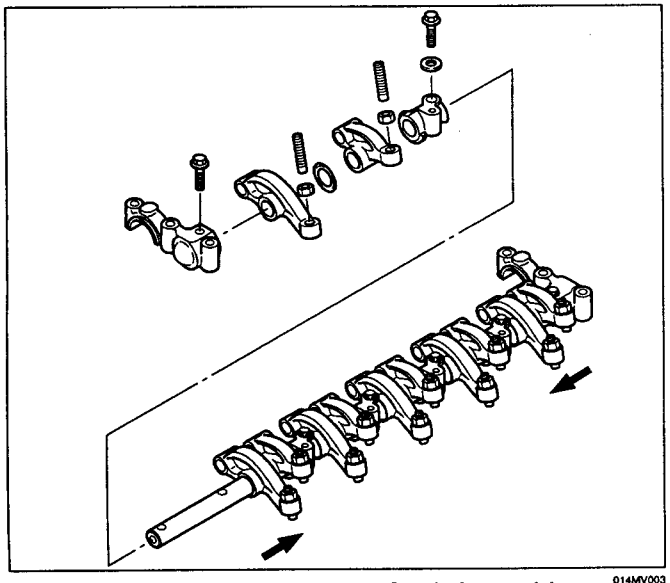
- Clearance refers to the gap between the larger cylinder body bore and the smaller cylinder liner outside diameter.

CYLINDER HEAD AND VALVE TRAIN COMPONENTS

VALVE TRAIN COMPONENTS

Remove or Disconnect (Figure 40)

1. Valve rocker arm shaft assembly from the cylinder head.



014MV003

Figure 40 – Rocker Arm Shaft Assembly

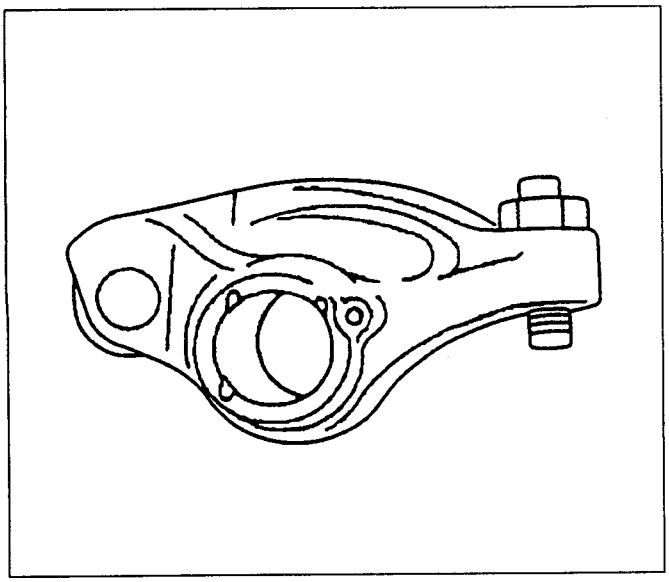
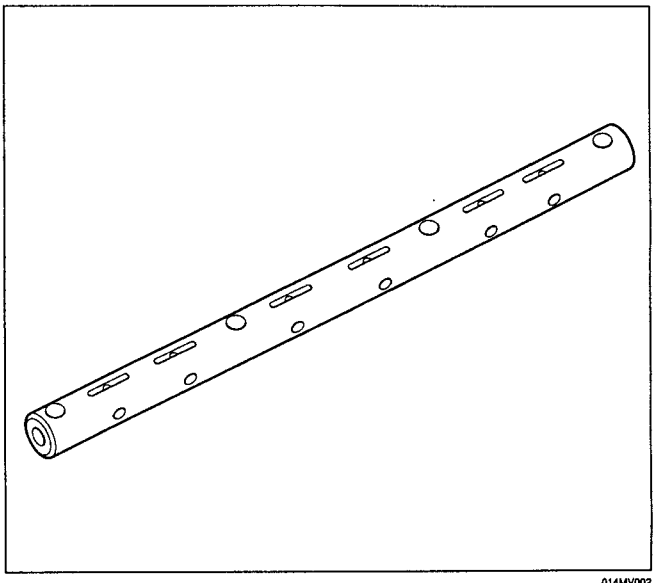


Figure 41 – Valve Rocker Arm



014MV002

Figure 42 – Valve Rocker Arm Shaft

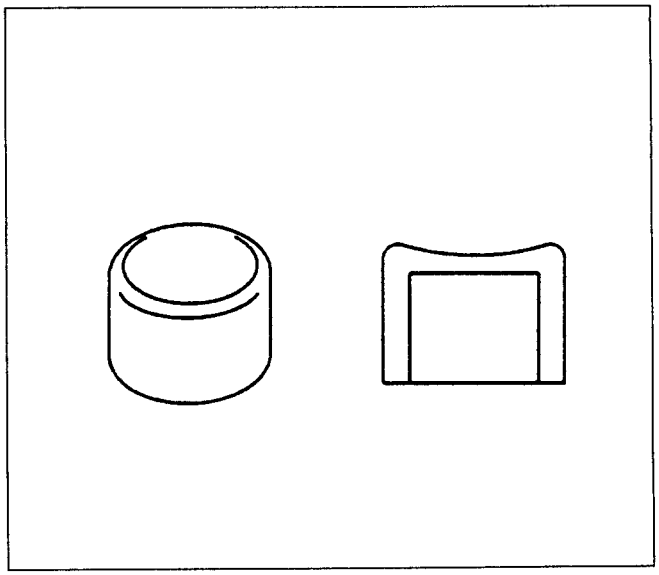


Figure 43 – Valve Bridge Cap

Disassemble

- Valve rocker arm shaft assembly.

Clean

- Clean all parts with cleaning solvent.
- Use compressed air to blow dry the parts. Wear safety eye glasses and gloves.

Inspect (Figures 41 through 43)

- Camshaft retaining brackets for cracks or damage.
- Valve rocker arm shaft for scoring or wear.
- Valve rocker arm inside diameter for scoring or wear.
- Valve rocker arm and the valve bridge cap contact area for pitting and excessive wear.

Measure

- Valve rocker arm inside diameter.
  - Production diameter is: 22.010 to 22.035 mm (0.8665 to 0.8675 in.).
  - Service limit: 22.15 mm (0.872 in.). Replace the part if the measurement is greater than the specification.
- Valve rocker arm shaft.
  - Production diameter: 21.979 to 22.0 mm (0.8653 to 0.8661 in.).
  - Service limit: 21.85 mm (0.8602 in.). Replace the part if the measurement is less than the specifications.
- Subtract the valve rocker arm shaft diameter from the valve rocker arm diameter to obtain the valve rocker arm clearance.
  - Production clearance: 0.010 to 0.056 mm (0.0004 to 0.0022 in.).
  - Service limit: 0.2 mm (0.0079 in.). Replace the part if the measurement is greater than the specification.
- With a pocket scale (ruler) across the top of the valve cap, measure the distance from the bottom of the scale (ruler) to the bottom of the valve cap. If the measurement is greater than 0.1 mm (0.004 in.)., replace the valve cap.

CAMSHAFT INSPECTION

Inspect

- Camshaft lobes and bearing journals for pitting, abnormal or excessive wear.
- Camshaft gear for chipped or broken teeth.

Measure (Figures 44 through 46)

- Camshaft journals at two different points.
  - Production diameter: 39.950 to 39.975 mm (1.5728 to 1.5738 in.).
  - Service limit: 39.85 mm (1.569 in.).

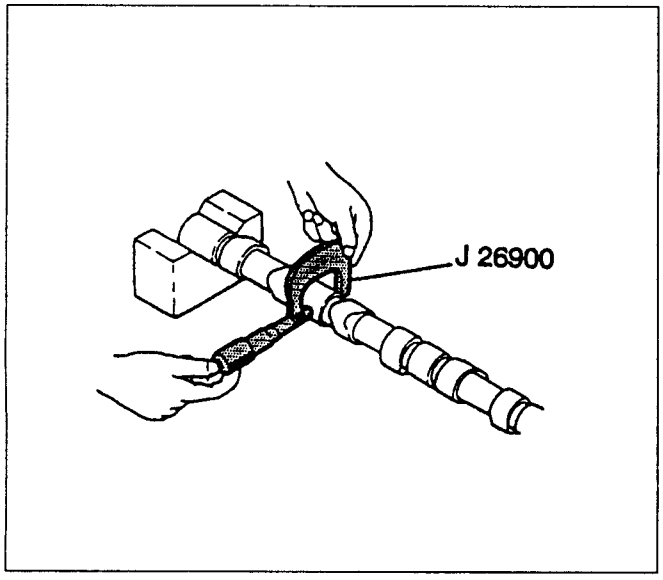


Figure 44 – Measuring the Camshaft Journals

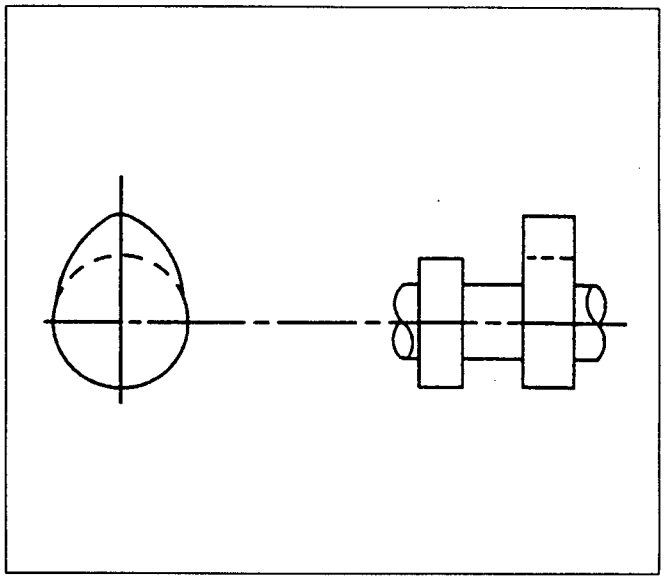


Figure 45 – Measuring the Camshaft Lobes

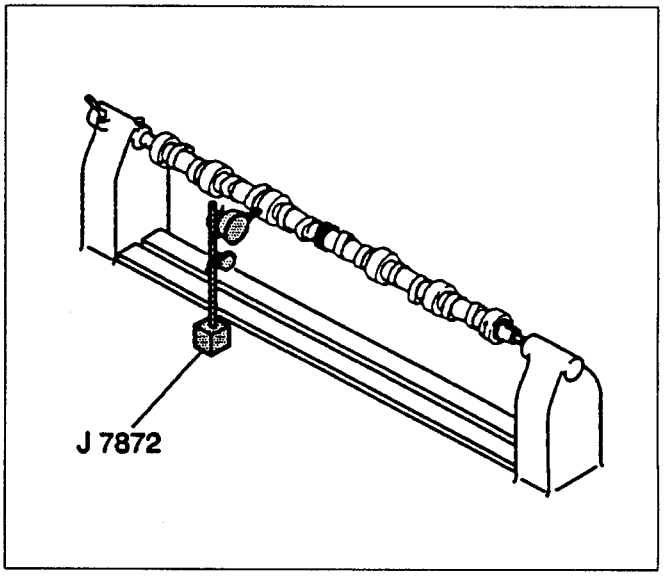


Figure 46 – Measuring Camshaft Runout

- Camshaft bearing inside diameter. The correct measurement is 40.0 to 40.04 mm (1.575 to 1.576 in.).
- Camshaft journal to camshaft bearing clearance.
  - Subtract the camshaft bearing journal diameter, from the camshaft inside diameter.
  - Production clearance: 0.025 to 0.09 mm (0.001 to 0.004 in.).
  - Service limit: 0.15 mm (0.006 in.).
- Camshaft lobe height.
  - Camshaft lobe height should be: 52.851 mm (2.0807 in.) for intake and 54.541 mm (2.1473 in.) for exhaust. Replace the camshaft if the measurement height is below 52.017 mm (2.0500 in.) for intake, 53.761 mm (2.1166 in.) for exhaust.
- Camshaft for runout.
- If the measurement is greater than 0.05 mm (0.0020 in.)., replace the camshaft.

CYLINDER HEAD CLEANING, INSPECTION AND REPAIR

Remove or Disconnect (Figure 47)

1. Remove the valve springs.

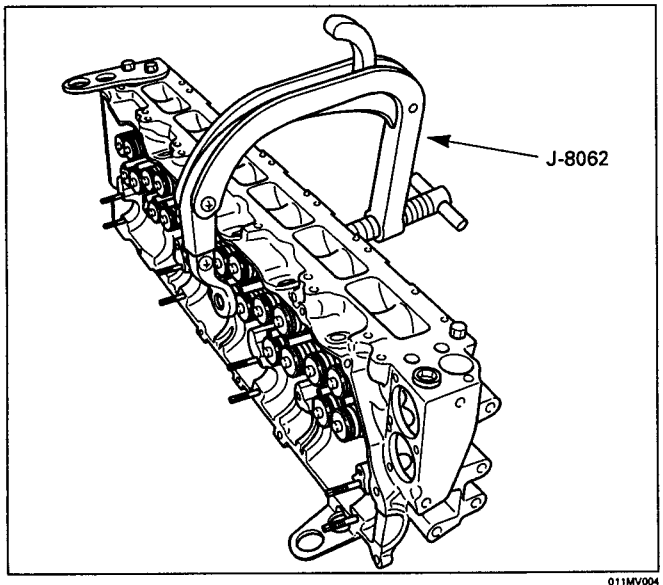


Figure 47 – Compressing the Valve Springs

Inspect

- Carbon from all of the valve ports and combustion chambers.
- Valve guide and bore of dirt and carbon.
- Valve stems and heads.

Important

- Do not use a wire wheel.
- Remove traces of the old gaskets from the cylinder head.

Inspect

- Cylinder head for cracks or damaged threaded holes.
- Cylinder head gasket mating surfaces for damage.
- Valves for damage.
- Valve seats for damage.

Measure (Figures 48 through 53)

- Cylinder head for flatness.
- Check in six different directions. If the cylinder head is distorted more than 0.2 mm (0.0078 in.)., replace the cylinder head.

Important

- **Do not resurface the cylinder head.***

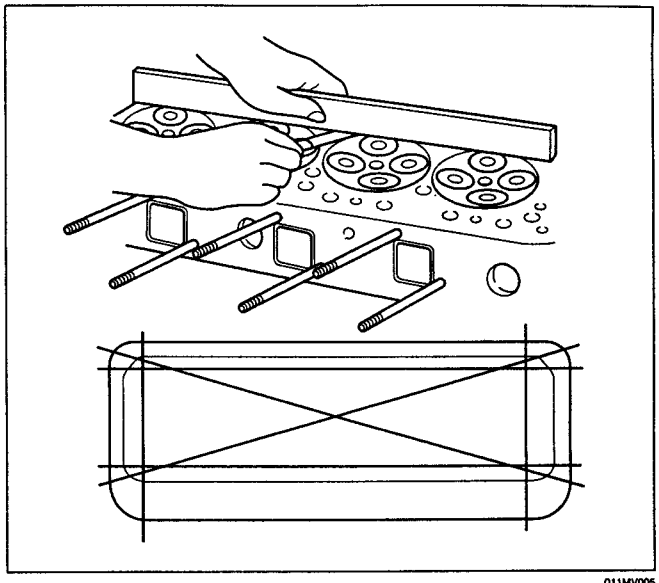


Figure 48 – Checking Cylinder Head for Flatness

2. Valve installed depth.
   - If the measurement is more than 2.5 mm (0.098 in.). for the intake valve and 2.8 mm (0.110 in.). for the exhaust valve, replace the valve or the valve seat as required.

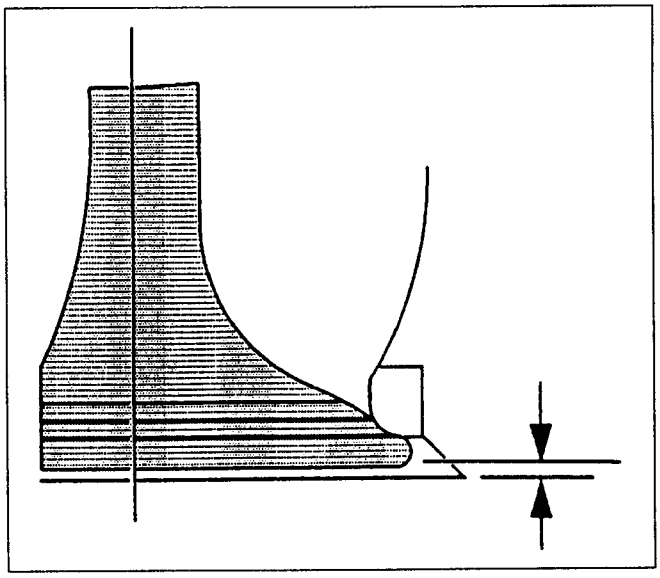


Figure 49 – Measuring the Valve Installed Depth

3. Valve stem diameter.
   - Production specification for the intake valve: 7.946 to 7.961 mm (0.3128 to 0.3134 in.).
   - Service limit: 7.88 mm (0.3102 in.).
   - Production specification for the exhaust valve: 7.921 to 7.936 mm (0.3118 to 0.3124 in.).
   - Service limit: 7.88 mm (0.3102 in.).

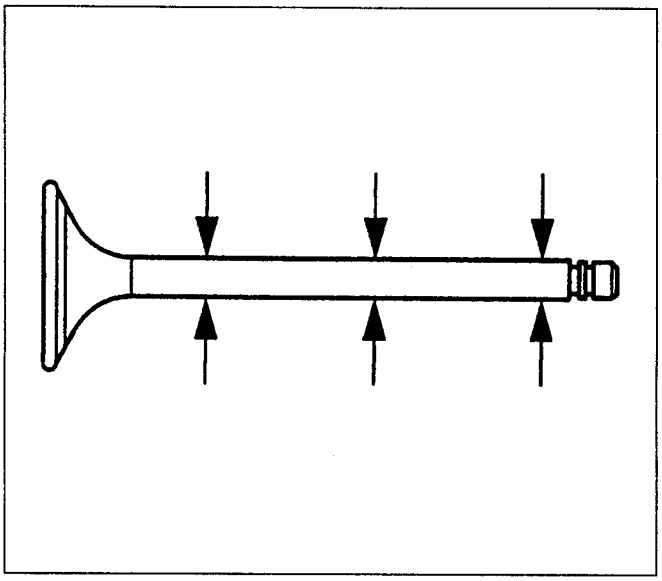


Figure 50 – Measuring the Valve Stem Diameter

4. Valve guide inside diameter.
5. Valve guide to valve stem clearance.
6. Locate the dial indicator so that the plunger is 10 mm (0.39370 in.). above the valve guide.

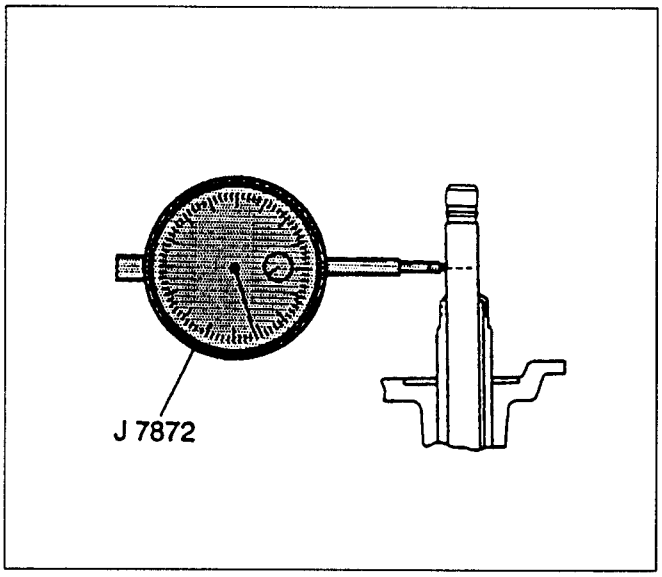


Figure 51 – Measuring the Valve Stem Clearance

7. Hold the valve on its seat.
8. Move the valve stem from side to side to obtain the clearance reading.
   - Production specification for the intake valve guide: 0.04 to 0.07 mm (0.0016 to 0.0028 in.).
   - Service limit: 0.2 mm (0.0079 in.).
   - Production specification for the exhaust valve guide: 0.06 to 0.1 mm (0.0024 to 0.0039 in.).
   - Service limit: 0.25 mm (0.0098 in.).
9. Valve spring length.
   - Production specification for intake valve spring: 65.9 mm (2.5945 in.).
   - Service limit: 64.8 mm (2.5512 in.).
   - Production specification for exhaust spring: 68.1 mm (2.6811 in.).
   - Service limit: 66.9 mm (2.6339 in.).

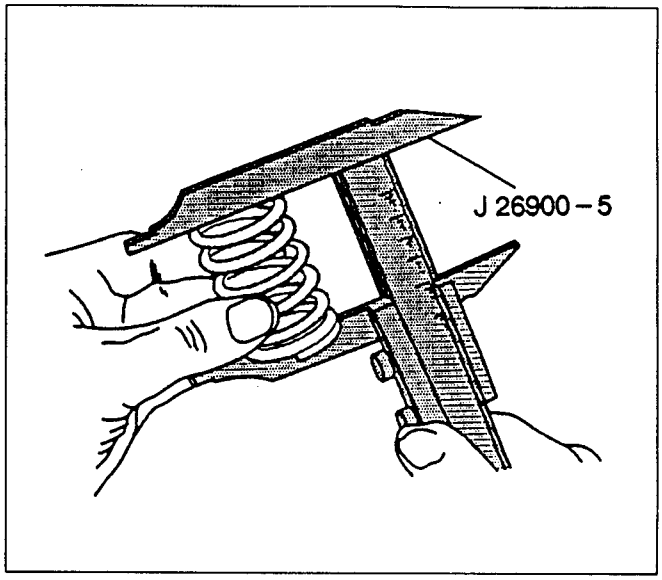


Figure 52 – Measuring the Valve Spring Length

10. Valve spring tension.
    - Compress the valve springs to the specified height.
      — Specified height 46 mm (1.8110 in.). length.
      — Intake Production: 348.1 N (78.3 lb.).
      — Service Limit: 296 N (67 lb.).
      — Exhaust Production: 382.5 N (86 lb.).
      — Service Limit: 325 N (73 lb.).
    - If valve springs are not within factory specifications, replace the valve springs.

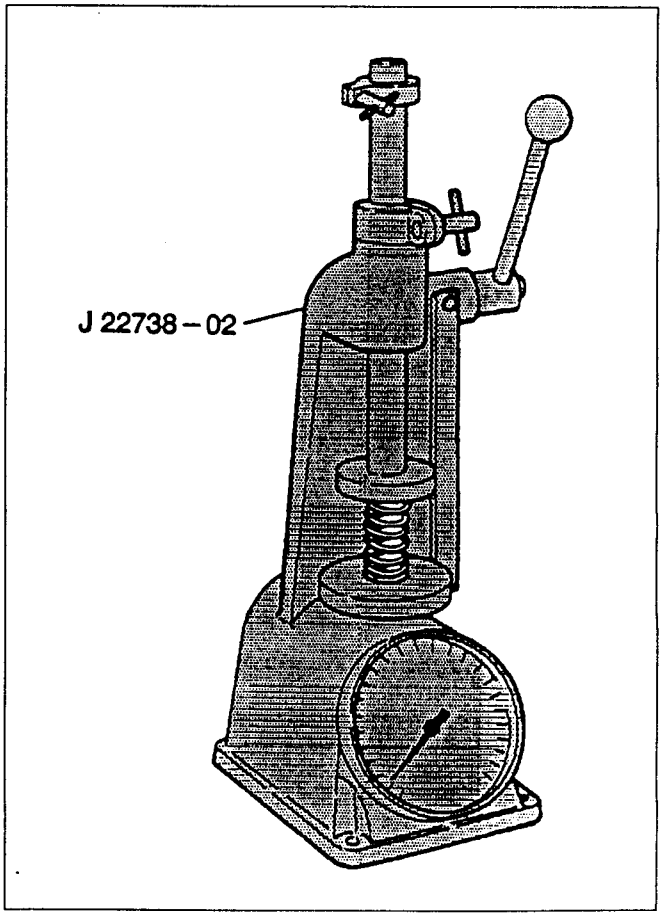


Figure 53 – Measuring the Valve Spring Tension

VALVE SEAT

Reconditioning of the valve seats is very important because the seating of the valves must be precise in order for the engine to deliver the power and the performance it was designed to produce.

Another important factor is the cooling of the valve head. Good contact between each valve and its seat in the cylinder head is a must to insure that the heat in the valve head will be properly dispersed.

Several different types of equipment are available for grinding of the valve seats. The recommendations of the equipment manufacturer should be carefully followed to attain the proper results.

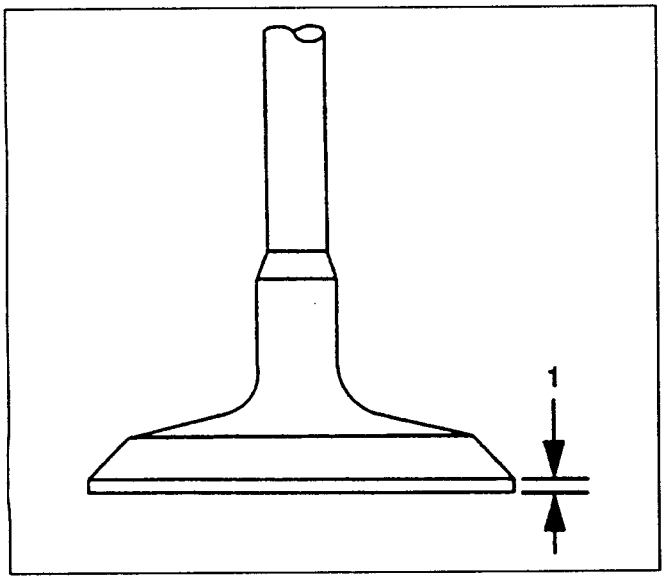
Regardless of what type of equipment is being used, it is necessary that the valve guide bores are clear of carbon or dirt to ensure the proper centering of the pilot in the valve guide. The correct seat angle is 89 degrees and 45 minutes for exhaust, 119 degrees and 45 minutes for intake.

If too much material is removed from the valve seat, the valve install depth may become too excessive. If this is the case, the valve seat must be replaced.

Valves that are pitted, should be replaced to the new part. Valve stems which show excessive wear, or valves that are warped, should be replaced.

Measure

1. Valve margin thickness.
   - Measurement for intake valves: 1.71 mm (0.0673 in.).
   - Measurement for exhaust valves: 1.75 mm (0.0689 in.).
2. Valve face angle.
   - Face angle for the intake valve: 60 degrees.
   - Face angle for the exhaust valve: 45 degrees.



Legend
(1) Valve Margin

Figure 54 — Valve Margin Thickness

VALVE GUIDE REPLACEMENT

Tools Required:
J43272 Valve Guide Remover and Installer

Remove or Disconnect (Figure 55)

1. Place the cylinder head on wooden blocks with combustion chamber facing up.
2. Drive valve guide out with tool J43272.

Clean

- Clean the valve guide bore in the cylinder head.

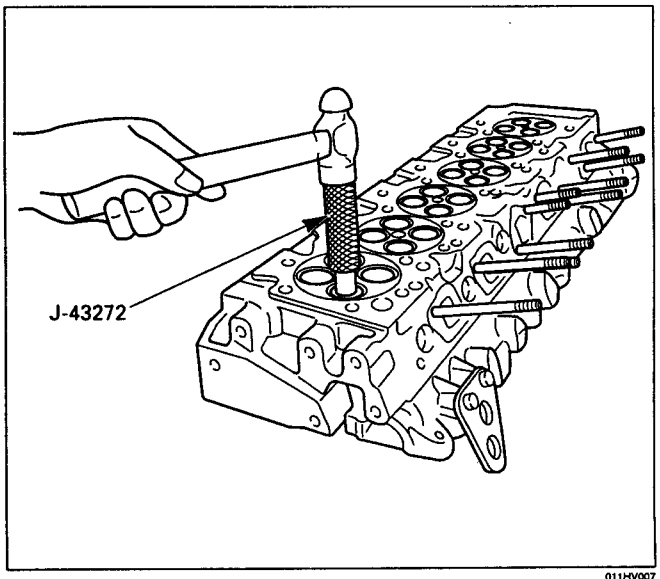


Figure 55 – Removing the Valve Guide

Install or Connect (Figure 56)

1. Install new valve guide with tool J43272, Valve Guide Installer.
   - Measure the distance from the top of the valve guide to the cylinder head surface.
     — 19 mm (0.7480 in.).
   - Tool J43272 is supplied with a installer designed to install the valve guide to the proper depth.

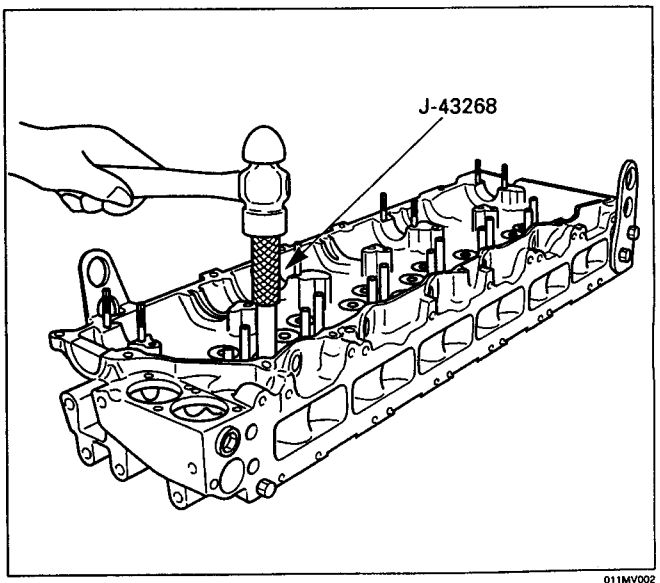


Figure 56 – Installing the Valve Guide

VALVE SEAT REPLACEMENT

Remove or Disconnect (Figure 55)

1. Grind the valve seat (intake and exhaust) until the seat measures (1) 0.5 to 1 mm (0.0196 to 0.04 in.). thick.
2. Remove the valve seat with a pry tool.

Clean

- Thoroughly clean the valve seat counter bore in the cylinder head before installing new seat.

Install or Connect (Figure 49)

1. Press the new valve seat into the cylinder head.
2. Grind valve seat.

Important

- When a new valve seat and new valve are used together, the installed depth should be 0.65 to 1.1 mm (0.0255 to 0.0433 in.). The installed depth should not be any greater than 2.5 mm (0.098 in.). for the intake valve, and 2.8 mm (0.110 in.). for the exhaust valve.

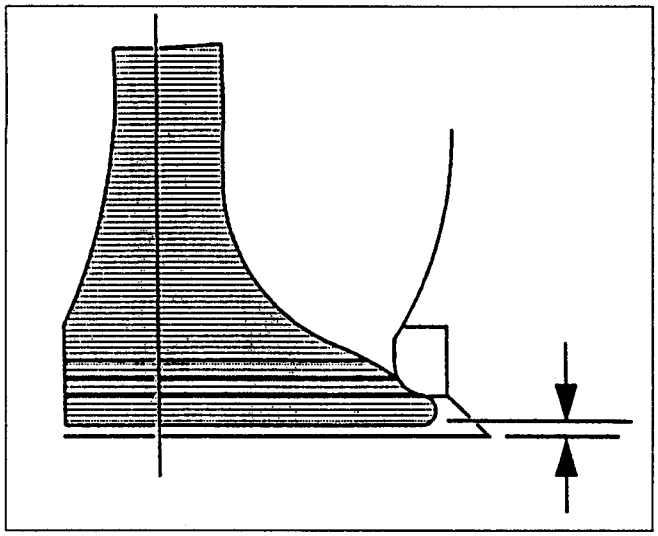


Figure 57 — Valve Installed Depth

VALVE LAPPING

The valves should be lapped just before the final assembly to assure a good valve seal.

1. Apply Prussian blue dye or equivalent to the valve seat.
2. Insert the valve into the proper port.
3. Rotate the valve lightly, then remove.
4. Inspect the valve face.

Measure

- The valve seat width will be indicated by the mark on the valve face.

5. Measure the valve seat width.
   - Intake valve should be: 3.2 mm (0.1260 in.).
   - Exhaust valve should be: 2.8 mm (0.1102 in.).

Important

- Contact area should be centered on the valve face. If not, check the condition of the valve seat and repair as needed.

6. Repeat steps 1 through 5 on the remaining valves.

Clean

- Clean all the Prussian blue dye from the valves and the valve seats.

7. Apply a medium valve lapping compound to the valve.
8. Lap the valve until a light gray ring appears all the way around the valve face.
9. Thoroughly clean all the valve lapping compound from the valve and valve seat.
10. Repeat this procedure on the remaining valve and valve seats.

INSTALLING THE VALVE SEALS

Tools Required:
J43267 Valve Seal Installer

Install or Connect (Figures 58 and 59)

1. Lubricate the valve stem seal with clean engine oil.
2. Install valve stem seal using tool J43267.

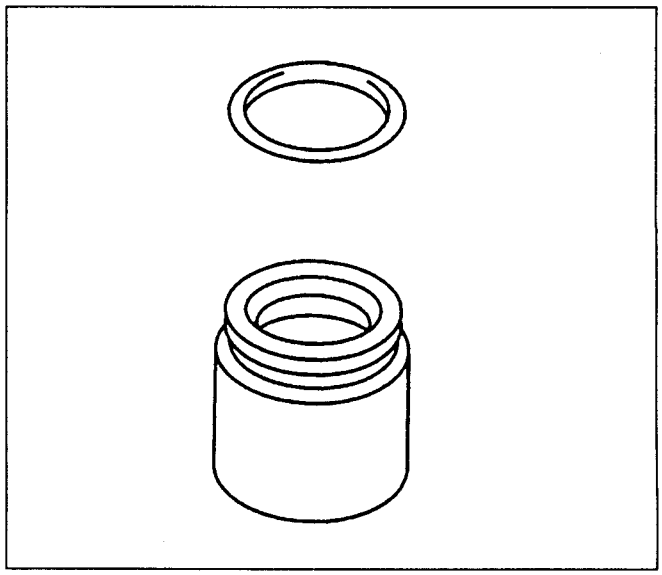


Figure 58 – Valve Seal and Garter Spring

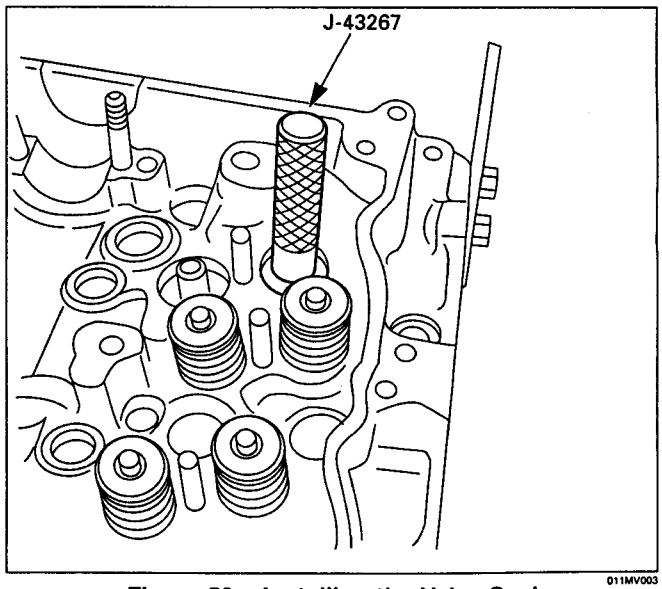


Figure 59 – Installing the Valve Seal

INJECTION NOZZLE SLEEVE REPLACEMENT

Tools Required:
J43265 Remover: Nozzle Sleeve
J43266 Installer: Nozzle Sleeve

Remove or Disconnect (Figure 60)

1. Place the cylinder head on wooden block with combustion chamber facing up.
2. Remove the injection nozzle sleeve with tool J43265.

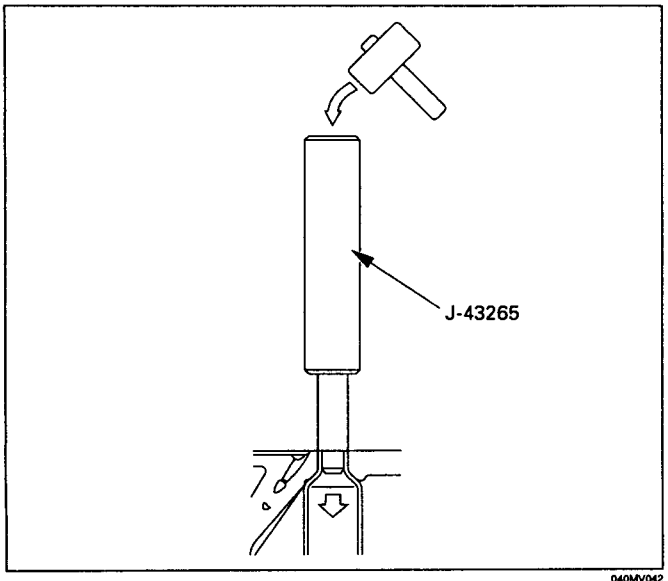


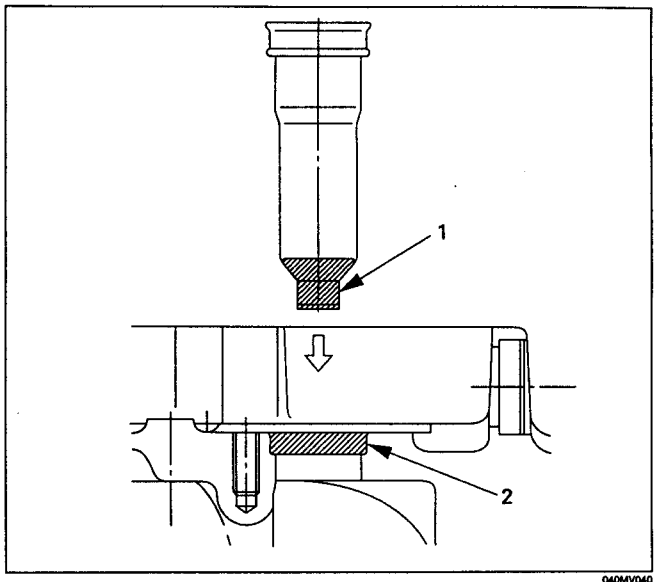
Figure 60 – Nozzle Sleeve Removal

Clean

- Clean the injection nozzle sleeve bore in the cylinder head.

Install or Connect (Figures 61 and 62)

1. Apply sealant to new injection nozzle sleeve (1) and cylinder head nozzle sleeve bore (2) as shown in the illustration.
2. Insert the injection nozzle sleeve to cylinder head.
3. Use injection nozzle clamp bolt to clamp the injection nozzle sleeve with tool J43266.
4. Put ball bearing (Outside diameter 9.525 mm (3.8 in.) into the injection nozzle sleeve and set too J43266.
5. Strike out the ball bearing by tool J43266.



Legend
(1) Sealant on Injection Nozzle Sleeve.
(2) Sealant on Cylinder Head Nozzle Sleeve Bore.

Figure 61 – Apply Sealant to Nozzle Sleeve

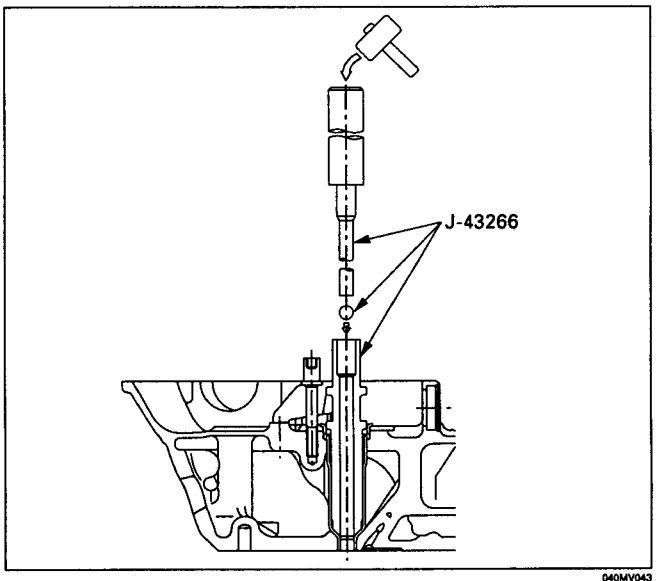


Figure 62 – Nozzle Sleeve Installation

ASSEMBLING THE CYLINDER HEAD

Tools Required:
J8062 Valve Spring Compressor

Install or Connect (Figure 63)

1. Apply clean engine oil to the valve stem.
2. Insert the valve into the proper port.
3. Valve spring seats to the cylinder head.
4. Valve spring with retainer.

Important

- Painted part of the valve springs (close spaced) coils must be toward the cylinder head.

5. Compress the valve springs, using J8062.
6. Apply a small amount of grease on the end of the valve stem.
   - Apply a small amount of grease to the end of the valve stem. This will help retain the valves keys in position while releasing tool J8062.
7. Valve keys to the valve stem.
8. Slowly release valve spring compressing tool J8062.

Important

- Make sure that the valve keys are installed properly before proceeding to the next set of valves.

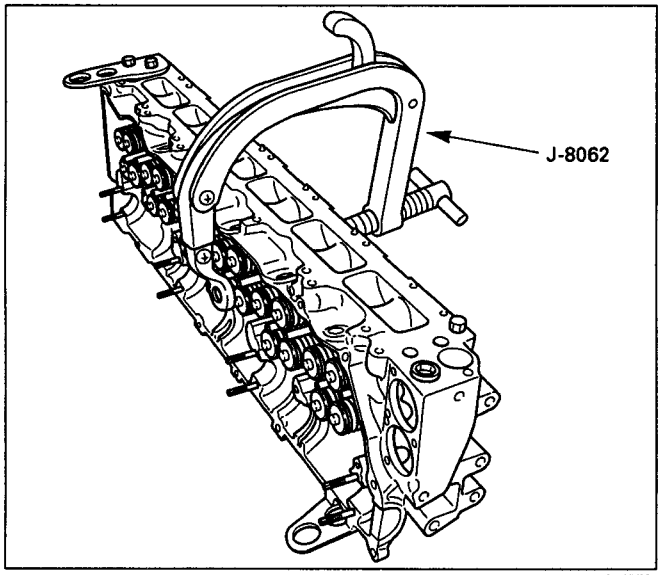


Figure 63 – Compressing the valve spring

ASSEMBLY OF THE ENGINE

OIL JET INSTALLATION

Install or Connect (Figure 64)

1. Bolt and washers to the oil jet.
2. Oil jet to the cylinder block.
3. Tighten the oil jet.

Tighten

- Bolts to 21 N·m (15 lb. ft.).

Important

- Failure to install the oil jets to the cylinder block will cause loss of oil pressure and possible engine damage.

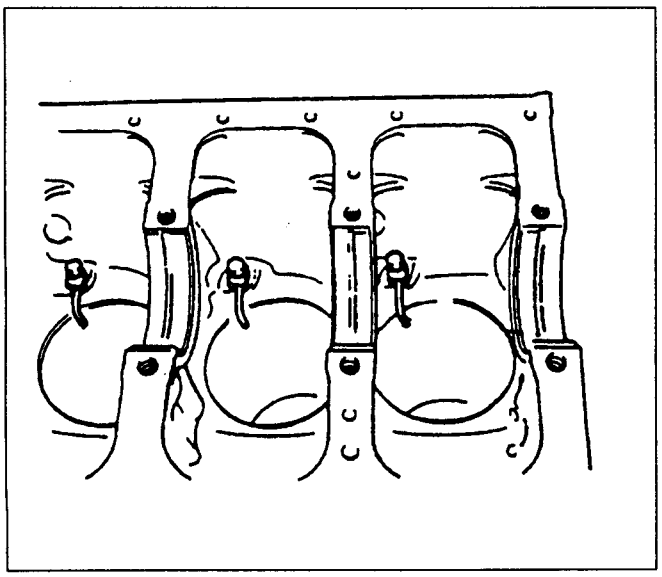


Figure 64 – Installation of the Oil Jets

OIL FILTER INSTALLATION

Install or Connect (Figure 8)

1. Oil filter bracket and gasket to the cylinder block .
2. Bolts to the oil filter bracket.
3. Tighten oil filter bracket bolts.

Tighten

- Bolts to 38 N·m (28 lb. ft.).

4. Install the oil filter.
   - Fill filter with oil before installing it to the bracket.

CRANKSHAFT INSTALLATION

Crankshaft main bearings are of the precision insert type and do not utilize shims for adjustment. If the clearances are found to be excessive, a new bearing, both upper and lower inserts will be required. If the clearances are still excessive with the new crankshaft main bearings, the crankshaft must be replaced. No undersize bearings are available for this engine.

The simplest and most accurate way to measure the crankshaft main bearing clearance is the use of plastic gauge. This wax-like material compresses evenly between the bearing and the crankshaft journal surfaces without damaging them.

Install or Connect (Figures 65 through 68)

1. Upper crankshaft main bearing inserts into the cylinder block.
   - Upper crankshaft main bearing inserts have the oil holes and grooves in them.
   - Make sure that the bearing inserts fit correctly into the cylinder block.
2. Crankshaft into the cylinder block.
3. Upper thrust washer into the cylinder block.
   - Upper thrust washer does not have a locating tab. It must be rolled into the cylinder block.
   - New thrust washers must be used if the crankshaft end play measurement at disassembly was excessive.
4. Lower crankshaft bearing inserts into the lower crankcase housing.
   - Lower crankshaft bearing inserts are plain and have no grooves in them.
   - Make sure that the bearing inserts fit correctly into the cylinder block.

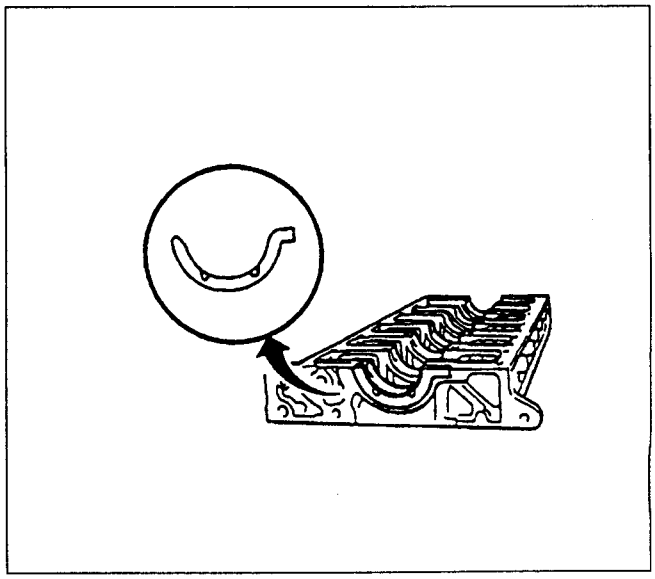


Figure 65 – Lower Thrust Washer Installation

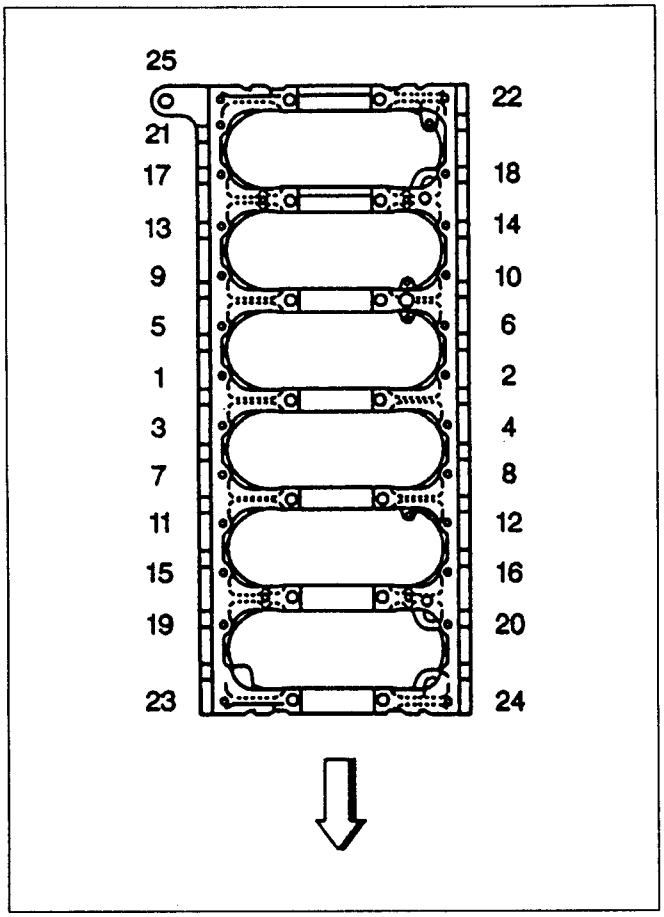


Figure 66 – Cylinder Block to Lower Crankcase Bolt Tightenng Sequence

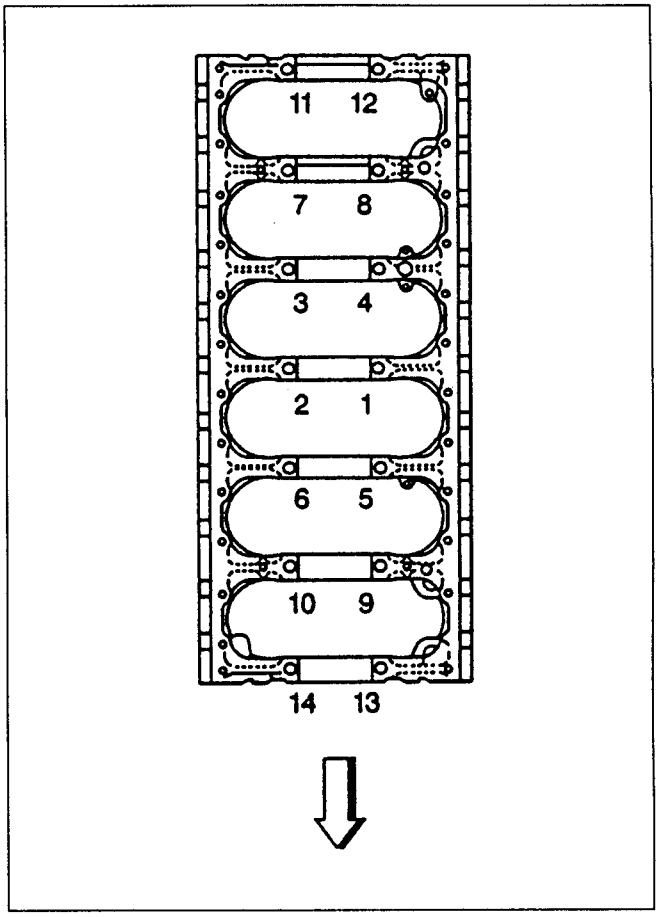


Figure 67 – Lower Crankcase Bolt Tightening Sequence

Install or Connect

1. Apply clean engine oil to the crankshaft main bearing and inserts.
2. Crankshaft into the cylinder block.
3. Apply sealant to sealing surface of lower crankcase.
4. Lower thrust washer half to the lower crankcase housing, with the grooves facing inward.
5. Apply a small amount of molybdenum grease to the bolts. (M14 Bolts only)
6. Bolts to the lower crankcase housing.
7. Tighten the bolts.
   - The head of the bolt will be marked 14.

Tighten

   - Tighten bolts in steps:
     — 98 N·m (73 lb. ft.).
     — 132 N·m (98 lb. ft.).
     — turn an additional 30 to 60 degrees.
8. Bolts (marked M10) to the crankcase.
   - Bolts evenly in sequence to 37 N·m (27 lb. ft.).
9. Rotate the crankshaft.
   - The crankshaft should rotate freely.
   - If the crankshaft does not rotate freely, loosen the lower crankcase housing bolts (marked M10), until the tight crankshaft main bearing is located.

Tighten

- Burrs on the crankshaft bores.
- Foreign matter between the cylinder block and lower crankcase housing.
- Faulty crankshaft main bearing insert.
- Repair as necessary.

Measure (Figure 68)

- Crankshaft for end play.
- Tap the crankshaft on the flywheel end with a brass hammer to force it forward.
- Insert a feeler gauge between the lower thrust washer half and the crankshaft.
- Production end play is 0.15 to 0.33 mm. (0.005 to 0.012 in.). The service limit is 0.4 mm. (0.0157 in.).

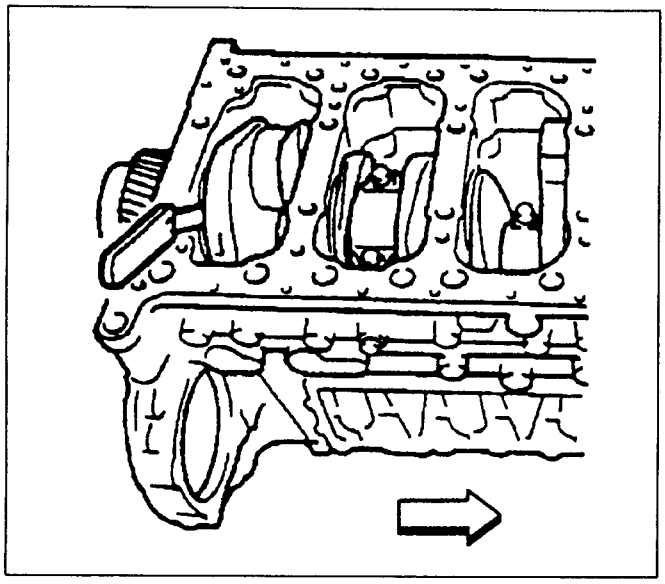


Figure 68 – Measuring Crankshaft End Play

FRONT COVER INSTALLATION

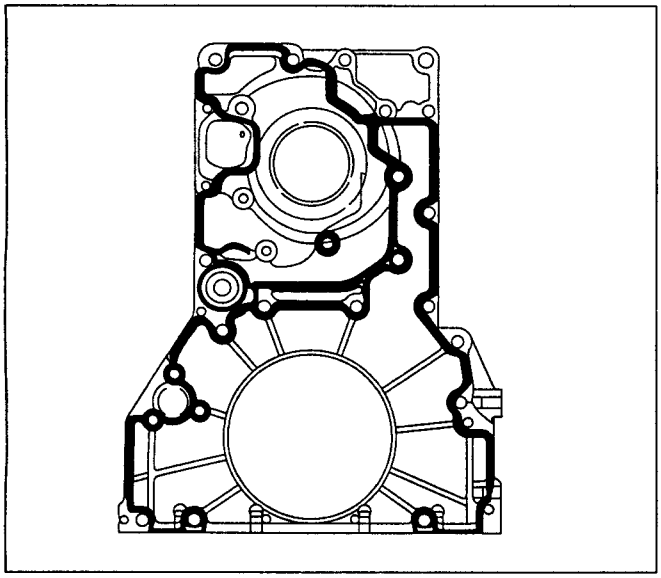
Tools Required:
J39046 Crankshaft Balancer (External) Remover and Installer
J41220 Oil Slinger Remover
J41221 Oil Seal Installer

Install or Connect (Figures 69 through 72)

1. Apply RTV sealant (Three Bond 1207C or equivalent) to the front cover.
2. Front cover to the cylinder block.
3. Bolts to the front cover.
4. Tighten the front cover bolts.

Tighten

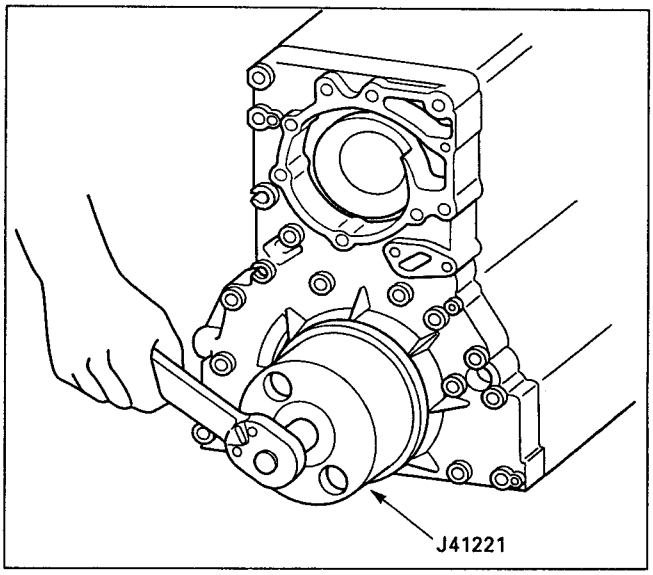
- Bolts to 19 N·m (14 lb. ft.).



020MV002

Figure 69 – Apply the Sealant

5. Oil slinger.
   - Install J41221.
     A. Apply clean engine oil to the oil slinger.
     B. Insert the oil slinger into the adapter.
     C. Install the oil slinger sleeve to the adapter, and tighten the center bolt until the sleeve comes in contact with the adapter and stops.
     D. After pressing in the oil slinger, make sure that the distance between the crankshaft end surface and the oil slinger is 11.5 ± 0.15 mm (0.453 ± 0.006 in.).
        - Check the measurement at several different points.



015MV002

Figure 70 – Install the Oil Slinger and Oil Seal

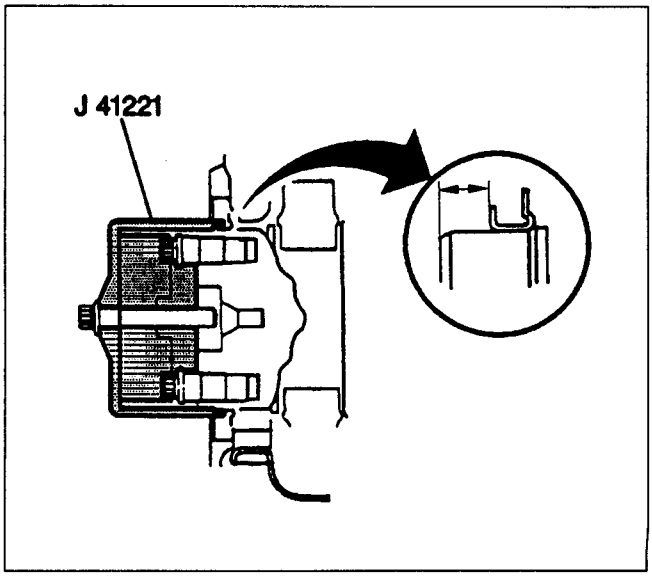


Figure 71 – Checking the Clearance

- Install J41221.
  A. Apply clean engine oil to the oil seal.
  B. Insert the oil seal into the adapter.
  C. *Install the* oil seal to the adapter, and tighten the center bolt until the sleeve comes in contact with the adapter and stops.
  D. After pressing in the oil seal, make sure that the distance between the crankshaft end surface and the oil slinger is 8.5 ± 0.15 mm (0.335 ± 0.006 in.).
     - Check the measurement at several different points.

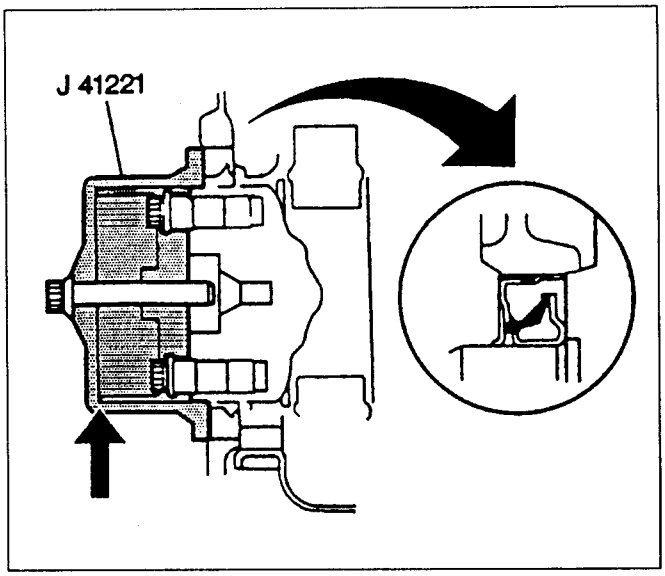


Figure 72 – Checking the Seal Clearance

Inspect

- Crankshaft balancer for excessive wear or damage.
- Crankshaft balancer for silicone leakage. If leakage appears, replace the crankshaft balancer.

6. Crankshaft balancer bolts, washers and the crankshaft balancer.

Tighten

- Bolts and nuts to 48 N·m (35 lb. ft.).

7. Crankshaft balancer to the crankshaft.
8. Crankshaft balancer bolt and washer to the crankshaft.

Tighten

- Crankshaft balancer bolt and washer to 200 N·m (148 lb. ft.).

WATER PUMP INSTALLATION

Install or Connect

1. Water pump and gasket to the cylinder block.
2. Water pump bolts to the cylinder block.
3. Tighten the water pump bolts.

Tighten

- Bolts (M10) to 36 N·m (28 lb. ft.).
- Bolts and nuts (M8) to 19 N·m (14 lb. ft.).

4. Water duct and the O-ring to the cylinder head and the water pump.
   - Apply a small amount of liquid soap on the O-ring for easier installation.
5. Bolts to the water duct.

Tighten

- Water duct bolts to:
  — Bolts marked M8 to 19 N·m (14 lb. ft.).
  — Bolts marked M16 to 103 N·m (76 lb. ft.).

CYLINDER LINER INSTALLATION

Install or Connect

1. Clean cylinder liners and bores with solvent.
2. Blow dry the cylinder liners with compressed air. Wear protective safety glasses and gloves.

Important

- All foreign material must be carefully removed from the cylinder liner and from the cylinder bore, before the cylinder liner installation.

3. Apply clean engine oil to outside cylinder liner.
4. Cylinder liner into the cylinder block.

Important

- The installation of the cylinder liner retaining bolt and washer will prevent the cylinder liners from moving or falling free, if the engine is being moved or rotated on the engine stand.

5. Cylinder liner retaining bolts and washers.
   - Cylinder liner retaining bolt.
     — Size and pitch: M14-2 mm.
     — Length: 30 mm (1.181 in.).
   - Cylinder liner retainer washer.
     — Thickness: 3 to 5 mm (0.118 to 0.197 in.).
     — Outside diameter: 40 mm (1.575 in.).

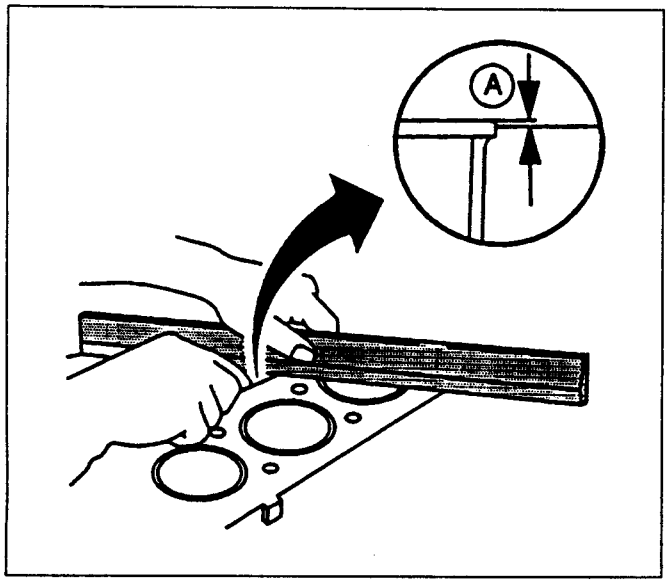
Important

- Remove the cylinder liner retaining bolt and washer when installing the piston assembly. Reinstall the retaining bolt and the washer, after the piston assembly has been installed.
- Leave the retaining bolt and the washer in place and do not remove until the installation of the cylinder head assembly.

6. Measure the amount of the cylinder liner projection (A).

Measure

- Use a straight edge and feeler gauge, as shown in (Figure 73). If properly installed, the cylinder liner should project 0.06 to 0.1 mm (0.0024 to 0.0039 in.). above the gasket mating surface of the cylinder head.
- The difference in the cylinder liner projection height between any two adjacent cylinders, must not exceed 0.03 mm (0.0012 in.).



Legend
(A) Measured Projection
Figure 73 — Measuring the Cylinder Liner Projection

7. Recheck the piston to cylinder liner clearance.

PISTON AND CONNECTING ROD INSTALLATION

Tools Required:
J8037 Piston Ring Compressor

Install or Connect (Figures 74 through 77)

1. Piston to the connecting rod.
   - Position the piston assembly, so the mark on the crown of the piston and the mark on connecting rod are facing opposite.
2. Separate the connecting rod and the connecting rod bearing cap.
3. Piston rings to the piston assembly.
   - Install the piston rings with marks facing up .

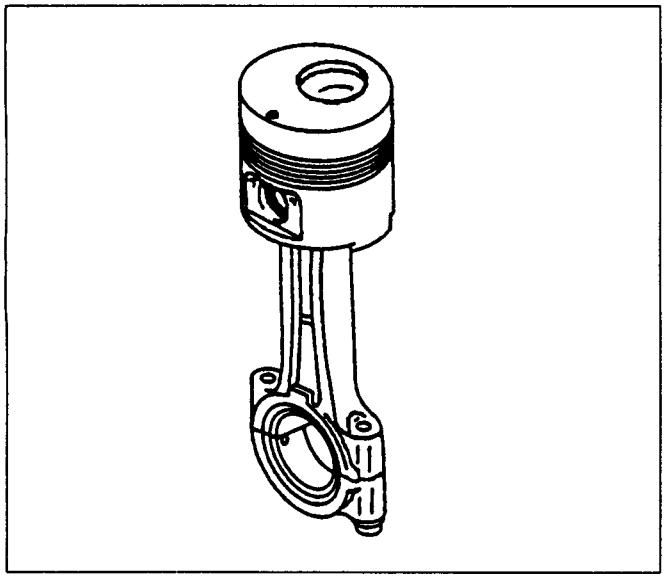


Figure 74 – Piston and Connecting Rod Alignment

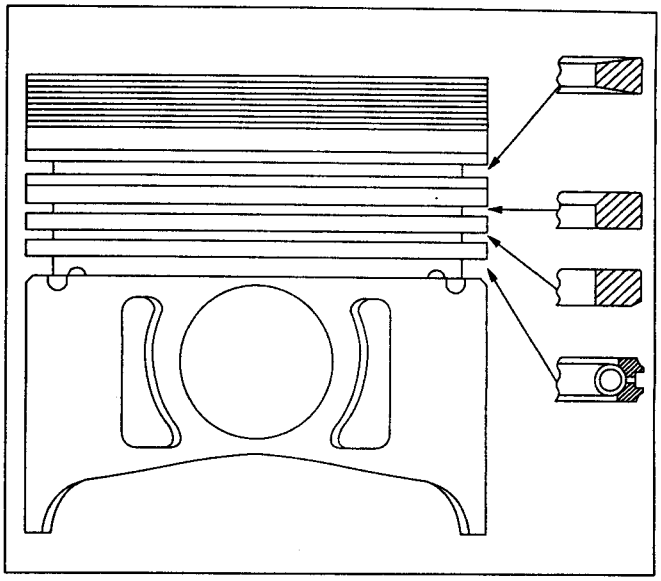


Figure 75 – Piston Ring Installation

   - Stagger the piston rings, so the piston ring gaps are 45 degrees apart.
4. Rotate the crankshaft so that the connecting rod journal being worked on is at the bottom of the compression stroke.
5. Apply clean engine oil to the piston assembly.
6. Install tool J8037 piston ring compressor to the piston assembly

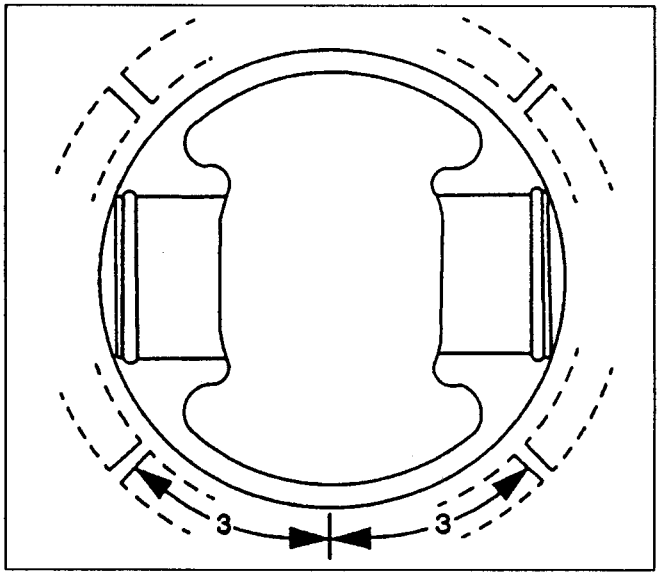


Figure 76 – Piston Ring Gap

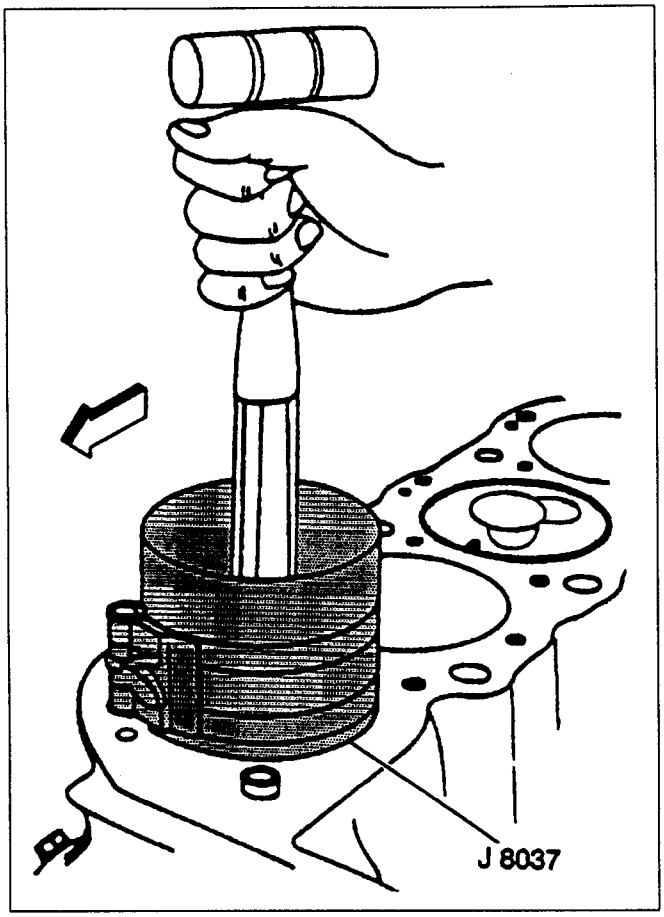


Figure 77 – Installing the Piston and Connecting Rod

7. With a hammer handle, use light blows to tap the piston down into its bore.
   - Hold the ring compressor against the cylinder block until all the piston rings have entered the cylinder bore.
   - From underneath the cylinder block, guide the connecting rod so that it does not come in contact with the connecting rod journal, and damage it.
8. Install the connecting rod bearing insert into the connecting rod and the connecting rod bearing cap.
9. Connecting rod cap to the connecting rod.
10. Bolts to the connecting rod.
11. Tighten the bolts.

Tighten

- Apply a small amount of molybdenum grease to connecting rod bolt.
- Tighten in three steps.
  - — First Step: 39 N·m (29 lb. ft.).
  - — Second Step: Turn both bolts 60 degrees.
  - — Third Step: Then turn both bolts an additional 30 degrees.

12. Rotate the engine.
    - A slight, but even effort will be needed to rotate the engine.
    - If the effort to rotate the engine is uneven or extremely hard, slightly loosen the connecting rod bolts one at a time and rotate the engine to locate the cause and repair as needed.

OIL PUMP INSTALLATION

Tools Required:
J41220 Oil Slinger Remover
J41221 Oil Seal installer

Install or Connect (Figures 78 through 85)

1. Idler gear shaft to the cylinder block.
2. Apply clean engine oil to the bushing inside the cylinder block.
3. Apply RTV sealant (Three Bond 1141E or equivalent) to the edge of the oil pump.

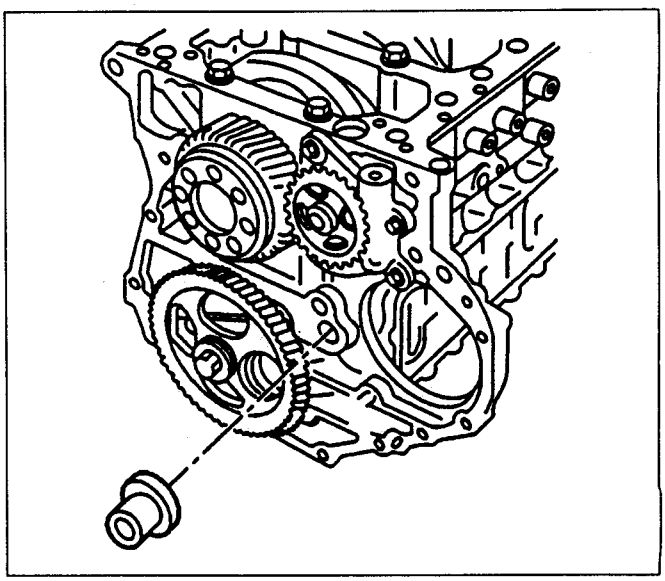


Figure 78 – Idler Gear Shaft

Important

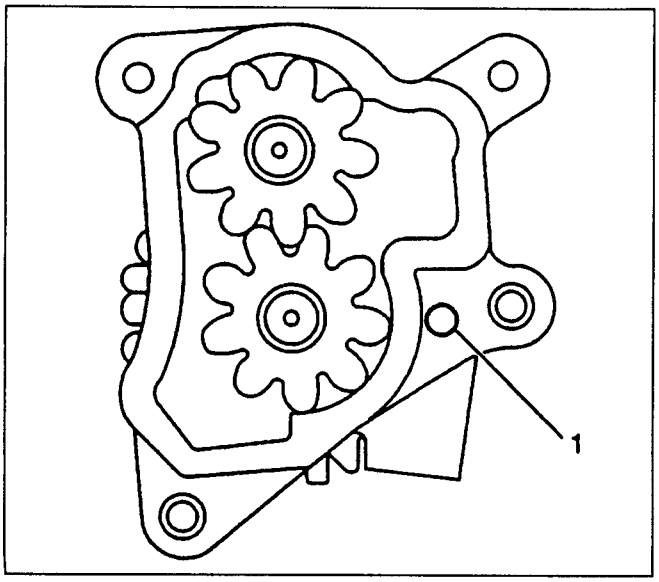
- Do not apply sealant over hole (1), refer to. This will restrict the flow of oil into the cylinder block.

4. Oil pump to the cylinder block.
5. Bolts to the oil pump.
6. Tighten the oil pump bolts.

Tighten

- Bolts to 24 N·m (17 lb. ft.).

7. Idler gear to the idler gear shaft.



Legend
(1) Oil Hole

Figure 79 — Applying Sealant to the Oil Pump

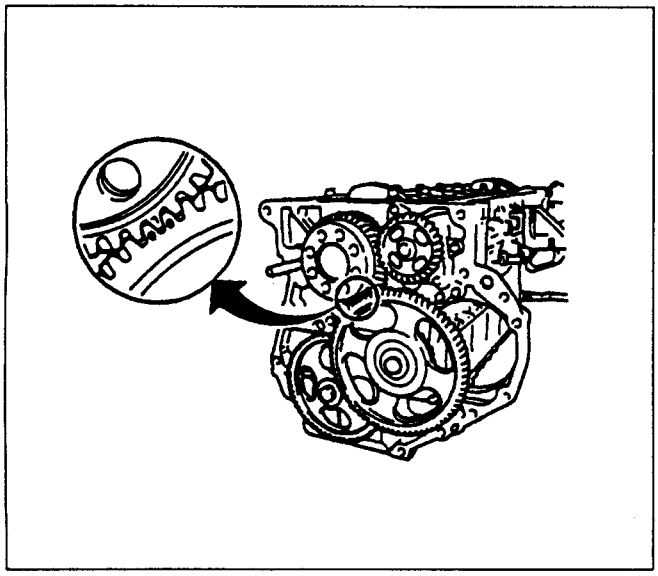


Figure 80 – Aligning the Timing Marks

8. Rotate crankshaft so that number 1 piston is on top dead center.
9. Align the crankshaft gear mark L and the idler gear (A) mark 0.
10. Tighten the idler gear (A) bolt.
    - Idler gear shaft oil port must be facing the cylinder block.

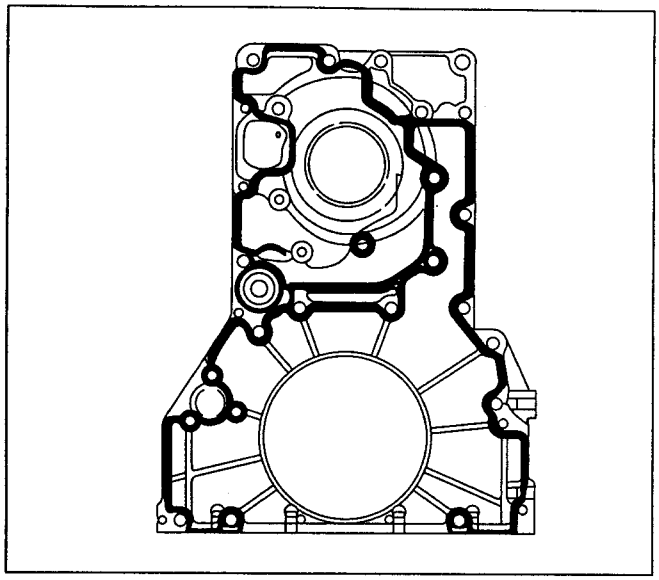


Figure 81 – Applying Sealant to the Flywheel Housing

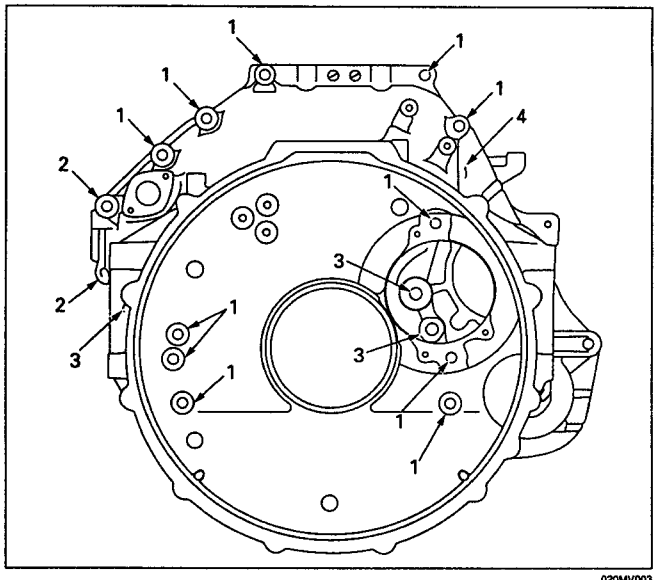


Figure 82 – Flywheel Housing Bolt Tightening Sequence

Tighten

- Apply molybdenum grease to bolts
- Tighten in two steps
  - — First stage 29 N·m (21 lb. ft.)
  - — Second stage 75 degrees

11. Apply RTV sealant (Three Bond 1141E or equivalent) to the flywheel housing fitting surfaces.
12. Flywheel housing to the cylinder block.
13. Bolts to the cylinder block.
14. Tighten the bolts.

Tighten

- Bolt marked 1, to 92 N·m (71 lb. ft.).
- Bolt marked 2, to 73 N·m (54 lb. ft.).
- Bolt marked 3, to 118 N·m (87 lb. ft.).
- Bolt marked 4, to 86 N·m (64 lb. ft.).

15. Oil slinger to crankshaft.
    A. Apply clean engine oil to the oil slinger.
    B. Insert the oil slinger into the adapter.
    C. Install the oil slinger sleeve to the adapter.
16. After pressing in the oil slinger, make sure that the distance between the crankshaft end surface and the oil slinger is (1) 10.5 ± 0.15 mm (0.413 ± 0.006 in.).
    A. Check the measurement at several different points.

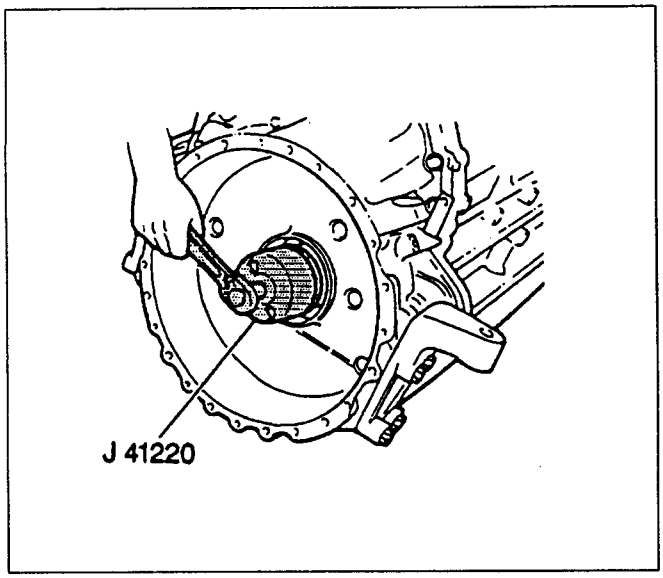
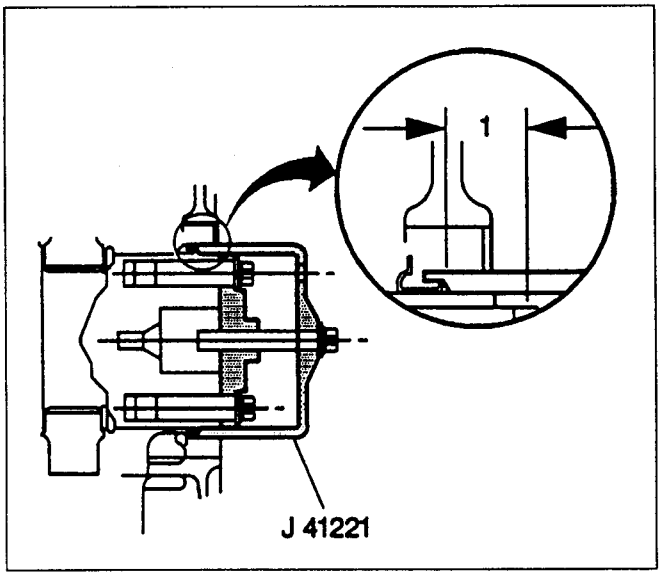


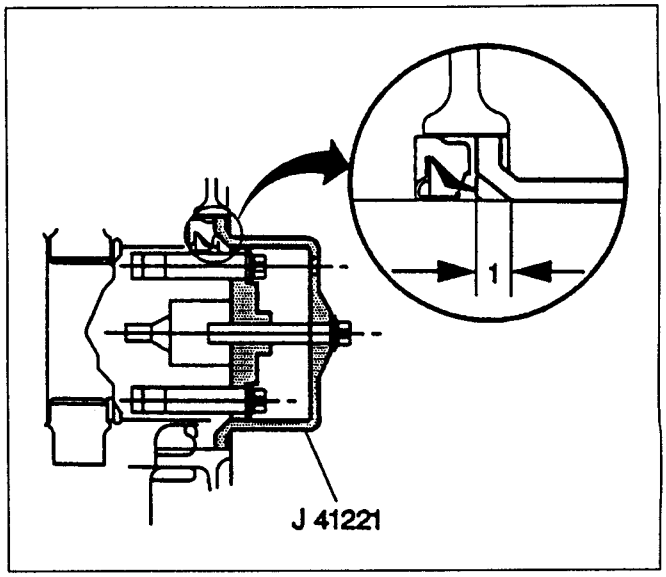
Figure 83 – Oil Slinger to the Crankshaft



Legend
(1) Measurement of the Oil Slinger

Figure 84 — Oil Slinger Installation

17. Crankshaft rear seal.
    • Install J41221.
    A. Apply clean engine oil to the oil seal.
    B. Insert the oil seal adapter.
    C. Install the oil seal to the adapter, and tighten the center bolt until the sleeve comes in contact with the adapter and stops.
    D. After pressing in the oil seal, make sure that the distance between the crankshaft end surface and the oil slinger is (1) 7.5 ± 0.15 mm (0.295 ± 0.006 in.).
    • Check the measurement at several different points.



Legend
(1) Measure Depth

Figure 85 — Oil Seal Installation

18. Flywheel to the crankshaft. Refer to SECTION 7A6.
19. Oil pump pick up tube and O-ring.
20. Bolts to the oil pump pick up tube.
21. Bolts.

Tighten

- Bolt marked M8, to 24 N·m (17 lb.ft.).
- Bolt marked M10, to 48 N·m (35 lb. ft.).

OIL PAN INSTALLATION

1. Refer to SECTION 6A6, for the installation of the oil pan.

CYLINDER HEAD INSTALLATION

Install or Connect (Figure 86 through 89)

1. Remove the cylinder liner retaining bolts and washers.
2. Apply RTV sealant (Three Bond 1207C or equivalent) to the rear corners of the cylinder block.
3. Install the cylinder head gasket with part number facing up.
4. Cylinder head bolts to the cylinder head.

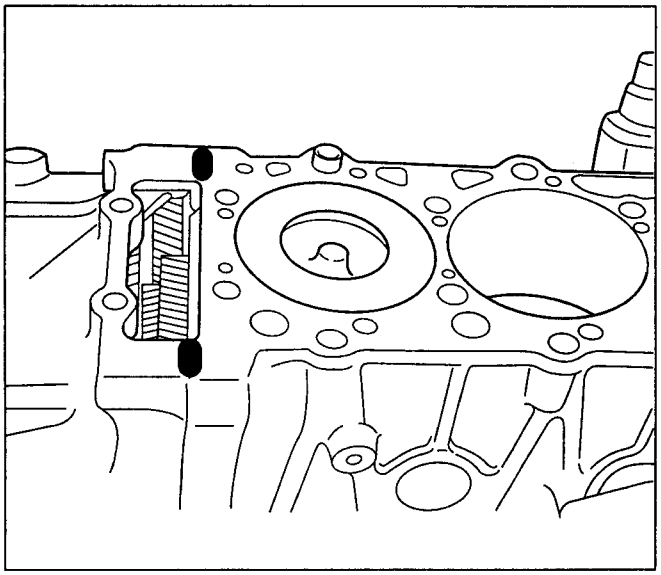


Figure 86 – Applying the Sealant

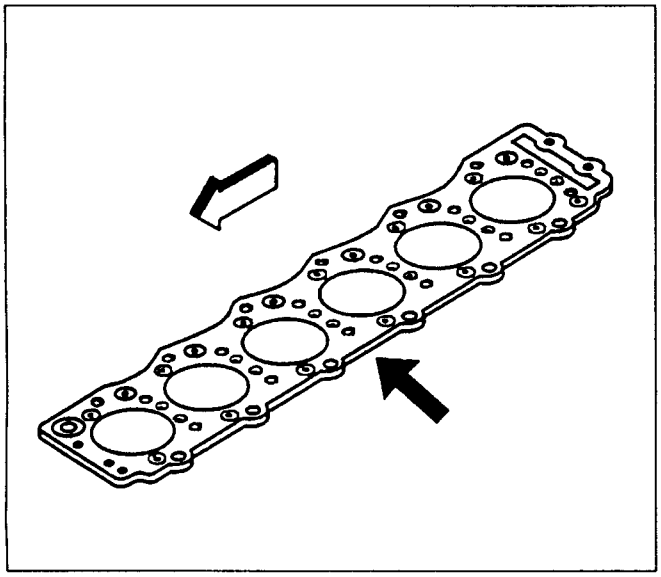


Figure 87 – Installation of the Cylinder Head Gasket

Tighten

- Apply a small amount of molybdenum grease to the M14 bolts.
- Cylinder head bolts in the following steps .
  - — 98 N·m (72 lb. ft.).
  - — 147 N·m (108 lb. ft.).
  - — Turn all the cylinder head bolts an additional 45 degrees.
- Apply clean engine oil to M10 bolts
  Tighten them to order number 27 to 28.
  - — 38 N·m (28 lb. ft.)

5. Install both of the thermostats.
6. Thermostat housing with gasket.
7. Thermostat housing bolts to the cylinder block.
8. Tighten thermostat housing bolts.

Tighten

- Bolts to 19 N·m (14 lb. ft.).

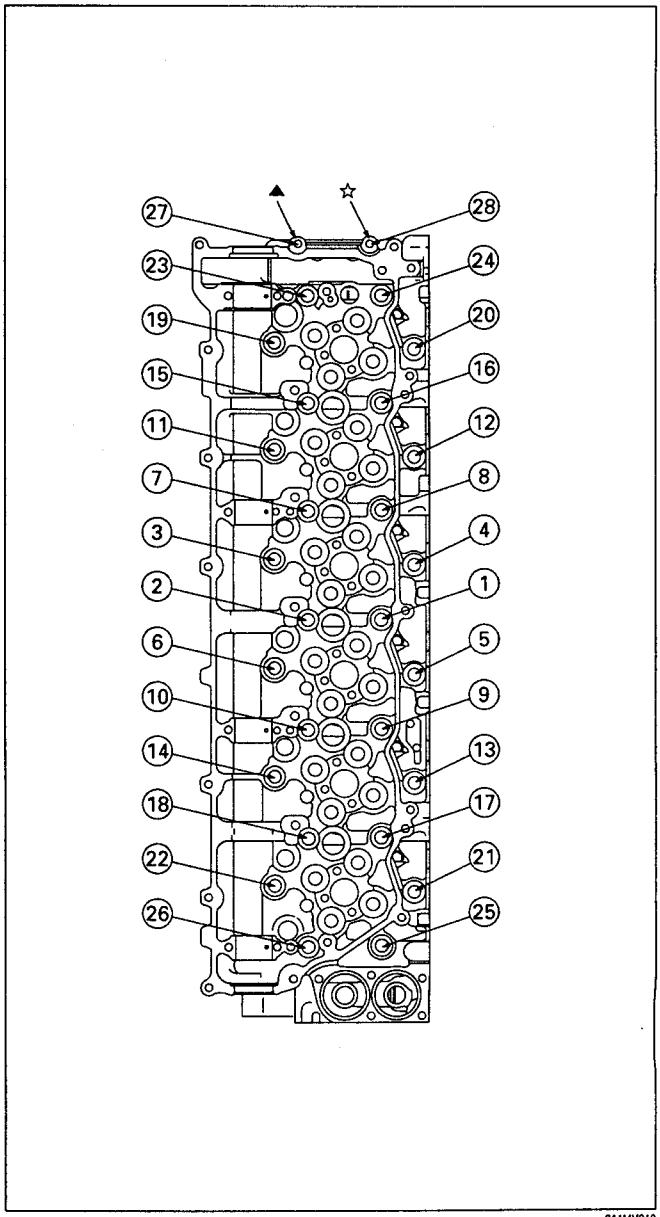


Figure 88 – Cylinder Head Torque Sequence

CAMSHAFT INSTALLATION

Install or Connect (Figures 90 and 91)

1. Apply clean engine oil to the camshaft bearing surfaces.
2. Camshaft and the drive gear to the cylinder head.

Important

- When installing the camshaft, make sure that the timing marks are in the proper alignment.

3. Bearing caps to the cylinder head.
   - When installing camshaft bearing caps, make sure that the bearing caps are in numerical sequence.
4. Camshaft bearing cap bolts to the cylinder head.
5. Camshaft bearing cap bolts.

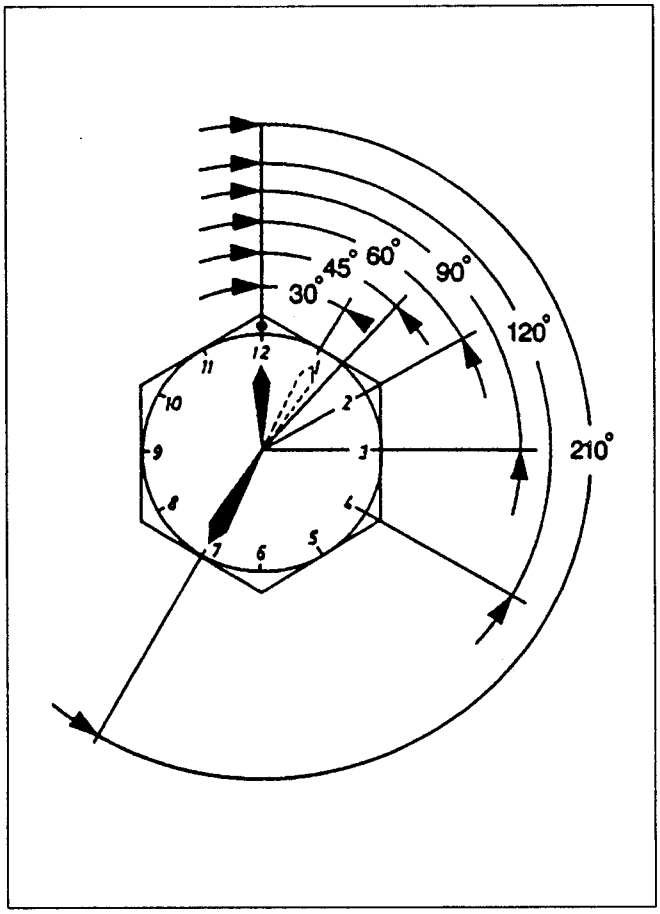


Figure 89 – Final Torque Step

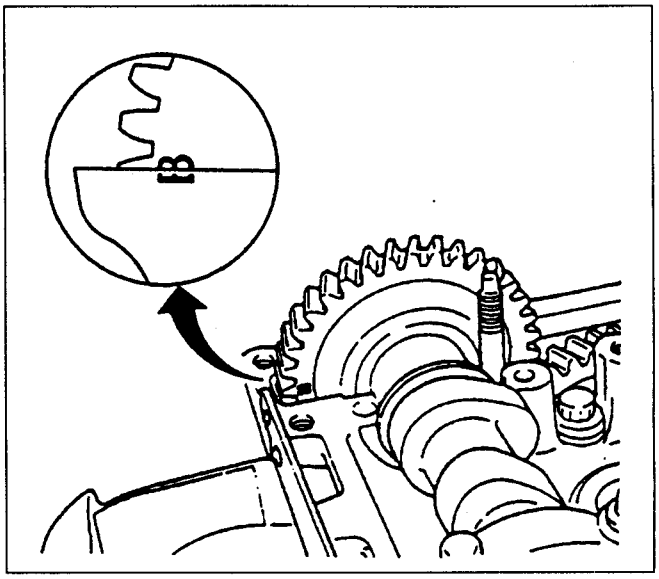


Figure 90 – Camshaft Timing Marks

Tighten

- Bolts to 27 N·m (20 lb. ft.).

VALVE TRAIN INSTALLATION

Install or Connect

1. Valve rocker arm shaft to the cylinder head.
2. Valve rocker arm bolts to the cylinder head.

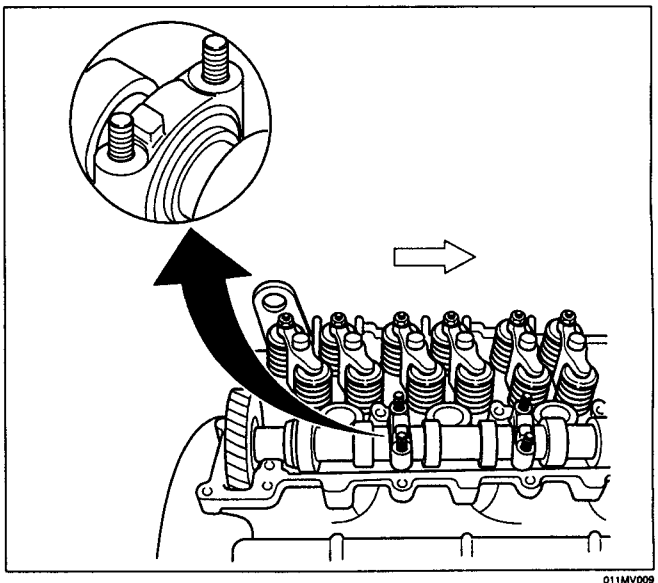


Figure 91 – Camshaft Bearing Caps

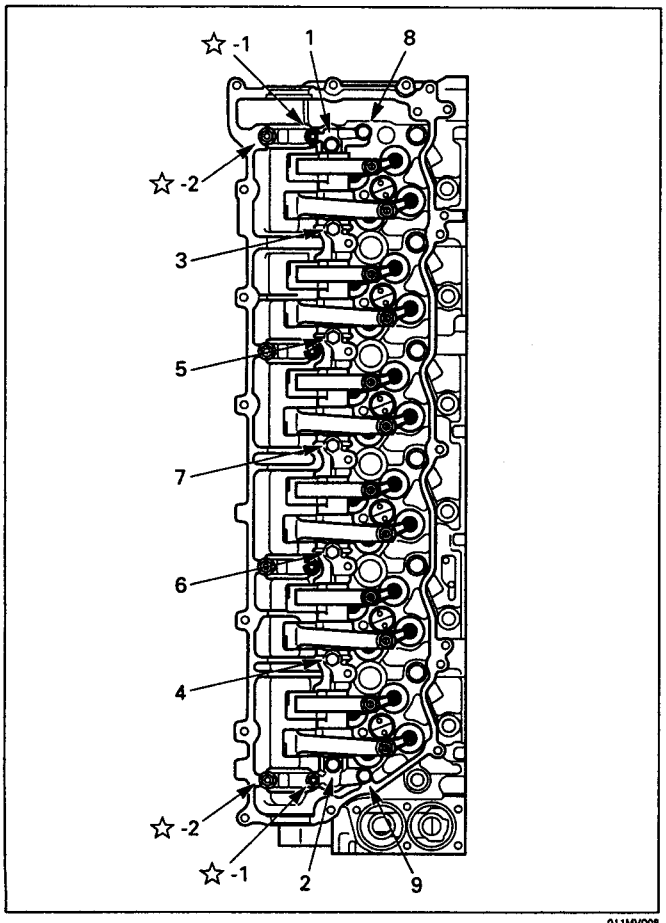


Figure 92 – Valve Rocker Arm Shaft Tightening Sequence

3. Tighten the valve rocker arm bolts.

Tighten

- First of all tighten star mark 1 nut then tighten star mark 2 nut.
- After tighten star mark 1 and 2, tighten rocker arm shaft braket bolts in sequence.
  - — Star mark nut 1 and 2 to 27 N·m (20 lb.ft.)
  - — Bolts 1 through 7 to 56 N·m (41 lb. ft.)
  - — Bolts 8 and 9 to 27 N·m (20 lb. ft.)

VALVE ADJUSTMENT

Adjust (Figures 93 through 96)

1. Rotate the engine so that the timing marks on the front cover and the crankshaft balancer are aligned. Number 1 cylinder should be at TDC.
2. Before adjust the valve clearance, loose adjustment screw both on the rocker arm and the valve bridge.
3. Adjust all the valves clearances to 0.4 mm (0.016 in.).
   - Insert a feeler gauge between the rocker arm and the cap of valve bridge and adjust by turning the adjusitng screw on the rocker arm until there is a slight drag on the feeler gauge. Tighten the lock nut securely.
   - With a feeler gauge inserted, screw in the adjusting screw on the bridge gradually until it touches to the end of the valve stem, and make sure that the movement of the feeler gauge becomes hard.

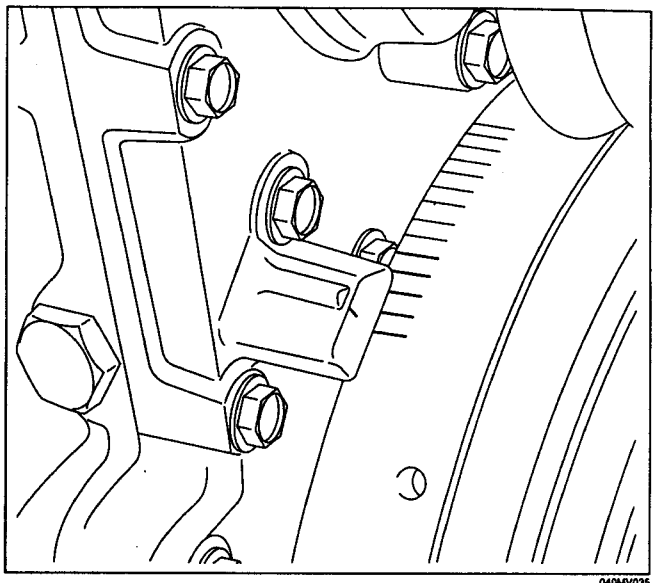


Figure 93 – Timing Marks

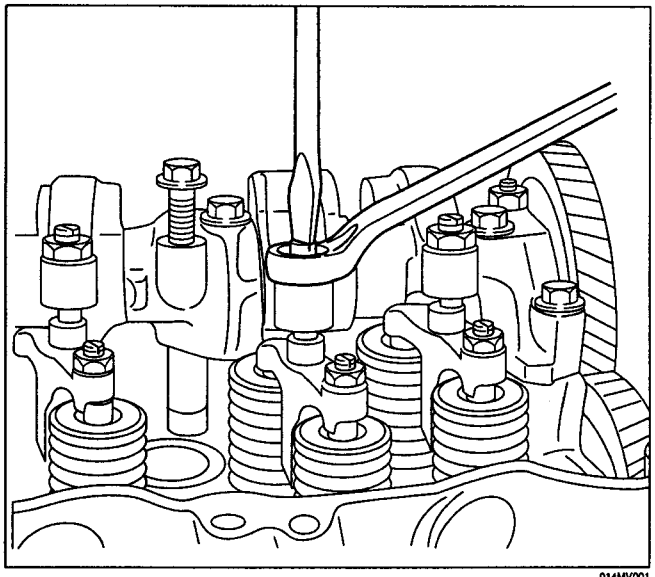


Figure 94 – Valve Adjustment

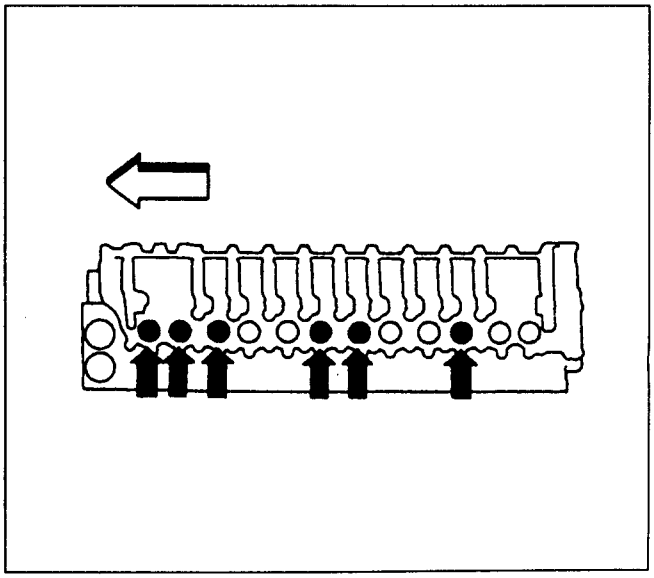


Figure 95 – Valve Adjustment Sequence One

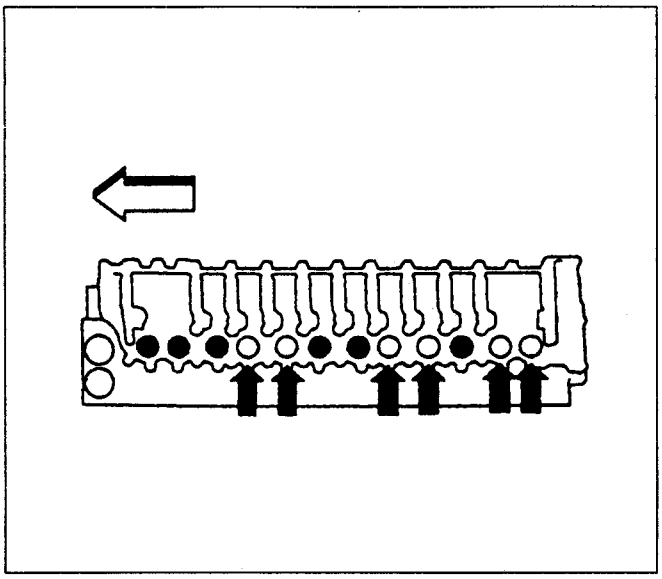


Figure 96 – Valve Adjustment Sequence Two

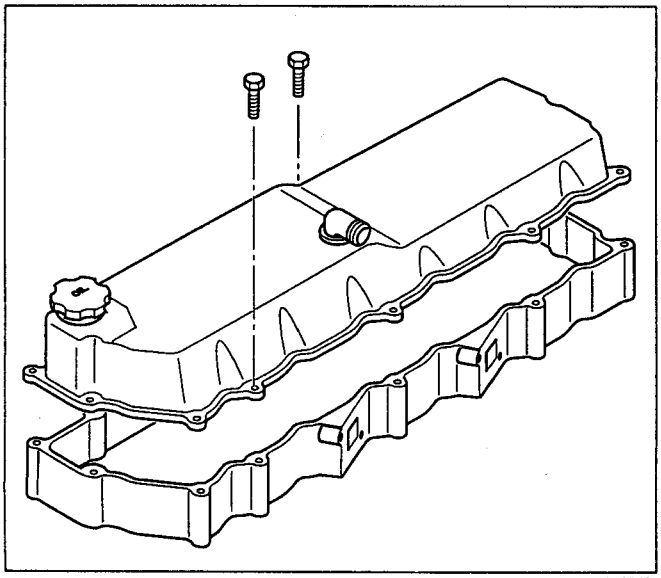
- In this condition, the opposite end of the bridge is raised. Readjust by loosening the adjusting screw on the bridge until there is a slight drag on the feeler gauge and tighten the lock nut securely.
- Adjust the intake valves on cylinders 1, 2, 4.
- Adjust the exhaust valves on cylinders 1, 3, 5.

3. Tighten adjusting lock nut.

Tighten

- Adjusting lock nut to 22 N·m (16 lb. ft.).

4. Rotate the engine one full turn so that the timing marks on the crankshaft balancer and the front cover are in alignment again.
5. Adjust all the valve clearances to 0.4 mm (0.016 in.).



010MV001

Figure 97 – Valve Rocker Arm Cover

- Insert a feeler gauge between the rocker arm and the cap of valve bridge and adjust by turning the adjusitng screw on the rocker arm until there is a slight drag on the feeler gauge. Tighten the lock nut securely.
- With a feeler gauge inserted, screw in the adjusting screw on the bridge gradually until it touches to the end of the valve stem, and make sure that the movement of the feeler gauge becomes hard.
- In this condition, the opposite end of the bridge is raised. Readjust by loosening the adjusting screw on the bridge until there is a slight drag on the feeler gauge and tighten the lock nut securely.
- Adjust the intake valves on cylinders 3, 5, 6 .
- Adjust the exhaust valves on cylinders 2, 4, 6.

6. Tighten adjusting lock nut.

Tighten

- Adjusting lock nut to 22 N·m (16 lb. ft.).

7. Recheck all the valve clearances and readjust if necessary.
8. Valve rocker arm cover and gasket to the cylinder head.
9. Valve rocker cover bolts to the cylinder head.
10. Tighten valve rocker arm cover bolts.

Tighten

- Valve rocker arm cover bolts to 13 N·m (113 lb. in.).
- Tighten center bolts first, then the outer bolts.

INTAKE MANIFOLD INSTALLATION

Install or Connect (Figures 98 and 99)

1. Intake manifold and gasket to the cylinder head.
2. Nuts and bolts to the intake manifold.
3. Tighten the nuts and bolts in sequence.

Tighten

- Nuts and bolts to 13 N·m (113 lb. in.).

EXHAUST MANIFOLD INSTALLATION

Install or Connect (Figure 100)

1. Exhaust manifold and gasket to the cylinder head.
2. Exhaust manifold nuts, bolts, washers and the spacers (Figure 100).

Tighten

- Nuts and bolts to 34 N·m (25 lb. ft.).

3. Turbocharger to the exhaust manifold. Refer to SECTION 6J.

GLOW PLUG INSTALLATION

For service of the glow plugs, refer to SECTION 6D6.

FUEL INJECTORS AND FUEL INJECTION PUMP INSTALLATION

For service of the fuel injectors and the fuel injection pump, refer to SECTION 6C2.

FLYWHEEL INSTALLATION

For service of the flywheel, refer to SECTION 7A6.

ENGINE ACCESSORY INSTALLATION

- Refer to the proper SECTION, for the following accessories:
  - Power Steering Pump.
  - Air Conditioning Compressor.
  - Generator.
  - Air compressor (for air brakes).
  - Starter Motor.
  - Hydraulic Pump (for normal brakes).
  - Drive Belts
  - Engine Cooling Fans and Clutch.

INSTALL THE ENGINE

For service of the engine, refer to SECTION 6A6.

THREAD REPAIR

General purpose thread repair kits are available commercially. Damaged threads may be reconditioned by drilling out, rethreading, and installing a suitable thread insert.

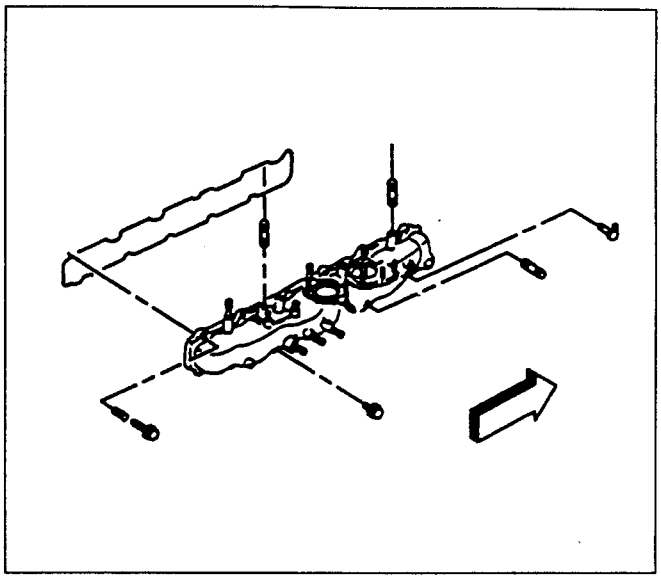


Figure 98 – Intake mamifold and Gasket

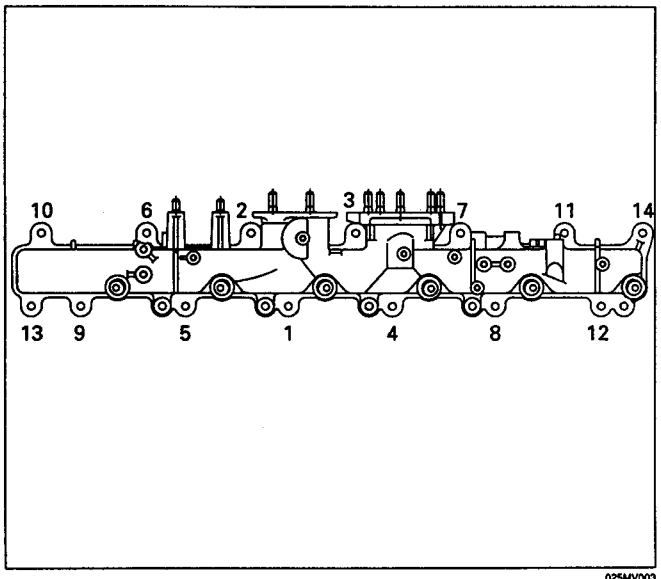


Figure 99 – Intake Manifold Tightening Sequence

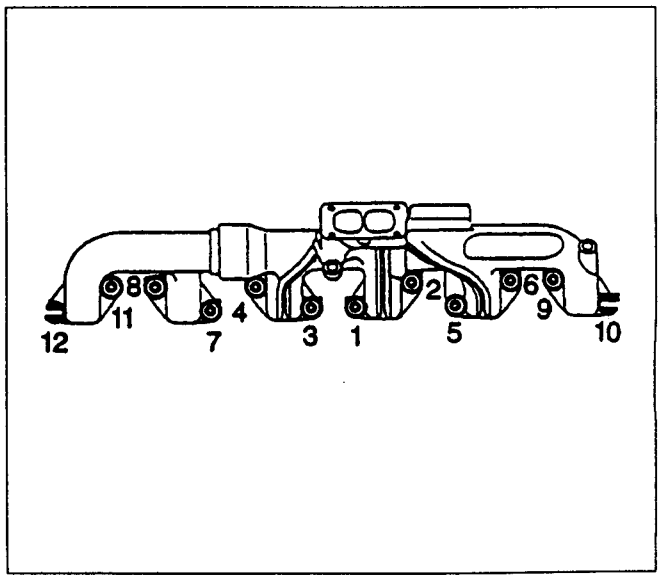


Figure 100 – Exhaust Manifold Nut Tightening Sequence

SPECIFICATIONS

GENERAL ENGINE SPECIFICATIONS

MODEL	6HK1-TC
Type	Inline 6, 4 stroke
Induction	Turbocharged
Combustion Chamber Type	Direct Injection
Bore	115 mm (4.5276")
Stroke	125 mm (4.9213")
Displacement	7.786 L (475 Cu.")
Compression Ratio	16.8:1
Firing Order	1-5-3-6-2-4
Valve Clearance, Cold	0.4 mm (0.16")
Full Flow Oil Filter	Cartridge Type
Oil Capacity	14.0L (14.79 Qts) *
Oil Pressure (Minimum at Idle)	Approximately 100 kPa (14 psi).
Compression Pressure at 200 RPM	
Production	3240 kPa (469 psi)
Service Limit	2157 kPa (313 psi)
Difference between each cylinder	Less than 196 kPa (28 psi)
* Includes full flow filter, which should be changed at each oil change.	

ENGINE SPECIFICATIONS

Item		Production	Service Limit
CAMSHAFT			
Camshaft Bearing Inside Diameter		40.0 to 40.04 mm (1.5748 to 1.5764")	40.19 mm (1.58228")
Camshaft Lobe Height	IN	52.851 mm (2.0807")	52.071 mm (2.0500")
	EXH	54.541 mm (2.1473")	53.761 mm (2.1166")
Camshaft Run-Out		–	0.05 mm (0.0020")
Journal Diameter		39.950 to 39.975 mm (1.57283 to 1.57382")	39.85 mm (1.5689")
Journal to Bearing Clearance		0.025 to 0.09 mm (0.0010 to 0.0035")	0.15 to (0.00590")
CONNECTING ROD.*			
Distortion (per 100 mm).		0.05 mm (0.0020") or less	0.2 mm (0.0079")
Piston Pin Bushing Inside Diameter		40.012 to 40 022 mm (1.5753 to 1.5757")	—
Piston Pin to Connecting Rod Bushing Clearance		0.012 to 0.027 mm (0.0005 to 0.0011")	0.05 mm (0.0020")
CRANKSHAFT AND CONNECTING ROD BEARINGS			
Available Undersize Connecting Rod Bearings		none	none
Connecting Rod Bearing Clearance		0.037 to 0.076 mm (0.00146 to 0.00299")	0.100 mm (0.00394")
Connecting Rod Journal Diameter		72.902 to 72.922 mm (2.8702 to 2.8709")	—
Available Crankshaft Undersize Main Bearings		none	none
CRANKSHAFT			
Crankshaft Main Bearing No. 4 (center) Crearance		0.093 to 0.124 mm (0.0037 to 0.0049")	0.14 mm (0.0055")

Item	Production	Service Limit
Crankshaft Main Bearings (except No. 4) Crearance	0.063 to 0.094 mm (0.0025 to 0.0037")	0.14 mm (0.0055")
Crankshaft End Play	0.15 to 0.33 mm (0.0059 to 0.0130")	0.4 mm (0.0157")
Crankshaft Run-out	0.06 mm (0.0024") or less	0.4 mm (0.0157")
CYLINDER HEAD		
Head Gasket Surface Distortion	0.05 mm (0.002") or less	0.2 mm (0.0079")
CYLINDER LINER		
Cylinder Liner Grade 1X for Service Part (Outside Diameter)	117.990 to 118.000 mm (4.6453 to 4.6457")	—
Cylinder Liner Grade 3X for Service Part (Outside Diameter)	118.001 to 118.010 mm (4.6457 to 4.6461")	—
Cylinder Liner Service Part Inside Diameter (Grade not available)	115.031 to 115.050 mm (4.5288 to 4.5295")	—
Cylinder Block Bore and Cylinder Liner Outside Diameter Clearance	0.011 to 0.029 mm (0.0004 to 0.0011")	—
Projection Above Cylinder Block Gasket Surface	0.06 to 0.1 mm (0.0236 to 0.0039")	—
OIL PUMP		
Drive Gear and Drive Gear Shaft Interference	0.015 to 0.044 mm (0.0006 to 0.0017")	—
Gear and Body Clearance	0.064 to 0.109 mm (0.0025 to 0.0043")	0.2 mm (0.0079")
Gear Shaft and Pump Body or Bushing Clearance	0.04 to 0.07 mm (0.0016 to 0.0028")	0.2 mm (0.0079")
Gear Shaft Outside Diameter	15.989 to 16.0 mm (0.6249 to 0.6299")	15.9 mm (0.6260")
Gear Tooth and Cover Inner Wall Clearance	0.125 to 0.221 mm (0.0049 to 0.0087")	0.3 mm (0.0118")
PISTON DIAMETER		
Service Part Size Grade is not available	114.970 to 115.000 mm (4.5264 to 4.5276")	—
Clearance between Piston and Liner	0.031 to 0.061 mm (0.0012 to 0.0024")	—
PISTON RING END GAP		
First Compression Ring	0.18 to 0.28 mm (0.0071 to 0.0110")	1.5 mm (0.0590")
Second and Third Compression Ring	0.35 to 0.5 mm (0.01378 to 0.01958")	1.5 mm (0.0590")
Oil Control Ring	0.15 to 0.35 mm (0.0059 to 0.0138")	1.5 mm (0.0590")
PISTON RING TO GROOVE CLEARANCE		
1st Compression Ring	0.09 to 0.13 mm (0.0035 to 0.0051")	0.2 mm (0.0079")
2nd and 3rd Compression Ring	0.03 to 0.07 mm (0.0012 to 0.0028")	0.15 mm (0.0059")
Oil Control Ring	0.030 to 0.07 mm (0.0012 to 0.0028")	0.15 mm (0.0059")
Piston Pin Diameter	39.995 mm (1.5746")	—
Piston Pin Hole Diameter in the Piston	40.004 to 40.012 mm (1.5750 to 1.5752")	—
Piston Pin to Piston Clearance	0.009 to 0.017 mm (0.0004 to 0.0007")	0.05 mm (0.002")

Item	Production	Service Limit
TIMING GEARS.*		
Idler Gear Backlash	0.1 to 0.17 mm (0.0039 to 0.0067")	0.3 mm (0.0118")
Idler Gear end Play Gear "A" and "B"	0.08 to 0.155 mm (0.0031 to 0.00610")	0.2 mm (0.0079")
Gear "C"	0.09 to 0.154 mm (0.0035 to 0.0061")	0.2 mm (0.0079")
VALVE GUIDES AND SEATS		
Minimum Valve Margin Thickness	—	—
Intake	1.71 mm (0.0673")	1.3 mm (0.0512")
Exhaust	1.75 mm (0.0689")	1.25 mm (0.0492")
Valve Face Angle : Intake	60 degrees	—
Valve Face Angle : Exhaust	45 degrees	—
VALVE GUIDE TO VALVE STEM CLEARANCE		
Intake	0.039 to 0.071 mm (0.0015 to 0.0028")	0.2 mm (0.0079")
Exhaust	0.064 to 0.096 mm (0.0025 to 0.0038")	0.25 mm (0.0098")
VALVE INSTALLED DEPTH		
Intake	1 mm (0.0394")	2.5 mm (0.0984")
Exhaust	1.3 mm (0.0512")	2.8 mm (0.1102")
VALVE STEM DIAMETER		
Intake	7.946 to 7.961 mm (0.3128 to 0.3134")	7.80 mm (0.3071")
Exhaust	7.921 to 7.936 mm (0.3118 to 0.3124")	7.77 mm (0.3059")
VALVE SEAT WIDTH		
Intake	3.2 mm (0.1260")	—
Exhaust	2.8 mm (0.1102")	—
VALVE SPRINGS		
FREE LENGTH		
Intake	65.9 mm (2.5945")	64.8 mm (2.5512")
Exhaust	68.1 mm (2.6811")	66.9 mm (2.6339")
INCLINATION		
Intake	2.5 mm (0.0984") or less	2.9 mm (0.1142")
Exhaustr	2.5 mm (0.0984") or less	3.0 mm (0.1181")
TENSION (At 46.0 mm [1.8110"] length)		
Intake	348.1 N (78.3 lb.).	296 N (69 lb.).
Exhaust	382.5 N (86 lb.).	325 N (73 lb.).
VALVE TRAIN		
Valve Rocker Arm Inside Diameter	22.01 to 22.035 mm (0.8665 to 0.8675")	22.15 mm (0.8720")
Valve Rocker Arm to Shaft Clearance	0.01 to 0.056 mm (0.0004 to 0.0022")	0.2 mm (0.0079")
Valve Rocker Arm to Shaft Diameter	21.979 to 22.0 mm (0.8653 to 0.8661")	21.85 mm (0.8602")

FASTENER TIGHTENING SPECIFICATIONS

Application	N·m	Lb Ft	Lb In.
Camshaft Bearing Cap	27	20	—
Camshaft Gear Bolt	142	105	—
Rocker Arm Shaft Bracket Nuts (Star mark 1 to 2)	27	20	—
Rocker Arm Shaft Bracket Bolts (8 to 9)	27	20	—
Rocket Arm Shaft Bracket Bolts (1 through 7)	56	41	—
Charge Air Pipe Bolt	37	27	—
Connecting Rod Bolt			
First Stage	39	29	—
Second Stage	plus 60 degrees	plus 60 degrees	—
Third Stage	plus 30 degrees	plus 30 degrees	—
Crankshaft Balancer Bolt and Washer	200	148	—
Crankshaft Pulley Bolt and Washer	48	35	—
Cylinder Body Lower Crankcase (M10)	37	27	—
Cylinder Lower Crankcase (M14) Apply molybdenum grease			
First Stage	98	72	—
Second Stage	132	98	—
Third Stage	plus 30 to 60 degrees	plus 30 to 60 degrees	—
Cylinder Head Bolt (M14) Apply molybdenum grease			
First Stage	98	72	—
Second Stage	147	108	—
Third Stage	plus 30 to 60 degrees	plus 30 to 60 degrees	—
Cylinder Head Bolt (M10) Apply engine oil	38	28	—
Engine Mounting Bolt to the Frame	36	26	—
Engine Mounting Nut to the Frame	83	61	—
Engine Mount Through Bolt	294	217	—
Exhaust Manifold Nut	34	25	—
Exhaust Pipe Adapter to the Exhaust Manifold	52	38	—
Flywheel Bolt Apply molybdenum grease			
First Stage	78	58	—
Second Stage	plus 60 degrees	plus 60 degrees	—
Third Stage	plus 60 degrees	plus 60 degrees	—
Front Cover Bolt	19	4	—
Front Engine Mount Bolt	79	57	—
Idler Gear Bolt (Idler A) Apply molybdenum grease			
First stage	29	21	—
Second stage	plus 75 degrees	plus 75 degrees	—
Idler Gear Bolt (Idler B)	95	70	—
Idler Gear Shaft Bolt (Idler B)	31	23	—
Intake Manifold Bolt	13	—	113
Oil Cooler Bolt	19	14	—
Oil Filter Bracket Bolt	38	28	—
Oil Jet Bolt	21	15	—
Oil Pan Bolt	24	17	—
Oil Pump Body Bolt	24	17	—
Oil Strainer Tube Bolt (M8)	24	17	—
Oil Strainer Tube Bolt (M10)	48	35	—
Rear Engine Mounting Nut and bolt to the Frame	108	80	—
Thermostat Housing Bolt to the Cylinder Head	19	14	—
Turbocharger Drain Line Bolt (to Block)	18	13	—
Turbocharger Drain Line Bolt (to Turbocharger)	27	20	—

Application	N·m	Lb Ft	Lb In.
Turbocharger Feed Line Bolt (to Block)	18	13	—
Turbocharger Feed Line Bolt (to Turbocharger)	18	13	—
Turbocharger to Exhaust Manifold Nut	52	38	—
Valve Rocker Arm Cover Bolt	13	—	113
Water Outlet Bolt (M8)	19	14	—
Water Pump Bolt (M16)	103	76	—

SPECIAL TOOLS

J26999-12 Compression Gauge
J29109 Engine Stand
J34915 Engine Stand Adapter
J43264 Compression Gauge Adapter
J43272 Valve Guide Remover and Installer
J43267 Valve Stem Seal Installer
J36660 Torque Angle Meter
J41220 Slinger Remover
J41221 Oil Seal Remover and Installer
J41222 Crankshaft Gear Installer
J43263 Valve Spring Compressor
J43269 Injection Pipe Seal Installer
J43266 Nozzle Sleeve Installer
J43265 Nozzle Sleeve Remover
J43268 Guide Bridge Installer

SECTION 6B1B

WATER PUMP OVERHAUL

NOTICE: *Always use the correct fastener in the correct location. When you replace a fastener, use ONLY the exact part number for that application. ISUZU will call out those fasteners that require a replacement after removal. ISUZU will also call out the fasteners that require thread lockers or thread sealant. UNLESS OTHERWISE SPECIFIED, do not use supplemental coatings (paints, greases, or other corrosion inhibitors) on threaded fasteners or fastener joint interfaces. Generally, such coatings adversely affect the fastener torque and the joint clamping force, and may damage the fastener. When you install fasteners, use the correct tightening sequence and specifications. Following these instructions can help you avoid damage to parts and systems.*

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Inspection and Repair	6B1B- 1
Pump Spindle Interferences	6B1B- 1
Assembly	6B1B- 1
Specifications	6B1B- 5
Pump Spindle Interferences	6B1B- 5
Seal Installation Height	6B1B- 5
Special Tools	6B1B- 5

DISASSEMBLY

Disassemble (Figures 1 through 5)

1. Impeller using a suitable puller.
2. Pulley using a suitable puller.
3. Dust thrower.
4. Snap ring using snap ring pliers.
5. Spindle, bearing and spacer using a plastic hammer to lightly tap the spindle free.
6. Front seal.
7. Seal unit using a arbor press and a suitable remover.
8. Bearings and spacer from the spindle using an arbor press.

INSPECTION AND REPAIR

Replace or repair any component that has wear, damage or any other abnormal condition found through inspection.

Inspect (Figures 1 and 6)

- For proper fit of the shaft to pulley center to pulley.
- Housing for cracks or burrs.
- Shaft for cracks, burrs or pitting. Replace as necessary.

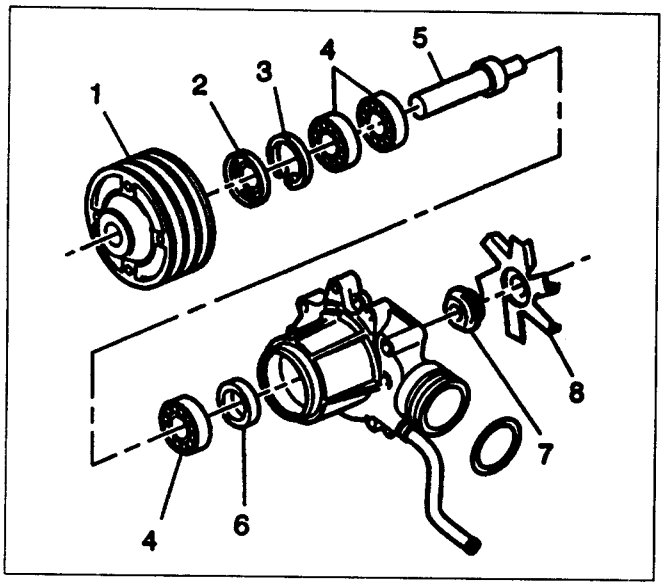
PUMP SPINDLE INTERFERENCES

Interference	mm	in.
Shaft to Pulley Center	0.048 – 0.078	0.0019 – 0.0031
Shaft to Impeller	0.027 – 0.120	0.0011 – 0.0047

ASSEMBLY

Assemble (Figures 7 through 12)

1. Bearings and spacer onto the spindle.
2. Spindle, bearings and spacer to housing using an arbor press and a suitable installer.
3. Prior to installing the front seal, perform the following:
   A. Apply multipurpose type grease to the lip seal.
   B. Apply engine oil to the lip seals outer circumference.
   C. Position the seal so that the lip of the seal is facing forward.
4. Front seal.
5. Snap ring using snap ring pliers.
6. Dust thrower.



Legend
(1) Pulley
(2) Dust Thrower
(3) Snap ring
(4) Bearings and Spacer
(5) Spindle
(6) Front Seal
(7) Seal Unit
(8) Impeller

Figure 1 – Water Pump Component

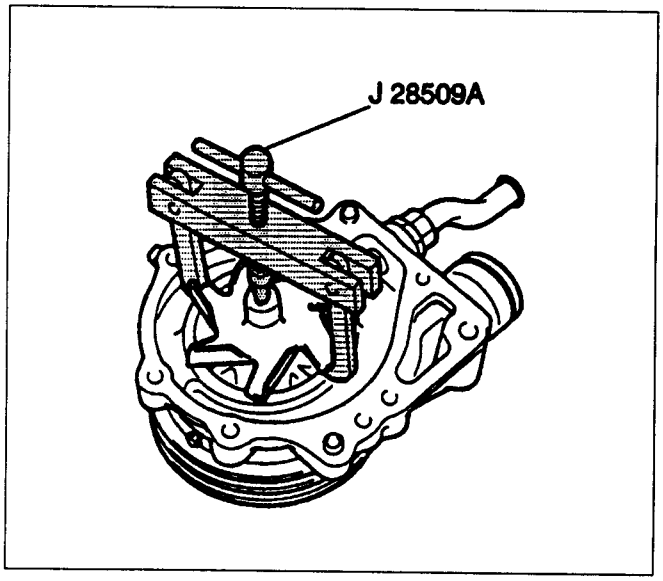


Figure 2 – Impeller Removal

7. Pulley using a bench press.

CAUTION: To protect the bearings and housing during this procedure, the press must contact the impeller side of the pump shaft and the pulley.

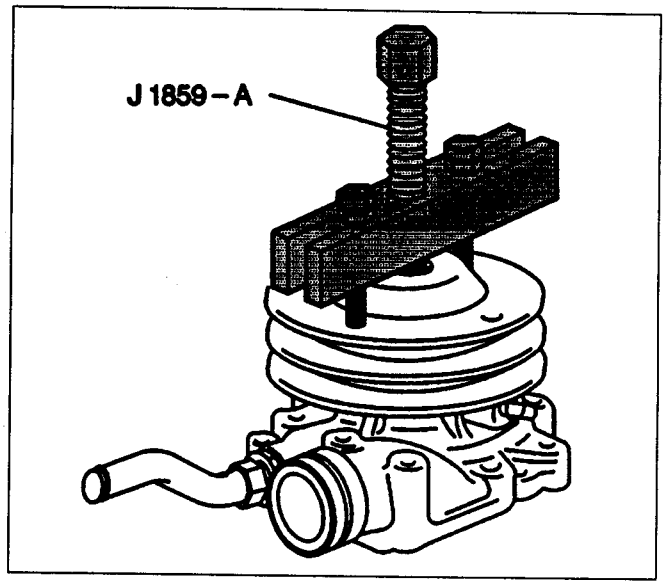


Figure 3 – Pulley Removal

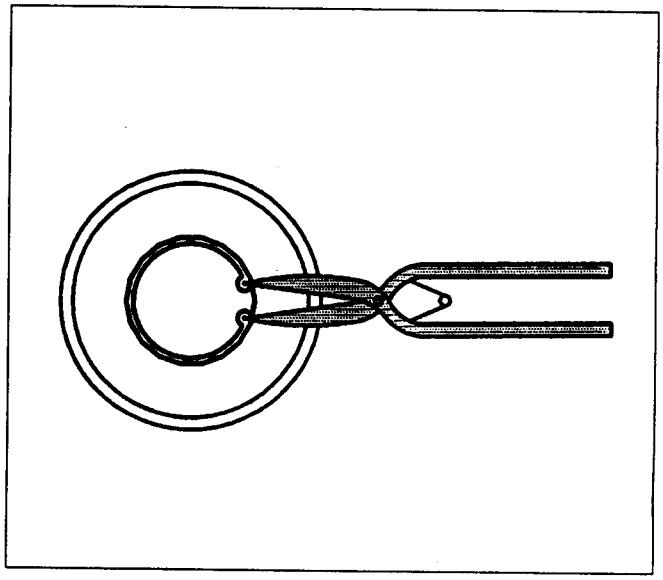


Figure 4 – Snap Ring Removal

8. Apply a thin coat of liquid gasket (Three Bond 1207C or equivalent) to the seal unit before installing.
9. Seal unit to the housing.

Measure

- Install seal unit to specified height using a bench press and installer.
- Seal height 11.0 – 11.6 mm (0.433 – 0.457 in.)

CAUTION: To protect the bearings and housing during this procedure, the press must contact the impeller and the pulley.

10. Impeller to the shaft using bench press, until the impeller bottoms out against the shaft.

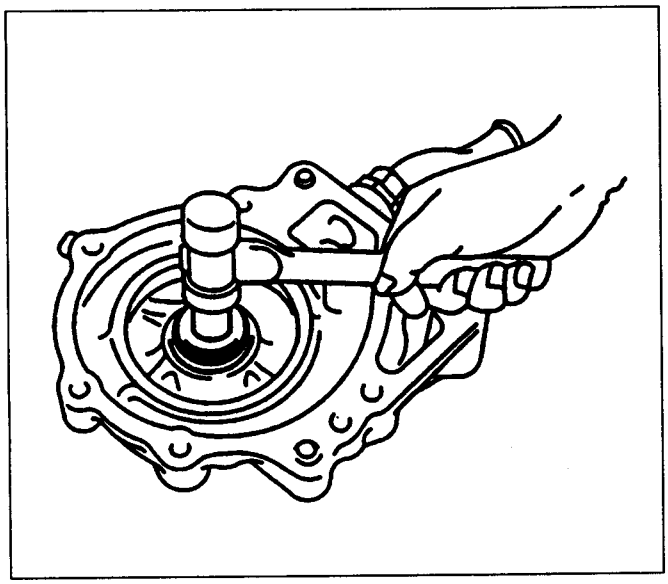


Figure 5 – Spindle and Bearing Removal

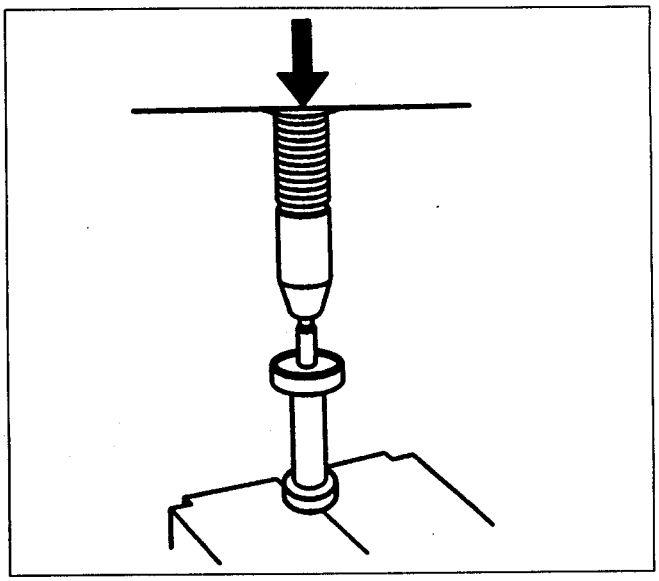


Figure 7 – Installing Bearings and Spacer

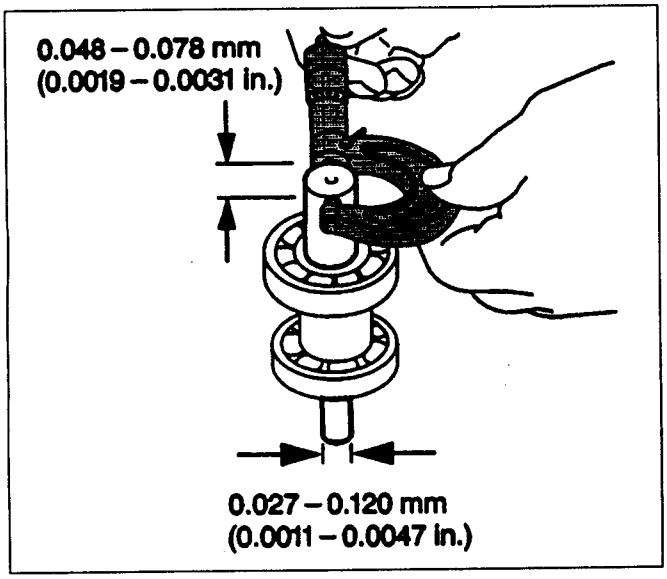


Figure 6 – Measuring and Shaft Interference

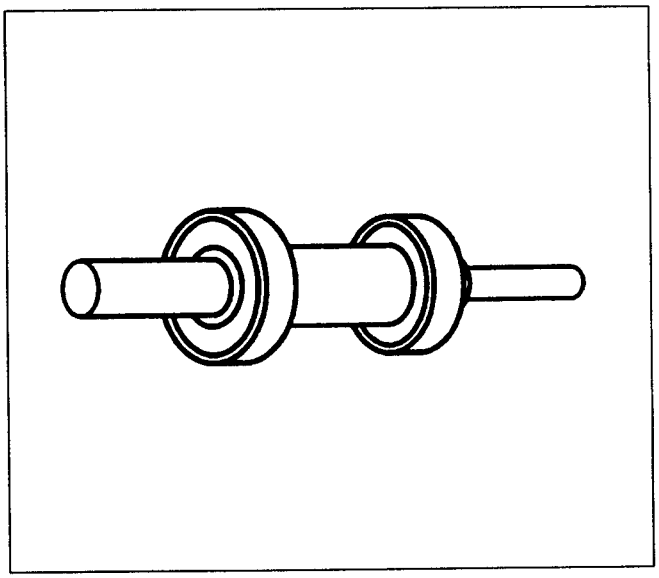


Figure 8 – Bearing Installed to Shaft

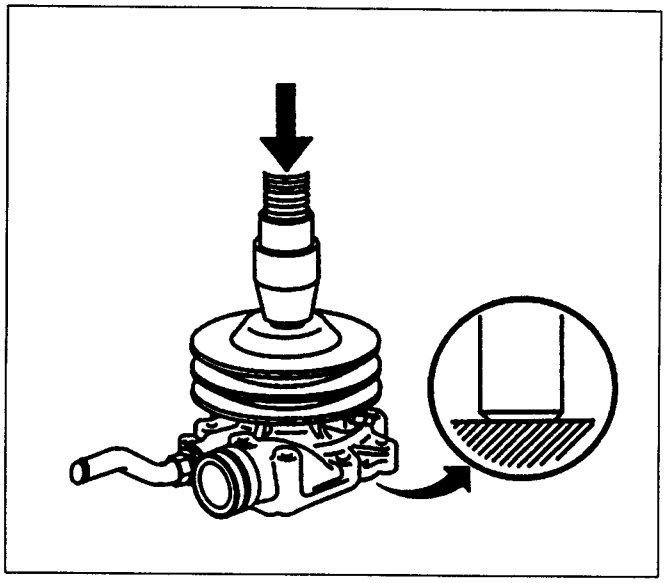


Figure 9 – Pulley Installation

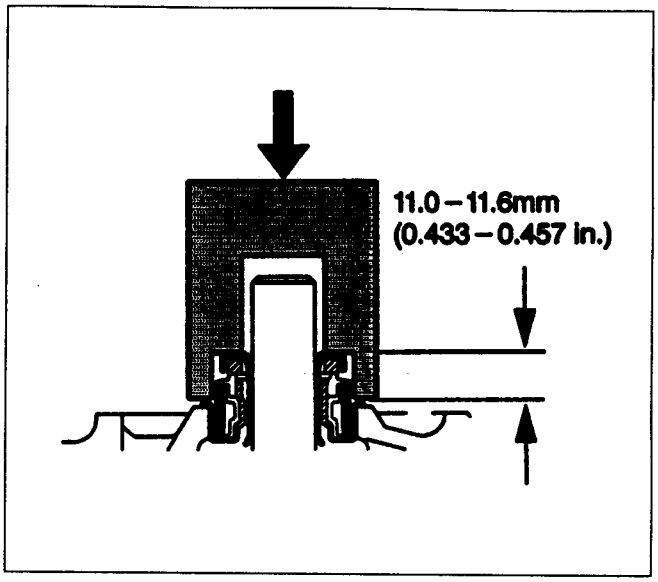


Figure 11 – Installing the Seal Unit

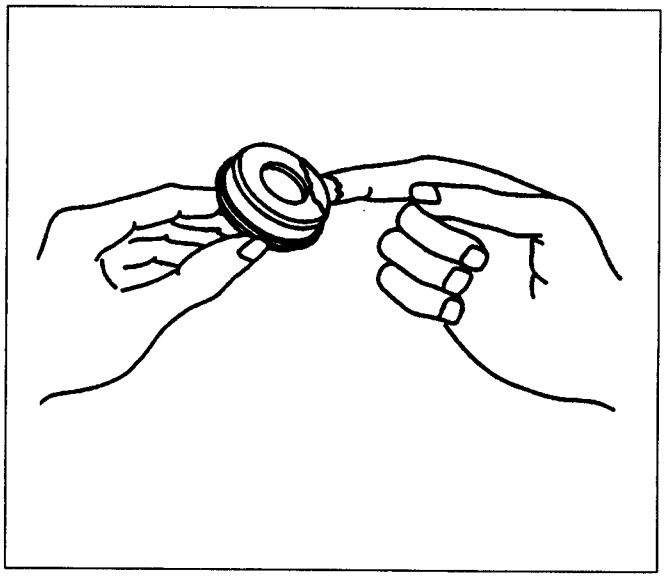


Figure 10 – Applying Liquid Gasket

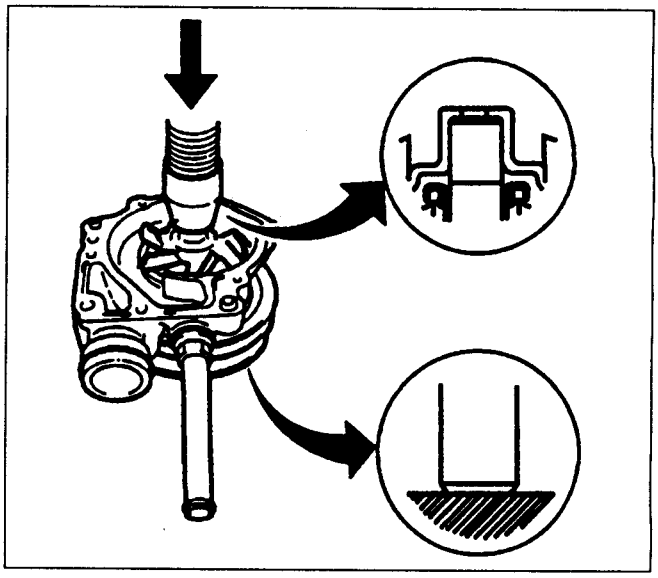


Figure 12 – Impeller Installation

SPECIFICATIONS

PUMP SPINDLE INTERFERENCES

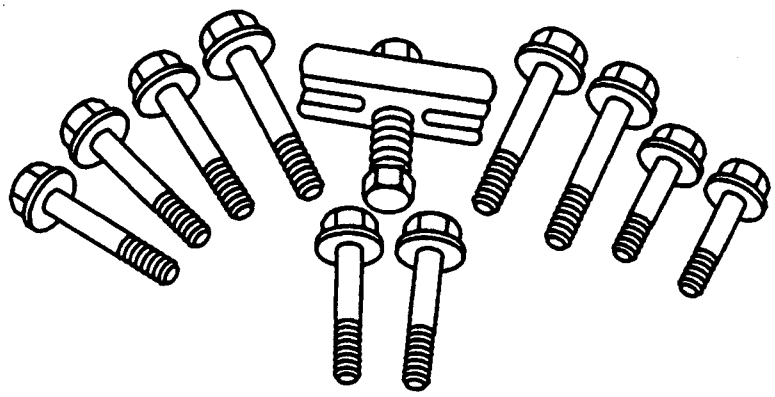
Interference	mm	in.
Shaft to Pulley Center	0.048 – 0.078	0.0019 – 0.0031
Shaft to Impeller	0.027 – 0.120	0.0011 – 0.0047

PUMP SPINDLE INTERFERENCES

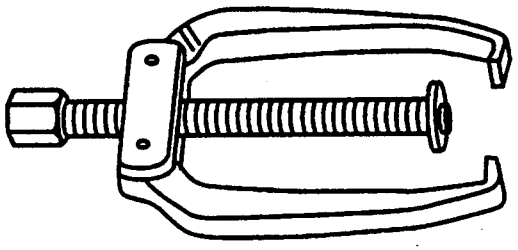
Seal Unit Installation	mm	in.
Seal Height	11.0 – 11.6	0.433 – 0.457

SPECIAL TOOLS

J 1859 – A



J 28509 – A



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SECTION 6C

FUEL SYSTEM

For information regarding fuel systems, refer to the appropriate Diesel Fuel Injection, Engine Emission and Electrical Diagnosis Service Manual.

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SECTION 6C2

DIESEL FUEL INJECTION

NOTICE: *Always use the correct fastener in the correct location. When you replace a fastener, use ONLY the exact part number for that application. ISUZU will call out those fasteners that require a replacement after removal. ISUZU will also call out the fasteners that require thread lockers or thread sealant. UNLESS OTHERWISE SPECIFIED, do not use supplemental coatings (paints, greases, or other corrosion inhibitors) on threaded fasteners or fastener joint interfaces. Generally, such coatings adversely affect the fastener torque and the joint clamping force, and may damage the fastener. When you install fasteners, use the correct tightening sequence and specifications. Following these instructions can help you avoid damage to parts and systems.*

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GENERAL DESCRIPTION

COMMON RAIL SYSTEM

This section covers the electronically controlled fuel injection system for 6HK1 diesel engine.

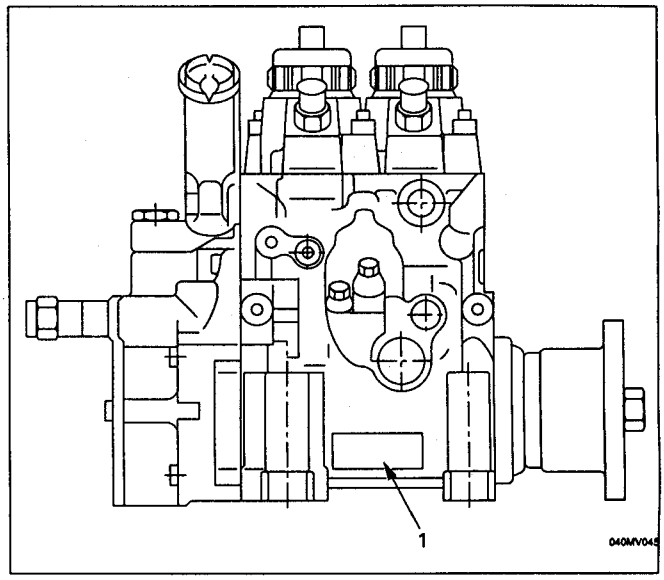
The 6HK1 (7.8L) diesel engine fuel system consists of the following.

- Fuel tank
- Fuel hoses and lines
- Water separator
- Fuel filter
- Fuel feed pump
- Fuel injection pump
- Fuel common rail
- Steel lines
- Six fuel injectors with solenoid valve

The fuel injection pump, fuel common rail and the fuel injectors are made by DENSO.

If an internal problem occurs in the fuel injection pump, the fuel injection pump must be removed from the engine and serviced by an authorized DENSO dealer. Do not open the fuel injection pump and injector assembly, or the warranty is void.

The fuel injection pump has an identification tag (1) attached to the fuel injection pump body (Figure 1).



Legend
(1) Identification Tag

Figure 1 – Identification Tag Location

SYSTEM OUTLINE

The COMMON RAIL SYSTEM detects engine conditions (engine speed, accelerator pedal angle, coolant temperature, etc.) by means of its sensors and generally control fuel injection amount, timing, and pressure by means of its microcomputer, thereby making the engine run in the best condition.

Further, the system performs the self-diagnosis/ lighting function to diagnose main components and, if abnormality found, worn the driver, the failsafe function to stop the engine depending on the parts to which trouble has occurred, and the backup function to switch over the control method to enable the vehicle to run continuously.

SYSTEM COMPOSITION

The system can be functionally divided into two systems, fuel and control.

(1) Fuel System

The high pressure fuel generated by injection pump is distributed to each cylinder. The solenoid valve in the injector opens and closes the nozzle needle valve, thereby controlling the start and end of fuel injection.

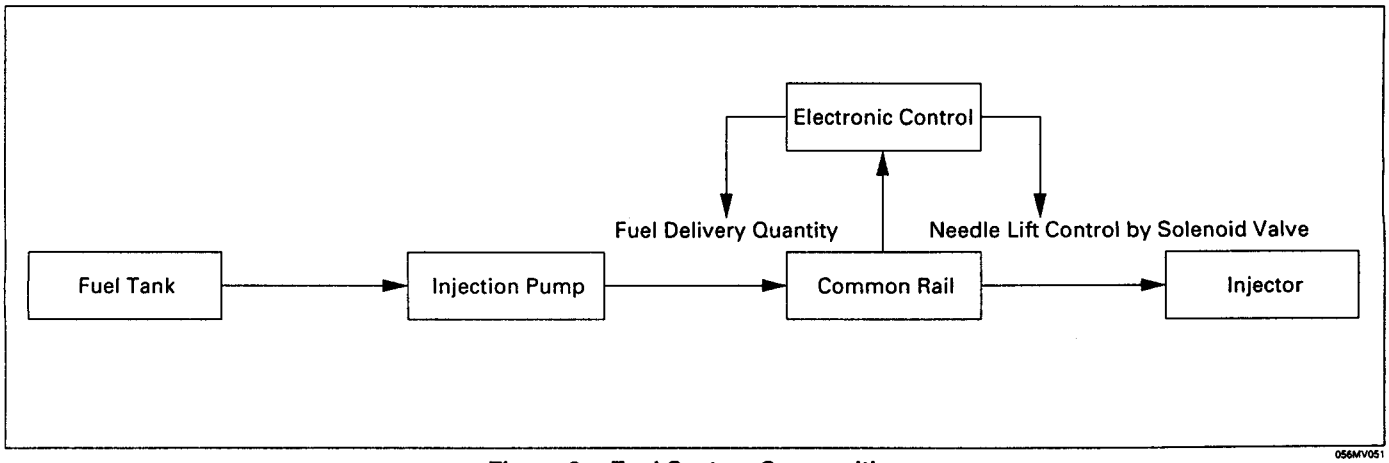


Figure 2 – Fuel System Composition

(2) Control System

ECM is used to compute and control from the signals received from the sensors installed to the engine and vehicle the timing and time for passing current to the injector so that the optimum quantity of fuel can be injected at the optimum timing.
The control system mainly comprises sensors, computer, and actuator.

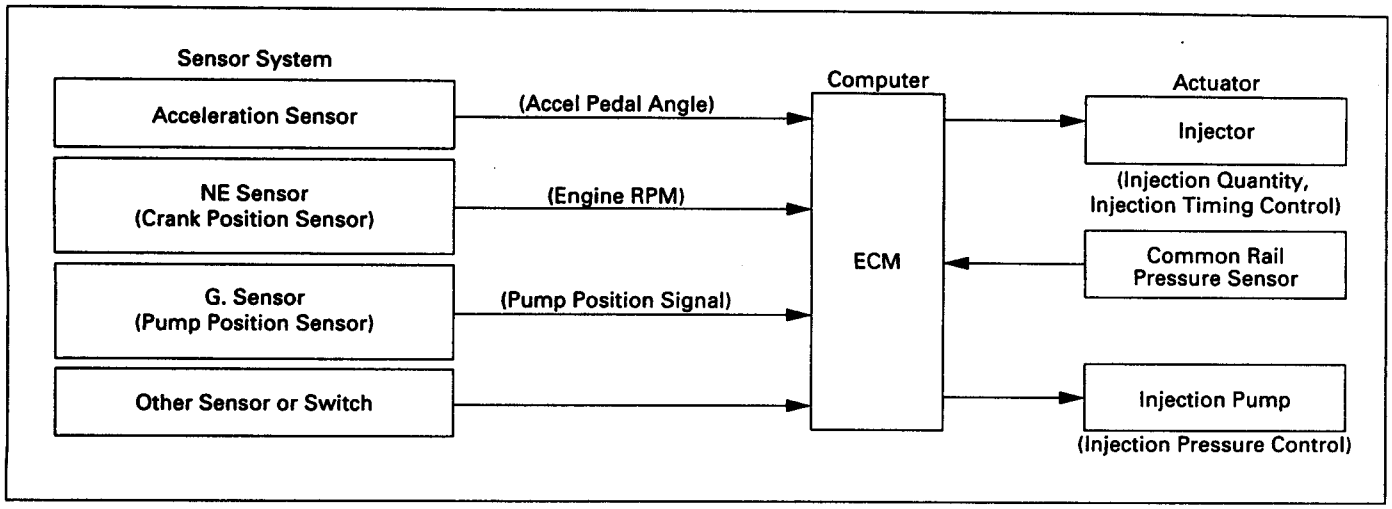


Figure 3 – Control System

(2) System Construction

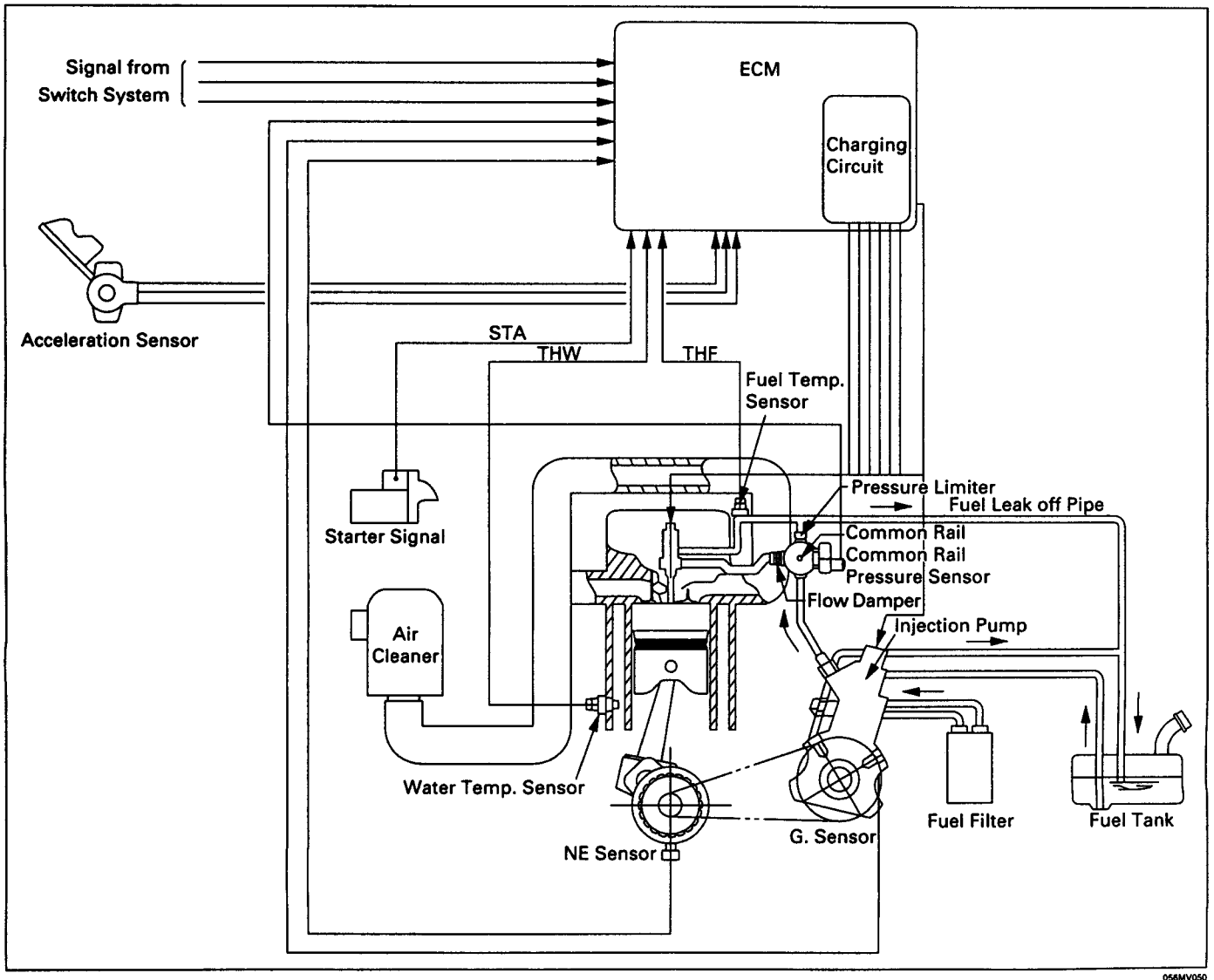


Figure 4 – System Construction

SYSTEM DESCRIPTION AND OPERATION

The COMMON RAIL SYSTEM consists of an injection pump, common rail, injector, ECM and sensors.

The injection pump generates the fuel pressure in the common rail. Fuel pressure is controlled depending on the fuel amount discharged from the injection pump. The fuel discharge amount is controlled by means of PCV provided in the injection pump which is opened/closed in response to electric signals from ECM.

The common rail receives and distributes the fuel pressure made by the injection pump to each cylinder. Fuel pressure is detected by means of a common rail pressure sensor installed to the common rail and is feedback controlled so that the instructed pressure value set according to engine speed and load can agree with an actual pressure value.

The fuel pressure in the common rail is applied through the injection pipe of each cylinder to the nozzle side and control chamber of the injector.

The injector controls injection amount and time by switching on and off a TWV (Two Way Valve). When the TWV is switched on (to carry current), the fuel circuit is changed over to such a status that the high pressure fuel in the control chamber may flow out through and outlet orifice. Owing to nozzle valve opening force caused by the nozzle side of high pressure fuel, the needle valve is lifted to start fuel injection. When the TWV is switched off (to cut current), the fuel circuit is changed over to such a status that the high pressure fuel is flowed back through the inlet orifice into the control chamber.

Therefore, the needle valve comes down to stop fuel injection.

Thus, fuel injection time can be electronically controlled by TWV switching on and fuel injecting amount, by TWV switching off.

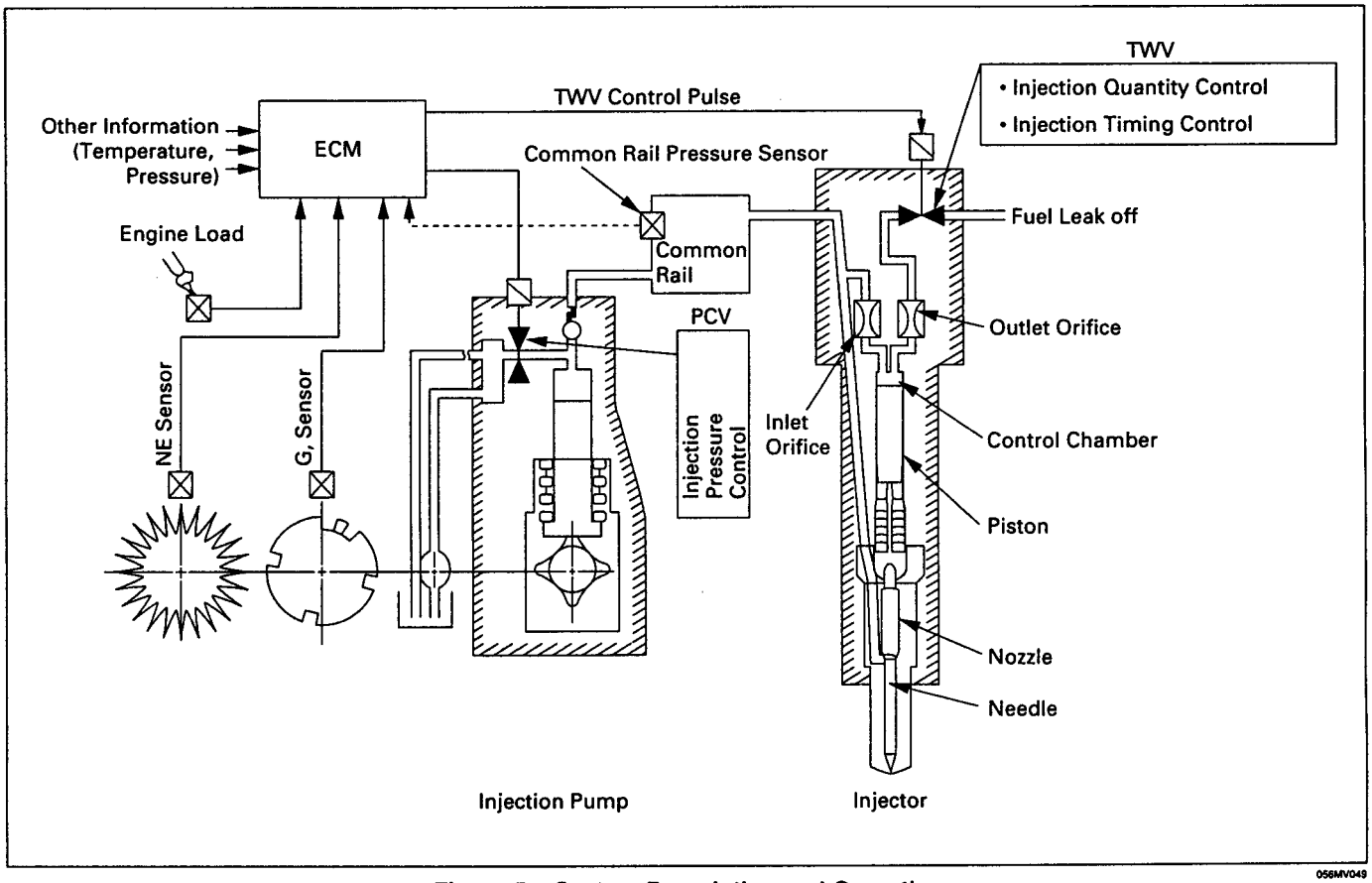


Figure 5 – System Description and Operation

VARIOUS CONTROLS

In comparison with the mechanical governor or timer used in the conventional type injection pump, fuel injection amount/timing can be controlled further properly.

ECM computes from signals coming from the sensors installed to engine and vehicle and controls the time point and length for carrying current to the injector so that the optimum injection can be performed at the optimum timing.

(1) Fuel Pilot Injection Control Function

This is a function to control either fuel pilot injection or not.

(2) Fuel Injection Amount Control Function

This is a function to control fuel injection based on signals from engine speed and accelerator opening sensors so that the optimum injection amount can be obtained. A substitute for the conventional mechanical governor.

(3) Fuel Injection Timing Control Function

This is a function to obtain the optimum injection timing from engine speed and fuel injection amount. A substitute for the conventional timer.

(4) Fuel Injection Pressure Control Function (Common Rail Pressure Control Function)

This is a function to measure fuel pressure with the common rail sensor and feed back the measurement to ECM thereby to control the discharge amount of the pump.

Pressure feedback control is carried out so that the optimum value (instructed value) set according to engine speed and fuel injection amount can be reached

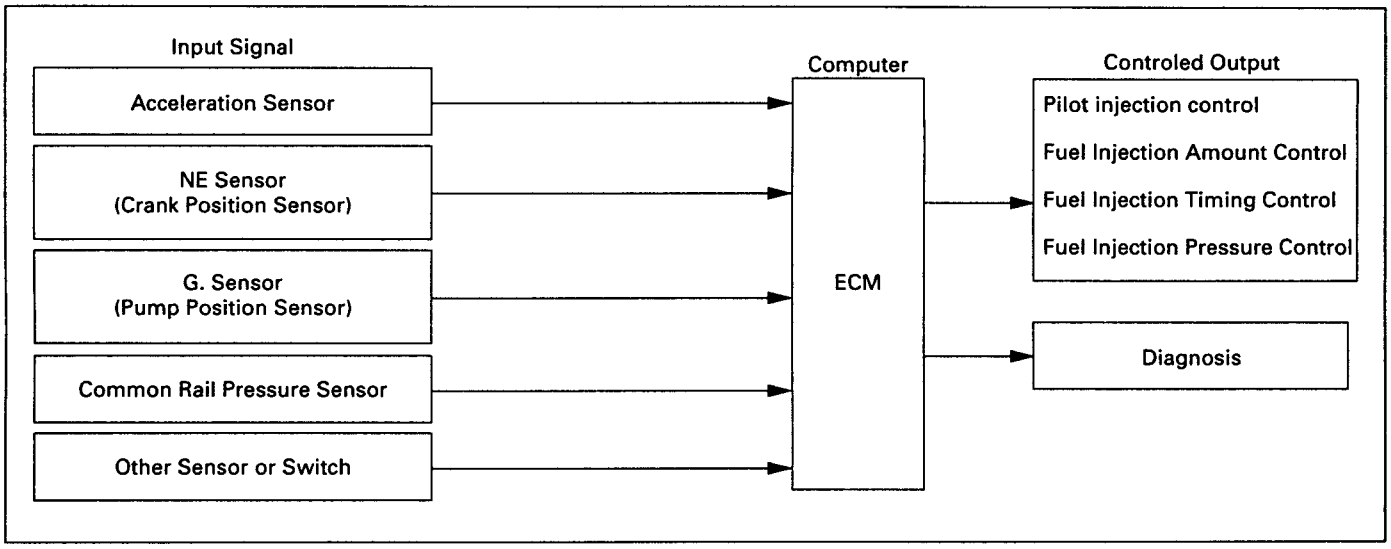


Figure 6 – Control System

FUEL INJECTION RATE CONTROL

(1) Main Injection

Same as the conventional system.

(2) Pilot Injection

This is a small amount of injection conducted prior to the conventional fuel injection (main injection).
Injection rate is increased as there is a rising tide of high pressure injection. But a time lag from fuel injection to combustion start (ignition delay) cannot be shortened over a certain value. As a result the fuel injected could be increased till ignition to cause instantaneous explosive combustion which would in turn increase NOx and noise. Pilot injection puts down an initial injection rate to the irreducible minimum to lessen the explosive combustion so that NOx and noise can be reduced.

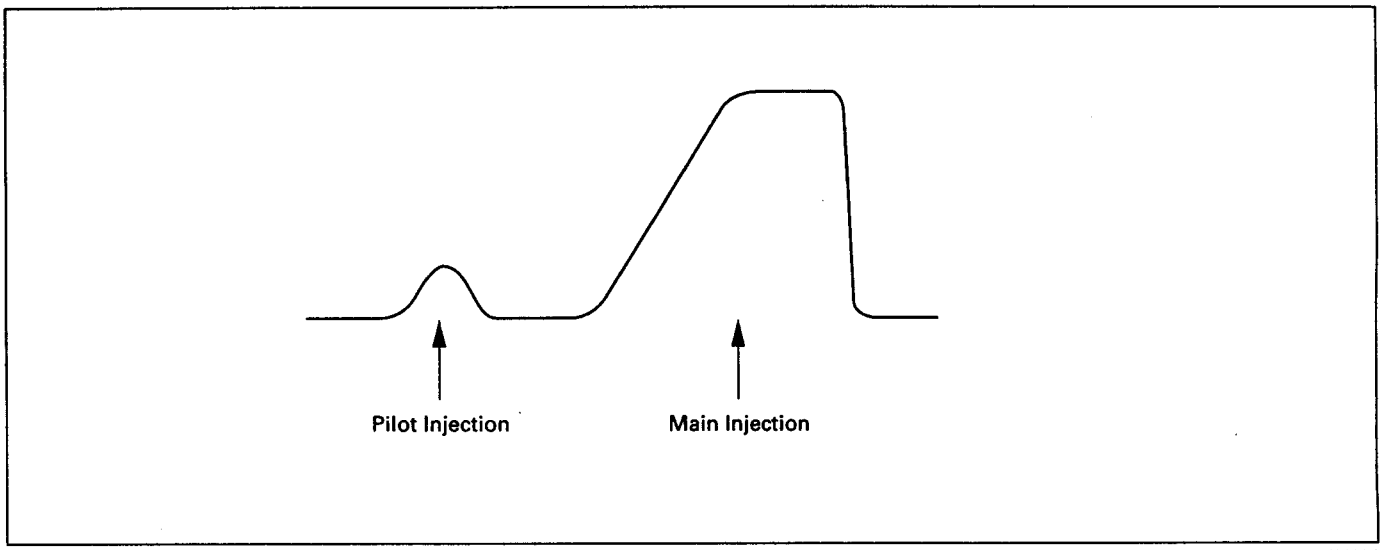


Figure 7 – Pilot Injection

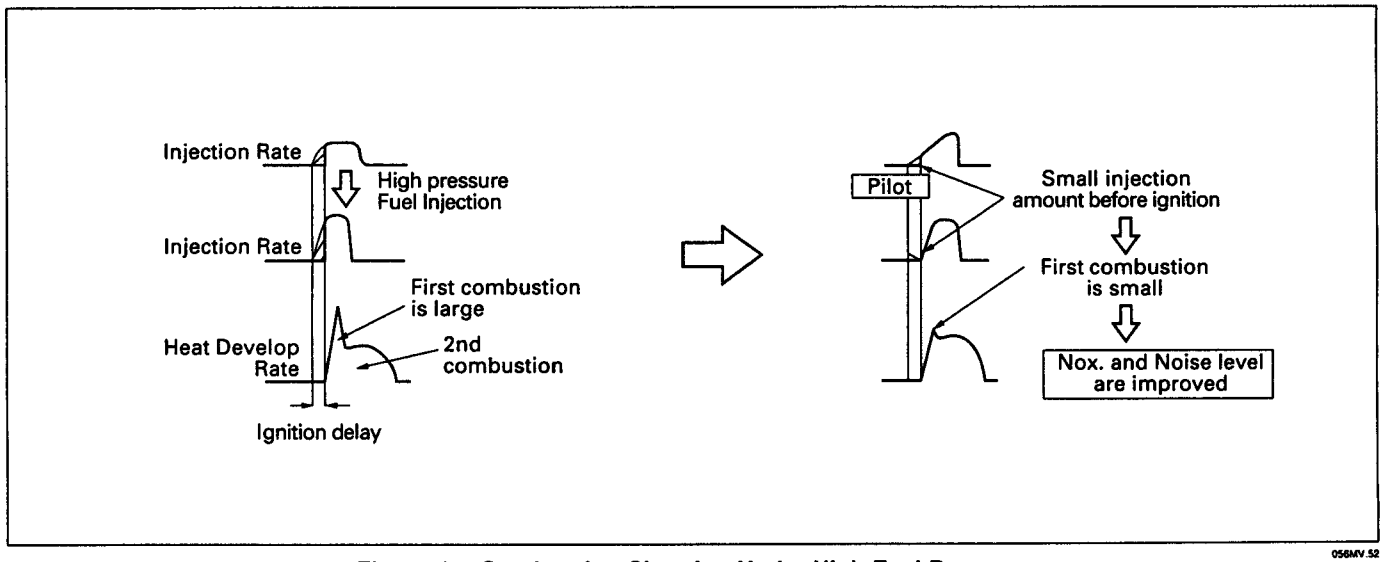


Figure 8 – Combustion Situation Under High Fuel Pressure

(3) Split Injection

This means two or more small amount fuel injections to be conducted prior to the conventional fuel injection (main injection) for increase engine start under cold weather.

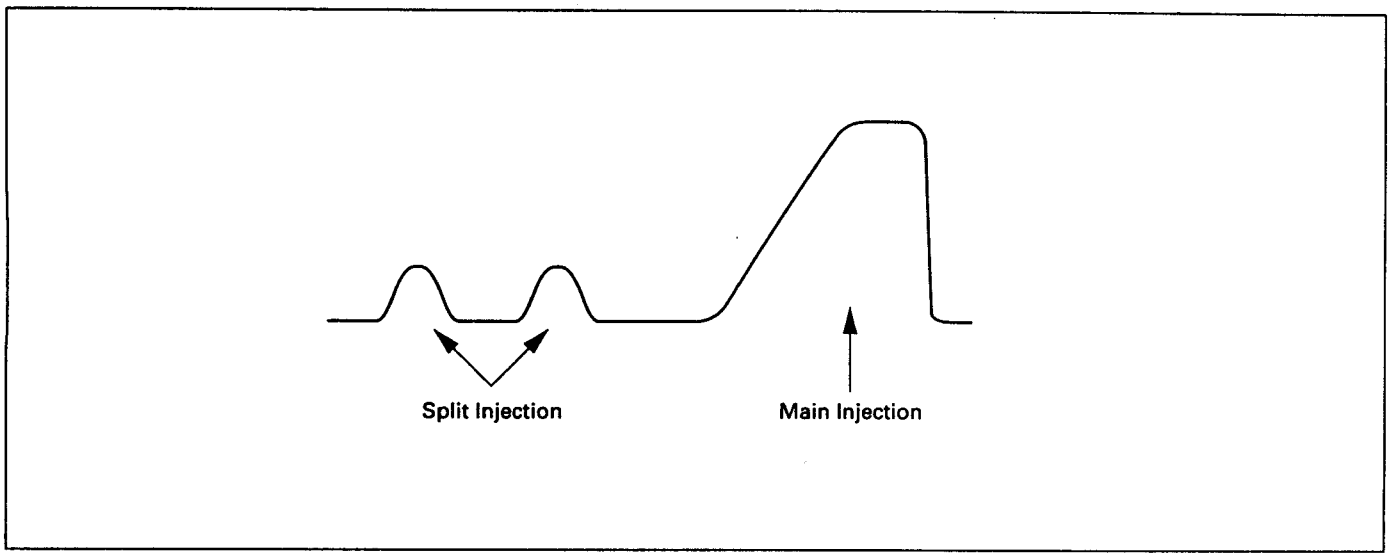


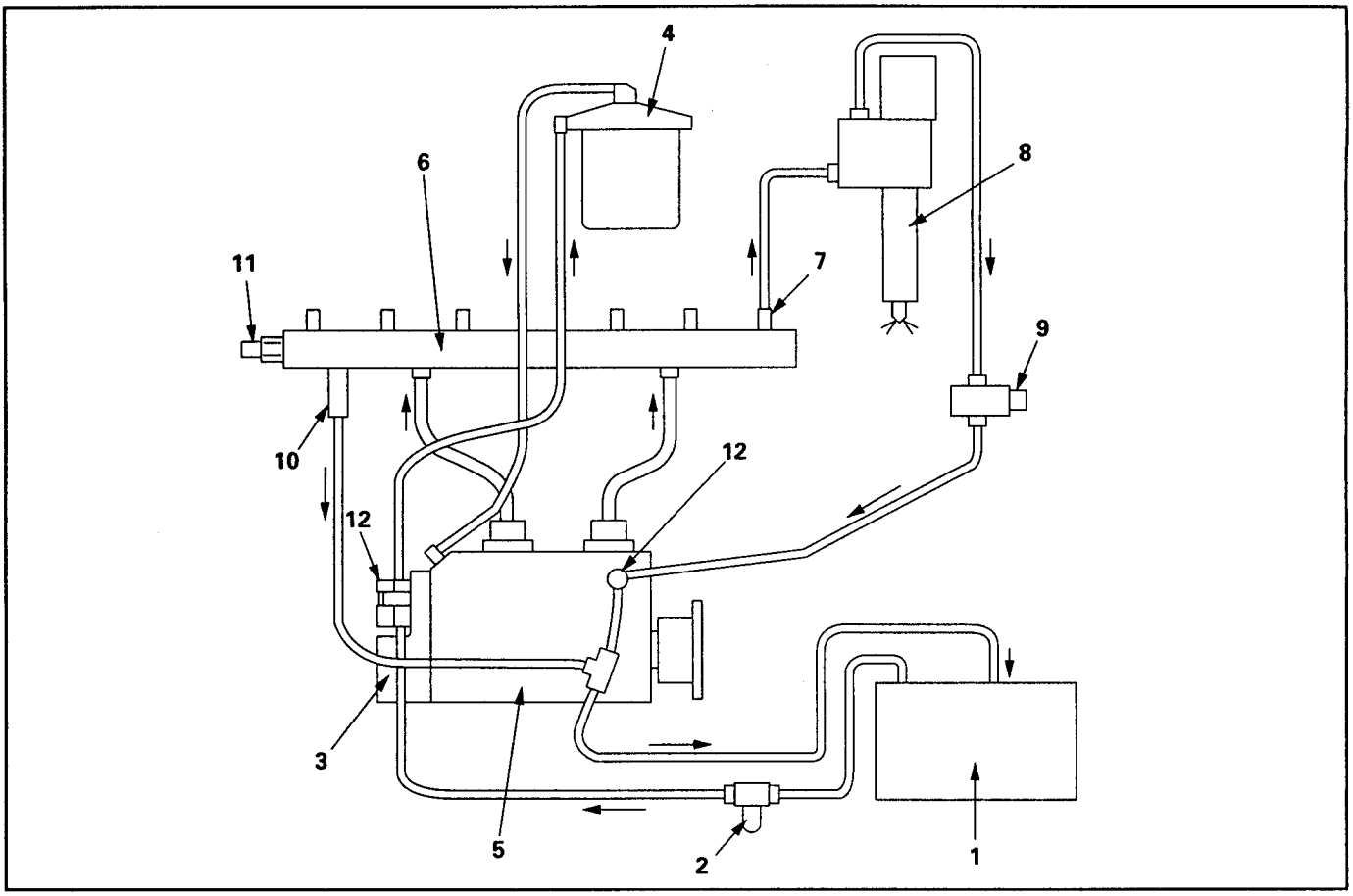
Figure 9 – Split Injection

FUEL INJECTION SYSTEM

SYSTEM OPERATION

Fuel is drawn through the fuel pre-filter (2) by the fuel feed feed pump (3), refer to (Figure 10). The fuel feed pumps the fuel into the fuel filter (4) and then into the fuel injection pump (5). The fuel injection pump then pressurizes and supplies the fuel to fuel common rail.

The pressured fuel distributes through the fuel injectors line to the fuel injectors (8). The high pressure fuel enters the fuel injector and forces the needle off its seat, same time the fuel enters the control room of fuel injectors. The fuel injection timing is controlled by ECM. The ECM command to open the fuel return line of solenoid valve on top of the injector, then the fuel is forced out of the fuel injector into the cylinder.

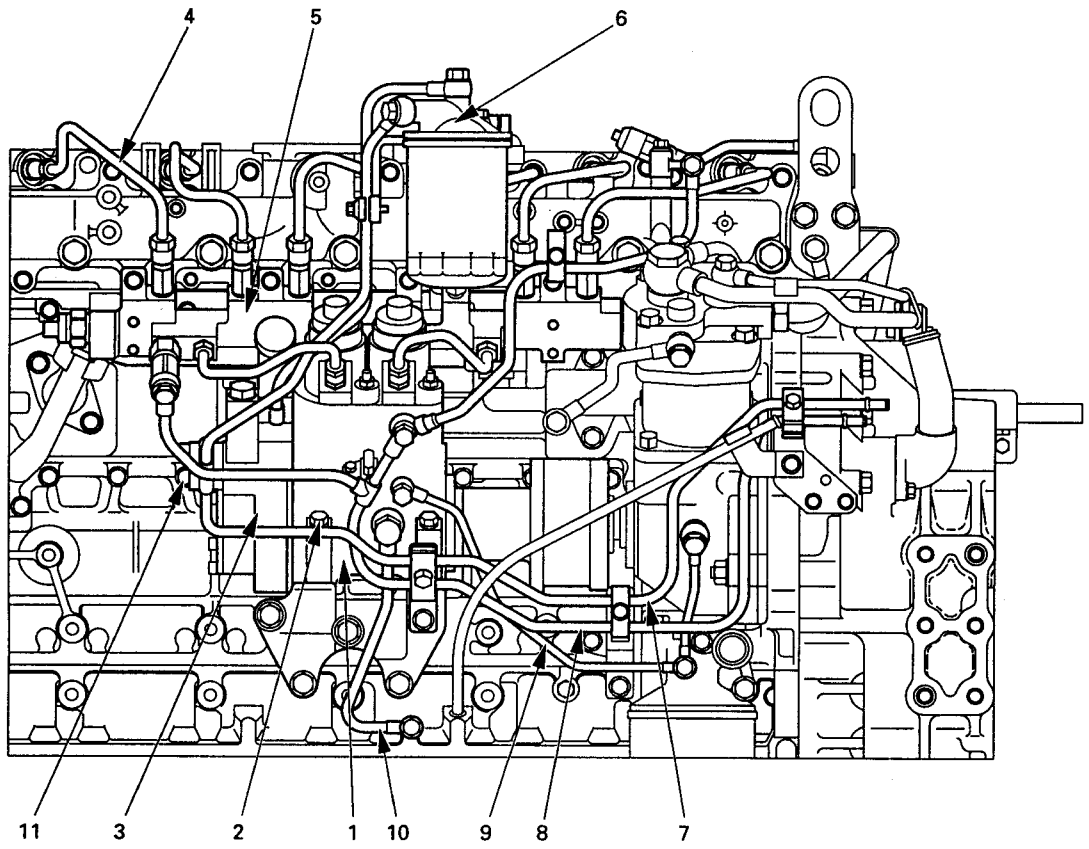


Legend

(1) Fuel Tank
(2) Fuel Pre-Filter
(3) Fuel Feed Pump
(4) Fuel Filter
(5) Injection Pump
(6) Fuel Common Rail
(7) Fuel Flow Dumper
(8) Injector Assembly
(9) Fuel Temperature Sensor
(10) Fuel Pressure Limiter
(11) Fuel Pressure Sensor
(12) Overflow Valve

Figure 10 — Fuel System Schematic

ON VEHICLE SERVICE



040MV046

Legend

(1) Fuel Injection Pump
(2) Bolt
(3) Fuel Transfer Pump
(4) Injection Pipe
(5) Common Rail
(6) Fuel Filter
(7) Fuel Feed Pipe
(8) Fuel Return Pipe
(9) Oil Feed Pipe
(10) Oil Return Pipe
(11) Fuel Return Overflow Pipe

Figure 11 — Location of Fuel System

FUEL INJECTION PUMP

Removal

1. Tilt the cab.
2. Disconnect the negative battery cable.
3. Disconnect PCV harness connector.
4. Disconnect G sensor harness connector.
5. Remove clamp bolts from the fuel feed pipe (7), fuel return pipe (8) and fuel supply pipe to fuel filter.
6. Remove fuel feed pipe (7).
7. Remove fuel return pipe (8).
8. Remove oil feed pipe.
9. Remove oil return pipe.
10. Remove two fuel supply pipes between injection pump and common rail.
11. Disconnect coupling fixing bolts.
12. Remove fuel injection pump fixing bolts.
13. Remove fuel injection pump assembly.

Installation

1. Turn crankshaft to align number 1 cylinder TDC mark to pointer.

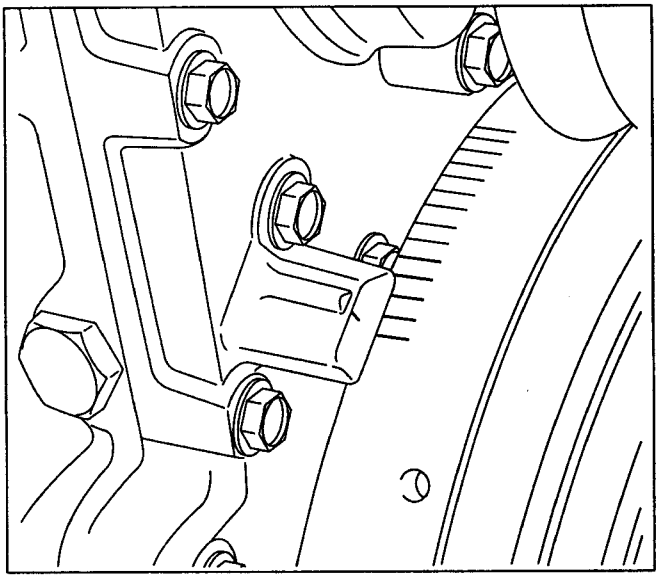


Figure 12 – TDC Mark

2. Turn coupling of injection pump for align timing mark on the injection pump and pointer on the air compressor body.

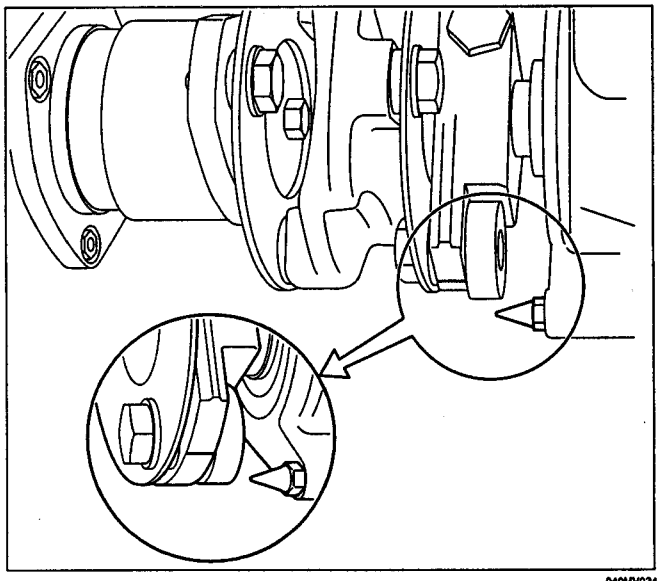
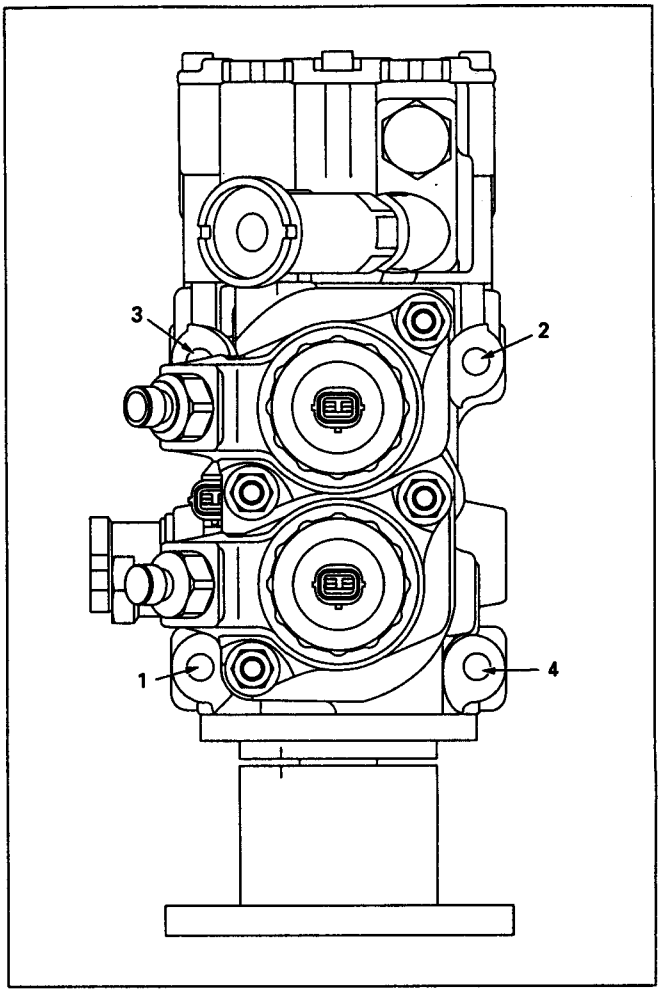


Figure 13 – Injection Pump Pointer

3. Install injection pump assembly onto the pump bracket.
4. Tighten injection pump fixing bolts to the specified torque.
   Torque : 25 N·m (18 lb·ft)



Legend
The number indicate to tighten order.

Figure 14 – Injection Pump Fixing Sequence

5. Tighten coupling bolts to the specified torque.
   Torque 1: 91 N·m (66 lb·ft)
   Torque 2: 61 N·m (46 lb·ft)
   Torque 3: 60 N·m (45 lb·ft)

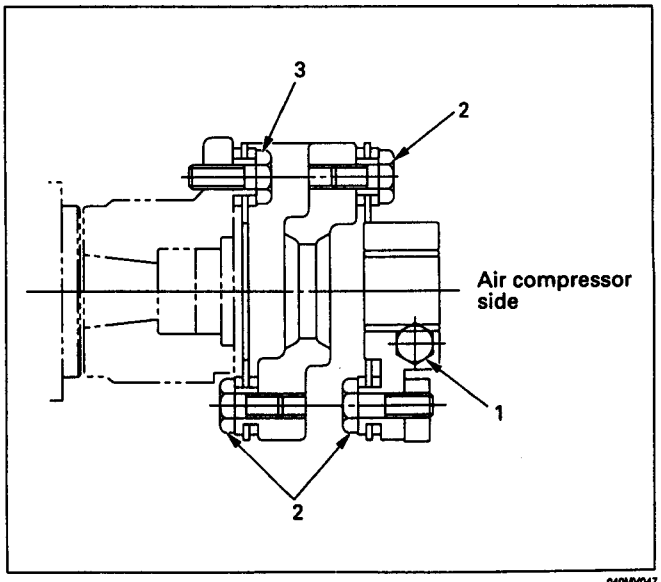


Figure 15 – Coupling Bolts

6. Install two fuel supply pipes between injection pump and commonrail.
7. Install oil return pipe.
8. Install oil feed pipe.
9. Install fuel return pipe.
10. Install fuel feed pipe.

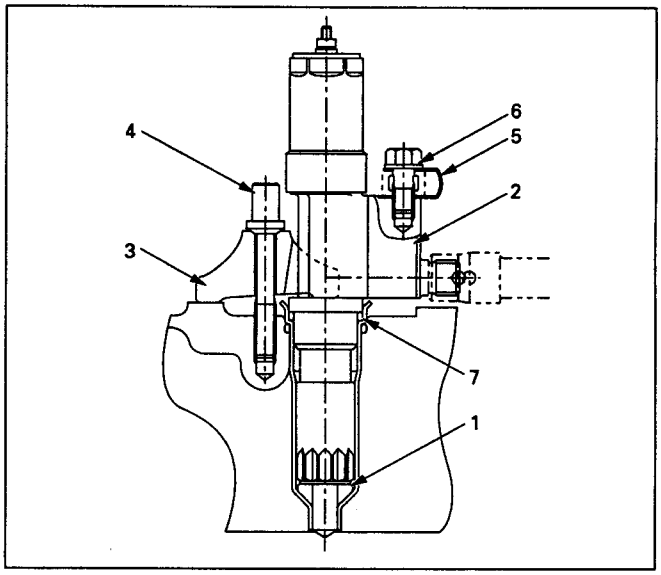
Caution: When install fuel feed pipe on the fuel feed pump, must use special gasket between feed pipe eye (on the relief valve) and return pipe eye (short return pipe). If use other gasket it will cause not start engine.

11. Tighten clamp bolts with clamp.
    Torque : 6 N·m (52 lb·in)
12. Reconnect G sensor harness connector.
13. Reconnect PCV harness connector.
14. Reconnect negative battery cable.
15. Down cab and lock.

FUEL INJECTOR

Removal

1. Tilt cab.
2. Disconnect the negative battery cable.
3. Disconnect two TWV harness connector at outside of lower case (Under the valve rocker arm cover).
4. Remove injection pipes between injector and injection pump.
5. Remove valve rocker arm cover.
6. Disconnect TWV harness connector from inside of lower case joint connector.
7. Loosen terminal nuts for TWV harness on the top of injector and remove TWV harness.
8. Remove TWV harness assembly from top of rocker arm assembly.
9. Loosen injector clamp bolt then remove injector assembly.



Legend

(1) Injector Gasket
(2) Injector Assembly
(3) Injector Clamp
(4) Clamp Bolt
(5) Gasket for Return Pipe
(6) Eye Bolt
(7) Injector Sleeve

Figure 16 – Fuel Injector

Installation

1. Standing put injector clamp on the valve spring seat as shown in the illustration.

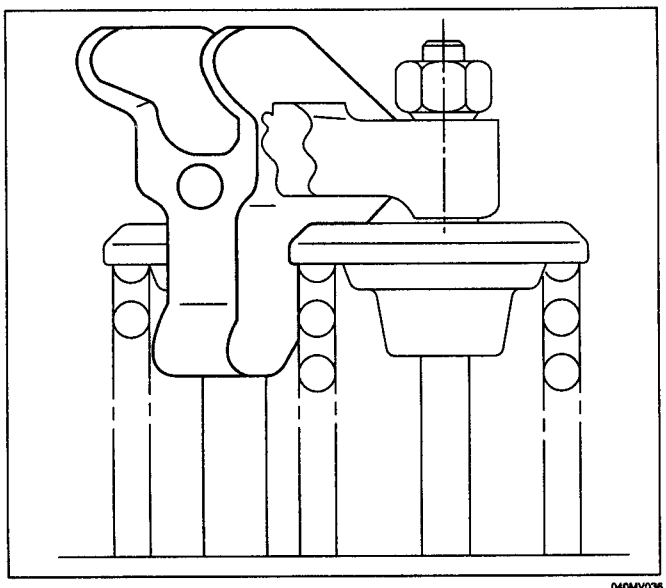
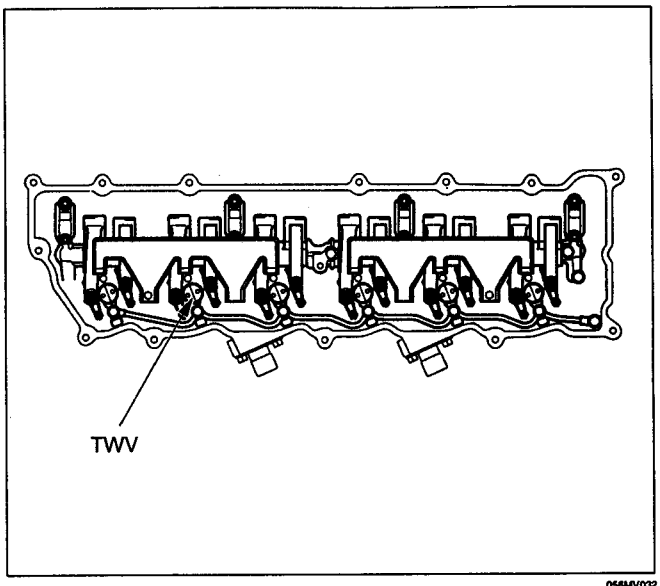

040MV036

Figure 17 – Fuel Injector Clamp



056MV032

Figure 18 – TWV

2. When injector assembly comes installation portion, the injector clamp putting on the injector then install the injector assembly together with clamp into injector sleeve hole.
3. Temporary tighten injection pipe to injector.
4. Apply molybdenum disulfide grease to clamp bolt, tighten injector clamp bolt to specified torque.
   Torque : 31 N·m (22 lb·ft)
5. Tighten injection pipe to the specified torque.
   Torque : 44 N·m (33 lb·ft)
6. Install fuel return pipe, tighten eye bolt to the specified torque.
   Torque : 12 N·m (106 lb·in)

Note:

1. ***Be confirm that tightening torque of injection pipe (Item 5 above) and fuel return pipe eye bolt (Item 6 above) after tighten them for prevent to dilute of engine oil.***
2. ***Make sure that the gasket for return pipe (5) not ride on the injector body when tighten eye bolt. (The correct direction shown in the Figure 16).***

7. Install TWV harness assembly, tighten fixing bolt to specified torque.
   Torque : 22 N·m (16 lb·ft)
8. Install TWV harness to TWV terminals, tighten fixing nut to the specified torque.
   Torque : 2 N·m (17.7 lb·in)

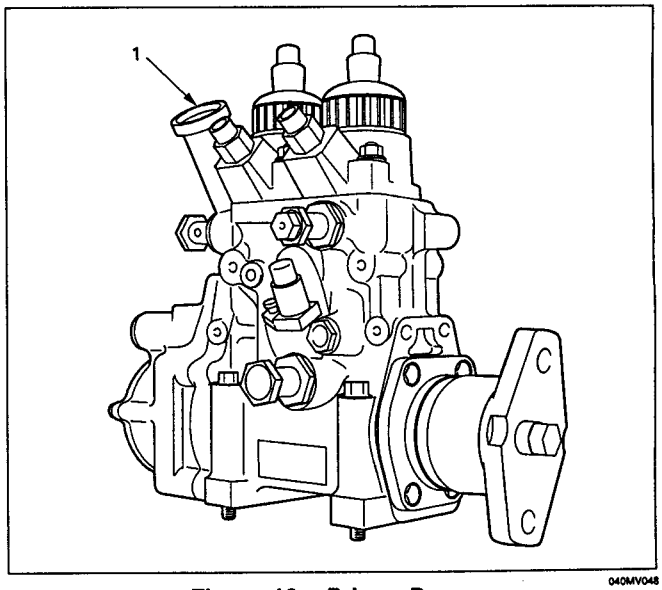
Note: Do not over tight TWV terminal nuts.

9. Reconnect TWV harness to lower case joint connector.
10. Install valve rocker arm cover to tighten to the specified torque.
    Torque : 13 N·m (113 lb·in)
11. Reconnect two TWV harness connector at outside of lower case.
12. Reconnect the negative battery cable.
13. Down cab.

Bleeding Fuel System

Note: The injector assembly must be replaced only assembly.
When the fuel system is opened to the atmosphere, it must be bleed to remove all the air. Air in the fuel system will cause a no start or poor engine performance.

1. Loosen the primer pump knob (1) on the fuel injection pump.



040MV048

Figure 19 – Primer Pump

2. Loosen the feed line eye bolt (1) on the fuel filter.

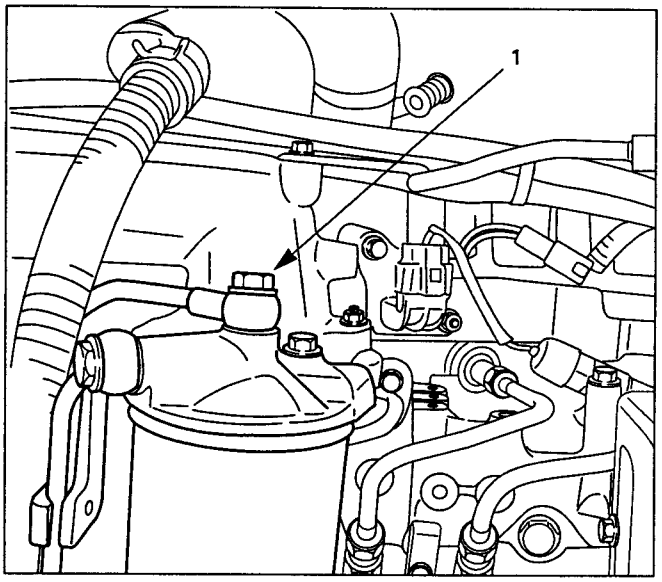


Figure 20 – Fuel Filter

3. Pump the primer pump (1, Figure 19), until a solid stream of fuel comes from the fuel filter feed line eye bolt (1, Figure 20).
4. Tighten the fuel filter eye bolt.
   Torque : 14 N·m (10 lb·ft)
5. Tighten primer pump knob (1) to close it.

Important tightening torque for fuel injection system

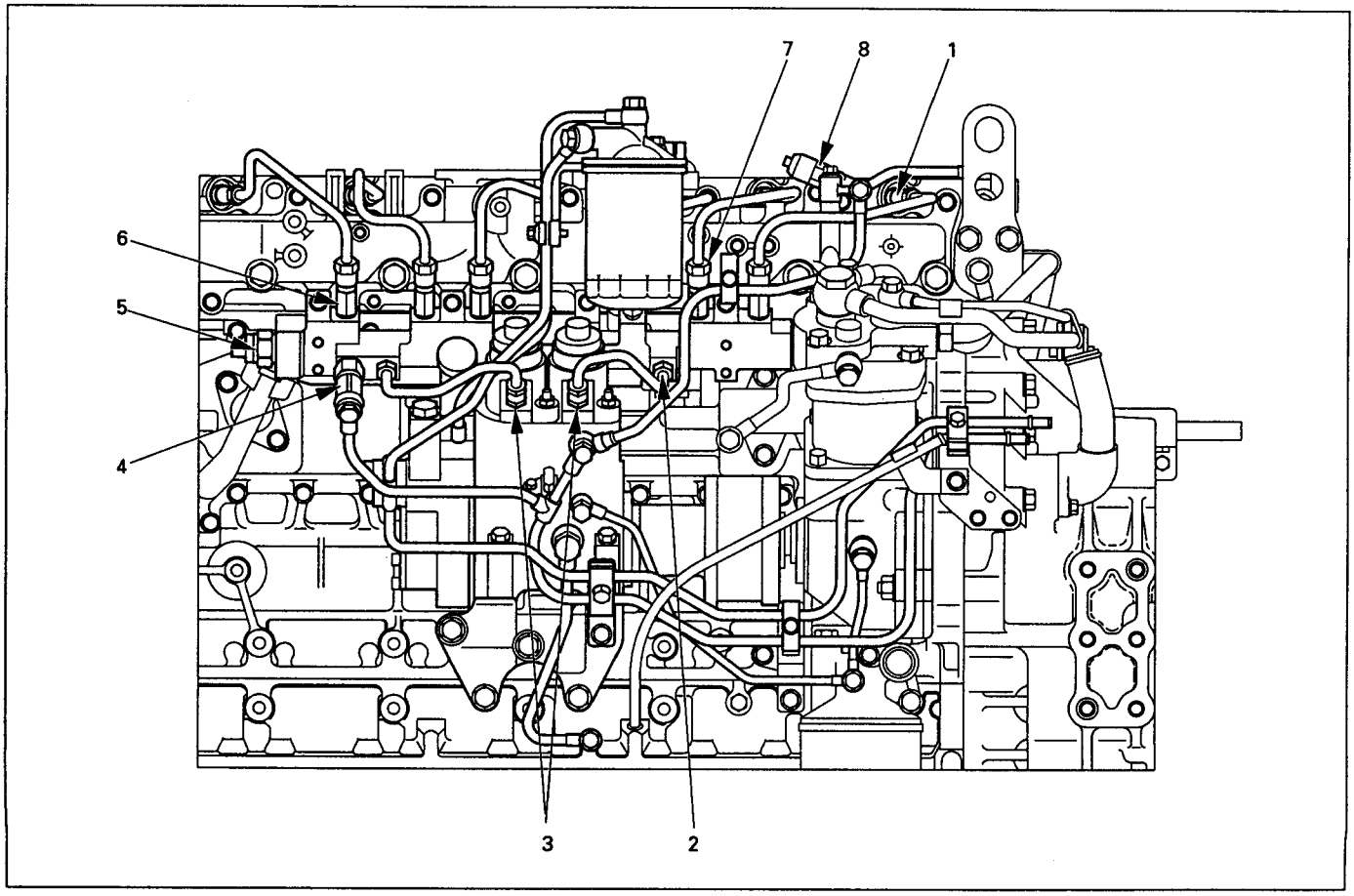


Figure 21 – Important Tightening Torque

Tightening torque

1. Injection pipe sleeve nut, injector side (6 places).
   Torque : 44 N·m (33 lb·ft)
2. High pressure fuel pipe sleeve nut, common rail side (2 places).
   Torque : 54 N·m (40 lb·ft)
3. High pressure fuel pipe sleeve nut, injection pump side (2 places).
   Torque : 44 N·m (33 lb·ft)
4. Fuel pressure limiter.
   Torque : 68.6 N·m (50.6 lb·ft)

5. Common rail pressure sensor.
   Torque : 68.6 N·m (50.6 lb·ft)
6. Flow damper (6 places)
   Torque : 98 N·m (72 lb·ft)
7. Injection pipe sleeve nut, common rail side (6 places)
   Torque : 44 N·m 33 lb·ft)
8. Fuel temperature sensor.
   Torque : 20 N·m (14.5 lb·ft)
9. Fuel return pipe eye bolt, top of injector (7 places)
   Torque : 12 N·m (106 lb·in)

SPECIFICATIONS

Fastener Tightening Specifications

Application	N·m	lb·ft	lb·in
Fuel injection pump bracket to cylinder block	50	37	
Fuel injection pump to pump bracket	25	18	
Fuel injection pump coupling bolt 1	91	66	
Fuel injection pump coupling bolt 2	61	46	
Fuel injection pump coupling bolt 3	60	45	
Fuel pipe clamp bolt	6		52
Fuel injector fixing bolt	31	22	
Fuel injection pipe sleeve nut	44	33	
Fuel return pipe eye bolt	12		106
TWV harness assembly fixing bolt	22	16	
TWV harness terminal nut	2		
Flow damper	98	72	
Pressure limiter	68.6	50.6	
Common rail pressure sensor	68.6	50.6	

BLANK

SECTION 6D6

DIESEL ELECTRICAL

NOTICE: *Always use the correct fastener in the correct location. When you replace a fastener, use ONLY the exact part number for that application. ISUZU will call out those fasteners that require a replacement after removal. ISUZU will also call out the fasteners that require thread lockers or thread sealant. UNLESS OTHERWISE SPECIFIED, do not use supplemental coatings (paints, greases, or other corrosion inhibitors) on threaded fasteners or fastener joint interfaces. Generally, such coatings adversely affect the fastener torque and the joint clamping force, and may damage the fastener. When you install fasteners, use the correct tightening sequence and specifications. Following these instructions can help you avoid damage to parts and systems.*

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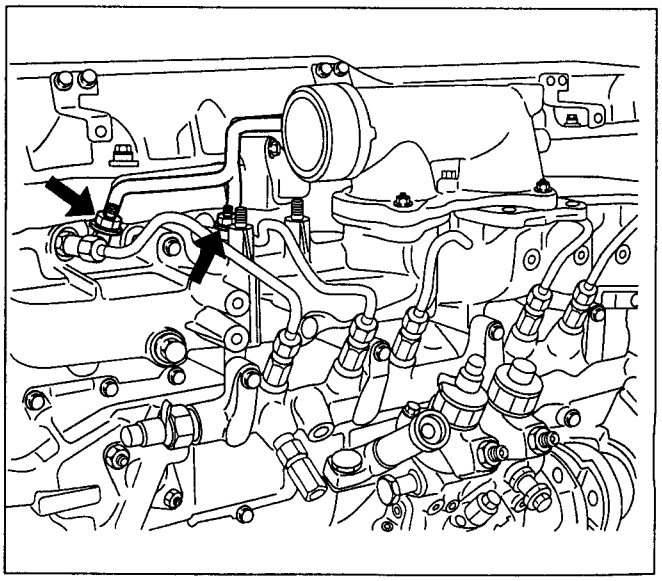
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Buss Bar Check	6D6- 3
On-Vehicle Service	6D6- 3
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Glow Plugs	6D6- 4
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Fastener Tightening Specifications	6D6- 4
Special Tools	6D6- 4

GENERAL DESCRIPTION

GLOW PLUGS

Diesel engines relay on the heat of compression to initiate combustion. Cold engine start-ups may require extra engine cranking time to create the necessary heat to ignite the diesel fuel. One of the devices available to aid in cold starting the diesel engine are glow plugs. Six glow plugs are used to preheat the combustion chambers as an aid to starting (Figure 1). The glow plugs (Figure 2) are 10.5 volt heaters, operated at 12 volts, when the engine control switch is turned to the "H" position. This provides a pre-heat feature to the combustion chamber and improves cold engine start ups.

NOTICE: ***Never manually spray starting aid fluids into the air intake where the fluid may come in contact with the heater element. This could result in an explosion and/or fire.***



F01MV002

Figure 1 – Glow Plugs

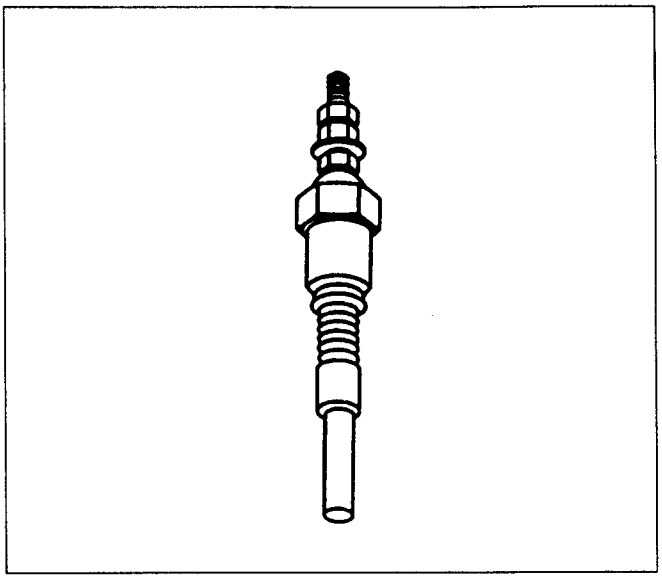


Figure 2 – Glow Plug

STARTING PROCEDURE

To initiate the glow plug operation, these starting procedures should be followed.

1. Turn the engine control switch to the "H" position. Wait until suitable time (according to atmospheric temperature) before cranking the engine.
2. Turn the engine control switch to the "START" position, and release the switch when the engine starts.
3. If the engine does not start after 15 seconds of cranking, repeat steps 1 through 3 until the engine starts.

GLOW PLUG OPERATION

When the engine control switch is turned to the "H" position, current flows through the glow plug relay, and to the glow plugs, heating the glow plugs to 800°C (1472°F). When the ambient temperature is about 0°C (32°F), the glow plugs will take 20 to 25 seconds to heat.

DIAGNOSIS

GLOW PLUG RELAY CHECK

Tools Required:

J 39200 Digital Multimeter

Test the relay circuit for voltage with the relay removed. Use a voltmeter and check for system voltage at cavities B and 30. Cavity 30 is hot at all times. Cavity B is energized by the engine control switch.

Use an ohmmeter to test cavities A and 31. Cavity A is the ground side for the relay. Cavity 31 is the load side (glow plugs) of the relay.

The relay's load side can be checked for high resistance with an ohmmeter. The reading should be 0.1 ohms or less. If the resistance is higher, replace the relay.

GLOW PLUG CHECK

Tools Required:

J 39200 Digital Multimeter

J 35590 Inductive Current Clamp

The glow plugs can be tested in two ways:

1. Take an amperage draw test with an inductive pick-up lead at each glow plug. The rated amp draw should be 6.0 – 7.5 amps per glow plug. Or install the inductive current clamp around the glow plug power supply wire, take the systems current draw reading and divide the reading by the number of glow plugs in the system.
2. A continuity check can also be made with an ohmmeter between the glow plug lead and ground, with the buss bars removed (Figure 3). If no continuity exists, the glow plug will not heat and should be replaced.

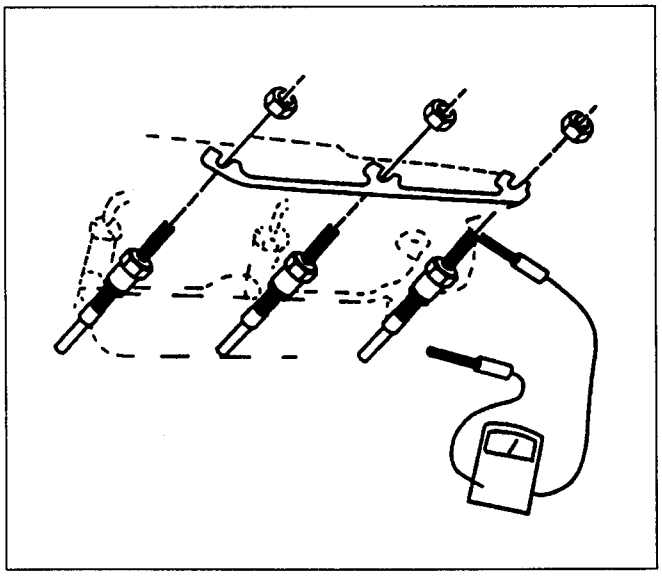


Figure 3 – Continuity Test

BUSS BAR CHECK

Tools Required:

J 39200 Digital Multimeter

J 35590 Inductive Current Clamp

Test for voltage at the buss bars with a voltmeter. Disconnect the negative battery cable and also disconnect the glow plug power supply wire from the buss bar (Figure 4). Connect the voltmeter positive lead to the glow plug power supply wire and the negative lead of the voltmeter to ground. Reconnect the negative battery cable. Turn the engine control switch to the "H" position. The reading should be over 10.5 volts.

A continuity check can be made with an ohmmeter between the buss bar and to the top of each glow plug. The reading should be 0.1 ohm or less. If not, check the glow plug nut contact to the buss bars. If the buss bars are corroded, clean them or replace them as necessary.

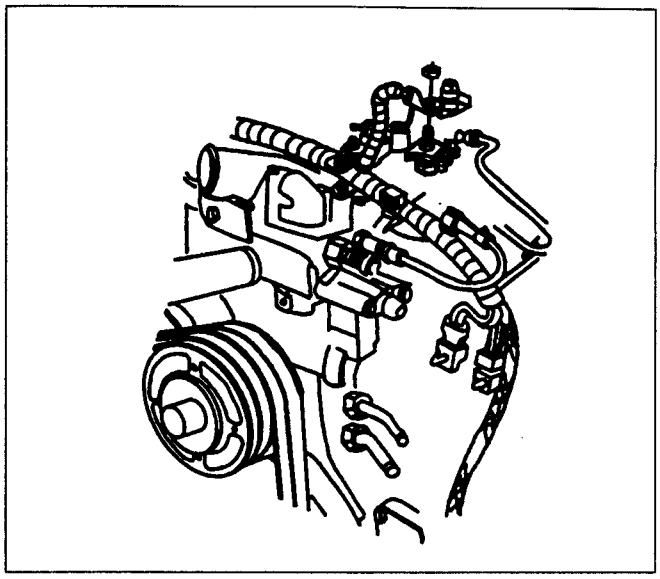


Figure 4 – Glow Plug Power Supply Wire

ON-VEHICLE SERVICE

GLOW PLUG RELAY

Remove or Disconnect

1. Negative battery cable. Refer to "Battery" in SECTION 6D1.
2. Console on the passenger side of instrument panel.
3. Glow plug relay.

Install or Connect

1. Glow plug relay
2. Console on the passenger side of instrument panel.
3. Negative battery cable.

GLOW PLUGS

Remove or Disconnect (Figures 1, 2 and 4)

1. Tilt the cab. Refer to "Cab Tilting" in SECTION 0A.
2. Negative battery cable. Refer to "Battery" in SECTION 6D1.
3. Glow plug power supply wire.
4. Glow plug buss bar.
5. Glow plug(s) from the cylinder head.

Install or Connect (Figures 1, 2 and 4)

1. Glow plug(s) to the cylinder head.

Tighten

- Glow plugs to cylinder head to 25 N·m (18 lb.ft.).

2. Glow plug buss bar.

Tighten

- Glow plugs to buss bar nut to 2 N·m (17 lb.in.).

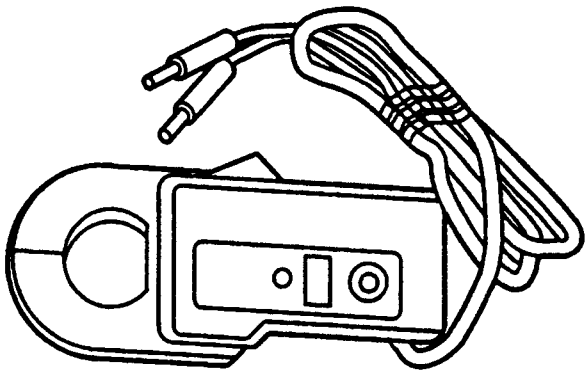
3. Glow plug power supply wire.
4. Negative battery cable.
5. Lower the cab.

SPECIFICATIONS

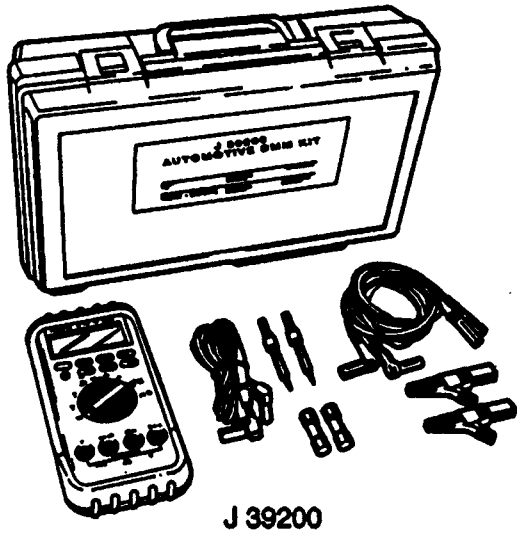
FASTENER TIGHTENING SPECIFICATIONS

Application	N·m	lb·ft	lb·in
Battery Top Post Terminal Nut	17	13	—
Buss Bar to Glow Plug Nut	2	—	17
Glow Plug to Cylinder Head	25	18	—

SPECIAL TOOLS



J 35590



J 39200

SECTION 6E

ENGINE EMISSION AND ELECTRICAL DIAGNOSIS

NOTICE: *Always use the correct fastener in the correct location. When you replace a fastener, use ONLY the exact part number for that application. ISUZU will call out those fasteners that require a replacement after removal. ISUZU will also call out the fasteners that require thread lockers or thread sealant. UNLESS OTHERWISE SPECIFIED, do not use supplemental coatings (paints, greases, or other corrosion inhibitors) on threaded fasteners or fastener joint interfaces. Generally, such coatings adversely affect the fastener torque and the joint clamping force, and may damage the fastener. When you install fasteners, use the correct tightening sequence and specifications. Following these instructions can help you avoid damage to parts and systems.*

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GENERAL DESCRIPTION

The emission and electrical control system operates on a twelve volt power supply with negative ground polarity. Each wire in the vehicle is of a specific size and has an identifying colored insulation.

These colors are indicated in wiring diagrams and will help in tracing circuits and making proper connections. Wire size is determined by load capacity and circuit length. Some wires are grouped together and taped. Such a grouping of wires is called a harness.

The harness use a split corrugated tube to protect the wires from the elements. Each circuit consists of the following:

- Power source – The battery and the alternator.
- Wires – To carry electrical current through the circuit.
- Fuses – To protect the circuit against current overload.
- Relays – To protect voltage drop between the battery and the circuit parts and to protect the switch points against burning.
- Switches – To open and close the circuit.
- Load – Any device, such as a light or a motor, which converts the electrical current into useful work.
- Ground – To allow the current to flow back to the power source.

In this manual, such electrical device is classified by system. For major parts shown on the circuit based on the circuit diagram for each system, 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 "OFF" position.
2) Disconnect the battery ground cable.
3) Disconnect the battery positive cable.

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

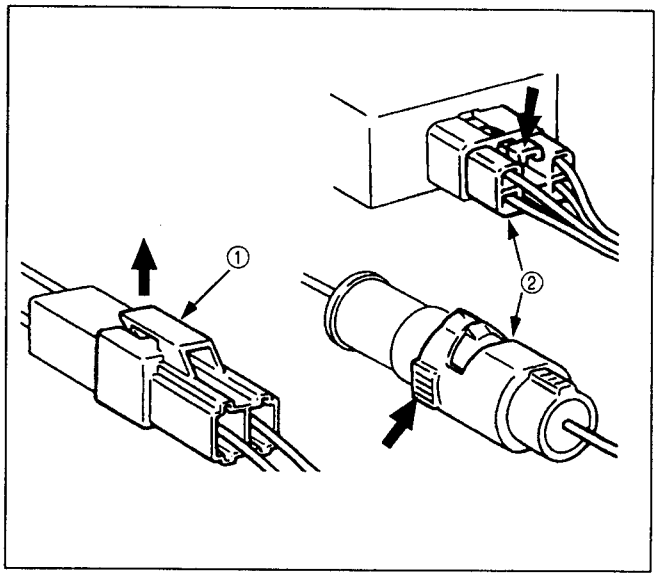
Follow the disconnecting procedure in the reverse order.

CAUTION:
Clean the battery terminal and apply a light coat of grease to prevent terminal corrosion.

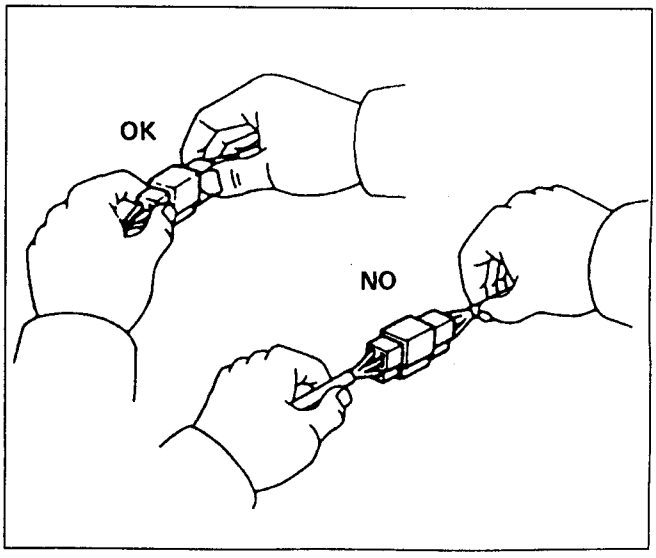
Connecting Handling

Disconnecting The Connectors

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.

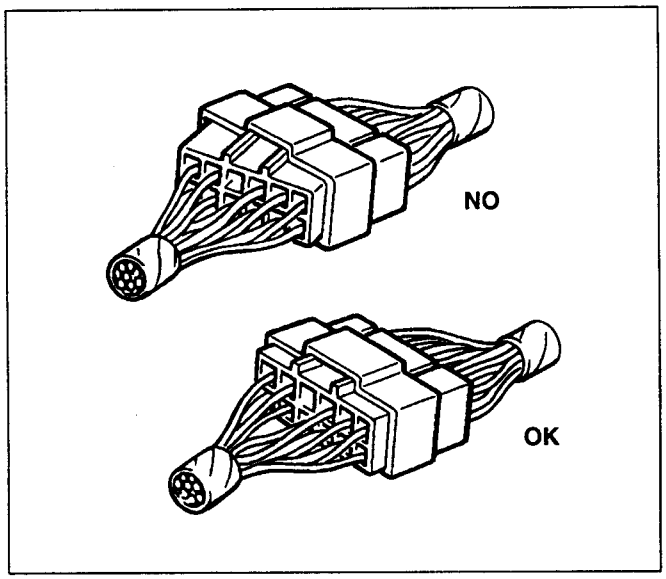


Never pull on the wires to separate the connectors. This will result in wire breakage.



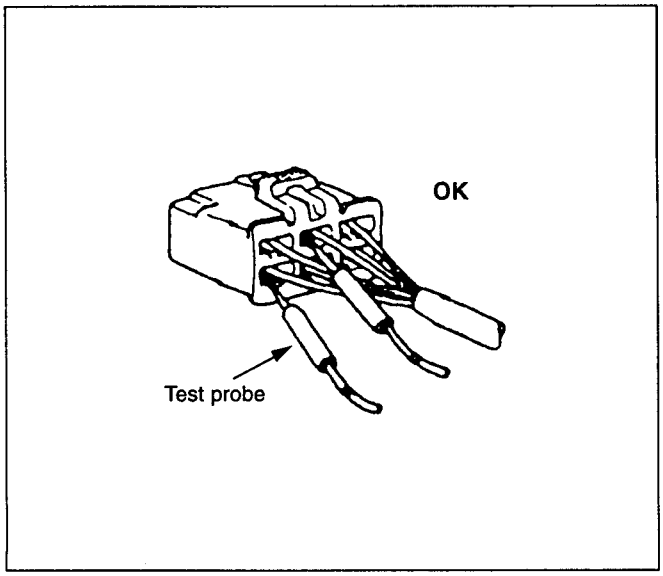
Connecting the Connector

Firmly grasp both sides (male and female) or 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.

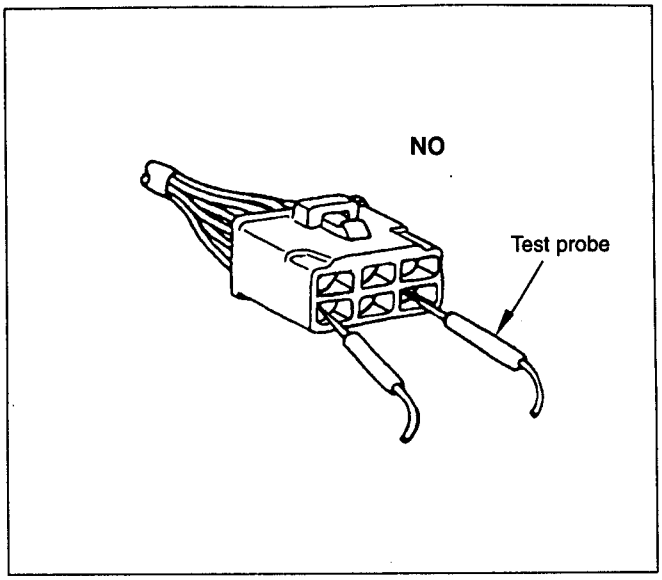


Connector Inspection

Use a circuit tester to check the connector for continuity. Insert the test probes from the connector wire side.

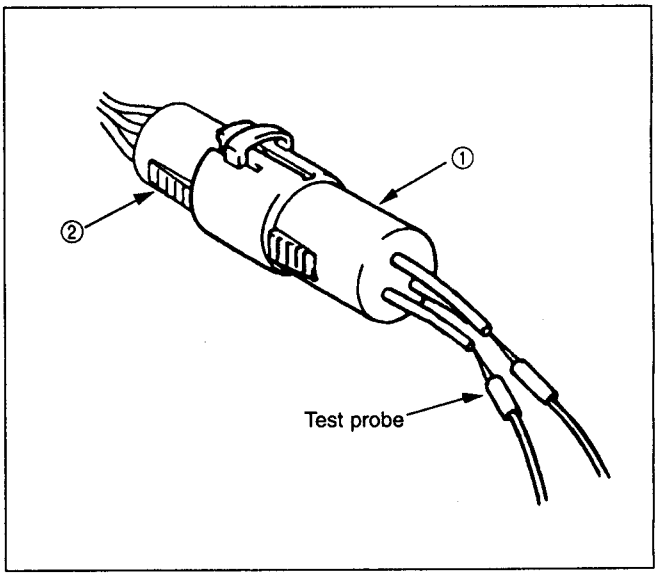


Never insert the circuit tester test probes into the connector open end to test the continuity. Broken or open connector terminals will result.



Waterproof Connector Inspection

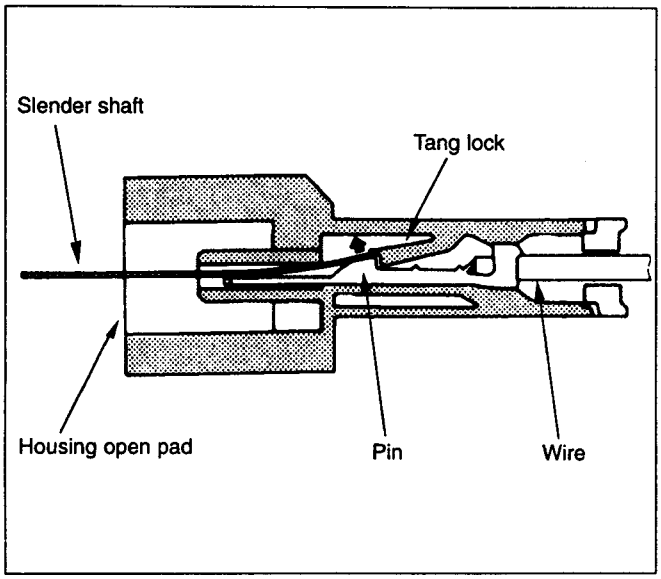
It is not possible to insert the test probes into the connector wire side of a waterproof connector. Use one side of a connector (1) with its wires cut to make the test. Connect the test connector (2) to the connector to be tested. Connect the test probes to the cut wires to check the connector continuity.



Connector Pin Removal

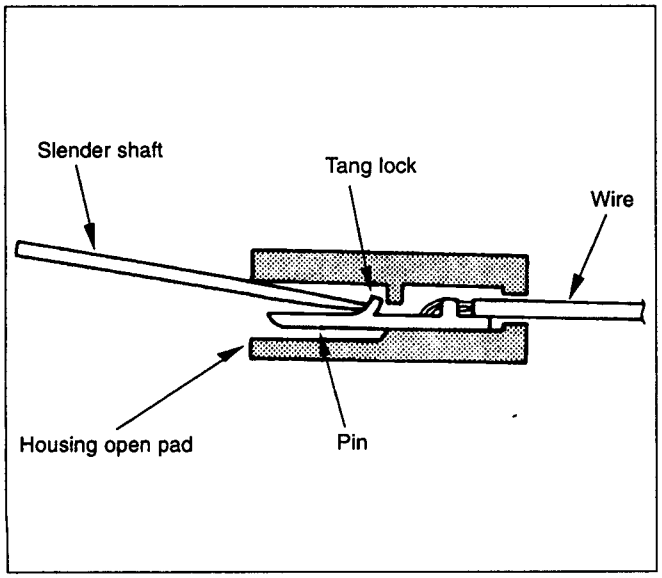
Connecting Housing Tang Lock Type

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.



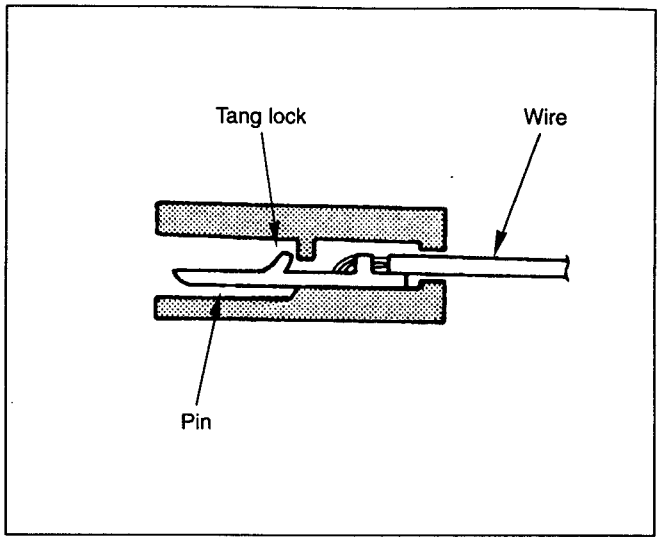
Pin Tang Lock Type

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.



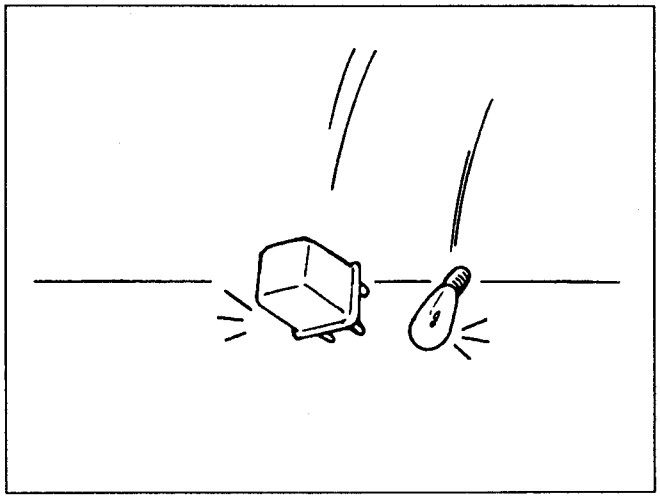
Connector Pin Insertion

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.



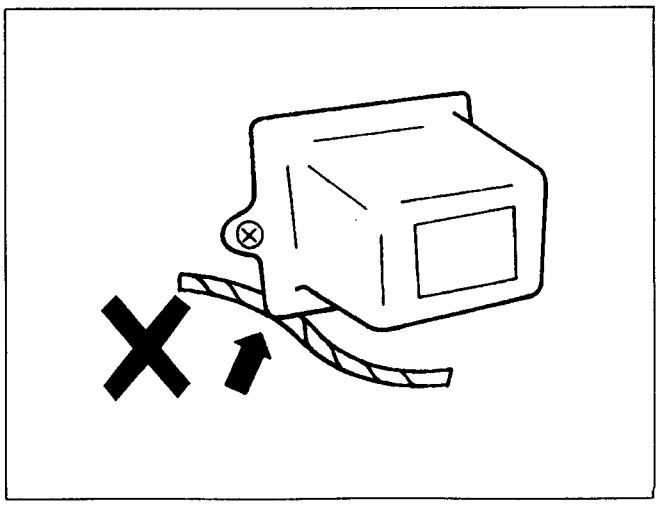
Parts Handling

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.



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**

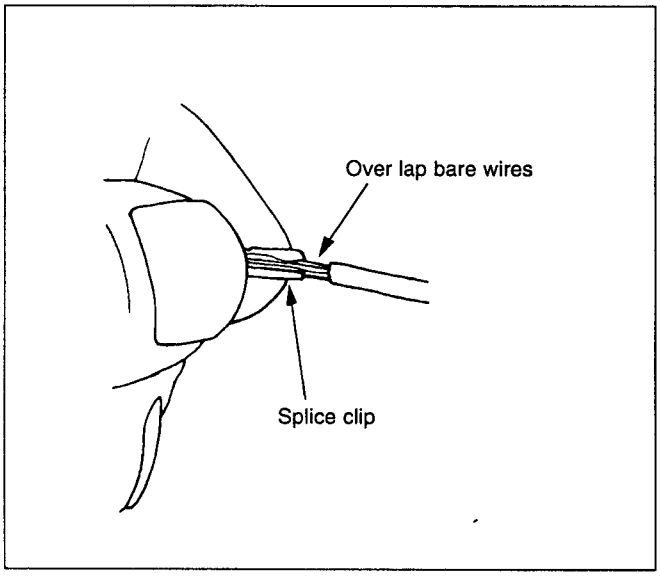
   Begin by cutting as little wire off the harness as possible. You may need the extra length of wire later if you decide to cut more wire off to change the location of a splice. You may have to adjust splice locations to make certain that each splice is at least 1-1/2 in (40 mm) away from other splices, harness branches, or connectors.

3. **Strip the insulation**

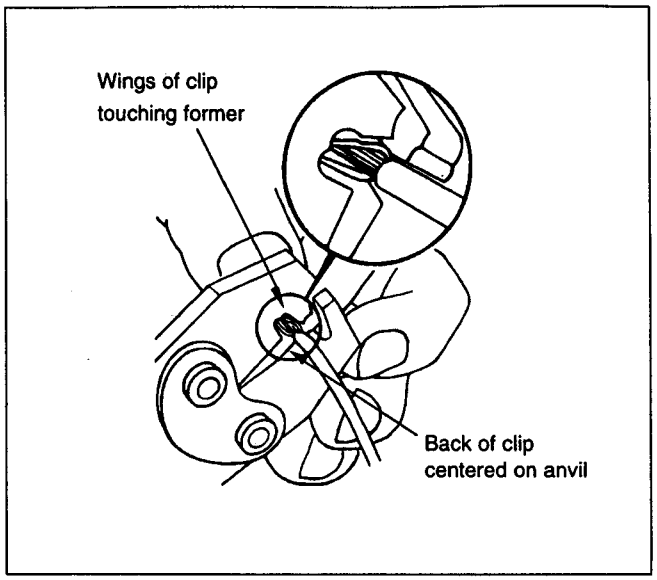
   When replacing a wire, use a wire of the same size as the original wire. Check the striped wire for nicks or cut stands. If the wire is damaged, repeat the procedure on a new section of wire. The two stripped wire ends should be equal in length.

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 you 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.



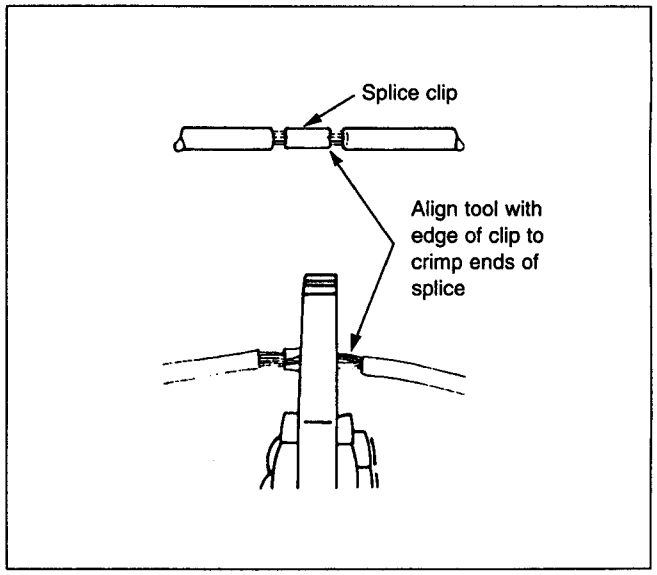
- Open the crimping tool to its full width and rest one handle on a firm flat surface.
- Center the back of the splice clip on the proper anvil and close the crimping tool to the point where the back of the splice clip touches the wings of the clip.
- Make sure that the clip and wires are still in the correct position. Then, apply steady pressure until the crimping tool closes.



Before crimping the ends of the clip, be sure that:

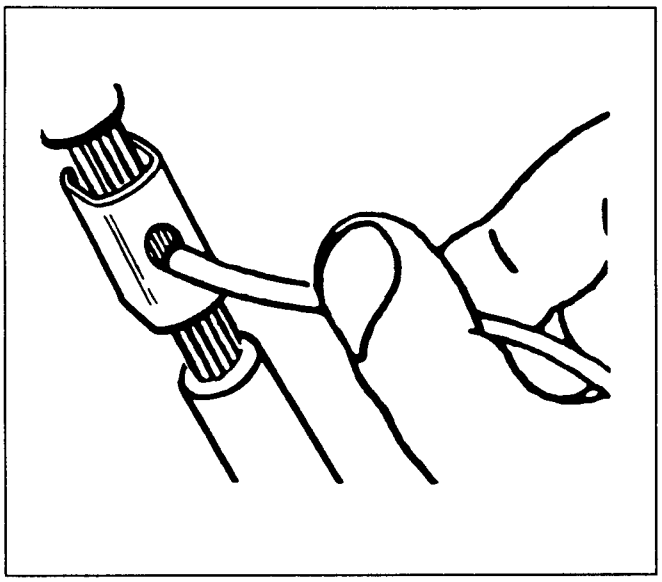
- The wires extend beyond the clip in each direction.
- No stands of wire are cut loose, and
- No insulation is caught under the clip.

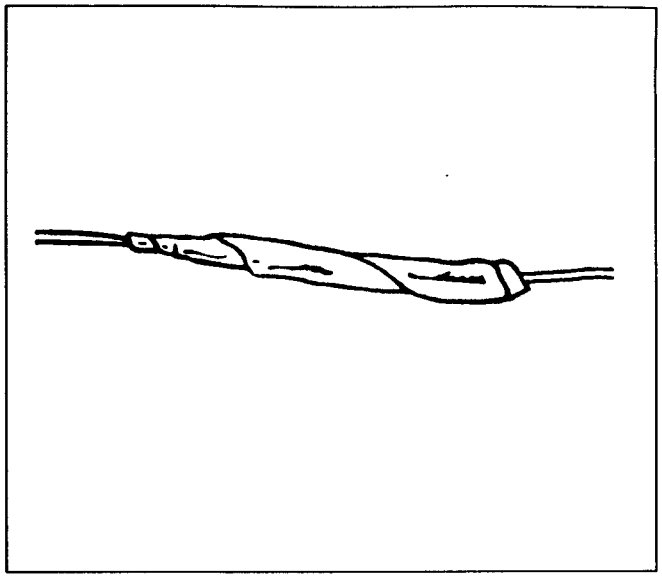
Crimp the splice again, once on each end. Do not let the crimping tool extend beyond the edge of the clip or you may damage or nick the wires.



5. **Solder**

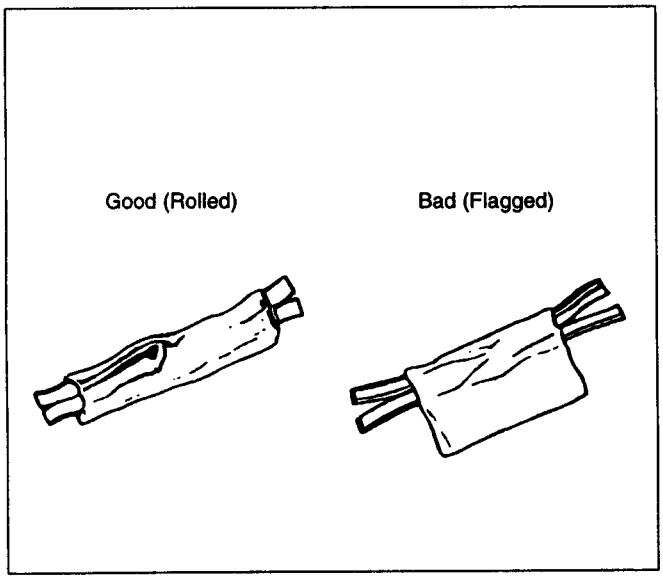
   Apply 60/40 rosin core colder to the opening in the back of the clip. Follow the manufacturer's instructions for the solder equipment you are using.





6. **Tape the Splice**

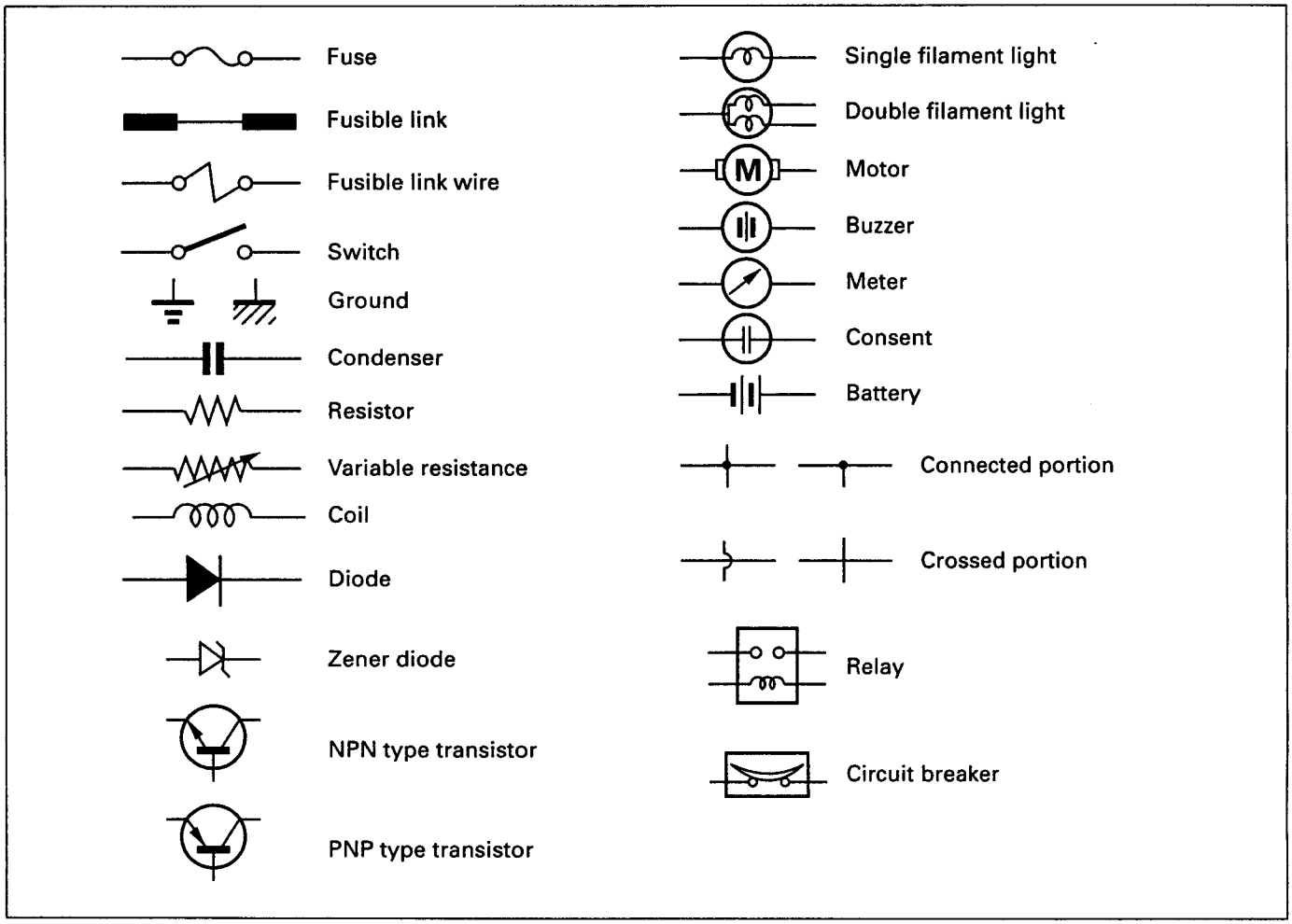
   Center and roll the splicing tape. The tape should cover the entire splice. Roll on enough tape to duplicate the thickness of the insulation on the existing wires. Do not flag the tape. Flagged tape may not provide enough insulation, and the flagged ends will tangle with the other wires in the harness.



   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



Abbreviations

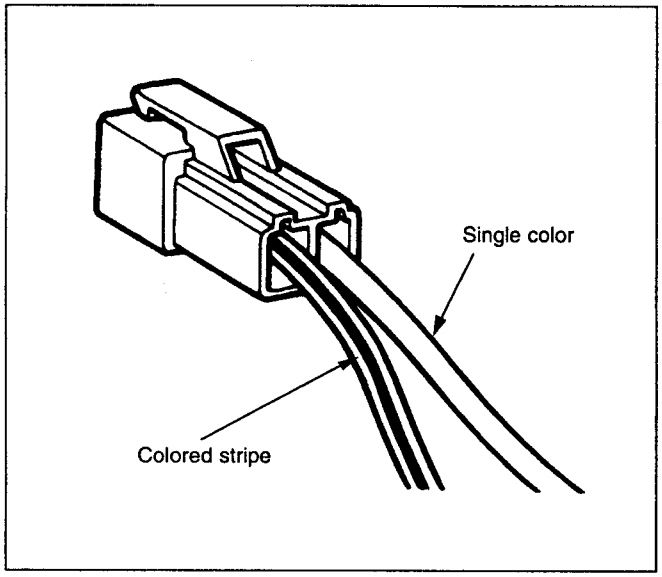
ABBREVIATION	MEANING	ABBREVIATION	MEANING
A	ANALOG	PATM	ATMOSPHERIC PRESSURE
A/C	AIR CONDITIONER	P BOOST	BOOST PRESSURE
A/D	ANALOG/DIGITAL	P/BRAKE	PARKING BRAKE
ACT	ACTUATOR	PC	COMMON RAIL PRESSURE
APP	ACCELERATOR PEDAL POSITION	PCV	PRESSURE CONTROL VALVE
		PGND	POWER GROUND (TO BODY EARTH)
BATT	BATTERY	PIN	PIN or TERMINAL
		P/L	PRESSURE LIMITER
CSS	COMBINED CHARGING SYSTEM	PRESS	PRESSURE
CONN	CONNECTOR	P/T	POWER TRAIN
C/U	CONTROL UNIT		
		Q ADJUSTMENT	INJECTION QUANTITY ADJUSTMENT
D	DIGITAL		
DC	DIRECT CURRENT		
D/CONN	DIAGNOSIS CONNECTOR	RH	RIGHT HAND (SIDE)
DTC	DIAGNOSTIC TROUBLE CODE	RHD	RIGHT HAND DRIVE
		R/L	RELAY
EC	ELECTRICAL CONTROL GOVERNOR	RR	REAR
ECM	ENGINE CONTROL MODULE	SIG	SIGNAL
EH	ELECTRICAL AND HYDRAULIC TIMER	SS	SPEED SENSOR
		SS C/U	SPEED SENSOR CONTROL UNIT
EXH	EXHAUST	STA	STARTER
		STD	STANDARD
FCCB	FUEL CONSUMPTION OF CYLINDER BALANCE	SW	SWITCH
FRT	FRONT	THA	ATMOSPHERIC TEMPERATURE
		THF	FUEL TEMPERATURE
G	PUMP POSITION	THW	WATER TEMPERATURE
GND	GROUND (BODY EARTH)	TICS	TIMING AND INJECTION RATE CONTROL SYSTEM
IN	INLET, INTAKE	TWV	TWO WAY VALVE
ISC	IDLE SPEED CONTROL		
		VCC	POWER SOURCE
LH	LEFT HAND (SIDE)		
LHD	LEFT HAND DRIVE	W/G	WASTE GATE
		W/L	WARNING LAMP
MAG	MAGNETIC		
ME/CONN	MEMORY ERASER CONNECTOR		
M/V	MAGNETIC VALVE		
N	NEUTRAL (TRANSMISSION GEAR)		
NE	CRANK POSITION		
N-TDC	NUMBERS TOP DEAD CENTER		
NR	NOISE REDUCER		
OFF	TURN OFF (SWITCH/LAMP)		
ON	TURN ON (SWITCH/LAMP)		
OPT	OPTION		

PARTS FOR ELECTRICAL CIRCUIT

Wiring

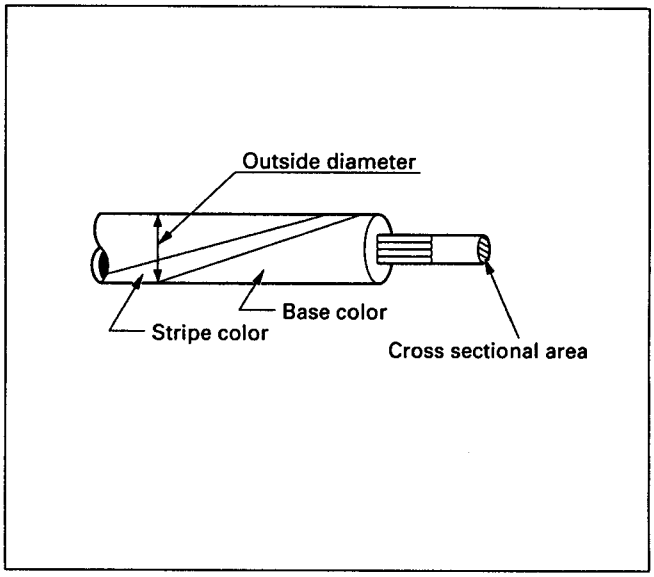
Wire Color

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.

Example: 0.5 G R



Abbreviations are used to indicate wire color within a circuit diagram.
Refer to the following table.

Wire Color Coding

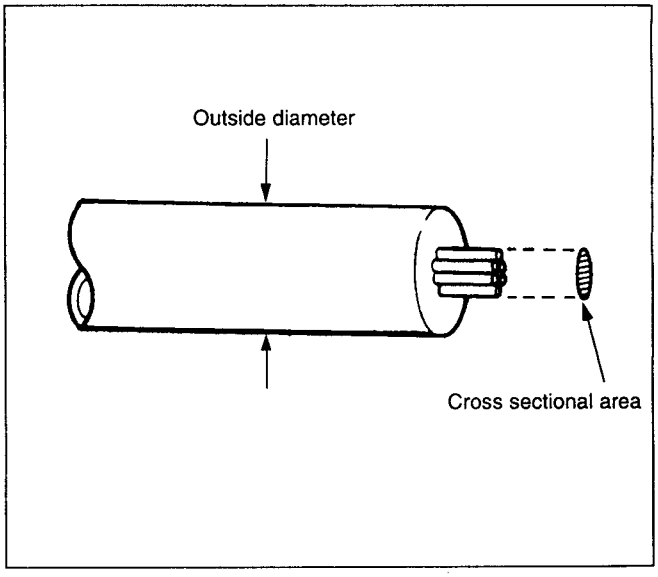
Color-coding	Meaning	Color-coding	Meaning
B	Black	Br	Brown
W	White	Lg	Light green
R	Red	Gr	Gray
G	Green	P	Pink
Y	Yellow	Sb	Sky blue
L	Blue	V	Violet
O	Orange		

Stripe Color Coding

Color coding	Base color	Stripe color
LB	Blue	Black
OB	Orange	Black
PB	Pink	Black
PG	Pink	Green
PL	Pink	Blue
RY	Red	Yellow
VR	Violet	Red
VW	Violet	White
YB	Yellow	Black
YB	Yellow	Green
YV	Yellow	Violet

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 JIS (Japanese Industrial Standard) (Nominal size means approximate cross sectional area)



Nominal size	Cross sectional area (mm^2)	Outside diameter (mm)	Allowable current (A)
0.3	0.372	1.8	9
0.5	0.563	2.0	12
0.85	0.885	2.2	16
1.25	1.287	2.5	21
2	2.091	2.9	28
3	3.296	3.6	37.5
5	5.227	4.4	53
8	7.952	5.5	67
15	13.36	7.0	75
20	20.61	8.2	97

Diagnosis

Strategy-Based Diagnostics

Strategy-Based Diagnostics

The strategy-based diagnostic is a uniform approach to repair all Electrical/Electronic (E/E) systems. The diagnostic flow can always be used to resolve an E/E system problem and is a starting point when repairs are necessary. The following steps will instruct the technician how to proceed with a diagnosis:

1. Verify the customer complaint.
   - To verify the customer complaint, the technician should know the normal operation of the system.
2. Perform preliminary checks.
   - Conduct a thorough visual inspection.
   - Review the service history.
   - Detect unusual sounds or odors.
   - Gather diagnostic trouble code information to achieve an effective repair.
3. Check bulletins and other service information.
   - This includes videos, newsletters, etc.
4. Refer to service information (manual) system check(s).
   - "System checks" contain information on a system that may not be supported by one or more DTCs. System checks verify proper operation of the system. This will lead the technician in an organized approach to diagnostics.
5. Refer to service diagnostics.

DTC Stored

Follow the designated DTC chart exactly to make an effective repair.

No DTC

Select the symptom from the symptom tables. Follow the diagnostic paths or suggestions to complete the repair. You may refer to the applicable component/system check in the system checks.

No Matching Symptom

1. Analyze the complaint.
2. Develop a plan for diagnostics.
3. Utilize the wiring diagrams and the theory of operation.

Call technical assistance for similar cases where repair history may be available. Combine technician knowledge with efficient use of the available service information.

Intermittents

Conditions that are not always present are called intermittents. To resolve intermittents, perform the following steps:

1. Observe history DTCs, DTC modes, and freeze frame data.
2. Evaluate the symptoms and the conditions described by the customer.
3. Use a check sheet or other method to identify the circuit or electrical system component.
4. Follow the suggestions for intermittent diagnosis found in the service documentation.

Most scan tool, such as the Tech II have data-capturing capabilities that can assist in detecting intermittents.

No Trouble Found

This condition exists when the vehicle is found to operate normally. The condition described by the customer may be normal. Verify the customer complaint against another vehicle that is operating normally. The condition may be intermittent. Verify the complaint under the conditions described by the customer before releasing the vehicle.

1. Re-examine the complaint
   When the Complaint cannot be successfully found or isolated, a re-evaluation is necessary. The complaint should be re-verified and could be intermittent as defined in Intermittents, or could be normal.
2. Repair and verify.
   After isolating the cause, the repairs should be made. Validate for proper operation and verify that the symptom has been corrected. This may involve road testing or other methods to verify that the complaint has been resolved under the following conditions:
   - Conditions noted by the customer.
   - If a DTC was diagnosed, verify a repair by duplicating conditions present when the DTC was set as noted in the Failure Records or Freeze Frame data.

Verifying Vehicle Repair

Verification of the vehicle repair will be more comprehensive for vehicles with OBD system diagnostics. Following a repair, the technician should perform the following steps:

IMPORTANT: Follow the steps below when you verify repairs on OBD systems. Failure to follow these steps could result in unnecessary repairs.

1. Review and record the Failure Records and the Freeze Frame data for the DTC which has been diagnosed (Freeze Frame data will only be stored for an A or B type diagnostic and only if the MIL ("Check Engine Soon" lamp) has been requested).
2. Clear the DTC(S).
3. Operate the vehicle within conditions noted in the Failure Records and Freeze Frame data.
4. Monitor the DTC status information for the specific DTC which has been diagnosed until the diagnostic test associated with that DTC runs.

WARNING: HIGH VOLTAGE IS APPLIED TO THE HARNESS CONNECTED TO ECM COMMON 1, COMMON 2, AND TWV No. 1 TO No. 6. SUFFICIENT CARE SHOULD BE TAKEN NOT TO GET AN ELECTRIC SHOCK.

General Service Information

OBD Serviceability Issues

The list of non-vehicle faults that could affect the performance of the OBD system has been complied. These non-vehicle faults vary from environmental conditions to the quality of fuel used.

The illumination of the MIL ("Check Engine Soon" lamp) due to a non-vehicle fault could lead to misdiagnosis of the vehicle, increased warranty expense and customer dissatisfaction. The following list of non-vehicle faults does not include every possible fault and may not apply equally to all product lines.

Poor Vehicle Maintenance

The sensitivity of OBD diagnostics will cause the MIL to turn on if the vehicle is not maintained properly. Restricted air filters, fuel filters, and crankcase deposits due to lack of oil changes or improper oil viscosity can trigger actual vehicle faults that were not previously monitored prior to OBD. Poor vehicle maintenance can not be classified as a "non-vehicle fault", but with the sensitivity of OBD diagnostics, vehicle maintenance schedules must be more closely followed.

Severe Vibration

The Misfire diagnostic measures small changes in the rotational speed of the crankshaft. Severe driveline vibrations in the vehicle, such as caused by an excessive amount of mud on the wheels, can have the same effect on crankshaft speed as misfire.

Maintenance Schedule

Refer to the Maintenance Schedule.

Visual/Physical Engine Compartment Inspection

Perform a careful visual and physical engine compartment inspection when performing any diagnostic procedure or diagnosing the cause of an emission test failure. This can often lead to repairing a problem without further steps. Use the following guidelines when performing a visual/physical inspection:

- Inspection all vacuum hoses for punches, cuts, disconnects, and correct routing.
- Inspect hoses that are difficult to see behind other components.
- Inspect all wires in e engine compartment for proper connections, burned or chafed spots, pinched wires, contact with sharp edges or contact with hot exhaust manifolds or pipes.

Basic Knowledge of Tools Required

NOTE: Lack of basic knowledge of this powertrain when performing diagnostic procedures could result in an incorrect diagnosis or damage to powertrain components. Do not attempt to diagnose a powertrain problem without this basic knowledge.

A basic understanding of hand tools is necessary to effectively use this section of the Service Manual.

Serial Data Communications

Class II Serial Data Communications

This vehicle utilizes the "Class II" communication system. Each bit of information can have one of two lengths: long or short. This allows vehicle wiring to be reduced by transmitting and receiving multiple signals over a single wire. The messages carried on Class II data streams are also prioritized. If two messages attempt to establish communications on the data line at the same time, only the message with higher priority will continue. The device with the lower priority message must wait. The most significant result is that it provides scan tool manufacturers with the capability to access data from any make or model vehicle that is sold.

The data displayed on the other scan tool will appear the same, with some exceptions. Some scan tools will only be able to display certain vehicle parameters as values that are a coded representation of the true or actual value.

On-Board Diagnostic (OBD)

On-Board Diagnostic Tests

A diagnostic test is a series of steps, the result of which is a pass or fail reported to the diagnostic executive. When a diagnostic test reports a pass result, the diagnostic executive records the following data:

- The diagnostic test has been completed since the last ignition cycle.
- The diagnostic test has passed during the current ignition cycle.
- The fault identified by the diagnostic test is not currently active.

When a diagnostic test reports a fail result, the diagnostic executive records the following data:

- The diagnostic test has been completed since the last ignition cycle.
- The fault identified by the diagnostic test is currently active.
- The fault has been active during this ignition cycle.
- The operating conditions at the time of the failure.

Remember, a fuel trim DTC may be triggered by a list of vehicle faults.

Passive and Active Diagnostic Tests

A passive test is a diagnostic test which simply monitors a vehicle system or component. Conversely, an active test, actually takes some sort of action when performing diagnostic functions, often in response to a failed passive test.

Intrusive Diagnostic Tests

This is any on-board test run by the Diagnostic Management System which may have an effect on vehicle performance or emission levels.

Warm-Up Cycle

A warm-up cycle means that engine at temperature must reach a minimum of 70°C (160°F) and rise at least 22°C (40°F) over the course of a trip.

Freeze Frame

Freeze Frame is an element of the Diagnostic Management System which stores various vehicle information at the moment an emissions-related fault is stored in memory and when the MIL is commanded on.

These data can help to identify the cause of a fault. Refer to Storing And Erasing Freeze Frame Data for more detailed information.

Failure Records

Failure Records data is an enhancement of the OBD Freeze Frame feature. Failure Records store the same vehicle information as does Freeze Frame, but will store that information for any fault which is stored in on-board memory, while Freeze Frame stores information only for emission-related faults that command the MIL on.

Common OBD Terms

Diagnostic

When used as a noun, the word diagnostic refers to any on-board test run by the vehicle's Diagnostic Management System. A diagnostic is simply a test run on a system or component to determine if the system or component is operating according to specification.

Enable Criteria

The term "enable criteria" is engineering language for the conditions necessary for a given diagnostic test to run. Each diagnostic has a specific list of conditions which must be met before the diagnostic will run. "Enable criteria" is another way of saying "conditions required".

Trip

Technically, a trip is a key on-run-key off cycle in which all the enable criteria for a given diagnostic are met, allowing the diagnostic to run. Unfortunately, this concept is not quite that simple. A trip is official when all the enable criteria for a given diagnostic are met. But because the enable criteria vary from one diagnostic to another, the definition of trip varies as well. Some diagnostic are run when the vehicle is at operating temperature, some when the vehicle first start up; some require that the vehicle be cruising at a steady highway speed, some run only when the vehicle is idle. Some run only immediately following a cold engine start-up.

A trip then, is defined as a key on-run-key off cycle in which the vehicle was operated in such a way as to satisfy the enables criteria for a given diagnostic, and this diagnostic will consider this cycle to be one trip. However, another diagnostic with a different set of enable criteria (which were not met) during this driving event, would not consider it a trip. No trip will occur for that particular diagnostic until the vehicle is driven in such a way as to meet all the enable criteria.

The Diagnostic Executive

The Diagnostic Executive is a unique segment of software which is designed to coordinate and prioritize the diagnostic procedures as well as define the protocol for recording and displaying their results. The main responsibilities of the Diagnostic Executive are listed as following:

- Commanding the MIL ("Check Engine Soon" lamp) on and off
- DTC logging and clearing
- Freeze Frame data for the first emission related DTC recorded
- Non-emission related Service Lamp (future)
- Operating conditions Failure Records buffer, (the number of records will vary)
- Current status information on each diagnostic
- System Status

The Diagnostic Executive records DTCs and turns on the MIL when emission-related faults occur. It can also turn off the MIL if the conditions cease which caused the DTC to set.

Diagnostic Information

The diagnostic charts and functional checks are designed to locate a faulty circuit or component through a process of logical decisions. The charts are prepared with the requirement that the vehicle functioned correctly at the time of assembly and that there are not multiple faults present.

There is a continuous self-diagnosis on certain control functions. This diagnostic capability is complemented by the diagnostic procedures contained in this manual. The language of communicating the source of the malfunction is a system of diagnostic trouble codes. When a malfunction is detected by the control module, a diagnostic trouble code is set and the Malfunction Indicator Lamp (MIL) is illuminated.

Malfunction Indicator Lamp (MIL)

The Malfunction Indicator Lamp (MIL) looks the same as the MIL you are already familiar with ("Check Engine Soon" lamp). However, OBD requires that the it illuminate under a strict set of guide lines.

Basically, the MIL is turned on when the ECM detects a DTC that will impact the vehicle emissions.

The MIL is under the control of the Diagnostic Executive. The MIL will be turned on if an emissions-related diagnostic test indicates a malfunction has occurred. It will stay on until the system or component passes the same test, for three consecutive trips, with no emissions related faults.

Extinguishing the MIL

When the MIL is on, the Diagnostic Executive will turn off the MIL after three consecutive trips that a "test passed" has been reported for the diagnostic test that originally caused the MIL to illuminate.

Although the MIL has been turned off, the DTC will remain in the ECM memory (both Freeze Frame and Failure Records) until forty (40) warm-up cycles after no faults have been completed.

If the MIL was set by either a fuel trim or misfire-related DTC, additional requirements must be met. In addition to the requirements stated in the previous paragraph, these requirements are as follows:

- The diagnostic tests that are passed must occur with 375 RPM of the RPM data stored at the time the last test failed.
- Plus or minus ten (10) percent of the engine load that was stored at the time the last failed.
- Similar engine temperature conditions (warmed up or warming up) as those stored at the time the last test failed.

Meeting these requirements ensures that the fault which turned on the MIL has been corrected.

The MIL is on the instrument panel and has the following function:

- It informs the driver that a fault affects vehicle emission levels has occurred and that the vehicle should be taken for service as soon as possible.
- As a bulb and system check, the MIL will come "ON" with the key "ON" and the engine not running. When the engine is started, the MIL will turn "OFF".
- When the MIL remains "ON" while the engine is running, or when a malfunction is suspected due to a driveability or emissions problem, a Powertrain On-Board

Diagnostic (OBD) System Check must be performed. The procedures for these checks are given in On-Board Diagnostic (OBD) System Check. These checks will expose faults may not be detected if other diagnostics are performed first.

DTC Types

Each DTC is directly related to a diagnostic test. The Diagnostic Management System sets DTC based on the failure of the tests during a trip or trips. Certain tests must fail two (2) consecutive trips before the DTC is set.

- Type A
  - Emissions related
  - Requests illumination of the MIL of the first trip with a fail
  - Stores a History DTC on the first trip with a fail
  - Stores a Freeze Frame (if empty)
  - Stores a Fail Record
  - Updates the Fail Record each time the diagnostic test fails
- Type B (Type B non-emissions related are not utilized on certain vehicle applications)
  - Non-Emissions related
  - Does not request illumination of any lamp
  - Does not stores a History DTC on the first trip with a fail
  - Does not store a Freeze Frame
  - Does not stores Fail Record when test fails

Storing and Erasing Freeze Frame Data and Failure Records

The data captured is called Freeze Frame data. The Freeze Frame data is very similar to a single record of operating conditions. Whenever the MIL is illuminated, the corresponding record of operating conditions is recorded to the Freeze Frame buffer.

Freeze Frame data can only be overwritten with data associated with a misfire or fuel trim malfunction. Data from these faults take precedence over data associated with any other fault. The Freeze Frame data will not be erased unless the associated history DTC is cleared.

Each time a diagnostic test reports a failure, the current engine operating conditions are recorded in the Failure Records buffer. A subsequent failure will update the recorded operating conditions.

Intermittent Malfunction Indicator Lamp

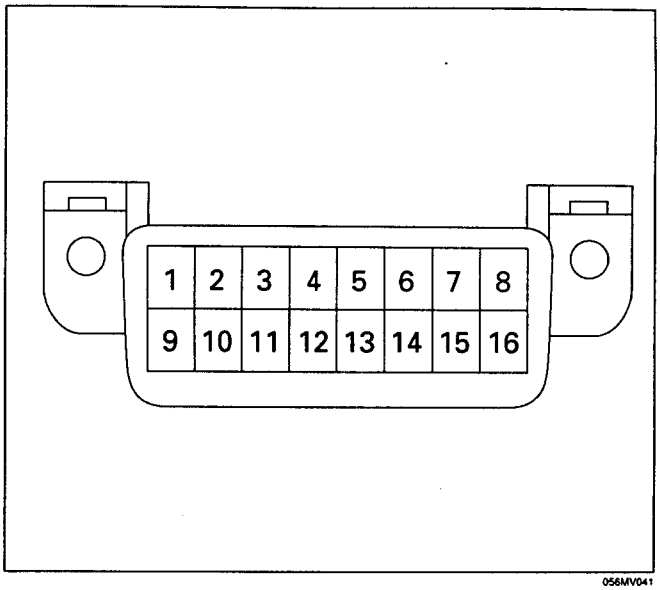
In the case of an "intermittent" fault, the MIL may illuminate and then (after three trips) go "OFF". However, the corresponding diagnostic trouble code will be stored in the memory. When unexpected diagnostic trouble codes appear, check for an intermittent malfunction.

A Diagnostic trouble code may reset. Consult the "Diagnostic Aids" associated with the diagnostic trouble code. A physical inspection of the applicable sub-system most often will resolve the problem.

Data Link Connector (DLC)

The provision for communication with the control module is the Data Link Connector (DLC). It is located at the lower left of the instrument panel behind a small square cover. The DLC is used to connect to a scan tool. Some common uses of the scan tool are listed below:

- Identifying stored Diagnostic Trouble Codes (DTCs).
- Clearing DTCs.
- Performing output control tests.
- Reading serial data.



Decimal/Binary/Hexadecimal Conversions

All scan tool manufacturer will display a variety of vehicle information which will aid in repairing the vehicle. Some scan tools will display encoded messages which will aid in determining the nature of the concern. The method of encoding involves the use of a two additional numbering systems: Binary and Hexadecimal.

The binary number system has a base of two numbers. Each digit is either a 0 or a 1. A binary number is an eight digit number and is read from right to left. Each digit has a position number with the farthest right being the 0 position and the farthest left being the 7 position. The 0 position, when displayed by a 1, indicates 1 in decimal. Each position to the left is double the previous position and added to any other position values marked as a 1.

A hexadecimal system is composed of 16 different alpha numeric characters. The alpha numeric characters used are numbers 0 through 9 and letters A through F. The hexadecimal system is the most natural and common approach for scan tool manufacturers to display data represented by binary numbers and digital code.

Verifying Vehicle Repair

Verification of vehicle repair will be more comprehensive for vehicles with OBD system diagnostic. Following a repair, the technician should perform the following steps:

1. Review and record the Fail Records and/or Freeze Frame data for the DTC which has been diagnosed (Freeze Frame data will only be stored for an A or B type diagnostic and only if the MIL has been requested).
2. Clear DTC(s).
3. Operate the vehicle within conditions noted in the Fail Records and/or Freeze Frame data.
4. Monitor the DTC status information for the specific DTC which has been diagnosed until the diagnostic test associated with that DTC runs.

Following these steps are very important in verifying repairs on OBD systems. Failure to follow these steps could result in unnecessary repairs.

Reading Diagnostic Trouble Codes Using A Tech 2 or Other Scan Tool

The procedure for reading diagnostic trouble code(s) is to used a diagnostic scan tool. When reading DTC(s), follow instructions supplied by tool manufacturer.

Clearing Diagnostic Trouble Codes

IMPORTANT: Do not clear DTCs unless directed to do so by the service information provided for each diagnostic procedure. When DTCs are cleared, the Freeze Frame and Failure Record data which may help diagnose an intermittent fault will also be erased from memory.

In the fault that caused the DTC to be stored into memory has been corrected, the Diagnostic Executive will begin to count the "warm-up" cycles with no further faults detected, the DTC will automatically be cleared from the ECM memory.

To clear Diagnostic Trouble Codes (DTCs), use the diagnostic scan tool "clear DTCs" or "clear information" function. When clearing DTCs follow instructions supplied by the tool manufacturer.

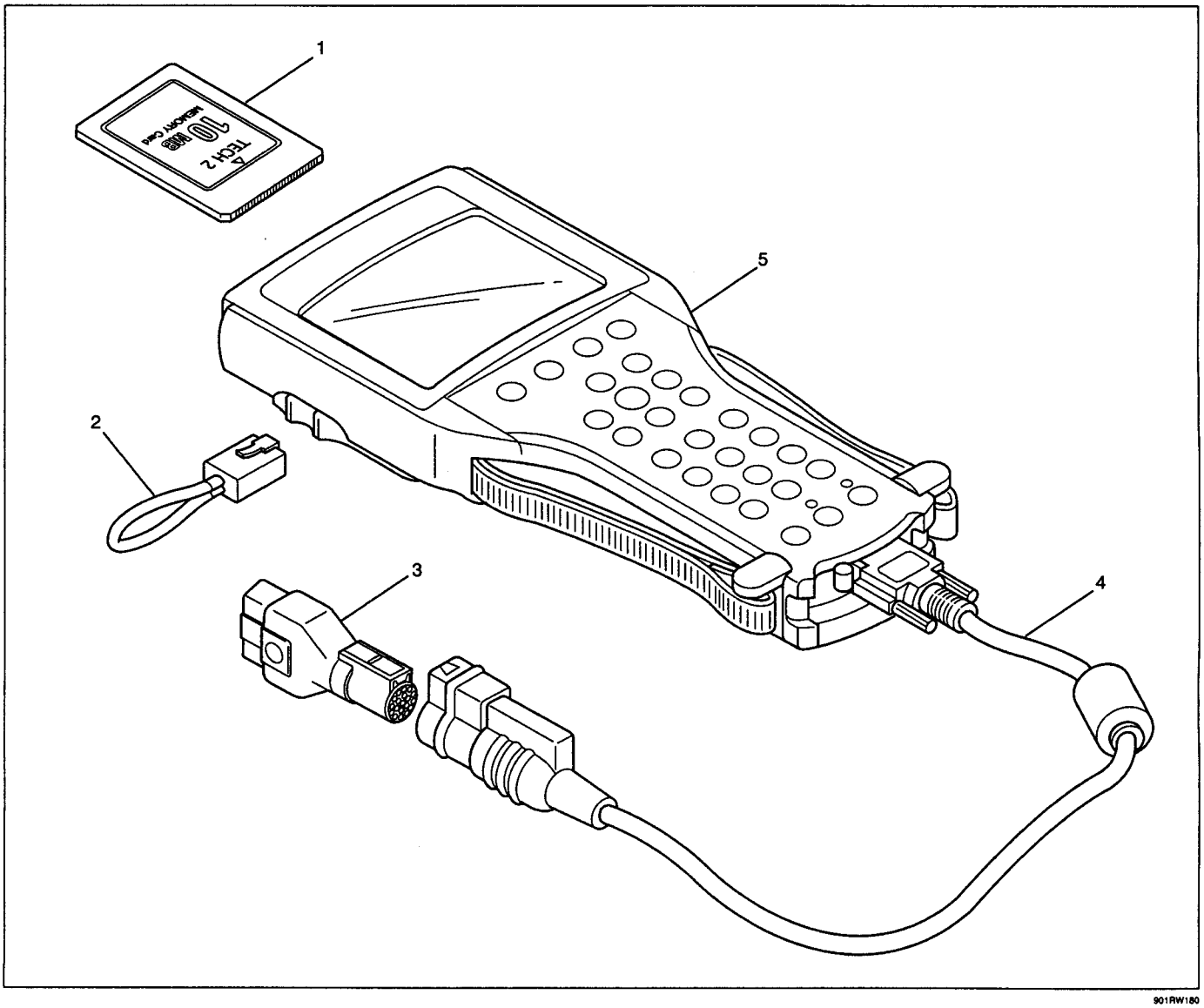
When a scan tool is not available, DTCs can also be cleared by disconnecting one of the following sources for at least thirty (30) seconds.

NOTE: To prevent system damage, the ignition key must be "OFF" when disconnecting or reconnecting battery power.

- The power source to the control module. Examples: fuse, pigtail at battery ECM connectors etc.
- The negative battery cable. (Disconnecting the negative battery cable will result in the loss of other on-board memory data, such as preset radio tuning).

Tech 2 Scan Tool

From 98 MY, Isuzu Dealer service departments are recommended to use Tech 2. Refer to Tech 2 scan tool user guide.



901RW180

Legend

(1) PCMCIA Card
(2) RS 232 Loop Back Connector
(3) SAE 16/19 Adaptor
(4) DLC Cable
(5) Tech-2

Getting Started

- Before operating the Isuzu PCMCIA card with the Tech 2, the following steps must be performed:
  1. The Isuzu 98 System PCMCIA card (1) inserts into the Tech 2 (5).
  2. Connect the SAE 16/19 adapter (3) to the DLC cable (4).
  3. Connect the DLC cable to the Tech 2 (5).
  4. Make sure the vehicle ignition key is off.
  5. Connect the Tech 2 SAE 16/19 adapter to the vehicle ALDL/DLC.
  6. The vehicle ignition turns on.
  7. Verify the Tech 2 power up display.

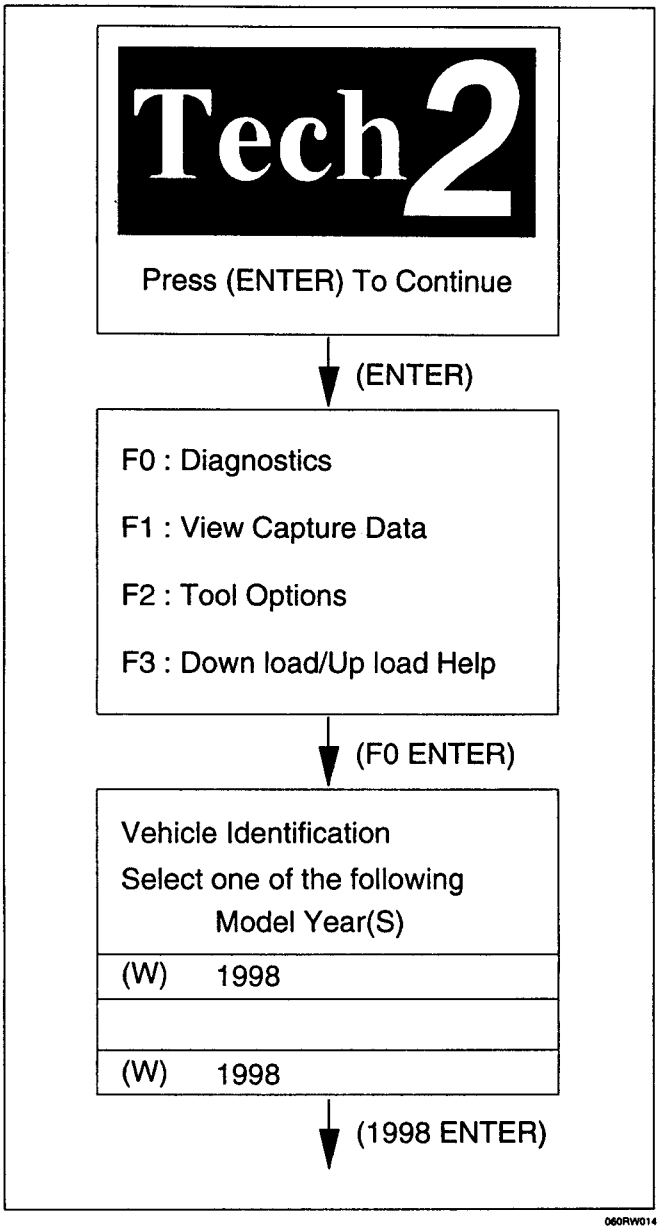


012RW105

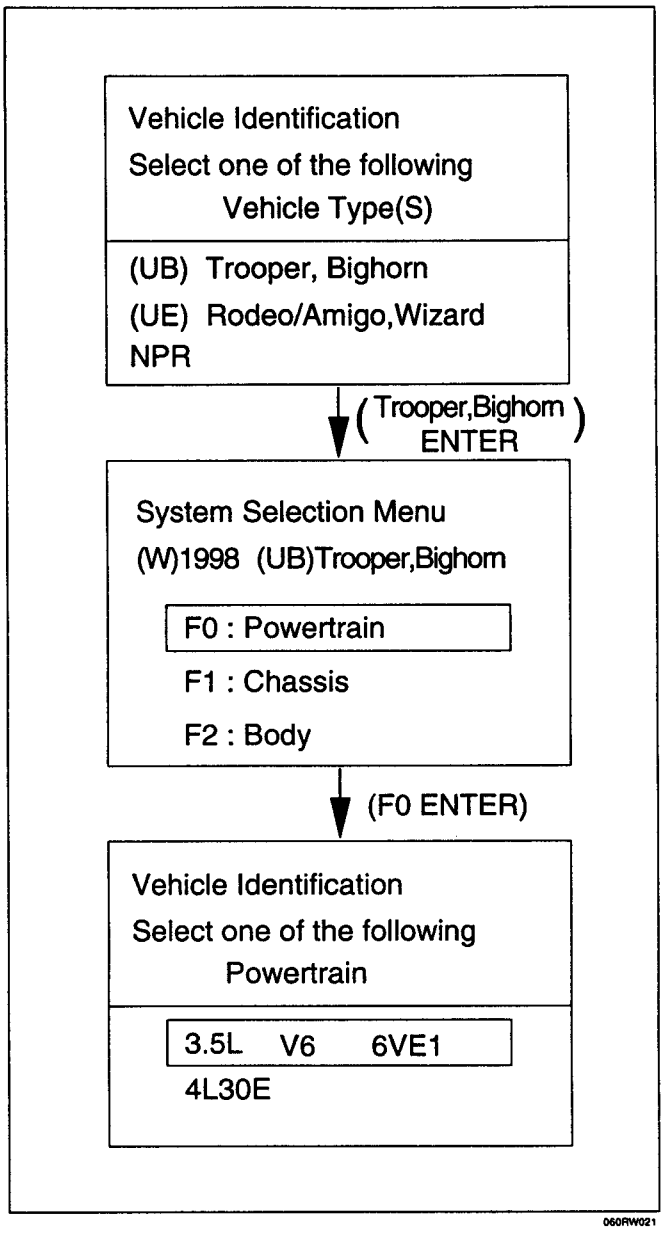
NOTE: The RS232 Loop back connector is only to use for diagnosis of Tech 2 and refer to user guide of the Tech 2.

Operating Procedure (For example)

The power up screen is displayed when you power up the tester with the Isuzu systems PCMCIA card. Follow the operating procedure below.



060RW014



Menu

- The following table shows, which functions are used the available equipment versions.

F0: Diagnostic Trouble Codes
- F0: Read DTC Info Ordered By Priority
- F1: Clear DTC Information
- F2: DTC Information
  - F0: History
  - F1: MIL SVS or Message Requested
  - F2: Last Test Failed
  - F3: Test Failed Since Code Cleared
  - F4: Not Ran Since Code Cleared
  - F5: Failed This Ignition

F1: Data Display
- F0: Engine Data
- F1: Misfire Data
- F2: O2 Sensor Data

F3: Miscellaneous Tests
- F0: Lamp
  - F0: MIL
  - F1: Transmission Checklight
  - F2: Upshift Lamp
  - F3: Low Fuel Lamp
- F1: Relays
  - F1: A/C Relay
  - F2: Fuel Pump Relay
- F2: EVAP
  - F1: Purge Solenoid
  - F2: Vent Solenoid
- F3: IAC System
  - F1: RPM Control
  - F2: IAC Control
  - F3: IAC Reset
- F4: Fuel System
  - F1: Fuel Trim Reset
  - F2: Fuel Gauge Output
- F5: Injector Balance
- F6: EGR
- F7: Service Bay Test

DTC Modes

On OBD has five options available in the scan tool DTC mode to display the enhanced information available. A description of the new modes, DTC Info and Specific DTC, follows. After selecting DTC, the following menu appears:

- DTC Info
- Specific DTC
- Freeze Frame
- Fail Records (not all applications)
- Clear Info

The following is a brief description of each of the sub menus in DTC Info and Specific DTC. The order in which they appear here is alphabetical and not necessarily the way they will appear on the scan tool.

DTC Information Mode

Use the DTC info mode to search for a specific type of store DTC information. There are seven choices. The service manual may instruct the technician to test for DTCs in a certain manner. Always follow published service procedures.

To get a complete description of any status, press the "Enter" key before pressing the desired F-key. For example, pressing "Enter" then an F-key will display a definition of the abbreviated scan tool status.

DTC Status

This selection will display any DTCs that have not run during the current ignition cycle or have reported a test failure during this ignition up to a maximum of 40 DTCs. DTC tests which run and pass will cause that DTC number to be removed from the scan tool screen.

Fail This Ignition

This selection will display all DTCs that have failed during the preset ignition cycle.

History

This selection will display only DTCs that are stored in the ECM's history memory. It will not display Type B DTCs that have not requested the MIL. It will display all type A DTCs that have requested the MIL and have failed within the last 40 warm-up cycles.

Last Test Failed

This selection will display only DTCs that have failed the last time the test ran. The last test may have run during a previous ignition cycle if a type A DTC is displayed.

Not Run Since Code Clear

This option will display up to 40 DTCs that have not run since the DTCs were last cleared. Since any displayed DTCs have not run, their condition (passing or failing) is unknown.

Test Failed Since Code Clear

This selection will display all active and history DTCs that have reported a test failure since the last time DTCs were cleared. DTCs that last failed more than 40 warm-up cycles before this option is selected will not be displayed.

System Parts Description

Injection Pump

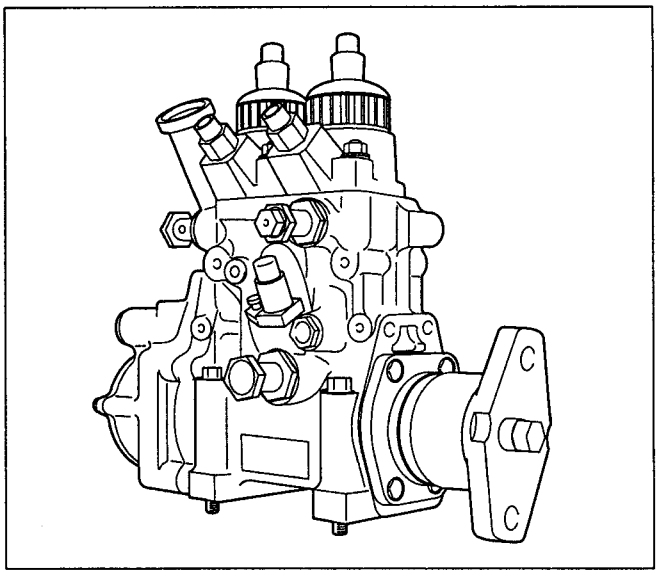
The injection pump comprised pump proper, feed pump, and coupling.

Engine output goes to idle gear, air compressor, and drive gear and is transmitted through coupling to the camshaft of injection pump.

Plunger is lubricated and cooled with fuel, be sure not to use any fuel other than specified one.

Injection Pump Unit

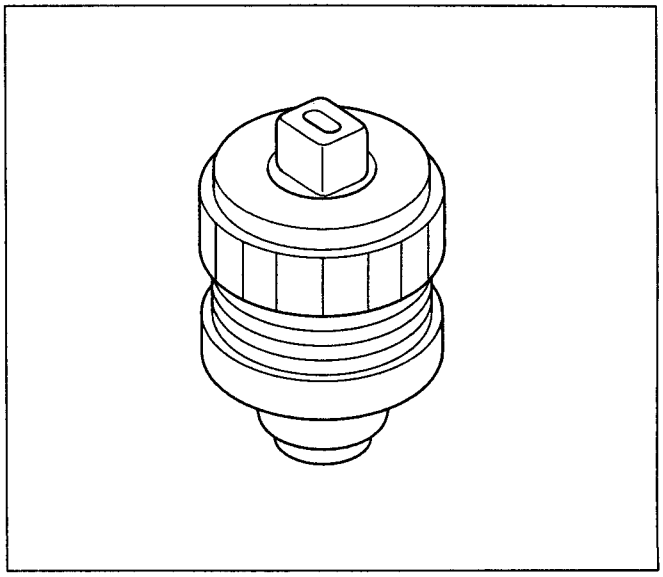
The injection pump unit comprises the same feed system as is used in the conventional duplex pump and two cylinders each having a pressure control valve (PCV). Using triple action cam has reduced the number of pump cylinders required to one third of the number of engine cylinders (2 cyl. pump in case of 6 cyl. engine). Further, the number of times of feeding to common rail is equal to that of injection, giving smooth, stable common rail pressure.



040MV033

Pressure Control Valve (PCV)

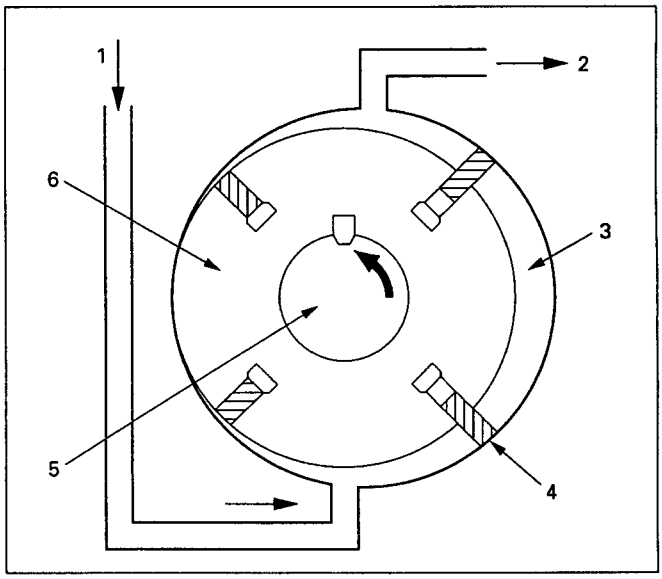
PCV is used to adjust injection pump discharge amount so as to adjust common rail pressure. Discharge amount from the injection pump to the common rail is determined by continuity timing to PCV.



056MV042

Feed Pump

The feed pump built in the injection pump to fuel pump up and supply fuel through fuel filter into the injection pump unit. Feed pump rotor is driven by camshaft. When the rotor starts to rotate, vanes are pushed outward by centrifugal force. As the rotor is eccentric with the pressure chamber, the fuel between the vanes are pressed to be pushed out of discharge port.



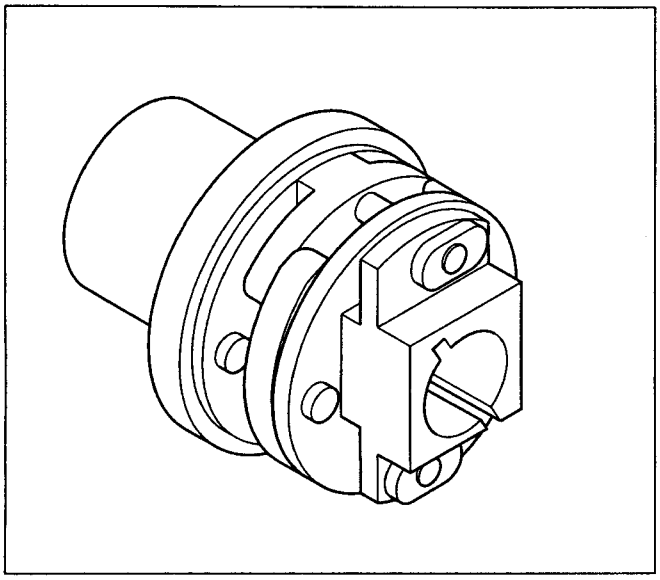
040MV050

Legend

(1) From fuel tank
(2) To fuel filter
(3) Pressure chamber
(4) Vane
(5) Camshaft
(6) Rotor

Coupling

The coupling is a laminated type, serving to transmit the driving torque from the engine side to the camshaft of the injection pump.



040MV049

Pump Position Sensor (G Sensor)

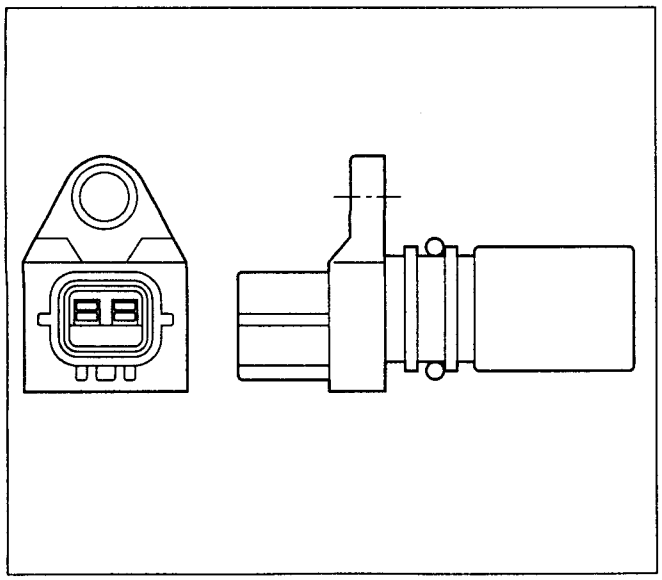
G sensor is installed at the side of the injection pump, serving to distinguish the cylinders of the engine and back up the detection of engine speed (in case of NE sensor trouble).

This G sensor comprises the same parts as in NE sensor, but the number of turns of its coil is different from that of NE sensor and installed to the injection pump.

With the engine started, the pulser notches in the middle of the injection pump camshaft cut off intermittently the magnetic field made by the sensor magnet, thereby generating alternating current.

The pulser notches are made every 60° of camshaft (every 120° of crank angle) and there is a surplus tooth.

Therefore, seven pulses are outputted per one rotation of camshaft (2 rotations of the engine). The pulse outputted by the surplus tooth is recognized as engine number 1 cylinder reference pulse.



056MV043

Common Rail

The common rail is installed to intake manifold, equipped with flow damper, pressure limiter, and common rail pressure sensor.

The common rail unit has a common fuel passage, fuel passage holes, and installing threaded holes. The common fuel passage is a through hole made in the common rail unit. The common rail pressure sensor is installed at the left end of the hole.

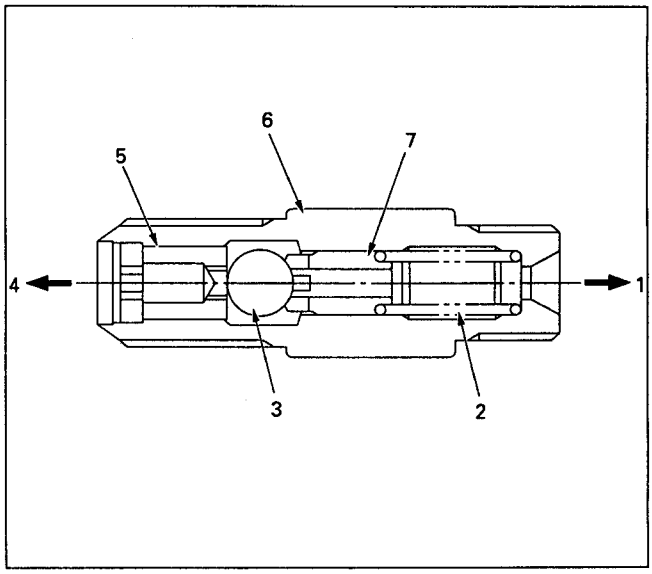
Flow Damper

The flow damper comprises a piston, ball, spring seat, and spring.

The flow damper is used to damp the pressure pulsating in the common rail and the injection pipe.

During driving the flow of fuel makes the piston, ball, and spring seat move a little to the injector side and float.

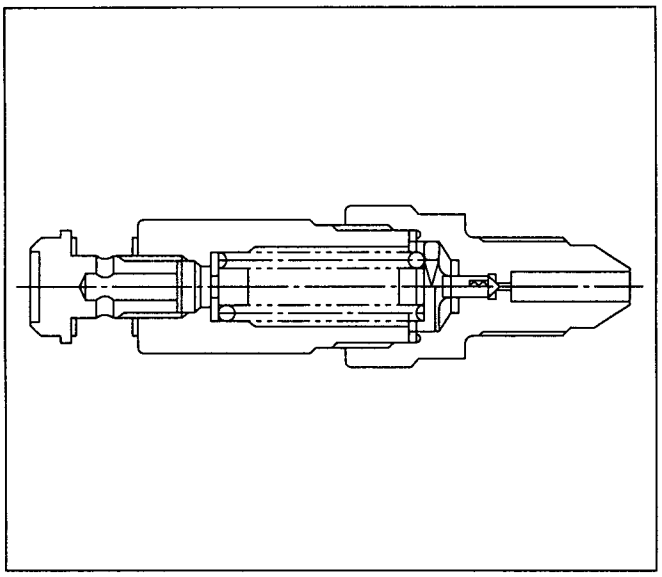
Should too much fuel pass the flow damper, the ball moves further toward the injector until the ball comes into contact with the seat surface of the flow damper unit, thereby shutting the fuel passages.



040MV052

Pressure Limiter

The pressure limiter opens when abnormally high pressure is generated, releasing the pressure. When the common rail pressure reaches approx. 140 MPa (1,420 kgf/cm^2), the pressure limiter is actuated (opens), and when the pressure drops to approx. 30 MPa (310 kpf/cm^2) later, it works to maintain the pressure, thereby enabling continuous running.



040MV051

Common Rail Pressure Sensor

The common rail pressure sensor, installed at left end of the common rail, serving the detect fuel pressure. It is a semiconductor type pressure sensor utilizing silicon's property that the electric resistance of pressurized silicone is varied.

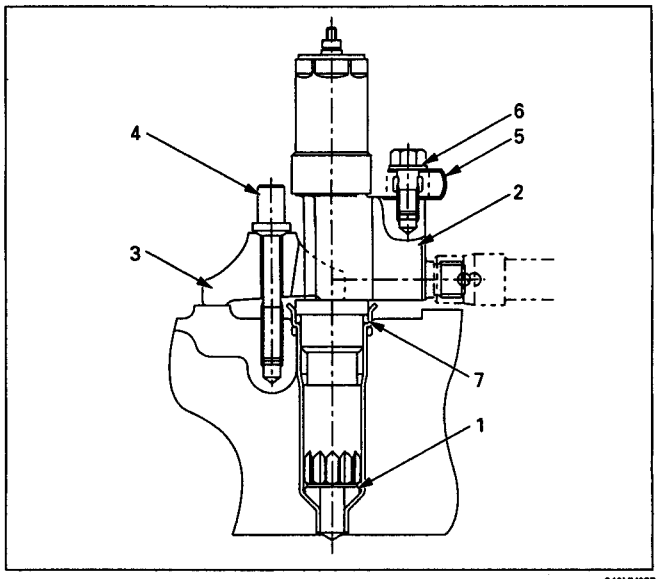
Further, a special gasket is used at the connection part with the common rail body so as to seal high pressure fuel.

Injector

The injector comprises a two-way solenoid valve, hydraulic piston, and nozzle. The solenoid valve controls the injection amount, injection timing, and injection rate of fuel by controlling the pressure in the control chamber.

The nozzle is a multihole type with a injection starting pressure (valve opening pressure) of 8.7 MPa (85 kg/cm^2).

The injection body is clamped. The cylinder head injection part is provided with an O-ring by which the entry of engine oil into the injector hole of the cylinder head is prevented.



040MV037

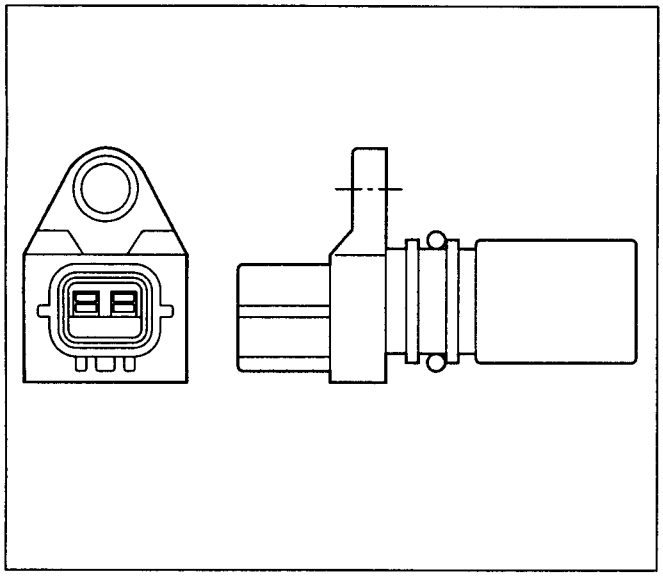
Legend

(1) Injector gasket
(2) Injector assembly
(3) Injector clamp
(4) Clamp bolt
(5) Fuel return pipe
(6) Eye bolt
(7) Injector sleeve

Crank Position Sensor (NE Sensor)

This sensor comprises a permanent magnet, coil, and iron core and is installed to the flywheel housing. With the engine started, the signal holes made on the outer periphery of the flywheel cut off intermittently the magnetic field made by the magnet, thereby generating AC in the coil.

The signal holes on the flywheel are provided every 15°, but one point is holeless. Therefore, the signal holes totals 23. Forty-six pulses are outputted per 2 rotations of the engine (one rotation of injection pump camshaft). By this signal, engine speed and 15°-based crank angle can be detected.

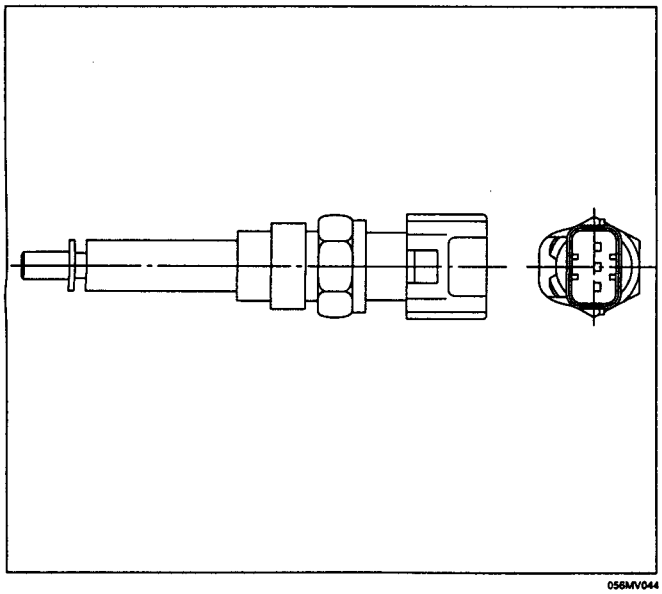


056MV043

THW Sensor

This sensor is a thermister type installed on the thermostat case. Change in coolant temperature as a resistance change signal is sent to ECM to optimize fuel injection control.

ECM applies voltage to the thermister and detects from the voltage divided between in ECM and thermister resistance values.

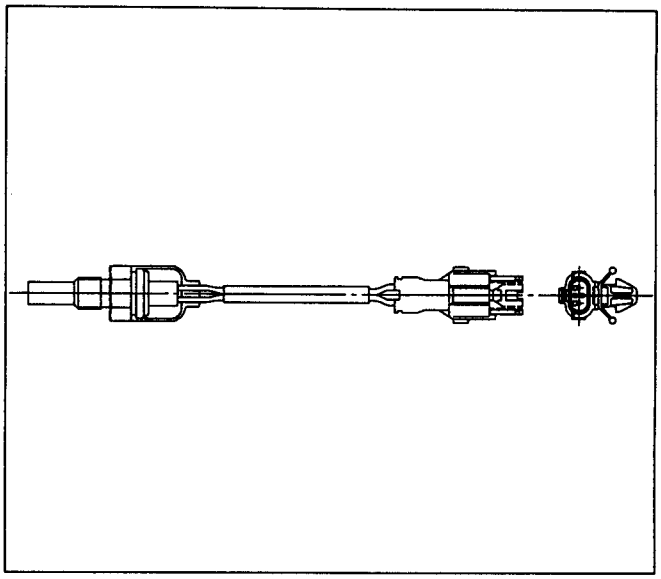


056MV044

THF Sensor

The THF sensor is a thermister type installed in the casing provided in the fuel return (from the injector) circuit.

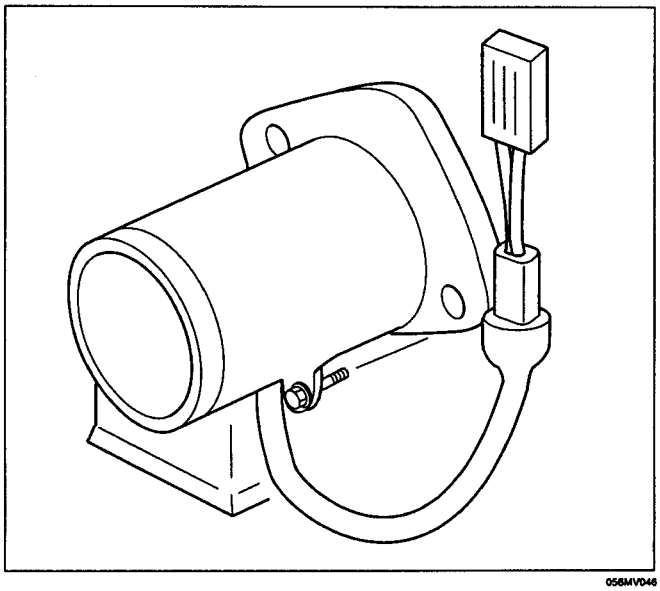
Change in fuel temperature is changed into a resistance change signal and sent to ECM for optimization of fuel injection control.



056MV045

Accelerator Sensor

This sensor is a hole IC type substituting electric signals for accelerator pedaling amount to be sent to ECM. It is installed to accelerator pedal bracket assembly.

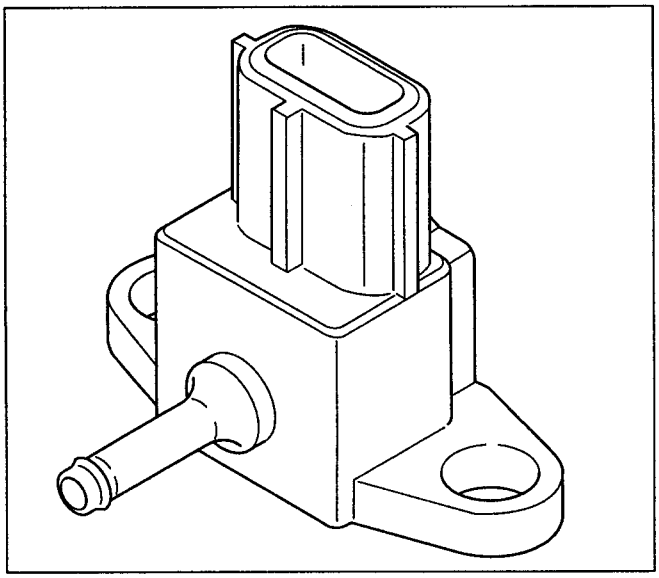


056MV046

Boost Sensor

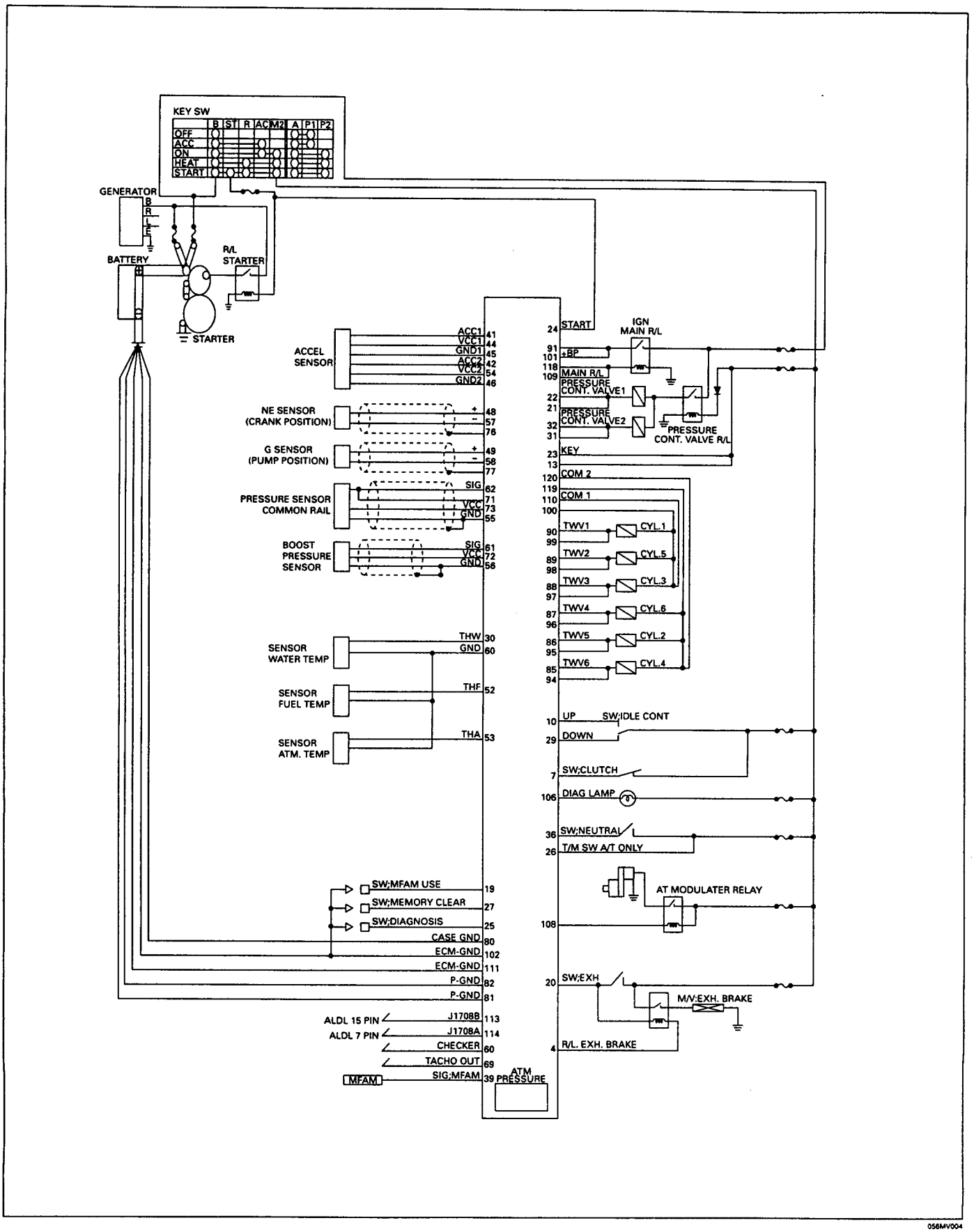
The boost sensor is fixed on the cab back frame and is connected to rear portion of inlet manifold by vacuum hose.

The boost sensor generates voltage according to air aspiration pressure and generation voltage is input to ECM for boost sensor signal.



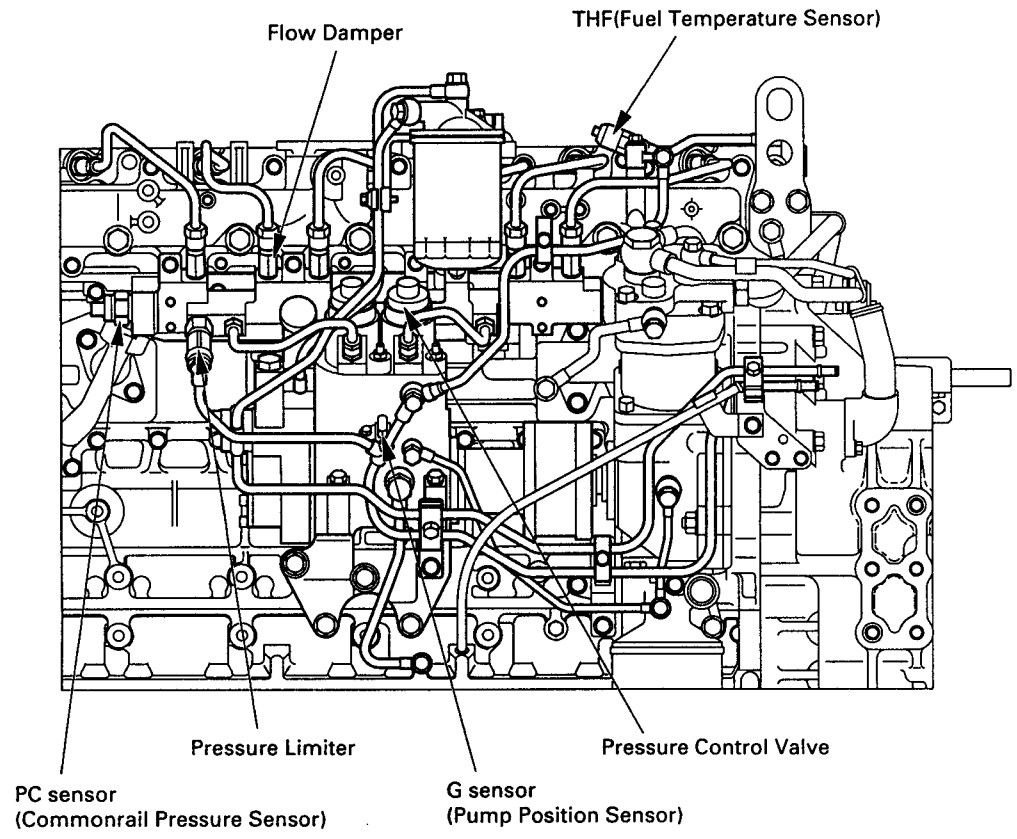
056MV047

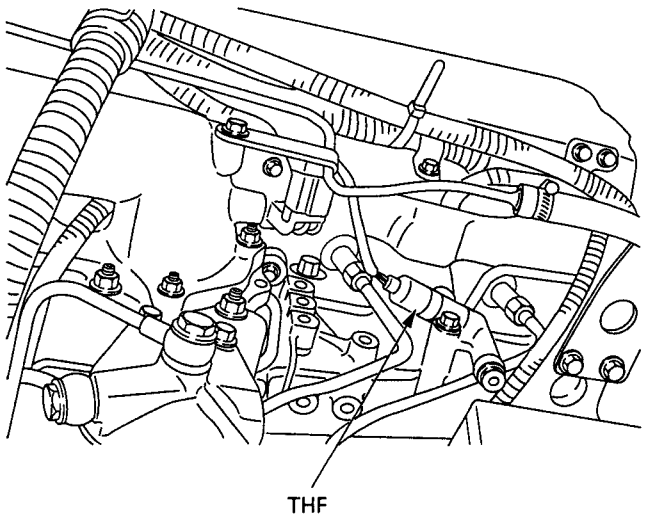
ECM SYSTEM WIRING DIAGRAM

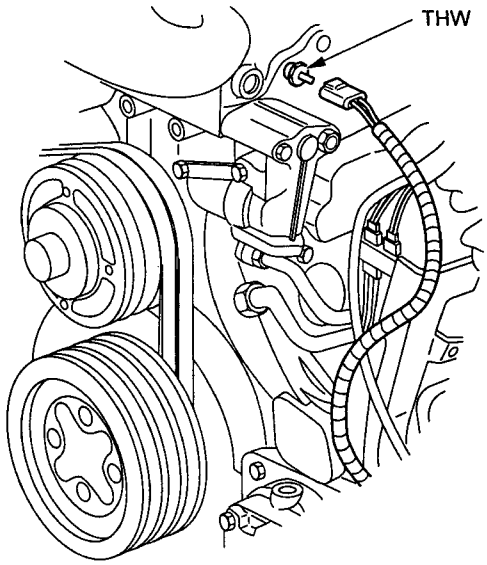


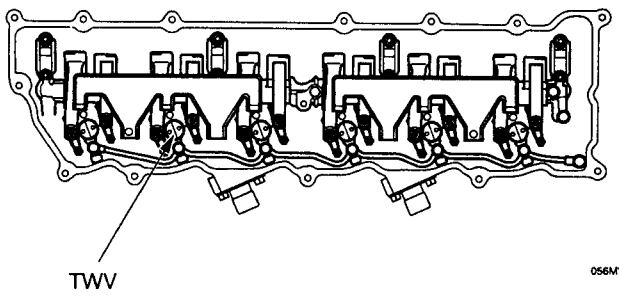
056MV004

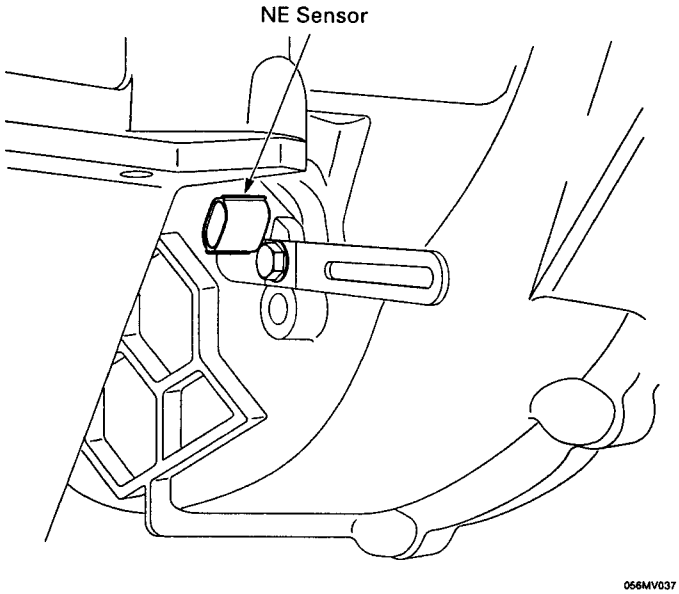
LOCATION OF SENSOR AND SWITCH

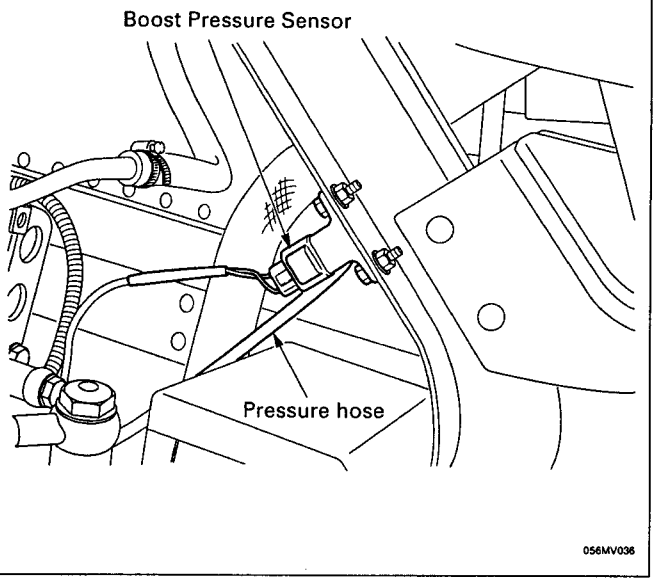












Location of the ALDL (Data Link Connector)

The ALDL is located under the inner part of left side instrument panel (Driver side).

Location of the memory clear switch

The memory clear switch is located under the passenger seat and the switch is blue color one pin connector.

Location of the diagnosis switch

The diagnosis switch is located under the passenger seat and the switch is white color one pin connector.

Location of the PCV relay and MAIN relay

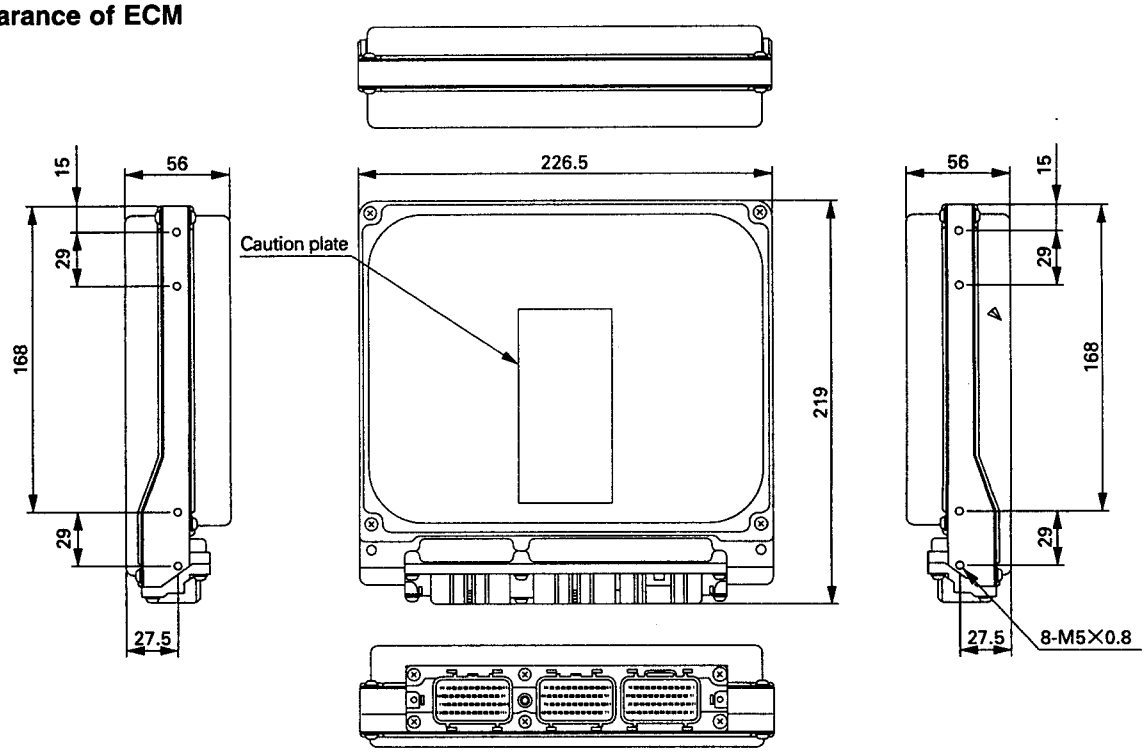
Both relay are located on upper portion of stand seat bracket (The ECM built in inside) in the cab.

Location of the THA (Atmospheric temperature) sensor

The THA sensor is located center of front on the dashpanel.

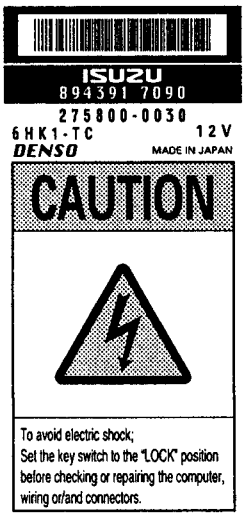
ENGINE CONTROL MODULE (ECM)

1. Appearance of ECM



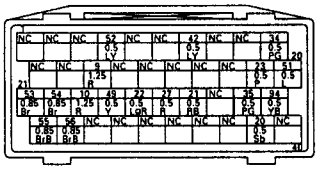
056MV030

2. Caution Plate on the ECM



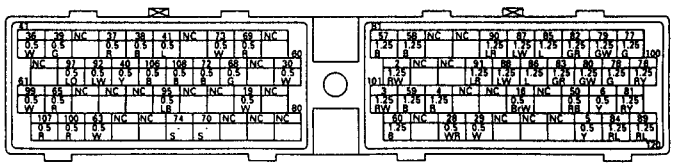
056MV038

3. Detail of 40 pin connector for Engine harness



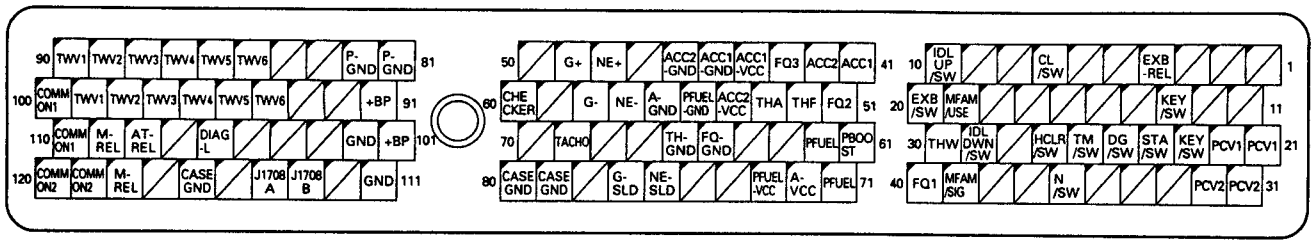
056MV0321

4. Detail of 80 pin connector for Engine harness



056MV0320

CHART OF ECM INPUT/OUTPUT



056MV0322

CONNECTOR PIN ASSIGNMENT

Connector	Connector Pin number	Connector pin assignment	
		Abbreviations	Assigned name
40 pin connector	1	——	Not used
	2	——	Not used
	3	——	Not used
	4	EXB–REL	Exhaust brake relay
	5	——	Not used
	6	——	Not used
	7	CL/SW	Clutch switch
	8	——	Not used
	9	——	Not used
	10	IDLUP/SW	Idling up switch
	11	——	Not used
	12	——	Not used
	13	KEY/SW	Key switch
	14	——	Not used
	15	——	Not used
	16	——	Not used
	17	——	Not used
	18	——	Not used
	19	MFAM/USE	MFAM connection
	20	EXB/SW	Exhaust brake switch
	21	PCV1	Pressure control valve 1
	22	PCV1	Pressure control valve 1
	23	KEY/SW	Key switch
	24	STA/SW	Starter switch
	25	DG/SW	Diagnosis switch
	26	TM/SW	Transmission judgment switch
	27	MCLR/SW	Memory clear switch
	28	——	Not used
	29	IDLDWN/SW	Idling down switch
	30	THW	Water temperature sensor
	31	PCV2	Pressure control valve 2
	32	PCV2	Pressure control valve 2

Connector	Connector Pin number	Connector pin assignment	
		Abbreviations	Assigned name
40 pin connector	33	——	Not used
	34	——	Not used
	35	——	Not used
	36	N/SW	Neutral switch
	37	——	Not used
	38	——	Not used
	39	MFAM/SIG	MFAM signal
	40	FQ1	Fuel quantity adjustment resistance 1
80 pin connector	41	ACC1	Acceleration sensor 1
	42	ACC2	Acceleration sensor 2
	43	FQ3	Fuel quantity adjustment resistance 3
	44	ACC1–VCC	Acceleration sensor 1 power source
	45	ACC1–GND	Acceleration sensor 1 ground
	46	ACC2–GND	Acceleration sensor 2 ground
	47	——	Not used
	48	NE+	Crank position sensor positive
	49	G+	Pump position sensor positive
	50	——	Not used
	51	FQ2	Fuel quantity adjustment resistance 3
	52	THF	Fuel temperature sensor
	53	THA	Atmospheric temperature sensor
	54	ACC2–VCC	Acceleration sensor 2 power source
	55	PFUEL–GND	Common rail pressure sensor ground
	56	A–GND	Sensor system ground
	57	NE–	Crank position sensor negative
	58	G–	Pump position sensor negative
	59	——	Not used
	60	CHECKER	Indication output (DLC)
	61	PBOOST	Boost pressure sensor
	62	PFUEL	Common rail pressure sensor
	63	——	Not used
	64	——	Not used
	65	FQ–GND	Fuel quantity adjustment resistance common ground
	66	TH–GND	Temperature sensor ground
	67	——	Not used
	68	——	Not used
	69	TACHO	Tachometer output
	70	——	Not used
	71	PFUEL	Common rail pressure sensor
	72	A–VCC	Sensor system power source

Connector	Connector Pin number	Connector pin assignment	
		Abbreviations	Assigned name
80 pin connector	73	PFUEL–VCC	Common rail pressure sensor power source
	74	——	Not used
	75	——	Not used
	76	NE–SLD	Crank position sensor sealed
	77	G–SLD	Pump position sensor sealed
	78	——	Not used
	79	CASE–GND	Common 1
	80	CASE–GND	Common 1
	81	P–GND	Power ground
	82	P–GND	Power ground
	83	——	Not used
	84	——	Not used
	85	TWV6	Two way valve 6
	86	TWV5	Two way valve 5
	87	TWV4	Two way valve 4
	88	TWV3	Two way valve 3
	89	TWV2	Two way valve 2
	90	TWV1	Two way valve 1
	91	+BP	Battery positive (Main relay)
	92	——	Not used
	93	——	Not used
	94	TWV6	Two way valve 6
	95	TWV5	Two way valve 5
	96	TWV4	Two way valve 4
	97	TWV3	Two way valve 3
	98	TWV2	Two way valve 2
	99	TWV1	Two way valve 1
	100	COMMON1	Common 1
	101	+BP	Battery positive (Main relay)
	102	GND	ECM ground
	103	——	Not used
	104	——	Not used
	105	——	Not used
	106	DIAG–L	Diagnostic lamp
	107	——	Not used
	108	AT–REL	Automatic transmission relay
	109	M–REL	Main relay
	110	COMMON1	Common 1
	111	GND	ECM ground
	112	——	Not used

Connector	Connector Pin number	Connector pin assignment	
		Abbreviations	Assigned name
80 pin connector	113	J1708B	J1708B
	114	J1708A	J1708A
	115	——	Not used
	116	CASE–GND	Case ground
	117	——	Not used
	118	M–REL	Main relay
	119	COMMON2	Common 2
	120	COMMON2	Common 2

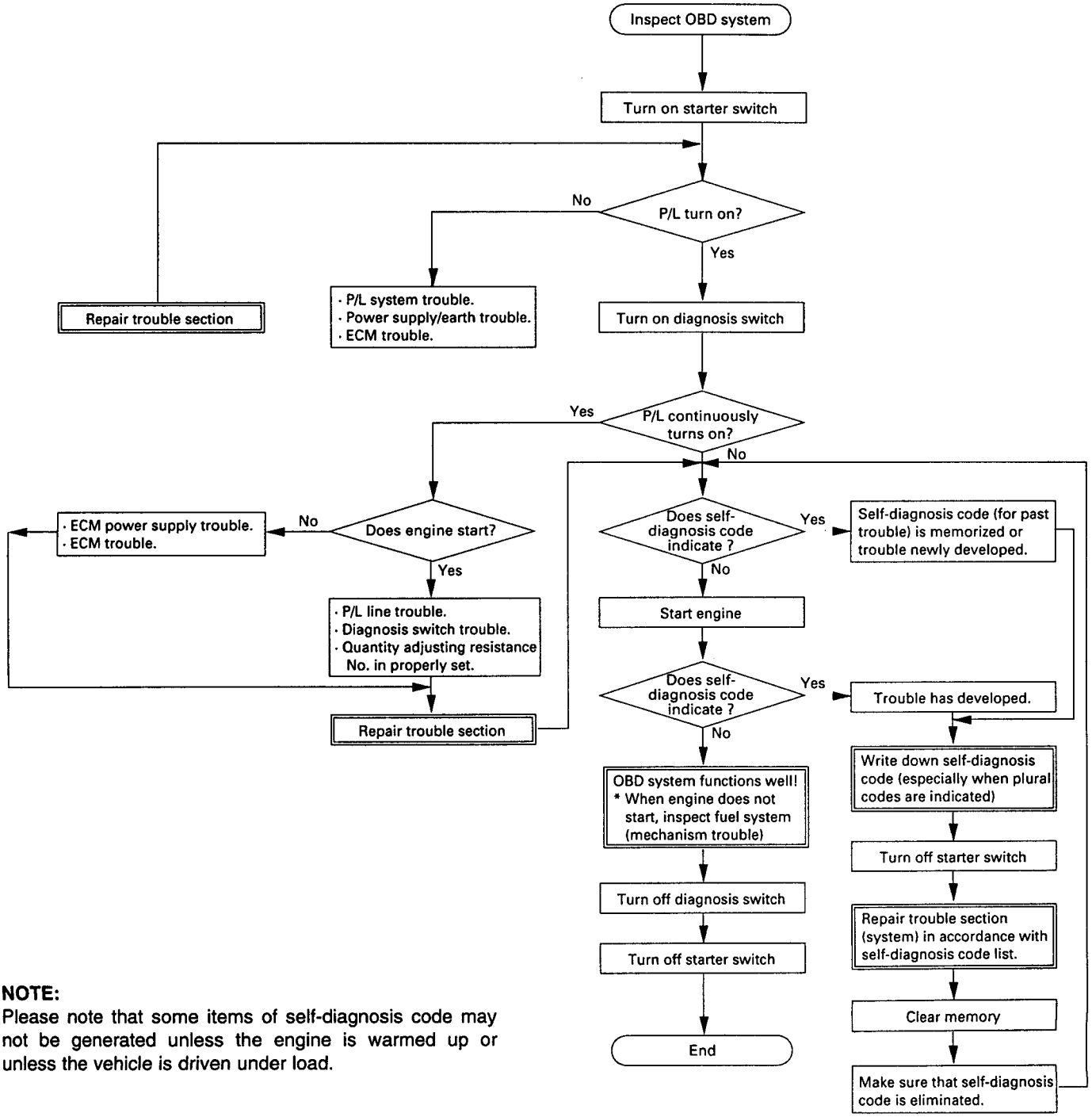
TROUBLESHOOTING

1. Caution taken in inspecting

(1) In inspecting the OBD system, write down self-diagnosis code to be indicated. (especially, when plural self-diagnosis codes are indicated.)

(2) Before eliminating the indicated self-diagnosis codes by a memory clear switch, doubly inspect abnormal places as indicated in self-diagnosis code.
(Self-diagnosis code means 'Warning.' Make sure to inspect abnormal section.)

2. Inspection procedure flowchart



NOTE:
Please note that some items of self-diagnosis code may not be generated unless the engine is warmed up or unless the vehicle is driven under load.

Method to confirm the self-diagnosis code (dealer mode)

The self-diagnosis code can be read from the flashing of indicator lamp (service engine soon). Reading self-diagnosis code from indicator lamp (service engine soon).

Operation:

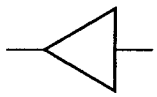
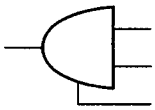
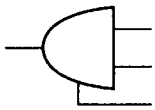
When the diagnosis connector mentioned below is connected, the indicator lamp will start flashing. The self-diagnosis code can be read from the flashing of the indicator lamp.

As to the method to read the self-diagnosis code, please refer to the 'How to Read the flashing of the indicator lamp' as mentioned later.

Diagnostic Indication

1. Contents of diagnostic indication.

In accordance with the conditions of Diagnostic switch, the diagnostic lamp indications are changed over as follows:

Control mode	Diag. lamp indicator	Condition
User Mode	ON	 Diagnostic switch "OFF" (Open) 056MV023
Dealer Mode 1	DTC indication of current trouble only	 Diagnostic switch "ON" (GND shorted) No engine stall For 1 sec. or more 056MV024
Dealer Mode 2	DTC indication of current and past troubles	 Diagnostic switch "ON" (GND shorted) Engine stall For 1 sec. or more 056MV025

- Mode changeover between User mode, Dealer mode 1 and Dealer mode 2 is made immediately.
- Mode changeover between Dealer mode 1 and Dealer mode 2 is made after a round of DTC output.

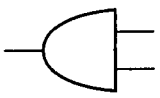
Priority of indications

Lamp control by user mode, Dealer mode 1 and 2 > Lamp check control.

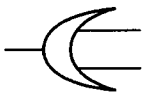
2. Diagnostic lamp patterns in User mode

Pattern 1 ..... Lighted all the time
Pattern 2 ..... Lighted after 20 sec. continuation of engine speed lower than 700 rpm.
Pattern 3 ..... Light goes out.

* Lighting condition of pattern 2
(1) Lighted by pattens 2 diagnostic.



(2) Not lighted by pattern 2 diagnostic.



3. Diagnostic code outputting in dealer mode

DTC indication is restarted after 2.4 sec. of light out.
The number of times of lighting/going out corresponding to the numeral in each figure are repeated.

Item	Light on time (Sec.)	Light out time (Sec.)
Figure of 100	0.3	0.6
Figure of 10	1.2	0.6
Figure of 1	0.3	0.6
Code intervals	—	2.4

Note: ***Tolerance of difference between light on and light out time is +0.3 to –0.1.***

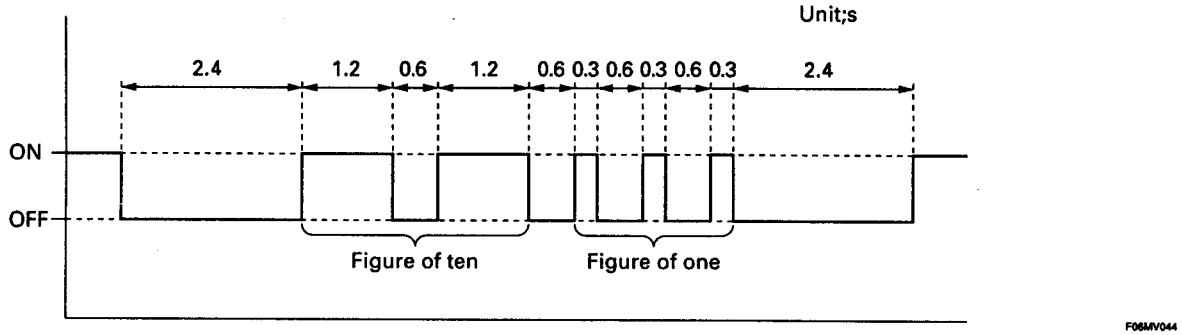
4. How to read flashing of the indicator lamp:

The three-digit self-diagnosis code flashes starting from hundred's figure, while the two-digit self-diagnosis code flashes starting from ten's figure to indicate the self-diagnosis code.
Please read the self-diagnosis code from the flashing.
If the plural self-diagnosis codes are indicated, the same sefl-diagnosis code is flashed repeatedly in steps of three times. Please read it correctly.

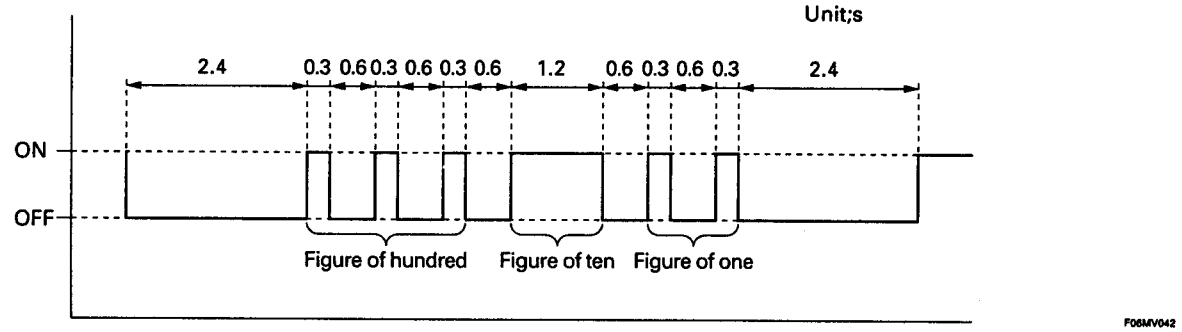
- DTC outputting is done in decreasingly order of DTC number.
- Indication is changed over on completion of output DTC indication.
- DTC indicator is stopped with diagnostic switch being off.
- When there is no DTC output, "1" is outputted in normal DTC code.
- After indicating 3 times pear 1 DTC, shift is conducted to the next DTC. (After making a round, the indications are repeated again.)
- In case of the same diagnostic code, it is used 1 DTC (3 times indication.)

Example Diagnosis Trouble Code Output

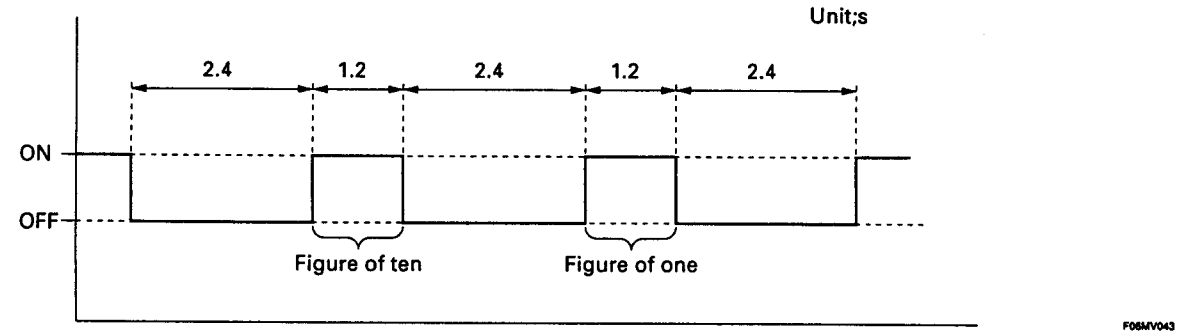
(For example) In case of indicate two degits fugure "DTC23"



(For example) In case of indicate three degits fugure "DTC312"

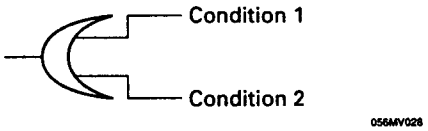


(For example) In case of indicate two degits fugure "DTC10"



5. Clearing method of diagnosis trouble code.

Under the following condition, the diagnosis code memorized in EEPROM is cleared.



Condition 1:

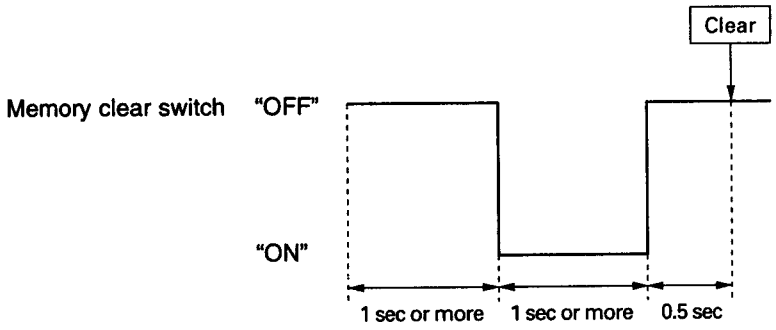
Memory clear switch "OFF" continues 1 sec. or more.

↓

Memory clear switch "ON" continues 1 sec. or more.

↓

Memory clear switch "OFF" continues 0.5 sec. or more.

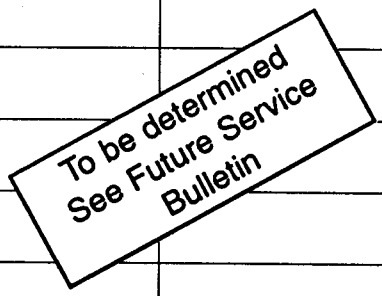


Condition 2:

EEPROM data does not match its mirror data.

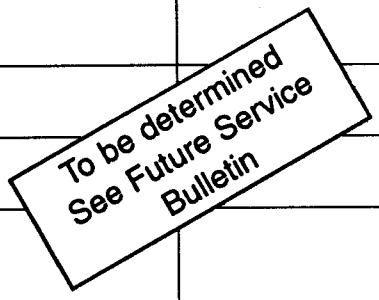
Typical Scan Data Values

Scan Tool Parameter	Data List	Units Displayed	Typical Data Values (Idle)	Typical Data Values (rpm)	Refer to
Engine Speed	Engine	RPM	630		
App Angle	Engine	%			
ECT Engine Coolant Temp.	Engine	°C			
Actual Fuel Rail	Engine	kpa			
Battery Voltage	Engine	Volts	12		
Final Fuel Rate	Engine				
Basic Fuel Rate	Engine				
Fuel Rate at Start	Engine				
Fuel Rate at Max Speed	Engine				
Fuel Rate Correction	Engine				
ISC Fuel Rate Correction 1	Engine				
ISC Fuel Rate Correction 2	Engine				
ISC Fuel Rate Correction 3	Engine				
Sprit Fuel Rate	Engine				
Fuel Rate Cylinder 1	Engine				
Fuel Rate Cylinder 5	Engine				
Fuel Rate Cylinder 3	Engine				
Fuel Rate Cylinder 6	Engine				
Fuel Rate Cylinder 2	Engine				
Fuel Rate Cylinder 4	Engine				
Flow Dumper 6	Engine				
Starter Switch	Engine	ONOFF			
Clutch Switch	Engine	ON/OFF			
Neutral Switch	Engine	ON/OFF			
Exhaust Brake Switch	Engine	ON/OFF			
Engine Stop Switch	Engine	ON/OFF			
Diagnosis Switch	Engine	ON/OFF			



Typical Scan Data Values

Scan Tool Parameter	Data List	Units Displayed	Typical Data Values (Idle)	Typical Data Values (rpm)	Refer to
Main Injection Timing	Engine				
Desired Rail Pressure	Engine	kpa			
Desired Idle Speed	Engine	RPM			
APP Sensor 1	Engine	Volts			
Injection Control Mode	Engine	Active/ Inactive			
Pump Control Mode	Engine	Active/ Inactive			
Maximum Fuel Temperature	Engine	°C			
Fuel Temperature Sensor	Engine	°C			
Over Speed Number of Times	Engine				
Overheat Number of Times	Engine				
Flow Damper 1	Engine				
Flow Damper 2	Engine				
Flow Damper 3	Engine				
Flow Damper 4	Engine				
Flow Damper 5	Engine				



ECM Diagnosis Trouble Codes

The following table lists the diagnosis trouble codes supported by this vehicle application. If any DTCs not listed here are displayed by a scan tool, the scan tool data may be faulty; notify the scan tool manufacture of any DTCs displayed that are not included in the following table.

ECM Diagnostic Trouble Codes

DTC	Description	Type	Illuminate MIL
P15	Crank Position Sensor Error	A	YES
P14	Pump Position Sensor Error	A	YES
P245	Abnormal Common Rail Pressure (PC Sensor System)	A	YES
P115	Common Rail Pressure Sensor Output Fixed	A	YES
P151	Abnormal Common Rail Pressure (Pump Over Pressure Supply)	A	YES
P118	1. Abnormal Common Rail Pressure (Control System 1st Stage) 2. Abnormal Common Rail Pressure (Control System 2nd Stage)	A	YES
P34	Q Adjustment Data Error (No History Recorded)	A	YES
P23	Water Temperature Sensor Error	A	YES
P211	Fuel Temperature Sensor Error	A	YES
P22	Atmospheric Temperature Sensor Error	A	YES
P24	1. Accelerator Sensor Error 1 2. Accelerator Sensor Error 2 3. Accelerator Sensor 1 Intermediate Trouble 4. Accelerator Sensor 2 Intermediate Voltage Hold Trouble	A	YES
P71	Atmospheric Pressure Sensor Error	A	YES
P417	Starter Switch Abnormal	A	YES
P261 or P276	Cylinder No. 1 to No. 6 Flow Dumper Activated	A	YES
P271 or P276	Disconnect on Cylinder No. 1 to No. 6 at TWV side	A	YES
P158	TWV Driving System +B Shorted	A	YES
P159	TWV Driving System Ground Shorted	A	YES
P226	Injection Pump does not Pressure Supply and/or Pressure Limiter Activation	A	YES
P227	Injection Pump does not Pressure Supply (Fuel Leakage)	A	YES
P217 P218	PCV1 (DTC P217) PCV2 (DTC P218) PCV Coil or Harness +B Shortage	A A	YES YES
P247 P248	PCV1 (DTC P247) PCV1 (DTC P248) PCV Coil or Harness Disconnect or Ground Shorted	A A	YES YES
P35	A/D Conversion Error (ECM inside trouble) CPU Monitoring IC Error (ECM inside trouble) Charging Circuit Error	A	YES
P421	PCV Relay System Error	A	YES
P416	Main Relay System Error (No History Record)	A	YES
P32	Boost Pressure Sensor Error	A	YES
P42	High Boost Pressure Abnormal	A	YES
P65	Low Boost Pressure Abnormal	A	YES
P543	Overrun Judgment	A	YES

Diagnosis Trouble Code List

Trouble code	Item	Symptom	Diagnosis	Backup	Control restoration condition	Diagnosis lamp indicating trouble		Remarks
						Diagnosis switch open (user)	Diagnosis switch close (dealer)	
P15	Crank Position Sensor Error (NE Sensor)	• White smoke in case of racing. • Poor output of tachometer (NE failure during drive is outputted till engine stop). • Unstable idling (FCCB stops)	When G sensor pulse (pump position, 40 times of pulse input) is normal (engine ON) there is no NE pulse input nor 1 sec. or more.	• When G sensor (pump position) is normal, backs up by G sensor. • When both failure, injection stops.	When NE sensor pulse is inputted over specified cycles.	△	1-5	
P14	Pump Position Sensor Error (G Sensor)	• Worsened startability.	NE sensor pulse (Crank position, 450 times of pulse input) is normal, there is no G sensor pulse input.	• When NE sensor (pump position) is normal, backs up by NE sensor. • When both failure, injection stops.	When G sensor pulse is inputted over specified cycles.	△	1-4	
P245	Abnormal Common Rail Pressure (PC Sensor System)	• No powerfulness felt. • Hard to start on a steep slope. • Hard to get maximum speed on the flat road.	• When sensor voltage is lower than 0.7V. • When sensor voltage is over than 4.7V. (The pressure is 0 MPa = 0.93V 160 MPa = 4.02V	Limits are set to common rail pressure open loop control, common rail pressure and injection amount. Common rail pressure: 60 MPa Injection amount: 50 mm^3/st	When out of diagnostic conditions.	○	2-4-5	
P115	Common Rail Pressure Sensor Output Fixed	Same as DTC P245	Excessive difference between the current and previous valves of common rail pressure, difference from the target value being greater than 10 MPa, common rail pressure being greater than 10 MPa and pump ordinary mode and not appear the DTC P245.	Same as DTC P245	When the difference between the current and prerevius values has become less than a specified value.	○	1-1-5	

Diagnosis Trouble Code List

Trouble code	Item	Symptom	Diagnosis	Backup	Control restoration condition	Diagnosis lamp indicating trouble		Remarks
						Diagnosis switch open (user)	Diagnosis switch close (dealer)	
P151	Abnormal Common Rail Pressure (Pump over pressure supply)	Same as DTC P245	NE sensor normal, pump normal mode, VB ≥ 8V, pump revolution is 450 rpm or more, water temperature 60°C or more, PCV open timing constant, no DTC P245 and P115, and common rail pressure continues to be greater than target plus 10 MPa.	Same as DTC P245	Engine stalled and common rail pressure is less than 10 MPa.	○	1-5-1	
P118	1. Abnormal Common Rail Pressure (Control System) 1st Stage	Same as DTC P245	No DTC P245 and common rail pressure over 125 Mpa continues for 0.2 sec.	Same as DTC P245	When common rail pressure is lower than 110 MPa.	○	1-1-8	
	2. Abnormal Common Rail Pressure (Control System) 2nd Stage	Injection stop (Controlled by TWV or PCV)	No DTC P245 and common rail pressure over 130 MPa continues for 0.2 sec.	Injection stop and pressue feed stop.	When engine stalled the common rail pressure is less than 10 MPa.	○	1-1-8	
P34	Q Adjustment Data Error (No history recorded)	Changes in full performance and injection amount.	Q adjustment resistance 1, 2, 3 (FQ1 to FQ3) input voltage is lower than 0.6V or over than 4.45V and EEPROM Q adjustment (Tech II) is not written to cotinues 0.2 sec.	Q adjustment data No. 4 selected (correction "0")	Any one of Q adjustment resistances 1, 2, 3 voltage is out of diagnostic conditions, or writing of Q adjustment data (Tech II) * When ECM replaced the light turn on, because there is no Q adjustment harness on the vehicle. The Tech II must be necessary.	○	3-4	

Diagnosis Trouble Code List

Trouble code	Item	Symptom	Diagnosis	Backup	Control restoration condition	Diagnosis lamp indicating trouble		Remarks
						Diagnosis switch open (user)	Diagnosis switch close (dealer)	
P23	Water Temperature Sensor Error	• Smoke observe when started after warming up. • Excessive white smoke when started in cold weather.	Water temperature sensor voltage exceeding 4.8V or lower than 0.1V continues for 1 sec. (4.8V = –50°C 0.1V = 110°C)	Starting: Based on –20°C Other: Based on 80°C	When out of the diagnostic range. (Voltage)	–	2-3	
P211	Fuel Temperature Sensor Error	No symptom in particular	Fuel temperature sensor voltage exceeding 4.8V or lower than 0.1V continues for 1 sec. (4.8V = –50°C 0.1V = 130°C)	Backup control by water temperature sensor (starting THF= –20°C Other = 80°C)	When out of the diagnostic range.	–	2-1-1	
P22	Atmospheric Temperature Sensor Error	White smoke at the engine starting in cold districts.	Atmospheric temperature sensor voltage exceeding 4.95V or lower than 0.1V continues 1 sec or more.	At starting: THA = –20°C Other = 80°C	When out of the diagnostic range.	–	2-2	
P24	1. Accelerator Sensor Error 1 2. Accelerator Sensor Error 2 3. Accelerator Sensor 1 Intermediate voltage hold toruble. 4. Accelerator Sensor 2 Intermediate voltage hold trouble.	• Poor racing when accelerated. • No accel. response. • 1200 rpm fixed.	• Item 1 and 2: Accel voltage exceeding 4.8V or lower than 0.5V continues 1 sec. or more. • Item 3 and 4: Difference between previous value and current value is lower than 0.05V (stationary), difference from the other sensor voltage exceeding 0.2V and no individual abnormality detected by sensor 1 and 2 continues.	Item 1, 2, 3 and 4: When one sensor is normal, backup by normal sensor. When both sensor are faulty accel. is fixed at 20%, however using an injection map for ASC mode.	Item 1 and 2: When 0.5V or higher and 1.4V or lower. Item 3 and 4: When difference between previous and current value is 0.05V or higher (moving) and sensor voltage is higher than 0.5V and lower than 1.4V.	○	2-4	

Diagnosis Trouble Code List

Trouble code	Item	Symptom	Diagnosis	Backup	Control restoration condition	Diagnosis lamp indicating trouble		Remarks
						Diagnosis switch open (user)	Diagnosis switch close (dealer)	
P71	Atmospheric Pressure Sensor Error (As built in ECM, it can be used for reference.)	• Worsening smoke on high land. • White smoke • Exhaust gas temperature rise as aneroid compensator fails.	Atmospheric pressure sensor voltage exceeding 4.7V and lower than 1.9V and continues 1 sec. or more.	Based on the atmospheric pressure of 100 kPa.	When out of the diagnostic range.	–	7-1	
P417	Starter Switch Abnormal	Inclease to remains applies on idling when cold start engine.	Starter switch turn on and idling speed higher than 1000 rpm also 16.4 ms x 100 times. When these conditions continues 1.6 sec.	—	When starter switch has became off.	–	4-1-7	
P261 to P266	Cylinder No. 1 to Cylinder No. 6 Flow Dumper Activated	Fuel leakage or no smooth rotation.	Not appear the DTC P271 to DTC P276, DTC P158 and DTC P159, water temperature higher than 60°C, correction of uneven injection amount exceeding 4 mm^3/st and these continues 20 times.	FCCB stops	Engine restarting after engine stall.	○	2-6-1 2-6-2 2-6-3 2-6-4 2-6-5 2-6-6	
		Fuel leakage or no smooth rotation.	When F/D working times is over 101 times.	Judgment cylinder injection stops.	When diagnostic data cleared.			
P271 to P276	Disconnect on Cylinder No. 1 to Cylinder No. 6 at TWV side	• No smooth rotation. • Lack of engine power etc.	TWV coil or harness disconnected and VB is over 10V except when jedged on overrun.	Injection amount limited to 80 mm^3/st or 0 boost FLT.	• Engine restarting after engine stall, VB exceeding 10V except when judged on overrun and driving current is normal.	○	2-7-1 2-7-2 2-7-3 2-7-4 2-7-5 2-7-6	

Diagnosis Trouble Code List

Trouble code	Item	Symptom	Diagnosis	Backup	Control restoration condition	Diagnosis lamp indicating trouble		Remarks
						Diagnosis switch open (user)	Diagnosis switch close (dealer)	
P158 (Common 1) P159 (Common 2)	TWV Driving System +B shorted.	• No smooth rotation. • Lack of engine power etc.	TWV harness +B shorted and/or common harness +B shorted and VB higher than 10V except when judged on overrun.	• Constant current control by common 1 or common 2 whichever normal (Abnormal system separated) • Injection amount limit 80 mm^3/st or 0 boost flat.	• Engine restarting after engine stall.	○	1-5-8 1-5-9	
	TWV Driving System Ground shorted		TWV harness ground shorted and/or common harness ground shorted and VB higher than 10V except when judged on overrun.					
P226	Injection Pump does not Pressure Supply and/or Pressure Limiter Activation	Smoke, power shortage etc., due to lack of common rail pressure (Pressure limiter activated)	Target ISC speed as detected by Tech II and common rail pressure not controlled, DTC P 245, P115, P217, P247 and P248 are not appear, NE sensor normal condition, pump normal mode, VB is higher than 8V, pump speed is higher than 450 rpm water temperature is higher than 60°C and PCV opening timing reached the limited value or feedback value reaches –60°C. When above condition continues 30 times.	• Injection amount limit is 60 mm^3/st. • Target common rail pressure is lower than 25 Mpa.	Engine restarting after engine stall.	○	2-2-6	

Diagnosis Trouble Code List

Trouble code	Item	Symptom	Diagnosis	Backup	Control restoration condition	Diagnosis lamp indicating trouble		Remarks
						Diagnosis switch open (user)	Diagnosis switch close (dealer)	
P227	Injection Pump does not Pressure Supply (Fuel leakage)	Lack of power due to fuel leakage, fuel pressure and injection amount limited.	ISC target speed, common rail pressure not controlled, DTC P245, P115, P217, P218, P247 and P248 are not appear, NE sensor normal condition, Pump normal mode, VB is higher than 8V, Pump speed higher than 450 rpm, Water temperature higher than 60°C, DTC P226 detected, common rail pressure higher than target pressure plus 5 Mpa and PCV opening timing reaches the limit or feedback value –60CA. When above condition continues 255 times.	• Fuel injection value lower than 60 mm^3/st. • Common rail pressure lower than 25 Mpa. • Time required for running into backup is varied with the difference common rail pressure against target pressure.	Engine restarting after engine stall.	○	2-2-7	
P217 P218	PCV1 (DTC P217) PCV2 (DTC P218) PCV Coil or Harness +B Shortage	Worsened smoke when depress accelerator pedal.	Abnormally high driving voltage with PCV on, Pump normal mode and VB higher than 10V when key switch ON.	Abnormally high driving voltage generated PCV off, the target pressure limited to 60 MPa or less.	Normal PCV driving voltage detected once in 4 sec., pump normal mode and VB higher than 10V.	○	2-1-7 2-1-8	
P247 P248	PCV1 (DTC P247) PCV2 (DTC P248) PCV Coil or Harness Disconnect or Ground Shorted	Worsening of smoke when depress accelerator pedal.	Abnormally low driving voltage with PCV off, pump normal mode, VB higher than 10V and NE sensor normal condition when key switch on.	Common rail pressure is limited to 60 Mpa or less.	PCV driving voltage normal, pump normal mode, VB is higher than 10V and NE sensor normal condition.	○	2-4-7 2-4-8	

Diagnosis Trouble Code List

Trouble code	Item	Symptom	Diagnosis	Backup	Control restoration condition	Diagnosis lamp indicating trouble		Remarks
						Diagnosis switch open (user)	Diagnosis switch close (dealer)	
P35	A/D Conversion Error (ECM inside trouble)	Worsening of running feels variously corrected by backup mode.	CPU A/D conversion not finished and CPU normal.	Analog sensor abnormality decision stops and backup mode	CPU A/D conversion normal and CPU normal	○	3-5	
	CPU Monitoring IC Error (ECM inside trouble)	Nothing in particular.	+B voltage higher than 10V after 2 sec. from resetting, starter switch off continues for 300 ms, timer pulse time abnormal continues over 50 times, or +B voltage higher than 10V after 2 sec. from resetting, starter switch off continues for 300 ms and timer pulse fixed continues over 500 ms.	—	Passed after 2 sec. from resetting, +B voltage higher than 10V, and starter switch off continues for 300 ms or more.			
	Charging Circuit Error (ECM inside trouble)	Lack of powerfulness and worsening of smoke	Charging voltage abnormal and VB higher than 10V, except judged on overrun.	Charging stops, driveable by constant current only, and injection amount limited to 80 mm^3/st.	Engine restarting after engine stall.			
P421	PCV Relay System Error	No difference in performance.	PCV driving voltage abnormal when key off it mean PCV circuit off condition.	Only diagnostic code memory.	—	–	4-2-1	
P416	Main Relay System Error (No history record)	Unrunnable	Main relay off continues for 5 sec. or more.	Only diagnostic lamp (Flashing lamp) can be lighted by key current.	—	△	4-1-6	

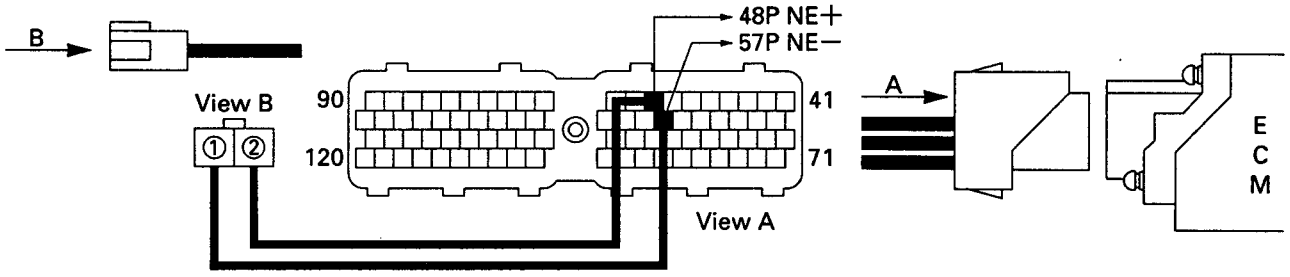
Diagnosis Trouble Code List

Trouble code	Item	Symptom	Diagnosis	Backup	Control restoration condition	Diagnosis lamp indicating trouble		Remarks
						Diagnosis switch open (user)	Diagnosis switch close (dealer)	
P32	Boost Pressure Sensor Error	Lack of power due to injection limitation.	(1)When engine stall and relative boost pressure higher than the determined value continues for 1 sec. or more. (2)Relative boost pressure lower than the determined value continues for 1 sec. or more. (3)After judgment on DTC P42, higher boost abnormal area continues for 10 sec. or more.	(1), (2) left: Based on relative pressure of 0 kPa. (3) left: Injection amount map is used for a fail safe mode.	(1)When engine stall and relative pressure lower than the determined value. (2)Relative boost pressure is less than the determined value. (3)Hold this condition until the ECM power source turn off.	–	3-2	
P42	High Boost Pressure Abnormal	Lack of engine power etc.	No engine stall, abnormal boost pressure (boost pressure sensor normal condition) and high boost pressue abnormal area continues for 0.5 sec. or more.	Injection amount map is used as a fail safe mode.	Hold this condition until the ECM power source turn off.	–	4-2	
P65	Low Boost Pressure Abnormal	Lack of engine power (Boost pressure shortage)	No engine stall, abnormal boost pressure not in the boost pressure sensor, accelerator open over than 80% and lower boost pressure area continues for 25 sec. or more.	—	Hold this condition until the ECM power source turn off.	–	6-5	
P543	Overrun Judgment	Fuel cut	At 4000 rpm or higher.	Fuel injection stop. Fuel pressure feed stop.	When engine speed 3800 rpm or lower.	–	5-4-3	

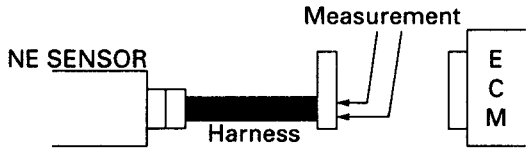
Note: When diagnosis switch opens (user mode), trouble indication sing shown as follows:

△ : Indicator turns on when less than 700 rpm last for 20 seconds. ○ : Indicator continuously turns on. – : Indicator does not turn on.

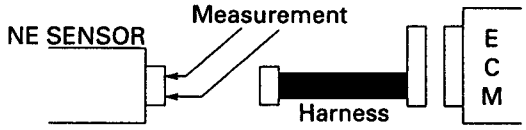
DTC P15 Crank Position Sensor Error (NE sensor)



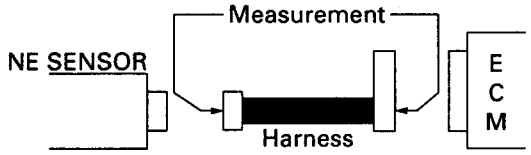
Measuring method 1



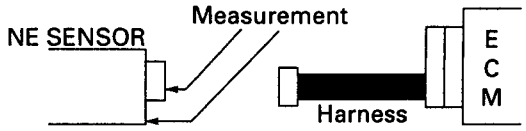
Measuring method 3



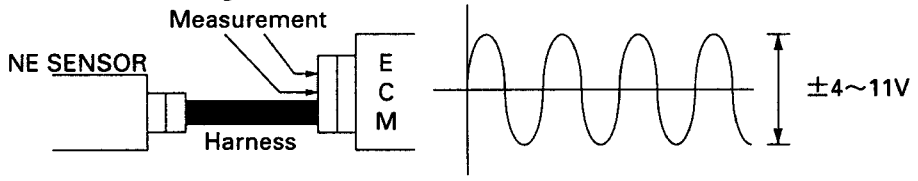
Measuring method 2



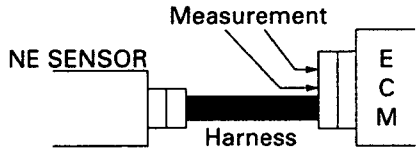
Measuring method 4

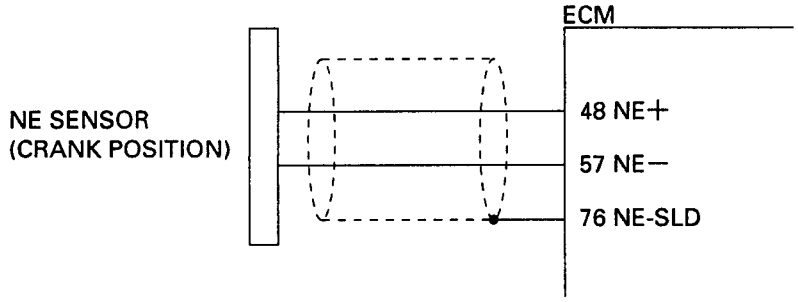


Measuring method 5



Measuring method 6



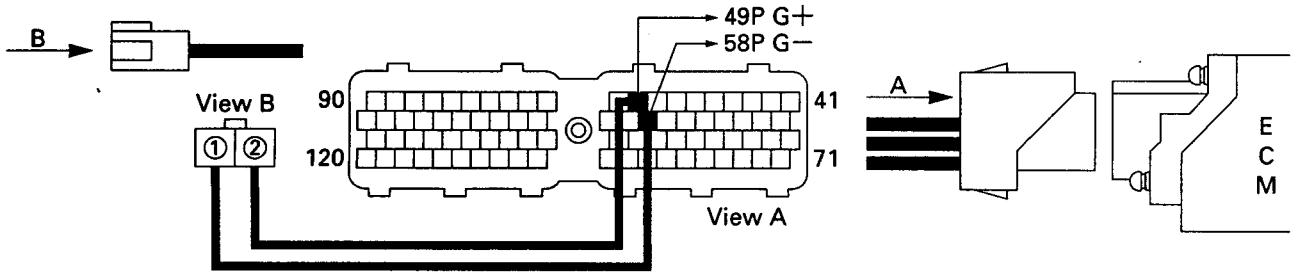


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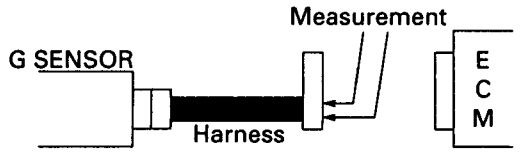
DTC P15 Crank Position Sensor Error (NE sensor)

STEP	ACTION	VALUE	YES	NO
1	Does DTC15 indicate continuous for 20 sec. after engine starting at 700 rpm or less.	—	Go to step 2	—
2	1. Key switch "OFF". 2. Disconnect ECM connector. 3. Measure the resistance between pin number 48 (NE+) and pin number 57 (NE–) on the NE sensor harness. (Measuring method 1)	109Ω to 143Ω	Go to step 6	Go to step 3
3	1. Disconnect NE sensor connector. 2. Measure the resistance between pin number 48 (NE+) and NE sensor pin number 2. 3. Measure the resistance between pin number 57 (NE–) and NE sensor pin number 1. (Measuring method 2) Is resistance within the value?	Less than 2Ω	Go to step 4	Repair NE sensor harness then Go to step 11
4	Measure NE sensor unit resistance. (Measuring method 3) Is resistance within the value?	109Ω to 143Ω	Go to step 5	Replace NE sensor then Go to step 11
5	Measure resistance between NE sensor terminal (+, –) and NE sensor body. (Insulation shortage check) (Measuring method 4) Is resistance within the value?	10MΩ or more	Go to step 11	Replace NE sensor then Go to step 11
6	1. Reconnect ECM connector and check DTC. 2. Measure NE sensor output voltage while engine in 1000 rpm operation. (Measuring method 5) 3. Observe NE sensor output peak to peak voltage waveform by oscilloscope. Does sign waveform appear?	Sign waveform	Go to step 9	Go to step 7
7	Check NE sensor for fitness and/or looseness. Is air gap between NE sensor and flywheel within the value?	Within 0.9 mm to 1.2 mm	Go to step 8	Adjustment then Go to step 11
8	Check NE sensor for damage. Is there damage on NE sensor?	—	Replace NE sensor	Go to step 9
9	1. Connect ECM connector and check DTC. 2. Observe NE sensor output waveform between pin number 48 (NE+) and ECM ground (NE– not used) by oscilloscope. • If normal, the sign waveform is shown. • If abnormal (the wave broken or not displayed), check flywheel for concave or convex. (measuring method 6) Does sign waveform appear?	Sign waveform	Go to step 10	Repair flywheel Go to step 11
10	1. Eliminate memory DTC. 2. Check DTC indication. Is DTC P15 displayed.	—	Replace ECM Go to step 11	Double check for connector cable etc. contact incomplete Go to step 11
11	Check DTC indication. Is DTC P15 displayed?	—	Go back step 2	Solved
	Note: **1. If TechII is used, intermittent trouble can be detected by NE sensor active flag.** **2. If NE sensor signal is completely lost, tachometer output is not produced (When NG in the midway, use G sensor to produce output).** **3. Under G sensor operation, diesel knocking and/or white smoke may often occur due to racing.**			

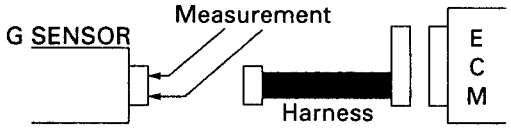
DTC P14 Pump Position Sensor Error (G sensor)



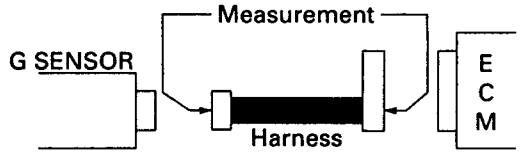
Measuring method 1



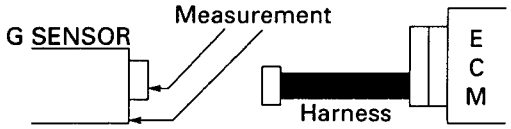
Measuring method 3



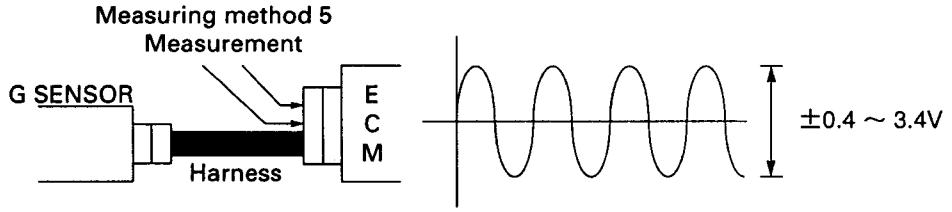
Measuring method 2



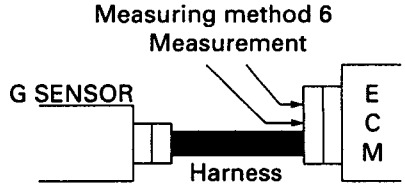
Measuring method 4

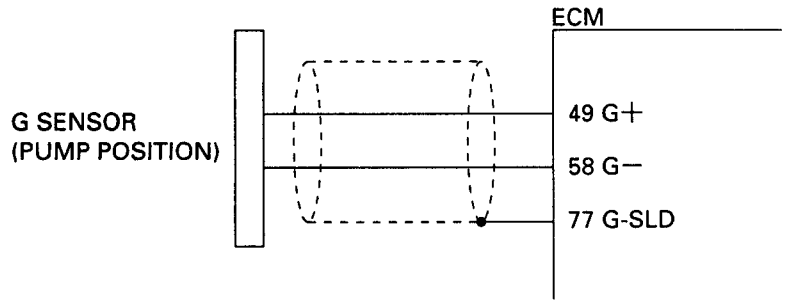


Measuring method 5



Measuring method 6



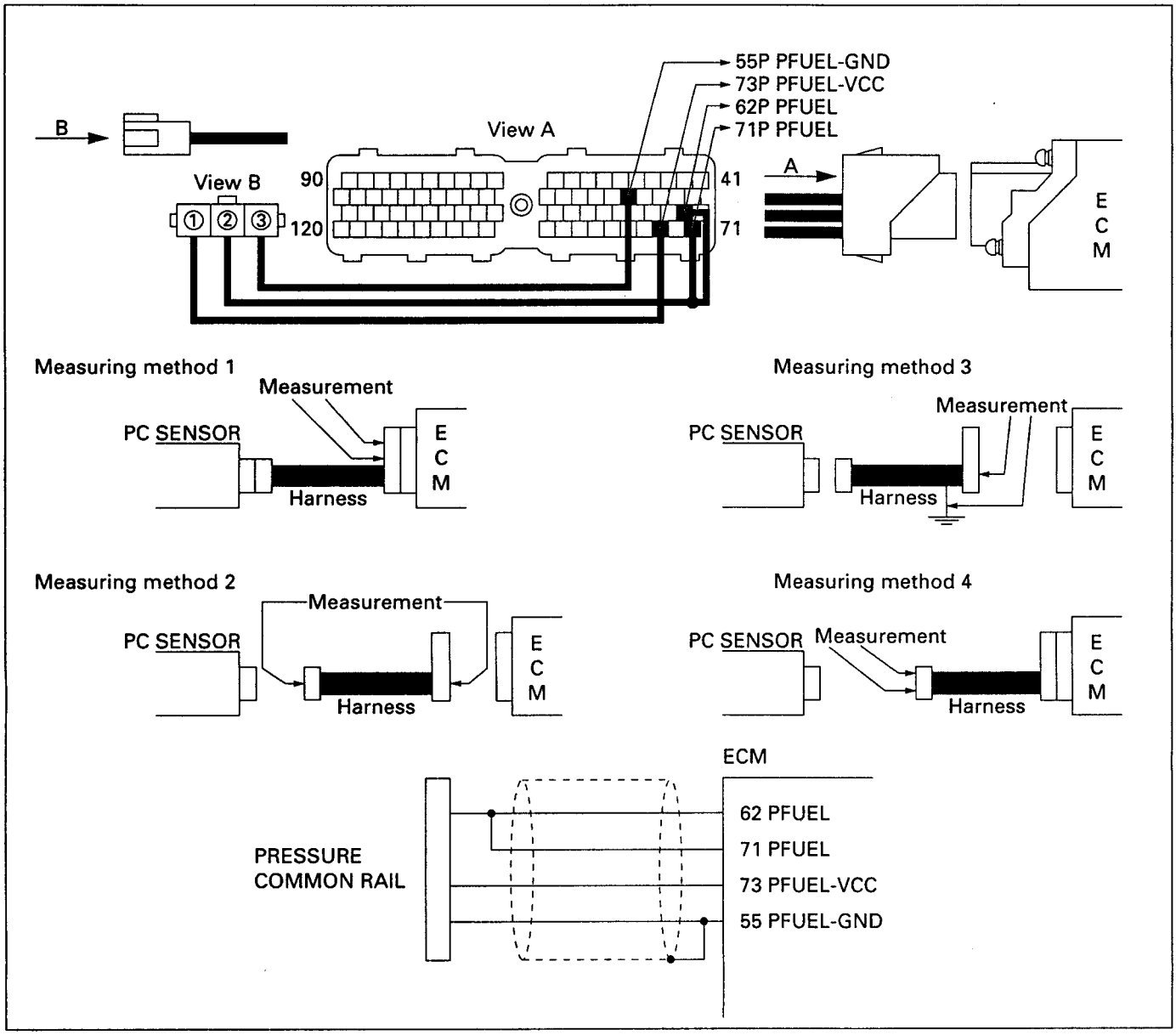


056MV013

DTC P14 Pump Position Sensor Error (G sensor)

STEP	ACTION	VALUE	YES	NO
1	Does DTC P14 indicate on continuous for 20 sec. after engine starting at 700 rpm or less.	—	Go to step 2	—
2	1. Key switch OFF. 2. Disconnect ECM connector. 3. Measure resistance between pin number 49 (G+) and pin number 58 (G–) on the G sensor harness. (Measuring method 1) Is resistance within the value?	1850Ω to 2450Ω	Go to step 6	Go to step 3
3	1. Disconnect G sensor harness. 2. Measure resistance between pin number 49 (G+) and pin number 2 (G sensor terminal 1 side) and between pin number 58 (G–) and pin number 1 (G sensor terminal 2 side). (Measuring method 2) Is resistance within the value?	Less than 2Ω	Go to step 4	Repair harness then Go to step 9
4	Measure resistance in between terminals on the G sensor. (Measuring method 3) Is resistance within the value?	1850Ω to 2450Ω	Go to step 5	Replace G sensor then Go to step 9
5	Measure shortage between G sensor terminal and G sensor body. (Measuring method 4) Is resistance within the value?	More than 10MΩ	Go to step 9	Replace G sensor then Go to step 9
6	1. Reconnect ECM connector and check DTC. 2. Measure G sensor output voltage while engine in operated. 3. Observe G sensor output voltage waveform (Measuring method 5) by oscilloscope. Is voltage within the value?	More than 0.4V/260 rpm More than 3.4V/2600 rpm	Go to step 7	Replace injection pump assembly then Go to step 9
7	1. Reconnect ECM connector and check DTC. 2. Observe G sensor waveform between pin number 49 (G+) and ECM ground (Do not use (G–)) (Measuring method 6) by oscilloscope. 3. If normal, the sign waveform displayed. Is observe normal waveform?	Sign waveform	Go to step 8	Replace injection pump assembly then Go to step 9
8	Check DTC indication. Is DTC P14 displayed?	—	Replace ECM then Go to step 9	Double check for connector cable etc. contact incomplete. Go to step 9
9	Recheck DTC indication. Is DTC P14 displayed?	—	Go back step 2	Solved
	Note: **1. As compared with G sensor, NE sensor is difficult to detect trouble because its influence is smaller.** **2. Intermittent G sensor trouble is when indication ON or OFF on the DTC P14, it will defect connector of G sensor.** **3. There are two countermeasure for G sensor error, one is G sensor replacement and the other is injection pump replacement.**			

DTC P245 Abnormal Common Rail Pressure (PC sensor system)



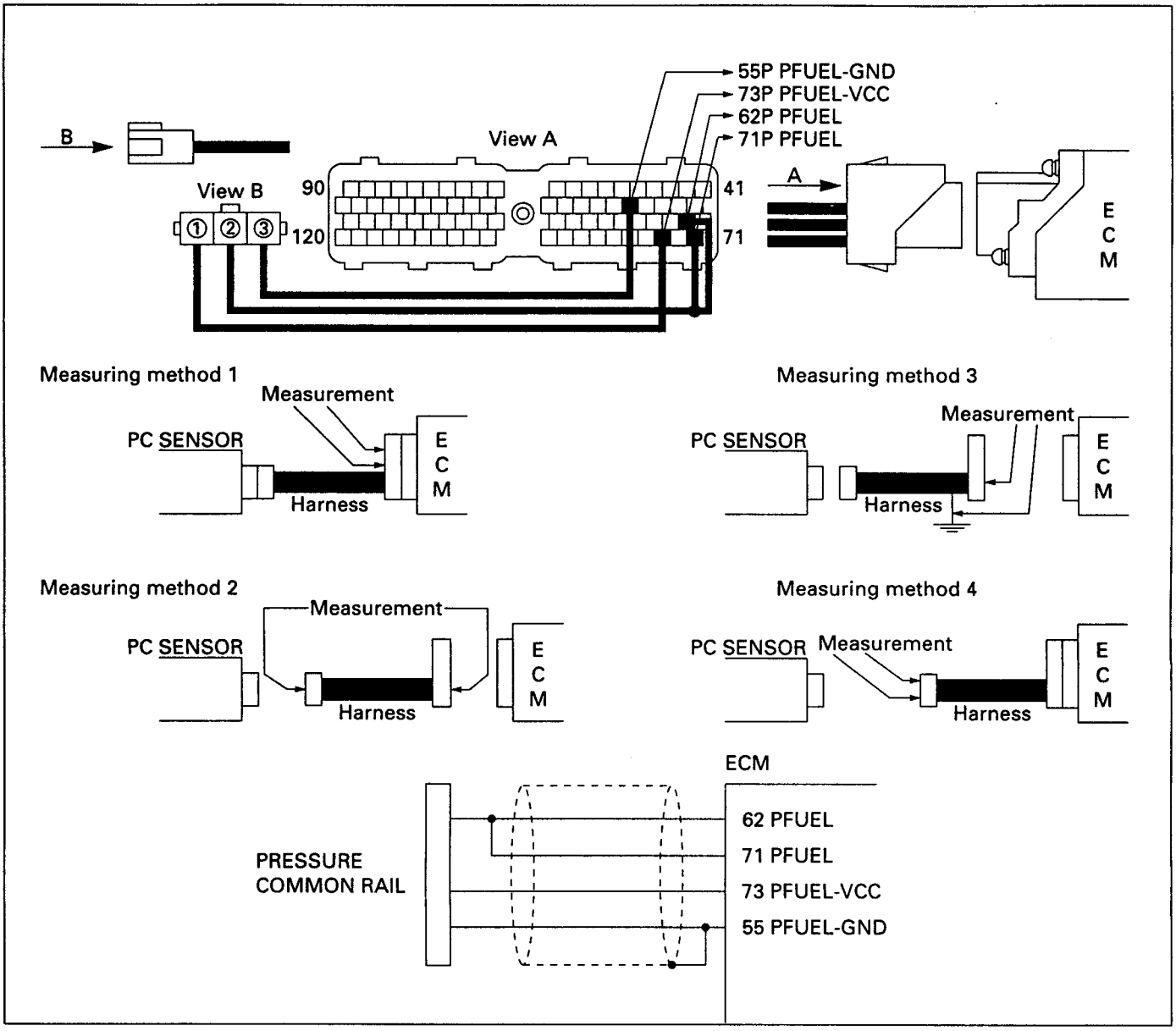
DTC P245 Abnormal Common Rail Pressure (PC sensor system)

STEP	ACTION	VALUE	YES	NO
1	When key switch on, does lamp indication code reads P245?	—	Go to step 2	—
2	Measure voltage between pin number 62 and 71 (PFUEL) and pin number 55 (PFUEL – GND) at ECM side (Measuring method 1) Is voltage diviates from value? (The voltage is about 1.4V more or less at idling with pressure 25 MPa)	0.7V to 4.7V	Go to step 3	Go to step 4
3	Clear the memoried code. Is DTC P45 indication?	—	Go to step 4	Solved
4	1. Key switch "ON". 2. Measure voltage between pin number 73 (PFUEL – VCC) and pin number 55 (PFUEL – GND) (Measuring method 1) Is voltage within the value?	4.75V to 5.25V	Go to step 8	Go to step 5
5	1. Key switch "ON". 2. Disconnect harness connector from ECM. 3. Measure resistance as below. • Between pin number 73 (PFUEL – VCC) of ECM side and pin number 1 sensor side on PC sensor harness. (Measuring method 2) • Between pin number 55 (PFUEL – GND) ECM side and pin number 3 sensor side on PC sensor harness. (Measuring method 2) Is resistance within the value?	2Ω or less	Go to step 6	Repair or replace the PC sensor harness then Go to step 14
6	Measure resistance as below. • Between pin number 73 (PFUEL – VCC) and GND on the PC sensor harness. • Between pin number 55 (PFUEL – GND) and GND on the PC sensor harness. (Measuring method 3) Is resistance within the value?	10MΩ or more	Go to step 7	Repair or replace PC sensor harness then Go to step 14
7	1. Reconnect harness connector to ECM. 2. Measure the voltage between pin number 1 and pin number 3 at sensor side on the PC sensor harness. (Measuring method 4) Is voltage within the value?	Beyond the compass of 5 ± 1V	Replace ECM assembly then Go to step 14	Check, Repair for harness and/or connector have temporary incomplete contact then Go to step 14
8	1. Key switch "OFF". 2. Disconnect PC sensor harness connector from ECM. 3. Measure resistance as below. • Between pin number 62 (PFUEL – VCC) of ECM side and pin number 2 sensor side on PC sensor harness. (Measuring method 2) • Between pin number 71 (PFUEL) of ECM side and pin number 2 sensor side on PC sensor harness. (Measuring method 2) • Between pin number 55 (PFUEL – GND) of ECM side and pin number 3 sensor side on PC sensor harness. (Measuring method 2) Is resistance within the value?	2Ω or less	Go to step 9	Repair/ or replace the PC sensor harness then go to step 15

DTC P245 Abnormal Common Rail Pressure (PC sensor system)

STEP	ACTION	VALUE	YES	NO
9	Measure the resistance between pin number 71 (PFUEL) and GND. Is resistance with the value?	10MΩ or more	Go to step 10	Repair or replace PC sensor harness then Go to step 14
10	1. Reconnect both ECM and PC sensor connector to PC sensor harness connector. 2. Observe PC sensor output waveform using oscilloscope. 3. Check for flooting PC sensor output waveform by noise etc. Is result OK?	—	Go to step 12	Go to step 11
11	Memory clear and recheck DTC. Is display DTC P245?	—	Replace PC sensor then Go to step 14	Go to step 12
12	Check PC sensor harness connector for incomplete contact. Is there poor contact?	—	Make complete contact then Go to step 13	Solved
13	Clear to memoried code. Is display DTC P245?	—	Replace ECM assembly then Go to step 14	Solved
14	Clear to memoried code. Is display DTC P245?	—	Go back to step 2	Solved
	Note: Sometimes it display DTC P261 to DTC P266 due to PC sensor fails.			

DTC P115 Common Rail Pressure Sensor Output Fixed



056MV002

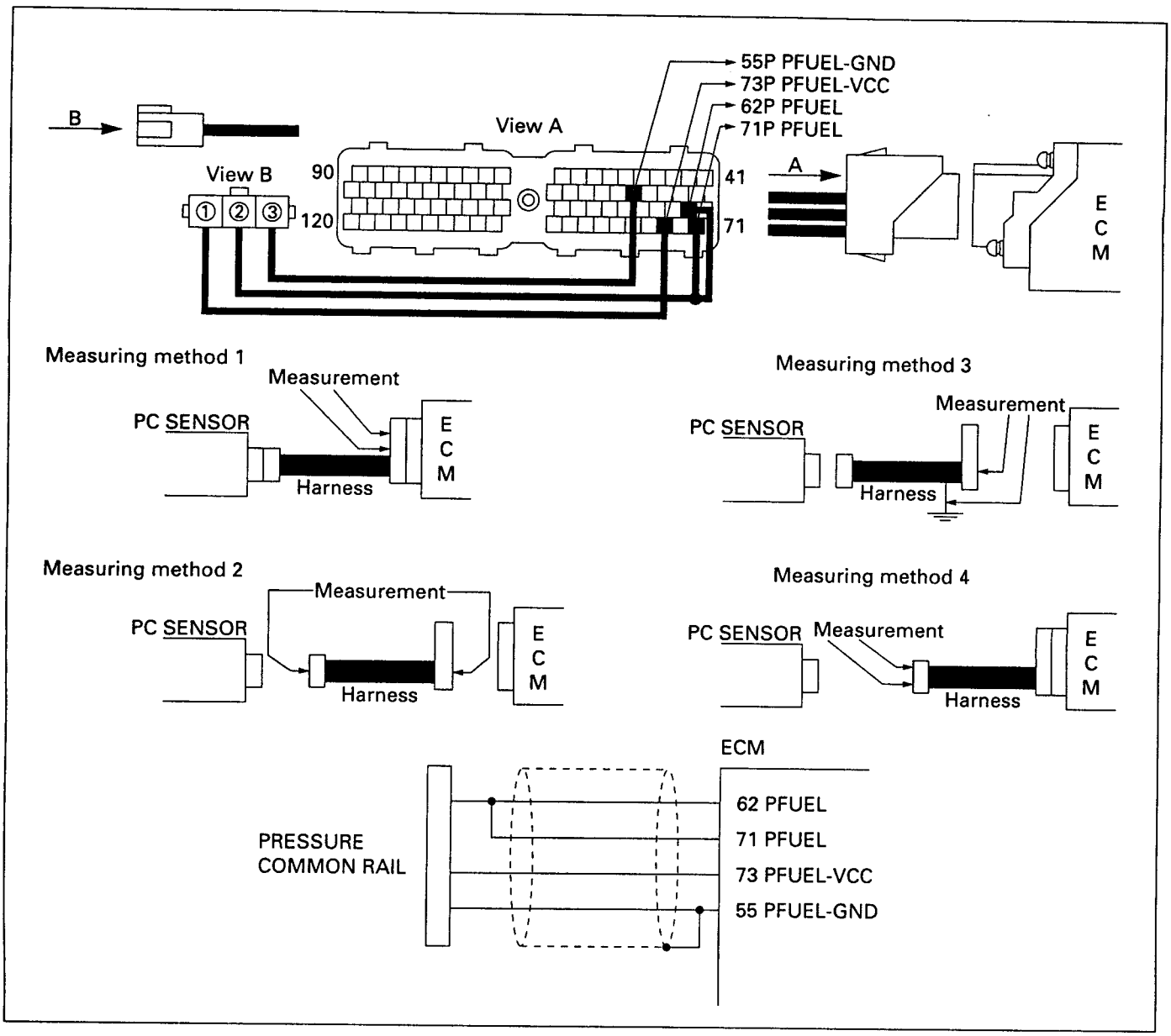
DTC P115 Common Rail Pressure Sensor Output Fixed

STEP	ACTION	VALUE	YES	NO
1	Does DTC P115 display while engine running on when key switch "ON"?	—	Go to step 2	—
2	1. Key switch "ON". 2. Measure the voltage between pin number 62 and 71 (PFUEL) on ECM side connector and pin number 55 (PFUEL – GND) (Measuring method 1) Does voltage within value? (At idling and fuel pressure 25 MPa, the voltage about 1.4V)	0.9V to 1.1V	Go to step 4	Go to step 3
3	1. Key switch "OFF". 2. Disconnect PC sensor harness from both PC sensor side and ECM side. 3. Measure resistance as below. • Between pin number 71 (PFUEL) at ECM side and pin number 2 at PC sensor side. • Between pin number 62 (PFUEL) at ECM side and pin number 2 at PC sensor side. • Between pin number 55 (PFUEL – GND) at ECM side and pin number 3 at PC sensor side. (Measuring method 2)	2Ω or less	Replace PC sensor or ECM assembly then Go to step 10	Repair or replace PC sensor harness then Go to step 10
4	1. Reconnect PC sensor harness. 2. Start the engine. 3. Measure the voltage between pin number 62 and 71 (PFUEL) at ECM side and pin number 55 (PFUEL – GND) at ECM side. (Measuring method 1) While measuring voltage the engine revolution at idling or at racing by depression of accelerator. Does voltage change?	Not change	Go to step 6	Go to step 5
5	Clear to memoried code. Does display DTC P115?	—	Replace ECM assembly then Go to step 10	Correct to incomplete contact of connector then Go to step 10
6	1. Key switch "OFF". 2. Disconnect connector from both ECM and PC sensor. 3. Measure the resistance as follow. • Between pin number 71 (PFUEL) at ECM side connector and pin number 2 at sensor side. • Between pin number 62 (PFUEL) at ECM side connector and pin number 2 sensor side. • Between pin number 55 (PFUEL – GND) at ECM side connector and pin number 3 sensor side. Is resistance within the value?	2Ω or less	Go to step 7	Repair the PC sensor harness then Go to step 10
7	Measure the resistance between pin number 71 and 62 (PFUEL) at ECM side connector and GND on PC sensor harness. Is resistance within value?	10MΩ or more	Go to step 8	Repair the PC sensor harness then Go to step 10
8	1. Reconnect all connector such as PC sensor harness etc. 2. Clear to memories code. Does display DTC P115?	—	Go to step 9	Correct to incomplete contact of connector, then Go to step 10

DTC P115 Common Rail Pressure Sensor Output Fixed

STEP	ACTION	VALUE	YES	NO
9	Engine start and acceleration racing several times. Does display DTC P115?	—	Replace PC sensor or ECM assembly then Go to step 10	Solved
10	Clear to memoried code. Does display DTC P115?	—	Go back to step 2	Solved
	Note: Sometimes it display DTC P261 to DTC P266 due to PC sensor fails.			

DTC P151 Common Rail Pressure Abnormal (Pump over pressure supply)

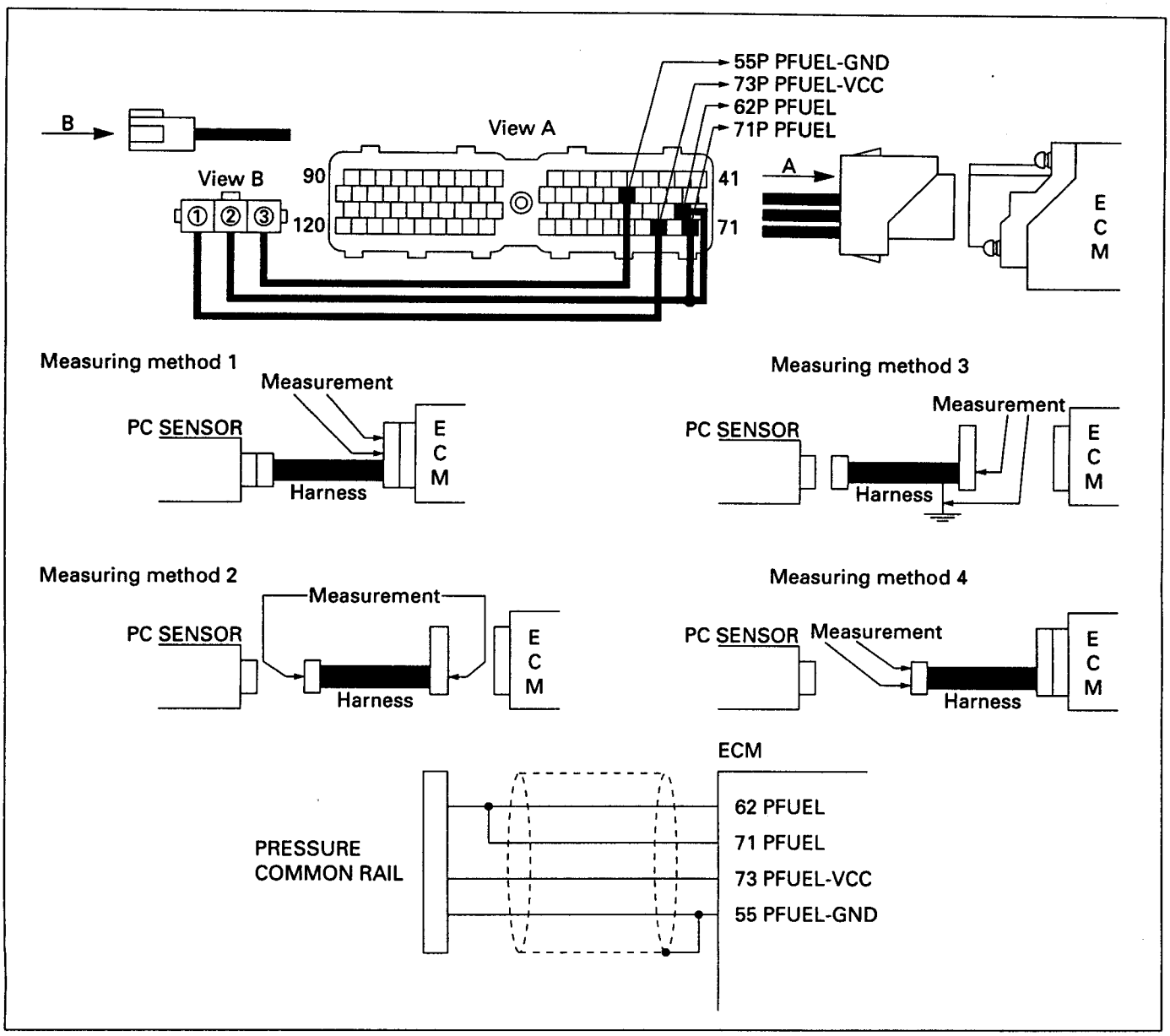


056MV002

DTC P151 Common Rail Pressure Abnormal (Pump over pressure supply)

STEP	ACTION	VALUE	YES	NO
1	Does DTC P151 display while engine running on when key switch "ON"?	—	Go to step 2	—
2	1. Key switch "OFF". 2. Disconnect PC sensor harness connector from PC sensor. 3. Key switch "ON". 4. Measure the voltage between pin number 2 (PFUEL) and pin number 3 (PFUEL – GND) at idling 650 rpm with water temperature more than 60°C. (Measuring method 4) Does voltage within value?	More than 1.4V	Go to step 6	Go to step 3
3	Clear to memoried code. Does display DTC P151?	—	Go to step 5	Go to step 4
4	Check incomplete connection on PC sensor harness connector. Is there complete connection?	—	Solved	Reconnect or repair PC sensor harness, then Go to step 10
5	1. Inspect to indicate any DTC for NE/G sensor. 2. Check complete installation injection pump. Do you find any problem during above inspection?	—	First,repair or replace for these problems.	Go to step 7
6	1. Key switch "OFF". 2. Disconnect PC sensor harness both side. 3. Measure the resistance following points. (Measuring method 2) • Between pin number 71 (PFUEL) at ECM side and pin number 2 at PC sensor side on the PC sensor harness. • Between pin number 62 (PFUEL) at ECM side and pin number 2 at PC sensor side on the PC sensor harness. • Between pin number 55 (PFUEL – GND) at ECM side and pin number 3 at PC sensor side on the PC sensor harness. Is resistance within value?	2Ω or less	Go to step 7	Repair/replace or correct connector contact for PC sensor harness. Then go to step 10
7	Measure the resistance following points. (Measuring method 3) • Between pin number 71 (PFUEL) at ECM side and GND on the PC sensor harness. • Between pin number 62 (PFUEL) at ECM side and GND on the PC sensor harness. • Between pin number 55 (PFUEL – GND) and GND on the PC sensor harness. Is resistance within value?	10MΩ or more	Go to step 8	Repair harness shortage or replace PC sensor harness. Then go to step 10
8	1. Reconnect PC sensor harness to both PC sensor and ECM. 2. Memory clear then engine start. 3. Acceleration racing several times. Is display DTC P151?	—	Replace PC sensor. Then go to step 10	Repair harness shortage or replace PC sensor harness. Then go to step 10
9	Clear to memoried code then engine start. Is display DTC P151?	—	Replace ECM assembly. Then go to step 10	Solved
10	Is display DTC P151?		Go back to step 2	Solved

DTC P118 Common Rail Pressure Abnormal (Control system) 1st and 2nd Stage

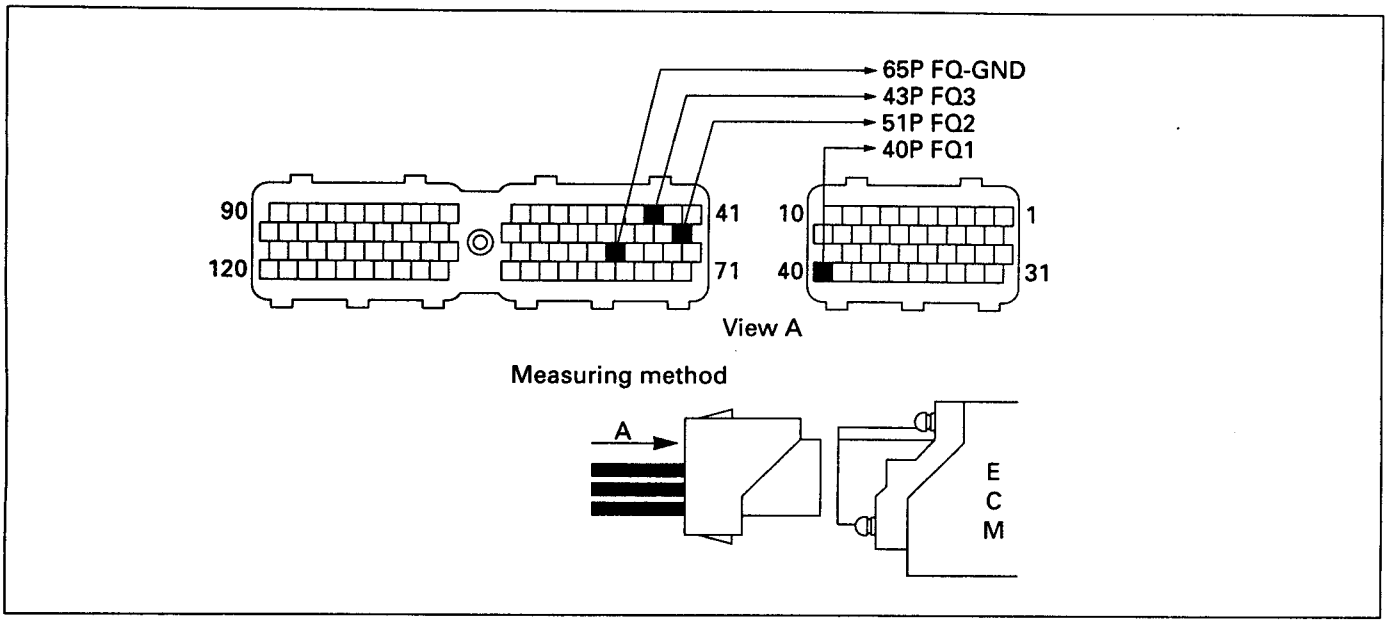


056MV002

DTC P118 Common Rail Pressure Abnormal (Control system) 1st and 2nd Stage

STEP	ACTION	VALUE	YES	NO
1	Does DTC P118 display?	—	Go to step 2	—
2	Measure the voltage while key switch "ON" as follow. (Measuring method 1) Between pin number 62 and 71 (PFUEL) and pin number 55 (PFUEL – GND) at ECM side.	3.4V or more (at 125 Mpa)	Go to step 6	Go to step 3
3	1. Clear the memory. 2. Engine start. Is display DTC P151 or P118? **Note: If you want to start engine, disconnect PC sensor connector (Make open loop circuit).**	—	Go to step 4	Repair incomplete connection on the connector Go to step 9
4	Does PC sensor voltage more than 3.4V when key "ON"?	3.4V or more	Replace PC sensor. Then go to step 5	Go back to step 3
5	Does display DTC P118?	—	Go to step 4	Solved
6	1. Disconnect PC sensor harness from both PC sensor and ECM. 2. Measure the resistance following points. (Measuring method 2) • Between pin number 71 and 62 (PFUEL) at ECM side and pin number 2 at PC sensor side on the PC sensor harness. • Between pin number 55 (PFUEL – GND) at ECM side and pin number 3 at PC sensor side on the PC sensor harness. Is resistance within value?	2Ω or less	Go to step 7	Repair/replace PC sensor harness. Then go to step 9
7	Measure resistance between pin number 62 and 72 (PFUEL) at ECM side and GND on the PC sensor harness. (Measuring method 3) Is resistance within value?	10MΩ or more	Replace PC sensor. Then go to step 8	Replace PC sensor harness then go to step 8
8	Reconnect all connector. Does display DTC P118?	—	Replace ECM assembly. Then go to step 9	Solved
9	Does display DTC P118?	—	Go back to step 2	Solved

DTC P34 Q-Adjusted Data Error (No history recorded)

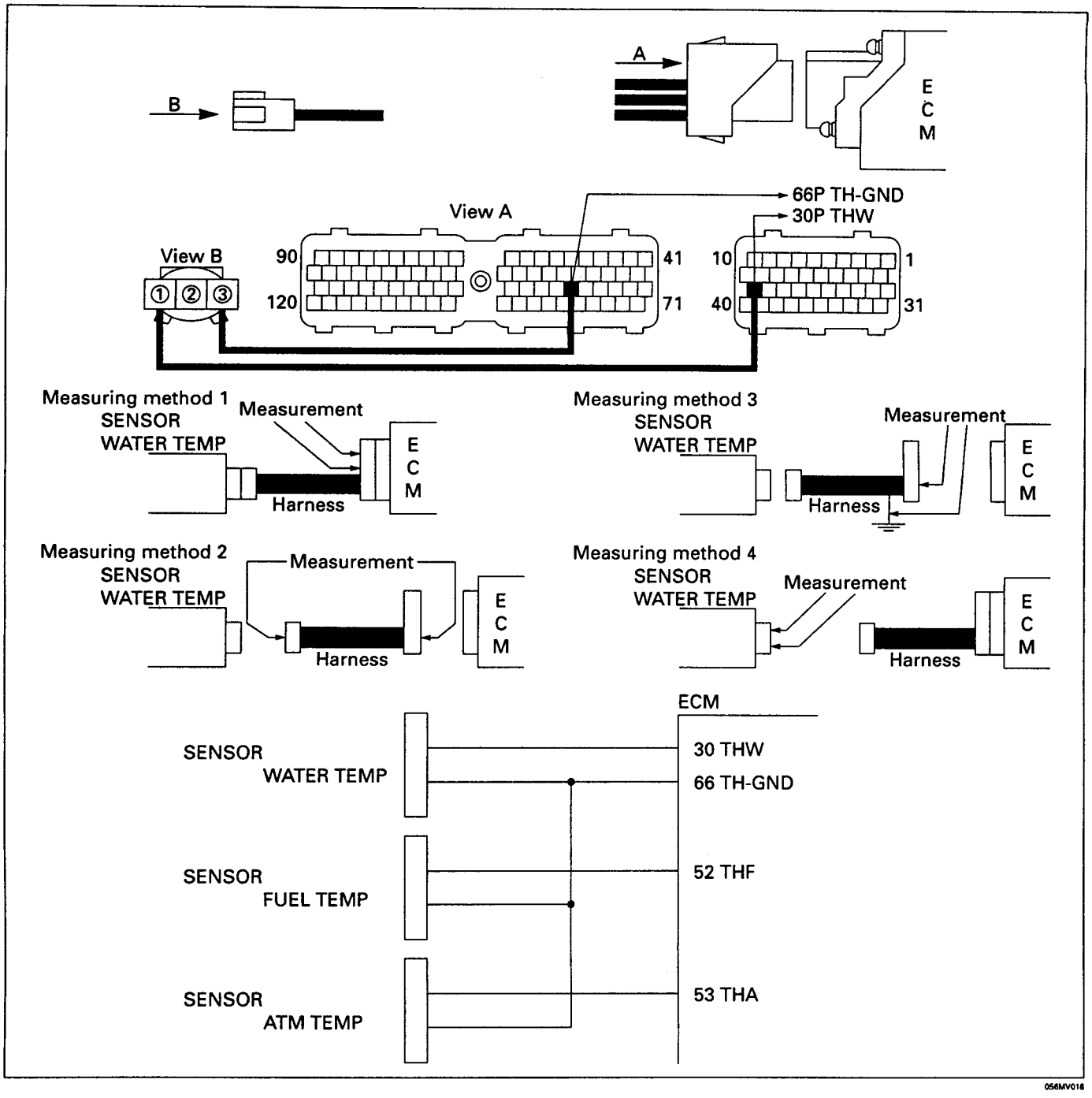


056MV019

DTC P34 Q-Adjusted Data Error (No history recorded)

STEP	ACTION	VALUE	YES	NO
1	Does DTC P34 display when key switch "ON"	—	Go to step 2	—
2	Assume that Q-adjusted data may not be writen to ECM after replaced ECM assembly. Did write the Q-adjusted data?	—	Check TechII connection and/or ECM connection. Then go to step 4	Go to step 3
3	Write Q-adjusted data to ECM use TechII. Does DTC P34 display after writing the Q-adjusted data?	—	Same as step 2	Solved
4	Does DTC P34 display after above action done?	—	Go back to step 2	Solved
	Note: • **When ECM assembly replaced, Tech2 is required.** • **Make sure that lamp is lighted when DTC P34 flag standing.** • **When ECM replaced, output Q-adjustment number from the old ECM, and then input it into new ECM by TechII.**			

DTC P23 Water Temperature Sensor Error

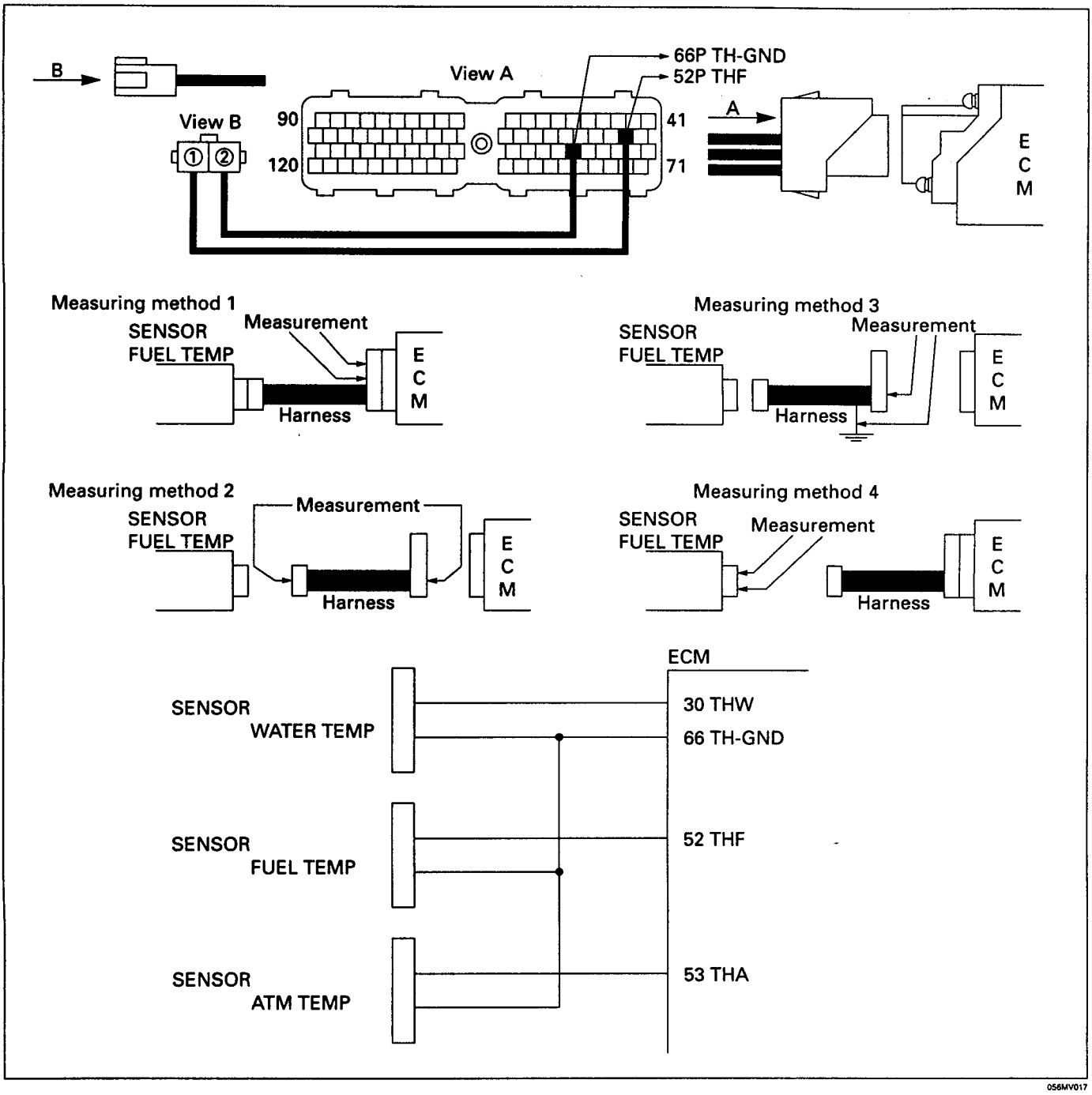


DTC P23 Water Temperature Sensor Error

<table>
<tr><th>STEP</th><th>ACTION</th><th>VALUE</th><th>YES</th><th>NO</th></tr>
<tr><td>1</td><td>Does lamp indication code reads DTC P23 when key switch "ON" or engine in operation?</td><td>—</td><td>Go to step 2</td><td>—</td></tr>
<tr><td>2</td><td>Measure the voltage between pin number 30 (THW) and pin number 66 (TH-GND) at ECM side while key switch "ON" and engine in operation. (Measuring method 1)
Is there voltage beyond compass from value?
(0.65V when water temp. about 80°C)
Note: When voltage abnormally high e.g. 12V, may be short circuited with +B line.</td><td>0.1V to 4.8V</td><td>Go to step 4</td><td>Go to step 3</td></tr>
<tr><td>3</td><td>Check intermittent incomplete connection in between connector and THW sensor harness or temporally overheating of engine.
Is there above problem?</td><td>—</td><td>Go to step 4</td><td>Go to step 5</td></tr>
<tr><td>4</td><td>Repair/replace engine cooling system such as radiator, fan and thermostat etc.
Did you done?</td><td>—</td><td>Go to step 2</td><td>Should be done.
Then go to step 9</td></tr>
<tr><td>5</td><td>1. Key switch "OFF".
2. Disconnect connector from ECM and THW sensor.
3. Measure resistance following points. (Measuring method 2)
• Between pin number 30 (THW) at ECM side and pin number 1 at sensor side.
• Between pin number 66 (TH-GND) at ECM side and pin number 3 at sensor side.
Is resistance within value?</td><td>2Ω or less</td><td>Go to step 6</td><td>Repair/replace to THW sensor harness</td></tr>
<tr><td>6</td><td>Measure the resistance between pin number 30 (THW) and GND on the THW sensor harness.
Is resistance within value?</td><td>10MΩ or more</td><td>Go to step 7</td><td>Repair/replace to THW sensor harness</td></tr>
<tr><td>7</td><td>Measure the resistance THW sensor unit.
Is resistance normal value?

Resistance for THW sensor unit
<table><tr><th>Water temperature (°C)</th><th>Resistance (kΩ)</th></tr><tr><td>20</td><td>About 2.7 (2.5V)</td></tr><tr><td>40</td><td>1.3 (1.6V)</td></tr><tr><td>60</td><td>0.6 (0.9V)</td></tr><tr><td>80</td><td>0.4 (0.65V)</td></tr></table></td><td>See table left</td><td>Go to step 8</td><td>Replace THW sensor</td></tr>
<tr><td>8</td><td>1. Reconnect THW sensor harness connector to both ECM and THW sensor.
2. Clear to memoried code.
Is display DTC P23?</td><td>—</td><td>Replace ECM assembly.
Then go to step 9</td><td>Solved</td></tr>
<tr><td>9</td><td>Clear to the memoried code.
Is display DTC P23?</td><td></td><td>Go back to step 2</td><td>Solved</td></tr>
<tr><td></td><td>Note: Water temperature GND is common. If disconnected or short circuited, all sensors become erroneous. (Water, atmospheric and fuel temperature)</td><td></td><td></td><td></td></tr>
</table>

DTC P211 Fuel Temperature Sensor Error



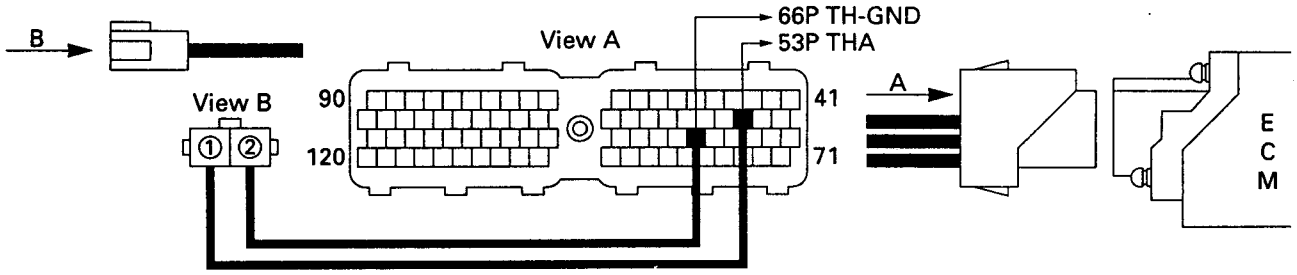
056MV017

DTC P211 Fuel Temperature Sensor Error

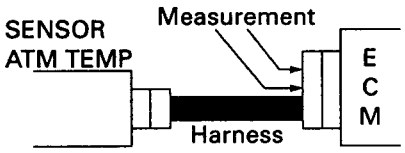
<table>
<tr><th>STEP</th><th>ACTION</th><th>VALUE</th><th>YES</th><th>NO</th></tr>
<tr><td>1</td><td>Does display DTC P211 while key switch "ON" or engine in operating?</td><td>—</td><td>Go to step 2</td><td>—</td></tr>
<tr><td>2</td><td>Measure the voltage between pin number 52 (THF) and pin number 66 (TH – GND) at ECM side while key switch "ON" and engine in operating. (Measuring method 1)
Is there voltage beyond compass from value?
(1.5V when fuel temp. about 60°C)</td><td>0.1V
to
4.8V</td><td>Go to step 4</td><td>Go to step 3</td></tr>
<tr><td>3</td><td>Check incomplete connection on connector.
Is there incomplete connection?</td><td>—</td><td>Correct to complete connection.</td><td>Go to step 4</td></tr>
<tr><td>4</td><td>Is there abnormally high or low fuel temperature?</td><td>—</td><td>Repair fuel system</td><td>Go to step 5</td></tr>
<tr><td>5</td><td>1. Key switch "OFF".
2. Disconnect THF sensor harness from both ECM and THF sensor.
3. Measure resistance following points.
• Between pin number 52 (THF) at ECM side and pin number 1 at THF sensor side on the THF sensor harness.
• Between pin number 66 (TH–GND) at ECM side and pin number 2 at THF sensor side on the THF sensor harness. (Measuring method 2)
Is resistance within value?</td><td>2Ω or less</td><td>Go to step 6</td><td>Repair/replace THF sensor harness.</td></tr>
<tr><td>6</td><td>Measure resistance between pin number 52 and GND. (Measuring method 3)
Is resistance within value?</td><td>10MΩ or more</td><td>Go to step 7</td><td>Repair/replace THF sensor harness</td></tr>
<tr><td>7</td><td>Measure resistance THF sensor unit. (Measuring method 4)
Is resistance within value?

Resistance for THF sensor unit
<table>
<tr><th>Fuel temperature (°C)</th><th>Resistance (kΩ)</th></tr>
<tr><td>20</td><td>About 2.7 (3V)</td></tr>
<tr><td>40</td><td>1.3 (2.2V)</td></tr>
<tr><td>60</td><td>0.6 (1.5V)</td></tr>
<tr><td>80</td><td>0.4 (1V)</td></tr>
</table></td><td>Ses table left</td><td>Go to step 8</td><td>Replace THF sensor</td></tr>
<tr><td>8</td><td>1. Reconnect THF sensor harness to ECM and THF sensor.
2. Clear to memoried code.
Is display DTC P211?</td><td>—</td><td>Replace ECM assembly then Go to step 9</td><td>Solved</td></tr>
<tr><td>9</td><td>Clear to memoried code.
Is display DTC P211?</td><td>—</td><td>Go back to step 2</td><td>Solved</td></tr>
<tr><td></td><td>Note: The temperature sensor GND is common. If disconnected or short circuited, all sensor become erroneous. (Water, atmospheric and fuel temperature.)</td><td></td><td></td><td></td></tr>
</table>

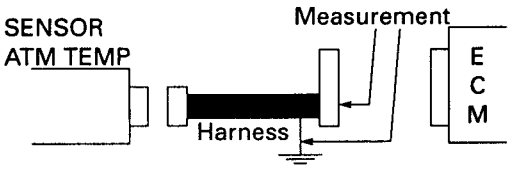
DTC P22 Atmospheric Temperature Sensor Error



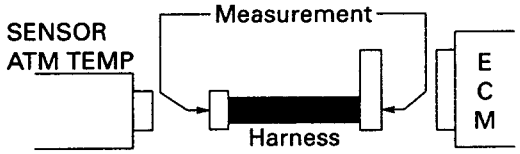
Measuring method 1



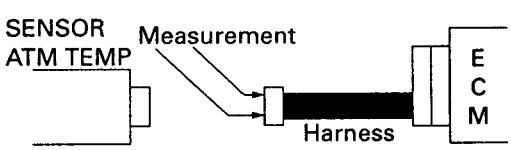
Measuring method 3

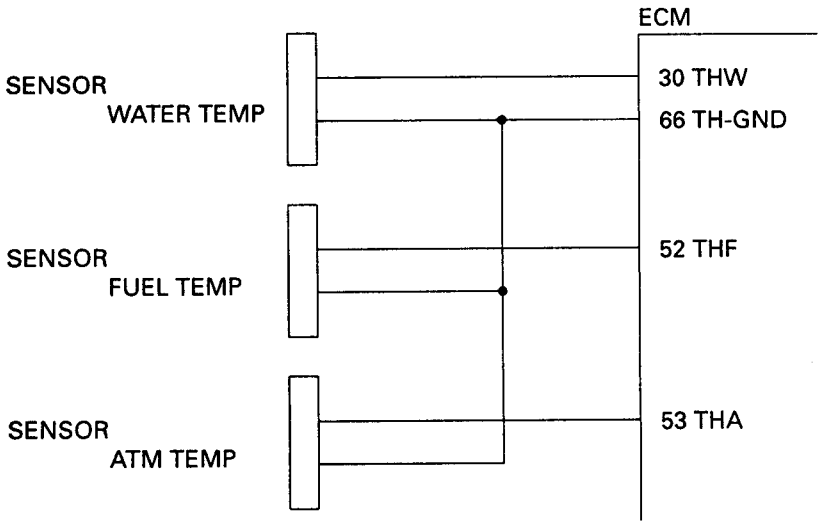


Measuring method 2



Measuring method 4



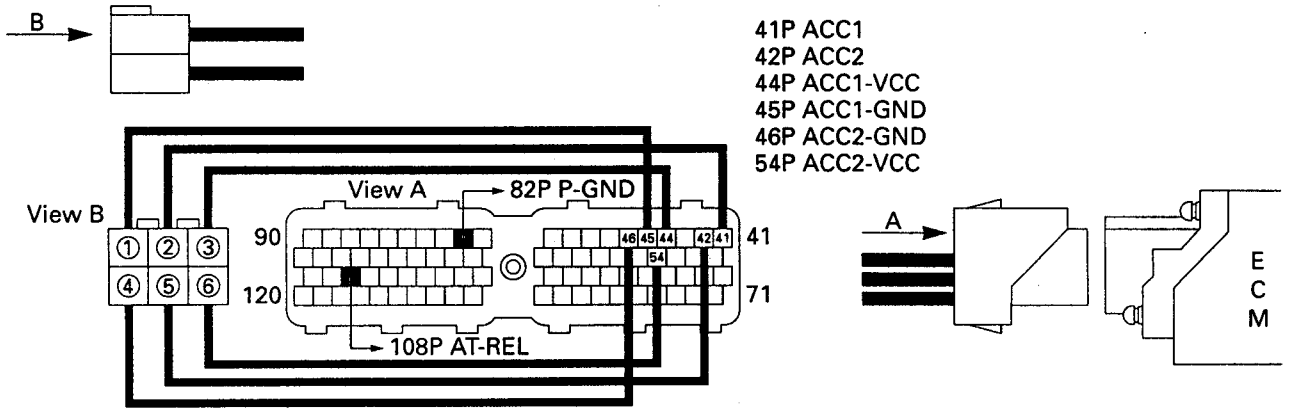


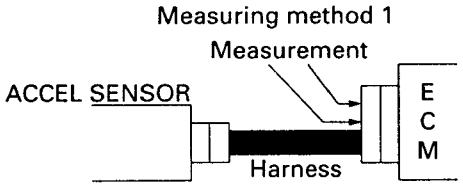
056MV016

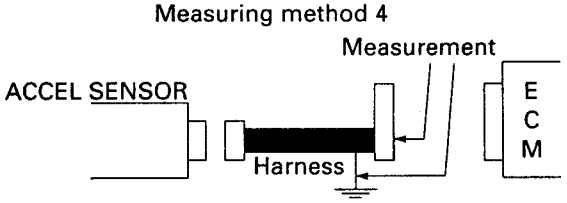
DTC P22 Atmospheric Temperature Sensor Error

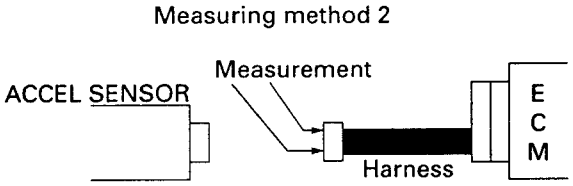
STEP	ACTION	VALUE	YES	NO
1	Does display DTC P22 while key switch "ON" or engine in operating?	—	Go to step 2	—
2	Measure the voltage between pin number 53 (THA) and pin number 66 (TH–GND) at ECM side. (Measuring method 1) Is there voltage beyond compass from value? (2.9V when air temp. about 20°C)	0.1V to 4.8V	Go to step 4	Go to step 3
3	Check incomplete connection connector on the THA sensor harness. Is there incomplete connection?	—	Repair THA sensor harness	Solved
4	Is there abnormal high or low atmospheric temperature at atmospheric temperature sensor fixing area?	—	Repair problem portion	Go to step 5
5	1. Key switch "OFF". 2. Disconnect THA sensor harness. 3. Measure resistance following points. (Measuring method 2) • Between pin number 53 (THA) at ECM side and pin number 1 at THA sensor side on the THA sensor harness. • Between pin number 66 (TH–GND) at ECM side and pin number 2 at THA sensor side on the THA sensor harness. Is resistance within value?	2Ω or less	Go to step 6	Repair disconnect THA sensor harness.
6	Measure resistance between pin number 53 (THA) and GND on the THA sensor harness. Is resistance within value?	10MΩ or more	Go to step 7	Repair/replace THA sensor harness. Then go to step 9
7	Measure resistance THA sensor unit. Is resistance within value? Resistance of THA sensor unit Atmospheric temperature (°C) / Resistance (kΩ) 20 / About 3.8 (2.9V) 40 / 1.6 (1.9V) 60 / 0.8 (1.1V) 80 / 0.4 (0.7V)	See table left	Go to step 8	Replace THA sensor assembly. Then go to step 9
8	1. Reconnect THA sensor harness to ECM and THA sensor. 2. Clear to memoried DTC. Is display DTC P22?	—	Replace ECM assembly then Go to step 9	Solved
9	Clear to memoried DTC. Is display DTC P22?	—	Go back to step 2	Solved
	Note: Sometimes it indicate DTC P22 at abnormal low atmospheric temperature (Less than minus 40°C).			

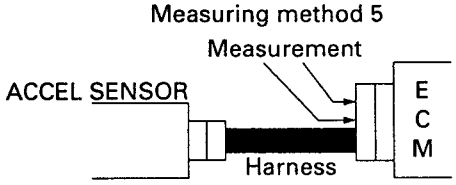
DTC P24 Accelerator Sensor Error 1 and 2 (Trouble for accelerator sensor intermediate hold)

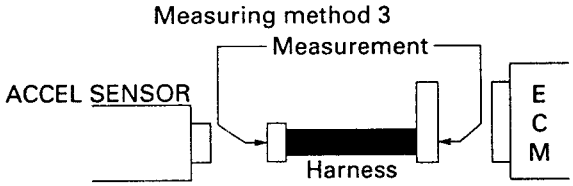


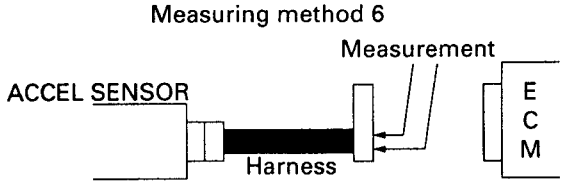


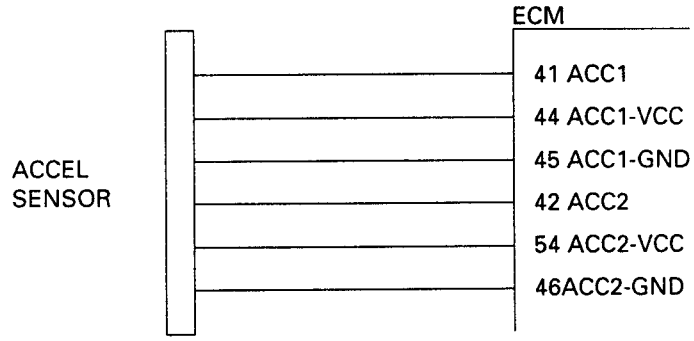






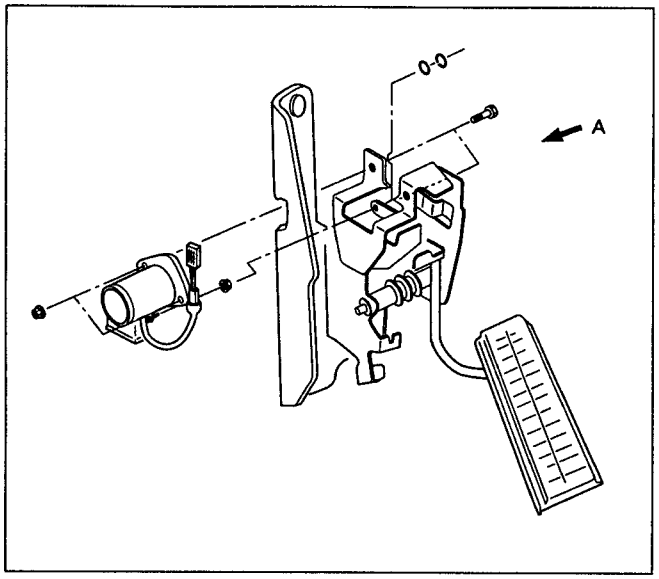




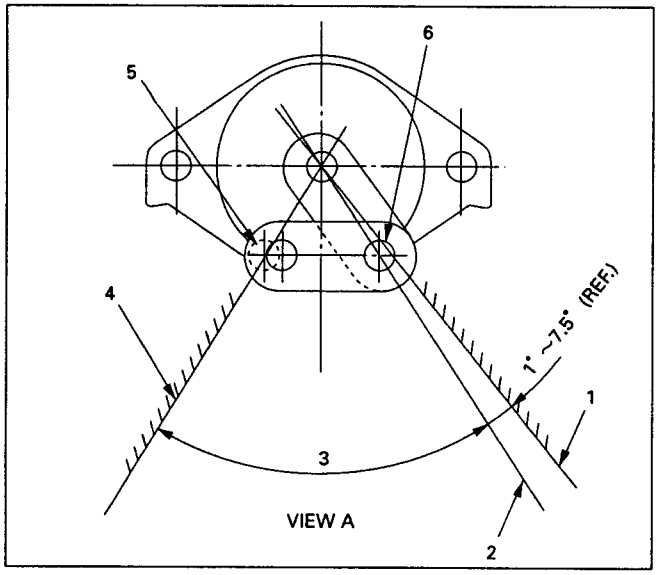


056MV015

Procedure Acceleration Sensor Adjustment



056MV040



056MV039

Legend

(1) Pedal Initial Position
(2) Sensor Set Position
(3) Sensor Travel (Deg.)
(4) Pedal Full Position
(5) Pedal Full Stroke Position
(6) Idling Side Sensor Set Position

Idling side adjustment

Set acceleration sensor output voltage 1.00 ± 0.05 volts at sensor set position (6).

Full Stroke side adjustment

Confirm sensor output voltage more than 3.49 volts when touch the pedal to pedal stopper (5).

DTC P24 Accelerator Sensor Error 1 and 2 (Trouble for accelerator sensor intermediate hold)

Note: The accelerator sensor is hole element type and non contact type, thus, when doing judgment to supplying voltage.

STEP	ACTION	VALUE	YES	NO
1	Does display DTC P24 while key switch "ON" or engine in operating?	—	Go to step 2	—
2	Measure voltage following points. (Measuring method 1) • Between pin number 41 (ACC1) and pin number 45 (ACC1–GND) at ECM side. • Between pin number 42 (ACC2) and pin number 46 (ACC2–GND) at ECM side. Is there voltage beyond compass from value?	At idling 0.95V to 1.05V At full around 4.5V (Max)	Go to step 4	Go to step 3
3	1. Repair incomplete contact on accelrator sensor harness. 2. Readjust accelerator sensor when idling voltage abnormally. Did repair/readjust above parts?	—	Go to step 13	Repair/readjust harness or accelerator sensor.
4	Measure voltage between pin number 41 (ACC1) and pin number 42 (ACC2) at ECM side when engine idling condition. (Measuring method 1)	0.2V or less	Go to step 6	Accelerator sensor intermediate hold error. Go to step 5
5	Does accelerator sensor voltage change when move the accelerator pedal?	—	Solved	Readjust accelerator sensor. Then Go to step 13
6	Measure voltage between pin number 41 (ACC1) and pin number 42 (ACC2) at ECM side when accelerator pedal moving idling to full acceleration condition. (Measuring method 1) Is voltage within value?	0.2V or less	Go to step 7	Repair accel. sensor harness connection condition or replace accelerator sensor. Then Go to step 15
7	1. Key switch "OFF". 2. Disconnect the accelerator sensor side connector. 3. Key switch "ON". 4. Measure voltage following point at ECM side. (Measuring method 2) • Between pin number 44 (ACC1–VCC) and pin number 45 (ACC1–GND). • Between pin number 54 (ACC2–VCC) and pin number 46 (ACC2–GND). Is voltage within value?	4V to 6V	Go to step 11	Go to step 8
8	1. Disconnect accelerator sensor harness from both ECM and sensor. 2. Measure resistance following points on the accelerator sensor harness. (Measuring method 3) • Between pin number 44 (ACC1–VCC) ECM side and pin number 4 sensor side. • Between pin number 45 (ACC1–GND) ECM side and pin number 6 sensor side. • Between pin number 54 (ACC2–VCC) ECM side and pin number 1 sensor side. • Between pin number 46 (ACC2–GND) ECM side and pin number 3 sensor side. Is resistance within value?	2Ω or less	Go to step 9	Repair/replace accelerator sensor harness. Then go to step 15

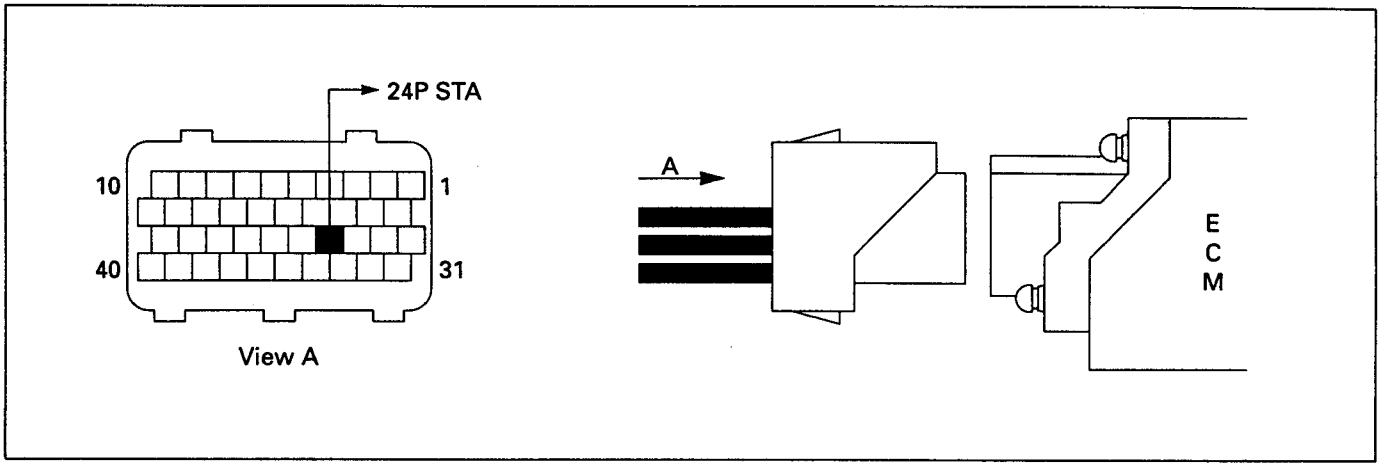
DTC P24 Accelerator Sensor Error 1 and 2 (Trouble for accelerator sensor intermediate hold)

STEP	ACTION	VALUE	YES	NO
9	Measure resistance following points on the accelerator sensor harness. (Measuring method 4) • Between pin number 44 (ACC1–VCC) and GND. • Between pin number 54 (ACC2–VCC) and GND. Is resistance within value?	10MΩ or more	Go to step 10	Repair/replace accelerator sensor harness. Then go to step 15
10	1. Reconnect connector of accelerator sensor harness to ECM. 2. Key switch "ON". 3. Measure voltage following point at ECM side. • Between pin number 44 (ACC1–VCC) and pin number 45 (ACC1–GND). • Between pin number 54 (ACC2–VCC) and pin number 46 (ACC2–GND). Is voltage within value?	4V to 6V	Replace accelerator sensor Then to go step 15	Replace ECM assembly. Then go to step 15
11	1. Disconnect connector from both ECM and accelerator sensor. 2. Key switch "OFF" condition. 3. Measure resistance following points. (Measuring method 3) • Between pin number 41 (ACC1) at ECM side and pin number 5 at accelerator sensor side on the accelerator sensor harness. • Between pin number 42 (ACC2) at ECM side and pin number 2 at accelerator sensor side on the accelerator sensor harness. Is resistance within value?	2Ω or less	Go to step 12	Repair/replace accelerator sensor harness. Then to go step 15
12	Measure resistance following point. (Measuring method 4) • Between pin number 41 (ACC1) and GND. • Between pin number 42 (ACC2) and GND. Is resistance within value?	10MΩ or more	Go to step 13	Repair/replace accelerator sensor harness.
13	Reconnect accelerator sensor harness to both ECM and accelerator sensor. Is lamp display DTC P24?	—	Replace accelerator sensor. Then go to step 14	Solved
14	Clear to memoried DTC. Is display DTC P24?	—	Replace ECM assembly	Solved
15	Clear to memoried DTC. Is display DTC P24?	—	Go back to step 2	Solved
	Note: When restoration from error, necessitate to return back to idling voltage.			

DTC P71 Atmospheric Pressure Sensor Error

STEP	ACTION	VALUE	YES	NO
1	Does DTC P71 display while key switch "ON" and engine in operating?	—	Go to step 2	—
2	Does display DTC P71 again after memory cleared?	—	Replace ECM assembly. Then go to step 3	Erroneous diagnosis due to electrical noise or temporality problem, operate vehicle few term.
3	Clear memoried DTC. Does display DTC P71?	—	Go back to step 2	Solved
	Note: Atmospheric pressure sensor be builted in ECM.			

DTC P417 Starter Switch Abnormal



056MV006

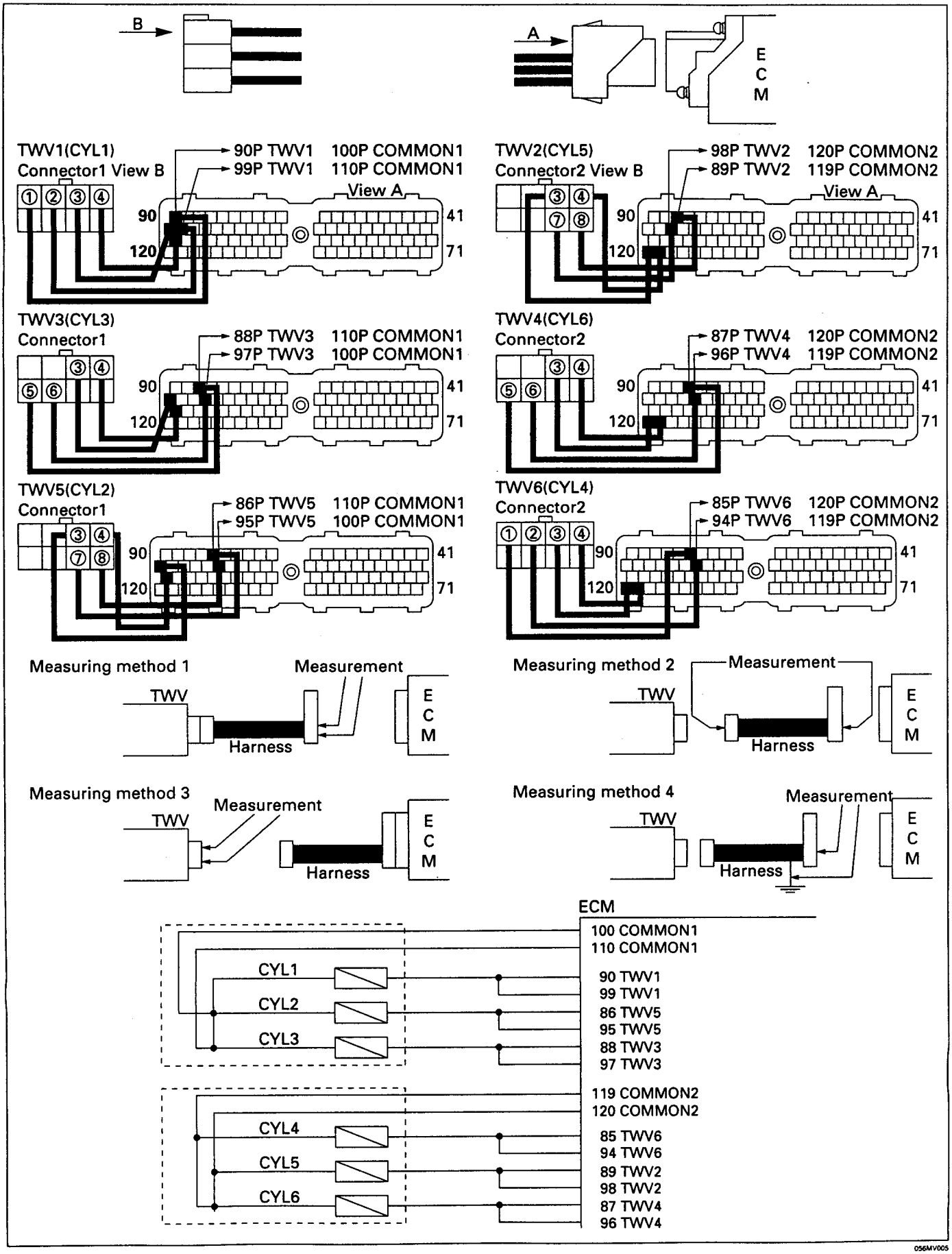
DTC P417 Starter Switch Abnormal

STEP	ACTION	VALUE	YES	NO
1	Does lamp indicate DTC P417 while key switch "ON" and engine in operation.	—	Go to step 2	—
2	Measure voltage between pin number 24 (STA) and GND while key switch "ON" and engine in operating condition. Does voltage indicate 12V.	12V always applied	Go to step 4	Go to step 3
3	Check wire harness and/or starter switch for shortage or starter switch melting (welding). Is there any problem above?	—	Repair/replace wire harness/ starter switch Then to go step 4	Go to step 4
4	Clear to memoried DTC. Is lamp indicate DTC P417?	—	Replace ECM assembly. Then go to step 5	Solved
5	Is lamp indicate DTC P417?	—	Go back to step 2	Solved

DTC P261 to P266 (Cylinder No. 1 to No. 6) Flow Damper Activated

STEP	ACTION	VALUE	YES	NO
1	Does display any DTC from DTC P261 to DTC P266 while key switch "ON" or engine in operation?	—	Go to step 2	—
2	1. After warming up engine (at 60°C or more), eliminate DTC. 2. Restart engine keep idling. Does display any DTC? **Note: Detect by rotation angle speed fluctuation. Angle speed change value small = Not exploded = Incomplete injection = Flow damper activated.**	—	Go to step 4	Go to step 3
3	Temporary trouble. Considerable erroneous diagnosis due to clutch judder when malfunction in neutral switch, clutch switch for judgment under no load. Have you any trouble above?	—	Repair/replace trouble portion. Then go to step 8	Solved
4	According to diagnostic code, (ex. DTC P261 = No. 1 cylinder problem) remove flow damper from common rail. Is flow dumper remain open?	Close	Replace flow damper	Go to step 5
5	Is there looseness or broken on the injection pipe?	—	Replace injection pipe. Then go to step 8	Go to step 6
6	Is there any poor activate on the injector assembly?	—	Replace injector. Then go to step 8	Go to step 7
7	Have you similar problem step 3?	—	Same as step 3	Solved
8	Engine start. Does display any DTC?	—	Go back to step 2	Solved
	Note: • Use TechII common rail pressure control to check fuel for leakage etc. Sometimes it display DTC P261 to DTC P266 due to PC sensor fails.			

DTC P271 to P276 (Cylinder No. 1 to No. 6) TWV Side Disconnected



DTC P271 to P276 (Cylinder No. 1 to No. 6) TWV Side Disconnected

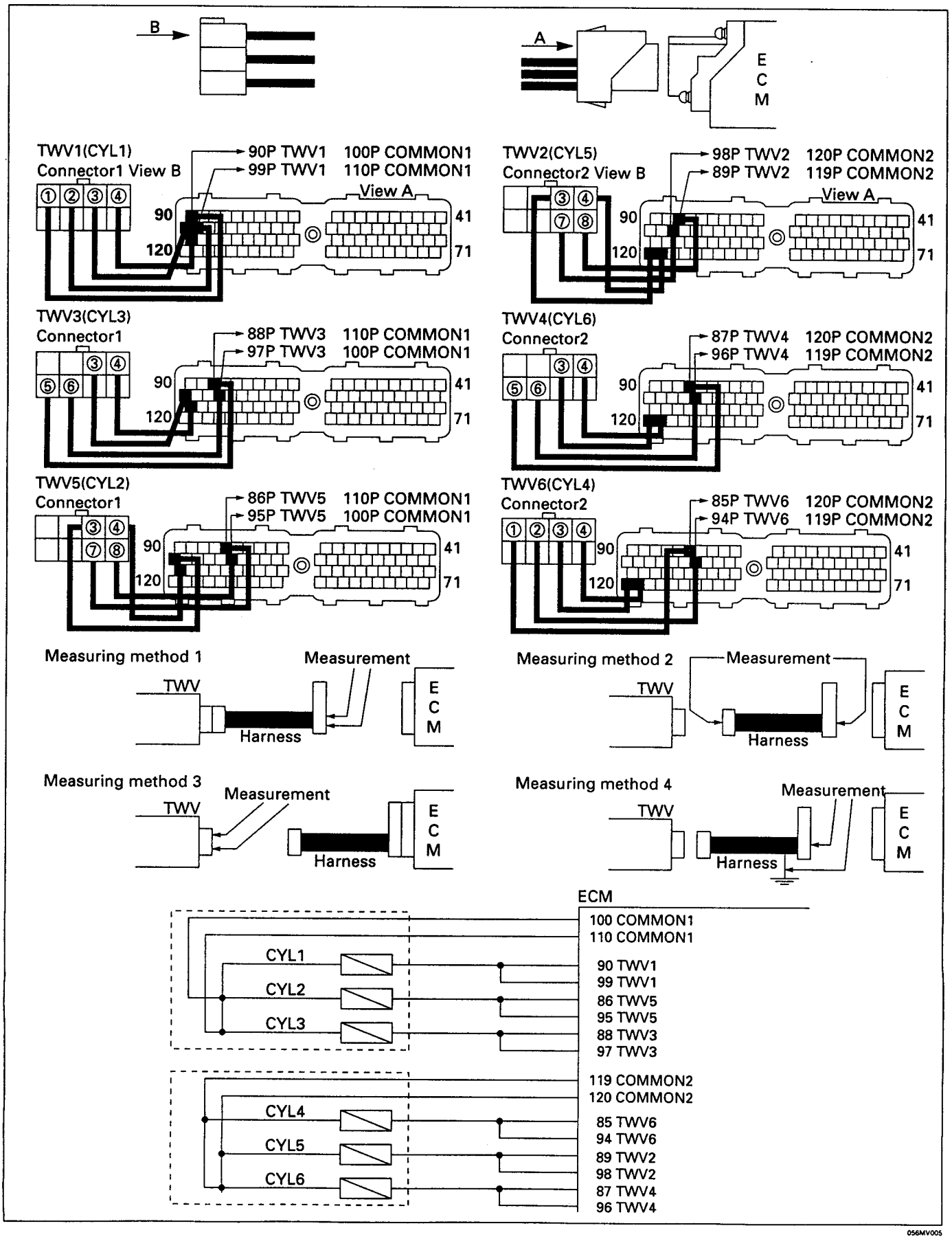
Note: If diagnosed simultaneous with flow dumper, inspect TWV trouble first.

STEP	ACTION	VALUE	YES	NO
1	Does display any TDC from DTC P271 to DTC P276 while key switch "ON" or engine in operating?	—	Go to step 2	—
2	1. Key switch "OFF". 2. Disconnect TWV harness connector from ECM side. 3. Measure resistance following points at ECM side connector of TWV harness. (Measuring method 1). • Between pin number 90, 99 (TWV1) and pin number 100 (COMMON1). • Between pin number 89, 98 (TWV2) and pin number 100 (COMMON1). • Between pin number 88, 97 (TWV3) and pin number 110 (COMMON1). • Between pin number 87, 96 (TWV4) and pin number 119 (COMMON2). • Between pin number 86, 95 (TWV5) and pin number 119 (COMMON 2). • Between pin number 85, 94 (TWV6) and pin number 120 (COMMON2). Is resistance within value?	2.0Ω or less for TWV harness resistance. 0.9Ω to 1.3Ω for TWV coil resistance. Thus minimum resistance is 0.9Ω to 1.3Ω. (If harness resistance 0)	Go to step 7 Before go to step 7, recheck incomplete connection on harness connector.	Go to step 3
3	1. Key switch "OFF". 2. Disconnect TWV harness connector from both ECM and TWV (cyl. head side). 3. Measure resistance following points on the TWV harness. (Measuring method 2) • Between pin number 90, 99 (TWV1) at ECM side and pin number 1, 2 (Connector 1) at TWV side. • Between pin number 89, 98 (TWV2) at ECM side and pin number 7, 8 (Connector 2) at TWV side. • Between pin number 88, 97 (TWV3) at ECM side and pin number 5, 6 (Connector 1) at TWV side. • Between pin number 87, 96 (TWV4) at ECM side and pin number 5, 6 (Connector 2) at TWV side. • Between pin number 86, 95 (TWV5) at ECM side and pin number 7, 8 (Connector 1) at TWV side. • Between pin number 85, 94 (TWV6) at ECM side and pin number 1, 2 (Connector 2) at TWV side. Is resistance within value?	2Ω or less	Go to step 4	Repair/replace TWV harness.
4	Measure resistance following points at TWV side connector. (TWV COIL unit resistance) (Measuring method 3) • Between pin number 1, 2 and 3, 4 at connector 1 for TWV1. • Between pin number 7, 8 and 3, 4 at connector 2 for TWV2. • Between pin number 5, 6 and 3, 4 at connector 1 for TWV3. • Between pin number 5, 6 and 3, 4 at connector 2 for TWV4. • Between pin number 7, 8 and 3, 4 at connector 1 for TWV5. • Between pin number 1, 2 and 3, 4 at connector 2 for TWV6. Is resistance within value?	0.4Ω to 0.8Ω	Go to step 6	Go to step 5

DTC P271 to P276 (Cylinder No. 1 to No. 6) TWV Side Disconnected

STEP	ACTION	VALUE	YES	NO
5	1. Remove cylinder head cover. 2. Inspect upper portion of cylinder head. Is these any problem? (ex. disconnect harness or broken wire etc.)	—	Repair problem portion. Then to to step 6	Go to step 6
6	1. Reconnect all connector and terminal of TWV harness. 2. Install cylinder head cover. 3. Key switch "ON". Is display DTC?	—	Replace ECM assembly. Then go to step 7	Solved
7	1. Clear to memoried DTC. 2. Key switch "ON". Is display DTC?	—	Go back to step 2	Solved

DTC P158, P159 TWV Driving System Error (+B Short Circuited or Ground Line Disconnected)



056MV005

DTC P158, P159 TWV Driving System Error (+B Short Circuited or Ground Line Shorted)

STEP	ACTION	VALUE	YES	NO
1	Does display DTC1 P58 or DTC1 P59 while key switch "ON" or engine in operting?	—	Go to step 2	—
2	1. Key switch "OFF". 2. Disconnect TWV harness from both ECM and TWV connector at cylinder head. 3. Key switch "ON". 4. Measure voltage following points on the TWV harness. (Measuring method 4) • Between pin number 100, 110 (COMMON1) and GND at ECM side connector. • Between pin number 119, 120 (COMMON2) and GND at ECM side connector. In this case, assumption to make short circuit with other +B line. Is voltage within value?	1V or less	Go to step 3	Repair common1 and/or common2 of TWV harness. Then go to step 7
3	1. Key switch "ON". 2. Measure voltage following points at ECM side connector on the TWV harness. (Measuring method 4) • Between pin number 90, 99 (TWV1) and GND. • Between pin number 89, 98 (TWV2) and GND. • Between pin number 88, 97 (TWV3) and GND. • Between pin number 87, 96 (TWV4) and GND. • Between pin number 86, 95 (TWV5) and GND. • Between pin number 85, 94 (TWV6) and GND. In this case, assumption to make short circuit with other GND line. Is voltage within value?	1V or less	Go to step 4	Repair/replace TWV harness. Then go to step 7
4	1. Key switch "OFF". 2. Measure resistance following points at ECM side connector on the TWV harness. (Measuring method 4) • Between pin number 119, 120 (COMMON2) and GND. • Between pin number 100, 110 (COMMON1) and GND. Is resistance within value?	10MΩ or more	Go to step 5	Repair/replace TWV harness. Then go to step 7
5	Measure resistance following points at ECM side connector on the TWV harness (Measuring method) • Between pin number 90, 99 (TWV1) and ECM body GND. • Between pin number 89, 98 (TWV2) and ECM body GND. • Between pin number 88, 97 (TWV3) and ECM body GND. • Between pin number 87, 96 (TWV4) and ECM body GND. • Between pin number 86, 95 (TWV5) and ECM body GND. • Between pin number 85, 94 (TWV6) and ECM body GND. Is voltage within value?	10MΩ or more	Go to step 6	Repair/replace TWV harness. Then go to step 7
6	1. Clear to memoried DTC. 2. Engine start. Does lamp flushing indicate DTC P158 or DTC P159?	—	Replace ECM assembly. Then go to step 7	Solved
7	1. Clear to memoried DTC. 2. Engine start. Does lamp flushing indicate DTC P158 or DTC P159?	—	Go back to step 2	Solved

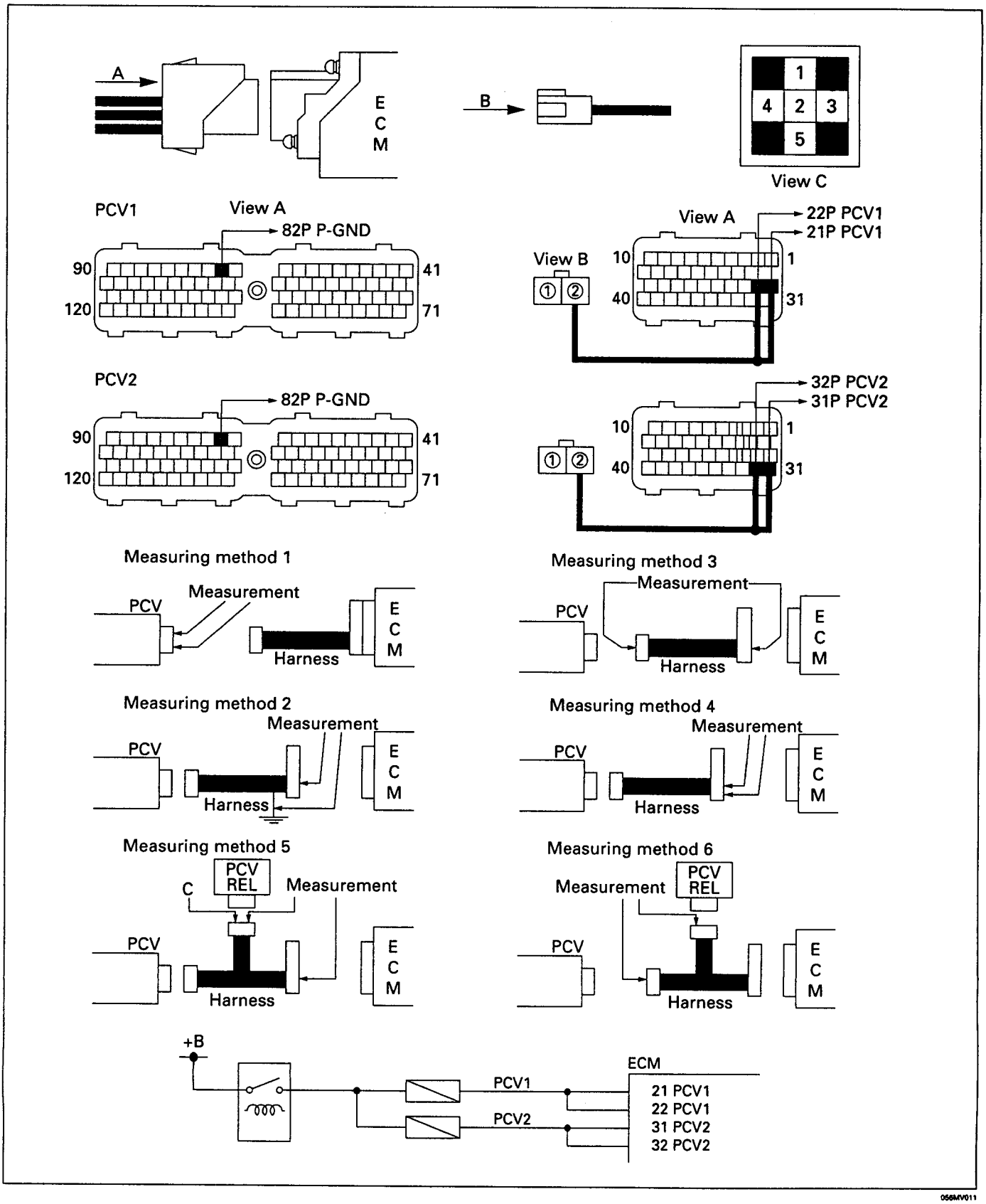
DTC P226 Injection Pump Non Pressure Supply or Pressure Limiter Activation

STEP	ACTION	VALUE	YES	NO
1	Does lamp indication DTC P226 read while key switch "ON" or engine in operation? **Note: In case of PC sensor and/or PCV abnormality, stop diagnosis. If simultaneously indicate PC sensor and PCV error, repair them first.**	—	Go to step 2	—
2	Inspect following items. • Injection pipe malfunction. • Pressure limiter not activated. Is fuel shortage flag standing?	—	Replace pressure limiter Then to to step 7	Go to step 3
3	Clear to memoried DTC. Is lamp indication DTC P226 again?	—	Go to step 5	Go to step 4
4	Check temporary problem ECM connector incomplete contact, pressure control (PC) sensor connector incomplete contact and ECM GND floating etc. Is there any problem? **Note: When PC sensor low pressure output fixed, DTC P226/P227 displayed.**	—	Repair problem portion then go to step 7	Solved
5	Check injection pump abnormality or pump stick. Do you find above problem?	—	Replace injection pump. Then go to step 6	Go to step 7
6	Clear to memoried DTC. Is lamp indication DTC P226 again?	—	Replace ECM. Then go to step 7	Solved
7	Clear to memoried DTC. Is DTC P226 indication?	—	Go back to step 2	Solved

DTC P227 Injection Pump Non Pressure Supply

STEP	ACTION	VALUE	YES	NO
1	Does lamp indication DTC P227 read while key switch "ON" or engine in operation? **Note: In case of PC sensor and/or PCV abnormality, stop diagnosis. If simultaneously indicate PC sensor and PCV error, repair them first.**	—	Go to step 2	—
2	Inspect following items. • Injeciton pipe leakage. • Pressure limiter activated. Is fuel shortage flag standing?	—	Repair/replace problem part. Then go to step 7	Go to step 3
3	Clear memoried DTC. Is lamp indication DTC P227?	—	Go to step 5	Go to step 4
4	Check temporary problem, ECM connector incomplete contact, PC sensor connector incomplete contact and pressure limiter temporary stick etc. Is there any problem? **Note: Check leakage injection line. When PC sensor output fixed at engine idling, does it occur? (DTC P115)**	—	Repair problem portion, then go to step 7	Go to step 6
5	Check injection pump abnormal. Do you find pump problem?	—	Replace injection pump. Then go to step 6	Go to step 6
6	Clear to memoried DTC. Is lamp indication DTC P227?	—	Replace ECM . Go to step 7	Solved
7	Same as step 6.	—	Go back to step 2	Solved

DTC P217, P218 PCV1, 2 (Coil or Harness) +B Shortage

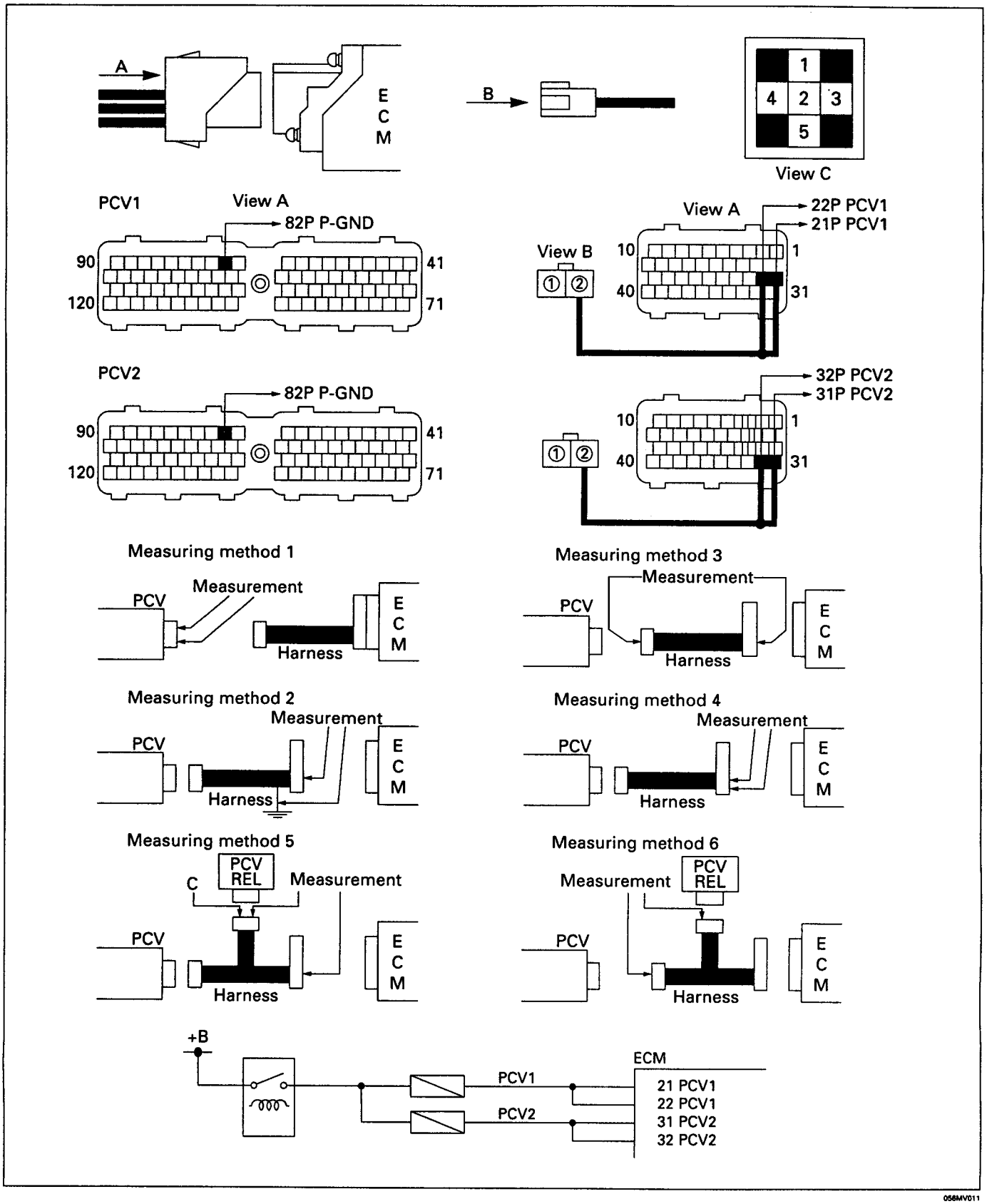


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DTC P217, P218 PCV1, 2 (Coil or Harness) +B Shortage

STEP	ACTION	VALUE	YES	NO
1	Does lamp indication DTC P217 or DTC P218 read, while key switch "ON" or engine in operation?	—	Go to step 2	—
2	1. Key switch "OFF". 2. Disconnect PCV1 and PCV2 connector. 3. Measure resistance following points. (Measuring method 1) • Between pin number 1 and 2 on the PCV1. • Between pin number 1 and 2 on the PCV2. Is resistance within value?	0.9Ω to 1.3Ω	Go to step 3	Replace PCV assembly. Then go to step 7
3	1. Key switch "OFF". 2. Disconnect ECM side connector. (PCV side connector remain connection) 3. Key switch "ON". 4. Measure voltage following points. (Measuring method 4) • Between pin number 21, 22 PCV1 side and pin number 82 (P–GND) ECM side on the PCV1 harness. • Between pin number 31, 32 PCV2 side and pin number 82 (P–GND) ECM side on the PCV2 harness. Is voltage within value?	1V or less	Go to step 5	Go to step 4
4	Repair between battery positive terminal (+B) and PCV input to ECM of PCV harness Did you repair them?	—	Go to step 7	Repair them. Then go to step 7
5	1. Key switch "OFF". 2. Reconnect all connector ECM and PCV harness. 3. Key switch "ON". Does indicate DTC P217 and/or DTC P218?	—	Replace ECM. Then go to step 7	Go to step 6
6	1. Key switch "OFF". 2. Disconnect PCV harness from PCV, PCV relay and ECM. 3. Measure voltage between pin number 1 at PCV relay side of PCV harness and pin number 82 (P–GND) at ECM side of PCV harness. (Measuring method 5) Is voltage within value?	Less than 1V	Go to step 7	Repair/replace PVC harness. Then go to step 7
7	Clear to memoried DTC. Does lamp indication DTC P217 or DTC P218 read while key "ON" or engine in operation?	—	Go back to step 2	Solved

DTC P247, P248 PCV1, 2 (Coil or Harness) Disconnect or GND Shorted



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DTC P247, P248 PCV1, 2 (Coil or Harness) Disconnect or GND Shorted

STEP	ACTION	VALUE	YES	NO
1	Does lamp indication DTC P247 or DTC P248 read, while key switch "ON" or engine in operation?	—	Go to step 2	—
2	1. Key switch "OFF". 2. Disconnect PCV harness connector from ECM. 3. Key switch "ON". 4. Measure voltage at ECM side on the PCV harness as following points. (Measuring method 4) • Between pin number 21, 22 for PCV1 and pin number 82 (P–GND). • Between pin number 31, 32 for PCV2 and pin number 82 (P–GND). Is voltage within value?	10V to 14V	Go to step 8	Go to step 3
3	If lamp indication code simultaneously reads 421, inspect voltage before measure the resistance. 1. Key switch "OFF". 2. Disconnect PCV connector. 3. Measure resistance following points. (Measuring method 2). • Between pin number 21, 22 for PCV1 and pin number 82 (P–GND). • Between pin number 31, 32 for PCV2 and pin number 82 (P–GND). Is resistance within value?	10MΩ or more	Go to step 5	Repair PCV harness Go to step 4
4	1. Key switch "OFF". 2. Disconnect PCV harness from PCV 1, 2, PCV relay and ECM. 3. Measure resistance pin number 1 at PCV relay side of PCV harness and pin number 82 (P–GND) at ECM side of PCV harness. (Measuring method 5) Is resistance within value?	Less than 10MΩ	Repair/replace PCV harness. Then go to step 12	Go to step 5
5	Measure resistance on PCV harness as following points. (Measuring method 3) • Between pin number 21, 22 for PCV1 and pin number 2. • Between pin number 31, 32 for PCV2 and pin number 2. Is resistance within value?	2Ω or less	Go to step 6	Repair PCV harness. Then go to step 12
6	1. Key switch "OFF". 2. Disconnect PCV harness from PCV 1, 2, PCV relay and ECM. 3. Measure resistance pin number 1 at PCV relay side of PCV harness and pin number 82 (P–GND) at ECM side of PCV harness. (Measuring method 5) Is resistance within value?	More than 10MΩ	Go to step 6	Go to step 12
7	1. Key switch "OFF". 2. Disconnect PCV harness from PCV 1, 2, PCV relay and ECM. 3. Measure resistance following points. • Between pin number 1 at PCV 1 side of PCV harness and pin number 1 at PCV relay of PCV harness. • Between pin number 1 at PCV 2 side of PCV harness and pin number 1 at PCV relay of PCV harness. (Measuring method 6) Is resistance within value?	Less than 2Ω	Go to step 7	Repair/replace PCV harness. Then go to step 12

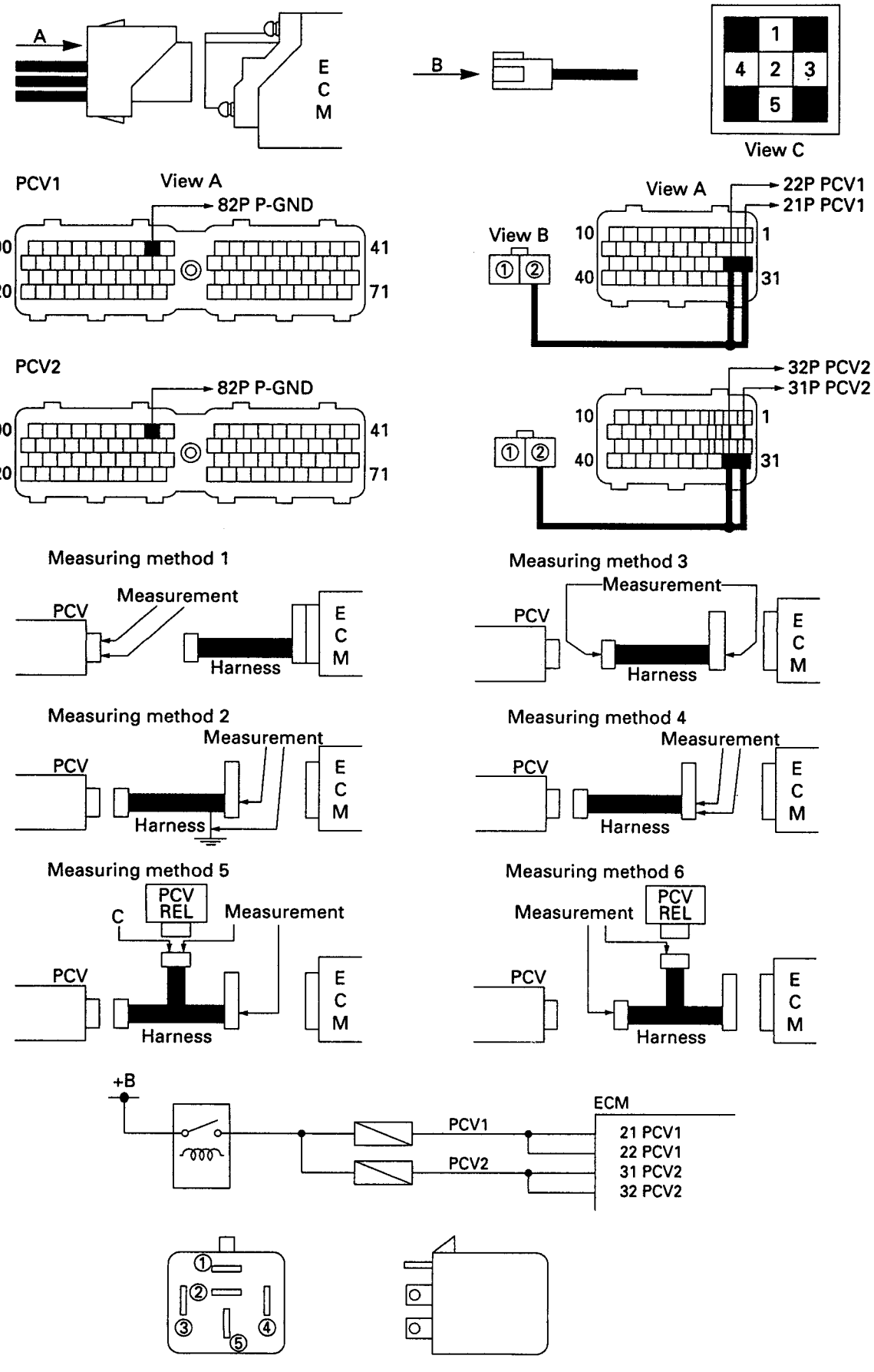
DTC P247, P248 PCV1, 2 (Coil or Harness) Disconnect or GND Shorted

STEP	ACTION	VALUE	YES	NO
8	Measure PCV coil resistance. (Measuring method 1) Is resistance within value?	0.9Ω to 1.3Ω	Go to step 9	Replace PCV and/or injection pump. Then go to step 12
9	1. Key switch "ON". 2. Measure voltage following points. (Measuring method 2) • Between pin number 1 for PCV1 and GND. • Between pin number 1 for PCV2 and GND. Is voltage within value?	10V to 14V	Go to step 11	Repair wire harness in between power supply and relay. Then go to step 12
10	Inspect incomplete connection connector on PCV harness. Is there any incomplete connection?	—	Repair it. Go to step 12	Solved
11	Clear to memoried DTC. Does lamp indication DTC P247, or DTC P248 read?	—	Replace ECM assembly. Go to step 12	Solved
12	Clear to memoried DTC. Does lamp indication DTC P246 or DTC P248 read?	—	Go back to step 2	Solved

DTC P35 Analog Digital Conversion Error, CPU Monitoring IC Error and Charging Circuit Error

STEP	ACTION	VALUE	YES	NO
1	Does lamp indication DTC P35 read, while key switch "ON" or engine in operation?	—	Go to step 2	—
2	Clear to memoried DTC. Is indicate DTC P35 again?	—	Go to step 4	Go to step 3
3	Check radio wave obstacle, temporary incomplete contact at harness connector, noise due to harness GND floating or ECM connector GND incomplete connection. Is there any problem in the above?	—	Repair problem point. Then go to step 5	Solved
4	Check GND floating, incomplete connection ECM connector. Clear to memoried DTC. Is indicate DTC P35 again?	—	Replace ECM assembly. Then go to step 5	Solved
5	Clear to memoried DTC. Is indicate DTC P35? **Note: This trouble is circuit problem within ECM. If no problem in power supply or GND, but DTC not disappeared, ECM considered abnormal.**	—	Go back to step 2	Solved

DTC P421 PCV Relay (R/L) System Error



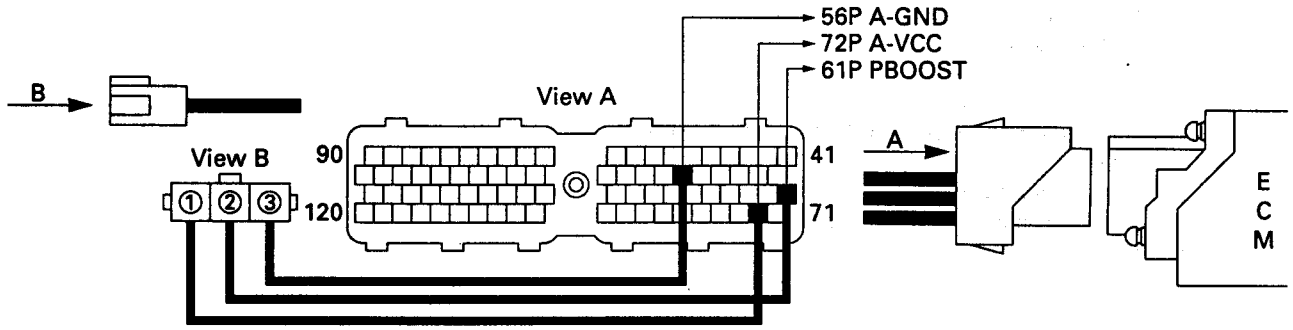
DTC P421 PCV Relay System Error

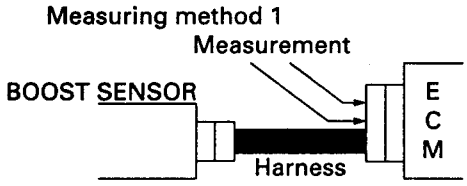
STEP	ACTION	VALUE	YES	NO
1	Does lamp indication DTC P421 read, while key switch "ON" or engine in operation?	—	Go to step 2	—
2	1. Key switch "OFF". 2. Disconnect PCV harness. 3. Measure voltage following points at ECM side connector. • Between pin number 21, 22 for PCV1 and pin number 82 for P–GND. • Between pin number 31, 32 for PCV2 and pin number 82 for P–GND. Is voltage keeping hi (12V)?	12V	Go to step 5	Go to step 3
3	Temporary weld on contact point. After DTC cleared, the lamp indication code reads DTC P421 again?	—	Go to step 4	Repair/replace PCV harness or PCV relay.
4	Does display DTC P421 even if no change from LO (0V)?	—	Replace ECM	Solved
5	1. Remove PCV relay. (R/L) 2. Measure resistance between contact point ⑤ and ①. Is resistance within value?	10MΩ or more	Go to step 6	Replace PCV R/L
6	Possible cause that the cable (Battery → R/L → PCV) on the side of PCV power supply short circuit with +B. 1. Key switch "OFF". 2. Disconnect PCV harness from PCV, PCV relay and ECM. 3. Measure voltage between pin number 1 at PCV relay side of PCV harness and pin number 82 (P–GND) at ECM side of PCV harness. (Measuring method 5) Is voltage within value?	Less than 1V	Go to step 7	Repair/replace PCV harness. Then go to step 7
7	Memory clear. Does indicate DTC P421?	—	Go back to step 2	Solved

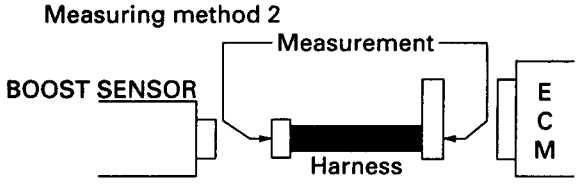
DTC P416 Main Relay System Error (No history records)

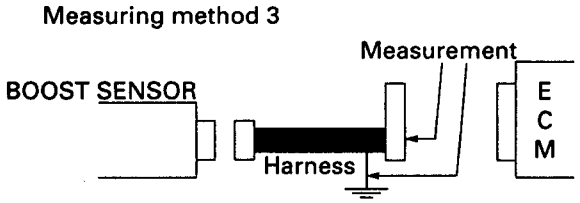
STEP	ACTION	VALUE	YES	NO
—	Lamp: Light at 700 rpm or less for continuously 20 sec. (Lighted at hard circuit). **Note:** • **If this injection system and main relay malfunction, the system does not work (either CPU or driving system).** **It is required to recheck.** • **See item regarding power supply inspection.**	—	—	—

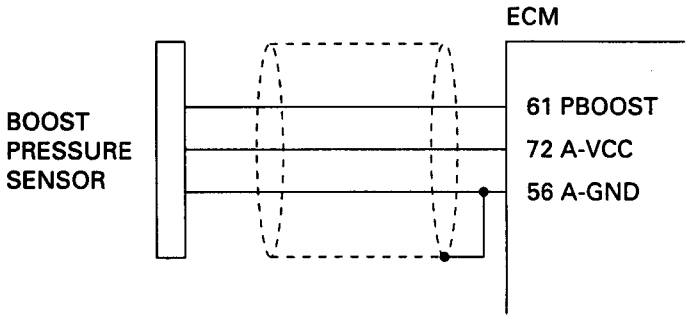
DTC P32 Boost Pressure Sensor Error











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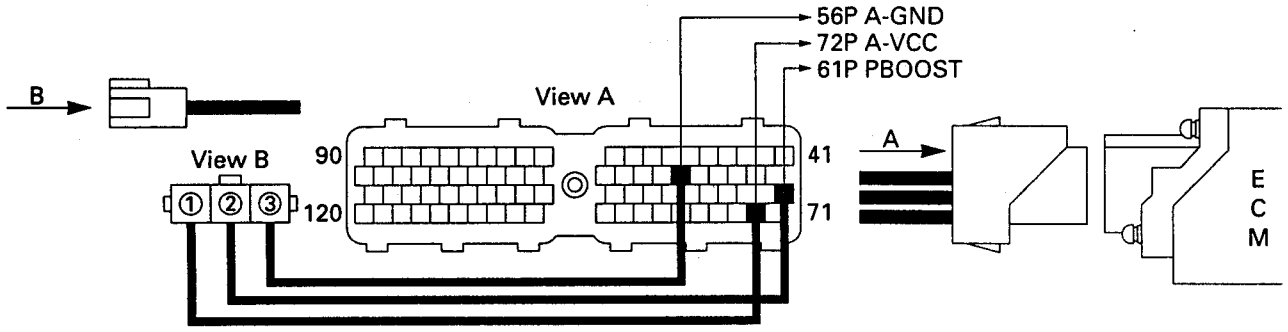
DTC P32 Boost Pressure Sensor Error

STEP	ACTION	VALUE	YES	NO
1	Does lamp indication DTC P32 read, while key switch "ON" or engine in operation?	—	Go to step 2	—
2	1. Key switch "ON". 2. Measure voltage between pin number 61 for boost sensor and pin number 56 for A–GND at ECM side connector. (Measuring method 1) Is voltage within value?	About 1.3V	Go to step 6	Go to step 3
3	Measure voltage between pin number 72 for A–VCC and pin number 56 for A–GND at ECM side connector. (Measuring method 1) Is voltage within value?	4.75V to 5.25V	Go to step 5	Go to step 4
4	1. Key switch "OFF". 2. Disconnect boost sensor harness connector from sensor and ECM. 3. Measure resistance following points on the boost sensor harness. (Measuring method 2) • Between pin number 72 (A–VCC) at ECM side connector and pin number 1 at sensor side. • Between pin number 56 (A–GND) at ECM side connector and pin number 3 at sensor side.	2Ω or less	Replace boost sensor. Then go to step 9	Repair boost pressure sensor harness.
	• Between pin number 72 (A–VCC) and GND. • Between pin number 56 (A–GND) and GND.	10MΩ or more		
5	1. Key switch "OFF" 2. Disconnect boost sensor harness connector from sensor and ECM. 3. Measure resistance following points on the boost sensor harness. (Measuring method 2) • Between pin number 61 (P BOOST) of ECM and pin number 3 (SENSOR). • Between pin number 56 (A–GND) and pin number 2 (SENSOR).	2Ω or less	Replace boost sensor or ECM assembly. Then go to step 9	Repair boost pressure sensor harness.
	• Between pin number 61 (P BOOST) of ECM and GND. • Between pin number 56 (A–GND) and GND.	10MΩ or more		
6	1. Connect pressure gauge to boost pressure sensor. 2. Supply pressure. Is voltage created to meet boost pressure?	Pressure (kPa) / Voltage (V) 0 / 1.029 50 / 1.75 162 / 3.43	Go to step 7	Replace boost sensor
7	1. Connect all connector. 2. Engine start. 3. Operate the vehicle several times. Are there any boost pressure abnormally and/or any leakage? **Note: It is required digital multi-meter, TechII etc.**	—	Go to step 8	Go to step 9
8	Check turbocharger condition, waste gate opening pressure and/or piping. Does correct opening pressure of waste gate?		Solved	Repair piping and/or readjust waste gate opening pressure

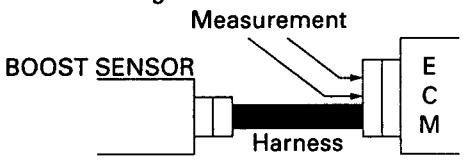
DTC P32 Boost Pressure Sensor Error

STEP	ACTION	VALUE	YES	NO
9	Clear to memoried DTC. Is indicate DTC P32?	—	Replace ECM assembly. Then go to step 10	Solved
10	Clear to memoried DTC. Is indicate DTC P32 again? **Note: High boost also abnormal.**	—	Replace ECM. Go to step 10	Solved

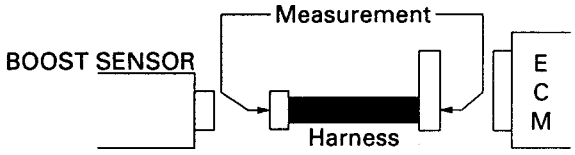
DTC P42, P32 High Boost Pressure Abnormal



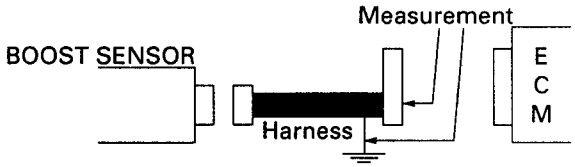
Measuring method 1

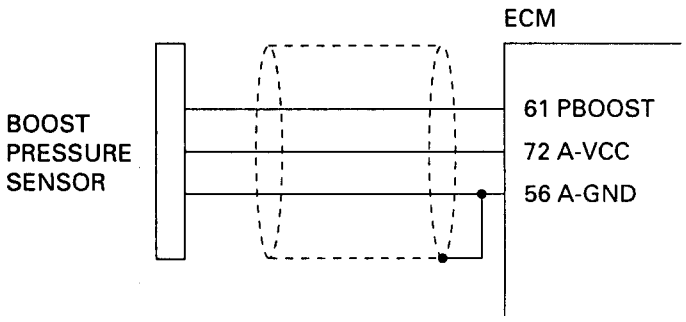


Measuring method 2



Measuring method 3





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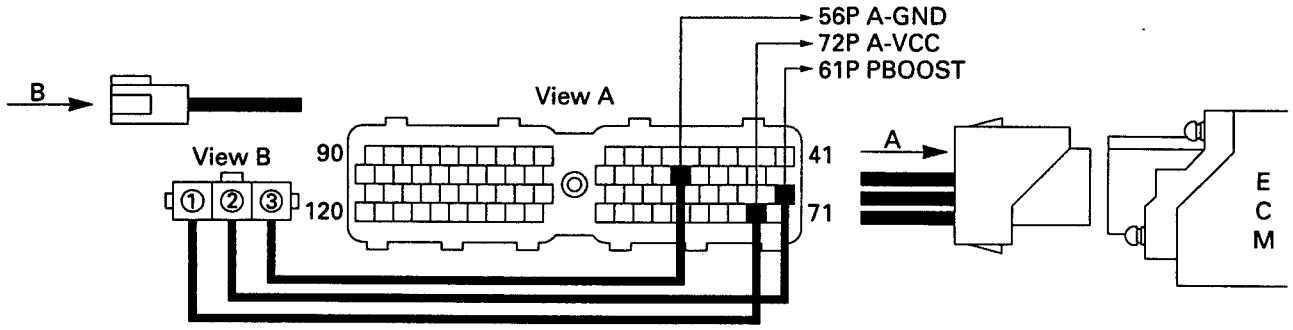
DTC P42, P32 High Boost Pressure Abnormal

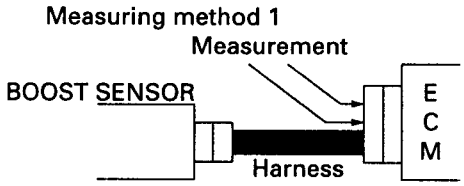
<table>
<tr><th>STEP</th><th>ACTION</th><th>VALUE</th><th>YES</th><th>NO</th></tr>
<tr><td>1</td><td>Does lamp indication DTC P42 or DTC P32 read, while key switch "ON" or engine in operation?
Note: When atmospheric pressure sensor abnormal, PATM is calculated at 100 kPa.</td><td>—</td><td>Go to step 2</td><td>—</td></tr>
<tr><td>2</td><td>1. Connect pressure gauge and pressure supplyer to boost sensor.
2. Measure voltage between pin number 61 (P BOOST) and pin number 56 (A–GND) at ECM side. (Measuring method 1)
Does voltage indicate normal value according to boost pressure?

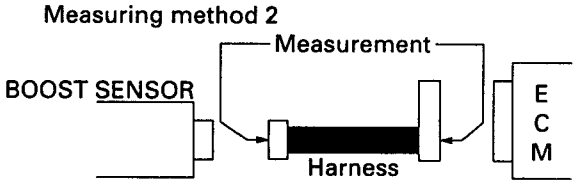
Normal value (When VCC = 5V)
<table><tr><th>Boost pressure</th><th>Sensor voltage</th></tr><tr><td>80 kPa</td><td>About 0.7V
(Negative pressure)</td></tr><tr><td>Atmospheric release</td><td>1.0V</td></tr><tr><td>169 kPa</td><td>2.0V</td></tr></table>Note: It indicate other error flag of relation for boost pressure when inspect this problem.</td><td>Normal value see table left</td><td>Go to step 3</td><td>Replace boost sensor and/or repair piping</td></tr>
<tr><td>3</td><td>When boost pressure applied, does waste gate pressure normal?</td><td>—</td><td>Go to step 4</td><td>Repair waste gate</td></tr>
<tr><td>4</td><td>Do you find leakage from piping and/or any problem on turbocharger?</td><td>—</td><td>Repair or replace abnormal portion.</td><td>Go to step 5</td></tr>
<tr><td>5</td><td>Make vehicle actually drive to check as following.
Does actual boost pressure and voltage indicate guide line?

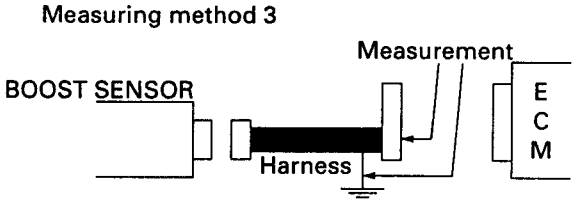
Guide line value (When PATM = 100 kPa)
<table><tr><td>Voltage</td><td>3.4 V or more</td></tr><tr><td>Boost pressure</td><td>162 kPa or more</td></tr><tr><td>NE</td><td>About 2,000 rpm</td></tr><tr><td>Acceleration</td><td>100%</td></tr></table></td><td>Guide line value see table left</td><td>Go to step 6</td><td>Repair/replace turbocharger and/or waste gate piping. Then go to step 6</td></tr>
<tr><td>6</td><td>Clear to memoried DTC.
Does indicate DTC P42 or DTC P32?</td><td>—</td><td>Replace ECM. Then go to step 7</td><td>Solved</td></tr>
<tr><td>7</td><td>Clear to memoried DTC.
Does indicate DTC still?</td><td>—</td><td>Go back to step 2</td><td>Solved</td></tr>
</table>

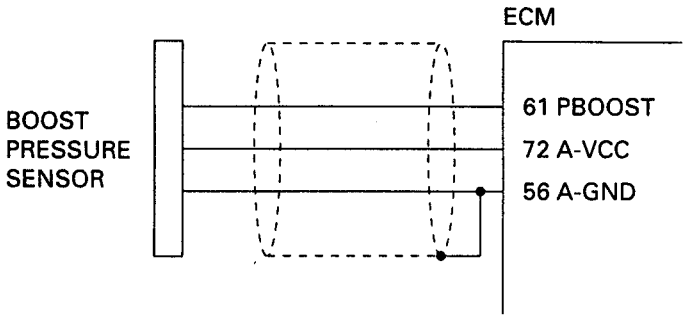
DTC P65 Low Boost Pressure Abnormal











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DTC P65 Low Boost Pressure Abnormal

<table>
<tr><th>STEP</th><th>ACTION</th><th>VALUE</th><th>YES</th><th>NO</th></tr>
<tr><td>1</td><td>Does lamp indication DTC P65 read, while key switch "ON" or engine in operation?</td><td>—</td><td>Go to step 2</td><td>—</td></tr>
<tr><td>2</td><td>1. Connect pressure gauge and pressure supplyer to hose of boost sensor side.
2. Key switch "ON".
3. Measure voltage between pin number 61 (P BOOST) and pin number 56 (A–GND) at ECM side. (Measuring method 1)
Does voltage indicate normal value according to boost pressure?

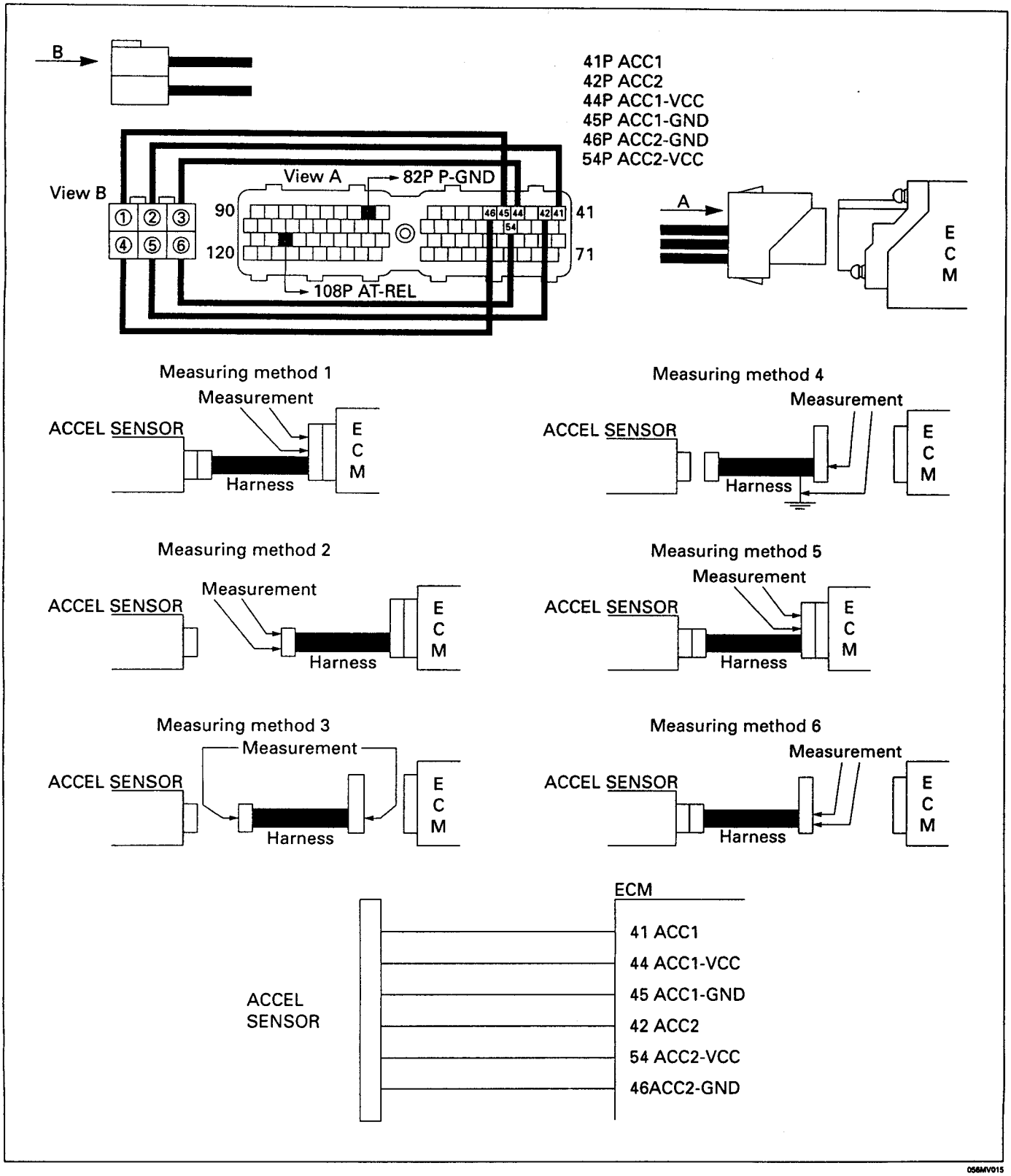
Normal value (When VCC = 5V)
<table><tr><th>Boost pressure</th><th>Sensor voltage</th></tr><tr><td>80 kPa</td><td>About 0.7V (Negative pressure)</td></tr><tr><td>Atmospheric release</td><td>1.0V</td></tr><tr><td>169 kPa</td><td>2.0V</td></tr></table>
Note: It indicate other error flag of relation for boost pressure when inspect this problem.</td><td>Normal value see table left</td><td>Go to step 3</td><td>Replace boost sensor or repair/replace boost sensor harness.</td></tr>
<tr><td>3</td><td>When boost pressure applied, does waste gate pressure normal?</td><td>—</td><td>Go to step 4</td><td>Repair waste gate</td></tr>
<tr><td>4</td><td>Do you find leakage from piping and/or any problem on turbocharger?</td><td>—</td><td>Repair or replace abnormal portion.</td><td>Go to step 5</td></tr>
<tr><td>5</td><td>Make vehicle actually drive to check as following.
Does actual boost pressure and voltage indicate guide line value? (at acceleration 80% or more opened)

Guide line value (When PATM = 100 kPa)
<table><tr><td>Voltage</td><td>2.0 V or less</td></tr><tr><td>Boost pressure</td><td>70 kPa or less</td></tr><tr><td>NE</td><td>2,000 rpm</td></tr><tr><td>Acceleration</td><td>100%</td></tr></table></td><td>Guide line value see table left</td><td>Go to step 6</td><td>Replace boost sensor and/or repair turbocharger. Refer to section 6J in this manual</td></tr>
<tr><td>6</td><td>Is there Q-limited due to other error?</td><td>—</td><td>Repair other DTC first.</td><td>Go to step 7</td></tr>
<tr><td>7</td><td>Clear to memoried DTC.
Is indicate DTC P65?</td><td>—</td><td>Replace ECM assembly. Then go to step 8</td><td>Solved</td></tr>
<tr><td>8</td><td>Clear to memoried DTC.
Is indicate DTC P65?</td><td>—</td><td>Go back to step 2</td><td>Solved</td></tr>
<tr><td></td><td colspan="4">Caution: The actual measuring output voltage of boost sensor will be drifted due to if power source voltage of boost sensor comes down.</td></tr>
</table>

DTC P543 Overrun Judgment

STEP	ACTION	VALUE	YES	NO
1	Does lamp indication DTC P543 read, while key switch "ON" or engine in operation?	—	Go to step 2	—
2	Ask if overrun caused by gear slip-out, shift error, etc.	—	Misusage by owner or operator.	

A/T Relay Output Error (Not available DTC)



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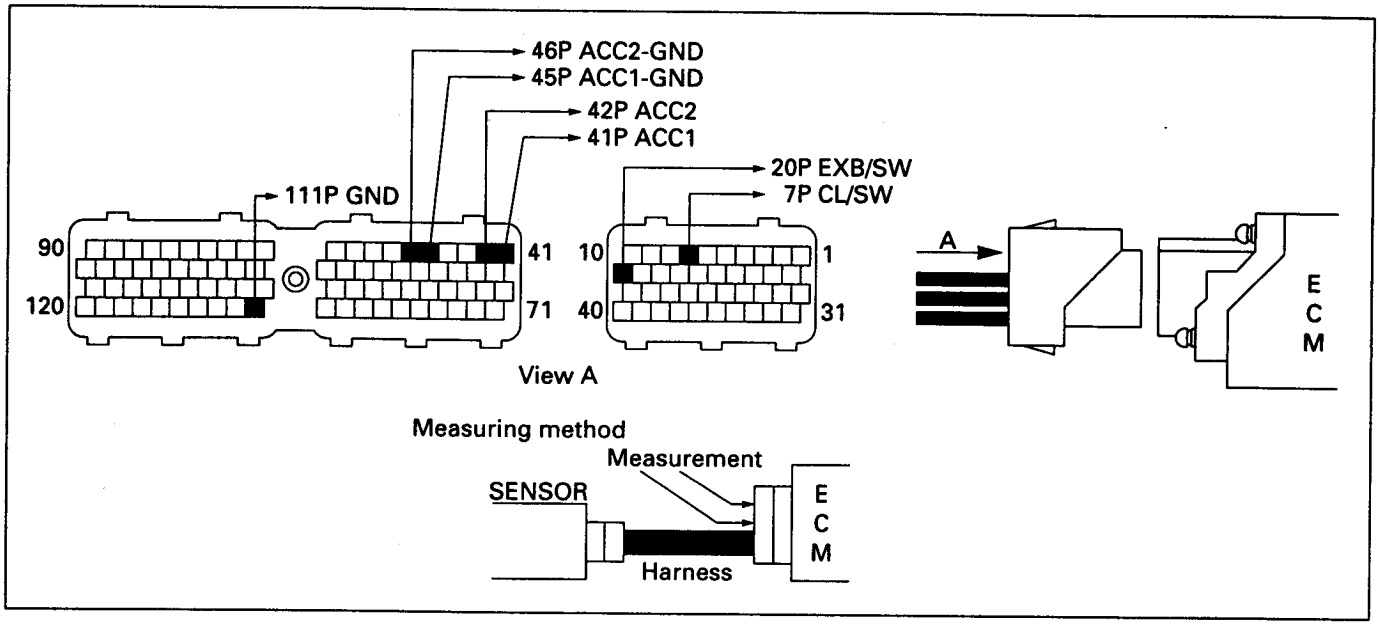
A/T Relay Output Error (Not available DTC)

STEP	ACTION	VALUE	YES	NO
1	When A/T has abnormal shift point. (ON/OFF error at A/T relay) There is not accelerator sensor system DTC P24 indicated. Is there shift point error?	—	Go to step 2	—
2	Does A/T relay turn ON when it is judged full acceleration (Accelerator open 83% or more)?	83% or more	Go to step 8	Go to step 3
3	Measure voltage following points at ECM side. (Measuring method 1) • Between pin number 41 (ACC 1) and pin number 45 (ACC1–GND). • Between pin number 42 (ACC 2) and pin number 46 (ACC2–GND). Is voltage within value?	3.5V or more	Go to step 5	Go to step 4
4	Check fixing condition for acceleration sensor and/or acceleration pedal. Do you find any abnormal condition? Refer to DTC P24 and Exhaust relay error section in this manual.	—	Readjust or retighten	Solved
5	1. Key switch "ON". 2. Measure voltage between pin number 108 (A/T–REL) and pin number 82 (P–GND) at ECM side (Measuring method 5) Is voltage within value?	12V	Go to step 7	Go to step 6
6	Is there any problem at A/T relay wiring and power supply wiring?	—	Repair problem portion.	Solved
7	1. Remove A/T relay unit from relay connector. 2. Connect relay unit to battery. Is relay activated ON or OFF when connect or disconnect to battery? **Note: A/T relay output turns ON and OFF not at full to zero acceleration, but it works under accelerator open between 83% and 63%. Thus, make sure to check intermediate voltage.**	—	Replace ECM	Replace A/T relay unit
8	Does turns OFF of A/T relay when acceleration OFF (It is judged 63% accelerator opened)?	—	It is normal condition it may cause other than ECM control.	Go to step 9
9	Measure voltage following points when acceleration "OFF". (Measuring method 1) • Between pin number 41 (ACC1) and pin number 45 (ACC1–GND). • Between pin number 42 (ACC2) and pin number 46 (ACC2–GND).	1.4V or less	Go to step 11	Go to step 10

A/T Relay Output Error (Not available DTC)

STEP	ACTION	VALUE	YES	NO
10	Does acceleration sensor and/or acceleration pedal complete fixing or adjusting? **Note: Refer to DTC P24 and exhaust relay error section in this manual.**	—	Replace relay	Repair or readjust for sensor or pedal
11	Measure resistance between pin number 108 (A/T–REL) and pin number 82 (P–GND) at ECM side connector of acceleration sensor harness. Is resistance within value?	10MΩ or more	Go to step 13	Go to step 12
12	Check acceleration sensor harness for shortage to GND during key switch "ON". Do you find any shortage?	—	Repair/replace sensor harness	Replace ECM
13	1. Remove relay unit from relay connector. 2. Make connection between relay and battery. Does relay work (ON/OFF) completely?	—	Replace ECM	Replace relay unit.
	Note: A/T relay output turns ON and OFF not at full to zero acceleration, but it works under accelerator open between 83% and 63%. Thus, make sure to check intermediate voltage.			

Exhaust Brake Relay Error (Not available DTC)

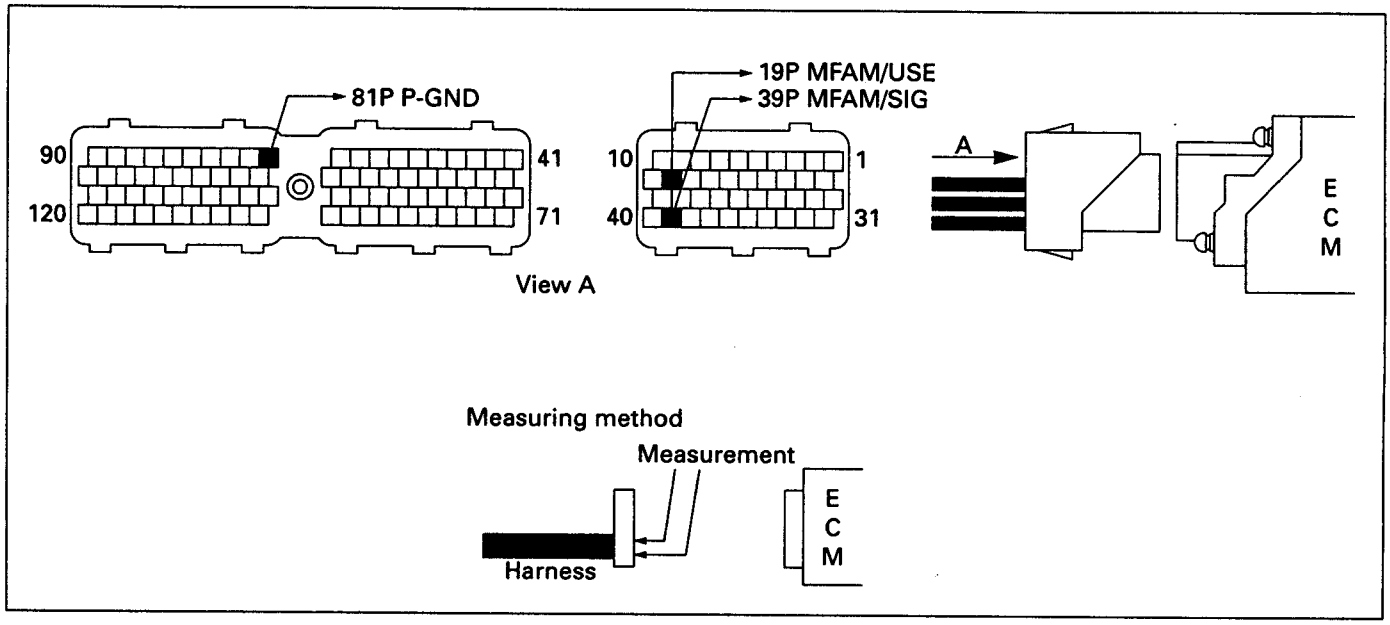


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Exhaust Brake Relay Error (Not available DTC)

STEP	ACTION	VALUE	YES	NO
1	Does exhaust brake relay not turns "ON" or remains "ON"?	—	Go to step 2	—
2	Do you find DTC P24?	—	Repair DTC P24 first	Go to step 3
3	Measure voltage following points during acceleration "OFF" at ECM ACC1 or ECM ACC2. • Between pin number 41 (ACC1) and pin number 45 (ACC1–GND). • Between pin number 42 (ACC2) and pin number 46 (ACC2–GND). Is voltage within value?	1.4V or less	Go to step 5	Go to step 4
4	Check brake pedal linkage lever condition and/or check sensor adjustment. Does them keep complete condition?	—	Replace Exh R/L	Repair/ readjustment
5	Measure voltage between pin number 20 (EXB/SW) and pin number 111 (GND) during key switch "ON", exhaust brake switch "ON" at ECM side connector. Is voltage within value?	12V	Go to step 6	Replace exhaust brake switch or repair wire harness.
6	Measure voltage between pin number 7 (CL/SW) and pin number 111 (GND) during key switch "ON" and clutch pedal not depressed at ECM side connector. Is voltage within value?	12V	Go to step 7	Replace clutch switch or repair wire harness.
7	1. Remove exhaust brake relay unit from relay connector. 2. Make connection relay unit to battery. Does relay works completely?	—	Go to step 8	Replace Exh R/L
	Restore all parts and harness. Does trouble continued?	—	Replace ECM	Solved

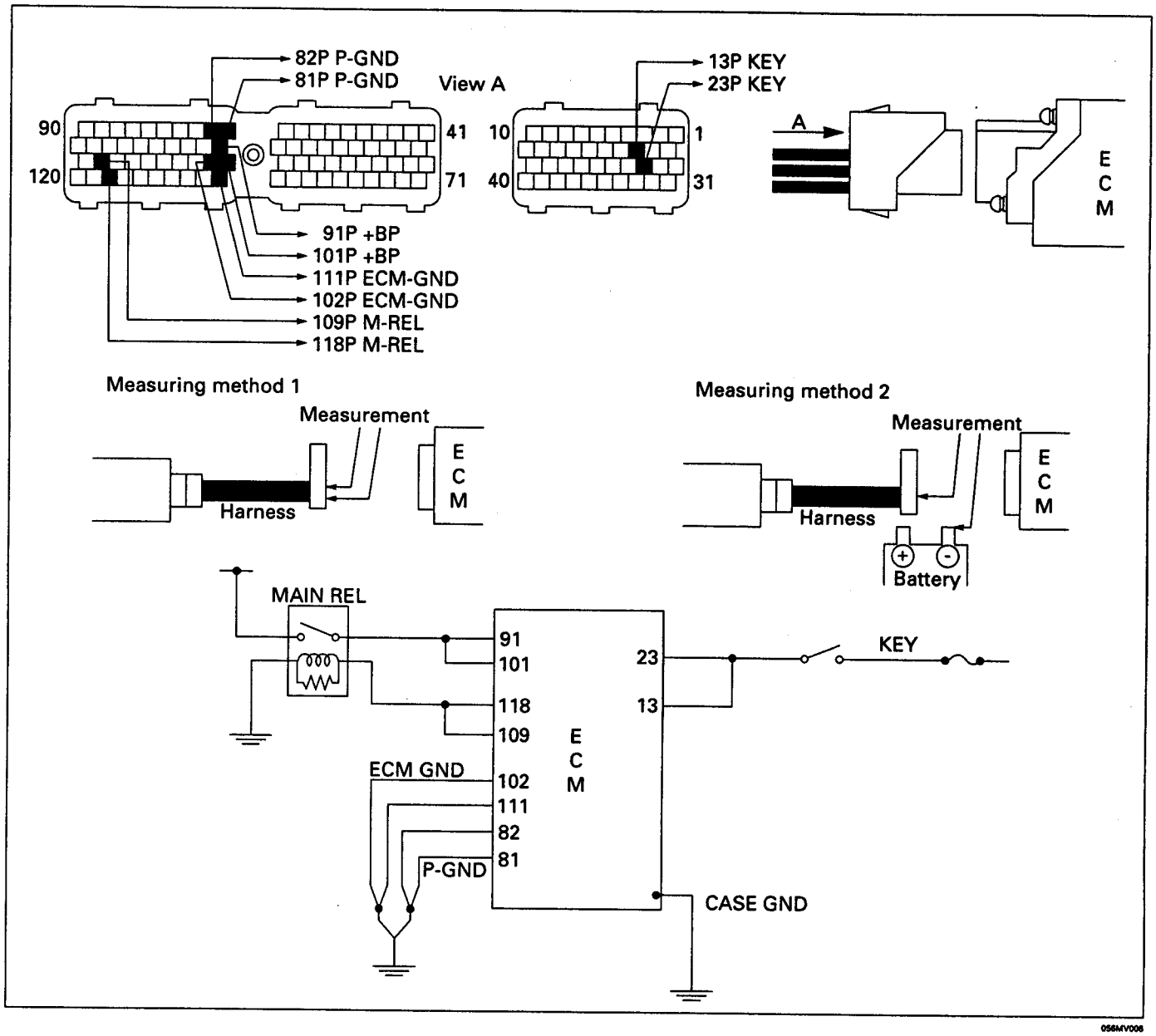
MFAM Signal Error (Option equipment) (Not available DTC)



MFAM Signal Error (Option equipment) (Not available DTC) (Control by multi function alarm module)

STEP	ACTION	VALUE	YES	NO
1	Do you have experience that engine not start or stalled. No overheat warning (as to vehicle equipped with such device). Not indicated DTC.	—	Go to step 2	Other problem
2	No overheat. Main relay normal condition. Engine cranking normal condition. But PCV, TWV not activated. Have you confirm above condition?	—	Go to step 3	Repair problem portion
3	1. Key switch "OFF". 2. Disconnect ECM side connector. 3. Measure resistance between pin number 19 (MFAM USE) and pin number 81 (P–GND). Is resistance within value?	10MΩ or more	No problem on the MFAM control system solved	Go to step 4
4	Does vehicle equipped with MFAM?	—	Go to step 6	Go to step 5
5	MFAM use or not use signal error. Check wire harness for shortage to GND. Do you find any shortage?	10MΩ or more	Repair shortage portion	Solved
6	Measure resistance between pin number 39 (MFAM) and pin number 81 (P–GND) at ECM side connector. Is resistance within value?	10MΩ or more	Go to step 8	Go to step 7
7	MFAM signal wire harness short-circuited to GND, causing engine stall. Check wire harness of MFAM signal line. Do you find short circuit?	—	Repair shorted circuit	Solved
8	Does any other DTC indicate?	—	Repair according to DTC.	Solved

Power Supply System Inspection (Not available DTC)



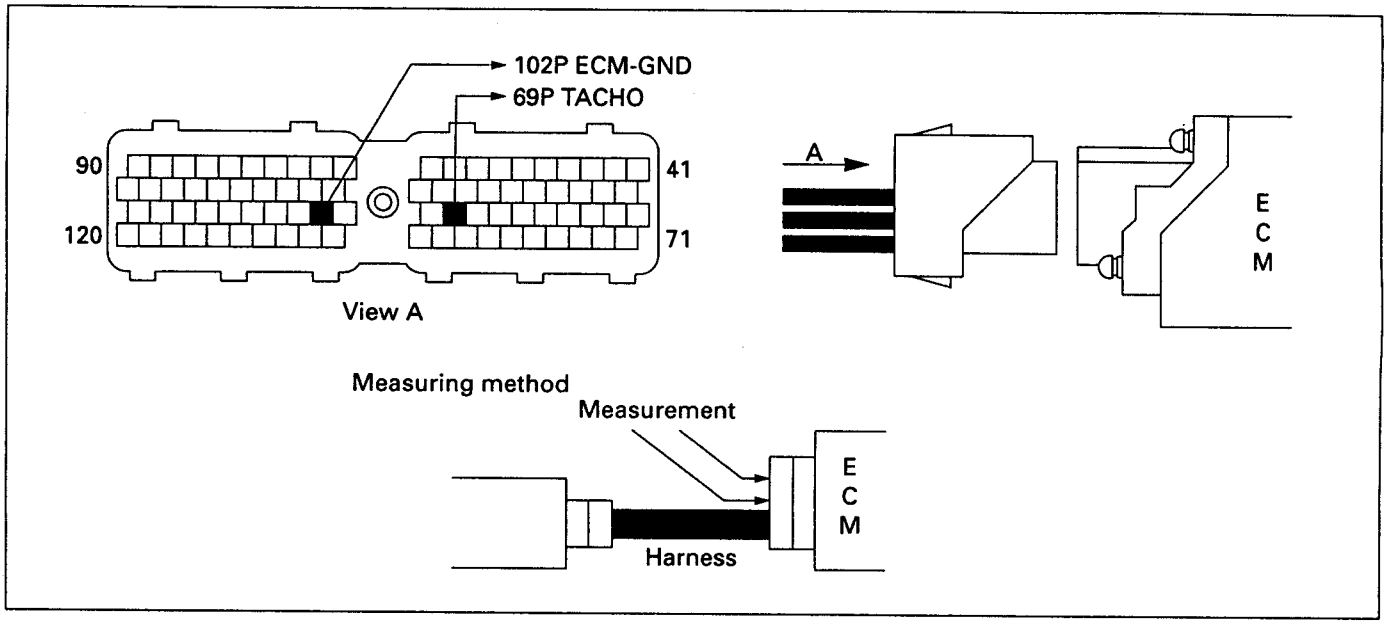
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Power Supply System Inspection (Not available DTC)

Under this injection system, the main relay is activated by key on signal, so that all the systems including CPU be started to supplied power according to main relay turn on.
If indicated DTC P416, refer to main relay error section in this manual.

STEP	ACTION	VALUE	YES	NO
1	Does power supply system not activate?	—	Go to step 2	—
2	1. Key switch "OFF". 2. Disconnect ECM side connector. 3. Key switch "ON". 4. Measure voltage between pin number 13, 23 (KEY) and pin number 81, 82 (P–GND) at ECM side on harness. (Measuring method 1) Is voltage within value?	10V or more	Go to step 8	Go to step 3
3	• Check disconnection between pin number 81, 82 (P–GND) and pin number 91, 101 (+BP). • Check disconnection between pin number 13, 23 (KEY) of ECM side connector and GND. Have you any disconnection?	—	Repair disconnection portion.	Go to step 8
4	1. Key switch "ON". 2. Measure voltage between pin number 91, 101 (+B) and pin number 81, 82 (P–GND). Is voltage within value? **Note: If ECM power supply voltage for lower than battery voltage, it assumes GND line floating.**	10V or more	Go to step 6	Go to step 5
5	Check following failure portions. • GND line floating. • Between ECM and main relay circuit. • Main relay unit. • Between main relay and battery positive side circuit. Is there any problem?	—	Repair problem portion.	Go to step 6
6	1. Key switch "OFF". 2. Measure resistance between pin number 102, 111 (ECM–GND) and battery GND. (Measuring method 2) Is resistance within value?	1Ω or less	Go to step 7	The cause is disconnection or incomplete contact of connector. Repair problem portion.
7	1. Key switch "OFF". 2. Measure resistance between pin number 81, 82 (P–GND) and battery GND. Is resistance within value?	1Ω or less	Replace ECM	Same as step 6
8	1. Key switch "ON". 2. Measure voltage between pin number 109, 118 (M–REL) and pin number 81, 82 (PGND) at ECM connector side. (measuring method 1) Is voltage within volue?	10V or more	Go to step 4	Go to step 9
9	Check following points. • Wiring between ECM and main relay. • Wiring between GND and main relay. • Main relay unit.	—	—	—
	Note: If radio noise worsened in addition to system abnormality, check case GND of ECM as well as the above GND.			

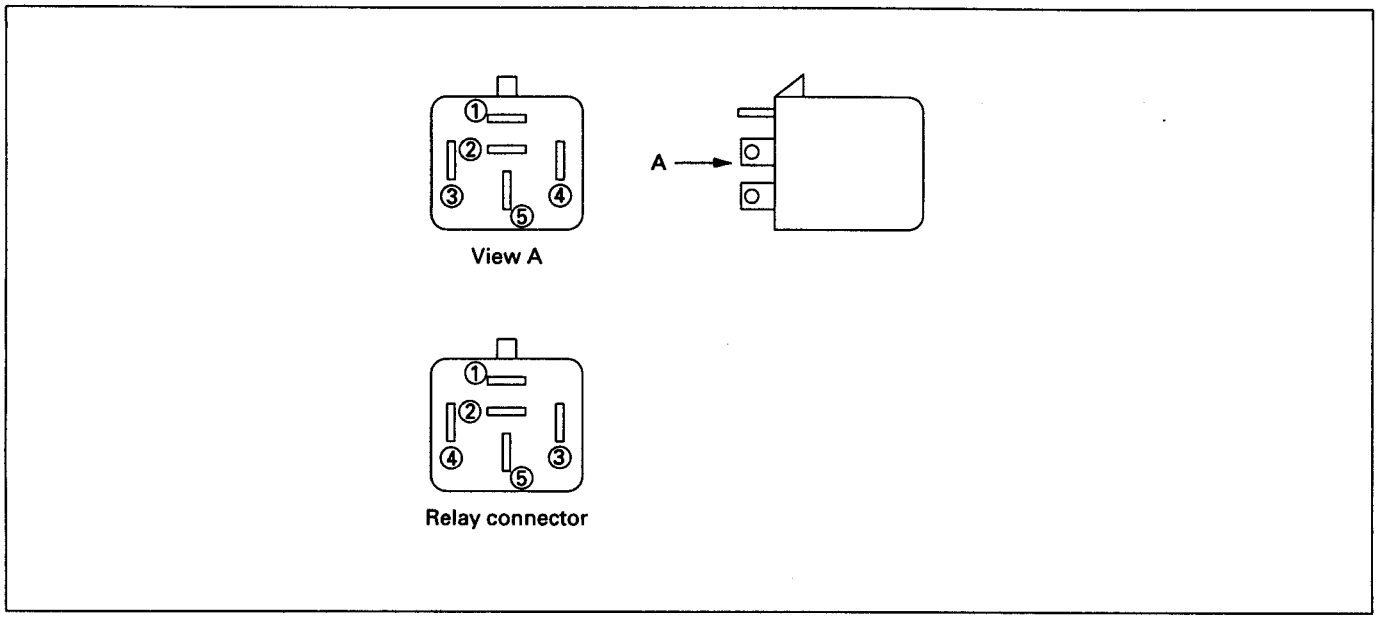
Tachometer Output Error (Not available DTC)



Tachometer Output Error (Not available DTC)

STEP	ACTION	VALUE	YES	NO
1	Does tachometer output error appear without NE sensor error and G sensor error indication during engine in operation? **Note: When NE sensor and G sensor instable (DTC not indicated), tachometer output become abnormal. If vehicle running performance adversely affected, repair the abnormality first. Unless NE sensor and G sensor signal both normal, tachometer output not produced.**	—	Go to step 2	• While engine running, NE sensor NG: Indication abnormal. G sensor NG: can be indicated. • After key "OFF", it either NE sensor or G sensor damaged, indication became abnormal.
2	Measure waveform between pin number 69 (TACHO) and pin number 102 (ECM–GND) at ECM side. Does appear the pulse?	Pulse (short wave)	Replace tachometer and/or repair tachometer wire harness.	Go to step 3
3	1. Disconnect capller tachometer side or intermediate connector. (Disconnect tachometer) 2. Measure waveform same as step 2. Does appear the pulse?	Pulse (short wave)	Solved	Replace ECM
	Note: • ECM delivers shortwave of 17.5 pulse (0 – 5V) per a rotation to tachometer. • Tachometer do not produce output at 230 rpm or less. • If checking by voltage, digital multimeter reads around 2.5V under engine idling, and 5V or 0V for output abnormality.			

PCV Relay Error (Not available DTC)



PCV Relay Error (Not available DTC)

STEP	ACTION	VALUE	YES	NO
1	1. Key switch "OFF". 2. Disconnect connector from PCV side and ECM side (40 pin connector). 3. Measure voltage following points. • Between pin number 1 (PCV1) PCV side and pin number 82 (P–GND) ECM side. • Between pin number 1 (PCV2) PCV side and pin number 82 (P–GND) ECM side. Does voltage more than 1V?	1V or less	Go to step 2	Go to step 3
2	Check harness between PCV1, 2 (Pin 1) and PCV relay. Is there any shortage?	—	Repair/replace harness	Go to step 3
3	1. Key switch "OFF". 2. Disconnect connector from PCV side and ECM side (40 pin connector). 3. Measure resistance following points. • Between pin number 1 (PCV1) PCV connector side and pin number 82 (P–GND) ECM side. • Between pin number 1 (PCV2) PCV connector side and pin number 82 (P–GND) ECM side. Does resistance within value?	10MΩ or more	Go to step 4	Repair ground line wire of PCV harness
4	Measure resistance following points. • Between pin number 1 at PCV connector side of PCV harness and pin number 1 at PCV relay connector. Does resistance within value? **Note: It is considered that sometimes the fuse is breakage when disconnection checking between PCV 1 or 2 (Pin number 1) and PCV relay.**	2Ω or less	Solved	Repair disconnection area on the PCV harness.

Engine Hunting

STEP	ACTION	VALUE	YES	NO
1	Is engine oil used within specification viscosity?	See owner's manual	Go to step 2	Replace engine oil
2	Do you find dilution of engine oil?	—	Replace engine oil and repair cause of dilution.	Go to step 3
3	Is fuel used within recommendation specification?	See owner's manual	Go to setp 4	Replace fuel with recommend specification.
4	Do you find to contaminate gasoline with fuel?	—	Replace fuel	Go to step 5
5	Do you find any breakage on the fuel pump, injection pipe etc.?	—	Repair/replace problem part.	Go to step 6
6	Is fuel filters (prefilter, gauze filter and fuel main filter) normal condition? (The gauze filter is fixed in suction eye bolt on the injection pump.)	—	Go to step 7	Clean/replace problem fuel filter
7	Is air filter normal condition?	—	Go to step 8	Repair/replace problem part
8	Do you done bleeding air from fuel line? **Note: Air bleeding procedure.** **1. Push priming pump more than one minute (one push per one second) then engine cranking 20 seconds.** **2. Repeat above 1 if necessary after 20 second rest.**	—	Go to step 9	Bleed air from fuel line
9	Is diagnosis lamp turn on?	—	Go to indicated DTC	Go to step 10
10	Check typical data at idling. Is typical data within value? To be determined	See table as shown left.	Go to step 11	Repair problem portion until come in the typical data.
11	Check injection balance each cylinder. Is injection balance with normal?		Solved	Go to step 12
12	Check activity flow damper and/or fuel pipe condition. Do you find any problem on the above part?	—	Replace problem part.	Replace injection pump assembly.
13	Finish this program and return diagnostic procedure if necessary.	—	—	—

STARTUP FAILURE
DO NOT COME INITIAL COMBUSTION

STEP	ACTION	VALUE	YES	NO
1	Is engine oil used within specification viscosity?	See owner's manual	Go to step 2	Replace engine oil.
2	Is fuel used within recommendation specification?	See owner's manual	Go to step 3	Replace fuel with recommend specification
3	Do you done bleeding air from fuel line? **Note: Air bleeding procedure.** **1. Push priming pump more than one minute (one push per one second) then engine cranking 20 seconds.** **2. Repeat above 1 if necessary after 20 seconds rest.**	—	Go to step 4	Bleed air from fuel line
4	Does compression normal indicate?	More than 2157 kpa (313 psi)	Go to step 5	Repair/replace problem portion (Piston ring, valve stem seal etc.)
5	Does glow plug normal operate?	—	Go to step 6	Repair/replace glow plug or it system.
6	Check injection timing. Does NE sensor output normal? Does G sensor output normal?	—	Go to step 7	Go to DTC P15 and/or DTC P14
7	Injection fuel pressure not supplied. Does PC sensor output normal?	—	Go to step 8	Go to DTC P245
8	Does PCV function normal operate?	—	Go to step 9	Go to DTC P217 or DTC P218
9	Does injection pump normal operate?	—	Solved	Replace injection pump assembly
10	Finish this program and return diagnostic procedure if necessary.	—	—	—

STARTUP FAILURE
INITIAL COMBUSTION DONE BUT DOES NOT ENGINE STARTUP

STEP	ACTION	VALUE	YES	NO
1	Is engine oil used within specification viscosity?	See owner's manual	Go to step 2	Replace engine oil.
2	Is fuel used within recommendation specification?	See owner's manual	Go to step 3	Replace fuel with recommend specification
3	Do you done bleeding air from fuel line? **Note: Air bleeding procedure.** **1. Push priming pump more than one minute (one push per one second) then engine cranking 20 seconds.** **2. Repeat above 1 if necessary after 20 seconds rest.**	—	Go to step 4	Bleed air from fuel line
4	Does compression normal indicate?	More than 2157 kpa (313 psi)	Go to step 5	Repair/replace problem portion (Piston ring, valve stem seal etc.)
5	Does glow plug normal operate?	—	Go to step 6	Repair/replace glow plug or it system.
6	Does exhaust brake switch turn off?	Off	Go to step 7	Should be exhaust brake switch "OFF"
7	Check injection timing. Does NE sensor output normal?	—	Go to step 8	Go to DTC P15 and/or DTC P14
8	Does electric current come to TWV?	—	Go to step 9	Repair problem portion or go to DTC P158 and/or DTC P159
9	Does flow damper normal operate?	—	Replace injector assembly	Replace flow damper
10	Finish this program and return diagnostic procedure if necessary.	—	—	—

STARTUP FAILURE
ENGINE START BUT DOES NOT REVOLUTION UP

STEP	ACTION	VALUE	YES	NO
1	Is engine oil used within specification viscosity?	See owner's manual	Go to step 2	Replace engine oil.
2	Is fuel used within recommendation specification?	See owner's manual	Go to step 3	Replace fuel with recommend specification
3	Do you done bleeding air from fuel line? **Note: Air bleeding procedure.** **1. Push priming pump more than one minute (one push per one second) then engine cranking 20 seconds.** **2. Repeat above 1 if necessary after 20 seconds rest.**	—	Go to step 4	Bleed air from fuel line
4	Does compression normal indicate?	More than 2157 kpa (313 psi)	Go to step 5	Repair/replace problem portion (Piston ring, valve stem seal etc.)
5	Does glow plug normal operate?	—	Go to step 6	Repair/replace glow plug or it system.
6	Does exhaust brake switch turn off?	—	Go to step 7	Exhaust brake switch "OFF"
7	Check ISC (Idling Speed Control) Does typical data normal indicate?	—	Solved	Go to step 8
8	Check ISC correction items. Does ISC correction items normal indicate?		Solved	Replace ECM
9	Finish this program and return diagnostic procedure if necessary.	—	—	—

WHITE SMOKE (EXCESSIVE) OR BLUE SMOKE

NOTE: Low cetane number fuel is used, may caused white smoke.

STEP	ACTION	VALUE	YES	NO
1	Is engine oil used within specification viscosity?	See owner's manual	Go to step 2	Replace engine oil.
2	Is fuel used within recommendation specification?	See owner's manual	Go to step 3	Replace fuel with recommend specification
3	Does gasoline contaminate into fuel?	—	Replace fuel	Go to step 4
4	Do you done bleeding air from fuel line? **Note: Air bleeding procedure.** **1. Push priming pump more than one minute (one push per one second) then engine cranking 20 seconds.** **2. Repeat above 1 if necessary after 20 seconds rest.**	—	Go to step 5	Bleed air from fuel line
5	Does compression normal indicate?	More than 2157 kpa (313 psi)	Go to step 6	Repair/replace problem portion (Piston ring, valve stem seal etc.)
6	Check THW system. Does water temperature sensor work normal? (When atmospher temperature low)	—	Go to step 7	Replace THW sensor
7	Does atmospheric temperature sensor work normal? (When atmospher temperature low)	—	Go to step 8	Replace THA sensor
8	Does NE sensor work normal? (When atmospher temperature normal)	—	Go to step 9	Replace NE sensor
9	Does G sensor work normal? (When atmospher temperature normal)	—	Go to step 10	Replace G sensor
10	Doe engine oil leak from turbocharger oil seal? (Blue smoke)	—	Replace oil seal	Go to step 11
11	Does oiling up from piston ring? (Blue smoke)	—	Replace piston ring	Go to step 12
12	Does oiling down from valve stem seal? (Blue smoke)	—	Replace valve stem seal	Solved
13	Finish this program and return diagnostic procedure if necessary.	—	—	—

BLACK SMOKE (EXCESSIVE)

STEP	ACTION	VALUE	YES	NO
1	Is engine oil used within specification viscosity?	See owner's manual	Go to step 2	Replace engine oil
2	Is fuel used within recommendation specification?	See owner's manual	Go to step 3	Replace fuel with recommend specification
3	Does compression normal indicate?	More than 2157 kpa (313 psi)	Go to step 4	Repair/replace problem portion (Piston ring, value stem seal etc.)
4	Does exhaust system work complete? (Include exhaust brake system)	—	Go to step 5	Repair/replace problem portion.
5	Does turbocharger work complete?	—	Go to step 6	Repair/replace turbocharger
6	Does boost sensor work complete?	—	Go to step 7	Go to DTC P32, DTC P42, DTC P65
7	Does carbon flower find on chip of injector?	—	Replace injector assembly	Go to step 8
8	Is there any abnormal condition on cylinder?	—	Repair/replace problem portion.	Solved
9	Finish this program and return diagnostic procedure if necessary.	—	—	—

LACK OF POWER

STEP	ACTION	VALUE	YES	NO
1	Check vehicle specification. Does vehicle specification correct?	—	Go to step 2	Make matching to specification
2	Is oil level OK?	—	Go to step 3	Readjust oil level.
3	Does oil pressure normal indicate?	About 170 kpa/idle (24.7 psi) 300 kpa/ 1500 rpm (43.5 psi)	Go to step 4	Repair/replace problem portion.
4	Is engine oil used within specification viscosity?	See owner's manual	Go to step 5	Replace engine oil
5	Is compression normal condition?	More than 2157 kpa (313 psi)	Go to step 6	Repair/replace problem portion.
6	Is air filter normal?	—	Go to step 7	Clean or replace element
7	Do you find any breakage on the fuel pump, injection pipe etc.?	—	Repair/replace problem part.	Go to step 8
8	Is fuel filter clog? (Prefilter, gauge filter and fuel main filter) (The gauge filter is fixed in suction eye bolt on the injection pump.)	—	Clean or replace problem part.	Go to step 9
9	Is air intake system clog?	—	Take out foreign material	Go to step 10
10	Does exhaust brake switch turn off.	—	Go to step 11	Turn exhaust brake switch "OFF"
11	Does accelerator pedal correct open when depress it full stroke?	100%	Go to step 12	Readjust acceleration sensor and/or repair the acceleration pedal assembly.
12	Does valve timing correct?	See section 6A6B in this manual	Go to step 13	Readjust to correct timing.
13	Check typical data. Is typical data correct?	See typical data list	Go to step 14	Readjust/ replace problem portion.
14	Do you feel little seizing inside engine? (If engine oil is diluted by fuel or other material may cause to seize the engine.)	—	Repair problem part	Go to step 15

LACK OF POWER

STEP	ACTION	VALUE	YES	NO
15	Does injection system work completely?	—	Solved	Replace injector or related sensor for injection system or ECM according to DTC. If so indicated.
16	Finish this program and return diagnostic procedure if necessary.	—	—	—

SURGING, HESITATION

STEP	ACTION	VALUE	YES	NO
1	Is engine oil used within specification viscosity?	See owner's manual	Go to step 2	Replace engine oil
2	Do you find dilution of engine oil?	—	Replace engine oil and repair cause of dilution.	Go to step 3
3	Is fuel used within recommendation specification?	See owner's manual	Go to step 4	Replace fuel with recommend specification
4	Do you find to contaminate gasoline with fuel?	—	Replace fuel	Go to step 5
5	Do you find any breakage on the fuel pump, injection pipe etc.?	—	Repair/replace problem part.	Go to step 6
6	Is fuel filters (prefilter, gauze filter and fuel main filter) normal condition? (The gauze filter is fixed in suction eye bolt on the injection pump)	—	Go to step 7	Clean/replace problem fuel filter
7	Is air filter normal condition?	—	Go to step 8	Repair/replace problem part
8	Do you done bleeding air from fuel line?	—	Go to step 9	Bleed air from fuel line
9	Is diagnosis lamp turn on?		Go to indicated DTC	Go to step 10
10	Check typical data at idling. Is typical data within value?	See table as shown left	Go to step 11	Repair problem portion until come in the typical data.
11	Check typical data at medium engine speed. Is typical data within value?	See table as shown left	Go to step 12	Repair problem portion until come in the typical data.
12	Check typical data at high engine speed. Is typical data within value?	See table as shown left	Go to step 13	Repair problem portion until
13	Check injection balance each cylinder Is injection balance with normal?	??	Solved	Go to step 14

SURGING, HESITATION

STEP	ACTION	VALUE	YES	NO
14	Check activity flow damper and/or fuel pipe condition. Do you find any problem on the above part?	—	Replace problem part.	Replace injection pump assembly and Go to step 15
15	Finish this program and return diagnostic procedue if necessary.	—	—	—

ENGINE STALL

STEP	ACTION	VALUE	YES	NO
Before act step	Check abnormal engine noise. If there is abnormal noise from engine, check and repair engine seizing first.	—	—	—
1	Check MFAM system (if so equipped). Does system work complete?	—	Go to step 2	Repair problem portion
2	Is battery normal condition?	More than 8V	Solved	Go to step 3
3	Check charging circuit and/or generator condition. Are they normal condition?	—	Go to step 4	Repair/replace problem part
4	Check ECM power source system. Does fuse break?	—	Replace breakage fuse	Go to step 5
5	Does main relay work normally?	—	Go to step 6	Repair/replace main relay
6	Does PCV relay work normally?	—	Go to step 7	Repair/replace PCV relay
7	Does wiring harness for main and PCV relay normal condition? (Include connector condition)	—	Go to step 8	Repair/replace problem harness
8	Is fuel used within specification?	See owner's manual —	Go to step 9	Replace fuel with recommend specification
9	Do you find to contaminate gasoline etc. to fuel?	—	Replace fuel	Go to step 10
10	Do you find any leakage on the fuel pump, injection pipe etc.?	—	Repair problem part	Go to step 11
11	Do you done bleeding air from fuel line?	—	Go to step 12	Bleed air from fuel line
12	Do you find clog, choke and breakage of air filter?	—	Repair/replace problem part	Go to step 13
13	Is fuel pre filter normal condition?	—	Go to step 14	Repair/replace problem part
14	Is gauze filter normal condition? (The gauze filter is fixed in suction eye bolt on the injection pump)	—	Go to step 15	Clean gauze filter or replace it.
15	Is fuel main filter normal condition? (Clog breakage etc.)	—	Solved	Replace fuel filter element
16	Finish this program and return diagnostic procedure if necessary.	—	—	—

ENGINE DOES NOT STOP

STEP	ACTION	VALUE	YES	NO
1	Does key switch work completely?	—	Go to step 2	Replace key switch assembly.
2	Does main relay work completely?	—	Go to step 3	Replace main relay.
3	Does PCV relay work completely?	—	Solved	Replace PCV relay.
4	Finish this program and return diagnostic procedure is necessary.	—	—	—

IDLE CONTROL ERROR

STEP	ACTION	VALUE	YES	NO
1	Disconnect the idle control switch connector and check voltage at power source side terminal on the idle control switch. Is voltage within value?	More than 8V	Go to step 2	Check wiring harness of power source.
2	Check voltage between idle control switch output terminal and pin number 10, 29 of ECM. Does voltage develop when idle control switch turns idle up side and idle down side?	More than 8V	Go to step 3	Replace idle control switch and/or repair wiring harness between idle control switch and ECM.
3	Same as step 2	More than 8V	Solved	Replace ECM
4	Finish this program and return diagnostic procedure if necessary.	—	—	—

HIGH IDLE ENGINE SPEED

STEP	ACTION	VALUE	YES	NO
1	Push idle control switch to down side. Does idle speed come down?	600 rpm to 660 rpm	Solved	Go to step 2
2	Check accelerator pedal condition. Does accelerator pedal linkage catch any where?	—	Repair program portion	Replace ECM
3	Finish this program and return diagnostic procedure if necessary.	—	—	—

BLANK

SECTION 6J

TURBOCHARGER

NOTICE: *Always use the correct fastener in the correct location. When you replace a fastener, use ONLY the exact part number for that application. ISUZU will call out those fasteners that require a replacement after removal. ISUZU will also call out the fasteners that require thread lockers or thread sealant. UNLESS OTHERWISE SPECIFIED, do not use supplemental coatings (paints, greases, or other corrosion inhibitors) on threaded fasteners or fastener joint interfaces. Generally, such coatings adversely affect the fastener torque and the joint clamping force, and may damage the fastener. When you install fasteners, use the correct tightening sequence and specifications. Following these instructions can help you avoid damage to parts and systems.*

CAUTION: *Turbochargers operate at high speeds and temperature. Do not operate the engine and/or turbocharger without all normally installed inlet piping and filters, along with all exhaust piping. Failure to install the above components could result in personal injury and damage to the vehicle.*

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GENERAL DESCRIPTION

The turbocharger is used to increase the amount of air that enters the engines 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 exhaust gas flow to the turbine wheel blades which drive the shaft wheel assembly. Since the compressor wheel is attached directly to the shaft, it rotates at the same speed as the turbine wheel. Clean air from the air cleaner and crankcase vapors are drawn into the compressor housing and wheel where it is compressed and delivered through a crossover pipe to the engine air intake manifold and then into the cylinders. The inside of the turbocharger compressor housing, compressor wheel, and the inside of the intake manifold can be quite oily due to the ingestion of the crankcase vapors. 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 Charger Air Cooler also helps the performance of the ISUZU 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 (intercooler) located in the front of the radiator. From the charge air cooler (intercooler), the air flows back into the intake manifold.

The charger air cooler (intercooler) 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.

ON-VEHICLE SERVICE

CHARGE AIR COOLER

Remove or Disconnect (Figure 1)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Clamps from the charge air intake hose.
4. Hose from the intake manifold inlet pipe and the charge air cooler.
5. Clamps from the air inlet hose.
6. Hose from the charge air cooler and the turbocharger inlet.
7. Mounting bolts from the charger air cooler to the radiator.
8. Charger air cooler from the radiator.

Install or Connect (Figure 1)

1. Charge air cooler to the radiator.
2. Mounting bolts to the radiator.

Tighten

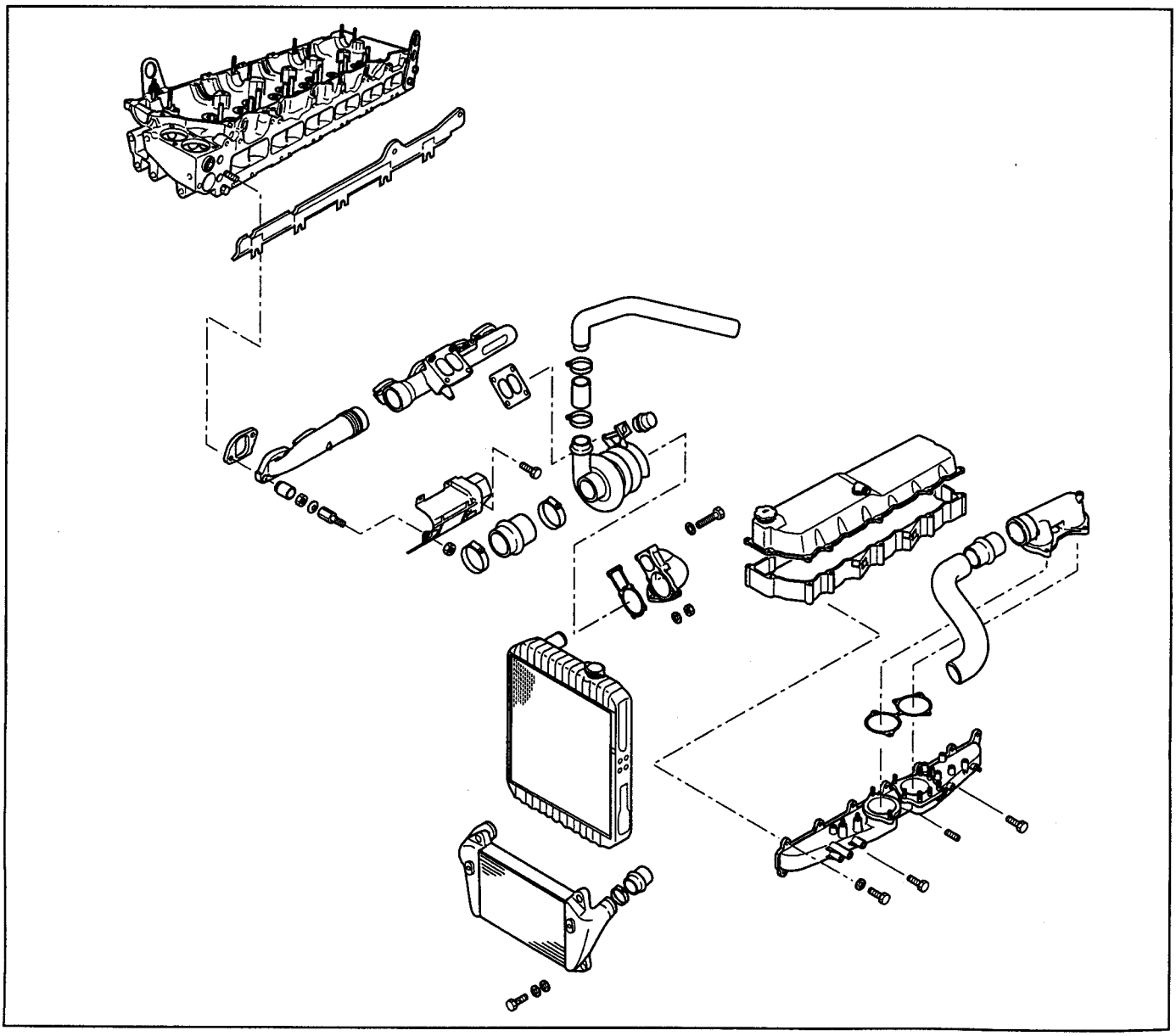
- Bolts to 45 N·m (33 lb·ft.).

3. Hose to the charge air cooler and the turbocharger inlet.
4. Hose to the charge air cooler and the intake manifold inlet pipe.
5. Tighten the hose clamps.

Tighten

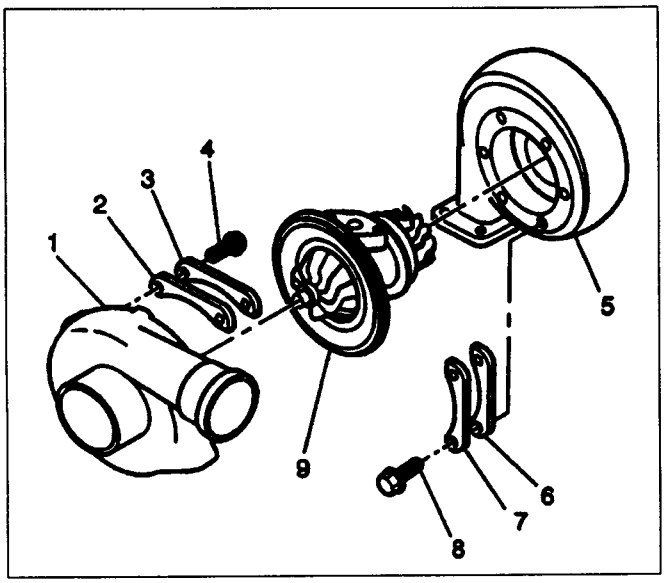
- Hose clamps to 6 N·m (53 lb.·in.).

6. Negative battery cables.
7. Lower the cab.



035MV001

Figure 1 — Turbocharger and Related Components



Legend
(1) Compressor Housing
(2) Clamp
(3) Lock Plate
(4) Bolt
(5) Turbine Housing
(6) Clamp
(7) Lock Plate
(8) Bolt
(9) Center Section Assembly

Figure 2 – Turbocharger Internal Components

TURBOCHARGER

The turbocharger assembly consists of the turbocharger housing, internal components, the waste-gate actuator, exhaust elbow, and heat shield.

Remove or Disconnect (Figures 1 and 3)

1. Tilt the cab. Refer to SECTION 0A.
2. Negative battery cables. Refer to SECTION 6D1.
3. Air inlet hose from the air intake duct.
4. Air inlet hose from the turbocharger.
5. Air inlet from the charge air cooler.
6. Exhaust from the turbocharger. Refer to SECTION 6F.
7. Heat shield at the starter.
8. Coolant feed line.
9. Coolant return line.
10. Oil feed line.
11. Oil return line.
12. Exhaust manifold. Refer to SECTION 6A6.
13. Exhaust manifold with the turbocharger.
14. Turbocharger from the exhaust manifold.

Inspect

- Turbocharger for any cracks at the gasket mating surfaces.
- Compressor blades for damage or carbon build up.

Measure

- Bearing radial clearance: Use a dial indicator with an offset plunger and a magnetic base.
  Adjust the plunger so that it touches the turbocharger main shaft and readjust the gauge to zero.
- Hold the turbocharger, and move the compressor wheel up and down and read the radial clearance. Clearance should be 0.076 to 0.152 mm (0.0030 to 0.0060 in.).
- Compressor end plug: Use a dial indicator with a magnetic base. Adjust the plunger so that it touches the turbocharger main shaft and readjust the gauge to zero.
- Move the turbocharger mainshaft back and forth and read the end play. Clearance should be 0.025 to 0.076 mm (0.0010 to 0.0030 in.).
- If the bearing radial clearance, or the compressor end play is out of specifications, replace the turbocharger center section assembly, item (9).

Important

- Scribe an alignment mark across the compressor housing, center assembly and the turbine housing. These parts must be reassembled in the original location.

Disassemble

1. Bolts, lock plates and clamps from the turbocharger.
2. Compressor housing.
3. Turbine housing.

Important

- Handle to center assembly with care. The assemble is precisely balanced. Even minor scratches or distortion can cause a malfunction.
- Do not attempt to disassemble the center assembly. Replace as a unit if faulty.

Assemble

1. Turbine housing to the center assembly.
   Align the marks made at disassembly.
2. Compressor housing to the center assembly.
3. Clamps, plates and bolts.

Tighten

- Bolts to the compressor housing to 23 N·m (17 lb·ft.).
- Bolts to the turbine housing to 23 N·m (17 lb·ft.).

Inspect

- Assembly for proper operation. Turn the compressor wheel by hand. The wheels must rotate freely, without binding or noise.

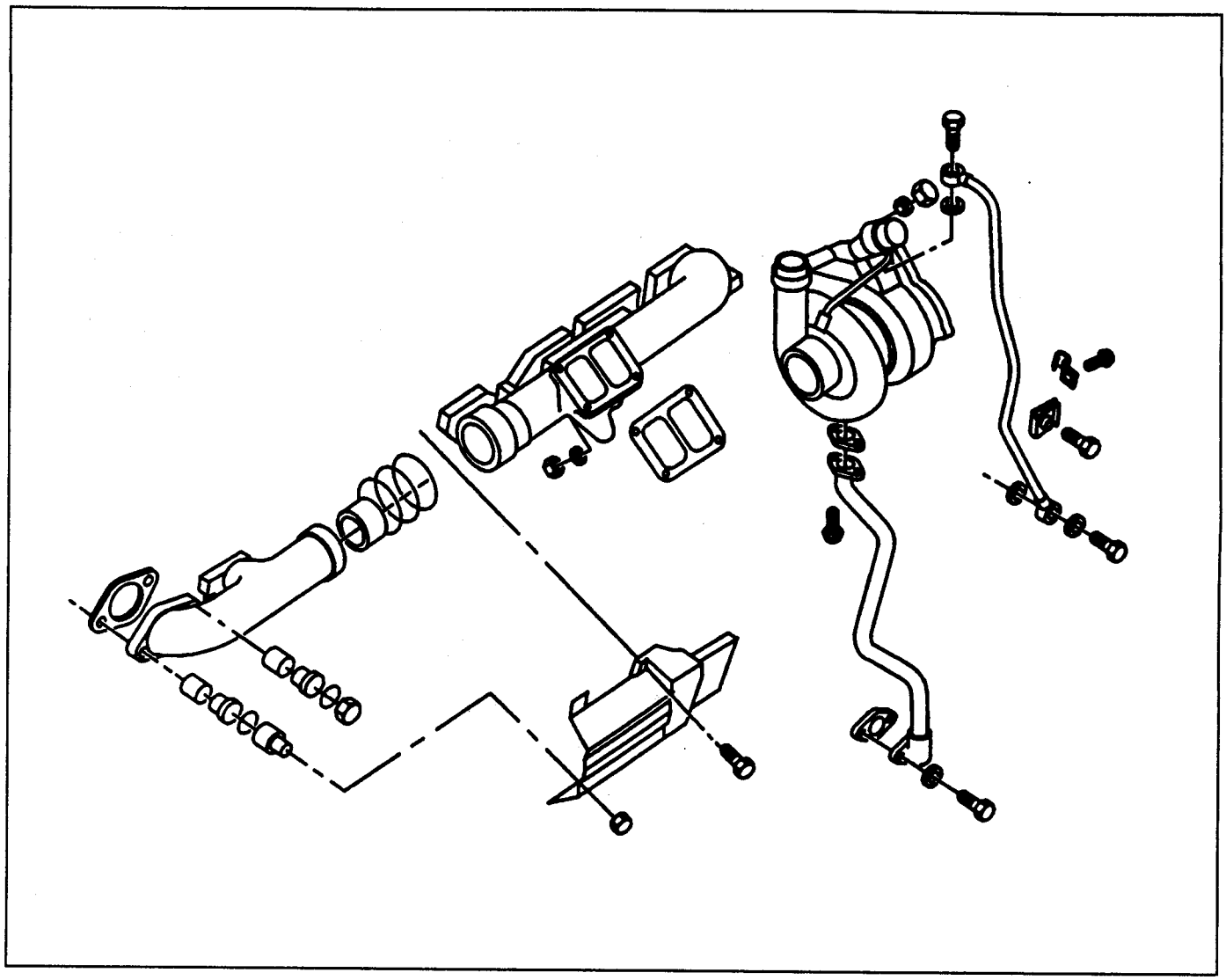


Figure 3 — Turbocharger Mounting

Install or Connect (Figures 1 and 3)

1. Gasket with the plain side towards the exhaust manifold.
2. Turbocharger to the exhaust manifold.
3. Washer and nuts to the exhaust manifold studs.

Tighten

- Nuts to 52 N·m (38 lb·ft.)

4. Oil drain tube and the gaskets to the turbocharger and the oil pan.

Tighten

- Bolts to 27 N·m (20 lb·ft.)

Tighten

- Prelubricate the turbocharger bearings with 4 fluid ounces of clean engine oil. Pour the clean engine oil into the oil feed port.
- Turn the compressor wheel by hand to distribute the oil in the turbocharger. Failure to do so could cause damage to the turbocharger.

5. Oil feed line to the turbocharger.
6. Joint bolt to the oil feed line.

Tighten

- Joint bolt to 18 N·m (13 lb·ft.)

7. Gasket to the exhaust pipe adapter.
8. Exhaust pipe adapter to the turbocharger.
9. Bolts and washers.

Tighten

- Bolts to 26 N·m (19 lb·ft.)

10. Heat shield to the starter.
11. Coolant feed lines.
12. Coolant return lines.
13. Air inlet hose to the charge air cooler.
14. Air inlet hose to the turbocharger.
15. Air inlet hose to air intake duct.
16. Negative battery cables.
17. Lower the cab.

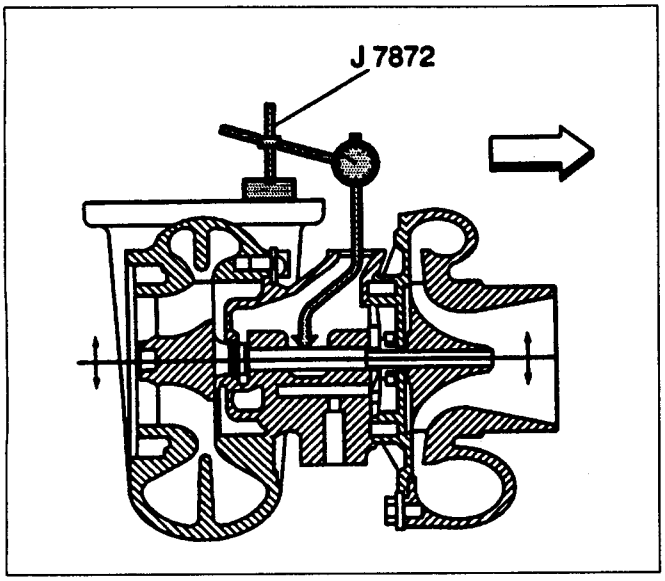


Figure 4 – Measuring Bearing Radial Clearance

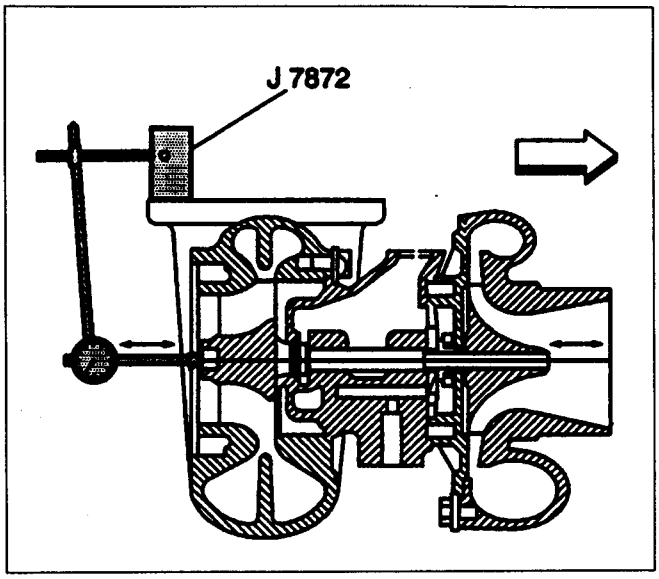


Figure 5 – Measuring Compressor End Play

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Application	N·m	lb·ft	lb·in
Charge Air Cooler Hose Clamp	6	–	53
Charge Air Cooler Mounting Bolt	45	33	–
Charge Air Tube Bolt	37	27	–
Compressor Housing Bolt	23	17	–
Exhaust Manifold	34	25	–
Exhaust Pipe Adapter to the Exhaust Manifold Bolt	26	19	–
Turbine Housing Bolt	23	17	
Turbocharger Drain Line Bolt (to the Turbocharger)	27	20	–
Turbocharger Drain Line Bolt (to the Cylinder Block)	18	13	–
Turbocharger Feed Lines Bolt (to the Turbocharger)	18	13	–
Turbocharger Feed Lines Bolt (to the Cylinder Block)	18	13	–
Turbocharger to the Exhaust Manifold Nut	52	38	–

SPECIAL TOOLS

J 7872 Magnetic Base Indicator Set

BLANK

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Transmission/Transaxle

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Manual Transmission - Medium Duty

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Frame Rail Bracket Bolts and Nuts	22 N·m	16 lb ft
Oil Drain Plug	69 N·m	51 lb ft
Oil Fill Plug	69 N·m	51 lb ft
Set Screw	6 N·m	53 lb in
Shift and Select Cable Nuts	45 N·m	33 lb ft
Transmission and Cable Bracket Bolts	39 N·m	29 lb ft

Lubrication Specifications

Application	Specification	
	Metric	English
API GL5, SAE 90 Multipurpose Oil (Use SAE 80 in Canada)	6.5 liters	6.9 quarts

Diagnostic Information and Procedures

Manual Transmission Diagnosis

Inspect the clutch system and shifting controls for proper operation before you repair the transmission. Ensure that the problem is inside the transmission prior to removing the transmission.

Run the engine at a normal idle with the transmission in neutral and the clutch disengaged. Shift the transmission into reverse and check for a grinding noise. If a grinding noise is heard, check the clutch system and clutch controls for damage or wear. Refer to *Clutch Noisy* or *Clutch Noisy During Engagement*.

If shifting the transmission is restricted, check for dirt, wear, or damage to the shift cables, mounting brackets, and shift cable linkage. Check the shift cable for proper adjustment. Adjust the shift cables if required.

If the clutch system and transmission shifting controls are operational, perform the following diagnosis in order to help locate the transmission problem.

Transmission Jumps Out of Gear

Problem	Action
The shift linkage is improperly adjusted.	Adjust the shift linkage.
The shift fork pads or groves in the sliding gear are worn excessively.	Overhaul the transmission.
The taper is worn on the clutch gear teeth.	Overhaul the transmission.
The transmission is out of alignment.	Align the transmission.
The shift rod poppet springs are broken.	Overhaul the transmission.
The shift rod poppet springs are worn.	Overhaul the transmission.
The shift rod is bent or out of line.	Overhaul the transmission.

Transmission Jumps Out of Gear (cont'd)

Problem	Action
The shift pad fork pads are not square with the shift rod bore.	Overhaul the transmission.
There is excessive end play in the drive gear, mainshaft, or countershaft.	Overhaul the transmission.
The thrust washers or faces are worn excessively or missing.	Overhaul the transmission.

Transmission Sticking in Gear

Problem	Action
The clutch linkage is improperly adjusted.	Adjust the clutch linkage.
The sliding clutch gears are tight on the sides.	Adjust the clutch system.
Chips are wedged between the spline of the shaft and the gears.	Overhaul the transmission.
There is a misaligned mainshaft of the countershaft.	Overhaul the transmission.

Noisy in the Gears

Problem	Action
The mainshaft rear bearing is worn.	Overhaul the transmission.
The rear bearing is rough, chipped, or tapered.	Overhaul the transmission.
The speedometer gears are worn.	Overhaul the transmission.
There is excessive end play of the mainshaft.	Overhaul the transmission.

Oil Leak Diagnosis

Problem	Action
The oil level is too high.	Adjust the oil level.
The lubricant in the transmission is incorrect.	Replace the transmission oil.
The bolts are loose or missing.	Tighten the loose bolts to the proper torque value. Refer to *Fastener Tightening Specifications.*
The bearing cap seals are worn.	Overhaul the transmission.
The transmission breather is plugged internally.	Overhaul the transmission.
The seal plugs are loose or missing.	Replace the seal plugs.
The gaskets are worn.	Overhaul the transmission.
There are cracks in the transmission case.	Overhaul the transmission.
The drain or filter plugs are loose.	Tighten the drain or filter plugs to the proper torque. Refer to *Fastener Tightening Specifications.*
The bearing caps are worn or plugged.	Clean or replace the bearing caps.

Noisy Bearings

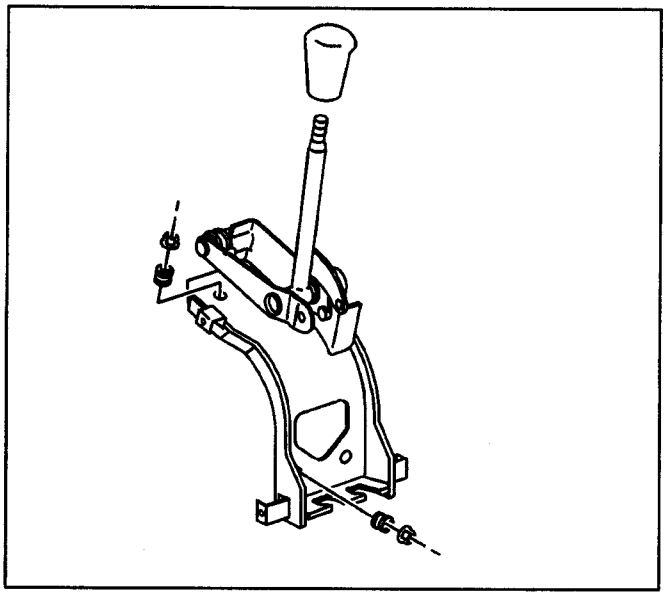
Problem	Action
There is dirt in the transmission oil.	Replace the transmission oil.
The lubricant is incorrect.	Replace the transmission oil.
The oil level is low.	Fill the transmission to the proper oil level.
The bearing retainer is worn or broken.	Overhaul the transmission.
Water or contaminants are in the transmission oil.	Replace the transmission oil.
The engine torque is too high for the transmission.	Adjust the engine torque.
The vehicle is overloaded.	Load the vehicle to the proper load limit.
There is excessive transmission vibration.	Overhaul the transmission.

Noisy in All Gears

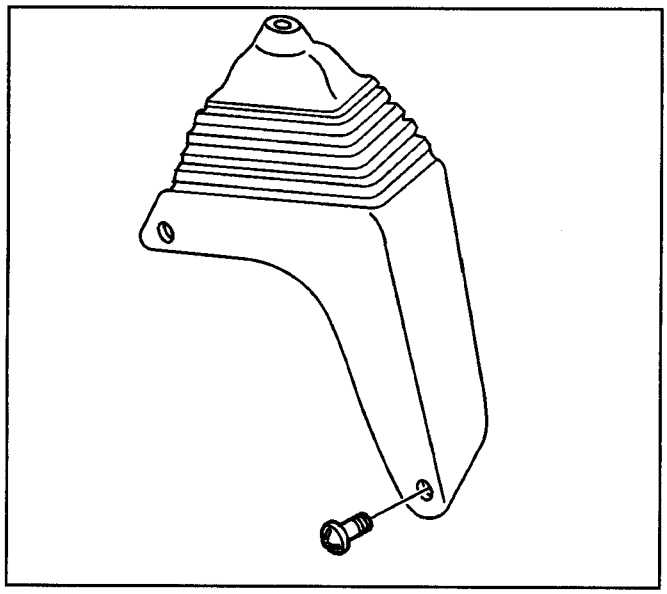
Problem	Action
The gears are chipped or cracked.	Overhaul the transmission.
Free running gears are seizing on the thrust face.	Overhaul the transmission.
There is lack of backlash between mating gears.	Overhaul the transmission.
The floating gears on the mainshaft have seized.	Overhaul the transmission.
There is a lack of transmission oil.	Fill the transmission to the proper oil level.

Noisy in Neutral with Engine Running

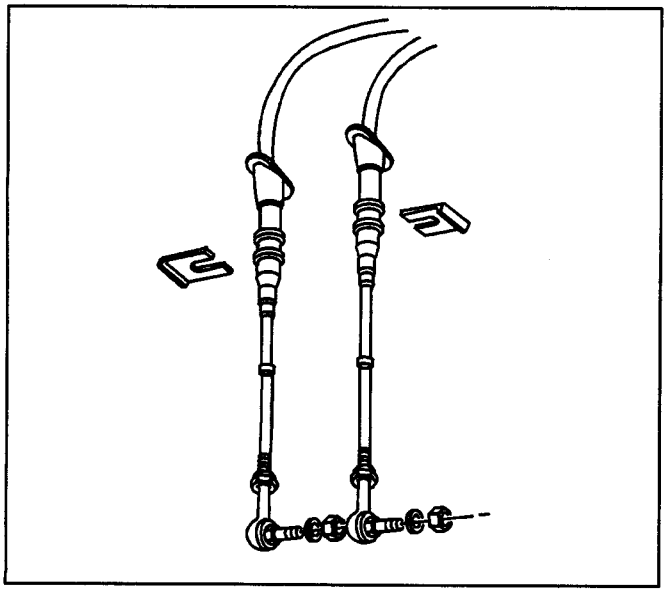
Problem	Action
The transmission is misaligned.	Align the transmission.
The flywheel pilot bearing is worn.	Replace the flywheel pilot bearing.
The countershaft bearing is worn.	Overhaul the transmission.
There is excessive end-play in the countershaft.	Overhaul the transmission.
There is excessive end-play in the idler gear.	Overhaul the transmission.
The reverse idler gear is worn.	Overhaul the transmission.
The countershaft is worn.	Overhaul the transmission.
The clutch linkage is adjusted incorrectly.	Overhaul the transmission.
The mainshaft pilot bearing is worn.	Overhaul the transmission.
The gear tooth contact surface is scuffed.	Overhaul the transmission.
There is a lack of transmission oil.	Fill the transmission to the proper oil level.
The transmission oil is the wrong grade.	Replace the transmission oil.



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Repair Instructions

Shift Cable Replacement

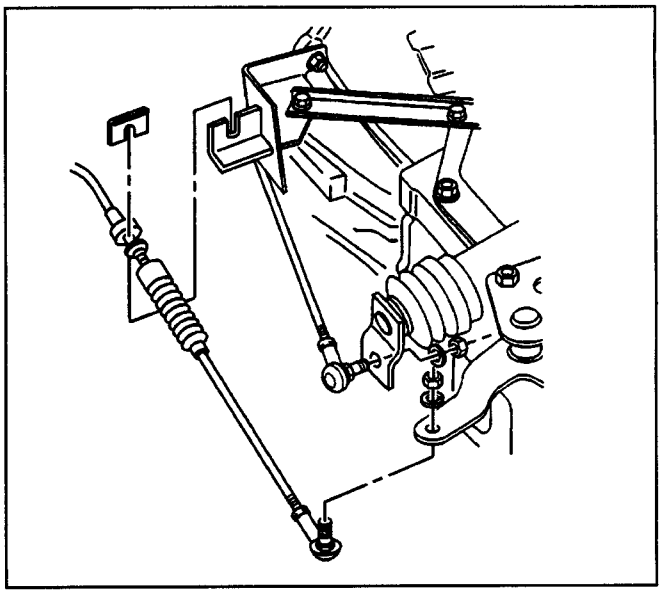
Removal Procedure

Important:

- Block all of the wheels on the vehicle prior to starting this procedure.
- Apply the park brake.
- Ensure that the shift control lever is in the Neutral position prior to removing the shift cables.

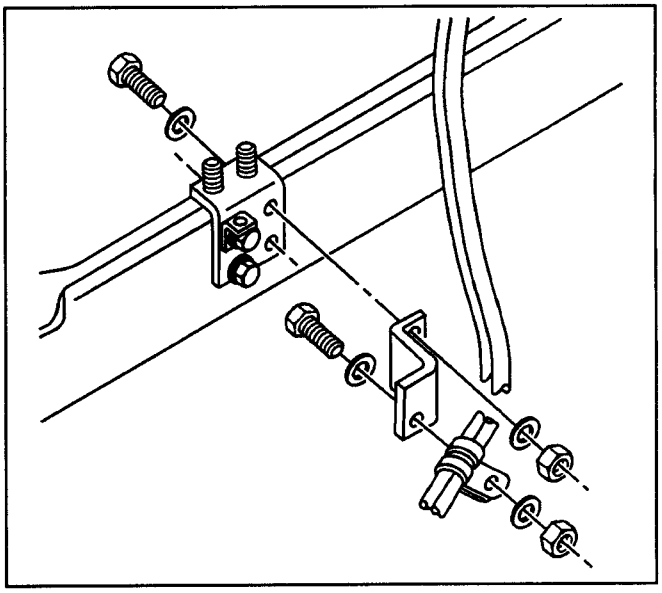
1. Remove the shift knob from the shift control lever.
2. Remove the four screws securing the shift boot to the shift control.
3. Remove the following fasteners securing the shift and select cables to the shift control:
   - The two nuts
   - The washers
   - The clips
4. Remove the two nuts and the washers securing the shift control to the panel.
5. Remove the shift and select cables from the panel.

6. Remove the fasteners securing the shift and select cables to the transmission control lever and clutch control lever as follows:
   - The two nuts
   - The washers
   - The clip



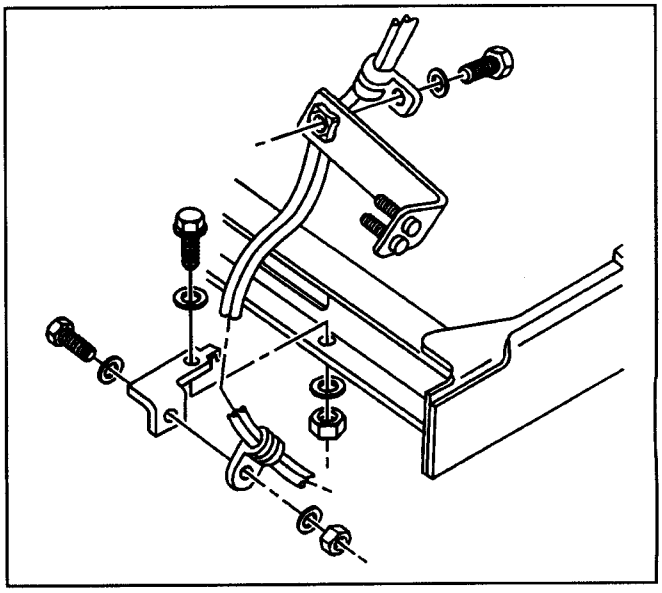
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7. Remove the bolts and the nuts that secure the shift and select cables to the frame rail brackets.

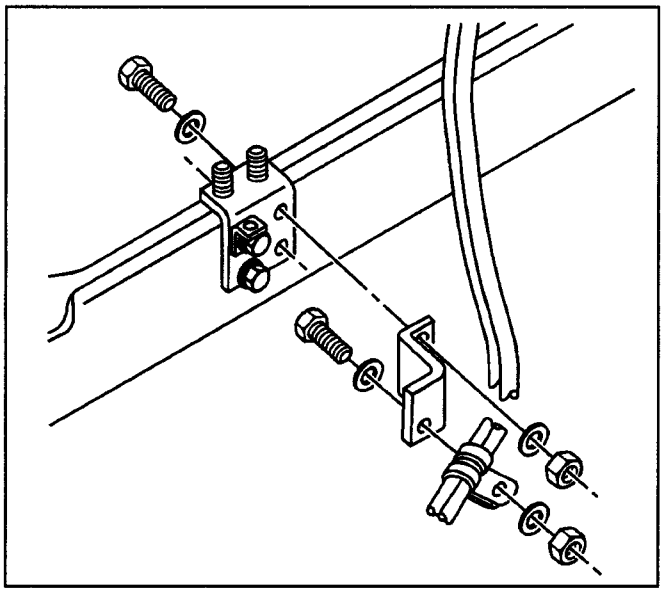


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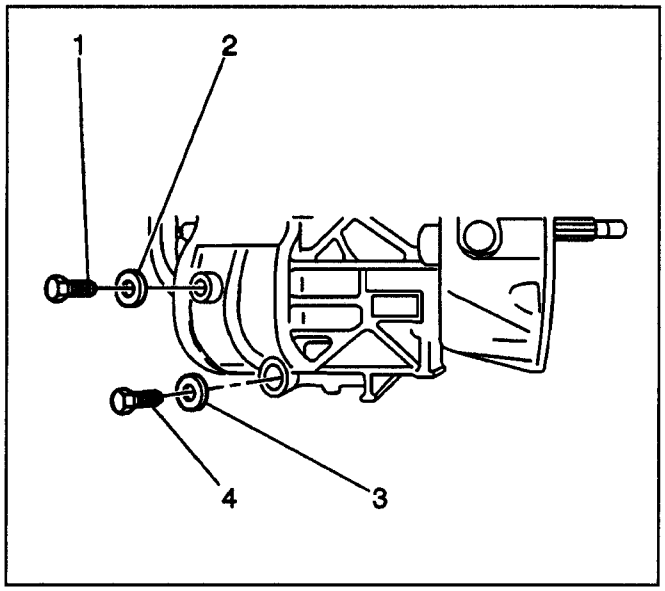
8. Remove the bolts and nuts securing the shift and select cables to the frame rail brackets. Note the routing of the shift and select cables.



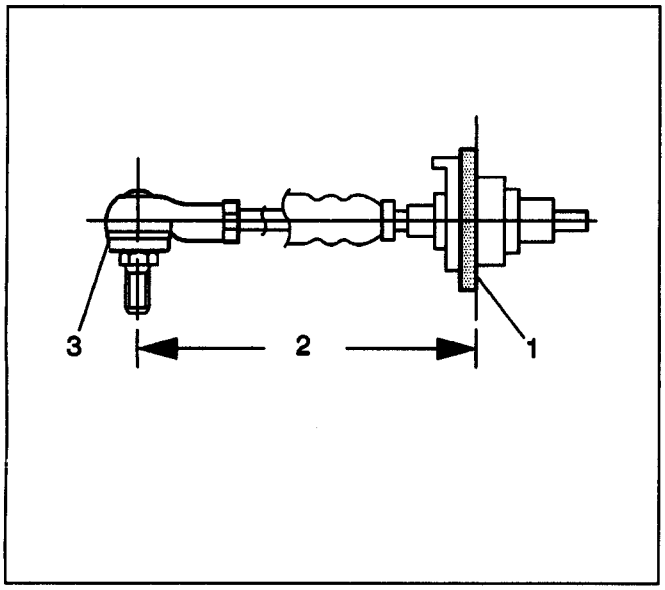
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Installation Procedure

1. Install the bolts and nuts securing the shift and select cables to the frame rail brackets.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the bolts and nuts securing the shift and select cables to the frame rail brackets.

   Tighten

   Tighten the frame rail bracket bolts and nuts to 22 N.m (16 lb ft).
3. Route the shift and select cables through the panels.
4. Install the two nuts and washers securing the shift control to the panel.

   Tighten

   Tighten the shift control panel nuts to 22 N.m (16 lb ft).
5. Install the following fasteners securing the shift and select cables to the shift control:

   Tighten

   Tighten the shift and select cable nuts to 45 N.m (33 lb ft).
   - The two nuts
   - The washers
   - The clips
6. Install the four screws securing the shift boot to the shift control.
7. Install the shift knob to the shift control lever.
8. Adjust the shift and select control cables. Refer to *Shift Cable Adjustment.*

Shift Cable Adjustment

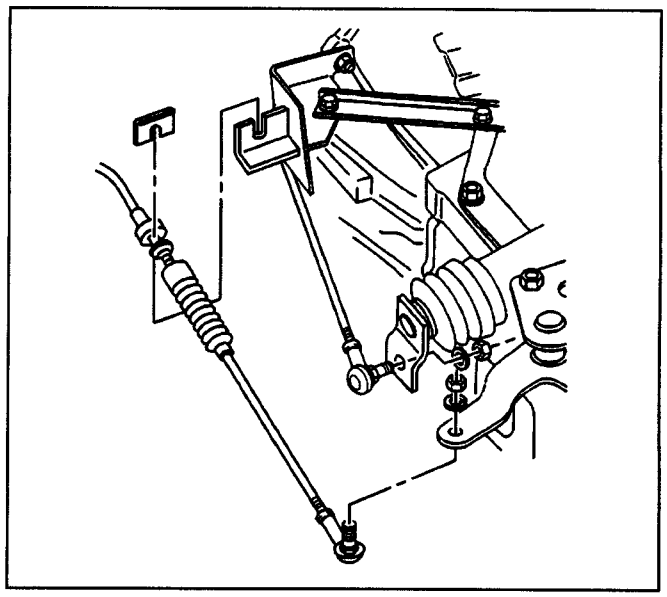
Important:

- The shift control cable attaches to the transmission control lever.
- The select control cable attaches to the select bell crank lever.

1. Remove the nut and washer securing the shift cable or the select control cable from the transmission control lever or the transmission select bell crank lever if applicable.
2. Ensure that the transmission select and shift levers are in the mechanical neutral position.
3. Turn the adjustment nut at the end (1) of the shift or select cable in order to obtain the proper rear side of bracket (3) to control lever distance.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the nuts, the washers, and the clip securing the shift and/or select cable(s) to the transmission control lever and/or the select bell crank lever.
   Tighten
   Tighten the shift and select cable nuts to 45 N·m 33 lb ft).
5. Start the engine and check for proper shift operation.

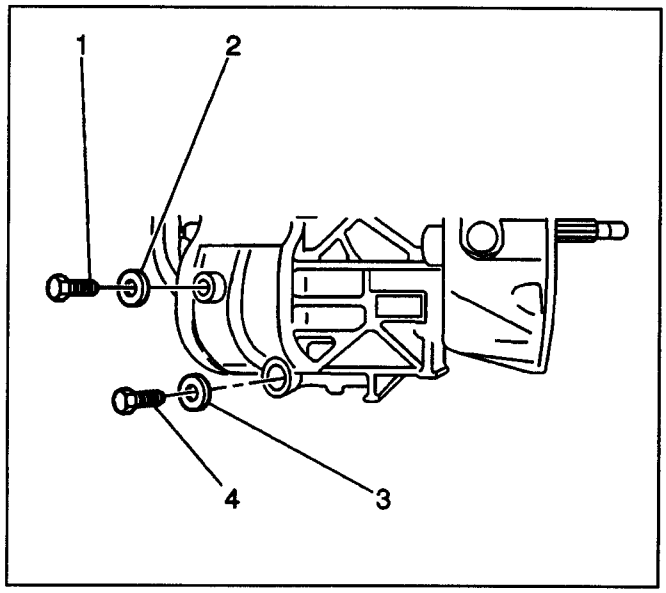


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Transmission Oil Change Procedure

Removal Procedure

1. Clean the area around the drain and fill plugs.
2. Remove the oil fill plug (1) and the seal (2) from the transmission case. Discard the seal.
3. Position a container under the oil drain hole to catch the transmission oil.
4. Remove the oil drain plug (3) and the seal (4) from the transmission case. Discard the seal.

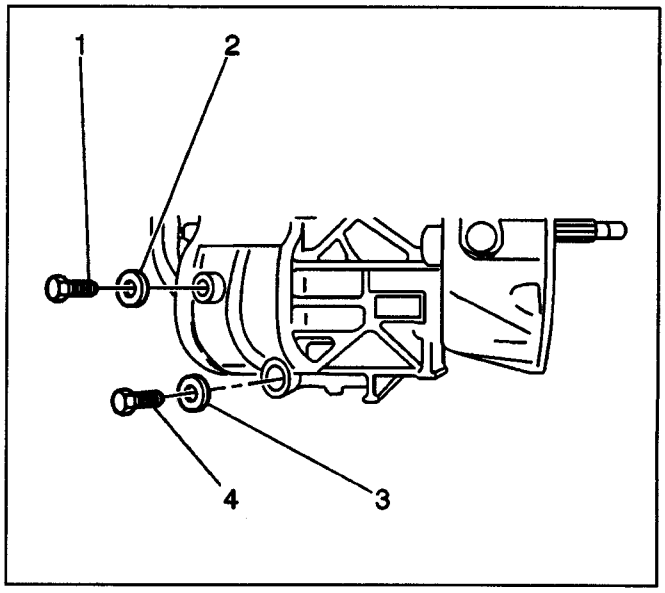


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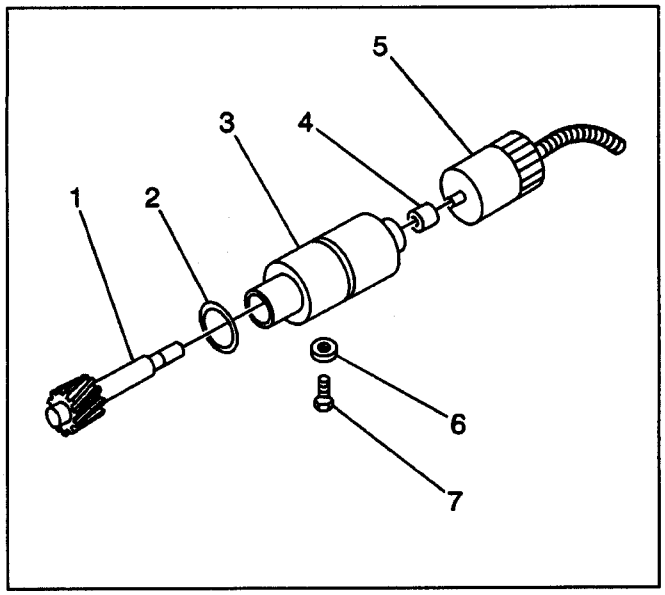
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the oil drain plug (3) and a new seal (4) into the transmission case.
   Tighten
   Tighten the oil drain plug to 69 N·m (51 lb ft).
2. Fill the transmission to the level of the oil fill plug hole with transmission oil. Refer to *Lubrication Specifications.*
3. Install the oil fill plug (1) and a new seal (2) to the transmission case.
   Tighten
   Tighten the oil fill plug to 69 N·m (51 lb ft).



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Speedometer Driven Gear Replacement

Removal Procedure

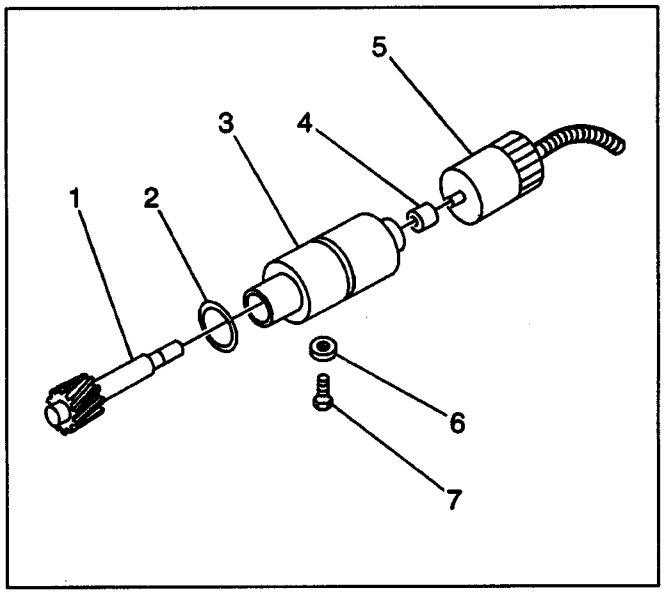
Tools Required

J 35833 Speedometer Driven Gear Bushing Remover

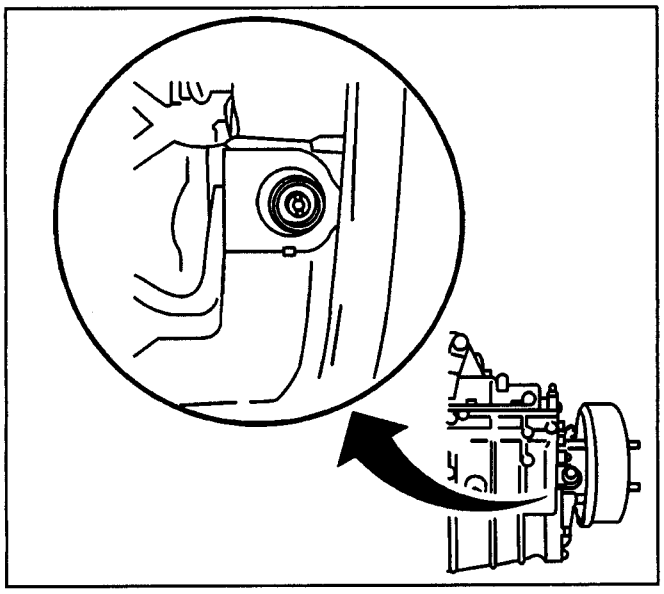
1. Remove the speed sensor (5) and speed sensor seal (4) from the speedometer driven gear bushing.
   Discard the speed sensor seal.
2. Remove the bushing set screw (7) and washer (6) from the speedometer driven gear bushing (3).
3. Use the *J 35833* in order to remove the speedometer driven gear bushing (3) from the transmission case.
4. Remove the speedometer driven gear seal from the transmission case.
   Discard the speedometer driven gear seal (2).
5. Remove the speedometer driven gear (1) from the transmission.

Installation Procedure

1. Install the speedometer driven gear (1) to the transmission.
2. Install a new speedometer driven gear seal (2) to the transmission case.
3. Install the speedometer driven gear bushing (3) to the transmission case.
4. Install the bushing set screw (7) and the washer (6) to the speedometer driven gear bushing.
5. Install the speed sensor (5) and a new speed sensor seal (4) to the speedometer driven gear bushing.



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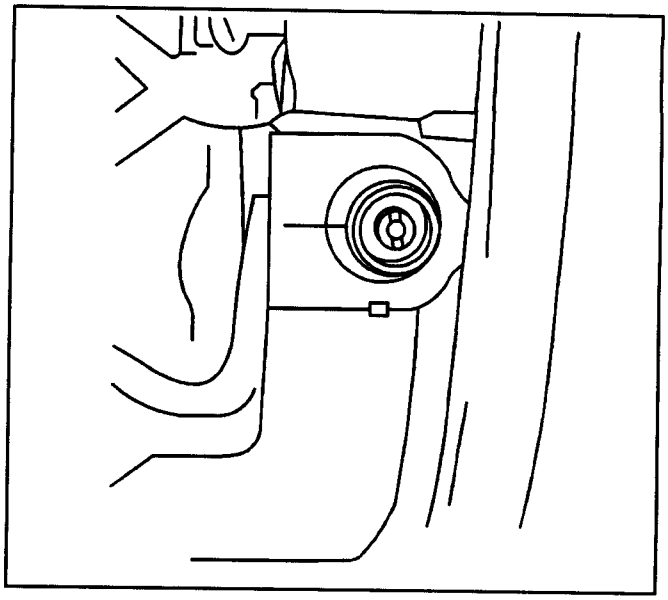


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Speedometer Driven Gear Backlash Adjustment

1. Remove the speedometer driven gear from the transmission. Refer to *Speedometer Driven Gear Replacement*.
2. Position the speedometer driven gear and the speedometer driven gear bushing into the transmission case rear cover.
3. Rotate the bushing in the direction toward the front of the vehicle until there is no backlash between the speedometer driven gear and the transmission drive gear.

4. Mark the bushing and transmission case rear cover.



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5. Rotate the bushing in the reverse direction (1) by the measurement shown in the Reverse Direction Distance Table.

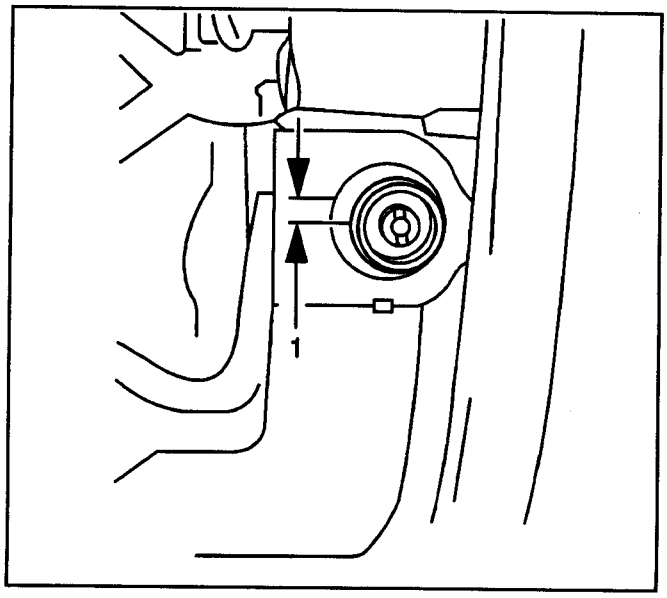
   Notice: The backlash between the gears will be in the specified range 0.1-0.3 mm (0.138-0.157 in) after performing this procedure.
6. Using a marker pin, mark a set screw hole boring position on the bushing through the rear case set screw mounting hole.
7. Remove the bushing and speedometer driven gear from the transmission rear case.
8. Drill a set screw access hole into the bushing.

   Drill one 4.5 mm (0.177 in) hole 3.5—4.0 mm (0.138–0.157 in) depth into the bushing.
9. Install the following components into the transmission rear case:
   - The speedometer driven gear
   - The speedometer driven gear seal
   - The speedometer driven gear bushing
10. Align the access hole in the bushing with the set screw hole.

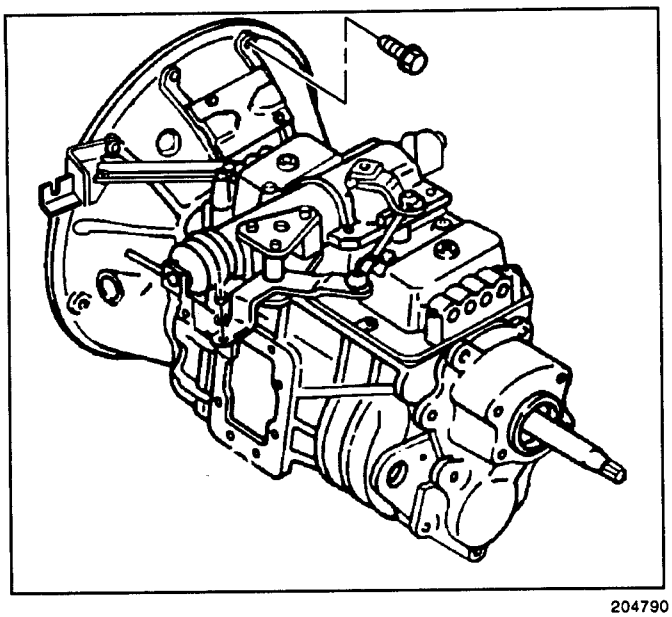
    Notice: Refer to *Fastener Notice* in Cautions and Notices.
11. Install the set screw and washer.

    Tighten

    Tighten the set screw to 6 N.m (53 lb in).
12. Install a new speed sensor seal and seal sensor.



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Transmission Replacement

Removal Procedure

1. Block all of the vehicle wheels.
2. Remove the transmission oil from the transmission. Refer to *Transmission Oil Change Procedure.*
3. Remove the propeller shaft. Refer to the following procedures:
   - *One-Piece Propeller Shaft Replacement (Full Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Full Yoke/305)*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/229)*
   - *One-Piece Propeller Shaft Replacement (Half Yoke/305)*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/229)*
   - *One-Piece Propeller Shaft Replacement (Outboard Slip/305)*
   - *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange)*
   - *Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke)*
4. Remove the clutch slave cylinder. Refer to Clutch in Transmission.
5. Remove the power take off drive shaft, if installed.
6. Remove the parking brake cable and bracket. Refer to Parking Brake Cable Replacement.
7. Remove the shift and select cable at the transmission. Refer to *Shift Cable Replacement.*
8. Remove the wiring harness connectors and the wiring harness.
9. Remove the speed sensor and seal from the speedometer driven gear bushing.

   Important:
   - Support the transmission with a cradle type jack prior to removing the transmission mounting bolts.
   - If a cradle type jack is not used, chain the transmission to the jack that you use.
   - Pull the transmission straight back on the clutch splines in order to avoid damage to the clutch system.
   - Do not let the transmission hang on the clutch splines when removing the transmission from the engine.
10. Remove the bolts that secure the transmission and cable brackets to the engine.

Installation Procedure

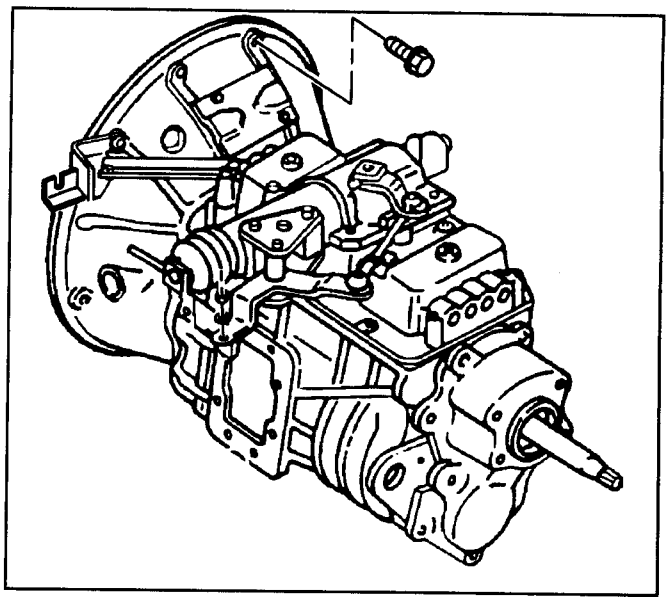
Important:

- Support the transmission with a cradle type jack prior to lifting the transmission.
- Do not let the transmission hang on the clutch splines when removing the transmission from the engine.

1. Align the transmission with the engine.
2. Align the direct gear shaft splines with the clutch hub splines.
3. Install the bolts that secure the transmission and the cable brackets to the engine.

   Tighten

   Tighten the transmission and cable bracket bolts to 39 N.m (29 lb ft).
4. Install the speed sensor and seal to the speedometer driven gear bushing.
5. Install the wiring harness connectors and the wiring harness.
6. Install the shift and select cable at the transmission. Refer to *Shift Cable Replacement.*
7. Install the parking brake cable and bracket. Refer to Parking Brake Cable Replacement in Parking Brake.
8. Install the power take off drive shaft, if necessary.
9. Install the clutch slave cylinder. Refer to Clutch in Transmission.
10. Install the propeller shaft. Refer to the following procedures:
    - *One-Piece Propeller Shaft Replacement (Full Yoke/229)*
    - *One-Piece Propeller Shaft Replacement (Full Yoke/305)*
    - *One-Piece Propeller Shaft Replacement (Half Yoke/229)*
    - *One-Piece Propeller Shaft Replacement (Half Yoke/305)*
    - *One-Piece Propeller Shaft Replacement (Outboard Slip/229)*
    - *One-Piece Propeller Shaft Replacement (Outboard Slip/305)*
    - *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange)*
    - *Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke)*
11. Fill the transmission with transmission oil. Refer to *Transmission Oil Change Procedure.*
12. Start the engine and check for the transmission operation.



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Description and Operation

Transmission Description and Operation

The six speed (MLD6Q) transmission has a constant mesh first and reverse gear. The remaining gears are synchronized. Shifting is done with a remote shift controlm connected to two cables that operate a shift quadrant mounted on the top of the transmission. The transmission is equipped with a drive that can be connected to a power takeoff system.

Overhaul Information

For the overhaul of the MLD6Q manual transmissions, refer to Manual Transmission Overhaul.

Automatic Transmission - Allison

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Auxiliary Oil Cooler Top Support Bolts	30 N.m	22 lb ft
Auxiliary Oil Cooler Bottom Support to Radiator Support Bolts	30 N.m	22 lb ft
Auxiliary Oil Cooler Top Support to Radiator Support Bolts	30 N.m	22 lb ft
Flywheel to Flexplate Bolts	56 N.m	41 lb ft
Modulator Clip Bolt	20 N.m	15 lb ft
Modulator Cable to Support Bracket Bolts	9 N.m	80 lb ft
Modulator Cable Nut	12 N.m	106 lb in
Oil Cooler Line Engine Block Bracket Bolts	30 N.m	22 lb ft
Oil Cooler Line Nuts to Auxiliary Oil Cooler	30 N.m	22 lb ft
Oil Cooler Line Nuts to Radiator	30 N.m	22 lb ft
Oil Cooler Line Nuts to Transmission Connectors	25 N.m	18 lb ft
Oil Cooler Line Transmission Case Bracket Bolts	30 N.m	22 lb ft
Oil Level Indicator Tube to Engine Bracket Bolt	55 N.m	41 lb ft
Oil Level Indicator Tube to Transmission Nut	130 N.m	96 lb ft
Transmission to Engine Bolts	55 N.m	41 lb ft

Fluid Capacity Specifications

Application	Specification	
	Metric	English
Allison AT 545 Use DEXRON® III Automatic Transmission Oil.	14 LITER	14.8 quarts

Diagnostic Information and Procedures

Shift Speed Too High

Problem	Action
The governor valve is stuck.	Clean or replace the governor screen and/or the governor.
The modulation is delayed.	Adjust the modulator. Refer to *Transmission Modulator Cable Adjustment.*
The mechanical actuator cable is kinked, broken, or not properly adjusted.	Replace, adjust, or repair the cable.
The mechanical actuator is obstructed.	Replace the actuator.
The shift signal valve adjustment is too high.	Adjust the shift points.
The valves are sticking.	Replace or rebuild the control valve assembly.
The modulation is improper.	Inspect the modulator valve and the modulator body.

Shift Speed Too Low

Problem	Action
The governor spring is weak or missing.	Replace the governor.
The mechanical actuator is kinked, broken, or not properly adjusted.	Replace, adjust, or repair the cable.
The adjustment of the shift signal valve spring is too loose.	Tighten the spring adjusting ring to the specification.
The modulator valve is stuck open.	Check the spring adjustment.
The modulator valve is stuck open.	Replace the modulator. Refer to *Transmission Modulator Replacement.*

Low Main Pressure in All Ranges

Problem	Action
The oil level is low.	Add oil in order to acquire the proper oil level. Refer to *Transmission Oil Checking Procedure.*
The external filter is clogged.	Replace the external filter. Refer to *External Transmission Oil Filter Replacement.*
The seal ring on the intake tube is leaking or missing.	Install a new seal ring onto the top end of the intake tube.
The main pressure regulator valve spring is weak.	Replace the spring.
The control valve body is leaking.	Replace or rebuild the valve body assembly.
The valves of the trimmer relays and main pressure regulator are sticking.	Replace or rebuild the valve body assembly.
The input charging pump is worn or damaged.	Replace or rebuild the pump.
The priority valve is missing.	Replace the missing valve.

Low Main Pressure in First Gear

Possible Cause	Action
The first range circuit is leaking in the control valve body.	Replace or rebuild the control valve body.
The first clutch piston seals are leaking excessively.	1. Overhaul the transmission. 2. Replace the seals.

Intermittent Buzzing Noise

Problem	Action
The oil level is low.	Add oil in order to acquire the proper oil level. Refer to *Transmission Oil Checking Procedure.*
Air is leaking at the intake tube due to a damaged O-ring.	Replace the intake tube seal and filter.
The oil pan filter is clogged.	Replace the oil pan filter. Refer to *Transmission Oil Pan and Filter Replacement.*
The oil is aerated.	Make sure the oil level is correct. Refer to *Transmission Oil Checking Procedure.*
The external oil filter is damaged.	Replace the external oil filter. Refer to *External Transmission Oil Filter Replacement.*

Excessive Creep in First and Reverse Gears

Problem	Action
The engine idle speed is set too high.	Adjust the idle speed. Refer to Idle Speed Adjustment in Diesel Fuel Injection.
The shift cable is disconnected.	Connect the shift cable end. Refer to *Shift Cable Replacement.*

Low Lubrication Pressure

Problem	Action
The oil level is low.	Add oil in order to acquire the proper oil level. Refer to *Transmission Oil Checking Procedure.*
The engine idle speed is too low.	Refer to Idle Speed Adjustment.
The oil cooler lines are restricted or leaking.	1. Check the lines for kinks or leaks. 2. Reroute or replace the lines as necessary. Refer to *Transmission Oil Cooler Line Replacement.*
The transmission is excessively leaking oil internally.	Overhaul the transmission.

Fluid Leaking into Converter Housing

Problem	Action
The rear oil seal of the engine crankshaft is leaking.	Refer to Crankshaft Rear Oil Seal Replacment in Engine Mechanical.
The metal-cased, lip-type seal at the front of the input charging pump is leaking.	Replace the pump seal.
The seal around the outer diameter of the oil pump is leaking.	Replace the outer diameter pump seal.
The cranked weld in the torque converter assembly is leaking.	Repair or replace the converter assembly.
The torque converter pump hub at the seal area is worn.	Replace the torque converter pump hub.

Transmission Overheats in All Ranges

Problem	Action
The cooler lines are restricted.	1. Remove the restrictions. 2. Clean or replace the lines as necessary. Refer to *Transmission Oil Cooler Line Replacement.*
The torque converter has broken parts.	Repair or replace the converter assembly.
The oil is aerated.	Check the following parts: • The seal ring at the intake tube • The input charging pump
Internal leakage is slowing the oil cooling flow.	Overhaul the transmission.

High Stall Speed

Problem	Action
The oil level is low.	Add oil in order to attain the proper fluid level. Refer to *Transmission Oil Checking Procedure.*
The clutch pressure is low.	Test the pressure.
The forward clutch slips.	Rebuild the forward clutch.
The first clutch slips.	Rebuild the first clutch.
The fourth clutch (reverse) is slipping.	Rebuild the fourth clutch.

Low Stall Speed

Problem	Action
The engine is not performing efficiently, possibly because of plugged or restricted injectors or high altitude conditions.	Refer to Engine Controls.
The converter parts are broken.	Replace or rebuild the converter assembly.
The vehicle stalls at speeds of 50 percent of normal, which implies a freewheeling stator.	Replace or rebuild the converter assembly.

Rough Shifting

Problem	Action
The governor valve is stuck.	Clean or replace the governor screen and/or the governor.
The valve spring of the vacuum modulator is not properly adjusted, or the vacuum hose is kinked or leaking.	Check the spring adjustment.
The mechanical actuator cable is kinked, broken, or not properly adjusted.	Replace, adjust, or repair the cable.
The mechanical actuator is obstructed.	1. Check the actuator. 2. Replace the actuator if necessary.
The modulator is inoperative.	Replace the modulator. Refer to *Transmission Modulator Replacement.*
The trimmer valve is sticking, or has a broken spring.	Replace or rebuild the control valve body assembly.
The control valve is sticking.	Replace or rebuild the control valve body assembly.

Rough Shifting (cont'd)

Problem	Action
The modulator valve is sticking.	1. Clean the valve. 2. Check the vacuum modulator. 3. Adjust the spring.
The engine idle speed in neutral to drive is too fast.	Adjust the engine idle screw. Refer to Idle Speed Adjustment in Engine Controls.
The selector linkage is out of adjustment.	Adjust the shift cable. Refer to *Shift Cable Adjustment.*

Excessive Slip and Clutch Chatter Only One Range

Problem	Action
The clutch is slipping in one range.	1. Rebuild the specific clutch that is slipping. 2. Replace the piston seals.
Oil is leaking excessively at the piston seals in one range.	Overhaul the clutch and piston assembly.
Oil is leaking in the valve components of one range.	Replace or rebuild the control valve body assembly.
The trimmer valve is stuck open.	1. Replace or rebuild the control valve body assembly. 2. Check the trimmer valve for freedom of movement.
The priority valve is cycling.	Replace or rebuild the control valve body assembly.

Dirty Fluid

Problem	Action
The oil has not been changed at proper intervals.	1. Drain the oil. 2. Replace the oil filter. Refer to *Transmission Oil Pan and Filter Replacement.* 3. Replace the external oil filter. Refer to *External Transmission Oil Filter Replacement.* 4. Fill the transmission with new oil.
The heat of the oil is excessive.	Check the cooling system.
The clutch is inoperative.	Overhaul the transmission.
The filter or filter elements are damaged.	Replace the filter or elements. Refer to *External Transmission Oil Filter Replacement.*
The engine rear oil seal is faulty.	Replace the engine rear oil seal. Refer to Engine Rear Oil Seal Replacement in Engine Mechanical.

Output Shaft Seal Fluid Leak

Problem	Action
The seal at the output flange is missing or faulty.	Install a new seal in the rear of the transmission housing.
The flange is worn at the seal surface.	Replace the flange.

Slips in All Forward Ranges

Problem	Action
The oil level is low.	Add oil in order to obtain the proper oil level. Refer to *Transmission Oil Checking Procedure.*
The clutch main pressure is low.	Test the pressure.
The forward clutch is slipping.	1. Rebuild the forward clutch. 2. Replace the piston seals.
The seal rings on the front support hub are broken.	Replace the seal rings.

Slips in Fourth and Reverse Gear Only

Problem	Action
The fourth clutch is slipping.	1. Rebuild the clutch. 2. Replace the piston seals.
The trimmer valve is sticking.	1. Replace or rebuild the control valve body assembly. 2. Inspect the trimmer valve.
The seal rings on the center support assembly hub are broken.	Replace the seal rings.
The seal rings of the clutch piston are cut.	Replace the seal rings.
The check balls are not seating in the rotating clutch housings.	Inspect the check balls for contamination and proper operation.

Slips in Reverse and First Gear Only

Problem	Action
The first clutch is slipping.	1. Overhaul the clutch. 2. Replace the piston seals.
The piston seal rings are cut.	Replace the seal rings.
The clutch-apply oil feed tube is loose or leaking.	Reset or replace the feed tube.

Vehicle Moves Forward in Neutral

Problem	Action
The idle speed is incorrect.	Adjust the idle speed. Refer to Idle Speed Adjustment in Engine Controls.
The shift selector linkage is not in adjustment.	Adjust the shift cable. Refer to *Shift Cable Adjustment.*
The forward clutch has failed and is dragging.	Rebuild the forward clutch.

Vehicle Moves Backward in Neutral

Problem	Action
The shift cable is not in adjustment.	Adjust the shift cable. Refer to *Shift Cable Adjustment.*
The fourth clutch is inoperative and is dragging.	Rebuild the fourth clutch.
The shift cable is faulty or broken.	Repair or replace the shift cable. Refer to *Shift Cable Replacement.*
The main pressure is low.	Test the pressure.
The shift selector is not engage at the control valve.	Install or replace the parts that are involved. The parts are found inside the oil pan.
The oil level is low.	Fill to the proper oil level. Refer to *Transmission Oil Checking Procedure.*

Fluid Out of Fill Tube or Breather

Problem	Action
The oil level indicator is loose.	1. Tighten the cap. 2. Replace the cap as necessary.
The oil level is too high.	Drain the oil in order to acquire the proper oil level. Refer to *Transmission Oil Checking Procedure.*
The oil level is too low.	Add oil in order to acquire the proper oil level. Refer to *Transmission Oil Checking Procedure.*
The modulator is faulty.	Replace the modulator. Refer to *Transmission Modulator Replacement.*
The oil level indicator tube is plugged.	1. Check the fill tube for blockage. 2. Clean the tube as necessary.
The breather is clogged.	Clean or replace the breather.
The transmission oil contains water.	1. Drain the oil. 2. Replace the oil. Refer to *Transmission Oil Checking Procedure.*
The oil level indicator gasket is worn.	Replace the gasket or the oil level indicator. Refer to *Transmission Oil Level Indicator Tube Replacement*
The oil level indicator is improperly marked.	Replace the oil level indicator. Refer to *Transmission Oil Level Indicator Tube Replacement.*

Oil Leak Diagnosis

The cause of most external leaks can generally be located and repaired with the transmission in the vehicle.

General Method

1. Verify that the leak is transmission oil.
2. Thoroughly clean the suspected leak area.
3. Operate the vehicle for about 15 minutes or until normal operating temperatures are reached.
4. Park the vehicle over clean paper or cardboard.
5. Turn the ignition to the OFF position.
6. Look for oil spots on the paper.
7. Make the necessary repairs.

Powder Method

1. Thoroughly clean the suspected leak area with solvent.
2. Apply an aerosol type powder (foot powder) to the suspected leak area.
3. Operate the vehicle for about 15 minutes or until the normal operating temperatures are reached.
4. Turn the ignition to the OFF position.
5. Inspect the suspected leak area.
6. Trace the leak path through the powder in order to find the source.
7. Make the necessary repairs.

Dye and Black Light Method

1. Follow the manufacturer's recommendation for the amount of dye to be used.
2. Find the leak with a black light.
3. Make the necessary repairs.

Gasket and Seal Checks

Once the leak has been pinpointed and traced back to the source, determine the cause of the leak in order to repair the leak properly. If a gasket is replaced, but the sealing flange is bent, the new gasket will not repair the leak. Repair the bent flange before attempting to repair a leak. In order to prevent leakage, correct any of the following conditions.

- Check the gasket areas for the following conditions that may cause a leak:
  - The fluid level or pressure is too high
  - A plugged vent or drain-back holes
  - Improperly tightened fasteners or dirty/damaged threads
  - Warped flanges or warped sealing surfaces
  - Damaged or worn gaskets
  - Cracking or porosity of the component
  - Improper sealant used (where applicable)
- Check the seal areas for the following conditions that may cause a leak:
  - The oil level or pressure is too high
  - A plugged vent or drain-back hole
  - A damaged seal bore (scratched, burred, or nicked)
  - A damaged or worn seal
  - Improper installation
  - Cracks in the component
  - The manual or output shaft surface is scratched, nicked, or missing
  - A loose or worn bearing causing excess seal wear

Possible Points of Oil Leaks

Oil leaks may occur in the following areas:

- The transmission or the transmission oil pan
  - Attaching bolts are not tightened to the correct specification.
  - A gasket is improperly installed or damaged.
  - The oil pan or mounting face is not flat.
- The transmission case
  - The filler tube multi-lip threads are leaking.
  - The governor cover or O-ring is damaged or missing.
  - The filler tube bracket is misaligned.
  - The vehicle speed sensor seal is damaged.
  - The manual shaft seal is damaged.
  - The oil cooler connector fittings are loose or damaged.
  - The propeller shaft oil seal is worn or damaged.
  - The governor cover is leaking.
  - The line pressure pipe plug is loose.
  - The casting is porous.
- The converter end seal
  - The seal lip is cut.
    Check the converter hub for damage.
  - The bushing is moved forward.
    The bushing is damaged.
  - The garter spring is missing from the seal.
- The converter end
  - The converter leaks in the weld area.
  - The casting in the case of the pump is porous.
- The vent pipe or the fill tube
  - The transmission oil level is too high.
  - Water or coolant is in the oil.
    The oil appears milky.
  - The case is porous.
  - The oil level indicator is incorrect.
  - The transmission vent is plugged.
  - The drain back holes are plugged.
  - The oil pump to case gasket, if equipped, is misaligned.

Repair Instructions

Parts Cleaning and Inspection

Service Precautions

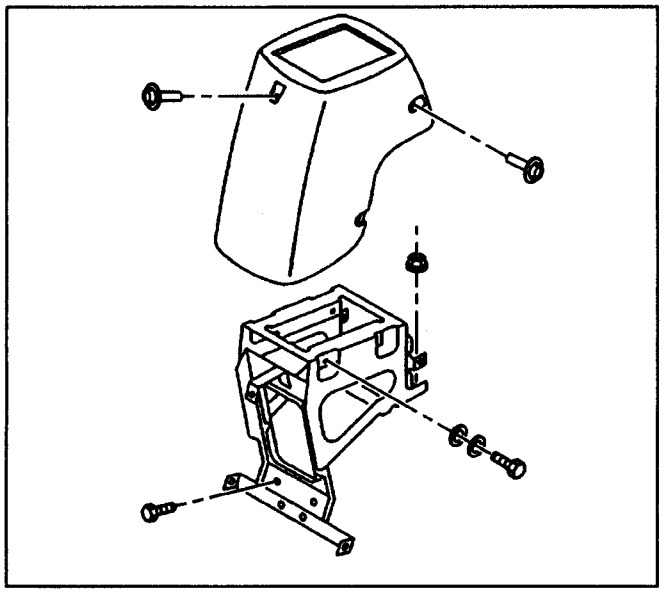
1. Use the following appropriate safety equipment:
   - Safety glasses
   - Safety shoes
   - Gloves
2. Keep the work area clean.
3. Keep the tools clean.
4. Clean the exterior of the transmission before removing any parts.
5. Do not use wipe cloths or rags.
6. Do not use solvents on rubber seals or plastic/Teflon® thrust washers.
7. Blow out all of the passages with compressed air.
8. Clean the small passages with a fine wire.
9. Handle the parts carefully in order to prevent damage.
10. Lubricate all of the internal parts with transmission oil during assembly.
11. When installing screws, bolts, or studs into aluminum, always dip the threads into transmission oil.
12. Always use a torque wrench for the proper torque.
13. Recondition damaged or stripped aluminum threads with thread inserts.
14. Replace all of the gaskets and O-ring seals. Do not use gasket cement or sealers.
15. Replace the plastic/Teflon® thrust washers.
16. Install the plastic/Teflon® thrust washers using the proper seal protector.

Inspection Procedure

1. Inspect the manual linkage for wear at the pivoting points and bent or broken links and rods.
2. Inspect the following items for nicks, cuts, or damage:
   - The seals
   - The gasket
   - The O-rings
   - The mating surfaces
3. Check the mating surfaces for the following defects:
   - Nicks
   - Cuts
   - Damage
4. Inspect the snap rings for the following conditions:
   - Expansion or compression
   - Distortion
   - Nicks
   - Proper ring-to-groove fit
5. Inspect the bearings and thrust surfaces for the following conditions:
   - Wear
   - Scoring
   - Pitting

Transmission Oil Pan and Filter Replacement

Refer to the Allison SA1241 Service Manual for the oil pan filter replacement.

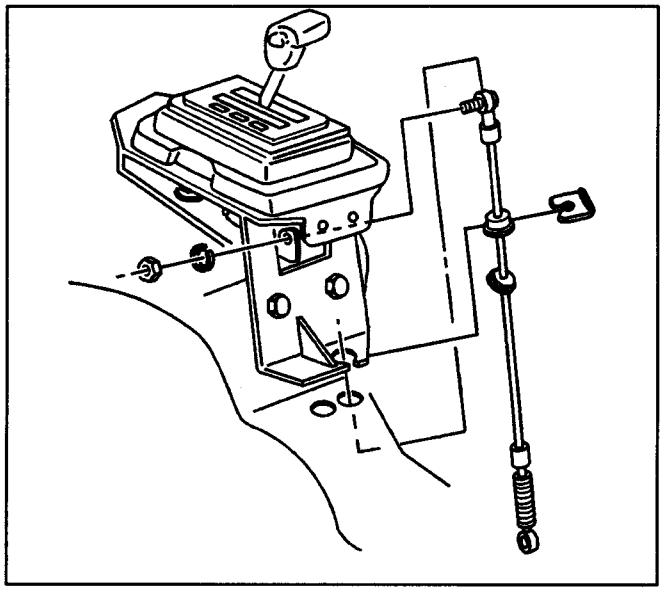


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Shift Cable Replacement

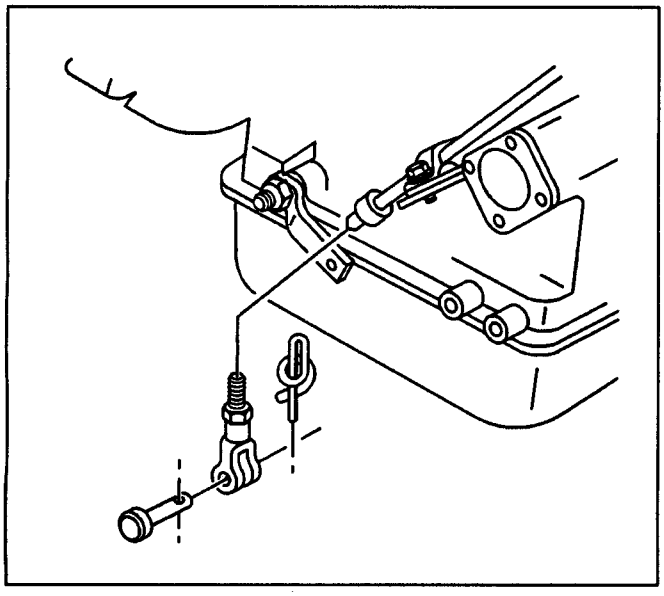
Removal Procedure

1. Remove the plugs and the screws securing the shift control housing to the shift control.



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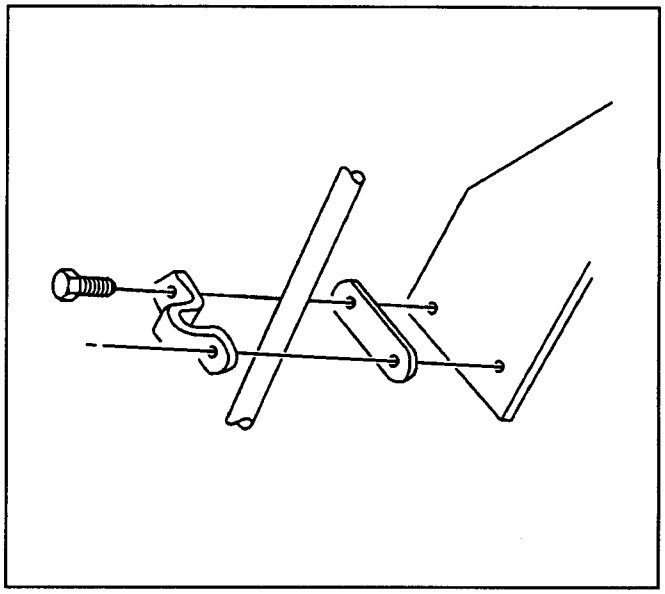
2. Remove the nut, the washer, and the clip securing the shift cable to the shift control.



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3. Remove the cotter pin and the clevis pin securing the shift cable to the transmission shift lever.

4. Remove the two screws, the clamp, and the spacer securing the shift cable to the shift cable support bracket.
5. Note the positions of the shift cable frame rail clamps prior to removal.
6. Remove the screws and clamps securing the shift cable to the frame rail.
7. Remove the grommets securing the shift cable to the cab and the frame rail.

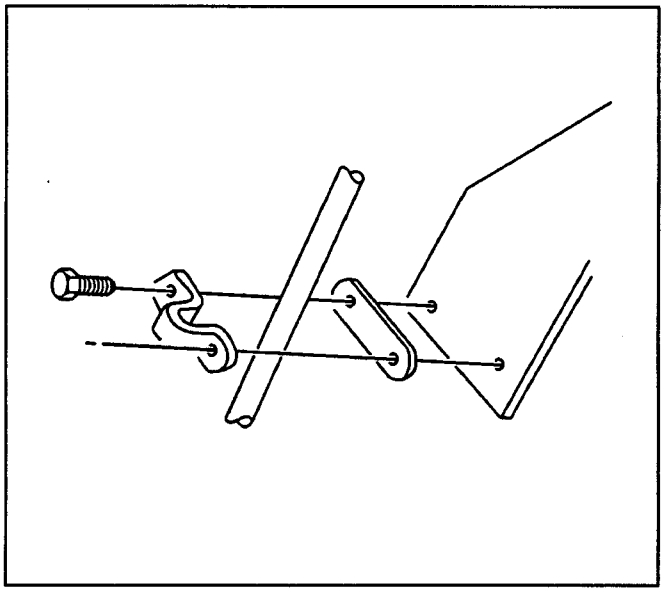


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Installation Procedure

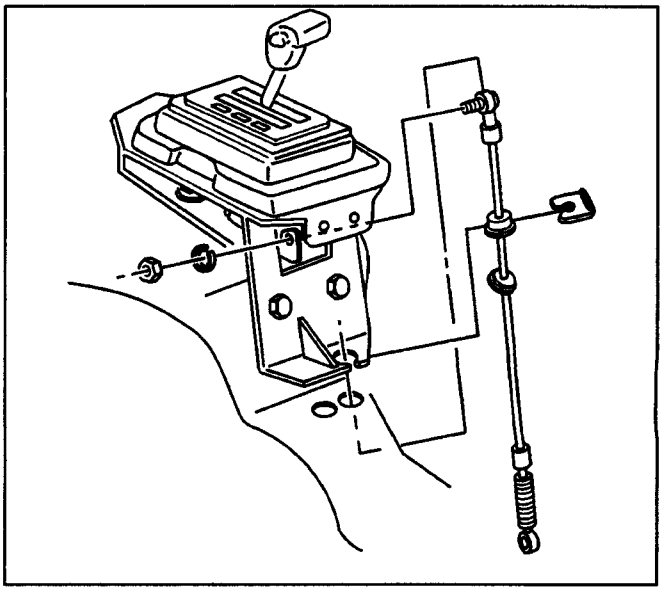
Notice: Ensure the shift control lever and the transmission shift lever are in the mechanical neutral position.

1. Install the screws and the clamps in order to secure the shift cable to the frame rail.
2. Install the two screws, the clamp, and the spacer in order to secure the shift cable to the shift cable support bracket.
3. Adjust the shift cable. Refer to *Shift Cable Adjustment.*

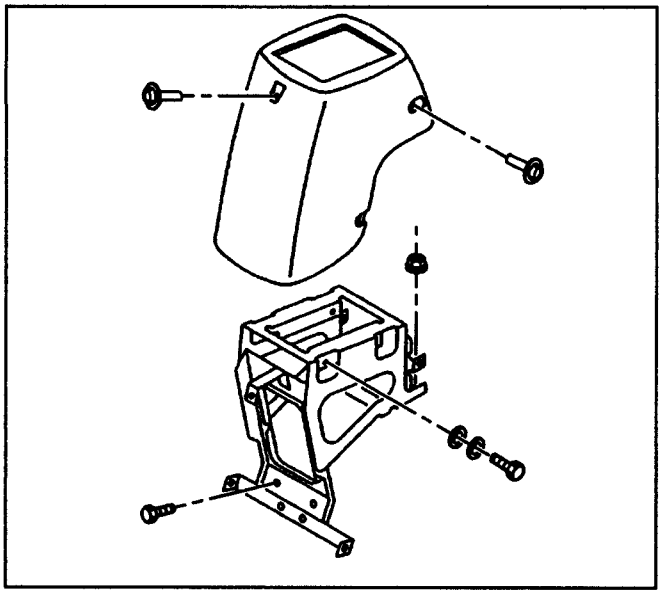


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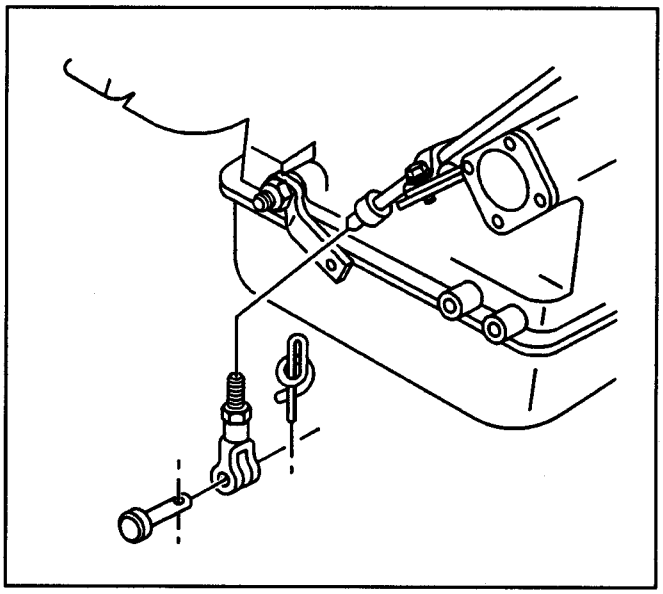
4. Install the nut, the washer, and the clip in order to secure the shift cable to the shift control.



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5. Install the plugs and screws in order to secure the shift control housing to the shift control.

Shift Cable Adjustment

Inspection Procedure

1. Turn the ignition OFF.
2. Block the wheels.
3. Shift the selector lever through each drive range while feeling for full engagement of the transmission.
   - 3.1. Make sure the shift control fully engages all the transmission detent positions in the transmission before the range selector hits a stop.
   - 3.2. Note the position of the selector lever after each shift.
   - 3.3. Make sure the transmission detent R (reverse) does not engage until the selector lever is completely out of the neutral notch.
4. If the selector lever is not properly located or operating, adjust the shift control cable.
   - If you cannot make a satisfactory adjustment, replace the shift cable. Refer to *Shift Cable Replacement.*
   - Before adjusting the shift cable, make sure that all the shift controls are not damaged and operate smoothly.
   - Have an assistant select the required range selector position while you listen for the full engagement of the gears at the transmission shift lever.

Adjustment Procedure

1. Place the range selector against the stop in the R (reverse) position.
2. Disconnect the clevis from the transmission shift lever.
3. Position the transmission shift lever into the mechanical reverse position.
4. Loosen the jam nut at the clevis.

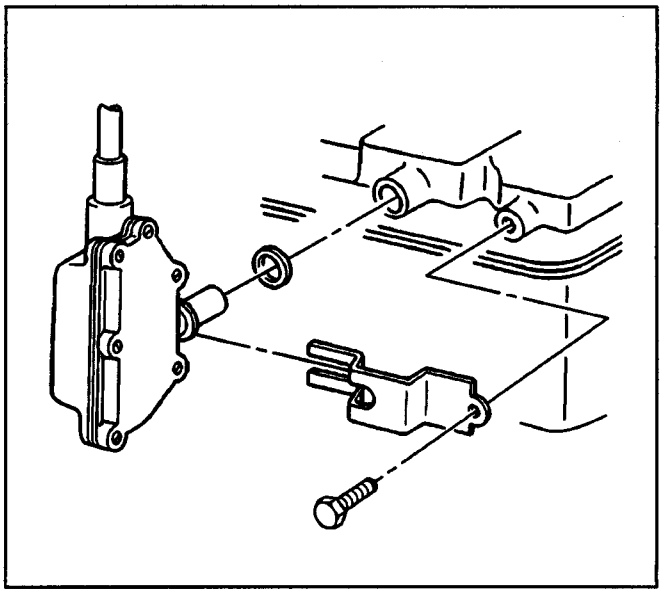
5. Turn the clevis on the threaded cable core until the holes in the clevis align with the hole in transmission shift lever.
6. Install the clevis pin.
   6.1. Make sure that the clevis pin enters the holes freely.
   6.2. If the clevis pin does not enter the holes freely, adjust the clevis by turning the clevis one half turn in either direction.

   Important: Do not spread the cotter pin.
7. Secure the clevis pin to the transmission shift lever with a new cotter pin.
8. Move the range selector lever in order to check for the detent engagement.
   8.1. Make sure the transmission detents fully engage just before the range selector lever hits the stops in the shift control lever.
   8.2. Check for the detent engagement in the N (neutral) position.
   8.3. Check for the detent engagement in the D (drive) position.
   8.4. Check for the detent engagement in the R (reverse) position.
   8.5. Check for the detent engagement in all the other range positions.
9. Spread the cotter pin.
10. Tighten the jam nut against the clevis pin.

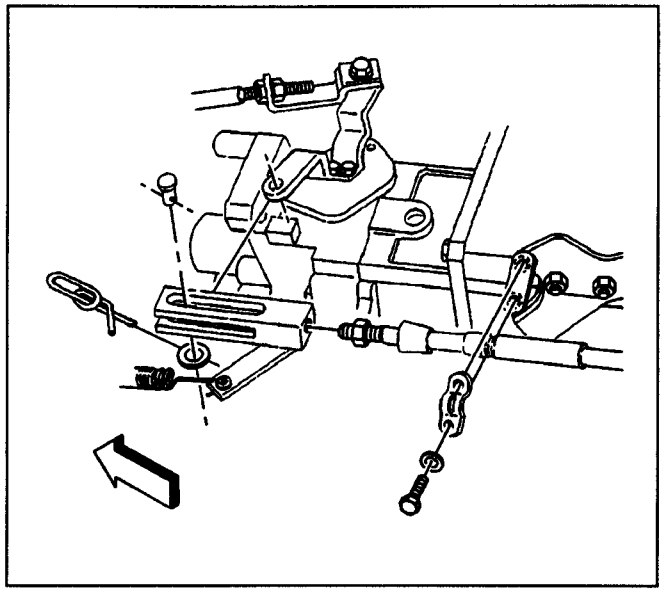
Transmission Modulator Replacement

Removal Procedure

1. Remove the bolt and clip securing the modulator and the O-ring to the transmission.

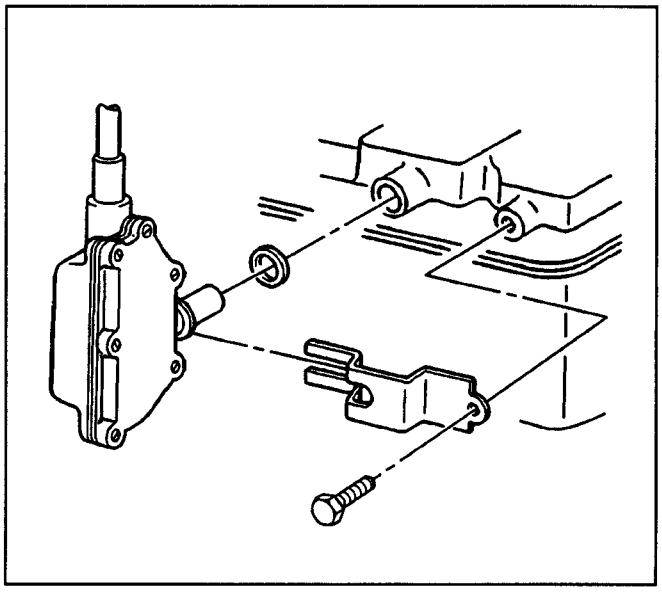


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2. Remove the two bolts and the washers securing the modulator cable to the support bracket.
3. Remove the cotter pin, the washer, and the clevis pin securing the clevis to the engine throttle lever.
4. Remove the clevis from the modulator cable.
5. Remove the modulator cable with the modulator from the vehicle.



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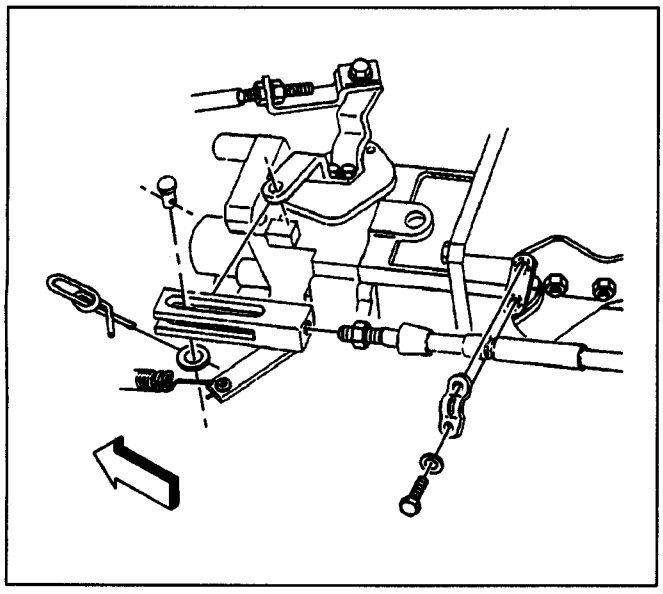
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the bolt and the clip in order to secure the modulator and the O-ring to the transmission.

   Tighten

   Tighten the bolt to 20 N·m (15 lb ft).



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2. Install the two bolts and the washers in order to secure the modulator cable to the support bracket.

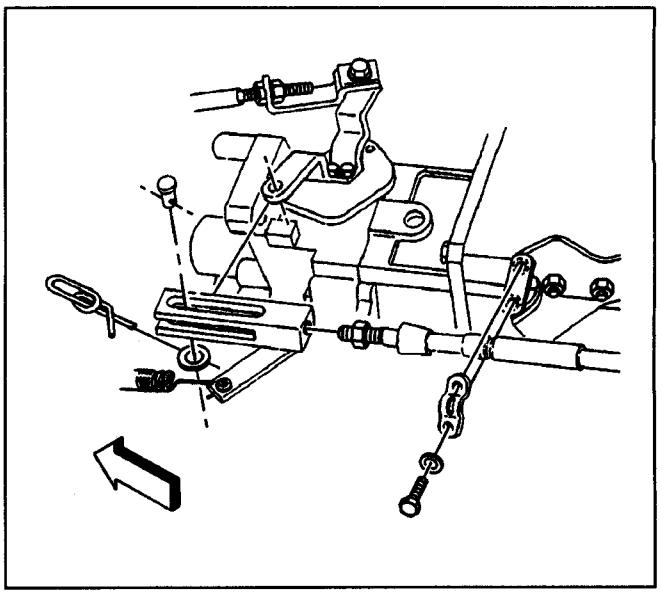
   Tighten

   Tighten the bolts to 9 N·m (80 lb in).
3. Adjust the modulator cable. Refer to *Transmission Modulator Cable Adjustment.*

Transmission Modulator Cable Adjustment

Removal Procedure

1. Remove the cotter pin, the clevis pin, and the washer securing the clevis to the throttle lever, if necessary.
2. Remove the clevis from the modulator cable, if necessary.



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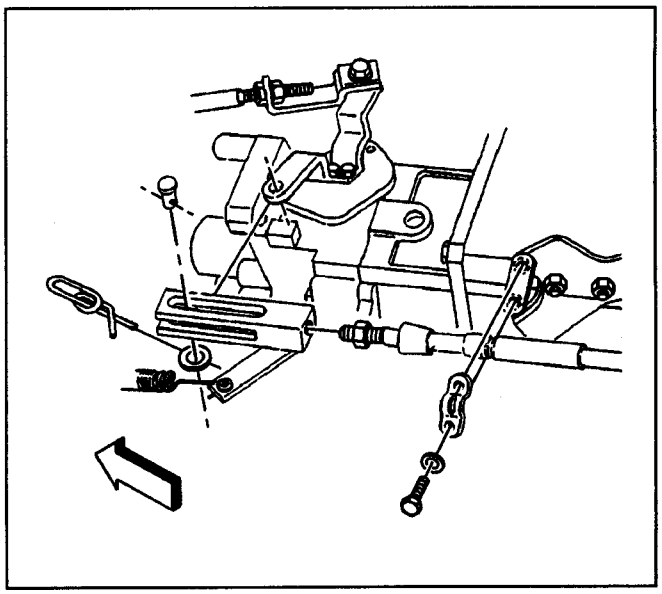
Adjustment Procedure

1. Install the clevis to the modulator cable.
2. Install the threads of the modulator cable into the clevis to a 20 mm (0.8 in) thread engagement.
3. With the engine OFF, position the throttle lever to the wide open position.
4. Position the clevis over the throttle lever mounting hole.
5. Position the clevis pin through the clevis and the throttle lever.
   - 5.1. Make sure the distance between the clevis pin and the end of the clevis slot away from the cable is between 1–2 mm (0.04–0.08 in).
   - 5.2. If the clearance is not between 1–2 mm (0.04–0.08 in), thread the modulator cable into or out of the clevis in order to acquire the correct clearance.

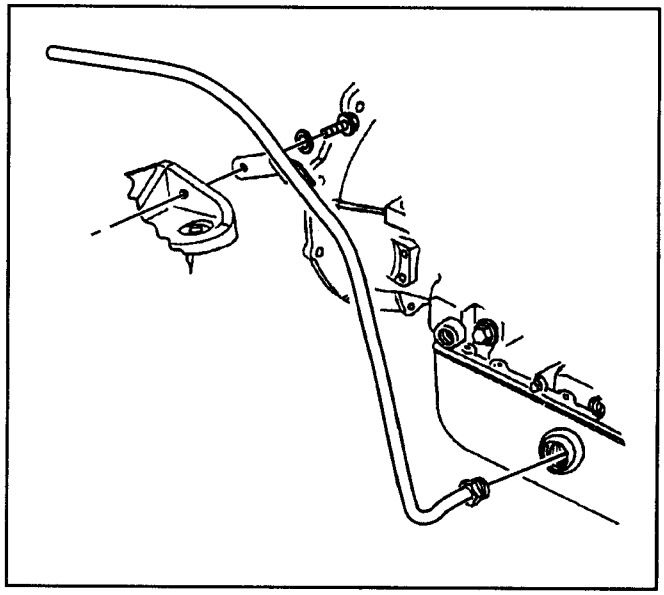
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
6. Secure the modulator cable nut to the clevis.

   Tighten

   Tighten the modulator cable nut to 12 N·m (106 lb in).
7. Secure the clevis pin to the clevis with the washer and the cotter pin.
8. Move the throttle lever from the wide open throttle position to the idle position three or four times.
9. Position the throttle lever in the wide open position.
10. Make sure that the clearance between the clevis pin and the end of the clevis slot away from the cable is between 1–2 mm (0.04–0.08 in).
11. Repeat the procedure, if necessary, in order to acquire the correct clearance.



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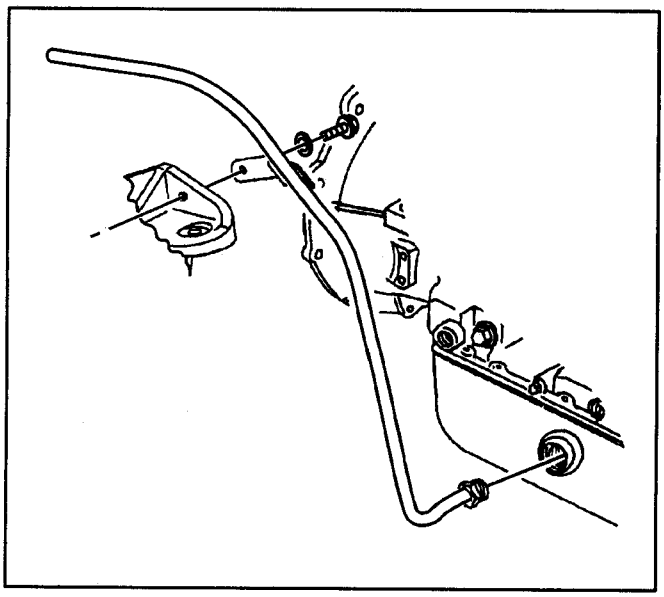


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Transmission Oil Level Indicator Tube Replacement

Removal Procedure

1. Remove the oil level indicator.
2. Remove the bolt and the washer securing the oil level indicator tube to the engine bracket.
3. Place a container under the transmission oil pan in order to catch the draining oil.
4. Remove the nut securing the oil level indicator tube to the transmission oil pan.

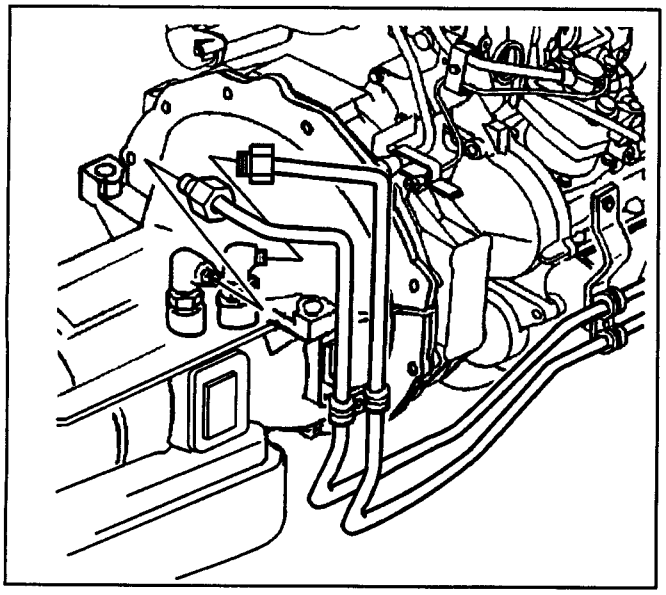


205280

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the nut in order to secure the oil level indicator tube to the transmission oil pan.
   Tighten
   Tighten the nut to 130 N.m (96 lb ft).
2. Install the bolt and washer in order to secure the oil level indicator tube to the engine bracket.
   Tighten
   Tighten the bolt to 55 N.m (41 lb ft).
3. Install the oil level indicator.
4. Check the transmission oil level. Add oil as necessary. Refer to *Transmission Oil Checking Procedure.*



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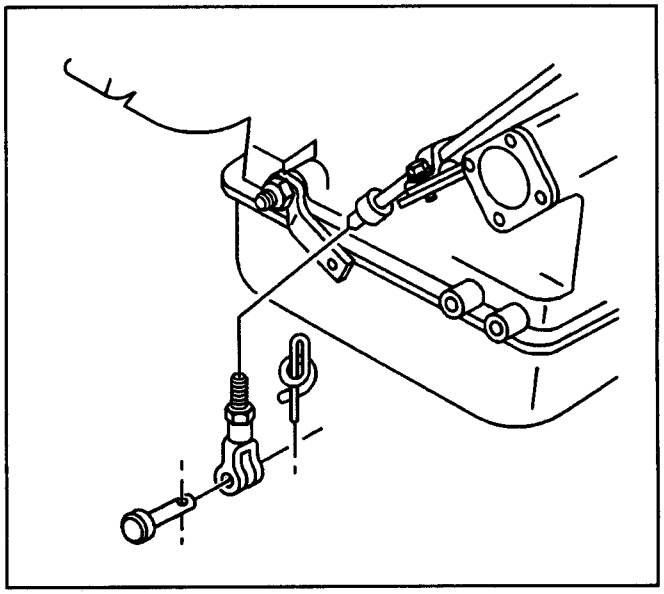
Transmission Replacement

Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Raise the vehicle.
3. Disconnect the exhaust pipes. Refer to Exhaust Pipe Replacement in Engine Exhaust.
4. Remove the transmission oil level indicator tube. Refer to *Transmission Oil Level Indicator Tube Replacement.*
5. Drain the transmission oil.
6. Cover the transmission oil pan opening in order to prevent the entry of foreign material.
7. Disconnect the oil cooler lines from the transmission case. Refer to *Transmission Oil Cooler Line Replacement.*

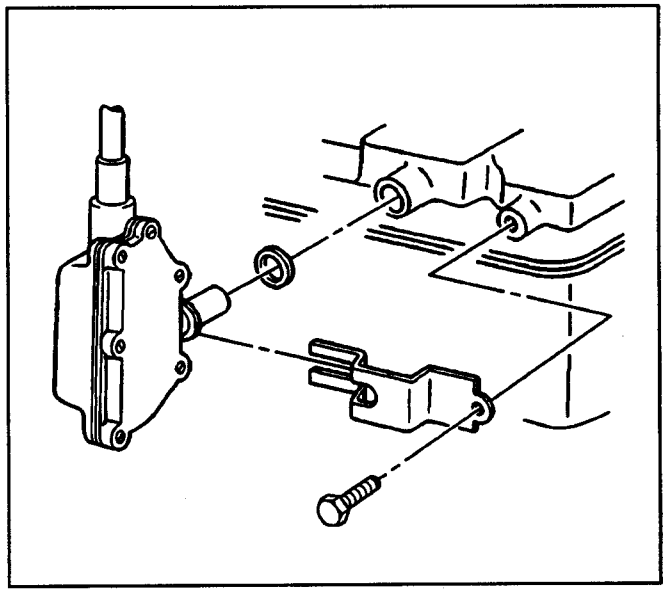
8. Disconnect the shift cable from the transmission. Refer to *Shift Cable Replacement.*



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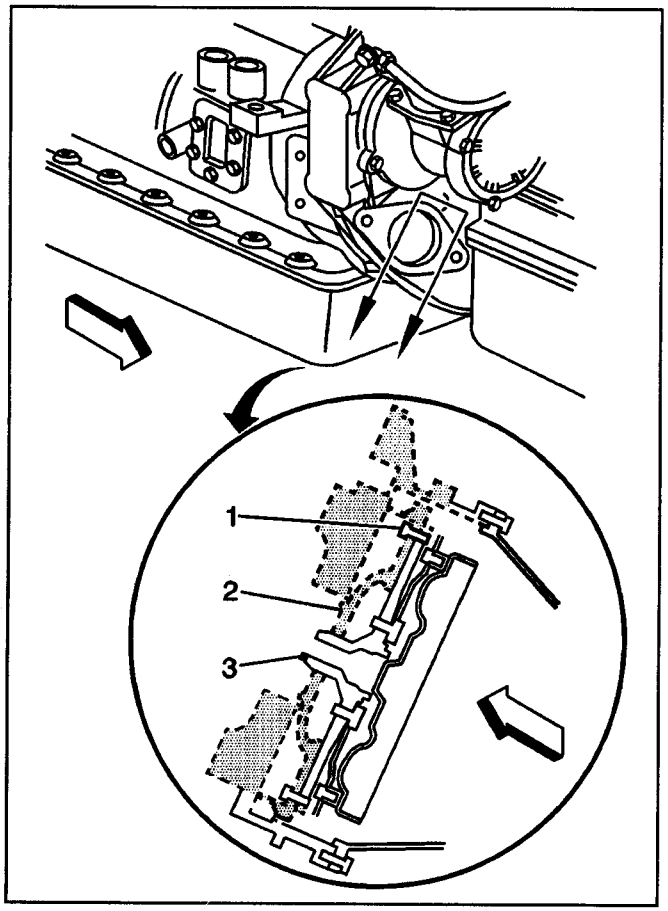
9. Remove the modulator from the transmission. Refer to *Transmission Modulator Replacement.*
10. Disconnect the wiring harness connectors from the transmission.
11. Remove the starter. Refer to Starter Motor Replacement in Engine Electrical.
12. Disconnect the propeller shaft from the transmission. Refer to the appropriate procedure:
    - One-piece propeller shafts:
      - *One-Piece Propeller Shaft Replacement (Full Yoke/229)*
      - *One-Piece Propeller Shaft Replacement (Full Yoke/305)*
      - *One-Piece Propeller Shaft Replacement (Half Yoke/229)*
      - *One-Piece Propeller Shaft Replacement (Half Yoke/305)*
      - *One-Piece Propeller Shaft Replacement (Outboard Slip/229)*
      - *One-Piece Propeller Shaft Replacement (Outboard Slip/305)*
    - *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange)*
    - *Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke)*
13. Disconnect the park brake cable from the park brake. Refer to Park Brake Cable Replacement in Park Brake.

    Notice: Carefully inspect the transmission and the surrounding areas to be sure no lines, hoses or wires will interfere with the transmission removal. In order to avoid damage to the transmission or the torque converter, support the transmission with a dolly jack. Do not let the torque converter fall.



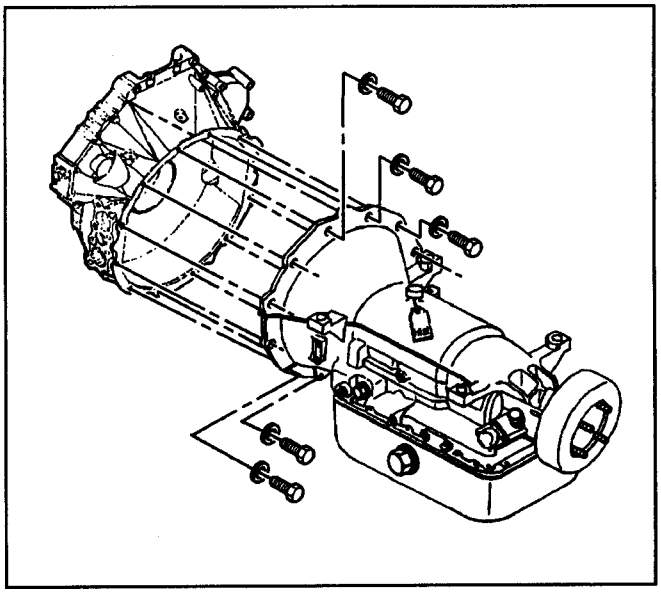
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14. Support the transmission with a transmission dolly that can hold a load of at least 349 kg (750 lb).
    14.1. Position the dolly so that the transmission oil pan will not support the weight of the transmission.
    14.2. Fasten a safety chain over the top of the transmission and on both sides of the dolly.
    14.3. Cushion the transmission in order to prevent cracks or tears to the transmission housing.
15. Remove the flywheel (2) from the flexplate (3).
    15.1. Remove the flywheel access cover.
    15.2. Using a pry bar, turn the flexplate (3) in order to align the flexplate to flywheel bolts (1) with the access hole.
    15.3. Remove the flexplate to flywheel bolts (1).
    15.4. Mark the flywheel (2) and flexplate alignment (3).



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16. Remove the transmission to engine bolts.
17. Move the transmission back from the engine.
18. Lower the transmission.
19. Remove the park brake from the transmission. Refer to Park Brake.



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Installation Procedure

Notice: Carefully inspect the transmission and the surrounding area to be sure no lines, hoses or wires will interfere with the transmission installation. When raising and moving the transmission, do not let the torque converter slip off the shaft. The transmission or torque converter can be damaged.

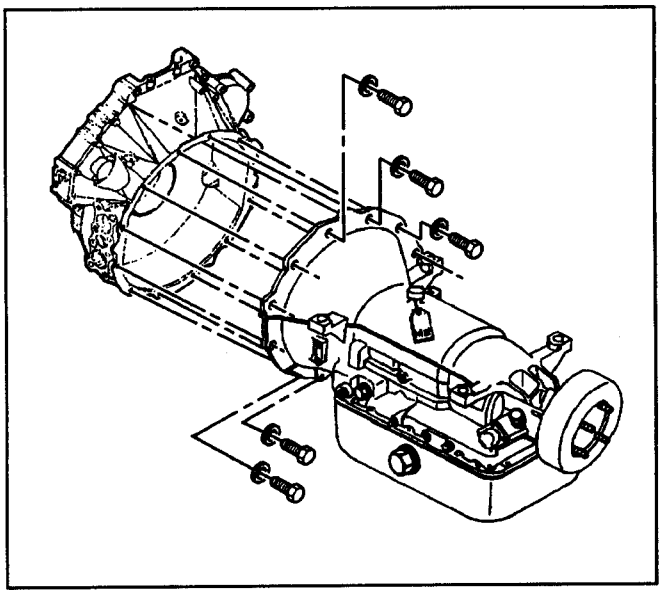
Important: Do not install the transmission without installing the park brake.

1. Install the park brake to the transmission. Refer to Park Brake Replacement in Park Brake.
2. Raise the vehicle.
3. Raise the transmission.
4. Move the transmission to the engine.
5. Install the transmission to engine.

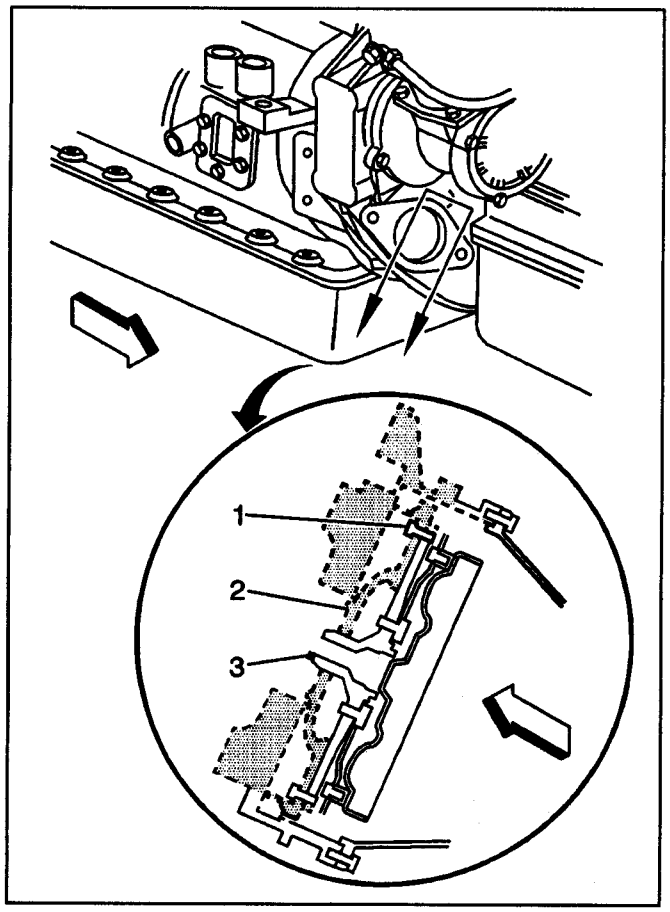
   Notice: Refer to *Fastener Notice* in Cautions and Notices.
6. Install the transmission to engine bolts.

   Tighten

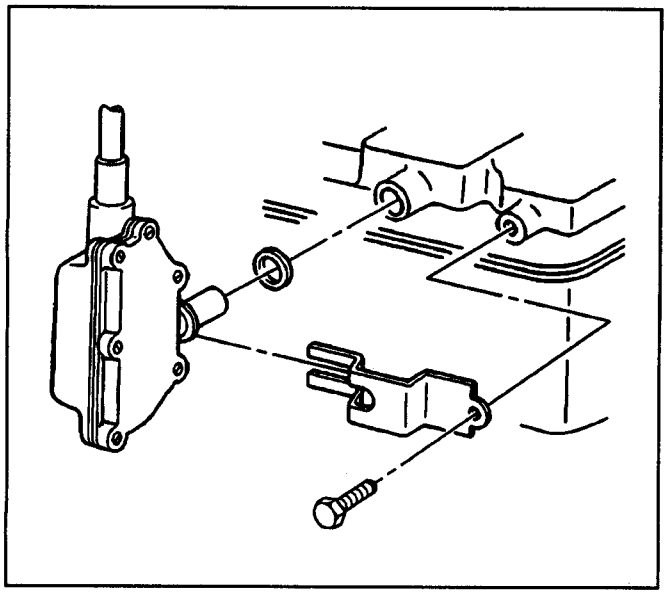
   Tighten the bolts to 55 N.m (41 lb ft).



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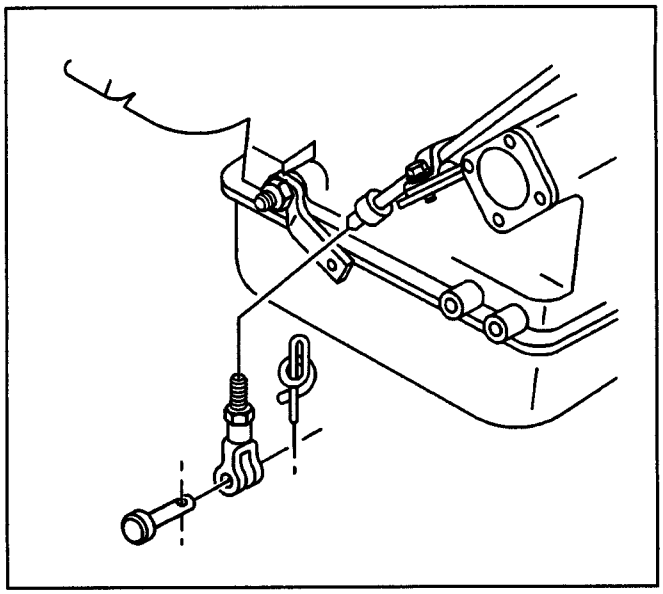
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7. Install the flywheel (2) to the flexplate (3).
   7.1. Using the alignment marks, align the flywheel (2) and the flexplate (3).
   7.2. Using a pry bar, turn the flexplate (3) in order to align the holes for the flexplate to flywheel bolts with the access hole.
   7.3. Install the flexplate to flywheel bolts (1) through the access hole.

   Tighten

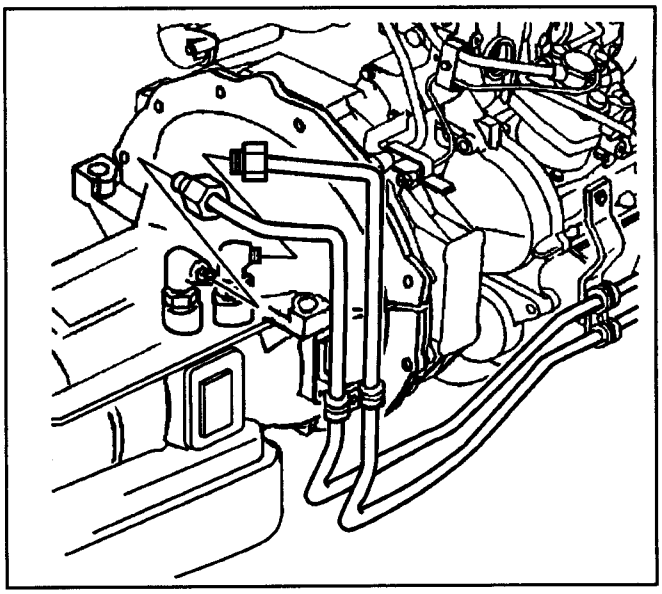
   Tighten the bolts to 56 N.m (41 lb ft).
8. Install the flywheel housing access cover.
9. Connect the park brake cable. Refer to Park Brake Cable Replacement in Park Brake.
10. Connect the propeller shaft to the transmission. Refer to the appropriate procedure:
    - One-piece propeller shafts:
      - *One-Piece Propeller Shaft Replacement (Full Yoke/229)*
      - *One-Piece Propeller Shaft Replacement (Full Yoke/305)*
      - *One-Piece Propeller Shaft Replacement (Half Yoke/229)*
      - *One-Piece Propeller Shaft Replacement (Half Yoke/305)*
      - *One-Piece Propeller Shaft Replacement (Outboard Slip/229)*
      - *One-Piece Propeller Shaft Replacement (Outboard Slip/305)*
    - *Two-Piece Propeller Shaft Replacement (Inboard Slip Joint and Flange)*
    - *Three-Piece Propeller Shaft Replacement (Center Bearing, Full Yoke)*
11. Install the starter. Refer to Starter Motor Replacement in Engine Electrical.
12. Connect the wiring harness connectors to the transmission.
13. Install the modulator to the transmission. Refer to *Transmission Modulator Replacement.*

14. Connect the shift cable to the transmission. Refer to *Shift Cable Replacement.*



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15. Connect the oil cooler lines to the transmission case. Refer to *Transmission Oil Cooler Line Replacement.*
16. Install the transmission oil level indicator tube. Refer to *Transmission Oil Level Indicator Tube Replacement.*
17. Connect the exhaust pipes. Refer to Exhaust Pipe Replacement in Engine Exhaust.
18. Connect the negative battery cable.
19. Check the transmission oil. Add transmission oil, if necessary. Refer to *Transmission Oil Checking Procedure.*

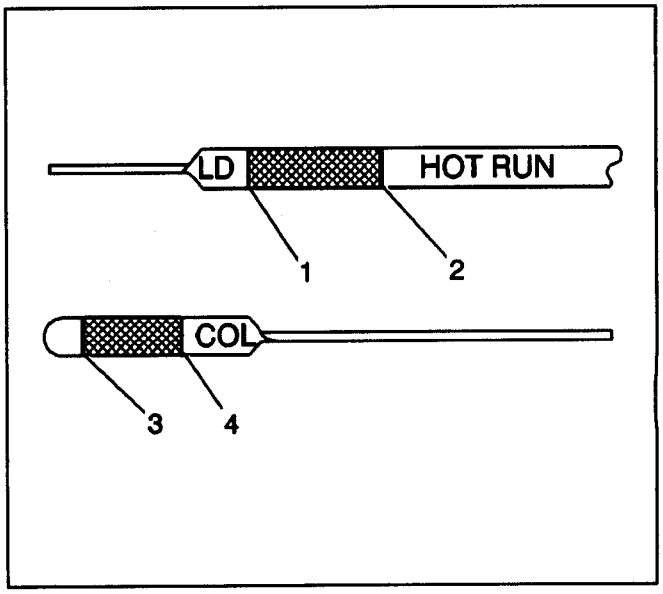


205259

Transmission Oil Checking Procedure

1. Start the engine.
2. Shift the transmission through all the ranges in order to fill the clutch cavities and oil passages.
3. Shift the transmission to neutral.
4. Idle the engine for at least 1 minute at 1,000–1,200 RPM in order to clear the system of air.
5. Make sure the parking brake is applied.

   Notice: When adding oil or checking the oil level, dirt or foreign material must not be allowed to enter the fill tube. Before removing the oil level indicator, clean around the end of the fill tube. Contaminated transmission oil will cause rapid wear and early failure of internal parts.
6. Check the oil while the vehicle is on level ground.

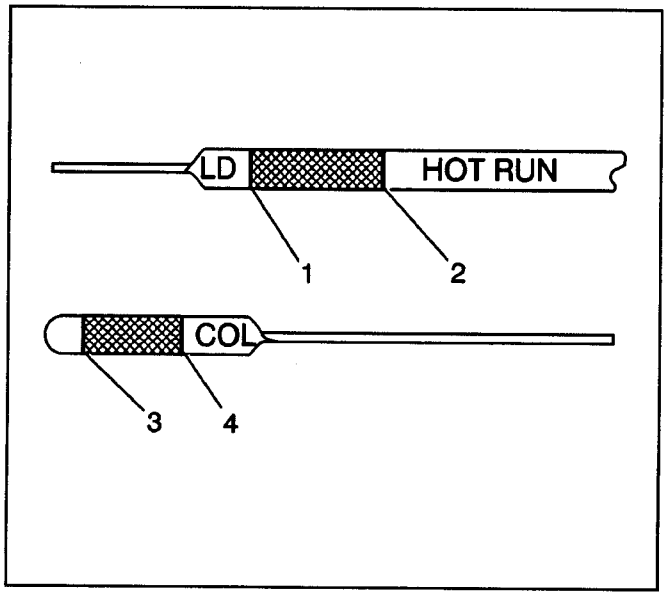


201483

Cold Oil Check

1. Idle the engine.
2. Make sure the oil temperature is at 16–49°C (60–120°F).
3. Remove the oil level indicator from the oil filler tube.
4. Check the oil level.
   - If the oil level registers between the COLD ADD (4) and the COLD FULL (3) bands, the transmission may be safely operated.

     Important: Do not overfill the transmission with oil. Refer to *Transmission Oil Checking Procedure.*
   - If the level registers at or below the COLD ADD (4) band, add oil in order to bring the oil level to the COLD FULL (3) band. Refer to Adjusting The Oil Level.
5. Make a hot oil check after the transmission reaches the operating temperature.

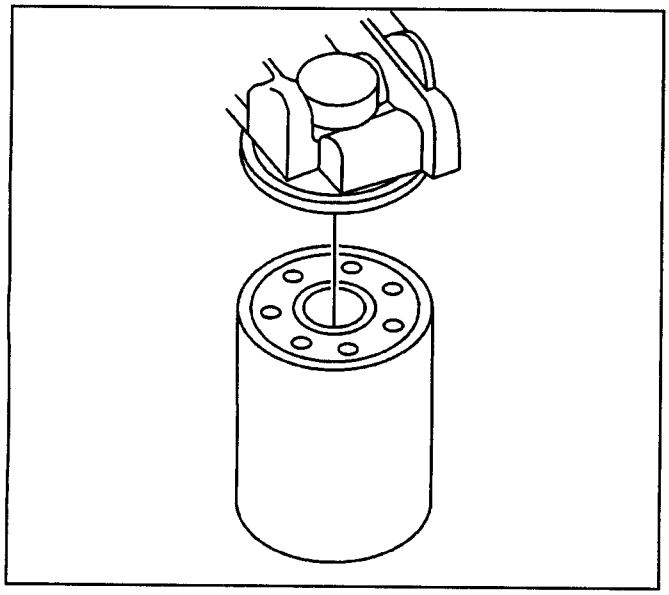


201483

Hot Oil Check

1. Idle the engine.
2. Make sure the oil sump temperature is at 38–49°C (100–120°F).
3. Remove the oil level indicator from the oil filler tube.
4. Check the oil level.
   - If the oil level registers between the HOT ADD (1) and the HOT FULL (2) bands, the transmission may be safely operated.

     Important: Do not overfill the transmission with oil. Refer to *Fluid Capacity Specifications.*
   - If the level registers at or below the HOT ADD (1) band, add oil in order to bring the oil level to the HOT FULL (2) band. Refer to Adjusting The Oil Level.



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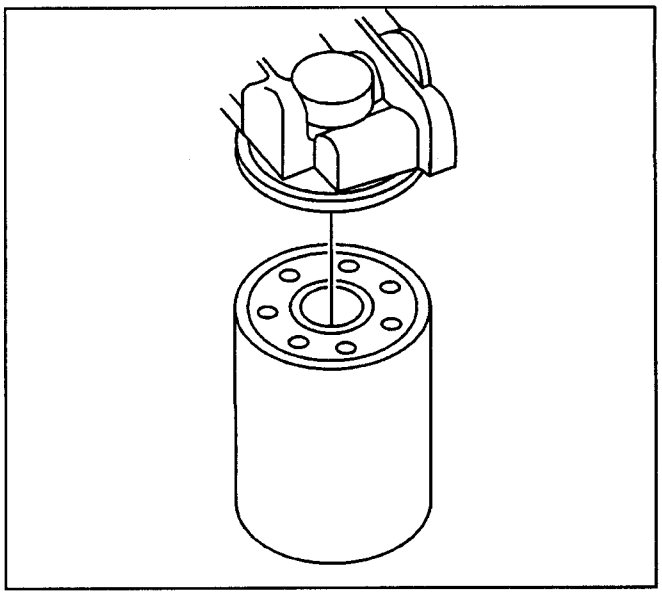
External Transmission Oil Filter Replacement

Removal Procedure

1. Locate the external oil filter connected in-line of the transmission oil cooler. The filter is mounted on the right frame rail.
2. Place a container under the oil filter in order to catch any draining oil.
3. Remove the filter from the oil filter cover.

Installation Procedure

1. Apply a light coat of transmission oil to the filter seal.
2. Install the filter to the oil filter cover.
3. Hand tighten the filter to the oil filter cover.

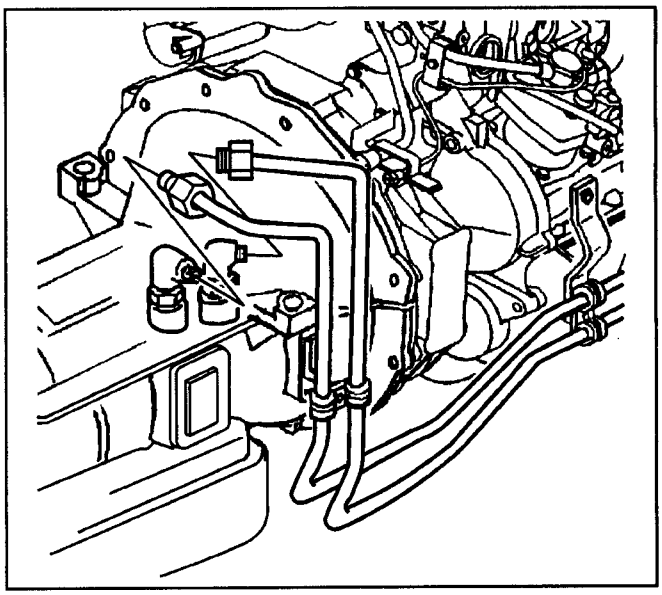


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Transmission Oil Cooler Line Replacement

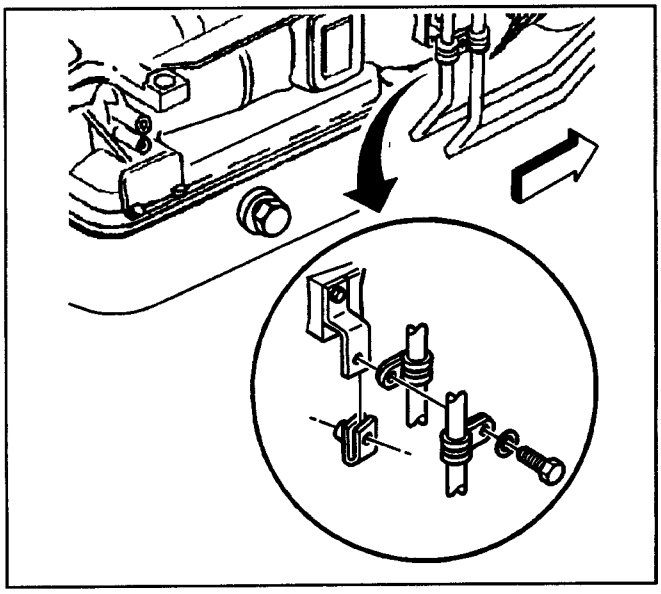
Removal Procedure

1. Remove the two nuts securing the two oil cooler lines to the transmission oil cooler line connectors.

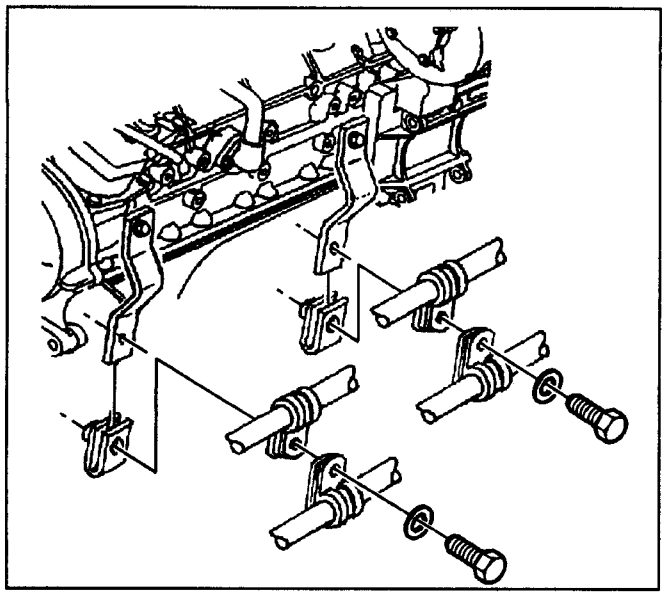


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2. Remove the bolt, the washer, and the nut securing the oil cooler line to the transmission case bracket.

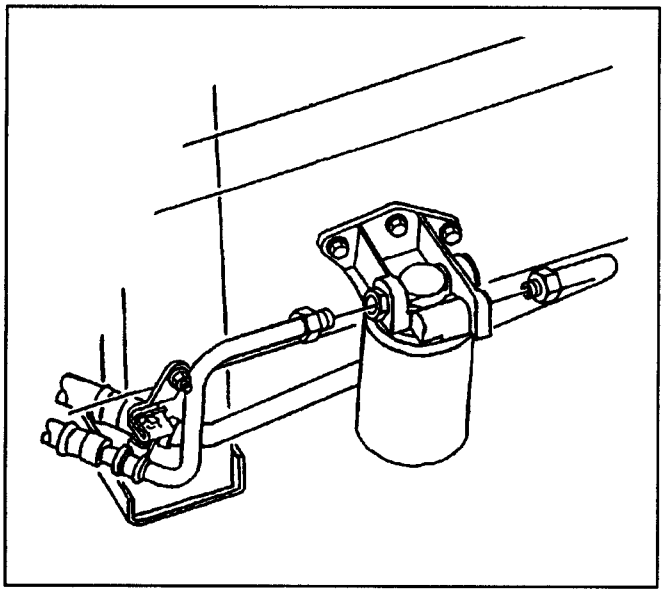


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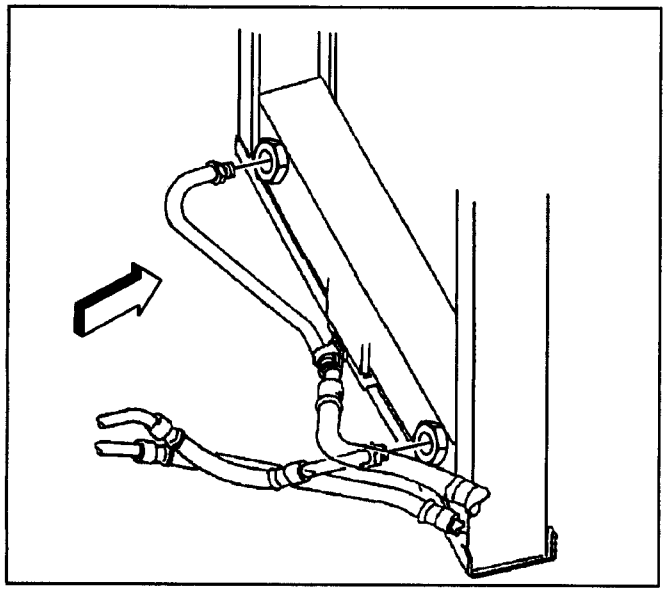
205265

3. Remove the two bolts, the washers, and the nuts securing the oil cooler lines to the engine block bracket.



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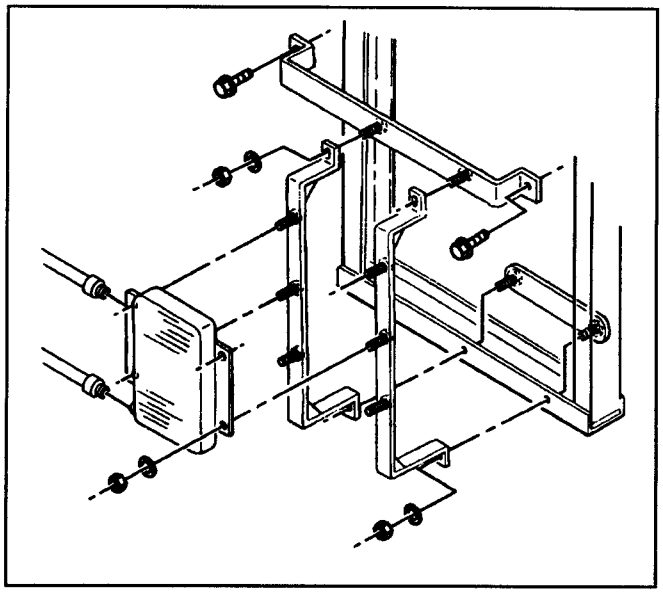
4. Remove the two nuts securing the two oil cooler lines to the transmission oil filter.



205273

5. Disconnect the two oil cooler lines from the radiator.

6. Disconnect the two oil cooler lines from the auxiliary oil cooler.
7. Remove the oil cooler lines from the vehicle.



205278

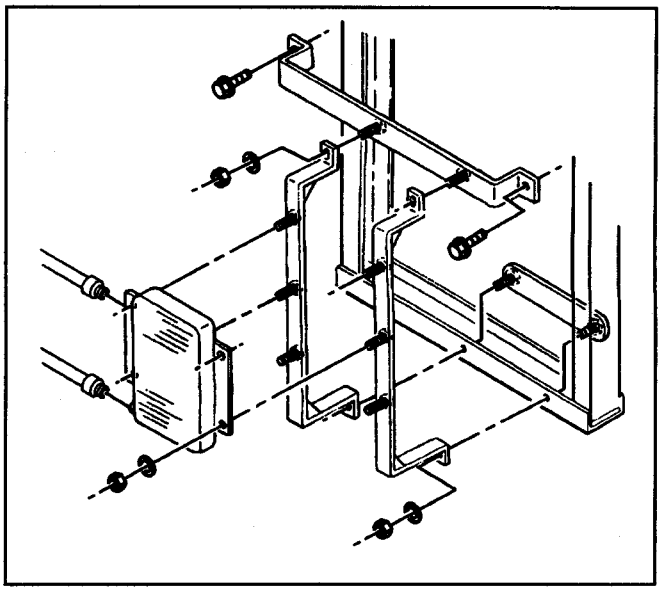
Installation Procedure

1. Install the oil cooler lines to the vehicle.

   Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Connect the two oil cooler lines to the auxiliary oil cooler.

   Tighten

   Tighten the oil cooler lines to 30 N·m (22 lb ft).

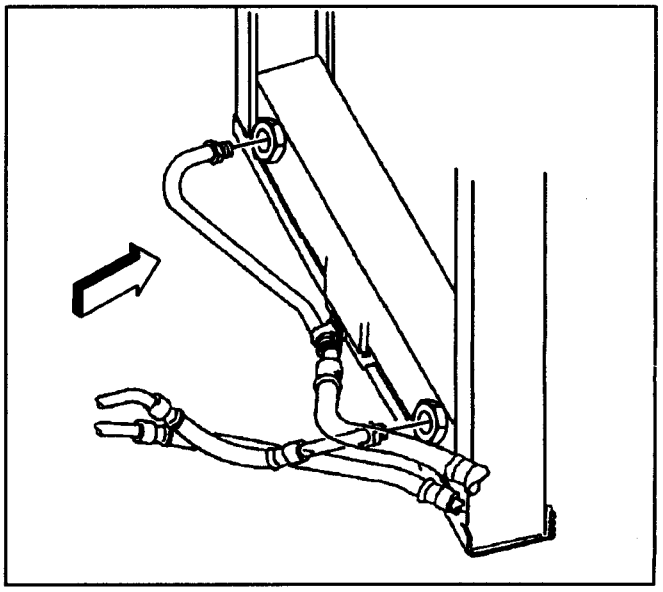


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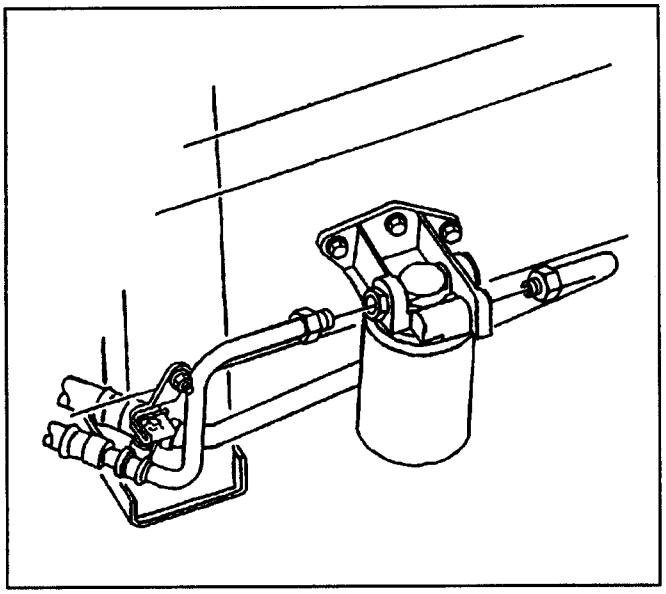
3. Install the two oil cooler lines to the radiator.

   Tighten

   Tighten the oil cooler lines to 30 N·m (22 lb ft).

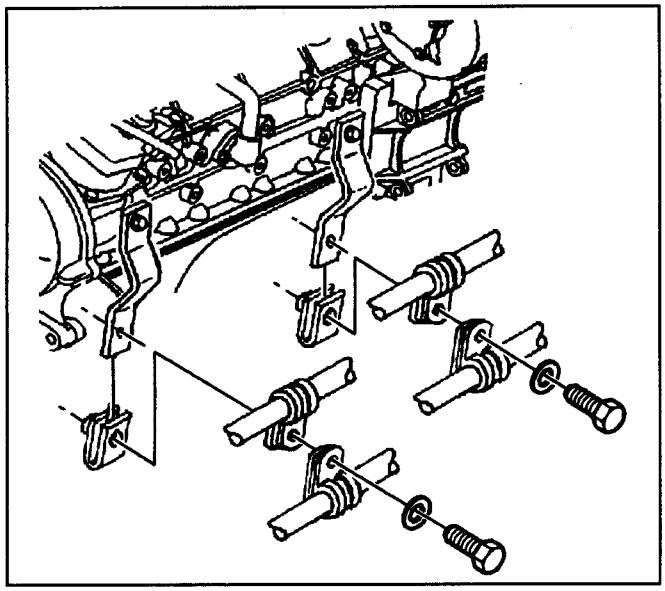


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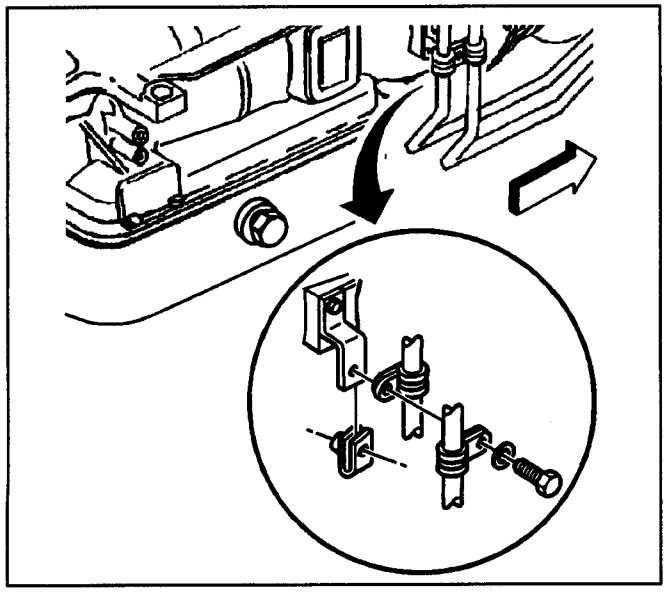
205270

4. Install the two nuts in order to secure the two oil cooler lines to the transmission oil filter.
   Tighten
   Tighten the nuts to 30 N·m (22 lb ft).



205265

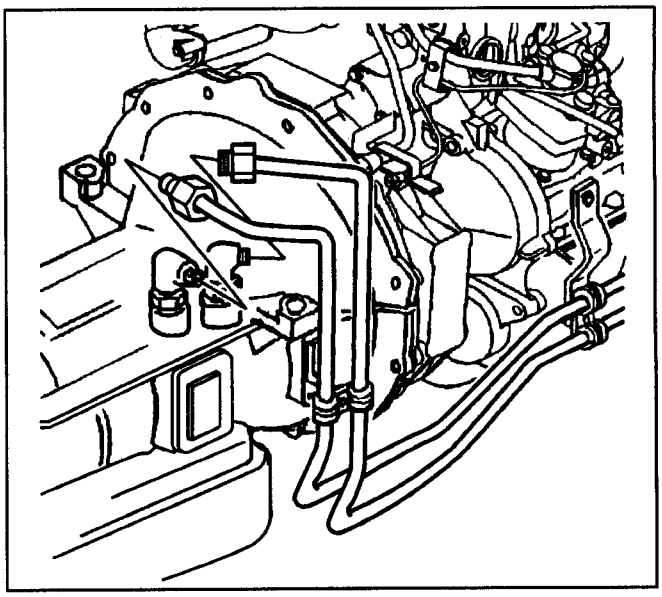
5. Install the two bolts, the washers, and the nuts in order to secure the oil cooler lines to the engine block bracket.
   Tighten
   Tighten the nuts to 30 N·m (22 lb ft).



205262

6. Install the bolt, the washer, and the nut in order to secure the oil cooler line to the transmission case bracket.
   Tighten
   Tighten the bolt to 30 N·m (22 lb ft).

7. Install the two nuts in order to secure the two cooler lines to the transmission oil cooler line connectors.
   Tighten
   Tighten the nuts to 25 N·m (18 lb ft).


205259

Flushing the Transmission Oil Cooler and Lines

Flush the oil cooler lines following a breakdown of the transmission in order to eliminate contaminated oil. This helps prevent trouble after repairs of the transmission.

1. Disconnect the oil cooler lines at the transmission case.
2. If an auxiliary filter has been installed, disconnect the oil cooler return line a the auxiliary filter instead of the transmission.
   Notice: Do not exceed 689 kPa (100 psi) air pressure or damage may result to the oil cooler.
3. Back flush the oil cooler and lines using clean mineral spirits and compressed air.
4. Flush all remaining mineral spirits from the oil cooler and lines using compressed air.
5. Flush the oil cooler lines again with transmission oil.
   5.1. Test the oil cooler for free flow of oil.
   5.2. If the flow of oil is restricted, replace the tank and cooler assembly.
   5.3. If debris from the oil cooler circuit persists, install a new auxiliary filter in the oil return line between the oil cooler and the transmission.

Description and Operation

Transmission Description and Operation

The Allison AT 545 automatic transmission includes a hydraulic torque converter, a planetary gear train, and a hydraulic control system. The control system automatically changes gears. The control system provides pressure in order to apply the clutches. With the transmission in the drive range, the torque converter multiplies the engine torque in order to start the movement of the vehicle. The converter also acts as a hydraulic cushion between the engine and the transmission. The clutches and the gear sets provide multiple speeds forward and one speed reverse.

Automatic up shifting and down shifting depends on the vehicle load, the speed, and the foot pressure on the accelerator. When the pedal is fully depressed, the automatic up shifting occurs near the governed engine speed. A partially depressed accelerator pedal causes up shifts to occur at a lower engine speed.

The automatic transmission shift control consists of three components: a range selector mounted in the cab, a shift control lever which is part of the transmission, and an adjustable cable that connects the range selector and the shift control lever.

This section details the service procedures for supporting vehicles for the Allison Automatic Transmission AT 545. Allison Transmission also provides a publication for the testing, servicing, overhaul, and troubleshooting diagnosis of the AT 545 transmission. The name of the publication is the Allison AT 500 and AT 1500 Series Transmission Service Manual SA 1241.

Obtain a copy of the Allison AT 500 and AT 1500 Series Transmission Service Manual SA 1241 from any local Allison distributor or dealer. Order the Service Manual SA 1241 and Allison automatically sends the latest printing of that service manual.

Contact the local Allison distributor for additional information and guidance on overhaul procedures and services.

Overhaul Information

For the overhaul and the internal parts inspection of the AT 545 automatic transmissions, refer to the Allison AT 500 and AT 1500 Series Service Manual SA 1241 and the Allison AT 545 Inspection Analysis Technicians Guide SA 1948.

Clutch

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Clutch Actuator to Support Bracket Nut	16 N·m	12 lb ft
Clutch Actuator to Swivel Nut	40 N·m	30 lb ft
Clutch Fork Bolts	15 N·m	11 lb ft
Clutch Housing Bolts	35 N·m	26 lb ft
Front Bearing Cover Bolts	27 N·m	20 lb ft
Master Cylinder to Support Bolts	20 N·m	15 lb ft
Pedal Shaft Bolts	45 N·m	33 lb ft
Pressure Plate Bolts 8 mm (0.31")	25 N·m	18 lb ft
Pressure Plate Bolts 9.5 mm (0.37")	50 N·m	36 lb ft

Sealers and Lubricants

Clutch System Fluid	Fluid Levels
Use a brake fluid that meets DOT 3 specifications when adding fluid to the clutch system reservoir.	Fill the reservoir to the specified level shown on the reservoir. Do not overfill the system.

Diagnostic Information and Procedures

Clutch Slipping

Cause	Action
The release levers in the pressure plate and the cover are binding.	Replace the clutch cover.
The clutch release levers are not properly adjusted.	If the levers are in place, adjust the clutch cable.
The clutch release bearing adjustment is improper.	Adjust the clutch cable for proper clearance.
The clutch pedal is binding or sticking	Check the clutch cable for proper operation.
The clutch pressure springs are weak or broken.	Replace the clutch cover.
The clutch facings are burnt.	Replace the driven disc.
The release bearing is binding in the drive gear.	Lubricate or replace the release bearing.

Clutch Grabbing (Chattering) (Chattering)

Causes	Action
Grease or oil is on the facings.	Repair the oil leak and replace the driven disc.
The pressure springs are weak.	Replace the clutch cover.
The pilot bearings are worn or broken.	Replace the pilot bearings.
The pressure plates are bent.	Replace the clutch cover.
The pressure plate or the flywheel is warped.	Replace the pressure plate or the flywheel.

Clutch Grabbing (Chattering) (Grabbing)

Causes	Action
There is grease or oil on the clutch facings.	Repair the oil leak and replace the driven disc.
The clutch pressure springs are too stiff.	Replace the clutch cover.

Clutch Rattle (Trans Click)

Causes	Action
The retractor spring is loose or worn.	Repair or replace the retractor spring.
The linkage is worn.	Repair or replace as necessary.

Clutch Noisy

Causes	Action
The pilot bearing or the bushing is worn or broken.	Replace the pilot bearing or the bushing.
The release bearing is worn or broken.	Replace the release bearing.

Clutch Noisy During Engagement

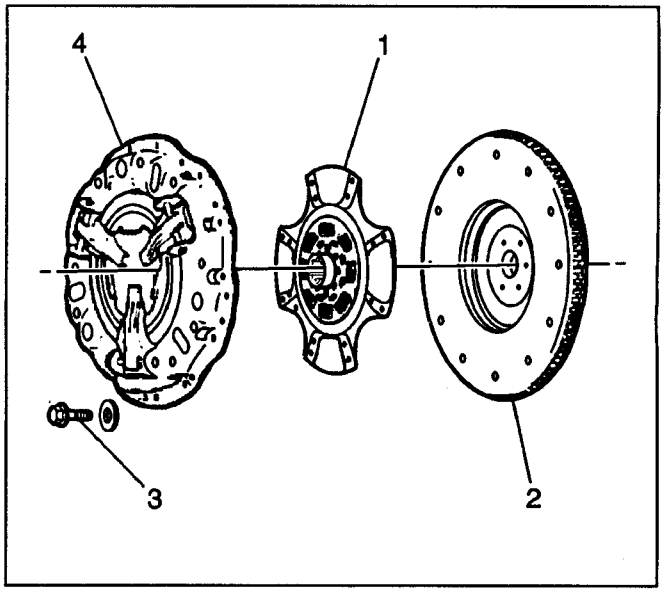
Causes	Action
The clutch release bearing is improper.	Adjust the clutch cable for pedal free play.
The clutch disc damper springs are weak or broken.	Replace the driven disc.
The clutch release bearing is binding.	Check for proper alignment. Replace the bearing if required.
The splines on the clutch disc are worn.	Replace the clutch disc.

Repair Instructions

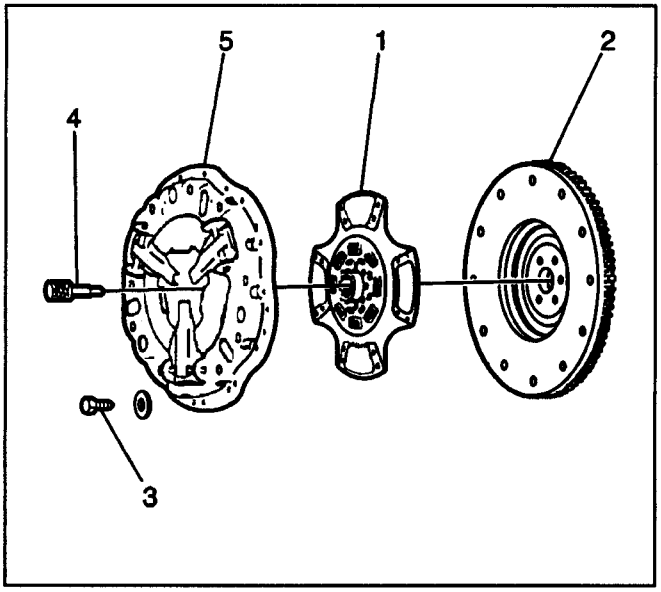
Clutch Pressure Plate and Clutch Driven Plate

Removal Procedure

1. Remove the transmission. Refer to *Transmission Replacement* in Manual Transmission.
2. Remove the bolts (3) and the washers that secure the pressure plate (4) and the driven plate (1) to the flywheel (2).
3. Remove the pressure plate.
4. Remove the driven plate.
5. Inspect the following parts:
   - The clutch fork for wear, cracks, or distortion
   - The release bearing for roughness
   - The driven plate for broken springs, loose rivets, and cracks
   - The hub splines for wear and damage
   - The pressure plate for wear and damage
   - The flywheel for wear or damage
6. Inspect for unnecessary grease or oil on any of the components.
7. Measure the following components:
   - The driven plate friction material for thickness
     Replace the driven plate if the material thickness is less than 1.27 mm (0.050 in).
   - The pressure plate friction surface flatness
     Replace the pressure plate if the friction surface flatness is less than 0.10 mm (0.0039 in).



203663



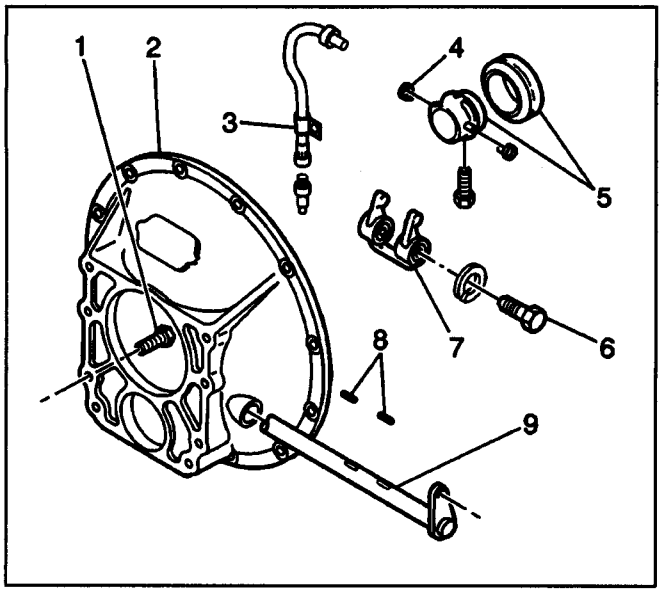
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Installation Procedure

Tools Required

J 37367 Clutch Pilot Aligner

1. Apply grease to the hub splines.
2. Install the driven plate (1).
3. Install the J 37367 to the center of the driven plate.
4. Install the pressure plate (5).
5. Install the bolts and the washers.
6. Remove the J 37367 from the driven plate.
7. Install the transmission. Refer to *Transmission Replacement* in Manual Transmission.



203656

Release Bearing Replacement

Removal Procedure

1. Remove the transmission. Refer to *Transmission Replacement* in Manual Transmission or *Transmission Replacement* in Automatic Transmission.
2. Remove the bolt (6) and the washers that secure the fork (7).
3. Remove the following parts from the housing:
   - The shaft (9)

     Use a drive bar in order to remove the shaft from the clutch housing.
   - The fork (7)
   - The keys (8)
4. For 200 HP models only, remove the flexible hose (3).
5. For 200 HP models only, remove the return spring (4).
6. Remove the release bearing (5) and the seal.

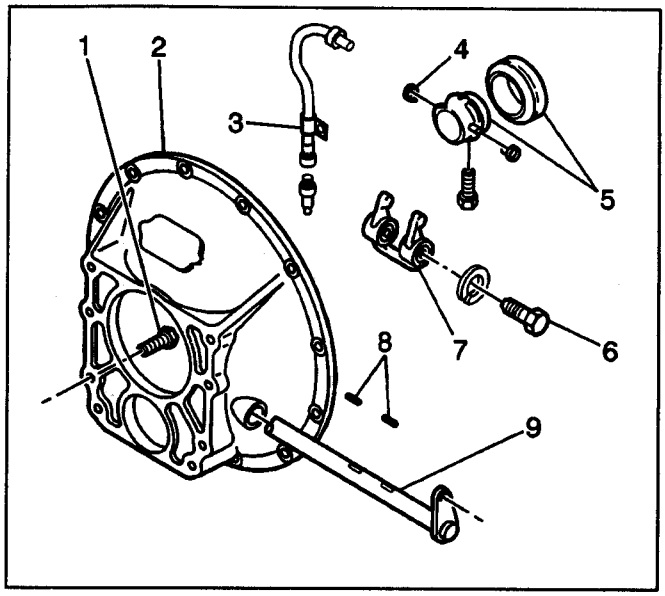
   Pry the seal from the clutch housing.

   Drive the bearing from the clutch housing.
7. Remove the bolts that secure the clutch housing to the transmission.

Installation Procedure

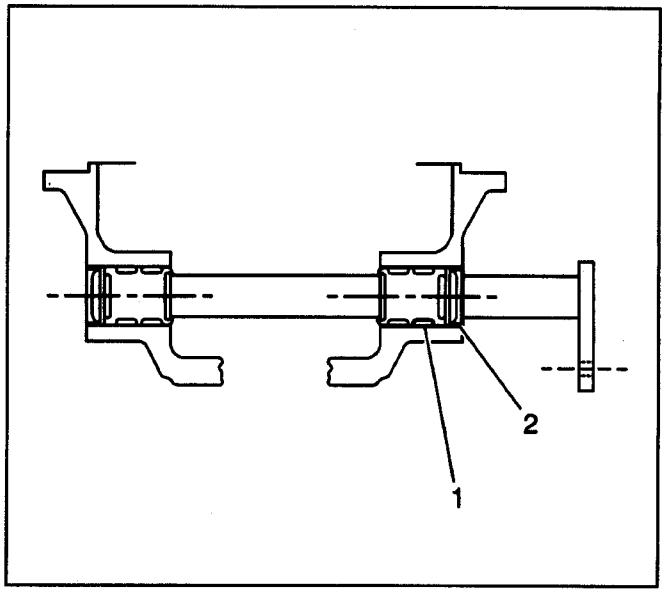
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the bolts that secure the clutch housing (2) to the transmission.
   Tighten
   Tighten the clutch housing bolts 35 N·m (26 lb ft).



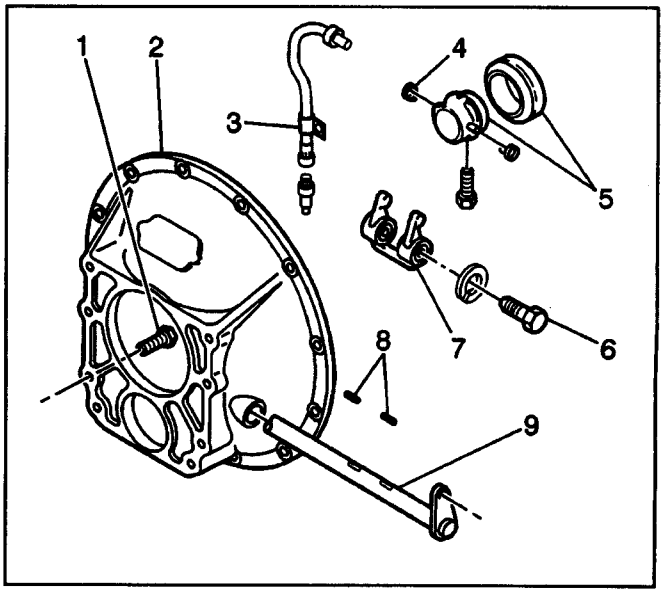
203656

2. Install the release bearing (1) and the NEW seal (2).
   - Apply grease to the bearing and the clutch housing cavity.
   - Apply grease to the area between the seal and the bearing.
   - Drive the bearing to 10 mm (0.39 in) depth.
   - Drive the seal to 2 mm (0.08 in) depth.



203652

3. For 200 HP models only, install the return spring (4).
4. For 200 HP models only, install the flexible hose (3).
5. Install the following parts to the housing:
   - The shaft (9)
   - The fork (7)
   - The keys (8)
6. Install the bolt (6) and the washers securing the fork (7).
   Tighten
   Tighten the fork bolt to 15 N·m (11 lb ft).
7. Install the transmission. Refer to *Transmission Replacement* in Manual Transmission or *Transmission Replacement* in Automatic Transmission.



203656

Description and Operation

Clutch 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. The pressure plate is fitted onto a steel cover that contains some of the operating members and is bolted to the flywheel.

Clutch Driven Members

The driven member is a clutch disc with a spined hub that is free to slide lengthwise along the splines of the clutch shaft, but does not drive the shaft through these same splines. The suitable frictional facings are attached to each side of the clutch disk by means of rivets. The facings must be heat resistant in order to operate in a friction heated environment.

Clutch Operating Members

The driving and the driven members are held in contact by spring pressure. The throw–out (clutch release) bearing a ball thrust bearing contained in the clutch housing is mounted on a sleeve attached to the front of the transmission case. The throw out 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 members when the clutch petal is pushed.

Hydraulic Clutch Description

The hydraulic clutch system provides automatic clutch adjustments, no adjustment of clutch linkage or pedal position is required for clutch disc wear. When the clutch disc wears, the fluid level in the master cylinder reservoir will rise in order to accommodate for the extra fluid not required in the hydraulic system.

SECTION 7B1B

MLD6Q MANUAL TRANSMISSION OVERHAUL

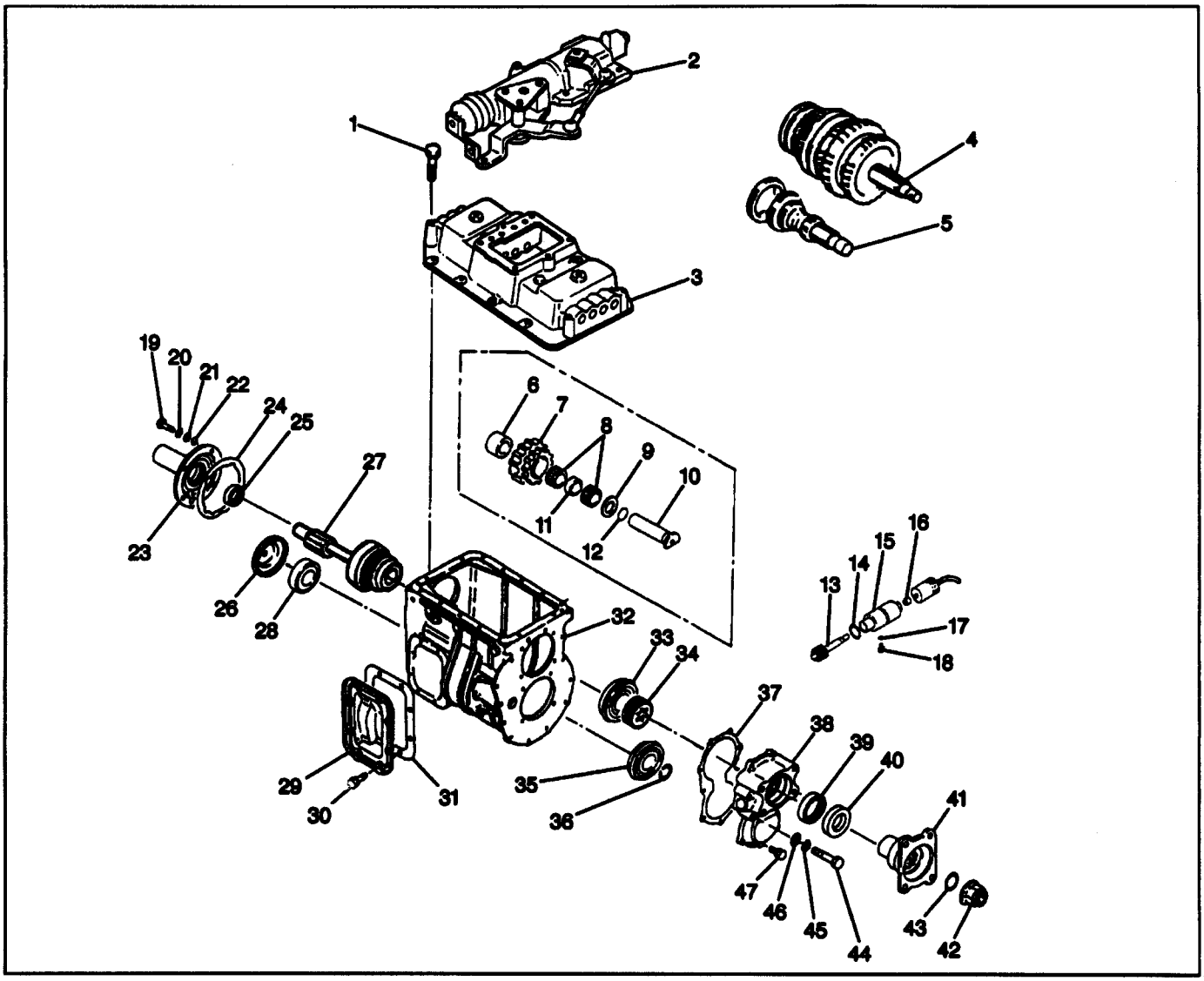
NOTICE: ***Always use the correct fastener in the correct location. When you replace a fastener, use ONLY the exact part number for that application. ISUZU will call out those fasteners that require a replacement after removal. ISUZU will also call out the fasteners that require thread lockers or thread sealant. UNLESS OTHERWISE SPECIFIED, do not use supplemental coatings (paints, greases, or other corrosion inhibitors) on threaded fasteners or fastener joint interfaces. Generally, such coatings adversely affect the fastener torque and joint clamping force, and may damage the fastener. When you install fasteners, use the correct tightening sequence and specifications. Following these instructions can help you avoid damage to parts and systems.***

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GENERAL DESCRIPTION

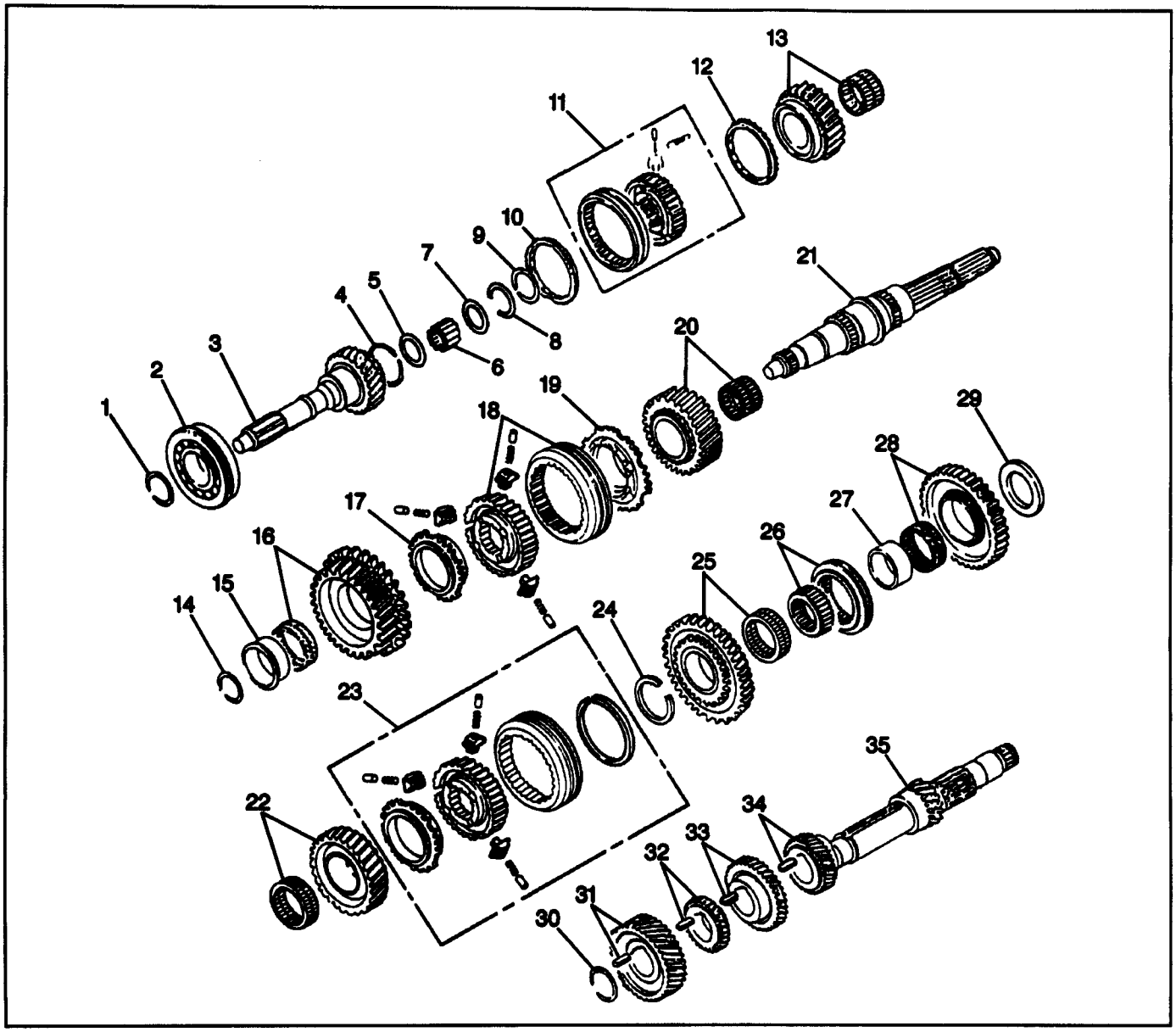
The six speed (MLD6Q) transmission has a constant mesh first and reverse gear. The remaining gears are synchronized. Shifting is done with a remote shift control connected to two cables that operate a shift quadrant mounted on the top of the transmission. The transmission is equipped with a drive that can be connected to a power takeoff system.



Legend

(1) Bolt,
(2) Box, Upper Quadrant
(3) Box, Lower Quadrant
(4) Mainshaft
(5) Countershaft
(6) Collar
(7) Gear, Reverse
(8) Bearing
(9) Washer, Thrust
(10) Shaft, Reverse Gear
(11) Piece, Distance
(12) Gasket
(13) Gear, Speedometer Driven
(14) Seal
(15) Bushing
(16) Seal
(17) Washer
(18) Screw
(19) Bolt
(20) Washer, Spring
(21) Washer
(22) O-Ring
(23) Cover, Front Bearing
(24) Gasket
(25) Seal
(26) Cover, Counter Shaft Bearing
(27) Shaft, Top Gear
(28) Bearing, Front Countershaft
(29) Cover
(30) Bolt
(31) Gasket
(32) Case, Transmission
(33) Bearing, Mainshaft Rear
(34) Gear, Speedometer Drive
(35) Bearing, Countershaft Rear
(36) Ring, Snap
(37) Gasket
(38) Cover, Rear Bearing
(39) Seal, Rear Oil
(40) Cover, Dust
(41) Flange
(42) Nut
(43) O-Ring
(44) Bolt
(45) Washer, Spring
(46) Washer
(47) Bolt

Figure 1—Manual Transmission Internal Components



Legend

(1) Ring, Snap
(2) Bearing
(3) Shaft, Top Gear
(4) Clip, Retaining
(5) Washer
(6) Bearing, Pilot
(7) Washer
(8) Ring, Snap
(9) Ring, Snap
(10) Ring, 6th Blocker
(11) Synchronizer, 5th and 6th
(12) Ring, 5th Blocker
(13) Gear and Bearing, 5th
(14) Ring, Snap
(15) Collar, 4th Gear
(16) Gear and Bearing, 4th
(17) Ring, 4th Blocker
(18) Synchronizer, 3rd and 4th
(19) Ring, 3rd Blocker
(20) Gear and Bearing, 3rd
(21) Mainshaft
(22) Gear and Bearing, 2nd
(23) Synchronizer, 1st and 2nd
(24) Ring, Snap
(25) Gear and Bearing, 1st
(26) Sleeve and Hub, Reverse
(27) Collar, Reverse Gear
(28) Gear and Bearing, Reverse
(29) Washer, Thrust
(30) Ring, Snap
(31) Gear and Key, Driven
(32) Gear and Key, 5th
(33) Gear and Key, 4th
(34) Gear and Key, 3rd
(35) Countershaft

Figure 2—Gearshaft and Components

OVERHAUL

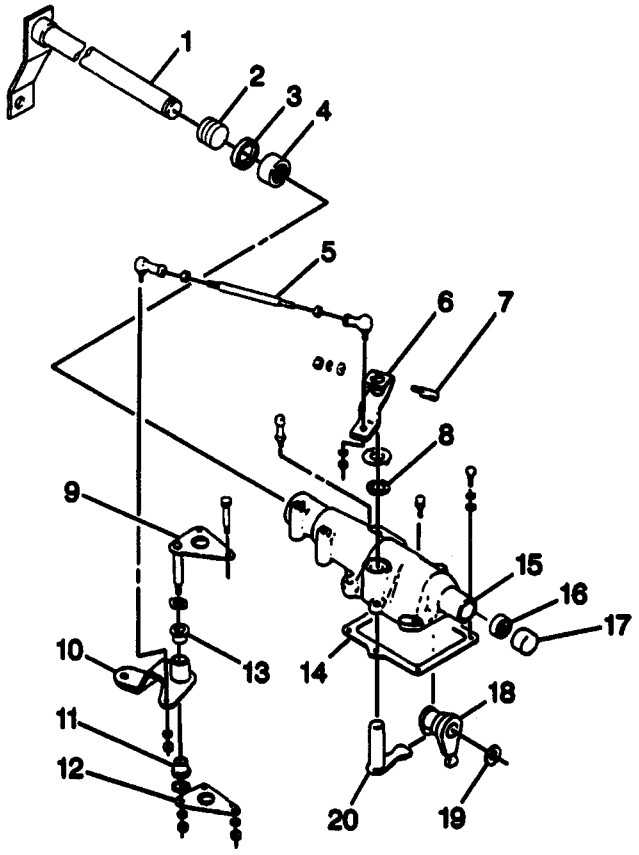
TRANSMISSION CASE DISASSEMBLY

Tool Required:
J 22912-01 Bearing Remover
J 34827 Countershaft and Mainshaft Bearing Remover
J 35669 Puller Bar and Screw
J 35833 Speedometer Gear Bushing Remover

Remove or Disconnect (Figures 1 through 6)

- Ensure the oil has been drained prior to transmission disassembly.

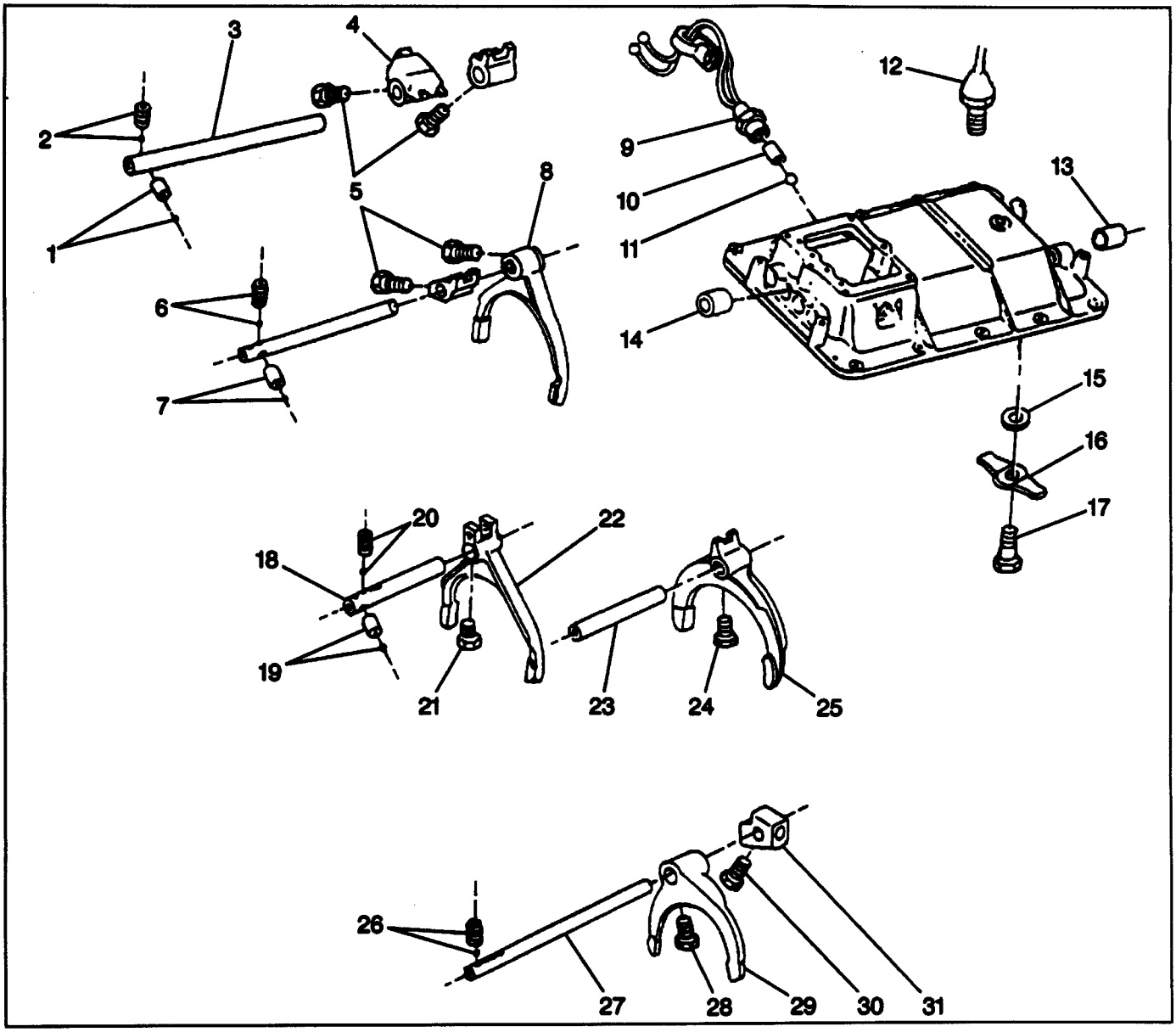
1. Upper and lower quadrant boxes from the transmission case (Figures 3 and 4).
   - Engage two gear sets to prevent the mainshaft from turning.
2. Flange nut, Flange and O-ring from the rear bearing cover (Figure 1).
3. Speedometer driven gear from the transmission. Refer to SECTION 7B.
4. Side cover and gasket.
5. Power takeoff if the transmission is equipped.
6. Clutch housing. Refer to SECTION 7C.
7. Front bearing cover, gasket, and oil seal.
8. Top gear shaft (Figure 5).
   - Use a screw driver between the top gear shaft and synchronizer clutch gear.
   - The synchronizer clutch gear can be separated from the top gear shaft.
9. Mainshaft rear bearing using J 34827 and J 2619-01.
10. Mainshaft assembly.



Legend

(1) Lever, External Shift
(2) Boot
(3) Seal
(4) Bushing
(5) Rod, Link
(6) Lever, External Select
(7) Bolt, Key
(8) Seal, Oil
(9) Bracket
(10) Arm, Select Cable
(11) Bushing
(12) Bracket
(13) Bushing
(14) Gasket
(15) Upper Quadrant Box
(16) Bushing
(17) Cap
(18) Lever, Internal Shift
(19) Ring, Snap
(20) Lever, Internal Select

Figure 3—Upper Quadrant Box Components



Legend

(1) Ball and Pin, Interlock
(2) Ball and Spring, Detent
(3) Rod, Reverse Block Shift
(4) Block, Reverse Shift
(5) Setscrew
(6) Ball and Spring, Detent
(7) Ball and Pin, Interlock
(8) Arm, 1st and 2nd Shift
(9) Neutral Position Switch
(10) Bar
(11) Ball, Interlock
(12) Switch, Back up Light
(13) Cap
(14) Cap
(15) Washer
(16) Lever, Shift
(17) Screw
(18) Rod, 3rd and 4th Shift
(19) Ball and Pin, Interlock
(20) Ball and Spring, Detent
(21) Setscrew
(22) Arm, 3rd and 4th Shift
(23) Rod, Reverse Shift
(24) Setscrew
(25) Arm, Reverse Shift
(26) Ball and Spring, Detent
(27) Rod, 5th and 6th Shift
(28) Setscrew
(29) Arm, 5th and 6th Shift
(30) Setscrew
(31) Block, 5th and 6th Shift

Figure 4—Lower Quadrant Box Components

11. Reverse gear shaft and O-Ring using J 34539 and J 2619-01.
12. Thrust washer, reverse gear, bearing, and distance piece.
13. Collar.
14. Snap ring and counter shaft rear bearing using J 22912-01 and J 35699.
15. Countershaft assembly.
16. Countershaft front bearing cover and bearing from the transmission case (Figure 6).

GEARSHAFTS DISASSEMBLY

Tools Required:
J 35699 Puller Bar and Screw
J 35909 Mainshaft Collar Remover

TOP GEAR SHAFT DISASSEMBLY

Disassemble (Figure 2)

1. Retaining clip.
2. Snap ring.
3. Washers and pilot bearing.
4. Snap ring and bearing.

MAINSHAFT DISASSEMBLY

Disassemble (Figures 2 and 7)

1. 6th blocker ring.
2. Thrust washer, reverse gear, bearing, and collar.
3. Reverse sleeve and hub.
4. 1st gear, bearing, and thrust washer.
5. Snap ring and 1st and 2nd synchronizer (Figure 7).

Important

- Remove the synchronizers as one piece to avoid losing the synchronizers springs and blocks.

6. 2nd gear and bearing.
7. Snap ring and 5th and 6th synchronizer.
8. 5th blocker ring.
9. 5th gear and bearing.
10. Snap ring and 4th gear collar.
11. 4th gear and bearing.
12. 4th blocker ring.
13. 3rd and 4th synchronizer.
14. 3rd blocker ring.
15. 3rd gear, bearing, and oil catcher.

COUNTERSHAFT DISASSEMBLY

Disassemble (Figures 2 and 8)

1. Snap ring.
2. Driven gear and key.
3. 5th gear and key.
4. 4th gear and key.
5. 3rd gear and key.

Clean

- All parts in a cleaning solvent.

Inspect

- All parts for wear or damage.
- Gear teeth and splines for chips and wear.
- Bearing and bearing surfaces for loose fit and pitting.
- Worn away blocker ring grooves (Figure 8).
  — Replace the blocker ring assembly if the blocker ring grooves are worn away.

Measure (Figure 9)

- Block spring length.
- Blocker ring slots.
- Blocker ring to gear clearance.

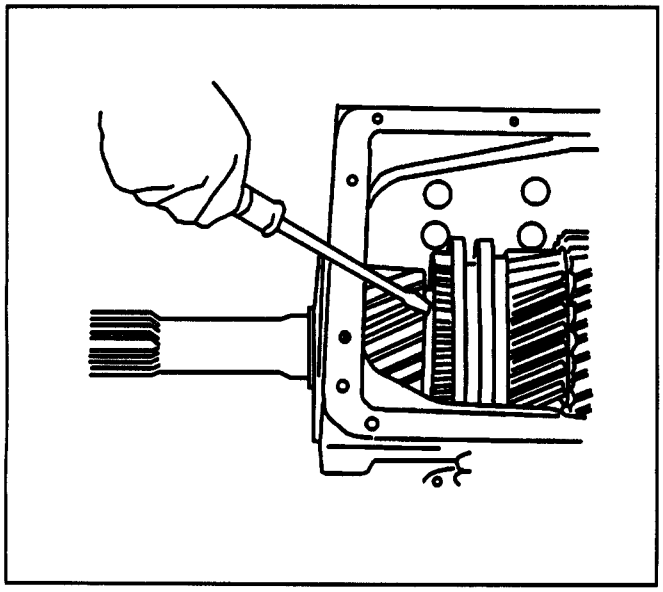
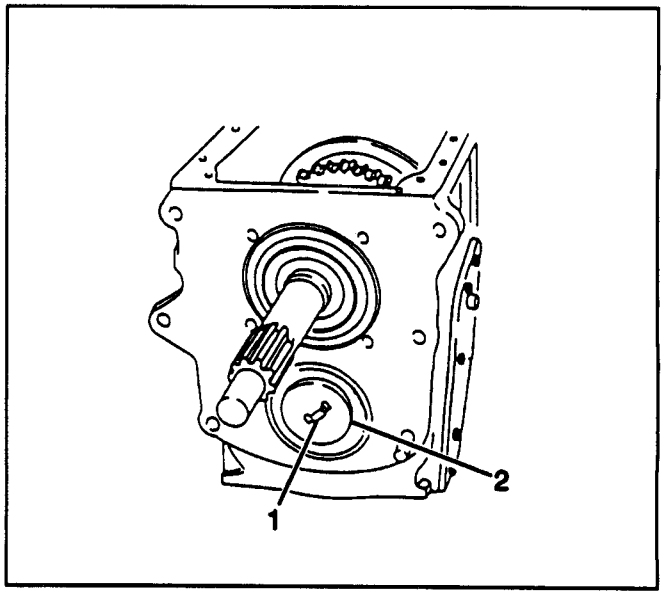


Figure 5—Top Gear Shaft Removal



Legend
(1) Tab
(2) Cover, Countershaft Front Bearing

Figure 6—Countershaft Front Bearing Cover

Important

- The standard clearance between the 5th and 6th blocker ring and the gear is 2.0 mm (0.0787 in.).
- The minimum clearance between the 5th and 6th blocker ring and the gear is 0.
- The standard clearance between the 2nd, 3rd, and 4th blocker ring and the gear is 2.0 mm (0.0787 in.).
- The minimum clearance between the 2nd, 3rd, and 4th blocker ring and the gear is 0.
- Block to hub clearance.

Important

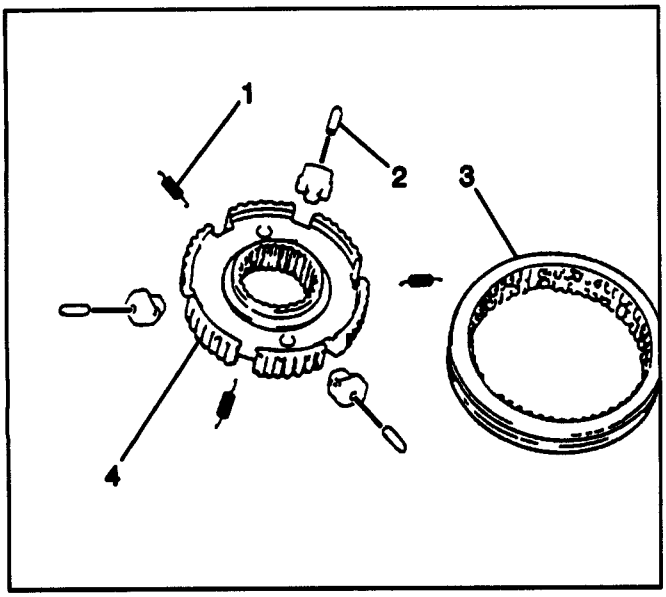
- The standard clearance between the block and the hub is 0.1 - 0.35 mm (0.00393 - 0.01377 in.).
- The maximum clearance between the block and the hub is 0.5 mm (0.0196 in.).

LOWER QUADRANT BOX DISASSEMBLY

Disassemble (Figure 3)

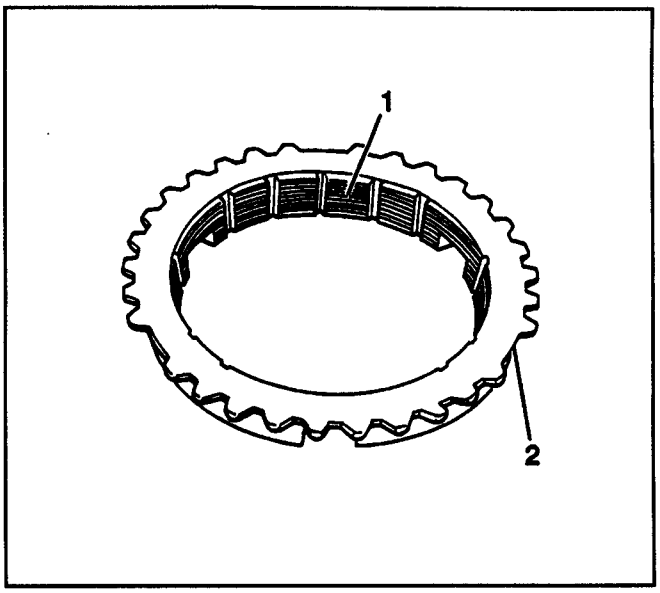
- Move all of the shift rods to the neutral position.
- Interlock and detent balls will fall from the lower quadrant box when the shift shafts are removed.

1. 1st and reverse shift rod and shift arm setscrew and shift block setscrew.
2. 1st and reverse shift rod, shift block, and shift arm.
3. Cap, interlock balls, pin, detent balls, and spring.
4. 2nd and 3rd shift rod and shift arm.
5. 2nd and 3rd shift rod and shift arm setscrew.
6. Cap, interlock balls, pin, detent balls, and spring.
7. 4th and 5th shift rod and shift arm setscrew.



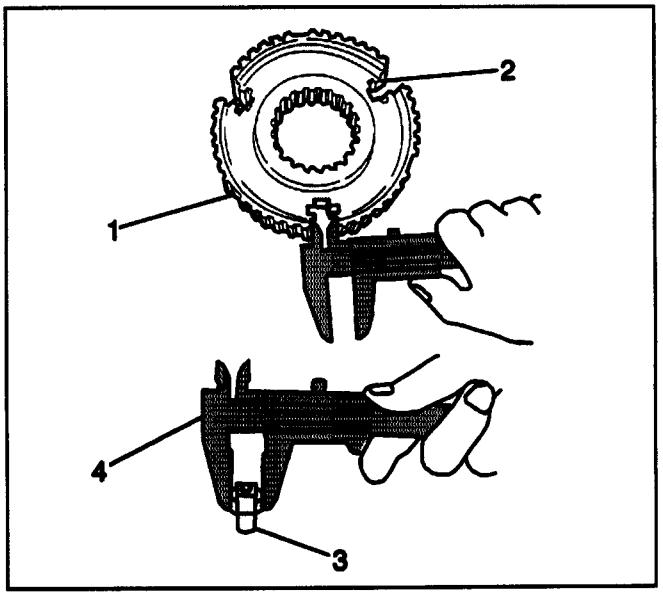
Legend
(1) Spring
(2) Blocker
(3) Sleeve
(4) Hub

Figure 7—Synchronizer Assembly



Legend
(1) Grooves
(2) Ring, Blocker

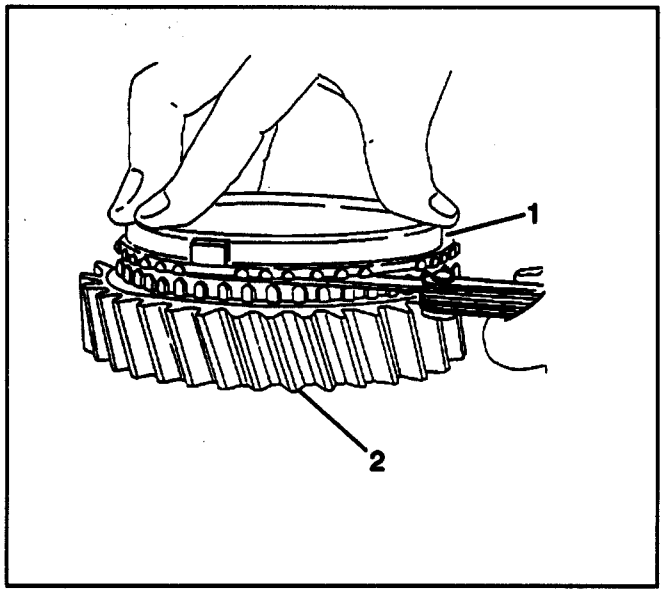
Figure 8—Blocker Ring



Legend
(1) Hub, Clutch
(2) Slot, Clutch Hub
(3) Block
(4) Caliper

Figure 9—Measuring the Block to Hub Clearance

8. 4th and 5th shift rod and shift arm.
9. Cap, detent ball and spring.
10. Nut, washer, and key bolt.
11. External select lever, washer, seal, and internal select lever.
12. Key pin, external shift lever, and seal.
13. Neutral switch.
14. Back-up light switch.



Legend
(1) Ring, Blocker
(2) Gear

Figure 10—Measuring the Blocker Ring to Gear Clearance

UPPER QUADRANT BOX DISASSEMBLY

Disassemble (Figure 4)

1. Link rod.
2. Select cable arm, bracket, and bushings.
3. Key bolt and external washer.
4. Washer and oil seal.
5. Internal select lever.
6. Snap ring, external lever, seal, and bushing.
7. Internal shift lever.

Clean

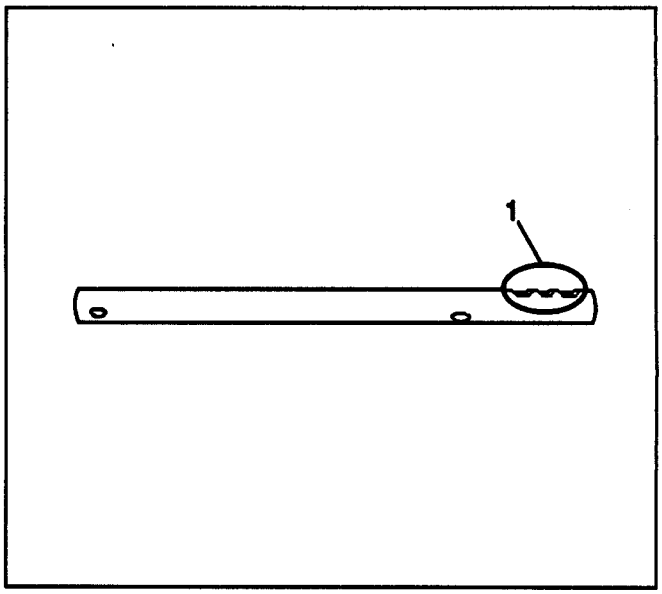
- Clean all parts with a cleaning solvent.

Inspect

- All parts for wear and damage.
- Seal surfaces for scratching and pitting.
- Shafts for rounding of detent shoulders (Figure 11).

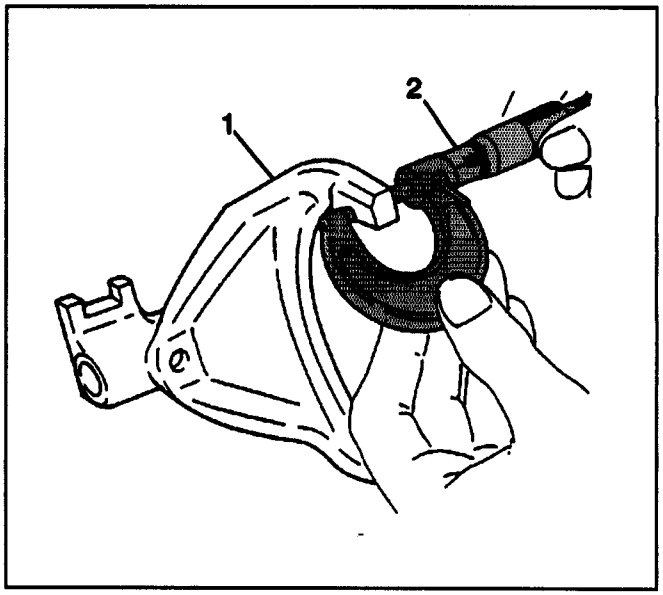
Measure (Figures 12 and 13)

1. Shift arm thickness (Figure 12).
   - The standard thickness of the shift arm is 11 mm (0.4331 in.).
   - The minimum thickness of the shift arm is 10 mm (0.3937 in.).
2. Detent spring length (Figure 13).
   - The standard length of the detent spring is 37.8 mm (1.4881 in.).
   - The minimum length of the detent spring is 34 mm (1.3385 in.).



Legend
(1) Shoulders

Figure 11—Shift Rod and Detent Shoulders



Legend
(1) Arm, Shift
(2) Micrometer

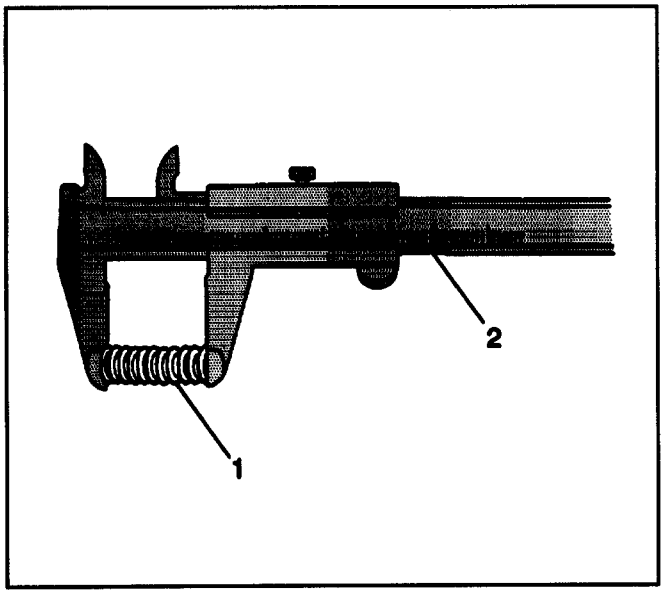
Figure 12—Shift Arm Thickness Measurement

UPPER QUADRANT BOX ASSEMBLY

Assemble (Figure 4)

- Apply a thin coat of transmission oil to all of the shift rods and bushings prior to installation.

1. Internal shift lever.
2. Bushing , seal, external lever, and NEW snap ring.
3. Internal select lever.
4. Oil seal and washer.
5. External washer and key bolt.
6. Bushings, bracket, and select cable arm.
7. Link rod.



Legend
(1) Spring, Detent
(2) Caliper

Figure 13—Detent Spring Measuring

LOWER QUADRANT BOX ASSEMBLY

Assemble (Figures 3, 14, and 15)

1. Back-up light switch.
2. Neutral switch.
3. Seal, external shift lever, and key pin.
4. Internal select lever, seal, washer, and external select lever.
5. Key bolt, washer, and nut.
6. Spring, detent ball, and cap.
7. Shift arm and 4th and 5th shift rod.
8. Shift arm setscrew and 4th and 5th shift rod.
9. Spring, detent balls, pin, interlock balls, and cap.
10. Shift arm setscrew and 2nd and 3rd shift rod.
11. Shift arm and 2nd and 3rd shift rod.
12. Spring, detent balls, pin, interlock balls, and cap.
13. Shift arm, shift block, and 1st and reverse shift rod.
14. Shift block setscrew, shift arm setscrew, and 1st and reverse shift rod.

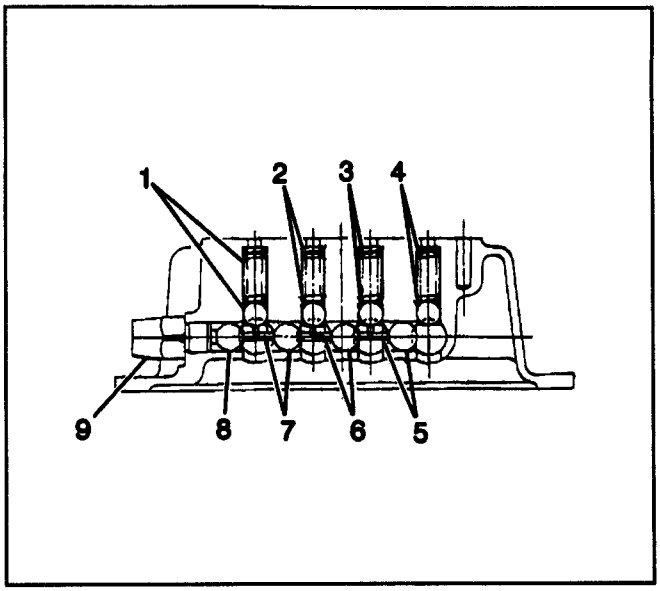
GEARSHAFTS ASSEMBLY

COUNTERSHAFT ASSEMBLY

Assemble (Figure 2)

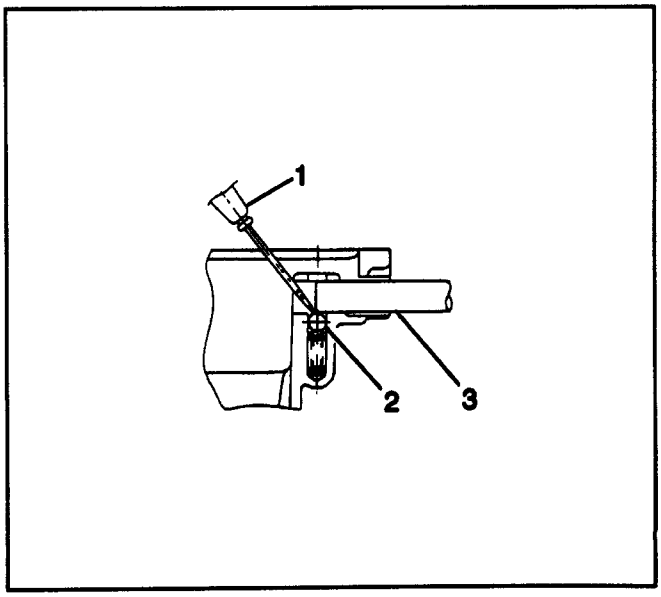
- Apply a light coat of transmission oil to all gears, bearings, and shafts prior to installation.

1. 3rd gear and key.
2. 4th gear and key.
3. 5th gear and key.
4. Driven gear and key.
5. NEW snap ring.



Legend
(1) Ball, Detent and Spring
(2) Ball, Detent and Spring
(3) Ball, Detent and Spring
(4) Ball, Detent and Spring
(5) Ball, Interlock and Pin
(6) Ball, Interlock and Pin
(7) Ball, Interlock and Pin
(8) Ball, Interlock
(9) Switch, Neutral

Figure 14—Interlock Balls, Detent Balls, and Springs



Legend
(1) Screwdriver
(2) Ball, Detent
(3) Rod, Shift

Figure 15—Shift Rod and Detent Ball Installation

MAINSHAFT ASSEMBLY

Assemble (Figures 2, 16, and 17)

1. Oil catcher, bearing, and 3rd gear.
2. 3rd blocker ring.
3. 3rd and 4th synchronizer (Figure 16).
4. 4th blocker ring.
5. Bearing and 4th gear.
6. 4th gear collar and NEW snap ring.
7. Bearing and 5th.
8. 5th blocker ring.
9. 5th and 6th synchronizer and NEW snap ring (Figure 16).
10. Bearing and 2nd gear.
11. 1st and 2nd synchronizer and NEW snap ring.
12. Thrust washer, bearing , and 1st gear.
13. Hub and reverse sleeve (Figure 17).
14. Collar, bearing, reverse gear, and thrust washer.
15. 6th blocker ring.

TOP GEAR SHAFT ASSEMBLY

Assemble (Figures 2 and 18)

1. Bearing and NEW snap ring.
   - Select a snap ring thickness that will allow a minimum amount of axial play.
   - White snap ring thickness 2.01 - 2.06 mm (0.0790 - 0.0811 in.).
   - Yellow snap ring thickness 2.53 - 2.58 mm (0.0996 - 0.1016 in.).
   - Blue snap ring thickness 2.57 - 2.62 mm (0.1012 - 0.1013 in.).
   - Green snap ring thickness 2.61 - 2.66 mm (0.1028 - 0.1047 in.).
2. Washers and pilot bearing.
3. NEW snap ring.
4. NEW retaining clip.

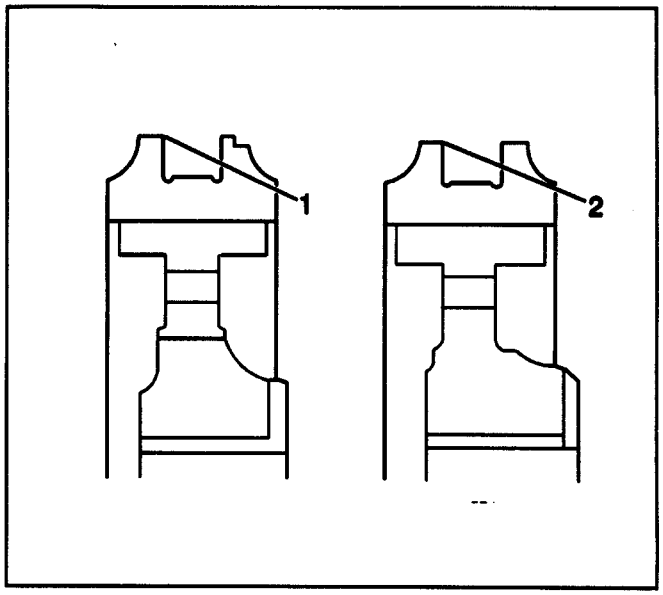
TRANSMISSION CASE ASSEMBLY

Install or Connect (Figures 1 through 4 and 19)

1. Countershaft front bearing to the transmission case.
2. Countershaft assembly.
3. Counter shaft rear bearing and NEW snap ring.
4. Collar.
5. Distance piece, bearing, reverse gear, and thrust washer.
6. NEW O-Ring and reverse gear shaft.
7. Mainshaft assembly.
8. Mainshaft rear bearing.
9. Top gear shaft.
10. Oil seal, NEW gasket, and front bearing cover.
    - Apply Loctite® 242 or the equivalent to the threads of the bolts.

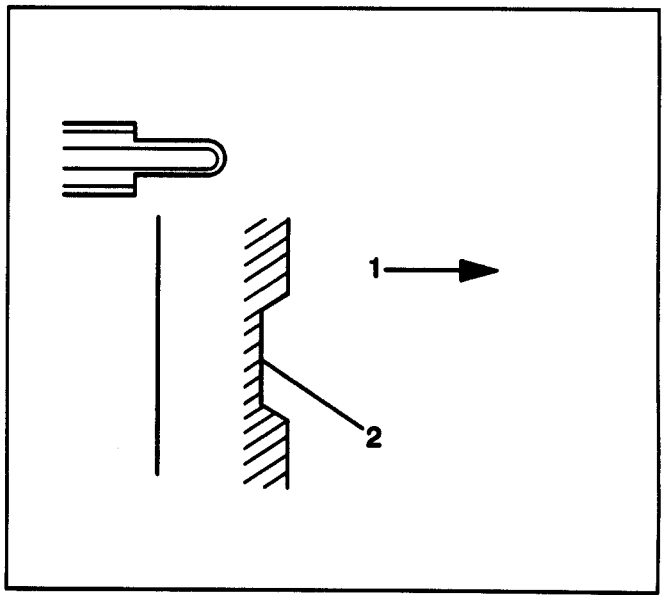
Tighten

- Front bearing cover bolts to 27 N.m (20 lb. ft.).



Legend
(1) Synchronizer, 5th and 6th
(2) Synchronizer, 3rd and 4th

Figure 16—Synchronizer Arrangement



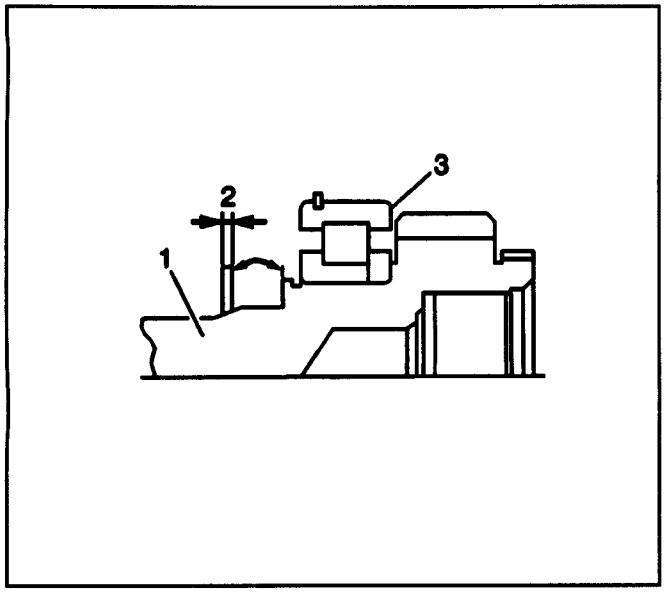
Legend
(1) Direction, Rear Side
(2) Groove, Oil

Figure 17—Reverse Sleeve and Hub

11. Clutch housing. Refer to SECTION 7C.
12. Power take off if the transmission is equipped.
13. NEW gasket and side cover.
14. Speedometer driven gear to the transmission. Refer to SECTION 7B.
15. Rear bearing cover.

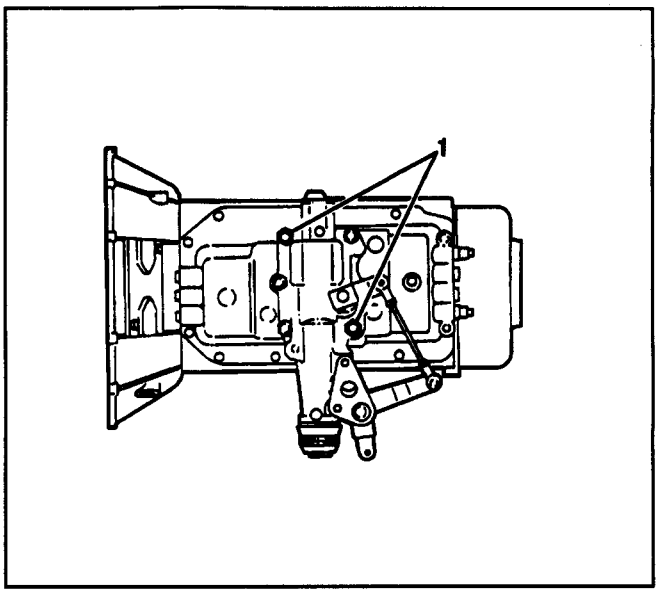
Tighten

- Rear bearing cover bolts to 71 N.m (52 lb. ft.).



Legend
(1) Shaft, Top Gear
(2) Thickness, Snap Ring
(3) Bearing

Figure 18—Top Gear Shaft Bearing Clearance



Legend
(1) Bolt, Reamer

Figure 19—Installing Reamer Bolts

16. O-ring, flange, and flange nut.

Tighten

- Flange nut to 800 N·m (590 lb. ft.), then stake the nut.

17. Upper and lower quadrant boxes to the transmission case.
    - Apply a thin coat of Loctite® 17430 or the equivalent to the transmission case and quadrant box sealing surfaces.
    - Install the reamer bolts first (Figure 19).

Tighten

- Reamer bolts to 37 N·m (27 lb. ft.).
- Install the remaining quadrant box bolts.

Tighten

- Quadrant bolts to 37 N·m (27 lb. ft.).

18. Countershaft front bearing cover to the transmission case.

SPECIFICATIONS

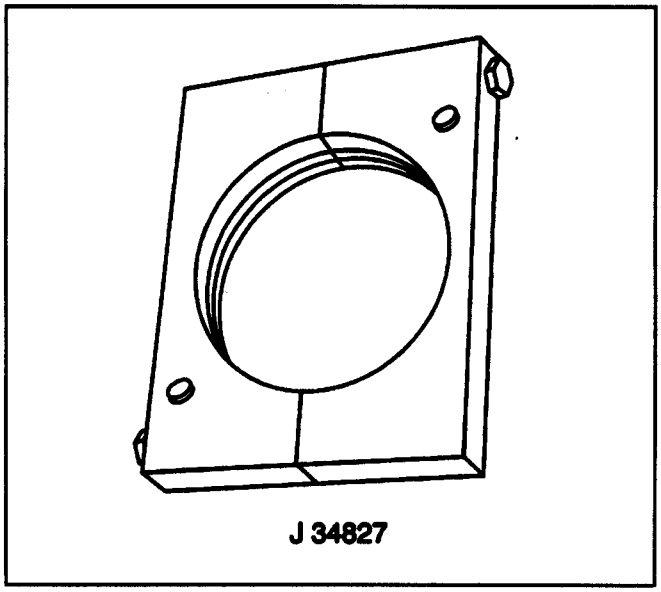
CAPACITIES

Application	Liters	Gallons	Quarts
API GL5, SAE 90 Multipurpose Oil (Use SAE 80 in Canada)	6.5	—	6.9

FASTENER TIGHTENING SPECIFICATIONS

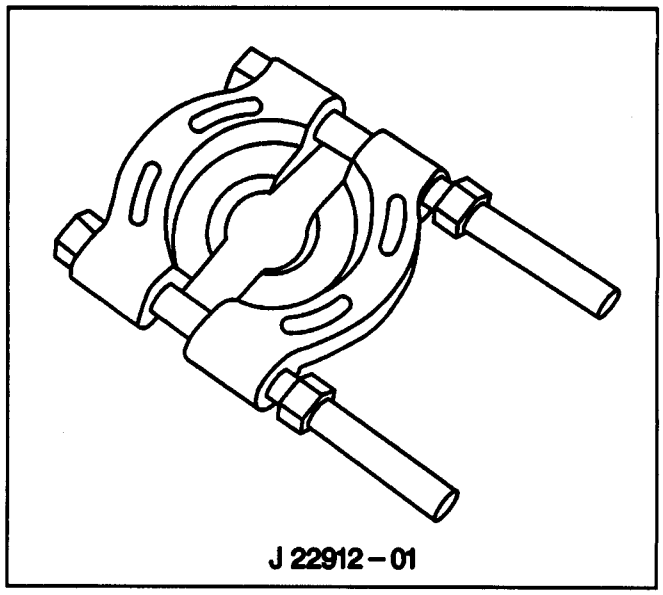
Application	N·m	Lb Ft	Lb In.
Flange Nuts	800	590	—
Front Bearing Cover Bolts	27	20	—
Quadrant Box Bolts	37	27	—
Reamer Bolts	37	27	—
Rear Bearing Cover Bolts	71	52	—

SPECIAL TOOLS



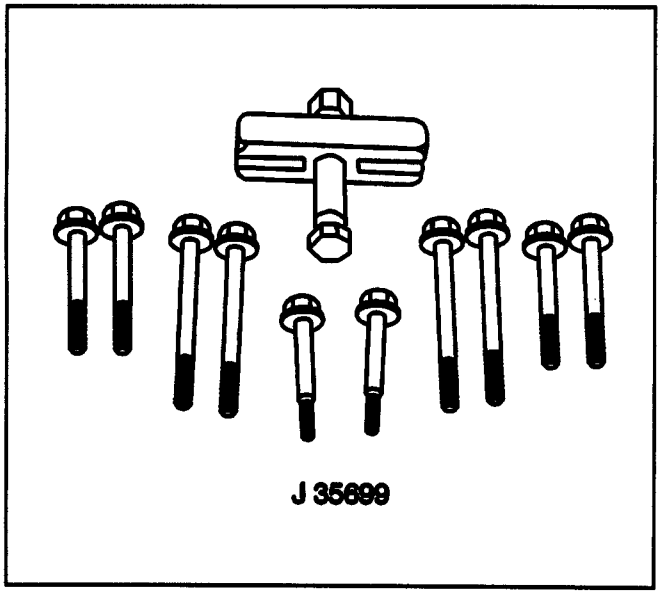
J 34827

Countershaft and Mainshaft Bearing Remover



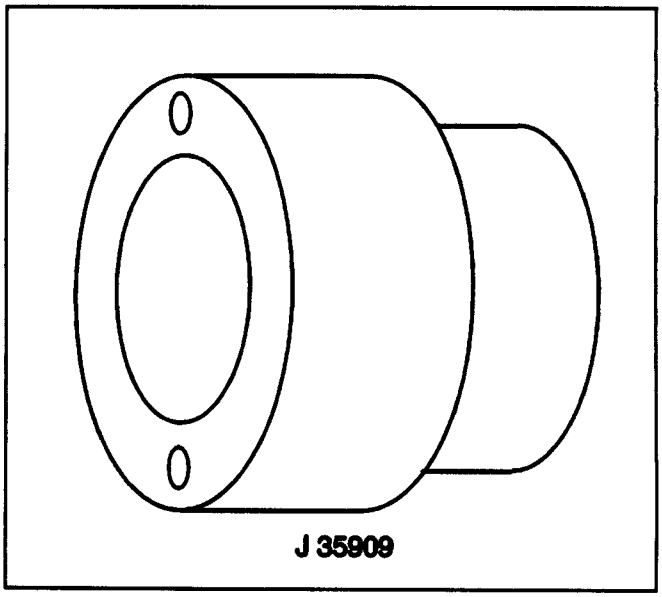
J 22912-01

Bearing Remover



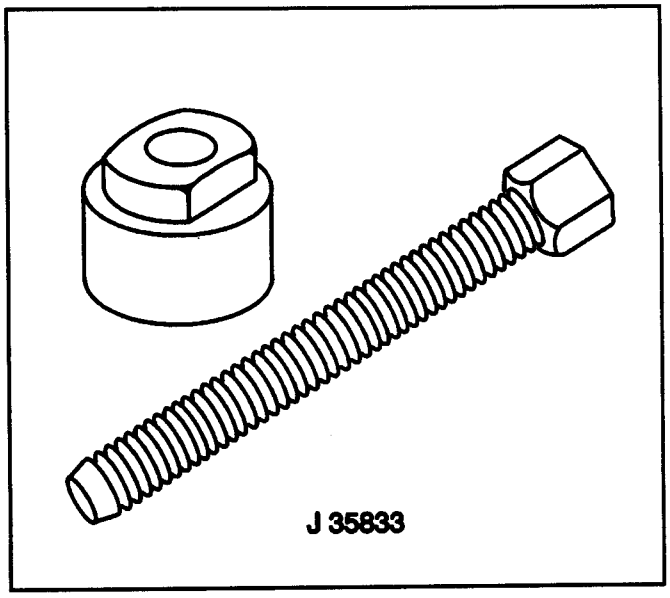
J 35699

Puller Bar and Screws



J 35909

Mainshaft Collar Tool



Speedometer Gear Bushing Remover

BLANK

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