AIR POLLUTION

Introduction

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

Certain 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 be concentrated in a specific area and under the right conditions, death could result due to the displacement or chemical change of the oxygen content in the air. These pollutants can cause much 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 before man appeared, and is still a factor to be considered when discussing air pollution, although it causes only a small percentage of the present overall pollution problem existing in our country. It is the direct result of decaying organic matter, wind born smoke and particulates from such natural events as plains 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 recent 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, where 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 traveled on their journey, the smoke dissipates into the atmosphere while the ash and moisture settle back to earth in a trail hundred of miles long. In many cases, lives are lost and millions of dollars of property damage result, and ironically, man can only stand by and watch it happen.

Industrial Pollutants

Industrial pollution is caused primarily by industrial processes, the burning of coal, oil and natural gas, which in turn produces smoke and fumes. Because the burning fuels contain much sulfur, the principal ingredients of smoke and fumes are sulfur dioxide (SO_2) 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 rules, regulations and by carefully monitoring the emissions, industries have greatly reduced the amount of pollutant emitted from their 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 the automotive emissions. The emissions from the internal combustion engine 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 the transportation areas because the majority of the 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 much emphasis placed on the individual vehicle per family member. As the increase in vehicle ownership and usage occurred, so did the pollutant levels in and around the cities, as the suburbanites drove daily to their businesses and employment in the city and its fringe area, returning at the end of the day to their homes in the suburbs.

It was noted that a fog and smoke type haze was being formed and at times, remained in suspension over the cities and did not quickly dissipate. At first this "smog'', derived from the words "smoke'' and "fog'', was thought to result from industrial pollution but it was determined that the 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 and was developed when certain oxides of nitrogen (NOx) and unburned hydrocarbons (HC) from the automobile emissions are exposed to sunlight. Pollution was more severe when the smog would become stagnant over an area in which a warm layer of air would settle over the top of a cooler air mass at ground level, trapping and holding the automobile emissions, instead of the emissions 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, the surface air is warmed by the heat radiating from the earth's surface and the sun's rays and will rise upward, into the atmosphere, to be cooled through a convection type heat expands with the cooler upper air. As the 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 warmer than the surface air, causing the cooler surface air to become trapped and unable to move. 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 only the smog level rising or lowering from ground level to a few hundred feet high. Meanwhile, the pollutant levels increases, causing eye irritation, respirator problems, reduced visibility, plant damage and in some cases, cancer type diseases.

This inversion phenomenon was first noted in the Los Angeles, California area. The city lies in a basin type of terrain and during 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 smog 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.

Internal Combustion Engine Pollutants

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 by putting in air and fuel, we obtain power from this mixture 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 concern ourselves.

Heat Transfer

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 having a liquid coolant solution surrounding the combustion area and transferring the heat of combustion through the cylinder walls and into the coolant. The coolant is then directed to a thin-finned, multi-tubed radiator, from which the excess heat is transferred to the outside air by 1 or all 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 along with the exhaust gases and into the exhaust system.

Many attempts have been made to minimize the amount of unburned fuel in the combustion chambers due to the snuffing out or quenching, by increasing the coolant temperature and lessening the contact area of the coolant around the combustion area. 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.

EXHAUST EMISSIONS

Composition Of The 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 review some basic chemistry.

When the air/fuel mixture is introduced into the engine, we are mixing air, composed of nitrogen (78%), oxygen (21%) and other gases (1%) with the fuel, which is 100% 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 pollutants are formed and are considered dangerous. These pollutants are carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NOx) oxides of sulfur (SOx) and engine particulates.

HYDROCARBONS

Hydrocarbons (HC) are essentially unburned fuel that have not been successfully burned during the combustion process or have 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 come from the vehicle's fuel tank and carburetor 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 more lean through improved carburetion, fuel injection 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 an air injection system, to inject fresh air into the exhaust manifolds and the installation of a catalytic converter, a unit that is able to burn traces of hydrocarbons without affecting the internal combustion process or fuel economy.

To control hydrocarbon emissions through fuel evaporation, modifications were made to the fuel tank and carburetor bowl to allow storage of the fuel vapors during periods of engine shut-down, and at specific times during engine operation, to purge and burn these same vapors by blending them with the air/fuel mixture.

CARBON MONOXIDE

Carbon monoxide is formed when not enough oxygen is present during the combustion process to convert carbon (C) to carbon dioxide (CO_2). 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 (NO_2). To accomplish this, carbon monoxide (CO) combines with oxygen (O_2) and nitrogen dioxide (NO_2) to produce carbon dioxide (CO_2) and nitrogen dioxide (NO_2). ($CO + O_2 + NO = CO_2 + NO_2$).

The dangers of carbon monoxide, which is an odorless, 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 being 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 (NOx) emission.

Oxides of nitrogen (NOx) are composed of approximately 97-98% 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 (NO_2). 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 (NO_2) is broken apart by the sunlight to form nitric oxide and oxygen. (NO_2 + sunlight = NO + O). This single atom of oxygen then combines with diatomic (meaning 2 atoms) oxygen (O_2) to form ozone (O_3). 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, acting 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. Recently, different types and better quality insulating materials have lengthened the life of the electrical cables.

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 (16-32km) 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.

There is much discussion concerning the ozone layer and its density. A feeling exists that this protective layer of ozone is slowly diminishing and corrective action must be directed to this problem. Much experimenting is presently being conducted to determine if a problem exists and if so, the short and long term effects of the problem and how it can be remedied.

OXIDES OF SULFUR

Oxides of sulfur (SOx) were initially ignored in the exhaust system emissions, since the sulfur content of gasoline as a fuel is less than $^{1}/_{10}$ of 1%. 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 pollutions and the introduction of catalytic converter to the automobile exhaust systems, a change was mandated. The automobile exhaust system, when equipped with a catalytic converter, changes the sulfur dioxide (SO_2) into the 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 and is extremely corrosive. This sulfuric acid mist that is formed, is the same mist that rises from the vents of an automobile storage 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 will rise and be distributed over a large ground area causing land, plant, crop, paints 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 percentage of particulates is 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 wears 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 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 a "like new'' condition 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 particular emission.

Good grades of engine lubricating oils should be used, meeting the manufacturers 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 emissions of particulate matter.

The cooling system is an important factor in the reduction of particulate matter. With the cooling system operating at a temperature specified by the manufacturer, the optimum of combustion will occur. 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.

Other Automobile Emission Sources

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

CRANKCASE EMISSIONS

Crankcase emissions are made up of water, acids, unburned fuel, oil fumes and particulates. The 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 during the compression and power strokes, between the cylinder walls and piston rings. The head of the compression and combustion help to form the remaining crankcase emissions.

Since the first engines, crankcase emissions were allowed to go into the air 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 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 type 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, soots, resins, acids and lead salts, resulting in the formation of sludge and varnishes. This condensation of the blow-by gases occur 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. The crankcase purge control or PCV system will be described in detail later in this section.

FUEL 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 redesigning of the storage areas and venting systems, the pollution factor has been diminished but not eliminated, from the refinery standpoint. However, the automobile still remained the primary source of vaporized, unburned hydrocarbon (HC) emissions.

Fuel pumped form an underground storage tank is cool, but when exposed to a warmer ambient temperature, it will expand. Before controls were mandated, an owner would 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 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.

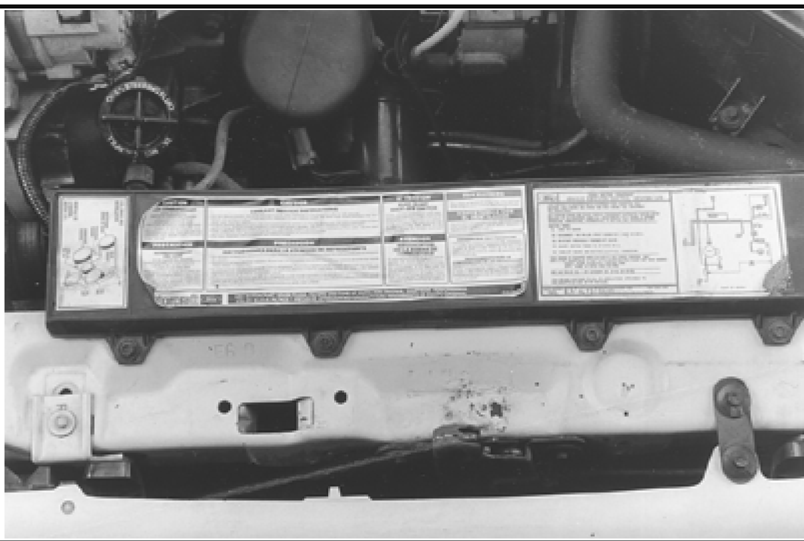
However, this did not control the fuel vapor emission from the fuel tank and the carburetor bowl. It was determined that most of the fuel evaporation occurred when the vehicle was stationary and the engine not operating. Most vehicles carry 5-25 gallons (19-95 liters) of gasoline. Should a large concentration 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 system is designed to trap the fuel vapors while the vehicle is stationary, by sealing the fuel system from the atmosphere. A storage system is used to collect and hold the fuel vapors from the carburetor and 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.

EMISSION CONTROLS

Introduction

There are three sources of automotive pollutants: crankcase fumes, exhaust gases and gasoline evaporation. The pollutants formed from these substances can be grouped into three categories: unburned hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NO_x). The equipment that is used to limit these pollutants is commonly called emission control equipment.



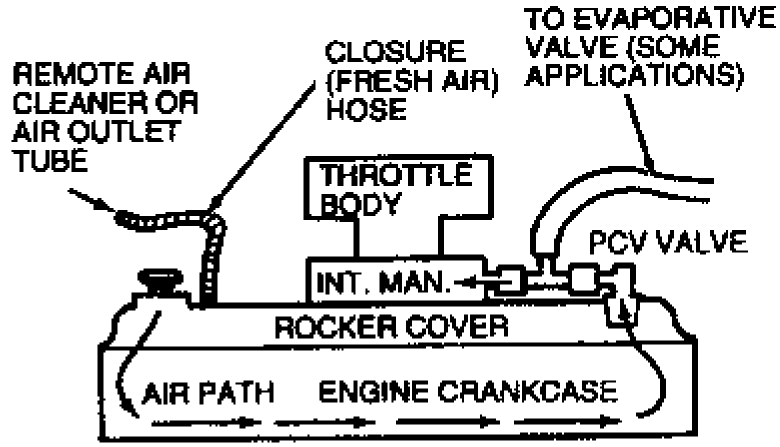
The vehicle emission control information label includes instructions for engine control system adjustment

Positive Crankcase Ventilation (PCV) System

OPERATION

The Positive Crankcase Ventilation (PCV) system is used on all vehicles covered by this manual. The PCV system vents harmful combustion blow-by fumes from the engine crankcase into the engine air intake for burning with the fuel and air mixture. The PCV system maximizes oil cleanliness by venting moisture and corrosive fumes from the crankcase.

All of the vehicles covered by this manual, except for the 3.0L and the 3.2L SHO engines, utilize a PCV valve. The PCV valve limits the fresh air intake to suit the engine demand and also serves to prevent combustion backfiring into the crankcase. The PCV valve controls the amount of blow-by vapors pulled into the intake manifold from the crankcase. It also acts as a one-way check valve that prevents air from entering the crankcase in the opposite direction.



Positive Crankcase Ventilation (PCV) system schematic-except SHO vehicles

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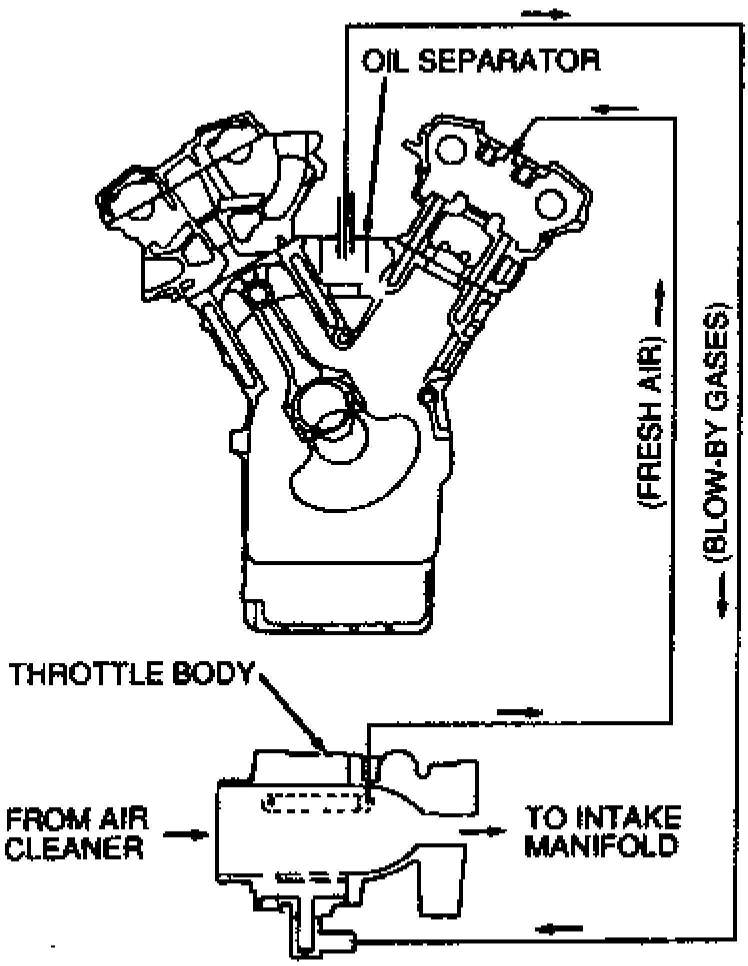
The PCV system on the SHO vehicles is unique because is does not use a PCV valve. Instead, the crankcase gases flow through an oil separator to three ports in the throttle body. Fresh air for the PCV system is supplied from another port on the throttle body to the cylinder head cover. Under various throttle conditions, the air and crankcase gases flow differently through the ports in the throttle body.



Positive Crankcase Ventilation (PCV) system schematic-3.0L and 3.2L SHO vehicles

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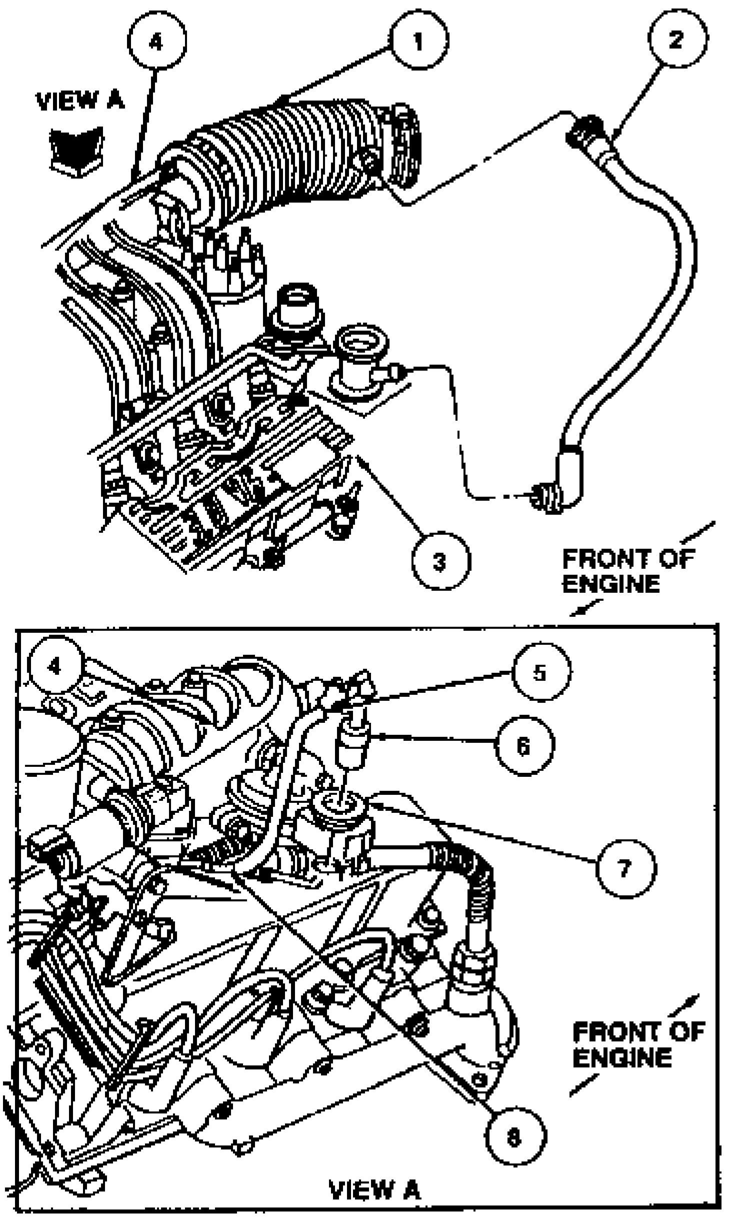
On some engine applications, the PCV system is connected with the evaporative emission system. Do not remove the PCV system from the engine, as doing so will adversely affect fuel economy and engine ventilation, with resultant shortening of engine life.

The components used in the PCV valve system consist of the PCV valve (or tube as in SHO applications), the rubber mounting grommet in the valve cover, the nipple in the air intake system and the necessary connecting hoses.



Item	Part Number	Description
1	9B659	Air Cleaner Outlet Tube
2	6853	Crankcase Ventilation Hose
3	6582	Valve Cover
4	9E926	Throttle Body
5	6853	Crankcase Ventilation Hose
6	6A666	Positive Crankcase Ventilation Valve
7	6A892	Crankcase Ventilation Grommet
8	9E926	Throttle Body

PCV system components-3.0L shown, 2.5L similar

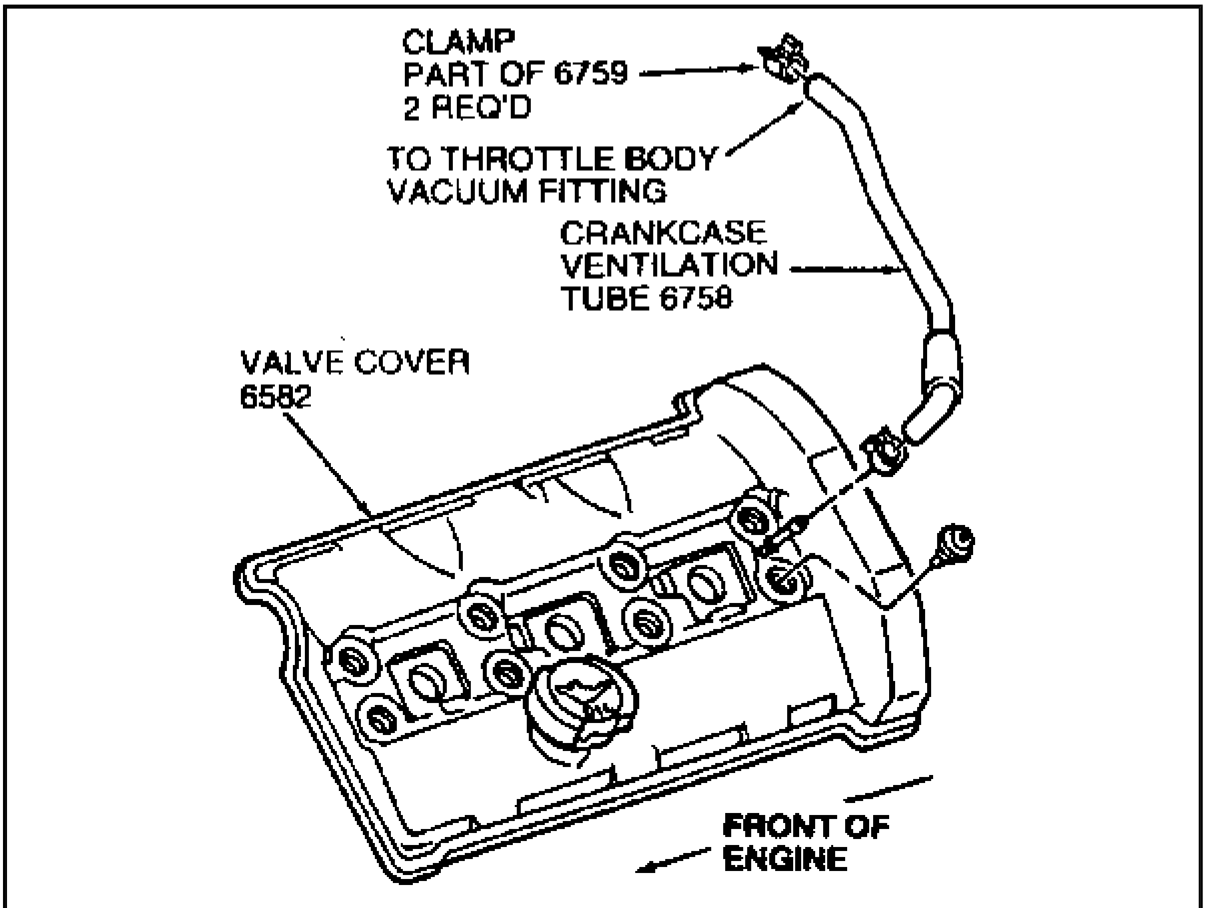
Click to enlarge

SYSTEM INSPECTION

1. **Visually inspect the components of the PCV system. Check for rough idle, slow**

starting, high oil consumption and loose, leaking, clogged or damaged hoses.

2. Check the fresh air supply hose and the PCV hose for air leakage or flow restriction caused by loose engagement, hose splitting, cracking, kinking, nipple damage, poor rubber grommet fit or any other damage.
3. If a component is suspected as the obvious cause of a malfunction, correct the cause before proceeding to the next step.
4. If all checks are okay, proceed to the pinpoint tests.



PCV system and related components-3.0L and 3.2L SHO vehicles

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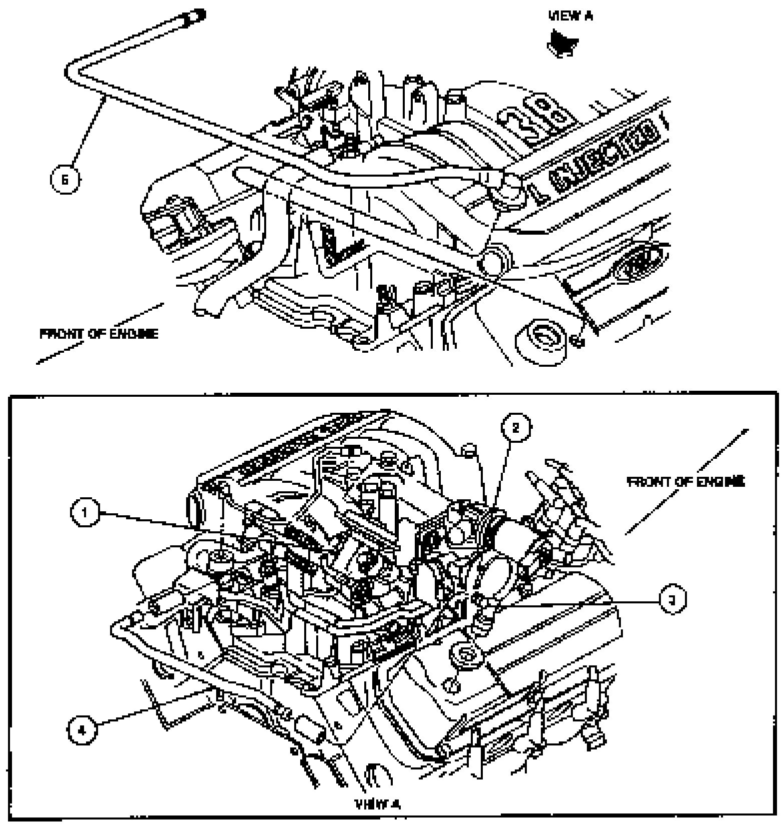
PINPOINT TESTS

1. Remove the PCV valve from the valve cover grommet and shake the valve. If the valve rattles when shaken, reinstall and proceed to Step 2. If the valve does not rattle, it is sticking and should be replaced.
2. Start the engine and bring to normal operating temperature.
3. On the 2.5L engine, remove the corrugated hose from the oil separator nipple. On all other engines, disconnect the hose from the remote air cleaner or air outlet tube.
4. Place a stiff piece of paper over the nipple or hose end and wait 1 minute. If vacuum holds the paper in place, the system is okay; reconnect the hose. If the paper is not held in place, the system is plugged or the evaporative emission valve, if so equipped, is leaking. If the evaporative emission valve is suspected of leaking, proceed to Step 5.
5. Disconnect the evaporative hose, if equipped, and cap the connector.

6. **Place a stiff piece of paper over the hose/nipple, as in Step 4 and wait 1 minute. If vacuum holds the paper in place, proceed to evaporative emission system testing. If the paper is not held in place, check for vacuum leaks/obstruction in the system: oil cap, PCV valve, hoses, cut grommets, the oil separator on the 2.5L engine and valve cover for bolt torque/gasket leak.**



Item	Part Number	Description
1	9D476	EGR Valve
2	9E926	Throttle Body
3	6A666	Positive Crankcase Ventilation Valve
4	6758	Crankcase Ventilation Tube
5	6853	Crankcase Ventilation Hose

PCV system and related components-3.8L shown

Click to enlarge

REMOVAL & INSTALLATION

1. **Remove the PCV valve from the mounting grommet in the valve cover.**
2. **Disconnect the valve from the PCV hose and remove the valve from the vehicle.**
3. **Installation is the reverse of the removal procedure.**

Evaporative Emission Control (EEC) System

OPERATION

The evaporative emission control system prevents the escape of fuel vapors to the atmosphere under hot soak and engine off conditions by storing the vapors in a carbon canister. Then, with the engine warm and running, the system controls the purging of stored vapors from the canister to the engine, where they are efficiently burned.

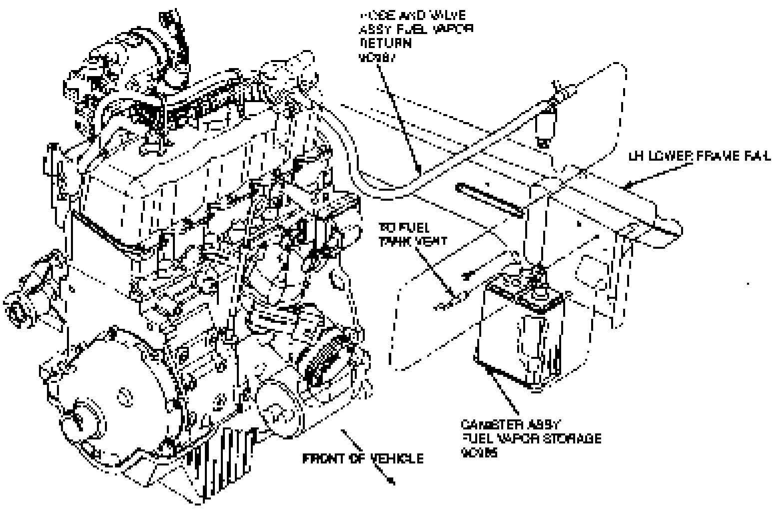
Evaporative emission control components consist of the carbon canister, purge valve(s), vapor valve, rollover vent valve, check valve and the necessary lines. All vehicles may not share all components.

The carbon canister contains vapor absorbent material to facilitate the storage of fuel vapors. Fuel vapors flow from the fuel tank to the canister, where they are stored until purged to the engine for burning.

The purge valves control the flow of fuel vapor from the carbon canister to the engine. Purge valves are either vacuum or electrically controlled. When electrically controlled, a purge valve is known as a purge solenoid. A vehicle may be equipped with a vacuum purge valve or purge solenoid or a combination of the two. Purging occurs when the engine is at operating temperature and off idle.

The vapor valve is located on or near the fuel tank. Its function is to prevent fuel from flooding the carbon canister. The vapor valve incorporates the rollover valve. In the event of a vehicle rollover, the valve blocks the vapor line automatically to prevent fuel leakage.

The check valve is located in the fuel filler cap or on the underside of the vehicle. Its function is to protect the fuel tank from heat build-up rupture and cool-down collapse by allowing air to pass in or out of the tank to equalize pressure. On cool-down, air enters either at the carbon canister vent or at the check valve.



EEC system for the 2.5L engine

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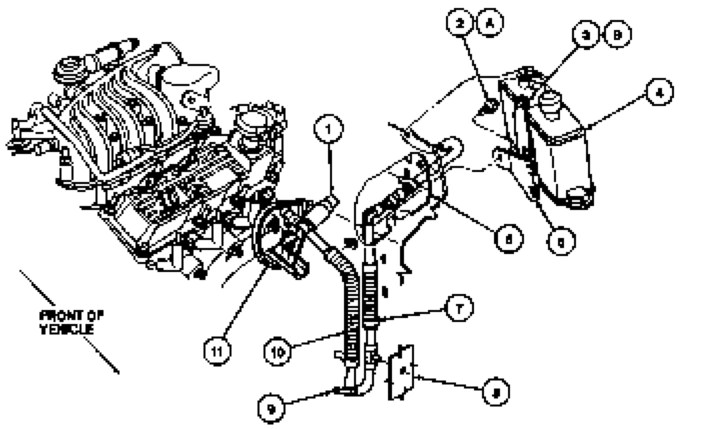
SYSTEM INSPECTION

1. **Visually inspect the components of the evaporative emission system. Check for the following, as applicable:**
   - **Discharged battery**
   - **Damaged connectors**
   - **Damaged insulation**
   - **Malfunctioning ECU**
   - **Damaged air flow meter or speed sensor**
   - **Inoperative solenoids**

- Fuel odor or leakage
- Damaged vacuum or fuel vapor lines
- Loose or poor line connections
- Poor driveability during engine warm-up

2. Check the wiring and connectors for the solenoids, vane air flow meter, speed sensor and ECU, as applicable, for looseness, corrosion, damage or other problems. This must be done with the engine fully warmed up so as to activate the purging controls.
3. Check the fuel tank, fuel vapor lines, vacuum lines and connections for looseness, pinching, leakage, damage or other obvious cause for malfunction.
4. If fuel line, vacuum line or orifice blockage is suspected as the obvious cause of an observed malfunction, correct the cause before proceeding further.



Item	Part Number	Description
1	9C915	Evaporative Emission Canister Purge Solenoid
2	N806888-S2	Bolt
3	N610608-S7	Nut
4	9D653	Evaporative Emissions Canister
6	9D664	Evaporative Emission Canister Bracket
8		L-H Headlamp Opening (Part of 16138)

Item	Part Number	Description
7	9K312	Evaporative Emission Tube
5	16138	Radiator Support
9	9A228	Fuel Tank Vent Tube (Part of 9K313)
10	9D687	Evaporative Emission Hose
11	95873	Tie Strap
A		Tighten to 21.2-28.8 N-m (15-21 Lb-Ft)
B	--	Tighten to 5.2-7.2 N-m (46-63 Lb-In)

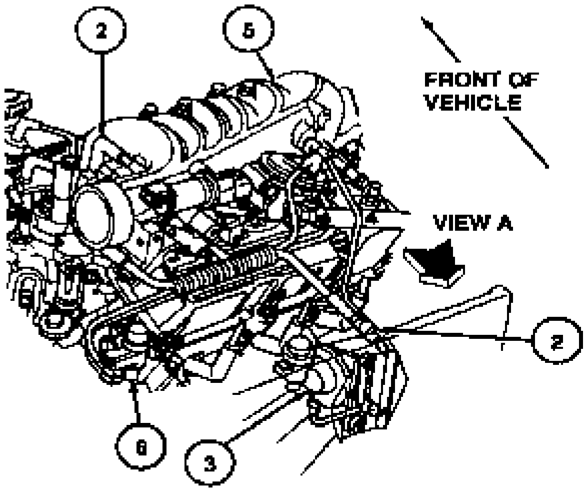
EEC system for the 3.0L engine (except SHO and Flexible Fuel)

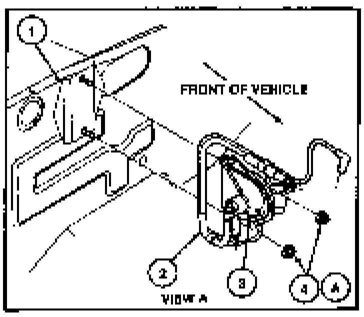
Click to enlarge

ADJUSTMENT

Carbon Canister

There are no moving parts and nothing to wear in the canister. Check for loose, missing cracked or broken connections and parts. There should be no liquid in the canister.

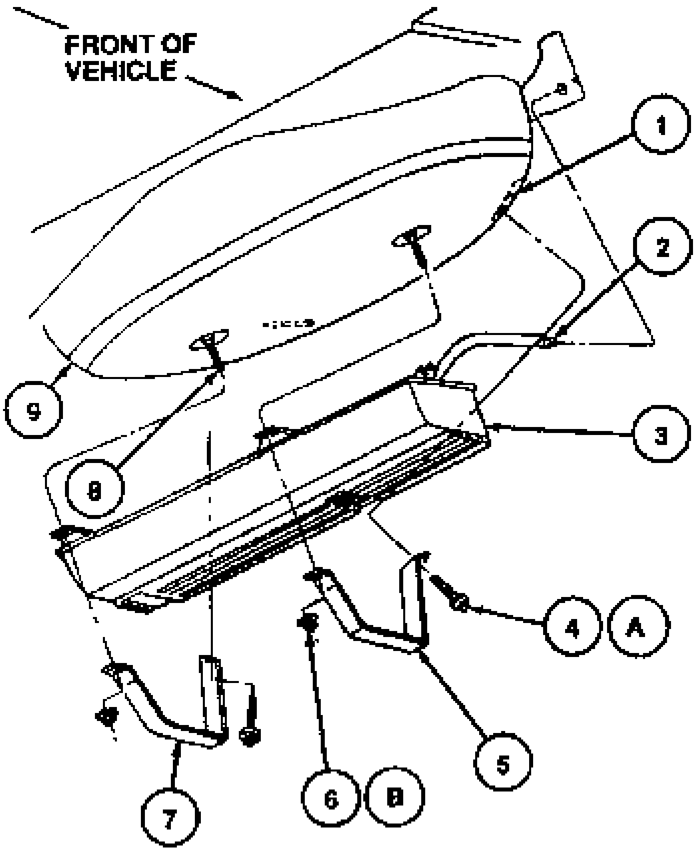




Item	Part Number	Description
1	01610	Dash Panel
2	9F480	Main Emission Vacuum Control Connector
3	9C915	Evaporative Emission Canister Purge Solenoid
4	[illegible]	Nut (2 Req'd)
5	9E926	Throttle Body
6	9J459	EGR Vacuum Regulator Control
A	—	Tighten to 7.8-10.4 N·m (69-92 Lb-In)

EEC system for the 3.0L Flexible Fuel (FF) engine

Click to enlarge



Item	Part Number	Description
1	N801658-S190	U-Nut (2 Req'd)
2	9J279	Fuel and Vapor Return Tube
3	9D653	Evaporative Emissions Canister
4	N804568-S190	Bolt (2 Req'd)
5	9D666	RH Evaporative Emission Canister Strap
6	N804796-S56	Nut (2 Req'd)
7	9D666	LH Evaporative Emission Canister Strap
8	14258	Stud (2 Req'd)
9	11215	Rear Floor Pan
A	—	Tighten to 40.3-54.7 N·m (30-40 Lb-Ft)
B	—	Tighten to 21.2-28.8 N·m (15-21 Lb-Ft)

The 3.0L Flexible Fuel vehicles utilize four canisters mounted under the rear floor pan

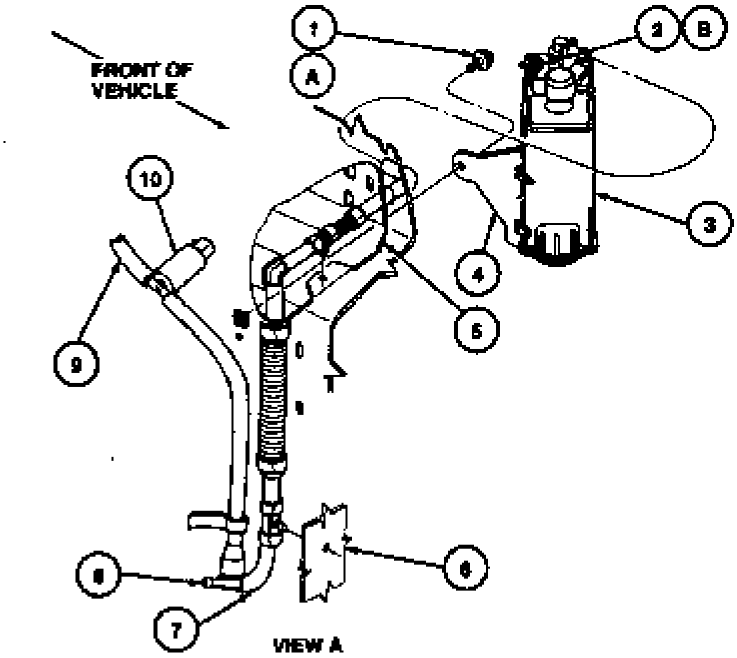
Click to enlarge

REMOVAL & INSTALLATION

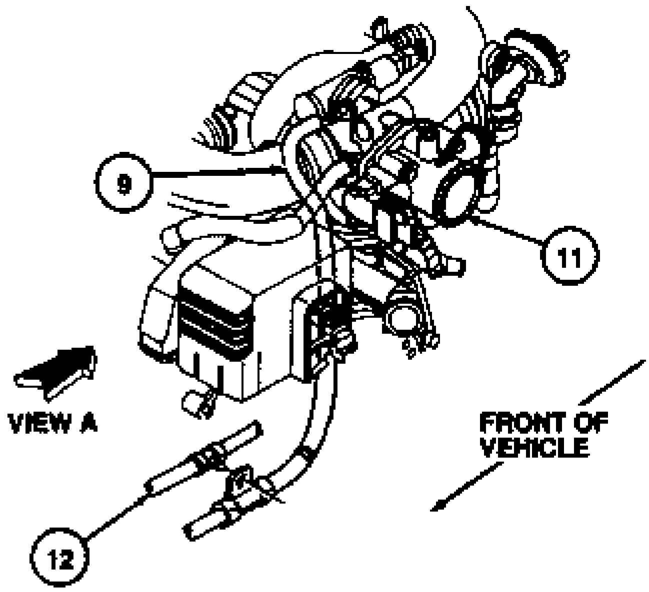
Carbon Canister

1. **Disconnect the negative battery cable.**
2. **Detach the vapor hoses from the carbon canister.**

3. **Remove the canister mounting bolts and/or retaining straps, then remove the canister. The 3.0L Flexible Fuel engine uses four canisters mounted under the rear floor pan.**
4. **Installation is the reverse of the removal procedure.**



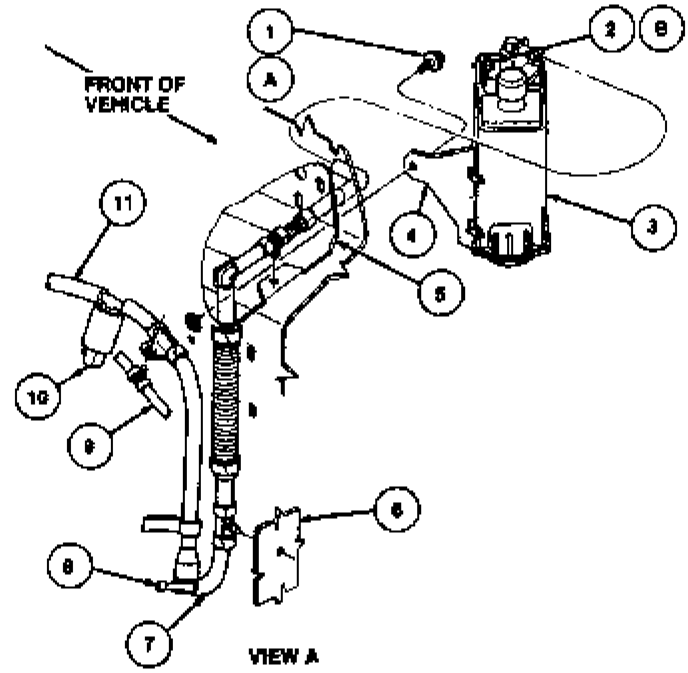
Item	Part Number	Description
1	N606688-S2	Bolt
2	N610959-S2	Bolt
3	9D653	Evaporative Emissions Canister
4	9D665	Evaporative Emission Canister Bracket
5	—	LH Headlamp Opening (Part of 16138)
6	16138	Radiator Support
7	9K313	Evaporative Emission Tube



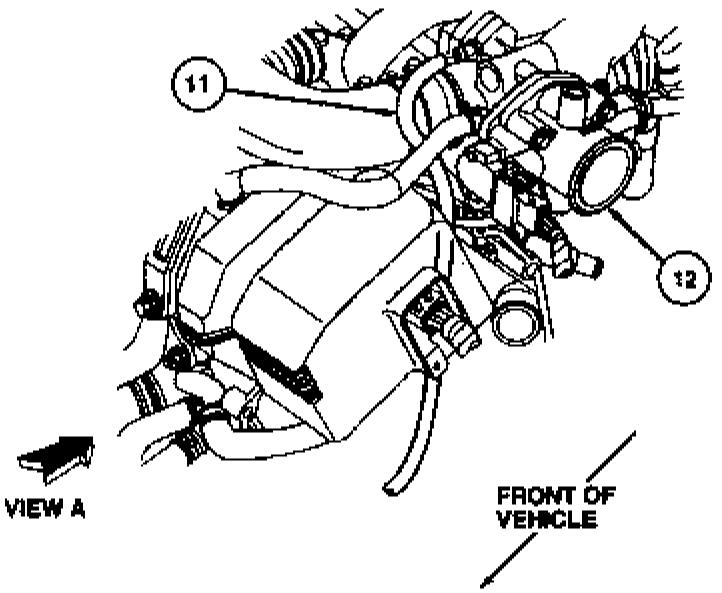
Item	Part Number	Description
8	9A228	Fuel Tank Vent Tube (Part of 9K313)
9	9E325	Evaporative Emission Hose
10	9C915	Evaporative Emission

EEC system for the 3.0L SHO engine

Click to enlarge



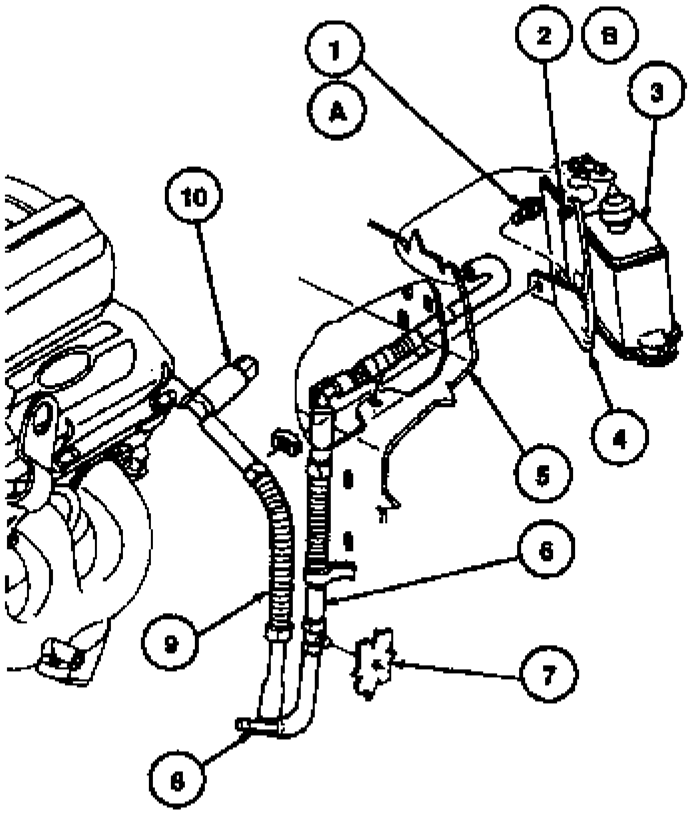
Item	Part Number	Description
1	N806689-S2	Screw and Washer Assy
2	N610969-S2	Bolt
3	9D653	Evaporative Emissions Canister
4	9D665	Evaporative Emission Canister Bracket
5	—	LH Headlamp Opening (Part of 16138)
6	16138	Radiator Support
7	9K313	Evaporative Emission Tube



Item	Part Number	Description
8	9A228	Fuel Tank Vent Tube (Part of

EEC system for the 3.2L SHO engine

Click to enlarge



Item	Part Number	Description
1	N606688-S2	Bolt
2	N610959-S2	Bolt
3	9D653	Evaporative Emissions Canister
4	9D665	Evaporative Emission Canister Bracket
5	—	LH Headlamp Opening (Part of 16138)
6	9K313	Evaporative Emission Tube
7	16138	Radiator Support
8	9A228	Fuel Tank Vent Tube
9	9C987	Evaporative Emission Hose
10	9C915	Evaporative Emission Canister Purge Solenoid
A	—	Tighten to 21.2-28.8 N·m (15-21 Lb-Ft)
B	—	Tighten to 5.2-7.2 N·m (46-63 Lb-In)

EEC system for the 3.8L engine

Click to enlarge

Purge Valves

1. **Disconnect the negative battery cable.**
2. **Disconnect the vacuum hose or the electrical connector from the purge valve.**
3. **Disconnect the vapor hoses and remove the purge valve from the vehicle.**
4. **Installation is the reverse of the removal procedure.**

Vapor Valve

1. **Disconnect the negative battery cable.**
2. **Raise and safely support the vehicle. Remove the fuel tank to gain access to the vapor valve.**
3. **Disconnect the vapor hoses from the vapor valve.**
4. **Remove the vapor valve mounting screws and the vapor valve from the underside of the vehicle, or remove the vapor valve from the fuel tank, as necessary.**
5. **Installation is the reverse of the removal procedure.**

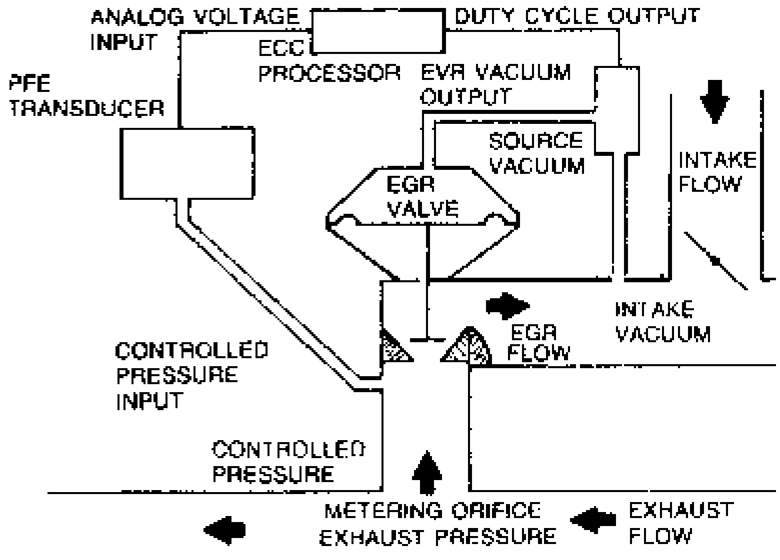
Exhaust Gas Recirculation System

OPERATION

The Exhaust Gas Recirculation (EGR) system is designed to reintroduce exhaust gas into the combustion cycle, thereby lowering combustion temperatures and reducing the formation of nitrous oxide. This is accomplished by the use of an EGR valve which opens under specific engine operating conditions, to admit a small amount of exhaust gas into the intake manifold, below the throttle plate. The exhaust gas mixes with the incoming air charge and displaces a portion of the oxygen in the air/fuel mixture entering the combustion chamber. The exhaust gas does not support combustion of the air/fuel mixture but it takes up volume, the net effect of which is to lower the temperature of the combustion chamber. There are a few different EGR systems used on front wheel drive vehicles.

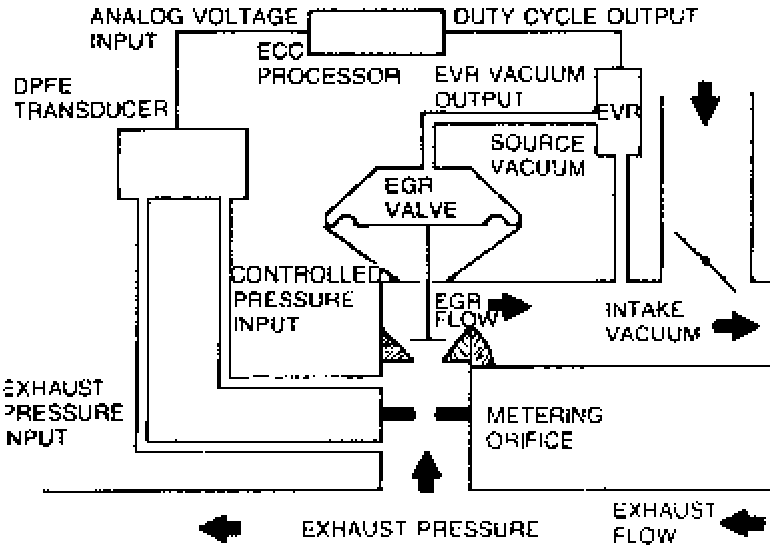
The most commonly used system is the Pressure Feedback Electronic (PFE) system. The PFE is a subsonic closed loop EGR system that controls EGR flow rate by monitoring the pressure drop across a remotely located sharp-edged orifice. The system uses a pressure transducer as the feedback device and controlled pressure is varied by valve modulation using vacuum output of the EGR Vacuum Regulator (EVR) solenoid. With the PFE system, the EGR valve only serves as a pressure regulator rather than a flow metering device.

The Differential Pressure Feedback Electronic (DPFE) EGR system operates in the same manner except it directly monitors the pressure drop across the metering orifice. This allows for a more accurate assessment of EGR flow requirements.



Pressure Feedback Electronic (PFE) EGR system schematic

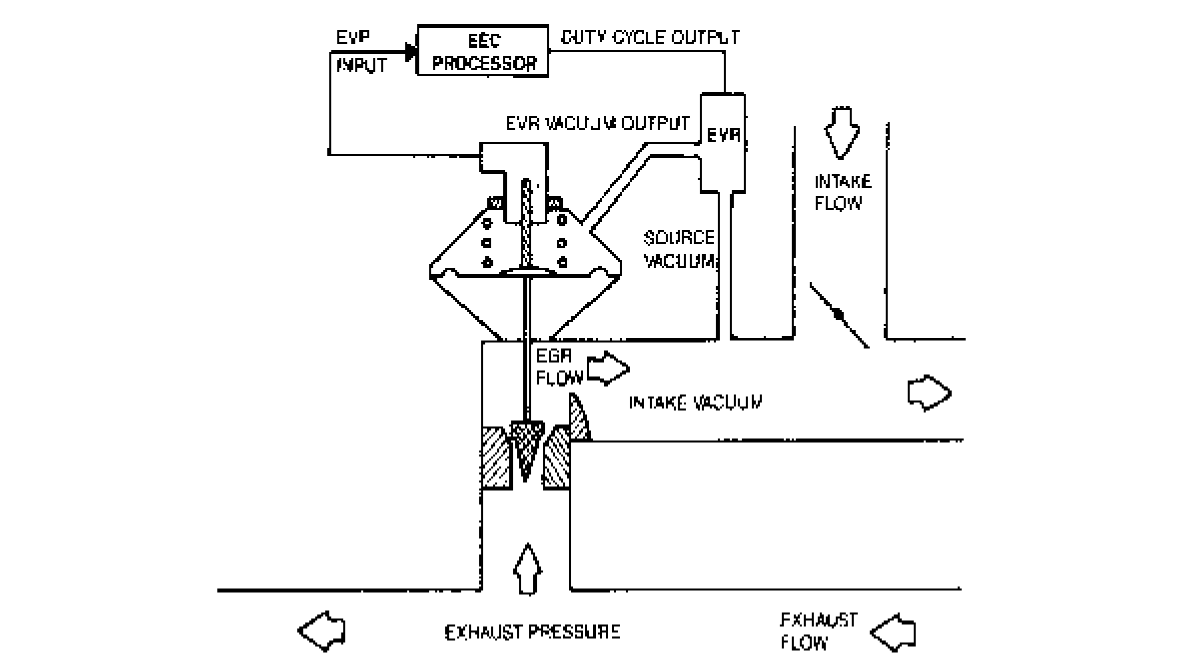
Click to enlarge



Differential Pressure Feedback Electronic (DPFE) EGR system schematic

Click to enlarge

The Electronic EGR (EEGR) valve system is used on some vehicles equipped with the 2.5L engine. An electronic EGR valve is required in EEC systems where EGR flow is controlled according to computer demands by means of an EGR Valve Position (EVP) sensor attached to the valve. The valve is operated by a vacuum signal from the electronic vacuum regulator which actuates the valve diaphragm. As supply vacuum overcomes the spring load, the diaphragm is actuated. This lifts the pintle off of its seat allowing exhaust gas to recirculate. The amount of flow is proportional to the pintle position. The EVP sensor mounted on the valve sends an electrical signal of its position to the ECU.



Electronic EGR (EEGR) system schematic

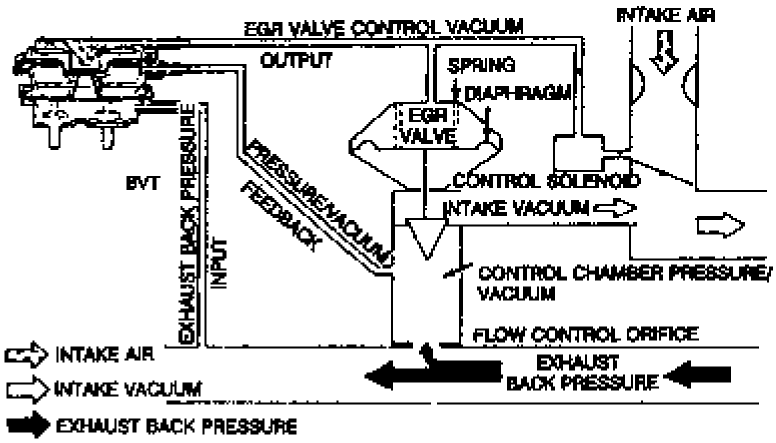
Click to enlarge

The ported EGR valve is the most common form of EGR valve. It is operated by a vacuum signal which actuates the valve diaphragm. As the vacuum increases sufficiently to overcome the power spring, the valve is opened allowing EGR flow. The vacuum to the EGR valve is controlled using devices such as the EVR or the BVT, depending on system application.

The Electronic EGR (EEGR) valve is similar to the ported EGR valve. It is also vacuum operated, lifting the pintle off of its seat to allow exhaust gas to recirculate when the vacuum signal is strong enough. The difference lies in the EVP sensor, which is mounted on top of the electronic EGR valve. The electronic EGR valve assembly is not serviceable. The EVP sensor and the EGR valve must be serviced separately.

The Pressure Feedback Electronic (PFE) EGR Transducer converts a varying exhaust pressure signal into a proportional analog voltage which is digitized by the ECU. The ECU uses the signal received from the PFE transducer to complete the optimum EGR flow.

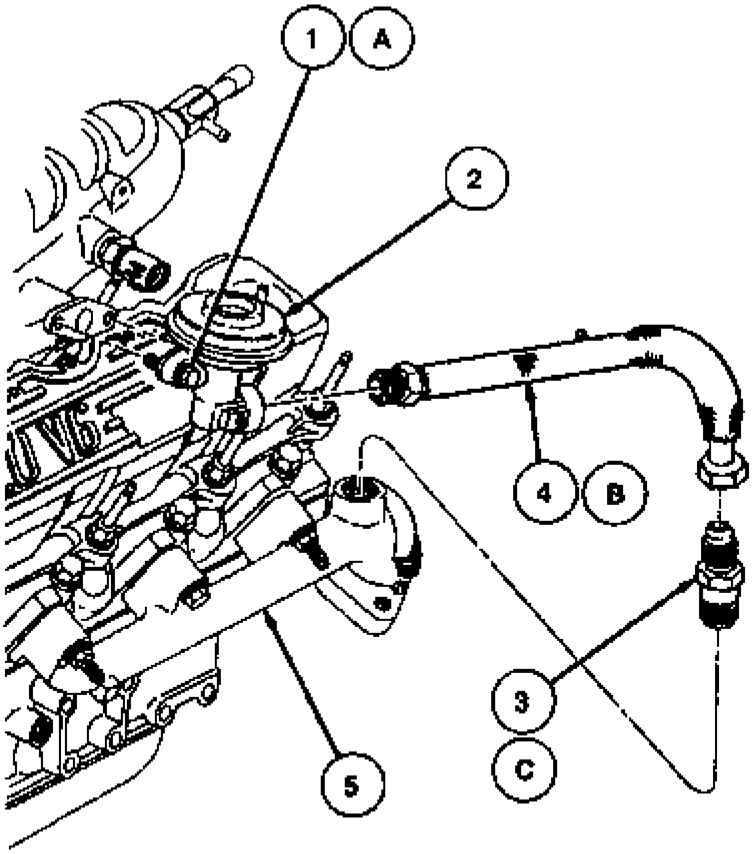
The EGR Valve Position (EVP) sensor provides the ECU with a signal indicating the position of the EGR valve. The Back pressure Variable Transducer (BVT) controls the vacuum input to the EGR valve based on the engine operating condition.



Back pressure Variable Transduced (BVT) EGR system schematic

Click to enlarge

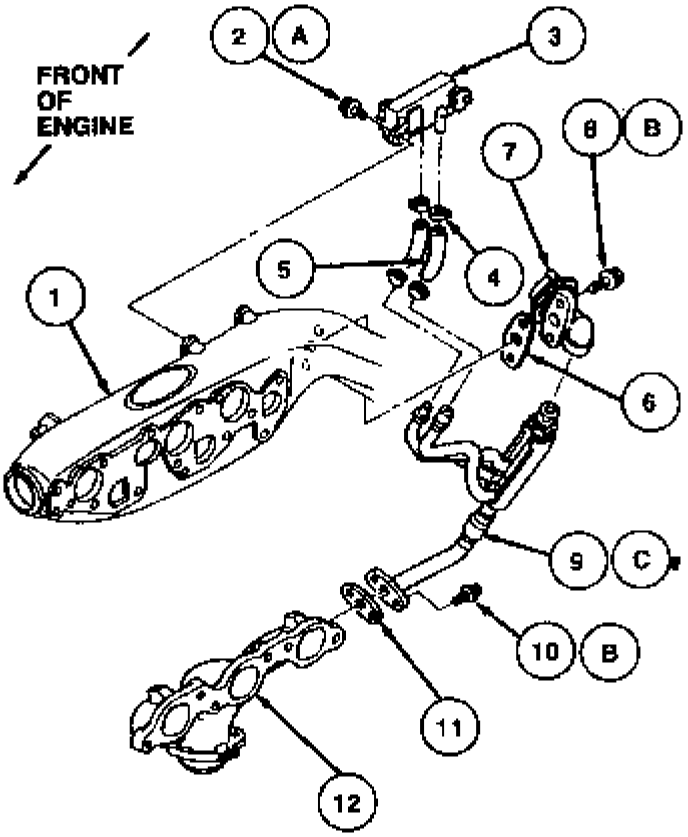
The EGR Vacuum Regulator (EVR) is an electromagnetic device which controls vacuum output to the EGR valve. The EVR replaces the EGR solenoid vacuum vent valve assembly. An electric current in the coil induces a magnetic field in the armature. The magnetic field pulls the disk back, closing the vent and increasing the vacuum level. The vacuum source is either manifold or vacuum. As the duty cycle is increased, an increased vacuum signal goes to the EGR valve.



Item	Part Number	Description
1A	N804073-S8	Bolt (2 Req'd)
2	9D475	EGR Valve
3C	9F485	EGR Valve Tube to Manifold Connector
4B	9D477	EGR Valve to Exhaust Manifold Tube
5	9430	Exhaust Manifold
A		Tighten to 20-30 N·m (15-22 Lb-Ft)
B		Tighten to 35-45 N·m (26-33 Lb-Ft)
C		Tighten to 45-65 N·m (33-48 Lb-Ft)

EGR system and related components for the 3.0L engine (except SHO)

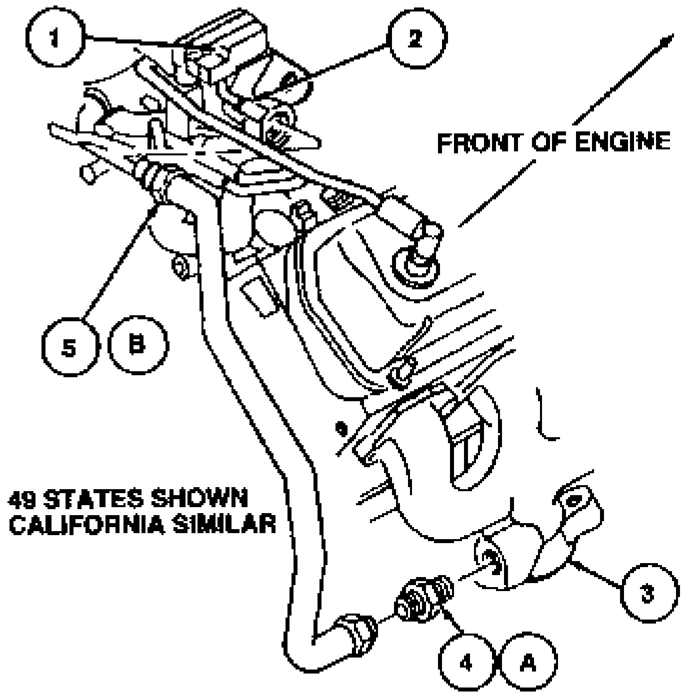
Click to enlarge



Item	Part Number	Description
1	9424	Intake Manifold
2A	90105-06531	Bolt (2 Req'd)
3	9J460	EGR Pressure Valve Sensor
4	—	Clamp (4 Req'd) (Part of 9P761)
5	9P761	EGR Pressure Valve Sensor Hose (2 Req'd)
6	9D476	EGR Valve Gasket
7	9D475	EGR Valve
8B	90119-08151	Bolt (2 Req'd)
9C	9D477	EGR Valve to Exhaust Manifold Tube
10B	90119-08146	Bolt (2 Req'd)
11	9F470	EGR Valve Tube Inlet Gasket
12	9430	Exhaust Manifold
A		Tighten to 2-3 N-m (18-27 Lb-In)
B		Tighten to 15-23 N-m (11-17 Lb-Ft)
C		Tighten to 45-65 N-m (33-48 Lb-Ft)

Exploded view of the EGR valve and related components-3.0L and 3.2L SHO engines

Click to enlarge



Item	Part Number	Description
1	9J460	EGR Pressure Valve Sensor
2	9D475	EGR Valve
3	9430	Exhaust Manifold
4A	9F485	EGR Valve Tube to Manifold Connector
5B	9D477	EGR Valve to Exhaust Manifold Tube
A		Tighten to 45-65 N·m (33-48 Lb-Ft)
B		Tighten to 35-45 N·m (26-33 Lb-Ft)

View of the EGR system components-late model 3.8L engine shown

Click to enlarge

TESTING

Back pressure Variable Transducer (BVT)

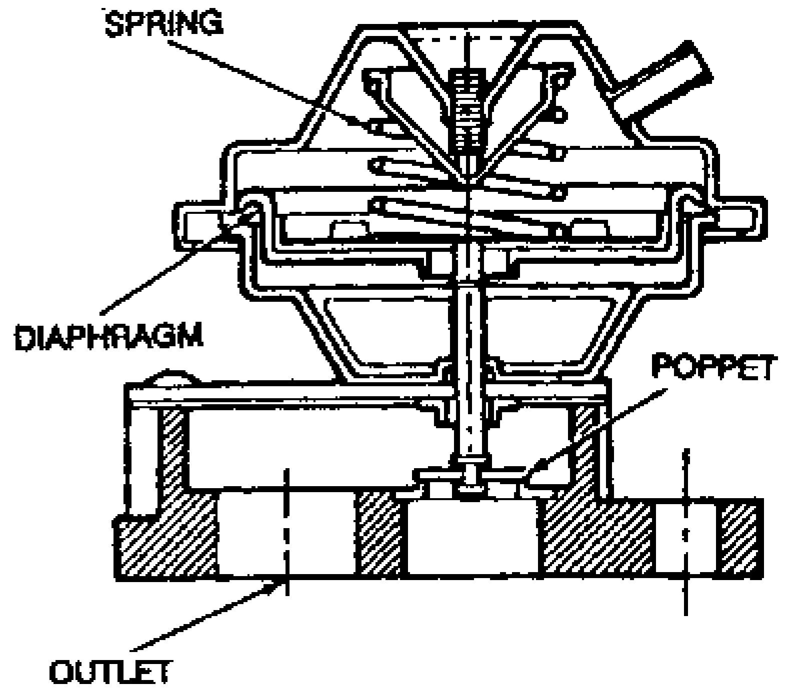
1. Make sure all vacuum hoses are correctly routed and securely attached. Replace cracked, crimped or broken hoses.
2. Make sure there is no vacuum to the EGR valve at idle with the engine at normal operating temperature.
3. Connect a suitable tachometer.
4. Detach the idle air bypass valve electrical connector.
5. Remove the vacuum supply hose from the EGR valve nipple and plug the hose.
6. Start the engine and let it idle with the transaxle selector lever in Neutral. Check the engine idle speed and adjust to the proper specification, if necessary.

7. Slowly apply 5-10 in. Hg (17-34 kPa) of vacuum to the EGR valve vacuum nipple using a suitable hand vacuum pump.
8. When vacuum is fully applied to the EGR valve, check for the following:
    1. If idle speed drops more than 100 rpm or if the engine stalls, perform the next step. Otherwise, check for a vacuum leak at the EGR valve, and, if a leak is found, replace the valve.
    2. If the EGR passages are blocked, clean the EGR valve using a suitable cleaner.
    3. Remove the vacuum from the EGR valve. If the idle speed does not return to normal specifications (or within 25 rpm), check for contamination; clean the valve.
    4. If the symptom still exists, replace the EGR valve.
9. Attach the idle air bypass valve electrical connector.
10. Unplug and reconnect the EGR vacuum supply hose.
11. Disconnect the vacuum connection at the BVT.
12. Gently blow into the hose to port C until the relief valve closes and at the same time apply 5-10 in. Hg (17-34 kPa) of vacuum to port E with the hand vacuum pump. Port E should hold vacuum as long as there is pressure on port C.
13. Apply a minimum of 5-10 in. Hg (17-34 kPa) of vacuum to ports B and C using the hand vacuum pump. Ports B and C should hold vacuum.
14. Replace the BVT if any of the ports do not hold vacuum.
15. Reconnect the vacuum at the BVT.
16. If neither the EGR valve nor the BVT were replaced, the system is okay.

REMOVAL & INSTALLATION

Ported EGR Valve

1. Disconnect the negative battery cable.
2. Detach the vacuum line(s) and/or electrical connector(s) from the EGR valve.
3. Unfasten the mounting bolts, then remove the EGR valve. Remove all old gasket material.

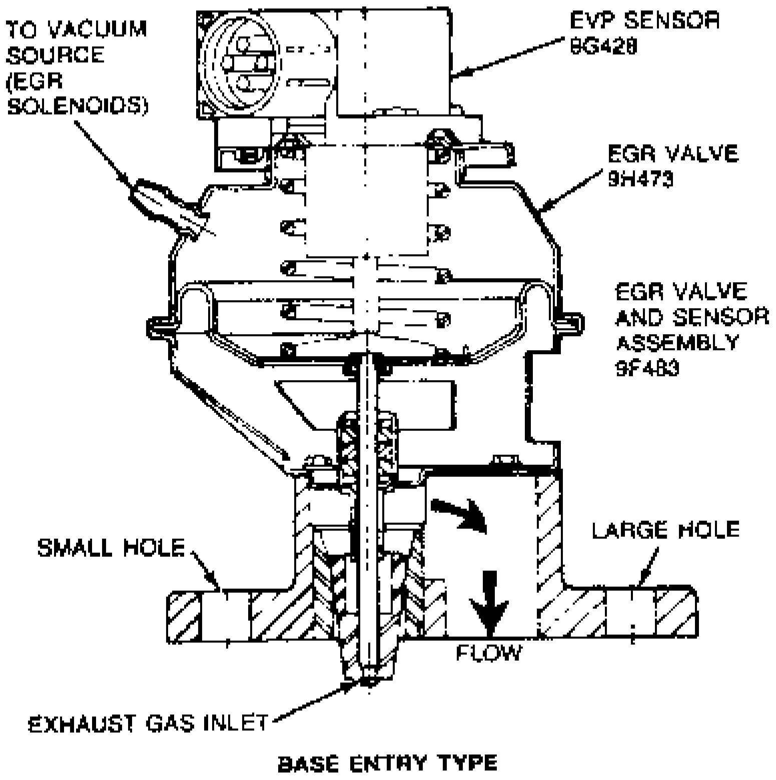


Cross-sectional view of a ported EGR valve assembly

To install:

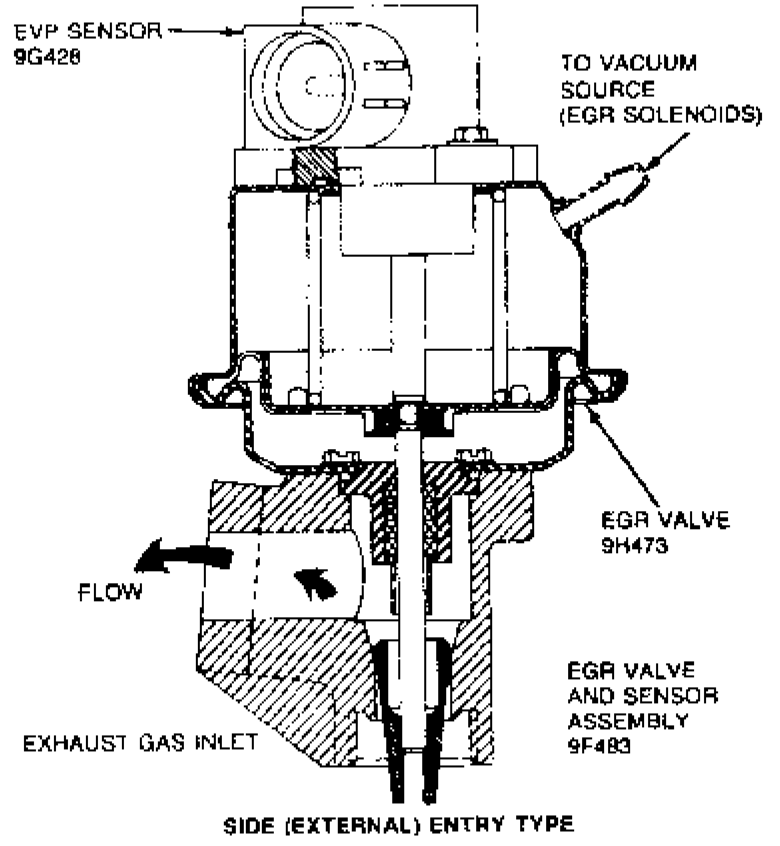
4. **Using a new gasket, install the EGR valve, then secure using the retaining bolts.**
5. **Attach any vacuum lines or electrical connectors disengaged during removal.**
6. **Connect the negative battery cable.**

Electronic EGR (EEGR) Valve



Cross-sectional view of a base entry-type electronic EGR valve

Click to enlarge



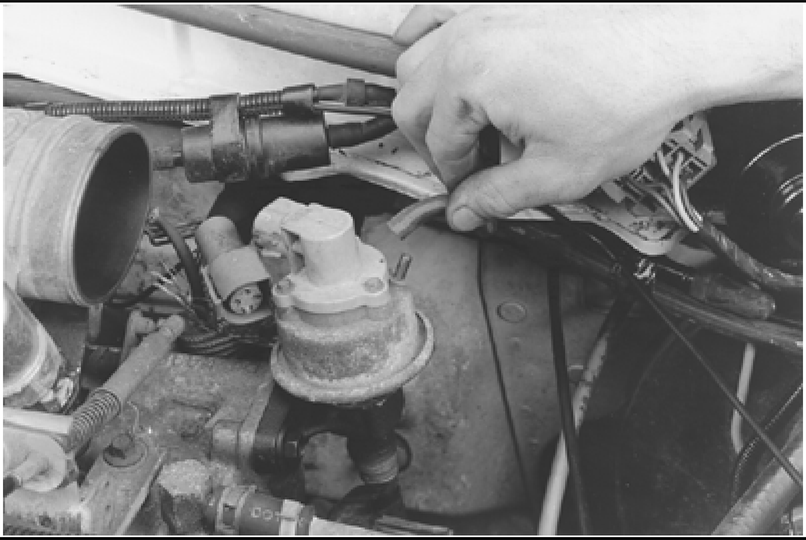
Cross-sectional view of a side (external) entry-type electronic EGR valve

Click to enlarge

1. **Disconnect the negative battery cable.**
2. **Disengage the the electrical connector from the EVP sensor.**

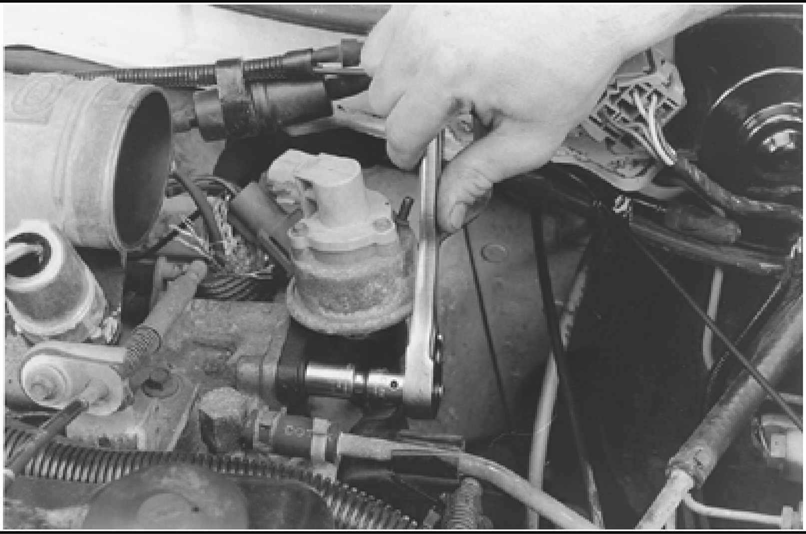
Disengage the electrical connector from the EVP sensor-early model 2.5L engine

3. **Disconnect the vacuum line from the EGR valve.**



Disconnect the vacuum line from the EGR valve

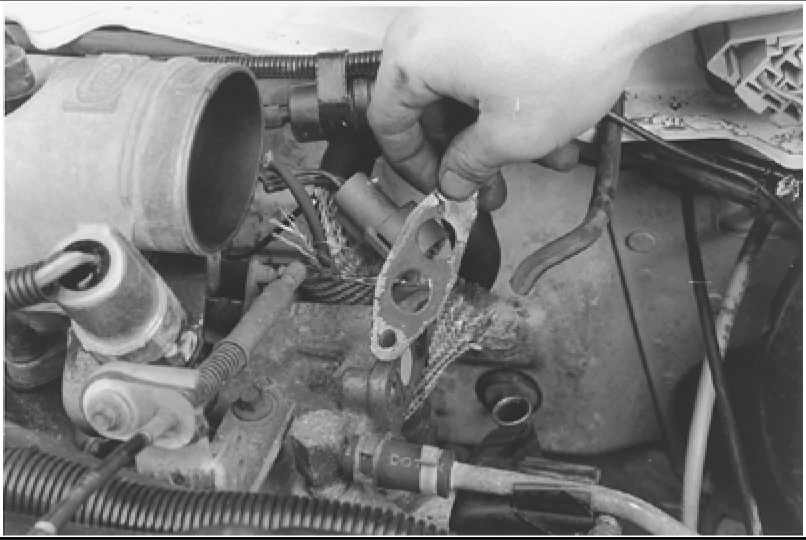
4. **Remove the mounting bolts and remove the EGR valve.**



Disconnect the mounting bolts from the EGR valve

Remove the mounting bolts from the EGR valve

Remove the EGR valve from the vehicle-early model engine shown



When installing the EGR valve, be sure to remove the old gasket and install a new one

5. **Remove the EVP sensor from the EGR valve.**
6. **Remove all old gasket material from the mating surfaces.**

To install:

7. **Install the EVP sensor to the EGR valve.**
8. **Using a new gasket, install the EGR valve in the vehicle, then secure using the retaining bolts.**
9. **Connect the vacuum line to the EGR valve, then engage the electrical connector.**
10. **Connect the negative battery cable.**

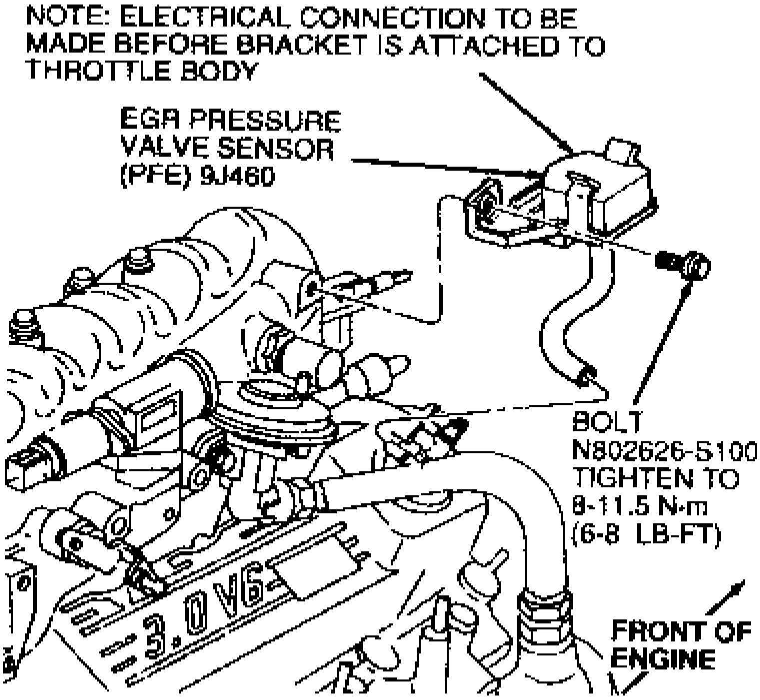
Pressure Feedback Electronic (PFE) EGR Transducer

1. **Disconnect the negative battery cable.**
2. **Separate the electrical connector and the exhaust pressure line from the transducer.**
3. **Remove the transducer from the vehicle.**

To install:

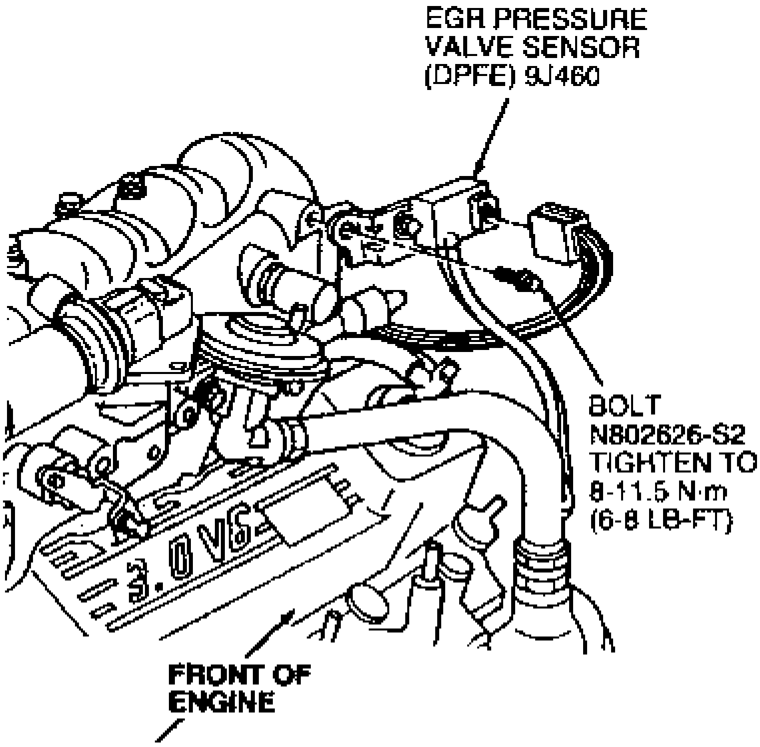
4. Install the transducer, then engage the electrical connector and connect the exhaust pressure line to the transducer.
5. Connect the negative battery cable.

EGR Valve Position (EVP) Sensor



EGR sensor-late model 3.0L (except SHO and Flexible Fuel) shown

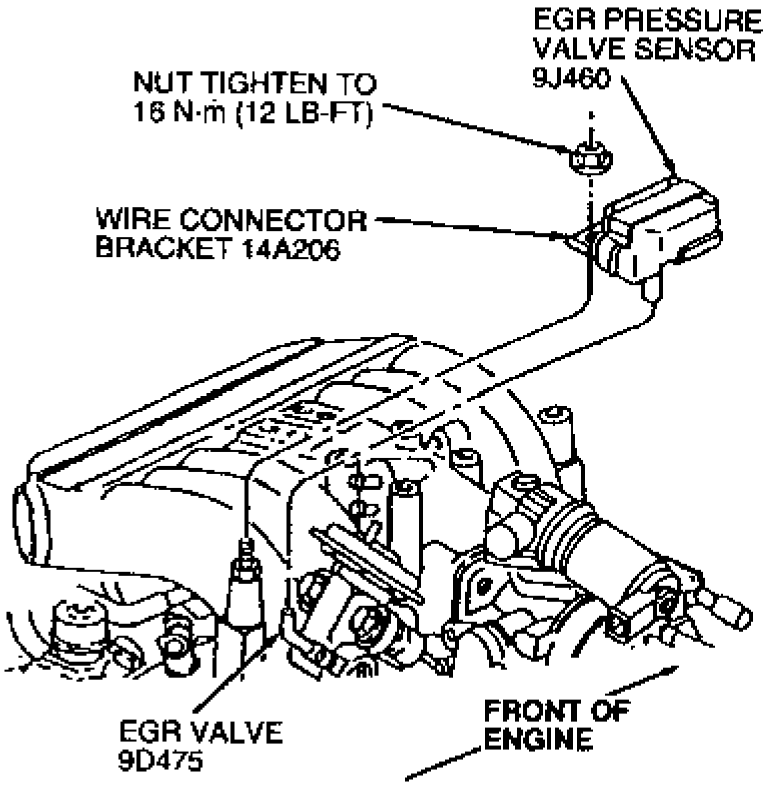
Click to enlarge



EGR sensor location-3.0L Flexible Fuel engines

Click to enlarge

1. **Disconnect the negative battery cable.**
2. **Disengage the electrical connector from the sensor.**



EGR sensor-late model 3.8L shown

Click to enlarge

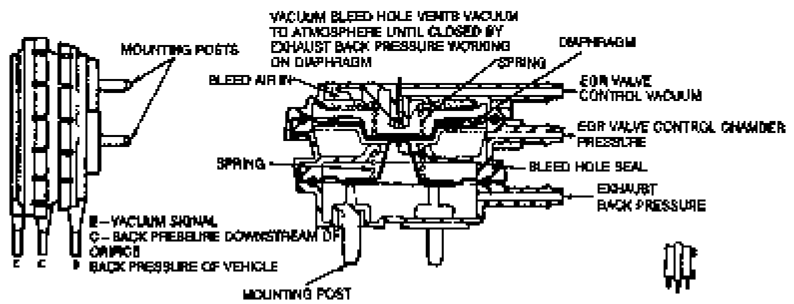
3. **Disconnect the sensor mounting nuts, then remove the sensor from the EGR valve.**

To install:

4. **Install the sensor on the EGR valve, then secure using the mounting nuts.**
5. **Engage the electrical connector to the sensor, then connect the negative battery cable.**

Back pressure Variable Transducer (BVT)

1. **Disconnect the negative battery cable.**
2. **Disconnect the vacuum lines from the BVT.**



Cross-sectional view of a Back Pressure Variable Transducer (BVT)

Click to enlarge

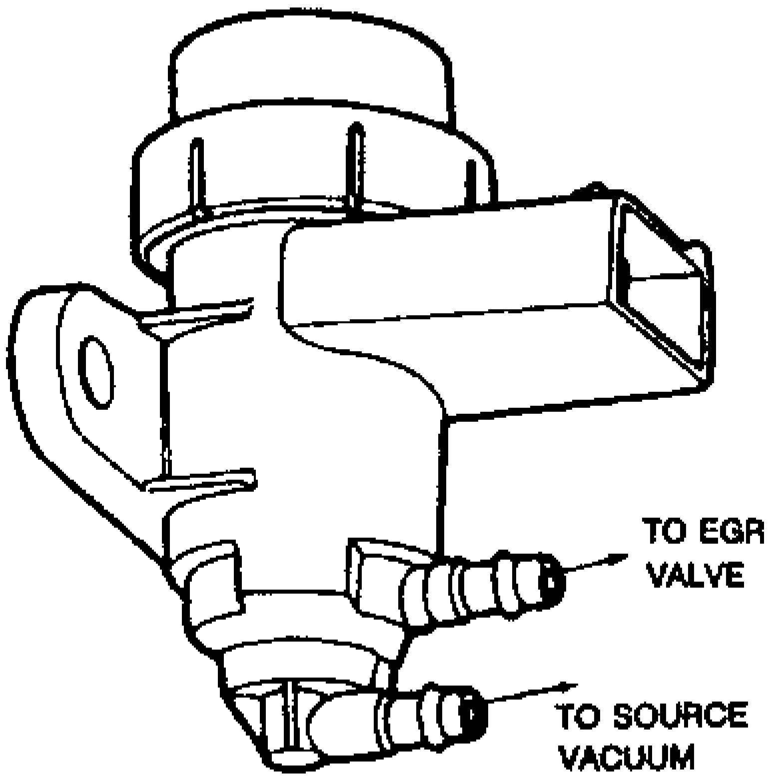
3. **Remove the BVT from its mounting position, then remove it from the vehicle.**

To install:

4. **Install the BVT in its mounting position.**
5. **Connect the vacuum lines to the BVT, then connect the negative battery cable.**

EGR Vacuum Regulator (EVR)

1. **Disconnect the negative battery cable.**
2. **Disengage the electrical connector and the vacuum lines from the regulator.**



EGR vacuum regulator assembly

3. **Remove the regulator mounting bolts, then remove the regulator from the vehicle.**

To install:

4. **Install the regulator in the vehicle, then secure using the retaining bolts.**
5. **Connect the vacuum lines, then engage the electrical connector to the regulator.**
6. **Connect the negative battery cable.**

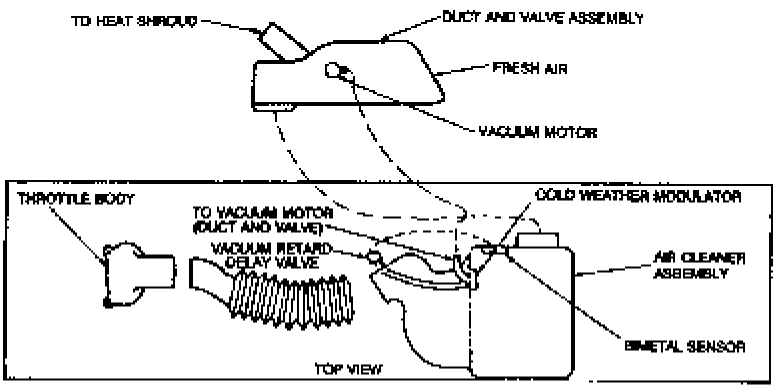
Exhaust Emission Control System

The exhaust emission control system begins at the air intake and ends at the tailpipe. Most vehicles are equipped with a thermostatic air inlet system, exhaust catalyst, and either a thermactor air injection system or pulse air injection system.

Thermostatic Air Inlet System

OPERATION

Most of the engines covered by this manual utilize the themostatic air inlet system. The thermostatic air inlet system regulates the air inlet temperature by drawing in air from a cool air source, as well as heated air from a heat shroud which is mounted on the exhaust manifold. The system consists of the following components: duct and valve assembly, heat shroud, bimetal sensor, cold weather modulator, vacuum delay valve and the necessary vacuum lines and air ducts. All vehicles do not share all components.

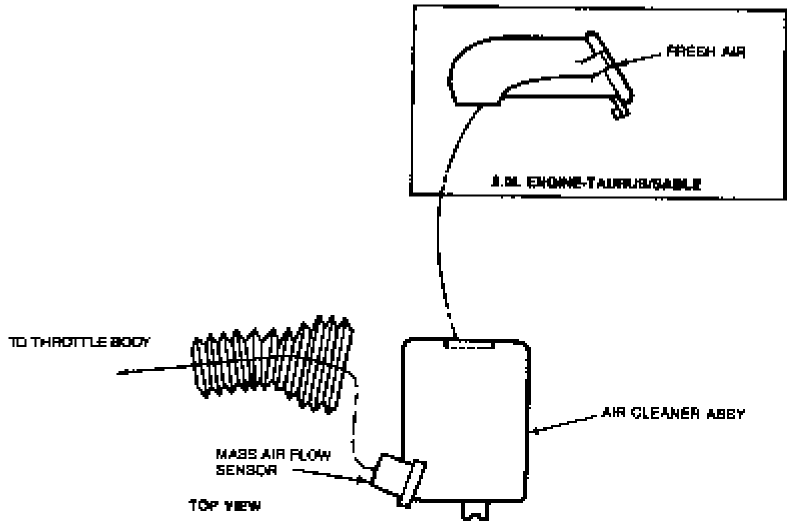


Thermostatic Air Inlet System-2.5L engine

Click to enlarge

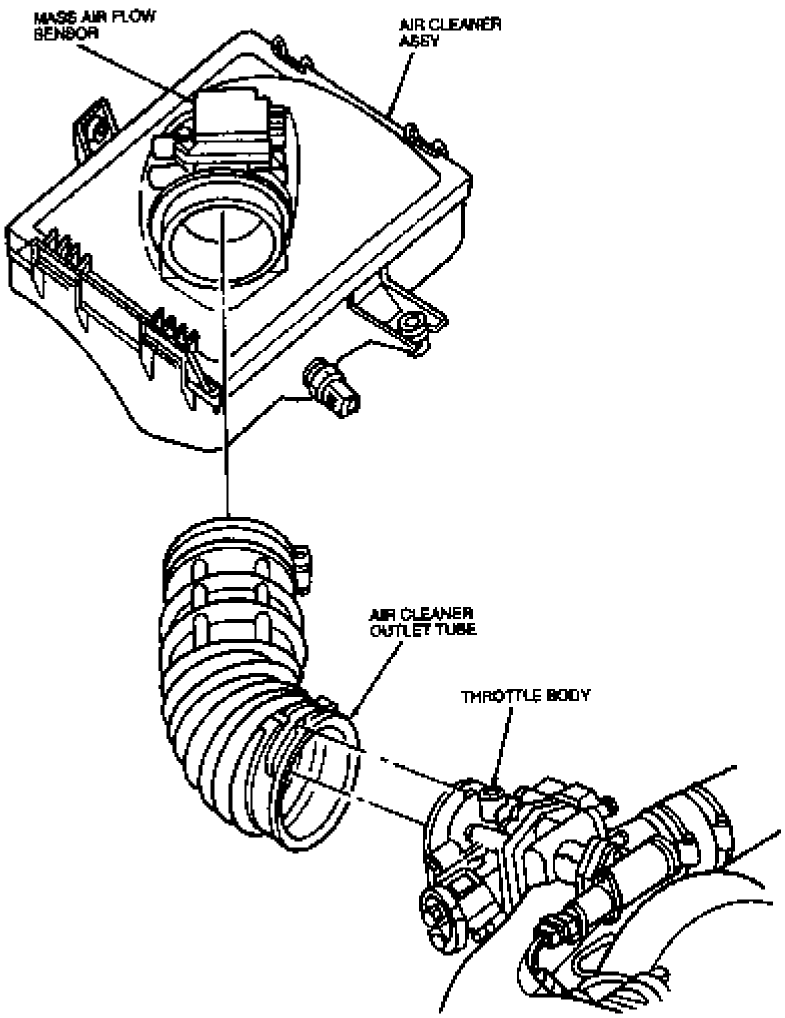
Duct and Valve Assembly

The duct and valve assembly which regulates the air flow from the cool and heated air sources is located either inside the air cleaner or mounted on the air cleaner. The flow is regulated by means of a door that is operated by a vacuum motor. The operation of the motor is controlled by delay valves, temperature sensors and other vacuum control systems. All vary with each application and engine calibration.



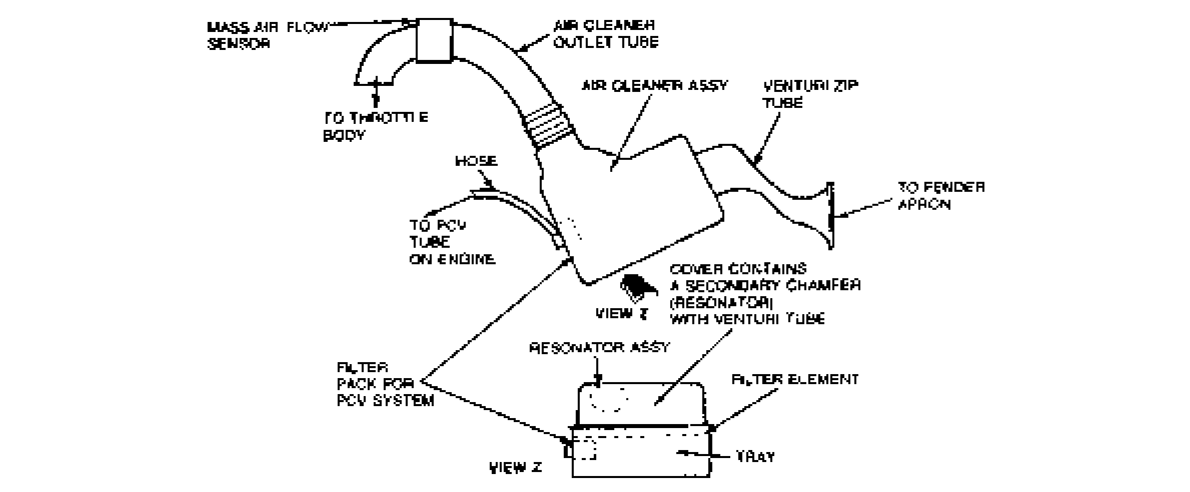
Duct assembly-3.0L engine (except SHO)

Click to enlarge



Duct assembly-3.0L/3.2L SHO engines

Click to enlarge



Duct assembly-3.8L engine

Click to enlarge

Bimetal Sensor

The core of the bimetal sensor is made of two different types of metals bonded together, each having different temperature expansion rates. At a given increase in temperature, the shape of the sensor core changes, bleeding off vacuum available at the vacuum motor. This permits the vacuum motor to open the duct door to allow fresh air in while shutting off full heat. The bimetal sensor is calibrated according to the needs of each particular application.

Cold Weather Modulator

The cold weather modulator is used in addition to the bimetal sensor to control the inlet air temperature. The modulator traps vacuum in the system, so the door will not switch to cold air when the vacuum drops during acceleration. The cold weather modulator only works when the outside air is cold.

Vacuum Delay Valve

The vacuum delay valve is used for the gradual release of vacuum to the vacuum motor.

TESTING

Duct and Valve Assembly

1. **If the duct door is in the closed to fresh air position, remove the hose from the air cleaner vacuum motor.**
2. **The door should go to the open to fresh air position. If it sticks or binds, service or replace, as required.**
3. **If the door is in the open to fresh air position, check the door by applying 8 in. Hg (27 kPa) or greater of vacuum to the vacuum motor.**
4. **The door should move freely to the closed to fresh air position. If it binds or sticks, service or replace, as required.**

Make sure the vacuum motor is functional before changing the duct and valve assembly.

Bimetal Sensor

1. Bring the temperature of the bimetal sensor below 75°F (24°C) and apply 16 in. Hg (54 kPa) of vacuum with a vacuum pump at the vacuum source port of the sensor.
2. The duct door should stay closed. If not, replace the bimetal sensor.
3. The sensor will bleed off vacuum to allow the duct door to open and let in fresh air at or above the following temperatures:
    1. Brown: 75°F (24°C)
    2. Pink, black or red: 90°F (32.2°C)
    3. Blue, yellow or green: 105°F (40.6°C) Do not cool the bimetal sensor while the engine is running.

Cold Weather Modulator

A 16 in. Hg (54 kPa) vacuum applied to the motor side of the modulator holds or leaks as follows:

- Black: holds below 20°F (-6.7°C) and leaks above 35°F (1.7°C)
- Blue: holds below 40°F (4.4°C) and leaks above 55°F (12.8°C)
- Green: holds below 50°F (10°C) and leaks above 76°F (24.4°C)
- Yellow: holds above 65°F (18.3°C) and leaks below 50°F (10°C)

Vacuum Delay Valve

1. Connect a hand vacuum pump to the vacuum delay valve.
2. Valves with 1 side black or white and the other side colored are good if vacuum can be built up in 1 direction but not the other direction and if that built up vacuum can be seen to slowly decrease.
3. Valves with both sides the same color are good if vacuum can be built up in both directions before visibly decreasing.

Be careful in order to prevent oil or dirt from getting into the valve.

REMOVAL & INSTALLATION

Duct and Valve Assembly

1. Disconnect the negative battery cable.
2. Disconnect the vacuum hose from the vacuum motor.
3. Separate the vacuum motor from the vacuum operated door and remove the vacuum motor.

To install:

4. Install the motor to the vacuum operated door.
5. Connect the vacuum hose to the vacuum motor.
6. Connect the negative battery cable.

Bimetal Sensor

1. **Disconnect the negative battery cable.**
2. **Remove the air cleaner housing lid to gain access to the sensor.**
3. **Disconnect the vacuum hoses from the sensor. It may be necessary to move the air cleaner housing to accomplish this.**
4. **Remove the sensor from the air cleaner housing.**

To install:

5. **Install the sensor in the air cleaner housing.**
6. **Connect the vacuum hoses to the sensor, then install the air cleaner housing lid.**
7. **Connect the negative battery cable.**

Cold Weather Modulator

1. **Disconnect the negative battery cable.**
2. **Remove the air cleaner housing lid to gain access to the modulator.**
3. **Disconnect the vacuum hoses from the modulator. It may be necessary to move the air cleaner housing to accomplish this.**
4. **Remove the modulator from the air cleaner housing.**

To install:

5. **Install the modulator in the air cleaner housing.**
6. **Connect the vacuum hoses to the modulator, then install the air cleaner housing lid.**
7. **Connect the negative battery cable.**

Vacuum Delay Valve

1. **Disconnect the negative battery cable.**
2. **Disconnect the vacuum hoses from the delay valve.**
3. **Remove the valve from the vehicle.**

To install:

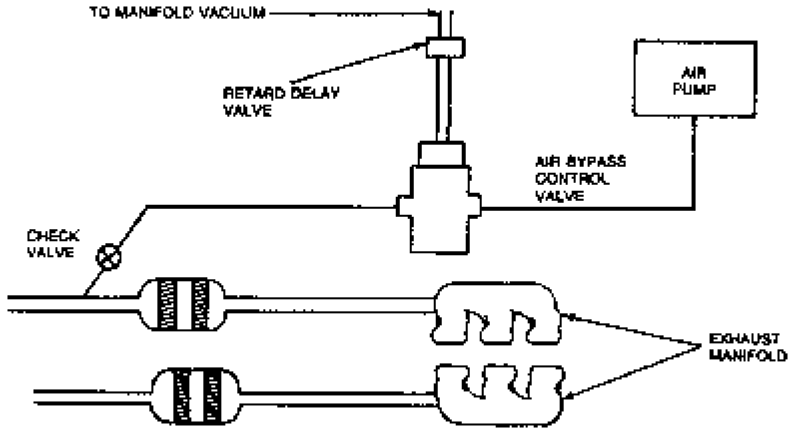
4. **Install the valve in the vehicle, then connect the vacuum hoses.**
5. **Connect the negative battery cable.**

Thermactor Air Injection System

OPERATION

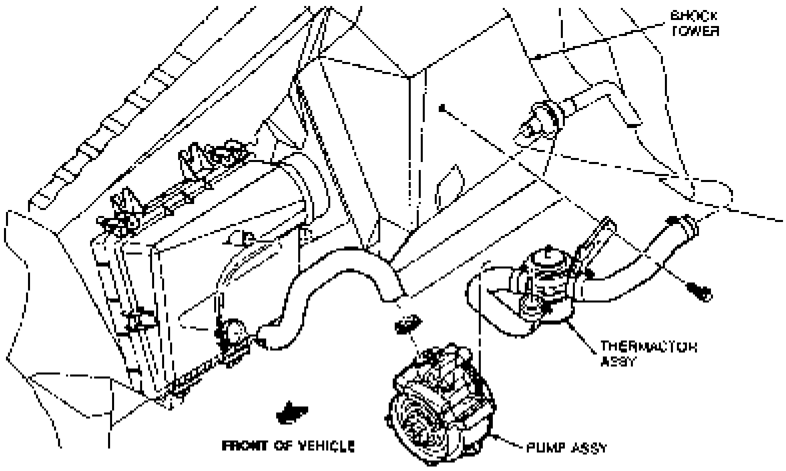
A conventional thermactor air injection system is used on some vehicles equipped with the 3.8L engine. The system reduces hydrocarbon and carbon monoxide content of the exhaust gases by continuing the combustion of unburned gases after they leave the combustion chamber. This is done by injecting fresh air into the hot exhaust stream leaving the exhaust ports, or into the catalyst. At this point, the fresh air mixes with hot exhaust gases to promote further oxidation of both the hydrocarbons and carbon monoxide, thereby reducing their concentration, and converting some of them into harmless carbon dioxide and water. During highway cruising and WOT operation, the thermactor air is dumped to atmosphere to prevent overheating in the exhaust system.

A typical air injection system consists of an air supply pump and filter, air bypass valve, check valves, air manifold, air hoses and air control valve.



Thermactor air injection system

Click to enlarge

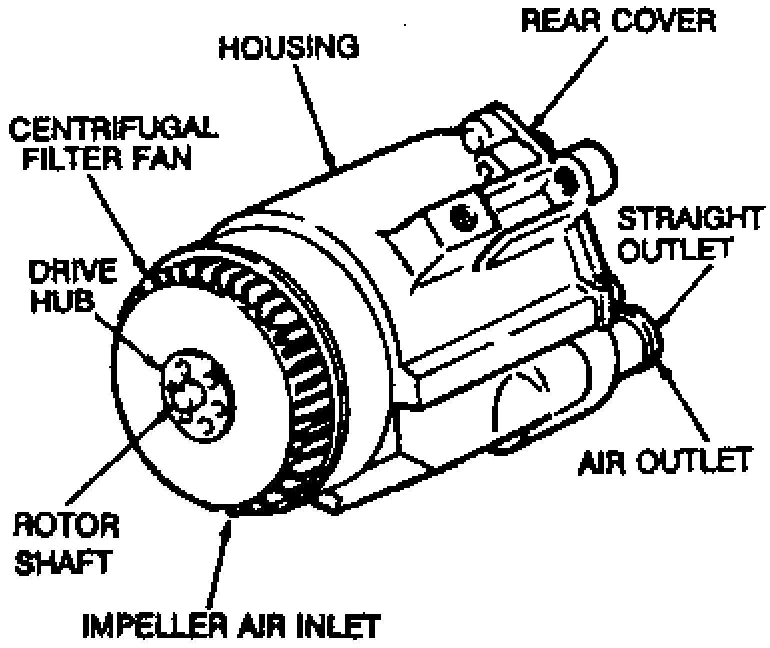


Thermactor air injection system components

Click to enlarge

Air Supply Pump

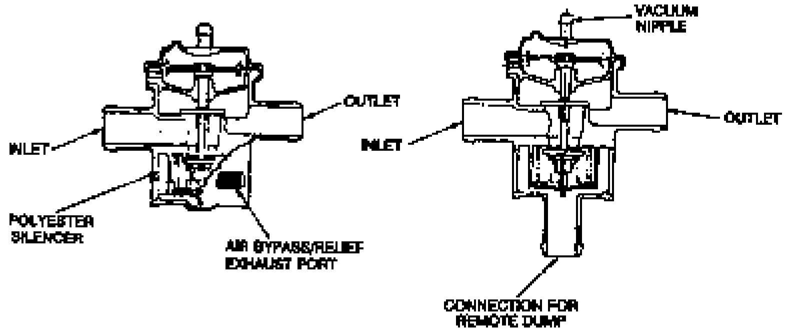
The air supply pump is a belt-driven, positive displacement, vane-type pump that provides air for the thermactor system. It is available in 19 and 22 cu. in. (311.35 and 360.5cc) sizes, either of which may be driven with different pulley ratios for different applications. The pump receives air from a remote silencer filter on the rear side of the engine air cleaner attached to the pump's air inlet nipple or through an impeller-type centrifugal filter fan.



Air supply pump assembly

Air Bypass Valve

The air bypass valve supplies air to the exhaust system with medium and high applied vacuum signals when the engine is at normal operating temperature. With low or no vacuum applied, the pumped air is dumped through the silencer ports of the valve or through the dump port.

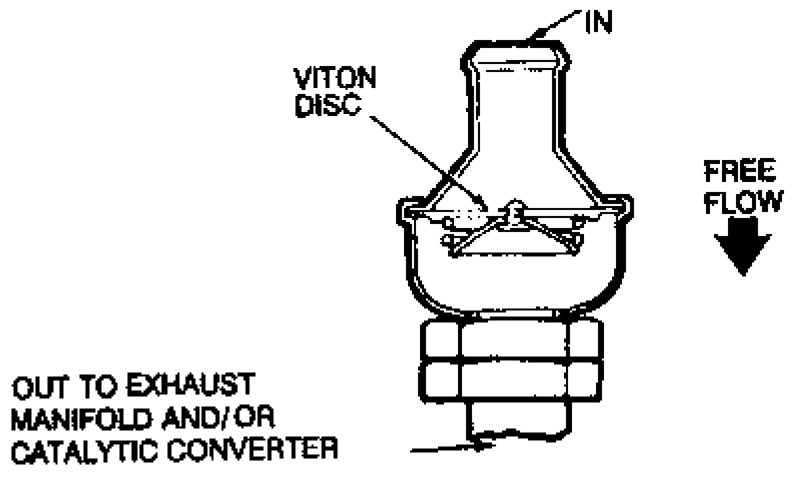


Cross-sectional view of an air bypass valve

Click to enlarge

Air Check Valve

The air check valve is a one-way valve that allows thermactor air to pass into the exhaust system while preventing exhaust gases from passing in the opposite direction.



Air check valve

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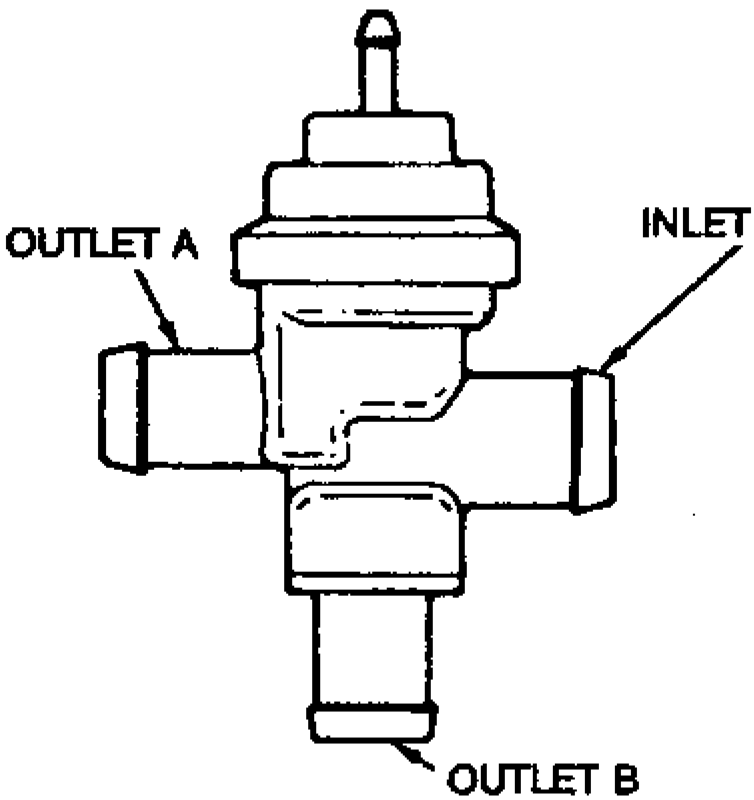
Air Supply Control Valve

The air supply control valve directs air pump output to the exhaust manifold or downstream to the catalyst system, depending upon the engine control strategy. It may also be used to dump air to the air cleaner or dump silencer.

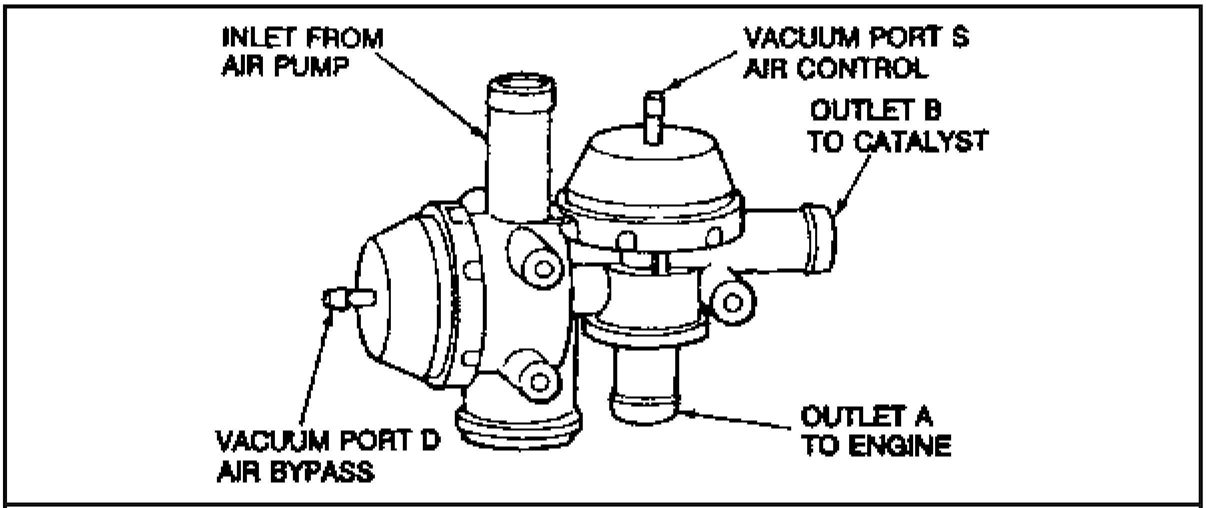


Air supply control valve

Combination Air Bypass/Air Control Valve

The combination air control/bypass valve combines the secondary air bypass and air control functions. The valve is located in the air supply line between the air pump and the upstream/downstream air supply check valves.

The air bypass portion controls the flow of thermactor air to the exhaust system or allows thermactor air to be bypassed to atmosphere. When air is not being bypassed, the air control portion of the valve switches the air injection point to either an upstream or downstream location.

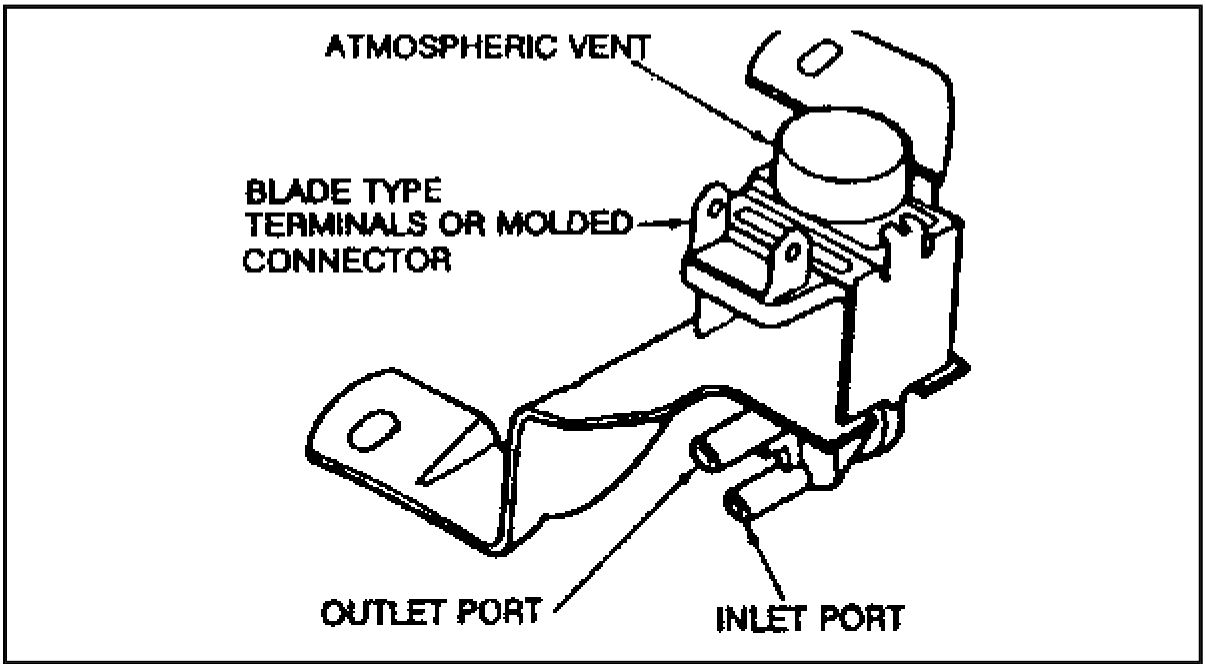


Combination air bypass/air control valve

Click to enlarge

Solenoid Vacuum Valve

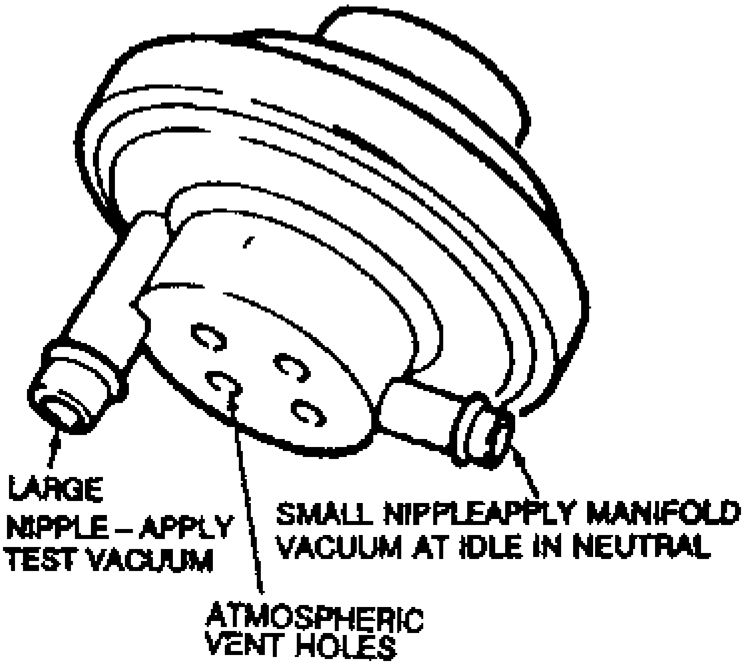
The normally closed solenoid valve assembly consists of 2 vacuum ports with an atmospheric vent. The valve assembly can be with or without control bleed. The outlet port of the valve is opened to atmospheric vent and closed to the inlet port when de-energized. When energized, the outlet port is opened to the inlet port and closed to atmospheric vent. The control bleed is provided to prevent contamination entering the solenoid valve assembly from the intake manifold.



Solenoid vacuum valve assembly

Thermactor Idle Vacuum (TIV) Valve

The TIV valve vents the vacuum signal to the atmosphere when the preset manifold vacuum or pressure is exceeded. It is used to divert thermactor airflow during cold starts to control exhaust backfire.



Thermactor idle vacuum valve assembly

TESTING

Air Supply Pump

1. Check belt tension and adjust if needed.

Do not pry on the pump to adjust the belt. The aluminum housing is likely to collapse.

2. Disconnect the air supply hose from the bypass control valve.
3. The pump is operating properly if airflow is felt at the pump outlet and the flow increases as engine speed increases.

Air Bypass Valve

1. Disconnect the air supply hose at the valve outlet.
2. Remove the vacuum line to check that a vacuum signal is present at the vacuum nipple. There must be vacuum present at the nipple before proceeding.
3. With the engine at 1500 rpm and the vacuum line connected to the vacuum nipple, air pump supply air should be heard and felt at the air bypass valve outlet.
4. With the engine at 1500 rpm, disconnect the vacuum line. Air at the outlet should be significantly decreased or shut off. Air pump supply air should be heard or felt at the silencer ports or at the dump port.
5. If the air bypass valve does not successfully complete these tests, check the air pump. If the air pump is operating properly, replace the air bypass valve.

Check Valve

1. Visually inspect the thermactor system hoses, tubes, control valve(s) and check valve(s) for leaks that may be due to the backflow of exhaust gas. If holes are found and/or traces of exhaust gas products are evident, the check valve may be suspect.
2. Check valves should allow free flow of air in the incoming direction only. The valves should check or block the free flow of exhaust gas in the opposite direction.
3. Replace the valve if air does not flow as indicated or if exhaust gas backflows in the opposite direction.

Air Supply Control Valve

1. Verify that airflow is being supplied to the valve inlet by disconnecting the air supply hose at the inlet and verifying the presence of airflow with the engine at 1500 rpm. Reconnect the air supply hose to the valve inlet.
2. Disconnect the air supply hose at outlets A and B.
3. Remove the vacuum line at the vacuum nipple.
4. Accelerate the engine to 1500 rpm. Airflow should be heard and felt at outlet B with little or no airflow at outlet A.
5. With the engine at 1500 rpm, connect a direct vacuum line from any manifold vacuum fitting to the air control valve vacuum nipple. Airflow should be heard and felt at outlet A with little or no airflow at outlet B.
6. If airflow is noted in Steps 4 and 5, the valve is okay. Reinstall the clamps and hoses. If the valve does not pass Step 4 and/or 5, replace the valve.

Combination Air Bypass/Air Control Valve

1. Disconnect the hoses from outlets A and B.
2. Disconnect and plug the vacuum line to port D.
3. With the engine operating at 1500 rpm, airflow should be noted coming out of the bypass vents.
4. Reconnect the vacuum line to port D, then disconnect and plug the vacuum line to port S. Make sure vacuum is present in the line to vacuum port D.
5. With the engine operating at 1500 rpm, airflow should be noted coming out of outlet B and no airflow should be detected at outlet A.
6. Apply 8-10 in. Hg (27-34 kPa) of vacuum to port S. With the engine operating at 1500 rpm, airflow should be noted coming out of outlet A.
7. If the valve is the bleed type, some lesser amount of air will flow from outlet A or B and the main discharge will change when vacuum is applied to port S.

Solenoid Vacuum Valve Assembly

1. The ports should allow air to flow when the solenoid is energized.
2. Check the resistance at the solenoid terminals with an ohmmeter. The resistance should be 51-108 ohms.
3. If the resistance is not as specified, replace the solenoid.

The valve can be expected to have a very small leakage rate when energized or de-energized. This leakage is not measurable in the field and is not detrimental to valve function.

Thermactor Idle Vacuum Valve

The following applies to TIV valves with the code words ASH or RED on the decal.

1. **Apply the parking brake and block the drive wheels. With the engine at idle, and the transaxle selector lever in N on automatic transaxle equipped vehicles or Neutral on manual transaxle equipped vehicles, apply vacuum to the small nipple and place fingers over the TIV valve atmospheric vent holes. If no vacuum is sensed, the TIV is damaged and must be replaced.**
2. **With the engine still idling and the transaxle selector lever remaining in N or Neutral, apply 1.5-3.0 in. Hg (5-10 kPa) of vacuum to the large nipple of the ASH TIV valve or 3.5-4.5 in. Hg (12-15 kPa) of vacuum to the large nipple of the RED TIV valve from a test source. If vacuum is still sensed when placing fingers over the vent holes, the TIV is damaged and must be replaced.**
3. **If the TIV valve meets both requirements, disconnect the TIV valve small nipple from the manifold vacuum and the TIV valve large nipple from the test vacuum. Reconnect the TIV valve to the original hoses or connectors.**

REMOVAL & INSTALLATION

Air Supply Pump

1. **Disconnect the negative battery cable.**
2. **Remove the drive belt from the air pump pulley.**
3. **Disconnect the air hose(s) from the air pump.**
4. **Remove the mounting bolts and, if necessary, the mounting brackets.**
5. **Remove the air pump from the vehicle.**

To install:

6. **Install the air pump in the vehicle, then secure using the mounting bolts and/or brackets.**
7. **Connect the air hose to the air pump, then install the belt on the air pump pulley.**
8. **Connect the negative battery cable.**

Air Bypass Valve

1. **Disconnect the negative battery cable.**
2. **Tag and disconnect the air inlet hose, the outlet hose and the vacuum hose from the bypass valve.**
3. **Remove the bypass valve from the vehicle.**

To install:

4. **Install the bypass valve in the vehicle.**
5. **Connect the vacuum hose, the outlet hose and the air inlet hose to the bypass valve, as tagged during removal.**
6. **Connect the negative battery cable.**

Check Valve

1. Disconnect the negative battery cable.
2. Disconnect the input hose from the check valve.
3. Remove the check valve from the connecting tube.

To install:

4. Fasten the check valve to the connecting tube.
5. Connect the input hose to the check valve.
6. Connect the negative battery cable.

Air Supply Control Valve

1. Disconnect the negative battery cable.
2. Disconnect the air hoses and the vacuum line from the air control valve.
3. Remove the air control valve from the vehicle.

To install:

4. Install the control valve in the vehicle.
5. Connect the vacuum line and the air hoses to the air control valve.
6. Connect the negative battery cable.

Combination Air Bypass/Air Control Valve

1. Disconnect the negative battery cable.
2. Disconnect the air hoses and vacuum lines from the valve.
3. Remove the valve from the vehicle.

To install:

4. Install the valve in the vehicle.
5. Connect the vacuum lines and the air hoses to the valve.
6. Connect the negative battery cable.

Solenoid Vacuum Valve Assembly

1. Disconnect the negative battery cable.
2. Detach the electrical connector and the vacuum lines from the solenoid valve.
3. Unfasten the mounting bolts and remove the solenoid valve.

To install:

4. Install the solenoid valve, then secure using the mounting bolts.
5. Connect the vacuum lines, then engage the electrical connector to the solenoid valve.
6. Connect the negative battery cable.

Thermactor Idle Vacuum Valve

1. **Disconnect the negative battery cable.**
2. **Disconnect the vacuum lines from the TIV valve, then remove the valve from the vehicle.**

To install:

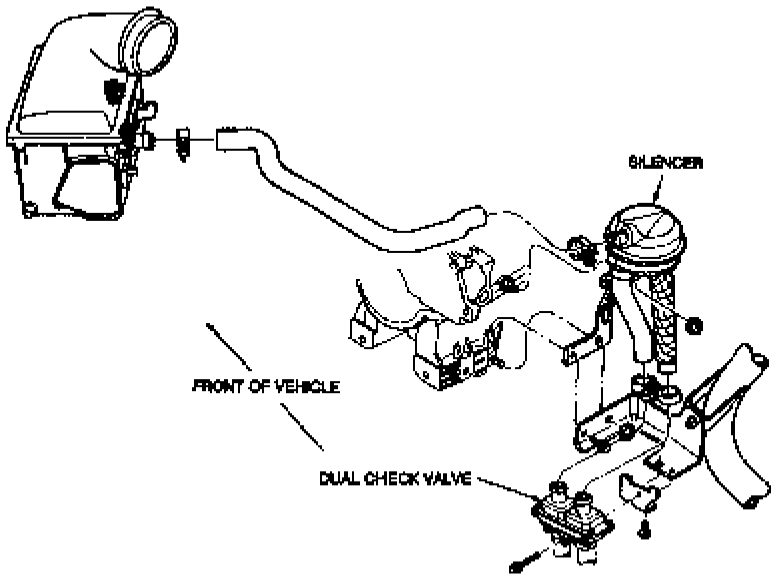
3. **Install the TIV valve in the vehicle, then connect the vacuum lines to the valve.**
4. **Connect the negative battery cable.**

Pulse Air Injection System

OPERATION

The pulse air injection system is used on some vehicles equipped with the 2.5L engine.

The pulse air injection system does not use an air pump. Instead the system uses natural pulses present in the exhaust system to pull air into the catalyst through a pulse air valve. The pulse air valve is connected to the catalyst with a long tube and to the air cleaner and silencer with hoses.



Pulse air injection system-2.5L engine

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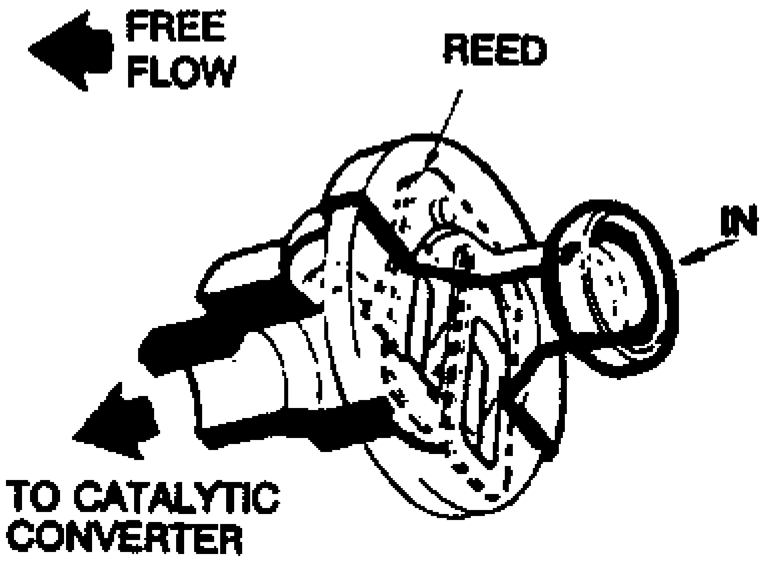
Pulse Air Valve

The pulse air control valve is normally closed. Without a vacuum signal from the solenoid, the flow of air is blocked.



Pulse air valve flow schematic

Air Silencer/Filter

The air silencer is a combustion silencer and filter for the pulse air system. The air silencer is mounted in a convenient position in the engine compartment and is connected to the pulse air valve inlet by means of a flexible hose.

Check Valve

The air check valve is a one-way valve that allows air to pass into the exhaust system while preventing exhaust gases from passing in the opposite direction.

Solenoid Vacuum Valve Assembly

The normally closed solenoid valve assembly consists of 2 vacuum ports with an atmospheric vent. The valve assembly can be with or without control bleed. The outlet port of the valve is opened to atmospheric vent and closed to the inlet port when de-energized. When energized, the outlet port is opened to the inlet port and closed to atmospheric vent. The control bleed is provided to prevent contamination entering the solenoid valve assembly from the intake manifold.

TESTING

Pulse Air Valve

1. **Visually inspect the system hoses, tubes, control valve(s) and check valve(s) for leaks that may be due to backflow of exhaust gas. If holes are found and/or traces of exhaust gas products are evident, the check valve may be suspect.**
2. **The valve should allow free flow of air in one direction only. The valve should check or block, the free flow of exhaust gas in the opposite direction.**
3. **Replace the valve if air does not flow as indicated or if exhaust gas backflows in the wrong direction.**
4. **Remove the inlet hose.**
5. **Apply the parking brake and block the drive wheels. With the engine idling at normal operating temperature and the transaxle selector lever in N on automatic transaxle equipped vehicles or Neutral on manual transaxle equipped vehicles, air**

should be drawn into the valve.

6. Remove the vacuum line; the air flow should stop.
7. If these conditions are met, the valve is operating properly.
8. If these conditions are not met, verify that vacuum is present at the valve. Check the solenoid valve if vacuum is not present.
9. If vacuum is present but no air flows, check the pulse air check valve, silencer filter and air cleaner for blocked or restricted passages.
10. If vacuum is present and no blocked or restricted passages are found, replace the valve.

Air Silencer/Filter

1. Inspect the hoses and air silencer for leaks.
2. Disconnect the hose from the air silencer outlet, remove the silencer and visually inspect for plugging.
3. The air silencer is operating properly, if no plugging or leaks are encountered.

Check Valve

1. Visually inspect the system hoses, tubes, control valve(s) and check valve(s) for leaks that may be due to the backflow of exhaust gas. If holes are found and/or traces of exhaust gas products are evident, the check valve may be suspect.
2. Check valves should allow free flow of air in the incoming direction only. The valves should check or block, the free flow of exhaust gas in the opposite direction.
3. Replace the valve if air does not flow as indicated or if exhaust gas backflows in the opposite direction.

Solenoid Vacuum Valve Assembly

1. The ports should flow air when the solenoid is energized.
2. Check the resistance at the solenoid terminals with an ohmmeter. The resistance should be 51-108 ohms.
3. If the resistance is not as specified, replace the solenoid.

The valve can be expected to have a very small leakage rate when energized or de-energized. This leakage is not measurable in the field and is not detrimental to valve function.

REMOVAL & INSTALLATION

Pulse Air Valve

1. Disconnect the negative battery cable.
2. Disconnect the air hose(s) from the pulse air valve.
3. Disconnect the vacuum line, if necessary.
4. Remove the pulse air valve.

To install:

5. Install the pulse air valve, then, if removed, connect the vacuum line.
6. Connect the air hose(s) from the pulse air valve.
7. Connect the negative battery cable.

Air Silencer/Filter

1. Disconnect the negative battery cable.
2. Disconnect the hose from the silencer.
3. Remove the silencer from the vehicle.

To install:

4. Install the silencer, then connect the hose.
5. Connect the negative battery cable.

Check Valve

1. Disconnect the negative battery cable.
2. Disconnect the input hose from the check valve.
3. Remove the check valve from the connecting tube.

To install:

4. Fasten the check valve to the connecting tube.
5. Connect the input hose to the check valve.
6. Connect the negative battery cable.

Solenoid Vacuum Valve Assembly

1. Disconnect the negative battery cable.
2. Disengage the electrical connector, then disconnect the vacuum lines from the solenoid valve.
3. Remove the mounting bolts, then remove the solenoid vacuum valve.

To install:

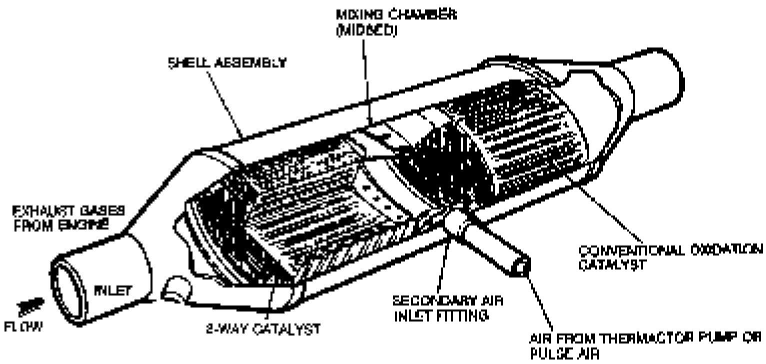
4. Install the solenoid valve, then fasten using the mounting bolts.
5. Connect the vacuum lines, then engage the electrical connector to the solenoid valve.
6. Connect the negative battery cable.

Catalytic Converters

Engine exhaust consists mainly of Nitrogen (N_2), however, it also contains Carbon Monoxide (CO), Carbon Dioxide (CO_2), Water Vapor (H_2O), Oxygen (O_2), Nitrogen Oxides (NOx) and Hydrogen (H), as well as various unburned Hydrocarbons (HC). Three of these exhaust components, CO, NOx and HC, are major air pollutants, so their emission to the atmosphere has to be controlled.

The catalytic converter, mounted in the engine exhaust stream, plays a major role in the emission control system. The converter works as a gas reactor whose catalytic function is to speed up the heat producing chemical reaction between the exhaust gas components in order to reduce the air pollutants in the engine exhaust. The catalyst material, contained inside the converter, is made of a ceramic substrate that is coated with a high surface area alumina and impregnated with catalytically active, precious metals.

All vehicles use a 3-way catalyst and some also use with a conventional oxidation catalyst. The conventional oxidation catalyst, containing Platinum (Pt) and Palladium (Pd), is effective for catalyzing the oxidation reactions of HC and CO. The 3-way catalyst, containing Platinum (Pt) and Rhodium (Rh) or Palladium (Pd) and Rhodium (Rh), is not only effective for catalyzing the oxidation reactions of HC and CO, but it also catalyzes the reduction of NOx.



Cross-sectional view of a catalytic converter assembly

Click to enlarge

The catalytic converter assembly consists of a structured shell containing a monolithic substrate; a ceramic, honeycomb construction. In order to maintain the converter's exhaust oxygen content at a high level to obtain the maximum oxidation for producing the heated chemical reaction, the oxidation catalyst usually requires the use of a secondary air source. This is provided by the pulse air or thermactor air injection systems.

The catalytic converter is protected by several devices that block out the air supply from the air injection system when the engine is laboring under one or more of the following conditions:

- **Cold engine operation with rich choke mixture**
- **Abnormally high engine coolant temperatures above 225°F (107°C), which may result from a condition such as an extended, hot idle on a hot day**
- **Wide-open throttle**
- **Engine deceleration**
- **Extended idle operation**

TEST STEP	RESULT	ACTION TO TAKE
B1 INSPECT EXHAUST SYSTEM		
• Visually inspect exhaust system. • Is exhaust system visually OK?	Yes	For 7.5L MFI: GO to B10. For all others: GO to B2.
	No	REPLACE any damaged exhaust components. VERIFY elimination of symptom. If problem is not corrected, GO to B2.
B2 VACUUM TEST		
• Attach vacuum gauge to intake manifold vacuum source. • Hook up tachometer. • Observe the vacuum gauge needle while performing the following: — Start engine and gradually increase the engine rpm to 2000 with the transmission in NEUTRAL. NOTE: The vacuum gauge reading may be normal when the engine is first started and idled. However, excessive restriction in the exhaust system will cause the vacuum gauge needle to drop to a low point even while the engine is idled. • Decrease engine speed to base idle rpm. • Did manifold vacuum reach above 16 inches of mercury with the engine rpm at 2000?	Yes	No restriction in the exhaust system. REFER to Section 2A, Diagnostic Routines Index, for Lack of Power.
	No	GO to B3.
B3 VACUUM TEST — RATE OF VACUUM GAUGE NEEDLE RETURN MOVEMENT		
• Vacuum gauge attached to intake manifold vacuum source. • Tachometer installed. • Increase the engine speed gradually from base idle rpm to 2000 rpm with the transmission in NEUTRAL. • Observe the rate of speed of the vacuum gauge needle as it falls and rises, while maintaining the increased engine rpm. NOTE: — On a non-restricted system, the vacuum gauge needle will drop to zero and then quickly return to the normal setting without delay. — On a restricted system, as the engine rpm is increased to 2000, the vacuum gauge needle will slowly drop to zero. As the increased rpm is maintained, the needle will slowly rise to normal. — The rate of speed at which the vacuum gauge needle returns to the normal setting is much slower on a restricted system than on a non-restricted system. • Decrease engine speed to base idle rpm. • Is rate of speed that the vacuum gauge needle returns to the normal setting much slower than that of a non-restricted system?	Yes	GO to B4.
	No	No restriction in the exhaust system. REFER to Section 2A, Diagnostic Routines Index, for Lack of Power.
B4 VACUUM TEST — EXHAUST DISCONNECTED		
• Turn engine off. • Disconnect exhaust system at exhaust manifold(s). • Repeat vacuum test found in Step B2. • Is manifold vacuum above 16 inches of mercury?	Yes	GO to B5.
	No	GO to B6.
B5 VACUUM TEST — CATALYTIC CONVERTER(S) ON / MUFFLER(S) OFF		
• Turn engine off. • Reconnect exhaust system at exhaust manifold(s). • Disconnect muffler(s). • Repeat vacuum test found in Step B2. • Is the manifold vacuum above 16 inches of mercury?	Yes	REPLACE muffler(s).
	No	REPLACE catalytic converter and inspect muffler to be sure converter debris has not entered muffler.
B6 EXHAUST MANIFOLD RESTRICTED		
• Remove the exhaust manifold(s). Inspect the ports for casting flash by dropping a length of chain into each port. NOTE: Do not use a wire or lamp to check ports. The restriction may be large enough for them to pass through, but small enough to cause excessive back pressure at high engine rpm. • Is a restriction present?	Yes	REMOVE casting flash. If flash cannot be removed, REPLACE exhaust manifold(s).
	No	REFER to Section 2A, Diagnostic Routines Index, for Lack of Power.

Catalyst and exhaust system diagnostic data

Click to enlarge

Service Interval Reminder Lights

RESETTING

Approximately every 5,000 or 7,500 miles (8,000 or 12,000 km), depending on engine application, the word SERVICE will appear on the electronic display for the first 1.5 miles (2.4 km) to remind the driver that is is time for the regular vehicle service interval maintenance (for example, an oil change).

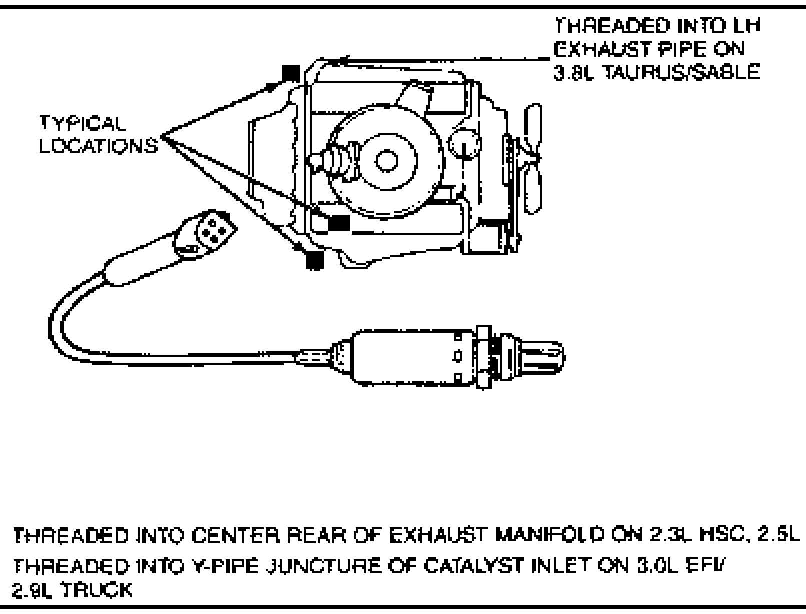
To reset the service interval reminder light for another interval, proceed as follows.

1. **With the engine running, press the ODO SEL and TRIP RESET buttons.**
2. **Hold the buttons down until the SERVICE light disappears from the display and 3 audible beeps are heard to verify that the service reminder has been reset.**

Do not confuse the service interval reminder light with the CHECK ENGINE or SERVICE ENGINE SOON Malfunction Indicator Light (MIL). An illuminated MIL likely indicates the presence of a self-diagnostic trouble code. Information on reading such trouble codes appears later in this section.

Oxygen Sensor

The oxygen sensor or Heated Exhaust Gas Oxygen (HEGO) sensor supplies the ECU with a signal which indicates a rich or lean condition during engine operation. This input information assists the ECU in determining the proper air/fuel ratio. The oxygen sensor is threaded into the exhaust manifold on all vehicles.



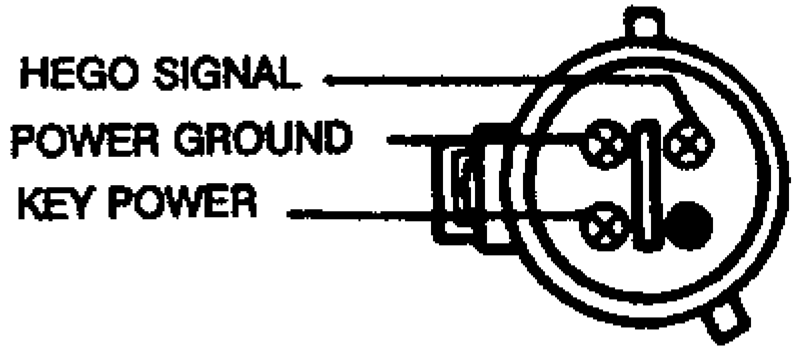
Heated Exhaust Gas Oxygen (HEGO) sensor assembly

Click to enlarge

TESTING

Except Engines Equipped With MAF Sensor

1. **Disconnect the oxygen sensor from the vehicle harness.**
2. **Connect a voltmeter between the HEGO signal terminal of the oxygen sensor connector and the negative battery terminal.**



Oxygen sensor (HEGO) assembly electrical connector

3. **Disconnect and plug the vacuum line at the MAP sensor and set the voltmeter on the 20 volt scale.**
4. **Apply 10-14 in. Hg (34-47 kPa) of vacuum to the MAP sensor.**
5. **Start the engine and run it at approximately 2000 rpm for 2 minutes.**
6. **If the voltmeter does not indicate greater than 0.5 volts within 2 minutes, replace the sensor.**

REMOVAL & INSTALLATION

1. **Disconnect the negative battery cable.**
2. **Disengage the oxygen/heated exhaust gas oxygen sensor electrical connector.**
3. **Remove the sensor from the exhaust manifold or exhaust pipes, as applicable.**

To install:

4. **Install the sensor in the exhaust manifold or pipe.**
5. **Engage the sensor electrical connector.**
6. **Connect the negative battery cable.**

ELECTRONIC ENGINE CONTROLS

General Information

The fuel injection system (CFI, EFI or SFI), is operated along with the ignition system to obtain optimum performance and fuel economy while producing a minimum of exhaust emissions. The various sensors described in this section are used by the computer control module for feedback to determine proper engine operating conditions. As the Taurus and Sable changed through the years, so did the name of the computer control module. Depending on the year of the vehicle it was called the EEC-IV Processor, Electronic Control Assembly (ECA), Electronic Control Unit (ECU) or Powertrain Control Module (PCM). Keep in mind, that even though the name of the component may have changed, its function did not.

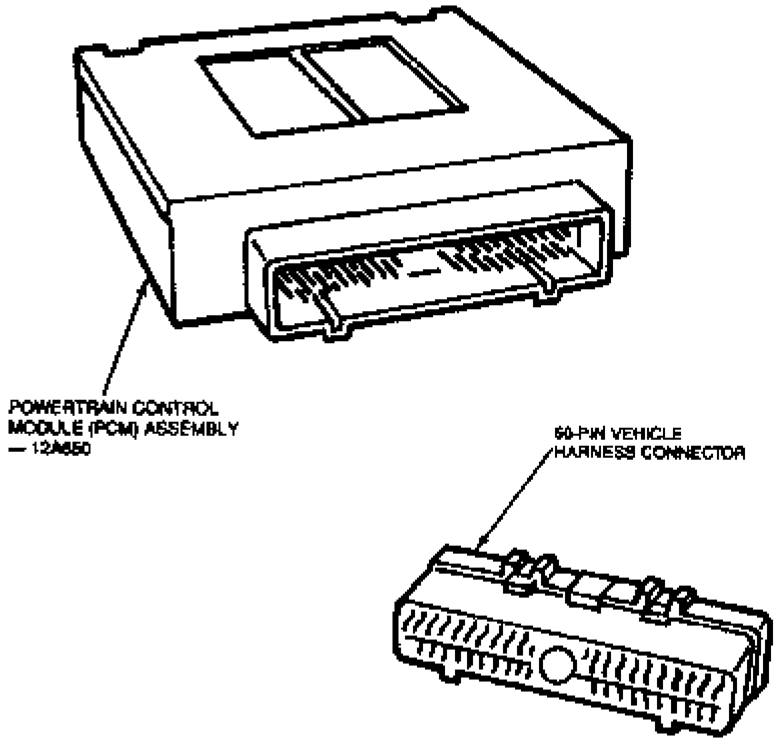
When dealing with the electronic engine control system, keep in mind that the system is sensitive to improperly connected electrical and vacuum circuits. The condition and connection of all hoses and wires should always be the first step when attempting to diagnose a driveability problem. Worn or deteriorated hoses and damaged or corroded wires may well make a good component appear faulty.

When troubleshooting the system, always check the electrical and vacuum connectors which may cause the problem before testing or replacing a component.

Computer Control Module

The heart of the electronic control system which is found on vehicles covered by this manual is a computer control module. Depending on the year of the vehicle, this module was called the EEC-IV Processor, Electronic Control Assembly (ECA), Electronic Control Unit (ECU) or Powertrain Control Module (PCM).

The computer control module is a microprocessor that receives data from sensors, switches, relays and other electronic components, then uses this information to control fuel supply and engine emission systems. The module contains a specific calibration for optimizing emissions, fuel economy and driveability. Based on information received and programmed into it's memory, the module generates output signals to control the fuel injection system. On the vehicles covered by this manual, the computer control module is located ahead of the glove box.



View of the computer control module-Powertrain Control Module (PCM) shown (other modules are basically identical)

Click to enlarge

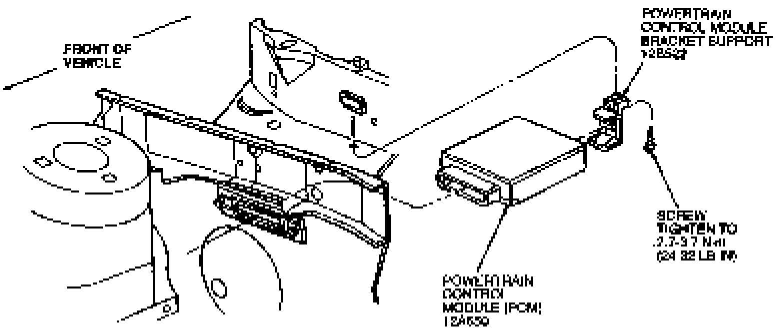
Regardless of the name, all computer control modules are serviced in a similar manner. Care must be taken when handling these expensive components in order to protect them from damage. Carefully follow all instructions included with the replacement part. Avoid touching pins or connectors to prevent damage from static electricity.

CAUTION

To prevent the possibility of permanent control module damage, the ignition switch MUST always be OFF when disconnecting power from or reconnecting power to the module. This includes unplugging the module connector, disconnecting the negative battery cable, removing the module fuse or even attempting to jump you dead battery using jumper cables.

REMOVAL & INSTALLATION

1. **Disconnect the negative battery cable.**
2. **If necessary, remove the glove box or kick panel.**
3. **Loosen the engine control sensor wiring to the computer control module connector retaining bolt. Remove the wiring connector from the module.**
4. **Loosen the module bracket support screw, located forward of the glove compartment. Remove the bracket, then remove the computer control module.**



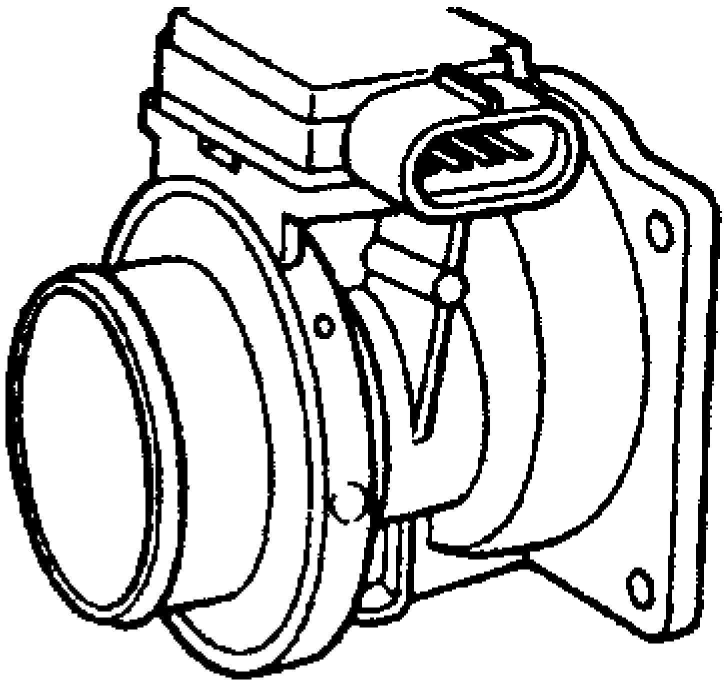
Computer control module mounting

Click to enlarge

5. **Installation is the reverse of the removal procedure. Tighten the module retaining screw to 24-32 inch lbs. (2.7-3.7 Nm). Tighten the engine control sensor wiring connector retaining bolt to 32 inch lbs. (3.7 Nm).**

Mass Air Flow (MAF) Sensor

The Mass Air Flow (MAF) sensor directly measures the mass of the air flowing into the engine. The sensor output is an analog signal ranging from about 0.5-5.0 volts. The signal is used by the ECU to calculate the injector pulse width. The sensing element is a thin platinum wire wound on a ceramic bobbin and coated with glass. This "hot wire'' is maintained at 11°F (200°C) above the ambient temperature as measured by a constant "cold wire''. The MAF sensor is located in the outlet side of the air cleaner lid assembly.



View of a common Mass Air Flow (MAF) sensor

TESTING

1. **Make sure the ignition key is OFF.**
2. **Connect Breakout Box T83L-50EEC-IV or equivalent, to the computer control**

module harness, then connect the control module.

3. Start the engine and let it idle.
4. Use a voltmeter to measure the voltage between test pin 50 of the breakout box and the battery negative post.
5. Replace the MAF sensor if the voltage is not 0.36-1.50 volts.

REMOVAL & INSTALLATION

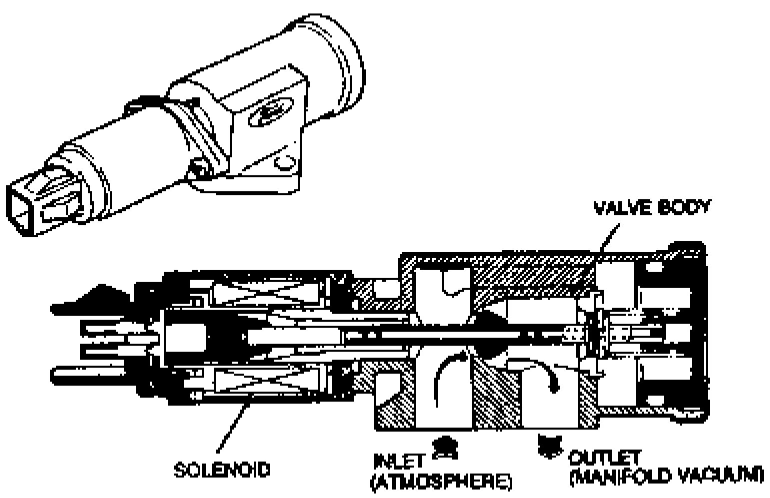
1. Disconnect the negative battery cable.
2. Remove the air intake tube.
3. Detach the MAF sensor electrical connector.
4. Unfasten the sensor attaching screws, then remove the sensor.

Inspect the MAF sensor-to-air cleaner lid gasket for any signs of deterioration. Replace the gasket, as necessary. If scraping is necessary, be careful not to damage the air cleaner lid or the MAF sensor gasket surfaces.

4. Installation is the reverse of the removal procedure.

Idle Air Bypass Valve

The idle air bypass valve is used to control engine idle speed and is operated by the computer control module, or in response to engine coolant temperature change, depending upon vehicle application. The valve allows air to flow into the intake air stream to control cold engine fast idle, no touch start, dashpot, over temperature idle boost and engine idle load correction. The air bypass valve, which is used on all EFI and SEFI systems, is located on the throttle body housing.



Cross-sectional view of the idle air bypass valve

Click to enlarge

TESTING

1. Make sure the ignition is in the OFF position.

2. Disconnect the air bypass valve.
3. Use an ohmmeter to measure the resistance between the terminals of the valve solenoid.

Due to the diode in the solenoid, place the ohmmeter positive lead on the VPWR pin and the negative lead on the ISC pin.

4. If the resistance is not between 7-13 ohms, replace the air bypass valve.

REMOVAL & INSTALLATION

1. Disconnect the negative battery cable.
2. Disengage the idle air bypass valve electrical connector from the wiring harness.
3. Remove the two retaining screws, then remove the idle air bypass valve and gasket assembly from the vehicle.

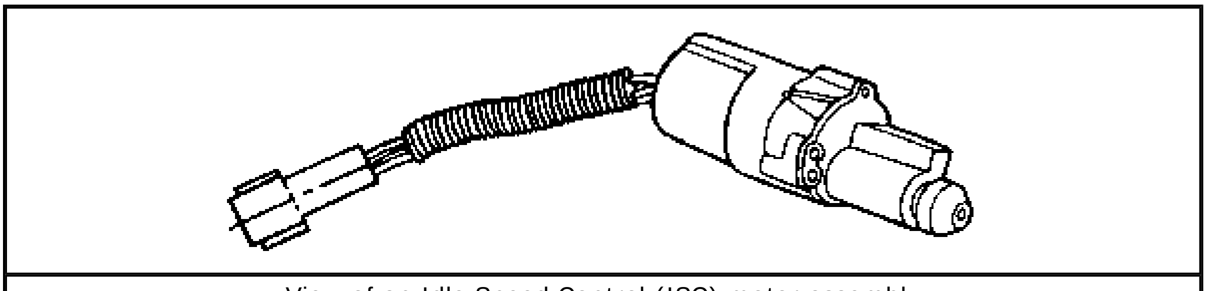
If scraping is necessary to clean the gasket mating surfaces, be careful not to damage the air bypass valve or throttle body gasket surfaces or drop any material into the throttle body.

To install:

4. Make sure the gasket mating surfaces are clean. Install a new gasket on the throttle body surface, then mount the valve assembly. Secure using the two retaining screws tightening them to 84 inch lbs. (9.5 Nm).
5. Engage the idle air bypass valve electrical connector to the wiring harness, then connect the negative battery cable.

Idle Speed Control (ISC) Motor

The Idle Speed Control (ISC) motor, which is used in the CFI system, controls idle speed by moving the throttle lever. It regulates airflow to maintain the desired engine rpm for both warm and cold engine idles. An idle tracking switch, integral to the motor, is utilized to determine when the throttle lever has contacted it, thereby signalling the need to control engine rpm. The motor extends or retracts a linear shaft through a gear reduction system. The motor direction is determined by the polarity of the applied voltage.



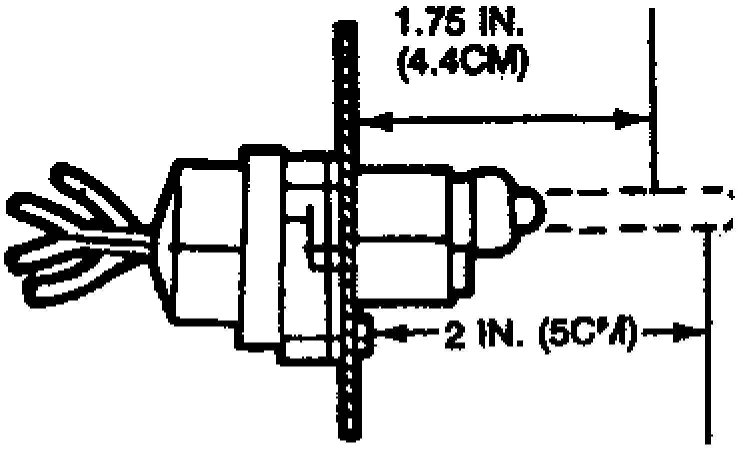
View of an Idle Speed Control (ISC) motor assembly

TESTING

1. Connect Breakout Box T83L-50EEC-IV, or equivalent, to the ECU wiring harness.
2. Use a jumper wire to connect the positive circuit of the ISC motor, test pin 21, to the positive battery terminal and connect another jumper wire between the

negative circuit of the motor, test pin 41, to battery ground for 4 seconds.

3. **Reverse the jumper wires, connecting the positive circuit of the ISC motor to battery ground and the negative circuit to battery positive for 4 seconds.**
4. **The ISC motor shaft should extend to greater than 2 in. (51mm) or retract to less than 1.75 in. (44.5mm) from the mounting bracket. If it does not, replace the ISC motor.**



The ISC motor shaft should extend to greater than 2 in. (51mm) or retract to less than 1.75 in. (44.5mm) from the mounting bracket

REMOVAL & INSTALLATION

1. **Disconnect the negative battery cable.**
2. **Detach the electrical connector from the ISC motor.**
3. **Unfasten the ISC motor mounting screws and remove the ISC motor.**
4. **Installation is the reverse of the removal procedure.**

Throttle Position (TP) Sensor

The Throttle Position (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. The TP sensor 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.

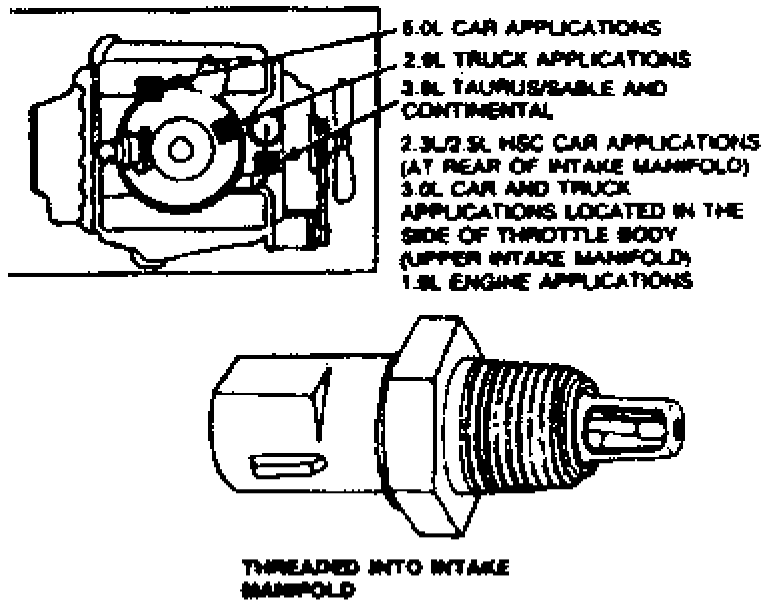
REMOVAL & INSTALLATION

1. **Disconnect the negative battery cable.**
2. **Detach the electrical connector from the TP sensor.**
3. **Unfasten the TP sensor mounting screws and remove the TP sensor.**
4. **Installation is the reverse of the removal procedure.**
5. **Adjust the sensor, if necessary.**

Air Charge Temperature (ACT) Sensor

The Air Charge Temperature (ACT) sensor in systems with vane air flow meters is used to measure the temperature of the incoming air and send the information to the computer control module. In all other systems, the sensor provides the computer control module with mixture, fuel and air temperature information.

The air temperature sensor is located in the meter in vane air flow meter systems. Otherwise, it is located in the air cleaner assembly or in the side of the throttle body.



View of a common Air Charge Temperature (ACT) sensor

Click to enlarge

TESTING

Without Vane Air Flow Meter

1. **Disconnect the temperature sensor.**
2. **Connect an ohmmeter between the sensor terminals and set the ohmmeter scale on 200,000 ohms.**
3. **Measure the resistance with the engine off and cool. Then measure the resistance with the engine running and warmed up. Compare the resistance values obtained with the accompanying chart.**
4. **Replace the sensor if the readings are incorrect.**

Temperature		Engine Coolant/Air Charge Temperature Sensor Values	
°F	°C	Voltage (volts)	Resistance (K ohms)
248	120	.27	1.18
230	110	.35	1.55
212	100	.46	2.07
194	90	.60	2.80
176	80	.78	3.84
158	70	1.02	5.37
140	60	1.33	7.70
122	50	1.70	10.97
104	40	2.13	16.15
86	30	2.60	24.27
68	20	3.07	37.30
50	10	3.51	58.75

ACT and ECT temperature sensor value chart

Click to enlarge

With Vane Air Flow Meter

1. Unfasten the vane air flow meter connector.
2. Access the sensor in the meter.
3. Monitor the temperature near the sensor.

If using a hot air gun to heat the sensor, be careful not to melt any plastic or rubber components.

4. Measure and record the resistance between the meter VAT terminal and the meter Signal Return (SIGRTN) terminal.
5. Compare the resistance readings with the accompanying chart. If the readings are incorrect, replace the sensor.

REMOVAL & INSTALLATION

Without Vane Air Flow Meter

1. Disconnect the negative battery cable.
2. Disengage the electrical connector from the air temperature sensor.
3. Remove the sensor.
4. Installation is the reverse of the removal procedure.

With Vane Air Flow Meter

The air charge temperature sensor is an integral component of the vane air flow meter. If the temperature sensor is defective, the vane air flow meter must be replaced.

Engine Coolant Temperature (ECT) Sensor

Temperature		Engine Coolant/Air Charge Temperature Sensor Values	
°F	°C	Voltage (volts)	Resistance (K ohms)
248	120	.27	1.18
230	110	.35	1.55
212	100	.46	2.07
194	90	.60	2.80
176	80	.78	3.84
158	70	1.02	5.37
140	60	1.33	7.70
122	50	1.70	10.97
104	40	2.13	16.15
86	30	2.60	24.27
68	20	3.07	37.30
50	10	3.51	58.75

ACT and ECT temperature sensor value chart

Click to enlarge

The Engine Coolant Temperature (ECT) sensor detects the temperature of engine coolant and supplies that information to the computer control module. The ECT sensor is located on the cylinder head or on the intake manifold. The sensor signal is used to modify ignition timing, EGR flow and air/fuel ratio as a function of engine coolant temperature.

TESTING

1. **Disconnect the temperature sensor.**
2. **Connect an ohmmeter between the sensor terminals and set the ohmmeter scale on 200,000 ohms.**
3. **Measure the resistance with the engine off and cool. Then, measure with the engine running and warmed up. Compare the resistance values obtained with the chart.**
4. **Replace the sensor if the readings are incorrect.**

REMOVAL & INSTALLATION

5. **Disconnect the negative battery cable.**
6. **Drain the cooling system to a level below the sensor.**
7. **Disengage the electrical connector from the ECT sensor.**
8. **Remove the ECT sensor.**
9. **Installation is the reverse of the removal procedure. Properly refill and bleed the cooling system.**

Manifold Absolute Pressure (MAP) Sensor

The MAP sensor measures manifold vacuum using a frequency. This gives the computer control module information on engine load. It is used as a barometric sensor for altitude compensation, updating the control module during key ON, engine OFF and every wide-open throttle. The ECU uses the MAP sensor for spark advance, EGR flow and air/fuel ratio.

TESTING

1. **Disconnect the vacuum supply hose from the MAP sensor.**
2. **Connect a suitable vacuum pump to the MAP sensor and apply 18 in. Hg (61 kPa) of vacuum.**
3. **If the MAP sensor does not hold vacuum, it must be replaced.**

REMOVAL & INSTALLATION

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.**
4. **Installation is the reverse of the removal procedure.**

SELF-DIAGNOSTIC SYSTEMS

General Information

All vehicles covered by this manual have self-diagnostic capabilities. Malfunctions in the engine control system are found through the Self-Test procedure. The vehicles covered by this manual use the Electronic Engine Control-IV (EEC-IV) system, which utilizes a Self-Test divided into 3 specialized tests: Key On Engine Off Self-Test, Engine Running Self-Test and Continuous Self-Test. The Self-Test is not a conclusive test by itself, but is used as a part of a functional Quick Test diagnostic procedure. The computer control module stores the Self-Test program in its permanent memory. When activated, it checks the EEC-IV system by testing its memory integrity and processing capability, then verifies that various sensors and actuators are connected and operating properly. The Key On Engine Off and Engine Running Self-Tests are functional tests which only detect faults present at the time of the Self-Test. Continuous Self-Test is an ongoing test that stores fault information in Keep Alive Memory (KAM) for retrieval at a later time.

Fault information is communicated through the Self-Test service codes. These service codes are 2-digit or 3-digit numbers representing the results of the Self-Test. The service codes are transmitted on the Self-Test output line found in the vehicle Self-Test connector. They are in the form of timed pulses and can be read on a voltmeter, STAR or SUPER STAR II tester and the malfunction indicator light.

Reading Codes

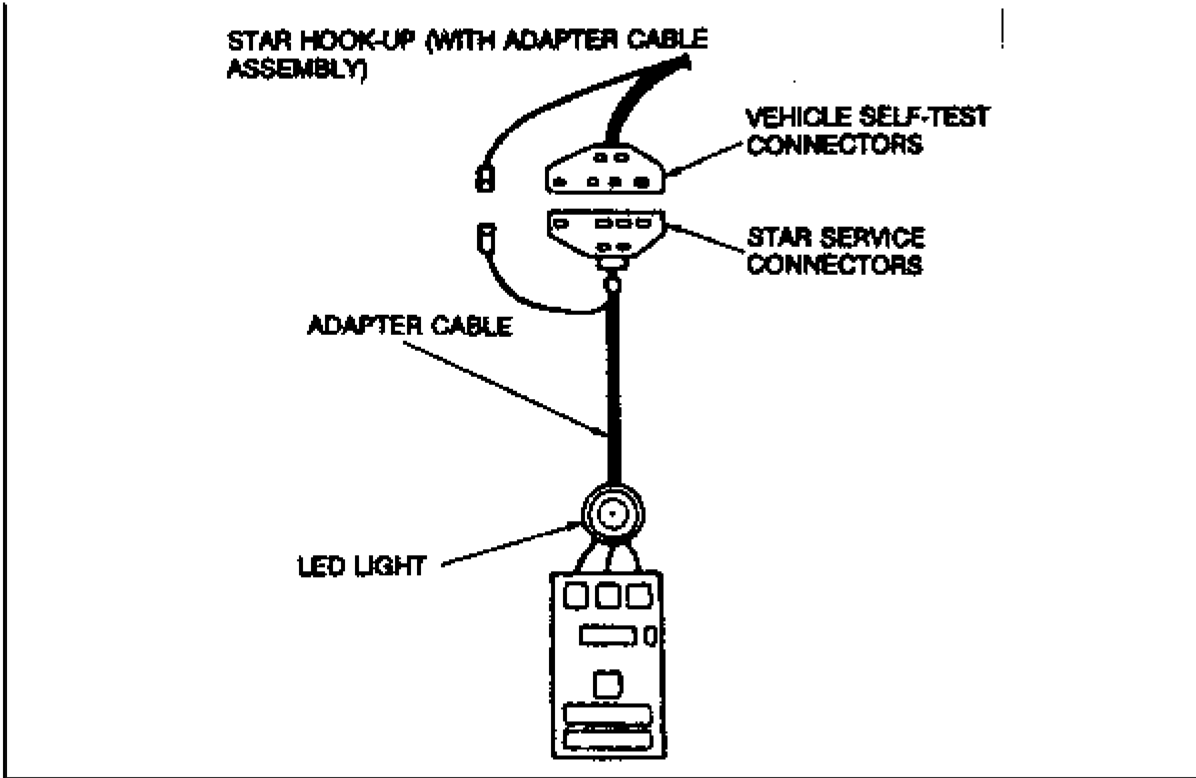
VEHICLE PREPARATION

1. **Apply the parking brake, place the transaxle shift lever firmly into P on automatic transaxle or Neutral on manual transaxles, and block the drive wheels.**
2. **Turn all electrical loads (radio, lights, blower fan, etc.) OFF.**

USING THE STAR OR SUPER STAR II TESTER

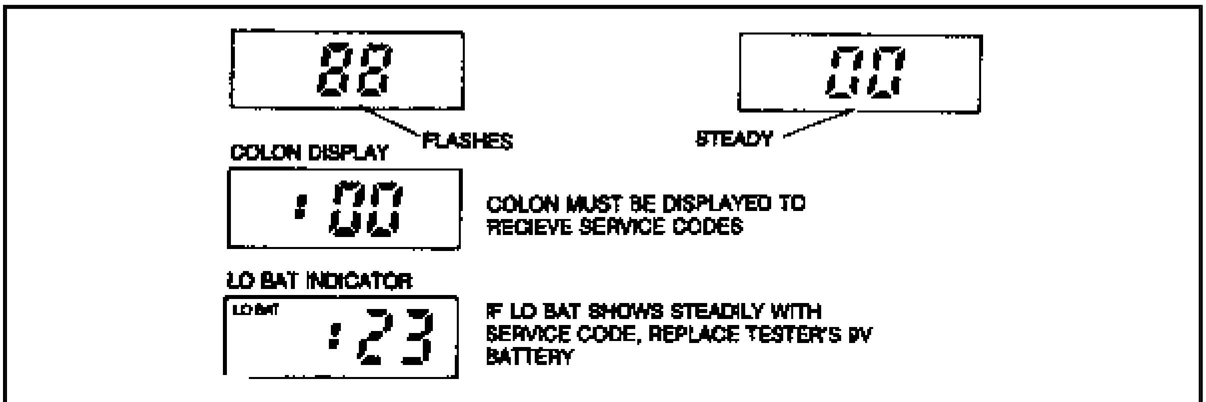
The STAR tester cannot be used to read 3-digit service codes. If the STAR tester is used on a 3-digit service code application, the display will be blank. The SUPER STAR II tester must be used to read 3-digit service codes.

After hooking up the STAR tester and turning on its power switch, the tester will run a display check and the numerals **88** will begin to flash in the display window. A steady **00** will then appear, indicating that the STAR tester is ready. To receive service codes, press the button on the front of the STAR tester. The button will latch down and a colon will appear in the display window in front of the **00** numerals. The colon must be displayed to receive the service codes.



STAR tester hook-up

Click to enlarge



STAR tester output code format

Click to enlarge

If it is desired to clear the display window during the Self-Test, turn **OFF** the vehicle's engine, press the tester's button once to unlatch it, then press the button again to latch down the button.

Connect the STAR or SUPER STAR II tester as follows:

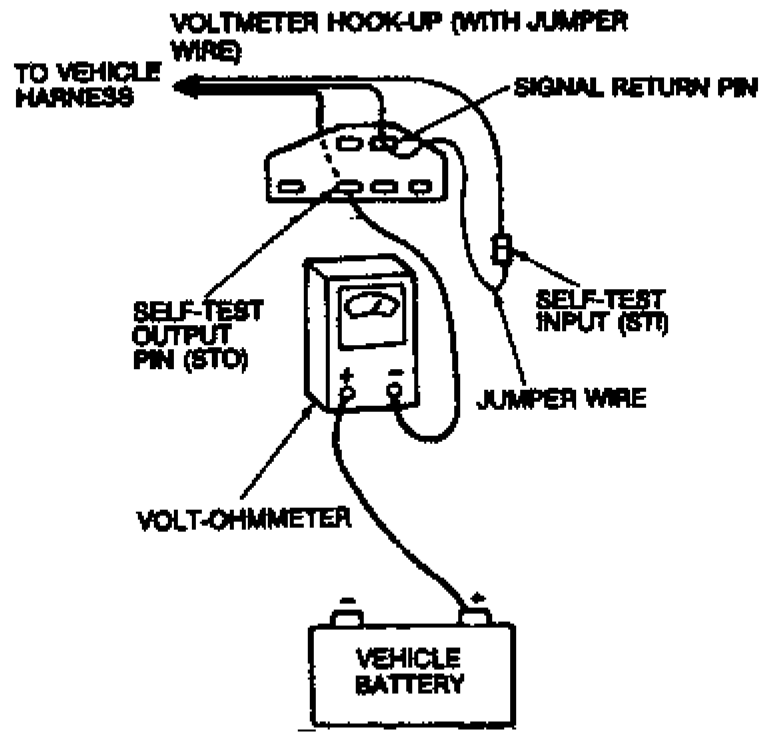
1. **Turn the ignition OFF.**
2. **Connect the color coded adapter cable to the STAR tester.**
3. **Connect the adapter cable leads to the proper Self-Test connectors.**
4. **Ground the adapter cable for vehicles using the SUPER STAR II tester.**
5. **Slide the SUPER STAR II tester switch to the MECS or EEC-IV position, according to the vehicle system.**

USING THE ANALOG VOLTMETER

Service codes will be represented by pulsing or sweeping movements of the voltmeter's needle across the dial face of the voltmeter. Therefore, a single digit number of 3 will be reported by 3 needle sweeps. However, a service code is represented by a 2-digit or 3-digit number, such as 23. As a result, the Self-Test service code of 23 will appear on the voltmeter as 2 needle sweeps, then after a 2 second pause, the needle will sweep 3 times.

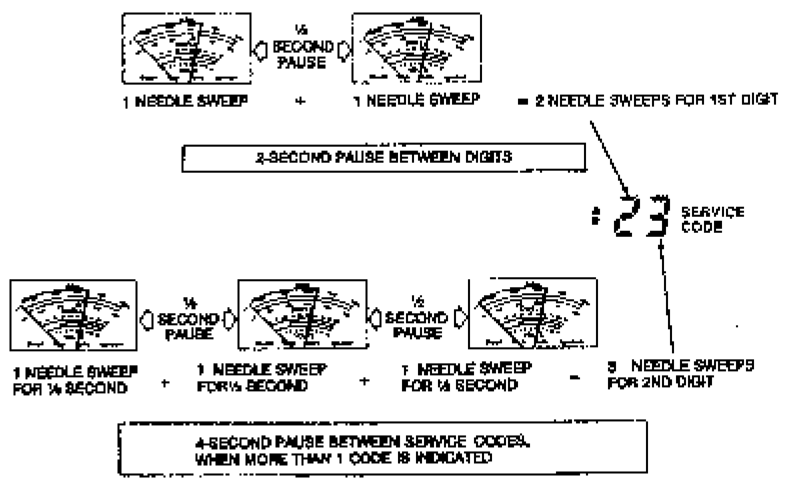
Connect the analog voltmeter as follows:

1. **Turn the ignition OFF.**



Voltmeter hook-up

Click to enlarge



Analog voltmeter output code format

Click to enlarge

2. **Set the voltmeter on a DC voltage range to read from 0-20 volts.**
3. **On all EEC-IV vehicles, connect the voltmeter from the battery positive post to the Self-Test Output (STO) pin of the large Self-Test connector. On all other vehicles, connect the positive voltmeter lead to the EEC STO line and the negative lead to engine ground, then jumper the EEC Self-Test Input (STI) to ground.**

USING THE MALFUNCTION INDICATOR LIGHT (MIL)

During the Self-Test,a service code is reported by the malfunction indicator light. It will represent itself as a flash on the CHECK ENGINE or SERVICE ENGINE SOON light on the dash panel. A single digit number of 3 will be reported by 3 flashes. However, a service code is represented by a 2-digit or 3-digit number, such as 23. As a result, the Self-Test service code of 23 will appear on the MIL light as 2 flashes, then, after a 2 second pause, the light will flash 3 times.

KEY ON ENGINE OFF SELF-TEST

Start the engine and let it run until it reaches normal operating temperature. Turn the engine **OFF** and activate the Self-Test.

1. **If using the STAR tester, proceed as follows:**
    1. **Latch the center button in the down position.**
    2. **Place the ignition key in the ON position.**
    3. **Record all service codes displayed.**
2. **If using the SUPER STAR II tester, proceed as follows:**
    1. **Latch the center button in the TEST position.**
    2. **Turn the ignition key ON.**
    3. **Turn the tester ON ; the tester will sound and 888 will be displayed for 2 seconds.**
    4. **Unlatch and relatch the center test button. After all codes are received, unlatch the center button to review all codes retained in tester memory. The SUPER STAR II tester has a mode switch. The tester will only display 3-digit service codes in fast code mode. If slow code mode is used on 3-digit service code applications, the display will be blank.**
3. **If using the analog voltmeter, jumper the Self-Test Input (STI) to the Signal Return (SIG RTN) at the Self-Test connectors, then, turn the ignition key and the voltmeter ON. Observe the needle for any code indications and record.**
4. **If using the malfunction indicator light; connect the jumper wire from STI to the SIG RTN at the Self-Test connectors and turn the ignition switch ON. Service codes will be flashed on the MIL.**

ENGINE RUNNING SELF-TEST

1. **Deactivate the Self-Test.**
2. **Start and run the engine at 2000 rpm for 2 minutes.**
3. **Turn the engine OFF and wait 10 seconds.**
4. **Activate the Self-Test.**

5. **Start the engine.**
6. **Record all service codes displayed.**

Engine identification codes are issued at the beginning of the Engine Running Self-Test and are 1-digit numbers represented by the number of pulses sent out. The engine identification code is equal to $^1/_2$ the number of engine cylinders. Two pulses equals 4 cylinders. The identification codes are used to verify that the proper processor is installed and that the Self-Test has been entered.

Clearing Codes

CONTINUOUS MEMORY

Do not disconnect the battery to clear continuous memory codes. This will erase the Keep Alive Memory (KAM) information which may cause a driveability concern.

1. **Run the Key On Engine Off Self-Test.**
2. **When the service codes begin to be displayed, deactivate the Self-Test as follows:**
    1. **STAR tester: unlatch the center button to the UP position.**
    2. **Analog voltmeter and MIL: remove the jumper wire from between the Self-Test Input (STI) connector and the signal return pin of the Self-Test connector.**
    3. **The continuous memory codes will be erased from the ECU memory.**

KEEP ALIVE MEMORY (KAM)

The computer control module stores information regarding vehicle operating conditions and uses this information to compensate for component tolerances. Whenever an emission related component is replaced, the Keep Alive Memory (KAM) should be cleared to erase the information stored by the control module from the original component.

To clear KAM, disconnect the negative battery cable for at least five minutes. After the KAM has been cleared, the vehicle may exhibit certain driveability concerns. If this is the case, it will be necessary to drive the vehicle at least 10 miles (16 km) for the computer to relearn the values for optimum driveability and performance.

DIAGNOSTIC TROUBLE CODES

Listings of the Diagnostic Trouble Codes (DTCs) for the various engine control systems covered in this manual are located in this section. When using these codes, remember that a code only points to the faulty circuit, NOT necessarily to a faulty component. Loose, damaged or corroded connections may contribute to a fault code on a circuit when the sensor or component it operating properly. Be sure that components are faulty before replacing them, especially the expensive ones.

Service Codes (ENGINE (Liters) / FUEL SYSTEM)	Quick Test Mode	2.5L HSC CFI	3.0L EFI	3.0L SHO SEFI	3.8L AXOD SEFI
11—System pass	O/R/C	✓	✓	✓	✓
12—Rpm unable to reach upper test limit	R	✓	✓	✓	✓
13—DC motor movement not detected	O	✓			
13—Rpm unable to achieve lower test limit	R	✓	✓	✓	✓
13—DC motor did not follow dashpot	C	✓			
14—PIP circuit failure	C	✓	✓	✓	✓
15—ECA read only memory test failed	O	✓	✓	✓	✓
15—ECA keep alive memory test failed	C	✓	✓	✓	✓
16—Idle rpm high with ISC off	R	✓			
16—Idle too low to perform EGO test	R				
17—Idle rpm low with ISC off	R	✓			
18—SPOUT circuit open or spark angle word failure	R	✓	✓	✓	✓
18—IDM circuit failure or SPOUT circuit grounded	C	✓	✓	✓	✓
19—Failure in ECA internal voltage	O		✓		✓
19—CID circuit failure	C		✓		
19—Rpm dropped too low in ISC off test	R				
19—Rpm for EGR test not achieved	R				
21—ECT out of self test range	O/R	✓	✓	✓	✓
22—BP sensor out of self-test range	O/C			✓	
22—BP or MAP out of self-test range	O/R/C	✓	✓		✓
23—TP out of self-test range	O/R		✓	✓	✓
23—TP out of self-test range	O/R/C	✓			
24—ACT sensor out of self test range	O/R	✓	✓	✓	✓
25—Knock not sensed during dynamic test	R			✓	✓
26—VAF/MAF out of self-test range	O/R			✓	
26—VAT out of self-test range	O/R				
29—Insufficient input from vehicle speed sensor	C	✓	✓	✓	✓
31—PFE, EVP or EVR circuit below minimum voltage	O/R/C	✓	✓	✓	✓
32—DPT circuit voltage low (PFE)	R/C		✓	✓	✓
32—EVP voltage below closed limit	O/R/C	✓			
32—EGR not controlling	R				
33—EGR valve opening not detected	R/C	✓	✓	✓	✓
33—EGR not closing fully	R				
34—Defective PFE sensor or voltage out of range	O		✓	✓	✓
34—EPT sensor voltage high (PFE)	R/C		✓	✓	✓
34—EVP voltage above closed limit	O/R/C	✓			
34—EGR opening not detected	R				
35—PFE or EVP circuit above maximum voltage	O/R/C	✓	✓	✓	✓
35—Rpm too low to perform EGR test	R				
38—Idle tracking switch circuit open	C	✓			
39—AXOD lock up failed	C		✓		
41—HEGO sensor circuit indicates system lean	R	✓	✓	✓ ①	✓ ②
41—No HEGO switching detected	R	✓	✓	✓ ①	✓ ②
42—HEGO sensor circuit indicates system rich	R	✓	✓	✓ ①	✓ ②
42—No HEGO switching detected—reads rich	C				
43—HEGO lean at wide open throttle	C				
44—Thermactor air system inoperative—cyl. side	R				
45—Thermactor air upstream during self-test	R			✓	
45—Coil 1 primary circuit failure	C				
46—Thermactor air not bypassed during self-test	R			✓	
46—Coil 2 primary circuit failure	C			✓	
47—Measured airflow low at base idle	R				
48—Coil 3 primary circuit failure	C			✓	
48—Measured airflow high at base idle	R				
49—SPOUT signal defaulted to 10° BTDC or SPOUT open	C			✓	
51—ECT/ACT reads −40°F or circuit open	O/C	✓	✓	✓	✓
52—Power steering pressure switch circuit open	O	✓	✓	✓	✓
52—Power steering pressure switch always open or closed	R	✓	✓	✓	✓

Diagnostic Trouble Codes

Click to enlarge

Service Codes (ENGINE (Liters) / FUEL SYSTEM)	Quick Test Mode	2.5L FLC CFI	3.0L EFI	3.0L SHO SEFI	3.8L AXOD SEFI
53—TP circuit above maximum voltage	O/C	✓	✓	✓	✓
54—ACT sensor circuit open	O/C	✓	✓	✓	✓
55—Keypower circuit open	R	✓			
56—VAF or MAF circuit above maximum voltage	O/C			✓	
56—MAF circuit above maximum voltage	O/R/C				
57—Octane adjust service pin in use	O				
57—AXOD neutral pressure switch circuit failed open	C		✓		✓
58—Idle tracking switch circuit open	O	✓			
58—Idle tracking switch closed/circuit grounded	R	✓			
58—VAT reads −40°F or circuit open	O/C	✓			
58—Idle adjust service pin in use	O				
59—AXOD 4/3 pressure switch circuit failed open	C		✓		✓
59—Low speed fuel pump circuit open—Battery to ECA	O/C			✓	
59—AXOD 4/3 pressure switch failed closed	O				✓
61—ECT reads 254°F or circuit grounded	O/C	✓	✓	✓	✓
62—AXOD 4/3 or 3/2 pressure switch circuit grounded	O		✓		
63—TP circuit below minimum voltage	O/C	✓	✓	✓	✓
64—ACT sensor input below test minimum or grounded	O/C	✓	✓	✓	✓
65—Never went to closed loop fuel control	C				
66—MAF sensor input below minimum voltage	C			✓	
66—VAF sensor below minimum voltage	O/C				
66—MAF circuit below minimum voltage	R/C				
67—Neutral/drive switch open or A/C on	O	✓	✓	✓	✓
67—Clutch switch circuit failure	C	✓			
67—Neutral/drive switch open or A/C on	O/R				
68—Idle tracking switch closed or circuit grounded	O	✓			
68—Idle tracking switch circuit open	R	✓			
68—AXOD transmission temperature switch failed open	O/R/C				✓
68—VAT reads 254°F or circuit grounded	O/C				
69—AXOD 3/2 pressure switch circuit failed closed	O				
69—AXOD 3/4 pressure switch circuit failed open	C		✓		✓
70—ECA DATA communications link circuit failure	C				✓
71—Software re-initialization detected	C				
71—Idle tracking switch shorted to ground	C	✓			
71—Cluster control assembly circuit failed	C				✓
72—Insufficient MAF/MAP change during dynamic test	R		✓	✓	
72—Power interrupt or re-initialization detected	C	✓			
72—Message center control assembly circuit failed	C				✓
73—Insufficient throttle position change	O	✓			
73—Insufficient TP change during dynamic test	R		✓	✓	
74—Brake on/off switch failure or not actuated	R	✓	✓	✓	✓
75—Brake on/off switch circuit closed or ECA input open	R				
76—Insufficient VAF change during dynamic test	R				
77—No WOT seen in self-test or operator error	R		✓	✓	
79—A/C or defrost on during self-test	O			✓	✓

Diagnostic Trouble Codes

Click to enlarge

Service Codes (ENGINE (Liters) / FUEL SYSTEM)	Quick Test Mode	2.5L FLC CFI	3.0L EFI	3.0L SHO SEFI	3.8L AXOD SEFI
81—IAS circuit failure	O			✓	
81—Air management 2 circuit failure	O				
82—Air management 1 circuit failure	O				
82—Supercharger bypass circuit failure	O				
83—High speed electro drive fan circuit failure	O	✓	✓		✓
83—Low speed fuel pump circuit failure	O/C			✓	
84—EGR vacuum solenoid circuit failure	O	✓	✓	✓	✓
84—EGR vacuum regulator circuit failure	O/R				
85—Canister purge circuit failure	O/R				
85—Canister purge solenoid circuit failure	O	✓	✓	✓	✓
85—Adaptive fuel lean limit reached	C				
86—3–4 shift solenoid circuit failure	O				
86—Adaptive fuel rich limit reached	C				
87—Fuel pump primary circuit failure	O/C	✓	✓	✓	✓
87—Fuel pump primary circuit failure	O/C/R				
87—Fuel pump primary circuit failure	O				
88—Electro drive fan circuit failure	O	✓	✓	✓	✓
89—Converter clutch override circuit failure	O				
89—Lock up solenoid circuit failure	O		✓		✓
91—HEGO sensor indicates system lean	R			✓ ①	✓ ③
91—No HEGO switching detected	C			✓ ①	✓ ②
92—HEGO sensor indicates system rich	R			✓ ①	✓ ③
93—TP sensor input low at maximum motor travel	O	✓			
94—Thermactor air system inoperative-left side	R				
95—Fuel pump secondary circuit failure—ECA to ground	O/C	✓	✓	✓	✓
96—Fuel pump secondary circuit failure—Battery to ECA	O/C	✓	✓		✓
97—High speed fuel pump circuit open	O/C			✓	
98—Hard fault present	R		✓	✓	✓
99—EEC has not learned to control idle; ignore codes 12 & 13	R	✓			

No Codes: Cannot begin self-test or erratic codes

Codes Not Listed: Do not apply to vehicle being tested

O—Key on engine off test

R—Key on engine running test

C—Continuous memory

① Front HEGO

② Right HEGO

③ Left HEGO

④ Rear HEGO

Diagnostic Trouble Codes

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Service Codes (ENGINE (Liters) / FUEL SYSTEM)	Quick Test Mode	2.5L AXOD-E SEFI	3.0L EFI	3.0L AXOD-E SEFI	3.8L AXOD-E SEFI
111—System pass	O/R/C	✓	✓	✓	✓
112—ACT sensor circuit grounded or reads 254°F	O/C	✓	✓	✓	✓
113—ACT sensor circuit grounded	O/R				
113—ACT sensor circuit open	O/R				
113—ACT sensor circuit open or reads –40°F	O/C	✓	✓	✓	✓
114—ACT outside test limits during KOEO or KOER tests	O/R	✓	✓	✓	✓
116—ECT outside test limits during KOEO or KOER tests	O/R	✓	✓	✓	✓
117—ECT sensor circuit grounded	O/C	✓	✓	✓	✓
118—ECT sensor circuit above maximum voltage or reads –40°F	O/C			✓	
118—ECT sensor circuit open	O/C	✓	✓		✓
121—Closed throttle voltage higher or lower than expected	O/R/C	✓	✓	✓	✓
122—TP sensor circuit below minimum voltage	O/C	✓	✓	✓	✓
123—TP sensor above maximum voltage	O/C	✓	✓	✓	✓
124—TP sensor voltage higher than expected, in range	C	✓		✓	✓
125—TP sensor voltage lower than expected in range	C	✓		✓	✓
126—BP or MAP sensor higher or lower than expected	O/R/C		✓		
129—Insufficient MAF change during Dynamic Response test	R	✓	✓	✓	✓
136—HEGO shows system always lean (front)	R			✓	✓
136—HEGO shows system always lean (left)	R				
137—HEGO shows system always rich (front)	R			✓	✓
137—HEGO shows system always rich (left)	R				
139—No HEGO switching (front)	C			✓	✓
139—No HEGO switching (left)	C				
144—No HEGO switching (rear)	C			✓	✓
144—No HEGO switching (right)	C				
144—No HEGO switching	C		✓		
144—No HEGO switching detected	C	✓			
157—MAF sensor circuit below minimum voltage	C	✓		✓	✓
158—MAF sensor circuit above maximum voltage	O/C	✓		✓	✓
158—MAF sensor circuit above maximum voltage	O/R/C				
159—MAF higher or lower than expected during KOEO and KOER test	O/R	✓		✓	✓
167—Insufficient TP change during Dynamic Response test	R	✓	✓	✓	✓
171—Fuel system at adaptive limit, HEGO unable to switch	C	✓			
171—Fuel system at adaptive limit, HEGO unable to switch (right)	C				
171—No HEGO switching; system at adaptive limit (rear)	C				
172—HEGO shows system always lean (rear)	R/C		✓	✓	✓
172—No HEGO switching seen; indicates lean	R/C	✓			
172—No HEGO switching seen; indicates lean (right)	R/C				
173—HEGO shows system always rich (rear)	R/C		✓	✓	✓
173—No HEGO switching seen; indicates rich	R/C	✓			
173—No HEGO switching seen; indicates rich (right)	R/C				
174—HEGO switching time is slow (right)	C				
175—No HEGO switching; system at adaptive limit (front)	C		✓	✓	✓
175—No HEGO switching; system at adaptive limit (left)	C				
176—HEGO shows system always lean (front)	C		✓	✓	✓
176—HEGO shows system always lean (left)	C	✓	✓		
177—HEGO shows system always rich (front)	C		✓	✓	✓
177—HEGO shows system always rich (left)	C				
178—HEGO switching time is slow (left)	C				
179—Fuel at lean adaptive limit at part throttle; system rich	C	✓			
179—System at lean adaptive limit at part throttle; system rich (rear)	C		✓	✓	✓
179—System at lean adaptive limit at part throttle; system rich (right)	C				

Diagnostic Trouble Codes

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Service Codes — ENGINE (Liters) / FUEL SYSTEM	Quick Test Mode	2.5L AXODE SEFI	3.0L EFI	3.0L AXODE SEFI	3.8L AXODE SEFI
181—Fuel at rich adaptive limit at part throttle; system lean	C	✓			
181—System at rich adaptive limit at part throttle; system lean (rear)	C		✓	✓	✓
181—System at rich adaptive limit at part throttle; system lean (right)	C				
182—Fuel at lean adaptive limit at idle; system rich	C	✓			
182—System at lean adaptive limit at idle; system rich (rear)	C		✓	✓	✓
182—System at lean adaptive limit at idle; system rich (right)	C				
183—Fuel at rich adaptive limit at idle; system lean	C	✓			
183—System at rich adaptive limit at idle; system lean (rear)	C		✓	✓	✓
184—MAF higher than expected	C	✓		✓	✓
185—MAF lower than expected	C	✓		✓	✓
186—Injector pulse width higher than expected	C	✓		✓	✓
187—Injector pulse width lower than expected	C	✓		✓	✓
188—System at lean adaptive limit at part throttle; system rich (front)	C		✓	✓	
188—System at lean adaptive limit at part throttle; system rich (left)	C				
189—System at rich adaptive limit at part throttle; system lean (front)	C		✓	✓	✓
189—System at rich adaptive limit at part throttle; system lean (left)	C				
191—System at lean adaptive limit at idle; system rich (front)	C		✓	✓	✓
191—System at lean adaptive limit at idle; system rich (left)	C				
192—System at rich adaptive limit at idle; system lean (front)	C		✓	✓	✓
192—System at rich adaptive limit at idle; system lean (left)	C				
211—PIP circuit fault	C	✓	✓	✓	✓
212—Loss of IDM input to EEC or SPOUT circuit grounded	C	✓	✓	✓	✓
213—SPOUT circuit open	R	✓	✓	✓	✓
214—Cylinder identification circuit failure	C	✓		✓	✓
215—EEC processor detected Coil 1 primary circuit failure	C				
216—EEC processor detected Coil 2 primary circuit failure	C				
218—Loss of IDM signal, left side	C				
219—Spark timing defaulted to 10°BTDC or SPOUT circuit open	C				
222—Loss of IDM signal, right side					
223—Loss of dual plug inhibit control	C	✓			
224—Erratic IDM input to processor	C	✓			
225—Knock not sensed during Dynamic Response test	R	✓			
311—Thermactor air system inoperative (right)	R				
312—Thermactor air not bypassed during self-test	R				
314—Thermactor air system inoperative (left)	R				
326—PFE or DPFE circuit voltage lower than expected	R/C	✓	✓	✓	✓
327—EVP or DPFE circuit below minimum voltage	O/R/C	✓	✓	✓	✓
328—EVR closed voltage lower than expected	O/R/C				
332—Insufficient EGR flow detected	R/C	✓	✓	✓	✓
334—EGR closed voltage higher than expected	O/R/C				
335—PFE or DPFE sensor voltage out of self-test range	O	✓	✓	✓	✓
336—PFE sensor voltage higher than expected	R/C	✓	✓	✓	✓
337—EVP or DPFE circuit above maximum voltage	O/R/C	✓	✓	✓	✓
341—Octane adjust service pin in use	O				
411—Cannot control rpm during KOER low rpm check	R	✓	✓	✓	✓
412—Cannot control rpm during KOER high rpm check	R	✓	✓	✓	✓
452—Insufficient input from vehicle speed sensor	C	✓	✓	✓	✓
511—EEC processor ROM test failed	O	✓	✓	✓	✓
512—EEC processor Keep Alive Memory test failed	O	✓			
512—EEC processor Keep Alive Memory test failed	C		✓	✓	✓
513—Failure in EEC processor internal voltage	O	✓	✓	✓	✓
519—Power steering pressure sensor circuit open	O	✓	✓	✓	✓

Diagnostic Trouble Codes

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DIAGNOSTIC TROUBLE CODES	DEFINITIONS
111	System Pass
112	Intake Air Temp (IAT) sensor circuit below minimum voltage / 254°F indicated
113	Intake Air Temp (IAT) sensor circuit above maximum voltage / -40°F indicated
114	Intake Air Temp (IAT) sensor circuit voltage higher or lower than expected
116	Engine Coolant Temp (ECT) sensor circuit voltage higher or lower than expected
117	Engine Coolant Temp (ECT) sensor circuit below minimum voltage / 254°F indicated
118	Engine Coolant Temp (ECT) sensor circuit above maximum voltage / -40°F indicated
121	Closed throttle voltage higher or lower than expected
121	Throttle position voltage inconsistent with the MAF sensor
122	Throttle Position (TP) sensor circuit below minimum voltage
123	Throttle Position (TP) sensor circuit above maximum voltage
124	Throttle Position (TP) sensor voltage higher than expected
125	Throttle Position (TP) sensor voltage lower than expected
126	MAP/BARO sensor circuit voltage higher or lower than expected
128	MAP sensor vacuum hose damaged / disconnected
129	Insufficient MAP - Mass Air Flow (MAF) change during dynamic response test KOER
136	Lack of Heated Oxygen Sensor (HO2S-2) switch during KOER, indicates lean (Bank #2)
137	Lack of Heated Oxygen Sensor (HO2S-2) switch during KOER, indicates rich (Bank #2)
139	No Heated Oxygen Sensor (HO2S-2) switches detected (Bank #2)
141	Fuel system indicates lean
144	No Heated Oxygen Sensor (HO2S-1) switches detected (Bank #1)
157	Mass Air Flow (MAF) sensor circuit below minimum voltage
158	Mass Air Flow (MAF) sensor circuit above maximum voltage
159	Mass Air Flow (MAF) sensor circuit voltage higher or lower than expected
167	Insufficient throttle position change during dynamic response test KOER
171	Fuel system at adaptive limits, Heated Oxygen Sensor (HO2S-1) unable to switch (Bank #1)
172	Lack of Heated Oxygen Sensor (HO2S-1) switches, indicates lean (Bank #1)
173	Lack of Heated Oxygen Sensor (HO2S-1) switches, indicates rich (Bank #1)
175	Fuel system at adaptive limits, Heated Oxygen Sensor (HO2S-2) unable to switch (Bank #2)
176	Lack of Heated Oxygen Sensor (HO2S-2) switches, indicates lean (Bank #2)
177	Lack of Heated Oxygen Sensor (HO2S-2) switches, indicates rich (Bank #2)
179	Fuel system at lean adaptive limit at part throttle, system rich (Bank #1)
181	Fuel system at rich adaptive limit at part throttle, system lean (Bank #1)
184	Mass Air Flow (MAF) sensor voltage higher than expected
185	Mass Air Flow (MAF) sensor voltage lower than expected
186	Injector pulsewidth higher than expected (with BARO sensor)
186	Injector pulsewidth higher or mass air flow lower than expected (without BARO sensor)
187	Injector pulsewidth lower than expected (with BARO sensor)
187	Injector pulsewidth lower or mass air flow higher than expected (without BARO sensor)
188	Fuel system at lean adaptive limit at part throttle, system rich (Bank #2)
189	Fuel system at rich adaptive limit at part throttle, system lean (Bank #2)
193	Flexible Fuel (FF) sensor circuit failure

Diagnostic Trouble Codes

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Service Codes (ENGINE (Liters) / FUEL SYSTEM)	Quick Test Mode	2.5L AXODE SEFI	3.0L EFI	3.0L AXODE SEFI	3.8L AXODE SEFI
519—Power steering pressure switch did not change state	R	✓	✓	✓	✓
522—Vehicle not in Park or Neutral during KOEO test	O	✓		✓	✓
525—Vehicle in gear or A/C on during self-test	O		✓		
528—Clutch switch circuit failure	C		✓		
536—Brake On/Off circuit failure/not actuated during KOER test	R/C	✓		✓	✓
538—Insufficient rpm change during KOER Dynamic Response test	R	✓	✓	✓	✓
539—A/C on or Defroster on during KOEO test	O				
542—Fuel pump secondary circuit failure: ECA to ground	O/C	✓	✓	✓	✓
543—Fuel pump secondary circuit failure: Batt to ECA	O/C	✓	✓	✓	✓
552—Air management 1 circuit failure	O				
556—Fuel pump primary circuit failure	O/C	✓	✓	✓	✓
558—EGR vacuum regulator circuit failure	O	✓	✓	✓	✓
563—High speed electro-drive fan circuit failure	O	✓	✓	✓	✓
564—Electro-drive fan circuit failure	O	✓	✓	✓	✓
565—Canister purge circuit failure	O	✓	✓	✓	✓
566—3–4 shift solenoid circuit failure	O				
621—Shift solenoid 1 circuit failure	O	✓		✓	✓
622—Shift solenoid 2 circuit failure	O	✓		✓	✓
624—EPC solenoid or driver circuit failure	O/C	✓		✓	✓
625—EPC driver open in ECA	O	✓		✓	✓
628—Lock-up solenoid failure, excessive clutch slippage	C	✓		✓	✓
629—Converter clutch control circuit failure	O	✓			
629—Lock-up solenoid failure	R			✓	✓
634—MLP sensor voltage out of self-test range	O	✓		✓	✓
636—TOT sensor voltage out of self-test range	O/R	✓		✓	✓
637—TOT sensor circuit above maximum voltage	O/C	✓		✓	✓
638—TOT sensor circuit below minimum voltage	O/C	✓		✓	✓
639—Insufficient input from turbine speed sensor	R/C	✓		✓	✓
641—Shift solenoid 3 circuit failure	O	✓		✓	✓
645—Incorrect gear ratio obtained for 1st gear	C	✓		✓	✓
646—Incorrect gear ratio obtained for 2nd gear	C	✓		✓	✓
647—Incorrect gear ratio obtained for 3rd gear	C	✓		✓	✓
648—Incorrect gear ratio obtained for 4th gear	C	✓		✓	✓
649—EPC range failure	C	✓		✓	✓
651—EPC circuit failure	C	✓		✓	✓
998—Hard fault present	R	✓	✓	✓	✓

Codes Not Listed: Do not apply to vehicle being tested
No Codes: Cannot begin self-test or cannot receive codes
O—Key on, engine off
R—Key on, engine running test
C—Continuous Memory

Diagnostic Trouble Codes

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DIAGNOSTIC TROUBLE CODES	DEFINITIONS
211	Profile Ignition Pickup (PIP) circuit failure
212	Loss of Ignition Diagnostic Monitor (IDM) input to PCM - SPOUT circuit grounded
213	SPOUT circuit open
214	Cylinder Identification (CID) circuit failure
215	PCM detected coil 1 primary circuit failure (EI)
216	PCM detected coil 2 primary circuit failure (EI)
217	PCM detected coil 3 primary circuit failure (EI)
218	Loss of Ignition Diagnostic Monitor (IDM) signal - left side (dual plug EI)
219	Spark timing defaulted to 10 degrees - SPOUT circuit open (EI)
221	Spark timing error (EI)
222	Loss of Ignition Diagnostic Monitor (IDM) signal - right side (dual plug EI)
223	Loss of Dual Plug Inhibit (DPI) control (dual plug EI)
224	PCM detected coil 1, 2, 3 or 4 primary circuit failure (dual plug EI)
225	Knock not sensed during dynamic response test KOER
226	Ignition Diagnostic Module (IDM) signal not received (EI)
232	PCM detected coil 1, 2, 3 or 4 primary circuit failure (EI)
238	PCM detected coil 4 primary circuit failure (EI)
241	ICM to PCM IDM pulsewidth transmission error (EI)
244	CID circuit fault present when cylinder balance test requested
311	AIR system inoperative during KOER (Bank #1 w/dual HO2S)
312	AIR misdirected during KOER
313	AIR not bypassed during KOER
314	AIR system inoperative during KOER (Bank #2 w/dual HO2S)
326	EGR (PFE / DPFE) circuit voltage lower than expected
327	EGR (EGRP / EVP / PFE / DPFE) circuit below minimum voltage
328	EGR (EVP) closed valve voltage lower than expected
332	Insufficient EGR flow detected (EGRP / EVP / PFE / DPFE)
334	EGR (EVP) closed valve voltage higher than expected
335	EGR (PFE / DPFE) sensor voltage higher or lower than expected during KOEO
336	Exhaust pressure high / EGR (PFE / DPFE) circuit voltage higher than expected
337	EGR (EGRP / EVP / PFE / DPFE) circuit above maximum voltage
338	Engine Coolant Temperature (ECT) lower than expected (thermostat test)
339	Engine Coolant Temperature (ECT) higher than expected (thermostat test)
341	Octane adjust service pin open
381	Frequent A/C clutch cycling
411	Cannot control RPM during KOER low RPM check
412	Cannot control RPM during KOER high RPM check
415	Idle Air Control (IAC) system at maximum adaptive lower limit
416	Idle Air Control (IAC) system at upper adaptive learning limit
452	Insufficient input from Vehicle Speed Sensor (VSS) to PCM
453	Servo leaking down (KOER IVSC test)
454	Servo leaking up (KOER IVSC test)
455	Insufficient RPM increase (KOER IVSC test)
456	Insufficient RPM decrease (KOER IVSC test)

Diagnostic Trouble Codes

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DIAGNOSTIC TROUBLE CODES	DEFINITIONS
457	Speed control command switch(s) circuit not functioning (KOEO IVSC test)
458	Speed control command switch(s) stuck / circuit grounded (KOEO IVSC test)
459	Speed control ground circuit open (KOEO IVSC test)
511	PCM Read Only Memory (ROM) test failure KOEO
512	PCM Keep Alive Memory (KAM) test failure
513	PCM internal voltage failure (KOEO)
519	Power Steering Pressure (PSP) switch circuit open KOEO
519	Power Steering Pressure (PSP) sensor circuit open
521	Power Steering Pressure (PSP) switch circuit did not change states KOER
521	Power Steering Pressure (PSP) sensor circuit did not change states KOER
522	Vehicle not in PARK or NEUTRAL during KOEO/PNP switch circuit open
524	Low speed fuel pump circuit open — battery to PCM
525	Indicates vehicle in gear / A/C on
527	Park/Neutral Position (PNP) switch circuit open — A/C on KOEO
528	Clutch Pedal Position (CPP) switch circuit failure
529	Data Communication Link (DCL) or PCM circuit failure
532	Cluster Control Assembly (CCA) circuit failure
533	Data Communication Link (DCL) or Electronic Instrument Cluster (EIC) circuit failure
536	Brake On/Off (BOO) circuit failure/not actuated during KOER
538	Insufficient RPM change during KOER dynamic response test
538	Invalid cylinder balance test due to throttle movement during test (SFI only)
538	Invalid cylinder balance test due to CID circuit failure
539	A/C on/Defrost on during Self-Test
542	Fuel pump secondary circuit failure
543	Fuel pump secondary circuit failure
551	Idle Air Control (IAC) circuit failure KOEO
552	Secondary Air Injection Bypass (AIRB) circuit failure KOEO
553	Secondary Air Injection Diverter (AIRD) circuit failure KOEO
554	Fuel Pressure Regulator Control (FPRC) circuit failure
556	Fuel pump relay primary circuit failure
557	Low speed fuel pump primary circuit failure
558	EGR Vacuum Regulator (EVR) circuit failure KOEO
559	Air Conditioning On (ACON) relay circuit failure KOEO
563	High Fan Control (HFC) circuit failure KOEO
564	Fan Control (FC) circuit failure KOEO
565	Canister Purge (CANP) circuit failure KOEO
566	3-4 shift solenoid circuit failure KOEO (A4LD)
567	Speed Control Vent (SCVNT) circuit failure (KOEO IVSC test)
568	Speed Control Vacuum (SCVAC) circuit failure (KOEO IVSC test)
569	Auxiliary Canister Purge (CANP2) circuit failure KOEO
571	EGRA solenoid circuit failure KOEO
572	EGRV solenoid circuit failure KOEO
578	A/C pressure sensor circuit shorted
579	Insufficient A/C pressure change

Diagnostic Trouble Codes

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DIAGNOSTIC TROUBLE CODES	DEFINITIONS
581	Power to Fan circuit over current
582	Fan circuit open
583	Power to Fuel pump over current
584	VCRM Power ground circuit open (VCRM Pin 1)
585	Power to A/C clutch over current
586	A/C clutch circuit open
587	Variable Control Relay Module (VCRM) communication failure
593	Heated Oxygen Sensor Heater (HO2S HTR) circuit failure
617	1-2 shift error
618	2-3 shift error
619	3-4 shift error
621	Shift Solenoid 1 (SS1) circuit failure KOEO
622	Shift Solenoid 2 (SS2) circuit failure KOEO
623	Transmission Control Indicator Lamp (TCIL) circuit failure
624	Electronic Pressure Control (EPC) circuit failure
625	Electronic Pressure Control (EPC) driver open in PCM
626	Coast Clutch Solenoid (CCS) circuit failure KOEO
627	Torque Converter Clutch (TCC) solenoid circuit failure
628	Excessive converter clutch slippage
629	Torque Converter Clutch (TCC) solenoid circuit failure
631	Transmission Control Indicator Lamp (TCIL) circuit failure KOEO
632	Transmission Control Switch (TCS) circuit did not change states during KOER
633	4x4L switch closed during KOEO
634	Transmission Range (TR) voltage higher or lower than expected
636	Transmission Fluid Temperature (TFT) higher or lower than expected
637	Transmission Fluid Temperature (TFT) sensor circuit above maximum voltage / -40°F (-40°C) indicated / circuit open
638	Transmission Fluid Temperature (TFT) sensor circuit below minimum voltage / 290°F (143°C) indicated / circuit shorted
639	Insufficient input from Turbine Shaft Speed Sensor (TSS)
641	Shift Solenoid 3 (SS3) circuit failure
643	Torque Converter Clutch (TCC) circuit failure
645	Incorrect gear ratio obtained for first gear
646	Incorrect gear ratio obtained for second gear
647	Incorrect gear ratio obtained for third gear
648	Incorrect gear ratio obtained for fourth gear
649	Electronic Pressure Control (EPC) higher or lower than expected
651	Electronic Pressure Control (EPC) circuit failure
652	Torque Converter Clutch (TCC) solenoid circuit failure
653	Transmission Control Switch (TCS) did not change states during KOER
654	Transmission Range (TR) sensor not indicating PARK during KOEO
656	Torque Converter Clutch continuous slip error
657	Transmission overtemperature condition occurred
659	High vehicle speed in park indicated

Diagnostic Trouble Codes

Click to enlarge

DIAGNOSTIC TROUBLE CODES	DEFINITIONS
667	Transmission Range sensor circuit voltage below minimum voltage
668	Transmission Range circuit voltage above maximum voltage
675	Transmission Range sensor circuit voltage out of range
998	Hard fault present — FMEM MODE

Diagnostic Trouble Codes

Click to enlarge

Service Codes / ENGINE (Liters) / FUEL SYSTEM	Quick Test Mode	2.5L FLC CFI	3.0L EFI	3.0L SHO SEFI	3.8L AXOD SEFI
11—System pass	O/R/C	✓	✓	✓	✓
12—Rpm unable to reach upper test limit	R	✓	✓	✓	✓
13—DC motor movement not detected	O	✓			
13—Rpm unable to achieve lower test limit	R	✓	✓	✓	✓
13—DC motor did follow dashpot	C	✓			
14—PIP circuit failure	C	✓	✓	✓	✓
15—ECA read only memory test failed	O	✓	✓	✓	✓
15—ECA keep alive memory test failed	C	✓	✓	✓	✓
16—Idle rpm high with ISC off	R	✓			
16—Idle too low to perform EGO test	R				
17—Idle rpm low with ISC off	R	✓			
18—SPOUT circuit open or spark angle word failure	R	✓	✓	✓	✓
18—IDM circuit failure or SPOUT circuit grounded	C	✓	✓	✓	✓
19—Failure in ECA internal voltage	O		✓		✓
19—CID circuit failure	C		✓		
19—Rpm dropped too low in ISC off test	R				
19—Rpm for EGR test not achieved	R				
21—ECT out of self-test range	O/R	✓	✓	✓	✓
22—BP sensor out of self-test range	O/C			✓	
22—BP or MAP out of self-test range	O/R/C	✓	✓		✓
23—TP out of self-test range	O/R		✓	✓	✓
23—TP out of self-test range	O/R/C	✓			
24—ACT sensor out of self-test range	O/R	✓	✓	✓	✓
25—Knock not sensed during dynamic test	R			✓	✓
26—VAF/MAF out of self-test range	O/R			✓	
28—VAT out of self-test range	O/R				
29—Insufficient input from vehicle speed sensor	C	✓	✓	✓	✓
31—PFE, EVP or EVR circuit below minimum voltage	O/R/C	✓	✓	✓	✓
32—EPT circuit voltage low (PFE)	R/C		✓	✓	✓
32—EVP voltage below closed limit	O/R/C	✓			
32—EGR not controlling	R				
33—EGR valve opening not detected	R/C	✓	✓	✓	✓
33—EGR not closing fully	R				
34—Defective PFE sensor or voltage out of range	O		✓	✓	✓
34—EPT sensor voltage high (PFE)	R/C		✓	✓	✓
34—EVP voltage above closed limit	O/R/C	✓			
34—EGR opening not detected	R				
35—PFE or EVP circuit above maximum voltage	O/R/C	✓	✓	✓	✓
35—Rpm too low to perform EGR test	R				
38—Idle tracking switch circuit open	C	✓			
39—AXOD lock up failed	C		✓		
41—HEGO sensor circuit indicates system lean	R	✓	✓	✓ ④	✓ ②
41—No HEGO switching detected	R	✓	✓	✓ ④	✓ ②
42—HEGO sensor circuit indicates system rich	R	✓	✓	✓ ④	✓ ②
42—No HEGO switching detected—reads rich	C				
43—HEGO lean at wide open throttle	C				
44—Thermactor air system inoperative—ride side	R				
45—Thermactor air upstream during self-test	R			✓	
45—Coil 1 primary circuit failure	C				
46—Thermactor air not bypassed during self-test	R			✓	
46—Coil 2 primary circuit failure	C			✓	
47—Measured airflow low at base idle	R				
48—Coil 3 primary circuit failure	C			✓	
48—Measured airflow high at base idle	R				
49—SPOUT signal defaulted to 10°BTDC or SPOUT open	C			✓	
51—ECT/ACT reads −40°F or circuit open	O/C	✓	✓	✓	✓
52—Power steering pressure switch circuit open	O	✓	✓	✓	✓
52—Power steering pressure switch always open or closed	R	✓	✓	✓	✓

Service Codes — ENGINE (Liters) / FUEL SYSTEM	Quick Test Mode	2.5L FLC CFI	3.0L EFI	3.0L SHO SEFI	3.8L AXOD SEFI
53—TP circuit above maximum voltage	O/C	✓	✓	✓	✓
54—ACT sensor circuit open	O/C	✓	✓	✓	✓
55—Keypower circuit open	R	✓			
56—VAF or MAF circuit above maximum voltage	O/C			✓	
56—MAF circuit above maximum voltage	O/R/C				
57—Octane adjust service pin in use	O				
57—AXOD neutral pressure switch circuit failed open	C		✓		✓
58—Idle tracking switch circuit open	O	✓			
58—Idle tracking switch closed/circuit grounded	R	✓			
58—VAT reads −40°F or circuit open	O/C	✓			
59—Idle adjust service pin in use	O				
59—AXOD 4/3 pressure switch circuit failed open	C		✓		✓
59—Low speed fuel pump circuit open—Battery to ECA	O/C			✓	
59—AXOD 4/3 pressure switch failed closed	O				✓
61—ECT reads 254°F or circuit grounded	O/C	✓	✓	✓	✓
62—AXOD 4/3 or 3/2 pressure switch circuit grounded	O		✓		
63—TP circuit below minimum voltage	O/C	✓	✓	✓	✓
64—ACT sensor input below test minimum or grounded	O/C	✓	✓	✓	✓
65—Never went to closed loop fuel control	C				
66—MAF sensor input below minimum voltage	C			✓	
66—VAF sensor below minimum voltage	O/C				
66—MAF circuit below minimum voltage	R/C				
67—Neutral/drive switch open or A/C on	O	✓	✓	✓	✓
67—Clutch switch circuit failure	C	✓			
67—Neutral/drive switch open or A/C on	O/R				
68—Idle tracking switch closed or circuit grounded	O	✓			
68—Idle tracking switch circuit open	R	✓			
68—AXOD transmission temperature switch failed open	O/R/C				✓
68—VAT reads 254°F or circuit grounded	O/C				
69—AXOD 3/2 pressure switch circuit failed closed	O				
69—AXOD 3/4 pressure switch circiut failed open	C		✓		✓
70—ECA DATA communications link circuit failure	C				✓
71—Software re-initialization detected	C				
71—Idle tracking switch shorted to ground	C	✓			
71—Cluster control assembly circuit failed	C				✓
72—Insufficient MAF/MAP change during dynamic test	R		✓	✓	
72—Power interrupt or re-initialization detected	C	✓			
72—Message center control assembly circuit failed	C				✓
73—Insufficient throttle position change	O	✓			
73—Insufficient TP change during dynamic test	R		✓	✓	
74—Brake on/off switch failure or not actuated	R	✓	✓	✓	✓
75—Brake on/off switch circuit closed or ECA input open	R				
76—Insufficient VAF change during dynamic test	R				
77—No WOT seen in self-test or operator error	R		✓	✓	
79—A/C or defrost on during self-test	O			✓	✓

Service Codes — ENGINE (Liters) / FUEL SYSTEM	Quick Test Mode	2.5L FLC CFI	3.0L EFI	3.0L SHO SEFI	3.8L AXOD SEFI
81—IAS circuit failure	O			✔	
81—Air management 2 circuit failure	O				
82—Air management 1 circuit failure	O				
82—Supercharger bypass circuit failure	O				
83—High speed electro drive fan circuit failure	O	✔	✔		✔
83—Low speed fuel pump circuit failure	O/C			✔	
84—EGR vacuum solenoid circuit failure	O	✔	✔	✔	✔
84—EGR vacuum regulator circuit failure	O/R				
85—Canister purge circuit failure	O/R				
85—Canister purge solenoid circuit failure	O	✔	✔	✔	✔
85—Adaptive fuel lean limit reached	C				
86—3-4 shift solenoid circuit failure	O				
86—Adaptive fuel rich limit reached	C				
87—Fuel pump primary circuit failure	O/C	✔	✔	✔	✔
87—Fuel pump primary circuit failure	O/C/R				
87—Fuel pump primary circuit failure	O				
88—Electro drive fan circuit failure	O	✔	✔	✔	✔
89—Converter clutch override circuit failure	O				
89—Lock-up solenoid circuit failure	O		✔		✔
91—HEGO sensor indicates system lean	R			✔ ①	✔ ③
91—No HEGO switching detected	C			✔ ①	✔ ③
92—HEGO sensor indicates system rich	R			✔ ①	✔ ③
93—TP sensor input low at maximum motor travel	O	✔			
94—Thermactor air system inoperative-left side	R				
95—Fuel pump secondary circuit failure—ECA to ground	O/C	✔	✔	✔	✔
96—Fuel pump secondary circuit failure—Battery to ECA	O/C	✔	✔	✔	✔
96—High speed fuel pump circuit open	O/C			✔	
98—Hard fault present	R		✔	✔	✔
99—EEC has not learned to control idle: ignore codes 12 & 13	R	✔			

No Codes: Cannot begin self-test or cannot transmit codes
Codes Not Listed: Do not apply to vehicle being tested
O—Key on, engine off test
R—Key on, engine running test
C—Continuous memory
① Front HEGO
② Right HEGO
③ Left HEGO
④ Rear HEGO

Service Codes / ENGINE (Liters) / FUEL SYSTEM	Quick Test Mode	2.5L AXODE SEFI	3.0L EFI	3.0L AXODE SEFI	3.8L AXODE SEFI
111—System pass	O/R/C	✓	✓	✓	✓
112—ACT sensor circuit grounded or reads 254°F	O/C	✓	✓	✓	✓
112—ACT sensor circuit grounded	O/R				
113—ACT sensor circuit open	O/R				
113—ACT sensor circuit open or reads −40°F	O/C	✓	✓	✓	✓
114—ACT outside test limits during KOEO or KOER tests	O/R	✓	✓	✓	✓
116—ECT outside test limits during KOEO or KOER tests	O/R	✓	✓	✓	✓
117—ECT sensor circuit grounded	O/C	✓	✓	✓	✓
118—ECT sensor circiut above maximum voltage or reads −40°F	O/C			✓	
118—ECT sensor circuit open	O/C	✓	✓		✓
121—Closed throttle voltage higher or lower than expected	O/R/C	✓	✓	✓	✓
122—TP sensor circuit below minimum voltage	O/C	✓	✓	✓	✓
123—TP sensor above maximum voltage	O/C	✓	✓	✓	✓
124—TP sensor voltage higher than expected, in range	C	✓		✓	✓
125—TP sensor voltage lower than expected in range	C	✓		✓	✓
126—BP or MAP sensor higher or lower than expected	O/R/C		✓		
129—Insufficient MAF change during Dynamic Response test	R	✓	✓	✓	✓
136—HEGO shows system always lean (front)	R			✓	✓
136—HEGO shows sytem always lean (left)	R				
137—HEGO shows system always rich (front)	R			✓	✓
137—HEGO shows system always rich (left)	R				
139—No HEGO switching (front)	C			✓	✓
139—No HEGO switching (left)	C				
144—No HEGO switching (rear)	C			✓	✓
144—No HEGO switching (right)	C				
144—No HEGO switching	C		✓		
144—No HEGO switching detected	C	✓			
157—MAF sensor circiut below minimum voltage	C	✓		✓	✓
158—MAF sensor circuit above maximum voltage	O/C	✓		✓	✓
158—MAF sensor circuit above maximum voltage	O/R/C				
159—MAF higher or lower than expected during KOEO and KOER test	O/R	✓		✓	✓
167—Insufficient TP change during Dynamic Response test	R	✓	✓	✓	✓
171—Fuel system at adaptive limit, HEGO unable to switch	C	✓			
171—Fuel system at adaptive limit, HEGO unable to switch (right)	C				
171—No HEGO switching; system at adaptive limit (rear)	C				
172—HEGO shows system always lean (rear)	R/C		✓	✓	✓
172—No HEGO switching seen; indicates lean	R/C	✓			
172—No HEGO switching seen; indicates lean (right)	R/C				
173—HEGO shows system always rich (rear)	R/C		✓	✓	✓
173—No HEGO switching seen; indicates rich	R/C	✓			
173—No HEGO switching seen; indicates rich (right)	R/C				
174—HEGO switching time is slow (right)	C				
175—No HEGO switching; system at adaptive limit (front)	C		✓	✓	✓
175—No HEGO switching; system at adaptive limit (left)	C				
176—HEGO shows system alway lean (front)	C		✓	✓	✓
176—HEGO shows system always lean (left)	C	✓	✓		
177—HEGO shows system always rich (front)	C		✓	✓	✓
177—HEGO shows system always rich (left)	C				
178—HEGO switching time is slow (left)	C				
179—Fuel at lean adaptive limit at part throttle; system rich	C	✓			
179—System at lean adaptive limit at part throttle; system rich (rear)	C		✓	✓	✓
179—System at lean adaptive limit at part throttle; system rich (right)	C				

Service Codes — ENGINE (Liters) / FUEL SYSTEM	Quick Test Mode	2.5L AXODE SEFI	3.0L EFI	3.0L AXODE SEFI	3.8L AXODE SEFI
181—Fuel at rich adaptive limit at part throttle; system lean	C	✓			
181—System at rich adaptive limit at part throttle; system lean (rear)	C		✓	✓	✓
181—System at rich adaptive limit at part throttle, system lean (right)	C				
182—Fuel at lean adaptive limit at idle; system rich	C	✓			
182—System at lean adaptive limit at idle; system rich (rear)	C		✓	✓	✓
182—System at lean adaptive limit at idle; system rich (right)	C				
183—Fuel at rich adaptive limit at idle; system lean	C	✓			
183—System at rich adaptive limit at idle; system lean (rear)	C		✓	✓	✓
184—MAF higher than expected	C	✓		✓	✓
185—MAF lower than expected	C	✓		✓	✓
186—Injector pulse width higher than expected	C	✓		✓	✓
187—Injector pulse width lower than expected	C	✓		✓	✓
188—System at lean adaptive limit at part throttle; system rich (front)	C		✓	✓	
188—System at lean adaptive limit at part throttle; system rich (left)	C				
189—System at rich adaptive limit at part throttle, system lean (front)	C		✓	✓	✓
189—System at rich adaptive limit at part throttle, system lean (left)	C				
191—System at lean adaptive limit at idle; system rich (front)	C		✓	✓	✓
191—System at lean adaptive limit at idle; system rich (left)	C				
192—System at rich adaptive limit at idle; system lean (front)	C		✓	✓	✓
192—System at rich adaptive limit at idle; system lean (left)	C				
211—PIP circuit fauilt	C	✓	✓	✓	✓
212—Loss of IDM input to ECA or SPOUT circuit grounded	C	✓	✓	✓	✓
213—SPOUT circuit open	R	✓	✓	✓	✓
214—Cylinder identification circuit faiulre	C	✓		✓	✓
215—EEC processor detected Coil 1 primary circuit failure	C				
216—EEC processor detected Coil 2 primary circuit failure	C				
218—Loss of IDM signal, left side	C				
219—Spark timing defaulted to 10°BTDC or SPOUT circ. open	C				
222—Loss of IDM signal, right side					
223—Loss of dual plug inhibit control	C	✓			
224—Erratic IDM input to processor	C	✓			
225—Knock not sensed during Dynamic Response test	R	✓			
311—Thermactor air system inoperative (right)	R				
313—Thermactor air not bypassed during self-test	R				
314—Thermactor air system inoperative (left)	R				
326—PFE or DPFE circuit voltage lower than expected	R/C	✓	✓	✓	✓
327—EVP or DPFE circuit below minimum voltage	O/R/C	✓	✓	✓	✓
328—EGR closed voltage lower than expected	O/R/C				
332—Insufficient EGR flow detected	R/C	✓	✓	✓	✓
334—EGR closed voltage higher than expected	O/R/C				
335—PFE or DPFE sensor voltage out of self-test range	O	✓	✓	✓	✓
336—PFE sensor voltage higher than expected	R/C	✓	✓	✓	✓
337—EVP or DPFE circiut above maximum voltage	O/R/C	✓	✓	✓	✓
341—Octane adjust service pin in use	O				
411—Cannot control rpm during KOER low rpm check	R	✓	✓	✓	✓
412—Cannot control rpm during KOER high rpm check	R	✓	✓	✓	✓
452—Insufficient input from vehicle speed sensor	C	✓	✓	✓	✓
511—EEC processor ROM test failed	O	✓	✓	✓	✓
512—EEC processor Keep Alive Memory test failed	O	✓			
512—EEC processor Keep Alive Memory test failed	C		✓	✓	✓
513—Failure in EEC processor internal voltage	O	✓	✓	✓	✓
519—Power steering pressure switch circuit open	O	✓	✓	✓	✓

DIAGNOSTIC TROUBLE CODES	DEFINITIONS
111	System Pass
112	Intake Air Temp (IAT) sensor circuit below minimum voltage / 254°F indicated
113	Intake Air Temp (IAT) sensor circuit above maximum voltage / -40°F indicated
114	Intake Air Temp (IAT) sensor circuit voltage higher or lower than expected
116	Engine Coolant Temp (ECT) sensor circuit voltage higher or lower than expected
117	Engine Coolant Temp (ECT) sensor circuit below minimum voltage / 254°F indicated
118	Engine Coolant Temp (ECT) sensor circuit above maximum voltage / -40°F indicated
121	Closed throttle voltage higher or lower than expected
121	Throttle position voltage inconsistent with the MAF sensor
122	Throttle Position (TP) sensor circuit below minimum voltage
123	Throttle Position (TP) sensor circuit above maximum voltage
124	Throttle Position (TP) sensor voltage higher than expected
125	Throttle Position (TP) sensor voltage lower than expected
126	MAP / BARO sensor circuit voltage higher or lower than expected
128	MAP sensor vacuum hose damaged / disconnected
129	Insufficient MAP / Mass Air Flow (MAF) change during dynamic response test KOER
136	Lack of Heated Oxygen Sensor (HO2S-2) switch during KOER, indicates lean (Bank #2)
137	Lack of Heated Oxygen Sensor (HO2S-2) switch during KOER, indicates rich (Bank #2)
139	No Heated Oxygen Sensor (HO2S-2) switches detected (Bank #2)
141	Fuel system indicates lean
144	No Heated Oxygen Sensor (HO2S-1) switches detected (Bank # 1)
157	Mass Air Flow (MAF) sensor circuit below minimum voltage
158	Mass Air Flow (MAF) sensor circuit above maximum voltage
159	Mass Air Flow (MAF) sensor circuit voltage higher or lower than expected
167	Insufficient throttle position change during dynamic response test KOER
171	Fuel system at adaptive limits, Heated Oxygen Sensor (HO2S-1) unable to switch (Bank #1)
172	Lack of Heated Oxygen Sensor (HO2S-1) switches, indicates lean (Bank # 1)
173	Lack of Heated Oxygen Sensor (HO2S-1) switches, indicates rich (Bank # 1)
175	Fuel system at adaptive limits, Heated Oxygen Sensor (HO2S-2) unable to switch (Bank #2)
176	Lack of Heated Oxygen Sensor (HO2S-2) switches, indicates lean (Bank #2)
177	Lack of Heated Oxygen Sensor (HO2S-2) switches, indicates rich (Bank #2)
179	Fuel system at lean adaptive limit at part throttle, system rich (Bank # 1)
181	Fuel system at rich adaptive limit at part throttle, system lean (Bank # 1)
184	Mass Air Flow (MAF) sensor voltage higher than expected
185	Mass Air Flow (MAF) sensor voltage lower than expected
186	Injector pulsewidth higher than expected (with BARO sensor)
186	Injector pulsewidth higher or mass air flow lower than expected (without BARO sensor)
187	Injector pulsewidth lower than expected (with BARO sensor)
187	Injector pulsewidth lower or mass air flow higher than expected (without BARO sensor)
188	Fuel system at lean adaptive limit at part throttle, system rich (Bank #2)
189	Fuel system at rich adaptive limit at part throttle, system lean (Bank #2)
193	Flexible Fuel (FF) sensor circuit failure

Service Codes / ENGINE (Liters) / FUEL SYSTEM	Quick Test Mode	2.5L AXODE SEFI	3.0L EFI	3.0L AXODE SEFI	3.8L AXODE SEFI
519—Power steering pressure switch did not change state	R	✓	✓	✓	✓
522—Vehicle not in Park or Neutral during KOEO test	O	✓		✓	✓
525—Vehicle in gear or A/C on during self-test	O		✓		
528—Clutch switch circuit failure	C		✓		
536—Brake On/Off circuit failure/not actuated during KOER test	R/C	✓		✓	✓
538—Insufficient rpm change during KOER Dynamic Response test	R	✓	✓	✓	✓
539—A/C on or Defroster on during KOEO test	O				
542—Fuel pump secondary circuit failure: ECA to ground	O/C	✓	✓	✓	✓
543—Fuel pump secondary circuit failure: Batt to ECA	O/C	✓	✓	✓	✓
552—Air management 1 circuit failure	O				
556—Fuel pump primary circuit failure	O/C	✓	✓	✓	✓
558—EGR vacuum regulator circuit failure	O	✓	✓	✓	✓
563—High speed electro-drive fan circuit failure	O	✓	✓	✓	✓
564—Electro-drive fan circuit failure	O	✓	✓	✓	✓
565—Canister purge circuit failure	O	✓	✓	✓	✓
566—3-4 shift solenoid circuit failure	O				
621—Shift solenoid 1 circuit failure	O	✓		✓	✓
622—Shift solenoid 2 circuit failure	O	✓		✓	✓
624—EPC solenoid or driver circuit failure	O/C	✓		✓	✓
625—EPC driver open in ECA	O	✓		✓	✓
628—Lock-up solenoid failure; excesive clutch slippage	C	✓		✓	✓
629—Converter clutch control circuit failure	O	✓			
629—Lock-up solenoid failure	o			✓	✓
634—MLP sensor voltage out of self-test range	C	✓		✓	✓
636—TOT sensor voltage out of self-test range	O/R	✓		✓	✓
637—TOT sensor circuit above maximum voltage	O/C	✓		✓	✓
638—TOT sensor circuit below mamimum voltage	O/C	✓		✓	✓
639—Insufficient input from turbine speed sensor	R/C	✓		✓	✓
641—Shift solenoid 3 circuit failure	O	✓		✓	✓
645—Incorrect gear ratio obtained for 1st gear	C	✓		✓	✓
646—Incorrect gear ratio obtained for 2nd gear	C	✓		✓	✓
647—Incorrect gear ratio obtained for 3rd gear	C	✓		✓	✓
648—Incorrect gear ratio obtained for 4th gear	C	✓		✓	✓
649—EPC range failure	C	✓		✓	✓
651—EPC circuit failure	C	✓		✓	✓
998—Hard fault present	R	✓	✓	✓	✓

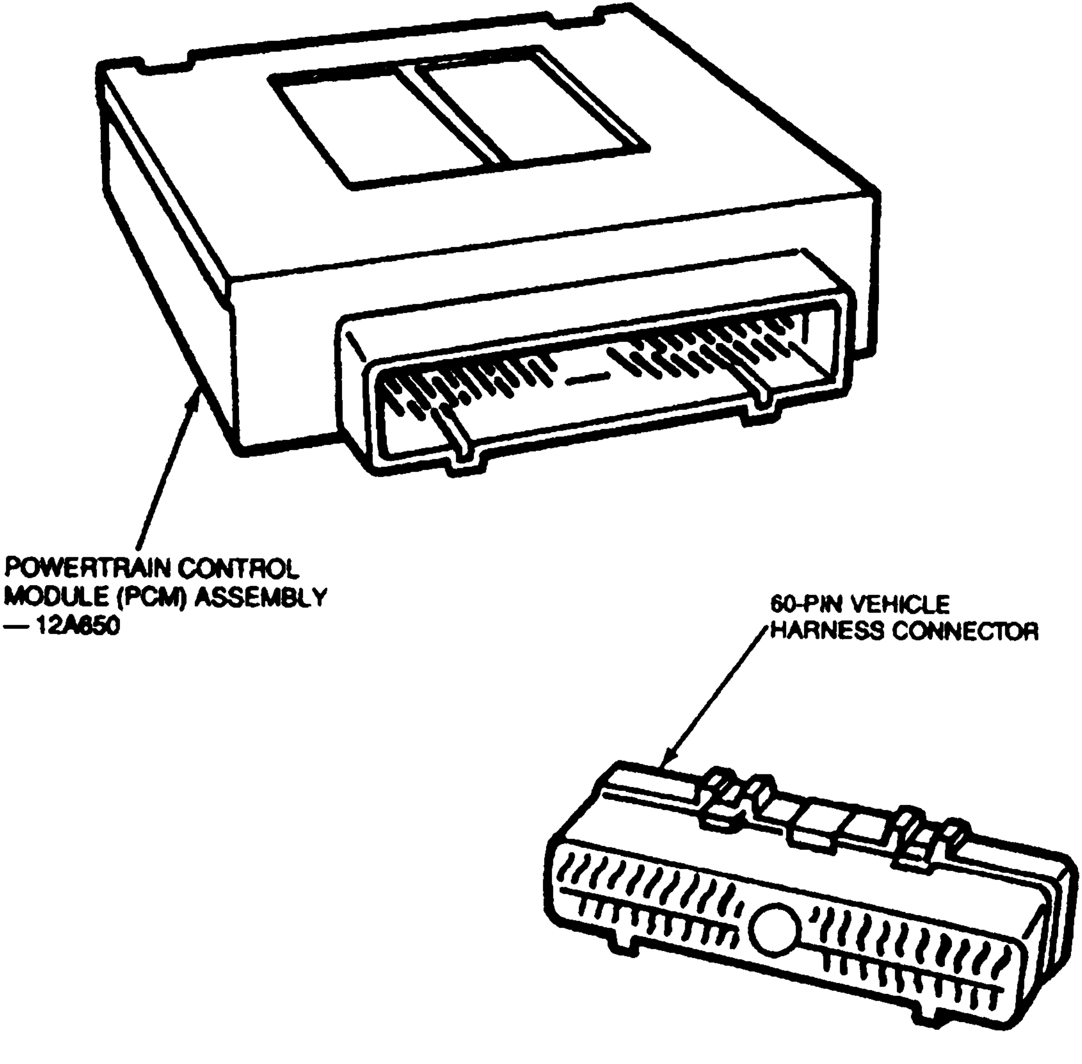
Codes Not Listed: Do not apply to vehicle being tested
No Codes: Cannot begin self-test or cannot transmit codes
O—Key on, engine off test
R—Key on, engine running test
C—Continuous memory

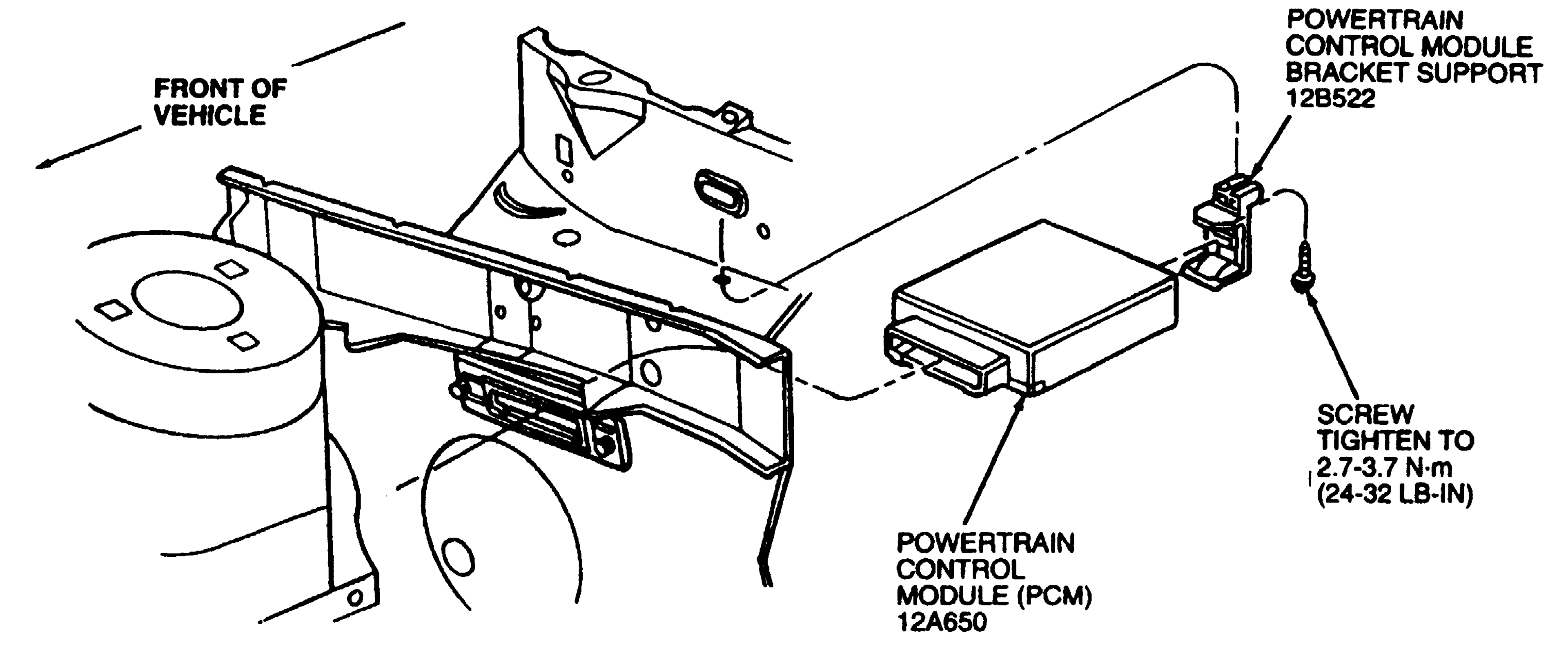
DIAGNOSTIC TROUBLE CODES	DEFINITIONS
211	Profile Ignition Pickup (PIP) circuit failure
212	Loss of Ignition Diagnostic Monitor (IDM) input to PCM / SPOUT circuit grounded
213	SPOUT circuit open
214	Cylinder Identification (CID) circuit failure
215	PCM detected coil 1 primary circuit failure (EI)
216	PCM detected coil 2 primary circuit failure (EI)
217	PCM detected coil 3 primary circuit failure (EI)
218	Loss of Ignition Diagnostic Monitor (IDM) signal-left side (dual plug EI)
219	Spark timing defaulted to 10 degrees-SPOUT circuit open (EI)
221	Spark timing error (EI)
222	Loss of Ignition Diagnostic Monitor (IDM) signal-right side (dual plug EI)
223	Loss of Dual Plug Inhibit (DPI) control (dual plug EI)
224	PCM detected coil 1, 2, 3 or 4 primary circuit failure (dual plug EI)
225	Knock not sensed during dynamic response test KOER
226	Ignition Diagnostic Module (IDM) signal not received (EI)
232	PCM detected coil 1, 2, 3 or 4 primary circuit failure (EI)
238	PCM detected coil 4 primary circuit failure (EI)
241	ICM to PCM IDM pulsewidth transmission error (EI)
244	CID circuit fault present when cylinder balance test requested
311	AIR system inoperative during KOER (Bank # 1 w / dual HO2S)
312	AIR misdirected during KOER
313	AIR not bypassed during KOER
314	AIR system inoperative during KOER (Bank # 2 w / dual HO2S)
326	EGR (PFE / DPFE) circuit voltage lower than expected
327	EGR (EGRP / EVP / PFE / DPFE) circuit below minimum voltage
328	EGR (EVP) closed valve voltage lower than expected
332	Insufficient EGR flow detected (EGRP / EVP / PFE / DPFE)
334	EGR (EVP) closed valve voltage higher than expected
335	EGR (PFE / DPFE) sensor voltage higher or lower than expected during KOEO
336	Exhaust pressure high / EGR (PFE / DPFE) circuit voltage higher than expected
337	EGR (EGRP / EVP / PFE / DPFE) circuit above maximum voltage
338	Engine Coolant Temperature (ECT) lower than expected (thermostat test)
339	Engine Coolant Temperature (ECT) higher than expected (thermostat test)
341	Octane adjust service pin open
381	Frequent A / C clutch cycling
411	Cannot control RPM during KOER low RPM check
412	Cannot control RPM during KOER high RPM check
415	Idle Air Control (IAC) system at maximum adaptive lower limit
416	Idle Air Control (IAC) system at upper adaptive learning limit
452	Insufficient input from Vehicle Speed Sensor (VSS) to PCM
453	Servo leaking down (KOER IVSC test)
454	Servo leaking up (KOER IVSC test)
455	Insufficient RPM increase (KOER IVSC test)
456	Insufficient RPM decrease (KOER IVSC test)

DIAGNOSTIC TROUBLE CODES	DEFINITIONS
457	Speed control command switch(s) circuit not functioning (KOEO IVSC test)
458	Speed control command switch(s) stuck / circuit grounded (KOEO IVSC test)
459	Speed control ground circuit open (KOEO IVSC test)
511	PCM Read Only Memory (ROM) test failure KOEO
512	PCM Keep Alive Memory (KAM) test failure
513	PCM internal voltage failure (KOEO)
519	Power Steering Pressure (PSP) switch circuit open KOEO
519	Power Steering Pressure (PSP) sensor circuit open
521	Power Steering Pressure (PSP) switch circuit did not change states KOER
521	Power Steering Pressure (PSP) sensor circuit did not change states KOER
522	Vehicle not in PARK or NEUTRAL during KOEO / PNP switch circuit open
524	Low speed fuel pump circuit open—battery to PCM
525	Indicates vehicle in gear / A / C on
527	Park / Neutral Position (PNP) switch circuit open—A / C on KOEO
528	Clutch Pedal Position (CPP) switch circuit failure
529	Data Communication Link (DCL) or PCM circuit failure
532	Cluster Control Assembly (CCA) circuit failure
533	Data Communication Link (DCL) or Electronic Instrument Cluster (EIC) circuit failure
536	Brake On / Off (BOO) circuit failure / not actuated during KOER
538	Insufficient RPM change during KOER dynamic response test
538	Invalid cylinder balance test due to throttle movement during test (SFI only)
538	Invalid cylinder balance test due to CID circuit failure
539	A / C on / Defrost on during Self-Test
542	Fuel pump secondary circuit failure
543	Fuel pump secondary circuit failure
551	Idle Air Control (IAC) circuit failure KOEO
552	Secondary Air Injection Bypass (AIRB) circuit failure KOEO
553	Secondary Air Injection Diverter (AIRD) circuit failure KOEO
554	Fuel Pressure Regulator Control (FPRC) circuit failure
556	Fuel pump relay primary circuit failure
557	Low speed fuel pump primary circuit failure
558	EGR Vacuum Regulator (EVR) circuit failure KOEO
559	Air Conditioning On (ACON) relay circuit failure KOEO
563	High Fan Control (HFC) circuit failure KOEO
564	Fan Control (FC) circuit failure KOEO
565	Canister Purge (CANP) circuit failure KOEO
566	3-4 shift solenoid circuit failure KOEO (A4LD)
567	Speed Control Vent (SCVNT) circuit failure (KOEO IVSC test)
568	Speed Control Vacuum (SCVAC) circuit failure (KOEO IVSC test)
569	Auxiliary Canister Purge (CANP2) circuit failure KOEO
571	EGRA solenoid circuit failure KOEO
572	EGRV solenoid circuit failure KOEO
578	A / C pressure sensor circuit shorted
579	Insufficient A / C pressure change

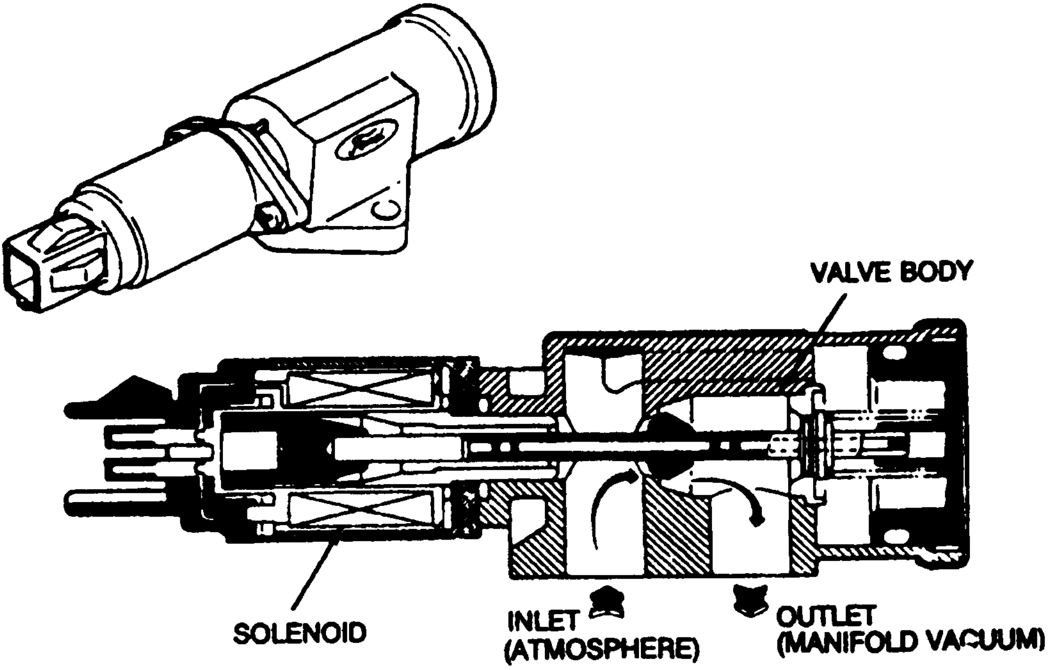
DIAGNOSTIC TROUBLE CODES	DEFINITIONS
581	Power to Fan circuit over current
582	Fan circuit open
583	Power to Fuel pump over current
584	VCRM Power ground circuit open (VCRM Pin 1)
585	Power to A/C clutch over current
586	A/C clutch circuit open
587	Variable Control Relay Module (VCRM) communication failure
593	Heated Oxygen Sensor Heater (HO2S HTR) circuit failure
617	1-2 shift error
618	2-3 shift error
619	3-4 shift error
621	Shift Solenoid 1 (SS1) circuit failure KOEO
622	Shift Solenoid 2 (SS2) circuit failure KOEO
623	Transmission Control Indicator Lamp (TCIL) circuit failure
624	Electronic Pressure Control (EPC) circuit failure
625	Electronic Pressure Control (EPC) driver open in PCM
626	Coast Clutch Solenoid (CCS) circuit failure KOEO
627	Torque Converter Clutch (TCC) solenoid circuit failure
628	Excessive converter clutch slippage
629	Torque Converter Clutch (TCC) solenoid circuit failure
631	Transmission Control Indicator Lamp (TCIL) circuit failure KOEO
632	Transmission Control Switch (TCS) circuit did not change states during KOER
633	4x4L switch closed during KOEO
634	Transmission Range (TR) voltage higher or lower than expected
636	Transmission Fluid Temperature (TFT) higher or lower than expected
637	Transmission Fluid Temperature (TFT) sensor circuit above maximum voltage / -40°F (-40°C) indicated / circuit open
638	Transmission Fluid Temperature (TFT) sensor circuit below minimum voltage / 290°F (143°C) indicated / circuit shorted
639	Insufficient input from Turbine Shaft Speed Sensor (TSS)
641	Shift Solenoid 3 (SS3) circuit failure
643	Torque Converter Clutch (TCC) circuit failure
645	Incorrect gear ratio obtained for first gear
646	Incorrect gear ratio obtained for second gear
647	Incorrect gear ratio obtained for third gear
648	Incorrect gear ratio obtained for fourth gear
649	Electronic Pressure Control (EPC) higher or lower than expected
651	Electronic Pressure Control (EPC) circuit failure
652	Torque Converter Clutch (TCC) solenoid circuit failure
653	Transmission Control Switch (TCS) did not change states during KOER
654	Transmission Range (TR) sensor not indicating PARK during KOEO
656	Torque Converter Clutch continuous slip error
657	Transmission overtemperature condition occurred
659	High vehicle speed in park indicated

DIAGNOSTIC TROUBLE CODES	DEFINITIONS
667	Transmission Range sensor circuit voltage below minimum voltage
668	Transmission Range circuit voltage above maximum voltage
675	Transmission Range sensor circuit voltage out of range
998	Hard fault present—FMEM MODE

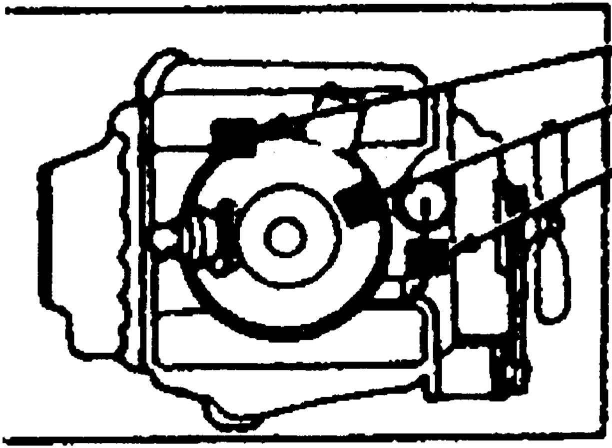

POWERTRAIN CONTROL
MODULE (PCM) ASSEMBLY
— 12A650
60-PIN VEHICLE
HARNESS CONNECTOR

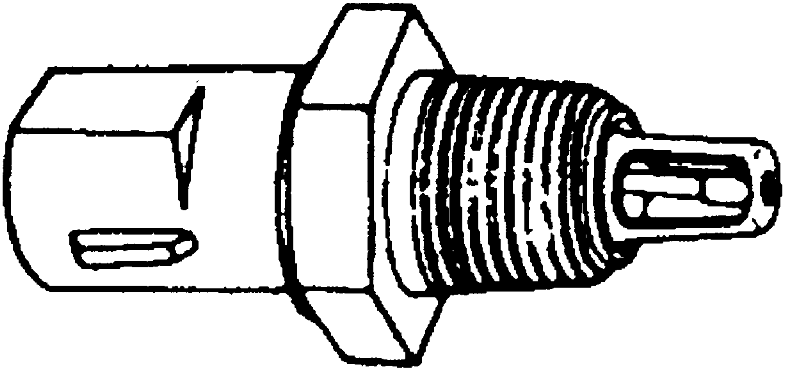


FRONT OF VEHICLE
POWERTRAIN CONTROL MODULE BRACKET SUPPORT 12B522
SCREW TIGHTEN TO 2.7-3.7 N·m (24-32 LB-IN)
POWERTRAIN CONTROL MODULE (PCM) 12A650



VALVE BODY
SOLENOID
INLET
(ATMOSPHERE)
OUTLET
(MANIFOLD VACUUM)





THREADED INTO INTAKE MANIFOLD

Temperature		Engine Coolant/Air Charge Temperature Sensor Values	
°F	°C	Voltage (volts)	Resistance (K ohms)
248	120	.27	1.18
230	110	.35	1.55
212	100	.46	2.07
194	90	.60	2.80
176	80	.78	3.84
158	70	1.02	5.37
140	60	1.33	7.70
122	50	1.70	10.97
104	40	2.13	16.15
86	30	2.60	24.27
68	20	3.07	37.30
50	10	3.51	58.75

Temperature		Engine Coolant/Air Charge Temperature Sensor Values	
°F	°C	Voltage (volts)	Resistance (K ohms)
248	120	.27	1.18
230	110	.35	1.55
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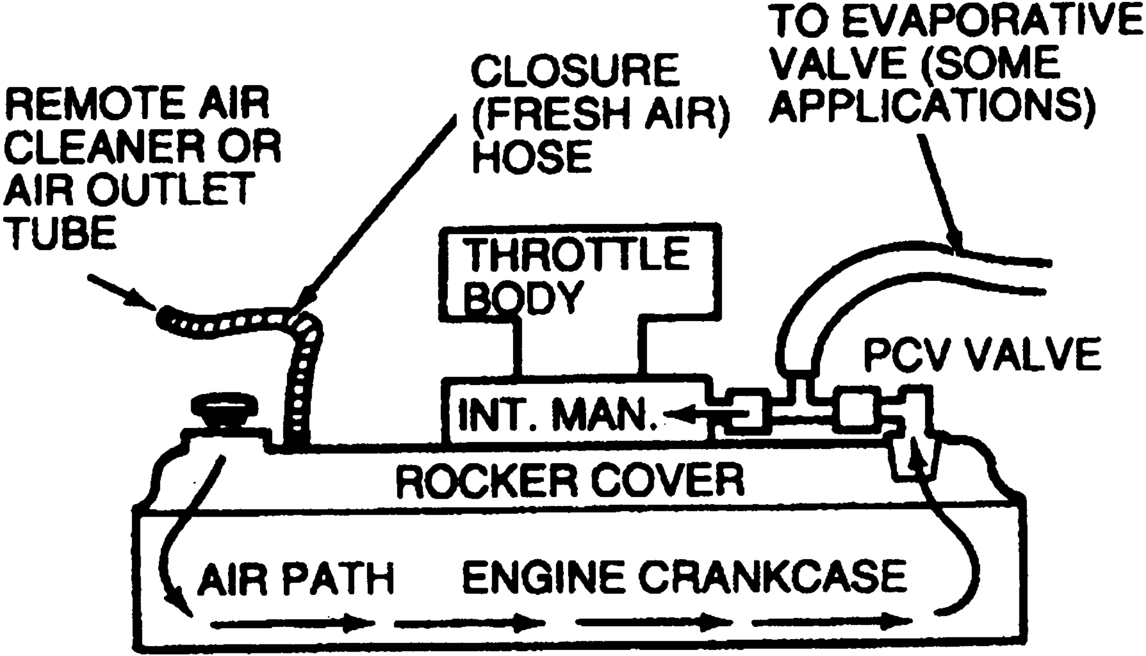
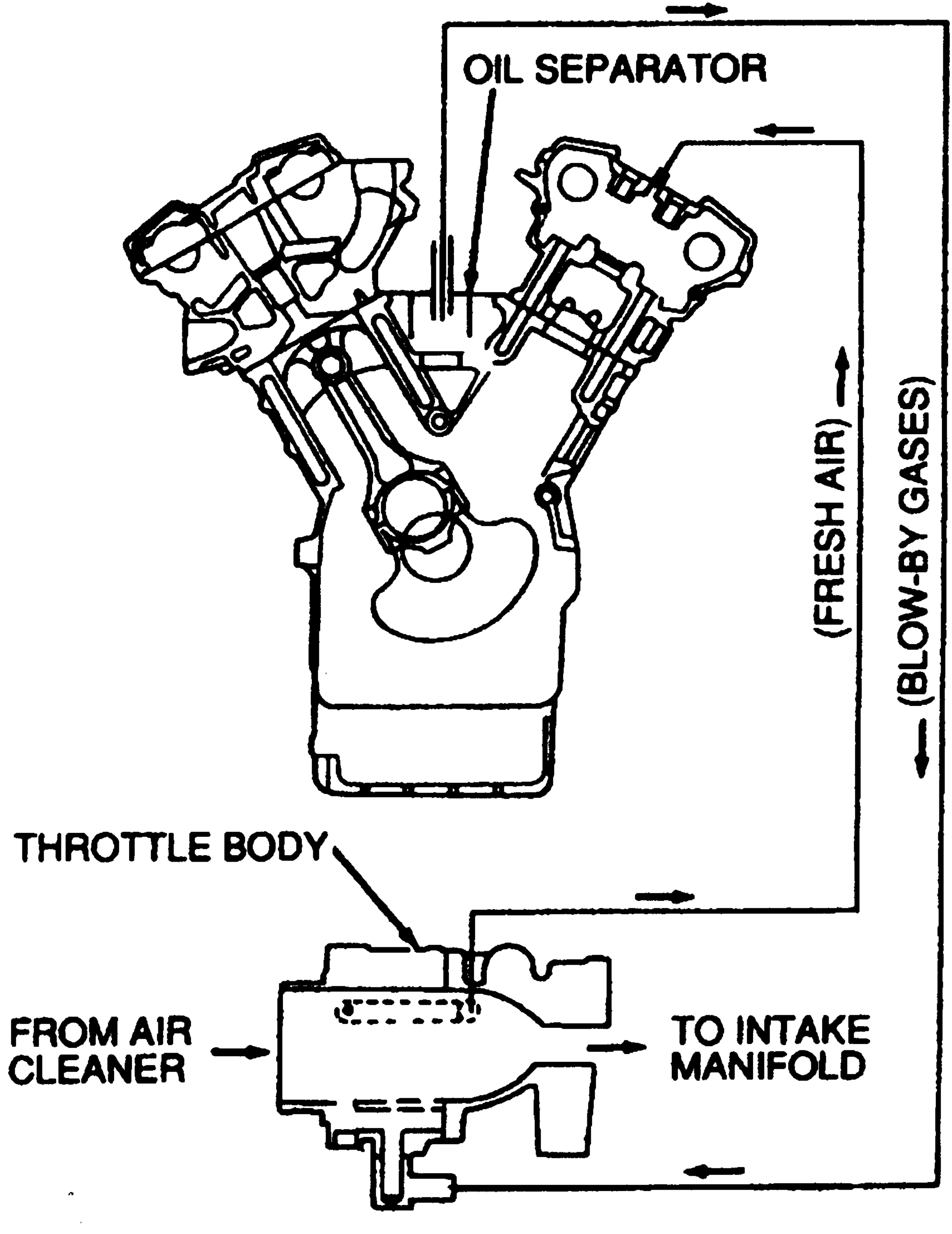
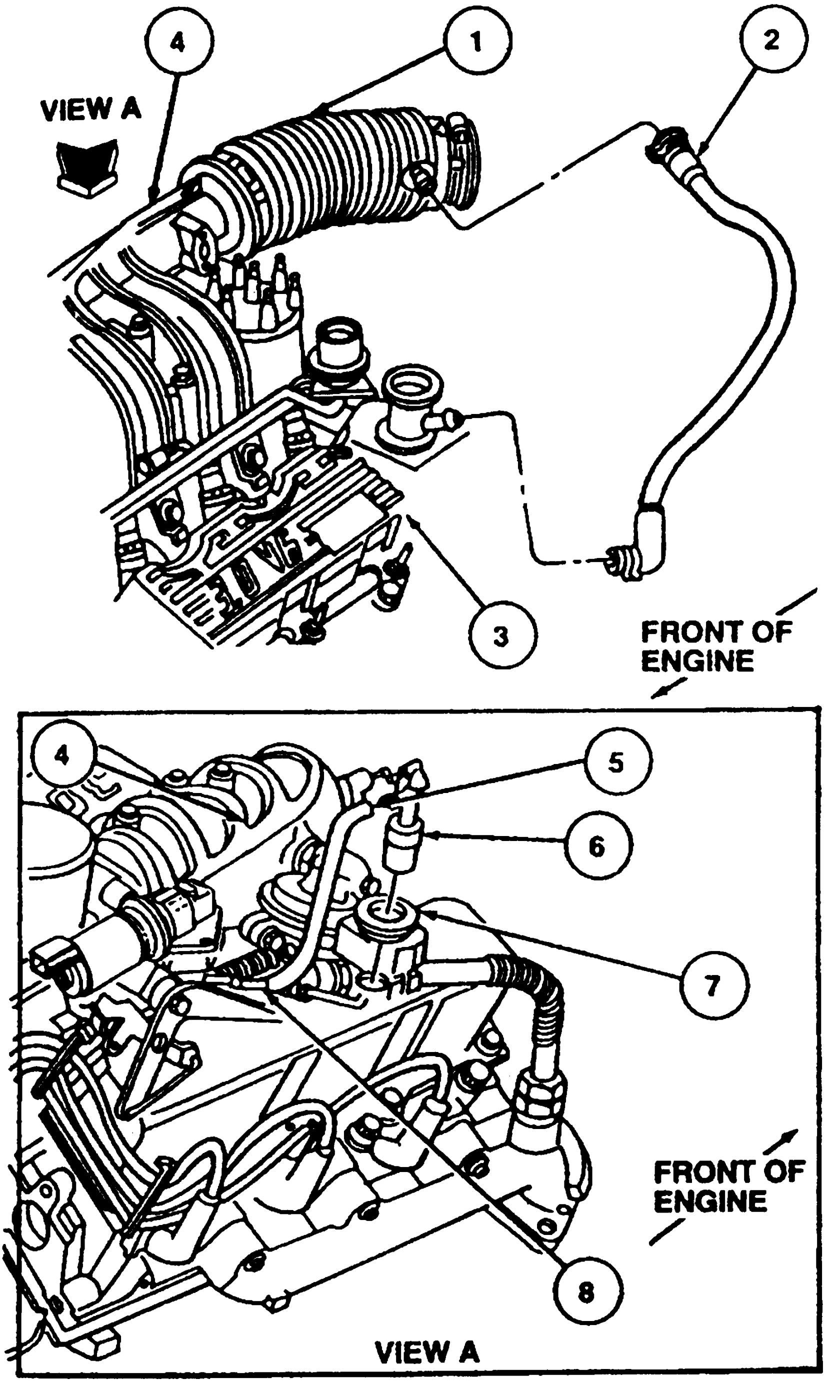
194	90	.60	2.80
176	80	.78	3.84
158	70	1.02	5.37
140	60	1.33	7.70
122	50	1.70	10.97
104	40	2.13	16.15
86	30	2.60	24.27
68	20	3.07	37.30
50	10	3.51	58.75

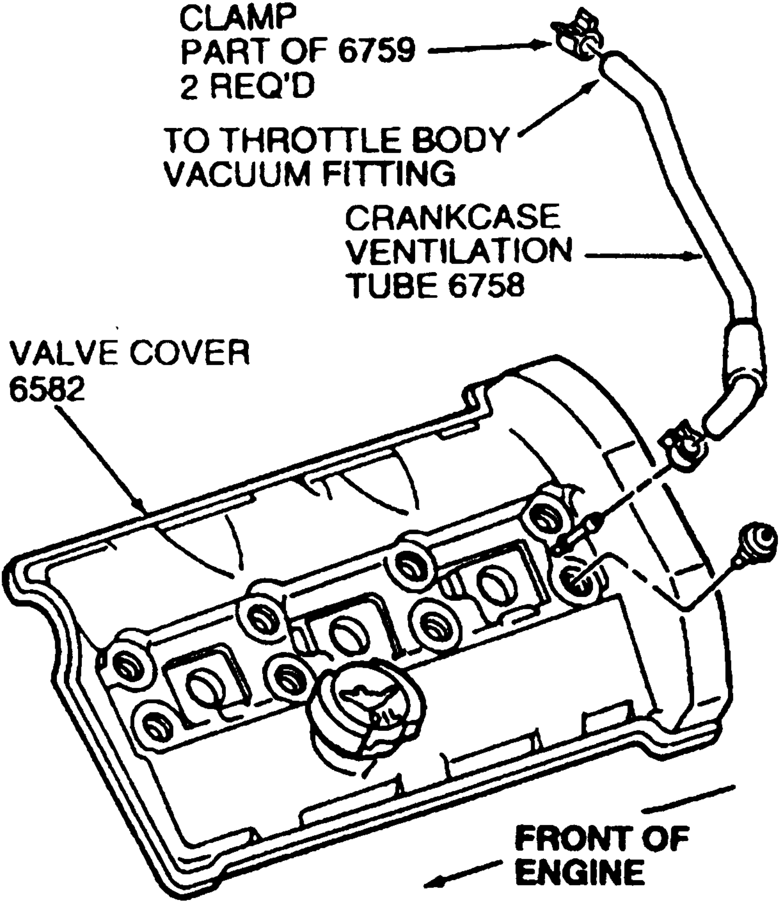

REMOTE AIR CLEANER OR AIR OUTLET TUBE
CLOSURE (FRESH AIR) HOSE
TO EVAPORATIVE VALVE (SOME APPLICATIONS)
THROTTLE BODY
PCV VALVE
INT. MAN.
ROCKER COVER
AIR PATH
ENGINE CRANKCASE

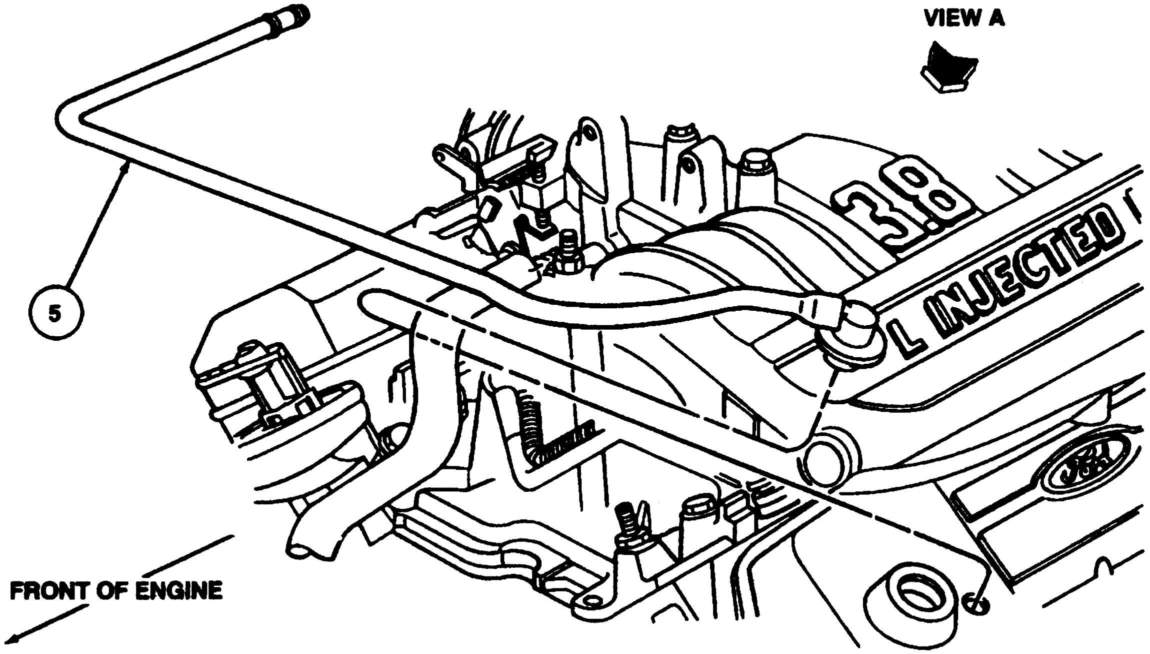


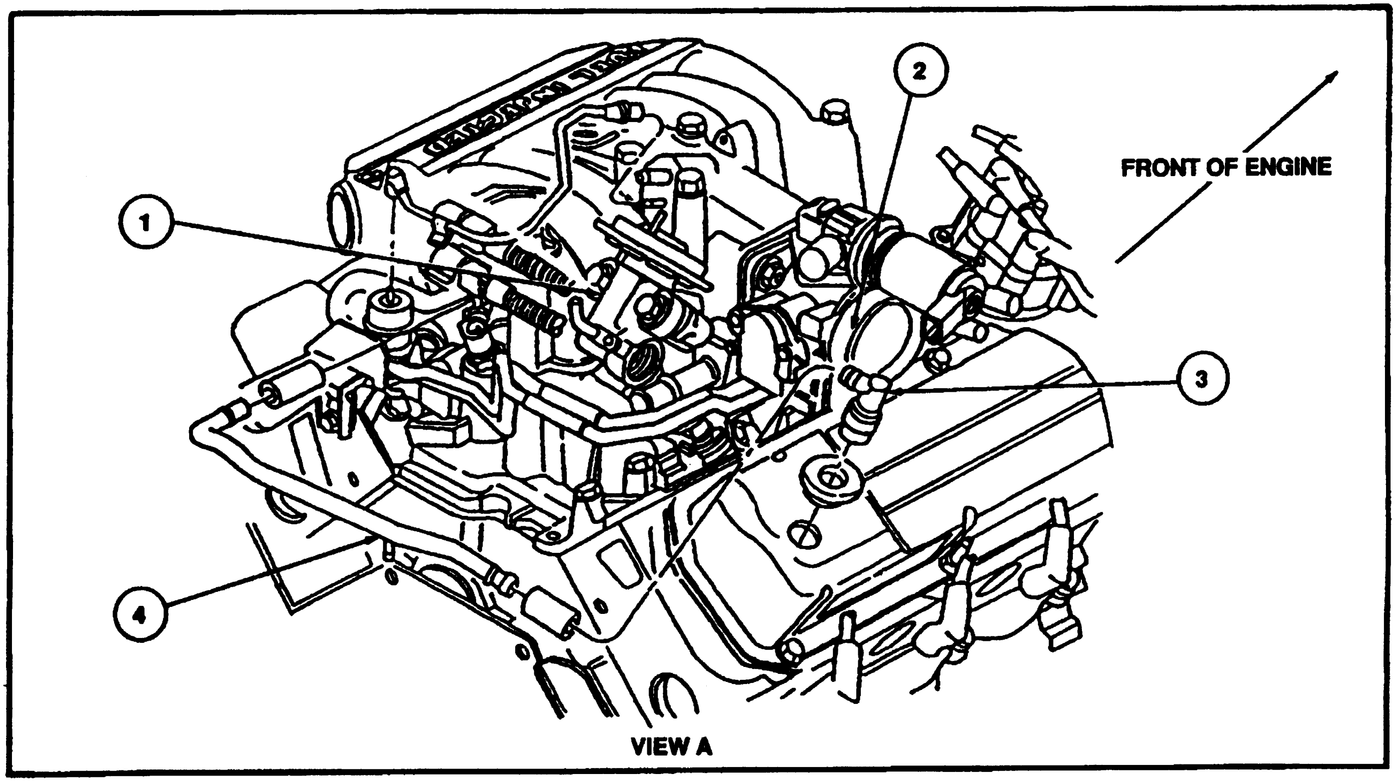
OIL SEPARATOR
(FRESH AIR)
(BLOW-BY GASES)
THROTTLE BODY
FROM AIR
CLEANER
TO INTAKE
MANIFOLD



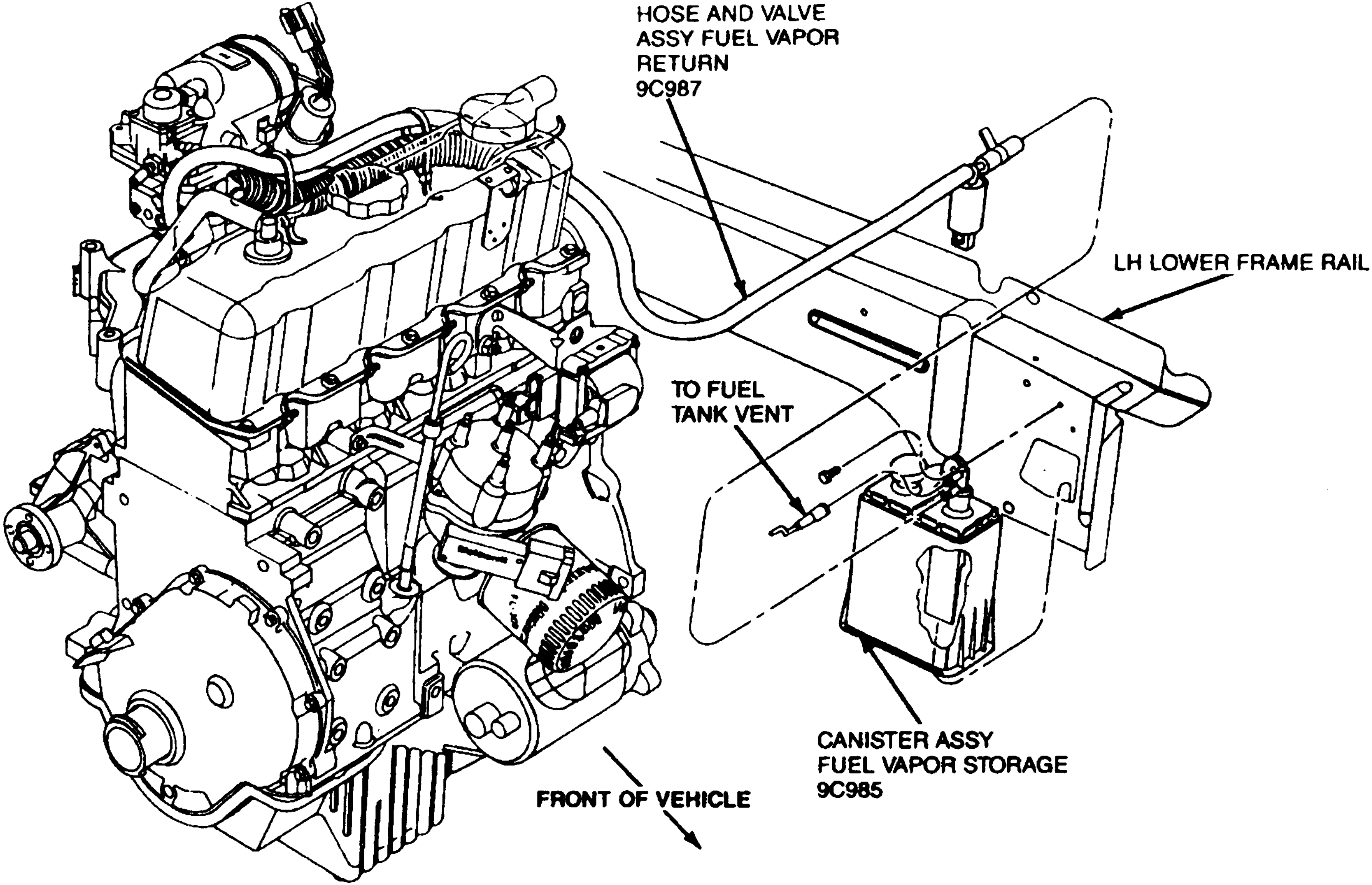
Item	Part Number	Description
1	9B659	Air Cleaner Outlet Tube
2	6853	Crankcase Ventilation Hose
3	6582	Valve Cover
4	9E926	Throttle Body
5	6853	Crankcase Ventilation Hose
6	6A666	Positive Crankcase Ventilation Valve
7	6A892	Crankcase Ventilation Grommet
8	9E926	Throttle Body

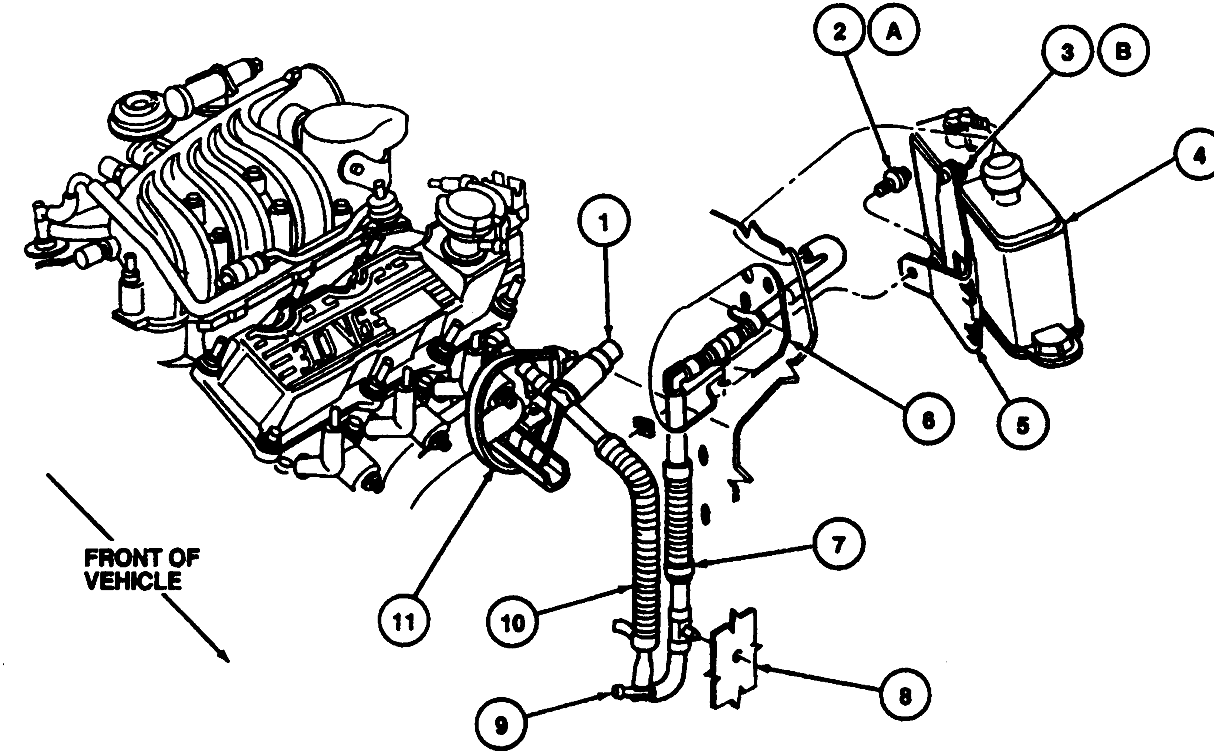

CLAMP
PART OF 6759
2 REQ'D
TO THROTTLE BODY
VACUUM FITTING
CRANKCASE
VENTILATION
TUBE 6758
VALVE COVER
6582
FRONT OF
ENGINE





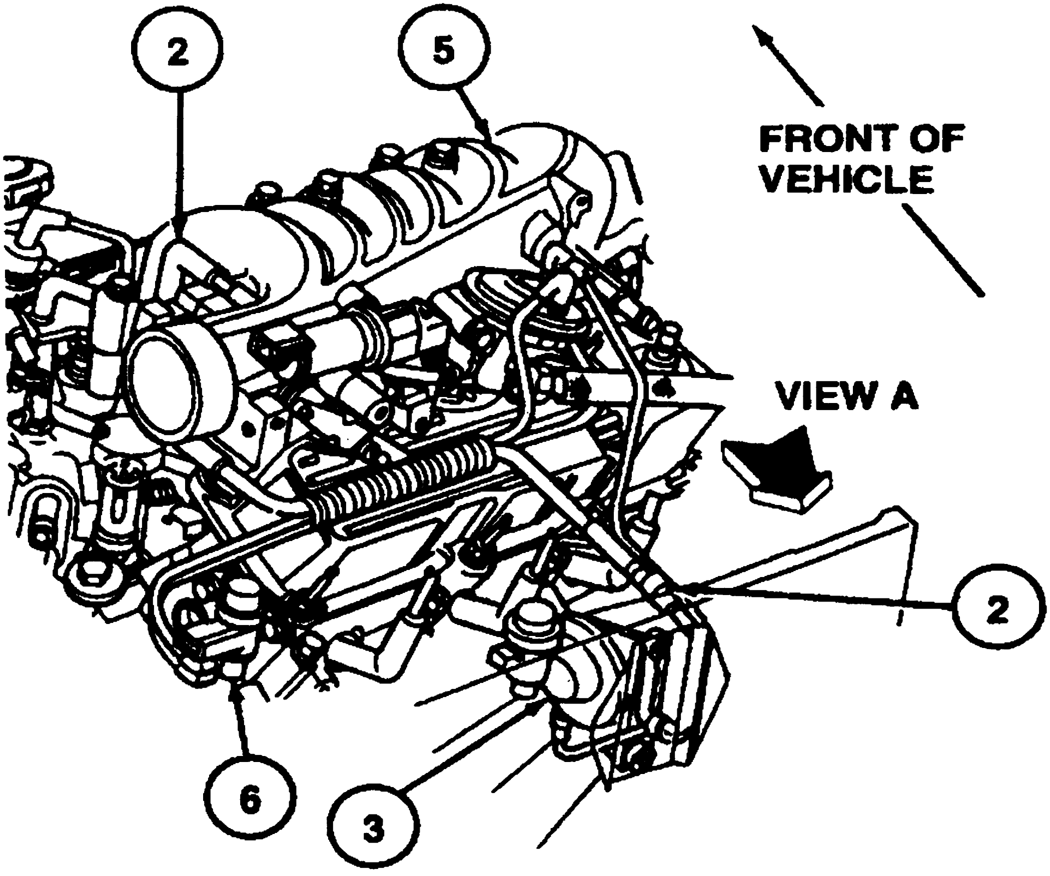
Item	Part Number	Description
1	9D475	EGR Valve
2	9E926	Throttle Body
3	6A666	Positive Crankcase Ventilation Valve
4	6758	Crankcase Ventilation Tube
5	6853	Crankcase Ventilation Hose

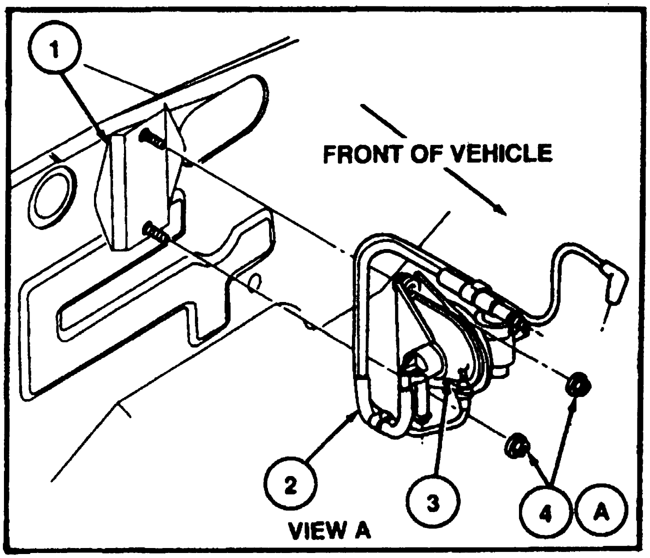

HOSE AND VALVE
ASSY FUEL VAPOR
RETURN
9C987
LH LOWER FRAME RAIL
TO FUEL
TANK VENT
CANISTER ASSY
FUEL VAPOR STORAGE
9C985
FRONT OF VEHICLE



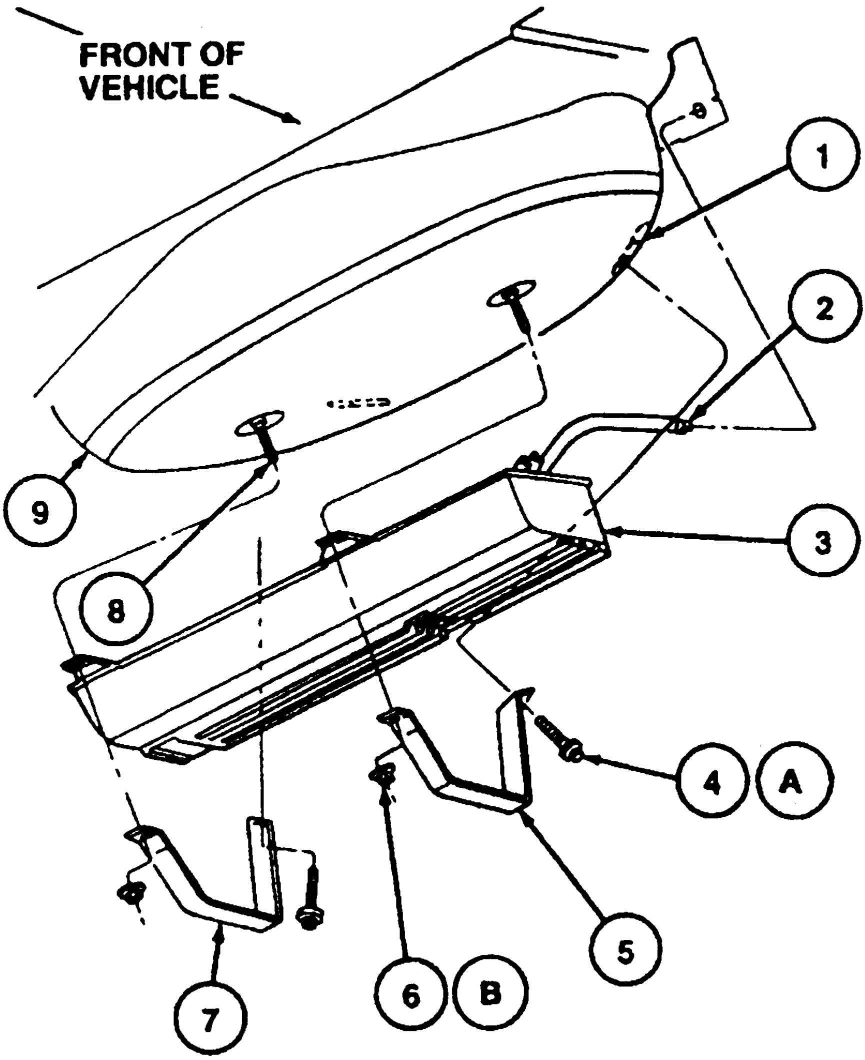
Item	Part Number	Description
1	9C915	Evaporative Emission Canister Purge Solenoid
2	N606688-S2	Bolt
3	N610959-S2	Bolt
4	9D653	Evaporative Emissions Canister
5	9D665	Evaporative Emission Canister Bracket
6	—	LH Headlamp Opening (Part of 16138)

Item	Part Number	Description
7	9K313	Evaporative Emission Tube
8	16138	Radiator Support
9	9A228	Fuel Tank Vent Tube (Part of 9K313)
10	9C987	Evaporative Emission Hose
11	95873	Tie Strap
A	—	Tighten to 21.2-28.8 N·m (15-21 Lb-Ft)
B	—	Tighten to 5.2-7.2 N·m (46-63 Lb-In)

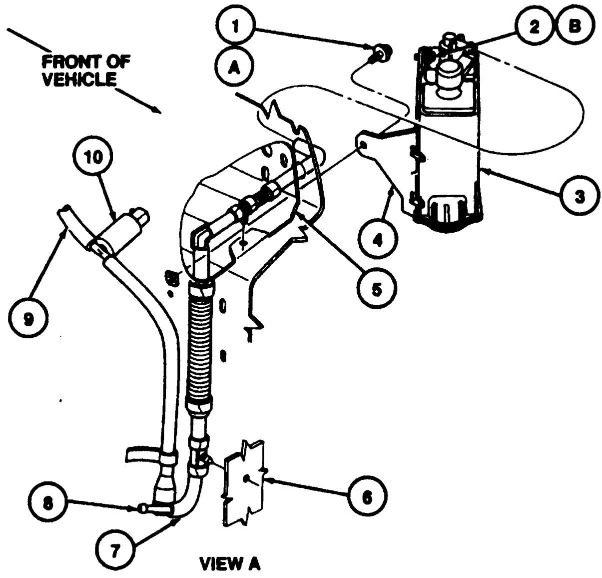




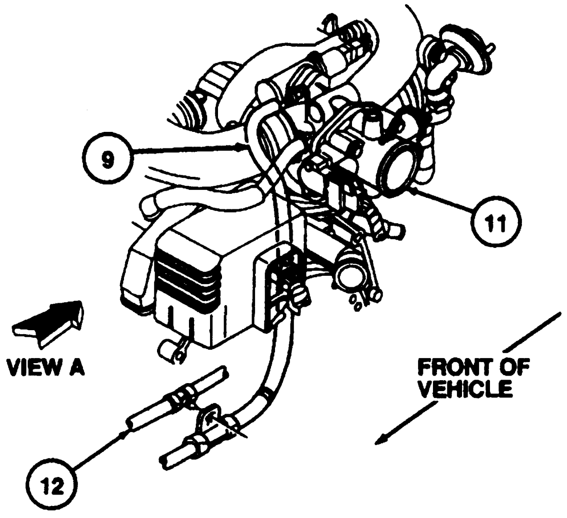
Item	Part Number	Description
1	01610	Dash Panel
2	9E498	Main Emission Vacuum Control Connector
3	9C915	Evaporative Emission Canister Purge Solenoid
4	N621905-S8	Nut (2 Req'd)
5	9E926	Throttle Body
6	9J459	EGR Vacuum Regulator Control
A	—	Tighten to 7.6-10.4 N·m (67-92 Lb-In)



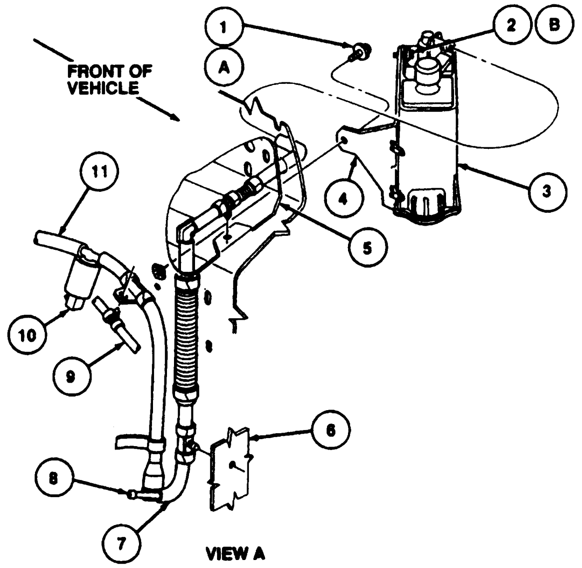
Item	Part Number	Description
1	N801658-S190	U-Nut (2 Req'd)
2	9J279	Fuel and Vapor Return Tube
3	9D653	Evaporative Emissions Canister
4	N804568-S190	Bolt (2 Req'd)
5	9D666	RH Evaporative Emission Canister Strap
6	N804796-S56	Nut (2 Req'd)
7	9D666	LH Evaporative Emission Canister Strap
8	14258	Stud (2 Req'd)
9	11215	Rear Floor Pan
A	—	Tighten to 40.3-54.7 N·m (30-40 Lb-Ft)
B	—	Tighten to 21.2-28.8 N·m (15-21 Lb-Ft)



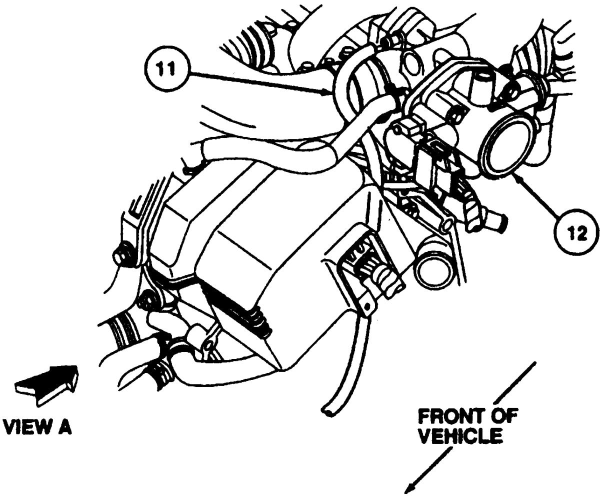
Item	Part Number	Description
1	N606688-S2	Bolt
2	N610959-S2	Bolt
3	9D653	Evaporative Emissions Canister
4	9D665	Evaporative Emission Canister Bracket
5	—	LH Headlamp Opening (Part of 16138)
6	16138	Radiator Support
7	9K313	Evaporative Emission Tube



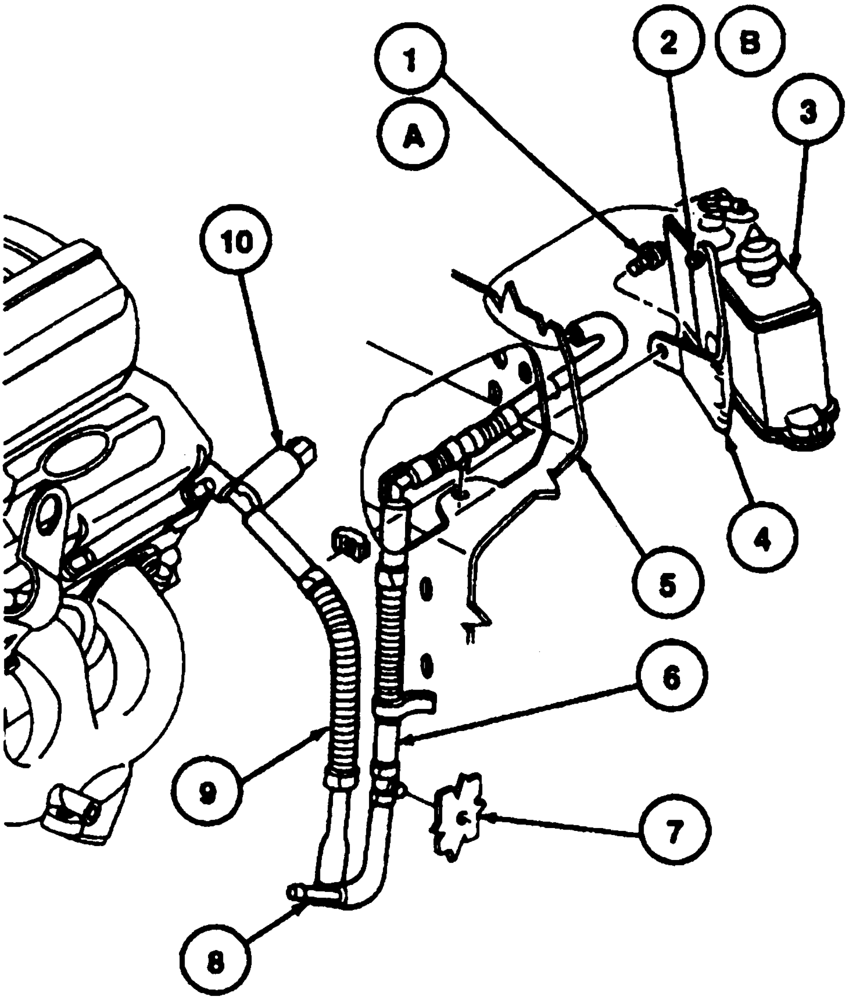
Item	Part Number	Description
8	9A228	Fuel Tank Vent Tube (Part of 9K313)
9	9E325	Evaporative Emission Hose
10	9C915	Evaporative Emission Canister Purge Solenoid
11	9E926	Throttle Body
12	14301	Battery Ground Cable
A	—	Tighten to 21.2-28.8 N·m (15-21 Lb-Ft)
B	—	Tighten to 5.2-7.2 N·m (46-63 Lb-In)



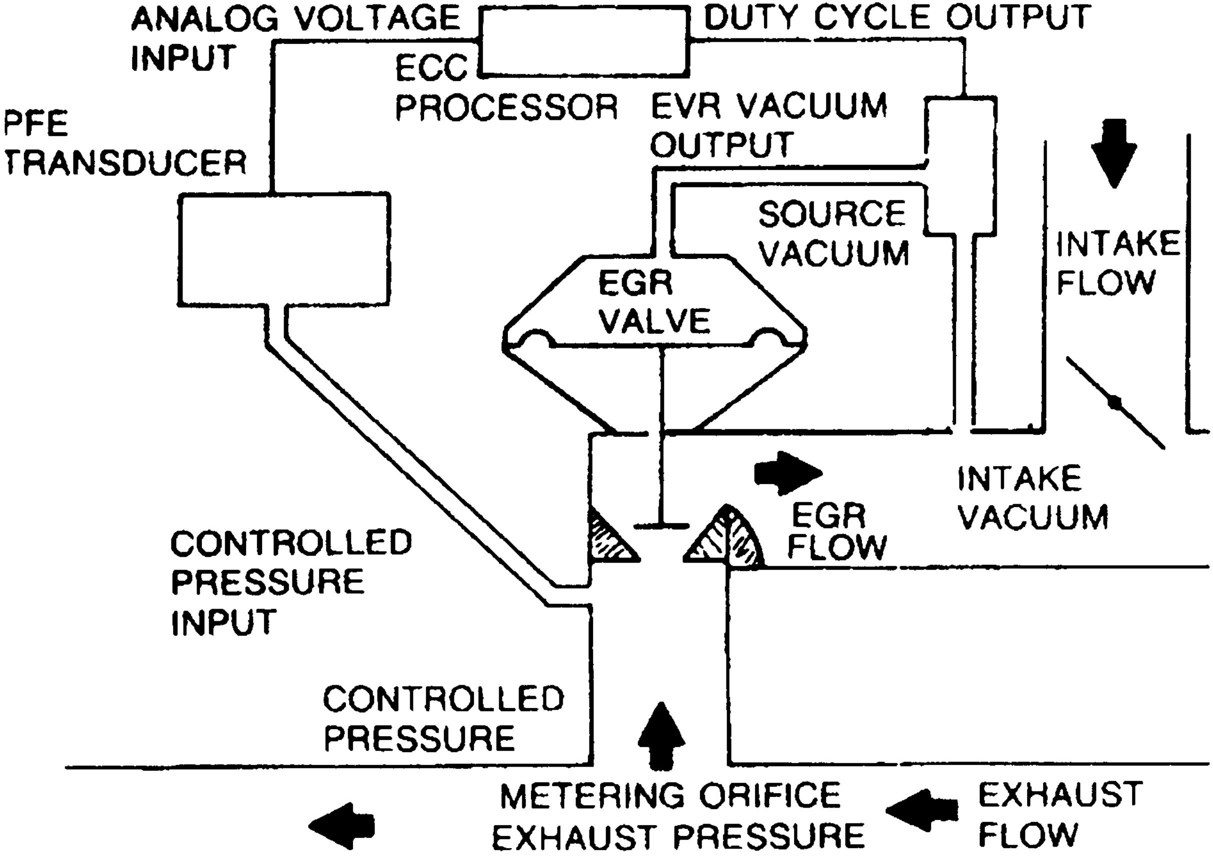
Item	Part Number	Description
1	N606689-S2	Screw and Washer Assy
2	N610959-S2	Bolt
3	9D653	Evaporative Emissions Canister
4	9D665	Evaporative Emission Canister Bracket
5	—	LH Headlamp Opening (Part of 16138)
6	16138	Radiator Support
7	9K313	Evaporative Emission Tube

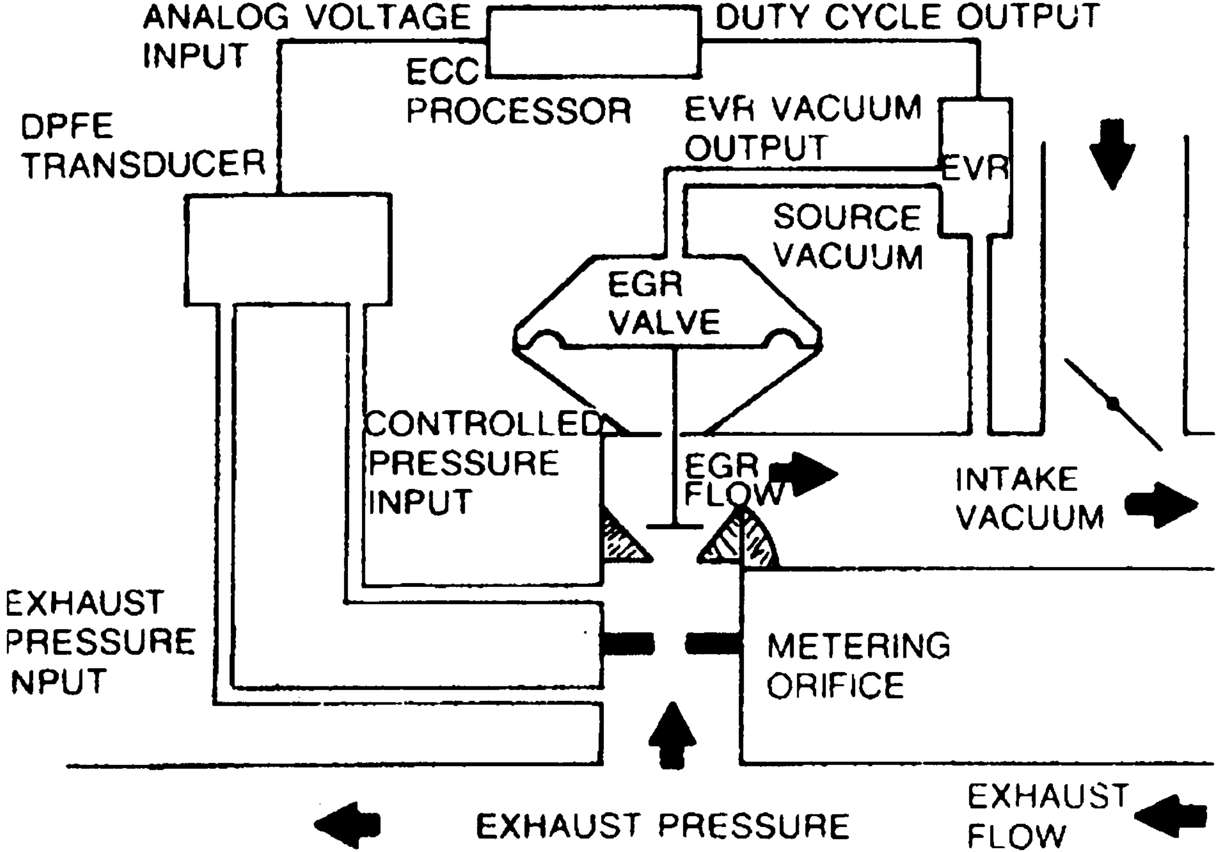


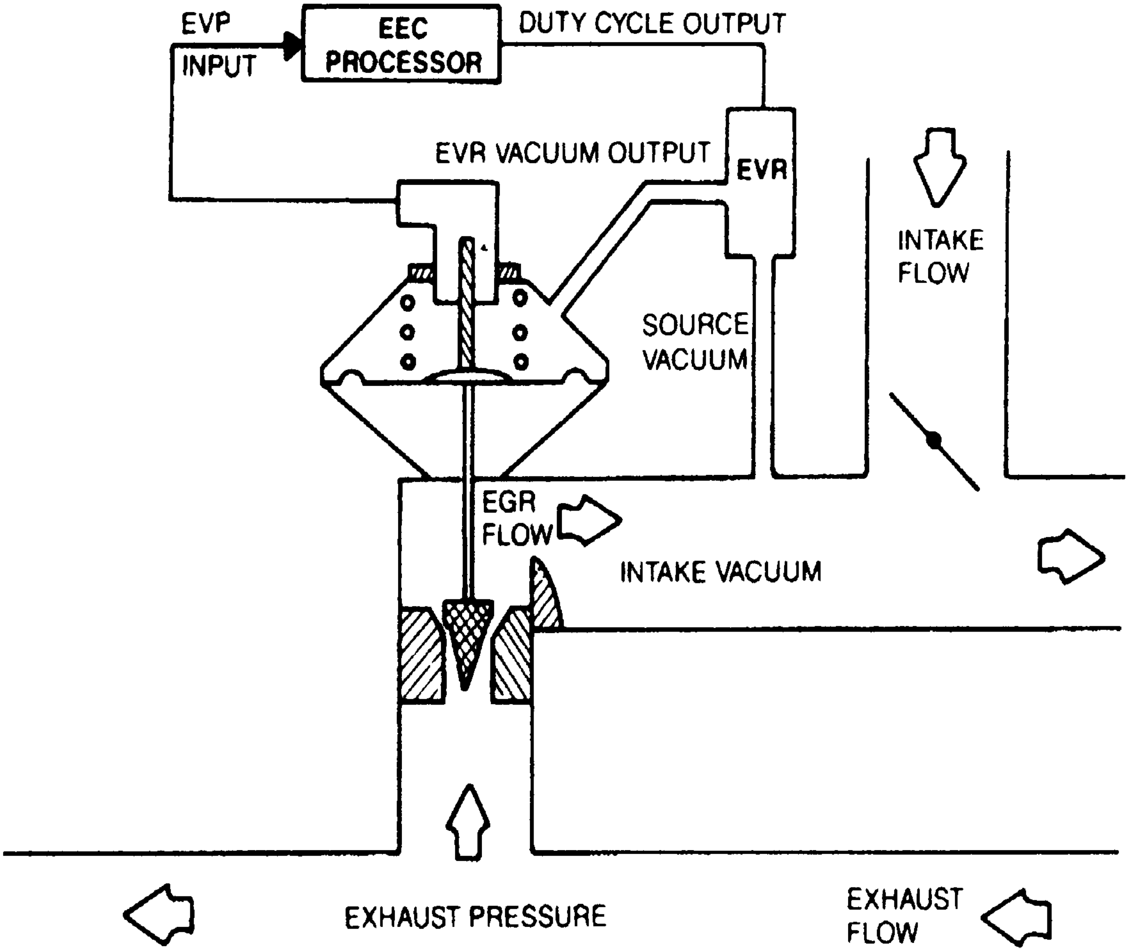
Item	Part Number	Description
8	9A228	Fuel Tank Vent Tube (Part of 9K313)
9	14301	Battery Ground Cable
10	9C915	Evaporative Emission Canister Purge Solenoid
11	9C987	Evaporative Emission Hose
12	9E926	Throttle Body
A	—	Tighten to 21.2-28.8 N·m (15-21 Lb-Ft)
B	—	Tighten to 5.2-7.2 N·m (46-63 Lb-In)



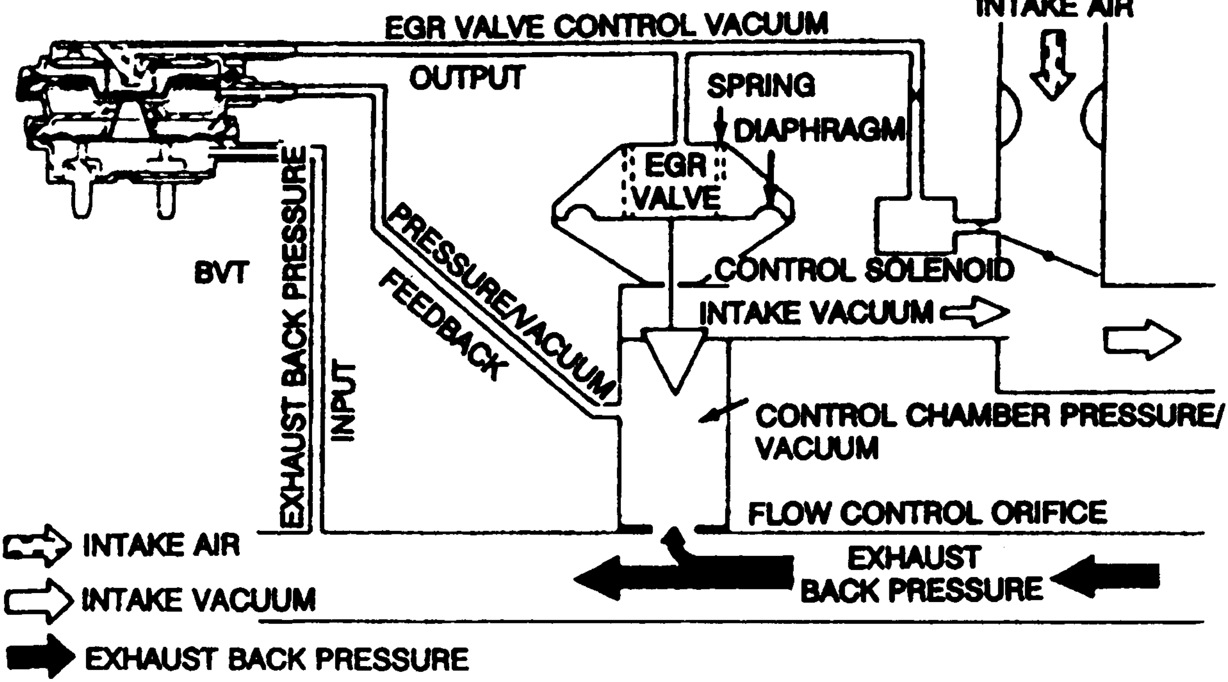
Item	Part Number	Description
1	N606688-S2	Bolt
2	N610959-S2	Bolt
3	9D653	Evaporative Emissions Canister
4	9D665	Evaporative Emission Canister Bracket
5	—	LH Headlamp Opening (Part of 16138)
6	9K313	Evaporative Emission Tube
7	16138	Radiator Support
8	9A228	Fuel Tank Vent Tube
9	9C987	Evaporative Emission Hose
10	9C915	Evaporative Emission Canister Purge Solenoid
A	—	Tighten to 21.2-28.8 N·m (15-21 Lb-Ft)
B	—	Tighten to 5.2-7.2 N·m (46-63 Lb-In)

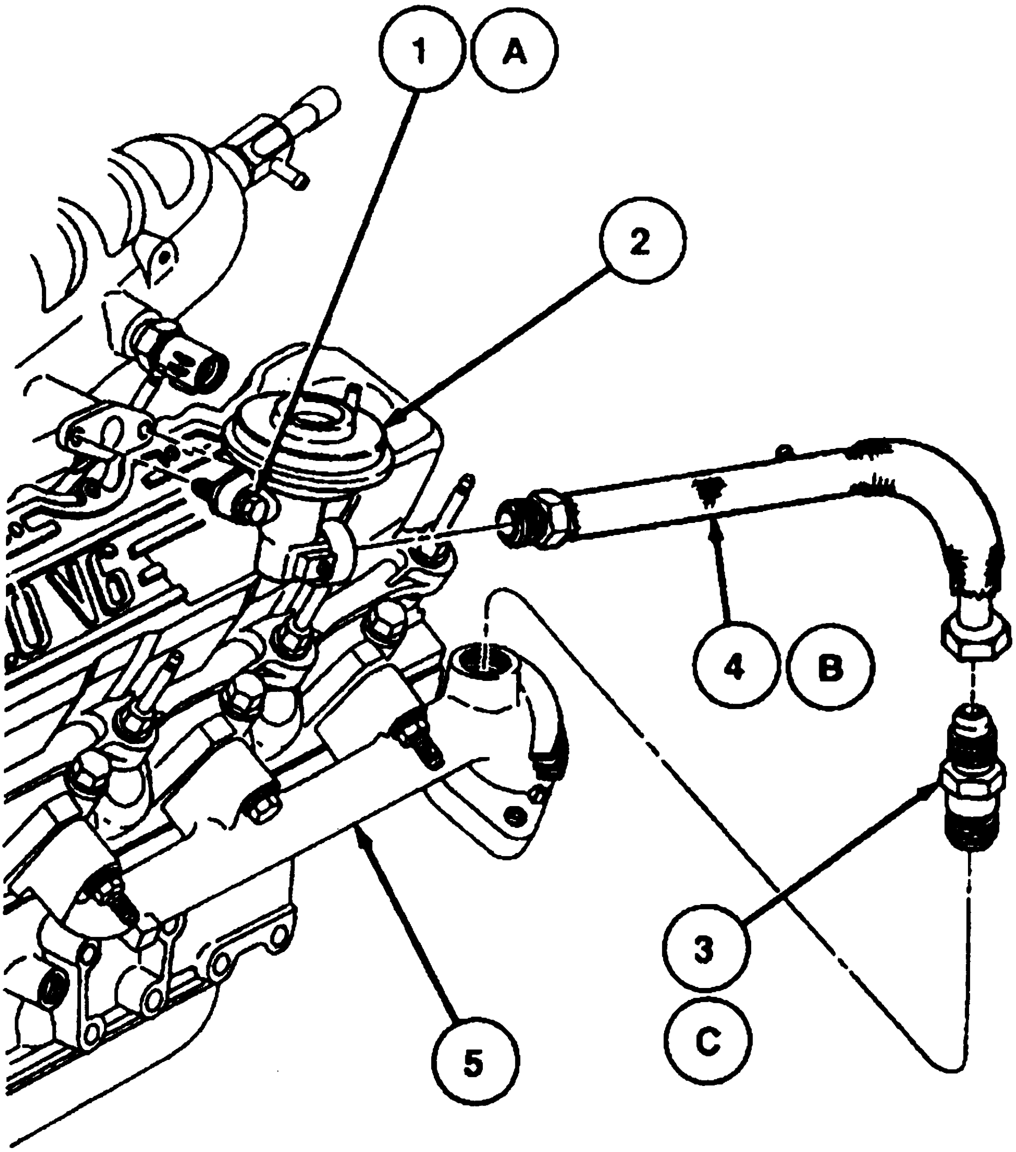

ANALOG VOLTAGE INPUT
DUTY CYCLE OUTPUT
ECC PROCESSOR
PFE TRANSDUCER
EVR VACUUM OUTPUT
SOURCE VACUUM
EGR VALVE
INTAKE FLOW
INTAKE VACUUM
EGR FLOW
CONTROLLED PRESSURE INPUT
CONTROLLED PRESSURE
METERING ORIFICE EXHAUST PRESSURE
EXHAUST FLOW


ANALOG VOLTAGE INPUT
DUTY CYCLE OUTPUT
ECC PROCESSOR
DPFE TRANSDUCER
EVR VACUUM OUTPUT
EVR
SOURCE VACUUM
EGR VALVE
CONTROLLED PRESSURE INPUT
EGR FLOW
INTAKE VACUUM
EXHAUST PRESSURE NPUT
METERING ORIFICE
EXHAUST PRESSURE
EXHAUST FLOW

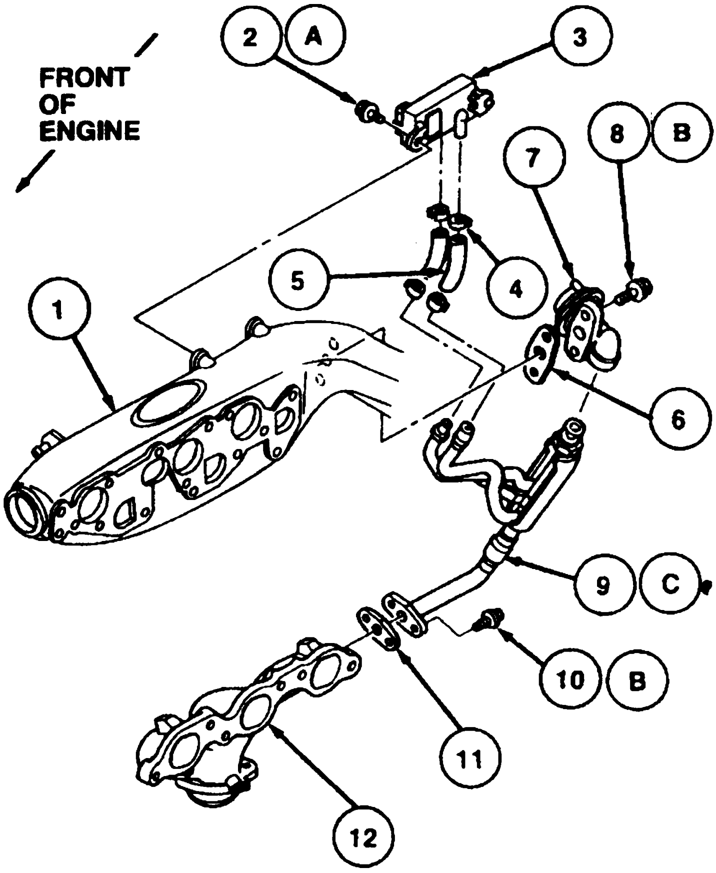


EVP
INPUT
EEC
PROCESSOR
DUTY CYCLE OUTPUT
EVR VACUUM OUTPUT
EVR
INTAKE
FLOW
SOURCE
VACUUM
EGR
FLOW
INTAKE VACUUM
EXHAUST PRESSURE
EXHAUST
FLOW

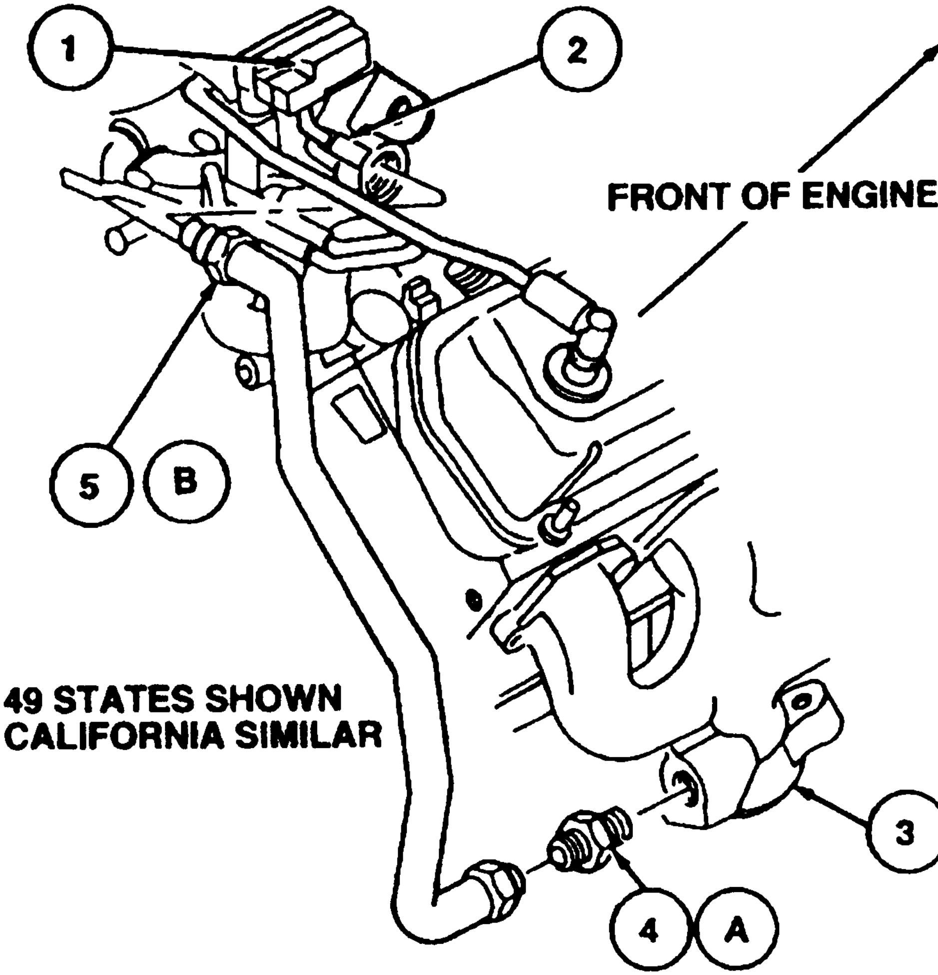

EGR VALVE CONTROL VACUUM
INTAKE AIR
OUTPUT
SPRING
DIAPHRAGM
EGR VALVE
BVT
EXHAUST BACK PRESSURE
INPUT
PRESSURE/VACUUM FEEDBACK
CONTROL SOLENOID
INTAKE VACUUM
CONTROL CHAMBER PRESSURE/ VACUUM
FLOW CONTROL ORIFICE
EXHAUST BACK PRESSURE
INTAKE AIR
INTAKE VACUUM
EXHAUST BACK PRESSURE



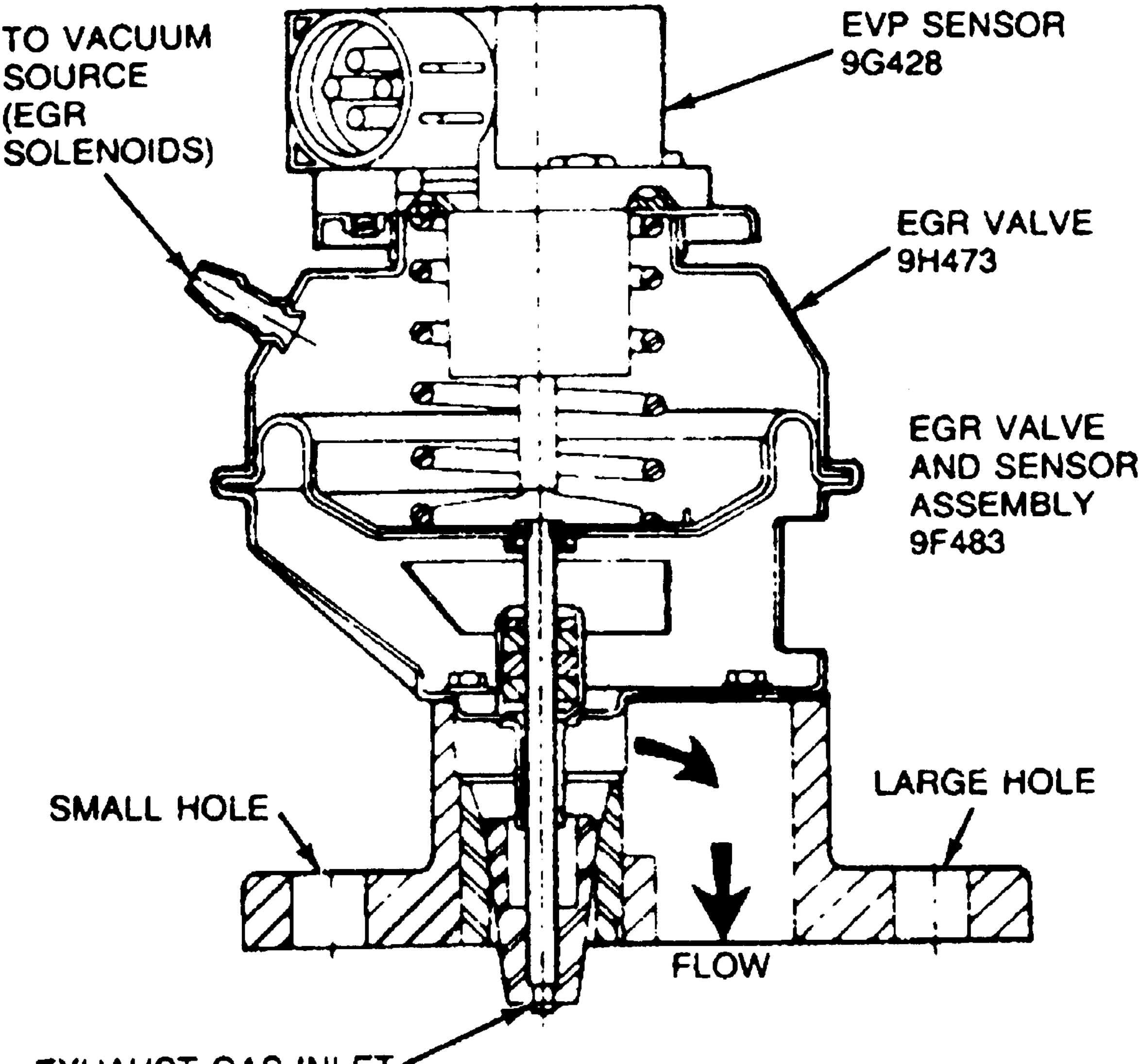
Item	Part Number	Description
1A	N804073-S8	Bolt (2 Req'd)
2	9D475	EGR Valve
3C	9F485	EGR Valve Tube to Manifold Connector
4B	9D477	EGR Valve to Exhaust Manifold Tube
5	9430	Exhaust Manifold
A		Tighten to 20-30 N·m (15-22 Lb-Ft)
B		Tighten to 35-45 N·m (26-33 Lb-Ft)
C		Tighten to 45-65 N·m (33-48 Lb-Ft)



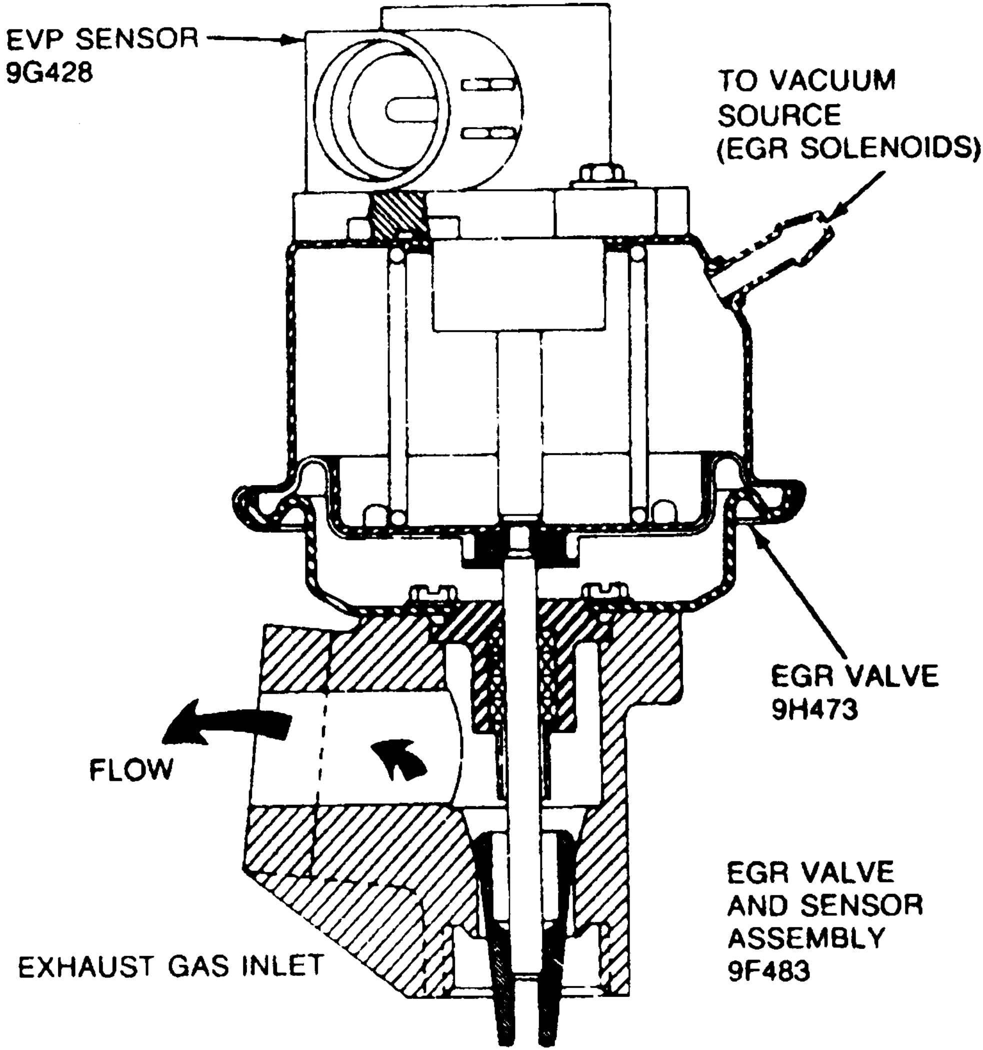
Item	Part Number	Description
1	9424	Intake Manifold
2A	90105-06531	Bolt (2 Req'd)
3	9J460	EGR Pressure Valve Sensor
4	—	Clamp (4 Req'd) (Part of 9P761)
5	9P761	EGR Pressure Valve Sensor Hose (2 Req'd)
6	9D476	EGR Valve Gasket
7	9D475	EGR Valve
8B	90119-08151	Bolt (2 Req'd)
9C	9D477	EGR Valve to Exhaust Manifold Tube
10B	90119-08146	Bolt (2 Req'd)
11	9F470	EGR Valve Tube Inlet Gasket
12	9430	Exhaust Manifold
A		Tighten to 2-3 N·m (18-27 Lb-In)
B		Tighten to 15-23 N·m (11-17 Lb-Ft)
C		Tighten to 45-65 N·m (33-48 Lb-Ft)



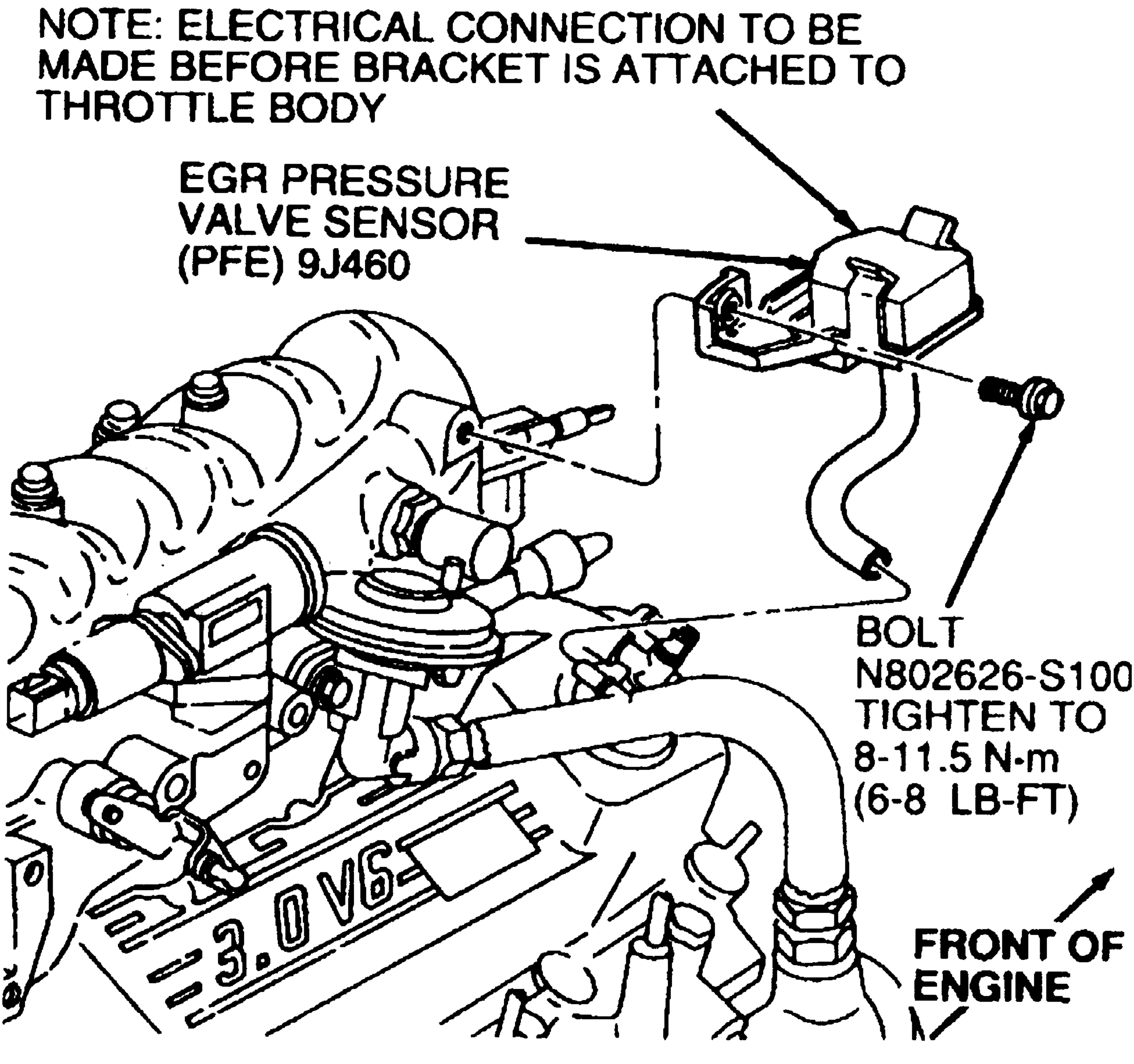
Item	Part Number	Description
1	9J460	EGR Pressure Valve Sensor
2	9D475	EGR Valve
3	9430	Exhaust Manifold
4A	9F485	EGR Valve Tube to Manifold Connector
5B	9D477	EGR Valve to Exhaust Manifold Tube
A		Tighten to 45-65 N·m (33-48 Lb-Ft)
B		Tighten to 35-45 N·m (26-33 Lb-Ft)

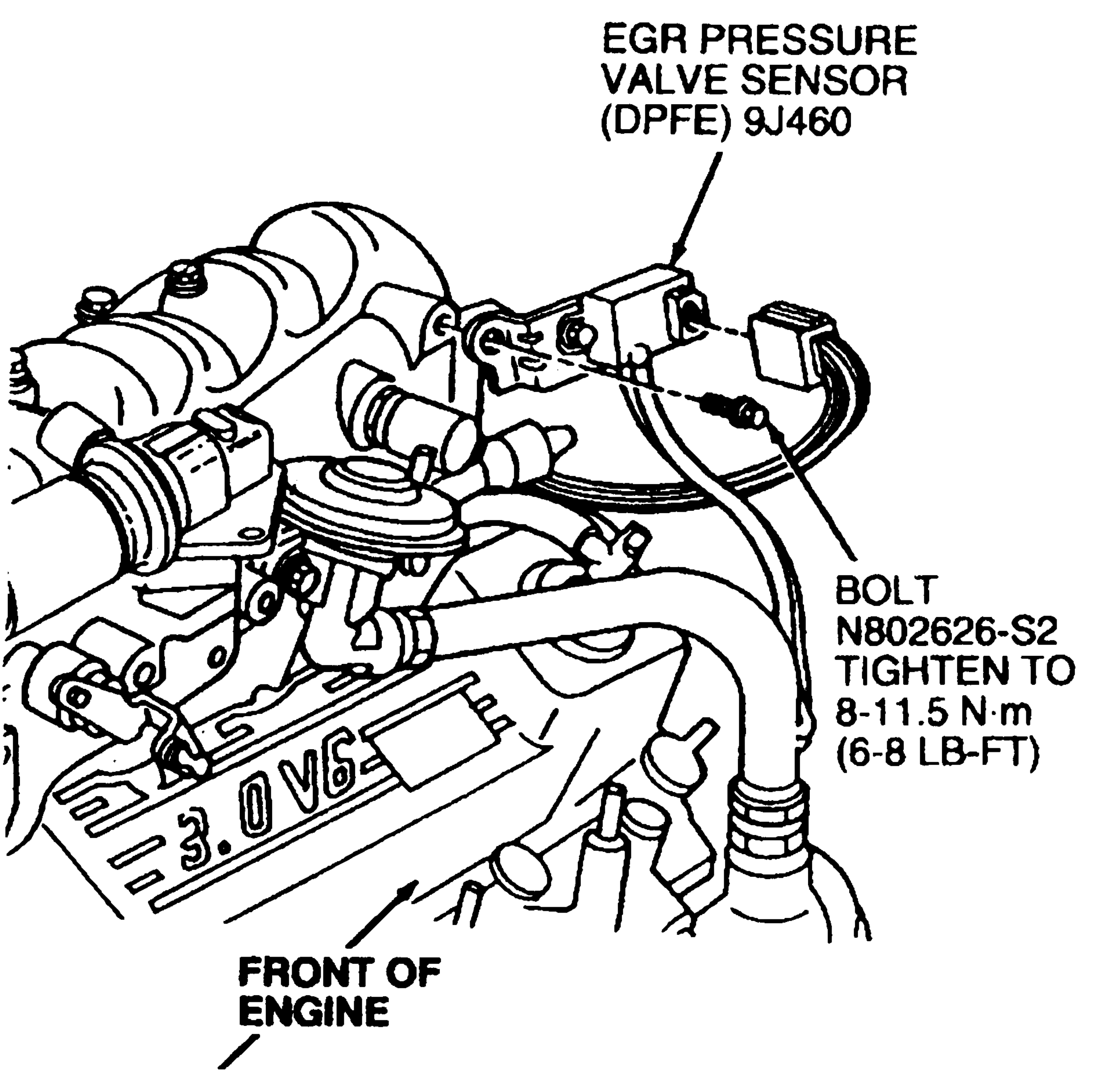


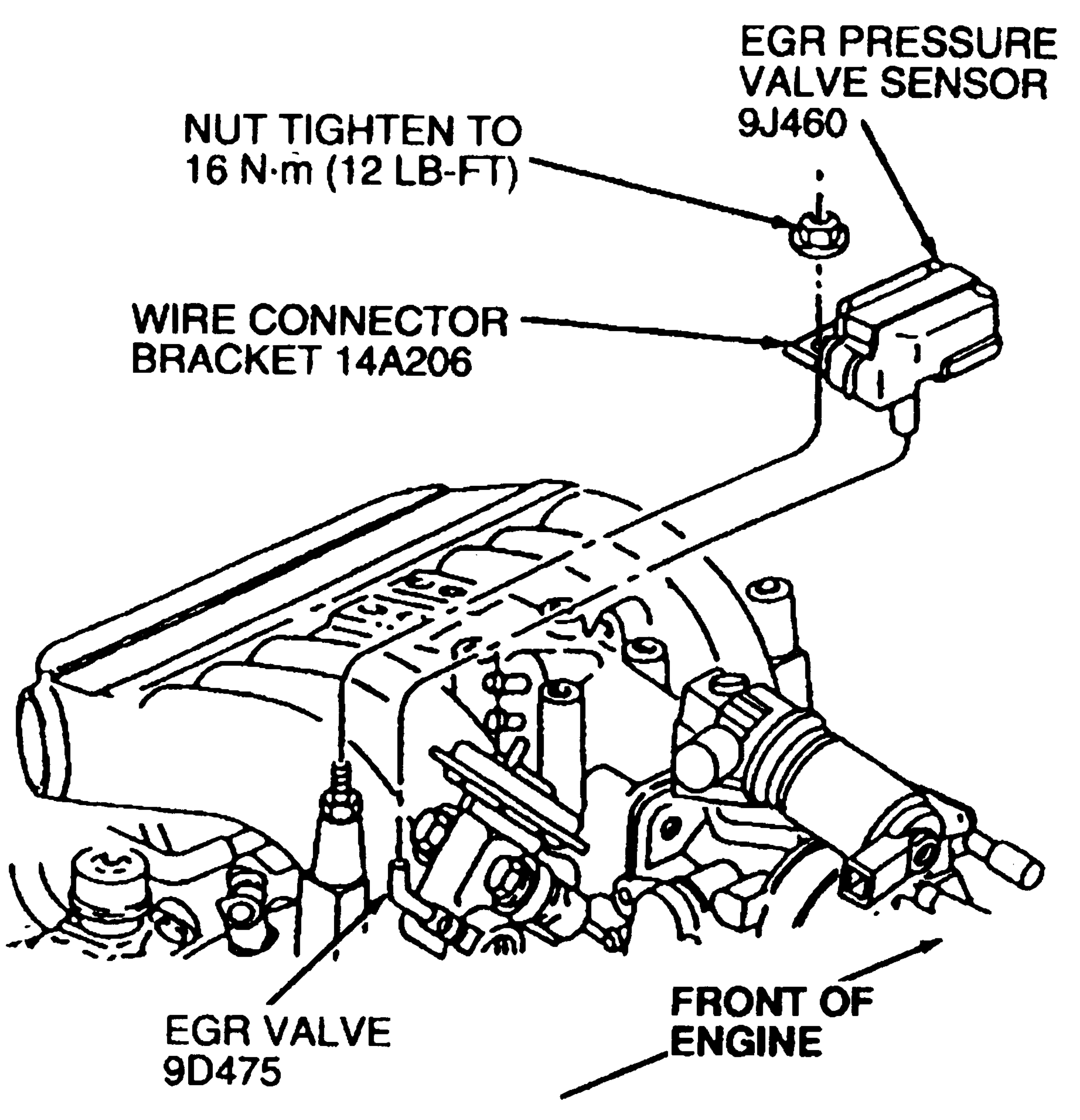
BASE ENTRY TYPE

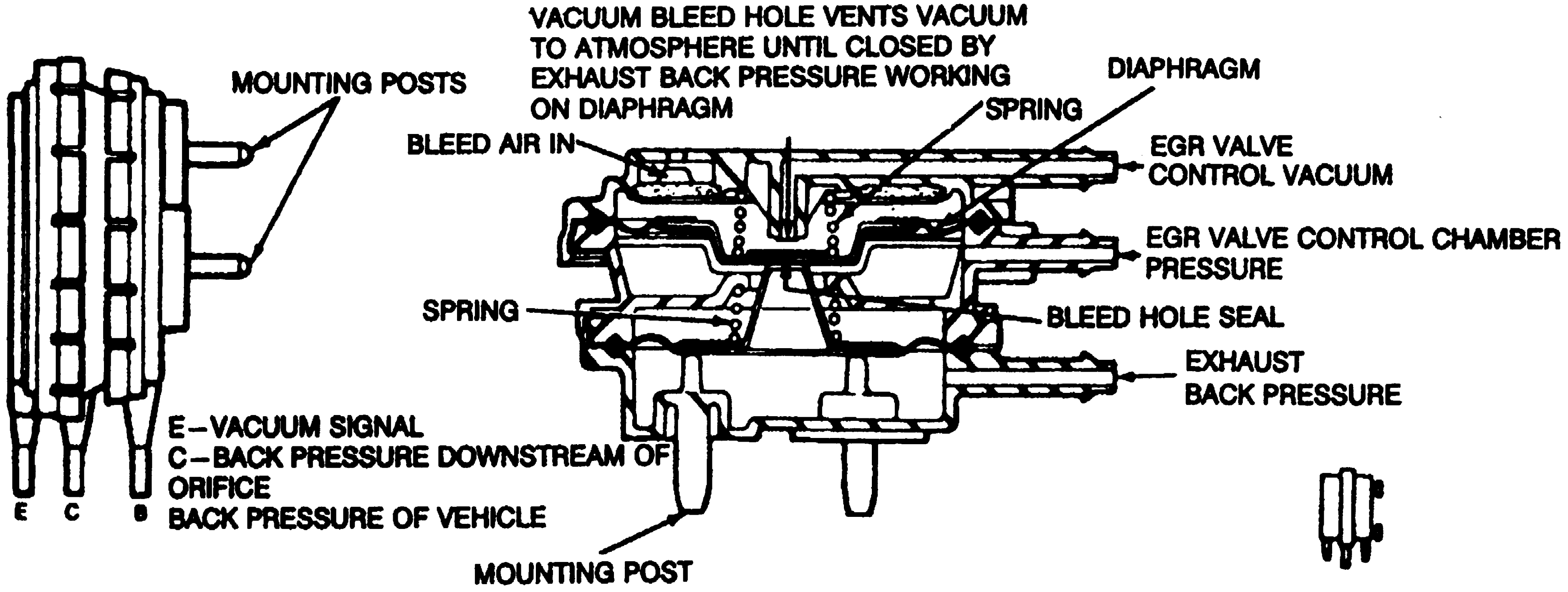


SIDE (EXTERNAL) ENTRY TYPE

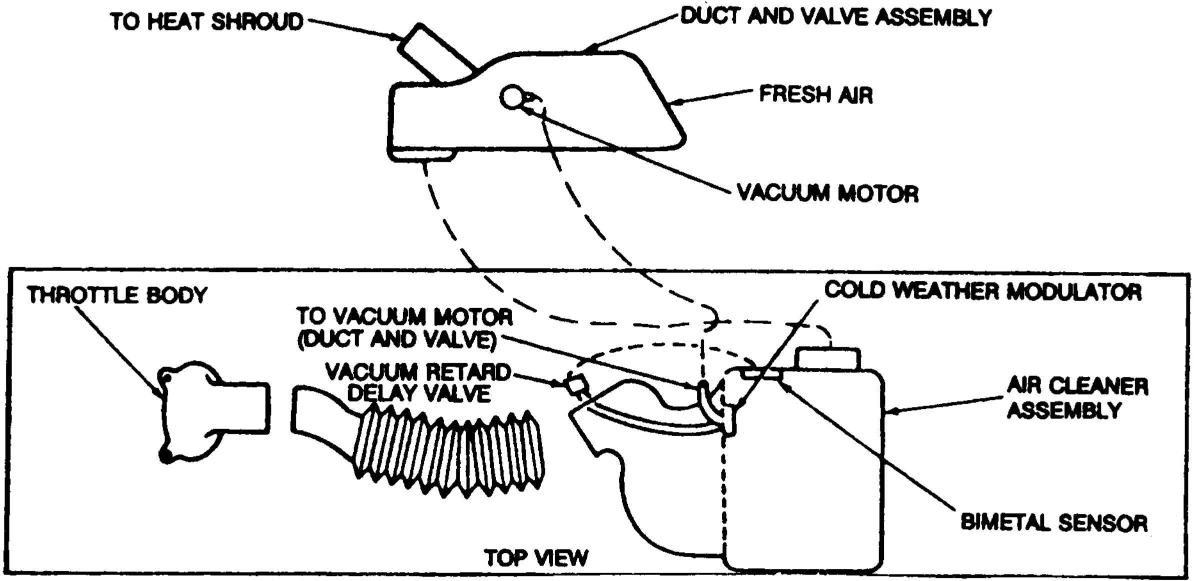

NOTE: ELECTRICAL CONNECTION TO BE MADE BEFORE BRACKET IS ATTACHED TO THROTTLE BODY
EGR PRESSURE VALVE SENSOR (PFE) 9J460
BOLT N802626-S100 TIGHTEN TO 8-11.5 N-m (6-8 LB-FT)
FRONT OF ENGINE
3.0 V6


EGR PRESSURE
VALVE SENSOR
(DPFE) 9J460
BOLT
N802626-S2
TIGHTEN TO
8-11.5 N·m
(6-8 LB-FT)
3.0 V6
FRONT OF
ENGINE

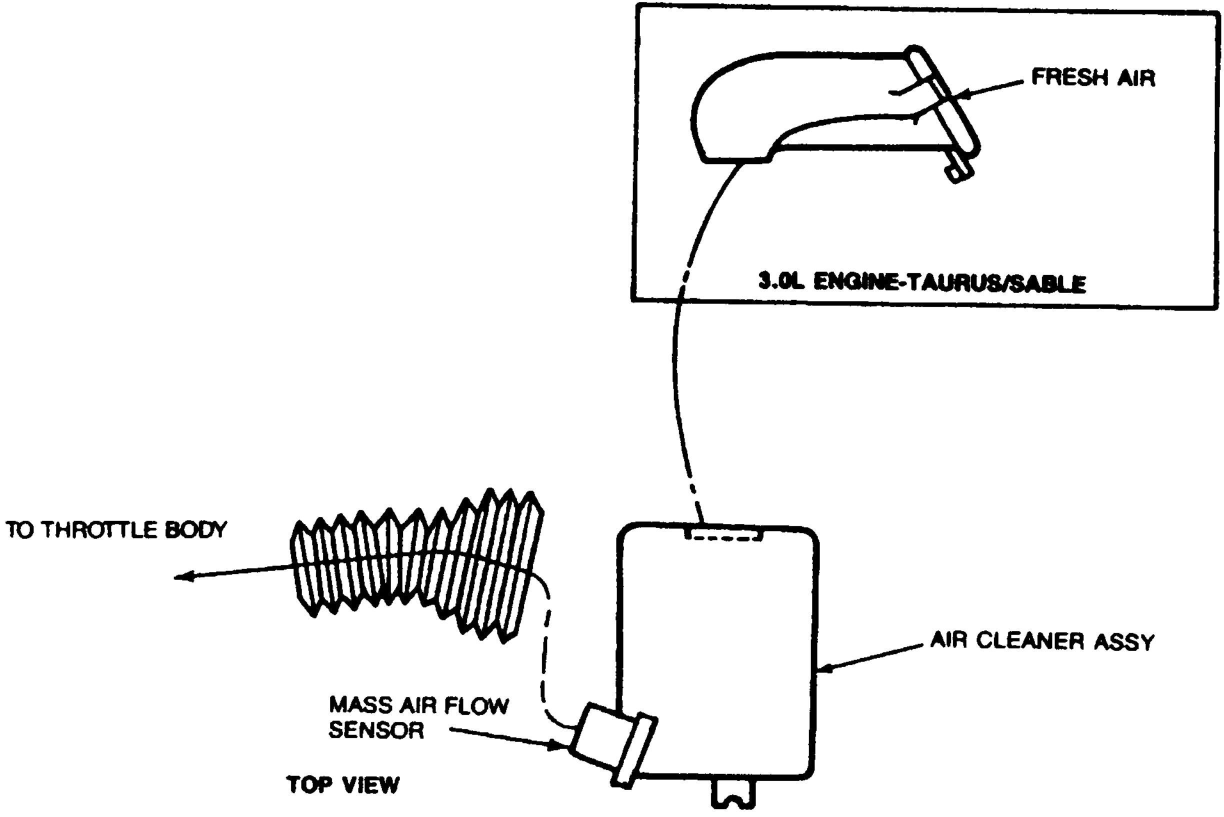

EGR PRESSURE
VALVE SENSOR
9J460
NUT TIGHTEN TO
16 N·m (12 LB-FT)
WIRE CONNECTOR
BRACKET 14A206
EGR VALVE
9D475
FRONT OF
ENGINE



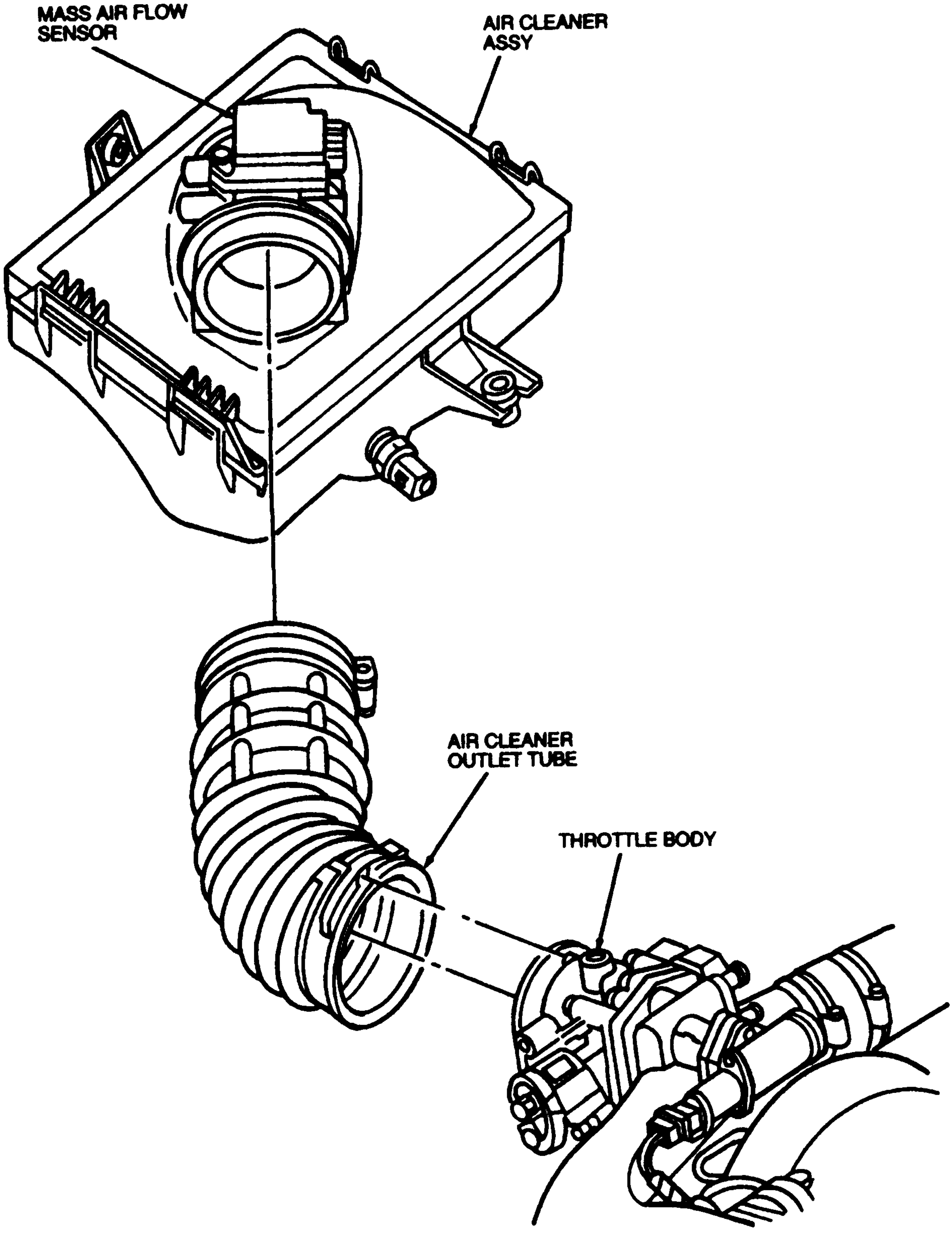
MOUNTING POSTS
VACUUM BLEED HOLE VENTS VACUUM TO ATMOSPHERE UNTIL CLOSED BY EXHAUST BACK PRESSURE WORKING ON DIAPHRAGM
DIAPHRAGM
SPRING
BLEED AIR IN
EGR VALVE CONTROL VACUUM
EGR VALVE CONTROL CHAMBER PRESSURE
SPRING
BLEED HOLE SEAL
EXHAUST BACK PRESSURE
E
C
B
E–VACUUM SIGNAL
C–BACK PRESSURE DOWNSTREAM OF ORIFICE
BACK PRESSURE OF VEHICLE
MOUNTING POST

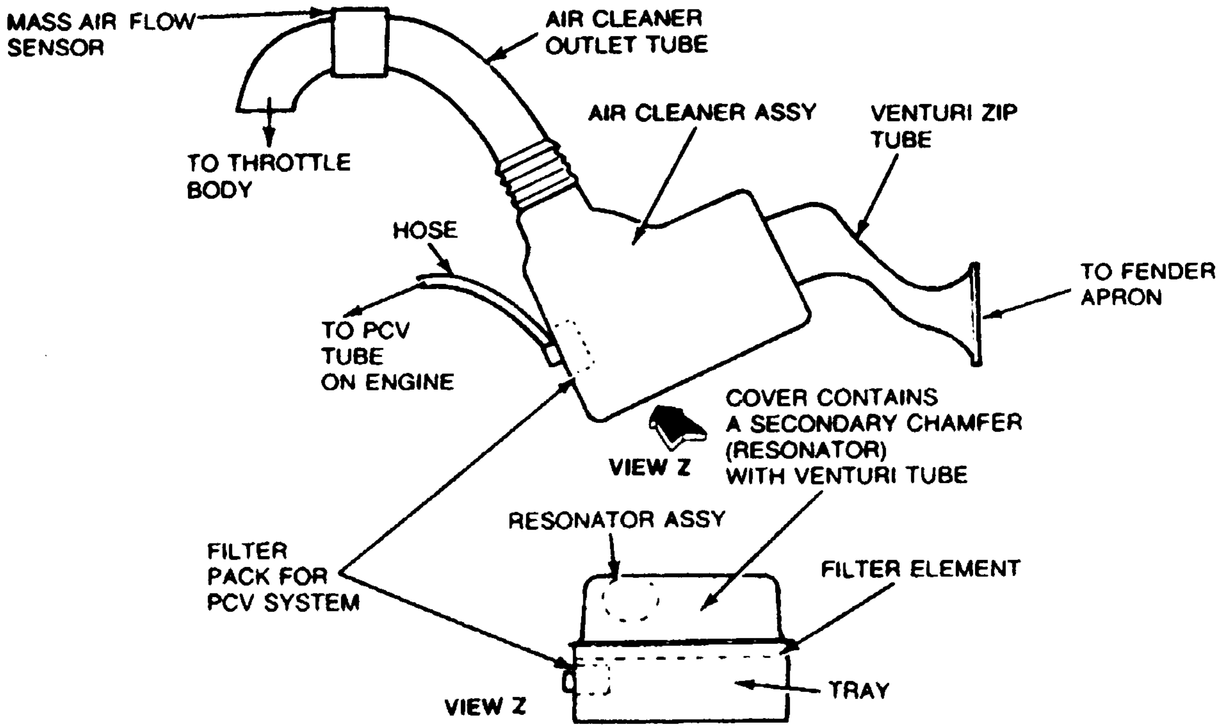


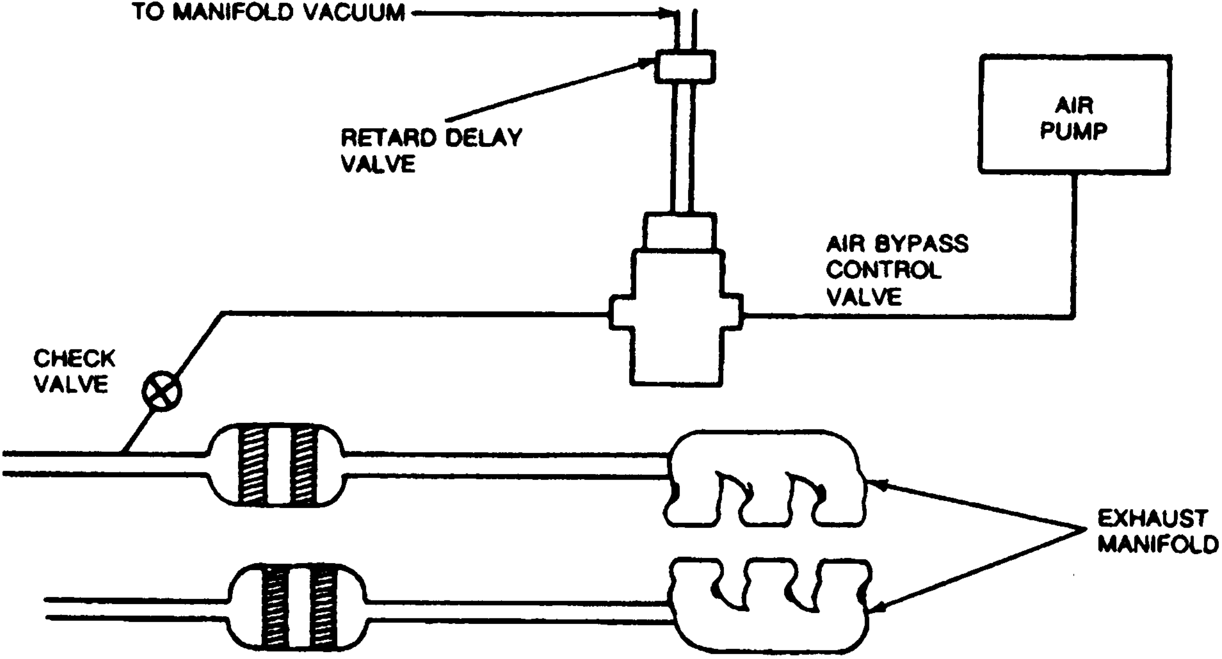
TO HEAT SHROUD
DUCT AND VALVE ASSEMBLY
FRESH AIR
VACUUM MOTOR
THROTTLE BODY
TO VACUUM MOTOR
(DUCT AND VALVE)
VACUUM RETARD
DELAY VALVE
COLD WEATHER MODULATOR
AIR CLEANER
ASSEMBLY
BIMETAL SENSOR
TOP VIEW

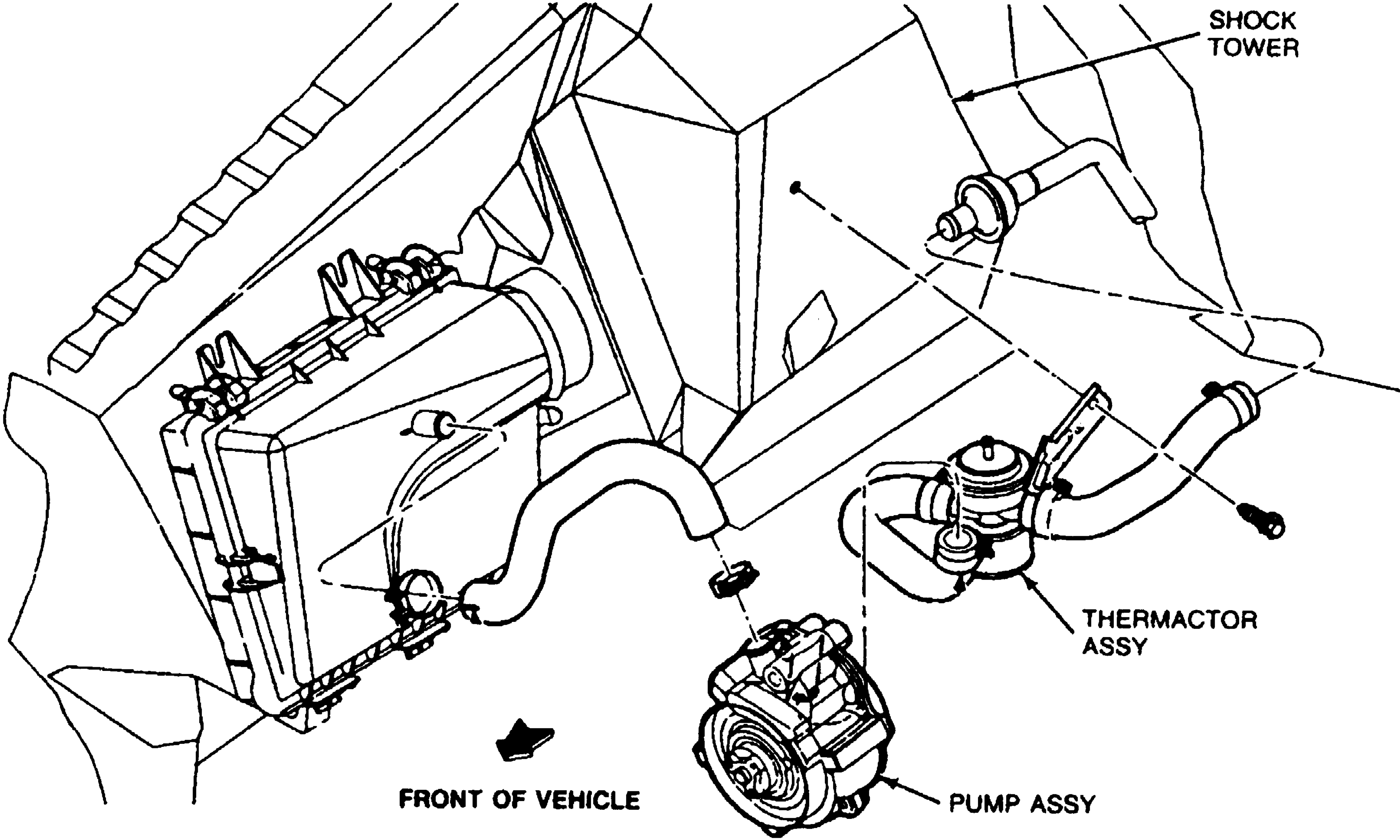


FRESH AIR
3.0L ENGINE-TAURUS/SABLE
TO THROTTLE BODY
AIR CLEANER ASSY
MASS AIR FLOW
SENSOR
TOP VIEW

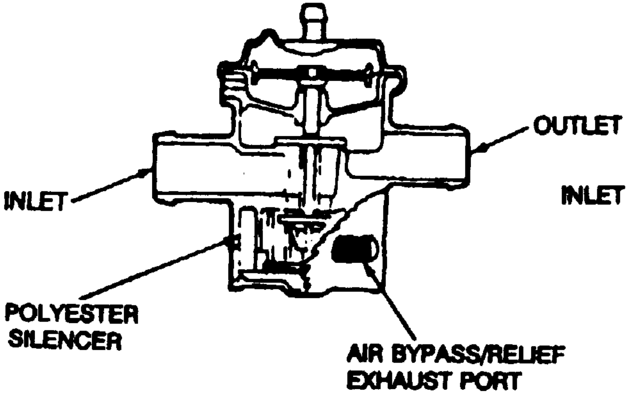

MASS AIR FLOW SENSOR
AIR CLEANER ASSY
AIR CLEANER OUTLET TUBE
THROTTLE BODY

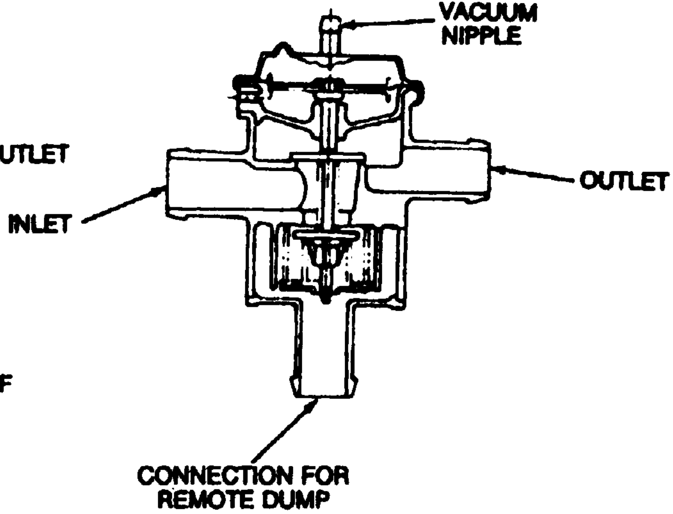

MASS AIR FLOW SENSOR
AIR CLEANER OUTLET TUBE
TO THROTTLE BODY
AIR CLEANER ASSY
VENTURI ZIP TUBE
HOSE
TO FENDER APRON
TO PCV TUBE ON ENGINE
COVER CONTAINS A SECONDARY CHAMFER (RESONATOR) WITH VENTURI TUBE
VIEW Z
RESONATOR ASSY
FILTER PACK FOR PCV SYSTEM
FILTER ELEMENT
TRAY
VIEW Z

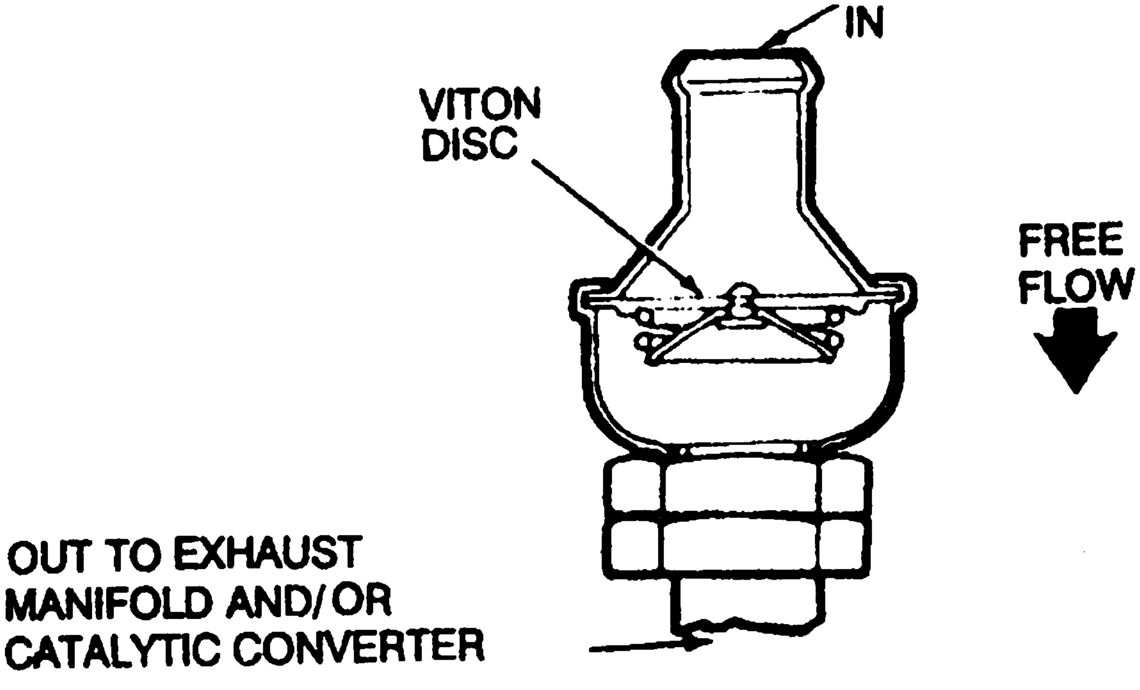

TO MANIFOLD VACUUM
RETARD DELAY VALVE
AIR PUMP
AIR BYPASS CONTROL VALVE
CHECK VALVE
EXHAUST MANIFOLD

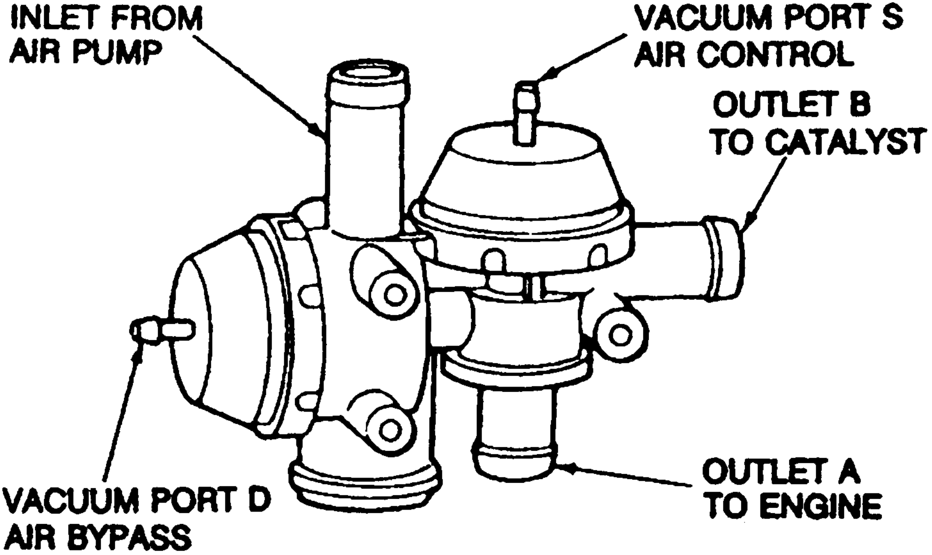


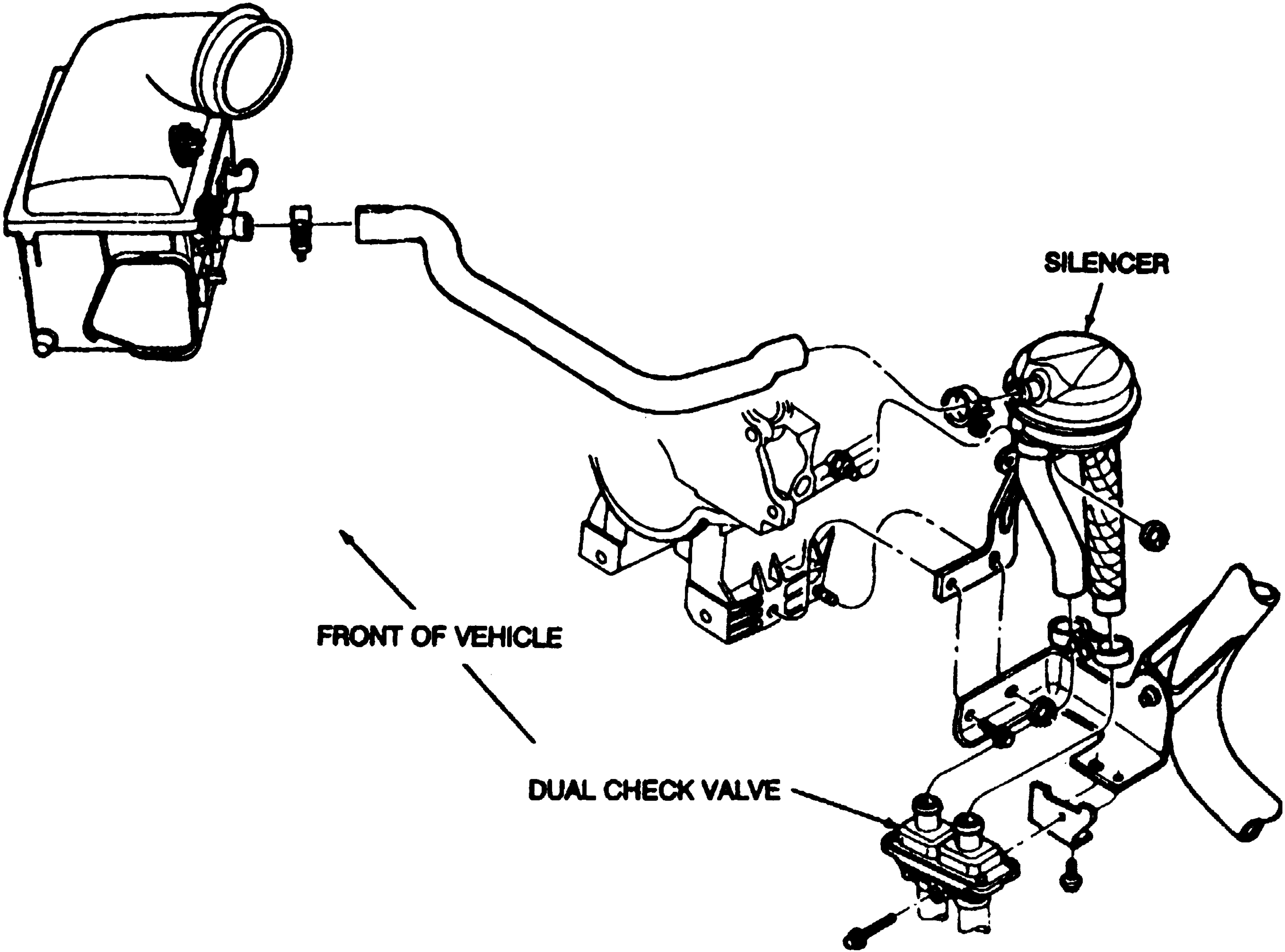
SHOCK TOWER
THERMACTOR ASSY
FRONT OF VEHICLE
PUMP ASSY

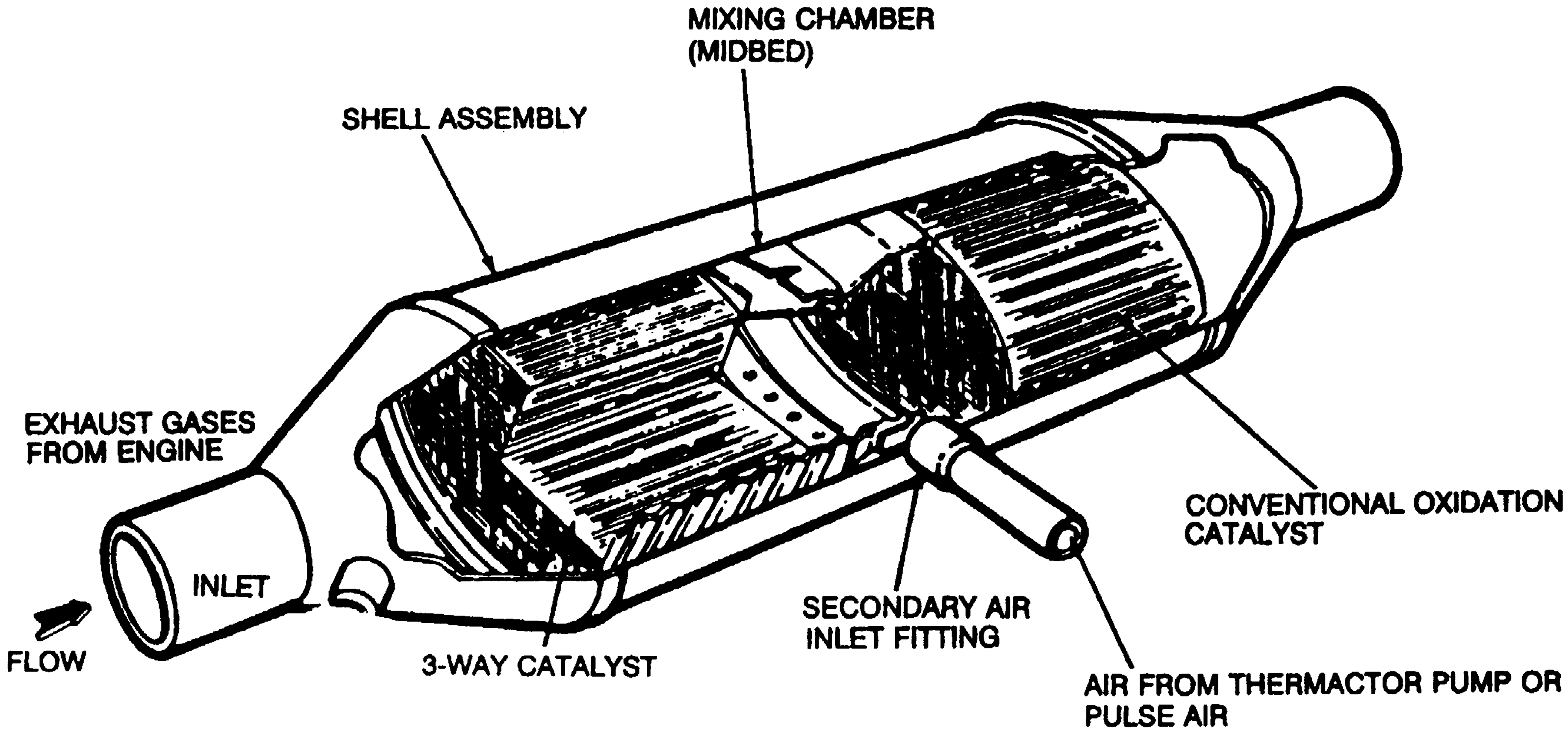

OUTLET
INLET
POLYESTER SILENCER
AIR BYPASS/RELIEF EXHAUST PORT


VACUUM NIPPLE
OUTLET
INLET
CONNECTION FOR REMOTE DUMP


IN
VITON
DISC
FREE
FLOW
OUT TO EXHAUST
MANIFOLD AND/OR
CATALYTIC CONVERTER


INLET FROM
AIR PUMP
VACUUM PORT S
AIR CONTROL
OUTLET B
TO CATALYST
OUTLET A
TO ENGINE
VACUUM PORT D
AIR BYPASS


SILENCER
FRONT OF VEHICLE
DUAL CHECK VALVE

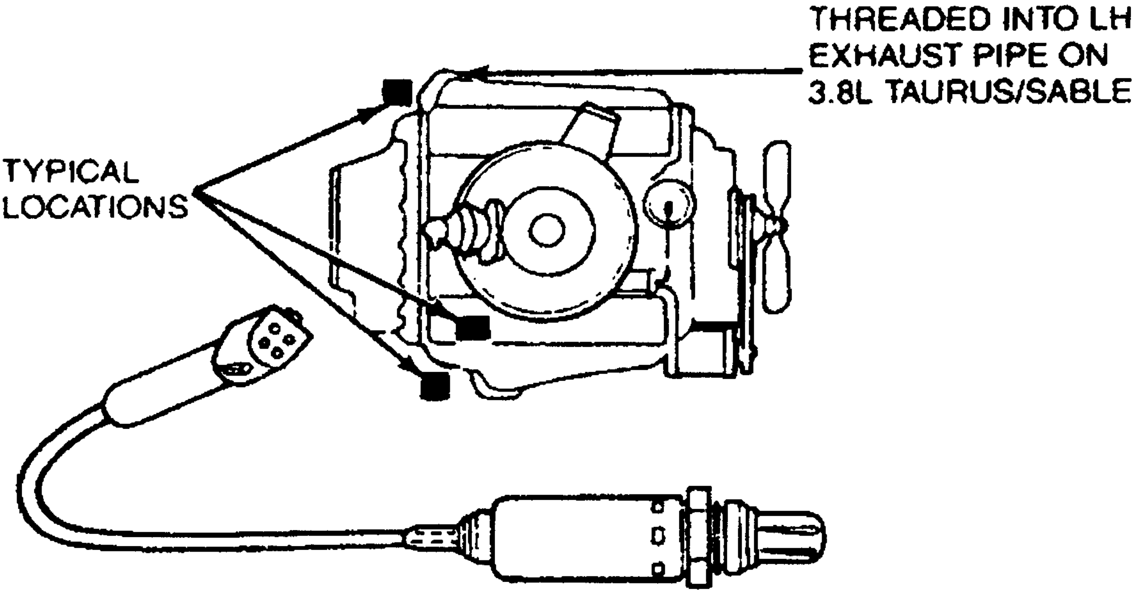


MIXING CHAMBER
(MIDBED)
SHELL ASSEMBLY
EXHAUST GASES
FROM ENGINE
INLET
FLOW
3-WAY CATALYST
SECONDARY AIR
INLET FITTING
CONVENTIONAL OXIDATION
CATALYST
AIR FROM THERMACTOR PUMP OR
PULSE AIR

TEST STEP		RESULT ▶	ACTION TO TAKE
B1	INSPECT EXHAUST SYSTEM		
	• Visually inspect exhaust system. • **Is exhaust system visually OK?**	Yes ▶	**For 7.5L MFI:** GO to B10. **For all others:** GO to B2.
		No ▶	REPLACE any damaged exhaust components. VERIFY elimination of symptom. If problem is not corrected, GO to B2.

TEST STEP		RESULT ▶	ACTION TO TAKE
B2	VACUUM TEST		
	• Attach vacuum gauge to intake manifold vacuum source. • Hook up tachometer. • Observe the vacuum gauge needle while performing the following: — Start engine and gradually increase the engine rpm to 2000 with the transmission in NEUTRAL. NOTE: **The vacuum gauge reading may be normal when the engine is first started and idled. However, excessive restriction in the exhaust system will cause the vacuum gauge needle to drop to a low point even while the engine is idled.** • Decrease engine speed to base idle rpm. • **Did manifold vacuum reach above 16 inches of mercury with the engine rpm at 2000?**	Yes ▶	No restriction in the exhaust system. REFER to Section 2A, Diagnostic Routines Index, for Lack of Power.
		No ▶	GO to B3.
B3	VACUUM TEST—RATE OF VACUUM GAUGE NEEDLE RETURN MOVEMENT		
	• Vacuum gauge attached to intake manifold vacuum source. • Tachometer installed. • Increase the engine speed gradually from base idle rpm to 2000 rpm with the transmission in NEUTRAL. • Observe the rate of speed of the vacuum gauge needle as it falls and rises, while maintaining the increased engine rpm. **NOTE:** — **On a non-restricted system, the vacuum gauge needle will drop to zero and then quickly return to the normal setting without delay.** — **On a restricted system, as the engine rpm is increased to 2000, the vacuum gauge needle will slowly drop to zero. As the increased rpm is maintained, the needle will slowly rise to normal.** — **The rate of speed at which the vacuum gauge needle returns to the normal setting is much slower on a restricted system than on a non-restricted system.** • Decrease engine speed to base idle rpm. • **Is rate of speed that the vacuum gauge needle returns to the normal setting much slower than that of a non-restricted system?**	Yes ▶	GO to B4.
		No ▶	No restriction in the exhaust system. REFER to Section 2A, Diagnostic Routines Index, for Lack of Power.

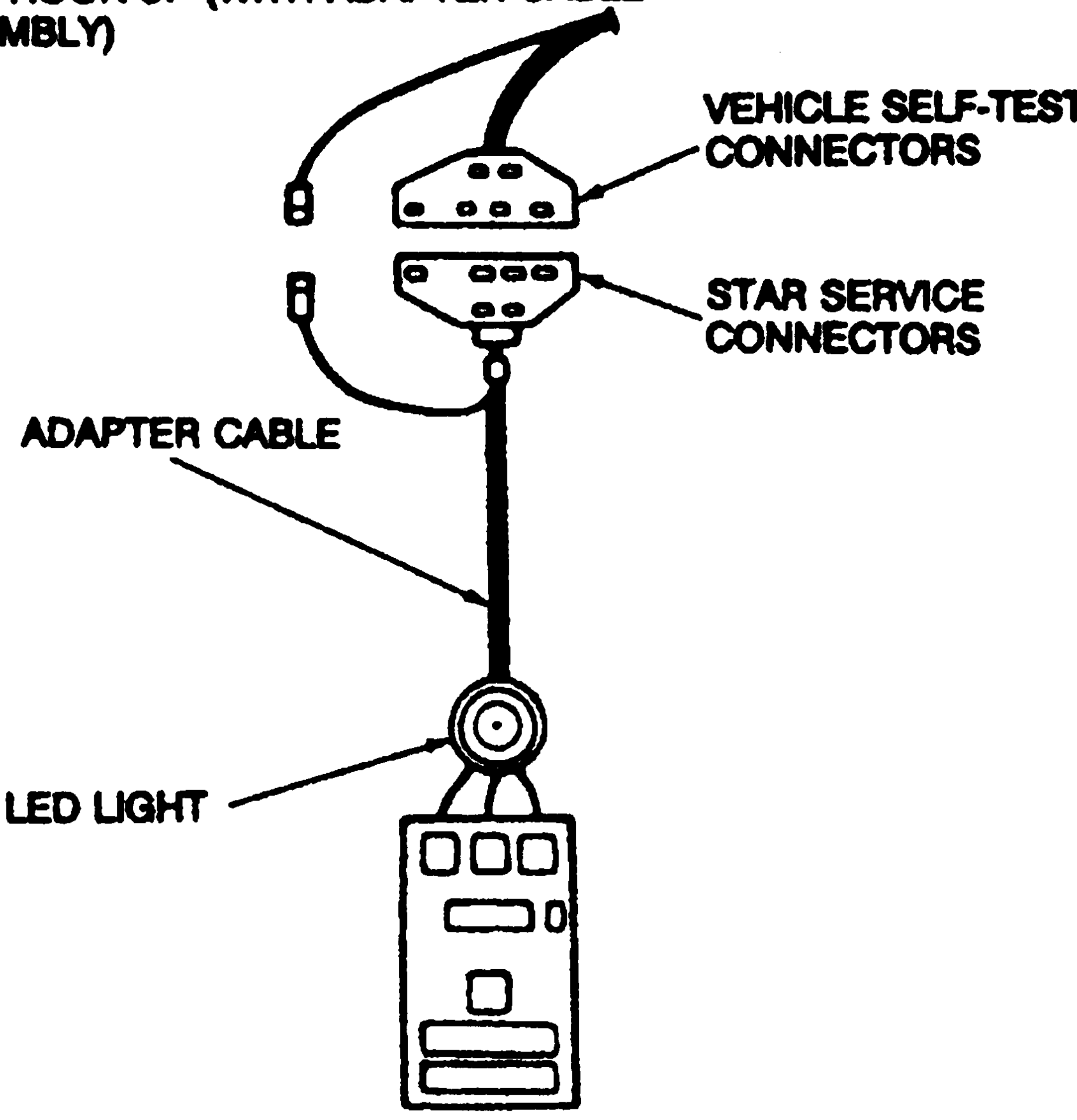
TEST STEP		RESULT ▶	ACTION TO TAKE
B4	VACUUM TEST—EXHAUST DISCONNECTED		
	• Turn engine off. • Disconnect exhaust system at exhaust manifold(s). • Repeat vacuum test found in Step B2. • **Is manifold vacuum above 16 inches of mercury?**	Yes ▶	GO to B5.
		No ▶	GO to B6.
B5	VACUUM TEST—CATALYTIC CONVERTER(S) ON/MUFFLER(S) OFF		
	• Turn engine off. • Reconnect exhaust system at exhaust manifold(s). • Disconnect muffler(s). • Repeat vacuum test found in Step B2. • **Is the manifold vacuum above 16 inches of mercury?**	Yes ▶	REPLACE muffler(s).
		No ▶	REPLACE catalytic converter and inspect muffler to be sure converter debris has not entered muffler.
B6	EXHAUST MANIFOLD RESTRICTED		
	• Remove the exhaust manifold(s). Inspect the ports for casting flash by dropping a length of chain into each port. NOTE: **Do not use a wire or lamp to check ports. The restriction may be large enough for them to pass through, but small enough to cause excessive back pressure at high engine rpm.** • Is a restriction present?	Yes ▶	REMOVE casting flash. If flash cannot be removed, REPLACE exhaust manifold(s).
		No ▶	REFER to Section 2A, Diagnostic Routines Index, for Lack of Power.



THREADED INTO CENTER REAR OF EXHAUST MANIFOLD ON 2.3L HSC, 2.5L

THREADED INTO Y-PIPE JUNCTURE OF CATALYST INLET ON 3.0L EFI/ 2.9L TRUCK

STAR HOOK-UP (WITH ADAPTER CABLE ASSEMBLY)

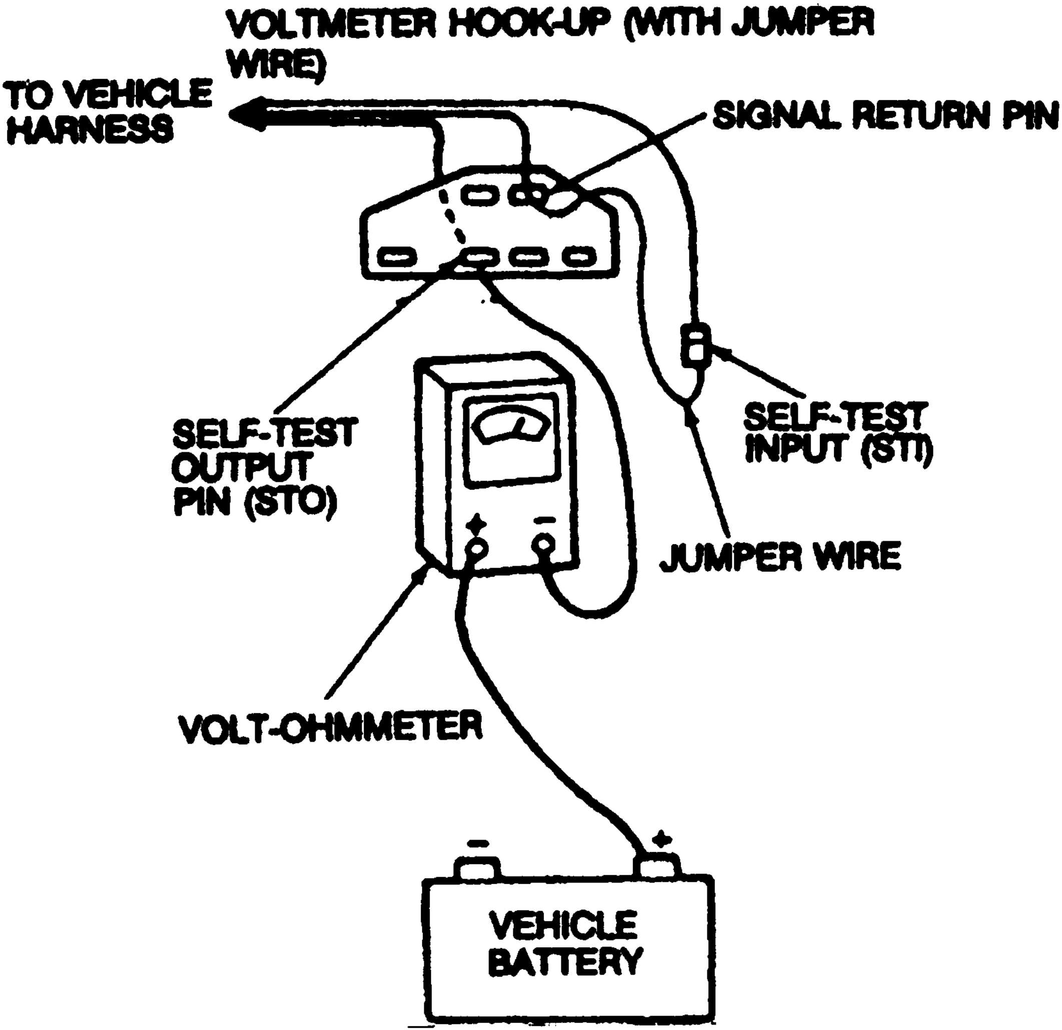


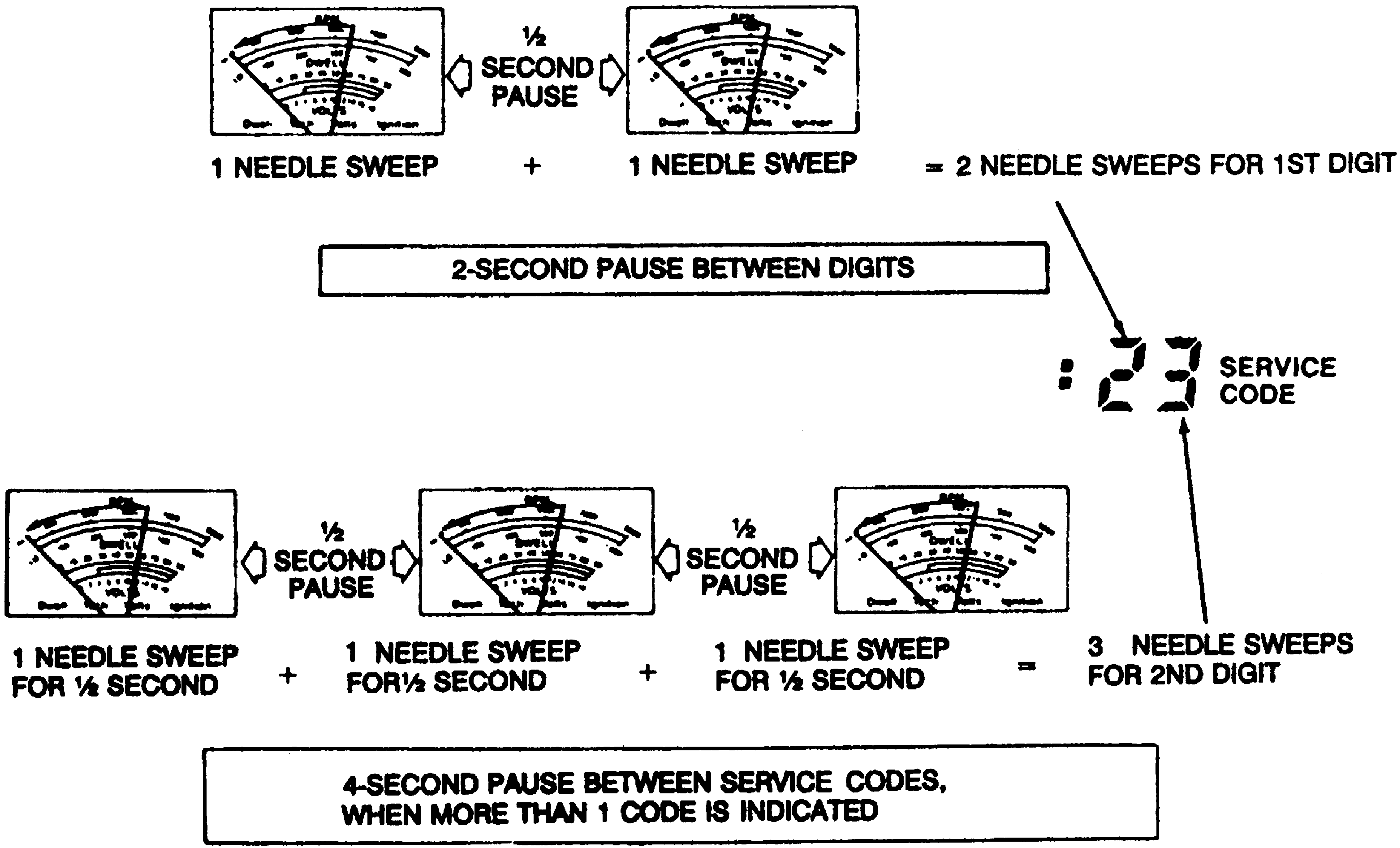
COLON DISPLAY

COLON MUST BE DISPLAYED TO RECIEVE SERVICE CODES

LO BAT INDICATOR

IF LO BAT SHOWS STEADILY WITH SERVICE CODE, REPLACE TESTER'S 9V BATTERY


VOLTMETER HOOK-UP (WITH JUMPER WIRE)
TO VEHICLE HARNESS
SIGNAL RETURN PIN
SELF-TEST OUTPUT PIN (STO)
SELF-TEST INPUT (STI)
JUMPER WIRE
VOLT-OHMMETER
VEHICLE BATTERY


½
SECOND
PAUSE
1 NEEDLE SWEEP
+
1 NEEDLE SWEEP
= 2 NEEDLE SWEEPS FOR 1ST DIGIT
2-SECOND PAUSE BETWEEN DIGITS
:23
SERVICE
CODE
½
SECOND
PAUSE
½
SECOND
PAUSE
1 NEEDLE SWEEP
FOR ½ SECOND
+
1 NEEDLE SWEEP
FOR½ SECOND
+
1 NEEDLE SWEEP
FOR ½ SECOND
=
3 NEEDLE SWEEPS
FOR 2ND DIGIT
4-SECOND PAUSE BETWEEN SERVICE CODES,
WHEN MORE THAN 1 CODE IS INDICATED