

ENGINE ELECTRICAL

Introduction

The engine electrical can be broken down into three distinct subsystems:

1. **The starting system**
2. **The charging system**
3. **The ignition system**

Battery and Starting System

The battery is the first link in the chain of mechanisms which work together to provide cranking of the engine. In most modern cars, the battery is a lead-acid electrochemical device consisting of six 2 volt (2V) subsections connected in series so the unit is capable of producing approximately 12V of electrical current. Each subsection, or cell, 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 causes a chemical reaction to be set up, and it is this reaction which produces current flow from the battery when its positive and negative terminals are connected to an electrical appliance such as a lamp or motor. The continued transfer of electrons would eventually convert the sulfuric acid in the electrolyte to water and make the two plates identical in chemical composition. As electrical energy is removed from the battery, its voltage output tends to drop. Thus, measuring battery voltage and battery electrolyte composition are two ways of checking the ability of the unit to supply power. During engine starting, electrical energy is removed from the battery. However, if the charging circuit is in good condition and the operating conditions are normal, the power removed from the battery will soon be replaced by the alternator which will force electrons back through the battery, reversing the normal flow, and restoring the battery to its original chemical state.

The battery and starting motor are linked by very heavy electrical cables designed to minimize resistance to the flow of current. Generally, the major power supply cable that leaves the battery goes directly to the starter, while other electrical system needs are supplied by a smaller cable. During starter operation, power flows from the battery to the starter and is grounded through the car's frame and the battery's negative ground strap.

The starting motor is a specially designed, direct current electric motor capable of producing a large amount of power for its size. One thing that allows the motor to produce a great deal of power is its tremendous rotating speed. It drives the engine through a tiny pinion gear (attached to the starter's armature), which drives the very large flywheel ring gear at a greatly reduced speed. Another factor allowing it to produce so much power is that only intermittent operation is required of it. Thus, little allowance for air circulation is required, and the windings can be built into a very small space.

The starter solenoid is a magnetic device which employs the small current

supplied by the starting switch circuit of the ignition switch. This magnetic action moves a plunger which mechanically engages the starter and electrically closes the heavy switch which connects it to the battery. The starting switch circuit commonly consists of the starting switch contained within the ignition switch, a transmission neutral or clutch safety switch and the wiring necessary to connect these with the starter solenoid or relay.

A pinion, which is a small gear, is mounted to a one-way drive clutch. This clutch is splined to the starter armature shaft. When the ignition switch is moved to the start position, the solenoid plunger slides the pinion toward the flywheel ring gear via a collar and spring. If the teeth butt one another, the spring will be compressed and will force the gears to mesh as soon as the starter turns far enough to allow them to do so. As the solenoid plunger reaches the end of its travel, it closes the contacts that connect the battery and starter, then the engine is cranked.

As soon as the engine starts, the flywheel ring gear begins turning fast enough to drive the pinion at an extremely high rate of speed. At this point, the one-way clutch begins allowing the pinion to spin faster than the starter shaft so that the starter will not operate at excessive speed. When the ignition switch is released from the starter position, the solenoid is de-energized, and a spring contained within the solenoid assembly pulls the gear out of mesh and interrupts the current flow to the starter.

Many late model starters employ a separate relay, mounted away from the starter, to switch the motor and solenoid current on and off. The relay thus replaces the solenoid electrical switch, but does not eliminate the need for a solenoid mounted on the starter used to mechanically engage the starter drive gears. The relay is used to mechanically engage the starter drive gears. The relay is used to reduce the amount of current the starting switch must carry.

Charging System

The automobile charging system provides electrical power for operation of the vehicle's ignition system, starting system and all of the electrical accessories. The battery serves as an electrical surge or storage tank, storing (in chemical form) the energy originally produced by the belt driven alternator. The system also provides a means of regulating alternator output to protect the battery from being overcharged and to avoid excessive voltage to the accessories.

The storage battery is a chemical device incorporating parallel lead plates in a tank containing a sulfuric acid/water solution. Adjacent plates are slightly dissimilar, and the chemical reaction of the two dissimilar plates produces electrical energy when the battery is connected to a load such as the starter motor. The chemical reaction is reversible, so that when the alternator is producing a voltage greater than that produced by the battery, electricity is forced into the battery, and the battery is returned to its fully charged state.

The vehicle's alternator is driven mechanically, through a belt, by the engine crankshaft. The alternator consists of two coils of fine wire, one stationary (the stator), and one movable (the rotor). The rotor may also be known as the armature, and consists of fine wire wrapped around an iron core mounted on a shaft. The electricity which flows through the two coils of wire (provided initially by the battery) creates an intense magnetic field around both rotor and stator, and the interaction between the two fields creates voltage, allowing the alternator to power the accessories and charge the battery.

All vehicles covered in this manual are equipped with an alternating current generator or alternator. Such units are more efficient than the generators used in older vehicles, can be rotated at higher speeds, and have fewer brush problems. In an alternator, the field rotates while all the current produced passes only through the stator windings. The brushes bear against continuous slip rings rather than a commutator. This prevents the current from traveling in the wrong direction. A series of diodes is wired together to permit the alternating flow of the stator to be converted to a pulsating, but unidirectional, flow at the alternator output. The alternator's field is wired in series with the voltage regulator.

The regulator consists of several circuits. Each circuit has a core, or magnetic coil of wire, which operates a switch. Each switch is connected to ground through one or more resistors. The coil of wire responds directly to system voltage. When the voltage reaches the required level, the magnetic field created by the winding of the wire closes the switch and inserts a resistance into the generator field circuit, thus reducing the output. The contacts of the switch cycle open and close many times each second to precisely control voltage. Alternators are self-limiting as far as maximum current is concerned.

Ignition System

There are two different types of ignition systems found on these vehicles. Most of the vehicles utilize a Distributor Ignition (DI) system which incorporates a conventional distributor. The SHO and the 3.0L Flexible Fuel (FF) vehicles utilize a distributorless ignition system known as Electronic Ignition (EI).

For more information, testing and removal/replacement procedures regarding the ignition systems, please refer to *Section 2* of this manual.

Safety Precautions

Observing these precautions will help avoid damage to the vehicle's electrical system and ensure safe handling of the system components:

- **Be absolutely sure of the polarity of a booster battery before making connections. Connect the cables positive-to-positive, and negative-to-a good ground. Connect positive cables first and then make the last connection to an engine ground on the vehicle with the dead battery so that arcing cannot ignite hydrogen gas that may have accumulated near the battery. Even momentary connection of a booster battery with the polarity reversed will damage alternator diodes.**
- **Disconnect both vehicle battery cables before attempting to charge a battery.**
- **NEVER ground the alternator output or battery terminal. Be cautious when using metal tools around a battery to avoid creating a short circuit between the terminals.**
- **NEVER run an alternator without load unless the field circuit is disconnected.**
- **NEVER attempt to polarize an alternator.**

Alternator

ALTERNATOR PRECAUTIONS

To prevent damage to the on-board computer, alternator and regulator, the following precautionary measures must be taken when working with the electrical

system.

- If the battery is removed for any reason, make sure it is reconnected with the correct polarity. Reversing the battery connections may result in damage to the one-way rectifiers. Always check the battery polarity visually. This should be done before any connections are made to be sure that all of the connections correspond to the battery ground polarity.
- When utilizing a booster battery as a starting aid, always connect the positive to positive terminals and the negative terminal from the booster battery to a good engine ground on the vehicle being started.
- NEVER use a fast charger as a booster to start vehicles.
- Disconnect the battery cables when charging the battery with a fast charger; the charger has a tendency to force current through the diodes in the opposite direction for which they were designed. This burns out the diodes.
- NEVER attempt to polarize the alternator.
- Do NOT use test lights of more than 12 volts when checking diode continuity.
- Do NOT short across or ground any of the alternator terminals.
- The polarity of the battery, alternator and regulator must be matched and considered before making any electrical connections within the system.
- NEVER separate the alternator on an open circuit. Make sure all connections within the circuit are clean and tight.
- Disconnect the battery ground terminal when performing any service on electrical components.
- Disconnect the battery if arc welding is to be done on the vehicle.

REMOVAL & INSTALLATION

The different engine applications that the Ford Taurus and Mercury Sable are equipped with utilize different types of alternators. The following is a list of vehicle applications.

For 1986-90 vehicles:

- The 3.0L and the 3.8L engines utilize a side terminal alternator.
- The 2.5L and the 3.8L (with Police Package only) engines utilize an alternator with an integral rear mount regulator and an internal fan.
- The 3.0L SHO engines utilize an alternator with an internal fan and regulator.

For 1991-93 vehicles:

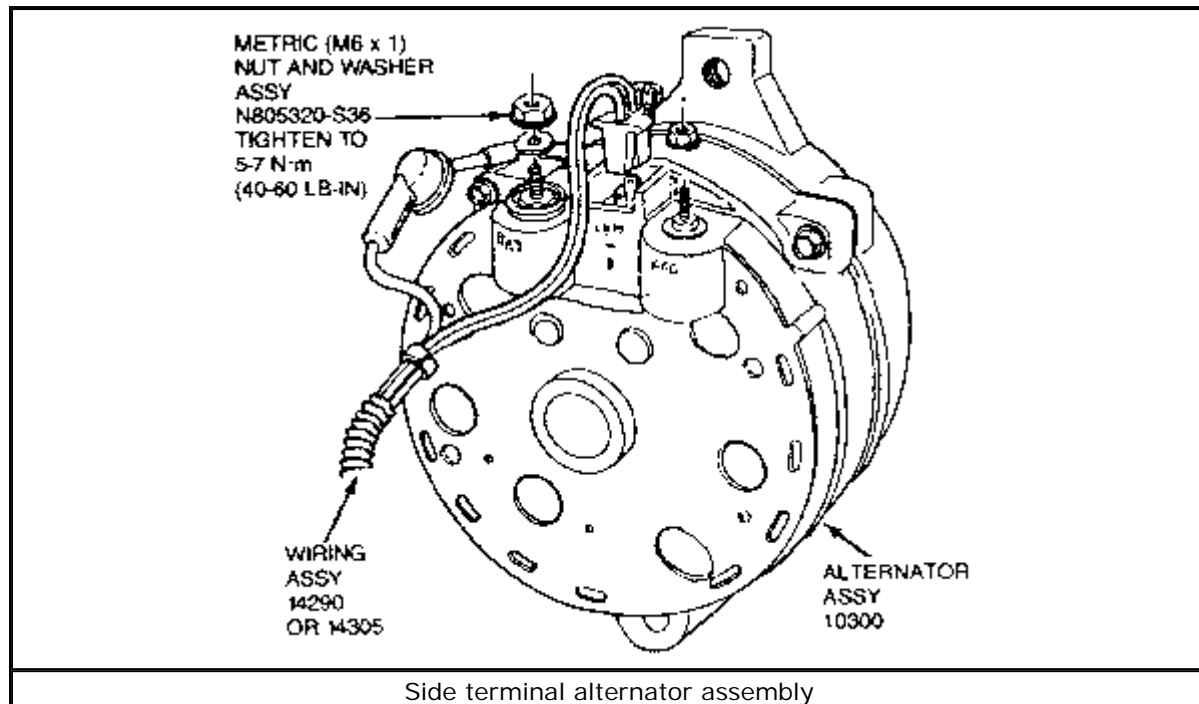
- The 2.5L, 3.0L and 3.8L engines utilize an alternator with a rear mount regulator and an internal fan.
- The 3.0L and 3.2L SHO engines utilize an alternator with an internal regulator and fan.

For 1994-95 vehicles:

- The 3.0L, 3.8L and 3.0L SHO engines utilize an alternator with a rear mount regulator and an internal fan.
- The 3.2L SHO vehicles utilize an alternator with a internal regulator and fan.

Side Terminal Alternator

1. Disconnect the negative battery cable.
2. Loosen the alternator pivot bolt, then remove the adjusting bolt.
3. Remove the alternator drive belt from the drive pulley.
4. Tag and disengage the wiring terminals from the back of the alternator. The stator and the field wiring are the push-on type of retainer. After depressing the lock tab, the connector should be pulled straight off of the terminal to prevent damage.
5. Remove the alternator pivot bolt, then remove the alternator from the engine.



[Click to enlarge](#)

To install:

6. Position the alternator on the engine.
7. Install the alternator pivot bolt and the adjusting bolt, but do NOT tighten the bolts until the drive belt is tensioned.
8. Engage the wiring terminals to the alternator, as tagged during removal.
9. Install the drive belt over the alternator drive pulley, then adjust the belt tension using Belt Tension Gauge 021-00019, or equivalent.

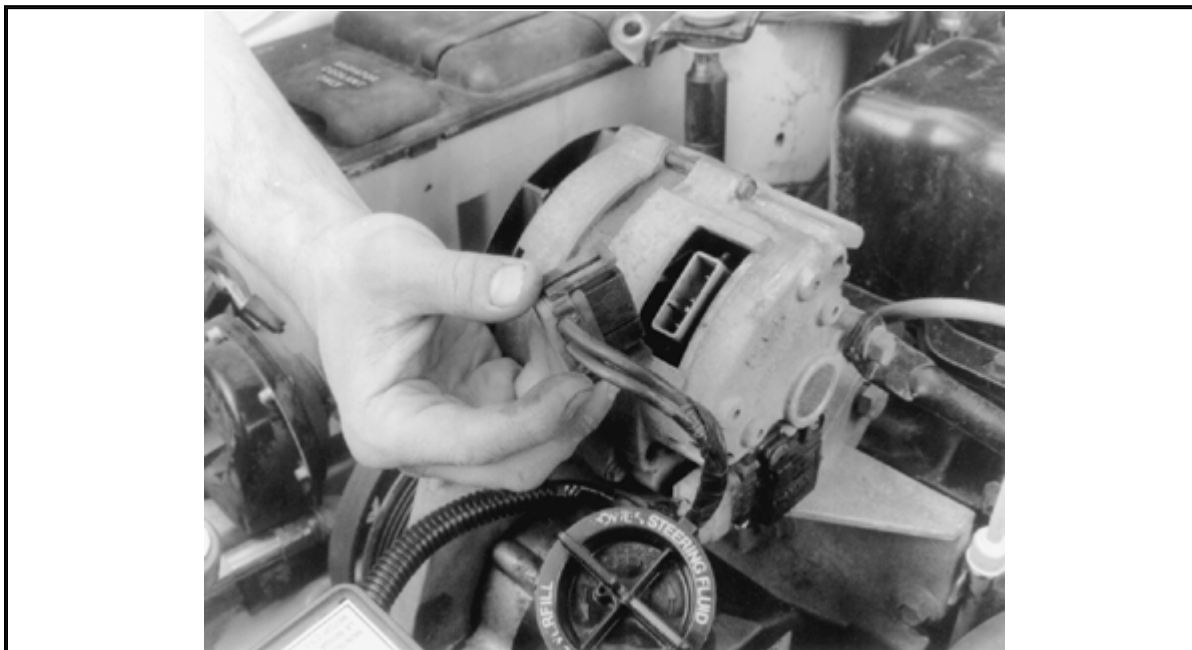
When adjusting belt tension, apply pressure on the fronthousing only.

10. Tighten the adjusting bolt to 30-45 ft. lbs. (41-61 Nm), then tighten the pivot bolt to 50-70 ft. lbs. (68-94 Nm).
11. Connect the negative battery cable.

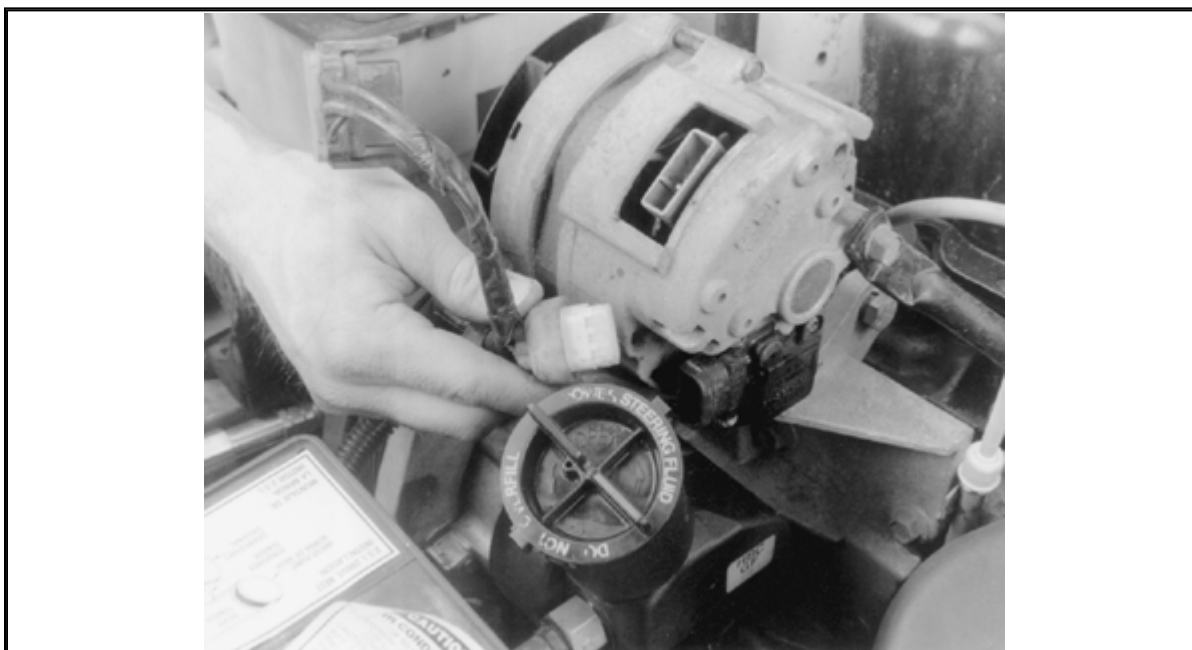
Rear Mount Regulator With Internal Fan

EXCEPT 3.0L SHO ENGINE

1. **Disconnect the negative battery cable.**
2. **Disengage the wiring harness electrical connectors from the alternator and the regulator.**



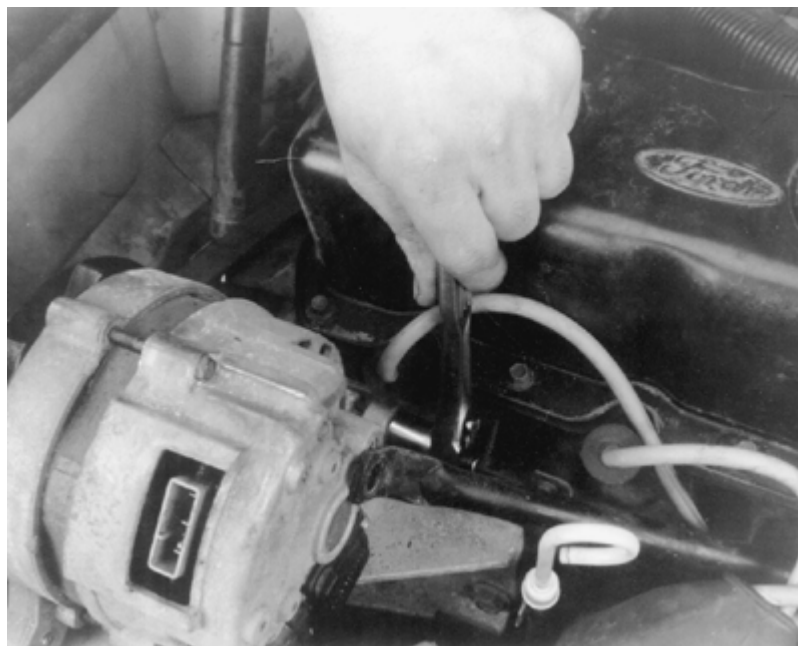
Disengage the wiring harness from the alternator-early model 2.5L shown



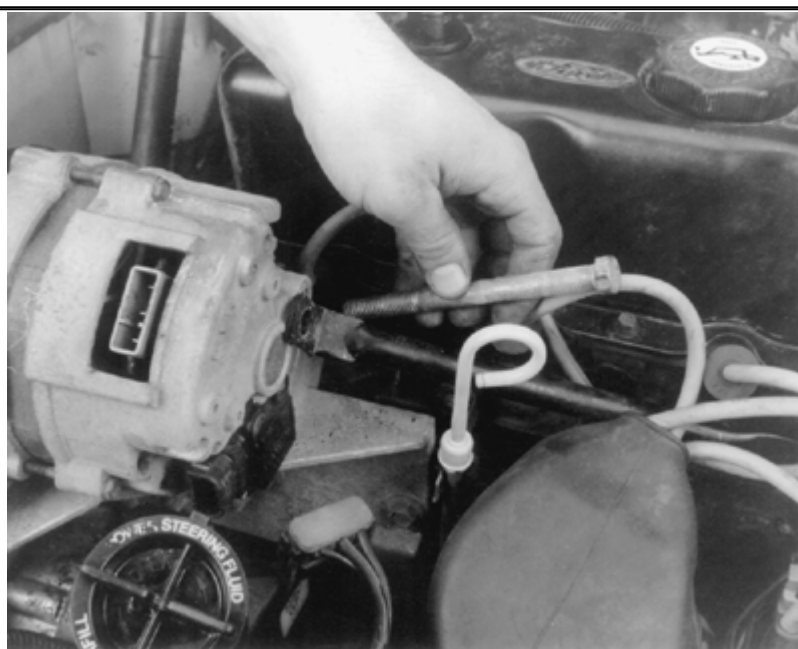
Disengage the wiring harness from the voltage regulator-early model 2.5L shown

3. **Loosen the pivot bolt, then remove the mounting brace bolt from the alternator.**



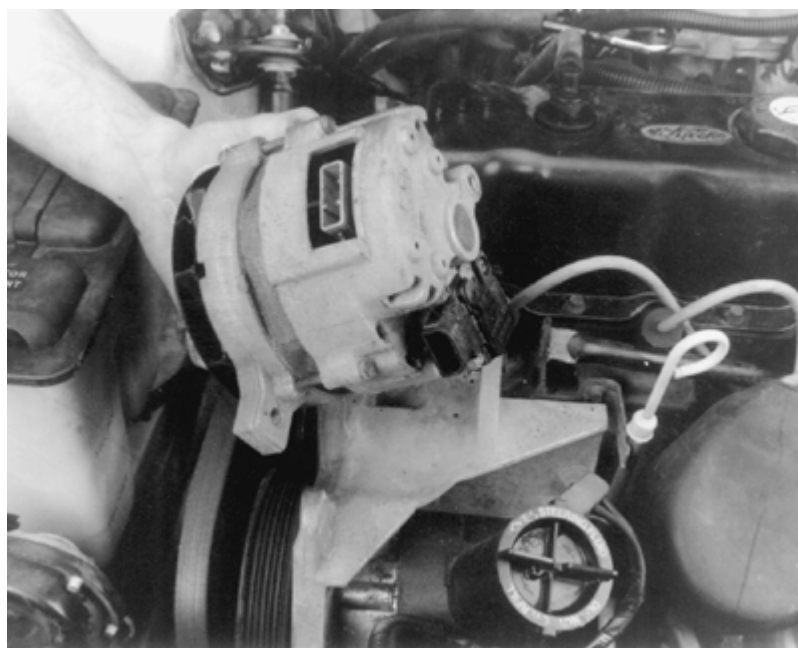


Loosen the mounting/pivot bolts-early model 2.5L shown



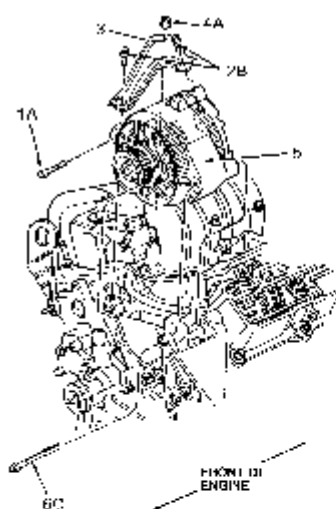
Remove the mounting/pivot bolts from the alternator-early model 2.5L shown

4. Remove the accessory drive belt from the alternator pulley.
5. If equipped, remove the alternator brace, then remove the alternator/voltage regulator assembly from the engine.



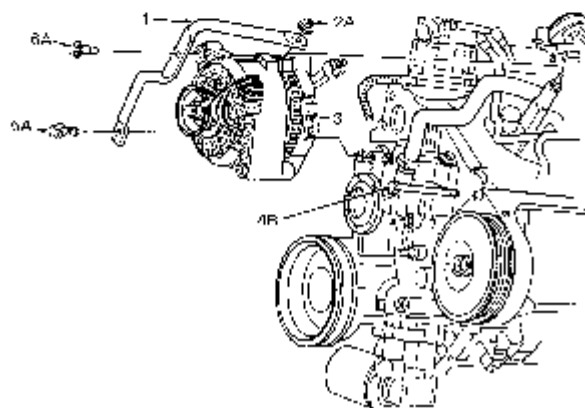
Remove the alternator/regulator assembly from the vehicle-early model 2.5L shown

3.0L SFI Engine



- 1A Mounting brace bolt
 - 2B Bolt (if req'd)
 - 3 Generator stator
 - 4A Nut and washer
 - 5 Generator
 - 6C Pulley
- A Tighten to 20-20 Nm (15-17 lb.ft.)
 B Tighten to 8.5-11 Nm (7.8-10 L)
 C Tighten to 10-55 Nm (7.5-41 lb.ft.)

3.8L SFI Engine



Alternator/regulator assemblies-late model 3.0L and 3.8L engines shown

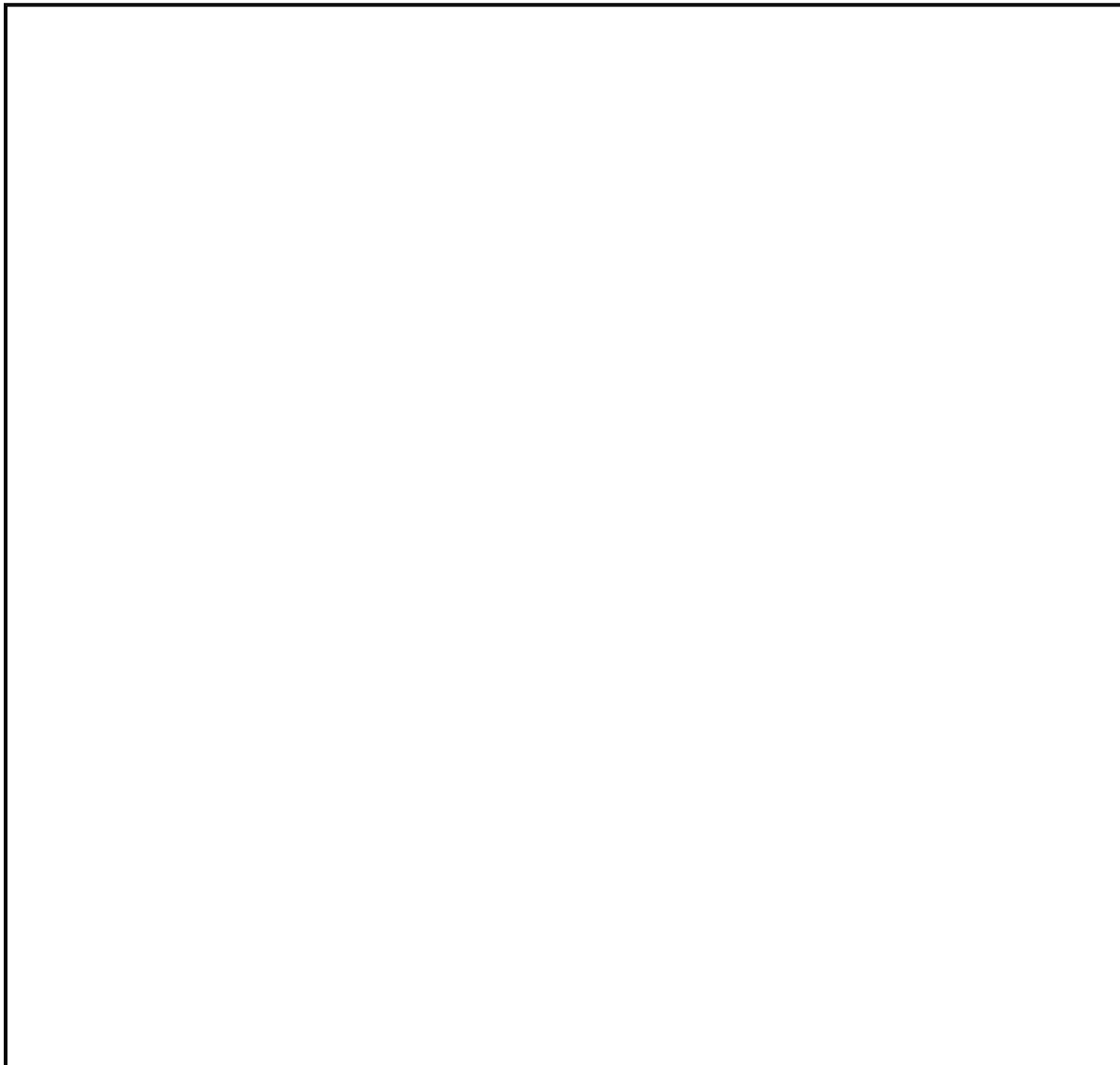
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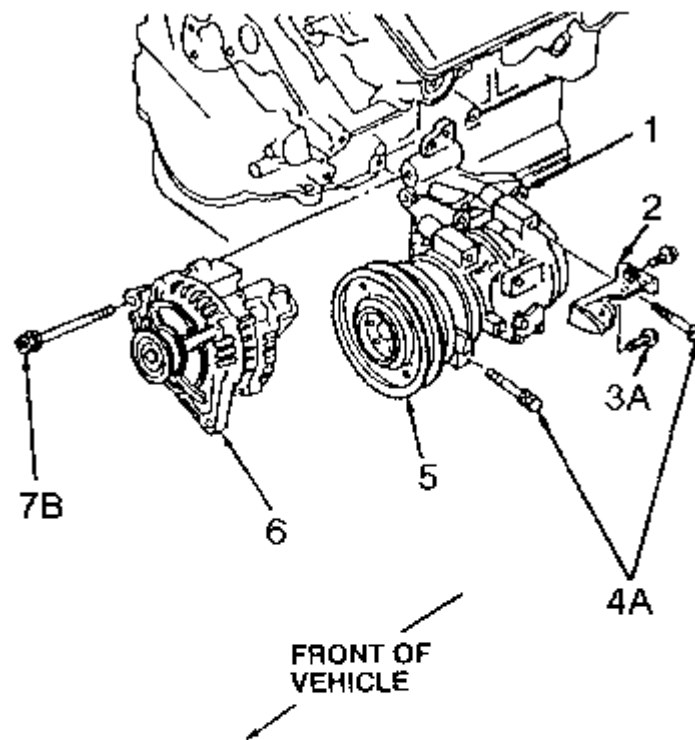
To install:

6. Position the alternator/regulator assembly on the engine, then install the pivot and mounting brace bolts, but do NOT tighten the bolts until the drive belt is tensioned.
7. If equipped, install the alternator brace. Tighten the retaining nut to 15-22 ft. lbs. (20-30 Nm). On the 3.0L engine, tighten the alternator brace bolts to 7-8 ft. lbs. (8.5-11 Nm).
8. Install the drive belt over the alternator pulley, then tighten the mounting brace bolt to 15-22 ft. lbs. (20-30 Nm) and the pivot bolt to 30-41 ft. lbs. (40-55 Nm).
9. Engage the wiring harness connector(s) to the alternator/voltage regulator, as applicable. If equipped, tighten the output terminal nut to 80-97 inch lbs. (9-11 Nm).
10. Connect the negative battery cable.

3.0L SHO ENGINE

1. Disconnect the negative battery cable.
2. Remove the accessory drive belt from the alternator.
3. Disengage the electrical harness connector and the output terminal wiring.
4. Remove the mounting bolt at the front of the alternator, and the two bolts at the rear.
5. Remove the alternator from the engine.





- 1 A/C compressor mounting bracket
- 2 Generator bracket
- 3 Mounting brace bolt (2 req'd)
- 4 A/C compressor mounting bolt (2 req'd)
- 5 A/C compressor
- 6 Generator
- 7 Pivot bolt
- A Tighten to 20-30 Nm (15-22 lb.ft.)
- B Tighten to 40-55 Nm (30-41 lb.ft.)

Alternator assembly-3.0L SHO engine equipped with the rear mount regulator and internal fan

[Click to enlarge](#)

To install:

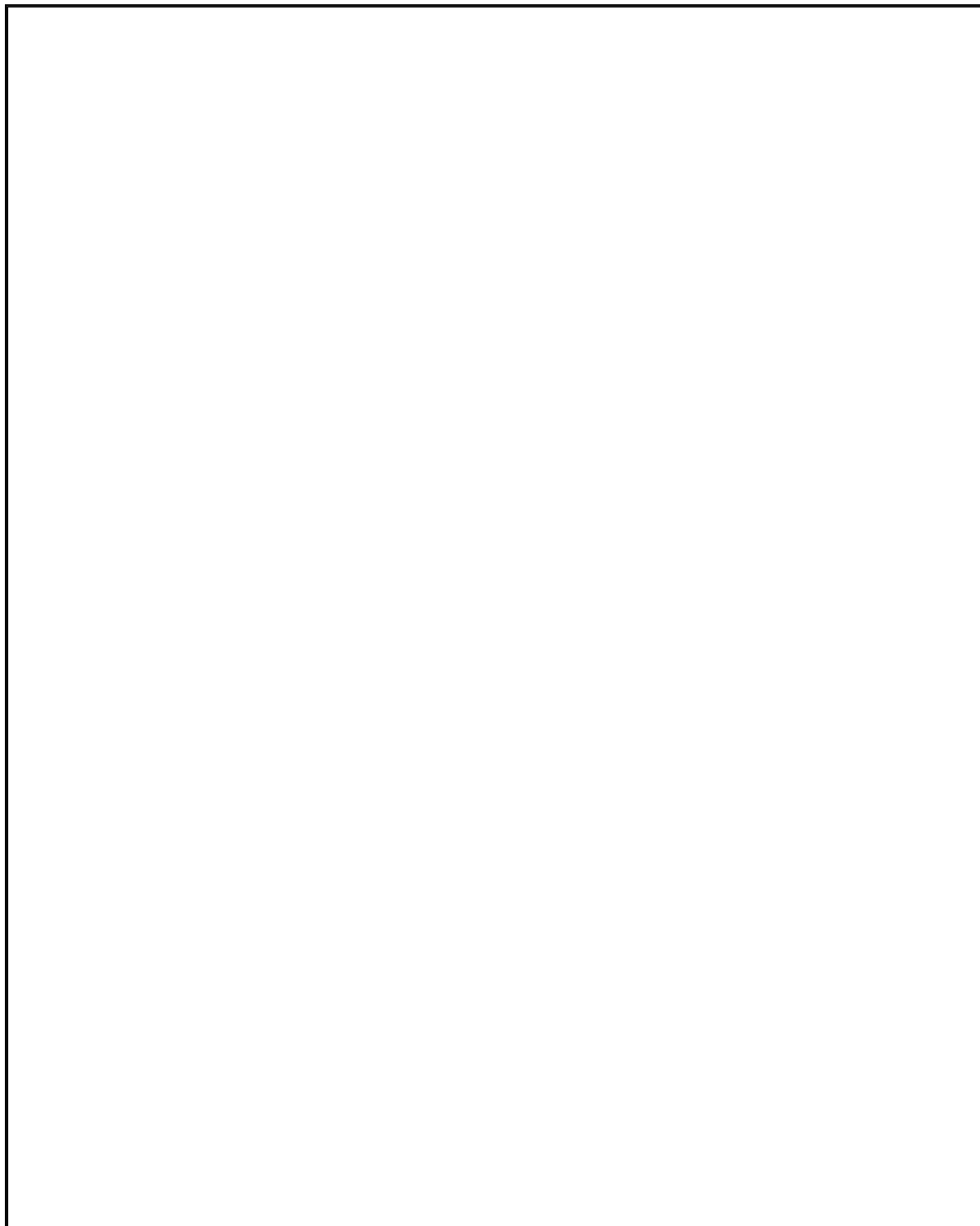
6. Position the alternator on the engine and install the mounting bolts. Tighten the rear mounting bolts to 15-22 ft. lbs. (20-30 Nm) and the front bolt to 30-41 ft. lbs. (40-55 Nm).
7. Engage the electrical connector and the output terminal wiring. Tighten the output terminal nut to 80-97 inch lbs. (9-11 Nm).
8. Install the alternator drive belt on the alternator, then connect the negative battery cable.

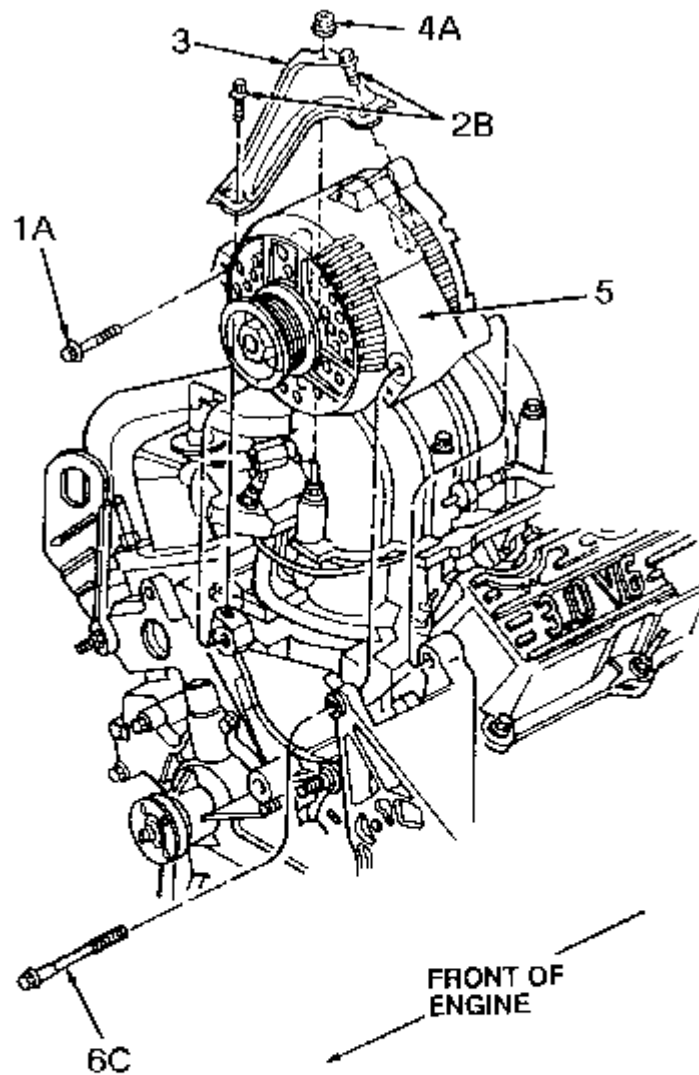
Internal Fan and Regulator

VEHICLES THROUGH 1993

For this procedure, you will need Belt Tension Gauge T63L-8620-A, Alternator Pulley Remover T65P-10300-B, and Rotunda Belt Tension Gauge 021-00019.

- 1. Disconnect the battery cables (negative, then positive), then remove the battery and battery tray. For details regarding this procedure, please refer to the procedure later in this section.**
- 2. Tag and disengage the electrical wiring harness connector and the output terminal wiring from the alternator.**
- 3. Loosen the belt tensioner, then remove the alternator belt from the pulley.**
- 4. Remove the mounting bolt on the front of the alternator and the two bolts from the rear of the alternator, then remove the alternator from the vehicle.**





- 1A Adjusting arm bolt
- 2B Bolt (2 req'd)
- 3 Alternator brace
- 4A Nut and washer
- 5 Alternator
- 6C Pivot bolt
- A Tighten to 20-30 Nm (15-22 lb.ft.)
- B Tighten to 8.5-11 Nm (7-8 lb.ft.)
- C Tighten to 40-55 Nm (30-41 lb.ft.)

Alternator assembly-3.0L and 3.2L SHO vehicles through 1993

[Click to enlarge](#)

To install:

5. Position the alternator in the vehicle, then install the three mounting bolts. Tighten the front bolt to 36-53 ft. lbs. (48-72 Nm) and the rear bolts to 26-36 ft. lbs. (34-50 Nm).
6. Install the alternator belt, then set the belt tension to 148-191 lbs. (658-854 N) for a

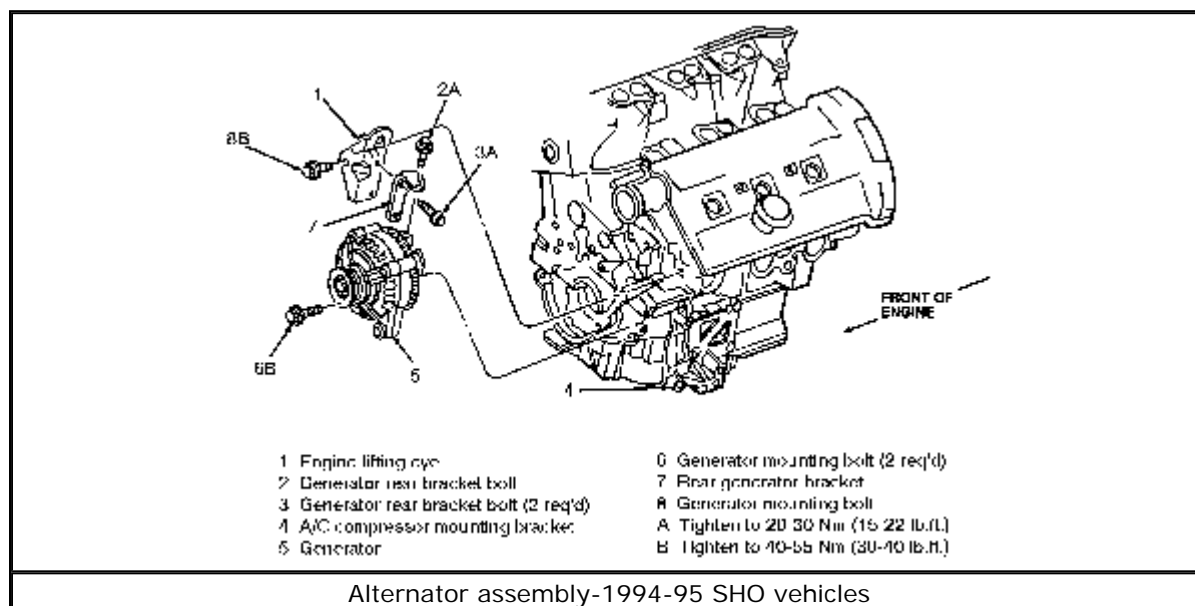
used belt, or to 220-264 lbs. (978-1178 N) for a new belt, using the earlier specified tension gauge.

7. Engage the output terminal wire and the electrical harness connector to the alternator.
8. Install the battery tray and the battery, then connect the battery cables. For details regarding battery and tray installation, please refer to the procedure later in this section.

1994-95 VEHICLES

Vehicles equipped with this alternator include the 1994 3.0L SHO and 1994-95 3.2L SHO.

1. Disconnect the negative battery cable.
2. Remove the drive belt from the alternator. For details regarding this procedure, please refer to *Section 1* of this manual.
3. Disengage the electrical harness connector and the output terminal wiring.
4. Remove the bolt from the rear alternator bracket-to-alternator, then remove the two mounting brackets.
5. Remove the alternator from the vehicle.



[Click to enlarge](#)

To install:

6. Position the alternator in the vehicle, then install the two mounting brackets. Tighten the bracket retaining bolts to 15-22 ft. lbs. (20-30 Nm).
7. Install the bolt to the rear bracket and tighten to 30-40 ft. lbs. (40-55 Nm).
8. Engage the output terminal wiring and the electrical harness connector.
9. Install the alternator belt, then connect the negative battery cable. For details regarding belt installation, please refer to *Section 1* of this manual.

Voltage Regulator

ADJUSTMENT

The electronic voltage regulator is calibrated and preset by the manufacturer. No adjustment is required or possible.

REMOVAL & INSTALLATION

Side Terminal Alternator

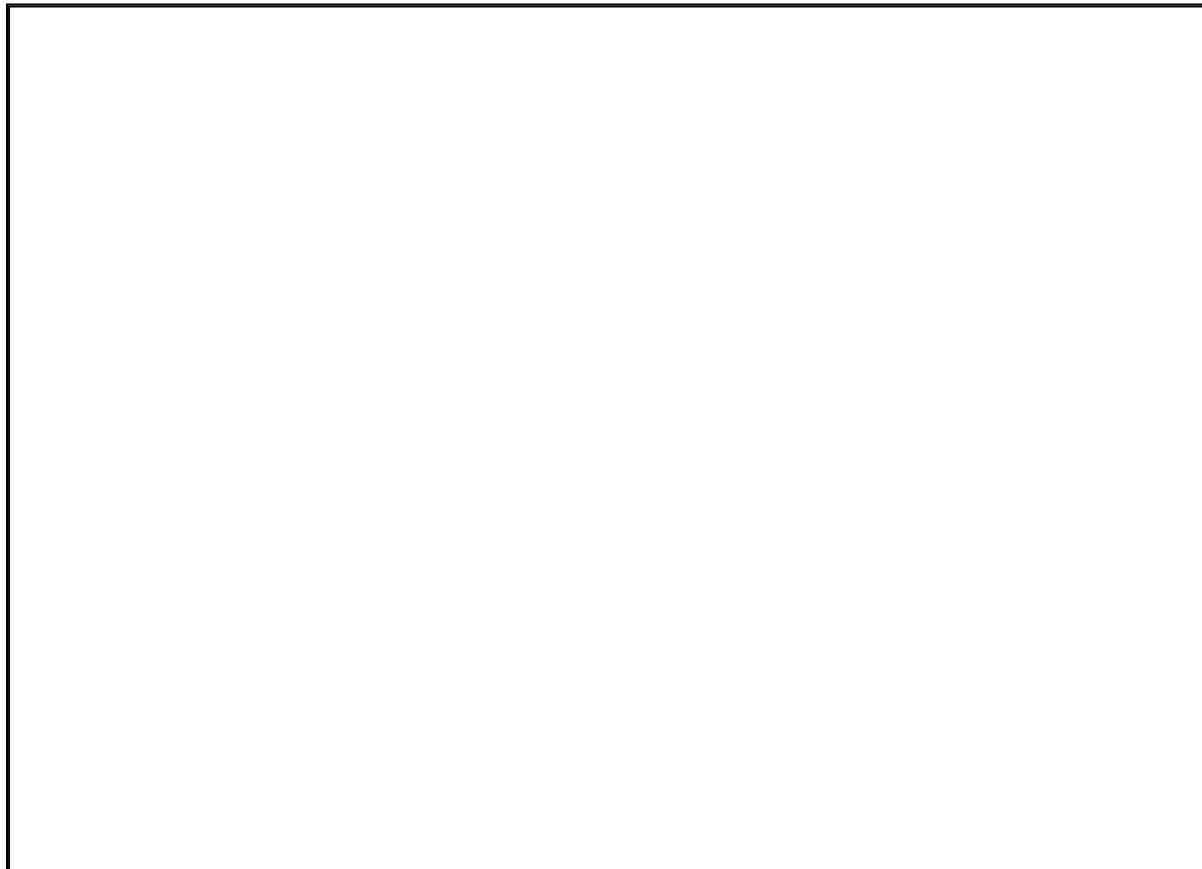
This voltage regulator is mounted on the right-hand fender apron of the vehicle.

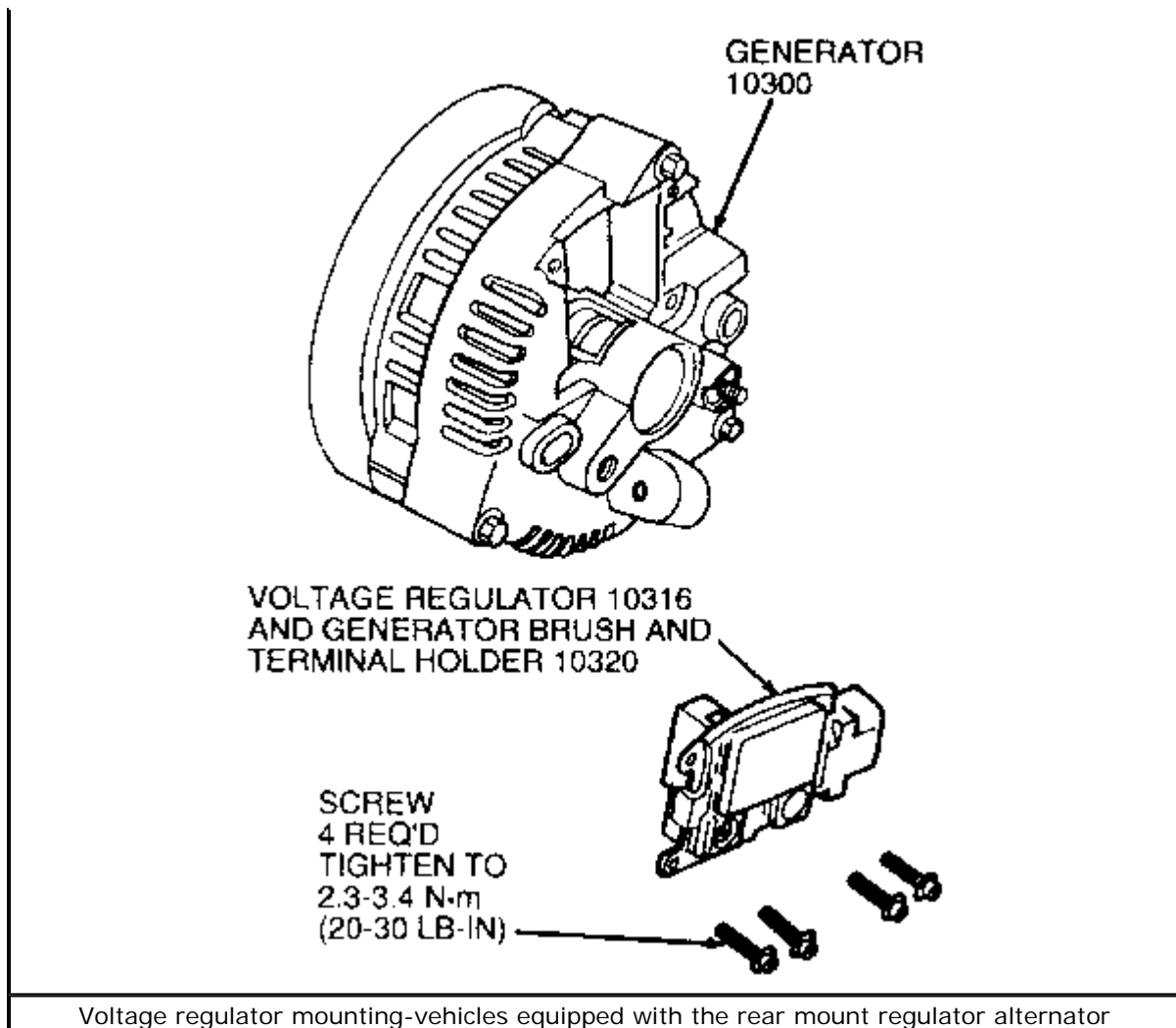
1. **Disconnect the negative battery cable.**
2. **Detach the electrical connectors from the wiring harness.**
3. **Remove the regulator mounting screws and the regulator.**
4. **Installation is the reverse of the removal procedure.**
5. **Connect the negative battery cable. Test the system for proper voltage regulation.**

Rear Mounted Regulator

This voltage regulator is mounted on the rear of the alternator housing.

1. **Disconnect the negative battery cable.**
2. **Remove the four retaining Torx® screws attaching the voltage regulator to the alternator rear housing.**
3. **Remove the regulator, with the alternator brush and terminal holder still attached, from the alternator.**





[Click to enlarge](#)

To install:

4. Install the regulator to the rear of the alternator assembly and fasten using the four retaining screws. Tighten the screws to 20-30 inch lbs. (2.3-3.4 Nm).
5. Connect the negative battery cable.

Battery

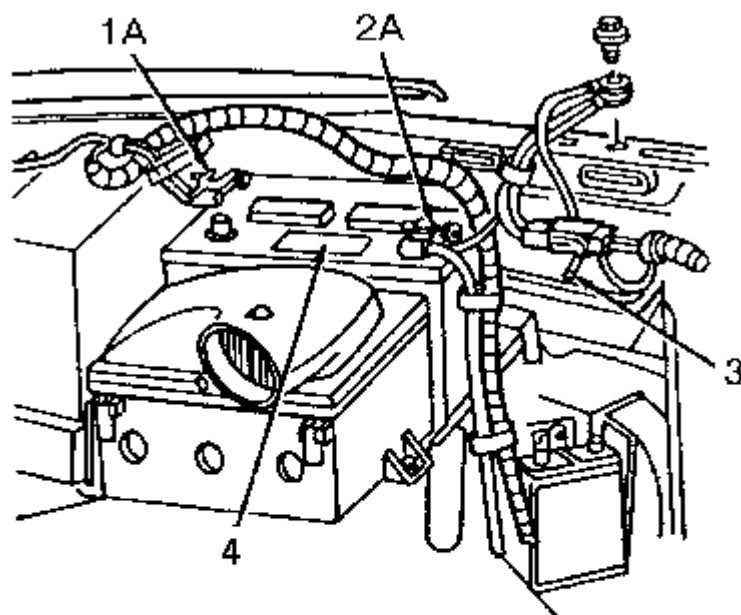
REMOVAL & INSTALLATION

Battery

1. Disconnect the negative battery cable, and then the positive battery cable.
2. Remove the battery hold-down bracket retaining bolt, then remove the hold-down bracket.

Before removing the battery from the vehicle, make sure to note the position of the positive and negative terminals.

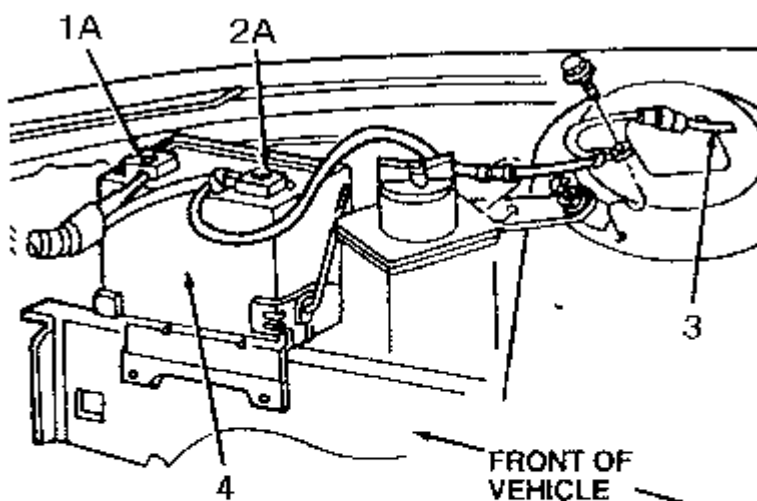
3. Carefully lift the battery from its mounting and remove it from the vehicle.



- 1 Positive battery terminal
- 2 Negative battery terminal
- 3 Anti-lock brake wiring
- 4 Front fender apron
- A Tighten to 6-10 Nm (60-90 lb.in.)

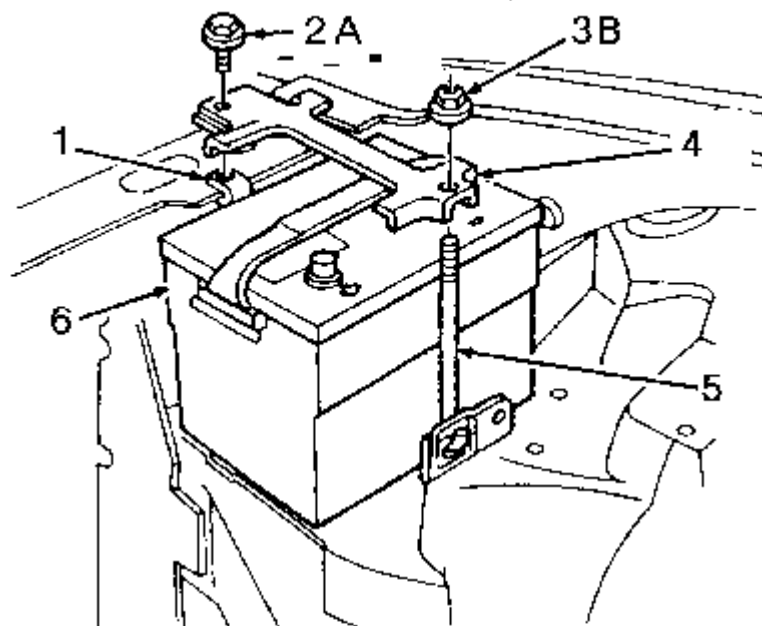
Battery and related components-3.0L (except SHO) and 3.8L shown, 2.5L similar

[Click to enlarge](#)



- 1 Positive battery terminal
- 2 Negative battery terminal
- 3 Engine control sensor wiring
- 4 Battery
- A Tighten to 7.6-10.4 Nm (68-92 lb.in.)

Battery and related components-3.0L and 3.2L SHO

[Click to enlarge](#)

- 1 U-nut
- 2 Bolt (1 req'd)
- 3 Nut (1 req'd)
- 4 Battery hold down clamp
- 5 Battery mounting clamp bolt
- 6 Battery
- A Tighten to 7-10 Nm (62-88 lb.in.)
- B Tighten to 3-5 Nm (27-44 lb.in.)

View of the battery hold-down clamp assembly

[Click to enlarge](#)**To install:**

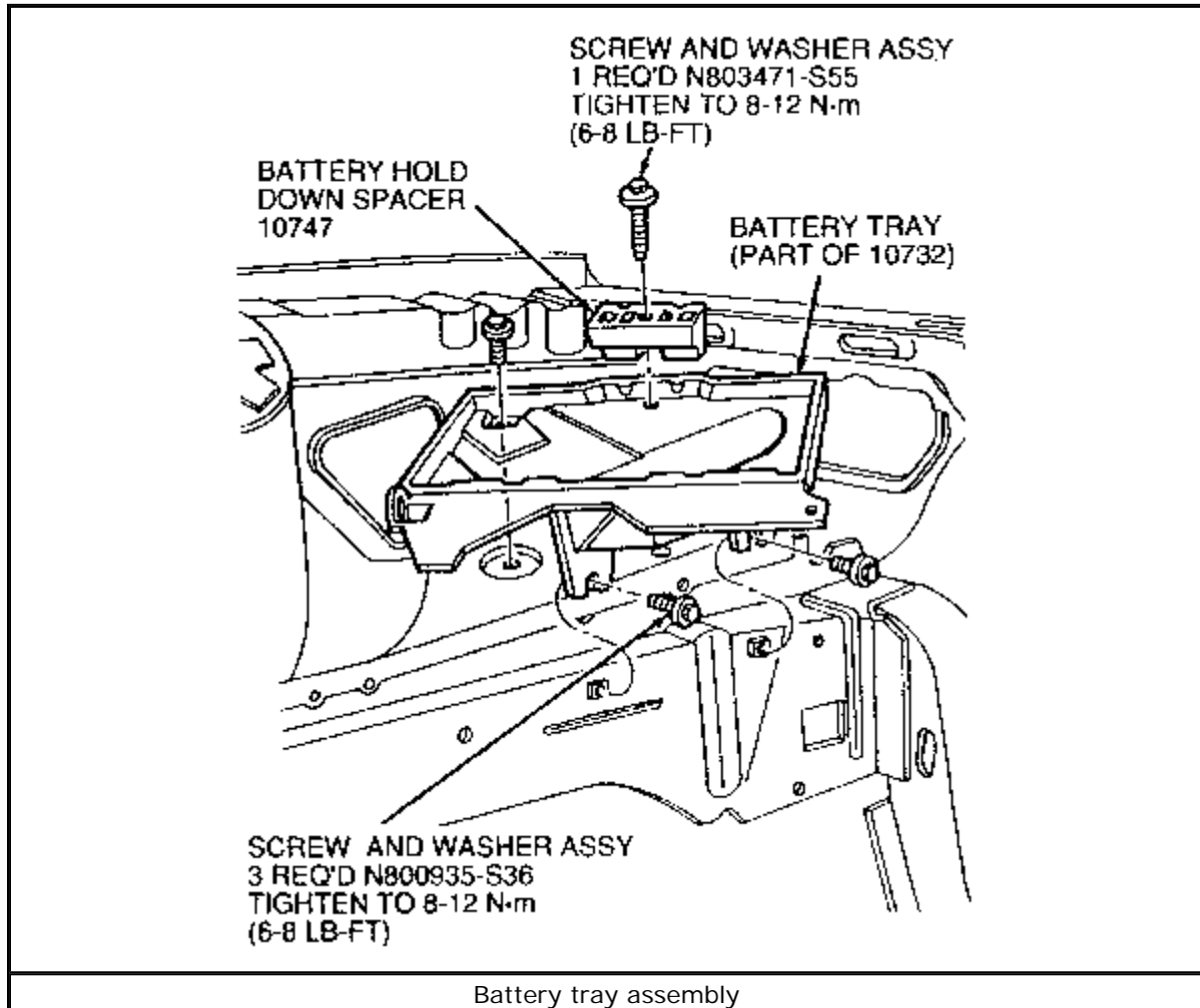
4. Clean the cable terminals and the hold-down clamp with a wire brush. Replace all cables or parts that are worn or frayed. Clean the battery tray with a wire brush and a suitable scraping tool.
5. Place the battery in the battery tray with the positive and negative terminals in the same position as prior to removal.
6. Assemble and tighten the hold-down hardware so the battery is secure. Do NOT overtighten.

When the battery is disconnected and reconnected, some abnormal driving symptoms may occur while the Powertrain Control Module (PCM) relearns its adaptive strategy. The car may have to be driven 10 or more miles to relearn this strategy.

7. Secure cables to the proper terminals, securing the positive cable first, but do NOT overtighten. Apply petroleum jelly to the battery terminals.

Battery Tray

1. Remove the battery from the vehicle, as explained previously in this section.
2. Remove the retaining bolts, screws and washers from the battery tray, then remove the tray from the vehicle.



[Click to enlarge](#)

To install:

3. Position the battery tray to the front fender apron in the engine compartment.
4. Install the retaining bolts, screws and washers, then tighten each to 6-8 ft. lbs. (8-12 Nm).
5. Install the battery in the engine compartment as previously outlined in this section, then tighten the hold-down spacer bolt to 6-8 ft. lbs. (8-12 Nm).

Starter

TESTING

Before removing the starter for repair or replacement, check the condition of all circuit wiring for damage. Inspect all connections to the starter motor, relay, ignition switch, and battery, including all ground connections. Clean and tighten

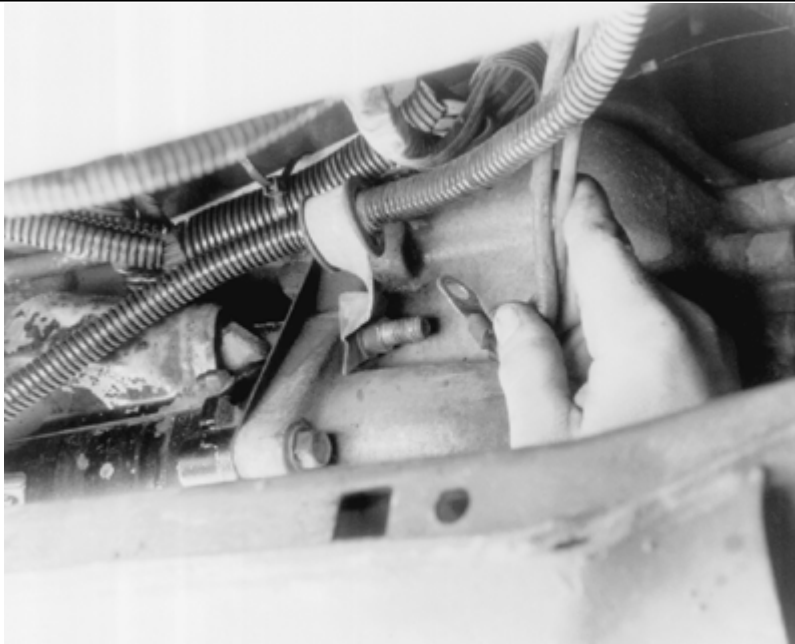
all connections as required.

REMOVAL & INSTALLATION

1986-91 Vehicles

ALL 2.5L AND 3.0L MODELS; 3.8L SEDAN

1. Disconnect the negative battery cable and the cable connection at the starter.
2. Raise and safely support the vehicle.
3. Remove the cable support and ground cable connection from the upper starter stud bolt.



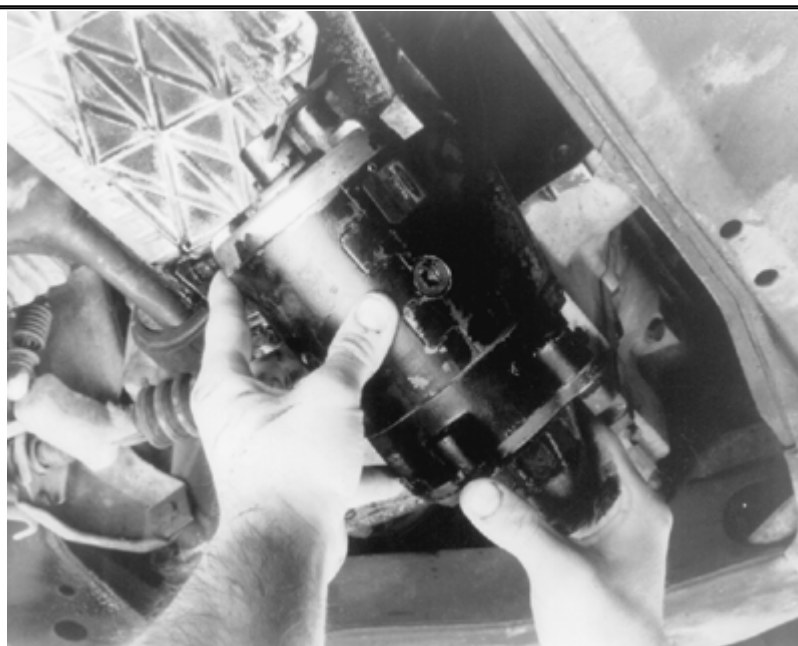
Disengage the connection from the upper starter stud bolt-early model 2.5L shown

4. If equipped, remove the starter brace from the cylinder block and the starter.
5. On 2.5L engines, remove the three starter-to-bell housing bolts. On 3.0L engines, remove the two starter-to bell housing bolts.

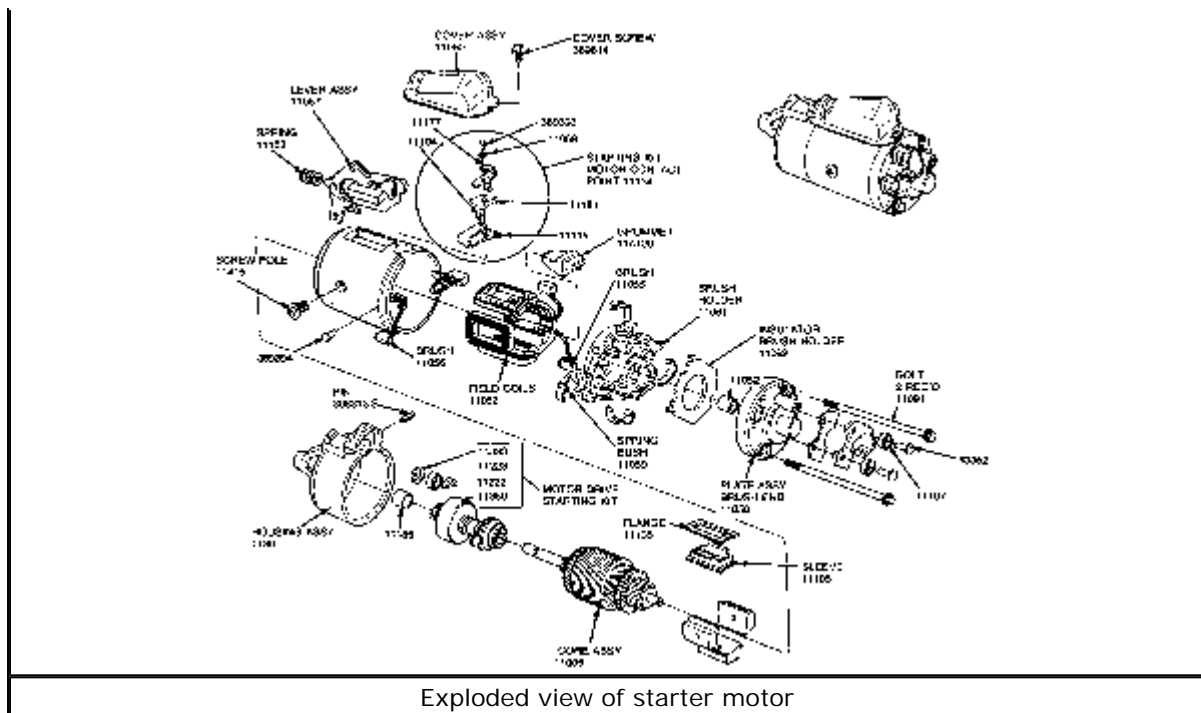


Remove the starter retaining bolts-early model 2.5L shown

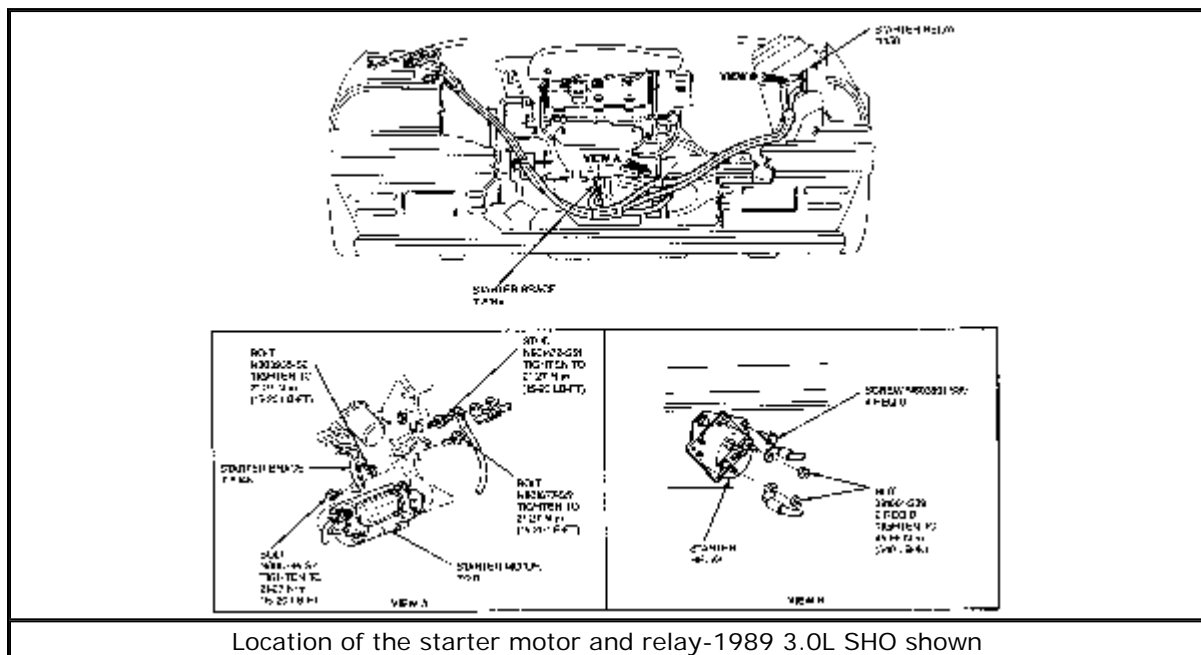
6. On vehicles equipped with an automatic transaxle, remove the starter between the subframe and the radiator. For vehicles equipped with a manual transaxle, remove the starter between the subframe and the engine.



Remove the starter motor from the vehicle-early model 2.5L shown



[Click to enlarge](#)



[Click to enlarge](#)

To install:

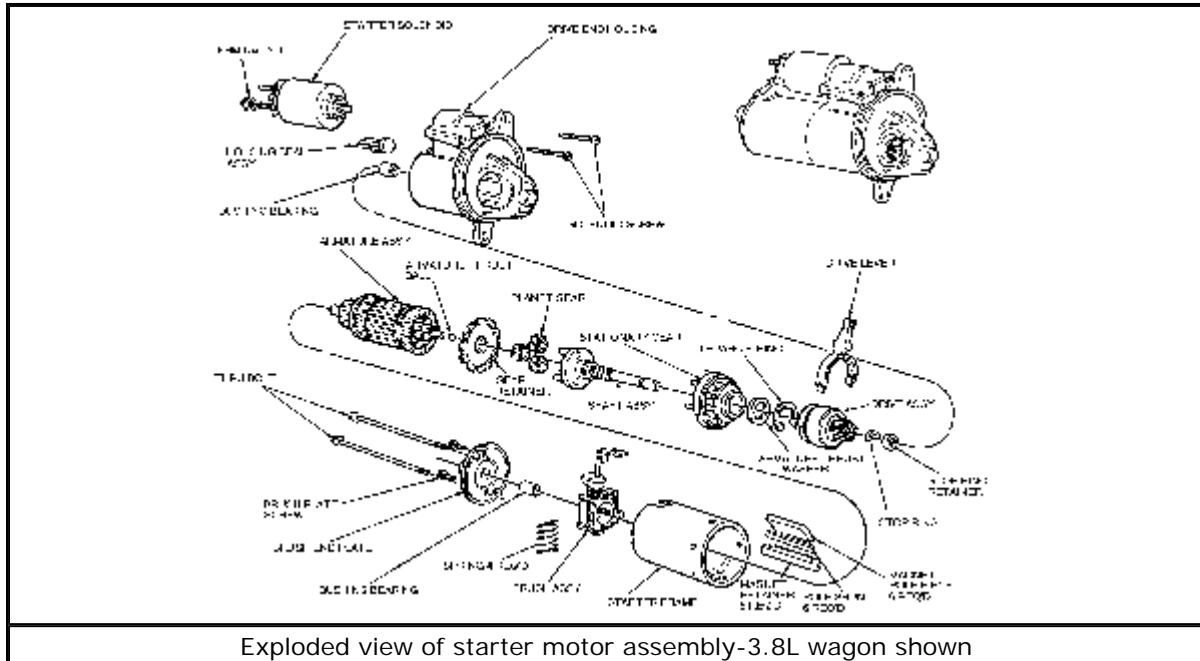
- Position the starter, then secure using the retaining bolts. Tighten the bolts to 15-20 ft. lbs. (20-27 Nm).
- If applicable, install the starter brace to the cylinder block and starter.
- Engage the ground cable connection to the upper starter stud bolt, then install the cable support.
- Lower the vehicle, engage the cable connection at the starter, then connect the negative battery cable.

3.8L STATION WAGON

1. Disconnect the negative battery cable, then raise and safely support the vehicle.
2. Disengage the the starter cable and the relay connector from the starter solenoid.

When disengaging the hardshell connector at the S-terminal, be sure to grasp the connector to pull it off. Do NOT pull on the wire!

3. Remove the starter retaining bolts, then remove the starter.



[Click to enlarge](#)

To install:

4. Position the starter motor to the engine, then finger-start the retaining bolts. Starting with the topmost bolt, tighten the bolts to 15-20 ft. lbs. (20-27 Nm).
5. Fasten the starter cable and the relay connector to the motor. Tighten the starter cable nut to 80-119 inch lbs. (9-13.5 Nm).
6. Lower the vehicle, then connect the negative battery cable.

1992-95 Vehicles

CAUTION

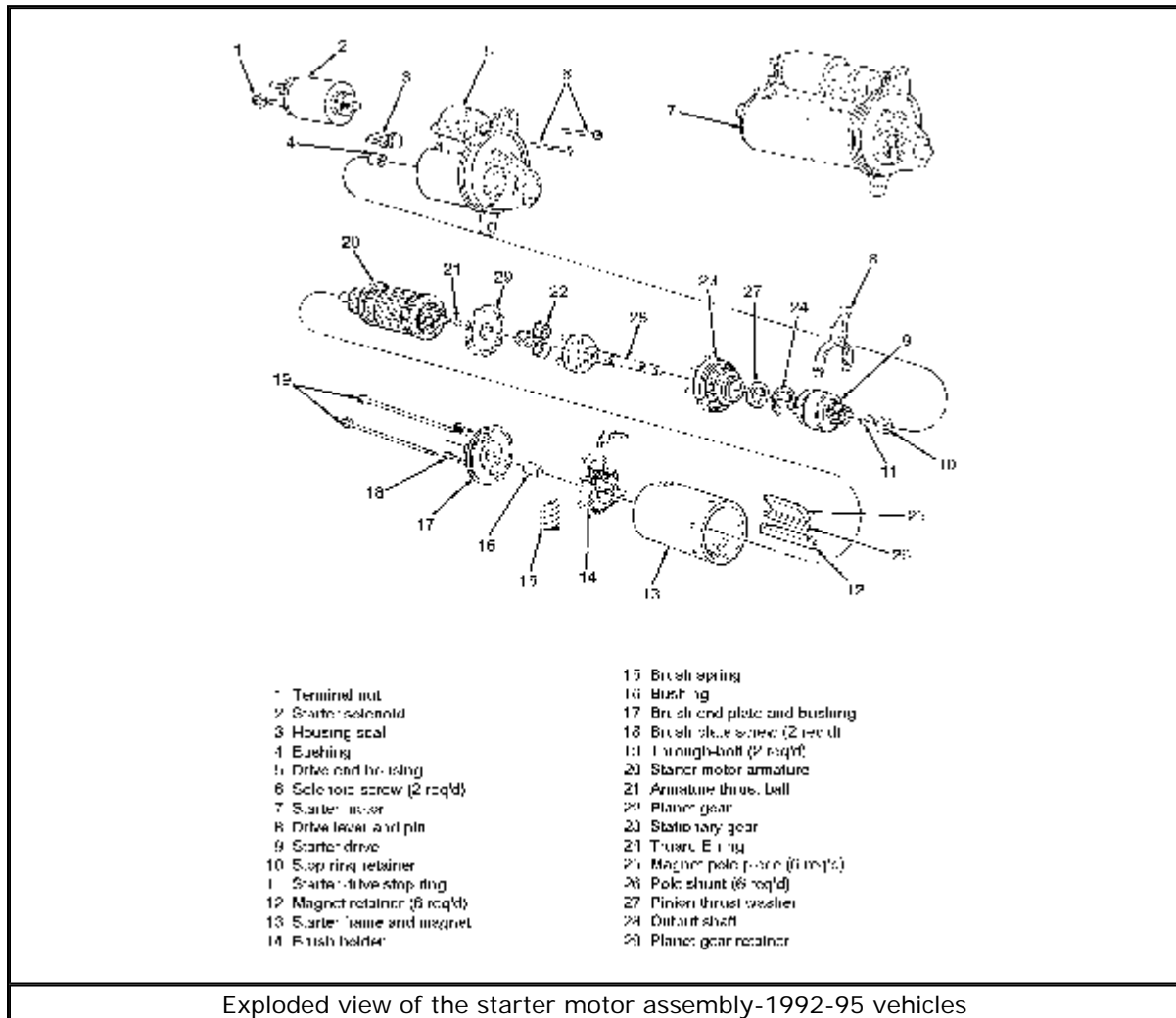
When performing any work on the starter, keep in mind that the heavy gauge input lead to the starter solenoid is hot at all times. To avoid injury be sure that the protective cap is installed over the terminal and is replaced after any service.

1. Disconnect the negative battery cable.

When the battery has been disconnected and reconnected, some abnormal driveability symptoms may occur while the PCM relearns its

adaptive strategy. The vehicle may have to be driven 10 or more miles to relearn its strategy.

2. Raise and safely support the vehicle.
3. Disengage the starter cable and the push-on connector from the starter solenoid.
4. Remove the upper and lower retaining bolts, then remove the starter motor from the vehicle.



[Click to enlarge](#)

To install:

5. Position the starter motor to the engine, then install the upper and lower retaining bolts finger-tight.
6. Tighten the retaining bolts to 15-20 ft. lbs. (20-27 Nm).
7. Engage the starter solenoid connector, making sure to push straight on until the connector locks in position. A noticeable click should be heard or detent felt.
8. Install the starter cable nut to the starter solenoid B terminal. Tighten the nut to 80-124 inch lbs. (9-14 Nm), then install the red starter solenoid safety cap.
9. Lower the vehicle, then connect the negative battery cable.

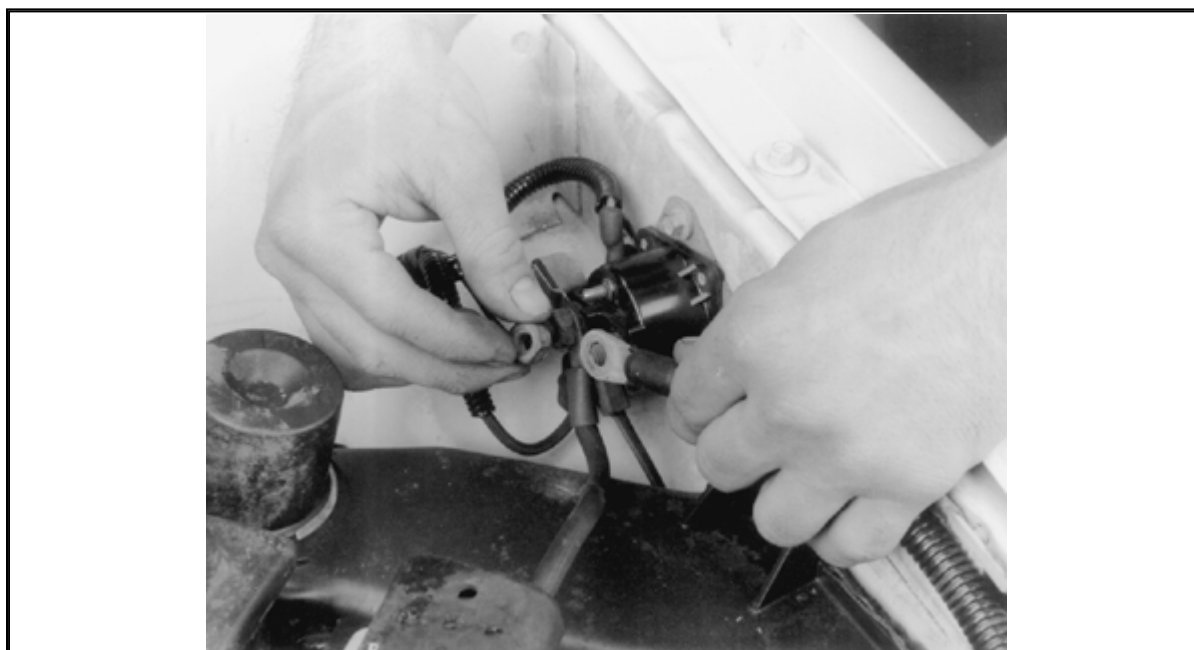
STARTER RELAY REPLACEMENT

1. Disconnect the negative battery cable.
2. Disengage the relay-to-ignition switch electrical connector.



Disengage the relay-to-ignition switch electrical connector-early model 2.5L shown

3. Disconnect the nut retaining the relay-to-starter and relay-to-battery electrical connectors.



Unfasten the nut retaining the starter and battery connections-early model 2.5L shown

4. Disconnect the retaining screws, then remove the relay from the vehicle.





After disconnecting the retaining screws, remove the relay from the vehicle

To install:

5. Position the relay in the vehicle, then install the retaining screws.
6. Fasten the nuts retaining the relay-to-starter and relay-to-battery electrical connectors. Tighten the nuts to 45-89 inch lbs. (5-10 Nm).
7. Engage the relay-to-ignition switch electrical connector.
8. Connect the negative battery cable.

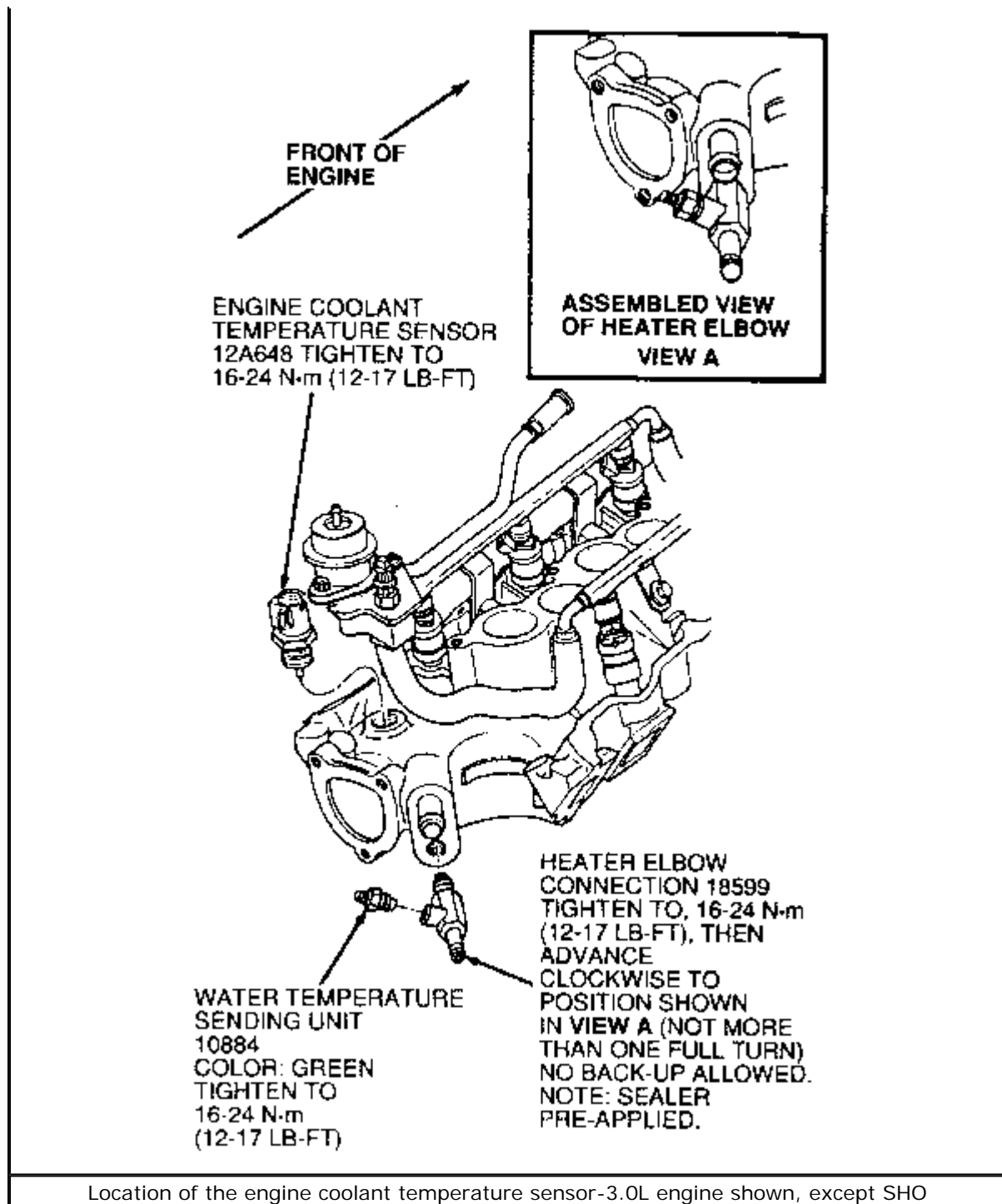
Sending Units and Sensors

REMOVAL & INSTALLATION

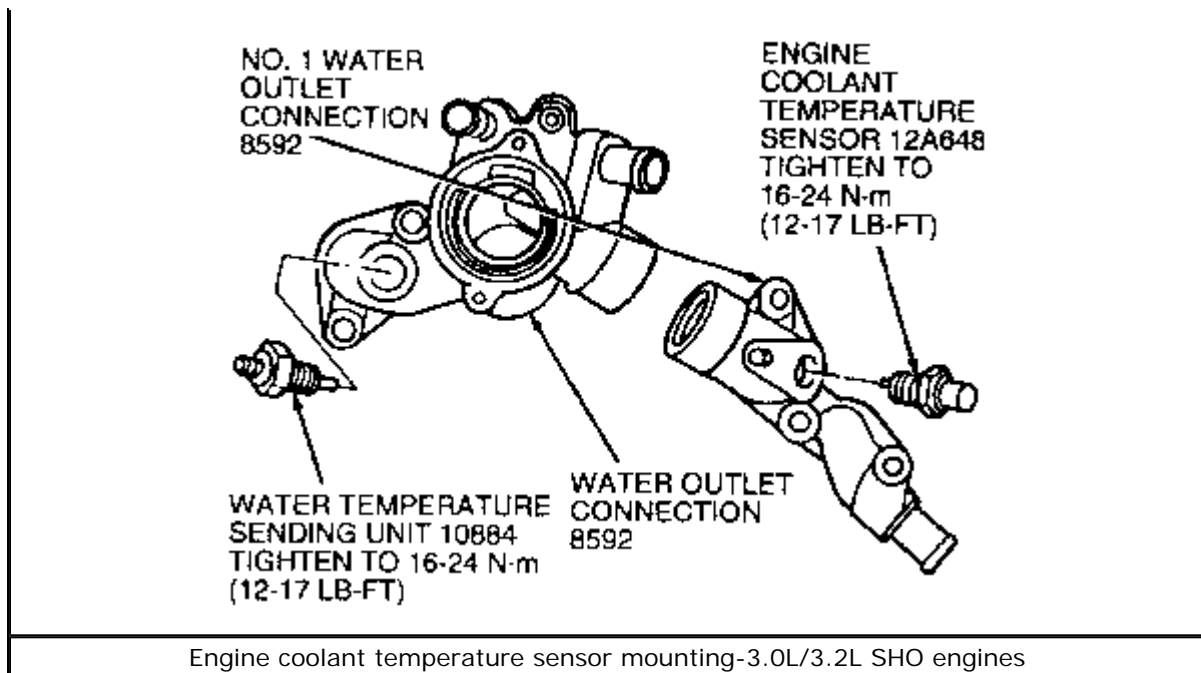
Engine Coolant Temperature (ECT) Sensor

The engine coolant temperature sensor detects the temperature of the engine coolant and sends a signal, supplying this information to the Powertrain Control Module (PCM). It is located at the rear of the intake manifold for all engines except some 3.0L SHO engines and all 3.2L SHO engines. For the 3.0L and the 3.2L SHO engines, the sensor is located at the rear of the right-hand side cylinder head, in the No. 1 water hose connection directly below the throttle body. The sensor signal is used to modify ignition timing, EGR flow and the air/fuel ratio as a function of the engine coolant temperature.

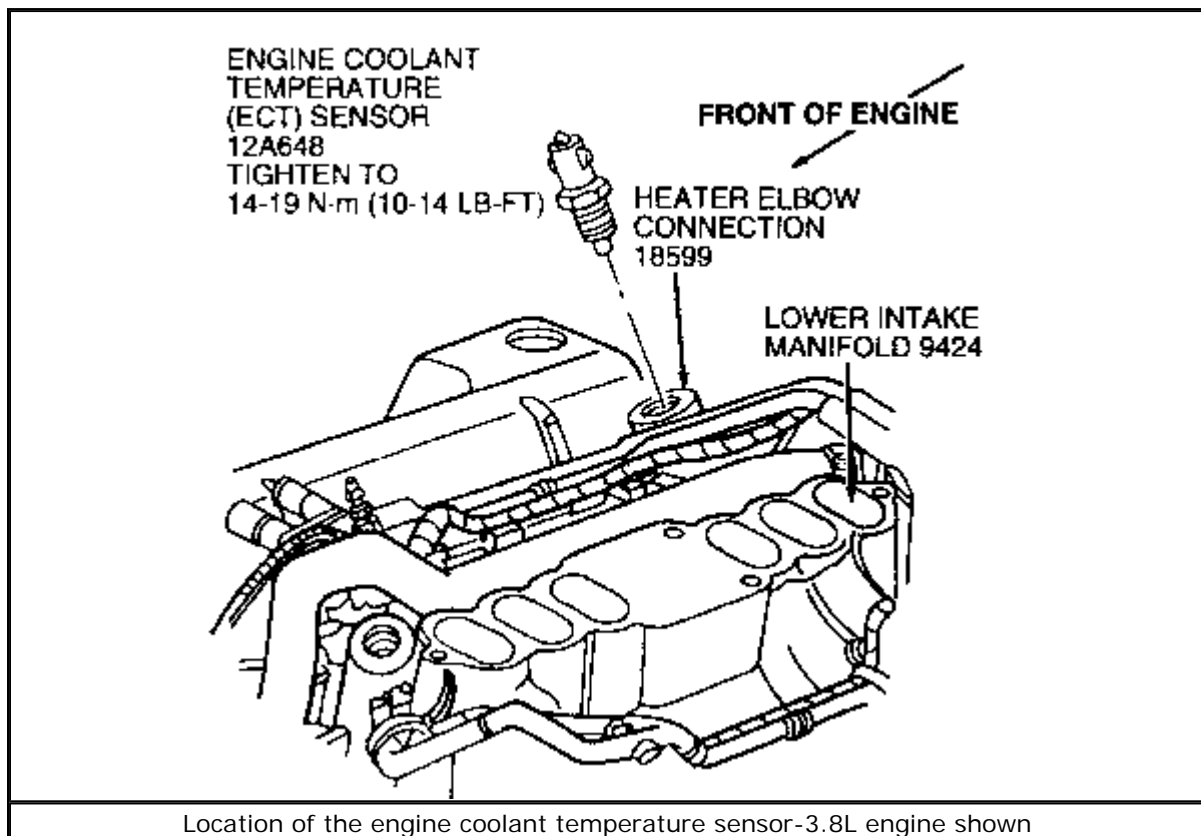
1. Disconnect the negative battery cable.
2. Drain the cooling system until its level is below that of the sensor. For information regarding this procedure, please refer to *Section 1* of this manual.
3. Disengage the engine control sensor wiring from the coolant temperature sensor.
4. Remove the necessary components to gain access to the sensor assembly.
5. Using the proper size wrench or socket and ratchet, remove the sensor from its mounting.



[Click to enlarge](#)



[Click to enlarge](#)



[Click to enlarge](#)

To install:

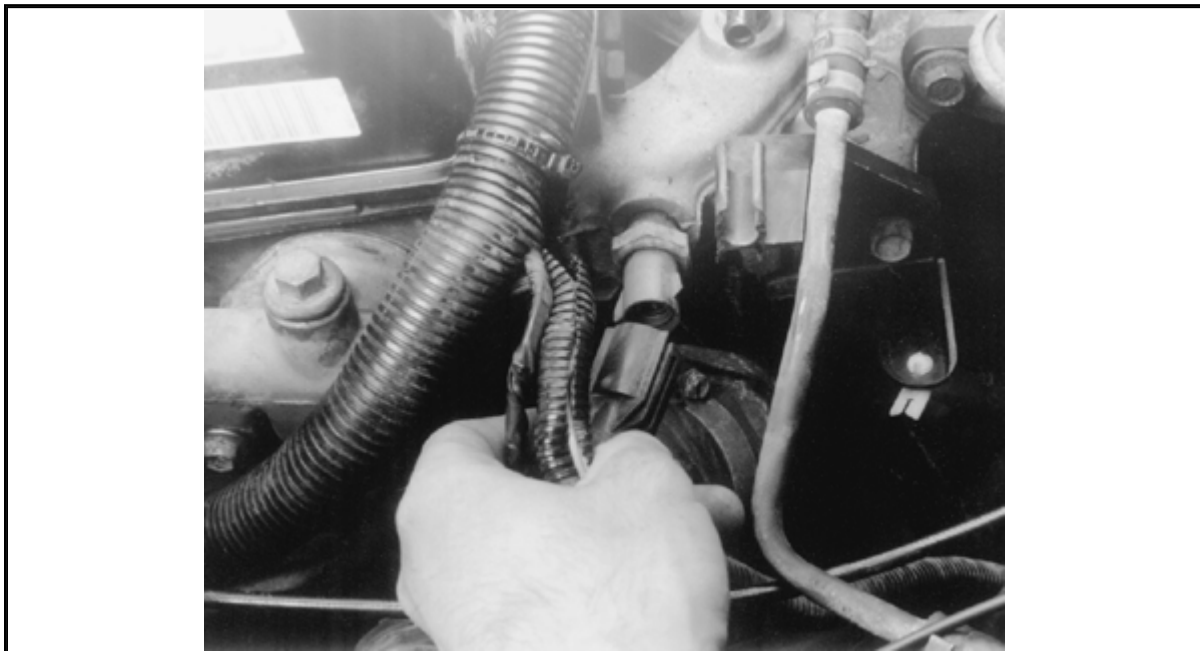
6. Before installing, apply Pipe Sealant with Teflon®, D8AZ-19554-A or equivalent, on the sensor threads.
7. Install the sensor to the intake manifold or water hose connection as applicable. Tighten the sensor to 12-17 ft. lbs. (16-23 Nm).

8. Engage the electrical connector, then refill the cooling system to the correct level with a 50/50 mixture of Ford approved coolant and water.
9. Connect the negative battery cable, then start the engine and check the coolant level.

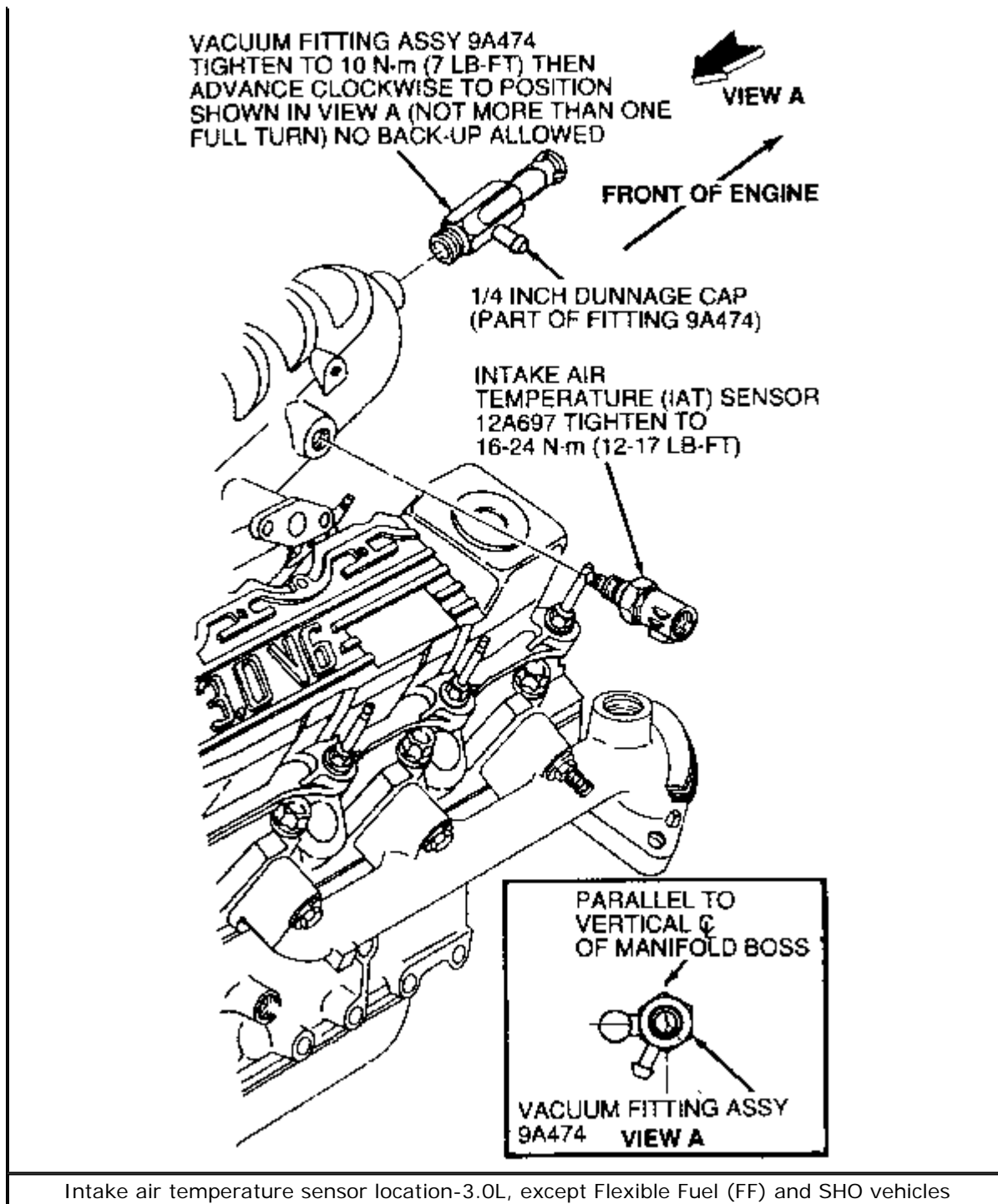
Intake Air Temperature (IAT)/Air Charge Temperature (ACT) Sensor

The intake air or air charge temperature sensor sends a signal to the PCM, indicating the temperature of air coming into the engine. It is located in the side of the throttle body or in the air cleaner assembly on late model vehicles. On early model vehicles, the sensor is located at the rear of the intake manifold, or on the side of the throttle body.

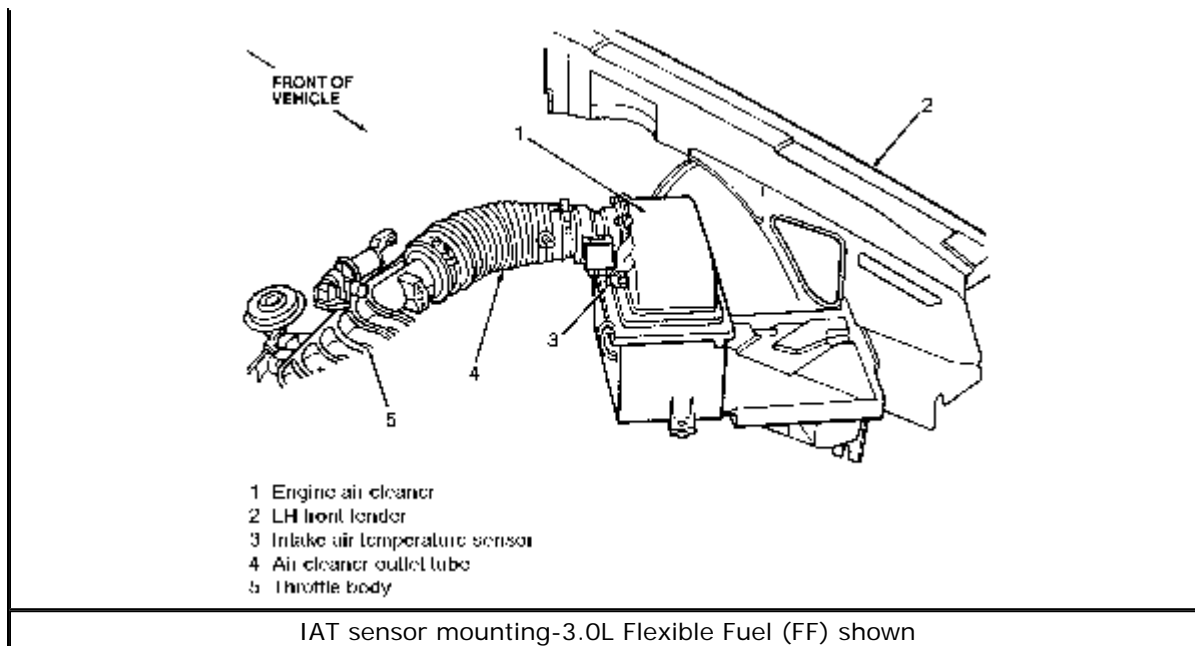
1. Disconnect the negative battery cable.
2. Disengage the electrical connector from the sensor.
3. To remove the sensor from the throttle body or intake manifold, unscrew the sensor, then remove it from the engine.
4. To remove the sensor from the air cleaner assembly, turn the sensor 90° counterclockwise, then remove it from the air cleaner cover or body, as applicable.



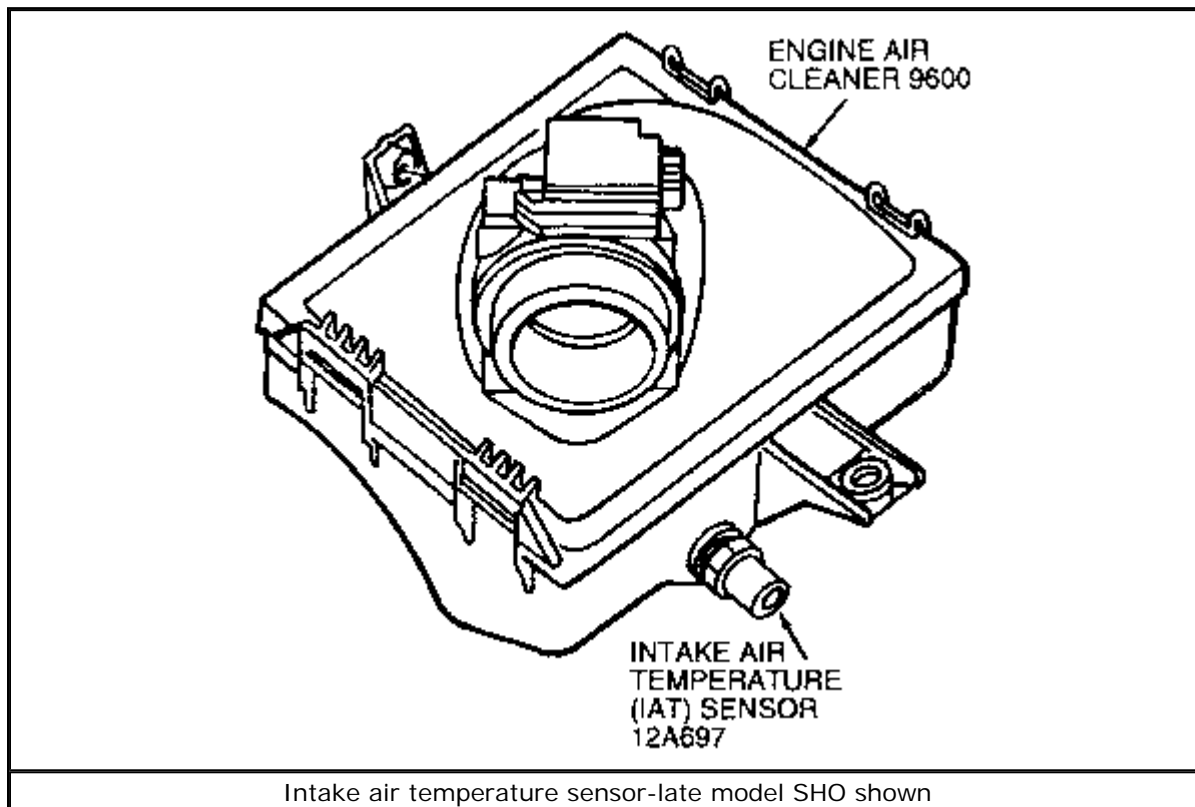
Disengage the IAT/ACT sensor electrical connector-early model 2.5L engine shown



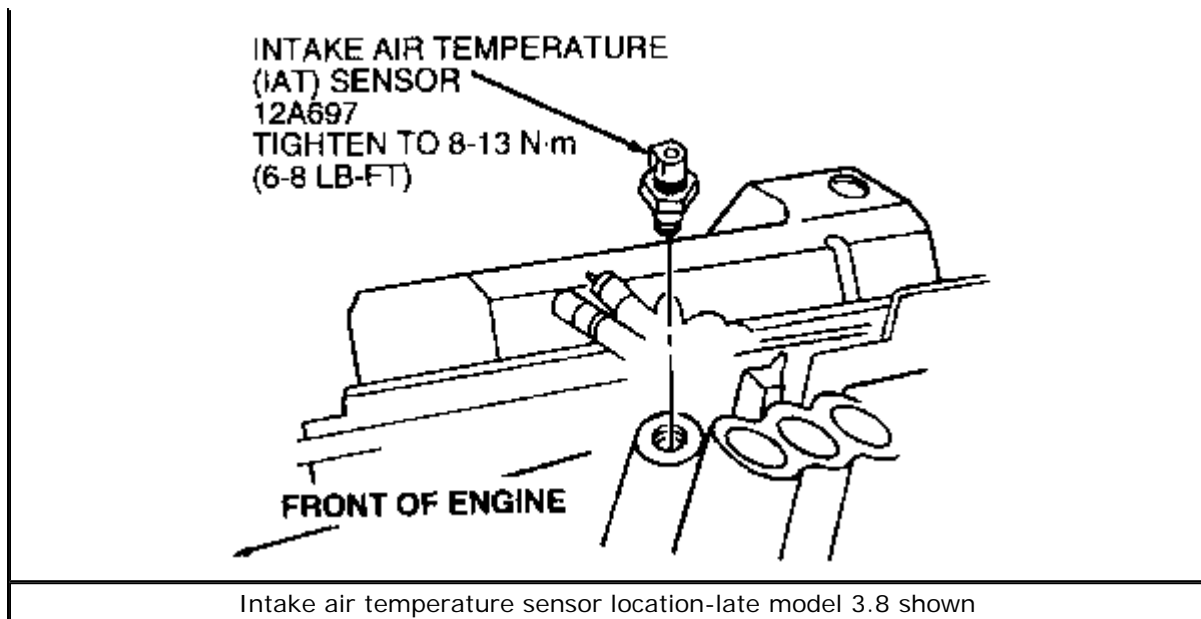
[Click to enlarge](#)



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To install:

5. If applicable, install the sensor into the throttle body or intake manifold, then tighten it to 12-17 ft. lbs. (16-23 Nm).
6. If applicable, install the sensor into the air cleaner cover or body, being careful not to damage the plastic threads.
7. Engage the electrical connector, then connect the negative battery cable.

Mass Air Flow (MAF) Sensor

The mass air flow sensor sends a voltage signal to the PCM indicating the mass or amount of air coming into the engine. The PCM then uses this signal to calculate the fuel injector pulse time, to achieve the correct fuel/air mixture. The sensor is located between the engine air cleaner and the throttle body, or mounted on the top of the air cleaner assembly.

3.0L ENGINE-EXCEPT SHO

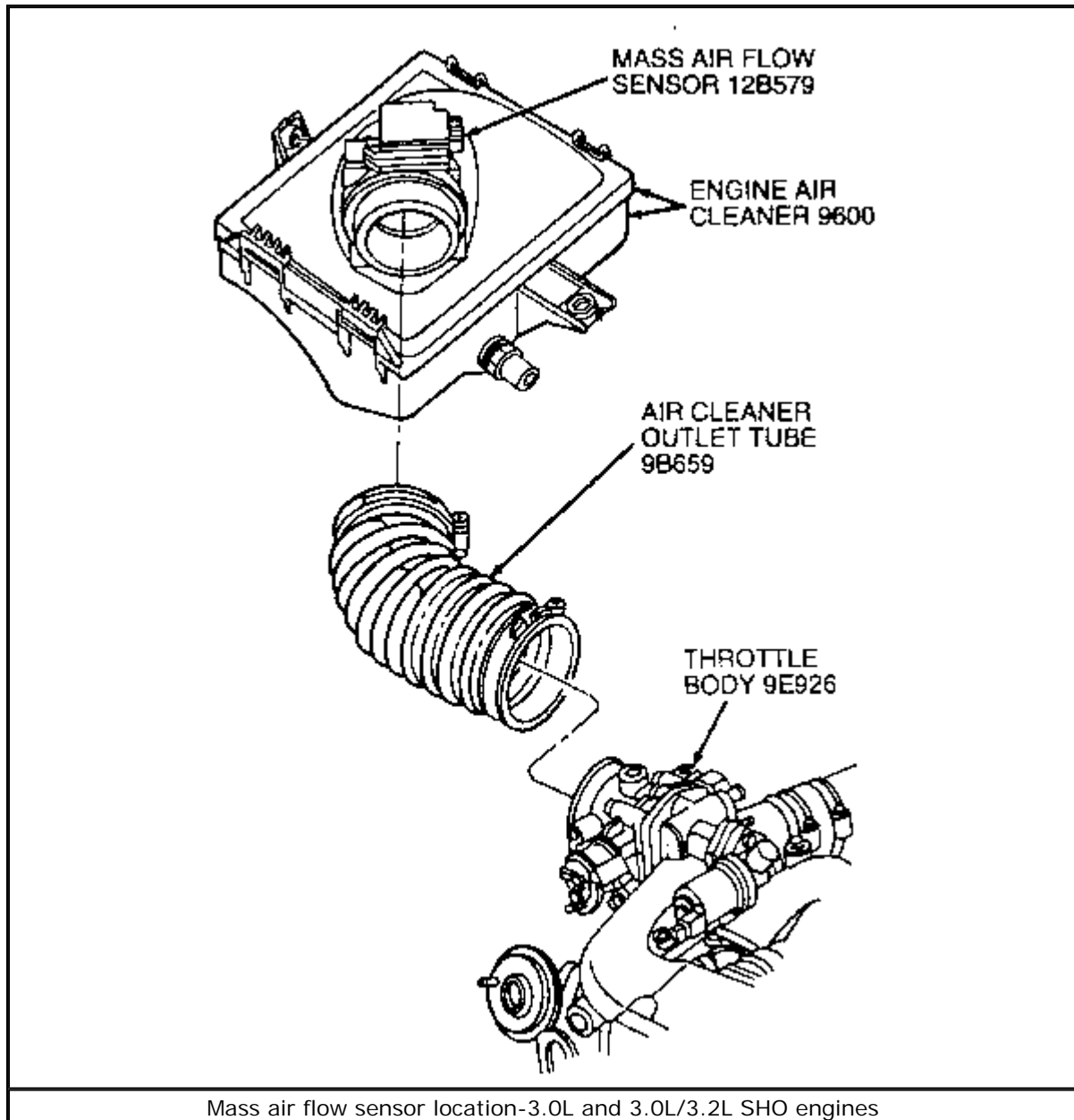
1. Disconnect the negative battery cable.
2. Remove the air cleaner outlet tube by loosening the retaining clamps, then tag and disconnect any hoses or tubes.
3. Disengage the engine control sensor wiring connector from the mass air flow sensor.
4. Remove the four retaining bolts, then carefully remove the sensor from the vehicle.
5. Discard the mass air flow gasket.

To install:

6. Position the mass air flow sensor with a new gasket onto the air cleaner cover.
7. Install the four retaining bolts, then tighten them to 25 inch lbs. (3 Nm).
8. Install the air cleaner outlet tube by aligning the white identification mark on the

tube with the tube stop on the throttle body, then tighten the retaining clamps to 24-48 inch lbs. (2.7-5.4 Nm).

9. Engage the engine control sensor wiring connector to the mass air flow sensor.
10. Connect the negative battery cable, then start the engine and check for vacuum leaks.



[Click to enlarge](#)

3.0L AND 3.2L SHO ENGINES

1. Disconnect the negative battery cable.
2. Remove the air cleaner outlet tube from the throttle body and the mass air flow sensor.
3. Disengage the engine control sensor wiring connector from the mass air flow sensor.
4. Remove the air cleaner cover from the air cleaner assembly.

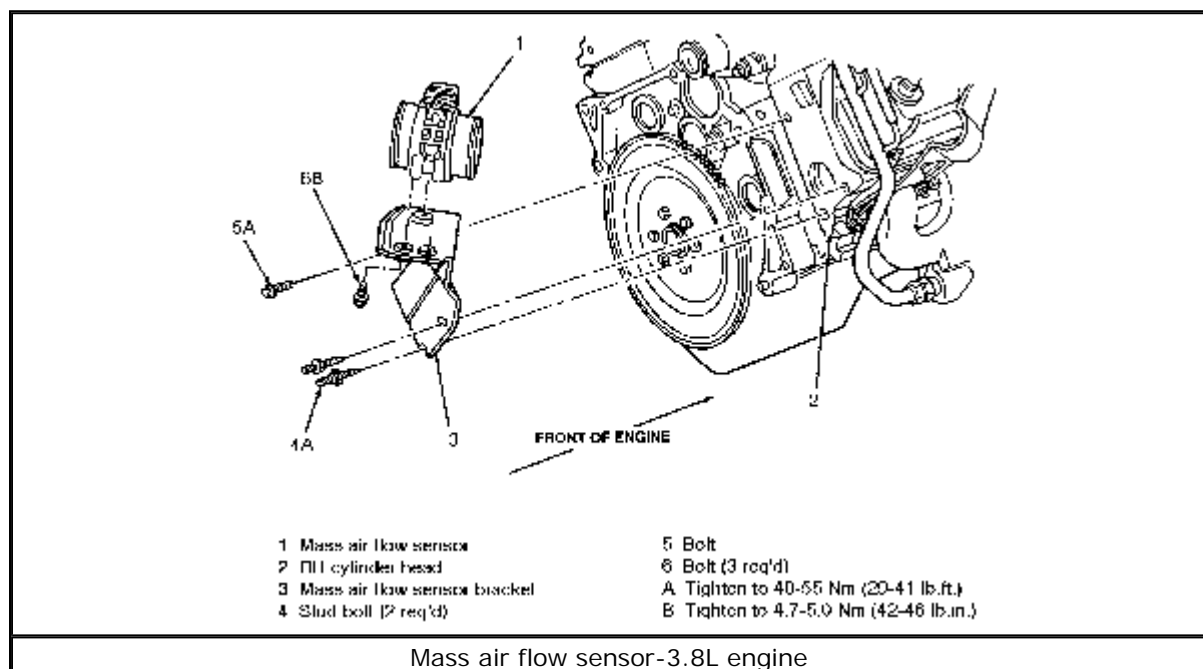
5. Loosen the sensor-to-air cleaner cover seal clamp.
6. Remove the sensor retaining screws from the air cleaner cover, then remove the mass air flow sensor.

To install:

7. Install the mass air flow sensor and fasten using the retaining screws. Tighten the screws to 71-102 inch lbs. (8-11 Nm).
8. Secure the sensor-to-air cleaner cover seal clamp, then install the cover onto the air cleaner assembly.
9. Engage the engine control sensor wiring connector to the mass air flow sensor, then install the air cleaner outlet tube. Tighten the tube clamps to 12-18 inch lbs. (1.4-2.0 Nm).
10. Connect the negative battery cable.

3.8L ENGINE

1. Disconnect the negative battery cable.
2. Disengage the engine control sensor wiring connector from the mass air flow sensor.
3. Loosen the air cleaner tube clamps on the engine air outlet tube and the air cleaner outlet tube, then disconnect the tubes from the mass air flow sensor.
4. Remove the mass air flow sensor-to-mass air flow sensor bracket retaining bolt(s), then remove the sensor.



[Click to enlarge](#)

To install:

5. Install the sensor to the bracket and fasten using the retaining bolt(s). Tighten the bolt(s) to 42-46 inch lbs. (4.7-5.0 Nm).
6. Connect the air cleaner tubes to the mass air flow sensor, and tighten the clamps

to 12-22 inch lbs. (1.4-2.5 Nm).

7. Engage the engine control sensor wiring connector to the mass air flow sensor.
8. Connect the negative battery cable.

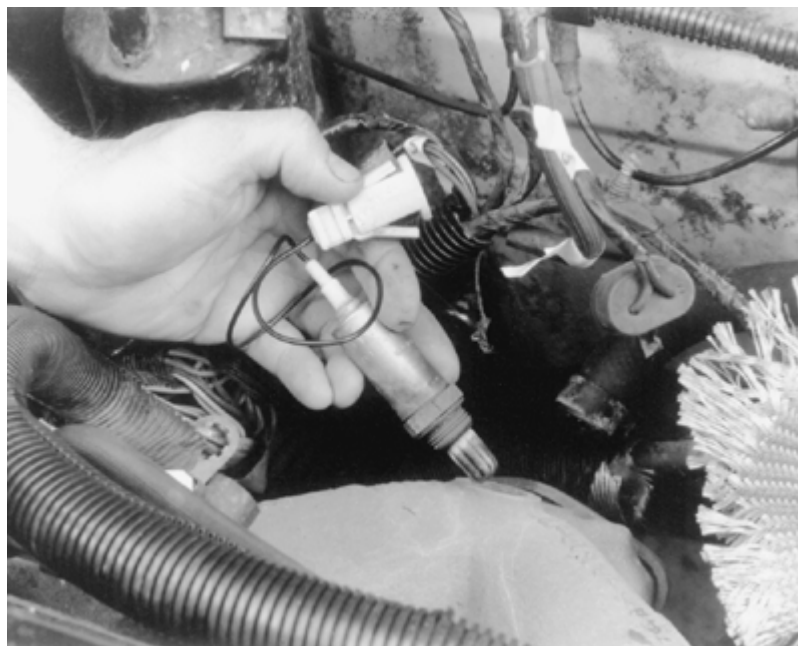
Heated Oxygen Sensor (HO₂S)

The oxygen sensor supplies the PCM with a signal which indicates a rich or lean condition during engine operation. This input information assists the PCM in determining the proper air/fuel ratio. The heated oxygen sensor is threaded into the exhaust manifold on 2.5L engines. It is threaded in the Y-pipe on the 3.0L and 3.0L/3.2L SHO engines. Early model 3.8L engines utilize a heated oxygen sensor threaded on the left-hand side exhaust pipe. Later model 3.8L engines utilize two heated oxygen control sensors for the engine control system, one located on the left-hand exhaust manifold, and the other located on the Y-pipe.

1. Disconnect the negative battery cable.
2. If necessary, raise and safely support the vehicle.
3. Disengage the heated oxygen sensor(s) from the engine control sensor wiring.



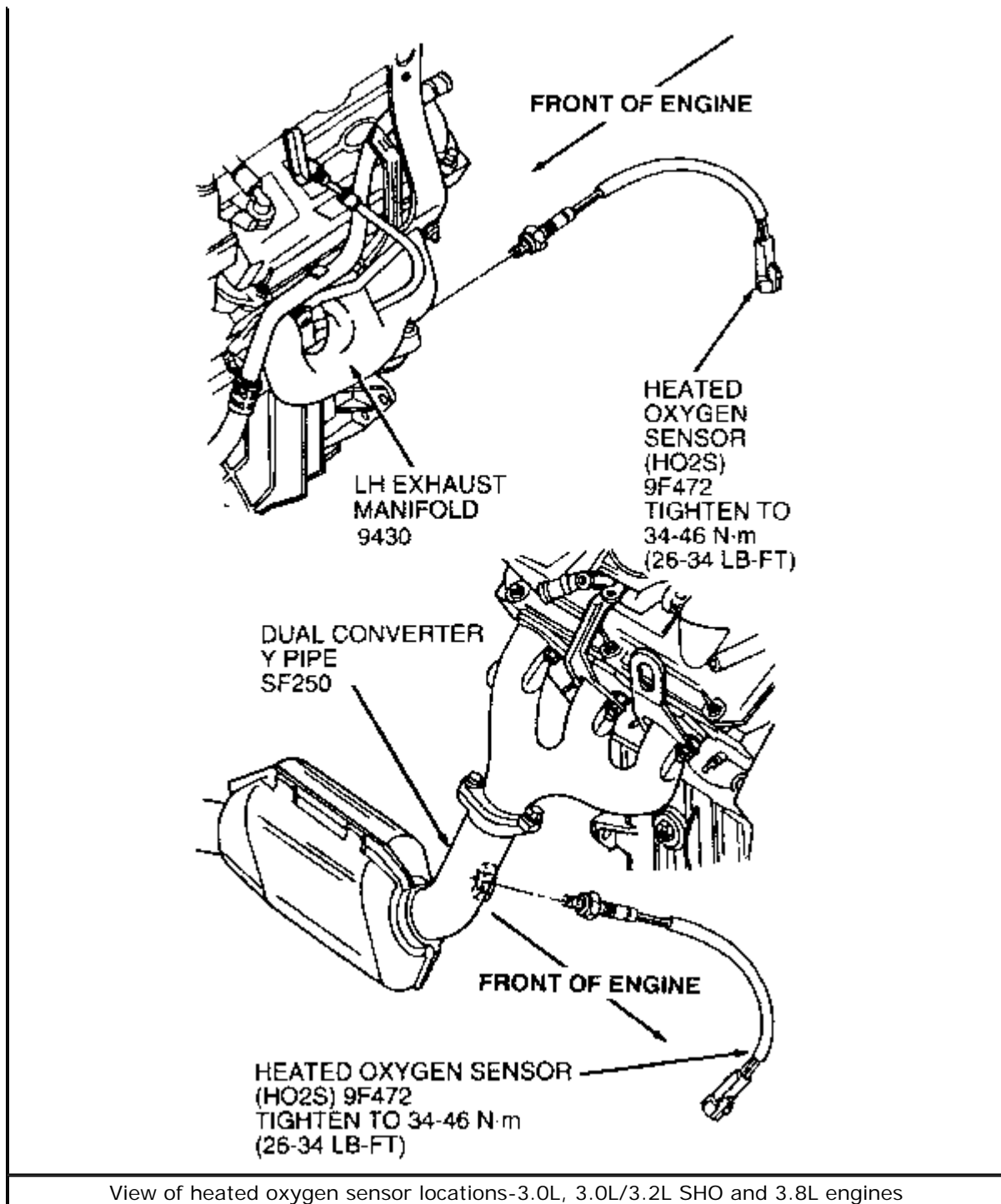
After disengaging the electrical connector, unscrew the heated oxygen sensor-2.5L engine shown



Remove the heated oxygen sensor from the vehicle-2.5L engine shown

If the heated oxygen sensor is difficult to take off, put a few drops of penetrating oil around the sensor to aid in removal.

- 4. Using Oxygen Sensor Wrench T94P-9472-A, or equivalent, remove the heated oxygen sensor(s) from the left-hand exhaust manifold and/or Y-pipe, as applicable.**



[Click to enlarge](#)

To install:

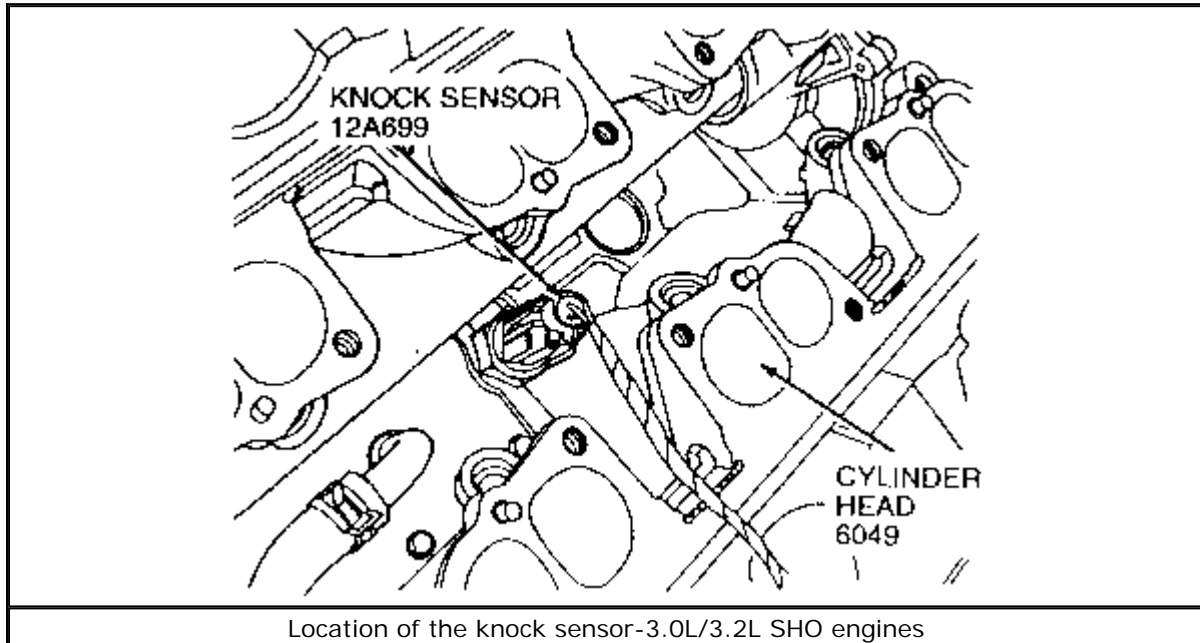
5. Install the sensor(s) to the exhaust manifold and/or Y-pipe, as applicable.
6. Engage the engine control sensor wiring connector(s) to the heated oxygen sensor(s).
7. If raised, carefully lower the vehicle, then connect the negative battery cable.

Knock Sensor

3.0L and 3.2L SHO ENGINES

The knock sensor detects spark knock or detonation, and if found, sends a signal to the PCM. After the PCM receives this signal, it will retard ignition timing as necessary to eliminate the knock/detonation. The knock sensor is located under the intake manifold and fuel injection rails.

1. **Disconnect the negative battery cable.**
2. **Disengage the engine control sensor wiring connector from the knock sensor.**
3. **Carefully unthread the sensor, then remove it from the engine.**



[Click to enlarge](#)

To install:

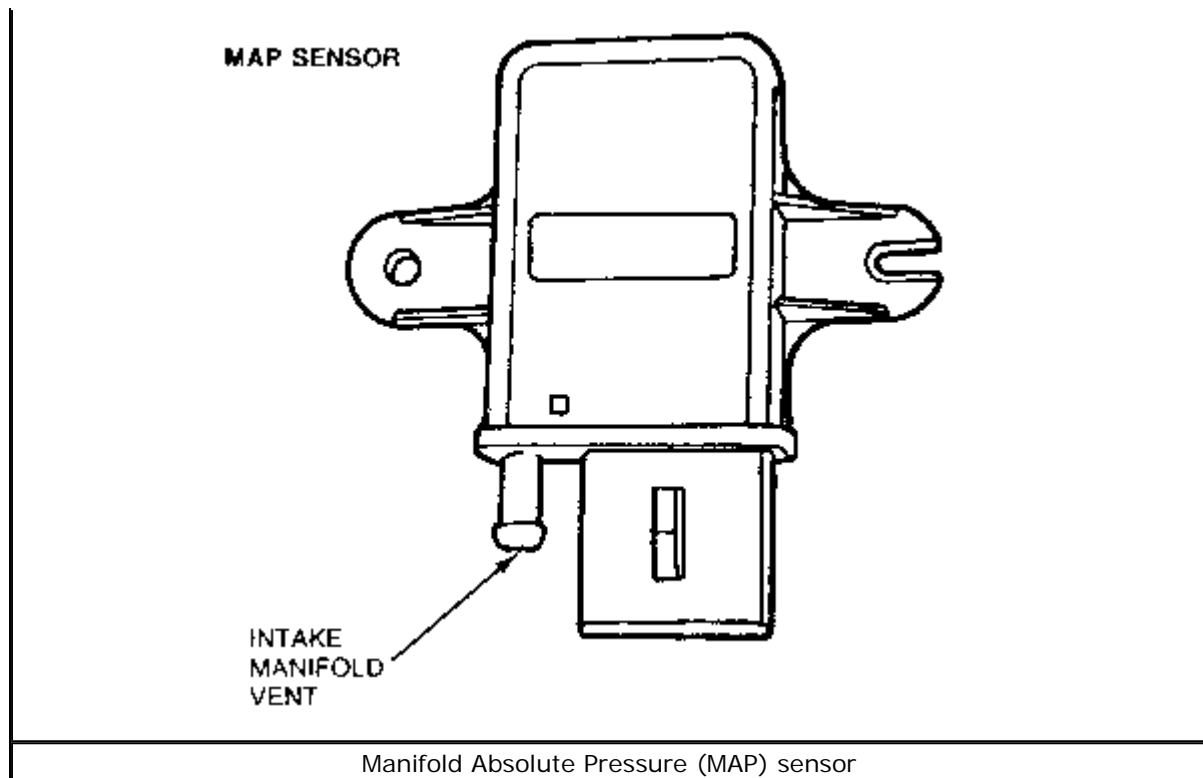
4. **Install the sensor, then tighten it to 21-29 ft. lbs. (29-7 Nm).**
5. **Engage the electrical connector, then connect the negative battery cable.**

Manifold Absolute Pressure (MAP) Sensor

The MAP sensor measures changes in manifold vacuum, resulting from changes in engine load and speed, then converts this to a voltage output. This gives the PCM information on engine load. It is used as a barometric sensor for altitude compensation, updating the PCM during key ON, engine OFF and every wide-open throttle. The PCM uses the MAP sensor for spark advance, EGR flow and air/fuel ratio.

1. **Disconnect the negative battery cable.**
2. **Disengage the electrical connector and the vacuum line from the sensor.**
3. **Unfasten the sensor mounting bolts, then remove the sensor.**





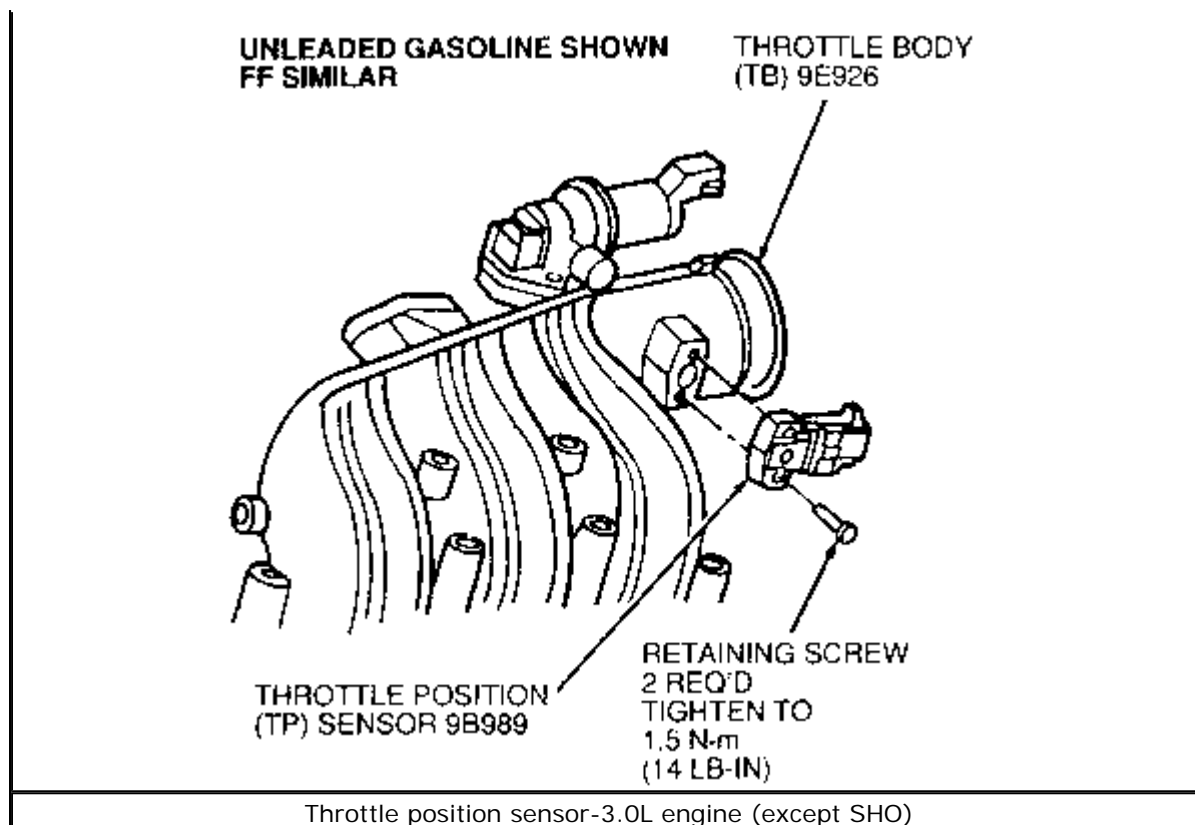
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To install:

4. Install the MAP sensor using the retaining bolts.
5. Engage the vacuum line and the electrical connector to the sensor.
6. Connect the negative battery cable.

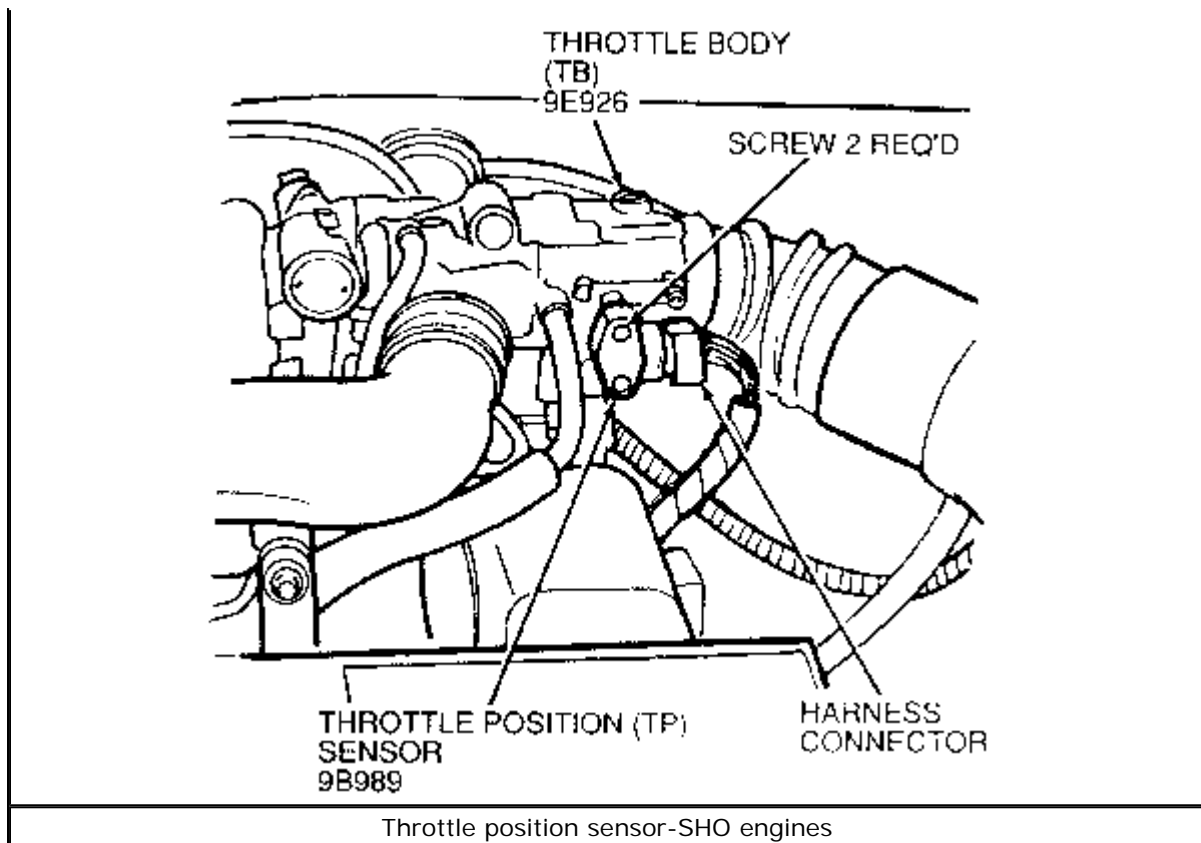
Throttle Position (TP) Sensor

The TP sensor is mounted to the throttle shaft and is used to supply a voltage output change proportional to the change in the throttle position. It is used by the ECU to determine engine operation mode: closed throttle, part throttle and wide-open throttle. The proper fuel mixture, spark and EGR will be output only when the operation mode has been determined correctly.



[Click to enlarge](#)

1. Disconnect the negative battery cable.
2. Make scribe marks on the throttle body and the throttle position sensor to indicated proper alignment during installation.
3. Disengage the electrical connector from the throttle position sensor.
4. Unfasten the mounting screws, then remove the sensor.



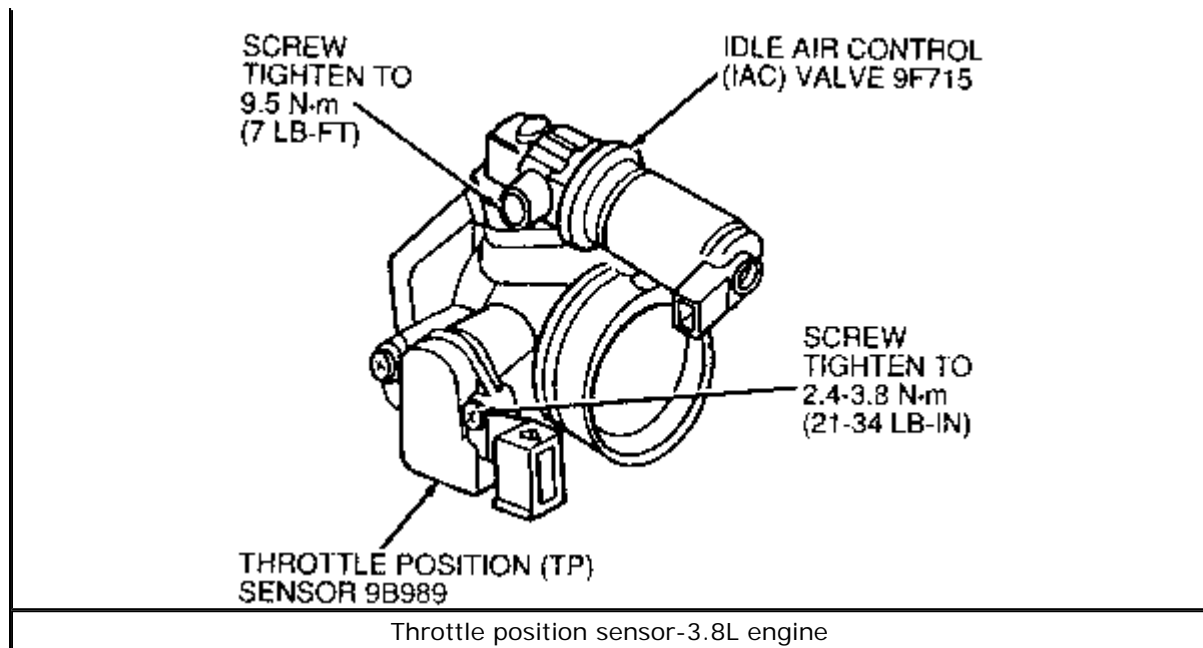
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To install:

5. Install the throttle position sensor. Make sure that the rotary tangs on the sensor are in proper alignment and that the wires are pointing down.

Slide the rotary tangs into position over the throttle shaft blade, then rotate the TP sensor clockwise **ONLY** to the installed position. Failure to install the sensor in this way may result in excessive idle speeds.

6. Align the scribe marks on the throttle body and the TP sensor. Secure the sensor to the throttle body using the retaining screws.



[Click to enlarge](#)

7. Engage the throttle position sensor electrical connector.
8. Connect the negative battery cable.

Relay, Sensor, Switch, Module and Computer Locations

- A/C Clutch Cycling Pressure Switch (except SHO engine) is at the right rear of the engine compartment, mounted on A/C accumulator.
- A/C Clutch Cycling Pressure Switch (SHO engine) is at the right front of the engine, mounted on the A/C accumulator.
- Air Bag Backup Power Supply is behind the right instrument panel, right side of the glove box.
- Air Bag Diagnostic Module is behind the center of the instrument panel.
- Air Bag Rear Sensor is inside the left kick panel.
- Air Charge Temperature Sensor (2.5L engine) is on the left rear of the intake manifold.
- Air Charge Temperature Sensor (3.0L engine) is on the top of the engine.
- Air Charge Temperature Sensor (SHO engine) is on the left side of the engine, in the air cleaner.
- Alternator Output Control Relay is between the right front inner fender and the fender splash shield.
- Ambient Temperature Sensor is at the left front of the engine compartment on the left side of the radiator.
- Anti-Lock Brake Control Module (except SHO engine) is at the right fender apron.
- Anti-Lock Brake Control Module (SHO engine) is at the lower left front of the engine compartment.
- Anti-Lock Brake Diode is on the left rear corner of the engine compartment, taped to the wiring harness.
- Anti-Lock Motor Relay is on the lower left front of the engine compartment.

- Anti-Lock Power Relay is at the left rear corner of the engine compartment.
- Anti-Lock Test Connector is at the left rear corner of the engine compartment.
- Autolamp Dual Coil Relay is behind the center of the instrument panel, mounted on a brace.
- AXOD Speed Sensor and Torque Converter Solenoid is at the lower left rear of the engine.
- Barometric Absolute Pressure (BAP) Sensor is on the right side of the firewall.
- Blower Motor Resistors are behind the right side of the instrument panel, inside the heater plenum.
- Brake Fluid Level Sensor is at the lower left front of the engine compartment.
- Brake Lamp Switch is behind the left-side instrument panel, on the pedal support.
- Camshaft Position Sensor is on the right side of the engine.
- Canister Purge Solenoid (2.5L, 3.0L and 3.8L engine) is on the left front side of the engine.
- Canister Purge Solenoid (SHO engine) is at the left side of the radiator support.
- Center Line Forward Crash Sensor is at the top center of the radiator support.
- Clutch Interrupt Switch is on the clutch pedal support, behind the left instrument panel.
- Cold Engine Lockout Switch is at the top left rear of the engine.
- Cracked Windshield Sense Resistor is at the right front of the engine compartment, at the alternator output control relay.
- Crankshaft Position Sensor is at the lower right rear of the engine.
- Daytime Running Lamps (DRL) Module (Canadian vehicles) is at the lower left front of the engine compartment.
- Diagnostic Warning Module is behind the right instrument panel, above the glove box.
- Distributorless Ignition System (DIS) Module is on the right side of the engine.
- Door Ajar Switches are at the door handle assemblies within the respective doors.
- Driver's Seat Belt Switch is within the left front seat belt assembly.
- Dual Brake Warning Switch is at the left rear of the engine compartment, within the brake master cylinder.
- EGR Vacuum Regulator Solenoid (2.5L and 3.0L engine) is at the right side of the engine compartment at the shock tower.
- EGR Vacuum Regulator Solenoid (SHO engine) is at the left rear of the engine compartment.
- Electronic Automatic Temperature Control (EATC) Module is behind the center of the instrument panel.
- Electronic Engine Control (EEC) Module is in the engine compartment, on the right side of the firewall.
- Engine Coolant Temperature Sensor (2.5L engine) is at the left rear of the engine, below the manifolds.
- Engine Coolant Temperature Sensor (3.0L, 3.8L and SHO engine) is at the top left side of the engine.

- Fan Dropping Resistor (2.5L and 3.0L engine) is at the left front of the engine.
- Fan Dropping Resistor (SHO engine) is at the center of the firewall.
- Fog Light Relay is behind the center of the instrument panel, mounted on a brace.
- Fog Light Fuse is behind the left side of the instrument panel, near the fuse panel.
- Forward Crash Sensor is inside the lower front of each front fender.
- Fuel Pump is inside the fuel tank.
- Fuel Sender is the inside fuel tank.
- Fuse Panel is behind the left lower instrument panel.
- Heated Exhaust Gas Oxygen (HEGO) Sensor #1 (2.5L engine) is at the center rear of the engine in the exhaust manifold.
- Heated Exhaust Gas Oxygen (HEGO) Sensor #1 (3.0L engine) is at the lower right front of the engine in the exhaust manifold.
- Heated Exhaust Gas Oxygen (HEGO) Sensor #1 (3.8L engine) is at the center rear of the engine in the exhaust manifold.
- Heated Exhaust Gas Oxygen (HEGO) Sensor #1 (SHO engine) is at the lower left rear of the engine in the exhaust manifold.
- Heated Exhaust Gas Oxygen (HEGO) Sensor #2 (3.8L engine) is at the lower right front of the engine in the exhaust manifold.
- Heated Exhaust Gas Oxygen (HEGO) Sensor #2 (SHO engine) is at the lower right front of the engine in the exhaust manifold.
- Heated Windshield Control Module is at the right side of the steering column, behind the instrument panel.
- Heated Windshield Test Connector is at the left rear of the engine compartment.
- Horn Relay is behind the center of the instrument panel, mounted on a brace.
- Idle Air Control is at the top rear of the engine.
- Idle Speed Control (2.5L engine) is at the top rear of the engine.
- Ignition Suppressor Resistor (2.5L engine) is on the left front of the engine, near the ignition coil.
- Ignition Suppressor Resistor (3.0L and 3.8L engine) is on the left side of the engine, near the ignition coil.
- Illuminated Entry Module (Sedan) is behind the rear seat, under the left side of the package tray.
- Illuminated Entry Module (Wagon) is inside the center of the left rear quarter panel.
- In Car Temperature Sensor is behind the top right side of the instrument panel.
- Inertia Switch (Sedan) is inside the front of the left rear quarter panel.
- Inertia Switch (Wagon) is inside the center of the rear quarter panel.
- Integrated Control Module is at the front of the engine compartment, on the radiator support.
- Interval Wiper/Washer Module is behind the center of the instrument panel, mounted on a brace.
- Key Warning Switch is contained within the ignition switch.
- Keyless Entry Module (Sedan) is behind the rear seat, under the left side of the

package tray.

- Keyless Entry Module (Wagon) is inside the center of the left rear quarter panel.
- Knock Sensor (except SHO engine) is at the center rear of the engine.
- Knock Sensor (SHO engine) is at the lower left front of the engine on the air cleaner assembly.
- LCD Dimming Relay is behind the center of the instrument panel, mounted on a brace.
- Liftgate Ajar Switch is at the lower center of the liftgate, part of the latch assembly.
- Liftgate Mercury Switch is inside the top of the liftgate.
- Liftgate Release Relay is at the right rear corner of the cargo area.
- Liftgate Release Solenoid is in the bottom of the liftgate.
- Light Sensor/Amplifier is attached to the underside of the right-side instrument panel.
- Low Oil Level Relay is behind the center of the instrument panel, mounted on a brace.
- Low Oil Level Switch (2.5L engine) is at the lower right rear of the engine.
- Low Oil Level Switch (3.0L, 3.8L and SHO engine) is at the lower center rear of the engine.
- Low Washer Fluid Level Switch is at the right front of the engine compartment, within the washer fluid reservoir.
- Luggage Compartment Mercury Switch is at the left front corner of the trunk lid, near the hinge.
- Manifold Absolute Pressure (MAP) Sensor is at the right side of the firewall.
- Mass Air Flow Sensor is on the top left side of the engine on the air cleaner assembly.
- Moonroof Relay is behind the right side of the instrument panel.
- Neutral Safety Switch is at the left side of the engine, on top of the transaxle.
- Oil Pressure Switch (2.5L engine) is at the center front of the engine, near the oil filter.
- Oil Pressure Switch (3.0L engine) is on the left side of the engine.
- Oil Pressure Switch (3.8L engine) is on the lower right side of the engine.
- Oil Pressure Switch (SHO engine) is at the lower left rear of the engine.
- Pedal Position Switch is behind the left side of the instrument panel, on the brake pedal support.
- Police Accessory Circuit Breaker is at the left side of the engine compartment, near the starter relay.
- Police Accessory Relay is behind the center of the instrument panel.
- Power Steering Pressure Switch is at the lower left rear of the engine.
- Pressure Feedback EGR Sensor (2.5L engine) is at the left rear of the engine.
- Pressure Feedback EGR Sensor (3.0L engine) is at the top right side of the engine.
- Pressure Feedback EGR Sensor (3.8L and SHO engine) is at the top left side of the engine.

- Radiator Coolant Sensor is at the right front of the engine compartment.
- Radio Noise Capacitor (2.5L and 3.0L engine) is at the left front of the engine, near the ignition coil.
- Radio Noise Capacitor (3.8L engine) is at the left rear of the engine, near the ignition coil.
- Radio Noise Capacitor (SHO engine) is at the top of the engine, at the left front.
- Rear Courtesy Lamp Diode is at the top left corner of the cargo compartment within the rear lamp harness.
- Rear Defogger Relay and Timer is inside the defogger switch housing.
- Reverse Switch is on the left side of the engine, on top of the transaxle.
- Self Test Input Connector is on the right rear of the engine compartment, near the EEC module.
- Shorting Plug #1 (2.5L engine) is at the center front of the engine.
- Shorting Plug #1 (3.0L engine) is at the left side of the engine.
- Shorting Plug #1 (3.8L engine) is at the right rear of the engine compartment.
- Shorting Plug #1 (SHO engine) is at the right rear side of the engine.
- Shorting Plug #2 (SHO engine) is at the center front of the engine compartment.
- Solenoid Control Valve Body is at the lower left front of the engine compartment.
- Speed Control Servo is on the left side of the engine compartment, on the shock tower.
- Starter Relay is on the left front fender apron, in front of the shock tower.
- Stop Lamp Switch is behind the left-side instrument panel, on the pedal support.
- Sunload Sensor is behind the top left side of the instrument panel.
- TFI Ignition Module (2.5L engine) is at the center front of the engine.
- TFI Ignition Module (3.0L engine) is at the top left side of the engine, connected to the distributor assembly.
- TFI Ignition Module (3.8L engine) is on the right side of the firewall.
- Throttle Position Sensor (2.5L engine) is at the rear center of the engine, on the right side of the injection assembly.
- Throttle Position Sensor (3.0L engine) is on the top left side of the engine.
- Throttle Position Sensor (3.8L engine) is on the top center of the engine.
- Throttle Position Sensor (SHO engine) is on the top left side of the engine compartment.
- Trunk Release Solenoid is at the right rear of the trunk lid, part of the trunk latch assembly.
- Variable Assist Power Steering (VAPS) Module is at the right side of the steering column, behind the instrument panel.
- Variable Assist Power Steering (VAPS) Test Connector is at the left rear of the engine compartment.
- Variable Assist Stepper Motor is at the lower left rear of the engine.
- Vehicle Speed Sensor (2.5L engine) is on the left rear of the transaxle.
- Vehicle Speed Sensor (3.0L, 3.8L engine) is at the center rear of the engine.

- **Vehicle Speed Sensor (SHO engine) is at the lower left rear of the engine or mounted on the transaxle.**
 - **VIP Self-Test Output Connector is at the right rear of the engine compartment, near the EEC module.**
 - **Voltage Regulator is on the left front fender apron.**
 - **Warning Chime Module is behind the lower left instrument panel.**
 - **Window Safety Relay is behind the right kick panel.**
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