

ESSENTIAL NOTES BEFORE PROCEEDING

Safety Notice

Proper service and repair procedures are vital to the safe, reliable operation of all motor vehicles, as well as the personal safety of those performing repairs. This information outlines procedures for servicing and repairing vehicles using, safe, effective methods. The procedures contain many NOTES, CAUTIONS and WARNINGS which should be followed, along with standard procedures, to eliminate the possibility of personal injury or improper service which could damage the vehicle or compromise its safety.

It is important to note that repair procedures and techniques, tools and parts for servicing motor vehicles, as well as the skill and experience of the individual performing the work, vary widely. It is not possible to anticipate all of the conceivable ways or conditions under which vehicles may be serviced, or to provide cautions as to all possible hazards that may result. Standard and accepted safety precautions and equipment should be used during cutting, grinding, chiseling, prying, or any other process that can cause material removal or projectiles.

Some procedures require the use of tools specially designed for a specific purpose. Before substituting another tool or procedure, you must be completely satisfied that neither your personal safety, nor the performance of the vehicle, will be endangered.

Although information in the data is based on industry sources and is complete as possible at the time of publication, the possibility exists that some vehicle manufacturers made later changes which could not be included here. While striving for total accuracy, the Publisher cannot assume responsibility for any errors, changes or omissions that may occur in the compilation of this data.

Part Numbers

Part numbers listed in this reference are not recommendations by the Publisher for any product brand name. They are references that can be used with interchange manuals and aftermarket supplier catalogs to locate each brand supplier's discrete part number.

Special Tools

Special tools are recommended by the vehicle manufacturer to perform their specific job. Use has been kept to a minimum, but, where absolutely necessary, they are referred to in the text by the part number of the tool manufacturer. These tools can be purchased, under the appropriate part number, from your local dealer or regional distributor, or an equivalent tool can be purchased locally from a tool supplier or parts outlet. Before substituting any tool for the one recommended, read the SAFETY NOTICE at the top of this page.

PRECAUTIONS

Before servicing any vehicle, please be sure to read all of the following precautions, which deal with personal safety, prevention of component damage, and important points to take into consideration when servicing a motor vehicle:

- Never open, service or drain the radiator or cooling system when the engine is hot; serious burns can occur from the steam and hot coolant.
- Observe all applicable safety precautions when working around fuel. Whenever servicing the fuel system, always work in a well-ventilated area. Do not allow fuel spray or vapors to come in contact with a spark, open flame, or excessive heat (a hot drop light, for example). Keep a dry chemical fire extinguisher near the work area. Always keep fuel in a container specifically designed for fuel storage; also, always properly seal fuel containers to avoid the possibility of fire or explosion. Refer to the additional fuel system precautions later in this section.
- Fuel injection systems often remain pressurized, even after the engine has been turned **OFF**. The fuel system pressure must be relieved before disconnecting any fuel lines. Failure to do so may result in fire and/or personal injury.
- Brake fluid often contains polyglycol ethers and polyglycols. Avoid contact with the eyes and wash your hands thoroughly after handling brake fluid. If you do get brake fluid in your eyes, flush your eyes with clean, running water for 15 minutes. If eye irritation persists, or if you have taken brake fluid internally, **IMMEDIATELY** seek medical assistance.
- The EPA warns that prolonged contact with used engine oil may cause a number of skin disorders, including cancer. You should make every effort to minimize your exposure to used engine oil. Protective gloves should be worn when changing oil. Wash your hands and any other exposed skin areas as soon as possible after exposure to used engine oil. Soap and water, or waterless hand cleaner should be used.
- All new vehicles are now equipped with an air bag system, often referred to as a Supplemental Restraint System (SRS) or Supplemental Inflatable Restraint (SIR) system. The system must be disabled before performing service on or around system components, steering column, instrument panel components, wiring and sensors. Failure to follow safety and disabling procedures could result in accidental air bag deployment, possible personal injury and unnecessary system repairs.
- Always wear safety goggles when working with, or around, the air bag system. When carrying a non-deployed air bag, be sure the bag and trim cover are pointed away from your body. When placing a non-deployed air bag on a work surface, always face the bag and trim cover upward, away from the surface. This will reduce the motion of the module if it is accidentally deployed. Refer to the additional air bag system precautions later in this section.
- Clean, high quality brake fluid from a sealed container is essential to the safe and proper operation of the brake system. You should always buy the correct type of brake fluid for your vehicle. If the brake fluid becomes contaminated, completely flush the system with new fluid. Never reuse any brake fluid. Any brake fluid that is removed from the system should be discarded. Also, do not allow any brake fluid to come in contact with a painted surface; it will damage the paint.
- Never operate the engine without the proper amount and type of engine oil; doing so **WILL** result in severe engine damage.

Servicing Your Vehicle Safely

It is virtually impossible to anticipate all of the hazards involved with automotive maintenance and service, but care and common sense will prevent most accidents.

The rules of safety for mechanics range from "don't smoke around gasoline," to "use the proper tool for the job." The trick to avoiding injuries is to develop safe work habits and take every possible precaution.

DO'S

- Do keep a fire extinguisher and first aid kit handy.
- Do wear safety glasses or goggles when cutting, drilling, grinding or prying, even if you have 20-20 vision. If you wear glasses for the sake of vision, wear safety goggles over your regular glasses.
- Do shield your eyes whenever you work around the battery. Batteries contain sulfuric acid. In case of contact with the eyes or skin, flush the area with water or a mixture of water and baking soda, then seek immediate medical attention.
- Do use safety stands (jackstands) for any undervehicle service. Jacks are for raising vehicles; jackstands are for making sure the vehicle stays raised until you want it to come down. Whenever the vehicle is raised, block the wheels remaining on the ground and set the parking brake.
- Do use adequate ventilation when working with any chemicals or hazardous materials. Like carbon monoxide, the asbestos dust resulting from some brake lining wear can be hazardous in sufficient quantities.
- Do disconnect the negative battery cable when working on the electrical system. The secondary ignition system contains EXTREMELY HIGH VOLTAGE. In some cases it can even exceed 50,000 volts.
- Do follow manufacturer's directions whenever working with potentially hazardous materials. Most chemicals and fluids are poisonous if taken internally.
- Do properly maintain your tools. Loose hammerheads, mushroomed punches and chisels, frayed or poorly grounded electrical cords, excessively worn screwdrivers, spread wrenches (open end), cracked sockets, slipping ratchets, or faulty droplight sockets can cause accidents.
- Likewise, keep your tools clean; a greasy wrench can slip off a bolt head, ruining the bolt and often harming your knuckles in the process.
- Do use the proper size and type of tool for the job at hand. Do select a wrench or socket that fits the nut or bolt. The wrench or socket should sit straight, not cocked.

DON'TS

- Don't run the engine in a garage or anywhere else without proper ventilation--EVER! Carbon monoxide is poisonous; it takes a long time to leave the human body and you can build up a deadly supply of it in your system by simply breathing in a little every day. You may not realize you are slowly poisoning yourself. Always use power vents, windows, fans and/or open the garage door.
- Don't work around moving parts while wearing loose clothing. Short sleeves are much safer than long, loose sleeves. Hard-toed shoes with neoprene soles protect your toes and give a better grip on slippery surfaces. Jewelry such as watches, fancy belt buckles, beads or body adornment of any kind is not safe working around a vehicle. Long hair should be tied back under a hat or cap.
- Don't use pockets for toolboxes. A fall or bump can drive a screwdriver deep into your body. Even a rag hanging from your back pocket can wrap around a spinning shaft or fan.
- Don't smoke when working around gasoline, cleaning solvent or other flammable material.
- Don't smoke when working around the battery. When the battery is being charged, it gives off explosive hydrogen gas.
- Don't use gasoline to wash your hands; there are excellent soaps available. Gasoline contains dangerous additives which can enter the body through a cut or through your pores. Gasoline also removes all the natural oils from the skin so that bone dry hands will suck up oil and grease.
- Don't service the air conditioning system unless you are equipped with the necessary tools and training. When liquid or compressed gas refrigerant is released to atmospheric pressure it will absorb heat from whatever it contacts. This will chill or freeze anything it touches. Although refrigerant is normally non-toxic, R-12 becomes a deadly poisonous gas in the presence of an open flame. One good whiff of the vapors from burning refrigerant can be fatal.
- Don't use screwdrivers for anything other than driving screws! A screwdriver used as an prying tool can snap when you least expect it, causing injuries. At the very least, you'll ruin a good screwdriver.
- Don't use a bumper or emergency jack (that little ratchet, scissors, or pantograph jack supplied with the vehicle) for anything other than changing a flat! These jacks are only intended for emergency use out on the road; they are NOT designed as a maintenance tool. If you are serious about maintaining your vehicle yourself, invest in a hydraulic floor jack of at least a 1 ½ ton capacity, and at least two sturdy jackstands.

Fig. 1: Always support your vehicle on jackstand while working underneath

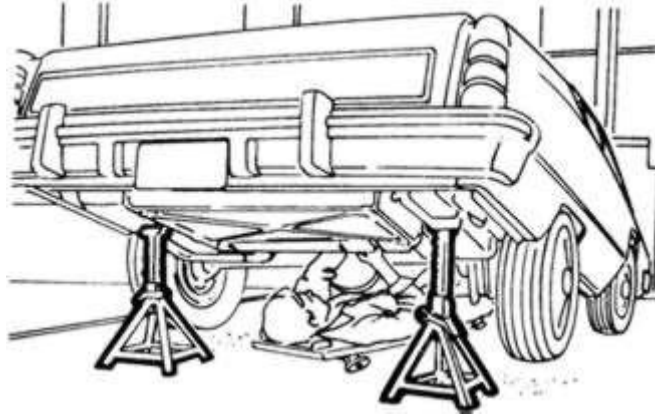
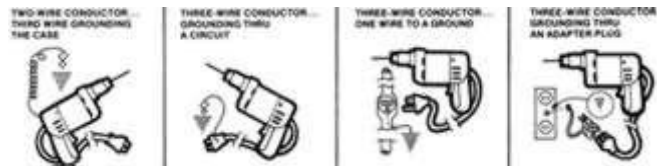


Fig. 2: If you're using portable electric tools, make sure they're grounded, preferably at the plug by a three wire connector



ENGINE ELECTRICAL

Service Precautions

Before servicing any vehicle read all of the following precautions that deal with personal safety, prevention of component damage, and important points to take into consideration when servicing a motor vehicle:

- If the battery is removed for any reason, ensure that it is reconnected with the correct polarity. Reversing the battery's polarity may result in damage to the one-way rectifiers.
- Never operate the generator with the main circuit broken. Ensure that the battery, generator, and regulator leads are not disconnected while the engine is running.
- Never attempt to polarize a generator.
- When charging a battery that is installed in the vehicle, disconnect the negative battery cable.
- When utilizing a booster battery as a starting aid always connect it in parallel; negative to negative and positive to positive.
- When arc (electric) welding is to be performed on any part of the vehicle disconnect the negative battery cable and generator leads.
- Never unplug the PCM while the engine is running or with the ignition in the ON position. Severe and expensive damage may result.
- Never attempt to charge or connect jumper cables to a frozen battery. The battery may explode. Bring the battery indoors where it can thaw before charging the battery.
- Never open, service or drain the radiator or cooling system when the engine is hot; serious burns and blindness can occur from the steam and hot coolant.
- Observe all applicable safety precautions when working around fuel. Whenever servicing the fuel system always work in a well ventilated area. Do not allow fuel spray or vapors to come in contact with sparks, open flame, or excessive heat (a hot drop light, for example). Keep a dry chemical fire extinguisher near the work area. Always keep fuel in a container specifically designed for fuel storage; and always properly seal fuel containers to avoid the possibility of fire or explosion. Refer to the additional fuel system precautions later in this section.
- Fuel injection systems often remain pressurized, even after the engine has been turned OFF. The fuel system pressure must be relieved before disconnecting any fuel lines. Failure to do so may result in fire and/or personal injury.
- The EPA warns that prolonged contact with used engine oil may cause a number of skin disorders including cancer. You should make every effort to minimize your exposure to used engine oil. Protective gloves should be worn when changing oil. Wash your hands and any other exposed skin areas as soon as possible after exposure to used engine oil. Soap and water or waterless hand cleaner should be used.
- Never operate the engine without the proper amount and type of engine oil. Doing so will result in severe engine damage.

- Timing belt maintenance is extremely important. Many models utilize an interference-type, non-freewheeling engine. If the timing belt breaks, the valves in the cylinder head may strike the pistons causing potentially serious (also time-consuming and expensive) engine damage. Refer to the maintenance interval charts in the front of this manual for the recommended replacement interval for the timing belt, and to the timing belt section for belt replacement and inspection.
- All new vehicles are now equipped with an air bag system. The system must be disabled before performing service on or around system components, steering column, instrument panel components, wiring and sensors. Failure to follow safety and disabling procedures could result in accidental air bag deployment, possible personal injury and unnecessary system repairs.
- Always wear safety goggles when working with, or around, the air bag system. When carrying a non-deployed air bag, be sure the bag and trim cover are pointed away from your body. When placing a non-deployed air bag on a work surface, always face the bag and trim cover upward, away from the surface. This will reduce the motion of the module if it is accidentally deployed. Refer to the additional air bag system precautions later in this section.
- Disconnecting the negative battery cable on some vehicles may interfere with the functions of the on-board computer system(s) and may require the computer to undergo a relearning process once the negative battery cable is reconnected.
- Batteries contain corrosive acid. Batteries supply current high enough to cause burns. Batteries produce explosive gases. When working on batteries always wear eye protection. Never allow battery acid to contact the skin or eyes. Do not allow sparks or flames near the battery.

NOTE: Disconnecting the negative battery cable on some vehicles may interfere with the functions of the on board computer system. The computer may undergo a relearning process once the negative battery cable is reconnected.

Ignition System

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

General Information

NOTE: For information on understanding electricity and troubleshooting electrical circuits, please refer to chassis electrical.

Coil on Plug (COP) System

The coil over plug system was developed so that spark and spark timing could be better controlled on an individual cylinder basis. Each cylinder has an ignition coil mounted directly above the spark plug on the cylinder head cover. A short suppresser/connector replaces the spark plug wire and links the coil to the plug. There are different methods used for primary triggering. Some manufacturers use a combination coil/module, which means each coil has its own control circuit that is activated by the PCM. Others use remote mounted modules to trigger the coils.

Each individual coil is allowed to saturate while all other cylinders fire. For a V-8 engine, this allows a period of seven firing events for coil saturation, compared to three events for the same V-8 engine with a waste spark system. The coil over plug system also benefits from a minimum amount of energy lost, due to the resistance of spark plug wires.

Magnetic Sensor / Pick-Up Coil

The magnetic sensor in electronic ignition system is made up of a small coil of wire wrapped around an iron core, a permanent magnet and a toothed wheel called a reluctor. These sensors can be found mounted in a distributor, or at the front, middle, or rear of the crankshaft or camshaft, and are two-wire sensors.

The permanent magnet produces a magnetic field that passes thru the center of the pick-up coil. As the reluctor turns, the small teeth enter the magnetic field. Because the metal is a better conductor for the field than the air between the magnet and reluctor, the field strength begins to increase and reaches its maximum when the reluctor teeth are closest to the sensor. An increase in magnetic field induces a positive voltage to the module. As the teeth leave the magnetic field, the decrease in pole strength induces a negative voltage into the module. This alternating positive and negative voltage causes a small AC current. This alternating current after passing through an analog/digital converter is used by the module or engine controller to trigger the primary circuit.

Hall-Effect Device

Another device that can be used to create a triggering signal is a hall-effect device. A hall-effect device can be thought of as a solid-state On/Off switch. The hall-effect switch is a three-wire device that must receive a power and ground. The hall-effect switch is used in conjunction with an interrupter ring with a series of slots or openings cut into it. Depending

on the application, these slots are spaced around the ring in a specific configuration. As the ring rotates, the slots pass between the hall-effect switch, and alternately turns the voltage off and on. When a slot aligns with the hall-effect switch, the controller sees voltage on the signal line. When the area between slots passes the hall-effect switch, the signal is pulled low. This results in a voltage of 0V–0.1V at the controller.

The rotation of the interrupter ring causes the signal to toggle, which causes a continual series of digital pulses on the signal line. This digital pulse is the timing signal that is used by the ignition module or engine computer to open and close the primary circuit. The controller processes these pulses as the RPM signal.

Ignition Coil

The heart of the automotive ignition system is the ignition coil. The ignition coil is a step-up transformer, since it boosts battery voltage to the high voltage that is necessary for proper combustion.

The ignition coil consists of a primary winding and secondary winding wrapped around a soft iron core. The primary winding is made up of several hundred turns of heavy wire, while the secondary winding consists of thousands of turns of fine wire. The iron core is used to conduct magnetic lines of force efficiently.

When current flows through the primary winding, a magnetic field is created. The more time current is permitted to flow, the stronger the magnetic field becomes. When the current is turned off, the magnetic field collapses causing a high voltage to be induced in the secondary winding through the process of induction.

A few hundred volts will be generated in the primary winding because of the collapsing magnetic field across the heavy primary wire. However, as the magnetic lines of force cut across the thousands of turns of fine wire in the secondary, a far greater voltage is produced. The production of primary voltage is called self-induction, since the primary winding essentially magnifies its own initial voltage when the magnetic field collapses.

Related Symptoms

Faulty ignition system components along with loose connections, bad grounds, high resistance or opens in the circuit, may cause the following symptoms:

- No start condition
- Stalling after cold start
- Stalling after hot start
- Surging off idle
- Extended crank time when engine is cold
- Unstable idle
- Running rough during off idle acceleration
- Bucking
- Hesitation
- Stumble
- Poor fuel economy
- Spark knock

Secondary Spark Test

This spark tester looks just like a spark plug. Attach the clip to ground and crank the engine to check for spark.



This spark tester has an adjustable air-gap for measuring spark strength and testing different voltage ignition systems.



Attach the clip to ground then crank the engine to check for spark.



This spark tester is the easiest to use. Just place it on a plug wire and the spark voltage is detected; the bulb on the top will flash with each pulse.



NOTE: The best way to perform this procedure is to use a spark tester (available at most automotive parts stores). Three types of spark testers are commonly available:

- The Neon Bulb type is connected to the spark plug wire and flashes with each ignition pulse.

- The Air Gap type must be adjusted to the individual spark plug gap specified for the engine.
- The last type of spark plug tester looks like a spark plug with a grounding clip on the side, but there is no side electrode for the spark to jump.

NOTE: The last two types of testers allow the user to not only detect the presence of spark, but also the intensity of the spark. Orange/yellow is weak, blue is strong.

1. Disconnect a spark plug wire at the spark plug end.
 2. Connect the plug wire to the spark tester and ground the tester to an appropriate location on the engine or frame.
 3. Crank the engine and check for spark at the tester.
 4. If spark exists at the tester, the ignition system is functioning properly.
 5. If spark does not exist at the spark plug wire, perform a diagnostic test of the ignition system using individual component diagnosis procedures.
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Firing Orders

4.2L Engine

1-5-3-6-2-4

5.3L & 6.0L Engines

1-8-7-2-6-5-4-3

Ignition Coil-On-Plug

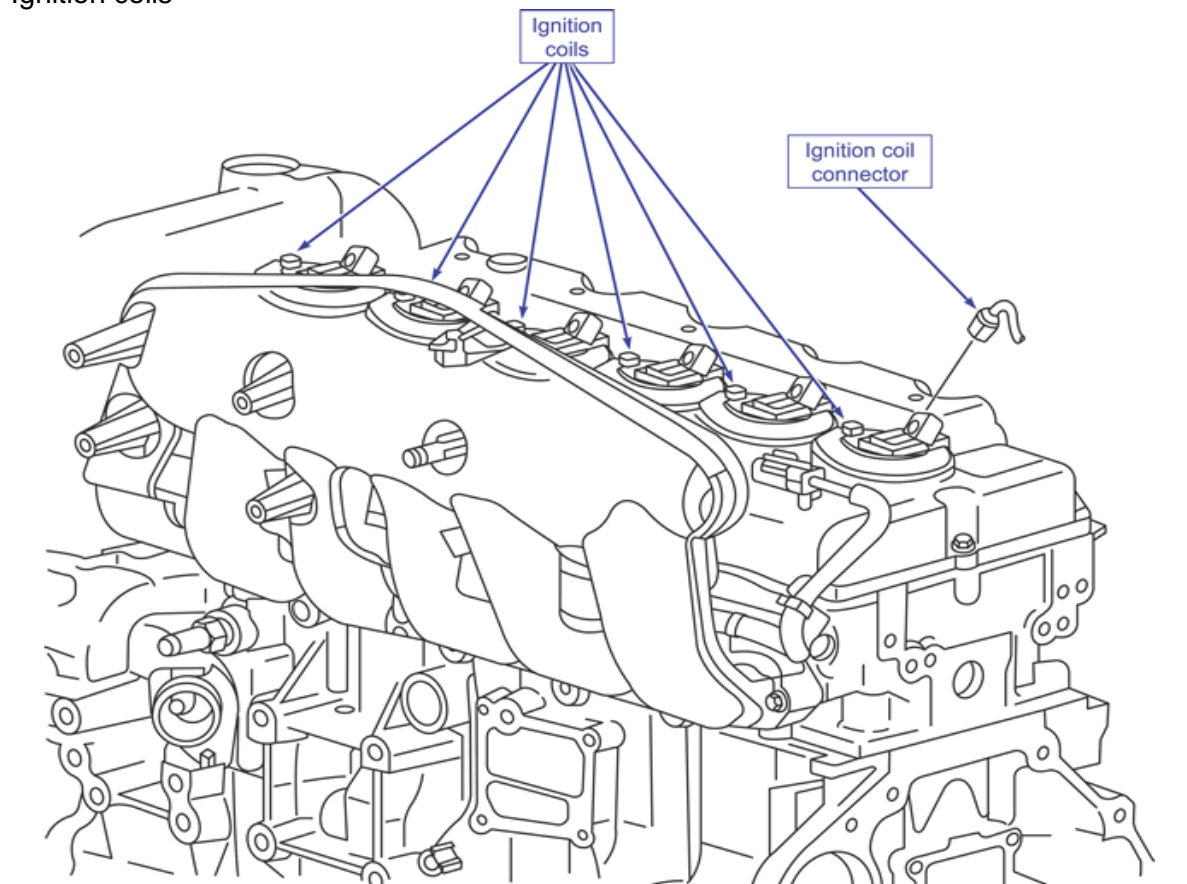
Removal & Installation

4.2L Engine

To Remove:

1. Remove the air cleaner outlet resonator from the engine.

Ignition coils



2. Disconnect the ignition coil connectors.
3. Detach the ignition coils from the engine.

To Install:

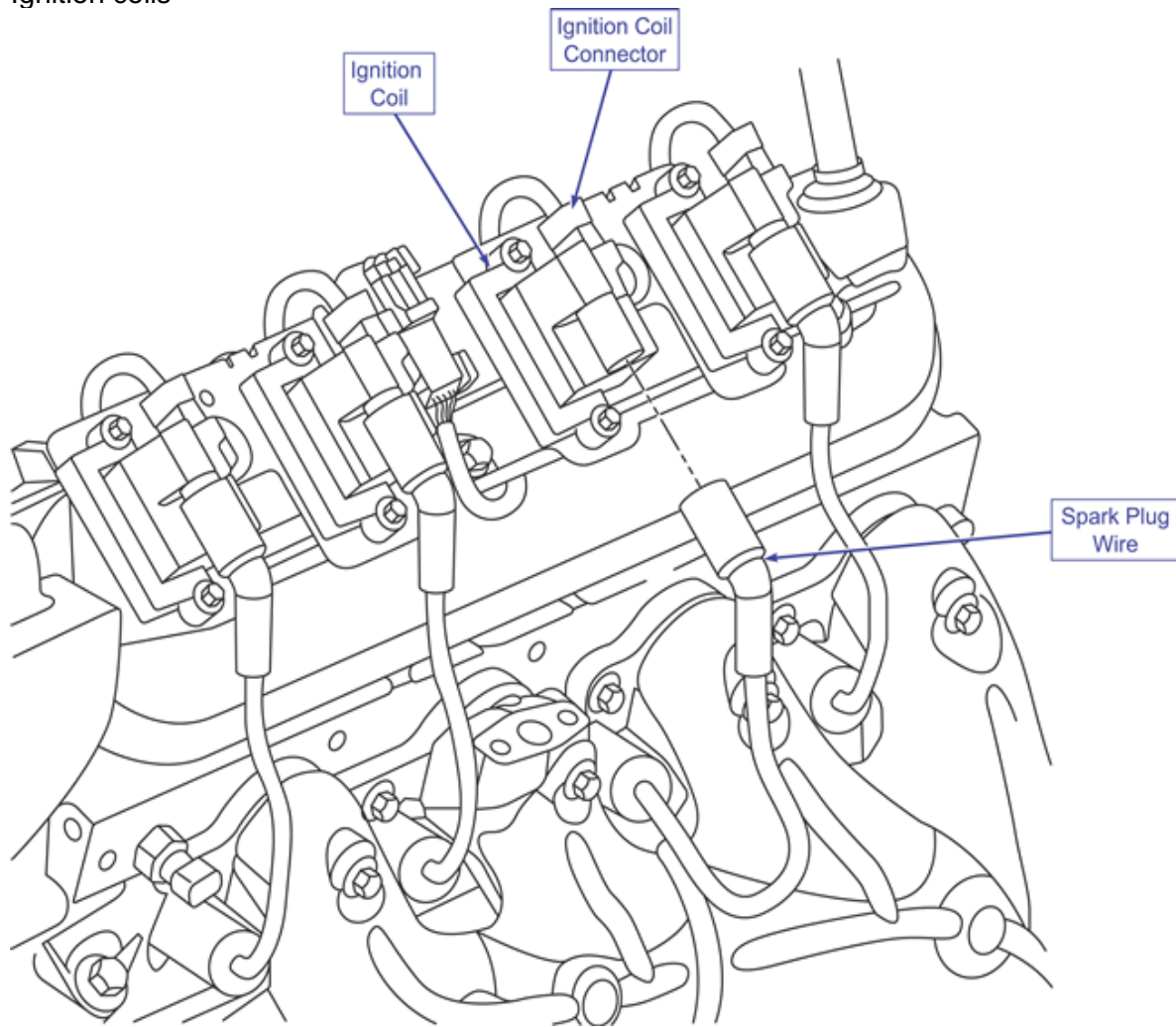
1. Attach the ignition coils to the engine. Torque the retaining bolts to **89 in-lb (10 Nm)**.
2. Connect the ignition coil connectors.
3. Install the air cleaner outlet resonator to the engine.

5.3L & 6.0L Engines

To Remove:

1. If equipped, remove the intake manifold sight shield from the engine.

Ignition coils



2. Disconnect the spark plug wires from the ignition coils.
3. Disconnect the ignition coil connectors.
4. Detach the ignition coils from the engine.

To Install:

1. Attach the ignition coils to the engine. Torque the bolts to **71 in-lb (8 Nm)**.
2. Connect the ignition coil connectors.
3. Connect the spark plug wires to the ignition coils.
4. If equipped, install the intake manifold sight shield to the engine.

Charging System

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

General Information

An automobile's charging system provides electrical power for the operation of the ignition, starting system, and all electrical accessories. The battery serves as a storage device holding a supply of electricity and is regenerated by the generator when the engine is running. The generator is constantly in motion while the engine is running. To prevent too much energy from being stored in the battery the generator is equipped with a regulating device designed to read the amount of voltage in the battery and to turn itself on and off at specific times to maintain the proper charge. On newer vehicles, the computer also maintains a vigil on battery storage capacity activating the regulator when needed.

Storage batteries are a chemical device incorporating parallel lead plates in a tank containing a solution of sulfuric acid and water. Adjacent plates are dissimilar and the chemical reaction of the two dissimilar plates produces electrical energy. The chemical reaction is reversible, so that when the generator is producing current greater than that produced by the battery, electricity is forced into the battery, and the battery is returned to full charge.

The generator is belt driven by a pulley from the engine's crankshaft. Generators actually produce alternating current (AC) commonly used in homes. As the current leaves the generator it is converted to direct current (DC) that is used by the storage battery, ignition and accessories. A generator contains a rotating field winding (or rotor), a stationary induction winding (or stator) and a diode assembly (or rectifier bridge). There is also a voltage regulator built into the generator and two internal fans to promote cooling to the circuits.

As the generator spins with engine rpm, two stationary carbon brushes ride on two rotating slip rings located at one end of the rotor. The rotor field winding is attached at either end to a slip ring permitting current to flow through the field winding. The regulator monitors the battery and stator voltage and changes the rotor field current to adjust generator output. The conversion of AC to DC is done by the Diode Rectifier Bridge. An alternating magnetic field is formed as the rotor assembly rotates within the stator winding. This spinning induces an AC voltage into the stator. Depending on the speed of the rotor and the magnetic field the voltage provided to the stator will vary.

Generator

Voltage Test

1. Make sure the engine is **OFF**, and turn the headlights on for 15-20 seconds to remove any surface charge from the battery.
2. Using a DVOM set to volts DC, probe across the battery terminals.
3. Measure the battery voltage.
4. Write down the voltage reading and proceed to the next test.

Load Test

1. With the engine running, turn on the blower motor and the high beams (or other electrical accessories to place a load on the charging system).
2. Increase and hold engine speed to 2000 rpm.
3. Measure the voltage reading at the battery.
4. The voltage should increase at least 0.5 volts from the voltage test. If the voltage does not meet specifications, the charging system is malfunctioning.

NOTE: Faulty wiring and other problems can cause the charging system to malfunction. Further testing, which is not covered by this book, will reveal the exact component failure. When all affected wires and components have been confirmed in good working order, under and overcharging is caused by a defective generator or internal regulator. Replacement of these components will then repair the condition

No-Load Test

1. Connect a tachometer to the engine

CAUTION

Place the transmission in P (Park), set the emergency brake and chock the rear wheels to prevent vehicle movement.

2. Turn off all electrical loads (radio, blower motor, wipers, etc.)

NOTE: it is a good practice to turn off all electrical accessories prior to shutting off the engine.

3. Start the engine and increase engine speed to 1500 rpm.
4. Measure the voltage reading at the battery with the engine holding a steady 1500 rpm. Voltage should have raised at least 0.5 volts, but no more than 2.5 volts.
5. If the voltage does not go up more than 0.5 volts, the generator is not charging. If the voltage goes up more than 2.5 volts, the generator is overcharging.

NOTE: Faulty wiring and other problems can cause the charging system to malfunction. Further testing, which is not covered by this book, will reveal the exact component failure. When all affected wires and components have been confirmed in good working order,

under and overcharging is caused by a defective generator or internal regulator. Replacement of these components will then repair the condition.

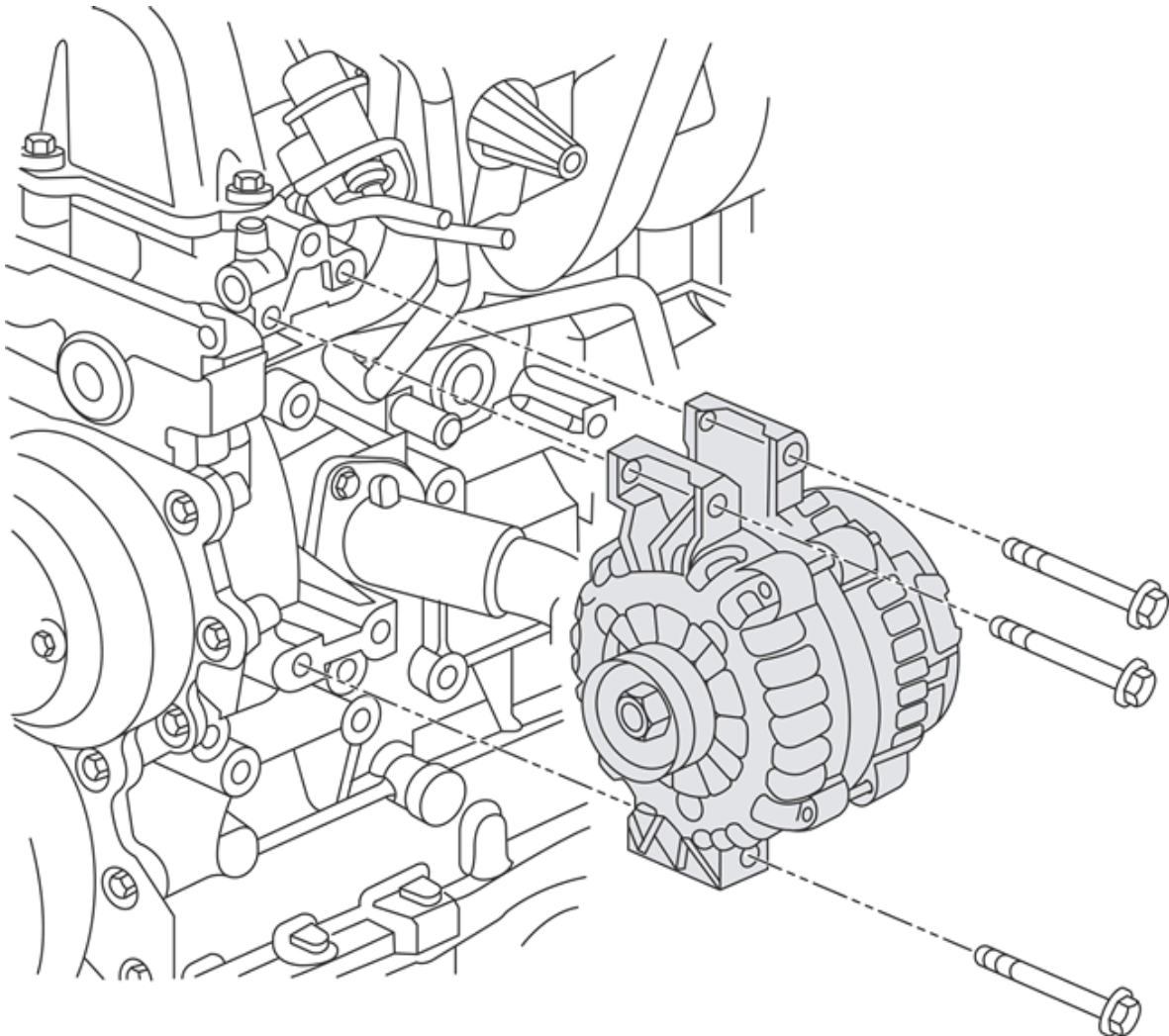
Removal & Installation

4.2L Engine

To Remove:

1. Disconnect the negative battery cable from the battery.
2. Remove drive belt from the pulleys.
3. Detach the A/C line mounting bracket from the engine lift hook.
4. Detach the right engine lift hook from the engine.

Generator removal and installation



5. Detach the generator from the engine.
6. Detach the battery positive cable from the generator.

To Install:

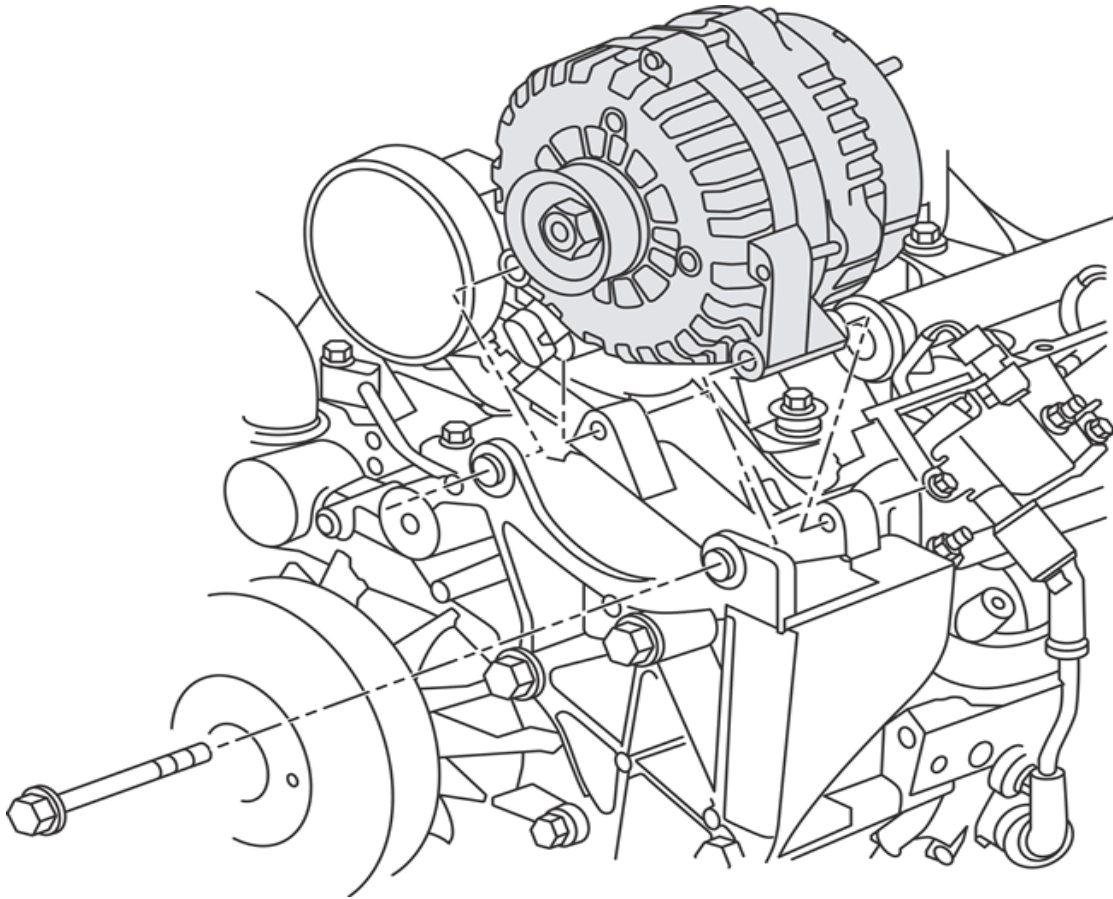
1. Attach the battery positive cable to the generator. Torque the nut to **80 in-lb (9 Nm)**.
2. Attach the generator to the engine. Torque the bolts to **37 ft-lb (50 Nm)**.
3. Attach the right engine lift hook to the engine. Torque the bolts to **37 ft-lb (50 Nm)**.
4. Attach the A/C line mounting bracket to the engine lift hook. Torque the bolt to **89 in-lb (10 Nm)**.
5. Install the drive belt onto the pulleys.
6. Connect the negative battery cable to the battery.

5.3L & 6.0L Engines

To Remove:

1. Disconnect the negative battery cable from the battery.
2. Remove the drive belt from of the pulleys.
3. Disconnect the generator connector.
4. Detach the generator cable from the generator.

Generator removal and installation



5. Detach the generator from the engine.

To Install:

1. Attach the generator to the engine. Torque the bolts to **37 ft-lb (50 Nm)**.
2. Attach the generator cable to the generator. Torque the nut to **80 in-lb (9 Nm)**.
3. Connect the generator connector.
4. Install the accessory drive belt on to the pulleys.
5. Connect the negative battery cable to the battery.

Generator Battery Control Module

Removal & Installation

2007

To Remove:

1. Disconnect the negative battery cable from the battery.
2. Disconnect the generator battery control module connector.
3. Remove the negative battery harness from the engine compartment.
4. Mark the position of the clips on the negative battery harness.
5. Remove the clips from the negative battery harness.
6. Remove the generator battery control module securing tape from the negative battery harness.
7. Squeeze together the branches of the negative battery harness.
8. Remove the generator battery control module by sliding it off of the negative battery harness.

To Install:

1. Squeeze together the branches of the negative battery harness.

2. Install the new generator battery control module by sliding it onto the negative battery harness and inserting the tab under the negative battery cable terminal cover.
3. Secure the generator battery control module to the negative battery cable by wrapping electrical tape around the module leg.
4. Install the clips onto the negative battery harness in the positions previously marked.
5. Install the negative battery harness into the engine compartment.
6. Connect the generator battery control module connector.
7. Connect the negative battery cable from the battery.

Maintenance Intervals

But the Owner's Manual is different?

We have provided a maintenance interval chart which is based on general industry standards. The time and mileage given are the most conservative figures (low end recommendations), and therefore should be sufficient to meet or beat most manufacturer's warranty requirements. If you have an owner's manual for your vehicle, we would still recommend that you consult it and see what the manufacturer specifically recommends (there may be some odd or atypical components on your vehicle that require special attention).

Because this chart is designed to cover all vehicles, we may have included items which are not applicable to your exact model (for instance, many vehicles use hydraulic valve lifters, making periodic adjustment of the valve clearance unnecessary). So when looking at items on the chart, remember to check if they are applicable to your vehicle (using an owner's manual or the online repair manual written specifically for your model).

Also, keep in mind that we may have included items which we believe are very important, even if your particular manufacturer does not. Brake fluid is one item of which not all manufacturers require periodic replacement in order to keep in warranty. But, that doesn't change the fact that brake fluid is hygroscopic meaning that it absorbs moisture from the

atmosphere. Over time moisture in the brake system will lead to corrosion and damage to internal parts. Also, a sufficient level of moisture in the fluid can dramatically lower its boiling point. Should temperatures during hard braking (mountain driving, trailer towing, racing, etc) allow the brake fluid to boil, you could experience a sudden and complete loss of braking ability. So if you plan on keeping a vehicle for any length of time, and/or you use it under harsh conditions (such as towing or racing), you would be wise to follow our fluid replacement guidelines.

But the Replacement Part is different?

Another thing to remember is that maintenance intervals may vary with the type of replacement parts which are used. Spark plugs and synthetic oils are two good examples of this. Although we have suggested changing your oil and filter every 3,000 miles, use of a synthetic oil may allow you to lengthen or even double this mileage, IF your usage fits the proper patterns (highway miles, above freezing, with little stop-and-go and no excessive speeds . . .). The recommendation we give for spark plugs is based on conventional plugs with an electronic ignition system, which probably covers most vehicles on the road. If you have an antique that uses a points ignition, well then you will probably have to replace the plugs more often. But, if you use special plugs, like the increasingly popular long-life Platinum plugs, you may easily be able to double the recommended replacement interval. The key here is to pay attention to the directions supplied with your replacement parts (and if you have never replaced an item before, check with the manufacturer for suggestions about original equipment).

Is My Driving 'Normal' or 'Severe'?

Sometimes we are puzzled at how manufacturer's chose the term "Normal" for the style of driving which most refer to in their maintenance charts as the opposite of "Severe." Check your owner's manual and you will likely see that you are NOT normal. Sorry to be the one to tell you, but it's probably true.

You see, to be "Normal" according to most manufacturer's driving and maintenance recommendations you would have to: Drive the car for more than 10 miles or so (to make sure it properly warms up) almost every time you start it (never under freezing conditions, but not in excessive heat, dry or dusty conditions either). Most miles would have to be on the highway, NOT stop-and-go (few red lights or stop signs), with no excessive idling (in traffic or curbside), but NOT at excessive speeds. Well, some of you reading this will find that this applies . . . but most won't.

If ALL of these conditions apply, then most manufacturers call your driving style "Severe" and lump it in with trailer towing, racing, cab or delivery driving or even police or fire vehicle usage. The truth is that most usage probably falls somewhere in between. Actual severe usage, such as those that we have just listed, should require a LOT of attention to all of the various systems of a car (including early replacement of all fluids). But, the average person, who does not race or tow, will be fine with the 3,000 mile/3 month engine oil change and most of the other recommendations we have given. If you compare those

recommendations with your manufacturer, you will probably find that they have listed those intervals for "SEVERE" usage and not "NORMAL." Maybe it is just a play on words. Just remember that it is your money (that you are driving around every day) and possibly even your life (kept safe by tires and brakes . . .) so remember the general rule, maintenance is cheaper than repair. Don't be afraid of not being "Normal." Go ahead and admit that your driving is "Severe" and maintain your vehicle to match.

Fig. 1: Typical underhood maintenance locations for inline-type engines (Refer to chart for descriptions)

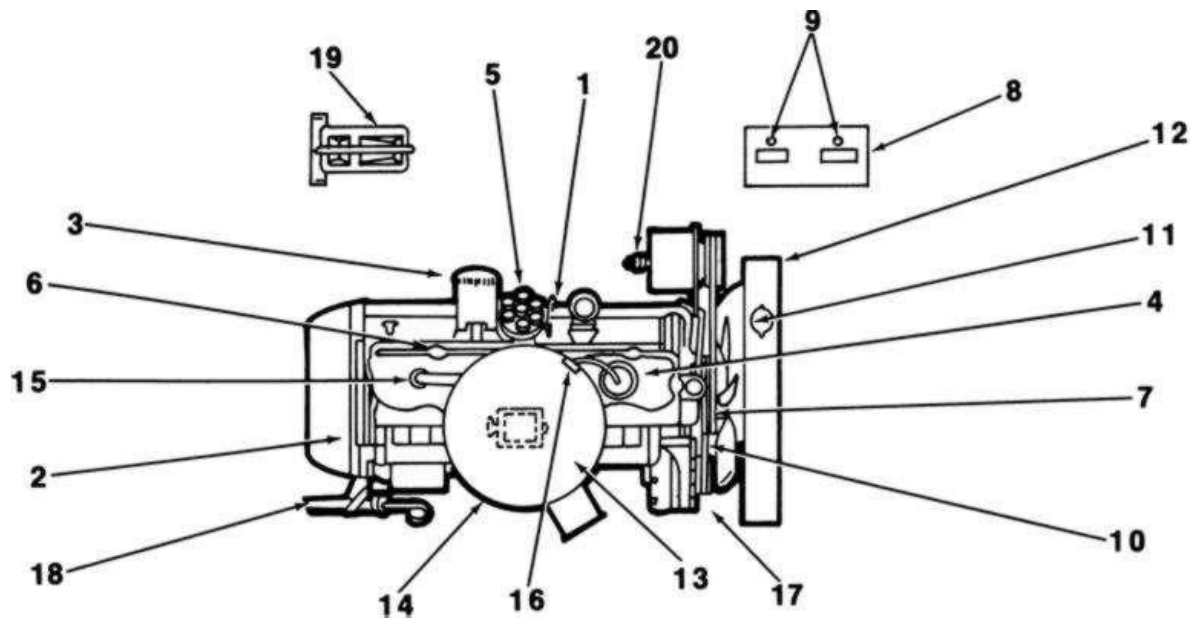


Fig. 2: Typical underhood maintenance locations for V or opposing-type engines (Refer to chart for descriptions)

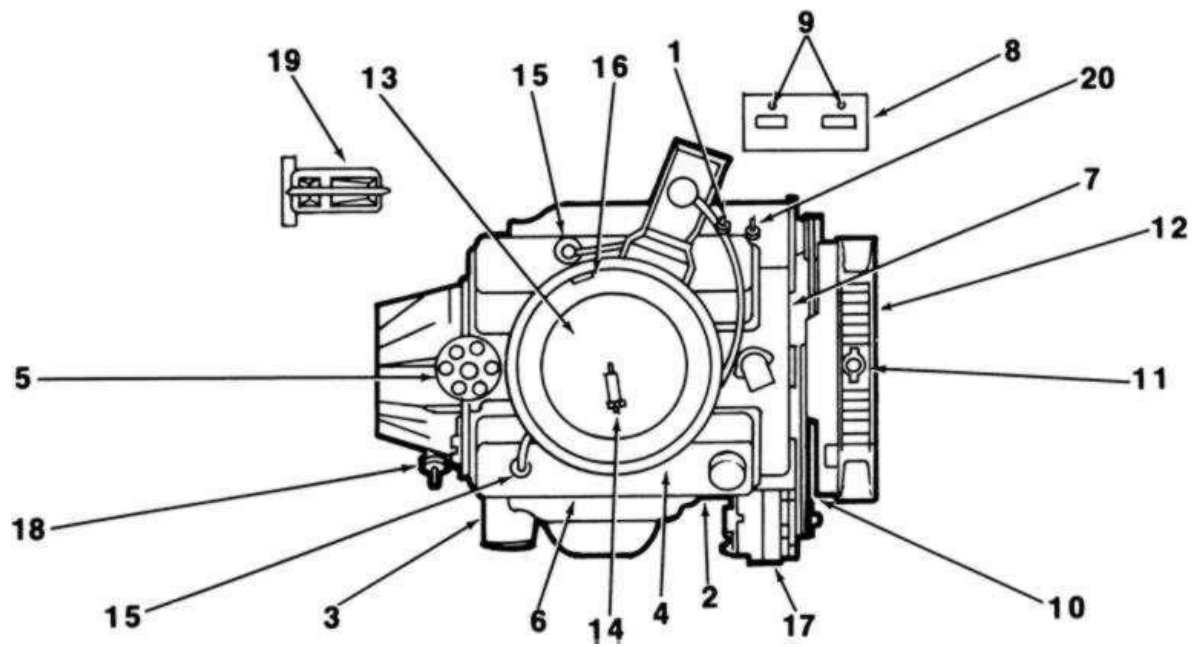


Fig. 3: Typical body and undervehicle maintenance locations (Refer to chart for descriptions)

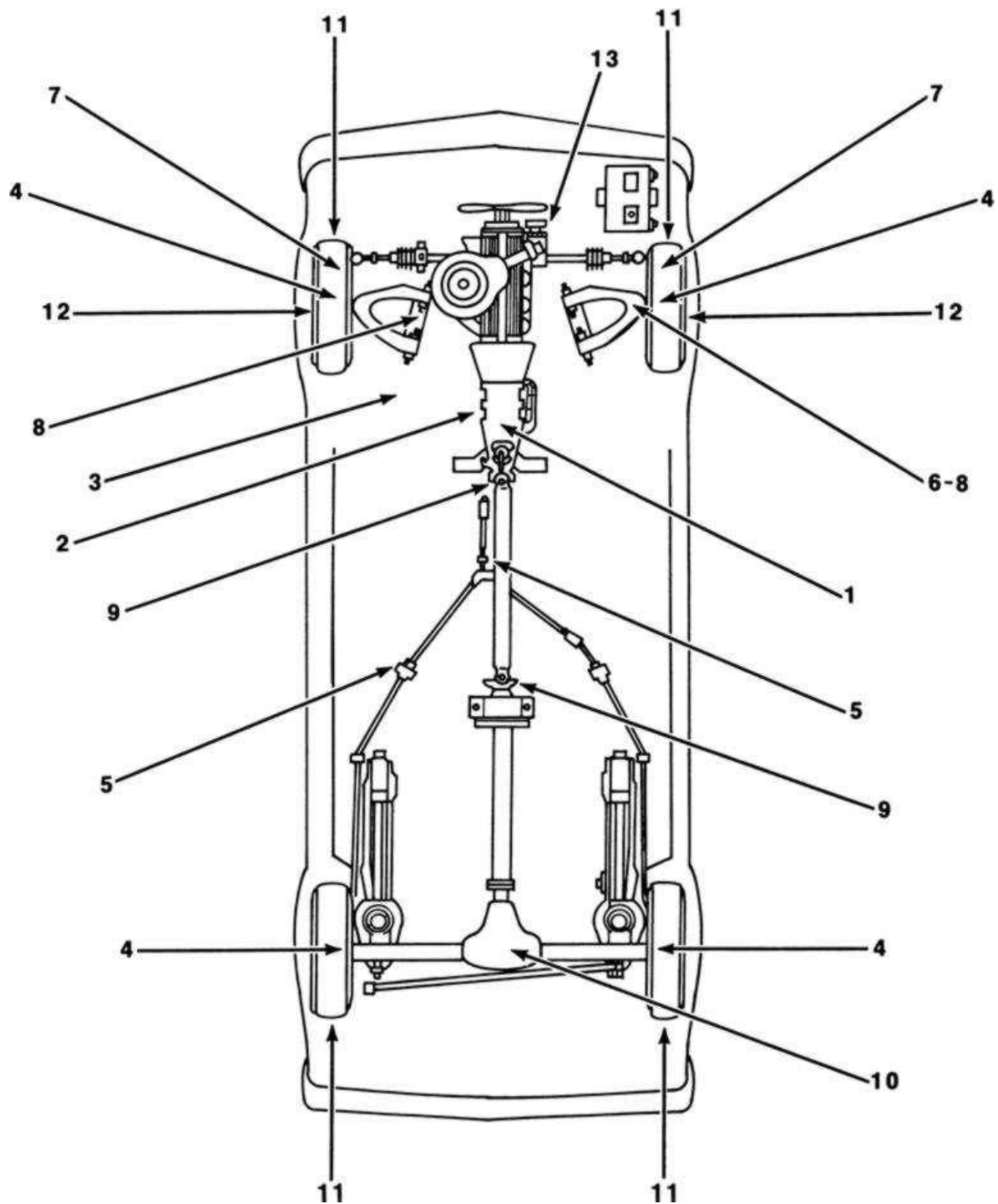


Fig. 4: Typical lubricants, from left to right: Engine Oil; Gear Oil; ATF; Wheel Bearing Grease; Brake Fluid; Chassis Grease; White Grease; and Silicone Spray



Fig. 5: Special tools make lubrication easier, from left to right: Oil Suction Gun; Oil Can; Funnel; Grease Gun; and Wheel Bearing Packers



UNDERHOOD MAINTENANCE INTERVALS

This chart gives minimum maintenance intervals by miles or time, whichever comes first, based on average of 12,000 miles per year. The recommendations given are general industry standards, and may be more strict than your manufacturer's schedules. Obviously, the type of driving you do will also affect your maintenance program. Refer to Fig. 1 and Fig. 2 for service locations. Note: This chart is an attempt to cover all vehicles, please refer to your owners manual for factory recommended service intervals.

Service Location	Item	Check Every
Engine		
1	Check oil, add if necessary	Fuel Stop
2	Drain oil	3000 miles/3 months
3	Replace oil filter	3000 miles/3 months
4*	Check valve clearance, adjust if necessary	12,000 miles/12 months
Ignition System		
6*	Replace spark plugs	18-30,000 miles/18-24 months
6*	Check spark plug wires	12,000 miles/12 months
6*	Replace spark plug wires	At least every 36,000 miles/3 years
5*	Replace distributor cap/rotor	12,000 miles/12 months
7*	Check/adjust ignition timing	12,000 miles/12 months
Battery		
9	Check/clean terminals and cables	3000 miles/3 months
Starter and Alternator		
9	Check electrical connections	3000 miles/3 months
10†	Check/adjust drive belt	3000 miles/3 months
10†	Replace drive belt	At least every 24,000 miles/2 years
Cooling System		
11	Check coolant level	1000 miles/1 month
12	Check condition of radiator hoses	1000 miles/1 month
11	Check condition of radiator cap	1000 miles/1 month
10†	Check/adjust drive belt	3000 miles/3 months
10†	Replace drive belt	At least every 24,000 miles/2 years
12	Clean radiator of debris	3000 miles/3 months
12	Drain/replace coolant	12,000 miles/12 months (Each Fall)
Fuel & Emissions System		
16*	Clean crankcase breather	12,000 miles/12 months
13	Replace air filter	12,000 miles/12 months
14	Replace fuel filter	12,000 miles/12 months
15*	Check PCV valve	12,000 miles/12 months
10*†	Check/adjust air pump belt tension	3,000 miles/3 months
10*†	Replace drive belt	At least every 24,000 miles/2 years
Air Conditioning		
12	Clean condenser grille	3000 miles/3 months
17	Check for leaks at connections	3000 miles/3 months
10*†	Check/adjust compressor belt	3,000 miles/3 months
10*†	Replace compressor drive belt	At least every 24,000 miles/2 years
Automatic transmission		
18*	Check fluid level/condition	6000 miles/6 months
Brakes		
19	Check brake master cylinder fluid level	1000 miles/1 month
19	Replace brake fluid	At least every 2 years
Hydraulic Clutch		
19*	Check clutch master cylinder fluid level	1000 miles/1 month
19*	Replace hydraulic clutch fluid	At least every 2 years
Power Steering		
20*	Check pump fluid level	3000 miles/3 months
10*†	Replace drive belt	At least every 24,000 miles/2 years
10*†	Check drive belt tension	3000 miles/1 month

(*) Denotes items that may not be applicable to all vehicles.

(†) Most modern accessory drive systems utilize one serpentine belt rather than numerous individual belts.

New drive belts will stretch with use. Recheck the tension of a newly installed belt after 200 miles.

BODY AND UNDERVEHICLE MAINTENANCE INTERVALS

This chart gives minimum maintenance intervals by miles or time, whichever comes first, based on average of 12,000 miles per year. The recommendations given are general industry standards, and may be more strict than your manufacturer's schedules. Obviously, the type of driving you do will also affect your maintenance program. Refer to Fig. 1 and Fig. 2 for service locations. Note: This chart is an attempt to cover all vehicles, please refer to your owners manual for factory recommended service intervals.

Service Location	Item	Check Every
	Automatic Transmission/Transaxle	
1	Change fluid	24,000 miles /2 years
1	Replace filter or clean screen	24,000 miles /2 years
	Manual Transmission/Transaxle	
2	Check lubricant level	3000 miles/3 months
2	Change lubricant	24,000 miles/2 years
	Transfer Case	
2*	Check lubricant level	3000 miles/3 months
2*	Change lubricant	24,000 miles/2 years
	Clutch	
3	Check clutch pedal free-play	6000 miles/6 months
2*	Lubricate shift and/or pedal linkage	6000 miles/6 months
	Brakes	
4	Check condition of brake pads or shoes	6000 miles/6 months
4	Check wheel cylinders, return springs, calipers, hoses, drums and/or rotors	6000 miles/6 months
5	Adjust parking brake	As necessary
	Suspension	
6	Check shock absorbers/struts	12,000 miles/12 months
7	Check tires for abnormal wear	1000 miles/1 month
8*	Lubricate front end	3000 miles/3 months
	Driveshaft	
9*	Lubricate U-joints	6000 miles/6 months
	CV-Joints/Boots	
6, 10*	Check for damage, wear and/or tears	3000 miles/3 months
	Drive Axles	
10	Check level of drive axle fluid	6000 miles/6 months
10	Replace drive axle fluid	24,000 miles/2 years
	Tires	
7	Check tires for abnormal wear	1000 miles/1 month
11	Clean tread of debris	As necessary
12	Check tire pressure	Each fuel stop/2 weeks
11	Rotate tires	6000 miles/6 months
11	Check tread depth	6000 miles/6 months
	Wheels	
12	Clean wheels	As necessary
12	Check wheel weights	Each fuel stop/2 weeks (when you check tire pressure)
11	Rotate wheel/tire	6000 miles/6 months
	Windshield wipers	
	Check and clean wiper blades	3000 miles/3 months
	Replace wiper blades	12,000 miles/12 months
	Lubricate linkage and pivots	6000 miles/6 months
	Check hoses and clean nozzles	3000 miles/3 months
	Windshield	
	Clean glass	Each fuel stop
	Air Conditioner	
13	Operate air conditioner for a few minutes	Once a week

(*) Denotes items that may not be applicable to all vehicles.

RECOMMENDED LUBRICANTS

Every manufacturer has specific recommendations for fluids and lubricants used in their vehicles Note: This chart is an attempt to cover all vehicles, please refer to your owners manual for factory recommended lubricants

Part	Lubricant
Engine	Engine oil API service rated SJ (gasoline engines) or CD (diesel engines) Viscosity determined by anticipated temperatures before next oil change or as recommended by the manufacturer
Automatic transmission	Automatic Transmission Fluid (ATF): Dexron III® / Mercon or Type F
Manual transmission/transaxle	SAE 80W-90 gear lubricant (API-GL4), ATF or engine oil Refer to the vehicles owner manual for specific fluid requirements
Transfer Case	SAE 80W-90 gear lubricant (API-GL4), ATF or engine oil Refer to the vehicles owner manual for specific fluid requirements
Power steering pump	Power steering fluid or ATF Refer to vehicles owner manual for specific fluid recommendations
Conventional drive axle	SAE 80W-90 through 90W-140 gear lubricant (API-GL4 minimum) Refer to the vehicles owner manual for specific fluid requirements
Limited slip drive axle	SAE 80W-90 through 90W-140 gear lubricant (API-GL5) Refer to the vehicles owner manual for specific fluid requirements NOTE: Special limited slip additive may be required
Wheel bearings	High melting point, long fiber wheel bearing grease
Brake master cylinder	Heavy duty brake fluid meeting DOT-3 specification or as noted on the cap
Clutch master cylinder	Heavy duty brake fluid meeting DOT-3 specification or as noted on the cap
Manual steering gear, suspension, ball joints, U-joints, clutch and gear shift linkage, steering linkage and other chassis lubrication points	Lithium base, multi-purpose chassis lubricant
Doors, hood, trunk and tailgate locks, seat tracks, parking brake	White grease
Accelerator linkage, door hinges, trunk and hood hinges	SAE 30 engine oil
Lock cylinders	Silicone spray lubricant or thin oil applied to key and inserted in lock
Weather stripping	Silicone spray lubricant

ENGINE ELECTRICAL

Service Precautions

Before servicing any vehicle read all of the following precautions that deal with personal safety, prevention of component damage, and important points to take into consideration when servicing a motor vehicle:

- If the battery is removed for any reason, ensure that it is reconnected with the correct polarity. Reversing the battery's polarity may result in damage to the one-way rectifiers.
- Never operate the generator with the main circuit broken. Ensure that the battery, generator, and regulator leads are not disconnected while the engine is running.
- Never attempt to polarize a generator.
- When charging a battery that is installed in the vehicle, disconnect the negative battery cable.
- When utilizing a booster battery as a starting aid always connect it in parallel; negative to negative and positive to positive.
- When arc (electric) welding is to be performed on any part of the vehicle disconnect the negative battery cable and generator leads.
- Never unplug the PCM while the engine is running or with the ignition in the ON position. Severe and expensive damage may result.
- Never attempt to charge or connect jumper cables to a frozen battery. The battery may explode. Bring the battery indoors where it can thaw before charging the battery.
- Never open, service or drain the radiator or cooling system when the engine is hot; serious burns and blindness can occur from the steam and hot coolant.
- Observe all applicable safety precautions when working around fuel. Whenever servicing the fuel system always work in a well ventilated area. Do not allow fuel spray or vapors to come in contact with sparks, open flame, or excessive heat (a hot drop light, for example). Keep a dry chemical fire extinguisher near the work area. Always keep fuel in a container specifically designed for fuel storage; and always properly seal fuel containers to avoid the possibility of fire or explosion. Refer to the additional fuel system precautions later in this section.
- Fuel injection systems often remain pressurized, even after the engine has been turned OFF. The fuel system pressure must be relieved before disconnecting any fuel lines. Failure to do so may result in fire and/or personal injury.
- The EPA warns that prolonged contact with used engine oil may cause a number of skin disorders including cancer. You should make every effort to minimize your exposure to used engine oil. Protective gloves should be worn when changing oil. Wash your hands and any other exposed skin areas as soon as possible after exposure to used engine oil. Soap and water or waterless hand cleaner should be used.
- Never operate the engine without the proper amount and type of engine oil. Doing so will result in severe engine damage.

- Timing belt maintenance is extremely important. Many models utilize an interference-type, non-freewheeling engine. If the timing belt breaks, the valves in the cylinder head may strike the pistons causing potentially serious (also time-consuming and expensive) engine damage. Refer to the maintenance interval charts in the front of this manual for the recommended replacement interval for the timing belt, and to the timing belt section for belt replacement and inspection.
- All new vehicles are now equipped with an air bag system. The system must be disabled before performing service on or around system components, steering column, instrument panel components, wiring and sensors. Failure to follow safety and disabling procedures could result in accidental air bag deployment, possible personal injury and unnecessary system repairs.
- Always wear safety goggles when working with, or around, the air bag system. When carrying a non-deployed air bag, be sure the bag and trim cover are pointed away from your body. When placing a non-deployed air bag on a work surface, always face the bag and trim cover upward, away from the surface. This will reduce the motion of the module if it is accidentally deployed. Refer to the additional air bag system precautions later in this section.
- Disconnecting the negative battery cable on some vehicles may interfere with the functions of the on-board computer system(s) and may require the computer to undergo a relearning process once the negative battery cable is reconnected.
- Batteries contain corrosive acid. Batteries supply current high enough to cause burns. Batteries produce explosive gases. When working on batteries always wear eye protection. Never allow battery acid to contact the skin or eyes. Do not allow sparks or flames near the battery.

NOTE: Disconnecting the negative battery cable on some vehicles may interfere with the functions of the on board computer system. The computer may undergo a relearning process once the negative battery cable is reconnected.

Ignition System

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

General Information

NOTE: For information on understanding electricity and troubleshooting electrical circuits, please refer to chassis electrical.

Coil on Plug (COP) System

The coil over plug system was developed so that spark and spark timing could be better controlled on an individual cylinder basis. Each cylinder has an ignition coil mounted directly above the spark plug on the cylinder head cover. A short suppresser/connector replaces the spark plug wire and links the coil to the plug. There are different methods used for primary triggering. Some manufacturers use a combination coil/module, which means each coil has its own control circuit that is activated by the PCM. Others use remote mounted modules to trigger the coils.

Each individual coil is allowed to saturate while all other cylinders fire. For a V-8 engine, this allows a period of seven firing events for coil saturation, compared to three events for the same V-8 engine with a waste spark system. The coil over plug system also benefits from a minimum amount of energy lost, due to the resistance of spark plug wires.

Magnetic Sensor / Pick-Up Coil

The magnetic sensor in electronic ignition system is made up of a small coil of wire wrapped around an iron core, a permanent magnet and a toothed wheel called a reluctor. These sensors can be found mounted in a distributor, or at the front, middle, or rear of the crankshaft or camshaft, and are two-wire sensors.

The permanent magnet produces a magnetic field that passes thru the center of the pick-up coil. As the reluctor turns, the small teeth enter the magnetic field. Because the metal is a better conductor for the field than the air between the magnet and reluctor, the field strength begins to increase and reaches its maximum when the reluctor teeth are closest to the sensor. An increase in magnetic field induces a positive voltage to the module. As the teeth leave the magnetic field, the decrease in pole strength induces a negative voltage into the module. This alternating positive and negative voltage causes a small AC current. This alternating current after passing through an analog/digital converter is used by the module or engine controller to trigger the primary circuit.

Hall-Effect Device

Another device that can be used to create a triggering signal is a hall-effect device. A hall-effect device can be thought of as a solid-state On/Off switch. The hall-effect switch is a three-wire device that must receive a power and ground. The hall-effect switch is used in conjunction with an interrupter ring with a series of slots or openings cut into it. Depending on the application, these slots are spaced around the ring in a specific configuration. As the ring rotates, the slots pass between the hall-effect switch, and alternately turns the voltage off and on. When a slot aligns with the hall-effect switch, the controller sees voltage on the signal line. When the area between slots passes the hall-effect switch, the signal is pulled low. This results in a voltage of 0V–0.1V at the controller.

Ignition Coil

The heart of the automotive ignition system is the ignition coil. The ignition coil is a step-up transformer, since it boosts battery voltage to the high voltage that is necessary for proper combustion.

The ignition coil consists of a primary winding and secondary winding wrapped around a soft iron core. The primary winding is made up of several hundred turns of heavy wire, while the secondary winding consists of thousands of turns of fine wire. The iron core is used to conduct magnetic lines of force efficiently.

When current flows through the primary winding, a magnetic field is created. The more time current is permitted to flow, the stronger the magnetic field becomes. When the current is turned off, the magnetic field collapses causing a high voltage to be induced in the secondary winding through the process of induction.

A few hundred volts will be generated in the primary winding because of the collapsing magnetic field across the heavy primary wire. However, as the magnetic lines of force cut across the thousands of turns of fine wire in the secondary, a far greater voltage is produced. The production of primary voltage is called self-induction, since the primary winding essentially magnifies its own initial voltage when the magnetic field collapses.

Related Symptoms

Faulty ignition system components along with loose connections, bad grounds, high resistance or opens in the circuit, may cause the following symptoms:

- No start condition
- Stalling after cold start
- Stalling after hot start
- Surging off idle
- Extended crank time when engine is cold
- Unstable idle
- Running rough during off idle acceleration
- Bucking
- Hesitation
- Stumble
- Poor fuel economy

Starting System

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

General Information

The starting system includes the battery, starter motor and solenoid, ignition switch, circuit protection and wiring connecting all of the components. An inhibitor switch located in the Transmission Range (TR) sensor is included in the starting system to prevent the vehicle from being started unless the transmission is in PARK. A similar function is performed by the clutch switch in manual transmission vehicles.

When the ignition key is turned to the START position, current flows and energizes the starter's solenoid coil. The solenoid plunger and clutch shift lever are activated and the clutch pinion engages the ring gear on the flywheel. The switch contacts close, and the starter cranks the engine until the engine starts.

To prevent damage caused by excessive starter armature rotation when the engine starts, the starter incorporates an over-running clutch in the pinion gear. This disengages the starter motor from the engine when the engine begins to run on its own.

Battery

Removal & Installation

To Remove:

CAUTION

Make sure to connect the correct battery cables to the correct battery terminals. Reversing the battery's polarity may result in extensive damage to electrical components.

1. Turn the ignition switch to the OFF position.
2. Turn off all lighting and accessories.
3. Disconnect the negative battery cable first, and then the positive cable.
4. Remove the hardware securing the battery to the tray.
5. If equipped, remove the battery cover.
6. Remove the battery from the tray.

To Install:

1. Position the battery on the tray and install the cover if equipped.
2. Clean the battery terminals and cable ends with a wire brush.
3. Install the battery hold down bracket and fasteners. Do not make the fastener so tight as to damage the battery.
4. Connect the positive battery cable first and then the negative cable.

Starter

Testing

Starting System Voltage Drop Tests

NOTE: The battery must be in good condition and fully charged prior to performing this test.

There are three area of the starter motor circuits that voltage drop test can be performed on. These include:

- The starter feed circuit
- The starter ground circuit
- The starter solenoid.

Starter Feed Circuit

1. Disable the fuel system by removing the fuel pump fuse or the fuel pump relay.
2. Verify that the vehicle will not start.
3. Connect the positive lead of a voltmeter to the positive terminal of the battery.
4. Connect the negative lead of a voltmeter to the starter B+ terminal.
5. Turn the ignition key to the START position and note the voltage displayed on the voltmeter.
 - Ideally, there should be no more than 0.1 volt drop for each connection displayed on the voltmeter. No voltage should be consumed by the vehicle wiring
 - A. If the battery cable connects directly to the starter motor there should be no more than a 0.2 volt drop measured
 - B. If the vehicle uses a starter solenoid between the battery and the starter motor terminal there should be no more than 0.4 volt displayed on the voltmeter

Starter Ground Circuit

1. Disable the fuel system by removing the fuel pump fuse or the fuel pump relay.
2. Verify that the vehicle will not start.
3. Connect the positive lead of the voltmeter to the case of the starter motor.
4. Connect the negative lead of the voltmeter to the negative terminal of the battery.
5. Turn the ignition key to the START position and note the voltage displayed on the voltmeter.
 - Ideally, there should be no more than 0.1 volt drop for each connection displayed on the voltmeter. No voltage should be consumed by the vehicle wiring
 - A. If the battery cable connects directly to the starter motor there should be no more than a 0.2 volt drop measured.

Starter Solenoid

1. Disable the fuel system by removing the fuel pump fuse or the fuel pump relay.
2. Verify that the vehicle will not start.
3. Connect the positive lead of the voltmeter to the case starter B+ terminal.
4. Connect the negative lead of the voltmeter to the lug (the starter **M** terminal) that connects the starter solenoid to the starter motor.
5. Turn the ignition key to the START position and note the voltage displayed on the voltmeter.
 - Ideally, there should be no more than 0.2 volt drop across the starter solenoid displayed on the voltmeter.

In general, there should be no more than a 1.0 volt drop throughout the entire starter motor feed and ground circuit. Any voltage drops measured in either the feed or ground circuits after connections have been cleaned will require replacement of the affected battery cable. Typically, any voltage drops measured in the solenoid are repaired by replacing the starter motor.

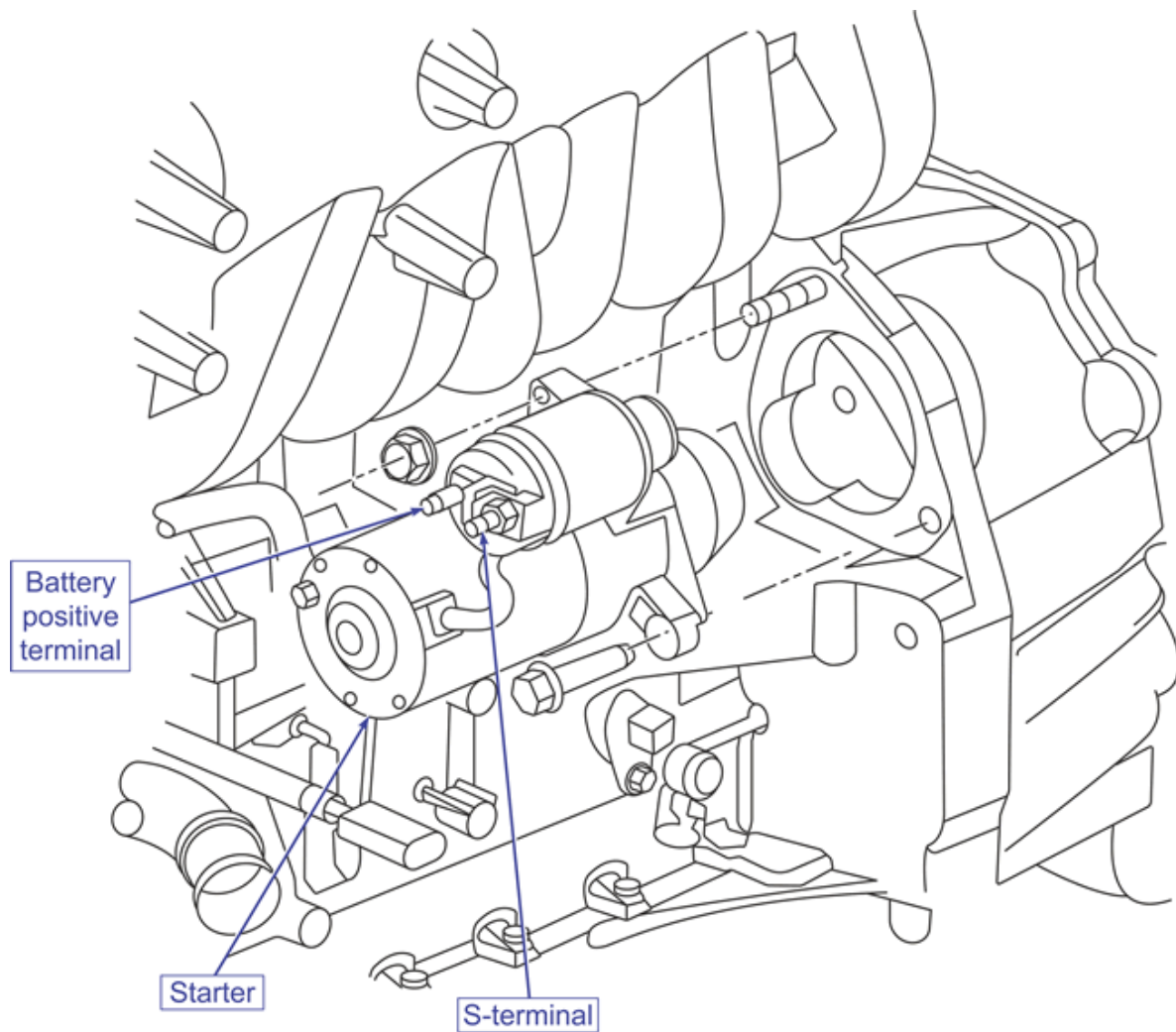
Removal & Installation

4.2L Engine

To Remove:

1. Disconnect the negative battery cable from the battery.
2. Disconnect the brake booster hoses from the engine.

Starter



3. Remove the positive battery cable and s-terminal lead from the starter.
4. Remove the starter from the engine.

To Install:

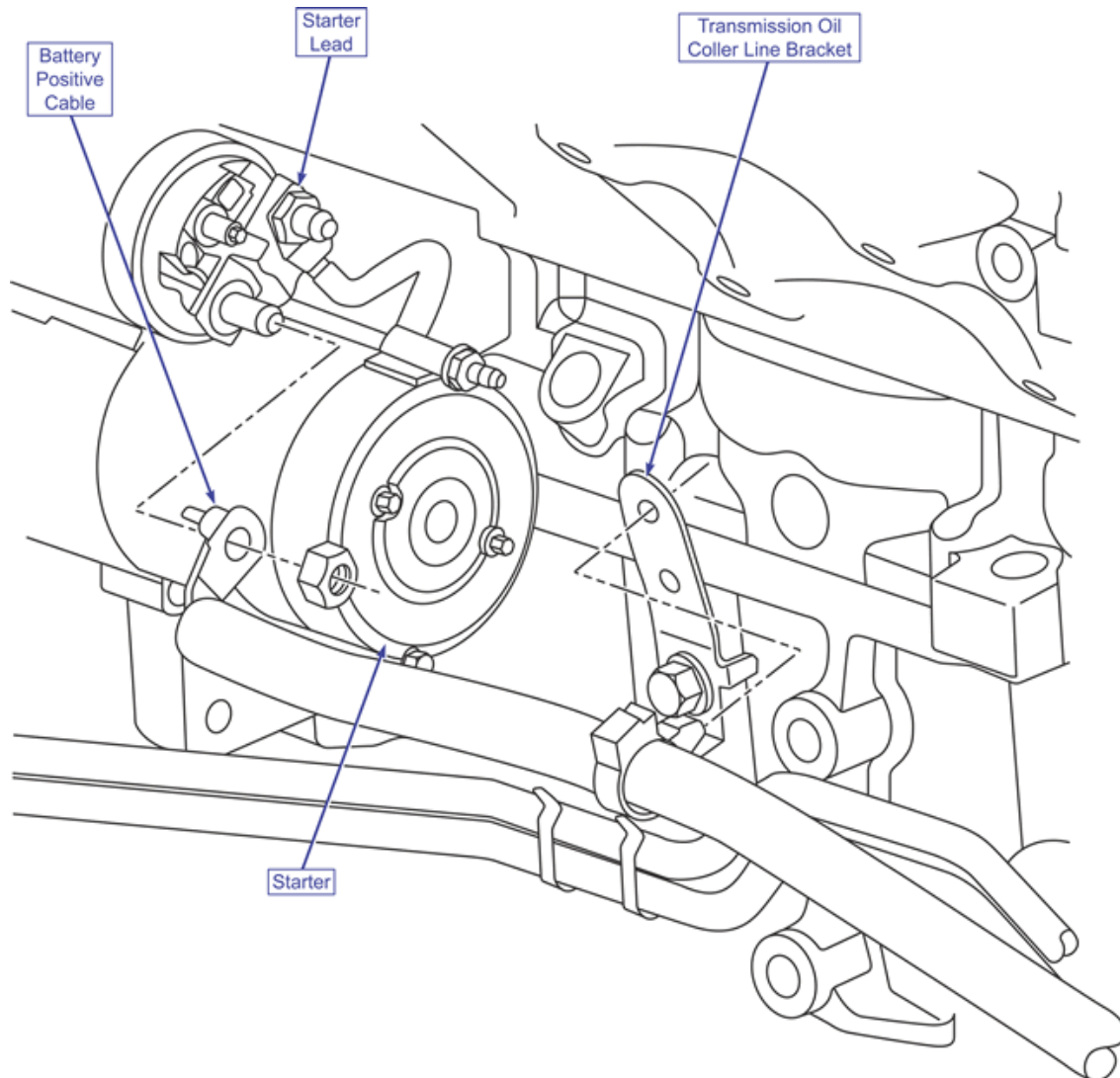
1. Install the starter to the engine. Tighten the nut and bolt to **37 ft-lb (50 Nm)**.
2. Install the positive battery cable and s-terminal to the starter. Tighten the battery cable nut to **80 in-lb (9 Nm)**. Tighten the s-terminal nut to **20 in-lb (2.3 Nm)**.
3. Connect the vacuum brake booster hose to the engine.
4. Connect the negative battery cable to the battery.

5.3L & 6.0L Engines

To Remove:

1. Disconnect the negative battery cable from the battery.
2. Raise and support the vehicle.
3. Remove the rear steering gear crossmember from the frame.

Starter



4. Detach the wire harness from the transmission oil cooler line bracket.
5. Detach the transmission oil cooler line bracket from the engine.
6. Remove the right transmission cover bolt from the transmission cover.
7. Detach the starter from the engine.
8. Slide the starter forward and remove the transmission cover.
9. Remove the heat shield from the starter.
10. Position the starter so that it can pass between the engine oil pan and transmission oil cooler lines.
11. Detach the starter lead and battery positive cable from the starter.
12. Remove the starter from the vehicle.

To Install:

1. Place the starter between the engine oil pan and transmission oil cooler lines.
2. Attach the battery positive cable to the starter and starter lead. Torque the battery positive cable nut to **80 in-lb (9 Nm)**. Torque the starter lead nut to **30 in-lb (3.4 Nm)**.
3. Install the heat shield to the starter.
4. Attach the starter from the engine. Torque the bolts to **37 ft-lb (50 Nm)**.
5. Install the right transmission cover bolt into the transmission cover. Torque the bolt to **80 in-lb (9 Nm)**.
6. Attach the transmission oil cooler line bracket to the engine. Torque the bolt to **80 in-lb (9 Nm)**.
7. Attach the wire harness to the transmission oil cooler line bracket.
8. Install the rear steering gear crossmember onto the frame.
9. Lower the vehicle.
10. Connect the negative battery cable to the battery.

Starter Relay

Removal & Installation

To Remove:

1. Remove the underhood fuse block cover.
2. Find the starter the relay.
3. Use the J 43244 relay puller pliers to remove the relay.

To Install:

1. Place the relay in the same orientation as before it was removed.
2. Replace the electrical center cover.

ENGINE REPAIR

Precautions

Before servicing any vehicle, please be sure to read all of the following precautions, which deal with personal safety, prevention of component damage and important points to take into consideration when servicing a motor vehicle:

- Always wear safety goggles or some type of eye/face protection when working with, around or under a vehicle.
- Be extremely careful while working on an operating engine, make sure you have no dangling jewelry, extremely loose clothes, power tool cords or other items that could get caught in any moving engine part.
- Never open, service or drain the radiator or cooling system when the engine is hot; serious burns can occur from the steam and hot coolant.
- Observe all applicable safety precautions when working around fuel. Whenever servicing the fuel system, always work in a well-ventilated area. Do not allow fuel spray or vapors to come in contact with a spark, open flame, or excessive heat (a hot drop light, for example). Keep a dry chemical fire extinguisher near the work area. Always keep fuel in a container specifically designed for fuel storage; also, always properly seal fuel containers to avoid the possibility of fire or explosion. Refer to the additional fuel system precautions later in this section.
- Fuel injection systems often remain pressurized, even after the engine has been turned OFF. The fuel system pressure must be relieved before disconnecting any fuel lines. Failure to do so may result in fire and/or personal injury.
- The EPA warns that prolonged contact with used engine oil may cause a number of skin disorders, including cancer! You should make every effort to minimize your exposure to used engine oil. Protective gloves should be worn when changing oil. Wash your hands and any other exposed skin areas as soon as possible after exposure to used engine oil. Soap and water, or waterless hand cleaner should be used.
- Never operate the engine without the proper amount and type of engine oil; doing so WILL result in severe engine damage.
- Brake fluid often contains polyglycol ethers and polyglycols. Avoid contact with the eyes and wash your hands thoroughly after handling brake fluid. If you do get brake fluid in your eyes, flush your eyes with clean, running water for 15 minutes. If eye irritation persists, or if you have taken brake fluid internally, IMMEDIATELY seek medical assistance.
- Timing belt maintenance is extremely important! Many models utilize an interference-type, non-freewheeling engine. If the timing belt breaks, the valves in the cylinder head may strike the pistons, causing potentially serious (also time-consuming and expensive) engine damage. Refer to the maintenance interval charts in the front of this manual for the recommended replacement interval for the timing belt and to the timing belt section for belt replacement and inspection.
- Disconnecting the negative battery cable on some vehicles may interfere with the functions of the on-board computer system(s) and may require the computer to undergo a relearning process once the negative battery cable is reconnected.

Cleanliness and Care, Shop Practice

- It should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

Engine Mechanical

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

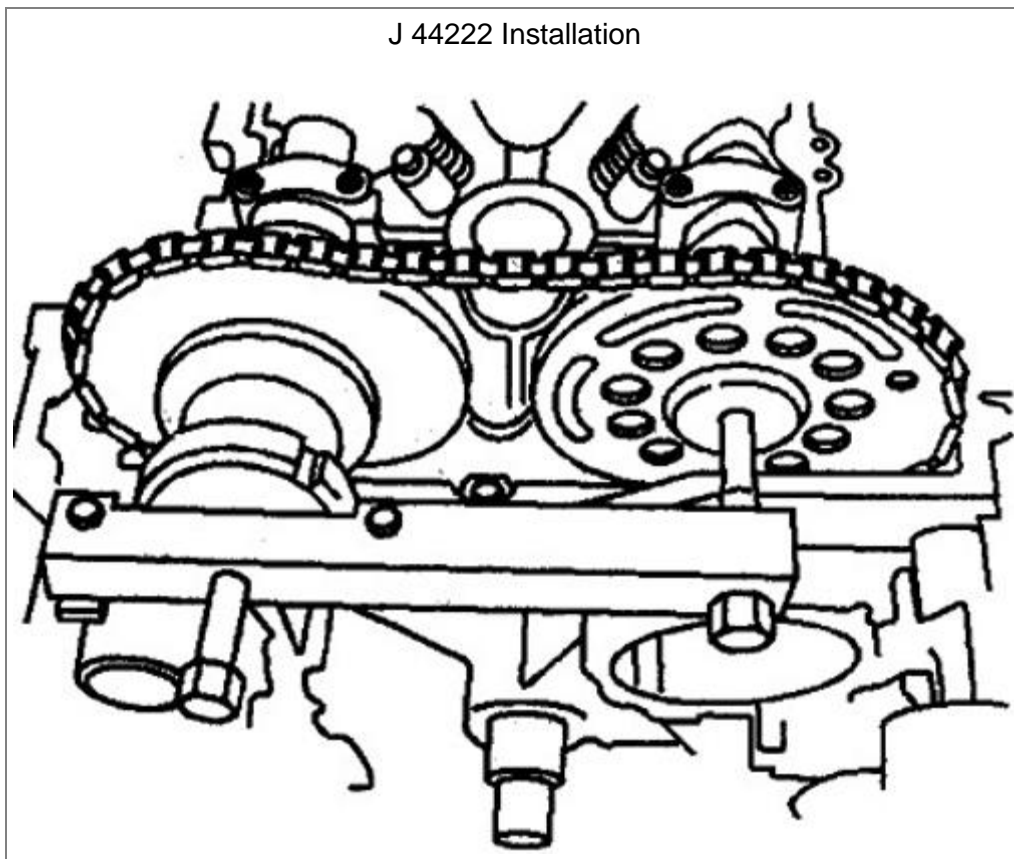
Camshaft

Removal & Installation

4.2L Engine

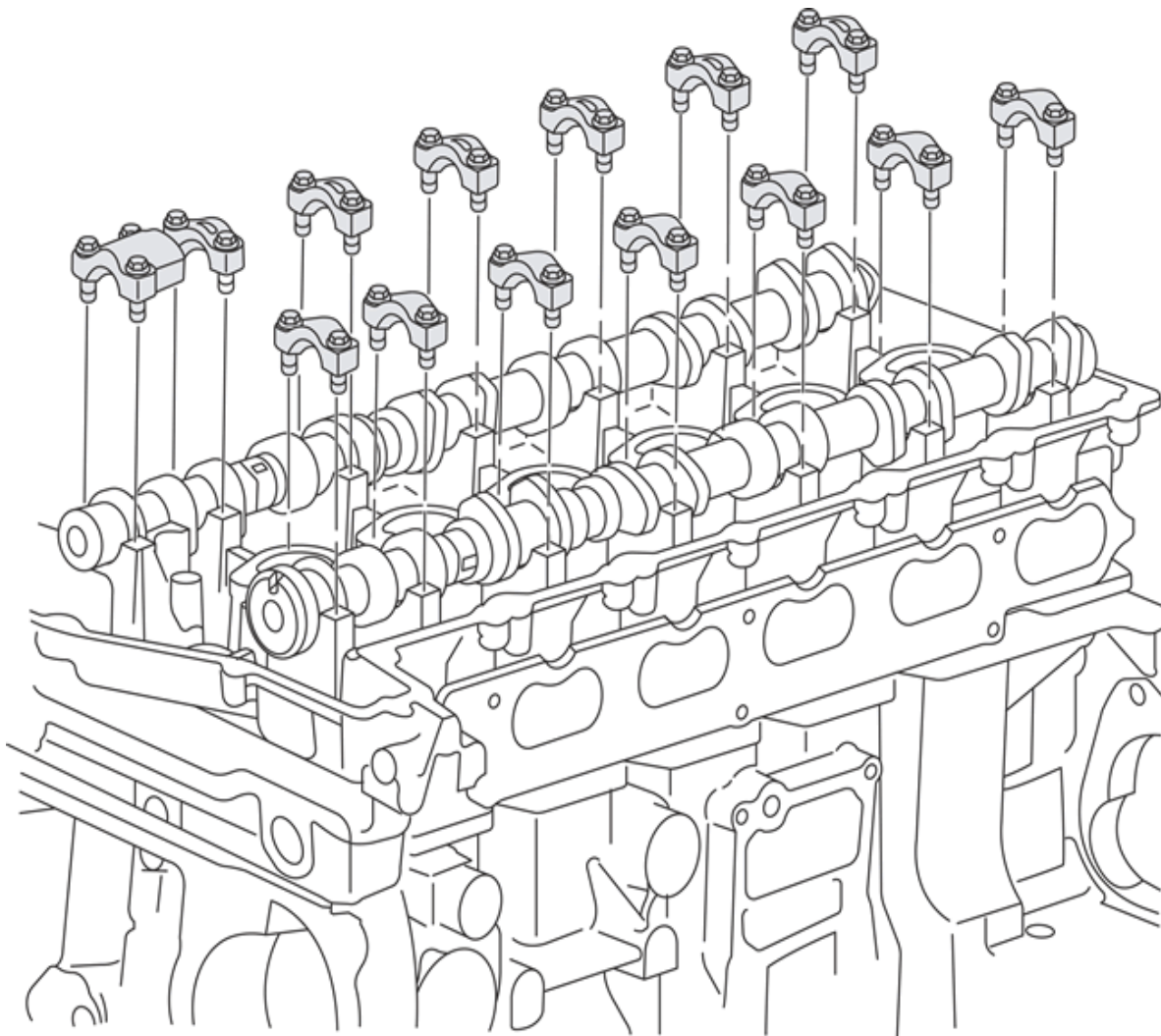
To Remove:

1. Remove the camshaft cover from the cylinder head.
2. Remove the bolt from the intake camshaft sprocket.
3. Remove the bolt from the exhaust camshaft actuator.



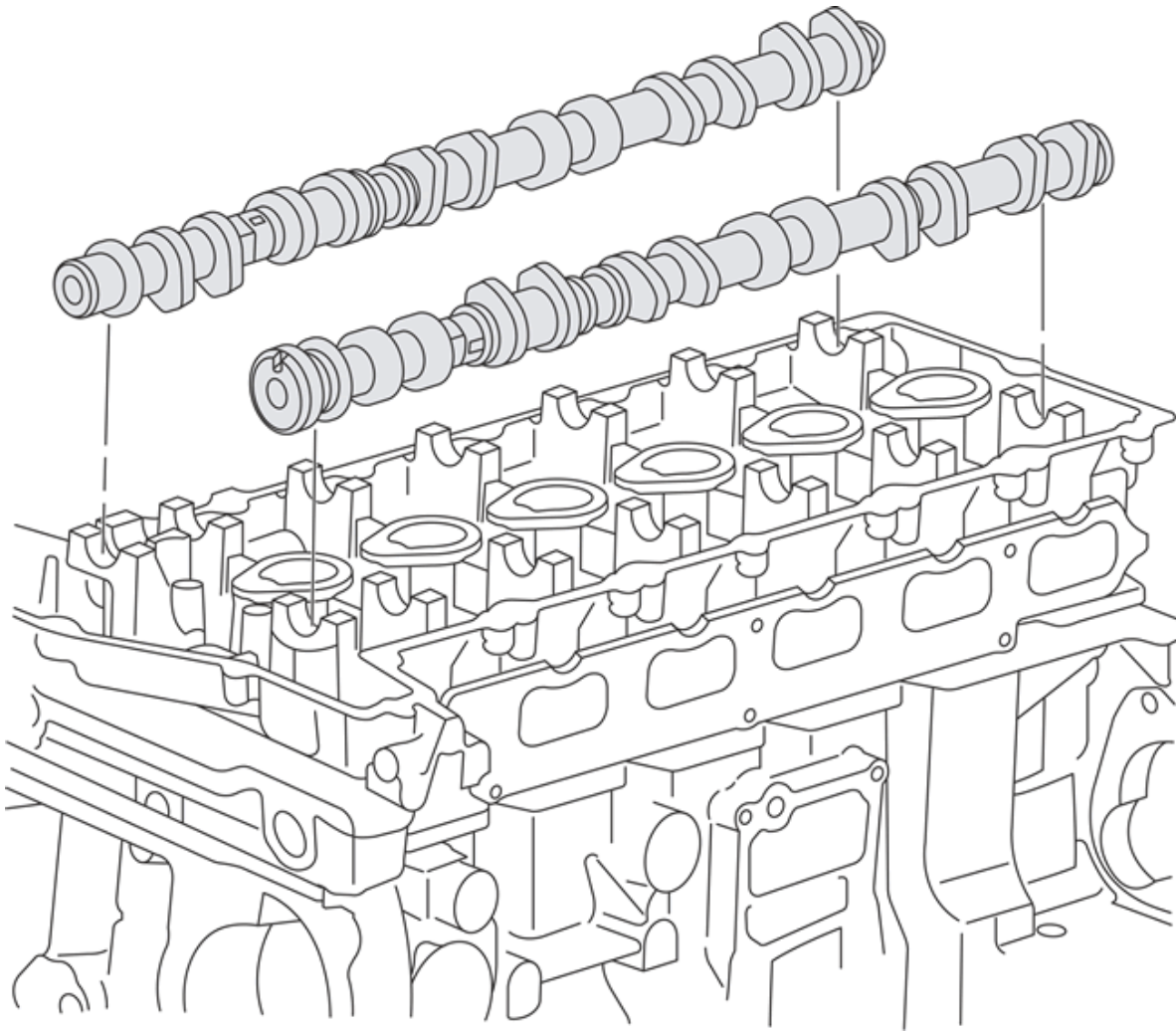
4. Attach a J 44222 camshaft sprocket holding tool to the camshaft sprockets.
5. Remove the camshaft sprockets with the J 44222 camshaft sprocket holding tool and timing chain from the camshafts.

Camshaft cap removal and installation



6. Detach the camshafts caps from the cylinder head. Make sure to place the caps in a rack to ensure they are installed in the same location they were removed from.

Camshaft removal and installation



7. Remove the camshafts from the cylinder head.

To Install:

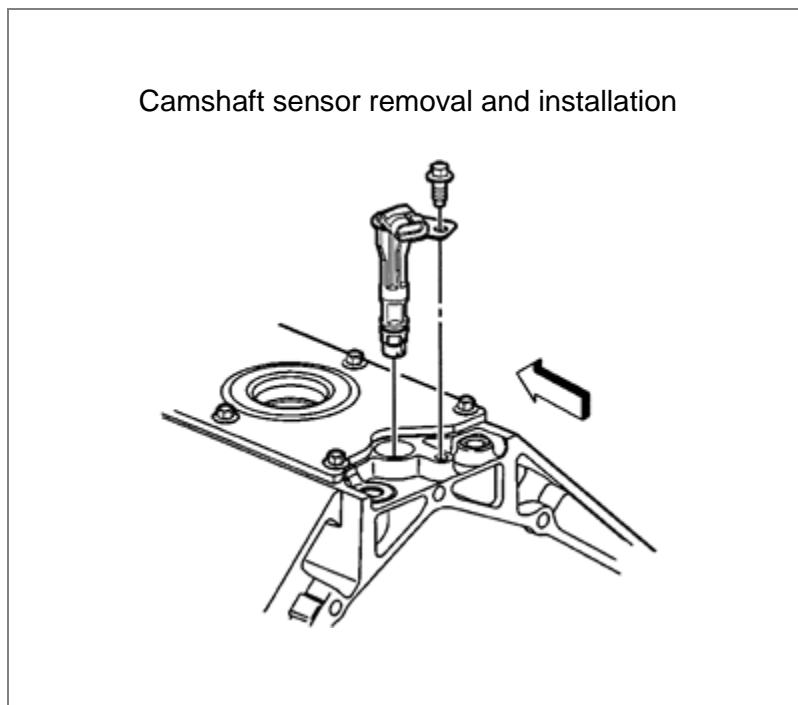
1. Use clean engine oil to coat the camshafts.
2. Install the camshafts into the cylinder head.
3. Attach a J 44221 camshaft holding tool to the camshafts. Make sure cylinder 1 is at top dead center and the camshaft flats are facing up.
4. Attach the camshaft caps to the cylinder head. Torque the bolts to **106 in-lb (12 Nm)**.
5. Detach the J 44221 camshaft holding tool from the camshafts.
6. Install the camshaft sprockets onto the camshafts.
7. Detach the J 44222 camshaft sprocket holding tool from the camshafts.
8. Install the bolt and washer into the intake camshaft sprocket. Torque the bolt to **15 lb-ft (20 Nm)**.
9. Use a J 36660-A torque/angle meter to turn the intake camshaft sprocket bolt **an additional 100 degrees**.

10. Install the bolt and washer into the exhaust camshaft actuator. Torque the bolt to **18 lb-ft (25 Nm)**.
11. Use a J 36660-A torque/angle meter to turn the exhaust camshaft actuator bolt **an additional 135 degrees**.
12. Install the camshaft cover onto the cylinder head.

5.3L & 6.0L Engines

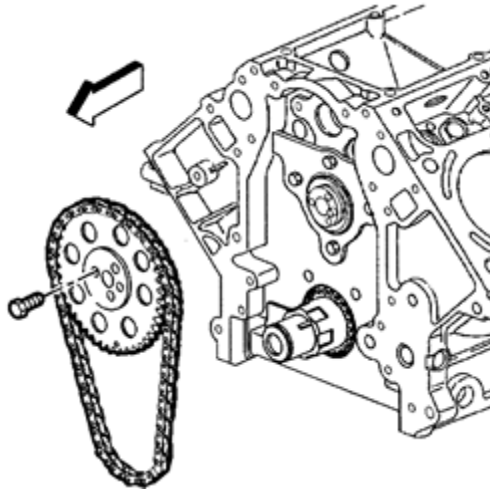
To Remove:

1. Remove the condenser from the radiator.
2. Remove the left and right cylinder heads and gaskets from the engine block.
3. Remove the valve lifters from the engine block.



4. Detach the camshaft sensor from the engine block.
5. Align the timing marks on the camshaft and crankshaft sprockets.

Camshaft sprocket removal and installation

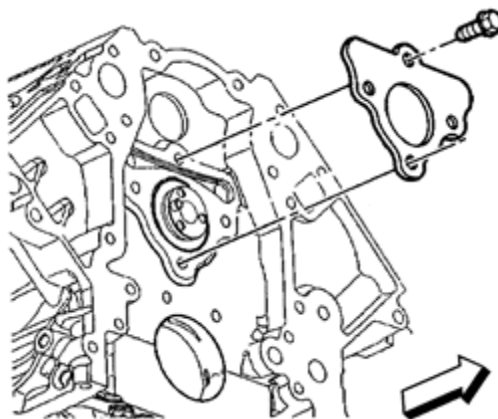


6. Detach the camshaft sprocket with the timing chain from the camshaft.

CAUTION

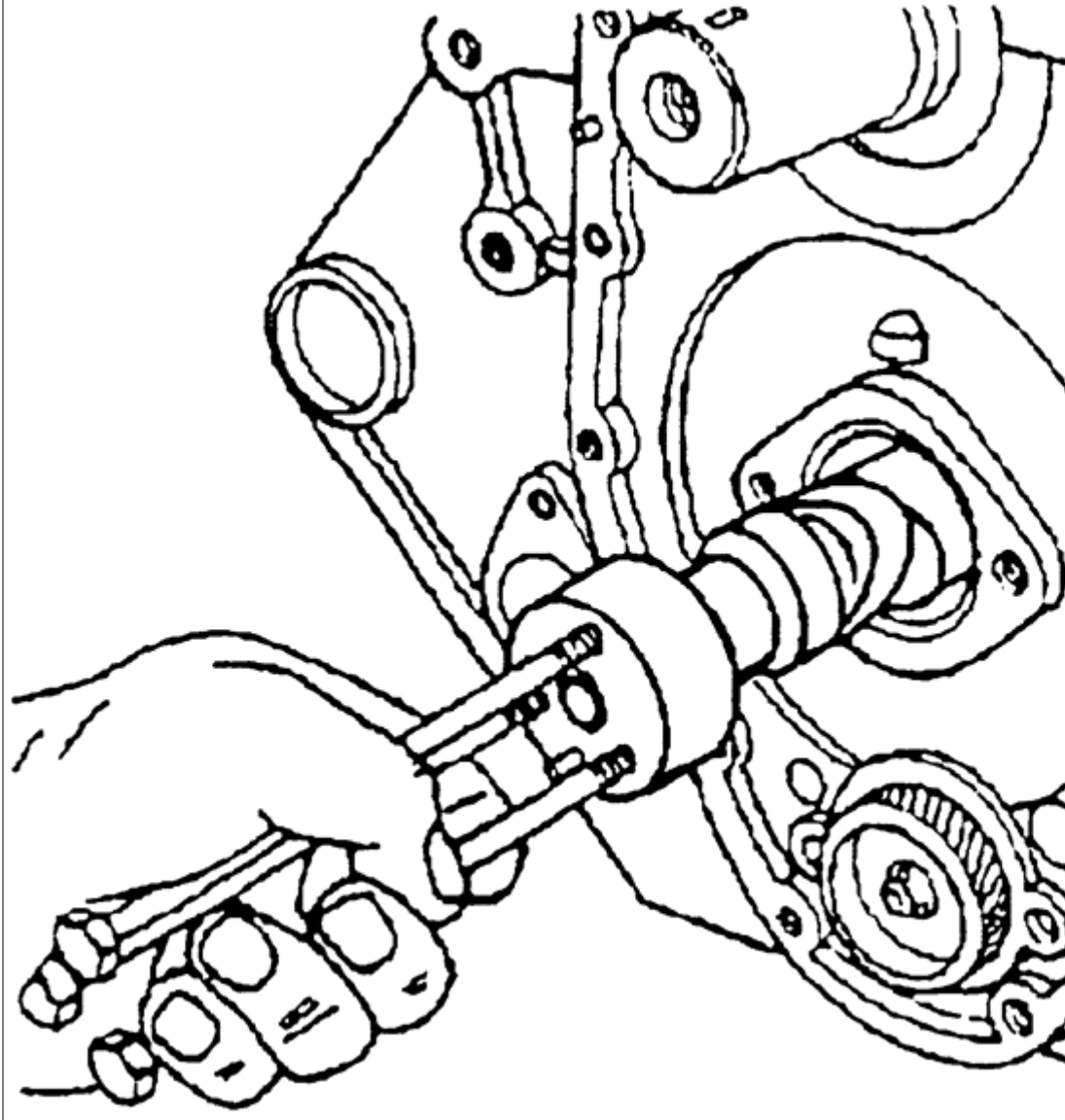
In order to prevent damage to the piston assemblies or valves, do not turn the crankshaft assembly after the camshaft sprocket has been removed.

Camshaft retainer removal and installation



7. Detach the camshaft retainer from the engine block.

Camshaft removal and installation



8. Install a M8-1.25 x 4.0 in (M8-1.25 x 100 mm) bolt into each of the bolt holes in the front of the camshaft.
9. Rotate and pull the camshaft out of the engine block using the bolts as a handle.
10. Clean sealing surfaces as necessary.

To Install:

1. Use clean engine oil to lubricate the camshaft.
2. Rotate and push the camshaft into the engine block using the bolts as a handle.
3. Remove the bolts from the bolt holes in the front of the camshaft.

4. Attach the camshaft retainer onto the engine block. Torque the bolts to **18 ft-lb (25 Nm)**.
5. Attach the camshaft sprocket with the timing chain onto the camshaft. Make sure the timing marks on the camshaft and crankshaft sprockets are lined up. Torque the bolts to **26 ft-lb (35 Nm)**.
6. Make sure the camshaft sensor is undamaged and lubricate it with clean engine oil.
7. Attach the camshaft sensor onto the engine block. Torque the bolt to **18 ft-lb (25 Nm)**.
8. Install the valve lifters into the engine block.
9. Install the left and right cylinder heads and gaskets onto the engine block.
10. Install the condenser into the radiator.

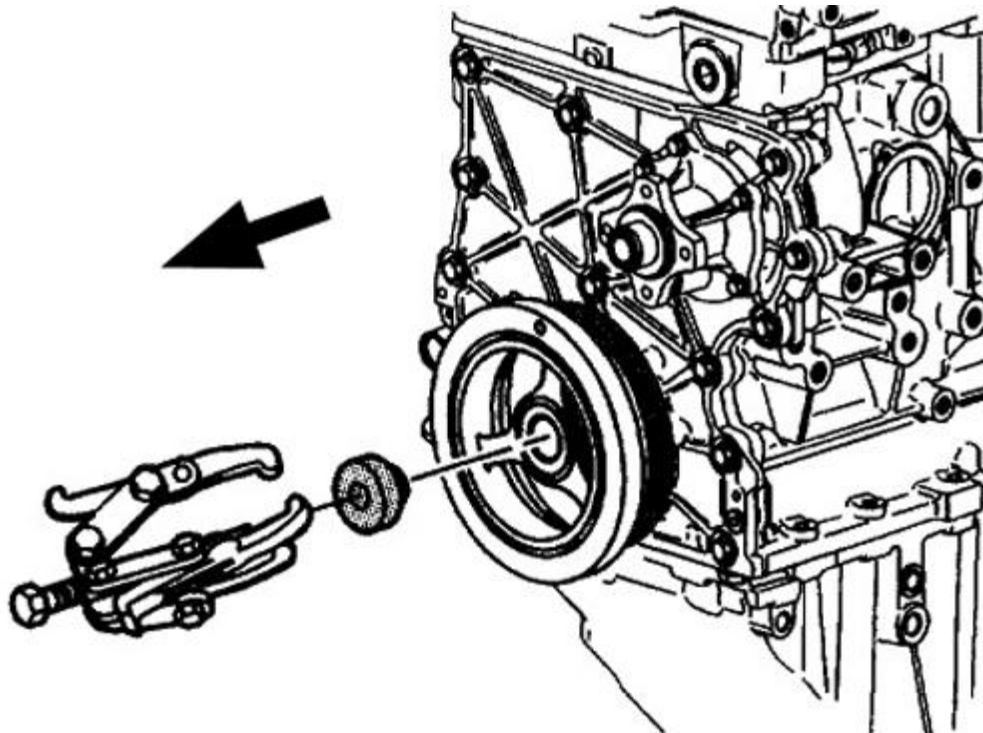
Removal & Installation

4.2L Engine

To Remove:

1. Remove the cooling fan and drive belt from the engine.
2. Remove the crankshaft balancer bolt from the crankshaft balancer.

Crankshaft balancer

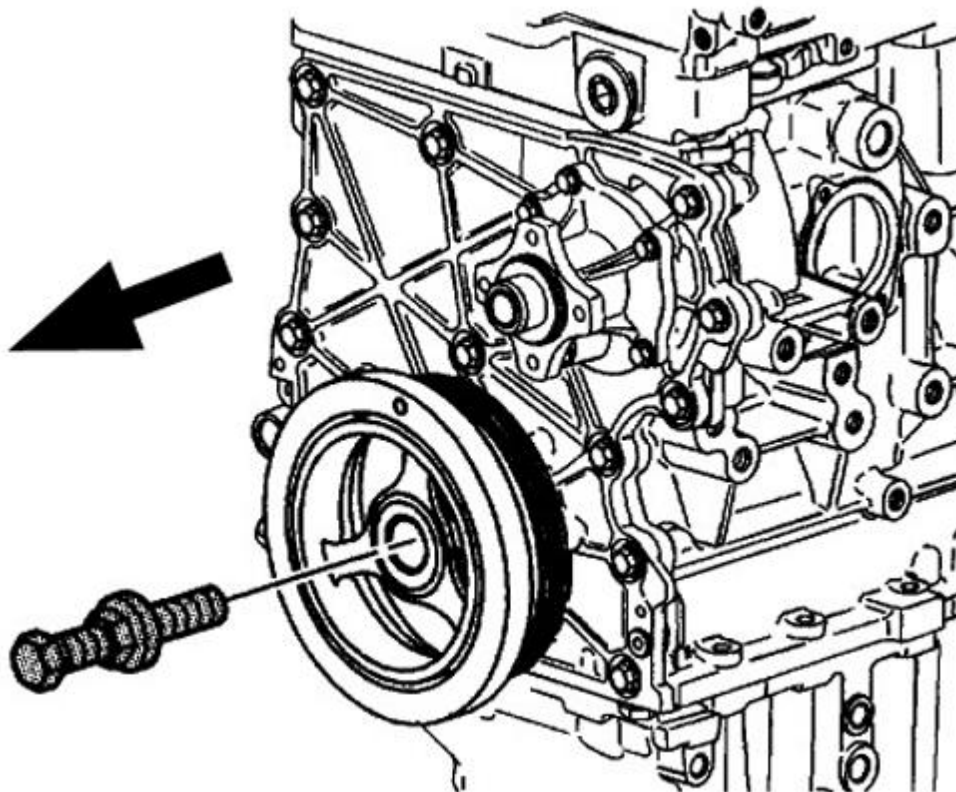


3. crankshaft end protector into the end of the crankshaft and use a 3 jaw puller to remove the crankshaft balancer.
4. crankshaft end protector from the end of the crankshaft.
5. Remove and discard the crankshaft balancer shim from the crankshaft snout.

To Install:

1. Lift the vehicle.
2. Remove the torque converter access plug from the oil pan.
3. Install a J 44226 crankshaft balancer holder to the torque converter.
4. Install a new crankshaft balancer shim on to the crankshaft snout.

Crankshaft balancer installer



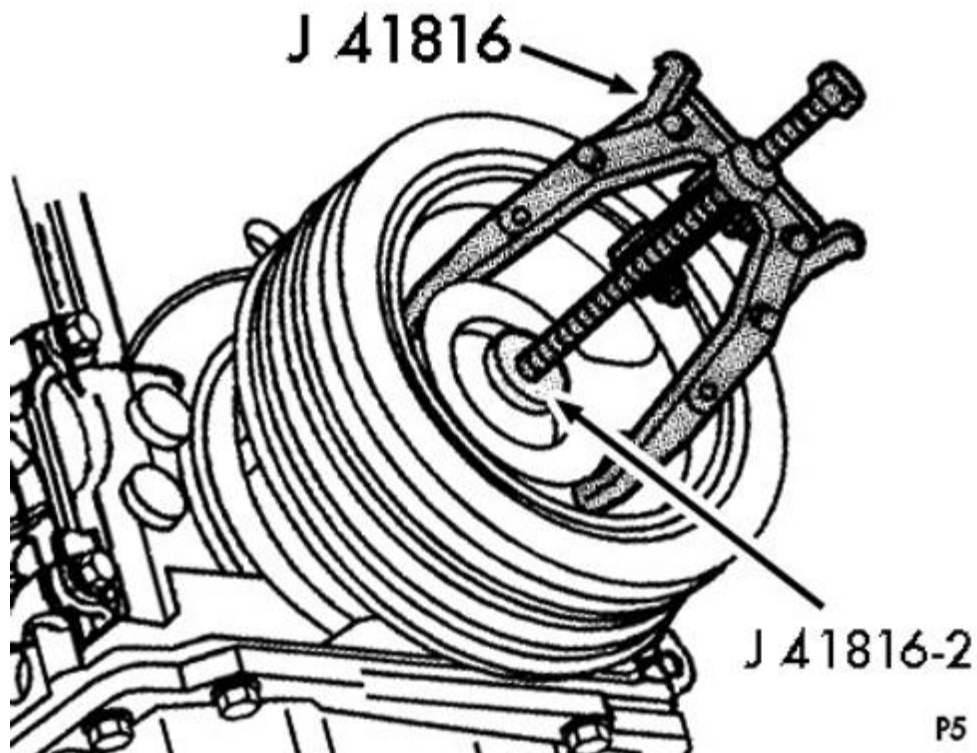
5. Use a EN-48034 harmonic balancer installer to install the crankshaft balancer to the crankshaft.
6. Remove the EN-48034 harmonic balancer installer from the crankshaft balancer.
7. Install a new crankshaft balancer washer and bolt. Torque the bolt to **110 ft-lb (150 Nm)**. Use a J 36660-A torque angle meter to turn the bolt an **additional 180 degrees**.
8. Remove the J 44226 crankshaft balancer holder from the torque converter.
9. Install the torque converter access plug back into the oil pan.
10. Lower the vehicle.
11. Install the drive belt and cooling fan onto the engine.

5.3L & 6.0L Engines

To Remove:

1. Remove the drive belt from the pulleys.
2. Remove the A/C drive belt from the pulleys.
3. Remove the cooling fan and starter from the engine.
4. Install a J 42386-A flywheel holding tool onto the flywheel. Torque the bolt to **37 ft-lb (50 Nm)**.
5. Remove the crankshaft balancer bolt from the crankshaft balancer.

Crankshaft balancer removal



6. crankshaft end protector into the end of the crankshaft and remove the crankshaft balancer.
7. crankshaft end protector from the crankshaft balancer.

To Install:

1. Use a J 41665 crankshaft balancer and sprocket installer to install the crankshaft balancer onto the crankshaft.
2. Install the old crankshaft balancer bolt into the crankshaft balancer. Tighten the bolt to **240 ft-lb (330 Nm)**.
3. Remove the old crankshaft balancer bolt from the crankshaft balancer.
4. Make sure the nose of the crankshaft is recessed 0.094-0.176 in (2.4-4.48 mm) into the balancer bore. If the dimensions are not correct, start over at step 1.
5. Install a new crankshaft balancer bolt into the crankshaft. Tighten the bolt to **37 ft-lb (50 Nm)**. Use a J 45059 angle meter to turn the bolt an **additional 140 degrees**.
6. Remove the J 42386-A flywheel holding tool from the flywheel.
7. Install the cooling fan and starter onto the engine.
8. Install the A/C drive belt onto the pulleys.
9. Install the drive belt onto the pulleys.

Cylinder Head

Removal & Installation

4.2L Engine

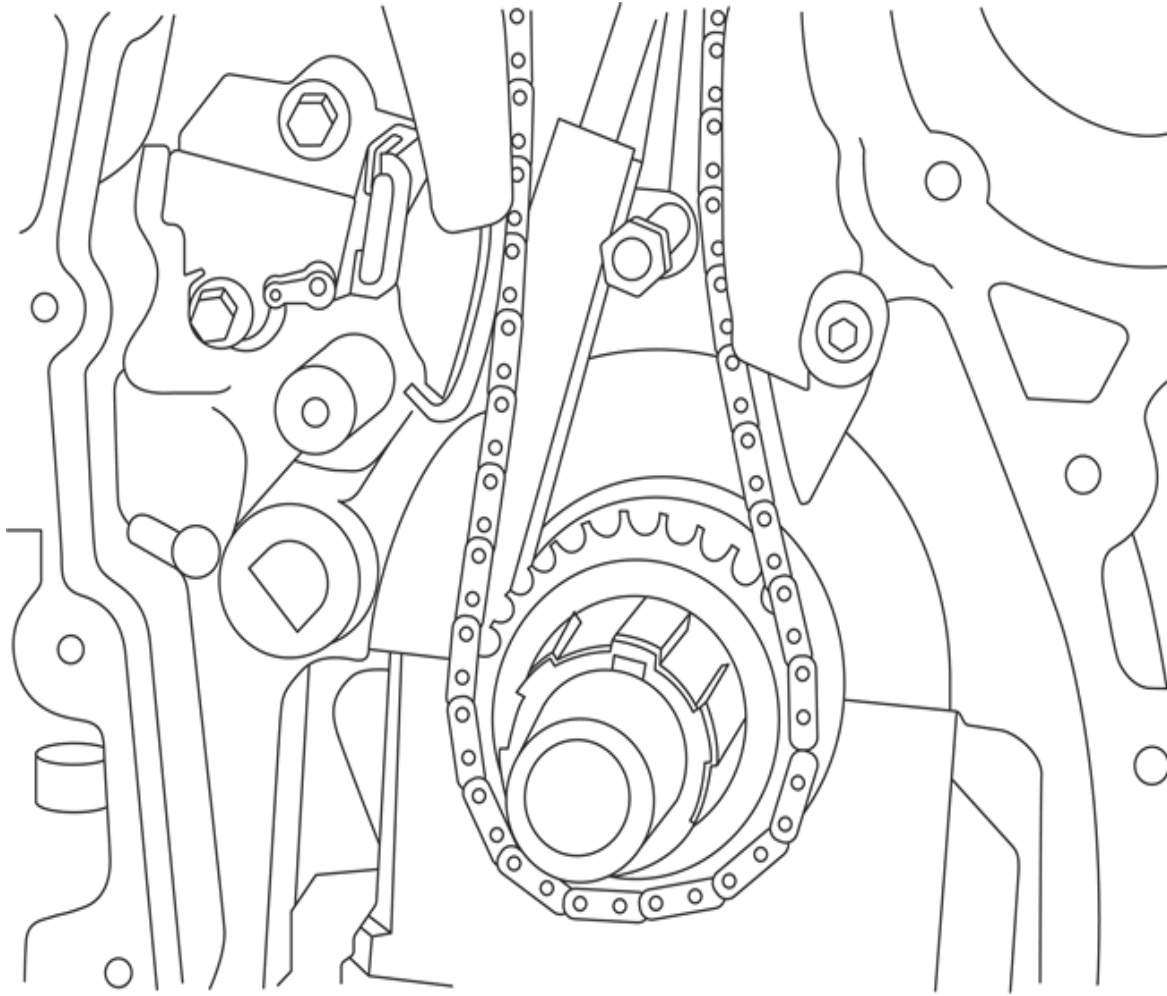
To Remove:

1. Remove the air cleaner element from the air outlet duct.
2. Remove the drive belt from the pulleys.
3. Remove the air cleaner outlet resonator assembly, powertrain control module (PCM), generator, and intake manifold from the engine.
4. Detach the exhaust manifold from the engine and set it aside.
5. Move the A/C line forward.
6. Disconnect the engine coolant temperature sensor, manifold absolute pressure (MAP) sensor, ignition coils, throttle body, camshaft sensors, camshaft actuators, fuel rail, and heated oxygen sensor (HO2S) connectors.
7. Detach the engine harness from the power steering pump and right front inner fender and set the harness aside.
8. Remove the camshaft cover from the cylinder head.
9. Lift the vehicle high enough to gain access to the thermostat housing through the wheelhouse.
10. Remove the left front wheel and wheelhouse liner.
11. Place a drain pan under the thermostat housing.
12. Detach the thermostat housing from the engine and slowly remove it.
13. Remove the thermostat housing from the engine when the coolant stops draining from the engine.
14. If necessary, replace the thermostat housing o-ring.
15. Make sure cylinder 1 is at top dead center.
16. Mark the position of the harmonic balancer to the front engine cover.
17. Lower the vehicle.
18. Attach a J 44221 camshaft holding tool to the camshafts. Make the camshaft flats are facing up.
19. Remove the upper timing chain guide from the cylinder head.
20. Use brake cleaner or a suitable solvent to clean the timing chain and gears.
21. Mark the position of the timing chain to the camshaft sprockets in the 12 o'clock position.

CAUTION

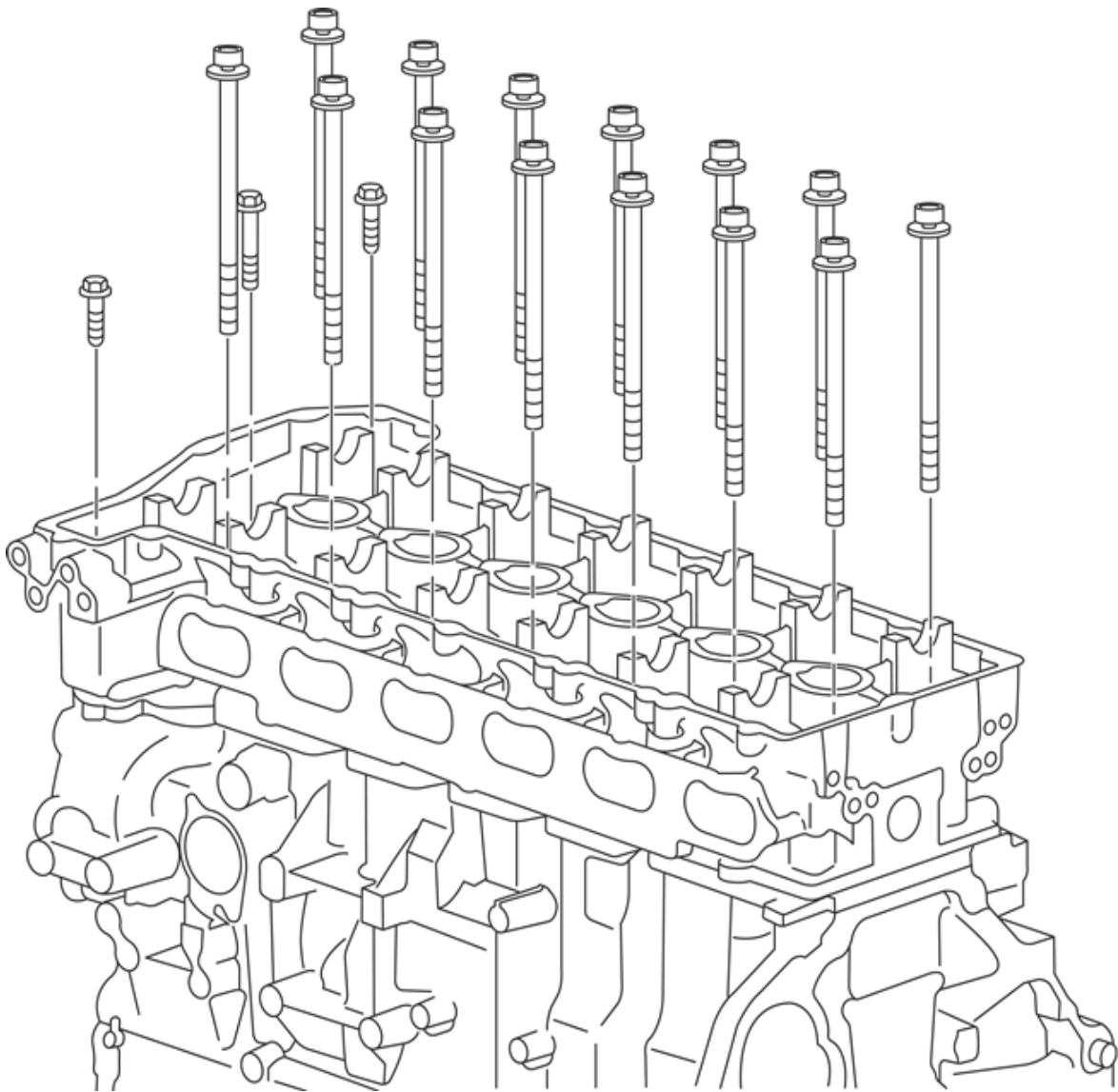
When seating the EN-48464, do not use excessive force. This may cause damage to the timing chain tensioner or break the front cover bolt.

EN-48464 Installation



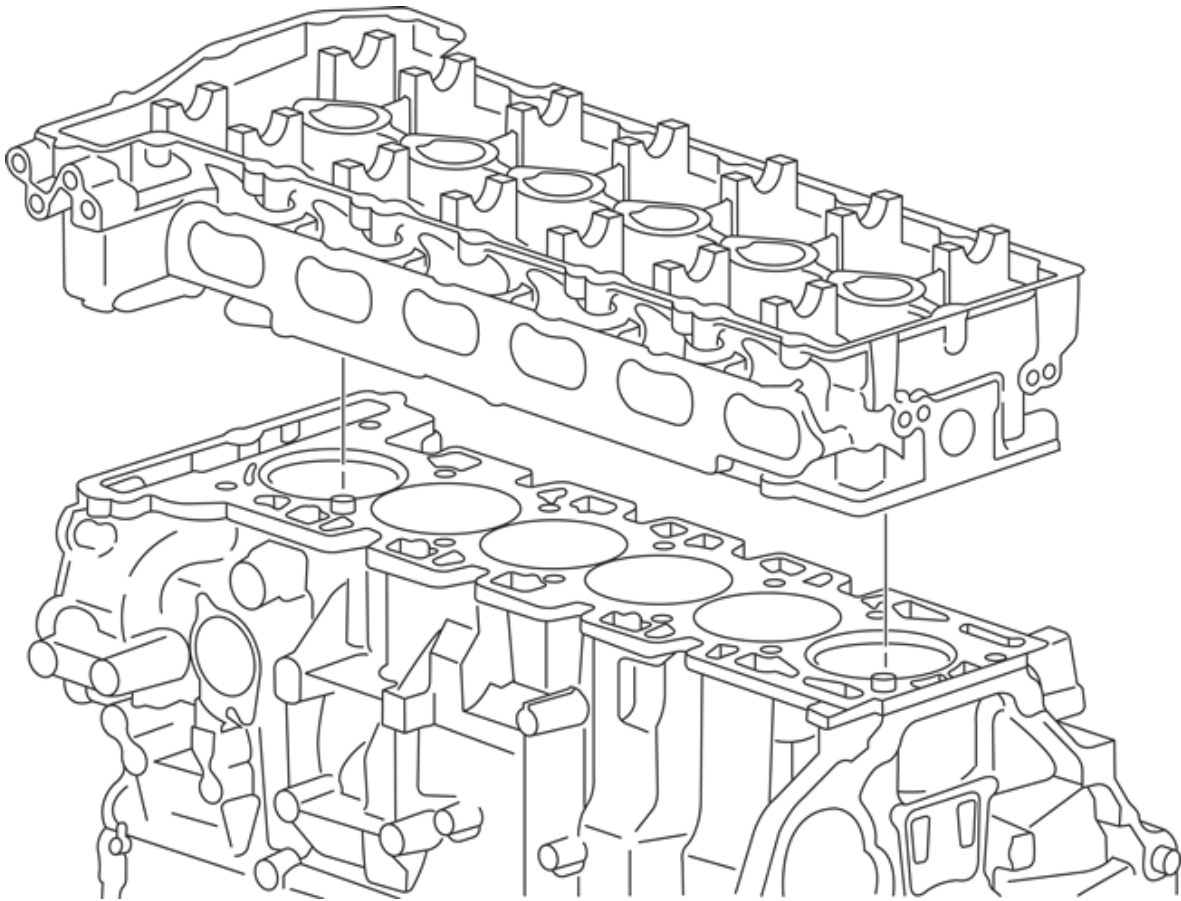
22. Install a EN-48464 lower timing gear tensioner holding tool between the timing chain and the crankshaft sprocket. Place it so that the narrow ramp of the wedge faces the timing chain. Seat the tool by taping it lightly with a plastic or brass hammer. Once seated, unscrew and remove the handle.
23. Remove the upper cylinder head access hole plugs.
24. Hold the camshafts in places using a 1 in (25 mm) open end wrench on the camshaft hexes.
25. Remove and discard the bolts from the cylinder head near intake and exhaust timing chain tensioner shoes.
26. Remove the upper timing chain tensioner shoes bolts from the engine block.
27. Remove and discard the bolts from the intake and exhaust camshaft sprockets.
28. Remove the intake and exhaust camshaft sprockets from the camshafts with the timing chain.
29. Remove the intake and exhaust sprockets from the timing chain.
30. Attach a piece of mechanic's wire to the timing chain and let it drop into the engine block.
31. Shock the cylinder head bolts using a drift punch and a hammer.

Cylinder head bolt removal and installation



32. Remove and discard the bolts from the cylinder head.

Cylinder head removal and installation

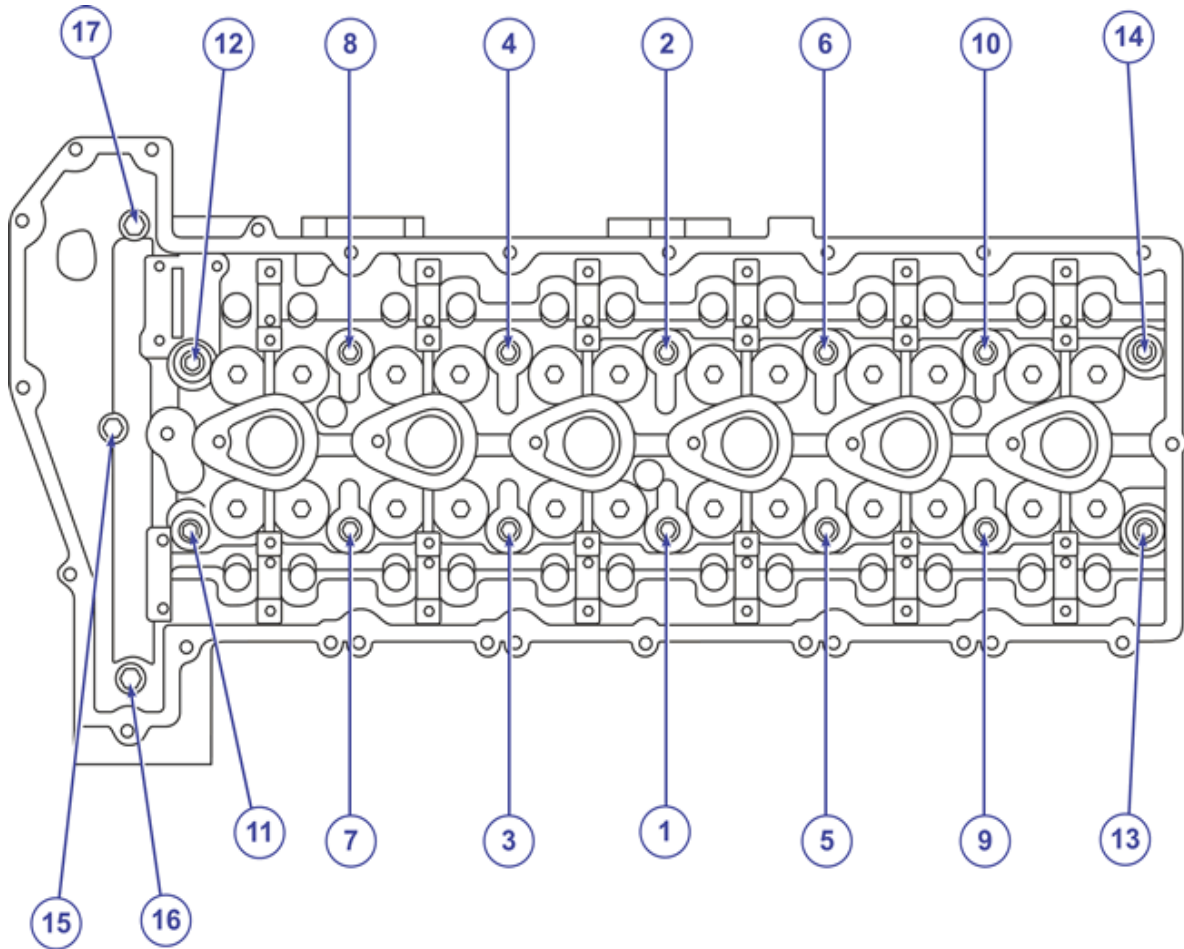


33. Remove the cylinder head from the engine block.
34. Set the cylinder head with the combustion chambers face up on a flat, clean surface.
35. Remove and discard the cylinder head gasket from the engine block.
36. Clean the sealing surfaces as necessary.

To Install:

1. Place the new cylinder head gasket on the engine block.
2. Place the cylinder head on the engine block.

Cylinder head bolt tightening sequence



1. Install cylinder head bolts 1 through 14 in sequence. Torque the bolts to **22 ft-lb (30 Nm)**. Use a J 45059 angle meter to turn the bolts, in sequence, **an additional 155 degrees**.
2. Install cylinder head bolts 16 and 17 in sequence. Torque the bolts to **62 in-lb (7 Nm)**. Use a J 45059 angle meter to turn the bolts, in sequence, **an additional 60 degrees**.
3. Install cylinder head bolt 15. Torque the bolt to **62 in-lb (7 Nm)**. Use a J 45059 angle meter to turn the bolts, in sequence, **an additional 120 degrees**.
4. Install the camshafts to the cylinder head with a J 44221 camshaft holding tool attached to prevent camshaft rotation.
5. Make sure the camshaft position actuator is fully advanced.
6. Align the exhaust camshaft sprocket with the mark on the timing chain.
7. Attach the exhaust camshaft sprocket with the timing chain to the exhaust camshaft. Hand tighten the new bolt.
8. Align the intake camshaft sprocket with the mark on the timing chain.
9. Attach the intake camshaft sprocket with the timing chain to the intake camshaft. Hand tighten the new bolt.
10. Attach the timing chain tensioner shoe to the engine. Torque the bolt to **18 ft-lb (25 Nm)**.
11. Attach the lower timing guide to the engine. Torque the bolts to **107 in-lb (12 Nm)**.
12. Install the cylinder head access hole plugs in to the cylinder head. Torque the plugs to **44 in-lb (5 Nm)**.
13. Torque the intake camshaft sprocket bolt to **15 ft-lb (20 Nm)**. Use a J 45059 angle meter to rotate bolt **an additional 100 degrees**.
14. Torque the exhaust camshaft sprocket bolt to **18 ft-lb (25 Nm)**. Use a J 45059 angle meter to rotate bolt **an additional 135 degrees**.
15. Detach the J 44221 camshaft holding tool from the back of the camshafts.
16. Remove the EN-48464 lower timing gear tensioner holding tool from the engine block.
17. Turn the crankshaft clockwise two complete turns until cylinder 1 is at top dead center.
18. Use a straight edge to verify the timing by placing the straight edge across the flats of the camshafts. Make sure a 0.005 inch feeler gage can not pass between either of the camshafts flats and the straight edge. If the gage can pass, then repeat step 19. If the gage can still pass, then the timing will have to be reset.
19. Apply threadlocker GM P/N 89021297 to the upper timing chain guide bolts and attach the upper timing chain guide to the engine. Torque the bolts to **89 in-lb (10 Nm)**.
20. Attach the camshaft cover to the cylinder head. Torque the bolts to **89 in-lb (10 Nm)**.
21. Attach the exhaust manifold to the engine.
22. Install the intake manifold on to the engine.
23. Lift the vehicle high enough to gain access to the thermostat housing through the wheelhouse.
24. Install the thermostat housing into the engine.
25. Install the left front wheel and wheelhouse liner.
26. Lower the vehicle.
27. Drain the oil from the engine.
28. Connect the engine coolant temperature sensor, manifold absolute pressure (MAP) sensor, ignition coils, throttle body, camshaft sensors, camshaft actuators, fuel rail, and heated oxygen sensor (HO2S) connectors.

29. Attach the engine harness to the power steering pump and right front inner fender and set the harness aside.
30. Install the air cleaner outlet resonator assembly, powertrain control module (PCM), and generator onto the engine.
31. Install the drive belt onto the pulleys.
32. Install the air cleaner element into the air outlet duct.
33. Refill the engine with oil and coolant.
34. Use scan tool the check for DTCs.
35. Road test the vehicle.

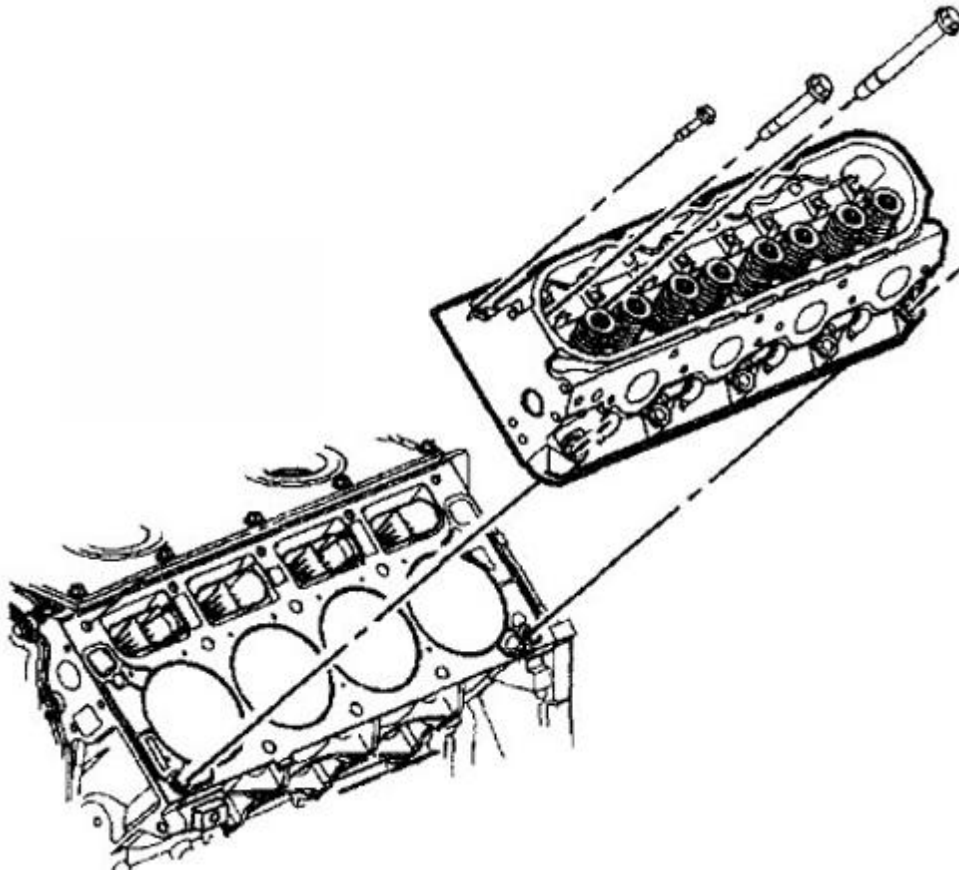
5.3L & 6.0L Engines

Left Side

To Remove:

1. Remove the generator and power steering pump from the engine.
2. Detach the generator bracket from the engine.
3. Drain the coolant from the engine.
4. Remove the coolant air bleed pipe from the engine.
5. Remove the left exhaust manifold from the cylinder head.
6. Remove the pushrods from the cylinder head.
7. Remove the auxiliary A/C bracket bolt from the auxiliary A/C bracket.

Left cylinder head removal and installation

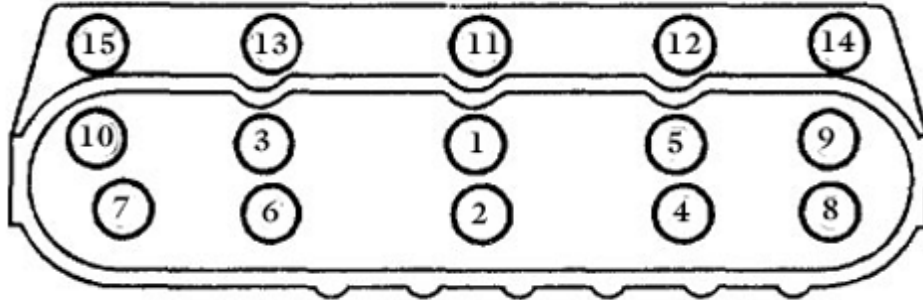


1. Detach the cylinder head from the engine block.
2. Set the cylinder head on wooden block.
3. Remove the cylinder head gasket and locating pins from the engine block.
4. Clean the sealing surfaces as necessary.

To Install:

1. Install the locating pins and new cylinder head gasket on to the engine block.
2. Attach the cylinder head to the engine block.

Cylinder head bolt tightening sequence



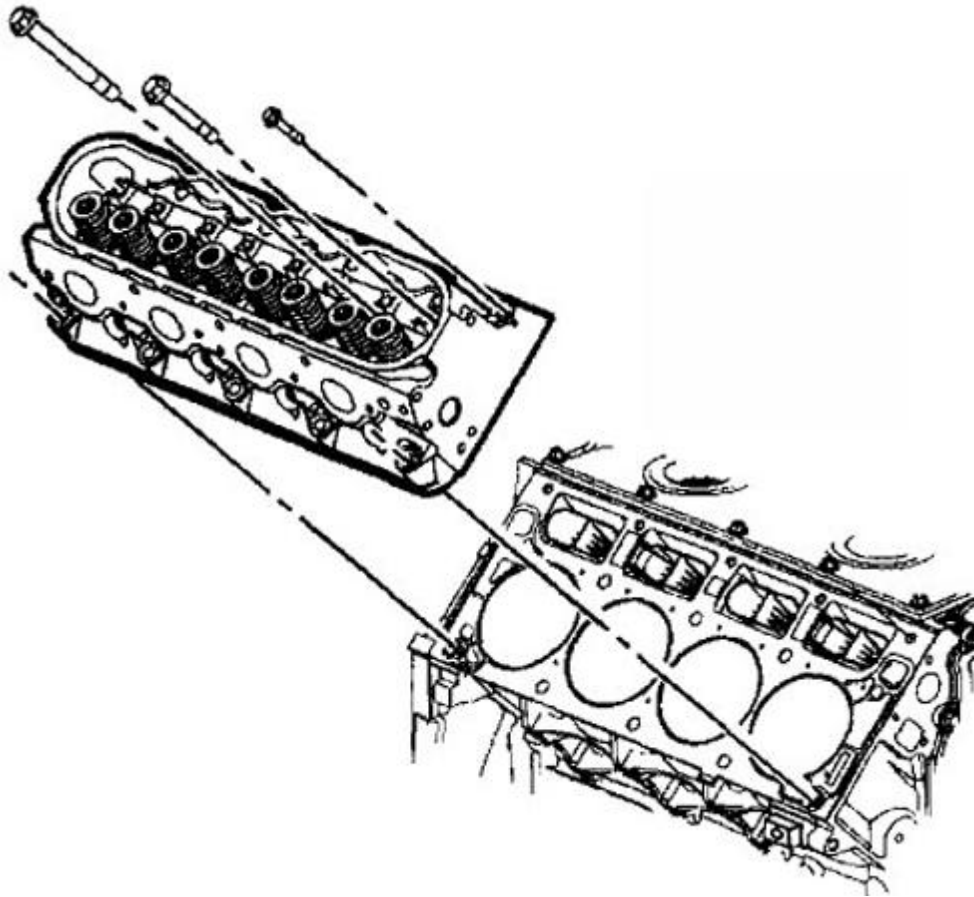
1. Torque the M11 bolts 1 through 10, in sequence to **22 ft-lb (30 Nm)**. Use a J 45059 angle meter to turn the bolts, in sequence, an **additional 90 degrees**. Use a J 45059 angle meter to turn the bolts, in sequence, an **additional 70 degrees**.
2. Torque the M8 bolts 11 through 15, to **22 ft-lb (30 Nm)**.
3. Install the auxiliary A/C bracket bolt from the auxiliary A/C bracket. Torque the bolt to **15 ft-lb (20 Nm)**.
4. Install the pushrods into the cylinder head.
5. Install the left exhaust manifold onto the cylinder head.
6. Install the coolant air bleed pipe onto the engine.
7. Refill the engine with coolant.
8. Attach the generator bracket to the engine. Torque the bolts to **37 ft-lb (50 Nm)**.
9. Install the generator and power steering pump onto the engine.

Right Side

To Remove:

1. Remove the oil level indicator and tube from the cylinder head.
2. Drain the coolant from the engine.
3. Remove the coolant air bleed pipe from the engine.
4. Remove the right exhaust manifold from the cylinder head.
5. Remove the pushrods from the cylinder head.
6. Remove the auxiliary A/C bracket nut from the auxiliary A/C bracket.

Right cylinder head removal and installation

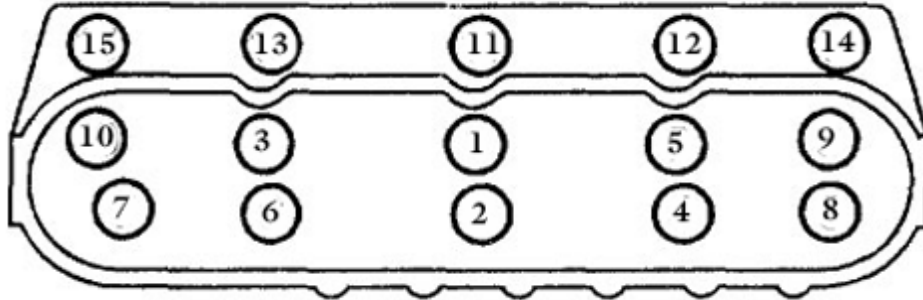


7. Detach the cylinder head from the engine block.
8. Set the cylinder head on wooden block.
9. Remove the cylinder head gasket and locating pins from the engine block.
10. Clean the sealing surfaces as necessary.

To Install:

1. Install the locating pins and new cylinder head gasket on to the engine block.
2. Attach the cylinder head to the engine block.

Cylinder head bolt tightening sequence



3. Torque the M11 bolts 1 through 10, in sequence to **22 ft-lb (30 Nm)**. Use a J 45059 angle meter to turn the bolts, in sequence, an **additional 90 degrees**. Use a J 45059 angle meter to turn the bolts, in sequence, **an additional 70 degrees**.
4. Torque the M8 bolts 11 through 15, to **22 ft-lb (30 Nm)**.
5. Install the auxiliary A/C bracket bolt from the auxiliary A/C bracket. Torque the nut to **15 ft-lb (20 Nm)**.
6. Install the pushrods into the cylinder head.
7. Install the right exhaust manifold onto the cylinder head.
8. Install the coolant air bleed pipe onto the engine.
9. Refill the engine with coolant.
10. Install the oil level indicator and tube onto the cylinder head.

Drive Belt

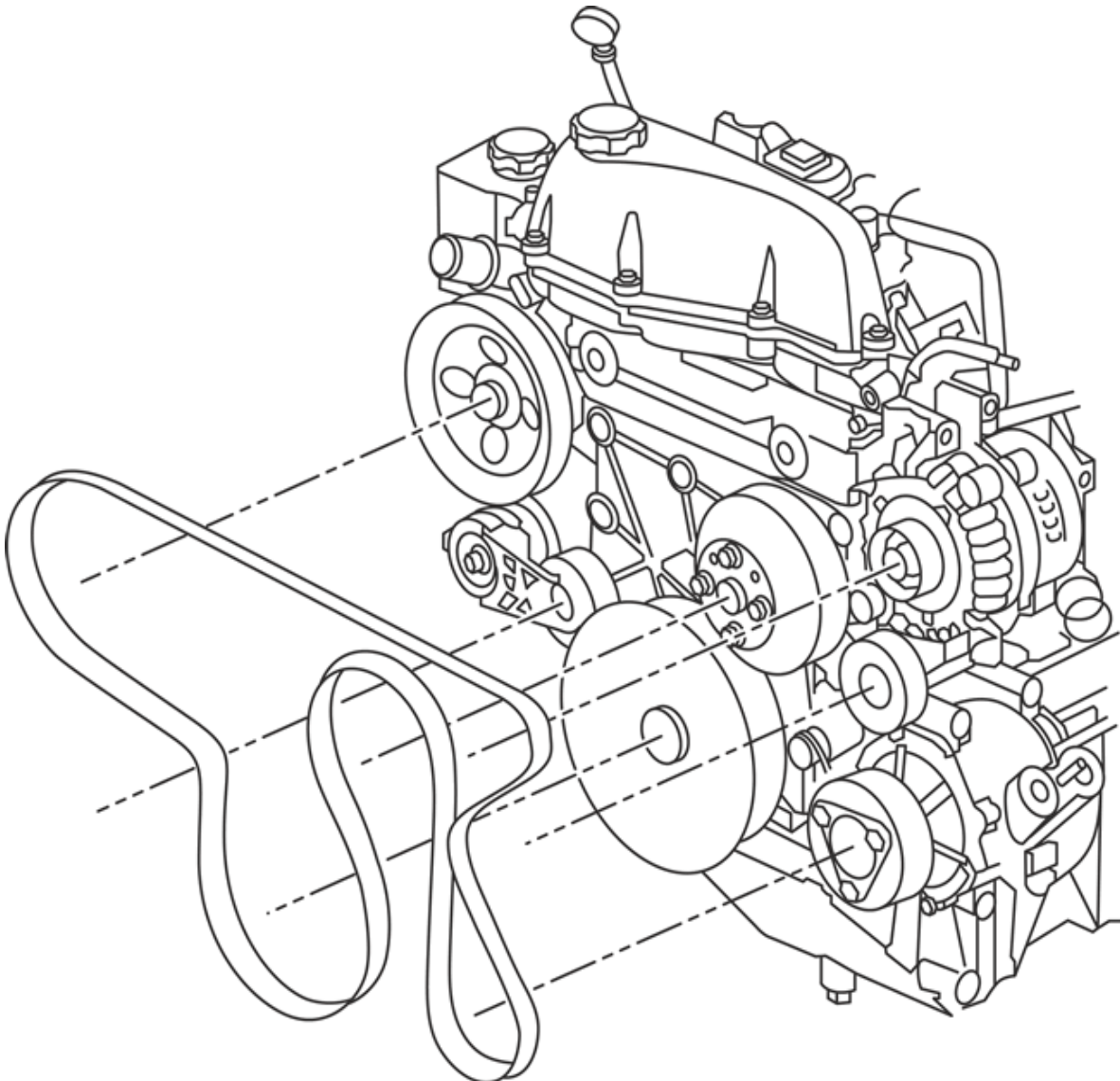
Removal & Installation

4.2L Engine

To Remove:

1. Install a 3/8 inch breaker bar onto the drive belt tensioner arm.
2. Turn the breaker bar clockwise until the tension on the drive belt is relieved.

Drive belt removal and installation



3. Remove the drive belt from the pulleys
4. Turn the breaker bar counterclockwise to release the tensioner arm.

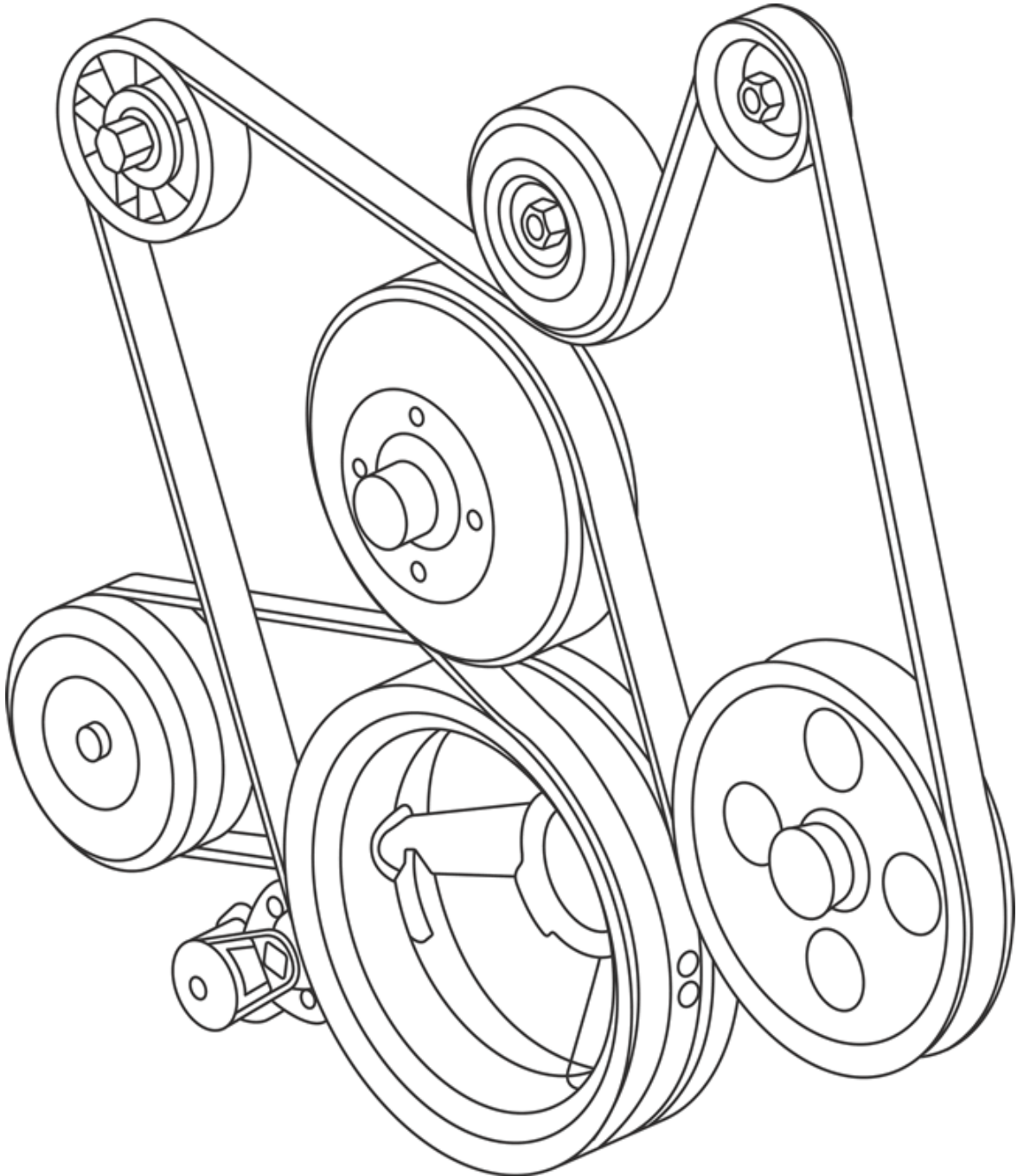
To Install:

1. Install the drive belt onto all the pulleys except the drive belt tensioner pulley.
2. Install a 3/8 inch breaker bar onto the drive belt tensioner arm.
3. Turn the breaker bar clockwise.
4. Install the drive belt onto the drive belts tensioner pulley.
5. Turn the breaker bar counterclockwise to release the tensioner arm.

5.3L & 6.0L Engines

To Remove:

1. Remove the air cleaner resonator outlet duct from the throttle body.
2. Install a hex-head socket breaker bar onto the drive belt tensioner.
3. Turn the breaker bar clockwise until the tension on the drive belt is relieved.



4. Remove the drive belt from the generator pulley.
5. Turn the breaker bar counterclockwise to release the tensioner arm.
6. Remove the breaker bar from the tensioner.
7. Remove the drive belt from the remaining pulleys.

To Install:

1. Install the drive belt onto all the pulleys except the generator pulley.
2. Install a hex-head socket breaker bar onto the drive belt tensioner.
3. Turn the breaker bar clockwise until the tension on the drive belt is relieved.
4. Install the drive belt onto the generator pulley.
5. Turn the breaker bar counterclockwise to release the tensioner arm.
6. Remove the breaker bar from the tensioner.
7. Install the air cleaner resonator outlet duct onto the throttle body.

Drive Belt Tensioner

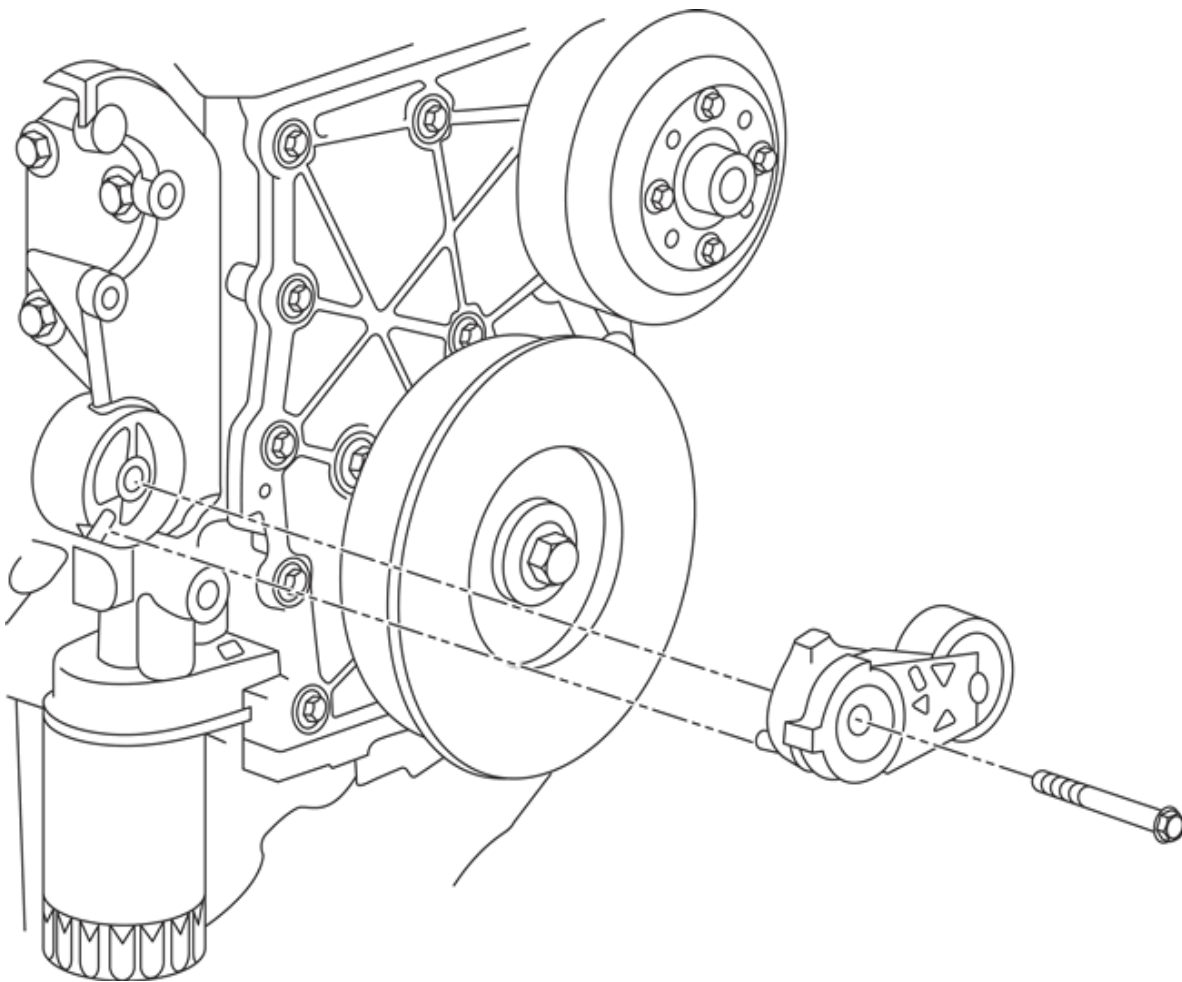
Removal & Installation

4.2L Engine

To Remove:

1. Remove the drive belt from the pulleys.

Drive belt tensioner removal and installation



2. Detach the drive belt tensioner from the engine.

To Install:

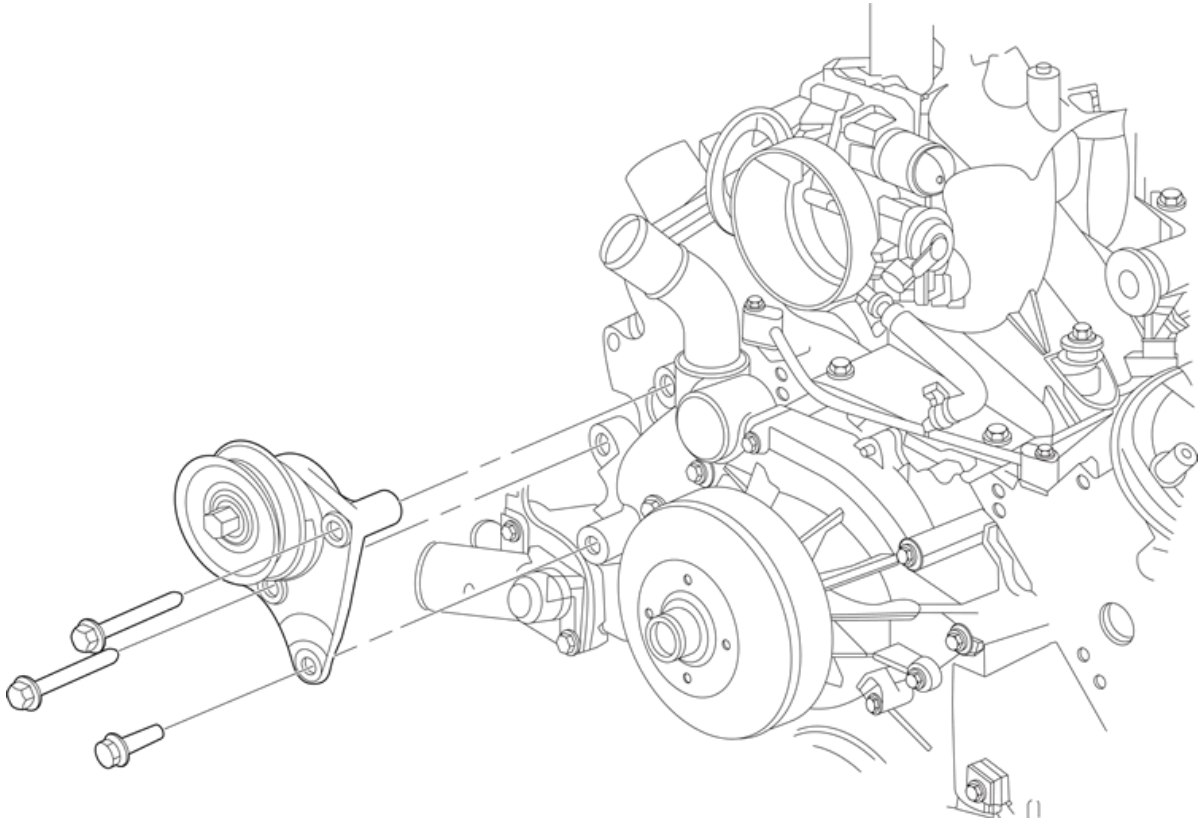
1. Attach the drive belt tensioner to the engine. Torque the bolt to **37 ft-lb (50 Nm)**.
2. Install the drive belt onto the pulleys.

5.3L & 6.0L Engines

To Remove:

1. Remove the drive belt from the pulleys.

accessory drive belt tensioner (5.3L, 6.0L)



2. Detach the drive belt tensioner from the engine.

To Install:

1. Attach the drive belt tensioner to the engine. Torque the bolt to **37 ft-lb (50 Nm)**.
2. Install the drive belt onto the pulleys.

Engine Assembly

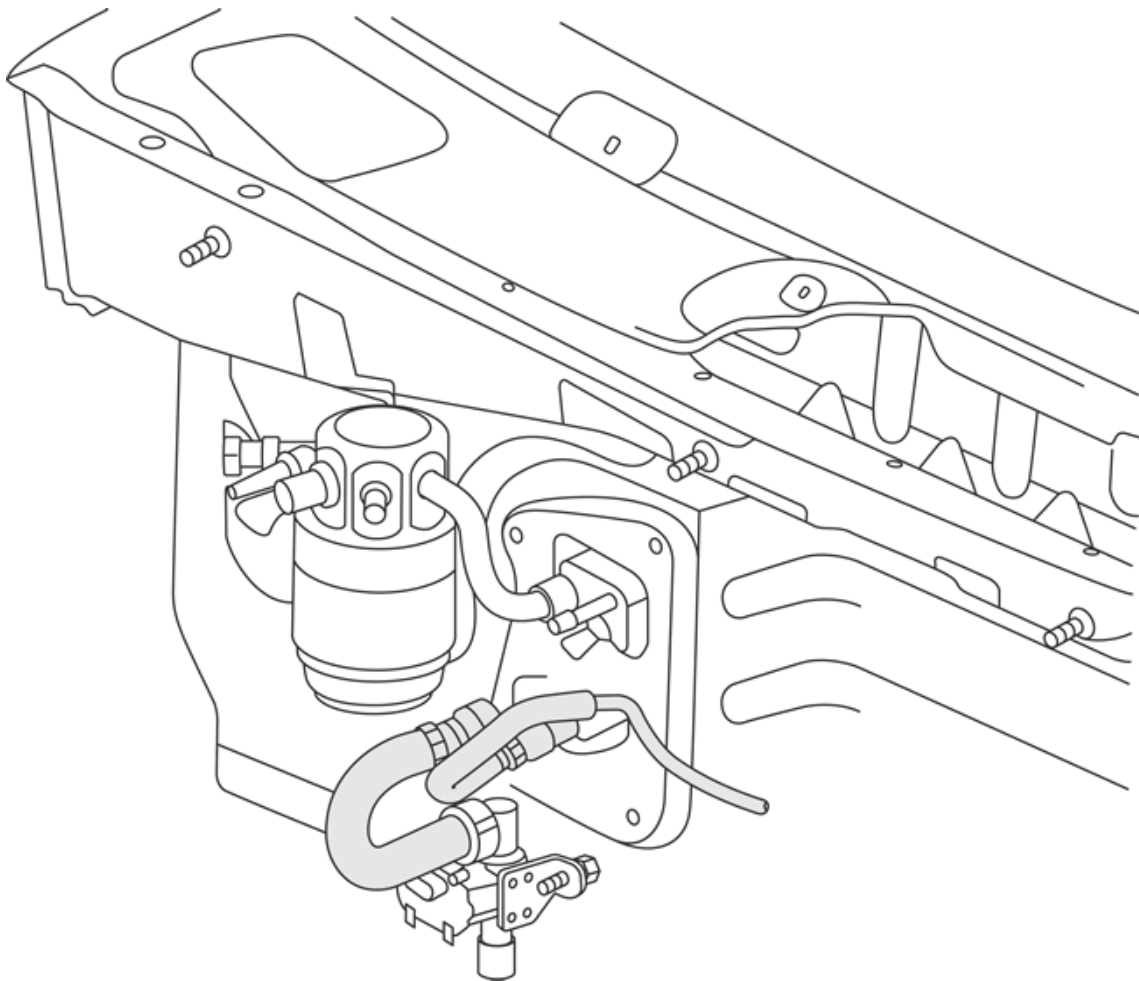
Removal & Installation

4.2L Engine

To Remove:

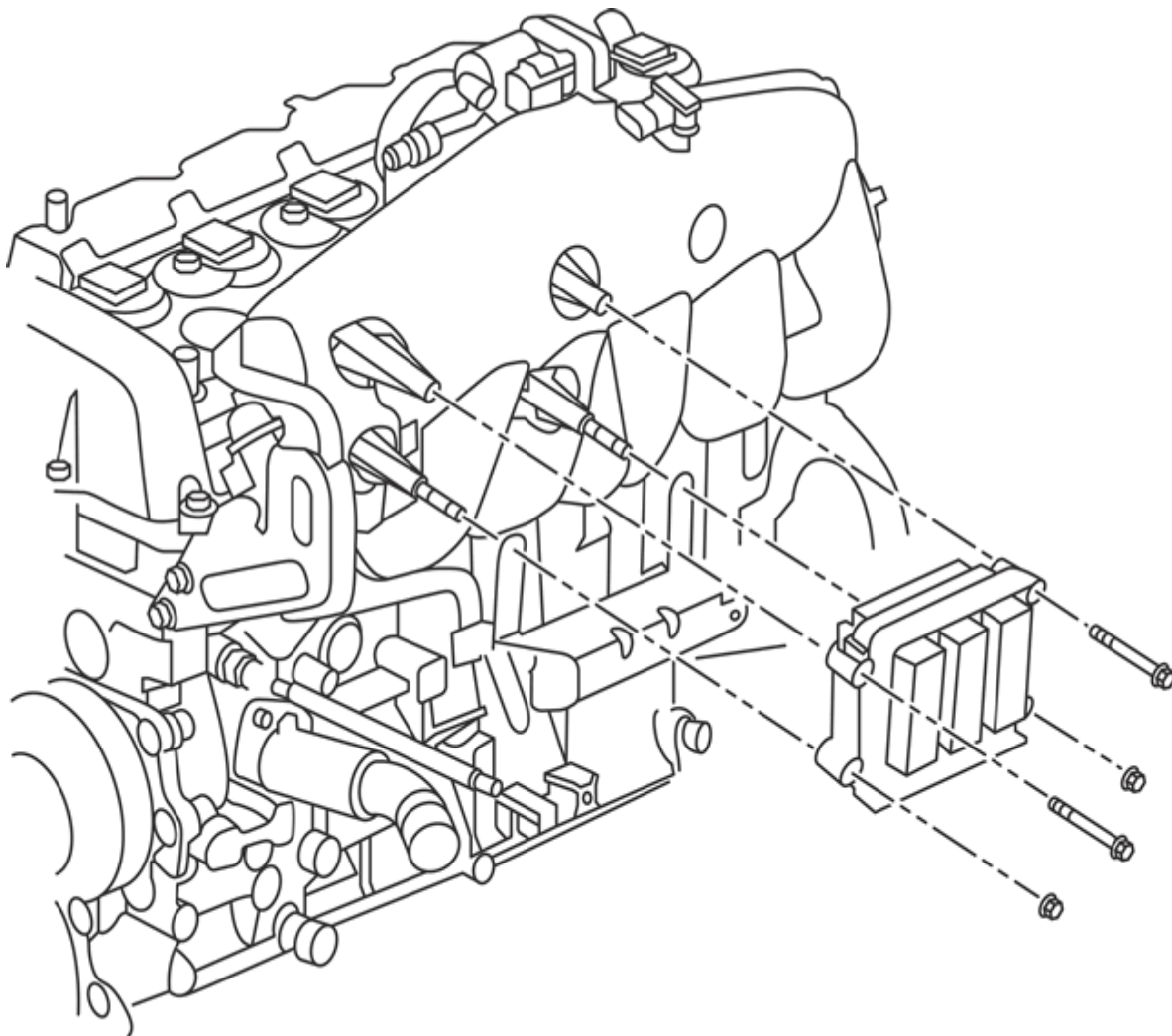
1. Remove the hood from the vehicle.
2. Disconnect the negative battery cable from the battery.
3. Drain the coolant from the engine.
4. Evacuate the refrigerant from the HVAC system.
5. Drain the oil from the engine.
6. Remove the air cleaner assembly and windshield washer solvent container from the vehicle.
7. Remove the throttle body and manifold absolute pressure (MAP) sensor from the engine.
8. Remove the grille from the front of the vehicle.
9. Remove the headlamp housings from the vehicle.
10. Remove the hood latch from the radiator support.
11. Remove the radiator support brace from the front of the vehicle.
12. Disconnect the A/C lines from the condenser.
13. Disconnect the transmission cooler lines from the engine.
14. Remove the cooling fan from the vehicle.
15. Remove the condenser and transmission cooler lines with the radiator from the vehicle.
16. Remove the drive belt from the pulleys.
17. Detach the power steering pump from the engine.

Heater core hoses



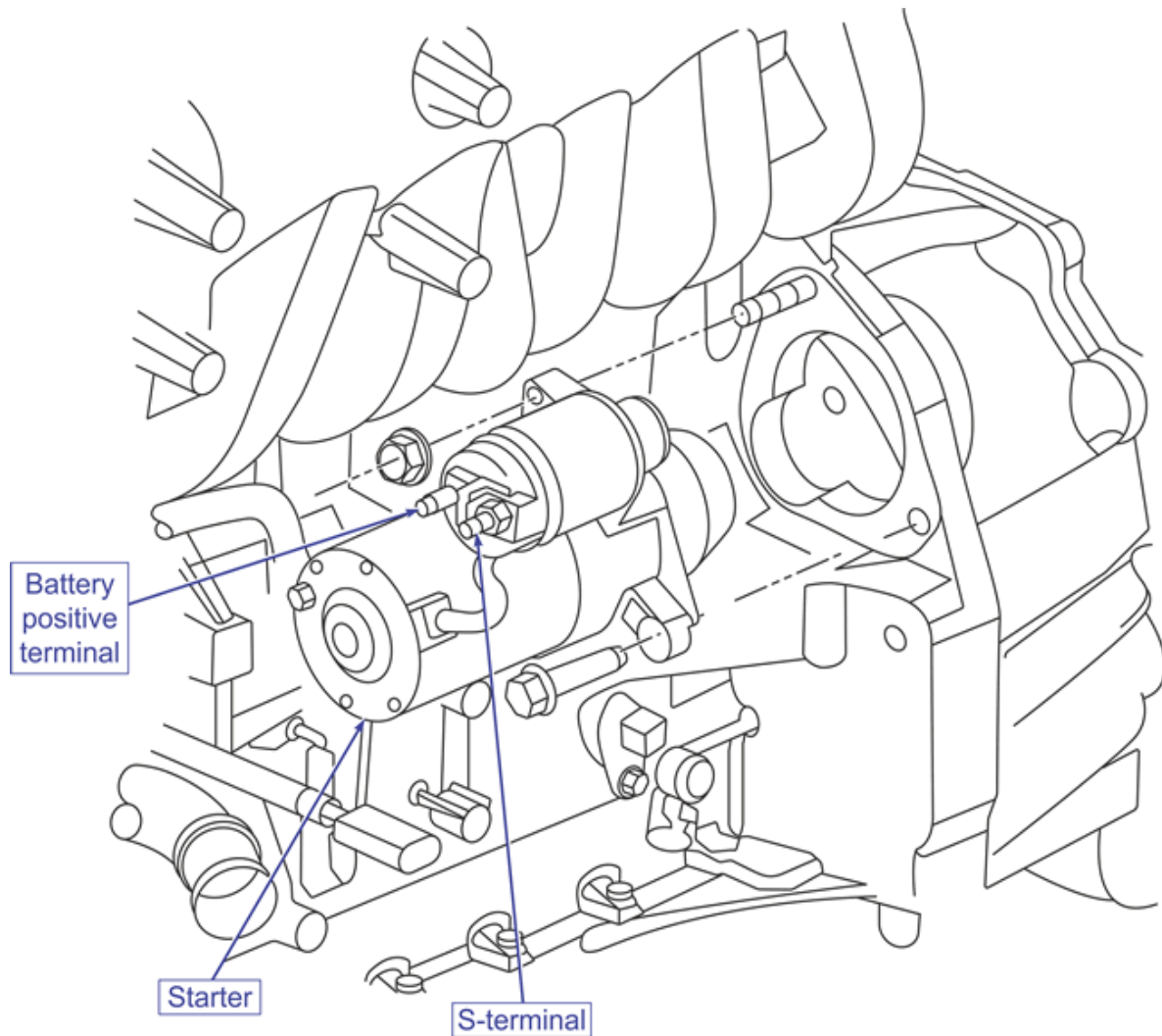
18. Disconnect the heater hoses from the heater core.
19. Remove the secondary air injection (AIR) reaction solenoid valve from the engine.
20. engine lift bracket to the secondary air injection (AIR) port on the engine head.
21. Disconnect the heated oxygen sensor (HO2S) connector.
22. Disconnect the camshaft phaser actuator valve connector.
23. Detach the transmission cooler lines from the engine block on the right side.
24. Disconnect the ignition coil connectors
25. Detach the ignition coil harness from the engine.
26. Disconnect the power brake booster hose from the power brake booster.

Powertrain control module (PCM) removal and installation



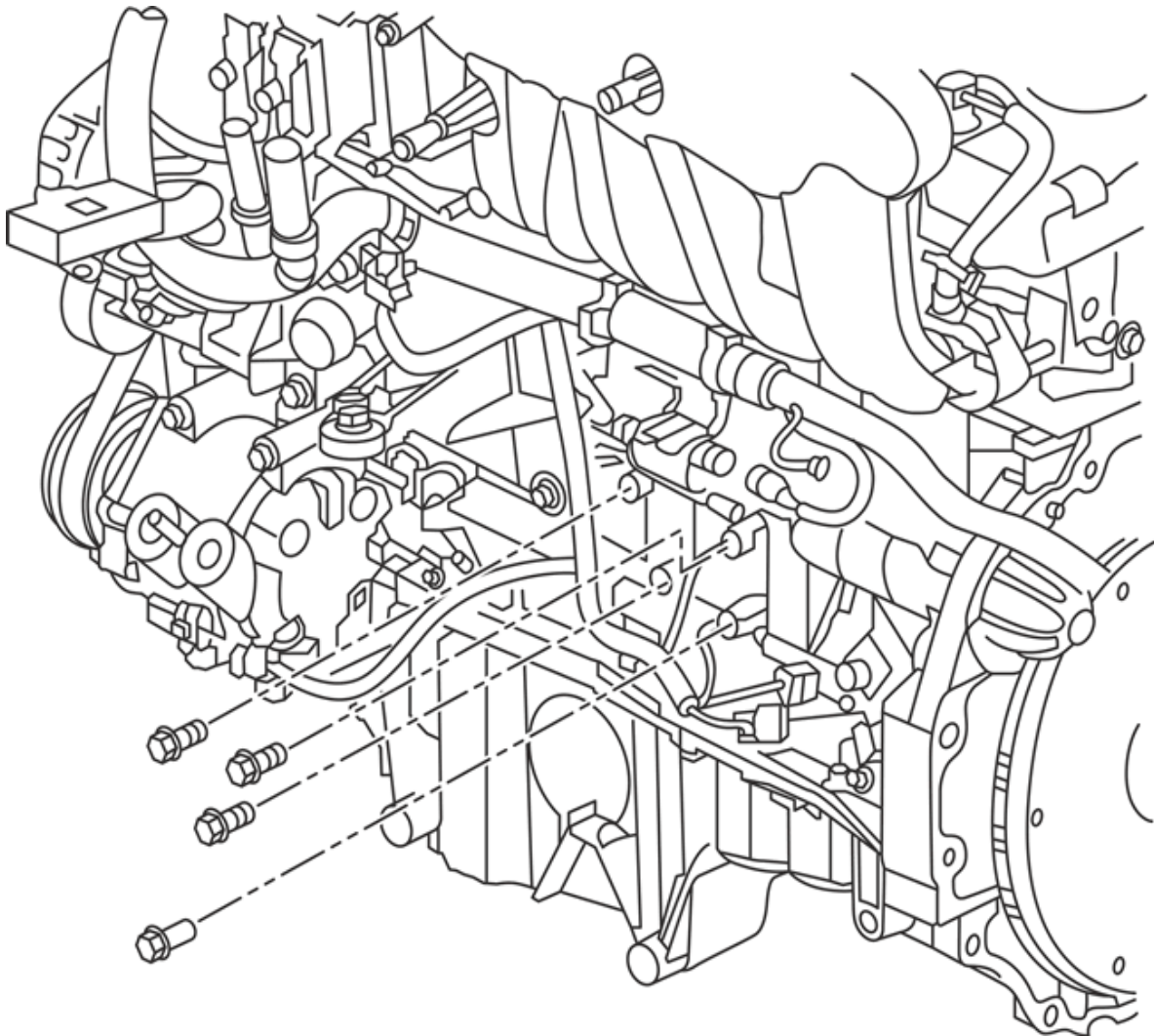
27. Remove the powertrain control module (PCM) from the engine.
28. Detach the harnesses and front differential vent hose from the engine harness bracket.
29. Detach the engine harness bracket from the engine.

Starter



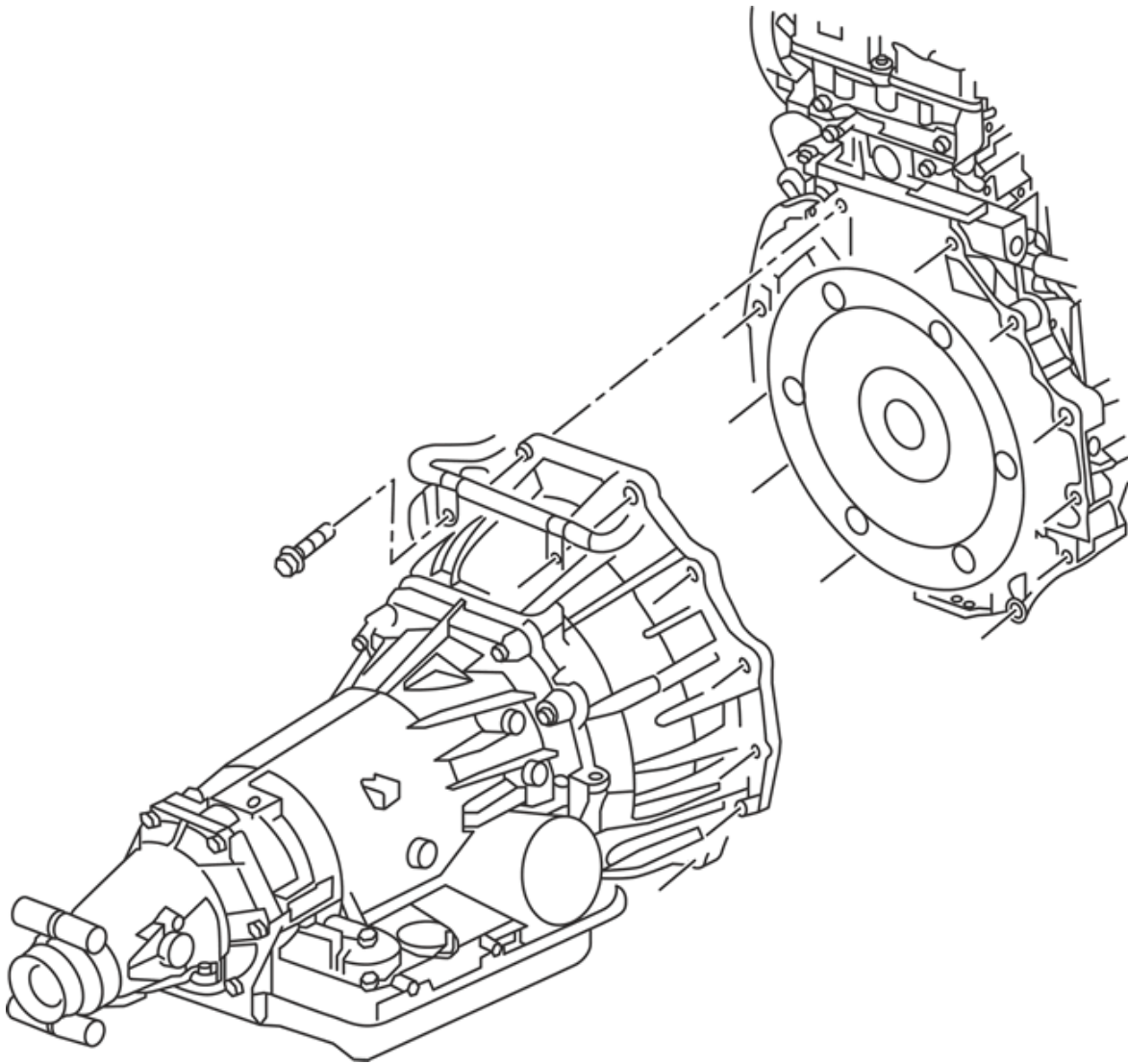
30. Remove the positive battery cable and s-terminal lead from the starter.
31. Disconnect the A/C pressure sensor and A/C clutch connectors.
32. Remove the battery positive cable from the generator.
33. Disconnect the generator, knock sensor, crankshaft sensor, and camshaft sensor connectors.

Engine grounds



34. Remove the grounds for the engine block on the left side.
35. Lift the vehicle.
36. Remove the left and right wheel drive shafts.
37. Remove the front propeller shaft from the transfer case.
38. Remove the engine protection shield from under the vehicle.
39. Detach the exhaust pipe from the exhaust manifold and move it towards the rear of the vehicle.
40. If equipped, remove the fuel tank shield from the frame.
41. Remove the secondary air injection (AIR) pipes from the Remove the secondary air injection (AIR) pump.
42. Remove the access covers and bolts from the torque converter.
43. Support the transmission with a transmission jack under the transmission oil pan.
44. Remove the transmission support from the frame.
45. Lower the transmission enough to gain access to the top of the transmission bell housing.

Transmission removal and installation



46. Remove the bolts from the top of the transmission bell housing.
47. Lift the transmission.
48. Install the transmission support to the frame, only using through bolts.
49. Remove the remaining bolts from the transmission bell housing.
50. Remove the nuts from the lower engine mounts.
51. Lower the vehicle.
52. Remove the nuts from the upper engine mounts.
53. Install the engine hoist to the engine.
54. Lift the engine out of the engine compartment; lift the engine slowly while continuing to support the transmission.
55. Remove the upper engine mounts to gain clearance.
56. Detach the secondary air injection (AIR) pipes fasteners from the back of the engine head and remove the pipes from the vehicle.
57. Lift the engine out of the vehicle.
58. Install the engine onto an engine stand.

To Install:

1. Remove the engine from the engine stand.
2. Slowly lower the engine into the engine compartment; make sure the engine brackets line up with the mounts.
3. Attach the secondary air injection (AIR) pipes to the back of the engine head.
4. Install the upper engine mounts to the chassis.
5. Install the nuts to the upper engine mounts. Torque the nuts to **51 ft-lb (70 Nm)**.
6. Remove the engine hoist from the engine.
7. Place the radiator into the vehicle.
8. Lift the vehicle.
9. Install the lower bolts into the transmission bell housing.
10. Remove the through bolts from the transmission support.
11. Lower the transmission.
12. Install the bolts into the top of the transmission bell housing.
13. Torque the transmission bell housing bolts to **37 ft-lb (50 Nm)**.
14. Lift the transmission.
15. Install the transmission support onto the frame.
16. Install the bolts and access covers into the torque converter. Torque the bolts to **44 ft-lb (60 Nm)**.
17. If removed, install the fuel tank shield to the frame.
18. Install the secondary air injection (AIR) pipes onto the secondary air injection (AIR) pump.
19. Install the engine protection shield to under the vehicle.
20. Install the front propeller shaft into the transfer case.
21. Attach the exhaust pipe to the exhaust manifold. Torque the bolts to **37 ft-lb (50 Nm)**.
22. Connect the oil pressure sensor connector.
23. Install the oil drain plug into the oil pan. Torque the plug to **19 ft-lb (26 Nm)**.
24. Install the left and right wheel drive shafts.
25. Lower the vehicle.
26. Install the grounds onto the engine block on the left side.
27. Connect the generator, knock sensor, crankshaft sensor, and camshaft sensor connectors.
28. Install the battery positive cable to the generator. Torque the nut to **80 in-lb (9 Nm)**.
29. Connect the A/C pressure sensor and A/C clutch connectors.
30. Install the positive battery cable and s-terminal to the starter. Tighten the battery cable nut to **80 in-lb (9 Nm)**. Tighten the s-terminal nut to **20 in-lb (2.3 Nm)**.
31. Attach the engine harness bracket to the engine. Torque the bolt to **37 ft-lb (50 Nm)**.
32. Attach the harnesses and front differential vent hose to the engine harness bracket.
33. Install the powertrain control module (PCM) onto the engine.
34. Connect the power brake booster hose to the power brake booster.
35. Attach the ignition coil harness to the engine.
36. Connect the ignition coil connectors
37. the transmission cooler lines to the engine block on the right side.
38. Connect the camshaft phaser actuator valve connector.
39. Connect the A/C lines to the condenser.
40. Connect the heated oxygen sensor (HO2S) connector.
41. engine lift bracket from the secondary air injection (AIR) port on the engine head.

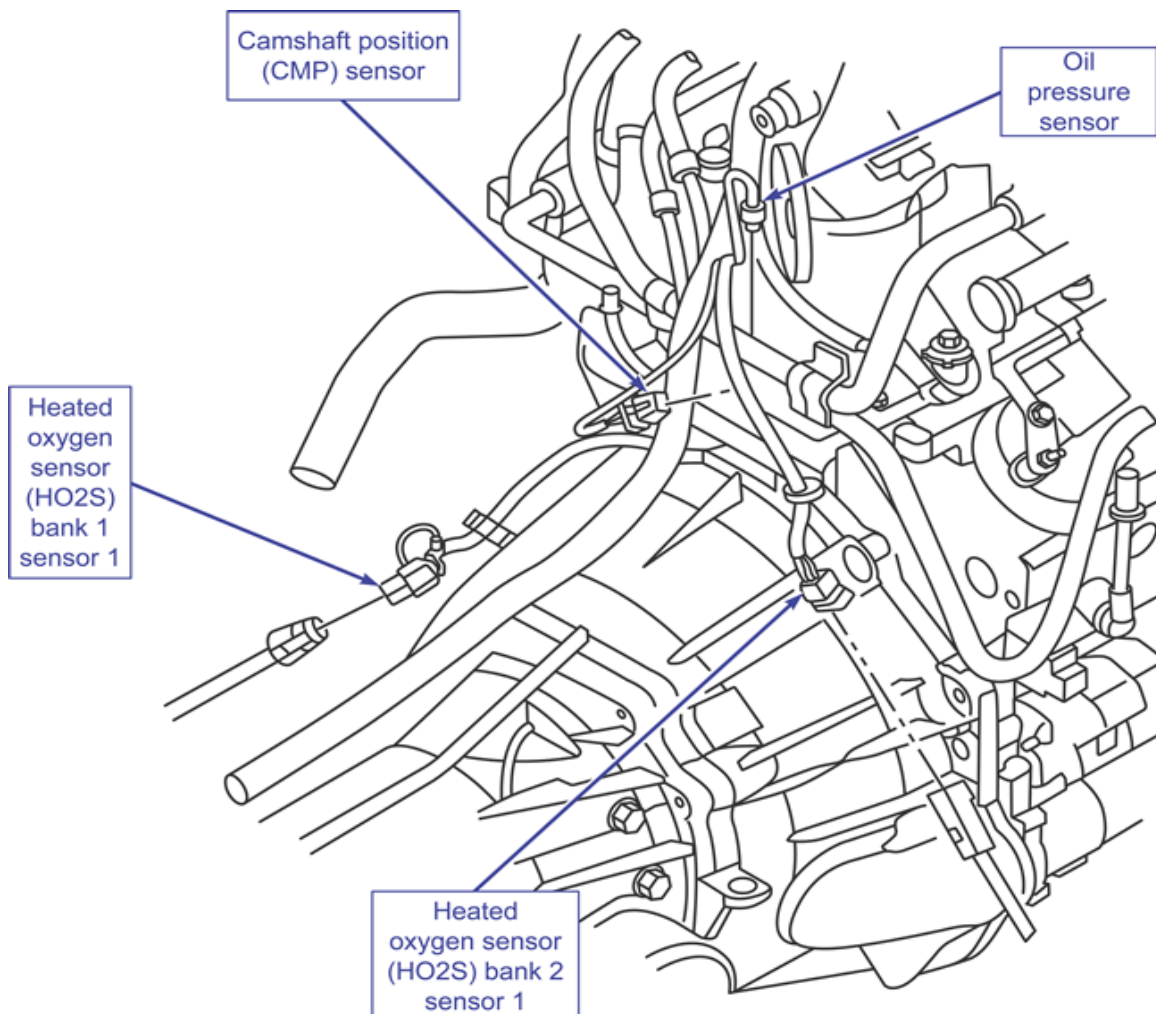
42. the secondary air injection (AIR) reaction solenoid valve onto the engine.
43. Connect the heater hoses to the heater core.
44. Attach the power steering pump to the engine. Torque the bolts to **18 ft-lb (25 Nm)**.
45. Install the drive belt onto the pulleys.
46. Install the cooling fan to the vehicle.
47. Completely install the radiator to the vehicle.
48. Connect the transmission cooler lines to the engine.
49. Install the throttle body and manifold absolute pressure (MAP) sensor to the engine.
50. Install the hood latch to the radiator support.
51. Install the headlamp housings into the vehicle.
52. Install the grille onto the front of the vehicle.
53. Install the air cleaner assembly and windshield washer solvent container into the vehicle.
54. Install the hood onto the vehicle.
55. Refill the engine with oil.
56. Refill the engine with coolant.
57. Recharge the HVAC system with refrigerant.
58. Connect the negative battery cable to the battery.
59. Make sure the engine is working properly.

5.3L & 6.0L Engines

To Remove:

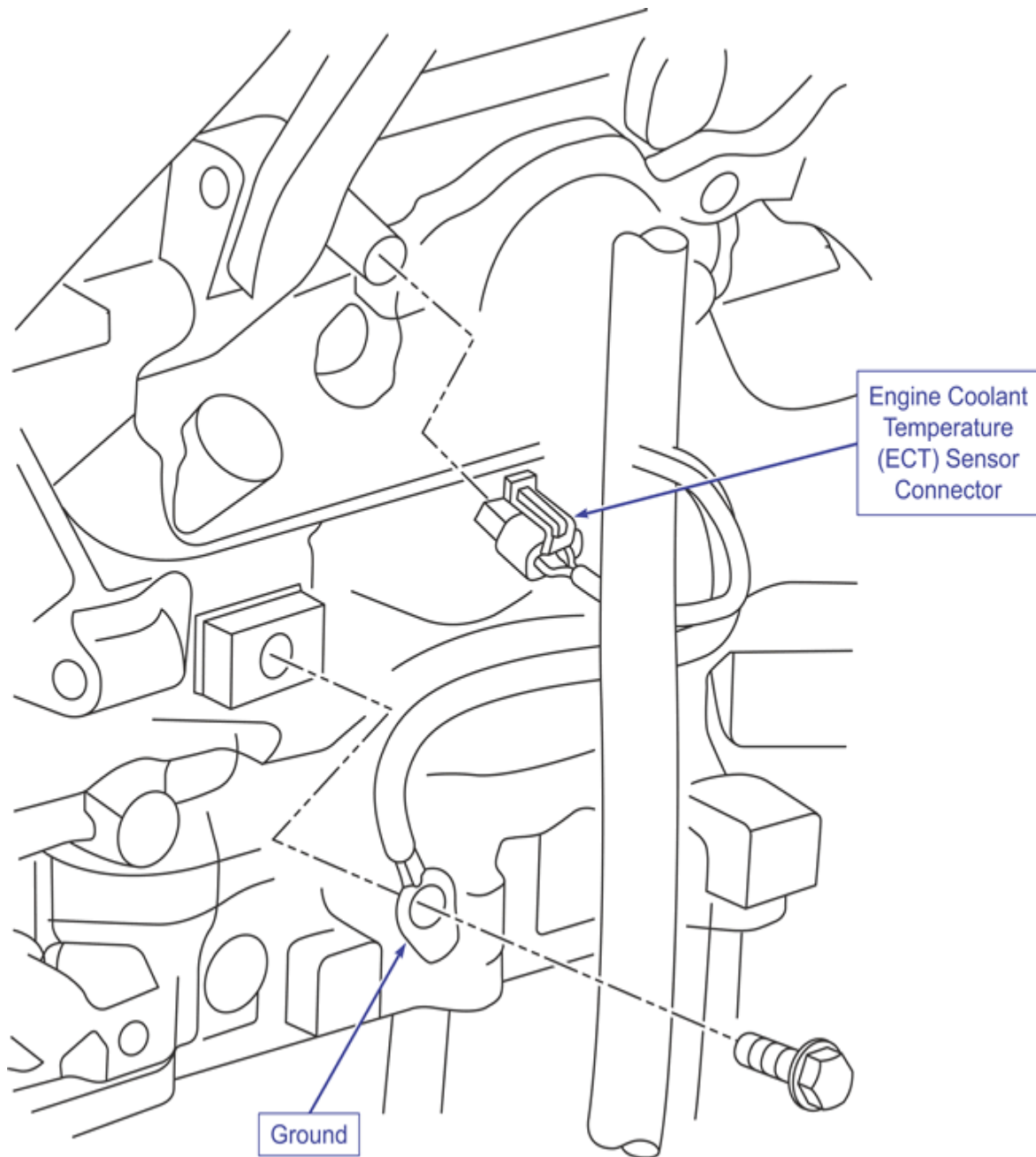
1. Remove the hood from the vehicle.
2. Cover both of the fenders.
3. Disconnect the negative battery cable from the battery.
4. Drain the coolant from the engine.
5. Evacuate the refrigerant from the HVAC system.
6. Drain the oil from the engine.
7. Remove the radiator from the vehicle.
8. Remove the radiator support brace from the front of the vehicle.
9. Remove the engine protection shield from under the vehicle.
10. For vehicles with 4WD, remove the front differential drive axle from the vehicle.
11. Remove the wheel drive shafts from the vehicle.
12. Remove the intake manifold from the engine.

Rear of the engine



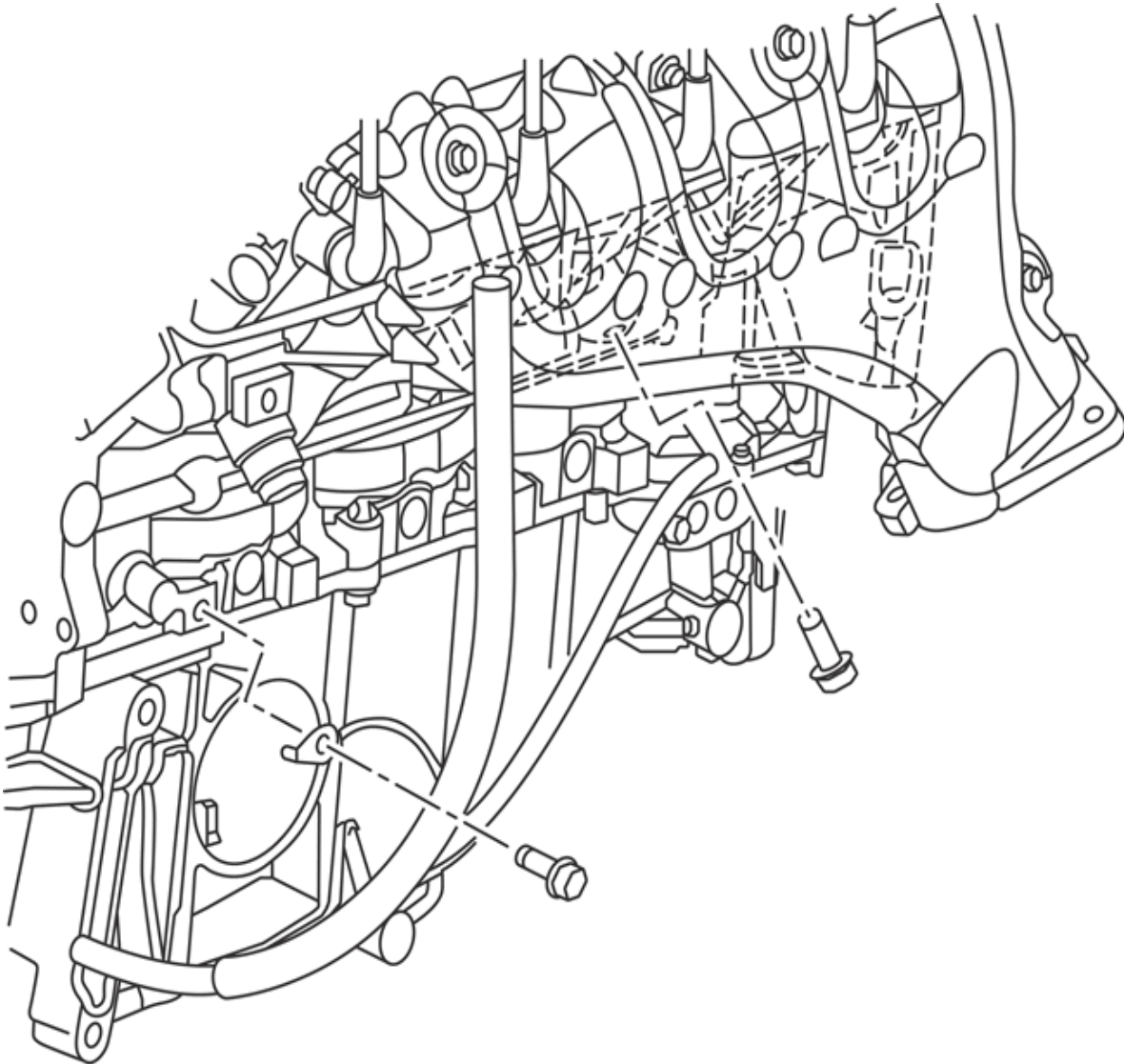
13. Disconnect the oil pressure sensor, heated oxygen sensor (HO2S) bank 1 sensor 1, heated oxygen sensor (HO2S) bank 2 sensor 1, and camshaft position (CMP) sensor connectors.
14. Remove the A/C compressor hose from the vehicle.
15. Detach the A/C compressor pipe from the engine and set aside.

Engine coolant temperature sensor (ECT) connector



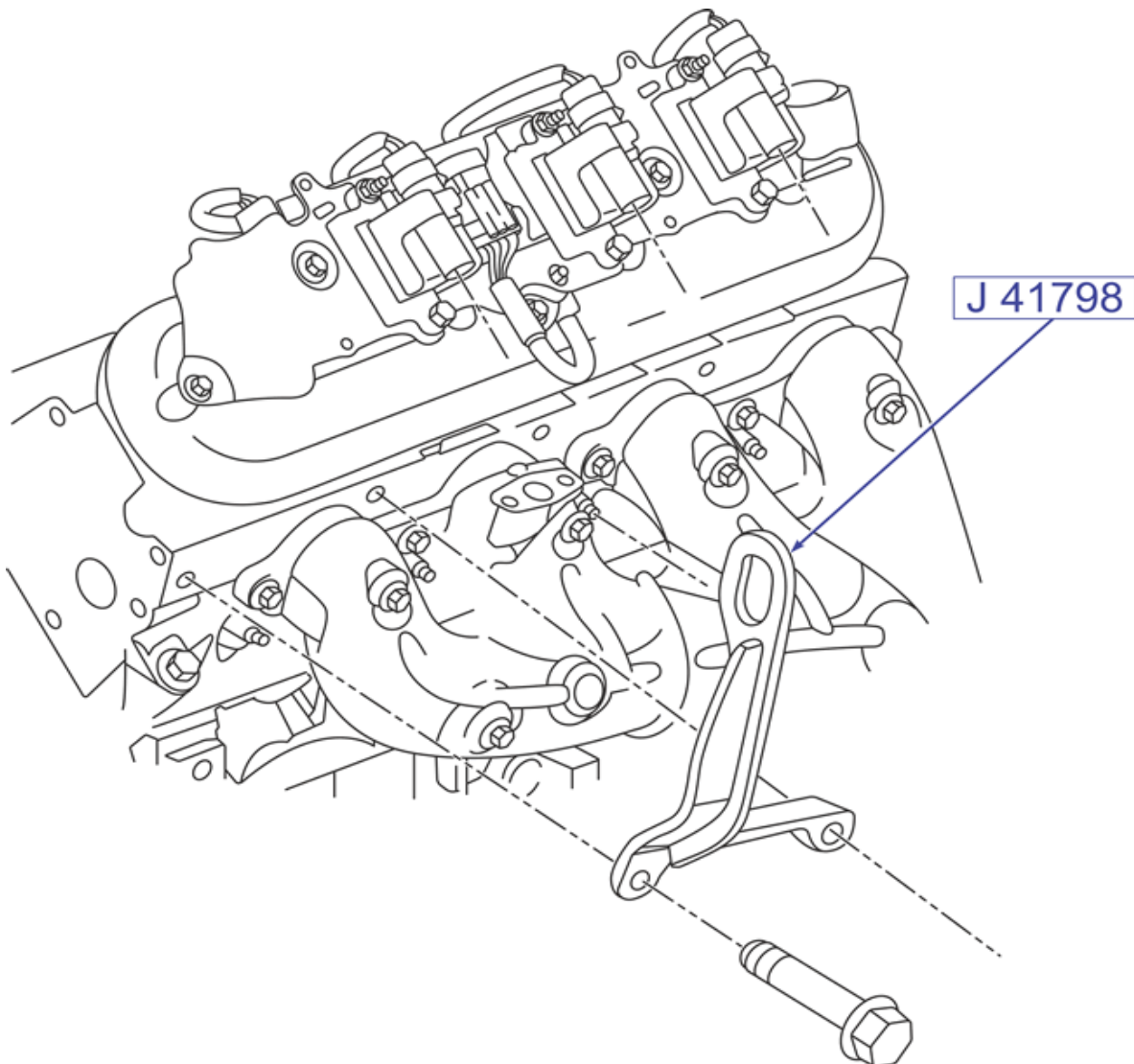
16. Disconnect the engine coolant temperature (ECT) sensor connector.
17. Detach the ground terminal from the engine near the engine coolant temperature (ECT) sensor.
18. Disconnect the A/C pressure switch connector.
19. Lift the vehicle.

Engine grounds



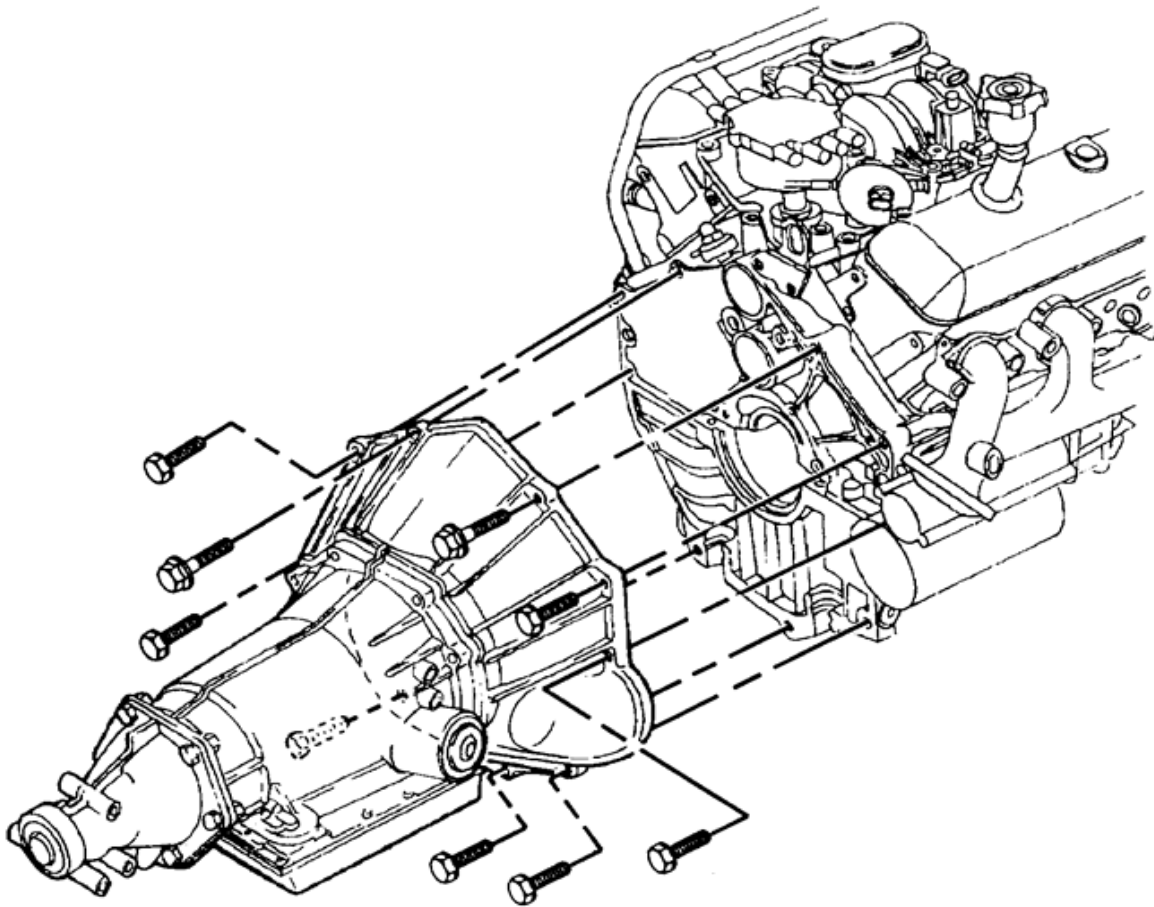
20. Detach the lower ground terminals from the engine.
21. Remove the starter from the engine.
22. Detach the battery cable channel from the oil pan.
23. Disconnect the A/C compressor connector.
24. Lower the vehicle.
25. Move the engine harness to the side.
26. Remove the generator from the engine.
27. Use a set of J 38185 hose clamp pliers to remove the inlet and outlet hoses from the water outlet.
28. Disconnect the auxiliary heater inlet and outlet hose/pipe assembly from the heater water shutoff valve pipes.
29. Use a set of J38185 hose clamp pliers to remove the auxiliary heater inlet and outlet hoses/pipes from the water pump.

Lift bracket removal and installation



30. Remove the necessary ignition coils from the engine to attach a J 41798 engine lift bracket.
31. Attach a J 41798 engine lift bracket to the engine. Torque the M8 bolts to **18 ft-lb (25 Nm)**. Torque the M10 bolts to **37 ft-lb (50 Nm)**.
32. Remove the catalytic converter from the exhaust pipe.
33. Remove the bolts from the left and right frame engine mounts.
34. Remove the bolts from the torque converter.
35. Detach the oil level indicator tube from the engine.

Transmission bolts and studs removal and installation



36. Remove the right transmission bolt and stud.
37. Remove the lower transmission bolts and studs.
38. Lower the vehicle.
39. Remove the upper transmission bolts and studs.
40. Attach an engine hoist to the J 41798 engine lift bracket.
41. Support the transmission with a transmission jack.
42. Lift the engine out of the vehicle.
43. Install the engine onto an engine stand.
44. Install a J 21366 converter holding strap.

To Install:

1. Remove the J 21366 converter holding strap.
2. Remove the engine from the engine stand.
3. Lower the engine into the vehicle.
4. Mate the transmission to the engine.
5. Remove the transmission jack.
6. Install the upper transmission bolts and studs. Torque the bolts and studs to **37 ft-lb (50 Nm)**.
7. Lift the vehicle.
8. Install the lower transmission bolts and studs. Torque the bolts and studs to **37 ft-lb (50 Nm)**.
9. Install the right transmission bolt and stud. Torque the bolt and stud to **37 ft-lb (50 Nm)**.
10. Attach the oil level indicator tube to the engine. Torque the nut to **89 ft-lb (10 Nm)**.
11. Install the bolts into the torque converter. Torque the nut to **44 ft-lb (60 Nm)**.
12. Install the bolts into the left and right frame engine mounts. Torque the bolts to **37 ft-lb (50 Nm)**.
13. Lower the vehicle.
14. Detach the J 41798 engine lift bracket from the engine.
15. Install the ignition coils removed from the engine. Torque the bolts to **71 in-lb (8 Nm)**.
16. Use a set of J38185 hose clamp pliers to install the auxiliary heater inlet and outlet hoses/pipes to the water pump.
17. Connect the auxiliary heater inlet and outlet hose/pipe assembly to the heater water shutoff valve pipes.
18. Use a set of J 38185 hose clamp pliers to install the inlet and outlet hoses to water outlet.
19. Install the generator onto the engine.
20. Reposition the engine harness onto the engine.
21. Lift the vehicle.
22. Connect the A/C compressor connector.
23. Attach the battery cable channel to the oil pan. Torque the bolt to **106 in-lb (12 Nm)**.
24. Install the starter onto the engine.
25. Attach the lower ground terminals to the engine. Torque the bolts to **18 ft-lb (25 Nm)**.
26. Lower the vehicle.
27. Connect the A/C pressure switch connector.
28. Attach the ground terminal to the engine near the engine coolant temperature (ECT) sensor. Torque the bolt to **18 ft-lb (25 Nm)**.
29. Connect the engine coolant temperature (ECT) sensor connector.
30. Attach the A/C compressor pipe to the engine. Torque the nut and bolt to **15 ft-lb (20 Nm)**. Torque the fitting to **12 ft-lb (16 Nm)**.
31. Install the A/C compressor hose to the vehicle.
32. Connect the oil pressure sensor, heated oxygen sensor (HO2S) bank 1 sensor 1, heated oxygen sensor (HO2S) bank 2 sensor 1, and camshaft position (CMP) sensor connectors.
33. Install the intake manifold to the engine.
34. Install the wheel drive shafts to the vehicle.
35. Install the engine protection shield onto the vehicle.

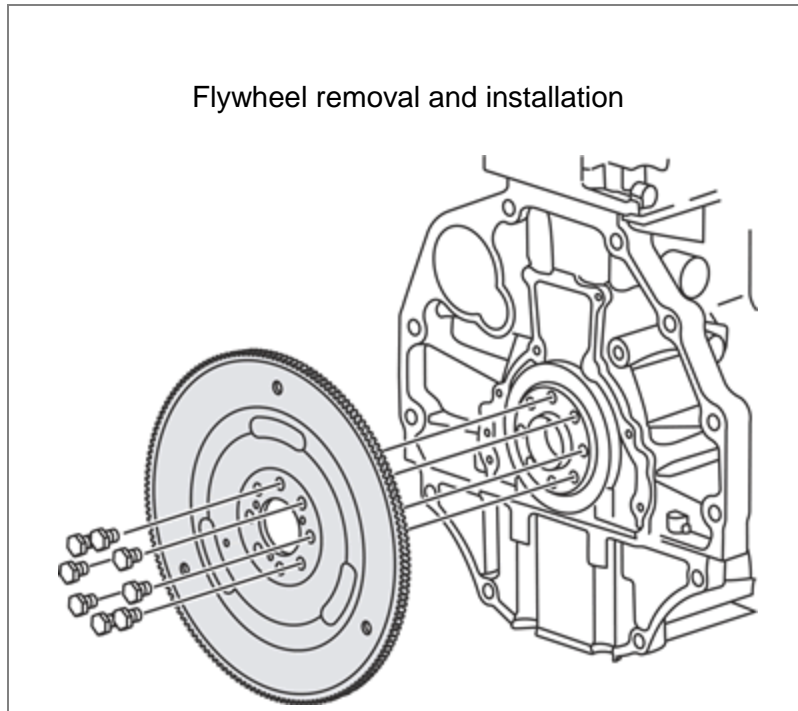
36. For vehicles with 4WD, install the front differential drive axle to the vehicle.
37. Install the radiator support brace to the front of the vehicle.
38. Install the radiator into the vehicle.
39. Recharge the HVAC system with refrigerant.
40. Connect the negative battery cable to the battery.
41. Remove the fender covers.
42. Refill the engine with oil.
43. Refill the engine with coolant.
44. Install the hood onto the vehicle.
45. Make sure the engine is working properly.

Flywheel

Removal & Installation

4.2L Engine

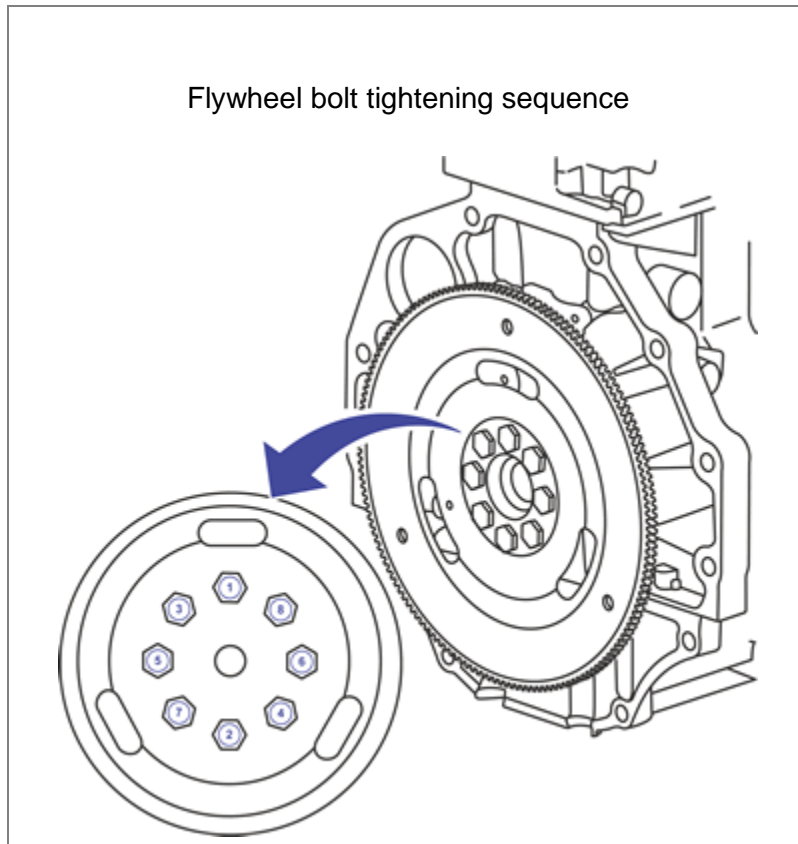
To Remove:



1. Remove the transmission from the vehicle.
2. Detach the flywheel from the crankshaft.

To Install:

1. Apply threadlock to the flywheel bolts.

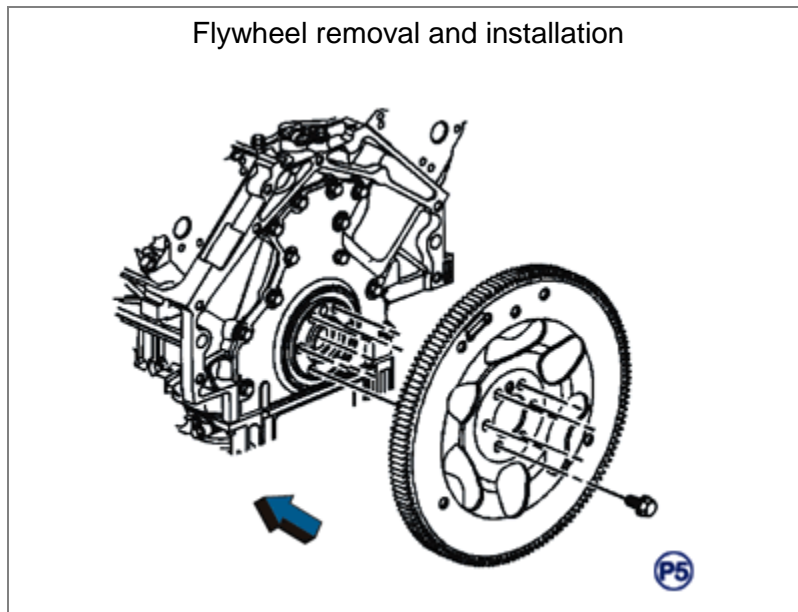


2. Attach the flywheel to the crankshaft. Torque the bolts, in sequence, to **18 ft-lb (25 Nm)**. Use a J 36660-A torque angle meter to turn the bolts an **additional 50 degrees**.
3. Install the transmission onto the vehicle.

5.3L & 6.0L Engines

To Remove:

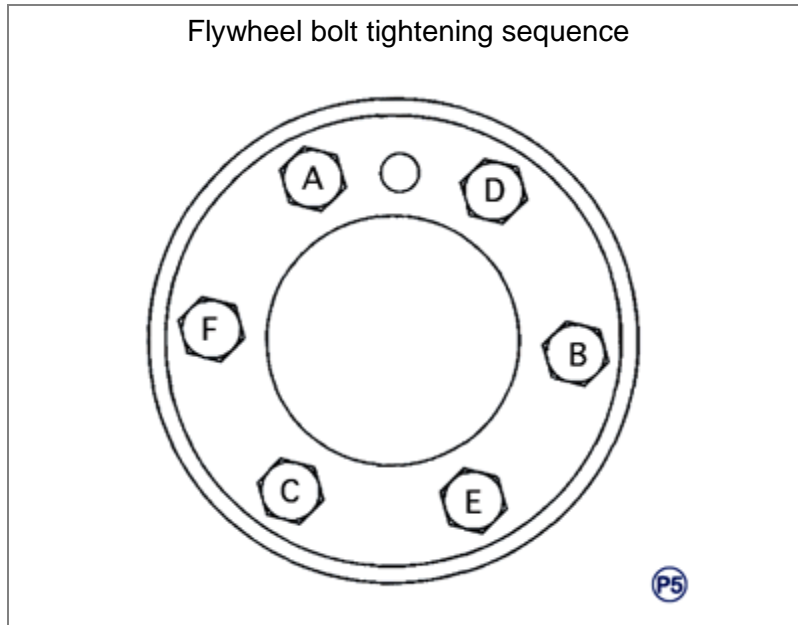
1. Remove the transmission from the vehicle.



2. Mark the position of the flywheel to the crankshaft.
3. Detach the flywheel from the crankshaft.

To Install:

1. Apply threadlock to the flywheel bolts.
2. Align the flywheel to the mark on the crankshaft.



3. Attach the flywheel to the crankshaft. Torque the bolts, in sequence, to **15 ft-lb (20 Nm)**. Torque the bolts again, in sequence, to **37 ft-lb (50 Nm)**. Torque the bolts a final time, in sequence, to **74 ft-lb (100 Nm)**.
4. Install the transmission onto the vehicle.

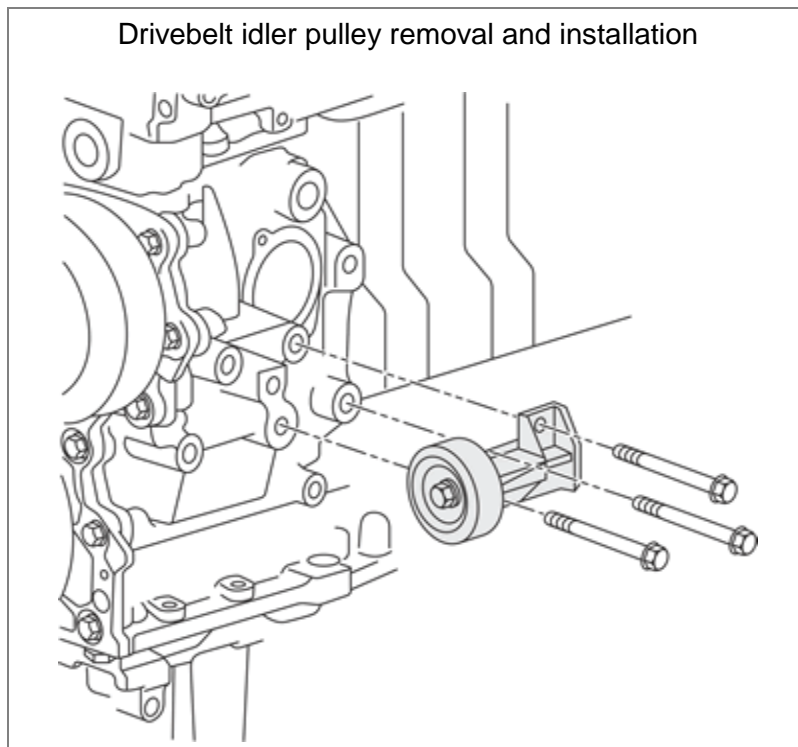
Drive Belt Idler Pulley

Removal & Installation

4.2L Engine

To Remove:

1. Remove the drive belt from the pulleys.
2. Lift the vehicle.
3. Remove the left front wheel from the vehicle.



4. Remove the bolts from the drive belt idler pulley through the left wheelhouse.
5. Lower the vehicle.
6. Remove the forward bolt from the drive belt idler pulley through the engine compartment.
7. Remove the drive belt idler pulley from the vehicle.

To Install:

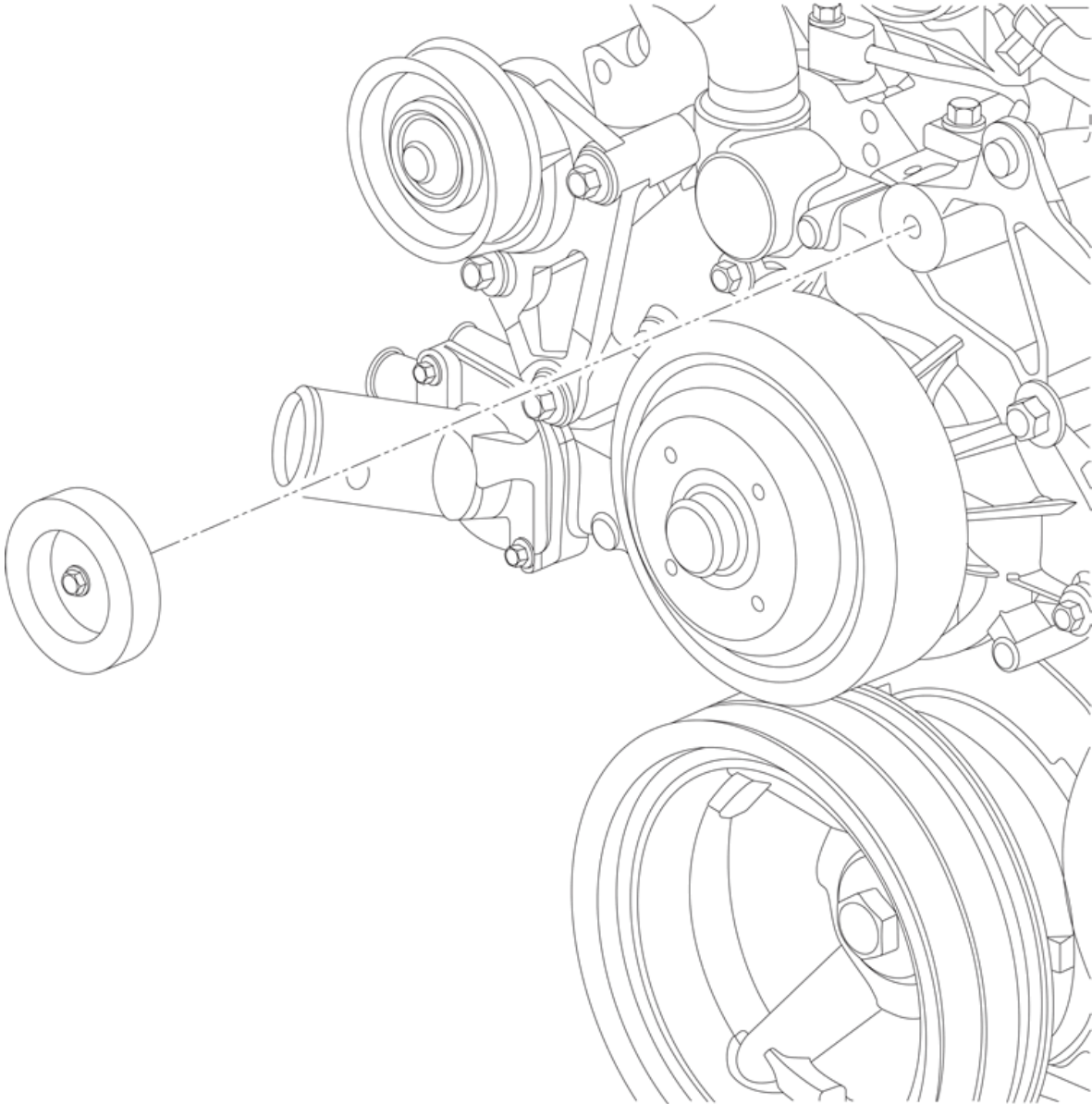
1. Install the drive belt idler pulley and forward bolt through the engine compartment.
2. Lift the vehicle.
3. Install the bolts into the drive belt idler pulley through the left wheelhouse. Torque the bolts to **37 ft-lb (50 Nm)**.
4. Install the left front wheel onto the vehicle.
5. Lower the vehicle.
6. Install the drive belt onto the pulleys.

5.3L Engine

To Remove:

1. Remove the drive belt from the pulleys.

Idler pulley



2. Detach the drive belt idler pulley from the engine.

To Install:

1. Attach the drive belt idler pulley to the engine. Torque the bolt to **37 ft-lb (50 Nm)**.
2. Install the drive belt onto the pulleys.

Intake Manifold

Removal & Installation

CAUTION

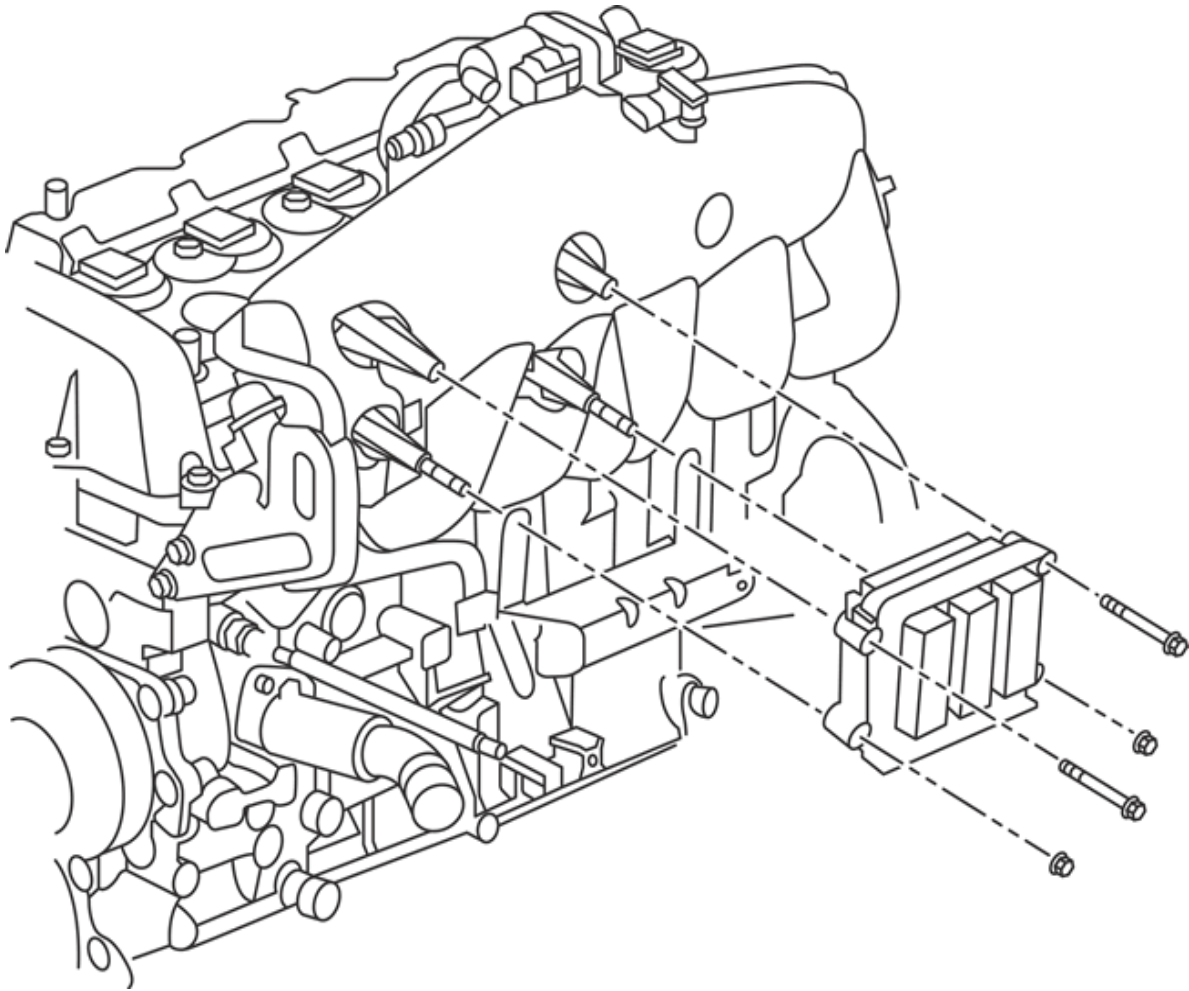
Do not use solvent of any type when cleaning the gasket surfaces on the intake manifold and the throttle body assembly, as damage to the gasket surfaces and throttle body assembly may result. Use care in cleaning the gasket surfaces on the intake manifold and the throttle body assembly, as sharp tools may damage the gasket surfaces

4.2L Engine

To Remove:

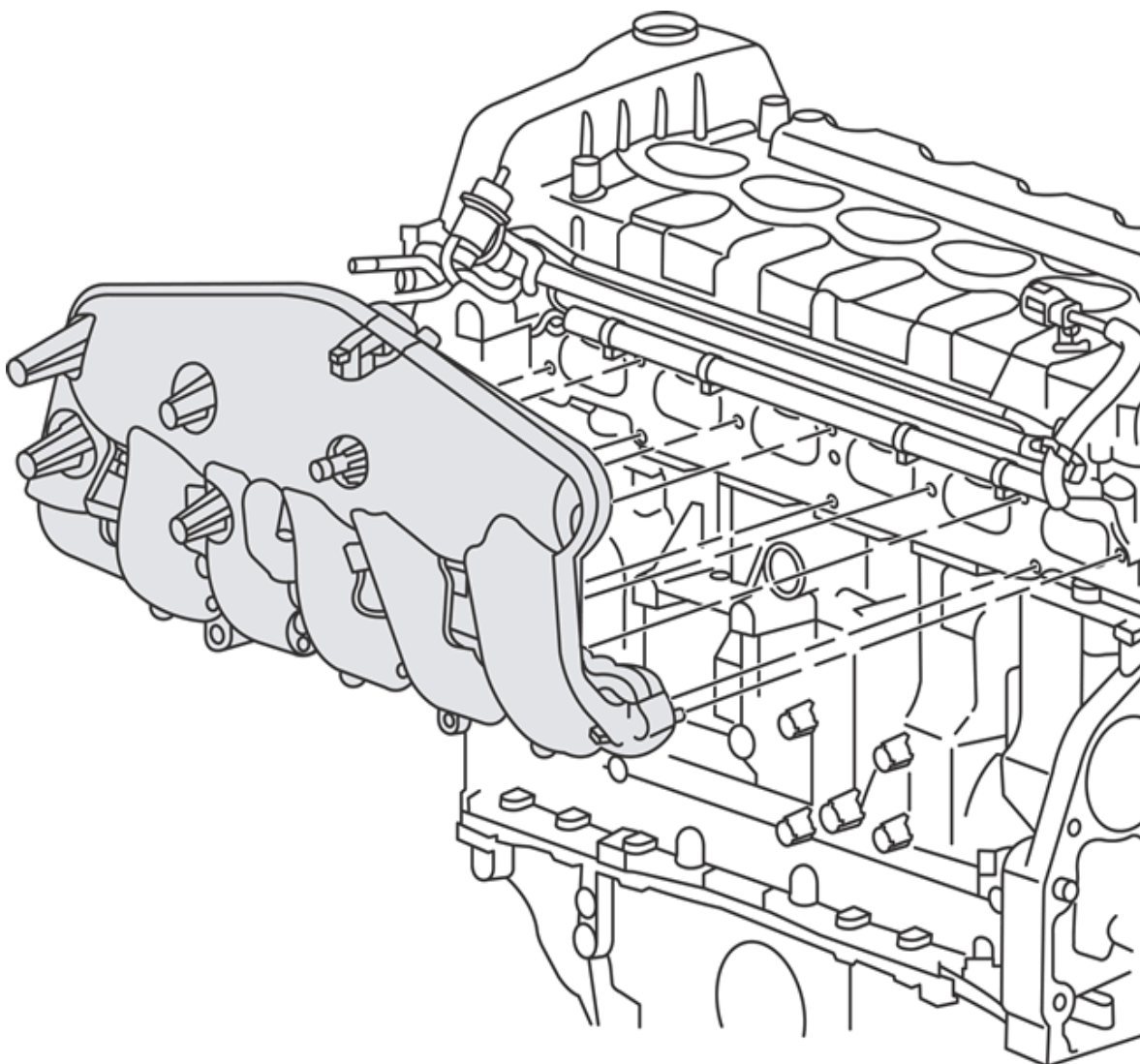
1. Disconnect the negative battery cable from the battery.
2. Relieve the pressure in the fuel system.

Powertrain control module (PCM) removal and installation



3. Remove the throttle body and powertrain control module (PCM) from the engine.
4. Detach the fuel feed pipe from the fuel rail.
5. Detach the integral clip from the engine harness bracket.
6. Detach the engine harness bracket from the engine.
7. Detach the harness and vacuum lines from the intake manifold.
8. Disconnect the manifold absolute pressure (MAP) sensor connector.
9. Detach the crankcase ventilation hose from the intake manifold.
10. Detach the vacuum brake booster hose from the intake manifold.
11. Remove the generator from the engine.

Intake manifold removal and installation



12. Detach the intake manifold from the engine.

To Install:

1. Place a new intake manifold gasket onto the intake manifold.
2. Attach the intake manifold onto the engine. Torque the bolts to **89 in-lb (10 Nm)**.
3. Install the generator onto the engine.
4. Attach the vacuum brake booster hose to the intake manifold.
5. Lubricate the inside of the crankcase ventilation hose opening and attach it to the intake manifold.
6. Connect the manifold absolute pressure (MAP) sensor connector.
7. Attach the harness and vacuum lines to the intake manifold.
8. Attach the engine harness bracket to the engine. Torque the bolt to **89 in-lb (10 Nm)**.
9. Attach the integral clip to the engine harness bracket.

10. Attach the fuel feed pipe to the fuel rail.
11. Install the powertrain control module (PCM) and throttle body onto the engine.
12. Connect the negative battery cable to the battery.
13. Check the fuel system for leaks by turning the ignition to on, with the engine off for 2 seconds. Turn the ignition to off for 10 seconds. Turn the ignition to on with the engine off.

5.3L & 6.0L Engines

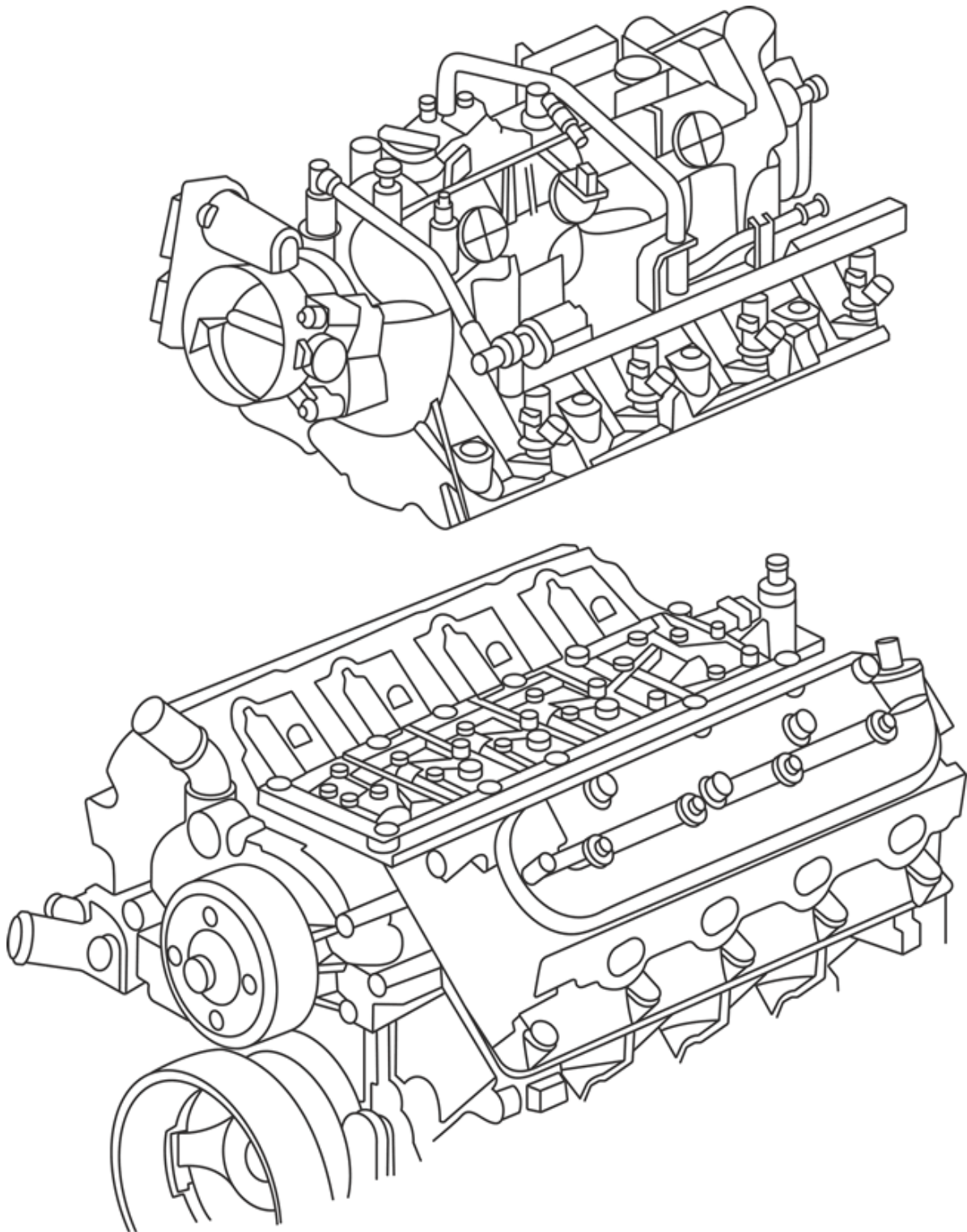
To Remove:

1. Disconnect the negative battery cable from the battery.
2. Remove the air cleaner outlet duct from the engine compartment.
3. Relieve the pressure in the fuel system.
4. Disconnect the A/C compressor pressure switch connector.
5. Detach the harness clip from the cylinder head.
6. Disconnect the mass air flow (MAF)/intake air temperature (IAT) sensor, fuel injectors, evaporative emission (EVAP) purge solenoid, throttle body harness, manifold absolute pressure (MAP) sensor, ignition coil harnesses, and generator connectors.
7. Remove the harness clips from the fuel rail.

8. Remove the positive crankcase ventilation (PCV) hose from the engine.
9. Detach the heater water shutoff valve actuator inlet hose from the intake manifold.
10. Remove the evaporative emission (EVAP) purge solenoid vent tubes from the engine.
11. Detach the fuel feed pipe from the fuel rail.
12. Detach the vacuum brake booster hose from the intake manifold.
13. Remove the engine harness retainer nut from the top of the engine.
14. Move the upper engine harness to gain clearance from the intake manifold.

NOTE: Unless the individual components are being serviced, the intake manifold, throttle body, fuel rail, and fuel injectors may be removed as an assembly.

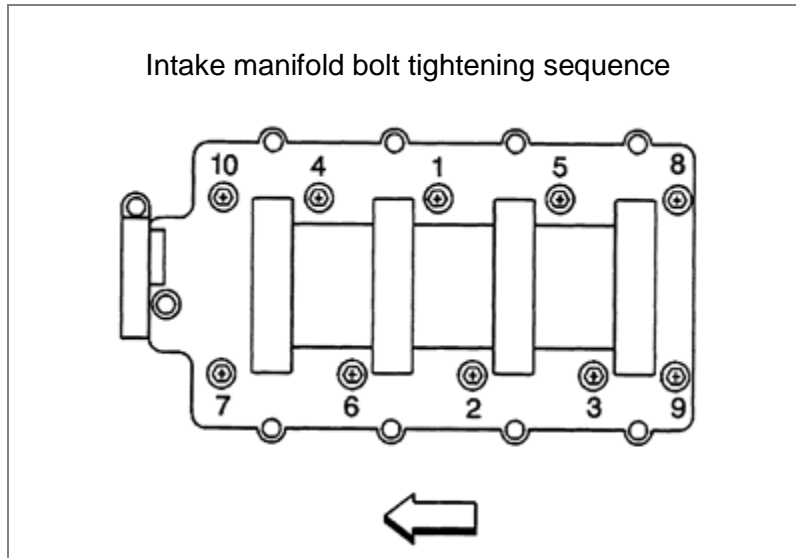
Intake manifold removal and installation



15. Detach the intake manifold from the cylinder head.
16. Remove and discard the gaskets from the intake manifold.
17. Clean the sealing surfaces as necessary.

To Install:

1. Install new gaskets onto the intake manifold.
2. Apply a 0.2 in (5 mm) bead of threadlock to the intake manifold bolts.



3. Attach the intake manifold to the cylinder head. Torque the bolts, in sequence, to **44 in-lb (5 Nm)**. Torque the bolts again, in sequence, to **89 in-lb (10 Nm)**.
4. Place the upper engine harness over the engine and install the retainer nut. Torque the nut the **89 in-lb (10 Nm)**.
5. Attach the vacuum brake booster hose to the intake manifold.
6. Attach the fuel feed pipe to the fuel rail.
7. Install the evaporative emission (EVAP) purge solenoid vent tubes onto the engine.
8. Attach the heater water shutoff valve actuator inlet hose to the intake manifold.
9. Install the positive crankcase ventilation (PCV) hose from the engine.
10. Install the harness clips to the fuel rail.
11. Connect the mass air flow (MAF)/intake air temperature (IAT) sensor, fuel injectors, evaporative emission (EVAP) purge solenoid, throttle body harness, manifold absolute pressure (MAP) sensor, ignition coil harnesses, and generator connectors.
12. Install the harness clips onto the fuel rail.
13. Connect the A/C compressor pressure switch connector.
14. Attach the harness clip to the cylinder head.
15. Install the air cleaner outlet duct into the engine compartment.
16. Disconnect the negative battery cable from the battery.
17. Check the fuel system for leaks by turning the ignition to on, with the engine off for 2 seconds. Turn the ignition to off for 10 seconds. Turn the ignition to on with the engine off.

Oil Pan

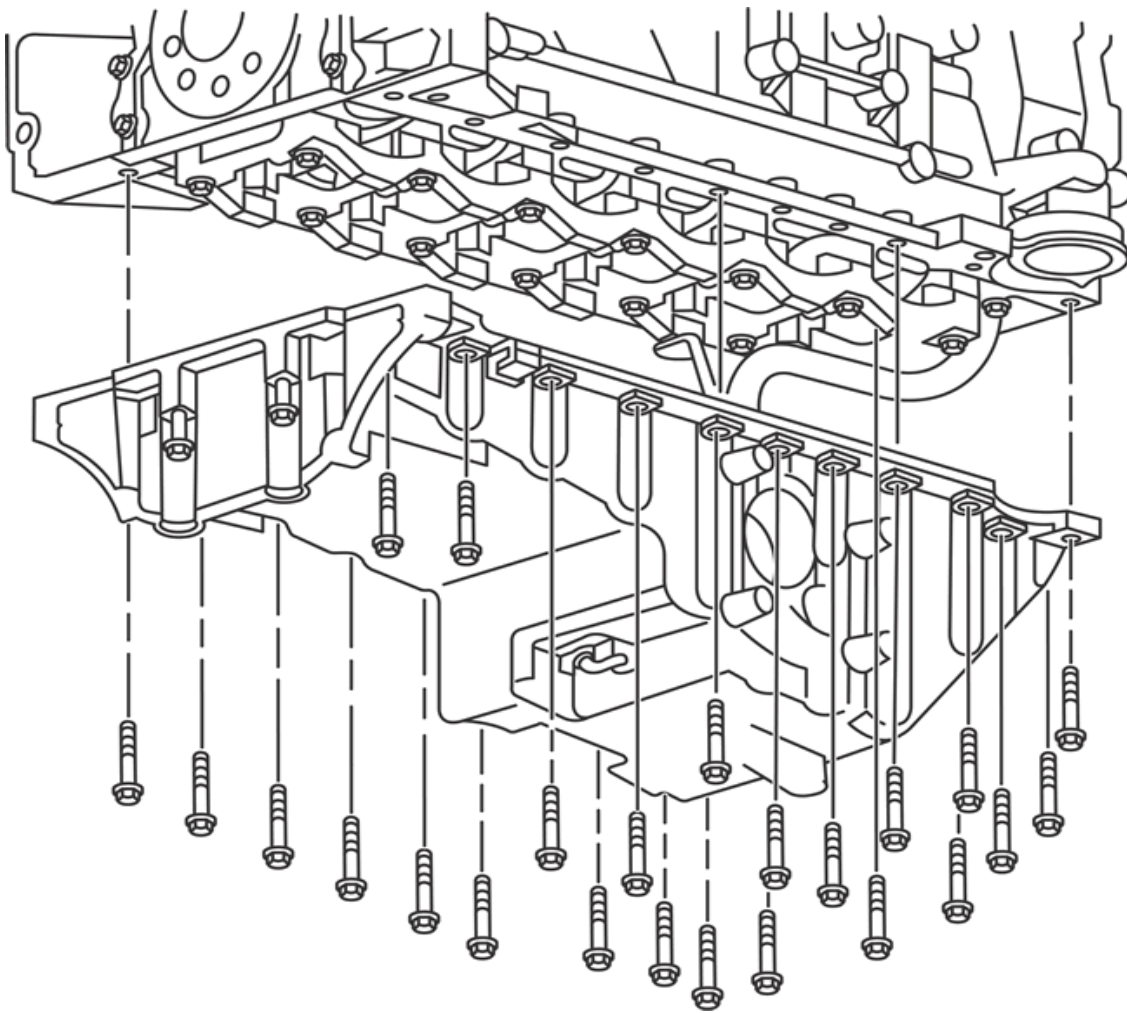
Removal & Installation

4.2L Engine

To Remove:

1. Disconnect the negative battery cable from the battery.
2. Remove the bottom bolts from the A/C compressor.
3. Loosen the top bolt in the A/C compressor.
4. Remove the oil level indicator and tube from the engine.
5. Remove the stabilizer shaft from the vehicle.
6. Remove the front differential from the engine and secure it to the frame.
7. Remove the front drive axle intermediate shaft bearing assembly from the vehicle.
8. Drain the oil from the engine.
9. Detach the transmission cooler lines from the engine block.
10. Remove the oil pan bolts from the transmission bell housing.

Oil pan removal and installation



11. Remove the remaining bolts from the oil pan.

12. Install two jack screws into the oil pan and tighten evenly to remove the oil pan from the engine.

To Install:

1. Apply a 0.12 in (3 mm) bead of sealer to the oil pan sealing surface on the engine.

NOTE: The oil pan must be installed no later than 10 minutes after applying the sealer.

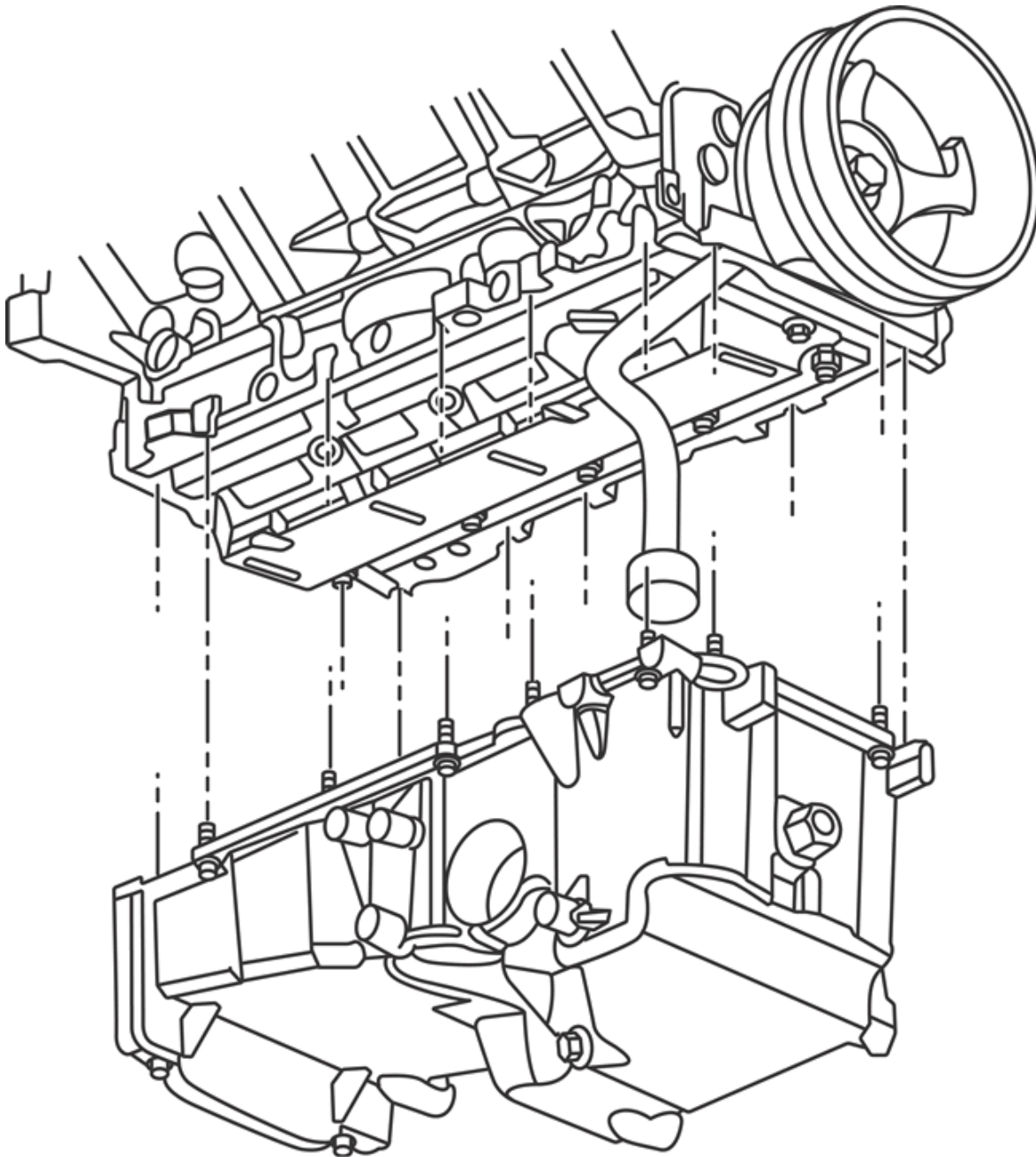
2. Place the oil pan on the bottom of the engine.
3. Install the bolts into the oil pan.
4. Use a straight edge on the rear of the engine block and oil pan to make sure they are properly aligned.
5. Torque the bolts on the side of the oil pan to **18 ft-lb (25 Nm)**.
6. Torque the bolts on the end of the oil pan to **89 in-lb (10 Nm)**.
7. Install the oil pan bolts into the transmission bell housing. Torque the bolts to **35 ft-lb (47 Nm)**.
8. Attach the transmission cooler lines to the engine block.
9. Install the front drive axle intermediate shaft bearing assembly into the vehicle.
10. Install the oil drain plug and oil filter into the vehicle.
11. Install the front differential onto the engine.
12. Install the stabilizer shaft onto the vehicle.
13. Install the bottom bolts into the A/C compressor. Torque all the bolts to **37 ft-lb (50 Nm)**.
14. Install the oil level indicator and tube onto the engine.
15. Connect the negative battery cable to the battery.
16. Refill the engine with oil.

5.3L & 6.0L Engines

To Remove:

1. Disconnect the negative battery cable from the battery.
2. Remove the oil level indicator and tube from the engine.
3. For vehicles with 4WD, remove the front differential from the engine and secure it to the frame.
4. Drain the oil from the engine.
5. Detach the transmission cooler lines from the engine.
6. Remove the starter from the engine.
7. Remove the flywheel inspection cover from the transmission on the left side.
8. Detach the battery cable channel from the oil pan.
9. Loosen the top bolts in the A/C compressor.
10. Remove the bottom bolts from the A/C compressor.
11. Remove the lower oil pan bolts from the transmission bell housing.

Oil pan removal and installation



12. Remove the remaining bolts from oil pan.
13. Remove the oil pan from the engine.
14. Remove the gasket from the oil pan by drilling out the rivets.

To Install:

NOTE: Make sure the oil pan is flush with the rear of the engine block when installing.

1. Apply a 0.2 in (5 mm) bead of sealant 0.8 in (20 mm) long to the front and rear tabs of the engine block that protrude into the oil pan surface.
2. Place the oil pan gasket onto the oil pan and insert the bolts through the oil pan and gasket.
3. Install the oil pan onto the engine. Hand tighten the bolts.
4. Install the oil pan bolts into the transmission bell housing. Torque the bolts to **37 lb-ft (50 Nm)**.
5. Torque the rear oil pan bolts to **106 in-lb (12 Nm)**.
6. Torque the remaining oil pan bolts to **18 ft-lb (25 Nm)**.
7. Install the bottom bolts into the A/C compressor. Torque the bolts to **37 ft-lb (50 Nm)**.
8. Torque the top A/C compressor bolts to **37 ft-lb (50 Nm)**.
9. Attach the battery cable channel to the oil pan. Torque the bolt to **106 in-lb (12 Nm)**.
10. Install the flywheel inspection cover into the transmission on the left side.
11. Install the starter onto the engine.
12. Attach the transmission cooler lines to the engine. Torque the bolt to **80 in-lb (9 Nm)**.
13. Install the oil level indicator and tube onto the engine.
14. Refill the engine with oil.
15. For vehicles with 4WD, install the front differential onto the engine.
16. Connect the negative battery cable to the battery.

Oil Pump

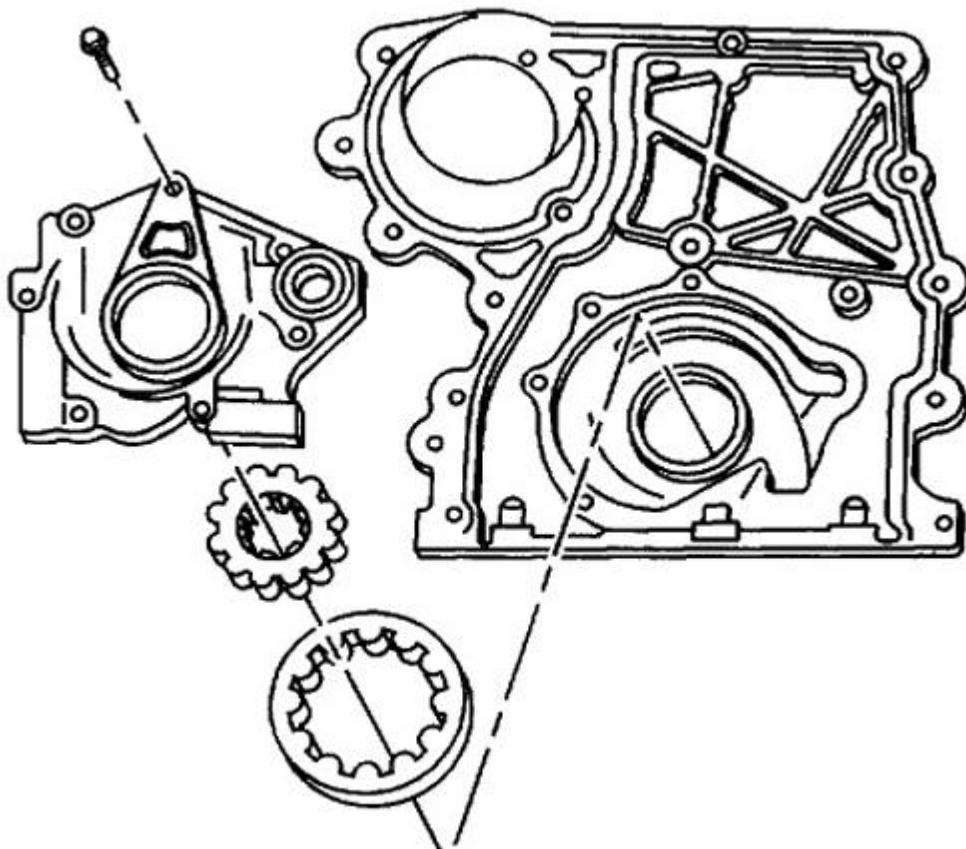
Removal & Installation

4.2L Engine

To Remove:

1. Remove the engine front cover from the engine block.

Oil pump cover



2. Detach the oil pump cover from the engine front cover.
3. Mark the position of the inner and the outer gears in relation to the oil pump housing.
4. Remove the inner and outer oil pump gears from the oil pump housing.
5. Remove the oil pump pressure relief valve plug, oil pump pressure relief valve, and spring from the oil pump housing.

To Install:

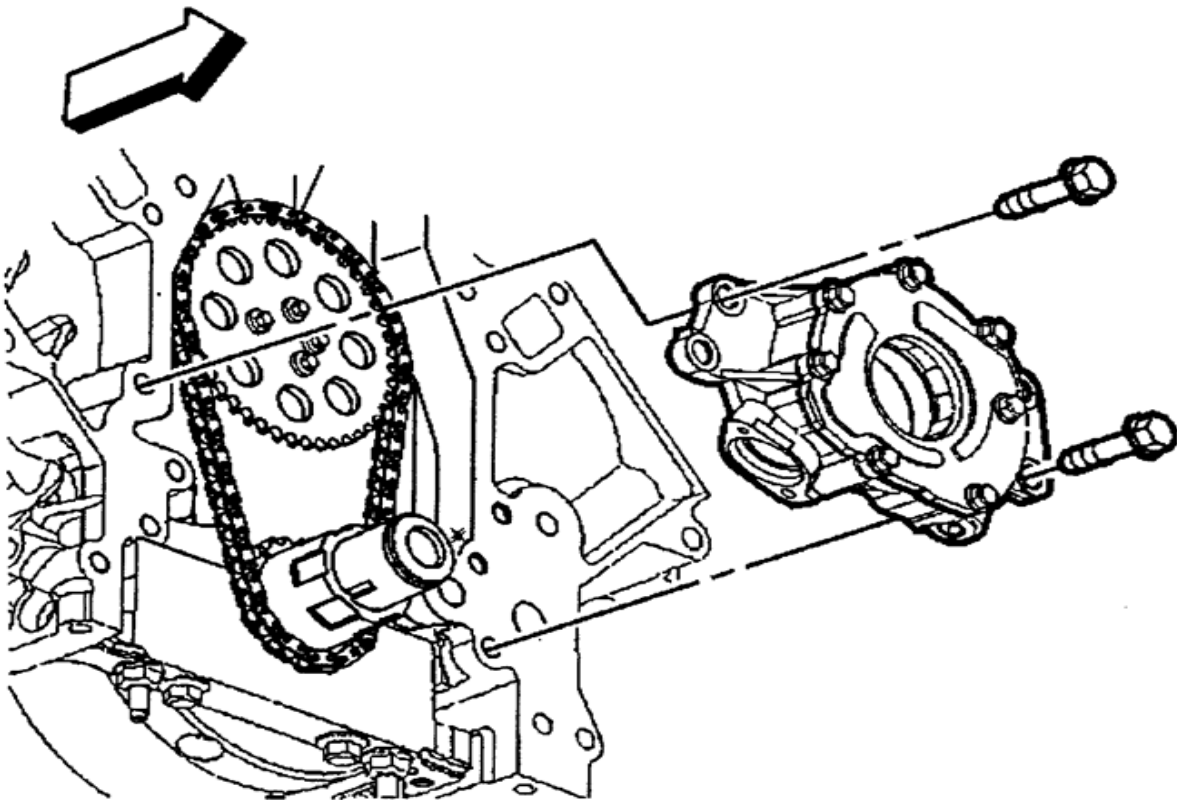
1. Install the oil pump pressure relief valve, spring, and oil pump pressure relief valve plug. Torque the plug to **124 in-lb (14 Nm)**.
2. Align the marks on the inner and outer oil pump gears to the oil pump housing and install the gears.
3. Attach the oil pump cover to the engine front cover. Torque the bolts to **89 in-lb (10 Nm)**.
4. Install the engine front cover onto the engine block.

5.3L & 6.0L Engines

To Remove:

1. Remove the oil pan from the engine.
2. Remove the engine front cover from the engine.
3. Detach the oil pump screen from the oil pump.
4. Remove and discard the o-ring from the oil pump screen.
5. Remove the crankshaft oil deflector from the engine block.

Oil pump removal and installation



6. Detach the oil pump from the engine block.

To Install:

1. Attach the oil pump to the engine block. Torque the bolts to **18 ft-lb (25 Nm)**.
2. Install the crankshaft oil deflector onto the engine block.
3. Use clean engine oil to lubricate the new oil pump screen o-ring and install it onto the screen.
4. Attach the oil pump screen to the oil pump. Torque the bolt to **106 in-lb (12 Nm)**. Torque the nuts to **18 ft-lb (25 Nm)**.
5. Install the engine front cover onto the engine.
6. Install the oil pan onto the engine.

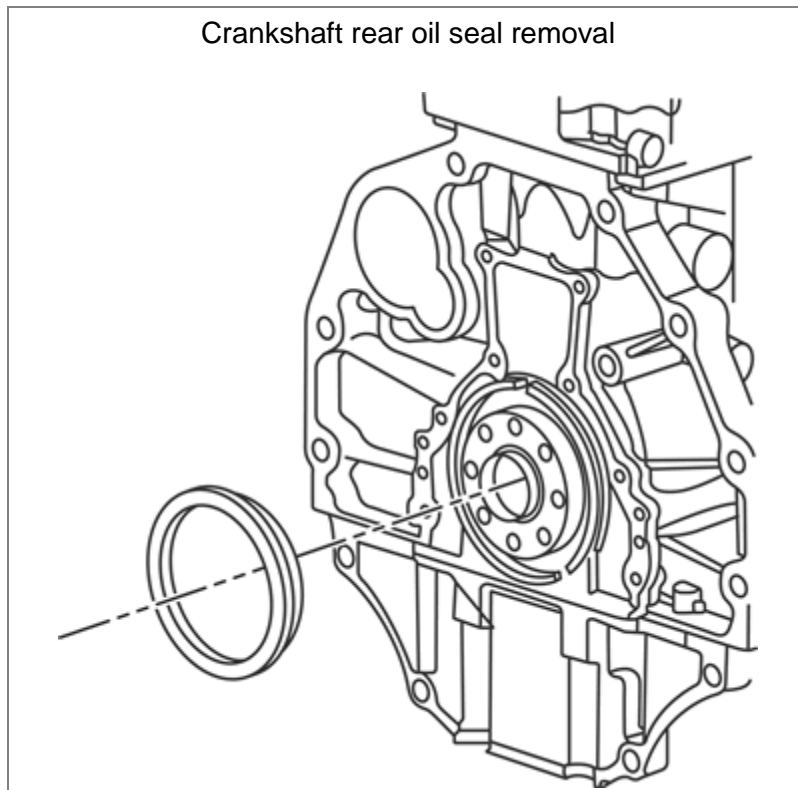
Crankshaft Rear Oil Seal

Removal & Installation

4.2L Engine

To Remove:

1. Remove the transmission from the engine.
2. Remove the flywheel from the crankshaft.



3. Use a suitable tool to pry the crankshaft rear oil seal from the housing.

To Install:

1. Use a J 44227 rear seal installer to install the crankshaft rear oil seal into the housing.
2. Install the flywheel onto the crankshaft.
3. Install the transmission onto the engine.

5.3L & 6.0L Engines

To Remove:

1. Remove the flywheel from the crankshaft.
2. Remove and discard the crankshaft rear oil seal from the rear cover.

To Install:

1. Use clean engine oil to lubricate the outside diameter of the crankshaft rear oil seal and rear cover oil seal bore.
2. Install the tapered cone and bolts of a J 41479 crankshaft rear oil seal installer onto the crankshaft.
3. Place the crankshaft rear oil seal onto the tapered cone.
4. Install the threaded rod of the J 41479 crankshaft rear oil seal installer into the tapered cone.
5. Install the crankshaft rear oil seal by turning the handle of the J 41479 clockwise.
6. Remove the J 41479 crankshaft rear oil seal installer from the crankshaft.
7. Install the flywheel onto the crankshaft.

Camshaft Cover

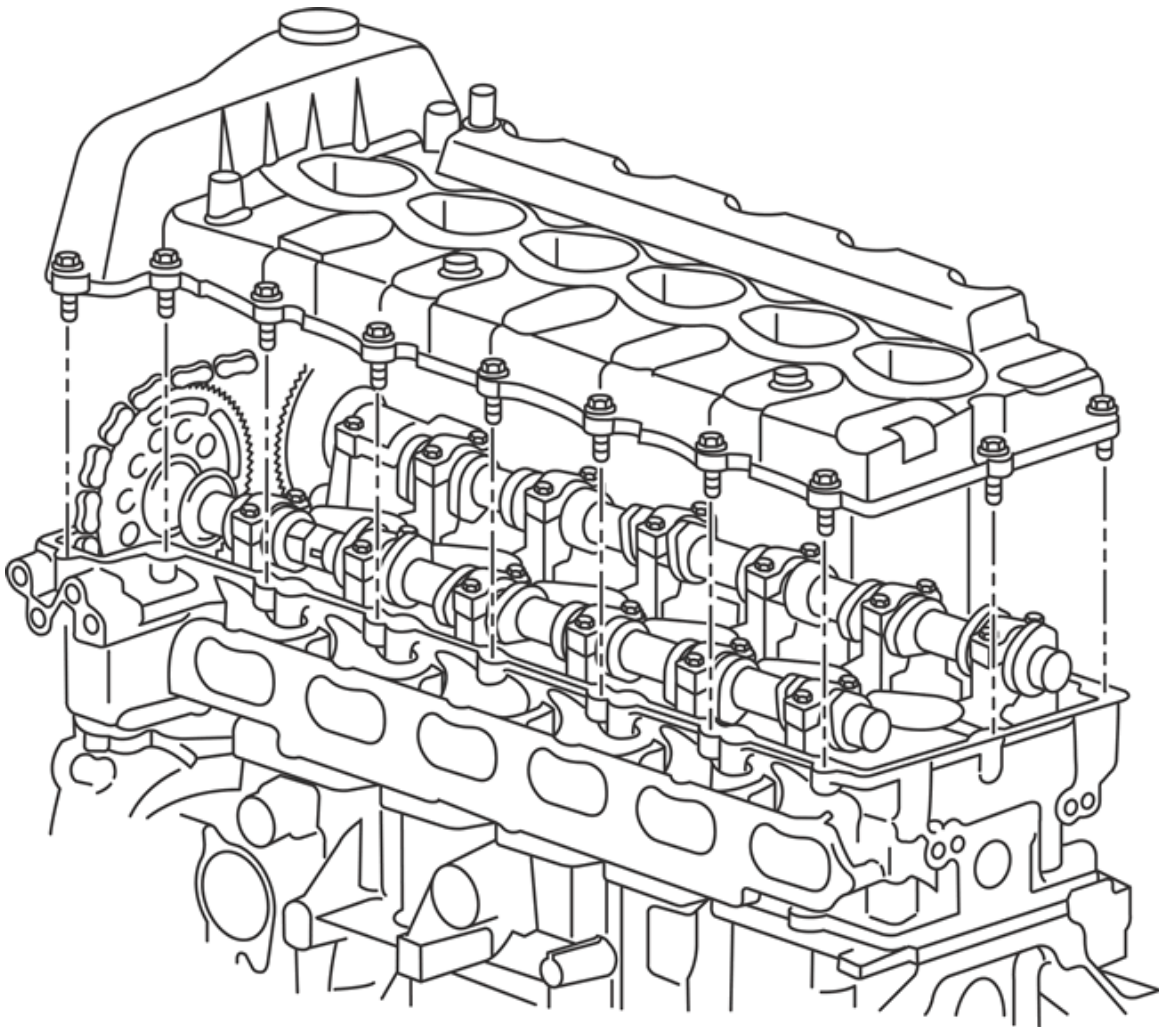
Removal & Installation

4.2L Engine

To Remove:

1. Remove the intake manifold from the engine.
2. Detach the A/C line bracket from the oil level indicator tube.
3. Detach the A/C line from the engine lift hook.
4. Set aside the A/C line.
5. Remove the engine lift hook from the engine.
6. Remove the ignition coils from the camshaft cover.
7. Detach the engine harness from the camshaft cover.
8. Disconnect the fuel injector harness connector.

Camshaft cover removal and installation



9. Detach the camshaft cover from the cylinder head.
10. Remove and discard the camshaft cover seal from the cylinder head.

To Install:

1. Place a new camshaft cover seal on the cylinder head.
2. Attach the camshaft cover to the cylinder head. Torque the bolts to **89 in-lb (10 Nm)**.
3. Install the ignition coils into the camshaft cover.
4. Connect the fuel injector harness connector.
5. Attach the engine harness to the camshaft cover.
6. Attach the A/C line bracket to the oil level indicator tube. Torque the nut to **62 in-lb (7 Nm)**.
7. Attach the engine lift hook to the engine. Torque the bolts to **37 ft-lb (50 Nm)**.
8. Attach the A/C line to the engine lift hook. Torque the bolt to **89 in-lb (10 Nm)**.
9. Install the intake manifold onto the engine.

Valve Rocker Arm Cover

Removal & Installation

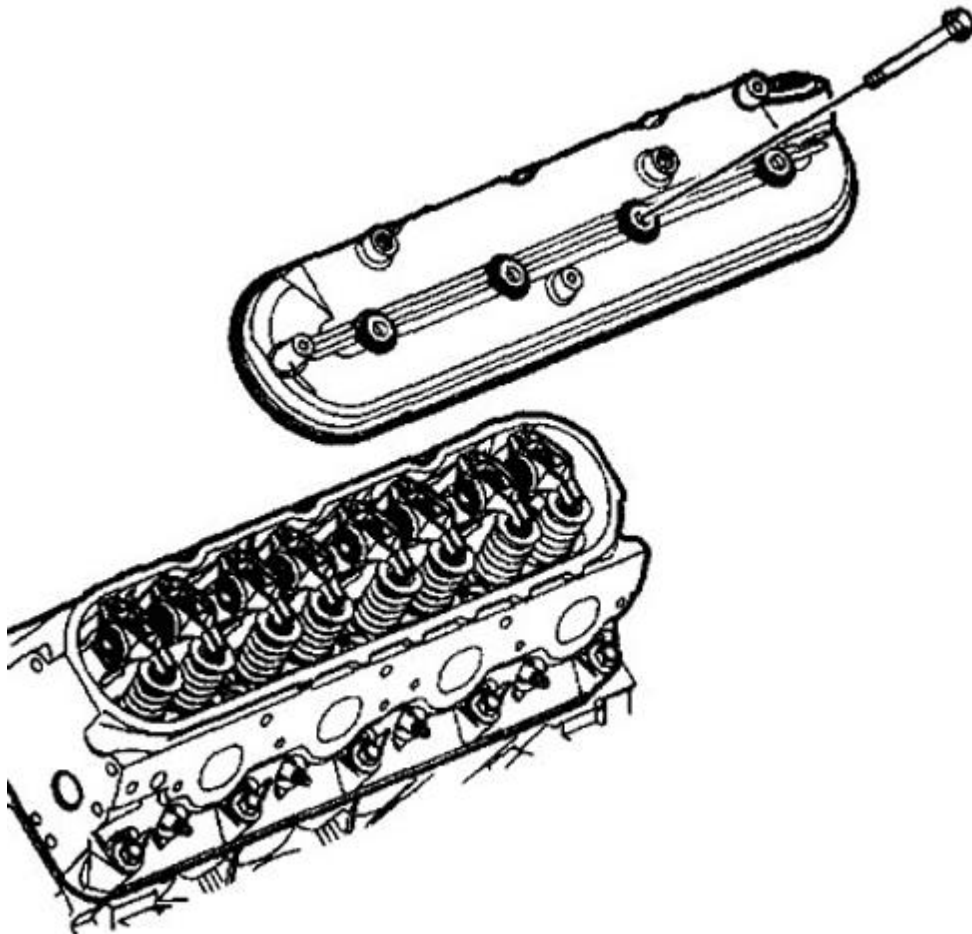
5.3L & 6.0L Engines

Left Side

To Remove:

1. If necessary, remove the intake manifold sight shield from the engine.
2. Disconnect the ignition coil harness connector.
3. Detach the engine harness from the engine and set aside.
4. Disconnect the spark plug wires from the ignition coils.
5. Remove the ignition coils from the valve rocker arm cover.
6. Detach the positive crankcase ventilation (PCV) hose from the valve rocker arm cover.

Left valve rocker arm cover removal and installation



7. Detach the valve rocker arm cover from the cylinder head.
8. Remove and discard the gasket from the valve rocker arm cover.
9. Clean the sealing surfaces as necessary.

To Install:

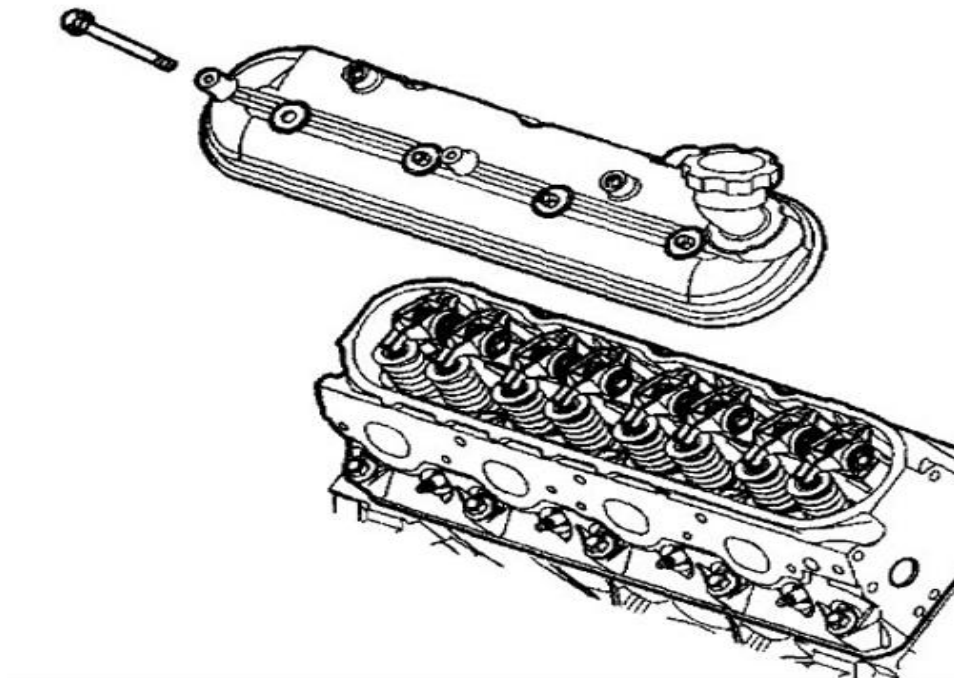
1. Install a new gasket onto the valve rocker arm cover.
2. Attach the valve rocker arm cover to the cylinder head. Torque the bolts to **106 in-lb (12 Nm)**.
3. Attach the positive crankcase ventilation (PCV) hose to the valve rocker arm cover.
4. Install the ignition coils onto the valve rocker arm cover.
5. Connect the spark plug wires to the ignition coils.
6. Attach the engine harness to the engine.
7. Connect the ignition coil harness connector.
8. If necessary, install the intake manifold sight shield to the engine.

Right Side

To Remove:

1. If necessary, remove the intake manifold sight shield from the engine.
2. Remove the A/C compressor hose from the vehicle.
3. Disconnect the ignition coil harness connector.
4. Detach the engine harness from the engine and set aside.
5. Disconnect the spark plug wires from the ignition coils.
6. Remove the ignition coils from the valve rocker arm cover.
7. Detach the vent hose from the valve rocker arm cover.

Right valve rocker arm cover removal and installation



8. Detach the valve rocker arm cover from the cylinder head.
9. Remove and discard the gasket from the valve rocker arm cover.
10. Remove the oil fill tube from the valve rocker arm cover.
11. Remove the cap from the oil fill tube and discard the tube.
12. Clean the sealing surfaces as necessary.

To Install:

1. Use clean engine oil to lubricate the o-ring of the new oil fill tube.
2. Install the oil fill tube into the valve rocker arm cover.
3. Install the cap onto the oil fill tube.
4. Install a new gasket onto the valve rocker arm cover.
5. Attach the valve rocker arm cover to the cylinder head. Torque the bolts to **106 in-lb (12 Nm)**.
6. Attach the vent hose to the valve rocker arm cover.
7. Install the ignition coils onto the valve rocker arm cover.
8. Connect the spark plug wires to the ignition coils.
9. Attach the engine harness to the engine.
10. Connect the ignition coil harness connector.
11. Install the A/C compressor hose into the vehicle.
12. If necessary, install the intake manifold sight shield to the engine.

Valve Rocker Arm & Valve Lash Adjuster

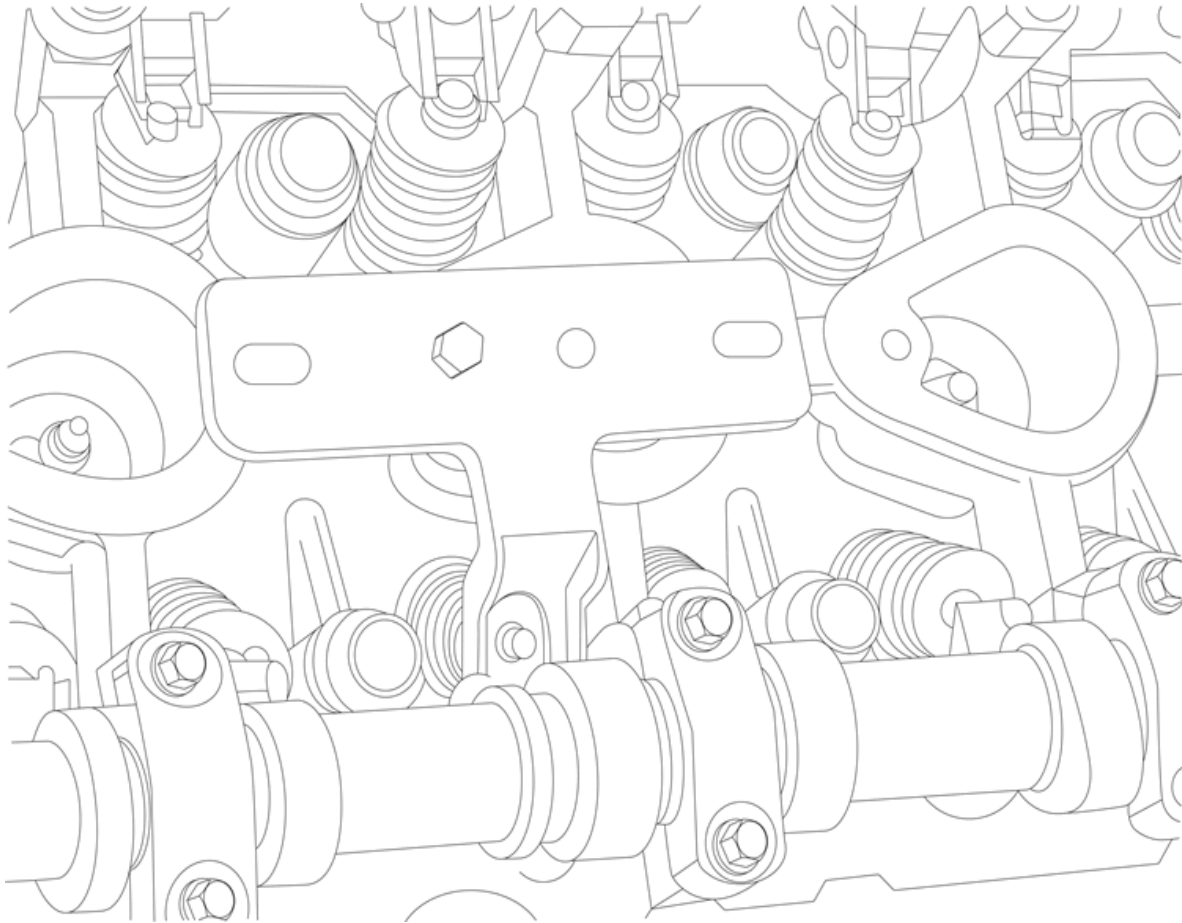
Removal & Installation

4.2L Engine

To Remove:

1. Remove the camshaft cover from the cylinder head.
2. Turn the crankshaft until the valve of the desired cylinder is fully open.

EN-47945 valve spring compressor



1. valve spring compressor to the engine cylinder head using the supplied fasteners in the coil fastener hole.
2. Turn the engine in clockwise until the cam is on the base circle, make sure not to completely turn the engine or the piston will contact and possibly damage the valves.
3. Remove the valve rocker arm from the cylinder head.
4. Remove the valve lash adjuster from the cylinder head.

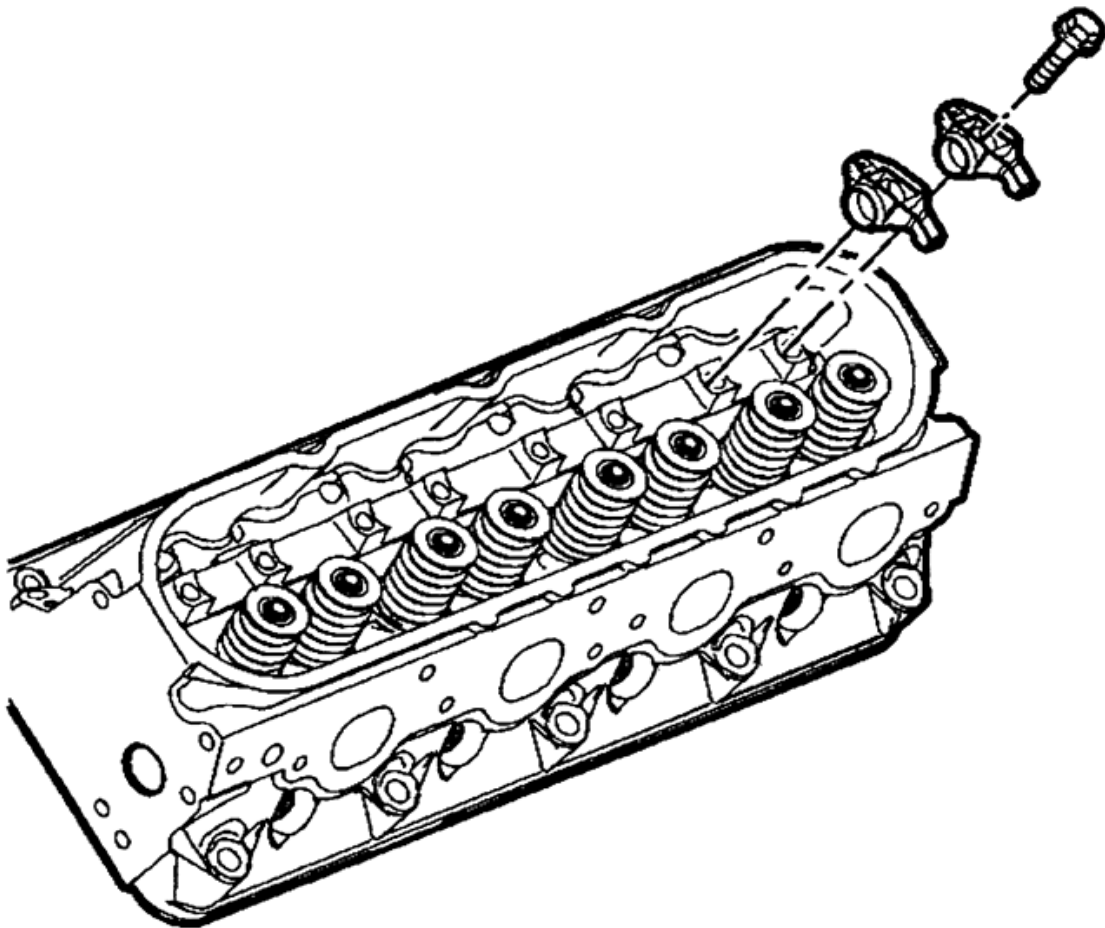
To Install:

1. Use oil to fill the valve lash adjuster and lubricate the valve rocker.
2. Install the valve lash adjuster into the cylinder head.
3. Install the valve rocker arm into the cylinder.
4. Turn the engine in the counterclockwise direction until the cam lobe is fully depressing the spring.
5. valve spring compressor from the engine cylinder head.
6. Install the camshaft cover onto the cylinder head.

5.3L & 6.0L Engines**To Remove:**

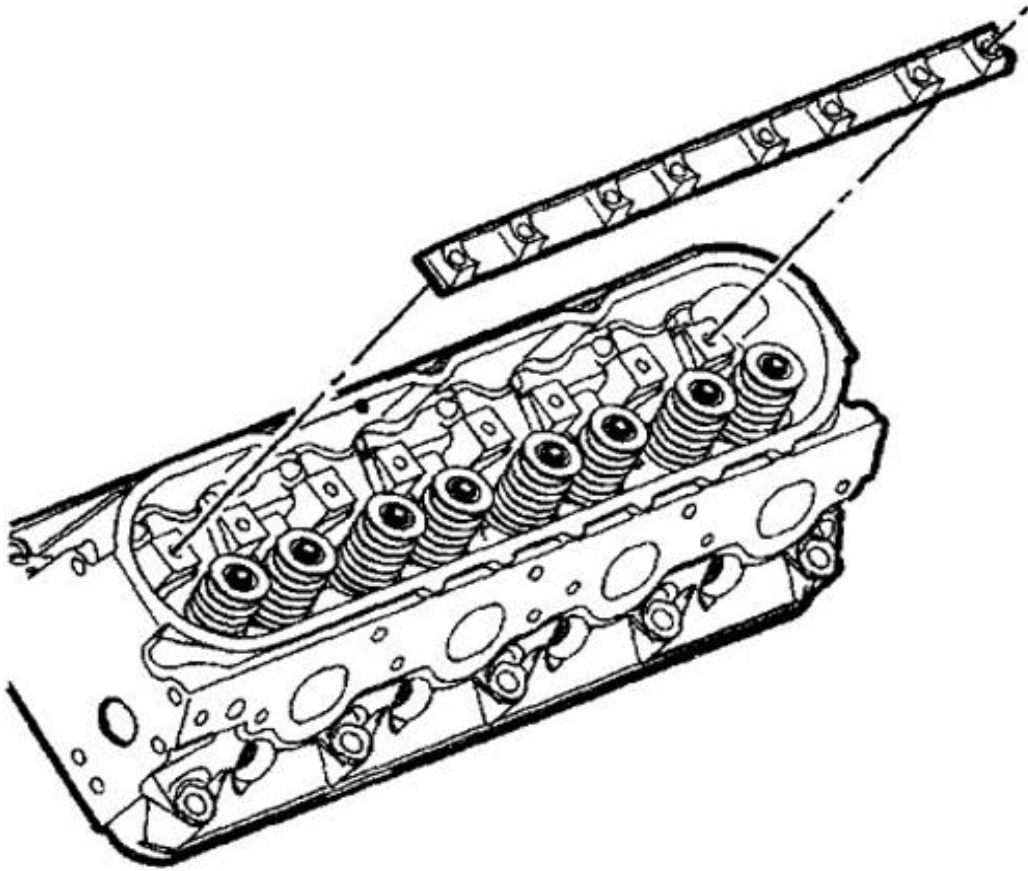
1. Remove the valve rocker arm covers from the cylinder heads.

Valve rocker arm removal and installation



2. Detach the valve rocker arms from the cylinder heads.

Valve rocker arm pivot support



3. Remove the valve rocker arm pivot supports from the cylinder heads.
4. Remove the pushrods from the pivot supports.

To Install:

1. Use clean engine oil to lubricate the valve rocker arms, pushrods, valve rocker arm flanges, and valve rocker arm bolts.
2. Install the valve rocker arm pivot supports into the cylinder heads.
3. Install the pushrods into the cylinder heads.
4. Attach the valve rocker arms to the cylinder heads, do not tighten the bolts.
5. Make sure cylinder 1 is at top dead center.
6. Torque the exhaust valve rocker arm bolts for cylinders 1, 2, 7, and 8 to **22 ft-lb (30 Nm)**.
7. Torque the intake valve rocker arm bolts for cylinders 1, 3, 4, and 5 to **22 ft-lb (30 Nm)**.
8. Turn the crankshaft 360 degrees.
9. Torque the exhaust valve rocker arm bolts for cylinders 3, 4, 5, and 6 to **22 ft-lb (30 Nm)**.
10. Torque the intake valve rocker arm bolts for cylinders 2, 6, 7, and 8 to **22 ft-lb (30 Nm)**.
11. Install the valve rocker arm covers onto the cylinder heads.

Engine Front Cover

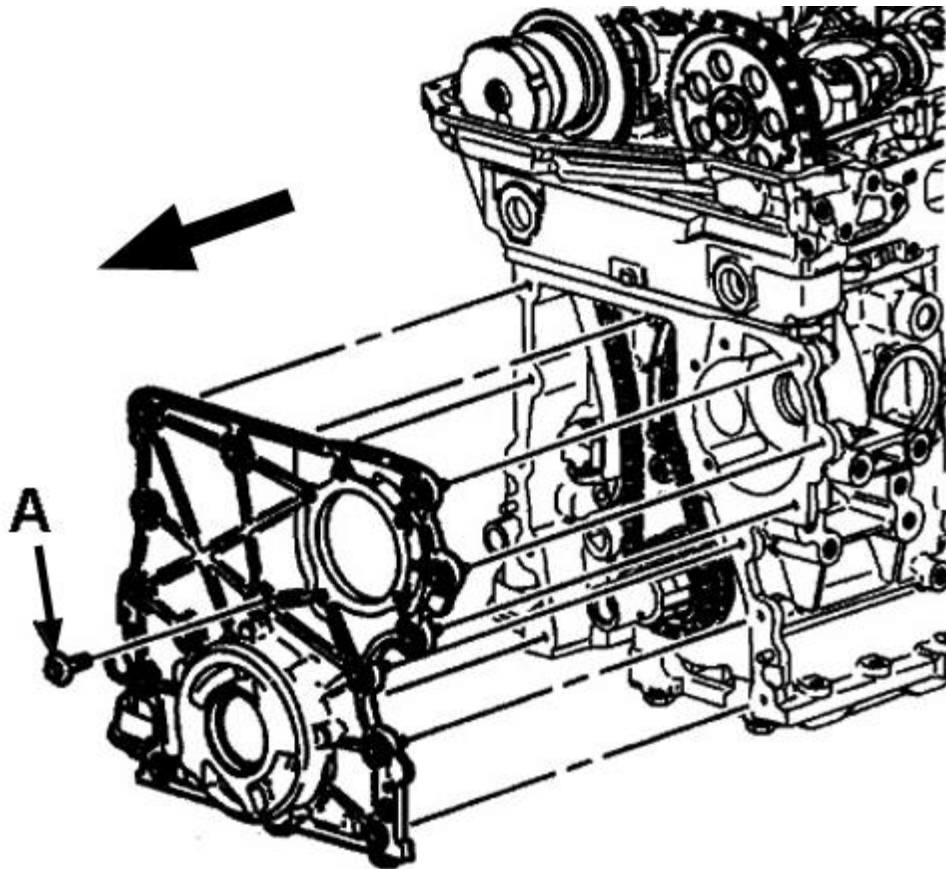
Removal & Installation

4.2L Engine

To Remove:

1. Drain the coolant from the engine.
2. Remove the cooling fan from the engine.
3. Remove the drive belt from the pulleys.
4. Remove the water pump from the engine.
5. Remove the crankshaft balancer from the crankshaft.
6. Remove the power steering pump from the engine.
7. Lift the vehicle.
8. Remove the oil pan from under the engine.
9. Lower the vehicle.

Engine front cover center bolt (A)

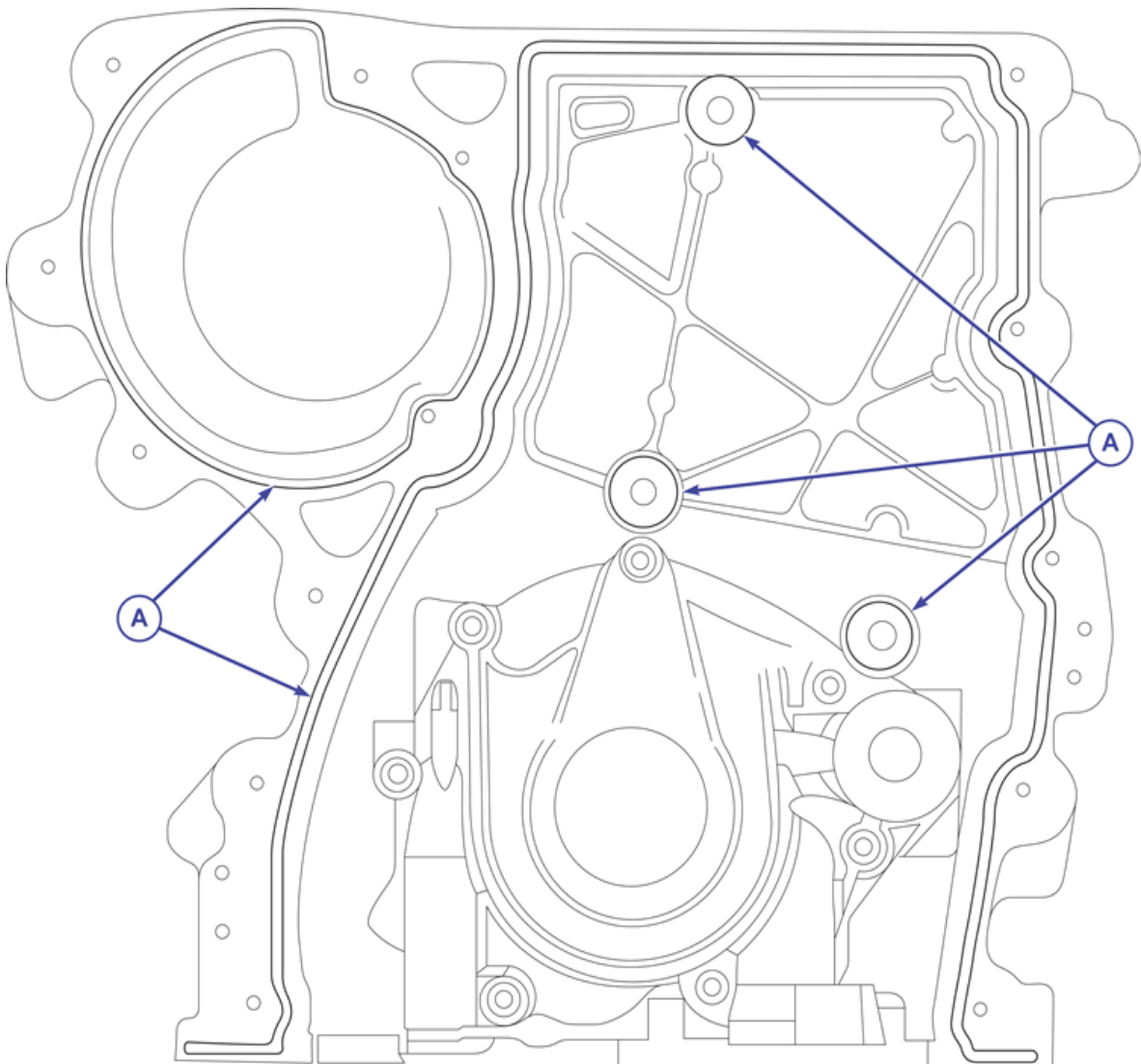


10. Remove the bolts from the engine front cover, starting with the center.
11. Install jack screws into the threaded holes and tighten evenly.
12. Remove the engine front cover and jack screws from the engine.
13. Remove the oil pump from the engine front cover.
14. Clean the sealing surfaces as necessary.

To Install:

1. cover alignment pins into the engine block.

Engine front cover sealer application



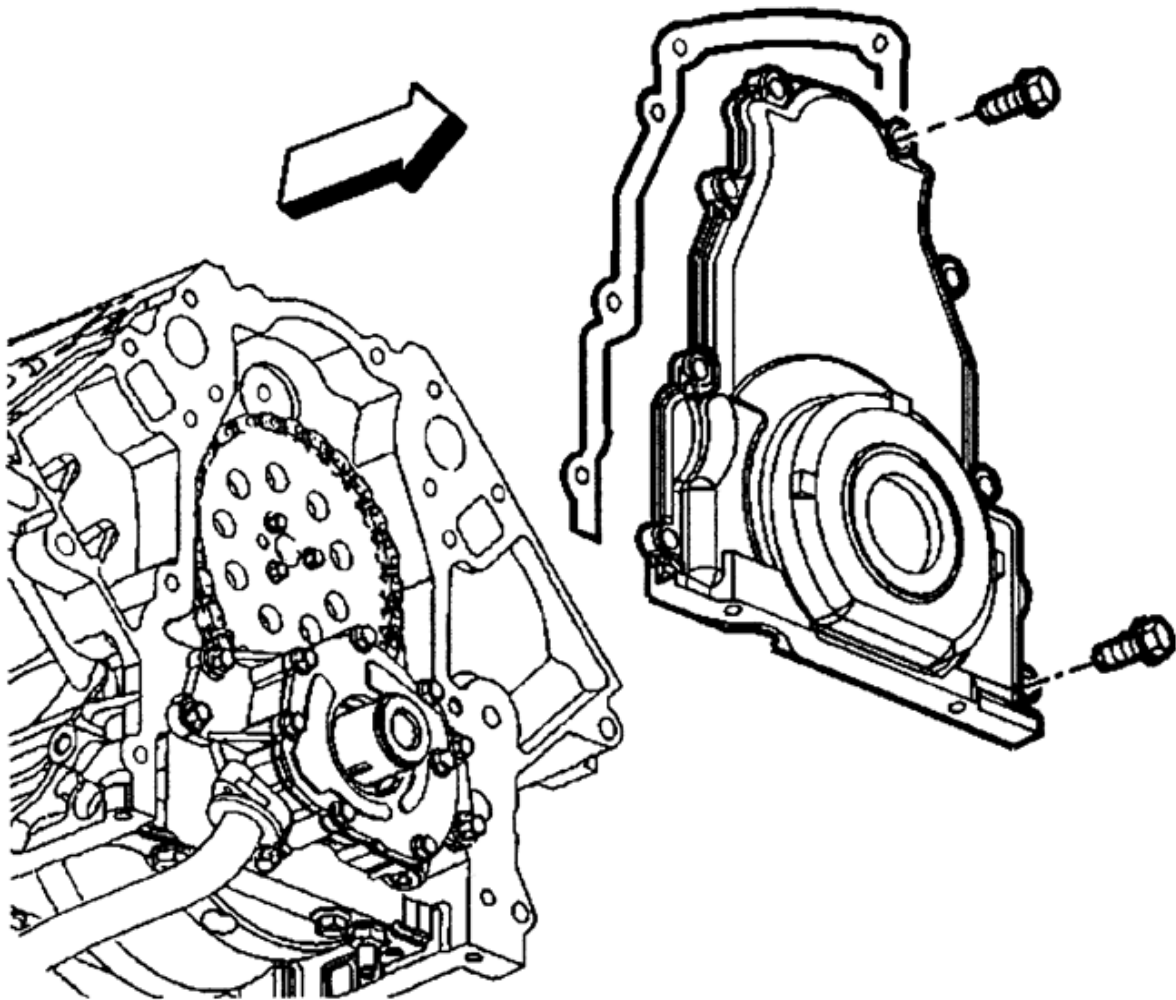
2. Apply a 0.12 in (3 mm) bead of sealer to the engine front cover in the areas marked above.
3. Align the oil pump with the splines on the crankshaft sprocket.
4. Place the engine front cover over the J 4219 cover alignment pins and loosely tighten the bolts.
5. Remove the J 4219 cover alignment pins and install the remaining engine front cover bolts.
6. Torque all engine front cover bolts except the center to **89 in-lb (10 Nm)**.
7. Torque the center engine front cover bolt to **89 in-lb (10 Nm)**.
8. Lift the vehicle.
9. Install the oil pan onto the engine.
10. Lower the vehicle.
11. Install the power steering pump onto the engine.
12. Install the crankshaft balancer into the crankshaft.
13. Install the water pump onto the engine.
14. Install the drive belt onto the pulleys.
15. Install the cooling fan onto the engine.
16. Refill the engine with coolant.

.3L & 6.0L Engines

To Remove:

1. Remove the A/C compressor and bracket from the engine.
2. Remove the water pump from the engine.
3. Remove the crankshaft balancer from the crankshaft.

Engine front cover removal and installation



4. Detach the engine front cover from the engine.
5. Detach and discard the gasket from the engine front cover.

To Install:

1. Apply a 0.2 in (5 mm) bead of sealant 0.8 in (20 mm) long to the oil pan and engine block junction.
2. Place a new gasket on the engine front cover.
3. Attach the engine front cover to the engine, hand tighten the bolts.
4. Install a J 41476 front and rear cover alignment tool onto the engine front cover.
5. Align the tapered legs of the J 41476 front and rear cover alignment tool with the alignment surfaces of the front cover.
6. Install the crankshaft balancer bolt into the crankshaft, hand tighten the bolt.
7. Torque the engine front cover to oil pan bolts to **18 ft-lb (25 Nm)**.
8. Torque the remaining engine front cover bolts to **18 ft-lb (25 Nm)**.
9. Remove the J 41476 front and rear cover alignment tool from the engine front cover.
10. Install a new crankshaft front oil seal into the engine front cover.
11. Install the crankshaft balancer into the crankshaft.
12. Install the water pump onto the engine.
13. Install the A/C compressor and bracket onto the engine.

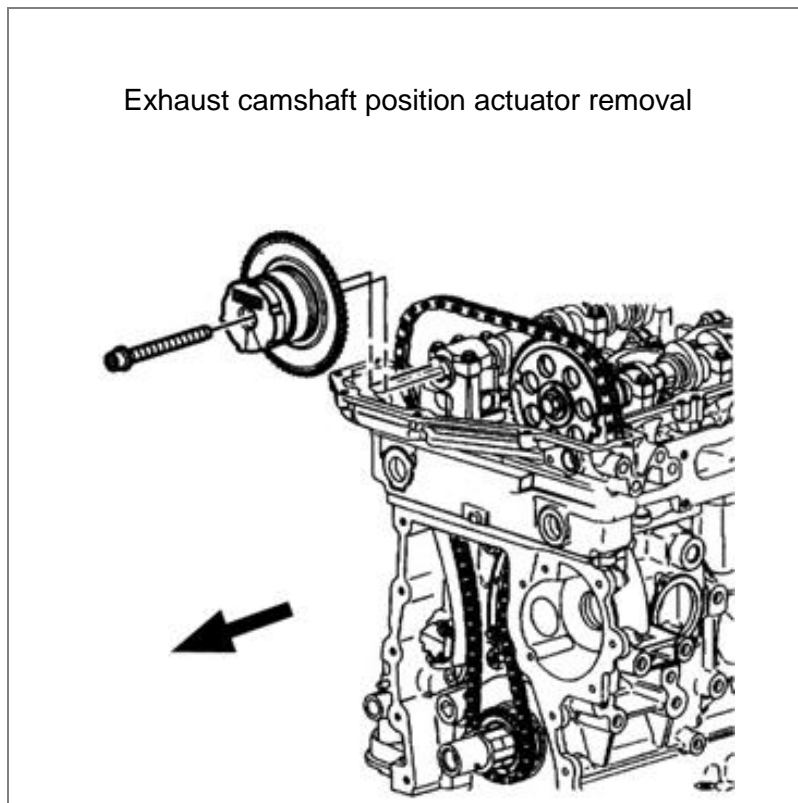
Camshaft Timing Chain, Sprocket, and Tensioner

Removal & Installation

4.2L Engine

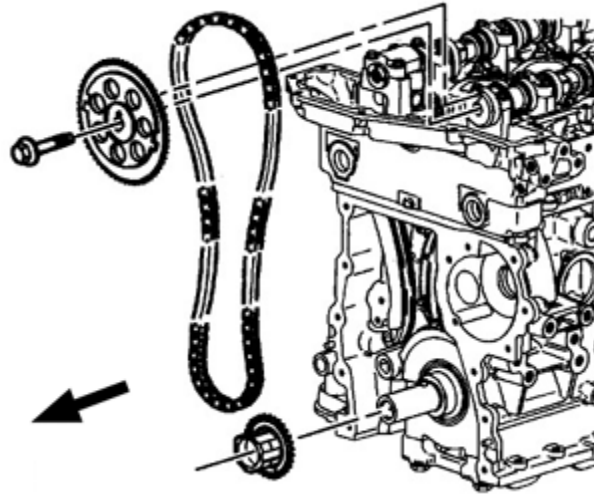
To Remove:

1. Remove the camshaft cover from the cylinder head.
2. Remove the engine front cover from the engine.
3. Move the timing chain tension shoe in to release the pressure on the chain.
4. Install a tee into the tensioner to hold the shoe in place.



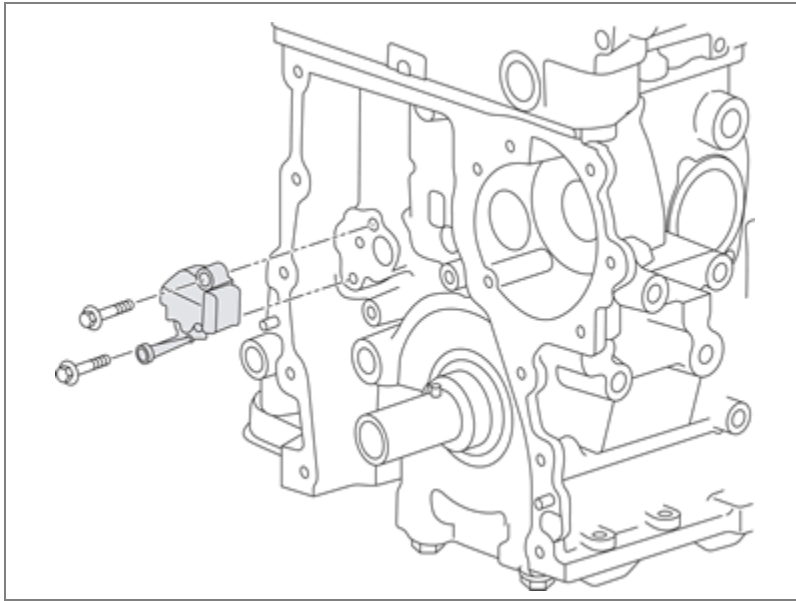
5. Detach the exhaust camshaft position actuator from the exhaust camshaft.

Intake camshaft sprocket removal



6. Detach the intake camshaft sprocket from the intake camshaft.
7. Remove the timing chain from the sprockets.
8. Remove the crankshaft sprocket from the crankshaft.
9. Remove the access hole plugs from the cylinder head.
10. Detach the timing chain tensioner shoe from the engine.
11. Detach the timing chain tensioner guide from the engine.

Timing chain tensioner removal and installation

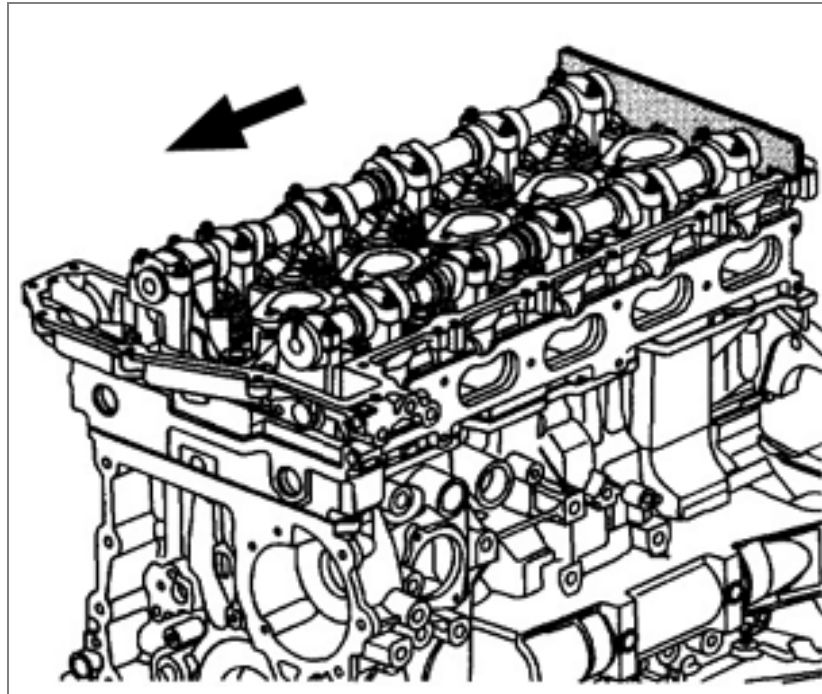


12. Detach the timing chain tensioner from the engine.

To Install:

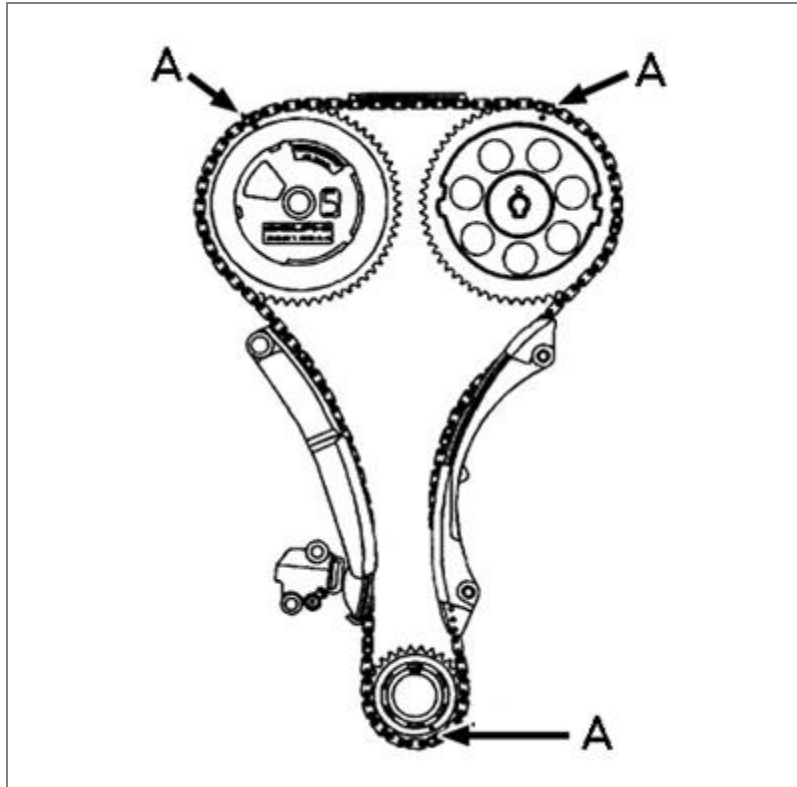
1. Attach the timing chain tensioner to the engine. Torque the bolts to **18 ft-lb (25 Nm)**.
2. Attach the timing chain tensioner guide to the engine. Torque the bolts to **89 in-lb (10 Nm)**.
3. Attach the timing chain tensioner shoe to the engine. Torque the bolts to **19 ft-lb (26 Nm)**.
4. Install the access hole plugs into the cylinder head. Torque the plugs to **44 in-lb (5 Nm)**.

J 44221 camshaft holding tool



5. Install a J 44221 camshaft holding tool onto the camshafts. Make sure cylinder 1 is at top dead center and the camshaft flats are facing up.
6. Install the crankshaft sprocket onto the crankshaft.

Timing chain alignment



7. Align the timing mark on the intake camshaft sprocket with the dark link on the timing chain.
8. Align the timing mark on the crankshaft sprocket with the dark link on the timing chain.
9. Attach the intake camshaft sprocket onto the intake camshaft, hand tighten the bolt.
10. Align the timing mark on the exhaust camshaft position actuator with the dark link on the timing chain.
11. Attach the exhaust camshaft position actuator from the exhaust camshaft. Torque the bolt to **18 ft-lb (25 Nm)**. Use a J 36660-A torque angle meter to turn the bolt an **additional 135 degrees**.
12. Torque the intake camshaft sprocket bolt to **15 ft-lb (20 Nm)**. Use a J 36660-A torque angle meter to turn the bolt an **additional 100 degrees**.
13. Remove the tee from the tensioner.
14. Remove the J 44221 camshaft holding tool from the camshafts.
15. Install the engine front cover onto the engine.
16. Install the camshaft cover onto the cylinder head.

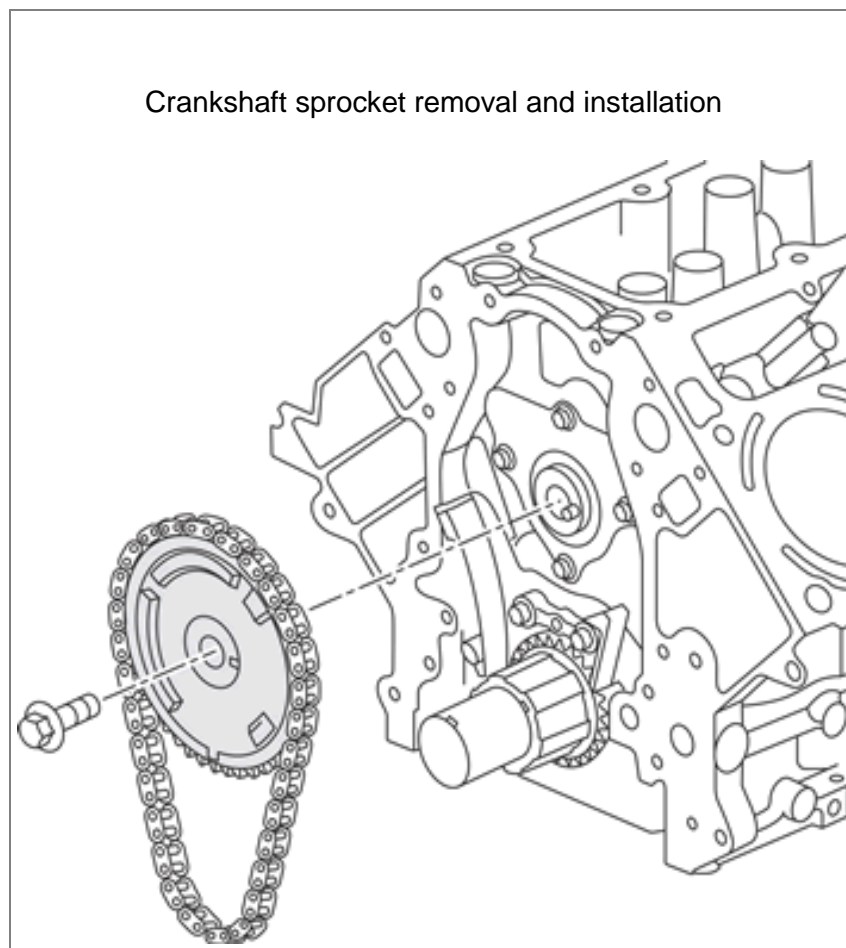
Timing Chain & Sprocket

Removal & Installation

5.3L Engine

To Remove:

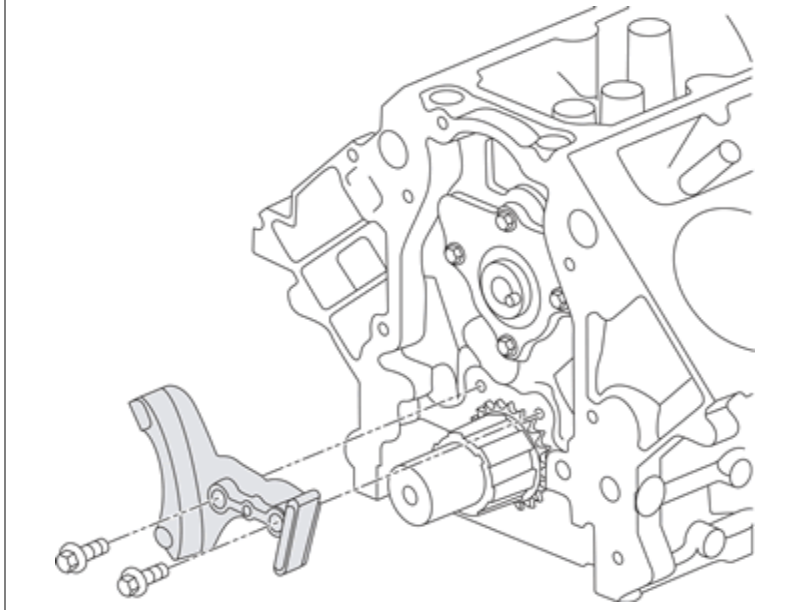
1. Remove the oil pump from the engine.
2. Turn the crankshaft until the crankshaft and camshaft sprockets are aligned.



3. Remove and discard the camshaft sprocket bolt.
4. Remove the camshaft sprocket with the timing chain from the camshaft.

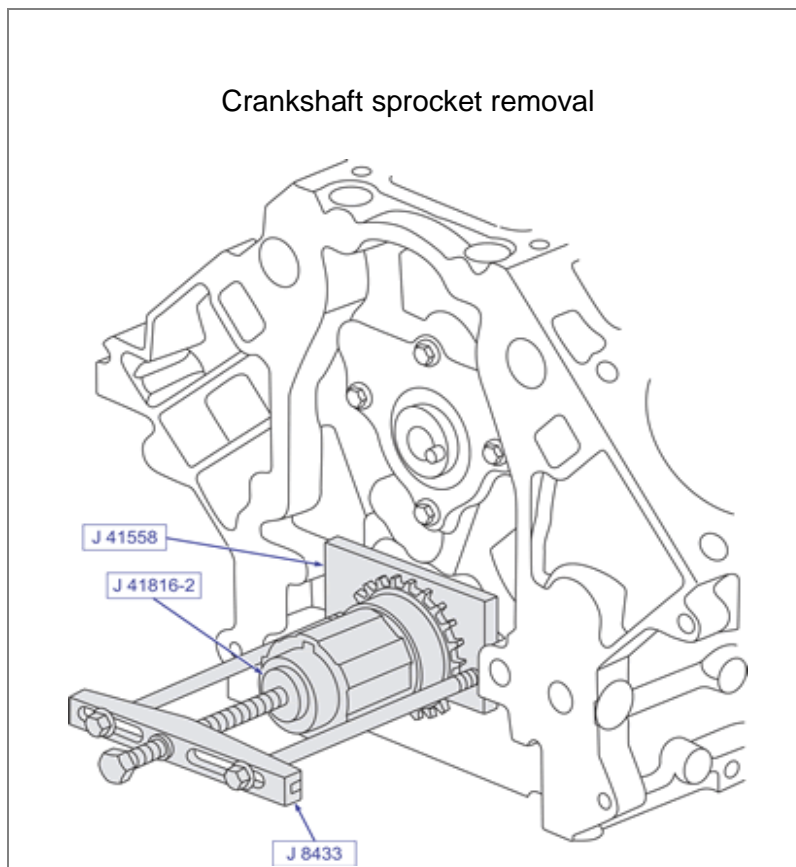


Timing chain tensioner removal and installation



5. Detach the timing chain tensioner from the engine.

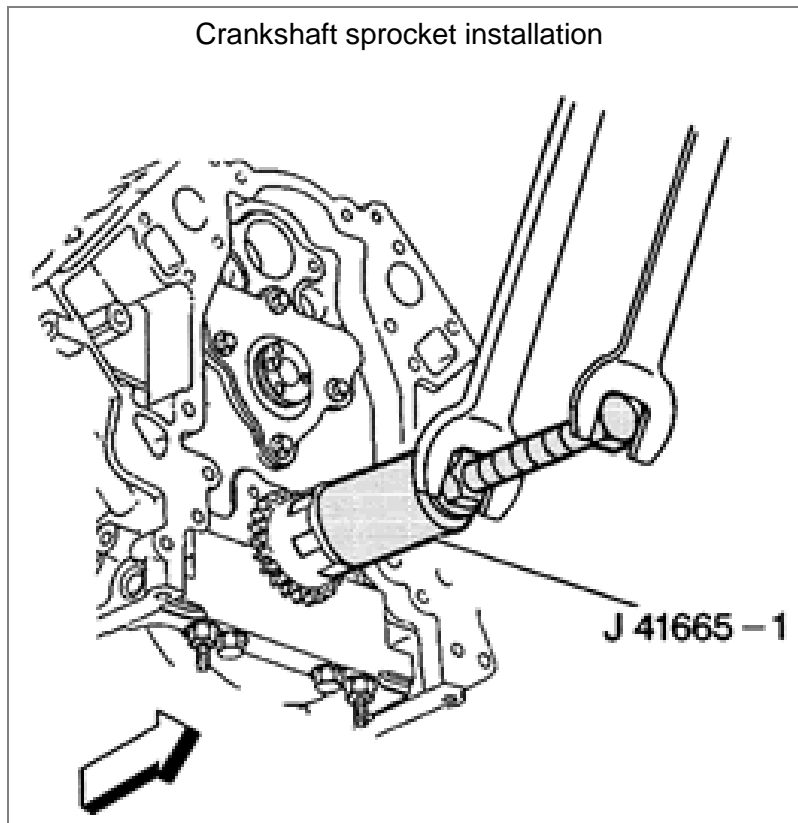
Crankshaft sprocket removal



6. Use a J 41816-2 crankshaft end protector, a J 41558 crankshaft sprocket remover, bolts, and a J 8433 puller bar to remove the crankshaft sprocket from the camshaft.
7. Remove the crankshaft sprocket key from the crankshaft.

To Install:

1. Install the crankshaft sprocket key into the crankshaft.
2. Align the crankshaft sprocket with the crankshaft sprocket key.



3. Use a J 41478 crankshaft front oil seal installer and a J 41665 crankshaft balancer and sprocket installer to install the crankshaft sprocket onto the crankshaft.
4. Turn the crankshaft until the alignment mark is in the 12 o'clock position.
5. Install an En 46330 into the timing chain tensioner guide.
6. Attach the timing chain tensioner to the engine. Torque the bolts to **18 ft-lb (25 Nm)**.
7. Install the camshaft sprocket with the timing chain onto the camshaft.
8. Make sure the camshaft sprocket alignment mark is in the 6 o'clock position.
9. Remove the EN 46330 from the timing chain tensioner.
10. Install the flywheel onto the crankshaft.
11. Install a J 42386-A flywheel holding tool onto the flywheel. Torque the bolt to **37 ft-lb (50 Nm)**.
12. Torque the camshaft sprocket bolt to **55 ft-lb (75 Nm)**. Use a J 45059 to turn the bolt an **additional 50 degrees**.
13. Remove the flywheel from the crankshaft.
14. Install the oil pump onto the engine.

Engine Cooling

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

WARNING

Never open, service or drain the radiator or cooling system when the engine is hot; serious burns can occur from the steam and hot coolant.

Coolant Reservoir

Removal & Installation

To Remove:

1. Remove the air cleaner assembly from the engine compartment.
2. Remove the accumulator from coolant recovery reservoir.
3. Remove the coolant hoses from the coolant recovery reservoir.
4. Install a suitable plug into the coolant recover reservoir outlets.
5. Detach the coolant recovery reservoir from the vehicle.

To Install:

1. Attach the coolant recovery reservoir to the vehicle. Torque the bolt to **106 in-lb (12 Nm)**. Torque the nut to **89 in-lb (10 Nm)**.
2. Install the coolant hoses onto the coolant recovery reservoir.
3. Install the accumulator onto the coolant recovery reservoir.
4. Install the air cleaner assembly into the vehicle.

Coolant

Filling & Bleeding

To Bleed:

WARNING

Do not remove the radiator cap or surge tank cap while the engine and radiator are hot. If the caps are removed while the engine and radiator are hot, scalding fluid and steam will be released under pressure.

1. When the engine and radiator are cool, remove the radiator cap from the radiator.
2. Lift the vehicle.
3. Position a drain pan under the radiator where the lower radiator hose attaches to the radiator.
4. Use a set of J 38185 hose clamp pliers to disconnect the lower radiator hose from the radiator.
5. Drain the coolant into the drain pan.
6. If the coolant is discolored, flush out the cooling system.
7. If a complete block drain is necessary, remove the plug from the engine block on the left side.

To Fill:

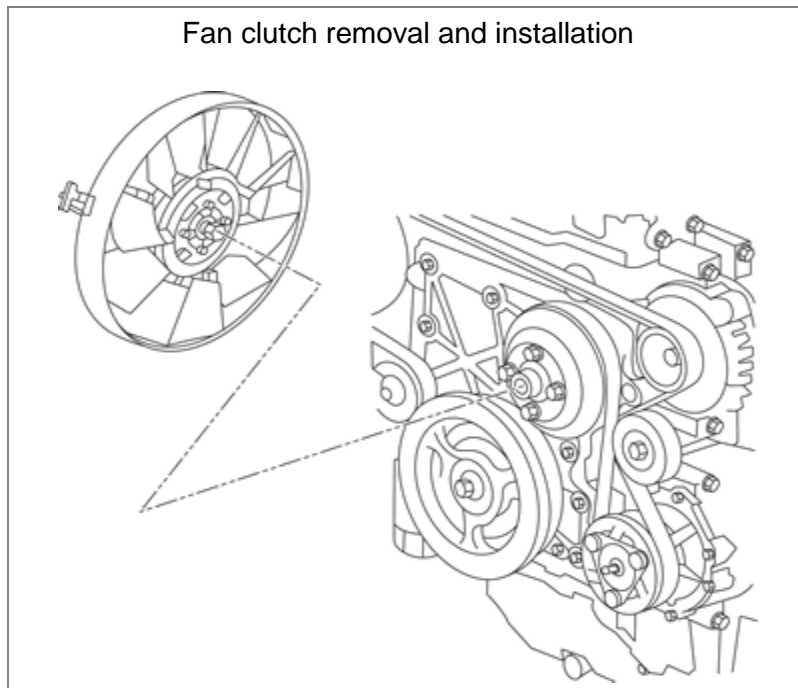
1. If a complete block drain is necessary, install the plug into the engine block on the left side.
2. Use a set of J 38185 hose clamp pliers to connect the lower radiator hose to the radiator.
3. Lower the vehicle.
4. Fill the radiator with a 50/50 mixture of antifreeze and deionized water.
5. Install the radiator cap onto the radiator.
6. Fill the coolant recovery reservoir with the coolant mixture.
7. Start the vehicle and run the engine at 1,000-3,000 RPM until it reaches normal operating temperature.
8. Idle the engine for 3 minutes.
9. Turn off the engine.
10. When the engine is cool, refill the coolant recovery reservoir with the coolant mixture.
11. Make sure there are no leaks in the cooling system.
12. Remove any excess coolant from the engine and engine compartment.
13. Use the J 26568 coolant and battery tester to check the concentration of the engine coolant.

Cooling Fan & Shroud

Removal & Installation

To Remove:

1. Drain the coolant from the engine.
2. Remove the air cleaner assembly from the engine compartment.
3. Remove the air resonator assembly from the engine.
4. Remove the inlet radiator hose from the radiator.
5. Detach the transmission oil cooler lines from the fan shroud.
6. Disconnect the fan clutch connector.



7. Use a J 46406 fan clutch remover and installer to remove the fan clutch from the water pump.
8. Remove the upper mounting bolts from the fan shroud.
9. Remove the fan shroud from the radiator by lifting the shroud and pushing inward.

To Install:

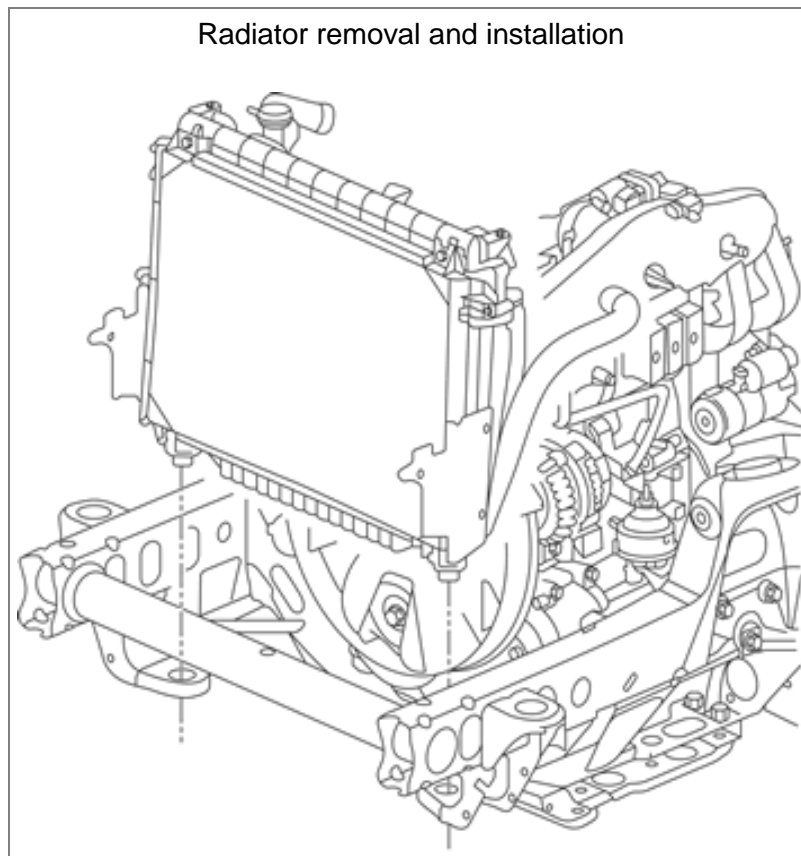
1. Attach shroud to the radiator. Torque the bolts to **21 ft-lb (28 Nm)**.
2. Use a J 46406 fan clutch remover and installer to install the fan clutch onto the water pump.
3. Connect the fan clutch connector.
4. Attach the transmission oil cooler lines to the fan shroud.
5. Install the inlet radiator hose to the radiator.
6. Install the air resonator assembly onto the engine.
7. Install the air cleaner assembly into the engine compartment.
8. Refill the engine with coolant.

Radiator

Removal & Installation

To Remove:

1. Drain the coolant from the radiator.
2. Lift the vehicle.
3. If equipped, remove the lower radiator support shield from the radiator.
4. Use a set of J 38185 hose clamp pliers to disconnect the outlet radiator hose from the radiator.
5. Use a set of J 38185 hose clamp pliers to disconnect the inlet radiator hose from the radiator.
6. Detach the transmission cooler lines from the radiator.
7. Lower the vehicle.
8. Remove the cooling fan from the engine.
9. Remove the radiator support diagonal brace from the vehicle.
10. Disconnect the coolant recovery line from the radiator.
11. Detach the side panels from the shroud.



12. Remove the radiator from the vehicle.
13. Detach the condenser from the radiator.

To Install:

1. Attach the condenser onto the radiator. Torque the bolts to **21 ft-lb (28 Nm)**.
2. Install the radiator into the vehicle.
3. Lift the vehicle.
4. Use a set of J 38185 hose clamp pliers to connect the outlet radiator hose to the radiator.
5. Use a set of J 38185 hose clamp pliers to connect the inlet radiator hose to the radiator.
6. Attach the transmission cooler lines to the radiator.
7. If equipped, install the lower radiator support shield onto the radiator.
8. Lower the vehicle.
9. Install the cooling fan onto the engine.
10. Connect the coolant recovery line to the radiator.
11. Install the radiator support diagonal brace onto the vehicle.
12. Refill the radiator with coolant.

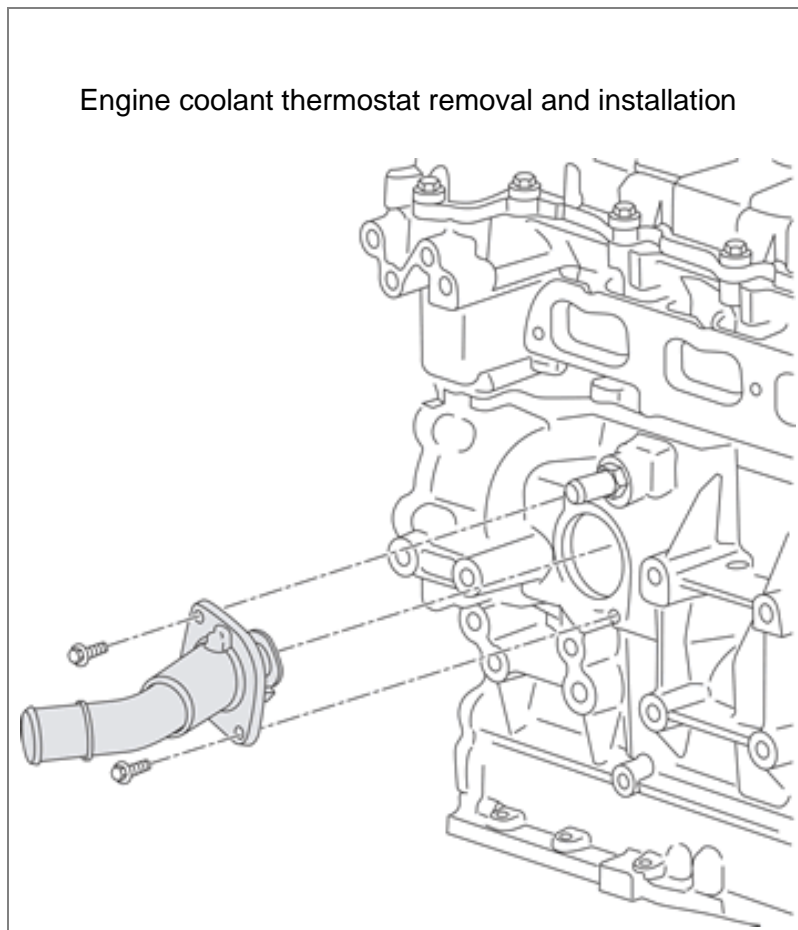
Engine Coolant Thermostat

Removal & Installation

4.2L Engine

To Remove:

1. Drain the coolant from the radiator.
2. Remove the generator from the engine.
3. Disconnect the outlet hose from the thermostat housing.



4. Detach the thermostat housing from the engine block.
5. Clean the sealing surfaces as necessary.

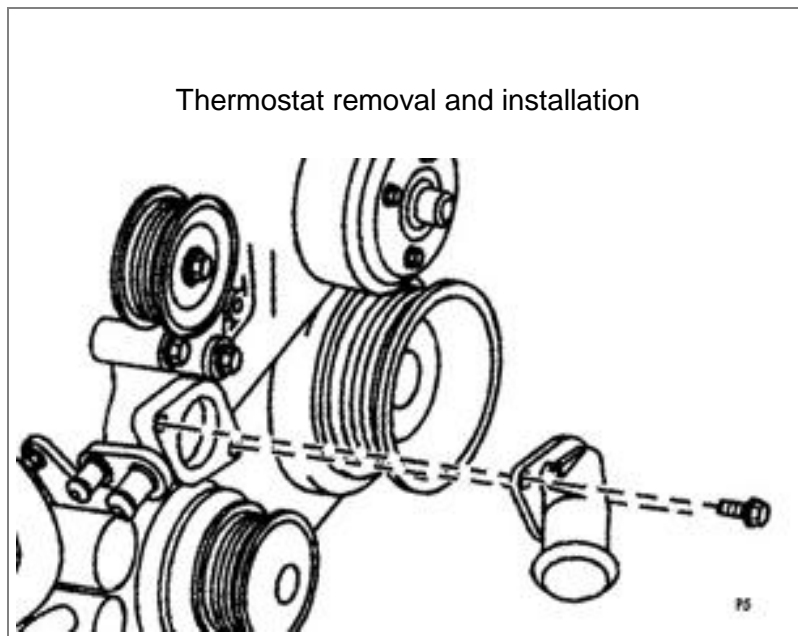
To Install:

1. Attach the thermostat housing to the engine block. Torque the bolts to **89 in-lb (10 Nm)**.
2. Use engine coolant to lubricate the inner diameter of the outlet hose.
3. Connect the outlet hose to the thermostat housing.
4. Install the generator onto the engine.
5. Refill the radiator with coolant.
6. Check the sealing surfaces for leaks.

5.3L & 6.0L Engines

To Remove:

1. Disconnect the radiator outlet hose from the engine.



2. Detach the water pump inlet and thermostat from the water pump.

To Install:

1. Attach the water pump inlet and thermostat to the water pump. Torque the bolts to **11 ft-lb (15 Nm)**.
2. Connect the radiator outlet hose to the engine.

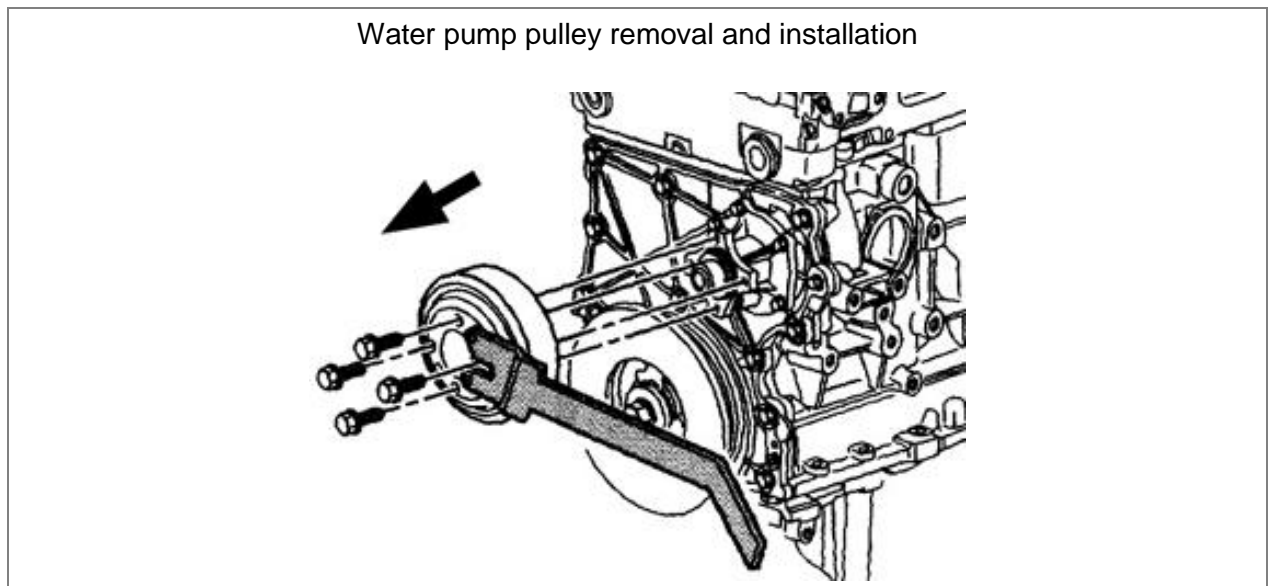
Water Pump

Removal & Installation

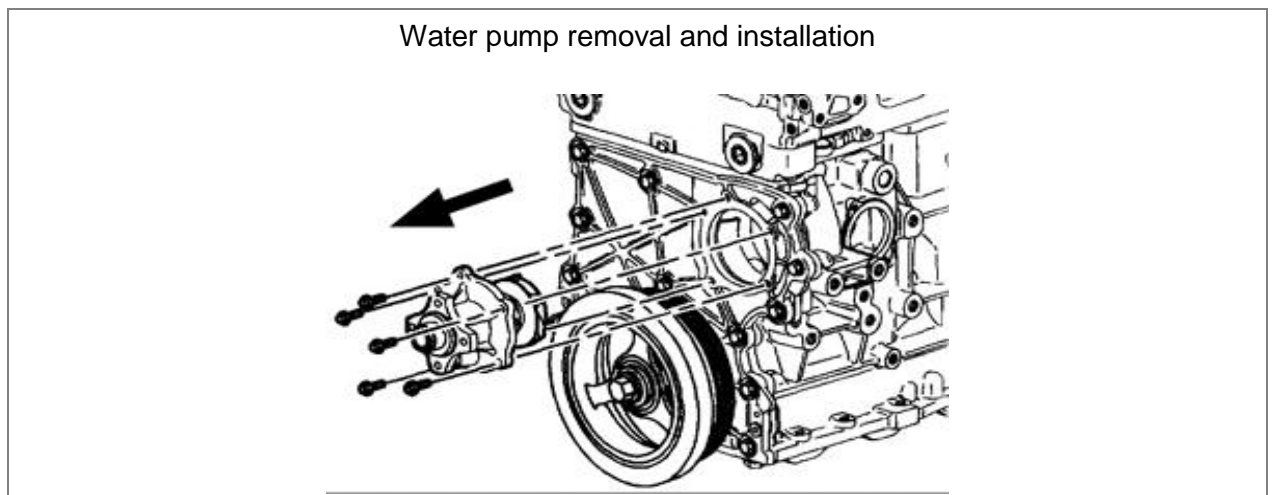
4.2L Engine

To Remove:

1. Drain the coolant from the engine.
2. Remove the fan from the engine
3. Remove the drive belt from the pulleys.



4. Use a J 41240 fan clutch remover and installer to secure the water pump pulley.
5. Remove the bolts from the water pump pulley.
6. Remove the J 41240 fan clutch remover and installer from the water pump pulley.
7. Remove the water pump pulley from the water pump.



8. Detach the water pump from the engine.
9. Remove and discard the gasket from the water pump.

To Install:

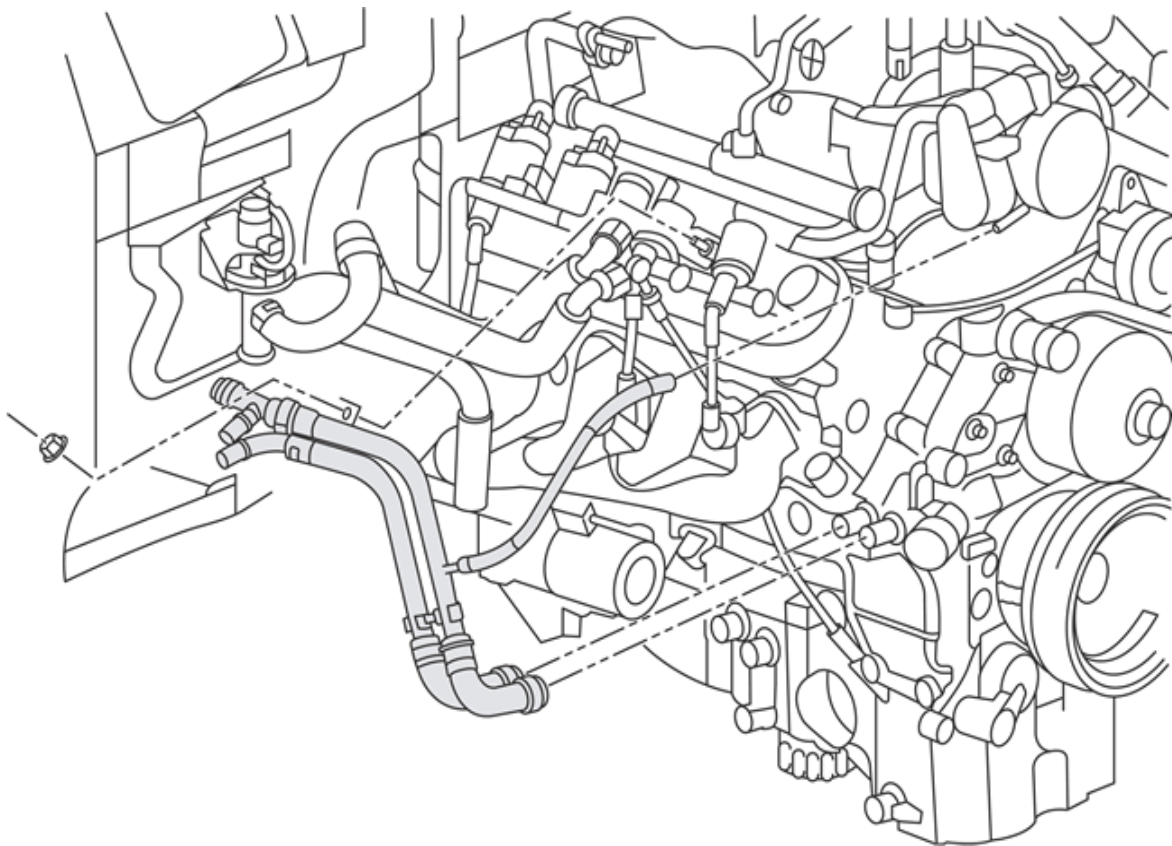
1. Install the new gasket onto the water pump.
2. Attach the water pump onto the engine. Torque the bolts to **35 in-lb (4 Nm)**.
Torque the bolts again to **89 in-lb (10 Nm)**.
3. Install the water pump pulley onto the water pump.
4. Use a J 41240 fan clutch remover and installer to secure the water pump pulley.
5. Install the bolts into the water pump pulley. Torque the bolts to **18 ft-lb (25 Nm)**.
6. Remove the J 41240 fan clutch remover and installer from the water pump pulley.
7. Install the drive belt onto the pulleys.
8. Install the fan onto the engine.
9. Refill the engine with coolant.
10. Check the water pump for leaks.

5.3L & 6.0L Engines

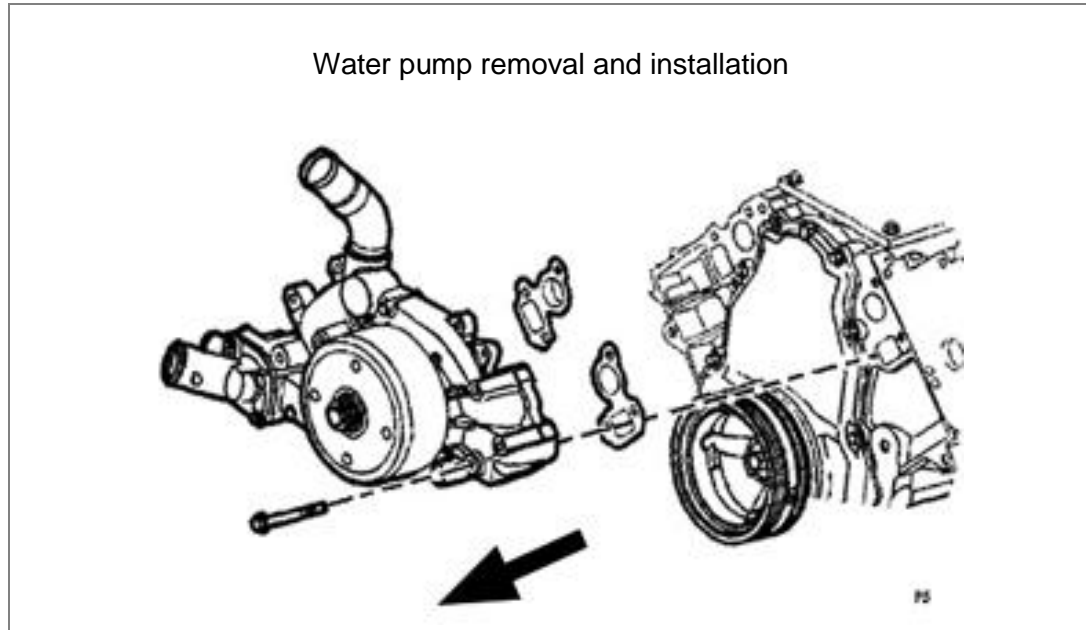
To Remove:

1. Drain the coolant from the engine.
2. Remove the air cleaner outlet duct from the engine compartment.
3. Remove the drive belt from the pulleys.
4. Remove the fan from the engine.
5. Use a set of J 38185 hose clamp pliers to disconnect the inlet hose from the water pump.
6. Use a set of J 38185 hose clamp pliers to disconnect the outlet hose from the water pump.

Auxiliary heater inlet and outlet hose/pipe removal and installation



7. Remove the nut from the auxiliary heater inlet and outlet hose/pipe.
8. Use a set of J 38185 hose clamp pliers to disconnect the hose from the throttle body.
9. Use a set of J 38185 hose clamp pliers to disconnect the auxiliary heater inlet and outlet hoses/pipes from the water pump.



10. Detach the water pump from the engine.
11. Remove and discard the gasket from the water pump.

To Install:

1. Install a new gasket to the water pump.
2. Attach the water pump to the engine. Torque the bolts to **11 ft-lb (15 Nm)**. Torque the bolts again to **22 ft-lb (30 Nm)**.
3. Install the nut onto the auxiliary heater inlet and outlet hose/pipe. Torque the nut to **89 in-lb (10 Nm)**.
4. Use a set of J 38185 hose clamp pliers to connect the hose to the throttle body.
5. Use a set of J 38185 hose clamp pliers to connect the auxiliary heater inlet and outlet hoses/pipes to the water pump.
6. Use a set of J 38185 hose clamp pliers to connect the outlet hose to the water pump.
7. Use a set of J 38185 hose clamp pliers to connect the inlet hose to the water pump.
8. Install the fan onto the engine.
9. Install the drive belt onto the pulleys.
10. Install the air cleaner outlet duct into the engine compartment.
11. Refill the engine with coolant.

Engine Exhaust

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Exhaust Manifold

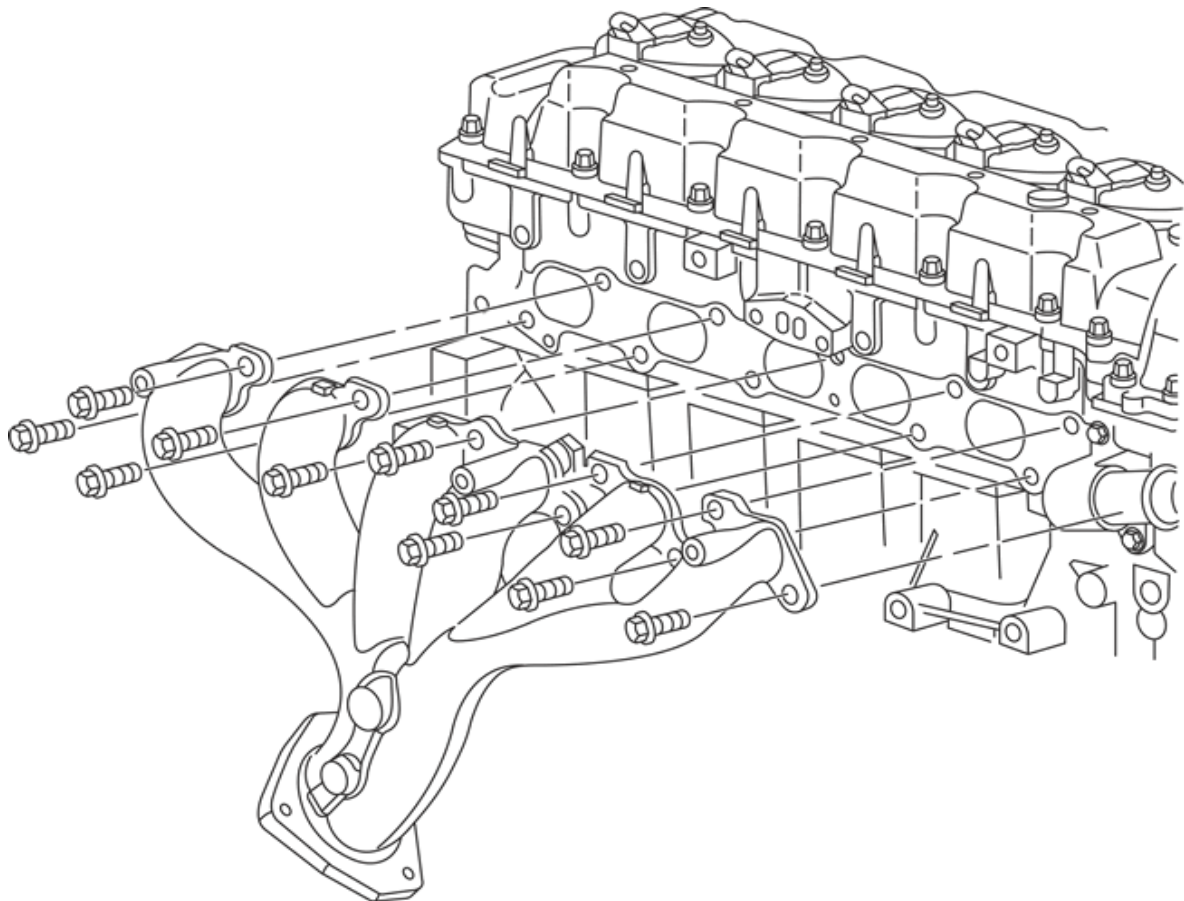
Removal & Installation

4.2L Engine

To Remove:

1. Lift the vehicle.
2. Detach the catalytic converter from the exhaust manifold.
3. Lower the vehicle.
4. Detach the heat shield from the exhaust manifold.

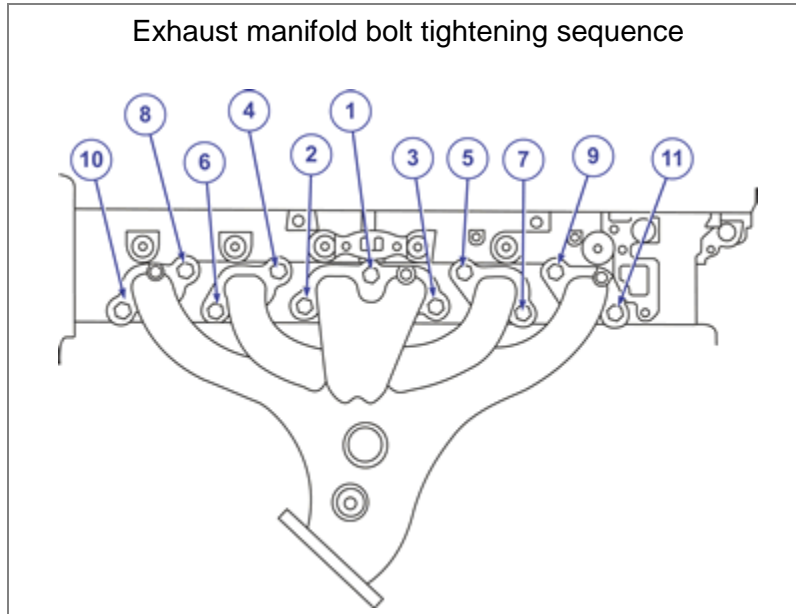
Exhaust manifold removal and installation



5. Detach the exhaust manifold from the engine.
6. Remove and discard the gasket from the exhaust manifold.

To Install:

1. Install a new gasket onto the exhaust manifold.
2. Apply threadlock GM P/N 12345493 to the exhaust manifold bolts.



3. Attach the exhaust manifold to the engine. Torque the bolts in sequence to **15 ft-lb (20 Nm)**. Torque the bolts again, in sequence to **15 ft-lb (20 Nm)**. Torque the bolts a final time, in sequence to **15 ft-lb (20 Nm)**.
4. Attach the heat shield to the exhaust manifold. Torque the studs to **89 in-lb (10 Nm)**.
5. Lift the vehicle.
6. Attach the catalytic converter to the exhaust manifold. Torque the nuts to **37 ft-lb (50 Nm)**.
7. Lower the vehicle.

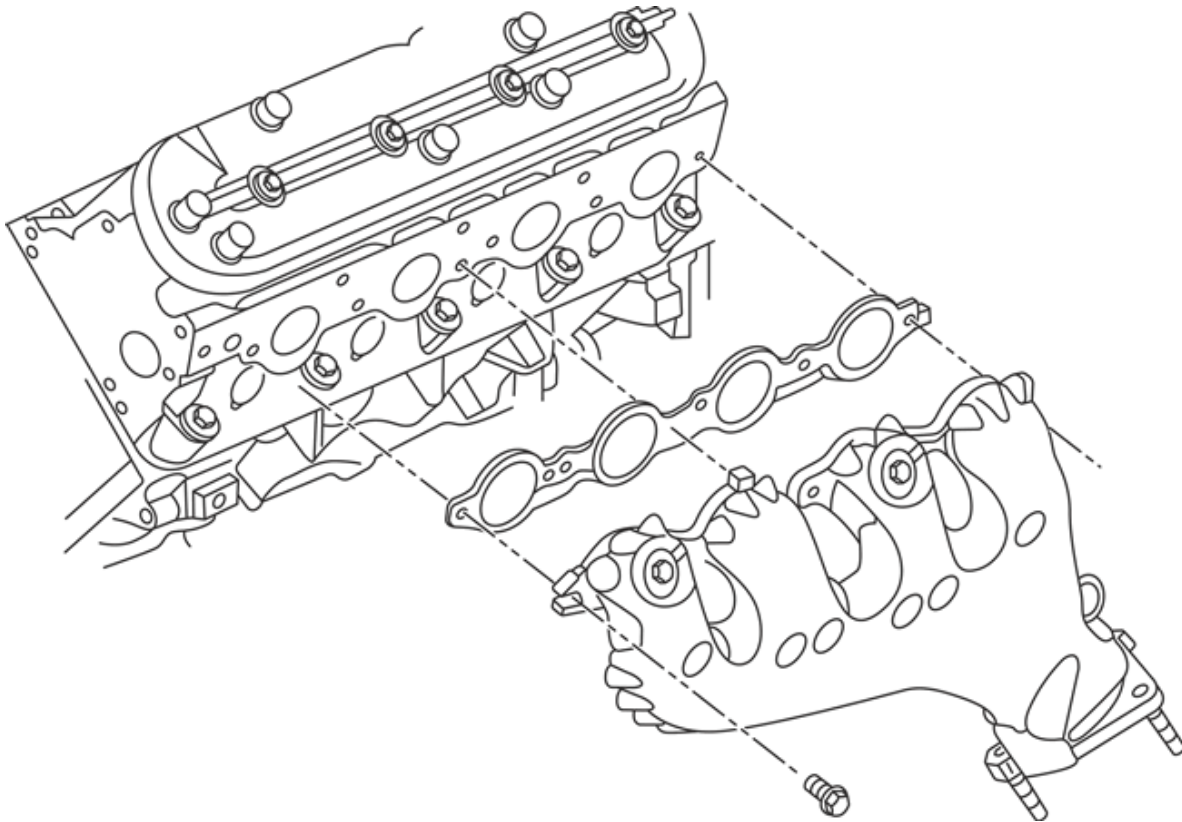
5.3L & 6.0L Engines

Left Side

To Remove:

1. Lift the vehicle.
2. Detach the catalytic converter from the exhaust manifold.
3. Lower the vehicle.
4. Remove the spark plugs from the cylinder head.
5. Detach the heat shield from the exhaust manifold.

Left exhaust manifold removal and installation



6. Detach the exhaust manifold from the engine.
7. Remove and discard the gasket from the exhaust manifold.

To Install:

1. Install a new gasket onto the exhaust manifold.
2. Apply threadlock GM P/N 12345493 to the exhaust manifold bolts.

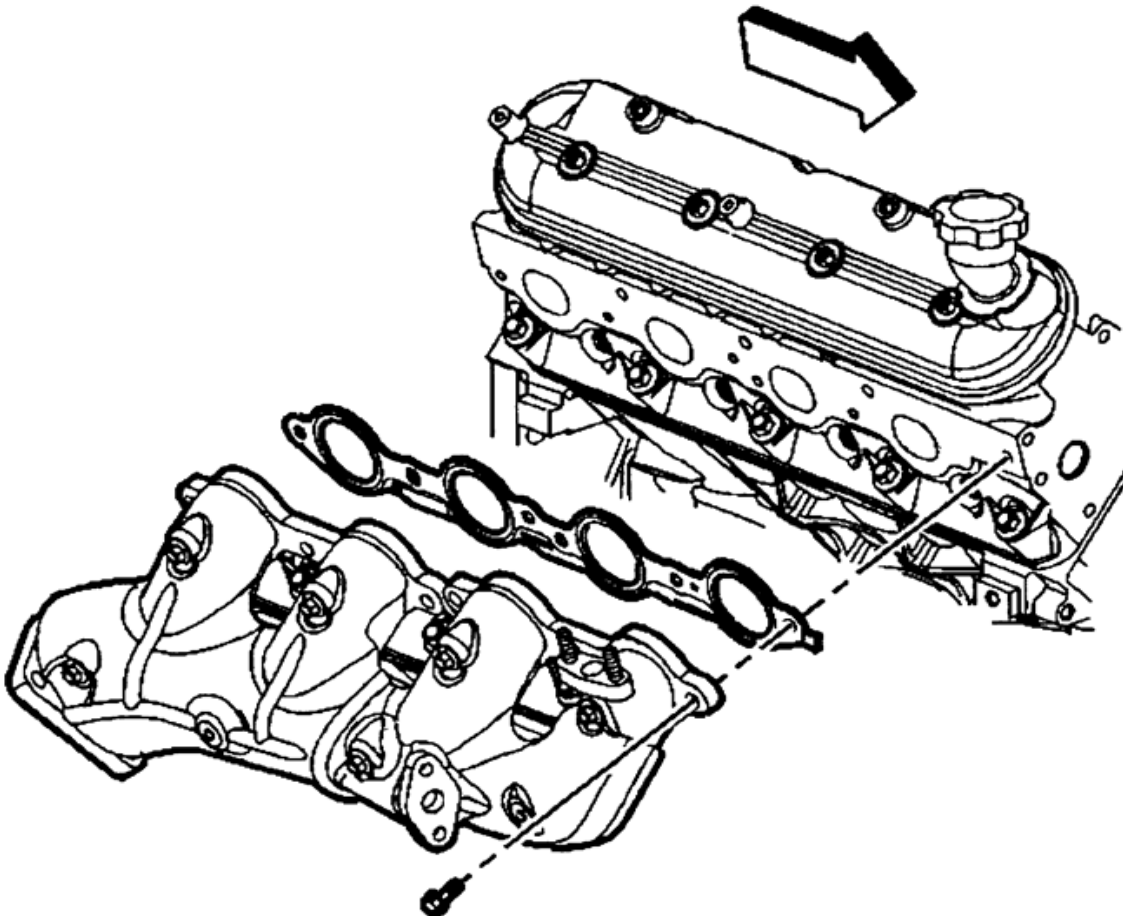
3. Attach the exhaust manifold to the engine. The bolts should be tightened starting with the center two and working outward, from side to side. Torque the bolts in sequence to **11 ft-lb (15 Nm)**. Torque the bolts again, in sequence to **18 ft-lb (25 Nm)**.
4. Attach the heat shield to the exhaust manifold. Torque the studs to **80 in-lb (9 Nm)**.
5. Install the spark plugs into the cylinder head.
6. Lift the vehicle.
7. Attach the catalytic converter to the exhaust manifold. Torque the nuts to **37 ft-lb (50 Nm)**.
8. Lower the vehicle.

Right Side

To Remove:

1. Lift the vehicle.
2. Detach the catalytic converter from the exhaust manifold.
3. Lower the vehicle.
4. Remove the spark plugs from the cylinder head.
5. Detach the heat shield from the exhaust manifold.

Right exhaust manifold removal and installation



6. Detach the exhaust manifold from the engine.
7. Remove and discard the gasket from the exhaust manifold.

To Install:

1. Install a new gasket onto the exhaust manifold.
2. Apply threadlock GM P/N 12345493 to the exhaust manifold bolts.
3. Attach the exhaust manifold to the engine. The bolts should be tightened starting with the center two and working outward, from side to side. Torque the bolts in sequence to **11 ft-lb (15 Nm)**. Torque the bolts again, in sequence to **18 ft-lb (25 Nm)**.
4. Attach the heat shield to the exhaust manifold. Torque the studs to **80 in-lb (9 Nm)**.
5. Install the spark plugs into the cylinder head.
6. Lift the vehicle.
7. Attach the catalytic converter to the exhaust manifold. Torque the nuts to **37 ft-lb (50 Nm)**.
8. Lower the vehicle.

Catalytic Converter

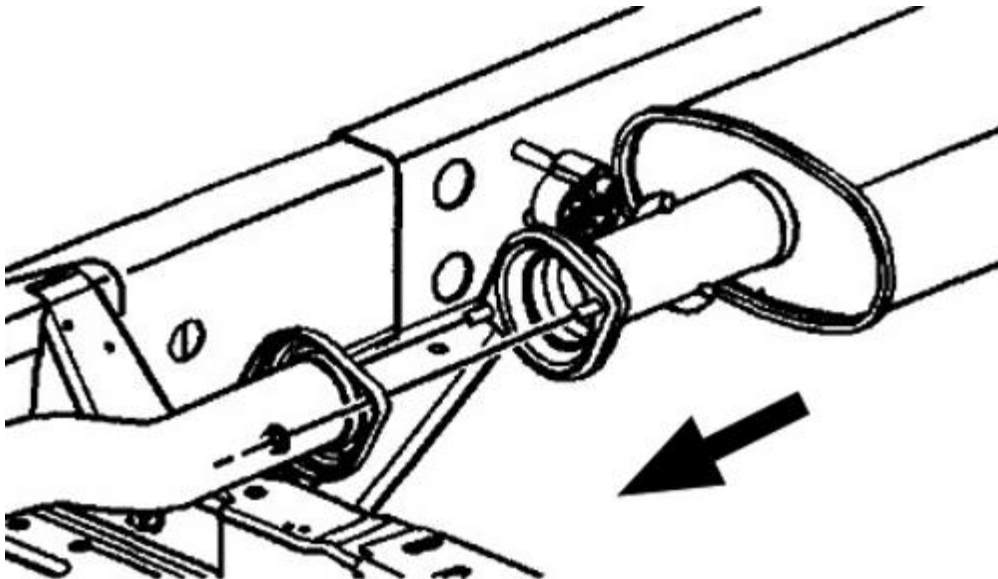
Removal & Installation

4.2L Engine

To Remove:

1. Lift the vehicle.
2. Remove the heated oxygen sensor (HO2S) from the catalytic converter.
3. Detach the catalytic converter from the exhaust manifold.
4. Remove and discard the seal from the catalytic converter.

Muffler removal and installation



5. Detach the catalytic converter from the muffler.
6. Remove the transmission mount from the frame.
7. Remove the catalytic converter from the vehicle.
8. Remove the exhaust hanger from the catalytic converter pipe.

To Install:

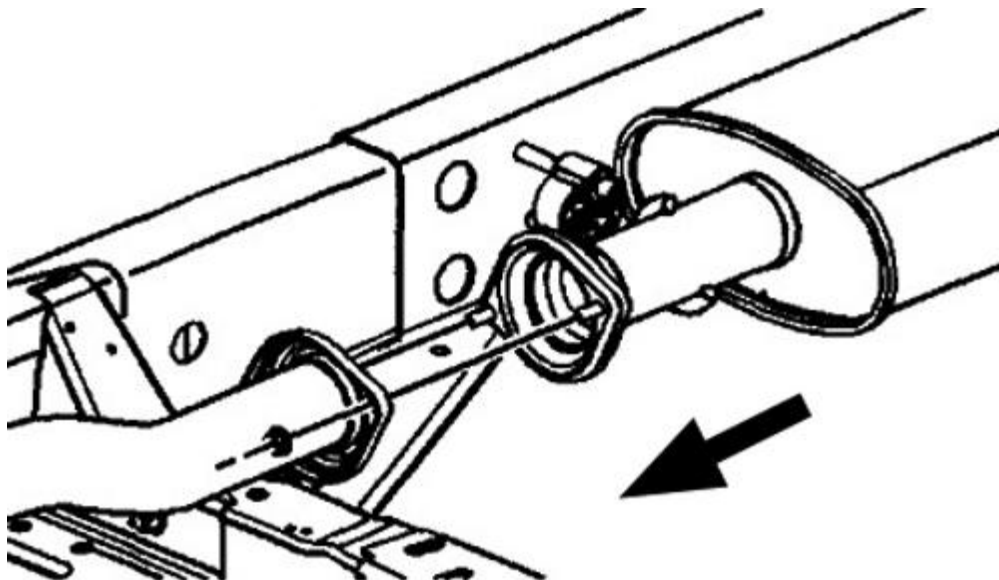
1. Install the exhaust hanger onto the catalytic converter pipe.
2. Place the catalytic converter into the vehicle.
3. Install the transmission mount onto the frame.
4. Attach the catalytic converter to the muffler. Torque the bolts evenly to **33 ft-lb (45 Nm)**.
5. Place a new seal on the catalytic converter.
6. Attach the catalytic converter to the exhaust manifold. Torque the bolts to **37 ft-lb (50 Nm)**.
7. Install the heated oxygen sensor (HO2S) into the catalytic converter.
8. Lower the vehicle.

5.3L & 6.0L Engines

To Remove:

1. Lift the vehicle.
2. Remove the heated oxygen sensors (HO2S) from the catalytic converter.
3. Remove the rear propeller shaft from the vehicle.
4. For vehicles with 4WD, remove the front propeller shaft from the vehicle.
5. Use a jack to support the transmission.
6. Remove the transmission support from the frame.

Muffler removal and installation



7. Detach the catalytic converter from the muffler.
8. Remove the exhaust hanger insulators from the exhaust system and move the exhaust system rearward.
9. Detach the catalytic converter from the left and right exhaust manifolds.
10. Remove the catalytic converter from the vehicle.

To Install:

1. Place the catalytic converter into the vehicle.
2. Install the exhaust hanger insulators onto the exhaust.
3. Attach the catalytic converter to the muffler. Torque the bolts evenly to **33 ft-lb (45 Nm)**.
4. Attach the catalytic converter to the left and right exhaust manifolds. Torque the nuts to **37 ft-lb (50 Nm)**.
5. Install the transmission support onto the frame.
6. Remove the jack supporting the transmission.
7. For vehicles with 4WD, install the front propeller shaft into the vehicle.
8. Install the rear propeller shaft into the vehicle.
9. If reinstalling the old heated oxygen sensors (HO2S), coat the threads with anti-seize compound GM P/N 12377953.
10. Install the heated oxygen sensors (HO2S) into the catalytic converter. Torque the sensors to **31 ft-lb (42 Nm)**.
11. Lower the vehicle.

Engine Reconditioning

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

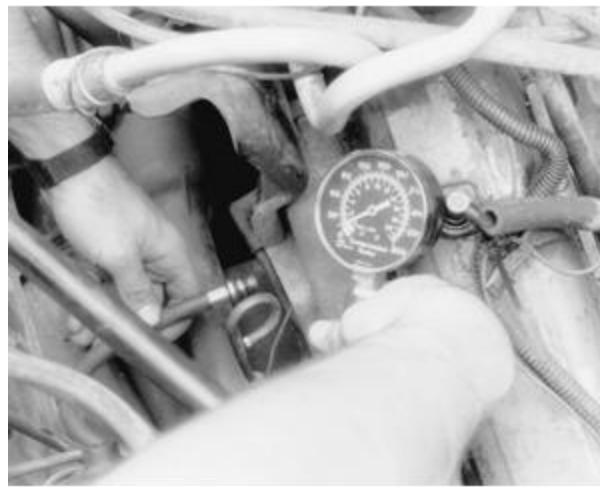
Determining Engine Condition

There are a number of methods for evaluating the condition of the engine. A compression test can reveal the condition of the pistons, piston rings, cylinder bores, head gasket(s), valves and valve seats. An oil pressure test can indicate possible engine bearing, or oil pump failures. Excessive oil consumption, evidence of oil in the engine air intake area and/or bluish smoke coming from the tailpipe may indicate worn piston rings, worn valve guides and/or valve seals. In general, it is acceptable for an engine to use one quart of oil every 1000 miles. Engines that use one quart of oil or more in less than 1000 miles should be checked for oil leaks first. Repair any oil leaks before determining how much oil is consumed by the engine, especially if blue smoke is not visible at the tailpipe.

Compression Test

A noticeable lack of engine power, excessive oil consumption and/or poor fuel mileage measured over an extended period are all indicators of internal engine wear. Worn piston rings, scored or worn cylinder bores, blown head gaskets, sticking or burnt valves, and worn valve seats are all possible causes. A check of each cylinder's compression will help locate the problem.

Screw-in type compression gauge



1. Ensure that the engine is filled with oil to the proper level and with the appropriate type (viscosity).
2. Ensure the battery is fully charged.
3. Warm-up the engine to normal operating temperature then shut off the engine.
4. Disable the fuel and ignition systems.
5. Label and disconnect all of the spark plug wires from the plugs.
6. Thoroughly clean the cylinder head area around the spark plug ports, and then remove the spark plugs.
7. Open the throttle plate fully to the wide-open-throttle position.
8. Block the accelerator linkage open, or have an assistant fully depress the accelerator pedal.
9. Install a screw-in type compression gauge into the No. 1 spark plug hole until the fitting is snug.
10. Connect a remote starting switch to the starting circuit.
11. With the ignition switch in the OFF position, use the remote starting switch to crank the engine through at least five compression strokes (approximately 5 seconds of cranking) and record the highest reading on the gauge.
12. Repeat the test on each cylinder, cranking the engine approximately the same number of compression strokes and/or time as the first.

13. Compare the highest readings from each cylinder to that of the others.
 - The indicated compression pressures are considered within specifications if the lowest reading cylinder is within 75 percent of the pressure recorded for the highest reading cylinder. For example, if your highest reading cylinder pressure was 150 psi (1034 kPa), then 75 percent of that would be 113 psi (779 kPa). So the lowest reading cylinder should be no less than 113 psi (779 kPa)
14. If a cylinder exhibits an unusually low compression reading, pour a tablespoon of clean engine oil into the cylinder through the spark plug hole and repeat the compression test.
 - If the compression rises after adding oil, it means that the cylinder's piston rings and/or cylinder bore are damaged or worn
 - If the pressure remains low, the valves may not be seating properly (a valve job is needed), or the head gasket may be blown near that cylinder.

Oil and coolant in the combustion chamber, combined with blue or constant white smoke emitted from the tailpipe, are symptoms of a blown head gasket. There may be evidence of water droplets on the engine dipstick and/or oil droplets in the cooling system if a head gasket is blown. The oil will become the consistency of chocolate milk if water is present, and the coolant will appear muddy if oil is present.

Oil Pressure Test

Check for proper oil pressure at the sending unit passage with an externally mounted mechanical oil pressure gauge. A tachometer may also be needed, as some specifications may require running the engine at a specific RPM.

1. While the engine is cold, locate and remove the oil pressure sending unit.
2. Following the manufacturer's instructions, connect a mechanical oil pressure gauge and, if necessary, a tachometer to the engine.
3. Start the engine and allow it to idle.
4. Note and record the oil pressure reading when the engine is cold. The engine may need to run at a specified RPM, if so check the vehicle's specification.
5. Run the engine until normal operating temperature is reached.
6. Check the oil pressure reading again with the engine hot and record the value. Turn off the engine.

Compare the hot oil pressure reading to the specification. If the reading is low, check the cold pressure reading against the specification. If the cold pressure is well above the specification, and the hot reading was lower than the specification, the engine may have the wrong viscosity oil. Change the oil, making sure to use the proper grade and quantity, and then repeat the test.

Low oil pressure readings could be attributed to internal component wear, pump related problems, a low oil level, or oil viscosity that is too low. High oil pressure readings could be caused by an overfilled crankcase, too high of an oil viscosity or a faulty pressure relief valve.

Overhaul Tips

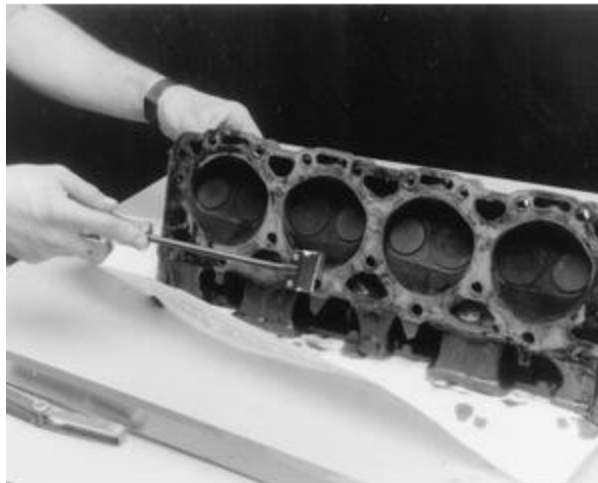
Aluminum has become extremely popular for use in engines, due to its weight savings. Observe the following precautions when handling aluminum parts:

- Never hot tank aluminum parts. The caustic hot tank solution will eat the aluminum
- Remove all aluminum parts (identification tag, etc.) from engine parts prior to tanking
- Always coat threads lightly with engine oil or anti-seize compounds before installation, to prevent seizure
- Never over tighten bolts in the block or spark plugs especially in aluminum heads
- When assembling the engine, any parts that will be exposed to frictional contact must be pre-lubed to provide lubrication at initial start-up. Any product specifically formulated for this purpose can be used, but engine oil is not recommended as a pre-lube in most cases
- When semi-permanent (locked, but removable) installation of bolts or nuts is desired, threads should be cleaned and coated with Loctite® or another similar, commercial non-hardening sealant.

Cleaning

Before the engine and its components are inspected, they must be thoroughly cleaned. You will need to remove any engine varnish, oil sludge and/or carbon deposits from all of the components to ensure an accurate inspection.

Scraping head gasket



Most of the cleaning process can be carried out with common hand tools and solvents. Carbon deposits can be chipped away using a hammer and a hard wooden chisel.

Old gasket material and varnish or sludge can usually be removed using a scraper and/or cleaning solvent. Hard to remove deposits may require the use of a power drill with a wire brush. If using a wire brush, use extreme care around any critical machined surfaces (such as the gasket surfaces, bearing saddles, cylinder bores, etc.). Use of a wire brush is not recommended on any aluminum components. Always follow any safety recommendations given by the manufacturer of the tool and/or solvents used. Always wear eye protection during any cleaning process involving scraping, chipping or spraying of solvents.

WARNING

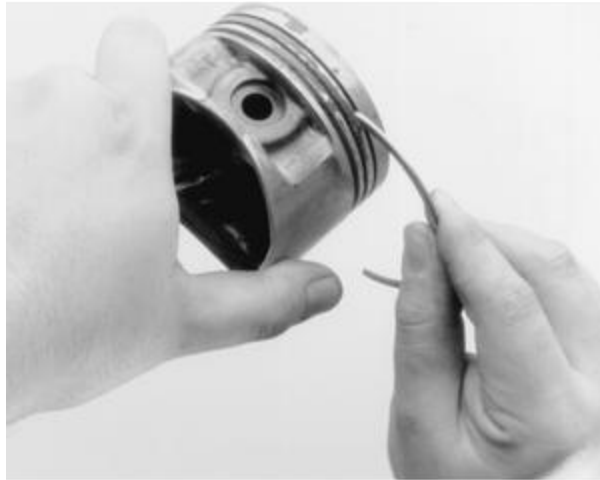
Always wear eye protection during any cleaning process involving scraping, chipping or spraying of solvents.

Remove any oil galley plugs, freeze plugs and/or pressed-in bearings and carefully wash and degrease all of the engine components including all fasteners. Small parts such as the valves, springs, etc., should be placed in a metal basket and allowed to soak. Use pipe cleaner type brushes to clean all oil and coolant passages of all the engine components. Use a ring expander and remove the rings from the pistons. Clean the piston ring grooves with a special tool or a piece of broken ring. Scrape the carbon from the top of the piston. You should never use a wire brush on the pistons. After preparing all of the piston assemblies in this manner, wash and degrease them again.

Ring groove cleaner tool



Cleaning groove with an old ring

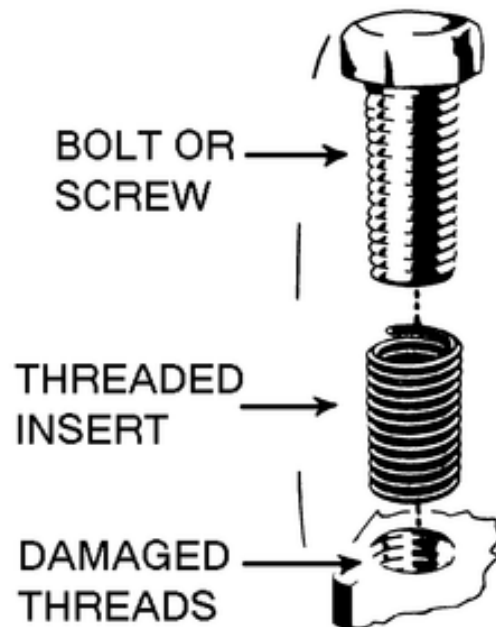


CAUTION

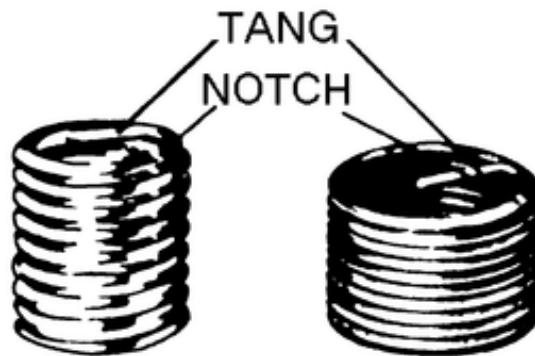
Minimize damage to the valve seats by removing carbon deposits before removing any valves from the cylinder heads. Choosing to de-carbonize the combustion chambers with the valves removed will increase the chances of damaging the valve seats.

Repairing Damaged Threads

Damaged bolt hole threads can be replaced with thread repair inserts



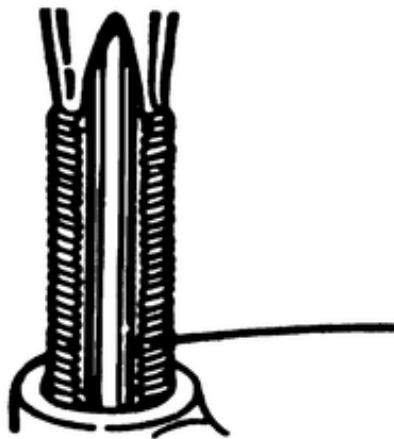
Standard thread repair insert (left), and spark plug thread insert



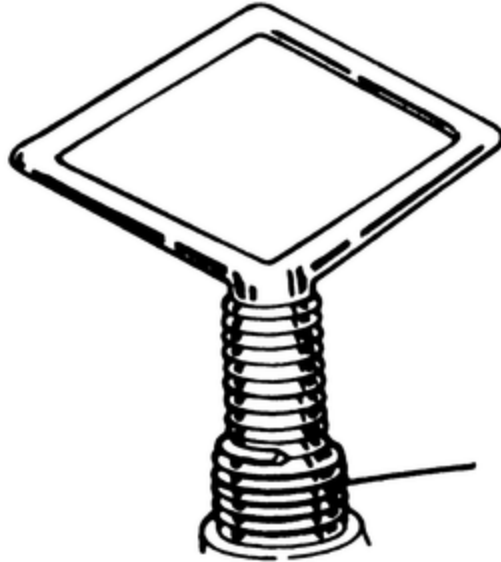
Drill out the damaged threads with the specified size bit. Be sure to drill completely through the hole or to the bottom of a blind hole



Using the kit, tap the hole in order to receive the thread insert. Keep the tap well oiled and back it out frequently to avoid clogging the threads



Screw the insert onto the installer tool until the tang engages the slot. Thread the insert into the hole until it is 1/4 - 1/2 turn below the top surface, then remove the tool and break off the tang using a punch



Two types of thread repair inserts are usually supplied: a standard type for most -SAE coarse, SAE fine, metric course and metric fine thread sizes and a spark plug type to fit most spark plug port sizes. Typical thread repair kits will contain a selection of pre-wound threaded inserts, a tap that corresponds to the outside diameter threads of the insert, and an installation tool. Spark plug inserts usually differ from conventional fastener inserts because they require a tap equipped with pilot threads and a combined reamer/tap section.

Cylinder Head

There are two basic types of cylinder heads used on today's automobiles: the Overhead Valve (OHV) and the Overhead Camshaft (OHC). The latter can also be broken down into two subgroups: the Single Overhead Camshaft (SOHC) and the Dual Overhead Camshaft (DOHC).

Most cylinder heads are made of an aluminum alloy because it is light weight, highly durable and transfers heat well. However, cast iron was the material of choice in the past, and is still used on many vehicles today. Whether made from aluminum or cast iron, all cylinder heads have valves and seats. Some use two valves per cylinder, while the more hi-tech engines will utilize a multi-valve configuration using three, four and even five valves per cylinder. All cylinder heads have a valve guide for each valve. The guide centers the valve to the seat and allows it to move up and down within it. The clearance between the valve and guide can be critical. Too much clearance and the engine may consume oil, lose vacuum and/or damage the seat. Too little, and the valve can stick in the guide causing the engine to run poorly if at all, and possibly causing severe damage. When the valve contacts the seat, sealing the combustion chamber, it does so with precision-machined surfaces. The last component all cylinder heads have are valve springs. The spring holds the valve against its seat. It also returns the valve to the closed position after the valve has opened. The spring is held in place around its corresponding valve by a retainer and valve locks. Aluminum heads will also have a valve spring cup to prevent the spring from wearing away the aluminum of the cylinder head.

Disassembly

OHV Heads

1. Remove the rocker arms and/or shafts.
2. Position the head so that the springs are easily accessed.

Valve spring compressor tool



3. Use a valve spring compressor tool, and relieve spring tension from the retainer.

A small magnet used in removal of valve locks



Valve locks (keepers)



5. Remove the valve locks from the valve tip and/or retainer.
6. Release the spring compressor and remove the valve spring.

O-ring type seal

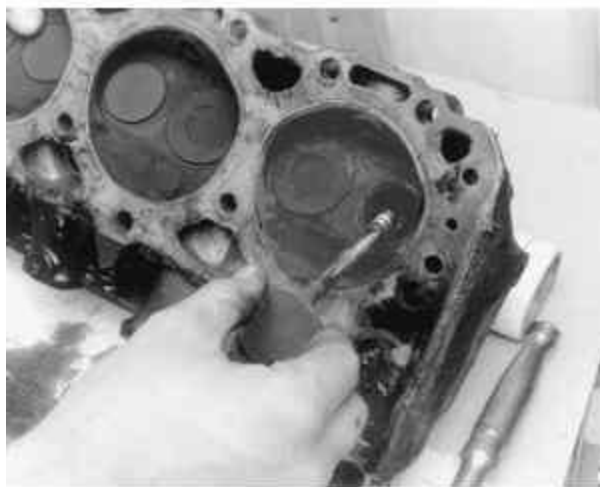


Umbrella/positive type seal



8. Remove the valve seal.

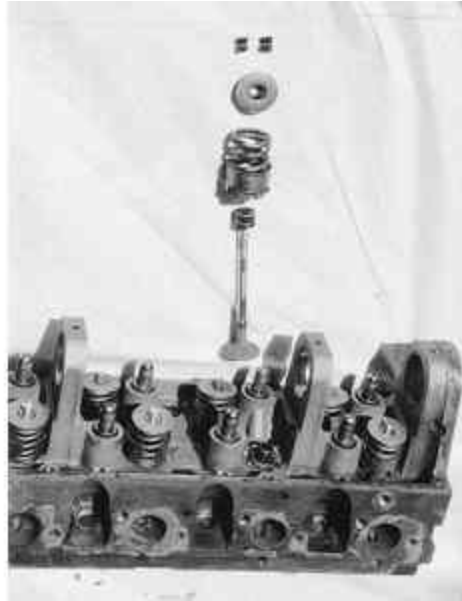
Removing exhaust valve



9. Position the head to allow access for withdrawing the valve.
10. Remove the valve from the cylinder head.
11. If equipped, remove the valve spring cup.

OHC Cylinder Heads

Exploded view of a valve, seal, spring, retainer and locks from an OHC cylinder head



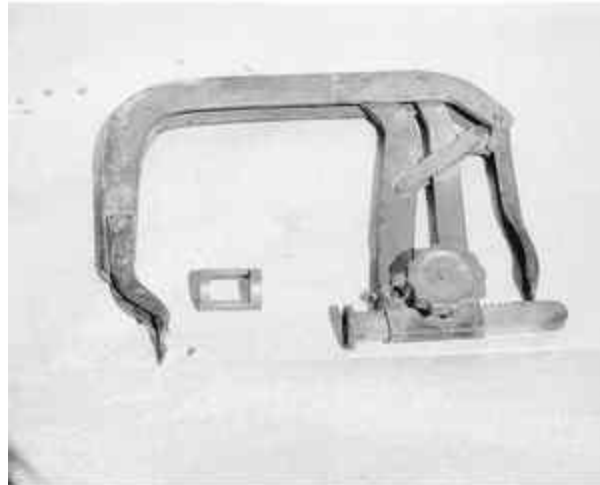
Example of a multi-valve cylinder head with 2 intake and 2 exhaust valve ports



Cup Type Camshaft Followers

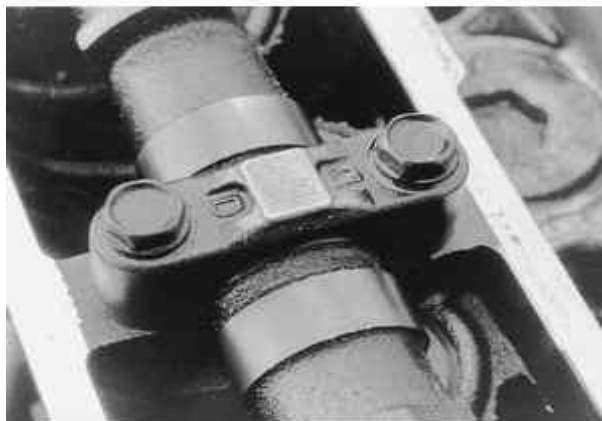
Most cylinder heads with cup type camshaft followers will have the valve spring, retainer and locks recessed within the follower's bore. You will need a C-clamp style valve spring compressor tool, an OHC spring removal tool (or its equivalent) as well as a small magnet to disassemble the head.

C-clamp type spring compressor and an OHC spring removal tool (center) for cup type followers



1. Remove the camshaft(s) and/or followers. Mark for reassembly.

Cup type bolt-on bearing caps



2. Position the cylinder head to allow use of a C-clamp style valve spring compressor tool.

OHC spring tool and C-clamp



3. Position the OHC spring removal adapter tool inside of the follower bore, then compress the valve spring using the C-clamp style valve spring compressor.
4. Remove the valve locks.
5. Release the compressor tool and remove the spring assembly.

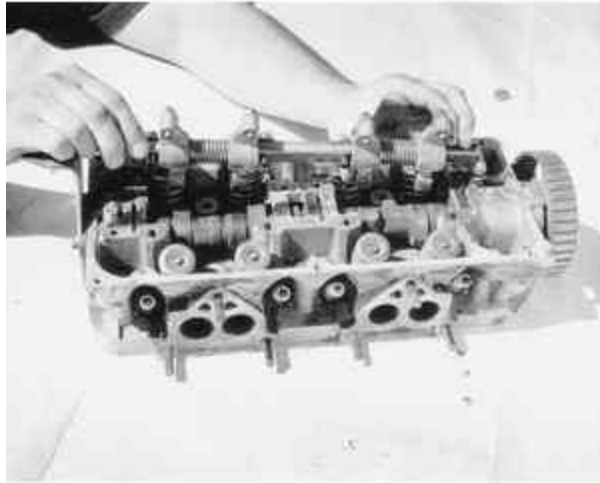
NOTE: Check for burrs or high spots on the valve tip and valve lock area. Use a metal file to remove burrs before removing the valve from the head.

6. Remove the valve from the cylinder head.
7. Remove the valve seal.
8. If equipped, remove the valve spring shim.
9. Repeat Steps 3 through 8 until all of the valves have been removed.

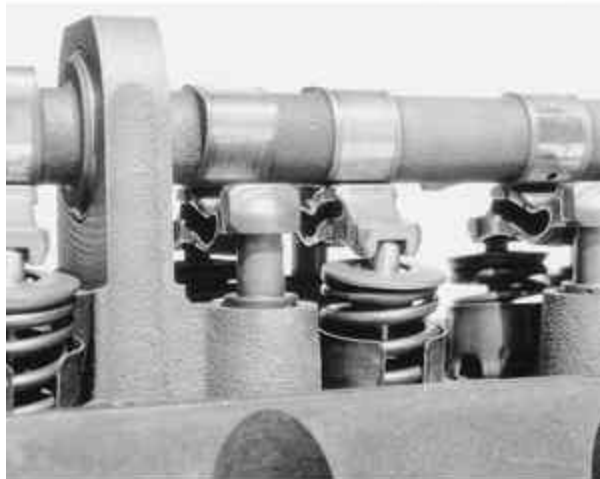
Rocker Arm Type Camshaft Followers

Most cylinder heads with rocker arm-type camshaft followers are easily disassembled using a standard valve spring compressor. Certain models may not have enough open space around the spring for the standard tool and may require you to use a C-clamp style compressor tool instead.

OHC shaft mounted rocker arms

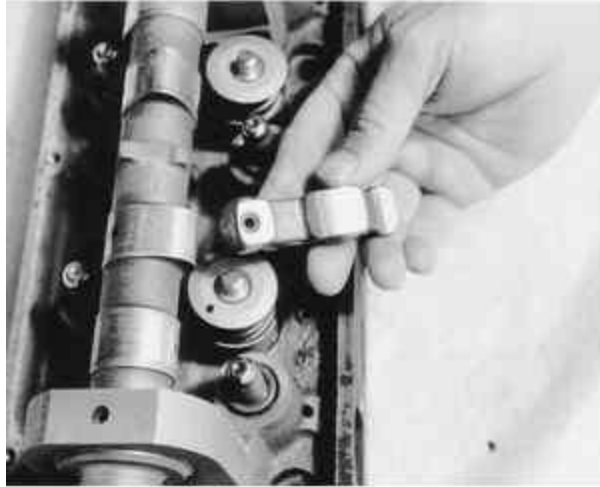


OHC rocker arm type head

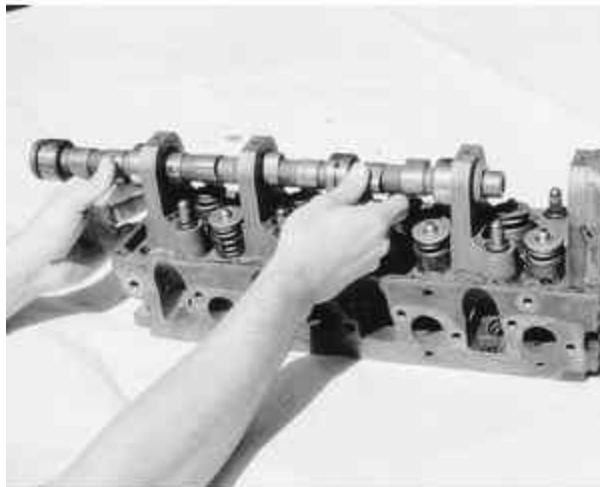


1. Removed the rocker arms and/or shafts and the camshaft.
2. If applicable remove the hydraulic lash adjusters. Mark for reassembly.

Remove the followers

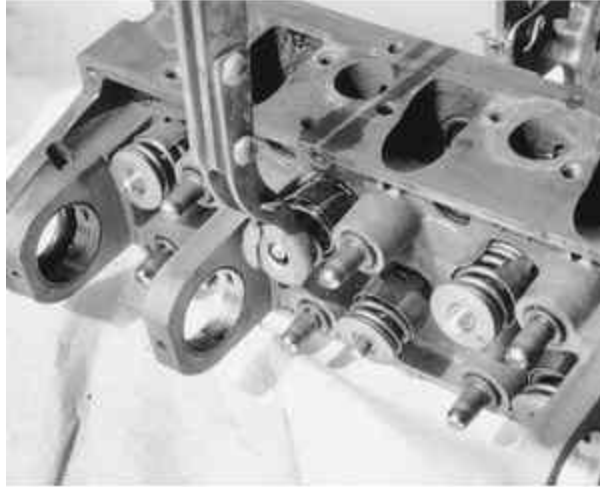


. . . then the camshaft can be removed by sliding it out (shown), or unbolting a bearing cap (not shown)

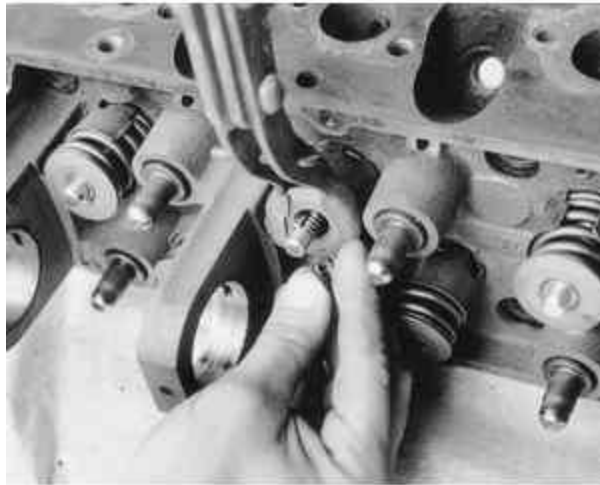


4. Position the cylinder head to allow access to the valve spring.
5. Use a valve spring compressor tool to relieve the spring tension from the retainer.

Compressing the valve spring

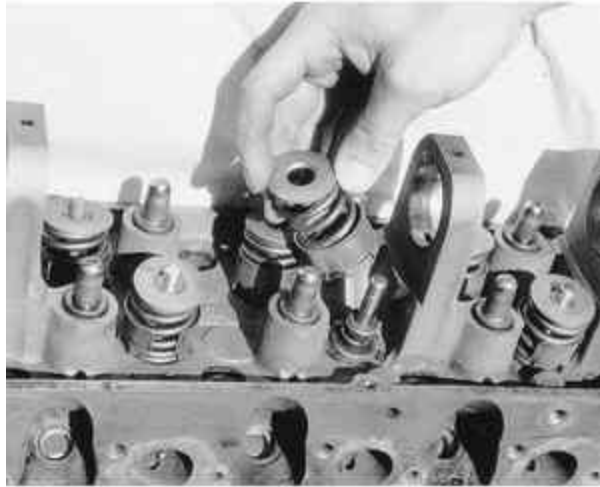


Removing the valve locks



7. Remove the valve locks from the valve tip and/or retainer.
8. Release the spring compressor and remove the valve spring off of the valve stem.

Valve spring and retainer



9. Remove the valve seal.

Removing valve seal from the guide.

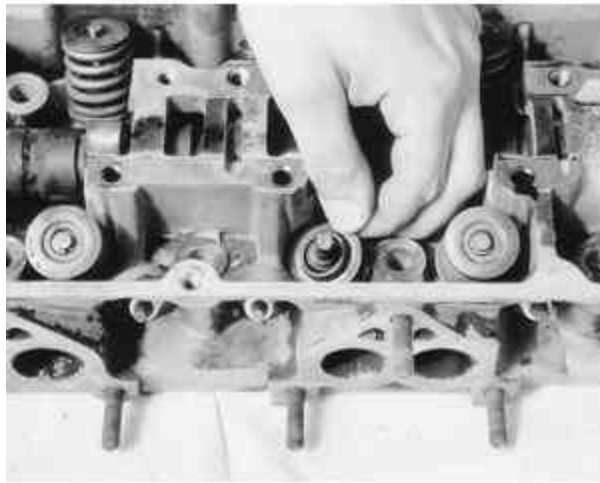


10. Position the head to allow access for removing the valve.

NOTE: Some cylinder heads may have mushroomed valve lock grooves and/or valve tips, making it difficult to remove valves. If so, use a metal file to carefully remove the high spots around the lock grooves and/or tip. File enough to make valve removal possible.

11. Remove the valve from the cylinder head.

Valve spring shim



12. If equipped, remove the valve spring shim.

13. Repeat Steps 3 through 9 until all of the valves have been removed

Inspection

Inspect the cylinder head components for wear and/or damage.

Valves

Inspect the heads of the valves first. Look closely at the head, margin and face for any cracks, excessive wear or burning. The margin is the best place to look for burning. It should have a squared edge with an even width all around the circumference of the valve. When a valve burns, the margin will look melted and the edges will appear rounded. Also inspect the valve head for any signs of tulipping. This will show as a lifting of the edges or dishing in the center of the valve head and will usually not occur to all of the valves. All of the valve heads should look the same. Any valves that seem dished more than others are probably bad. Next, inspect the valve lock grooves and valve tips. Check for any burrs around the lock grooves, especially if they had to be filed to remove the valve. Valve tips should appear flat and square to the valve stem. Slight rounding with high mileage engines is considered normal. Slightly worn valve tips will need to be machined flat. Last, measure the valve stem diameter with the micrometer. Measure the area that rides within the guide, especially towards the tip where most of the wear occurs. Take several measurements along its length and compare them to each other. Wear should be even along the length with little to no taper. If no minimum diameter is given in the specifications, then the stem should not read more than 0.001 in. (0.025mm) below an unworn area of the valve stem. Any valves that fail these inspections should be replaced.

Valve stems may be rolled on a flat surface to check for bends



Use a micrometer to check the valve stem diameter



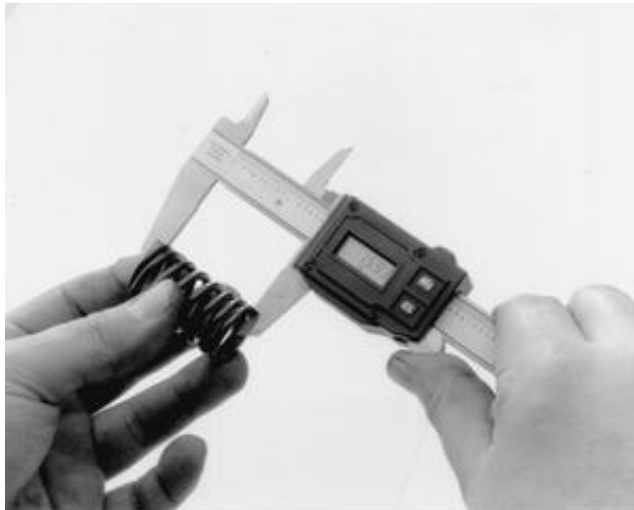
Springs, Retainers & Valve Locks

Perform a visual inspection for broken springs. Check the free length and squareness of each spring. If applicable, ensure to distinguish between intake and exhaust springs. Use a ruler and/or machinist's square to measure the length. A machinist's square should be used to check the springs for squareness. If a spring tension test gauge is available, check each spring's rating and compare to the specifications. Valve springs should be replaced as a complete set.

Check the spring retainer-to-spring mating surface and the valve lock retention area for any signs of excessive wear. Check for any signs of cracking. Replace any retainers that are questionable.

Valve locks should be inspected for excessive wear on the outside contact area as well as on the inner notched surface. Any locks which appear worn or broken should be replaced along with its respective valve.

Spring free-length check



Valve spring squareness check



Valve Guides

Check the guides carefully and inspect them for any cracks, chips or breakage. Also if the guide is a removable style (as in most aluminum heads), check them for any looseness or evidence of movement. All of the guides should appear to be at the same height from the spring seat. If any seem lower (or higher) from another, measure the heights to determine if the guide has moved.

Mount a dial indicator onto the spring side of the cylinder head. Lightly oil the valve stem and insert it into the cylinder head. Position the dial indicator against the valve stem near the tip and zero the gauge. Grasp the valve stem and wiggle towards and away from the dial indicator and observe the readings. Mount the dial indicator 90 degrees from the initial point and zero the gauge and again take a reading. Compare the two readings for an out of round condition. Check the readings against the specifications given. An Inside Diameter (I.D.) gauge designed for valve guides will give you an accurate valve guide bore measurement. If the I.D. gauge is used, compare the readings with the specifications. Any guides that fail these inspections should be replaced or machined.

Reading stem-to-guide clearance



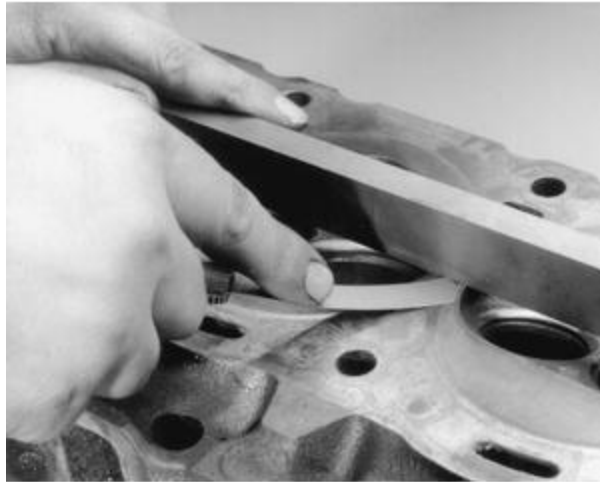
Valve Seats

A slightly worn and pitted surface where the valve face contacts the seat will typically be apparent when valve seats are inspected. Inspect the seat carefully for severe pitting or cracks. A seat that is badly worn will be recessed into the cylinder head. A severely worn or recessed seat may need to be replaced. All cracked seats must be replaced. Use a seat concentricity gauge to check the seat run-out. If run-out exceeds specifications the seat must be machined. If a specification can not be found, use 0.002 in. (0.051mm) as a general rule of thumb for concentricity.

Cylinder Head Surface Flatness

Clean the gasket surface of the cylinder head. Check the head for flatness.

Machinist's straight edge and feeler gauge



Diagonal check



Place a machinist's straight edge across the gasket mating surface. Using feeler gauges, determine the clearance at the center of the machinist's straight edge and across the cylinder head at several points. Check along the centerline and diagonally on the head surface. If the warpage exceeds 0.003 in. (0.076 mm) within a 6.0 in. (15.2 cm) span, or 0.006 in. (0.152 mm) over the total length of the head, the cylinder head must be resurfaced. After resurfacing the heads of a V-type engine, the intake manifold flange surface should be checked, and if necessary, milled proportionally to allow for the change in its mounting position.

Cracks & Physical Damage

Check the cylinder head for cracks in the spark plug holes, valve ports, exterior surface, or in the valve spring/rocker arm area. Check the exhaust seat/port first as this becomes the hottest area on a cylinder head.

Some reliable methods for finding cracks include Magnaflux®, (a magnetic process) or Zyglo®, (a dye penetrant). Magnaflux is used only on ferrous metal (cast iron) cylinder heads. Zyglo is a method that uses a spray on fluorescent mixture along with a black light to reveal the cracks and is suitable for aluminum cylinder heads.

Check for physical damage such as a broken mounting ear from dropping the head or a bent or broken stud and/or bolt. These defects should be repaired or the head should be replaced.

Camshaft & Followers

Refinishing & Repairing

Valves

Any valves that were not replaced should be refaced and the tips ground flat. If the valves are in extremely good condition, as well as the valve seats and guides, they may be lapped in without performing machine work.

It is recommended to lap the valves even after machine work has been performed and/or new valves are used. This ensures a positive seal between the valve and seat.

Lapping The Valves

NOTE: Before lapping the valves to the seats ensure that all related parts are in acceptable condition.

NOTE: Before any valve seat machining and/or lapping can be performed, the guides must be within factory recommended specifications.

1. Invert the cylinder head.
2. Lightly lubricate the valve stems and insert them into the cylinder head in their numbered order.
3. Remove the valve from the seat and apply a small amount of fine lapping compound to the valve face. Reinstall the valve into the guide.
4. Moisten the suction head of a hand-lapping tool and attach it to the head of the valve.
5. Rotate the tool between the palms of both hands, changing the position of the valve on the valve seat and lifting the tool often to prevent grooving.
6. Lap the valve until a smooth, polished circle is evident on the valve and seat.
7. Remove the tool and valve. Wipe away all traces of the grinding compound and store the valve to maintain its original location.

NOTE: Match the valves to their numbered cylinders. They must be matched with the same valve seat with which they were lapped

Springs, Retainers & Valve Locks

There is no repair or refinishing possible with the springs, retainers and valve locks. Worn or defective springs, retainers and valve locks must be replaced with new (or known good) parts.

Valve Guide

NOTE: If any machining or replacements are made to the valve guides, the valve seats must be machined.

Unless the valve guides need machining or replacing, the only service to perform is to thoroughly clean them.

There are only two types of valve guides used on automobile engines: the replaceable-type (all aluminum heads) and the cast-in integral-type (most cast iron heads). There are four recommended methods for repairing worn guides:

- Knurling
- Inserts
- Reaming
- Replacing

Knurling is a process in which metal is displaced and raised, thereby reducing clearance, providing a true center, and oil control. In some cases, a knurled valve guide will not stand up for more than a short time.

Installing a guide insert involves machining the worn guide to accept a bronze insert. One style is the coil-type which is installed into a guide that has been threaded. Another is the thin-walled insert where the worn guide is reamed oversize to accept a split-sleeve insert. After the insert is installed, a special tool is then run through the guide to expand the insert, locking it to the guide. The insert is then reamed to provide the proper valve stem clearance.

Reaming for oversize valves restores normal clearances and provides a true valve seat. Most cast-in type guides can be reamed to accept a valve with an oversize stem. Oversized valves are generally 0.003 to 0.030 in. (0.076 to 0.762mm), with 0.015 in. (0.381mm) being the most common.

To replace cast-in type valve guides, they must be drilled out, and then reamed to accept replacement guides. This must be done on a fixture which will allow centering and leveling off of the original valve seat or guide, otherwise a serious guide-to-seat misalignment can occur making it impossible to properly machine the seat.

Replaceable-type guides, commonly found in aluminum cylinder heads are pressed into the cylinder head. A hammer and a stepped drift or punch may be used to install and remove the guides. Before removing the guides, measure the protrusion on the spring side of the head and record it for installation. Use the stepped drift to hammer out the old guide from the combustion chamber side of the head. When installing, determine whether or not the guide seals a water jacket in the head. If it does, use the recommended sealing agent. If the valve guides do not seal any water jackets grease the valve guide and its bore. Use the stepped drift and a hammer to drive the new guide into the cylinder head from the spring side (top) of the cylinder head. A stack of washers the same thickness as the measured protrusion may help the installation process. Measure the guide heights to verify correct installation.

Valve Seats

NOTE: Before any valve seat machining can be performed, the guides must be within factory recommended specifications.

NOTE: If any machining or replacements were made to the valve guides, the seats must be machined.

If the seats are in good condition, the valves can be lapped to the seats, and the cylinder head assembled.

If the valve seats are worn, cracked or damaged, they must be replaced. The valve seat must be perfectly centered to the valve guide, which requires very accurate machining.

Cylinder Head Surface

If the cylinder head is warped, it must be machined flat. If the warpage is extremely severe, the head may need to be replaced. In some instances, it may be possible to straighten a warped head enough to allow machining.

NOTE: Any overhead valve cylinder head that shows excessive warpage should have the camshaft bearing journals align bored after the cylinder head has been resurfaced.

CAUTION

Failure to align bore the camshaft bearing journals could result in severe engine damage including but not limited to: valve and piston damage, connecting rod damage, camshaft and/or crankshaft damage.

Cracks And Physical Damage

Certain cracks can be repaired in both cast iron and aluminum heads. For cast iron, a tapered threaded insert is installed along the length of the crack. Aluminum cylinder heads can also be repaired with the tapered inserts; however welding is the preferred method. Some physical damage can be repaired through brazing or welding.

NOTE: Cracks in cast-iron heads require furnace braising to create an adequate seal.

Assembly

All cylinder head parts should be cleaned and arranged in their respective order to ease reassembly.

OHV Engines

1. Lightly lubricate the valve stems and insert all of the valves into the cylinder head in their original locations.
2. Install any valve spring shims which were removed.
3. Install the new valve stem seals as follows:
 - If the valve seal presses over the guide, lightly lubricate the outer guide surfaces.
 - If the seal is an O-ring type, it is installed just after compressing the spring but before installing the valve locks.
4. Place the valve spring and retainer over the stem.
5. Position the spring compressor tool and compress the spring.
6. Install the valve locks.
7. Relieve the spring tension slowly.
8. Ensure that the valve locks are properly seated
9. Remove the spring compressor tool.

OHC Engines

Cup Type Camshaft Followers

1. Lightly lubricate the valve stems and insert all of the valves into the cylinder head in their original locations.
2. Install any valve spring shims that were removed if using the original springs
3. Install the new valve seals as follows:
 - If the valve seal presses over the guide, lightly lubricate the outer guide surfaces.
 - If the seal is an O-ring type, install it after compressing the spring but before installing the valve locks.
4. Place the valve spring and retainer over the stem.
5. Position the spring compressor and OHC tool over the spring and retainer. Compress the spring and install the valve locks on the stem.
6. Relieve the spring pressure slowly and ensure both valve locks are properly held in place by the retainer.
7. Remove the spring compressor tool.
8. Install the followers, camshaft(s) and any other components that were removed for disassembly.

Rocker Arm Type Camshaft Followers

1. Lightly lubricate the valve stems and insert all of the valves into the cylinder head in their original locations.
2. Install any valve spring shims that were removed if using the original springs.
3. Install the new valve seals as follows:
 - If the valve seal presses over the guide, lightly lubricate the outer guide surfaces.
 - If the seal is an O-ring type, install it after compressing the spring but before installing the valve locks.
4. Place the valve spring and retainer over the stem.
5. Position the spring compressor tool over the spring and retainer. Compress the spring and install the valve locks on the stem.
6. Relieve the spring pressure slowly and ensure that both valve locks are properly held in place by the retainer.
7. Remove the spring compressor tool.
8. Install the camshaft(s), rockers, shafts and any other components that were removed for disassembly.

Engine Block

General Information

NOTE: Replace only the components that show signs of wear or are physically damaged.

Disassembly

Pushrod Engines

Mount the engine on a suitable engine stand. Remove the pushrods and lifters. Remove the timing gears and/or timing chain assembly. Remove the oil pump drive assembly. Remove the camshaft from the engine block. Remove the oil pick-up and oil pump assembly. Remove any balance or auxiliary shafts if equipped. Remove the cylinder ridge from the top of the bore.

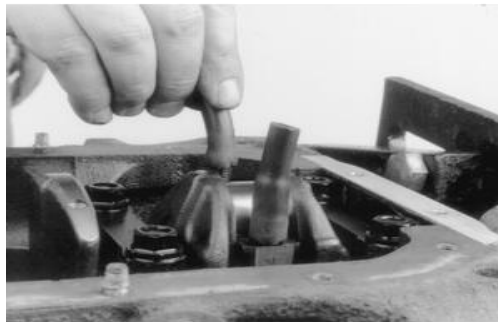
OHC Engines

Remove the oil pick-up and pump assembly. If necessary remove the oil pump drive. If necessary remove any balance or auxiliary shafts. Remove the cylinder ridge from the top of any cylinder bore if required.

All Engines

Turn the engine over so that the crankshaft is exposed. Use a number punch and mark each connecting rod and cap with its respective cylinder number. On V-block engines, always stamp the rods and caps on the side closest to the exterior of the block for proper installation. The cylinder closest to the front of the engine is always number 1. However, depending on the engine placement, the front of the engine could either be the flywheel or damper/pulley end. Generally the front of the engine faces the front of the vehicle. Use a number punch or scribe and also mark the main bearing caps from front to rear with the front most cap being number 1.

Place rubber hose over the connecting rod studs to protect the crankshaft and cylinder bores from damage



CAUTION

The sharp threads of the rod bolts/studs can score the crankshaft journal. Install rubber hose sections or plastic caps over the rod bolts when pushing the piston and connecting rod assembly out of the engine.

Carefully tap the piston out of the bore using a wooden hammer handle or piston knocker



Reposition the engine block, so that the number one cylinder bore (head surface) is facing up. Rotate the crankshaft until the number one piston is at the bottom of its travel. This will allow the maximum access to its connecting rod. Remove the connecting rod fasteners and cap. Place two lengths of rubber hose over the rod bolts/studs to protect the crankshaft from damage. Using a wooden hammer handle (or piston hammer), push the connecting rod up about 1 in. (25mm) from the crankshaft and remove the upper bearing insert. Continue pushing or tapping the connecting rod up until the piston rings are out of the cylinder bore. Remove the piston and rod by hand, put the upper half of the bearing insert back into the rod, install the cap with its bearing insert installed, and hand-tighten the cap fasteners. On V-style engines, remove all of the pistons from one bank, then reposition the engine with the other cylinder bank head surface up, and remove that bank's piston assemblies.

Loosen the main bearing caps evenly until the bolts can be turned by hand. Remove the bolts and caps. Remove the crankshaft from the engine block. Clean all the components.

Cylinder Ridge Removal

NOTE: You must remove cylinder ridges before removing the piston and connecting rod assemblies.

1. Rotate the crankshaft until the piston is at the bottom of its travel.
2. Cover the head of the piston with a rag.
3. Follow the tool manufacturers' instructions and cut away the ridge, exercising extreme care to avoid cutting too deeply.
4. Remove the ridge reamer, the rag and as many of the cuttings as possible.

Inspection

Check the engine for cracks. Perform a visual inspection on all of the components. Some reliable methods for inspecting for cracks include Magnaflux® a magnetic process or Zyglo®, a dye penetrant. Magnaflux is used only on ferrous metal (cast iron). Zyglo uses a spray on fluorescent mixture along with a black light to reveal the cracks and is suitable for aluminum engine components.

Crankshaft Bearing Alignment

Inspect all the main bearing saddles and caps for damage, burrs or high spots. If damage is found, and was caused by a spun main bearing, the block will need to be align-bored or, if severe enough, replaced. Any burrs or high spots should be carefully removed with a deburring tool.

Place a machinist's straight edge along the bearing saddles in the engine block. If any clearance exists between the machinist's straight edge and the saddles, the block must be align-bored.

Align-boring consists of machining the main bearing saddles and caps by means of a fly cutter that runs through the bearing saddles.

Deck Flatness

Ensure that the deck surface is clear of dirt, carbon deposits and old gasket material. Place a machinist's straight edge across the surface of the deck along its centerline. Check the clearance along several points using feeler gauges. . Move the machinist's straight edge diagonally across the deck surface and check clearances along the diagonal line. If the reading exceeds 0.003 in. (0.076 mm) within a 6.0 inch (15.2 cm) span, or 0.006 in. (0.152 mm) over the total length of the deck, it must be machined.

Cylinder Bores

The cylinder bores are slightly larger than the pistons themselves. A common piston-to-bore clearance is 0.0015 - 0.0025 in. (0.0381 - 0.0635 mm). Inspect and measure the cylinder bores. All bores should be checked for out-of-roundness, taper and size. The

results of this inspection will determine whether the cylinder can be used in its existing size and condition, or a re-bore to the next oversize is required (or in the case of removable sleeves, have replacements installed).

Measuring cylinder bore diameter



Measurements are taken at three locations in each cylinder: at the top, middle and bottom. Two measurements are taken at each location. One that is perpendicular (ninety degrees) from the crankshaft centerline and the other that is parallel to the crankshaft centerline. The measurements are made with either a dial indicator or a telescopic gauge and micrometer.

Start measurements at the top of the cylinder bore, and proceed to the middle and finally at the bottom. A total of six measurements will be taken for each cylinder bore.

1. Measure the cylinder as follows:
 - A. Position the gauge in a cylinder bore near the top.
 - B. Loosen the gauge lock and allow it to expand.
 - C. Hold the gauge squarely in the bore, perpendicular (90 degrees) to the crankshaft centerline.
 - D. Tighten the lock.
 - E. Tilt the gauge back to remove it from the bore.
 - F. Measure the gauge with the micrometer and record the reading.
 - G. Position the gauge squarely in the same bore parallel (in-line) to the crankshaft centerline. Repeat steps A to F.
 - H. Measure the gauge with the micrometer and record this reading.
 - I. The difference between these two readings is the out-of-round measurement of the cylinder.

The difference between these measurements will indicate the cylinder wear. The measurements taken perpendicular (90 degrees) to the crankshaft centerline will typically

reflect the most wear. This is where the greatest force is exerted on the cylinder as the piston is forced down during combustion. This is known as thrust wear. Take the top, 90 degree measurement and compare it to the bottom, 90 degree measurement. The difference between them is the cylinder taper. The amount of cylinder wall wear is always greater at the top of the cylinder than at the bottom. Any cylinder that has a taper of 0.0012 in. (0.305 mm) or more must be re-bored.

Compare the cylinder bore measurements to the size of the pistons to determine piston-to-wall clearance.

Crankshaft

Inspect the crankshaft for visible signs of wear or damage. All of the journals (piston and main bearing) should be perfectly round and smooth. Slight scores are normal for a used crankshaft, but should hardly be felt with a fingernail. Make the crankshaft measurements with a micrometer at the front and rear of each journal (x). Turn the micrometer 90 degrees and take two more readings (y), front and rear. The difference between the x and y reading is the out-of-round measurement. Generally, there should be no taper or out-of-roundness found. A difference up to 0.0005 in. (0.0127mm) for taper or out-of roundness is acceptable. All measurements should be within the factory specifications for journal diameters.

If the crankshaft journals are within specifications, it is recommended that they be polished before being reusing the crankshaft. Polishing the crankshaft ensures that any minor burrs or scoring are smoothed, thereby reducing the chance of scoring the new crankshaft bearings.

Pistons & Connecting Rods

Pressed-On Pistons

The piston should be visually inspected for any signs of cracking or burning (caused by hot spots or detonation), scuffing or excessive wear on the skirts. The piston should move freely on the wrist pin. It should slide and pivot freely. Grasp the connecting rod securely, or mount it in a vise, and try to rock the piston back and forth along the centerline of the wrist pin. There should not be any excessive play evident between the piston and the wrist pin. If C-clips retain the pin in the piston then the piston may be equipped with wrist pin bushings in the connecting rod. There should not be any excessive play between the wrist pin and the rod bushing. Normal wrist pin clearance is approx. 0.001 - 0.002 in. (0.025-0.051 mm). Check the manufacturer's specifications for the exact values.

Measuring the piston's outer diameter



Use a micrometer and measure the outside diameter of the piston perpendicular to the wrist pin at the skirt. Compare this measurement to the cylinder measurement obtained earlier. The difference between the two readings is the piston-to-wall clearance. If the clearance is within specifications, the piston may be used as is. If the piston is out of specification and the bore is not, you will need a new piston. If both the piston and the bore are out of specification, you will need the cylinder re-bored and an oversized piston. Generally, if two or more pistons or bores are out of specification, it is best to re-bore the entire block and install oversize pistons. If the pistons are worn, but the cylinders are acceptable, one alternative is to use +0.005 inch oversize pistons and hone the cylinders to the correct size.

Connecting Rod

Check the connecting rod for straightness. If the connecting rod is bent, it will unevenly wear the bearing and piston, as well as place greater stress on these components. Any connecting rods that are bent or twisted must be replaced. If the rods are straight and the wrist pin clearance is within specifications, then only the bearing end of the rod need be checked. Place the connecting rod into a vice, with the bearing inserts in place, install the cap to the rod and torque the fasteners to specifications. Use a telescoping gauge and carefully measure the inside diameter of the bearings. Compare this reading to the rods original crankshaft journal diameter measurement. The difference is the oil clearance. If the oil clearance is not within specifications, install new bearings in the rod and take another measurement. If the clearance is still out of specifications, and the crankshaft is not, the rod will need to be reconditioned or replaced.

NOTE: You can also use Plastigage® to check the bearing clearances.

Bearings

All of the engine bearings including full circle ones used on most camshafts, auxiliary shafts and balance shafts should be visually inspected for wear and/or damage. The bearing should look evenly worn all around with no deep scores or pits. If the bearing is severely worn, scored, pitted or heat blued, then the bearing, and the components that use it, should be inspected.

Oil Pump

NOTE: The oil pump is responsible for providing constant lubrication to the entire engine. Always replace the oil pump when rebuilding the engine.

Refinishing

If the cylinders are not to be re-bored, then the cylinder glaze can be removed with a ball hone. When removing cylinder glaze with a ball hone, use a light or penetrating type oil to lubricate the hone. Do not allow the hone to run dry as this may cause excessive scoring of the cylinder bores and wear on the hone.

CAUTION

If new pistons are required, they will need to be installed in the correct relationship to the rod or engine damage can occur.

Ball type cylinder hone



Pistons & Connecting Rods

Free floating or C-clip pistons can be disassembled with conventional tools. Press fit pistons require a press to remove the piston from the rod, and a special heating device to install the new piston to the connecting rod.

All pistons will have a mark indicating the direction to the front of the engine and the must be installed into the engine in that manner. Usually a notch or arrow can be found on the top of the piston, or the letter F is cast or stamped into the piston.

Front of piston mark



Assembly

Mount the engine block onto the engine stand. Wash and dry the block including the cylinder bores, oil passages and crankshaft. Replace any freeze or oil galley plugs that were removed during disassembly.

Crankshaft

NOTE: The oil holes in the bearing inserts must be aligned with the oil holes in the cylinder block.

1. Position the upper main bearing inserts in the bores aligning the tang with the notch.
2. Install the lower main bearing inserts on the bearing caps.
3. Carefully lower the crankshaft into place. Be careful not to damage any bearing surfaces.
4. Check the clearance of each main bearing by placing a piece of Plastigage® or its equivalent, on the bearing surface across the full width of the bearing cap, about 1/4 inch off center.
5. Install the corresponding bearing cap and torque the bolts to specifications.

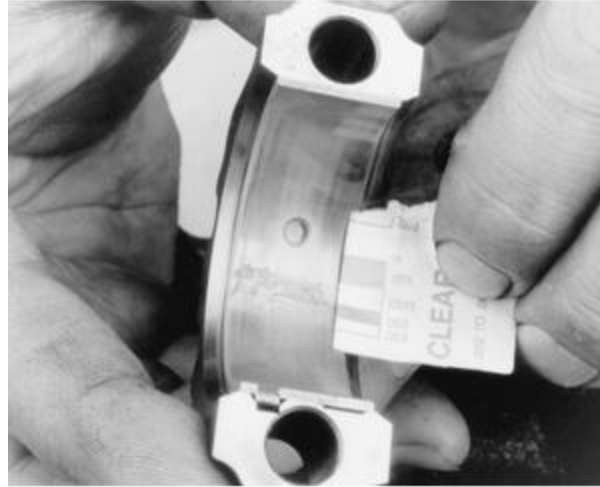
Checking bearing clearance with gauging material



6. Remove the cap; check the width of the Plastigage® at its widest point to get the maximum clearance and its narrowest point to get the minimum clearance. The difference between the readings is the oil clearance.

NOTE: Do not turn the crankshaft while the Plastigage® is in place.

Measuring bearing clearance gauging material



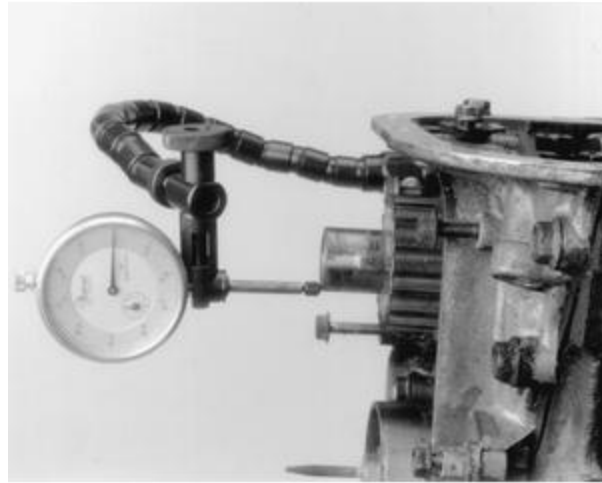
If clearance exceeds specified limits, try a 0.001 in. or 0.002 in. undersize bearing in combination with the standard bearing. Bearing clearance must be within specified limits. If a standard and 0.002 in. undersize bearing does not bring clearance within desired limits, refinish crankshaft journal, and install undersize bearings.

7. Install the rear main seal.

NOTE: Be sure that main bearing caps are installed in the original locations.

8. After the bearings have been fitted, apply a light coat of engine oil to the crankshaft journals and bearings.
9. Install the rear main bearing cap.
10. Install all bearing caps except the thrust bearing cap.
11. Torque all bearing cap bolts to specification.
12. Install the thrust bearing cap as follows:
 - A. Install the bearing cap with bolts finger-tight.
 - B. Pry the crankshaft forward against the thrust surface of the upper half of the bearing.
 - C. Hold the crankshaft forward and pry the thrust bearing cap to the rear.
 - D. Retain the forward pressure on the crankshaft and torque the cap bolts to specifications.
13. Measure the crankshaft end-play as follows:

Use a dial gauge to check crankshaft end-play



- A. Mount a dial gauge to the engine block and position the tip of the gauge to read from the crankshaft end.
- B. Pry the crankshaft toward the rear of the engine and zero the gauge.

Measuring crankshaft end-play



- C. Pry the crankshaft toward the front of the engine and read the gauge.
 - D. Confirm that the reading is within the specified range.
 - E. If not, install a new thrust bearing and repeat the procedure.
 - F. If the measurement remains out of the specified range after installing a new thrust bearing, inspect the thrust surfaces of the crankshaft, and if possible, repair it.
14. Rotate the crankshaft to position the first rod journal (cylinder number one) to the bottom of its stroke

Pistons, Rings & Connecting Rods

Before installing the piston/connecting rod assembly, oil the pistons, piston rings and the cylinder walls with light engine oil.

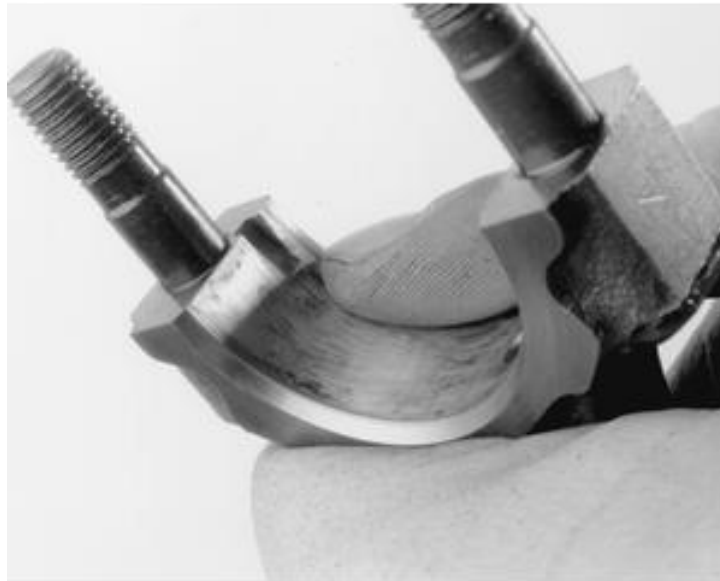
1. Install connecting rod bolt protectors or rubber hose onto the connecting rod bolts/studs.
 - Select the proper ring set for the size cylinder bore
 - Position the ring in the bore in which it is going to be used
 - Push the ring down into the bore area where normal ring wear is not encountered
 - Use the head of the piston to position the ring in the bore so that the ring is square with the cylinder wall. Use caution to avoid damage to the ring or cylinder bore
 - Measure the gap between the ends of the ring with a feeler gauge. Ring gap in a worn cylinder is normally greater than specification. If the ring gap is greater than the specified limits, use an oversize ring set.

Checking ring groove clearance



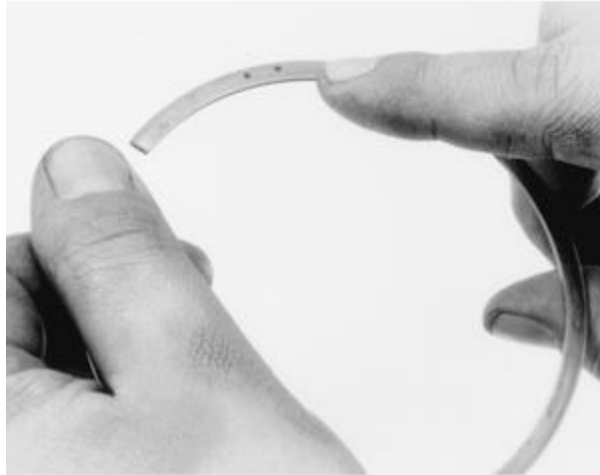
2. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land according to specification. The gauge should slide freely around the entire ring circumference without binding. Any wear that occurs will form a step at the inner portion of the lower land. If the lower lands have high steps, the piston should be replaced.

Bearing cap notch



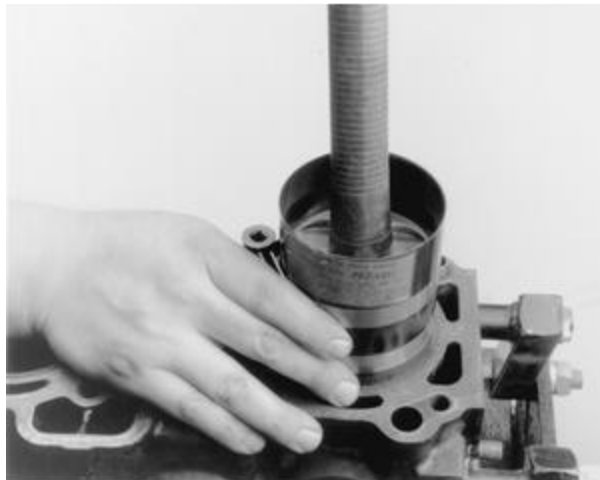
3. Unless new pistons are installed, be sure to install the pistons in the cylinders from which they were removed. The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from one engine or cylinder to another, new bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number. The notch on the piston head goes toward the front of the engine.
4. Install all rod bearing inserts into the rods and caps.

Ring top side marks



5. Install the rings on the pistons. Install the oil control ring first, then the second compression ring and finally the top compression ring. Use a piston ring expander tool to aid in installation and to help reduce the chance of breakage.

Piston and rod assembly installation



6. Make sure the ring gaps are properly spaced around the circumference of the piston. Fit a piston ring compressor around the piston and slide the piston and connecting rod assembly down into the cylinder bore, pushing it in with the wooden hammer handle. Push the piston down until it is only slightly below the top of the cylinder bore. Guide the connecting rod onto the crankshaft bearing journal carefully, to avoid damaging the crankshaft.
7. Check the bearing clearance of all the rod bearings, fitting them to the crankshaft bearing journals. Follow the procedure in the crankshaft installation above using Plastigage®.
8. After the bearings have been fitted, apply a light coating of assembly oil to the journals and bearings.
9. Turn the crankshaft until the appropriate bearing journal is at the bottom of its stroke, then push the piston assembly all the way down until the connecting rod bearing seats on the crankshaft journal. Be careful not to allow the bearing cap screws to strike the crankshaft bearing journals.
10. After the piston and connecting rod assemblies have been installed, check the connecting rod side clearance on each crankshaft journal.
11. Prime and install the oil pump and the oil pump intake tube.
12. Install the assembled auxiliary/balance shaft(s).

OHV Engines

Camshaft, Lifters & Timing Assembly

1. Install the camshaft.
2. Install the timing gears/chain assembly.
3. Install the lifters/followers into their bores.

Cylinder Head(s)

1. Install the cylinder head(s) using new gaskets and torque to the specified amount.
2. Assemble the valve train (pushrods and rocker arms and/or shafts).

OHC Engines

Cylinder Head(s)

1. Install the cylinder head(s) using new gaskets and torque to the specified amount.
2. Install the timing sprockets/gears and the belt/chain assemblies.

Engine Covers & Components

Install the timing cover(s) and oil pan. Install any components that were removed from the engine after it was lifted from the engine compartment.

Engine Start-Up & Break-In

Starting the Engine

1. Fill the crankcase with the proper quantity and grade of engine oil.
2. Fill the cooling system with a 50/50 mixture of coolant/water.
3. Connect the vehicle battery.
4. Disable the ignition and crank the engine to develop oil pressure. Check the oil pressure indicator; if oil pressure is not developed within 10 seconds STOP the engine.

CAUTION

Damage to the engine can result if it is allowed to run with no oil pressure. Check the engine oil level to make sure that it is full. Check for any leaks and if found, repair the leaks before continuing. If there is still no indication of oil pressure, prime the system.

5. Confirm that there are no fluid leaks.
6. Start the engine and maintain an idle of 2500 RPM for a period of 20 minutes to properly break-in the cam and lifters.
7. Allow the engine to reach normal operating temperature.
8. Install any remaining components or body panels that were removed.

DRIVABILITY & EMISSIONS CONTROLS

Precautions

Before servicing any vehicle, please be sure to read all of the following precautions, which deal with personal safety, prevention of component damage and important points to take into consideration when servicing a motor vehicle:

- Always wear safety goggles or some type of eye/face protection when working with, around or under a vehicle.
- Be extremely careful while working on an operating engine, make sure you have no dangling jewelry, extremely loose clothes, power tool cords or other items that could get caught in any moving engine part.
- Never open, service or drain the radiator or cooling system when the engine is hot; serious burns can occur from the steam and hot coolant.
- Observe all applicable safety precautions when working around fuel. Whenever servicing the fuel system, always work in a well-ventilated area. Do not allow fuel spray or vapors to come in contact with a spark, open flame, or excessive heat (a hot drop light, for example). Keep a dry chemical fire extinguisher near the work area. Always keep fuel in a container specifically designed for fuel storage; also, always properly seal fuel containers to avoid the possibility of fire or explosion. Refer to the additional fuel system precautions later in this section.
- Fuel injection systems often remain pressurized, even after the engine has been turned OFF. The fuel system pressure must be relieved before disconnecting any fuel lines. Failure to do so may result in fire and/or personal injury.
- The EPA warns that prolonged contact with used engine oil may cause a number of skin disorders, including cancer! You should make every effort to minimize your exposure to used engine oil. Protective gloves should be worn when changing oil. Wash your hands and any other exposed skin areas as soon as possible after exposure to used engine oil. Soap and water, or waterless hand cleaner should be used.
- Never operate the engine without the proper amount and type of engine oil; doing so WILL result in severe engine damage.
- Brake fluid often contains polyglycol ethers and polyglycols. Avoid contact with the eyes and wash your hands thoroughly after handling brake fluid. If you do get brake fluid in your eyes, flush your eyes with clean, running water for 15 minutes. If eye irritation persists, or if you have taken brake fluid internally, IMMEDIATELY seek medical assistance.
- Timing belt maintenance is extremely important! Many models utilize an interference-type, non-freewheeling engine. If the timing belt breaks, the valves in the cylinder head may strike the pistons, causing potentially serious (also time-consuming and expensive) engine damage. Refer to the maintenance interval charts in the front of this manual for the recommended replacement interval for the timing belt and to the timing belt section for belt replacement and inspection.
- Disconnecting the negative battery cable on some vehicles may interfere with the functions of the on-board computer system(s) and may require the computer to undergo a relearning process once the negative battery cable is reconnected.

CAUTION

Many electronic components are considered to be "static sensitive". This means that their electronic components are vulnerable to damage from the natural static electricity that builds up on people and other objects if not properly discharged.

In the event of static damage, components might fail immediately or might continue to operate, but suffer unexpected failure later. To eliminate the problem you and the work place where you handle static sensitive components must be designed to discharge any static electricity that might build up and do so in a safe manner. "Safe" means safe to you and the component/device being handled. Static electricity arises when non-conducting materials move (rub) over each other. Electronic components can be damaged at very low voltages, starting from as low as five volts. Static electricity is generated every time you move, but the principal causes are walking on a man made surface (nylon carpet), movement in your chair (clothes against the fabric of the seat) and movement between your clothes and yourself. As a rule man made materials (nylon, polyester) are more vulnerable than natural materials such as leather and cotton. Voltages of hundreds to low thousands are common. The "snap" of a static discharge that you can hear on a dry day occurs at voltages far in excess of those at which damage might occur in electronic devices. Thus you will not be aware if you are carrying dangerous levels of static, you must assume that you are. To protect an electronic device, you, your tools, your work bench and the electronic device must be at the same potential. Practically speaking that potential value is ground.

In order to discharge any static electricity that might build up, you need to discharge it to ground. For the most technicians, the best way to achieve this is by wearing an appropriate wrist strap. The wrist strap will have a wire to ground to discharge any body potential. The ground wire MUST contain a series resistor of at least 1 million ohms, (10M is a good value) this will avoid an accidental induction of current into the wrist band if the ground lead comes in contact with live current.

Cleanliness and Care, Shop Practice

- It should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

Emissions Controls System Overview

General Information

The first emissions controls implemented in the mid 1960s consisted of engine modifications and add on pollution control devices. These pollution control systems moderately lowered emissions, but they also caused a reduction in engine performance and increased fuel consumption.

In 1972 the federal government initiated a standardized test procedure for measuring vehicle compliance with federal emissions standards. This test incorporates a chassis dynamometer to provide a consistent and accurate way to measure the amount of HC, NO_x, CO, and CO₂ that a vehicle produces. This Federal Test Procedure (FTP) applies to both Light-Duty Vehicles (LDV) and Light-Duty Trucks (LDT). Over the years it has been tailored to the support the amended federal emissions requirements.

The FTP is designed to simulate typical driving conditions in urban areas. This FTP certification is a requirement of all pre-production vehicles that are to be sold in the U.S. Being compliant includes being able to pass the FTP throughout the vehicle's useful life. Because of this, the FTP is also used on in-use vehicles.

In 1975, catalytic converters were introduced to help lower the emissions of HC and CO. Catalytic converter efficiency of this era was poor and required cumbersome air management systems. By cleaning-up the exhaust (post-combustion) instead of reducing engine emissions (pre-combustion), auto manufacturers were able to address the Federal Government's concerns regarding pollution contributed by automobiles, however this did nothing for fuel efficiency.

The Federal Government's emissions standards combined with the price and availability of fuel at the time created a demand for the auto manufacturers to produce vehicles that were more fuel efficient and had lower emissions. At the time, the easiest way to reduce both fuel consumption and vehicle emissions was to lower the engine displacement and lean the air/fuel ratio out. Though emissions were lowered, the smaller, leaner engines created additional hurdles including a lack of performance.

One hurdle caused by the smaller engines pulling heavy vehicle weights was compounded by the leaner air fuel mixtures, which resulted in increased cylinder temperatures. These increased cylinder temperatures caused a dramatic rise in the production of oxides of nitrogen (NO_x).

The air that enters the combustion chamber consists of approximately 20.8 percent oxygen, 78 percent nitrogen and 1.2 percent mixed gases. As the air/fuel mixture enters the combustion chamber and ignition occurs, the nitrogen forms various compounds with the oxygen. These compounds have varying amounts of oxygen and are known as NO_x - oxides of nitrogen.

Oxides of nitrogen are present during all phases of combustion; however, they are developed in high quantities when combustion chamber temperatures reach 2500° F.

Emission Control Systems

In order to help reduce emissions and improve fuel economy in the 1980s, manufacturers started equipping vehicles with three-way catalysts and electronic fuel metering systems. By 1988, the California Air Resources Board (CARB) began regulation of the OBD systems sold in California. These OBD systems were designed to monitor fuel, ignition, and emissions system components to determine if they were operating correctly. When a system was found to be operating out of specification, a fault code was stored in the Engine Control Module (ECM). In some cases, a "check engine light" would illuminate. Technicians could connect to the ECM through a Data Link Connector (DLC) and download fault codes.

The new emission control systems were a significant departure from traditional engine systems. Instead of using mechanical systems to control key engine components, such as the carburetor and ignition system, these components are controlled by the on-board computer known as the ECM. Control of emissions is now geared toward the precise tuning of combustion for each set of operating conditions as determined by the input from specific sensors. This minimizes engine emissions while improving performance.

Three-way catalysts are effective in simultaneously reducing emissions of HC, CO and NO_x . Proper operation of a three-way catalyst requires precise control of the fuel metering system. If there's too much air, the converter will not reduce NO_x emissions. If there's too much fuel, the converter will not reduce HC and CO emissions.

To achieve this precise control, electronic fuel metering systems began incorporating oxygen sensors in the exhaust to provide feedback to the ECM on whether the air/fuel mixture was rich (too much fuel) or lean (too much air). When these electronic fuel metering systems read the input from the oxygen sensor, they are said to be running in "closed loop". "Open loop" describes the mode of operation when these electronic fuel metering systems disregard the oxygen sensor signal.

A closed loop fuel control system precisely controls the air/fuel mixture. The vehicle's ECM maintains the air/fuel mixture at the optimum conditions for minimizing emissions, while maximizing performance.

The fuel system and catalytic converter must have the proper balance of air and fuel in order to maintain low emissions. The stoichiometric 14.7:1 air/fuel ratio is the proper reference point in which catalyst efficiency is greatest in uniformly reducing all emissions. The carbon monoxide emissions will be lower at a fuel mixture leaner than 14.7:1, but a sacrifice is made with an increase in hydrocarbons and oxides of nitrogen.

The fuel program that the engine uses is based on an air/fuel ratio of 14.7:1 for optimum catalyst efficiency. This balance is difficult to maintain under normal circumstances because of the changing variables such as RPM and engine load. To overcome the difficulties of maintaining balance, the fuel management system forces the system rich for approximately 300 milliseconds and then forces the system lean for the same amount of time. If the system stayed rich longer than it stayed lean, the system is correcting for a lean condition and is still considered to be in "closed loop" fuel control. The carbureted fuel control systems of this era were only capable of making approximately 10 changes in a second.

The Clean Air Act Amendments of 1990 recognized the fact that vehicles with malfunctioning emissions control systems could go undetected for extended periods. Annual emissions inspection programs were not enough. The EPA required vehicle manufacturers to produce vehicle OBD systems capable of immediately identifying the vehicle operator of emissions faults, effective from 1996. As part of the OBD II system, all emissions-related components would be monitored for malfunction or deterioration.

On today's new vehicles, HC and CO emissions are reduced by more than 95% when compared to a 1960's vintage vehicle; NO_x emissions are reduced by 90%.

The exhaust emissions of automotive engines contain a number of harmful pollutants. In order to minimize the amount of harmful pollutants being produced, manufacturers have developed automotive emissions controls. The following is a list of the harmful exhaust gases manufacturers plan to reduce, which includes how the gases are formed and why they are dangerous.

Carbon Monoxide (CO)

Consists of carbon & oxygen. This colorless, odorless, poisonous gas is the product of incomplete combustion. By weight, carbon monoxide accounts for the 47% of air pollution.

Hydrocarbon (HC)

Hydrocarbons consist of carbon and hydrogen. Hydrocarbons are emitted in an unburned form from equipment which uses a petroleum product as a source of fuel. Hydrocarbons are one of the key elements responsible for the production of photochemical smog.

Oxides of Nitrogen (NO_x)

Oxides of nitrogen consist of nitrogen combined with varying amounts of oxygen. NO_x are produced by heat and pressure during the combustion process. NO_x are also a main component in smog.

Photochemical Smog

Photochemical smog, commonly referred to simply as smog, is a by-product of the combination of HC and NO_x. In the presence of sunlight these two elements form ozone (O₃), nitrogen dioxide, and nitrogen nitrate; all of which cause respiratory problems. Nitrogen dioxide is a light brown colored gas which can affect visibility in the air corridors around major airport terminals and above highways.

Particulates

Particulates are tiny particles of liquids and solids which are dispersed into the atmosphere during any burning process. Particulates are composed of carbon, ash, oil, grease, and metal oxides. Smoke, haze, and dust are types of air pollution which are readily visible and are known to complicate respiratory problems caused by smog.

Sulfur Oxides (SO_x)

Sulfur oxides consist of various amounts of oxygen and sulfur. Sulfur oxides result from the burning of lower grades of fossil fuels, such as coal or oil.

Air Pollution

The earth's atmosphere, at or near sea level, consists approximately of 78 percent nitrogen, 21 percent oxygen and 1 percent other gases. If it were possible to remain in this state, 100 percent clean air would result. However, many varied sources allow other gases and particulates to mix with the clean air, causing our atmosphere to become unclean or polluted.

Some of these pollutants are visible while others are invisible, with each having the capability of causing distress to the eyes, ears, throat, skin and respiratory system. Should these pollutants become concentrated in a specific area and under certain conditions, death could result due to the displacement or chemical change of the oxygen content in the air. These pollutants can also cause great damage to the environment and to the many man made objects that are exposed to the elements.

To better understand the causes of air pollution, the pollutants can be categorized into 3 separate types, natural, industrial and automotive.

Natural Pollutants

Natural pollution has been present on earth since before man appeared and continues to be a factor when discussing air pollution, although it causes only a small percentage of the overall pollution problem. It is the direct result of decaying organic matter, wind born smoke and particulates from such natural events as plain and forest fires (ignited by heat or lightning), volcanic ash, sand and dust which can spread over a large area of the countryside.

Such a phenomenon of natural pollution has been seen in the form of volcanic eruptions, with the resulting plume of smoke, steam and volcanic ash blotting out the sun's rays as it spreads and rises higher into the atmosphere. As it travels into the atmosphere the upper air currents catch and carry the smoke and ash, while condensing the steam back into water vapor. As the water vapor, smoke and ash travel on their journey, the smoke dissipates into the atmosphere while the ash and moisture settle back to earth in a trail hundreds of miles long. In some cases, lives are lost and millions of dollars of property damage result.

Industrial Pollutants

Industrial pollution is caused primarily by industrial processes, the burning of coal, oil and natural gas, which in turn produce smoke and fumes. Because the burning fuels contain large amounts of sulfur, the principal ingredients of smoke and fumes are sulfur dioxide and particulate matter. This type of pollutant occurs most severely during still, damp and cool weather, such as at night. Even in its less severe form, this pollutant is not confined to just cities. Because of air movements, the pollutants move for miles over the surrounding countryside, leaving in its path a barren and unhealthy environment for all living things.

Working with Federal, State and Local mandated regulations and by carefully monitoring emissions, big business has greatly reduced the amount of pollutant introduced from its industrial sources, striving to obtain an acceptable level. Because of the mandated industrial emission clean up, many land areas and streams in and around the cities that were formerly barren of vegetation and life, have now begun to move back in the direction of nature's intended balance.

Automotive Pollutants

The third major source of air pollution is automotive emissions. The emissions from the internal combustion engines were not an appreciable problem years ago because of the small number of registered vehicles and the nation's small highway system. However, during the early 1950's, the trend of the American people was to move from the cities to the surrounding suburbs. This caused an immediate problem in transportation because the majority of suburbs were not afforded mass transit conveniences. This lack of transportation created an attractive market for the automobile manufacturers, which resulted in a dramatic increase in the number of vehicles produced and sold, along with a marked increase in highway construction between cities and the suburbs. Multi-vehicle families emerged with a growing emphasis placed on an individual vehicle per family member. As the increase in vehicle ownership and usage occurred, so did pollutant levels in and around the cities, as suburbanites drove daily to their businesses and employment, returning at the end of the day to their homes in the suburbs.

It was noted that a smoke and fog type haze was being formed and at times, remained in suspension over the cities, taking time to dissipate. At first this "smog," derived from the words "smoke" and "fog," was thought to result from industrial pollution but it was determined that automobile emissions shared the blame. It was discovered that when normal automobile emissions were exposed to sunlight for a period of time, complex chemical reactions would take place.

It is now known that smog is a photo chemical layer which develops when certain oxides of nitrogen (NO_x) and unburned hydrocarbons (HC) from automobile emissions are exposed to sunlight. Pollution was more severe when smog would become stagnant over an area in which a warm layer of air settled over the top of the cooler air mass, trapping and holding the cooler mass at ground level. The trapped cooler air would keep the emissions from being dispersed and diluted through normal air flows. This type of air stagnation was given the name "Temperature Inversion."

Temperature Inversion

In normal weather situations, surface air is warmed by heat radiating from the earth's surface and the sun's rays. This causes it to rise upward, into the atmosphere. Upon rising it will cool through a convection type heat exchange with the cooler upper air. As warm air rises, the surface pollutants are carried upward and dissipated into the atmosphere.

When a temperature inversion occurs, we find the higher air is no longer cooler, but is warmer than the surface air, causing the cooler surface air to become trapped. This warm air blanket can extend from above ground level to a few hundred or even a few thousand feet into the air. As the surface air is trapped, so are the pollutants, causing a severe smog condition. Should this stagnant air mass extend to a few thousand feet high, enough air

movement with the inversion takes place to allow the smog layer to rise above ground level but the pollutants still cannot dissipate. This inversion can remain for days over an area, with the smog level only rising or lowering from ground level to a few hundred feet high. Meanwhile, the pollutant levels increase, causing eye irritation, respiratory problems, reduced visibility, plant damage and in some cases, even disease.

This inversion phenomenon was first noted in the Los Angeles, California area. The city lies in terrain resembling a basin and with certain weather conditions, a cold air mass is held in the basin while a warmer air mass covers it like a lid.

Because this type of condition was first documented as prevalent in the Los Angeles area, this type of trapped pollution was named Los Angeles Smog, although it occurs in other areas where a large concentration of automobiles are used and the air remains stagnant for any length of time.

Heat Transfer

Consider the internal combustion engine as a machine in which raw materials must be placed so a finished product comes out. As in any machine operation, a certain amount of wasted material is formed. When we relate this to the internal combustion engine, we find that through the input of air and fuel, we obtain power during the combustion process to drive the vehicle. The by-product or waste of this power is, in part, heat and exhaust gases with which we must dispose.

The heat from the combustion process can rise to over 4000°F (2204°C). The dissipation of this heat is controlled by a ram air effect, the use of cooling fans to cause air flow and a liquid coolant solution surrounding the combustion area to transfer the heat of combustion through the cylinder walls and into the coolant. The coolant is then directed to a thin-finned, multi-tube radiator, from which the excess heat is transferred to the atmosphere by 1 of the 3 heat transfer methods, conduction, convection or radiation.

The cooling of the combustion area is an important part in the control of exhaust emissions. To understand the behavior of the combustion and transfer of its heat, consider the air/fuel charge. It is ignited and the flame front burns progressively across the combustion chamber until the burning charge reaches the cylinder walls. Some of the fuel in contact with the walls is not hot enough to burn, thereby snuffing out or quenching the combustion process. This leaves unburned fuel in the combustion chamber. This unburned fuel is then forced out of the cylinder and into the exhaust system, along with the exhaust gases.

Many attempts have been made to minimize the amount of unburned fuel in the combustion chambers due to quenching, by increasing the coolant temperature and lessening the contact area of the coolant around the combustion area. However, design limitations within the combustion chambers prevent the complete burning of the air/fuel charge, so a certain amount of the unburned fuel is still expelled into the exhaust system, regardless of modifications to the engine.

Automotive Emissions

Before emission controls were mandated on internal combustion engines, other sources of engine pollutants were discovered along with the exhaust emissions. It was determined that engine combustion exhaust produced approximately 60 percent of the total emission pollutants, fuel evaporation from the fuel tank produced 20 percent, with the final 20 percent being produced through the crankcase as a by-product of the combustion process.

Exhaust Gases

The exhaust gases emitted into the atmosphere are a combination of burned and unburned fuel. To understand the exhaust emission and its composition, we must review some basic chemistry.

When the air/fuel mixture is introduced into the engine, we are mixing air, composed of nitrogen (78 percent), oxygen (21 percent) and other gases (1 percent) with the fuel, which is 100 percent hydrocarbons (HC), in a semi-controlled ratio. As the combustion process is accomplished, power is produced to move the vehicle while the heat of combustion is transferred to the cooling system. The exhaust gases are then composed of nitrogen, a diatomic gas (N_2), the same as was introduced in the engine, carbon dioxide (CO_2), the same gas that is used in beverage carbonation, and water vapor (H_2O). The nitrogen (N_2), for the most part, passes through the engine unchanged, while the oxygen (O_2) reacts (burns) with the hydrocarbons (HC) and produces the carbon dioxide (CO_2) and the water vapors (H_2O). If this chemical process would be the only process to take place, the exhaust emissions would be harmless. However, during the combustion process, other compounds are formed which are considered dangerous. These pollutants are hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x) oxides of sulfur (SO_x) and engine particulates.

Hydrocarbons

Hydrocarbons (HC) are essentially fuel which was not burned during the combustion process or which has escaped into the atmosphere through fuel evaporation. The main sources of incomplete combustion are rich air/fuel mixtures, low engine temperatures and improper spark timing. The main sources of hydrocarbon emission through fuel evaporation on most vehicles used to be the vehicle's fuel tank and carburetor float bowl.

To reduce combustion hydrocarbon emission, engine modifications were made to minimize dead space and surface area in the combustion chamber. In addition, the air/fuel mixture was made leaner through the improved control which feedback carburetion and fuel injection offers and by the addition of external controls to aid in further combustion of the hydrocarbons outside the engine. Two such methods were the addition of air injection systems, to inject fresh air into the exhaust manifolds and the installation of catalytic converters, units that are able to burn traces of hydrocarbons without affecting the internal combustion process or fuel economy.

Carbon Monoxide

Carbon monoxide is formed when not enough oxygen is present during the combustion process to convert carbon (C) to carbon dioxide (CO₂). An increase in the carbon monoxide (CO) emission is normally accompanied by an increase in the hydrocarbon (HC) emission because of the lack of oxygen to completely burn all of the fuel mixture.

Carbon monoxide (CO) also increases the rate at which the photo chemical smog is formed by speeding up the conversion of nitric oxide (NO) to nitrogen dioxide (NO₂). To accomplish this, carbon monoxide (CO) combines with oxygen (O₂) and nitric oxide (NO) to produce carbon dioxide (CO₂) and nitrogen dioxide (NO₂). ($\text{CO} + \text{O}_2 + \text{NO} = \text{CO}_2 + \text{NO}_2$).

The dangers of carbon monoxide, which is an odorless and colorless toxic gas, are many. When carbon monoxide is inhaled into the lungs and passed into the blood stream, oxygen is replaced by the carbon monoxide in the red blood cells, causing a reduction in the amount of oxygen supplied to the many parts of the body. This lack of oxygen causes headaches, lack of coordination, reduced mental alertness and, should the carbon monoxide concentration be high enough, death could result.

Nitrogen

Normally, nitrogen is an inert gas. When heated to approximately 2500°F (1371°C) through the combustion process, this gas becomes active and causes an increase in the nitric oxide (NO) emission.

Oxides of nitrogen (NO_x) are composed of approximately 97-98 percent nitric oxide (NO). Nitric oxide is a colorless gas but when it is passed into the atmosphere, it combines with oxygen and forms nitrogen dioxide (NO₂). The nitrogen dioxide then combines with chemically active hydrocarbons (HC) and when in the presence of sunlight, causes the formation of photo-chemical smog.

Ozone

To further complicate matters, some of the nitrogen dioxide (NO₂) is broken apart by the sunlight to form nitric oxide and oxygen. ($\text{NO}_2 + \text{sunlight} = \text{NO} + \text{O}$). This single atom of oxygen then combines with diatomic (meaning 2 atoms) oxygen (O₂) to form ozone (O₃). Ozone is one of the smells associated with smog. It has a pungent and offensive odor, irritates the eyes and lung tissues, affects the growth of plant life and causes rapid deterioration of rubber products. Ozone can be formed by sunlight as well as electrical discharge into the air.

The most common discharge area on the automobile engine is the secondary ignition electrical system, especially when inferior quality spark plug cables are used. As the surge of high voltage is routed through the secondary cable, the circuit builds up an electrical field around the wire, which acts upon the oxygen in the surrounding air to form the ozone. The faint glow along the cable with the engine running that may be visible on a dark night is called the "corona discharge." It is the result of the electrical field passing from a high along the cable, to a low in the surrounding air, which forms the ozone gas. The combination of corona and ozone has been a major cause of cable deterioration.

Although ozone at ground level can be harmful, ozone is beneficial to the earth's inhabitants. By having a concentrated ozone layer called the "ozonosphere," between 10 and 20 miles (16 - 32 km) up in the atmosphere, much of the ultra violet radiation from the sun's rays are absorbed and screened. If this ozone layer were not present, much of the earth's surface would be burned, dried and unfit for human life.

Oxides of Sulfur

Oxides of sulfur (SO_x) were initially ignored in the exhaust system emissions, since the sulfur content of gasoline as a fuel is less than 1/10 of 1 percent. Because of this small amount, it was felt that it contributed very little to the overall pollution problem. However, because of the difficulty in solving the sulfur emissions in industrial pollution and the introduction of catalytic converters to automobile exhaust systems, a change was mandated. The automobile exhaust system, when equipped with a catalytic converter, changes the sulfur dioxide (SO_2) into sulfur trioxide (SO_3).

When this combines with water vapors (H_2O), a sulfuric acid mist (H_2SO_4) is formed and is a very difficult pollutant to handle since it is extremely corrosive. This sulfuric acid mist that is formed, is the same mist that rises from the vents of an automobile battery when an active chemical reaction takes place within the battery cells.

When a large concentration of vehicles equipped with catalytic converters are operating in an area, this acid mist may rise and be distributed over a large ground area causing land, plant, crop, paint, and building damage.

Particulate Matter

A certain amount of particulate matter is present in the burning of any fuel, with carbon constituting the largest percentage of the particulates. In gasoline, the remaining particulates are the burned remains of the various other compounds used in its manufacture. When a gasoline engine is in good internal condition, the particulate emissions are low but as the engine wear internally, the particulate emissions increase. By visually inspecting the tail pipe emissions, a determination can be made as to where an engine defect may exist. An engine with light gray or blue smoke emitting from the tail pipe normally indicates an increase in the oil consumption through burning due to internal engine wear. Black smoke would indicate a defective fuel delivery system, causing the engine to operate in a rich mode. Regardless of the color of the smoke, the internal part of the engine or the fuel delivery system should be repaired to prevent excess particulate emissions.

Diesel and turbine engines emit a darkened plume of smoke from the exhaust system because of the type of fuel used. Emission control regulations are mandated for this type of emission and more stringent measures are being used to prevent excess emission of the particulate matter. Electronic components are being introduced to control the injection of the fuel at precisely the proper time of piston travel, to achieve the optimum in fuel ignition and fuel usage. Other particulate after-burning components are being tested to achieve a cleaner emission.

Good grades of engine lubricating oils should be used, which meet the manufacturer's specification. Cut-rate oils can contribute to the particulate emission problem because of

their low flash or ignition temperature point. Such oils burn prematurely during the combustion process causing emission of particulate matter.

The cooling system is an important factor in the reduction of particulate matter. The optimum combustion will occur, with the cooling system operating at a temperature specified by the manufacturer. The cooling system must be maintained in the same manner as the engine oiling system, as each system is required to perform properly in order for the engine to operate efficiently for a long time.

Crankcase Emissions

Crankcase emissions are made up of water, acids, unburned fuel, oil fumes and particulates. These emissions are classified as hydrocarbons (HC) and are formed by the small amount of unburned, compressed air/fuel mixture entering the crankcase from the combustion area (between the cylinder walls and piston rings) during the compression and power strokes. The head of the compression and combustion help to form the remaining crankcase emissions.

Since the first engines, crankcase emissions were allowed into the atmosphere through a road draft tube, mounted on the lower side of the engine block. Fresh air came in through an open oil filler cap or breather. The air passed through the crankcase mixing with blow-by gases. The motion of the vehicle and the air blowing past the open end of the road draft tube caused a low pressure area (vacuum) at the end of the tube. Crankcase emissions were simply drawn out of the road draft tube into the air.

To control the crankcase emission, the road draft tube was deleted. A hose and/or tubing was routed from the crankcase to the intake manifold so the blow-by emission could be burned with the air/fuel mixture. However, it was found that intake manifold vacuum, used to draw the crankcase emissions into the manifold, would vary in strength at the wrong time and not allow the proper emission flow. A regulating valve was needed to control the flow of air through the crankcase.

Testing, showed the removal of the blow-by gases from the crankcase as quickly as possible, was most important to the longevity of the engine. Should large accumulations of blow-by gases remain and condense, dilution of the engine oil would occur to form water, soot, resins, acids and lead salts, resulting in the formation of sludge and varnishes. This condensation of the blow-by gases occurs more frequently on vehicles used in numerous starting and stopping conditions, excessive idling and when the engine is not allowed to attain normal operating temperature through short runs.

Evaporative Emissions

Gasoline fuel is a major source of pollution, before and after it is burned in the automobile engine. From the time the fuel is refined, stored, pumped and transported, again stored until it is pumped into the fuel tank of the vehicle, the gasoline gives off unburned hydrocarbons (HC) into the atmosphere. Through the redesign of storage areas and venting systems, the pollution factor was diminished, but not eliminated, from the refinery standpoint. However, the automobile still remained the primary source of vaporized, unburned hydrocarbon (HC) emissions.

Fuel pumped from an underground storage tank is cool but when exposed to a warmer ambient temperature, will expand. Before controls were mandated, an owner might fill the fuel tank with fuel from an underground storage tank and park the vehicle for some time in warm area, such as a parking lot. As the fuel would warm, it would expand and should no provisions or area be provided for the expansion, the fuel would spill out of the filler neck and onto the ground, causing hydrocarbon (HC) pollution and creating a severe fire hazard. To correct this condition, the vehicle manufacturers added overflow plumbing and/or gasoline tanks with built in expansion areas or domes.

However, this did not control the fuel vapor emission from the fuel tank. It was determined that most of the fuel evaporation occurs when the vehicle is stationary and the engine is off. Most vehicles carry 5-25 gallons (19-95 liters) of gasoline. Should a large concentration of vehicles be parked in one area, such as a large parking lot, excessive fuel vapor emissions would take place, increasing as the temperature increases.

To prevent the vapor emission from escaping into the atmosphere, the fuel systems were designed to trap the vapors while the vehicle is stationary, by sealing the system from the atmosphere. A storage system is used to collect and hold the fuel vapors from the fuel tank when the engine is not operating. When the engine is started, the storage system is then purged of the fuel vapors, which are drawn into the engine and burned with the air/fuel mixture.

Electronic Engine Controls

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

General Information

The Engine Management System (EMS) uses several different sensors and actuators to gather and control various emissions and driveability aspects of the vehicle. These may include but are not limited to:

- **MAP** – Manifold Absolute Pressure Sensor
- **FTP** – Fuel Tank Pressure Sensor
- **ECT** – Engine Coolant Temperature Sensor
- **A/F** – Air Fuel Ratio Sensor
- **APP** – Accelerator Pedal Position Sensor
- **CKP** – Crankshaft Position Sensor
- **CMP** – Camshaft Position Sensor
- **HO2S** – Heated Oxygen Sensor
- **IAT** – Intake Air Temperature Sensor
- **KS** – Knock Sensor
- **MAF** – Mass Air Flow Sensor
- **TP** – Throttle Position Sensor
- **VSS** – Vehicle Speed Sensor

These sensors provide critical information to the EMS such as, barometric pressure, atmospheric pressure, intake manifold/engine vacuum, fuel tank pressures and changes as the vehicle is operated.

MAP Sensor

The EMS uses the MAP sensor on systems that have a Mass Airflow Sensor (MAF) as a backup. The EMS also uses the MAP sensor as an EGR diagnostic device and as an engine load verification device. The EMS system uses this information to calculate engine load and EGR flow rates. The EMS uses speed-density calculations (non-mass airflow sensor systems) to determine the required amount of fuel delivery.

FTP Sensor

The Fuel Tank Pressure (FTP) sensor is part of the evaporative emissions system. The engine control system monitors gasoline vapor pressures in the fuel tank to determine fuel tank sealing. The FTP sensor can be used in conjunction with an EVAP vent valve and an EVAP canister purge valve.

Canister Purge Valve Only Vehicles

When ambient temperatures are above 68° Fahrenheit the gasoline in the fuel tank vaporizes increasing fuel tank pressure. The FTP sensor is used to determine how much

evaporative pressure is being maintained in fuel tank. This is a test for gross evaporative emissions leaks.

Vehicles with Canister Purge and Vent Valves

Some vehicles will route a small amount of engine vacuum through the canister purge valve to the fuel tank. When both the canister purge valve and vent solenoid valve are closed the vacuum is trapped between the fuel tank and canister purge valve. The fuel tank pressure sensor signals the EMS that the vacuum is present. The vacuum in the system should reach a certain level and remain for a pre-determined amount of time. This is used to test for minute system pressure leaks.

ECT Sensor

The engine coolant temperature (ECT) sensor is a variable resistor that measures the temperature of the engine coolant. When the engine coolant temperature is low, the sensor resistance is high. When the engine coolant temperature is high, the sensor resistance is low. The Engine Coolant Temperature Sensor (ECT) input to the PCM is a primary input for calculation strategies, fuel delivery control and spark timing. The ECT is also used to determine loop status timer requirements (inside of PCM) and to support cooling fan operation. ECT failures can cause excessive rich conditions, increased injector pulse-width and retarded spark timing.

A/F Sensor

The air fuel ratio (A/F) sensor like the oxygen sensor is used by the powertrain control module to measure the amount of oxygen in the exhaust. The PCM uses this data to control the air fuel mixture in the engine. The (A/F) sensor can meter fuel more accurately than an oxygen sensor. The A/F sensor changes current output by measuring the amount of oxygen in the exhaust. The A/F sensor operates at a much higher temperature than an oxygen sensor. The PCM measures the amount of current that is output by the A/F sensor and converts this current flow data to a voltage signal. When the mixture is lean and the oxygen content is high the voltage signal will be above 3.3V. When the mixture is rich and the oxygen content is low the voltage signal will be below 3.3V. When the mixture is at 14.7 to 1 the voltage signal will be at 3.3V. The heater circuit in the A/F sensor shortens the time required for the sensor to reach operating temperature and provides a more accurate signal.

APP Sensor

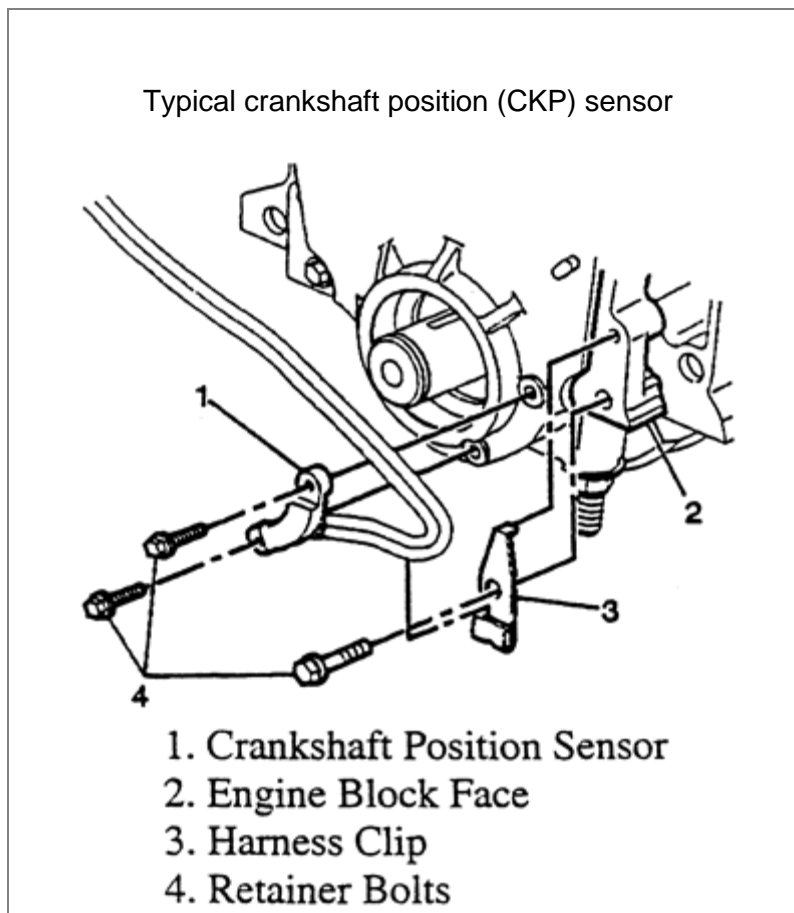
The Accelerator Pedal Position (APP) sensor contains 2 potentiometer sensors that convert the accelerator pedal position into two signals. Each sensor has three circuits a 5V reference, a signal and a low reference. The APP sensor provides the PCM with voltage signals proportional to the pedal movement. The voltage signal differs by 1 volt between the two sensors. When one APP sensor signal measures 0.5V the other TP sensor will measure 1.5V.

CKP Sensor

The crankshaft position (CKP) sensor generates a magnetic pulse signal when the engine is cranking or running. This signal is used by the powertrain control module (PCM) to detect the crankshaft position of each cylinder.

Engine speed is a very important input to the PCM. Crankshaft speed and position are the basis for many calculations made by the computer. Crankshaft position values are transmitted to the computer by pickup coils also known as Permanent Magnet (P/M) generators, Hall Effect sensors or optical sensors. The Crankshaft Position Sensor (CKP) also known as engine speed sensor is typically located in proximity to the crankshaft.

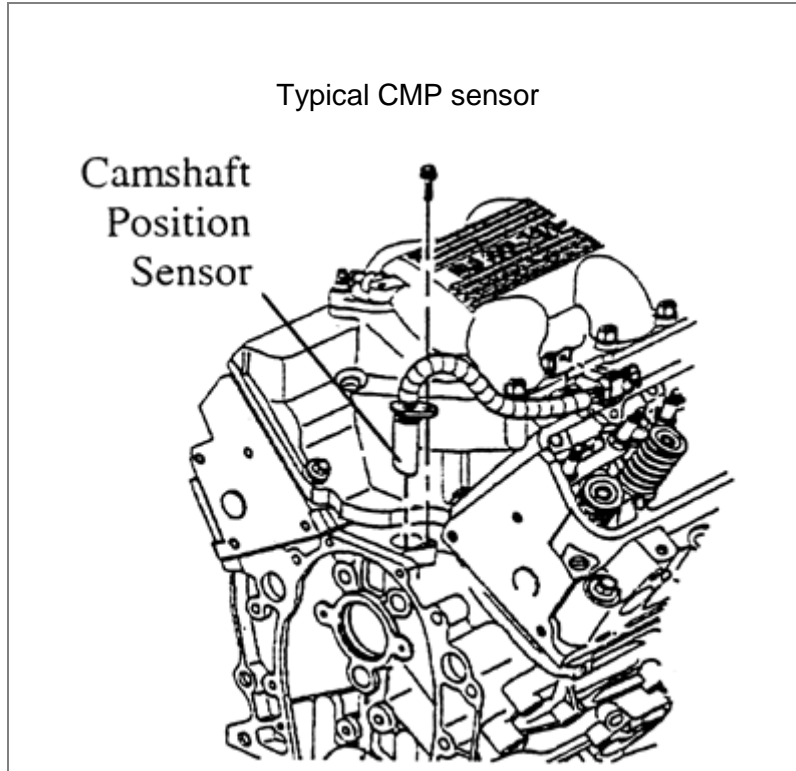
In addition, the PCM uses the CKP sensor in conjunction with the camshaft position sensor to calculate and perform misfire diagnostics.



CMP Sensor

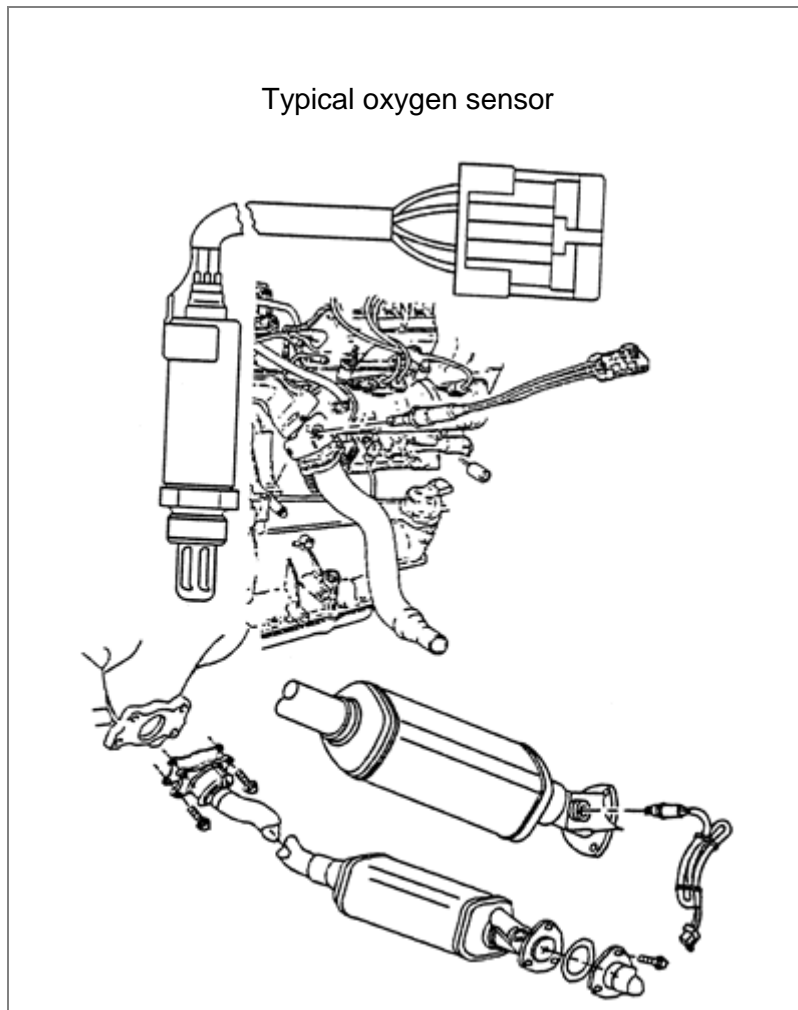
The Camshaft Position (CMP) sensor consists of a permanent magnet, yoke and coil. The CMP sensor is positioned next to the cam gear. As each cam gear tooth passes the sensor magnetic pick-up an AC voltage pulse is induced in the coil. The PCM counts the number of pulses to determine the camshaft speed. The number of pulses counted in one second is the signal frequency.

The Powertrain Control Module (PCM) uses the camshaft position sensor to manage sequential fuel injection and as part of misfire diagnosis. The PCM constantly monitors the number of pulses on the signal circuit. The PCM compares the number of camshaft sensor reference pulses and the number of crankshaft position sensor reference pulses received. If the PCM receives an incorrect number of pulses, Diagnostic Trouble Codes (DTCs) should be stored in the PCM. Some PCM systems will then default to multi-port or "gang-fire" injector operation. The camshaft position sensor signal is required to sequence the injector operation to the proper cylinder timing. If the camshaft position sensor or circuit is faulty, most engines will start. However, the PCM misfire diagnostic will likely be affected.



HO₂S

The heated oxygen sensor is used by the powertrain control module to measure the amount of oxygen in the exhaust. The PCM uses this data to control the air fuel mixture in the engine. The PCM sends a bias voltage of approximately 450 mV to the oxygen sensor. At operating temperature the oxygen sensor signal varies between 0 and 1,000 mV. When the mixture is rich the oxygen content is low and the voltage signal will remain on the high side of the 450 mV mid-range. When the mixture is lean the oxygen content is high and the voltage signal will remain on the low side below the 450 mV mid-range.



The oxygen sensors on later model vehicles are equipped with a heater circuit. The heater circuit in the oxygen sensor shortens the time required for the sensor to reach operating temperature and provides a more accurate signal.

IAT Sensor

The Intake Air Temperature (IAT) sensor is variable temperature sensitive resistor that measures the temperature of the air in the intake system. Sensor resistance will change based on air temperature. The higher the temperature is, the lower the resistance. The Power Train Control Module (PCM) provides a reference voltage and monitors the voltage drop between a fixed value internal resistance and the sensor resistance. This is called a voltage divider circuit.

IAT sensor values are used by the PCM processor to assist with the calculation of idle speed, fuel mixture and spark advance.

Inaccurate voltages from the IAT sensor may affect pulse-width, idle quality, and tail pipe emissions. Intermittent signals may cause hesitation, stumble and surging. If an IAT

sensor failure accompanies an Engine Coolant Temperature (ECT) sensor failure, cooling fan operation may also be affected.

Some manufacturers incorporate the Intake Air Temperature (IAT) sensor as part of the Mass Air Flow (MAF) sensor (Air Flow Meter).

Knock Sensor

The purpose of the Knock Sensor (KS) is to monitor pre-ignition or "engine knock" and send the signal to the PCM. The PCM responds by adjusting ignition timing until the knocking stops. The sensor works by generating a signal produced by the frequency of the knock as recorded by the piezoelectric ceramic disc inside the KS. The disc absorbs the shock waves from the knock vibration and exerts a pressure on the metal diaphragm inside the KS. This compresses the crystals inside the disc which generates a voltage signal proportional to the frequency of the knock vibration.

MAF Sensor

Mass Airflow (MAF) sensors measure the weight and rate of air moving through a passage of a known volume or size. Typically, MAF sensors utilize hot wire or thick film technology. Signals generated may be analog or digital depending on manufacturer. As more air passes through the MAF sensor, the voltage or frequency increases proportionally. The PCM uses this information to calculate injector pulse-width and spark advance. Performance issues from MAF sensor failures range from no-start conditions to stalling, hesitation, stumble and improper air/fuel mixtures. The MAF sensor values vary from 0.2V (0 gm/sec) to 4.8V (175 gm/sec).

Some manufacturers incorporate the Intake Air Temperature (IAT) sensor as part of the Mass Air Flow (MAF) sensor (Air Flow Meter).

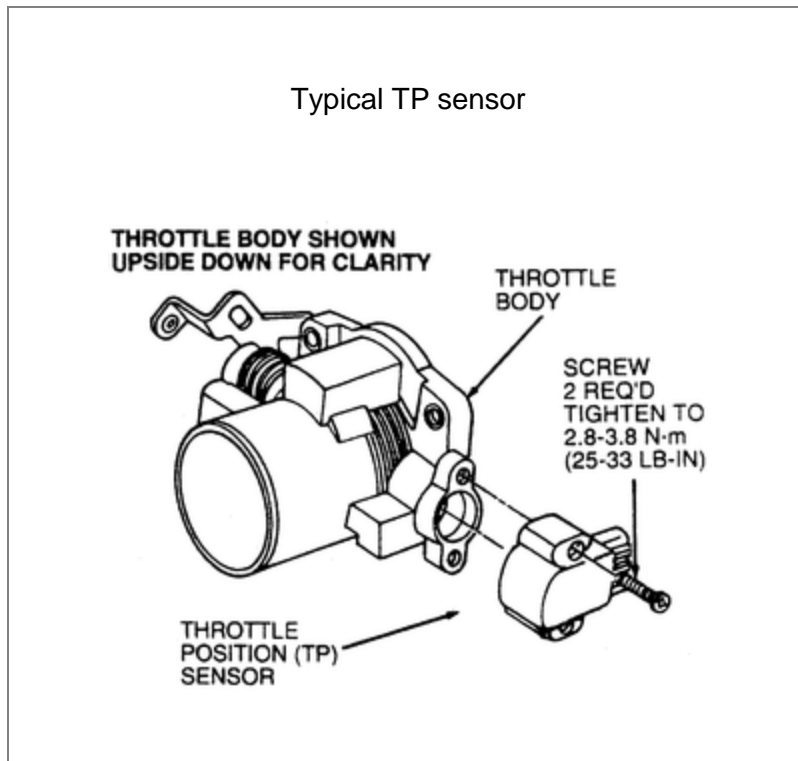
Some manufacturers incorporate a 6.0V to 9.0V circuit from the MAF sensor to the PCM to control the MAF sensor reset signal.

TP Sensor

The Throttle Position (TP) sensor and accelerator pedal position (APP) sensor are the only sensors sending data to the Powertrain Control Module (PCM) that the vehicle operator has direct control over. The TP sensor is a three wire potentiometer that provides an analog signal to the computer. This signal represents how far the throttle plates have opened.

The Powertrain Control Module calculates how much air should have entered the engine and compares this value with the Manifold Absolute Pressure (MAP) sensor or Mass Air Flow (MAF) sensor value. The PCM uses this information to calculate fuel delivery and ignition timing requirements.

The PCM on vehicles equipped with an electronic transmission utilize the TP sensor in combination with the MAP and MAF sensor values to determine shift schedules and torque converter clutch application.



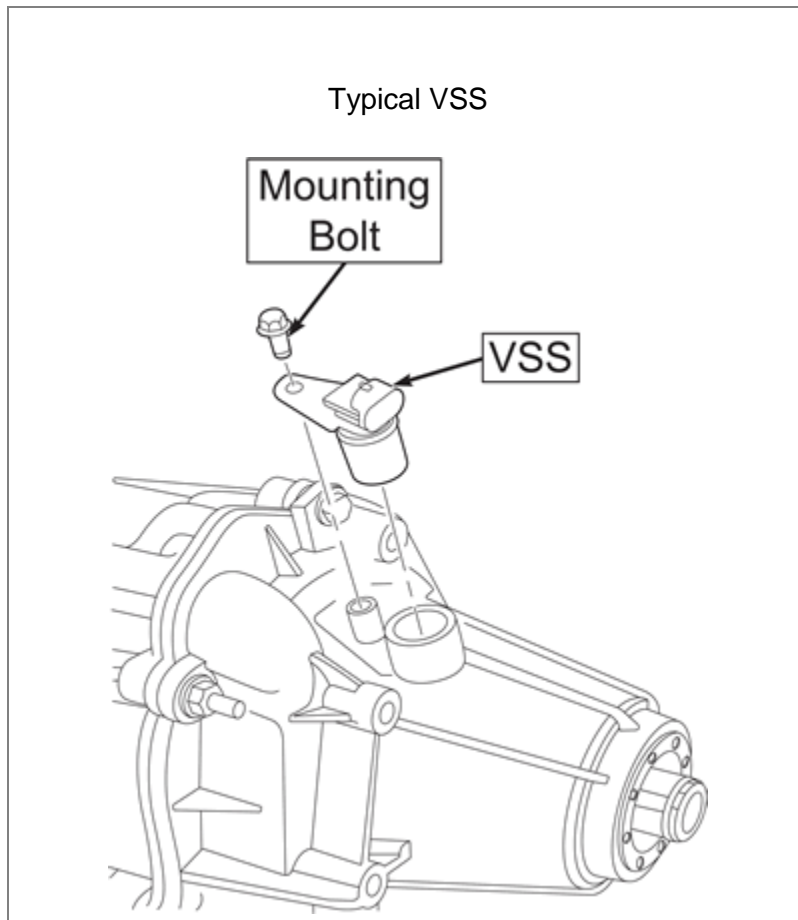
VSS Sensor

The Vehicle Speed (VSS) Sensor input is used by the PCM to determine vehicle speed. The VSS generates a signal that increases in frequency proportionate to vehicle speed. The PCM has a base frequency stored in memory for a distance of one mile. By comparing the input and stored value, the PCM calculates vehicle speed.

VSS types include: photo-optic, permanent magnet generators or hall effect technology. The PCM may use other sensors on the vehicle (ABS Wheel Speed) to validate VSS operation.

VSS information is used to calculate vehicle loads including: torque converter application, cruise control, fuel cutoff/speed governance strategies, instrument panel speedometer and more.

Modified drivetrain components such as final gear sets and/or tires can alter VSS input values to the PCM. Improper signals can alter Torque Converter Clutch (TCC) application, shift points, cruise control operation as well as many other systems relying on vehicle speed input.



WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

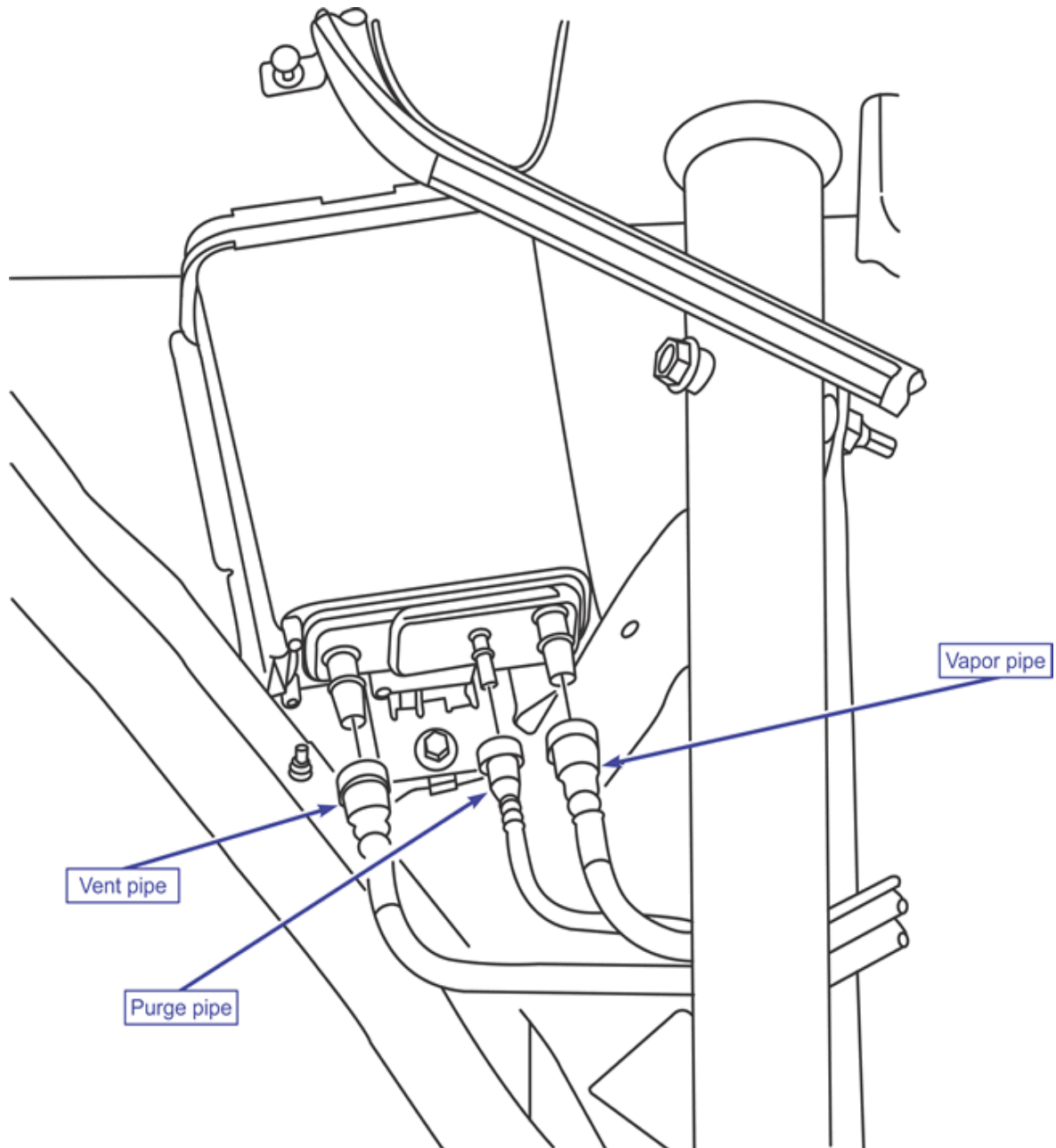
Evaporative Emission Canister

Removal & Installation

To Remove:

1. Remove the spare tire from the vehicle.
2. Lift the vehicle.
3. If equipped, remove the fuel tank shield from the frame.

Evaporative emission canister



4. Disconnect the evaporative emission (EVAP) vapor pipe, purge pipe, and vent pipe from the evaporative emission (EVAP) canister.
5. Detach the evaporative emission (EVAP) canister and mounting bracket assembly from the vehicle.
6. Detach the evaporative emission (EVAP) canister from the mounting bracket.
7. Remove the evaporative emission (EVAP) retaining bracket from the evaporative emission (EVAP) canister.

To Install:

1. Install the evaporative emission (EVAP) retaining bracket onto the evaporative emission (EVAP) canister.
2. Attach the evaporative emission (EVAP) canister to the mounting bracket. Torque the bolt to **15 ft-lb (20 Nm)**.
3. Attach the evaporative emission (EVAP) canister and mounting bracket assembly to the vehicle. Torque the bolt to **15 ft-lb (20 Nm)**.
4. Connect the evaporative emission (EVAP) vapor pipe, purge pipe, and vent pipe to the evaporative emission (EVAP) canister.
5. If equipped, install the fuel tank shield onto the frame.
6. Lower the vehicle.
7. Install the spare tire to the vehicle.

Evaporative Emission Canister Purge Solenoid Valve

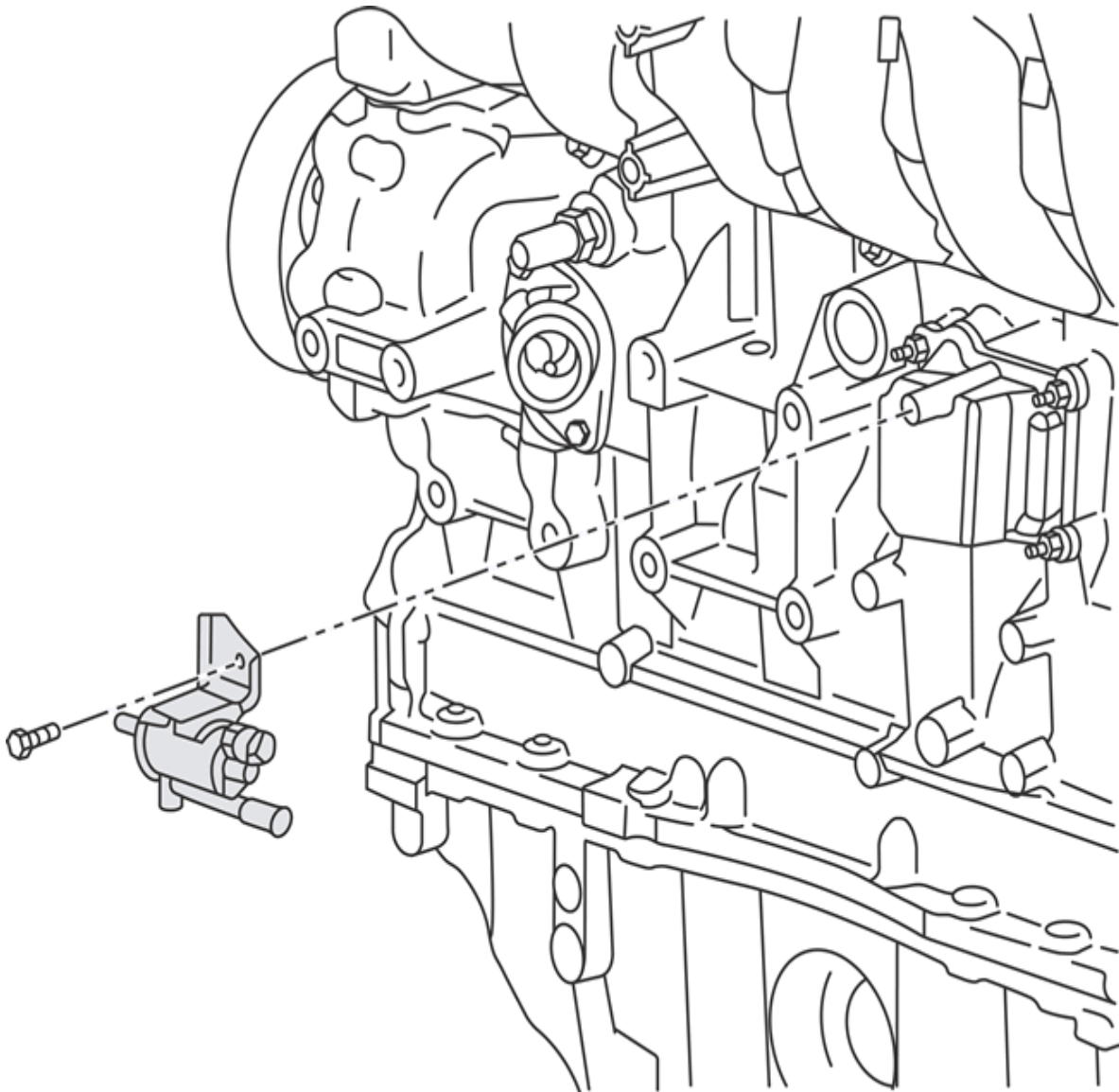
Removal & Installation

4.2L Engine

To Remove:

1. Lift the vehicle.
2. Disconnect the evaporative emission (EVAP) canister purge solenoid valve connector.
3. Disconnect the evaporative emission (EVAP) purge pipe and engine vacuum pipe from the evaporative emission (EVAP) canister purge solenoid valve.

Evaporative emission canister purge solenoid valve removal and installation



1. Remove the evaporative emission (EVAP) canister purge solenoid valve from the mounting bracket.
2. If replacing the bracket, detach the bracket from the engine.

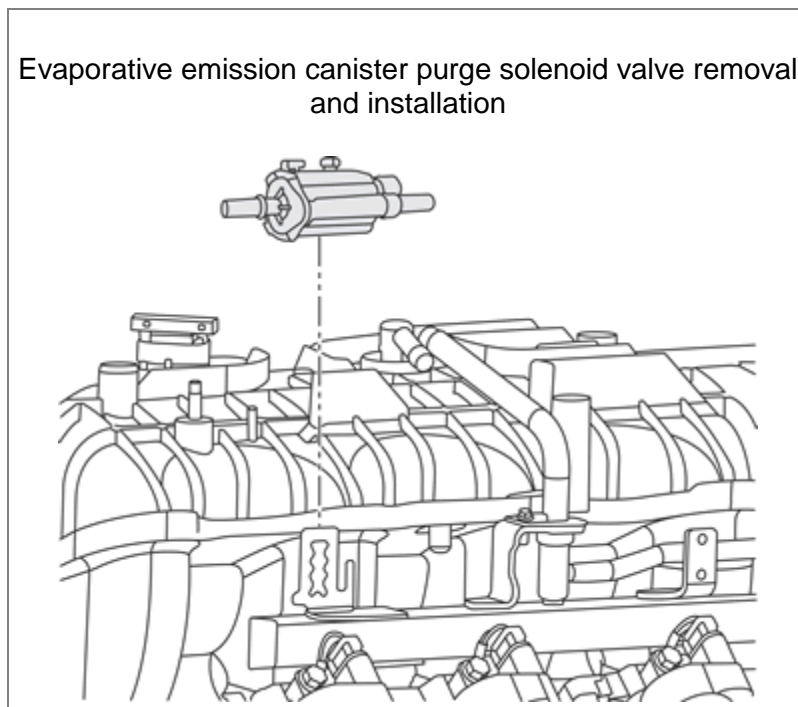
To Install:

1. If replacing the bracket, attach the bracket to the engine. Torque the bolt to **89 in-lb (10 Nm)**.
2. Install the evaporative emission (EVAP) canister purge solenoid valve onto the mounting bracket.
3. Connect the evaporative emission (EVAP) purge pipe and engine vacuum pipe to the evaporative emission (EVAP) canister purge solenoid valve.
4. Connect the evaporative emission (EVAP) canister purge solenoid valve connector.
5. Lower the vehicle.

5.3L & 6.0L Engines

To Remove:

1. If equipped, remove the intake manifold sight shield from the engine.
2. Disconnect the evaporative emission (EVAP) pipes from the evaporative emission (EVAP) canister purge solenoid.
3. Disconnect the evaporative emission (EVAP) canister purge solenoid connector.



4. Remove the evaporative emission (EVAP) canister purge solenoid from the fuel rail.

To Install:

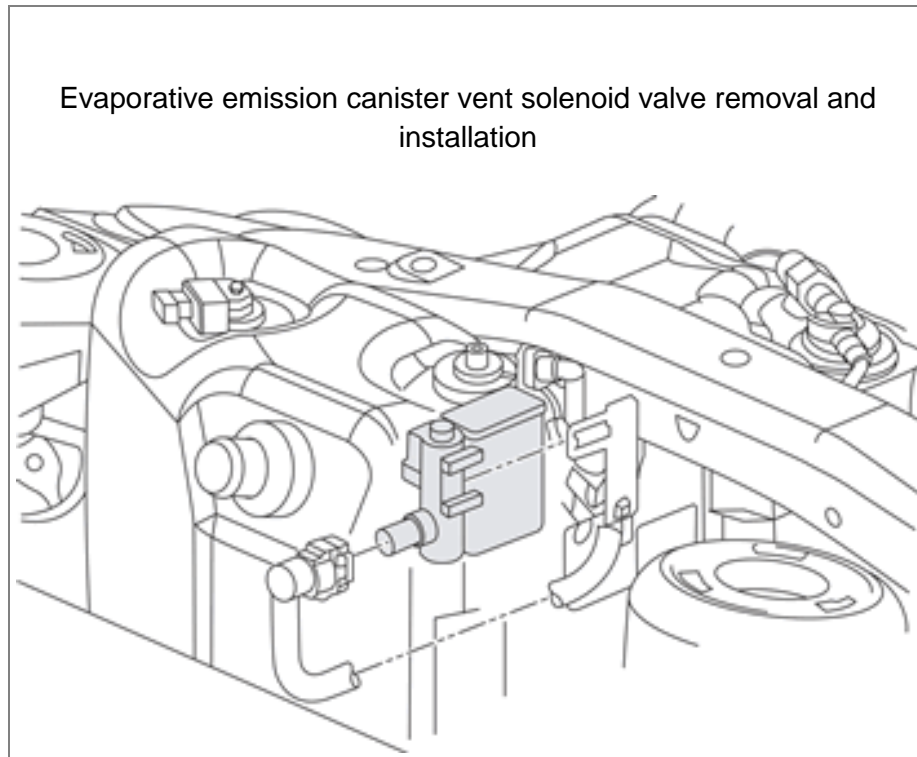
1. Install the evaporative emission (EVAP) canister purge solenoid to the fuel rail.
2. Connect the evaporative emission (EVAP) canister purge solenoid connector.
3. Connect the evaporative emission (EVAP) pipes from the evaporative emission (EVAP) canister purge solenoid.
4. If equipped, install the intake manifold sight shield onto the engine.

Evaporative Emission Canister Vent Solenoid Valve

Removal & Installation

To Remove:

1. Lift the vehicle.
2. Disconnect the evaporative emission (EVAP) canister vent solenoid valve connector.



3. Disconnect the evaporative emission (EVAP) vent pipe from the evaporative emission (EVAP) canister vent solenoid valve.
4. Remove the evaporative emission (EVAP) canister vent solenoid valve from the bracket.

To Install:

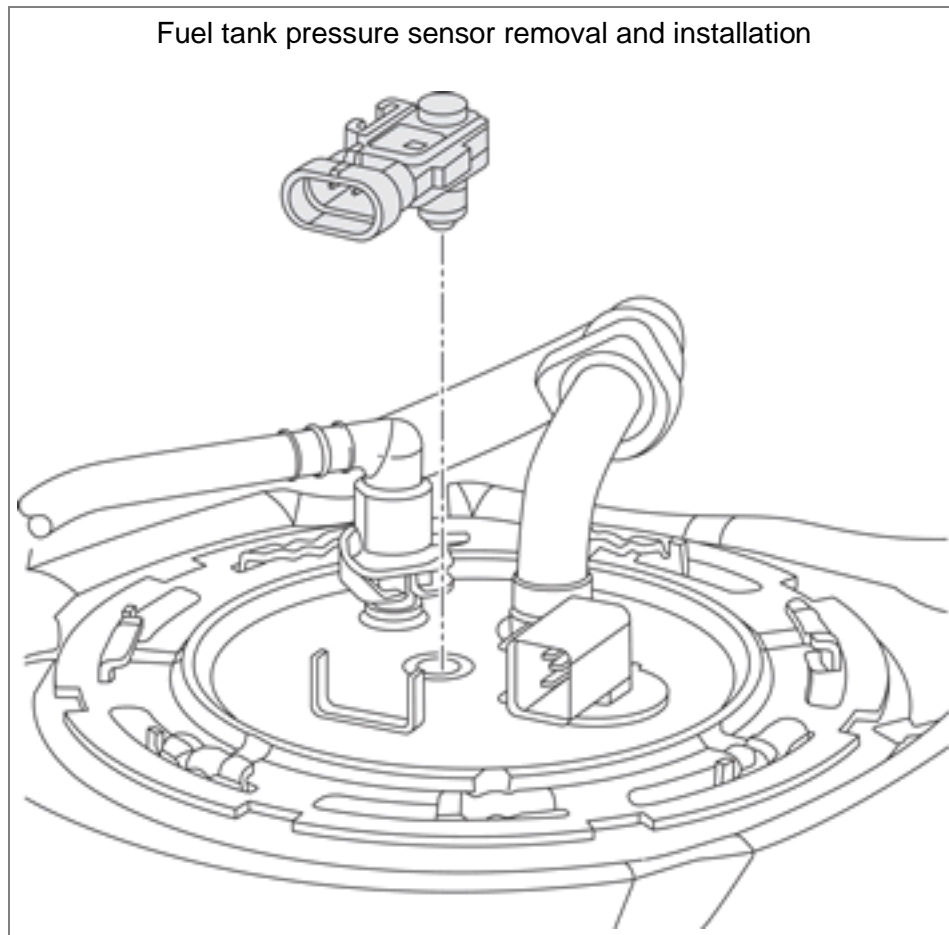
1. Install the evaporative emission (EVAP) canister vent solenoid valve onto the bracket.
2. Connect the evaporative emission (EVAP) vent pipe to the evaporative emission (EVAP) canister vent solenoid valve.
3. Connect the evaporative emission (EVAP) canister vent solenoid valve connector.
4. Lower the vehicle.

Fuel Tank Pressure Sensor

Removal & Installation

To Remove:

1. Remove the fuel tank from the vehicle.
2. Disconnect the fuel tank pressure sensor connector.



3. Remove the fuel tank pressure sensor from the fuel tank.
4. Remove and discard the seal from the fuel tank pressure sensor.

To Install:

1. Install a new seal onto the fuel tank pressure sensor.
2. Install the fuel tank pressure sensor into the fuel tank.
3. Connect the fuel tank pressure sensor connector.
4. Install the fuel tank into the vehicle.

Positive Crankcase Ventilation Hoses

Removal & Installation

4.2L Engine

To Remove:

1. Disconnect the positive crankcase ventilation dirty air hose from the intake manifold and positive crankcase ventilation (PCV) orifice tube.
2. Loosen the clamps on the throttle body.
3. Disconnect the fuel pressure regulator vacuum supply hose from the air cleaner outlet resonator.
4. Remove the air cleaner outlet resonator bolts from the engine.
5. Lift up on the front of the air cleaner outlet resonator for clearance.
6. Disconnect the positive crankcase ventilation clean air hose from the valve cover port and the air cleaner outlet resonator.

To Install:

1. Connect the positive crankcase ventilation clean air hose from the valve cover port and the air cleaner outlet resonator.
2. Install the air cleaner outlet resonator bolts into the engine. Torque the bolts to **53 in-lb (6 Nm)**.
3. Torque the clamps on the throttle body to **35 in-lb (4 Nm)**.
4. Connect the fuel pressure regulator vacuum supply hose to the air cleaner outlet resonator.
5. Lubricate the inner diameter of the positive crankcase clean air hose.
6. Connect the positive crankcase ventilation dirty air hose to the intake manifold and positive crankcase ventilation (PCV) orifice tube.

5.3L & 6.0L Engine

To Remove:

1. Disconnect the positive crankcase ventilation dirty air hose from the intake manifold and valve rocker arm cover.
2. Remove the air cleaner outlet resonator duct from the engine compartment.
3. Disconnect the positive crankcase ventilation clean air hose from the valve rocker arm cover and throttle body.

To Install:

1. Connect the positive crankcase ventilation clean air hose from the valve rocker arm cover and throttle body.
2. Install the air cleaner outlet resonator duct into the engine compartment.
3. Connect the positive crankcase ventilation dirty air hose to the intake manifold and valve rocker arm cover.
4. If equipped, install the intake manifold sight shield onto the engine.

Mass Airflow/Intake Air Temperature Sensor

Removal & Installation

4.2L Engine

To Remove:

CAUTION

Make sure not to dent, puncture, or damage the honeycell in the air inlet end of the mass airflow/intake air temperature sensor. Do not touch or allow anything to come into contact with the sensing elements of the mass airflow/intake air temperature sensor.

1. Disconnect the mass airflow/intake air temperature sensor connector.
2. Detach the mass airflow/intake air temperature sensor from the air cleaner outlet duct.

To Install:

1. Attach the mass airflow/intake air temperature sensor to the air cleaner outlet duct. Torque the screws to **5 in-lb (0.6 Nm)**.
2. Connect the mass airflow/intake air temperature sensor connector.

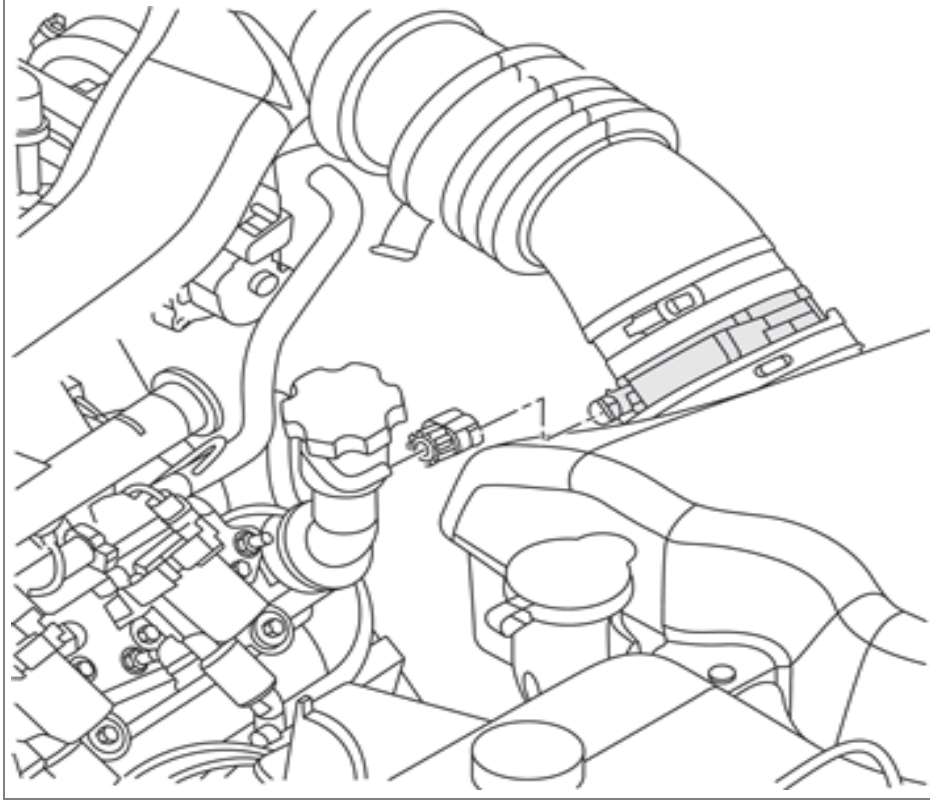
5.3L & 6.0L Engines

To Remove:

CAUTION

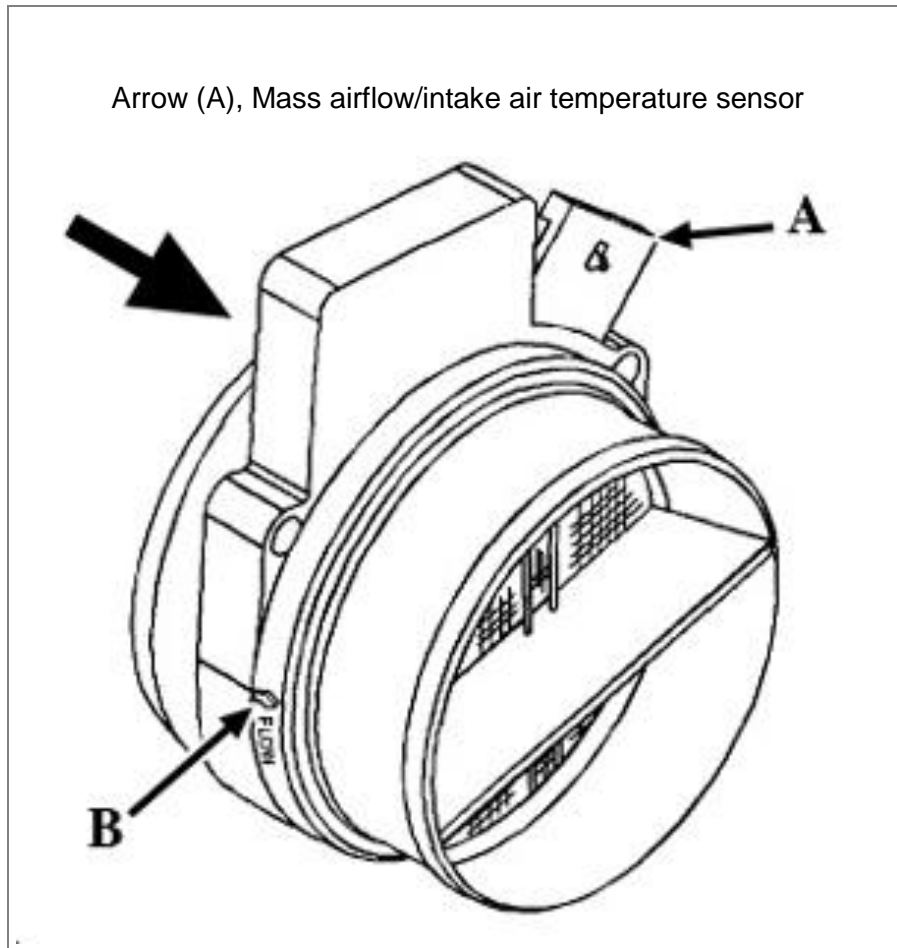
Make sure not to dent, puncture, or damage the honeycell in the air inlet end of the mass airflow/intake air temperature sensor. Do not touch or allow anything to come into contact with the sensing elements of the mass airflow/intake air temperature sensor.

Mass airflow/intake air temperature sensor



1. Disconnect the mass airflow/intake air temperature sensor connector.
2. Loosen the air cleaner outlet duct clamps at the mass airflow/intake air temperature sensor and throttle body.
3. Remove the air cleaner outlet duct bolt from the engine.
4. Remove the air cleaner outlet duct from the engine compartment.
5. Loosen the mass airflow/intake air temperature sensor clamp at the air cleaner housing.
6. Remove the mass airflow/intake air temperature sensor from the air cleaner housing.

To Install:



1. Install the mass airflow/intake air temperature sensor into the air cleaner housing with the arrow pointing toward the engine.
2. Torque the mass airflow/intake air temperature sensor clamp at the air cleaner housing to **62 in-lb (7 Nm)**.
3. Install the air cleaner outlet duct into the engine compartment.
4. Install the air cleaner outlet duct bolt into the engine. Torque the bolt to **89 in-lb (10 Nm)**.
5. Torque the air cleaner outlet duct clamps at the mass airflow/intake air temperature sensor and throttle body to **62 in-lb (7 Nm)**.
6. Connect the mass airflow/intake air temperature sensor connector.

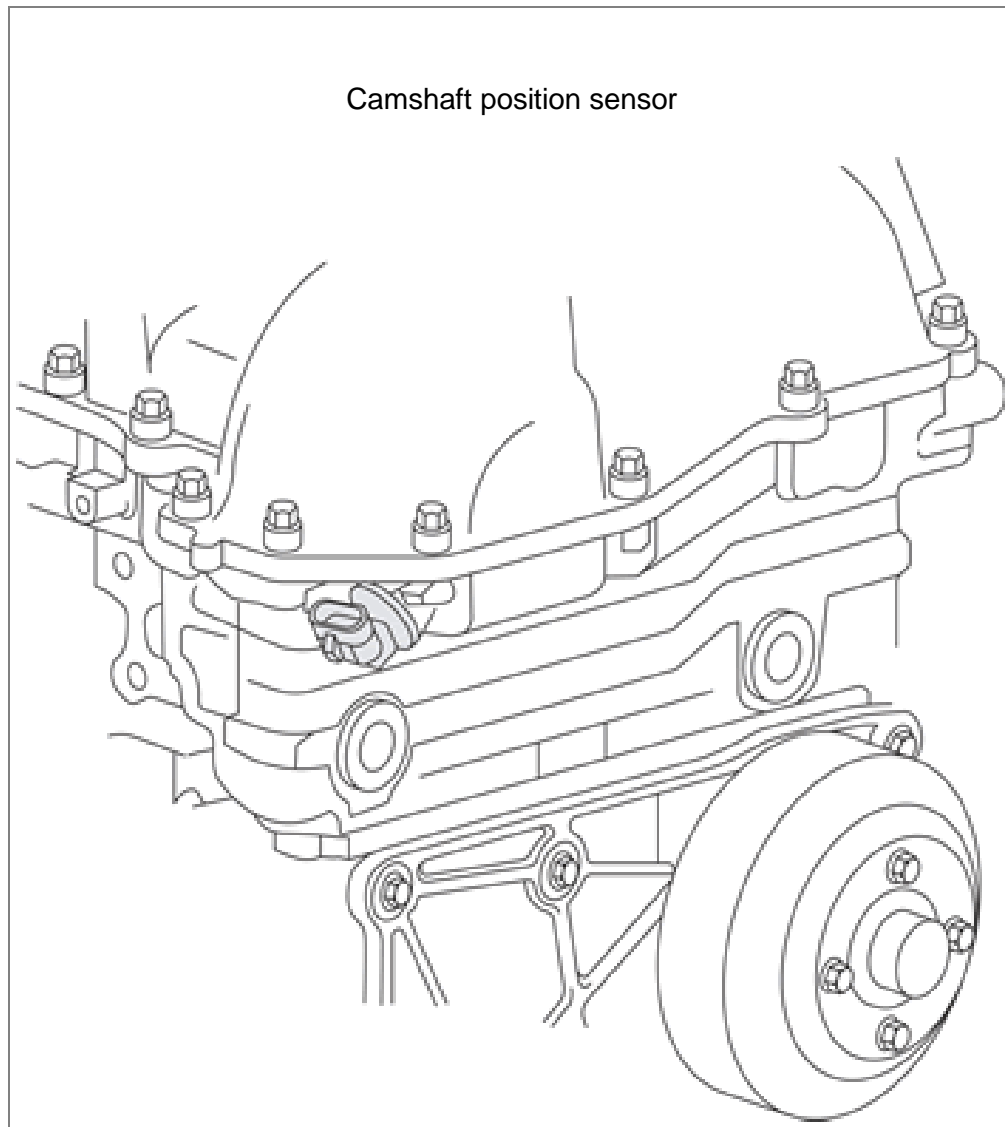
Camshaft Position Sensor

Removal & Installation

4.2L Engine

To Remove:

1. Disconnect the camshaft position (CMP) sensor connector.



2. Detach the camshaft position (CMP) sensor from the engine.

To Install:

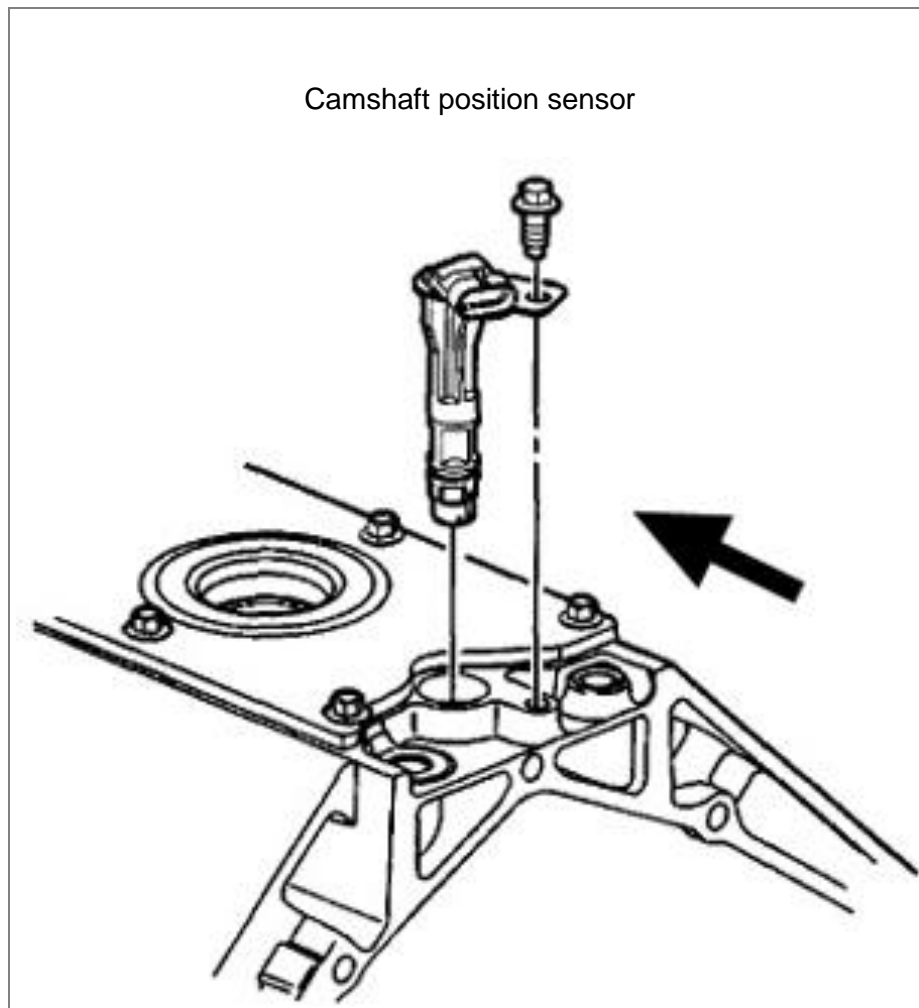
1. Attach the camshaft position (CMP) sensor into the engine. Torque the bolt to **89 in-lb (10 Nm)**.
2. Connect the camshaft position (CMP) sensor connector.

5.3L Engine

2003-2004

To Remove:

1. Remove the intake manifold from the engine.
2. Disconnect the camshaft position (CMP) sensor connector.



3. Detach the camshaft position (CMP) sensor from the engine.

To Install:

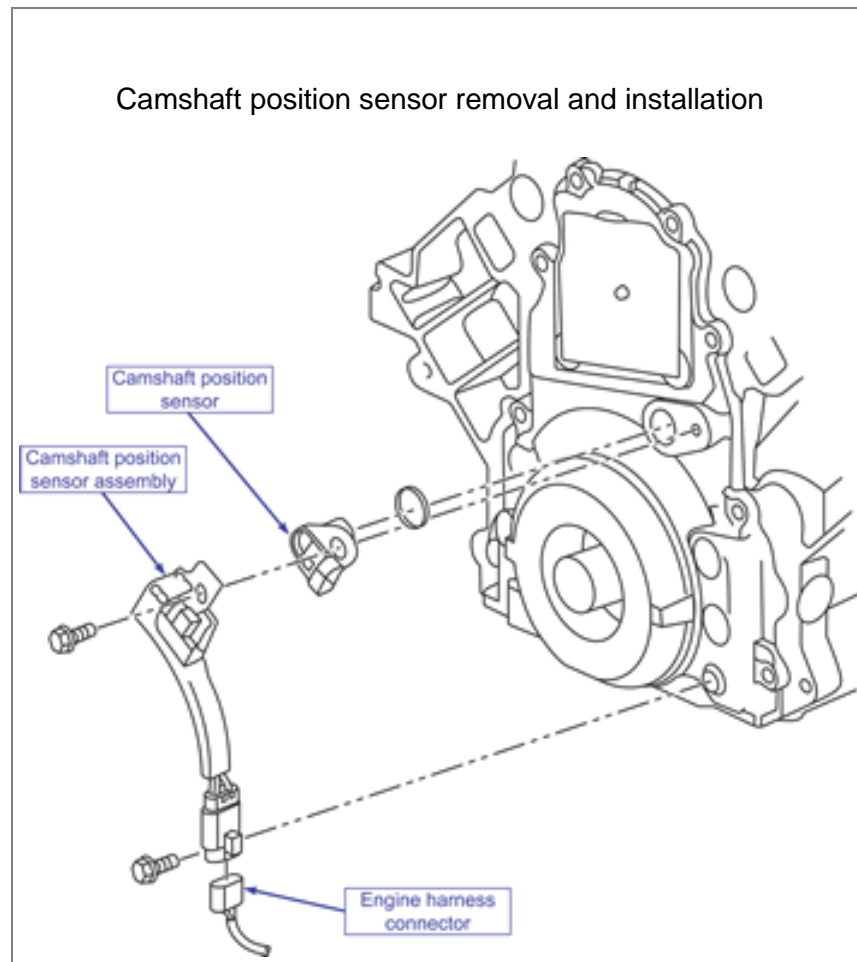
1. Attach the camshaft position (CMP) sensor to the engine. Torque the bolt to **21 ft-lb (29 Nm)**.
2. Connect the camshaft position (CMP) sensor connector.
3. Install the intake manifold onto the engine.

5.3L & 6.0L Engines

2005-2007

To Remove:

1. Remove the generator bracket assembly from the engine.



2. Disconnect the engine harness from the camshaft position sensor jumper harness.
3. Detach the camshaft position sensor assembly from the engine.
4. Remove the o-ring from the camshaft position sensor.
5. Disconnect the camshaft position sensor from the camshaft position sensor jumper harness.

To Install:

1. Connect the camshaft position sensor to the camshaft position sensor jumper harness.
2. Install the o-ring onto the camshaft position sensor.
3. Attach the camshaft position sensor assembly to the engine. Torque the bolts to **18 ft-lb (25 Nm)**.
4. Connect the engine harness to the camshaft position sensor jumper harness.
5. Install the generator bracket assembly onto the engine.

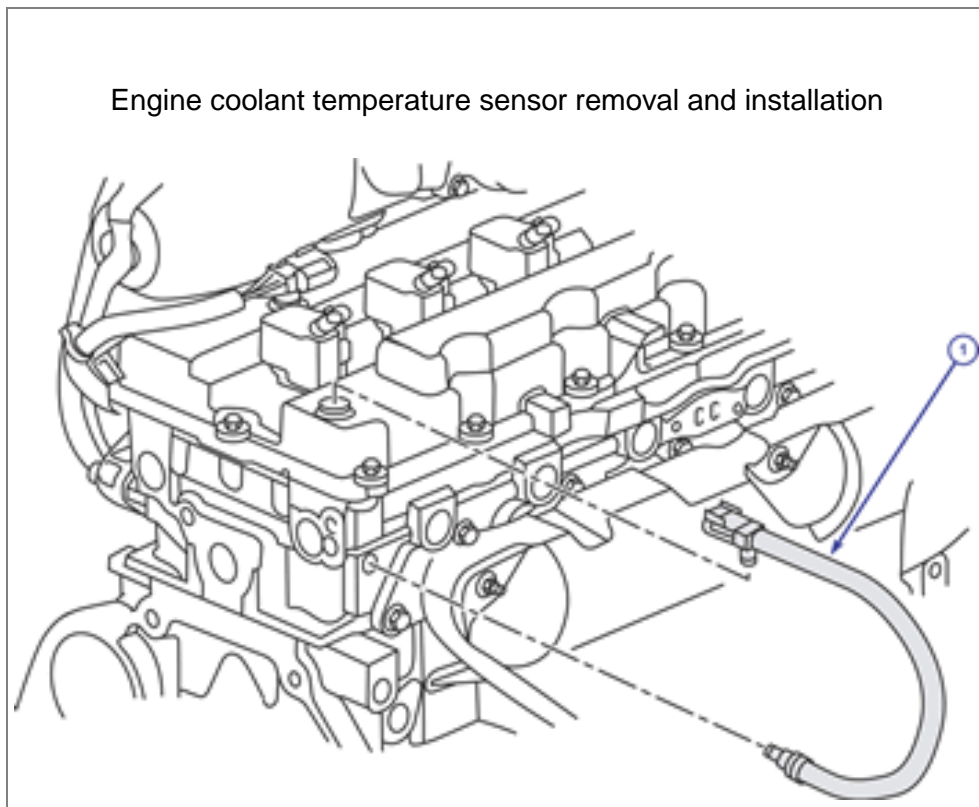
Engine Coolant Temperature Sensor

Removal & Installation

4.2L Engine

To Remove:

1. Disconnect the negative battery cable from the battery.
2. Drain the coolant from the engine.
3. Disconnect the engine coolant temperature (ECT) sensor connector.



4. Remove the engine coolant temperature (ECT) sensor from the engine.

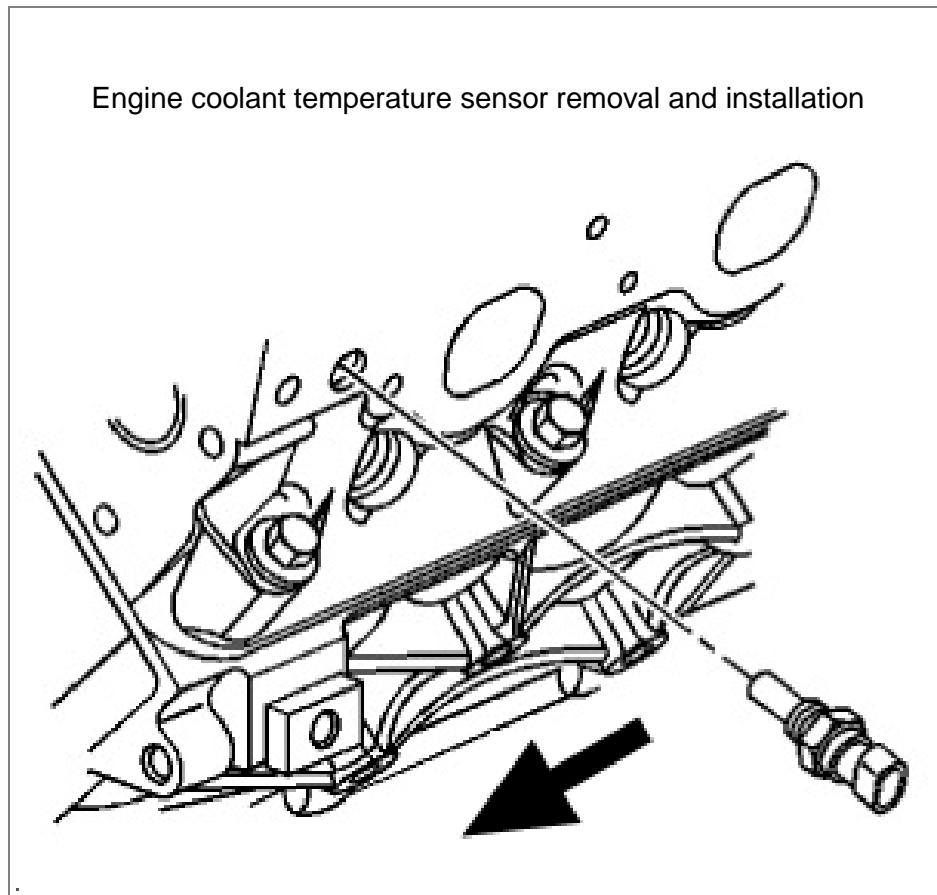
To Install:

1. Apply thread sealer P/N 12346004 or equivalent to the engine coolant temperature (ECT) sensor threads.
2. Install the engine coolant temperature (ECT) sensor into the engine. Torque the sensor to **12 ft-lb (16 Nm)**.
3. Connect the engine coolant temperature (ECT) sensor connector.
4. Refill the engine with coolant.
5. Connect the negative battery cable to the battery.

5.3L & 6.0L Engines

To Remove:

1. Drain the coolant from the engine.
2. Disconnect the engine coolant temperature (ECT) sensor connector.



3. Remove the engine coolant temperature (ECT) sensor from the left cylinder head.

To Install:

1. Apply thread sealer P/N 12346004 or equivalent to the engine coolant temperature (ECT) sensor threads.
2. Install the engine coolant temperature (ECT) sensor into the left cylinder head. Torque the sensor to **15 ft-lb (20 Nm)**.
3. Connect the engine coolant temperature (ECT) sensor connector.
4. Refill the engine with coolant.

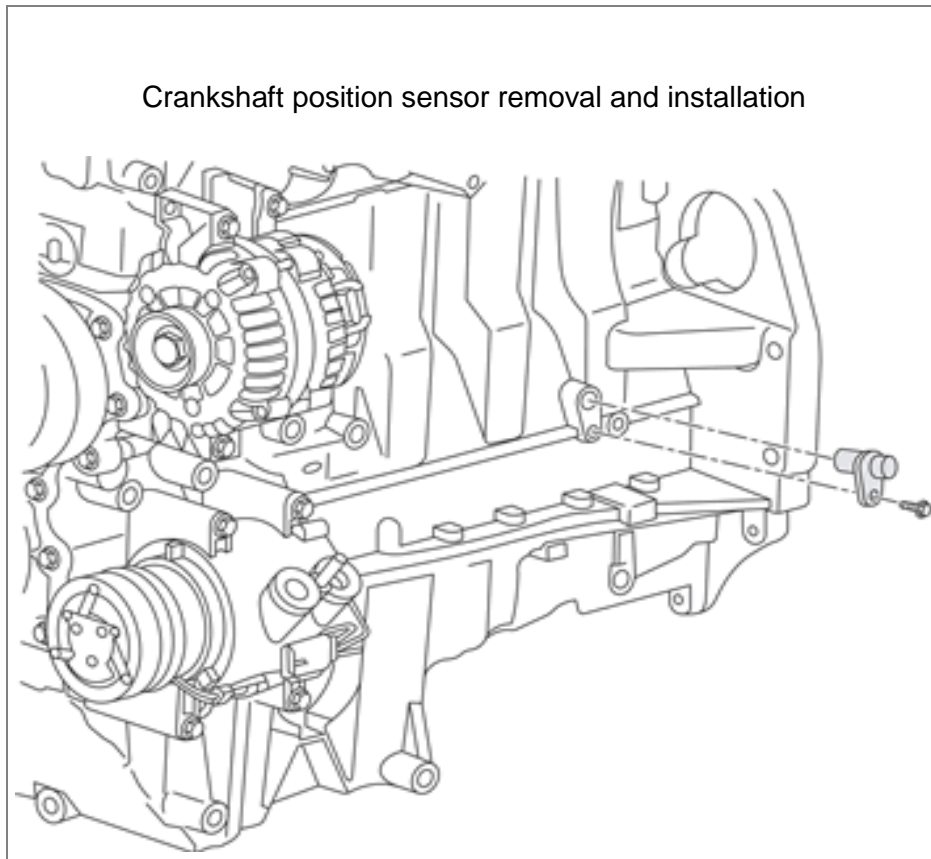
Crankshaft Position Sensor

Removal & Installation

To Remove:

4.2L Engine

1. Lift the vehicle.
2. Disconnect the crankshaft position (CKP) sensor connector.



3. Detach the crankshaft position (CKP) sensor from the engine block.
4. If necessary, remove and discard the o-ring from the crankshaft position (CKP) sensor.

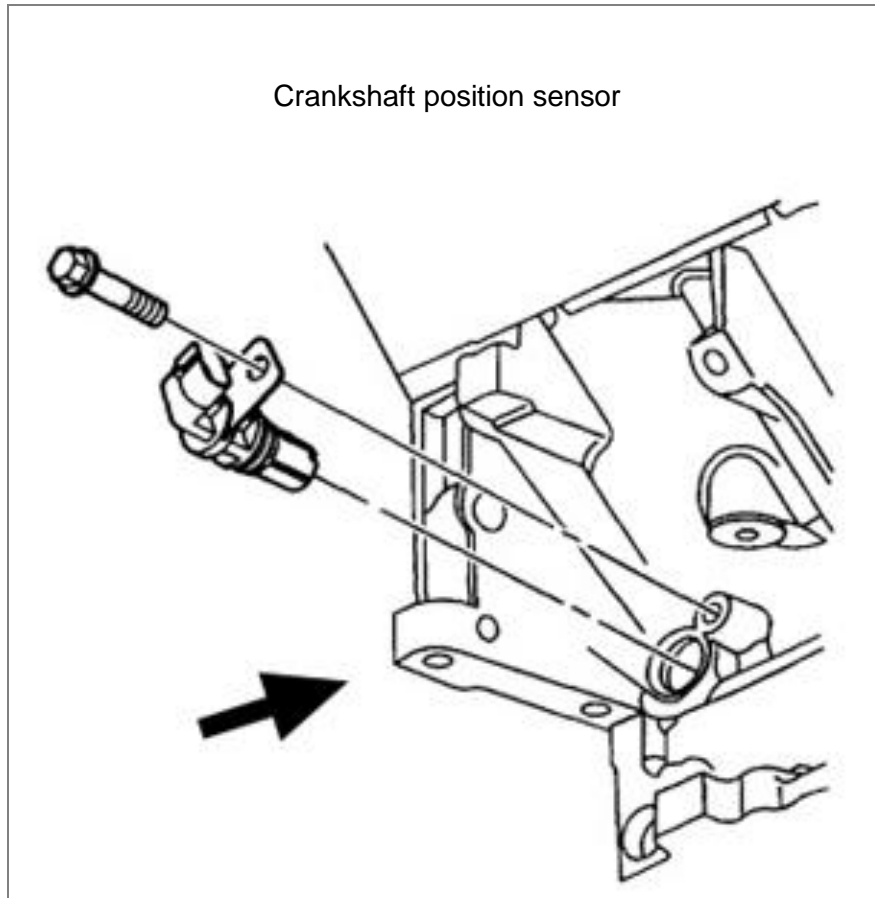
To Install:

1. If necessary, use clean engine oil to lubricate the o-ring and install it onto the crankshaft position (CKP) sensor.
2. Attach the crankshaft position (CKP) sensor to the engine block. Torque the bolt to **89 in-lb (10 Nm)**.
3. Connect the crankshaft position (CKP) sensor connector.
4. Lower the vehicle.

5.3L & 6.0L Engines

To Remove:

1. Remove the starter from the engine
2. Disconnect the crankshaft position (CKP) sensor connector.
3. Make sure the area around the crankshaft position (CKP) sensor is clean.



4. Detach the crankshaft position (CKP) sensor from the engine.

To Install:

1. Attach the crankshaft position (CKP) sensor to the engine. Torque the bolt to **18 ft-lb (25 Nm)**.
2. Connect the crankshaft position (CKP) sensor connector.
3. Install the starter onto the engine.

Powertrain Control Module (PCM)

Removal & Installation

CAUTION

The control module is sensitive to static discharge. Make sure to touch a nearby metal object to discharge any static electricity that may be built up on your body.

4.2L Engine

2002-2005

NOTE: Make sure the ignition is in the off position when connector or disconnecting power to the powertrain control module (PCM).

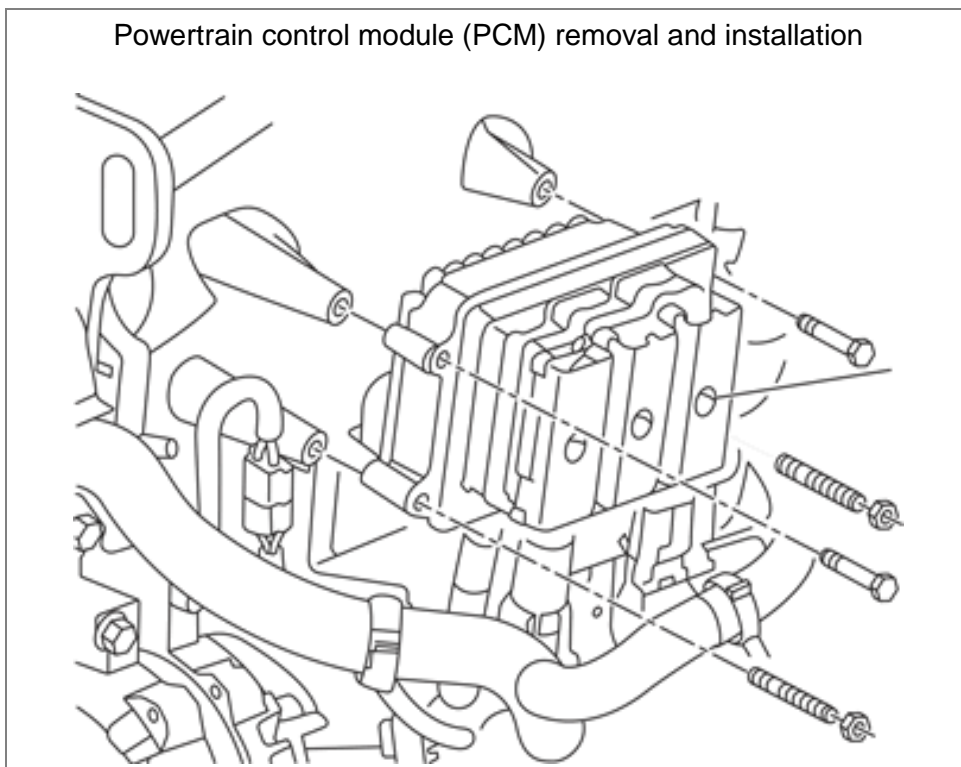
NOTE: Make sure to remove any debris from the powertrain control module (PCM) connector surfaces and inspect the gaskets.

NOTE: Do not allow the powertrain control module (PCM) to contact battery voltage.

NOTE: Do not touch the connector pins or soldered components on the circuit board.

To Remove:

1. Use a scan tool to retrieve and record the remaining engine oil life.



2. Detach the powertrain control module (PCM) connectors.
3. Remove the powertrain control module (PCM) retaining nuts and bolts from the intake manifold.
4. Remove the powertrain control module (PCM) from the intake manifold.
5. If replacing the mounting studs, remove the mounting studs from the intake manifold.

To Install:

1. If replacing the mounting studs, install the mounting studs into the intake manifold. Torque the studs to **53 in-lb (6 Nm)**.
2. Install the powertrain control module (PCM) onto the intake manifold over the mounting studs.
3. Install the powertrain control module (PCM) retaining nuts and bolts into the intake manifold. Torque the nuts to **71 in-lb (8 Nm)**.
4. Attach the powertrain control module (PCM) connectors. Torque the bolts to **71 in-lb (8 Nm)**.
5. If a new powertrain control module (PCM) was installed, program the module.
6. Use a scan tool to set the engine oil life.

2006-2007

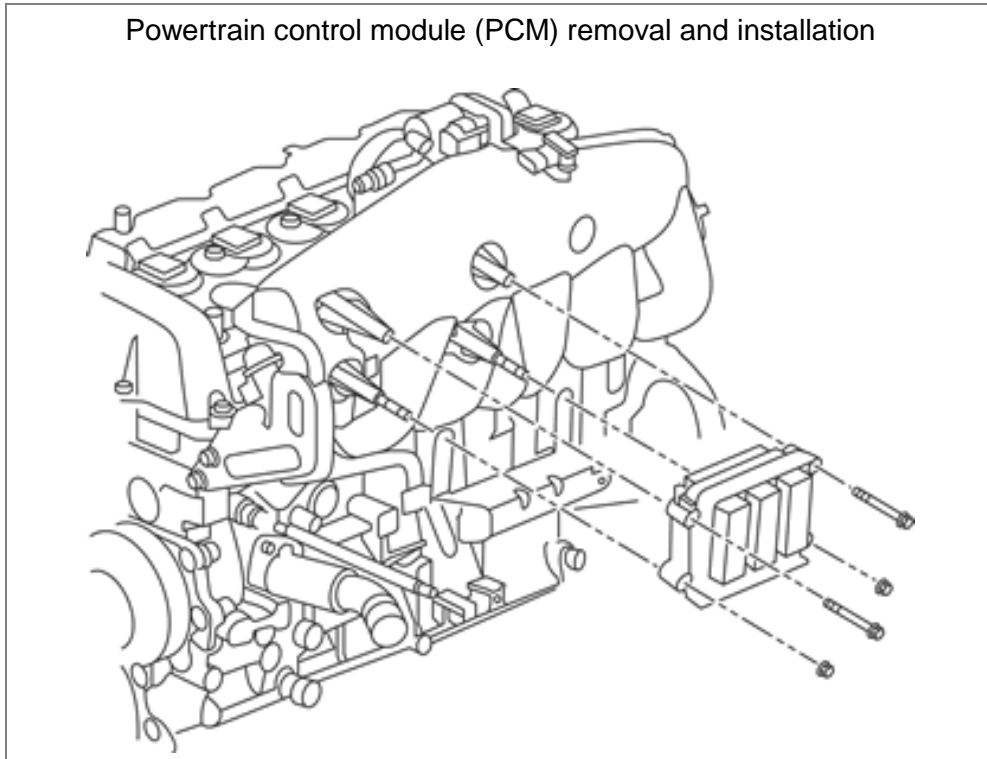
NOTE: Make sure the ignition is in the off position when connector or disconnecting power to the powertrain control module (PCM).

NOTE: Make sure to remove any debris from the powertrain control module (PCM) connector surfaces and inspect the gaskets.

To Remove:

1. Use a scan tool to retrieve and record the remaining engine oil life.
2. Disconnect the powertrain control module (PCM) connectors.

Powertrain control module (PCM) removal and installation



3. Detach the powertrain control module (PCM) and bracket from the intake manifold.

To Install:

1. Attach the powertrain control module (PCM) and bracket to the intake manifold. Torque the nuts and bolts to **80 in-lb (9 Nm)**.
2. Connect powertrain control module (PCM) connectors.
3. If a new powertrain control module (PCM) was installed, program the module.
4. Use a scan tool to set the engine oil life.

5.3L Engine

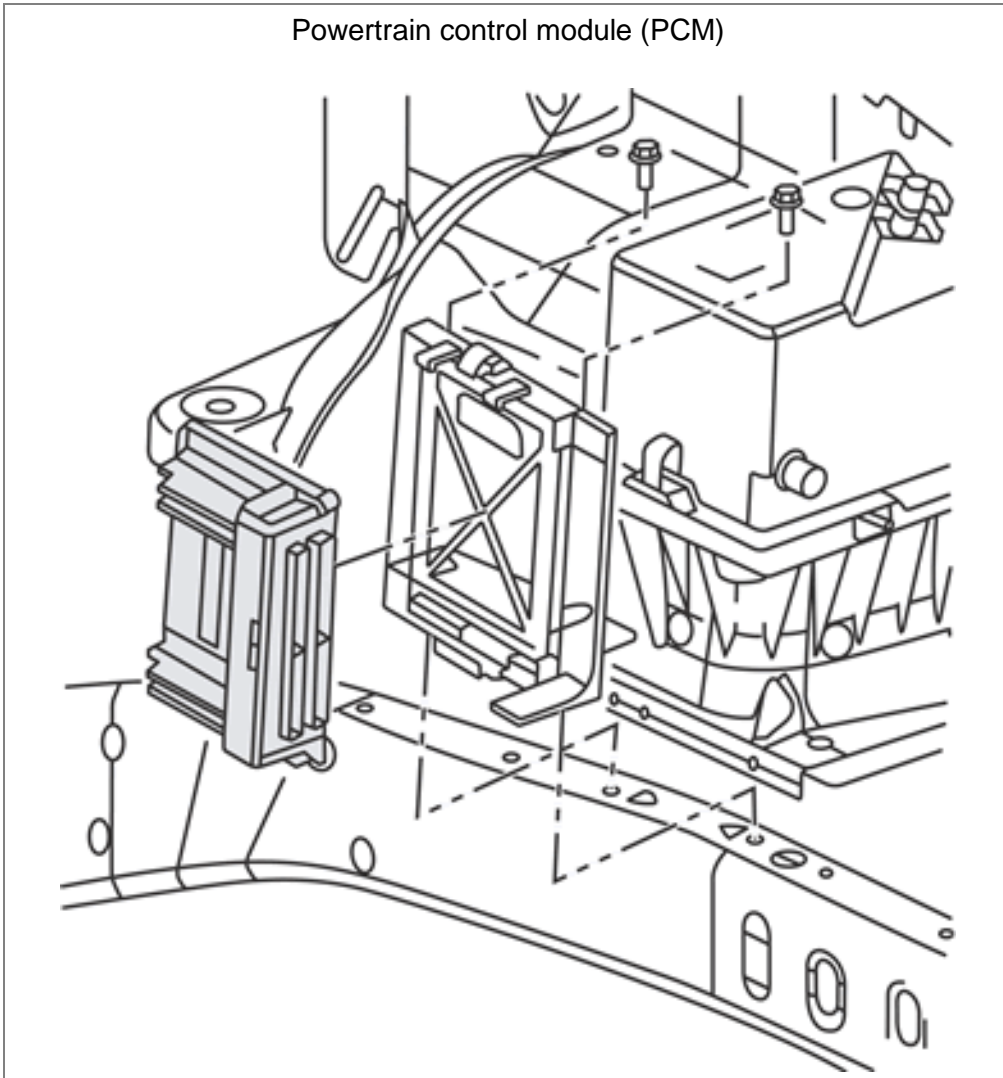
2003-2004

NOTE: Make sure to remove any debris from the powertrain control module (PCM) connector surfaces and inspect the gaskets.

To Remove:

1. Use a scan tool to retrieve and record the remaining engine oil life.
2. Disconnect the negative battery cable from the battery.
3. Remove the powertrain control module (PCM) cover from the powertrain control module (PCM).

Powertrain control module (PCM)



4. Remove the powertrain control module (PCM) from the bracket.
5. Detach the connectors from the powertrain control module (PCM).

To Install:

1. Attach the connectors to the powertrain control module (PCM). Torque the bolts to **71 in-lb (8 Nm)**.
2. Install the powertrain control module (PCM) into the bracket.
3. Install the powertrain control module (PCM) cover onto the powertrain control module (PCM).
4. Connect the negative battery cable to the battery.
5. If a new powertrain control module (PCM) was installed, program the module.
6. Use a scan tool to set the engine oil life.

Engine Control Module (ECM)

Removal & Installation

5.3L & 6.0L Engines

2005-2007

NOTE: Make sure the ignition is in the off position when connector or disconnecting power to the powertrain control module (PCM).

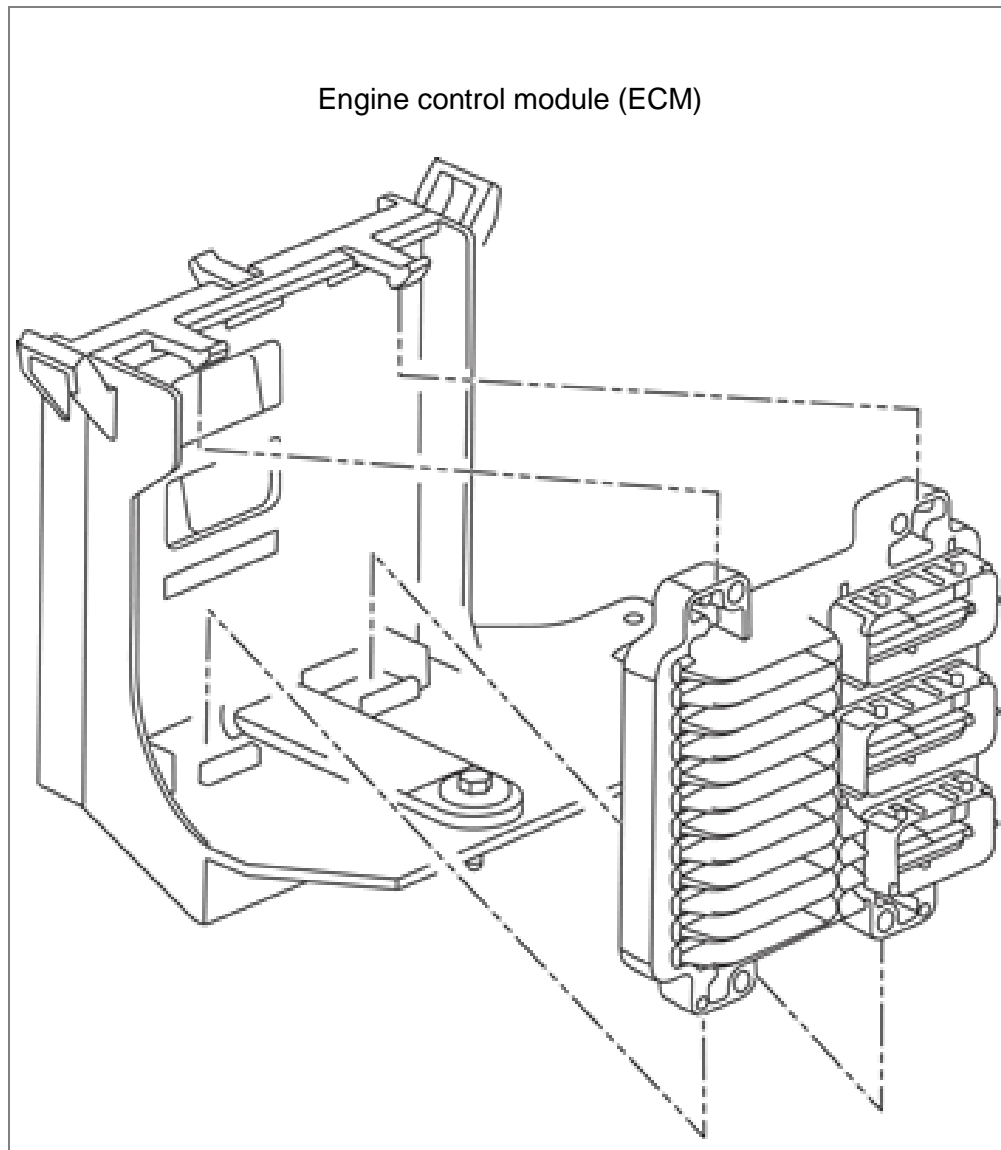
NOTE: Make sure to remove any debris from the powertrain control module (PCM) connector surfaces and inspect the gaskets.

NOTE: Do not allow the powertrain control module (PCM) to contact battery voltage.

NOTE: Do not touch the connector pins or soldered components on the circuit board.

To Remove:

1. Use a scan tool to retrieve and record the remaining engine oil life.
2. Disconnect the negative battery cable from the battery.
3. Disconnect the cooling fan connector.
4. Remove the cover from the transmission control module (TCM)/engine control module (ECM).
5. Disconnect the engine control module (ECM) connectors.



6. Remove the engine control module (ECM) from the bracket.
7. If replacing the bracket, detach the transmission control module (TCM)/engine control module (ECM) bracket from the frame.

To Install:

1. If replacing the bracket, attach the transmission control module (TCM)/engine control module (ECM) bracket to the frame. Torque the bolts to **89 in-lb (10 Nm)**.
2. Install the engine control module (ECM) into the bracket.
3. Connect the engine control module (ECM) connectors.
4. Install the cover over the transmission control module (TCM)/engine control module (ECM).
5. Connect the cooling fan connector.
6. Connect the negative battery cable to the battery.
7. If a new engine control module (ECM) was installed, program the module.
8. Use a scan tool to set the engine oil life.

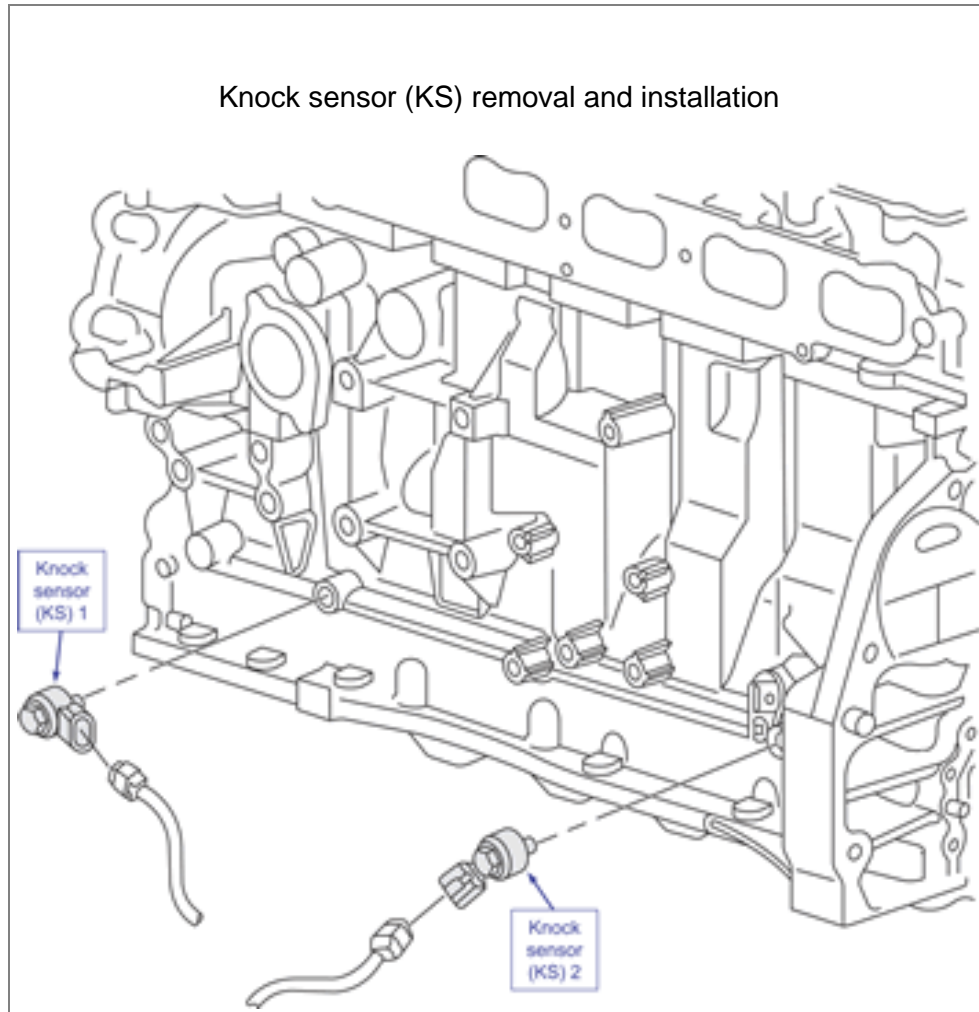
Knock Sensor (KS)

Removal & Installation

4.2L Engine

To Remove:

1. Lift the vehicle.



2. Disconnect the knock sensor (KS) connectors.
3. Detach the knock sensors (KS) from the engine block.

To Install:

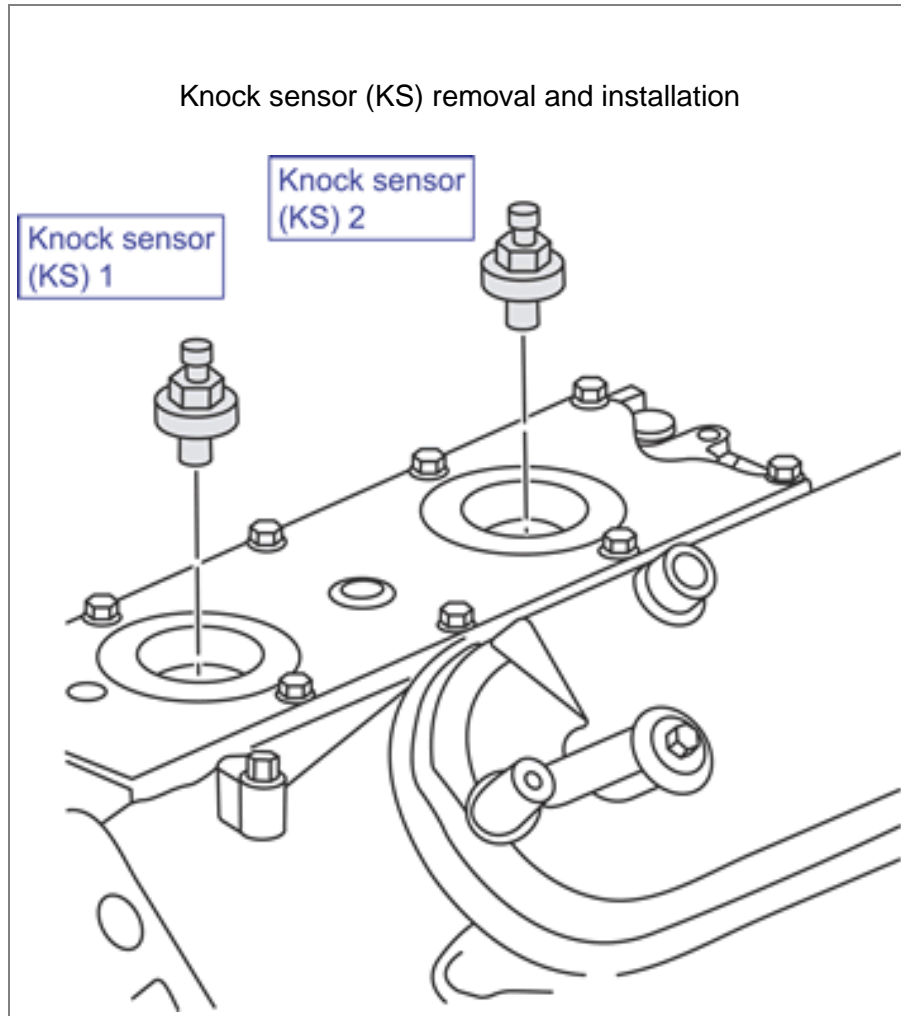
1. Attach the knock sensors (KS) to the engine block. Torque the sensor to **18 ft-lb (25 Nm)**.
2. Connect the knock sensor (KS) connectors.
3. Lower the vehicle.

5.3L Engine

2003-2004

To Remove:

1. Remove the intake manifold from the engine.
2. Remove the knock sensor (KS) covers from the engine.
3. Disconnect the knock sensor (KS) connectors.



4. Remove the knock sensors (KS) from the engine.

To Install:

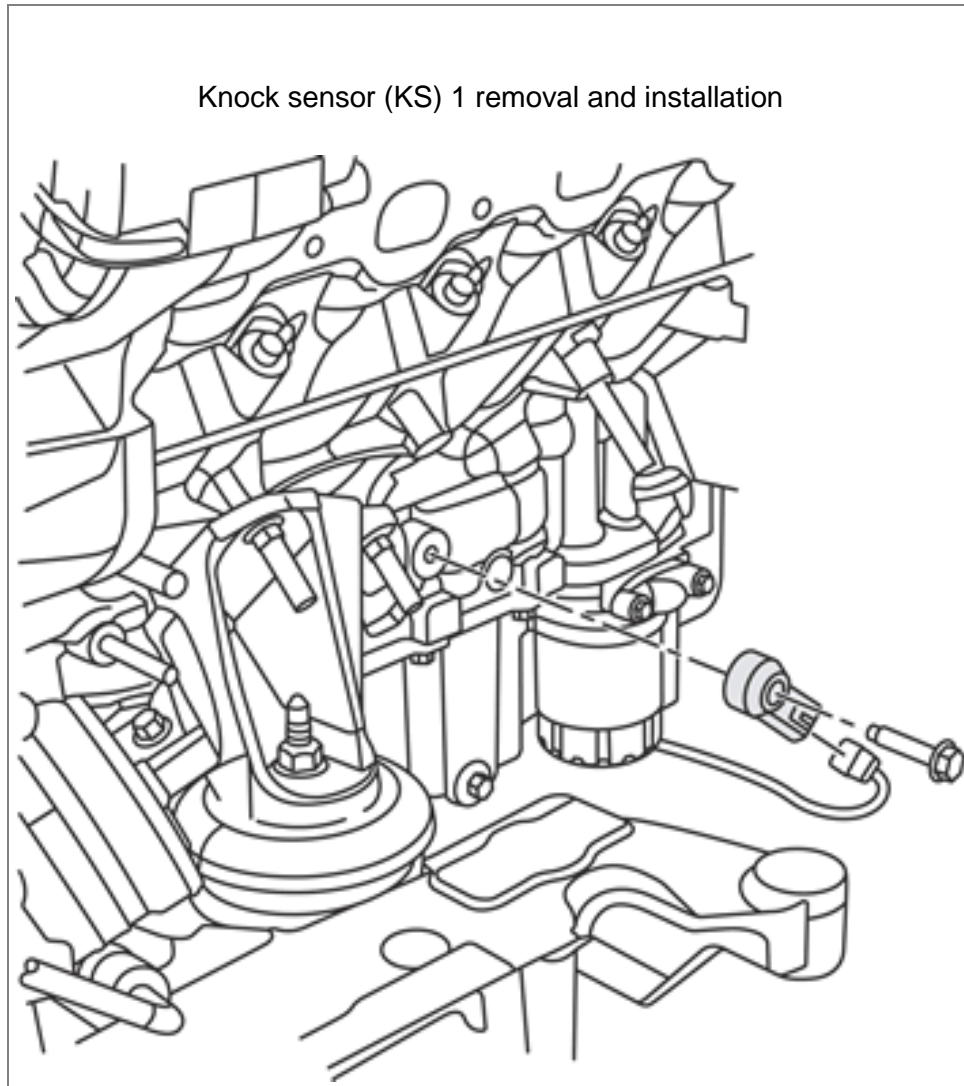
1. Install the knock sensors (KS) into the engine. Torque the sensors to **15 ft-lb (20 Nm)**.
2. Connect the knock sensor (KS) connectors.
3. Install the knock sensor (KS) covers onto the engine.
4. Install the intake manifold onto the engine.

5.3L & 6.0L Engines

2005-2007

Left Side

To Remove:



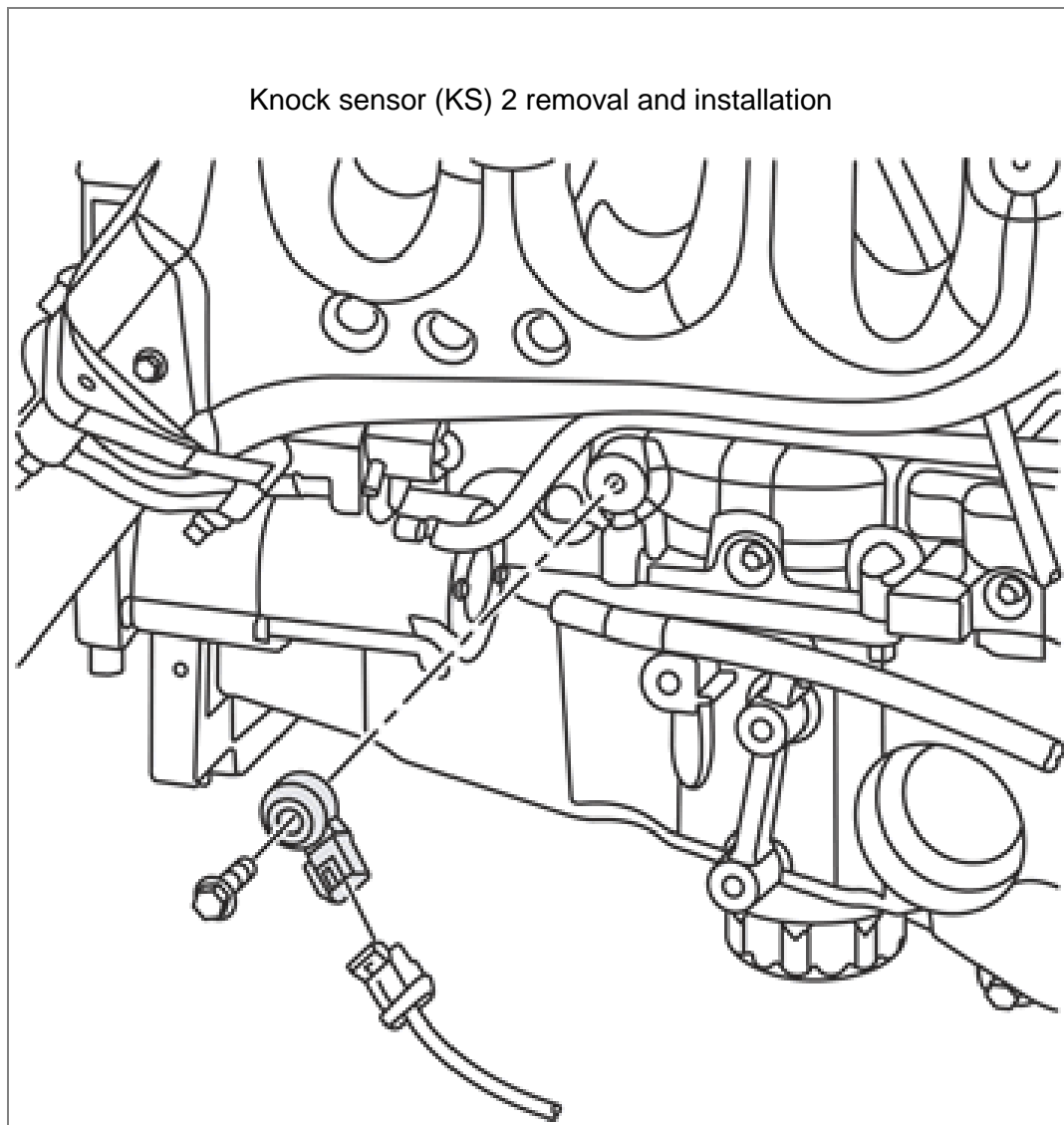
1. Disconnect the knock sensor (KS) 1 connector.
2. Detach knock sensor (KS) 1 from the left side of the engine block.

To Install:

1. Attach knock sensor (KS) 1 to the left side of the engine block. Torque the bolt to **15 ft-lb (20 Nm)**.
2. Connect the knock sensor (KS) 1 connector.

Right Side

To Remove:



1. Disconnect the knock sensor (KS) 2 connector.
2. Detach knock sensor (KS) 2 from the right side of the engine block.

To Install:

1. Attach knock sensor (KS) 2 to the right side of the engine block. Torque the bolt to **15 ft-lb (20 Nm)**.
2. Connect the knock sensor (KS) 2 connector.

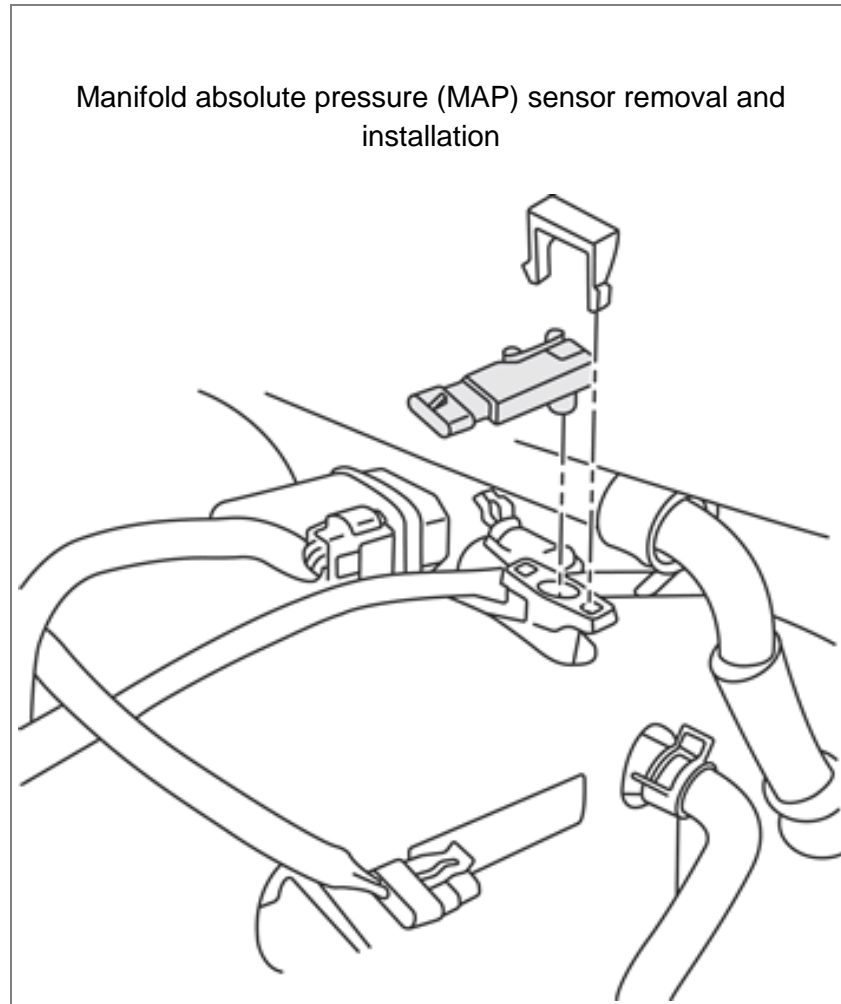
Manifold Absolute Pressure (MAP) Sensor

Removal & Installation

4.2L Engine

To Remove:

1. Disconnect the manifold absolute pressure (MAP) sensor connector.



2. Detach the manifold absolute pressure (MAP) sensor from the intake manifold.
3. If necessary, remove and discard the manifold absolute pressure (MAP) sensor seal.

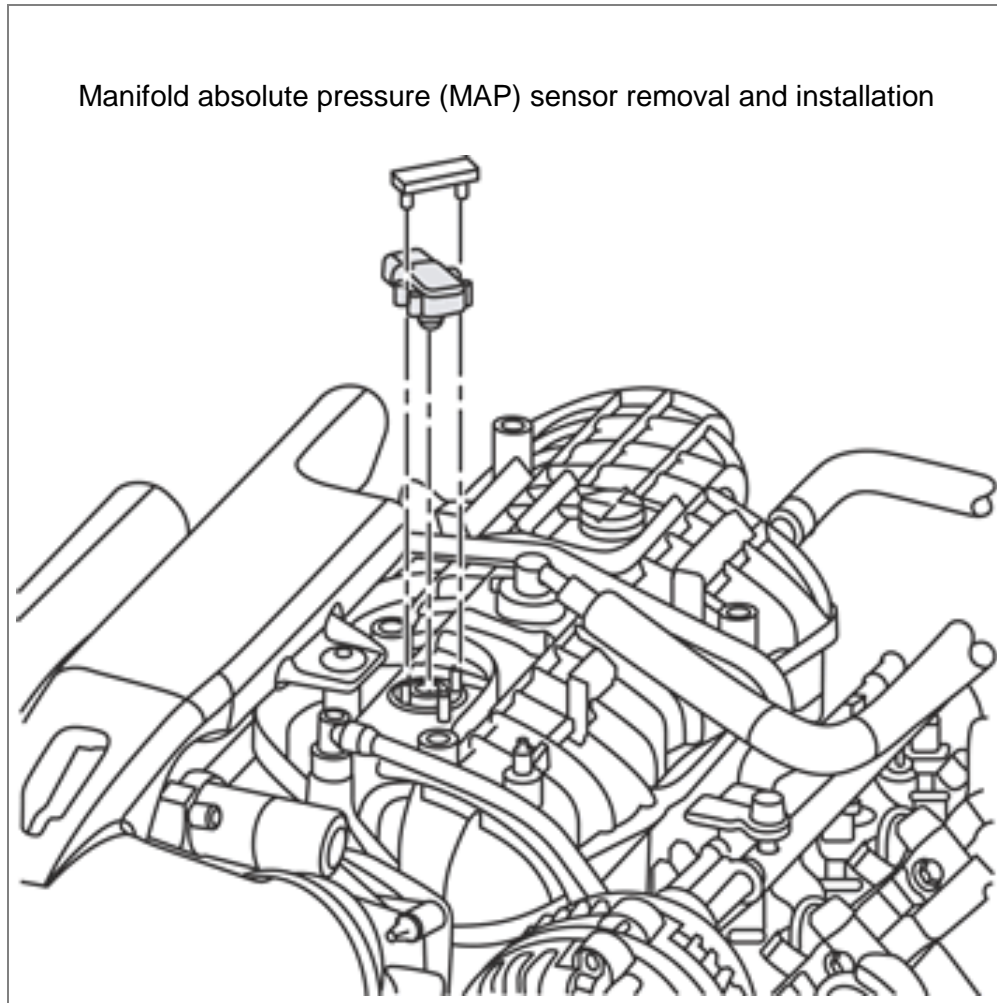
To Install:

1. If necessary, install the new manifold absolute pressure (MAP) sensor seal.
2. Attach the manifold absolute pressure (MAP) sensor to the intake manifold.
3. Disconnect the manifold absolute pressure (MAP) sensor connector.

5.3L Engine

To Remove:

1. If equipped, remove the intake manifold sight shield from the intake manifold.
2. Disconnect the manifold absolute pressure (MAP) sensor connector.



3. Remove the manifold absolute pressure (MAP) sensor from the intake manifold.

To Install:

1. Use clean engine oil to lubricate the manifold absolute pressure (MAP) sensor seal.
2. Install the manifold absolute pressure (MAP) sensor onto the intake manifold.
3. Connect the manifold absolute pressure (MAP) sensor connector.
4. If equipped, install the intake manifold sight shield onto the intake manifold.

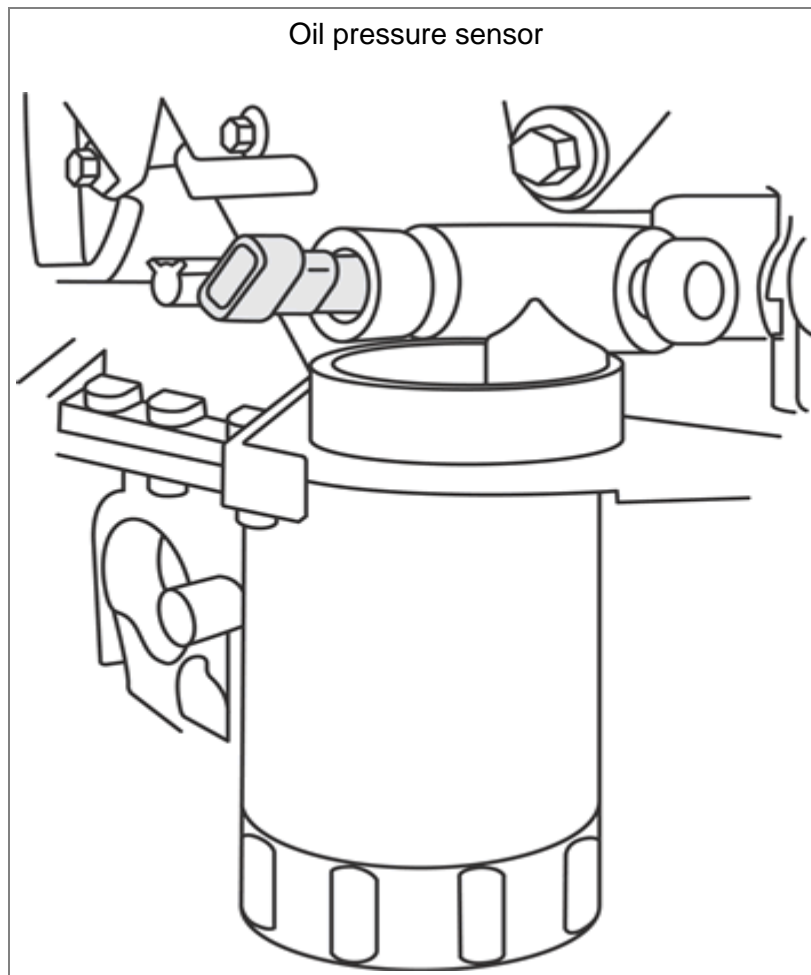
Oil Pressure Switch

Removal & Installation

4.2L Engine

To Remove:

1. Lift the vehicle.
2. Remove the engine shield from the frame.
3. Disconnect the oil pressure switch connector.



4. Remove the oil pressure switch from the engine block.

To Install:

1. Install the oil pressure switch into the engine block.
2. Connect the oil pressure switch connector.
3. Install the engine shield onto the frame.
4. Lower the vehicle.

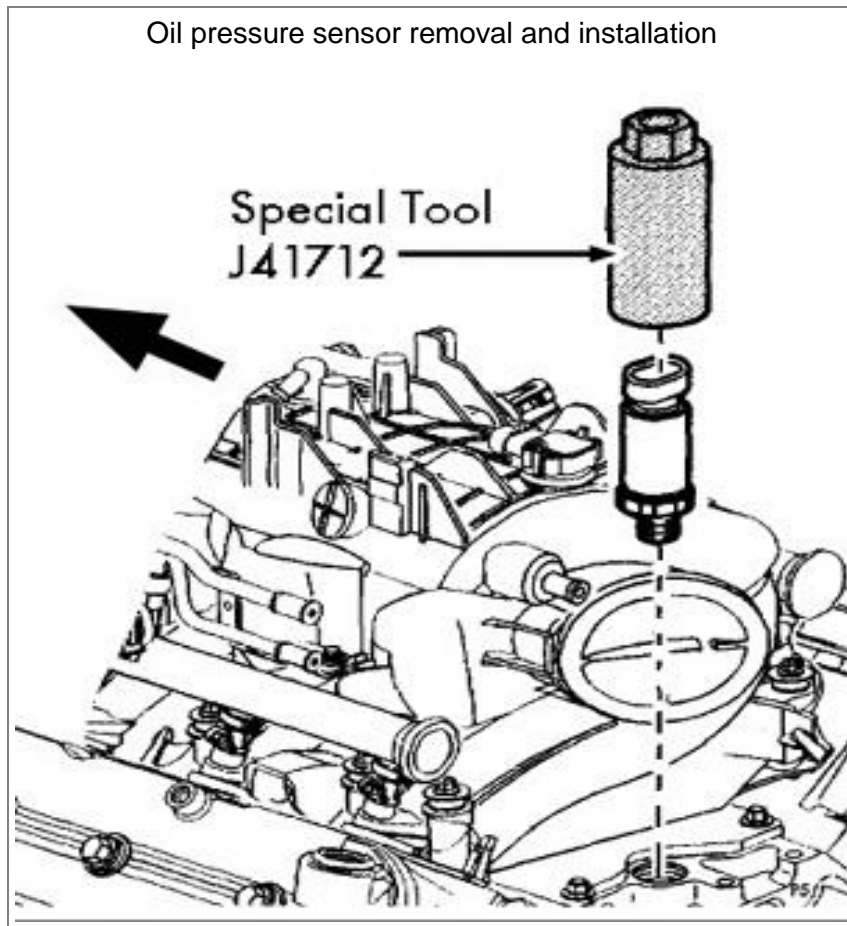
Oil Pressure Sensor

Removal & Installation

5.3L & 6.0L Engines

To Remove:

1. Remove the intake manifold from the engine.
2. Disconnect the oil pressure sensor connector.



3. Use a J 41712 oil pressure sensor socket to remove the oil pressure sensor from the engine.

To Install:

1. Apply sealant GM P/N 12346004 to the oil pressure sensor threads.
2. Use a J 41712 oil pressure sensor socket to install the oil pressure sensor into the engine. Torque the sensor to **26 ft-lb (35 Nm)**.
3. Connect the oil pressure sensor connector.
4. Install the intake manifold onto the engine.

Heated Oxygen Sensor

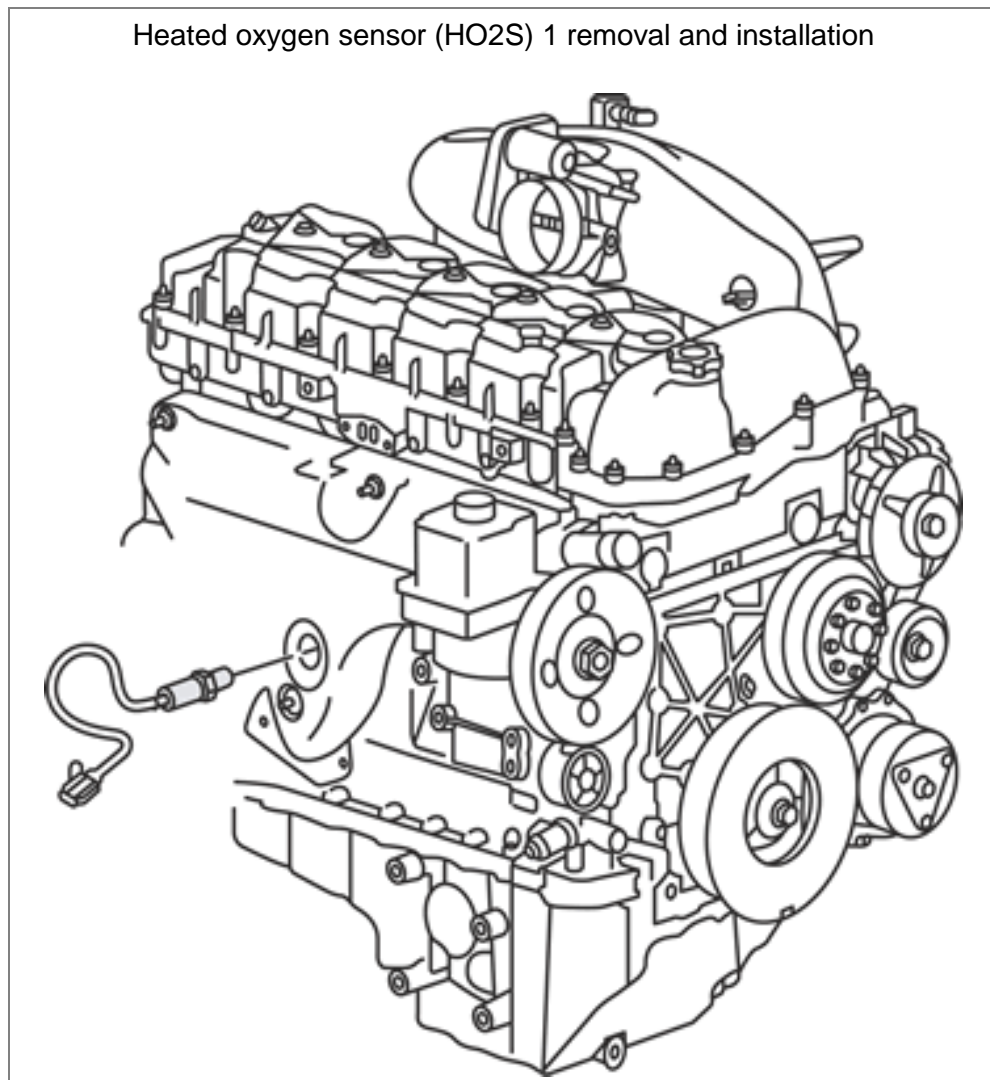
Removal & Installation

4.2L Engine

Sensor 1

To Remove:

1. Disconnect the heated oxygen sensor (HO2S) connector.



2. For 2002 through 2003 model years, use a J 39194-C oxygen sensor wrench to remove the heated oxygen sensor (HO2S) from the engine.
3. For 2004 through 2007 model years, use a J 39194-B heated oxygen sensor wrench to remove the heated oxygen sensor (HO2S) from the engine.

To Install:

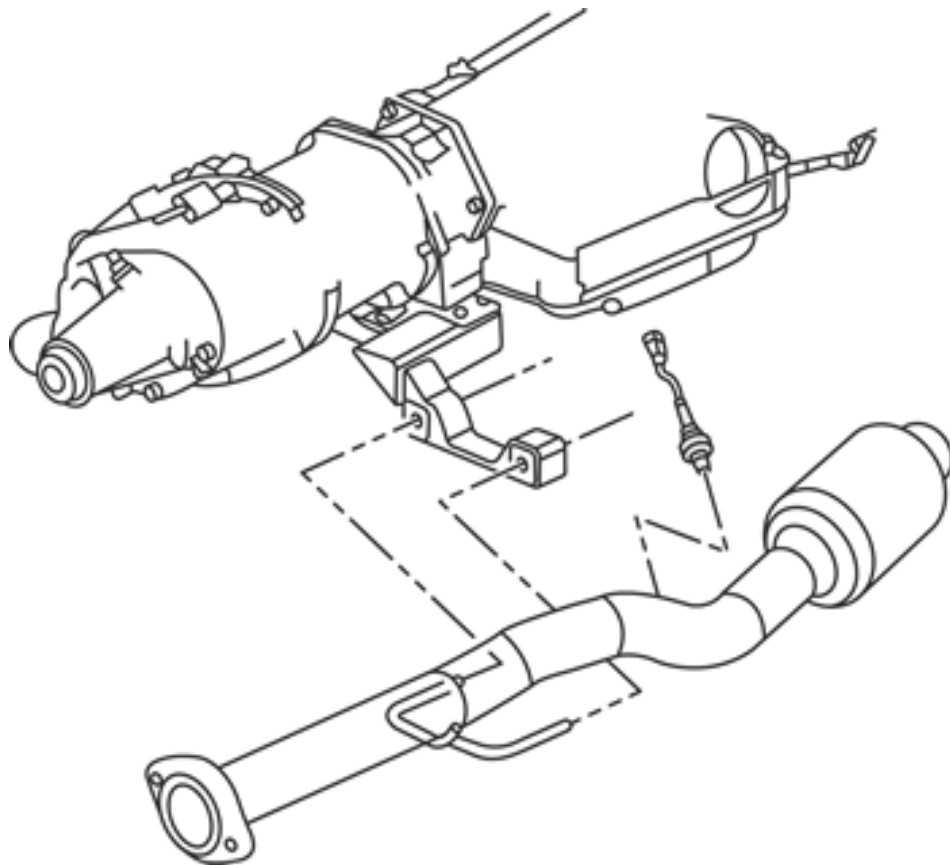
1. Apply an anti-seize compound to the heated oxygen sensor (HO2S) threads.
2. For 2002 through 2003 model years, use a J 39194-C oxygen sensor wrench to install the heated oxygen sensor (HO2S) into the engine.
3. For 2004 through 2007 model years, use a J 39194-B heated oxygen sensor wrench to install the heated oxygen sensor (HO2S) into the engine.
4. Torque the heated oxygen sensor (HO2S) to **30 ft-lb (41 Nm)**.
5. Connect the heated oxygen sensor (HO2S) connector.

Sensor 2

To Remove:

1. Lift the vehicle.
2. Disconnect the heated oxygen sensor (HO2S) connector.

Heated oxygen sensor (HO2S) 2 removal and installation



3. Use a J 39194-B heated oxygen sensor wrench to remove the heated oxygen sensor (HO2S) from the engine.

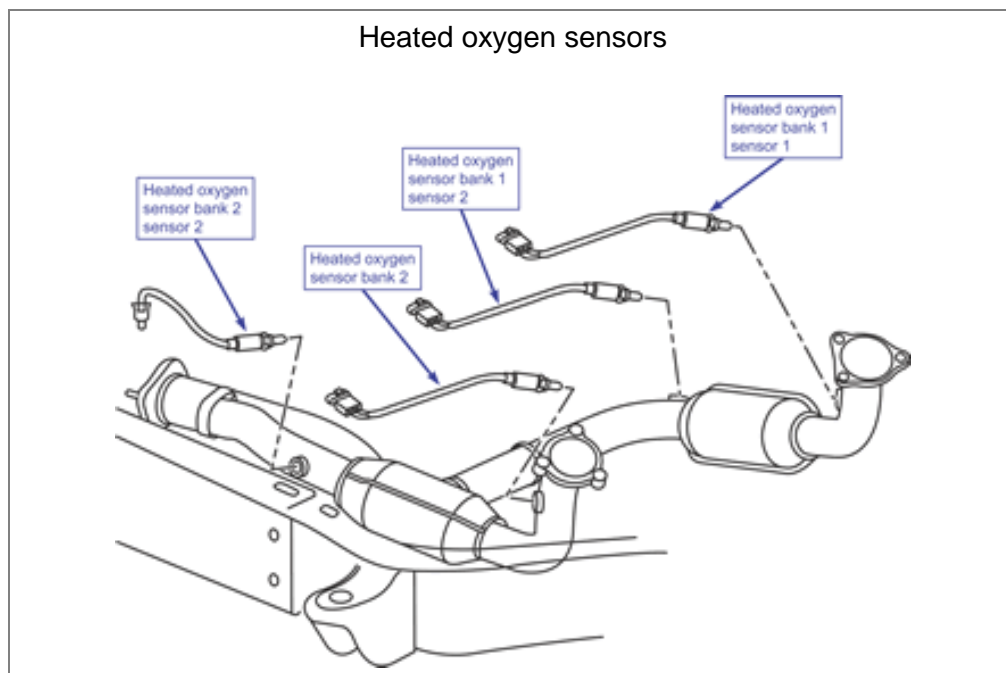
To Install:

1. Apply an anti-seize compound to the heated oxygen sensor (HO2S) threads.
2. Use a J 39194-B heated oxygen sensor wrench to install the heated oxygen sensor (HO2S) into the engine. Torque the heated oxygen sensor (HO2S) to **30 ft-lb (41 Nm)**.
3. Connect the heated oxygen sensor (HO2S) connector.
4. Lower the vehicle.

5.3L & 6.0L Engines

To Remove:

1. Lift the vehicle.
2. Disconnect the heated oxygen sensor (HO2S) connector.



3. Remove the heated oxygen sensor (HO2S) from the catalytic converter.

To Install:

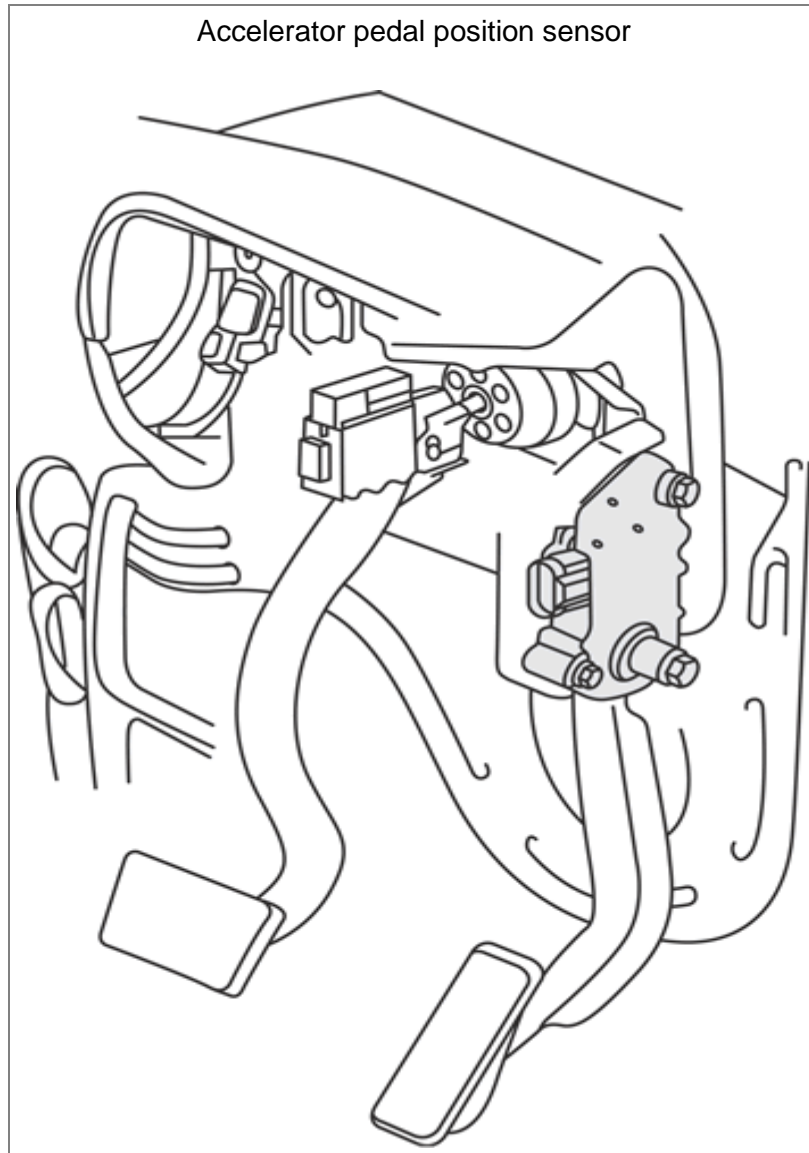
1. If reinstalling the old sensor, apply an anti-seize compound to the heated oxygen sensor (HO2S) threads.
2. Install the heated oxygen sensor (HO2S) into the catalytic converter. Torque the sensor to **31 ft-lb (42 Nm)**.
3. Connect the heated oxygen sensor (HO2S) connector.
4. Lower the vehicle.

Accelerator Pedal Position Sensor

Removal & Installation

To Remove:

1. Disconnect the accelerator pedal position (APP) sensor connector.



2. Detach accelerator pedal position (APP) sensor from the accelerator pedal.

To Install:

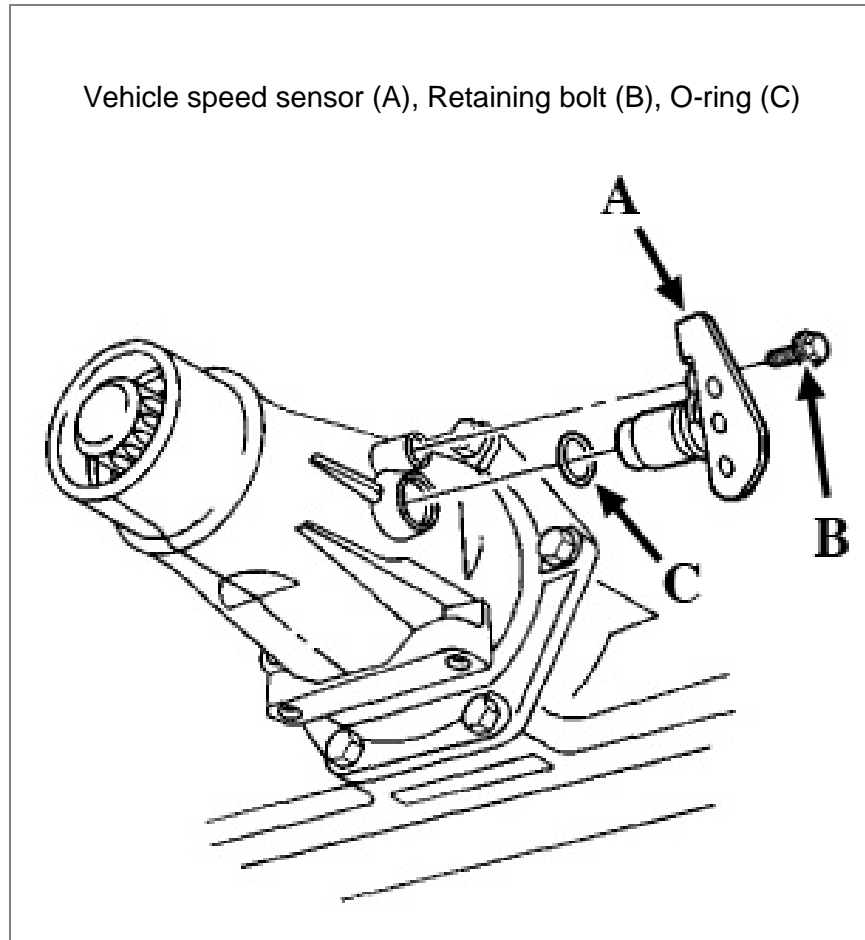
1. Attach the accelerator pedal position (APP) sensor to the accelerator pedal. Torque the fasteners to **89 in-lb (10 Nm)**.
2. Connect the accelerator pedal position (APP) sensor connector.

Vehicle Speed Sensor

Removal & Installation

To Remove:

1. Disconnect the vehicle speed sensor connector.



2. Detach the vehicle speed sensor from the transfer case.
3. Remove the o-ring from the vehicle speed sensor.

To Install:

1. Apply transmission fluid to the o-ring.
2. Install the o-ring onto the vehicle speed sensor.
3. Attach the vehicle speed sensor to the transfer case. Torque the bolt to **97 in-lb (11 Nm)**.
4. Connect the vehicle speed sensor connector.

Trouble Codes

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

General Information

Scan Tools

All late-model vehicles utilize computers to monitor and control the functions of on-board systems. These modules are known by many names such as Engine Control Unit (ECU), Engine Control Module (ECM), Powertrain Control Module (PCM), Transmission Control Module (TCM) and Vehicle Control Module (VCM). When problems occur in control circuits these modules record a diagnostic trouble code that can be used to help solve the problem. There is also freeze frame data and an OBD status report available to the technician. Over the years there have been many different variations of systems, each with their own unique way of retrieving these codes. On a good number of the older systems the stored codes were flashed on check engine lights (found in the dash cluster) once a small jumper wire was placed across the proper diagnostic terminals. However the use of a hand-held scan tool was still preferred for these systems by dealership service departments.

For some models produced during the 1995 model year and on almost every single 1996 and later model a new form of trouble code reporting was developed which required the use of a scan tool. On Board Diagnostic-II (OBD-II) compliant vehicles use a 5 digit, alphanumeric code which would be difficult or impossible to read using a flashing light. Trouble code reading on an OBD-II compliant vehicle requires a scan tool. Flashing trouble codes are a thing of the past.

The scan tool allows any stored codes to be read from the ECM. The tool also allows the operator to view the data being used by the engine management computer while the engine is running, or with the engine OFF and the key ON. This ability has obvious diagnostic advantages; the use of the scan tool is frequently required for component testing. The scan tool makes collecting information easier; the data must be correctly interpreted by an operator familiar with the vehicles operating systems.

An example of the usefulness of the scan tool may be seen in the case of a temperature sensor which has changed its electrical characteristics. The computer module is reacting to an apparently warmer engine (causing a driveability problem) but the sensor's voltage has not changed enough to set a fault code. The voltage signal being sent to the module may be viewed by connecting a scan tool. Comparison to normal values or a known good vehicle reveals the problem quickly.

Generic Codes

DTC Description

P0109 Manifold Absolute Pressure/Barometric Pressure Circuit Intermittent
P0110 Intake Air Temperature Sensor 1 Circuit
P0111 Intake Air Temperature Sensor 1 Circuit Range/Performance
P0112 Intake Air Temperature Sensor 1 Circuit Low
P0113 Intake Air Temperature Sensor 1 Circuit High
P0114 Intake Air Temperature Sensor 1 Circuit Intermittent
P0115 Engine Coolant Temperature Circuit
P0116 Engine Coolant Temperature Circuit Range/Performance
P0117 Engine Coolant Temperature Circuit Low
P0118 Engine Coolant Temperature Circuit High
P0119 Engine Coolant Temperature Circuit Intermittent
P0120 Throttle/Pedal Position Sensor/Switch "A" Circuit
P0121 Throttle/Pedal Position Sensor/Switch "A" Circuit Range/Performance
P0122 Throttle/Pedal Position Sensor/Switch "A" Circuit Low
P0123 Throttle/Pedal Position Sensor/Switch "A" Circuit High
P0124 Throttle/Pedal Position Sensor/Switch "A" Circuit Intermittent
P0125 Insufficient Coolant Temperature for Closed Loop Fuel Control
P0126 Insufficient Coolant Temperature for Stable Operation
P0127 Intake Air Temperature Too High
P0128 Coolant Thermostat (Coolant Temp Below Thermostat Operating Temp
P0129 Barometric Pressure Too Low
P0130 O2 Sensor Circuit - Bank 1 Sensor 1
P0131 O2 Sensor Circuit Low Voltage - Bank 1 Sensor 1
P0132 O2 Sensor Circuit High Voltage - Bank 1 Sensor 1
P0133 O2 Sensor Circuit Slow Response - Bank 1 Sensor 1
P0134 O2 Sensor Circuit No Activity Detected - Bank 1 Sensor 1
P0135 O2 Sensor Heater Circuit - Bank 1 Sensor 1
P0136 O2 Sensor Circuit - Bank 1 Sensor 2
P0137 O2 Sensor Circuit Low Voltage - Bank 1 Sensor 2
P0138 O2 Sensor Circuit High Voltage - Bank 1 Sensor 2
P0139 O2 Sensor Circuit Slow Response - Bank 1 Sensor 2
P0140 O2 Sensor Circuit No Activity Detected - Bank 1 Sensor 2
P0141 O2 Sensor Heater Circuit - Bank 1 Sensor 2
P0142 O2 Sensor Circuit - Bank 1 Sensor 3
P0143 O2 Sensor Circuit Low Voltage - Bank 1 Sensor 3
P0144 O2 Sensor Circuit High Voltage - Bank 1 Sensor 3
P0145 O2 Sensor Circuit Slow Response - Bank 1 Sensor 3
P0146 O2 Sensor Circuit No Activity Detected - Bank 1 Sensor 3
P0147 O2 Sensor Heater Circuit - Bank 1 Sensor 3
P0148 Fuel Delivery Error
P0149 Fuel Timing Error
P0150 O2 Sensor Circuit - Bank 2 Sensor 1
P0151 O2 Sensor Circuit Low Voltage - Bank 2 Sensor 1
P0152 O2 Sensor Circuit High Voltage - Bank 2 Sensor 1
P0153 O2 Sensor Circuit Slow Response - Bank 2 Sensor 1
P0154 O2 Sensor Circuit No Activity Detected - Bank 2 Sensor 1

P0155 O2 Sensor Heater Circuit - Bank 2 Sensor 1
P0156 O2 Sensor Circuit - Bank 2 Sensor 2
P0157 O2 Sensor Circuit Low Voltage - Bank 2 Sensor 2
P0158 O2 Sensor Circuit High Voltage - Bank 2 Sensor 2
P0159 O2 Sensor Circuit Slow Response - Bank 2 Sensor 2
P0160 O2 Sensor Circuit No Activity Detected - Bank 2 Sensor 2
P0161 O2 Sensor Heater Circuit Bank 2 Sensor 2
P0162 O2 Sensor Circuit Bank 2 Sensor 3
P0163 O2 Sensor Circuit Low Voltage Bank 2 Sensor 3
P0164 O2 Sensor Circuit High Voltage Bank 2 Sensor 3
P0165 O2 Sensor Circuit Slow Response Bank 2 Sensor 3
P0166 O2 Sensor Circuit No Activity Detected Bank 2 Sensor 3
P0167 O2 Sensor Heater Circuit Bank 2 Sensor 3
P0168 Fuel Temperature Too High
P0169 Incorrect Fuel Composition
P0170 Fuel Trim Bank 1
P0171 System Too Lean Bank 1
P0172 System Too Rich Bank 1
P0173 Fuel Trim Bank 2
P0174 System Too Lean Bank 2
P0175 System Too Rich Bank 2
P0176 Fuel Composition Sensor Circuit
P0177 Fuel Composition Sensor Circuit Range/Performance
P0178 Fuel Composition Sensor Circuit Low
P0179 Fuel Composition Sensor Circuit High
P0180 Fuel Temperature Sensor A Circuit
P0181 Fuel Temperature Sensor A Circuit Range/Performance
P0182 Fuel Temperature Sensor A Circuit Low
P0183 Fuel Temperature Sensor A Circuit High
P0184 Fuel Temperature Sensor A Circuit Intermittent
P0185 Fuel Temperature Sensor B Circuit
P0186 Fuel Temperature Sensor B Circuit Range/Performance
P0187 Fuel Temperature Sensor B Circuit Low
P0188 Fuel Temperature Sensor B Circuit High
P0189 Fuel Temperature Sensor B Circuit Intermittent
P0190 Fuel Rail Pressure Sensor Circuit
P0191 Fuel Rail Pressure Sensor Circuit Range/Performance
P0192 Fuel Rail Pressure Sensor Circuit Low
P0193 Fuel Rail Pressure Sensor Circuit High
P0194 Fuel Rail Pressure Sensor Circuit Intermittent
P0195 Engine Oil Temperature Sensor
P0196 Engine Oil Temperature Sensor Range/Performance
P0197 Engine Oil Temperature Sensor Low
P0198 Engine Oil Temperature Sensor High
P0199 Engine Oil Temperature Sensor Intermittent
P0200 Injector Circuit/Open
P0201 Injector Circuit/Open Cylinder 1
P0202 Injector Circuit/Open Cylinder 2
P0203 Injector Circuit/Open Cylinder 3
P0204 Injector Circuit/Open Cylinder 4
P0205 Injector Circuit/Open Cylinder 5

P0206 Injector Circuit/Open Cylinder 6
P0207 Injector Circuit/Open Cylinder 7
P0208 Injector Circuit/Open Cylinder 8
P0209 Injector Circuit/Open Cylinder 9
P0210 Injector Circuit/Open Cylinder 10
P0211 Injector Circuit/Open Cylinder 11
P0212 Injector Circuit/Open Cylinder 12
P0213 Cold Start Injector 1
P0214 Cold Start Injector 2
P0215 Engine Shutoff Solenoid
P0216 Injector/Injection Timing Control Circuit
P0217 Engine Coolant Over Temperature Condition
P0218 Transmission Fluid Over Temperature Condition
P0219 Engine Overspeed Condition
P0220 Throttle/Pedal Position Sensor/Switch "B" Circuit
P0221 Throttle/Pedal Position Sensor/Switch "B" Circuit Range/Performance
P0222 Throttle/Pedal Position Sensor/Switch "B" Circuit Low
P0223 Throttle/Pedal Position Sensor/Switch "B" Circuit High
P0224 Throttle/Pedal Position Sensor/Switch "B" Circuit Intermittent
P0225 Throttle/Pedal Position Sensor/Switch "C" Circuit
P0226 Throttle/Pedal Position Sensor/Switch "C" Circuit Range/Performance
P0227 Throttle/Pedal Position Sensor/Switch "C" Circuit Low
P0228 Throttle/Pedal Position Sensor/Switch "C" Circuit High
P0001 Fuel Volume Regulator Control Circuit/Open
P0002 Fuel Volume Regulator Control Circuit Range/Performance
P0003 Fuel Volume Regulator Control Circuit Low
P0004 Fuel Volume Regulator Control Circuit High
P0005 Fuel Shutoff Valve "A" Control Circuit/Open
P0006 Fuel Shutoff Valve "A" Control Circuit Low
P0007 Fuel Shutoff Valve "A" Control Circuit High
P0008 Engine Position System Performance Bank 1
P0009 Engine Position System Performance Bank 2
P0010 a) "A" Camshaft Position Actuator Circuit Bank 1
P0011 a) "A" Camshaft Position - Timing Over-Advanced or System Performance A
P0012 a) "A" Camshaft Position - Timing Over-Retarded Bank 1
P0013 b) "B" Camshaft Position - Actuator Circuit Bank 1
P0014 b) "B" Camshaft Position - Timing Over-Advanced or System Performance
P0015 b) "B" Camshaft Position - Timing Over-Retarded Bank 1
P0016 Crankshaft Position Camshaft Position Correlation Bank 1 Sensor A
P0017 Crankshaft Position Camshaft Position Correlation Bank 1 Sensor B
P0018 Crankshaft Position Camshaft Position Correlation Bank 2 Sensor A
P0019 Crankshaft Position Camshaft Position Correlation Bank 2 Sensor B
P0020 a) "A" Camshaft Position Actuator Circuit Bank 2
P0021 a) "A" Camshaft Position - Timing Over-Advanced or System Performance
P0022 a) "A" Camshaft Position - Timing Over-Retarded Bank 2
P0023 b) "B" Camshaft Position - Actuator Circuit Bank 2
P0024 b) "B" Camshaft Position - Timing Over-Advanced or System Performance
P0025 b) "B" Camshaft Position - Timing Over-Retarded Bank 2
P0026 Intake Valve Control Solenoid Circuit Range/Performance Bank 1
P0027 Exhaust Valve Control Solenoid Circuit Range/Performance Bank 1
P0028 Intake Valve Control Solenoid Circuit Range/Performance Bank 2

P0029 Exhaust Valve Control Solenoid Circuit Range/Performance Bank 2
P0030 HO2S Heater Control Circuit Bank 1 Sensor 1
P0031 HO2S Heater Control Circuit Low Bank 1 Sensor 1
P0032 HO2S Heater Control Circuit High Bank 1 Sensor 1
P0033 Turbo Charger Bypass Valve Control Circuit
P0034 Turbo Charger Bypass Valve Control Circuit Low
P0035 Turbo Charger Bypass Valve Control Circuit High
P0036 HO2S Heater Control Circuit Bank 1 Sensor 2
P0037 HO2S Heater Control Circuit Low Bank 1 Sensor 2
P0038 HO2S Heater Control Circuit High Bank 1 Sensor 2
P0039 Turbo/Super Charger Bypass Valve Control Circuit Range/Performance
P0040 O2 Sensor Signals Swapped Bank 1 Sensor 1/ Bank 2 Sensor 1
P0041 O2 Sensor Signals Swapped Bank 1 Sensor 2/ Bank 2 Sensor 2
P0042 HO2S Heater Control Circuit Bank 1 Sensor 3
P0043 HO2S Heater Control Circuit Low Bank 1 Sensor 3
P0044 HO2S Heater Control Circuit High Bank 1 Sensor 3
P0045 Turbo/Super Charger Boost Control Solenoid Circuit/Open
P0046 Turbo/Super Charger Boost Control Solenoid Circuit Range/Performance
P0047 Turbo/Super Charger Boost Control Solenoid Circuit Low
P0048 Turbo/Super Charger Boost Control Solenoid Circuit High
P0049 Turbo/Super Charger Turbine Overspeed
P0050 HO2S Heater Control Circuit Bank 2 Sensor 1
P0051 HO2S Heater Control Circuit Low Bank 2 Sensor 1
P0052 HO2S Heater Control Circuit High Bank 2 Sensor 1
P0053 HO2S Heater Resistance Bank 1 Sensor 1
P0054 HO2S Heater Resistance Bank 1 Sensor 2
P0055 HO2S Heater Resistance Bank 1 Sensor 3
P0056 HO2S Heater Control Circuit Bank 2 Sensor 2
P0057 HO2S Heater Control Circuit Low Bank 2 Sensor 2
P0058 HO2S Heater Control Circuit High Bank 2 Sensor 2
P0059 HO2S Heater Resistance Bank 2 Sensor 1
P0060 HO2S Heater Resistance Bank 2 Sensor 2
P0061 HO2S Heater Resistance Bank 2 Sensor 3
P0062 HO2S Heater Control Circuit Bank 2 Sensor 3
P0063 HO2S Heater Control Circuit Low Bank 2 Sensor 3
P0064 HO2S Heater Control Circuit High Bank 2 Sensor 3
P0065 Air Assisted Injector Control Range/Performance
P0066 Air Assisted Injector Control Circuit or Circuit Low
P0067 Air Assisted Injector Control Circuit High
P0068 MAP/MAF Throttle Position Correlation
P0069 Manifold Absolute Pressure Barometric Pressure Correlation
P0070 Ambient Air Temperature Sensor Circuit
P0071 Ambient Air Temperature Sensor Range/Performance
P0072 Ambient Air Temperature Sensor Circuit Low
P0073 Ambient Air Temperature Sensor Circuit High
P0074 Ambient Air Temperature Sensor Circuit Intermittent
P0075 Intake Valve Control Solenoid Circuit Bank 1
P0076 Intake Valve Control Solenoid Circuit Low Bank 1
P0077 Intake Valve Control Solenoid Circuit High Bank 1
P0078 Exhaust Valve Control Solenoid Circuit Bank 1
P0079 Exhaust Valve Control Solenoid Circuit Low Bank 1

P0080 Exhaust Valve Control Solenoid Circuit High Bank 1
P0081 Intake Valve Control Solenoid Circuit Bank 2
P0082 Intake Valve Control Solenoid Circuit Low Bank 2
P0083 Intake Valve Control Solenoid Circuit High Bank 2
P0084 Exhaust Valve Control Solenoid Circuit Bank 2
P0085 Exhaust Valve Control Solenoid Circuit Low Bank 2
P0086 Exhaust Valve Control Solenoid Circuit High Bank 2
P0087 Fuel Rail/System Pressure - Too Low
P0088 Fuel Rail/System Pressure - Too High
P0089 Fuel Pressure Regulator 1 Performance
P0090 Fuel Pressure Regulator 1 Control Circuit
P0091 Fuel Pressure Regulator 1 Control Circuit Low
P0092 Fuel Pressure Regulator 1 Control Circuit High
P0093 Fuel System Leak Detected Large Leak
P0094 Fuel System Leak Detected Small Leak
P0095 Intake Air Temperature Sensor 2 Circuit
P0096 Intake Air Temperature Sensor 2 Circuit Range/Performance
P0097 Intake Air Temperature Sensor 2 Circuit Low
P0098 Intake Air Temperature Sensor 2 Circuit High
P0099 Intake Air Temperature Sensor 2 Circuit Intermittent/Erratic
P0100 Mass or Volume Air Flow Circuit
P0101 Mass or Volume Air Flow Circuit Range/Performance
P0102 Mass or Volume Air Flow Circuit Low Input
P0103 Mass or Volume Air Flow Circuit High Input
P0104 Mass or Volume Air Flow Circuit Intermittent
P0105 Manifold Absolute Pressure/Barometric Pressure Circuit
P0106 Manifold Absolute Pressure/Barometric Pressure Circuit Range/Performance
P0107 Manifold Absolute Pressure/Barometric Pressure Circuit Low Input
P0108 Manifold Absolute Pressure/Barometric Pressure Circuit High Input
P0229 Throttle/Pedal Position Sensor/Switch "C" Circuit Intermittent
P0230 Fuel Pump Primary Circuit
P0231 Fuel Pump Secondary Circuit Low
P0232 Fuel Pump Secondary Circuit High
P0233 Fuel Pump Secondary Circuit Intermittent
P0234 Turbo/Super Charger Overboost Condition
P0235 Turbo/Super Charger Boost Sensor "A" Circuit
P0236 Turbo/Super Charger Boost Sensor "A" Circuit Range/Performance
P0237 Turbo/Super Charger Boost Sensor "A" Circuit Low
P0238 Turbo/Super Charger Boost Sensor "A" Circuit High
P0239 Turbo/Super Charger Boost Sensor "B" Circuit
P0240 Turbo/Super Charger Boost Sensor "B" Circuit Range/Performance
P0241 Turbo/Super Charger Boost Sensor "B" Circuit Low
P0242 Turbo/Super Charger Boost Sensor "B" Circuit High
P0243 Turbo/Super Charger Wastegate Solenoid "A"
P0244 Turbo/Super Charger Wastegate Solenoid "A" Range/Performance
P0245 Turbo/Super Charger Wastegate Solenoid "A" Low
P0246 Turbo/Super Charger Wastegate Solenoid "A" High
P0247 Turbo/Super Charger Wastegate Solenoid "B"
P0248 Turbo/Super Charger Wastegate Solenoid "B" Range/Performance
P0249 Turbo/Super Charger Wastegate Solenoid "B" Low
P0250 Turbo/Super Charger Wastegate Solenoid "B" High

P0251 Injection Pump Fuel Metering Control "A" (Cam/Rotor/Injector)
P0252 Injection Pump Fuel Metering Control "A" Range/Performance (Cam/Rotor/Injector)
P0253 Injection Pump Fuel Metering Control "A" Low (Cam/Rotor/Injector)
P0254 Injection Pump Fuel Metering Control "A" High (Cam/Rotor/Injector)
P0255 Injection Pump Fuel Metering Control "A" Intermittent (Cam/Rotor/Injector)
P0256 Injection Pump Fuel Metering Control "B" (Cam/Rotor/Injector)
P0257 Injection Pump Fuel Metering Control "B" Range/Performance (Cam/Rotor/Injector)
P0258 Injection Pump Fuel Metering Control "B" Low (Cam/Rotor/Injector)
P0259 Injection Pump Fuel Metering Control "B" High (Cam/Rotor/Injector)
P0260 Injection Pump Fuel Metering Control "B" Intermittent (Cam/Rotor/Injector)
P0261 Cylinder 1 Injector Circuit Low
P0262 Cylinder 1 Injector Circuit High
P0263 Cylinder 1 Contribution/Balance
P0264 Cylinder 2 Injector Circuit Low
P0265 Cylinder 2 Injector Circuit High
P0266 Cylinder 2 Contribution/Balance
P0267 Cylinder 3 Injector Circuit Low
P0268 Cylinder 3 Injector Circuit High
P0269 Cylinder 3 Contribution/Balance
P0270 Cylinder 4 Injector Circuit Low
P0271 Cylinder 4 Injector Circuit High
P0272 Cylinder 4 Contribution/Balance
P0273 Cylinder 5 Injector Circuit Low
P0274 Cylinder 5 Injector Circuit High
P0275 Cylinder 5 Contribution/Balance
P0276 Cylinder 6 Injector Circuit Low
P0277 Cylinder 6 Injector Circuit High
P0278 Cylinder 6 Contribution/Balance
P0279 Cylinder 7 Injector Circuit Low
P0280 Cylinder 7 Injector Circuit High
P0281 Cylinder 7 Contribution/Balance
P0282 Cylinder 8 Injector Circuit Low
P0283 Cylinder 8 Injector Circuit High
P0284 Cylinder 8 Contribution/Balance
P0285 Cylinder 9 Injector Circuit Low
P0286 Cylinder 9 Injector Circuit High
P0287 Cylinder 9 Contribution/Balance
P0288 Cylinder 10 Injector Circuit Low
P0289 Cylinder 10 Injector Circuit High
P0290 Cylinder 10 Contribution/Balance
P0291 Cylinder 11 Injector Circuit Low
P0292 Cylinder 11 Injector Circuit High
P0293 Cylinder 11 Contribution/Balance
P0294 Cylinder 12 Injector Circuit Low
P0295 Cylinder 12 Injector Circuit High
P0296 Cylinder 12 Contribution/Balance
P0297 Vehicle Overspeed Condition
P0298 Engine Oil Over Temperature
P0299 Turbo/Super Charger Underboost
P0300 Random/Multiple Cylinder Misfire Detected
P0301 Cylinder 1 Misfire Detected

P0302 Cylinder 2 Misfire Detected
P0303 Cylinder 3 Misfire Detected
P0304 Cylinder 4 Misfire Detected
P0305 Cylinder 5 Misfire Detected
P0306 Cylinder 6 Misfire Detected
P0307 Cylinder 7 Misfire Detected
P0308 Cylinder 8 Misfire Detected
P0309 Cylinder 9 Misfire Detected
P0310 Cylinder 10 Misfire Detected
P0311 Cylinder 11 Misfire Detected
P0312 Cylinder 12 Misfire Detected
P0313 Misfire Detected with Low Fuel
P0314 Single Cylinder Misfire (Cylinder not Specified)
P0315 Crankshaft Position System Variation Not Learned
P0316 Engine Misfire Detected on Startup (First 1000 Revolutions)
P0317 Rough Road Hardware Not Present
P0318 Rough Road Sensor "A" Signal Circuit
P0319 Rough Road Sensor "B"
P0320 Ignition/Distributor Engine Speed Input Circuit
P0321 Ignition/Distributor Engine Speed Input Circuit Range/Performance
P0322 Ignition/Distributor Engine Speed Input Circuit No Signal
P0323 Ignition/Distributor Engine Speed Input Circuit Intermittent
P0324 Knock Control System Error
P0325 Knock Sensor 1 Circuit Bank 1 or Single Sensor
P0326 Knock Sensor 1 Circuit Range/Performance Bank 1 or Single Sensor
P0327 Knock Sensor 1 Circuit Low Bank 1 or Single Sensor
P0328 Knock Sensor 1 Circuit High Bank 1 or Single Sensor
P0329 Knock Sensor 1 Circuit Input Intermittent Bank 1 or Single Sensor
P0330 Knock Sensor 2 Circuit Bank 2
P0331 Knock Sensor 2 Circuit Range/Performance Bank 2
P0332 Knock Sensor 2 Circuit Low Bank 2
P0333 Knock Sensor 2 Circuit High Bank 2
P0334 Knock Sensor 2 Circuit Input Intermittent Bank 2
P0335 Crankshaft Position Sensor "A" Circuit
P0336 Crankshaft Position Sensor "A" Circuit Range/Performance
P0337 Crankshaft Position Sensor "A" Circuit Low
P0338 Crankshaft Position Sensor "A" Circuit High
P0339 Crankshaft Position Sensor "A" Circuit Intermittent
P0340 Camshaft Position Sensor "A" Circuit Bank 1 or Single Sensor
P0341 Camshaft Position Sensor "A" Circuit Range/Performance Bank 1 or Single Sensor
P0342 Camshaft Position Sensor "A" Circuit Low Bank 1 or Single Sensor
P0343 Camshaft Position Sensor "A" Circuit High Bank 1 or Single Sensor
P0344 Camshaft Position Sensor "A" Circuit Intermittent Bank 1 or Single Sensor
P0345 Camshaft Position Sensor "A" Circuit Bank 2
P0346 Camshaft Position Sensor "A" Circuit Range/Performance Bank 2
P0347 Camshaft Position Sensor "A" Circuit Low Bank 2
P0348 Camshaft Position Sensor "A" Circuit High Bank 2
P0349 Camshaft Position Sensor "A" Circuit Intermittent Bank 2
P0350 Ignition Coil Primary/Secondary Circuit
P0351 Ignition Coil "A" Primary/Secondary Circuit
P0352 Ignition Coil "B" Primary/Secondary Circuit

P0353 Ignition Coil "C" Primary/Secondary Circuit
P0354 Ignition Coil "D" Primary/Secondary Circuit
P0355 Ignition Coil "E" Primary/Secondary Circuit
P0356 Ignition Coil "F" Primary/Secondary Circuit
P0357 Ignition Coil "G" Primary/Secondary Circuit
P0358 Ignition Coil "H" Primary/Secondary Circuit
P0359 Ignition Coil "I" Primary/Secondary Circuit
P0360 Ignition Coil "J" Primary/Secondary Circuit
P0361 Ignition Coil "K" Primary/Secondary Circuit
P0362 Ignition Coil "L" Primary/Secondary Circuit
P0363 Misfire Detected Fueling Disabled
P0364 Reserved
P0365 Camshaft Position Sensor "B" Circuit Bank 1
P0366 Camshaft Position Sensor "B" Circuit Range/Performance Bank 1
P0367 Camshaft Position Sensor "B" Circuit Low Bank 1
P0368 Camshaft Position Sensor "B" Circuit High Bank 1
P0369 Camshaft Position Sensor "B" Circuit Intermittent Bank 1
P0370 Timing Reference High Resolution Signal "A"
P0371 Timing Reference High Resolution Signal "A" Too Many Pulses
P0372 Timing Reference High Resolution Signal "A" Too Few Pulses
P0373 Timing Reference High Resolution Signal "A" Intermittent/Erratic Pulses
P0374 Timing Reference High Resolution Signal "A" No Pulse
P0375 Timing Reference High Resolution Signal "B"
P0376 Timing Reference High Resolution Signal "B" Too Many Pulses
P0377 Timing Reference High Resolution Signal "B" Too Few Pulses
P0378 Timing Reference High Resolution Signal "B" Intermittent/Erratic Pulses
P0379 Timing Reference High Resolution Signal "B" No Pulses
P0380 Glow Plug/Heater Circuit "A"
P0381 Glow Plug/Heater Indicator Circuit
P0382 Glow Plug/Heater Circuit "B"
P0383 P0384 Reserved by document
P0385 Crankshaft Position Sensor "B" Circuit
P0386 Crankshaft Position Sensor "B" Circuit Range/Performance
P0387 Crankshaft Position Sensor "B" Circuit Low
P0388 Crankshaft Position Sensor "B" Circuit High
P0389 Crankshaft Position Sensor "B" Circuit Intermittent
P0390 Camshaft Position Sensor "B" Circuit Bank 2
P0391 Camshaft Position Sensor "B" Circuit Range/Performance Bank 2
P0392 Camshaft Position Sensor "B" Circuit Low Bank 2
P0393 Camshaft Position Sensor "B" Circuit High Bank 2
P0394 Camshaft Position Sensor "B" Circuit Intermittent Bank 2
P0400 Exhaust Gas Recirculation Flow
P0401 Exhaust Gas Recirculation Flow Insufficient Detected
P0402 Exhaust Gas Recirculation Flow Excessive Detected
P0403 Exhaust Gas Recirculation Control Circuit
P0404 Exhaust Gas Recirculation Control Circuit Range/Performance
P0405 Exhaust Gas Recirculation Sensor "A" Circuit Low
P0406 Exhaust Gas Recirculation Sensor "A" Circuit High
P0407 Exhaust Gas Recirculation Sensor "B" Circuit Low
P0408 Exhaust Gas Recirculation Sensor "B" Circuit High
P0409 Exhaust Gas Recirculation Sensor "A" Circuit

P0410 Secondary Air Injection System
P0411 Secondary Air Injection System Incorrect Flow Detected
P0412 Secondary Air Injection System Switching Valve "A" Circuit
P0413 Secondary Air Injection System Switching Valve "A" Circuit Open
P0414 Secondary Air Injection System Switching Valve "A" Circuit Shorted
P0415 Secondary Air Injection System Switching Valve "B" Circuit
P0416 Secondary Air Injection System Switching Valve "B" Circuit Open
P0417 Secondary Air Injection System Switching Valve "B" Circuit Shorted
P0418 Secondary Air Injection System Control "A" Circuit
P0419 Secondary Air Injection System Control "B" Circuit
P0420 Catalyst System Efficiency Below Threshold Bank 1
P0421 Warm Up Catalyst Efficiency Below Threshold Bank 1
P0422 Main Catalyst Efficiency Below Threshold Bank 1
P0423 Heated Catalyst Efficiency Below Threshold Bank 1
P0424 Heated Catalyst Temperature Below Threshold Bank 1
P0425 Catalyst Temperature Sensor Bank 1
P0426 Catalyst Temperature Sensor Range/Performance Bank 1
P0427 Catalyst Temperature Sensor Low Bank 1
P0428 Catalyst Temperature Sensor High Bank 1
P0429 Catalyst Heater Control Circuit Bank 1
P0430 Catalyst System Efficiency Below Threshold Bank 2
P0431 Warm Up Catalyst Efficiency Below Threshold Bank 2
P0432 Main Catalyst Efficiency Below Threshold Bank 2
P0433 Heated Catalyst Efficiency Below Threshold Bank 2
P0434 Heated Catalyst Temperature Below Threshold Bank 2
P0435 Catalyst Temperature Sensor Bank 2
P0436 Catalyst Temperature Sensor Range/Performance Bank 2
P0437 Catalyst Temperature Sensor Low Bank 2
P0438 Catalyst Temperature Sensor High Bank 2
P0439 Catalyst Heater Control Circuit Bank 2
P0440 Evaporative Emission System
P0441 Evaporative Emission System Incorrect Purge Flow
P0442 Evaporative Emission System Leak Detected (small leak)
P0443 Evaporative Emission System Purge Control Valve Circuit
P0444 Evaporative Emission System Purge Control Valve Circuit Open
P0445 Evaporative Emission System Purge Control Valve Circuit Shorted
P0446 Evaporative Emission System Vent Control Circuit
P0447 Evaporative Emission System Vent Control Circuit Open
P0448 Evaporative Emission System Vent Control Circuit Shorted
P0449 Evaporative Emission System Vent Valve/Solenoid Circuit
P0450 Evaporative Emission System Pressure Sensor/Switch
P0451 Evaporative Emission System Pressure Sensor/Switch Range/Performance
P0452 Evaporative Emission System Pressure Sensor/Switch Low
P0453 Evaporative Emission System Pressure Sensor/Switch High
P0454 Evaporative Emission System Pressure Sensor/Switch Intermittent
P0455 Evaporative Emission System Leak Detected (large leak)
P0456 Evaporative Emission System Leak Detected (very small leak)
P0457 Evaporative Emission System Leak Detected (fuel cap loose/off)
P0458 Evaporative Emission System Purge Control Valve Circuit Low
P0459 Evaporative Emission System Purge Control Valve Circuit High
P0460 Fuel Level Sensor "A" Circuit

P0461 Fuel Level Sensor "A" Circuit Range/Performance
P0462 Fuel Level Sensor "A" Circuit Low
P0463 Fuel Level Sensor "A" Circuit High
P0464 Fuel Level Sensor "A" Circuit Intermittent
P0465 EVAP Purge Flow Sensor Circuit
P0466 EVAP Purge Flow Sensor Circuit Range/Performance
P0467 EVAP Purge Flow Sensor Circuit Low
P0468 EVAP Purge Flow Sensor Circuit High
P0469 EVAP Purge Flow Sensor Circuit Intermittent
P0470 Exhaust Pressure Sensor
P0471 Exhaust Pressure Sensor Range/Performance
P0472 Exhaust Pressure Sensor Low
P0473 Exhaust Pressure Sensor High
P0474 Exhaust Pressure Sensor Intermittent
P0475 Exhaust Pressure Control Valve
P0476 Exhaust Pressure Control Valve Range/Performance
P0477 Exhaust Pressure Control Valve Low
P0478 Exhaust Pressure Control Valve High
P0479 Exhaust Pressure Control Valve Intermittent
P0480 Fan 1 Control Circuit
P0481 Fan 2 Control Circuit
P0482 Fan 3 Control Circuit
P0483 Fan Rationality Check
P0484 Fan Circuit Over Current
P0485 Fan Power/Ground Circuit
P0486 Exhaust Gas Recirculation Sensor "B" Circuit
P0487 Exhaust Gas Recirculation Throttle Position Control Circuit
P0488 Exhaust Gas Recirculation Throttle Position Control Range/Performance
P0489 Exhaust Gas Recirculation Control Circuit Low
P0490 Exhaust Gas Recirculation Control Circuit High
P0491 Secondary Air Injection System Insufficient Flow Bank 1
P0492 Secondary Air Injection System Insufficient Flow Bank 2
P0493 Fan Overspeed
P0494 Fan Speed Low
P0495 Fan Speed High
P0496 Evaporative Emission System High Purge Flow
P0497 Evaporative Emission System Low Purge Flow
P0498 Evaporative Emission System Vent Valve Control Circuit Low
P0499 Evaporative Emission System Vent Valve Control Circuit High
P0500 Vehicle Speed Sensor "A"
P0501 Vehicle Speed Sensor "A" Range/Performance
P0502 Vehicle Speed Sensor "A" Circuit Low Input
P0503 Vehicle Speed Sensor "A" Intermittent/Erratic/High
P0504 Brake Switch "A"/"B" Correlation
P0505 Idle Air Control System
P0506 Idle Air Control System RPM Lower Than Expected
P0507 Idle Air Control System RPM Higher Than Expected
P0508 Idle Air Control System Circuit Low
P0509 Idle Air Control System Circuit High
P0510 Closed Throttle Position Switch
P0511 Idle Air Control Circuit

P0512 Starter Request Circuit
P0513 Incorrect Immobilizer Key
P0514 Battery Temperature Sensor Circuit Range/Performance
P0515 Battery Temperature Sensor Circuit
P0516 Battery Temperature Sensor Circuit Low
P0517 Battery Temperature Sensor Circuit High
P0518 Idle Air Control Circuit Intermittent
P0519 Idle Air Control System Performance
P0520 Engine Oil Pressure Sensor/Switch Circuit
P0521 Engine Oil Pressure Sensor/Switch Range/Performance
P0522 Engine Oil Pressure Sensor/Switch Low Voltage
P0523 Engine Oil Pressure Sensor/Switch High Voltage
P0524 Engine Oil Pressure Too Low
P0525 Cruise Control Servo Control Circuit Range/Performance
P0526 Fan Speed Sensor Circuit
P0527 Fan Speed Sensor Circuit Range/Performance
P0528 Fan Speed Sensor Circuit No Signal
P0529 Fan Speed Sensor Circuit Intermittent
P0530 A/C Refrigerant Pressure Sensor "A" Circuit
P0531 A/C Refrigerant Pressure Sensor "A" Circuit Range/Performance
P0532 A/C Refrigerant Pressure Sensor "A" Circuit Low
P0533 A/C Refrigerant Pressure Sensor "A" Circuit High
P0534 Air Conditioner Refrigerant Charge Loss
P0535 A/C Evaporator Temperature Sensor Circuit
P0536 A/C Evaporator Temperature Sensor Circuit Range/Performance
P0537 A/C Evaporator Temperature Sensor Circuit Low
P0538 A/C Evaporator Temperature Sensor Circuit High
P0539 A/C Evaporator Temperature Sensor Circuit Intermittent
P0540 Intake Air Heater "A" Circuit
P0541 Intake Air Heater "A" Circuit Low
P0542 Intake Air Heater "A" Circuit High
P0543 Intake Air Heater "A" Circuit Open
P0544 Exhaust Gas Temperature Sensor Circuit Bank 1 Sensor 1
P0545 Exhaust Gas Temperature Sensor Circuit Low Bank 1 Sensor 1
P0546 Exhaust Gas Temperature Sensor Circuit High Bank 1 Sensor 1
P0547 Exhaust Gas Temperature Sensor Circuit Bank 2 Sensor 1
P0548 Exhaust Gas Temperature Sensor Circuit Low Bank 2 Sensor 1
P0549 Exhaust Gas Temperature Sensor Circuit High Bank 2 Sensor 1
P0550 Power Steering Pressure Sensor/Switch Circuit
P0551 Power Steering Pressure Sensor/Switch Circuit Range/Performance
P0552 Power Steering Pressure Sensor/Switch Circuit Low Input
P0553 Power Steering Pressure Sensor/Switch Circuit High Input
P0554 Power Steering Pressure Sensor/Switch Circuit Intermittent
P0555 Brake Booster Pressure Sensor Circuit
P0556 Brake Booster Pressure Sensor Circuit Range/Performance
P0557 Brake Booster Pressure Sensor Circuit Low Input
P0558 Brake Booster Pressure Sensor Circuit High Input
P0559 Brake Booster Pressure Sensor Circuit Intermittent
P0560 System Voltage
P0561 System Voltage Unstable
P0562 System Voltage Low

P0563 System Voltage High
P0564 Cruise Control Multi-Function Input "A" Circuit
P0565 Cruise Control On Signal
P0566 Cruise Control Off Signal
P0567 Cruise Control Resume Signal
P0568 Cruise Control Set Signal
P0569 Cruise Control Coast Signal
P0570 Cruise Control Accelerate Signal
P0571 Brake Switch "A" Circuit
P0572 Brake Switch "A" Circuit Low
P0573 Brake Switch "A" Circuit High
P0574 Cruise Control System - Vehicle Speed Too High
P0575 Cruise Control Input Circuit
P0576 Cruise Control Input Circuit Low
P0577 Cruise Control Input Circuit High
P0578 Cruise Control Multi-Function Input "A" Circuit Stuck
P0579 Cruise Control Multi-Function Input "A" Circuit Range/Performance
P0580 Cruise Control Multi-Function Input "A" Circuit Low
P0581 Cruise Control Multi-Function Input "A" Circuit High
P0582 Cruise Control Vacuum Control Circuit/Open
P0583 Cruise Control Vacuum Control Circuit Low
P0584 Cruise Control Vacuum Control Circuit High
P0585 Cruise Control Multi-Function Input "A"/"B" Correlation
P0586 Cruise Control Vent Control Circuit/Open
P0587 Cruise Control Vent Control Circuit Low
P0588 Cruise Control Vent Control Circuit High
P0589 Cruise Control Multi-Function Input "B" Circuit
P0590 Cruise Control Multi-Function Input "B" Circuit Stuck
P0591 Cruise Control Multi-Function Input "B" Circuit Range/Performance
P0592 Cruise Control Multi-Function Input "B" Circuit Low
P0593 Cruise Control Multi-Function Input "B" Circuit High
P0594 Cruise Control Servo Control Circuit/Open
P0595 Cruise Control Servo Control Circuit Low
P0596 Cruise Control Servo Control Circuit High
P0597 Thermostat Heater Control Circuit/Open
P0598 Thermostat Heater Control Circuit Low
P0599 Thermostat Heater Control Circuit High
P0600 Serial Communication Link
P0601 Internal Control Module Memory Check Sum Error
P0602 Control Module Programming Error
P0603 Internal Control Module Keep Alive Memory (KAM) Error
P0604 Internal Control Module Random Access Memory (RAM) Error
P0605 Internal Control Module Read Only Memory (ROM) Error
P0606 ECM/PCM Processor
P0607 Control Module Performance
P0608 Control Module VSS Output "A"
P0609 Control Module VSS Output "B"
P0610 Control Module Vehicle Options Error
P0611 Fuel Injector Control Module Performance
P0612 Fuel Injector Control Module Relay Control
P0613 TCM Processor

P0614 ECM / TCM Incompatible
P0615 Starter Relay Circuit
P0616 Starter Relay Circuit Low
P0617 Starter Relay Circuit High
P0618 Alternative Fuel Control Module KAM Error
P0619 Alternative Fuel Control Module RAM/ROM Error
P0620 Generator Control Circuit
P0621 Generator Lamp/L Terminal Circuit
P0622 Generator Field/F Terminal Circuit
P0623 Generator Lamp Control Circuit
P0624 Fuel Cap Lamp Control Circuit
P0625 Generator Field/F Terminal Circuit Low
P0626 Generator Field/F Terminal Circuit High
P0627 Fuel Pump "A" Control Circuit /Open
P0628 Fuel Pump "A" Control Circuit Low
P0629 Fuel Pump "A" Control Circuit High
P0630 VIN Not Programmed or Incompatible ECM/PCM
P0631 VIN Not Programmed or Incompatible TCM
P0632 Odometer Not Programmed ECM/PCM
P0633 Immobilizer Key Not Programmed ECM/PCM
P0634 PCM/ECM/TCM Internal Temperature Too High
P0635 Power Steering Control Circuit
P0636 Power Steering Control Circuit Low
P0637 Power Steering Control Circuit High
P0638 Throttle Actuator Control Range/Performance Bank 1
P0639 Throttle Actuator Control Range/Performance Bank 2
P0640 Intake Air Heater Control Circuit
P0641 Sensor Reference Voltage "A" Circuit/Open
P0642 Sensor Reference Voltage "A" Circuit Low
P0643 Sensor Reference Voltage "A" Circuit High
P0644 Driver Display Serial Communication Circuit
P0645 A/C Clutch Relay Control Circuit
P0646 A/C Clutch Relay Control Circuit Low
P0647 A/C Clutch Relay Control Circuit High
P0648 Immobilizer Lamp Control Circuit
P0649 Speed Control Lamp Control Circuit
P0650 Malfunction Indicator Lamp (MIL) Control Circuit
P0651 Sensor Reference Voltage "B" Circuit/Open
P0652 Sensor Reference Voltage "B" Circuit Low
P0653 Sensor Reference Voltage "B" Circuit High
P0654 Engine RPM Output Circuit
P0655 Engine Hot Lamp Output Control Circuit
P0656 Fuel Level Output Circuit
P0657 Actuator Supply Voltage "A" Circuit/Open
P0658 Actuator Supply Voltage "A" Circuit Low
P0659 Actuator Supply Voltage "A" Circuit High
P0660 Intake Manifold Tuning Valve Control Circuit/Open Bank 1 a)
P0661 Intake Manifold Tuning Valve Control Circuit Low Bank 1 a)
P0662 Intake Manifold Tuning Valve Control Circuit High Bank 1 a)
P0663 Intake Manifold Tuning Valve Control Circuit/Open Bank 2 a)
P0664 Intake Manifold Tuning Valve Control Circuit Low Bank 2 a)

P0665 Intake Manifold Tuning Valve Control Circuit High Bank 2 a)
P0666 PCM/ECM/TCM Internal Temperature Sensor Circuit
P0667 PCM/ECM/TCM Internal Temperature Sensor Range/Performance
P0668 PCM/ECM/TCM Internal Temperature Sensor Circuit Low
P0669 PCM/ECM/TCM Internal Temperature Sensor Circuit High
P0670 Glow Plug Module Control Circuit
P0671 Cylinder 1 Glow Plug Circuit
P0672 Cylinder 2 Glow Plug Circuit
P0673 Cylinder 3 Glow Plug Circuit
P0674 Cylinder 4 Glow Plug Circuit
P0675 Cylinder 5 Glow Plug Circuit
P0676 Cylinder 6 Glow Plug Circuit
P0677 Cylinder 7 Glow Plug Circuit
P0678 Cylinder 8 Glow Plug Circuit
P0679 Cylinder 9 Glow Plug Circuit
P0680 Cylinder 10 Glow Plug Circuit
P0681 Cylinder 11 Glow Plug Circuit
P0682 Cylinder 12 Glow Plug Circuit
P0683 Glow Plug Control Module to PCM Communication Circuit
P0684 Glow Plug Control Module to PCM Communication Circuit Range/Performance
P0685 ECM/PCM Power Relay Control Circuit /Open
P0686 ECM/PCM Power Relay Control Circuit Low
P0687 ECM/PCM Power Relay Control Circuit High
P0688 ECM/PCM Power Relay Sense Circuit /Open
P0689 ECM/PCM Power Relay Sense Circuit Low
P0690 ECM/PCM Power Relay Sense Circuit High
P0691 Fan 1 Control Circuit Low
P0692 Fan 1 Control Circuit High
P0693 Fan 2 Control Circuit Low
P0694 Fan 2 Control Circuit High
P0695 Fan 3 Control Circuit Low
P0696 Fan 3 Control Circuit High
P0697 Sensor Reference Voltage "C" Circuit/Open
P0698 Sensor Reference Voltage "C" Circuit Low
P0699 Sensor Reference Voltage "C" Circuit High
P0700 Transmission Control System (MIL Request)
P0701 Transmission Control System Range/Performance
P0702 Transmission Control System Electrical
P0703 Brake Switch "B" Circuit
P0704 Clutch Switch Input Circuit Malfunction
P0705 Transmission Range Sensor Circuit Malfunction (PRNDL Input)
P0706 Transmission Range Sensor Circuit Range/Performance
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P0709 Transmission Range Sensor Circuit Intermittent
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P0716 Input/Turbine Speed Sensor "A" Circuit Range/Performance
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P0767 Shift Solenoid "D" Stuck On
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P0879 Transmission Fluid Pressure Sensor/Switch "D" Circuit Intermittent
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P0882 TCM Power Input Signal Low
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P0943 Hydraulic Pressure Unit Cycling Period Too Short
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P0954 Auto Shift Manual Control Circuit Intermittent
P0955 Auto Shift Manual Mode Circuit
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P0957 Auto Shift Manual Mode Circuit Low
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P0960 Pressure Control Solenoid "A" Control Circuit/Open
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P0966 Pressure Control Solenoid "B" Control Circuit Low
P0967 Pressure Control Solenoid "B" Control Circuit High
P0968 Pressure Control Solenoid "C" Control Circuit/Open
P0969 Pressure Control Solenoid "C" Control Circuit Range/Performance
P0970 Pressure Control Solenoid "C" Control Circuit Low

P0971 Pressure Control Solenoid "C" Control Circuit High
P0972 Shift Solenoid "A" Control Circuit Range/Performance
P0973 Shift Solenoid "A" Control Circuit Low
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P0975 Shift Solenoid "B" Control Circuit Range/Performance
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P0978 Shift Solenoid "C" Control Circuit Range/Performance
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P0989 Transmission Fluid Pressure Sensor/Switch "E" Circuit Low
P0990 Transmission Fluid Pressure Sensor/Switch "E" Circuit High
P0991 Transmission Fluid Pressure Sensor/Switch "E" Circuit Intermittent
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P0994 Transmission Fluid Pressure Sensor/Switch "F" Circuit Low
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P2015 Intake Manifold Runner Position Sensor/Switch Circuit Range/Performance Bank 1 a)
P2016 Intake Manifold Runner Position Sensor/Switch Circuit Low Bank 1 a)
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P2019 Intake Manifold Runner Position Sensor/Switch Circuit Bank 2 a)
P2020 Intake Manifold Runner Position Sensor/Switch Circuit Range/Performance Bank 2 a)
P2021 Intake Manifold Runner Position Sensor/Switch Circuit Low Bank 2 a)
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P2026 Evaporative Emissions (EVAP) Fuel Vapor Temperature Sensor Circuit Low Voltage
P2027 Evaporative Emissions (EVAP) Fuel Vapor Temperature Sensor Circuit High Voltage
P2028 Evaporative Emissions (EVAP) Fuel Vapor Temperature Sensor Circuit Intermittent
P2029 Fuel Fired Heater Disabled
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P2031 Exhaust Gas Temperature Sensor Circuit Bank 1 Sensor 2
P2032 Exhaust Gas Temperature Sensor Circuit Low Bank 1 Sensor 2
P2033 Exhaust Gas Temperature Sensor Circuit High Bank 1 Sensor 2
P2034 Exhaust Gas Temperature Sensor Circuit Bank 2 Sensor 2
P2035 Exhaust Gas Temperature Sensor Circuit Low Bank 2 Sensor 2
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P2037 Reductant Injection Air Pressure Sensor Circuit
P2038 Reductant Injection Air Pressure Sensor Circuit Range/Performance

P2039 Reductant Injection Air Pressure Sensor Circuit Low Input
P2040 Reductant Injection Air Pressure Sensor Circuit High Input
P2041 Reductant Injection Air Pressure Sensor Circuit Intermittent
P2042 Reductant Temperature Sensor Circuit
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P2048 Reductant Injector Circuit Low Bank 1 Unit 1
P2049 Reductant Injector Circuit High Bank 1 Unit 1
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P2059 Reductant Injection Air Pump Control Circuit/Open
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P2063 Reductant Supply Control Circuit Low
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P2065 Fuel Level Sensor "B" Circuit
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P2067 Fuel Level Sensor "B" Circuit Low
P2068 Fuel Level Sensor "B" Circuit High
P2069 Fuel Level Sensor "B" Circuit Intermittent
P2070 Intake Manifold Tuning (IMT) Valve Stuck Open a)
P2071 Intake Manifold Tuning (IMT) Valve Stuck Closed a)
P2075 Intake Manifold Tuning (IMT) Valve Position Sensor/Switch Circuit a)
P2076 Intake Manifold Tuning (IMT) Valve Position Sensor/Switch Circuit
Range/Performance a)
P2077 Intake Manifold Tuning (IMT) Valve Position Sensor/Switch Circuit Low a)
P2078 Intake Manifold Tuning (IMT) Valve Position Sensor/Switch Circuit High a)
P2079 Intake Manifold Tuning (IMT) Valve Position Sensor/Switch Circuit Intermittent a)
P2080 Exhaust Gas Temperature Sensor Circuit Range/Performance Bank 1 Sensor 1
P2081 Exhaust Gas Temperature Sensor Circuit Intermittent Bank 1 Sensor 1
P2082 Exhaust Gas Temperature Sensor Circuit Range/Performance Bank 2 Sensor 1
P2083 Exhaust Gas Temperature Sensor Circuit Intermittent Bank 2 Sensor 1
P2084 Exhaust Gas Temperature Sensor Circuit Range/Performance Bank 1 Sensor 2
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P2086 Exhaust Gas Temperature Sensor Circuit Range/Performance Bank 2 Sensor 2
P2087 Exhaust Gas Temperature Sensor Circuit Intermittent Bank 2 Sensor 2
P2088 1) "A" Camshaft Position Actuator Control Circuit Low Bank 1 b)
P2089 1) "A" Camshaft Position Actuator Control Circuit High Bank 1 b)
P2090 1) "B" Camshaft Position Actuator Control Circuit Low Bank 1 c)
P2091 1) "B" Camshaft Position Actuator Control Circuit High Bank 1 c)

P2092 1) "A" Camshaft Position Actuator Control Circuit Low Bank 2 b)
P2093 1) "A" Camshaft Position Actuator Control Circuit High Bank 2 b)
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P2096 Post Catalyst Fuel Trim System Too Lean Bank 1
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P2100 Throttle Actuator Control Motor Circuit/Open
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P2102 Throttle Actuator Control Motor Circuit Low
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P2104 Throttle Actuator Control System - Forced Idle
P2105 Throttle Actuator Control System - Forced Engine Shutdown
P2106 Throttle Actuator Control System - Forced Limited Power
P2107 Throttle Actuator Control Module Processor
P2108 Throttle Actuator Control Module Performance
P2109 Throttle/Pedal Position Sensor "A" Minimum Stop Performance
P2110 Throttle Actuator Control System - Forced Limited RPM
P2111 Throttle Actuator Control System - Stuck Open
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P2113 Throttle/Pedal Position Sensor "B" Minimum Stop Performance
P2114 Throttle/Pedal Position Sensor "C" Minimum Stop Performance
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P2116 Throttle/Pedal Position Sensor "E" Minimum Stop Performance
P2117 Throttle/Pedal Position Sensor "F" Minimum Stop Performance
P2118 Throttle Actuator Control Motor Current Range/Performance
P2119 Throttle Actuator Control Throttle Body Range/Performance
P2120 Throttle/Pedal Position Sensor/Switch "D" Circuit
P2121 Throttle/Pedal Position Sensor/Switch "D" Circuit Range/Performance
P2122 Throttle/Pedal Position Sensor/Switch "D" Circuit Low Input
P2123 Throttle/Pedal Position Sensor/Switch "D" Circuit High Input
P2124 Throttle/Pedal Position Sensor/Switch "D" Circuit Intermittent
P2125 Throttle/Pedal Position Sensor/Switch "E" Circuit
P2126 Throttle/Pedal Position Sensor/Switch "E" Circuit Range/Performance
P2127 Throttle/Pedal Position Sensor/Switch "E" Circuit Low Input
P2128 Throttle/Pedal Position Sensor/Switch "E" Circuit High Input
P2129 Throttle/Pedal Position Sensor/Switch "E" Circuit Intermittent
P2130 Throttle/Pedal Position Sensor/Switch "F" Circuit
P2131 Throttle/Pedal Position Sensor/Switch "F" Circuit Range Performance
P2132 Throttle/Pedal Position Sensor/Switch "F" Circuit Low Input
P2133 Throttle/Pedal Position Sensor/Switch "F" Circuit High Input
P2134 Throttle/Pedal Position Sensor/Switch "F" Circuit Intermittent
P2135 Throttle/Pedal Position Sensor/Switch "A" / "B" Voltage Correlation
P2136 Throttle/Pedal Position Sensor/Switch "A" / "C" Voltage Correlation
P2137 Throttle/Pedal Position Sensor/Switch "B" / "C" Voltage Correlation
P2138 Throttle/Pedal Position Sensor/Switch "D" / "E" Voltage Correlation
P2139 Throttle/Pedal Position Sensor/Switch "D" / "F" Voltage Correlation
P2140 Throttle/Pedal Position Sensor/Switch "E" / "F" Voltage Correlation
P2141 Exhaust Gas Recirculation Throttle Control Circuit Low
P2142 Exhaust Gas Recirculation Throttle Control Circuit High

P2143 Exhaust Gas Recirculation Vent Control Circuit/Open
P2144 Exhaust Gas Recirculation Vent Control Circuit Low
P2145 Exhaust Gas Recirculation Vent Control Circuit High
P2146 Fuel Injector Group "A" Supply Voltage Circuit/Open
P2147 Fuel Injector Group "A" Supply Voltage Circuit Low
P2148 Fuel Injector Group "A" Supply Voltage Circuit High
P2149 Fuel Injector Group "B" Supply Voltage Circuit/Open
P2150 Fuel Injector Group "B" Supply Voltage Circuit Low
P2151 Fuel Injector Group "B" Supply Voltage Circuit High
P2152 Fuel Injector Group "C" Supply Voltage Circuit/Open
P2153 Fuel Injector Group "C" Supply Voltage Circuit Low
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P2160 Vehicle Speed Sensor "B" Circuit Low
P2161 Vehicle Speed Sensor "B" Intermittent/Erratic
P2162 Vehicle Speed Sensor "A" / "B" Correlation
P2163 Throttle/Pedal Position Sensor "A" Maximum Stop Performance
P2164 Throttle/Pedal Position Sensor "B" Maximum Stop Performance
P2165 Throttle/Pedal Position Sensor "C" Maximum Stop Performance
P2166 Throttle/Pedal Position Sensor "D" Maximum Stop Performance
P2167 Throttle/Pedal Position Sensor "E" Maximum Stop Performance
P2168 Throttle/Pedal Position Sensor "F" Maximum Stop Performance
P2169 Exhaust Pressure Regulator Vent Solenoid Control Circuit/Open
P2170 Exhaust Pressure Regulator Vent Solenoid Control Circuit Low
P2171 Exhaust Pressure Regulator Vent Solenoid Control Circuit High
P2172 Throttle Actuator Control System – Sudden High Airflow Detected
P2173 Throttle Actuator Control System – High Airflow Detected
P2174 Throttle Actuator Control System – Sudden Low Airflow Detected
P2175 Throttle Actuator Control System – Low Airflow Detected
P2176 Throttle Actuator Control System – Idle Position Not Learned
P2177 System Too Lean Off Idle Bank 1
P2178 System Too Rich Off Idle Bank 1
P2179 System Too Lean Off Idle Bank 2
P2180 System Too Rich Off Idle Bank 2
P2181 Cooling System Performance
P2182 Engine Coolant Temperature Sensor 2 Circuit
P2183 Engine Coolant Temperature Sensor 2 Circuit Range/Performance
P2184 Engine Coolant Temperature Sensor 2 Circuit Low
P2185 Engine Coolant Temperature Sensor 2 Circuit High
P2186 Engine Coolant Temperature Sensor 2 Circuit Intermittent/Erratic
P2187 System Too Lean at Idle Bank 1
P2188 System Too Rich at Idle Bank 1
P2189 System Too Lean at Idle Bank 2
P2190 System Too Rich at Idle Bank 2
P2191 System Too Lean at Higher Load Bank 1
P2192 System Too Rich at Higher Load Bank 1
P2193 System Too Lean at Higher Load Bank 2

P2194 System Too Rich at Higher Load Bank 2
P2195 O2 Sensor Signal Stuck Lean Bank 1 Sensor 1
P2196 O2 Sensor Signal Stuck Rich Bank 1 Sensor 1
P2197 O2 Sensor Signal Stuck Lean Bank 2 Sensor 1
P2198 O2 Sensor Signal Stuck Rich Bank 2 Sensor 1
P2199 Intake Air Temperature Sensor 1 / 2 Correlation
P2200 NOx Sensor Circuit Bank 1
P2201 NOx Sensor Circuit Range/Performance Bank 1
P2202 NOx Sensor Circuit Low Input Bank 1
P2203 NOx Sensor Circuit High Input Bank 1
P2204 NOx Sensor Circuit Intermittent Input Bank 1
P2205 NOx Sensor Heater Control Circuit/Open Bank 1
P2206 NOx Sensor Heater Control Circuit Low Bank 1
P2207 NOx Sensor Heater Control Circuit High Bank 1
P2208 NOx Sensor Heater Sense Circuit Bank 1
P2209 NOx Sensor Heater Sense Circuit Range/Performance Bank 1
P2210 NOx Sensor Heater Sense Circuit Low Input Bank 1
P2211 NOx Sensor Heater Sense Circuit High Input Bank 1
P2212 NOx Sensor Heater Sense Circuit Intermittent Bank 1
P2213 NOx Sensor Circuit Bank 2
P2214 NOx Sensor Circuit Range/Performance Bank 2
P2215 NOx Sensor Circuit Low Input Bank 2
P2216 NOx Sensor Circuit High Input Bank 2
P2217 NOx Sensor Circuit Intermittent Input Bank 2
P2218 NOx Sensor Heater Control Circuit/Open Bank 2
P2219 NOx Sensor Heater Control Circuit Low Bank 2
P2220 NOx Sensor Heater Control Circuit High Bank 2
P2221 NOx Sensor Heater Sense Circuit Bank 2
P2222 NOx Sensor Heater Sense Circuit Range/Performance Bank 2
P2223 NOx Sensor Heater Sense Circuit Low Bank 2
P2224 NOx Sensor Heater Sense Circuit High Bank 2
P2225 NOx Sensor Heater Sense Circuit Intermittent Bank 2
P2226 Barometric Pressure Circuit
P2227 Barometric Pressure Circuit Range/Performance
P2228 Barometric Pressure Circuit Low
P2229 Barometric Pressure Circuit High
P2230 Barometric Pressure Circuit Intermittent
P2231 O2 Sensor Signal Circuit Shorted to Heater Circuit Bank 1 Sensor 1
P2232 O2 Sensor Signal Circuit Shorted to Heater Circuit Bank 1 Sensor 2
P2233 O2 Sensor Signal Circuit Shorted to Heater Circuit Bank 1 Sensor 3
P2234 O2 Sensor Signal Circuit Shorted to Heater Circuit Bank 2 Sensor 1
P2235 O2 Sensor Signal Circuit Shorted to Heater Circuit Bank 2 Sensor 2
P2236 O2 Sensor Signal Circuit Shorted to Heater Circuit Bank 2 Sensor 3
P2237 O2 Sensor Positive Current Control Circuit/Open Bank 1 Sensor 1
P2238 O2 Sensor Positive Current Control Circuit Low Bank 1 Sensor 1
P2239 O2 Sensor Positive Current Control Circuit High Bank 1 Sensor 1
P2240 O2 Sensor Positive Current Control Circuit/Open Bank 2 Sensor 1
P2241 O2 Sensor Positive Current Control Circuit Low Bank 2 Sensor 1
P2242 O2 Sensor Positive Current Control Circuit High Bank 2 Sensor 1
P2243 O2 Sensor Reference Voltage Circuit/Open Bank 1 Sensor 1
P2244 O2 Sensor Reference Voltage Performance Bank 1 Sensor 1

P2245 O2 Sensor Reference Voltage Circuit Low Bank 1 Sensor 1
P2246 O2 Sensor Reference Voltage Circuit High Bank 1 Sensor 1
P2247 O2 Sensor Reference Voltage Circuit/Open Bank 2 Sensor 1
P2248 O2 Sensor Reference Voltage Performance Bank 2 Sensor 1
P2249 O2 Sensor Reference Voltage Circuit Low Bank 2 Sensor 1
P2250 O2 Sensor Reference Voltage Circuit High Bank 2 Sensor 1
P2251 O2 Sensor Negative Current Control Circuit/Open Bank 1 Sensor 1
P2252 O2 Sensor Negative Current Control Circuit Low Bank 1 Sensor 1
P2253 O2 Sensor Negative Current Control Circuit High Bank 1 Sensor 1
P2254 O2 Sensor Negative Current Control Circuit/Open Bank 2 Sensor 1
P2255 O2 Sensor Negative Current Control Circuit Low Bank 2 Sensor 1
P2256 O2 Sensor Negative Current Control Circuit High Bank 2 Sensor 1
P2257 Secondary Air Injection System Control "A" Circuit Low
P2258 Secondary Air Injection System Control "A" Circuit High
P2259 Secondary Air Injection System Control "B" Circuit Low
P2260 Secondary Air Injection System Control "B" Circuit High
P2261 Turbo/Super Charger Bypass Valve - Mechanical
P2262 Turbo Boost Pressure Not Detected - Mechanical
P2263 Turbo/Super Charger Boost System Performance
P2264 Water in Fuel Sensor Circuit
P2265 Water in Fuel Sensor Circuit Range/Performance
P2266 Water in Fuel Sensor Circuit Low
P2267 Water in Fuel Sensor Circuit High
P2268 Water in Fuel Sensor Circuit Intermittent
P2269 Water in Fuel Condition
P2270 O2 Sensor Signal Stuck Lean Bank 1 Sensor 2
P2271 O2 Sensor Signal Stuck Rich Bank 1 Sensor 2
P2272 O2 Sensor Signal Stuck Lean Bank 2 Sensor 2
P2273 O2 Sensor Signal Stuck Rich Bank 2 Sensor 2
P2274 O2 Sensor Signal Stuck Lean Bank 1 Sensor 3
P2275 O2 Sensor Signal Stuck Rich Bank 1 Sensor 3
P2276 O2 Sensor Signal Stuck Lean Bank 2 Sensor 3
P2277 O2 Sensor Signal Stuck Rich Bank 2 Sensor 3
P2278 O2 Sensor Signals Swapped Bank 1 Sensor 3 / Bank 2 Sensor 3
P2279 Intake Air System Leak
P2280 Air Flow Restriction / Air Leak Between Air Filter and MAF
P2281 Air Leak Between MAF and Throttle Body
P2282 Air Leak Between Throttle Body and Intake Valves
P2283 Injector Control Pressure Sensor Circuit
P2284 Injector Control Pressure Sensor Circuit Range/Performance
P2285 Injector Control Pressure Sensor Circuit Low
P2286 Injector Control Pressure Sensor Circuit High
P2287 Injector Control Pressure Sensor Circuit Intermittent
P2288 Injector Control Pressure Too High
P2289 Injector Control Pressure Too High – Engine Off
P2290 Injector Control Pressure Too Low
P2291 Injector Control Pressure Too Low – Engine Cranking
P2292 Injector Control Pressure Erratic
P2293 Fuel Pressure Regulator 2 Performance
P2294 Fuel Pressure Regulator 2 Control Circuit
P2295 Fuel Pressure Regulator 2 Control Circuit Low

P2296 Fuel Pressure Regulator 2 Control Circuit High
P2297 O2 Sensor Out of Range During Deceleration Bank 1 Sensor 1
P2298 O2 Sensor Out of Range During Deceleration Bank 2 Sensor 1
P2299 Brake Pedal Position / Accelerator Pedal Position Incompatible
P2300 Ignition Coil "A" Primary Control Circuit Low
P2301 Ignition Coil "A" Primary Control Circuit High
P2302 Ignition Coil "A" Secondary Circuit
P2303 Ignition Coil "B" Primary Control Circuit Low
P2304 Ignition Coil "B" Primary Control Circuit High
P2305 Ignition Coil "B" Secondary Circuit
P2306 Ignition Coil "C" Primary Control Circuit Low
P2307 Ignition Coil "C" Primary Control Circuit High
P2308 Ignition Coil "C" Secondary Circuit
P2309 Ignition Coil "D" Primary Control Circuit Low
P2310 Ignition Coil "D" Primary Control Circuit High
P2311 Ignition Coil "D" Secondary Circuit
P2312 Ignition Coil "E" Primary Control Circuit Low
P2313 Ignition Coil "E" Primary Control Circuit High
P2314 Ignition Coil "E" Secondary Circuit
P2315 Ignition Coil "F" Primary Control Circuit Low
P2316 Ignition Coil "F" Primary Control Circuit High
P2317 Ignition Coil "F" Secondary Circuit
P2318 Ignition Coil "G" Primary Control Circuit Low
P2319 Ignition Coil "G" Primary Control Circuit High
P2320 Ignition Coil "G" Secondary Circuit
P2321 Ignition Coil "H" Primary Control Circuit Low
P2322 Ignition Coil "H" Primary Control Circuit High
P2323 Ignition Coil "H" Secondary Circuit
P2324 Ignition Coil "I" Primary Control Circuit Low
P2325 Ignition Coil "I" Primary Control Circuit High
P2326 Ignition Coil "I" Secondary Circuit
P2327 Ignition Coil "J" Primary Control Circuit Low
P2328 Ignition Coil "J" Primary Control Circuit High
P2329 Ignition Coil "J" Secondary Circuit
P2330 Ignition Coil "K" Primary Control Circuit Low
P2331 Ignition Coil "K" Primary Control Circuit High
P2332 Ignition Coil "K" Secondary Circuit
P2333 Ignition Coil "L" Primary Control Circuit Low
P2334 Ignition Coil "L" Primary Control Circuit High
P2335 Ignition Coil "L" Secondary Circuit
P2336 Cylinder #1 Above Knock Threshold
P2337 Cylinder #2 Above Knock Threshold
P2338 Cylinder #3 Above Knock Threshold
P2339 Cylinder #4 Above Knock Threshold
P2340 Cylinder #5 Above Knock Threshold
P2341 Cylinder #6 Above Knock Threshold
P2342 Cylinder #7 Above Knock Threshold
P2343 Cylinder #8 Above Knock Threshold
P2344 Cylinder #9 Above Knock Threshold
P2345 Cylinder #10 Above Knock Threshold
P2346 Cylinder #11 Above Knock Threshold

P2347 Cylinder #12 Above Knock Threshold
P2400 Evaporative Emission System Leak Detection Pump Control Circuit/Open
P2401 Evaporative Emission System Leak Detection Pump Control Circuit Low
P2402 Evaporative Emission System Leak Detection Pump Control Circuit High
P2403 Evaporative Emission System Leak Detection Pump Sense Circuit/Open
P2404 Evaporative Emission System Leak Detection Pump Sense Circuit
Range/Performance
P2405 Evaporative Emission System Leak Detection Pump Sense Circuit Low
P2406 Evaporative Emission System Leak Detection Pump Sense Circuit High
P2407 Evaporative Emission System Leak Detection Pump Sense Circuit
Intermittent/Erratic
P2408 Fuel Cap Sensor/Switch Circuit
P2409 Fuel Cap Sensor/Switch Circuit Range/Performance
P2410 Fuel Cap Sensor/Switch Circuit Low
P2411 Fuel Cap Sensor/Switch Circuit High
P2412 Fuel Cap Sensor/Switch Circuit Intermittent/Erratic
P2413 Exhaust Gas Recirculation System Performance
P2414 O2 Sensor Exhaust Sample Error Bank 1 Sensor 1
P2415 O2 Sensor Exhaust Sample Error Bank 2 Sensor 1
P2416 O2 Sensor Signals Swapped Bank 1 Sensor 2 / Bank 1 Sensor 3
P2417 O2 Sensor Signals Swapped Bank 2 Sensor 2 / Bank 2 Sensor 3
P2418 Evaporative Emission System Switching Valve Control Circuit /Open
P2419 Evaporative Emission System Switching Valve Control Circuit Low
P2420 Evaporative Emission System Switching Valve Control Circuit High
P2421 Evaporative Emission System Vent Valve Stuck Open
P2422 Evaporative Emission System Vent Valve Stuck Closed
P2423 HC Adsorption Catalyst Efficiency Below Threshold Bank 1
P2424 HC Adsorption Catalyst Efficiency Below Threshold Bank 2
P2425 Exhaust Gas Recirculation Cooling Valve Control Circuit/Open
P2426 Exhaust Gas Recirculation Cooling Valve Control Circuit Low
P2427 Exhaust Gas Recirculation Cooling Valve Control Circuit High
P2428 Exhaust Gas Temperature Too High Bank 1
P2429 Exhaust Gas Temperature Too High Bank 2
P2430 Secondary Air Injection System Air Flow/Pressure Sensor Circuit Bank 1
P2431 Secondary Air Injection System Air Flow/Pressure Sensor Circuit
Range/Performance Bank 1
P2432 Secondary Air Injection System Air Flow/Pressure Sensor Circuit Low Bank 1
P2433 Secondary Air Injection System Air Flow/Pressure Sensor Circuit High Bank 1
P2434 Secondary Air Injection System Air Flow/Pressure Sensor Circuit
Intermittent/Erratic Bank 1
P2435 Secondary Air Injection System Air Flow/Pressure Sensor Circuit Bank 2
P2436 Secondary Air Injection System Air Flow/Pressure Sensor Circuit
Range/Performance Bank 2
P2437 Secondary Air Injection System Air Flow/Pressure Sensor Circuit Low Bank 2
P2438 Secondary Air Injection System Air Flow/Pressure Sensor Circuit High Bank 2
P2439 Secondary Air Injection System Air Flow/Pressure Sensor Circuit
Intermittent/Erratic Bank 2
P2440 Secondary Air Injection System Switching Valve Stuck Open Bank 1
P2441 Secondary Air Injection System Switching Valve Stuck Closed Bank 1
P2442 Secondary Air Injection System Switching Valve Stuck Open Bank 2
P2443 Secondary Air Injection System Switching Valve Stuck Closed Bank 2

P2444 Secondary Air Injection System Pump Stuck On Bank 1
P2445 Secondary Air Injection System Pump Stuck Off Bank 1
P2446 Secondary Air Injection System Pump Stuck On Bank 2
P2447 Secondary Air Injection System Pump Stuck Off Bank 2
P2500 Generator Lamp/L-Terminal Circuit Low
P2501 Generator Lamp/L-Terminal Circuit High
P2502 Charging System Voltage
P2503 Charging System Voltage Low
P2504 Charging System Voltage High
P2505 ECM/PCM Power Input Signal
P2506 ECM/PCM Power Input Signal Range/Performance
P2507 ECM/PCM Power Input Signal Low
P2508 ECM/PCM Power Input Signal High
P2509 ECM/PCM Power Input Signal Intermittent
P2510 ECM/PCM Power Relay Sense Circuit Range/Performance
P2511 ECM/PCM Power Relay Sense Circuit Intermittent
P2512 Event Data Recorder Request Circuit/ Open
P2513 Event Data Recorder Request Circuit Low
P2514 Event Data Recorder Request Circuit High
P2515 A/C Refrigerant Pressure Sensor "B" Circuit
P2516 A/C Refrigerant Pressure Sensor "B" Circuit Range/Performance
P2517 A/C Refrigerant Pressure Sensor "B" Circuit Low
P2518 A/C Refrigerant Pressure Sensor "B" Circuit High
P2519 A/C Request "A" Circuit
P2520 A/C Request "A" Circuit Low
P2521 A/C Request "A" Circuit High
P2522 A/C Request "B" Circuit
P2523 A/C Request "B" Circuit Low
P2524 A/C Request "B" Circuit High
P2525 Vacuum Reservoir Pressure Sensor Circuit
P2526 Vacuum Reservoir Pressure Sensor Circuit Range/Performance
P2527 Vacuum Reservoir Pressure Sensor Circuit Low
P2528 Vacuum Reservoir Pressure Sensor Circuit High
P2529 Vacuum Reservoir Pressure Sensor Circuit Intermittent
P2530 Ignition Switch Run Position Circuit
P2531 Ignition Switch Run Position Circuit Low
P2532 Ignition Switch Run Position Circuit High
P2533 Ignition Switch Run/Start Position Circuit
P2534 Ignition Switch Run/Start Position Circuit Low
P2535 Ignition Switch Run/Start Position Circuit High
P2536 Ignition Switch Accessory Position Circuit
P2537 Ignition Switch Accessory Position Circuit Low
P2538 Ignition Switch Accessory Position Circuit High
P2539 Low Pressure Fuel System Sensor Circuit
P2540 Low Pressure Fuel System Sensor Circuit Range/Performance
P2541 Low Pressure Fuel System Sensor Circuit Low
P2542 Low Pressure Fuel System Sensor Circuit High
P2543 Low Pressure Fuel System Sensor Circuit Intermittent
P2544 Torque Management Request Input Signal "A"
P2545 Torque Management Request Input Signal "A" Range/Performance
P2546 Torque Management Request Input Signal "A" Low

P2547 Torque Management Request Input Signal "A" High
P2548 Torque Management Request Input Signal "B"
P2549 Torque Management Request Input Signal "B" Range/Performance
P2550 Torque Management Request Input Signal "B" Low
P2551 Torque Management Request Input Signal "B" High
P2552 Throttle/Fuel Inhibit Circuit
P2553 Throttle/Fuel Inhibit Circuit Range/Performance
P2554 Throttle/Fuel Inhibit Circuit Low
P2555 Throttle/Fuel Inhibit Circuit High
P2556 Engine Coolant Level Sensor/Switch Circuit
P2557 Engine Coolant Level Sensor/Switch Circuit Range/Performance
P2558 Engine Coolant Level Sensor/Switch Circuit Low
P2559 Engine Coolant Level Sensor/Switch Circuit High
P2560 Engine Coolant Level Low
P2561 A/C Control Module Requested MIL Illumination
P2562 Turbocharger Boost Control Position Sensor Circuit
P2563 Turbocharger Boost Control Position Sensor Circuit Range/Performance
P2564 Turbocharger Boost Control Position Sensor Circuit Low
P2565 Turbocharger Boost Control Position Sensor Circuit High
P2566 Turbocharger Boost Control Position Sensor Circuit Intermittent
P2567 Direct Ozone Reduction Catalyst Temperature Sensor Circuit
P2568 Direct Ozone Reduction Catalyst Temperature Sensor Circuit Range/Performance
P2569 Direct Ozone Reduction Catalyst Temperature Sensor Circuit Low
P2570 Direct Ozone Reduction Catalyst Temperature Sensor Circuit High
P2571 Direct Ozone Reduction Catalyst Temperature Sensor Circuit Intermittent/Erratic
P2572 Direct Ozone Reduction Catalyst Deterioration Sensor Circuit
P2573 Direct Ozone Reduction Catalyst Deterioration Sensor Circuit Range/Performance
P2574 Direct Ozone Reduction Catalyst Deterioration Sensor Circuit Low
P2575 Direct Ozone Reduction Catalyst Deterioration Sensor Circuit High
P2576 Direct Ozone Reduction Catalyst Deterioration Sensor Circuit Intermittent/Erratic
P2577 Direct Ozone Reduction Catalyst Efficiency Below Threshold
P2600 Coolant Pump Control Circuit/Open
P2601 Coolant Pump Control Circuit Range/Performance
P2602 Coolant Pump Control Circuit Low
P2603 Coolant Pump Control Circuit High
P2604 Intake Air Heater "A" Circuit Range/Performance
P2605 Intake Air Heater "A" Circuit/Open
P2606 Intake Air Heater "B" Circuit Range/Performance
P2607 Intake Air Heater "B" Circuit Low
P2608 Intake Air Heater "B" Circuit High
P2609 Intake Air Heater System Performance
P2610 ECM/PCM Internal Engine Off Timer Performance
P2611 A/C Refrigerant Distribution Valve Control Circuit/Open
P2612 A/C Refrigerant Distribution Valve Control Circuit Low
P2613 A/C Refrigerant Distribution Valve Control Circuit High
P2614 Camshaft Position Signal Output Circuit/Open
P2615 Camshaft Position Signal Output Circuit Low
P2616 Camshaft Position Signal Output Circuit High
P2617 Crankshaft Position Signal Output Circuit/Open
P2618 Crankshaft Position Signal Output Circuit Low
P2619 Crankshaft Position Signal Output Circuit High

P2620 Throttle Position Output Circuit/Open
P2621 Throttle Position Output Circuit Low
P2622 Throttle Position Output Circuit High
P2623 Injector Control Pressure Regulator Circuit/Open
P2624 Injector Control Pressure Regulator Circuit Low
P2625 Injector Control Pressure Regulator Circuit High
P2626 O2 Sensor Pumping Current Trim Circuit/Open Bank 1 Sensor 1
P2627 O2 Sensor Pumping Current Trim Circuit Low Bank 1 Sensor 1
P2628 O2 Sensor Pumping Current Trim Circuit High Bank 1 Sensor 1
P2629 O2 Sensor Pumping Current Trim Circuit/Open Bank 2 Sensor 1
P2630 O2 Sensor Pumping Current Trim Circuit Low Bank 2 Sensor 1
P2631 O2 Sensor Pumping Current Trim Circuit High Bank 2 Sensor 1
P2632 Fuel Pump "B" Control Circuit /Open
P2633 Fuel Pump "B" Control Circuit Low
P2634 Fuel Pump "B" Control Circuit High
P2635 Fuel Pump "A" Low Flow / Performance
P2636 Fuel Pump "B" Low Flow / Performance
P2637 Torque Management Feedback Signal "A"
P2638 Torque Management Feedback Signal "A" Range/Performance
P2639 Torque Management Feedback Signal "A" Low
P2640 Torque Management Feedback Signal "A" High
P2641 Torque Management Feedback Signal "B"
P2642 Torque Management Feedback Signal "B" Range/Performance
P2643 Torque Management Feedback Signal "B" Low
P2644 Torque Management Feedback Signal "B" High
P2645 "A" Rocker Arm Actuator Control Circuit/Open Bank 1
P2646 "A" Rocker Arm Actuator System Performance or Stuck Off Bank 1
P2647 "A" Rocker Arm Actuator System Stuck On Bank 1
P2648 "A" Rocker Arm Actuator Control Circuit Low Bank 1
P2649 "A" Rocker Arm Actuator Control Circuit High Bank 1
P2650 "B" Rocker Arm Actuator Control Circuit/Open Bank 1
P2651 "B" Rocker Arm Actuator System Performance or Stuck Off Bank 1
P2652 "B" Rocker Arm Actuator System Stuck On Bank 1
P2653 "B" Rocker Arm Actuator Control Circuit Low Bank 1
P2654 "B" Rocker Arm Actuator Control Circuit High Bank 1
P2655 "A" Rocker Arm Actuator Control Circuit/Open Bank 2
P2656 "A" Rocker Arm Actuator System Performance or Stuck Off Bank 2
P2657 "A" Rocker Arm Actuator System Stuck On Bank 2
P2658 "A" Rocker Arm Actuator Control Circuit Low Bank 2
P2659 "A" Rocker Arm Actuator Control Circuit High Bank 2
P2660 "B" Rocker Arm Actuator Control Circuit/Open Bank 2
P2661 "B" Rocker Arm Actuator System Performance or Stuck Off Bank 2
P2662 "B" Rocker Arm Actuator System Stuck On Bank 2
P2663 "B" Rocker Arm Actuator Control Circuit Low Bank 2
P2664 "B" Rocker Arm Actuator Control Circuit High Bank 2
P2665 Fuel Shutoff Valve "B" Control Circuit/Open
P2666 Fuel Shutoff Valve "B" Control Circuit Low
P2667 Fuel Shutoff Valve "B" Control Circuit High
P2668 Fuel Mode Indicator Lamp Control Circuit
P2669 Actuator Supply Voltage "B" Circuit /Open
P2670 Actuator Supply Voltage "B" Circuit Low

P2671 Actuator Supply Voltage "B" Circuit High
P2700 Transmission Friction Element "A" Apply Time Range/Performance
P2701 Transmission Friction Element "B" Apply Time Range/Performance
P2702 Transmission Friction Element "C" Apply Time Range/Performance
P2703 Transmission Friction Element "D" Apply Time Range/Performance
P2704 Transmission Friction Element "E" Apply Time Range/Performance
P2705 Transmission Friction Element "F" Apply Time Range/Performance
P2706 Shift Solenoid "F"
P2707 Shift Solenoid "F" Performance or Stuck Off
P2708 Shift Solenoid "F" Stuck On
P2709 Shift Solenoid "F" Electrical
P2710 Shift Solenoid "F" Intermittent
P2711 Unexpected Mechanical Gear Disengagement
P2712 Hydraulic Power Unit Leakage
P2713 Pressure Control Solenoid "D"
P2714 Pressure Control Solenoid "D" Performance or Stuck Off
P2715 Pressure Control Solenoid "D" Stuck On
P2716 Pressure Control Solenoid "D" Electrical
P2717 Pressure Control Solenoid "D" Intermittent
P2718 Pressure Control Solenoid "D" Control Circuit / Open
P2719 Pressure Control Solenoid "D" Control Circuit Range/Performance
P2720 Pressure Control Solenoid "D" Control Circuit Low
P2721 Pressure Control Solenoid "D" Control Circuit High
P2722 Pressure Control Solenoid "E"
P2723 Pressure Control Solenoid "E" Performance or Stuck Off
P2724 Pressure Control Solenoid "E" Stuck On
P2725 Pressure Control Solenoid "E" Electrical
P2726 Pressure Control Solenoid "E" Intermittent
P2727 Pressure Control Solenoid "E" Control Circuit / Open
P2728 Pressure Control Solenoid "E" Control Circuit Range/Performance
P2729 Pressure Control Solenoid "E" Control Circuit Low
P2730 Pressure Control Solenoid "E" Control Circuit High
P2731 Pressure Control Solenoid "F"
P2732 Pressure Control Solenoid "F" Performance or Stuck Off
P2733 Pressure Control Solenoid "F" Stuck On
P2734 Pressure Control Solenoid "F" Electrical
P2735 Pressure Control Solenoid "F" Intermittent
P2736 Pressure Control Solenoid "F" Control Circuit/Open
P2737 Pressure Control Solenoid "F" Control Circuit Range/Performance
P2738 Pressure Control Solenoid "F" Control Circuit Low
P2739 Pressure Control Solenoid "F" Control Circuit High
P2740 Transmission Fluid Temperature Sensor "B" Circuit
P2741 Transmission Fluid Temperature Sensor "B" Circuit Range Performance
P2742 Transmission Fluid Temperature Sensor "B" Circuit Low
P2743 Transmission Fluid Temperature Sensor "B" Circuit High
P2744 Transmission Fluid Temperature Sensor "B" Circuit Intermittent
P2745 Intermediate Shaft Speed Sensor "B" Circuit
P2746 Intermediate Shaft Speed Sensor "B" Circuit Range/Performance
P2747 Intermediate Shaft Speed Sensor "B" Circuit No Signal
P2748 Intermediate Shaft Speed Sensor "B" Circuit Intermittent
P2749 Intermediate Shaft Speed Sensor "C" Circuit

P2750 Intermediate Shaft Speed Sensor "C" Circuit Range/Performance
P2751 Intermediate Shaft Speed Sensor "C" Circuit No Signal
P2752 Intermediate Shaft Speed Sensor "C" Circuit Intermittent
P2753 Transmission Fluid Cooler Control Circuit/Open
P2754 Transmission Fluid Cooler Control Circuit Low
P2755 Transmission Fluid Cooler Control Circuit High
P2756 Torque Converter Clutch Pressure Control Solenoid
P2757 Torque Converter Clutch Pressure Control Solenoid Control Circuit Performance or Stuck Off
P2758 Torque Converter Clutch Pressure Control Solenoid Control Circuit Stuck On
P2759 Torque Converter Clutch Pressure Control Solenoid Control Circuit Electrical
P2760 Torque Converter Clutch Pressure Control Solenoid Control Circuit Intermittent
P2761 Torque Converter Clutch Pressure Control Solenoid Control Circuit/Open
P2762 Torque Converter Clutch Pressure Control Solenoid Control Circuit Range/Performance
P2763 Torque Converter Clutch Pressure Control Solenoid Control Circuit High
P2764 Torque Converter Clutch Pressure Control Solenoid Control Circuit Low
P2765 Input/Turbine Speed Sensor "B" Circuit
P2766 Input/Turbine Speed Sensor "B" Circuit Range/Performance
P2767 Input/Turbine Speed Sensor "B" Circuit No Signal
P2768 Input/Turbine Speed Sensor "B" Circuit Intermittent
P2769 Torque Converter Clutch Circuit Low
P2770 Torque Converter Clutch Circuit High
P2771 Four Wheel Drive (4WD) Low Switch Circuit
P2772 Four Wheel Drive (4WD) Low Switch Circuit Range/Performance
P2773 Four Wheel Drive (4WD) Low Switch Circuit Low
P2774 Four Wheel Drive (4WD) Low Switch Circuit High
P2775 Upshift Switch Circuit Range/Performance
P2776 Upshift Switch Circuit Low
P2777 Upshift Switch Circuit High
P2778 Upshift Switch Circuit Intermittent/Erratic
P2779 Downshift Switch Circuit Range/Performance
P2780 Downshift Switch Circuit Low
P2781 Downshift Switch Circuit High
P2782 Downshift Switch Circuit Intermittent/Erratic
P2783 Torque Converter Temperature Too High
P2784 Input/Turbine Speed Sensor "A"/"B" Correlation
P2785 Clutch Actuator Temperature Too High
P2786 Gear Shift Actuator Temperature Too High
P2787 Clutch Temperature Too High
P2788 Auto Shift Manual Adaptive Learning at Limit
P2789 Clutch Adaptive Learning at Limit
P2790 Gate Select Direction Circuit
P2791 Gate Select Direction Circuit Low
P2792 Gate Select Direction Circuit High
P2793 Gear Shift Direction Circuit
P2794 Gear Shift Direction Circuit Low
P2795 Gear Shift Direction Circuit High
P2A00 O2 Sensor Circuit Range/Performance Bank 1 Sensor 1
P2A01 O2 Sensor Circuit Range/Performance Bank 1 Sensor 2
P2A02 O2 Sensor Circuit Range/Performance Bank 1 Sensor 3

P2A03 O2 Sensor Circuit Range/Performance Bank 2 Sensor 1
P2A04 O2 Sensor Circuit Range/Performance Bank 2 Sensor 2
P2A05 O2 Sensor Circuit Range/Performance Bank 2 Sensor 3
P3400 Cylinder Deactivation System Bank 1
P3401 Cylinder 1 Deactivation/Intake Valve Control Circuit/Open
P3402 Cylinder 1 Deactivation/Intake Valve Control Performance
P3403 Cylinder 1 Deactivation/Intake Valve Control Circuit Low
P3404 Cylinder 1 Deactivation/Intake Valve Control Circuit High
P3405 Cylinder 1 Exhaust Valve Control Circuit/Open
P3406 Cylinder 1 Exhaust Valve Control Performance
P3407 Cylinder 1 Exhaust Valve Control Circuit Low
P3408 Cylinder 1 Exhaust Valve Control Circuit High
P3409 Cylinder 2 Deactivation/Intake Valve Control Circuit/Open
P3410 Cylinder 2 Deactivation/Intake Valve Control Performance
P3411 Cylinder 2 Deactivation/Intake Valve Control Circuit Low
P3412 Cylinder 2 Deactivation/Intake Valve Control Circuit High
P3413 Cylinder 2 Exhaust Valve Control Circuit/Open
P3414 Cylinder 2 Exhaust Valve Control Performance
P3415 Cylinder 2 Exhaust Valve Control Circuit Low
P3416 Cylinder 2 Exhaust Valve Control Circuit High
P3417 Cylinder 3 Deactivation/Intake Valve Control Circuit/Open
P3418 Cylinder 3 Deactivation/Intake Valve Control Performance
P3419 Cylinder 3 Deactivation/Intake Valve Control Circuit Low
P3420 Cylinder 3 Deactivation/Intake Valve Control Circuit High
P3421 Cylinder 3 Exhaust Valve Control Circuit/Open
P3422 Cylinder 3 Exhaust Valve Control Performance
P3423 Cylinder 3 Exhaust Valve Control Circuit Low
P3424 Cylinder 3 Exhaust Valve Control Circuit High
P3425 Cylinder 4 Deactivation/Intake Valve Control Circuit/Open
P3426 Cylinder 4 Deactivation/Intake Valve Control Performance
P3427 Cylinder 4 Deactivation/Intake Valve Control Circuit Low
P3428 Cylinder 4 Deactivation/Intake Valve Control Circuit High
P3429 Cylinder 4 Exhaust Valve Control Circuit/Open
P3430 Cylinder 4 Exhaust Valve Control Performance
P3431 Cylinder 4 Exhaust Valve Control Circuit Low
P3432 Cylinder 4 Exhaust Valve Control Circuit High
P3433 Cylinder 5 Deactivation/Intake Valve Control Circuit/Open
P3434 Cylinder 5 Deactivation/Intake Valve Control Performance
P3435 Cylinder 5 Deactivation/Intake Valve Control Circuit Low
P3436 Cylinder 5 Deactivation/Intake Valve Control Circuit High
P3437 Cylinder 5 Exhaust Valve Control Circuit/Open
P3438 Cylinder 5 Exhaust Valve Control Performance
P3439 Cylinder 5 Exhaust Valve Control Circuit Low
P3440 Cylinder 5 Exhaust Valve Control Circuit High
P3441 Cylinder 6 Deactivation/Intake Valve Control Circuit/Open
P3442 Cylinder 6 Deactivation/Intake Valve Control Performance
P3443 Cylinder 6 Deactivation/Intake Valve Control Circuit Low
P3444 Cylinder 6 Deactivation/Intake Valve Control Circuit High
P3445 Cylinder 6 Exhaust Valve Control Circuit/Open
P3446 Cylinder 6 Exhaust Valve Control Performance
P3447 Cylinder 6 Exhaust Valve Control Circuit Low

P3448 Cylinder 6 Exhaust Valve Control Circuit High
P3449 Cylinder 7 Deactivation/Intake Valve Control Circuit/Open
P3450 Cylinder 7 Deactivation/Intake Valve Control Performance
P3451 Cylinder 7 Deactivation/Intake Valve Control Circuit Low
P3452 Cylinder 7 Deactivation/Intake Valve Control Circuit High
P3453 Cylinder 7 Exhaust Valve Control Circuit/Open
P3454 Cylinder 7 Exhaust Valve Control Performance
P3455 Cylinder 7 Exhaust Valve Control Circuit Low
P3456 Cylinder 7 Exhaust Valve Control Circuit High
P3457 Cylinder 8 Deactivation/Intake Valve Control Circuit/Open
P3458 Cylinder 8 Deactivation/Intake Valve Control Performance
P3459 Cylinder 8 Deactivation/Intake Valve Control Circuit Low
P3460 Cylinder 8 Deactivation/Intake Valve Control Circuit High
P3461 Cylinder 8 Exhaust Valve Control Circuit/Open
P3462 Cylinder 8 Exhaust Valve Control Performance
P3463 Cylinder 8 Exhaust Valve Control Circuit Low
P3464 Cylinder 8 Exhaust Valve Control Circuit High
P3465 Cylinder 9 Deactivation/Intake Valve Control Circuit/Open
P3466 Cylinder 9 Deactivation/Intake Valve Control Performance
P3467 Cylinder 9 Deactivation/Intake Valve Control Circuit Low
P3468 Cylinder 9 Deactivation/Intake Valve Control Circuit High
P3469 Cylinder 9 Exhaust Valve Control Circuit/Open
P3470 Cylinder 9 Exhaust Valve Control Performance
P3471 Cylinder 9 Exhaust Valve Control Circuit Low
P3472 Cylinder 9 Exhaust Valve Control Circuit High
P3473 Cylinder 10 Deactivation/Intake Valve Control Circuit/Open
P3474 Cylinder 10 Deactivation/Intake Valve Control Performance
P3475 Cylinder 10 Deactivation/Intake Valve Control Circuit Low
P3476 Cylinder 10 Deactivation/Intake Valve Control Circuit High
P3477 Cylinder 10 Exhaust Valve Control Circuit/Open
P3478 Cylinder 10 Exhaust Valve Control Performance
P3479 Cylinder 10 Exhaust Valve Control Circuit Low
P3480 Cylinder 10 Exhaust Valve Control Circuit High
P3481 Cylinder 11 Deactivation/Intake Valve Control Circuit/Open
P3482 Cylinder 11 Deactivation/Intake Valve Control Performance
P3483 Cylinder 11 Deactivation/Intake Valve Control Circuit Low
P3484 Cylinder 11 Deactivation/Intake Valve Control Circuit High
P3485 Cylinder 11 Exhaust Valve Control Circuit/Open
P3486 Cylinder 11 Exhaust Valve Control Performance
P3487 Cylinder 11 Exhaust Valve Control Circuit Low
P3488 Cylinder 11 Exhaust Valve Control Circuit High
P3489 Cylinder 12 Deactivation/Intake Valve Control Circuit/Open
P3490 Cylinder 12 Deactivation/Intake Valve Control Performance
P3491 Cylinder 12 Deactivation/Intake Valve Control Circuit Low
P3492 Cylinder 12 Deactivation/Intake Valve Control Circuit High
P3493 Cylinder 12 Exhaust Valve Control Circuit/Open
P3494 Cylinder 12 Exhaust Valve Control Performance
P3495 Cylinder 12 Exhaust Valve Control Circuit Low
P3496 Cylinder 12 Exhaust Valve Control Circuit High
P3497 Cylinder Deactivation System Bank 2
U0001 High Speed CAN Communication Bus

U0002 High Speed CAN Communication Bus Performance
U0003 High Speed CAN Communication Bus (+) Open
U0004 High Speed CAN Communication Bus (+) Low
U0005 High Speed CAN Communication Bus (+) High
U0006 High Speed CAN Communication Bus (–) Open
U0007 High Speed CAN Communication Bus (–) Low
U0008 High Speed CAN Communication Bus (–) High
U0009 High Speed CAN Communication Bus (–) shorted to Bus (+)
U0010 Medium Speed CAN Communication Bus
U0011 Medium Speed CAN Communication Bus Performance
U0012 Medium Speed CAN Communication Bus (+) Open
U0013 Medium Speed CAN Communication Bus (+) Low
U0014 Medium Speed CAN Communication Bus (+) High
U0015 Medium Speed CAN Communication Bus (–) Open
U0016 Medium Speed CAN Communication Bus (–) Low
U0017 Medium Speed CAN Communication Bus (–) High
U0018 Medium Speed CAN Communication Bus (–) shorted to Bus (+)
U0019 Low Speed CAN Communication Bus
U0020 Low Speed CAN Communication Bus Performance
U0021 Low Speed CAN Communication Bus (+) Open
U0022 Low Speed CAN Communication Bus (+) Low
U0023 Low Speed CAN Communication Bus (+) High
U0024 Low Speed CAN Communication Bus (–) Open
U0025 Low Speed CAN Communication Bus (–) Low
U0026 Low Speed CAN Communication Bus (–) High
U0027 Low Speed CAN Communication Bus (–) shorted to Bus (+)
U0028 Vehicle Communication Bus A
U0029 Vehicle Communication Bus A Performance
U0030 Vehicle Communication Bus A (+) Open
U0031 Vehicle Communication Bus A (+) Low
U0032 Vehicle Communication Bus A (+) High
U0033 Vehicle Communication Bus A (–) Open
U0034 Vehicle Communication Bus A (–) Low
U0035 Vehicle Communication Bus A (–) High
U0036 Vehicle Communication Bus A (–) shorted to Bus A (+)
U0037 Vehicle Communication Bus B
U0038 Vehicle Communication Bus B Performance
U0039 Vehicle Communication Bus B (+) Open
U0040 Vehicle Communication Bus B (+) Low
U0041 Vehicle Communication Bus B (+) High
U0042 Vehicle Communication Bus B (–) Open
U0043 Vehicle Communication Bus B (–) Low
U0044 Vehicle Communication Bus B (–) High
U0045 Vehicle Communication Bus B (–) shorted to Bus B (+)
U0046 Vehicle Communication Bus C
U0047 Vehicle Communication Bus C Performance
U0048 Vehicle Communication Bus C (+) Open
U0049 Vehicle Communication Bus C (+) Low
U0050 Vehicle Communication Bus C (+) High
U0051 Vehicle Communication Bus C (–) Open
U0052 Vehicle Communication Bus C (–) Low

U0053 Vehicle Communication Bus C (–) High
U0054 Vehicle Communication Bus C (–) shorted to Bus C (+)
U0055 Vehicle Communication Bus D
U0056 Vehicle Communication Bus D Performance
U0057 Vehicle Communication Bus D (+) Open
U0058 Vehicle Communication Bus D (+) Low
U0059 Vehicle Communication Bus D (+) High
U0060 Vehicle Communication Bus D (–) Open
U0061 Vehicle Communication Bus D (–) Low
U0062 Vehicle Communication Bus D (–) High
U0063 Vehicle Communication Bus D (–) shorted to Bus D (+)
U0064 Vehicle Communication Bus E
U0065 Vehicle Communication Bus E Performance
U0066 Vehicle Communication Bus E (+) Open
U0067 Vehicle Communication Bus E (+) Low
U0068 Vehicle Communication Bus E (+) High
U0069 Vehicle Communication Bus E (–) Open
U0070 Vehicle Communication Bus E (–) Low
U0071 Vehicle Communication Bus E (–) High
U0072 Vehicle Communication Bus E (–) shorted to Bus E (+)
U0073 Control Module Communication Bus Off
U0074 Reserved by Document
U0075 Reserved by Document
U0076 Reserved by Document
U0077 Reserved by Document
U0078 Reserved by Document
U0079 Reserved by Document
U0080 Reserved by Document
U0081 Reserved by Document
U0082 Reserved by Document
U0083 Reserved by Document
U0084 Reserved by Document
U0085 Reserved by Document
U0086 Reserved by Document
U0087 Reserved by Document
U0088 Reserved by Document
U0089 Reserved by Document
U0090 Reserved by Document
U0091 Reserved by Document
U0092 Reserved by Document
U0093 Reserved by Document
U0094 Reserved by Document
U0095 Reserved by Document
U0096 Reserved by Document
U0097 Reserved by Document
U0098 Reserved by Document
U0099 Reserved by Document
U0100 Lost Communication With ECM/PCM "A"
U0101 Lost Communication with TCM
U0102 Lost Communication with Transfer Case Control Module
U0103 Lost Communication With Gear Shift Module

U0104 Lost Communication With Cruise Control Module
U0105 Lost Communication With Fuel Injector Control Module
U0106 Lost Communication With Glow Plug Control Module
U0107 Lost Communication With Throttle Actuator Control Module
U0108 Lost Communication With Alternative Fuel Control Module
U0109 Lost Communication With Fuel Pump Control Module
U0110 Lost Communication With Drive Motor Control Module
U0111 Lost Communication With Battery Energy Control Module "A"
U0112 Lost Communication With Battery Energy Control Module "B"
U0113 Lost Communication With Emissions Critical Control Information
U0114 Lost Communication With Four-Wheel Drive Clutch Control Module
U0115 Lost Communication With ECM/PCM "B"
U0116 Reserved by Document
U0117 Reserved by Document
U0118 Reserved by Document
U0119 Reserved by Document
U0120 Reserved by Document
U0121 Lost Communication With Anti-Lock Brake System (ABS) Control Module
U0122 Lost Communication With Vehicle Dynamics Control Module
U0123 Lost Communication With Yaw Rate Sensor Module
U0124 Lost Communication With Lateral Acceleration Sensor Module
U0125 Lost Communication With Multi-axis Acceleration Sensor Module
U0126 Lost Communication With Steering Angle Sensor Module
U0127 Lost Communication With Tire Pressure Monitor Module
U0128 Lost Communication With Park Brake Control Module
U0129 Lost Communication With Brake System Control Module
U0130 Lost Communication With Steering Effort Control Module
U0131 Lost Communication With Power Steering Control Module
U0132 Lost Communication With Ride Level Control Module
U0133 Reserved by Document
U0134 Reserved by Document
U0135 Reserved by Document
U0136 Reserved by Document
U0137 Reserved by Document
U0138 Reserved by Document
U0139 Reserved by Document
U0140 Lost Communication With Body Control Module
U0141 Lost Communication With Body Control Module "A"
U0142 Lost Communication With Body Control Module "B"
U0143 Lost Communication With Body Control Module "C"
U0144 Lost Communication With Body Control Module "D"
U0145 Lost Communication With Body Control Module "E"
U0146 Lost Communication With Gateway "A"
U0147 Lost Communication With Gateway "B"
U0148 Lost Communication With Gateway "C"
U0149 Lost Communication With Gateway "D"
U0150 Lost Communication With Gateway "E"
U0151 Lost Communication With Restraints Control Module
U0152 Lost Communication With Side Restraints Control Module Left
U0153 Lost Communication With Side Restraints Control Module Right
U0154 Lost Communication With Restraints Occupant Sensing Control Module

U0155 Lost Communication With Instrument Panel Cluster (IPC) Control Module
U0156 Lost Communication With Information Center "A"
U0157 Lost Communication With Information Center "B"
U0158 Lost Communication With Head Up Display
U0159 Lost Communication With Parking Assist Control Module
U0160 Lost Communication With Audible Alert Control Module
U0161 Lost Communication With Compass Module
U0162 Lost Communication With Navigation Display Module
U0163 Lost Communication With Navigation Control Module
U0164 Lost Communication With HVAC Control Module
U0165 Lost Communication With HVAC Control Module Rear
U0166 Lost Communication With Auxiliary Heater Control Module
U0167 Lost Communication With Vehicle Immobilizer Control Module
U0168 Lost Communication With Vehicle Security Control Module
U0169 Lost Communication With Sunroof Control Module
U0170 Lost Communication With "Restraints System Sensor A"
U0171 Lost Communication With "Restraints System Sensor B"
U0172 Lost Communication With "Restraints System Sensor C"
U0173 Lost Communication With "Restraints System Sensor D"
U0174 Lost Communication With "Restraints System Sensor E"
U0175 Lost Communication With "Restraints System Sensor F"
U0176 Lost Communication With "Restraints System Sensor G"
U0177 Lost Communication With "Restraints System Sensor H"
U0178 Lost Communication With "Restraints System Sensor I"
U0179 Lost Communication With "Restraints System Sensor J"
U0180 Lost Communication With Automatic Lighting Control Module
U0181 Lost Communication With Headlamp Leveling Control Module
U0182 Lost Communication With Lighting Control Module Front
U0183 Lost Communication With Lighting Control Module Rear
U0184 Lost Communication With Radio
U0185 Lost Communication With Antenna Control Module
U0186 Lost Communication With Audio Amplifier
U0187 Lost Communication With Digital Disc Player/Changer Module "A"
U0188 Lost Communication With Digital Disc Player/Changer Module "B"
U0189 Lost Communication With Digital Disc Player/Changer Module "C"
U0190 Lost Communication With Digital Disc Player/Changer Module "D"
U0191 Lost Communication With Television
U0192 Lost Communication With Personal Computer
U0193 Lost Communication With "Digital Audio Control Module A"
U0194 Lost Communication With "Digital Audio Control Module B"
U0195 Lost Communication With Subscription Entertainment Receiver Module
U0196 Lost Communication With Rear Seat Entertainment Control Module
U0197 Lost Communication With Telephone Control Module
U0198 Lost Communication With Telematic Control Module
U0199 Lost Communication With "Door Control Module A"
U0200 Lost Communication With "Door Control Module B"
U0201 Lost Communication With "Door Control Module C"
U0202 Lost Communication With "Door Control Module D"
U0203 Lost Communication With "Door Control Module E"
U0204 Lost Communication With "Door Control Module F"
U0205 Lost Communication With "Door Control Module G"

U0206 Lost Communication With Folding Top Control Module
U0207 Lost Communication With Moveable Roof Control Module
U0208 Lost Communication With "Seat Control Module A"
U0209 Lost Communication With "Seat Control Module B"
U0210 Lost Communication With "Seat Control Module C"
U0211 Lost Communication With "Seat Control Module D"
U0212 Lost Communication With Steering Column Control Module
U0213 Lost Communication With Mirror Control Module
U0214 Lost Communication With Remote Function Actuation
U0215 Lost Communication With "Door Switch A"
U0216 Lost Communication With "Door Switch B"
U0217 Lost Communication With "Door Switch C"
U0218 Lost Communication With "Door Switch D"
U0219 Lost Communication With "Door Switch E"
U0220 Lost Communication With "Door Switch F"
U0221 Lost Communication With "Door Switch G"
U0222 Lost Communication With "Door Window Motor A"
U0223 Lost Communication With "Door Window Motor B"
U0224 Lost Communication With "Door Window Motor C"
U0225 Lost Communication With "Door Window Motor D"
U0226 Lost Communication With "Door Window Motor E"
U0227 Lost Communication With "Door Window Motor F"
U0228 Lost Communication With "Door Window Motor G"
U0229 Lost Communication With Heated Steering Wheel Module
U0230 Lost Communication With Rear Gate Module
U0231 Lost Communication With Rain Sensing Module
U0232 Lost Communication With Side Obstacle Detection Control Module Left
U0233 Lost Communication With Side Obstacle Detection Control Module Right
U0234 Lost Communication With Convenience Recall Module
U0235 Lost Communication With Cruise Control Front Distance Range Sensor
U0300 Internal Control Module Software Incompatibility
U0301 Software Incompatibility with ECM/PCM
U0302 Software Incompatibility with Transmission Control Module
U0303 Software Incompatibility with Transfer Case Control Module
U0304 Software Incompatibility with Gear Shift Control Module
U0305 Software Incompatibility with Cruise Control Module
U0306 Software Incompatibility with Fuel Injector Control Module
U0307 Software Incompatibility with Glow Plug Control Module
U0308 Software Incompatibility with Throttle Actuator Control Module
U0309 Software Incompatibility with Alternative Fuel Control Module
U0310 Software Incompatibility with Fuel Pump Control Module
U0311 Software Incompatibility with Drive Motor Control Module
U0312 Software Incompatibility with Battery Energy Control Module A
U0313 Software Incompatibility with Battery Energy Control Module B
U0314 Software Incompatibility with Four-Wheel Drive Clutch Control Module
U0315 Software Incompatibility with Anti-Lock Brake System Control Module
U0316 Software Incompatibility with Vehicle Dynamics Control Module
U0317 Software Incompatibility with Park Brake Control Module
U0318 Software Incompatibility with Brake System Control Module
U0319 Software Incompatibility with Steering Effort Control Module
U0320 Software Incompatibility with Power Steering Control Module

U0321 Software Incompatibility with Ride Level Control Module
U0322 Software Incompatibility with Body Control Module
U0323 Software Incompatibility with Instrument Panel Control Module
U0324 Software Incompatibility with HVAC Control Module
U0325 Software Incompatibility with Auxiliary Heater Control Module
U0326 Software Incompatibility with Vehicle Immobilizer Control Module
U0327 Software Incompatibility with Vehicle Security Control Module
U0328 Software Incompatibility with Steering Angle Sensor Module
U0329 Software Incompatibility with Steering Column Control Module
U0330 Software Incompatibility with Tire Pressure Monitor Module
U0331 Software Incompatibility with Body Control Module "A"
U0400 Invalid Data Received
U0401 Invalid Data Received From ECM/PCM
U0402 Invalid Data Received From Transmission Control Module
U0403 Invalid Data Received From Transfer Case Control Module
U0404 Invalid Data Received From Gear Shift Control Module
U0405 Invalid Data Received From Cruise Control Module
U0406 Invalid Data Received From Fuel Injector Control Module
U0407 Invalid Data Received From Glow Plug Control Module
U0408 Invalid Data Received From Throttle Actuator Control Module
U0409 Invalid Data Received From Alternative Fuel Control Module
U0410 Invalid Data Received From Fuel Pump Control Module
U0411 Invalid Data Received From Drive Motor Control Module
U0412 Invalid Data Received From Battery Energy Control Module A
U0413 Invalid Data Received From Battery Energy Control Module B
U0414 Invalid Data Received From Four-Wheel Drive Clutch Control Module
U0415 Invalid Data Received From Anti-Lock Brake System Control Module
U0416 Invalid Data Received From Vehicle Dynamics Control Module
U0417 Invalid Data Received From Park Brake Control Module
U0418 Invalid Data Received From Brake System Control Module
U0419 Invalid Data Received From Steering Effort Control Module
U0420 Invalid Data Received From Power Steering Control Module
U0421 Invalid Data Received From Ride Level Control Module
U0422 Invalid Data Received From Body Control Module
U0423 Invalid Data Received From Instrument Panel Control Module
U0424 Invalid Data Received From HVAC Control Module
U0425 Invalid Data Received From Auxiliary Heater Control Module
U0426 Invalid Data Received From Vehicle Immobilizer Control Module
U0427 Invalid Data Received From Vehicle Security Control Module
U0428 Invalid Data Received From Steering Angle Sensor Module
U0429 Invalid Data Received From Steering Column Control Module
U0430 Invalid Data Received From Tire Pressure Monitor Module
U0431 Invalid Data Received From Body Control Module "A"

FUEL SYSTEM

Service Precautions

Safety is the most important factor when performing not only fuel system maintenance but also any type of maintenance. Failure to conduct maintenance and repairs in a safe manner may result in serious personal injury or death. Maintenance and testing of the vehicle's fuel system components can be accomplished safely and effectively by adhering to the following rules and guidelines.

- Always wear safety glasses or some type of eye/face protection when working with, around or under a vehicle.
- To avoid the possibility of fire and personal injury, always disconnect the negative battery cable unless the repair or test procedure requires that battery voltage be applied.
- Always relieve the fuel system pressure prior to disconnecting any fuel system component (injector, fuel rail, pressure regulator, etc.), fitting or fuel line connection. Exercise extreme caution whenever relieving fuel system pressure, to avoid exposing skin, face and eyes to fuel spray. Please be advised that fuel under pressure may penetrate the skin or any part of the body that it contacts.
- Always place a shop towel or cloth around the fitting or connection prior to loosening to absorb any excess fuel due to spillage. Ensure that all fuel spillage (should it occur) is quickly removed from engine surfaces. Ensure that all fuel soaked cloths or towels are deposited into a suitable waste container.
- Always keep a dry chemical (Class B) fire extinguisher near the work area.
- Do not allow fuel spray or fuel vapors to come into contact with a spark or open flame.
- Always use a back-up wrench when loosening and tightening fuel line connection fittings. This will prevent unnecessary stress and torsion to fuel line piping.
- Always replace worn fuel fitting O-rings with new. Do not substitute fuel hose or equivalent where fuel pipe is installed.
- Do not smoke or carry lighted tobacco or open flame of any type when working on or near any fuel-related component. Highly flammable mixtures are always present and may be ignited. Failure to follow these instructions can result in personal injury.
- Do not carry personal electronic devices such as cell phones, pagers or audio equipment of any type when working on or near any fuel-related components. Highly flammable mixtures are always present and may be ignited. Failure to follow these instructions can result in personal injury.
- Fuel in the fuel system remains under high pressure even when the engine is not running. Before servicing or disconnecting any of the fuel system components, the fuel system pressure must be relieved to prevent accidental spraying of fuel, causing personal injury or a fire hazard.

Fuel Injection

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

General Information

Electronic fuel injectors for all gasoline engine applications are basically the same. They consist of an injector body, an electric solenoid, spring, nozzle and a filter. The injector is supplied a constant supply of pressurized fuel from the fuel system. The primary function of the fuel injector is to atomize gasoline into the surrounding air at the proper time.

Throttle body injectors atomize fuel into the intake manifold or combustion chamber in much the same manner as a conventional carburetor (wet intake); port fuel injectors direct the atomized fuel at the back side of each cylinder's intake valve(s) (dry intake). Gasoline direct injection systems operate at substantially higher pressure and direct the atomized fuel directly into the combustion chamber of each cylinder.

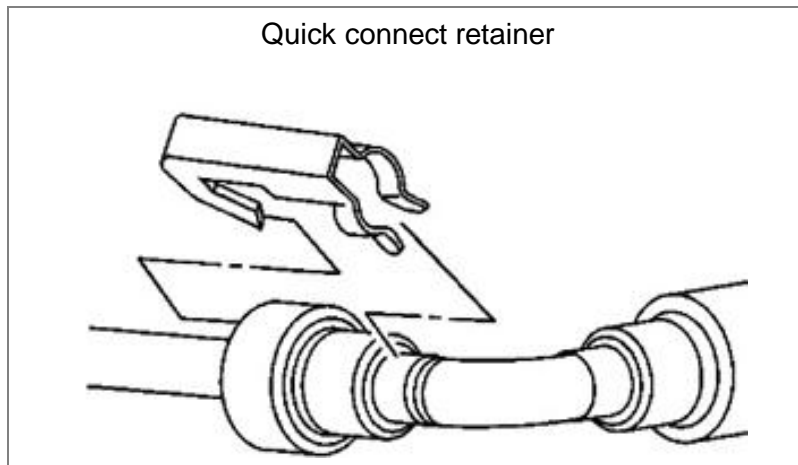
Fuel Lines and Fittings

Removal & Installation

Quick Connect Fitting(S) Service (Metal Collar)

To Remove:

1. Relieve the pressure in the fuel system.

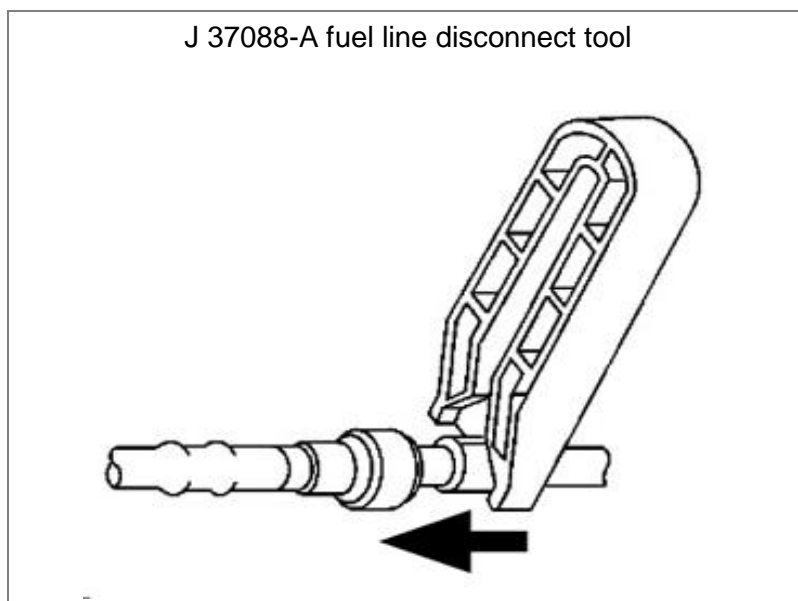


2. Detach the retainer from the fitting.

CAUTION

When using compressed air, be sure to wear safety glasses.

3. Use compressed air to remove any dirt in the fitting.



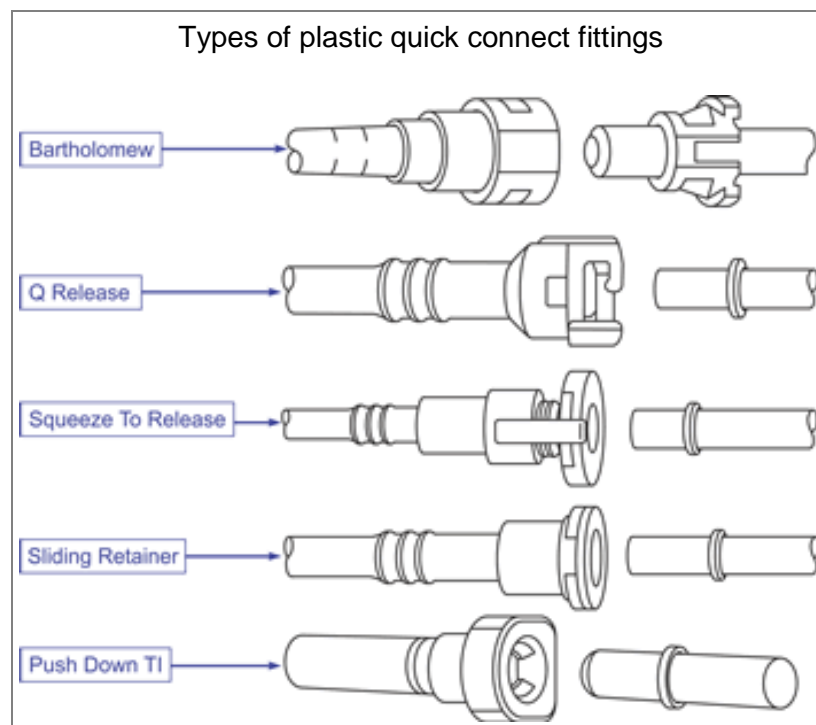
4. Use a J 37088-A fuel line disconnect tool to release the locking tabs by inserting it into the female connector and pushing in.
5. Pull the male side of the connection from the female.
6. Wipe off the male pipe end with a clean shop towel.
7. Check the connectors for any dirt, rust, or burrs.

To Install:

1. Use a few drops of clean engine oil to lubricate the male pipe end.
2. Insert the male pipe end into the female connection and push on both sides until the retaining tabs snap into place.
3. Make sure the connection is secure by pulling on both sides of the quick-connect fitting.
4. Attach the retainer to the quick-connect fitting.

Quick Connect Fitting(S) Service (Plastic Collar)

To Remove:

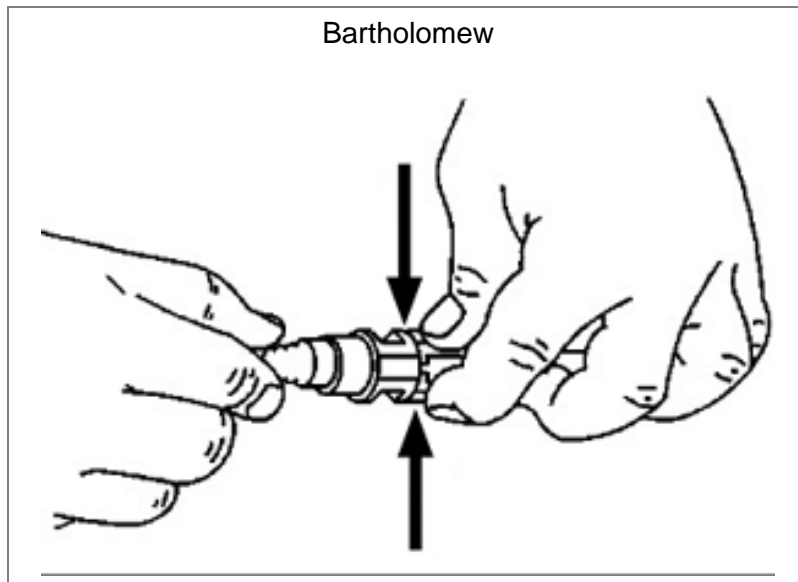


1. Relieve the pressure in the fuel system.

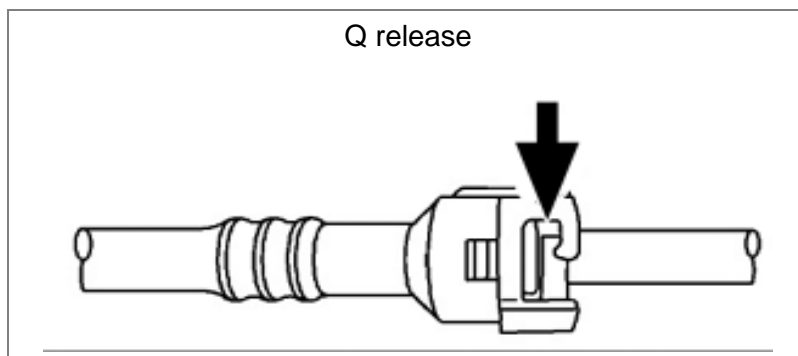
CAUTION

When using compressed air, be sure to wear safety glasses.

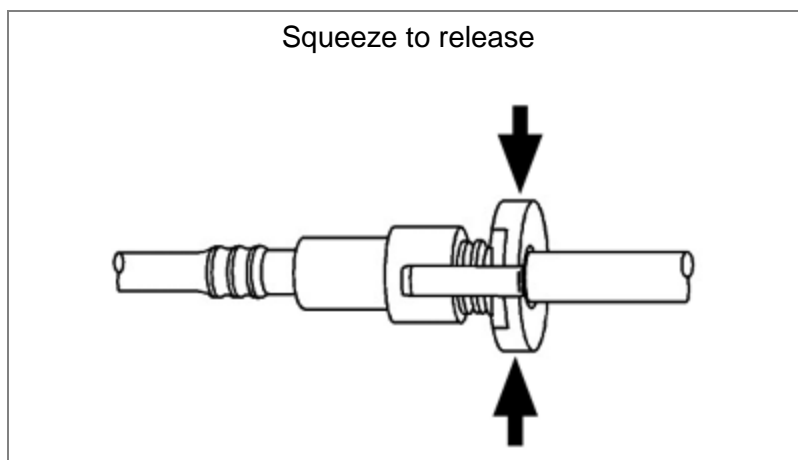
2. Use compressed air to remove any dirt in the fitting.



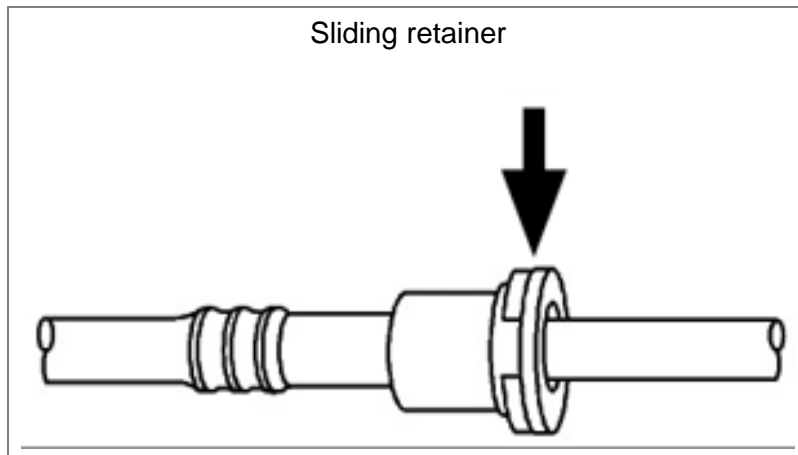
3. For Bartholomew connectors, squeeze the plastic release tabs.



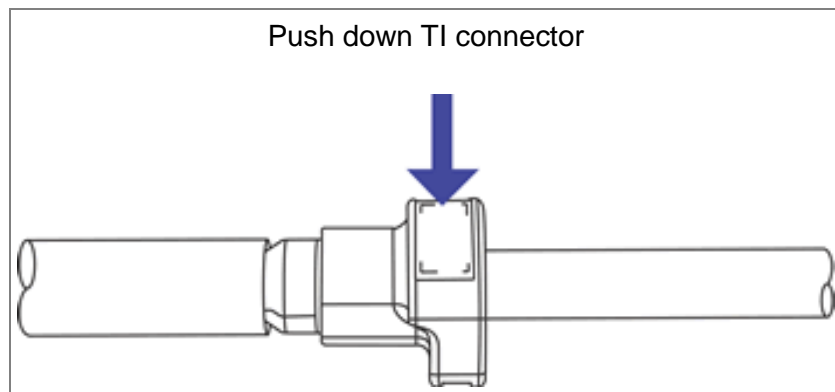
4. For Q release connectors, push the tab to the other end of the slot to release the fitting.



5. For squeeze to release connectors, squeeze the plastic ring where shown.



6. For sliding retainer connectors, push in on the side of the release tab. If the tab does not move, push in on the other side.



7. For push down TI connector, press down on the tab where shown.
8. Pull the male side of the connection from the female.

To Install:

1. Use a few drops of clean engine oil to lubricate the male pipe end.
2. Insert the male pipe end into the female connection and push on both sides until the retaining tabs snap into place.
3. Make sure the connection is secure by pulling on both sides of the quick-connect fitting.

Fuel Injectors

Testing

WARNING

Stay clear of all moving engine parts. Do not wear dangling jewelry or loose clothes. Keep power tool cords or other items that might get caught in a moving part away from fan and pulleys. Also, do not work on an open fuel system around open flames, welders, or any device that can cause a spark.

Checking fuel injector operation with the engine running is as simple as listening for a clicking sound coming from the injectors. Use a mechanic's stethoscope, or a section of rubber hose. Place the end of the stethoscope or the rubber hose onto the body of the injector. Place the stethoscope in your ears, or place the end of the hose against your ear. An audible clicking noise should be heard; this is the solenoid operating. If the injector makes this noise, the injector driver circuit and computer are operating as designed. Continue testing all the injectors this way.

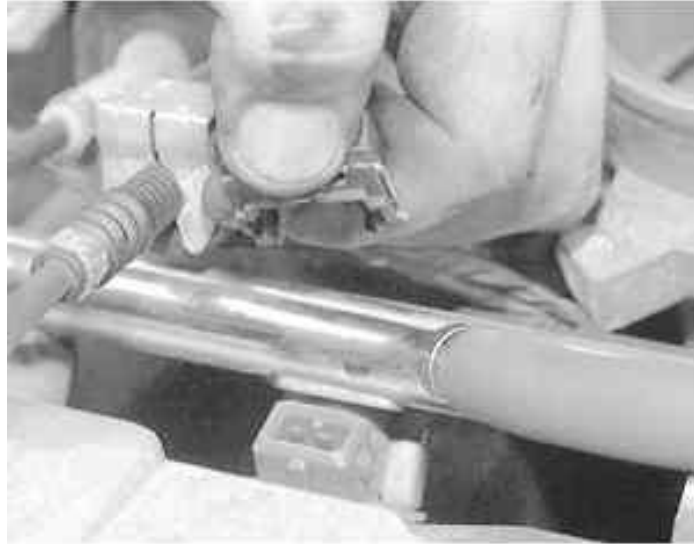
All Injectors Clicking

If you've determined that all injectors are clicking, but the problem is the fuel system continue diagnostics. Make sure that you have checked fuel pump pressure as outlined. An easy way to determine a weak or unproductive cylinder is a cylinder drop test. This is accomplished by cancelling one cylinder at a time, and seeing which cylinder causes the least difference in the idle. The cylinder(s) that causes the least change is the weak cylinder(s).

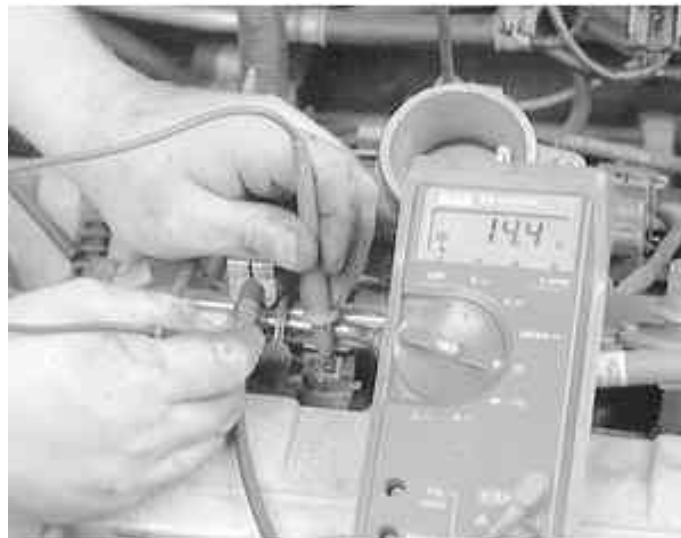
If the injectors were all clicking and the ignition system is functioning properly, remove the injector of the suspect cylinder and have it bench tested. This is accomplished by checking for a spray pattern from the injector itself. The injectors are placed in a device that applies an electrical signal to the injector and a supply of pressurized solvent (not fuel) to check the spray pattern. If no spray is achieved, replace the injector and check the engine performance

One or More Injectors Are Not Clicking

Unplug the fuel injector connector



Probe the two terminals of a fuel injector to check resistance



Plug the correct "noid" light directly into the injector harness connector



If the correct "noid" light flashes while the engine is running, the injector driver circuit inside the PCM is working



If one or more injectors are found to be inoperative, testing the injector driver circuit and computer can be accomplished using a "noid" light. First, with the engine not running and the ignition key in the **OFF** position, remove the connector from the injector you plan to

test, then plug the "noid" light into the injector connector. Start the engine and the "noid" light should flash, signaling that the injector driver circuit is working. If the "noid" light flashes, but the injector does not click when plugged in, test the injector's resistance. Resistance should be between 13.8-15.2 Ohms. Repeat this procedure on each injector, noting which cylinder(s) are faulty.

If the "noid" light does not flash, the injector driver circuit is faulty. Shut OFF the engine, and then disconnect the negative battery cable. Unplug the "noid" light from the injector connector and unplug the PCM. Check the harness between the appropriate pins on the harness side of the PCM connector and the injector connector. Resistance should be less than 5.0 ohms; if not, repair the circuit. If resistance is within specification, the injector driver inside the PCM is faulty. Replace the PCM.

Fuel Injector Balance Test

Preliminary Checks

1. Verify spark or lack of spark available at each cylinder
2. Verify fuel pressure and condition of fuel supply system

Injector Balance Test Procedure

1. Connect a fuel pressure gauge to the fuel rail pressure connection.
2. Connect a Scan Tool, turn the to "ON" and Select Special Functions, Fuel System - Injector Balance Test
3. Select injector #1; the fuel system will prime. Record the initial pressure reading immediately after the fuel pump shuts off.
4. Press the soft key to pulse the first injector. Record the 'Pressure After Pulse' reading immediately after the injector stops pulsing
5. Select and test each remaining injector. Be sure to record the Initial Pressure reading after each fuel system prime!

Injector Balance Test Analysis

1. Subtract the 'Pressure After Pulse' reading from the Initial Pressure reading for each cylinder, record as Subtracted Value.
2. Identify and record the 'Maximum Subtracted Value' and the 'Minimum Subtracted Value'.
3. Subtract the Minimum Reading from the Maximum Reading to obtain Max Difference.
4. If the Max Difference is less than 20 kPa (2.9psi), the injector are all flowing about the same and should not be replaced.
5. If the Max Difference is greater than 20 kPa (2.9psi), you have one or more faulty injector(s). Replace the injector that appears to be different than the rest (Injector #4 in the example above). Repeat the balance test with the new injector to make sure that Max Difference is now less than 20 kPa (2.9psi).

Removal & Installation

4.2L Engine

To Remove:

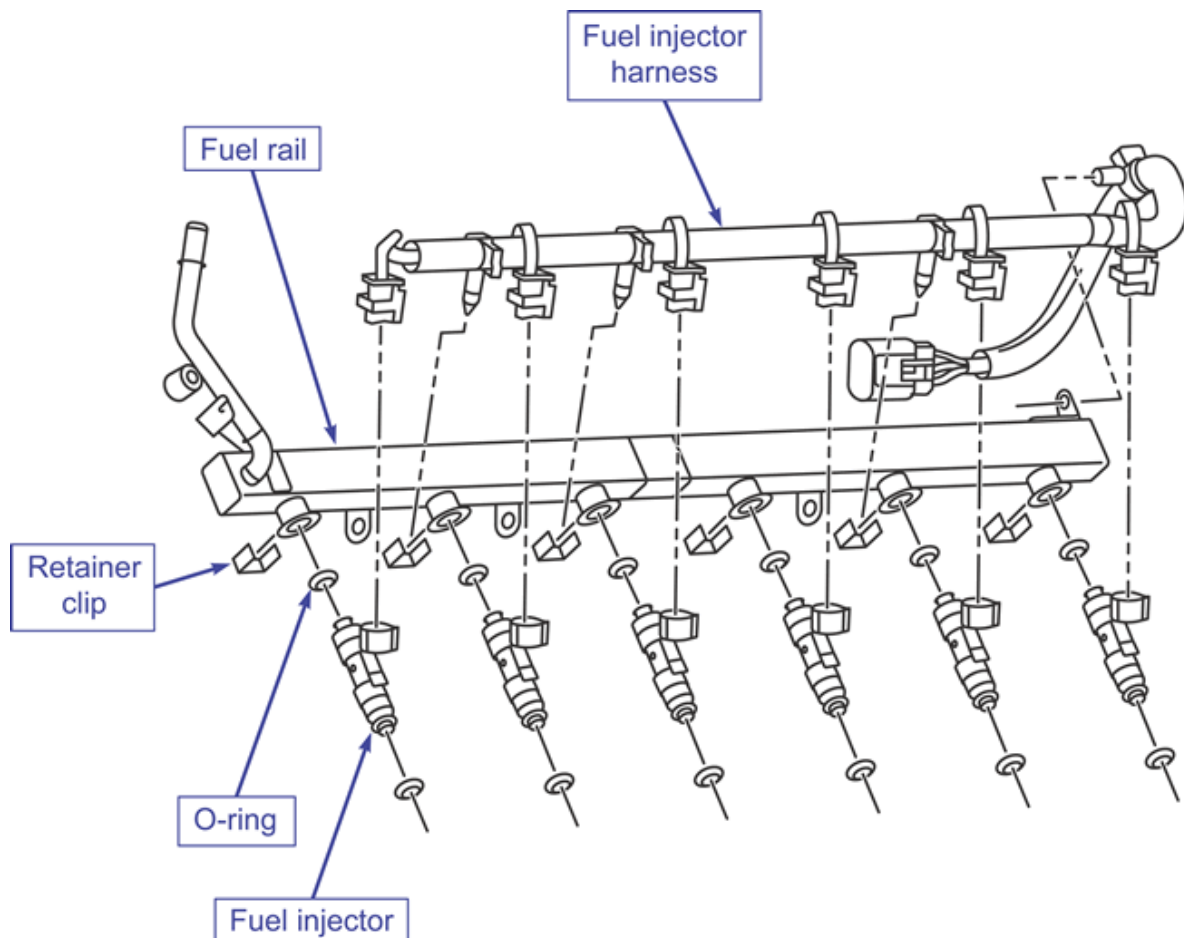
WARNING

Be careful when removing the fuel injectors in order to prevent damage to the connector pins and nozzles. Submerging the injectors in any cleaners or solvents may damage the injectors.

CAUTION

Fuel injector leakage may contaminate the engine oil.

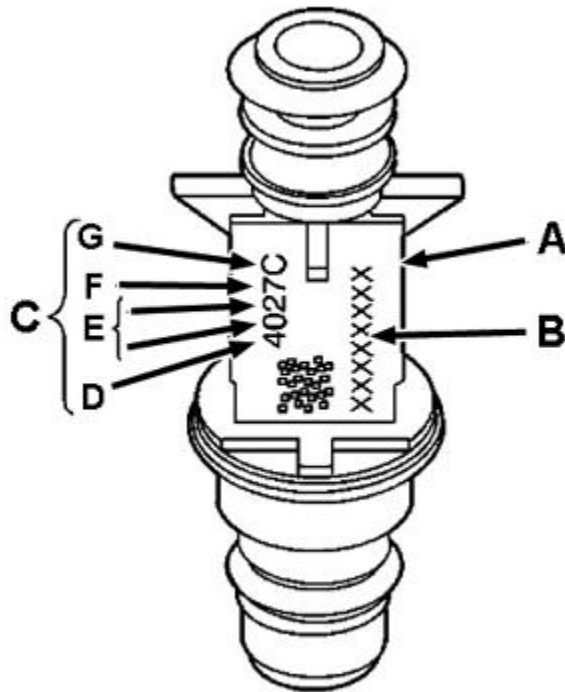
Fuel injector removal and installation



1. Remove the fuel rail assembly from the cylinder head.
2. Disconnect the fuel injector connectors.
3. Remove and discard the fuel injector retainer clips from the fuel injectors
4. Remove the fuel injectors from the fuel rail.
5. Remove and discard the fuel injector o-ring seals.

To Install:

Fuel injector (A), Part number (B), Build date code (C),
Month (D), Day (E), Year (F), Shift (G)



NOTE: Use the correct part number when ordering new fuel injectors.

1. Use clean engine oil to lubricate the new o-ring seals.
2. Install new fuel injector o-ring seals to the fuel injectors.
3. Install new retainer clips to the fuel injectors.
4. Install the fuel injectors into the fuel rail.
5. Connect the fuel injector connectors.
6. Install the fuel rail assembly to the cylinder head.

5.3L & 6.0L Engines

To Remove:

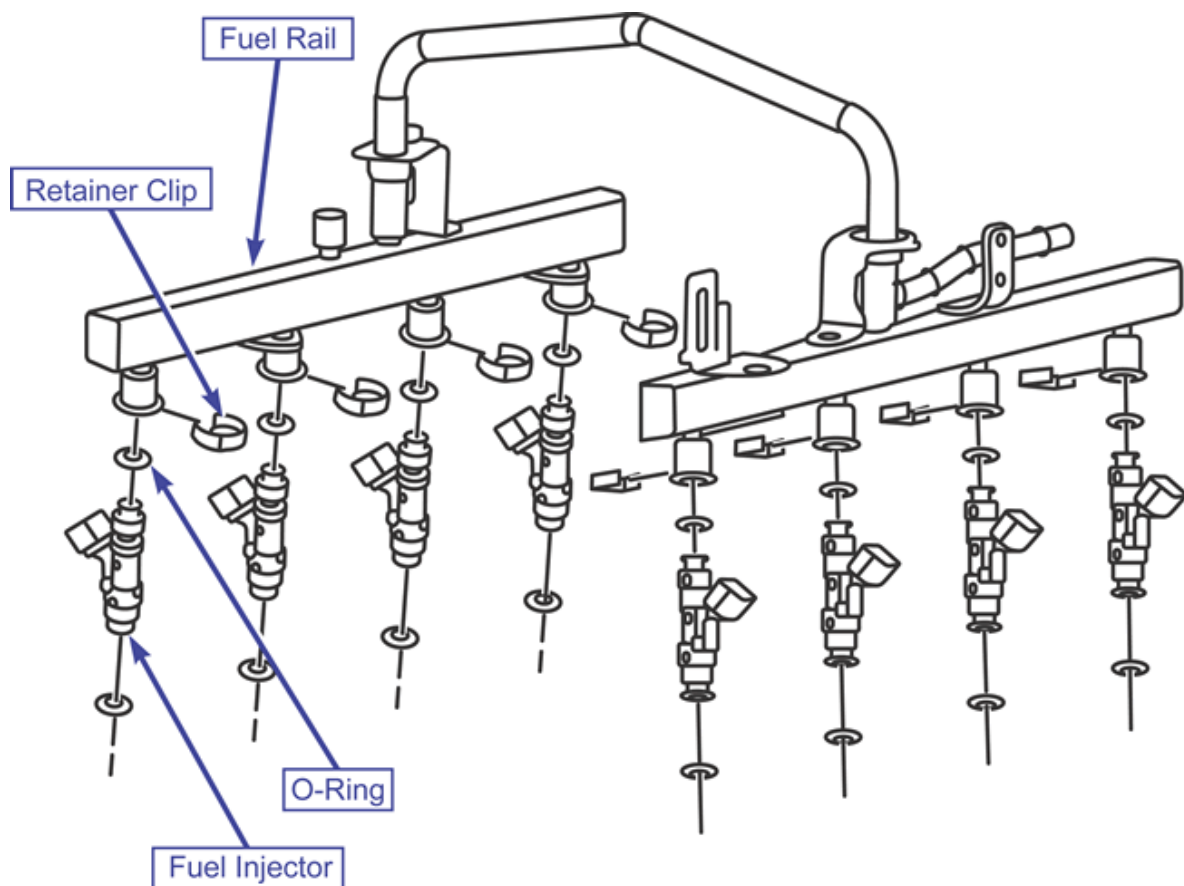
WARNING

Be careful when removing the fuel injectors in order to prevent damage to the connector pins and nozzles. Submerging the injectors in any cleaners or solvents may damage the injectors.

CAUTION

Fuel injector leakage may contaminate the engine oil.

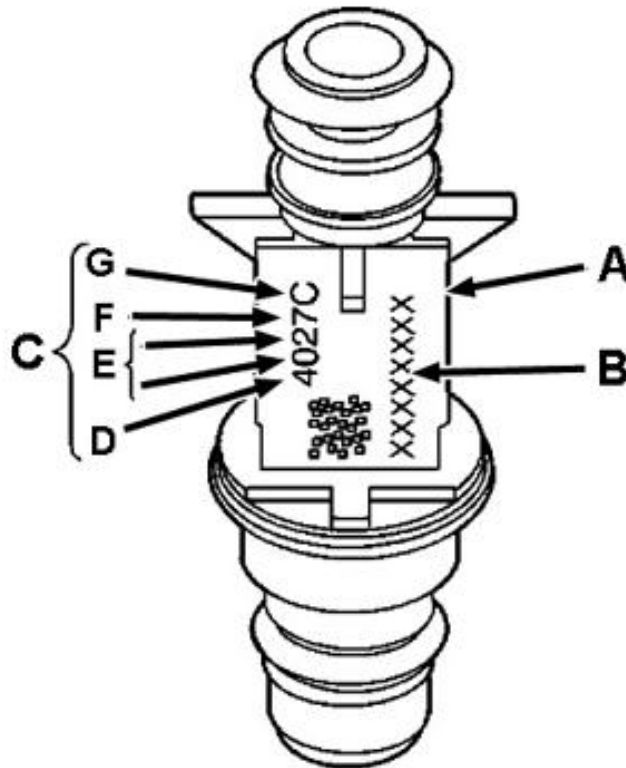
Fuel injector removal and installation



1. Remove the fuel rail assembly from the cylinder head.
2. Disconnect the fuel injector connectors.
3. Remove and discard the fuel injector retainer clips from the fuel injectors
4. Remove the fuel injectors from the fuel rail.
5. Remove and discard the fuel injector o-ring seals.

To Install:

Fuel injector (A), Part number (B), Build date code (C),
Month (D), Day (E), Year (F), Shift (G)



NOTE: Use the correct part number when ordering new fuel injectors.

1. Use clean engine oil to lubricate the new o-ring seals.
2. Install new fuel injector o-ring seals to the fuel injectors.
3. Install new retainer clips to the fuel injectors.
4. Install the fuel injectors into the fuel rail.
5. Connect the fuel injector connectors.
6. Install the fuel rail assembly to the cylinder head.

Fuel Rail Assembly

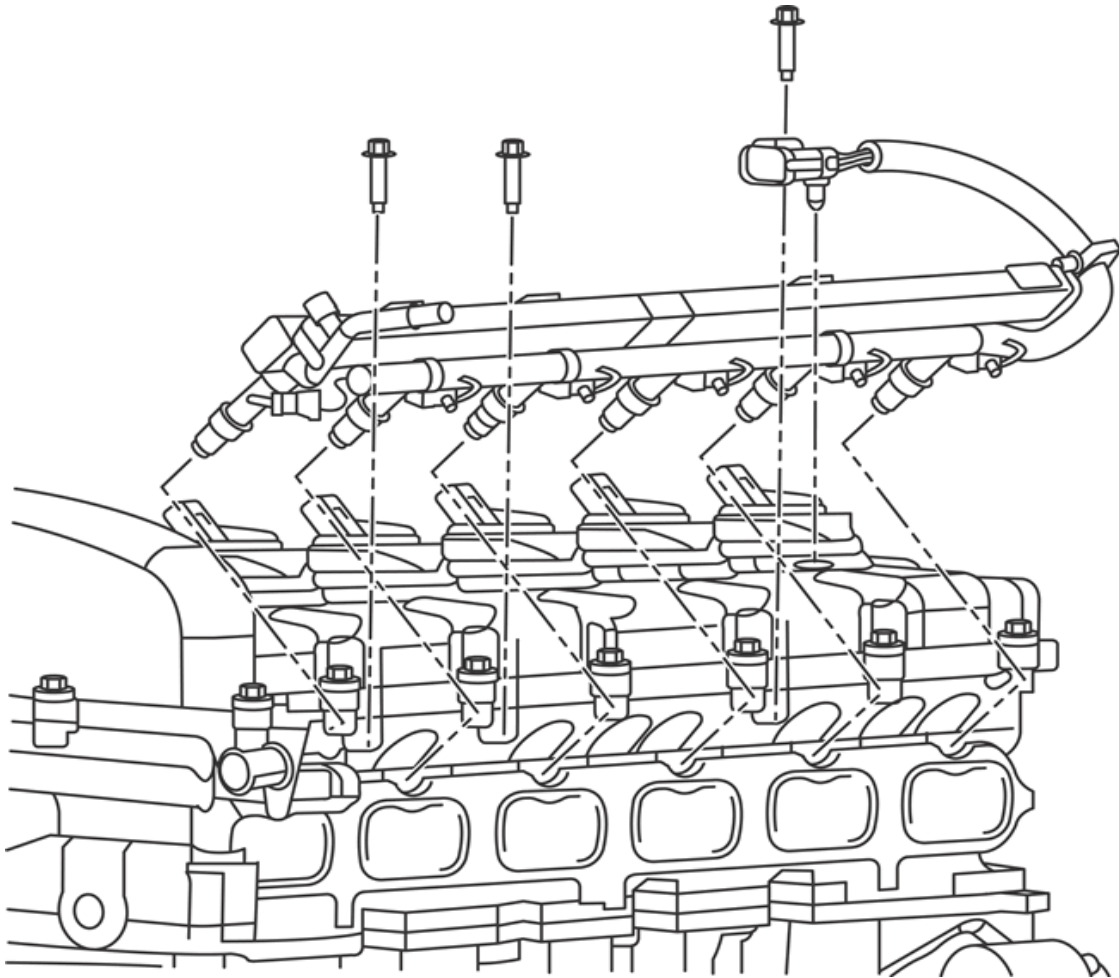
Removal & Installation

4.2L Engine

To Remove:

1. Relieve the pressure in the fuel system.
2. Remove the intake manifold from the engine.
3. Disconnect the fuel feed pipe from the fuel rail.
4. Use GM X-30A or an equivalent spray type cleaner to clean the fuel rail assembly and cylinder head.
5. Disconnect the fuel injector harness connector from the engine harness.
6. Detach the fuel injector harness connector from the camshaft cover.

Fuel rail assembly removal and installation



1. Detach the fuel rail assembly from the cylinder head.
2. Remove and discard the lower o-ring seals from the fuel injectors.

To Install:

1. Use clean engine oil to lubricate the new o-ring seals.
2. Install the o-ring seals onto the fuel injectors.
3. Apply GM P/N 12345382 threadlock or equivalent to the fuel rail bolt threads.
4. Attach the fuel rail assembly to the cylinder head. Torque the bolts to **89 in-lb (10 Nm)**.
5. Attach the fuel injector harness connector to the camshaft cover.
6. Connect the fuel injector harness connector to the engine harness.
7. Connect the fuel feed pipe to the fuel rail.
8. Install the intake manifold onto the engine.
9. Turn on the ignition for 2 seconds, with the engine off, and then turn off the ignition. After 10 seconds, turn the ignition back on with the engine off.
10. Check for leaks in the fuel lines.

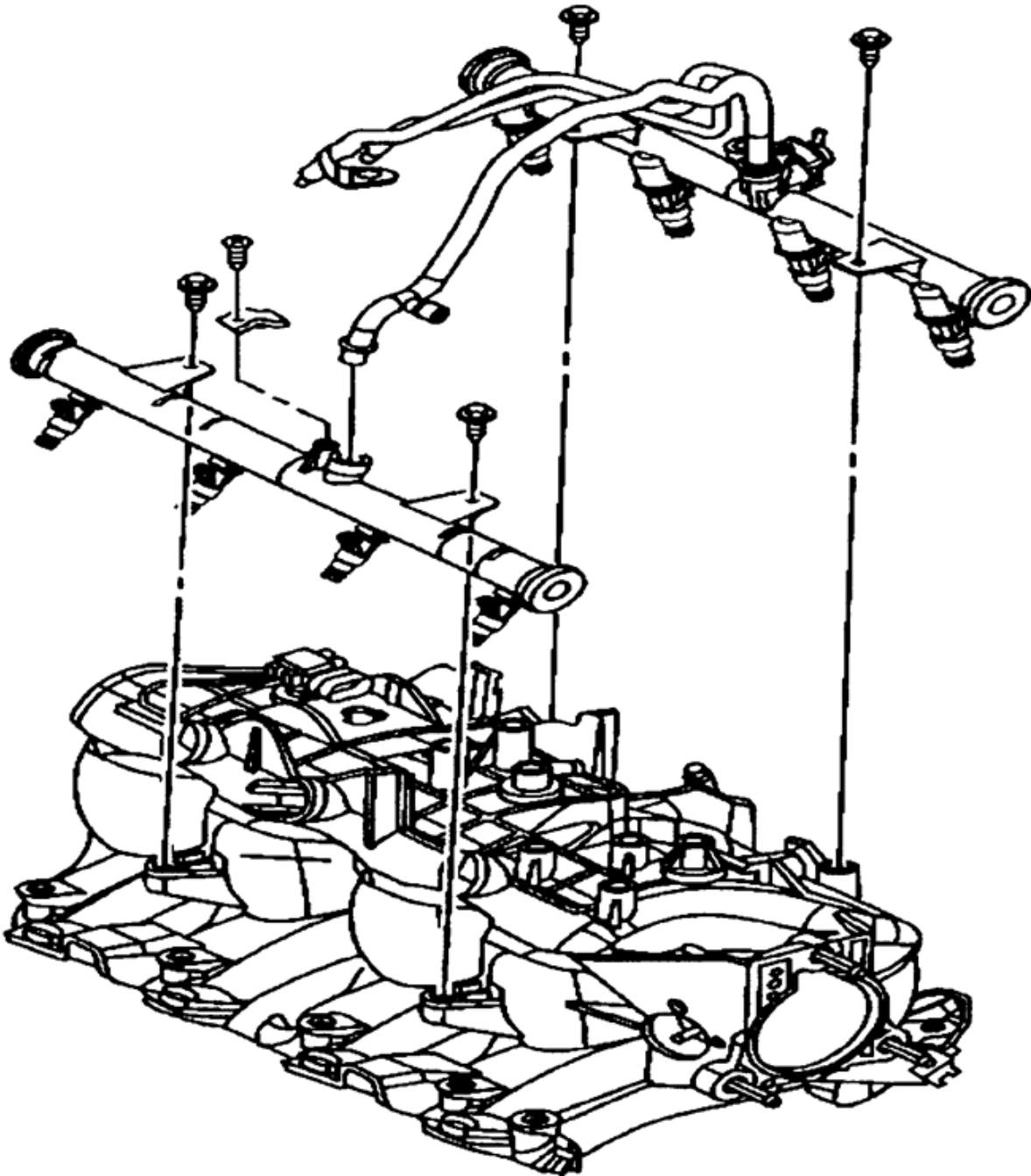
5.3L & 6.0L Engines

To Remove:

NOTE: Make sure to be careful when removing the fuel rail assembly to avoid damaging the fuel injector spray tips and the fuel injector connector terminals.

1. Remove the air cleaner outlet duct from the engine compartment.
2. Relieve the pressure in the fuel system.
3. Disconnect the positive crankcase ventilation dirty air hose from the intake manifold and positive crankcase ventilation (PCV) orifice tube.
4. Detach the fuel injector harness connectors from the valve rocker arm covers.
5. Disconnect the A/C compressor pressure switch, mass airflow/intake air temperature sensor, generator, ignition coil harnesses, electronic throttle control, fuel injector harnesses, evaporative emission purge solenoid, knock sensor, and manifold absolute pressure sensor connectors.
6. Detach the fuel injector harness connectors from the valve rocker arm covers.
7. Detach the harnesses from the ignition coil brackets.
8. Remove the upper engine harness retainer nut from the top of the engine.
9. Set aside the upper engine harness.
10. Disconnect the fuel feed pipe from the fuel rail.
11. Remove the evaporative emission canister purges solenoid from the fuel rail.
12. Use GM X-30A or an equivalent spray type cleaner to clean the fuel rail assembly and cylinder head.

Fuel rail assembly removal and installation



13. Remove the fuel rail assembly bolts from the cylinder heads.
14. Loosen the fuel rail crossover pipe retainer clip screws.
15. Remove the fuel rail assemblies from the cylinder heads.
16. To avoid system contamination, plug the holes and cap the fittings.
17. Remove and discard the lower o-ring seals from the fuel injectors.

To Install:

1. Use clean engine oil to lubricate the new o-ring seals.
2. Install the new lower o-ring seals onto the fuel injectors.
3. Install the fuel rail assemblies onto the cylinder heads.
4. Apply GM P/N 12345382 threadlock or equivalent to the fuel rail bolt threads.
5. **lb (10 Nm).**
6. Install the fuel rail assembly bolts into the cylinder heads. Torque the bolts to **89 in-lb (10 Nm).**
7. Tighten the fuel rail crossover pipe retainer clip screws. Torque the screws to **34 in-lb (3.8 Nm).**
8. Attach the fuel injector harness connectors to the valve rocker arm covers.
9. Install the evaporative emission canister purges solenoid onto the fuel rail.
10. Connect the fuel feed pipe to the fuel rail.
11. Reposition the upper engine harness onto the top of the engine and install the retainer nut into the engine. Torque the nut to **44 in-lb (5 Nm).**
12. Attach the harnesses to the ignition coil brackets.
13. Connect the A/C compressor pressure switch, mass airflow/intake air temperature sensor, generator, ignition coil harnesses, electronic throttle control, fuel injector harnesses, evaporative emission purge solenoid, knock sensor, and manifold absolute pressure sensor connectors.
14. Connect the positive crankcase ventilation dirty air hose to the intake manifold and positive crankcase ventilation (PCV) orifice tube.
15. Install the air cleaner outlet duct into the engine compartment.
16. Turn on the ignition for 2 seconds, with the engine off, and then turn off the ignition. After 10 seconds, turn the ignition back on with the engine off.
17. Check for leaks in the fuel lines.

Fuel Filter

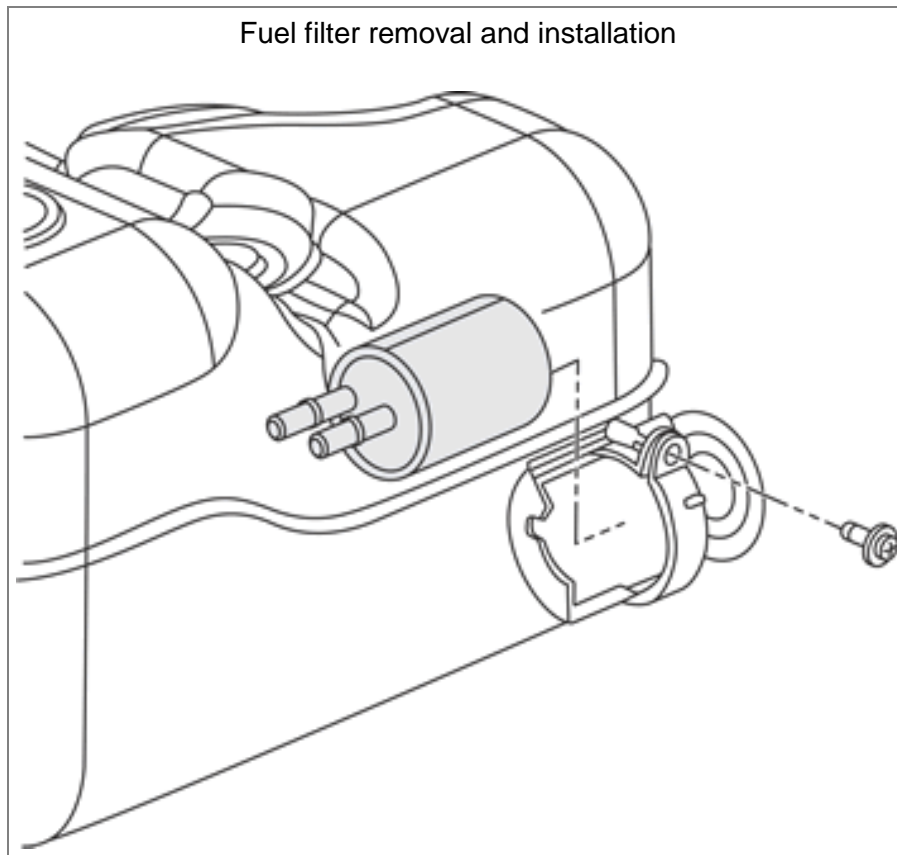
Removal & Installation

2002-2004

To Remove:

NOTE: If a fuel filter is restricted, clean and inspect the inside of the fuel tank.

1. Relieve the pressure in the fuel system.
2. Lift the vehicle.
3. If necessary, remove the fuel tank shield from the frame.
4. Make sure the fuel pipe and hose connections, as well as the surrounding areas, are clean.
5. Disconnect the fuel pipes from the fuel filter; keep the retaining clips with the filter.
6. To avoid fuel loss and fuel system contamination, cap off the fuel pipes.



7. Remove the screw from the fuel filter bracket.
8. Remove the fuel filter from the fuel filter bracket.

To Install:

1. Install the fuel filter into the fuel filter bracket.
2. For vehicles with a 4.2L engine, install the screw into the fuel filter bracket. Torque the screw to **13 in-lb (1.5 Nm)**.
3. For vehicles with a 5.3L engine, install the screw into the fuel filter bracket. Torque the screw to **106 in-lb (12 Nm)**.
4. Uncap the fuel pipes.
5. Connect the fuel pipes to the fuel filter.
6. Turn on the ignition for 2 seconds, with the engine off, and then turn off the ignition. After 10 seconds, turn the ignition back on with the engine off.
7. Check for leaks in the fuel lines.
8. Lift the vehicle.
9. If previously removed, install the fuel tank shield to the frame.
10. Lower the vehicle.

Fuel Pressure Regulator

Removal & Installation

4.2L Engine

2002-2004

To Remove:

1. Relieve the pressure in the fuel system.
2. Remove the air cleaner outlet resonator from the engine.
3. Detach the engine harness from the front of the engine.
4. Disconnect the fuel pressure regulator vacuum line from the fuel pressure regulator.
5. Make sure the fuel pressure regulator and surrounding areas are free from dirt and debris.
6. Detach the fuel rail return pipe from the fuel rail.
7. Remove the fuel return pipe retainer from the fuel return pipe.
8. Remove the fuel pressure regulator retainer from the fuel pressure regulator.
9. Remove the fuel pressure regulator from the fuel rail.
10. If the fuel pressure regulator filter screen is contaminated, discard the fuel pressure regulator.
11. Remove and discard the o-ring seal from the fuel pressure regulator.

To Install:

1. If the fuel pressure regulator is not being replaced, install a new fuel pressure regulator screen.
2. Use clean engine oil to lubricate the o-ring.
3. Install a new o-ring seal to the fuel pressure regulator.
4. Install the fuel pressure regulator onto the fuel rail.
5. Install the fuel pressure regulator retainer onto the fuel pressure regulator. Torque the screw to **71 in-lb (8 Nm)**.
6. Remove the fuel return pipe retainer from the fuel return pipe. Torque the screw to **71 in-lb (8 Nm)**.
7. Attach the fuel rail return pipe to the fuel rail.
8. Connect the fuel pressure regulator vacuum line to the fuel pressure regulator.
9. Turn on the ignition for 2 seconds, with the engine off, and then turn off the ignition. After 10 seconds, turn the ignition back on with the engine off.
10. Check for leaks in the fuel lines.
11. Attach the engine harness to the front of the engine.
12. Install the air cleaner outlet resonator onto the engine.

5.3L Engine

2003-2004

To Remove:

1. Relieve the pressure in the fuel system.
2. Disconnect the fuel pressure regulator vacuum line from the fuel pressure regulator.
3. Make sure the fuel pressure regulator and surrounding areas are free from dirt and debris.
4. Remove and discard the fuel pressure regulator retainer from the fuel pressure regulator.
5. Remove the fuel pressure regulator from the fuel rail.
6. Make sure the backup ring, o-ring seal, and regulator filter are not still in the fuel rail.

To Install:

1. If necessary, install the backup ring, o-ring seal, and regulator filter onto the fuel pressure regulator.
2. Use clean engine oil to lubricate the o-ring.
3. Install a new o-ring seal to the fuel pressure regulator.
4. Install the fuel pressure regulator onto the fuel rail.
5. Install the new fuel pressure regulator retainer onto the fuel pressure regulator.
6. Connect the fuel pressure regulator vacuum line to the fuel pressure regulator.
7. Turn on the ignition for 2 seconds, with the engine off, and then turn off the ignition. After 10 seconds, turn the ignition back on with the engine off.
8. Check for leaks in the fuel lines.

Fuel Sender Assembly

Removal & Installation

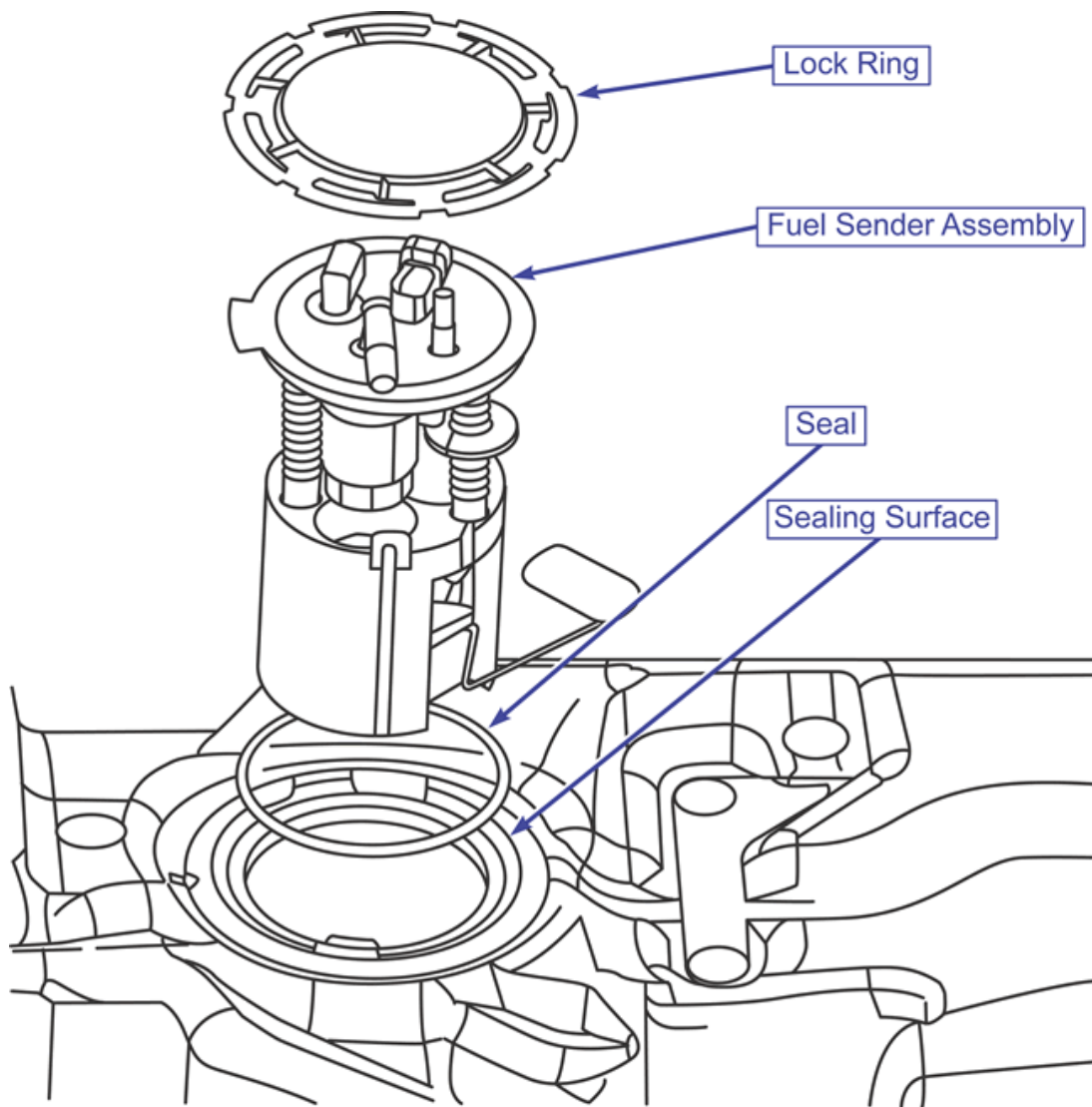
To Remove:

1. Remove the fuel tank from the vehicle.
2. Use a J 45722 fuel tank sending unit wrench and a long breaker bar to turn the fuel sender lock ring counterclockwise.

CAUTION

Handling the fuel sender assembly by the fuel pipes may cause damage to the joints.

Fuel sender assembly removal and installation



1. Remove the fuel sender assembly from the fuel tank.
2. Remove and discard the fuel sender assembly seal from the fuel tank.
3. Drain the fuel from the fuel sender assembly into an appropriate container.
4. Clean the sealing surfaces as necessary.
5. Set the lock ring on a flat surface and measure the clearance between the ring and the surface at seven points.
6. If the clearance is more than 0.016 in (0.41 mm), replace the lock ring.

To Install:

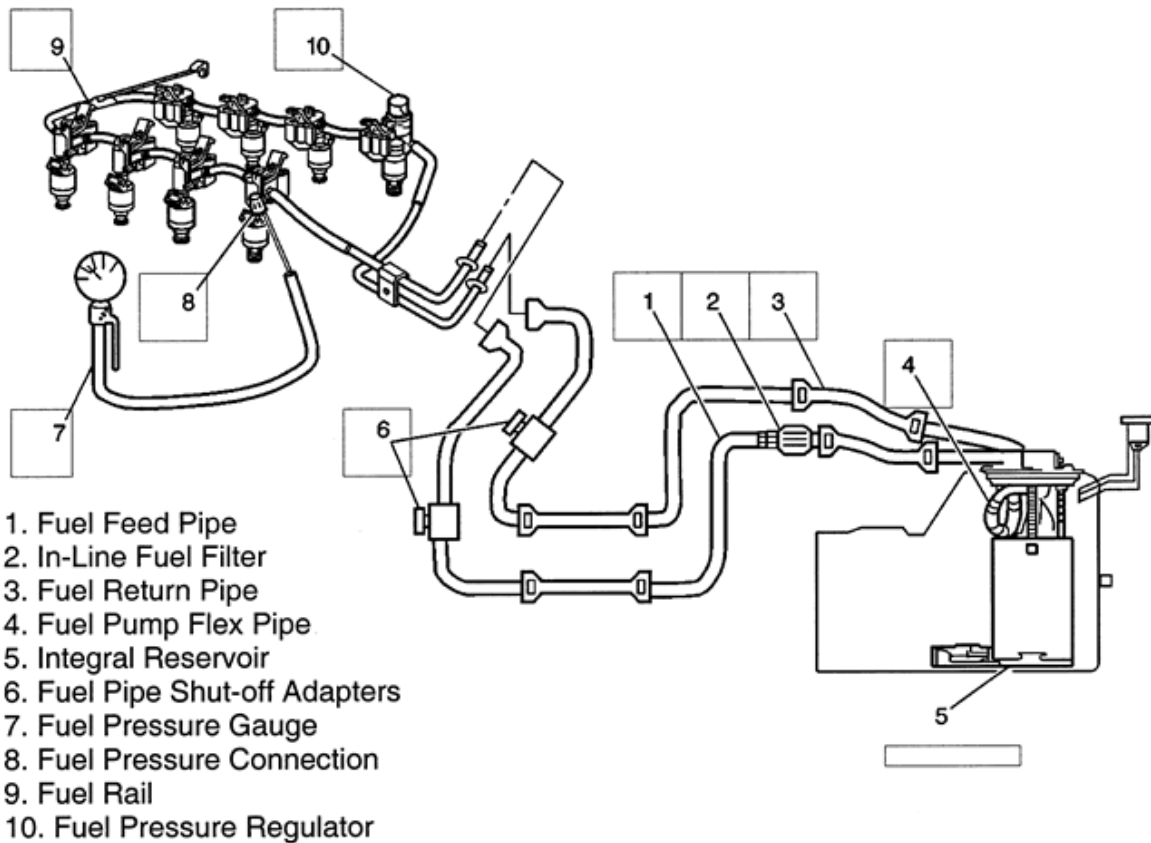
1. Install a new fuel sender assembly seal onto the fuel tank.
2. Install a new fuel sender assembly into the fuel tank.
3. Use a J 45722 fuel tank sending unit wrench and a long breaker bar to turn the fuel sender lock ring clockwise.
4. Install the fuel tank into the vehicle.

Fuel System Pressure

Relieving Fuel System Pressure

1. Before servicing the vehicle, refer to the precautions in the beginning of this section.
2. Disconnect the negative battery cable.
3. Remove the fuel filler cap from the filler neck.
4. Remove the appearance cover from the fuel supply manifold.
5. Connect a suitable fuel pressure gauge to the fuel pressure test port. Wrap a shop towel around the fitting while connecting the gauge to prevent fuel spillage.
6. Install the gauge bleed hose into a suitable container and open the valve to bleed the system.
7. Drain any remaining fuel from the gauge into the container and remove the gauge from the test port.

Fuel system circuit showing the pressure test port on the supply rail (typical)



Fuel System Pressure Test

1. Before servicing the vehicle, refer to the precautions in the beginning of this section.
2. Remove the injector cover.
3. Connect a suitable fuel pressure gauge to the fuel supply line. Wrap a shop towel around the fitting while connecting the gauge to prevent fuel spillage.
4. Turn ignition ON.
5. Install the gauge bleed hose into a suitable container and open the valve to bleed air from the system.
6. Activate fuel pump with scan tool.
7. Close bleed valve.
8. Check for leaks. With the key on and engine off the pressure should be within the manufactures recommended specifications.

Fuel Tank

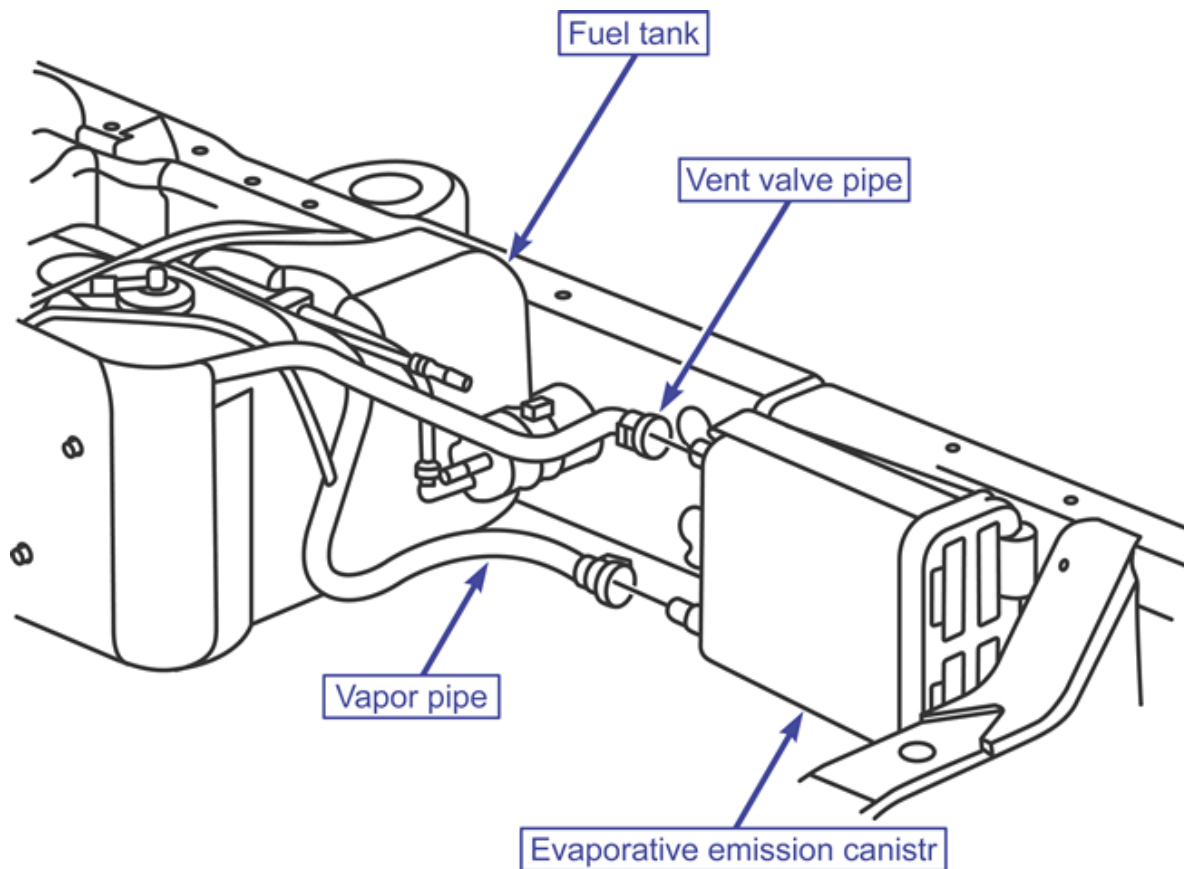
Removal & Installation

2002-2004

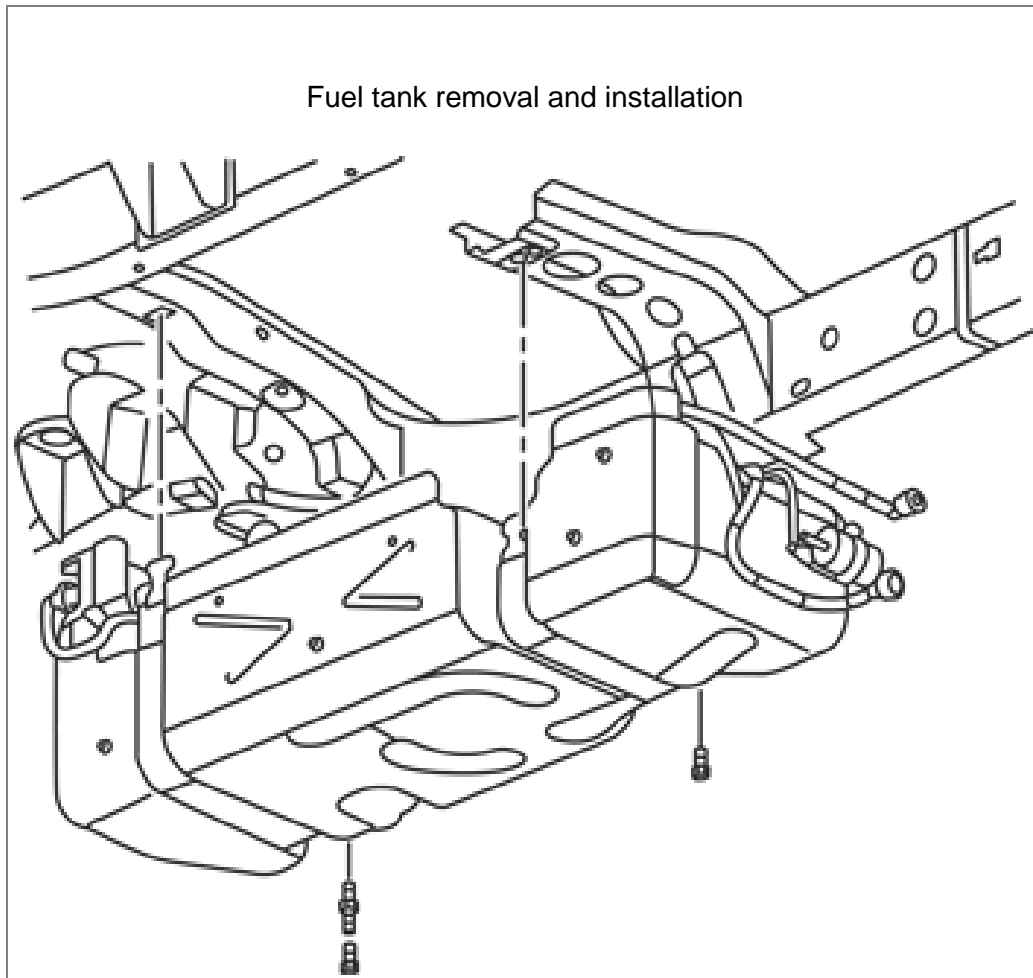
To Remove:

1. Relieve the pressure in the fuel system.
2. Lift the vehicle.
3. Remove the frame brace from the frame.
4. Remove the fuel tank shield from the fuel tank.
5. Drain the fuel from the tank into an approved container.
6. Loosen the fuel hose clamp and disconnect the hose from the fuel tank.
7. Disconnect the evaporative emission (EVAP) vent valve and fuel tank pressure sensor connectors.

Evaporative emission canister pipes removal and installation



1. Disconnect the evaporative emission (EVAP) vapor and vent valve pipes from the evaporative emission (EVAP) canister.
2. Disconnect the fuel return and feed pipes from the fuel tank.
3. To avoid system contamination, cap the evaporative emission (EVAP) and fuel pipes.
4. Use a jack to support the fuel tank.



5. Detach the fuel tank straps from the frame.
6. Lower the fuel tank.
7. Disconnect the fuel sender connector.
8. Remove the fuel tank from the vehicle.

To Install:

1. Place the fuel tank under the vehicle.
2. Connect the fuel sender connector.
3. Attach the fuel tank straps to the frame. Torque the bolts to **24 ft-lb (32 Nm)**.
4. Remove the caps from the evaporative emission (EVAP) and fuel pipes.
5. Connect the evaporative emission (EVAP) vapor and vent valve pipes to the evaporative emission (EVAP) canister.

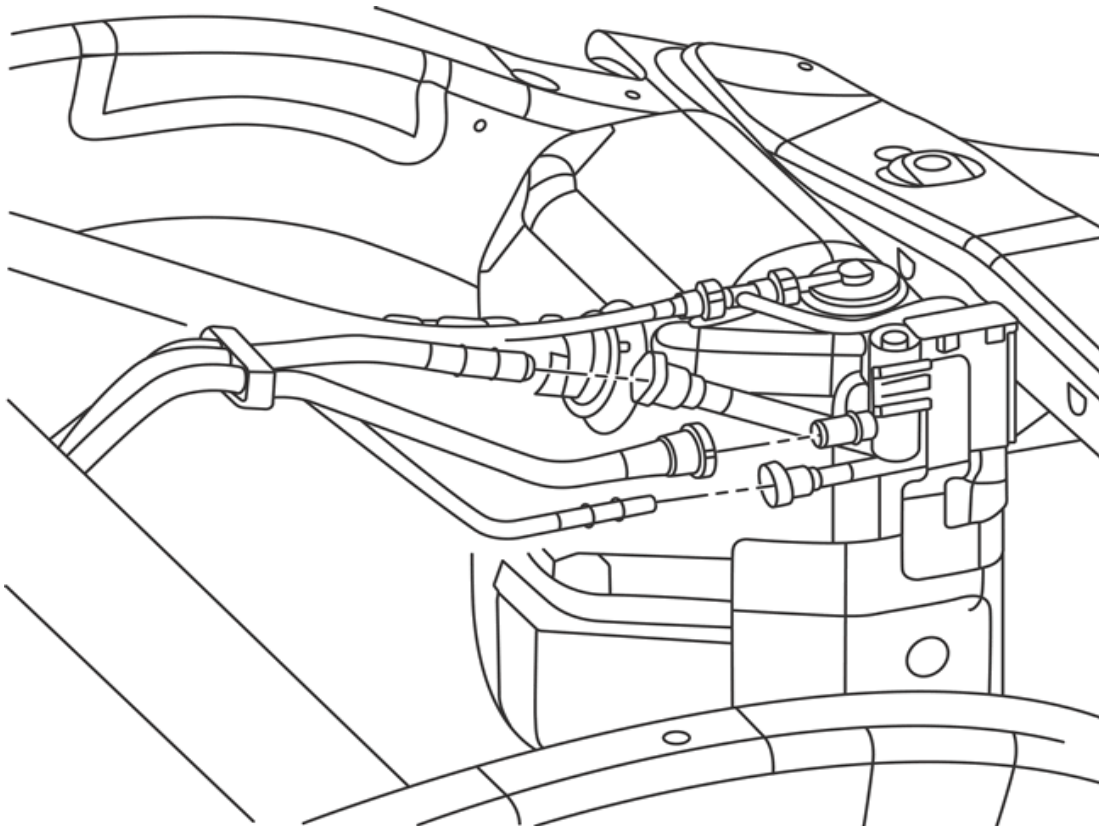
6. Connect the evaporative emission (EVAP) vent valve and fuel tank pressure sensor connectors.
7. Connect the fuel hose to the fuel tank. Torque the clamp to **22 in-lb (2.5 Nm)**.
8. Connect the fuel return and feed pipes to the fuel tank.
9. Lower the vehicle.
10. Refill the fuel tank.
11. Turn on the ignition for 2 seconds, with the engine off, and then turn off the ignition.
After 10 seconds, turn the ignition back on with the engine off.
12. Lift the vehicle.
13. Check for leaks in the fuel lines.
14. Install the fuel tank shield onto the fuel tank.
15. Install the frame brace onto the frame.
16. Lower the vehicle.

2005-2007

To Remove:

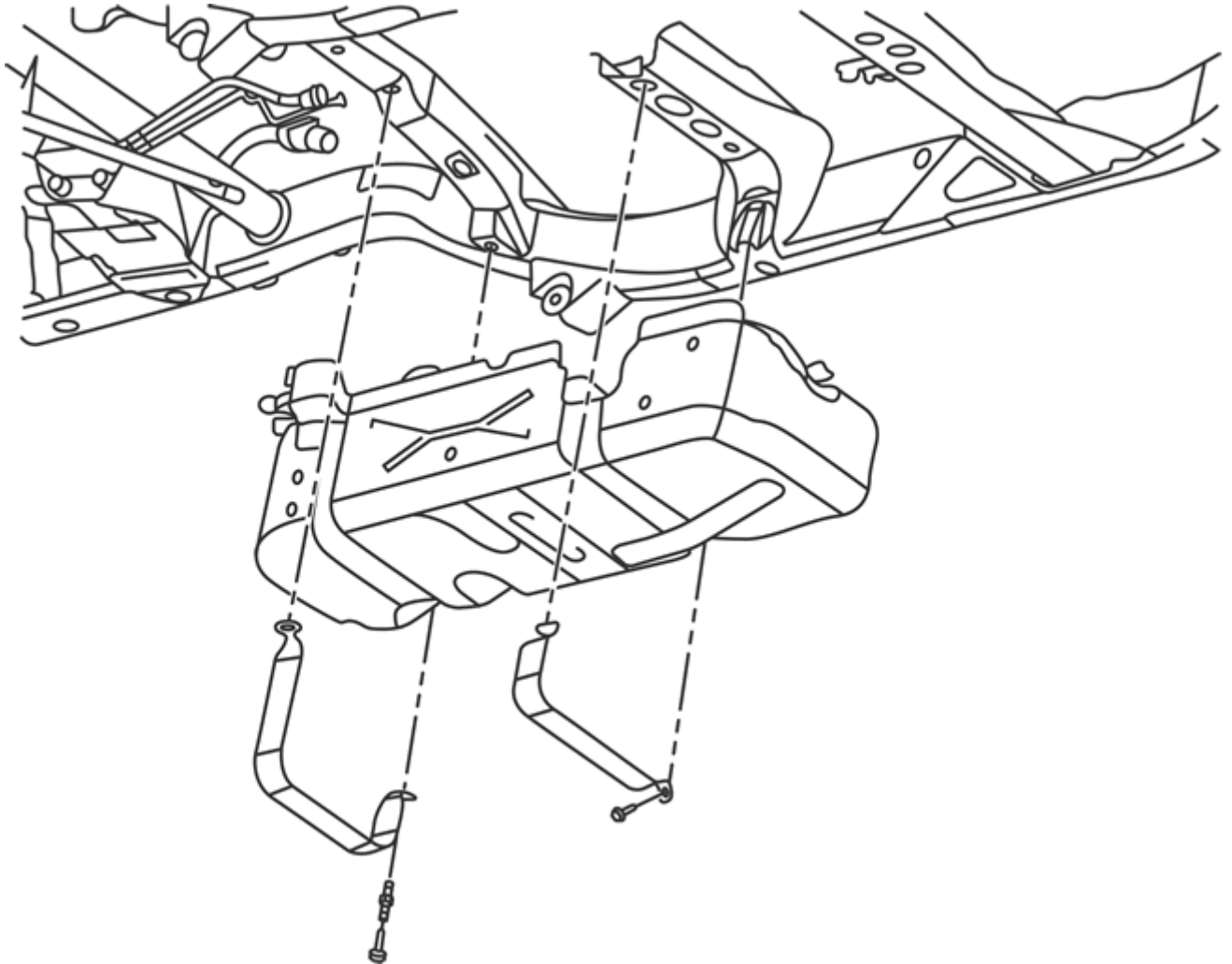
1. Relieve the pressure in the fuel system.
2. Lift the vehicle.
3. Remove the frame brace from the frame.
4. Remove the fuel tank shield from the fuel tank.
5. Drain the fuel from the tank into an approved container.

Evaporative emission canister pipes removal and installation



6. Disconnect the evaporative emission (EVAP) canister fresh air, solenoid, and purge pipes from the evaporative emission (EVAP) canister.
7. Disconnect the fuel filler pipe recirculation hose from the fuel tank.
8. Loosen the fuel fill pipe clamp and disconnect the pipe from the fuel tank.
9. Disconnect the fuel feed and evaporative emission (EVAP) pipes from the fuel tank.
10. To avoid system contamination, cap the pipes.
11. Use a jack to support the fuel tank.

Fuel tank removal and installation



12. Detach the fuel tank straps from the frame.
13. Lower the fuel tank.
14. Disconnect the evaporative emission (EVAP) vent valve, fuel tank pressure sensor, and fuel sender connectors.
15. Remove the fuel tank from the vehicle.

To Install:

1. Place the fuel tank under the vehicle.
2. Connect the evaporative emission (EVAP) vent valve, fuel tank pressure sensor, and fuel sender connectors.
3. Lift the fuel tank.
4. Attach the fuel tank straps to the frame. Torque the screws to **24 ft-lb (32 Nm)**.
5. Remove the caps from the pipes.
6. Connect the fuel feed and evaporative emission (EVAP) pipes to the fuel tank.
7. Connect the fuel fill pipe to the fuel tank. Torque the clamp to **22 in-lb (2.5 Nm)**.
8. Connect the fuel filler pipe recirculation hose to the fuel tank.
9. Connect the evaporative emission (EVAP) canister fresh air, solenoid, and purge pipes to the evaporative emission (EVAP) canister.
10. Lower the vehicle.
11. Refill the fuel tank.
12. Turn on the ignition for 2 seconds, with the engine off, and then turn off the ignition. After 10 seconds, turn the ignition back on with the engine off.
13. Lift the vehicle.
14. Check for leaks in the fuel lines.
15. Install the fuel tank shield onto the fuel tank.
16. Install the frame brace onto the frame.
17. Lower the vehicle.

Throttle Body

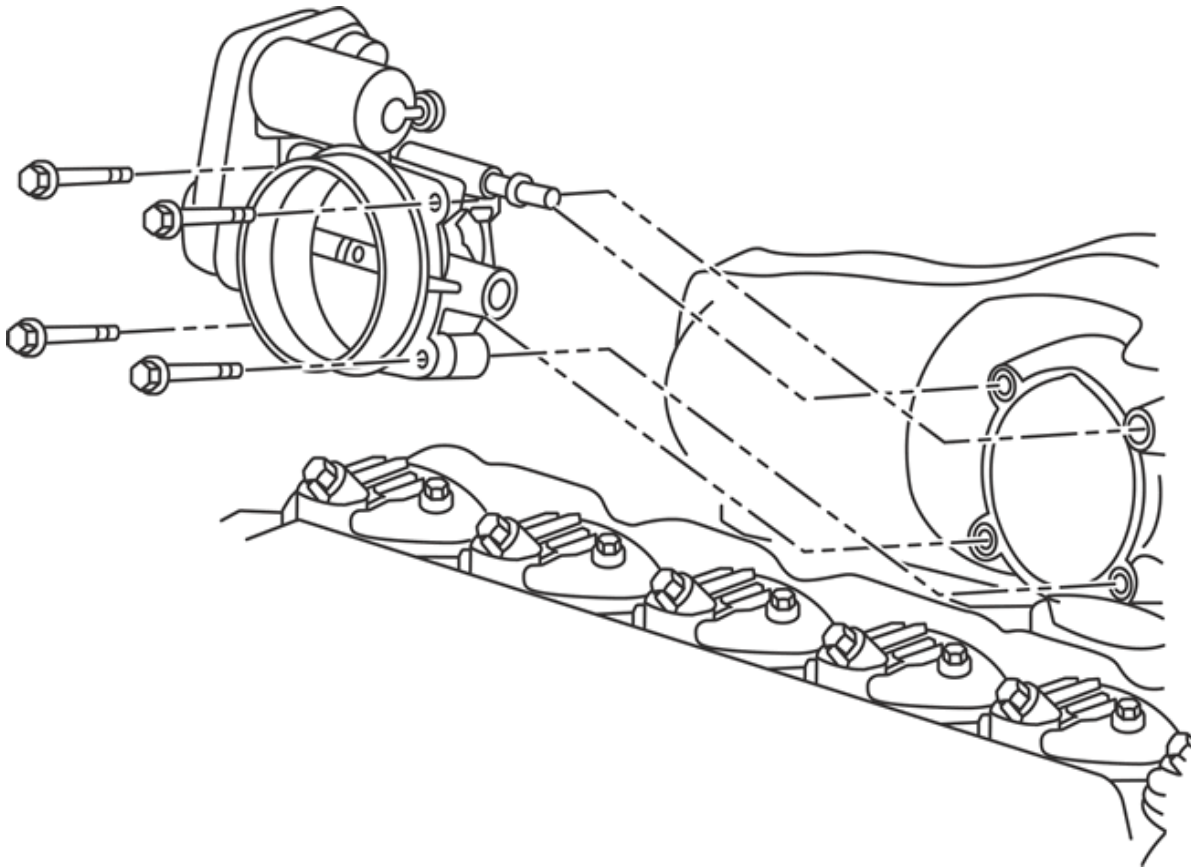
Removal & Installation

4.2L Engine

To Remove:

1. Remove the air cleaner outlet resonator from engine.
2. Disconnect the evaporative emission (EVAP) canister purge line from the throttle body.
3. Disconnect the throttle body connector.

Throttle body removal and installation



4. Disconnect the throttle body with the gasket from the intake manifold.
5. Clean the sealing surfaces as necessary.

To Install:

1. Apply GM P/N 12346004 sealer the throttle body bolts.
2. Attach the throttle body with the gasket to the intake manifold. Torque the bolts to **89 in-lb (10 Nm)**.
3. Connect the throttle body connector.
4. Connect the evaporative emission (EVAP) canister purge line to the throttle body.
5. Install the air cleaner outlet resonator onto the engine.

5.3L & 6.0L Engines

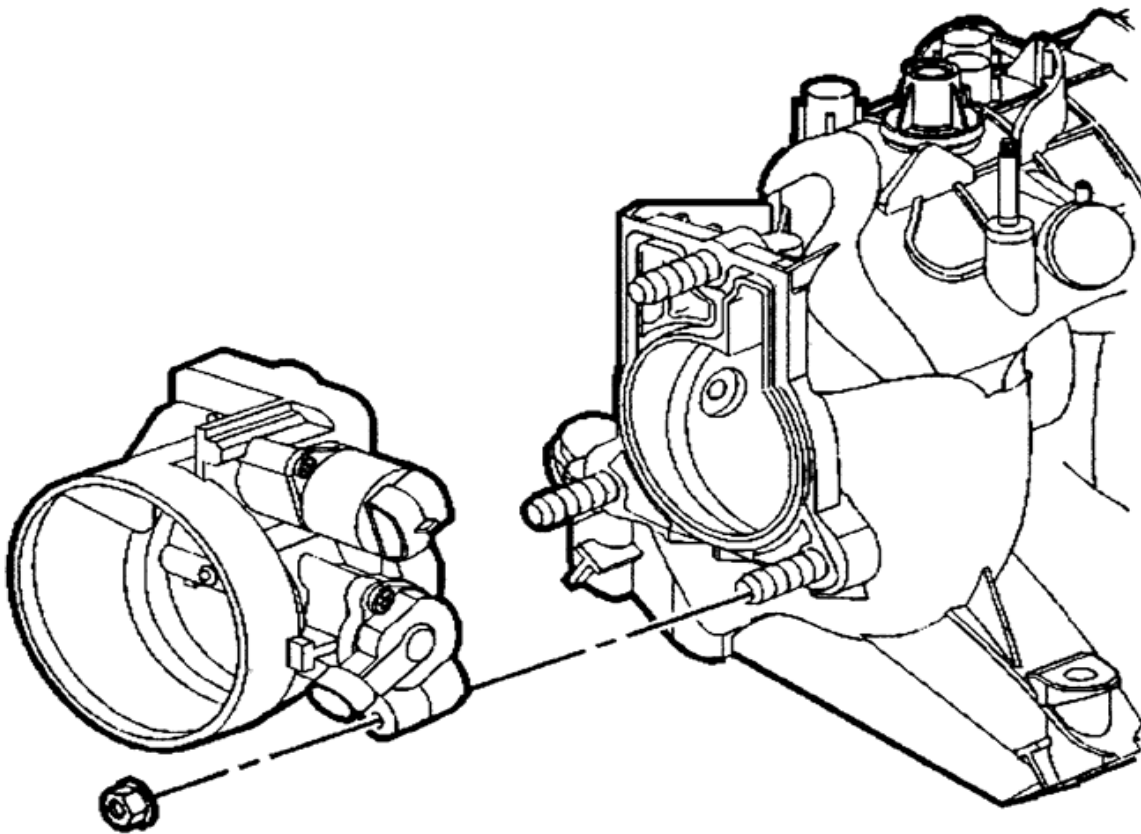
To Remove:

WARNING

Do not insert a screwdriver or other small tools into the throttle body to hold the throttle plate open.

1. Drain the cooling system.
2. Remove the air cleaner outlet duct from the engine compartment.
3. Disconnect the throttle actuator motor connector.
4. Disconnect the throttle body coolant hoses from the throttle body.

Throttle body removal and installation (2002-2004)



5. Detach the throttle body from the intake manifold.
6. Remove and discard the gasket from the throttle body.

To Install:

1. Install a new throttle body gasket to the throttle body.
2. For 2002-2004, attach the throttle body to the intake manifold. Torque the bolts to **89 in-lb (10 Nm)**.
3. For 2005-2007, attach the throttle body to the intake manifold. Torque the nuts and bolts to **53 in-lb (6 Nm)**.
4. Connect the throttle body coolant hoses to the throttle body.
5. Connect the throttle actuator motor connector.
6. Install the air cleaner outlet duct into the engine compartment.
7. Refill the cooling system.
8. Make sure the vehicle is not in a reduced engine power mode, the ignition switch is in the on position, and the engine is off.
9. Use a scan tool to check for a proper throttle opening and closing range.
10. Start the engine and check for leaks in the cooling system.

CHASSIS ELECTRICAL

Precautions

Before servicing any vehicle, please be sure to read all of the following precautions, which deal with personal safety, prevention of component damage and important points to take into consideration when servicing a motor vehicle:

- Always wear safety goggles or some type of eye/face protection when working with, around or under a vehicle.
- Be extremely careful while working on an operating engine, make sure you have no dangling jewelry, extremely loose clothes, power tool cords or other items that could get caught in any moving engine part.
- Never open, service or drain the radiator or cooling system when the engine is hot; serious burns can occur from the steam and hot coolant.
- Observe all applicable safety precautions when working around fuel. Whenever servicing the fuel system, always work in a well-ventilated area. Do not allow fuel spray or vapors to come in contact with a spark, open flame, or excessive heat (a hot drop light, for example). Keep a dry chemical fire extinguisher near the work area. Always keep fuel in a container specifically designed for fuel storage; also, always properly seal fuel containers to avoid the possibility of fire or explosion. Refer to the additional fuel system precautions later in this section.
- Fuel injection systems often remain pressurized, even after the engine has been turned OFF. The fuel system pressure must be relieved before disconnecting any fuel lines. Failure to do so may result in fire and/or personal injury.
- The EPA warns that prolonged contact with used engine oil may cause a number of skin disorders, including cancer! You should make every effort to minimize your exposure to used engine oil. Protective gloves should be worn when changing oil. Wash your hands and any other exposed skin areas as soon as possible after exposure to used engine oil. Soap and water, or waterless hand cleaner should be used.
- Never operate the engine without the proper amount and type of engine oil; doing so WILL result in severe engine damage.
- Brake fluid often contains polyglycol ethers and polyglycols. Avoid contact with the eyes and wash your hands thoroughly after handling brake fluid. If you do get brake fluid in your eyes, flush your eyes with clean, running water for 15 minutes. If eye irritation persists, or if you have taken brake fluid internally, IMMEDIATELY seek medical assistance.
- Timing belt maintenance is extremely important! Many models utilize an interference-type, non-freewheeling engine. If the timing belt breaks, the valves in the cylinder head may strike the pistons, causing potentially serious (also time-consuming and expensive) engine damage. Refer to the maintenance interval charts in the front of this manual for the recommended replacement interval for the timing belt and to the timing belt section for belt replacement and inspection.
- Disconnecting the negative battery cable on some vehicles may interfere with the functions of the on-board computer system(s) and may require the computer to undergo a relearning process once the negative battery cable is reconnected.

Supplemental Inflatable Restraint (SIR) System Service Precautions

WARNING

Work on these (SIR) systems should be performed by qualified service technicians.

WARNING

When performing service on or near the SIR components or the SIR wiring, you must disable the SIR system. Refer to Disarming & Arming for the disable/enable procedure. Failure to follow the correct procedure could cause air bag deployment, personal injury, or unnecessary SIR system repairs.

WARNING

Safety precautions must be followed when handling a deployed inflator module (air bag). After deployment, the inflator module (air bag) surface may contain a small amount of sodium hydroxide, a by-product of deployment that is irritating to the skin and eyes.

- Most of the powder on the inflator module (air bag) is harmless. As a precaution, wear gloves and safety glasses when handling a deployed inflator module (air bag), and wash your hands with mild soap and water afterwards.
- When carrying a live inflator module (air bag), make sure the bag and trim cover are pointed away from you. Never carry inflator module (air bag) by the wires or connector on the underside of the module. In case of an accidental deployment, the bag will deploy with minimal chance of injury. When placing a live inflator module (air bag) on a bench or other surface, always face bag and trim cover up, away from the surface.
- Never rest a steering column assembly on the steering wheel with the inflator module (air bag) face down and column vertical. This is necessary so that a free space is provided to allow the inflator module (air bag) to expand in the unlikely event of accidental deployment. Otherwise, personal injury could result.

Cleanliness and Care, Shop Practice

- It should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

Basic Electricity

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Basic Electrical Theory

Electricity is based on the principle that electrons are attracted to protons. Electron movement can be created when the atomic structure of a material is forced to become imbalanced. Atoms are made up of an equal quantity of positively and negatively charged parts. The nucleus contains protons, with a positive charge, and neutrons with a neutral charge. The negative charge or electrons constantly orbit around the nucleus in valence rings.

If an electron were to be separated from an atom it would assume a net positive charge and become a positive ion. On the other hand, if an element were to "acquire" an electron it would have a net negative charge and become a negative ion. If we were to store these positive and negative ions in a container we would have a power source, or battery.

Voltage

Electricity is the flow of electrons from a greater potential (more electrons) to a lesser potential (less electrons). If a path were provided for the electrons from the negative ions to flow to the positive ions each ion could then maintain its balanced condition. The pressure that the electrons exert when returning to its source is called voltage. When voltage (V) is measured with a voltmeter, the value displayed represents the attractive force, or electromotive force available to get the atoms in balance again.

Amperage

Amperage is a measure of the actually quantity of electrons that flow from the net negative charge to the net positive charge. This movement of electrons, or current, is what actually does the work in an electrical circuit. Current flow is measured in units of Amperes, or Amps (A). Amperage is a time-based unit. One Amp is equal to 6.28×10^{28} electrons moving past one point in one second. When an ammeter is connected in series with a circuit, the actual quantity of electrons that flow through the circuit are measured.

Resistance

Resistance is an element's ability to oppose current flow. The resistance of an element depends upon its atomic structure- specifically how many electrons are held in orbit in the outermost or valence ring. to eight electrons can occupy the valence ring of an atom. When fewer electrons are present in the valence ring there is more "room" for electrons to flow across the surface of an atom.

Electrically speaking, elements can be categorized as conductors, insulators and semi-conductors. Conductors are elements with between one and three electrons in their

valence ring. Insulators are elements that contain between five and eight valence ring electrons. Semi-conductors are elements that contain four electrons in their valence ring.

Impedance is something that restricts flow. If you put a number of connections along an electrical circuit, each connection becomes a source of resistance slowing the flow of electricity to its final destination. A common analogy would be a coke bottle; if you turn a coke bottle upside down to empty its contents it takes a longer period of time to do so. There is resistance within the bottle to empty a large volume of fluid through a low volume orifice. Now, take the same bottle turned on its side so there is air space present at the mouth of the bottle while pouring out the fluid. The process takes less time due to low impedance (less resistance). The resistance we find in an electrical circuit is measured in Ohms. The resistance of a circuit varies depending on the amount and type of components used in the circuit. an Ohmmeter is used to measure resistance. Current is applied to the component from a power source (battery) in the meter. The voltage that returns to the meter is converted to a resistive value.

The main factors which determine resistance are the material used, the size and cross section of the wire, the length of the wire and the temperature that these items operate. Some materials have more resistance than others. Those with high resistance are said to be insulators. Rubber materials (or rubber-like plastics) are some of the most common insulators used in vehicles as they have a very high resistance to electricity. Very low resistance materials are said to be conductors. Copper wire is among the best conductors. Most automotive wiring is made of copper. Silver is actually a superior conductor to copper and is used in some relay contacts, but its high cost prohibits its use as common wiring. Airbag systems commonly use gold plated terminal to ensure that current will readily flow through the system. Gold, while cost prohibitive, will not react to air and contaminants that can contribute to unwanted voltage drops.

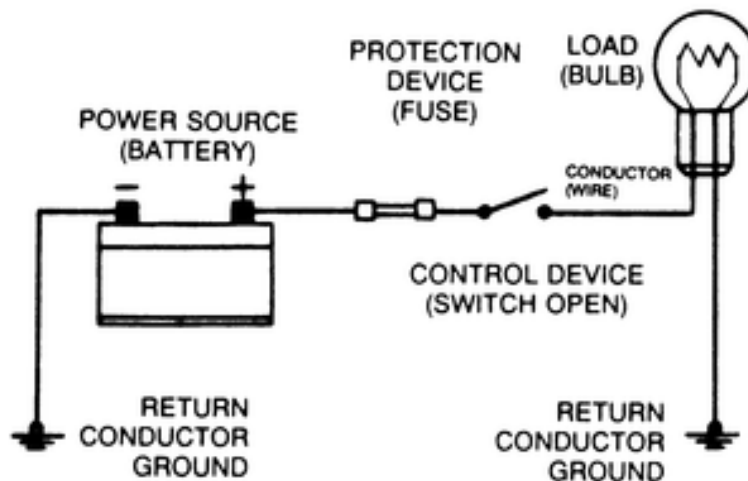
Larger diameter wires provide more surface area for current flow. The larger the wire size being used, the less resistance the wire will have. Solid conductors provide less surface area when compared to stranded conductors. Stranded conductors have the capacity to carry greater currents when compared to solid conductors of the same gauge (size). This is because the individual strands of a stranded conductor contribute to greater surface area. This is why components which use large amounts of electricity have larger wires supplying current to them. All elements offer some degree of resistance. While copper wire, as an example, is a conductor, it too has a resistive value. For a given thickness of wire, the longer the wire, the greater the resistance. The shorter the wire, the less the resistance. When determining the proper wire for a circuit, both size (gauge) and length must be considered to design a circuit that can handle the current needed to provide enough power to the component being powered. With many materials, the higher the temperature, the greater the resistance (positive temperature coefficient). Some materials exhibit the opposite trait of lower resistance with higher temperatures (negative temperature coefficient). These principles are used in many of the sensors on the engine. As voltage flows through the wiring, these varying properties effect the overall performance of the electrical system, but the current is what actually does the work.

For any 12 volt, negative ground, electrical system to operate, the electricity must travel in a complete circuit. This simply means that current (power) from the positive (+) terminal of the battery must eventually return to the negative (-) terminal of the battery. Along the way, this current will travel through wires, fuses, switches and components. If, for any

reason, the flow of current through the circuit is interrupted, the component fed by that circuit will cease to function properly.

Perhaps the easiest way to visualize a circuit is to think of connecting a light bulb (with two wires attached to it) to the battery—one wire attached to the negative (–) terminal of the battery and the other wire to the positive (+) terminal. With the two wires touching the battery terminals, the circuit would be complete and the light bulb would illuminate. Electricity would follow a path from the battery to the bulb and back to the battery. It's easy to see that with longer wires on our light bulb, it could be mounted anywhere. Further, one wire could be fitted with a switch so that the light could be turned on and off.

This example illustrates a simple circuit. When the switch is closed, power from the positive (+) battery terminal flows through the fuse and the switch, and then to the light bulb. The light illuminates and the circuit is completed through the ground wire back to the negative (–) battery terminal. In reality, the two ground points shown in the illustration are attached to the metal frame of the vehicle, which completes the circuit back to the battery.



The normal automotive circuit differs from this simple example in two ways. First, instead of having a return wire from the bulb to the battery, the current travels through the frame of the vehicle. Since the negative (–) battery cable is attached to the frame (made of electrically conductive metal), the frame of the vehicle can serve as a ground wire to complete the circuit. Secondly, most automotive circuits contain multiple components

which receive power from a single circuit. This lessens the amount of wire needed to power components on the vehicle.

How Does Electricity Work: The Water Analogy

Electricity is the flow of electrons-the subatomic particles that constitute the outer shell of an atom. Electrons spin in an orbit around the center core of an atom. The center core is comprised of protons (positive charge) and neutrons (neutral charge). Electrons have a negative charge and balance out the positive charge of the protons. When an outside force causes the number of electrons to unbalance the charge of the protons, the electrons will split off the atom and look for another atom to balance out. If this imbalance is kept up, electrons will continue to move and an electrical flow will exist.

Many people have been taught electrical theory using an analogy with water. In a comparison with water flowing through a pipe, the electrons would be the water and the wire is the pipe.

The flow of electricity can be measured much like the flow of water through a pipe. The unit of measurement used is amperes, frequently abbreviated as amps (a). You can compare amperage to the volume of water flowing through a pipe. When connected to a circuit, an ammeter will measure the actual amount of current flowing through the circuit. When relatively few electrons flow through a circuit, the amperage is low. When many electrons flow, the amperage is high.

Water pressure is measured in units such as pounds per square inch (psi); The electrical pressure is measured in units called volts (v). When a voltmeter is connected to a circuit, it is measuring the electrical pressure.

The actual flow of electricity depends not only on voltage and amperage, but also on the resistance of the circuit. The higher the resistance, the higher the force necessary to push the current through the circuit. The standard unit for measuring resistance is an ohm. Resistance in a circuit varies depending on the amount and type of components used in the circuit. The main factors which determine resistance are:

- Material-some materials have more resistance than others. Those with high resistance are said to be insulators. Rubber materials (or rubber-like plastics) are some of the most common insulators used in vehicles as they have a very high resistance to electricity. Very low resistance materials are said to be conductors. Copper wire is among the best conductors. Silver is actually a superior conductor to copper and is used in some relay contacts, but its high cost prohibits its use as common wiring. Most automotive wiring is made of copper.
- Size-the larger the wire size being used, the less resistance the wire will have. This is why components which use large amounts of electricity usually have large wires supplying current to them.
- Length-for a given thickness of wire, the longer the wire, the greater the resistance. The shorter the wire, the less the resistance. When determining the proper wire for a circuit, both size and length must be considered to design a circuit that can handle the current needs of the component.
- Temperature-with many materials, the higher the temperature, the greater the resistance (positive temperature coefficient). Some materials exhibit the opposite

trait of lower resistance with higher temperatures (negative temperature coefficient). These principles are used in many of the sensors on the engine.

Ohm's Law

There is a direct relationship between current, voltage and resistance. The relationship between current, voltage and resistance can be summed up by a statement known as Ohm's law.

Voltage (E) is equal to amperage (I) times resistance (R): $E = I \times R$

Other forms of the formula are $R = E/I$ and $I = E/R$

In each of these formulas, E is the voltage in volts, I is the current in amps and R is the resistance in ohms. The basic point to remember is that as the resistance of a circuit goes up, the amount of current that flows in the circuit will go down, if voltage remains the same.

The amount of work that the electricity can perform is expressed as power. The unit of power is the watt (w). The relationship between power, voltage and current is expressed as:

Power (w) is equal to amperage (I) times voltage (E): $W = I \times E$

This is only true for direct current (DC) circuits; the alternating current formula is a tad different, but since the electrical circuits in most vehicles are DC type, we need not get into AC circuit theory.

Electrical Components

Power Source

Power is supplied to the vehicle by two devices: The battery and the alternator. The battery supplies electrical power during starting or during periods when the current demand of the vehicle's electrical system exceeds the output capacity of the alternator. The alternator supplies electrical current when the engine is running. Not only does the alternator supply the current needs of the vehicle, but it recharges the battery.

The Battery

In most modern vehicles, the battery is a lead/acid electrochemical device consisting of six 2 volt subsections (cells) connected in series, so that the unit is capable of producing approximately 12 volts of electrical pressure. Each subsection consists of a series of positive and negative plates held a short distance apart in a solution of sulfuric acid and water.

The two types of plates are of dissimilar metals. This sets up a chemical reaction, and it is this reaction which produces current flow from the battery when its positive and negative terminals are connected to an electrical load. The power removed from the battery is replaced by the alternator, restoring the battery to its original chemical state.

The Alternator

Some older vehicles use a generator instead of an alternator. The difference is that an alternator supplies alternating current which is then changed to direct current for use on the vehicle, while a generator produces direct current. Alternators tend to be more efficient and that is why they are used.

Alternators and generators are devices that consist of coils of wires wound together making big electromagnets. One group of coils spins within another set and the interaction of the magnetic fields causes a current to flow. This current is then drawn off the coils and fed into the vehicles electrical system.

Ground

Two types of grounds are used in automotive electric circuits. Direct ground components are grounded to the frame through their mounting points. All other components use some sort of ground wire which is attached to the frame or chassis of the vehicle. The electrical current runs through the chassis of the vehicle and returns to the battery through the ground (–) cable. The battery ground cable is connected between the battery and the frame or chassis of the vehicle.

NOTE: It should be noted that a good percentage of electrical problems can be traced to bad grounds.

Protective Devices

It is possible for large surges of current to pass through the electrical system of the vehicle. If this surge of current were to reach the load in the circuit, the surge could burn it out or severely damage it. It can also overload the wiring, causing the harness to get hot and melt the insulation. To prevent this, fuses, circuit breakers and/or fusible links are connected into the supply wires of the electrical system. These items are nothing more than a built-in weak spot in the system. When an abnormal amount of current flows through the system, these protective devices work as follows to protect the circuit:

- Fuse-when an excessive electrical current passes through a fuse, the fuse "blows" (the conductor melts) and opens the circuit, preventing the passage of current. Most vehicles use one or more fuse panels.

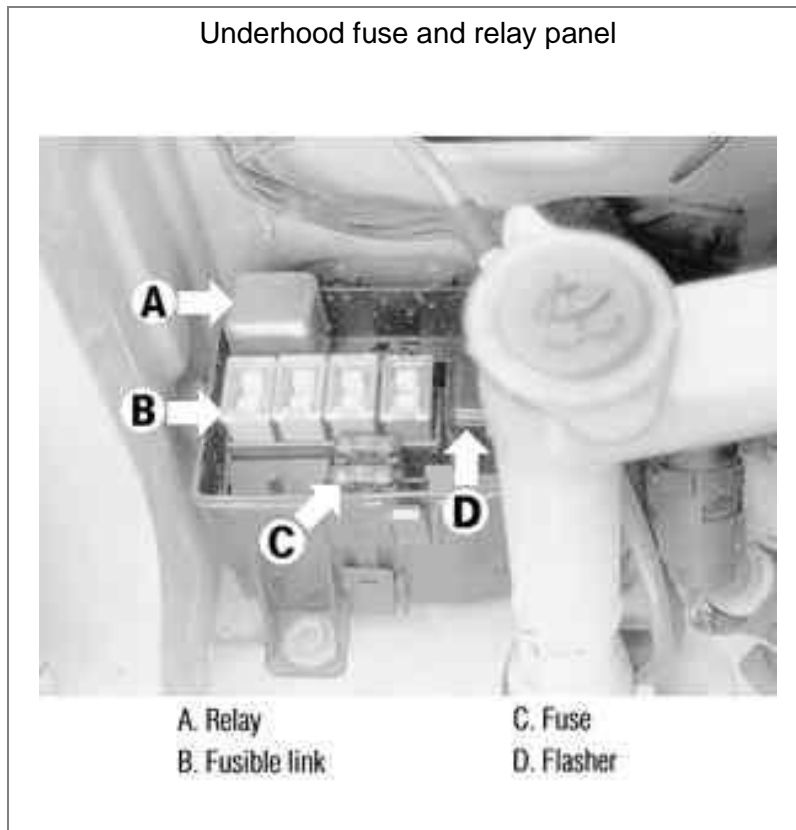
Fuse panel inside driver's side kick panel



- Circuit Breaker-a circuit breaker is basically a self-repairing fuse. It will open the circuit in the same fashion as a fuse, but when the surge subsides, the circuit breaker can be reset and does not need replacement.
- Fusible Link-a fusible link (fuse link or main link) is a short length of special, high temperature insulated wire that acts as a fuse. When an excessive electrical current passes through a fusible link, the thin gauge wire inside the link melts, creating an intentional open to protect the circuit. To repair the circuit, the link must be replaced. Some newer type fusible links are housed in plug-in modules, which are simply replaced like a fuse, while older type fusible links must be cut and spliced if they melt. Since this link is very early in the electrical path, it's the first place to look if nothing on the vehicle works, yet the battery seems to be charged and is properly connected.

Switches & Relays

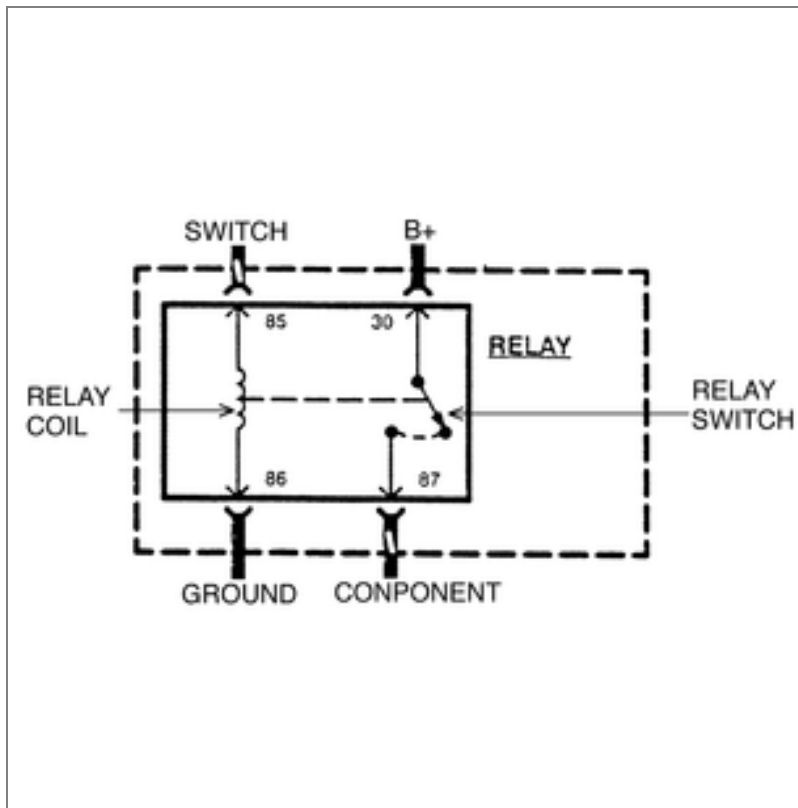
Switches are used in electrical circuits to control the passage of current. The most common use is to open and close circuits between the battery and the various electric devices in the system. Switches are rated according to the amount of amperage they can handle. If sufficient amperage rated switch is not used in a circuit, the switch could overload and cause damage.



Some electrical components which require a large amount of current to operate use a special switch called a relay. Since these circuits carry a large amount of current, the thickness of the wire in the circuit is also greater. If this large wire were connected from the load to the control switch, the switch would have to carry the high amperage load and the fairing or dash would be twice as large to accommodate the increased size of the wiring harness. To prevent these problems, a relay is used.

Relays are composed of a coil and a set of contacts. When the coil has a current passed through it, a magnetic field is formed and this field causes the contacts to move together, completing the circuit. Most relays are normally open, preventing current from passing through the circuit, but they can take any electrical form depending on the job they are intended to do. Relays can be considered "remote control switches." They allow a smaller current to operate devices that require higher amperages. When a small current operates the coil, a larger current is allowed to pass by the contacts. Some common circuits which

may use relays are the horn, headlights, starter, electric fuel pump and other high draw circuits.



The internal components of a relay consist of a coil and a switch. These two components are linked together so that when one operates, the other operates at the same time. The large wires in the circuit are connected from the battery to one side of the relay switch (B+) and from the opposite side of the relay switch to the load (component). Smaller wires are connected from the relay coil to the control switch for the circuit and from the opposite side of the relay coil to ground

Load

Every electrical circuit must include a "load" (something to use the electricity coming from the source). Without this load, the battery would attempt to deliver its entire power supply from one pole to another. This is called a "short circuit." All this electricity would take a short cut to ground and cause a great amount of damage to other components in the circuit by developing a tremendous amount of heat. This condition could develop sufficient heat to melt the insulation on all the surrounding wires and reduce a multiple wire cable to a lump of plastic and copper.

Wiring & Harnesses

The average vehicle contains many feet of wiring, with hundreds of individual connections. To protect the many wires from damage and to keep them from becoming a confusing tangle, they are organized into bundles, enclosed in plastic or taped together and called wiring harnesses. Different harnesses serve different parts of the vehicle. Individual wires are color coded to help trace them through a harness where sections are hidden from view.

Automotive wiring or circuit conductors can be single strand wire, multi-strand wire or printed circuitry. Single strand wire has a solid metal core and is usually used inside such components as alternators, motors, relays and other devices. Multi-strand wire has a core made of many small strands of wire twisted together into a single conductor. Most of the wiring in an automotive electrical system is made up of multi-strand wire, either as a single conductor or grouped together in a harness. All wiring is color coded on the insulator, either as a solid color or as a colored wire with an identification stripe. A printed circuit is a thin film of copper or other conductor that is printed on an insulator backing. Occasionally, a printed circuit is sandwiched between two sheets of plastic for more protection and flexibility. A complete printed circuit, consisting of conductors, insulating material and connectors for lamps or other components is called a printed circuit board. Printed circuitry is used in place of individual wires or harnesses in places where space is limited, such as behind instrument panels.

Since automotive electrical systems are very sensitive to changes in resistance, the selection of properly sized wires is critical when systems are repaired. A loose or corroded connection or a replacement wire that is too small for the circuit will add extra resistance and an additional voltage drop to the circuit.

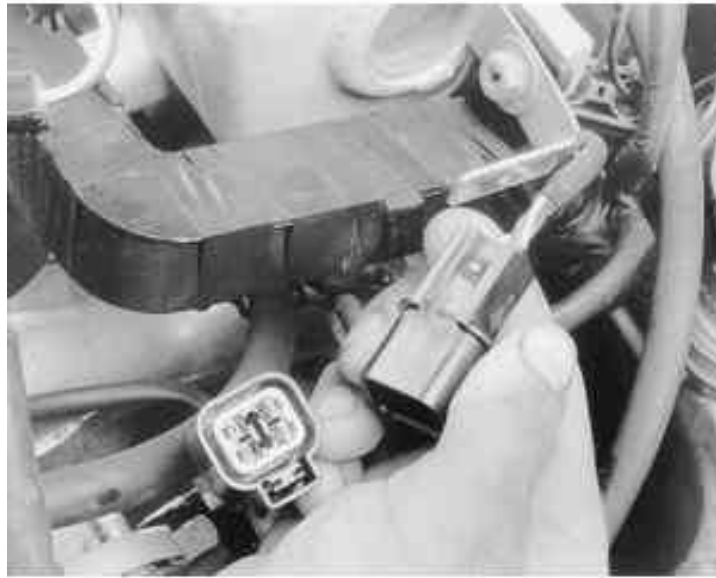
The wire gauge number is an expression of the cross-section area of the conductor. Vehicles from countries that use the metric system will typically describe the wire size as its cross-sectional area in square millimeters. In this method, the larger the wire, the greater the number. Another common system for expressing wire size is the American Wire Gauge (AWG) system. As gauge number increases, area decreases and the wire becomes smaller. An 18 gauge wire is smaller than a 4 gauge wire. A wire with a higher gauge number will carry less current than a wire with a lower gauge number. Gauge wire size refers to the size of the strands of the conductor, not the size of the complete wire with insulator. It is possible, therefore, to have two wires of the same gauge with different diameters because one may have thicker insulation than the other.

It is essential to understand how a circuit works before trying to figure out why it doesn't. Electrical schematic shows the electrical current paths when a circuit is operating properly. Schematics break the entire electrical system down into individual circuits. In a schematic, usually no attempt is made to represent wiring and components as they physically appear on the vehicle; switches and other components are shown as simply as possible. Face views of harness connectors show the cavity or terminal locations in all multi-pin connectors to help locate test points.

Connectors

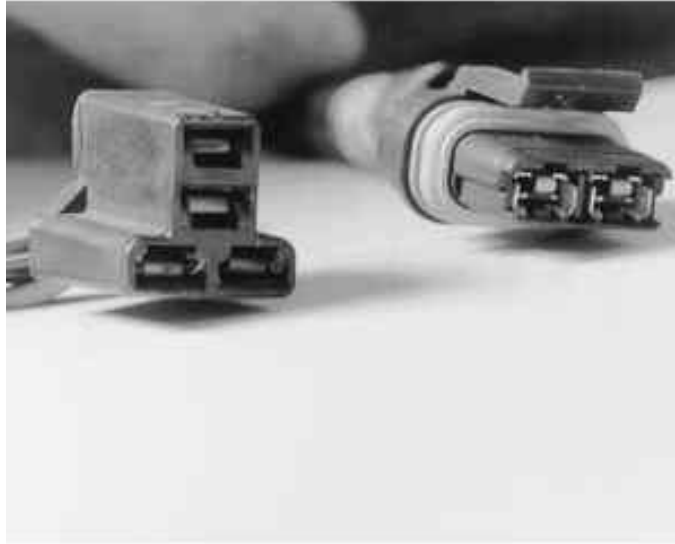
Three types of connectors are commonly used in automotive applications-weatherproof, molded and hard shell.

Weatherproof connector



- Weatherproof-these connectors are most commonly used where the connector is exposed to the elements. Terminals are protected against moisture and dirt by sealing rings which provide a watertight seal. All repairs require the use of a special terminal and the tool required to service it. Unlike standard blade type terminals, these weatherproof terminals cannot be straightened once they are bent. Make certain that the connectors are properly seated and all of the sealing rings are in place when connecting leads.
- Molded-these connectors require complete replacement of the connector if found to be defective. This means splicing a new connector assembly into the harness. All splices should be soldered to insure proper contact. Use care when probing the connections or replacing terminals in them, as it is possible to create a short circuit between opposite terminals. If this happens to the wrong terminal pair, it is possible to damage certain components. Always use jumper wires between connectors for circuit checking and NEVER probe through weatherproof seals.

Hard shell (left) and weatherproof (right) connectors



- Hard Shell-unlike molded connectors use replaceable terminal contacts. Replacement usually involves the use of a special terminal removal tool that depresses the locking tangs (barbs) on the connector terminal and allows the connector to be removed from the rear of the shell. The connector shell should be replaced if it shows any evidence of burning, melting, cracks, or breaks. Replace individual terminals that are burnt, corroded, distorted or loose.

Test Equipment

Pinpointing the exact cause of trouble in an electrical circuit is most times accomplished by the use of special test equipment. The following describes different types of commonly used test equipment and briefly explains how to use them in diagnosis. In addition to the information covered below, the tool manufacturer's instructions booklet (provided with the tester) should be read and clearly understood before attempting any test procedures.

Jumper Wires

CAUTION

Never use jumper wires made from a thinner gauge wire than the circuit being tested. If the jumper wire is of too small a gauge, it may overheat and possibly melt. Never use jumpers to bypass high resistance loads in a circuit. Bypassing resistances, in effect, creates a short circuit. This may, in turn, cause damage and fire. Jumper wires should only be used to bypass lengths of wire or to simulate switches.

Jumper wires are simple, yet extremely valuable, pieces of test equipment. They are basically test wires which are used to bypass sections of a circuit. Although jumper wires can be purchased, they are usually fabricated from lengths of standard automotive wire and whatever type of connector (alligator clip, spade connector or pin connector) that is required for the particular application being tested. In cramped, hard-to-reach areas, it is advisable to have insulated boots over the jumper wire terminals in order to prevent accidental grounding. It is also advisable to include a standard automotive fuse in any jumper wire. This is commonly referred to as a "fused jumper". By inserting an in-line fuse holder between a set of test leads, a fused jumper wire can be used for bypassing open circuits. Use a 5 amp fuse to provide protection against voltage spikes.

Jumper wires are used primarily to locate open electrical circuits, on either the ground (–) side of the circuit or on the power (+) side. If an electrical component fails to operate, connect the jumper wire between the component and a good ground. If the component operates only with the jumper installed, the ground circuit is open. If the ground circuit is good, but the component does not operate, the circuit between the power feed and component may be open. By moving the jumper wire successively back from the component toward the power source, you can isolate the area of the circuit where the open is located. When the component stops functioning, or the power is cut off, the open is in the segment of wire between the jumper and the point previously tested.

You can sometimes connect the jumper wire directly from the battery to the "hot" terminal of the component, but first make sure the component uses 12 volts in operation. Some electrical components, such as fuel injectors or sensors, are designed to operate on about 4 to 5 volts, and running 12 volts directly to these components will cause damage.

Test Lights

12 volt test light



The test light is used to check circuits and components while electrical current is flowing through them. It is used for voltage and ground tests. To use a 12 volt test light, connect the ground clip to a good ground and probe wherever necessary with the pick. The test light will illuminate when voltage is detected. This does not necessarily mean that 12 volts (or any particular amount of voltage) is present; it only means that some voltage is present. It is advisable before using the test light to touch its ground clip and probe across the battery posts or terminals to make sure the light is operating properly.

CAUTION

Do not use a test light to probe electronic ignition, spark plug or coil wires. Never use a pick-type test light to probe wiring on computer controlled systems unless specifically instructed to do so. Any wire insulation that is pierced by the test light probe should be taped and sealed with silicone after testing.

Like the jumper wire, the 12 volt test light is used to isolate opens in circuits. But, whereas the jumper wire is used to bypass the open to operate the load, the 12 volt test light is used to locate the presence of voltage in a circuit. If the test light illuminates, there is power up to that point in the circuit; if the test light does not illuminate, there is an open circuit (no power). Move the test light in successive steps back toward the power source until the light in the handle illuminates. The open is between the probe and a point which was previously probed.

The self-powered test light is similar in design to the 12 volt test light, but contains a 1.5 volt penlight battery in the handle. It is most often used in place of a multimeter to check for open or short circuits when power is isolated from the circuit (continuity test).

The battery in a self-powered test light does not provide much current. A weak battery may not provide enough power to illuminate the test light even when a complete circuit is made (especially if there is high resistance in the circuit). Always make sure that the test battery is strong. To check the battery, briefly touch the ground clip to the probe; if the light glows brightly, the battery is strong enough for testing.

NOTE: A self-powered test light should not be used on any computer controlled system or component. The small amount of electricity transmitted by the test light is enough to damage many electronic automotive components.

Multimeters

Multimeters are an extremely useful tool for troubleshooting electrical problems. A multimeter is a voltmeter, ammeter and ohmmeter (along with other features) combined into one instrument. It is often used when testing solid state circuits because of its high input impedance (usually 10 megaohms or more). A brief description of the multimeter main test functions follows:

- **Voltmeter**-the voltmeter is used to measure voltage at any point in a circuit, or to measure the voltage drop across any part of a circuit. Voltmeters usually have various scales and a selector switch to allow the reading of different voltage ranges. The voltmeter has a positive and a negative lead. To avoid damage to the meter, always connect the negative lead to the negative (–) side of the circuit (to ground or nearest the ground side of the circuit) and connect the positive lead to

the positive (+) side of the circuit (to the power source or the nearest power source). Note that the negative voltmeter lead will always be black and that the positive voltmeter will always be some color other than black (usually red).

- Ohmmeter-the ohmmeter is designed to read resistance (measured in ohms) in a circuit or component. Most ohmmeters will have a selector switch which permits the measurement of different ranges of resistance (usually the selector switch allows the multiplication of the meter reading by 10, 100, 1,000 and 10,000). Some ohmmeters are "auto-ranging" which means the meter itself will determine which scale to use. Since the meters are powered by an internal battery, the ohmmeter can be used like a self-powered test light. When the ohmmeter is connected, current from the ohmmeter flows through the circuit or component being tested. Since the ohmmeter's internal resistance and voltage are known values, the amount of current flow through the meter depends on the resistance of the circuit or component being tested. The ohmmeter can also be used to perform a continuity test for suspected open circuits. In using the meter for making continuity checks, do not be concerned with the actual resistance readings. Zero resistance, or any ohm reading, indicates continuity in the circuit. Infinite resistance indicates an opening in the circuit. A high resistance reading where there should be none indicates a problem in the circuit. Checks for short circuits are made in the same manner as checks for open circuits, except that the circuit must be isolated from both power and normal ground. Infinite resistance indicates no continuity, while zero resistance indicates a dead short.

CAUTION

Never use an ohmmeter to check the resistance of a component or wire while there is voltage applied to the circuit.

- Ammeter-an ammeter measures the amount of current flowing through a circuit in units called amperes or amps. At normal operating voltage, most circuits have a characteristic amount of amperes, called "current draw" which can be measured using an ammeter. By referring to a specified current draw rating, then measuring the amperes and comparing the two values; one can determine what is happening within the circuit to aid in diagnosis. An open circuit, for example, will not allow any current to flow, so the ammeter reading will be zero. A damaged component or circuit will have an increased current draw, so the reading will be high. The ammeter is always connected in series with the circuit being tested. All of the current that normally flows through the circuit must also flow through the ammeter; if there is any other path for the current to follow, the ammeter reading will not be accurate. The ammeter itself has very little resistance to current flow and, therefore, will not affect the circuit, but it will measure current draw only when the circuit is closed and electricity is flowing. Excessive current draw can blow fuses and drain the battery, while a reduced current draw can cause motors to run slowly, lights to dim and other components to not operate properly.

Basic Troubleshooting

When diagnosing a specific problem, organized troubleshooting is a must. The complexity of a modern automotive vehicle demands that you approach any problem in a logical, organized manner. There are certain troubleshooting techniques, however, which are standard:

- Establish when the problem occurs. Does the problem appear only under certain conditions? Were there any noises, odors or other unusual symptoms? Isolate the problem area. To do this, make some simple tests and observations, and then eliminate the systems that are working properly. Check for obvious problems, such as broken wires and loose or dirty connections. Always check the obvious before assuming something complicated is the cause.
- Test for problems systematically to determine the cause once the problem area is isolated. Are all the components functioning properly? Is there power going to electrical switches and motors. Performing careful, systematic checks will often turn up most causes on the first inspection, without wasting time checking components that have little or no relationship to the problem.
- Test all repairs after the work is done to make sure that the problem is fixed. Some causes can be traced to more than one component, so a careful verification of repair work is important in order to pick up additional malfunctions that may cause a problem to reappear or a different problem to arise. A blown fuse, for example, is a simple problem that may require more than another fuse to repair. If you don't look for a problem that caused a fuse to blow, a shorted wire (for example) may go undetected.

Experience has shown that most problems tend to be the result of a fairly simple and obvious cause, such as loose or corroded connectors, bad grounds or damaged wire insulation which causes a short. This makes careful visual inspection of components during testing essential to quick and accurate troubleshooting.

Testing

Open Circuits



This test already assumes the existence of an open in the circuit and it is used to help locate the open portion.

1. Isolate the circuit from power and ground.
2. Connect the self-powered test light or ohmmeter ground clip to the ground side of the circuit and probe sections of the circuit sequentially.
3. If the light is out or there is infinite resistance, the open is between the probe and the circuit ground.
4. If the light is on or the meter shows continuity, the open is between the probe and the end of the circuit toward the power source.

Short Circuits

NOTE: Never use a self-powered test light to perform checks for opens or shorts when power is applied to the circuit under test. The test light can be damaged by outside power.

1. Isolate the circuit from power and ground.

2. Connect the self-powered test light or ohmmeter ground clip to a good ground and probe any easy-to-reach point in the circuit.
3. If the light comes on or there is continuity, there is a short somewhere in the circuit.
4. To isolate the short, probe a test point at either end of the isolated circuit (the light should be on or the meter should indicate continuity).
5. Leave the test light probe engaged and sequentially open connectors or switches, remove parts, etc. until the light goes out or continuity is broken.
6. When the light goes out, the short is between the last two circuit components which were opened.

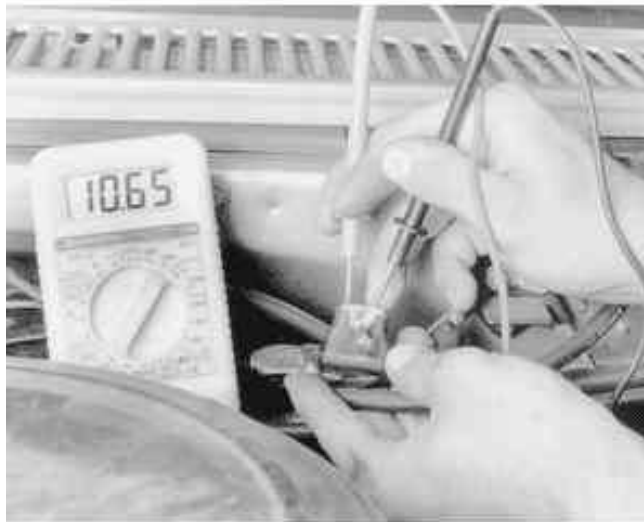
Voltage

This test determines voltage available from the battery and should be the first step in any electrical troubleshooting procedure after visual inspection. Many electrical problems, especially on computer controlled systems, can be caused by a low state of charge in the battery. Excessive corrosion at the battery cable terminals can cause poor contact that will prevent proper charging and full battery current flow.

1. Set the voltmeter selector switch to the 20V position.
2. Connect the multimeter negative lead to the battery's negative (–) post or terminal and the positive lead to the battery's positive (+) post or terminal.
3. Turn the ignition switch **ON** to provide a load.
4. A well charged battery should register over 12 volts. If the meter reads below 11.5 volts, the battery power may be insufficient to operate the electrical system properly.

Voltage Drop

Low voltage measurement



When current flows through a load, the voltage beyond the load drops. This voltage drop is due to the resistance created by the load and also by small resistances created by corrosion at the connectors and damaged insulation on the wires. The maximum allowable voltage drop under load is critical, especially if there is more than one load in the circuit, since all voltage drops are cumulative.

1. Set the voltmeter selector switch to the 20 volt position.
2. Connect the multimeter negative lead to a good ground.
3. Operate the circuit and check the voltage prior to the first component (load).
4. There should be little or no voltage drop in the circuit prior to the first component. If a voltage drop exists, the wire or connectors in the circuit are suspect.
5. While operating the first component in the circuit probe the ground side of the component with the positive meter lead and observe the voltage readings. A small voltage drop should be noticed. This voltage drop is caused by the resistance of the component.
6. Repeat the test for each component (load) down the circuit.
7. If a large voltage drop is noticed, the preceding component, wire or connector is suspect.

Resistance

Coolant temperature sensor resistance



Spark plug wire resistance



CAUTION

Never use an ohmmeter with power applied to the circuit. The ohmmeter is designed to operate on its own power supply. The normal 12 volt electrical system voltage could damage the meter!

1. Isolate the circuit from the vehicle's power source.
2. Ensure that the ignition key is **OFF** when disconnecting any components or the battery.
3. Where necessary, also isolate at least one side of the circuit to be checked, in order to avoid reading parallel resistances. Parallel circuit resistances will always give a lower reading than the actual resistance of either of the branches.
4. Connect the meter leads to both sides of the circuit (wire or component) and read the actual measured ohms on the meter scale. Make sure the selector switch is set to the proper ohm scale for the circuit being tested, to avoid misreading the ohmmeter test value.

Battery Cables

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Disconnecting The Cables

Before disconnecting the cable(s), first turn the ignition to the **OFF** position. This will prevent a draw on the battery which could cause arcing (electricity trying to ground itself to the body of a vehicle, just like a spark plug jumping the gap) and, of course, damaging some components such as the alternator diodes.

Always disconnect the negative (–) battery cable first. This will prevent accidentally grounding the positive (+) terminal to the body of the vehicle when disconnecting it, thereby preventing damage to the above mentioned components.

When the battery cable(s) are reconnected (negative cable last), be sure to check that the lights, windshield wipers and other electrically operated safety components are all working correctly. If the vehicle contains an Electronically Tuned Radio (ETR), don't forget to also reset the radio stations and clock.

Air Bag (Supplemental Restraint System)

General Information

The SRS is a safety device which, when used with the seat belt, is designed to help protect the driver and front passenger in a frontal impact exceeding a certain set speed limit. The system consists of the SRS unit, including safing sensor and impact sensor, the cable reel, the driver's airbag, the front passenger's airbag, side airbags, side curtain airbags, seat belt tensioners, front impact sensors, side impact sensors and roll rate sensor. Since the driver's and front passenger's airbags use the same sensors, both normally inflate at the same time. However, it is possible for only one airbag to inflate. This can occur when the severity of a collision is at the margin, or threshold, that determines whether or not the airbags will deploy. In such cases, the seat belt will provide sufficient protection, and the supplemental protection offered by the airbag would be minimal.

Service Precautions

- Use replacement parts which are manufactured to the same standards and quality as the original parts. Do not install used SRS parts. Use only new parts when making SRS repairs.
- Carefully inspect any SRS part before you install it.
- Do not install any part that shows signs of being dropped or improperly handled, such as dents, cracks or deformation.
- Before removing any SRS parts (including disconnection of connectors), always disconnect the SRS connector.
- Use only a digital multimeter to check the system. Ensure that the multimeter output is 10 mA (0.01 A) or less when switched to the lowest value in the

ohmmeter range. A tester with a higher output could cause accidental deployment and possible injury.

- Do not put objects on the front passenger's airbag.
- The original radio has a coded theft protection circuit. Be sure to get the customer's radio and navigation system codes and write down the frequencies for the radio's preset stations before disconnecting the battery negative cable.
- Before returning the vehicle to the customer, enter the radio and navigation system codes, then enter the customer's audio presets and set the clock.
- After disconnecting the battery negative cable, perform the powertrain control module (PCM) idle learn procedure and the power window control unit reset procedure.
- Never perform electrical inspections to the airbags, such as measuring resistance.
- Do not position yourself in front of the airbag during removal, inspection, or replacement.

Disarming & Arming

Air Bag Fuse

To Disarm:

1. Straighten the front wheels of the vehicle.
2. Turn the ignition switch to off.
3. Remove all the fuses supplying power to the inflatable restraint sensing and diagnostic module (SDM).
4. Do not work on the air bag system for 1 minute.

To Arm:

1. Turn the ignition switch to off.
2. Install all the fuses supplying power to the inflatable restraint sensing and diagnostic module (SDM).
3. Turn the ignition switch to on, the air bag indicator will flash a few times then stop.

Negative Battery Cable

To Disarm:

1. Straighten the front wheels of the vehicle.
2. Turn the ignition switch to off.
3. Detach the negative battery cable from the battery.
4. Do not work on the air bag system for 1 minute.

To Arm:

1. Turn the ignition switch to off.
2. Attach the negative battery cable to the battery.
3. Turn the ignition switch to on, the air bag indicator will flash a few times then stop.

4. Circuit Protection

WARNING

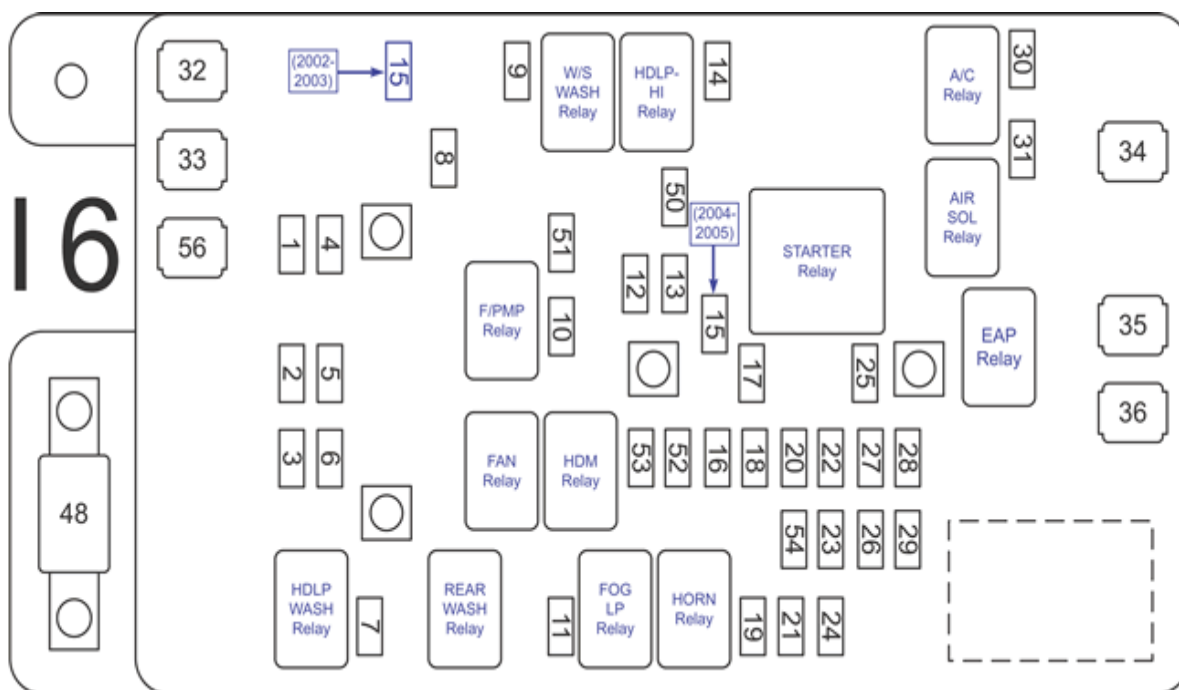
To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Underhood Fuse Block

4.2L Engine

Except Saab

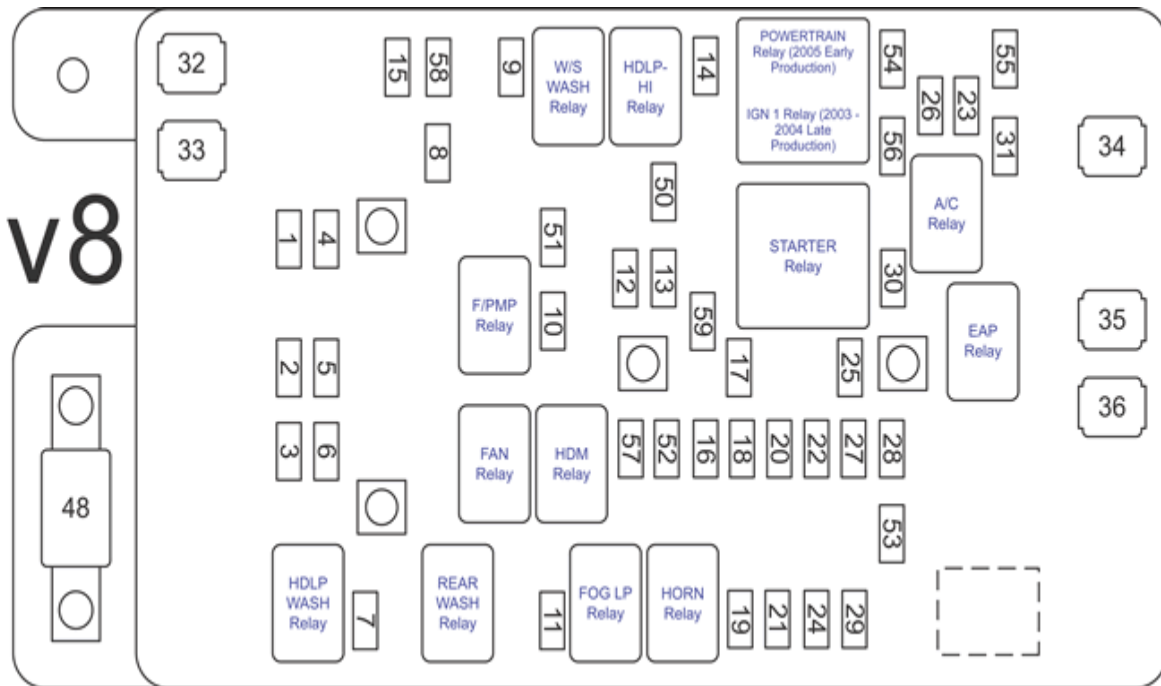
Underhood Fuse Block (2002 - 2005 Early Production)



5.3L Engine

Except Saab

Underhood Fuse Block (2003 - 2005 Early Production)



Entertainment Systems

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

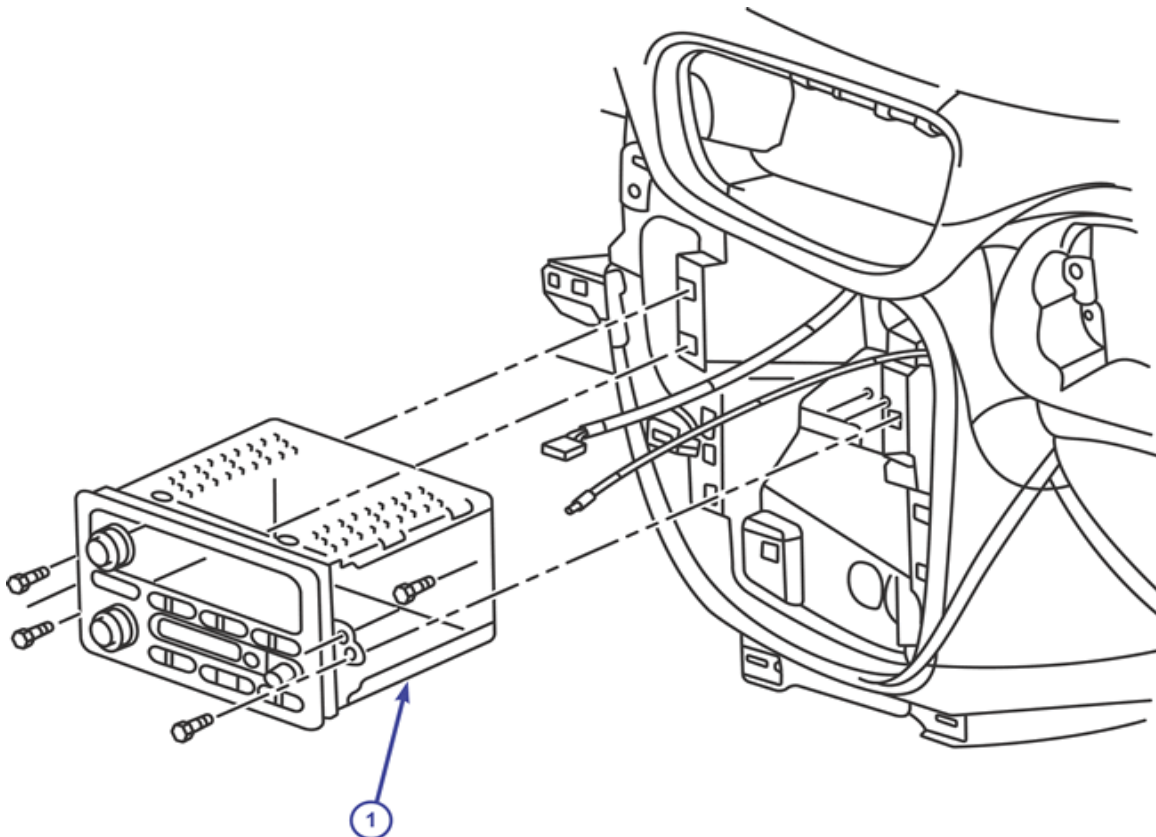
Radio

Removal & Installation

To Remove:

1. For GMC vehicles, remove the lower closeout/insulator panel from the instrument panel (I/P).
2. For Oldsmobile vehicles, remove the center console shift lever bezel from the center console.
3. Remove the accessory trim plate from the instrument panel (I/P).
4. Remove the retaining screws from the radio.
5. Pull the radio out of the instrument panel (I/P) far enough to gain access to the radio connectors
6. Disconnect the radio antenna cable from the radio.
7. Disconnect the radio connectors.

Radio removal and installation



8. Remove the radio from the instrument panel (I/P).

To Install:

1. Place the radio in the instrument panel (I/P).
2. Connect the radio connectors.
3. Connect the radio antenna cable to the radio.
4. Install the radio into the instrument panel (I/P).
5. Install the retaining screws into the radio. Torque the screws to **18 in-lb (2 Nm)**.
6. Install the accessory trim plate to the instrument panel (I/P).
7. For Oldsmobile vehicles, install the center console shift lever bezel onto the center console.
8. For GMC vehicles, install the lower closeout/insulator panel onto the instrument panel (I/P).

Cruise Control

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Cruise Control Switch

NOTE: The cruise control switch is integral to the turn signal/multifunction switch.

Instruments & Switches

Brake Light Switch

Removal & Installation

To Remove:

1. Remove the left sound insulator from the instrument panel (I/P).
2. Remove the pushrod retainer, stop lamp switch, and pushrod from the brake pedal pin.
3. Disconnect the stop lamp switch connector.

To Install:

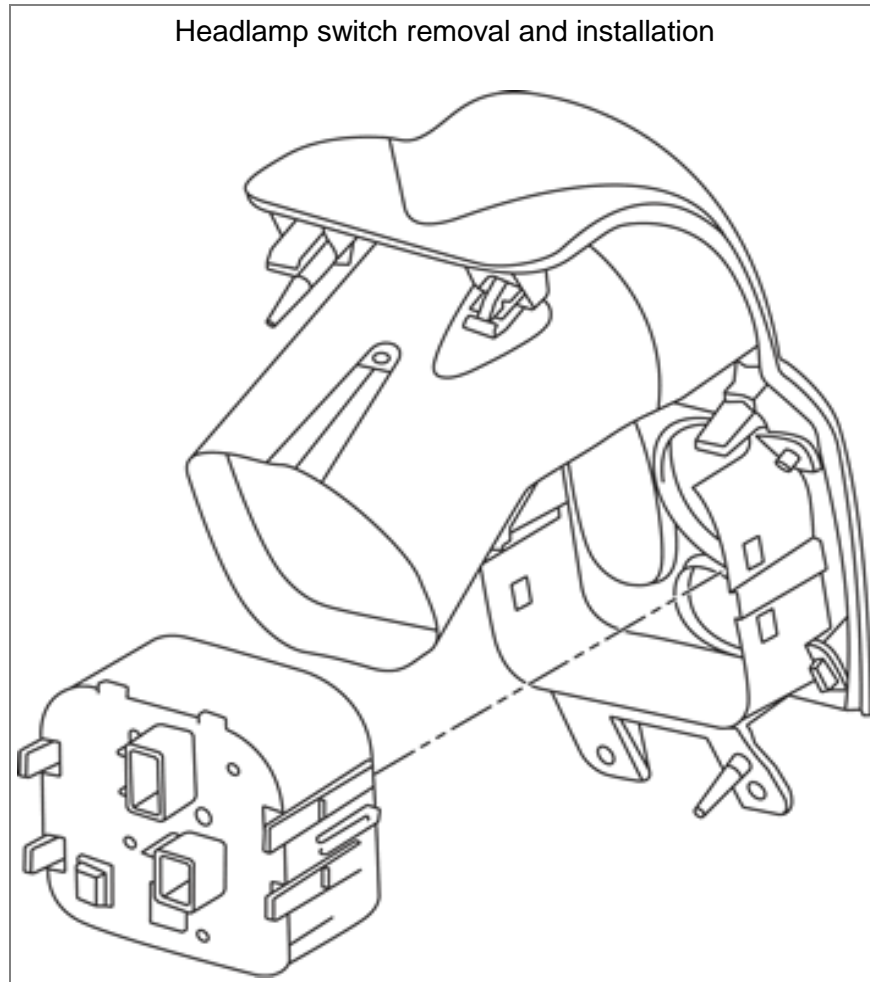
1. Connect the stop lamp switch connector.
2. Install the pushrod, stop lamp switch, and pushrod retainer onto the pedal pin.
3. Install the left sound insulator onto the instrument panel (I/P).

Headlamp Switch

Removal & Installation

To Remove:

1. Remove the access cover from the left of the instrument panel (I/P).



2. Release the headlamp switch retaining tabs behind the instrument panel (I/P).
3. Pull the headlamp switch out through the access hole.
4. Disconnect the headlamp switch connectors.

To Install:

1. Connect the headlamp switch connectors.
2. Place the headlamp switch behind the instrument panel (I/P) through the access hole.
3. Install the headlamp switch into the retaining tabs behind the instrument panel (I/P).
4. Install the access cover onto the left of the instrument panel (I/P).

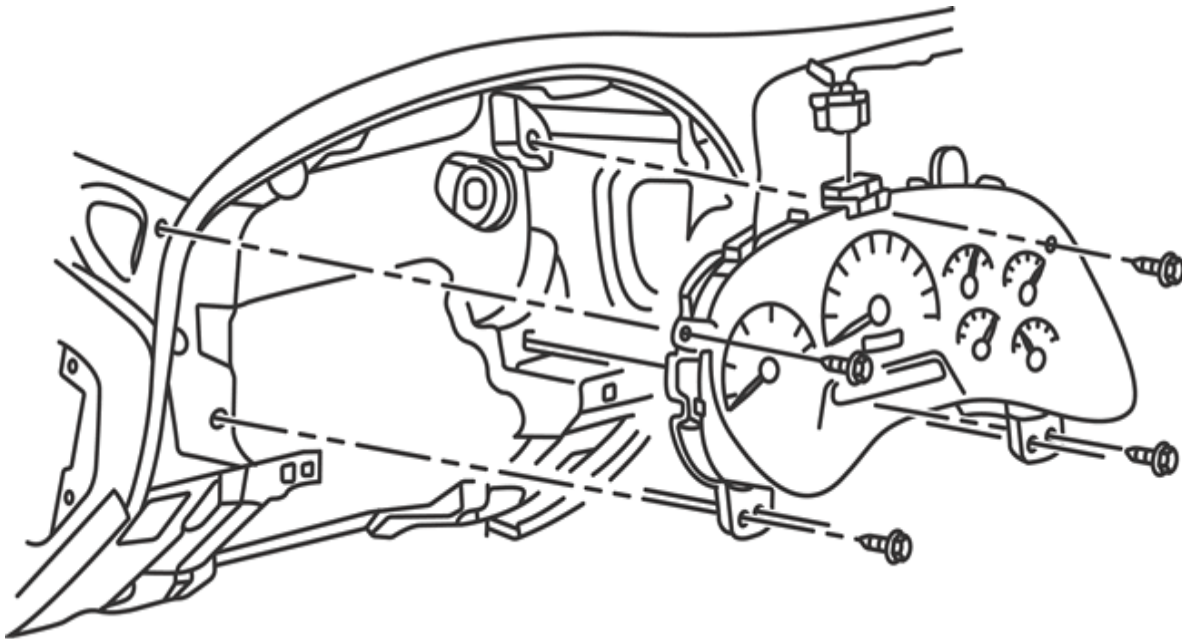
Instrument Panel Cluster

Removal & Installation

To Remove:

1. Remove the left closeout insulator panel from the instrument panel (I/P).
2. Remove the knee bolster trim panel from the instrument panel (I/P).
3. Remove the instrument panel cluster (IPC) bezel from the instrument panel (I/P).

Instrument panel cluster removal and installation



4. Remove the retaining screws from the instrument panel cluster (IPC).
5. Pull the instrument panel cluster (IPC) out far enough to gain access to the instrument panel cluster (IPC) connector.
6. Disconnect the instrument panel cluster (IPC) connector.

To Install:

1. Connect the instrument panel cluster (IPC) connector.
2. Place the instrument panel cluster (IPC) into the instrument panel.
3. Install the retaining screws into the instrument panel cluster (IPC). Torque the screws to **22 in-lb (2.5 Nm)**.
4. Install the instrument panel cluster (IPC) bezel into the instrument panel (I/P).
5. Install the knee bolster trim panel onto the instrument panel (I/P).
6. Install the left closeout insulator panel onto the instrument panel (I/P).
7. If a new instrument panel cluster (IPC) was installed, program the cluster.

8. Lighting

9. **WARNING**

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

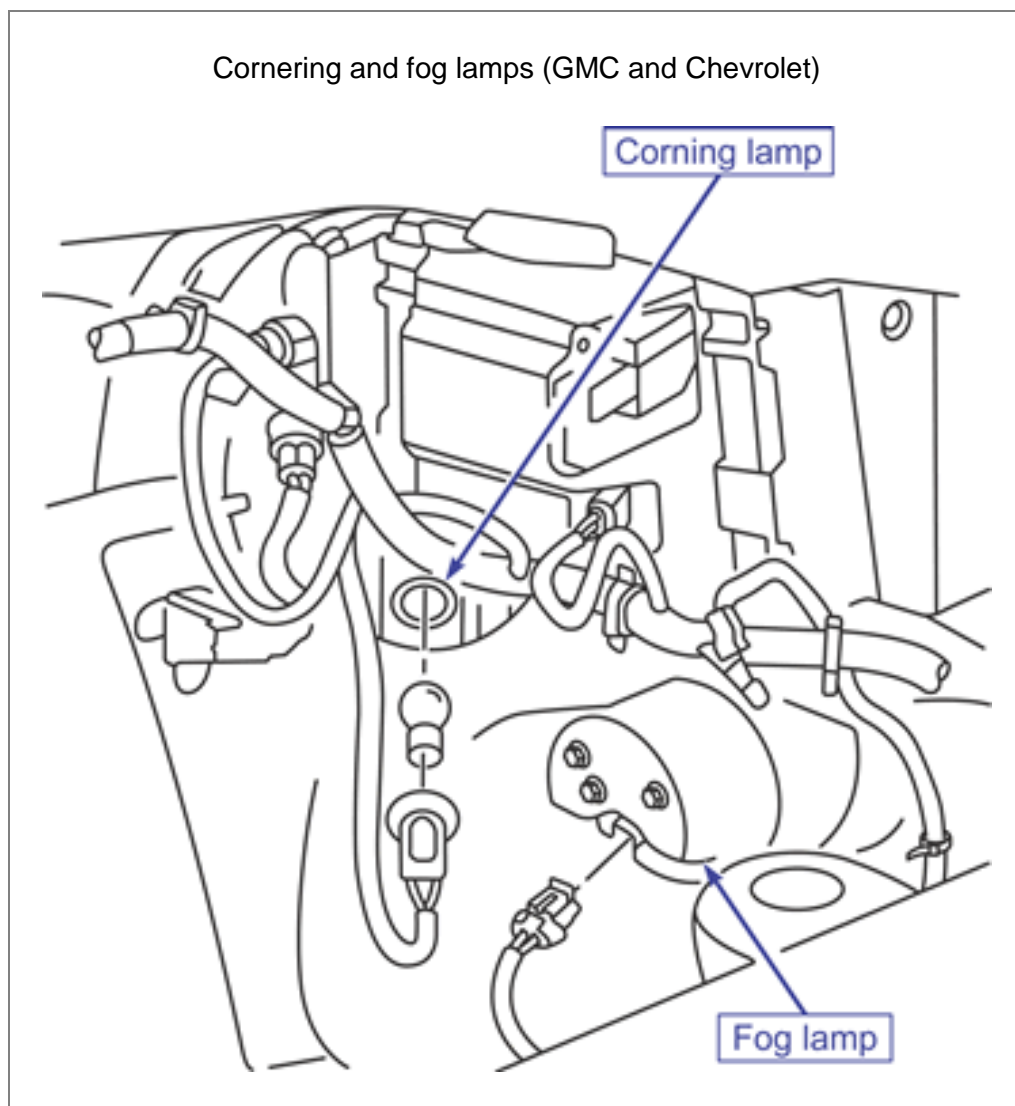
Front Fog Lamp

Removal & Installation

Chevrolet, GMC, and Isuzu

To Remove:

1. Remove the fog lamp bulb and socket from the fog lamp.



2. Detach the fog lamp from the fascia

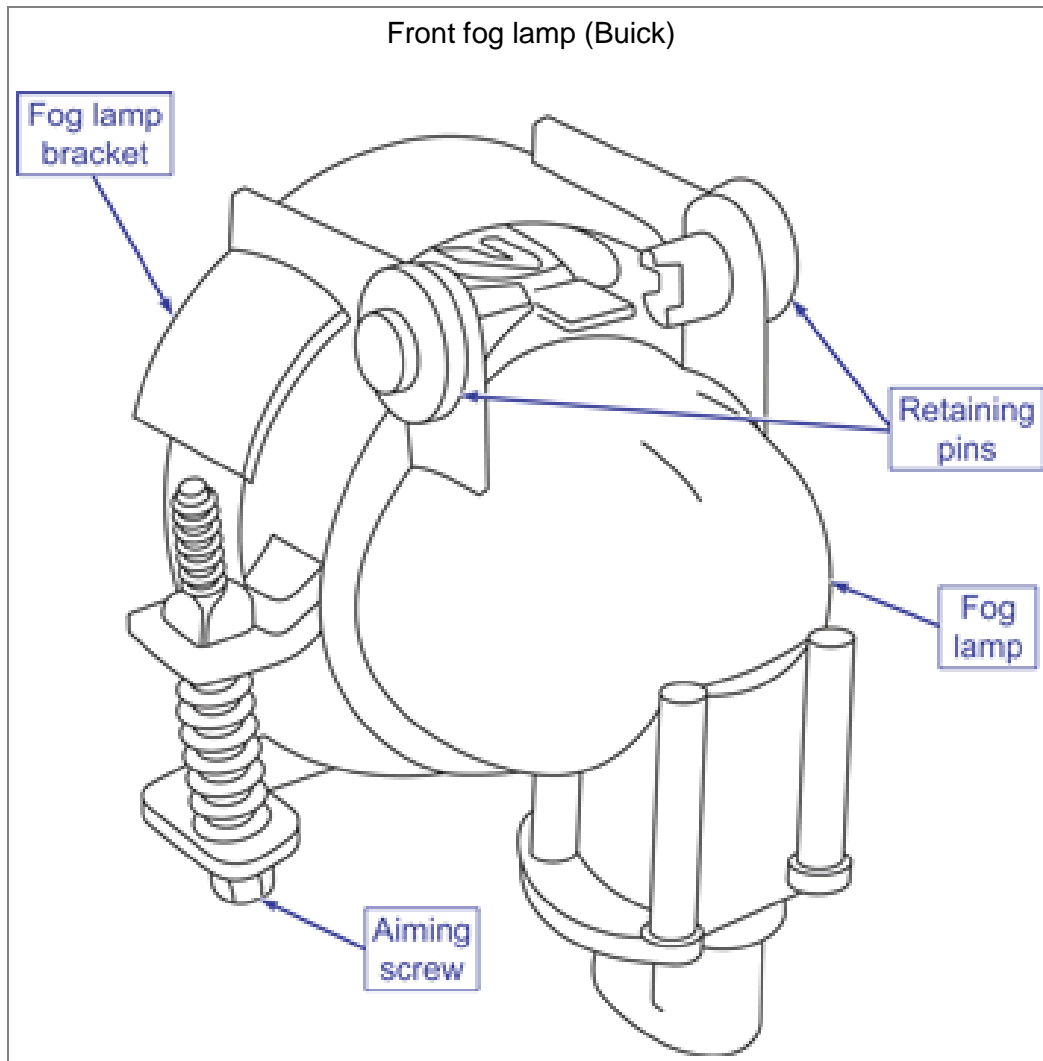
To Install:

1. Attach the fog lamp to the fascia. Torque the nuts to **88 in-lb (10 Nm)**.
2. Install the fog lamp bulb and socket into the fog lamp.
3. Aim the fog lamp.

Oldsmobile and Buick

To Remove:

1. Remove the fog lamp bulb and socket from the fog lamp housing.



2. Remove the fog lamp retaining pins from the fog lamp bracket.
3. Remove the aim adjustment screw from the fog lamp.
4. Remove the fog lamp from the fog lamp bracket.

To Install:

1. Place the fog lamp onto the fog lamp bracket.
2. Install the fog lamp retaining pins into the fog lamp bracket.
3. Install the fog lamp aim adjustment screws.
4. Install the fog lamp bulb and socket into the fog lamp housing.
5. Aim the fog lamp.

Headlamp

Removal & Installation

Bulb Replacement

To Remove:

CAUTION

Halogen bulbs contain pressurized gas. Mishandling a bulb may result in the bulb shattering into flying glass fragments.

CAUTION

Make sure to wear eye protection when handling a halogen bulb.

CAUTION

Do not touch the glass of a halogen bulb, only handle the bulb by the base.

CAUTION

Do not allow a halogen bulb to come into contact with dirt or moisture.

CAUTION

Make sure to dispose of a used halogen bulb properly.

CAUTION

Do not allow children to handle halogen bulbs.

1. Turn the lamp switch to the off position.
2. Make sure the bulb is cool before changing.
3. Remove the headlamp assembly from the headlamp panel.
4. Remove the rear access cover from the headlamp assembly.
5. Disconnect the headlamp connector.
6. Remove the bulb from the headlamp assembly by rotating the bulb and socket counterclockwise.

To Install:

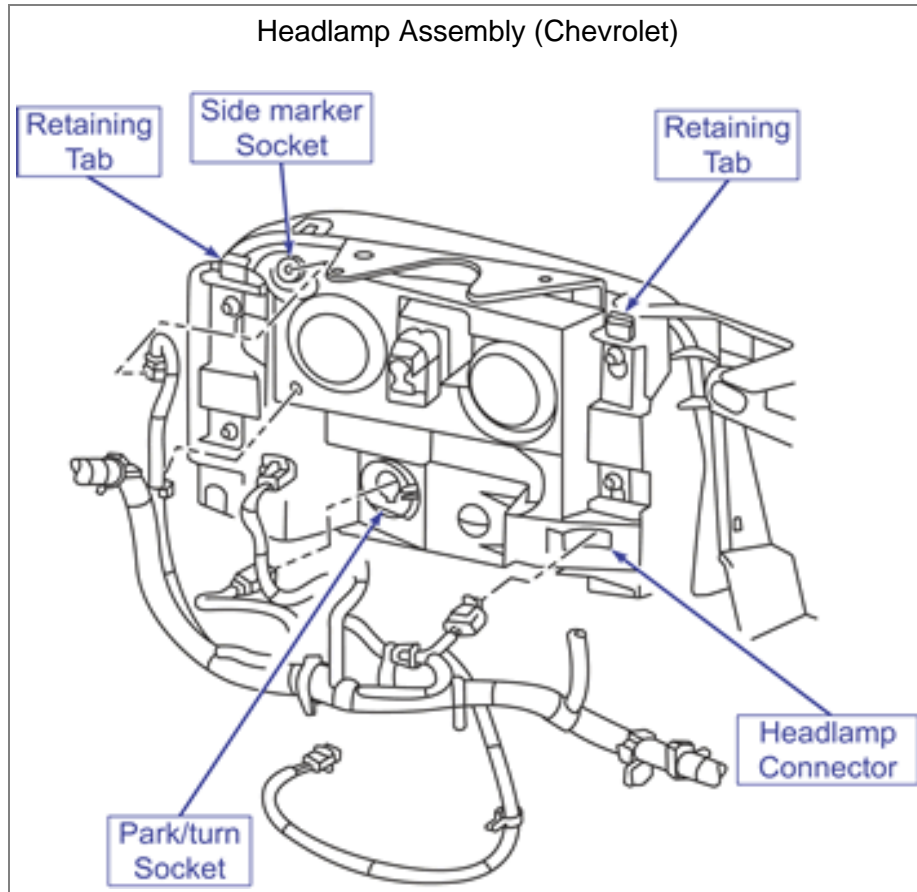
1. Connect the headlamp connector.
2. Install the bulb into the headlamp assembly by rotating the bulb and socket clockwise.
3. Install the rear access cover onto the headlamp assembly.

4. Install the headlamp assembly into the headlamp panel.

Headlamp Assembly

Chevrolet

To Remove:



1. Remove the grille from the front of the vehicle.
2. Release the headlamp assembly retaining tabs.
3. If equipped, disconnect the headlamp leveling motor connector.
4. Disconnect the headlamp connector.
5. Remove the park/turn and side marker bulb sockets from the headlamp assembly.
6. Remove the headlamp assembly from the headlamp panel.

To Install:

1. Place the headlamp assembly into the headlamp panel.
2. Install the park/turn and side marker bulb sockets into the headlamp assembly.
3. Connect the headlamp connector.
4. If equipped, connect the headlamp leveling motor connector.
5. Lock the headlamp assembly retaining tabs.
6. Install the grille onto the front of the vehicle.

Aiming

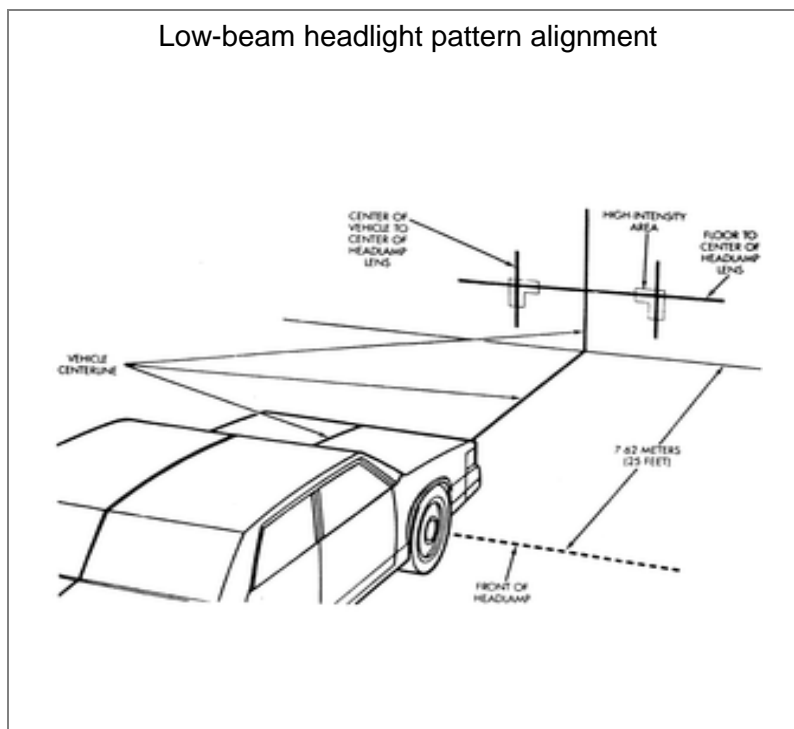
When adjusted properly, the lights should not glare in oncoming traffic's windshields, nor should they illuminate the passenger compartment of vehicles driving in front of you.

CAUTION

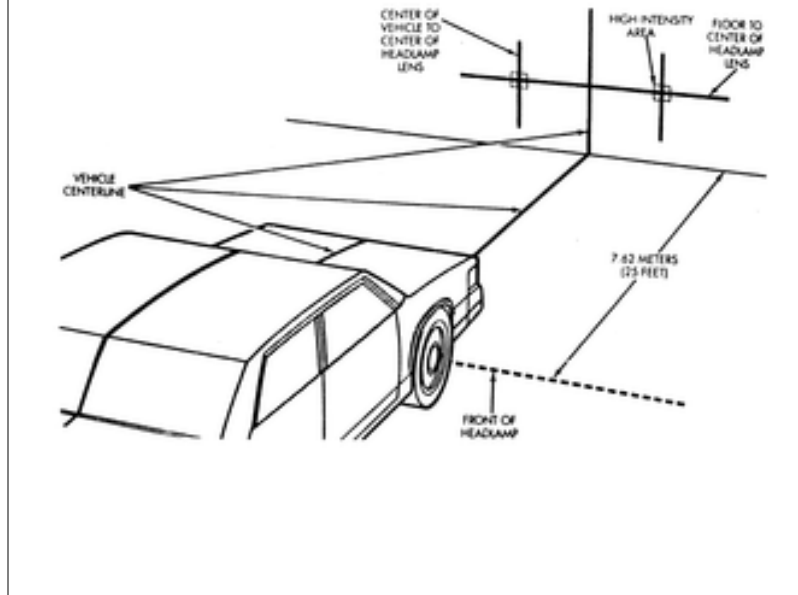
When headlights are replaced or any time front-end work is performed on the vehicle, the headlights should be aimed using the proper equipment. Headlights not properly aimed can make it virtually impossible to see and may blind other drivers on the road, causing injury or death.

1. Park the vehicle on a level-surface, with the fuel tank about 1/2 full and with the vehicle empty of all extra cargo (unless normally carried)
 - The vehicle should be facing a wall that is no less than six feet (1.8m) high and 12 feet (3.7m) wide
 - The front of the vehicle should be about 25 feet from the wall
 - If aiming is to be performed outdoors, wait until dusk to properly see the headlight beams on the wall
 - If done in a garage, darken the area around the wall as much as possible by closing shades or hanging cloth over windows
2. Turn the headlights **ON**.
3. Mark the wall at the center of each light's low beam.
4. Turn on the high beams and mark the center of each headlight's high beam.
5. A short length of masking tape that is visible from the front of the vehicle may be used.

NOTE: Although marking all four positions is advisable, marking one position from each light should be sufficient.



High-beam headlight pattern alignment



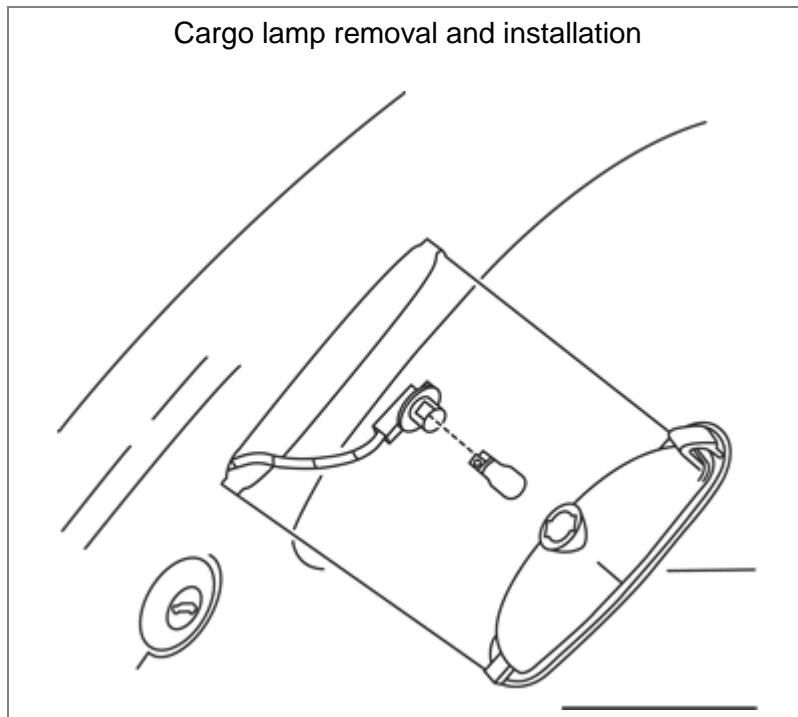
6. Perform the necessary repairs.
7. Turn the headlights **ON**.
8. Adjust the beams to match the marks on the wall.

Cargo Lamp

Removal & Installation

To Remove:

1. Insert a flat bladed tool into the slot at the bottom of the cargo lamp and push up on the lamp.



2. Pull the bottom of the cargo lamp out from the body trim panel.
3. Remove the cargo lamp from the body trim panel by pulling down on the lamp.
4. Remove the bulb socket from the cargo lamp.

To Install:

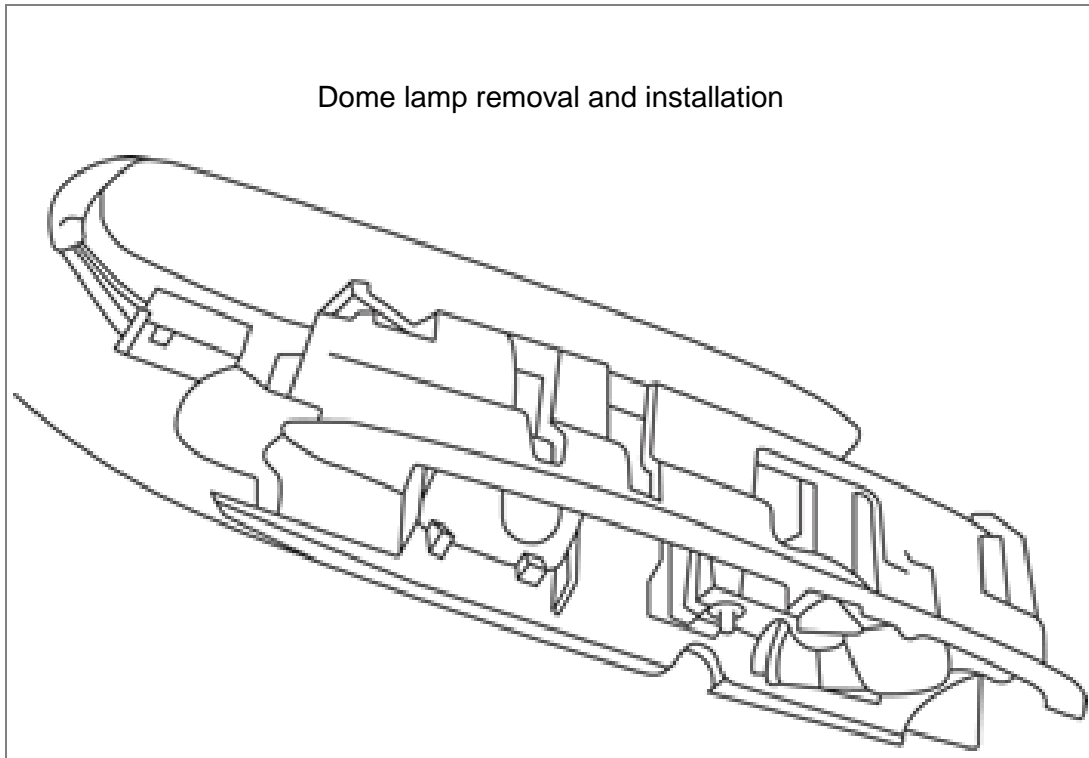
1. Install the bulb socket into the cargo lamp.
2. Install the bottom of the cargo lamp into the body trim panel.
3. Push on the top of the cargo lamp to engage the locking tab.

Dome Lamp

Removal & Installation

To Remove:

1. Remove the lens from the dome lamp.
2. Release the retaining tabs by moving the lamp forward.



3. Remove the dome lamp from the headliner.
4. Disconnect the dome lamp connector.

To Install:

1. Connect the dome lamp connector.
2. Place the dome lamp into the headliner.
3. Engage the retaining tab by moving the dome lamp rearward.
4. Install the lens onto the dome lamp.

High Mount Stop Lamp

Removal & Installation

To Remove:

CAUTION

Raising the liftgate with the liftgate window open can damage the high mount stop lamp, liftgate hinges, and the liftgate window.

1. Raise the liftgate.
2. Lower the rear of the headliner by removing the rear headliner pins.
3. Disconnect the high mount stop lamp connector.
4. Remove the high mount stop lamp grommet from the body.
5. Lower the liftgate.
6. Open the liftgate window.
7. Remove the high mount stop lamp retaining screws from the liftgate window molding.
8. Remove the high mount stop lamp from the vehicle.

To Install:

1. Place the high mount stop lamp onto the vehicle.
2. Install the high mount stop lamp retaining screws into the liftgate window molding. Torque the screws to **22 in-lb (2.5 Nm)**.
3. Close the liftgate window.
4. Lift the liftgate.
5. Install the high mount stop lamp grommet into the body.
6. Connect the high mount stop lamp connector.
7. Install the rear of the headliner by inserting the retaining pins.

Cornering Lamp

Removal & Installation

To Remove:

1. Remove the bulb socket from the cornering lamp.
2. Release the cornering lamp forward retaining tab and pull the front of the lamp away from the fascia.
3. Remove the cornering lamp rearward retaining stem from the fascia by pulling the lamp forward.

To Install:

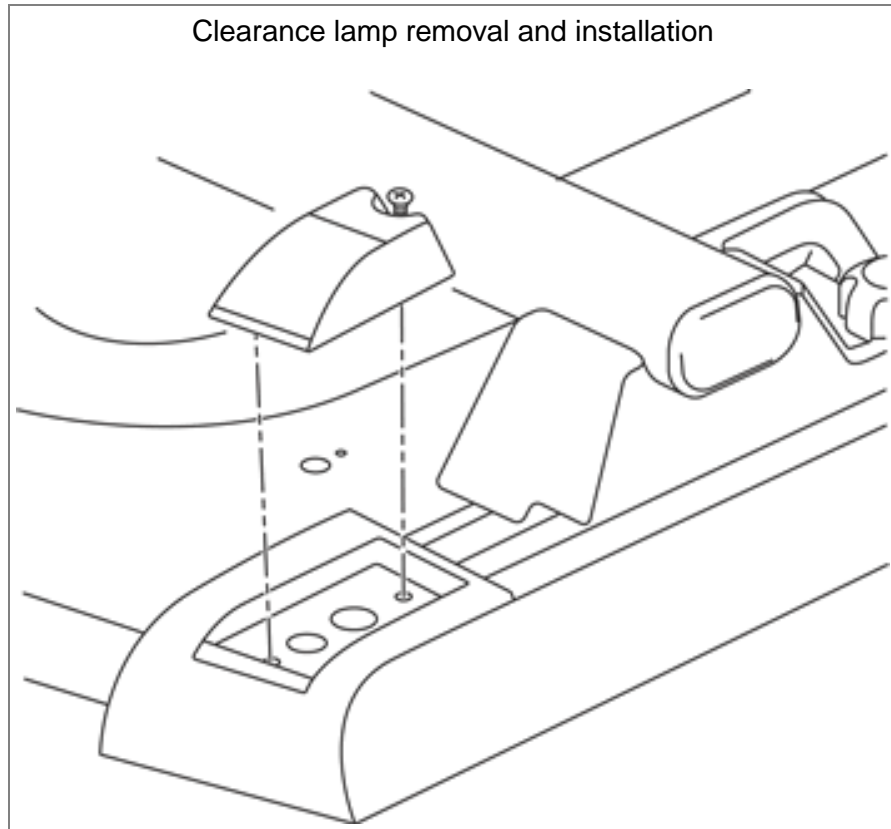
1. Place the cornering lamp rearward retaining stem into the slot in the fascia.
2. Engage the cornering lamp forward retaining tab into the fascia by pushing in on the front of the lamp.
3. Install the bulb socket into the cornering lamp.

Clearance Lamp

Removal & Installation

To Remove:

1. Turn the headlamp switch to the off position.



2. Remove the push pin from the clearance lamp.
3. Use a flat bladed tool to pry up the rear of the clearance lamp lens.
4. Remove the clearance lamp lens from the lamp by pulling the lens rearward.
5. Remove the bulb from the cornering lamp.

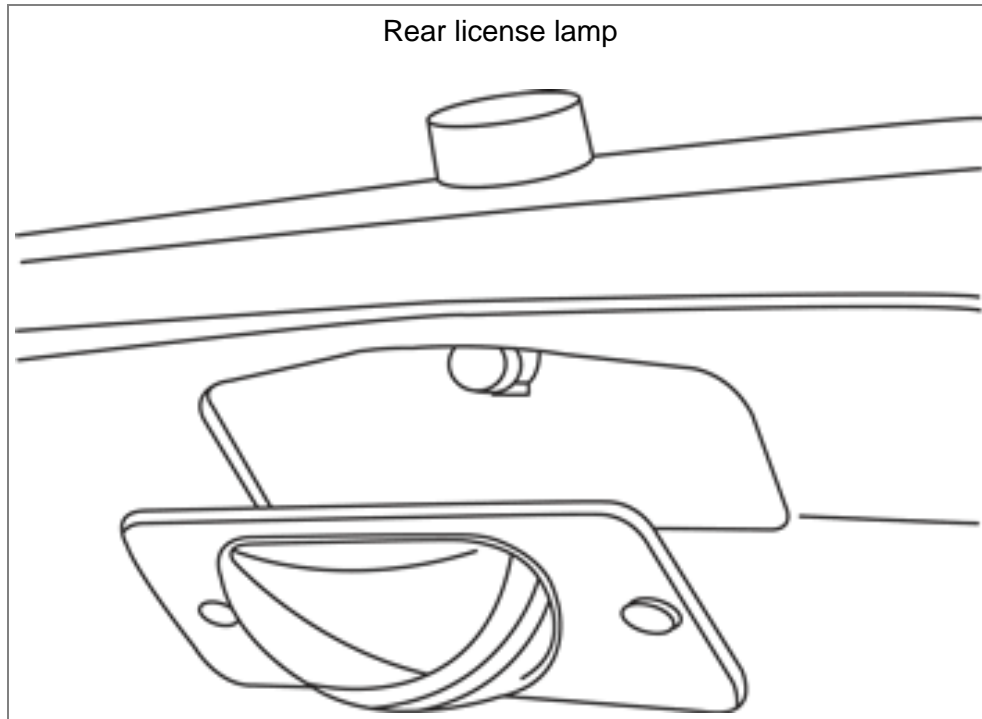
To Install:

1. Install the bulb into the cornering lamp.
2. Place the forward edge of the lens in the opening in the lamp and push down on the rear of the lens.
3. Install the push pin into the clearance lamp.

Rear License Lamp

Removal & Installation

To Remove:



1. Detach the license lamp lens from the liftgate.
2. Remove the license lamp bulb from the socket.

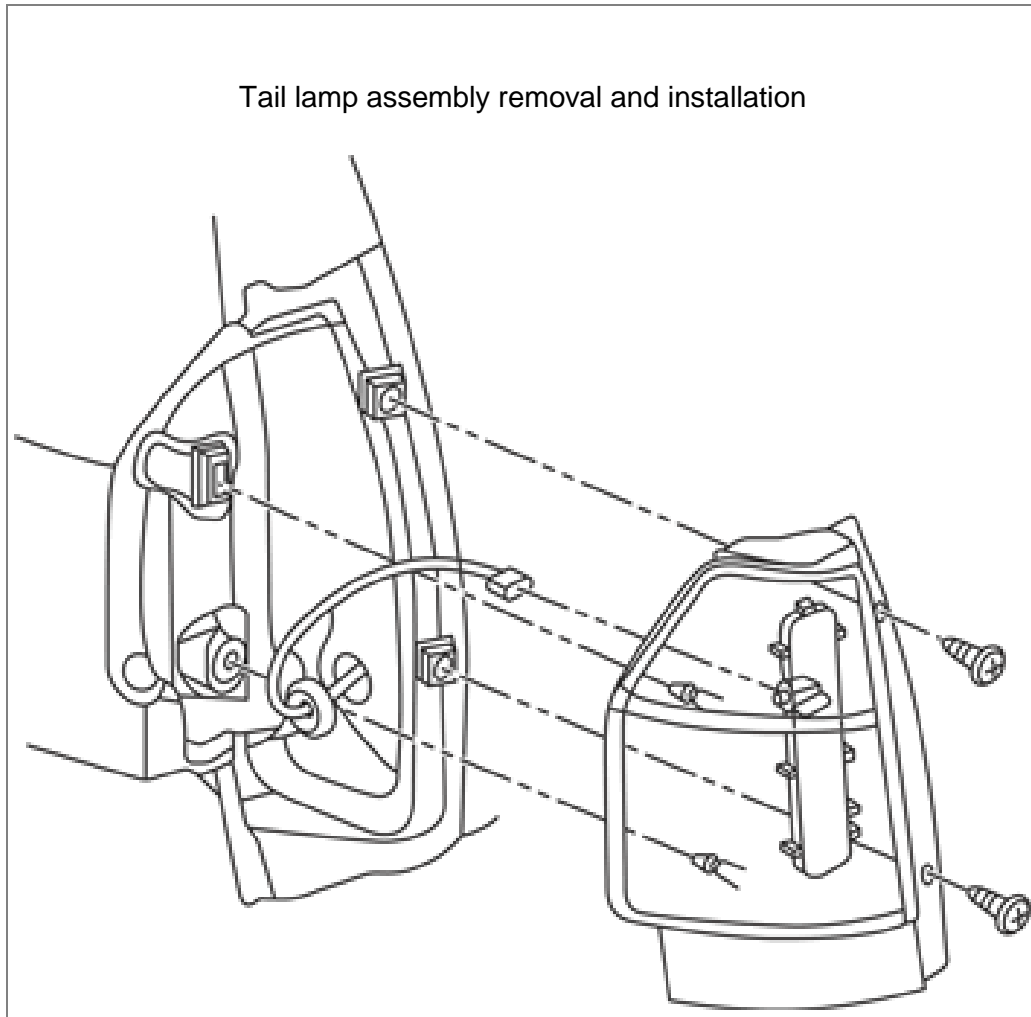
To Install:

1. Install the license lamp bulb into the socket.
2. Make sure the bulb is clean.
3. Attach the license lamp lens to the liftgate. Torque the screws to **12 in-lb (1.4 Nm)**.

Tail Lamp Assembly

Removal & Installation

To Remove:



1. Remove the tail lamp assembly retaining screws from the body.
2. Release the locking pins by pulling the assembly directly rearward.
3. Disconnect the tail lamp assembly connector.
4. Remove the tail lamp circuit board from the assembly.

To Install:

1. Install the tail lamp circuit board into the assembly.
2. Connect the tail lamp assembly connector.
3. Push the assembly directly forward into the opening to engage the locking pins.
4. Install the tail lamp assembly retaining screws into the body. Torque the screws to **17 in-lb (1.9 Nm)**.

5. Wiper & Washer

6. **WARNING**

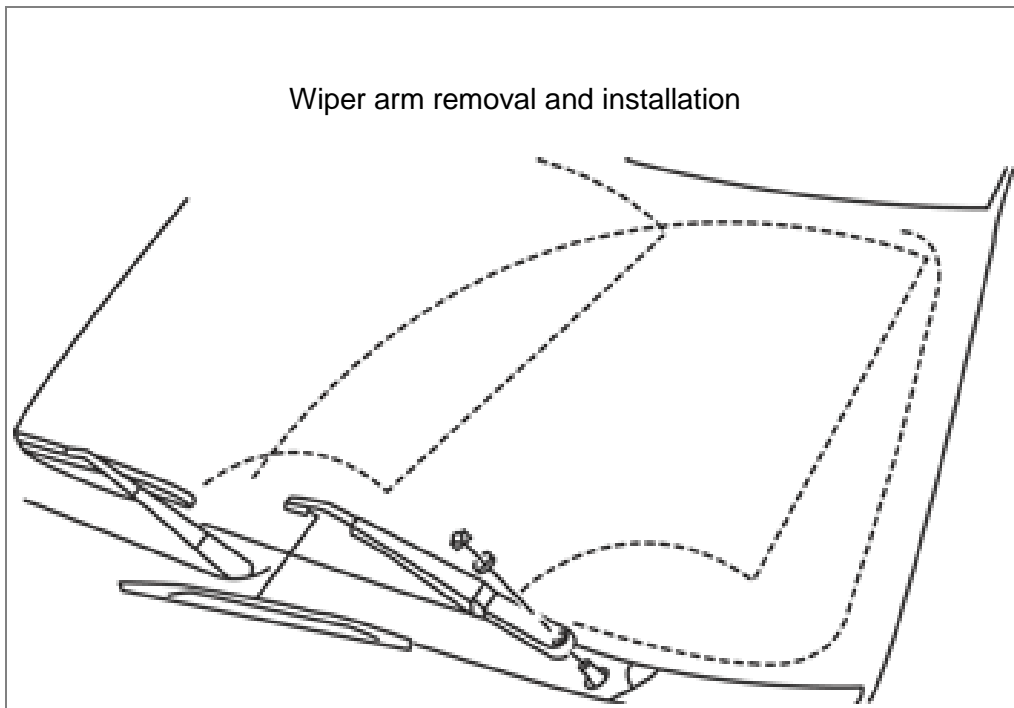
To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Windshield Wiper Arm

Removal & Installation

To Remove:

1. Remove the wiper arm nut cover from the nut.



2. Remove the wiper arm nut from the wiper arm.
3. Loosen the wiper arm pivot by pushing inward.
4. Remove the wiper arm from the pivot shaft, use a battery terminal puller if necessary.
5. Remove the wiper blade from the wiper arm.
6. Use a soft wire brush to clean the pivot shaft knurls.

To Install:

1. Install the wiper blade onto the wiper arm.
2. Install the wiper arm onto the pivot shaft.
3. Install the wiper arm nut onto the wiper arm. Torque the nut to **22 lb-ft (30 Nm)**.
4. Install the wiper arm nut cover onto the nut.
5. Make sure the wipers are functioning properly.

Windshield Wiper Blade

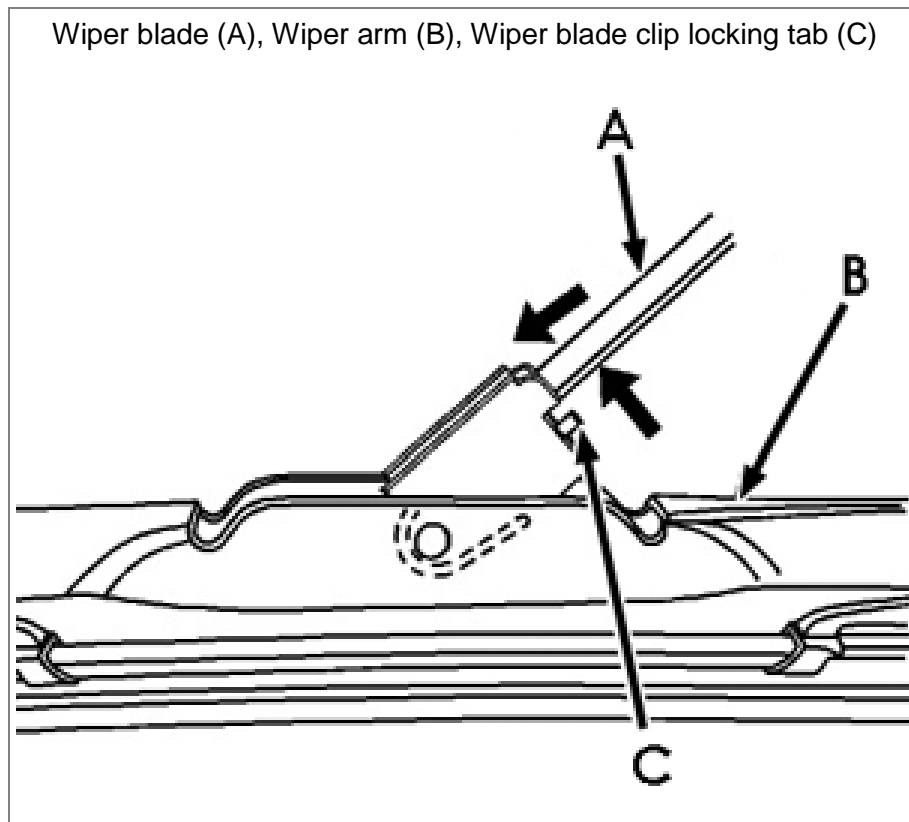
Removal & Installation

To Remove:

CAUTION

Do not let the windshield wiper arm snap back against the windshield.

1. Pull the wiper arm into the upright position.



2. Disengage the wiper blade clip locking tab and pull down on the wiper blade.
3. Remove the wiper blade from the inside radius of the wiper arm.
4. Pull the wiper blade through the wiper arm opening.

To Install:

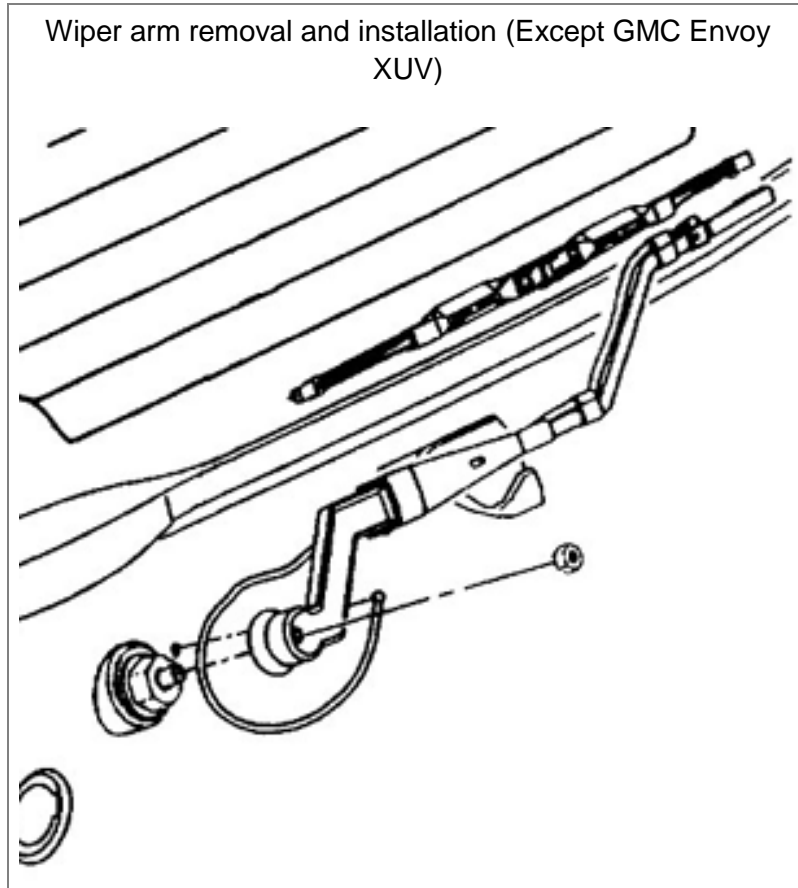
1. Insert the wiper blade into the wiper arm opening.
2. Install the wiper blade onto the inside radius of the wiper arm.
3. Pull up on the wiper blade and engage the wiper blade clip locking tab.
4. Lower the wiper arm onto the windshield, do not let the arm snap back against the windshield.

Rear Window Wiper Arm

Removal & Installation

Except GMC Envoy XUV

To Remove:



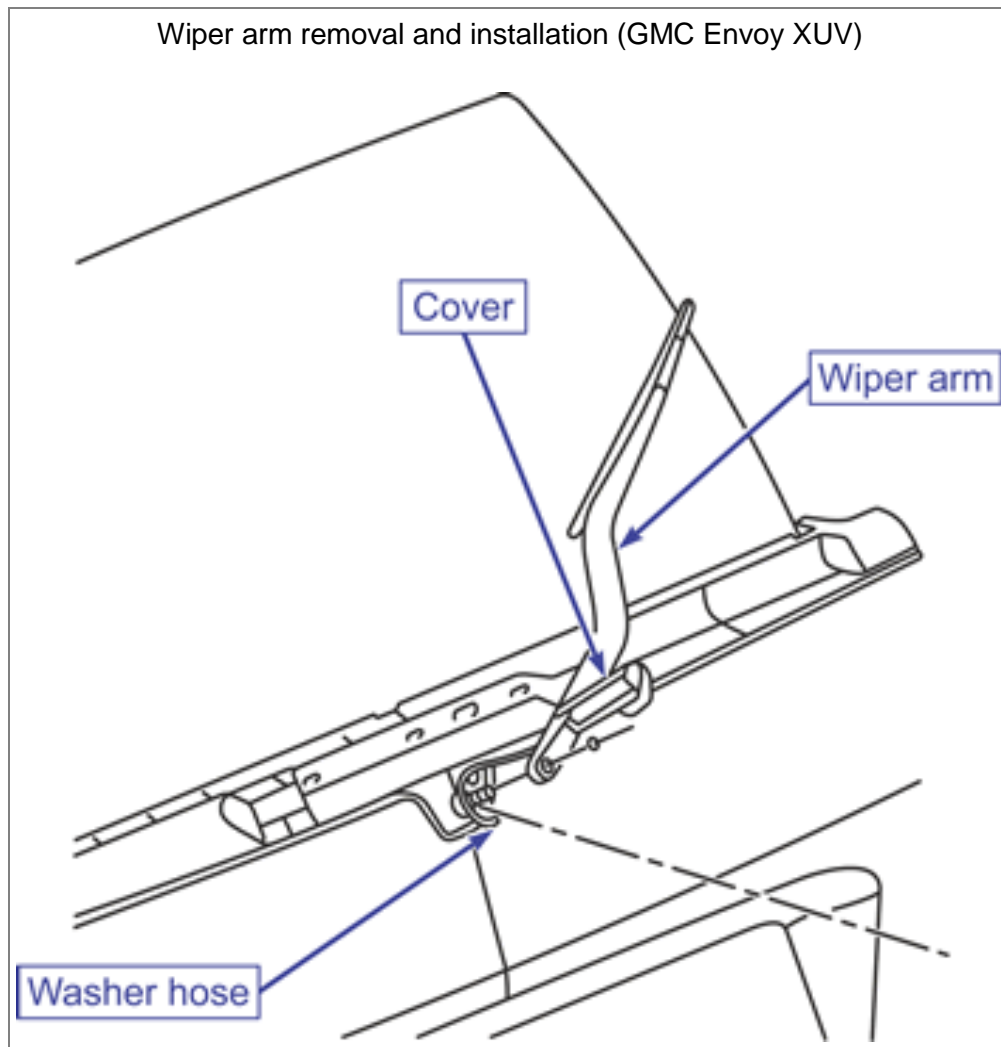
1. With the wiper arm in the mid-wipe position, disconnect the washer hose from the wiper arm.
2. Remove the cover from the wiper arm.
3. Detach the wiper arm from the pivot shaft.
4. If necessary, remove the wiper blade from the wiper arm.

To Install:

1. If necessary, install the wiper blade onto the wiper arm.
2. With the wiper motor in the park position, attach the wiper arm to the pivot shaft. Torque the nut to **15 ft-lb (20 Nm)**.
3. Install the cover onto the wiper arm.
4. Connect the washer hose to the wiper arm.

GMC Envoy XUV

To Remove:



1. Remove the cover from the wiper arm.
2. Detach the wiper arm from the pivot shaft.
3. Disconnect the washer hose from the wiper arm.
4. Use a soft wire brush to clean the pivot shaft knurls.
5. If necessary, remove the wiper blade from the wiper arm.

To Install:

1. If necessary, install the wiper blade onto the wiper arm.
2. With the engine off and the ignition switch in the run position, turn the rear wiper on to full speed.
3. Remove the rear wiper fuse from the rear fuse block.
4. Turn the rear wiper off.
5. Install the rear wiper fuse into the rear fuse block.

6. Turn the ignition switch to the lock position.
7. Connect the washer hose to the wiper arm.
8. Attach the wiper arm to the pivot shaft. Torque the nut to **55-89 in-lb (6-10 Nm)**.
9. Install the cover onto the wiper arm.
10. With the engine off and the ignition switch in the run position, cycle the rear wiper to verify the park location of the arm.
11. Make sure the endgate window is operating properly.

Rear Window Wiper Blade

Removal & Installation

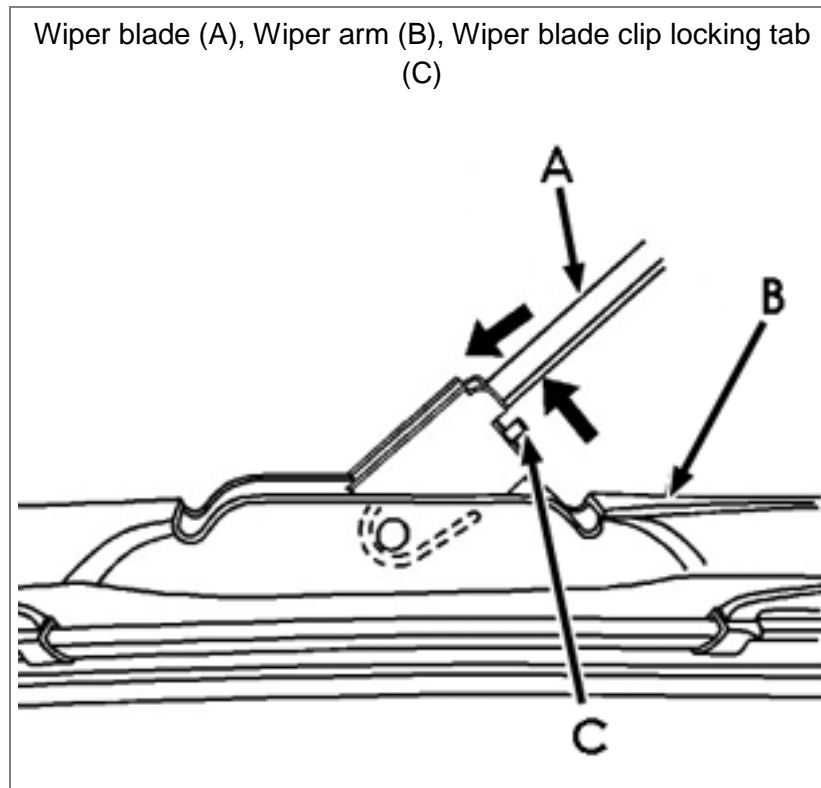
Chevrolet, GMC (Except Envoy XUV), Oldsmobile, Buick, and Isuzu

To Remove:

CAUTION

Do not let the windshield wiper arm snap back against the window.

1. Pull the wiper arm off of the park ramp.



2. Disengage the wiper blade clip locking tab and pull down on the wiper blade.
3. Remove the wiper blade from the inside radius of the wiper arm.
4. Pull the wiper blade through the wiper arm opening.

To Install:

1. Insert the wiper blade into the wiper arm opening.
2. Install the wiper blade onto the inside radius of the wiper arm.
3. Pull up on the wiper blade and engage the wiper blade clip locking tab.
4. Lower the wiper arm onto the park ramp, do not let the arm snap back against the window.

Saab and GMC Envoy XUV

To Remove:**CAUTION**

Do not let the windshield wiper arm snap back against the window.

1. Pull the wiper arm off of the park ramp.
2. Rotate the wiper blade until it is horizontal to the wiper arm.
3. Remove the wiper blade from the wiper arm by pushing the blade away from the arm.

To Install:

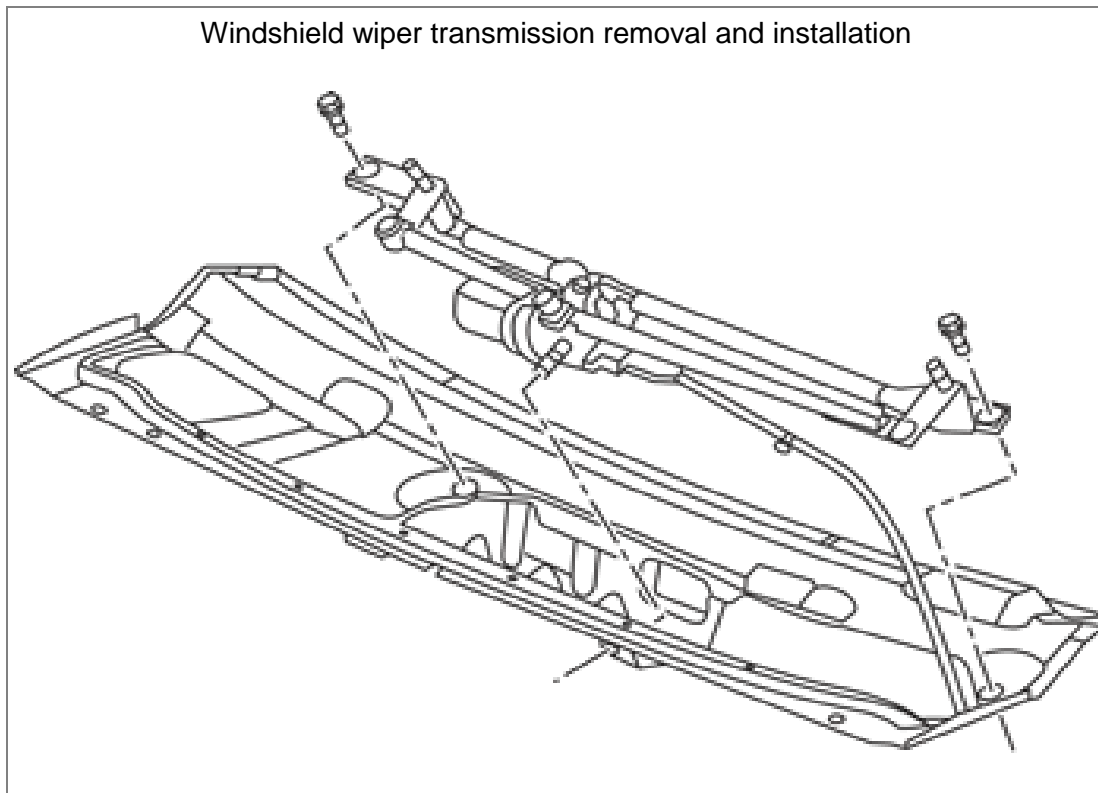
1. Install the wiper blade onto the wiper arm by pushing the blade onto the arm.
2. Lower the wiper arm onto the park ramp, do not let the arm snap back against the window.

Windshield Wiper Motor

Removal & Installation

To Remove:

1. Remove the windshield wiper arms from the pivot shafts.
2. Remove the air inlet grill from the vehicle.



3. Remove the wiper transmission assembly retaining bolts from the vehicle.
4. Disengage the wiper motor from the slot in the plenum by pushing the wiper transmission assembly rearward.
5. Disconnect the windshield wiper motor connector.
6. Remove the wiper transmission assembly from the plenum.

To Install:

1. Install the wiper transmission assembly into the plenum.
2. Connect the windshield wiper motor connector.
3. Engage the wiper motor into the slot in the plenum by pushing the wiper transmission assembly forward.
4. Install the wiper transmission assembly retaining bolts into the vehicle. Torque the bolts to **71 in-lb (8 Nm)**.
5. Install the air inlet grill onto the vehicle.
6. Install the windshield wiper arms onto the pivot shafts.

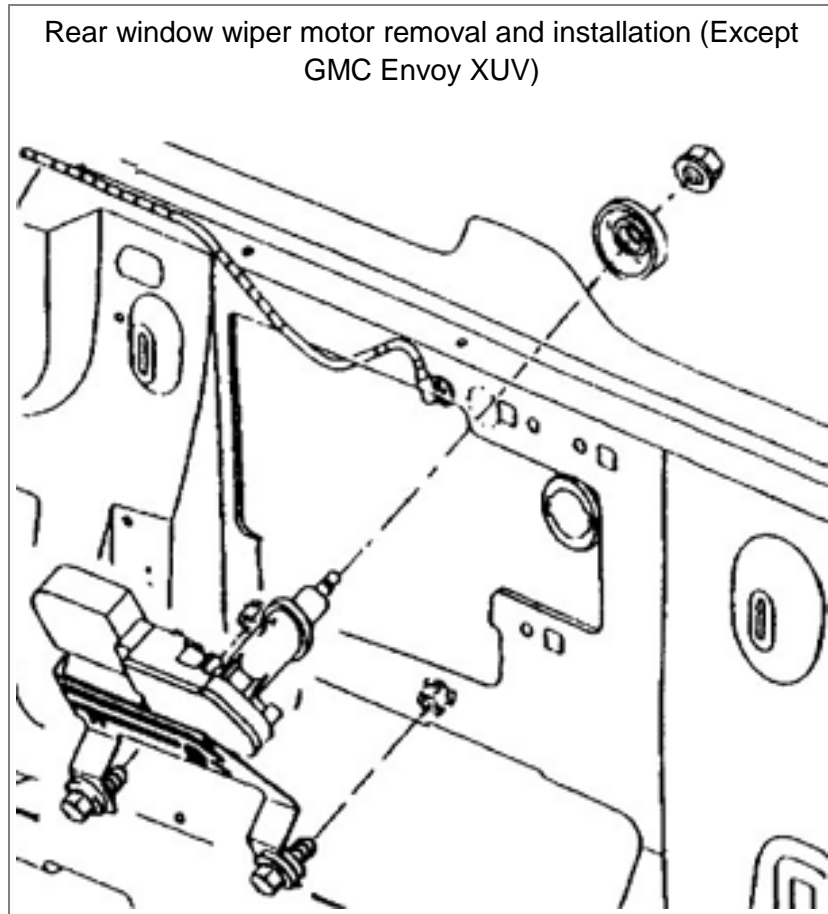
Rear Window Wiper Motor

Removal & Installation

Except GMC Envoy XUV

To Remove:

1. Remove the wiper arm from the pivot shaft.



2. Remove the nut and spacer from the pivot shaft.
3. Remove the interior trim panel from the liftgate.
4. Disconnect the wiper motor connector.
5. Detach the wiper motor from the liftgate.

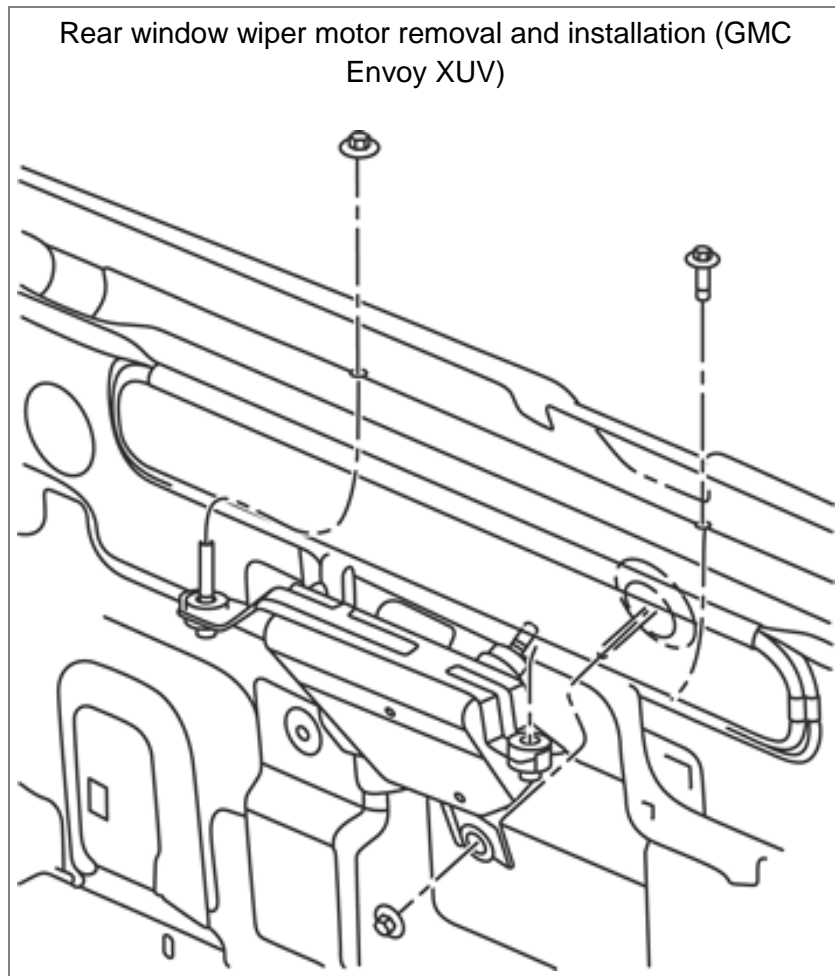
To Install:

1. Attach the wiper motor to the liftgate. Torque the bolts to **71 in-lb (8 Nm)**.
2. Connect the wiper motor connector.
3. Install the interior trim panel to the liftgate.
4. Install the nut and spacer onto the pivot shaft. Torque the nut to **71 in-lb (8 Nm)**.
5. Install the wiper arm onto the pivot shaft.

GMC Envoy XUV

To Remove:

1. Remove the wiper arm and spacer from the pivot shaft.
2. Remove the interior trim panel from the endgate.
3. Remove the window from the endgate.
4. Disconnect the rear wiper motor connector.



5. Detach the rear wiper motor from the endgate.

To Install:

1. Attach the wiper motor to the endgate. Torque the nuts and bolts to **71 in-lb (8 Nm)**.
2. Connect the rear wiper motor connector.
3. Install the window onto the endgate.
4. Install the interior trim panel to the endgate.
5. Install the spacer and wiper arm onto the pivot shaft.
6. Make sure the rear wiper is operating properly.

Windshield Wiper Switch

NOTE: The windshield wiper switch is integral to the turn signal/multifunction switch.

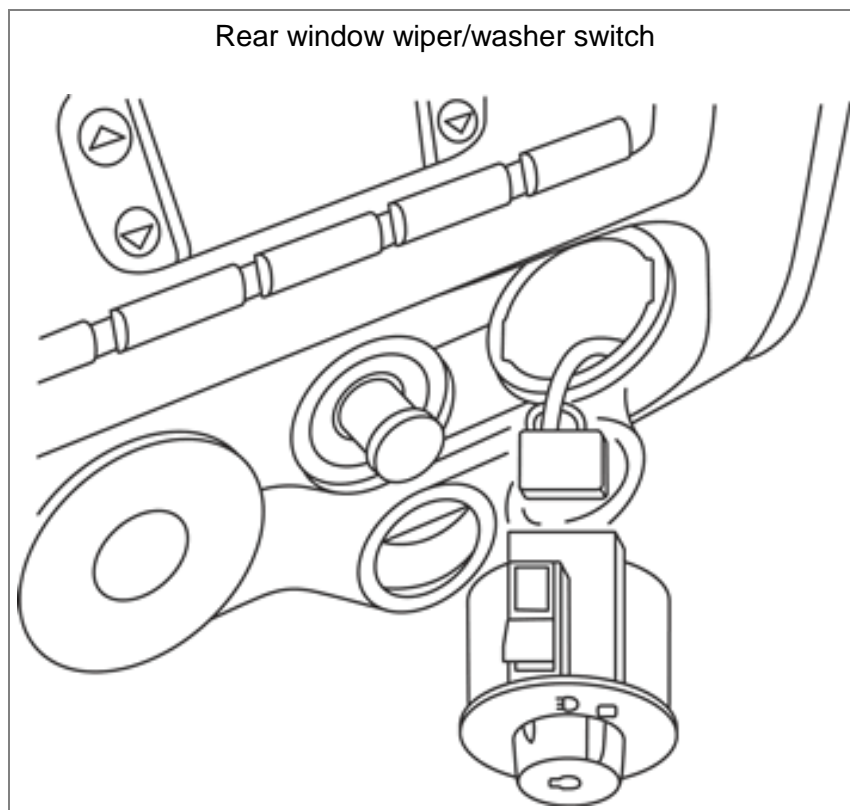
Rear Window Wiper/Washer Switch

Removal & Installation

Except Saab

To Remove:

1. Remove the trim plate from the instrument panel (I/P).



2. Disconnect the rear window wiper/washer switch connector.
3. Detach the rear window wiper/washer switch from the trim plate.

To Install:

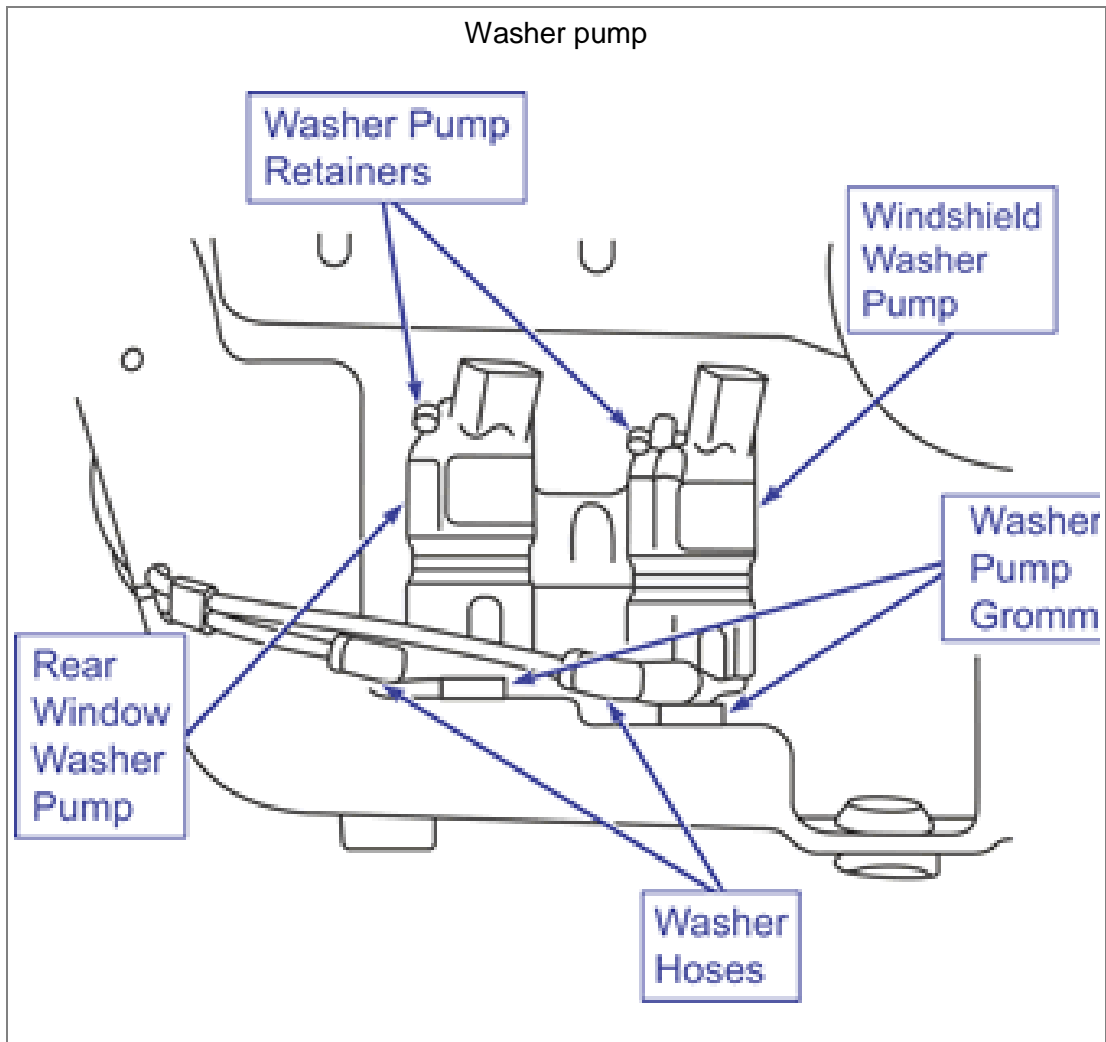
1. Connect the rear window wiper/washer switch connector.
2. Attach the rear window wiper/washer switch to the trim plate.
3. Install the trim plate onto the instrument panel (I/P).

Windshield Washer Pump

Removal & Installation

To Remove:

1. Remove the washer solvent container from the vehicle.



2. Disconnect the washer hose from the windshield washer pump.
3. Pull the windshield washer pump from the retainer.
4. Remove and discard the grommet from the windshield washer pump.

To Install:

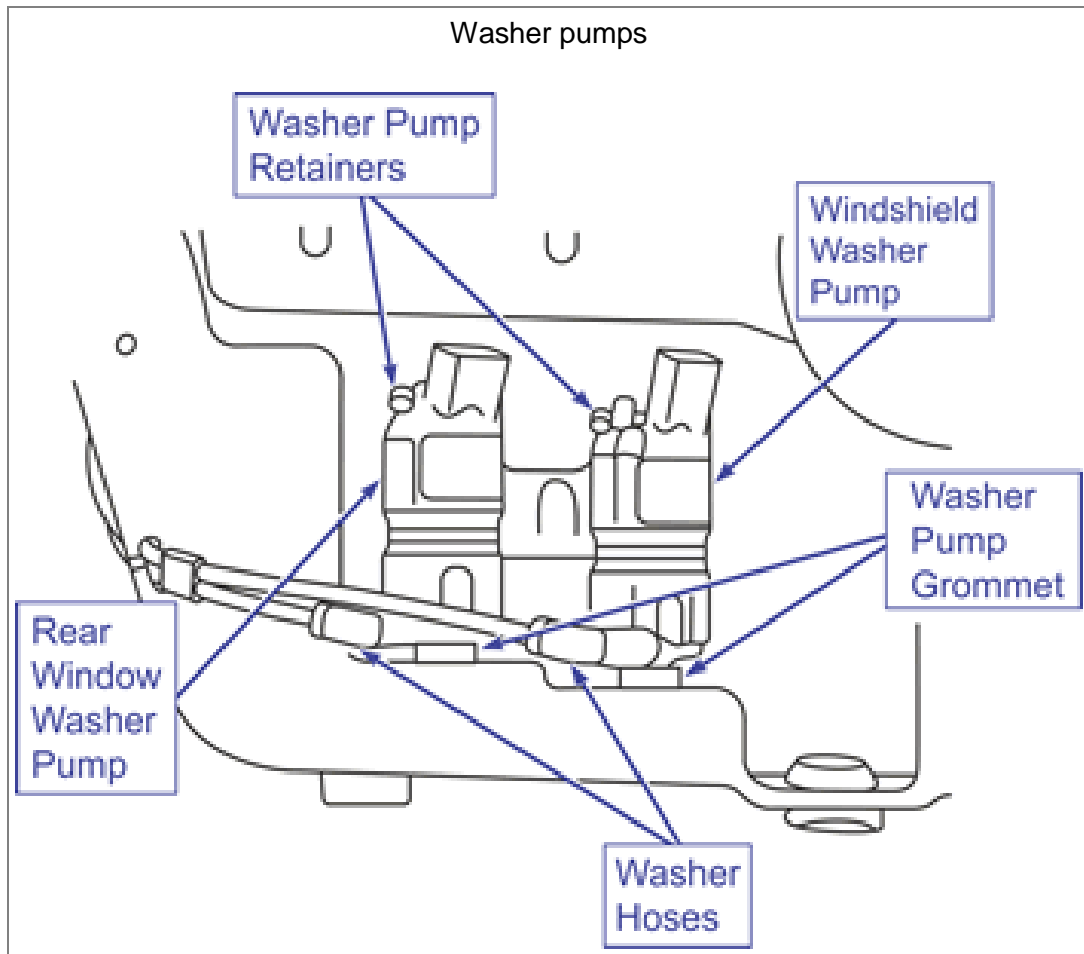
1. Install a new grommet to the windshield washer pump.
2. Push the windshield washer pump into the retainer.
3. Connect the washer hose to the windshield washer pump.
4. Install the washer solvent container into the vehicle.

Rear Window Washer Pump

Removal & Installation

To Remove:

1. Remove the washer solvent container from the vehicle.



2. Disconnect the washer hose from the rear window washer pump.
3. Pull the rear window washer pump from the retainer.
4. Remove and discard the grommet from the rear window washer pump.

To Install:

1. Install a new grommet to the rear window washer pump.
2. Push the rear window washer pump into the retainer.
3. Connect the washer hose to the rear window washer pump.
4. Install the washer solvent container into the vehicle.

Doors

WARNING

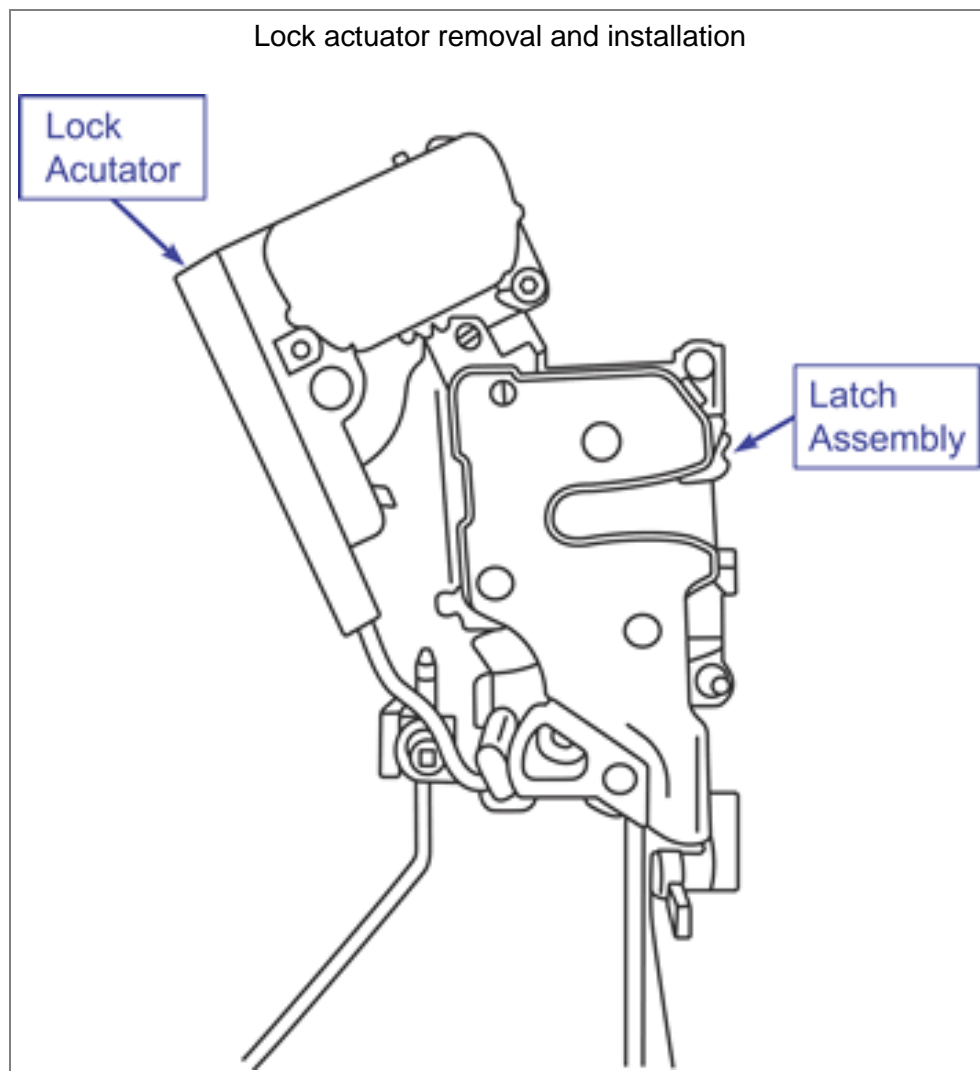
To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Door Lock Actuator

Removal & Installation

To Remove:

Remove the trim panel, water deflector, and door latch assembly from the door. Remove the door lock actuator retaining screws from the lock. Disengage the rubber bumper from the latch by lifting up and rotating the door lock actuator.



Remove the door lock actuator from the latch.

To Install:

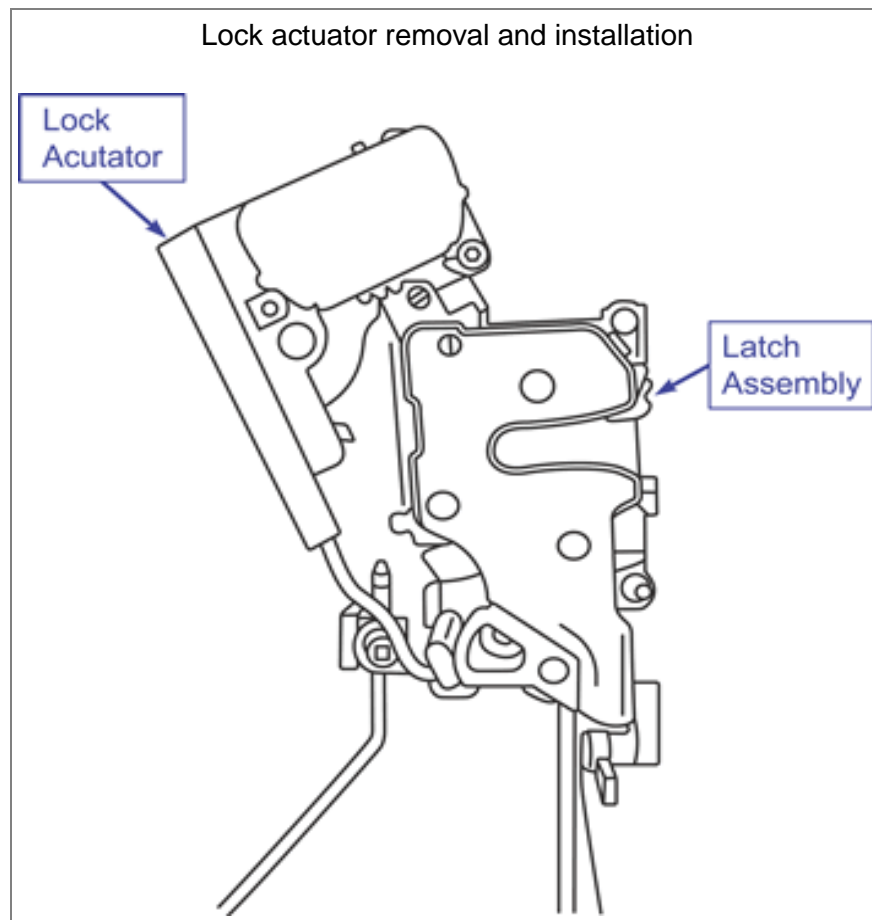
1. Install the rubber bumper into the latch.
2. Engage the rubber bumper by rotating the actuator toward the latch.
3. Install the door lock actuator onto the top of the latch, make sure that the first gear on the actuator is aligned to the first gear on the latch.
4. Install the door lock actuator retaining screws into the lock. Torque the screws to **6 in-lb (0.75 Nm)**.
5. Install the door latch assembly, water deflector, and trim panel onto the door.

Liftgate Lock Actuator

Removal & Installation

To Remove:

1. Remove liftgate latch assembly from the liftgate.
2. Remove the liftgate lock actuator retaining screws from the lock.
3. Disengage the rubber bumper from the latch by lifting up and rotating the liftgate lock actuator.



4. Remove the liftgate lock actuator from the latch.

To Install:

1. Install the rubber bumper into the latch.
2. Engage the rubber bumper by rotating the actuator toward the latch.
3. Install the liftgate lock actuator onto the top of the latch, make sure that the first gear on the actuator is aligned to the first gear on the latch.
4. Install the liftgate lock actuator retaining screws into the lock. Torque the screws to **6 in-lb (0.75 Nm)**.
5. Install the liftgate latch assembly onto the liftgate.

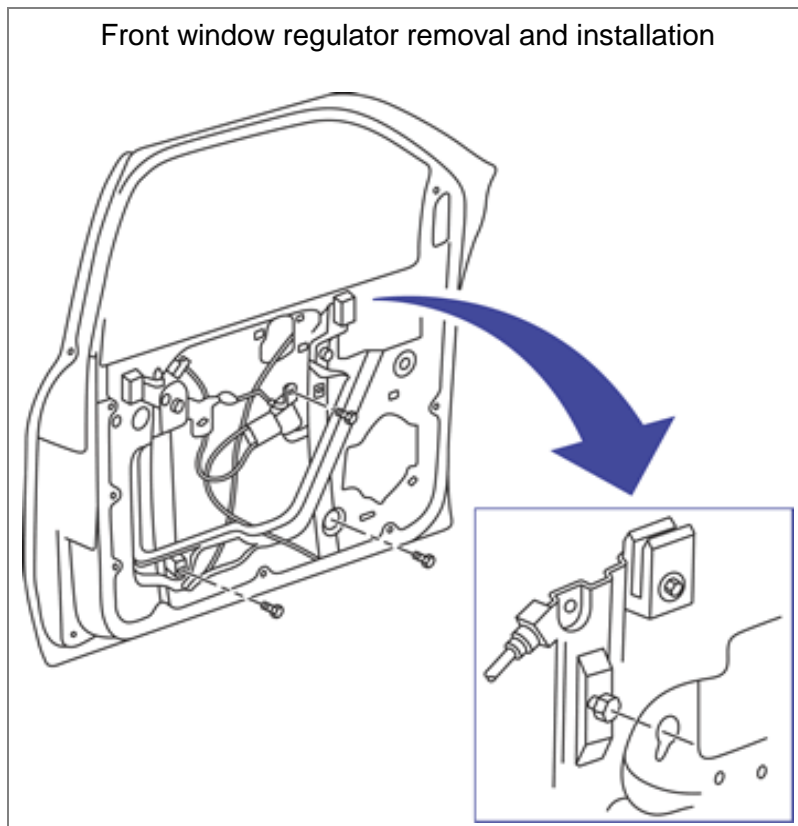
Window Regulator Motor

Removal & Installation

Front

To Remove:

1. Remove the door trim panel, speaker, and water deflector from the front door.
2. Loosen the window carrier bolts.
3. Lift the window off of the carrier.
4. Disconnect the window regulator motor connector.



5. Loosen the window regulator bolts in the keyhole slots, but do not remove the bolts.
6. Remove the remaining window regulator retaining bolts from the front door.
7. Lift the window regulator and push the bolts through the keyhole slots.
8. Remove the window regulator through the door opening.
9. Remove the upper window regulator retaining bolts from the window regulator.
10. Detach the window regulator motor from the window regulator.

To Install:

1. Attach the window regulator motor to the window regulator. Torque the bolts to **9 in-lb (5 Nm)**.
2. Partially install the upper window regulator retaining bolts into the window regulator.
3. Install the window regulator through the door opening.
4. Position the window regulator retaining bolts into the keyhole slots.
 - Install the remaining window regulator retaining bolts. Torque the middle bolt to **80 in-lb (9 Nm)**. Torque the remaining bolts to **88 in-lb (10 Nm)**.
 - Connect the window regulator motor connector.
 - Lower the window into the carrier and loosely tighten the bolts.
 - Operate the window until it is in the full up position and the window is in the carrier.
 - Torque the window carrier bolts to **88 in-lb (10 Nm)**.
 - Install the water deflector, speaker, and door trim panel from the front door.

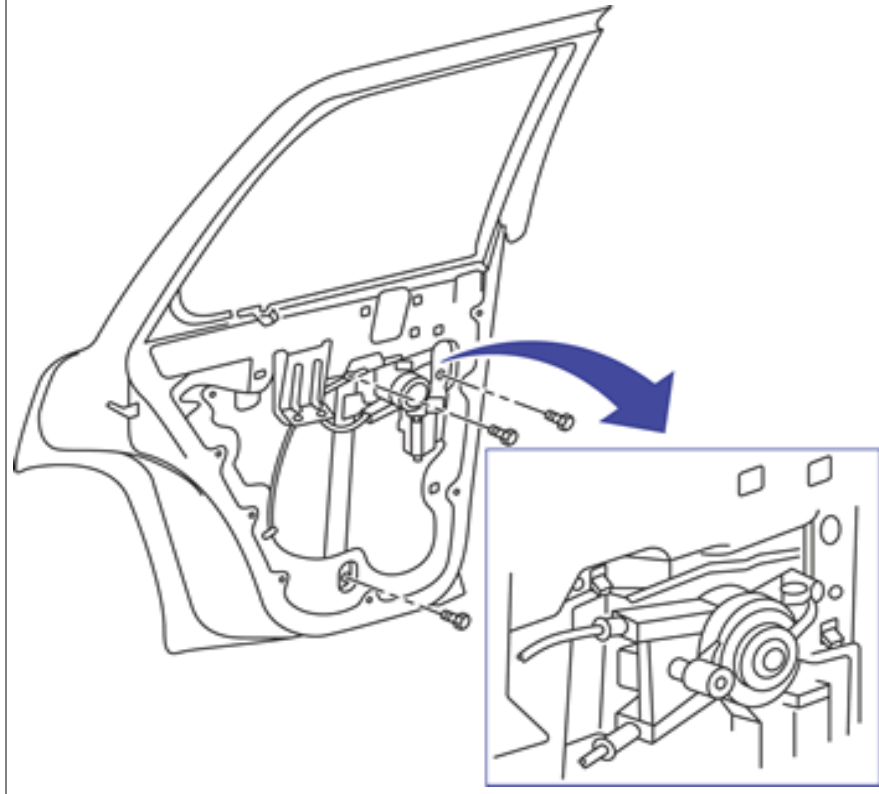
Rear

Short Wheel Base

To Remove:

1. Remove the door trim panel, water deflector, and speaker from the rear door.
2. Loosen the window carrier bolts.
3. Lift the window off of the carrier.
4. Disconnect the window regulator motor connector.

Rear window regulator removal and installation



5. Detach the window regulator from the rear door.
6. Detach the window regulator motor from the window regulator.

To Install:

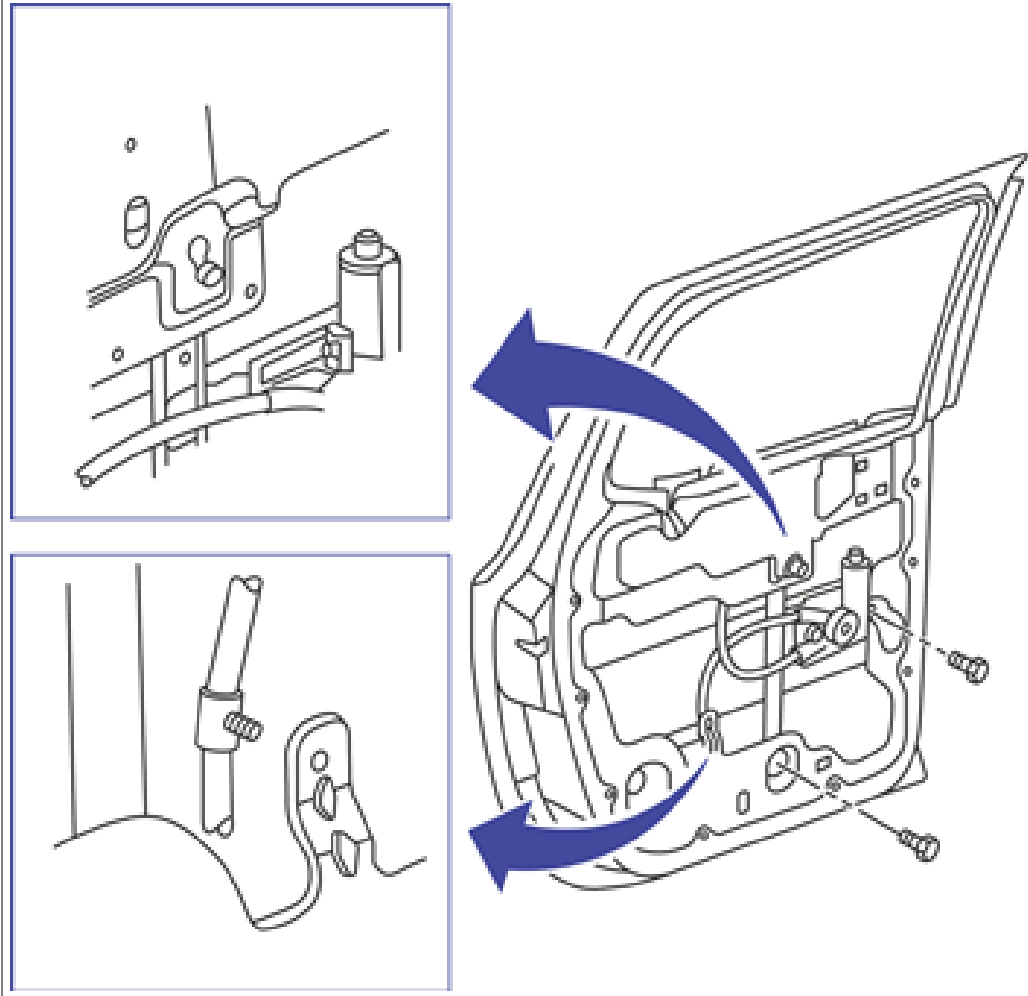
1. Attach the window regulator motor to the window regulator. Torque the bolts to **9 in-lb (5 Nm)**.
2. Attach the window regulator to the rear door. Torque the bolts to **88 in-lb (10 Nm)**.
3. Connect the window regulator motor connector.
4. Lower the window into the carrier and loosely tighten the bolts.
5. Operate the window until it is in the full up position and the window is in the carrier.
6. Torque the window carrier bolts to **88 in-lb (10 Nm)**.
7. Install the speaker, water deflector, and door trim panel onto the rear door.

Long Wheel Base

To Remove:

1. Lower the window to the midway point.
2. Remove the door trim panel and water deflector from the rear door.
3. Loosen the window carrier bolts.
4. Lift the window off of the carrier.
5. Disconnect the window regulator connector.

Rear window regulator removal and installation



6. Detach the regulator cable from the rear door.
7. Loosen the window regulator bolt in the keyhole slot, but do not remove the bolts.
8. Remove the remaining window regulator retaining bolts from the rear door.
9. Lift the window regulator and push the bolts through the keyhole slots.
10. Remove the window regulator through the door opening.
11. Detach the window regulator motor from the window regulator.

To Install:

1. Attach the window regulator motor to the window regulator. Torque the bolts to **9 in-lb (5 Nm)**.
2. Install the window regulator through the rear door opening.
3. Position the window regulator retaining bolt into the keyhole slots.
4. Install the remaining window regulator retaining bolts into the rear door.
5. Torque the lower window regulator retaining bolt to **89 in-lb 10 (Nm)**.
6. Torque the upper window regulator retaining bolt to **89 in-lb 10 (Nm)**.

7. Torque the lower window regulator retaining bolt to **89 in-lb 10 (Nm)**.
8. Attach the regulator cable to the rear door.
9. Connect the window regulator connector.
10. Lower the window into the carrier and loosely tighten the bolts.
11. Operate the window until it is in the full up position and the window is in the carrier.
12. Torque the window carrier bolts to **89 in-lb (10 Nm)**.
13. Install the water deflector and door trim panel into the rear door.

Power Seats

WARNING

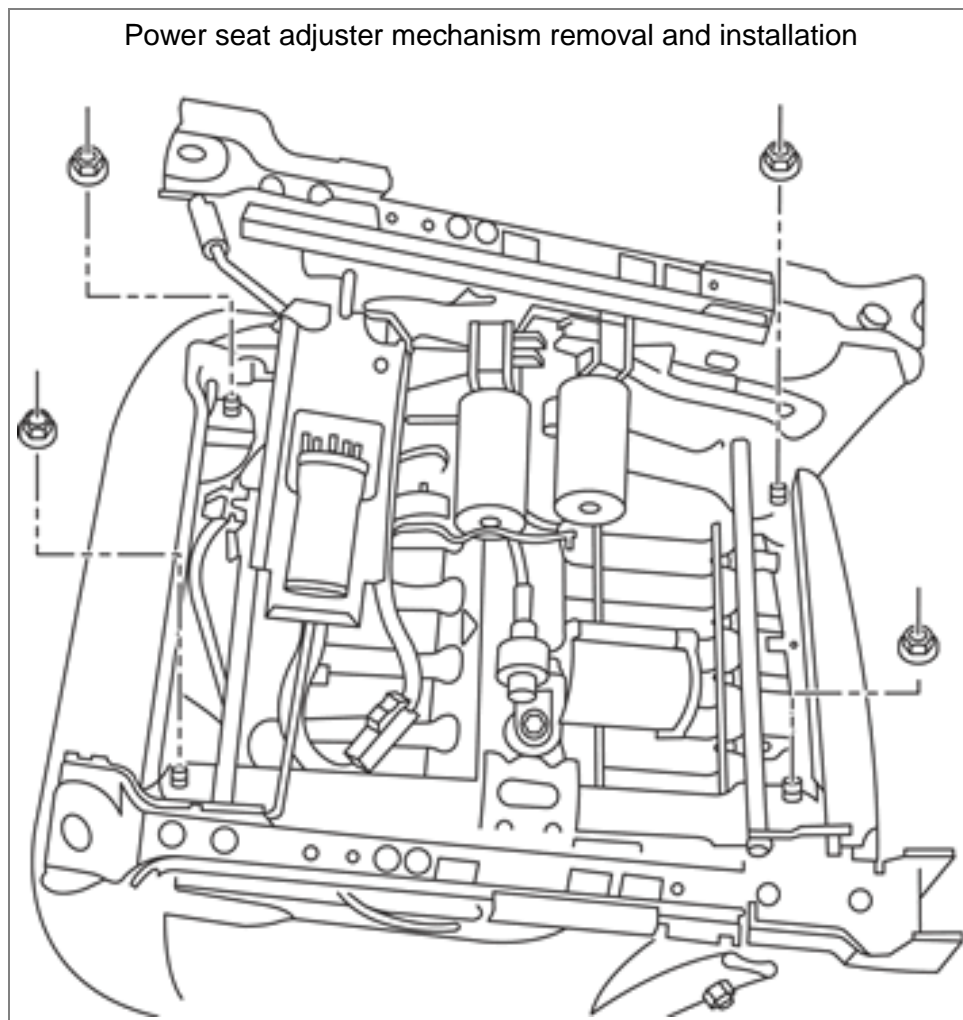
To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Power Seat Adjuster Mechanism

Removal & Installation

To Remove:

1. Remove the seat from the vehicle.
2. Remove the trim panel from the seat.
3. Detach the seat belt buckle from the seat.
4. Disconnect the driver seat harness connector from the body harness connector.
5. Disconnect the seat belt buckle and lumbar motor connectors.
6. Remove the SIR harness from the seat.



7. Detach the power seat adjuster from the seat pan.
8. Remove the seat back from the seat.
9. If replacing the adjuster mechanism, remove the seat position sensor from the mechanism.

To Install:

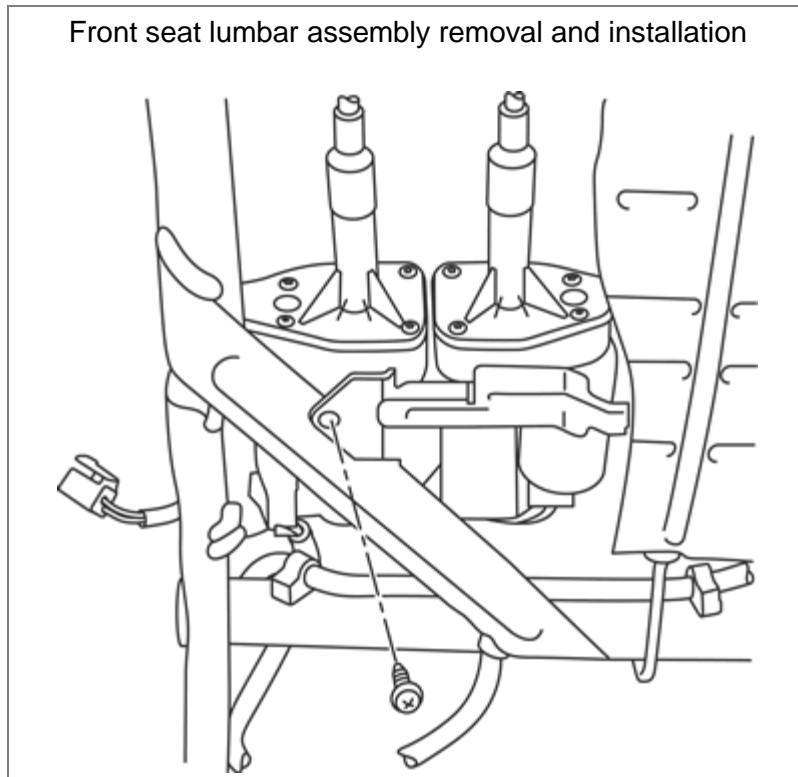
1. If replacing the adjuster mechanism, install the seat position sensor into the mechanism.
2. Install the seat back onto the seat.
3. Attach the power seat adjuster to the seat pan. Torque the nuts to **18 ft-lb (25 Nm)**.
4. Install the SIR harness into the seat.
5. Connect the seat belt buckle and lumbar motor connectors.
6. Connect the driver seat harness connector to the body harness connector.
7. Attach the seat belt buckle to the seat. Torque the nut to **41 ft-lb (55 Nm)**.
8. Install the trim panel onto the seat.
9. Install the seat into the vehicle.
10. For vehicles with memory seats, calibrate the seat.

Front Seat Lumbar Assembly

Removal & Installation

To Remove:

1. Remove the front seat from the vehicle.
2. Remove the cover and pad from the seat back.
3. Remove the panel from the seat back.
4. Disconnect the lumbar motor connector.
5. Remove the lumbar clip from the top of the seat back frame.



6. Detach the lumbar assembly from the seat back frame.

To Install:

1. Attach the lumbar assembly to the seat back frame. Torque the screw to **71 in-lb (8 Nm)**.
2. Install the lumbar clip onto the top of the seat back frame.
3. Connect the lumbar motor connector.
4. Install the panel into the seat back.
5. Install the cover and pad onto the seat back.
6. Install the front seat into the vehicle.

DRIVE TRAIN

Precautions

Before servicing any vehicle, please be sure to read all of the following precautions, which deal with personal safety, prevention of component damage and important points to take into consideration when servicing a motor vehicle:

- Always wear safety goggles or some type of eye/face protection when working with, around or under a vehicle.
- Be extremely careful while working on an operating engine, make sure you have no dangling jewelry, extremely loose clothes, power tool cords or other items that could get caught in any moving engine part.
- Never open, service or drain the radiator or cooling system when the engine is hot; serious burns can occur from the steam and hot coolant.
- Observe all applicable safety precautions when working around fuel. Whenever servicing the fuel system, always work in a well-ventilated area. Do not allow fuel spray or vapors to come in contact with a spark, open flame, or excessive heat (a hot drop light, for example). Keep a dry chemical fire extinguisher near the work area. Always keep fuel in a container specifically designed for fuel storage; also, always properly seal fuel containers to avoid the possibility of fire or explosion. Refer to the additional fuel system precautions later in this section.
- Fuel injection systems often remain pressurized, even after the engine has been turned OFF. The fuel system pressure must be relieved before disconnecting any fuel lines. Failure to do so may result in fire and/or personal injury.
- The EPA warns that prolonged contact with used engine oil may cause a number of skin disorders, including cancer! You should make every effort to minimize your exposure to used engine oil. Protective gloves should be worn when changing oil. Wash your hands and any other exposed skin areas as soon as possible after exposure to used engine oil. Soap and water, or waterless hand cleaner should be used.
- Never operate the engine without the proper amount and type of engine oil; doing so WILL result in severe engine damage.
- Brake fluid often contains polyglycol ethers and polyglycols. Avoid contact with the eyes and wash your hands thoroughly after handling brake fluid. If you do get brake fluid in your eyes, flush your eyes with clean, running water for 15 minutes. If eye irritation persists, or if you have taken brake fluid internally, IMMEDIATELY seek medical assistance.
- Timing belt maintenance is extremely important! Many models utilize an interference-type, non-freewheeling engine. If the timing belt breaks, the valves in the cylinder head may strike the pistons, causing potentially serious (also time-consuming and expensive) engine damage. Refer to the maintenance interval charts in the front of this manual for the recommended replacement interval for the timing belt and to the timing belt section for belt replacement and inspection.
- Disconnecting the negative battery cable on some vehicles may interfere with the functions of the on-board computer system(s) and may require the computer to undergo a relearning process once the negative battery cable is reconnected.

Cleanliness and Care, Shop Practice

- It should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

Automatic Transaxle

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Understanding the Automatic Transmission

The automatic transmission allows engine torque and power to be transmitted to the rear wheels within a narrow range of engine operating speeds. It will allow the engine to turn fast enough to produce plenty of power and torque at very low speeds, while keeping it at a sensible rpm at high vehicle speeds (and it does this job without driver assistance). The transmission uses a light fluid as the medium for the transmission of power. This fluid also works in the operation of various hydraulic control circuits and as a lubricant. Because the transmission fluid performs all of these functions, trouble within the unit can easily travel from one part to another. For this reason, and because of the complexity and unusual operating principles of the transmission, a very sound understanding of the basic principles of operation will simplify troubleshooting.

Torque Converter

The torque converter replaces the conventional clutch. It has three functions:

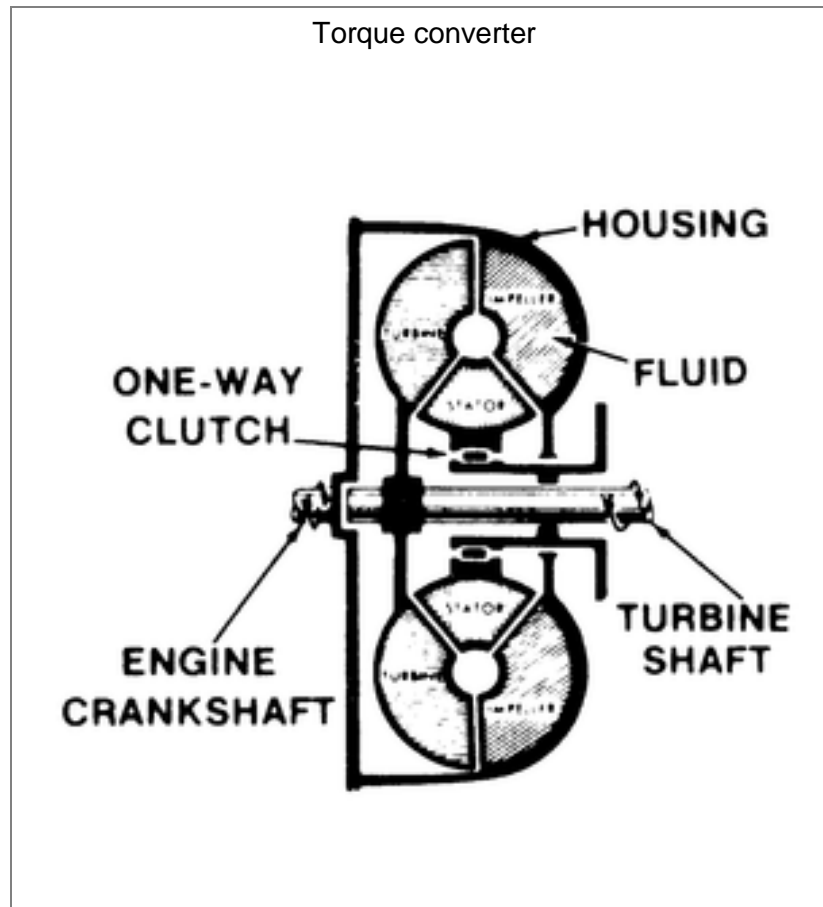
1. It allows the engine to idle with the vehicle at a standstill, even with the transmission in gear.
2. It allows the transmission to shift from range-to-range smoothly, without requiring that the driver close the throttle during the shift.
3. It multiplies engine torque to an increasing extent as vehicle speed drops and throttle opening is increased. This has the effect of making the transmission more responsive and reduces the amount of shifting required.

The torque converter is a metal case which is shaped like a sphere that has been flattened on opposite sides. It is bolted to the rear end of the engine's crankshaft. Generally, the entire metal case rotates at engine speed and serves as the engine's flywheel.

The case contains three sets of blades. One set is attached directly to the case. This set forms the impeller or pump. Another set is directly connected to the output shaft, and forms the turbine. The third set is mounted on a hub which, in turn, is mounted on a stationary shaft through a one-way clutch. This third set is known as the stator.

A pump, which is driven by the converter hub at engine speed, keeps the torque converter full of transmission fluid at all times. Fluid flows continuously through the unit to provide cooling.

Under low speed acceleration, the torque converter functions as follows:



The torque converter housing is rotated by the engine's crankshaft, and turns the impeller. The impeller then spins the turbine, which gives motion to the turbine shaft, driving the gears.

The impeller is turning faster than the turbine. It picks up fluid at the center of the converter and, through centrifugal force, slings it outward. Since the outer edge of the converter moves faster than the portions at the center, the fluid picks up speed.

The fluid then enters the outer edge of the turbine blades. It then travels back toward the center of the converter case along the turbine blades. After making contact with the turbine blades, the fluid loses the energy picked up in the impeller.

If the fluid was now returned directly into the impeller, both halves of the converter would have to turn at approximately the same speed at all times, and torque input and output would both be the same.

In flowing through the impeller and turbine, the fluid picks up two types of flow, or flow in two separate directions. It flows through the turbine blades, and it spins with the engine. The stator, whose blades are stationary when the vehicle is being accelerated at low speeds, converts one type of flow into another. Instead of allowing the fluid to flow straight back into the impeller, the stator's curved blades turn the fluid almost 90° toward the direction of rotation of the engine. Thus the fluid does not flow as fast toward the impeller, but is already spinning when the impeller picks it up. This has the effect of allowing the

impeller to turn much faster than the turbine. This difference in speed may be compared to the difference in speed between the smaller and larger gears in any gear train. The result is that engine power output is higher, and engine torque is multiplied.

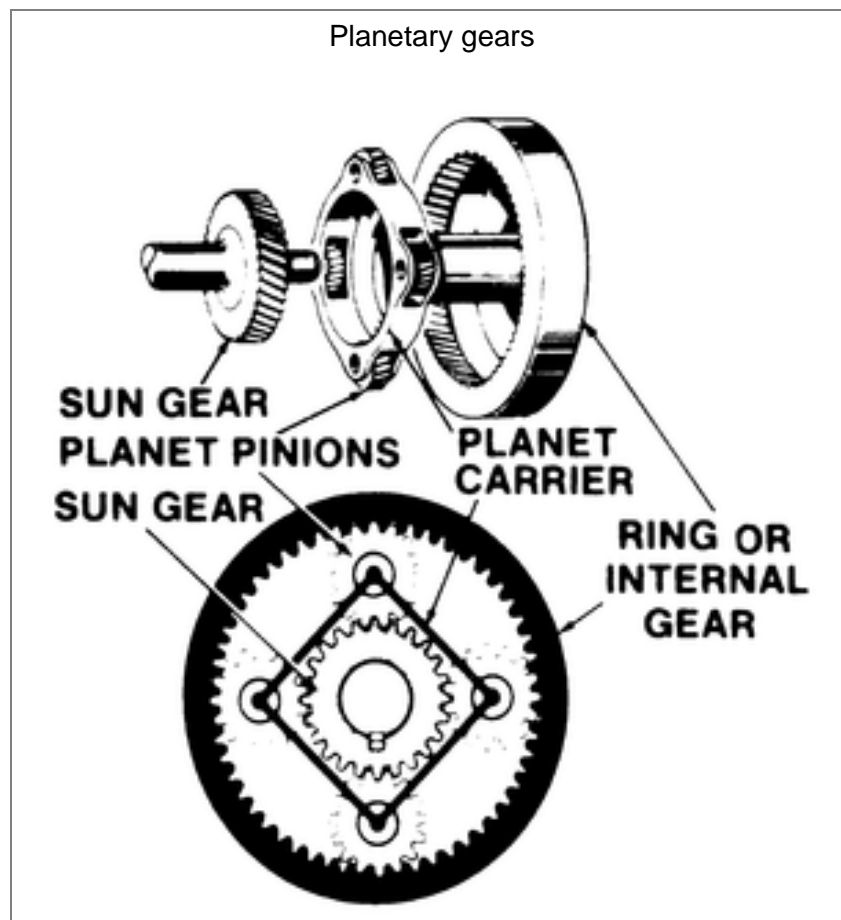
As the speed of the turbine increases, the fluid spins faster and faster in the direction of engine rotation. As a result, the ability of the stator to redirect the fluid flow is reduced. Under cruising conditions, the stator is eventually forced to rotate on its one-way clutch in the direction of engine rotation. Under these conditions, the torque converter begins to behave almost like a solid shaft, with the impeller and turbine speeds being almost equal.

Lock-up Converter

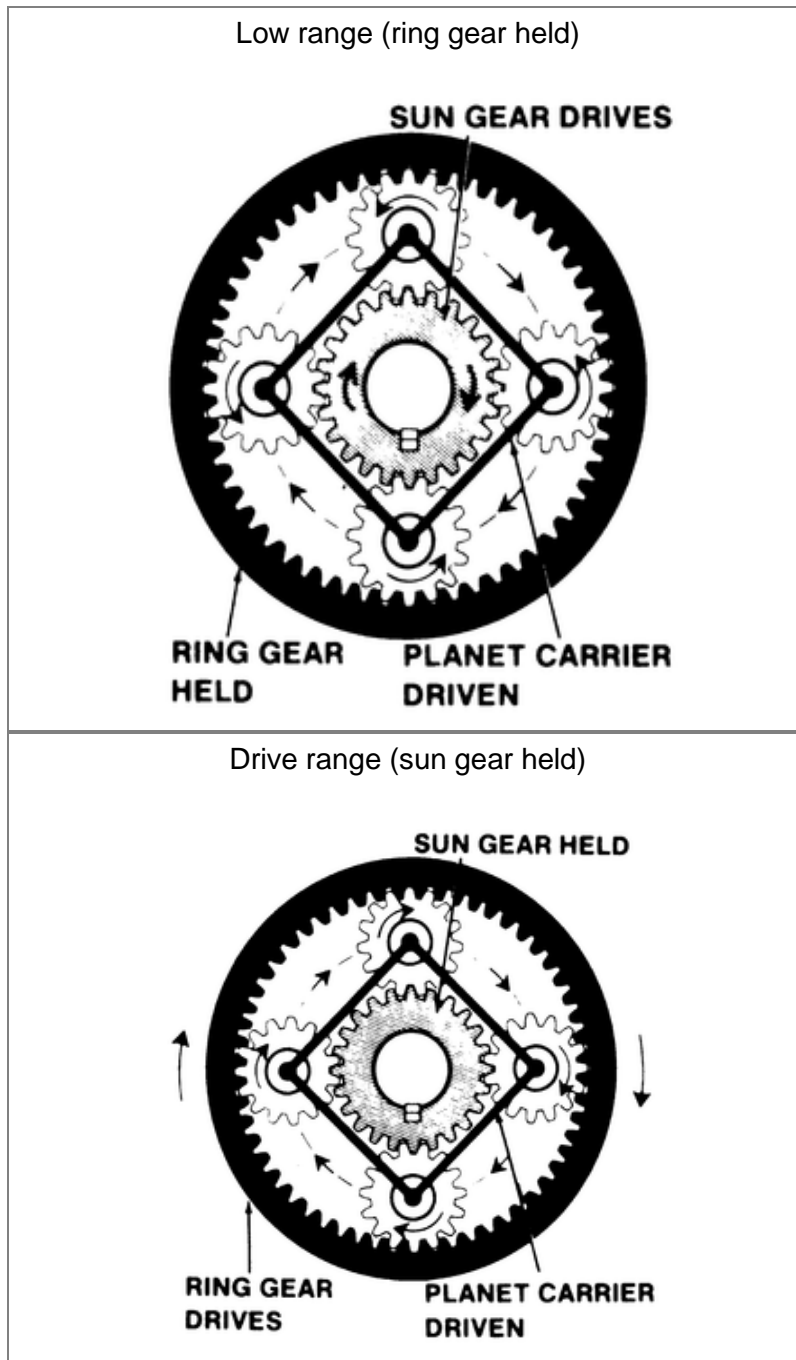
The lock-up converter contains the same components as a conventional converter but also includes a clutch assembly that, when applied connects the engine directly to the transmission. The result is no slippage, and therefore virtually no power loss. An electronic control system is used to determine when to apply the converter clutch.

Planetary Gearbox

The ability of the torque converter to multiply engine torque is limited. Also, the unit tends to be more efficient when the turbine is rotating at relatively high speeds. Therefore, a planetary gearbox is used to carry the power output of the turbine to the driveshaft.



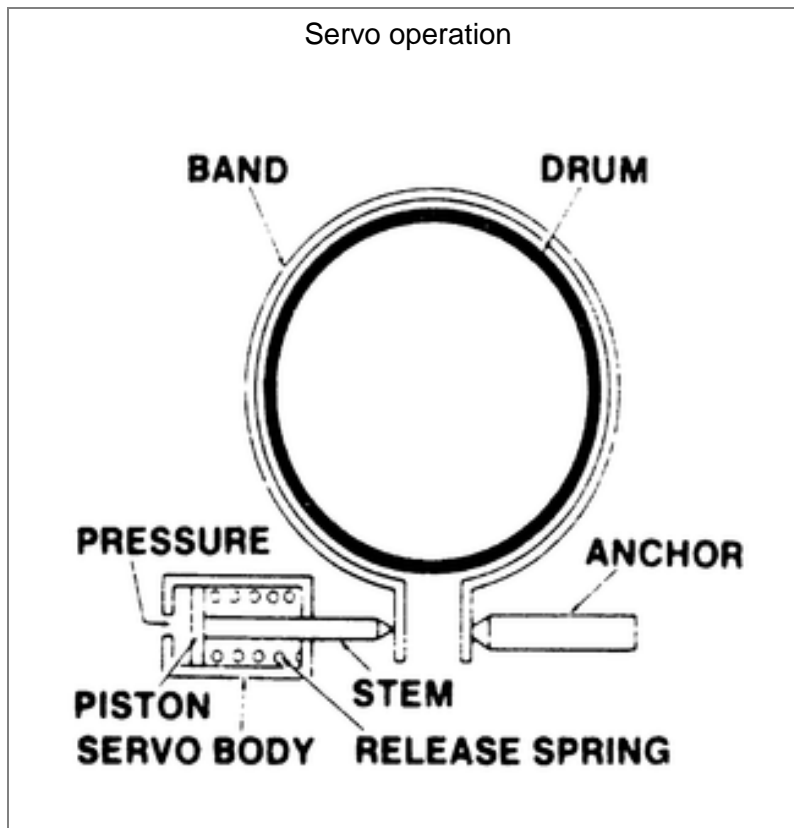
Planetary gears function very similarly to conventional transmission gears. However, their construction is different in that three elements make up one gear system, and, in that all three elements are different from one another. The three elements are: an outer gear that is shaped like a hoop, with teeth cut into the inner surface; a sun gear, mounted on a shaft and located at the very center of the outer gear; and a set of three planet gears, held by pins in a ring-like planet carrier, meshing with both the sun gear and the outer gear. Either the outer gear or the sun gear may be held stationary, providing more than one possible torque multiplication factor for each set of gears. Also, if all three gears are forced to rotate at the same speed, the gear set forms, in effect, a solid shaft.



Most automatics use the planetary gears to provide various reductions ratios. Bands and clutches are used to hold various portions of the gear sets to the transmission case or to the shaft on which they are mounted. Shifting is accomplished, then, by changing the portion of each planetary gear set which is held to the transmission case or to the shaft.

Servos/Accumulators

The servos are hydraulic pistons and cylinders. They resemble the hydraulic actuators used on many other machines, such as bulldozers. Hydraulic fluid enters the cylinder, under pressure, and forces the piston to move to engage the band or clutches.



The accumulators are used to cushion the engagement of the servos. The transmission fluid must pass through the accumulator on the way to the servo. The accumulator housing contains a thin piston, which is sprung away from the discharge passage of the accumulator. When fluid passes through the accumulator on the way to the servo, it must move the piston against spring pressure, and this action smooths out the action of the servo.

Hydraulic Control System

The hydraulic pressure used to operate the servos comes from the main transmission oil pump. This fluid is channeled to the various servos through the shift valves. There is generally a manual shift valve, which is operated by the transmission selector lever, and a shift valve for each up shift the transmission provides.

Most automatic transmissions are electronically controlled; electrical solenoids are used to control the hydraulic fluid. The shift solenoids are regulated by an electronic control module. Shift timing is regulated through sensor feedback information provided to the electronic controller.

On older transmissions there are two pressures that control the shift valves. One is the governor pressure which is affected by vehicle speed. The other is the modulator pressure which is affected by intake manifold vacuum or throttle position. Governor pressure rises with an increase in vehicle speed, and modulator pressure rises as the throttle is opened wider. By responding to these two pressures, the shift valves cause the up shift points to be delayed with increased throttle opening to make the best use of the engine's power output.

Older transmissions also make use of an auxiliary circuit for downshifting. This circuit may be actuated by the throttle linkage, vacuum that actuates the modulator, or by a cable or solenoid. It applies pressure to the downshift surface on the shift valve or valves.

The transmission modulator also governs the line pressure, used to actuate the servos. In this way, the clutches and bands will be actuated with a force matching the torque output of the engine.

Transmission

Removal & Installation

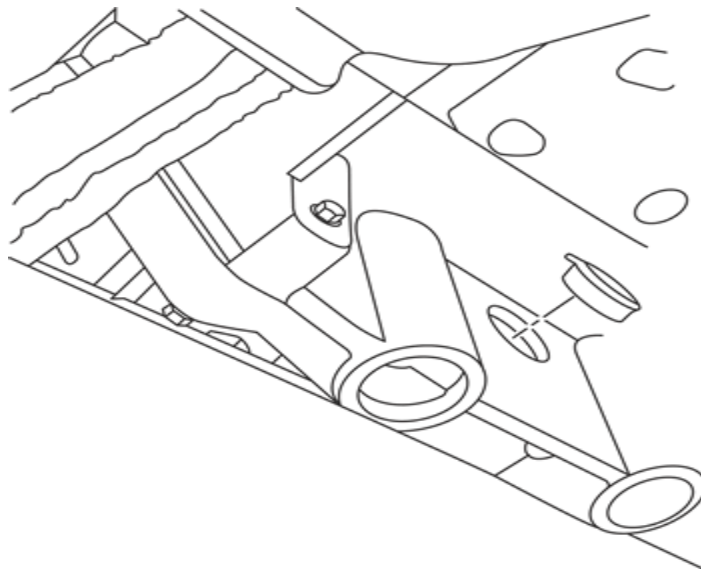
4.2L Engine

2002, 2003

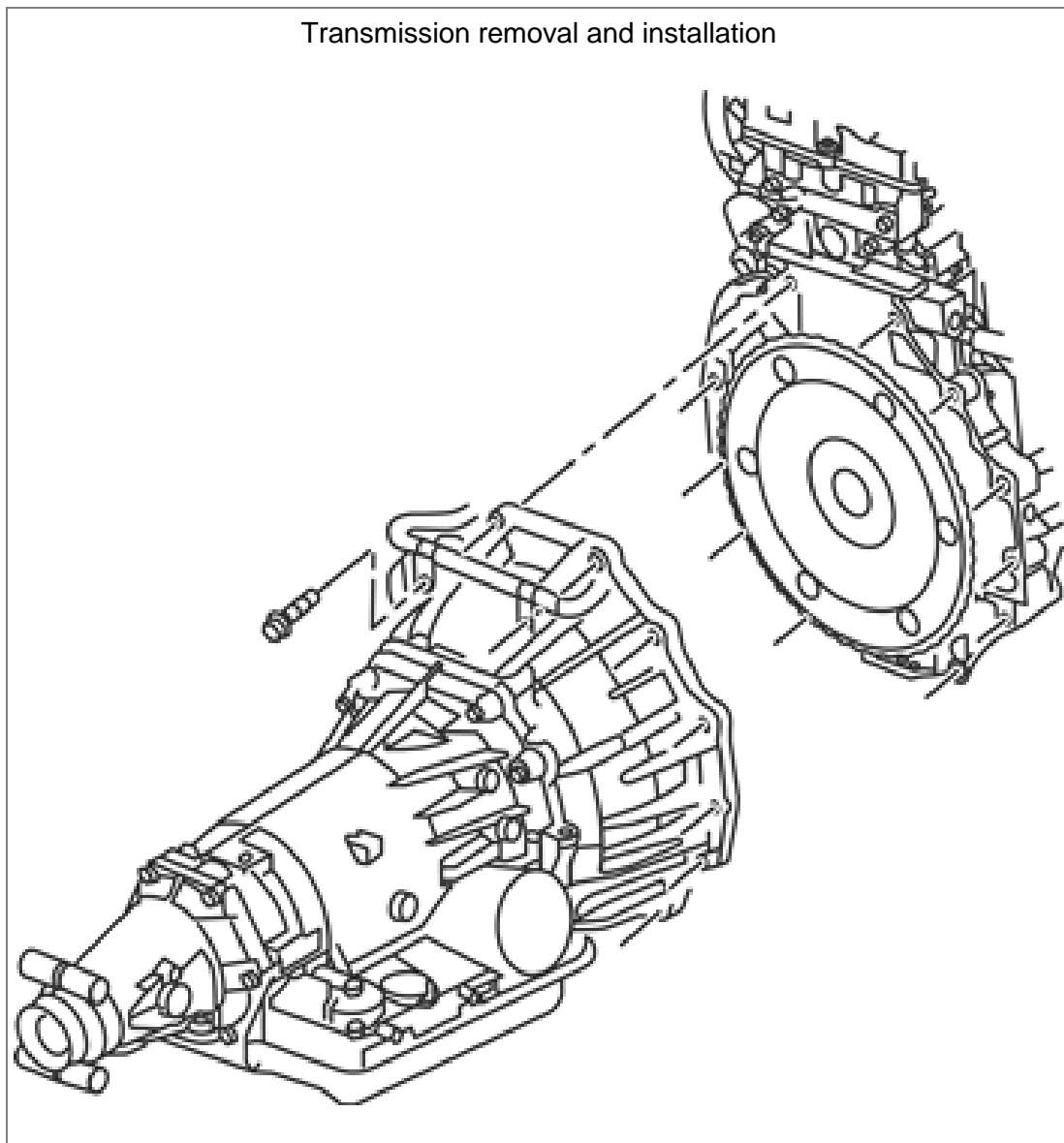
To Remove:

1. Disconnect the negative battery cable.
2. Detach the filler tube from the right side of the engine.
3. Lift the vehicle.
4. Drain the fluid from the transmission.
5. Remove the rear propeller shaft from the vehicle.
6. Use a jack to support the transmission.
7. Remove the nuts holding the transmission mount to the transmission support.
8. Detach the evaporative emission (EVAP) canister from the mounting bracket.
9. Remove the fuel tank shield from the fuel tank.
10. Remove the transmission support from the frame.
11. Detach the transmission mount from the transmission.
12. Remove the front exhaust pipe from the vehicle.
13. Lower the transmission enough to gain access to the top of the transmission.
14. If equipped, remove the transfer case from the vehicle.
15. Remove the range selector cable from the bracket.
16. Detach the transmission heat shield from the transmission.
17. Disconnect the transmission vent hose from the transmission.
18. Disconnect the transmission and park/neutral position switch connectors.
19. Detach the fuel line bracket from the left side of the transmission.

Torque converter access plug removal and installation



20. Remove the torque converter access plug from the transmission.
21. Mark the orientation of the flywheel and torque converter.
22. Remove the flywheel bolts from the torque converter.
23. Disconnect the transmission oil cooler lines from the transmission.
24. Plug the transmission oil cooler lines holes in the transmission.
25. Install a safety chain around the transmission.
26. Detach the fuel line bracket from the bell housing.
27. Remove the coolant pipe bracket bolts from the bell housing.



28. Remove the transmission nuts, studs, and bolts from the engine.
29. Retain the torque converter by installing a J 21366 converter holding strap onto the bell housing.
30. Remove the transmission from the engine by pulling the transmission rearward.
31. Lower the transmission.

To Install:

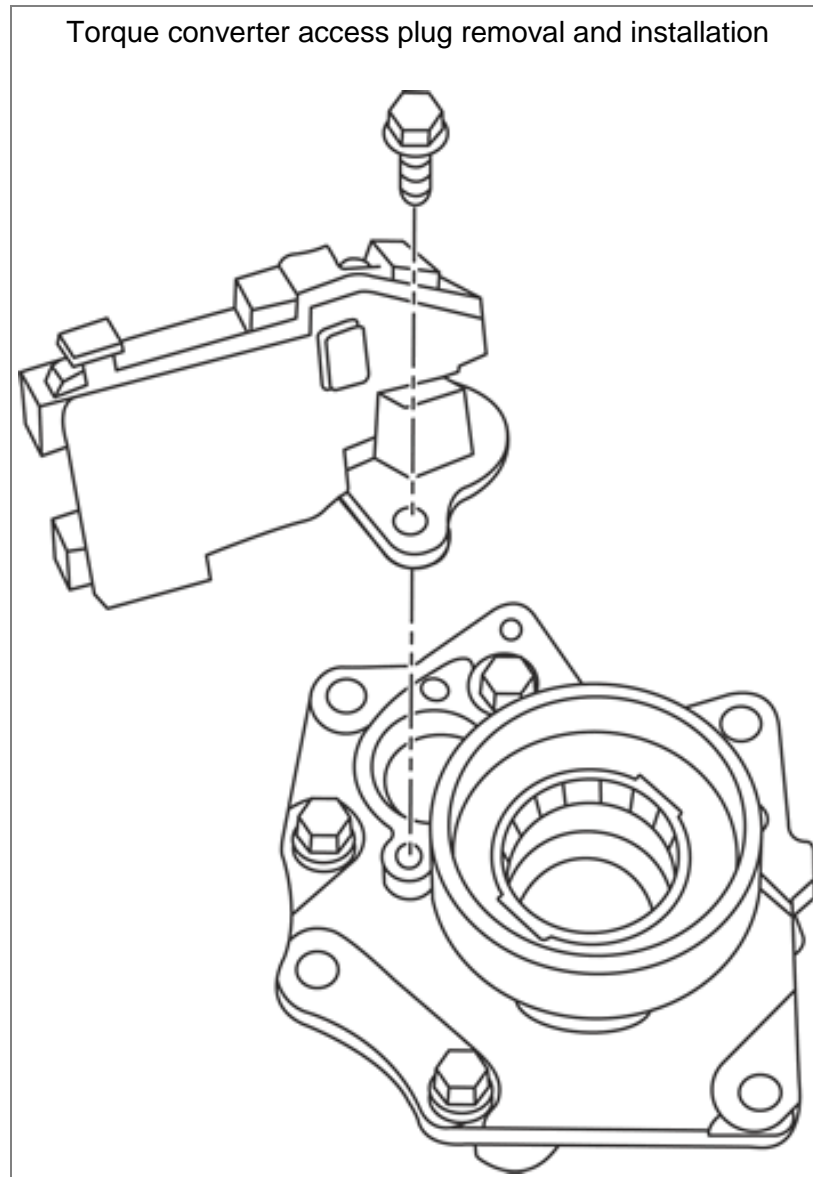
1. Lift the transmission.
2. Remove the J 21366 converter holding strap from the bell housing.
3. Install the transmission onto the engine by pushing the transmission forward. Make sure the transmission is aligned with the locator pins and the torque converter is aligned with the mark on the flywheel.
4. Install the transmission nuts, studs, and bolts into the engine. Torque the nuts, studs, and bolts to **37 ft-lb (50 Nm)**.
5. Install the flywheel bolts into the torque converter. Torque the bolts to **44 ft-lb (60 Nm)**.
6. Install the torque converter access plug into the transmission.
7. Remove the safety chain from around the transmission.
8. Connect the transmission vent hose to the transmission.
9. Connect the transmission and park/neutral position switch connectors.
10. Attach the fuel line bracket to the left side of the transmission.
11. Attach the fuel line bracket to the bell housing.
12. Attach the transmission heat shield to the transmission. Torque the bolts to **13 ft-lb (17 Nm)**.
13. Install the range selector cable onto the bracket.
14. If equipped, install the transfer case into the vehicle.
15. Install the front exhaust pipe into the vehicle.
16. Attach the transmission mount to the transmission. Torque the bolts to **18 ft-lb (25 Nm)**.
17. Install the transmission support onto the frame.
18. Install the fuel tank shield onto the fuel tank.
19. Attach the evaporative emission (EVAP) canister to the mounting bracket.
20. Lower the transmission jack and remove from under the vehicle.
21. Install the nuts holding the transmission mount to the transmission support. Torque the nuts to **35 ft-lb (46 Nm)**.
22. Install the rear propeller shaft into the vehicle.
23. Flush the transmission oil cooler and cooling lines.
24. Connect the transmission oil cooler lines to the transmission.
25. Lower the vehicle.
26. Attach the filler tube to the right side of the engine. Torque the nut to **71 ft-lb (10 Nm)**.
27. Connect the negative battery cable.
28. Refill the transmission with DEXRON® VI transmission fluid and inspect for leaks.
29. Reset the transmission adaptive pressure (TAP) values.

5.3L & 6.0L Engines

To Remove:

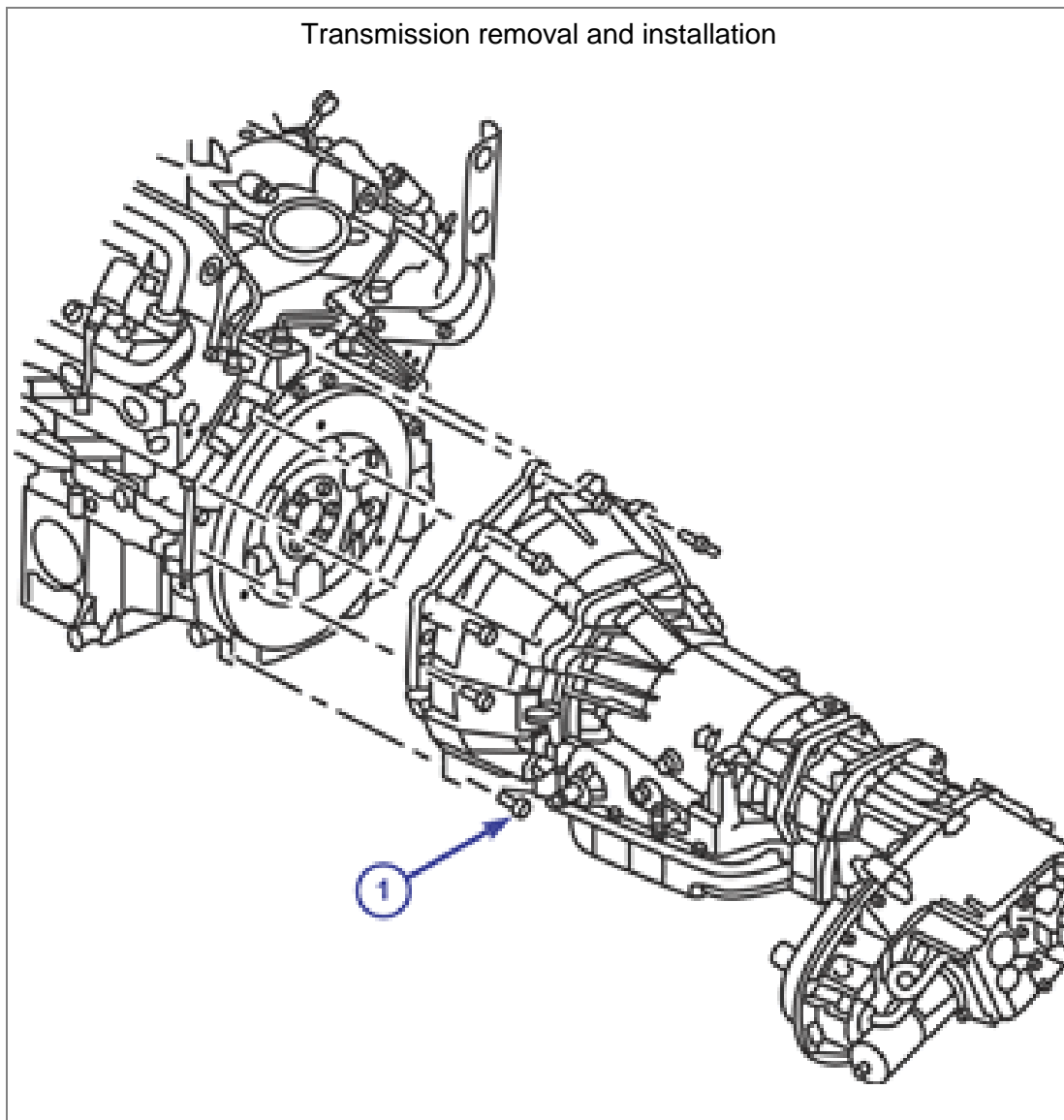
1. Disconnect the negative battery cable.
2. Lift the vehicle.
3. Drain the fluid from the transmission.
4. Remove the rear propeller shaft from the vehicle.
5. Use a jack to support the transmission.
6. Remove the nuts holding the transmission mount to the transmission support.

7. Remove the transmission support from the frame.
8. Detach the transmission mount from the transmission.
9. Remove the front exhaust pipe from the vehicle.
10. Lower the transmission enough to gain access to the top of the transmission.
11. If equipped, remove the transfer case from the vehicle.
12. Remove the range selector cable from the bracket.
13. Detach the transmission heat shield from the transmission.
14. Disconnect the transmission vent hose from the transmission.
15. Detach the transmission harness from the transmission.
16. Detach the fuel line bracket from the left side of the transmission.



17. Remove the torque converter access plug from the transmission.
18. Mark the orientation of the flywheel and torque converter.
19. Remove the flywheel bolts from the torque converter.
20. Disconnect the transmission oil cooler lines from the transmission.

21. Plug the transmission oil cooler lines holes in the transmission.
22. Install a safety chain around the transmission.
23. Detach the filler tube from the transmission.



24. Remove the transmission nuts, studs, and bolts from the engine.
25. Retain the torque converter by installing a J 21366 converter holding strap onto the bell housing.
26. Remove the transmission from the engine by pulling the transmission rearward.
27. Lower the transmission.

To Install:

1. Lift the transmission.
2. Remove the J 21366 converter holding strap from the bell housing.
3. Install the transmission onto the engine by pushing the transmission forward. Make sure the transmission is aligned with the locator pins and the torque converter is aligned with the mark on the flywheel.
4. Install the transmission nuts, studs, and bolts into the engine. Torque the nuts, studs, and bolts to **37 ft-lb (50 Nm)**.
5. Install the flywheel bolts into the torque converter. Torque the bolts to **44 ft-lb (60 Nm)**.
6. Install the torque converter access plug into the transmission.
7. Remove the safety chain from around the transmission.
8. Attach the filler tube to the transmission. Torque the nut to **7 ft-lb (10 Nm)**.
9. Connect the transmission vent hose to the transmission.
10. Attach the fuel line bracket to the left side of the transmission.
11. Attach the transmission harness to the transmission.
12. Attach the transmission heat shield to the transmission. Torque the bolts to **13 ft-lb (17 Nm)**.
13. Install the range selector cable onto the bracket.
14. If equipped, install the transfer case to the vehicle.
15. Install the front exhaust pipe into the vehicle.
16. Attach the transmission mount to the transmission. Torque the bolts to **18 ft-lb (25 Nm)**.
17. Install the transmission support onto the frame.
18. Lower the transmission jack and remove from under the vehicle.
19. Install the nuts holding the transmission mount to the transmission support. Torque the nuts to **35 ft-lb (46 Nm)**.
20. Install the rear propeller shaft into the vehicle.
21. Flush the transmission oil cooler and cooling lines.
22. Connect the transmission oil cooler lines to the transmission.
23. Lower the vehicle.
24. Connect the negative battery cable.
25. Refill the transmission with DEXRON® VI transmission fluid and inspect for leaks.
26. Reset the transmission adaptive pressure (TAP) values.

Transmission Fluid

Fluid Level Checking

Pre-Check Procedure

1. Park the vehicle on a level surface and start the engine.
2. Apply the parking brake and make sure the shift lever in PARK (P).
3. Depress the brake pedal and move the shift lever through each gear range, pausing for about 3 seconds in each range. Then, return the shift lever back to PARK (P).
4. Allow the engine to idle 500-800 RPM for at least 1 minute. Slowly release the brake pedal.
5. Keep the engine running and observe the transmission fluid temperature (TFT) using the Driver Information Center (DIC) or a scan tool.
6. Using the TFT reading, determine and perform the appropriate check procedure. If the TFT reading is not within the required temperature ranges, allow the vehicle to cool, or operate the vehicle until the appropriate TFT is reached.

Cold Check Procedure

CAUTION

Use the cold check procedure only as a reference to determine if the transmission has enough fluid to be operated safely until the hot check procedure can be made.

NOTE: Use this cold check procedure to check fluid level when the fluid temperature is between 80-90°F (27-32°C).

Start the engine and remove the dipstick from the tube, then wipe the dipstick end with a clean rag or paper towel. Install the dipstick completely in the dipstick tube, wait three seconds and then pull it back out again.

CAUTION

Always check the fluid level at least twice. Consistent readings are important to maintaining proper fluid level. If inconsistent readings are noted, inspect the transmission vent assembly to ensure it is clean and unclogged.

Keep the dipstick pointing down and check both sides of the dipstick, and read the lower level. Repeat the check procedure to verify the reading. If the fluid level is below the COLD check line, add only enough fluid as necessary to bring the level into the COLD line. It does not take much fluid, generally less than one pint. Do not overfill. If the fluid level is in the acceptable range, install the dipstick in the tube and flip the handle down to lock it in place. Perform the hot check when the transmission reaches a normal operating temperature between 180-200°F (82-93°C).

Hot Check Procedure

CAUTION

Use this procedure to check the transmission fluid level when the fluid temperature is between 180-200°F (82-93°C). The fluid level rises as fluid temperature increases, so it is important to ensure the transmission temperature is within range.

1. Start the engine and remove the dipstick from the tube, then wipe the dipstick end with a clean rag or paper towel.
2. Install the dipstick completely in the tube, wait three seconds and then pull it back out.

CAUTION

Always check the fluid level at least twice. Consistent readings are important to maintaining proper fluid level. If inconsistent readings are noted, inspect the transmission vent assembly to ensure it is clean and unclogged.

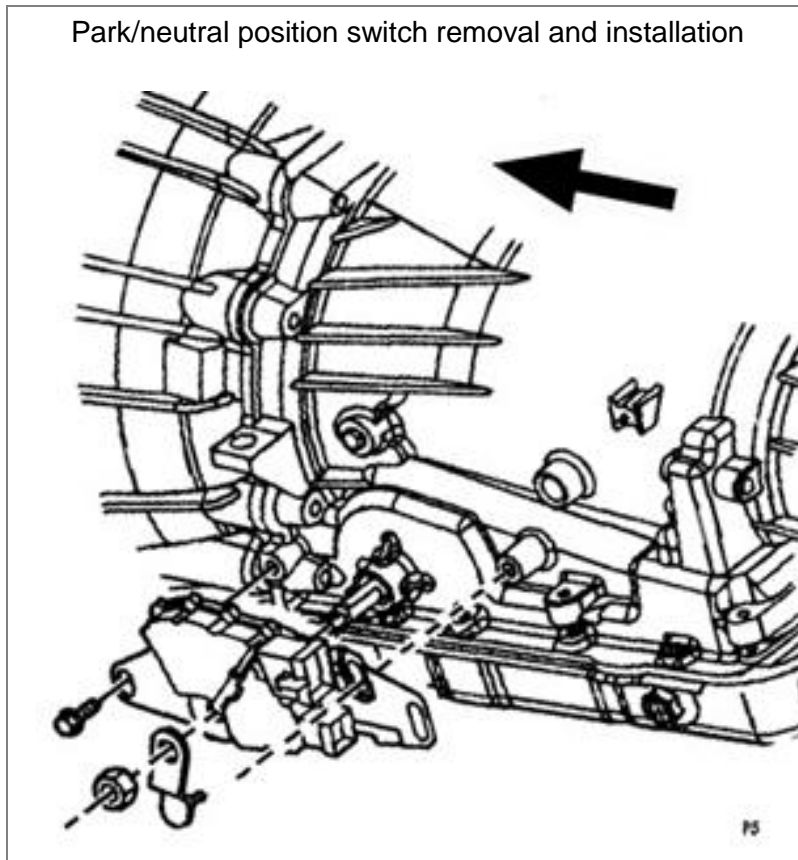
3. Keep the dipstick tip pointing down and check both sides of the dipstick. Read the lower level. Repeat the check procedure to verify the reading.
4. A safe operating fluid level is within the HOT crosshatch band on the dipstick. If the fluid level is not within the HOT band, and the transmission temperature is between 180-200°F (82-93°C), add or drain fluid as necessary to bring the level into the HOT band. If the fluid level is low, add only enough fluid to bring the level into the HOT band.
5. If the fluid level is low, add only enough fluid to bring the level into the HOT band. It does not take much fluid, generally less than one pint. Do not overfill. Also, if the fluid level is low, inspect the transmission for leaks.
6. If the fluid level is in the acceptable range, push the dipstick back into the dipstick tube all the way, and then flip the handle down to lock the dipstick in place.
7. If equipped, reset the transmission oil life monitor if the fluid was changed.

Park/Neutral Position Switch

Removal & Installation

To Remove:

1. Apply the parking brake.
2. Shift the transmission to the neutral position.
3. Lift the vehicle.
4. Detach the transmission control lever from the manual shaft.
5. Disconnect the park/neutral position switch connector.

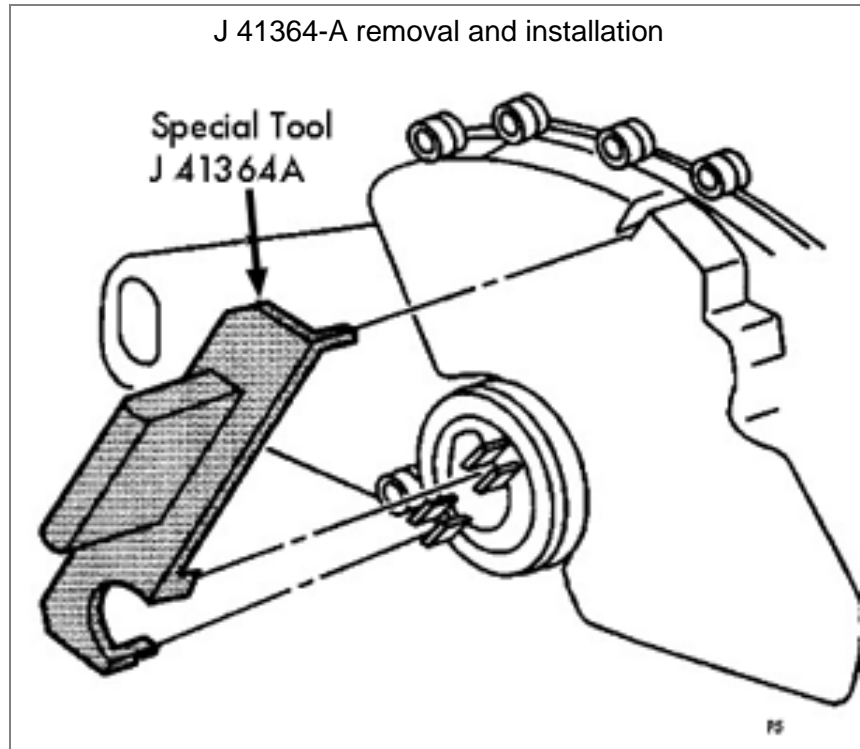


6. Detach the park/neutral position switch from the transmission.
7. Remove the park/neutral position switch from the manual shaft. If the switch does not slide off the shaft, file the edge of the shaft to remove and burrs.

To Install:

1. Install the park/neutral position switch onto the manual shaft, aligning the switch hub flats with the shaft flats.
2. Attach the park/neutral switch to the transmission. Tighten the bolts with your fingers.

J 41364-A removal and installation



3. **NOTE:** It will not be necessary to use a J 41364-A park/neutral switch aligner if installing a new switch. A new switch will come with a positive assurance bracket.
4. Install a J 41364-A park/neutral switch aligner onto the switch.
5. Turn the J 41364-A park/neutral switch aligner until the upper pin is aligned with the slot on the switch.
6. Torque the park/neutral switch bolts to **18 ft-lb (25 Nm)**.
7. Remove the J 41364-A park/neutral switch aligner or positive assurance bracket from the switch.
8. Connect the park/neutral position switch connector.
9. Attach the transmission control lever to the manual shaft. Torque the nut to **18 ft-lb (25 Nm)**.
10. Lower the vehicle.
11. Make sure the switch is operating properly. If the switch is not operating properly, replace the switch.

Adjustment

NOTE: Only perform this procedure if the park/neutral position switch is not being removed or replaced. If the park/neutral position switch is being removed or replaced, use the removal and installation procedure.

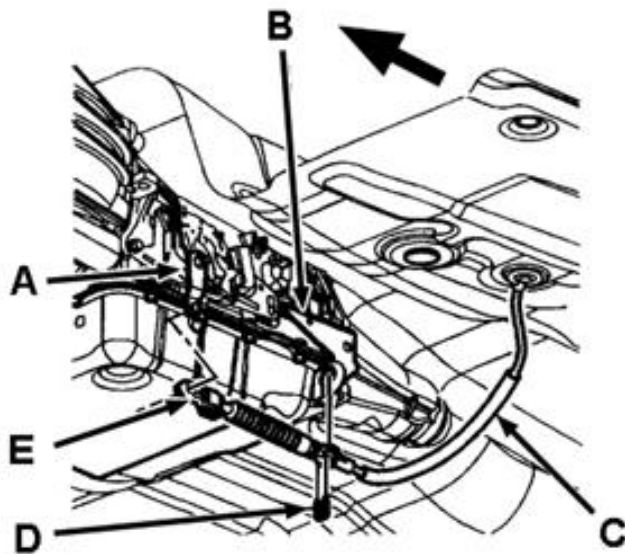
1. Apply the parking brake.
2. Make sure the engine will only start with the transmission in the park or neutral positions.
3. Shift the transmission to the neutral position.
4. Lift the vehicle.
5. Loosen the park/neutral position switch mounting bolts.
6. Put the vehicle in the neutral position and attempt to start the vehicle while turning the park/neutral position switch.
7. When the engine starts, turn off the engine.
8. Torque the park/neutral position switch mounting bolts to **18 ft-lb (25 Nm)**.
9. Lower the vehicle.
10. Make sure the switch is operating properly. If the switch is not operating properly, replace the switch.

Range Selector Lever Cable

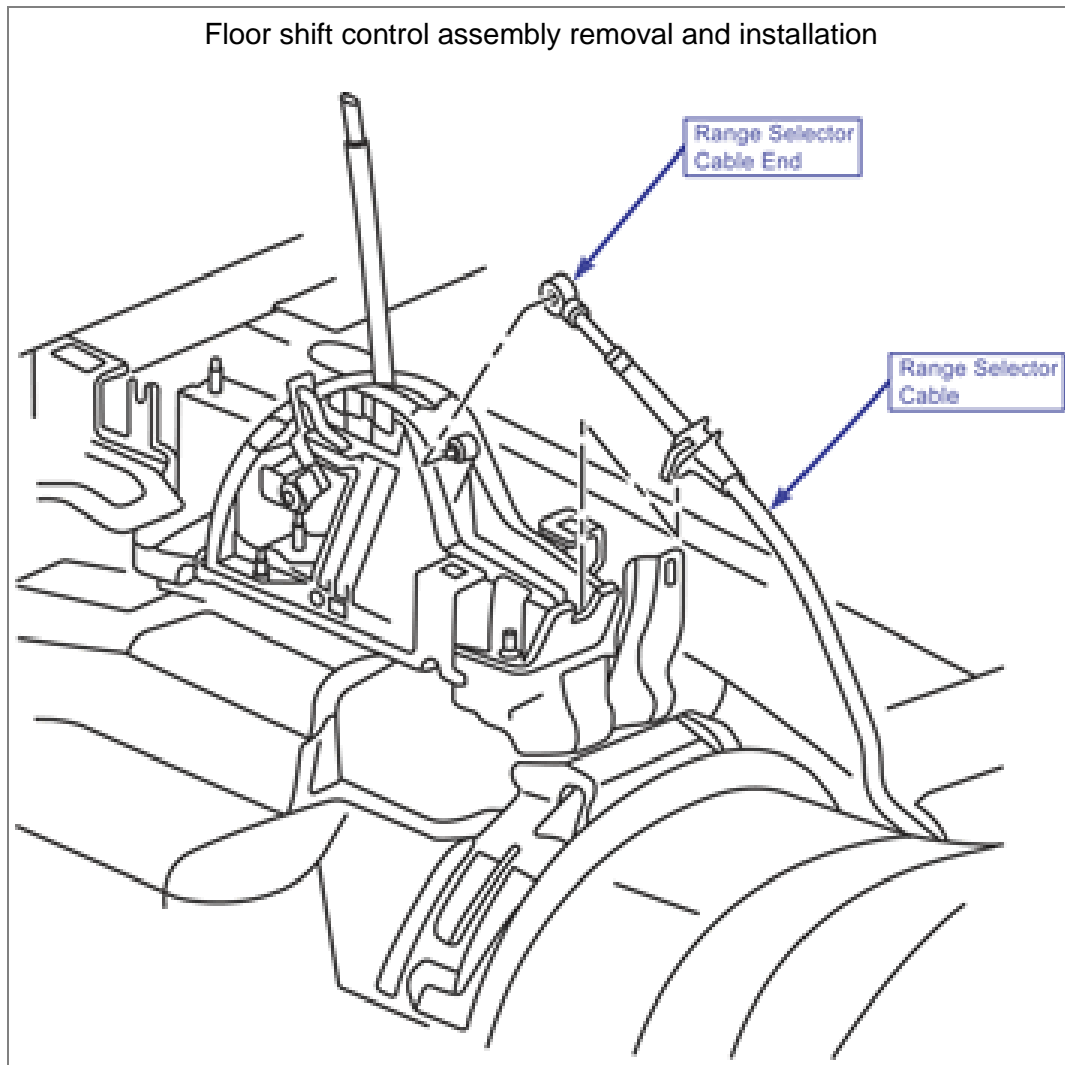
To Remove:

1. Shift the transmission to the park position.
2. Lift the vehicle.

Range selector lever (A), Range selector lever cable bracket (B), Range selector lever cable (C), Range selector lever cable retainer (D), Range selector lever cable end (E)



3. Remove the range selector lever cable from the transmission range selector lever ball stud.
4. Remove the range selector lever cable retainer from the range selector bracket.
5. Remove the range selector lever cable from the range selector bracket.
6. For 2WD vehicles, detach the range selector lever cable from the floor panel.
7. For 4WD vehicles, detach the range selector lever cable from the transfer case.
8. Remove the range selector lever cable grommet from the floor panel by pushing up on the grommet from under the vehicle.
9. Lower the vehicle.
10. Remove the center console from the vehicle.
11. Remove the carpet and floor mat from the driver's side floor panel.



12. Remove the range selector lever cable from the floor shift control ball stud.
13. Detach the range selector lever cable from the floor shift control assembly.
14. Pull the range selector lever cable through the hole in the floor panel.

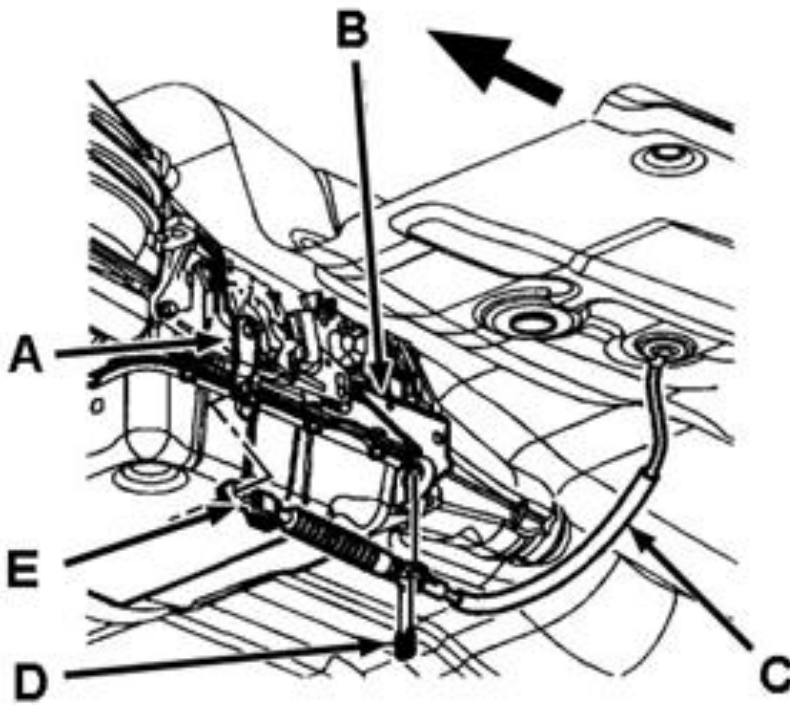
To Install:

1. Insert the range selector lever cable through the hole in the floor panel.
2. Install the range selector lever cable grommet into the floor panel by pushing down on the grommet from inside the vehicle.
3. Attach the range selector lever cable to the floor shift control assembly.
4. Install the range selector lever cable onto the floor shift control ball stud.
5. Install the carpet and floor mat onto the driver's side floor panel.
6. Install the center console into the vehicle.
7. Lift the vehicle.
8. For 4WD vehicles, attach the range selector lever cable to the transfer case.
9. For 2WD vehicles, attach the range selector lever cable to the floor panel.
10. Install the range selector lever cable into the range selector bracket.
11. Install the range selector lever cable retainer onto the range selector bracket.
12. Install the range selector lever cable onto the transmission range selector lever ball stud.
13. Adjust the range selector lever cable.
14. Lower the vehicle.
15. Make sure the shift lever is operating properly.

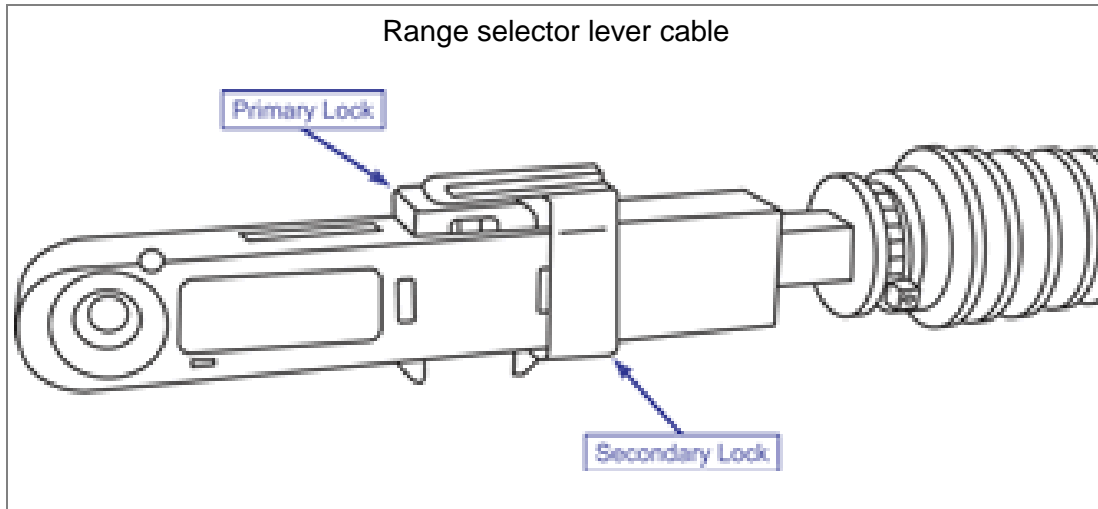
Adjustment

1. Make sure the range selector lever cable is not restricted.
2. Shift the transmission to the park position.
3. Lift the vehicle.

Range selector lever (A), Range selector lever cable bracket (B), Range selector lever cable (C), Range selector lever cable retainer (D), Range selector lever cable end (E)



4. Remove the range selector cable from the transmission range selector lever ball stud.
5. Make sure the range selector lever is in the park position.



6. Release the range selector lever cable end secondary locking tab.
7. Slide the range selector lever cable end secondary lock off of the primary lock.
8. Disengage the range selector lever cable end primary lock by squeezing the locking tabs together.
9. Pull up on the range selector lever cable end primary lock.
10. Align the range selector lever cable to the transmission range selector lever ball stud.
11. Install the range selector lever cable to the transmission range selector lever ball stud.
12. Push down on the primary lock.
13. Slide the range selector lever cable end secondary lock over the range selector lever cable primary lock.
14. Make sure the range selector lever cable secondary lock tab is secure.
15. Lower the vehicle.
16. Make sure the shift lever is operating properly.

Transmission Fluid Pan & Filter

Removal & Installation

To Remove:

1. Lift the vehicle.
2. Remove the catalytic converter from the vehicle.
3. Place a drain pan under the transmission fluid pan.
4. If equipped, remove the transmission fluid pan drain plug from the transmission fluid pan.
5. Remove the bolts from the front and sides of the transmission fluid pan.
6. Loosen the rear transmission fluid pan bolts.
7. Use a rubber mallet to lightly tap the transmission fluid pan until loose.
8. Drain the transmission fluid from the transmission fluid pan into the drain pan.
9. Remove the remaining fluid from the transmission fluid pan.
10. Remove the transmission fluid pan from the transmission.
11. Remove and discard the gasket from the transmission fluid pan.
12. Remove the transmission fluid filter by pulling down on the filter while twisting.
13. Remove and discard the filter seal from the transmission.
14. Inspect the transmission fluid color and the filter.
15. Clean the sealing surfaces as necessary.

To Install:

1. Apply transmission fluid to the new filter seal.
2. Install the filter seal into the transmission using a mallet and a suitable size socket.
3. Install the filter onto the transmission.
4. Install a new gasket onto the transmission fluid pan.
5. Install the transmission fluid pan onto the transmission. Torque the bolts alternately to **97 in-lb (11 Nm)**.
6. Apply GM P/N 12346004 sealant to the transmission fluid pan drain plug threads.
7. Install the transmission fluid pan drain plug into the transmission fluid pan. Torque the plug to **13 ft-lb (18 Nm)**.
8. Install the catalytic converter into the vehicle.
9. Lower the vehicle.
10. Refill the transmission with DEXRON® VI transmission fluid.
11. Check the cold fluid level reading.
12. Inspect the transmission for leaks.

Driveline & U-Joints

WARNING

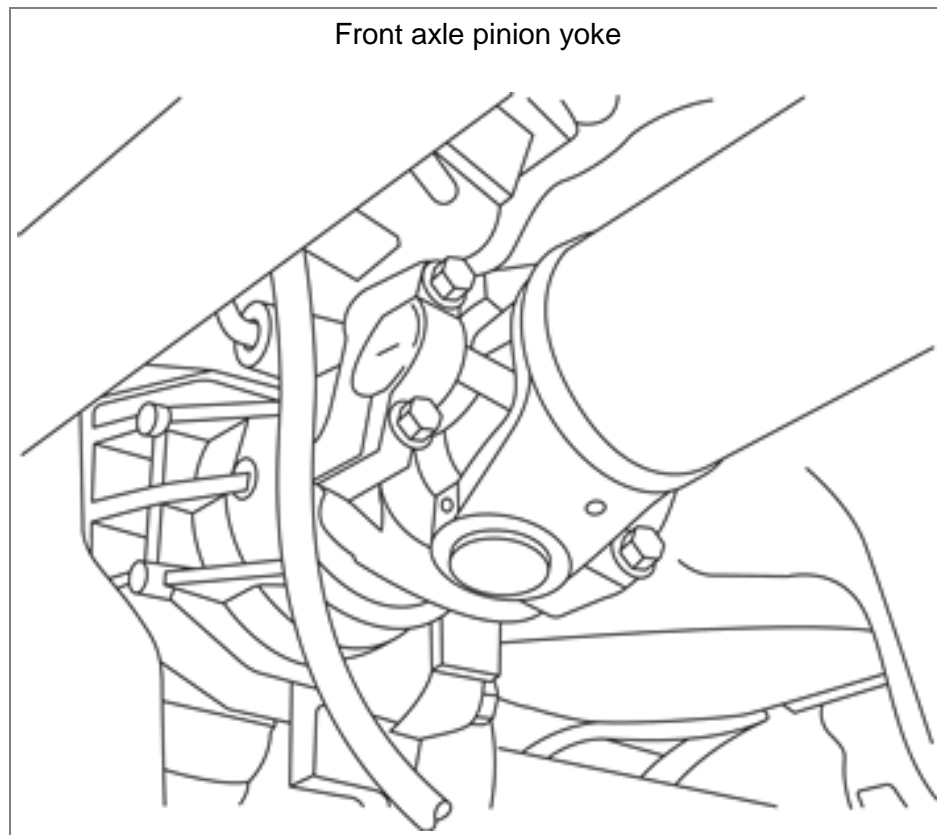
To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Front Propeller Shaft

Removal & Installation

To Remove:

1. Lift the vehicle.
2. Remove the steering gear crossmember from the frame.

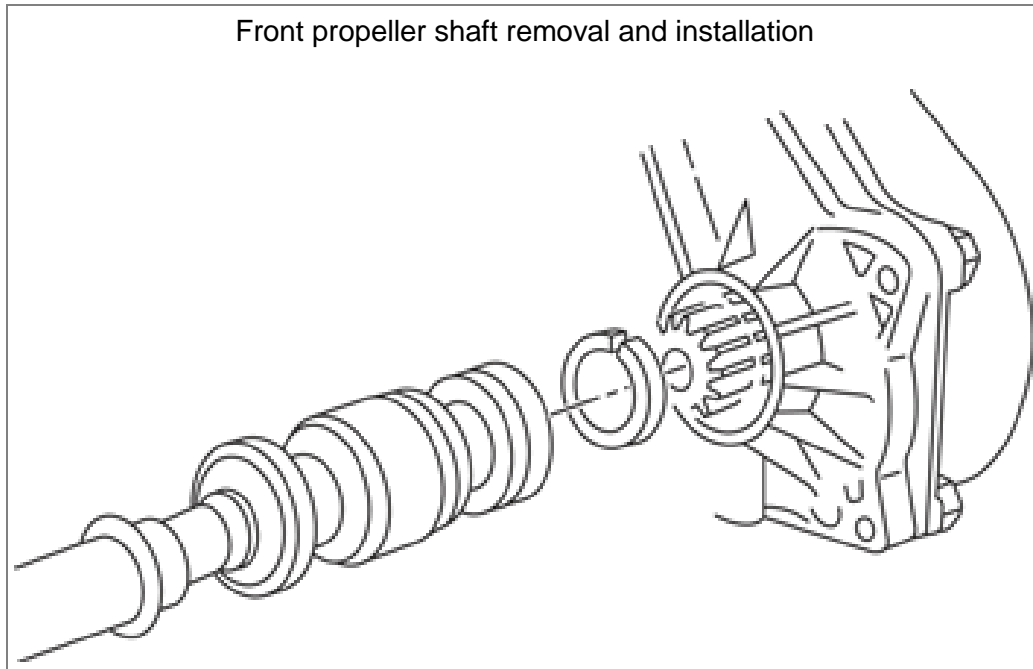


3. Mark the orientation of the front propeller shaft to the front axle pinion yoke.
4. Detach the retainers from the front axle pinion yoke.

CAUTION

Do not attempt to remove the shaft by pounding on the yoke ears or using a tool between the yoke and the universal joint. If the propeller shaft is removed by using such means, the injection joints may fracture and lead to premature failure of the joint.

5. Disconnect the front propeller shaft from the front axle pinion yoke.
6. To prevent the loss of bearing rollers, wrap the bearing caps with tape.



7. Remove the front propeller shaft from the transfer case output shaft.

To Install:

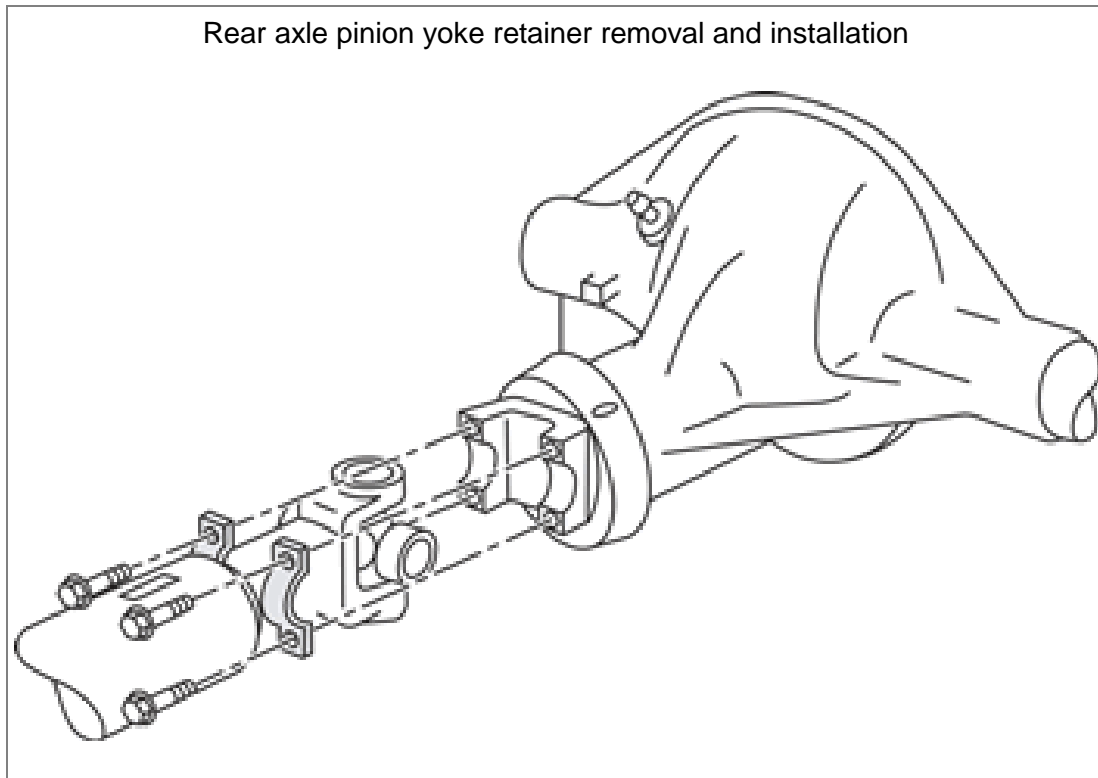
1. Apply GM P/N 12377985 grease to the transfer case output shaft.
2. Install the front propeller shaft onto the transfer case output shaft.
3. Align the front propeller shaft to the marks on the front axle pinion yoke.
4. Connect the front propeller shaft from the front axle pinion yoke.
5. Attach the retainers to the front axle pinion yoke. Torque the bolts to **15 ft-lb (20 Nm)**.
6. Install the steering gear crossmember onto the frame.
7. Lower the vehicle.

Rear Propeller Shaft

Removal & Installation

To Remove:

1. Lift the vehicle.
2. Mark the orientation of the rear propeller shaft to the rear axle pinion yoke.
3. Mark the orientation of the rear propeller shaft to the transmission or transfer case.



4. Detach the retainers from the rear axle pinion yoke.

CAUTION

Do not attempt to remove the shaft by pounding on the yoke ears or using a tool between the yoke and the universal joint. If the propeller shaft is removed by using such means, the injection joints may fracture and lead to premature failure of the joint.

5. Remove the rear propeller shaft from the rear axle pinion yoke.
6. Remove the rear propeller shaft from the transmission or transaxle.

To Install:

1. Apply GM P/N 12377985 grease to the slip yoke.
2. Align the rear propeller shaft to the marks on the transmission or transaxle.
3. Install the rear propeller shaft into the transmission or transaxle.
4. Align the rear propeller shaft to the marks on the rear axle pinion yoke.
5. Install the front propeller shaft onto the rear axle pinion yoke.
6. Attach the retainers to the rear axle pinion yoke. Torque the bolts to **15 ft-lb (20 Nm)**.
7. Lower the vehicle.

Universal Joint

Removal & Installation

External Snap Ring

To Remove:

1. Lay the propeller shaft on table level with the press table.
2. Mark the transmission and rear axle ends of the propeller shaft.
3. Remove the snap rings by using a pair of pliers to squeeze the ends together.
4. If necessary, relieve the ring pressure by lightly tapping the end of the cup.
5. Set the lower ear of the yoke on a 1-1/8 in (30 mm) hex head socket or a 1-1/16 in (27 mm) socket.
6. Use a J9522-3 universal joint bearing separator on the open horizontal bearing cups to press the lower bearing cup out of the yoke ear.
7. If necessary, place a J 9522-5 universal joint bearing spacer remover between the seal and the lower bearing cup and continue to press.
8. Rotate the propeller shaft and press the opposite bearing cup out of the yoke.
9. If replacing the front universal joint, remove the slip yoke bearing cups in the same way.
10. Check the retaining ring grooves for dirt, corrosion, or pieces of the old ring.
11. Check the bearing cup bores for burrs or imperfections.
12. Clean the retaining ring grooves.

To Install:

1. Remove the bearing cups from the universal joint.
2. Install the bottom bearing cup partially into the yoke.
3. Install the cross into the yoke with the trunnion seated freely in the bearing cup.
4. Press the bearing cup into the yoke until the cup is even with the yoke ear.
5. Install the top bearing cup partially into the yoke ear.
6. Make sure that the trunnions start straight into both bearing cups.
7. Press the bearing cup into the yoke until the cup is even with the yoke ear. Make sure the cross moves freely in the bearing cups.
8. Press the bearing cup further into the yoke. Make sure the retainer groove is visible.
9. Install the bearing retainer into the retainer groove.
10. Press the other bearing cup into the yoke until the retainer groove is visible.
11. Install the other bearing retainer into the retainer groove.
12. If necessary, spring the yoke with a firm blow with a dead blow hammer to help seat the retainer.
13. Lubricate the snap rings with chassis grease and insert the rings into the bearing cup groove.

Nylon Injected Ring

To Remove:

1. Lay the propeller shaft on table level with the press table.
2. Mark the transmission and rear axle ends of the propeller shaft.
3. Set the lower ear of the yoke on a 1-1/8 in (30 mm) socket.
4. Use a J9522-3 universal joint bearing separator on the open horizontal bearing cups to press the lower bearing cup out of the yoke ear.
5. If necessary, place a J 9522-5 universal joint bearing spacer remover between the seal and the lower bearing cup and continue to press.
6. Rotate the propeller shaft and press the opposite bearing cup out of the yoke.
7. Mark the position of the slip yoke to the tube.
8. Remove the cross from the yoke.
9. Remove the rest of the universal joint parts from the yoke.
10. If replacing the front universal joint, remove the slip yoke bearing cups in the same way.
11. Check the retaining ring grooves for plastic.
12. Check the bearing cup bores for burrs or imperfections.
13. Clean the remaining sheared plastic from the grooves of the yoke.

To Install:

1. Remove the bearing cups from the universal joint.
2. Install the bottom bearing cup partially into the yoke.
3. Install the cross into the yoke with the trunnion seated freely in the bearing cup.
4. Press the bearing cup into the yoke until the cup is even with the yoke ear.
5. Install the top bearing cup partially into the yoke ear.
6. Make sure that the trunnions start straight into both bearing cups.
7. Press the bearing cup into the yoke until the cup is even with the yoke ear. Make sure the cross moves freely in the bearing cups.
8. Press the bearing cup further into the yoke. Make sure the retainer groove is visible.
9. Install the bearing retainer into the retainer groove.
10. Press the other bearing cup into the yoke until the retainer groove is visible.
11. Install the other bearing retainer into the retainer groove.
12. If necessary, spring the yoke with a firm blow with a dead blow hammer to help seat the retainer.
13. Lubricate the snap rings with chassis grease and insert the rings into the bearing cup groove.

Universal Joint

Removal & Installation

External Snap Ring

To Remove:

1. Lay the propeller shaft on table level with the press table.
2. Mark the transmission and rear axle ends of the propeller shaft.
3. Remove the snap rings by using a pair of pliers to squeeze the ends together.
4. If necessary, relieve the ring pressure by lightly tapping the end of the cup.
5. Set the lower ear of the yoke on a 1-1/8 in (30 mm) hex head socket or a 1-1/16 in (27 mm) socket.
6. Use a J9522-3 universal joint bearing separator on the open horizontal bearing cups to press the lower bearing cup out of the yoke ear.
7. If necessary, place a J 9522-5 universal joint bearing spacer remover between the seal and the lower bearing cup and continue to press.
8. Rotate the propeller shaft and press the opposite bearing cup out of the yoke.
9. If replacing the front universal joint, remove the slip yoke bearing cups in the same way.
10. Check the retaining ring grooves for dirt, corrosion, or pieces of the old ring.
11. Check the bearing cup bores for burrs or imperfections.
12. Clean the retaining ring grooves.

To Install:

1. Remove the bearing cups from the universal joint.
2. Install the bottom bearing cup partially into the yoke.
3. Install the cross into the yoke with the trunnion seated freely in the bearing cup.
4. Press the bearing cup into the yoke until the cup is even with the yoke ear.
5. Install the top bearing cup partially into the yoke ear.
6. Make sure that the trunnions start straight into both bearing cups.
7. Press the bearing cup into the yoke until the cup is even with the yoke ear. Make sure the cross moves freely in the bearing cups.
8. Press the bearing cup further into the yoke. Make sure the retainer groove is visible.
9. Install the bearing retainer into the retainer groove.
10. Press the other bearing cup into the yoke until the retainer groove is visible.
11. Install the other bearing retainer into the retainer groove.
12. If necessary, spring the yoke with a firm blow with a dead blow hammer to help seat the retainer.
13. Lubricate the snap rings with chassis grease and insert the rings into the bearing cup groove.

Nylon Injected Ring

To Remove:

1. Lay the propeller shaft on table level with the press table.

2. Mark the transmission and rear axle ends of the propeller shaft.
3. Set the lower ear of the yoke on a 1-1/8 in (30 mm) socket.
4. Use a J9522-3 universal joint bearing separator on the open horizontal bearing cups to press the lower bearing cup out of the yoke ear.
5. If necessary, place a J 9522-5 universal joint bearing spacer remover between the seal and the lower bearing cup and continue to press.
6. Rotate the propeller shaft and press the opposite bearing cup out of the yoke.
7. Mark the position of the slip yoke to the tube.
8. Remove the cross from the yoke.
9. Remove the rest of the universal joint parts from the yoke.
10. If replacing the front universal joint, remove the slip yoke bearing cups in the same way.
11. Check the retaining ring grooves for plastic.
12. Check the bearing cup bores for burrs or imperfections.
13. Clean the remaining sheared plastic from the grooves of the yoke.

To Install:

1. Remove the bearing cups from the universal joint.
2. Install the bottom bearing cup partially into the yoke.
3. Install the cross into the yoke with the trunnion seated freely in the bearing cup.
4. Press the bearing cup into the yoke until the cup is even with the yoke ear.
5. Install the top bearing cup partially into the yoke ear.
6. Make sure that the trunnions start straight into both bearing cups.
7. Press the bearing cup into the yoke until the cup is even with the yoke ear. Make sure the cross moves freely in the bearing cups.
8. Press the bearing cup further into the yoke. Make sure the retainer groove is visible.
9. Install the bearing retainer into the retainer groove.
10. Press the other bearing cup into the yoke until the retainer groove is visible.
11. Install the other bearing retainer into the retainer groove.
12. If necessary, spring the yoke with a firm blow with a dead blow hammer to help seat the retainer.
13. Lubricate the snap rings with chassis grease and insert the rings into the bearing cup groove.

Differential Carrier Assembly

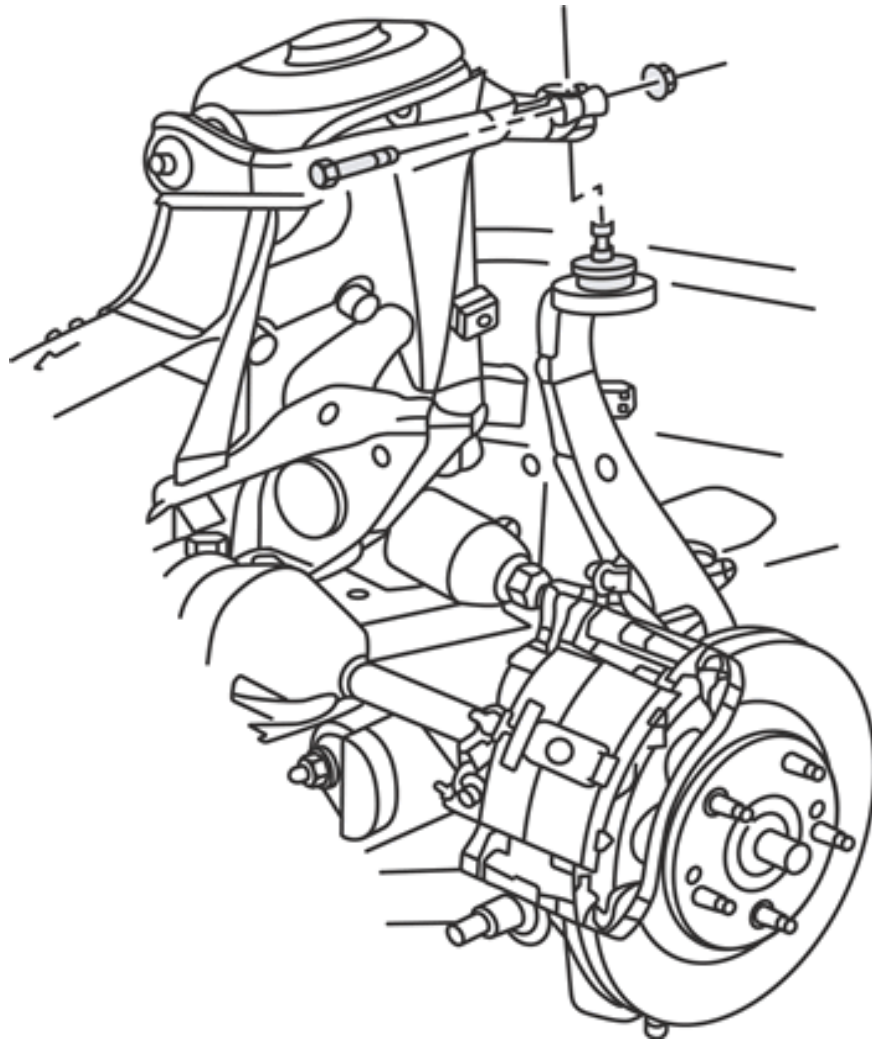
Removal & Installation

4.2L Engine

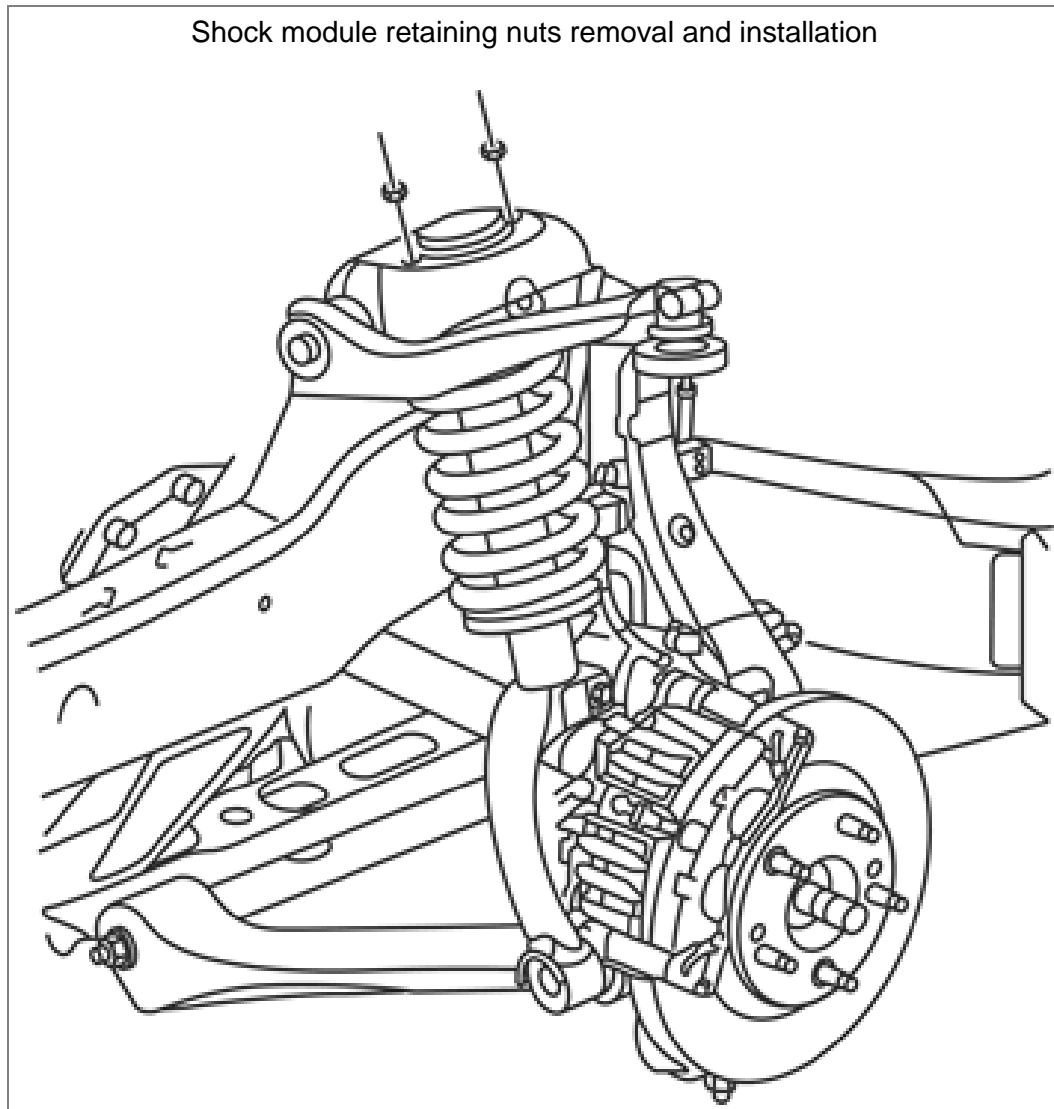
To Remove:

1. Remove the front wheels from the vehicle.
2. Remove the engine protection shield from under the frame.
3. Drain the fluid from the differential carrier.
4. Remove the front propeller shaft from the differential carrier.
5. Detach the antilock brake system (ABS) harnesses from the wheel wells.
6. Detach the brake hose retainers from the frame.
7. Remove the vent hose from the differential carrier.

Upper ball pinch nut and bolt removal and installation

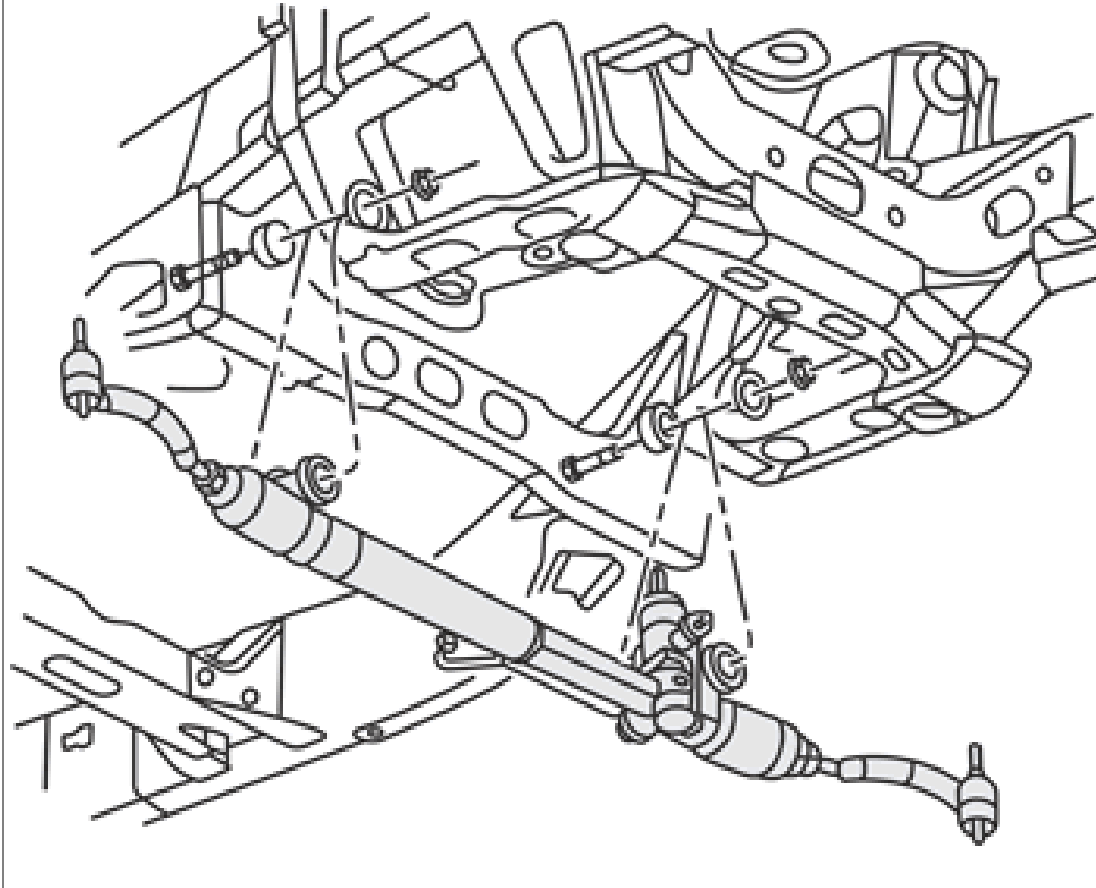


8. Remove the nut and bolt from the upper ball pinches.



9. Remove the retaining nuts from the upper shock modules.
10. Remove the front stabilizer bar links and shock modules from the frame.
11. Remove the steering knuckle from the upper control arm.
12. Remove the front wheel drive shafts from the differential carrier.
13. Secure the front wheel drive shafts to the frame.
14. Use mechanics wire to support the front shock modules and steering knuckle.

Power steering gear assembly removal and installation



15. Remove the power steering gear assembly from the vehicle.
16. Remove the inner shaft from the differential carrier.
17. Detach the differential carrier from the oil pan and secure it to the frame.
18. Remove the oil pan from the engine.
19. Remove the differential carrier from the vehicle.

To Install:

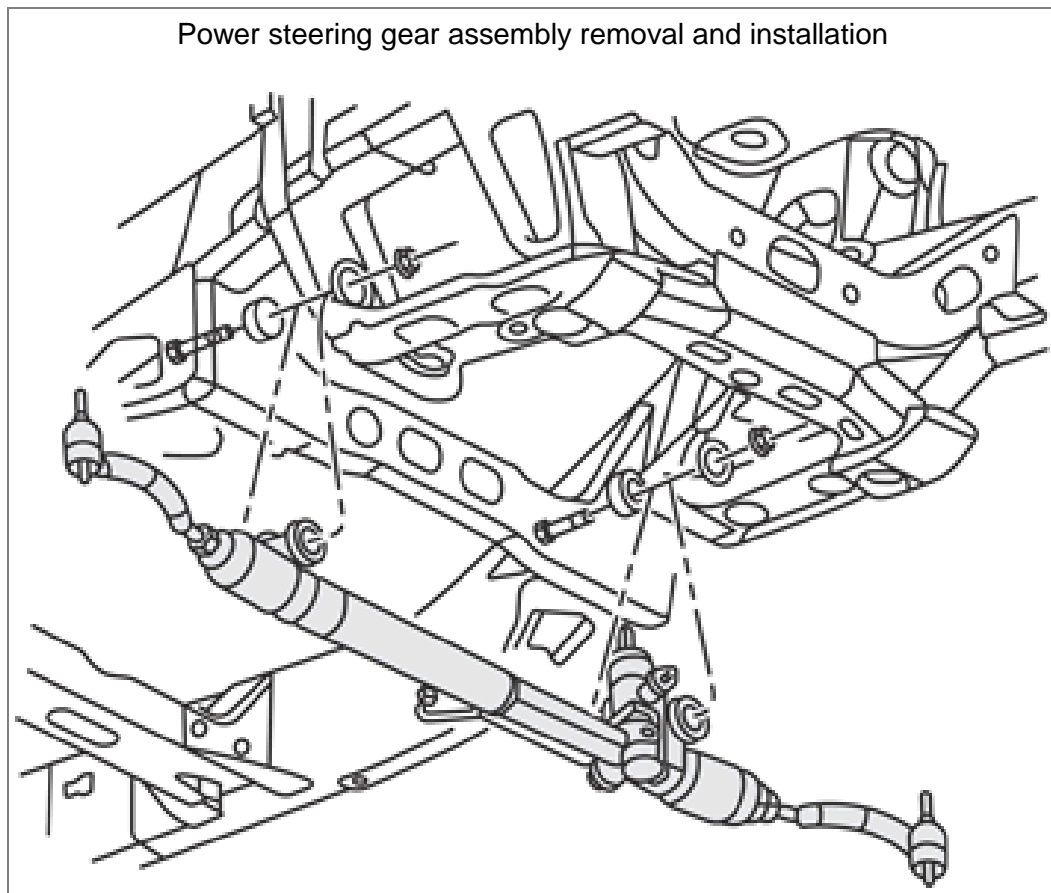
1. Secure the differential carrier to the frame.
2. Install the oil pan onto the engine.
3. Attach the differential carrier to the oil pan. Torque the bolts to **63 ft-lb (85 Nm)**.
4. Install the inner shaft into the differential carrier.
5. Install the power steering gear assembly into the vehicle.
6. Detach the front wheel drive shafts from the frame.
7. Detach the front shock modules and steering knuckle from their supports.
8. Install the front wheel drive shafts into the differential carrier.
9. Install the vent hose onto the differential carrier.
10. Install the upper shock module retaining nuts. Torque the nuts to **74 ft-lb (100 Nm)**.
11. Install the steering knuckle onto the upper control arm.
12. Install the nut and bolt into the upper ball pinches. Torque the nut and bolt to **30 ft-lb (40 Nm)**.

13. Install the front stabilizer bar links to the frame.
14. Attach the brake hose retainers to the frame. Torque the bolts to **18 ft-lb (25 Nm)**.
15. Attach the antilock brake system (ABS) harnesses to the wheel wells.
16. Install the front propeller shaft into the differential carrier.
17. Refill the fluid in the differential carrier.
18. Install the engine protection shield under the frame.
19. Install the front wheels onto the vehicle.

5.3L & 6.0L Engines

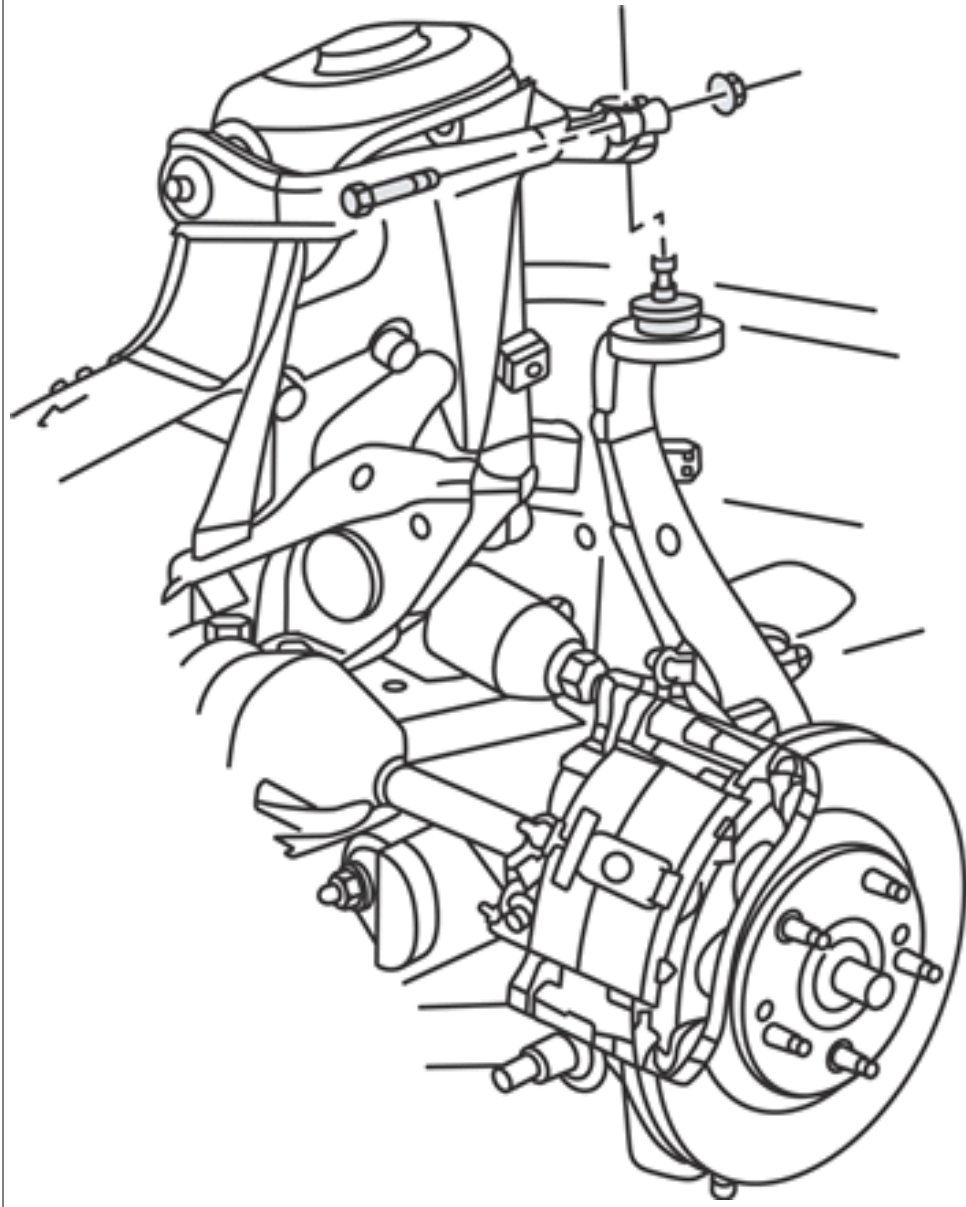
To Remove:

1. Remove the front wheels from the vehicle.
2. Remove the engine protection shield from under the frame.
3. Drain the fluid from the differential carrier.
4. Detach the antilock brake system (ABS) harnesses from the wheel wells.
5. Disconnect the wheel speed sensor (WSS) connectors.
6. Detach the brake hose retainers from the frame.
7. Remove the sway bar link pins from the lower control arms.



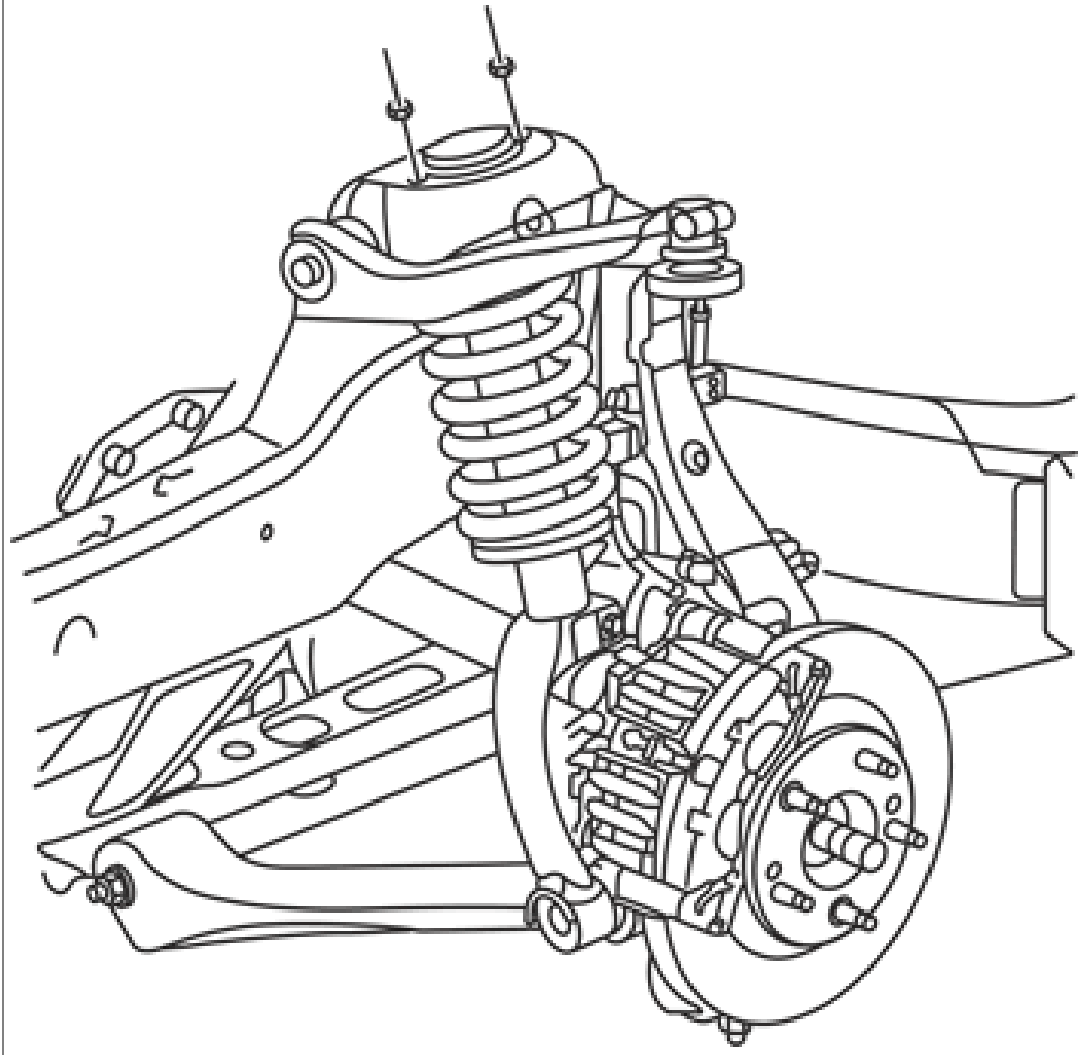
8. Remove the steering gear from the vehicle.
9. Support the lower control arms with adjustable jack stands.

Upper ball pinch nut and bolt removal and installation



10. Remove the nut and bolt from the upper ball pinches.
11. Remove the steering knuckles from the upper control arms.

Shock module retaining nuts removal and installation



12. Remove the retaining nuts from the upper shock modules.
13. Lower the jack stands supporting the lower control arms.
14. Remove the front wheel drive shafts from the differential carrier using a brass drift.
15. Set aside the front wheel drive shafts.
16. Secure the front shock modules to the frame.
17. Remove the jack stands supporting the lower control arms.
18. Remove the front propeller shaft from the pinion yoke.
19. Set aside and secure the front propeller shaft.
20. Remove the inner shaft from the differential carrier.
21. Detach the differential carrier from the oil pan and secure it to the frame.
22. Remove the oil pan from the engine.
23. Remove the differential carrier from the vehicle.

To Install:

1. Secure the differential carrier to the frame.
2. Install the oil pan onto the engine.
3. Attach the differential carrier to the oil pan. Torque the bolts to **63 ft-lb (85 Nm)**.
4. Install the inner shaft into the differential carrier.
5. Support the lower control arms with adjustable jack stands.
6. Install the front wheel drive shafts into the differential carrier.
7. Lift the jack stands supporting the lower control arms.
8. Install the steering knuckles onto the upper control arms.
9. Install the nut and bolt into the upper ball pinches. Torque the nut and bolt to **30 ft-lb (40 Nm)**.
10. Remove the jack stands supporting the lower control arms.
11. Install the retaining nuts onto the upper shock modules. Torque the nuts to **33 ft-lb (45 Nm)**.
12. Install the steering gear into the vehicle.
13. Attach the brake hose retainers to the frame. Torque the bolts to **18 ft-lb (25 Nm)**.
14. Install the sway bar link pins into the lower control arms.
15. Connect the wheel speed sensor (WSS) connectors.
16. Attach the antilock brake system (ABS) harnesses to the wheel wells.
17. Install the front propeller shaft into the pinion yoke.
18. Refill the fluid in the differential carrier.
19. Install the engine protection shield under the frame.
20. Install the front wheels onto the vehicle.

Axle Housing Bushing

Removal & Installation

To Remove:

1. Raise and safely support the vehicle.
2. Remove the control arm from the axle housing.
3. Use a commercially available bushing remover/installer to remove the bushing from the axle housing.

To Install:

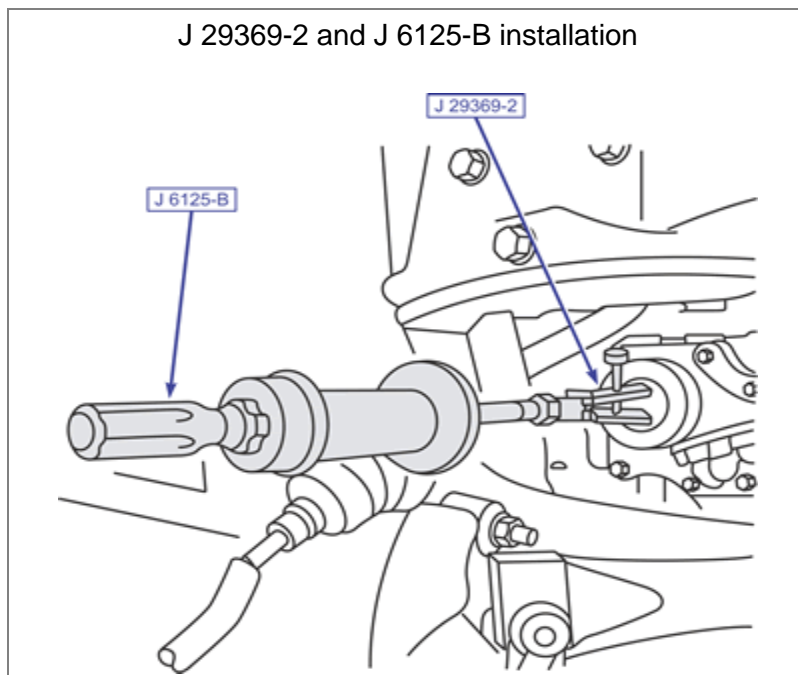
1. Install the bushing with a commercially available bushing remover/installer.
2. Install the control arm to the axle housing. Do not tighten the fasteners at this time.
3. Load the suspension and tighten the control arm fasteners when the suspension is at normal vehicle ride height.

Intermediate Shaft Bearing & Oil Seal

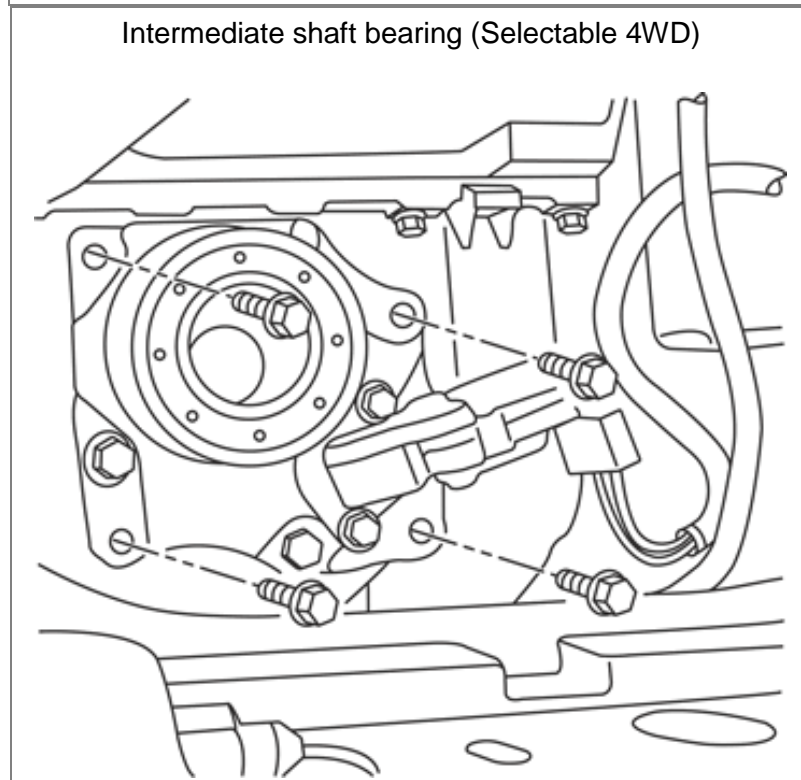
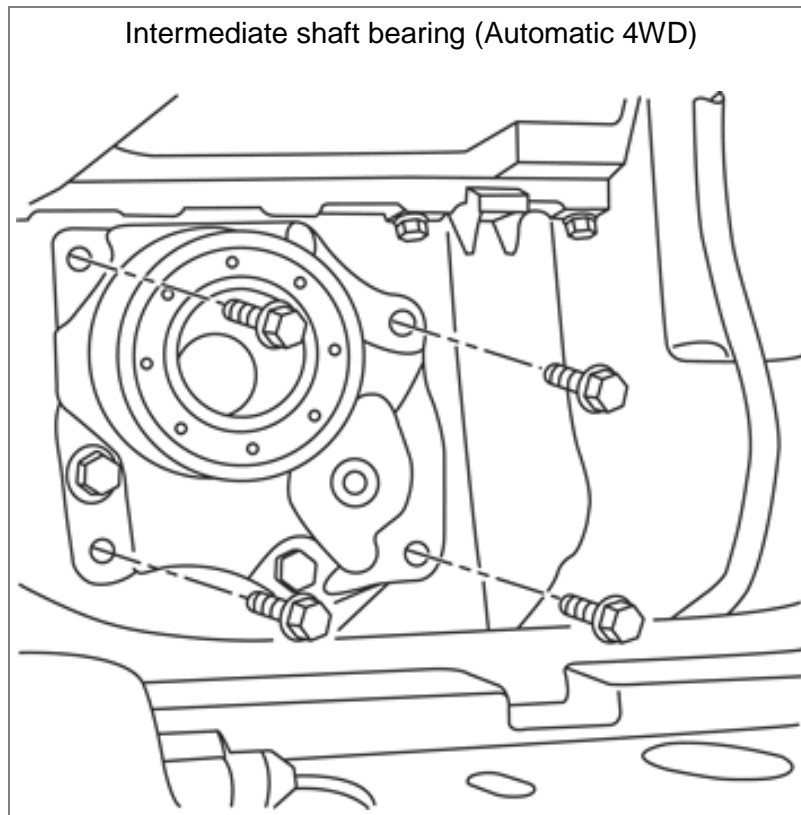
Removal & Installation

To Remove:

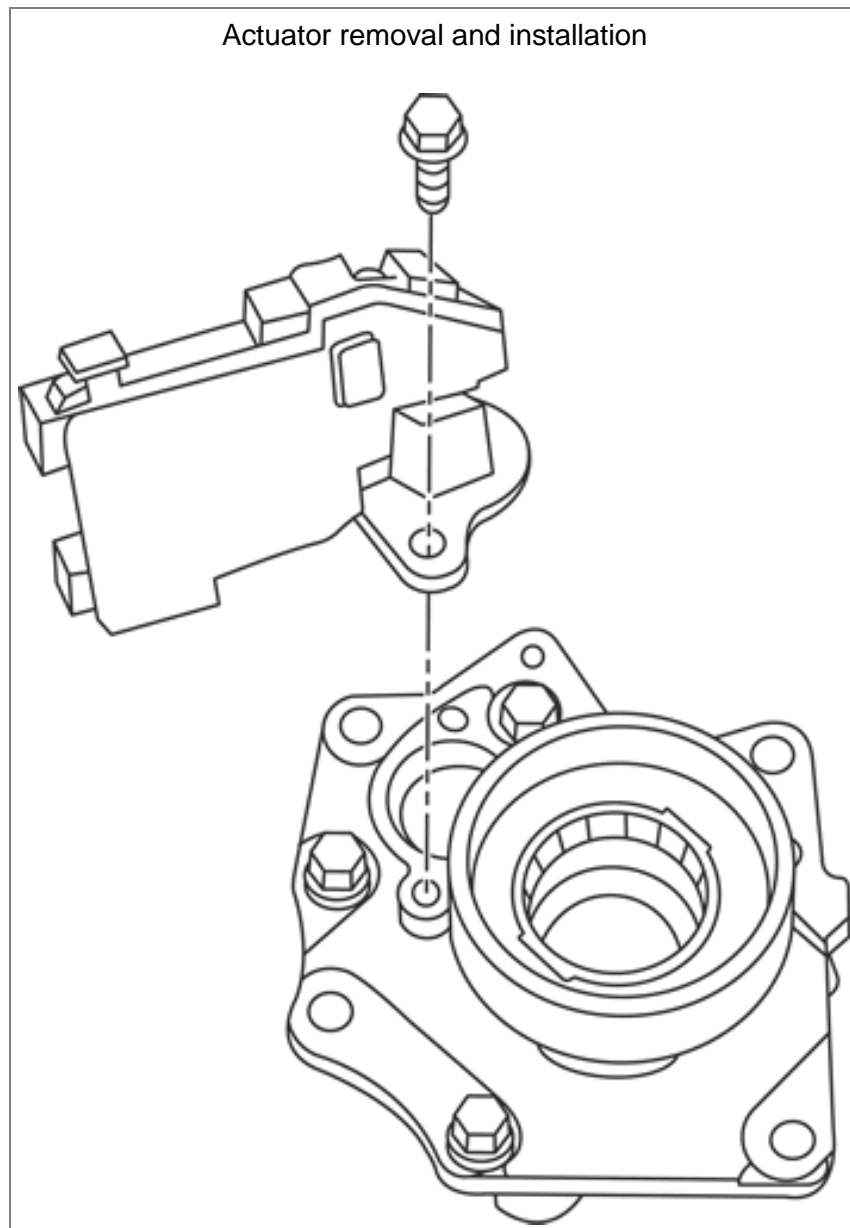
1. Lift the vehicle.
2. Remove the right drive shaft from the vehicle.
3. Install a J 29369-2 bushing and bearing remover and a J 6125-B slide hammer into the outboard intermediate shaft bearing oil seal.



4. Remove and discard the outboard intermediate shaft bearing oil seal from the intermediate shaft bearing.

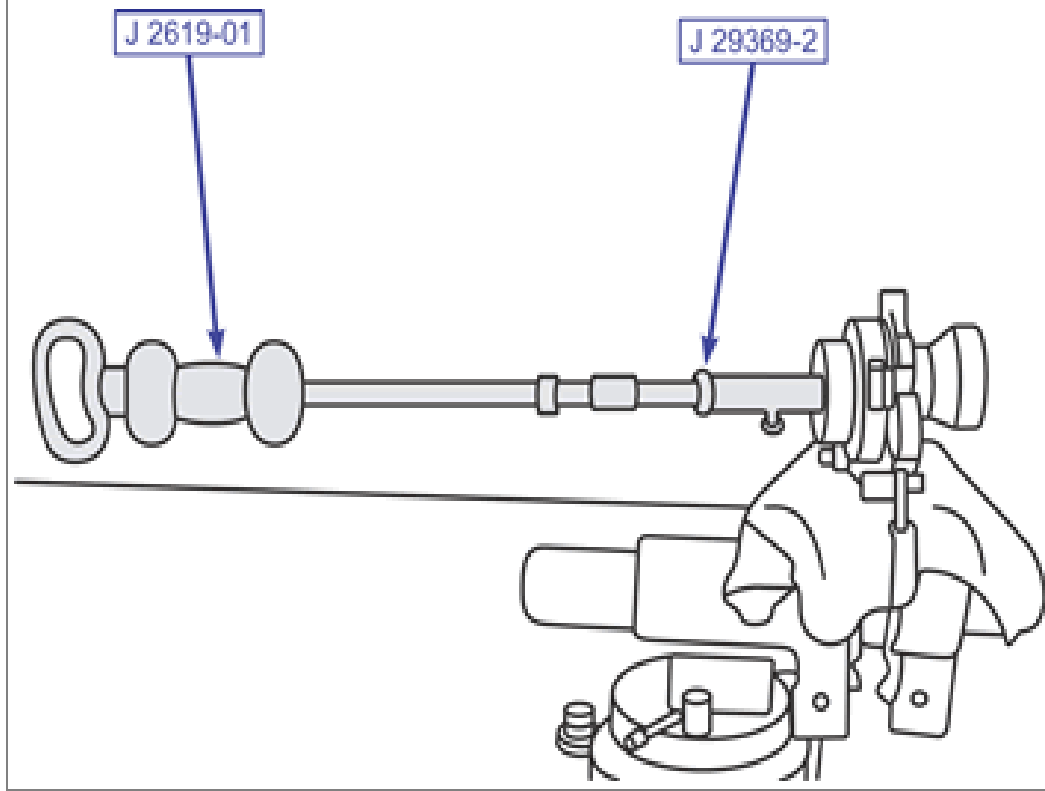


6. For vehicles with selectable 4WD, disconnect the actuator connector.
7. Detach the wire harness from the intermediate shaft bearing.
8. Detach the intermediate shaft bearing from the oil pan.



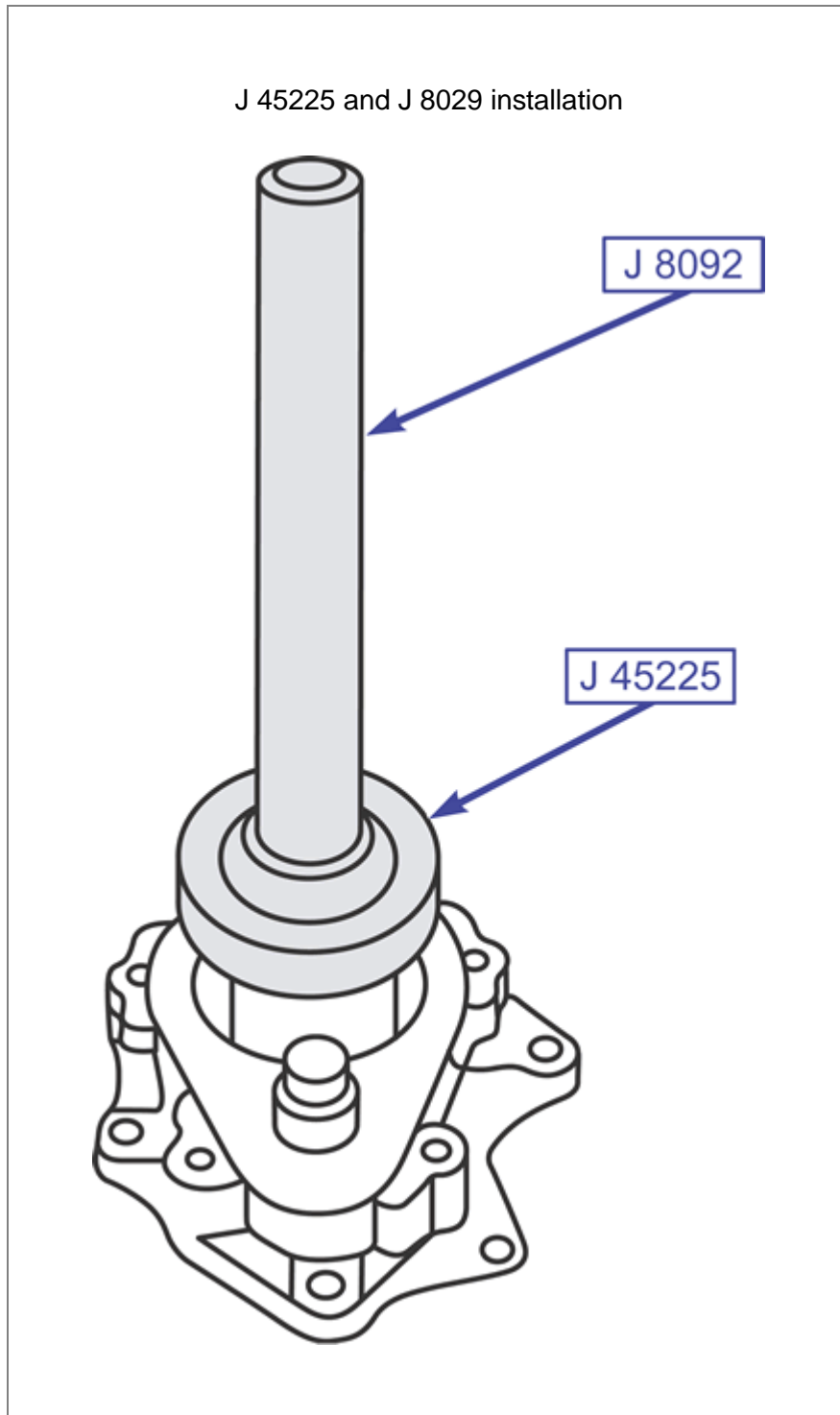
9. For vehicles with selectable 4WD, detach the actuator from the intermediate shaft bearing.
10. Install the intermediate shaft bearing into a vise.

J 29369-2 and J 2619-01 Installation



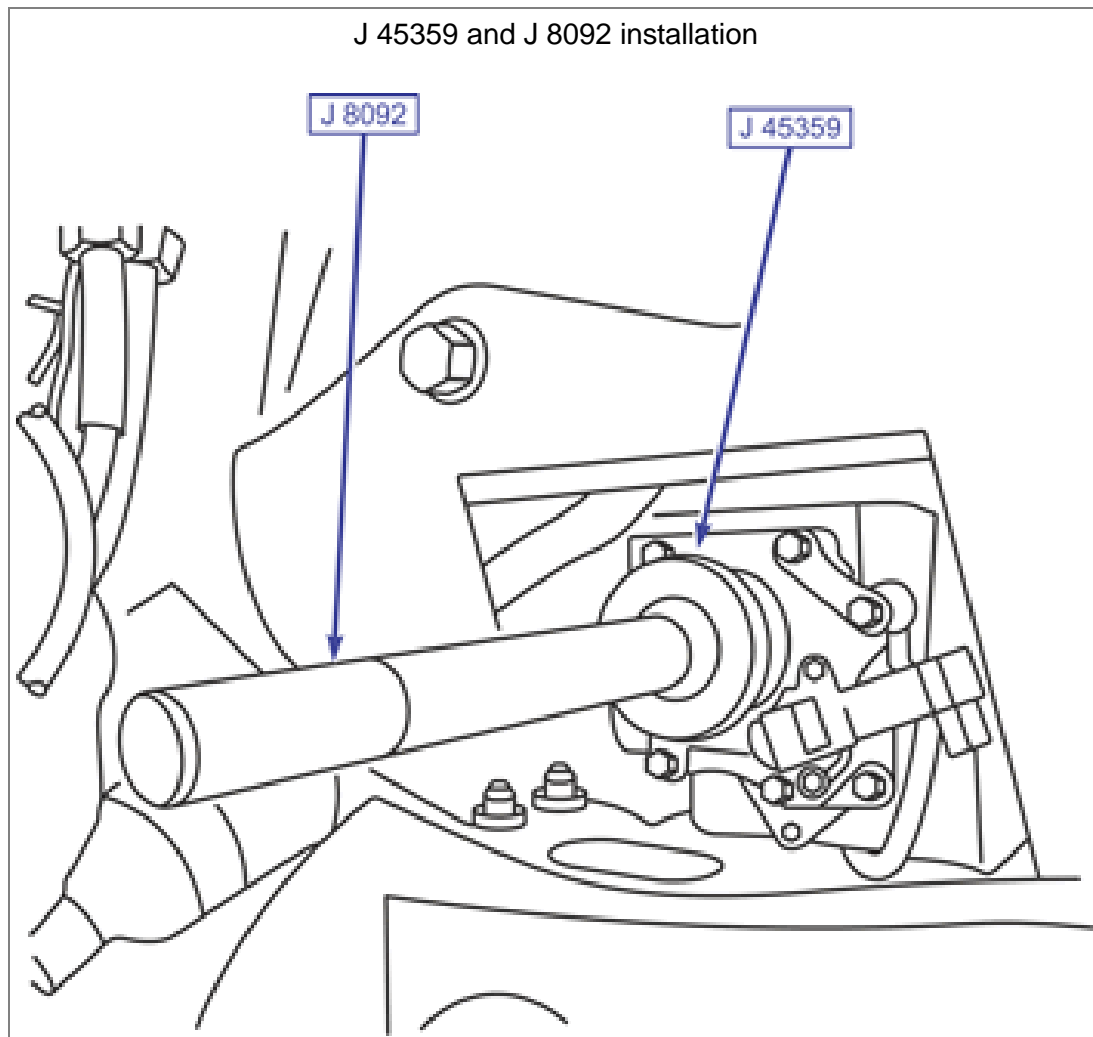
11. Install a J 29369-2 bushing and bearing remover and a J 2619-01 slide hammer with adapter into the inboard intermediate shaft bearing oil seal.
12. Remove and discard the inboard intermediate shaft bearing oil seal from the intermediate shaft bearing.

To Install:



1. Install a new inboard intermediate shaft bearing oil seal into the intermediate shaft bearing using a J 45225 axle seal installer and a J 8092 universal driver handle.
2. For vehicles with selectable 4WD, attach the actuator to the intermediate shaft bearing.

3. Attach the intermediate shaft bearing onto the oil pan. Torque the bolts to **35 ft-lb (48 Nm)**.
4. Attach the wire harness to the intermediate shaft bearing.
5. For vehicles with selectable 4WD, connect the actuator connector.



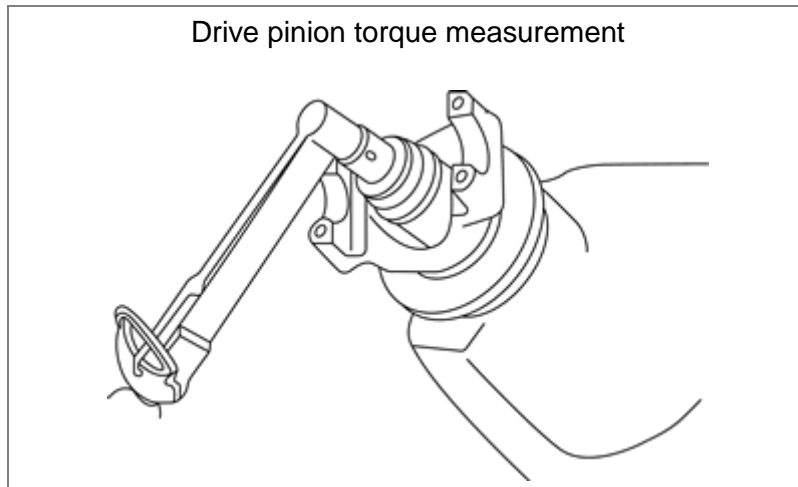
6. Install the outboard intermediate shaft bearing oil seal into the intermediate shaft bearing using a J 45359 axle seal installer and a J 8092 universal driver handle.
7. Install the right drive shaft into the vehicle.
8. Lower the vehicle.

Drive Pinion Seal

Removal & Installation

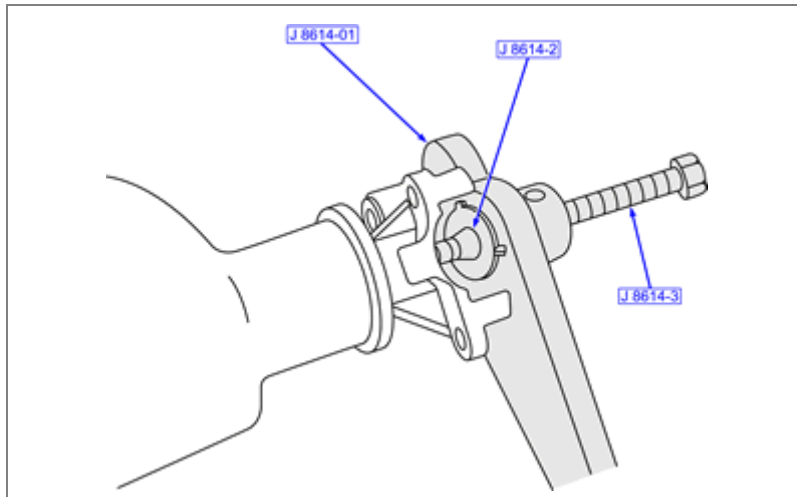
To Remove:

1. Lift the vehicle.
2. Remove the engine protection shield from under the frame.
3. Drain the fluid from the differential carrier.
4. Remove the front propeller shaft from the vehicle.
5. Remove the steering gear crossmember from the frame.



6. Use an inch-pound torque wrench to measure the amount of torque needed to turn the drive pinion. Write down this measurement.
7. Mark the orientation of the pinion yoke to the drive pinion shaft.
8. Install a J 8614-01 flange and pulley holding tool onto the drive pinion.
9. Remove the pinion nut from the pinion while holding the J 8614-01 flange and pulley holding tool.

Drive pinion flange removal



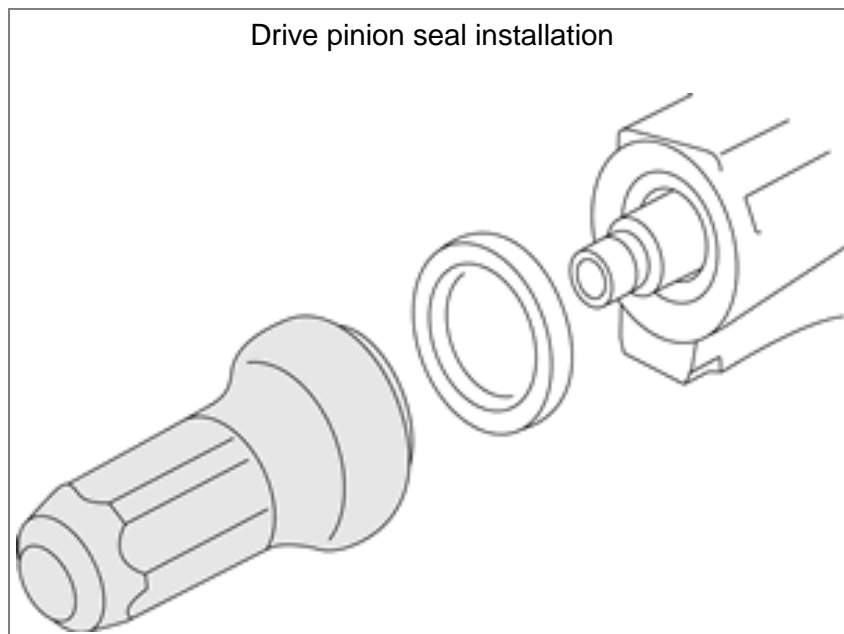
10. Install a J 8614-2 and a J 8614-3 into the J 8614-01 flange and pulley holding tool.
11. Hold the J 8614-01 flange and pulley holding tool while turning the J 8614-3 clockwise to remove the pinion yoke.

NOTE: Make sure not to distort or scratch the aluminum case while removing the seal from the bore.

12. Use a seal removal tool to remove the drive pinion seal from the drive pinion.
13. Use a soft-faced hammer to remove the dust deflector from the pinion yoke. Discard the deflector.

To Install:

1. Use a soft-faced hammer to install the dust deflector onto the pinion yoke.



2. Use a J 33782 and a hammer to install the pinion seal into the drive pinion.
3. Apply GM P/N 12346004 or equivalent to the drive pinion yoke splines.
4. Align the pinion yoke to the marks on the drive pinion shaft.
5. Install the pinion yoke onto the drive pinion shaft.
6. Seat the pinion yoke by tapping it with a soft-faced hammer.
7. Install a new washer and pinion nut onto the pinion shaft.
8. Install a J 8614-01 flange and pulley holding tool onto the drive pinion.
9. Hold the J 8614-01 and tighten the pinion nut until the pinion end play is just taken up. Seat the bearings by rotating the pinion while tightening the nuts.
10. Use an inch-pound torque wrench to measure the amount of torque needed to turn the drive pinion.
11. If the torque of the pinion nut is not **3-5 in-lb (0.40-0.57 Nm)** greater than the recorded value, tighten the nut until it is.
12. Rotate the pinion several times to make sure the bearing have been seated.
13. Recheck the rotating torque to make sure it is still within the specified range.
14. Install the steering gear crossmember onto the frame.
15. Install the front propeller shaft into the vehicle.
16. Install the engine protection shield under the frame.
17. Refill the fluid into the differential carrier.
18. Lower the vehicle.

Rear Axle

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Axle Housing Assembly

Removal & Installation

To Remove:

1. Lift the vehicle.
2. Drain the lubricant from the rear axle housing.
3. Remove the rear axle assembly from the vehicle.
4. Remove the brake caliper brackets from the rear hubs.
5. Remove the rear cover and gasket from the rear axle housing.
6. Remove the rear axle shafts from the vehicle.
7. Remove the rear differential assembly from the vehicle.
8. Remove the brake backing plates from the rear hubs.
9. Remove the rear drive pinion shaft yoke and seal from the drive pinion.
10. Remove the drive pinion from the rear axle housing.

To Install:

1. Install the drive pinion into the rear axle housing.
2. Install the rear drive pinion shaft yoke and seal onto the drive pinion.
3. Install the rear differential assembly into the vehicle.
4. Adjust the differential side bearing preload and the backlash.
5. Perform a gear tooth contact pattern check.
6. Install the brake backing plates onto the rear hubs.
7. Install the rear axle shafts into the vehicle.
8. Install the rear cover and gasket onto the rear axle housing.
9. Install the brake caliper brackets onto the rear hubs.
10. Install the rear axle assembly into the vehicle.
11. Refill the lubricant in the rear axle housing.
12. Lower the vehicle.

Axle Housing Bushing

Removal & Installation

To Remove:

1. Raise and safely support the vehicle.
2. Remove the control arm from the axle housing.
3. Use a commercially available bushing remover/installer to remove the bushing from the axle housing.

To Install:

1. Install the bushing with a commercially available bushing remover/installer.
2. Install the control arm to the axle housing. Do not tighten the fasteners at this time.
3. Load the suspension and tighten the control arm fasteners when the suspension is at normal vehicle ride height.

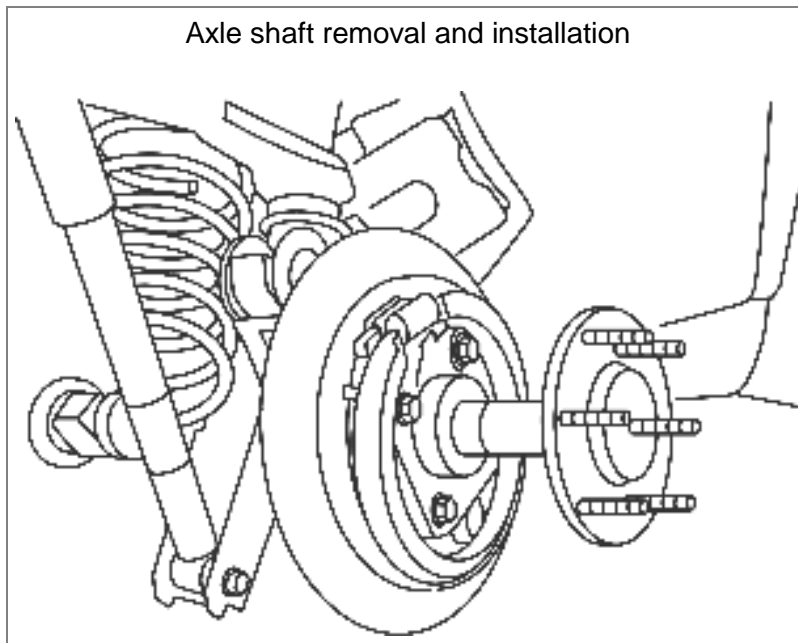
Axle Shaft

Removal & Installation

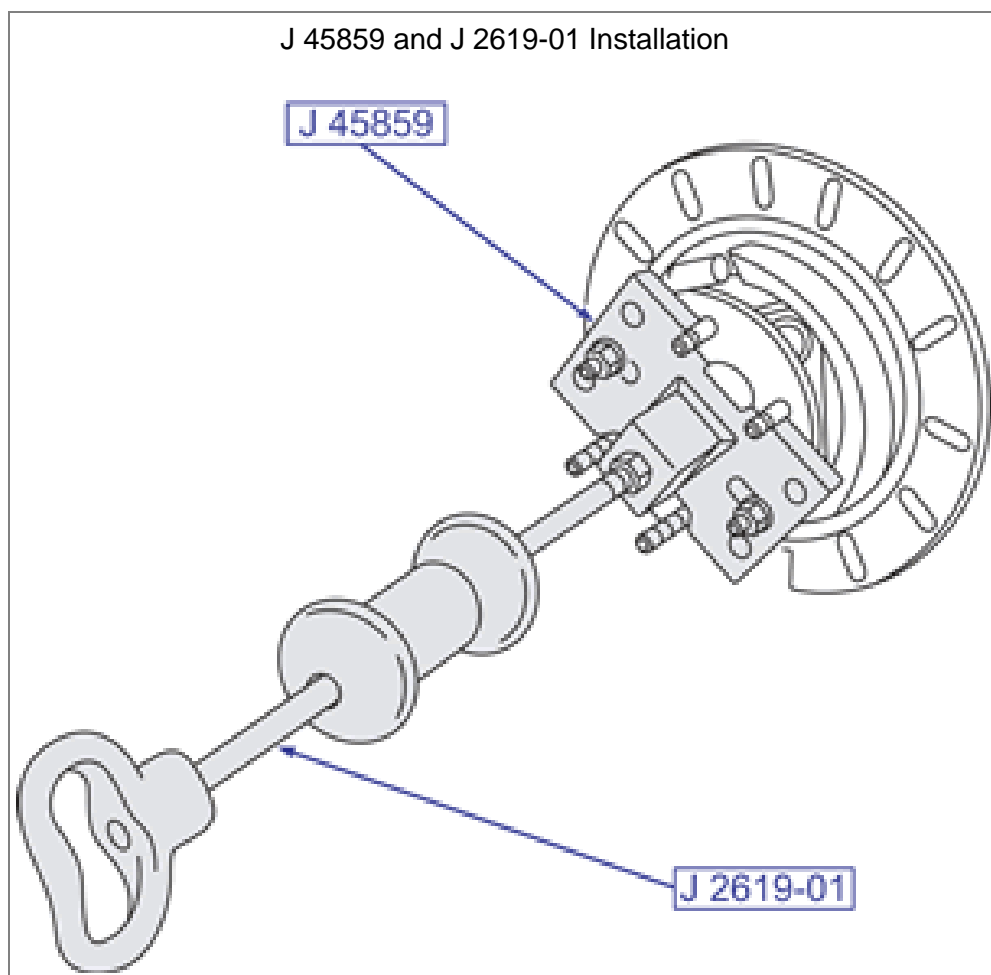
To Remove:

1. Lift the vehicle.
2. Remove the rear wheels from the vehicle.
3. Remove the brake caliper from the hub.
4. Remove the rear wheel speed sensor from the hub.
5. Remove the cover and gasket from the rear axle housing.
6. Remove the pinion shaft locking bolt from the rear axle housing.
7. For axles without a locking differential, remove the pinion shaft from the rear axle housing.
8. For axles with a locking differential, partially remove the pinion shaft from the rear axle housing and rotate the case until the pinion shaft touches the housing.
9. For axle with a locking differential, use a flat bladed tool to rotate the C-lock until it aligns with the thrust block.
10. Remove the C-lock from the button end of the axle shaft.

NOTE: Do not rotate the axle shaft while removing the shaft from the rear axle housing; this will cause misalignment of the gears.



11. Remove the axle shaft from the rear axle housing.



12. If necessary, use a J 45859 axle remover and a J 2619-01 slide hammer to remove the axle shaft from the rear axle housing.

To Install:

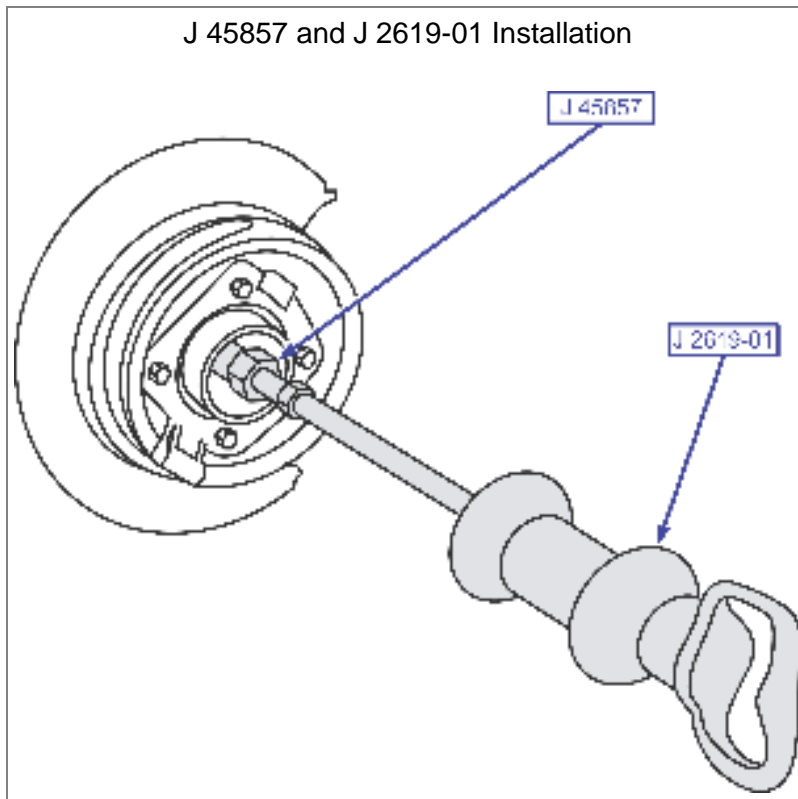
1. Install the axle shaft into the rear axle housing.
2. Engage the axle shaft splines with the differential side gear.
3. For axles without a locking differential, install the C-lock onto the button end of the axle shaft.
4. For axle with a locking differential, install the C-lock onto the axle shaft with the ends flush with the thrust block.
5. Seat the C-lock into the differential gear by pulling the shaft flange outward.
6. Install the pinion shaft into the rear axle housing.
7. For a 8.0/8.6 inch axle, install the pinion shaft locking bolt into the rear axle housing. Torque the bolt to **27 ft-lb (36 Nm)**.
8. For a 9.5 LD inch axle, install the pinion shaft locking bolt into the rear axle housing. Torque the bolt to **37 ft-lb (50 Nm)**.
9. Install the brake caliper onto the hub.
10. Install the rear wheel speed sensor into the hub.
11. Install the rear wheels onto the vehicle.
12. Fill the lubricant in the rear axle.
13. Lower the vehicle.

Axle Shaft Bearing & Seal

Removal & Installation

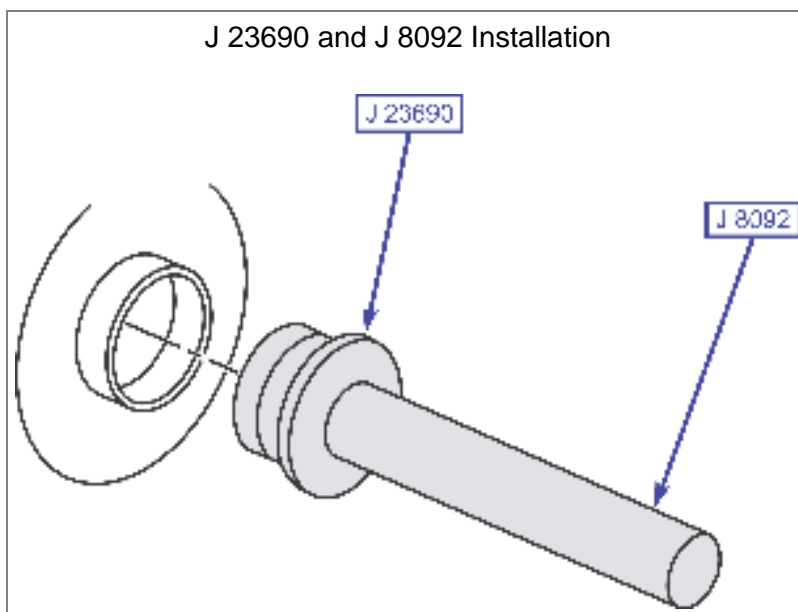
To Remove:

1. Lift the vehicle.
2. Remove the wheel from the vehicle.
3. Remove the cover and gasket from the rear axle housing.
4. Remove the axle shaft from the vehicle.



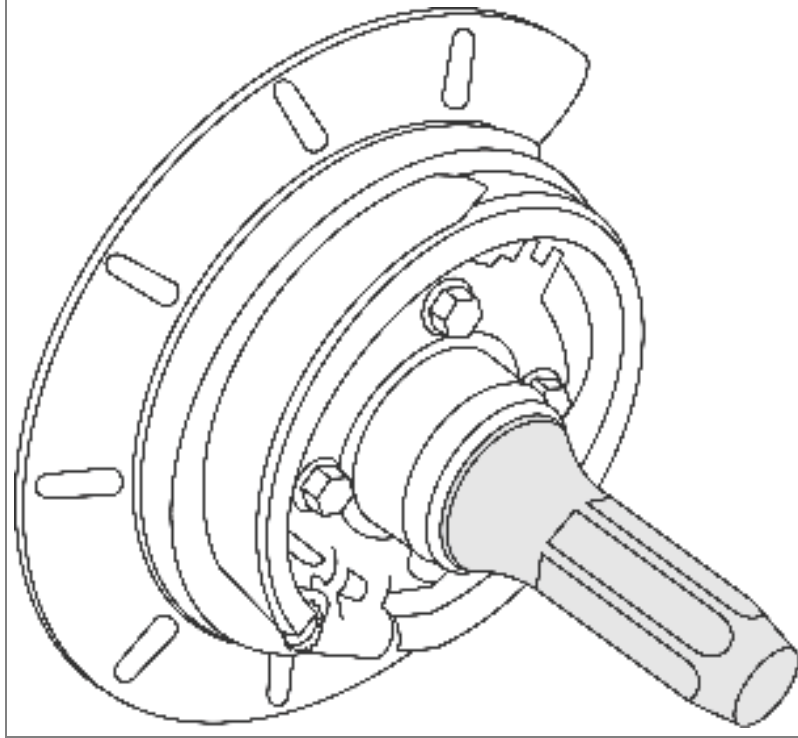
5. Use a J 45857 bearing remover and a J 2619-01 slide hammer to remove the axle shaft bearing and seal.

To Install:



1. Use a J 23690 bearing installer and a J 8092 universal driver handle to install the axle shaft bearing.

J 21128 Installation



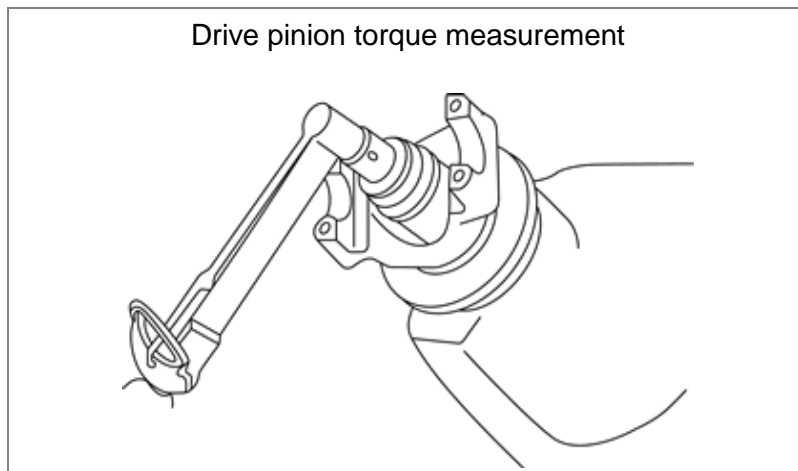
2. Use a J 21128 axle pinion oil seal installer to install the axle shaft seal.
3. Install the axle shaft into the vehicle.
4. Install the cover and gasket onto the rear axle housing.
5. Install the wheel onto the vehicle.
6. Lower the vehicle.

Drive Pinion Seal

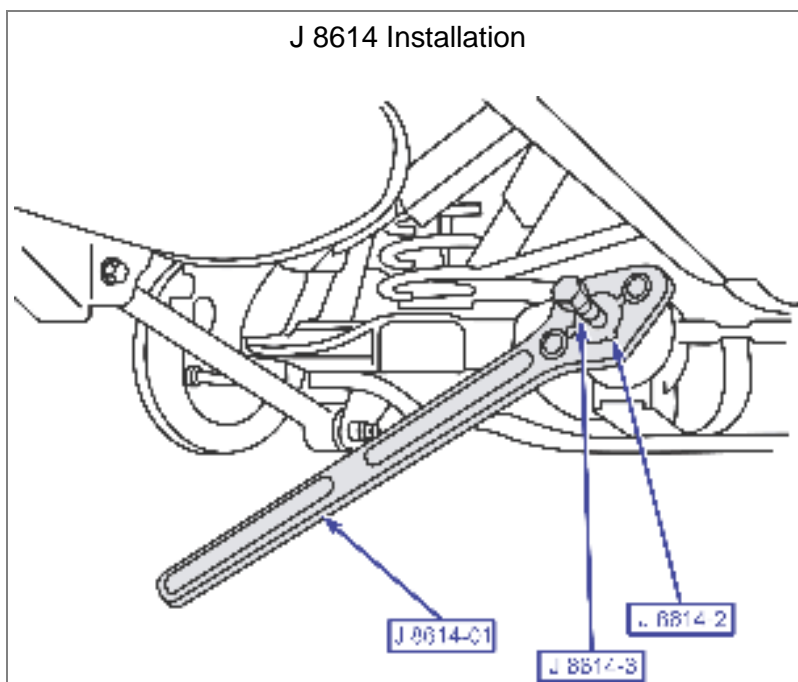
Removal & Installation

To Remove:

1. Lift the vehicle.
2. Remove the rear wheels.
3. Remove the rear brake calipers and rotors from the rear hubs.
4. Remove the rear propeller shaft from the vehicle.

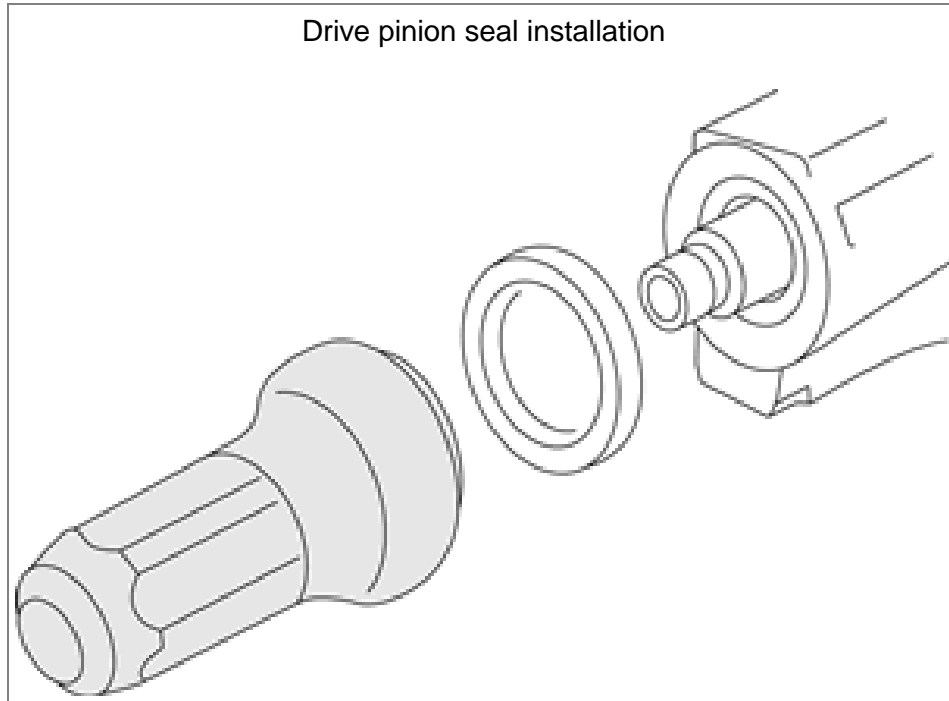


5. Use an inch-pound torque wrench to measure the amount of torque needed to turn the drive pinion. Write down this measurement.
6. Mark the orientation of the pinion yoke to the drive pinion.



7. Install a J 8614-01 flange and pulley holding tool onto the drive pinion.
8. Remove the pinion nut from the pinion while holding the J 8614-01 flange and pulley holding tool.
9. Install a J 8614-2 and a J 8614-3 into the J 8614-01 flange and pulley holding tool.
10. Hold the J 8614-01 flange and pulley holding tool while turning the J 8614-3 clockwise to remove the pinion yoke.
11. Use a seal removal tool to remove the drive pinion seal from the drive pinion.

To Install:



1. Use a J 33782 and a hammer to install the pinion seal into the drive pinion.
2. Apply GM P/N 12346004 or equivalent to the drive pinion yoke splines.
3. Align the pinion yoke to the marks on the drive pinion.
4. Install the pinion yoke onto the drive pinion shaft.
5. Seat the pinion yoke by tapping it with a soft-faced hammer.
6. Install a new washer and pinion nut onto the pinion shaft.
7. Install a J 8614-01 flange and pulley holding tool onto the pinion yoke.
8. Hold the J 8614-01 and tighten the pinion nut until the pinion end play is just taken up. Seat the bearings by rotating the pinion while tightening the nuts.
9. Use an inch-pound torque wrench to measure the amount of torque needed to turn the drive pinion.
10. If the torque of the pinion nut is not **3-5 in-lb (0.40-0.57 Nm)** greater than the recorded value, tighten the nut until it is.
11. Install the rear propeller shaft into the vehicle.
12. Install the rear brake calipers and rotors onto the rear hubs.
13. Install the rear wheels.
14. Lower the vehicle.

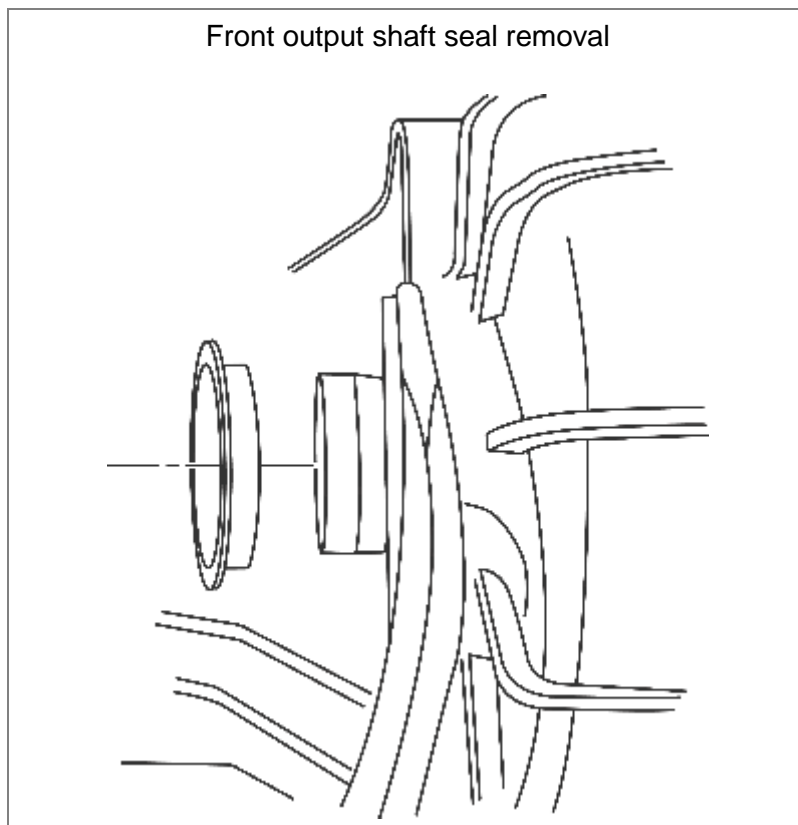
Transfer Case

Front Output Shaft Seal

Removal & Installation

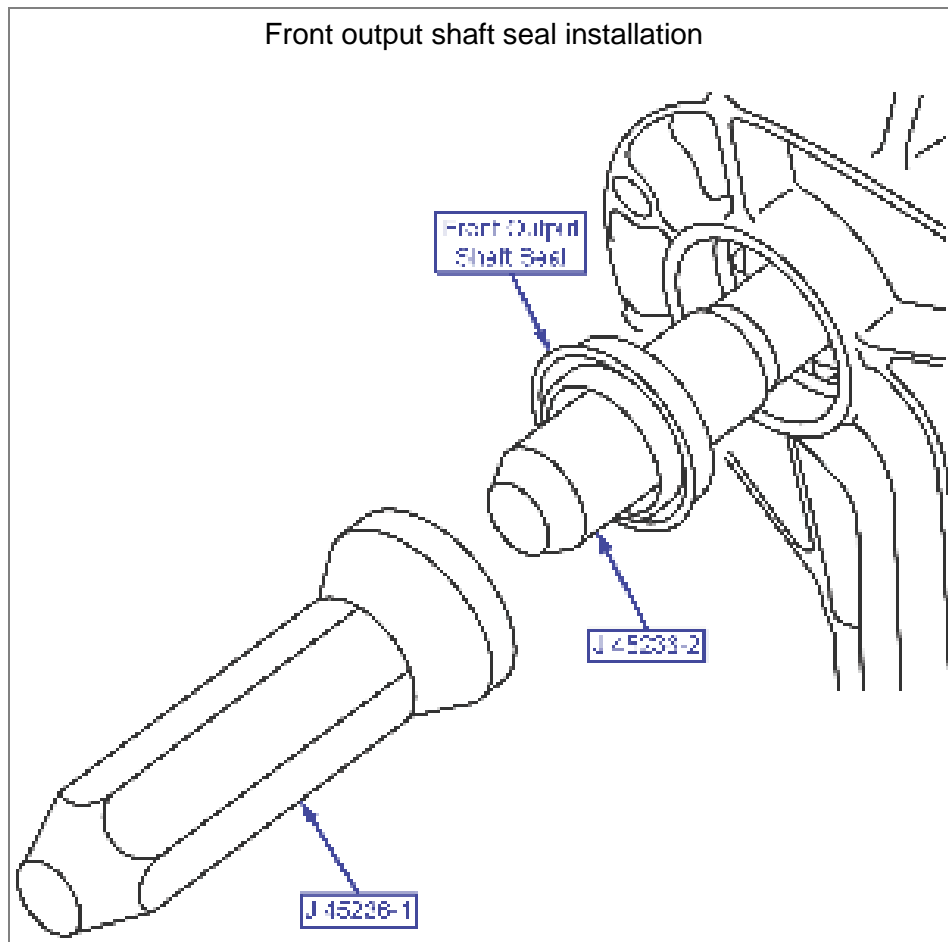
To Remove:

1. Lift the vehicle.
2. If equipped, remove the fuel tank shield from the fuel tank.
3. If equipped, remove the transfer case shield from the transfer case.
4. Remove the front propeller shaft from the vehicle.
5. Remove the dust shield from the front output shaft.



6. Remove the front output shaft seal from the front output shaft by tapping a screwdriver around the edge of the seal and prying it away.

To Install:



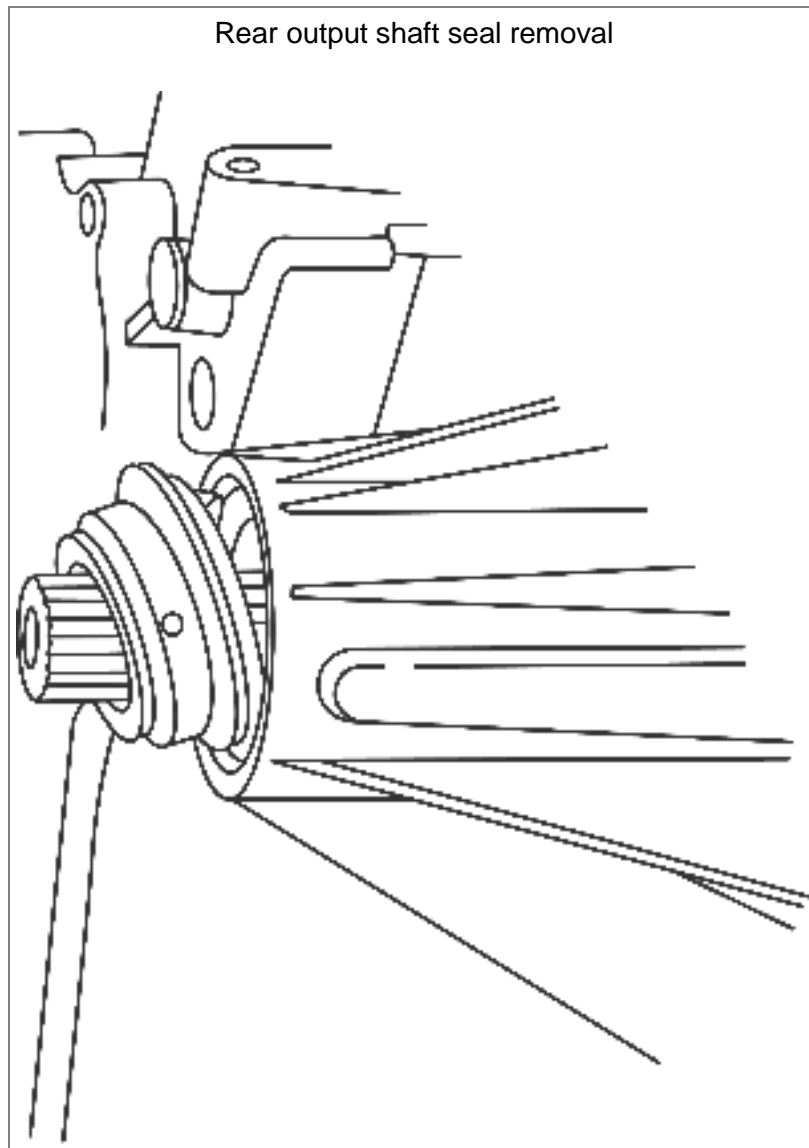
1. Install a J 45236-2 front output shaft seal installer onto the front output shaft.
2. Install the front output shaft seal over the J 45236-2 front output shaft seal installer.
3. Install the front output shaft seal onto the front output shaft using a J 45236-1 front output shaft seal installer.
4. Remove the J 45236-1 and J 45236-2 front output shaft seal installer from the front output shaft.
5. Install the dust shield onto the front output shaft.
6. Install the front propeller shaft into the vehicle.
7. Check the fluid level in the transfer case.
8. If equipped, install the transfer case shield onto the transfer case.
9. If equipped, install the fuel tank shield onto the fuel tank.
10. Lower the vehicle.

Rear Output Shaft Seal

Removal & Installation

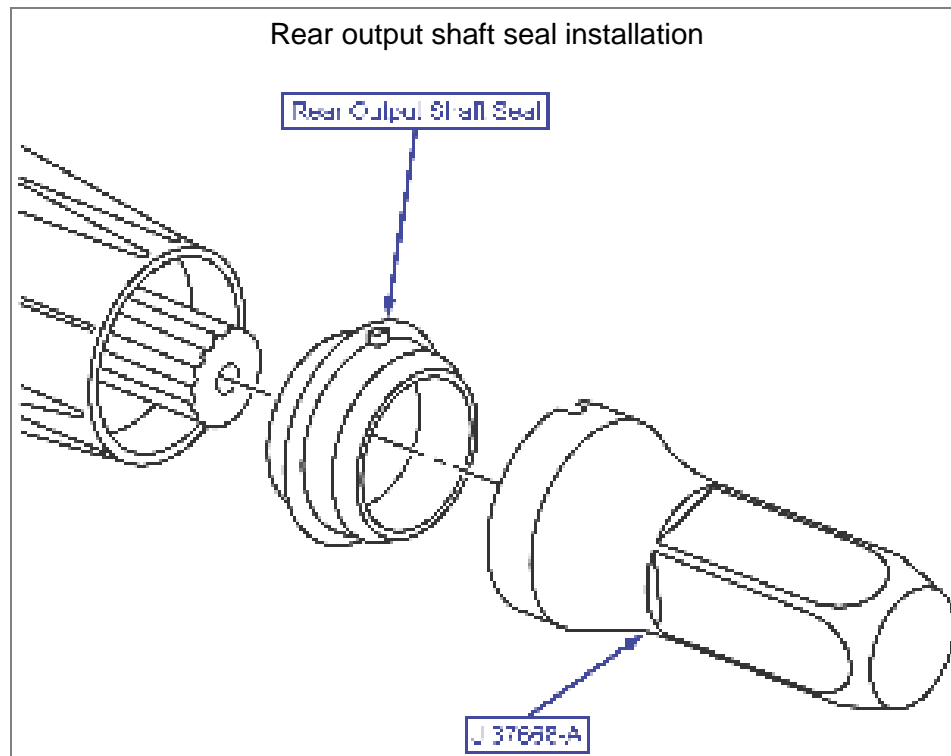
To Remove:

1. Lift the vehicle.
2. Remove the rear propeller shaft from the vehicle.



3. Remove the rear output shaft seal from the rear output shaft by prying it away.

To Install:



1. Install the rear output shaft seal onto the rear output shaft using a J 37668-A output shaft seal installer.
2. Install the rear propeller shaft into the vehicle.
3. Check the fluid level in the transfer case.
4. Lower the vehicle.

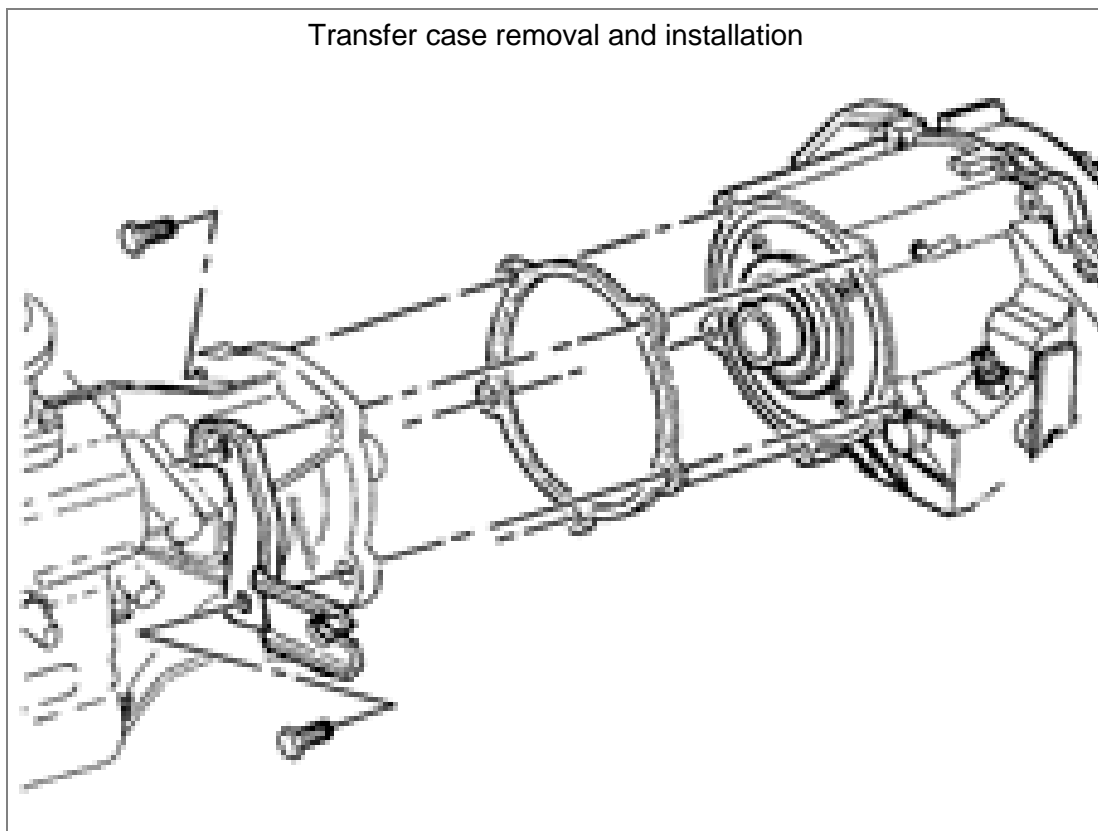
Transfer Case Assembly

Removal & Installation

NP4 & NP8 Transfer Cases

To Remove:

1. Lift the vehicle.
2. If equipped, remove the fuel tank shield from the fuel tank.
3. If equipped, remove the transfer case shield from the transfer case.
4. Remove the front and rear propeller shafts from the vehicle.
5. Drain the fluid from the transfer case.
6. Remove the fuel lines from the retainer.
7. Detach the electrical harness from the transfer case.
8. Disconnect the speed sensor connectors.
9. Disconnect the motor/encoder connector.
10. Disconnect the vent hose from the transfer case.



11. Remove the transfer case mounting nuts from the transfer case adapter.
12. Lower the transfer case.
13. Remove the gasket from the transfer case.

To Install:

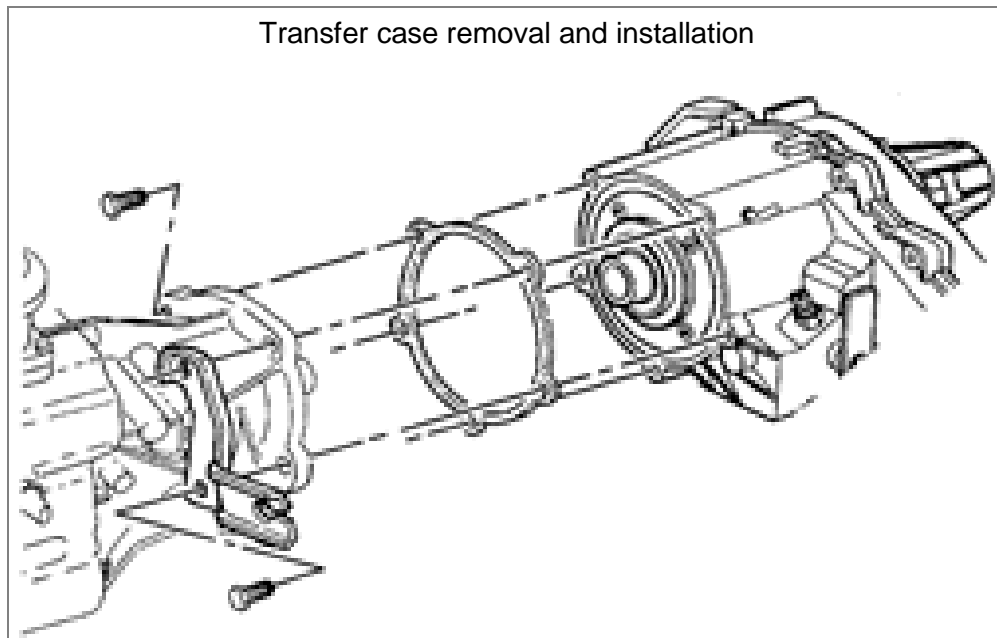
NOTE: Replace the transfer case gasket if it is damaged.

1. Install the gasket onto the transfer case.
2. Lift the transfer case.
3. Install the transfer case mounting nuts into the transfer case adapter. Torque the nuts to **35 ft-lb (47 Nm)**.
4. Remove the transfer case jack.
5. Connect the speed sensor connectors.
6. Connect the vent hose to the transfer case.
7. Connect the motor/encoder connector.
8. Attach the electrical harness to the transfer case.
9. Install the fuel lines into the retainer.
10. Install the front and rear propeller shafts into the vehicle.
11. Refill the fluid in the transfer case.
12. If equipped, install the fuel tank shield onto the fuel tank.
13. If equipped, install the transfer case shield onto the transfer case.
14. Lower the vehicle.

NR9 Transfer Case

To Remove:

1. Lift the vehicle.
2. Drain the fluid from the transfer case.
3. Remove the front and rear propeller shafts from the vehicle.
4. Disconnect the speed sensor connector.
5. Disconnect the vent hose from the transfer case.
6. Support the transfer case with a jack.



7. Remove the transfer case mounting nuts from the transfer case adapter.
8. Lower the transfer case.
9. Detach the electrical harness from the transfer case.
10. Remove the gasket from the transfer case.

To Install:

NOTE: Replace the transfer case gasket if it is damaged.

1. Install the gasket onto the transfer case.
2. Lift the transfer case.
3. Attach the electrical harness to the transfer case.
4. Install the transfer case mounting nuts into the transfer case adapter. Torque the nuts to **35 ft-lb (47 Nm)**.
5. Remove the transfer case jack.
6. Connect the speed sensor connector.
7. Connect the vent hose to the transfer case.
8. Install the front and rear propeller shafts into the vehicle.
9. Refill the fluid in the transfer case.
10. Lower the vehicle.

Half Shafts & CV-Joints

WARNING

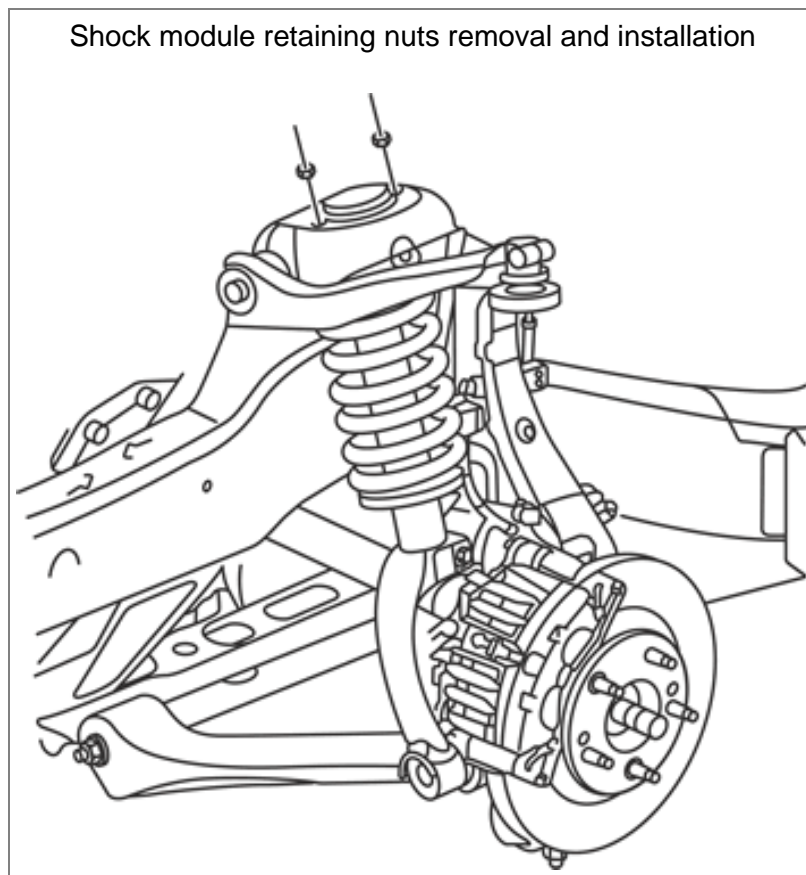
To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Half Shafts

Removal & Installation

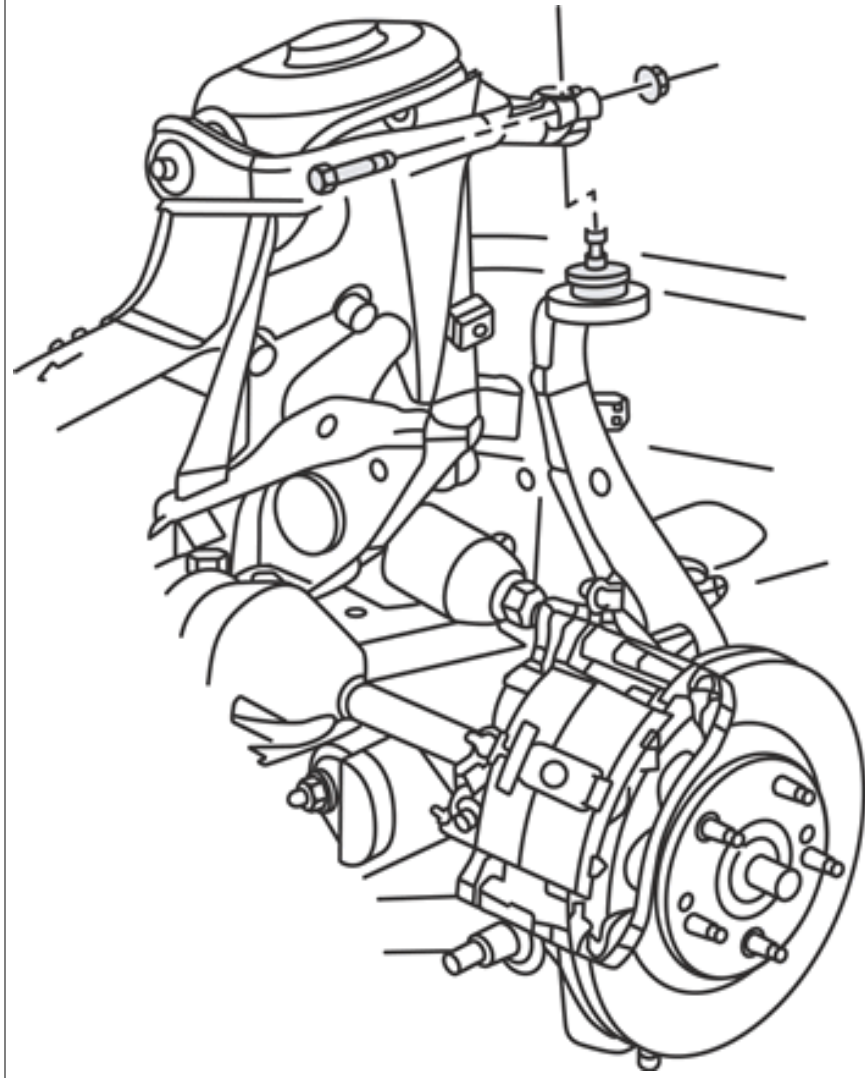
To Remove:

1. Lift the vehicle.
2. Remove the front wheels from the vehicle.
3. Remove the engine protection shield from under the frame.
4. Detach the wheel speed sensor harnesses from the wheel wells.
5. Disconnect the wheel speed sensor connectors.
6. Detach the front brake hose retainers from the wheel wells.
7. Remove the stabilizer bar link from the lower control arm.



8. Remove the upper shock module retaining nuts from the shock towers.
9. Remove the tie rod ends from the steering knuckles.

Upper ball pinch nut and bolt removal and installation



10. Remove the nut and bolt from the upper ball pinch joints.
11. Remove the shock modules from the shock towers.
12. Remove the steering knuckles from the upper control arms.
13. Remove the half shafts from the steering knuckles.
14. Support the front shock modules and steering knuckles to the frame using mechanics wire.
15. Place a brass drift against the tripot housing of the left half shaft and remove the shaft from the differential carrier by striking the drift with a hammer.
16. Place a brass drift against the tripot housing of the right half shaft and remove the shaft from the clutch fork housing by striking the drift with a hammer.
17. Remove the half shafts from the vehicle.

To Install:

1. Install the left half shaft into the differential carrier.
2. Install the right half shaft into the clutch fork housing.
3. Remove the wiring supporting the shock modules and steering knuckles to the frame.
4. Install the half shafts into the steering knuckles.
5. Install the shock modules into the shock towers.
6. Install the steering knuckles onto the upper control arms.
7. Install the nut and bolt into the upper ball joints pinches.
8. Install the upper shock module retaining nuts onto the shock towers.
9. Install the retaining nuts onto the half shafts. Torque the nuts to **103 ft-lb (140 Nm)**.
10. Install the tie rod ends onto the steering knuckles.
11. Install the stabilizer bar link onto the lower control arm.
12. Attach the front brake hose retainers to the wheel wells.
13. Attach the wheel speed sensor harnesses to the wheel wells.
14. Connect the wheel speed sensor connectors.
15. Install the engine protection shield under the frame.
16. Install the front wheels onto the vehicle.
17. Lower the vehicle.

CV-Joints

Overhaul

These vehicles use several different types of joints. Engine size, transaxle type, whether the joint is an inboard or outboard joint, even which side of the vehicle is being serviced could make a difference in joint type. Be sure to properly identify the joint before attempting joint or boot replacement. Look for identification numbers at the large end of the boots and/or on the end of the metal retainer bands.

The 3 types of joints used are the Birfield Joint, (B.J.), the Tripod Joint (T.J.) and the Double Offset Joint (D.O.J.).

NOTE: Do not disassemble a Birfield joint. Service with a new joint or clean and repack using a new boot kit.

The distance between the large and small boot bands is important and should be checked prior to and after boot service. This is so the boot will not be installed either too loose or too tight, which could cause early wear and cracking, allowing the grease to get out and water and dirt in, leading to early joint failure.

NOTE: The driveshaft joints use special grease; do not add any grease other than that supplied with the kit.

Removal & Installation

Double Offset Joint

To Remove:

NOTE: The Double Offset Joint (D.O.J.) is bigger than other joints and, in these applications, is normally used as an inboard joint.

1. Remove the halfshaft from the vehicle.
2. Side cutter pliers can be used to cut the metal retaining bands. Remove the boot from the joint outer race.
3. Locate and remove the large circlip at the base of the joint. Remove the outer race (the body of the joint).
4. Remove the small snap ring and take off the inner race, cage and balls as an assembly. Clean the inner race, cage and balls without disassembling.
5. If the boot is to be reused, wipe the grease from the splines and wrap the splines in vinyl tape before sliding the boot from the shaft.
6. Remove the inner (D.O.J.) boot from the shaft. If the outer (B.J.) boot is to be replaced, remove the boot retainer rings and slide the boot down and off of the shaft at this time.

To Install:

NOTE: Be sure to tape the shaft splines before installing the boots. Fill the inside of the boot with the specified grease. Often the grease supplied in the replacement parts kit is meant to be divided in half, with half being used to lubricate the joint and half being used inside the boot.

1. Install the cage onto the halfshaft so the small diameter side of the cage is installed first. With a brass drift pin, tap lightly and evenly around the inner race to install the race until it comes into contact with the rib of the shaft. Apply the specified grease to the inner race and cage and fit them together. Insert the balls into the cage.
2. Install the outer race (the body of the joint) after filling with the specified grease. The outer race should be filled with this grease.
3. Tighten the boot bands securely. Make sure the distance between the boot bands is correct.
4. Install the halfshaft to the vehicle.

Except Double Offset Joint

To Remove:

1. Disconnect the negative battery cable. Remove the halfshaft.
2. Use side cutter pliers to remove the metal retaining bands from the boot(s) that will be removed. Slide the boot from the T.J. case.
3. Remove the snap ring and the tripod joint spider assembly from the halfshaft. Do not disassemble the spider and use care in handling.

4. If the boot is to be reused, wrap vinyl tape around the spline part of the shaft so the boot(s) will not be damaged when removed. Remove the dynamic damper, if used, and the boots from the shaft.

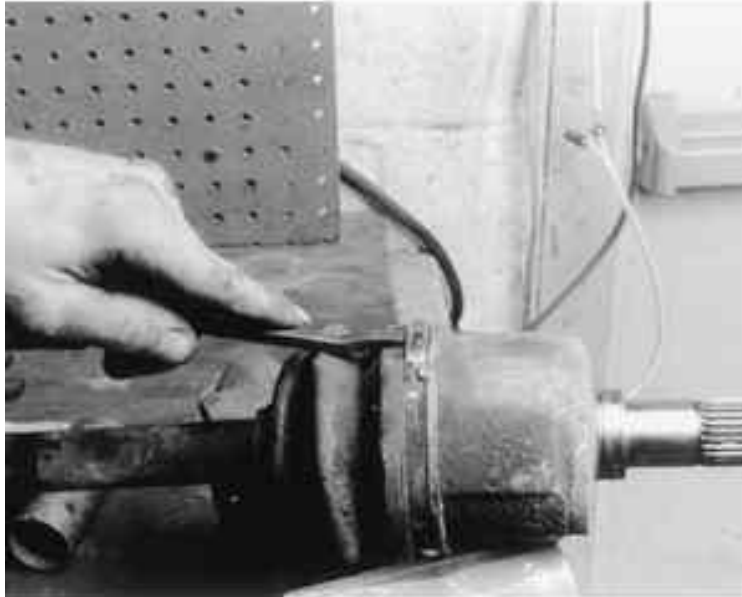
To Install:

1. Double check that the correct replacement parts are being installed. Wrap vinyl tape around the splines to protect the boot and install the boots and damper, if used, in the correct order.
2. Install the joint spider assembly to the shaft and install the snap ring.
3. Fill the inside of the boot with the specified grease. Often the grease supplied in the replacement parts kit is meant to be divided in half, with half being used to lubricate the joint and half being used inside the boot. Keep grease off the rubber part of the dynamic damper (if used).
4. Secure the boot bands with the halfshaft in a horizontal position. Make sure distance between boot bands is correct.
5. Install the halfshaft to the vehicle and reconnect the negative battery cable.

Check the CV-boot for wear



Removing the outer band from the CV-boot



Removing the inner band from the CV-boot



Removing the CV-boot from the joint housing



Clean the CV-joint housing prior to removing boot



Removing the CV-joint housing assembly



Removing the CV-joint



Inspecting the CV-joint housing



Removing the CV-joint outer snap ring



Checking the CV-joint snap ring for wear



CV-joint snap ring (typical)



Removing the CV-joint assembly



Removing the CV-joint inner snap ring



Installing the CV-joint assembly (typical)



STEERING AND SUSPENSION

Precautions

Before servicing any vehicle, please be sure to read all of the following precautions, which deal with personal safety, prevention of component damage and important points to take into consideration when servicing a motor vehicle:

- Always wear safety goggles or some type of eye/face protection when working with, around or under a vehicle.
- Be extremely careful while working on an operating engine, make sure you have no dangling jewelry, extremely loose clothes, power tool cords or other items that could get caught in any moving engine part.
- Never open, service or drain the radiator or cooling system when the engine is hot; serious burns can occur from the steam and hot coolant.
- Observe all applicable safety precautions when working around fuel. Whenever servicing the fuel system, always work in a well-ventilated area. Do not allow fuel spray or vapors to come in contact with a spark, open flame, or excessive heat (a hot drop light, for example). Keep a dry chemical fire extinguisher near the work area. Always keep fuel in a container specifically designed for fuel storage; also, always properly seal fuel containers to avoid the possibility of fire or explosion. Refer to the additional fuel system precautions later in this section.
- Fuel injection systems often remain pressurized, even after the engine has been turned OFF. The fuel system pressure must be relieved before disconnecting any fuel lines. Failure to do so may result in fire and/or personal injury.
- The EPA warns that prolonged contact with used engine oil may cause a number of skin disorders, including cancer! You should make every effort to minimize your exposure to used engine oil. Protective gloves should be worn when changing oil. Wash your hands and any other exposed skin areas as soon as possible after exposure to used engine oil. Soap and water, or waterless hand cleaner should be used.
- Never operate the engine without the proper amount and type of engine oil; doing so WILL result in severe engine damage.
- Brake fluid often contains polyglycol ethers and polyglycols. Avoid contact with the eyes and wash your hands thoroughly after handling brake fluid. If you do get brake fluid in your eyes, flush your eyes with clean, running water for 15 minutes. If eye irritation persists, or if you have taken brake fluid internally, IMMEDIATELY seek medical assistance.
- Timing belt maintenance is extremely important! Many models utilize an interference-type, non-freewheeling engine. If the timing belt breaks, the valves in the cylinder head may strike the pistons, causing potentially serious (also time-consuming and expensive) engine damage. Refer to the maintenance interval charts in the front of this manual for the recommended replacement interval for the timing belt and to the timing belt section for belt replacement and inspection.
- Disconnecting the negative battery cable on some vehicles may interfere with the functions of the on-board computer system(s) and may require the computer to undergo a relearning process once the negative battery cable is reconnected.

WARNING

To avoid accidental deployment and possible personal injury, the backup power supply must be depleted before repairing or replacing any front or side air bag supplemental restraint system (SRS) components and before servicing, replacing, adjusting or striking components near the front or side air bag sensors, such as doors, instrument panel, console, door latches, strikers, seats and hood latches.

WARNING

Always wear safety glasses when repairing an air bag supplemental restraint system (SRS) vehicle and when handling an air bag module. This will reduce the risk of injury in the event of an accidental deployment.

WARNING

Never probe the connectors on the air bag module or any air bag components. Doing so can result in air bag deployment, which can result in personal injury.

Cleanliness and Care, Shop Practice

- It should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

General Information

The air bag supplemental restraint system (SRS) is designed to provide increased collision protection for front seat occupants in addition to that provided by the 3-point safety belt system. The SRS will also provide increased collision protection for the rear occupants when equipped with optional safety canopy modules. Safety belt use is necessary to obtain the best occupant protection and to receive the full advantage of the SRS.

Many vehicles contain dual-stage deployment (advanced restraint system) driver and front passenger air bag modules. Many vehicles are also equipped with optional safety canopy modules.

Vehicles equipped with safety canopy modules are also equipped with seat side air bag modules. Safety canopy modules deploy from the headliner, protecting the first and second row outboard occupants or first, second and third row outboard occupants during a side impact or if a rollover condition is detected. Seat side air bag modules deploy from the outboard front seat backrest upon a side impact.

The front impact severity sensors are located on the radiator support bracket near the front headlamp assemblies.

The first row side impact sensors (if equipped) are located at or near the base of the B-pillars.

The second row side impact sensors (if equipped) are located near the C-pillars.

Steering

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

WARNING

Most vehicles are equipped with an air bag system, also known as the Supplemental Inflatable Restraint (SIR) system or Supplemental Restraint System (SRS). The system must be disabled before performing service on or around system components, steering column, instrument panel components, wiring and sensors. Failure to follow safety and disabling procedures could result in accidental air bag deployment, possible personal injury and unnecessary system repairs.

CAUTION

Many systems require special tools or equipment to service the (SIR/SRS) system. If you are unfamiliar with these systems or do not have the proper training and equipment you should not attempt to remove or disconnect the (SIR/SRS) components.

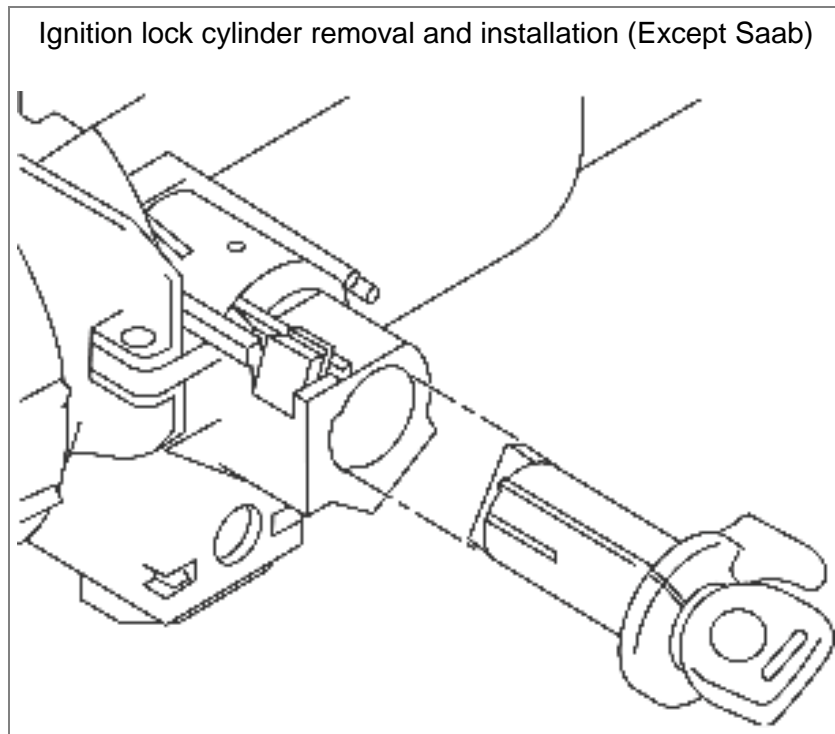
Ignition Lock Cylinder

Removal & Installation

Except Saab

To Remove:

1. Disable the SIR system by disconnecting the negative battery cable.
2. Remove the left insulator panel and knee bolster from under the instrument panel (I/P).
3. Remove the trim covers from the steering column.
4. Use the key to turn the ignition switch to run.
5. Release the ignition lock cylinder locking tab by inserting an allen wrench into the hole on the top of the ignition lock cylinder housing and pushing down.



6. Remove the ignition lock cylinder from the ignition lock cylinder housing.

To Install:

1. Install the key into the ignition lock cylinder.
2. Use a screwdriver to turn the ignition lock cylinder housing gear clockwise to the start position, let the spring return it to the run position.
3. Install the ignition lock cylinder into the ignition lock cylinder housing.
4. Install the trim covers onto the steering column.
5. Install the left insulator panel and knee bolster under the instrument panel (I/P).
6. Connect the negative battery cable.

Ignition Switch

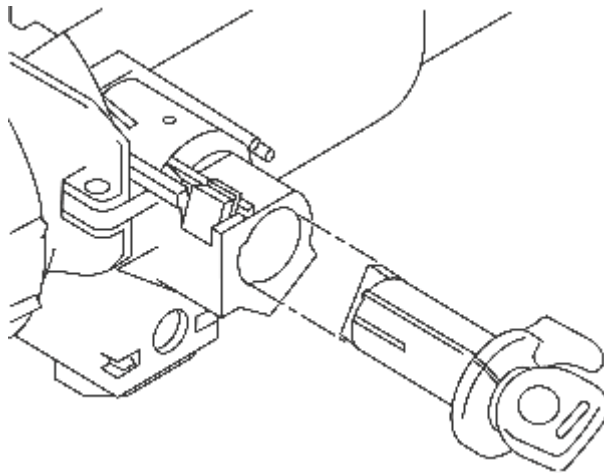
Removal & Installation

Except Saab

To Remove:

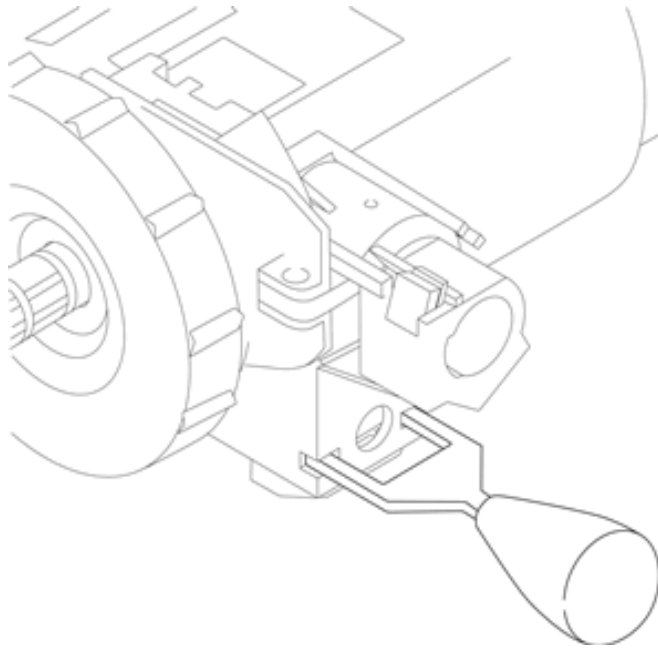
1. Disable the SIR system by disconnecting the negative battery cable.
2. Remove the left insulator panel and knee bolster from under the instrument panel (I/P).
3. Remove the trim covers from the steering column.
4. Release the ignition lock cylinder locking tab by inserting an allen wrench into the hole on the top of the ignition lock cylinder housing and pushing down.
- 5.

Ignition lock cylinder removal and installation (Except Saab)



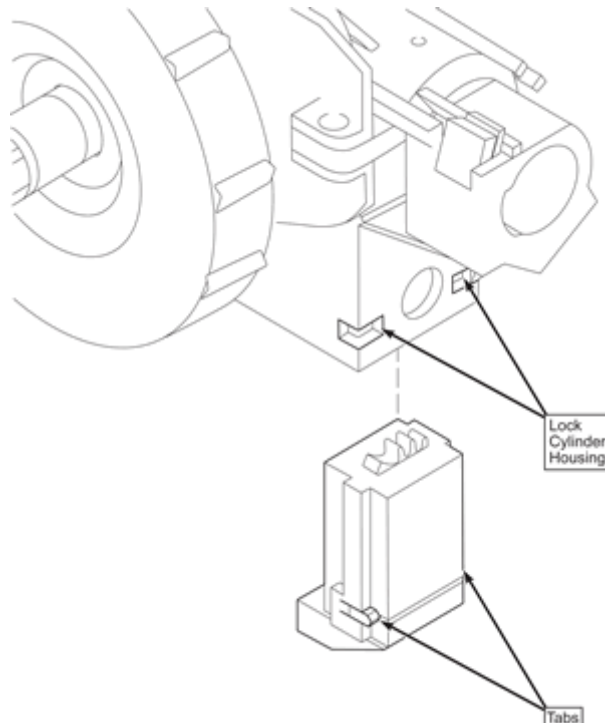
6. Remove the ignition lock cylinder from the ignition lock cylinder housing.
7. Disconnect the passlock and key buzzer from the ignition lock cylinder housing.

Use the special tool to release the tabs on the ignition switch



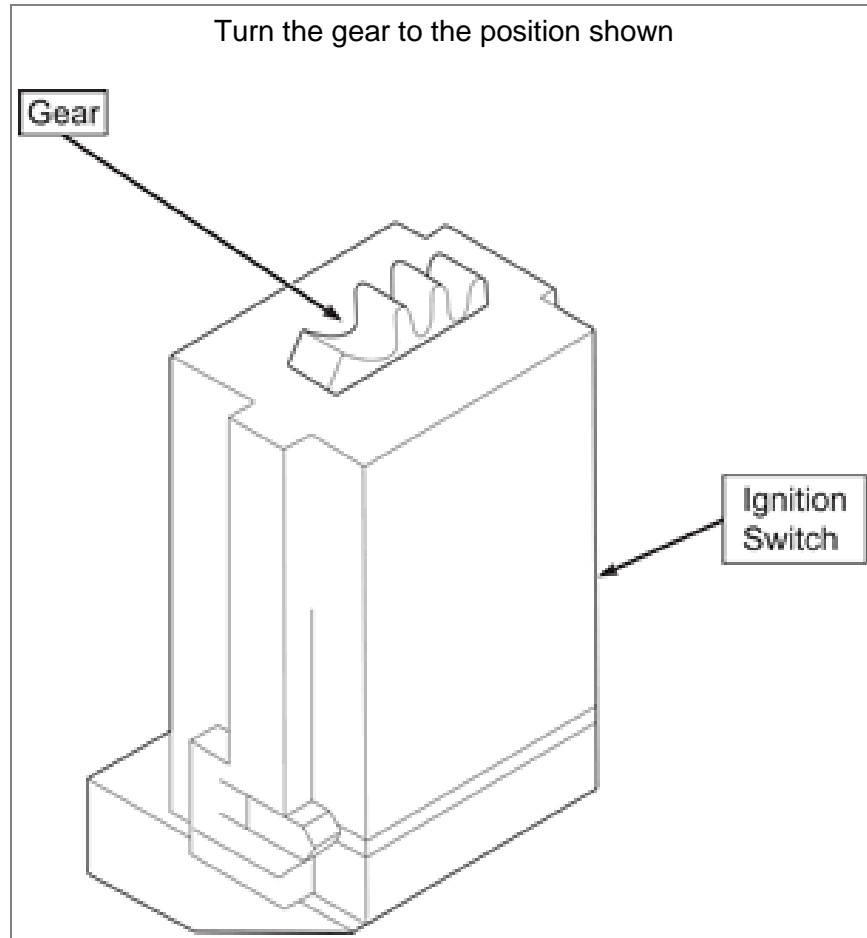
8. Release the ignition switch tabs by inserting a J 42759 ignition switch connector release tool into the ignition lock cylinder housing.

Ignition switch removal/installation



9. Remove the ignition switch from the ignition lock cylinder housing.
10. Disconnect the ignition switch connector.

To Install:



1. Turn the ignition switch gear until it is in the position shown above.
2. Use a screwdriver to rotate the ignition lock cylinder housing gear counterclockwise until it hits a stop.
3. Connect the ignition switch connector.
4. Install the ignition switch into the ignition lock cylinder housing.
5. Install the trim covers onto the steering column.
6. Install the left insulator panel and knee bolster under the instrument panel (I/P).
7. Connect the negative battery cable.

Turn Signal/Multifunction Switch

Removal & Installation

To Remove:

1. Disable the SIR system by disconnecting the negative battery cable.
2. Remove the trim covers from the steering column.
3. Tilt the steering column to the center position.
4. Disconnect the turn signal/multifunction switch connectors.
5. Detach the turn signal/multifunction switch from the steering column.

To Install:

1. Attach the turn signal/multifunction switch to the steering column. Torque the top screw to **27 in-lb (3 Nm)**. Torque the side screw to **62 in-lb (7 Nm)**.
2. connect the turn signal/multifunction switch connectors.
3. Install the trim covers onto the steering column.
4. Connect the negative battery cable.

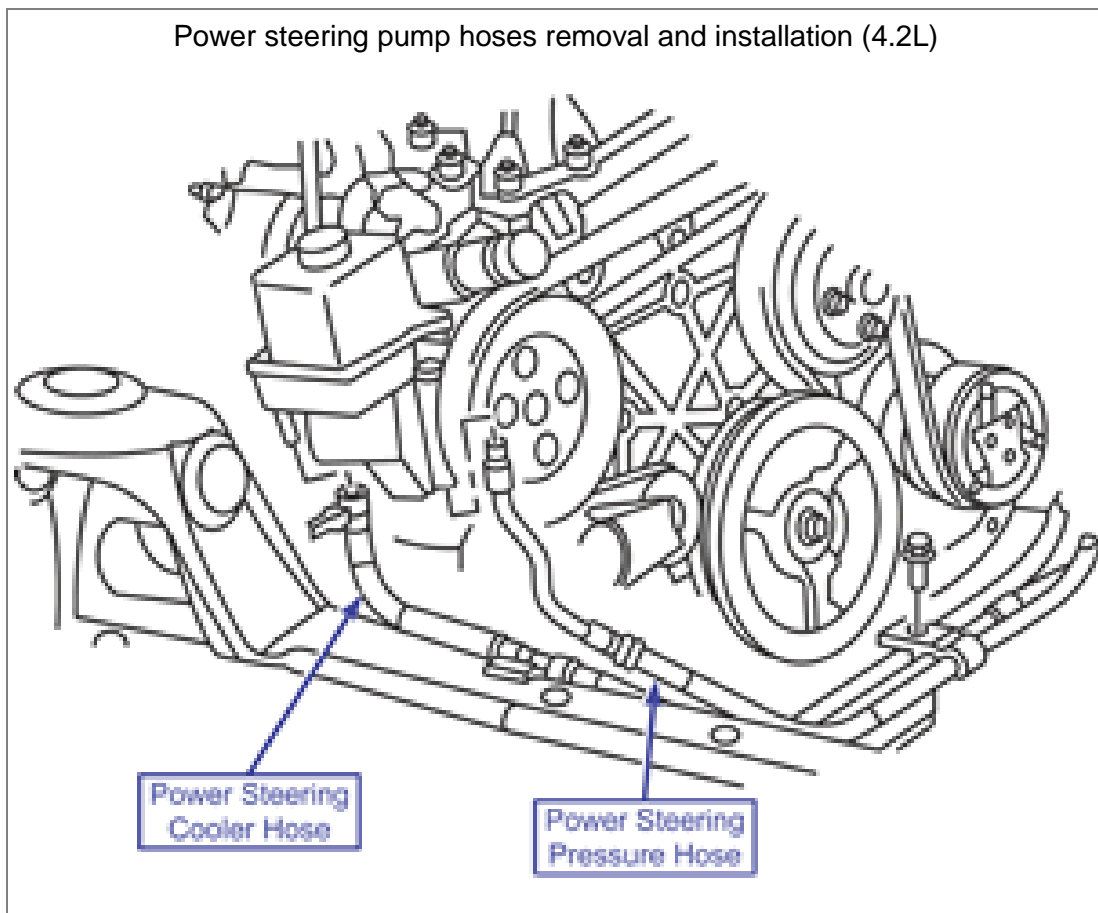
Power Steering Pump

Removal & Installation

4.2L Engine

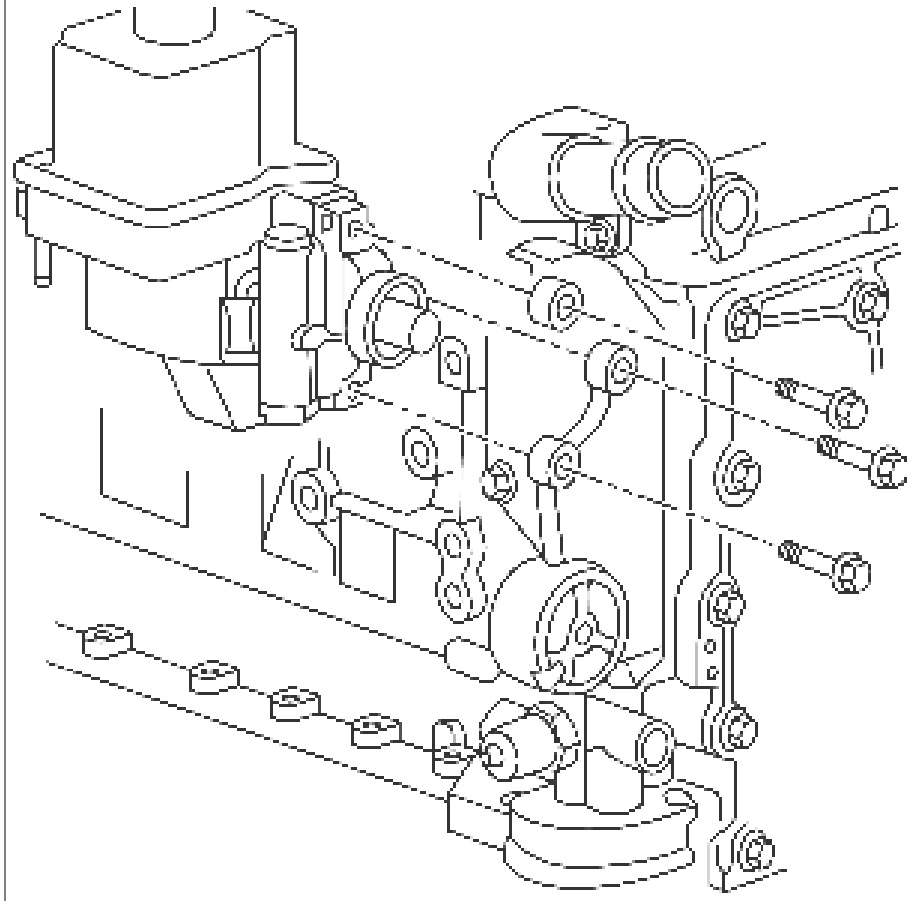
To Remove:

1. Remove the air cleaner assembly from the engine compartment.
2. Remove the drive belt from the pulleys.
3. Place a drain pan under the vehicle.



4. Disconnect the power steering pressure and cooler hoses from the power steering pump.
5. Detach the wiring harness from the power steering pump.

Power steering pump removal and installation (4.2L)



6. Detach the power steering pump from the engine.
7. Remove the power steering pump pulley from the power steering pump.

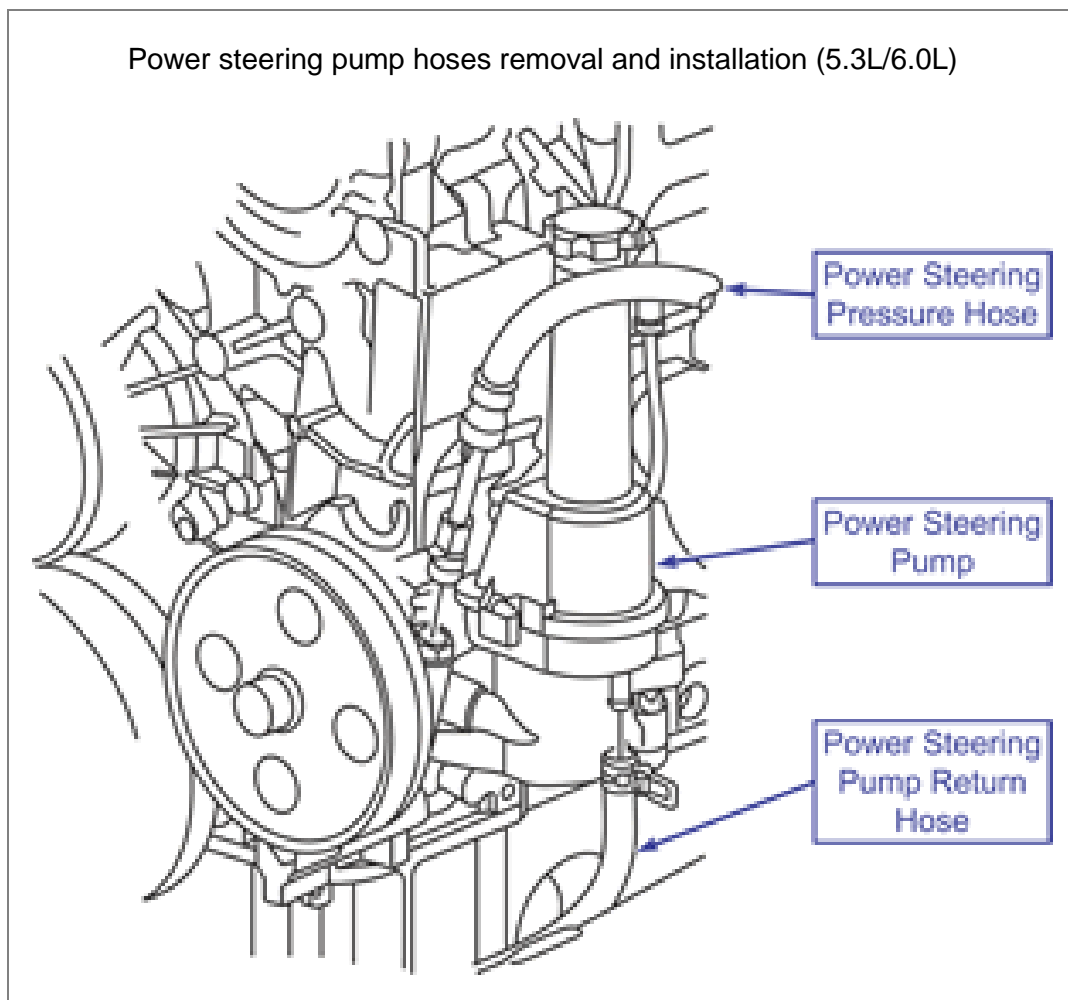
To Install:

1. Install the power steering pump pulley onto the power steering pump.
2. Attach the power steering pump to the engine. Torque the bolts to **18 ft-lb (25 Nm)**.
3. Connect the power steering pressure and cooler hoses to the power steering pump. Torque the hose fittings to **18 ft-lb (25 Nm)**.
4. Remove the drain pan from under the vehicle.
5. Install the drive belt onto the pulleys.
6. Bleed the power steering system.
7. Check the power steering hoses for leaks and clearance.
8. Install the air cleaner assembly into the engine compartment.

5.3L & 6.0L Engines

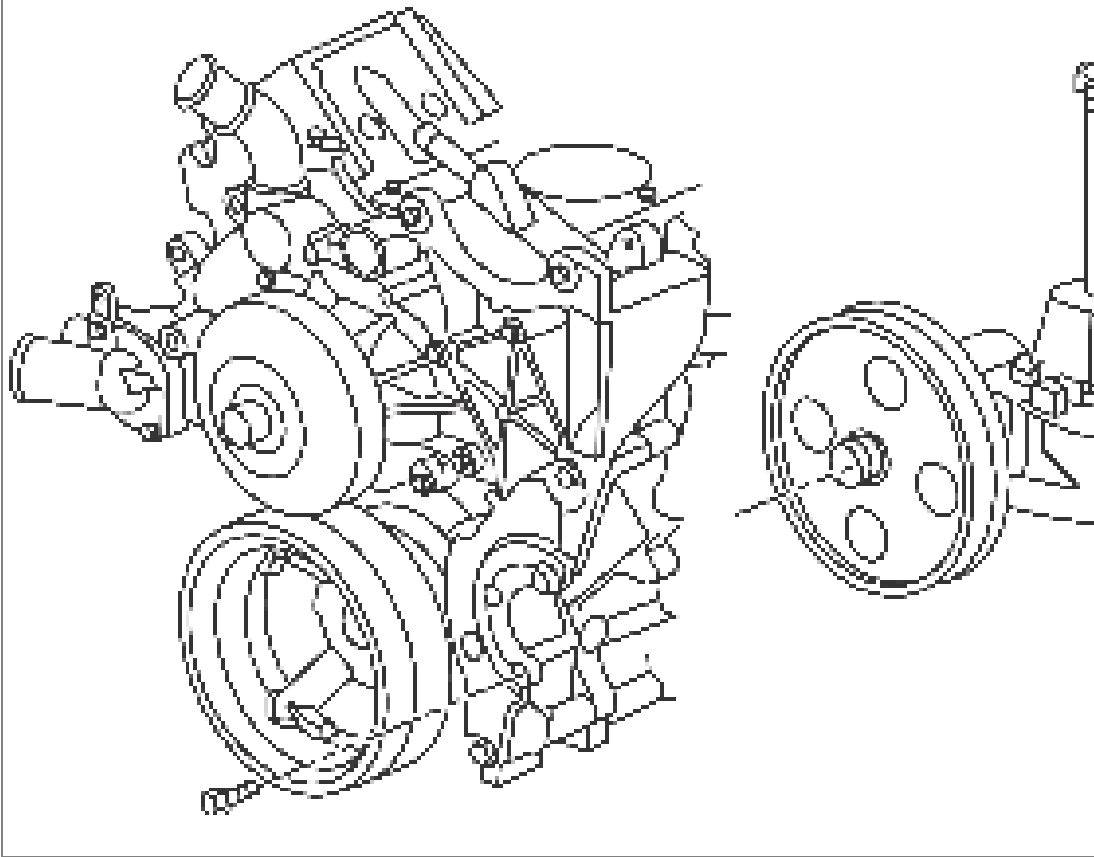
To Remove:

1. Remove the drive belt from the pulleys.
2. For 2005-2007 vehicles, remove the engine control module (ECM) from the mounting bracket and set aside.
3. For 2003-2004 vehicles, remove the powertrain control module (PCM) from the mounting bracket and set aside.
- 4.



5. Disconnect the power steering pressure and pump return hoses from the power steering pump.

Power steering pump removal and installation (5.3L/6.0L)



6. Detach the power steering pump from the engine.
7. Remove the power steering pump pulley from the power steering pump.

To Install:

1. Install the power steering pump pulley onto the power steering pump.
2. Attach the power steering pump to the engine. Torque the bolts to **18 ft-lb (25 Nm)**.
3. Connect the power steering pressure and cooler hoses from the power steering pump. Torque the hose fittings to **18 ft-lb (25 Nm)**.
4. For 2003 through 2004 vehicles, install the powertrain control module (PCM) onto the mounting bracket.
5. For 2005 through 2007 vehicles, install the engine control module (ECM) onto the mounting bracket.
6. Install the drive belt onto the pulleys.
7. Bleed the power steering system.

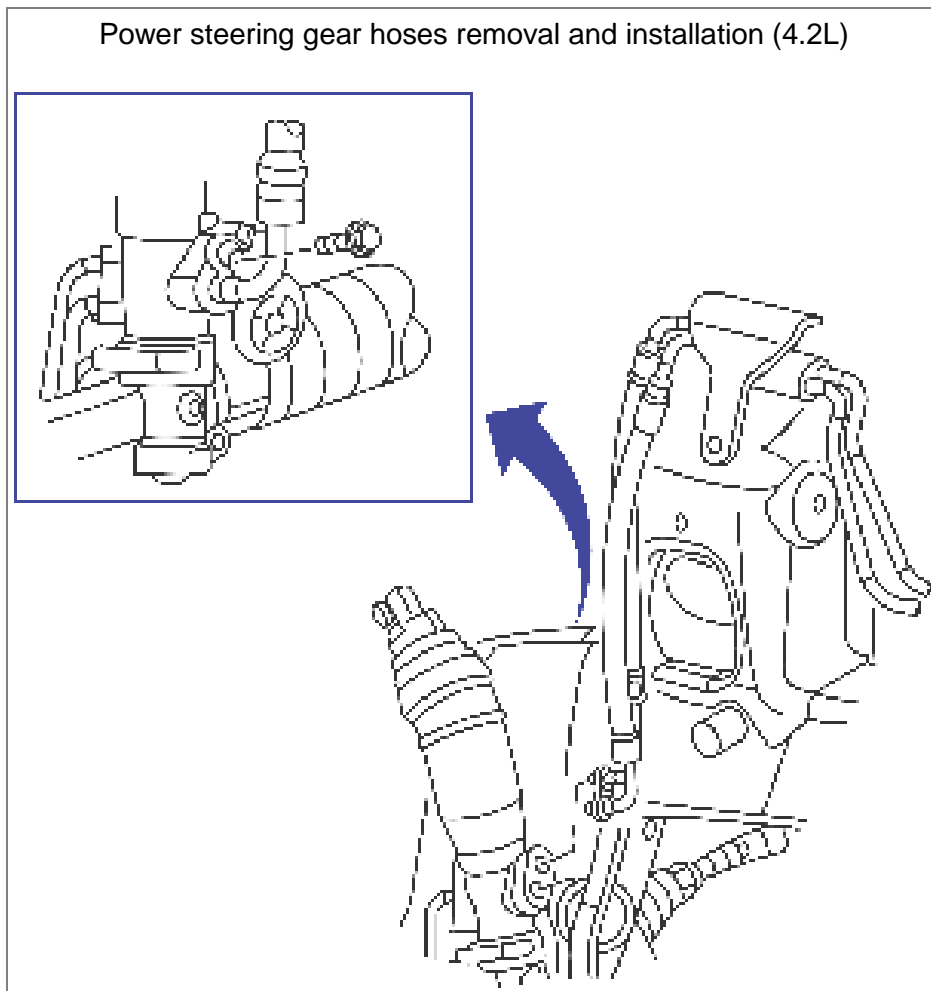
Power Steering Hose Assembly

Removal & Installation

4.2L Engine

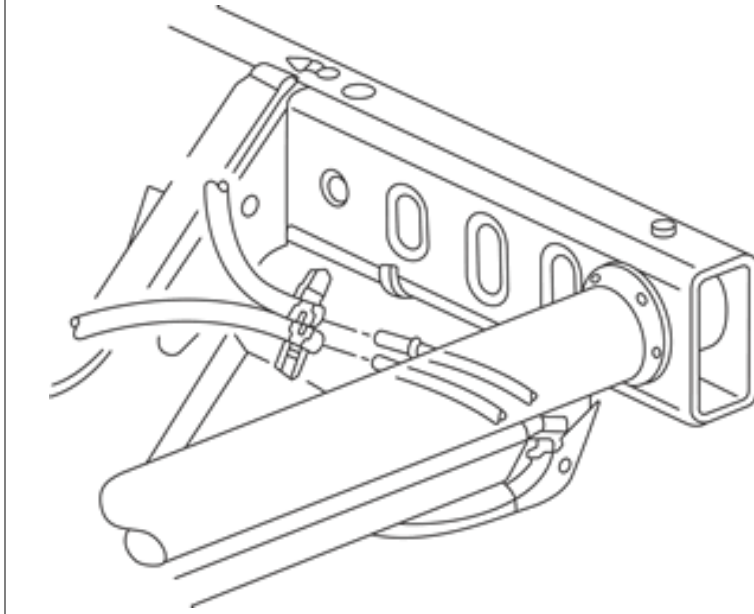
To Remove:

1. Lift the vehicle.
2. Remove the engine protection shield from under the frame.
3. Place a drain pan under the vehicle.



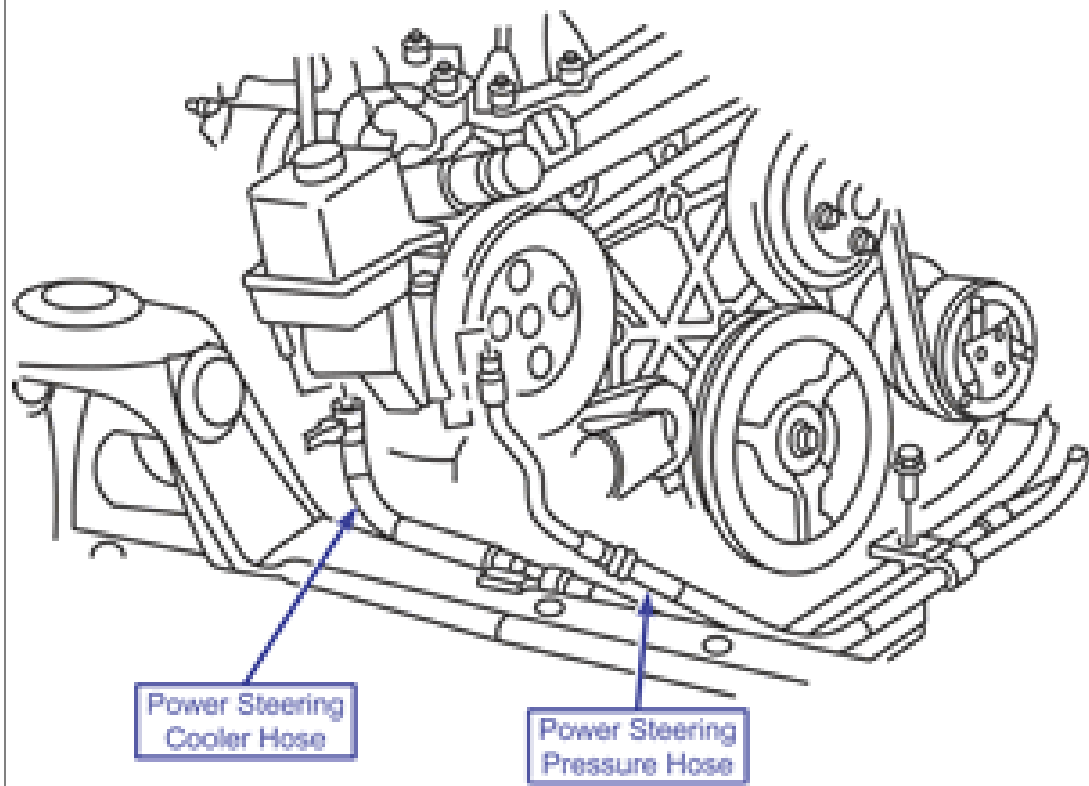
4. Detach the power steering hose assembly from the power steering gear.

Power steering cooler hoses removal and installation

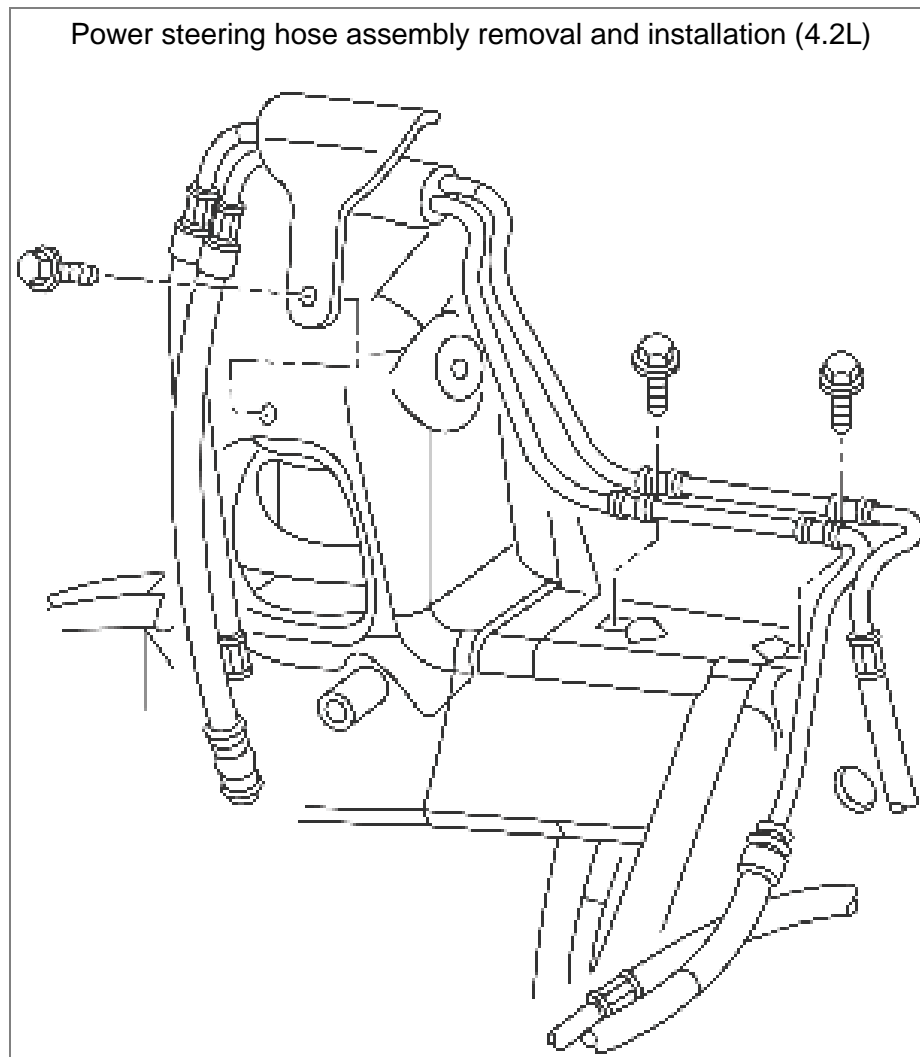


5. Disconnect the power steering return and cooler hoses from the power steering cooler.

Power steering pump hoses removal and installation (4.2L)

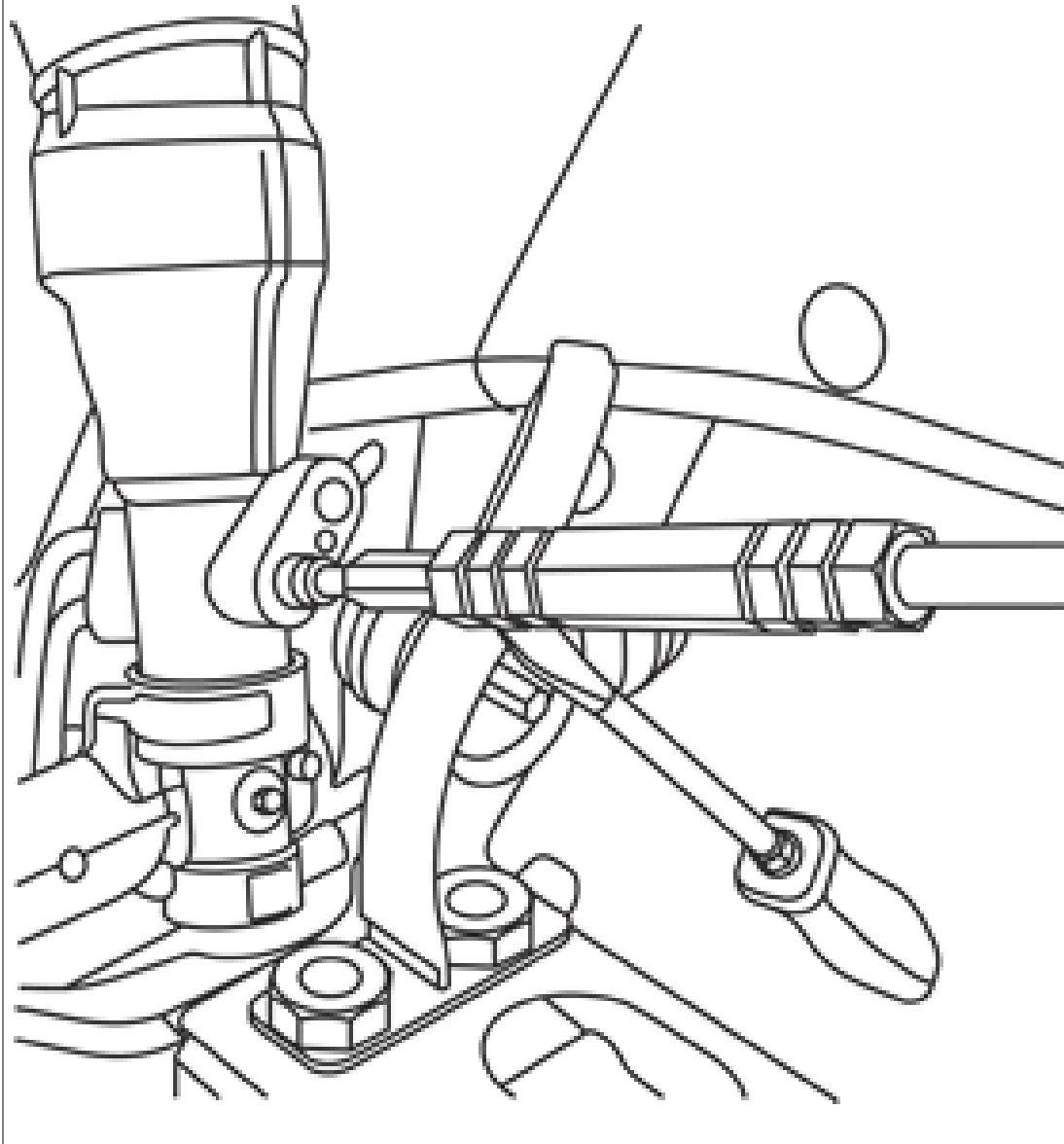


6. Disconnect the power steering pressure and cooler hoses from the power steering pump.
7. Lower the vehicle.
8. Detach the power steering hose assembly from the front crossmember.
9. Remove the battery and battery tray from the vehicle.
10. Remove the underhood fuse block cover.
11. Detach the negative battery cable from the fender and fuse block.
12. Detach the positive battery cable from the fuse block.
13. Disconnect the fuse block connectors from the fuse block and bracket.
14. Remove the fuse block harnesses from the wiring loops.
15. Detach the wiring harness from the fender.
16. Detach the upper fuse block from the lower fuse block and set it on the engine.



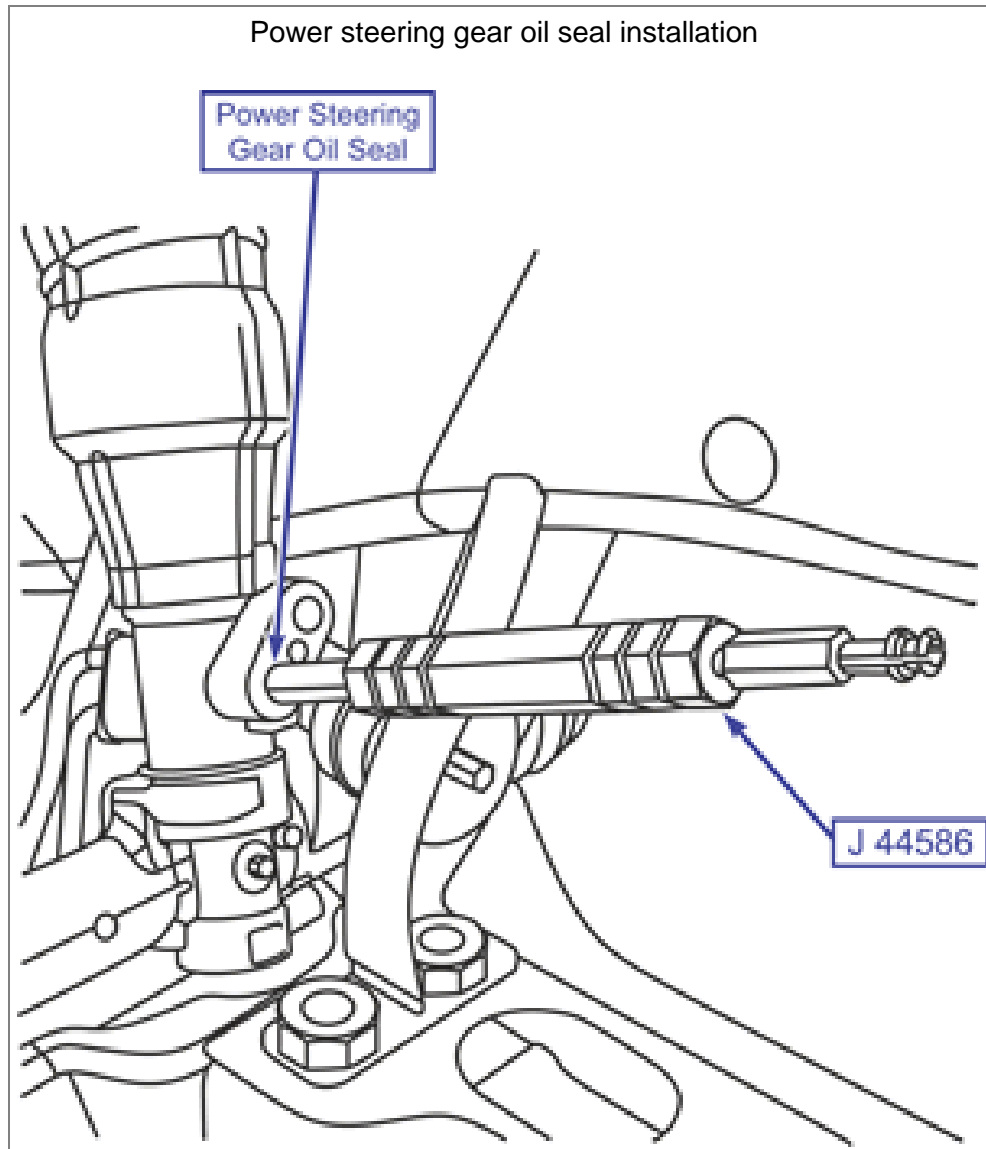
17. Detach the power steering hose assembly from the wheel well and frame.
18. Remove the power steering hose assembly from the engine compartment.
19. Lift the vehicle.
20. Thoroughly clean the power steering gear inlet and outlet ports of any debris.

Power steering gear oil seal removal



21. Use the removal end of a J 44586 power steering gear oil seal remover/installer and a flat head screwdriver to remove the power steering gear oil seal from the power steering gear. Discard the seal.

To Install:



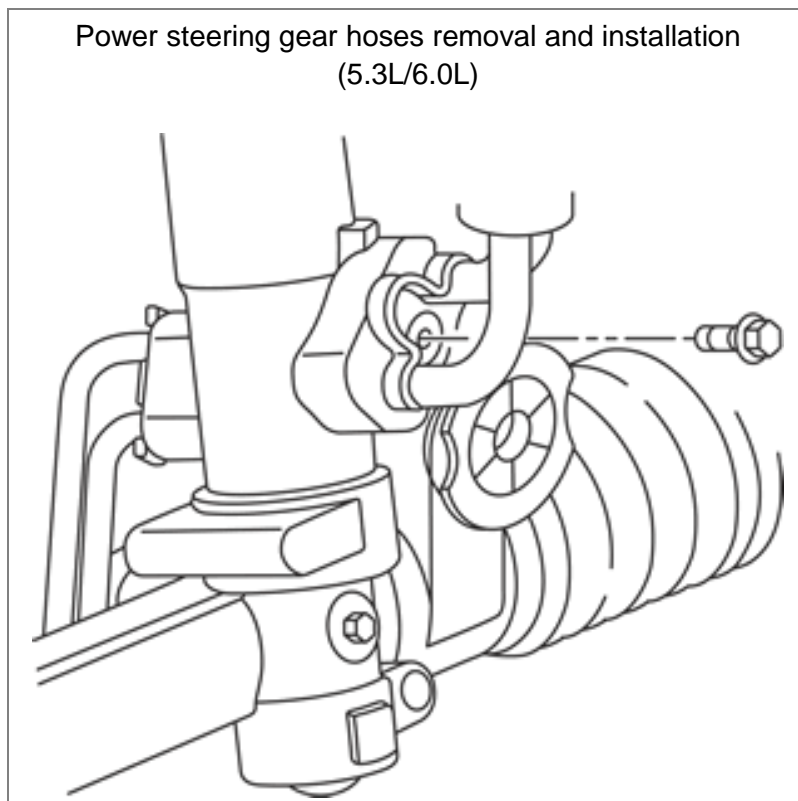
1. Use the installation end of a J 44586 power steering gear oil seal remover/installer to install a new power steering gear oil seal into the power steering gear.
2. Lower the vehicle.
3. Place the power steering hose assembly into the engine compartment.
4. Attach the power steering hose assembly to the frame. Torque the bolts to **89 in-lb (10 Nm)**.
5. Attach the power steering hose assembly to the wheel well. Torque the bolts to **89 in-lb (10 Nm)**.
6. Attach the upper fuse block to the lower fuse block. Torque the bolts to **53 in-lb (6 Nm)**.
7. Attach the wiring harness to the fender.
8. Install the fuse block harnesses into the wiring loops.
9. Connect the fuse block connectors to the fuse block and bracket.
10. Attach the positive battery cable to the fuse block.

11. Attach the negative battery cable to the fender and fuse block.
12. Install the underhood fuse block cover.
13. Install the battery and battery tray into the vehicle.
14. Attach the power steering hose assembly to the front crossmember. Torque the bolt to **89 in-lb (10 Nm)**.
15. Lift the vehicle.
16. Connect the power steering pressure and cooler hoses to the power steering pump. Torque the hose fittings to **18 ft-lb (25 Nm)**.
17. Connect the power steering return and cooler hoses to the power steering cooler.
18. Attach the power steering hose assembly to the power steering gear.
19. Remove the drain pan from under the vehicle.
20. Install the engine protection shield under the frame.
21. Lower the vehicle.
22. Bleed the power steering system.

5.3L & 6.0L Engines

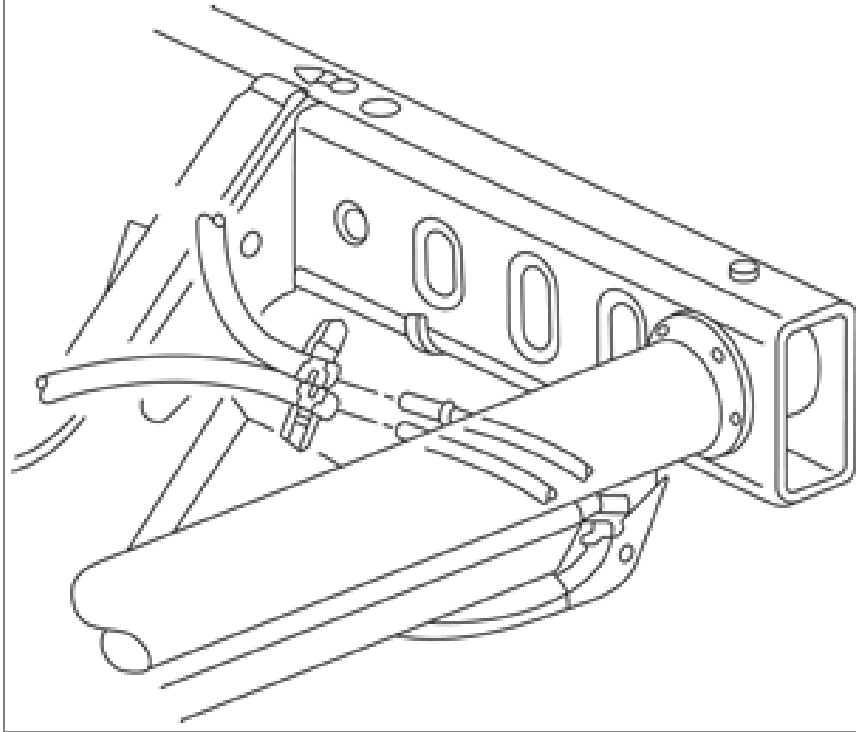
To Remove:

1. Lift the vehicle.
2. Place a drain pan under the vehicle.



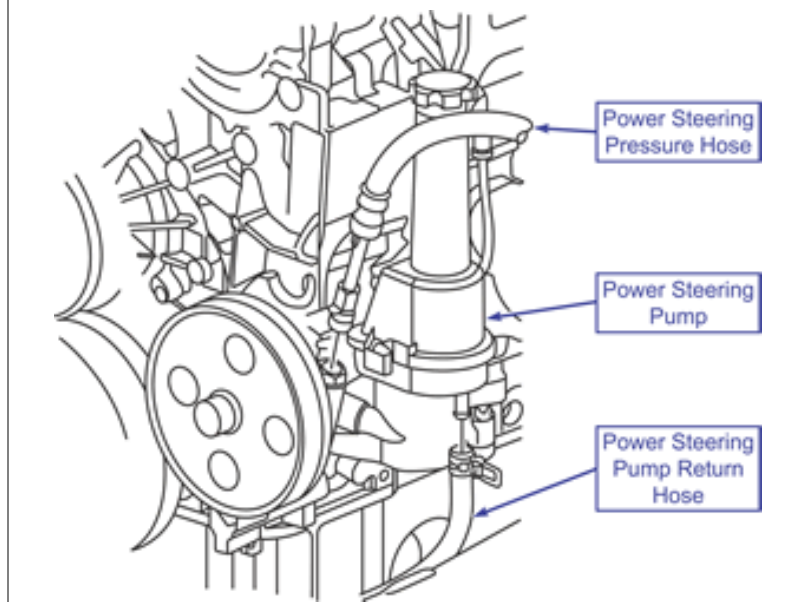
3. Detach the power steering hose assembly from the power steering gear.

Power steering cooler hoses removal and installation

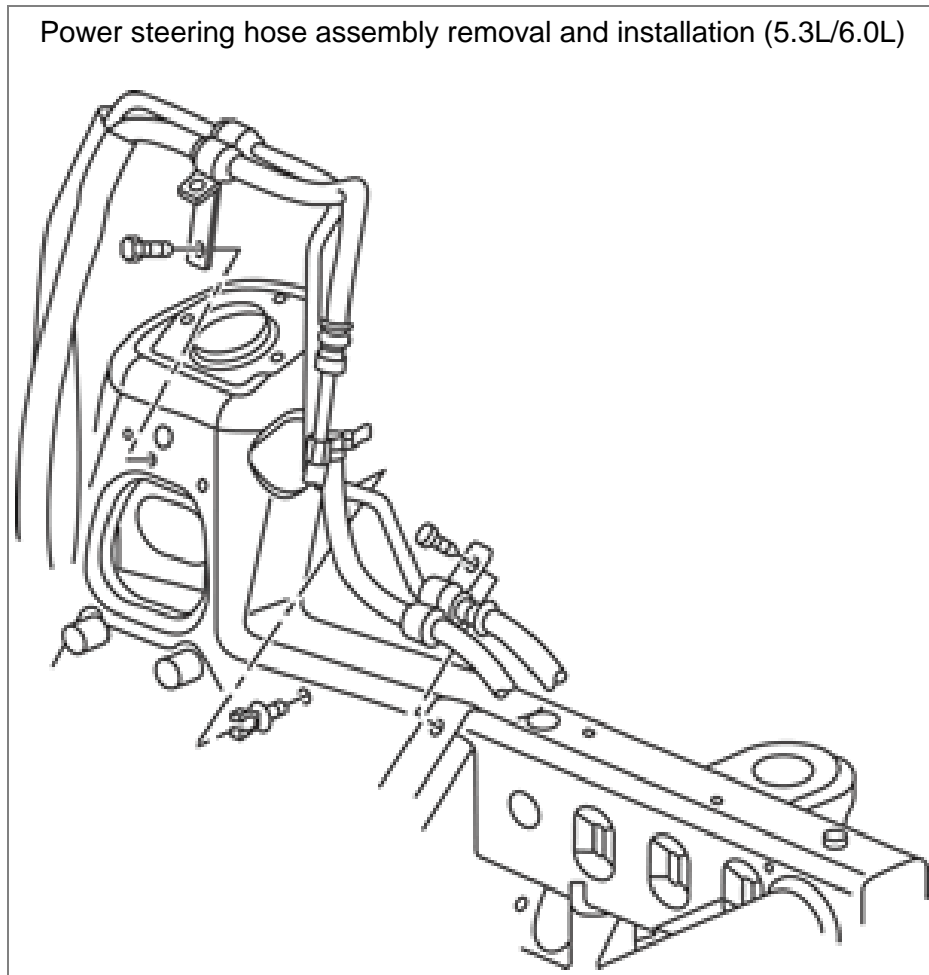


4. Disconnect the power steering return and cooler hoses from the power steering cooler.
5. Lower the vehicle.

Power steering pump hoses removal and installation (5.3L/6.0L)

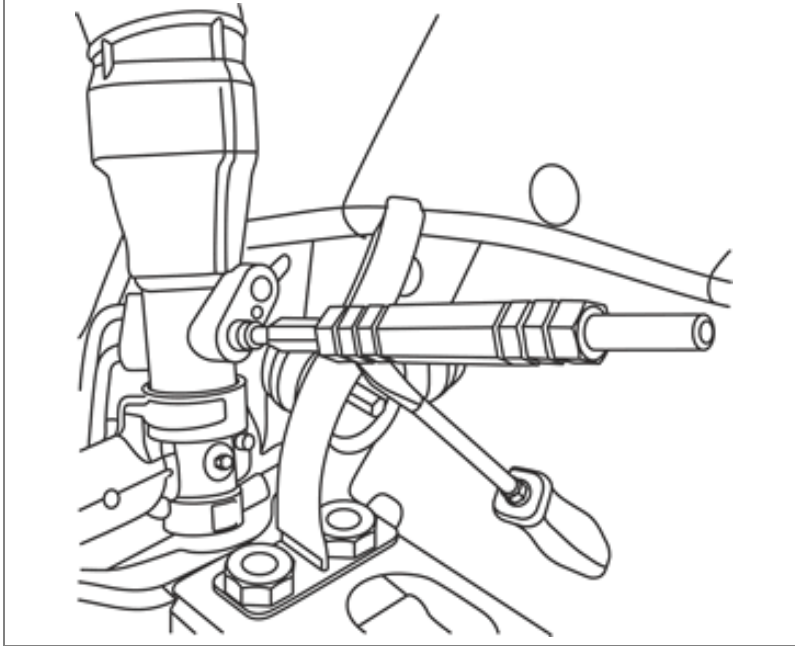


6. Disconnect the power steering pressure and pump return hoses from the power steering pump.
7. For 2003 through 2004 vehicles, remove the powertrain control module (PCM) from the mounting bracket and set it aside.
8. For 2005 through 2007 vehicles, remove the engine control module (ECM) from the mounting bracket and set it aside.



9. Detach the power steering hose assembly from the frame.
10. Remove the power steering hose assembly from the engine compartment.
11. Lift the vehicle.
12. Thoroughly clean the power steering gear inlet and outlet ports of any debris.

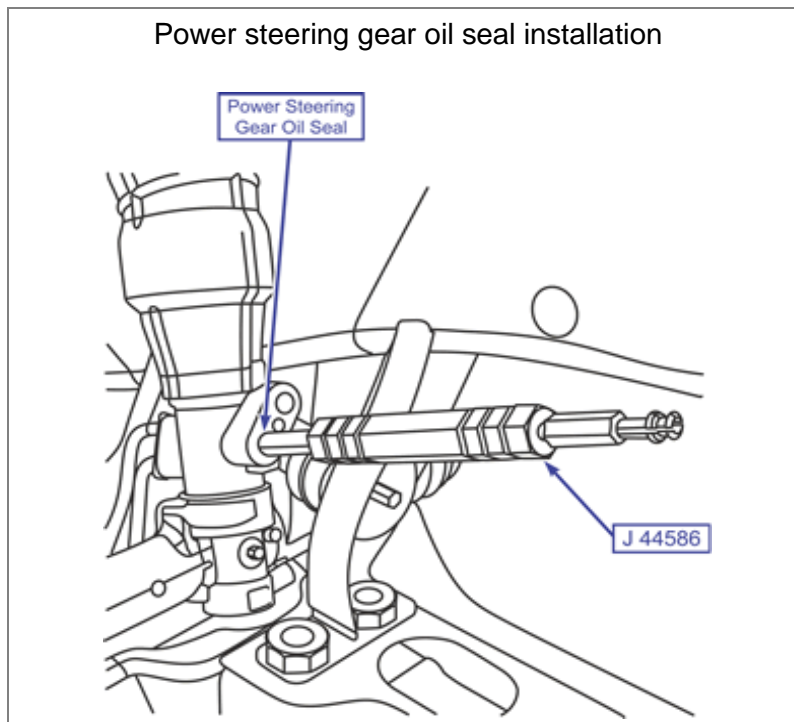
Power steering gear oil seal removal



13. Use the removal end of a J 44586 power steering gear oil seal remover/installer and a flat head screwdriver to remove the power steering gear oil seal from the power steering gear. Discard the seal.

To Install:

Power steering gear oil seal installation



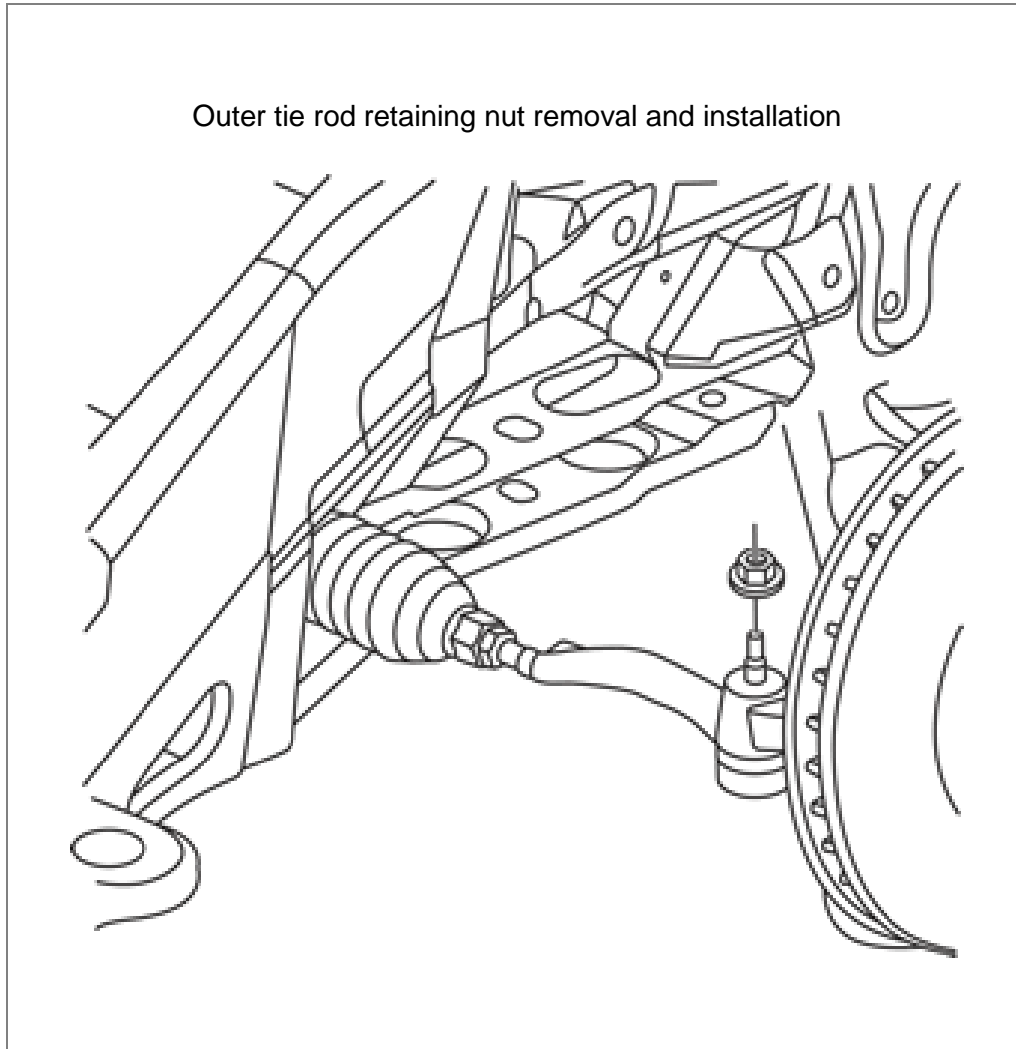
1. Use the installation end of a J 44586 power steering gear oil seal remover/installer to install a new power steering gear oil seal into the power steering gear.
2. Lower the vehicle.
3. Place the power steering hose assembly into the engine compartment.
4. Attach the power steering hose assembly to the frame. Torque the bolts to **89 in-lb (10 Nm)**.
5. Connect the power steering pressure and pump return hoses from the power steering pump. Torque the hose fittings to **18 ft-lb (25 Nm)**.
6. For 2003 through 2004 vehicles, install the powertrain control module (PCM) onto the mounting bracket.
7. For 2005 through 2007 vehicles, install the engine control module (ECM) onto the mounting bracket.
8. Lift the vehicle
9. Connect the power steering return and cooler hoses to the power steering cooler.
10. Attach the power steering hose assembly to the power steering gear. Torque the bolt to **106 in-lb (12 Nm)**.
11. Remove the drain pan from under the vehicle.
12. Lower the vehicle.

Steering Gear

Removal & Installation

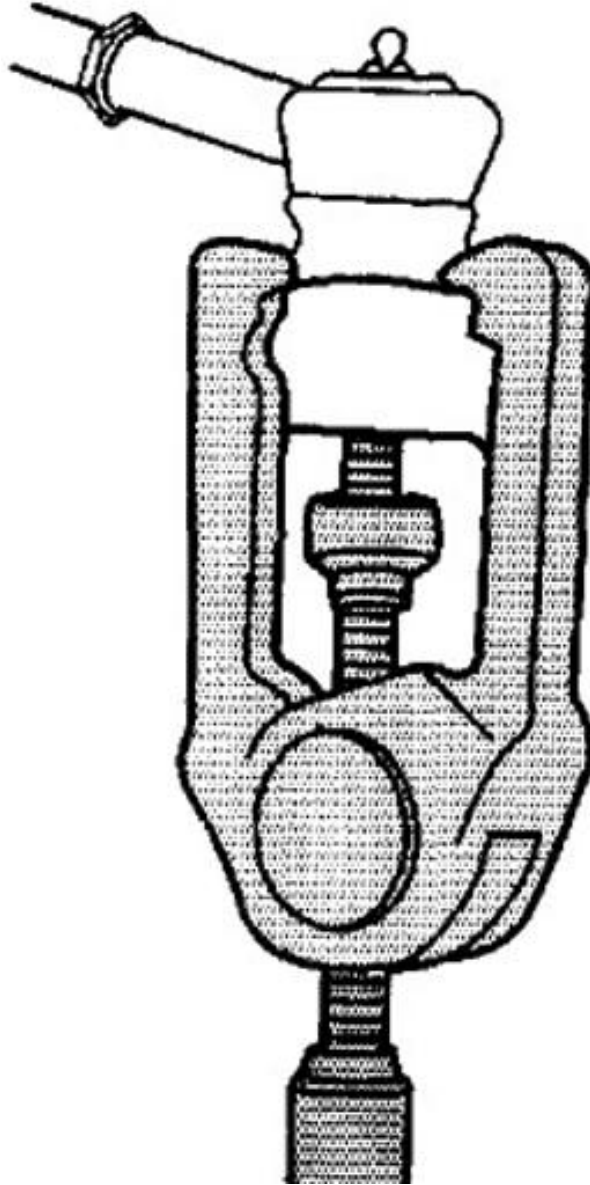
To Remove:

1. Lift the vehicle.
2. Place a drain pan under the vehicle.
3. Remove the front wheels from the vehicle.



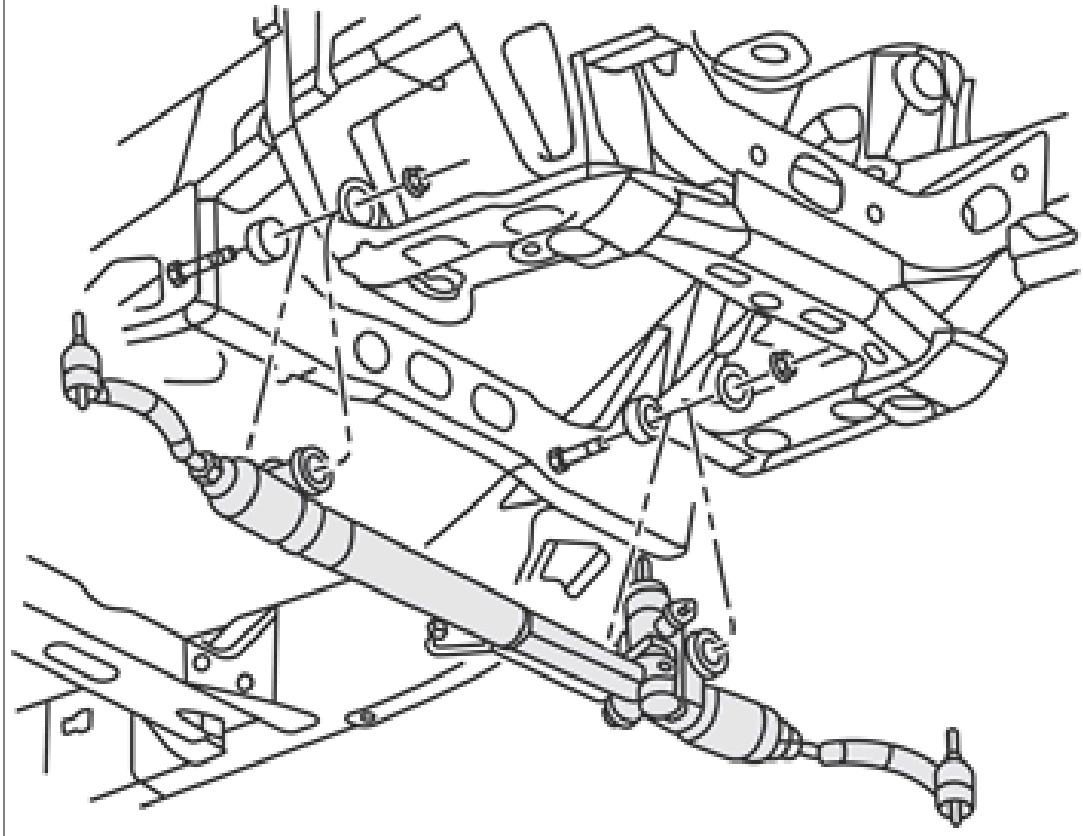
4. Remove the retaining nuts from the outer tie rod ends.

J 24319-B steering linkage and tie rod puller



5. Use a J 24319-B steering linkage and tie rod puller to detach the outer tie rod ends from the steering knuckles.
6. Remove the steering gear crossmember from under the vehicle.
7. Remove the lower intermediate shaft from the steering gear.
8. Detach the power steering hose assembly from the steering gear.
9. Use a jack to support the steering gear.
10. Remove the mounting bolts from the steering gear.

Power steering gear assembly removal and installation



11. Remove the steering gear from the vehicle.
12. Remove the outer tie rods from the inner tie rods.

To Install:

1. Install the outer tie rods into the inner tie rods.
2. Install the steering gear into the vehicle.
3. Install the mounting bolts into the steering gear. Torque the bolts to **81 ft-lb (110 Nm)**.
4. Remove the steering gear jack.
5. Attach the power steering hose assembly to the steering gear. Torque the bolt to **106 in-lb (12 Nm)**.
6. Install the lower intermediate shaft onto the steering gear.
7. Install the steering gear crossmember under the vehicle.
8. Attach the outer tie rods to the steering knuckles.
9. Install the retaining nuts into the outer tie rod ends.
10. Install the front wheels onto the vehicle.
11. Remove the drain pan under the vehicle.
12. Lower the vehicle.
13. Bleed the power steering system.

Power Steering Fluid

Filling & Bleeding

NOTE: Always use new power steering fluid when filling.

NOTE: Make sure that no hoses touch the frame. Hoses touching the frame may cause system noise.

NOTE: Make sure that all hose connections are tight. Loose connection might not leak, but do allow air into the system.

1. Fill the power steering fluid reservoir with clean fluid.
2. For vehicles with hydro-boost, make sure the hydro-boost accumulator is fully charged by starting the engine, press the brake pedal ten to fifteen times, then turning off the engine.

NOTE: Pressing the brake pedal with the engine off will discharge the hydro-boost accumulator.

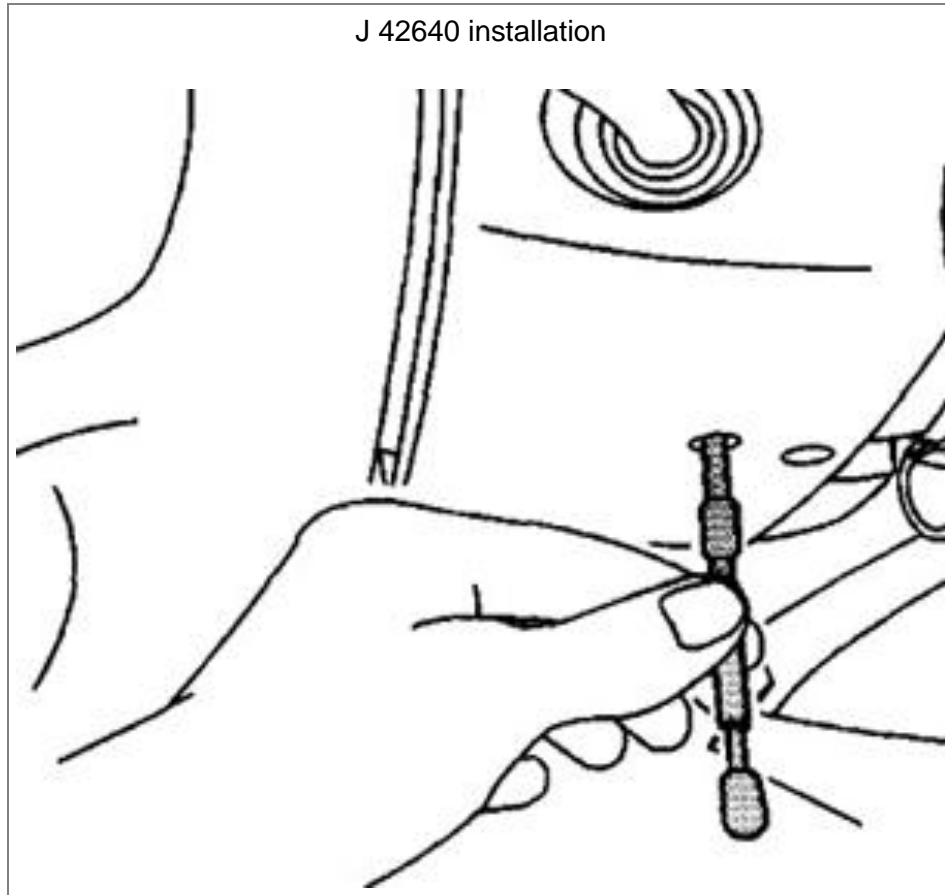
3. Lift the vehicle
4. Make sure the ignition is in the off position.
5. Turn the steering wheel from the left full stop to the right full stop at least twelve times.
6. Make sure the power steering fluid reservoir is still full.
7. Start the vehicle.
8. Turn the steering wheel from left to right and check for noise from the pump.
9. Make sure the power steering fluid reservoir is still full.
10. If necessary, repeat this process.

Steering Column

Removal & Installation

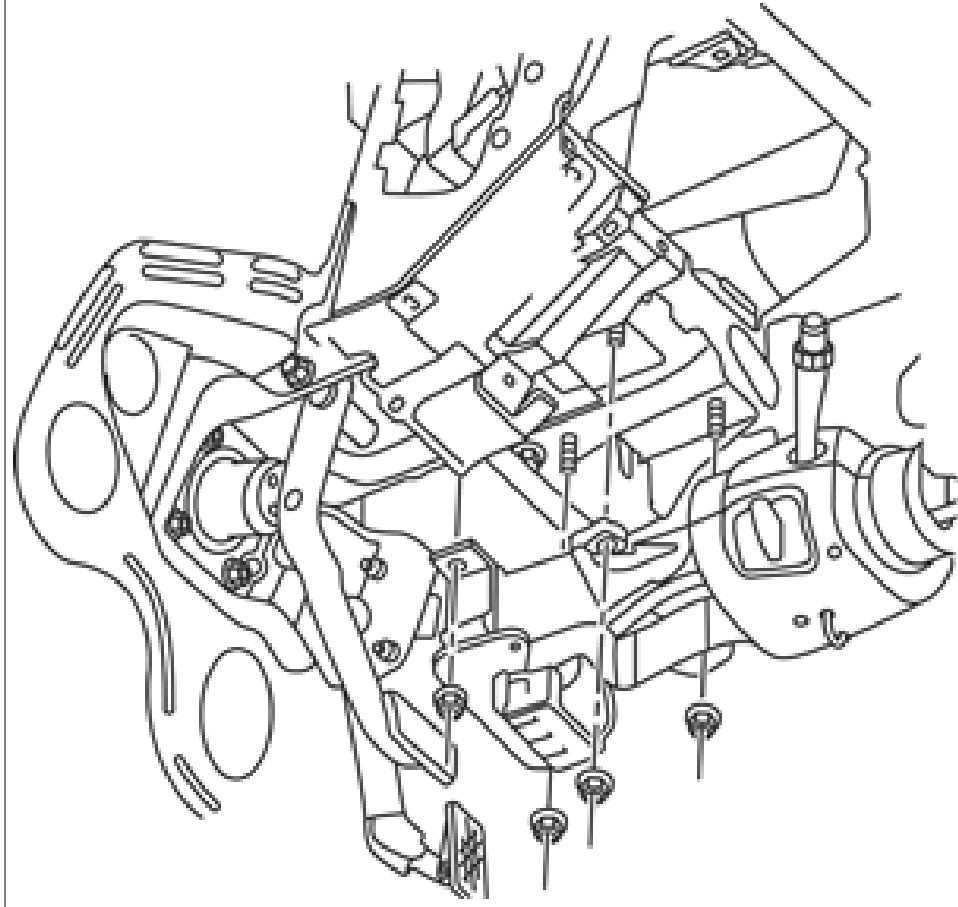
To Remove:

1. Turn the steering wheel to point the front wheels straight-ahead.
2. Disconnect the negative battery cable to disable the supplemental inflatable restraint (SIR) system.



3. Insert a J 42640 steering column anti-rotation pin through the access hole in the lower steering column trim cover to lock the steering column in place.
4. Remove the steering wheel from the steering column.
5. Remove the knee bolster from under the instrument panel.
6. Disconnect the steering column connector from the vehicle harness connector.
7. Detach the body harness from the lower steering column bracket.
8. Remove the retaining screw from the left HVAC floor duct.
9. Disconnect the left HVAC floor duct temperature sensor connector.
10. Remove the left HVAC floor duct from under the instrument panel (I/P).
11. Remove the intermediate shaft bolt from the steering column.

Steering column removal and installation



12. Remove the mounting nuts from the steering column.
13. Remove the steering column from the vehicle.

To Install:

1. Place the steering column into the vehicle.
2. Install the mounting nuts into the steering column. Torque the nuts to **20 ft-lb (27 Nm)**.
3. Clean the intermediate shaft bolt with denature alcohol.
4. Apply GM P/N 12345382 threadlocker or equivalent to the threads of the intermediate shaft bolt.
5. Install the intermediate shaft bolt into the steering column. Torque the bolt to **37 ft-lb (50 Nm)**.
6. Install the left HVAC floor duct under the instrument panel (I/P).
7. Connect the left HVAC floor duct temperature sensor connector.
8. Install the retaining screw into the left HVAC floor duct. Torque the screw to **17 in-lb (1.9 Nm)**.
9. Attach the body harness to the lower steering column bracket.
10. Connect the steering column connector from the vehicle harness connector. Torque the screw to **53 ft-lb (6 Nm)**.

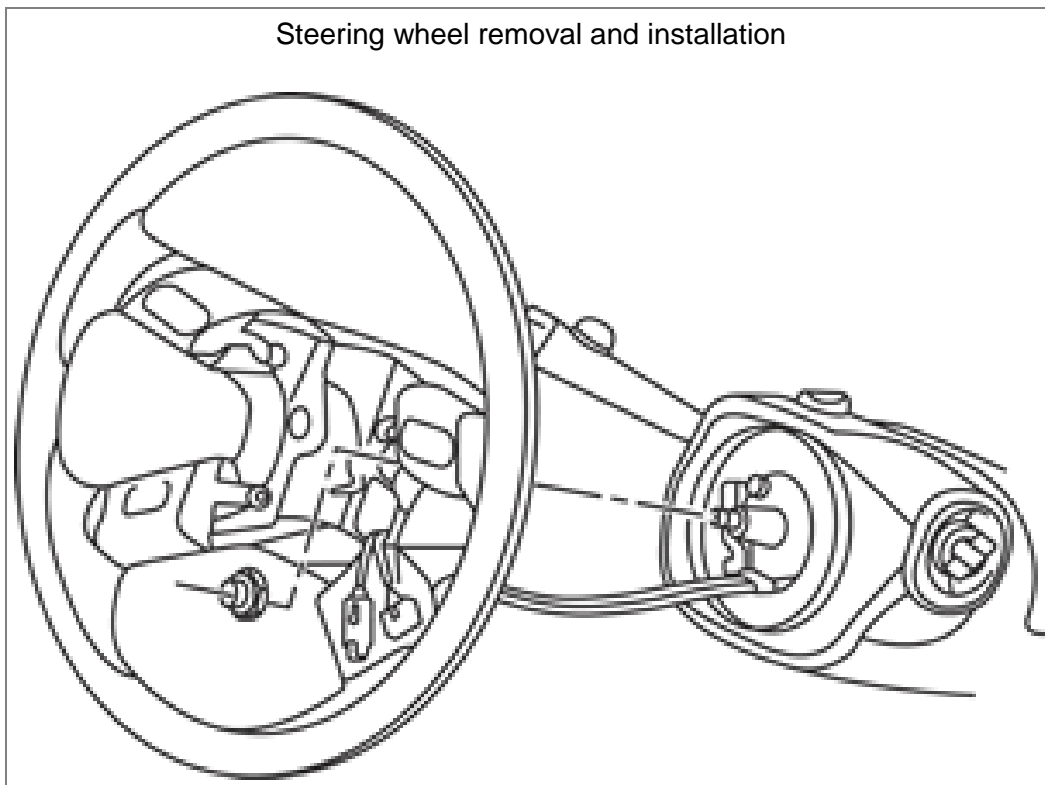
11. Install the knee bolster under the instrument panel.
12. Install the steering wheel onto the steering column.
13. Remove the J 42640 steering column anti-rotation pin from the access hole in the lower steering column trim cover to unlock the steering column.
14. Connect the negative battery cable.

Steering Wheel

Removal & Installation

To Remove:

1. Disconnect the negative battery cable to disable the supplemental inflatable restraint (SIR) system.
2. Remove the inflator module from the steering wheel.
3. Press the horn plunger inward to the stop and rotate it 90 degrees to remove it from the steering wheel.
4. Disconnect the steering wheel connector.
5. Remove the steering wheel nut from the steering wheel shaft.



6. Install a J 1859-A steering wheel puller with a J-36541-A steering wheel puller adapter or J 42578 steering wheel puller legs onto the steering wheel.
7. Remove the steering wheel from the steering column using the J 1859-A steering wheel puller.

To Install:

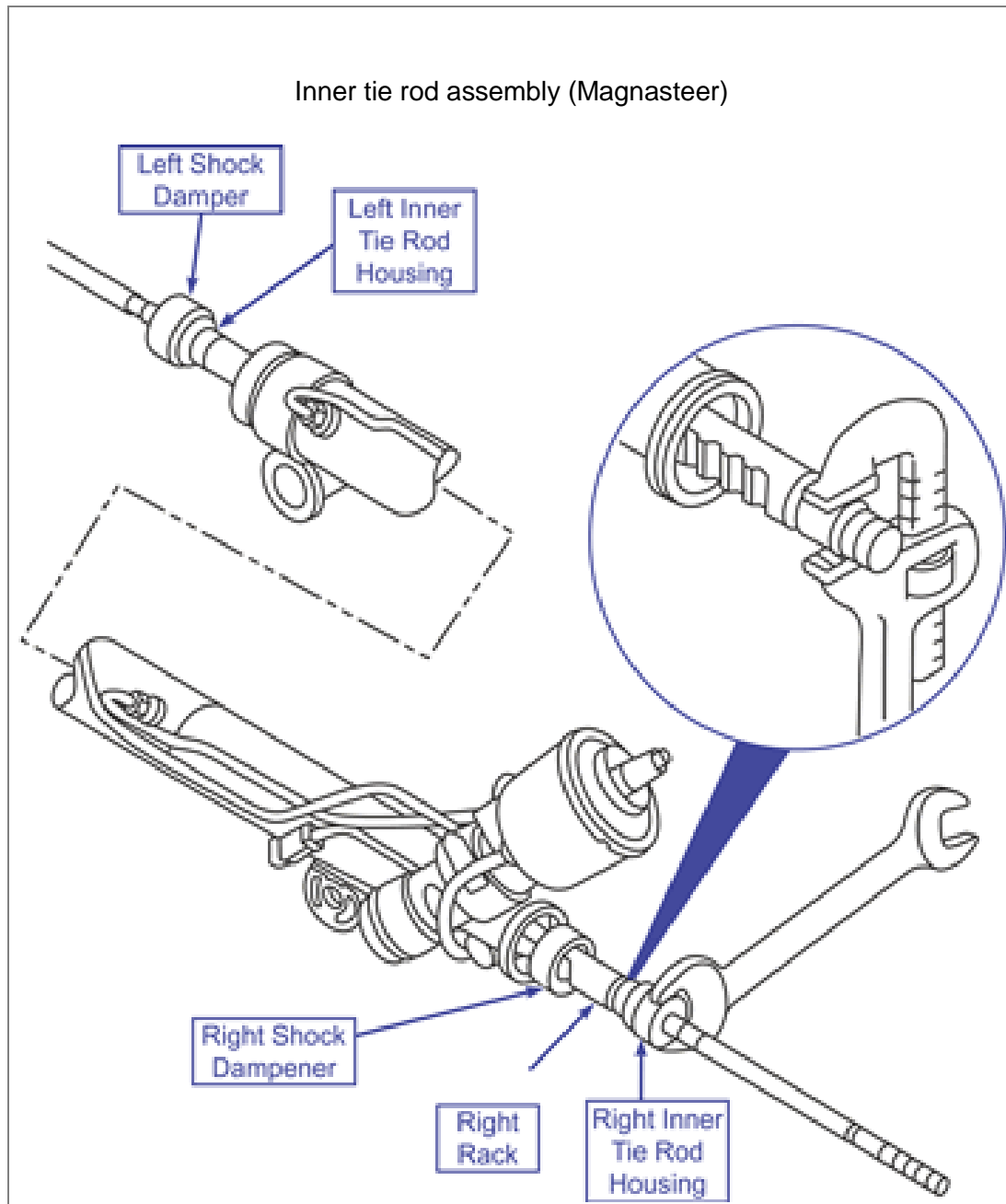
1. Install the steering wheel onto the steering column.
2. Install the steering wheel nut onto the steering wheel shaft. Torque the nut to **30 ft-lb (41 Nm)**.
3. Connect the steering wheel connector.
4. Install the horn plunger into the steering wheel.
5. Install the inflator module into the steering wheel.
6. Connect the negative battery cable.

Tie Rod End

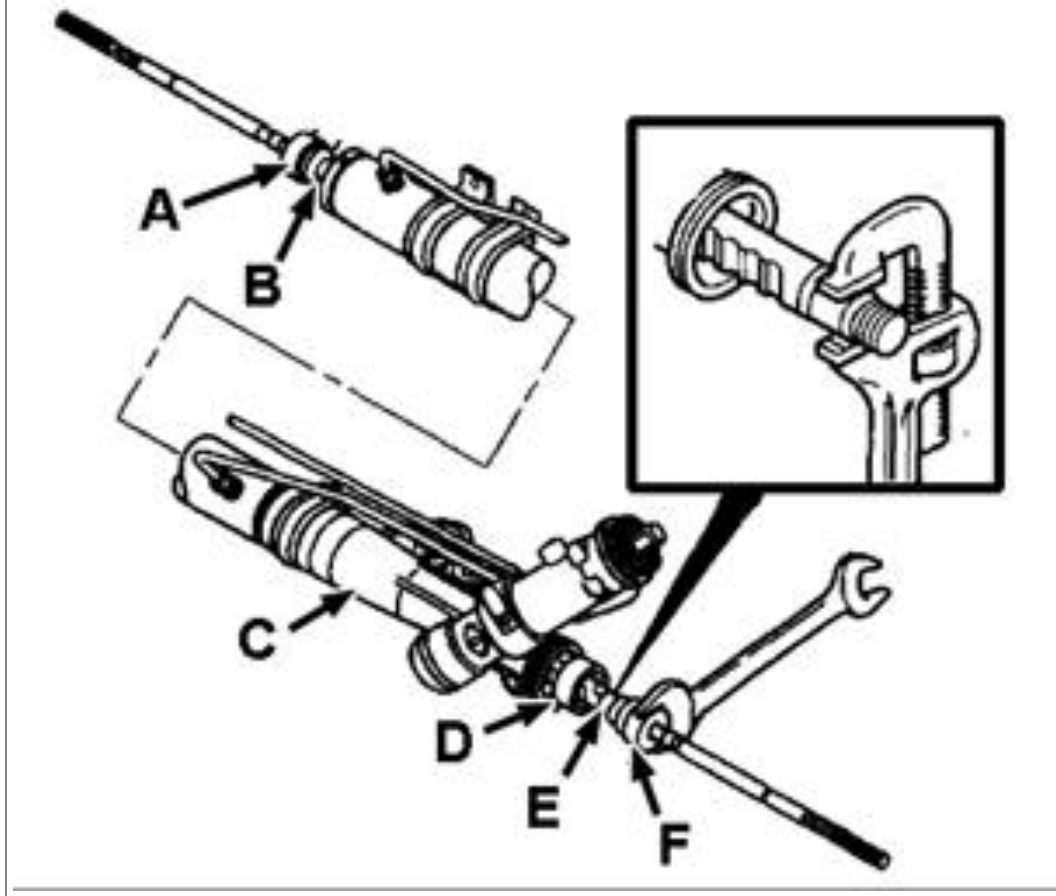
Removal & Installation

Inner Tie Rod End

To Remove:



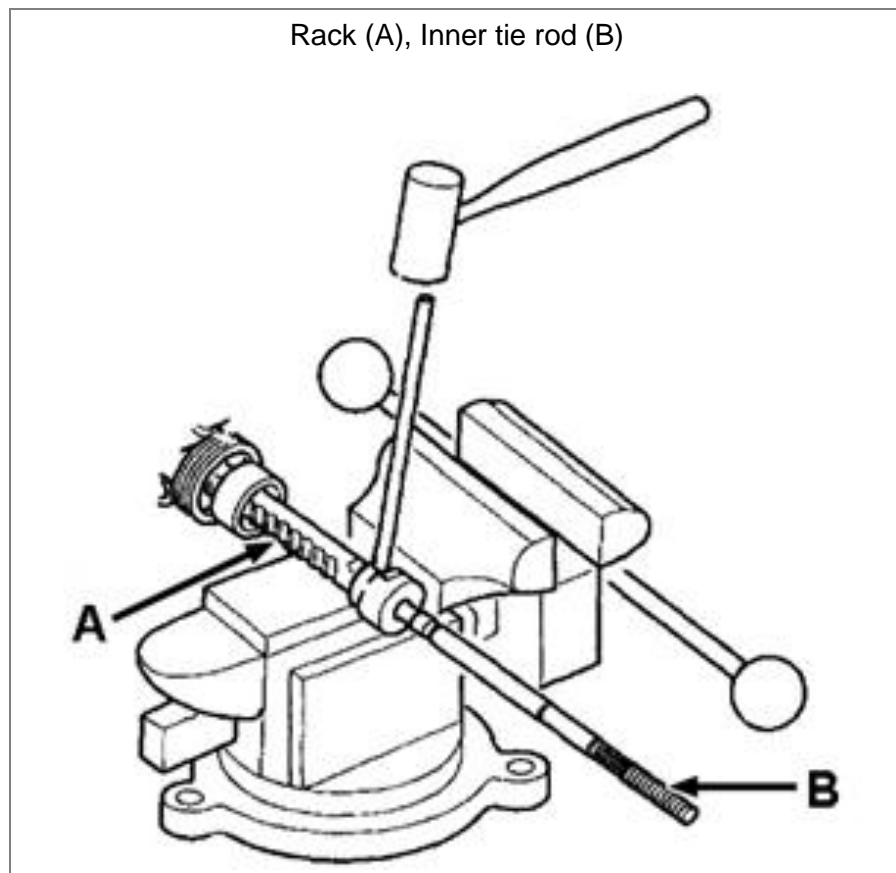
Left inner tie rod housing (A), Left shock dampener (B), Inner tie rod assembly (Quiet Valve) (C), Right shock dampener (D), Right rack (E), Right inner tie rod housing (F)



1. Remove the rack and pinion boot from the inner tie rod assembly.
2. Place the inner tie rod assembly into a vice.
3. Remove the right shock dampener from the right inner tie rod housing.
4. Move the right shock dampener back off the right rack.
5. Clamp a pipe wrench onto the right rack next to right inner tie rod housing.
6. Attach a wrench to the flats of the right inner tie rod housing.
7. Separate the right inner tie rod from the right rack by turning the inner tie rod housing counterclockwise while holding the rack stationary.
8. Remove the left shock dampener from the left inner tie rod housing.
9. Move the left shock dampener back off the left rack.
10. Clamp a pipe wrench onto the left rack next to left inner tie rod housing.
11. Attach a wrench to the flats of the left inner tie rod housing.
12. Separate the left inner tie rod from the left rack by turning the inner tie rod housing counterclockwise while holding the rack stationary.
13. If necessary, clean the tie rod threads.

To Install:

1. Move the right shock dampener onto the right rack.
2. If the rack is female, and the inner tie rod is male, coat the inner tie rod threads with LOCTITE ® 262 or equivalent sealant.
3. Attach the right inner tie rod to the right rack.
4. Clamp a pipe wrench onto the right rack next to the right inner tie rod housing.
5. Attach a torque wrench and J 34028 inner tie rod wrench to the flats of the right inner tie rod housing. Torque the rod to **74 ft-lb (100 Nm)**.
6. Move the left shock dampener onto the left rack.
7. If the rack is female, and the inner tie rod is male, coat the inner tie rod threads with LOCTITE ® 262 or equivalent sealant.
8. Attach the left inner tie rod to the left rack.
9. Clamp a pipe wrench onto the left rack next to the left inner tie rod housing.
10. Attach a torque wrench and J 34028 inner tie rod wrench to the flats of the left inner tie rod housing. Torque the rod to **74 ft-lb (100 Nm)**.

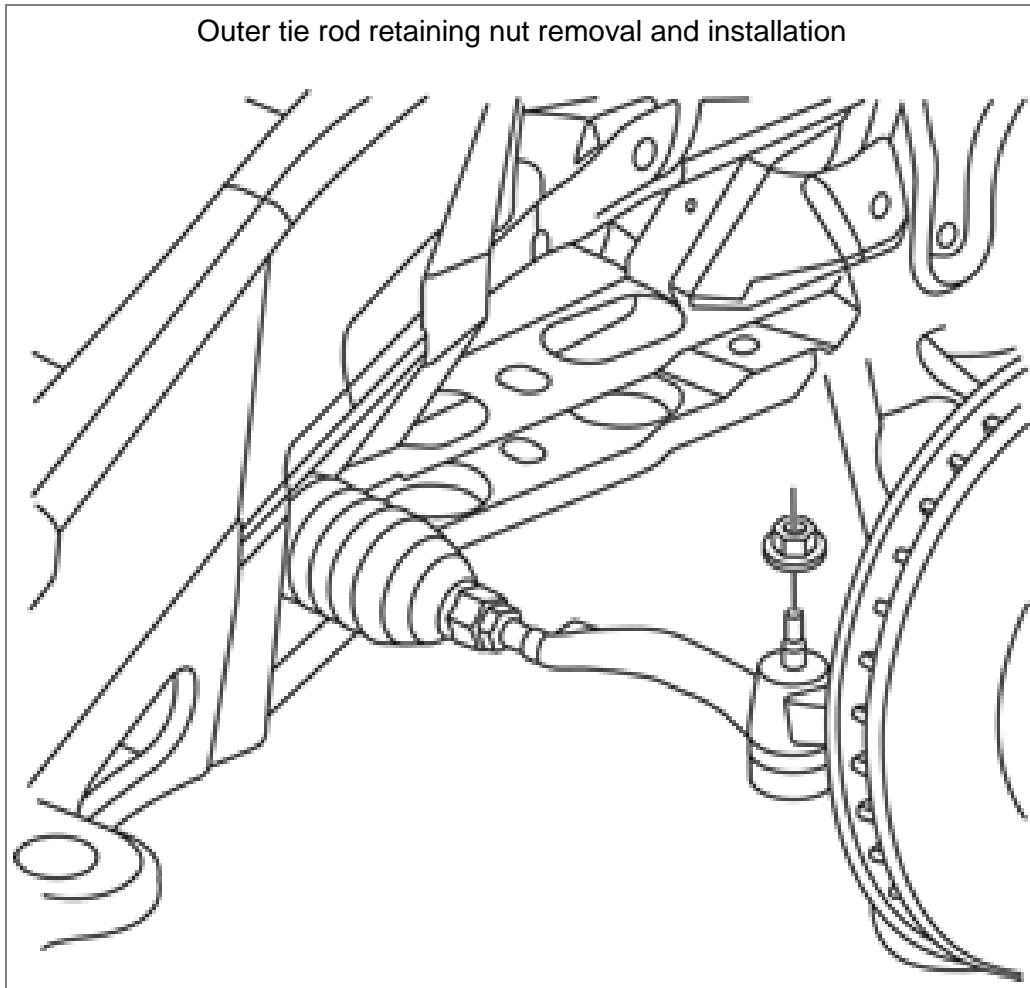


11. Put the inner tie rod assembly into a vise.
12. If the rack is male, and the inner tie rod is female, stake both sides of the inner tie rod assembly to the rack.
13. Make sure a 0.25 mm gage wire can not pass between the rack and housing stake.
14. Move the shock dampener over the inner tie rod assembly.
15. Install the rack and pinion boot onto the inner tie rod assembly.

Outer Tie Rod End

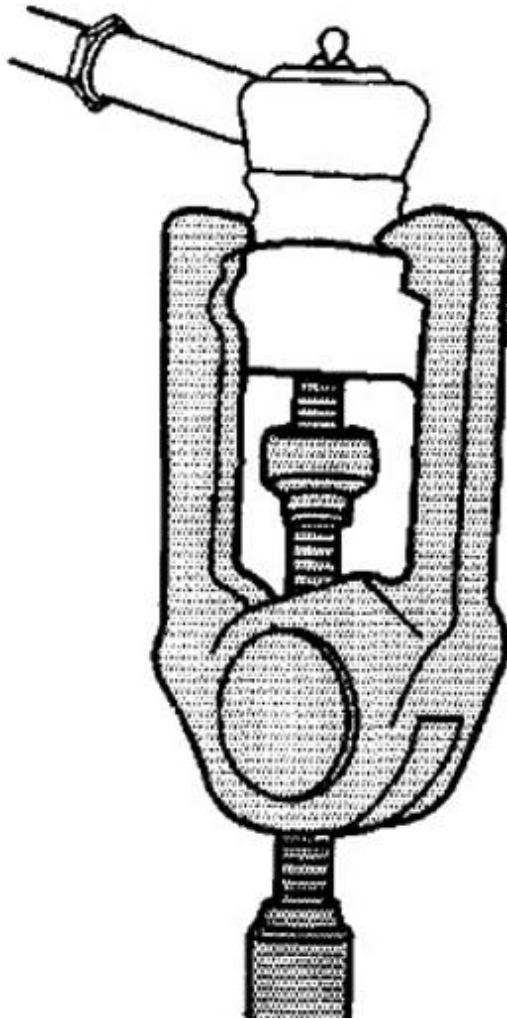
To Remove:

1. Lift the vehicle.
2. Remove the wheel from the vehicle.



3. Remove and discard the retaining nut from the outer tie rod.

J 24319-B steering linkage and tie rod puller



4. Use a J 24319-B steering linkage and tie rod puller to detach the outer tie rod from the steering knuckle.
5. Remove the outer tie rod from the inner tie rod by loosening the jam nut.
6. Check the shaft for bent or damaged threads.
7. Make sure the tapered surfaces of the steering knuckle are clean.

To Install:

1. Use chassis lubricant to coat the threads of the inner tie rod.
2. Use a new jam nut to install the outer tie rod into the inner tie rod.
3. Install the outer tie rod onto the steering knuckle.
4. Install the new retaining nut into the outer tie rod. Torque the retaining nut to **44 ft-lb (60 Nm)**.
5. Install the wheel onto the vehicle.
6. Lower the vehicle.
7. If necessary, adjust the front toe setting.

8. Front Suspension

9. WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

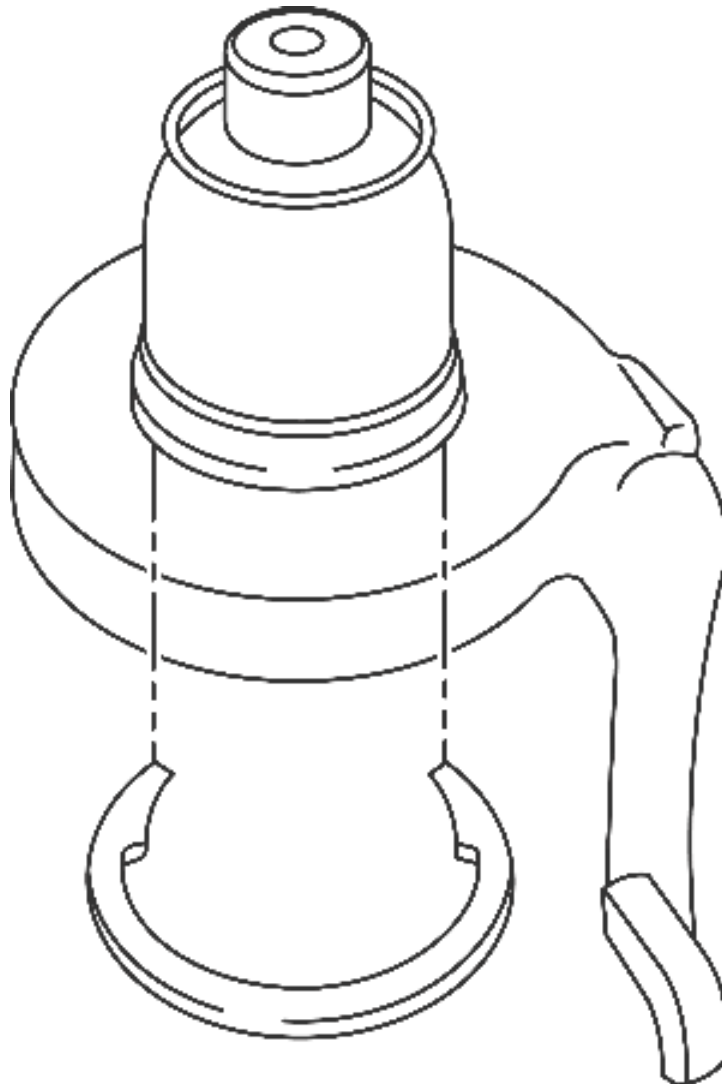
Upper Control Arm Ball Joint

Removal & Installation

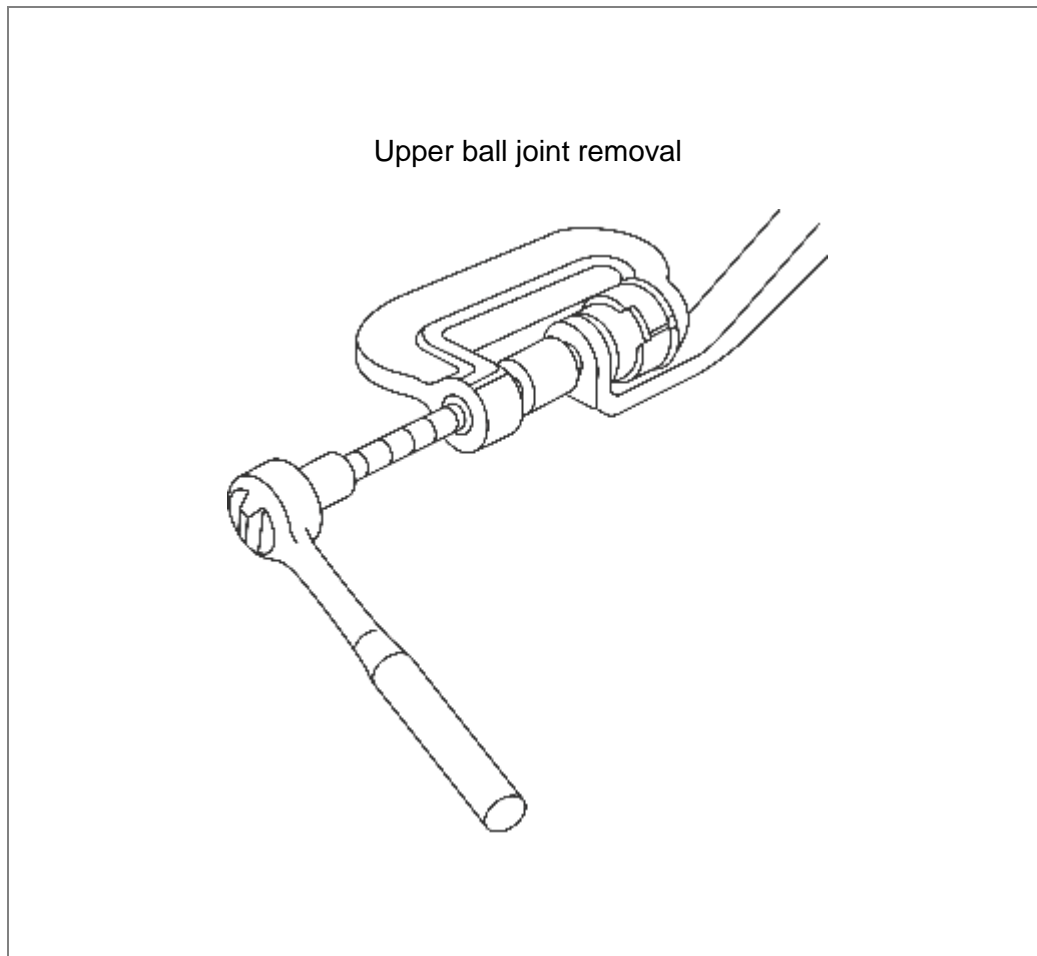
To Remove:

1. Lift the vehicle.
2. Remove the wheel from the vehicle.
3. Remove the steering knuckle from the vehicle.

Upper ball joint retaining clip removal and installation

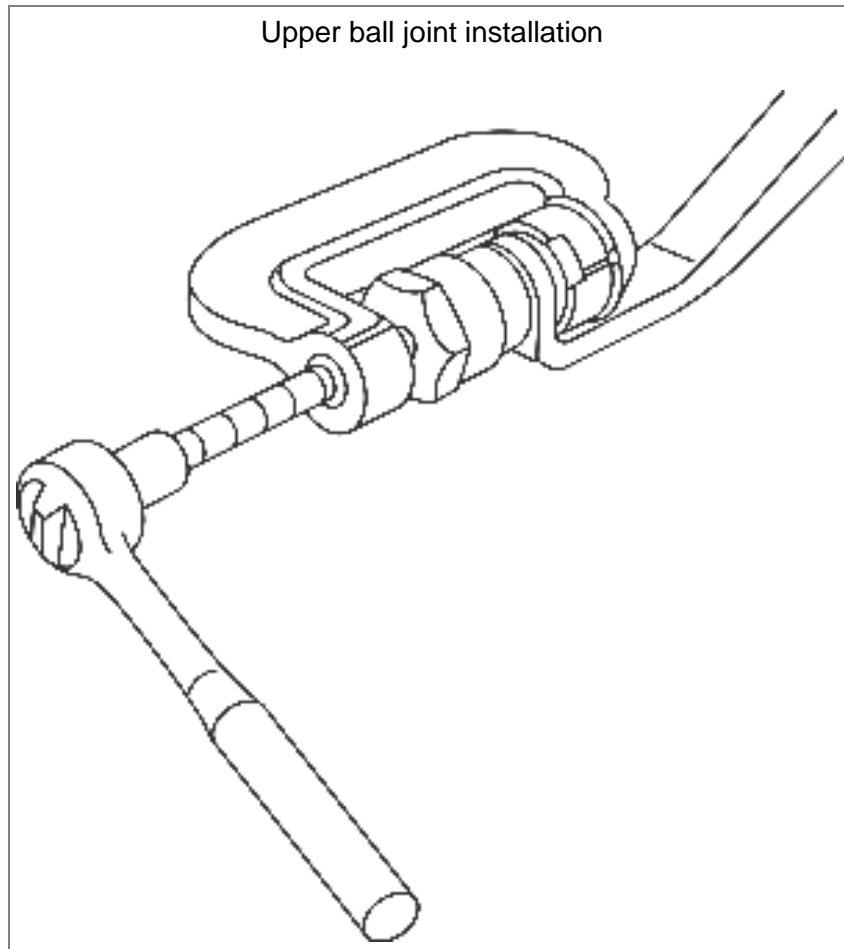


4. Remove the retaining clip from the upper ball joint.
5. Remove the boot from the upper ball joint.



6. Use a J 9519-E ball joint remover and installer to remove the upper ball joint from the steering knuckle.

To Install:



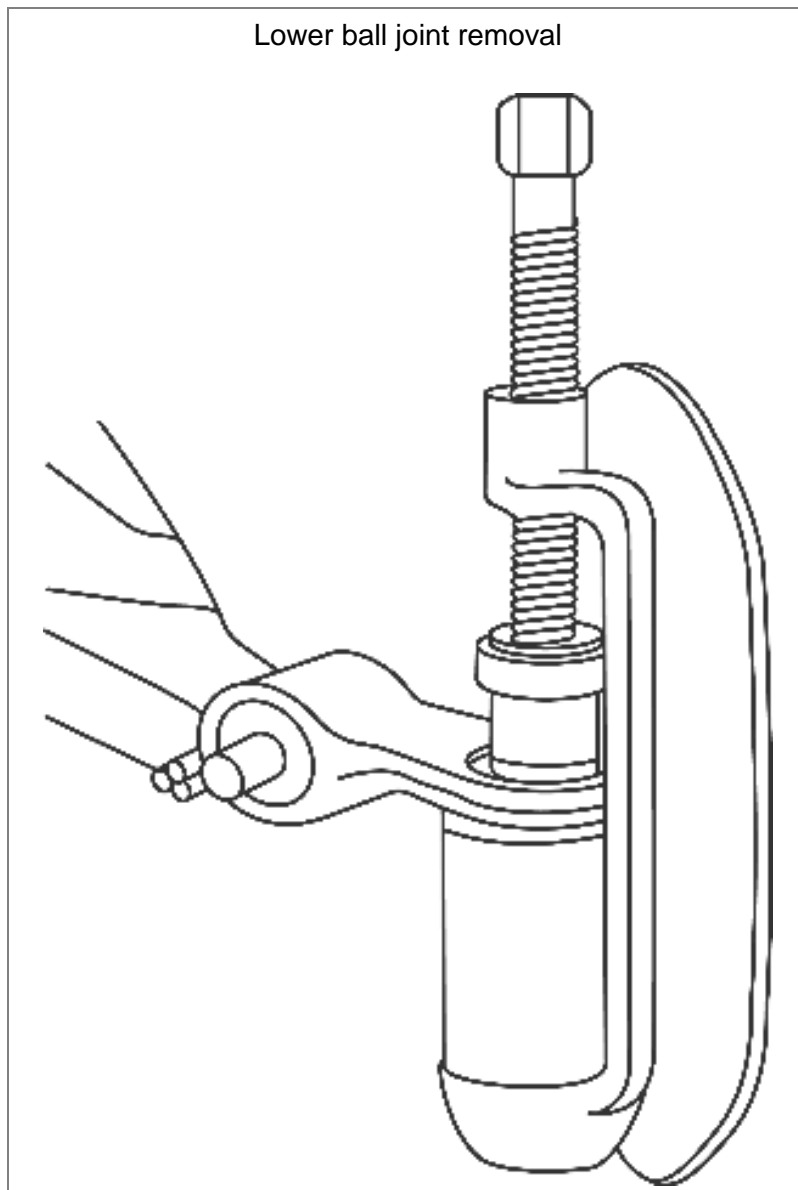
1. Use a J 9519-E ball joint remover and installer, J21474-01 control arm bushing set, and J 45117 ball joint installation spacer to install the upper ball joint onto the steering knuckle.
2. Install the retaining clip onto the upper ball joint.
3. Install the steering knuckle onto the vehicle.
4. Install the wheel onto the vehicle.
5. Lower the vehicle.
6. Check the alignment of the front wheels.

Lower Control Arm Ball Joint

Removal & Installation

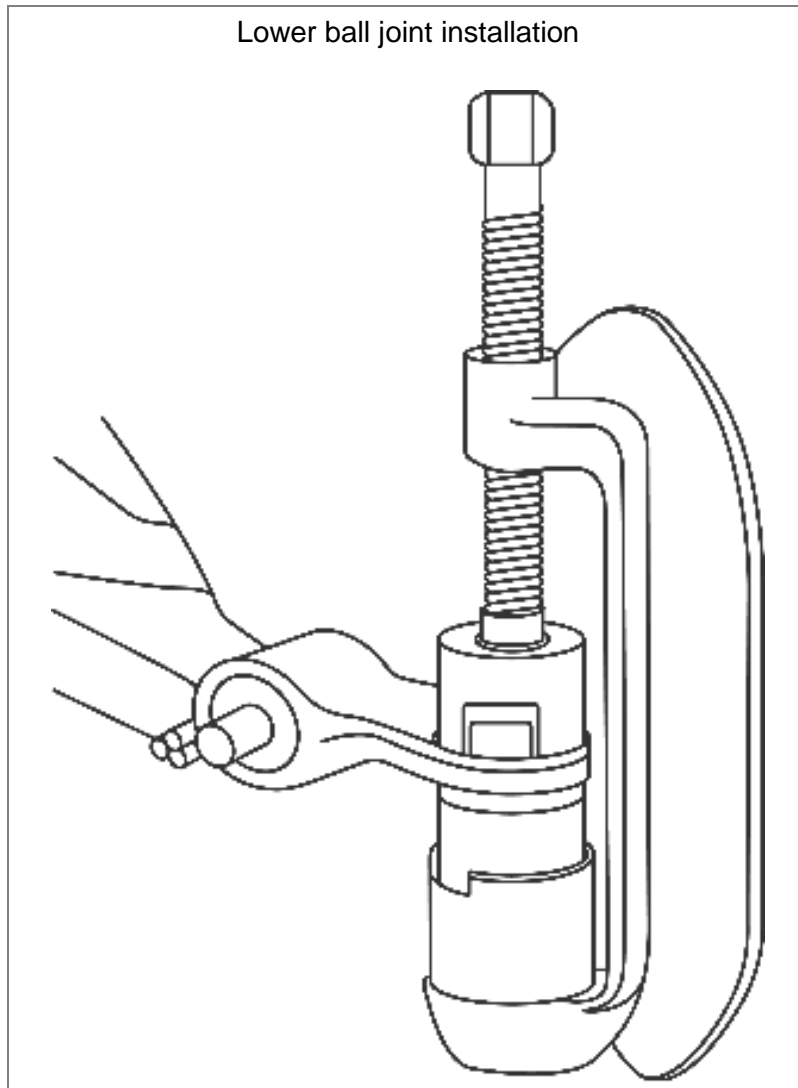
To Remove:

1. Lift the vehicle.
2. Remove the wheel from the vehicle.
3. Remove the steering knuckle from the vehicle.
4. Use a chisel to remove the flange from the lower ball joint.



5. Use a J 9519-E ball joint remover and installer and J 34874 booster seal remover and installer to remove the lower ball joint from the lower control arm.

To Install:



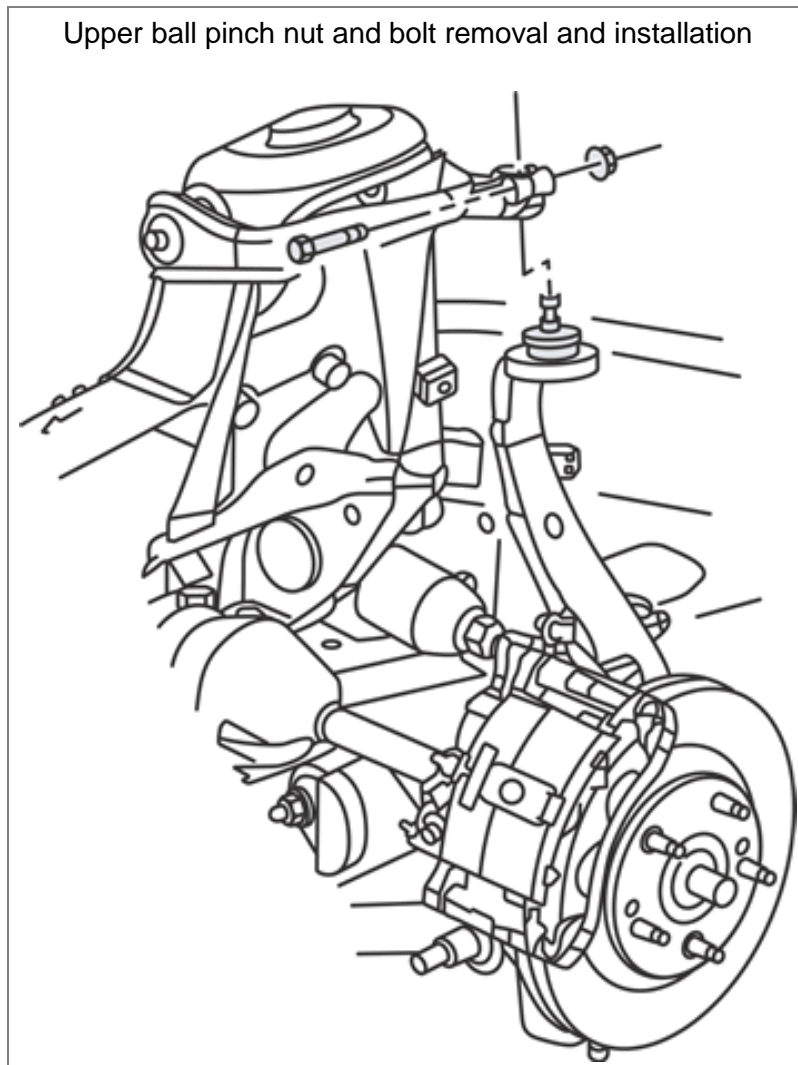
1. Use a J 9519-E ball joint remover and installer, J 41435 ball joint installer, and J 45105-2 receiver to install the lower ball joint onto the lower control arm.
2. Use a J 9519-E ball joint remover and installer and J 45105-1 ball joint flaring adapter to flare the lower ball joint flange.
3. Install the steering knuckle onto the vehicle.
4. Install the wheel onto the vehicle.
5. Lower the vehicle.
6. Check the alignment of the front wheels.

Upper Control Arm

Removal & Installation

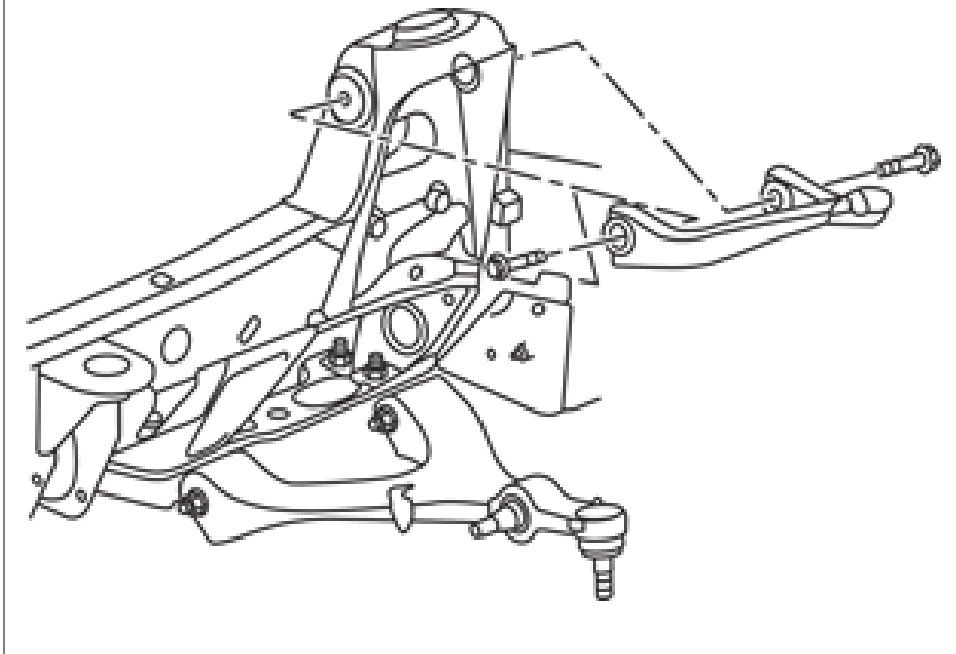
To Remove:

1. Lift the vehicle.
2. Remove the front wheel from the vehicle.



3. Remove and discard the nut and bolt from the upper control arm pinch.
4. Remove the steering knuckle from the upper control arm.
5. Detach the wheel speed sensor harness from the upper control arm.
6. If removing the left upper control arm, remove the battery and battery tray from the engine compartment.
7. Pry out the inner fender body panel to gain access to the forward facing bolt.

Upper control arm removal and installation



8. Detach the upper control arm from the frame.

To Install:

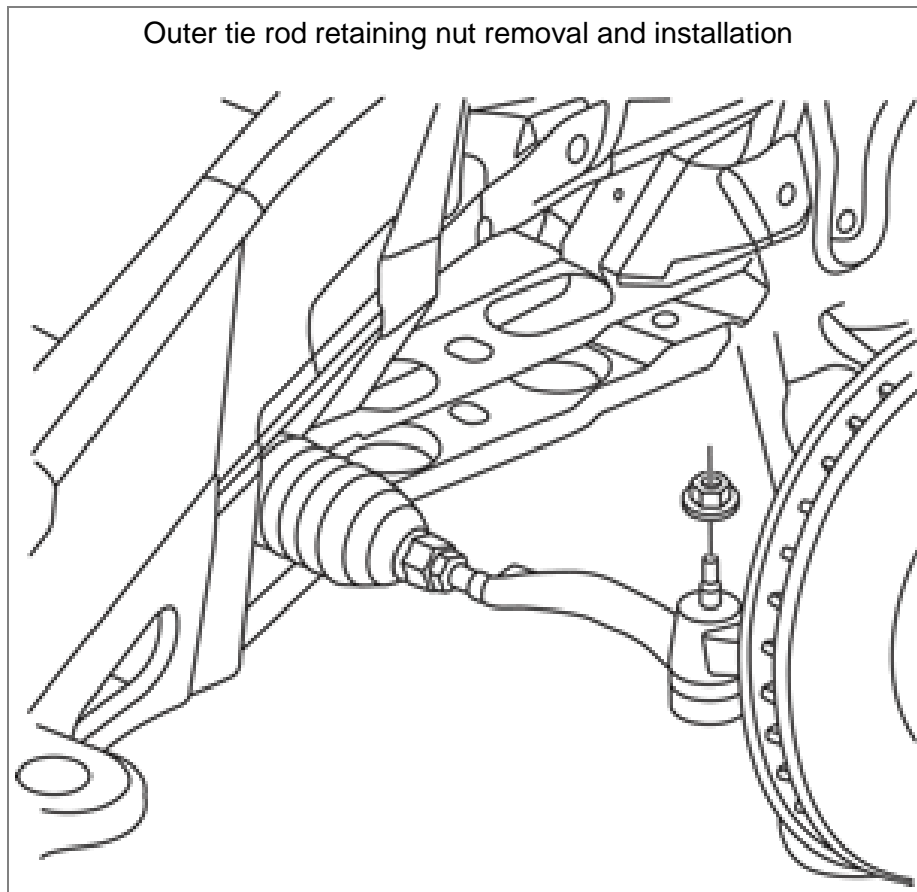
1. Attach the upper control arm to the frame. Torque the mounting bolts to **108 ft-lb (146 Nm)**.
2. If installing the left upper control arm, install the battery and battery tray into the engine compartment.
3. Attach the wheel speed sensor harness to the upper control arm.
4. Install the steering knuckle onto the upper control arm.
5. Install a new nut and bolt into the upper control arm pinch. Torque the nut and bolt to **30 ft-lb (41 Nm)**.
6. Install the front wheel onto the vehicle.
7. Lower the vehicle.
8. Check the alignment of the front wheels.

Lower Control Arm

Removal & Installation

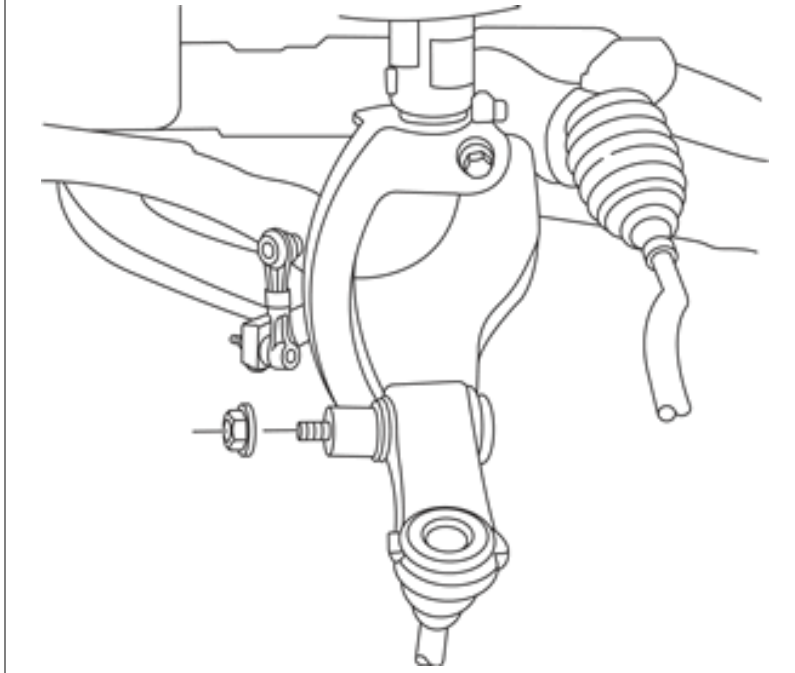
To Remove:

1. Lift the vehicle.
2. Remove the wheel from the vehicle.



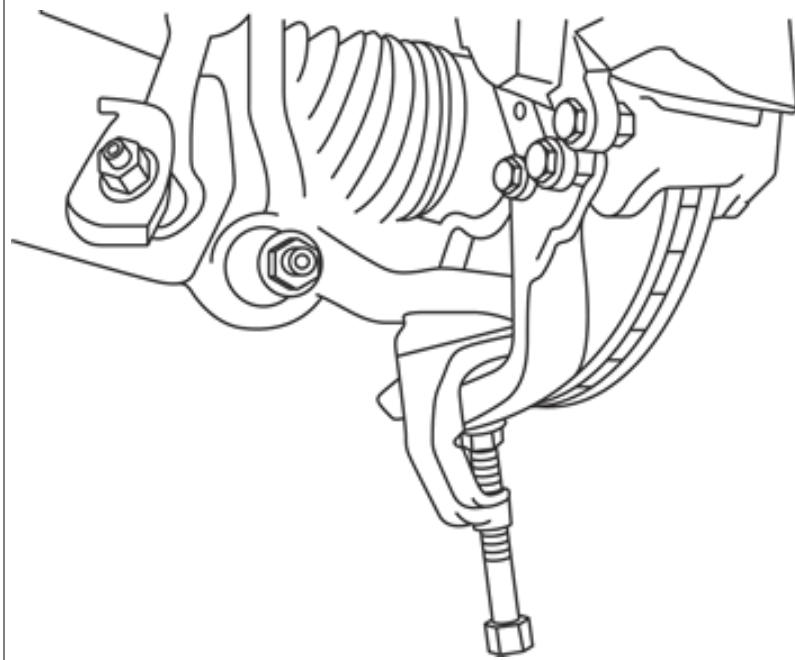
3. Remove and discard the retaining nut from the outer tie rod.
4. Use a J 36607 steering linkage and tie rod puller to disconnect the outer tie rod from the steering knuckle.
5. Remove the retaining nut from the stabilizer shaft link.

Shock absorber module yoke nut removal and installation

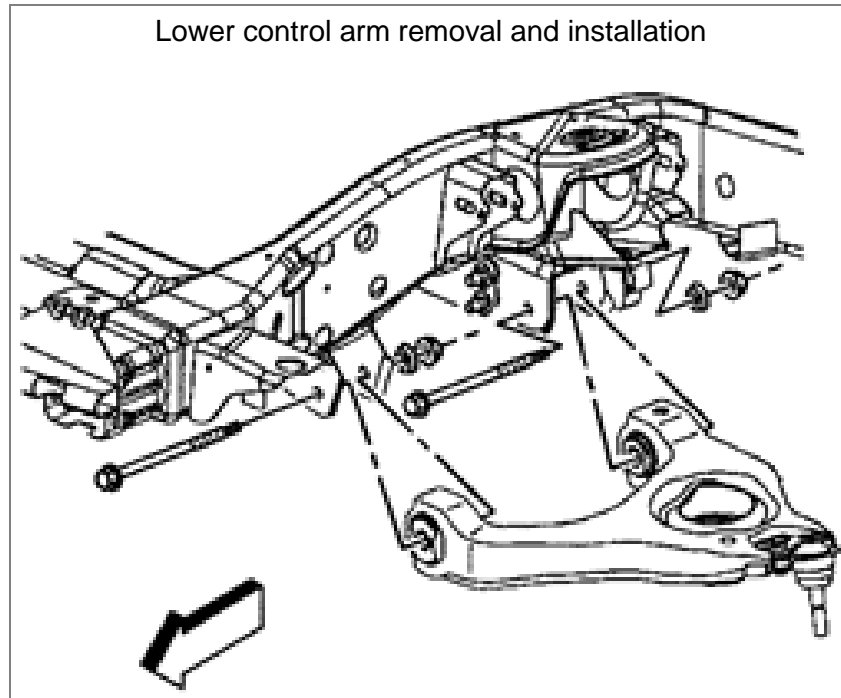


6. Remove the mounting nut from the shock absorber module yoke.
7. Use a J 36607 steering linkage and tie rod puller to disconnect the shock absorber module yoke from the lower control arm.
8. Remove and discard the retaining nut from the lower ball joint.

Lower ball joint removal



9. Use a J 43631 ball joint remover to disconnect the lower ball joint from the steering knuckle.



10. Remove the lower control arm mounting nuts from the lower control arm mounting bracket.

NOTE: Make note of the direction of the mounting bolts for reassembly.

11. Remove the lower control arm mounting bolts from the lower control arm mounting bracket.
12. Remove the lower control arm from the lower control arm mounting bracket.

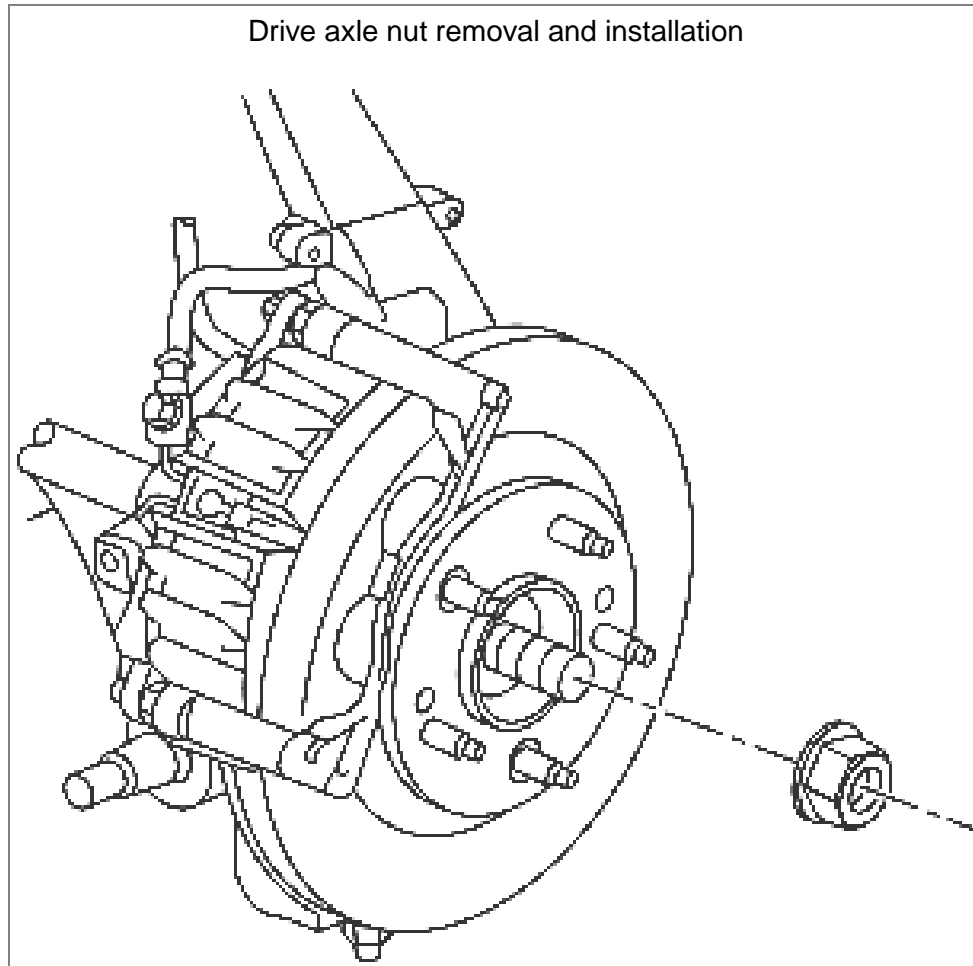
To Install:

1. Install the lower control arm onto the lower control arm mounting bracket.
2. Install the lower control arm mounting bolts into the lower control arm mounting bracket.
3. Install the lower control arm mounting nuts onto the lower control arm mounting bracket. Torque the nuts to **96 ft-lb (130 Nm)**.
4. Install the shock absorber module yoke onto the lower control arm.
5. Install the mounting nut onto the shock absorber. Torque the nut to **82 ft-lb (111 Nm)**.
6. Install a new retaining nut onto the lower ball joint. Torque the nut to **79 ft-lb (107 Nm)**.
7. Install the retaining nut onto the stabilizer shaft link. Torque the nut to **17 ft-lb (23 Nm)**.
8. Install the outer tie rod onto the steering knuckle.
9. Install a new retaining nut into the outer tie rod. Torque the nut to **40 ft-lb (57 Nm)**.
10. Install the wheel onto the vehicle.

Hub & Bearing

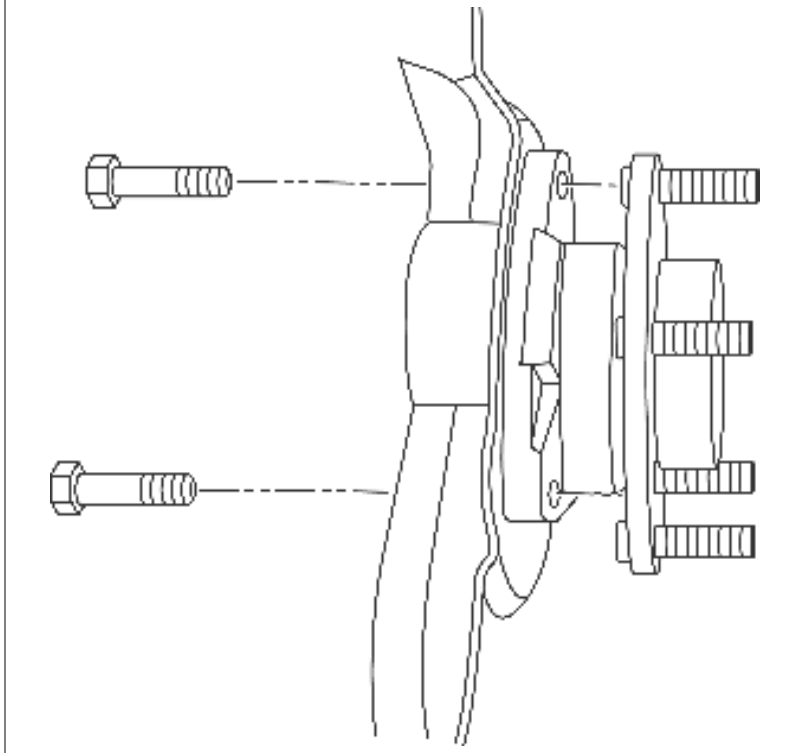
Removal & Installation

To Remove:



1. For vehicles with 4wd, remove the nut from the drive axle.
2. Lift the vehicle.
3. Remove the wheel from the vehicle.
4. Remove the brake rotor from the hub.
5. For vehicles with 4wd, use a hammer and brass drift to disengage the drive axle from the hub and bearing.
6. Detach the wheel speed sensor from the hub.

Hub and bearing removal and installation



7. Detach the hub and bearing from the steering knuckle.
8. Remove the splash shield from the steering knuckle.

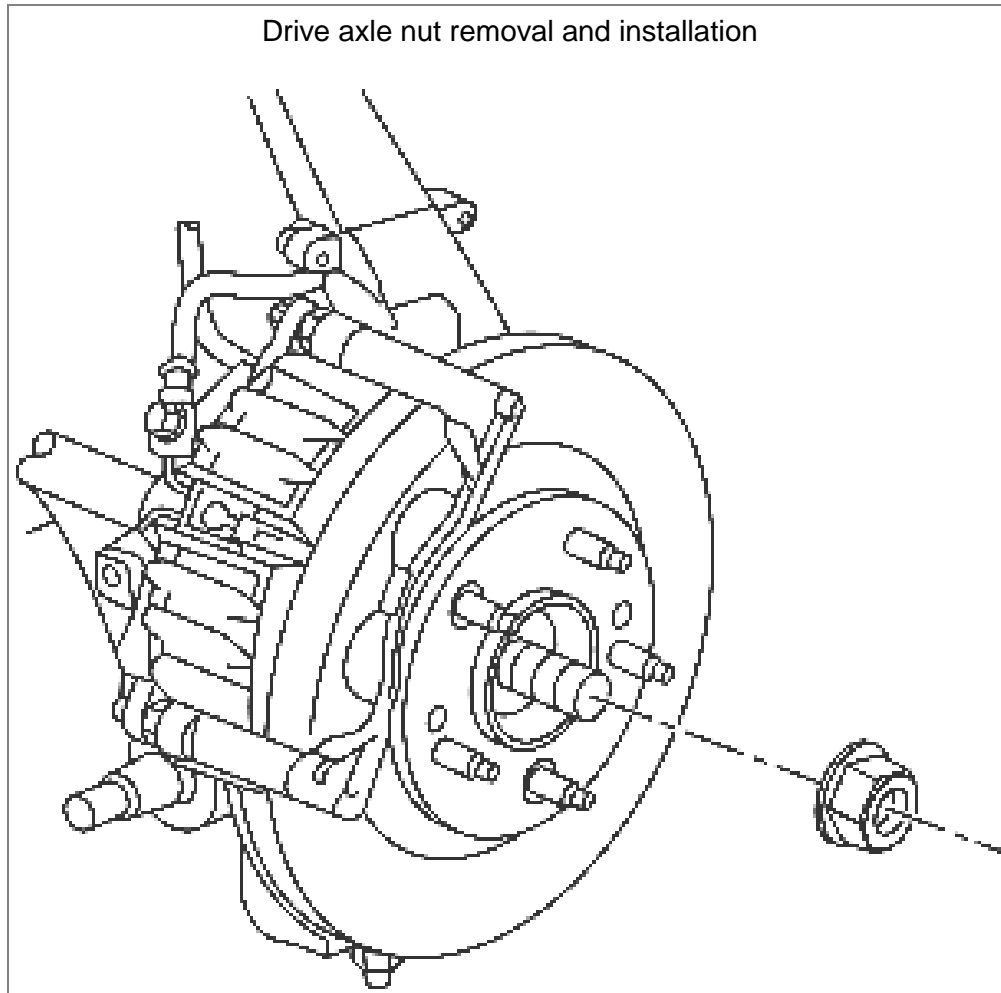
To Install:

1. Install the splash shield into the steering knuckle.
2. Attach the hub and bearing to the steering knuckle. Torque the bolts to **77 ft-lb (105 Nm)**.
3. Attach the wheel speed sensor to the hub. Torque the bolts to **13 ft-lb (18 Nm)**.
4. Install the brake rotor onto the hub.
5. Install the wheel onto the vehicle.
6. Lower the vehicle.
7. For vehicles with 4wd, install the nut onto the drive axle. Torque the nut the **103 ft-lb (140 Nm)**.

Steering Knuckle

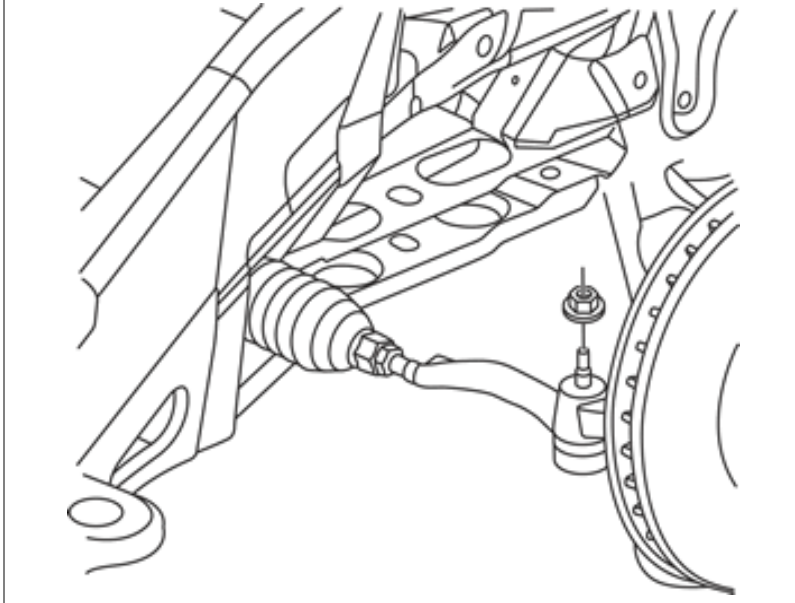
Removal & Installation

To Remove:



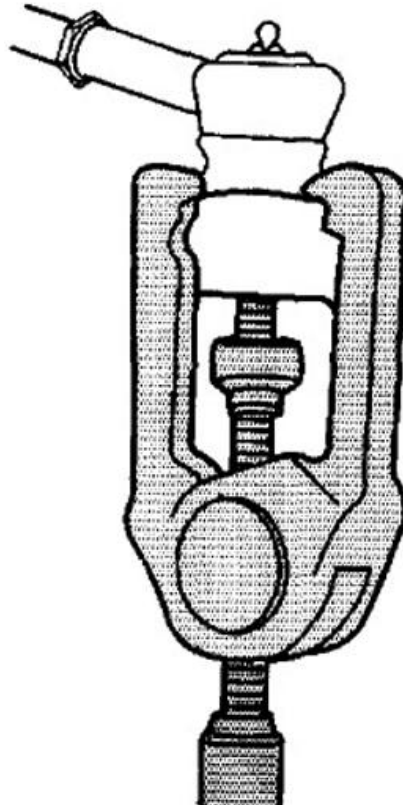
1. For vehicles with 4WD, remove the nut from the drive axle.
2. Lift the vehicle.
3. Remove the wheel from the vehicle.
4. Remove the hub and bearing from the steering knuckle.

Outer tie rod retaining nut removal and installation

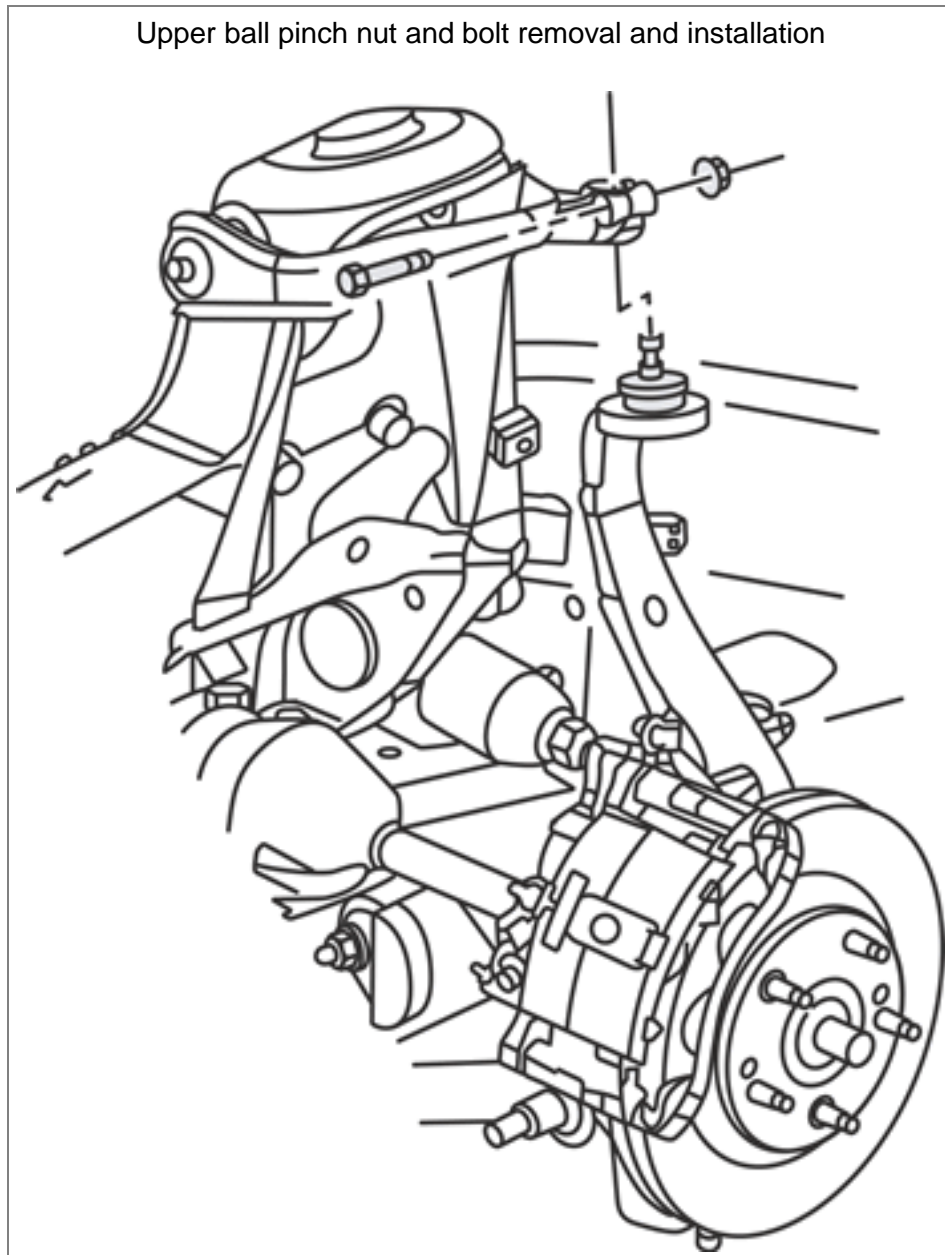


5. Remove and discard the retaining nut from the outer tie rod end.

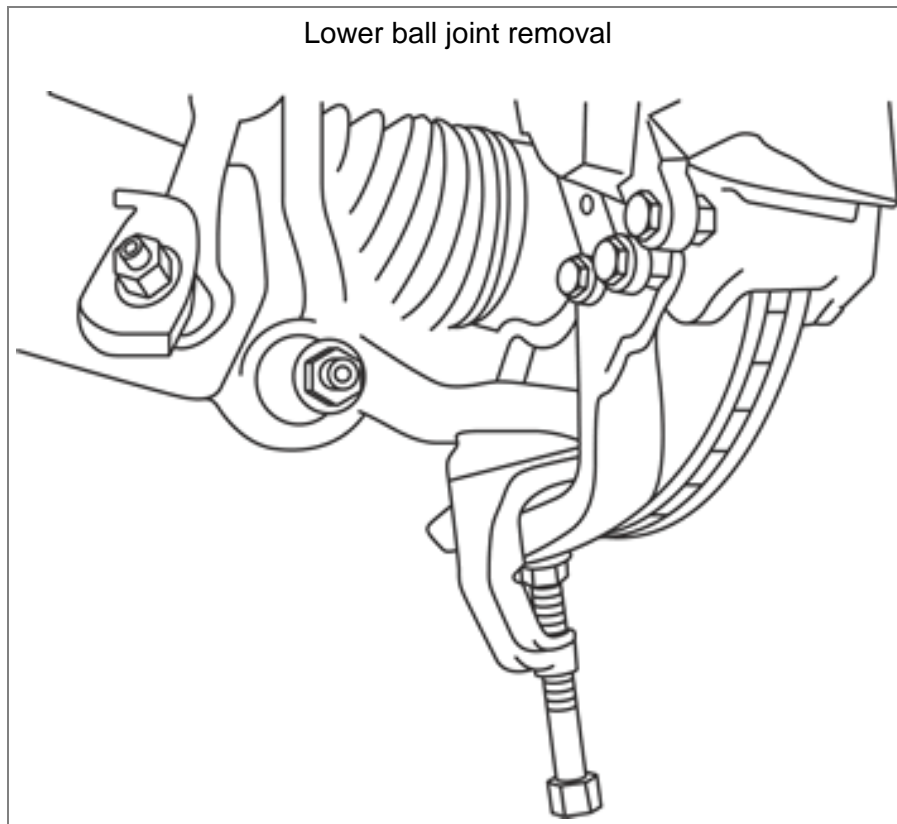
J 24319-B steering linkage and tie rod puller



6. Use a J 24319-B steering linkage and tie rod puller to detach the outer tie rod.
7. Detach the brake hose bracket from the steering knuckle.
8. Detach the wheel speed sensor from the steering knuckle.



9. Remove and discard the nut and bolt from the upper control arm pinch.
10. Remove the steering knuckle from the upper control arm.
11. Remove and discard the retaining nut from the lower ball joint.



12. Use a J 43631 ball joint remover to disconnect the lower ball joint from the steering knuckle.
13. Remove the steering knuckle from the vehicle.

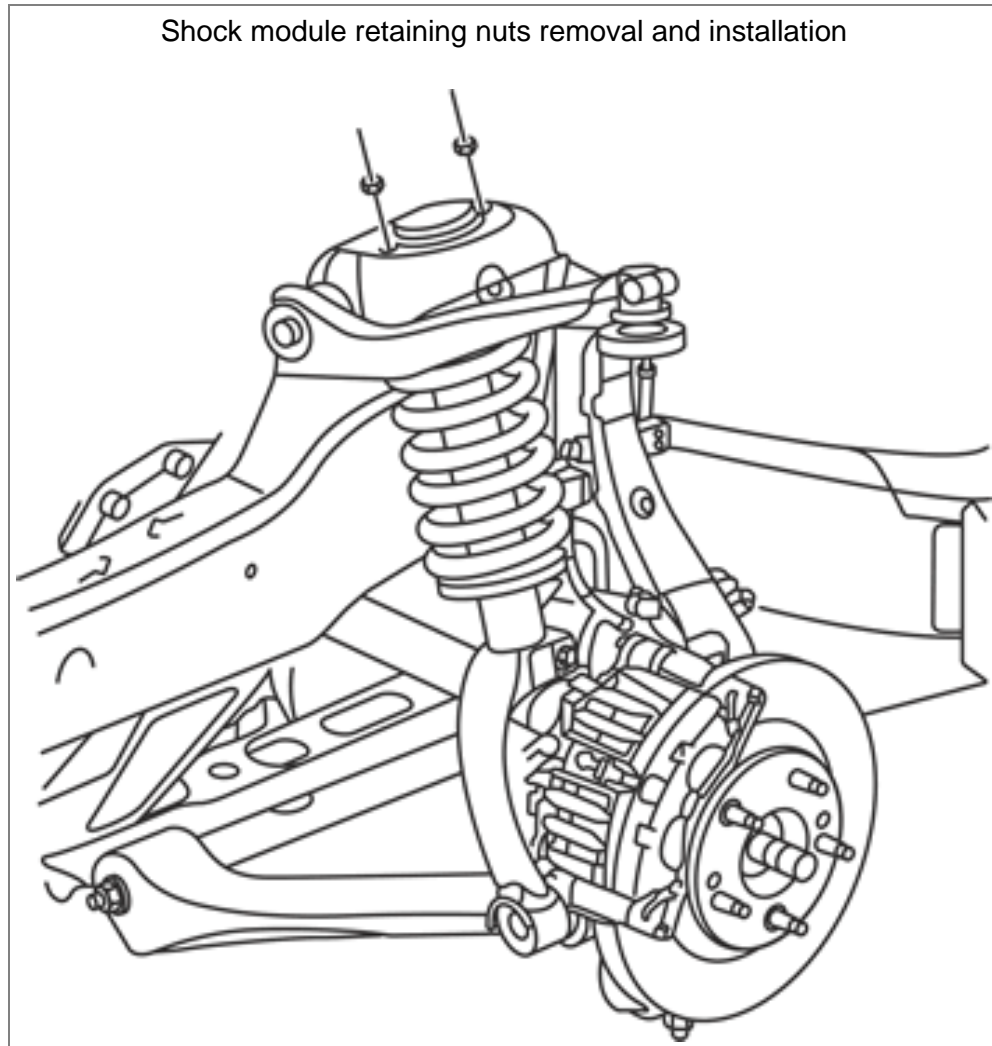
To Install:

1. Install the steering knuckle onto the lower control arm.
2. Install a new retaining nut onto the lower ball joint. Torque the nut to **81 ft-lb (110 Nm)**.
3. Install the steering knuckle onto the upper control arm.
4. Install a new nut and bolt into the upper control arm pinch. Torque the nut to **30 ft-lb (40 Nm)**.
5. Attach the wheel speed sensor to the steering knuckle.
6. Attach the brake hose bracket to the steering knuckle. Torque the nut to **89 in-lb (10 Nm)**.
7. Install the outer tie rod onto the steering knuckle.
8. Install a new retaining nut into the outer tie rod end. Torque the nut to **44 ft-lb (60 Nm)**.
9. Install the hub and bearing onto the steering knuckle.
10. Install the wheel onto the vehicle.
11. Lower the vehicle.
12. For vehicles with 4WD, install the nut onto the drive axle. Torque the nut the **103 ft-lb (140 Nm)**.
13. Check the alignment of the front wheels.

Shock Absorber Module

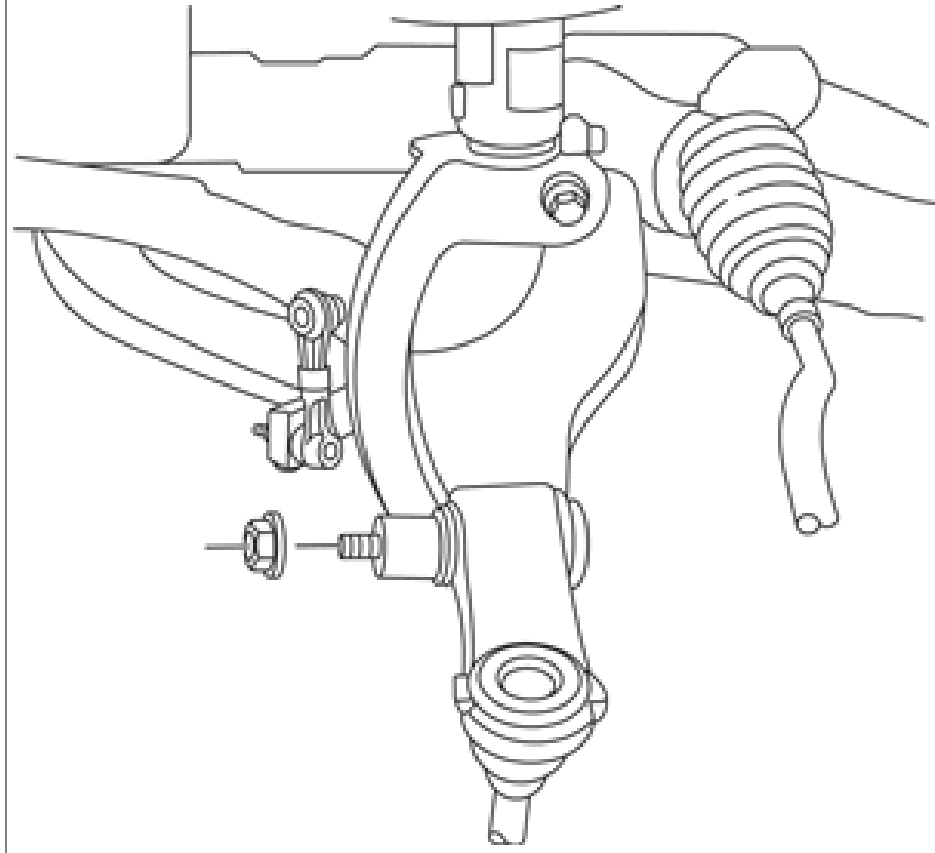
Removal & Installation

To Remove:



1. Remove the upper retaining nuts from the shock absorber module.
2. Lift the vehicle.
3. Remove the wheel from the vehicle.

Shock absorber module yoke nut removal and installation



4. Loosen the mounting nut from the shock absorber module yoke.
5. Use a J 36607 ball joint separator to remove the yoke from the lower control arm.
6. Remove the J 36607 ball joint separator and retaining nut from the shock absorber module yoke.
7. Remove the shock absorber module from the shock tower.

To Install:

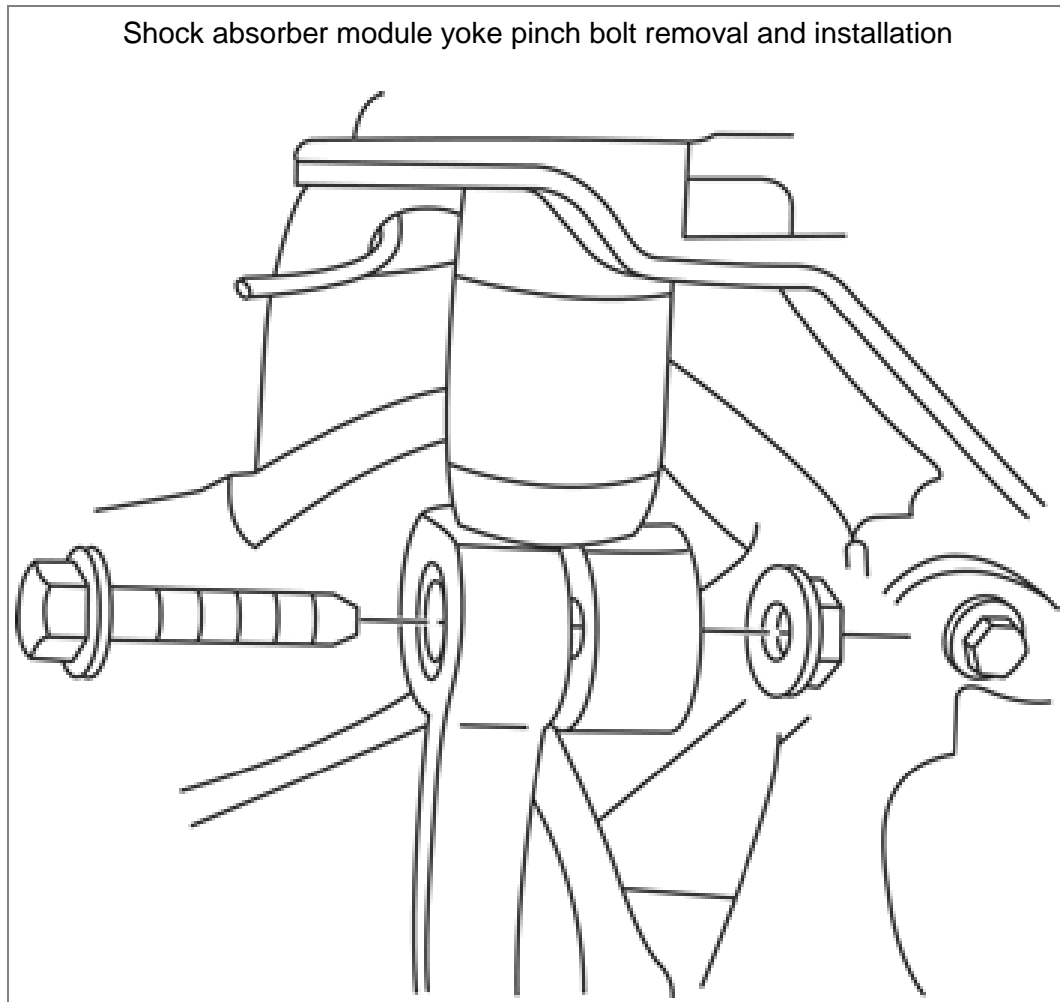
1. Install the shock absorber module into the shock tower.
2. Install the shock absorber module yoke to the lower control arm.
3. Lower the vehicle.
4. Install the upper retaining nuts into the shock absorber. Torque the nuts to **33 ft-lb (45 Nm)**.
5. Lift the vehicle.
6. Install the mounting nut onto the shock absorber module yoke. Torque the nut to **82 ft-lb (111 Nm)**.
7. Lower the vehicle.

Shock Absorber

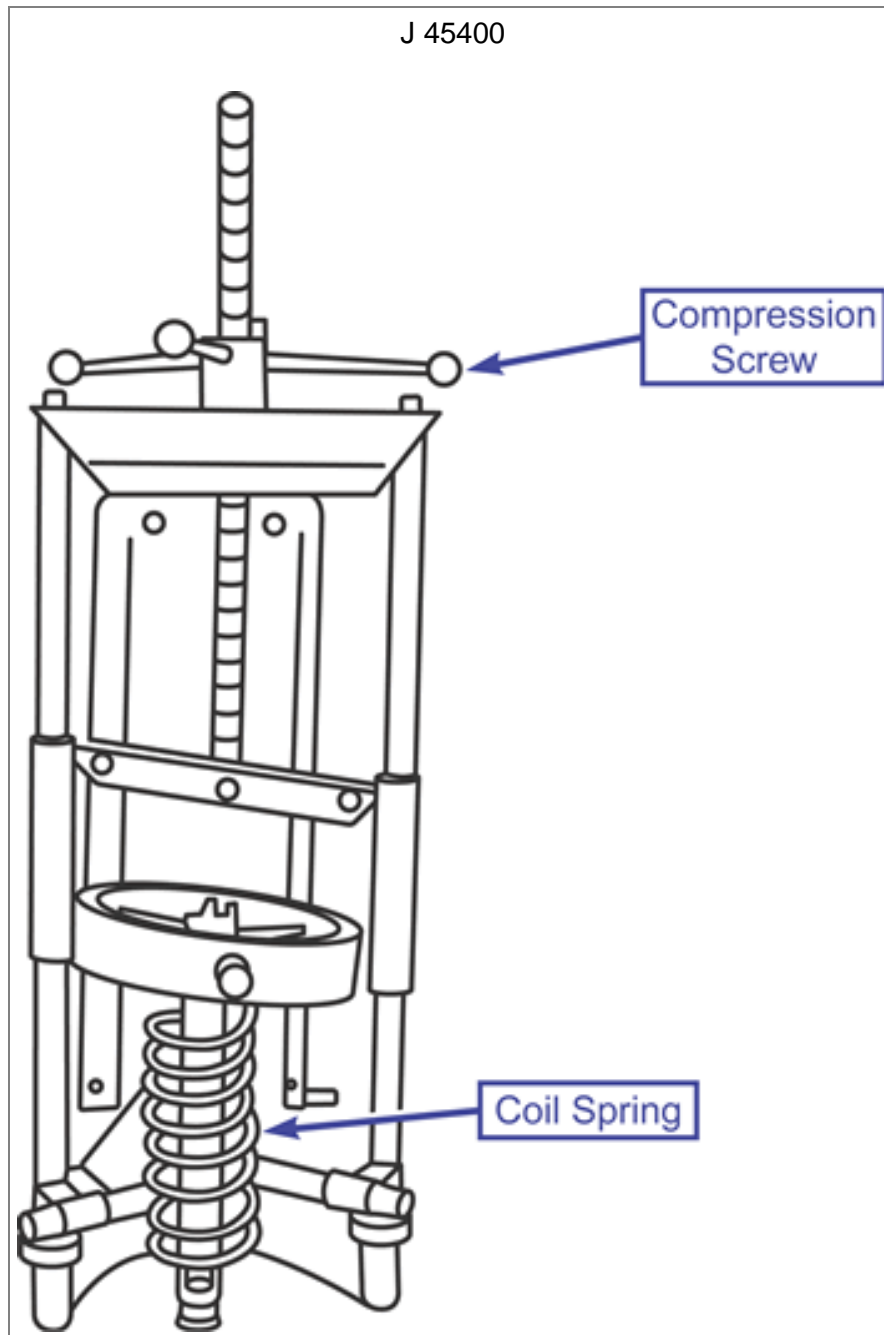
Removal & Installation

To Remove:

1. Lift the vehicle.
2. Remove the wheel from the vehicle.
3. Remove the shock absorber module from the vehicle.



4. Remove the shock absorber module yoke pinch nut and bolt from the shock absorber.
5. Use a flat bladed tool and hammer to spread the shock absorber module yoke.
6. Remove the shock absorber module yoke from the shock absorber module.
7. Install the shock absorber module into a J 45400 strut spring compressor.



8. Turn the J 45400 strut spring compressor compression screw to compress the shock absorber module spring.
9. Remove the upper retaining nut and washer from the shock absorber.
10. Remove the shock absorber from the shock absorber module.
11. Remove the washer, dust boot, jounce bumper, and lower spring isolator from the shock absorber.
12. Turn the J 45400 strut spring compressor compression screw to decompress the shock absorber module spring.
13. Remove the upper mounting plate and coil spring from the J 45400 strut spring compressor.

To Install:

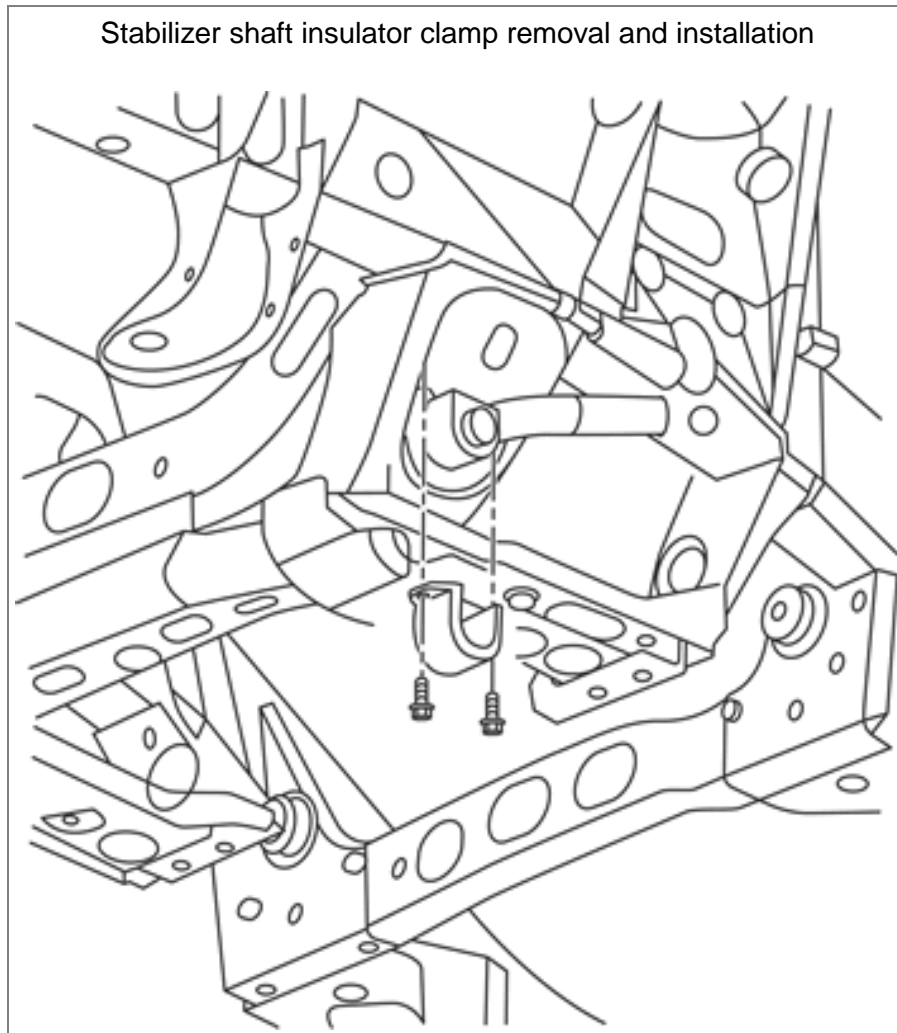
1. Install the coil spring and upper mounting plate into the J 45400 strut spring compressor.
2. Turn the J 45400 strut spring compressor compression screw to compress the shock absorber module spring.
3. Install the washer, dust boot, jounce bumper, and lower spring isolator onto the shock absorber.
4. Install the shock absorber into the shock absorber module.
5. Install the upper retaining nut and washer onto the shock absorber. Torque the retaining nut to **33 ft-lb (45 Nm)**.
6. Turn the J 45400 strut spring compressor compression screw to decompress the shock absorber module spring.
7. Remove the shock absorber module from the J 45400 strut spring compressor.
8. Install the shock absorber module yoke onto the shock absorber module.
9. Install the shock absorber module yoke pinch nut and bolt into the shock absorber. Torque the bolt to **52 ft-lb (70 Nm)**.
10. Install the shock absorber module into the vehicle.
11. Install the wheel onto the vehicle.
12. Lift the vehicle.

Stabilizer Shaft

Removal & Installation

To Remove:

1. Lift the vehicle.
2. Remove the wheels from the vehicle.
3. Remove the stabilizer shaft links from the stabilizer shaft.



4. Detach the stabilizer shaft insulator clamps from the stabilizer shaft.
5. Remove the stabilizer shaft insulator from the stabilizer shaft.
6. For vehicles with a 4.2L engine, remove the engine protection shield from under the frame.
7. For vehicles with a 4.2L engine, remove the engine mount bracket nuts from the frame.
8. For vehicles with a 4.2L engine, place a block of wood on a jack and use the jack to support the oil pan.

9. For vehicles with a 4.2L engine, lift the engine off of the front suspension crossmember.
10. Remove the stabilizer shaft from the vehicle.

To Install:

1. Install the stabilizer shaft into the vehicle.
2. For vehicles with a 4.2L engine, lower the.
3. For vehicles with a 4.2L engine, install the engine mount bracket nuts into the frame. Torque the nuts to **52 ft-lb (70 Nm)**.
4. For vehicles with a 4.2L engine, remove the jack to supporting the oil pan.
5. For vehicles with a 4.2L engine, install the engine protection shield under the frame.
6. Install the stabilizer shaft insulator onto the stabilizer shaft.
7. Attach the stabilizer shaft insulator clamps onto the stabilizer shaft. Torque the bolts to **40 ft-lb (54 Nm)**.
8. Install the stabilizer shaft links onto the stabilizer shaft.
9. Install the wheels onto the vehicle.
10. Lower the vehicle.

Rear Suspension

WARNING

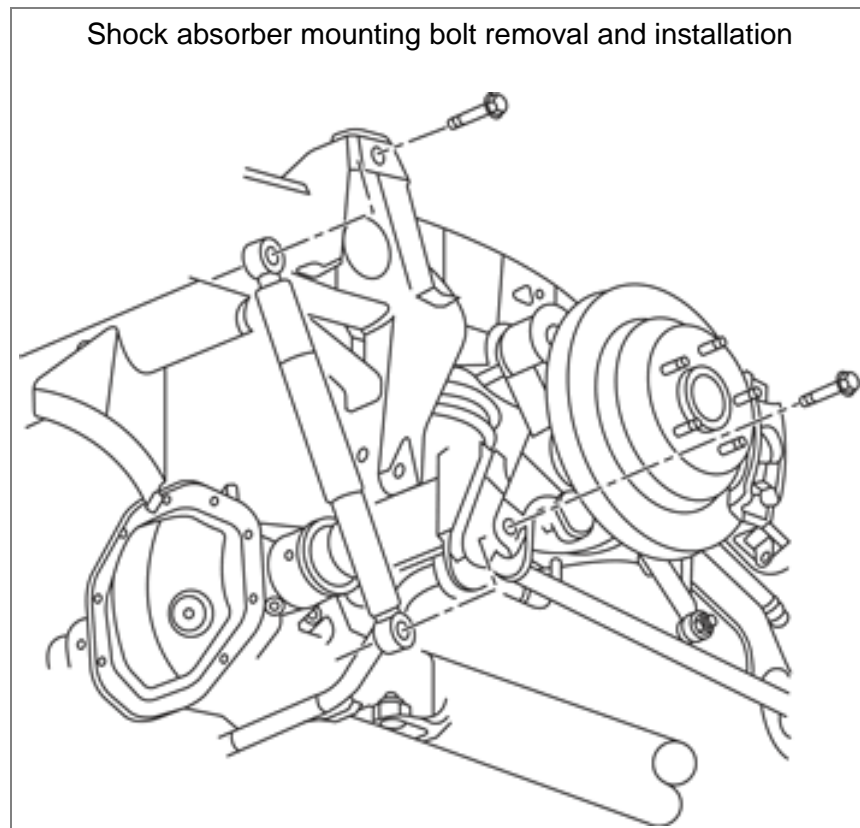
To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Coil Spring

Removal & Installation

To Remove:

1. Lift the vehicle.
2. Install a support for the rear axle.

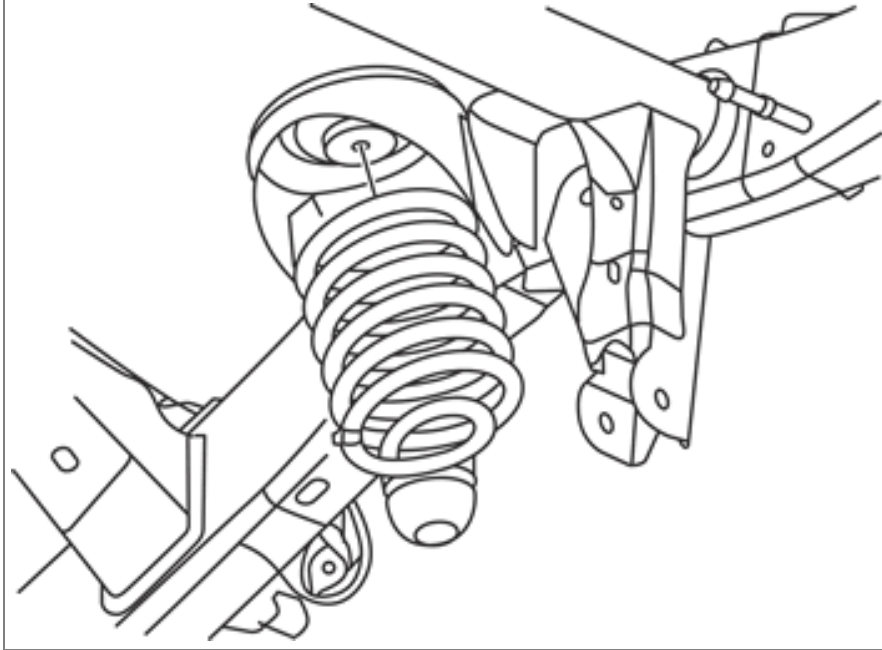


3. Remove the lower mounting bolts from the shock absorber.

NOTE: Do not let the upper control arm contact the frame while lowering the rear axle.

4. Lower the rear axle.

Coil spring removal and installation



5. Remove the rear coil spring from the vehicle.

To Install:

1. Install the rear coil spring into the vehicle.
2. Lift the rear axle.
3. Install the lower mounting bolts into the shock absorber.
4. Remove the support from the rear axle.
5. Lower the vehicle.

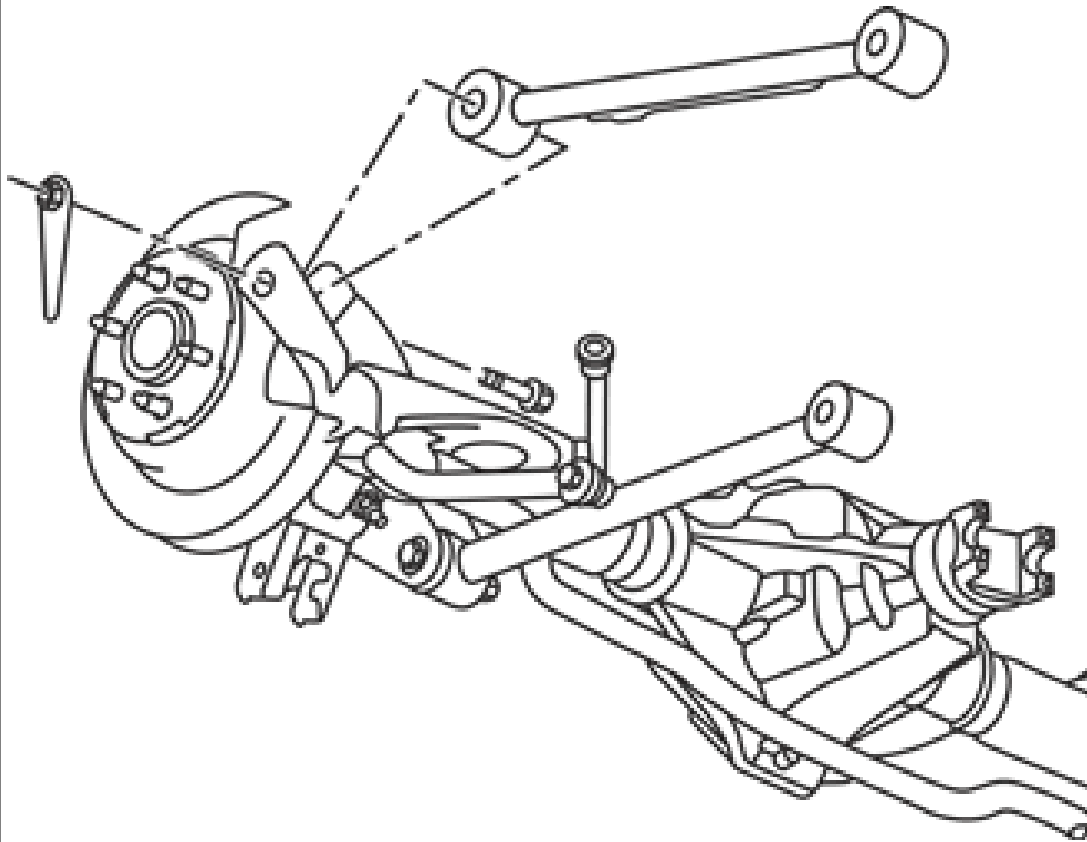
Upper Control Arm

Removal & Installation

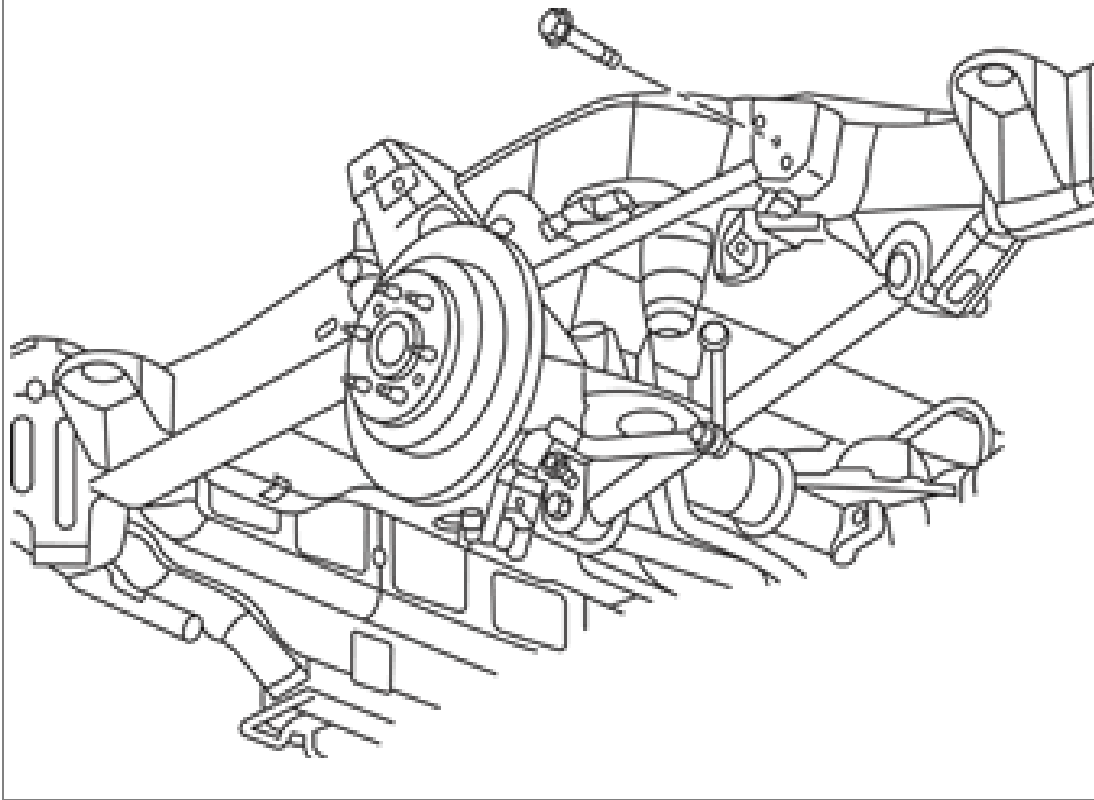
To Remove:

1. Lift the vehicle.
2. Remove the wheel from the vehicle.
3. Remove the panel from the wheelhouse.
4. Lift the rear axle to drive height.
5. If equipped with air suspension, depressurize the air suspension system.
6. If equipped with air suspension, detach the air suspension leveling sensor from the rear axle upper control arm.

Upper control arm axle mounting bolt removal and installation



Upper control arm frame mounting bolt removal and installation



8. Detach the upper control arm the axle and frame.

To Install:

1. Install the upper control arm into the vehicle.
2. Attach the upper control arm the axle and frame. Torque the bolts to **97 ft-lb (131 Nm)**.
3. If equipped with air suspension, attach the air suspension leveling sensor to the rear axle upper control arm.
4. Lower the rear axle.
5. Install the panel into the wheel house.
6. Install the wheel onto the vehicle.
7. Lower the vehicle.

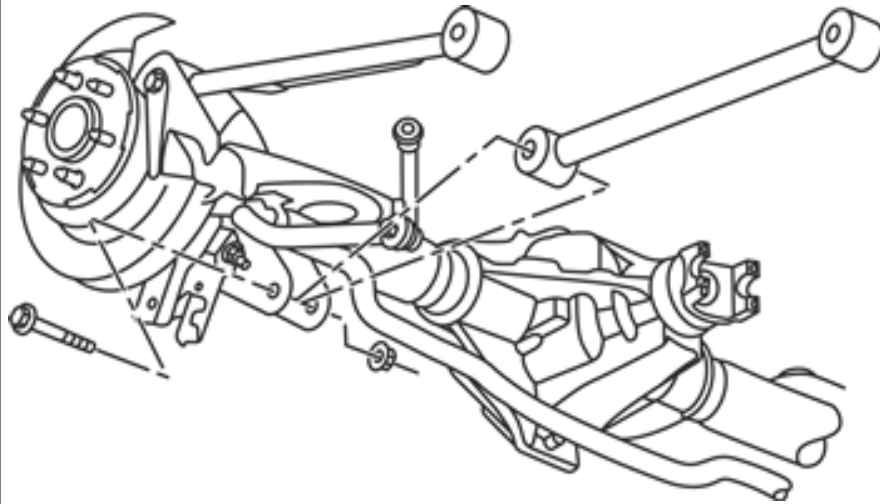
Lower Control Arm

Removal & Installation

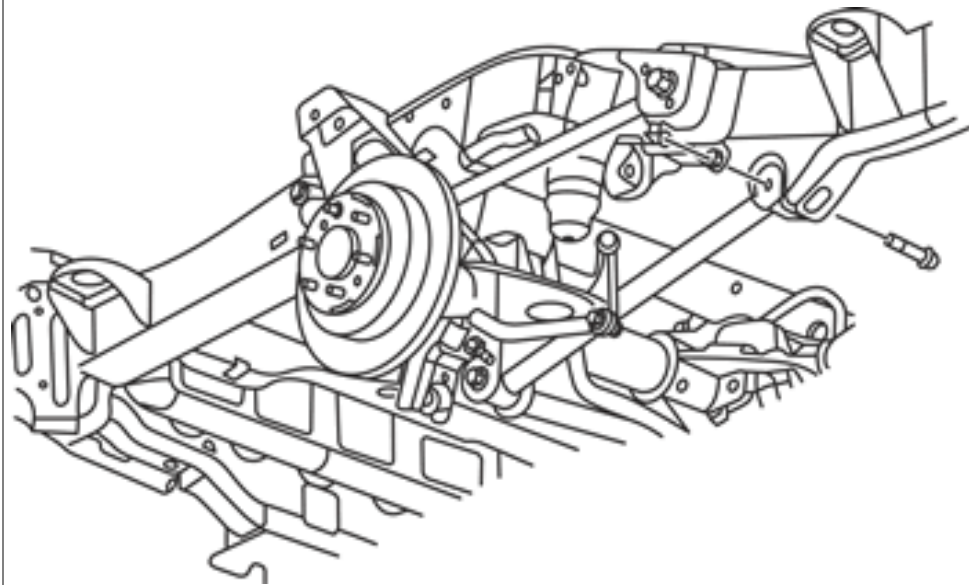
To Remove:

1. Lift the vehicle.
2. Lift the rear axle to drive height.
3. If equipped with air suspension, depressurize the air suspension system.

Lower control arm axle mounting bolt removal and installation



Lower control arm frame mounting bolt removal and installation



5. Detach the lower control arm from the axle and frame.

To Install:

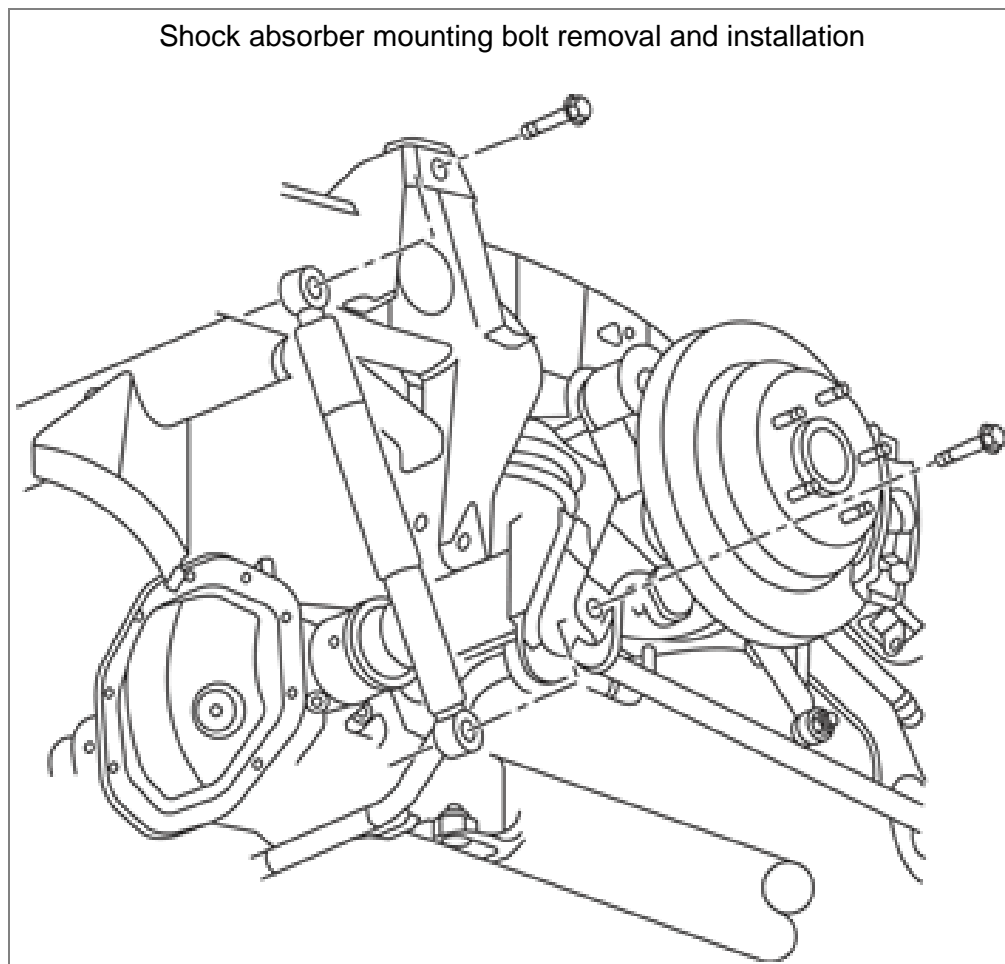
1. Attach the lower control arm to the axle and frame. Torque the bolts to **74 ft-lb (100 Nm)**.
2. Lower the rear axle.
3. Lower the vehicle.

Shock Absorber

Removal & Installation

To Remove:

1. Lift the vehicle.
2. Install a support for the rear axle.



3. Remove the upper mounting bolt from the shock absorber.
4. Remove the lower mounting bolt from the shock absorber.
5. Remove the shock absorber from the vehicle.

To Install:

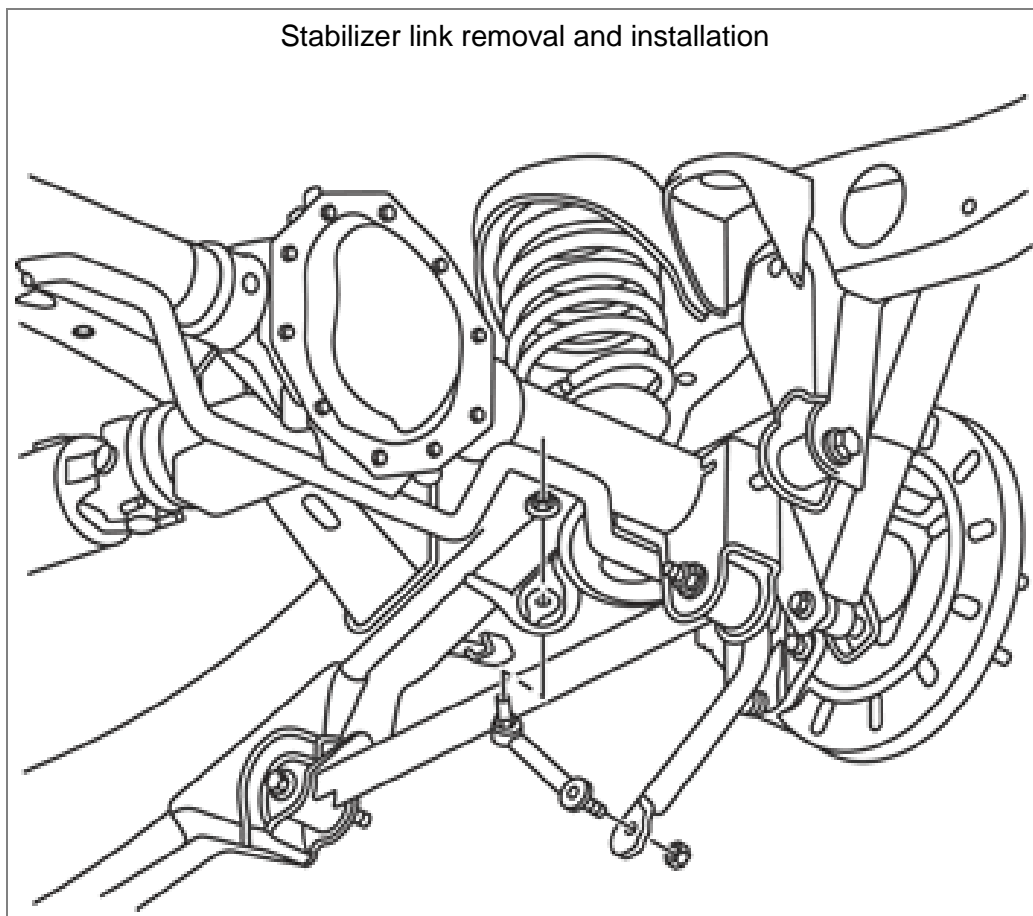
1. Install the shock absorber into the vehicle.
2. Install the lower mounting bolt into the shock absorber. Torque the bolt to **63 ft-lb (85 Nm)**.
3. Install the upper mounting bolt into the shock absorber. Torque the bolt to **63 ft-lb (85 Nm)**.
4. Remove the support from the rear axle.
5. Lower the vehicle.

Stabilizer Shaft

Removal & Installation

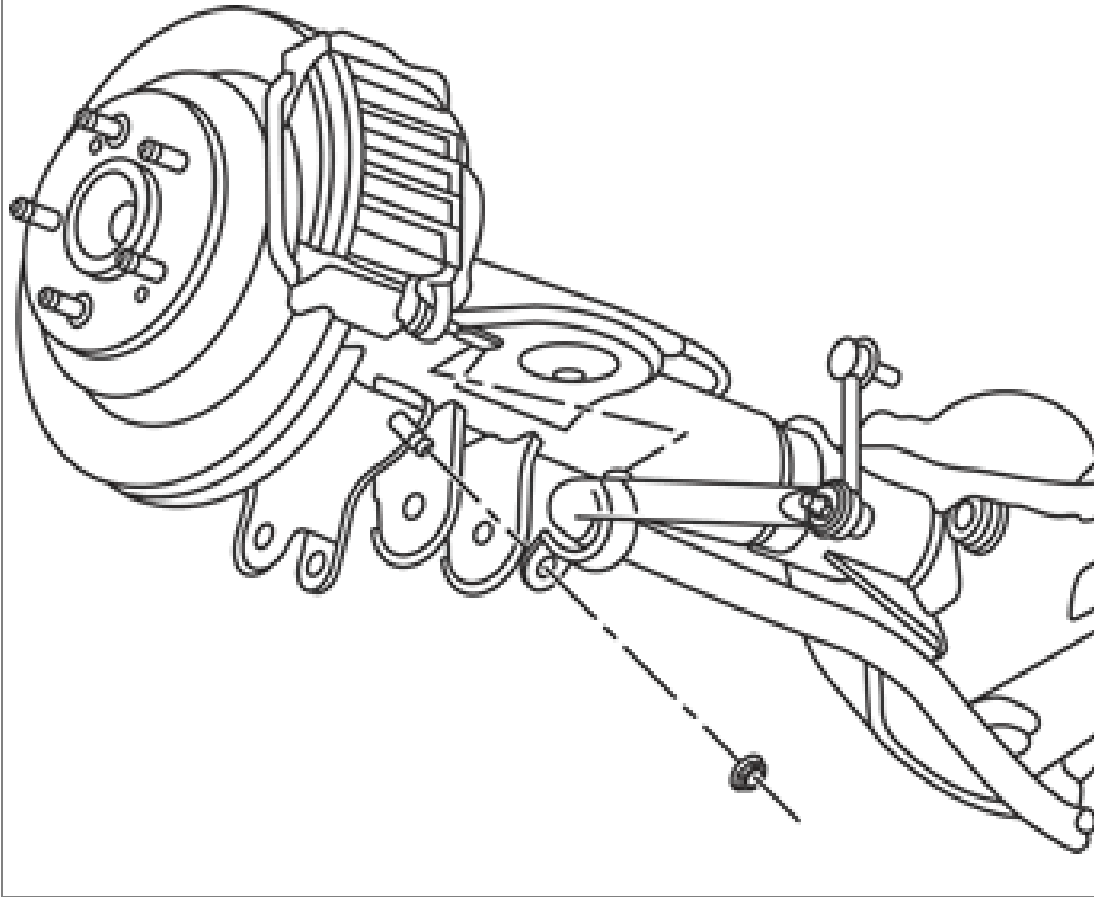
To Remove:

1. Lift the vehicle.
2. Remove wheels from the vehicle.



3. Detach the stabilizer shaft links from the stabilizer shaft.

Stabilizer shaft insulator clamp mounting nut removal and installation



4. Remove the mounting nuts from the stabilizer shaft insulator clamps.
5. Remove the stabilizer shaft from the vehicle.
6. Remove the stabilizer shaft insulators from the stabilizer shaft.

To Install:

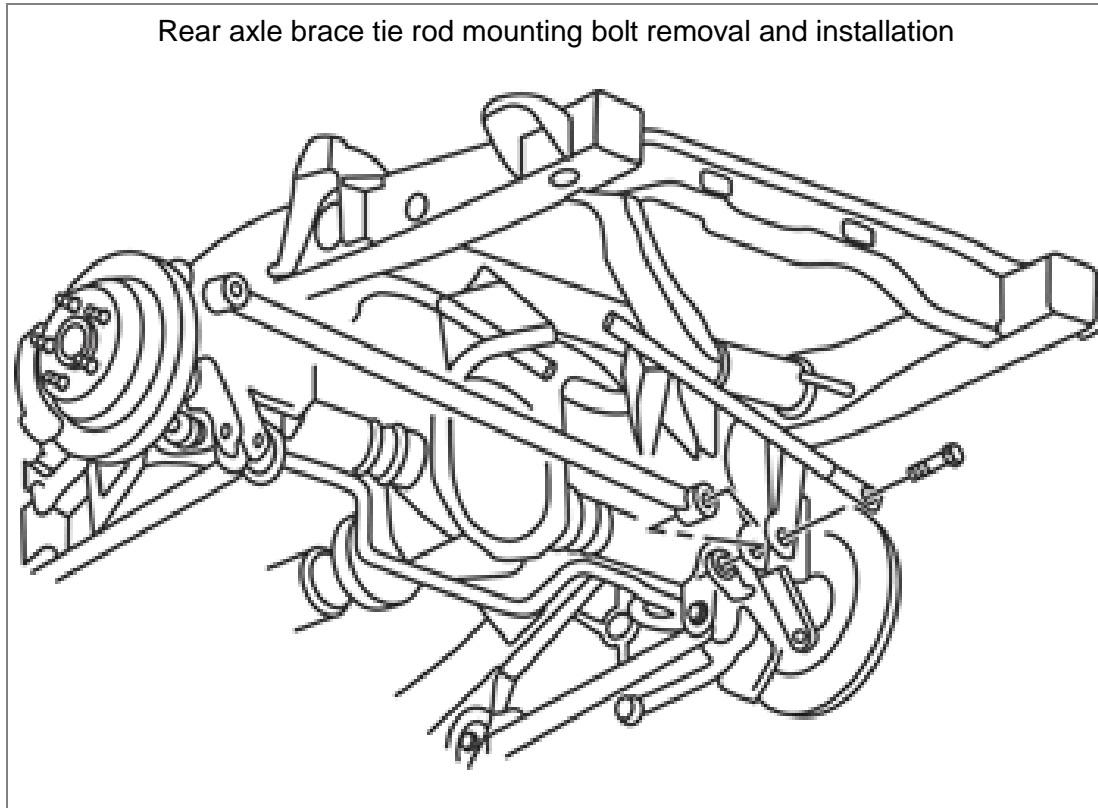
1. Install the stabilizer shaft insulators onto the stabilizer shaft.
2. Install the stabilizer shaft into the vehicle.
3. Install the mounting nuts onto the stabilizer shaft insulator clamps. Torque the nuts to **55 ft-lb (75 Nm)**.
4. Attach the stabilizer shaft links to the stabilizer shaft. Torque the nuts to **66 ft-lb (90 Nm)**.
5. Install the wheels onto the vehicle.
6. Lower the vehicle.

Rear Axle Brace

Removal & Installation

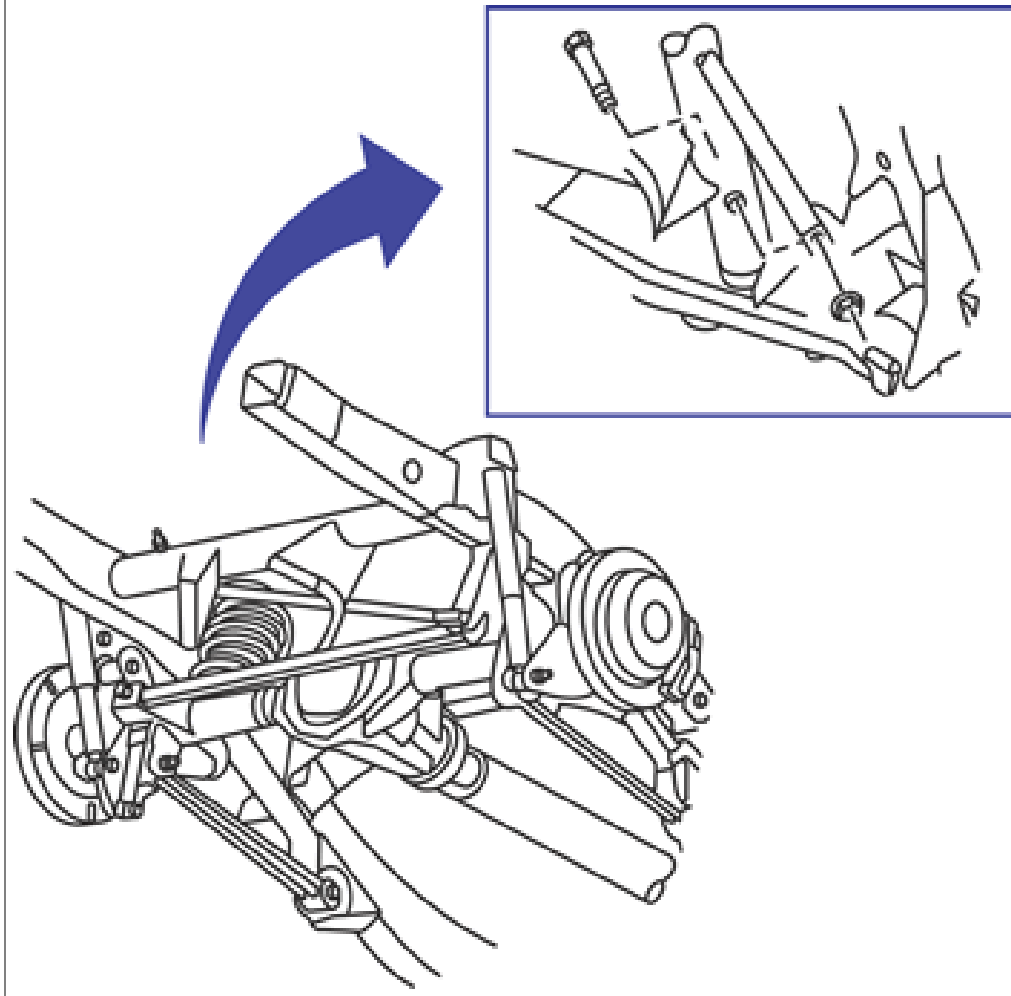
To Remove:

1. Lift the vehicle.
2. Lift the rear axle to drive height.
3. If equipped with air suspension, depressurize the air suspension system.



4. Remove the rear axle brace mounting bolt from the rear axle tie rod.

Rear axle frame mounting nut removal and installation



5. Remove the rear axle brace mounting nut from the frame.
6. Remove the rear axle brace from the vehicle.

To Install:

1. Install the rear axle brace into the vehicle.
2. Install the rear axle brace mounting nut onto the frame. Torque the nut to **70 ft-lb (95 Nm)**.
3. Install the rear axle brace mounting bolt into the rear axle tie rod. Torque the bolt to **140 ft-lb (190 Nm)**.
4. Lower the rear axle.
5. Lower the vehicle.

Wheels & Tires

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Wheels

Inspection

Tires should be inspected to ensure that there are no lacerations, puncture marks, nails and other sharp objects compromising the integrity of the tread area and sidewall. When inspecting the tires, check for proper air pressure and adequate tread depth. Repair or replace as necessary. Always check tire inflation with cold tires. Check the wheel assemblies for dents, cracks, and rust. Repair or replace as necessary.

Wheel Lug Studs

Removal & Installation

Front Disc Brakes W/Integral Hub & Rotor

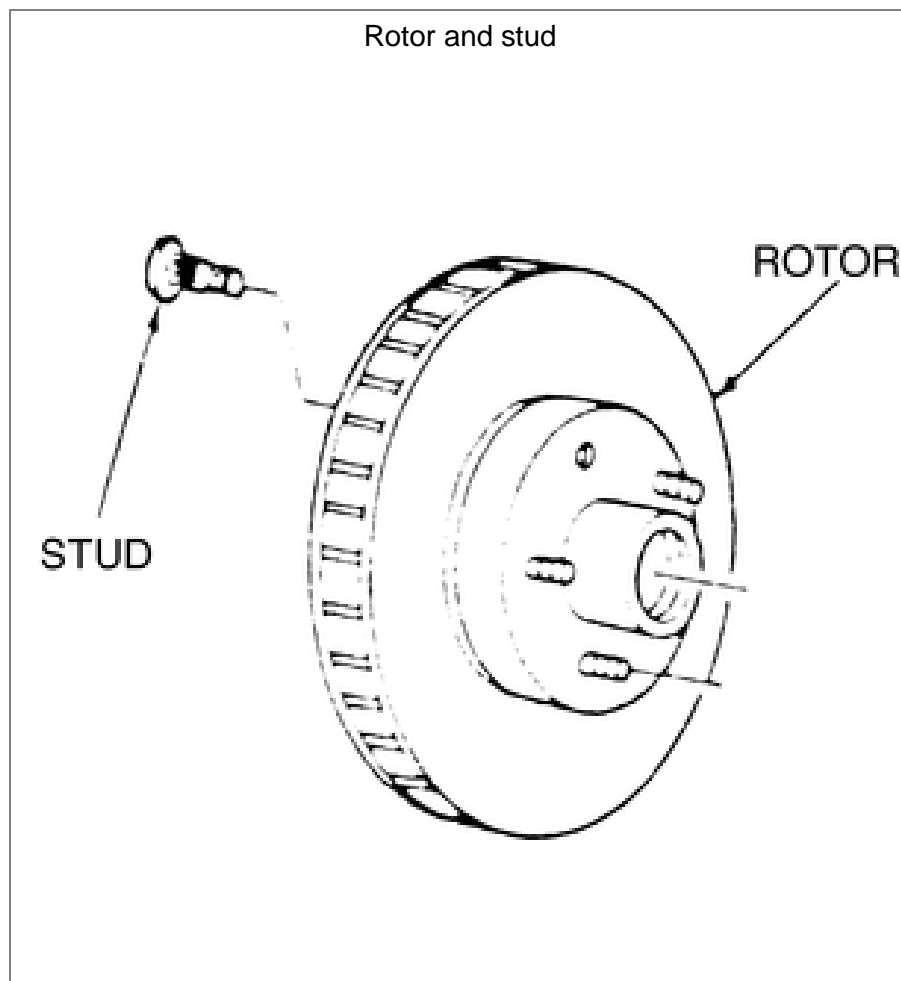
To Remove:

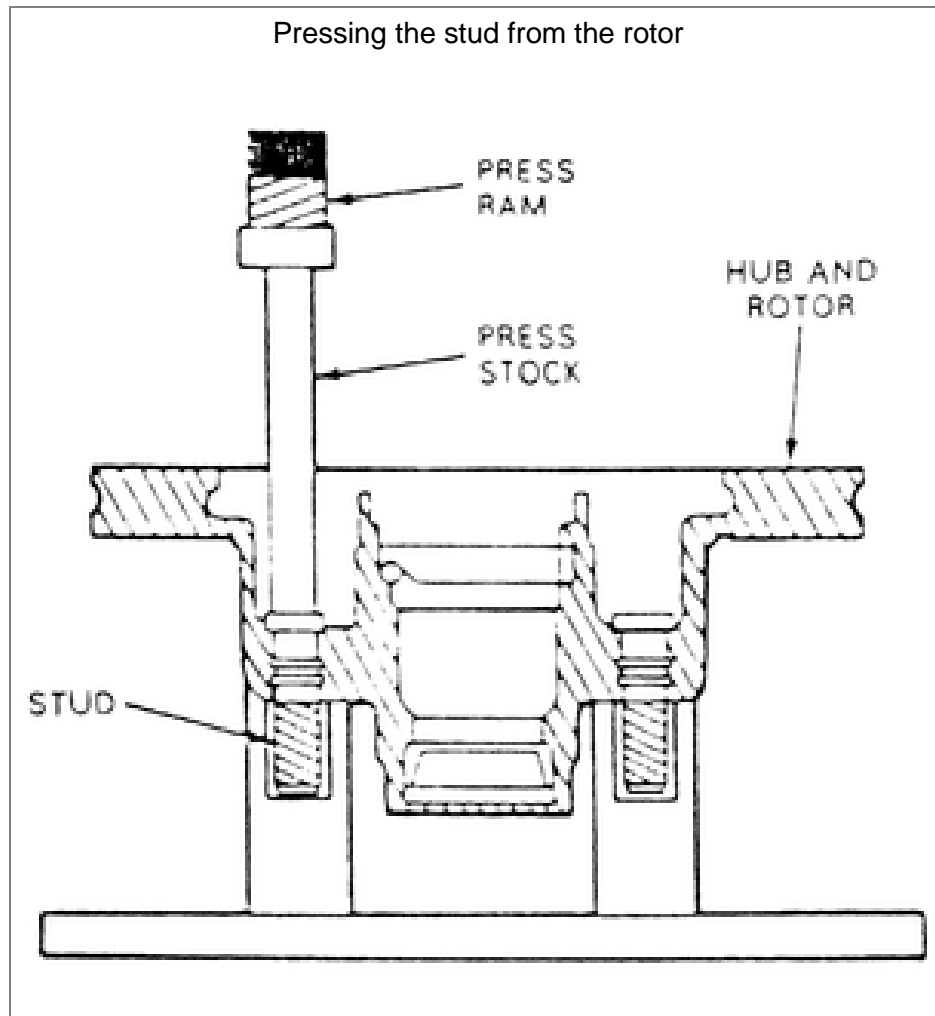
1. Raise and safely support the vehicle.
2. Remove the wheel and tire assembly.

CAUTION

Failure to support the brake caliper could result in brake hose failure.

3. Remove and support the brake caliper.
4. Remove the rotor from the spindle.
5. Support the rotor using press bars.
- 6.



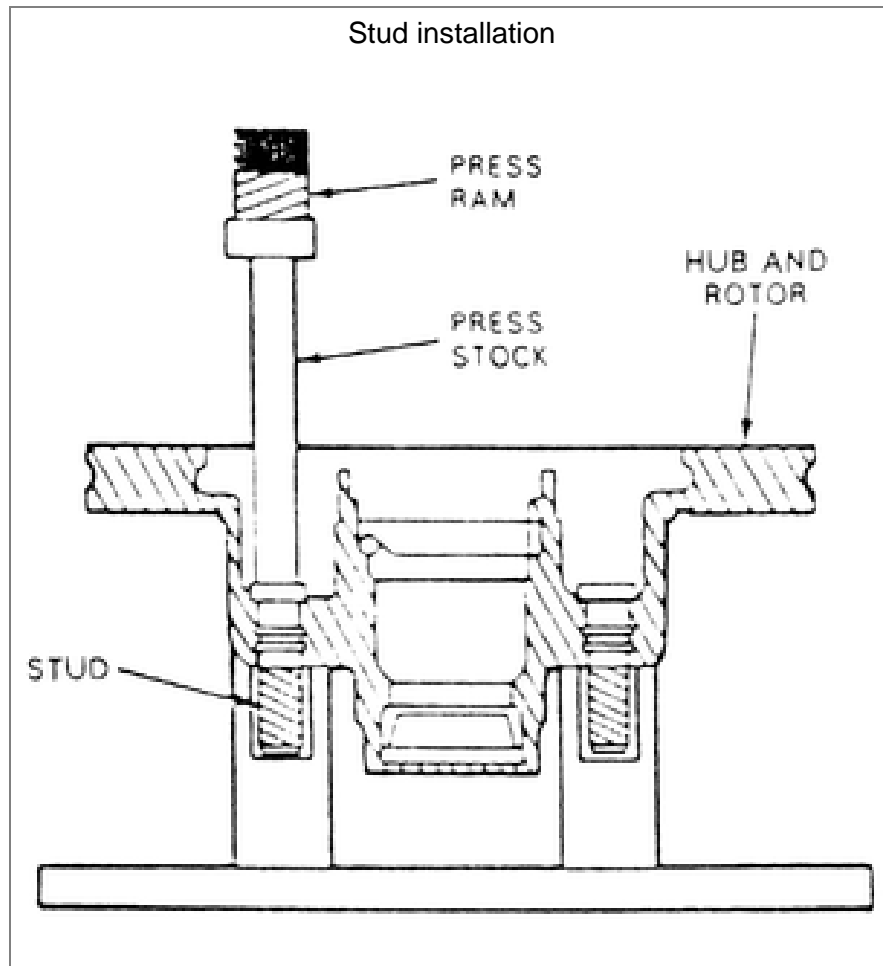


8. Drive the stud out using an arbor press.

NOTE: If a press is not available, carefully drive the old stud out using a blunt drift. Ensure that the rotor is properly and evenly supported or damage may result.

To Install:

1. Clean the stud hole with a wire brush and start the new stud with a hammer and drift pin.



2. Finish installing the stud with the press.

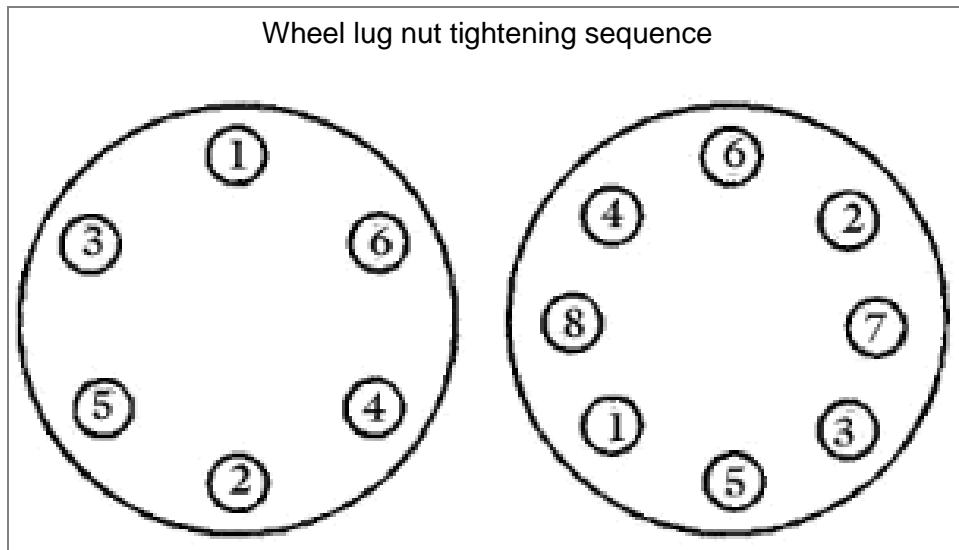
NOTE: If a press is not available, use the following procedure:

- A. Start the lug stud through the bore in the hub.
- B. Place approximately four flat washers over the stud and thread the lug nut to the stud.
- C. Hold the hub/rotor while tightening the lugnut. Draw the stud into position.
- D. Remove the lug nut and washers.

CAUTION

Ensure that the stud is fully seated.

- E. Install the brake rotor.
- F. Install the brake caliper.
- G. Install the wheel and tire assembly.



- H. Torque the lug nuts to specification.
- I. Lower the vehicle

Front & Rear Disc Brakes W/Removable Rotor

To Remove:

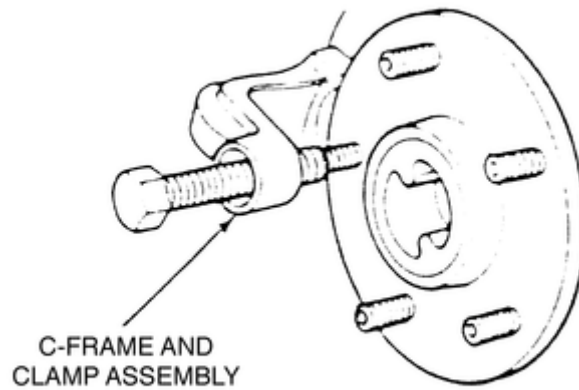
1. Raise and safely support the vehicle.
2. Remove the wheel and tire assembly.

CAUTION

Failure to support the brake caliper could result in brake hose failure.

3. Remove and support the brake caliper.
4. W/rear disc brakes, remove the anchor bracket.
5. Remove the brake rotor from the hub/axle flange.

Removing stud with C-clamp and socket

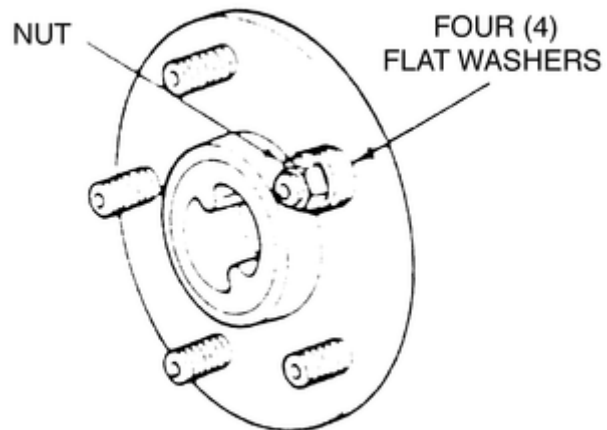


6. Use a large C-clamp and socket to press the stud from the hub/axle flange.

To Install:

1. Clean the stud hole with a wire brush.
2. Start the lug stud through the bore in the hub/axle flange.

Installing lug stud

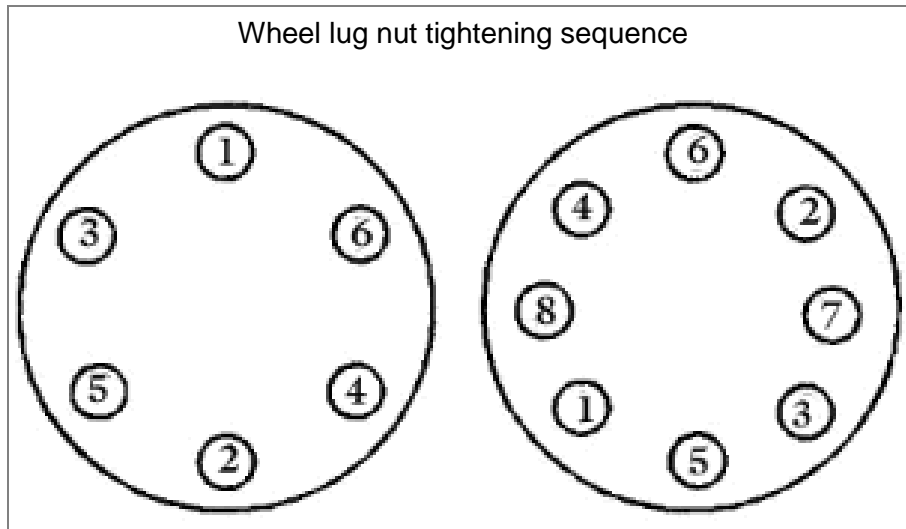


3. Place approximately four flat washers over the stud and thread the lug nut to the stud.
4. Hold the axle hub/flange while tightening the lugnut. Draw the stud into position.
5. Remove the lug nut and washers.

CAUTION

Ensure that the stud is fully seated.

6. Install the brake rotor.
7. W/rear disc brakes install the anchor bracket.
8. Install the brake caliper.
9. Install the wheel and tire assembly.



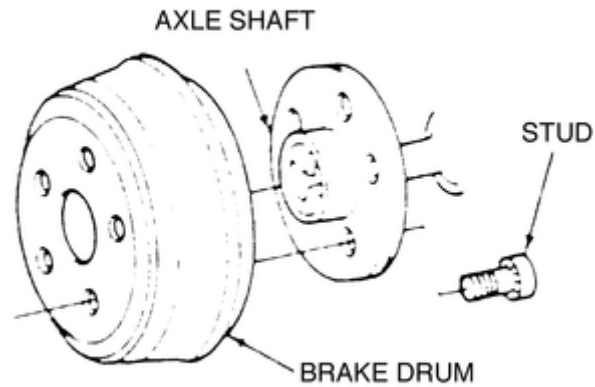
10. Torque the lug nuts to specification.
11. Lower the vehicle

Rear W/Drum Brakes

To Remove:

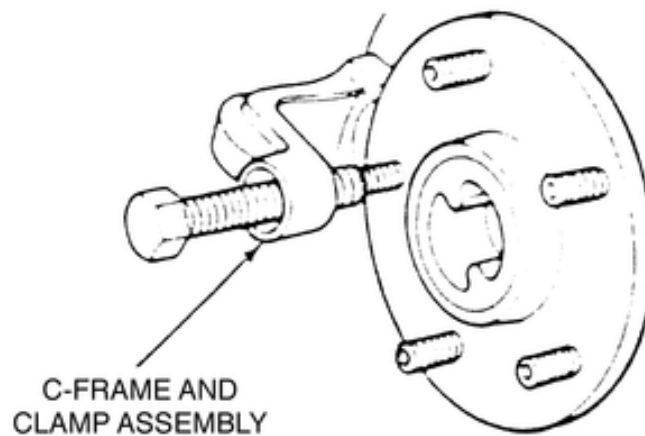
1. Raise and safely support the vehicle.
2. Remove the wheel and tire assembly.

Exploded view of the drum, axle flange and stud



3. Remove the brake drum from the axle shaft flange.
4. Remove the brake shoes if necessary to provide clearance.

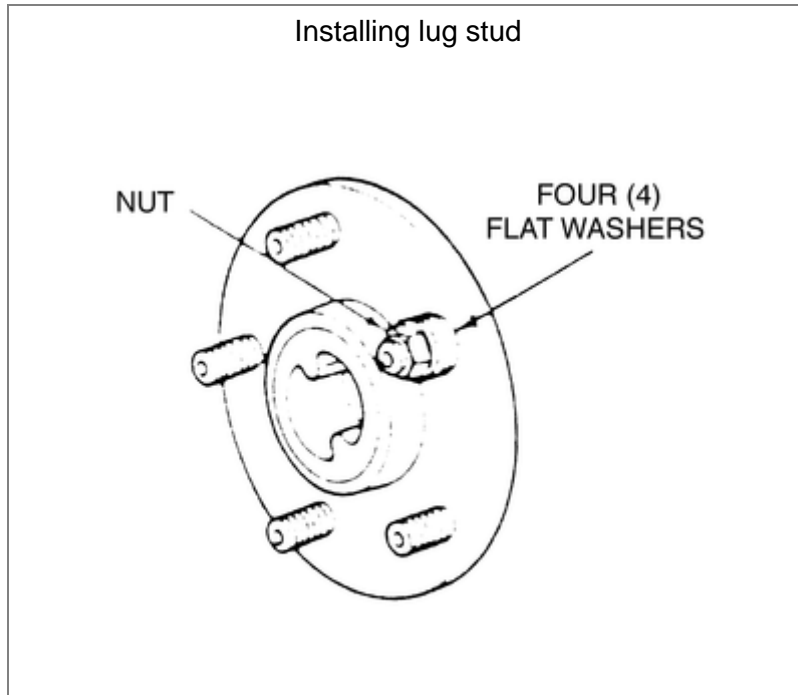
Removing stud with C-clamp and socket



5. Use a large C-clamp and socket to press the stud from the axle flange.

To Install:

1. Clean the stud hole with a wire brush.
2. Start the lug stud through the bore in the axle flange.

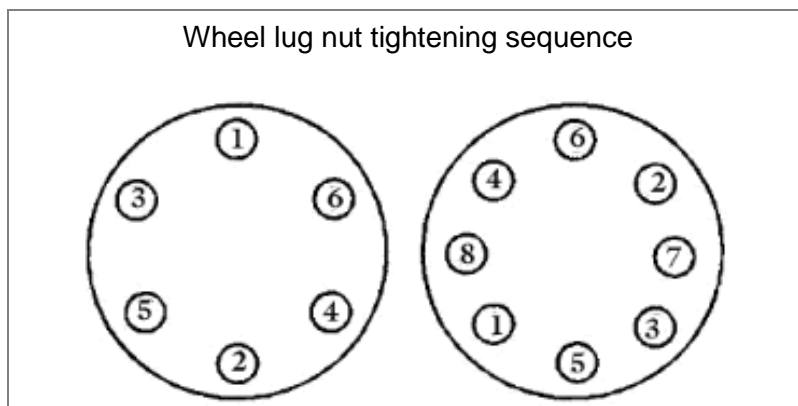


3. Place approximately four flat washers over the stud and thread the lug nut to the stud.
4. Hold the axle flange while tightening the lugnut. Draw the stud into position.
5. Remove the lug nut and washers.

CAUTION

Ensure that the stud is fully seated.

6. Install the brake shoes if removed.
7. Install the brake drum.
8. Install the wheel and tire assembly.



9. Torque the lug nuts to specification.
10. Lower the vehicle.

Wheel Alignment

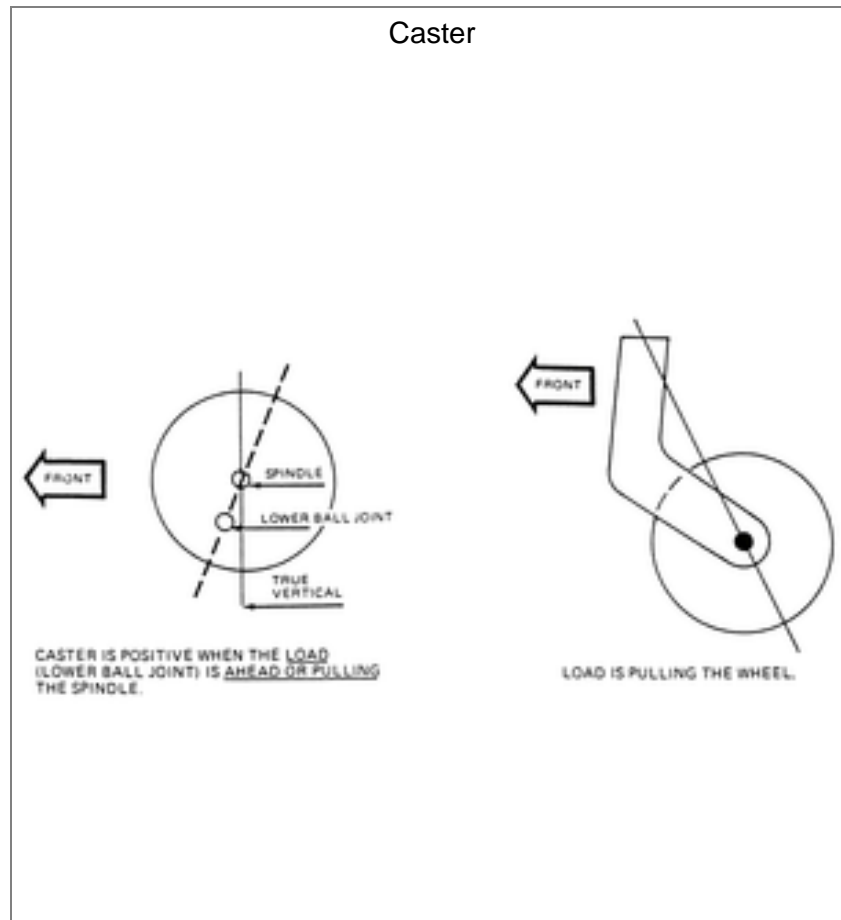
WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

General Information

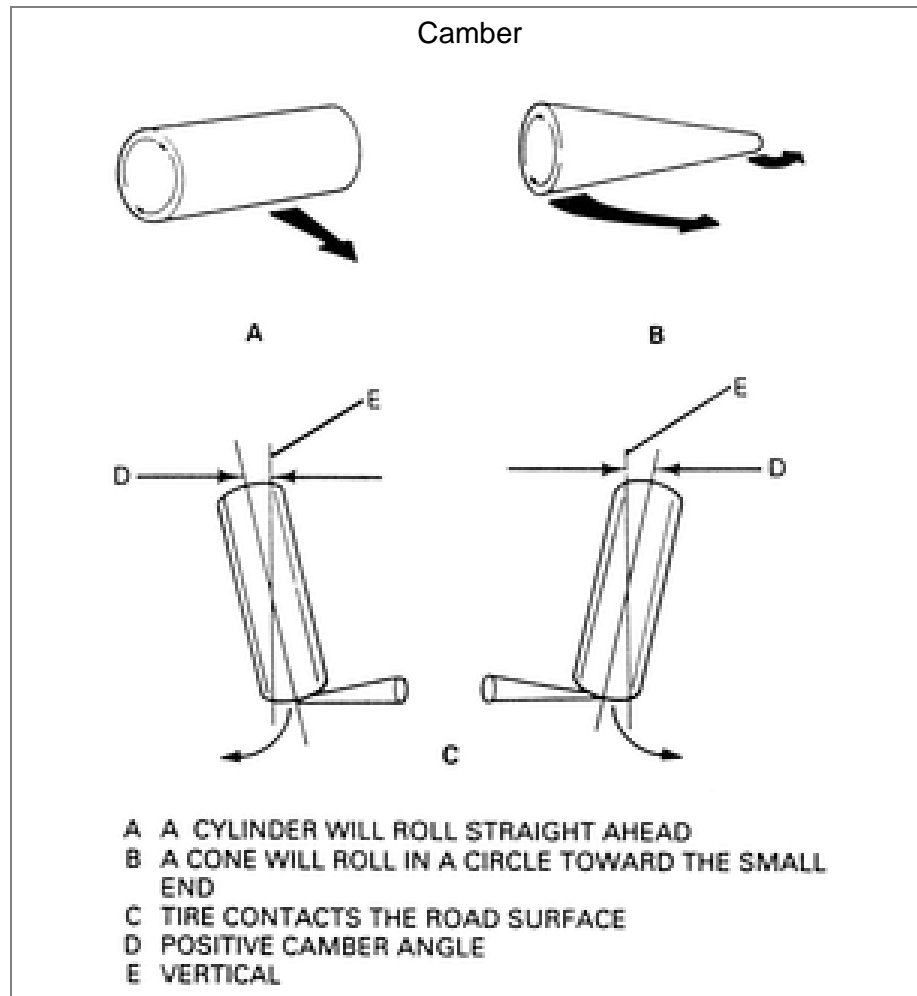
Caster

Looking at a vehicle from the side, caster angle describes the steering axis from front to rear. The steering knuckle is attached to a control arm or strut at the top and a control arm at the bottom. The wheel pivots around the line between these points to steer the vehicle. When the upper point is tilted back, this is described as positive caster. Having positive caster tends to make the wheels self-centering increasing directional stability. Excessive positive caster makes the wheels hard to steer, while an uneven caster will cause a pull to one side. Overloading the vehicle or sagging rear springs will affect caster, as it will raise the rear of the vehicle. If the rear of the vehicle is lower than normal, the caster becomes more positive. Caster affects straight-line stability. Caster wheels used on shopping carts, for example, employ negative caster.



Camber

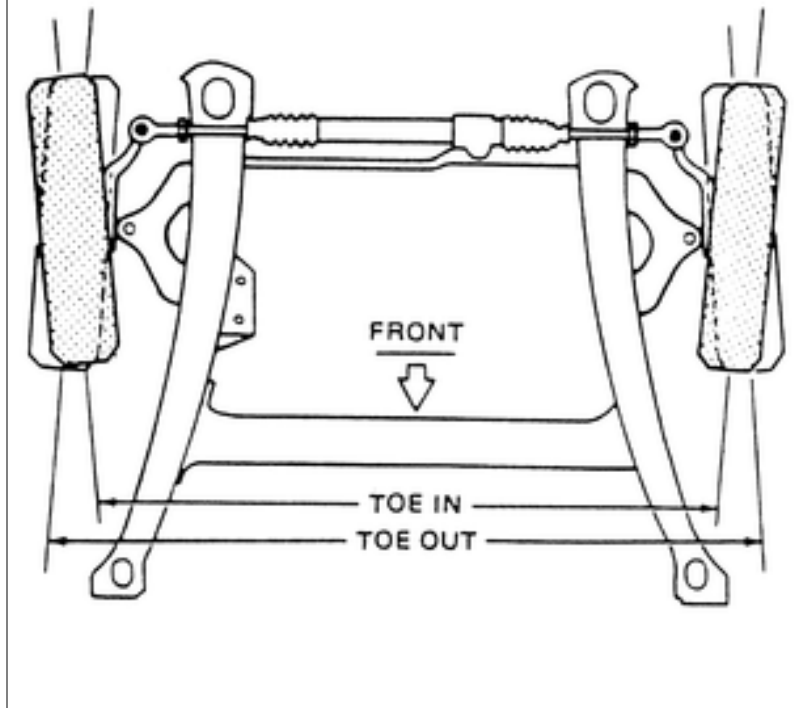
Looking from the front of the vehicle, camber is the inward or outward tilt of the top of wheels. When the tops of the wheels are tilted in, this is negative camber; if they are tilted out, positive. In a turn a slight amount of negative camber helps maximize contact of the tire with the road. Too much negative camber compromises straight-line stability, increases bump steer and torque steer. Camber influences tire contact with the road



Toe

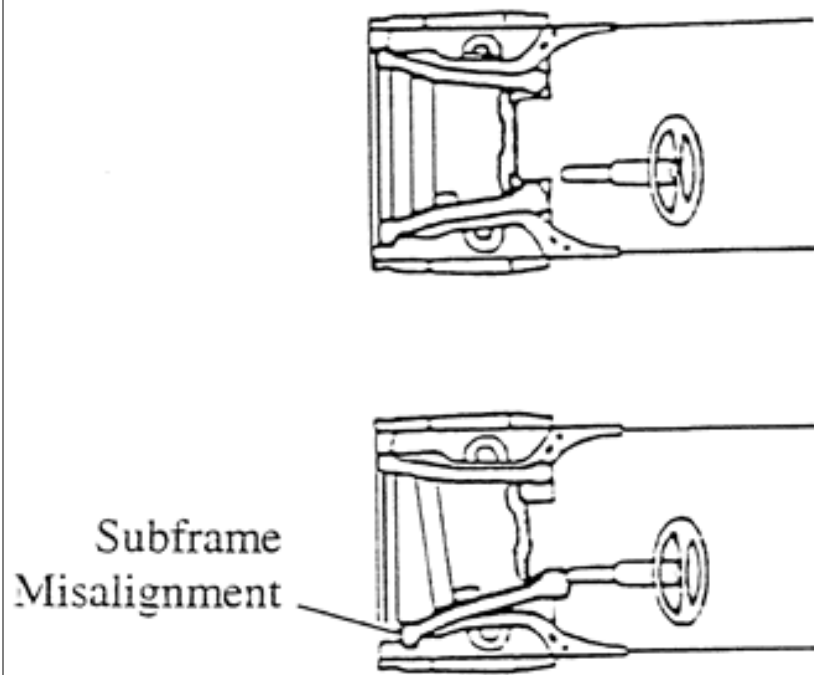
Looking down at the wheels from above the vehicle, toe angle is the difference in distance between the front of the wheels, to the back of the wheels. If the wheels are closer at the front, they are said to be toed-in or to have negative toe. A small amount of negative toe enhances directional stability and provides a smoother ride on the highway.

Toe-in



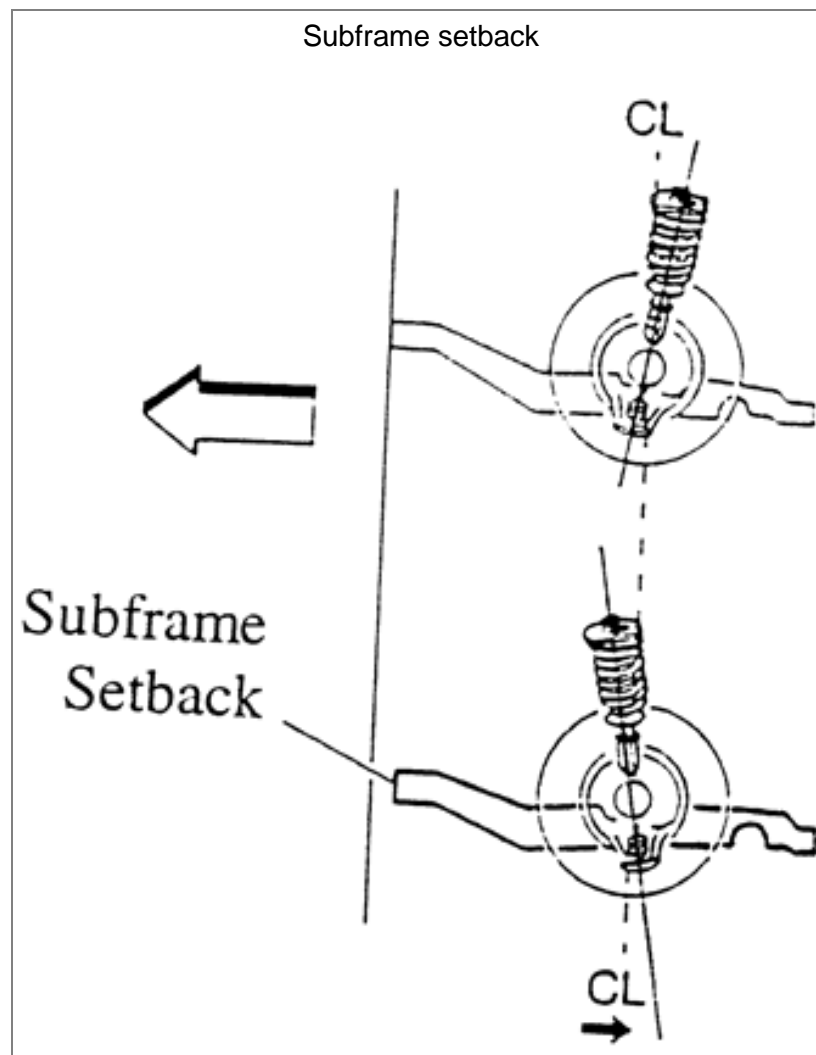
Frame Misalignment

Frame misalignment



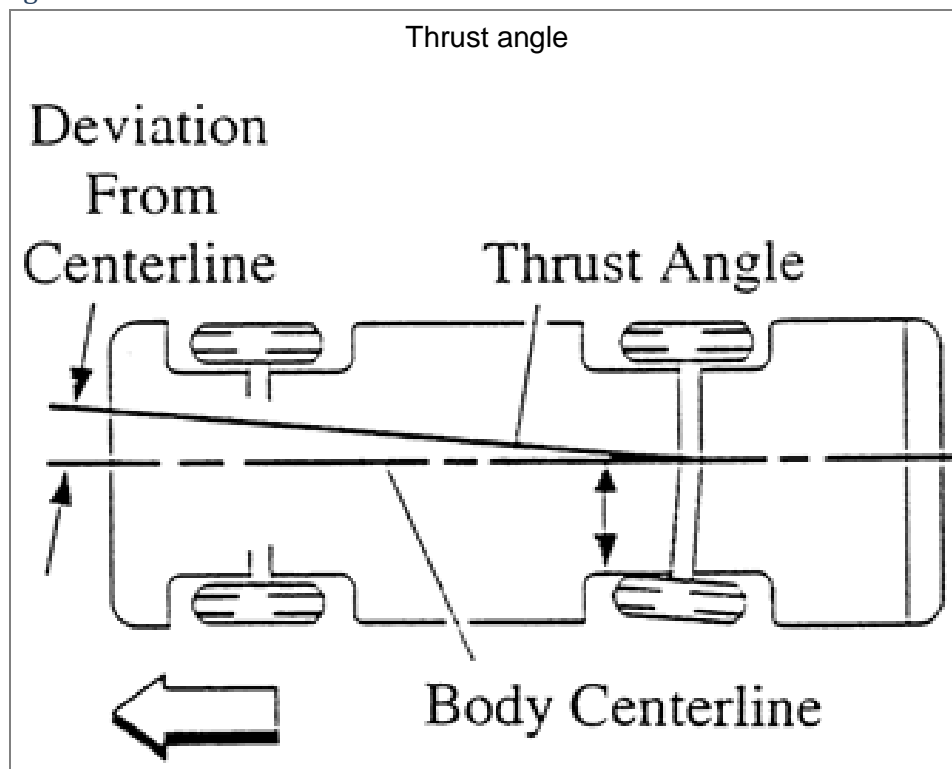
There are two types of frames commonly used, the ladder frame or full length frame and the subframe. Both frames are isolated from the body using rubber isolators. The subframe does not run the full length of the vehicle. The subframe supports the engine and transaxle. The subframe provides the mounting point for the front suspension lower control arms. Any misalignment of the subframe (accident damage, improperly performed heavy engine work where the subframe is loosened, lowered and/or removed, etc.) causes a misalignment of the front wheels. Movement of the subframe usually causes an increase in caster on one side of the vehicle and decrease in caster on the other side. This can cause the exhaust system to bind up, problems with control cables and unacceptable noise. Check the frame/subframe for any obvious damage, especially on a used vehicle with an unknown history.

Setback



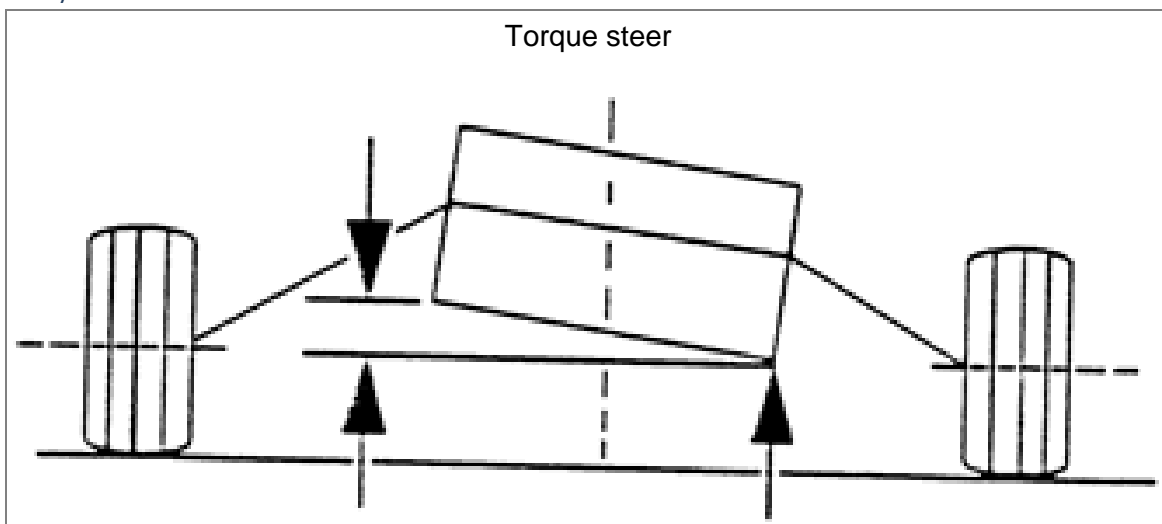
Setback applies to both the front and the rear wheels. Setback is the amount that one wheel spindle may be aligned behind the other wheel spindle. Setback may be the result of a road hazard (heavily hit pothole, for example) or a collision. The first clue is a caster difference from side-to-side of more than one degree.

Thrust Angles



The front wheels aim or steer the vehicle. The rear wheels control tracking. This tracking action relates to the thrust angle. The thrust angle is the path that the rear wheels take. Ideally the thrust angle is geometrically aligned with the body centerline. If, for example, the toe-in on the left rear wheel is out of specification, it moves the thrust line off center. The resulting deviation from the centerline is the thrust angle.

Lead/Pull



Lead is the deviation of the vehicle from a straight path on a level road, without hand pressure on the steering wheel. Lead is usually the result of tire construction, uneven

parking brake adjustment or the wheel alignment. The way in which a tire is built may produce lead. Rear tires do not cause lead.

Torque Steer

A vehicle pulls or leads in one direction during hard acceleration. A vehicle pulls or leads in the other direction during deceleration. The following factors may cause torque steer to be more apparent on a particular vehicle:

- A slightly smaller diameter tire on the right front increases a right torque lead. Inspect the front tires for differences in the brand, the construction or the size. If the tires appear to be similar, change the front tires from side-to-side and retest the vehicle. Tire and wheel assemblies have the most significant effect on torque steer correction.
- A large difference in the right and left front tire pressure.
- Left-to-right differences in the front view axle angle may cause significant steering pull in the vehicle. The pull will be to the side with the most downward sloping axle from the differential to the wheels. Axles (halfshafts) typically slope downward from the differential. The slope of the transaxle pan to level ground may be used as an indication of bias axle angles. The side with the higher transaxle pan has the most downward sloping axle angle.

Memory Steer

Memory steer is when the vehicle wants to lead or pull in the direction the driver previously turned the vehicle. Additionally, after turning in the opposite direction, the vehicle will want to lead or pull in that direction.

Wander

Wander is the undesirable drifting or deviation of a vehicle toward either side from a straight path with hand pressure on the steering wheel. Wander is a symptom of a vehicle's sensitivity to external disturbances, such as road crown and crosswind. A poor, on-center steering feel accentuates a wander condition.

Preliminary Alignment Inspection

Perform a number of checks before attempting a vehicle alignment. Loose or worn suspension parts prevent an accurate setting of alignment angles. Checks should include:

- The tires should be checked for proper inflation pressures.
- Check the tires for normal tread wear.
- Check the front hub and bearing assembly for excessive wear.
- Check the ball joints and tie rods for looseness.
- Inspect the wheels and tires for runout, resulting from bent wheels or faulty tires.
- The vehicle trim height should be checked. If the trim heights are not within specification, it will be necessary to make corrections before adjusting the alignment.
- The steering gear should be checked for looseness.

- The struts should be inspected for wear or damage.
- The control arms should be checked for loose or worn bushings.
- The stabilizer shaft (sway bar) attachments should be checked for loose or missing components.
- The frame fasteners should be checked for proper torque.
- The frame insulators should be checked for wear or damage.

BRAKES

Precautions

Before servicing the brake system, please be sure to read all of the following precautions, which deal with personal safety, prevention of component damage and important points to take into consideration when servicing the brake system.

- Brake pads or shoes may contain asbestos, which has been determined to be a cancer causing agent. Never clean brake components with compressed air. Avoid inhaling brake dust. When cleaning brake surfaces, use a commercially available brake cleaning fluid.
- Protect eyes and skin from contact with brake fluid. Rinse eyes with water and wash skin with soap and water if contaminated with brake fluid.
- Protect the painted surfaces on the vehicle from brake fluid. Brake fluid may damage the paint. Rinse brake fluid off of painted surfaces immediately.
- Apply the brake pedal several times to make sure it does not go to the floor after performing any service to the brake system before moving the vehicle.
- Always use clean brake fluid from a sealed container to ensure the safe and proper operation of the brake system.
- Never reuse brake fluid. Used brake fluid should be discarded.
- Always wear safety goggles or some type of eye/face protection when working with, around or under a vehicle.
- Be extremely careful while working on an operating engine, make sure you have no dangling jewelry, extremely loose clothes, power tool cords or other items that could get caught in any moving engine part.
- Never open, service or drain the radiator or cooling system when the engine is hot; serious burns can occur from the steam and hot coolant.
- Observe all applicable safety precautions when working around fuel. Whenever servicing the fuel system, always work in a well-ventilated area. Do not allow fuel spray or vapors to come in contact with a spark, open flame, or excessive heat (a hot drop light, for example). Keep a dry chemical fire extinguisher near the work area. Always keep fuel in a container specifically designed for fuel storage; also, always properly seal fuel containers to avoid the possibility of fire or explosion. Refer to the additional fuel system precautions later in this section.
- Fuel injection systems often remain pressurized, even after the engine has been turned OFF. The fuel system pressure must be relieved before disconnecting any fuel lines. Failure to do so may result in fire and/or personal injury.
- The EPA warns that prolonged contact with used engine oil may cause a number of skin disorders, including cancer! You should make every effort to minimize your exposure to used engine oil. Protective gloves should be worn when changing oil. Wash your hands and any other exposed skin areas as soon as possible after exposure to used engine oil. Soap and water, or waterless hand cleaner should be used.
- Never operate the engine without the proper amount and type of engine oil; doing so WILL result in severe engine damage.
- Disconnecting the negative battery cable on some vehicles may interfere with the functions of the on-board computer system(s) and may require the computer to undergo a relearning process once the negative battery cable is reconnected.

Cleanliness and Care, Shop Practice

- It should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

Basic Operating Principles

Hydraulic systems are used to actuate the brakes of all modern automobiles. The system transports the power required to force the frictional surfaces of the braking system together from the pedal to the individual brake units at each wheel. A hydraulic system is used for two reasons.

First, fluid under pressure can be carried to all parts of an automobile by small pipes and flexible hoses without taking up a significant amount of room or posing routing problems.

Second, a great mechanical advantage can be given to the brake pedal end of the system, and the foot pressure required to actuate the brakes can be reduced by making the surface area of the master cylinder pistons smaller than that of any of the pistons in the wheel cylinders or calipers.

The master cylinder consists of a fluid reservoir along with a double cylinder and piston assembly. Double type master cylinders are designed to separate the front and rear braking systems hydraulically in case of a leak. The master cylinder converts mechanical motion from the pedal into hydraulic pressure within the lines. This pressure is translated back into mechanical motion at the wheels by either the wheel cylinder (drum brakes) or the caliper (disc brakes).

Steel lines carry the brake fluid to a point on the vehicle's frame near each of the vehicle's wheels. The fluid is then carried to the calipers and wheel cylinders by flexible tubes in order to allow for suspension and steering movements.

In drum brake systems, each wheel cylinder contains two pistons, one at either end, which pushes outward in opposite directions and force the brake shoe into contact with the drum.

In disc brake systems, the cylinders are part of the calipers. At least one cylinder in each caliper is used to force the brake pads against the disc.

All pistons employ some type of seal, usually made of rubber, to minimize fluid leakage. A rubber dust boot seals the outer end of the cylinder against dust and dirt. The boot fits around the outer end of the piston on disc brake calipers, and around the brake actuating rod on wheel cylinders.

The hydraulic system operates as follows: When at rest, the entire system, from the piston(s) in the master cylinder to those in the wheel cylinders or calipers, is full of brake fluid. Upon application of the brake pedal, fluid trapped in front of the master cylinder piston(s) is forced through the lines to the wheel cylinders. Here, it forces the pistons outward, in the case of drum brakes, and inward toward the disc, in the case of disc brakes. The motion of the pistons is opposed by return springs mounted outside the cylinders in drum brakes, and by spring seals, in disc brakes.

Upon release of the brake pedal, a spring located inside the master cylinder immediately returns the master cylinder pistons to the normal position. The pistons contain check valves and the master cylinder has compensating ports drilled in it. These are uncovered as the pistons reach their normal position. The piston check valves allow fluid to flow toward the wheel cylinders or calipers as the pistons withdraw. Then, as the return springs force the brake pads or shoes into the released position, the excess fluid reservoir through the compensating ports. It is during the time the pedal is in the released position that any fluid that has leaked out of the system will be replaced through the compensating ports.

Dual circuit master cylinders employ two pistons, located one behind the other, in the same cylinder. The primary piston is actuated directly by mechanical linkage from the brake pedal through the power booster. The secondary piston is actuated by fluid trapped between the two pistons. If a leak develops in front of the secondary piston, it moves forward until it bottoms against the front of the master cylinder, and the fluid trapped between the pistons will operate the rear brakes. If the rear brakes develop a leak, the primary piston will move forward until direct contact with the secondary piston takes place, and it will force the secondary piston to actuate the front brakes. In either case, the brake pedal moves farther when the brakes are applied, and less braking power is available.

All dual circuit systems use a switch to warn the driver when only half of the brake system is operational. This switch is usually located in a valve body which is mounted on the firewall or the frame below the master cylinder. A hydraulic piston receives pressure from both circuits, each circuit's pressure being applied to one end of the piston. When the pressures are in balance, the piston remains stationary. When one circuit has a leak, however, the greater pressure in that circuit during application of the brakes will push the piston to one side, closing the switch and activating the brake warning light.

In disc brake systems, this valve body also contains a metering valve and, in some cases, a proportioning valve. The metering valve keeps pressure from traveling to the disc brakes on the front wheels until the brake shoes on the rear wheels have contacted the drums, ensuring that the front brakes will never be used alone. The proportioning valve controls the pressure to the rear brakes to lessen the chance of rear wheel lock-up during very hard braking.

Warning lights may be tested by depressing the brake pedal and holding it while opening one of the wheel cylinder bleeder screws. If this does not cause the light to go on,

substitute a new lamp, make continuity checks, and, finally, replace the switch as necessary.

The hydraulic system may be checked for leaks by applying pressure to the pedal gradually and steadily. If the pedal sinks very slowly to the floor, the system has a leak. This is not to be confused with a springy or spongy feel due to the compression of air within the lines. If the system leaks, there will be a gradual change in the position of the pedal with a constant pressure.

Check for leaks along all lines and at wheel cylinders. If no external leaks are apparent, the problem is inside the master cylinder.

Disc Brakes

Disc brake systems utilize a disc (rotor) with brake pads positioned on either side of it. An easily-seen analogy is the hand brake arrangement on a bicycle. The pads squeeze onto the rim of the bike wheel, slowing its motion. Automobile disc brakes use the identical principle but apply the braking effort to a separate disc instead of the wheel.

The disc (rotor) is a casting, usually equipped with cooling fins between the two braking surfaces. This enables air to circulate between the braking surfaces to aid in cooling the rotor.. Dirt and water do not drastically affect braking action since contaminants are thrown off by the centrifugal action of the rotor or scraped off the by the pads. Also, the equal clamping action of the two brake pads tends to ensure uniform, straight line stops. Disc brakes are inherently self-adjusting. There are three general types of disc brake:

- A fixed caliper.
- A floating caliper.
- A sliding caliper.

The fixed caliper design uses two pistons mounted on either side of the rotor (in each side of the caliper). The caliper is mounted rigidly and does not move.

The sliding and floating designs are quite similar. In fact, these two types are often lumped together. In both designs, the pad on the inside of the rotor is moved into contact with the rotor by hydraulic force. The caliper, which is not held in a fixed position, moves slightly, bringing the outside pad into contact with the rotor. There are various methods of attaching floating calipers. Some pivot at the bottom or top, and some slide on mounting bolts. In any event, the end result is the same.

Drum Brakes

Drum brakes employ two brake shoes mounted on a stationary backing plate. These shoes are positioned inside a circular drum which rotates with the wheel assembly. The shoes are held in place by springs. This allows them to slide toward the drums (when they are applied) while keeping the linings and drums in alignment. The shoes are actuated by a wheel cylinder which is mounted at the top of the backing plate. When the brakes are applied, hydraulic pressure forces the wheel cylinder's actuating links outward. Since these links bear directly against the top of the brake shoes, the tops of the shoes are then forced

against the inner side of the drum. This action forces the bottoms of the two shoes to contact the brake drum by rotating the entire assembly slightly (known as servo action). When pressure within the wheel cylinder is relaxed, return springs pull the shoes back away from the drum.

Most modern drum brakes are designed to self-adjust themselves during application when the vehicle is moving in reverse. This motion causes both shoes to rotate very slightly with the drum, rocking an adjusting lever, thereby causing rotation of the adjusting screw. Some drum brake systems are designed to self-adjust during application whenever the brakes are applied. This on-board adjustment system reduces the need for maintenance adjustments and keeps both the brake function and pedal feel satisfactory.

Power Boosters

Virtually all modern vehicles use a vacuum assisted power brake system to multiply the braking force and reduce pedal effort. Since vacuum is always available when the engine is operating, the system is simple and efficient. A vacuum diaphragm is located on the front of the master cylinder and assists the driver in applying the brakes, reducing both the effort and travel he must put into moving the brake pedal.

The vacuum diaphragm housing is normally connected to the intake manifold by a vacuum hose. A check valve is placed at the point where the hose enters the diaphragm housing, so that during periods of low manifold vacuum brakes assist will not be lost.

Depressing the brake pedal closes off the vacuum source and allows atmospheric pressure to enter on one side of the diaphragm. This causes the master cylinder pistons to move and apply the brakes. When the brake pedal is released, vacuum is applied to both sides of the diaphragm and springs return the diaphragm and master cylinder pistons to the released position.

If the vacuum supply fails, the brake pedal rod will contact the end of the master cylinder actuator rod and the system will apply the brakes without any power assistance. The driver will notice that much higher pedal effort is needed to stop the car and that the pedal feels harder than usual.

Brake Hoses And Pipes

Always use double walled steel brake lines when replacing rusted or damaged brake lines. The use of any other tubing is not approved and may cause brake failure. Carefully route and retain replacement brake lines. Always use the correct fasteners and the original location for replacement brake pipes. Failure to properly route and retain brake lines may cause damage to the brake lines and cause brake system failure, resulting in possible personal injury.

The steel brake lines use what is called an I.S.O. flare. This is different from the flare used on American vehicles for many years. If a brake line is damaged and requires replacement, you must obtain a replacement brake line with the correct flare. Most automotive parts stores stock straight lengths of steel brake line, already flared, with the correct fittings installed. Brake line replacement requires obtaining a piece of brake line as close in length to the original as possible. The brake line must be of the correct diameter

and flare. The replacement length of brake line is carefully bent to conform to the shape of the original brake line.

One of the major causes of brake line replacement is twisting off or otherwise damaging a piece of brake line when replacing other components. For example, when replacing a rear wheel cylinder, if the brake line is rusted, loosening the brake line fitting backs the fitting over rusted portions of the brake line. This binds up the fitting so it seizes on the brake line. Continuing to loosen the brake line fitting usually results in snapping off the brake line, requiring replacement of that section of brake line. Many technicians take the time to polish off any rust and corrosion from the brake line next to the fitting, using fine emery cloth or crocus cloth, then using a penetrating oil to loosen the brake line fitting. The time spent cleaning the brake line before attempting to loosen the fitting pays off by saving the original brake line.

Another condition requiring brake line replacement is when the fittings are damaged. This is almost always caused by using the wrong wrench. Brake line wrenches (sometimes called Flare Nut Wrenches) should be used. These wrenches wrap around the fitting, grasping it on five of the six wrench flats on the fitting. This reduces (but doesn't eliminate) the chance of rounding off the fitting's corners so that it cannot be removed, or, if removed, cannot be adequately tightened at installation. Brake line wrenches are available at most auto supply stores, in both standard and metric sizes.

Brake hoses are used to carry the brake fluid to parts that are in motion, mainly the front and rear brakes which move with the independent suspension. Generally, brake hoses give little trouble but should be inspected at least twice a year. Check the brake hoses for road hazard damage, crack, chafing of the outer cover, leaks, blisters and for proper routing and mounting. A light and mirror may be needed for an adequate inspection. If any of these conditions are found, it will be necessary to replace the brake hose.

NOTE: Never allow components to hang from the flexible brake hoses as damage to the hoses may occur. Some brake hoses have protective rings or covers to prevent direct contact of the hose with other chassis parts. Besides causing possible structural damage to the hose, excessive tension could cause the hose rings to move out of proper locations.

Hydraulic Brake System

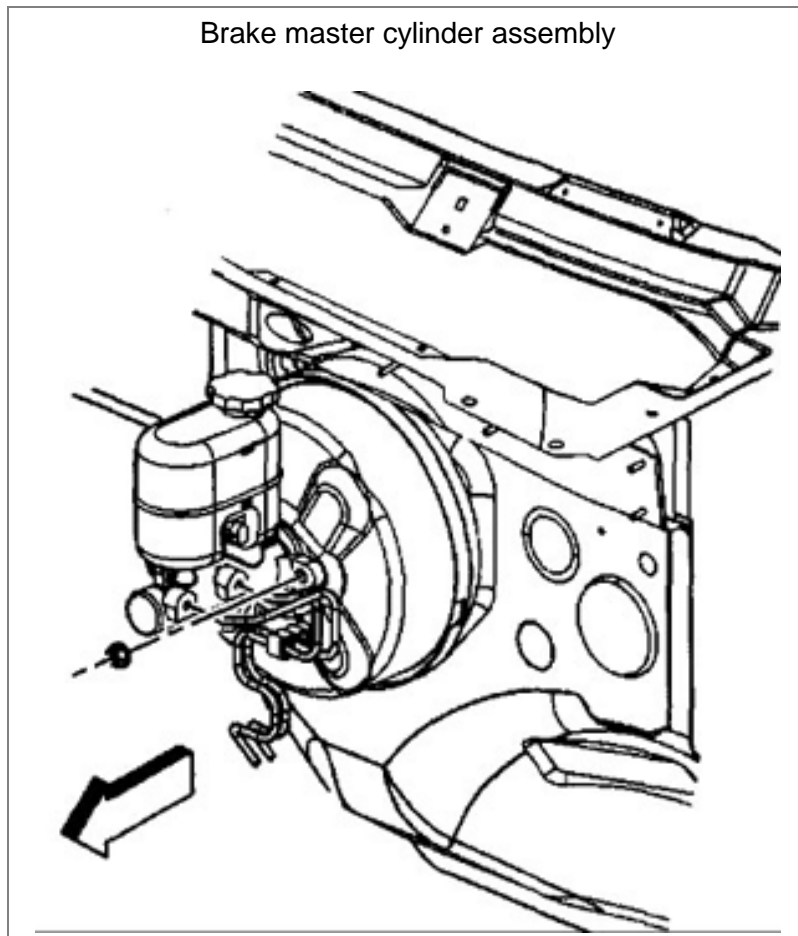
WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

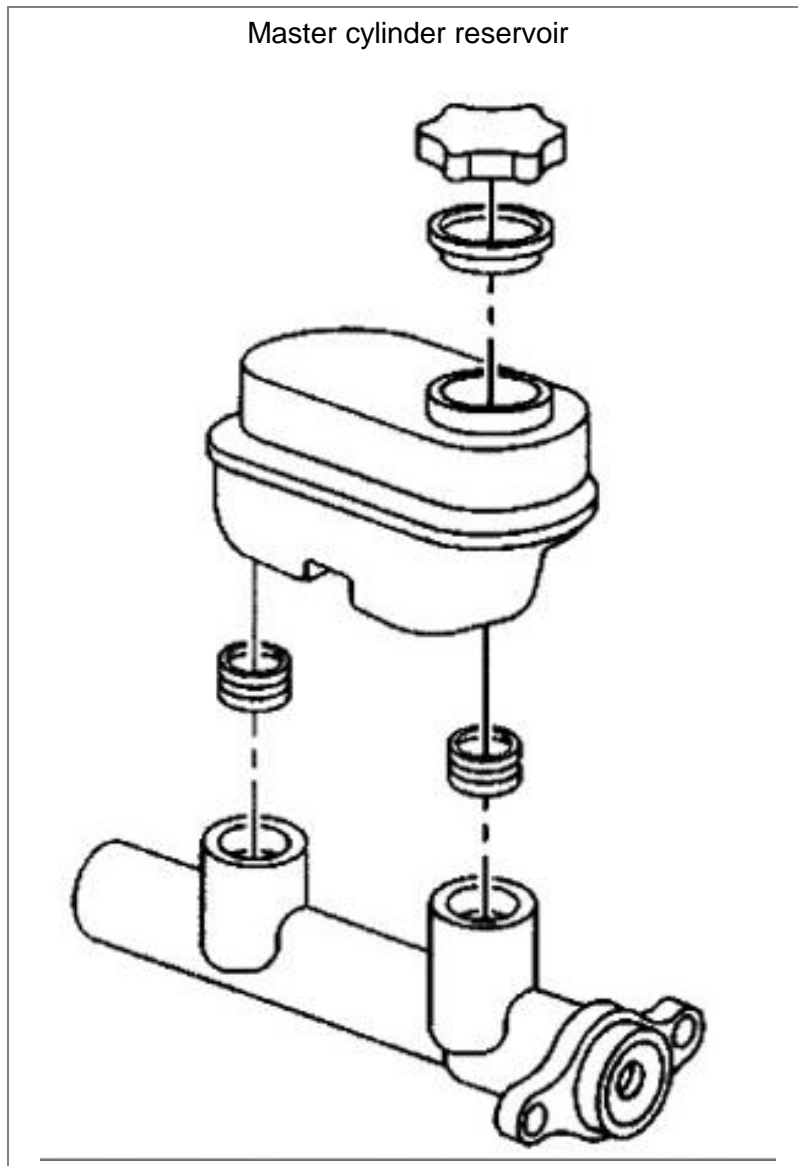
Master Cylinder Reservoir

Removal & Installation

To Remove:



1. Remove the brake master cylinder assembly from the power vacuum brake booster.
2. Drain the brake fluid from the master cylinder reservoir.
3. Place the master cylinder assembly in a vise; clamp the vise onto the master cylinder flange.
4. Remove the master cylinder reservoir retaining pins from the brake master cylinder assembly.



5. Remove the master cylinder reservoir from the brake master cylinder assembly.
6. Remove and discard the master cylinder reservoir seals from the brake master cylinder assembly.
7. Use denatured alcohol to clean the brake master cylinder assembly.
8. Use non-lubricated, filtered air to dry the brake master cylinder assembly.

To Install:

1. Use DOT-3 brake fluid to lubricate the new master cylinder reservoir seals.
2. Install the master cylinder reservoir seals onto the brake master cylinder assembly.
3. Install the master cylinder reservoir onto the brake master cylinder assembly.
4. Install the master cylinder reservoir retaining pins into the brake master cylinder assembly.
5. Remove the master cylinder assembly from the vise.
6. Install the brake master cylinder assembly to the power vacuum brake booster.

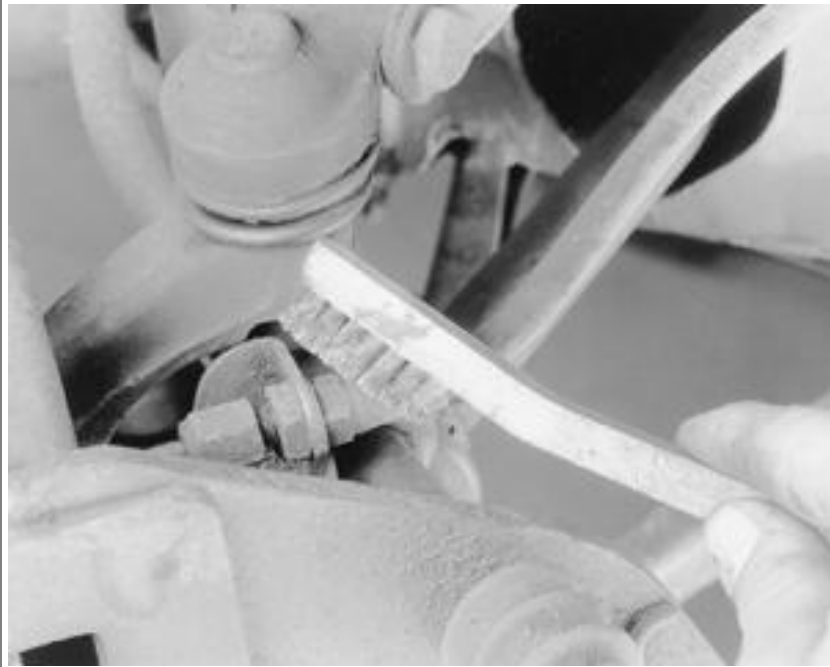
Brake Hoses and Steel Lines

Removal & Installation

To Remove:

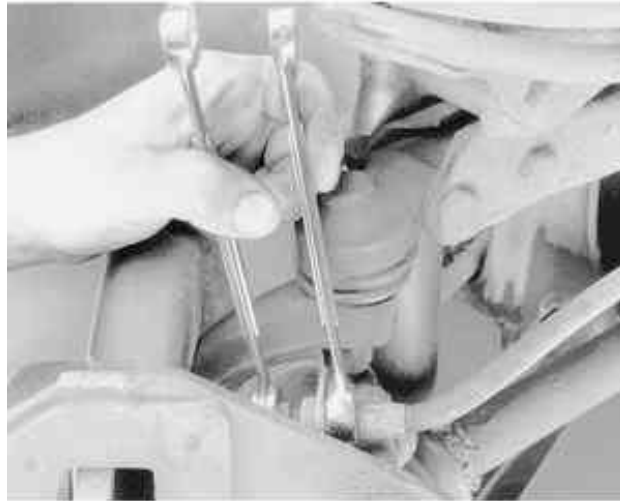
1. Disconnect the negative battery cable.
2. Park the vehicle on a level surface. Place the vehicle in PARK (automatic) or REVERSE (manual) with the engine OFF, and apply the parking brake. Chock the rear wheels to prevent vehicle movement.
3. Raise and safely support the vehicle.
4. Remove any wheel and tire assemblies necessary for access to the particular line you are removing.
5. Thoroughly clean the surrounding area at the joints to be disconnected.

Use a brush to clean the fittings of any debris



6. Place a suitable drain pan under the connection to be disconnected.
7. Using two line wrenches (one to hold the connection and one to turn the fitting), disconnect the hose or line to be replaced.

Use two wrenches to loosen the fitting. If available, use flare nut type wrenches



8. Disconnect the other end of the line or hose, moving the drain pan if necessary. Always use a line wrench to avoid damaging the fitting.
9. Disconnect any retaining clips or brackets holding the line and remove the line from the vehicle.

NOTE: If the brake system is to remain open for more time than it takes to swap lines, tape or plug each remaining clip and port to keep contaminants out, and fluid in.

Any gaskets/crush washers should be replaced with new ones during installation



Tape or plug the line to prevent contamination



To Install:

NOTE: Install the new line or hose, starting with the end farthest from the master cylinder. Connect the other end, and then confirm that both fittings are correctly threaded and turn smoothly using finger pressure. Make sure the new line will not rub against any other part. Brake lines must be at least 1/2 in. (13mm) from the steering column and other moving parts. Any protective shielding or insulators must be reinstalled in the original location.

WARNING

Make sure the hose is NOT kinked or touching any part of the frame or suspension after installation. These conditions may cause the hose to fail prematurely.

1. Using two line wrenches as before, tighten each fitting.
2. Install any retaining clips or brackets on the lines.
3. If removed, install the wheel and tire assemblies, then carefully lower the vehicle to the ground.
4. Install the wheel and tire assembly.
5. Refill the brake master cylinder reservoir with clean, fresh brake fluid, meeting the DOT specification recommended by the manufacturer. Properly bleed the brake system.

Stop Lamp Switch

NOTE: Refer to Chassis Electrical for Stop Lamp Switch removal and installation.

Master Cylinder

Removal & Installation

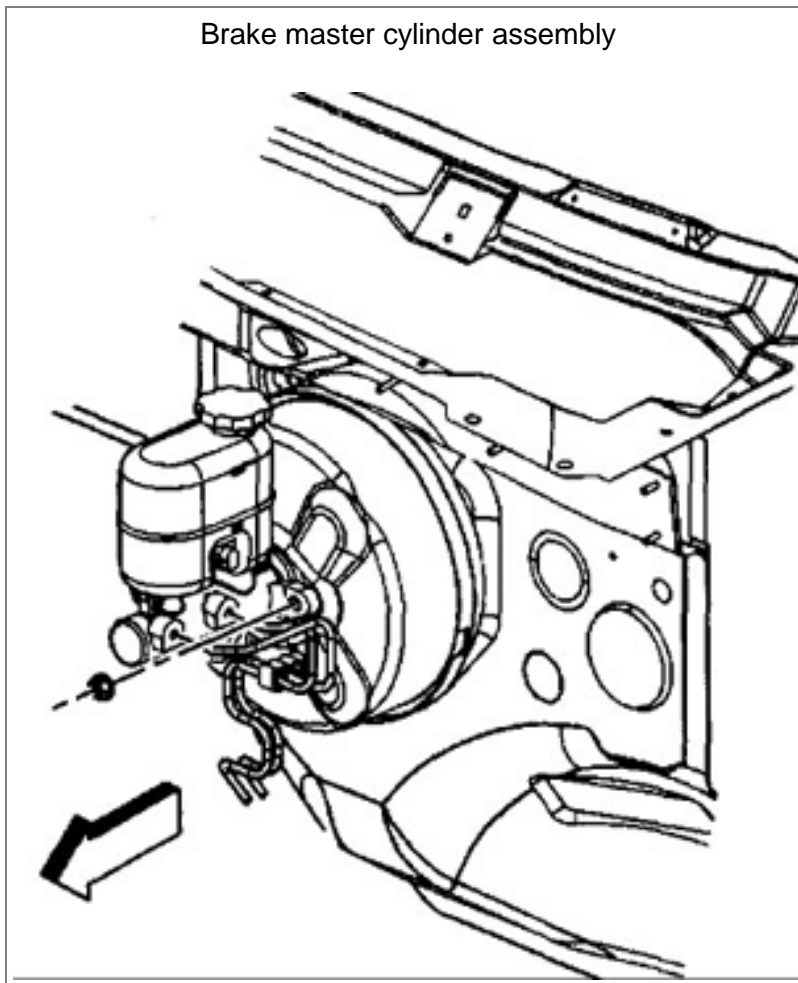
To Remove:

1. Apply the parking brake.
2. Disconnect the master cylinder fluid level sensor connector.
3. Remove the brake pipes from the master cylinder.

CAUTION

Install a rubber cap or plug to the exposed brake pipe ends to prevent brake fluid loss and contamination.

4. Install plugs into the open brake pipe ends.



5. Detach the master cylinder assembly from the power vacuum brake booster.
6. Drain the brake fluid from the master cylinder reservoir.

To Install:

1. Bench bleed the master cylinder.
2. Attach the master cylinder assembly from the power vacuum brake booster. Torque the mounting nuts to **27 ft-lb (36 Nm)**.
3. Remove the plugs from the open brake pipe ends.
4. Install the brake pipes into the master cylinder. Torque the fittings to **24 ft-lb (32 Nm)**.
5. Connect the master cylinder fluid level sensor connector.
6. Bleed the hydraulic brake system.

Bench Bleeding

CAUTION

All new master cylinders should be bench bled prior to installation. It is very difficult to remove the air trapped in the master cylinder once it is installed on the vehicle. You will also introduce air into the vehicle's hydraulic brake system.

1. Secure the master cylinder in a bench vise using soft jaws.
2. Remove the master cylinder reservoir cap.
3. Manufacture or purchase bleeding tubes and install them on the master cylinder.
4. Fill the master cylinder reservoir with clean, fresh brake fluid until the level is within 0.25 in. of the reservoir top.

NOTE: Ensure the bleeding tubes are below the level of the brake fluid, otherwise air may get into the system making your bleeding efforts ineffective.

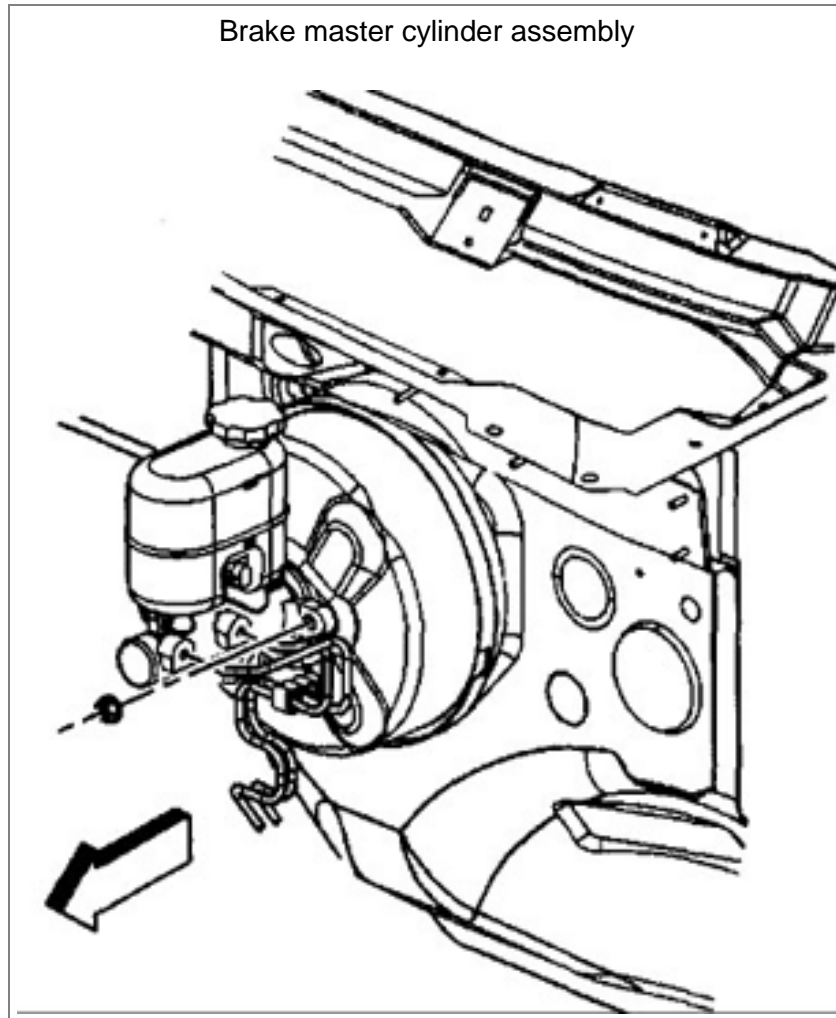
5. Use a blunt tipped rod to slowly depress the master cylinder piston. Make sure the piston travels its full stroke.
6. As the piston is depressed, bubbles will come out of the bleeding tubes. Continue depressing and releasing the piston until all bubbles cease.
7. Refill the master cylinder with fluid.
8. Remove the bleeding tubes.
9. Install the master cylinder reservoir cap.
10. Install the master cylinder on the vehicle.

Power Vacuum Brake Booster

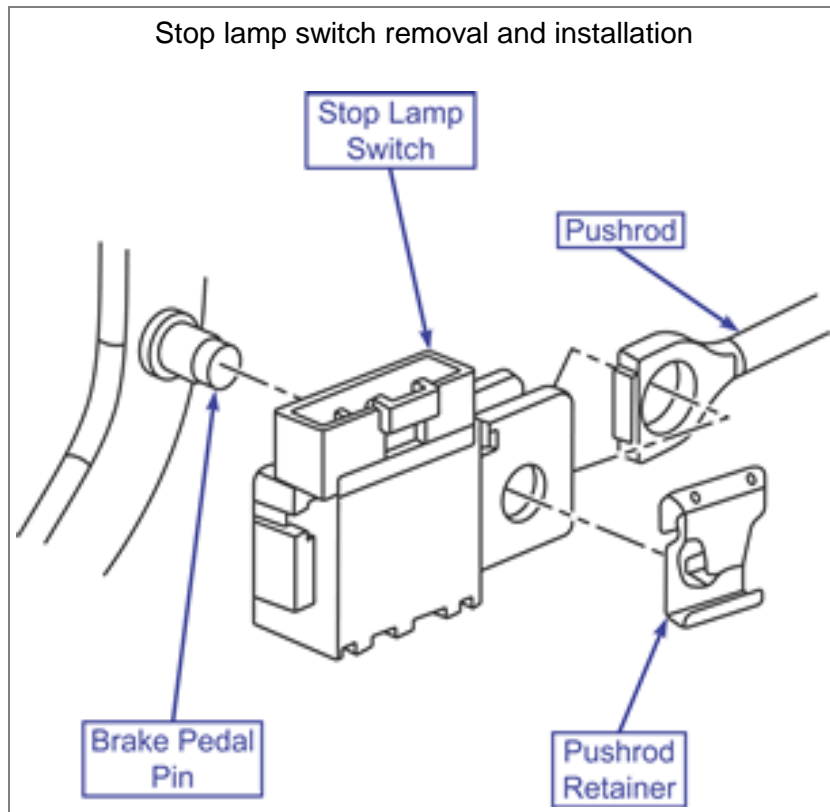
Removal & Installation

To Remove:

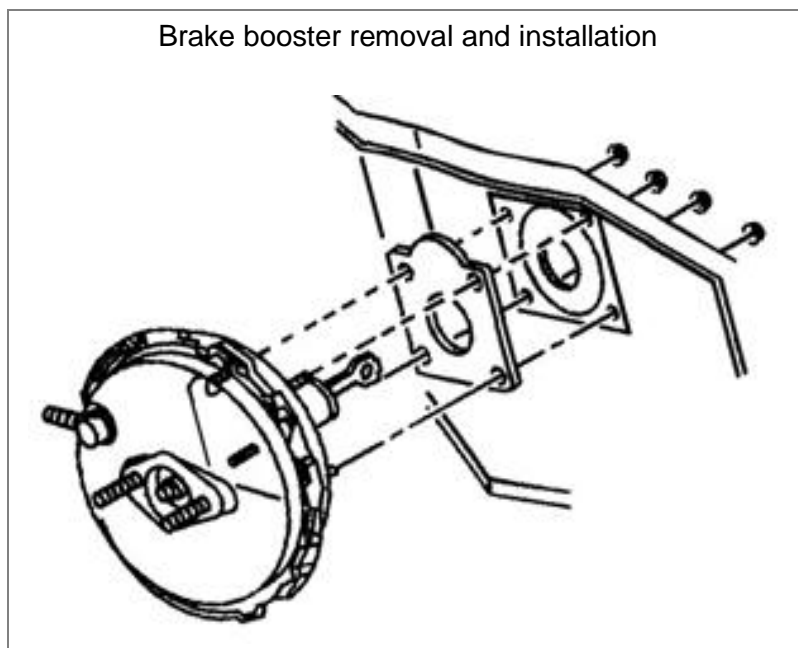
1. Apply the parking brake.



2. Remove the master cylinder assembly from the power vacuum brake booster.
3. Remove the power vacuum brake booster hose from the power vacuum brake booster and the engine.
4. Remove the left insulator panel from under the instrument panel (I/P).



5. Disconnect the pushrod retainer from the brake pedal pin.
6. Remove the stop lamp switch and pushrod from the brake pedal pin.



7. Detach the power vacuum brake booster from the vehicle.
8. Remove the gasket from the power vacuum brake booster.

To Install:

1. Install the gasket onto the power vacuum brake booster.
2. For 2002 through 2004 vehicles, attach the power vacuum brake booster to the vehicle. Torque the mounting nuts to **30 ft-lb (40 Nm)**.
3. For 2005 through 2007 vehicles, attach the power vacuum brake booster to the vehicle. Torque the mounting nuts to **27 ft-lb (36 Nm)**.
4. Install the stop lamp switch and pushrod onto the brake pedal pin.
5. Connect the pushrod retainer to the brake pedal pin.
6. Install the left insulator panel under the instrument panel (I/P).
7. Install the power vacuum brake booster hose onto the power vacuum brake booster and the engine.
8. Install the master cylinder assembly onto the power vacuum brake booster.

Testing

Vacuum Leak Test

1. Operate the engine at idle without touching the brake pedal for at least one minute.
2. Turn off the engine and wait one minute.
3. Test for the presence of assist vacuum by depressing the brake pedal and releasing it several times. If vacuum is present in the system, light application will produce less and less pedal travel. If there is no vacuum, air is leaking into the system.

System Operation Test

1. With the engine **OFF**, pump the brake pedal until the supply vacuum is entirely gone.
2. Put light, steady pressure on the brake pedal.
3. Start the engine and let it idle. If the system is operating correctly, the brake pedal should fall toward the floor if the constant pressure is maintained.

Brake Fluid

Bleeding the Brake System (Non ABS)

1. Clean all dirt from around the master cylinder fill cap, remove the cap and fill the master cylinder with brake fluid until the level is within 1/4 in. (6mm) of the top edge of the reservoir.
2. Clean the bleeder screws at all 4 wheels. The bleeder screws are located on the top of the brake calipers.
3. Attach a length of rubber hose over the bleeder screw and place the other end of the hose in a glass jar, submerged in brake fluid.
4. Starting at the right rear proceed in this order left front, left rear and right front.
5. Open the bleeder screw 1/2 - 3/4 turn. Have an assistant slowly depress the brake pedal.
6. Close the bleeder screw and tell your assistant to allow the brake pedal to return slowly. Continue this process to purge all air from the system.

7. When bubbles cease to appear at the end of the bleeder hose, close the bleeder screw and remove the hose.
8. Check the fluid level in the master cylinder and add fluid accordingly. Do this after bleeding each wheel.
9. Fill the master cylinder reservoir to the proper level.

Bleeding the Brake System (ABS)

Auto Bleed Procedure

NOTE: Perform a manual bleeding procedure. If the brake pedal height and firmness results are not achieved, perform the auto bleed procedure below.

1. Raise and support the vehicle.
2. Remove the tire and wheel assemblies.
3. Inspect the battery state of charge.
4. Install a scan tool.
5. Turn ON the ignition, with the engine OFF.
6. With the scan tool, establish communications with the ABS/TCS system. Select Special Functions from the ABS/TCS menu. Select Automated Bleed from the Special Functions menu.
7. Bleed the base brake system.
8. Follow the scan tool directions until the desired brake pedal height is achieved.
9. If the bleed procedure is aborted, a malfunction exists. Perform the following steps before resuming the bleed procedure:
10. If a DTC is detected, refer to Diagnostic Trouble Code (DTC) List and diagnose the appropriate DTC.
11. If the brake pedal feels spongy, perform the conventional brake bleed procedure again.
12. When the desired pedal height is achieved, press the brake pedal in order to inspect for firmness.
13. Remove the scan tool.
14. Install the tire and wheel assemblies.
15. Inspect the brake fluid level.
16. Road test the vehicle while inspecting that the pedal remains high and firm.

Disc Brakes

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

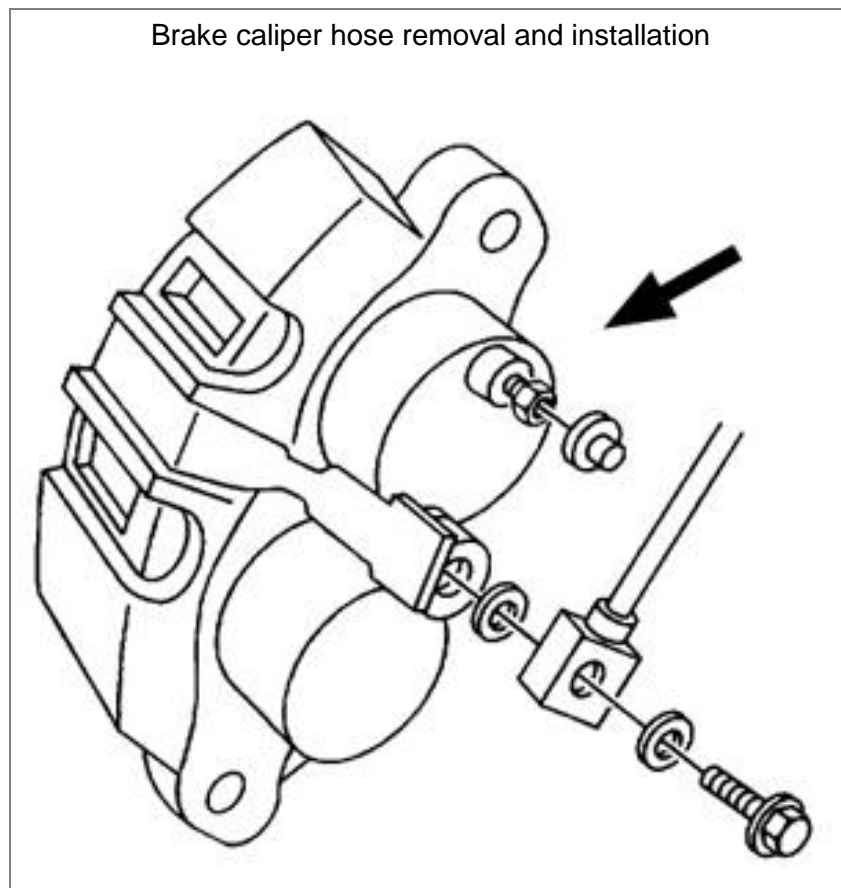
Brake Caliper

Removal & Installation

Front

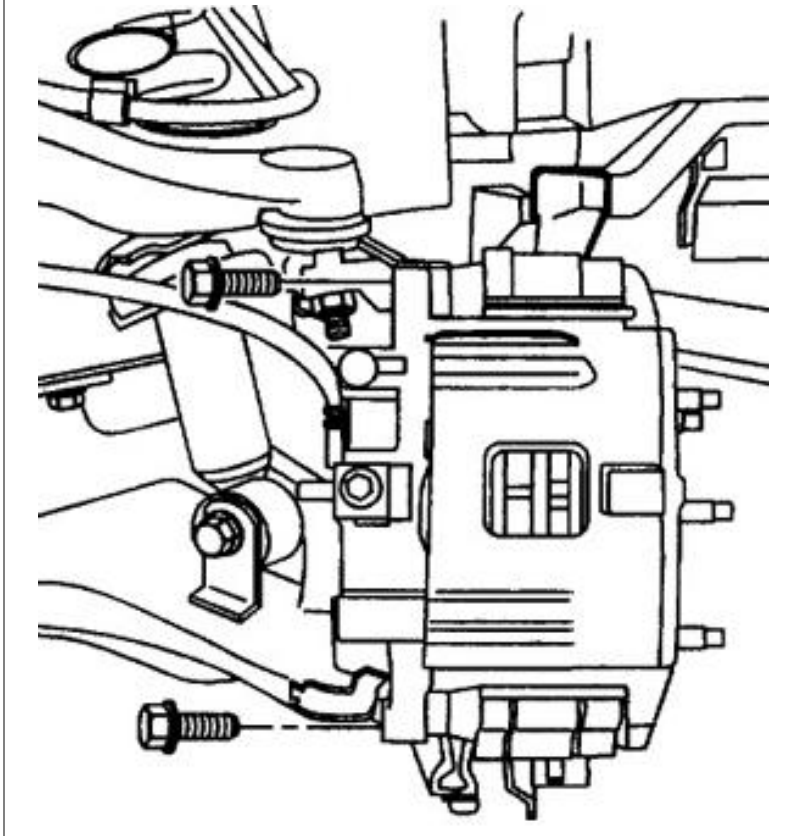
To Remove:

1. Lift the vehicle.
2. Remove the wheel from the vehicle.



3. Detach the brake caliper hose from the brake caliper.
4. To prevent excessive brake fluid loss, install a plug into the front brake caliper hose.
5. Discard the brake caliper hose gasket.

Brake caliper mounting bolts removal and installation



6. Detach the brake caliper from the mounting bracket.

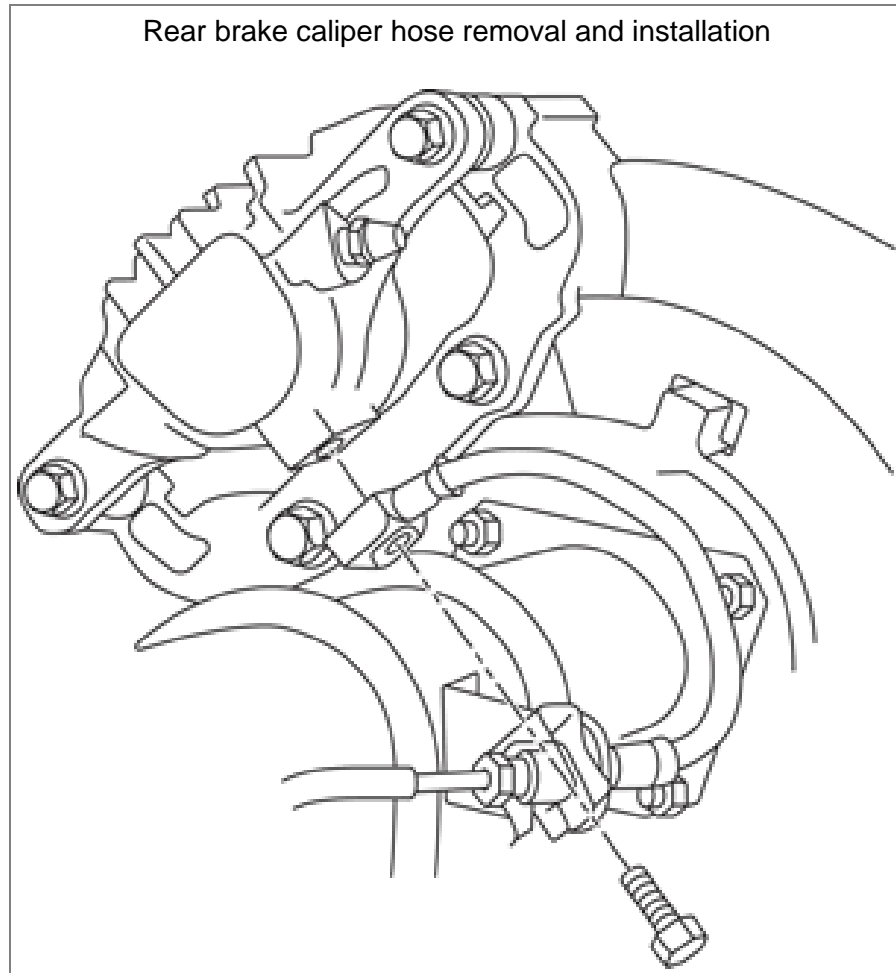
To Install:

1. Use denatured alcohol to clean the brake caliper guide pin bolts.
2. Use non-lubricated, filtered air to dry the brake caliper guide pin bolts.
3. Apply high temperature silicone brake lubricant to the brake caliper guide pin bolts.
4. For 2002 through 2005 vehicles, attach the brake caliper to the mounting bracket. Torque the bolts to **31 ft-lb (42 Nm)**.
5. For 2006 through 2007 vehicles, attach the brake caliper to the mounting bracket. Torque the bolts to **47 ft-lb (64 Nm)**.
6. Install new brake caliper hose gaskets to the front brake caliper hose bolt.
7. For 2003 through 2007 vehicles, attach the brake caliper hose to the brake caliper. Torque the bolt to **30 ft-lb (40 Nm)**.
8. For 2002 vehicles, attach the brake caliper hose to the brake caliper. Torque the bolt to **40 ft-lb (54 Nm)**.
9. Bleed the hydraulic brake system.
10. Install the wheel onto the vehicle.
11. Lower the vehicle.

Rear

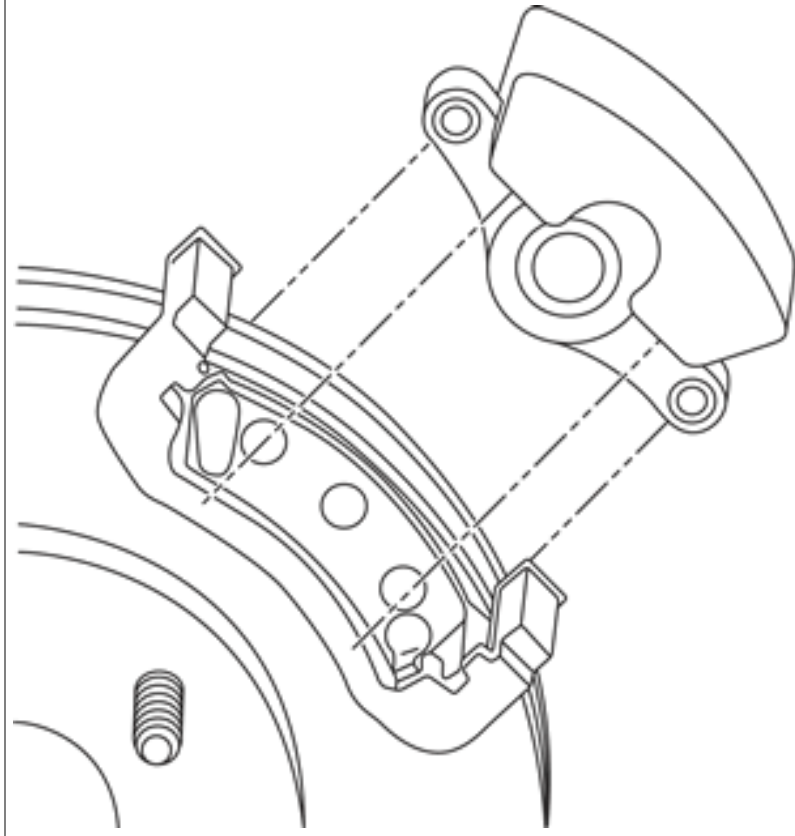
To Remove:

1. Lift the vehicle.
2. Remove the wheel from the vehicle.



3. Detach the brake caliper hose from the brake caliper.
4. To prevent excessive brake fluid loss, install a plug into the front brake caliper hose.
5. Discard the brake caliper hose gasket.

Rear brake caliper removal and installation



6. Detach the brake caliper from the mounting bracket.

To Install:

1. Use denatured alcohol to clean the brake caliper mounting bolts.
2. Use non-lubricated, filtered air to dry the brake caliper mounting bolts.
3. Apply high temperature silicone brake lubricant to the brake caliper mounting bolts.
4. Attach the brake caliper to the mounting bracket. Torque the bolts to **23 ft-lb (31 Nm)**.
5. Install new brake caliper hose gaskets to the front brake caliper hose bolt.
6. For 2003 through 2007 vehicles, attach the brake caliper hose to the brake caliper. Torque the bolt to **30 ft-lb (40 Nm)**.
7. For 2002 vehicles, attach the brake caliper hose to the brake caliper. Torque the bolt to **33 ft-lb (44 Nm)**.
8. Bleed the hydraulic brake system.
9. Install the wheel onto the vehicle.
10. Lower the vehicle.

Overhaul

To Disassemble:

1. Remove the caliper from the vehicle and place on a clean workbench.

WARNING

NEVER place your fingers in front of the pistons in an attempt to catch or protect the pistons when applying compressed air. This could result in personal injury!

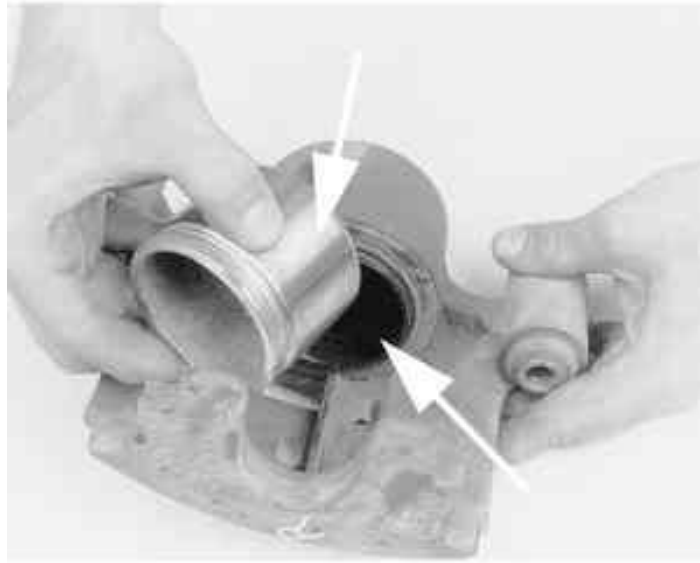
NOTE: Depending upon the vehicle, there are two different procedures to remove the piston from the caliper. Refer to the brake pad replacement procedure to make sure you have the correct procedure for your vehicle.

2. The first procedure is as follows:
 - A. Stuff a shop towel or a block of wood into the caliper to catch the piston.
 - B. Remove the caliper piston using compressed air applied into the caliper inlet hole. Inspect the piston for scoring, nicks, corrosion and/or worn or damaged chrome plating. The piston must be replaced if any of these conditions are found.
 - C.

Using compressed air to remove piston



Removing piston from caliper bore



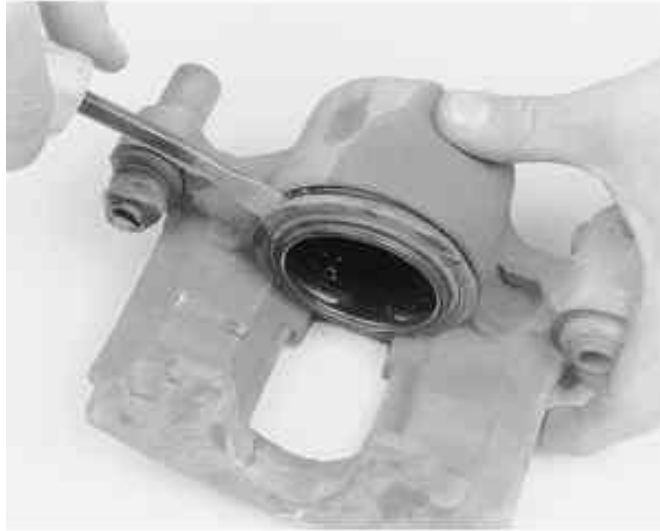
4. For the second procedure, you must rotate the piston to retract it from the caliper.
5. If equipped, remove the anti-rattle clip.

Removing anti-rattle clip



6. Use a pry tool to remove the caliper boot, being careful not to scratch the housing bore.

Prying edge of boot



Removing boot from caliper



8. Remove the piston seals from the groove in the caliper bore.



9. Carefully remove the brake bleeder valve cap and valve from the caliper housing.
10. Inspect the caliper bores, pistons and mounting threads for scoring or excessive wear.
11. Use crocus cloth to polish out light corrosion from the piston and bore.
12. Clean all parts with denatured alcohol and dry with compressed air.

To Assemble:

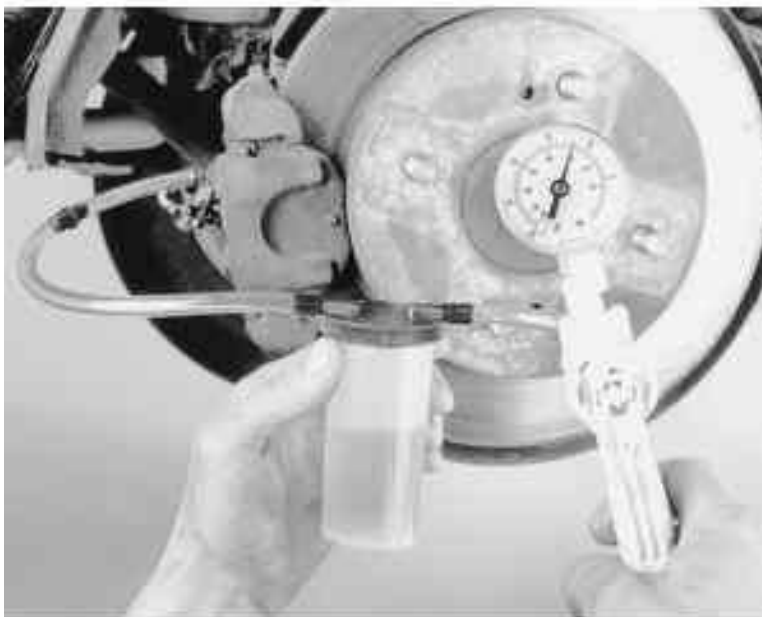
1. Lubricate and install the bleeder valve and cap.
2. Install the new seals into the caliper bore grooves, making sure they are not twisted.
3. Lubricate the piston bore.
4. Install the pistons and boots into the bores of the calipers and push to the bottom of the bores.
5. Use a suitable installer to seat the boots in the housing.

Installing boot



6. Install the caliper in the vehicle.
7. Install the wheel and tire assembly, then carefully lower the vehicle.
8. Properly bleed the brake system.

Bleeding caliper



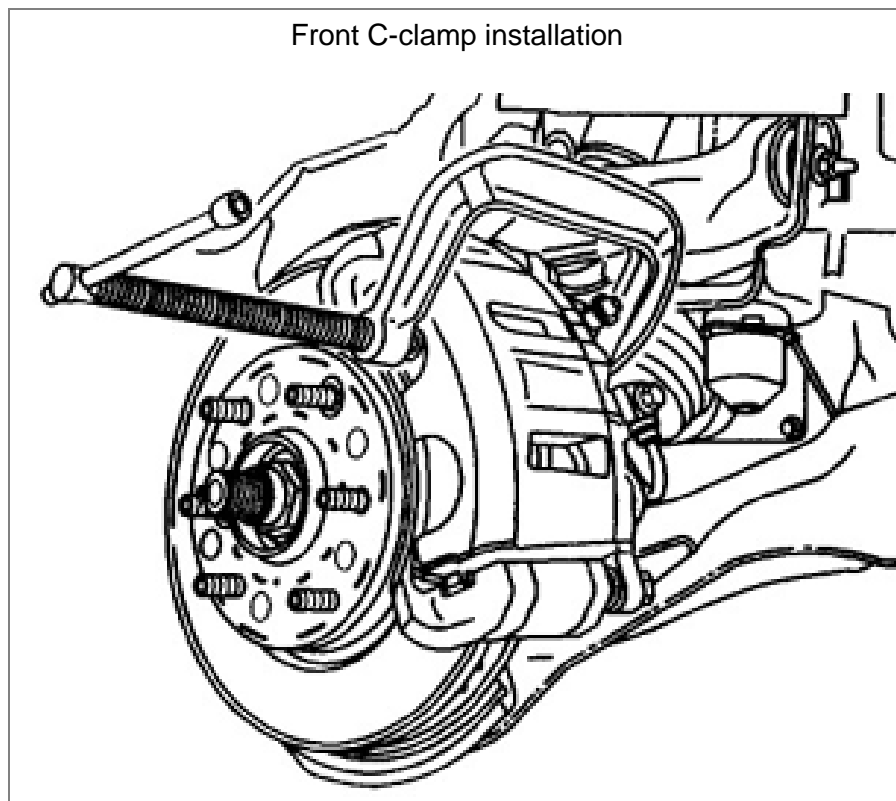
Brake Rotor

Removal & Installation

Front

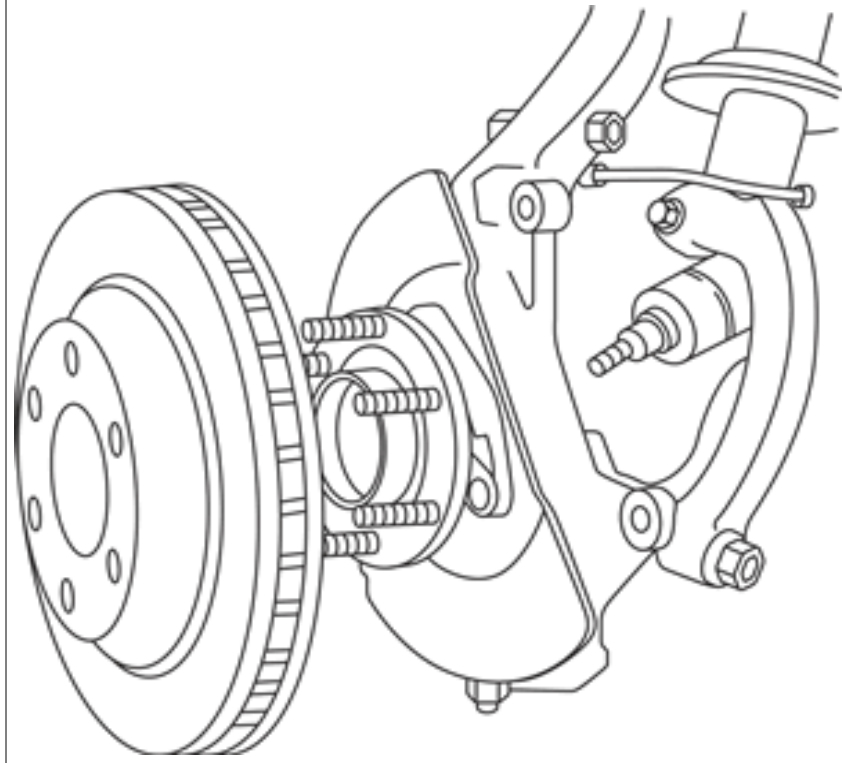
To Remove:

1. Make sure the fluid level in the brake master cylinder reservoir is between the MIN and MAX level.
2. Lift the vehicle.
3. Remove the wheel from the vehicle.



4. Install a large C-clamp over the brake caliper housing and against the back of the outboard brake pad.
5. Tighten the clamp until the brake caliper is pushed in enough to slide the brake caliper from the rotor.
6. Remove the clamp from the brake caliper.
7. Detach the brake caliper assembly from the steering knuckle.
8. Remove the retaining clips from the brake rotor.
9. Mark the orientation of the brake rotor to the wheel stud.

Front brake rotor removal and installation



10. Remove the brake rotor from the wheel hub.
11. Use a J 42450-A wheel hub cleaning kit to clean the contact surface of the front hub.

To Install:

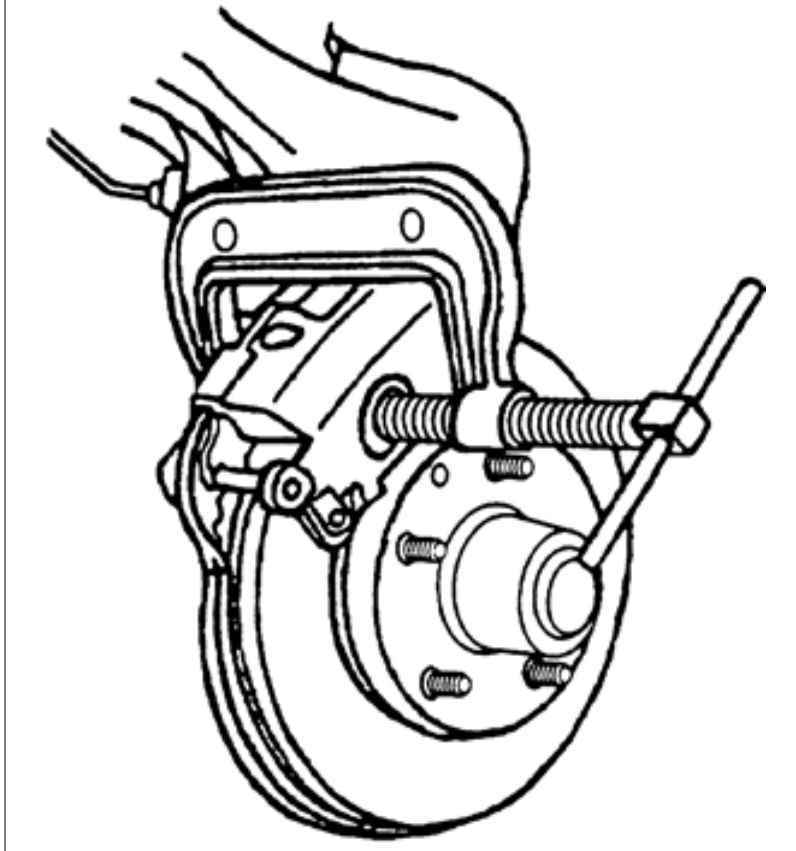
1. Align the brake rotor to the marks on the wheel stud.
2. Install the brake rotor onto the wheel hub.
3. Attach the brake caliper assembly to the steering knuckle. Torque the bolt to **110 ft-lb (150 Nm)**.
4. Install the wheel onto the vehicle.
5. Lower the vehicle.
6. Fill the brake master cylinder reservoir to the proper level.
7. Seat the brake pads by pumping the brake pedal slowly.

Rear

To Remove:

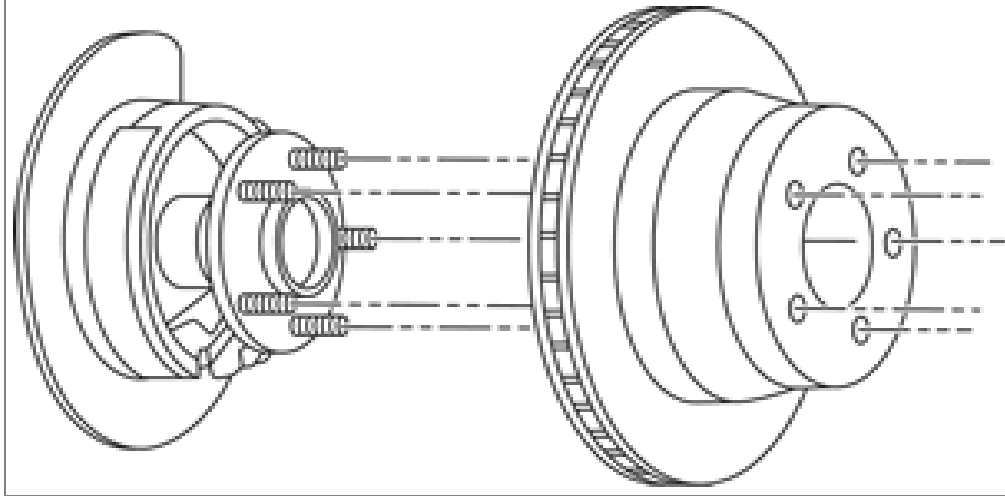
1. Make sure the fluid level in the brake master cylinder reservoir is between the MIN and MAX level.
2. Lift the vehicle.
3. Remove the wheel from the vehicle.

Rear C-clamp installation



4. Install a large C-clamp over the brake caliper housing and against the back of the outboard brake pad.
5. Tighten the clamp until the brake caliper is pushed in enough to slide the brake caliper from the rotor.
6. Remove the clamp from the brake caliper.
7. Remove the brake caliper assembly from the mounting surface.
8. Remove the retaining clips from the brake rotor.
9. Mark the orientation of the brake rotor to the wheel stud.

Rear brake rotor removal and installation



10. Remove the brake rotor from the wheel hub.
11. If necessary, use a J-46277 rotor removal tool and J 2619-01 slide hammer to remove the brake rotor from the wheel hub.
12. Use a J 42450-A wheel hub cleaning kit to clean the contact surface of the hub.
13. Check the park brake components for and replace any bent or broken hold down springs; broken, cracked, or worn brake shoe linings; bent or damaged brake shoes; or worn, bent, or damaged backing plates.

To Install:

1. Use denatured alcohol to clean the park brake shoes.
2. Use non-lubricated, filtered air to dry the park shoes.
3. Use high temperature silicone brake lubricant to lubricate the area between the park brake shoe and the backing plate.
4. Adjust the park brake.
5. Slowly turn the axle flange while installing the brake rotor onto the wheel hub.
6. Install the brake caliper assembly onto the mounting surface.
7. Install the wheel onto the vehicle.
8. Lower the vehicle.
9. Fill the brake master cylinder reservoir to the proper level.
10. Seat the brake pads by pumping the brake pedal slowly.

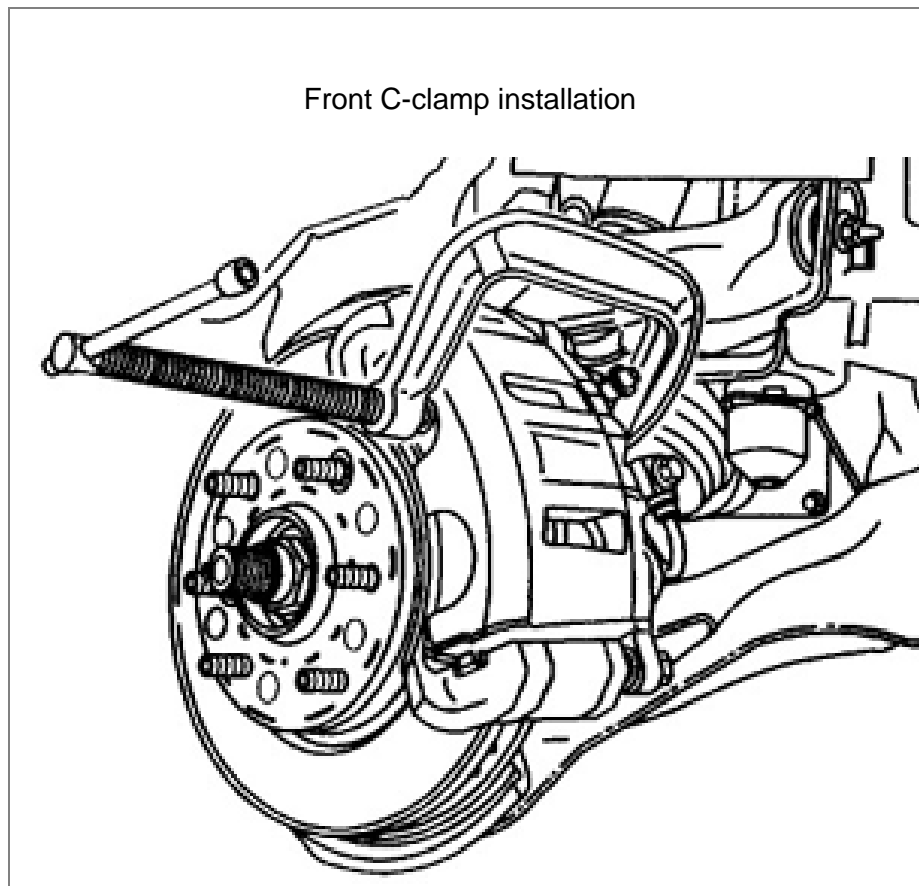
Brake Pads

Removal & Installation

Front

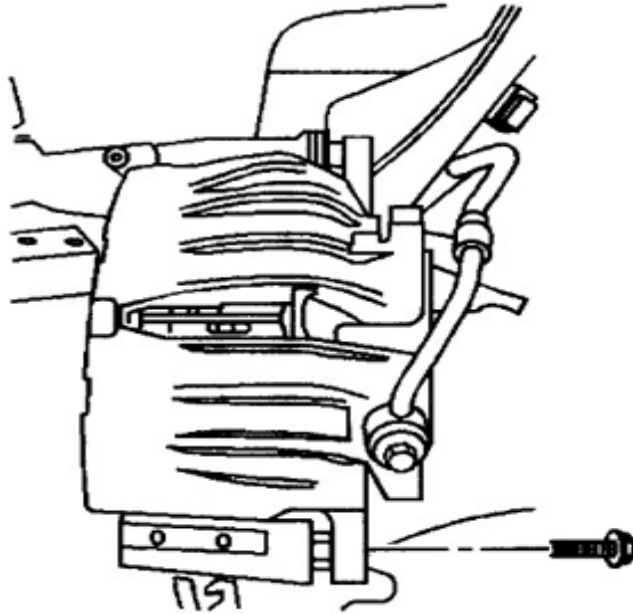
To Remove:

1. Make sure the fluid level in the brake master cylinder reservoir is between the MIN and MAX level.
2. Lift the vehicle.
3. Remove the wheel from the vehicle.
- 4.



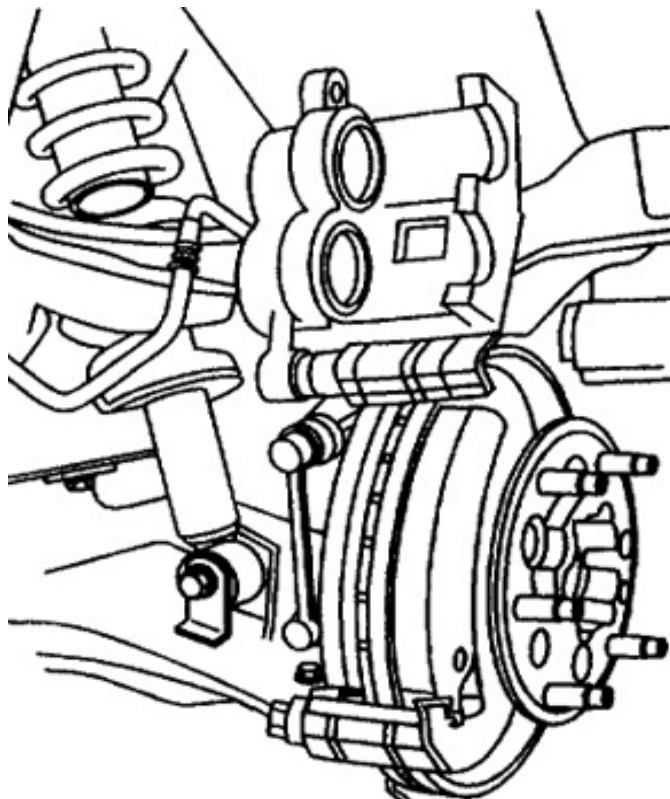
5. Install a large C-clamp over the brake caliper housing and against the back of the outboard brake pad.
6. Tighten the clamp until the brake caliper is pushed in enough to slide the brake caliper from the rotor.

Brake caliper mounting bolt removal and installation

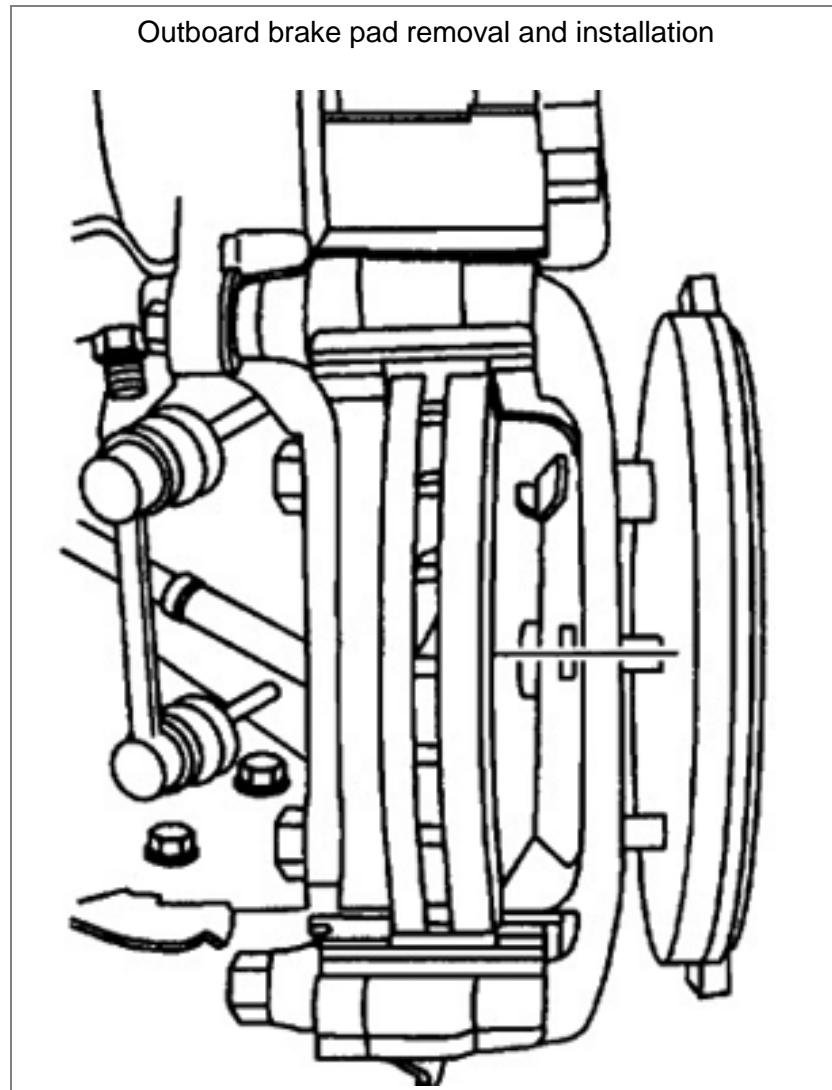


7. Remove the lower mounting bolt from the brake caliper.

Brake caliper

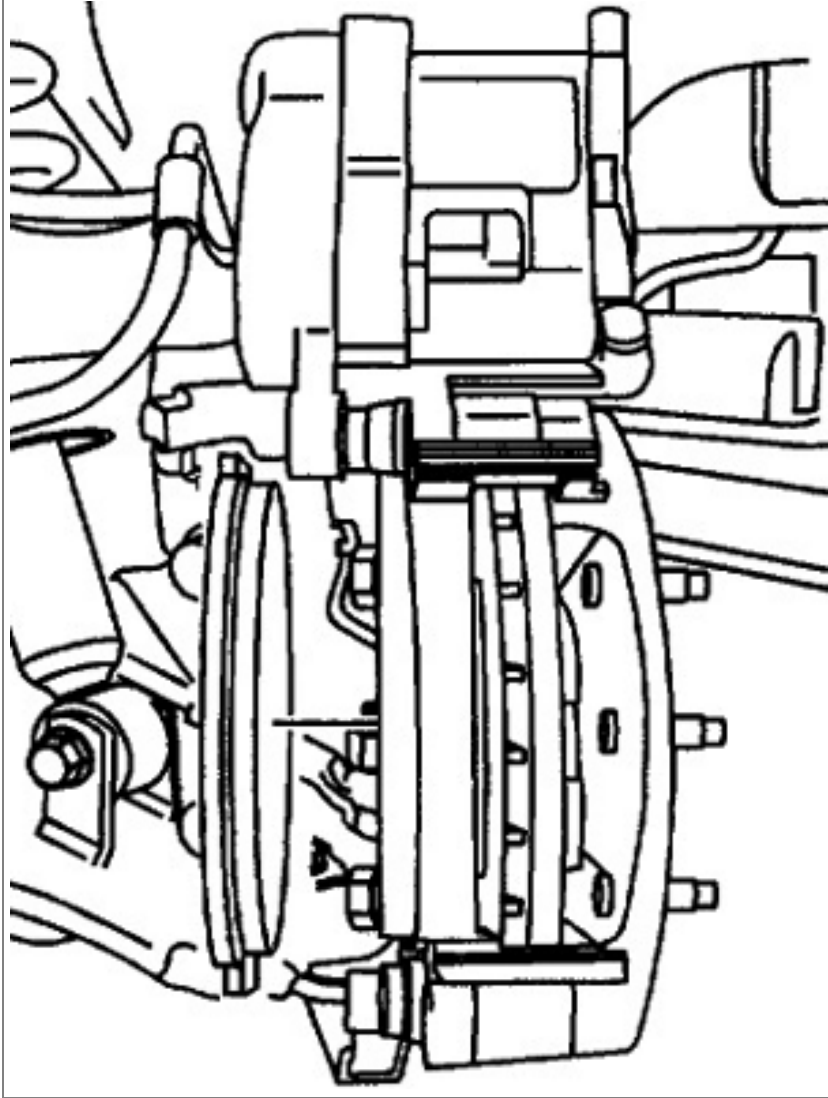


8. Lift the bottom of the brake caliper out of the mounting bracket.



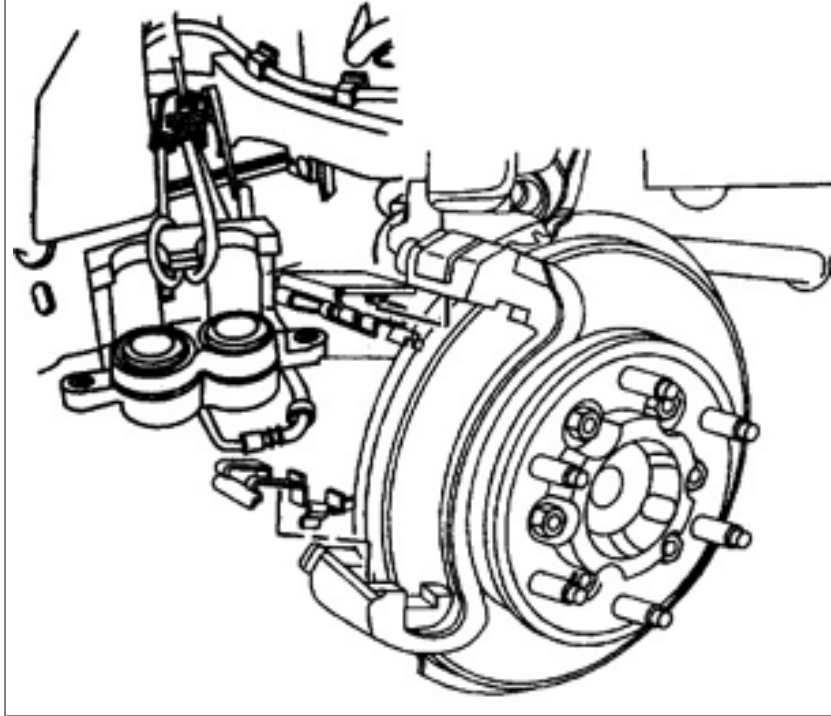
9. Remove the outboard brake pad from the brake caliper.

Inboard brake pad removal and installation



10. Remove the inboard brake pad from the brake caliper.

Brake pad shim removal and installation



11. Remove and discard the brake pad retaining clips from the brake caliper mounting bracket.
12. Use denatured alcohol to clean the brake caliper.

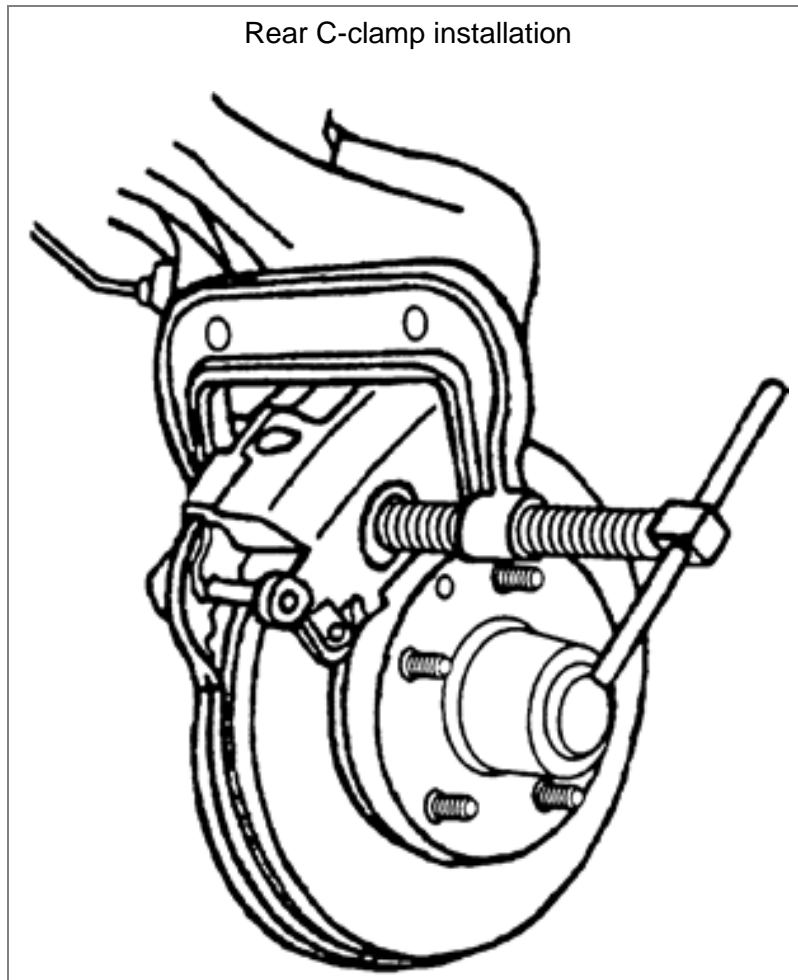
To Install:

1. Install the new brake pad retaining clips into the brake caliper mounting bracket.
2. Install the inboard brake pad into the brake caliper.
3. Install the outboard brake pad into the brake caliper.
4. Lower the bottom of the brake caliper into the mounting bracket.
5. For 2002 through 2005 vehicles, install the lower mounting bolt into the brake caliper. Torque the bolt to **31 ft-lb (42 Nm)**.
6. For 2006 through 2007 vehicles, install the lower mounting bolt into the brake caliper. Torque the bolt to **47 ft-lb (64 Nm)**.
7. Install the wheel onto the vehicle.
8. Lower the vehicle.
9. Fill the brake master cylinder reservoir to the proper level.
10. Seat the brake pads by pumping the brake pedal slowly.

Rear

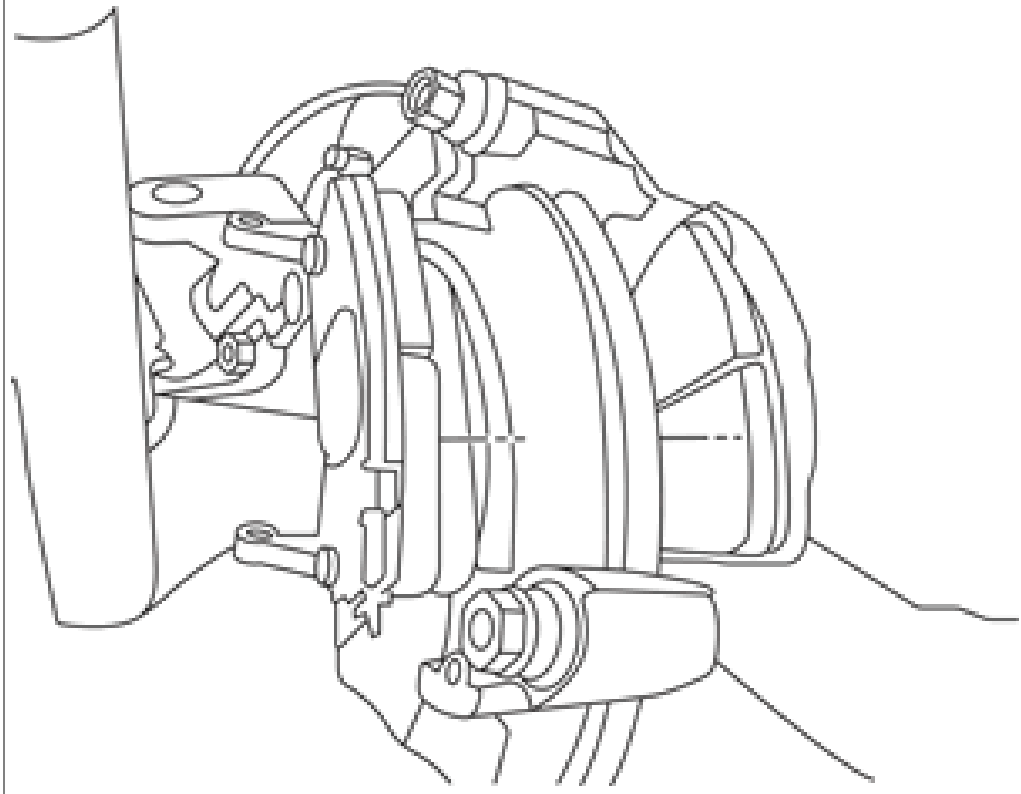
To Remove:

1. Make sure the fluid level in the brake master cylinder reservoir is between the MIN and MAX level.
2. Lift the vehicle.
3. Remove the wheel from the vehicle.



4. Install a large C-clamp over the brake caliper housing and against the back of the outboard brake pad.
5. Tighten the clamp until the brake caliper is pushed in enough to slide the brake caliper from the rotor.
6. Remove the clamp from the brake caliper.
7. Remove the upper mounting bolt from the brake caliper.
8. Pull the top of the brake caliper out of the mounting bracket.

Rear brake pad removal and installation



9. Remove the brake pads from the brake caliper.
10. Remove the brake pad retaining clips from the brake caliper mounting bracket.
11. Use denatured alcohol to clean the brake caliper.

To Install:

1. Install the brake pad retaining clips into the brake caliper mounting bracket.
2. Install the brake pads into the brake caliper.
3. Lower the top of the brake caliper into the mounting bracket.
4. Install the upper mounting bolt into the brake caliper. Torque the bolt to **23 ft-lb (31 Nm)**.
5. Install the wheel onto the vehicle.
6. Lower the vehicle.
7. Fill the brake master cylinder reservoir to the proper level.
8. Seat the brake pads by pumping the brake pedal slowly.

Parking Brake

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

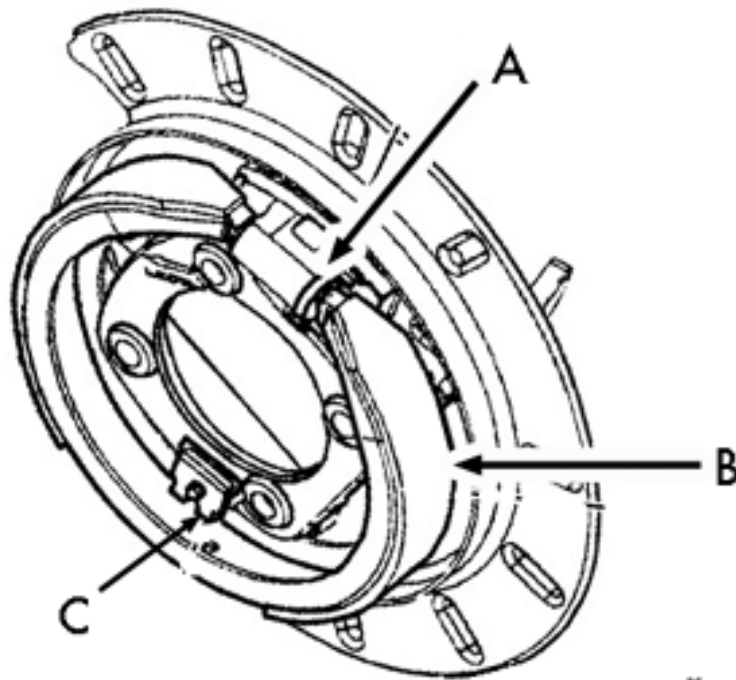
Brake Shoes

Removal & Installation

To Remove:

1. If applied, release the parking brake.
2. Lift the vehicle.
3. Remove the wheel from the vehicle.
4. Remove the brake caliper from the mounting bracket.
5. Remove the brake rotor from the hub.
6. Disconnect the parking brake cable from the parking brake lever.

Actuator mechanism (A), Parking brake shoe (B), Hold down spring (C)



7. Disengage the parking brake shoe from the hold down spring by sliding the shoe down.
8. Lift the parking brake shoe away from the backing plate and slide the shoe up and off the actuation mechanism.

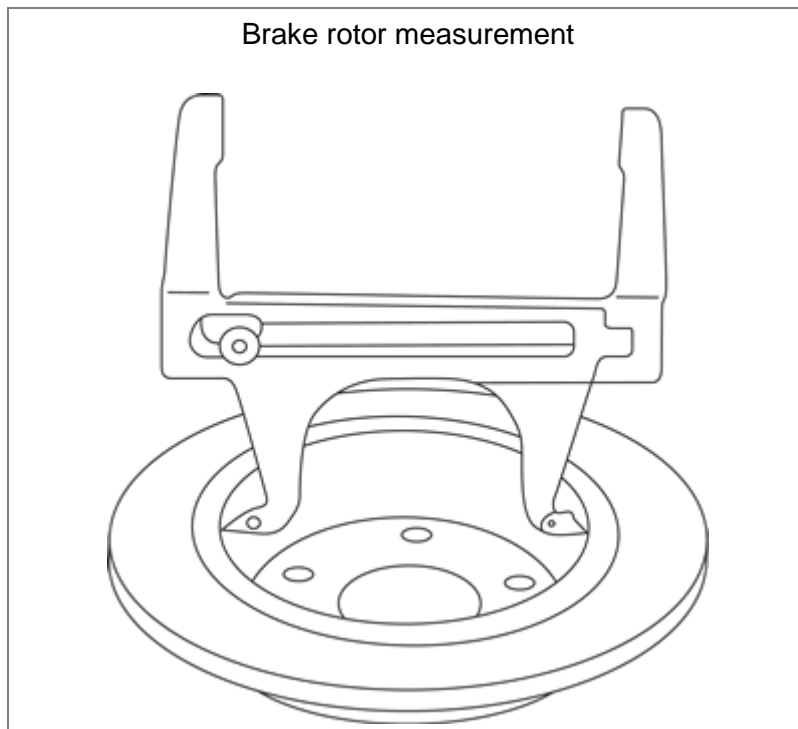
9. Remove and discard the parking brake shoe from the backing plate, over the axle flange.
10. Use a clean towel to clean the debris and dust from the parking brake components.
11. Turn the adjustment screw until it is in the fully home position in the notched adjustment nut, and then turn it in the opposite direction $\frac{1}{4}$ of a turn.
12. Align the adjusting screw and tappet slots to be parallel with the backing plate face.
13. Use denatured alcohol to clean the rear backing plate.
14. Use non-lubricated, filtered air to dry the backing plate.

To Install:

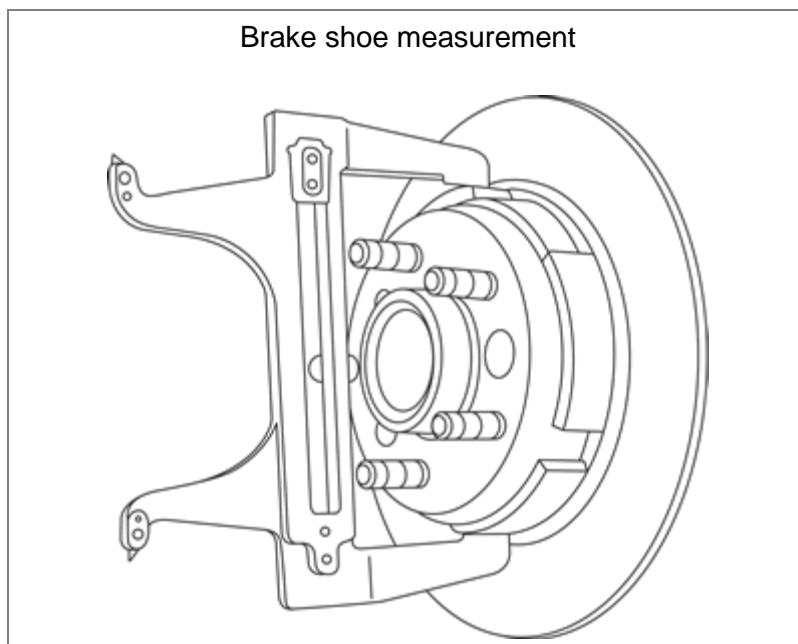
1. Install a new parking brake shoe into the backing plate, over the axle flange.
2. Place the parking brake shoe onto the actuation mechanism.
3. Slide the parking brake shoe down, over the top of the hold down spring while holding the lower end of the shoe away from the backing plate.
4. Push the lower end of the shoe to the backing plate.
5. Make sure the shoe is central on the backing plate with both tips in the slots of the actuation mechanism.
6. Manually move the parking brake actuator lever to check for proper operation.
7. Connect the parking brake cable to the parking brake lever.
8. Adjust the park brake shoe.
9. Install the brake rotor onto the hub.
10. Install the brake caliper onto the mounting bracket.
11. Install the wheel onto the vehicle.
12. Lower the vehicle.

Adjustment

1. Remove the rotor from the rear hub.



2. Adjust a J 21177-A drum to brake shoe clearance gage until it contact the inside diameter of the rotor.



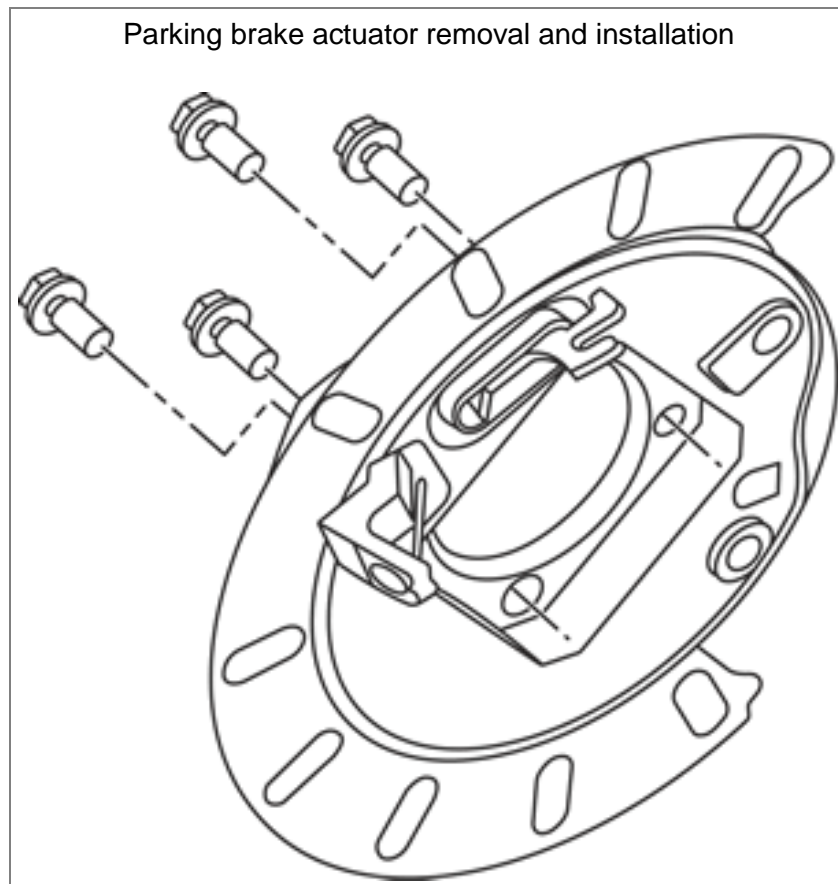
3. Place the J 21177-A drum to brake shoe clearance gage over the parking brake shoe lining at the widest point.
4. Turn the adjuster nut until the lining comes into contact with the J 21177-A drum to brake shoe clearance gage.
5. The clearance between the rear parking brake shoe lining and the rotor should be between 0.010 in (0.25mm) and 0.020 in (0.50 mm).
6. Install the rotor onto the rear hub.

Parking Brake Actuator

Removal & Installation

To Remove:

1. Disable the parking brake cable adjuster.
2. Lift the vehicle.
3. Remove the wheel from the vehicle.
4. Remove the parking brake cable from the mounting bracket.
5. Remove the parking brake cable from the parking brake actuator lever.
6. Remove the brake caliper assembly from the mounting surface.
7. Remove the brake rotor from the hub.
8. Remove the axle shaft from the vehicle.
9. Remove the parking brake shoe from the backing plate.



10. Detach the park brake actuator from the backing plate.
11. Clean the sealing surfaces as necessary.
12. Use brake parts cleaner to clean the threads of the park brake actuator bolts.
13. Use denatured alcohol to clean the backing plate.
14. Use non-lubricated, filtered air to dry the backing plate.

To Install:

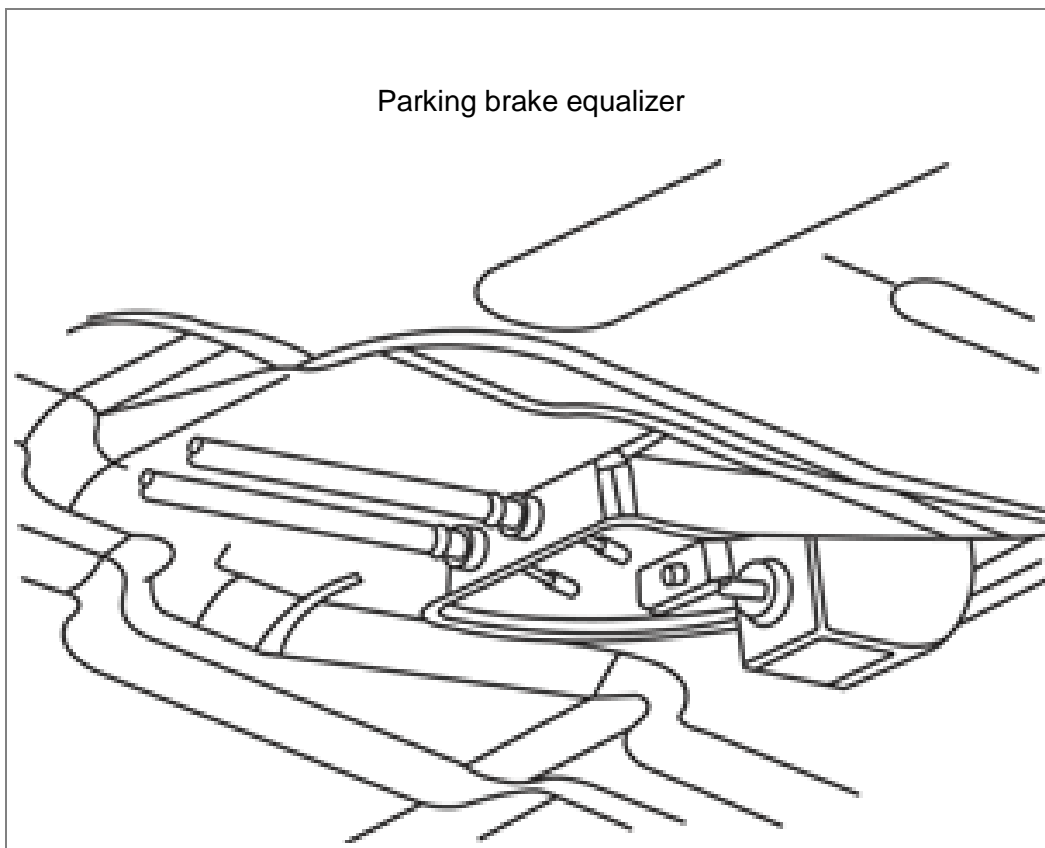
1. Apply GM P/N 12345493 threadlocker to the threads of the park brake actuator bolts.
2. Attach the park brake actuator to the backing plate. Torque the bolts to **100 ft-lb (135 Nm)**.
3. Install the parking brake shoe into the backing plate.
4. Install the axle shaft into the vehicle.
5. Adjust the parking brake shoe.
6. Install the brake rotor onto the hub.
7. Install the parking brake cable onto the parking brake actuator lever.
8. Install the parking brake cable onto the mounting bracket.
9. Install the brake caliper assembly onto the mounting surface.
10. Install the wheel onto the vehicle.
11. Lower the vehicle.
12. Enable the parking brake cable adjuster.

Parking Brake Cables

Removal & Installation

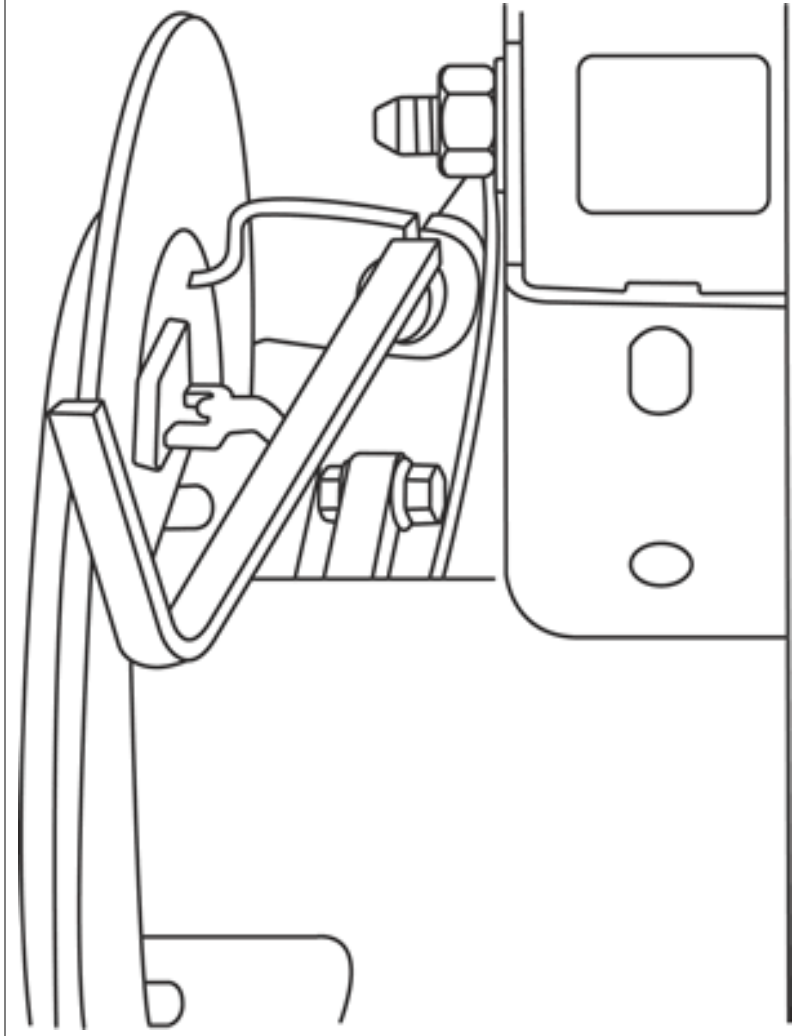
To Remove:

1. Disable the parking brake cable adjuster.
2. Lift the vehicle.
3. Remove the rear propeller shaft from the vehicle.



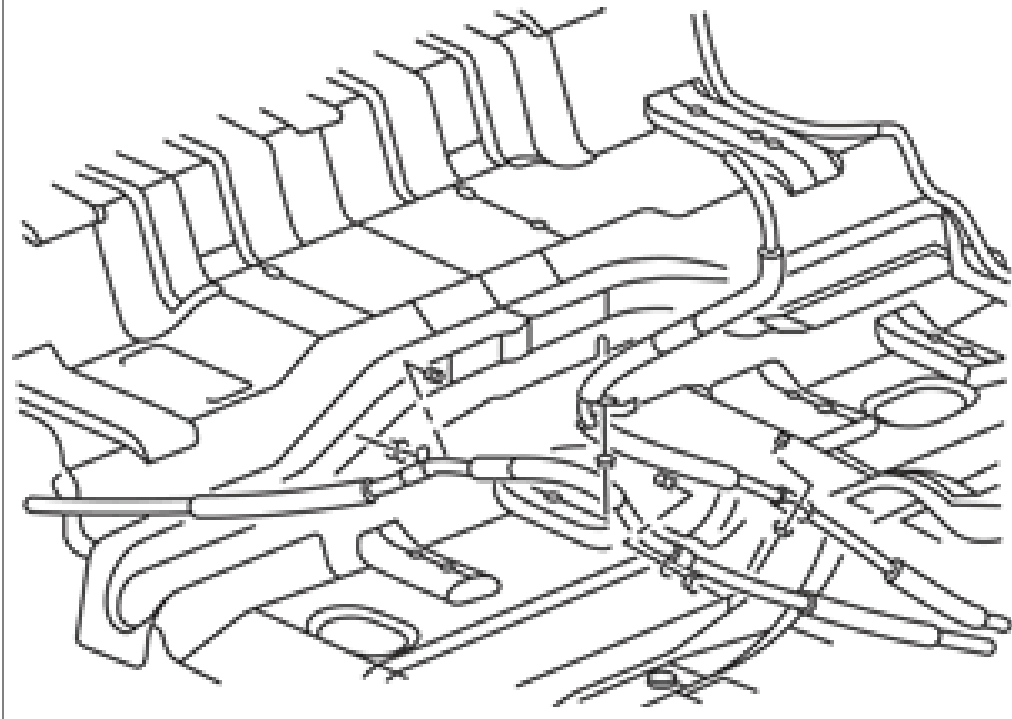
4. Remove the parking brake cables from the parking brake equalizer.

J 37043



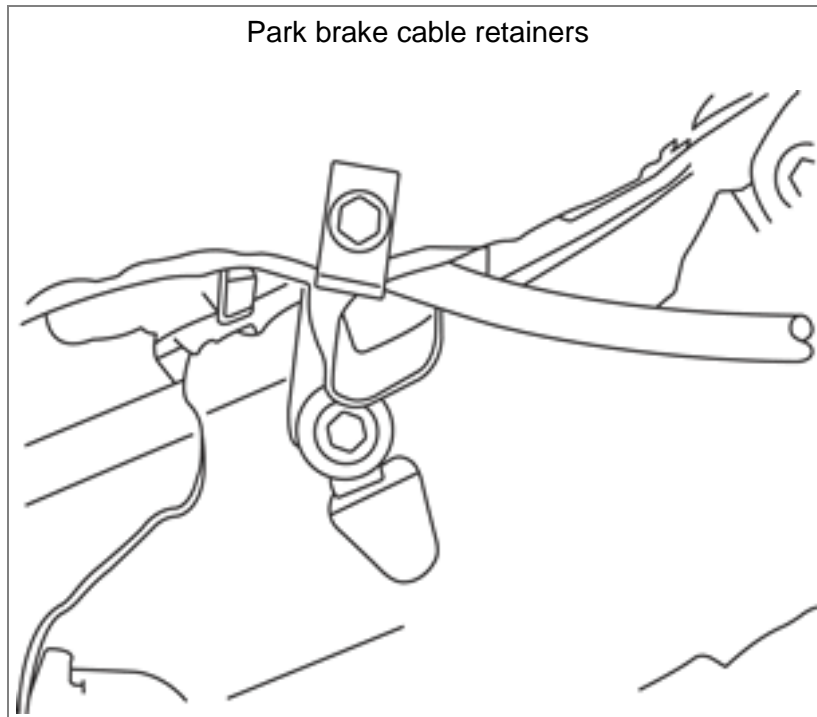
5. Use a J 37043 parking brake cable release tool to remove the parking brake cables from the frame retainers.
6. Place a pole jack with a wooden block under the fuel tank.
7. Remove the fuel tank shield from the fuel tank.
8. Remove the rear support bracket from the fuel tank.
9. Lower the fuel tank enough to gain access to the parking brake cable retainer about the fuel tank.

Under body mounting studs

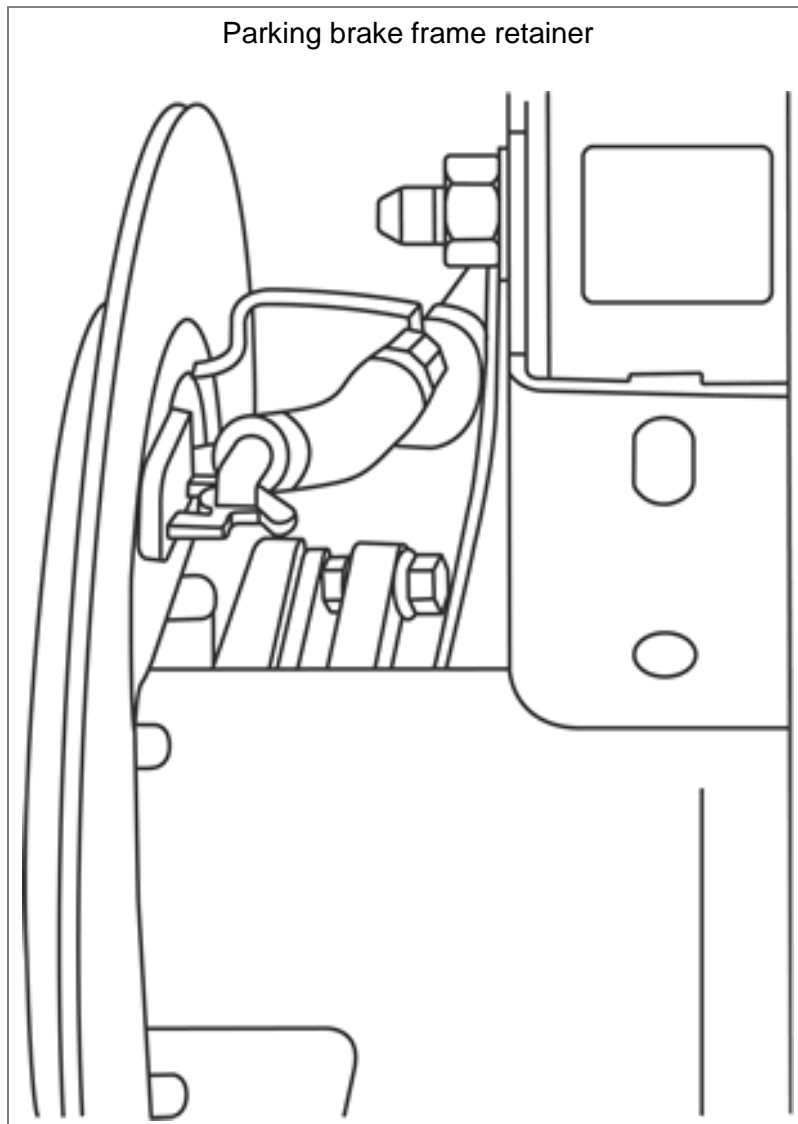


10. Detach the parking brake cables from the underbody mounting studs.

Park brake cable retainers



11. Remove the parking brake cables from the retainers.



12. Detach the parking brake cable retainers from the frame.
13. Remove the parking brake from the mounting bracket.
14. Remove the parking brake cables from the parking brake actuators.
15. Remove the parking brake cables from the vehicle.

To Install:

1. Route the parking brake cable through the vehicle.
2. Attach the parking brake cables to the underbody mounting studs. Torque the nuts to **7 ft-lb (10 Nm)**.
3. Lift the fuel tank.
4. Install the rear support bracket onto the fuel tank.
5. Remove the pole jack supporting the fuel tank.
6. Install the parking brake cables onto the parking brake actuators.
7. Install the parking brake cables into the frame retainers.

8. Attach the parking brake cable retainers to the frame. Torque the bolts to **15 ft-lb (20 Nm)**.
9. Install the parking brake cables into the retainers.
10. Install the fuel tank shield onto the fuel tank.
11. Install the parking brake cables into the parking brake equalizer.
12. Install the rear propeller shaft into the vehicle.
13. Lower the vehicle.
14. Enable the parking brake cable adjuster.
15. Make sure the parking brakes are operating properly.
16. Adjust the parking brake shoes.

Anti-Lock Brake System

WARNING

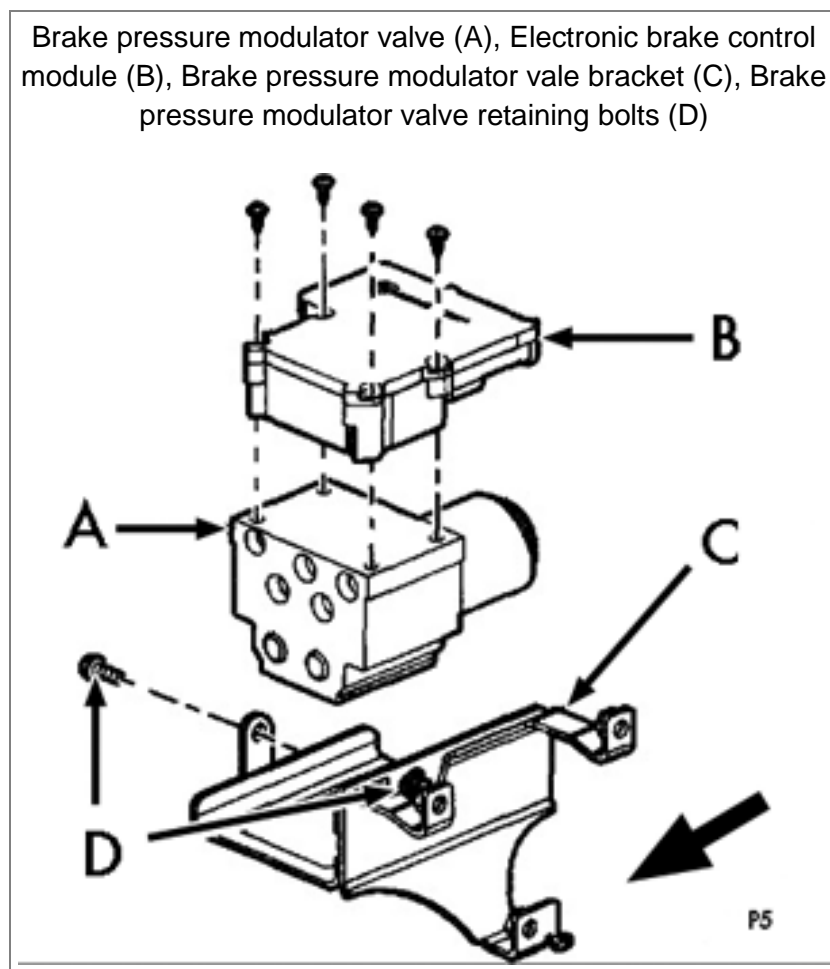
To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Electronic Brake Control Module

Removal & Installation

To Remove:

1. Disconnect the electronic brake control module (EBCM) connectors.



2. Detach the electronic brake control module (EBCM) from the brake pressure modulator valve (BPMV). A light amount of force may be necessary, do not pry about with a tool. Discard the screws.
3. Clean the sealing surfaces as necessary.

To Install:

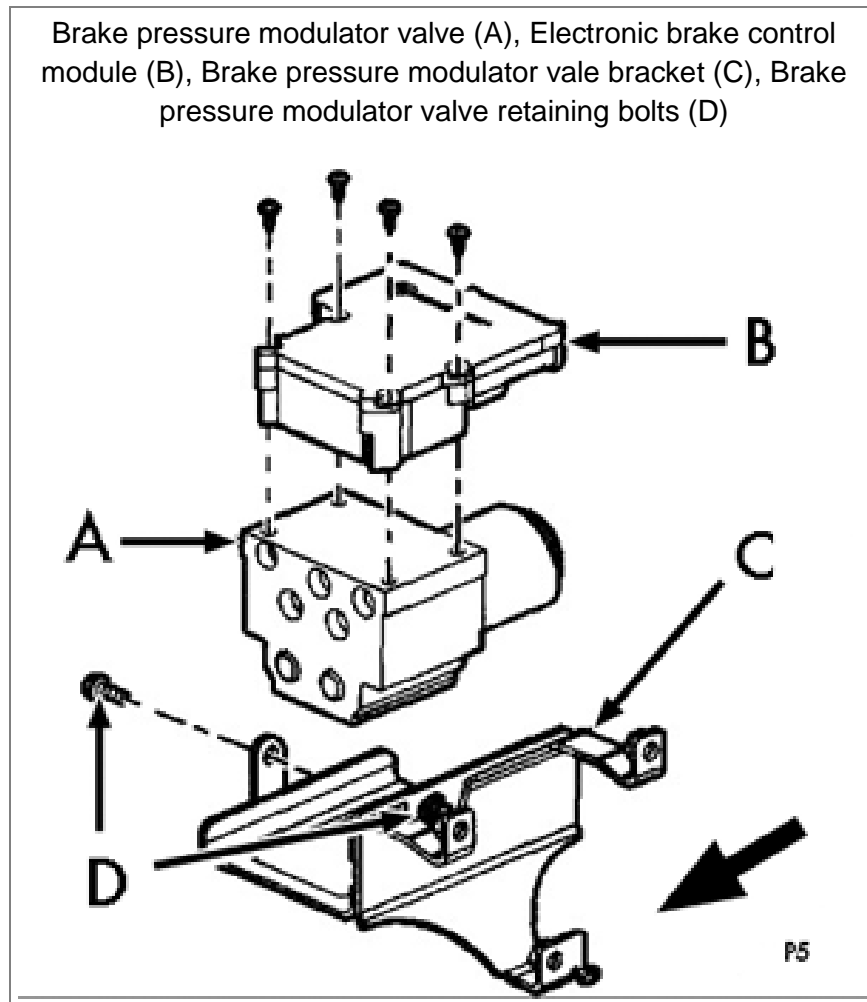
1. For 2002 through 2005 vehicles, attach the electronic brake control module (EBCM) from the brake pressure modulator valve (BPMV). Torque the new T-25 TORX® screws to **39 in-lb (5 Nm)**.
2. For 2006 through 2007 vehicles, attach the electronic brake control module (EBCM) from the brake pressure modulator valve (BPMV). Torque the new screws to **26 in-lb (3 Nm)**.
3. Connect the electronic brake control module (EBCM) connectors.
4. Use the scan tool to revise the tire calibration.

Brake Pressure Modulator Valve

Removal & Installation

To Remove:

1. Disconnect the electronic brake control module (EBCM) connectors.
2. Disconnect the brake pipes from the brake pressure modulator valve (BPMV).



3. Detach the brake pressure modulator valve (BPMV) from the mounting bracket.
4. Disconnect the ABS pump motor connector.
5. Detach the electronic brake control module (EBCM) from the brake pressure modulator valve (BPMV). A light amount of force may be necessary, do not pry about with a tool. Discard the screws.
6. Clean the sealing surfaces as necessary.

To Install:

1. For 2002 through 2005 vehicles, attach the electronic brake control module (EBCM) from the brake pressure modulator valve (BPMV). Torque the new T-25 TORX® screws to **39 in-lb (5 Nm)**.
2. For 2006 through 2007 vehicles, attach the electronic brake control module (EBCM) from the brake pressure modulator valve (BPMV). Torque the new screws to **26 in-lb (3 Nm)**.
3. Connect the ABS pump motor connector.
4. Attach the brake pressure modulator valve (BPMV) to the mounting bracket.
5. Connect the electronic brake control module (EBCM) connectors.
6. Connect the brake pipes from the brake pressure modulator valve (BPMV). Torque the pipe fittings to **18 ft-lb (25 Nm)**.
7. Bleed the brake system.

Bleeding

NOTE: Wait until the brake pedal is firm to drive the vehicle.

NOTE: Do not reuse the brake fluid used to bleed the system.

NOTE: Use this procedure only for base brakes.

1. Lift the vehicle high enough to access the bleed screws.
2. Start the procedure with the right rear wheel.
3. Install a clear hose onto the bleed screw.
4. Place the other end of the clear hose into a container partially filled with clean DOT 3 brake fluid.
5. Turn the bleed screw $\frac{1}{2}$ to one turn.
6. Slowly depress the brake pedal.
7. When the brake pedal is fully depressed, turn the bleed screw to close.
8. Release the brake pedal and wait 10 to 15 seconds for the master cylinder pistons to return to standing position.
9. Repeat steps 3 through 8 for the remaining wheels.

NOTE: More than a pint of brake fluid may be used per wheel for this procedure. Check the fluid level in the master cylinder reservoir every four to six strokes.

10. Firmly press in on the brake pedal and run the scan tool automated bleed procedure. Release the brake pedal between each test.
11. Repeat steps 3 through 8 for all four wheels until the brake pedal is firm.

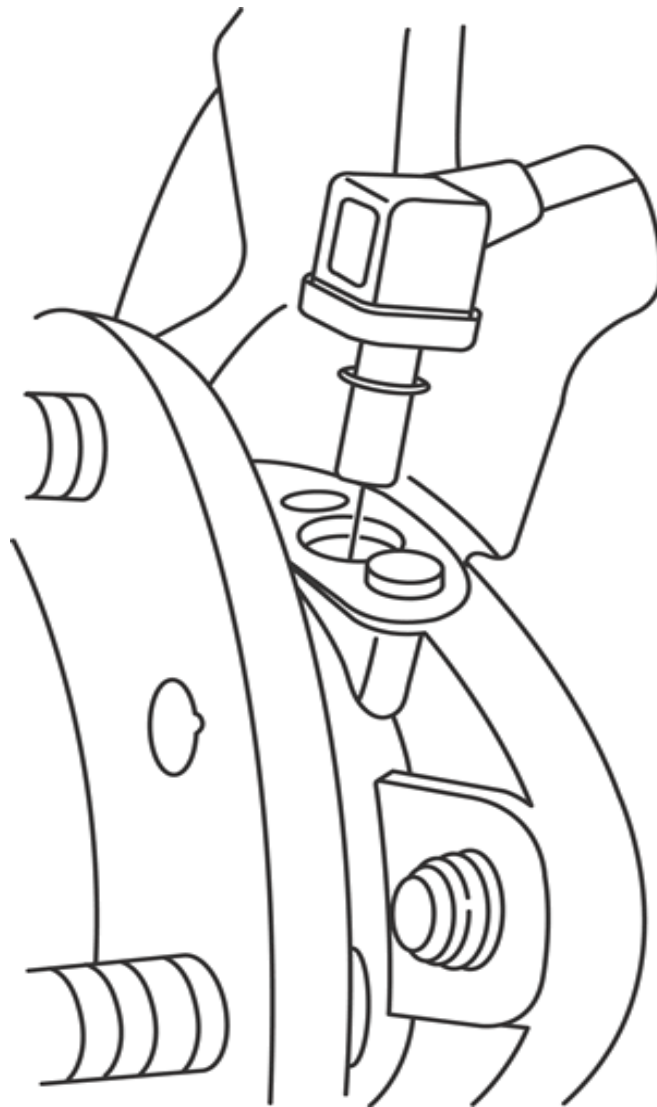
Front Wheel Speed Sensor

Removal & Installation

To Remove:

1. Lift the vehicle.
2. Remove the wheel from the vehicle.
3. Remove the brake rotor from the hub.
4. Remove the wheel speed sensor harness from the frame and control arm retainers.
5. Disconnect the wheel speed sensor connector.

Front wheel speed sensor removal and installation



6. Detach the wheel speed sensor from the hub.

To Install:

1. Attach the wheel speed sensor to the hub. Torque the screw to **13 ft-lb (18 Nm)**.
2. Connect the wheel speed sensor connector.

NOTE: If installing a new wheel speed sensor, the harness will have retainers already installed on it. Use these instead of the old retainers.

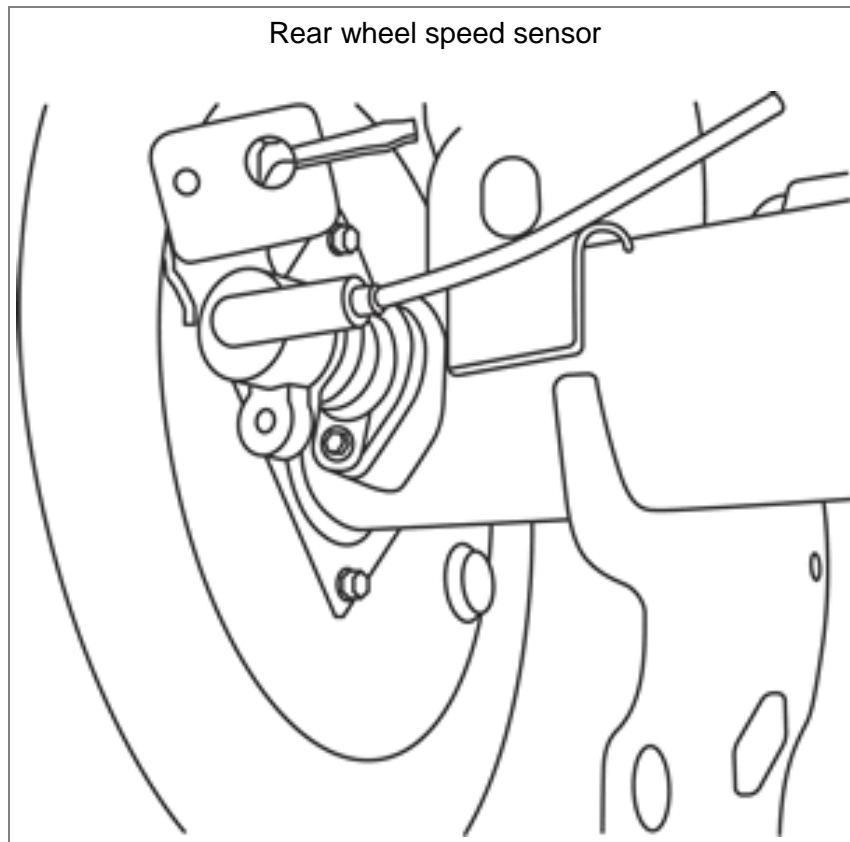
3. Install the wheel speed sensor harness into the frame and control arm retainers.
4. Install the rotor onto the hub.
5. Install the wheel onto the vehicle.
6. Lower the vehicle.

Rear Wheel Speed Sensor

Removal & Installation

To Remove:

1. Lift the vehicle.
2. Disconnect the wheel speed sensor connector.



3. Remove the wheel speed sensor from the sensor boss.

To Install:

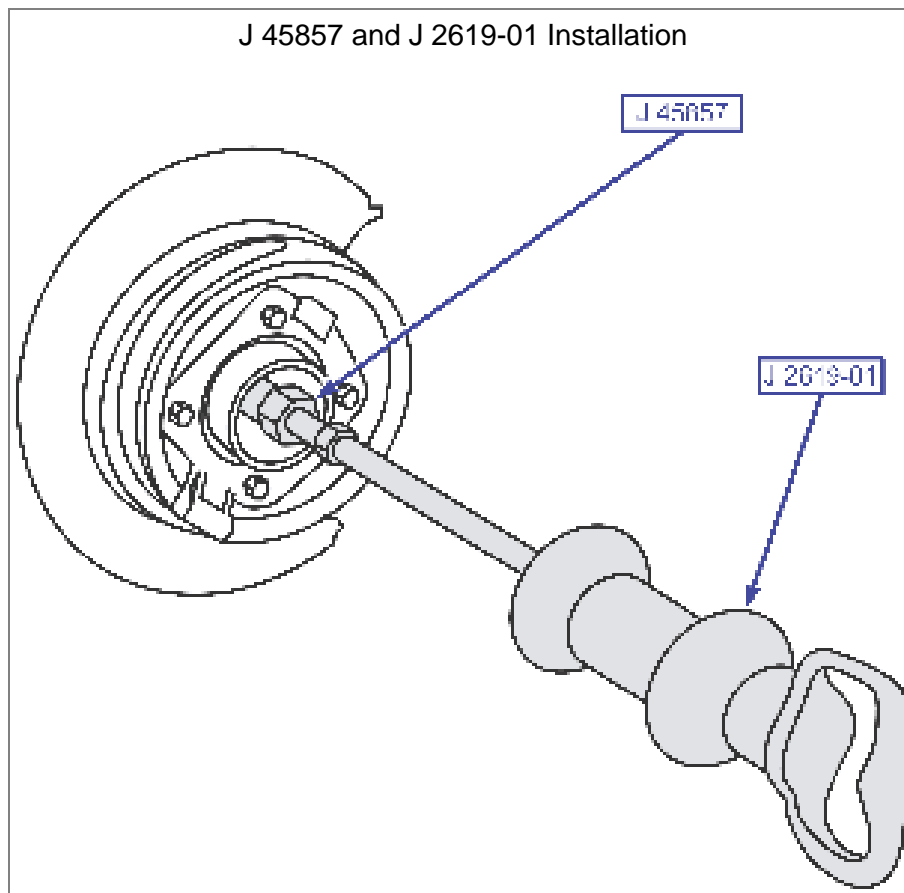
1. Make sure the wheel speed sensor and sensor boss are clean.
2. Lubricate the inside of the sensor boss with a small amount of axle grease.
3. Install the wheel speed sensor into the sensor boss. Torque the screw to **115 in-lbs (13 Nm)**.
4. Connect the wheel speed sensor connector.
5. Lower the vehicle.

Wheel Speed Sensor Ring

Removal & Installation

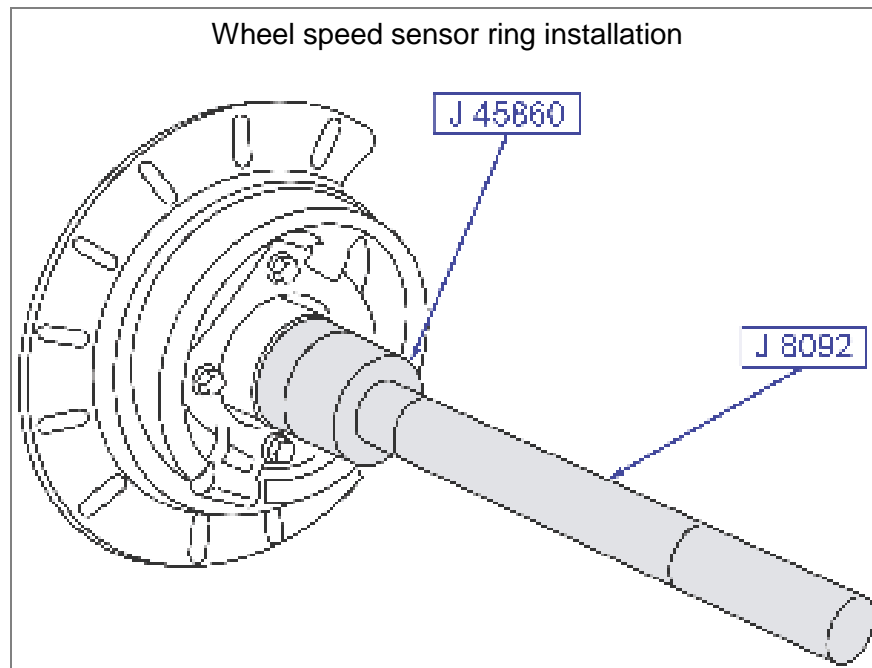
To Remove:

1. Lift the vehicle.
2. Remove the wheel from the vehicle.
3. Remove the wheel speed sensor from the wheel.
4. Remove the rear axle housing cover from the rear axle.
5. Remove the rear axle shaft from the vehicle.

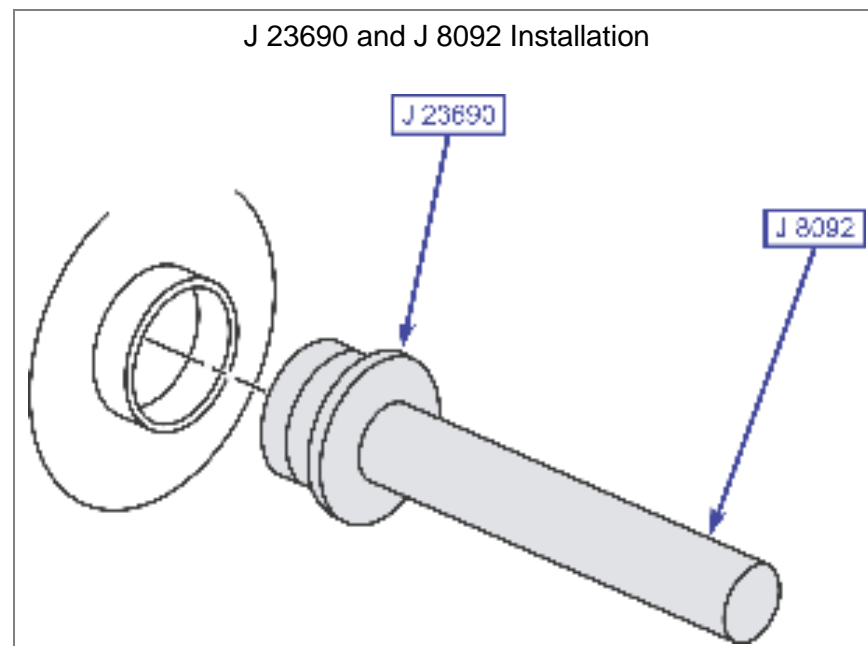


6. Use a J 45857 and J 2619-01 to remove the axle shaft seal, bearing, and wheel speed sensor ring from the axle housing.

To Install:

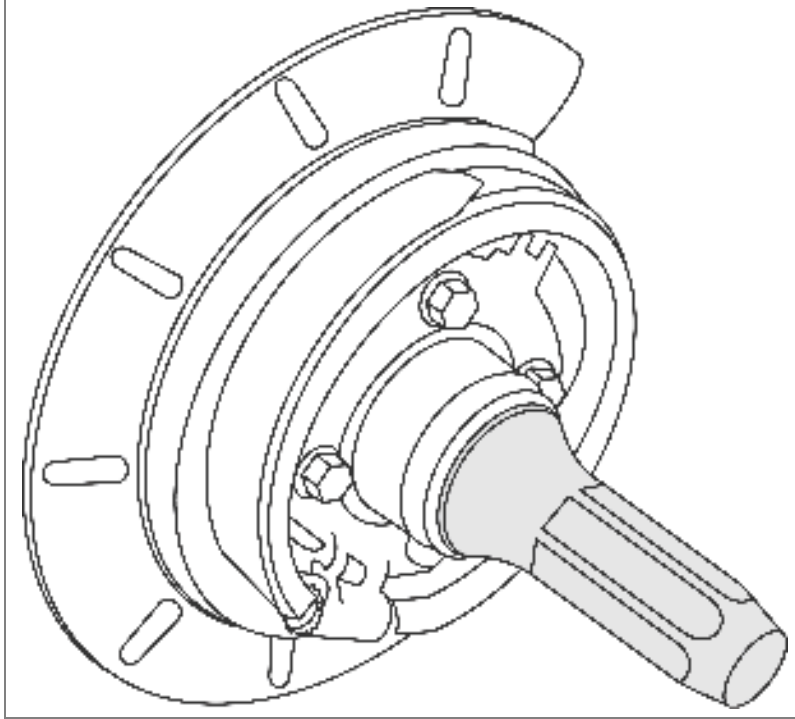


1. Use a J 45860 and J 8092 to install the wheel speed sensor ring into the rear axle housing.



2. Use a J 23690 and J 8092 to install the axle shaft bearing into the rear axle housing.

J 21128 Installation



3. Use a J 21128 to install the axle shaft seal into the rear axle housing.
4. Install the rear axle shaft into the vehicle.
5. Install the rear axle housing cover onto the rear axle housing.
6. Install the wheel speed sensor into the wheel.
7. Install the wheel onto the vehicle.
8. Refill the rear axle with fluid.
9. Lower the vehicle.

AIR CONDITIONING & HEATING SYSTEMS

Service Precautions

CAUTION

By law, in the manner as recommended by the manufacturer, only certified HVAC technicians can legally perform operations that involve installation and/or the removal/recovery of vehicle refrigerant. This is true of any and all operations that involve the potential exposure of vehicle refrigerant into the atmosphere.

Safety is the most important factor when performing not only fuel system maintenance but also any type of maintenance. Failure to conduct maintenance and repairs in a safe manner may result in serious personal injury or death.

- To avoid the possibility of fire and personal injury, always disconnect the negative battery cable unless the repair or test procedure requires that battery voltage be applied.
- Always relieve the fuel system pressure prior to disconnecting any fuel system component (injector, fuel rail, pressure regulator, etc.), fitting or fuel line connection. Exercise extreme caution whenever relieving fuel system pressure, to avoid exposing skin, face and eyes to fuel spray. Please be advised that fuel under pressure may penetrate the skin or any part of the body that it contacts.
- Always place a shop towel or cloth around the fitting or connection prior to loosening to absorb any excess fuel due to spillage. Ensure that all fuel spillage (should it occur) is quickly removed from engine surfaces. Ensure that all fuel soaked cloths or towels are deposited into a suitable waste container.
- Always keep a dry chemical (Class B) fire extinguisher near the work area.
- Do not allow fuel spray or fuel vapors to come into contact with a spark or open flame.
- Wear eye protection when servicing the air conditioning refrigerant system. Serious eye injury can result from eye contact with refrigerant. If eye contact is made, seek medical attention immediately.
- Do not expose refrigerant to open flame. Poisonous gas is created when refrigerant is burned. An electronic type leak detector is recommended.
- Large amounts of refrigerant released in a closed work area will displace the oxygen and cause suffocation.
- The evaporation rate of refrigerant at average temperature and altitude is extremely high. As a result, anything that comes in contact with the refrigerant will freeze. Always protect skin or delicate objects from direct contact with refrigerant. R-134a service equipment or vehicle A/C system should not be pressure tested or leak tested with compressed air.
- Some mixtures of air and R-134a have been shown to be combustible at elevated pressures. These mixtures are potentially dangerous and may result in fire or explosion causing injury or property damage.
- Antifreeze is an ethylene glycol base coolant and is harmful if swallowed or inhaled. Seek medical attention immediately if swallowed or inhaled. Do not store in open or unmarked containers. Wash skin and clothing thoroughly after coming in contact with ethylene glycol. Keep out of reach of children and pets.

- Do not open a cooling system when the engine is at running temperature. Personal injury can result.
- Kinks in the refrigerant tubing or sharp bends in the refrigerant hose lines will greatly reduce the capacity of the entire system.
- High pressures are produced in the system when it is operating. Extreme care must be exercised to make sure that all connections are pressure tight. Dirt and moisture can enter the system when it is opened for repair or replacement of lines or components. The refrigerant oil will absorb moisture readily out of the air. This moisture will convert into acids within a closed system.
- The system must be completely empty before opening any fitting or connection in the refrigeration system. Open fittings with caution even after the system has been emptied. If any pressure is noticed as a fitting is loosened, retighten fitting and evacuate the system again.
- A good rule for the flexible hose lines is to keep the radius of all bends at least 10 times the diameter of the hose. Sharper bends will reduce the flow of refrigerant. The flexible hose lines should be routed so they are at least **3 in. (80 mm)** from the exhaust manifold. Inspect all flexible hose lines to make sure they are in good condition and properly routed.
- The use of correct wrenches when making connections is very important. Improper wrenches or improper use of wrenches can damage the fittings.
- The internal parts of the A/C system will remain stable as long as moisture-free refrigerant and refrigerant oil is used. Abnormal amounts of dirt, moisture or air can upset the chemical stability. This may cause operational troubles or even serious damage if present in more than very small quantities.
- When opening a refrigeration system, have everything you will need to repair the system ready. This will minimize the amount of time the system must be opened. Cap or plug all lines and fittings as soon as they are opened. This will help prevent the entrance of dirt and moisture. All new lines and components should be capped or sealed until they are ready to be used.
- All tools, including the refrigerant dispensing manifold, the manifold gauge set, and test hoses should be kept clean and dry.

Cleanliness and Care, Shop Practice

- It should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

CAUTION

By law only certified HVAC technicians can legally perform operations that involve installation and/or the removal/recovery of vehicle refrigerant. This is true of any and all operations that involve the potential for releasing of refrigerant into the atmosphere.

General Troubleshooting

Leak Testing

WARNING

Never leak test the A/C system with compressed air. A mixture of air and R-134A can become combustible at high pressure. This mixture may result in fire or explosion causing injury and/or property damage.

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

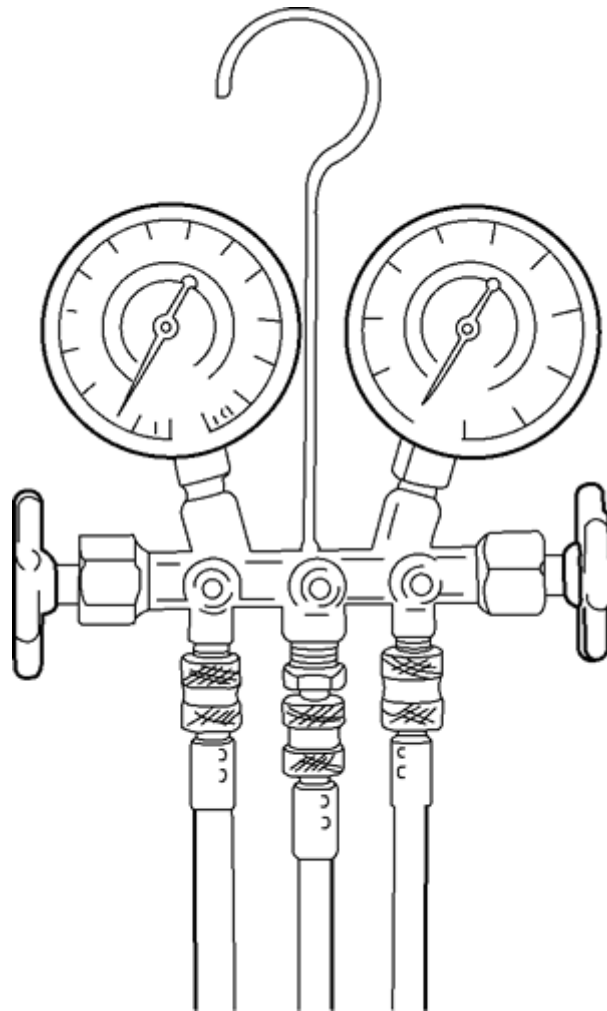
A/C system service requires the use of a manifold gauge set with vacuum pump or a refrigerant recovery/recycling station. The best way to determine if the system has a leak is to evacuate the refrigerant from the vehicle into a refrigerant recovery/recycling station. Once the refrigerant has been recovered the refrigerant recovery/recycling station will pull a vacuum on the system. Isolate the A/C system by closing the valves when the vacuum reaches -26 in. Hg (-88 kPa). A leak free system should be able to hold vacuum for at least 15 minutes or more. If you can not reach the vacuum specified, air is leaking into the system, and the source must be located and repaired.

Leaks will most likely occur at hose fittings and connections. A leak can also occur at the compressor shaft seal at the front of the compressor. The A/C system contains refrigerant oil mixed with refrigerant. Look for oily deposits at hose and pipe connections that indicate a leak. Fluorescent refrigerant system dye can be added to the refrigerant system to assist in refrigerant system leak diagnosis using an ultraviolet black-light.

Use an electronic refrigerant leak detector to validate leaks.

NOTE: Fluorescent refrigerant system dye is added to the refrigerant system at the factory on some vehicles. It is not necessary to add additional dye to the refrigerant system before diagnosing leaks, even if a significant amount of refrigerant has been removed from the system.

Manifold gauge set components



Refrigerant recovery/recycling station



Refrigerant Recovery & Recharging

NOTE: It is not possible to determine the amount of refrigerant in an A/C system without completely evacuating the system and recharging it. Always refer to the underhood heating and air conditioning specification tag for the proper amount of refrigerant.

CAUTION

Do not add more refrigerant to the system than specified by the manufacturer. Excessive system pressure may cause compressor failure.

CAUTION

A small amount of refrigerant oil is removed from the system each time the refrigerant is recovered into a refrigerant recovery/recycling station. This amount of oil must be returned to the system when the system is recharged. Follow the manufacturer's instructions that came with the equipment being used.

A refrigerant recovery/recycling station is needed to recover refrigerant from an A/C system. Connect the equipment to the vehicle's A/C system according to the manufacturer's instructions.

System Flushing

After a catastrophic compressor failure, it is extremely important to eliminate and/or contain the debris from the compressor that may have circulated through the A/C system. The debris generated from a catastrophic compressor failure will be discharged into the compressor suction line, discharge line, condenser and liquid line and may cause the new compressor to fail prematurely. In addition to flushing, a liquid line filter should be installed in the system to stop any remaining debris from circulating through the system.

Most refrigerant recovery/recycling stations have the ability to flush the system with cleaned and dry refrigerant. Keep in mind that the refrigerant oil in the system will also be removed and must be replaced when refrigerant is added to the system. Follow the instructions that came with the equipment to properly flush the A/C system.

Odor Correction

The air conditioning system may emit odors under certain conditions. This is usually due to the growth of mold on the evaporator and in the evaporator case. Water vapor from the air condenses on the fins of the evaporator as the A/C system is operating and collects in the evaporator housing. A drain hole at the bottom of the evaporator case is used to allow the water to drip out of the case and onto the ground. If the hole becomes clogged, it can be cleared with compressed air.

In order to correct the odor problem, the mold must be neutralized by using chemicals. Chemicals and cleaning systems have been specifically designed for disinfecting evaporator cores and housings.

The use of the cleaning system will vary slightly depending on how the A/C system is designed. Cleaning the evaporator core and housing generally involves spraying a cleaning solution into the housing and allowing the solution to soak for a period of time. The solution is then rinsed out with water. On some vehicles, the blower resistor can be removed from the housing under the hood and the solution can be sprayed in the resistor hole. On other vehicles, a hole must be drilled on the housing and patched with silicone or putty when the cleaning operation is completed. Evaporator cleaning systems vary; always follow the instructions that come with the kit.

Troubleshooting by Symptom

Poor Heater System Performance

CAUTION

Check all fluid levels and adjust as needed, before operating vehicle for extended periods at idle.

1. Start the engine.
2. Idle the engine until the thermostat opens (upper radiator hose will be hot) Is the engine at normal operating temperature (approx. 200° F)? If yes, go to the next step. If no, go to step 16.
3. Set the mode selector to FLOOR mode.
4. Set the heater control selector to the warmest temperature setting.
5. Set the blower speed the lowest setting.
6. Carefully feel the inlet and outlet heater hoses at the heater core. Is the inlet heater hose significantly hotter than the outlet heater hose? If yes, go to step 14. If no, go to the next step.
7. Set the mode selector to PANEL mode.
8. Select the maximum blower speed.
9. Select the warmest temperature setting.
10. Place a thermometer into the center I/P PANEL air outlet and affix a second thermometer to the heater core outlet heater hose.
11. Record the temperature at the center I/P PANEL air outlet and at the heater core outlet heater hose. Are the two temperature readings about equal? If yes, go to the next step. If no, go to step 13.
12. Inspect and repair the cowl, cowl area, recirculation door, and the HVAC evaporator/heater core case for cold air leaks. Repair any problems found, go to step 17.
13. Inspect the temperature door operation. Repair any problems found, go to step 17.
14. Turn OFF the engine. Back-flush the heater core. Start the engine. Select the FLOOR mode and the lowest blower speed. Select the warmest temperature setting. Feel the temperature of the inlet and outlet heater hoses at the heater core. Is the inlet heater hose feel significantly hotter than the outlet heater hose? If yes, go to the next step. If no, go to step 17.
15. Replace the heater core. When the repair is completed, go to step 17.
16. Check for low engine temperature problems, Repair or replace as needed, go to step 17.
17. Operate the system in order to verify the repair. If the system operates properly, the repair is complete. If the heater still does not work properly, repeat the entire procedure.

Insufficient Defrosting

CAUTION

Check all fluid levels and adjust as needed, before operating vehicle for extended periods at idle.

1. Start the engine, select the DEFROST mode, and select the maximum blower speed. Does sufficient air flow from the defroster outlets? If yes, go to the next step. If there is insufficient airflow, go to step 9.
2. Measure the engine operating temperature. Does the engine reach normal operating temperature (approx. 200° F)? If yes, go to the next step. If the engine does not reach normal operating temperature, go to step 7.
3. Select the minimum blower speed. Select the warmest temperature setting. Carefully feel the inlet and outlet heater hoses at the heater core. Is the inlet heater hose significantly hotter than the outlet heater hose? If yes, go to step 10. If the hose temperature feels approx. the same, go to the next step.
4. Test the operation of the A/C compressor clutch. Does the A/C compressor clutch engage? If yes, go to step 6. If the compressor clutch does not engage, go to step 5.
5. Inspect A/C compressor clutch and controls. Repair or replace as needed, go to step 13.
6. Determine if the A/C system is operating within specifications. If yes, go to step 8. If no, go to step 11.
7. Check the low engine temperature problem. Repair any problems found, go to step 13.
8. Inspect for correct operation of the recirculation door. If the door is operating correctly, go to step 13. If the door is not operating properly, go to step 12.
9. Check air delivery system. Repair any problems found, go to step 13.
10. Check the heater core for blockage. Repair or replace as needed, go to step 13.
11. Check A/C performance. Repair or replace as needed, go to step 13.
12. Repair the recirculation door concern. When the repair is complete, go to step 13.
13. Operate the system in order to verify the repair. If the system is operating properly, the procedure is complete. If the system is still not providing proper defrosting, repeat the entire test.

Noise from Blower Motor

1. Inspect the air inlet grille for debris. If the grille has debris, go to step 7. If the grille is clear, go to the next step.
2. From inside the vehicle, close all vehicle doors and windows, turn ON the ignition, with the engine OFF, and cycle the blower motor through all speeds in order to determine where and when the noise occurs. If noise is heard during the blower operation, go to step 3. If there is no noise, go to step 10.
3. Inspect for excessive vibration at each blower motor speed by feeling the blower case. If there is vibration, go to step 5. If no vibration is present, go to the next step.

4. Listen to the blower motor at each blower speed. Is the blower motor making a squeaking or chirping noise? If yes, go to step 8. If no noise exists, go to step 10.
5. Remove the blower motor, and inspect the blower motor and impeller for deposits of foreign material. If there is debris, go to step 7. If there is no debris, go to the next step.
6. Inspect the blower motor impeller for cracked blades, loose impeller retainer, or improper impeller alignment. If any of these conditions exist, go to step 8. If none of these exist, go to step 9.
7. Remove the foreign material, go to step 10.
8. Repair or replace blower motor or impeller as needed, go to step 10.
9. Install the blower motor, go to step 10.
10. Operate the system in order to verify the repair. If the condition has been corrected, the repair is complete. If noise still exists, repeat the entire procedure.

Noise from A/C System

NOTE: Noise from the A/C system may be heard as squealing, chirping or moaning noises, or as a vibration noise.

1. Start the engine and verify operation of the A/C system. If a screeching or squealing noise heard when the A/C is engaged go to step 2. If not, go to step 8.
2. With engine OFF, inspect the drive belt for excessive wear. If the belt is excessively worn, go to step 17. If the belt is not worn, go to step 3.
3. Inspect the drive belt tension. If the tension is correct, go to step 4. If the tension is not correct, go to step 18.
4. Inspect the drive belt for excessive oil coverage. If the belt is covered with oil, go to step 16. If there is no oil present, go to next step.
5. Start the engine, ensure the A/C system is ON, and visually inspect the compressor and the clutch. If the compressor does not turn, go to step 23. If the compressor and clutch are visually okay, go to step 6.
6. Check compressor clutch for slippage, if the compressor is slipping, go to step 22. If the clutch is not slipping, go to step 7.
7. Using a stethoscope, listen to the A/C compressor for any abnormal noise. If noise appears to be caused by the compressor, go to step 14. If the compressor is not the cause of the noise, go to step 9.
8. Does a moaning noise exist when the A/C clutch is engaged? If yes, go to the next step. If not, go to step 11.
9. Listen to the A/C compressor components and mounting for noise concerns using a stethoscope. Are any of these components loose, damaged or excessively worn? If yes, go to step 19. If no, go to the next step.
10. Idle the engine and engage the A/C compressor clutch. Using a stethoscope, move around the entire refrigerant plumbing system. Listening for any abnormal noises caused by a component of the A/C system touching another component. Are any of the A/C components grounding out and causing a vibration noise? If yes, go to step 21. If no, go to step 12.
11. Does a vibration or rattle noise exist when the A/C clutch is engaged? If yes, go to the next step. If no, go to step 13.
12. Does the noise stop when the A/C clutch is disengaged? If yes, go to step 14. If no, go to step 24.

13. Idle the engine in PARK with the A/C compressor clutch engaged. Using a stethoscope, move around the entire A/C system testing for any abnormal noises caused by a component. Do any of the A/C components cause an abnormal noise? If yes, go to step 20. If no, go to step 24.
14. Verify that the A/C system is properly charged. If it is properly charged, go to step 23. If not properly charged, go to the next step.
15. Recharge the A/C system to specification. Is the abnormal compressor noise still present? If yes, go to step 23. If no, go to step 25.
16. Repair the oil leak. When the repair is complete, go to step 17.
17. Replace the drive belt. When the repair is complete, go to step 25.
18. Replace the drive belt tensioner or adjust drive belt tension. When the repair is complete, go to step 25.
19. Repair or replace the A/C compressor mounting component. When the repair is complete, go to step 25.
20. Repair or replace the component that is causing the moaning concern as needed. When the repair is complete, go to step 25.
21. Correctly route or insulate the A/C component. When the repair is complete, go to step 25.
22. Verify A/C system is not overcharged. Replace the A/C compressor clutch. When the repair is complete, go to step 25.
23. Inspect the A/C compressor. Repair or replace as needed. When the repair is complete, go to step 25.
24. The concern may be caused by an engine related component. If the concern is found and repaired, go to step 25.
25. Operate the system in order to verify the repair. If the system is okay, the repair is complete. If not, repeat the entire procedure.

Noise from the HVAC Housing (Evaporator Case)

1. Start the engine. Cycle through all blower speeds, A/C mode settings and temperature control settings. Determine the type of noise, whether it is a scraping, popping, ticking, clicking, chirping or groaning, or an air rush or whistle. Is a scrape or pop noise evident when selecting modes or temperature settings? If yes, go to step 5. If no, go to the next step.
2. Is a tick/click, chirping, groaning or scraping noise present, but decreases as blower motor speed is decreased? If yes, go to step 5. If no, go to the next step.
3. Is an air rush/whistle noise evident in all modes but not all temperature settings? If yes, go to step 5. If no, go to the next step.
4. Is an air rush/whistle noise evident only in defrost or floor mode? If yes, go to step 5. If no, examine for other sounds, repeat step 1.
5. Remove components as needed to access the HVAC module. When complete, go to the next step.
6. Inspect the airflow doors for proper operation and the ducts for obstructions or foreign materials. Were any of these conditions found? If yes, go to step 9. If no, go to the next step.
7. Inspect the mode and temperature doors and seals for warping or cracking. Are the doors in normal condition? If yes, go to step 9. If no, go to the next step.
8. Replace the appropriate door and/or seals. When the repair is complete, go to step 10.
9. Remove any obstructions or foreign material found. When the repair is complete, go to step 10.

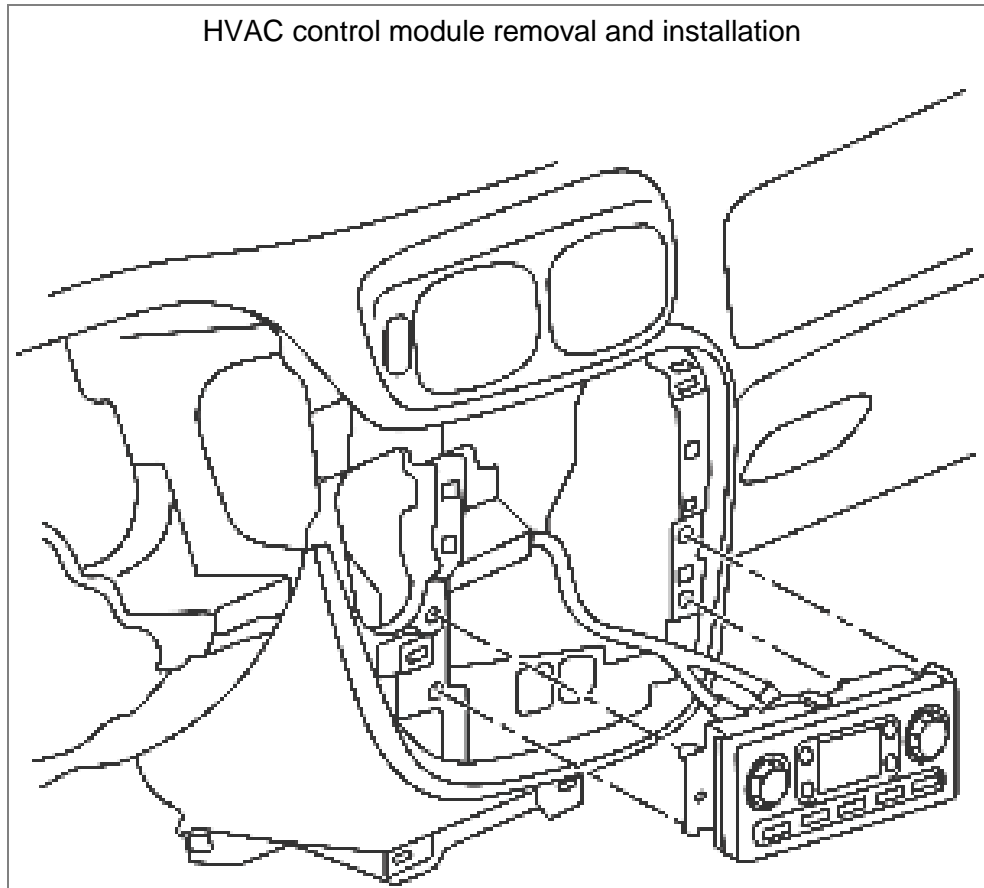
10. Install the components removed in step 5. When complete, go to the next step.
11. Operate the system to verify the repair. If system operates without noise, the repair is complete. If noise still exists, repeat the entire procedure.

HVAC Control Module

Removal & Installation

To Remove:

1. Remove the accessory trim plate from the instrument panel.



2. Remove the retaining screws from the HVAC control module.
3. Remove the HVAC control module from the instrument panel (I/P) by depressing the retaining tabs.
4. Disconnect the HVAC control module connectors.

To Install:

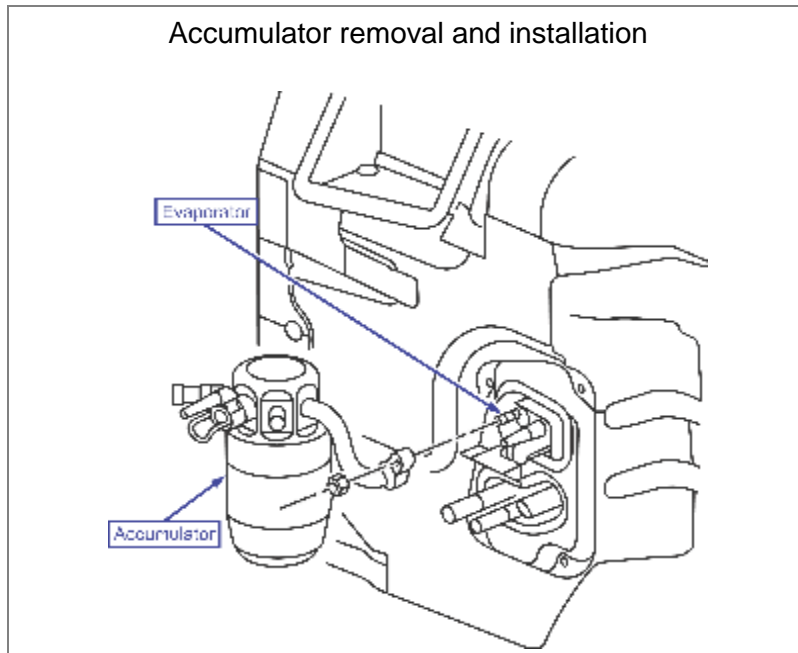
1. Connect the HVAC control module connectors.
2. Install the HVAC control module into the instrument panel (I/P).
3. Install the retaining screws into the HVAC control module. Torque the screws to **17 ft-lb (1.9 Nm)**.
4. Install the accessory trim plate onto the instrument panel.

Accumulator

Removal & Installation

To Remove:

1. Recover the refrigerant from the A/C system.
2. Disconnect A/C low pressure switch connector.
3. Remove the A/C low pressure switch from the accumulator.



4. Remove the accumulator retaining nut from the evaporator.
5. Remove the compressor suction hose assembly from the accumulator.
6. Remove and discard the O-rings from the accumulator.
7. Remove the nut from the accumulator clamp.
8. Remove the accumulator from the vehicle.

To Install:

1. Install the accumulator into the vehicle.
2. Install the nut onto the accumulator clamp. Torque the nut to **88 in-lb (10 Nm)**.
3. Install the A/C low pressure switch into the accumulator. Torque the switch to **44 in-lb (5 Nm)**.
4. Install the O-rings onto the accumulator.
5. Install the accumulator retaining nut onto the evaporator. Torque the nut to **21 ft-lb (28 Nm)**.
6. Install the compressor suction hose assembly onto the accumulator. Torque the nut to **35 ft-lb (48 Nm)**.
7. Connect A/C low pressure switch connector.
8. Evacuate and recharge the refrigerant in the A/C system.
9. Use a J 39400-A halogen leak detector to leak test the component fittings.

Air Door Actuators

Removal & Installation

Console Mode

To Remove:

1. Remove the center console from the vehicle.
2. Detach the air outlet duct from the center console.
3. Disconnect the console mode actuator connector.
4. Detach the console mode actuator from the center console.

To Install:

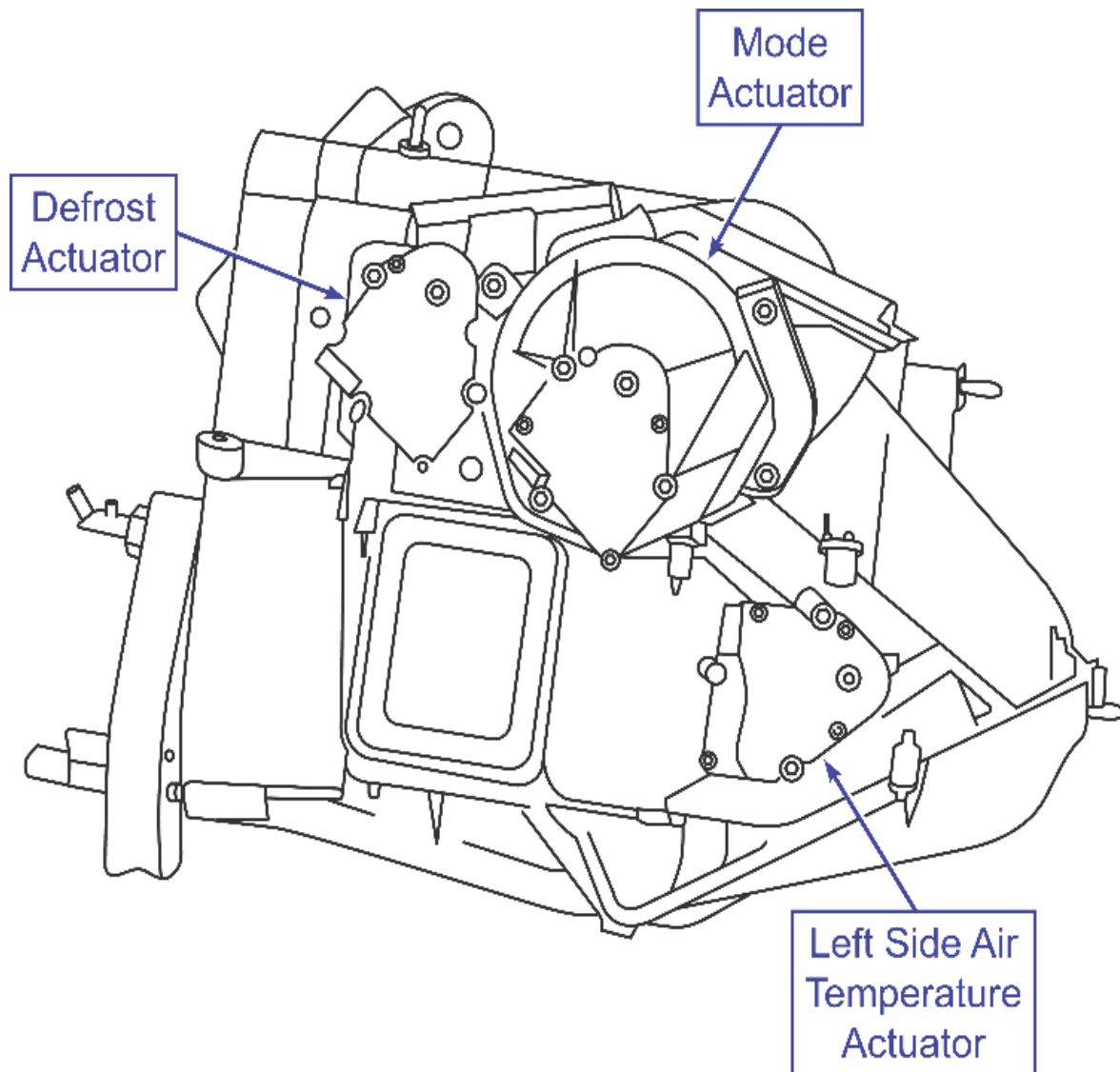
1. Attach the console mode actuator to the center console. Torque the screws to **17 in-lb (1.9 Nm)**.
2. Connect the console mode actuator connector.
3. Attach the air outlet duct to the center console. Torque the screw to **17 in-lb (1.9 Nm)**.
4. Install the center console into the vehicle.

Left Side Air Temperature

To Remove:

1. Remove the instrument panel carrier from the instrument panel.
2. Disconnect the left side air temperature actuator connector.

HVAC control module - left side



3. Detach the left side air temperature actuator from the HVAC module.

To Install:

1. Attach the left side air temperature actuator to the HVAC module. Torque the screw to **17 in-lb (1.9 Nm)**.
2. Connect the left side air temperature actuator connector.
3. Install the instrument panel carrier onto the instrument panel.
4. Recalibrate the left side air temperature actuator.

Right Side Air Temperature

To Remove:

1. Remove the instrument panel carrier from the instrument panel.
2. Disconnect the right side air temperature actuator connector.
3. Detach the right side air temperature actuator from the HVAC module.

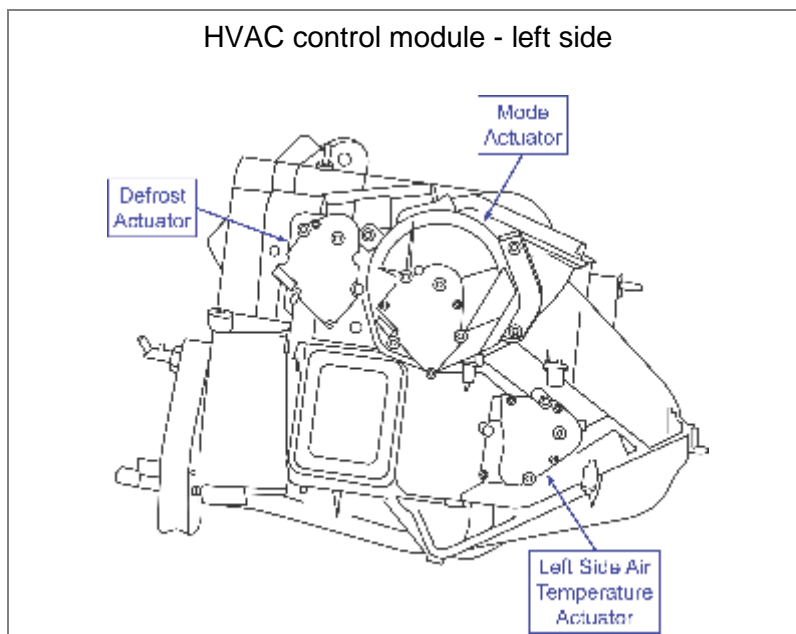
To Install:

1. Attach the right side air temperature actuator to the HVAC module. Torque the screw to **17 in-lb (1.9 Nm)**.
2. Connect the left side air temperature actuator connector.
3. Install the instrument panel carrier onto the instrument panel.
4. Recalibrate the right side air temperature actuator.

Mode

To Remove:

1. Remove the left floor duct from under the instrument panel (I/P).
2. Disconnect the mode actuator connector.



3. Detach the mode actuator from the HVAC module.

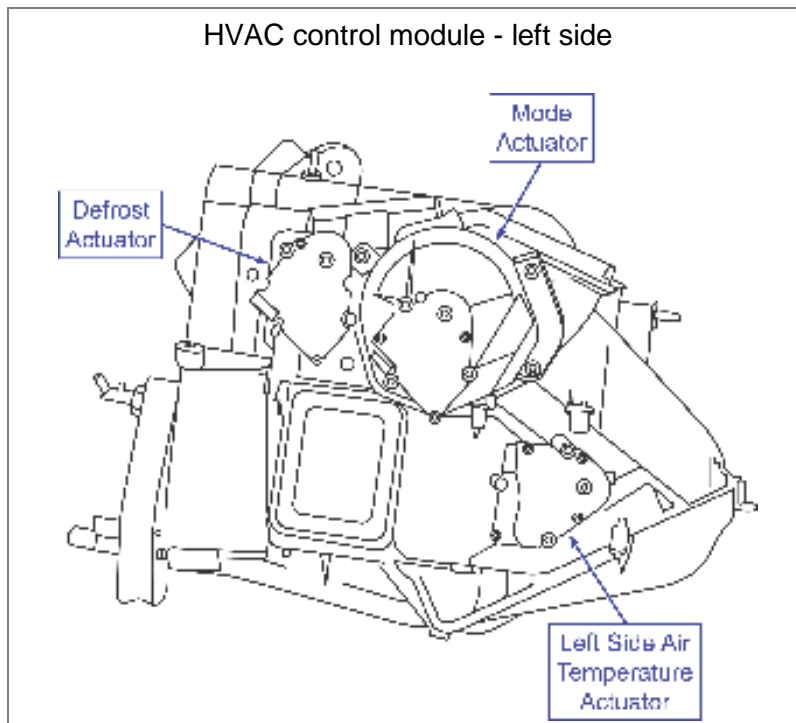
To Install:

1. If installing a new mode actuator, move the mode door to the middle position.
2. Attach the mode actuator to the HVAC module. Torque the screw to **17 in-lb (1.9 Nm)**.
3. Connect the mode actuator connector.
4. Install the left floor duct under the instrument panel (I/P).
5. Recalibrate the mode actuator.

Defrost Valve

To Remove:

1. Remove the instrument panel carrier from the instrument panel.
2. Disconnect the defrost valve actuator connector.



3. Detach the defrost valve actuator from the HVAC module.

To Install:

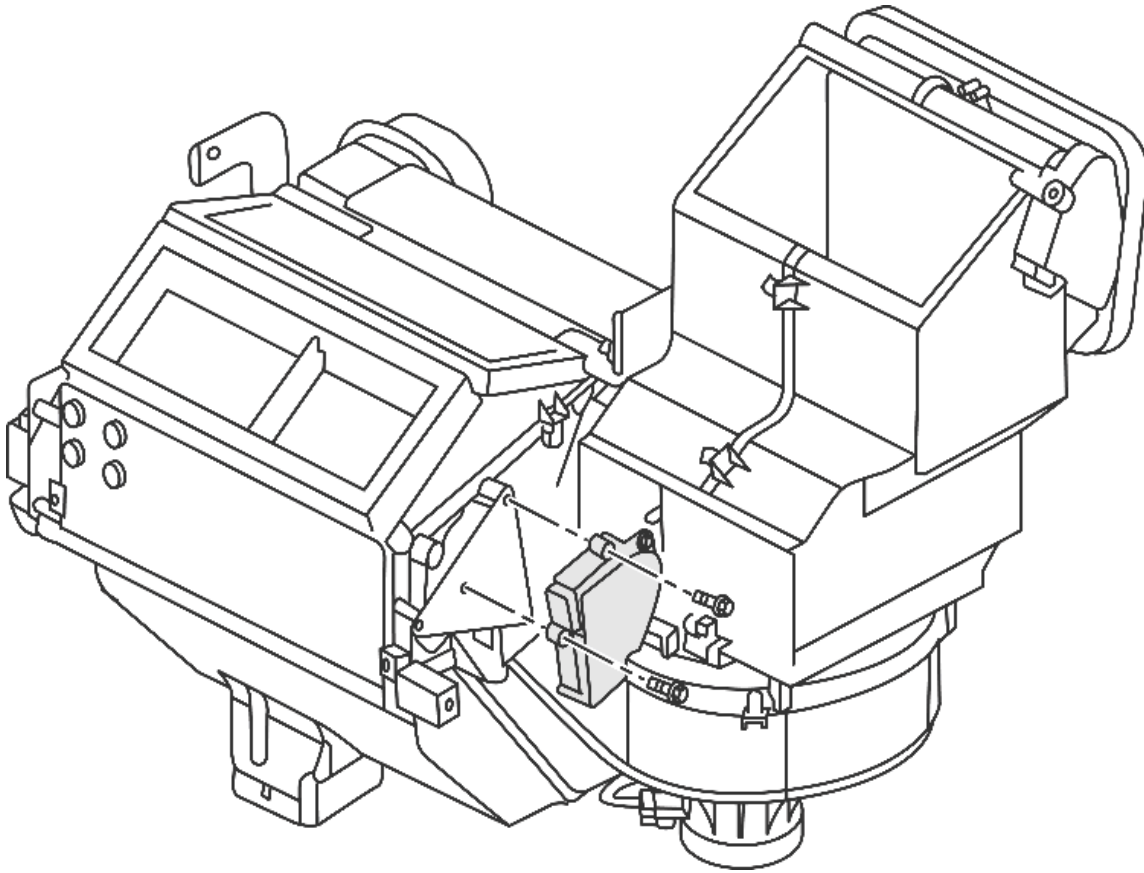
1. Attach the defrost valve actuator to the HVAC module. Torque the screw to **17 in-lb (1.9 Nm)**.
2. Connect the defrost valve actuator connector.
3. Install the instrument panel carrier onto the instrument panel.

Recirculation

To Remove:

1. Remove the HVAC module from the instrument panel.
2. Detach the air inlet assembly from the HVAC module.

Recirculation actuator removal and installation



3. Disconnect the recirculation actuator connector.
4. Detach the recirculation actuator from the HVAC module.

To Install:

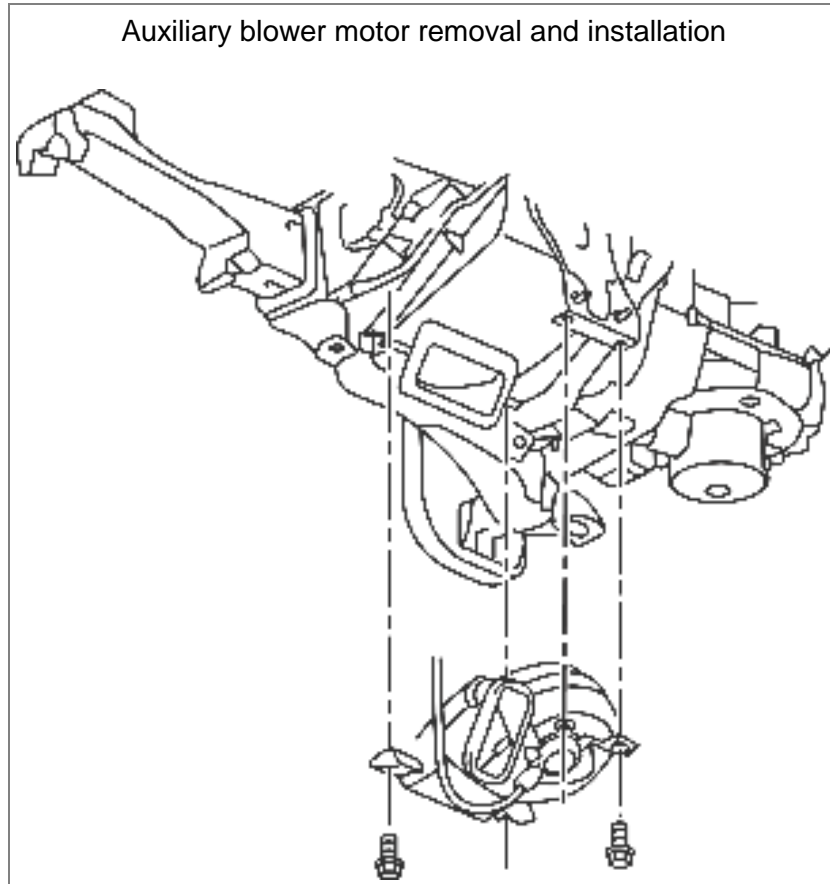
1. Attach the recirculation actuator to the HVAC module. Torque the screw to **17 in-lb (1.9 Nm)**.
2. Attach the air inlet assembly to the HVAC module. Torque the screw to **17 in-lb (1.9 Nm)**.
3. Connect the recirculation actuator connector.
4. Install the HVAC module into the instrument panel.
5. Recalibrate the recirculation actuator.

Front Auxiliary Blower Motor

Removal & Installation

To Remove:

1. For Buick and Saab vehicles, remove the instrument panel (I/P) from the vehicle.
2. For all vehicles except Buick and Saab, remove the center console from the vehicle.



3. Disconnect the auxiliary blower motor connectors.
4. Remove the air outlet duct from the auxiliary blower motor.
5. Detach the auxiliary blower motor from the HVAC module.

To Install:

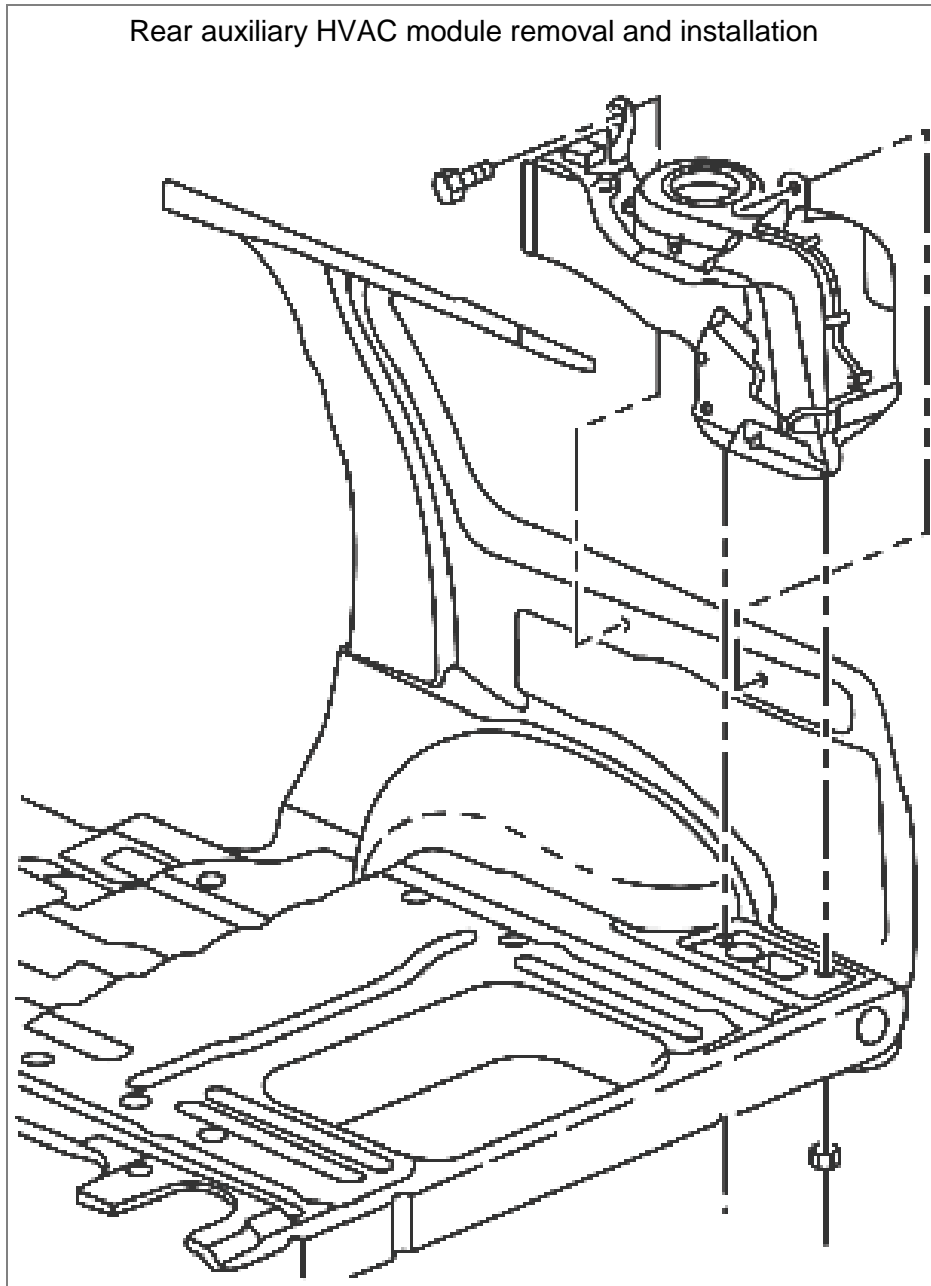
1. Attach the auxiliary blower motor to the HVAC module. Torque the screws to **88 in-lb (10 Nm)**.
2. Install the air outlet duct onto the auxiliary blower motor.
3. Connect the auxiliary blower motor connectors.
4. For all vehicles except Buick and Saab, install the center console into the vehicle.
5. For Buick and Saab vehicles, install the instrument panel (I/P) into the vehicle.

Rear Auxiliary Blower Motor

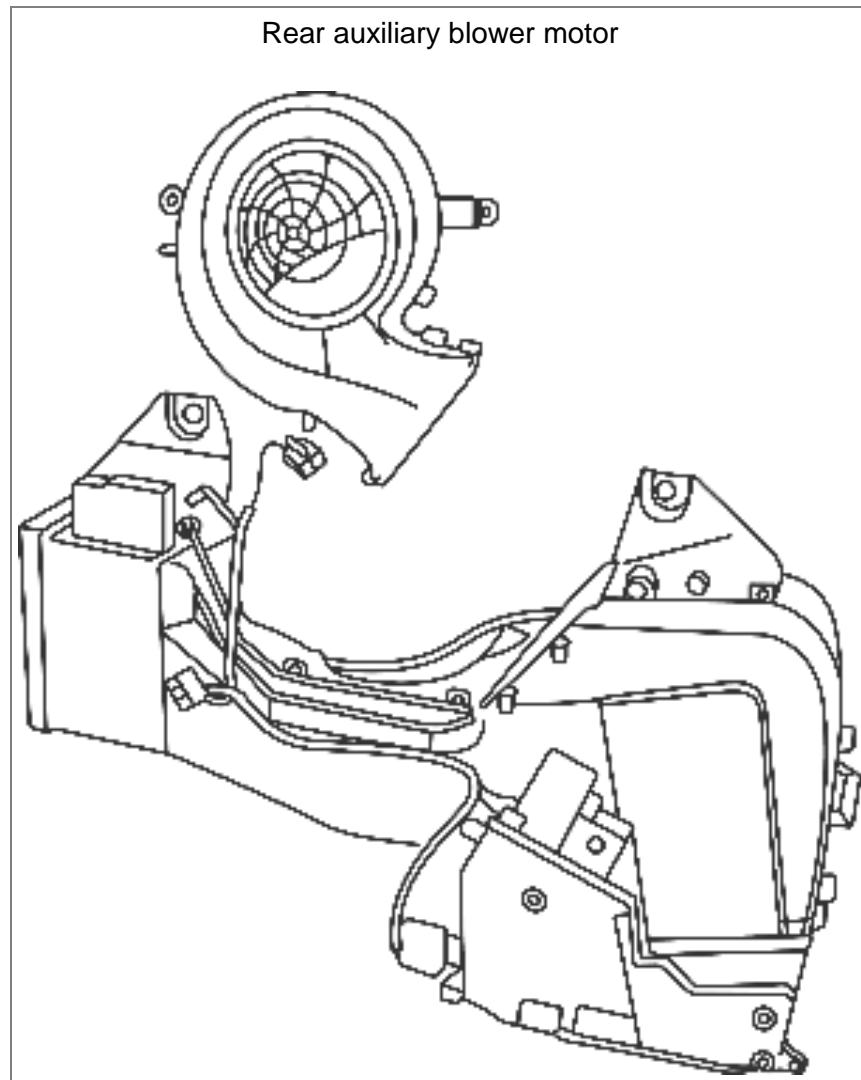
Removal & Installation

To Remove:

1. Remove the right rear quarter trim panel from the vehicle.



2. Detach the rear auxiliary HVAC module from the right side and floor of the vehicle.



3. Disconnect the rear auxiliary blower motor connectors.
4. Detach the rear auxiliary blower motor from the rear auxiliary HVAC module.

To Install:

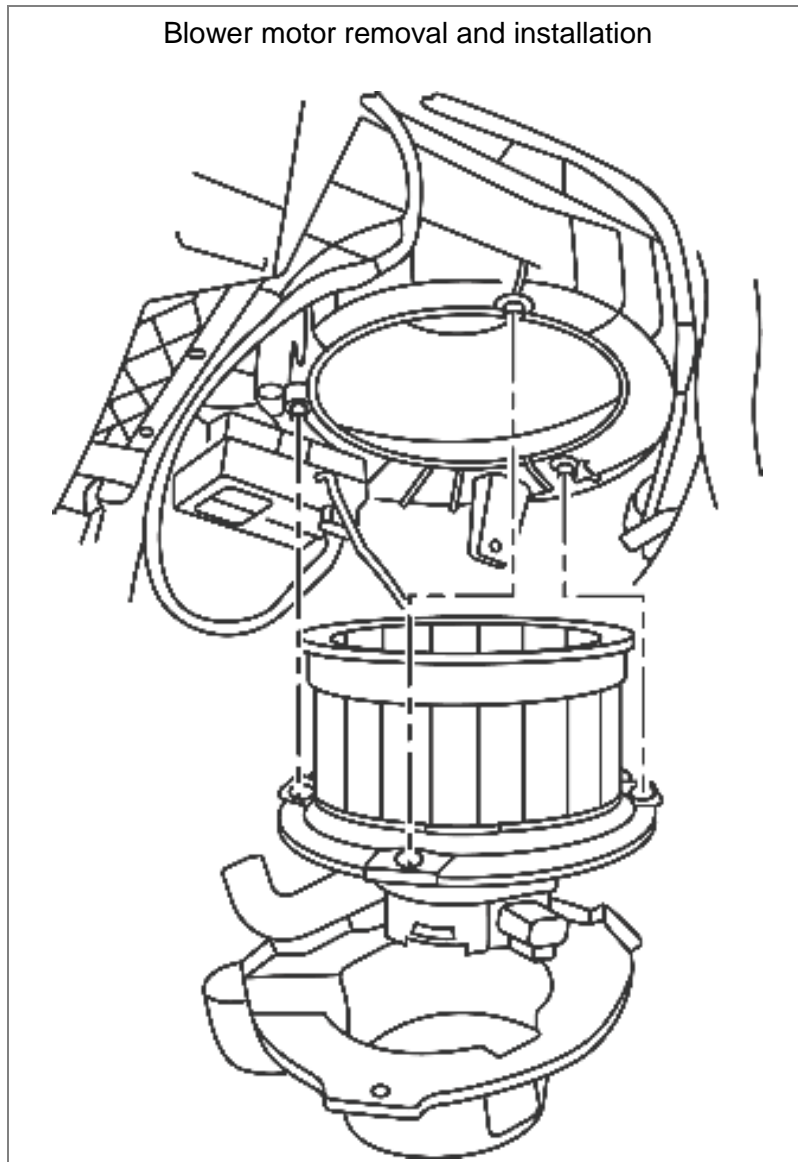
1. Attach the rear auxiliary blower motor to the rear auxiliary HVAC module. Torque the screws to **18 in-lb (2 Nm)**.
2. Connect the rear auxiliary blower motor connectors.
3. Attach the rear auxiliary HVAC module from the right side and floor of the vehicle. Torque the side bolts and under floor nuts to **88 in-lb (10 Nm)**.
4. Install the right rear quarter trim panel into the vehicle.

Blower Motor

Removal & Installation

To Remove:

1. Remove the right insulator panel from the instrument panel (I/P).
2. Remove the storage compartment door from the instrument panel (I/P).
3. Disconnect the blower motor connector.



4. Remove the mounting screws from the blower motor.
5. Disconnect the cooling tube from the blower motor.
6. Remove the blower motor from the HVAC module.

To Install:

1. Install the blower motor into the HVAC module.
2. Connect the cooling tube to the blower motor.
3. Install the mounting screws into the blower motor. Torque the screws to **18 in-lb (2 Nm)**.
4. Connect the blower motor connector.
5. Install the storage compartment door onto the instrument panel (I/P).
6. Install the right insulator panel onto the instrument panel (I/P).

Blower Motor Control Processor

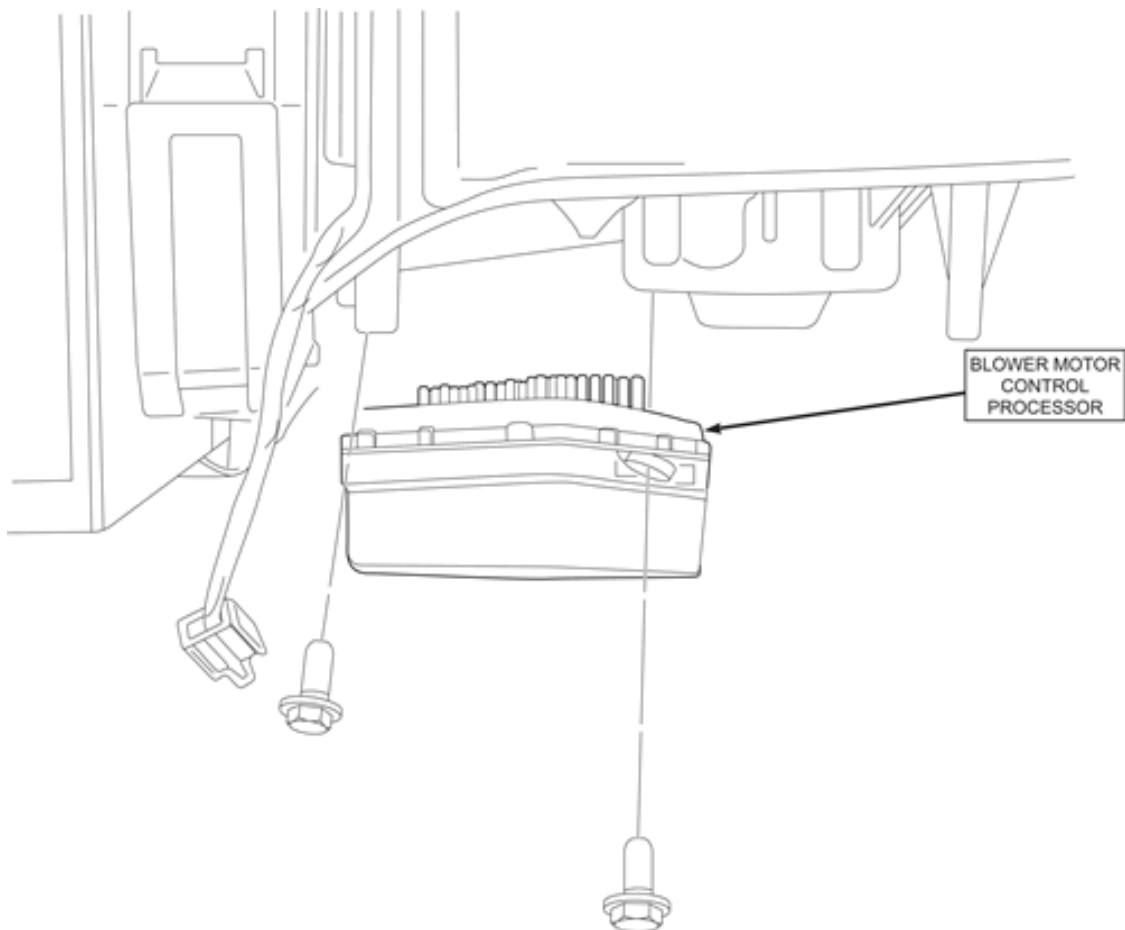
Removal & Installation

Automatic HVAC

To Remove:

1. Remove the right insulator panel from the instrument panel.
2. Disconnect the blower motor connector.

Blower motor control processor removal



3. Disconnect the blower motor control processor connector.
4. Detach the blower motor control processor from the HVAC module.

To Install:

1. Attach the blower motor control processor from the HVAC module. Torque the screws to **17 in-lb (1.9 Nm)**.
2. Connect the blower motor control processor connector.
3. Connect the blower motor connector.
4. Install the right insulator panel onto the instrument panel.

Blower Motor Resistor Assembly

Removal & Installation

To Remove:

1. Remove the right insulator panel from the instrument panel.
2. Disconnect the blower motor resistor assembly connector.
3. Detach the blower motor resistor assembly from the HVAC module.

To Install:

1. Attach the blower motor resistor assembly from the HVAC module. Torque the screws to **17 in-lb (1.9 Nm)**.
2. Connect the blower motor resistor assembly connector.
3. Install the right insulator panel onto the instrument panel.

A/C Compressor

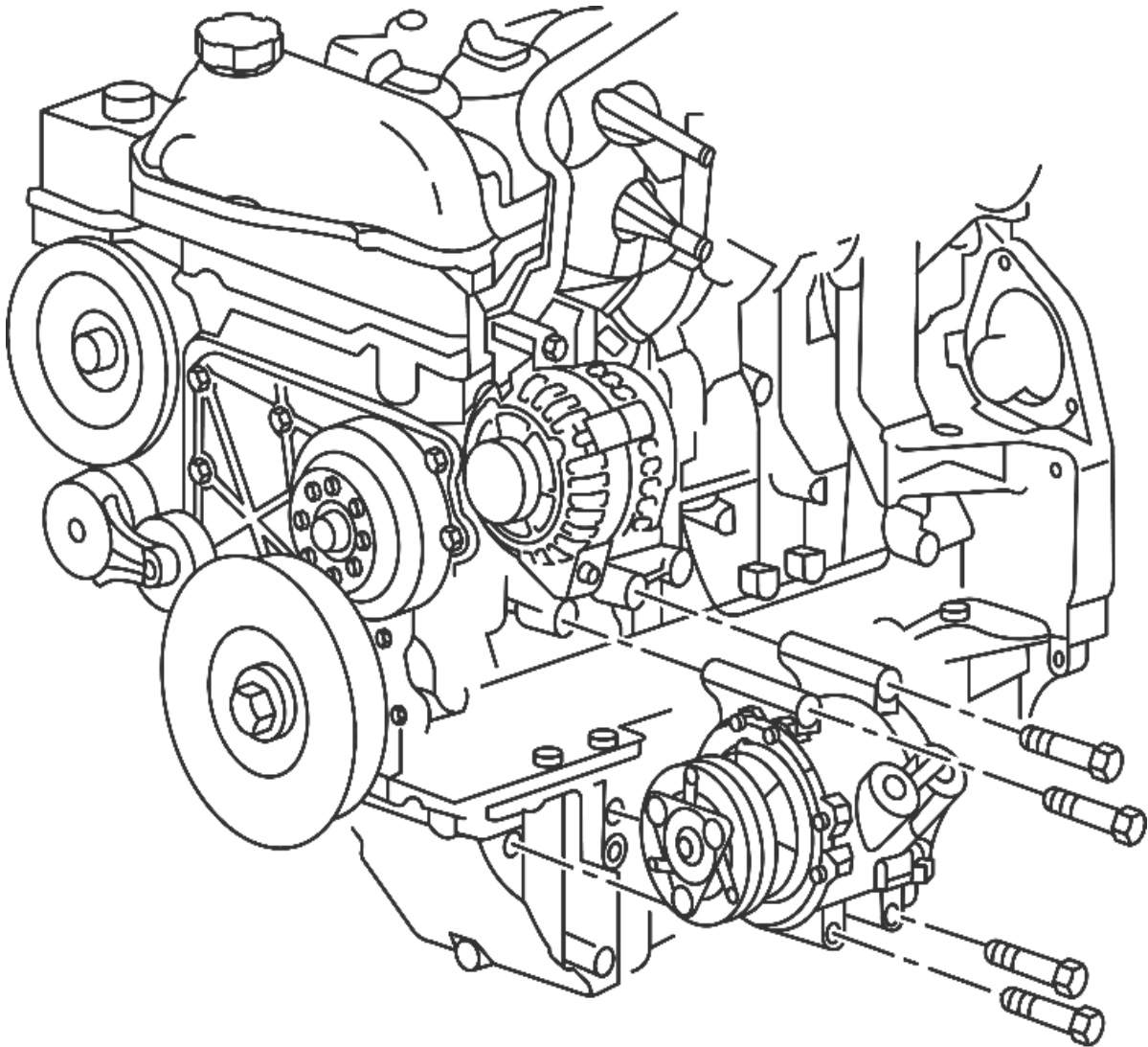
Removal & Installation

4.2L Engine

To Remove:

1. Recover the refrigerant from the A/C system.
2. Remove the generator from the engine.
3. Remove the idler pulley from the engine.
4. Disconnect the a/c compressor connector.
5. Detach the a/c compressor hose assembly block from the a/c compressor.

A/C compressor removal and installation (4.2L)



6. Detach the a/c compressor from the engine.
7. Drain the oil from the a/c compressor and measure the amount of oil.

To Install:

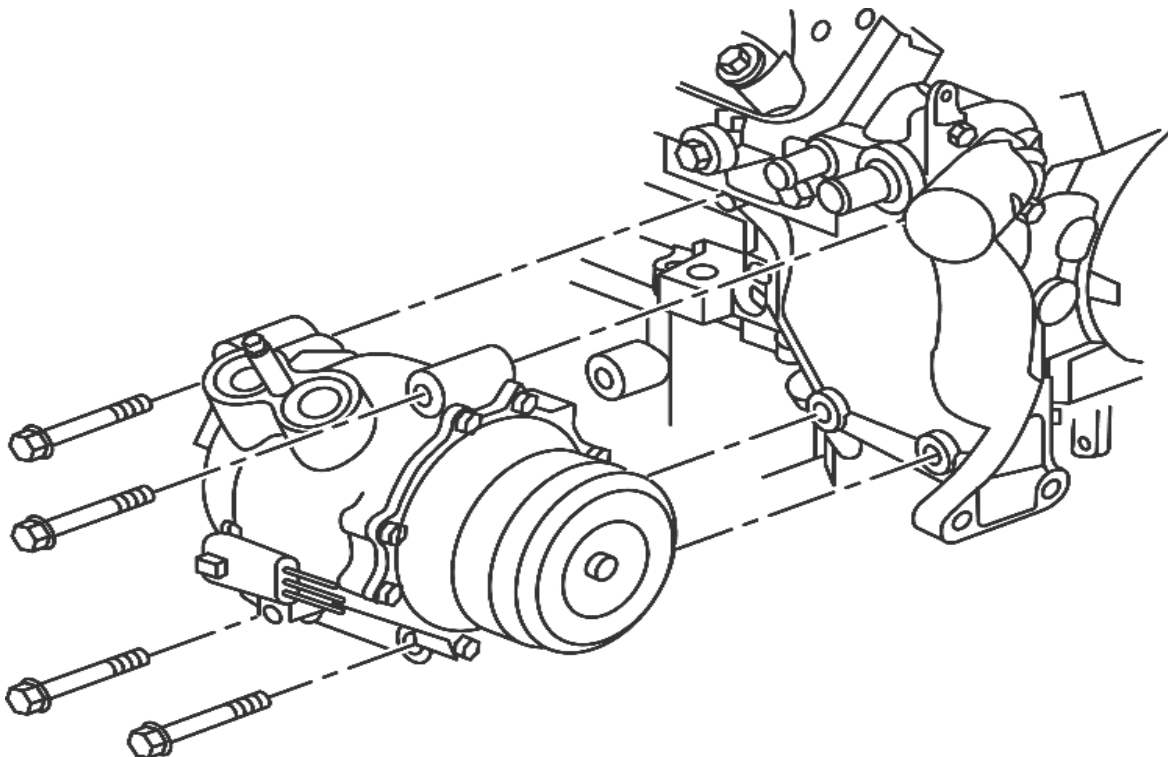
1. Refill the a/c compressor with the amount of oil drained.
2. Attach the a/c compressor to the engine. Torque the bolts to **37 ft-lb (50 Nm)**.
3. Attach the a/c compressor hose assembly block to the a/c compressor. Torque the bolts to **24 ft-lb (33 Nm)**.
4. Connect the a/c compressor connector.
5. Install the idler pulley onto the engine.
6. Install the generator onto the engine.
7. Evacuate and recharge the refrigerant in the A/C system.
8. Use a J 39400-A halogen leak detector to leak test the component fittings.

5.3L & 6.0L Engines

To Remove:

1. Recover the refrigerant from the A/C system.
2. Remove the washer solvent container from the engine compartment.
3. Remove the air cleaner resonator outlet duct from the engine compartment.
4. Remove the cooling fan and shroud from the engine compartment.
5. Remove the drive belt from the a/c compressor.
6. Detach the a/c compressor hose assembly from the a/c compressor.

A/C compressor removal and installation (5.3L/6.0L)



7. Remove the upper a/c compressor mounting bolts from the bracket.
8. Remove the lower coolant hose from the engine compartment.
9. Lift the vehicle.
10. Disconnect the a/c compressor connector.
11. Remove the lower a/c compressor mounting bolts from the bracket.
12. Lower the vehicle.
13. Move the a/c compressor and mounting bracket to gain access to the remaining bracket bolts.
14. Remove the upper a/c compressor mounting bolts from the engine.
15. Remove the a/c compressor from the bracket.
16. Remove the a/c compressor bracket from the engine.
17. Drain the oil from the a/c compressor and measure the amount of oil.

To Install:

1. Refill the a/c compressor with the amount of oil drained.
2. Position the a/c compressor and bracket onto the engine.
3. Install the upper a/c compressor mounting bolts into the engine. Torque the bolts to **37 ft-lb (50 Nm)**.
4. Install the upper a/c compressor mounting bolts into the bracket. Torque the bolts to **37 ft-lb (50 Nm)**.
5. Lift the vehicle.
6. Install the lower a/c compressor mounting bolts into the bracket. Torque the bolts to **37 ft-lb (50 Nm)**.
7. Connect the a/c compressor connector.
8. Install the lower coolant hose into the engine compartment.
9. Lower the vehicle.
10. Attach the a/c compressor hose assembly to the a/c compressor. Torque the bolts to **12 ft-lb (16 Nm)**.
11. Install the drive belt onto the a/c compressor.
12. Install the cooling fan and shroud into the engine compartment.
13. Install the air cleaner resonator outlet duct into the engine compartment.
14. Install the washer solvent container into the engine compartment.
15. Install the washer solvent container into the engine compartment.
16. Refill the engine cooling system.
17. Evacuate and recharge the refrigerant in the A/C system.
18. Use a J 39400-A halogen leak detector to leak test the component fittings.

Condenser

Removal & Installation

To Remove:

1. Recover the refrigerant from the A/C system.
2. Detach the compressor discharge hose from the condenser.
3. Remove the hood latch from the vehicle.
4. Remove the headlamp housing panel from the vehicle.
5. Remove the radiator diagonal brace from the radiator.
6. Detach the upper radiator support from the radiator.
7. Detach the evaporator tube from the condenser.
8. Detach the inlet and outlet studs from the condenser.
9. Detach the upper left hand bracket from the condenser.
10. Detach the condenser from the radiator.

To Install:

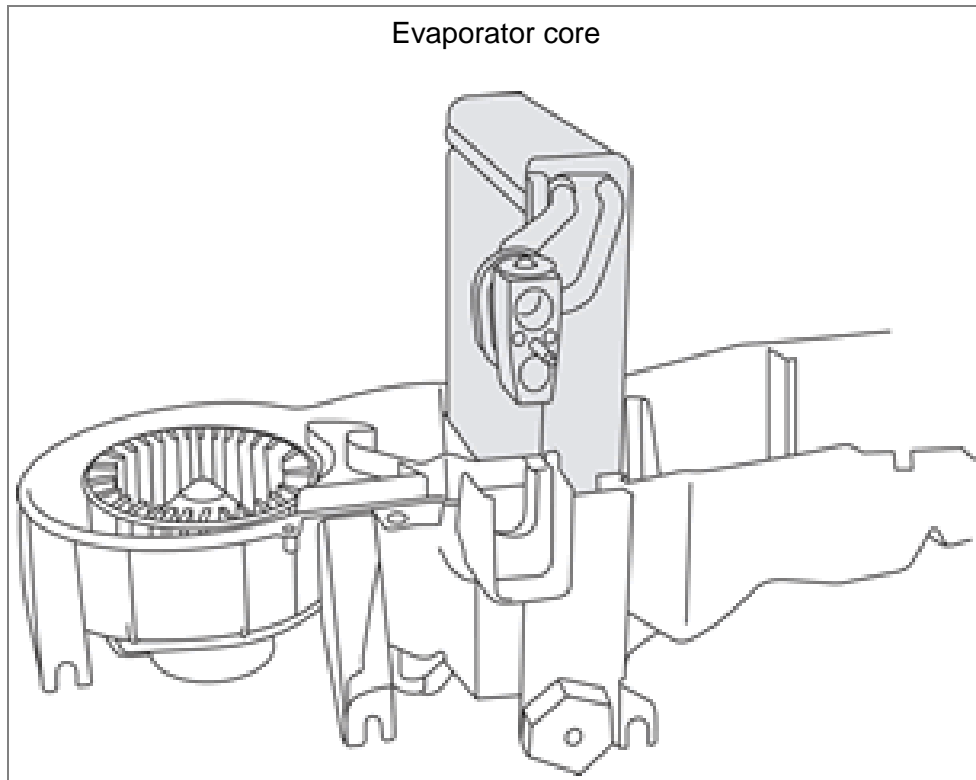
1. Attach the condenser to the radiator. Torque the bolts to **80 in-lb (9 Nm)**.
2. Attach the upper left hand bracket to the condenser. Torque the bolts to **80 in-lb (9 Nm)**.
3. Attach the inlet and outlet studs to the condenser. Torque the bolts to **40 in-lb (4.5 Nm)**.
4. Attach the evaporator tube to the condenser. Torque the nut to **21 ft-lb (28 Nm)**.
5. Attach the upper radiator support from the radiator. Torque the nut to **37 ft-lb (50 Nm)**.
6. Install the radiator diagonal brace onto the radiator.
7. Install the headlamp housing panel into the vehicle.
8. Install the hood latch onto the vehicle.
9. Attach the compressor discharge hose to the condenser. Torque the nut to **12 ft-lb (16 Nm)**.
10. Evacuate and recharge the refrigerant in the A/C system.
11. Use a J 39400-A halogen leak detector to leak test the component fittings.

Evaporator Core

Removal & Installation

To Remove:

1. Remove the HVAC module from the instrument panel carrier.
2. Remove the screws from the HVAC module.
3. Detach the top of the HVAC module from the bottom.



4. Remove the evaporator core from the HVAC module.
5. Remove the HVAC module seal from between the two halves.

To Install:

NOTE: Add refrigerant oil to the evaporator core if the core is being replaced.

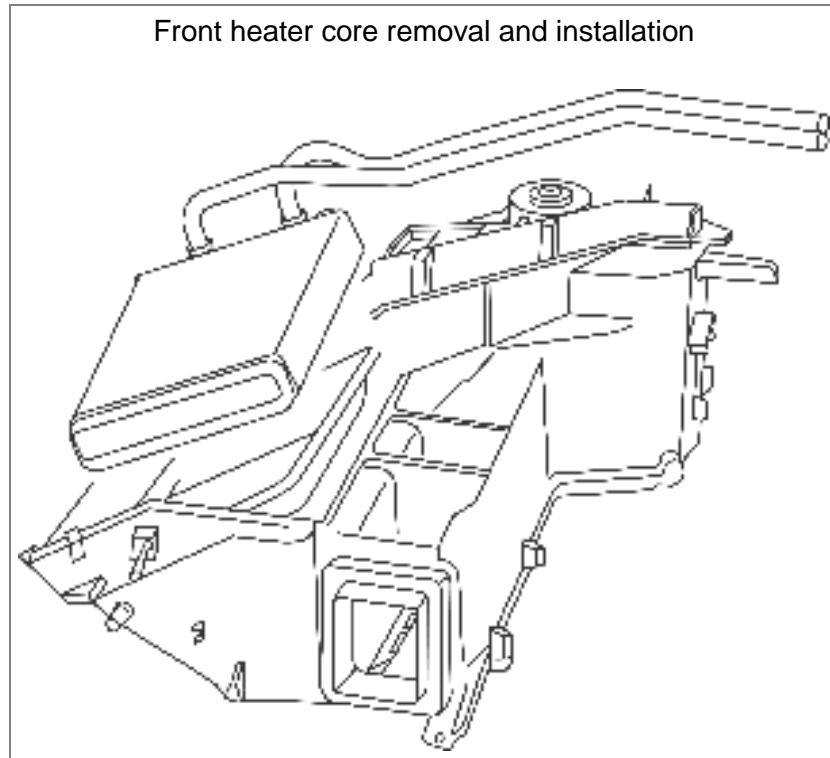
1. Install the HVAC module seal between the two halves.
2. Install the evaporator core into the HVAC module.
3. Attach the top of the HVAC module to the bottom.
4. Install the screws into the HVAC module. Torque the screws to **17 in-lb (1.9 Nm)**.
5. Install the HVAC module onto the instrument panel carrier.

Front Heater Core

Removal & Installation

To Remove:

1. Remove the HVAC module from the instrument panel carrier.
2. Detach the heater core access cover from the HVAC module.



3. Remove the heater core from the HVAC module.

To Install:

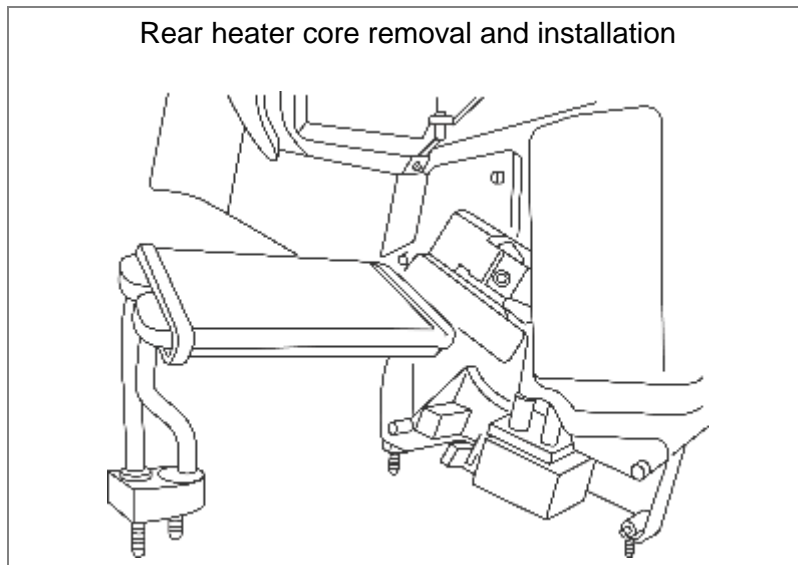
1. Install the heater core into the HVAC module.
2. Attach the heater core access cover from the HVAC module. Torque the screws to **17 in-lb (1.9 Nm)**.
3. Install the HVAC module onto the instrument panel carrier.

Rear Heater Core

Removal & Installation

To Remove:

1. Remove the rear auxiliary HVAC module from the vehicle.
2. Detach the heater core access cover from the rear auxiliary HVAC module.



3. Remove the pass through seal from the auxiliary rear HVAC module.
4. Remove the heater core from the rear auxiliary HVAC module.

To Install:

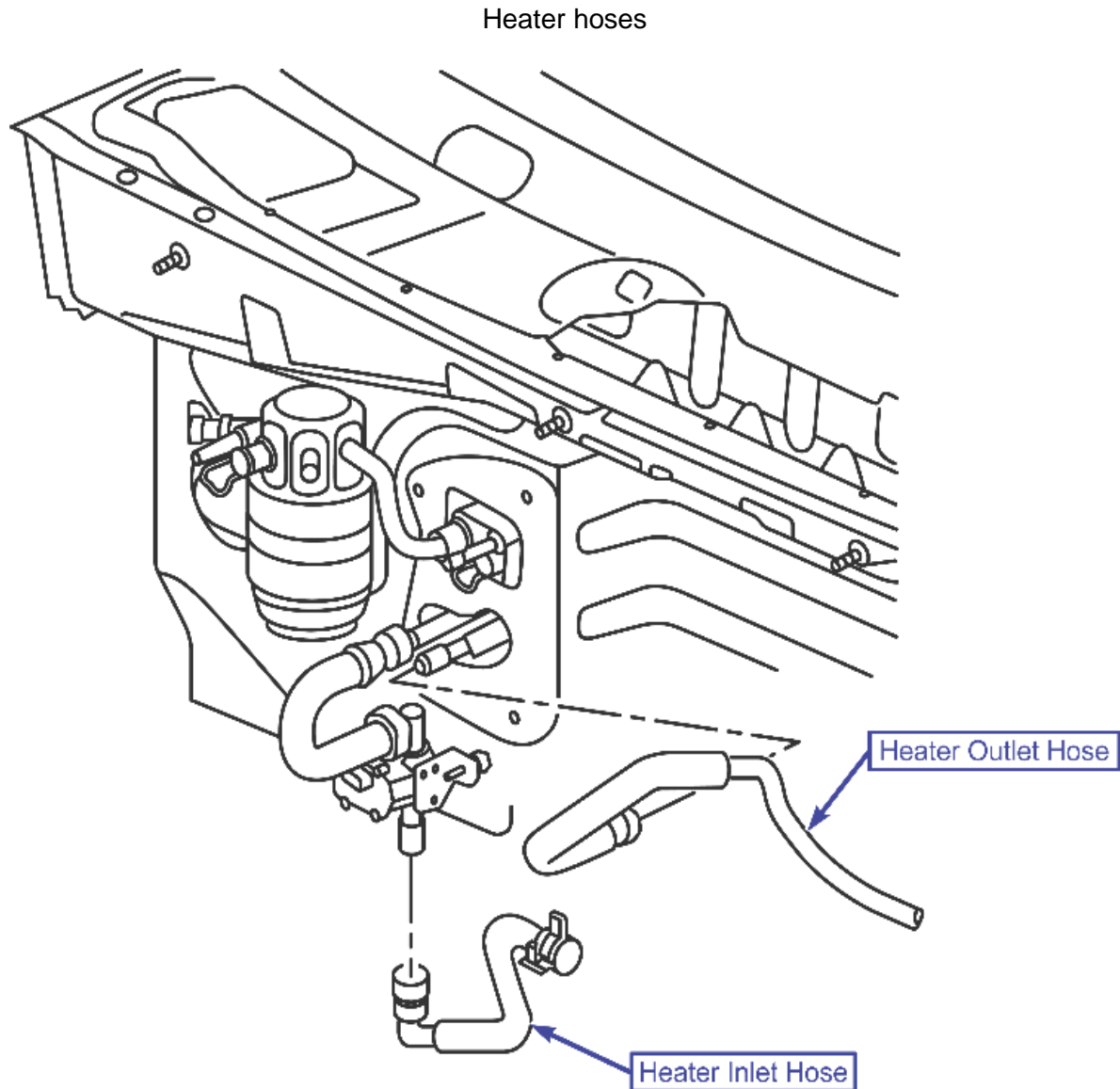
1. Install the heater core into the rear auxiliary HVAC module.
2. Install the pass through seal into the auxiliary rear HVAC module.
3. Attach the heater core access cover to the rear auxiliary HVAC module. Torque the screws to **18 in-lb (2 Nm)**.
4. Install the rear auxiliary HVAC module into the vehicle.

Heater Inlet Hose

Removal & Installation

To Remove:

1. Drain the coolant from the engine.



2. Use a set of J 43181 heater line quick connect release tool to disconnect the heater inlet hose from the heater core inlet tube.
3. Use a set of GE-47622 hose clamp pliers to disconnect the heater inlet hose from the engine block heater inlet hose fitting.

To Install:

1. Use engine coolant to lubricate the ends of the heater inlet hose.
2. Use a set of GE-47622 or J 38185 hose clamp pliers to connect the heater inlet hose to the engine block heater inlet hose fitting.
3. Connect the heater inlet hose to the heater core inlet tube.
4. Refill the engine with coolant.

Heater Outlet Hose*Removal & Installation***To Remove:**

1. Drain the coolant from the engine.
2. Remove the transmission from the vehicle.
3. Remove the generator from the engine.
4. Use a set of J 43181 heater line quick connect release tool to disconnect the heater outlet hose from the heater core outlet tube.
5. Use a set of 47622 or J 38185 hose clamp pliers to disconnect the heater outlet hose from the water pump hose fitting.

To Install:

1. Use a set of 47622 or J 38185 hose clamp pliers to connect the heater outlet hose to the water pump hose fitting.
2. Connect the heater outlet hose to the heater core outlet tube.
3. Install the transmission into the vehicle.
4. Install the generator onto the engine.
5. Refill the engine with coolant.

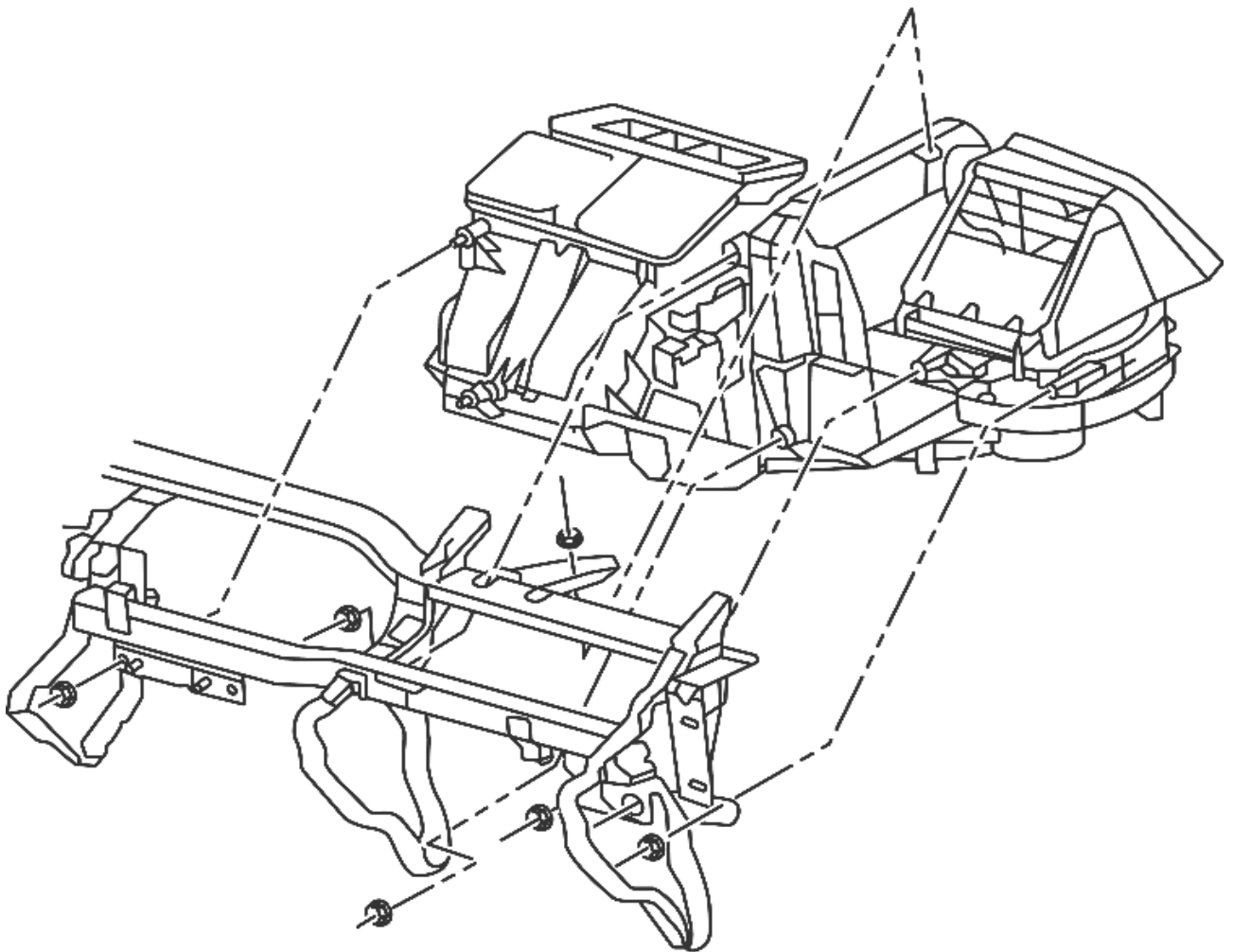
Front HVAC Module

Removal & Installation

To Remove:

1. Drain the coolant from the engine.
2. Recover the refrigerant from the A/C system.
3. Remove the instrument panel carrier from the instrument panel (I/P).
4. Use a J 43181 heater line quick connect release tool to remove the heater hoses from the heater core.
5. Detach the accumulator from the evaporator.
6. Disconnect the evaporator tube from the evaporator.
7. Disconnect the HVAC module connectors.

Front HVAC module removal and installation



8. Remove the HVAC module from the instrument panel (I/P).

To Install:

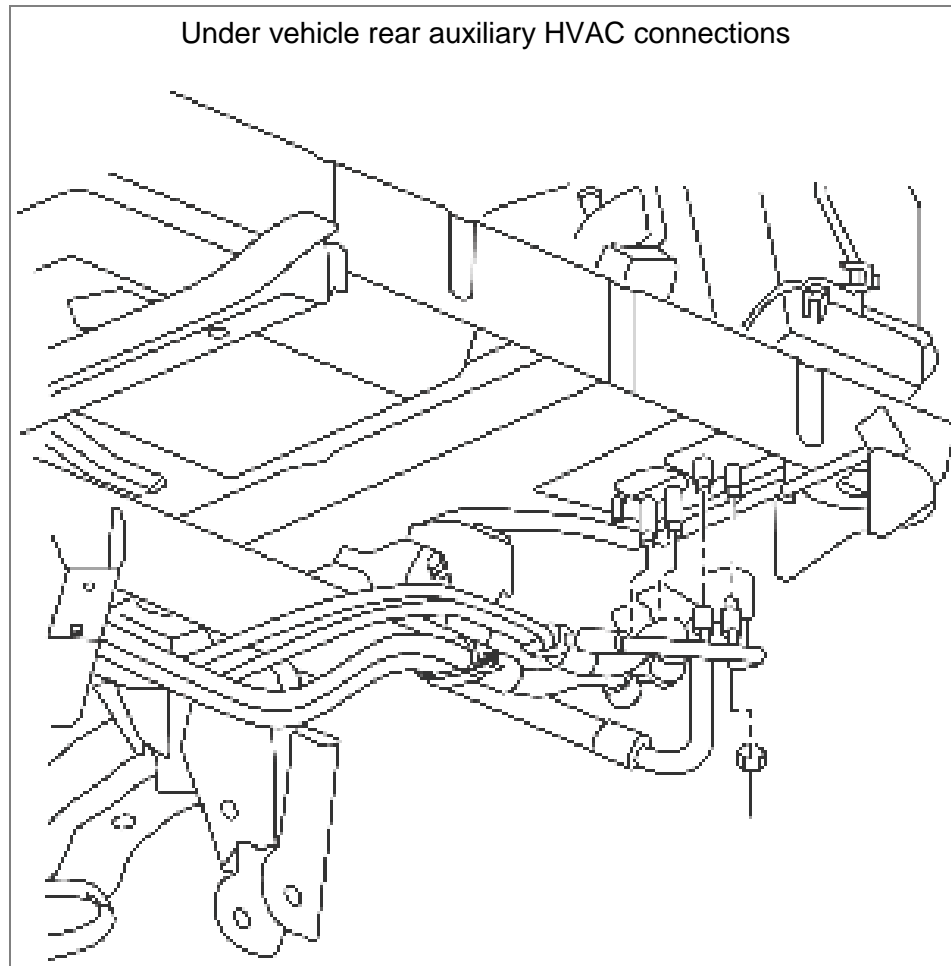
1. If replacing the HVAC module, transfer any necessary components from the old module to the new module.
2. Install the HVAC module into the instrument panel (I/P).
3. Connect the HVAC module connectors.
4. Connect the heater hoses to the heater core.
5. Connect the evaporator tube to the evaporator.
6. Attach the accumulator to the evaporator. Torque the nut to **40 in-lb (4.5 Nm)**.
7. Install the instrument panel carrier to the instrument panel (I/P).
8. Evacuate and recharge the refrigerant in the A/C system.
9. Use a J 39400-A halogen leak detector to leak test the component fittings.

Rear Auxiliary HVAC Module

Removal & Installation

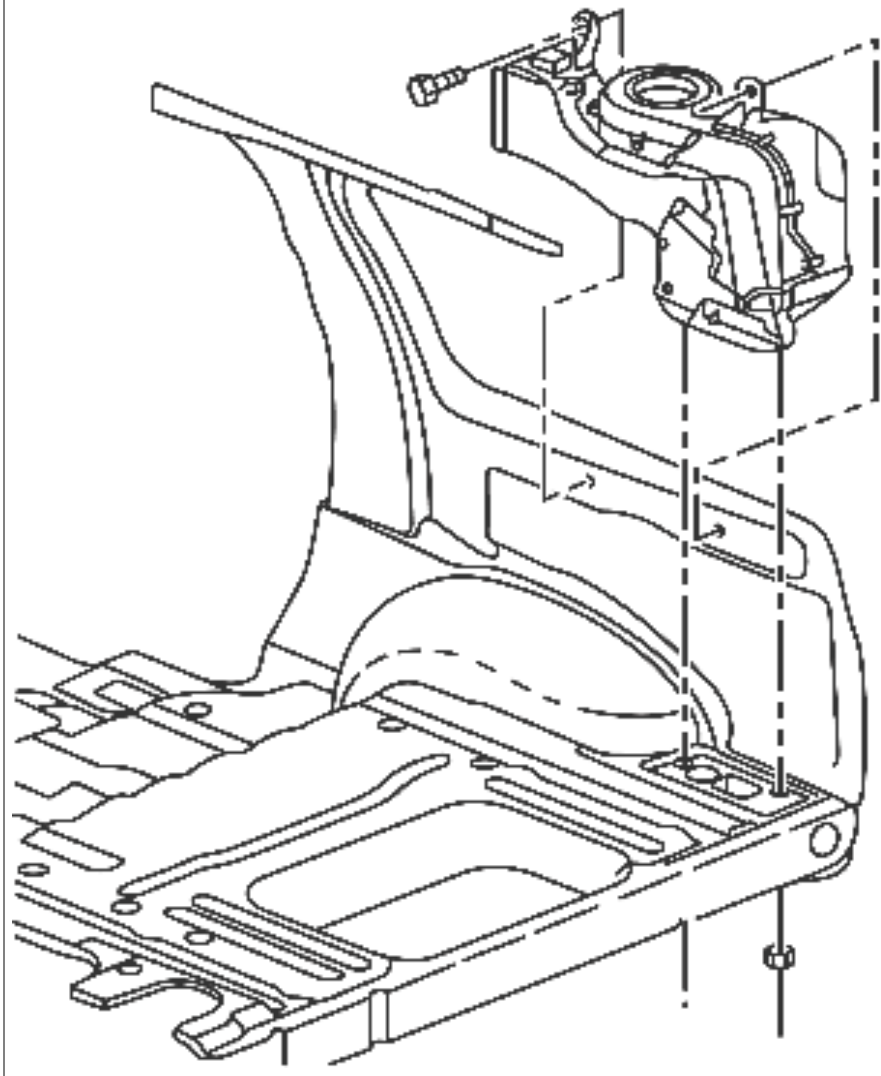
To Remove:

1. Recover the refrigerant from the A/C system.
2. Drain the cooling system.
3. Lift the vehicle.



4. Detach the a/c lines from the rear block fittings under the vehicle.
5. Cap the a/c refrigerant lines.
6. Remove and discard the o-rings from the a/c line block fittings.
7. Remove the heater hoses from the rear auxiliary HVAC module under the vehicle.
8. Lower the vehicle.
9. Remove the right rear quarter trim panel.
10. Disconnect the rear auxiliary HVAC module connectors.
11. Disconnect the rear auxiliary air outlet ducts from the rear auxiliary HVAC module.

Rear auxiliary HVAC module removal and installation



12. Detach the rear auxiliary HVAC module from the right side and floor of the vehicle.
13. Remove and discard the pass through seal from the rear auxiliary HVAC module.

To Install:

1. Install a new pass through seal onto the rear auxiliary HVAC module.
2. Attach the rear auxiliary HVAC module from the right side and floor of the vehicle.
Torque the bolts to **89 in-lb (10 Nm)**.
3. Connect the rear auxiliary air outlet ducts to the rear auxiliary HVAC module.
4. Connect the rear auxiliary HVAC module connectors.
5. Install the right rear quarter trim panel.
6. Lift the vehicle.
7. Install the heater hoses onto the rear auxiliary HVAC module under the vehicle.
8. Uncap the a/c refrigerant lines.
9. Install new o-rings onto the a/c line block fittings.

10. Attach the a/c lines to the rear block fittings under the vehicle. Torque the nuts to **15 ft-lb (20 Nm)**.
11. Lower the vehicle.
12. Refill the cooling system.
13. Evacuate and recharge the refrigerant in the A/C system.
14. Use a J 39400-A halogen leak detector to leak test the component fittings.

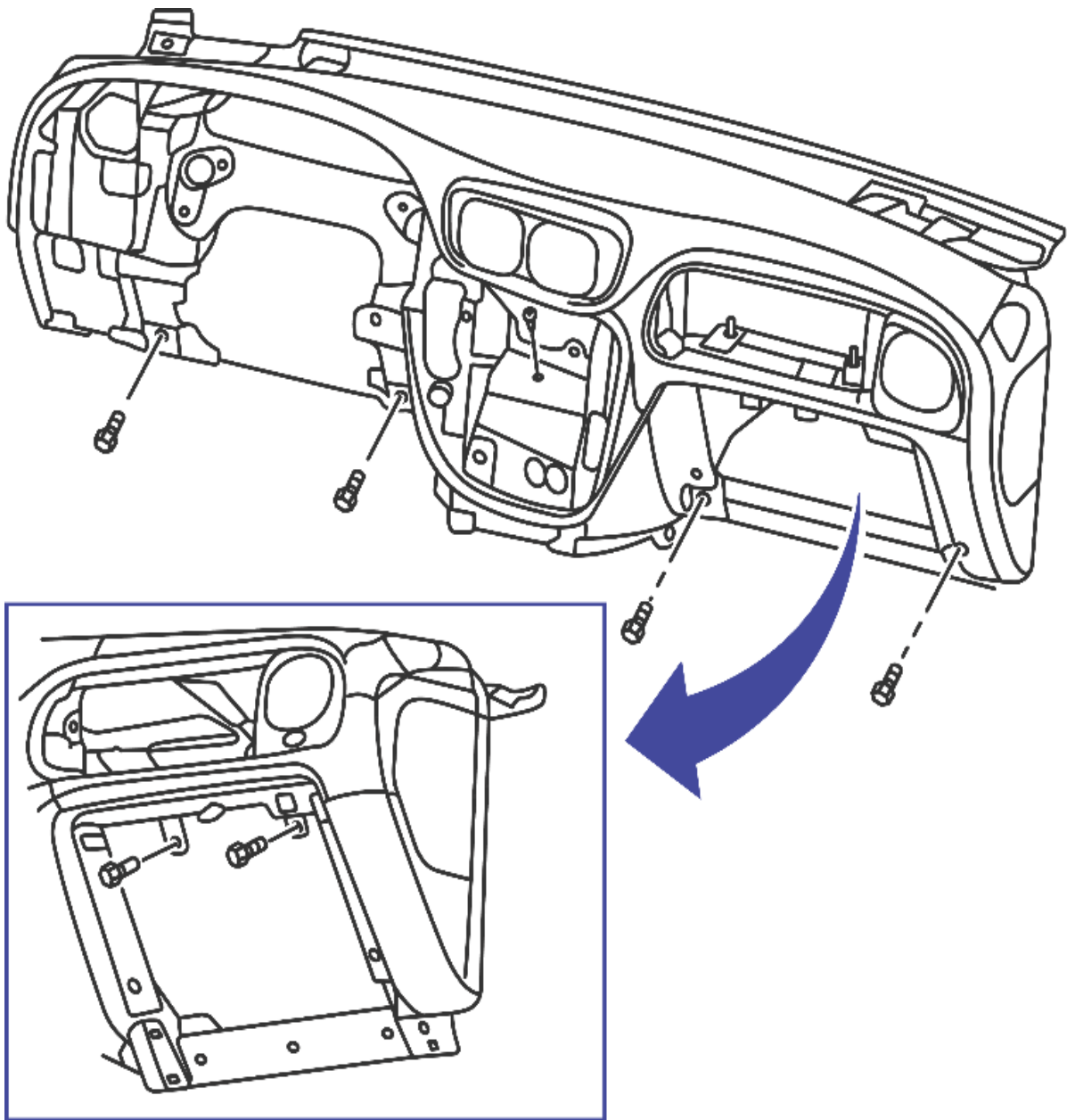
Instrument Panel

Removal & Installation

To Remove:

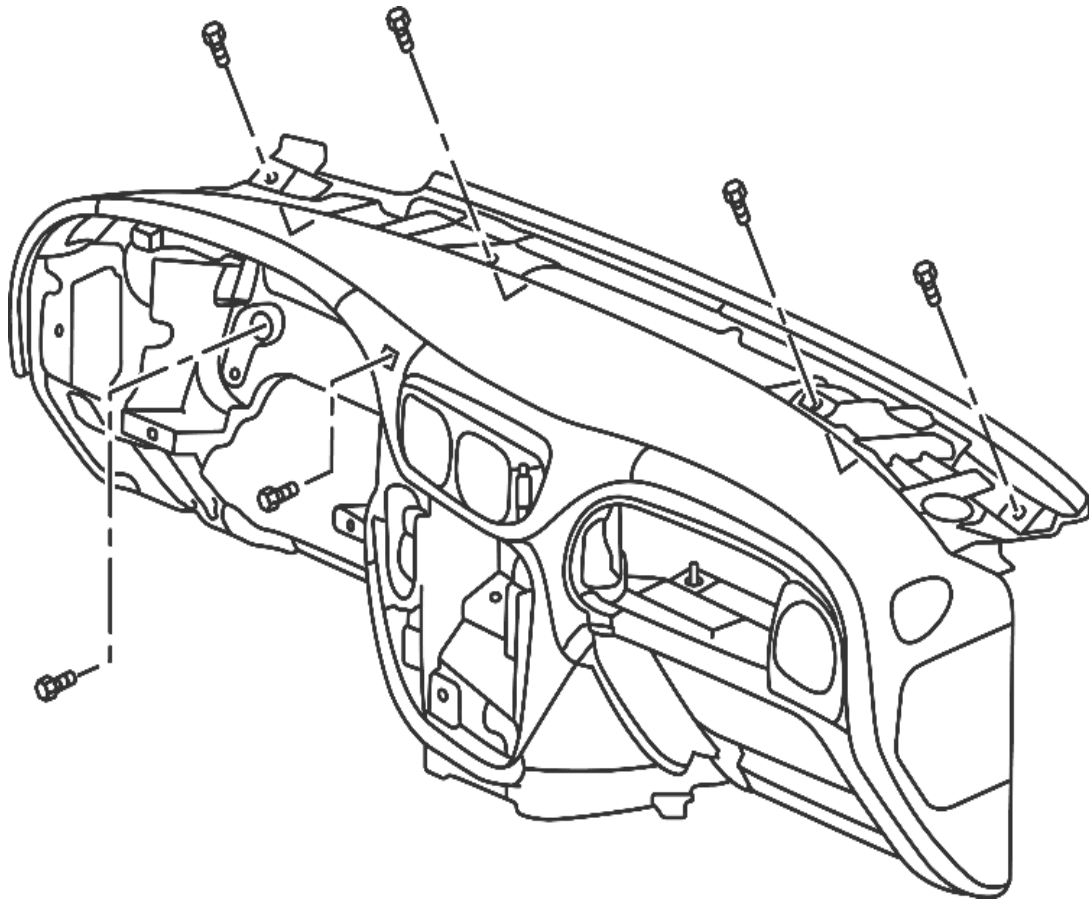
1. Disconnect the negative battery cable to disable the SIR system.
2. Remove the left insulator panel from the instrument panel (I/P).
3. Remove the knee bolster from the instrument panel (I/P).
4. Detach the left HVAC floor duct from the instrument panel (I/P).
5. Remove the steering column from the vehicle.
6. For Oldsmobile vehicles, remove the shift lever bezel from the center console.
7. Remove the center console from the vehicle.
8. For GMC and Chevrolet vehicles, remove the lower sound insulator panel from the instrument panel (I/P).
9. For GMC and Oldsmobile vehicles, remove the accessory trim plate from the instrument panel (I/P).
10. For Chevrolet vehicles, remove the instrument cluster bezel from the instrument panel (I/P).
11. Remove the instrument cluster from the instrument panel (I/P).
12. Remove the right insulator panel from the instrument panel (I/P).
13. Remove the storage compartment door from the instrument panel (I/P).
14. Remove the radio from the instrument panel (I/P).
15. Remove the front HVAC module from the instrument panel (I/P).
16. Remove the HVAC module harness from the instrument panel (I/P) substrate.
17. Remove the left access cover from the instrument panel (I/P).
18. Remove the headlamp switch from the instrument panel (I/P).
19. If replacing the instrument panel (I/P), remove the headlamp bezel from the instrument panel (I/P).
20. Remove the garnish molding from the left and right A-pillars.
21. Remove the upper trim pad from the instrument panel (I/P).
22. Remove the upper front speaker from the instrument panel (I/P).
23. Remove the right access cover from the instrument panel (I/P).
24. Remove the screw from the side window defogger outlet.

Lower instrument panel retaining bolts



25. Remove the lower retaining bolts from the instrument panel (I/P)

Upper instrument panel retaining bolts



1. Remove the middle and upper bolts from the instrument panel (I/P).
2. Release the instrument panel (I/P) from the positioning locators by lifting up on the bottom of the instrument panel (I/P).
3. Remove the instrument panel (I/P) from the vehicle.
4. If replacing the instrument panel (I/P), remove the inflatable restraint instrument panel (I/P) module from the instrument panel (I/P).
5. If replacing the instrument panel (I/P), remove the air distribution duct vents from the instrument panel (I/P).

To Install:

1. If replacing the instrument panel (I/P), install the air distribution duct vents into the instrument panel (I/P).
2. If replacing the instrument panel (I/P), install the inflatable restraint instrument panel (I/P) module into the instrument panel (I/P).
3. Place the instrument panel (I/P) into the vehicle.

NOTE: Make sure that there are no wiring harnesses or connectors pinched behind the instrument panel (I/P).

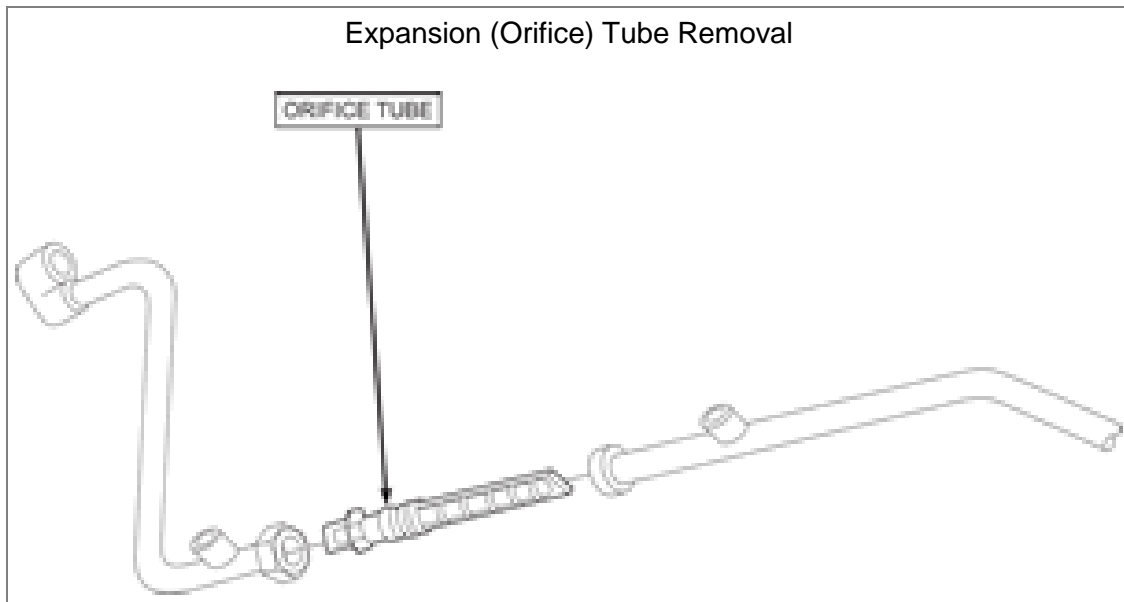
4. Seat the instrument panel (I/P) onto the positioning locators.
5. Install the middle and upper bolts into the instrument panel (I/P).
6. Install the lower retaining bolts into the instrument panel (I/P).
7. After all bolts have been installed, torque the bolts to **62 in-lb (7 Nm)**.
8. Install the screw into the side window defogger outlet.
9. Install the right access cover onto the instrument panel (I/P).
10. Install the upper front speaker into the instrument panel (I/P).
11. Install the upper trim pad onto the instrument panel (I/P).
12. Install the garnish molding onto the left and right A-pillars.
13. If replacing the instrument panel (I/P), install the headlamp bezel into the instrument panel (I/P).
14. Install the headlamp switch into the instrument panel (I/P).
15. Install the left access cover onto the instrument panel (I/P).
16. Install the HVAC module harness into the instrument panel (I/P) substrate.
17. Install the front HVAC module into the instrument panel (I/P).
18. Install the radio into the instrument panel (I/P).
19. Install the instrument cluster into the instrument panel (I/P).
20. For Chevrolet vehicles, install the instrument cluster bezel into the instrument panel (I/P).
21. For GMC and Oldsmobile vehicles, install the accessory trim plate onto the instrument panel (I/P).
22. For GMC and Chevrolet vehicles, install the lower sound insulator panel onto the instrument panel (I/P).
23. Install the center console into the vehicle.
24. For Oldsmobile vehicles, install the shift lever bezel from the center console.
25. Install the storage compartment door onto the instrument panel (I/P).
26. Install the right insulator panel onto the instrument panel (I/P).
27. Install the steering column into the vehicle.
28. Attach the left HVAC floor duct to the instrument panel (I/P).
29. Install the knee bolster onto the instrument panel (I/P).
30. Install the left insulator panel onto the instrument panel (I/P).
31. Connect the negative battery cable to enable the SIR system.

Expansion (Orifice Tube)

Removal & Installation

To Remove:

1. Recover the refrigerant from the A/C system.
2. Remove the accumulator from the vehicle.
3. Remove the coolant reservoir from the vehicle.
4. Detach the evaporator tube from the evaporator.
5. Remove and discard the o-ring from the evaporator.
6. Detach the evaporator tubes from the block fittings.



7. Use a J 26549-E to remove the expansion tube from the evaporator tube.

To Install:

1. Use a J 26549-E to install the expansion tube into the evaporator tube, install the shorter screen end first.
2. Install a new o-ring onto the evaporator.
3. Attach the evaporator tubes to the block fittings. Torque the nut to **21 ft-lb (28 Nm)**.
4. Attach the evaporator tube to the evaporator. Torque the nut to **21 ft-lb (28 Nm)**.
5. Install the coolant reservoir into the vehicle.
6. Install the accumulator into the vehicle.
7. Evacuate and recharge the refrigerant in the A/C system.
8. Use a J 39400-A halogen leak detector to leak test the component fittings.

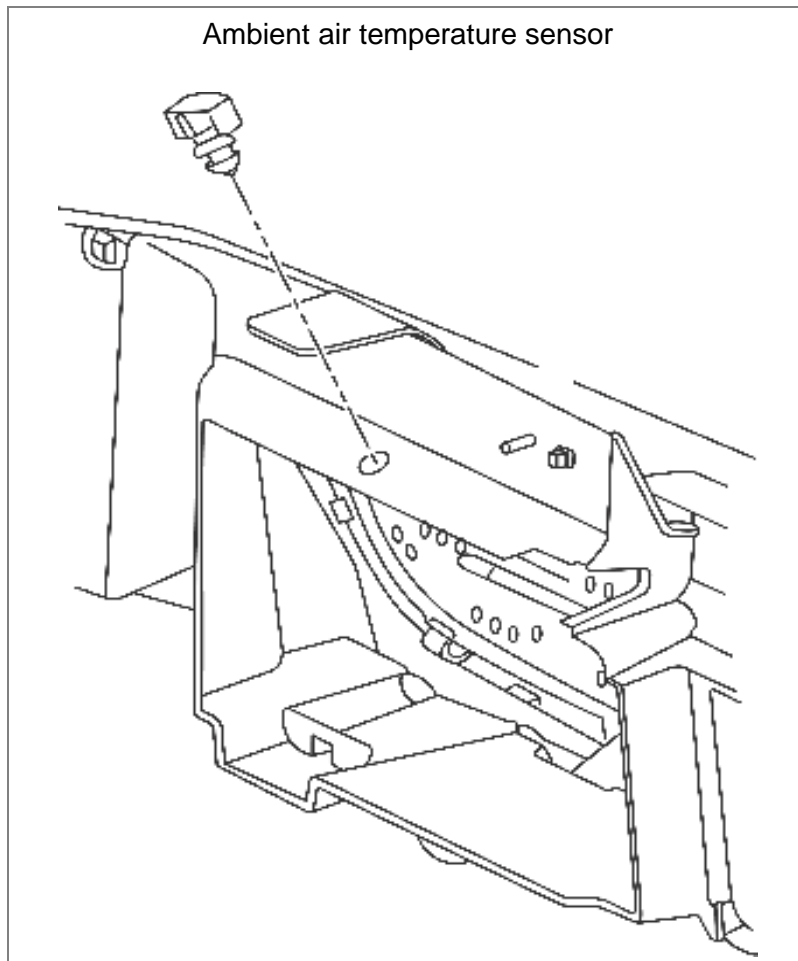
9. Sensors, Switches & Valves

WARNING

To avoid personal injury and/or vehicle damage, refer to the service precautions at the beginning of this section.

Ambient Air Temperature Sensor*Removal & Installation***To Remove:**

1. Remove the grille from the vehicle.



2. Remove the ambient air temperature sensor from the panel assembly.
3. Disconnect the ambient air temperature sensor connector.

To Install:

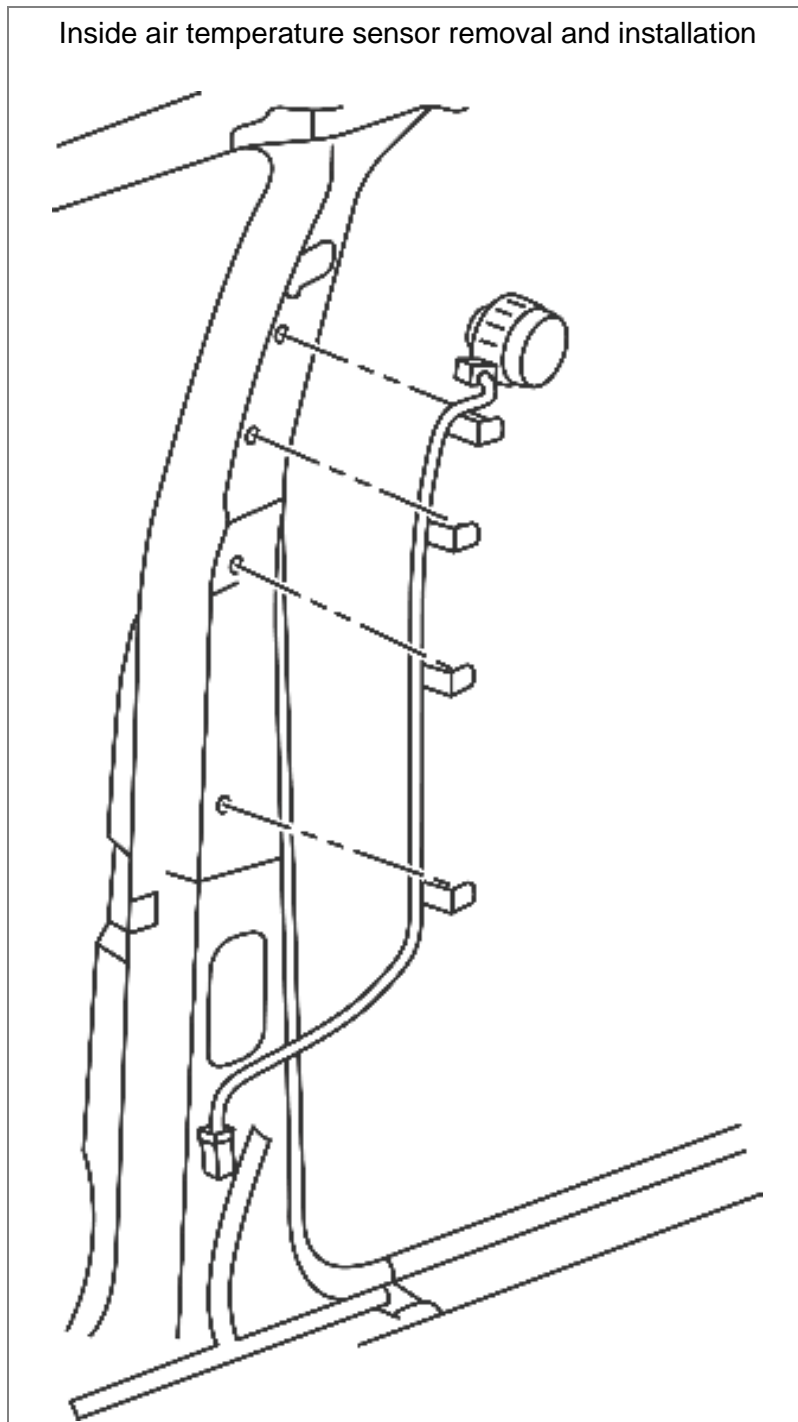
1. Connect the ambient air temperature sensor connector.
2. Install the ambient air temperature sensor onto the panel assembly.
3. Install the grille onto the vehicle.

Inside Air Temperature Sensor

Removal & Installation

To Remove:

1. Remove the trim panel from the upper portion of the left B-pillar.



2. Disconnect the inside air temperature sensor connector.
3. Detach the inside air temperature sensor assembly from the B-pillar.

To Install:

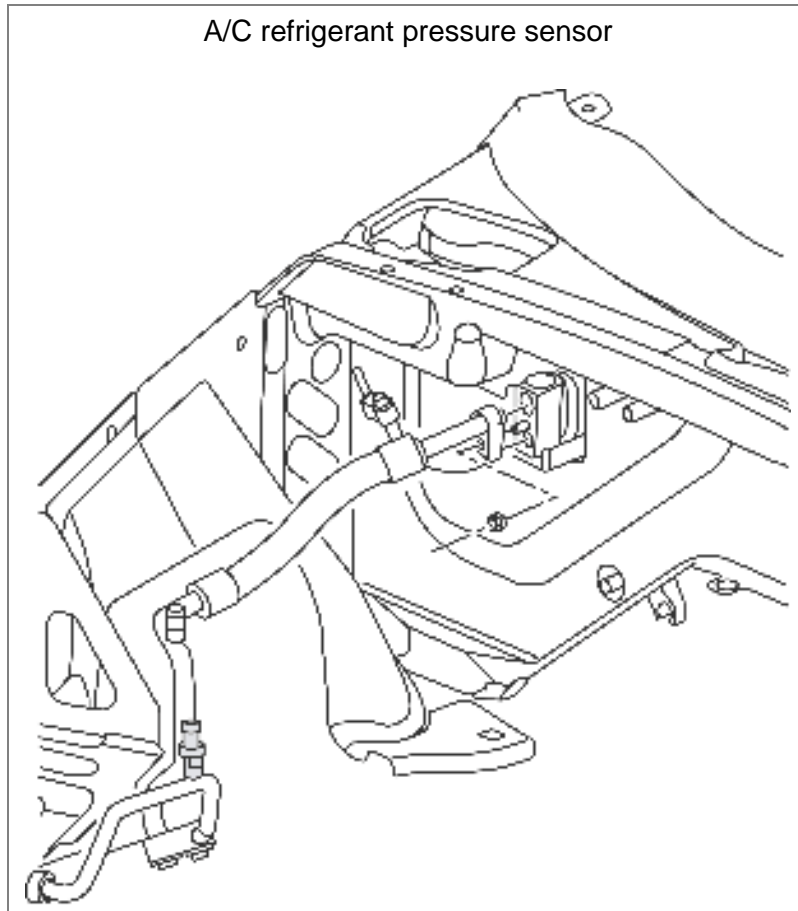
1. Connect the inside air temperature sensor connector.
2. Attach the inside air temperature sensor assembly to the B-pillar.
3. Install the trim panel onto the upper portion of the left B-pillar.

A/C Refrigerant Pressure Sensor

Removal & Installation

To Remove:

1. Lift the vehicle.



2. Disconnect the a/c refrigerant pressure sensor connector.
3. Remove the a/c refrigerant pressure sensor from the compressor hose block.
4. Remove and discard the o-ring from the a/c refrigerant pressure sensor.

To Install:

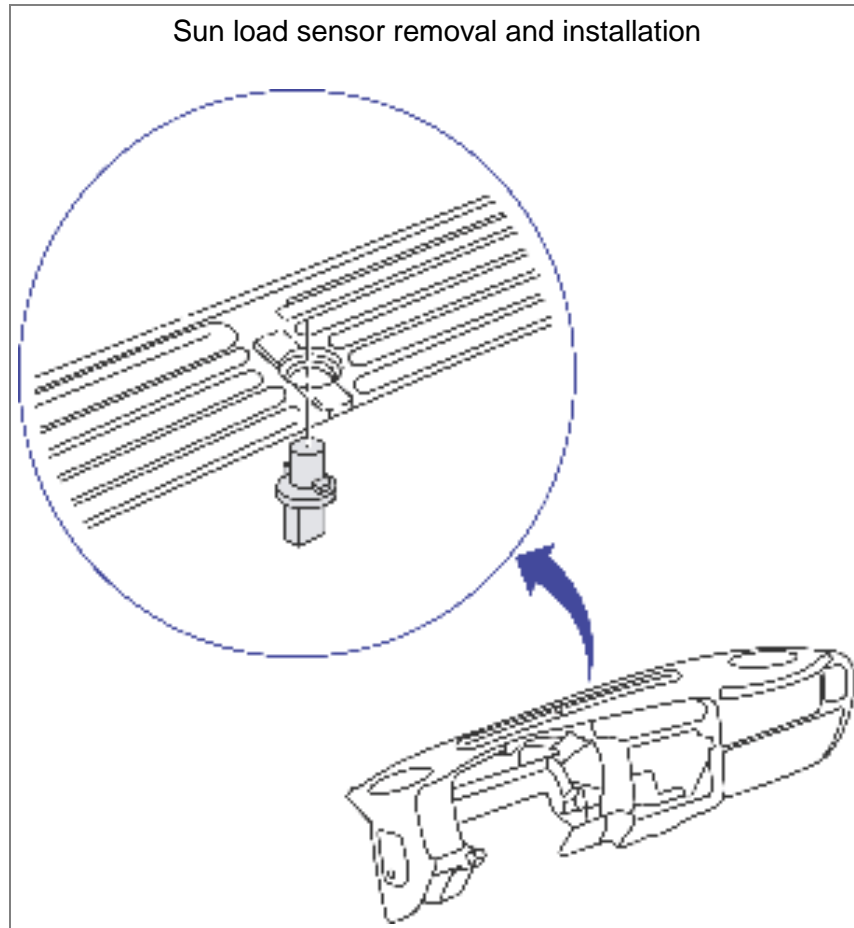
1. Install a new o-ring onto the a/c refrigerant pressure sensor.
2. Install the a/c refrigerant pressure sensor into the compressor hose block. Torque the sensor to **42 in-lb (4.8 Nm)**.
3. Connect the a/c refrigerant pressure sensor connector.
4. Use a J 39400-A halogen leak detector to leak test the component fittings.

Sun Load Sensor

Removal & Installation

To Remove:

1. Remove the upper trim pad from the instrument panel (I/P).



2. Turn the sun load sensor counterclockwise and remove it from the upper trim pad.
3. Disconnect the sun load sensor connector.

To Install:

1. Connect the sun load sensor connector.
2. Install the sun load sensor into the upper trim pad and turn it clockwise.
3. Install the upper trim pad onto the instrument panel (I/P).

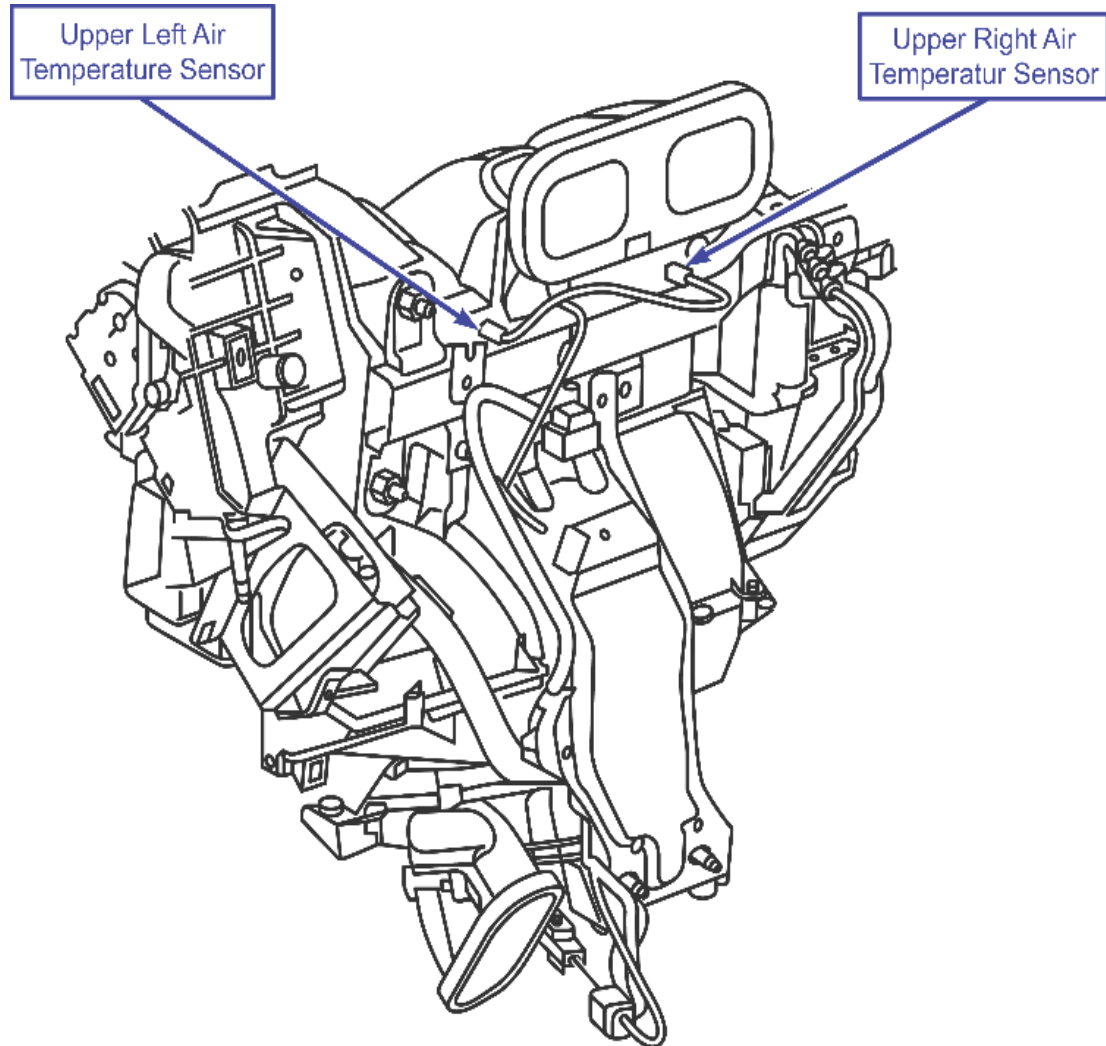
Upper Left Air Temperature Sensor

Removal & Installation

To Remove:

1. Remove the radio and HVAC control module from the instrument panel (I/P).

Upper air temperature sensors



1. Remove the upper left air temperature sensor from the upper air duct.
2. Disconnect the upper left air temperature sensor connector.

To Install:

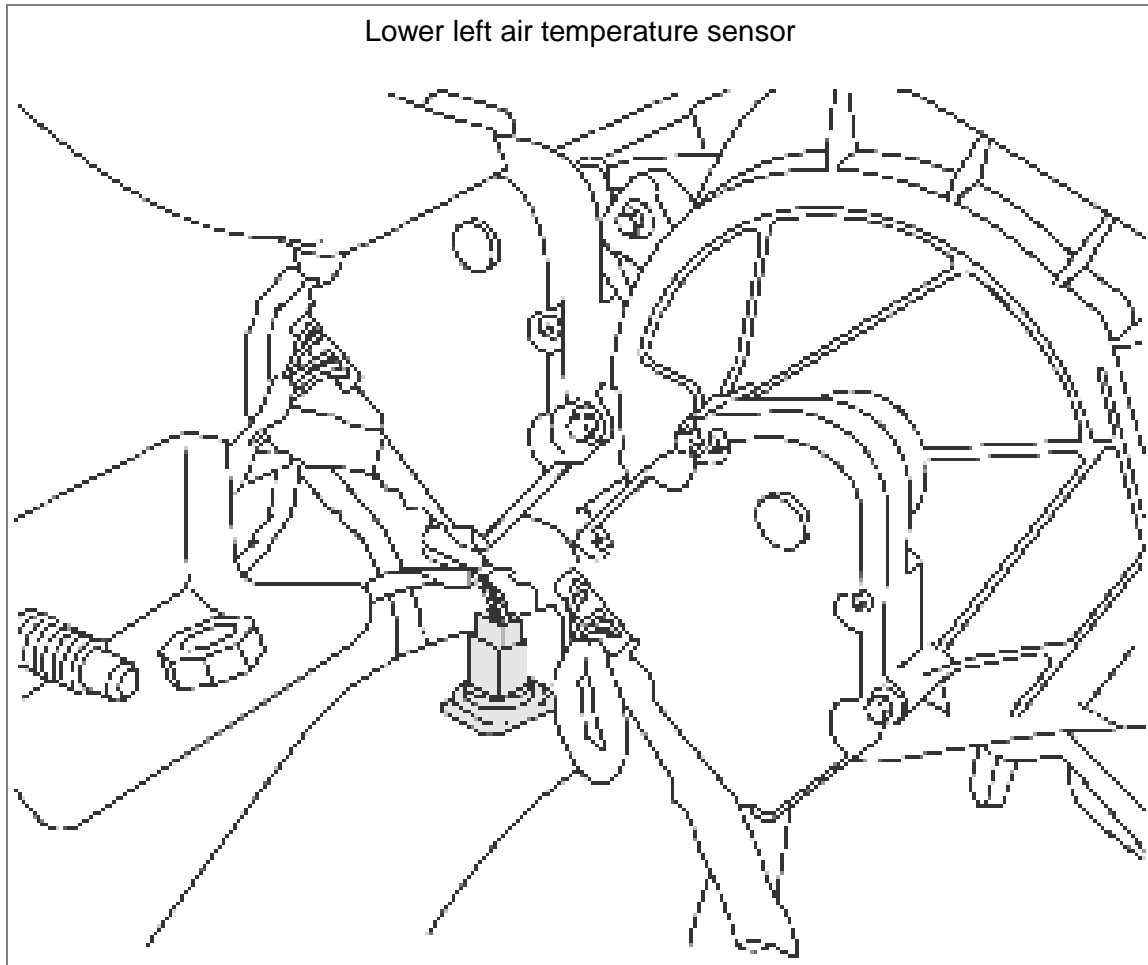
1. Connect the upper left air temperature sensor connector.
2. Install the upper left air temperature sensor into the upper air duct.
3. Install the radio and HVAC control module into the instrument panel (I/P).

Lower Left Air Temperature Sensor

Removal & Installation

To Remove:

1. Remove the instrument panel from the vehicle.



2. Disconnect the lower left air temperature sensor connector.
3. Remove the lower left air temperature sensor from the lower left air duct.

To Install:

1. Install the lower left air temperature sensor into the lower left air duct.
2. Connect the lower left air temperature sensor connector.
3. Install the instrument panel into the vehicle.

Upper Right Air Temperature Sensor

Removal & Installation

To Remove:

1. Remove the radio from the instrument panel (I/P).
2. Disconnect the upper right air temperature sensor connector.
3. Remove the upper right air temperature sensor from the upper air duct.

To Install:

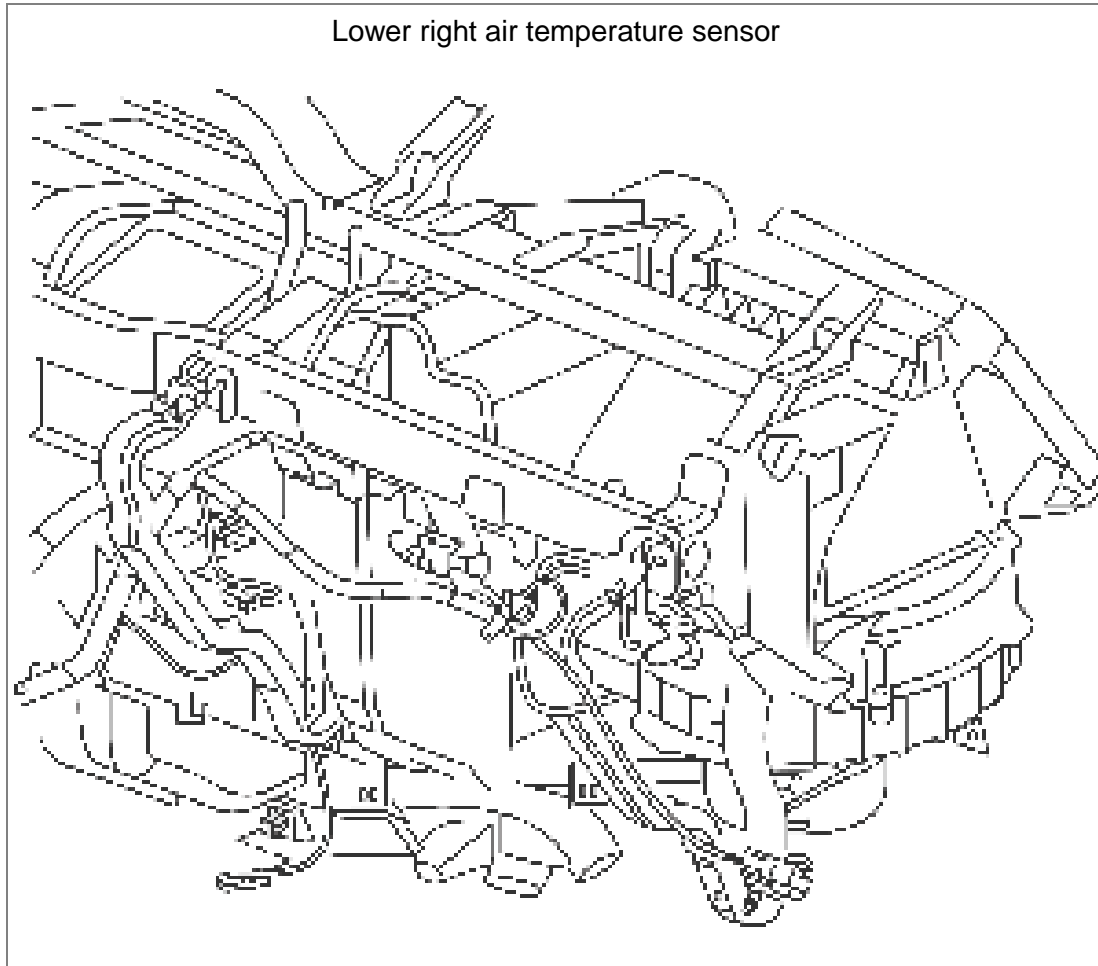
1. Install the upper right air temperature sensor into the upper air duct.
2. Connect the upper right air temperature sensor connector.
3. Install the radio and HVAC control module into the instrument panel (I/P).

Lower Right Air Temperature Sensor

Removal & Installation

To Remove:

1. Remove the right insulator panel from the instrument panel (I/P).
2. Remove the lower insulator panel from the lower right air duct.
3. Disconnect the lower right air temperature sensor connector.



4. Remove the lower right air temperature sensor connector from the instrument panel (I/P).

To Install:

1. Install the lower right air temperature sensor connector into the lower right air duct.
2. Connect the lower right air temperature sensor connector.
3. Install the lower insulator panel onto the instrument panel (I/P).
4. Install the right insulator panel onto the instrument panel (I/P).

A/C Low Pressure Switch

Removal & Installation

To Remove:

1. Disconnect the a/c low pressure switch connector.
2. Remove the a/c low pressure switch from the accumulator.
3. Remove and discard the o-ring from the accumulator.

To Install:

1. Install a new o-ring onto the accumulator.
2. Install the a/c low pressure switch onto the accumulator. Torque the switch to **42 in-lb (4.8 Nm)**.
3. Connect the a/c low pressure switch connector.

A/C Specifications

Air Conditioning Specifications				
Description		In-Lbs	Ft-Lbs	Nm
Refrigerant Type	R-134a			
Refrigerant Capacity:	1.9 lb (0.86 kg)			
System Oil Type	PAG Refrigerant Oil			
System Oil Capacity	—			
Accumulator	2 oz (60 ml)*			
Compressor	2 oz (60 ml)**			
Condenser	1 oz (30 ml)**			
Evaporator	3 oz (90 ml)**			
Total system capacity	8 oz (240 ml)			
Torque Specifications:	—			
A/C compressor cycling switch		44	—	5
A/C compressor mounting bolts		—	37	50
A/C compressor rear bracket bolts		18	—	25
A/C evaporator and blower module shield screws		19	—	2.2
A/C refrigerant pressure sensor		42	—	4.8
Accumulator clamp screw		88	—	10
Accumulator to evaporator fitting		—	21	28
Air distributor duct mounting screw		17	—	1.9
Air inlet assembly mounting stud		40	—	4.5
Air outlet assembly retaining screw		22	—	2.5
Air temperature actuator retaining screw		17	—	1.9
Blower assembly mounting nut (C42)		40	—	4.5
Blower assembly mounting screw (C42)		40	—	4.5
Blower assembly mounting stud (C42)		40	—	4.5
Blower motor access cover screw (C60/C68)		22	—	2.5
Blower motor and fan assembly mounting screw		17	—	1.9
Blower motor relay bracket mounting screw		17	—	1.9
Blower motor resistor mounting screw		17	—	1.9
Body harness connector support bracket mounting nuts		80	—	9
Compressor discharge hose to condenser fitting		—	21	28
Compressor pressure relief valve		80	—	9
Compressor suction and discharge hose to compressor bolt		—	24	33
Compressor suction hose to accumulator fitting		—	35	48
Compressor insulator retaining screw		17	—	1.9
Evaporator case section to blower case section retaining screw		17	—	1.9
Evaporator tube clip screw		17	—	1.9
Evaporator tube to condenser fitting		—	21	28
Floor air outlet mounting screw		17	—	1.9
Heater core access cover screw		17	—	1.9
Heater inlet and outlet hoses bracket bolt		—	18	25
Heater inlet hose fitting at intake manifold		—	17	23.5
Heater outlet hose bracket bolt		—	18	25
Heater/vent module mounting nut		40	—	4.5
Heater/vent module mounting screw		40	—	4.5
Heater/vent module mounting stud		40	—	4.5
Intermediate bracket bolts		88	—	10
Knee bolster bracket nuts		49	—	5.5
* Add PAG oil equal to the amount drained from the old component plus the specified additional amount.				
**If more oil than the specified amount was drained from the component, refill with the amount drained.				

