

CARBURETOR SPECIFICATIONS - HOLLEY 4BBL

Model	Cfm	Engine	Year	Choke Setting	Choke Unloader In. (mm) ①	Choke Vacuum in. (mm) ①	Float Setting	Initial Idle Mixture (Turns)	Main Jet	Power Valve	Accelerator Pump Lever in. (mm)	Accelerator Pump Cam Position	Secondary Throttle Plate (Turns)
750	7.5L	1987-88	1989	1 notch lean	0.270-0.330 (6.8-8.4)	0.130-0.150 (3.3-3.9)	②	1 112 Turns Out	73	65	0.005-0.015 (0.127-0.381)	#2 Hole	1/4 Beyond Contact
				1 notch rich	0.270-0.330 (6.8-8.4)	0.130-0.150 (3.3-3.9)	②	1 112 Turns Out	73	65	0.005-0.015 (0.127-0.381)	#2 Hole	1/4 Beyond Contact
			1989	1 notch lean	0.270-0.330 (6.8-8.4)	0.130-0.150 (3.3-3.9)	②	1 112 Turns Out	73	65	0.005-0.015 (0.127-0.381)	#1 Hole	1/4 Beyond Contact
4150	750	7.4L	1990	5 notches lean	1/4-1/2 (6.3-12.7)	0.415-0.425 (10.5-10.8)	②	1 Turn Out	88 (Pri.) 84 (Sec.)	6.5 (Pri.) 3.5 (Sec.)	0.010-0.015 (0.254-0.381)	#2 Hole	1/8 Beyond Contact
			1991-97	6 notches lean	0.344 (8.74)	0.312 (7.92)	②	1/4 off seat	73 (Pri.) 56 (Sec.)	25 (Pri.) 25 (Sec.)	0.010-0.015 (0.254-0.381)	Orange #1 Hole	1/8 Beyond Contact
			850	7.4L	114-112 (6.3-12.7)	0.415-0.425 (10.5-10.8)	②	1 Turn Out	88 (Pri.) 84 (Sec.)	6.5 (Pri.) 3.5 (Sec.)	0.010-0.015 (0.254-0.381)	Orange #1 Hole	1/8 Beyond Contact
4160	575	4.3 HO	1990	5 notches lean	0.300 (7.62)	0.250 (6.35)	②	3/4 Turn Out	67	25	0.010-0.015 (0.254-0.381)	#2 Hole	1/4 Beyond Contact
			1991	5 notches lean	0.300 (7.62)	0.250 (6.35)	②	3/4 Turn Out	67	25	0.010-0.015 (0.254-0.381)	#1 Hole	1/4 Beyond Contact
			1993	5 notches lean	0.300 (7.62)	0.250 (6.35)	②	3/4 Turn Out	67	2.5	0.010-0.015 (0.254-0.381)	Orange #2 Hole	1/4 Beyond Contact
			4.3GL, 4.3GS	5 notches lean	0.300 (7.62)	0.250 (6.35)	②	3/4 off seat	67	2.5	0.010-0.015 (0.254-0.381)	Orange #1 Hole	1/4 Beyond Contact
			1998	5 notches lean	0.300 (7.62)	0.250 (6.35)	②	1 1/8 off seat	63	2.5	0.010-0.015 (0.254-0.381)	Green #1 hole	1/8-1/4 Beyond Contact
			600	5.8L	0.300 (7.62)	0.140 (3.6)	②	1 1/2 Turns Out	73	65	0.010-0.015 (0.254-0.381)	#1 Hole	1/4 Beyond Contact
351	750	7.5L	1991-96	3 notches lean	0.300 (7.62)	0.228 (5.8)	②	7/8 off seat	67	2.5	0.010-0.015 (0.254-0.381)	Orange #1 Hole	1/8 Beyond Contact
			1992	3 notches lean	0.300 (7.62)	0.228 (5.8)	②	3/4 off seat	69	4.5	0.010-0.015 (0.254-0.381)	Orange #1 Hole	1/8 Beyond Contact
			1990	1 notch lean	0.300 (7.62)	0.140 (3.6)	②	1 1/2 Turns Out	73	6.5	0.010-0.015 (0.254-0.381)	#1 Hole	1/4 Beyond Contact

① Measured at lower edge of plate

② Both parallel to fuel bowl when bowl is inverted

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Model	Cfm	Engine	Year	Choke Setting	Choke Unloader in. (mm) ①	Choke Vacuum in. (mm) ①	Float Setting	Initial Idle Mixture (Turns)	Main Jet	Power Valve	Accelerator Pump Lever in. (mm)	Accelerator Pump Cam Position	Secondary Throttle Plate (Turns)
4175	650	5.7L	1990	Index	0.230-0.240 (5.9-6.1)	0.228 (5.8)	Level	1/4 off seat	60	50	0.010-0.015 (0.254-0.381)	#2 Hole	1/8 Beyond Contact
			1991	Index	0.230-0.240 (5.9-6.1)	0.228 (5.8)	②	1/4 off seat ③	60	5.0 ④	0.010-0.015 (0.254-0.381)	#1 Hole	1/8 Beyond Contact
			1992	Index	0.230-0.240 (5.9-6.1)	0.228 (5.8)	②	1/2 off seat	60	2.5	0.010-0.015 (0.254-0.381)	Orange #2 Hole	1/8 Beyond Contact
			5.7GL	1997	Index	0.230-0.240 (5.9-6.1)	②	1/2 off seat	60	2.5	0.010-0.015 (0.254-0.381)	Orange #2 Hole	1/8 Beyond Contact
			5.7 LE, 350	1990	Index	0.230-0.240 (5.9-6.1)	Level	1 off seat	60	5.0	0.010-0.015 (0.254-0.381)	#2 Hole	1/8 Beyond Contact
			1991	Index	0.230-0.240 (5.9-6.1)	0.228 (5.8)	②	1 off seat ⑤	60	5.0 ⑥	0.010-0.015 (0.254-0.381)	#1 Hole	1/8 Beyond Contact
			1992	Index	0.230-0.240 (5.9-6.1)	0.228 (5.8)	②	1/2 off seat	60	2.5	0.010-0.015 (0.254-0.381)	Orange #2 Hole	1/8 Beyond Contact

① Measured at lower edge of plate

② Both parallel to fuel bowl when bowl is inverted

③ For Part #986714, Part #987190: 1/2 turn off seat

④ For Part #986714, Part #987190: 2.5

⑤ Part #80390 is 1/2 turn off seat

⑥ Part #80390 and 80391 should be 2.5

8-42 FUEL SYSTEMS – CARBURETORS

CARBURETOR SPECIFICATIONS - ROCHESTER 2BBL

Year	Model	Engine	Float Level in. (mm)	Float Drop in. (mm)	Accelerator Pump Rod in. (mm)	Vacuum Break in. (mm)	Choke Unloader in. (mm)	Initial Choke Setting	Initial Idle Mixture (Turns)
1986	17086064	2.5L, 3.0L	1/2 (12.7)	1 3/4 (44.5)	7/8 (22.4)	-	5/64 (2.1)	Index	2 Out
	17083110	4.3L	17/32 (13.6)	1 3/4 (44.5)	1 15/64 (31.2)	3/16 (4.8)	5/16 (7.6)	Index	2 1/2 Out
1987	17086107	2.3L	17/32 (13.6)	1 3/4 (44.5)	1 15/64 (31.2)	3/16 (4.8)	5/16 (7.6)	Index	2 1/2 Out
	17086064	3.0L	1/2 (12.7)	1 3/4 (44.5)	7/8 (22.4)	-	5/64 (2.1)	Index	2 Out
	17085008	4.3L	17/32 (13.6)	1 3/4 (44.5)	1 15/64 (31.2)	3/16 (4.8)	5/16 (7.6)	Index	2 1/2 Out
1988	17086107	2.3L	17/32 (13.6)	1 3/4 (44.5)	1 15/64 (31.2)	3/16 (4.8)	5/16 (7.6)	Index	2 1/2 Out
	17086064	3.0L	1/2 (12.7)	1 3/4 (44.5)	7/8 (22.4)	-	5/64 (2.1)	Index	2 Out
	17085008	4.3L	17/32 (13.6)	1 3/4 (44.5)	1 15/64 (31.2)	3/16 (4.8)	5/16 (7.6)	Index	2 1/2 Out
	17059060	5.0L	17/32 (13.6)	1 3/4 (44.5)	1 15/64 (31.2)	3/16 (4.8)	5/16 (7.6)	Index	2 1/2 Out
1989	17086107	2.3L	17/32 (13.6)	1 3/4 (44.5)	1 15/64 (31.2)	3/16 (4.8)	5/16 (7.6)	Index	2 1/2 Out
	17086064	3.0L	1/2 (12.7)	1 3/4 (44.5)	7/8 (22.4)	-	5/64 (2.1)	Index	2 Out
	17085008	4.3L	17/32 (13.6)	1 3/4 (44.5)	1 15/64 (31.2)	3/16 (4.8)	5/16 (7.6)	Index	2 1/2 Out

CARBURETOR SPECIFICATIONS - ROCHESTER 4BBL

Year	Model	Engine	Float Level in. (mm)	Pump Rod Adjustment in. (mm)	Pump Rod Position	Vacuum Break in. (mm)	Choke Unloader in. (mm)	initial Idle Mixture (Turns)
1986	17082515	4.3L	5/16 (7.77)	23/64 (9.14)	Inner Hole	1/8 (3.18)	15/64 (5.94)	3 3/4 Out
	17058286	5.0L, 5.7L	5/16 (7.77)	23/64 (9.14)	Inner Hole	1/8 (3.18)	15/64 (5.94)	3 3/4 Out
1987	17082515	4.3L	5/16 (7.77)	23/64 (9.14)	Inner Hole	1/8 (3.18)	15/64 (5.94)	3 3/4 Out
	17059286	5.0L, 5.7L	5/16 (7.77)	23/64 (9.14)	Inner Hole	1/8 (3.18)	15/64 (5.94)	3 3/4 Out
1988	17082515	4.3L	5/16 (7.77)	23/64 (9.14)	Inner Hole	1/8 (3.18)	15/64 (5.94)	3 3/4 Out
	17059286	5.0L, 5.7L	5/16 (7.77)	23/64 (9.14)	Inner Hole	1/8 (3.18)	15/64 (5.94)	3 3/4 Out
1989	17082515	4.3L, 262	5/16 (7.77)	23/64 (9.14)	Inner Hole	1/8 (3.18)	15/64 (5.94)	3 3/4 Out
	17059286	5.7L, 350	5/16 (7.77)	23/64 (9.14)	Inner Hole	1/8 (3.18)	15/64 (5.94)	3 3/4 Out

COMPONENT LOCATIONS	9-73
DIAGNOSTIC TROUBLE CODES (DTC)	
READING CODES	
FORD	9-19
GM	9-48
CLEARING CODES	
FORD	9-20
GM	9-48
DIAGNOSTIC TROUBLE CODE (DTC)	
CHARTS	9-70
ECM PIN LOCATIONS	
FORD	9-21
GM	9-60
ELECTRONIC CONTROL ASSEMBLY (ECA)	
FORD	9-9
ELECTRONIC CONTROL MODULE (ECM)	
GM	9-26
ENGINE COOLANT TEMPERATURE	
SENSOR (ECT)	
FORD	9-8
GM	9-26
FORD ELECTRONIC MULTI-POINT	
FUEL INJECTION (MFI)	9-3
AIR CHARGE TEMPERATURE	
SENSOR (ACT)	9-8
CIRCUIT BREAKER	9-8
CLEARING CODES	9-20
DESCRIPTION & OPERATION	9-3
DIAGNOSTIC TROUBLE CODES	9-18
EEC POWER RELAY	9-9
ELECTRONIC CONTROL	
ASSEMBLY (ECA)	9-9
ENGINE COOLANT TEMPERATURE	
SENSOR (ECT)	9-8
FUEL INJECTOR	9-10
FUEL PRESSURE REGULATOR	9-10
FUEL PUMP	9-10
FUEL RAIL	9-11
FUEL RESERVOIR/VAPOR	
SEPARATOR	9-12
IDLE SPEED CONTROL (ISC)	
SOLENOID	9-12
KNOCK SENSOR (KS) AND	
AMPLIFIER	9-12
MANIFOLD ABSOLUTE PRESSURE	
(MAP) SENSOR	9-13
PIN LOCATIONS	9-21
READING CODES	9-19
RELIEVING FUEL PRESSURE	9-8
SYSTEM DIAGNOSIS	9-14
THROTTLE BODY	9-14
THROTTLE POSITION SENSOR (TP)	9-14
VACUUM DIAGRAMS	9-21
FUEL AND COMBUSTION	9-2
FUEL	9-2
COMBUSTION	9-2
FUEL FLOW DIAGRAMS	9-71
FUEL INJECTOR	
FORD	9-10
GM - TBI	9-27
GM - MFI	9-27
FUEL PRESSURE REGULATOR	
FORD	9-10
GM	9-29
FUEL PUMP	
FORD	9-10
GM	9-30

GM THROTTLE BODY FUEL INJECTION	
(TBI)	9-22
GM MULTI-POINT FUEL INJECTION (MFI)	9-22
CIRCUIT BREAKER	9-26
CLEARING CODES	9-48
COOLANT COVER ASSEMBLY	9-26
DESCRIPTION & OPERATION	9-22
DIAGNOSTIC TEST SCHEMATICS	9-44
DIAGNOSTIC TROUBLE CODES	9-48
DIAGNOSTIC TROUBLE CODE	
SCHEMATICS	9-51
ELECTRONIC CONTROL MODULE	
(ECM)	9-26
ENGINE COOLANT TEMPERATURE	
SENSOR (ECT)	9-26
FUEL INJECTORS	9-27
FUEL METER BODY	9-28
FUEL METER COVER	9-29
FUEL PRESSURE REGULATOR	9-29
FUEL PUMP	9-30
FUEL PUMP RELAY	9-32
FUEL RAIL	9-32
GENERAL DIAGNOSTIC TESTS	9-40
IDLE AIR CONTROL VALVE (IAC)	9-33
INTAKE AIR TEMPERATURE SENSOR	
(IAT)	9-35
KNOCK SENSOR (KS)	9-35
KNOCK SENSOR MODULE	9-35
MANIFOLD ABSOLUTE PRESSURE	
SENSOR (MAP)	9-35
READING CODES	9-48
RELIEVING FUEL PRESSURE	9-26
SYSTEM DIAGNOSIS	9-40
THROTTLE BODY	9-35
THROTTLE BODY ADAPTER PLATE	9-37
THROTTLE POSITION SENSOR (TP)	9-39
VAPOR SEPARATOR TANK/FUEL	
RESERVOIR	9-39
KNOCK SENSOR (KS)	
FORD	9-12
GM	9-35
MANIFOLD ABSOLUTE PRESSURE	
(MAP) SENSOR	9-13
FORD	9-13
GM	9-35
RELIEVING FUEL PRESSURE	
FORD	9-8
GM	9-26
SPECIFICATIONS	
VOLTAGE REFERENCE VALUES (FORD)	9-20
SYSTEM DIAGNOSIS	
FORD	9-14
GM	9-40
THROTTLE BODY	
FORD	9-14
GM - TBI	9-35
GM - MFI	9-37
THROTTLE POSITION SENSOR (TP)	
FORD	9-14
GM	9-39
WIRING SCHEMATICS	
DIAGNOSTIC TESTS (GM)	9-44
DTC	9-51
SYSTEM (FORD)	9-53
SYSTEM (GM)	9-56
TORQUE	9-77

9

FUEL SYSTEMS FUEL INJECTION

FUEL AND COMBUSTION	9-2
FORD ELECTRONIC MULTI-POINT	
FUEL INJECTION (MFI)	9-3
SYSTEM DIAGNOSIS	9-14
GM THROTTLE BODY FUEL INJECTION	
(TBI)	9-22
GM MULTI-POINT FUEL INJECTION	
(MFI)	9-22
SPECIFICATIONS	9-20
WIRING SCHEMATICS	9-44
DIAGNOSTIC TROUBLE CODE	
(DTC) CHARTS	9-70
FUEL FLOW DIAGRAMS	9-71
COMPONENT LOCATIONS	9-73

9-2 FUEL SYSTEMS – FUEL INJECTION

FUEL AND COMBUSTION

FUEL SYSTEM APPLICATIONS

Year	Model	Displacement L/Cu. In.	Engine Type	Fuel Delivery
1993	5.0L	5.0/302	V8	MFI - FORD
	5.8L	5.8/351	V8	MFI - FORD
1994	5.0Fi	5.0/302	V8	MFI - FORD
	5.8Fi, 351	5.8/351	V8	MFI - FORD
1995	5.0 EFI	5.0/302	V8	MFI - FORD
	5.8 EFI	5.8/351	V8	MFI - FORD
	7.4 EFI	7.4/454	V8	MFI - GM
1996	4.3Gi	4.3/262	V6	TBI
	5.0Fi	5.0/302	V8	MFI - FORD
	5.7Gi	5.7/350	V8	TBI
	5.8Fi/Fsi	5.8/351	V8	MFI - FORD
	7.4Gi	7.4/454	V8	MFI - GM
	4.3Gi	4.3/262	V6	TBI
1997	5.7Gi/GSi	5.7/350	V8	TBI
	7.4Gi	7.4/454	V8	MFI - GM
	4.3Gi	4.3/262	V6	TBI
1998	5.7GSi	5.7/350	V8	TBI
	7.4Gi/GSi	7.4/454	V8	MFI - GM
	8.2GSi	8.2/502	V8	MFI - GM
	4.3Gi	4.3/262	V6	TBI

Fuel

Fuel recommendations have become more complex as the chemistry of modern gasoline changes. The major driving force behind the changes in gasoline chemistry is the search for additives to replace lead as an octane booster and lubricant. These new additives are governed by the types of emissions they produce in the combustion process. Also, the replacement additives do not always provide the same level of combustion stability, making a fuel's octane rating less meaningful.

In the 1960's and 1970's, leaded fuel was common. The lead served two functions. First, it served as an octane booster (combustion stabilizer) and second, in 4-stroke engines, it served as a valve seat lubricant. For 2-stroke engines, the primary benefit of lead was to serve as a combustion stabilizer. Lead served very well for this purpose, even in high heat applications.

Today, all lead has been removed from the refining process. This means that the benefit of lead as an octane booster has been eliminated. Several substitute octane boosters have been introduced in the place of lead. While many are adequate in an engine, most do not perform nearly as well as lead did, even though the octane rating of the fuel is the same.

OCTANE RATING

A fuel's octane rating is a measurement of how stable the fuel is when heat is introduced. Octane rating is a major consideration when deciding whether a fuel is suitable for a particular application. For example, in an engine, we want the fuel to ignite when the spark plug fires and not before, even under high pressure and temperatures. Once the fuel is ignited, it must burn slowly and smoothly, even though heat and pressure are building up while the burn occurs. The unburned fuel should be ignited by the traveling flame front, not by some other source of ignition, such as carbon deposits or the heat from the expanding gasses. A fuel's octane rating is known as a measurement of the fuel's anti-knock properties (ability to burn without exploding).

Usually a fuel with a higher octane rating can be subjected to a more severe combustion environment before spontaneous or abnormal combustion occurs. To understand how two gasoline samples can be different, even though they have the same octane rating, we need to know how octane rating is determined.

The American Society of Testing and Materials (ASTM) has developed a universal method of determining the octane rating of a fuel sample. The octane rating you see on the pump at a fuel dock is known as the pump octane number. Look at the small print on the pump. The rating has a formula. The rating is determined by the R+M/2 method. This number is the average of the research octane reading and the motor octane rating.

- The Research Octane Rating is a measure of a fuel's anti-knock properties under a light load or part throttle conditions. During this test, combustion heat is easily dissipated.

- The Motor Octane Rating is a measure of a fuel's anti-knock properties under a heavy load or full throttle conditions, when heat buildup is at maximum.

VAPOR PRESSURE

Fuel vapor pressure is a measure of how easily a fuel sample evaporates. Many additives used in gasoline contain aromatics. Aromatics are light hydrocarbons distilled off the top of a crude oil sample. They are effective at increasing the research octane of a fuel sample but can cause vapor lock (bubbles in the fuel line) on a very hot day. If you have an inconsistent running engine and you suspect vapor lock, use a piece of clear fuel line to look for bubbles, indicating that the fuel is vaporizing.

One negative side effect of aromatics is that they create additional combustion products such as carbon and varnish. If your engine requires high-octane fuel to prevent detonation, de-carbon the engine more frequently with an internal engine cleaner to prevent ring sticking due to excessive varnish buildup.

ALCOHOL-BLENDED FUELS

When the Environmental Protection Agency mandated a phase-out of the leaded fuels in January of 1986, fuel suppliers needed an additive to improve the octane rating of their fuels. Although there are multiple methods currently employed, the addition of alcohol to gasoline seems to be favored because of its favorable results and low cost. Two types of alcohol are used in fuel today as octane boosters, methanol (wood alcohol) or ethanol (grain alcohol).

When used as a fuel additive, alcohol tends to raise the research octane of the fuel. There are, however, some special considerations due to the effects of alcohol in fuel.

- Since alcohol contains oxygen, it replaces gasoline without oxygen content and tends to cause the air/fuel mixture to become leaner.
- On older engines, the leaching affect of alcohol may, in time, cause fuel lines and plastic components to become brittle to the point of cracking. Unless replaced, these cracked lines could leak fuel, increasing the potential for hazardous situations.
- ~~r alcohol blended fuel: some contaminated with water, the water combines with the alcohol then settles to the bottom of the tank. This leaves the gasoline on a top layer.~~

☐ Modern fuel lines and plastic fuel system components have been specially formulated to resist alcohol leaching effects.

RECOMMENDATIONS

All engine covered here are designed to run on unleaded fuel. Never use leaded fuel in your boat's engine. The minimum octane rating of fuel being used for your engine must be at least 87 AKI (outside the US: 90 RON), which means regular unleaded, but some engines may require higher octane ratings. OMC actually recommends the use of 89 AKI (93 RON) fuel as the ideal—in fact, anything less than this on many 4.3L/5.7L engines will require a change to the ignition timing. Fuel should be selected for the brand and octane that performs best with your engine. Check your owner's manual if in doubt. Premium unleaded is more stable under severe conditions but also produces more combustion products. Therefore, when using premium unleaded, more frequent de-carboning is necessary.

The use of a fuel too low in octane (a measure of anti-knock quality) will result in spark knock. Newer systems have the capability to adjust the engine's ignition timing to compensate to some extent, but if persistent knocking occurs, it may be necessary to switch to a higher grade of fuel. Continuous or heavy knocking may result in engine damage.

Combustion

In a high heat environment like an modern engine, the fuel must be very stable to avoid detonation. If any parameters affecting combustion change suddenly (the engine runs lean for example), uncontrolled heat buildup will occur very rapidly.

The combustion process is affected by several interrelated factors. This means that when one factor is changed, the other factors also must be changed to maintain the same controlled burn and level of combustion stability.

- **Compression**—determines the level of heat buildup in the cylinder when the air-fuel mixture is compressed. As compression increases, so does the potential for heat buildup
- **Ignition Timing**—determines when the gasses will start to expand in relation to the motion of the piston. If the ignition timing is too advanced, gasses will be ignited and begin to expand too soon, such as they would during pre-ignition. The motion of the piston opposes the expansion of the gasses, resulting in extremely high combustion chamber pressures and heat. If the ignition timing is retarded, the gases are ignited later in relation to piston position. This means that the piston has already traveled back down the bore toward the bottom of the cylinder, resulting in less usable power.
- **Fuel Mixture**—determines how efficient the burn will be. A rich mixture burns slower than a lean one. If the mixture is too lean, it can't become explosive. The slower the burn, the cooler the combustion chamber, because pressure buildup is gradual.

- **Fuel Quality (Octane Rating)**—determines how much heat is necessary to ignite the mixture. Once the burn is in progress, heat is on the rise. The unburned poor quality fuel is ignited all at once by the rising heat instead of burning gradually as a flame front of the burn passing by. This action results in detonation (pinging).

There are two types of abnormal combustion —pre-ignition and detonation.

- **Pre-ignition**—occurs when the air-fuel mixture is ignited by some incandescent source other than the correctly timed spark from the spark plug.
 - **Detonation**—occurs when excessive heat and or pressure ignites the air/fuel mixture rather than the spark plug. The burn becomes explosive.
- In general, anything that can cause abnormal heat buildup can be enough to push an engine over the edge to abnormal combustion, if any of the four basic factors previously discussed are already near the danger point, for example, excessive carbon buildup raises the compression and retains heat as glowing embers.

FORD ELECTRONIC MULTI-POINT FUEL INJECTION (MFI)

Description And Operation

- See Figures 1, 2, 3, 4 and 5

The purpose of this section is to describe—in layman's terms whenever possible—the Multi-Port Fuel Injection (MFI) system installed on many Ford engines covered here.

Visual inspections, and simple tests that may be performed using only basic shop test equipment, will be given wherever possible. Again, we emphasize: specialized test equipment, hours of training and considerable experience is required to perform detailed service on a fuel injection system.

The first fuel injection system was introduced in Europe over 60 years ago—in 1932 on diesel truck engines. In the beginning, the system and individual components were quite expensive. Over the years, state-of-the-art microprocessors (commonly referred to as “computer chips”), have lowered the cost of electronically controlled fuel injection systems. Today, the price of EFI is getting close to the cost of modern carbureted systems.

An electronic fuel injection system is quite different from a carburetor system—even though they appear similar. The fuel injection system has a more efficient delivery of fuel to the cylinders than can be obtained with standard carburetor operation.

The EFI system provides a means of fuel distribution by precisely controlling the air/fuel mixture and under all operating conditions for, as near as possible, complete combustion.

On MFI systems, there is a throttle body located on the intake manifold, much like a carburetor except that only air is distributed and metered through the bores on the throttle body. Air for combustion is controlled by a throttle valve connected to the throttle linkage. Fuel is supplied by individual injectors mounted in the intake manifold and attached to a fuel rail assembly.

Each injector is “pulsed” or “timed” to open or close by an electronic signal from the ECM. While constantly receiving input from various sensors, the ECM performs high speed calculations of engine fuel requirements and then “pulses the injectors open or closed.

Ford's multi-point fuel injection system is a pulse time/speed density fuel injection system. This is to say that fuel is metered into the intake air stream based on the engine's demand via 8 fuel injectors mounted on a tuned intake manifold.

Inputs from various engine sensors are fed into an on-board electronic engine control computer (EEC-IV) which computes the necessary fuel flow rates to maintain the prescribed air/fuel ratio at all times the engine is operating. The computer then sends an output signal to the injectors so they meter the correct quantity of fuel. The EEC-IV system is also capable of determining, and compensating for, engine age, uniqueness and altitude changes.

The fuel delivery system consists of two fuel pumps—a low pressure pump mounted on the engine, between the fuel tank and vapor separator; and a high pressure pump mounted in the separator reservoir, delivering fuel to the injectors. Also included are a vapor separator reservoir, a fuel filter and a fuel charging system.

The fuel charging system incorporates the electronic fuel injectors directly over each of the eight intake ports. When energized, the injectors spray a metered quantity of fuel directly into the intake air stream.

A pressure regulator located downstream from the injectors maintains constant pressure across the injector nozzles. Excess fuel supplied by the pump, but not needed by the engine, passes through the regulator and back to the separator reservoir.

On alternate revolutions of the crankshaft, one group of 4 injectors is energized simultaneously; with the remaining groups of four being energized on the next revolution. Injector “on time”, or pulse width more accurately, is controlled by the EEC computer.

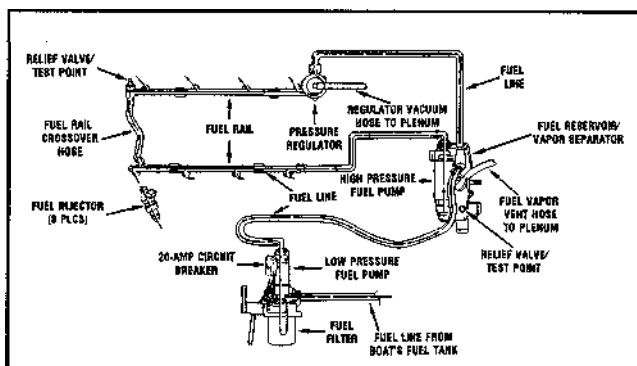


Fig. 1 MFI system diagram

FUEL CIRCUIT

Fuel from the fuel tank is delivered, through the fuel filter, to the vapor separator reservoir via the low pressure fuel pump. Once the ignition key is switched to the ON position, the pump will energize for approximately 2 seconds and then shut off until the electronic control assembly (ECA) receives a signal from the profile ignition pick-up (PIP) indicating that the engine is cranking or running.

The vapor separator reservoir is a fuel containment/vapor purge reservoir located at the rear of the engine, eliminating the need for fuel return lines. Fuel enters the reservoir from the bottom, passes through the high pressure pump on top of the assembly and then on to the fuel rail and injectors.

When fuel demand is less than the volume of fuel being supplied, line pressure will open an internal regulator in the low pressure pump allowing the fuel to circulate internally. Power for the delivery system and appropriate timing for the injectors is controlled by the ECA.

A vacuum/pressure operated diaphragm-type pressure regulator is located on the end of the fuel rail, downstream of the injectors. One side of the regulator senses fuel pressure while the other detects manifold vacuum; thus allowing the regulator to maintain the appropriate, and equal, fuel pressure at each injector.

Because of fuel vapors, the reservoir, and the fuel itself, are cooled by incoming seawater. Water enters passages in the reservoir from the transom shield water line and then continues on to the thermostat housing.

9-4 FUEL SYSTEMS – FUEL INJECTION

Inside the reservoir there is a float and needle mechanism, very similar to what you're familiar with on a carburetor, which is connected to a vacuum line from the air plenum. Any vapor will separate from the liquid fuel and rise to the top of the reservoir. As the amount of vapor increases, the fuel volume will decrease, causing the float to open the needle valve. Vacuum will then pull the vapor from the reservoir and into the intake plenum. A pulse limiter at the plenum prevents backfire from igniting these vapors. Once the vapor has been purged, the low pressure pump will feed more fuel into the reservoir, causing the level to rise and the float to close the needle valve.

Both the reservoir and the fuel rails are equipped with pressure relief valves.

ELECTRICAL CIRCUIT

As the ignition key is moved to the **ON** position, the EEC power relay is energized—providing power (current) to both the ECA and the fuel pump relay. Power for the pumps is supplied via 20 amp circuit breaker connected to the main 60 amp breakers on the engine.

As mentioned previously, if the switch is not moved past the **ON** position and into the **START** position, the ECA will shut off the pump after approximately 2 seconds. Once moved to the **START** and cranking commences, the ECA will receive a signal from the PIP and once again energize the pump. The pump will continue to run until the engine speed drops below 120 rpm.

COMPONENTS

Fuel

- ◆ See Figure 6

There are 8 electro-mechanical injectors attached to the fuel rail. They are charged with metering and atomizing fuel as delivered to the engine. Each injector body consists of a solenoid-actuated pintle and needle valve assembly.

A signal from the ECA activates the injector solenoid, causing the pintle to move inward and off the seat; thus allowing fuel to flow to the intake port. Fuel flow to the engine is regulated by the duration of solenoid energization, while atomization is obtained by contouring the pintle at the point where the fuel separates.

OMC utilizes a Deposit Resistant Injector (DRI) so that lean fuel delivery problems caused by bad fuel (low grade) have been eliminated.

These injectors have no pintle on the tip of the injector (as most injectors do); instead, fuel is metered via four small holes in a metering plate on the injector tip. As the inevitable fuel deposits coat the tip of the injector, the holes will not be affected; so metering characteristics remain correct.

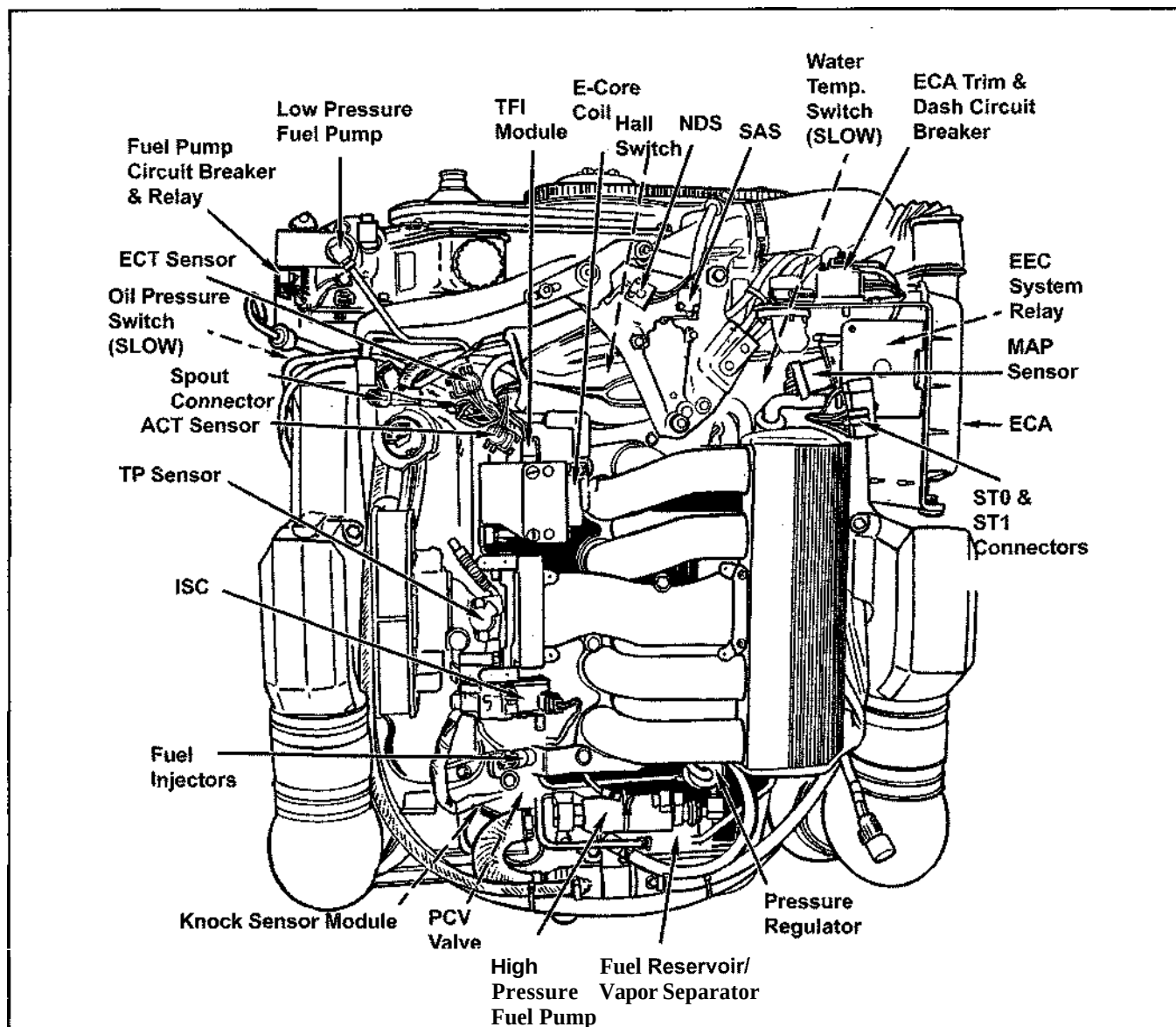


Fig. 2 MFI system component locations—1993-94

Fuel Pumps

As discussed previously, there are two electric fuel pumps utilized with this system. A low pressure pump attached to the fuel filter bracket and a high pressure pump mounted on top of the vapor separator reservoir.

Fuel Pressure Regulator

The fuel pressure regulator is mounted on the rear of the Starboard rail, downstream of the injectors.

The regulator is a simple diaphragm-type relief valve. One side of the diaphragm senses fuel pressure while the other side takes vacuum from the intake manifold. Nominal fuel pressure is established via the spring preload being applied to the diaphragm. Manifold pressure balance the other side of the diaphragm in order to maintain a constant pressure drop across all of the injectors. Excess fuel not needed by the engine bypasses the regulator and is returned to the separator reservoir.

Fuel Rail

The fuel rail delivers high pressure fuel from the vapor separator reservoir to each of the 8 injectors. The actual assembly consists of two hollow fails (one for each bank of cylinders) connected by a crossover. All fuel injectors and the pressure regulator are connected to the rail. All fuel rails are serviced as an assembly only, only the injectors and the regulator may be individually serviced.

Intake Manifold

The manifold assembly is actually made up of two separate manifolds; and upper and a lower. Runner lengths on the upper plenum are pre-tuned to optimize engine torque and power output.

Fuel injector pockets are machined into the lower manifold in order to prevent any air or fuel leakage. These pockets are also positioned so that they the injector fuel pattern sprays directly in front of each intake valve.

Throttle Body

The throttle body is mounted to the upper intake manifold, Port side and controls airflow to the engine by means of a butterfly-style valve. All throttle bodies are one-piece aluminum with a single bore. There is an air bypass channel around the throttle plate controlling all engine idle airflow, regulated by an electro-mechanical device controlled by the ECA. A linear actuator is incorporated into the throttle body which positions a variable area metering valve known as the Idle Speed Control (ISC) valve.

Vapor Separator Tank

The reservoir is located at the rear of the engine and consists of the assembly itself, the high pressure fuel pump, float assembly and various fuel and cooling lines. Operational details are discussed in the Description and Operation section.

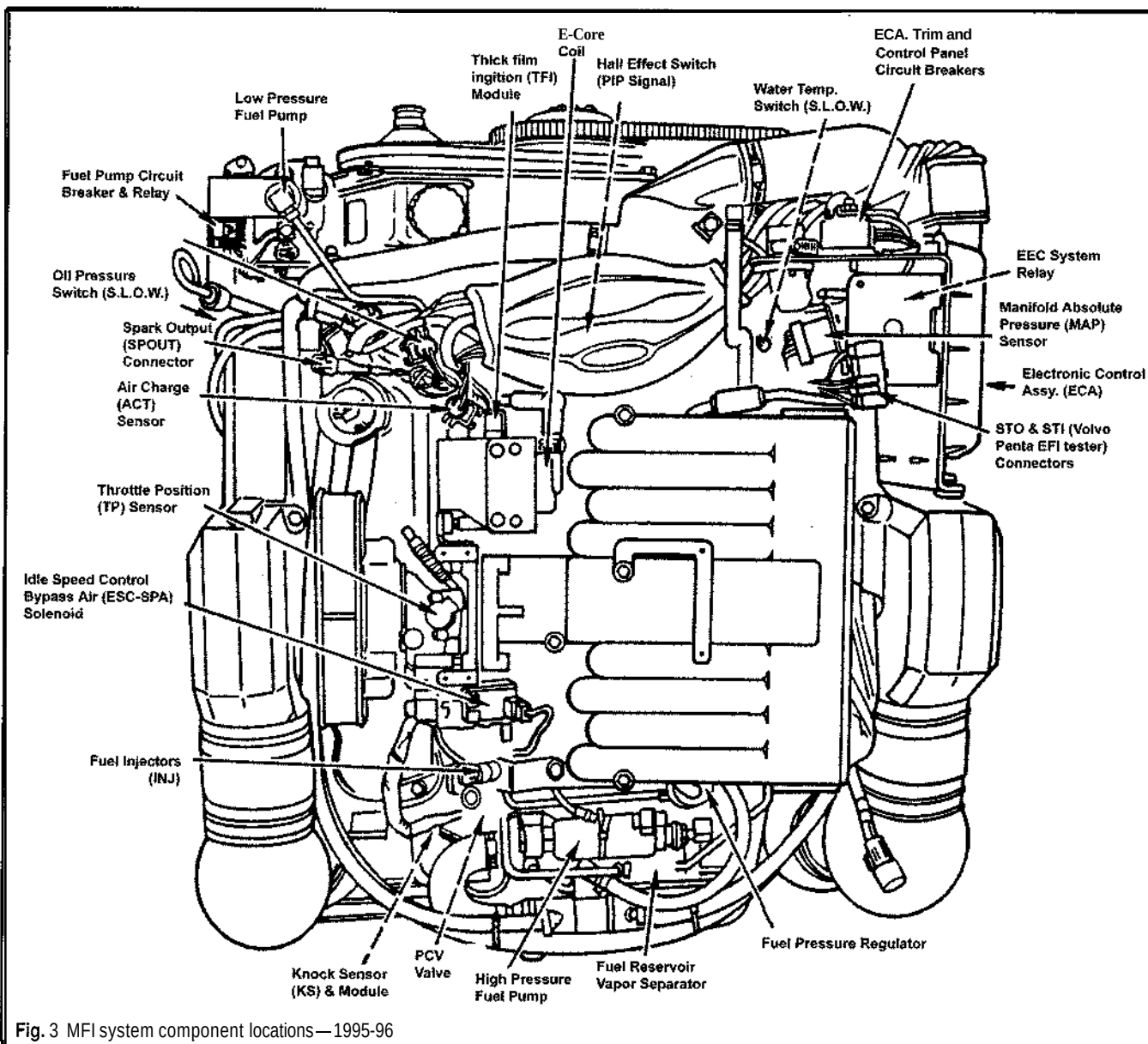


Fig. 3 MFI system component locations—1995-96

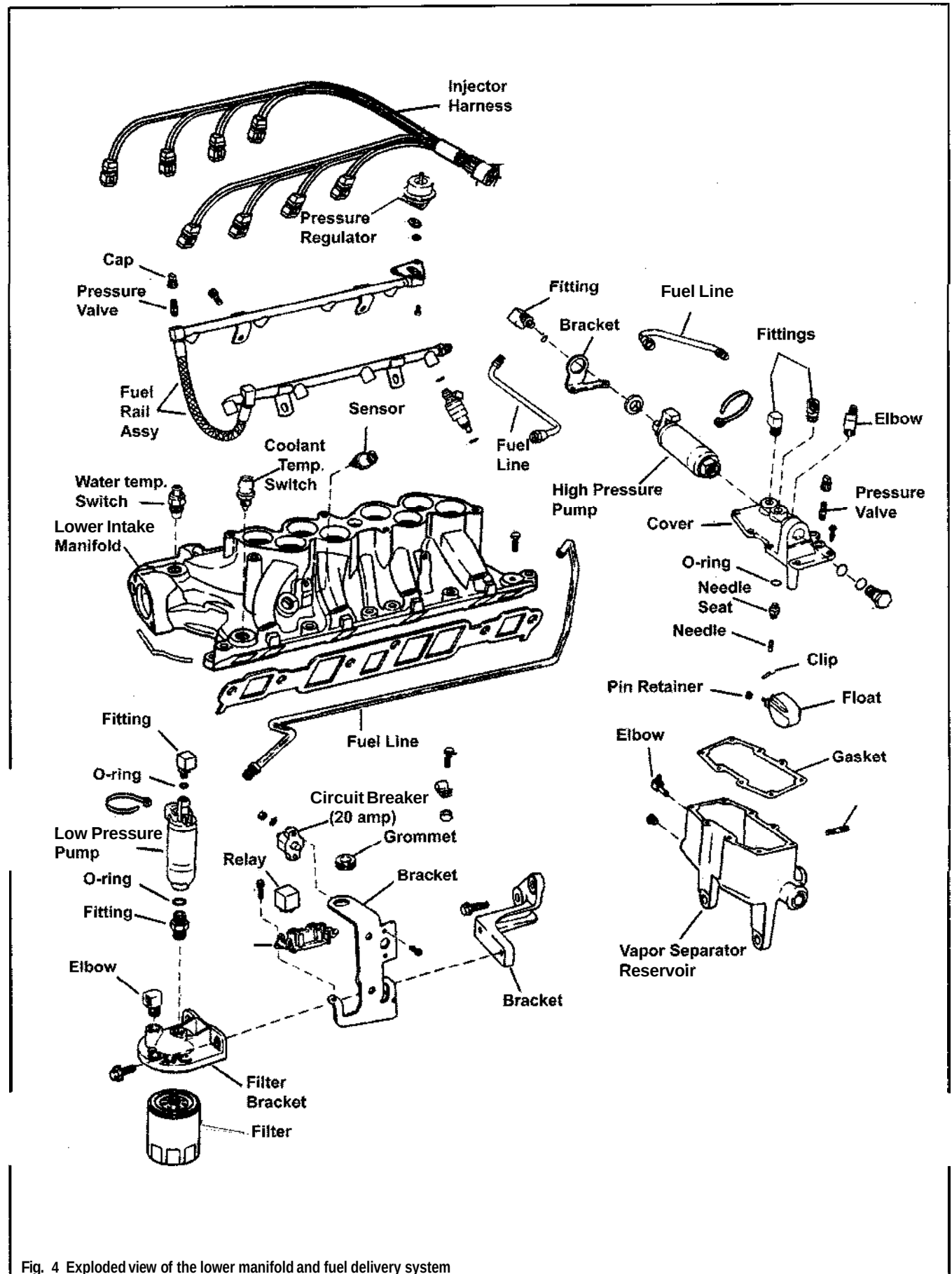


Fig. 4 Exploded view of the lower manifold and fuel delivery system

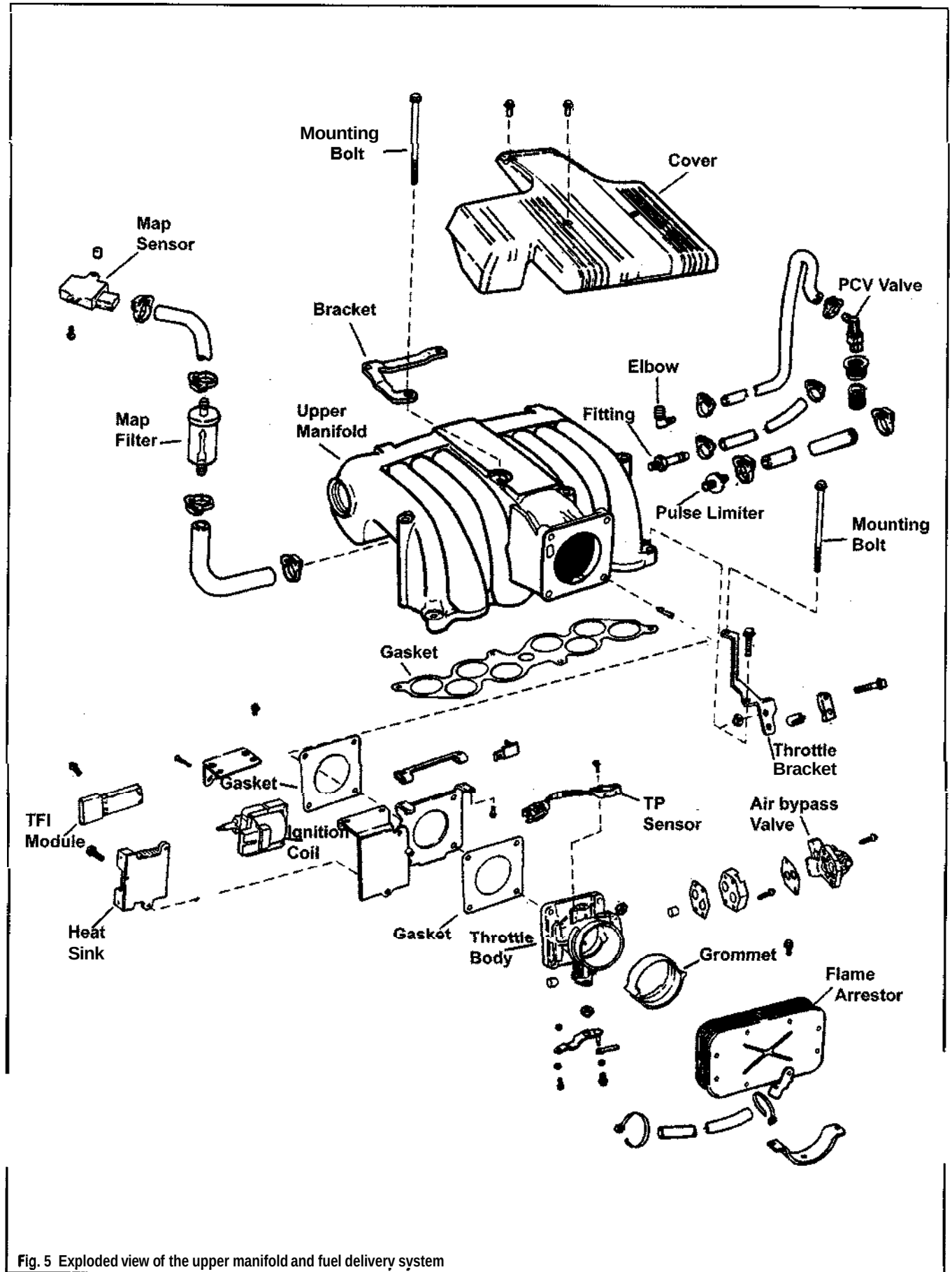


Fig. 5 Exploded view of the upper manifold and fuel delivery system

9-8 FUEL SYSTEMS – FUEL INJECTION

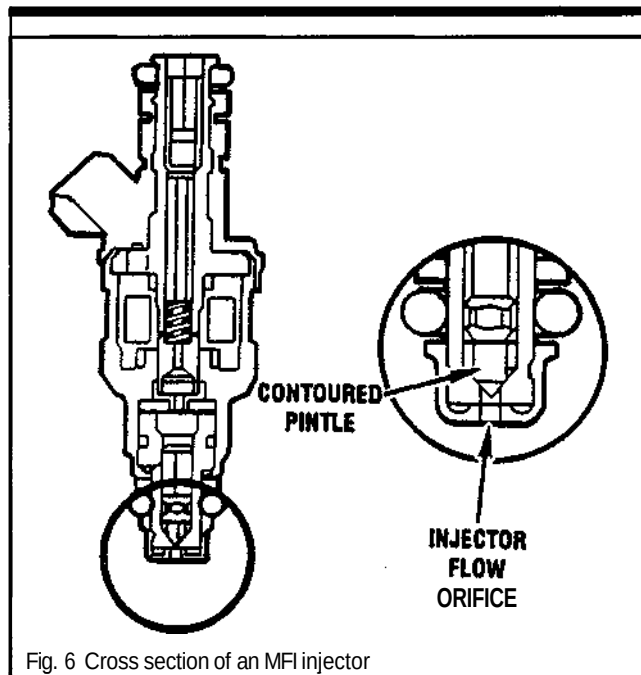


Fig. 6 Cross section of an MFI injector

Water Separating Fuel Filter

The water separator is a "typical" unit designed to prevent moisture from continuing on through the fuel lines and eventually through the injectors into the cylinders. It can be found on the front of the engine.

Relieving Fuel Pressure

✖ ✖ CAUTION

To reduce the risk of fire and personal injury, it is necessary to relieve the fuel system pressure before servicing any fuel system component. If this procedure is not performed, fuel may be sprayed out of a connection under extreme pressure. Always keep a dry chemical fire extinguisher near the work area when servicing the fuel system.

1. Tag and disconnect the electrical leads at each of the electric fuel pumps and move the harness out of the way.
2. Turn the ignition key and crank the engine for ten seconds to relieve any residual pressure in the system. If the engine starts, don't worry, allow it to run until it dies out and then crank the engine again for a few more seconds.
3. Reconnect the fuel pump leads.
4. Disconnect the battery cables before commencing any additional procedures.

Air Charge Temperature Sensor (ACT)

The air charge temperature sensor (or air bypass valve) monitors incoming air temperature changes and relays this information directly to the ECA. The ECA will then advance spark timing so the idle speed will increase at lower engine temperatures. Since cold air contains more oxygen, the ECA will richen the fuel/air mixture when outside air is colder.

REMOVAL & INSTALLATION

- ◆ See Figures 2 and 3



1. Open the engine compartment and disconnect the battery cables.
2. Remove the 4 retaining screws and lift off the plastic engine cover.
3. Tag and disconnect the coil high tension lead, the E-coil connector and the TFI-IV connector at the TFI module, just forward of the throttle body. Move them all out of the way.
4. Tag and disconnect the electrical lead at the ACT sensor, just in front of the TFI module. Unscrew the sensor.

To Install:

5. Install the sensor and tighten it to 12-18 ft. lbs. (16.3-24.4 Nm). Coat the electrical lead with Terminal Grease and reconnect it.
6. Apply Terminal Grease to the lead and two connectors from the module and reconnect them. Confirm that each connection is secure.
7. Install the plastic cover and tighten the screws to 24-36 inch lbs. (2.7-4.1 Nm).
8. Connect the battery cables.

TESTING

- ◆ See Figures 7 and 8

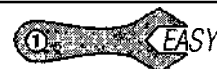


1. With the ignition switch in the OFF position, disconnect the electrical lead at the ACT sensor.
2. Measure the resistance across the two terminals in the sensor connector.
3. Match your reading to that in the chart for the given temperature. If within specification, the sensor is OK, otherwise replace the sensor.

Circuit Breaker

REMOVAL & INSTALLATION

- ◆ See Figures 2,3 and 4



1. Open the engine compartment and disconnect the battery cables.
2. Locate the circuit breaker on the fuel pump lift bracket (front of engine, Port side) and disconnect the two electrical leads.
3. Remove the screws/nuts and lift off the breaker.
4. Install a new circuit breaker and tighten the screws/nuts to 20-25 inch lbs. (2.3-2.8 Nm).
5. Connect the Red lead to one stud on the circuit breaker and the Red/Purple lead to the other. Tighten the nuts 20-25 inch lbs. (2.3-2.8 Nm). Coat the two terminals with Liquid Neoprene.

Engine Coolant Temperature Sensor (ECT)

This sensor is a thermistor immersed in the engine coolant passageway. A thermistor is a resistor capable of changing value based on temperature. Low coolant temperature produces a high resistance and a high temperature causes low resistance.

SENSOR DATA

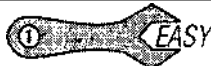
Temperature (F) (C)		Voltage (Volts)	Resistance (K Ohms)
248	120	0.28	1.18
212	100	0.47	2.07
176	80	0.80	3.84
140	60	1.35	7.60
104	40	2.16	16.15
68	20	3.06	37.30
32	0	3.87	94.98
-4	-20	4.33	271.20

Voltage values calculated for VREF equal 5V
Due to sensor and VREF variations, these values may vary by 15%

Fig. 7 Sensor testing values

REMOVAL & INSTALLATION

✦ See Figures 2, 3, 9 and 10



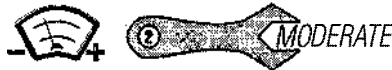
1. Open the engine compartment and disconnect the battery cables.
2. Remove the 4 retaining screws and lift off the plastic engine cover.
3. Tag and disconnect the coil high tension lead, the E-coil connector and the TFI-IV connector at the TFI module, just forward of the throttle body. Move them all out of the way.
4. Tag and disconnect the electrical lead at the ECT sensor, just in front of the TFI module. Unscrew the sensor.

To Install:

5. Install the sensor and tighten it to 10-15 ft. lbs. (13.6-20.3 Nm). Coat the electrical lead with Terminal Grease and reconnect it.
6. Apply Terminal Grease to the lead and two connectors from the module and reconnect them. Confirm that each connection is secure.
7. Install the plastic cover and tighten the screws to 24-36 inch lbs. (2.7-4.1 Nm).
8. Connect the battery cables.

TESTING

✦ See Figures 7 and 11



1. With the ignition switch in the **OFF** position, disconnect the electrical lead at the ECT sensor.
2. Measure the resistance across the two terminals in the sensor.
3. Start the engine and allow it to reach normal operating temperature. Check the resistance again.
4. Check the two readings against those in the chart and replace the sensor if they are incorrect.

EEC Power Relay

✦ See Figures 12 and 13

The EEC power relay receives direct battery power, protected by a circuit breaker and a fuse, via a red/purple electrical lead. Voltage from the ignition switch actuates the relay through a purple lead containing a diode to protect against reverse battery polarity. Finally, the purple/black lead carries battery voltage on the ECA at pins 37/157. All EEC-IV system components receive power via this lead.

REMOVAL & INSTALLATION

✦ See Figures 2, 3, 12 and 13



1. Open the engine compartment and disconnect the battery cables.
2. Remove the ECA bracket and then disconnect the small vacuum hose to the MAP sensor.
3. Disconnect the electrical leads at the relay.
4. Cut the plastic tie, remove the retaining screw and lift off the relay.
5. Attach the relay to the bracket. Tighten the retaining screw to 24-36 inch lbs. (2.7-4.1 Nm) and install a new plastic tie.
6. Install the ECA bracket and reconnect the vacuum line.
7. Connect the battery cables.

Electronic Control Assembly (ECA)

REMOVAL & INSTALLATION

✦ See Figures 2 and 3



1. Turn the ignition key to the **OFF** position. Do not perform any further steps in this procedure until you have done this.
2. Open the engine compartment and disconnect the battery cables.
3. Locate the ECA on the front side of the engine (Starboard) and cut the plastic tie around the rubber boot. Pull the boot back and remove the 10mm Hex screw holding the 60 pin connector on the front of the assembly. Unplug the connector and position it out of the way.
4. Remove the 4 cover retaining screws and then remove the plastic cover and the ECA.

To Install:

5. Position the assembly into the plastic cover so that the keyway lines up.
6. Attach the cover assembly to the bracket and tighten the screws to 24-36 inch lbs. (2.7-4.1 Nm).
7. Coat ALL terminal on the 60 pin connector with Terminal Grease and then plug it into the ECA. Tighten the Hex to 46-64 inch lbs. (5-7 Nm).
8. Stretch the rubber boot over the connector and install a new plastic tie.
9. Connect the battery cables.

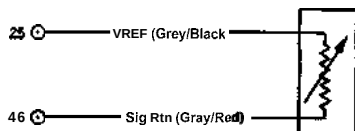


Fig. 8 ACT sensor schematic

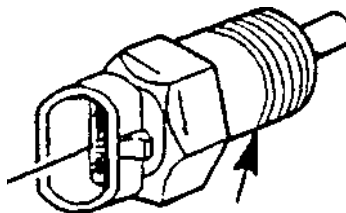


Fig. 9 Typical ECT sensor

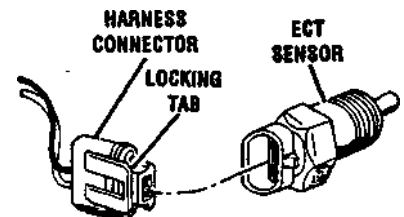


Fig. 10 The connector is held in place by a lock tab

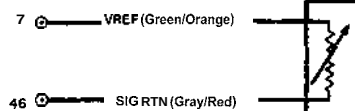


Fig. 11 ECT sensor schematic

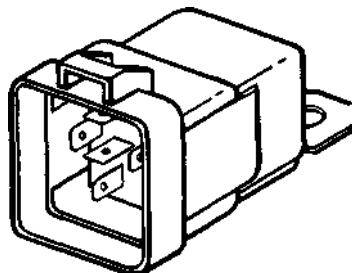


Fig. 12 EEC power relay

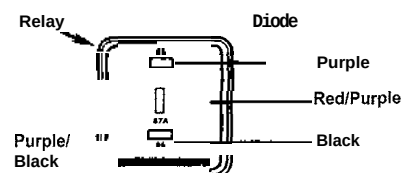


Fig. 13 EEC power relay pin locations

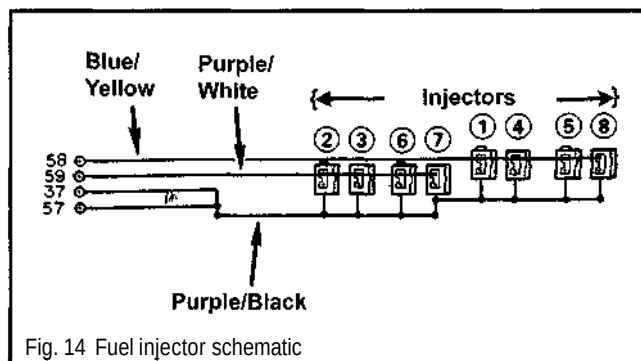
9-10 FUEL SYSTEMS – FUEL INJECTION

Fuel Injector

◆ See Figure 14

All EEC-IV EFI engine utilize an injector firing sequence that OMC calls 'bank-to-bank'—four injectors fire on one revolution of the crankshaft, while the remaining four fire on the next revolution of the shaft. All injectors receive power via the purple/black lead from the power relay at ECA pins 37/57. Ground circuits in the ECA control the actual firing; pin 58 fires the #1, 4, 5 and 8 injectors via the blue/yellow lead, while pin 59 fires the #2, 3, 6 and 7 injectors via the purple/white lead.

Fuel injector or circuit failure will NOT prompt the ECA to store a trouble code in its memory.



REMOVAL & INSTALLATION

◆ See Figures 4 and 6



□ Always have a fire extinguisher handy when working on any part of the fuel system. Remember, a very small amount of fuel vapor in the bilge, has the tremendous potential explosive power.

1. Relieve the fuel pressure as previously detailed.
2. Open the engine compartment and disconnect the battery cables.
3. Remove the upper intake plenum and fuel rail. There is a good chance that the injectors will come up with the rail—if this happens, disconnect the lead and pull the injector out of the holder on the rail.
4. Tag and disconnect the electrical lead at the injector you intend to remove.
5. Grab the body of the injector with your hand and pull it upward while wiggling it back and forth.

To Install:

6. Replace the two O-rings on the injector, coating them with a light engine oil before slipping them on. Make sure that they are the fuel resistant type and are Brown in color.

✖✖ WARNING

Never use silicone grease on the injector O-ring.

7. Install the injector back into the rail the same way you removed it.
8. Install the fuel rail and reconnect the electrical lead to the injector. Make sure you coat both terminals and connector with Terminal grease.
9. Install the upper intake plenum and connect the battery cables.

Fuel Pressure Regulator

REMOVAL & INSTALLATION

◆ See Figures 2, 3, 4 and 15



□ Always have a fire extinguisher handy when working on any part of the fuel system. Remember, a very small amount of fuel vapor in the bilge, has the tremendous potential explosive power.

1. Relieve the fuel pressure as previously detailed.
2. Open the engine compartment and disconnect the battery cables.
3. Remove the upper intake plenum and fuel rail as previously detailed.
4. Remove the 3 Allen screws retaining the regulator and lift it off of the rail. Discard the gasket.

To Install:

5. Inspect the O-ring for cracks or other signs of deterioration, replace as necessary. We think it's a good idea to replace the O-ring regardless of condition. Either way, coat it with clean engine oil.

✖✖ WARNING

Never use silicone grease on the regulator O-ring.

6. Make sure that all residual gasket material is removed from the two mating surfaces and position a new gasket.
7. Install the regulator and tighten the screws to 27-40 inch lbs. (3.0-4.5 Nm).
8. Install the fuel rail and upper plenum.
9. Connect the battery cables.

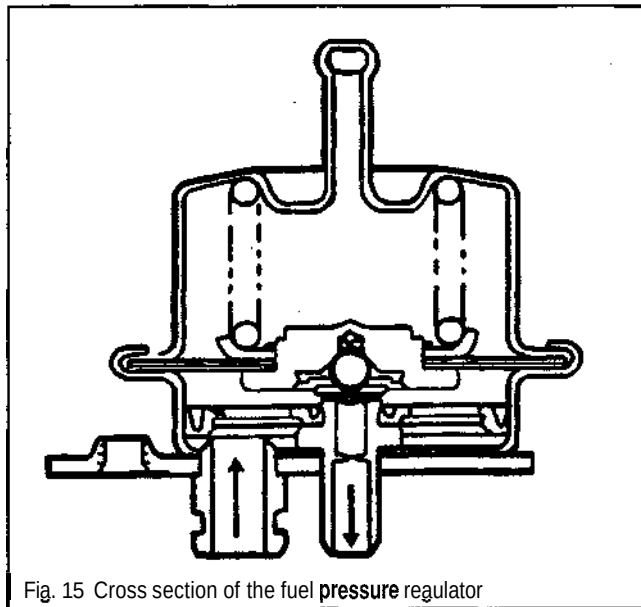


Fig. 15 Cross section of the fuel pressure regulator

Fuel Pump

REMOVAL & INSTALLATION

High Pressure



◆ See Figures 2,3 and 4

□ Always have a fire extinguisher handy when working on any part of the fuel system. Remember, a very small amount of fuel vapor in the bilge, has the tremendous potential explosive power.

✖✖ CAUTION

All OMC fuel pumps are designed to meet U.S. Coast Guard fuel system regulations. Never substitute and automotive style pump.

1. Open or remove the engine hatchcover and relieve the fuel system pressure as detailed previously. Disconnect the battery cable.
2. Locate the pump at the rear of the engine, on top of the fuel reservoir/vapor separator.
3. Make a note of the fitting elbow positioning and then hold the elbow while removing the fuel line; be sure to have some rags handy to catch any spilled fuel and make sure you plug the line before moving it out of the way.

4. With your wrench still on the elbow, back off the lock nut with another wrench. The lock nut is the nut immediately inside of the elbow; do not confuse it with the end cap nut on the end of the pump. Unscrew the elbow from the end of the pump and set it aside.

5. Remove the 2 screws securing the end bracket to the reservoir and then remove the bracket from the pump.

6. Remove the banjo nut from the end of the pump and then remove the pump. Discard all O-rings.

To Install:

7. Lubricate new O-rings with clean engine oil. Slide the small one onto the elbow fitting (right up against the flange) and the larger one onto the banjo nut so it sits in the groove on the inner side of the head.

8. Slide the banjo nut into the hole on the reservoir cover. Coat another new O-ring with clean engine oil and position it over the threads and up against the bracket.

9. Position the pump at a 45° angle, hold the end cap with a wrench and thread the banjo nut into the pump. Tighten it to 18-22 ft. lbs. (24.4-29.8 Nm). Be very careful to hold the end cap while tightening the banjo nut or you risk damaging the internal O-ring.

10. Position the support bracket over the other end of the pump and tighten the screws to 25-35 inch lbs. (2.8-4.0 Nm).

11. Screw the elbow fitting into the end of the pump so that it is in the same position as when removed. Cinch the lock nut down against the pump outlet and then tighten it to 60-84 inch lbs (6.8-9.5 Nm) while holding the pump end cap.

12. Install the fuel line and connect the battery cables.

Low Pressure

◆ See Figures 2,3 and 4

□ Always have a fire extinguisher handy when working on any part of the fuel system. Remember, a very small amount of fuel vapor in the bilge, has the tremendous potential explosive power.

✱✱ CAUTION

All OMC fuel pumps are designed to meet U.S. Coast Guard fuel system regulations. Never substitute and automotive style pump.

1. Open or remove the engine hatchcover and relieve the fuel system pressure as detailed previously. Disconnect the battery cable.

2. Position a container under the pump/filter assembly and remove the fuel inlet line at the filter bracket and the outlet line at the top of the pump. It is important to use two open-end wrenches; one to hold the fuel fitting nut or elbow and the other to loosen the line nut. Plug the line with a golf tee or something similar to prevent additional fuel spillage (OMC actually sells a plug for this purpose). Take care not to spill fuel on a hot engine, because such fuel may ignite.

3. Cut the plastic tie holding the electrical leads to the body of the pump. Unplug the electrical harness at the pump suppressor connector and move it out of the way.

4. Hold the pump end cap (just under the lower edge of the upper retaining bracket) with a wrench while loosening the lock nut (on top of bracket, under elbow). Unscrew the upper elbow.

✱✱ CAUTION

Not holding the end cap while loosening the lock nut will damage the internal O-ring, causing fuel leakage during operation.

5. Remove the 2 fuel filter bracket mounting bolts and lift off the pump/bracket/filter as an assembly, sliding the pump out of the upper grommet. Be careful of spilling fuel.

6. Lay the assembly down, or carefully mount the bracket in a vise. Hold the lower pump end cap with a wrench and unscrew the filter bracket-to-pump adapter.

✱✱ CAUTION

Not holding the end cap while loosening the lock nut will damage the internal O-ring, causing fuel leakage during operation.

To Install:

7. Slide a new O-ring over the threads of the adapter until it rests on the upper side of the hex nut.

8. Screw the adapter/bracket assembly into the pump while holding the lower end cap. Tighten the adapter to 8-10 ft. lbs. (11-14 Nm).

9. Slide the assembly up through the grommet in the bracket and position it so the mounting holes line up on the bracket. Tighten the filter bracket bolts to 20-25 ft. lbs. (27-34 Nm).

10. Thread the upper lock nut onto the elbow until it reaches the underside of the fitting. Slip on the washer and then a new O-ring. Thread the elbow into the top of the pump until it stops and then back it out just enough to align with the fuel line. Connect the line and tighten it securely.

11. Hold the upper end cap again and tighten the lock nut to 60-84 inch lbs. (6.8-9.5 Nm).

12. Reconnect the suppressor lead—push it in until the tabs click.

□ If you notice any of the suppressor holes open, be sure to coat them with Liquid Neoprene to prevent water from entering.

13. Install a new plastic tie around the pump body and electrical leads.

14. Reconnect the inlet line and tighten it securely.

15. Install the pump guard if removed.

16. Remove the container and connect the battery cables. Start the engine and check for fuel leaks.

Fuel Rail

REMOVAL & INSTALLATION

4 See Figure 4

□ Always have a fire extinguisher handy when working on any part of the fuel system. Remember, a very small amount of fuel vapor in the bilge, has the tremendous potential explosive power.

1. Open or remove the engine hatchcover and relieve the fuel system pressure as detailed previously. Disconnect the battery cable.

2. Remove the upper intake plenum/throttle body assembly as detailed previously.

3. Clean any and all debris from around the rail and injectors to prevent it from falling into the intake ports.

4. Carefully disconnect the fuel supply line at the rear Port side of the rail. Do the same with the return line on the Starboard side. Plug the lines and make sure you have plenty of rags available to mop up the inevitable spillage.

5. Make a note of the injector harness positioning on the rail and where it is secured. Cut the plastic ties securing the harness to the rails.

6. Remove the 4 rail retaining bolts (2 per side), carefully disengage the rails from each injector and lift off the rail. An alternate way is to simply remove the rail with the injectors attached, and then remove the injectors if necessary—we like this way better, particularly if you do not intend on replacing the rail or injectors. Cover the injector holes.

To Install:

7. If the injectors were removed, confirm that the caps are clean and debris-free.

8. Replace the two O-rings on each injector, coating them with a light engine oil before slipping them on. Make sure that the O-rings are the fuel resistant type and are Brown in color. No you don't have to replace the O-rings if they are in good condition, but why would you not do it while you've got the injectors out?? Cheap insurance, and can save you a lot of headache and time down the road.

✱✱ WARNING

Never use silicone grease on the injector O-ring.

9. If you left the injectors in position, seat each one into the rail cup, making sure the O-ring snaps into place. Otherwise, position the assembly over the ports and carefully pop the injectors into place. Once everything is in position, install the retaining bolts and tighten them to 70-105 inch lbs. (7.9-11.9 Nm).

10. Reroute the injector harness so that it approximates the original positioning and then install new plastic ties where you had removed the old ones. Make sure that all terminals and connections have been coated with Terminal Grease.

11. Install the manifold and throttle body assembly.

12. Connect the battery cables.



9-12 FUEL SYSTEMS – FUEL INJECTION

Fuel Reservoir/Vapor Separator

REMOVAL & INSTALLATION

- ◆ See Figures 2, 3 and 4



Always have a fire extinguisher handy when working on any part of the fuel system. Remember, a very small amount of fuel vapor in the bilge, has the tremendous potential explosive power.

1. Open or remove the engine hatch/cover and relieve the fuel system pressure as detailed previously. Disconnect the battery cable.
 2. Loosen the hose clamps and then remove the water inlet and outlet hoses from the tank.
 3. Remove the power steering cooler retaining bracket bolt and position the cooler out of the way. There is a special flat washer behind the cooler bracket—don't lose it when lifting off the assembly.
 4. Clip the plastic tie securing the pump harness to the pump and then unplug the connector and move the harness out of the way.
 5. Remove the small clamp and wiggle the vent hose from the nipple at the rear of the reservoir. Position it out of the way.
 6. Remove the fuel inlet line from the low pressure pump. Remove the line running between the reservoir and pressure regulator. Remove the high pressure pump outlet line. Please refer to the Fuel Pump procedures for specific details on removing the fuel lines.
 7. Loosen the clamp and remove the cooling outlet line (running to the thermostat housing) connected to the elbow on the Starboard side of the reservoir.
 8. Remove the 2 mounting bolts at the bottom of the reservoir and lift off the assembly.
- To Install:
9. Adjust the float level as detailed later in this section.
 10. Position the reservoir onto the engine and tighten the mounting bolts to 24-36 ft. lbs. (38-49 Nm).
 11. Reattach the coolant line to the elbow on the reservoir and tighten the clamp securely.
 12. Connect the three fuel lines to the pump and reservoir as detailed in the Fuel Pump section.
 13. Connect the vent line running from the upper manifold and tighten the clamp securely, but not so tight as to pinch the hose.
 14. Coat the terminals on the fuel pump and pump harness connector with Terminal Grease and plug the connector into the pump. Secure the harness to the pump body with a new plastic tie.
 15. Slide the flay washer over the mounting stud on the rear of the reservoir and then install the power steering cooler. Tighten the lock nut to 20-25 ft. lbs. (27-34 Nm).
 16. Reconnect the cooling hoses and tighten their hose clamps securely.
 17. Connect the battery cables.

FLOAT LEVEL

- ◆ See Figures 4 and 16



1. Disconnect all fuel lines and remove the high pressure fuel pump.
2. Remove the 8 reservoir cover retaining screws and lift off the cover and pump brackets. Discard the gasket.
3. Flip the cover assembly over and allow the float to drop down until it seats the float needle.
4. Measure the distance between the bottom edge of the inverted float (actually the top edge when installed in the reservoir) and the inner mounting surface of the reservoir cover.
5. Bend the float adjustment tab very carefully until the gap is 3/16 in. (4.76mm). Rotate the assembly once or twice and check that the float moves freely and that the gap has not changed.

□ Never force the float needle tip against the seat or you will damage the special tip.

6. Position a new cover gasket onto the reservoir and then carefully install the cover assembly. Tighten the retaining screws to 25-35 inch lbs. (2.8-4.0 Nm).
7. Install the fuel pump and reconnect the fuel lines.

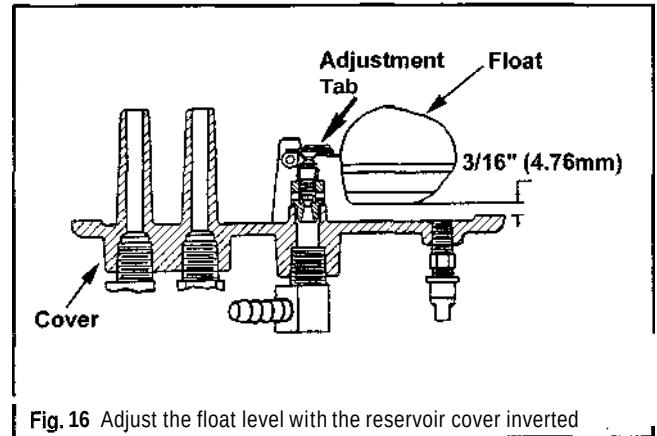


Fig. 16 Adjust the float level with the reservoir cover inverted

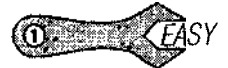
Idle Speed Control (ISC) Solenoid

- ◆ See Figures 17 and 18

The idle speed control by-pass air solenoid receives battery voltage via the purple/black lead from ECA pins 37/57. Ground is via the white/black ground wire from the ECA. This ground circuit serves to control voltage to the solenoid; the varying voltage then changes the position of the air by-pass valve. The greater the voltage, the more air will be allowed to bypass the throttle plate.

REMOVAL & INSTALLATION

- 4 See Figures 2, 3 and 4



1. Open or remove the engine hatchcover and relieve the fuel system pressure as detailed previously. Disconnect the battery cable.
 2. Tag the 2-pin connector at the rear of the ISC solenoid and disconnect it from the solenoid. The solenoid is attached to the aft side of the throttle body.
 3. Remove the 2 solenoid retainina screws and pull it off the adaotor Discard the gasket.
 4. Remove the 2 adaptor retaining screws and pull it off the throttle body. Discard the gasket. Pull the small muffler out of the adaptor body.
- To Install:
5. Carefully wash the muffler in solvent and allow it to air dry.
 6. Clean any residual gasket material from both sides of the adaptor, and from the throttle body and solenoid mating surfaces.
 7. Insert the muffler into the adaptor so that is flush with, or below, the surface.
 8. Position a new gasket onto the throttle body and then install the adaptor. Tighten the screws to 71-102 inch lbs. (8-11 Nm).
 9. Position a new gasket onto the adaptor and install the solenoid. Tighten the screws to 71-102 inch lbs. (8-11 Nm).
 10. Coat all terminals of the connector with Terminal Grease and reconnect the lead to the solenoid.
 11. Install the engine cover and connect the battery cables.

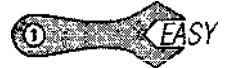
Knock Sensor (KS) And Amplifier

- See Figures 19 and 20

At the first sign of spark knock, a pulsing signal is produced by the sensor and then sent through an amplifier to the ECA. After receiving this signal, the ECA will retard timing in three steps (but no more than 12° from the starting point) until knock is no longer sensed by the sensor. Once the MAP sensor detects a 3-4 in. Hg. change in engine vacuum, or the engine is shut off, the ECA will return the engine to its normal spark advance.

REMOVAL & INSTALLATION

- ◆ See Figure 19



1. Open or remove the engine hatchcover and relieve the fuel system pressure as detailed previously. Disconnect the battery cable.

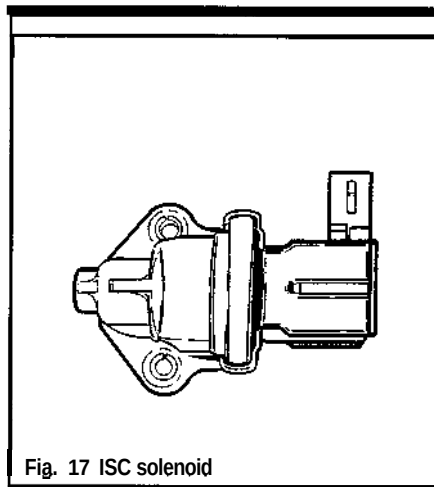


Fig. 17 ISC solenoid

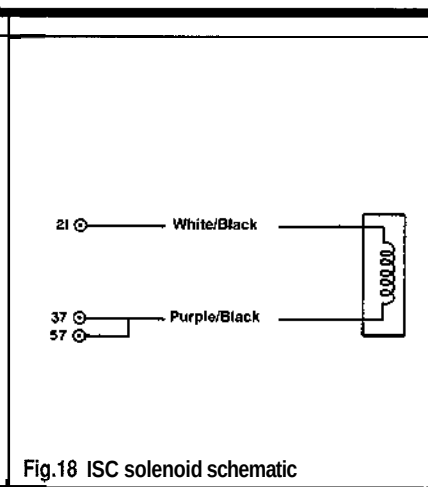


Fig. 18 ISC solenoid schematic

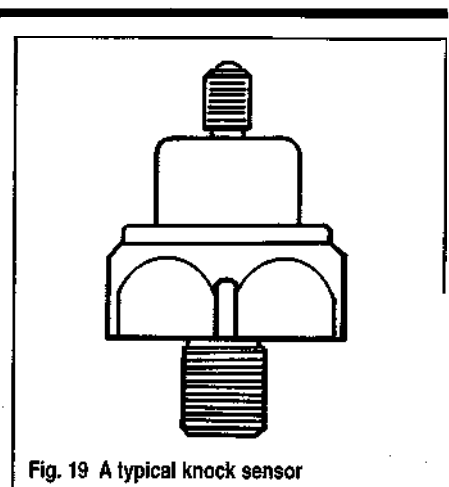


Fig. 19 A typical knock sensor

2. Locate the knock sensor on the rear of the cylinder block, just above the flywheel housing and behind the port side leg of the separator reservoir. Tag and disconnect the electrical lead at the sensor and then unscrew the sensor.

CAUTION

The sensor is fragile and must be handled with care. If it is dropped, or banged in any manner, you must replace it.

3. Working right next to the sensor, cut the plastic tie around the amplifier and pop it out of its bracket. Pry off the retainer and then unplug the amplifier connector.

To Install:

4. Coat all terminals with Terminal Grease and plug in the amplifier connector. Press the retainer into position. Position the amplifier on the bracket and secure it with a new plastic tie.

5. Thoroughly clean the threads of the knock sensor and its hole. The sensor grounds through the threads, so there can be no residual paint or dirt. Carefully screw the sensor in and tighten it to 7-10 ft. lbs. (9.5-13.5 Nm).

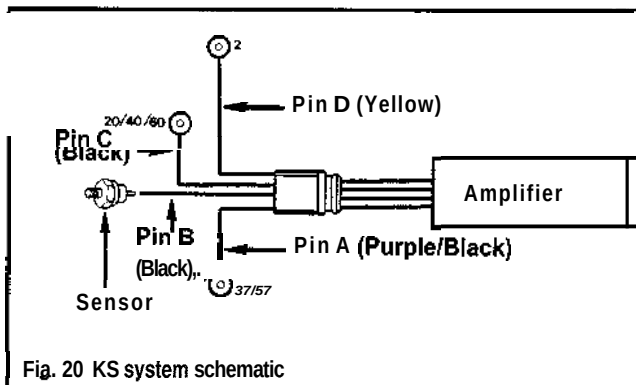


Fig. 20 KS system schematic

CAUTION

DO NOT OVER-TIGHTEN THE KNOCK SENSOR.

6. Attach the sensor lead and connect the battery cables.

Manifold Absolute Pressure (MAP) Sensor

◆ See Figure 21, 22 and 23

The MAP sensor is a pressure transducer capable of measuring the changes in the intake manifold pressure. Pressure changes are the result of engine load and speed changes. MAP is the opposite of what is measured with a vacuum gauge.

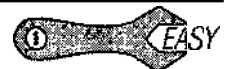
When manifold pressure is high, vacuum is low—requires more fuel and of course the opposite is true. A low pressure—higher vacuum requires less fuel. The MAP sensor is also used to measure barometric pressure under certain conditions. This feature permits the ECM to automatically adjust for changes in operating altitude.

The ECM uses the MAP sensor to control fuel delivery and ignition timing.

Reference voltage (VREF) is supplied to the sensor via a brown/yellow lead from the ECA. The sensor then outputs a frequency signal back to the ECA via the green/black lead and the circuit is completed with a signal return (SIG RTN) from the ECA to the sensor via the grey/red lead.

REMOVAL & INSTALLATION

◆ See Figures 2, 3 and 5



1. Open or remove the engine hatchcover and relieve the fuel system pressure as detailed previously. Disconnect the battery cable.
2. Remove the Self-Test connector and cover from the top of the ECA bracket just forward of the Starboard exhaust elbow.
3. Remove the 3 ECA bracket mounting screws.
4. Loosen the small hose clamp and pull the vacuum line off the nipple on the sensor. Tag the line and position it out of the way. Remove the sensor filter at the other end of the line and clean it in a mild solvent,

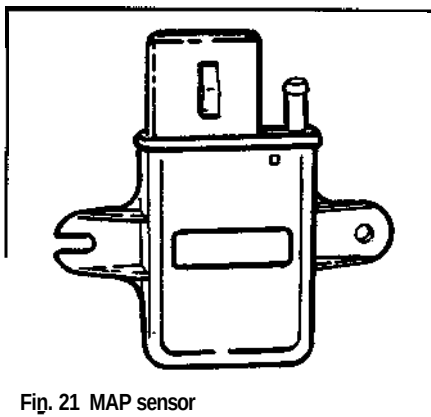


Fig. 21 MAP sensor

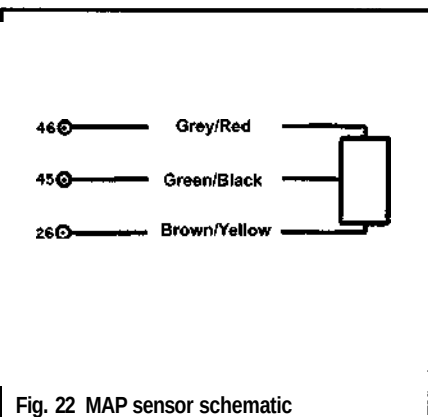


Fig. 22 MAP sensor schematic

Manifold Vacuum in. Hg	kPa	Frequency Hz
0	0	159
6	20.3	141
12	40.6	125
18	61	109
24	81.3	95
30	101.6	80

Fig. 23 MAP sensor data table

9-14 FUEL SYSTEMS – FUEL INJECTION

5. Tag the sensor lead and disconnect it from the sensor body.
6. Remove the 2 retaining screws and pull the sensor off the bracket.

To Install:

7. Attach the sensor to the ECA bracket so that the flat side is facing up (toward the bracket). Tighten the screws to 24-36 inch lbs (2.7-4.1 Nm). It is very important that the sensor is installed upside down to prevent condensation damage.
8. Install the sensor filter into the vacuum lines so that the arrow is pointing toward the sensor. Slide the vacuum line onto the sensor nipple and tighten all clamps securely. You may find it easier to connect the sensor terminal first.
9. Coat the connector terminals with Terminal Grease and snap together the connection.
10. Position the ECA bracket on the engine and tighten the screws to 60-84 inch lbs. (6.8-9.5 Nm).
11. Attach the Self-Test connector and cover. Connect the battery cables.

Throttle Body

REMOVAL & INSTALLATION

◆ See Figures 5 and 24



1. Open or remove the engine hatch/cover and relieve the fuel system pressure. Disconnect the battery cable.
2. Remove the 4 screws and lift off the plastic engine cover.
3. Remove mounting nut(s) and then remove the flame arrestor. Certain models will have a bracket holding the arrestor on.
4. Remove the throttle cable locknut at the arm on the throttle body and then disconnect the throttle linkage.
5. Tag and disconnect the wiring harness for the ISC solenoid and TP sensor.
6. Remove the 4 throttle body mounting nuts. Lift out the throttle body and set it down in a holding fixture to avoid damage to the valves. Stuff a clean, lint-free rag into the plenum opening.
7. Remove the TP sensor and ISC valve with their O-rings from the assembly if necessary.
8. Lift the coil bracket off of the studs.

To Install:

9. Carefully clean the throttle bore and valve. Do not use anything containing methyl ethyl ketone! If you didn't remove the TP sensor and ISC valve, make sure that you get no solvent on them during cleaning. CAREFULLY scrape any gasket material off the mating surfaces. Make sure all passages are free of dirt and completely dry before installation.

□ The inside of the throttle bore and the back (inner) side of the throttle valve have been coated with a special protective material which created a ridge at the point that the valve meets the bore—do not remove this ridge, or spray any kind of cleaner on the surfaces.

10. Slide a new gasket over the studs in the manifold so that the tab is at the bottom and facing rearward. Slide on the coil bracket.
11. Install the sensor and valve into the throttle body if they were removed.
12. Position the throttle body and new gasket (tab at bottom and facing the rear) over the studs and tighten the nuts to 12-18 ft. lbs. (16-24 Nm).
13. Connect the IAC and TP leads.
14. Connect the throttle cable and adjust as necessary.
15. Install the flame arrestor and engine cover.
16. Reconnect the battery cables.

Throttle Position Sensor (TP)

◆ See Figures 25, 26 and 27

The TP sensor is a potentiometer connected to the throttle shaft on the throttle body. One end of the sensor is connected to a 5-volt reference signal (VREF) from the ECA via a brown/yellow lead and the other end is connected to ECA ground.

A third wire (grey/white) is connected directly to the ECM to measure the voltage from the TP sensor. The voltage output of the TP sensor changes when the throttle valve angle is changed. The circuit is completed when the signal is returned (SIG RTN) via the grey/red wire.

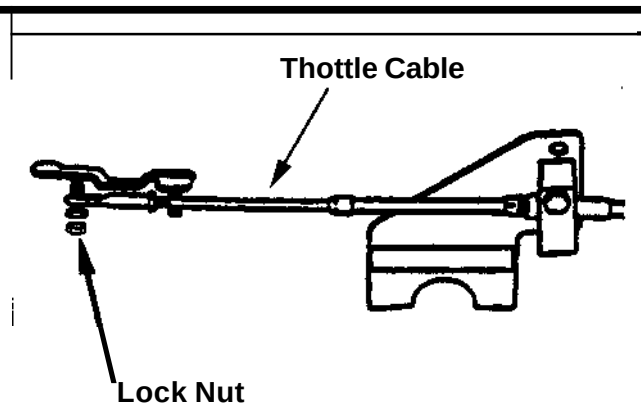


Fig. 24 Disconnect the throttle cable and move it out of the way

When the throttle position is closed, the voltage output of the TP sensor is low—about 112 volt. When the throttle valve is opened, the output increases and at WOT the output voltage should be close to 5 volts.

Therefore, the ECM can determine fuel delivery requirements based on throttle valve angle—operator demand.

REMOVAL & INSTALLATION

◆ See Figures 2, 3 and 5



1. Open or remove the engine hatch/cover and relieve the fuel system pressure. Disconnect the battery cable.
2. Remove the 4 screws and lift off the plastic engine cover.
3. Remove mounting nut(s) and then remove the flame arrestor.
4. Tag and disconnect the electrical connector at the sensor and move it out of the way.
5. Using a magic marker, draw a line across the body of the sensor and the throttle body to use as a reference mark on installation.
6. Unscrew the 2 mounting screws and remove the sensor. Clean the sensor with a dry cloth; make sure that the sensor is in good condition (no wear, cracks or damage), if not replace it.

□ If replacing the sensor with a new one, make sure to use the two new screws that came with the package.

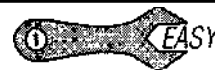
7. Install the sensor so that the wiring harness would be laying across flame arrestor. Rotate the sensor clockwise until the reference mark made earlier lines up and tighten the screws to 18-26 inch lbs. (2-3 Nm).
8. Coat the connector terminals with Terminal Grease and then plug them together.
9. Install the flame arrestor and cover. Connect the battery cables.

System Diagnosis

◆ See Figure 28

□ The following system checks and tests MUST be followed in the order that they are presented so that system diagnosis can be properly exercised.

SYSTEM INTEGRITY CHECK



1. Inspect the entire fuel delivery system for leaks, looseness, kinks, corrosion, grounding or other damage. Be certain to check:
 - Fuel tank and lines
 - Fuel filter
 - Fuel pumps
 - Fuel injectors
 - Pressure regulator
 - All electrical connections and lines
 - Vapor Separator
2. Repair or replace any component not standing up to the inspection.
3. If the fuel delivery system shows no evidence of damage, etc., proceed to the Fuel Injection Pressure Test.

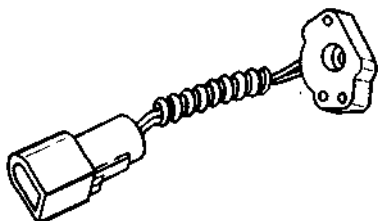


Fig. 25 TP sensor



Fig. 26 TP sensor schematic

Throttle Angle (deg.)	Voltage A (V)
0	0.50
10	0.97
20	1.44
30	1.90
40	2.37
50	2.84
60	3.31
70	3.78
80	4.24

A Voltage values calculated for VREF = 5V and may vary +/-15% due to sensor/VREF variations

Fig. 27 TP sensor data table

SYMPTOM CHART

SYMPTOM	CHECKS TO BE PERFORMED									
	Fuel System	Fuel Injectors	Throttle Body	Ignition System	Sensors	Electrical System	Cooling System	Engine Mechanical	Air Intake	Other
Cranking										
Will Not Crank		X				X		X		
Cranks But Does Not Run	X	X	X	X		X		X	X	
Hard To Start - Long Cranking Time	X	X		X	X			X	X	
Stalls After Start/Idle	X		X	X	X			X	X	
Idling										
Slow Return To Idle	X		X	X	X			X	X	
Rolling Idle/Runs Rough/Misses	X	X	X	X	X			X	X	
Fast Idle/Diesels	X		X	X			X	X	X	
Low Idle/Stalls/Quits After Decel			X			X			X	
Backfires While Idling	X			X	X			X		
Acceleration										
Stalls/Quits On Acceleration	X	X	X	X						
Bucks/Jerks During Acceleration	X	X	X	X					X	
Hesitation/Stumble/Surge	X	X	X	X	X				X	①
Backfires	X	X	X	X	X			X		
Lack Of/Low Power Output	X	X		X	X		X	X	X	②
Spark Knock	X			X	X		X	X	X	
Cruising										
Runs Rough/Cuts Out/Misses	X	X		X	X			X		
RPM Limited To 2700 Or Under	X	X		X	X		X	X		
Surges	X	X		X	X			X	X	
Backfires	X			X	X			X		
Low Power Output	X	X		X	X		X	X	X	②
Spark Knock	X			X	X		X	X	X	
Other Conditions										
Poor Fuel Economy	X			X			X	X	X	② ③
Strong Fuel Odors	X	X	X							④

- ① Check the throttle linkage and cable for binding
- ② Check stern drive oil. Possible drive bearing problems
- ③ Check hull for marine growth
- ④ Check fuel tank, vents and fuel lines for leaks

Fig. 28

FUEL INJECTION PRESSURE TEST



◆ See Figure 29

1. With the ignition switch in the OFF position, install a fuel pressure gauge at the pressure valve on the fuel rail.
2. Ground the Blue/Orange fuel pump lead at the STO (Self-Test Output) connector (pin #52).
3. Turn the ignition switch to the ON position (but do not start the engine) so that the fuel pumps are energized.
4. If the gauge reads 36-42 psi (248-290 kPa), proceed to the Fuel Pressure Leakdown Test.
5. If the gauge reads 0 or very low, proceed to Checking Voltage At FP Relay.

6. If the gauge shows the pressure to be high, proceed to Checking the Regulator For High Pressure.

FUEL PRESSURE LEAKDOWN TEST



◆ See Figure 29

1. With the ignition switch in the OFF position, install a fuel pressure gauge at the pressure valve on the fuel rail.
2. Connect a jumper wire to the Blue/Orange lead at the STO Self-Test connector (pin #52).
3. Turn the ignition switch to the ON position (but do not start the engine). Connect the jumper lead from the previous step to a suitable ground, run the fuel pumps for 30 seconds and then disconnect the jumper.

9-16 FUEL SYSTEMS – FUEL INJECTION

Take note of the fuel pressure reading on the gauge.

4. The pressure should remain within 3 psi of the running pressure for at least 3 minutes after the jumper is removed from ground.

5. If the pressure held, proceed to Pressure Regulator Diaphragm Check.

6. If the pressure did not remain constant, proceed to Pressure Regulator Valve Seat Check.

PRESSURE REGULATOR DIAPHRAGM CHECK



1. With the ignition switch in the **OFF** position, install a fuel pressure gauge at the pressure valve on the fuel rail.

2. Start the engine and allow it to run for 10 seconds. Turn it off for 10 seconds and then start it again and allow it to run for another 10 seconds.

3. Turn off the engine and disconnect the vacuum line at the regulator.

4. Examine the port and regulator body for signs of leakage.

5. If no fuel is present, proceed to Fuel Pressure Under Load Check.

6. If fuel leakage is present, replace the regulator and then perform the Fuel Injection Pressure Test again.

FUEL PRESSURE UNDER LOAD CHECK



1. With the ignition switch in the **OFF** position, install a fuel pressure gauge at the pressure valve on the fuel rail.

2. Start the engine and allow it to idle.

3. Disconnect the vacuum line at the pressure regulator. If the line has vacuum, plug it. Otherwise, determine why there is no vacuum, fix the problem, and then plug the line.

4. Run the engine up to full throttle and then back to idle at least 4 or 5 times while checking the fuel pressure gauge.

5. If the fuel pressure remains within 3 psi of itself across all readings, unplug the vacuum line and reconnect it.

6. If the pressure readings vary more than 3 psi, proceed to Fuel Filter Check.

FUEL PRESSURE REGULATOR CHECK



1. With the ignition switch in the **OFF** position, install a fuel pressure gauge at the pressure valve on the fuel rail.

2. Install a "T" in the vacuum line running from the regulator and the upper plenum. Install a vacuum gauge to the "T".

3. Start the engine and check both the pressure and vacuum gauges.

4. Increase the engine speed so that the vacuum level falls and check the pressure gauge.

5. If the fuel pressure increases as you accelerate and the vacuum decreases; and, if it decreases as you decelerate while the vacuum begins to increase, remove the gauges.

6. If the vacuum and pressure reading do not act inversely to one another, proceed to Vacuum Supply Check.

VACUUM SUPPLY CHECK



1. With the ignition switch in the **OFF** position, install a fuel pressure gauge at the pressure valve on the fuel rail.

2. Disconnect the vacuum line at the pressure regulator and plug it.

3. Connect a hand-operated vacuum pump to the regulator at the nipple.

4. Start the engine and check the fuel pressure while pumping the vacuum pump.

5. If the pressure reading changes as the vacuum changes, service the vacuum system and reconnect the vacuum line to the regulator.

6. If the fuel pressure does not change, replace the regulator.

FUEL PUMP RELAY VOLTAGE CHECK

◆ See Figure 29



1. With the ignition switch in the **OFF** position and the battery fully charged, ground the Blue/Orange fuel pump lead at the STO Self-Test connector (pin #52).

2. Connect a DVOM to the fuel pump relay.

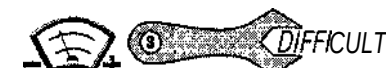
3. Turn the ignition switch to the **ON** position (but do not start the engine). Measure the voltage at the relay.

4. If voltage is more than 10.5V, look for an open circuit between the relay and the ECA.

5. If voltage is less than 10.5V, proceed to Fuel Pump Relay Power Supply Check.

FUEL PUMP RELAY POWER SUPPLY CHECK

◆ See Figure 30



1. With the ignition switch in the **OFF** position and the battery fully charged, disconnect the electrical leads and remove the relay.

2. Turn the ignition switch to the **ON** position (but do not start the engine). Measure the voltage between the ground terminal in the relay connector (black lead, pin #86) and both **B+** pins (red/purple lead, pin #30 and purple/black lead, pin #85).

3. If voltage on both **B+** pins is higher than 10.5V, proceed to Fuel Pump Relay Operation Check.

4. If voltage is not higher than 10.5V, check for a crimped or torn wire between the pump relay and the EEC power relay or the battery (**t**).

FUEL PUMP RELAY OPERATION CHECK

◆ See Figure 30



1. Remove the relay from the bracket.

2. Ground terminal #86 with a jumper wire and then connect a **B+** 12V power supply to #85. Measure the resistance between #30 and #87.

3. Resistance should be less than 1 ohm with the power source supplied and greater than 10,000 ohms when it is removed.

4. If not, replace the fuel pump relay.

FUEL PUMP OPERATION CHECK

◆ See Figure 29



1. With the ignition switch in the **OFF** position and the battery fully charged, ground the Blue/Orange fuel pump lead at the STO Self-Test connector (pin #52).

2. Turn the ignition switch to the **ON** position (but do not start the engine). You should be able to hear the fuel pumps and also feel a slight vibration to the touch.

3. If they are working, proceed to Fuel Filter Check.

4. If they are not working, check that the 20 amp circuit breaker is operating and the wiring is good. If everything is OK, proceed to Fuel Pump Voltage Check.

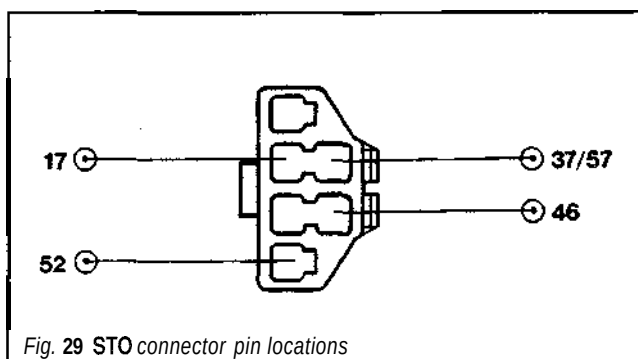
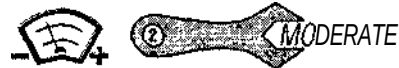


Fig. 29 STO connector pin locations

FUEL PUMP VOLTAGE CHECK

◆ See Figure 29



1. With the ignition switch in the **OFF** position and the battery fully charged, ground the Blue/Orange fuel pump lead at the STO Self-Test connector (pin #52).
2. Disconnect the electrical leads at the two fuel pumps.
3. Turn the ignition switch to the **ON** position (but do not start the engine).
4. Measure the voltage at the green/yellow power supply leads at each pump. If greater than 10.5V at each pump, proceed to Fuel Pump Ground Check.
5. If voltage is less than 10.5V, check the circuit between the ECA and the fuel pump connector and then proceed to Fuel Injection Pressure Test.

FUEL PUMP GROUND CHECK



1. With the ignition switch in the **OFF** position and the battery fully charged, disconnect the electrical leads at the two fuel pumps.
2. Measure the resistance between the black wire terminal and ground.
3. If each pump is less than 1 ohm, replace the pumps and then proceed to Fuel Injection Pressure Test.
4. If more than 1 ohm, check for an open wire to ground and then proceed to Fuel Injection Pressure Test.

FUEL FILTER CHECK



1. Remove the fuel filter and check its condition and also for any water.
2. If the filter requires replacement, proceed to Fuel Pump Ground Check.
3. If the filter is OK, reinstall it and repeat the Fuel Injection Pressure Test.

PRESSURE REGULATOR VALVE SEAT CHECK



1. Visually check the O-ring, gasket, mounting surfaces and regulator body for cracks or damage.
2. Connect a vacuum tester to the fuel outlet on the regulator and apply 20 in. Hg of vacuum.
3. If the vacuum drops below 10 in. Hg within 10 seconds, replace the regulator and then repeat the Fuel Injection Pressure Test.
4. If vacuum stays within specifications, proceed to Fuel Injector Function Check.

PRESSURE REGULATOR HIGH PRESSURE CHECK



1. With the ignition switch in the **OFF** position and the battery fully charged, remove the fuel return line at the fuel rail and the vapor separator.
2. Install a clear, fuel resistant, hose between the rail and the reservoir.
3. Install a fuel pressure gauge at the pressure valve.

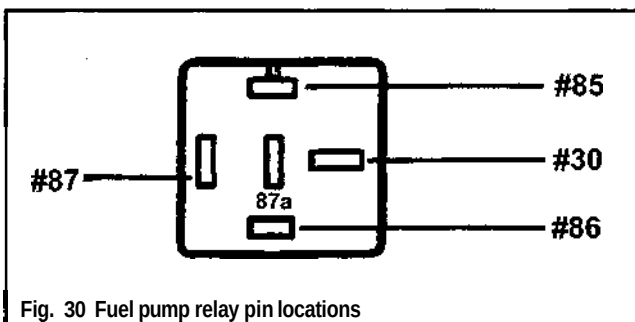


Fig. 30 Fuel pump relay pin locations

4. Ground the fuel pump lead as detailed in the Fuel Injection Pressure Check.
5. Turn the ignition switch to the **ON** position (but do not start the engine).
6. Note the fuel pressure reading and confirm that fuel is being returned to the reservoir through the clear tube.

CAUTION

Do not keep the pump lead grounded for more than 10 seconds.

7. If the pressure is still higher than 36-42 psi (248-290 kPa), replace the pressure regulator and then repeat the Fuel Injection Pressure Test.
8. If pressure is no longer high, proceed to the Fuel Return System Check.

FUEL RETURN SYSTEM HIGH PRESURE CHECK



1. Check the fuel return lines for blockage or kinking.
2. Remove the return line at the pressure regulator and apply 3-5 lbs. of compressed air to the line.
3. If you hear air entering the reservoir, reconnect the line.
4. If no air can be heard entering the reservoir, proceed to the Fuel Return System Check.

FUEL RETURN SYSTEM CHECK



1. With the ignition switch in the **OFF** position and the battery fully charged, remove the fuel return line at the pressure regulator and the vapor separator reservoir.
2. Apply 3-5 lbs. of compressed air to the line at the regulator.
3. If air flows freely through the line, service the reservoir.
4. If air does not flow through the line, replace it or attempt to clear the blockage. Install the line and repeat the Fuel Injection Pressure Check.

FUEL INJECTOR FUNCTION CHECK



1. With the engine at normal operating temperature and idling, check that you can hear each injector pulsing with a mechanic's stethoscope.

If the engine will not start, perform this step with the engine cranking.

2. If you can detect that the injectors are operating, proceed to Fuel Injector Flow/Leakage Check.
3. If they are not working, proceed to Fuel Injector Resistance Check.

FUEL INJECTOR RESISTANCE CHECK



1. With the ignition switch in the **OFF** position and the battery fully charged, disconnect each injector connector individually.
2. Check that the resistance on each injector is 13-16 ohms.
3. If within range, proceed to Fuel Injector Continuity Signal Check.
4. If outside the range, replace the injector.

FUEL INJECTOR CONTINUITY CHECK



1. With the ignition switch in the **OFF** position and the battery fully charged, disconnect any injector lead on bank 1.
2. Connect a 12V test light to the B+ terminal in the connector and then touch the probe to the other connector terminal.
3. Start the engine and observe whether the test light blinks or not. Obviously, if the tester lights, then the circuit has been completed.

9-18 FUEL SYSTEMS – FUEL INJECTION

4. Repeat this procedure for bank 2.
5. If the circuit has been completed, proceed to Fuel Injector Flow/Leakage Check.
6. If the circuit does not indicate continuity on either bank, go back and test each injector connector on that bank. Service or replace the individual lead as necessary.

FUEL INJECTOR FLOW/LEAKAGE CHECK



1. Using a Fuel Injector Tester/Cleaner (#113-00001), clean and test the injectors. Now clean them once more. Match the color range on the tester to the top color of the injector and confirm that the flow rate is within specifications.
2. Check for any appreciable pressure drop while the special tool is connected to the system, either due to leakage or turning the unit off.
3. Check injector leak rate using the tool, anything over 1 droplmin. is too much.
4. If flow and leak rates were within specification, check all fuel lines for leaks. If all lines are OK, replace the fuel pump assembly and then repeat the Fuel Injection Pressure Check.
5. If either were out of specification, replace any defective injectors and then repeat this test and the Fuel Pressure Leakdown Check.

Diagnostic Trouble Codes—EEC IV System

- **No Code**—Loss of VREF
- **Code 10**—Vapor Separator
- **Code 11**—System Pass
- **Code 12**—RPM outside Self-Test upper band limit
- **Code 13**—RPM outside Self-Test lower band limit
- **Code 14**—PIP circuit fault
- **Code 15**—ROM test failed/KAM power in continuous (1993)
- **Code 15**—ROM test failed/KAM power interrupt (1994-96)
- **Code 18**—Loss of TACH input to ECA/SPOUT circuit grounded
- **Code 19**—Failure in EEC reference voltage
- **Code 21**—ECT out of Self-test range
- **Code 22**—MAP out of Self-test range
- **Code 23**—TP out of Self-test range
- **Code 24**—ACT out of Self-test range
- **Code 25**—Inactive - Ignore code
- **Code 51**—40° indicated. ECT sensor circuit open
- **Code 52**—Shift assist circuit
- **Code 53**—TP circuit above maximum voltage
- **Code 54**—40° indicated. ACT sensor circuit open
- **Code 61**—254° indicated. ECT sensor circuit grounded
- **Code 63**—TP circuit below minimum voltage
- **Code 64**—254° indicated. ACT sensor circuit grounded
- **Code 67**—NDS circuit open
- **Code 72**—Insufficient MAP change - DYN RSP test
- **Code 73**—Insufficient TP change - DYN RSP test
- **Code 77**—Operator error - DYN RSP test
- **Code 87**—Fuel pump circuit failure
- **Code 95**—Fuel pump circuit open - ECA-to-motor ground
- **Code 96**—Fuel pump circuit open - BAT-to-relay
- **Code 98**—FMEM failure

GENERAL INFORMATION

Electronic Control Assembly (ECA)

One portion of the ECA is devoted to monitoring both input and output functions within the system. This ability forms the core of the self-diagnostic system. If a problem is detected within a circuit, the controller will recognize the fault, assign it an identification code, and store the code in memory. All codes are 2-digit numbers and may be retrieved during diagnosis.

While the EEC-IV system is capable of recognizing many internal faults, certain faults will not be recognized. Because the computer system sees only electrical signals, it cannot sense or react to mechanical or vacuum faults that may affect engine operation. Some of these faults though may affect another component which will set a code.

For example, the ECA monitors the output signal to the fuel injectors, but cannot detect a clogged injector. As long as the output driver is responding

correctly, the computer will read the system as functioning properly. However, the improper fuel will probably result in a lean mixture. This could, in turn, be detected by the knock sensor and then noticed by the ECA. Once the signal falls outside the pre-programmed limits, the ECA would notice a fault and then set a code.

Failure Mode Effects Management (FMEM)

The ECA contains back-up programs which allow the engine to operate if a sensor signal is lost. If a sensor input is seen to be out of range—either high or low—the FMEM program kicks in. The processor substitutes a fixed value for the missing sensor signal. The engine will continue to operate, although performance and driveability may be noticeably reduced. This function of the controller is sometimes referred to as the limp-home or fail-safe mode. If the missing sensor signal is restored, the FMEM system immediately returns the system to normal operation.

When this cycle is in effect, the Self-Test function will show a service code 98.

The error code associated with a particular fault will be stored in the Keep Alive Memory (KAM). If the fault is no longer detected, the engine will return to normal operating mode and the code will then be stored in Continuous Memory for the next 40 engine cycles before it is erased.

HAND-HELD SCAN TOOLS

◆ See Figure 31

Although codes may be read through the flashing of the light, the use of hand-held scan tools like the OMC MFI Tester (#500004) or an equivalent is highly recommended. There are alternate manufacturers of these tools so be very certain that the tools is correct for your intended use and application.

The scan tools allows any stored fault codes to be read from the ECA memory. Use of the scan tool also provides additional data during troubleshooting, but does not eliminate the use of charts. Scan tools make data collection much easier, but the data must be correctly interpreted by an operator familiar with the system.

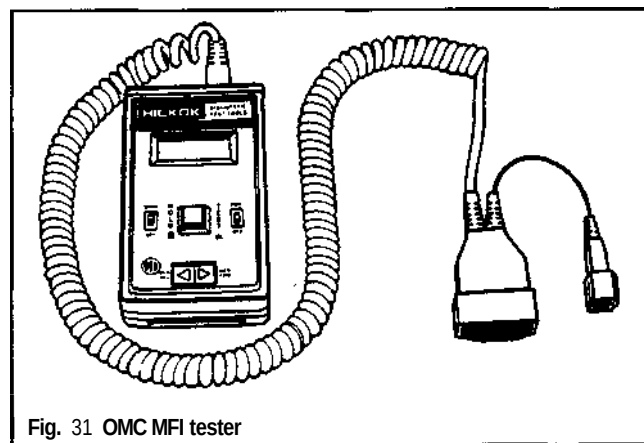


Fig. 31 OMC MFI tester

ELECTRICAL TOOLS

◆ See Figure 32

The most commonly required electrical diagnostic tool is the digital multi-meter (DVOM); allowing voltage, ohmage (resistance) and amperage to be read by one instrument. Many diagnostic tests require the use of a volt or ohmmeter during diagnosis.

The multi-meter must be a high impedance unit, with 10 megohms of impedance in the voltmeter. This type of meter will not place an additional load on the circuit being tested—extremely important when testing low voltage circuits. The multi-meter must be of high quality in all respects. It should be handled carefully and protected from impact or damage. Replace the batteries frequently.

Additionally, an analog (needle-type) voltmeter may be used to read stored fault codes if the MFI tester is not available. Codes will be transmitted as visible needle sweeps on the face of the instrument.

Almost all diagnostic procedures will require the use of a Breakout Box, a device which connects to the EEC-IV harness and provides testing ports for

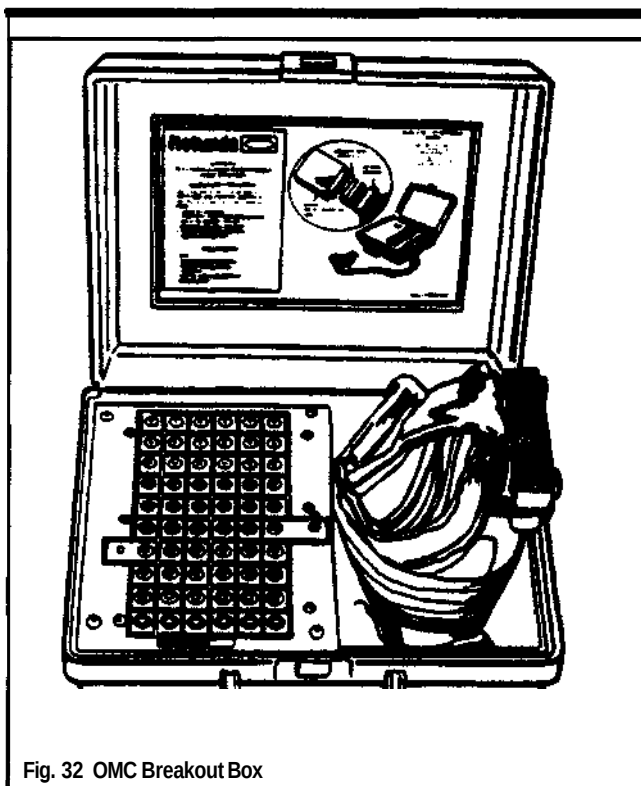


Fig. 32 OMC Breakout Box

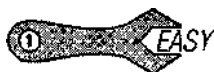
the 60 wires in the harness. Direct testing of the harness connectors at the terminals or by back-probing is not recommended; damage to the wiring and terminals is almost certain to occur.

Other necessary tools include a quality tachometer with inductive pick-up, a fuel pressure gauge with system adaptors and a vacuum gauge with an auxiliary source of vacuum.

READING CODES

Diagnosis of a problem requires attention to detail and following the diagnostic procedures in the correct order. Always resist the temptation to begin extensive testing before completing the preliminary diagnostic steps. The preliminary or visual inspection must be completed in detail before the diagnosis begins. In many cases this will shorten diagnostic time and often cure the problem without electronic testing.

Visual Inspection



This is possibly the most critical step of all diagnoses. A detailed examination of all connectors, wiring and vacuum hoses can often lead to a repair without further diagnosis. Performance of this step relies heavily on the skill of the person performing it; a careful inspector will inspect the underside of all hoses as well as the integrity of hard-to-reach hoses blocked by other components. All wiring should be checked carefully for any signs of strain, burning, crimping or terminal pull-out from a connector.

Checking connectors at components or in harnesses is required; usually pushing them together will reveal a loose fit. Pay particular attention to ground circuits, making certain they are not loose or corroded. Remember to check connectors and hose fittings at components not mounted on the engine. Any component or wiring in the vicinity of a fluid leak or spill should be given particular attention during inspection.

Additionally, inspect maintenance items such as belt condition and tension, battery charge and condition, and the radiator cap. Any of these items can easily set off a condition that will create a fault code.

Electronic Testina



If a code was set before a problem was self-corrected (such as a momentarily loose connector), the code will be erased if the problem does not re-occur within 40 engine cycles. Codes will be output and displayed as numbers on the hand-held tester.

In all cases, the code **11** is used to indicate PASS during testing. Please note that the PASS code may appear followed by other stored codes. These are codes from the Continuous Memory and may indicate intermittent faults, even though the system does not presently contain the fault. The PASS designation only indicates that the system passes all internal tests at the moment.

Key On Engine Off (KOEO) Test

The engine must be a normal operating temperature before performing this test and all visual checks should be completed.

1. Connect the MFI Tester to the STO and STI connectors on top of the ECA cover.
2. Set the Mode switch on the tester to the **FAST** position.
3. Set the SPKR switch on the tester to the **OFF** position.
4. Set the HOLD/TEST button to the **HOLD** position (raised).
5. Turn on the PWR switch. It should beep once and then briefly display 888 and then settle in at **000**.
6. Turn the ignition key to the ON position, but do not start the engine.
7. Press the HOLD/TEST button down to put the ECA into the Self-Test mode. After approximately 1 minute, any service codes should begin to appear on the screen.

*** WARNING

Do not press the HOLD/TEST button again while the system is in Self-Test mode or you will erase all Continuous Memory codes.

8. Self-Test is complete when **CCRCVD** appears in the window. Press the HOLD/TEST button again to release it and lock all codes into the tester's memory.

9. Turn the ignition key to **OFF**.

10. You can use the **MEM/FWD** and **MEMREV** buttons to review the codes stored in the tool's memory. The first code will always be proceeded by a "beep" and the **1ST CD** prompt. Always review codes in the EXACT order in which they have been displayed.

Key On Engine Running (KOER) Test

The engine must be a normal operating temperature before performing this test and all visual checks should be completed.

1. Connect the MFI Tester to the STO and STI connectors on top of the ECA cover.
2. Set the Mode switch on the tester to the **FAST** position.
3. Set the SPKR switch on the tester to the **OFF** position.
4. Set the HOLD/TEST button to the **HOLD** position (raised).
5. Turn on the PWR switch. It should beep once and then briefly display 888 and then settle in at **000**.
6. Start the engine and allow it to idle for 10 seconds prior to moving on to the next step.
7. Press the HOLD/TEST button down to put the ECA into the Self-Test mode. After approximately 2 minutes, any service codes should begin to appear on the screen. For the first minute, the system will actuate the "High Idle" Self-test so you can confirm the ECA's control of timing.

If a DYN RSP prompt appears, or a Code 10 appears toward the end of the "High Idle" test, ignore it.

XX WARNING

Do not press the HOLD/TEST button again while the system is in Self-Test mode or you will erase all Continuous Memory codes.

8. Self-Test is complete when **CCRCVD** appears in the window. Press the HOLD/TEST button again to release it and lock all codes into the tester's memory.

9. Turn the ignition key to **OFF**.

10. You can use the **MEM/FWD** and **MEMREV** buttons to review the codes stored in the tool's memory. The first code will always be proceeded by a "beep" and the **1ST CD** prompt. Always review codes in the EXACT order in which they have been displayed.

9-20 FUEL SYSTEMS – FUEL INJECTION

CLEARING CODES

Continuous Memory Codes



As mentioned previously, these codes are normally stored in the ECA memory for a duration of 40 engine warm-up cycles. To clear the codes for

the purpose of testing or repair confirmation, perform the KOEO test. When the codes are just beginning to come up on the display, Press off the **HOLD/TEST** button and the codes will automatically be erased from the system's memory.

Do not disconnect the battery to clear the codes—they'll clear, but in the process set another code (19) for the ECA power loss.

VOLTAGE REFERENCE VALUES

Sensors

Sensor	DVOM Setting	Black Lead	Red Lead	Value	Notes
VREF	DCV	46	26	4.74-5.25V	-
TP	DCV	46	47	0.9-1.15V 4.65V	Throttle Closed WOT
ECT	DCV	46	7	0.87-1.17V	①
ACT	DCV	46	25	1.13-1.53V	①
MAP	Hz	46	45	159 Hz	②
PIP	DCV	46	56	0.0-0.3V	③
				VBAT	④
KS	DCV	46	2	0.3V	-
SAS (1993)	DCV	40	10	0	Not Actuated
				VBAT	Actuated
NDS (1993)	DCV	46	30	0	Neutral
				5	FWD & REV

① Measure the temperature with a pyrometer at the base of the sensor

② Based on 30 in.Hg pressure. Signal increases as pressure increases

③ Distributor cup opening in alignment with Hall Effect device

④ Distributor cup vane in alignment with Hall Effect device

Actuators

Sensor	DVOM Setting	Black Lead	Red Lead	Value
INJ Bank #1	DCV	40	58	VBAT
INJ Bank #2	DCV	40	59	VBAT
ISC	DCV	40	21	VBAT
FP	DCV	40	52	VBAT

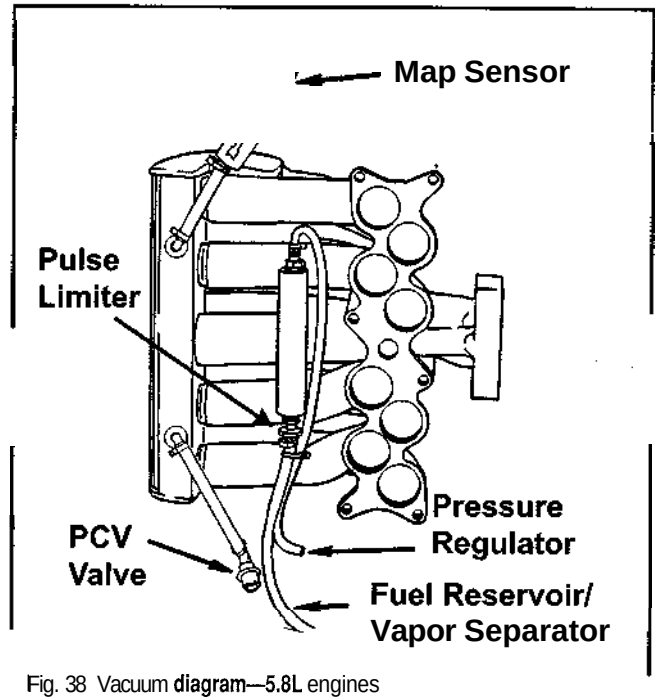
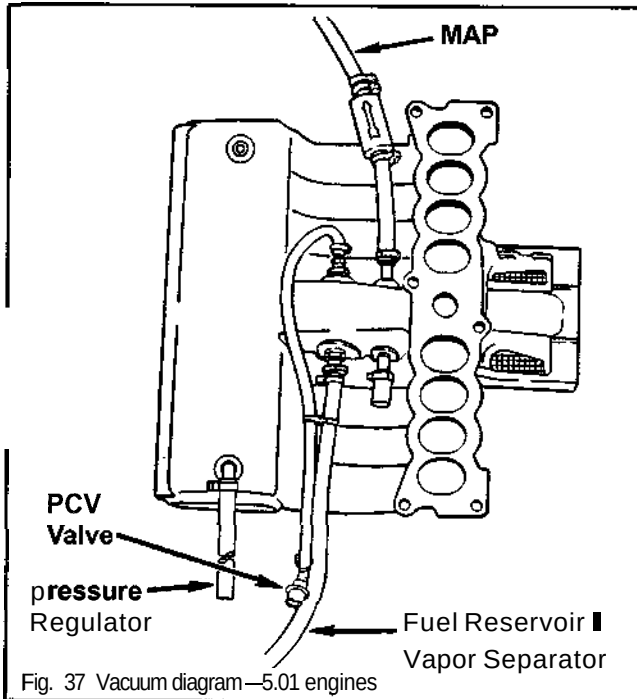
Grounds

Sensor	DVOM Setting	Black Lead	Red Lead	Value
IGN	DCV	40160	16	0
CSE	DCV	40/60	20	0
PWR	DCV	40160	20	0

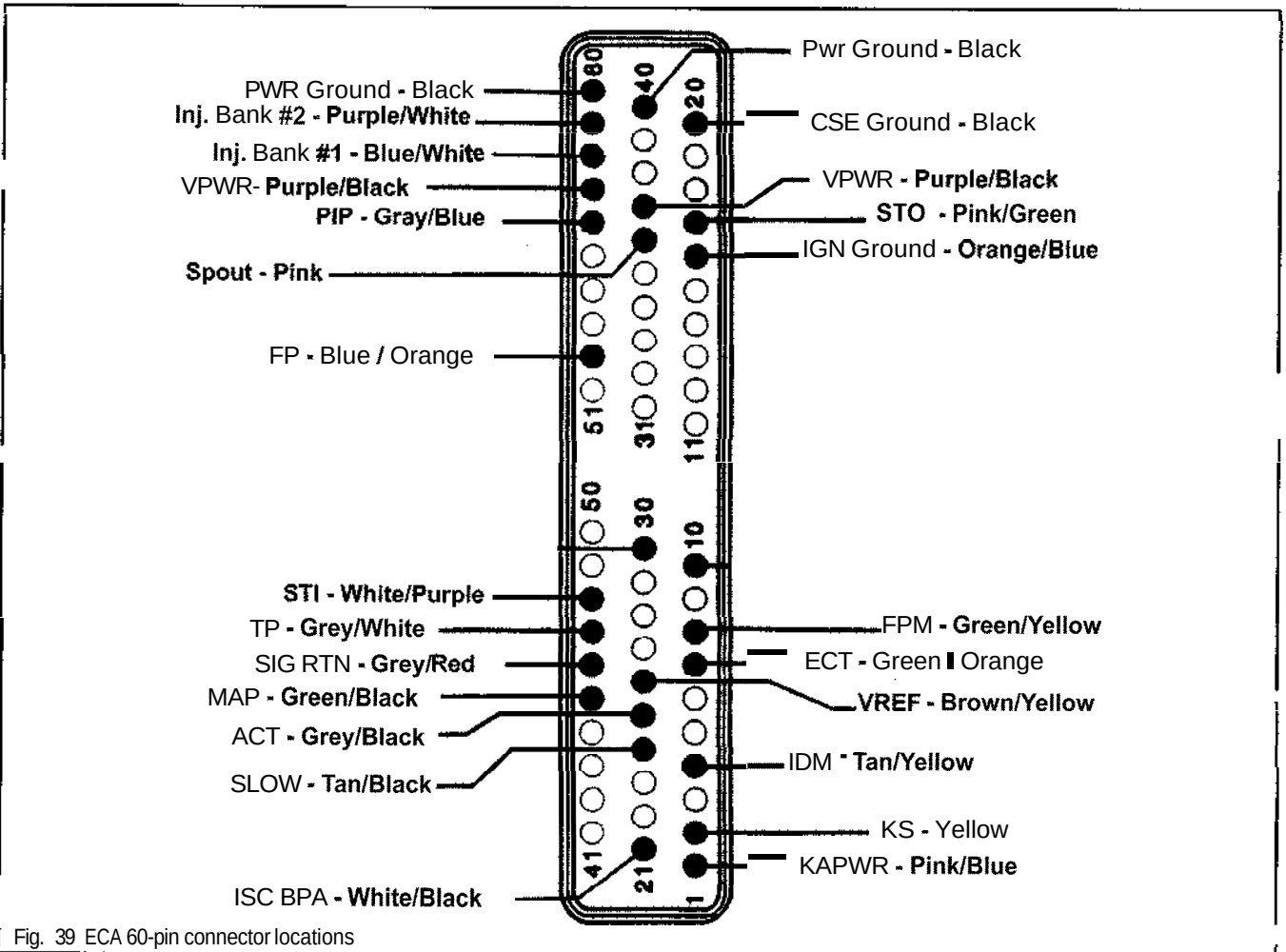
Power Supply

Sensor	DVOM Setting	Black Lead	Red Lead	Value	Notes
KAPWR	DCV	40/60	1	VBAT	Key On & Off
VPWR	DCV	40160	37/57	VBAT	Key On only

VACUUM DIAGRAMS



PIN LOCATIONS



9-22 FUEL SYSTEMS – FUEL INJECTION

GM THROTTLE BODY FUEL INJECTION (TBI)

GM MULTI-POINT FUEL INJECTION (MPI)

Description And Operation

The purpose of this section is to describe—in layman's terms whenever possible—the Throttle Body Fuel Injection (TBI) and Multi-Point Fuel Injection (MPI) systems installed on many GM engines covered in this manual.

Visual inspections, and simple tests that may be performed using only basic shop test equipment. Again, we emphasize: specialized test equipment, hours of training and considerable experience is required to perform detailed service on a fuel injection system which may or may not be beyond the scope of your skill level.

The first fuel injection system was introduced in Europe over 60 years ago—in 1932 on diesel truck engines. In the beginning, the system and individual components were quite expensive. Over the years, state-of-the-art microprocessors (commonly referred to as "computer chips"), have lowered the cost of electronically controlled fuel injection systems. Today, the price of EFI is getting close to the cost of modern carbureted systems.

An electronic fuel injection system is quite different from a carburetor system—even though they appear similar (particularly TBI). The fuel injection system has a more efficient delivery of fuel to the cylinders than can be obtained with standard carburetor operation.

The EFI system provides a means of fuel distribution by precisely controlling the air/fuel mixture and under all operating conditions for, as near as possible, complete combustion.

This is accomplished by using an Electronic Control Module (ECM), a small 'on-board' micro-computer that receives electrical inputs from various sensors about engine operating conditions. The ECM uses these inputs to modify fuel delivery to achieve, as near as possible, an ideal air/fuel ratio of 14.7:1.

The ECM program automatically signals the fuel injectors in the throttle body assembly to provide the correct quantity of fuel for a wide range of operating conditions. Several sensors are used to determine existing operating conditions and the ECM then signals the injectors to provide the precise amount of fuel.

The ECM has a "learning" capability. That is, if the battery is disconnected for any reason, the learning process has to begin all over again.

On TBI systems, the TBI assembly is located on the intake manifold, much like a carburetor, where air and fuel are distributed through a bore in the throttle body. Air for combustion is controlled by a throttle valve connected to the throttle linkage. Fuel is supplied by two injectors mounted in the TBI assembly; their metering tips are located directly above the throttle valve.

On MPI systems, there is a throttle body located on the intake manifold, much like a carburetor except that only air is distributed and metered through the bores on the throttle body. Air for combustion is controlled by a throttle valve connected to the throttle linkage. Fuel is supplied by individual injectors mounted in the intake manifold and attached to a fuel rail assembly.

Each injector is "pulsed" or "timed to open or close by an electronic signal from the ECM. While constantly receiving input from various sensors, the ECM performs high speed calculations of engine fuel requirements and then "pulses the injectors open or closed.

MODES OF OPERATION

The ECM receives signals from several sensors, and then responds by delivering the proper amount of fuel to the cylinders under one of several conditions. These conditions are labeled "modes" and are controlled by the ECM, as described in the following short sections.

Starting Mode

When the ignition switch is rotated to the crank position, the ECM energizes the fuel pump relay for 2 seconds and the pump builds up pressure. The ECM then checks the Engine Coolant Temperature (ECT) sensor, Manifold Absolute Pressure (MAP) sensor, Intake Air Temperature (IAT) sensor and the Throttle Position (TP) sensor. From these incoming signals, the ECM determines the correct air/fuel ratio for starting the engine. The ECM controls the amount of fuel delivered in the starting mode by changing the length of time the injectors are turned on and off. This is accomplished by "pulsing" the injectors briefly.

Clear Flood Mode

A flooded engine can be cleared by opening the throttle to 75% of its travel. Once this is done, the ECM shuts down the fuel injectors and no fuel is delivered to the cylinders. The ECM will hold this injector rate as long as the throttle remains at 75% open and engine speed is below 400 rpm. If the throttle position changes to greater than 75% or slightly less than 75%, the ECM will return to the starting mode.

Run Mode

When the engine is first started and operating above 400 rpm, the system operates in the Run Mode. The ECM will calculate the desired air/fuel ratio based on rpm and input from the MAP, TP, IAT or ECT sensors. Higher engine load, from the MAP, and colder engine temperature, from the ECT requires more fuel, or a richer air/fuel ratio.

Acceleration Mode

If the ECM receives rapid change signals from the TP sensor, the ECM will provide extra fuel by increasing the injector pulse width.

Fuel Cut-off Mode

When the ignition switch is in the **OFF** position, no fuel is delivered to the cylinders by the injectors. Therefore, "dieseling" is prevented. If the ECM does not receive a distributor reference pulse—the engine is not operating—no fuel pulses are delivered to the injectors.

The fuel cut-off mode is also enabled at high engine rpm. This feature is an over-speed protection for the engine. Now, when cut-off is in effect due to high rpm, injector pulses will resume after engine rpm drops below the maximum OEM rpm specification (you now this as 'rev limit').

RPM Reduction Mode (SLOW)

The rpm reduction mode operates as an engine protection feature. The reduction mode permits normal fuel injection up to OEM specifications of approximately 2500 rpm. The ECM can recognize a change of state in a discrete input identifying an abnormal condition affecting engine operation. If a switch changes from its normal 'at rest' position, the ECM will sense the change in voltage and send the engine into Speed Limited Operational Warning (SLOW) safety mode.

Once the max rev rpm is hit, the system will disable half the injectors until engine speed drops below 1200 rpm.

Deceleration Mode

When backing off the throttle (decelerating) on certain late-model MPI engines, the air flow into the engine is reduced. The ECM recognizes the corresponding changes in the throttle position and manifold pressure and then shuts off fuel supply if the deceleration is very abrupt or for a long period.

SUBSYSTEMS

Fuel Metering System

◆ See Figures 40 and 41

As the name suggests, the fuel metering system "meters" the correct amount of fuel delivered to the cylinders through the intake manifold under all engine operating conditions. Fuel is delivered by the throttle body (TBI) or the individual injector (MPI) and is controlled by the ECM.

Fuel Supply

Naturally, the fuel supply will begin at the boat's fuel tank. From the fuel tank, the fuel is drawn through a water separating fuel filter and then moved by the low pressure fuel pump to the Vapor Separator Tank (VST). All models utilize an additional high pressure fuel pump found in the VST, which then moves the fuel on to the TBI unit. A pressure regulator is standard on all engines.

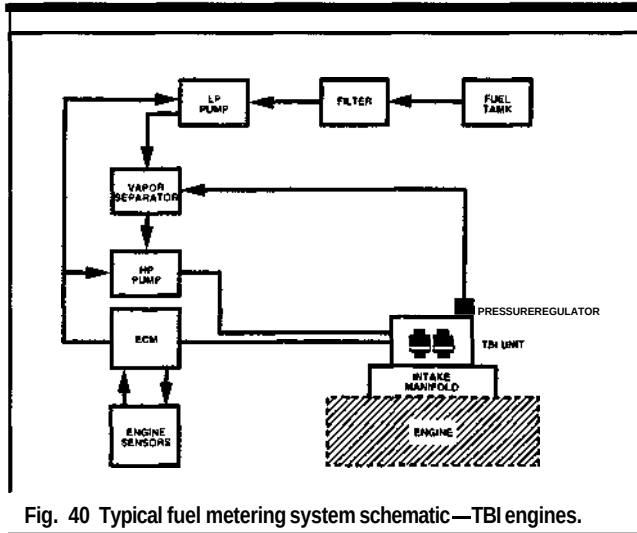


Fig. 40 Typical fuel metering system schematic—TBI engines.

Water Separating Fuel Filter

The water separator is a "typical" unit designed to prevent moisture from continuing on through the fuel lines and eventually through the injectors into the cylinders.

Electric Fuel Pump

◆ See Figure 42

The low pressure fuel pump is located in line, just after the fuel separator assembly.

The high pressure fuel pump is located internally in the vapor separator tank.

When the ignition switch is moved to the ON position, the ECM will energize the fuel pump relay to ON, but only for a couple of seconds. The fuel pump almost instantly pressurizes the fuel system. As soon as the ignition switch is moved to the START position, the ECM energizes the fuel pump relay again and the fuel pump begins to operate.

Now, if the ECM fails to receive ignition reference pulses—indicating the engine is either cranking or actually operating—the ECM de-energizes the fuel pump relay and the fuel pump will stop.

An inoperative fuel pump relay can cause an "Engine Cranks, But Fails To Operate" condition.

The pump is capable of providing more fuel than is required by the injectors at WOT (wide open throttle). A pressure regulator is an integral part of the system maintaining fuel to the injectors at a predetermined regulated pressure. Excess fuel not required by the injectors is returned to the vapor separator tank by a separate fuel line.

Vapor Separator Tank/Fuel Reservoir

The vapor separator tank contains the internal electric fuel pump that pressurizes fuel to the throttle body. The tank also collects all excess fuel returned from the injectors through the pressure regulator.

A float valve on the fuel inlet line will keep the fuel level in the tank at a pre-determined height at all times. As the fuel is consumed by the engine and the level begins to drop, the float valve opens and allows fresh fuel to enter the tank. This float valve operates identically to a float in a carburetor.

Throttle Body

Models With TBI

- The throttle body consists of the following assemblies:
- Fuel Meter Cover—also houses the pressure regulator on models with a vapor separator tank or fuel cell.
 - Fuel Meter Body—two fuel injectors.
 - Throttle Body.
 - Throttle Valves—two throttle valves controlling air flow into the cylinders.
 - IAC (Idle Air Control) valve.
 - TP (Throttle Position) sensor.

From the above list of components, it can easily be appreciated why the throttle body is considered one of the most critical items in the injection system. If the proper amount of air and fuel are not injected into the cylinders, the engine will not operate efficiently or may even fail to start.

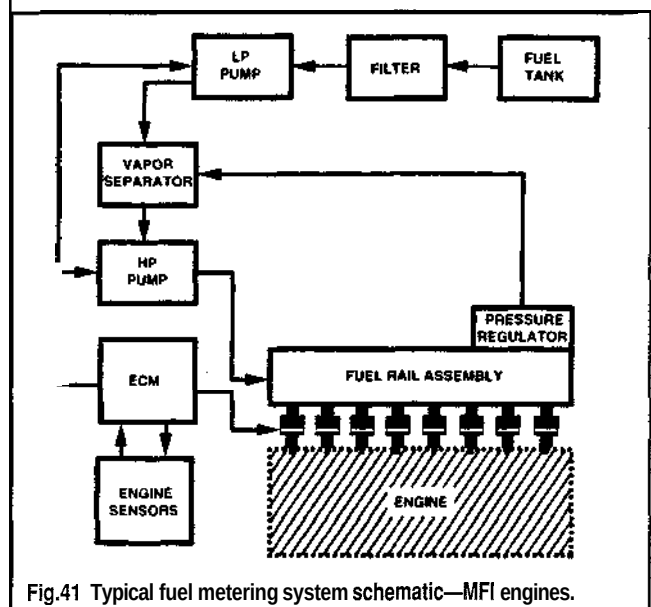


Fig. 41 Typical fuel metering system schematic—MFI engines.

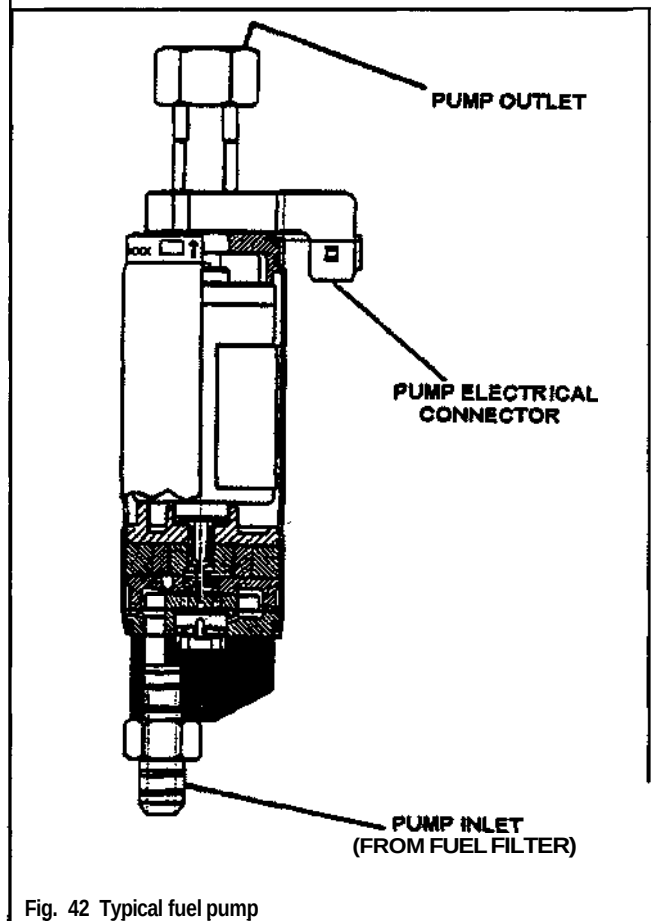


Fig. 42 Typical fuel pump

Models With MFI

The throttle body assembly is attached to the intake manifold or plenum and controls air flow to the engine, thus controlling engine output. Throttle valves within the assembly are controlled by the throttle cables. At idle, the valves are almost completely closed, while they open wider in proportion to the amount of throttle applied by the operator.

The TP sensor and IAC valve can also be found mounted to the throttle body.

9-24 FUEL SYSTEMS – FUEL INJECTION

Fuel Rail

Models With MFI

The fuel rail positions the injectors in the intake manifold, distributes fuel evenly to each injector and integrates the pressure regulator into the entire metering system.

Fuel Pressure Regulator

◆ See Figure 43

The pressure regulator is a diaphragm operated relief valve with fuel pump pressure on one side, and regulator spring pressure on the other side. The purpose of the regulator is to maintain a constant pressure differential across the injectors at all times under all conditions.

The regulator is located in the throttle body assembly on TBI models with a vapor separator tank or fuel cell, while on MFI models it is mounted on the fuel rail.

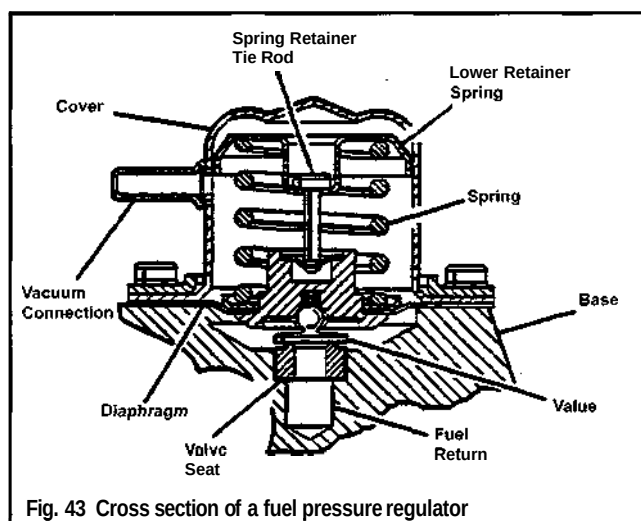


Fig. 43 Cross section of a fuel pressure regulator

Fuel Injectors

◆ See Figures 44 and 45

TBI Engines

Each injector is a solenoid-operated device, controlled by the ECM, that meters pressurized fuel into the intake manifold. When the injector's solenoid is energized by the ECM, a ball valve opens allowing fuel to flow past the valve and through a recessed flow director plate.

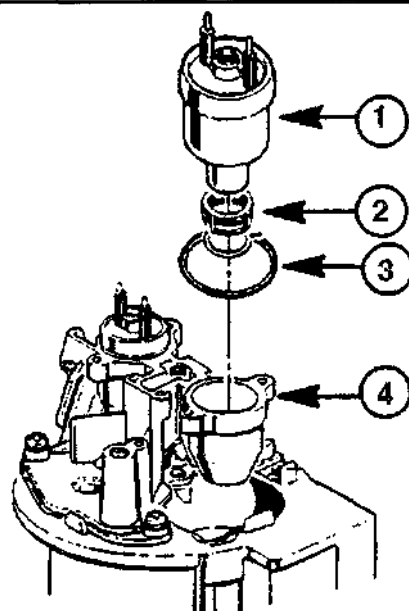
The director plate has 6 holes that control the fuel flow, generating a conical spray pattern of atomized fuel at the injector tip. Fuel is directed at the intake valve, becoming further atomized and then vaporized prior to entering the combustion chamber.

MFI Engines

Each injector is a solenoid-operated device, controlled by the ECM, that meters pressurized fuel into an individual engine cylinder. When the injector's solenoid is grounded by the ECM, a ball valve opens allowing fuel to flow past the valve and through a flow director plate. The director plate has six holes that control the fuel flow, generating a conical spray pattern of atomized fuel at the injector tip.

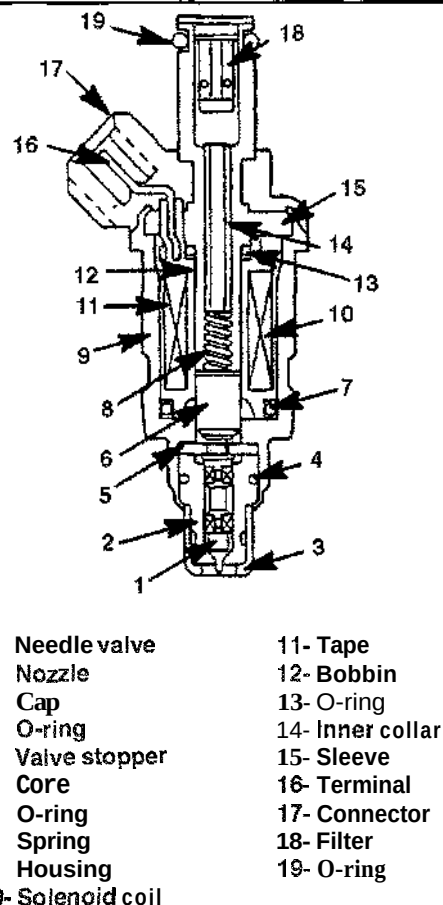
Intake Air Temperature Sensor (IAT)

This sensor, primarily used on many MFI engines, is a thermistor mounted on the underside of the intake plenum. A thermistor is a resistor capable of changing value based on temperature. Low coolant temperature produces a high resistance and a high temperature causes low resistance.



- 1- Fuel injector
- 2- Fuel filter
- 3- Seal ring
- 4- Fuel meter body

Fig. 44 On TBI engines, there are two fuel injectors in the throttle body



- 1- Needle valve
- 2- Nozzle
- 3- Cap
- 4- O-ring
- 5- Valve stopper
- 6- Core
- 7- O-ring
- 8- Spring
- 9- Housing
- 10- Solenoid coil
- 11- Tape
- 12- Bobbin
- 13- O-ring
- 14- Inner collar
- 15- Sleeve
- 16- Terminal
- 17- Connector
- 18- Filter
- 19- O-ring

Fig. 45 Cross-section of the fuel injector on MFI engines

Idle Air Control Valve (IAC)

◆ See Figure 46

The IAC valve assembly is mounted in the throttle body and controls engine idle speed. At the same time, the assembly prevents stalls due to changes in engine load.

Operation of the IAC can best be described as a device to control bypass air around the throttle valves. This feature is accomplished by moving a conical valve known as a "pintle" inward towards a seat—to decrease air flow or outward, away from the seat—to increase air flow. In this manner, a controlled amount of air moves around the throttle valve.

If rpm is too low, more air is bypassed around the throttle valve to increase rpm. If rpm is too high, less air is bypassed around the throttle valve to decrease rpm.

The ECM moves the IAC valve in small increments. These increments can only be measured using expensive special scan tool test equipment plugged into a DLC (Data Link Connector).

During engine idle speed, the proper position of the IAC valve is calculated by the ECM, and is based on coolant temperature and engine rpm. If the rpm drops below specification and the throttle valve is closed, the ECM senses a near stall condition and calculates a new valve position to prevent the stall.

Understand—engine idle speed is a function of total air flow into the cylinders based on IAC valve "pintle" position to maintain the desired idle speed for all engine operating conditions and loads.

The minimum idle air rate is set at the factory with a stop screw. This setting allows sufficient air flow by the throttle valves to cause the IAC valve "pintle" to be positioned a calibrated number of steps (counts) from the seat during "controlled" idle operation.

Throttle Position Sensor (TP)

◆ See Figure 47

The TP sensor is a potentiometer connected to the throttle shaft on the throttle body. One end of the sensor is connected to 5-volts from the ECM and the other end is connected to ECM ground.

A third wire is connected directly to the ECM to measure the voltage from the TP sensor. The voltage output of the TP sensor changes when the throttle valve angle is changed.

When the throttle position is closed, the voltage output of the TP sensor is low—about 112 V. When the throttle valve is opened, the output increases and at WOT the output voltage should be close to 5 V.

Therefore, the ECM can determine fuel delivery requirements based on throttle valve angle—operator demand.

Engine Coolant Temperature Sensor (ECT)

◆ See Figure 48

This sensor is a thermistor immersed in the engine coolant passageway. A thermistor is a resistor capable of changing value based on temperature. Low coolant temperature produces a high resistance and a high temperature causes low resistance.

Manifold Absolute Pressure Sensor (MAP)

+ See Figure 48

The MAP sensor is a pressure transducer capable of measuring the changes in the intake manifold pressure. Pressure changes are the result of engine load and speed changes. MAP is the opposite of what is measured with a vacuum gauge.

When manifold pressure is high, vacuum is low—requires more fuel and of course the opposite is true. A low pressure—higher vacuum requires less fuel. The MAP sensor is also used to measure barometric pressure under certain conditions. This feature permits the ECM to automatically adjust for changes in operating altitude.

The ECM uses the MAP sensor to control fuel delivery and ignition timing.

Knock Sensor (KS)

◆ See Figure 50

The KS is usually mounted on the engine block drain "Y" fitting located on the lower starboard side of the engine block. On many other engines, the KS sensor is mounted on the block, next to the starter motor.

The ECM uses this signal in calculating ignition timing.

Knock Sensor Module

◆ See Figure 51

Used on 1994-98 engines, the KS module contains solid-state circuitry monitoring the KS AC voltage signal. If no spark knock is present an 8-10 volt signal is sent to the ECM. If a spark knock is present, the module will remove the 8-10 volt signal to the ECM.

Ignition Control (IC) Reference

The Hi Reference signal is supplied to the ECM by way of the "IC REF" line from the ignition module. The reference signal is used by the ECM to determine engine speed. This pulse type signal input creates the timing signal for pulsing of the fuel injections as well as the Ignition Control (IC) functions.

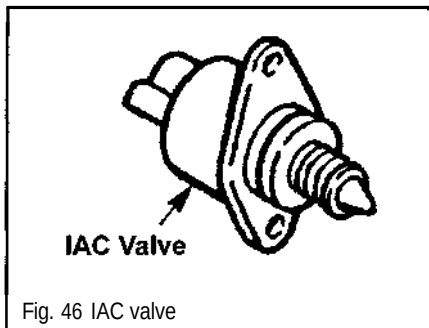


Fig. 46 IAC valve

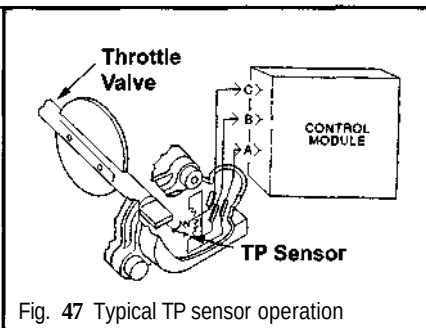


Fig. 47 Typical TP sensor operation

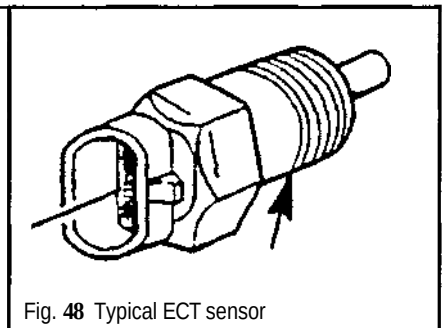


Fig. 48 Typical ECT sensor

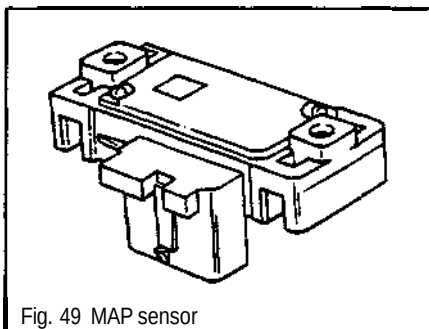


Fig. 49 MAP sensor

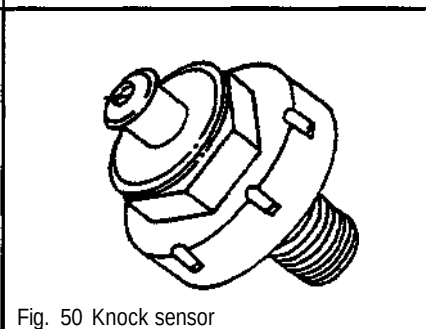


Fig. 50 Knock sensor

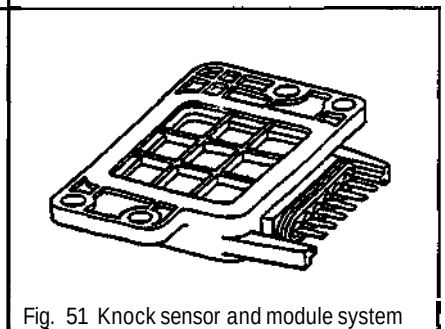


Fig. 51 Knock sensor and module system

9-26 FUEL SYSTEMS – FUEL INJECTION

Discrete Switch Inputs

Discrete switch inputs are utilized by the EFI system to identify abnormal conditions that could affect engine and stern drive operation. Normally these switches are at rest in an open position. When one of the discrete switches changes state from open to closed, the ECM will detect a change in the voltage value and responds by placing the engine into the power reduction mode.

The power reduction mode is an engine protection feature that allows the operator limited engine power up to 2500 rpm. Should the operator attempt to surpass this rpm limit, the ECM will reduce fuel and spark timing until the engine speed drops to approximately 1200 rpm. The power reduction mode will allow the operator maneuvering power but eliminates the possibility of high rpm engine damage, until the discrete switch fault condition is corrected.

Discrete switches are used to detect the critical engine and stern drive operations—namely Engine Oil Pressure, Oil Level, Emergency Stop, Water Flow and Stern Drive Fluid Level.

Trim Position Sensor

The trim position sensor provides the ECM with trim angle information which allows the ECM to determine if trim angle too high. When the angle reaches a pre-determined position, the system will move into an over-trim protection mode which is identical to the RPM Reduction Mode described previously.

Engine Control Module (ECM)

The ECM is the control center of the fuel injection system, monitoring input information from all sensors and then turning this information into system commands that affect engine performance.

Additionally, it will perform a diagnostic function check of the entire system; recognizing system problems and storing the resultant diagnostic trouble codes.

Relieving Fuel Pressure

✱✱ CAUTION

To reduce the risk of fire and personal injury, it is necessary to relieve the fuel system pressure before servicing any fuel system component. If this procedure is not performed, fuel may be sprayed out of a connection under extreme pressure. Always keep a dry chemical fire extinguisher near the work area when serving the fuel system.

TBI ENGINES

The throttle body utilizes a constant bleed feature that relieves fuel system pressure whenever the ignition switch is turned OFF and the engine is not running. No pressure relief procedure is required although prior to fuel system work, the negative battery cable should always be disconnected and the fuel tank filler cap should be loosened.

MFI ENGINES



1. Open the engine compartment and disconnect the battery cables.
2. Unscrew the relief valve cap on the high pressure fuel pump. Connect the special adapter (Owatonna #OTC-7272) to the valve and then connect a fuel pressure gauge (Owatonna #OTC-7211) to the adapter.

✱✱ CAUTION

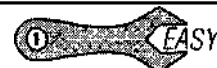
Wrap a towel around the valve while connecting the special tools to avoid excessive fuel spillage.

3. Position the bleeder hose in an appropriate container and open the valve to bleed off all pressure (and any excess fuel!)
4. Remove the special tools and install the valve cap.

Circuit Breaker

REMOVAL & INSTALLATION

- ◆ See Figure 67



1. Open the engine compartment and disconnect the battery cables.
2. Locate the circuit breaker on the fuel pump lift bracket (front of engine) or the electrical bracket on later engines and disconnect the two electrical leads.

Please refer to the Component Locations section.

3. Remove the screws/nuts and lift off the breaker.
4. Install a new circuit breaker and tighten the screws/nuts to 20-25 inch lbs. (2.3-2.8 Nm).
5. Connect the Red lead to one stud on the circuit breaker and the Red/Purple lead to the other. Tighten the nuts 20-25 inch lbs. (2.3-2.8 Nm). Coat the two terminals with Liquid Neoprene.

Coolant Cover Assembly

REMOVAL & INSTALLATION



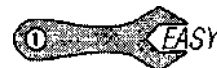
1996-98 MFI Engines Only (Except 1998 7.4Gi)

- ◆ See Figure 75

1. Remove the throttle body from the upper plenum as detailed elsewhere.
2. Remove the IAC valve.
3. Carefully turn the throttle body over and remove the coolant cover retaining screws. Lift off the cover and gasket.
4. Position a new gasket on the throttle body and then install the cover. Tighten the screws to 28 inch lbs. (3.2 Nm).
5. Install the IAC valve.
6. Install the throttle body.

Engine Coolant Temperature Sensor (ECT)

REMOVAL & INSTALLATION



- ◆ See Figures 52, 53, 71 and 72

□ Please refer to the Component Locations section.

1. Disconnect the battery cables.
2. Tag and disconnect the electrical connector at the sensor and move it out of the way.
3. Unscrew the ECT from the intake manifold (or housing) and remove it. Clean the sensor with a dry cloth; make sure to remove any excess sealant from the threads.
4. Coat the threads of the sensor with Teflon pipe sealant. Screw the sensor into the housing until it is hand tight and then tighten it to 108 inch lbs. (12 Nm).
5. Connect the electrical lead. Connect the battery cables.

Electronic Control Module (ECM)

REMOVAL & INSTALLATION



□ Static electricity can severely damage the ECM! Take great care when removing the module that you never touch the connector pins on either side of the casing.

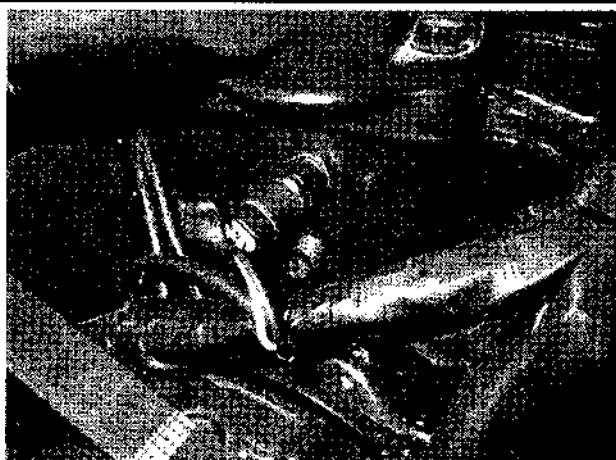


Fig. 52 The ECT sensor is located in the intake manifold on early TBI and MFI models (7.4L shown)...

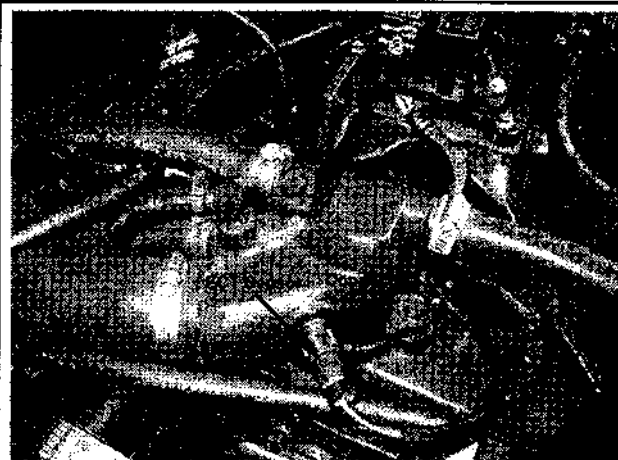


Fig. 53 ...or in the thermostat housing on later TBI and MFI models...

1. Open the engine compartment and disconnect the battery cables.
2. Locate the ECM and carefully disconnect the two harness leads (J1 and J2) going into each side of the module.

☐ Please refer to the Component Locations section.

3. Loosen the 4 mounting screws and lift the ECM from the mounting bracket. Clean only with a clean, lint-free dry cloth. Check all connector pins for straightness and corrosion.

☐ If replacing the ECM, make sure that the new one has the same part and service number as the one being replaced.

4. Install the ECM and tighten the mounting screws to 88-124 inch lbs. (10-14 Nm).
5. Reconnect the electrical lead at each end; the connectors and their sockets should be marked.

Fuel Injectors

REMOVAL & INSTALLATION

TBI Engines

- ◆ See Figures 54, 55, 56, 57, 58 and 59



⚠ CAUTION

To reduce the risk of fire and personal injury, it is necessary to relieve the fuel system pressure before servicing any fuel system component. If this procedure is not performed, fuel may be sprayed out of a connection under extreme pressure. Always keep a dry chemical fire extinguisher near the work area when serving the fuel system.

1. Open or remove the engine hatch/cover and relieve the fuel system pressure. Disconnect the battery cable.
2. Remove the flame arrestor and then squeeze the plastic tabs on the injector electrical connectors and pull straight up until they come apart. Position the leads out of the way and make sure you tag them for correct reassembly. Many models will utilize a small grommet to secure the two harnesses to the side of the throttle body—just pop it out of the recess.
3. Loosen and remove the meter cover mounting screws and carefully lift the cover straight up and off of the throttle body assembly. Watch for the regulator seal and the outlet passage and cover gaskets—they may be hanging from the bottom of the cover.
4. Make sure that the old meter cover gasket is still in place. Lay a small metal rod across the throttle body and then insert a small pry bar under the injector lip and carefully pry the injector out and up using the metal rod as a fulcrum. On later models, you should be able to press on the injector tip with your finger to pop it out of the bore—try this first.

■ Fuel injectors are serviced as an assembly. No disassembly is necessary or possible.

To Install:

5. Inspect the injectors for damage or clogging. OMC recommends replacing damaged injectors. Always replace injectors with new ones that are the identical part number (as shown on the injector itself). All injectors are uniquely calibrated for flow rates so check the part number on the one being replaced and replace it with the same.
6. Install a new lower (small) O-ring after soaking it in automatic transmission fluid (1996), or Power Trim/Tilt & Power Steering Fluid (1997-98). Press the O-ring all the way up and against the injector fuel filter.
7. On certain 1996 engines, insert a new steel washer into the injector bore on the fuel meter body—do this only if your system had one there in the first place.
8. Soak a new upper O-ring in automatic transmission fluid (1996), or Power Trim/Tilt & Power Steering Fluid (1997-98). Install it into the injector bore on the fuel meter body. Make sure that it is seated correctly and flush with the top of the meter body surface.
9. Align the raised lug on the injector body with the notch in the meter cavity and install the injector, pushing it in until it is fully seated. The injector terminals should now be parallel with the throttle shaft.
10. Install the fuel meter cover and gasket. Reconnect the injector leads.
11. Install the flame arrestor and connect the battery cables. Turn the ignition switch to the ON position and check for leaks. Do not actually start the engine until confirming that there are no leaks at the throttle body or fuel lines.

MFI Engines



- ◆ See Figures 60, 61, 71 and 72

⚠ CAUTION

To reduce the risk of fire and personal injury, it is necessary to relieve the fuel system pressure before servicing any fuel system component. If this procedure is not performed, fuel may be sprayed out of a connection under extreme pressure. Always keep a dry chemical fire extinguisher near the work area when serving the fuel system.

1. Relieve the pressure in the fuel system as detailed earlier.
2. Remove the upper intake plenum and fuel rail as detailed previously.
3. Slide the injector retaining clip to the side and pull the injector out of the rail. Remove and discard the two O-rings from the ends of the injector.
4. Inspect the injector bores in the rail and the plenum for nicks, burrs or other damage. Clean the injector with a quality spray cleaner and dry completely with a lint-free cloth.

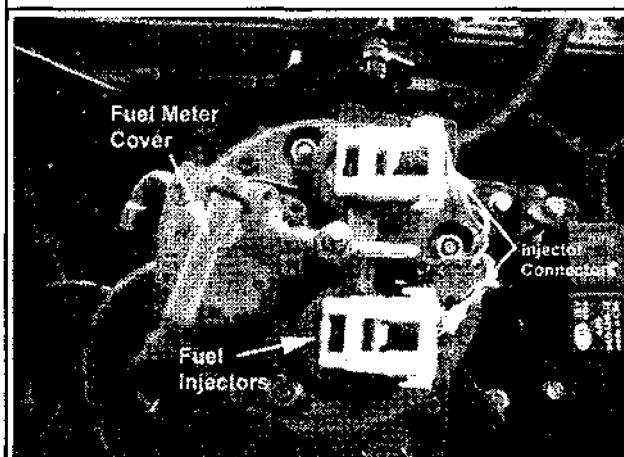


Fig. 54 Remove the connectors...

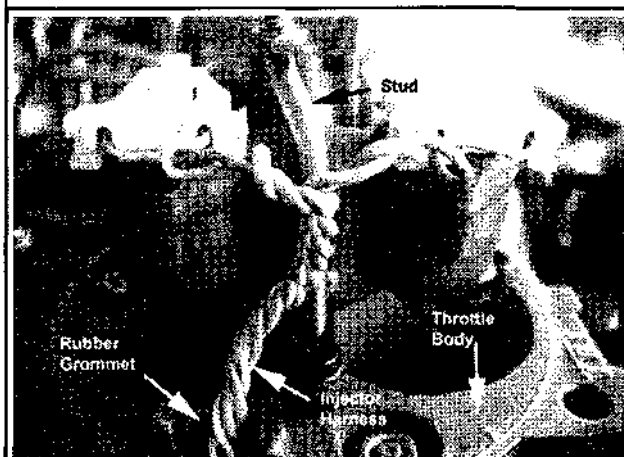


Fig. 55 ...pop out the grommet securing the harness...

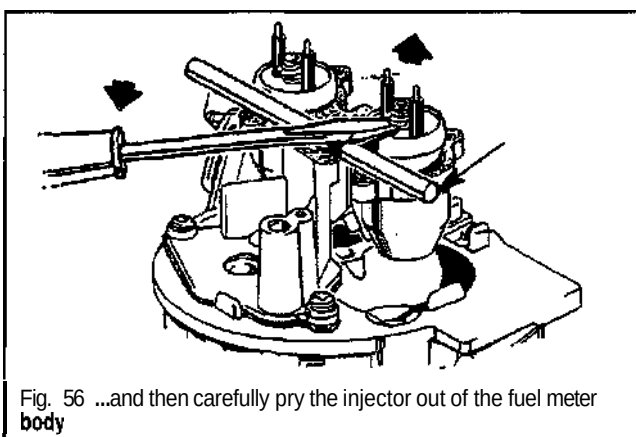


Fig. 56 ...and then carefully pry the injector out of the fuel meter body

** CAUTION

Fuel injectors are pre-coated with an anti-corrosion material — do not use an abrasive cleaner or wire brush when cleaning them.

5. Coat new O-rings with clean engine oil and slide them onto each end of the injector. Press a new injector clip over the injector. If replacing the injector, make absolutely certain that the new part carries the exact same number inscribed on the injector body.

6. Press the injector into the fuel rail so that the connector is facing away from the rail. Make sure that the new retainer clip snaps into the grooves on the rail.

7. Install the fuel rail and upper plenum.

Fuel Meter Body

REMOVAL & INSTALLATION

TBI Engines Only

◆ See Figure 62



□ The pressure regulator assembly is contained within the cover and is preset at the factory. Do not remove the four mounting screws for the pressure regulator installed in the fuel meter cover.

** CAUTION

To reduce the risk of fire and personal injury, it is necessary to relieve the fuel system pressure before servicing any fuel system component. If this procedure is not performed, fuel may be sprayed out of a connection under extreme pressure. Always keep a dry chemical fire extinguisher near the work area when serving the fuel system.

1. Open or remove the engine hatchcover and relieve the fuel system pressure. Disconnect the battery cable.

2. Remove the flame arrestor and then squeeze the plastic tabs on the injector electrical connectors and pull straight up until they come apart. Position the leads out of the way and make sure you tag them for correct reassembly.

3. Remove the fuel meter cover assembly.

4. Remove the fuel injectors.

5. Disconnect the fuel inlet and outlet lines at the throttle body. Remove the fittings and their gaskets. Discard the gaskets. It may be necessary to remove the distributor cap on many models in order to gain access to the lines.

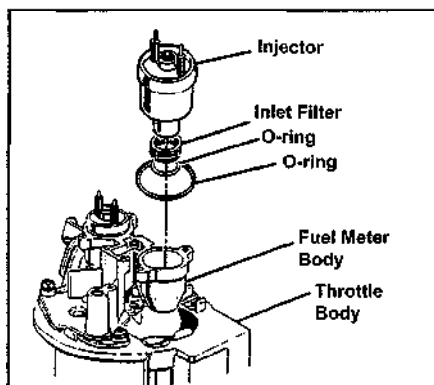


Fig. 57 Position the injector and components...

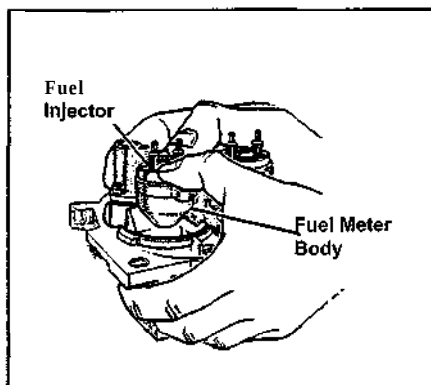


Fig. 58 ...and then press it into the meter body

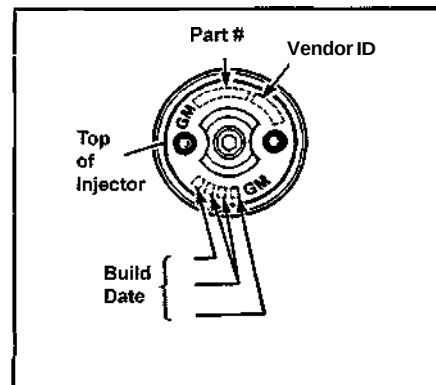


Fig. 59 Always check that the ID information on the new injector matches the old one

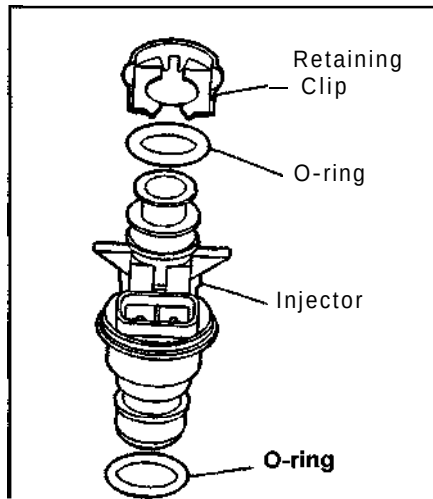


Fig. 60 Exploded view of an injector

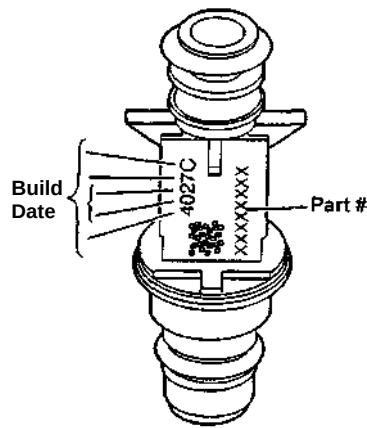


Fig. 61 When replacing the injector, always make certain that the identification codes match

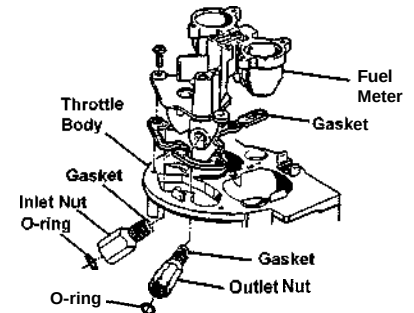


Fig. 62 Removing the fuel meter body

■ Although the fittings look similar, the inlet has a much larger bore than the outlet fitting so make sure you mark each of them for installation.

6. Remove the flame arrestor stud if you haven't already done so.
7. Remove the mounting screws and lift the meter body out of the throttle body. Remove the gasket and discard it.
To Install:
8. Position a new gasket on the throttle body mating surface. Make sure that the cut-outs in the gasket match the openings in the throttle body and then lower the meter body into place.
9. Coat the mounting screws with locking compound (Loctite 242) and then tighten them to 30 inch lbs. (4 Nm).
10. Position new gaskets and then spin in the two fuel fittings. Make sure you've got the right ones in position and then tighten the inlet to 30 ft. lbs. (40 Nm) and the outlet to 21 ft. lbs. (29 Nm).
11. Press new O-rings into the fittings and then screw the fuel lines in. Hold the fitting nut with a wrench while tightening the fuel line nut to 17 ft. lbs. (23 Nm).
12. Install the injectors and fuel meter cover as detailed in their respective procedures.
13. Install the flame arrestor stud.
14. Pop the injector lead connectors back on and connect the battery cables. Turn the ignition key to the ON position so that the fuel pump is energized and check for any fuel leaks. Do not actually start the engine until confirming that there are no leaks at the throttle body or fuel lines. Install the flame arrestor.

Fuel Meter Cover

REMOVAL & INSTALLATION

TBI Engines Only



◆ See Figure 63

□ The pressure regulator assembly is contained within the cover and is preset at the factory. Do not remove the four mounting screws for the pressure regulator installed in the fuel meter cover.

CAUTION

To reduce the risk of fire and personal injury, it is necessary to relieve the fuel system pressure before servicing any fuel system component. If this procedure is not performed, fuel may be sprayed out of a connection under extreme pressure. Always keep a dry chemical fire extinguisher near the work area when serving the fuel system.

1. Open or remove the engine hatchcover and relieve the fuel system pressure. Disconnect the battery cable.

2. Remove the flame arrestor and then squeeze the plastic tabs on the injector electrical connectors and pull straight up until they come apart. Position the leads out of the way and make sure you tag them for correct reassembly.

3. Loosen and remove the meter cover mounting screws (there are long and short screws so make sure you note which hole each one came out of) and carefully lift the cover straight up and off of the throttle body assembly. Watch for the damper seal and the outlet passage and cover gaskets—they may be hanging from the bottom of the cover.

■ On certain later models, you may have to loosen the flame arrestor stud and rotate it 180° to gain access to the screws.

4. Never immerse the cover in solvents or cleaner as damage to the regulator diaphragm could occur. Inspect the mating surfaces of the throttle body assembly and the regulator/cover for damage—use a magnifying glass if necessary! If any damage or scoring is found, replace the assembly.

5. Position a new regulator seal in the throttle body cavity and then position the outlet passage and cover gaskets on the assembly.

6. Drop the meter cover into position and then slip in the mounting screws. Make sure they are coated with locking compound and that the short screws go into the holes next to the injectors. Tighten all screws to 28 inch lbs. (3 Nm).

7. Pop the injector lead connectors back on and connect the battery cables. Turn the ignition key to the ON position so that the fuel pump is energized and check for any fuel leaks. Do not actually start the engine until confirming that there are no leaks at the throttle body or fuel lines. Install the flame arrestor.

Fuel Pressure Regulator

REMOVAL & INSTALLATION

TBI Engines

The pressure regulator is located in the throttle body fuel meter body and is not normally removed or serviced.

MFI Engines—Except 1998 7.4Gi



◆ See Figures 64 and 71

CAUTION

To reduce the risk of fire and personal injury, it is necessary to relieve the fuel system pressure before servicing any fuel system component. If this procedure is not performed, fuel may be sprayed out of a connection under extreme pressure. Always keep a dry chemical fire extinguisher near the work area when serving the fuel system.

9-30 FUEL SYSTEMS – FUEL INJECTION

1. Open the engine cover and disconnect the battery cables. Relieve the fuel system pressure.
2. Remove the upper intake plenum and fuel rail as detailed previously.
3. Wiggle the vacuum line off of the regulator.

■ Please refer to the Component Locations section.

4. Hold the regulator body with a wrench and then disconnect the fuel return line.
 5. Remove the mounting bolt and pull the regulator out of the rail. Discard the O-ring.
 6. Use a small awl and carefully pry the regulator filter out of the fuel inlet port—this is the time to replace it.
- To Install:
7. Inspect the regulator mounting surface for damage or irregularities. Clean the filter and blow it dry with compressed air if you have decided not to replace it.
 8. Soak a new O-rings in clean engine oil and then position it into the regulator-to-rail bore and over the fuel line nipple.
 9. Slide the regulator into position on the rail. Tighten the bolt to 84 inch lbs. (9.5 Nm).
 10. Connect the outlet line to the regulator and spin in the fitting so it is finger-tight. Tighten the line nut to 13 A. lbs. (17.5 Nm).
 11. Connect the vacuum line and install the fuel rail and upper plenum. Connect the battery cables.
 12. Turn the ignition switch to the ON position for 2 seconds and then turn it to the OFF position for 10 seconds. Now turn it back to the ON position and check for any fuel leaks before starting the engine.

MFI Engines—1998 7.4Gi

◆ See Figures 65 and 72

✖ CAUTION

To reduce the risk of fire and personal injury, it is necessary to relieve the fuel system pressure before servicing any fuel system component. If this procedure is not performed, fuel may be sprayed out of a connection under extreme pressure. Always keep a dry chemical fire extinguisher near the work area when serving the fuel system.

1. Open the engine cover and disconnect the battery cables. Relieve the fuel system pressure.
2. Remove the upper intake plenum and fuel rail as detailed previously.

Please refer to the Component Locations section.

3. Wiggle the vacuum line off of the regulator.
4. Remove the retaining ring at the rear of the regulator and then pull the unit from the housing along with the 2 O-rings, spacer and screen.
5. Coat new O-rings with clean engine oil and then install the spacer, large O-ring, screen and small O-ring onto the regulator in order. Hold the pieces on the regulator and slide it into the housing.
6. Press in the retaining ring and connect the vacuum line.

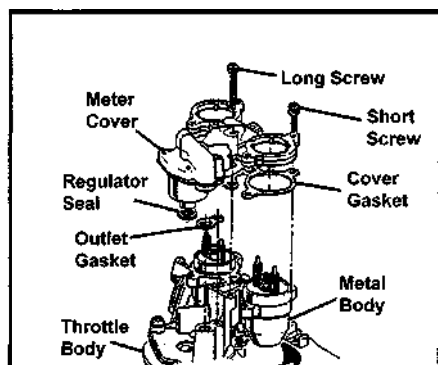


Fig. 63 When removing the fuel meter cover, keep track of the gaskets and seals

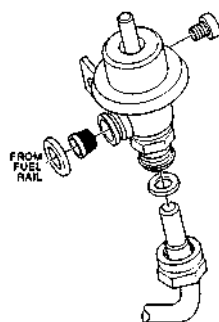


Fig. 64 The regulator is attached to the fuel rail

7. Connect the battery cables. Turn the ignition switch to the ON position for 2 seconds and then turn it back to the OFF position for 10 seconds. Turn the switch back ON and check for any fuel leaks before starting the engine.

Fuel Pump

REMOVAL & INSTALLATION

High Pressure

◆ See Figure 66



Always have a fire extinguisher handy when working on any part of the fuel system. Remember, a very small amount of fuel vapor in the bilge, has the tremendous potential explosive power.

✖ CAUTION

All OMC fuel pumps are designed to meet U.S. Coast Guard fuel system regulations. Never substitute and automotive style pump.

1. Open or remove the engine hatchcover and relieve the fuel system pressure as detailed previously. Disconnect the battery cable.
2. Locate the pump at the rear of the engine, on top of the fuel reservoir/vapor separator.

Please refer to the Component Locations section.

3. Make a note of the fitting elbow positioning and then hold the elbow while removing the fuel line; be sure to have some rags handy to catch any spilled fuel and make sure you plug the line before moving it out of the way.
 4. With your wrench still on the elbow, back off the lock nut with another wrench. The lock nut is the nut immediately inside of the elbow; do not confuse it with the end cap nut on the end of the pump. Unscrew the elbow from the end of the pump and set it aside.
 5. Remove the 2 screws securing the end bracket to the reservoir and then remove the bracket from the pump.
 6. Remove the banjo nut from the end of the pump and then remove the pump. Discard all O-rings.
- To Install:
7. Lubricate new O-rings with clean engine oil. Slide the small one onto the elbow fitting (right up against the flange) and the larger one onto the banjo nut so it sits in the groove on the inner side of the head.
 8. Slide the banjo nut into the hole on the reservoir cover. Coat another new O-ring with clean engine oil and position it over the threads and up against the bracket.
 9. Position the pump at a 45° angle, hold the end cap with a wrench and thread the banjo nut into the pump. Tighten it to 18-22 ft. lbs. (24.4-29.8 Nm). Be very careful to hold the end cap while tightening the banjo nut or you risk damaging the internal O-ring.
 10. Position the support bracket over the other end of the pump and tighten the screws to 25-35 inch lbs. (2.8-4.0 Nm).

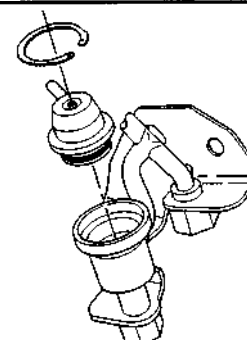


Fig. 65 The regulator is attached to a bracket at the rear of the fuel rail on 7.4Gi engine

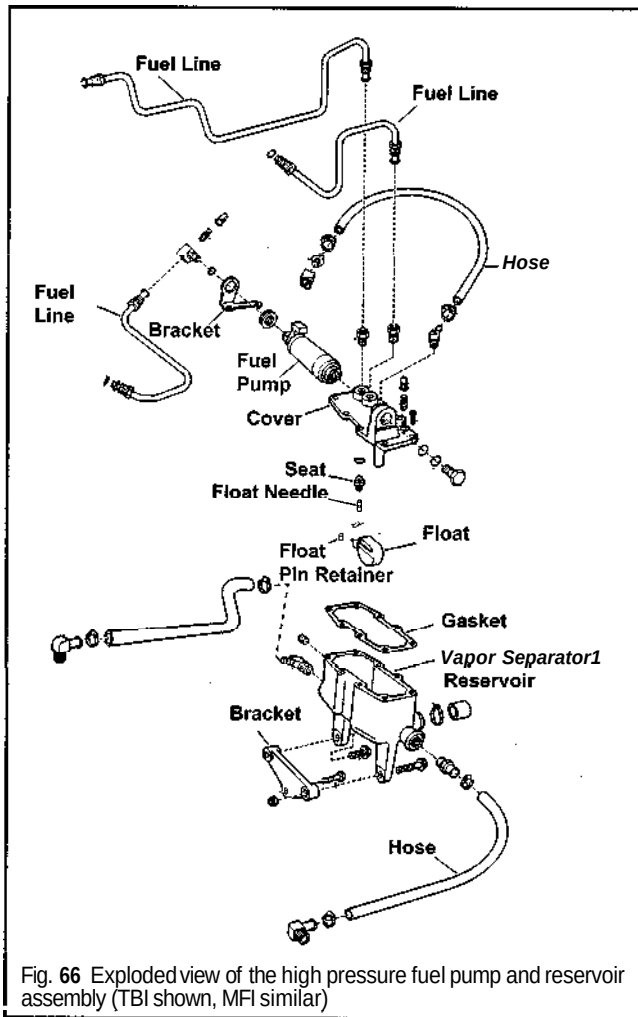


Fig. 66 Exploded view of the high pressure fuel pump and reservoir assembly (TBI shown, MFI similar)

11. Screw the elbow fitting into the end of the pump so that it is in the same position as when removed. Cinch the lock nut down against the pump outlet and then tighten it to 60-84 inch lbs (6.8-9.5 Nm) while holding the pump end cap.

12. Install the fuel line and connect the battery cables.

Low Pressure

◆ See Figures 67, 68 and 69

Always have a fire extinguisher handy when working on any part of the fuel system. Remember, a very small amount of fuel vapor in the bilge, has the tremendous potential explosive power.

✖✖ CAUTION

All OMC fuel pumps are designed to meet U.S. Coast Guard fuel system regulations. Never substitute an automotive style pump.

1. Open or remove the engine hatch/cover and relieve the fuel system pressure as detailed previously. Disconnect the battery cable.

Please refer to the Component Locations section.

2. Position a container under the pump/filter assembly and remove the fuel inlet line at the filter bracket and the outlet line at the top of the pump. It is important to use two open-end wrenches; one to hold the fuel fitting nut or elbow and the other to loosen the line nut. Plug the line with a golf tee or something similar to prevent additional fuel spillage (OMC actually sells a plug for this purpose). Take care not to spill fuel on a hot engine, because such fuel may ignite.

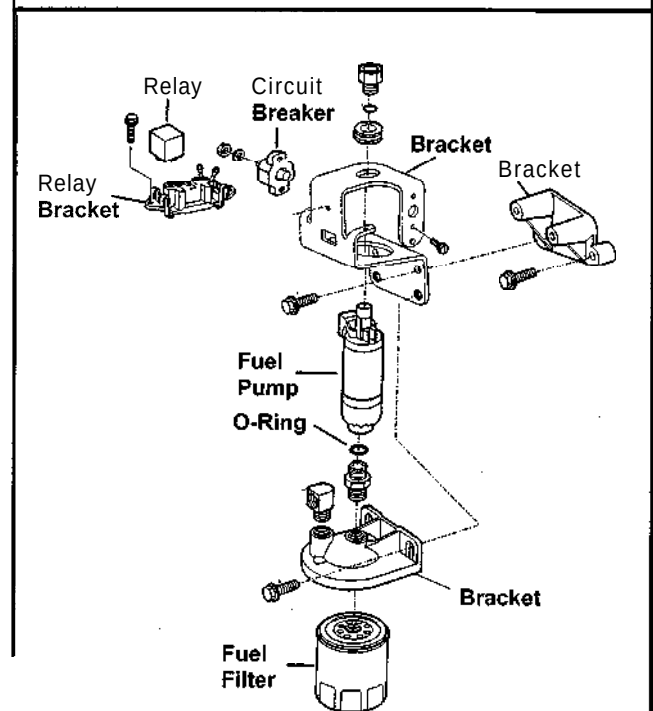


Fig. 67 Exploded view of the low pressure fuel pump and filter assembly (all engines similar)

3. Cut the plastic tie holding the electrical leads to the body of the pump. Unplug the electrical harness at the pump suppressor connector and move it out of the way.

4. Hold the pump end cap (just under the lower edge of the upper retaining bracket) with a wrench while loosening the lock nut (on top of bracket, under elbow). Unscrew the upper elbow.

✖✖ CAUTION

Not holding the end cap while loosening the lock nut will damage the internal O-ring, causing fuel leakage during operation.

5. Remove the 2 fuel filter bracket mounting bolts and lift off the pump/bracket/filter as an assembly, sliding the pump out of the upper grommet. Be careful of spilling fuel.

6. Lay the assembly down, or carefully mount the bracket in a vise. Hold the lower pump end cap with a wrench and unscrew the filter bracket-to-pump adapter.

✖✖ CAUTION

Not holding the end cap while loosening the lock nut will damage the internal O-ring, causing fuel leakage during operation.

To Install:

7. Slide a new O-ring over the threads of the adapter until it rests on the upper side of the hex nut.

8. Screw the adapter/bracket assembly into the pump while holding the lower end cap. Tighten the adapter to 8-10 ft. lbs. (11-14 Nm).

9. Slide the assembly up through the grommet in the bracket and position it so the mounting holes line up on the bracket. Tighten the filter bracket bolts to 20-25 ft. lbs. (27-34 Nm).

10. Thread the upper lock nut onto the elbow until it reaches the underside of the fitting. Slip on the washer and then a new O-ring. Thread the elbow into the top of the pump until it stops and then back it out just enough to align with the fuel line. Connect the line and tighten it securely.

11. Hold the upper end cap again and tighten the lock nut to 60-84 inch lbs. (6.8-9.5 Nm).

12. Reconnect the suppressor lead—push it in until the tabs click.

If you notice any of the suppressor holes open, be sure to coat them with Liquid Neoprene to prevent water from entering.

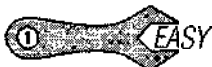
9-32 FUEL SYSTEMS – FUEL INJECTION

13. Install a new plastic tie around the pump body and electrical leads.
14. Reconnect the inlet line and tighten it securely.
15. Install the pump guard if removed.
16. Remove the container and connect the battery cables. Start the engine and check for fuel leaks.

Fuel Pump Relay

REMOVAL & INSTALLATION

- ◆ See Figure 70



- Please refer to the Component Locations section.

Locate the relay in the engine electrical box on the low pressure fuel pump bracket. Tag and disconnect the electrical lead (if equipped). Remove the relay from the bracket. Do not soak the relay in any solvent of cleaner.

Fuel Rail

REMOVAL & INSTALLATION

MFI Engines—Except 1998 7.4Gi

- ◆ See Figure 71



1. Open or remove the engine hatch/cover and relieve the fuel system pressure. Disconnect the battery cable.
2. Remove the flame arrestor, throttle body and upper intake plenum as detailed elsewhere.
3. Tag and disconnect the electrical harness at each injector, moving all of them out of the way. Cut the plastic ties holding the injector harness to the rail and then carefully position the harness out of the way.
4. Making sure you have a container and plenty of rags available, remove the inlet and outlet fuel lines from the rail. Plug the lines and keep track of the O-rings.
5. Remove the 4 rail mounting screws and lift out the fuel rail. There's a good chance that some of the injectors are going to come out with the rail while others may stay in the manifold—don't worry about this.
6. Remove all injectors from the rail and the intake manifold.

To Install:

7. Inspect the injector seating recess in the fuel rail for pitting, nicks, burrs or any other irregularities. Replace the rail assembly if necessary.
8. Soak new injector O-rings in clean engine oil for a minute and then press them onto each side of the injector.
9. Press each injector (with a new retaining clip) into its recess on the rail until it clicks into place.
10. Position the rail/injector assembly onto the intake manifold and gently press down on the rail until the injectors seat fully into their bores. Install the rail mounting screws and tighten them to 88 inch lbs. (10 Nm).
11. Move the injector harness into position and reconnect all injectors. Secure the harness to the rail with new plastic ties.

12. Connect the two fuel lines, tightening the fittings to 13 ft. lbs. (17.5 Nm).
13. Install the plenum, throttle body and flame arrestor. Connect the battery cables.
14. Turn the ignition switch to the **ON** position for 2 seconds and then turn it to the **OFF** position for 10 seconds. Now turn it back to the **ON** position and check for any fuel leaks before starting the engine.

MFI Engines—1998 7.4Gi

- ◆ See Figure 72



1. Open or remove the engine hatch/cover and relieve the fuel system pressure. Disconnect the battery cable.
2. Remove the flame arrestor, throttle body and upper intake plenum as detailed elsewhere.
3. Tag and disconnect the electrical harness at each injector, moving all of them out of the way. Disconnect the 10-pin injector harness connector.
4. Remove the nut and retainer that secures the MAP sensor and then lift off the sensor—this is also one of the fuel rail retaining bolts.
5. Making sure you have a container and plenty of rags available, remove the inlet and outlet fuel lines from the rail and pressure regulator. Plug the lines.
6. Remove the 2 rail mounting bolts and the stud. Remove the 2 bolts holding down the fuel line bracket. Disconnect the vacuum line at the pressure regulator and then lift out the fuel rail and injector assembly. There's a good chance that some of the injectors are going to come out with the rail while others may stay in the manifold—don't worry about this.

- You will probably want to remove the distributor to provide better access to the two fuel line bracket mounting bolts.

7. Remove all injectors from the rail.

To Install:

8. Inspect the injector seating recess in the fuel rail for pitting, nicks, burrs or any other irregularities. Replace the rail assembly if necessary.
9. Soak new injector O-rings in clean engine oil for a minute and then press them onto each side of the injector.
10. Press each injector (with a new retaining clip) into its recess on the rail until it clicks into place.
11. Position the rail/injector assembly onto the intake manifold and gently press down on the rail until the injectors seat fully into their bores. Install the rail mounting screws and tighten them to 88 inch lbs. (10 Nm). Tighten the stud to 18 ft. lbs. (25 Nm).
12. Move the injector harness into position and reconnect all injectors. Plug in the 10-pin harness connector.
13. Wiggle the vacuum line over the fitting on the regulator.
14. Connect the two fuel lines, tightening the fittings to 10-12 ft. lbs. (13.6-16.3 Nm). Make sure you use new O-rings and position them properly.
15. Install the MAP sensor.
16. Install the plenum, throttle body and flame arrestor. Connect the battery cables.

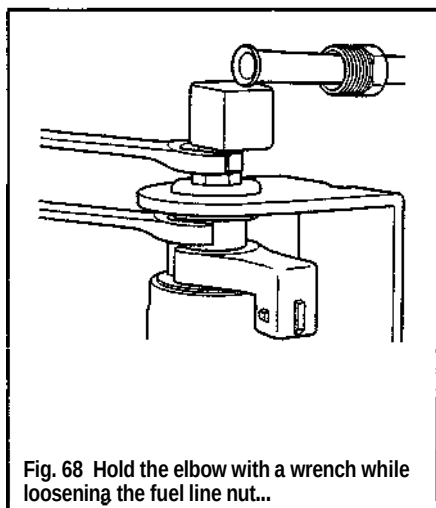


Fig. 68 Hold the elbow with a wrench while loosening the fuel line nut...

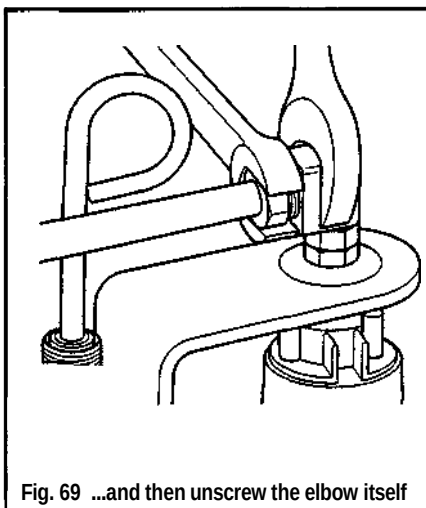


Fig. 69 ...and then unscrew the elbow itself

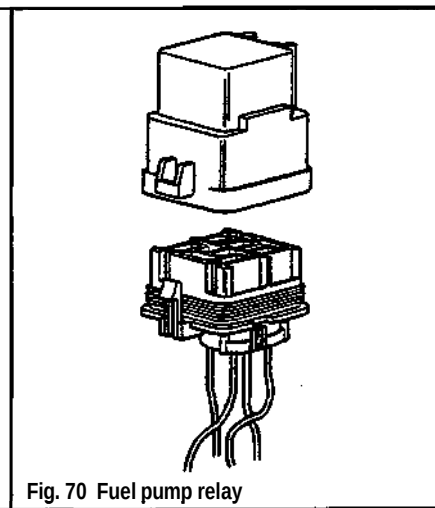


Fig. 70 Fuel pump relay

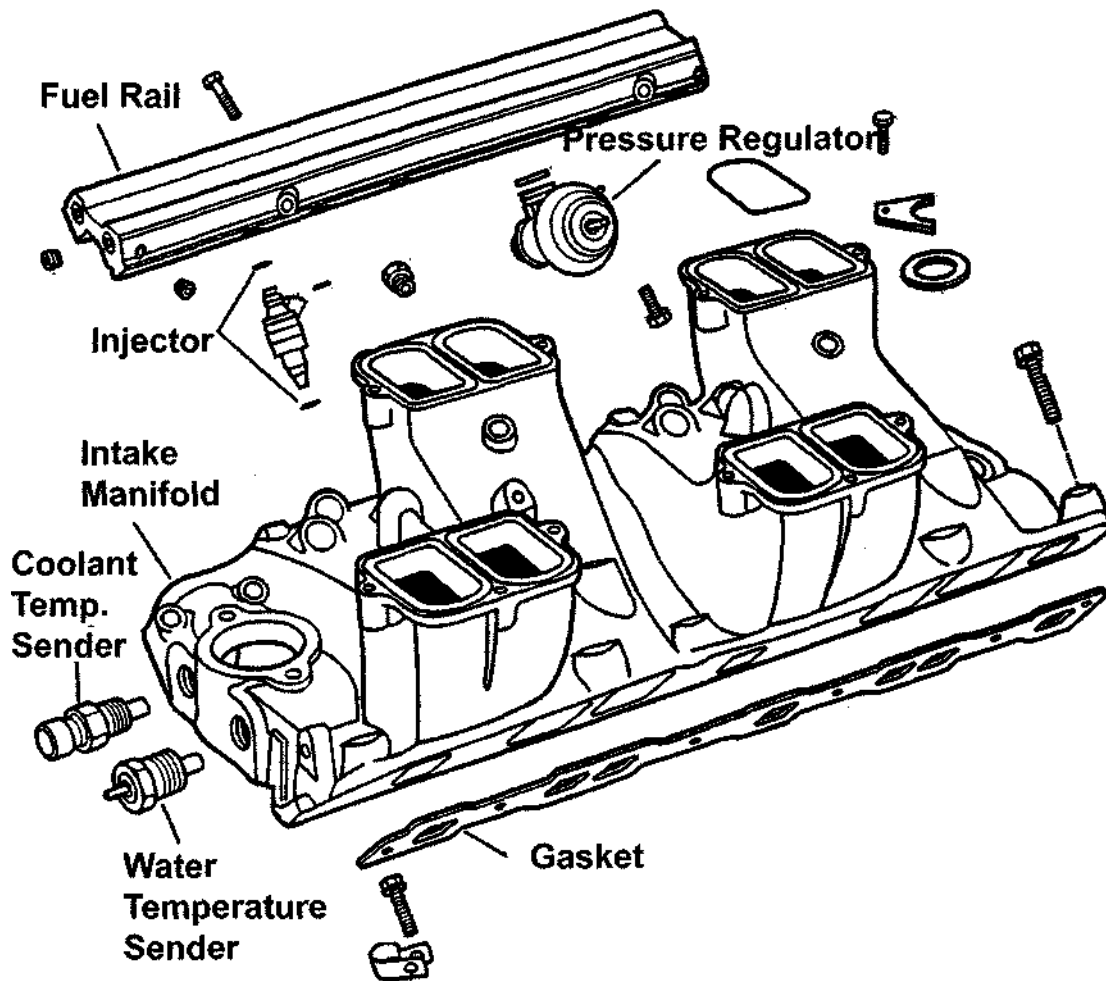


Fig. 71 Exploded view of the fuel rail assembly—MFI engines except the 1998 7.4Gi

17. Turn the ignition switch to the ON position for 2 seconds and then turn it to the OFF position for 10 seconds. Now turn it back to the ON position and check for any fuel leaks before starting the engine.

Idle Air Control Valve (IAC)

REMOVAL & INSTALLATION

◆ See Figures 73 and 74



1. Open the engine compartment and disconnect the battery cables
2. Remove the flame arrestor.

Please refer to the Component Locations section.

3. Tag and disconnect the electrical connector at the valve and move it out of the way.

4. On flange-mounted valves, remove the 2 mounting screws and remove the valve. Remove the O-ring from the valve and throw it away.

To Install:

5. On either valve, clean the valve mating surfaces, pintle valve seat and air passage with carburetor cleaner—do not push or pull on the valve pintle. Do not soak the valve in liquid cleaner or solvent. Don't be concerned if you notice shiny spots on the pintle or seat. If you are planning to reinstall the original valve, there should be thread locking compound on the threads of the valve or mounting bolts, do not attempt to clean this compound

■ If replacing the IAC valve, make sure that the new one has the same pintle shape and diameter. Measure the distance between the tip of the pintle and the valve mounting surface (A in the illustrations). If this measurement is greater than 1.102 in. (28mm), press the pintle in with your finger until it is within the specification. Measure the diameter of the pintle cone (B in the illustrations) and make sure that it is the same as the old valve.

6. Install a new O-ring or gasket onto the valve. Coat the O-ring with clean engine oil.

7. Install the valve and tighten the screws to 28 inch lbs. (3.2 Nm).

8. Reconnect the electrical lead.

9. Install the flame arrestor.

10. Connect the battery cables.

11. On 1996 TBI engines, turn the ignition key to the ON position for 10 seconds, start the engine and run it for 5 seconds, turn the key to the OFF position for 10 seconds. Start the engine and check that the idle is OK.

12. On all MFI engines and on 1997-98 TBI engines, start the engine and allow it to idle for 30 seconds, turn it Off for 10 seconds and then restart the engine and check that the idle is OK.

9-34 FUEL SYSTEMS – FUEL INJECTION

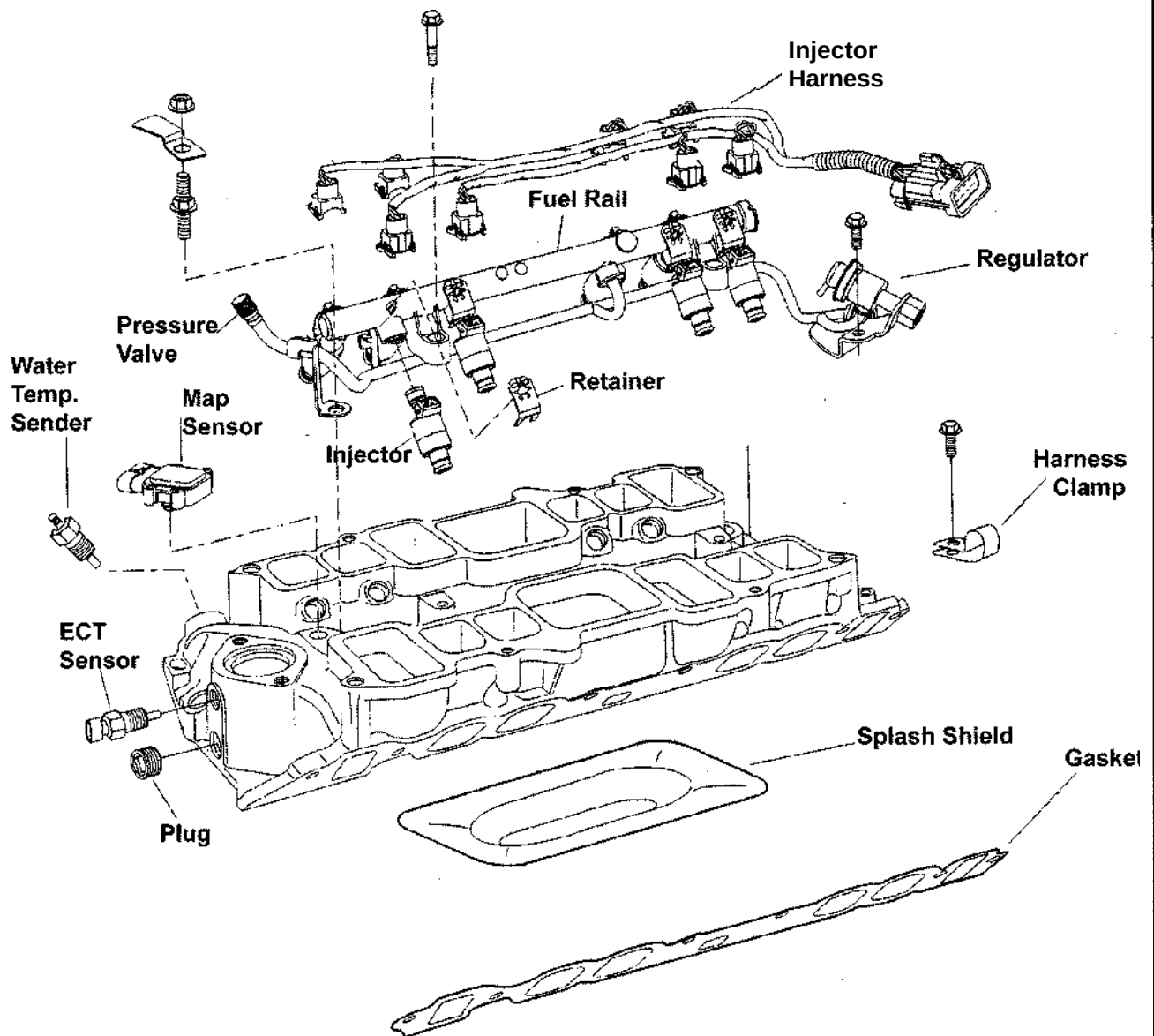


Fig. 72 Exploded view of the fuel rail assembly—1998 7.4Gi engines

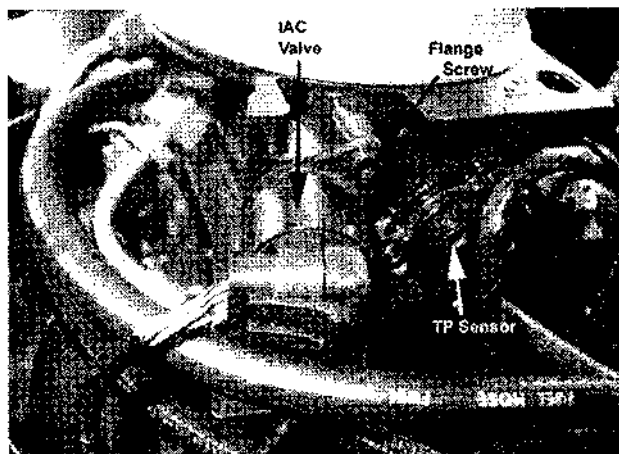


Fig. 73 Most IAC valves on TBI engines are flange mounted...

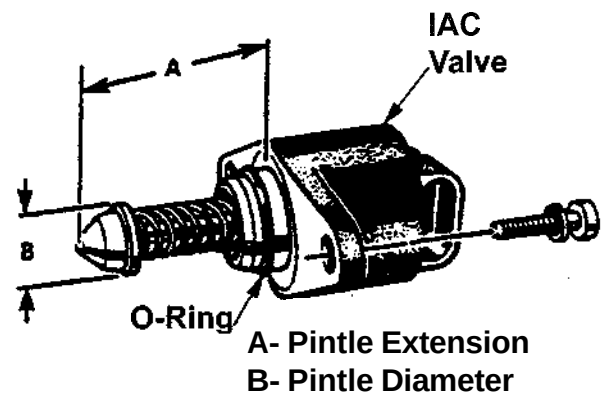
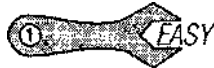


Fig. 74 ...while others use bolts. Note the measuring points for comparison

Intake Air Temperature Sensor (IAT)

REMOVAL & INSTALLATION



1. Open the engine compartment and disconnect the battery cables.

□ Please refer to the Component Locations section.

2. Tag and disconnect the electrical lead and unscrew the sensor from the upper intake plenum.
3. Clean the sensor with a dry cloth and inspect for signs of damage.
4. Coat the threads of the sensor with Teflon pipe sealant, install it into the plenum and tighten it to 11 ft. lbs. (15 Nm).
5. Connect the sensor lead and the battery cables.

Knock Sensor (KS)

REMOVAL & INSTALLATION

◆ See Figure 75



Some engines will have two sensors (1998 7.4Gi), one on each side of the engine.

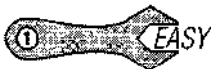
1. Disconnect the battery cables.
2. Tag and disconnect the electrical connector at the sensor and move it out of the way.

Please refer to the Component Locations section.

3. Unscrew the sensor from the side of the cylinder block (or T-fitting) and remove the sensor. Clean the sensor with a dry cloth; especially the threads. If replacing the sensor, make sure that the new one is the same part number as the original.
4. Repeat Steps 2 and 3 for the second sensor on engines so equipped.
5. Install the sensor into the block or "T" and tighten it to 11-16 ft. lbs. (15-22 Nm). Do not use any thread sealer or locking solution unless it is positioned in a water jacket. Proper torque is imperative to ensure precise performance.
6. Connect the electrical lead and the battery cables.

Knock Sensor Module

REMOVAL & INSTALLATION



1998 7.4Gi engines will require removal of the oil fill tube for access to the module.

1. Disconnect the battery cables.

Please refer to the Component Locations section.

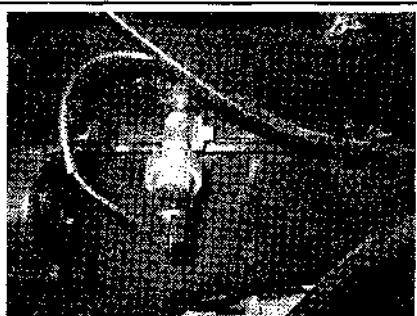


Fig. 75 The knock sensor is usually found just forward of the starter



Fig. 76 On all TBI engines, the MAP sensor is located on the ECM electrical bracket..



Fig. 77 ...or attached to the manifold on MFI engines

2. Tag and disconnect the electrical connector at the module and move it out of the way.

3. Remove the 2 (or 4) module mounting bolts and lift off the module.

⚠⚠ WARNING

Never soak the module in liquid cleaner or solvent.

4. Install the module and tighten the mounting bolts securely.
5. Connect the electrical lead and the battery cables.

Manifold Absolute Pressure Sensor (MAP)

REMOVAL & INSTALLATION

+ See Figures 72, 76 and 77



1. Open or remove the engine hatchcover and disconnect the battery cable.
2. Locate the MAP sensor—on TBI engines it can be found on the ECM electrical bracket. On most MFI engines it is attached directly to the Starboard side of the upper intake plenum or directly to the intake manifold on 1998 7.4Gi engines.

Please refer to the Component Locations section.

3. Remove the upper intake plenum on the 1998 7.4Gi.
4. Tag and disconnect the electrical connector and the vacuum line (TBI only) at the sensor and move them out of the way.
5. Unscrew the mounting screw(s) and remove the sensor. On the 1998 7.4Gi, you must first remove the sensor retainer attached to the fuel rail. Clean the sensor with a dry cloth; make sure that the sensor seal is in good condition, if not replace it.
6. Install the sensor seal and then install the sensor and tighten the screws to 44-62 inch lbs. (5-7 Nm), except on the 1998 7.4Gi where you need to tighten the retainer nut to 18 ft. lbs. (24 Nm).
7. Install the upper plenum if removed.
8. Connect the electrical lead and the battery cables. Don't forget the vacuum line on TBI engines.

Throttle Body

REMOVAL & INSTALLATION

TBI Engines



◆ See Figure 78, 79 and 80

1. Open or remove the engine hatchcover and relieve the fuel system pressure. Disconnect the battery cable.
2. Remove the flame arrestor and then squeeze the plastic tabs on the injector electrical connectors and pull straight up until they come apart. Position the leads out of the way and make sure you tag them for correct reassembly. Many models will utilize a rubber grommet securing the two harnesses to the side of the throttle body—just pop it out of the recess.
3. Disconnect the throttle cable and carefully move it out of the way.
4. Remove the distributor cap. Although not always necessary, this will make access much easier.

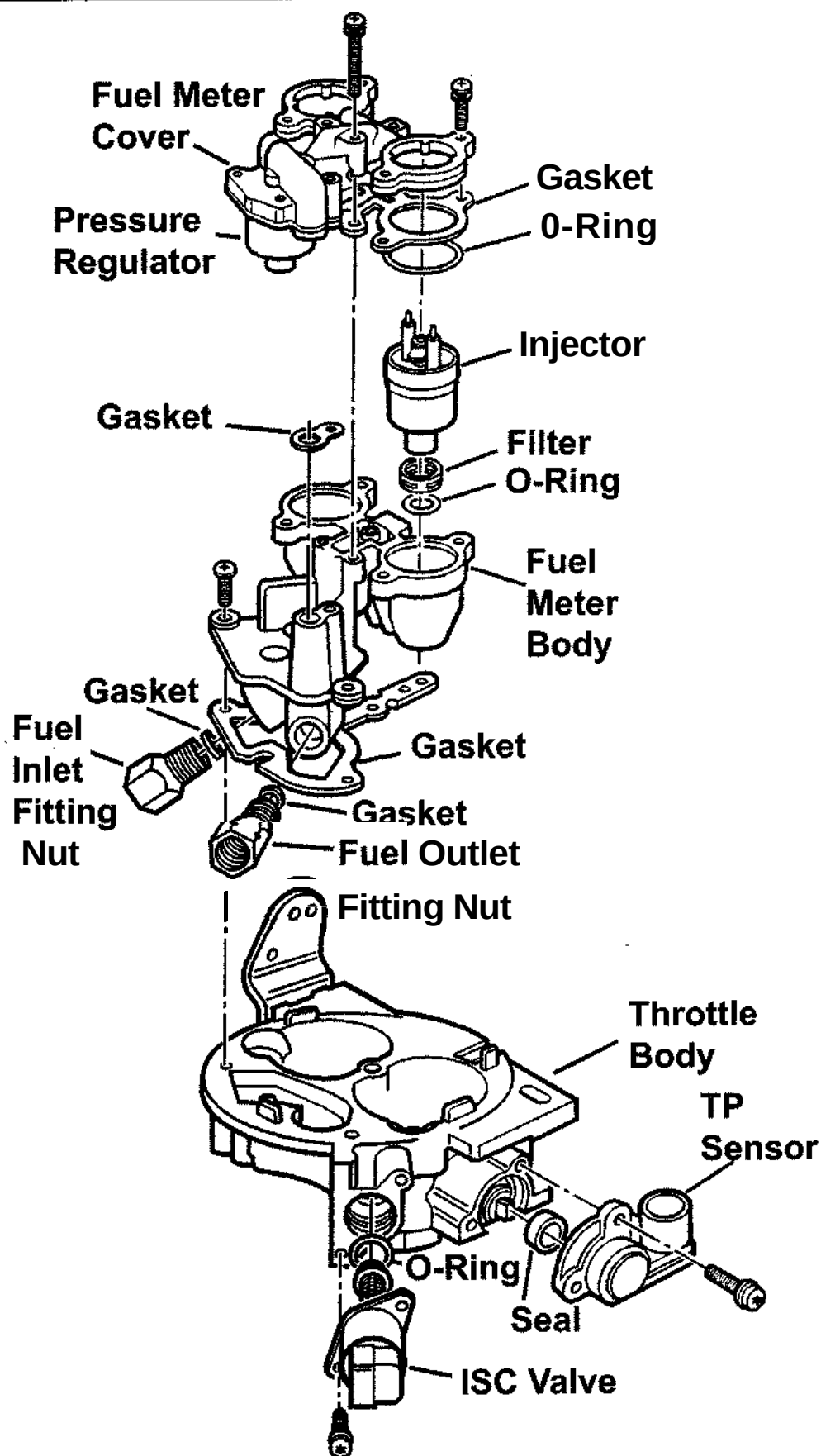


Fig. 78 Exploded view of the typical throttle body assembly

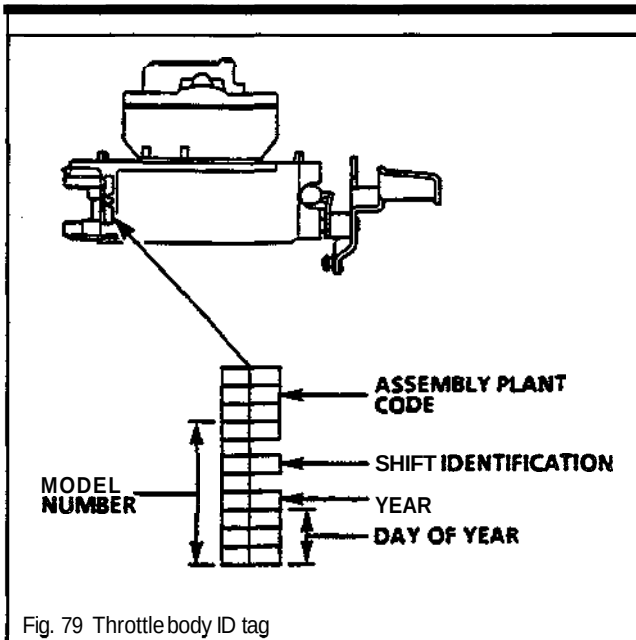


Fig. 79 Throttle body ID tag

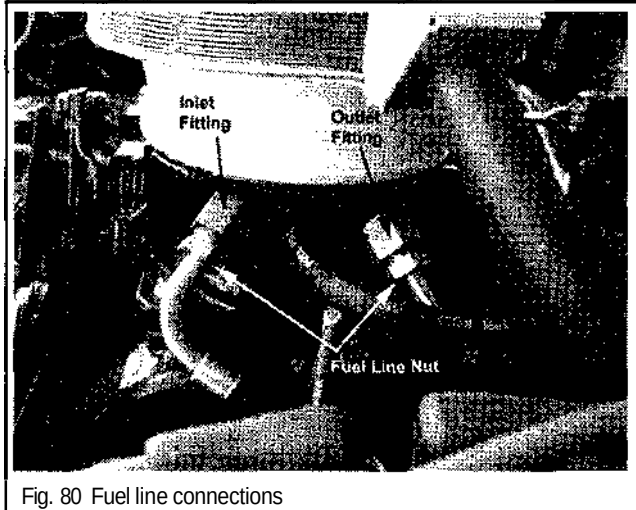


Fig. 80 Fuel line connections

5. Unplug the electrical connectors at the TP sensor and the IAC valve. Tag each lead and move them out of the way.
6. Disconnect the MAP sensor vacuum line at the throttle body (between the fuel lines on later engines).
7. Hold a container under the connections and then remove the fuel inlet and outlet lines at the throttle body. Have some rags available to wipe up any spills. Plug the fuel lines to prevent any further spillage. Don't forget to use a second flare wrench to hold the fitting nuts.
8. Remove the mounting bolts/nuts and lift the throttle body off of the adapter plate. Cover the manifold opening with a rag,

■ Be very careful of how, and where, you lay the unit down.

To Install:

9. Remove the TP sensor, IAC valve, fuel injectors and the meter cover and then thoroughly clean the throttle body assembly in an immersion type cleaner. Dry with compressed air if available and make certain all passages are clean.
10. Inspect all mating and casting surfaces for damage or cracks and scoring.
11. Install the sensor, valve, injectors and meter cover as detailed elsewhere in this section.
12. Position a new gasket on the adapter plate, install the throttle body and tighten the mounting nuts/bolts to 12 ft. lbs. (16 Nm).

13. Connect and adjust the throttle linkage.
14. Connect the MAP vacuum line if removed.
15. Connect the fuel lines and tighten the flange nuts to 17 ft. lbs. (23 Nm) using a back-up flare wrench on the fittings. Make sure that you install new O-rings prior to tightening the lines.
16. Connect the TP sensor and IAC valve electrical leads.
17. Press the harness grommet into the recess and then pop the injector lead connectors back on and connect the battery cables. Turn the ignition key to the ON position so that the fuel pump is energized and check for any fuel leaks. Do not actually start the engine until confirming that there are no leaks at the throttle body or fuel lines. Install the flame arrestor.
18. Start the engine and check for fuel leakage.

MFI Engines



◆ See Figure 81

1. Open or remove the engine hatchcover and relieve the fuel system pressure. Disconnect the battery cable.
2. Remove mounting nut(s) and then remove the flame arrestor. Certain models will have a bracket holding the arrestor on.
3. Remove the throttle link nut and then separate the link from the throttle arm.
4. Tag and disconnect the wiring harness for the IAC valve and TP sensor.
5. Remove the 4 throttle body mounting bolts (some models use 3 nuts). Lift out the throttle body and set it down in a holding fixture to avoid damage to the valves. Stuff a clean, lint-free rag into the plenum opening and discard the gasket.
6. If necessary, remove the TP sensor and IAC valve with their O-rings from the assembly.
- To Install:
7. Carefully clean the throttle bore and valves. Do not use anything containing methyl ethyl ketone and do not soak it in solvent—use a spray carb/choke cleaner! If you didn't remove the TP sensor and IAC valve, make sure that you get no solvent on them during cleaning. CAREFULLY scrape any gasket material off the mating surfaces. Make sure all passages are free of dirt and completely dry before installation.
8. Install the sensor and valve if removed. Position the throttle body and new gasket on the plenum and tighten the bolts to 11 ft. lbs. (15 Nm). If your engine uses nuts (1998 7.4Gi), tighten them to 89 inch lbs. (10 Nm).
9. Check that the throttle lever moves freely, snapping back to the closed position and then reconnect the throttle link to the lever. Tighten the nut securely. Make sure the rod end on 1998 7.4Gi engines has 0.5-0.75 in. (12.70-19.05mm) of available thread for correct engagement.
10. Connect the IAC and TP leads.
11. Install the flame arrestor.
12. Reconnect the battery cables.
13. Start the engine and allow it to idle for 30 seconds, turn it OFF for 10 seconds and then restart the engine and check that the idle is OK.

Throttle Body Adapter Plate

REMOVAL & INSTALLATION

TBI Engines Only



1. Open or remove the engine hatchcover and relieve the fuel system pressure. Disconnect the battery cable.
2. Remove the flame arrestor and then squeeze the plastic tabs on the injector electrical connectors and pull straight up until they come apart. Position the leads out of the way and make sure you tag them for correct reassembly.
3. Remove the throttle body as detailed in the preceding procedure. Lift the gasket off the adapter if it hasn't already come up with the throttle body.
4. Remove the four mounting screws and lift off the adapter plate. Plug the intake manifold with a clean rag.
5. Install the adapter plate with a new gasket and tighten the mounting screw to 15 ft. lbs (19 Nm) on the V6 and 1998 V8, 30 ft. lbs. (40 Nm) on the 1996-97 V8.
6. Install the throttle body.

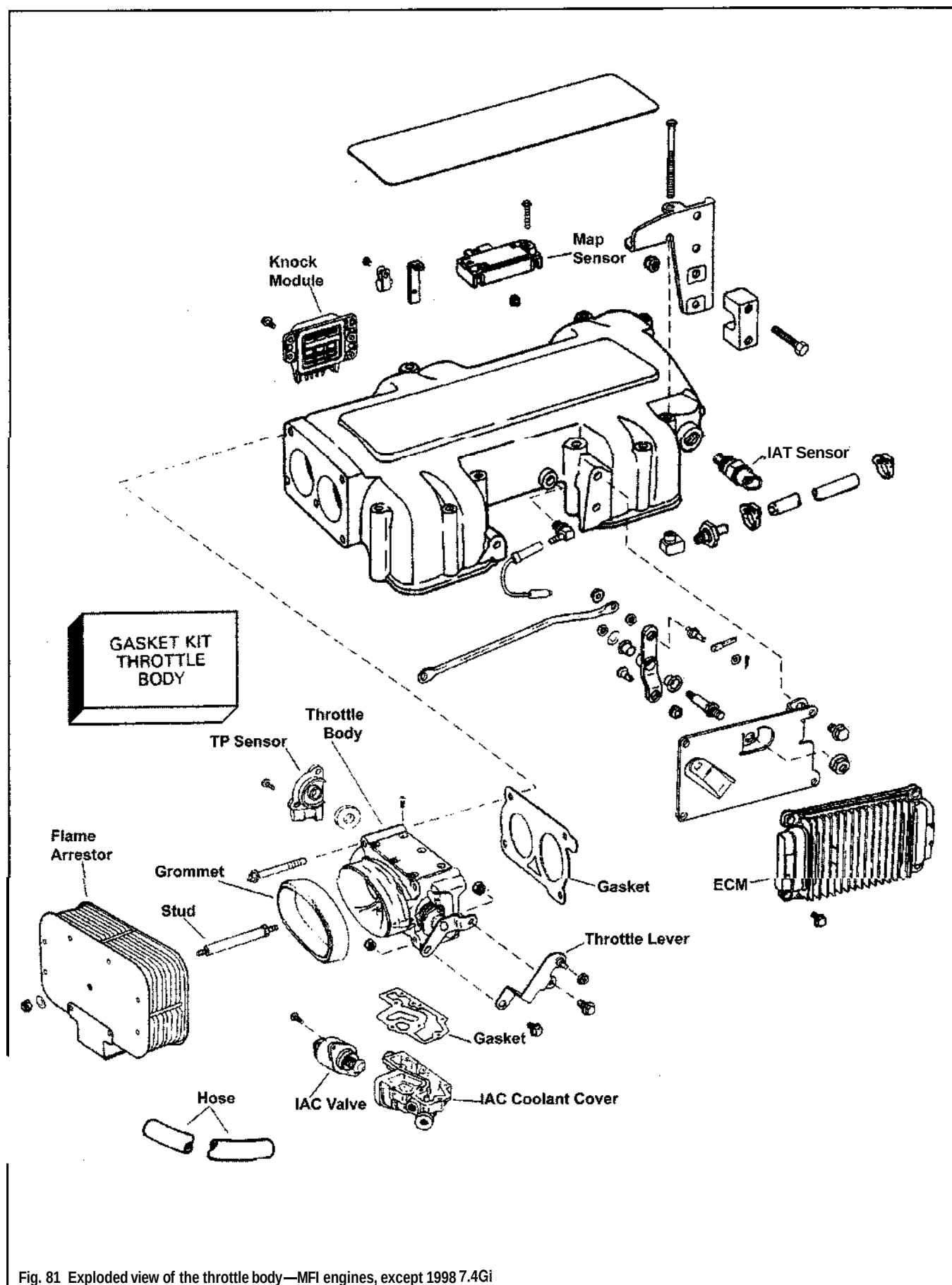


Fig. 81 Exploded view of the throttle body—MFI engines, except 1998 7.4Gi