

Outboard FourStroke II

Technician's Guide

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Section 1 - General Information

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Exhaust Emissions Standards

Through the Environmental Protection Agency (EPA), the federal government has established exhaust emissions standards for all new marine engines sold in the U.S.

What Are Emissions?

Emissions are what comes out of the exhaust system in the exhaust gas when the engine is running. They are formed as a result of the process of combustion or incomplete combustion. To understand exhaust gas emissions, remember that both air and fuel are made of several elements. Air contains oxygen and nitrogen among other elements; gasoline contains mainly hydrogen and carbon. These four elements combine chemically during combustion. If combustion were complete, the mixture of air and gasoline would result in these emissions: water, carbon dioxide and nitrogen, which are not harmful to the environment. But combustion is not usually complete. Also, potentially harmful gases can be formed during and after combustion.

All marine engines must reduce the emission of certain pollutants, or potentially harmful gases, in the exhaust to conform with levels legislated by the EPA. Emissions standards become more stringent each year. Standards are set primarily with regard to three emissions: hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NOx).

Hydrocarbons - HC

Gasoline is a hydrocarbon fuel. The two elements of hydrogen and carbon are burned during combustion in combination with oxygen. But they are not totally consumed. Some pass through the combustion chamber and exit the exhaust system as unburned gases known as hydrocarbons.

Carbon Monoxide - CO

Carbon is one of the elements that make up the fuel burned in the engine along with oxygen during the combustion process. If the carbon in the gasoline could combine with enough oxygen (one carbon atom with two oxygen atoms), it would come out of the engine in the form of carbon dioxide (CO₂). CO₂ is a harmless gas. But carbon often combines with insufficient oxygen (one carbon atom with one oxygen atom). This forms carbon monoxide, CO. Carbon monoxide is the product of incomplete combustion and is a dangerous, potentially lethal gas.

Oxides of Nitrogen - Nox

NO_x is a slightly different byproduct of combustion. Nitrogen is one of the elements that makes up the air going into the engine. Under extremely high temperatures it combines with oxygen to form oxides of nitrogen (NO_x). This happens in the engine's combustion chambers when temperatures are too high. NO_x itself is not harmful, but when exposed to sunlight it combines with unburned hydrocarbons to create the visible air pollutant known as smog. Smog is a serious problem in California as well as many other heavily populated areas of the United States.

Stoichiometric (14.7:1) Air/Fuel Ratio

In the search to control pollutants and reduce exhaust emissions, engineers have discovered that they can be reduced effectively if a gasoline engine operates at an air/fuel ratio of 14.7:1. The technical term for this ideal ratio is stoichiometric. An air/fuel ratio of 14.7:1 provides the best control of all three elements in the exhaust under almost all conditions. The HC and CO content of the exhaust gas is influenced significantly by the air/fuel ratio. At an air/fuel ratio leaner than 14.7:1, HC and CO levels are low, but with a ratio richer than 14.7:1 they rise rapidly. It would seem that controlling HC and CO by themselves might not be such a difficult task; the air/fuel ratio only needs to be kept leaner than 14.7:1. However, there is also NO_x to consider.

As the air/fuel ratio becomes leaner, combustion temperatures increase. Higher combustion temperatures raise the NO_x content of the exhaust. But, enriching the air/fuel ratio to decrease combustion temperatures and reduce NO_x also increases HC and CO, as well as lowering fuel economy. So the solution to controlling NO_x - as well as HC and CO - is to keep the air/fuel ratio as close to 14.7:1 as possible.

Notes

Engine Emission Certification Label

Your outboard has been labeled on the cowl with one of the following star labels.

The Symbol for Cleaner Marine Engines Means:

Cleaner Air and Water – for a healthier lifestyle and environment.

Better Fuel Economy – burns up to 30-40 percent less gas and oil than conventional carbureted two-stroke engines, saving money and resources.

Longer Emission Warranty – Protects consumer for worry free operation.

	The one-star label identifies engines that meet the CARB's 2001 exhaust emission standards. Engines meeting these standards have 75% lower emissions than conventional carbureted 2-stroke engines. These engines are equivalent to the U.S. EPA's 2006 standards
	The two-star label identifies engines that meet the CARB's 2004 exhaust emission standards. Engines meeting these standards have 20% lower emissions than One Star - Low Emission engines.
	The three-star label identifies engines that meet the CARB's 2008 exhaust emission standards. Engines meeting these standards have 65% lower emissions than One Star - Low Emission engines.
	The four Star label identifies engines that meet the Air Resources Board's Sterndrive and Inboard marine engine 2009 exhaust emission standards. Personal Watercraft and Outboard marine engines may also comply with these standards. Engines meeting these standards have 90% lower emissions than One Star - Low Emission engines.

Propeller Selection

For best all around performance from your outboard/boat combination, select a propeller that allows the engine to operate at or near the top of the recommended full throttle RPM range with the boat normally loaded (refer to Specifications). This RPM range allows for better acceleration while maintaining maximum boat speed.

If changing conditions cause the RPM to drop below the recommended range (such as warmer, more humid weather, operation at higher elevations, increased boat load or a dirty boat bottom/gear case) a propeller change or cleaning may be required to maintain performance and ensure the outboard's durability.

Diagnostic Tip: Over propping can cause a FourStroke to stall when shifting into gear. These symptoms can result in misdiagnosis of the fuel system. When the engine that is overloaded with too large a prop may allow excess fuel to bypass the piston rings and **dilute** the crank case oil. The long term effects would be premature powerhead failure.

Under propping can cause overrev condition. The long term effects could lead to oil coming out of the breather. As a general rule for every 1 inch of pitch change, the effect will be approximately 200 RPM.

Check full-throttle RPM using an accurate tachometer with the engine trimmed out to a balanced-steering condition (steering effort equal in both directions) without causing the propeller to "break loose".

Refer to "Quicksilver Accessory Guide" for a complete list of available propellers.

- 1) Select a propeller that will allow the engine to operate at or near the top of the recommended full throttle RPM range (listed in "Specifications," preceding) with a normal load. Maximum engine speed (RPM) for propeller selection exists when boat speed is maximum and trim is minimum for that speed. (High RPM, caused by an excessive trim angle, should not be used in determining correct propeller.) Normally, there is a 150-350RPM change between propeller pitches.
- 2) If full throttle operation is below the recommended range, the propeller **MUST BE** changed to one with a lower pitch to prevent loss of performance and possible engine damage.
- 3) After initial propeller installation, the following common conditions may require that the propeller be changed to a lower pitch:
 - a) Warmer weather and great humidity will cause an RPM loss.
 - b) Operating in a higher elevation causes an RPM loss.
 - c) Operating with a damaged propeller or a dirty boat bottom or gear housing will cause an RPM loss.
 - d) Operation with an increased load (additional passengers, equipment, pulling skiers, etc.).

Tip: All 4-Stroke engines should be propped to the top of recommended RPM range for best overall performance and customer satisfaction.

Notes

Prop Rattle and Flo-Torq III Propeller Hub

Prop Rattle

Crankshaft and driveshaft speed varies during rotation due to power strokes. This is the result of the piston coming up on its power stroke and combustion occurring, which in turn causes the crankshaft and prop shaft speed to increase. In between power strokes the crankshaft speed slows down due to normal drag in the system, while inertia of the prop causes the propeller shaft to remain rotating close to the same speed.

Prop rattle is seen more often in engines that use stainless steel props. The increased weight, and the resulting increased inertial force generated by these stainless steel props allow the props to maintain more of a constant speed, as compared with that of the crankshaft's speed. Consequently, the stainless steel prop does not slow down at the same rate as the crankshaft, and accordingly the clutch dogs separate slightly between the clutch and the gear.

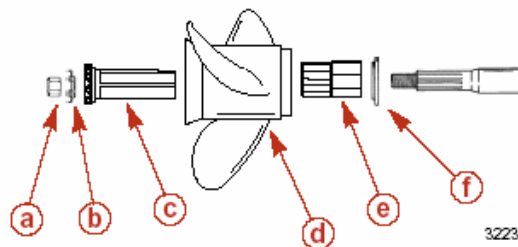
On the next power stroke, the crankshaft will again accelerate and create a slight noise when the clutch dogs on the drive gear catch up with the dogs on the clutch/prop shaft. When this is repeated over and over it results in prop rattle.

IMPORTANT: This prop rattle does not damage the clutch dogs or lower unit, and is normally only heard at idle or just off idle speeds.

FLO-TORQ III PROP HUB

The Flo-Torq III plastic drive sleeve assembly has a small forward/aft clearance so that it or the prop is not locked to the prop shaft. This allows the two hub pieces to rotate $\pm 10^\circ$ relative to each other, and allows the springs to absorb the impacts from the combustion cycles instead of the clutch dogs. The plastic drive sleeve assembly has clearance, which allows it to move forward and aft slightly over the inner brass hub that is supplied with the Flo-Torq III hub kit. This free movement, along with the spring wires between the forward and aft section of the plastic hub, act as a shock absorber, reducing the noise. Do not shorten the inner brass hub of a Flo-Torq III prop hub; the prop must be allowed to have a slight forward and aft clearance. Aluminum props do not have the weight and mass (inertia) to remain at a constant speed. Generally aluminum props tend to remain at crankshaft speed. Because of this, the clutch dogs do not separate and there is very little or no prop rattle.

NOTE: With prop shaft held stationary, the prop will have approximately 0.7620 mm (0.030) in. to 3.1750 mm (0.125) in. end play and will rotate approximately $\pm 10^\circ$.



- a** - Prop nut
- b** - Tab washer
- c** - Flo-Torq III inner brass hub/adaptor
- d** - Propeller
- e** - Flo-Torq III plastic drive sleeve
- f** - Forward thrust washer

Diagnostic Tip: Customer complaining of low pitch whine from gearcase at 1200-2400 RPM.

Models: 1997 and newer 25-60hp fourstrokes usually on pontoon applications using 8, 9, or 10.5 inch pitch propellers.

Possible cause: is propeller vibration which will not effect the gearcase durability.

Correction: install propeller that has trailing edge tapered in the form of chisel point.

<u>Pitch</u>	<u>Diameter</u>	<u>Previous P/N</u>	<u>Chisel Edge New P/N</u>
8	12-1/2	48-42738A10	48-42738A11
8 Cupped	12-1/2	48-42738A12	48-42738A13
9	12-1/4	48-87818A10	48-87818A11
10-1/2	11-5/8	48-827312A10	48-827312A11
10-1/2	12	48-42740A10	48-42740A11

Propellers for Pontoon

<i>Style</i>	<i>Part Number</i>	<i>Diameter & Pitch</i>	<i># Blades</i>	<i>Material</i>	<i>Feature</i>
Mercury 9.9 - 15 HP					
Black	48-				
Max	850204A12	9 3/4" x 6	4	Aluminum	Large blade area used on Pro Kicker
Mercury 9.9 - 15 HP BigFoot, 20 - 25 HP					
Black					
Max	48-19636A10	10 3/8" x 9 1/2"	3	Aluminum	Large blade area with cup
Mercury 25 HP BigFoot, 30-40 & 50-60 HP					
Black					
Max	48-42738A13	12 1/2" x 8"	3	Aluminum	Large blade area with extra cup
Black					
Max	48-42738A11	12 1/2" x 8"	3	Aluminum	Large blade area with cup
Black					
Max	48-87818A11	12 1/4" x 9"	3	Aluminum	Large blade area with cup
Black					
Max	48-42740A11	12" x 10 1/2"	3	Aluminum	Large blade area with cup
Mercury 40 - 60 HP BigFoot					
Black	48-				
Max	854340A33	14" x 9"	3	Aluminum	Large blade area with special rubber hub
Black	48-				
Max	854342A33	14" x 10"	3	Aluminum	Large blade area with special rubber hub
Black					
Max	48-77338A33	14" x 11"	3	Aluminum	Large blade area with special rubber hub

Special Aluminum Propellers Required for 40/50/60 Bigfoot 4-Stroke Models

MERCURY/MARINER 2000 40/50/60 Bigfoot 4-Stroke USA 0G960500 and Above

Outboards listed, require the use of specially designed rubber hub aluminum propellers to reduce both the instances and severity of gear case clutch rattle. The use of other propellers, (including stainless steel propellers) although not detrimental to either performance or durability could result in clutch rattle.

IMPORTANT: These specially designed rubber hub aluminum propellers are now rated for 60 horsepower MAXIMUM. This new 60 rating applies to and supercedes the previous 50 rating listed for these propellers.

Mercury/Mariner 40/50 Bigfoot 4–Stroke 2.31:1

Wide Open Throttle RPM : 5500-6000

Recommended Transom Heights : 20", 25"

Right Hand Rotation Standard

Gear Reduction : 2.31:1

Diameter Pitch	No. of Blades	Material	Approx. Gross Boat Weight (lbs)	Approx. Boat Length	Speed Range (mph)	Propeller Part Number
13-3/4" 15"	3	Alum.	1500-2000	14-16'	25-32	48-77342A33
14" 13"	3	Alum.	1800-2600	16-18'	23-27	48-77340A33
14" 11"	3	Alum.	2800-4000	Pontoon	17-21	48-77338A33
14" 10"	3	Alum.	3000+	Pontoon/work	14-19	48-854342A33
14" 9"	3	Alum.	5000+	Houseboat/work	1-16	48-854340A33

Mercury/Mariner 60 Bigfoot 4–Stroke 2.31:1

Wide Open Throttle RPM : 5500-6000

Recommended Transom Heights : 20", 25"

Right Hand Rotation Standard

Gear Reduction : 2.31:1

Diameter Pitch	No. of Blades	Material	Approx. Gross Boat Weight (lbs)	Approx. Boat Length	Speed Range (mph)	Propeller Part Number
13-3/4" 15"	3	Alum.	2000-2500	16-18'	25-32	48-77342A33
14" 13"	3	Alum.	2300-3200	17-20'	23-27	48-77340A33
14" 11"	3	Alum.	3000-4300	Pontoon	17-21	48-77338A33
14" 10"	3	Alum.	3500+	Pontoon/work	14-19	48-854342A33
14" 9"	3	Alum.	5500+	Houseboat/work	1-16	48-854340A33

When using Mercury stainless steel propellers 40-60 HP Bigfoot and 75-115 4-stroke engines, use Flo-Torq III hub kit P/N 835257K9.

This hub kit is specially designed to reduce gearcase operating sound and to increase customer satisfaction.

Notes

Battery

Precautions

When charging batteries, an explosive gas mixture forms in each cell. A portion of this gas escapes thru holes in vent plugs and may form an explosive atmosphere around battery if ventilation is poor. This explosive gas may remain in or around battery for several hours after it has been charged. Sparks or flames can ignite this gas and cause an internal explosion which may shatter the battery.

The following precautions should be observed to prevent an explosion.

- 1) DO NOT smoke near batteries being charged or which have been charged very recently.
- 2) DO NOT break live circuits at terminals of batteries because a spark usually occurs at the point where a live circuit is broken. Always be careful when connecting or disconnecting cable clamps on chargers. Poor connections are a common cause of electrical arcs which cause explosions.
- 3) DO NOT reverse polarity of battery cables on battery terminals.
- 4) Wear eye protection.

CAUTION

If battery acid comes into contact with skin or eyes, wash skin immediately with a mild soap. Flush eyes with water immediately and see a doctor.

Battery Specification

Model	Cold Cranking Amps (CCA)	Marine Cranking Amps (MCA)
4-Stroke		
8.0 – 25	350	465
30-90/115/225 Carb & EFI Models	350 Above 32° F (0°C) 775 Below 32° F (0°C)	465 Above 32° F (0°C) 1000 Below 32° F (0°C)

NOTE: Battery specifications listed are minimum requirements for the outboard motor only, boats with additional electrical accessories will require larger batteries than listed.

Battery Rating System

There are two major rating systems used in the USA for marine engine cranking batteries. The most common is CCA (cold cranking amps) which rates the cranking amps at 0° F. The second system, mca (marine cranking amps), rates the cranking amps at 32° F. The mca rating of a given battery is always higher than the cca rating.

Cold Cranking Amps (CCA)

This figure represents in amps the current flow the battery can deliver for 30 seconds at 0° Fahrenheit without dropping below 1.2 volts per cell (7.2 volts on a standard 12 volt battery). The higher the number, the more amps it can deliver to crank the engine. (CCA x 1.3 = MCA).

Marine Cranking Amps (MCA)

This figure is similar to the CCA test figure except that the test is run at 32° Fahrenheit instead of "0". (MCA x .77 = CCA). This is more in line with actual boat operating conditions.

Reserve Capacity

This figure represents the time in minutes that a fully charged battery at 80° Fahrenheit can deliver 25 amps, without dropping below 1.75 volts per cell (10.5 volts on a standard 12 volt battery). The reserve capacity rating defines the length of time that a typical vehicle can be driven after the charging system fails. The 25 amp figure takes into account the power required by the ignition, lighting and other accessories. The higher the reserve capacity rating, the longer the vehicle could be driven after a charging system failure.

Notes

Amperage/Hour Rating

The ampere hour rating method is also called the 20 hour rating method. This rating represents the steady current flow that the battery will deliver for 20 hours while at 80° Fahrenheit without dropping below 1.75 volts per cell (10.5 volts on a standard 12 volt battery). The rating is actually the steady current flow times the 20 hours.

Example: A 60 amp-hour battery will deliver 3 amps continuously for 20 hours.

Charging Guide

12 Volt Battery Recommended Rate* and Time for Fully Discharged Condition

Twenty Hour Rating	5 Amperes	10 Amperes	20 Amperes	30 Amperes	40 Amperes	50 Amperes
50 Ampere-Hours or less	10 Hours	5 Hours	2-1/2 Hours	2 Hours		
Above 50 to 75 Ampere-Hours	15 Hours	7-1/2 Hours	3-1/2 Hours	2-1/2 Hours	2 Hours	1-1/2 Hours
Above 75 to 100 Ampere-Hours	20 Hours	10 Hours	5 Hours	3 Hours	2-1/2 Hours	2 Hours
Above 100 to 150 Ampere-Hours	30 Hours	15 Hours	7-1/2 Hours	5 Hours	3-1/2 Hours	3 Hours
Above 150 Ampere-Hours		20 Hours	10 Hours	6-1/2 Hours	5 Hours	4 Hours

* Initial rate for constant voltage taper rate charger

To avoid damage, charging rate must be reduced or temporarily halted, if:

1. Electrolyte temperature exceeds 125° F (52° C).
2. Violent gassing or spewing of electrolyte occurs.

Battery is fully charged when, over a two hour period at a low charging rate in amperes, all cells are gassing freely and no change in specific gravity occurs.

For the most satisfactory charging, the lower charging rates in amperes are recommended. Full charge specific gravity is 1.260-1.280, corrected for temperature with electrolyte level at split ring.

Effects of Temperature on a Standing Battery

The parasitic drain will be fairly constant over a range of temperatures. The important temperature is that of the boat at the time a start is attempted. Colder temperature raises the threshold of a no-start by increasing the residual power needed. When the temperature falls to 0°C (32°F), the battery will be able to put out only about 85% of its normally available starting power, and the engine may need as much as 165% of the usual power to start.

The combined effect of these two factors is to reduce the number of days the battery can stand with a parasitic drain. At 0°C (32°F), the battery can stand only half as long as it could at 25°C (77°F). And at -19°C (0°F), the standing days are reduced to one-fourth.

Temperatures above the moderate climate of 25°C (77°F) increase the battery's internal self discharge. If the battery is in a location where the temperature is averaging 32°C (90°F), an additional 5% to 10% of the available ampere-hours will be lost in a month due to self-discharge within the battery. At temperatures below the moderate range, self-discharge will be low enough to be insignificant compared to the parasitic loss.

Discharged batteries can freeze at temperatures as high as 0°C (32°F), causing permanent damage. Other permanent damage may result from allowing batteries to stand discharged for extended periods.

IMPORTANT: The battery specification listed below is generic specification.

The battery run down time will vary depending on cold cranking amperage (CCA) and reserve capacity (RC). If the CCA and RC are higher, then the battery run down time would be longer. If the CCA and RC are lower, then the battery run down time would be shorter. The graph below indicates roughly how many days a 690 CCA battery with at 110 min. RC (60.5 AH) starting at 80 percent state of charge will last with a constant current draw until it reaches 50 percent state of charge. Differences in battery rating and temperature will affect the results.

Current Drain	Days
25 mA	30.5
50 mA	16.5
75 mA	11
100 mA	8.25
250 mA	3.3
500 mA	1.65
750 mA	1
1 A	0.8
2 A	0.4

Battery Cable Wire Gauge Size

Only use copper battery cables. See chart below for correct wire gage size.

Copper Battery Cable Wire Gauge Size					
Wire Gauge Size Number SAE					
Models		6-25 hp	30-115 hp (except OptiMax)	125-250 hp (except OptiMax)	OptiMax/Verado
Cable Length	2.4 m (8 ft.)	8 ¹ .	6 ¹ .	-	-
	2.7 m (9 ft.)	6	4	-	-
	3.0 m (10 ft.)	6	4	6 ¹ .	-
	3.4 m (11 ft.)	6	4	4	-
	3.7 m (12 ft.)	6	4	4	4 ¹ .
	4.0 m (13 ft.)	6	2	4	2
	4.3 m (14 ft.)	4	2	4	2
	4.6 m (15 ft.)	4	2	4	2
	4.9 m (16 ft.)	4	2	2	2
	5.2 m (17 ft.)	4	2	2	2
	5.5 m (18 ft.)	4	2	2	2
	5.8 m (19 ft.)	4	2	2	2
	6.1 m (20 ft.)	4	2	2	2
	6.4 m (21 ft.)	2	1	2	1
	6.7 m (22 ft.)	2	1	2	1
	7.0 m (23 ft.)	2	1	2	1
	7.3 m (24 ft.)	2	1	2	1
	7.6 m (25 ft.)	2	1	2	1
	7.9 m (26 ft.)	2	1/0	1	1/0
	8.2 m (27 ft.)	2	1/0	1	1/0
	8.5 m (28 ft.)	2	1/0	1	1/0
	8.8 m (29 ft.)	2	1/0	1	1/0
	9.1 m (30 ft.)	2	1/0	1	1/0
	9.4 m (31 ft.)	2	1/0	1	1/0
	9.8 m (32 ft.)	2	1/0	1	1/0
	10.1 m (33 ft.)	2	2/0	1/0	2/0
	10.4 m (34 ft.)	2	2/0	1/0	2/0
	10.7 m (35 ft.)	1	2/0	1/0	2/0
	11.0 m (36 ft.)	1	2/0	1/0	2/0
	11.3 m (37 ft.)	1	2/0	1/0	2/0
	11.6 m (38 ft.)	1	2/0	1/0	2/0
	11.9 m (39 ft.)	1	2/0	1/0	2/0
	12.2 m (40 ft.)	1	2/0	1/0	2/0

1. Standard (original) cable length and wire gauge size.

Fuel-Alcohol and Contaminants

Water contamination in the fuel system may cause driveability conditions such as hesitation, stalling, no start, or misfires in one or more cylinders. Water may collect near a single fuel injector at the lowest point in the fuel rail, and cause a misfire in that cylinder. If the fuel system is contaminated with water, inspect the fuel system components for rust, or deterioration.

Alcohol concentrations of 10 percent or greater in fuel can be detrimental to fuel system components. Alcohol contamination may cause fuel system corrosion, deterioration of rubber components, and subsequent fuel filter restriction. Fuel contaminated with alcohol may cause driveability conditions such as hesitation, lack of power, stalling, or no start. Some types of alcohol are more detrimental to fuel system components than others.

Alcohol in Fuel Testing Procedure

The fuel sample should be drawn from the bottom of the tank so that any water present in the tank will be detected. The sample should be bright and clear. If alcohol contamination is suspected then use the following procedure to test the fuel quality.

1. Using a 3.4 oz (100 ml) specified cylinder with 0.03 oz (1 ml) graduation marks, fill the cylinder with fuel to the 3.0 oz (90 ml) mark.
2. Add 0.34 oz (10 ml) of water in order to bring the total fluid volume to 100 ml and install a stopper.
3. Shake the cylinder vigorously for 10-15 seconds.
4. Carefully loosen the stopper in order to release the pressure.
5. Install the stopper and shake the cylinder vigorously again for 10 to 15 seconds.
6. Put the cylinder on a level surface for approximately 5 minutes in order to allow adequate liquid separation.

If alcohol is present in the fuel, the volume of the lower layer, which would now contain both alcohol and water, will be more than 0.34 oz (10 ml). For example, if the volume of the lower layer is increased to 0.51 oz (15 ml), this indicates at least 5 percent alcohol in the fuel. The actual amount of alcohol may be somewhat more because this procedure does not extract all of the alcohol from the fuel.

Contaminants in Fuel Testing Procedure

The fuel sample should be drawn from the bottom of the tank so that any water present in the tank will be detected. The sample should be bright and clear. If the sample appears cloudy, or contaminated with water, as indicated by a water layer at the bottom of the sample, use the following procedure to diagnose the fuel.

1. Using an approved fuel container, draw approximately 0.5 quart (0.5 liter) of fuel.
2. Place the cylinder on a level surface for approximately 5 minutes in order to allow settling of the particulate contamination.

Notes

Notes

Particulate contamination will show up in various shapes and colors. Sand will typically be identified by a white or light brown crystals. Rubber will appear as black and irregular particles. If particles are found clean the entire fuel system thoroughly.

Effects of Fuel on Carbureted Models

Carburetors on FourStrokes engines are made with great precision (small passages) to deliver the exact amount of fuel in order to complete very clean combustion process. Improper storage (causing varnishing) and contaminated fuel can result in plugging these passages.

Effects of Fuel on EFI Models

EFI models are not exempt from improper storage and fuel contamination. The Vapor Separator Tank (VST) is vented just as a carburetor bowl. If fuel remains in the VST untreated during storage it will varnish. Only in this case the electric fuel pump could be damaged from the varnish adhering to the commutator and brushes. The injectors also have filters in their inlets that can restrict the flow of fuel resulting in lack of power, misfire complaint or flat spot. The injector might be able to flow the fuel at low RPM but not as fuel demand increases.

. Educating the customer of the importance of proper winterization and filter maintenance can help in eliminating these issues. Remind your customers about the proper use of fuel stabilizers. Reference the Owners Manual for specific procedures. Do not treat the symptom without addressing the cause or a repeat failure will occur.

Oil Dilution

All FourStroke outboards will have some degree of oil dilution. Normally, the oil level fluctuates a small degree without notice. In some cases the dilution rate exceeds the normal amount and causes an issue when the oil pan completely fills and restricts crankcase ventilation.

There are several possible causes to keep in mind when diagnosing an excessive oil dilution complaint. Engine temperature is very critical to obtain proper piston ring sealing. Verify proper heat range of spark plugs and engine operating temperature. Excessive fuel in the combustion chamber and overpropping could also contribute. **Most often the problem is caused by improper breakin procedure during the first hours of engine run operation. During this phase the rings are seating into their final position in the ring land of the piston. If the engine is run at a very low RPM for long durations the rings may never seat.**

Section 2 Product Updates

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Product Changes - 2004 MY

4/5/6

Starting serial number

Japan 0R036272 June 1, 2003

Belgium 0P268000 June 1, 2003

EMISSIONS

California 2 star rating.



9.9/15

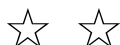
Starting serial number:

USA 0T801000 March 24, 2003

Belgium 0P268000 April 28, 2003

EMISSIONS

California 2 star rating.



25

Starting serial number:

USA 0T801000 March 24, 2003

Belgium 0P268000 April 28, 2003

EMISSIONS

California 3 star rating.

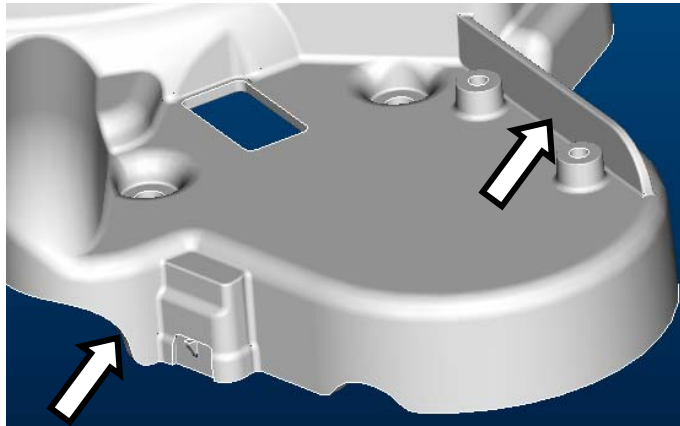


Notes

Recoil Starter Housing - 25 thru 40

Several changes to the recoil starter housing to improve durability.

- 1) Reinforcement rib added on the starboard rear to prevent cracking.
- 2) Larger radius on rear port side to prevent cracking.
- 3) Recoil inter lock cable mount has a metal insert for a machine screw for improved cable end retention.
- 4) Interlock cable mount is improved to prevent turning and maintain adjustment.
- 5) Recoil rope sheave pin has machined flats in place of a 360° "V" groove to improve retention into the housing.
- 6) Rope opening is enlarged to prevent rope contact.



30/40

Starting serial number:

USA 0T801000 March 24, 2003

Belgium 0P268000 April 28, 2003

EMISSIONS

California 3 star rating.



Electric Fuel Pump - 30 thru 60 EFI

A carbon communicator is used to improve the fuel pump durability. The carbon communicator will eliminate the internal corrosion of the previous copper communicator.

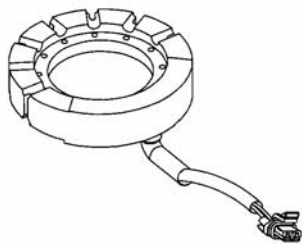


Notes

Notes

Stator - 30/40 EFI & 40/50/60 EFI

Stator output on EFI models only is changed to provide improved battery charging at low engine speeds. Advertised output at WOT is changed from 20 amps to 18 amps. The stator can be installed on previous EFI models.



AMPERAGE OUTPUT TABLE

RPM	Previous Gross Output	New Gross Output	Previous Net Battery Charging	New Net Battery Changing
700	4.1	5.9	1.4	2.8
800	6.5	8.1	3.5	4.7
900	9.1	10.2	5.2	5.7
1,000	11.2	11.7	6.4	6.8
2,000	17.4	16.6	10.6	9.8
3,000	18.7	16.9	11.2	9.9
4,000	19.1	17.3	11.4	9.8
5,000	19.3	17.4	10.8	9.1
6,000	19.3	17.4	10.8	9.1

40BF/50/60

Starting serial number:

USA 0T801000 March 24, 2003

Belgium 0P268000 April 28, 2003

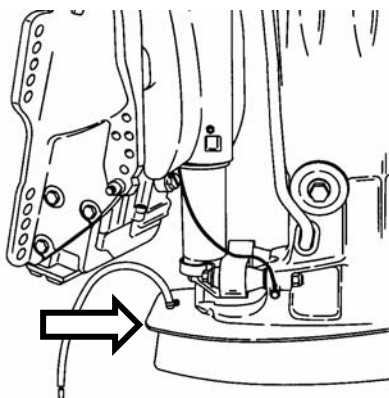
EMISSIONS

California 3 star rating.



Speedometer Tube - Removed

Production has removed the 33 cm (13 inch) long speedometer tube 32-86862 and the speedometer tube nylon coupler 22-85822 from the standard and Big Foot models. Production is installing cap 19-816622 over the gearcase fitting. The change has been requested by OEM's.



Notes

Notes

75/90/115

Starting serial number:

USA OT801000 April 7, 2003

EMISSIONS

California ? star rating.



Carburetor Calibration - 90

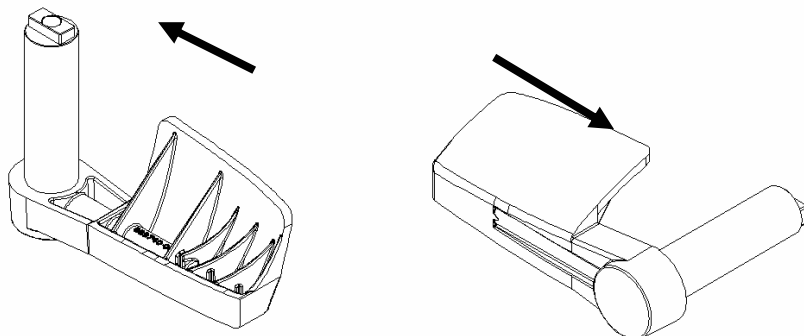
New carburetor calibration changes the main jet and nozzle, to eliminate acceleration bog. Main jet/nozzle kit to fix existing units will be available (parts for one carburetor).

Main Jet/Nozzle Kit 889682A01 available in stock.

Changed:

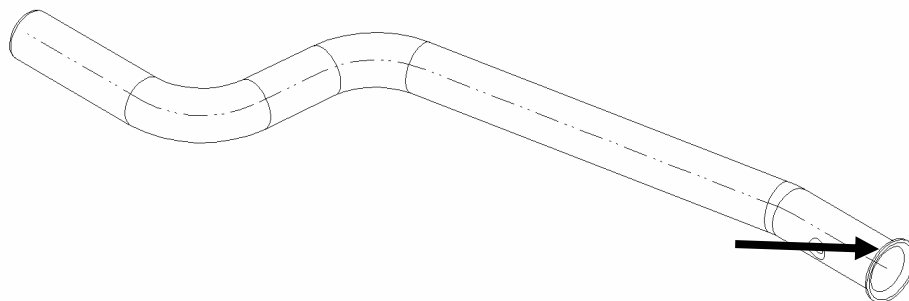
Cowl Latch Handle

Cowl Latch Handle p/n 889740001 has been enhanced by changing from a die casting to an injection molded hand grip with a stainless steel pivot pin. Additionally the tang at the end of the pivot pin has been strengthened.



Water Tube (Copper-Nickel)

New Copper-Nickel (EDP) water tubes will be a running change and will be available as a service replacement part. Copper-Nickel provides an extra added margin of corrosion protection for saltwater applications. A spherical dimple at the top of the tube identifies the Copper-Nickel material.



Model	Previous Part	New Part
75/90/115 L	32-858575—4 Copper/EDP	32-858575006 Copper-Nickel/EDP
75/90/115 XL	32-858575—3 Copper/EDP	32-858575005 Copper-Nickel/EDP

Notes

[illegible]

Notes

Desmodromic (EZ Shift) Gearcase

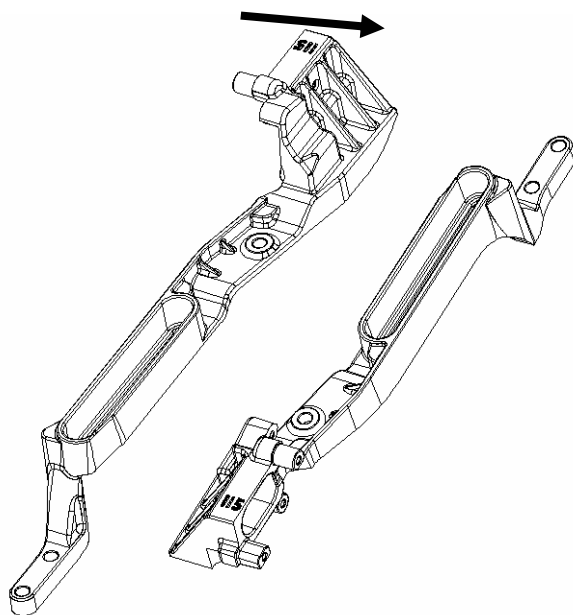
New gearcase shift design similar to small V6 to reduce shift loads. Requires new shift linkage adjustment. Requires installation manual (throttle cable) adjustment changes and service manual updating.

Adapter Plate (EZ Shift)

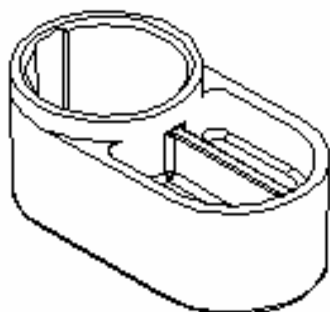
P/N 888830C

Shift Link Bracket (EZ Shift)

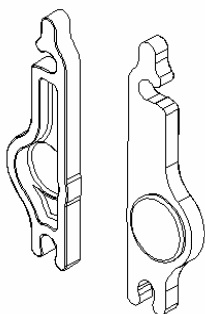
Shift Link Bracket p/n 888834A1 required for EZ Shift outboard is stamped to identify unique location for "115" throttle cable barrel cup retainer. The 75/90 (4-Stroke) models must be assembled with the throttle cable barrel cup retainer facing aft (no ID mark is provide).



Notes

[illegible]

New Throttle Cable Control Cable Latch p/n 889529 required for EZ Shift outboards. Latch is assembled either of two positions, one for the 75/90 (4-Stroke) and one for the 115 (4-Stroke) to correspond with the to the throttle cable barrel installation.



Clutch jaws for reverse gear utilize a 5° hook design which is required to hold clutch into reverse gear on outboards with EZ Shift systems. Previous design was a 5° push out design.

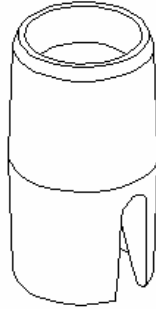
Model (Ratio)	Previous Part	New Part (EZ Shift)
75/90 (2.33:1) T28	43-882814T	43-889990T
115 EFI (2.07:1) T29	43-850036T	43-889991T

90-898313

Notes

Shift Shaft Bushing (EZ Shift)

New Shift Shaft Bushing required to guide the upper and lower shift shafts together when installing lower unit onto driveshaft housing. p/n 23-891637

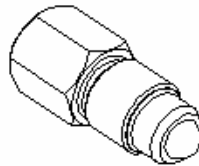


Upper Shift Shaft Assembly (EZ Shift)

New Upper Shift Shaft Assembly p/n 888835A1 required for EZ Shift Outboards. Top end of shift shaft provides cam for shift detent as well and neutral switch for 115 EFI.

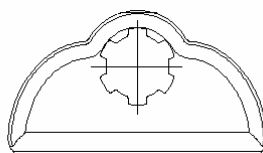
Shift Detent Assembly (EZ Shift)

New Shift Detent Assembly p/n 88823001 required for EZ Shift outboards. Detent provides positive feel of gear position.



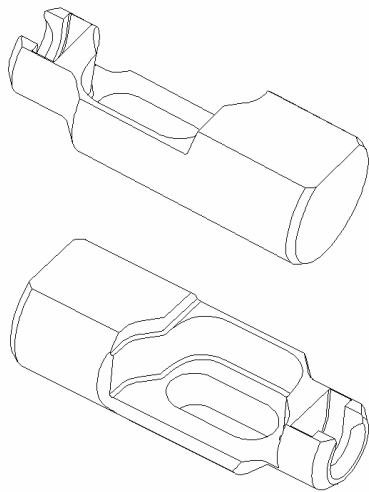
Shift Cam (EZ Shift)

New shift cam p/n 77172 required for EZ Shift outboards. Five digit part number utilized due the lack of available room for a part number stamp on the cam.



Cam Follower (EZ Shift)

New Cam Follower p/n 888807 required for EZ Shift outboards.



Tiller Handle Kit – 75/90 &115 EFI (4-Stroke)

A new tiller handle kit will be required for the 75/90 & 115 EFI (4-Stroke) model for 2004 because of the EZ Shift.

Notes

225

Starting serial number:

USA OT801000 June 2, 2003

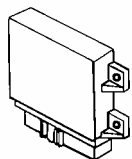
EMISSIONS

New California 3 star rating.



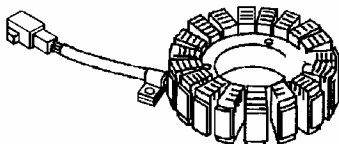
ECM

A new calibration is used to achieve California 3 Star Emissions Rating. Previous 888286T1 supersedes to 888286T10.



FLYWHEEL & STATOR

The flywheel and stator are changed to increase the electrical output, especially at lower engine speeds.



Gross Charging - Engine Operation & Battery Charging

		<u>Previous</u>	<u>New</u>
Idle	700 rpm	17 amp.	23 amp.
WOT	6,000 rpm	44 amp.	45 amp.

Net Battery Charging

		<u>Previous</u>	<u>New</u>
Idle	700 rpm	10 amp.	16 amp.
WOT	6,000 rpm	29 amp.	30 amp.

Product and Running Model Year Changes 2005-2006

Notes

4/5/6

CALIFORNIA LOW EMISSIONS HANG TAG

California is requiring that the hang tag for low emissions product be provided with the outboard by the manufacturer. In the past the hang tags were supplied by Mercury directly to dealers in California via a separate mailing or by them ordering the parts. The tag will be purchased by Mercury, stocked in plant 3 and sold to TMC, after which TMC will include it in the literature bag for each finished outboard. This change is only for low emissions (F-4,5,6) complete units, not for MPE models.

EMISSIONS

New California 3 star rating.



NEW CARBURETOR CALIBRATION

US version for 3 Star EPA specification

IGNITION SYSTEM

New ignition system to accommodate the three star calibration. New CD ignition system which eliminates the need for CD box.

New ignition timing spec. n/a time of printing

ELIMINATE CLIP ON VALVE GUIDE

Serial Break: 0R028048

ADD RELIEF TO TOP OF PISTON

Serial Break: 0R028048

OIL PAN

New oil pan, O-ring, and power head gasket set were introduced to improve oil sealing. Depths of the o-ring cavity in the oil pan were changed to incorporate a deeper design.

Serial number break: 0R057259

– New part numbers:

- Oil pan: 803531001
- O-ring: 25-803513010
- Powerhead gasket set: 27-803508A05

Notes

STIFFER FUEL PUMP SPRING

The new fuel pump will have a stronger spring so that this fuel pump can also be used on the new Fourstroke 8/9.9 hp outboard. Service Information: The old fuel pump is superseded to the new fuel pump. The old and new fuel pumps are fully interchangeable when used on F-4,5,6 hp outboards.

Serial Break: 0R036272

SPADE TO EYELET STYLE

The ground terminal is changing from a spade style to an eyelet style. The purpose of this change is the help prevent the ground terminal from slipping off the bolt.

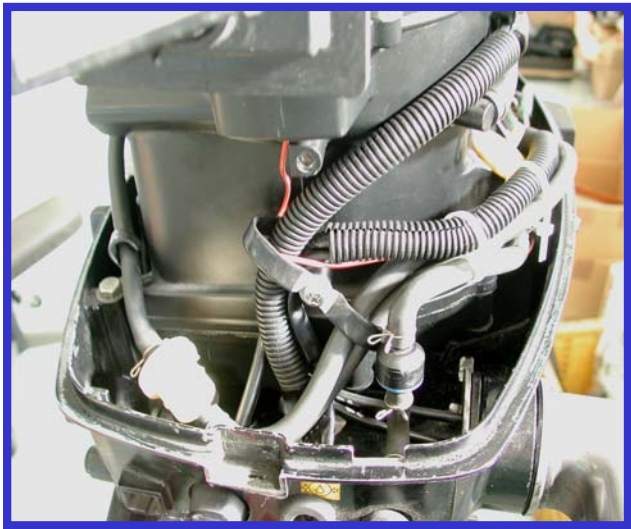
Serial Break: 0R036272

REVISED THROTTLE WIRE ROUTING

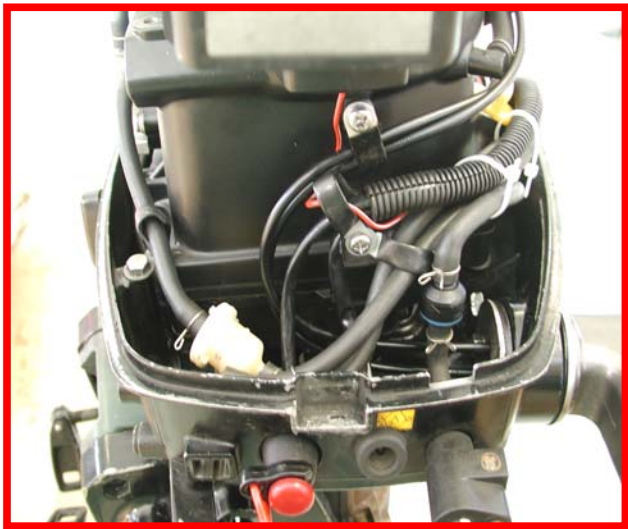
Serial Break: 0R036272

Notes

4 HP New Routing



4 HP Old Routing



Notes

9.9/15

FUEL FILTER SCREEN CHANGE

Serial Break: 0T850768

ADD SCREEN TO CARBURETOR

Micron was increased to help contamination

Serial Break: 0T897683

NEW FUEL LINE

Due to undersized fit and splitting when installed on the fuel filter. New part numbers are 32-8566829-27 and 32-856829-31

8-9.9 TMC/Mercury Joint Venture

8/9.9hp FourStroke released at 2005 model year

NEW TILLER TUBES IMPLEMENTED

- Tiller tubes were stripping out in the field when customers would attempt to shift the unit into gear.
- Service Bulletin 2004-10 was released to address this issue.
- Implemented at engine 0R053618.
- New part number is 803998004

NEW REVERSE HOOKS WERE IMPLEMENTED

- Customers/dealers complained that their engines were coming out of the water when speed up in reverse.
- Service Bulletin 2004-09 was released to address this issue.
- Implemented at engine 0R053618.
- New part number is 42141 1.

SHIFTING SYSTEM

Shifting system was changed to accommodate a 3.0 inch shift stroke. Engines previous had a shift stroke of 2.5 inches.

- Customer can now use any style of Mercury control box with the “SAE” end cables.
- This change was implemented on all BigFoot model engines, and at 0R052327 for standard gearcase engines.

CHOKE KNOB

The material in the choke knob was changed to prevent a “cracking” condition.

- New part number: 855565001
- Starting serial number: 0R054295

IDLE ADJUSTMENT SCREW SPRING

Changed the idle adjustment screw spring to a stiffer spring design. This was implemented to address the screw loosening up, which allowed the idle rpm to change.

- Serial number at implementation:0R052328
- New part number :24-16264003

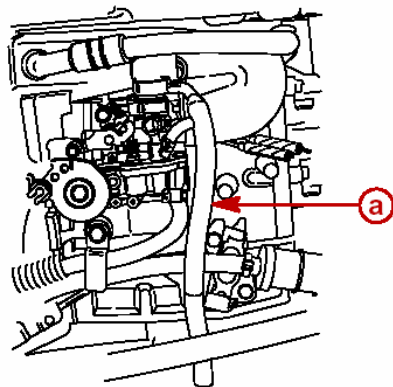
NEW TILT STOP PIN STRONGER

New part number:815094003

25HP

VENT HOSE ORIENTATION

Fuel was leaking out of the carburetor when tilted up. This resolved the issue. Service Bulletin 2003-01 was written to communicate the issue to the field.



a) Carburetor Float Bowl Vent Hose

Serial Break: 0T756311

Notes

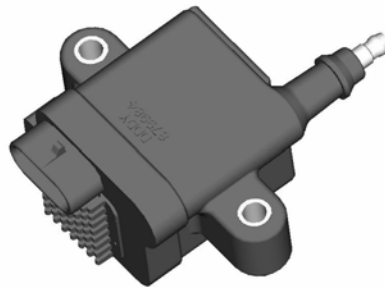
30/40 3 Cylinder EFI & 40/50/60 4 Cylinder EFI

RESOURCE IGNITION COILS, HIGH TENSION LEADS, AND COIL PLATE TO MARSHALL COIL.

We will utilize this V-6 style ignition coil as a cost reduction. The high tension leads will now be 90deg rather than a 45deg plug end. New engine, ECM and trim harness. These will not back fit.

Model year 2004 Implementation. s/n OT980000

Part number: 879984T00



25 AMP IGNITION FUSE

Serial break: 1B036320

- The root cause of the fuse implementation was the 3cylinder 40 hp blowing ignition fuses.
- To repair this condition in the field a 25amp ignition fuse and ECU calibration 891952-029 should be installed.
- The 20 amp smartcraft fuse was also changed to a 5 amp concurrently with this change.

KEHIN VST

The complete assembly will backfit older product.
Implemented in July 2004 S/N 1B036614

WALBORO MECHANICAL FUEL PUMP

Changed the mechanical fuel pump return spring and the retention rate of the plunger washer to keep the plunger from sticking or turning. New part numbers are: 881862T07 for Carbureted engines and 881862T08 for EFI models. Change implemented on January 12th of 2004 for production.

DAEWA MECHANICAL FUEL PUMP

Implementation Planned for August 2004 S/N 1B049660
Part number: 892874T01
Backfittable

DELPHI “MULTEC” FUEL INJECTOR

Implementation Planed for 2005 model year.

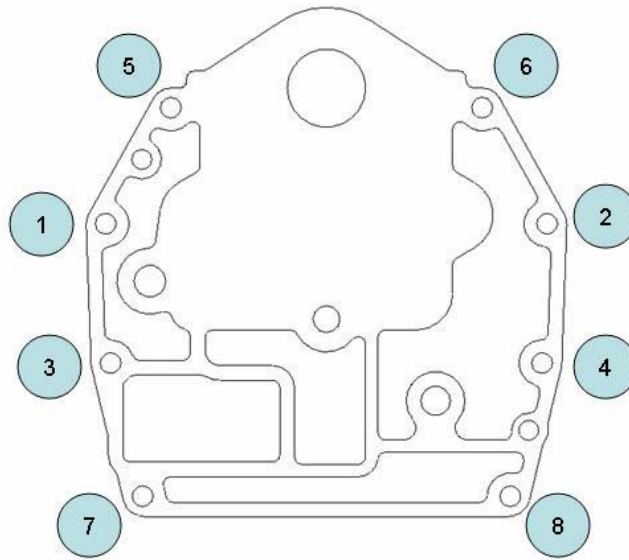
Notes

Notes

TORQUE AND TURN PROCEDURE

Implemented on this model for the adapter plate mounting bolts to improve bolt torque consistency. Service bulletin 2004-13

F25-60 Powerhead Torque Sequence



Torque M8x110 screws to 20 ft-lb + 90 degree turn

WATER TUBE (COOPER-NICKEL)

Implementation: February 2005

- Backfittable
- Part number:
- Short: 850169002
- Long: 888591001

30-60 EFI FOURSTROKE FUEL COOLER HOSE REPLACEMENT

Models Covered	Serial Number Or Year
Mercury/Mariner 30 through 60 EFI FourStroke	1B036614 through 1B101240
Mercury/Mariner 30 through 60 EFI FourStroke	Belgium 0P340242 through 0P354961

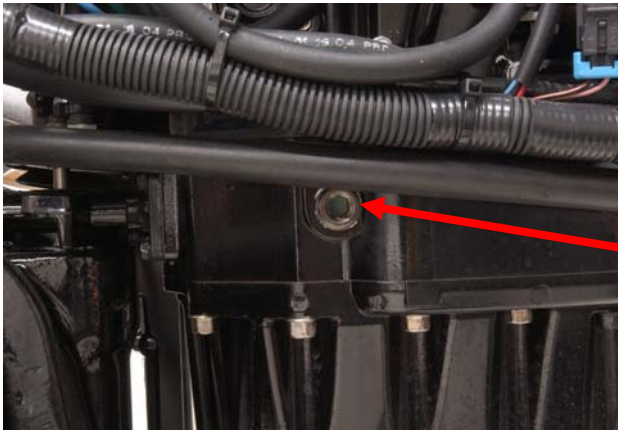
Bulletin No. 2005-03

The engine models listed above are at risk to have the fuel cooler water return hose damaged by the cowl mounted trim switch. Mercury Marine has installed protective sleeves on all production built product after serial number 1B101240 to prevent the trim switch from damaging the hose

30-60 FOURSTROKE OIL LEAKS

For engines leaking engine oil around the adapter plate and power head base areas please follow these steps to assure proper repair of the engine.

- Inspect the oil sump for signs of leaks externally. This could include casting flaws or cracks in the oil sump.
- Inspect the oil plug on the port side of the adapter plate for proper sealing/torque. The lower cowls will need to be removed for this inspection.

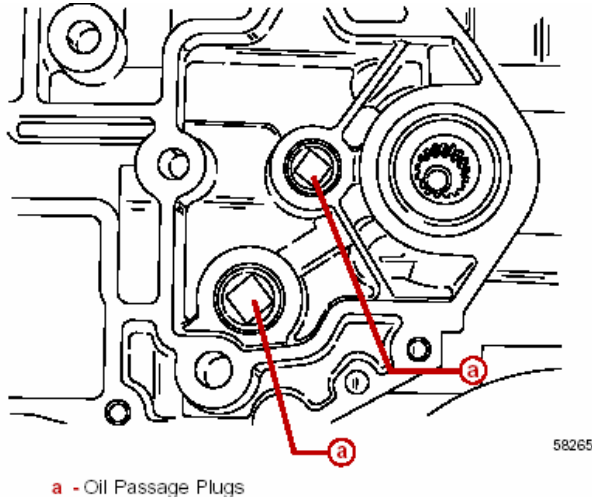


Oil plug

- Remove the p/h and inspect the oil galley plugs for proper seal and torque. If they are leaking, remove, clean, and reseal the plugs with Loctite 567 PST Pipe Sealant part number 92-809822. DO NOT use Teflon tape. The tape may tear during assembly and plug an internal oil passage. Install the plug until it is flush with the surface. Installing the plug to an increased depth may restrict the oil flow inside the oil passage.

Notes

Notes



- Replace powerhead base (892319001) and Adapter plate (892320001) gaskets with the new MLS (Multi-Layer Steel) gaskets. Be sure to torque the 5 rear adapter plate bolts to 28lb-ft and the 8 power head bolts per the following “torque and turn” sequence:

25-60 FOURSTROKE OIL PRESSURE

The new four strokes using the new 25-40 oil will exhibit a higher oil pressure at 3000 rpm than what our service manual reflects as the correct range. Currently we state a normal oil pressure range of 30-40 PSI at 3000 RPM with a warm engine. The engines now running the thicker viscosity oils will have a range of 50-60 PSI at that same engine RPM. We will be addressing the service manual discrepancy shortly.

225 EFI

APPLY DIELECTRIC GREASE TO END OF HARNESS WITH DISPENSING SYSTEM

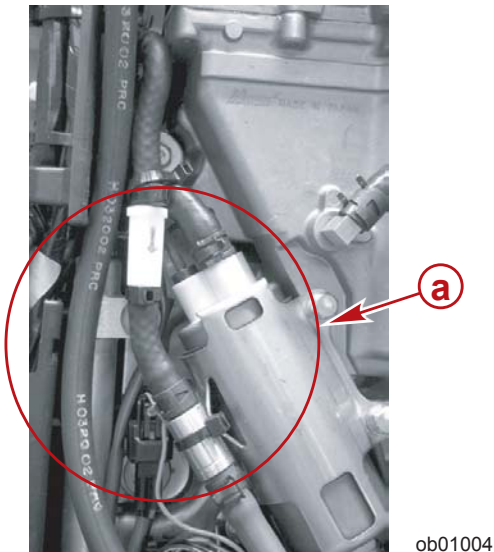
Serial Break: 0T862494

CHANGE PRODUCT TO 2004.5 MY AND UPDATE EPA RATING FROM 2 STAR TO 3 STAR

Serial Break: 0T922540

INSTALL FUEL FILTER BEFORE CHECK VALVE INTO THE LOW PRESSURE FUEL PUMP RECIRCULATION SYSTEM

2004.5 model year implementation. Serial number 0T922540



ob01004

INSTALLATION OF LINK ROD KITS

To eliminate throttle sticking situations per service bulletin 2005-01.
Replacement link rod kits serial number 0T653945. through 1B055871

Notes

2005/2006 Model Year Changes14 Pin Adapter and Control Harnesses

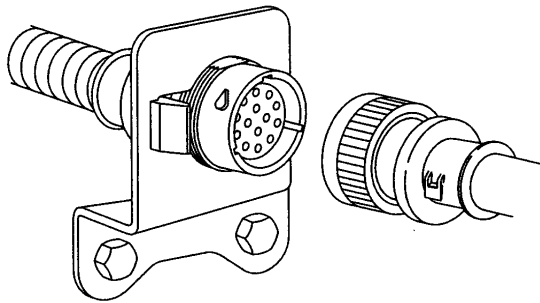
Models Affected

4-stroke models 9.9 thru 225 HP V-6 EFI (Excluding Verado)

2-stroke V-6 Outboards 135 thru 250 HP (Excluding Jet Drive)

The 2006 models listed above will be changing to a 14 pin connector for the main engine to boat control harness connection. A number of harness adapters have been developed to allow the use of older controls on new engines that use the 14 pin connector. Some of the new adapters will also allow the 2005 and prior models to use the new style 14 pin controls and key/choke harnesses.

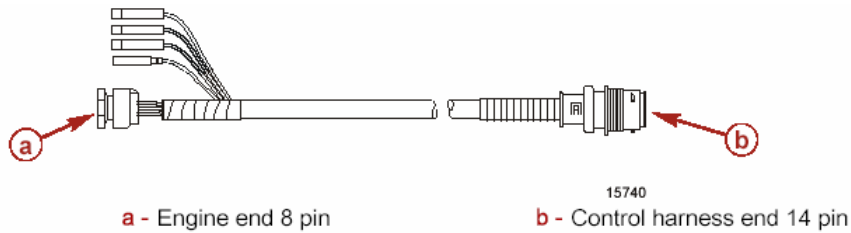
- New engine harness requires a new 14 pin key/choke harnesses & controls. CAN # 1 & 3 built into harness with separate terminator locations. Old will NOT supersede to new.
- Reference Current Parts Catalogue for part numbers.



Notes

84-896541T_

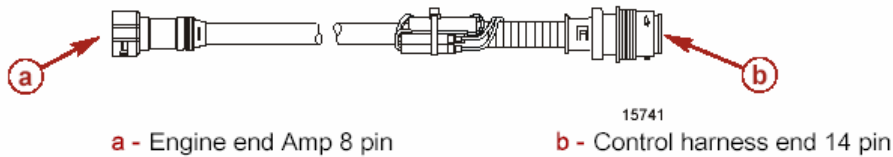
Adapts the 2005 model and newer 8/9.9 HP (209cc) 4-Stroke engines to the new 14 pin control or key/choke harness.



Part Number	Length
84-896541T01	91.44 cm (36 inches)

84-858740T_

Adapts the 2005 model year and prior 75/90 HP 4-Stroke Carb/EFI, 115 HP and 225 HP V-6 EFI 4-Stroke engines; and the 2006 model and newer 75/90/115 HP (International 80/100 HP) EFI, 225 V-6 EFI 4-Stroke to the new 14 pin control or key/choke harness.

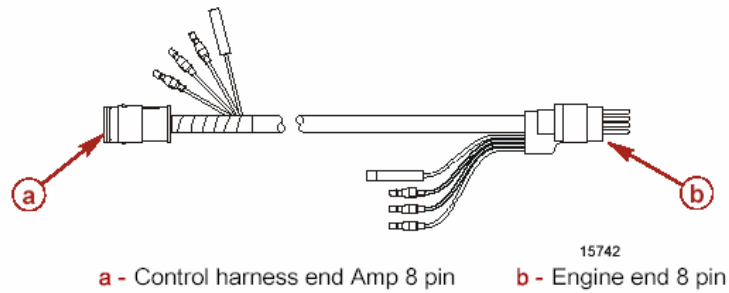


Part Number	Length
84-858740T06	40.64 cm (16 inches)

Notes

84-898142T_

Adapts engines with the round 8 pin to controls with the Amp 8 pin connector.



Part Number	Length
84-898142T01	30.48 cm (12 inches)

Section 3 EFI Systems Components/Operation

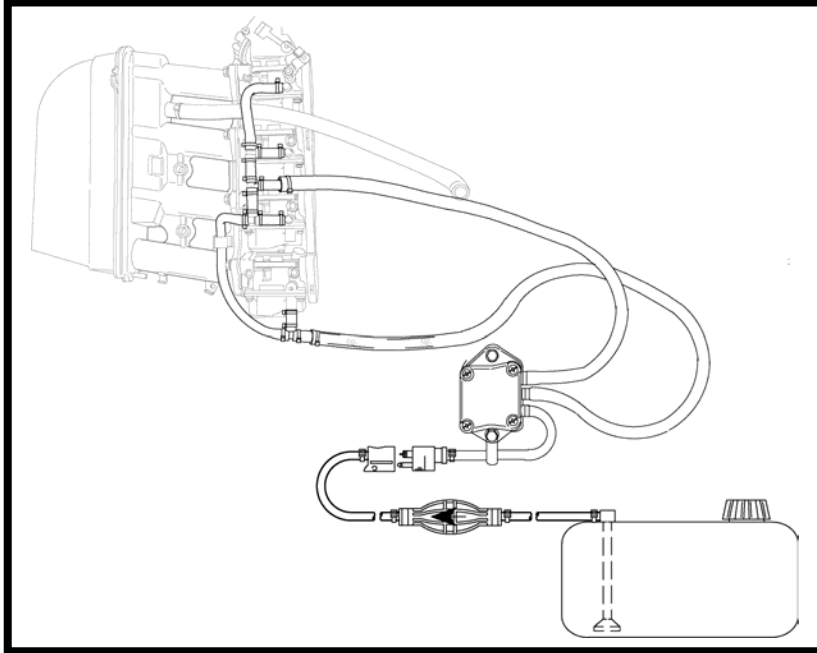


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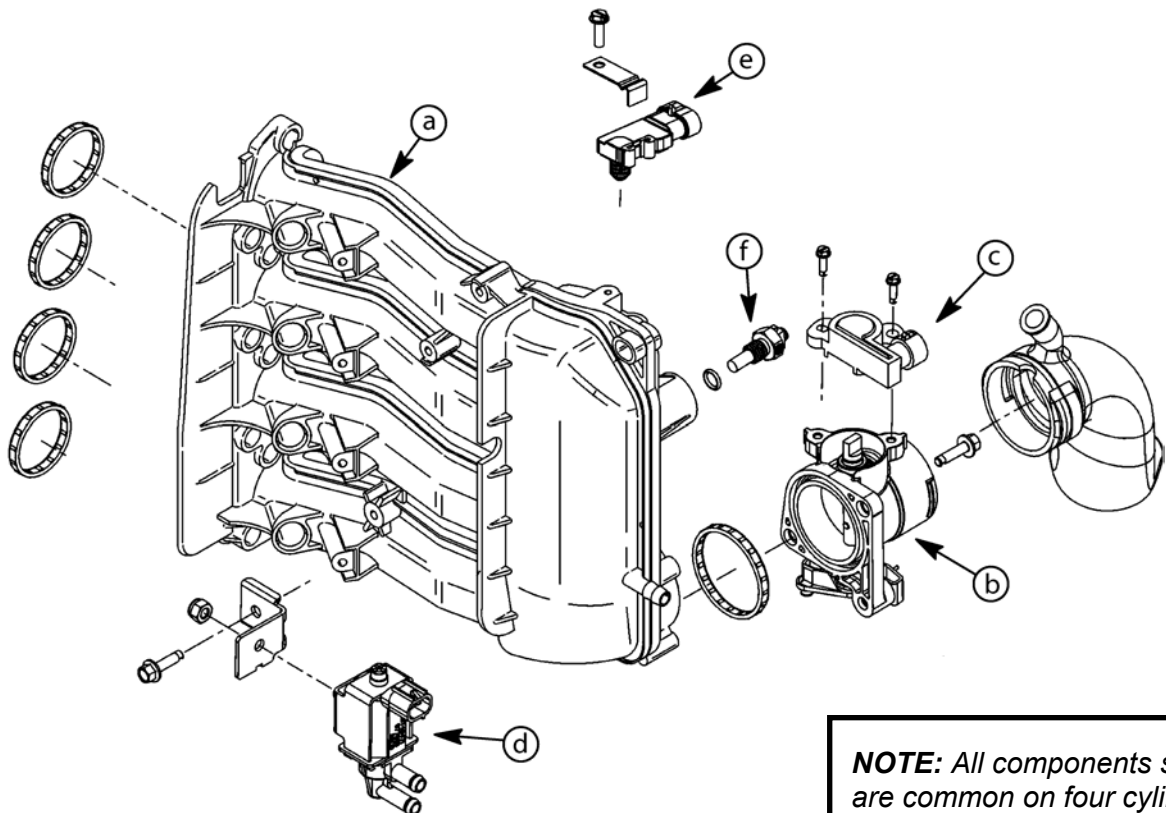
Abbreviations

amp	Amperes	IAC	Idle Air Control
BARO	Barometric Pressure	IGN	Ignition
Bat	Battery Positive Terminal, Battery or System Voltage	in. hg	Inches Of Mercury
B+	Battery Positive	INJ	Injection
Bps	Beeeps	kPa	Kilopascal
CAM	Camshaft	KS	Knock Sensor System
cond	Condition	kV	Kilovolts
cont	Continuous	mA	milliamperes
Crank	Crankshaft	MPR	Main Power Relay
CAN	Control Area Network	MAP	Manifold Air Pressure
CKT	Circuit	MAT	Manifold Air Temperature
CMP	Camshaft Position Sensor	mohms	Milliohms
Conn	Connector	mSec	Millisecond
CPS	Crankshaft Position Sensor	N/C	Normally Closed
Cyl	Cylinder	N/O	Normally Open
DDT	Digital Diagnostic Terminal	PCM	Propulsion Control Module
Deg	Degrees	RAM	Random Access Memory
Diag	Diagnostic	REF HI	Reference High
Dis	Distributorless Ignition System	REF LO	Reference Low
DLC	Data Link Connector	ROM	Read Only Memory
Dtc	Diagnostic Trouble Code	SW	Switch
DMM DMT DVM DVOM	Digital Multimeter	TACH	Tachometer
ECM	Engine Control Module	TERM	Terminal
ECT	Engine Coolant Temperature	TPS	Throttle Position Sensor
EFI	Electronic Fuel Injector	V	Volts
EMCT	Exhaust Manifold Coolant Temperature	VAC	Vacuum
ENG	Engine	WOT	Wide Open Throttle
GND	Ground		

30-60 Electronic Fuel Injection System

Air Induction System

The air induction system consists of an intake manifold (an intake runner for each cylinder joined to a common air box), a single throttle body/shutter with attached Throttle Position Sensor (TPS), an Idle Air Control (IAC), a Manifold Absolute Pressure (MAP) sensor, and a Manifold Air Temperature (MAT) sensor. The intake manifold also mounts the fuel distribution manifold and the fuel injectors.

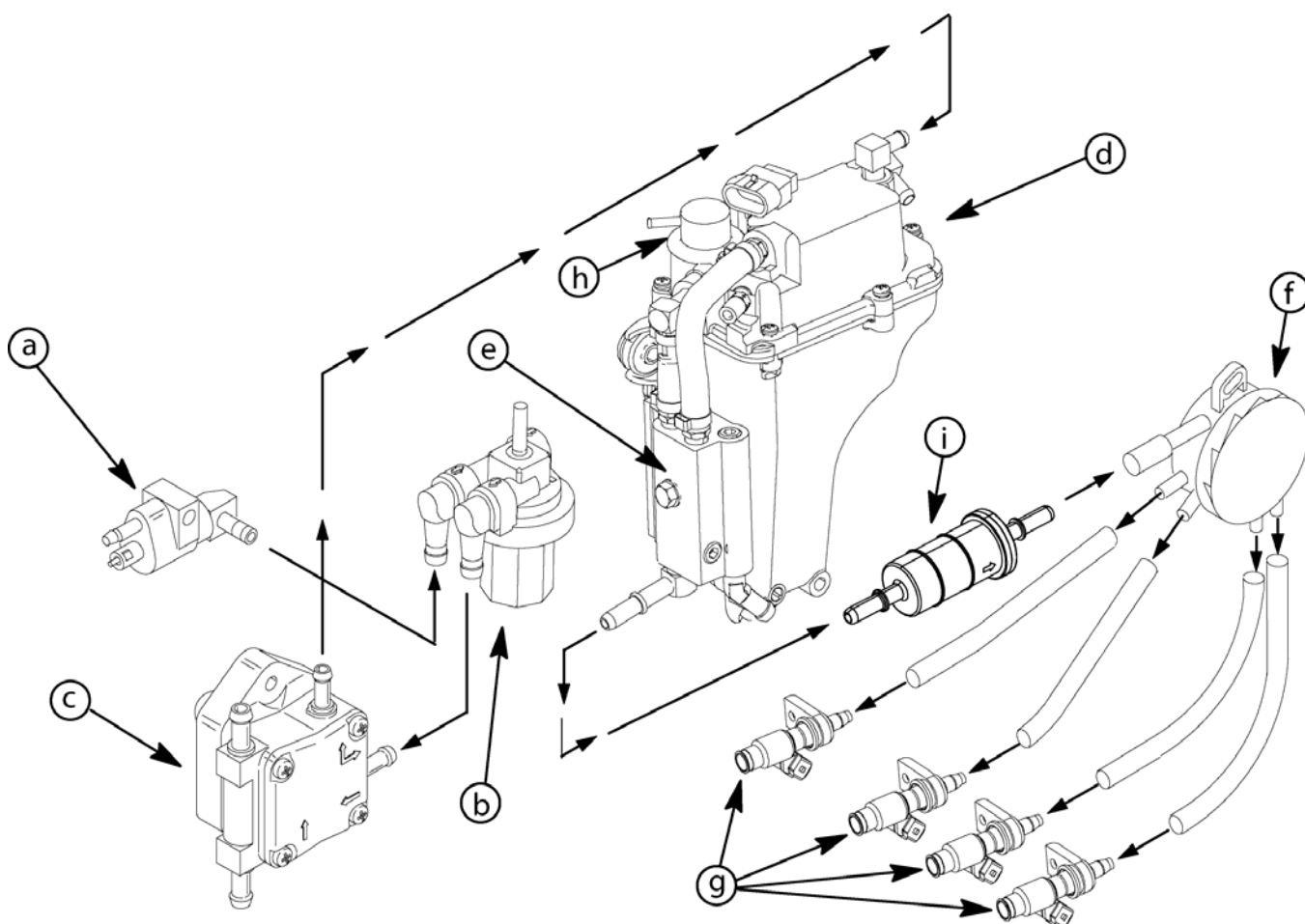


- a) Intake Manifold
- b) Throttle Body/Shutter
- c) Throttle Position Sensor (TPS)
- d) Idle Air Control (IAC)
- e) Manifold Absolute Pressure (MAP) Sensor
- f) Manifold Air Temperature (MAT) Sensor

NOTE: All components shown are common on four cylinder models. The 40 & 50 HP models also have a restrictor plate.

Fuel System

The fuel system consists of a fuel line connector, a water separating fuel filter, a low-pressure mechanical fuel pump, a high-pressure electric fuel pump, a fuel distribution manifold, fuel injectors, a fuel cooler and a fuel pressure regulator. The low-pressure mechanical fuel pump draws fuel from the fuel tank, through the fuel line connector and fuel filter, then delivers it to the high-pressure fuel pump within the vapor separator tank. High-pressure fuel is circulated through the fuel cooler and supplied to the fuel distribution manifold and fuel injectors to be sprayed into the intake manifold. Fuel not used by the fuel injectors (fuel not entering the high-pressure fuel line to the fuel distribution manifold) circulates through the fuel cooler, then flows through pressure regulator, and returns to the vapor separator tank.



- a) Fuel Line Connector
- b) Water Separating Fuel Filter
- c) Low-Pressure Mechanical Fuel Pump
- d) Vapor Separator Tank/High Pressure Electric Fuel Pump
- e) Fuel Cooler
- f) Fuel Distribution Manifold
- g) Fuel Injectors (4)
- h) Pressure Regulator
- i) High Pressure Fuel Filter

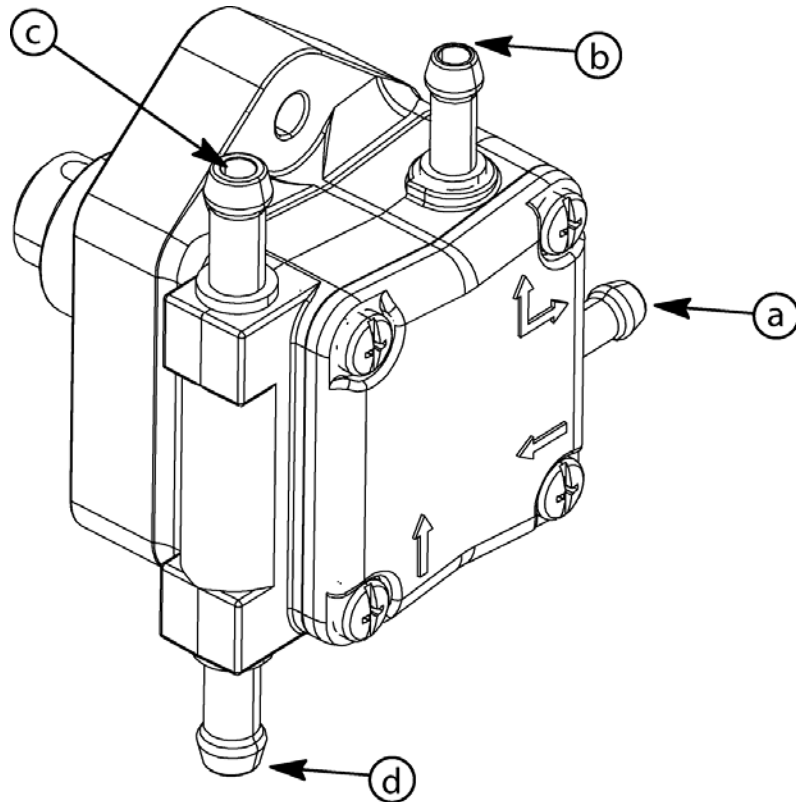
Fuel System Components

Notes

Fuel Pump

The fuel pump is a diaphragm pump which is mechanically driven off of the rocker arm.

The pump base insulates the fuel pump from the heat of the engine block. The fuel pump is water cooled to help prevent vapor lock by cooling the fuel.



- a) Fuel From Filter/Tank
- b) Fuel Outlet to VST
- c) Water Inlet From VST Fuel Cooler
- d) Water Outlet to Tell-tale

Diagnostic Tip: Customer complaining of knocking noise from powerhead.

Possible Cause: If the lift pump has fuel restriction it will knock potentially misleading technician to false internal powerhead failure.

Correction: Complete lift pump vacuum test should be less than 2.0 Hg.

Vapor Separators

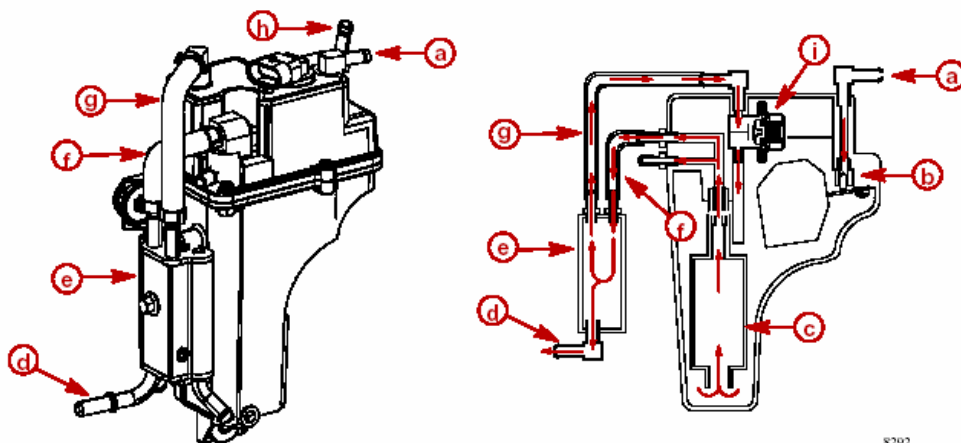
NEW VST MANUFACTURER (KEIHIN) FOR 2005 MY (RUNNING CHANGE) 40/50/60 FOUR CYLINDER AND 30-40 THREE CYLINDER

The newer VST will supersede the earlier version. It looks almost identical. Following are some brief highlights:

- Fuel pressure regulator will now be inside.
- The main seal between the top and bottom will now be an o-ring.
- The float will be a hollow design, instead of a solid material.
- The main fittings will now be pressed in, instead of being threaded.
- The new electrical fuel pump is a Turbine Pump, instead of a Gerotor Pump.

The vapor separator maintains a liquid fuel supply for the high pressure fuel pump located in the vapor separator tank. Fuel delivered from the mechanical low-pressure fuel pump is supplied to the top of the vapor separator and is controlled by the inlet needle/float assembly. Pressurized fuel from the high-pressure pump circulates through the fuel cooler, to the fuel distribution manifold and injectors. Excess fuel flows through the pressure regulator back to the vapor separator tank.

1B036614 AND ABOVE



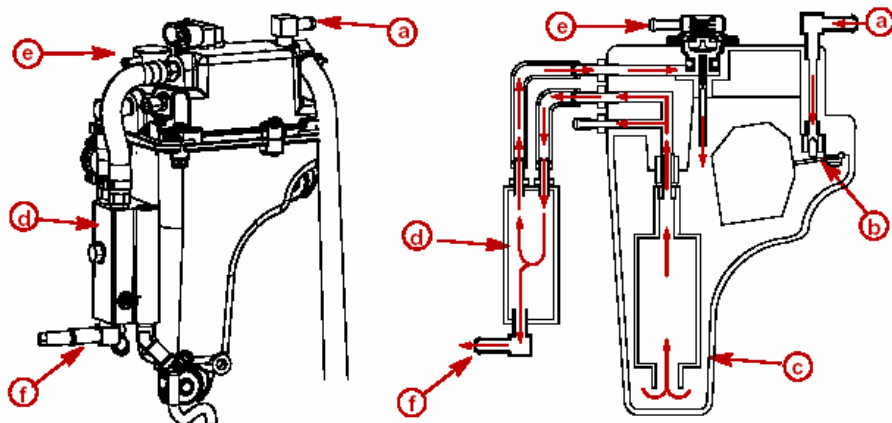
8292

- a - Fuel inlet from mechanical fuel pump
- b - Inlet needle
- c - High pressure fuel pump
- d - High pressure fuel to fuel distribution manifold
- e - Fuel cooler
- f - Fuel line from high pressure pump to fuel cooler
- g - Fuel line from fuel cooler to fuel pressure regulator
- h - VST vent to intake manifold
- i - Fuel pressure regulator

Notes

Notes

1B036613 AND BELOW



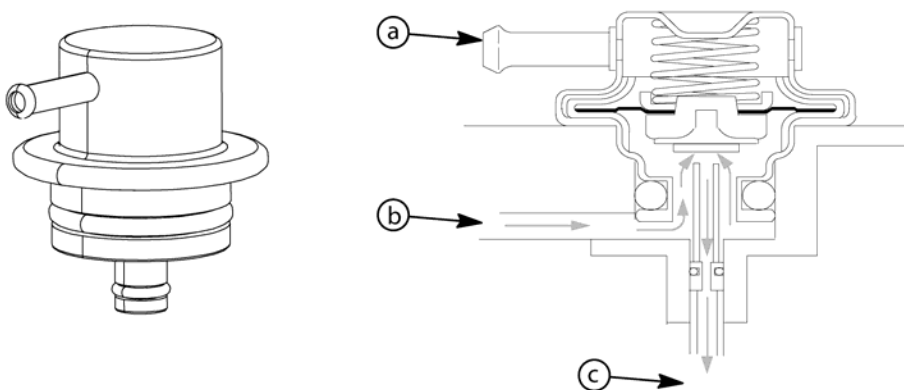
- a - Fuel From Mechanical Fuel Pump
- b - Inlet Needle and Float Valve
- c - High Pressure Electric Fuel Pump
- d - Fuel Cooler
- e - Pressure Regulator
- f - Fuel Outlet to Fuel Distribution Manifold

Fuel Pressure Regulator

1B036613 AND BELOW

The fuel pressure regulator mounted on top of the vapor separator maintains a stable fuel pressure between the high-pressure fuel pump and the fuel injectors. The pressure regulator consists of a spring-loaded diaphragm which actuates a valve/seat assembly. Excess fuel pressure unseats the valve returning fuel to the vapor separator tank. The excess fuel is channeled below the fuel level in the vapor separator tank through an internal pipe to prevent fuel vaporization.

The spring side of the diaphragm is vented to atmosphere allowing barometric conditions to act on the diaphragm in addition to spring pressure.



- a) Vent to Atmosphere
- b) High Pressure Fuel From Fuel Cooler
- c) Excess Fuel Flows to VST

1B036614 AND ABOVE

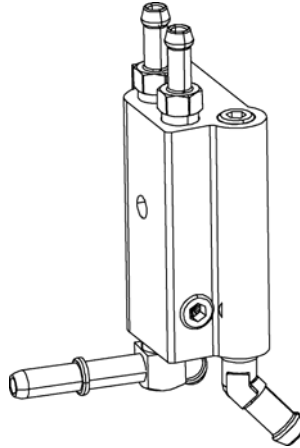
The fuel pressure regulator is mounted inside the VST on the vapor separator cover and maintains a stable fuel pressure between the high pressure fuel pump and the fuel injectors. The pressure regulator consists of a spring-loaded diaphragm which actuates a valve/seat assembly. Excess fuel pressure unseats the valve returning fuel to the vapor separator tank. The excess fuel is channeled below the fuel level in the vapor separator tank through an internal pipe to prevent fuel vaporization. The spring side of the diaphragm is vented inside the VST tank. The VST tank is vented to atmosphere pressure allowing barometric pressure changes to act on the diaphragm in addition to spring pressure.

Notes

Notes

Fuel Cooler

A fuel cooler (heat exchanger) is attached to the vapor separator, and uses engine cooling water to cool the high-pressure fuel supply to the fuel injectors as well as a return circuit to the VST. Removing heat from the circulating high-pressure fuel prevents the formation of fuel vapors.



Electronic Control Module

The ECM is the control center for the fuel injection system. It constantly monitors information from various sensors (engine temperature, throttle opening, engine speed, air temperature and pressure) and controls the systems that affect engine performance (engine timing and injector pulse width).

There are three types of memory storage within the ECM: ROM, RAM and EEPROM.

Read Only Memory (ROM) is the permanent memory inside the ECM. The ROM contains the overall control programs and once programmed cannot be changed. The control program is the list of instruction the ECM will follow in performing its routines. The ROM memory is non-erasable and does not need power to be retained.

Random Access Memory (RAM) is the microprocessor“scratch pad”. The processor can write into, or read from, this memory as needed. The ECM uses RAM to store temporary values and data like coolant temperature or manifold pressure signals. This memory is erasable and needs a constant supply of voltage to be retained.

Electronic Erasable Programmable Read Only Memory (EEPROM) is the portion of the ECM that contains the different engine calibration information that is specific to each marine application. Information like fuel curve, spark advance and default values are stored in EEPROM. This type of memory will retain information until erased for insertion of new information. Changing EEPROM memory requires special equipment and is usually not performed at the dealership without factory assistance. CDS is currently developing cables and software to program ECM in the field.

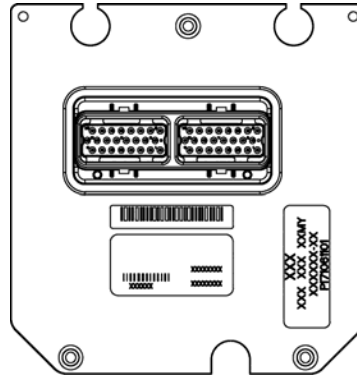
The ECM supplies 5 or 12 volts to power various sensors or switches. This is done through resistance in the ECM which is so high in value that a test light will not light when connected to the circuit. **Care should be taken to use a 10 meg-ohm input impedance digital meter for accurate readings.** The ECM can also perform a diagnostic function check of the system. It can recognize operational problems and store a code or codes which identify the problem areas to aid the technician in making repairs.

Notes

[illegible]

Notes

The ECM is turned on through the “wake-up” line, which is key-switched battery voltage. The ECM then turns on the Main Power Relay, which feeds battery voltage (12 volts) to most of the actuators (such as the ignition system and fuel injectors). The ECM also supplies 5 volts (called “Power 1” [PWR1]) to various sensors and switches. This is normally done through a current limiting resistor to protect the ECM’s power supply from short circuits.



ECM and Voltage Signals

- The ECM uses voltage to send and receive information.
- Voltage is electrical pressure that does not flow in circuits.
- Voltage causes current which does the real work in electrical circuits.
- It is the flow of electrically charged particles (current), that energizes solenoids, closes relays and lights lamps.
- Voltage is used as a signal to send information by changing levels, changing wave-form (shape), or changing the speed at which the signal switches from one level to another.
- Different sections inside the ECM also use voltage signals to communicate with each other.

There are two kinds of voltage signals.

a. Analog

b. Digital

It is important to understand the difference between them and the different ways they are used.

Analog Signals

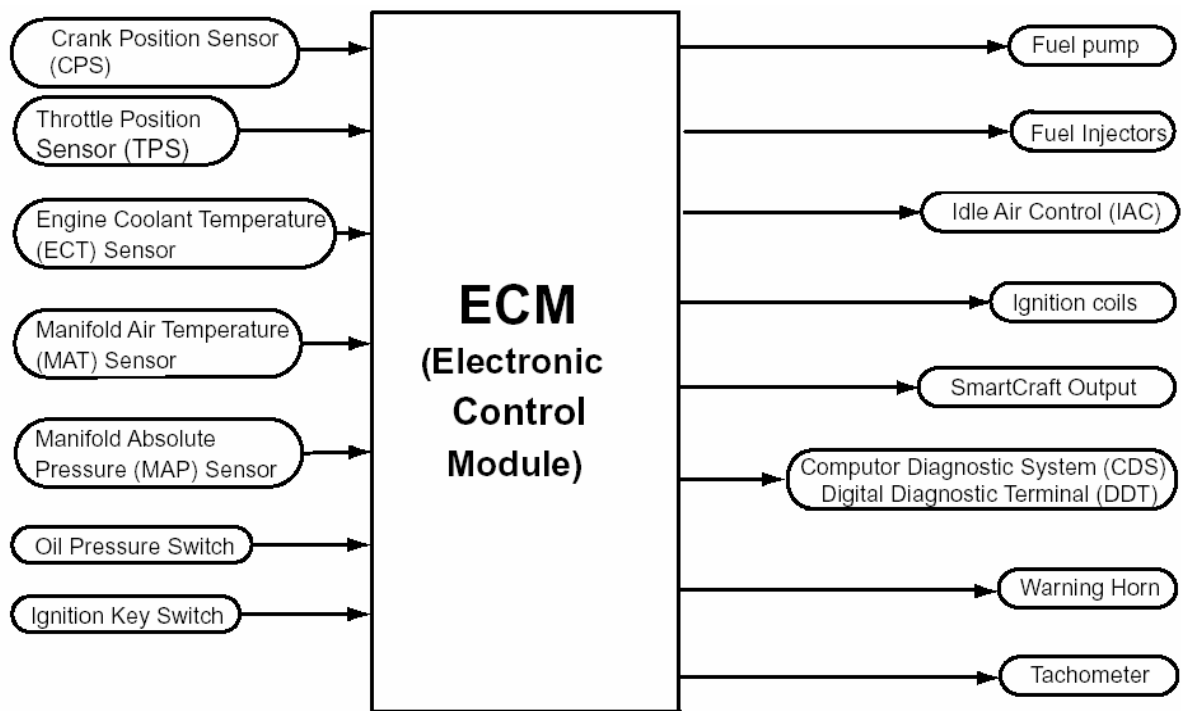
1. An analog signal is continuously variable and can be any voltage within a certain range.
2. An analog signal usually gives information about a condition that changes continuously over a certain range.
3. Temperature is usually provided by an analog signal.

Digital Signals

Notes

1. The ECM uses digital signals (Digital Binary Code), that contains only ones and zeros.
2. Digital BinaryCode is computer language between a computer (ECM) and any electronic device that understands the code. By stringing together thousands of bits, computers can communicate and store an infinite variety of information. To a computer that understands binary code, 11001011 might mean that it should reset engine RPM at a lower level. Although the computer uses 8-bit digital codes internally and when talking to another computer, each bit can have a meaning.
3. A digital signal is limited to two voltage levels.
 - a. One level is a positive voltage (Column),which is the high voltage of the digital signal representing a one (1).
 - b. The other is no voltage (zero volts)(Space). No voltage represents a zero (0).
 - c. A Digital Binary Signal is a square wave.
4. Each zero and each one is called a bit of information, or just a bit. Eight bits together are called a word. A word, therefore, contains some combination of eight binary code bits: eight ones, eight zeros, five ones and three zeros, and so on.
5. Digital signals (Digital Binary Code) is especially useful when the information can only refer to two possible conditions;
 - Yes or No
 - On or Off
 - High or Low
6. Digital signals are variable, but not continuously and can only be represented by distinct voltages within a range.

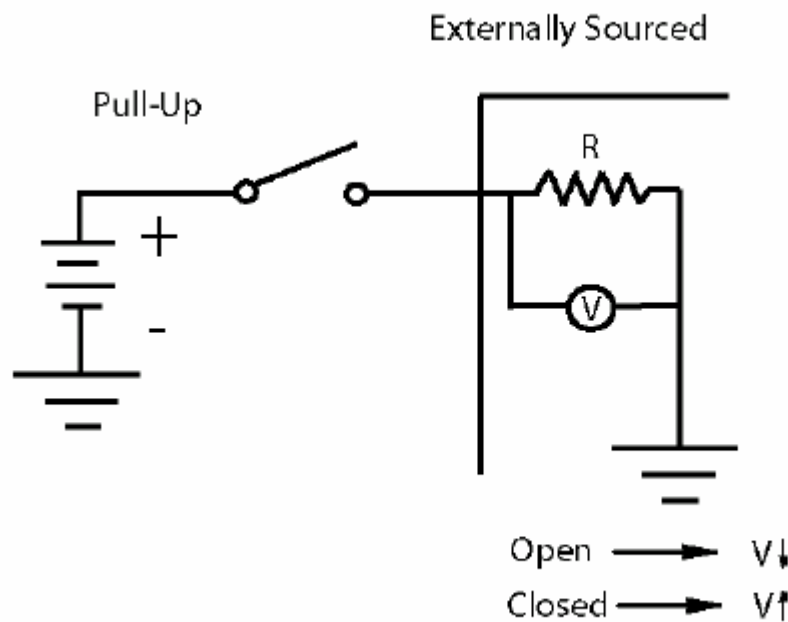
ECM Control Module Functions



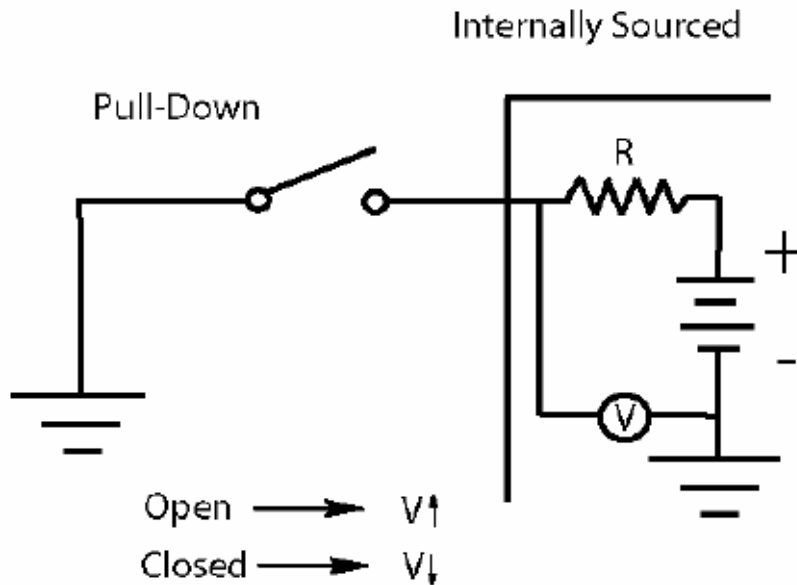
Notes

Switches

The simplest kind of signal the ECM receives is known as a “switched” input. A switched input is a clear high or low signal, depending on whether the switch is open or closed. However, the ECM can receive two types of switched input, depending on the source of power to the circuit. A “pull-up” circuit has a power source outside the ECM. The ECM is not providing the reference voltage signal. When the switch is closed, external source voltage generates a high reference signal to the ECM. An open switch, on the other hand, generates a low reference signal.



A “pull-down” circuit is provided with a reference voltage signal from the ECM. The power source for the circuit is internal to the ECM. When the switch is closed, source voltage is pulled low to an external ground. The ECM registers a low voltage reference signal. When the switch is open, the ECM registers a high reference signal.

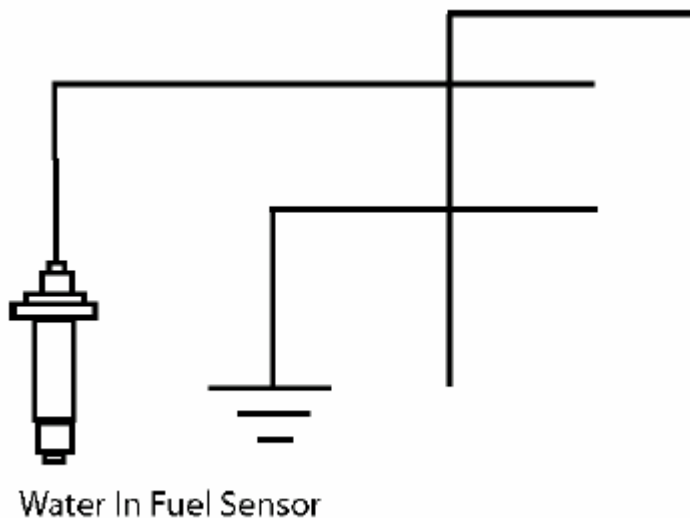


Sensors

One, Two and Three Wire Sensors

If a sensor has one wire, this wire carries the reference signal from the ECM, and the circuit is completed to ground through the body of the sensor.

Example:

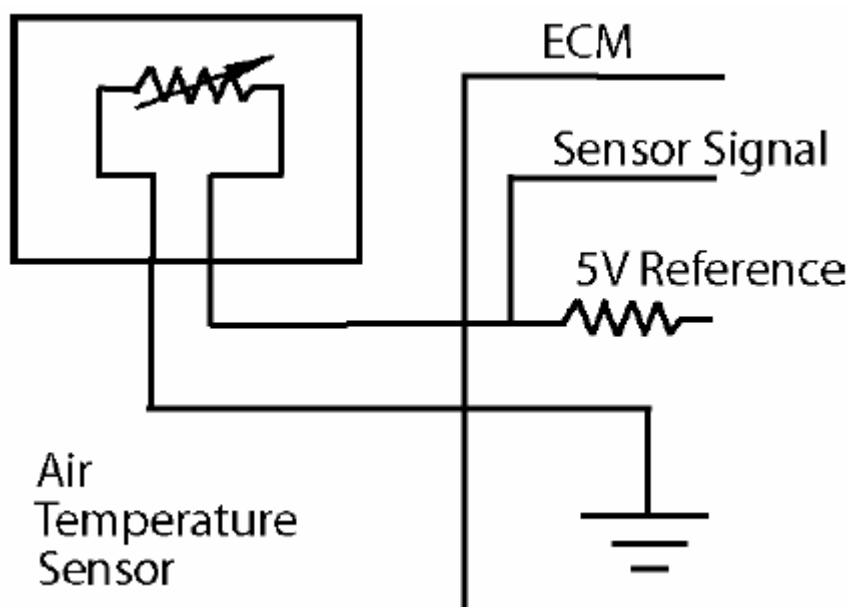


Notes

Two Wire Sensor

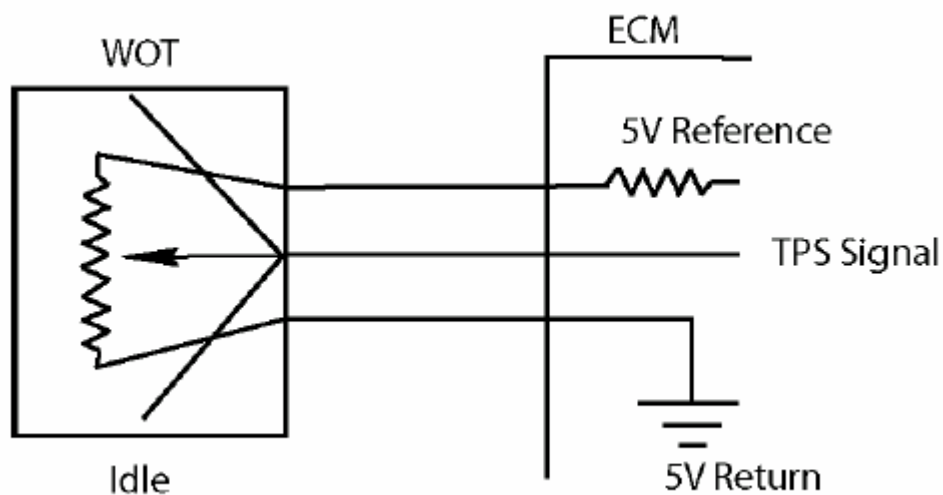
In a two-wire sensor, one wire is the reference signal, which goes either to the ECM or to an external ground.

Notes



Three Wire Sensor

In the three-wire sensor, there is a reference circuit, a signal voltage circuit to the ECM and a ground circuit. Example TPS sensor.



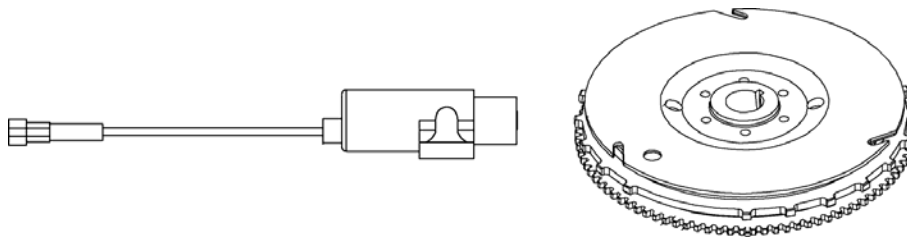
The TPS is a good example of how this type of sensor operates. The signal voltage wire bringing the sensor voltage signal back to the ECM is connected to the wiper terminal. The amount of voltage sensed by the wiper depends on where it is touching the resistor. If it touches the resistor close to the 5-volt input, it senses essentially the full 5 volts.. But if it touched the resistor close to ground, the wiper senses close to 0 volts, with varying sensor voltages at positions between the extremes.

Crank Position Sensor (CPS)

As the flywheel rotates, the CPS senses the location of the 54 teeth on the flywheel and supplies the trigger signal information to the ECM. The ECM utilizes the CPS information and determines when to trigger each ignition coil and fuel injector.

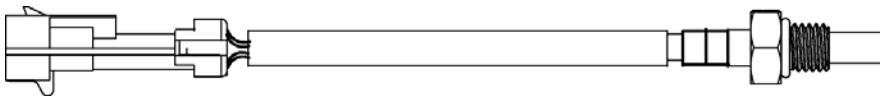
The CPS provides the ECM with crank angle position and engine speed information, which the ECM uses in determining fuel delivery and spark timing.

If the ECM fails to receive a crank position sensor signal it will stop the engine. The ECM requires a signal before activating the ignition system, fuel pump, etc.



Engine Coolant Temperature (ECT) Sensor

The ETC sensor is located on the engine's exhaust cover and protrudes into the return water passage. The sensor monitors the temperature of the cooling water that has passed through the engine as controlled by the thermostat and sends signals to the ECM for processing. Low coolant temperature produces a high resistance, while high temperature causes low resistance. The ECM supplies a 5 volt signal to the ECT through a resistor in the ECM and measures the voltage. The voltage will be high when the engine is cold, and low when the engine is hot. By measuring the voltage, the ECM knows the engine coolant temperature. Engine coolant temperature affects most systems the ECM controls.

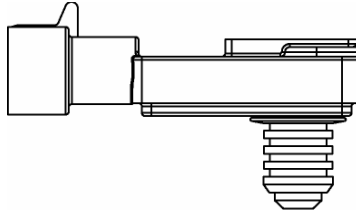


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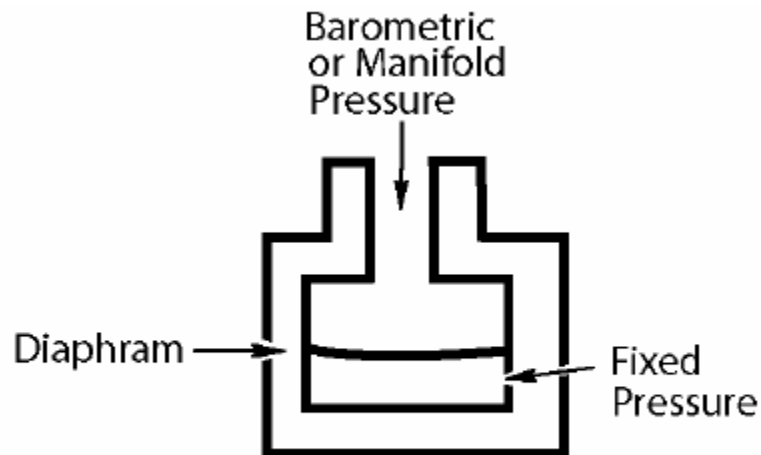
Manifold Absolute Pressure (MAP) Sensor

The MAP sensor measures changes in intake manifold air pressure. The ECM takes information from the MAP sensor, indicating engine load, in order to calculate fuel and spark timing requirements.

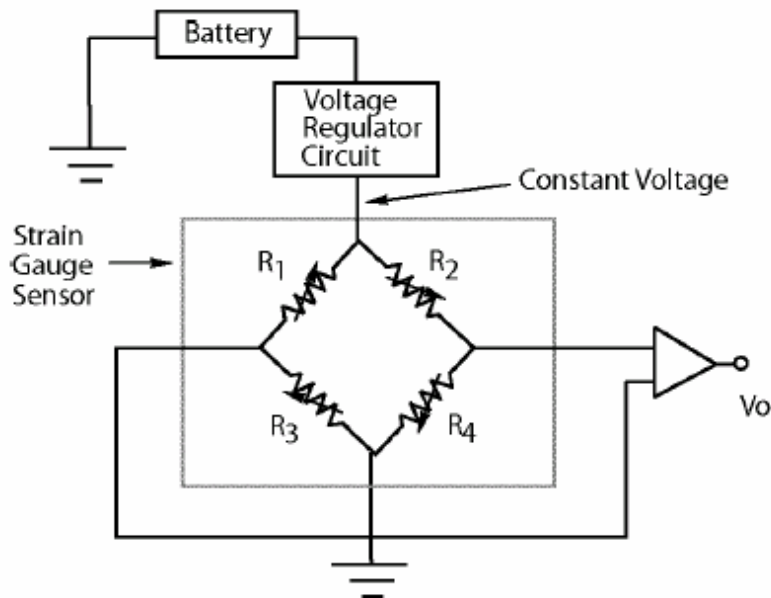


Manifold absolute pressure is the exact opposite of manifold vacuum. That is, MAP is low when vacuum is high (such as closed throttle), and MAP is high when vacuum is low (such as at wide-open-throttle). When the engine is not running, the manifold is at atmospheric pressure and the MAP sensor is registering barometric (BARO) pressure.

THE BARO reading is used at engine start up for fuel delivery calculations, as well as during engine run for fuel and spark calculations. An absolute sensor compares intake manifold pressure to reference pressure sealed inside the sensor. This type of sensor is used for MAP and BARO sensors.



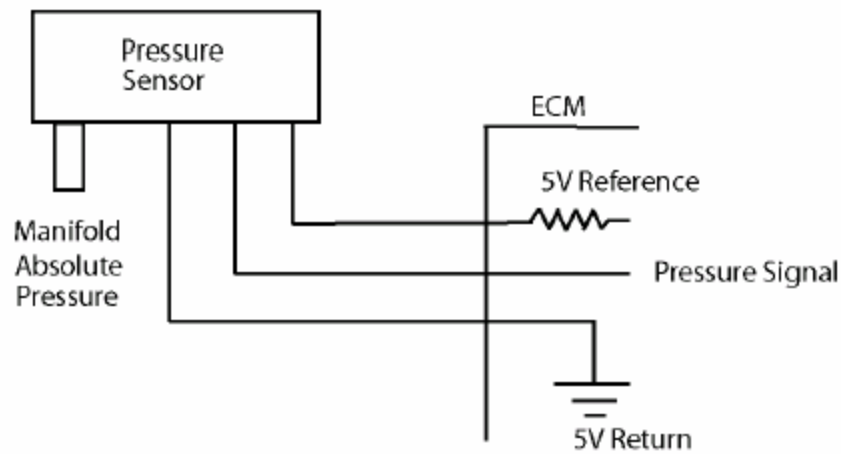
A pressure sensor consists of a small silicone chip about 3mm square. The thickness of the chip at the outer edges is about 250 micrometers, but the center of the chip is only 25 micrometers thick. This construction forms a diaphragm that flexes with pressure changes. A set of resistors are placed around the edge of this diaphragm forming a circuit known as a WHEATSTONE BRIDGE. This entire assembly is placed in a sealed housing that is connected to the in-take manifold vacuum.



As intake manifold pressure changes, it causes the diaphragm to flex. The deflection of the diaphragm causes the value of the resistance to change in proportion with intake manifold pressure. This change in resistance is called PIEZO RESISTIVITY, which is the proportional change in resistance to the change in length. The ECM places a constant 5 volts across the sensor. When there is no strain on the diaphragm all of the resistors are of equal value. As the diaphragm flexes, it causes the resistance to change in such a way that " R_1 " and " R_3 " increase while, simultaneously, " R_2 " and " R_4 " proportionally decrease. This causes a voltage difference at points "A" and "B". The differential amplifier then outputs a voltage that is proportional to the difference in voltage between points "A" and "B". This signal voltage is used by the ECM to determine engine load.

Notes

Notes

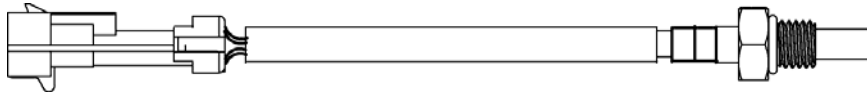


Manifold Vacuum / Pressure Reference Chart

Manifold Vacuum	Absolute Pressure		Manifold Vacuum	Absolute Pressure	
psi	psi	kPa	psi	psi	kPa
0	14.7	101.3	7 1/4	7.45	51.4
1/4	14.45	99.6	7 1/2	7.2	49.6
1/2	14.2	97.9	7 3/4	6.95	47.9
3/4	13.95	96.2	8	6.7	46.2
1	13.7	94.4	8 1/4	6.45	44.5
1 1/4	13.45	92.7	8 1/2	6.2	42.7
1 1/2	13.2	91.0	8 3/4	5.95	41.0
1 3/4	12.95	89.3	9	5.7	39.3
2	12.7	87.5	9 1/4	5.45	37.6
2 1/4	12.45	85.8	9 1/2	5.2	35.8
2 1/2	12.2	84.1	9 3/4	4.95	34.1
2 3/4	11.95	82.4	10	4.7	32.4
3	11.7	80.6	10 1/4	4.45	30.7
3 1/4	11.45	78.9	10 1/2	4.2	29.0
3 1/2	11.2	77.2	10 3/4	3.95	27.2
3 3/4	10.95	75.5	11	3.7	25.5
4	10.7	73.8	11 1/4	3.45	23.8
4 1/4	10.45	72.0	11 1/2	3.2	22.1
4 1/2	10.2	70.3	11 3/4	2.95	20.3
4 3/4	9.95	68.6	12	2.7	18.6
5	9.7	66.9	12 1/4	2.45	16.9
5 1/4	9.45	65.1	12 1/2	2.2	15.2
5 1/2	9.2	63.4	12 3/4	1.95	13.4
5 3/4	8.95	61.7	13	1.7	11.7
6	8.7	60.0	13 1/4	1.45	10.0
6 1/4	8.45	58.2	13 1/2	1.2	8.3
6 1/2	8.2	56.5	13 3/4	0.95	6.5
6 3/4	7.95	54.8	14	0.7	4.8
7	7.7	53.1	14 1/4	0.45	3.1
			14 1/2	0.2	1.4

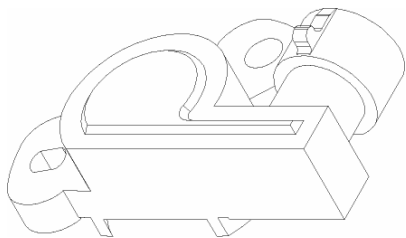
Manifold Air Temperature (MAT) Sensor

The MAT sensor is mounted into the intake manifold and measures the charge air temperature. This information is then conducted to the ECM for processing. Low temperature produces a high resistance, while high temperature causes a low resistance. The ECM supplies a 5 volt signal to the sensor through a resistor in the ECM and measures the voltage. The voltage will be high when the intake air is cold, and low when the intake manifold air is hot.



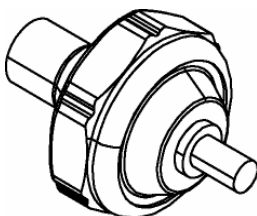
Throttle Position Sensor (TPS)

The TPS sensor is located on the throttle body and connected to the throttle shaft. It provides the ECM with throttle angle information. The TPS has one end connected to 5 volts from the ECM and the other to ECM ground. A third wire is connected to the ECM to measure the voltage from the TPS. As the throttle valve angle is changed, the voltage output of the TPS also changes. At a closed throttle position, the voltage output of the TPS is low. As the throttle valve opens, the output increases so that at wide-open-throttle (W.O.T.), the output voltage should be near 4.5 volts. By monitoring the output voltage from the TPS, the ECM can determine fuel delivery based on throttle valve angle (driver demand). A broken or loose TPS can cause intermittent bursts of fuel from the injector and an unstable idle, because the ECM thinks the throttle is moving.



Oil Pressure Switch

The oil pressure switch is located port side of the engine and protrudes into the pressurized oil galley between the oil pump and the oil filter. The switch sends a low oil pressure signal to the ECM, which activates ignition/injection cut-off/warning horn.



Notes

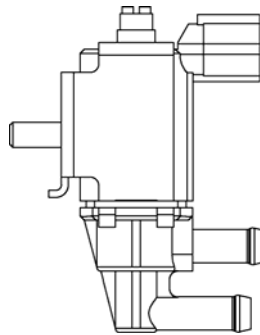
Actuators

Actuators receive input signals from the ECM and perform functions, which control air-fuel ratios, spark advance, and idle rpm.

Idle Air Control (IAC)

The Idle Air Control (IAC) is an electrically operated spring-loaded solenoid valve, which controls the amount of intake air that bypasses the closed throttle shutter. Signals from the ECM regulate the duty cycle that the IAC valve remains open, or (spring-loaded) closed. Duty cycle of the IAC valve ranges from 0% to 100% open. The IAC controls three operating functions:

- 1) Provides additional intake air (bypass) for engine start-up and allows increased idle rpm during engine warm-up.
- 2) Controls idle speed according to varying engine loads and running conditions.
- 3) Functions as an electronic dashpot by providing additional bypass air as the throttle quickly closes during a rapid deceleration, preventing engine stalling.



Diagnostic Tip: If the IAC readings are low (0%) customer might experience any or all of the following symptoms.

1. Engine idling to high which could result in hard shifting effort.
2. Engine runs rough.
3. Engine does not accelerate well.

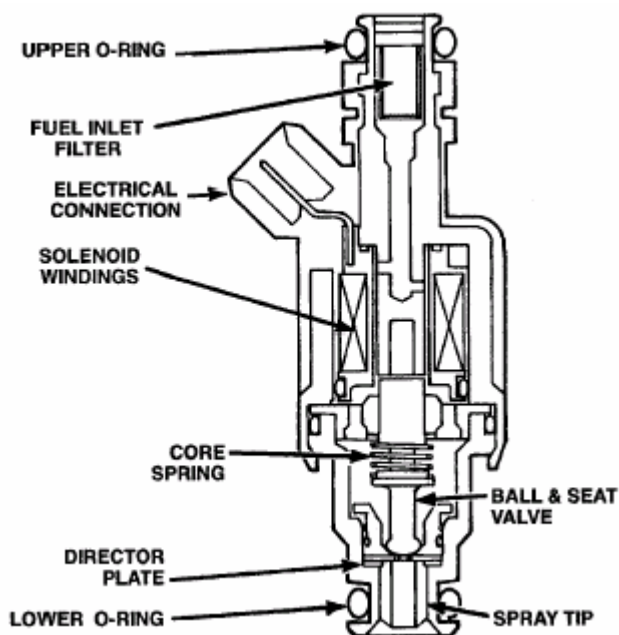
Possible causes of condition.

1. Air leak in the intake system.
2. Misadjusted throttle linkage.

Fuel Injector

The fuel injector is an electrically operated spring-loaded solenoid, which delivers a metered amount of fuel into the intake manifold runner, just ahead of the intake valve. The injectors are electrically charged as the key switch is set to the "RUN" position. The ECM controls the injection by completing the ground circuit, lifting the solenoid, which allows high-pressure fuel to flow. The ECM then opens the ground circuit allowing the spring to close the injector and stop the fuel flow.

Notes

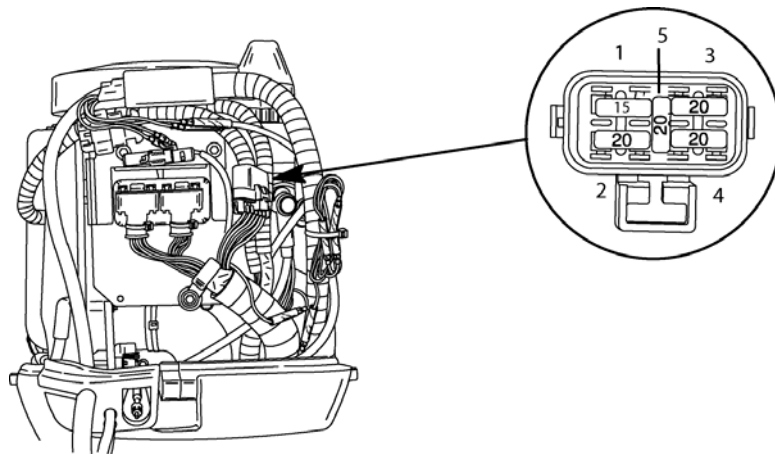


Notes

Fuse Holder Assembly

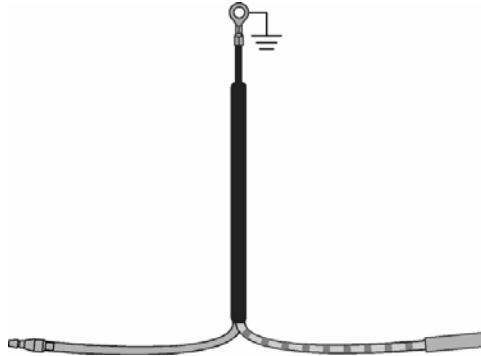
The fuse holder hold four function fuses and one spare fuse.

- 4) Fuse number one protects the SmartCraft wiring.
- 5) Fuse number two is powered by the main relay. It protects red/blue leads on the engine. This fuse provides power to the injectors, idle air control, and electric fuel pump.
- 6) Fuse number three protects red/purple leads on the engine, the main power relay, and key switch. When the key switch is on, the purple leads on the engine, key switch and dash gauges are also powered/protected through this fuse.
- 7) Fuse number four is powered by the main relay. It protects red/yellow leads on the engine. This fuse provides power to the ignition coils.
- 8) Fuse number 5 is a spare 20 AMP fuse.



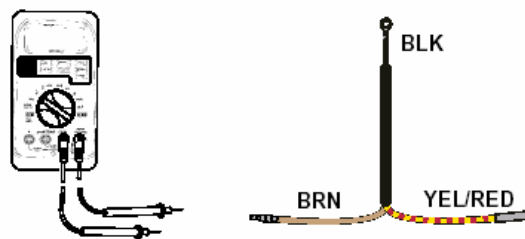
Suppression Diode

The suppression diode is located between the brown start solenoid lead and the yellow/red key switch lead (within the engine harness), and connects to the engine ground. The purpose of the suppression diode is to eliminate the inductive spike created as the start solenoid is de-energized (key switch turned from START to RUN).



Diagnostic Tip: When turning the key to start position if the 20 amp main power relay/accessory fuse blows check the suppression diode. If the battery is connected backwards, the diode will fail providing a direct short to ground each time the starter is engaged.

Suppression Diode Tests



DIODE TEST

BLK	RED	YEL/RED	BRN	BLK
YEL/RED		X	0V or SHORT	0.4 - 0.8V
BRN		0V or SHORT	X	0.4 - 0.8V
BLK		OUCH, OL, ∞	OUCH, OL, ∞	X

RESISTANCE TEST

BLK	RED	YEL/RED	BRN	BLK
YEL/RED		X	$< 0.5\Omega$	1 - 3M Ω
BRN		$< 0.5\Omega$	X	1 - 3M Ω
BLK		OUCH, OL, ∞	OUCH, OL, ∞	X

Notes

[illegible]

Notes

ECM Operating Modes

While all of the sensors are important, the ECM looks at certain key sensors during its different modes of operation.

Start/Crank Mode

In this mode the ECM engages the fuel pump relay to pressurize the fuel rail, reads the signals from the CPS and reads the input from the ECT sensor to establish the temperature of the engine. Cold engines will result in a longer pulse-width to the injectors and warm engines will result in a shorter pulsewidth.

Run Mode

Once the engine starts, the ECM keeps the main power relay engaged and reads the following sensors to determine the correct air/fuel mixture and ignition timing. CPS to determine engine rpm and crankshaft position, MAP to determine the density of the air in the intake manifold and engine load, MAT to fine tune the calculations of air density and ECT to adjust fuel delivery and spark timing based on engine coolant temperature. For example, an engine with high rpm and low load will run a much higher spark advance than an engine with low rpm and high load.

Acceleration

Sudden changes in the MAP and TP sensors signal the ECM that the engine is accelerating and extra fuel will be added by increasing pulse width (much like an accelerator pump on a carbureted engine). Ignition timing will also change quickly to improve throttle response.

Deceleration

During deceleration (sudden TP closing and low MAP pressure readings), the ECM will reduce fuel flow to prevent flooding and open the IAC valve to prevent stalling.

RPM limit

Each ECM is programmed with a RPM limit. If the engine reaches this limit for whatever reason (incorrect propping, ventilation, wake-jumping, etc.), the ECM will turn off fuel injectors and ignition coils as necessary to hold rpm at the limit programmed into it. This number is generally about 150 rpm above the maximum recommended speed. This is actually a Guardian program function and the warning horn will sound continuously during the RPM limit event.

Speed / Density Theory and Operation

Speed/Density Theory

Notes

Most EFI engines operate on the fuel injection strategy called "Speed/Density". This means that the ECM primarily looks at the engine's speed and the intake manifold's air density in order to calculate the correct amount of fuel to inject.

The engine requires an air/fuel mixture of approximately 14:7 to 1 in the combustion chambers. Since the EFI system doesn't control air flow, it must determine how much air is flowing through the engine in order to calculate the correct amount of time to fire the fuel injectors. The net result is that there must be 1 part of fuel for every 14.7 parts of air going through the engine.

Since the engine is basically an air pump, we know that an engine is capable of pumping a certain maximum amount of air at any specific rpm. The actual amount of air it pumps at a specific rpm depends on the density of the air in the intake manifold. The air density (in the intake manifold) will vary depending on rpm, throttle plate position and barometric pressure. If the air density in the intake manifold is known, the actual amount of air flowing through the engine (the "Air Mass" or "Mass Air Flow") can be calculated. The calculated (and the actual) air flow is a repeatable function, meaning that at a specific rpm and a specific manifold absolute pressure reading, the air flow through the engine will always be the same.

However, in the speed/density system we do not actually calculate the actual air flow. Instead, the ECM measures the rpm and the air density, then refers to a programmed "lookup table" in the ECM's EEPROM. This lookup table will be programmed with the correct fuel injector information for every rpm and density reading. The programming engineer has to come up with these figures, because the ECM is not actually calculating the Mass Air Flow.

The speed-density system depends on the engine being unmodified from its original production state. If we change the volumetric efficiency of the engine in any manner, the amount of air flow for a given rpm and air density will change, causing the ECM to deliver the incorrect amount of fuel. Any modification to the following components will influence the air flow through the engine, throwing the speed-density system out of calibration.

1. Pistons and combustion chambers (anything that changes the compression ratio).
2. Camshaft changes (effecting the valve timing, lift and duration).
3. Changes to intake and exhaust valve size, as well as "porting and polishing"
4. Installing different intake and/or exhaust manifolds.

Speed/Density Operation

Notes

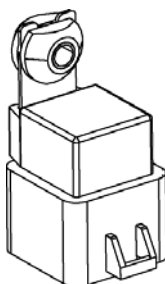
The engine's RPM is easily determined from the input of crank position sensor.

To determine the density of the air in the intake manifold, we need to know the intake manifold vacuum, which is measured with the MAP (Manifold Absolute Pressure) sensor. It is important to remember that a MAP sensor measures the manifold pressure **above** absolute zero (like a barometer), while a conventional vacuum gauge measures the manifold pressure **below** the **ambient** atmospheric pressure. The use of the Manifold Absolute Pressure Sensor allows us to compensate for variations in atmospheric pressure due to weather and altitude changes. A conventional vacuum gauge would not provide us with this needed information.

In review, our standard, unmodified production engines flow a repeatable (and therefore "known") amount of air at any specific engine rpm and manifold pressure. With this knowledge, the ECM can be programmed to deliver the correct amount of fuel from the combination of the speed sensor (distributor signal) and density information (from the MAP sensor). It is often said that the speed-density system runs "in theory alone", since the ECM doesn't really know how much air is flowing through the engine, it is just assuming it knows how much (based on the repeatability of airflow theory). In reality, the system is simple, rugged and works extremely well. But, the ECM cannot compensate for changes in volumetric efficiency of the engine.

Main Power Relay

The main power relay is controlled by the ECM. It provides power to the ignition coils, idle air control, injectors, and high pressure fuel pump.



Ignition Description

When the ignition key switch is turned to the “RUN” position battery voltage is applied to both the ECM through the purple wire, and the main power relay through the red/purple wire. As the ECM receives the “RUN” signal it internally completes the ground circuit of the main relay for a period of two seconds, energizing the ignition/injection systems for start-up. As the engine is cranked with the starter motor, the ECM receives the run signal from the Crank Position Sensor (CPS) and completes the ground circuit to the main relay for engine operation.

With the main relay closed (completed circuit) D.C. current from the battery/charging system is transferred through the 20 ampere main relay fuse to the positive terminal of all ignition coil primary windings. The negative terminals of the ignition coil primaries are connected to the engine ground through the coils internal driver, which is triggered by the ECM. With the coil drivers closed, an electric magnetic field is allowed to build up within the ignition coil.

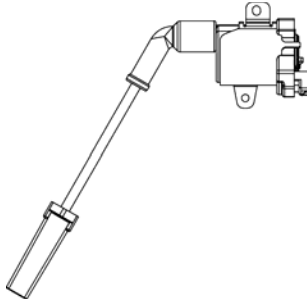
As the flywheel rotates, the CPS senses the location of the 54 teeth on the flywheel and supplies the trigger signal information to the ECM. The ECM utilizes the CPS information and determines when to remove the trigger signal from the coil driver of each ignition coil. The coil driver then opens the coil primary ground circuit which allows it's magnetic field to rapidly collapse across the coil secondary winding which induces a high voltage charge (50,000 volts) that fires the spark plug.

Notes

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Ignition Coils (EST)

Notes



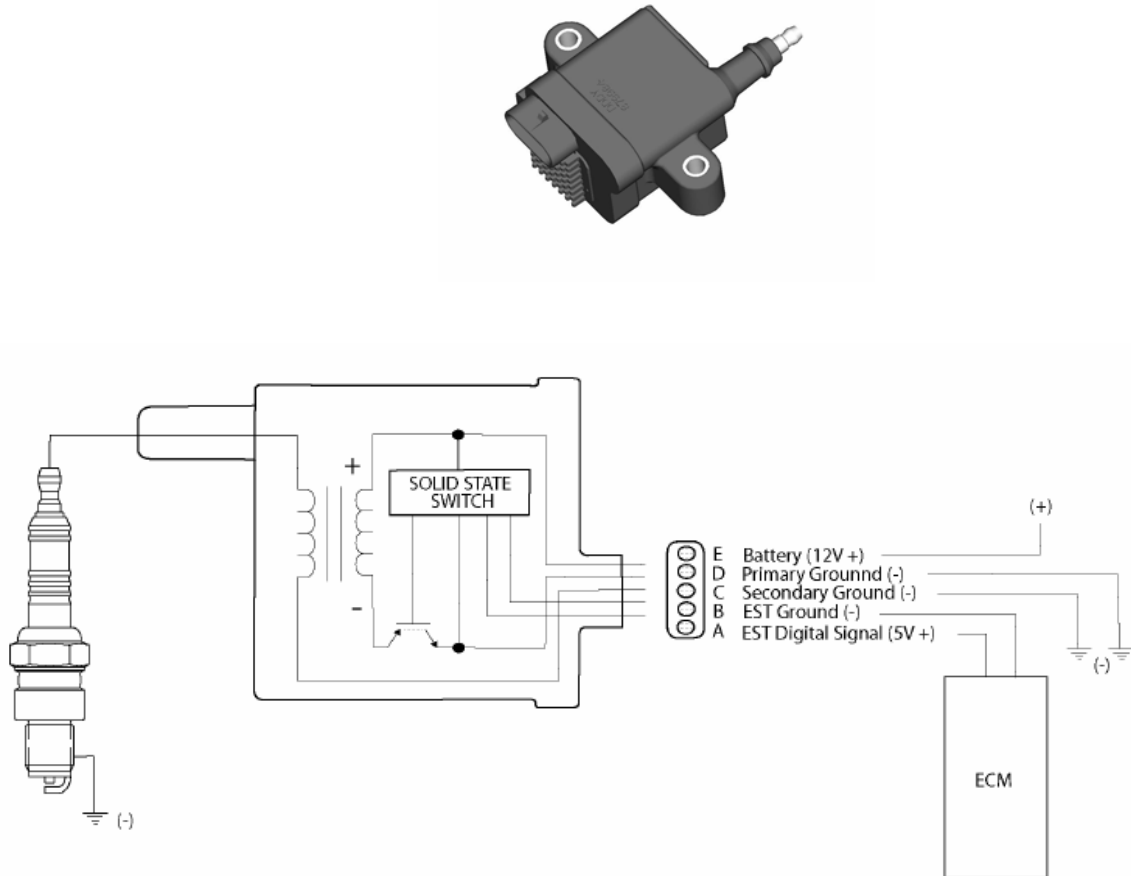
The negative terminals of the ignition coil primaries are connected to the engine ground through the coils internal driver, which is triggered by the ECM. With the coil drivers closed, an electric magnetic field is allowed to build up within the ignition coil.

As the flywheel rotates, the CPS senses the location of the 54 teeth on the flywheel and supplies the trigger signal information to the ECM. The ECM utilizes the CPS information and determines when to remove the trigger signal from the coil driver of each ignition coil. The coil driver then opens the coil primary ground circuit which allows it's magnetic field to rapidly collapse across the coil secondary winding which induces a high voltage charge (50,000 volts) that fires the spark plug.

New Ignition Coil for 2005 MY

The new ignition coil being used on all 40 thru 60 EFI engines is the same 5-Pin Coil that has been used on V6 EFI Outboards. This is an EST type coil that operates basically the same as the previous EST coils.

NOTE: The wiring harnesses on the 2005 engines will not back-fit to older models.



Guardian Protection System

The guardian protection system monitors critical engine functions and will reduce engine power accordingly in an attempt to keep the engine running within safe operating parameters.

IMPORTANT: The Guardian System cannot guarantee that powerhead damage will not occur when adverse operating conditions are encountered. The Guardian System is designed to (1) warn the boat operator that the engine is operating under adverse conditions and (2) reduce power by limiting maximum rpm in an attempt to avoid or reduce the possibility of engine damage. The boat operator is ultimately responsible for proper engine operation.

Warning Horn/ Guardian System Operation		
Sound	Condition	Description
One Beep on key up	Normal	System Test
Six Beeps on key up, or during a running failure.	Failure detected with MAP, MAT *, TPS, or Flash Check Sum (ECM)	Engine should run well however, service will be required.
Three Beeps every 4 Minutes.	Failure detected with: - Battery Voltage * - EST *- Open detected at key up. Short detected with engine running - Fuel Injector - Detected while cranking/running * - Coolant Sensor * - IAC **	Engine will start hard, run rough and/or stall. Utilizing the neutral fast idle feature may assist starting. Service is required.
Intermittent Beeps Failure detected with:	Failure detected with: - Fuel Pump - May start momentarily ** - Main Power Relay - No start ** - ECM Reference Voltage to MAP/TPS - Starts but stalls under load	Engine may or may not start. If engine starts it easily stalls. Service is required.
Continuous	Engine Overheat	Engine Guardian System is activated. Power limit will vary with level of overheat. Stop engine and check water intake for obstruction. Advancing throttle above idle may provide additional cooling
	Low Oil Pressure	Guardian System is activated. Engine power is limited to 10% of maximum. Stop engine and check oil level. Add oil if necessary.
	Battery Voltage Less Than 10v or More Than 16v	Engine Guardian System is activated. Engine power is limited to 75% of maximum.
	Coolant Sensor Failure	Engine Guardian System is activated. Engine power is limited to 50% of maximum. Engine overheat protection is compromised.
	Engine Speed Limiter	Exceeding 6200 rpm cuts spark/injection on cylinders #2 and #3 to reduce engine speed. Exceeding 6350 rpm cuts spark/injection on all cylinders to reduce engine speed.

Notes

25-30 TMC Electronic Fuel Injection

Powerhead

This three cylinder powerhead has displacement of 526cc (32cu.in). This is interference powerhead your attention to valve timing is important or severe powerhead damage could occur.

Intake System

The air induction system consists of an intake manifold with an intake runner for each cylinder for a smooth air flow to the combustion chamber. Each runner has a single fuel injector controlled by the ECM. The fuel injector has a single pintel or nozzle to help atomize the fuel when injected into the runner as the cylinder valve opens. A single throttle body/shutter with attached Throttle Position Sensor (TPS) along with an Idle Air Control (IAC), manages the amount of air entering the induction system. A Manifold Absolute Pressure (MAP) sensor, and a Manifold Air Temperature (MAT) sensor sends temperature information to the ECM to regulate the fuel injector pulse width and modulate the IAC.

Fuel Injector

The fuel injector is an electrically operated spring-loaded solenoid, which delivers a metered amount of fuel into the intake manifold runner, just ahead of the intake valve. The injectors are electrically charged by the ECM through the stator assembly when the flywheel starts to rotate. The ECM controls the injection by completing the ground circuit, lifting the solenoid, which allows high-pressure fuel to flow. The ECM then opens the ground circuit allowing the spring to close the injector and stop the fuel flow. An injector filter is located on the fuel inlet side of the injector. The filter is not serviceable but can be cleaned of debris.

Fuel Injection System

This Kokusan-Denki EFI system does not require a battery to operate. Regulated supply voltage is generated by the magneto. An independent coil supplies the injectors and the fuel pump with a stable power source.

The ECM requires minimum of 6 volts to operate. If the ECM should fail, the engine will stop running. The ECM directly controls the ground circuit of fuel injectors, ignition coils, and idle air control. Indirectly controls the positive circuit of fuel injectors, ignition coils, and idle air control. The inputs to the ECM can be monitored and tested by the Computer Diagnostic System (CDS).

Fuel Pressure Test

Engine running idle warm pressure should be 36 psi (250 kPa)

CDS Information

Notes

- The ECM data can be monitored by upcoming version of Computer Diagnostic System (CDS) software 6.09 using a new data cable part number 84-899150A01
- When the diagnostic cable is plugged it provides 12 volts to the ECM (remember this is batteryless system) and the ECM goes into "service mode".
- **DATA LIST:**
 - Engine RPM
 - Driver Power (the voltage from the charge coils under the flywheel that operates the fuel injection system).
 - Baro Pressure
 - Manifold Pressure
 - Throttle Position
 - Ignition Timing
 - IAC Duty Cycle
 - Engine Coolant Temp
 - Intake Air Temp
 - Fuel Flow Rate (GPH)
 - Injector Pulse Width
 - Low Oil Pressure switch (on or off)
 - Stop Switch (on or off)

FAULT LIST: Fault Status: only displayed when occurred. Not stored in memory, they are cleared each time you shut down the engine.

- ACG Coil 1
- ACG Coil 2
- ACG Coil 3
- Ignition Coil 1
- Ignition Coil 2
- Ignition Coil 3
- Injector 1
- Injector 2
- Injector 3
- ISC (IAC)
- Throttle Position Sensor
- Intake Air Temp Sensor
- Engine Coolant Temp Sensor
- Manifold Pressure Sensor
- Oil Pressure Low (oil pressure switch is on, always occurs before starting the engine if the diagnostic cable is connected to a battery)

- **Run History:** We can read total run time, but not individual RPM bands.

Water Test and Host record are supported just like previous engines.

The air induction system consists of an intake manifold with an intake runner for each cylinder for a smooth air flow to the combustion chamber.

Notes

Each runner has a single fuel injector controlled by the ECM.

A single throttle body/shutter with attached Throttle Position Sensor (TPS) along with an Idle Air Control (IAC), manages the amount of air entering the induction system.

A Manifold Absolute Pressure (MAP) sensor, and a Manifold Air Temperature (MAT) sensor sends temperature information to the ECM to regulate the fuel injector pulse width and modulate the IAC.

Models	25	30
Full Throttle Range	5000-6000 RPM	5250-6250 RPM
Idle Speed in Forward Gear	850 +/- 25RPM	
Number of Cylinders	3	
Piston Displacement	526 cc (32.09 cu. in.)	
Cylinder Bore	61.0 mm (2.40 in.)	
Stroke	60 mm (2.36 in.)	
Recommended Spark Plug	NGK DCPR6E	
Spark Plug Gap	0.8-0.9 mm (0.031-0.035 in.)	
Gear Ratio	1.92:1	
Recommended Gasoline	Automotive unleaded with a minimum pump posted octane rating of 87 (R+M)/2	
Gearcase Lubricant Capacity	280 ml (9.5 fl. oz.)	
Engine Oil Capacity	1.8 liter (1.9 quarts)	
Battery Rating	465 Marine Cranking Amps (MCA) or 350 Cold Cranking Amps (CCA)	

Ignition System

The ignition exciter stator is composed of several layers of steel plates called a bobbin laminate. The bobbin laminate is wound with a fine wire in order to generate a high voltage that is required for the ECM/ignition to function. As the flywheel rotates, magnets secured to the inside of the flywheel pass close to the ignition exciter stator, generating a strong alternating current. There are three separate coils (windings) to generate specific circuits with power. Having three separate windings (listed below) spreads out the electrical load which is important for EFI system that do not require a battery to operate.

1. The injector/fuel pump coil generates A.C current which is sent to the ECM where it is rectified to direct current (D.C.) voltage.
2. Battery charging coil (if so equipped) supplies the regulator/rectifier with A.C. voltage to charge the battery.
3. Exciter coil for ignition supply

There are 2 crank position sensors on the cylinder block. They are offset from each other. The offset CPS configuration helps the ECM determine the crankshaft position and the engine RPM. The crank position sensor is a hall effect switch. The hall effect switch changes when its magnetic field collapses. This collapse of the magnetic field occurs when the flywheel timing key passes near the CPS. This type of crankshaft position recognition, is highly accurate, very reliable, and will not change values with extreme temperature conditions.

As the timing key passes the first crankshaft position sensor, an electrical pulse is generated and sent to the ECM. The ECM then calculates the position of the crankshaft based on the electrical pulse generated when the timing key passes the second crank position sensor. The ECM will use this information to regulate ignition and fuel injector timing. The flywheel also has magnets on the inside circumference to generate A.C. voltage needed for the ECM to operate. These same magnets are also used generate voltage to charge a battery.

Warning Lamp

The warning lamp flashes on the first five seconds after engine starting. If the oil pressure switch is turned on, overheat or over-rev mode is detected. Flashing on and off occurs when TPS, MAT, MAP, ECT sensor or circuit is high/low.

Warning System				
Function	Sound	Warning Light	Description	Engine Speed Limited to 2800 RPM
Start up	One beep	On for 5 seconds	Normal system test	
Engine over temperature	Continuous	On	Engine over heat	X
Low oil pressure	Continuous	On	Low oil pressure	X
Engine overspeed	Continuous	On	Engine speed exceeds maximum allowable RPM	
Water temp or MAP sensor out of range	Intermittent short beep	Flashes	Engine speed will limited. Consult your dealer for assistance	X

75-90 Electronic Fuel Injection System

Notes

Powerhead

This powerhead has a displacement of 1596cc (97.39cu.in) is in-line four cylinder with dual overhead cams and 16 valves per cylinder. This is interference powerhead your attention to valve timing is important or severe powerhead damage could occur.

Intake System

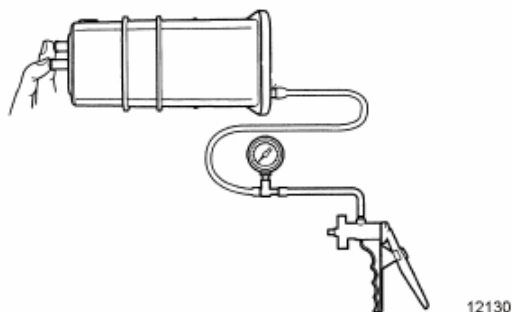
This engine is equipped with single throttle body for a more compact design which also reduces the load for throttle operation. The manifold has 4 runners for the air to flow smoothly to the combustion chamber. Fresh air enters the cowl and is drawn into the silencer air box. Throttle noise is baffled for quiet operation as the air passes through the silencer air box. Each runner has a single fuel injector controlled by the ECM.

Vapor Separator Tank

Fuel delivered from the low pressure fuel pump located on the cylinder block valve cover, supplies fuel to the top inlet port of the VST. The fuel level inside the VST is controlled by an inlet needle and float assembly. High pressure fuel is pushed through a dual port area in the VST cover where the pressure is controlled by the fuel pressure regulator and supplies fuel to the fuel rail. Excess fuel pressure is returned to the VST through the cooler.

Vapor Canister

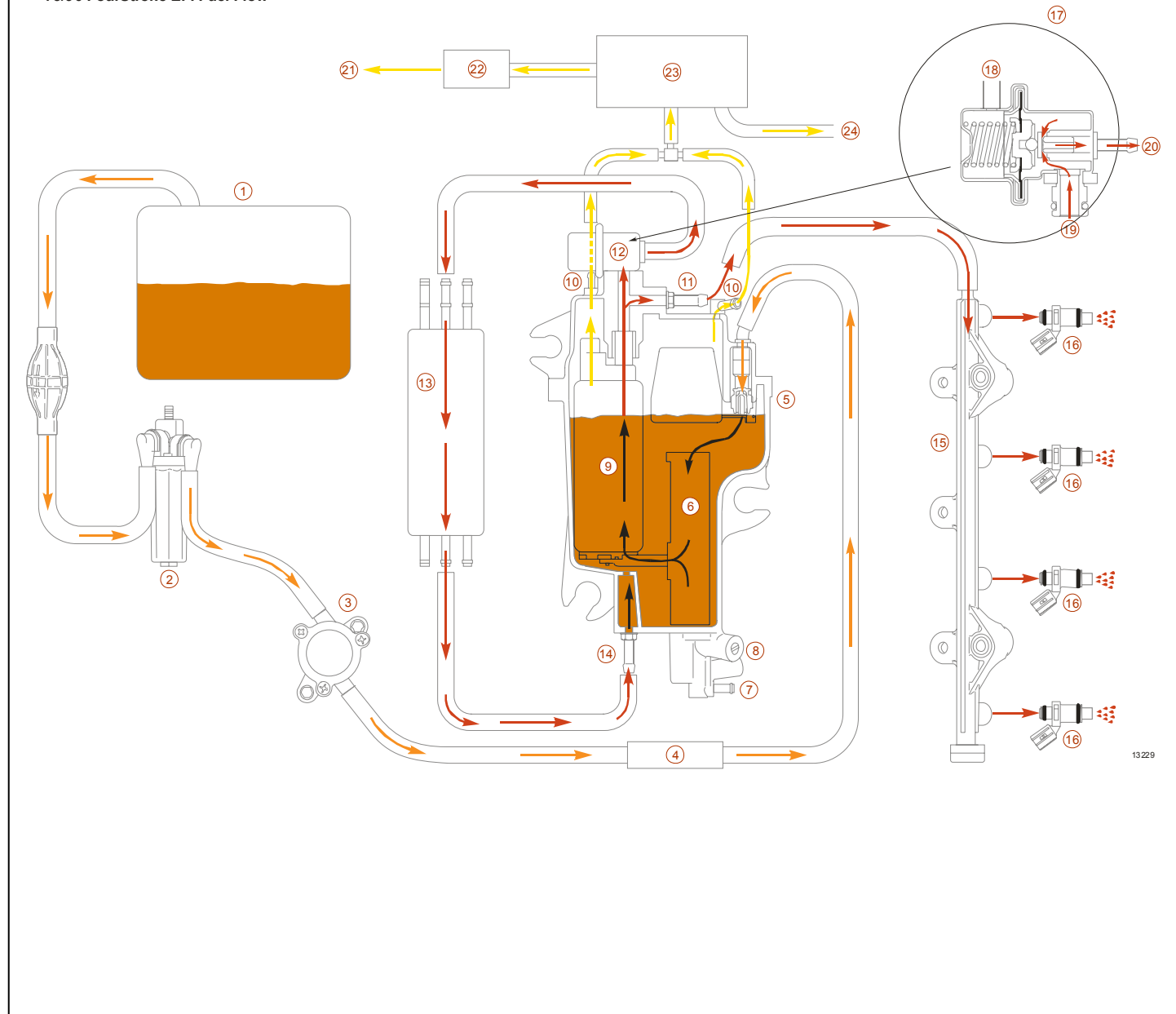
The purpose of the vapor canister is to capture fuel vapors. Fuel vapors will accumulate in the VST during all engine operations and when the engine is not running. When the engine is running, the fuel vapors are pulled through various hoses and the vapor canister. The vapor canister is connected to the intake manifold at the IAC control valve assembly where the vapor is pulled into the combustion chamber. After the engine has reached operating temperatures and turned off, vapors will increase in the VST. The vapor canister will accumulate these vapors and gradually discharge the vapor through a charcoal filter element into the atmosphere.



Vapor Canister Pressure Specification

Pressure	19.6 kPa (2.8 psi)
----------	--------------------

75/90 FourStroke EFI Fuel Flow



- | | |
|---|--|
| 1. Boat fuel tank. | 13. Fuel cooler |
| 2. Water separating fuel filter assembly | 14. Fuel return to VST from fuel cooler |
| 3. Mechanical fuel pump. | 15. Fuel rail |
| 4. Fuel filter (in-line) | 16. Fuel injector |
| 5. Float valve assembly | 17. Fuel regulator internal view |
| 6. High pressure fuel pump filter | 18. Fuel regulator vent to intake manifold |
| 7. Vapor Separator Tank (VST) drain fitting | 19. High pressure fuel inlet to regulator |
| 8. Vapor Separator Tank (VST) drain screw | 20. High pressure fuel to fuel cooler |
| 9. High pressure fuel pump. | 21. Vent to atmosphere |
| 10. Vapor Separator Tank (VST) fuel vapor fitting | 22. Vapor canister filter |
| 11. High pressure fuel out to fuel rail. | 23. Vapor canister |
| 12. Fuel pressure regulator. | 24. To intake manifold |

Fuel Injection System

The fuel injection system uses a synchronous (batch) for fuel control. Fuel is injected into the intake manifold two cylinders at a time, every second revolution of the engine. This type of fuel injection (synchronous) allows for simple fuel injection control programming. The fuel injector is unique and has ten holes for the fuel to be injected into the combustion chamber. The ten hole design allows for a better atomization of the fuel. The ECM controls the injection by completing the ground circuit, lifting the solenoid, which allows high-pressure fuel to flow. An injector filter is located at fuel inlet side and is non-serviceable. Fuel injection volume is initially charted in the ECM when the engine electrical system is activated with turning the key to the "ON" position.

Idle Air Control

This system consists of a motor constructed of a magnet operated rotor, and a stator coil; a threaded portion which converts the rotation into a linear movement of the valve. The electric current flowing through two stator coils is switched in steps. Air flow volume is adjusted by the rotation of the rotor, which raises or lowers the valve to adjust the amount of air passing through. The direction that the rotor rotates is determined by the electric flow through the stator coils. The valve of this IAC can be opened from fully closed to fully open in 120 steps. The valve can be commanded with CDS.

Computer Diagnostic Systems (CDS)

The Mercury Computer Diagnostic System version 6.xx will have the ability to view and perform the following:

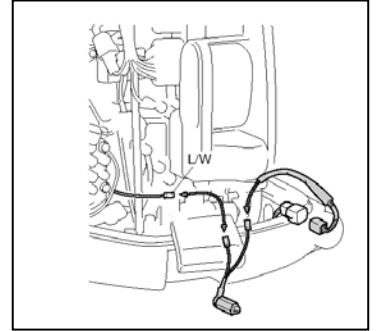
1. View Fault Codes
2. Monitor and Record Engine Data
3. Perform Various Active Tests.

Notes

Notes

Self-Diagnoses

1. Start the engine let it idle.
2. Attach the Malfunction Indicator Lamp.
p/n 91-881824001 to the test terminal.
3. Reference the number of flashes
to diagnostic code chart.



Code Number	Description
01	Normal
13	Crank position sensor failure
15	Cylinder block water temperature sensor
18	Throttle position indicator (TPI)
19	Battery (incorrect voltage)
23	Manifold air temperature sensor (MAP-T)
28	Shift position switch
29	Manifold air pressure sensor (MAP-T)
37	Idle air control (IAC)
44	Engine shut off switch
49	Thermostat
50	ECM memory

Checking fuel pressure

Fuel pressure gauge adaptor 91-881824003

Engine running idle warm fuel pressure should be 30 to 34 psi.



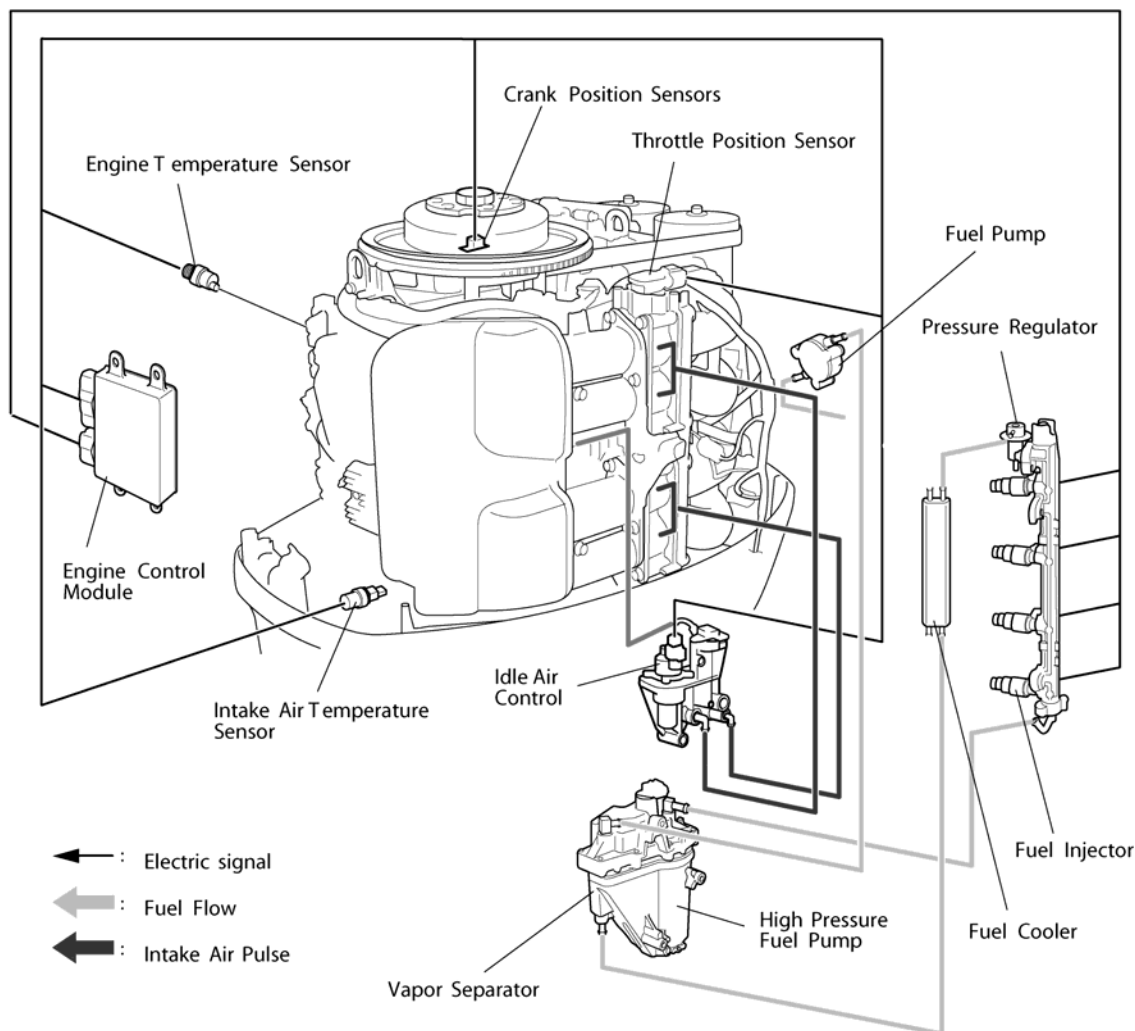
115 Electronic Fuel Injection System

Powerhead

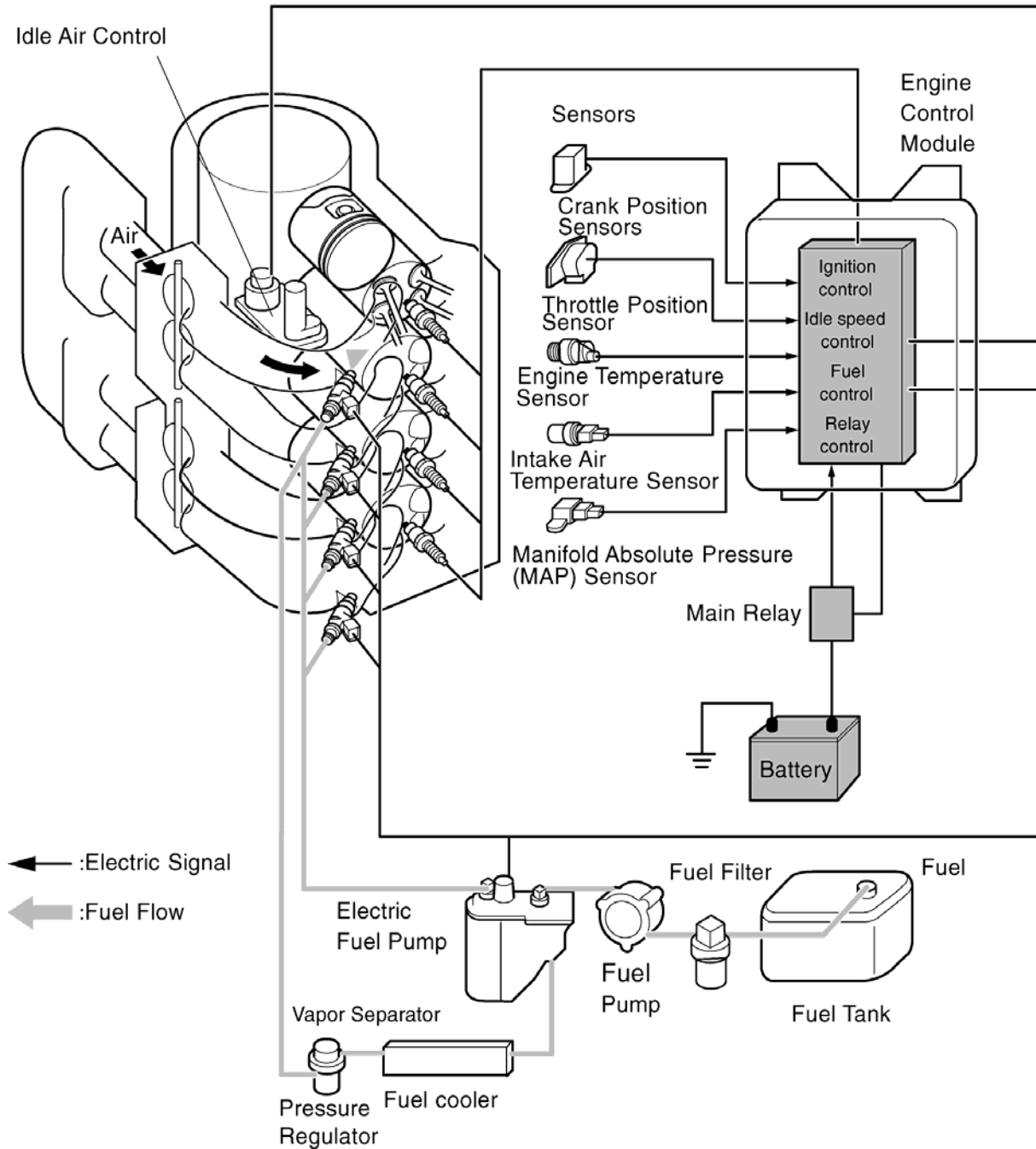
Although based on the previous 75/90 (4-Stroke) carburetor engine, the 115 EFI (4-Stroke) has an increased displacement and is equipped with an electronic fuel-injection system. With a newly designed crankshaft, connecting rod and pistons, the engine takes its valve system and durability from the 75/90 (4-Stroke) while increasing its power.

This engine is equipped with four independent throttle bodies, an Idle Air Control (IAC) and a fuel cooler to improve fuel economy. Fuel consumption, starting, and acceleration are improved due to an electronic fuel-injection system with sensor-based control and correction. The electronic fuel-injection system of the 115 EFI (4-Stroke) determines the optimal air-fuel ratio using the throttle position sensor, Manifold Absolute Pressure (MAP) sensor, intake air temperature sensor, crank position sensors, water temperature sensor, oil pressure switch and Electronic Control Module (ECM).

Charging output for battery has increased to 25 A to comply with the electronic fuel-injection system.



Electronic Fuel Injection System



Notes

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Notes

Idle Air Control (IAC)

The IAC controls an optimum idling engine speed depending on the cooling-water temperature and the condition of the engine.

STARTING AND IDLING

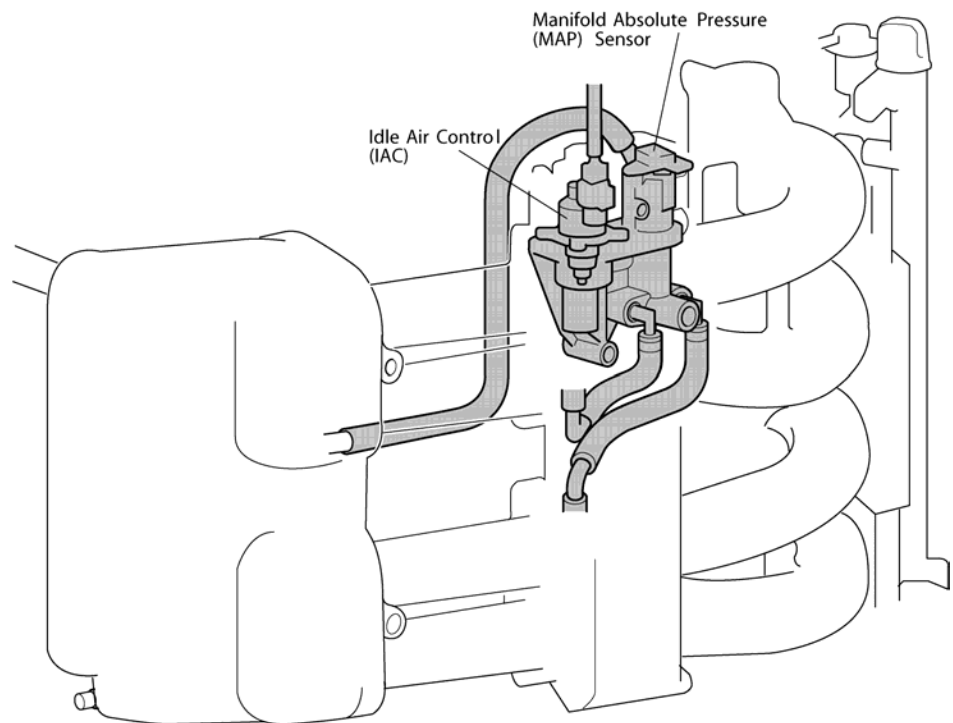
With the throttle valve fully closed, the air quantity in the bypass is controlled by a step-motor-type actuator equipped in the IAC.

WARMING UP

To warm up the engine, the IAC valve located in the bypass is opened and air is supplied to the engine to increase the engine speed. After the engine is warmed up, the valve is closed to decrease the engine speed and to maintain the specified idling speed.

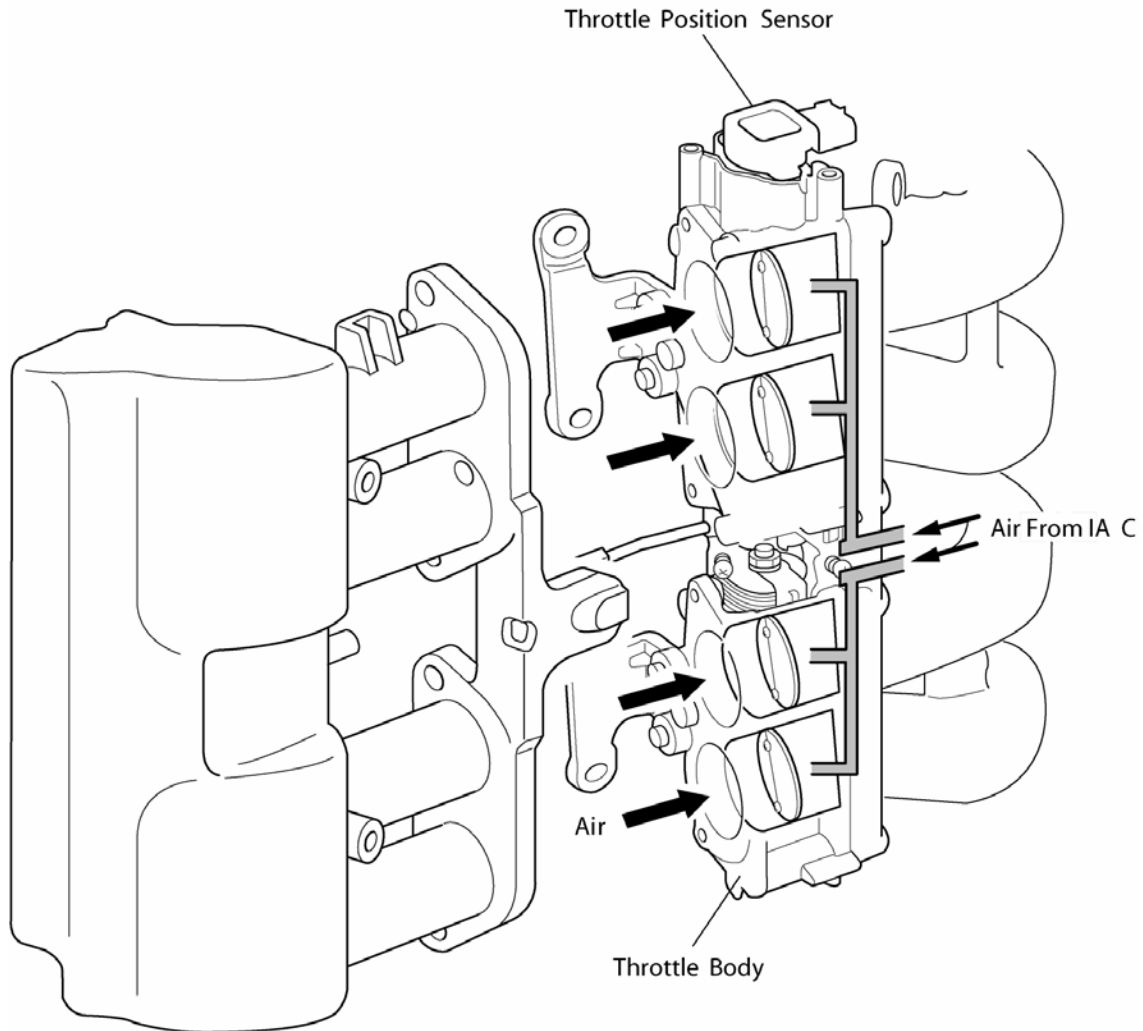
RAPID DECELERATION

When the throttle valve quickly returns to the fully closed position, the IAC valve will open just before the throttle valve is fully closed and act as a dashpot to prevent the engine from stalling.



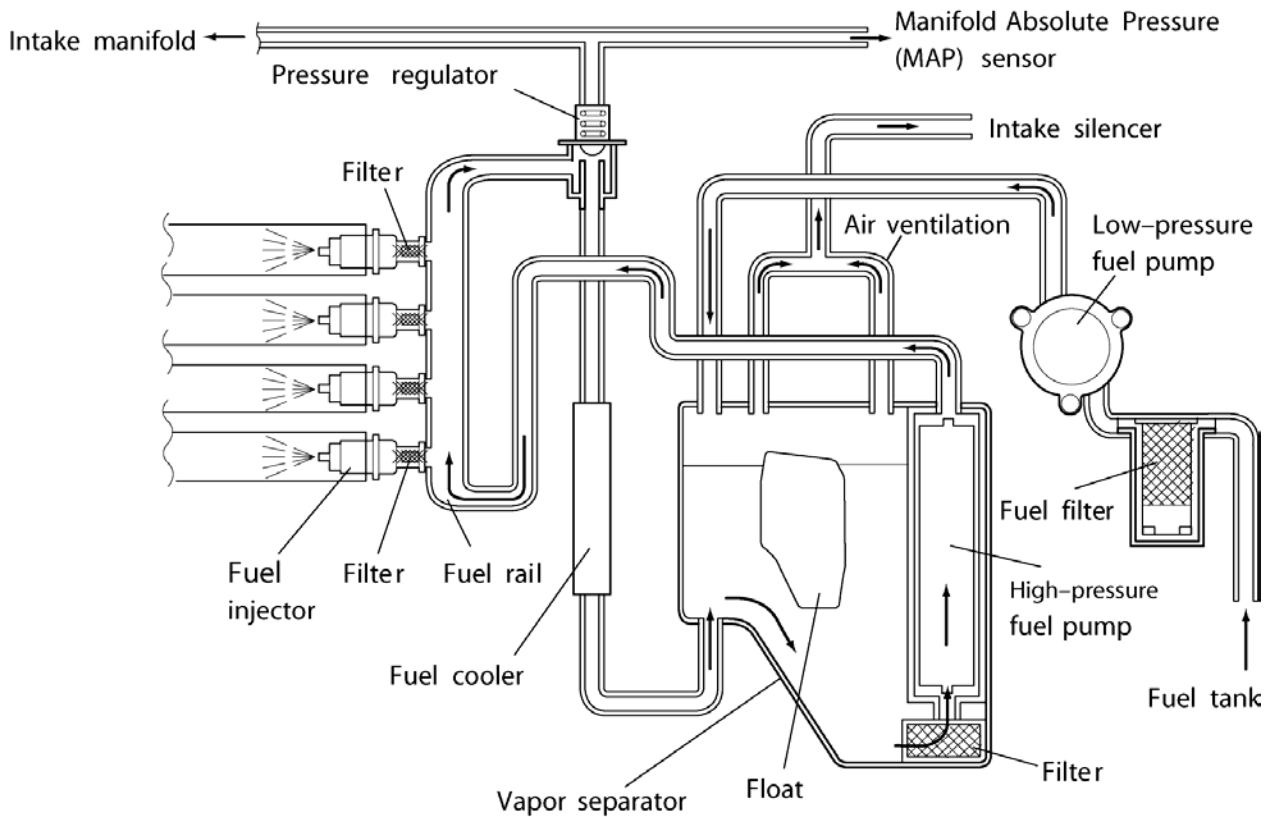
Air Induction System

The air induction system consists of the throttle bodies, throttle valves, throttle position sensor, intake air temperature sensor, Manifold Absolute Pressure (MAP) sensor, and the Idle Air Control (IAC). The intake silencer attenuates the sound of the air drawn into the engine to provide quiet operation. The throttle valves are installed in two independent throttle bodies (two sets of two throttle bodies).



Fuel System

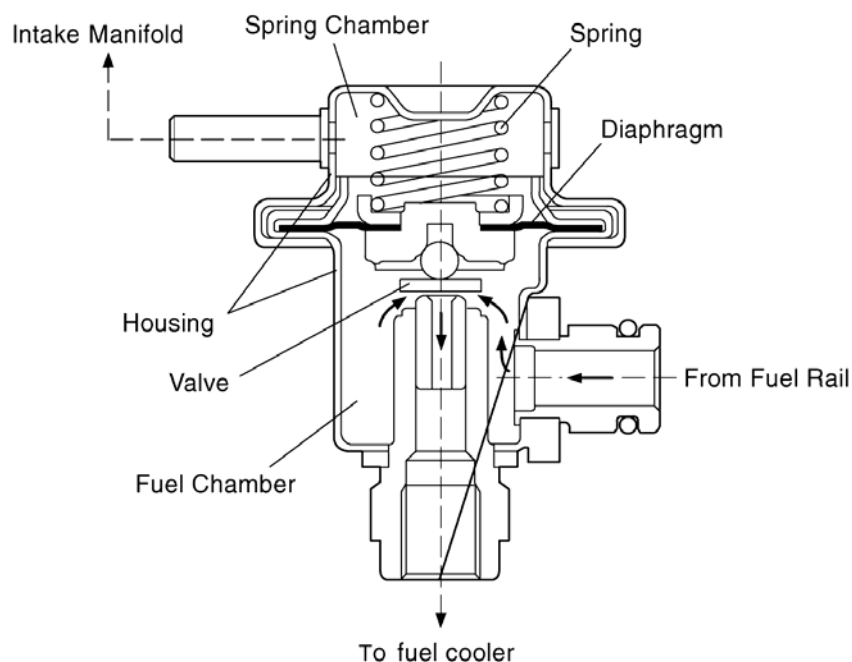
The fuel system consists of a low-pressure fuel pump, a high-pressure fuel pump, a fuel rail, fuel injectors, a pressure regulator, and a fuel cooler. The low-pressure pump sends fuel to the vapor separator tank, which is then pressurized to 43.5 psi (300 kPa) by the high-pressure pump. The pressurized fuel then travels through the fuel rail where it is injected from the fuel injectors into the intake manifold. Fuel not injected into the intake manifold goes through the pressure regulator, the fuel cooler, and is then returned to the vapor separator tank. The fuel pressure is maintained at 43.5 psi (300 kPa) between the high pressure fuel pump and the fuel injectors by the pressure regulator. High fuel-injection pressure maximizes the atomization of the fuel, resulting in increased combustion efficiency.



Diagnostic Tip: The 115 does not have high pressure fuel filter. When diagnosing misfire or lack of power don't forget an injector can work electrically but have debris in screen or mechanical problem.

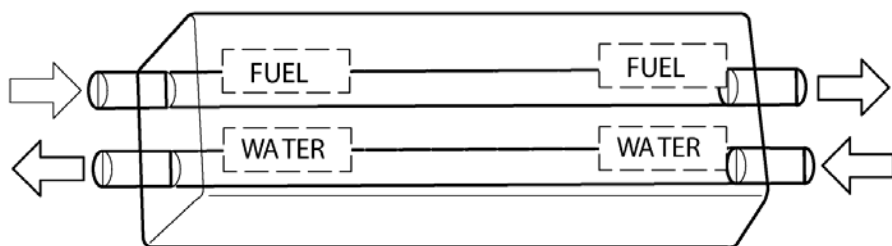
Pressure Regulator

A pressure regulator is installed in the upper part of the fuel rail. The pressure regulator maintains a stable fuel pressure according to the vacuum pressure in the intake manifold. With a maintained fuel pressure, control of an accurate fuel injection volume is increased.



Fuel Cooler

The 115 EFI (4-Stroke) is equipped with a fuel cooler that uses the engine cooling water to decrease the fuel temperature and reduce vapors. A brass pipe is used to prevent corrosion.

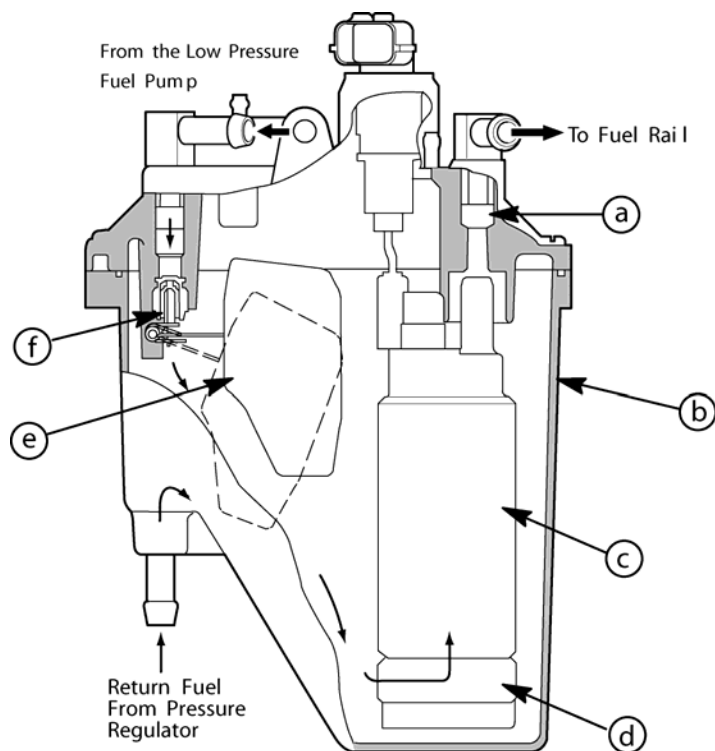


Notes

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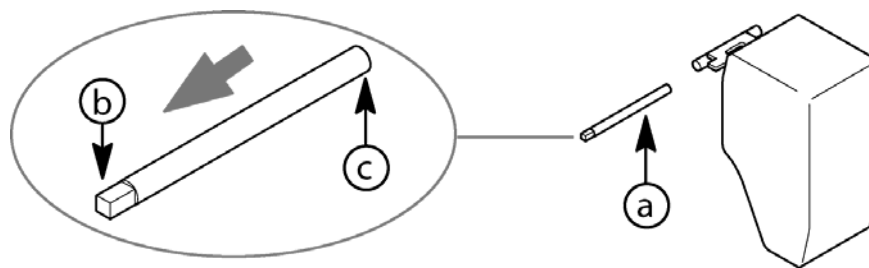
Vapor Separator

The vapor separator maintains a liquid fuel supply for the high pressure fuel pump located in the vapor separator tank. Fuel delivered from the mechanical low pressure fuel pump is supplied to the top port of the vapor separator and is controlled by the inlet needle/float. Low pressure fuel returning from the pressure regulator, passes through the fuel cooler and is supplied to the lower port of the vapor separator.



- d) Check Valve
- e) Vapor Separator
- f) High Pressure Electric Fuel Pump
- g) Filter
- h) Fuel Float
- i) Inlet Needle

NOTE: Remove float pin by pressing on the round end, NOT THE SQUARE END. Drive the pin out in the direction shown.



- j) Float Pin
- k) Square End
- l) Round End

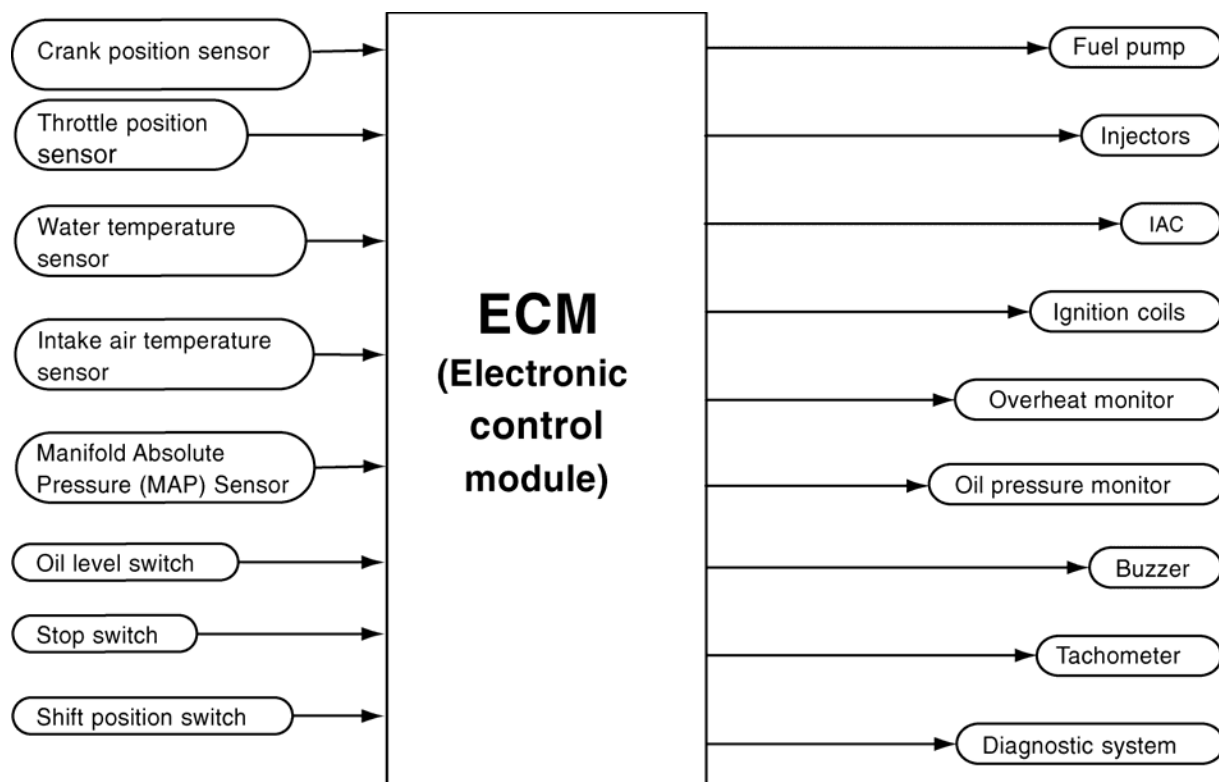
Ignition System

The 115 EFI (4-Stroke) has a newly designed ignition system, which provides the longer discharge duration required to burn the fuel injected into the cylinder in an extremely short period.

The ECM induces a high voltage in the ignition coil by allowing battery current to flow into the ignition circuit and turning on and off the ECM's ignition signals with the transistor.

Electronic Control System

The ECM of the 115 EFI (4-Stroke) controls the ignition timing, the fuel injection timing, the fuel injection volume, and the IAC, maintaining the optimal air-fuel ratio in all operating conditions. The ECM converts the signals from the input sensors and sends instructions to each part of the fuel injection system.



Notes

Fuel Injection Control

BATCHED FUEL INJECTION (INJECTION AT EACH REVOLUTION)

Fuel is injected into cylinder in pairs, (#1 & #4 or #2 & #3) with the charge to each cylinder requiring two revolutions.

Fuel Injection

Fuel is injected in two different ways: a batched injection, which divides the cylinders into two pairs (#1 & #4 and #2 & #3), and an asynchronous injection which accrues across all cylinders and does not depend on the crankshaft angle.

NOTE: *Asynchronous injection occurs as an accelerator pump or dash pot function.*

BATCHED INJECTION

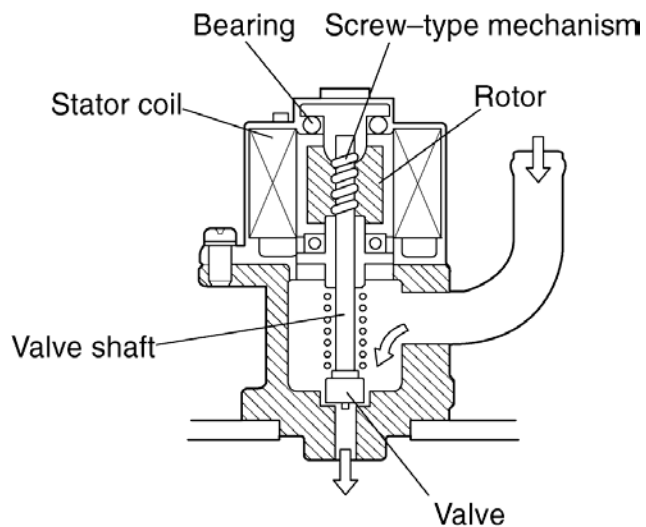
Injection groups are divided into two pairs (#1 & #4 and #2 & #3). With this type of system, the injection timing will change according to the ECM control based on the water temperature sensor and the intake air temperature sensor.

Idle Air Control (IAC)

Step-Motor-Type Actuator

This system consists of a motor (constructed of a magnet-operated rotor and a stator coil), a threaded portion (which converts the rotation into a linear movement of the valve), and a valve.

The electric current flowing through the stator coils is switched in steps. The regular rotation and counter-rotation of the rotor raises or lowers the valve to adjust the amount of air that flows through. The direction that the rotor rotates is determined by the electric flow through the stator coils. The valve of this IAC can be opened from fully closed to fully open in 120 steps.



Notes

Notes

Ignition Control

Ignition Timing Control During Engine Start Up

The ignition timing is mainly determined by signals from the throttle position sensor and the crank position sensors. Corrections are controlled by the water temperature sensor, the oil pressure switch, the shift position switch, the engine stop switch after engine start and the main switch. During cranking, the ignition timing is 10° BTDC until the engine starts, then it is retarded 1° per second until it reaches 4° ATDC. The ignition timing is normally controlled between 4° ATDC and 26° BTDC. While the engine is warming up, the ignition timing is fixed at 4° ATDC. At rapid acceleration or deceleration ignition timing changes according to the throttle valve opening angle.

Over-Revolution Control

If the engine speed exceeds 6,200 rpm, the ignition of either cylinder #1 or #4 is cut. If the engine speed exceeds 6,250 rpm, the ignition of both cylinders #1 and #4 is cut. If the engine speed exceeds 6,350 rpm, the ignition of cylinders #1 and #4, and either cylinder #2 or #3 is cut. If the engine speed exceeds 6,450 rpm, the ignition of all four cylinders is cut.

Overheating Control

When the engine speed is less than 2,000 rpm, this control mode is delayed 60 seconds after the engine is started. When the engine speed is 2,000 rpm or more, this control mode is delayed 20 seconds after the engine is started. The engine is considered to be over-heating if its temperature increases from 167° F (75° C) to 185° F (85° C). If its temperature exceeds 194° F (90° C), this control mode begins. The overheat warning buzzer sounds, and the ignition and injection are cut according to the misfiring rate.

If the engine overheats, the ignition of both cylinders #1 and #4 is cut, however the ignition of cylinders #2 and #3 is not cut. After the engine temperature decreases to less than 167°F (75°C) the overheat warning can be cancelled by decreasing the throttle opening angle to less than 2° and turning the ignition key to the off position.

Low Oil Pressure Control

When the oil pressure drops below 21.75 psi (150 kPa) the oil pressure warning buzzer sounds, and the ignition and injection are cut according to the misfiring rate.

The low oil pressure control operates in the same way as the overheating control.

Fail Safe Function Table

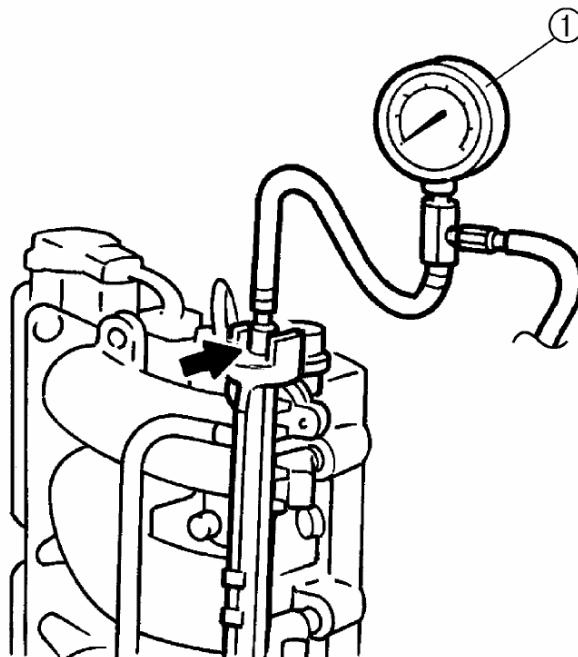
Symptoms	FAIL SAFE FUNCTION			
	Ignition	Fuel Injection	IAC	Engine Condition
Abnormal signal from crank position sensor	Four cylinder ignition is fixed at 40° ATDC	Cylinders with no input signal will be stopped	900 rpm	Engine idling speed increases. Top speeds cannot be reached.
Abnormal signal from throttle position sensor	When throttle opening angle is less than -10° or more than 100°: Ignition is fixed at 10° BTDC	When the throttle opening angle is less than -10° or more than 100°: Injection is controlled only by the boost map	900 rpm	Engine idling speed increases. Top speeds cannot be reached.
Abnormal signal from Manifold Absolute Pressure (MAP) sensor	When the intake air pressure is less than 1.9 psi (100 mmHg) or more than 17.4 psi (900 mmHg): Ignition is fixed at 10° BTDC	When the intake air pressure is less than 1.9 psi (100 mmHg) or more than 17.4 psi (900 mmHg): Injection is controlled with throttle opening map	900 rpm	Engine idling speed increases. Top speeds can be reached.
Abnormal signal from water temperature sensor	When less than 0.1 V or more than 4.52 V are detected (substitutes the intake air temperature sensor): Ignition is fixed at 10° BTDC	When less than 0.1 V or more than 4.52 V are detected (substitutes the intake air temperature sensor): Normal Operation	900 rpm	Engine idling speed increases. Top speeds can be reached.
Abnormal signal from intake air temperature sensor	When less than 0.1 V or more than 4.52 V are detected (the intake air temperature sensor is fixed at 4°): Ignition is fixed at 10° BTDC	When less than 0.1 V or more than 4.52 V are detected (the intake air temperature sensor is fixed at 4°): Normal Operation	900 rpm	Engine idling speed increases. Top speed can be reached.
Abnormal signal from engine stop switch	On is detected Ignition is cut	On is detected Ignition is cut	IAC is stopped	Engine is stopped.

Notes

Service Information

Measuring the Fuel Pressure (High-Pressure Fuel Line)

- 9) Install high pressure fuel gauge.
- 10) Start engine and then measure the fuel pressure.



Self-Diagnosis

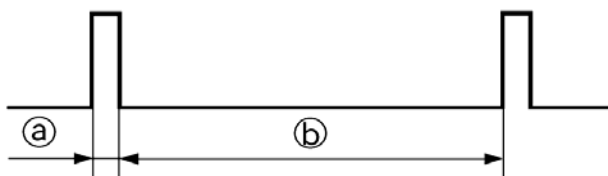
Notes

DIAGNOSIS CODE INFORMATION

Normal condition (no defective part or irregular processing is found).

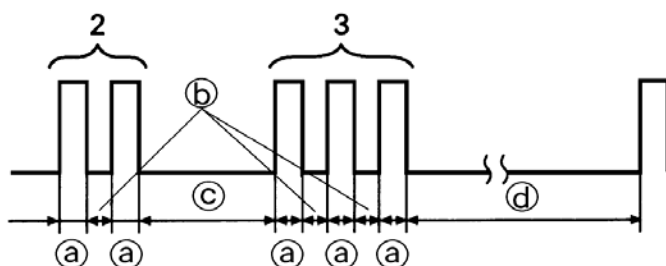
Single flash is given every 4.95 seconds.

- a) Light on, 0.33 second
- b) Light off, 4.95 seconds



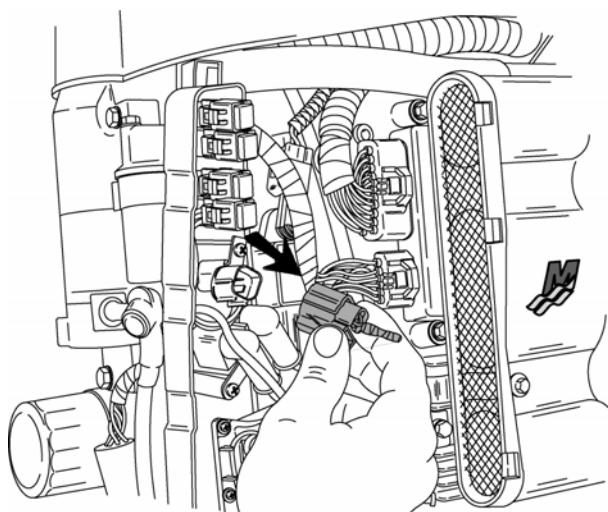
Trouble code indication. Example: The illustration indicates code number 23.

- a) Light on, 0.33 second
- b) Light off, 0.33 second
- c) Light off, 1.65 seconds
- d) Light off, 4.95 seconds.



DIAGNOSIS OF THE ELECTRONIC CONTROL SYSTEM

11) Remove wire connector test plug cap.



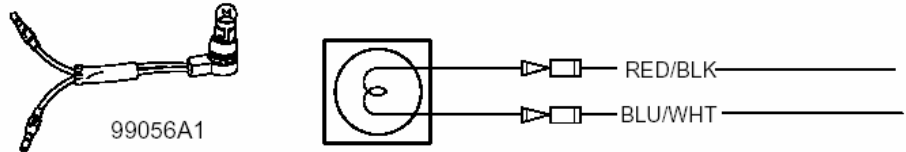
Notes

12) Install Malfunction Indicator Lamp

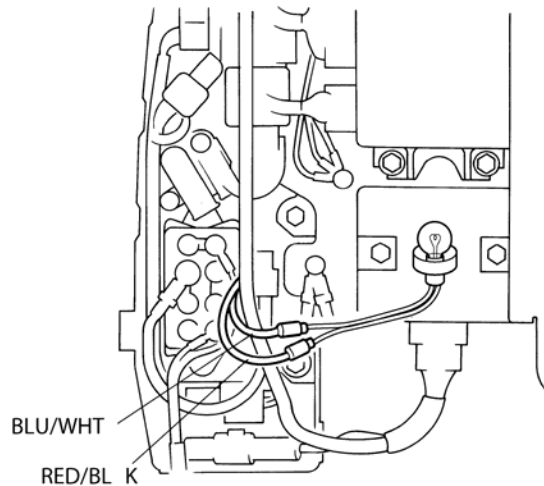
a) Model Year 2001 and Prior - Install Malfunction Indicator Lamp (MIL) p/n 99056A1, or create your own test light.

(1.) Remove rubber plugs from engine harness bullet connectors.

(2.) Connect leads of the Malfunction Indicator Lamp (MIL) p/n 99056A1 to the engine harness connectors.



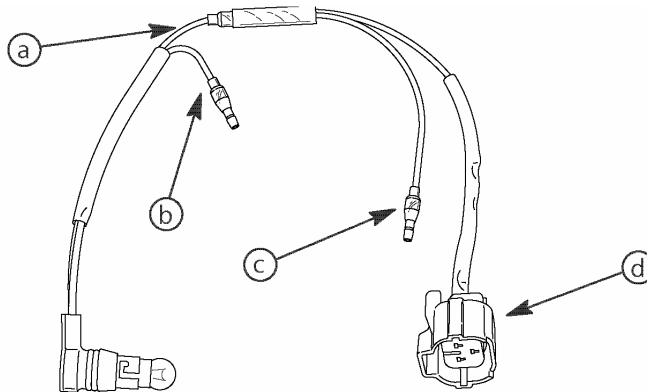
NOTE: When performing this diagnosis, all of the electrical wires must be properly connected.



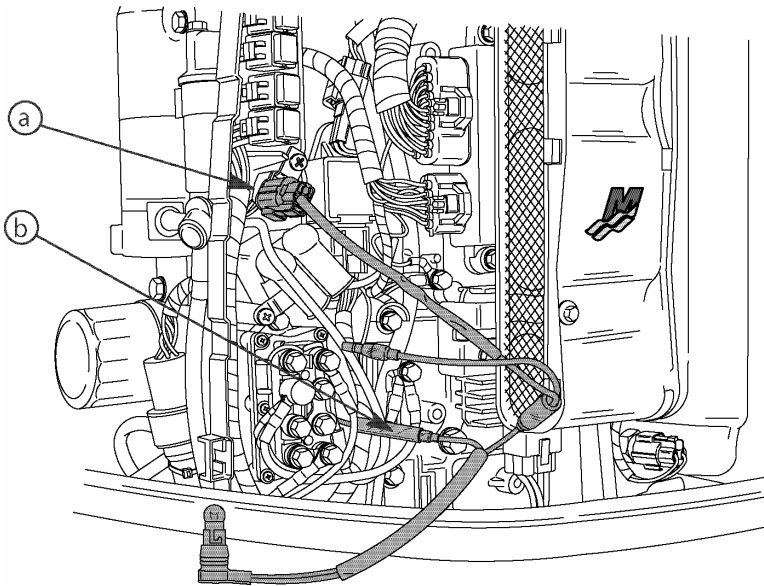
- b) Model Year 2002 and Newer - Install Malfunction Indicator Lamp (MIL)
p/n 91-884793A1.

NOTE: This new service tool must be used on 2002 model year product. The new tool consists of the previous diagnostic lam 99056A1 and an additional harness with a 3 pin terminal connector.

- (1.) Remove rubber plug from engine harness bullet connector.
- (2.) Connect the harness terminal to the diagnostic test terminal.
- (3.) Connect the lamp wire bullet terminal to the blue/white wire bullet terminal on the engine harness.



- m) Lamp Wire
n) Lamp Wire
o) Green/Red Wire (Not Used)
p) Harness Terminal



CAUTION:

Do not allow the GRN/RED wire to touch ground. During diagnosis of the electronic control system, the GRN/RED wire is supplied with battery voltage. Any contact with ground will damage a fuse.

Also, DO NOT accidentally connect the GRN/RED wire to the BLU/WHT wire from the engine harness. Doing so WILL damage the ECM.

- q) Harness terminal
r) Bullet terminal

- 13) Check diagnosis code(s)
- a) Code 1 is indicated - normal
 - b) Code 13-29 indicated - Check the applicable parts.
 - c) Code 33-44 indicated - Microcomputer processing information problem.

Notes

CHECKING STEPS

14) Start the engine and let it idle.

15) Check the malfunction indicator lamp's flash pattern to determine if there are any malfunctions.

NOTE: The ignition key must be returned to the "OFF" position to clear a corrected failure code.

NOTE: When more than one problem is detected, the malfunction indicator lamp light flashes in the pattern of the lowest numbered problem. After that problem is corrected, the lamp flashes in the pattern of the next lowest numbered problem. This continues until all of the problems are detected and corrected.

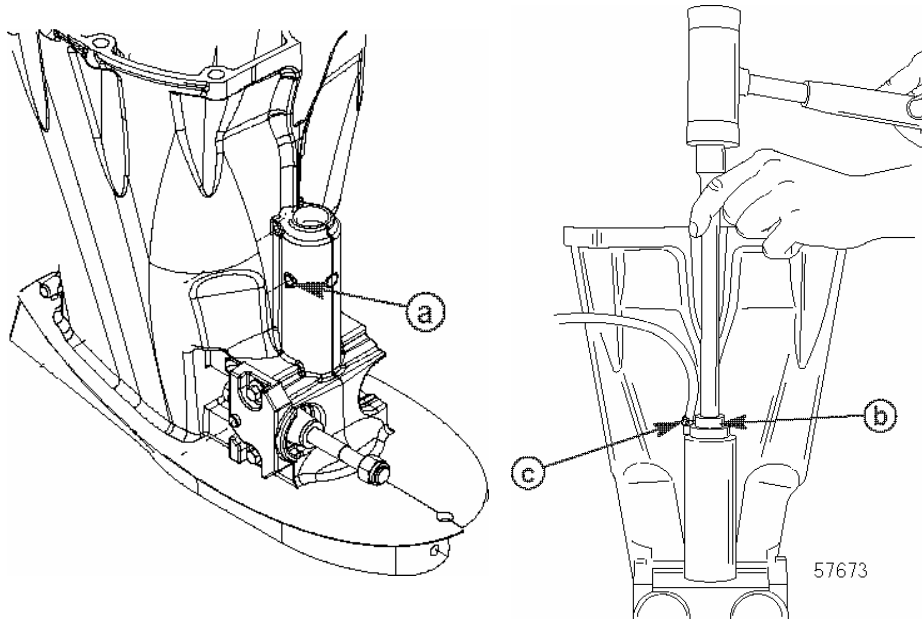
Diagnostic Code Chart

Code	Symptom
13	Incorrect crank position sensor input signal
15	Incorrect engine cooling water temperature sensor input signal
18	Incorrect throttle position sensor input signal
19	Incorrect battery positive voltage
23	Incorrect intake air temperature sensor input signal
28	Incorrect shift position switch
29	Incorrect manifold absolute pressure sensor input signal (out of normal operating range)
(33)	Ignition timing is being slightly corrected (when starting a cold engine).
(37)	Intake passage air leakage
(44)	Engine stop switch control operating

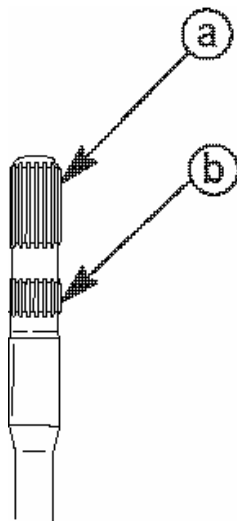
Drive Shaft Bushing Removal (75/90/115 4-Stroke Models)

Notes

- 1) Using a suitable punch, drive roll pin to inside of drive shaft housing.
- 2) Remove drive shaft bushing with Bushing Installation Tool 91-875215.



- a) Roll Pin
- b) Bushing Installation Tool 91-875215
- c) Water Hose



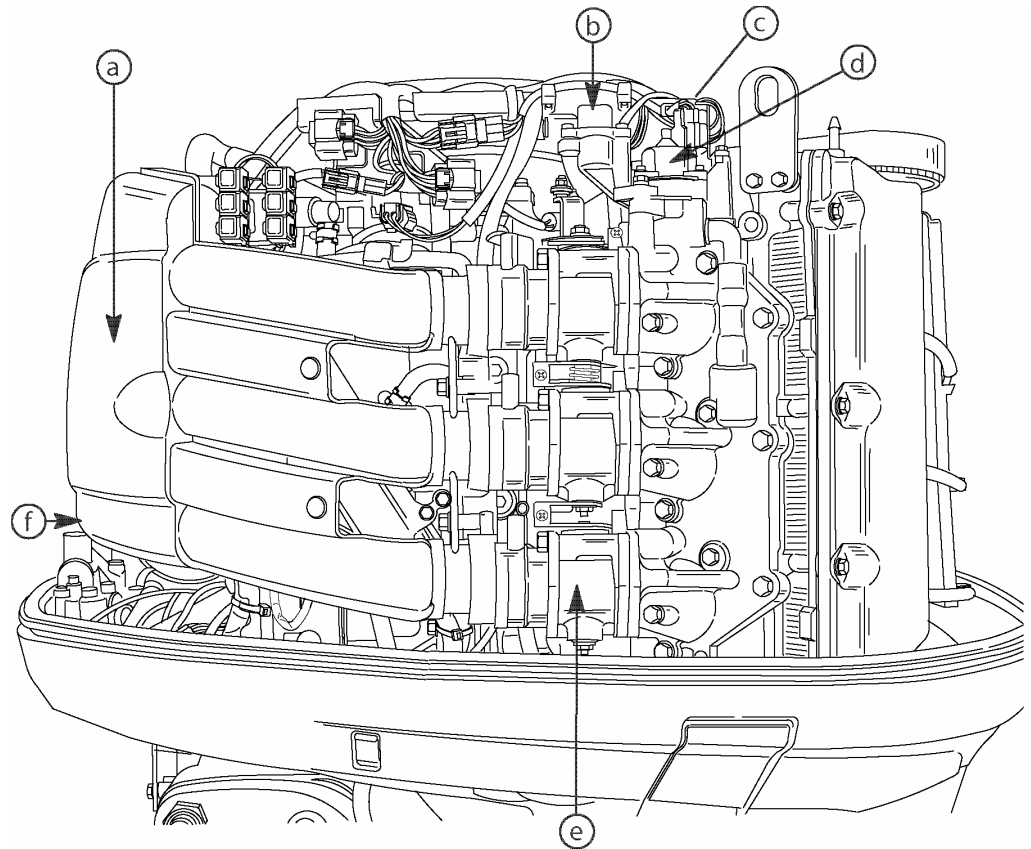
- a) Crankshaft/Driveshaft Splines
- b) Oil Pump Drive Splines (75/90/115 4-Stroke Only)

NOTE: Refer to Service Bulletin 2001-8 for more information.

225 Electronic Fuel Injection System

Air Induction System

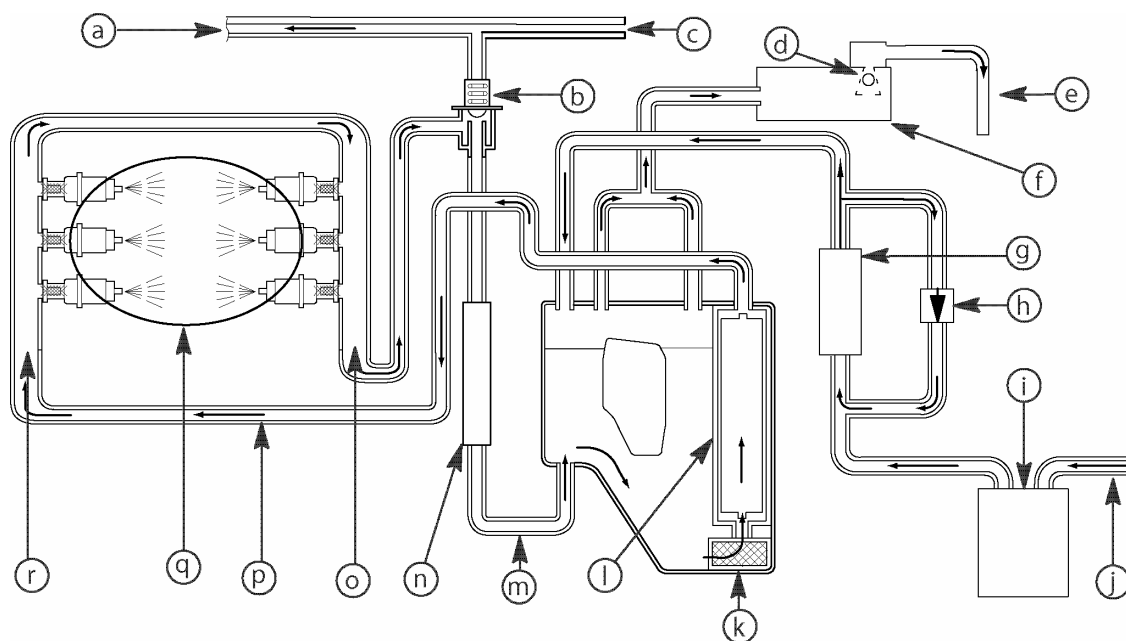
The air induction system consists of the throttle bodies, throttle valves, throttle position sensor, intake air temperature sensor, Manifold Absolute Pressure (MAP) sensor, and the Idle Air Control (IAC). The intake silencer attenuates the sound of the air drawn into the engine to provide quiet operation. The throttle valves are installed in six independent throttle bodies.



- a - Intake silencer
- b - MAP sensor
- c - Throttle position sensor (Located on #1 throttle body)
- d - IAC motor
- e - Throttle bodies with throttle valves
- f - Intake air temperature sensor (Located on lower front of intake silencer)

Fuel System

The fuel system consists of a low pressure fuel pump, a high pressure fuel injection pump, a fuel rail, fuel injectors, a pressure regulator, and a fuel cooler. The low pressure fuel pump pulls fuel from the fuel tank, sends fuel to the vapor separator tank, which is then pressurized to 44 psi (310 kPa) by the high pressure fuel injection pump. The pressurized fuel then travels through the fuel rail where it is injected from the fuel injectors into the intake manifold. Fuel not injected into the intake manifold goes through the pressure regulator, the fuel cooler, and is then returned to the vapor separator tank. The fuel pressure is maintained at 38 psi (270 kPa) between the high pressure injection fuel pump and the fuel injectors by the pressure regulator when the engine is running. High fuel injection pressure maximizes the atomization of the fuel, resulting in increased combustion efficiency.



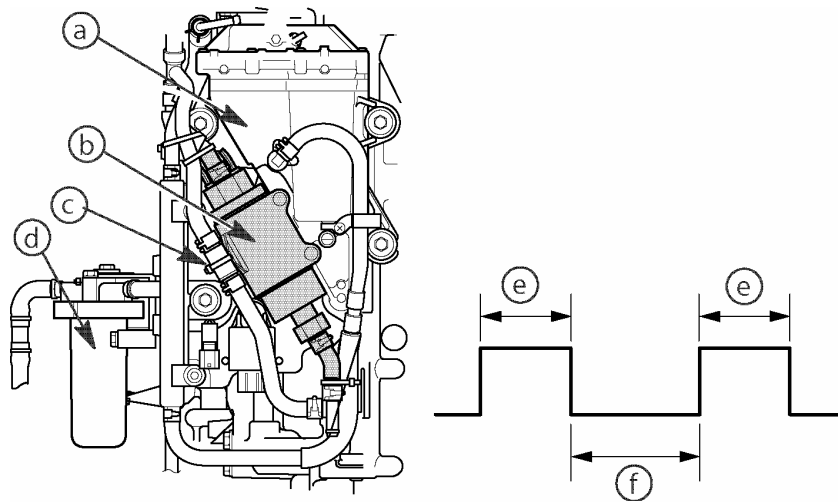
- a - Intake manifold
- b - Fuel pressure regulator
- c - To MAP sensor
- d - Over flow check valve
- e - Secondary VST overflow to adaptor plate
- f - Secondary VST
- g - Low pressure fuel pump
- h - Fuel bypass check valve (10-12 psi)
- i - Fuel filter
- j - From fuel tank
- k - High pressure fuel pump filter
- l - High pressure fuel pump
- m - Fuel return from fuel cooler
- n - Fuel cooler
- o - Port fuel rail
- p - High pressure fuel hose from VST
- q - Fuel injectors
- r - Starboard fuel rail

Notes

Fuel System Components

Low Pressure Fuel Pump

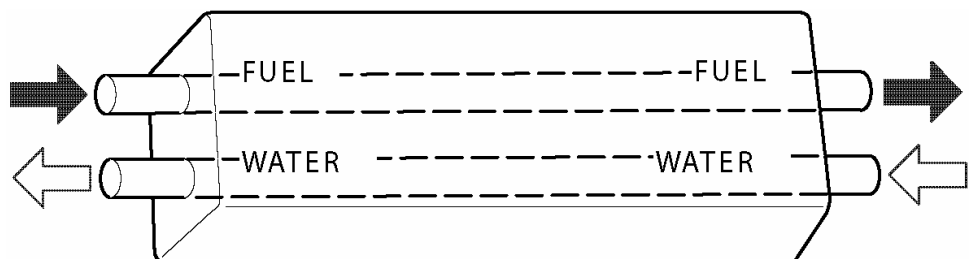
The fuel system has a low pressure electric fuel pump, in place of the mechanical fuel pump used in the previous electronic fuel injection systems. With the electric fuel pump, the routing of the fuel system is more compact. After start up, the fuel pump will operate continuously for 3 minutes. After the 3 minutes, to prevent the over pumping of fuel, the pump operates for 10 seconds, and stops for 20 seconds when the engine is operating below 1200 rpm. The pump operates constantly when the engine speed is 1200 rpm or higher.



- a - VST
- b - Fuel pump
- c - Low pressure fuel bypass check valve
- d - Fuel filter
- e - Pump operation for 10 seconds
- f - Pump not operating for 20 seconds

Fuel Cooler

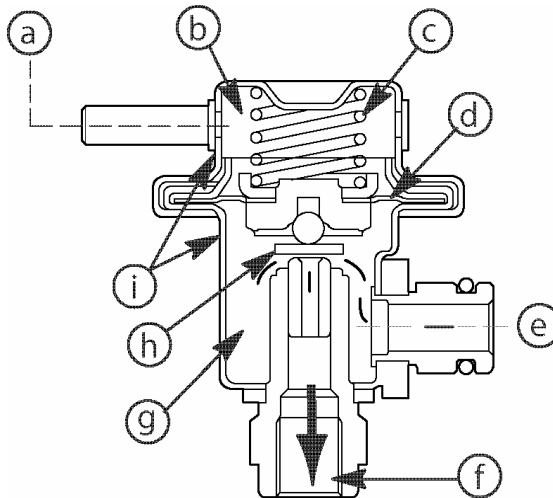
The system is equipped with a fuel cooler that uses the engine cooling water to decrease the fuel temperature and reduce vapors. A brass pipe is used to prevent corrosion.



Pressure Regulator

A pressure regulator is installed in the upper part of the port fuel rail. The pressure regulator maintains a stable fuel pressure according to the vacuum pressure in the intake manifold. With a maintained fuel pressure, control of an accurate fuel injection volume is increased.

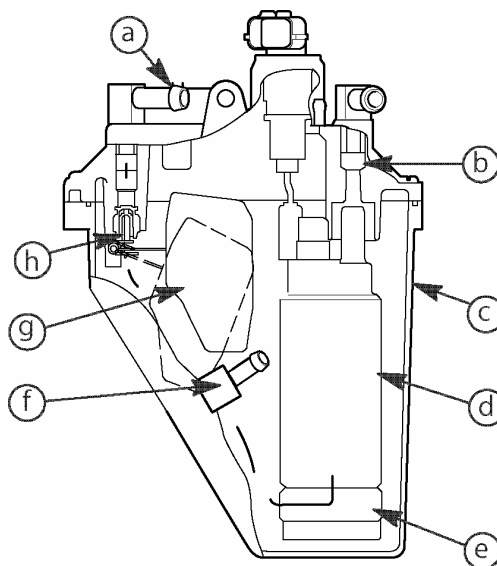
- a - Intake manifold
- b - Spring chamber
- c - Spring
- d - Diaphragm
- e - From fuel rail
- f - To fuel cooler
- g - Fuel chamber
- h - Valve
- i - Housing



Vapor Separator

The vapor separator maintains a liquid fuel supply for the high pressure fuel pump located in the vapor separator tank. Fuel delivered from the low pressure fuel pump is supplied to the top port of the vapor separator and is controlled by the inlet needle/float. Low pressure fuel returning from the pressure regulator passes through the fuel cooler and is supplied to the lower elbow on the vapor separator.

- a - Fuel inlet
- b - Check valve
- c - Vapor separator
- d - High pressure fuel pump
- e - Filter
- f - Fuel return from fuel cooler.
- g - Fuel float
- h - Inlet needle

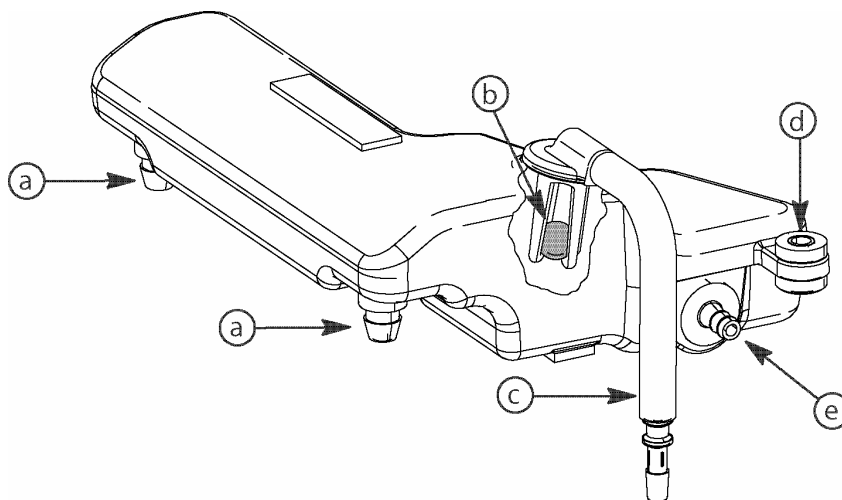


Notes

Notes

Secondary Vapor Separator

The secondary vapor separator is a reservoir to hold liquid fuel if the vapor separator float or needle valve fail. The SVS has a check valve (float ball) used to close the SVS atmosphere vent. It also is a purge for the vapor separator, eliminating the chance of vapor lock. The SVS eliminates any possibility of uncontrolled liquid fuel or fuel vapors to enter the engine and alter the running quality.



- a - SVS locating tab
- b - Check valve (float ball)
- c - Atmosphere vent hose
- d - SVS mounting screw grommet
- e - SVS inlet

Diagnostic tip: Customer complaining of stalling below 1200 RPM will restart once the fuel system is reprimed. Might not be able to duplicate.

2004-2005 Model year 225 Fourstroke

The possible cause of this situation may be a contaminated fuel return check valve. Debris in this check valve will not allow the system to purge any air out of the vapor separator under 1200 RPM due to predetermined low pressure fuel pump cycling. Once the vapor separator runs out of fuel, the engine will stall. This will usually occur within 5-10 minutes of running below 1200 RPM. See bulletin 2003-07.

Electronic Control System

The ECM of the 225 EFI (4-Stroke) controls the ignition timing, the fuel injection timing, the fuel injection volume, and the IAC, while maintaining the optimal air-fuel ratio in all operating conditions. The ECM converts the signals from the input sensors and sends instructions to each part of the fuel injection system.

EFI System

The injection system employs a 120° synchronous (batch) injection method which groups cylinders #1 and #4, and cylinders #2 and #5, and cylinders #3 and #6. In order to make corrections according to the engine conditions, an asynchronous injection is performed in all modes regardless of the crank angle signal. In addition, the injector of the 225 EFI (4-Stroke) is equipped with a function that cleans the nozzle by operating it one time to prevent the injector needle from sticking when the main switch is turned to ON.

Ignition System

The 225 EFI (4-Stroke) has an ignition system which provides a longer discharge duration, required to burn the fuel injected into the cylinder in an extremely short period.

The ECM induces a high voltage in the ignition coil by allowing battery current to flow into the ignition circuit. The ECM controls the signal to the ignition coils. Ignition occurs on two cylinders at once; #1 and #4, #2 and #5, #3 and #6. This type of ignition is called wasted spark.

Computer Diagnostic System (CDS) Now Used for Diagnostics

The Mercury Computer Diagnostic System has some new diagnostic capabilities as of Version 3.2x. The CDS System will have the ability to view and/or perform the following:

- View Fault Codes
- Monitor and Record Engine Data
- Perform Various Active Tests

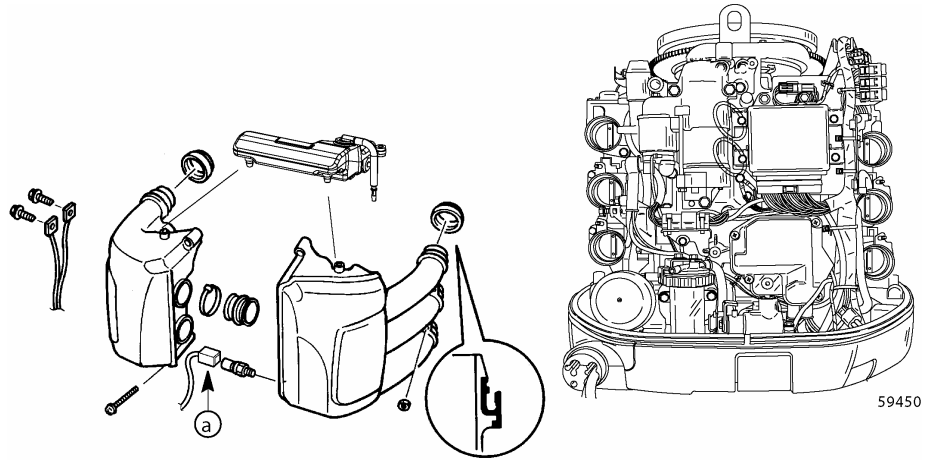
Refer to the end of this section for a view of some sample screens.

Notes

Sensors

Intake Air Temperature Sensor

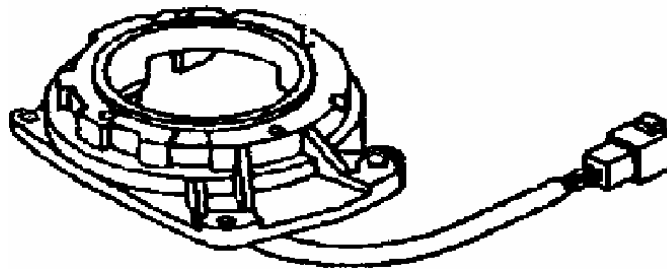
Monitors the intake air temperature. Sends signals to the ECM which aid in determining the optimal air-fuel ratio, fuel injection timing and fuel injection volume.



a - Air Temperature Sensor

Crank Position Sensors

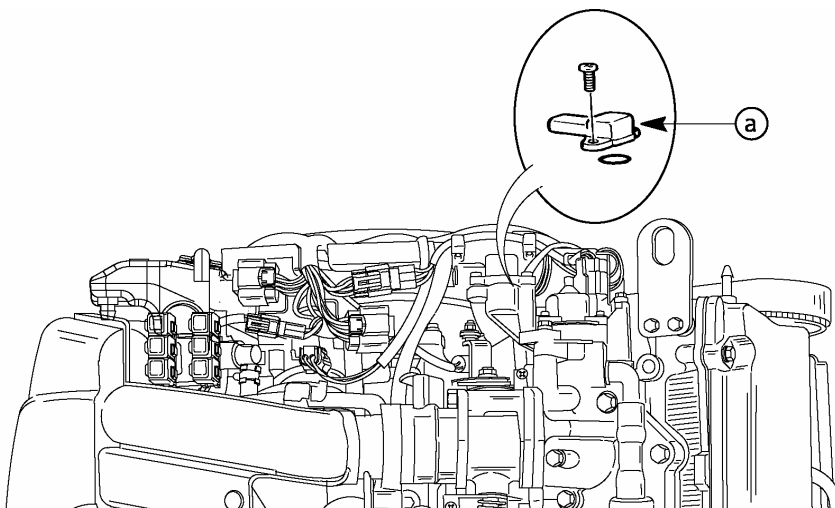
Provides the ECM with crank position information and engine speed which the ECM uses in determining optimal air-fuel ratio, fuel injection volume, ignition timing, and ignition/injection cut-off/warning for over revolution control.



As the crankshaft rotates, the CPS's (3) sense a passing tooth on the rotor (located on the crankshaft, under the cam belt drive gear). The CPS's send signals to the microcomputer (located within the ECM), which then determines both the crankshaft position and engine speed.

Manifold Absolute Pressure (MAP) Sensor

Monitors the intake manifold pressure. Sends signals to the ECM which aid in determining the optimal air-fuel ratio and fuel injection volume.

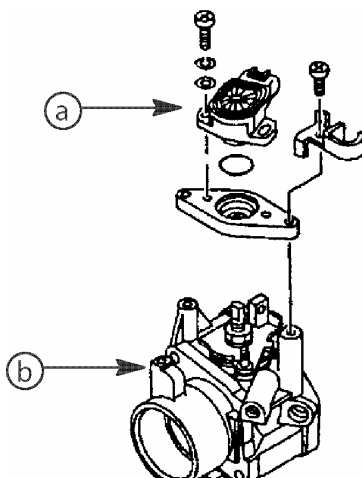


a - MAP sensor

Throttle Position Sensor (TPS)

Provides the ECM with throttle angle information which the ECM uses in determining optimal air-fuel ratio, fuel injection timing and fuel injection volume.

If the TPS is faulty, the ignition timing will automatically be fixed at 10° BTDC, corrections are made to the basic injection map, the IAC opening angle is fixed to 60 % and idle speed in neutral increases to 900 rpm.



a - Throttle Position Sensor
b - Starboard throttle body

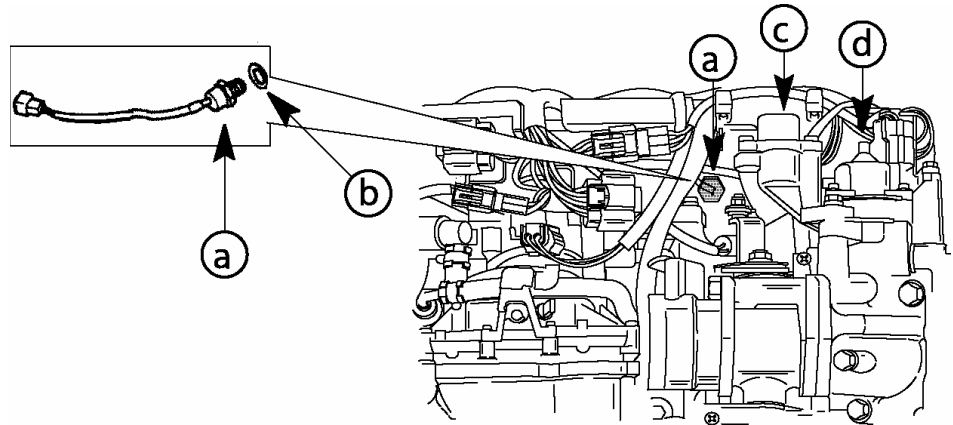
Notes

Notes

Engine Temperature Sensor

Monitors the engine temperature. Sends signals to the ECM which aids in determining the optimal air-fuel ratio, fuel injection volume, and ignition/injection cut-off/warning for engine overheat control.

If the engine temperature sender is faulty, the ECU will adjust to read 40 °C (104 °F). This will activate normal fuel injection control and the idle speed increases.



- a - Engine temperature sensor
- b - Gasket
- c - MAP
- d - IAC

Shift Cutoff Control

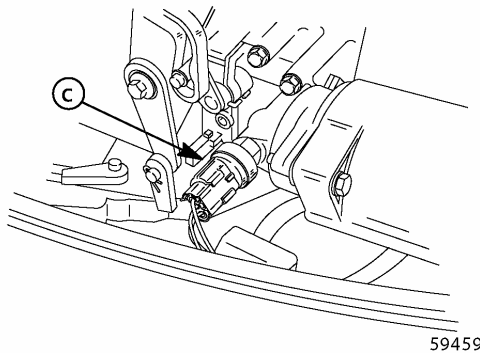
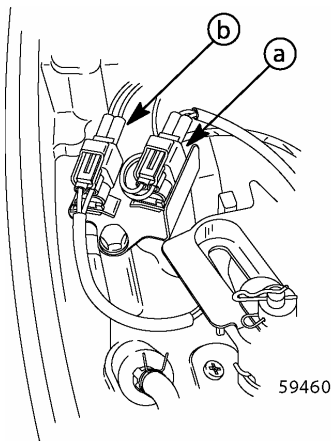
If the shift switch is activated with the engine operating under 2000 rpm, the ECU causes one or two cylinders to misfire in order to facilitate shifting. The ECU causes cylinders #1 and #2, or #4 and #5 to misfire when the engine speed is over 850 rpm, and cylinder #1 or #4 to misfire when the engine speed is under 850 rpm.

Neutral Switch

Sends a signal to the ECM indicating in gear or neutral. When the outboard is in neutral, the switch is closed. When the switch is in the closed position, the ECM will limit the engine speed to less than 4500 rpm as described in the over-revolution control.

Oil Pressure Sensor

Monitors engine oil pressure. Sends signals to the ECM which activates ignition/injection cut-off/warning for low oil pressure.



- a- Neutral start switch connector
- b- Shift cut switch connector
- c- Oil pressure switch

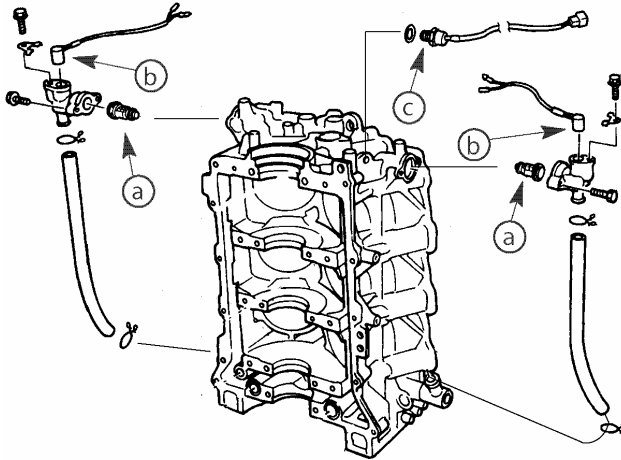
Notes

Notes

Engine Temperature Switch

Sends a signal to the ECM that the engine temperature has reached 120 °C (248 °F) or higher. The ECM causes cylinder pairs #2 and #5, #3 and #6 to misfire until the engine decreases speed to 2000 rpm. The warning light will be illuminated and the warning horn will sound continuously until the thermostwitch is deactivated and the throttle is fully closed.

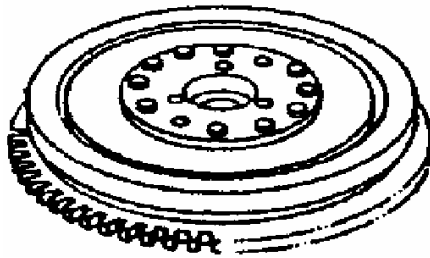
If the engine temperature switch fails, the engine will idle at 900 rpm in neutral and the overheating control will activate.



- a - Thermostat
- b - Engine Temperature Switch
- c - Engine Temperature Sender

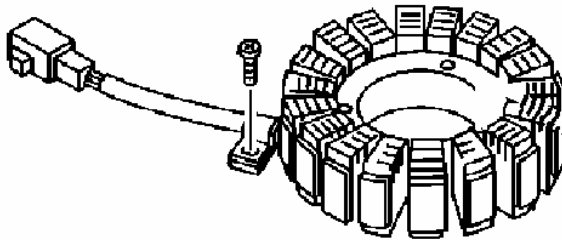
Other System Components

Flywheel Assembly



The flywheel assembly contains six permanently charged magnet segments which are bonded and retained to the inner wall of the flywheel. Each magnet contains a north and a south pole providing a 12 pole system.

Stator Assembly



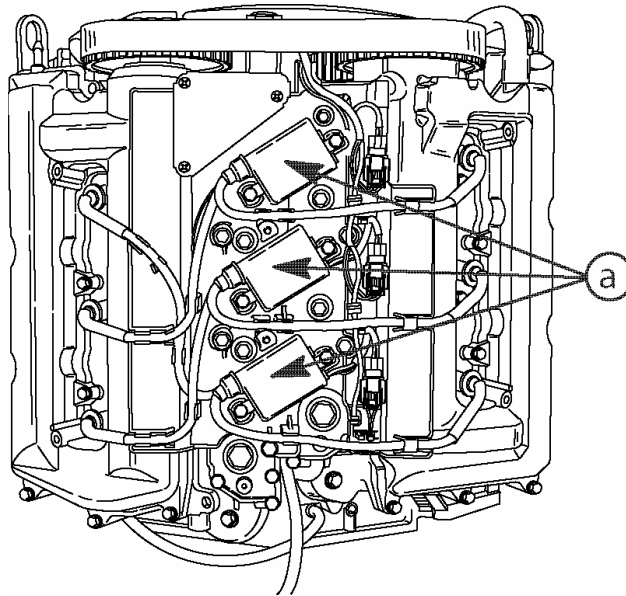
The stator assembly, located under the flywheel, contains coil windings which provides three-phase AC voltage to the voltage regulator.

As the flywheel permanent magnets pass the coil windings, an AC pulse current is produced at each coil winding as the magnet polarity changes. (South to North), (North to South) etc.

Notes

Notes

Ignition Coils



a - Ignition Coils

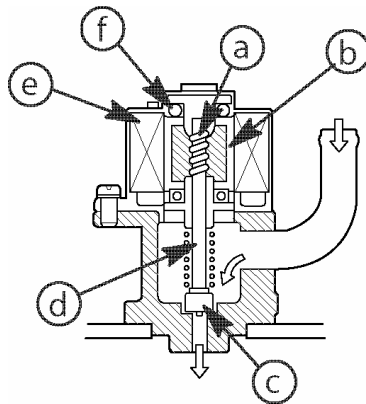
The primary (+) side of the ignition coil receives battery voltage from the main power relay. When the ECM receives a signal from the CPS, the main power relay ground circuit is completed through the ECM. The main power relay transfers battery voltage to 3 coils. The negative side of the coil is connected to the engine ground through the ECM. When this circuit is closed, a magnetic field is allowed to be built up in the ignition coils. When the ECM is supplied with a trigger signal, the ECM opens the circuit and the magnetic field collapses across the coil secondary winding creating a high voltage charge that is sent to the spark plugs.

Actuators

Idle Air Control

STEP-MOTOR-TYPE ACTUATOR

This system consists of a motor (constructed of a magnet-operated rotor and a stator coil), a threaded portion (which converts the rotation into a linear movement of the valve), and a valve. The electric current flowing through the stator coils is switched in steps. The regular rotation and counter-rotation of the rotor raises or lowers the valve to adjust the amount of air that flows through. The direction that the rotor rotates is determined by the electric flow through the stator coils. The valve of this IAC can be opened from fully closed to fully open in 120 steps.



- a - Screw-type mechanism
- b - Rotor
- c - Valve
- d - Valve Shaft
- e - Stator coil
- f - Bearing

STARTING AND IDLING

The IAC controls an optimum idling engine speed depending on the cooling-water temperature and the condition of the engine. With the throttle valve fully closed, the air quantity in the bypass is controlled by the step-motor-type actuator equipped in the IAC.

WARMING UP

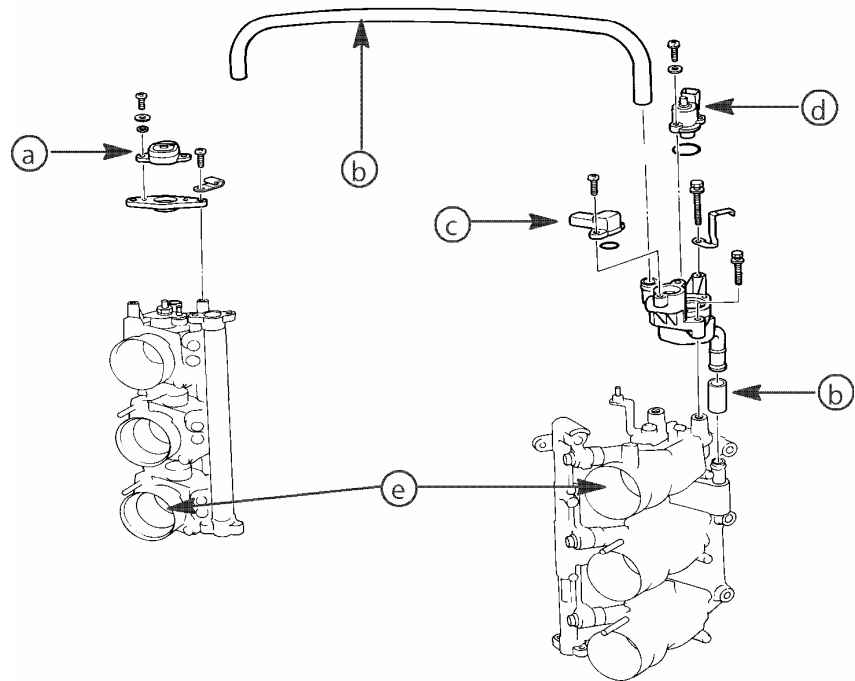
To warm up the engine, the IAC valve located in the bypass is opened and air is supplied to the engine to increase the engine speed. After the engine is warmed up, the valve is closed to decrease the engine speed and to maintain the specified idling speed.

Notes

Notes

RAPID DECELERATION

When the throttle valve quickly returns to the fully closed position, the IAC valve will open just before the throttle valve is fully closed to prevent the engine from stalling.



- a - Throttle position sensor
- b - IAC hose
- c - Map sensor
- d - IAC motor
- e - Throttle body

Ignition System

Theory of Operation

The ignition system uses a microcomputer-controlled CDI (Capacitor Discharge Ignition) system. This system provides quick voltage buildup and strong spark required for high power and high performance engines.

When the ignition key is turned to the RUN position, battery voltage is applied to the main power relay. When the ECM receives a signal from the CPS (Crank Position Sensor) the main power relay ground is completed through the ECM. The main power relay is then closed and battery voltage is transferred to the coils, and fuel injectors. The coils and fuel injectors are protected by a 20 amperage fuse. The negative terminal of the coil primary is connected to the engine ground through the ECM. When this circuit is closed a magnetic field is allowed to be built up in the ignition coil. The CPS sends a signal to the ECM supplying information on the engine position (degrees of rotation) and the rpm of the engine. The ECM opens the ground circuit of the coil primary. The magnetic field of the ignition coil primary collapses causing high voltage charge in the secondary winding of the coil. This high voltage charge is then sent to the spark plug.

Electronic Control Module (ECM)

Under normal operating conditions the microcomputer-controlled CDI system has two basic modes of operation: Ignition Timing Control During Engine Start-up, and Normal Operation.

Ignition Timing Control During Engine Start Up

The ignition timing is mainly determined by signals from the throttle position sensor and the crank position sensors. Corrections are controlled by the water temperature sensor, the oil pressure switch, the shift position switch, the engine stop switch after engine start and the main switch. During cranking, the ignition timing is 10° BTDC until the engine starts, then it is retarded 1° per second until it reaches TDC. The ignition timing is normally controlled between TDC and 24° BTDC. At rapid acceleration or deceleration ignition timing changes according to the throttle valve opening angle.

Normal Operation

This mode operates between TDC and 24° BTDC. The ignition timing is automatically adjusted by the microcomputer. The microcomputer receives three signals (i.e., crankshaft position, engine revolution, and throttle position) every 5ms (microseconds) and then adjusts the ignition timing accordingly.

Three crank position sensors (CPS) send signals to the microcomputer which then determines the crankshaft position and engine revolution.

The throttle position sensor (TPS) also sends signals to the microcomputer which then determines the throttle position. The microcomputer uses these three signals to determine the proper ignition timing.

Notes

Notes

Protection Controls

This ignition system incorporates four protection controls that are described below.

Over-revolution Control

Neutral - If the engine speed exceeds 4,500 rpm in neutral, either cylinder #1 or #4 will misfire. If the engine speed exceeds 4,750 in neutral, the ignition is cut.

In Gear - If the engine speed in gear exceeds 6,200 rpm, cylinders #1 or #4 will misfire. If the engine speed exceeds 6,350 rpm, cylinder #1 and #4, #2 and #5 will misfire. If the engine speed exceeds 6,450 rpm, the ignition on all cylinders is cut.

Overheating Control

When the engine speed is less than 2,000 rpm, this control mode is delayed 75 seconds. When the engine speed is 2,000 rpm or more, this control mode is delayed 25 seconds. The engine is considered to be over-heating if its temperature reaches 120 °C (248 °F) or higher.

When the ECM has entered the overheat control mode, and the delay time has elapsed, the ECM causes cylinder pair #2 and #5, #3 and #6 to misfire, and will not operate the fuel injector to the misfiring cylinders, until the engine speed has decreased to 2000 rpm or less. At this time the warning indicator will illuminate and the warning horn will sound. The control will not deactivate until the ignition key is turned to the OFF position

Shift Cut Out Switch

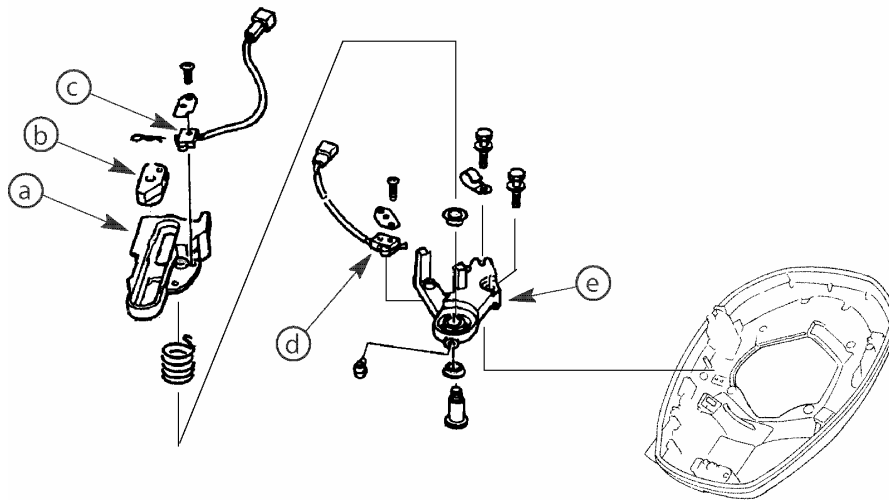
When the shift cut out switch is activated with the engine speed under 2000 rpm, one or two cylinders will misfire in order to facilitate shifting. Cylinder #1 or #4 will misfire when the engine speed is below 850 rpm. The ECM causes cylinder #1 and #2 or #4 and #5 to misfire when the engine speed is over 850 rpm.

225 FourStroke Fault List

Fault #	CDS Fault Description
1	System Normal
13	Crank Position Sensor Fault
15	Coolant Temperature Sensor Circuit High or Low
18	Throttle Position Sensor Circuit High or Low
19	Battery Voltage Fault
22	MAP Sensor Circuit High or Low
23	Intake Air Temperature Sensor Circuit High or Low
28	Shift Position Switch Fault
29	MAP Sensor Signal Fault
37	Idle Air Control Fault
39	Oil Pressure Sensor Circuit High or Low
42	Warning Signal Recognition Fault
43	Warning Horn Recognition Fault
44	Emergency Stop Switch Fault
45	Shift Cut-Out Switch Fault
46	Coolant Temperature Overheat

Neutral Switch

The neutral switch provides out of gear over-revolution protection as described in the over-revolution control.



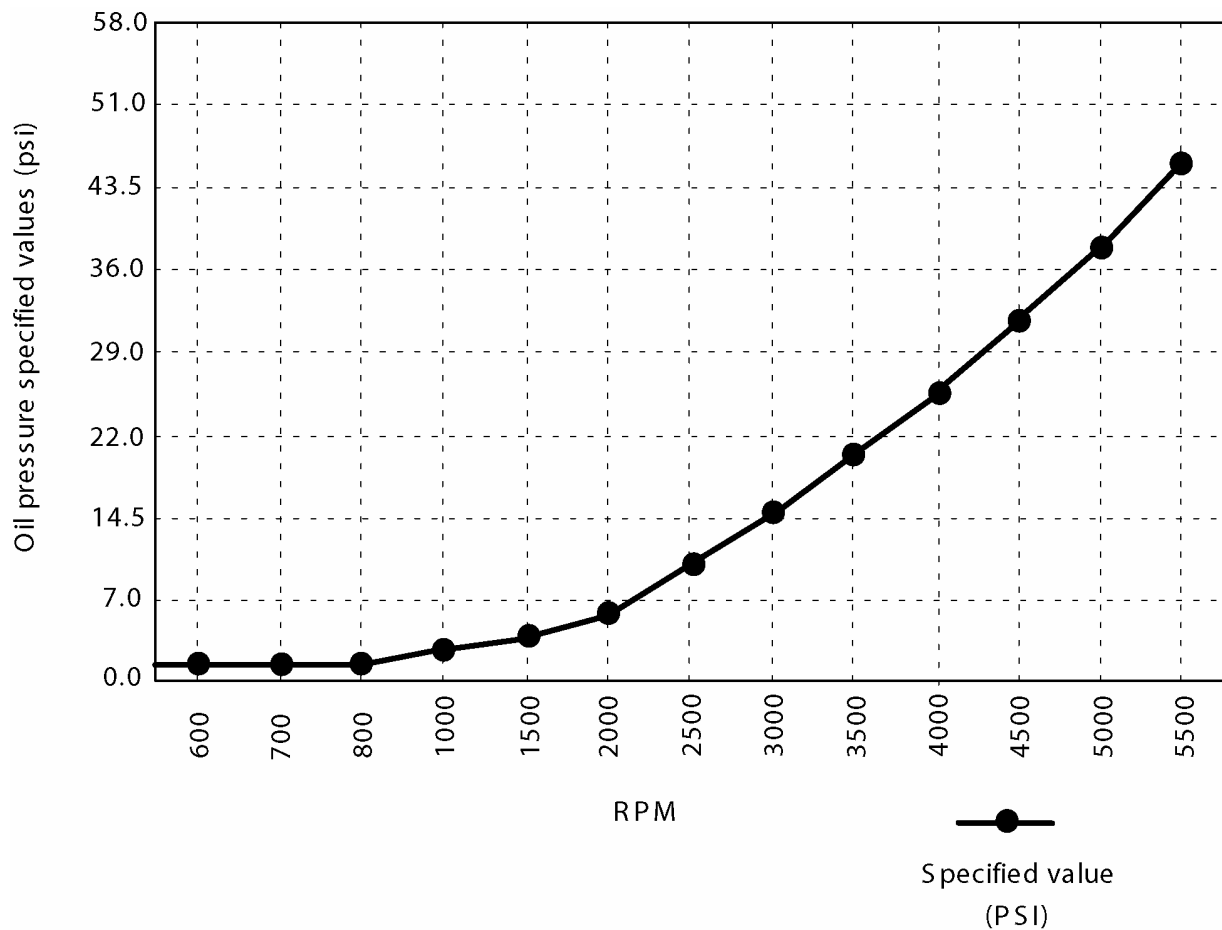
- a - Bracket
- b - Shift slide
- c - Neutral switch
- d - Shift cut out switch
- e - Bracket

Notes

Low Oil Pressure Protection

The low oil pressure warning activation varies in accordance with the engine speed. When the value detected by the oil pressure sensor drops below the specified value on the graph, the ECM determines a drop in oil pressure has occurred and activates the oil pressure control. When the oil pressure control mode is activated, the oil warning light is illuminated and the warning horn sounds. This warning mode will not be deactivated until the ignition switch is turned to the OFF position.

When the system enters low oil pressure protection, the engine will not exceed 2000 rpm. If operating above 2000 rpm, the ECM causes cylinder pairs #2 and #5, #3 and #6 to misfire until the engine speed decreases to 2000 rpm and will continue to misfire until the oil pressure has exceeded the specified value. The ECM will not open the fuel injectors to the specified cylinder pairs when the oil pressure is lower than the specified value (see graph below).



Section 4 - Diagnostics

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Battery Cable Test

This test is used to determine if there is excessive resistance in the battery positive or negative cables or to determine if the cable is sized properly to carry the necessary current needed to crank the engine at the proper rpm.

IMPORTANT: This test must be performed while the key switch is in the START position. Any voltage readings taken without the circuit under load should be ignored.

Notes

WARNING

Do not allow yourself or any loose clothing to come in contact with moving engine components. Failure to heed this warning could result in serious personal injury or death.

1. Perform a load test on the battery following the instructions supplied with the load tester.

Ensure that the battery is brought to a full charge after being tested.

2. Measure the voltage across the battery posts (not the cable clamps) with the key switch in the START position. Record the voltage reading. If the voltage is not above 10 VDC, replace the battery.

NOTE: The voltage reading in step 2 is the base voltage. The base voltage reading will be compared to the voltage readings obtained in the following steps.

3. Measure the voltage from the battery positive post (not the cable clamp) to the starter post (the stud where the battery positive cable is connected to) with the key switch in the START position. Record the voltage reading.
4. Measure the voltage from the starter case to the battery negative post (not the cable clamp) with the key switch in the START position. Record the voltage reading.

Results:

5. If the voltage reading in step 3 was more than 1.0 VDC:
 - Check the connections and cable for tightness and corrosion.
 - If the cables are tight and not corroded, replace the cable with a larger diameter cable.
6. If the voltage reading in step 4 was more than 1.0 VDC:
 - Check the connections and cable for tightness and corrosion.
 - If the cables are tight and not corroded, replace the cable with a larger diameter cable.

The relationship between the battery's voltage and the voltage drop of the cables changes the amount of available amperage to the starter. If corrosion is introduced into the equation or if the starter is worn, there may not be enough amperage available to turn the starter motor.

If the total voltage drop in the starting circuit leaves the starter with less than 9 VDC, the engine may not start. Everything possible should be done to lower the voltage drop in the starting circuit to avoid starting problems.

Notes

Battery Parasitic Drain Information

A parasitic drain is an electrical load that draws current from the battery when the ignition is turned off. Some devices, such as ECM/PCM, charging systems, radio memory are intended to draw very small amount continuously. These draws are measured in milliamps (mA).

In normal use, parasitic drains aren't usually cause for concern, because the battery is replenished each time the boat used. But in long term storage situations, parasitic drains may discharge the battery enough to cause a no start condition.

An abnormal parasitic drain could be from electronic components that may have malfunctioned. Or an electrical accessory staying powered up.

In most cases of discharged batteries in low-age, low-hours, proper charging procedures with approved equipment is the only repair necessary.

Here are some rules of thumb that might help relate parasitic drains to how long a battery would last on a boat that is not being used.

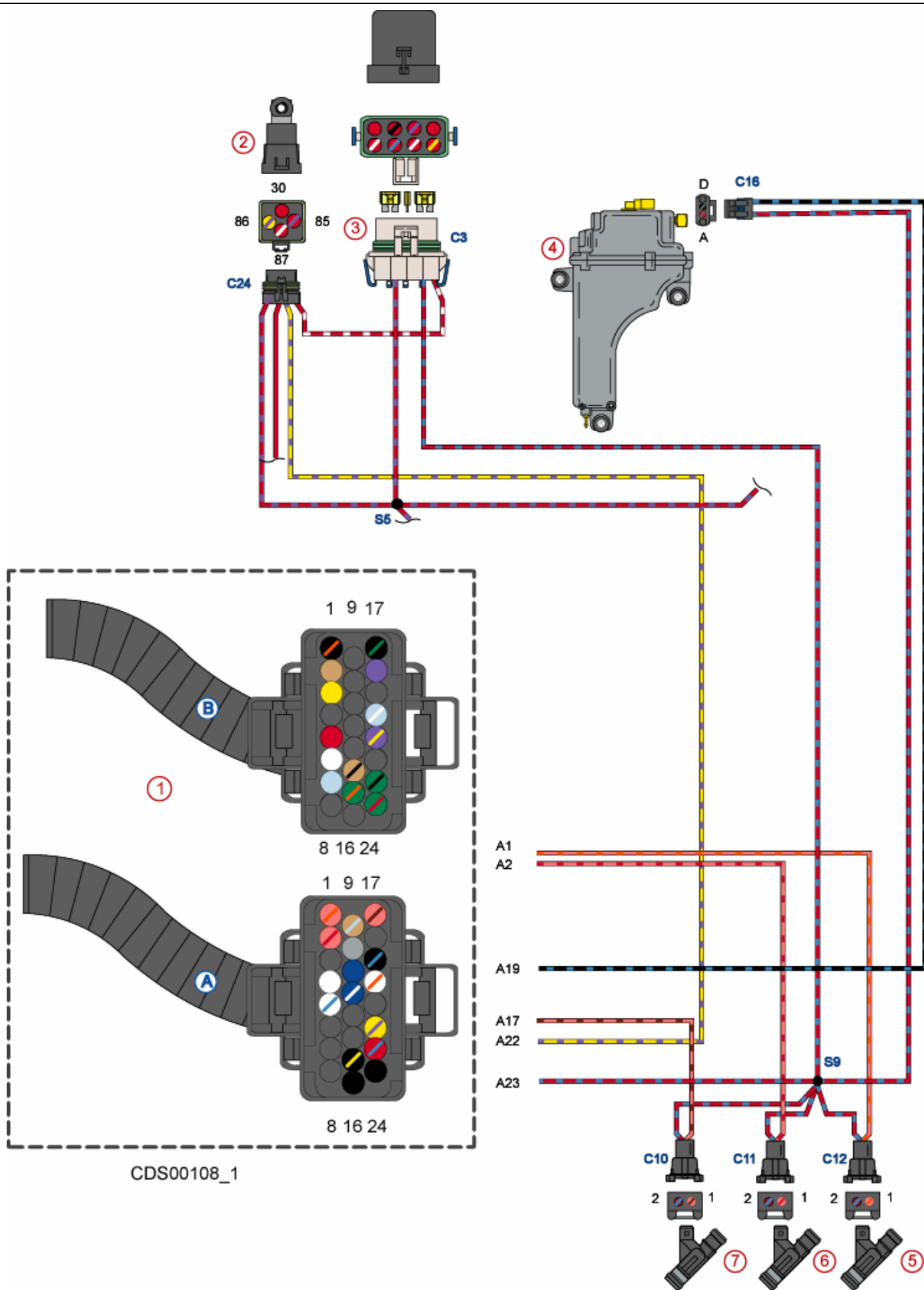
The Reserve Capacity (RC) rating multiplied by 0.6 gives the approximate available ampere-hours (AH) from full charge to complete rundown. Somewhere between full charge and complete rundown, the battery will reach a point at which it can no longer start the engine, although it may still operate some of the electrical accessories.

Using up about 40% of the total available ampere-hour will usually take a fully-charged battery to a no-start condition at moderate temperatures of 25°C (77°F). Put another way, for a typical battery in a storage situation, depleting the available AH by 20 to 30 AH will result in a no-start condition.

IMPORTANT: If the battery begins storage at 90% of full charge will reduce the available AH.

Multiply the drain (in amps) by the time (in hours) the battery sits without being recharged. The result is the amount of amp-hours consumed by the parasitic drain. The actual drain may be small, but over time the battery grows steadily weaker.

Here's an example: With a 30 mA drain and a fully-charged 70 reserve capacity battery will last 23 days. But if that battery is at only 65% of full charge it is going to last only 15 days before causing a no-start.



Notes

Troubleshooting Guide

Faults

A “Fault” indicates that the ECM has either sensed that the circuit in question has recorded a sensor value outside of its acceptable “window” or that a sensor value has gone outside its “normal” range. For example:

1. A circuit with an open or short would give a fault that is “CKT HI” or “CKT LO”. This means that the sensor itself has failed with an open or short circuit, or one of the leads between the sensor and the ECM is open or shorted. A “CKT HI” fault means that the ECM is seeing a 5.0 (or nearly 5) volt signal and a “CKT LO” fault means that the ECM is seeing a 0.0 (or nearly 0) volt signal.

2. A sensor showing a reading outside of its normal range, but not shorted or open, would give a fault identifying an abnormal operating condition, such as “ECT Coolant Overheat”, which means the ECT circuit is operating correctly, but the engine is simply overheating.

A Diagnostic Trouble Code indicates that the ECM has sensed that the circuit in question has recorded a sensor value outside of its acceptable “window” for at least as long as its pre-programmed time period.

Default Sensor Values

Default sensor values are preprogrammed amounts used by the ECM to calculate fuel and ignition values, when the sensor in question has exceeded its preprogrammed diagnostic limits. Default sensor values typically are used when the sensor has a circuit high or circuit low fault. Most temperature sensors default to 0 °C (32 °F). **This should be verified by unplugging the sensor in question and watching the data stream value with the CDS or the DDT**

Most pressure sensors default to a preprogrammed number also. MAP sensors usually default to 100 kPa (29.5 in. Hg). **This should be verified by unplugging the sensor in question and watching the data stream value. Other pressure sensors will have their own default values which may be determined as described previously.** Most faults can be detected with the engine running, or key-on, engine off. However, some faults require the presence of engine RPM, and cannot be detected key-on, engine off. Examples of this type of fault are EST (cylinders 1 through 8) shorted circuit and all injector faults (fuel and direct). Some faults are only detected in the key-on, engine off mode. Examples of the type of fault would be EST (cylinders 1 through 8) open circuit. Faults also take a certain time to set. The time it takes to set a fault varies greatly and can also vary with engine RPM. Faults generally set faster at higher engine speed

Sticky/Non-Sticky Faults

All faults are classified as either sticky or non-sticky. Sticky means that the fault, once set, will continue to show up as active, even in the circuit or problem has corrected itself. A key switch cycle is required to reset a sticky fault. A non-sticky fault is a fault that will change it's status from active to inactive without requiring a key switch cycle. The diagnostic tools (CDS or DDT) will continue to display a sticky fault as active, even though the cause of the fault has been corrected. Cycle the key to reset all faults if there is difficulty correcting a fault.

Engine Guardian

Almost every fault will cause the guardian program (within the ECM) to become active. The amount of guardian protection is expressed as a percentage. The higher the percentage, the more power the engine is allowed to produce. If available power (on the CDS or DDT) is showing 100%, then guardian is not currently active and the engine is capable of producing full power. The engine power is reduced by changing injector and ignition operation. Guardian is always accompanied by another fault or faults that actually caused the guardian to become active. The more severe the fault, the more the guardian reduces available power. A small problem, such as a non-critical sensor going circuit high or circuit low, will result in available power of 90% depending on product line. A severe problem such as low oil pressure will result in forced idle which is usually displayed as 5-6% available power. Several minor faults occurring at the same time will cause the ECM to treat the faults as a more severe situation.

Diagnostic Tip: Guardian is not actively displayed unless the rpm limit is hit pertaining to the particular fault limit. View the parameter called AVAILABLE POWER % on the data screen if 100% is displayed then engine Guardian is not responsible for the reduction in RPM. Anything less than 100% indicates a problem and Guardian is or soon will be active.

Warning Horn Signals

Most faults will cause the warning horn circuit to activate. How the warning horn activates depends on how serious the problem is. There are four warning horn states:

Caution- horn signal varies with product line and calibration. Minimal Guardian

Warning - horn signal varies with product line and calibration.

Severe - horn is constant (solid).

Critical - horn is constant (solid) and guardian will be at forced idle.

Notes

Notes

Diagnostic Guide

The goal of this guide is to provide guidance when you create a plan of action for each specific situation. Following a similar plan for each diagnostic situation you will achieve maximum efficiency when you diagnose and repair vessels. You are not required to complete every step in order to successfully diagnose a customer concern.

1. The process begins with a Customer Complaint or when the technician notes an "Observable Symptom".

- A. A very important part of diagnosing a customer concern is obtaining as much information prior to diagnosing a problem.

1. What aftermarket and dealer –installed accessories exist?
2. What related systems operate properly?
3. When does the problem occur?
4. Where does the problem occur?
5. How long does the problem occur?
6. How long has the condition existed?
7. How often does the problem occur?
8. Has the severity of the problem increased, decreased or stayed the same?

2. The technician must Verify (or Duplicate) the complaint (or symptom).

- A. To verify the customer concern, you will need to know the correct(normal) operating behavior of the system and verify that the customer concern is a valid failure of the system. As the system is operated to duplicate the concerns, it may be necessary to refer to either the Owner's Manual or the Service Manual for operating information. You may be familiar with similar systems on other engines, but it is important to refer to the information for the specific engine you are diagnosing. **Diagnostic Tip: Use CDS to record data (saved events) of various engine families at a variety of RPM's. These saved events can be replayed to view normal engine data parameters.**

- B. Another way to verify customer concern is to operate an identical engine and compare the two engines.

- C. **Isolate the suspect systems to the engine or the boat.**

Diagnostic Tip: For outboards with mechanical shift you can use part number 15000A7 which include key switch with horn. If application has SmartCraft disconnect boat harness at engine including input sensors (fuel level and paddle wheel).

Isolate the vessels fuel tank by using test tank.

If twin application make sure common ground is used.

3. Preliminary Checks

- A. Verify the engine will start.
- B. Operate the suspected system.
- C. Visually inspecting the harness routing and accessible /visible power and ground circuits. **Check battery cable connections make sure clean and tight.**
- D. Checking for blown fuses
- E. Visually inspecting the condition of the connectors; may include checking terminals for damage and tightness.
- F. Observing unusual conditions; noise, vibration, feel and smells.
- G. Investigate the engines service history.

Notes

4. Check for diagnostic faults (trouble codes)

- A. A Diagnostic Trouble Code indicates that the ECM has sensed that the circuit in question has recorded a sensor value outside of its acceptable “window” for at least as long as its pre-programmed time period.
- B. Diagnose the **active** codes first starting with the lowest number code to highest number code.
 - 1. When troubleshooting active codes the system in question is experiencing a failure **right now**.
 - a. Looking for open or short in the wires involved with the sensor in question.
 - b. Inspecting connections at sensor and ECM.
 - c. The sensor itself has failed.
 - d. Follow Outboard ECM/PCM Fault Listings
 - 1) SmartCraft DTS 10 Pin 90-895372
 - 2) SmartCraft DTS 14 Pin 90-895072
- C. When troubleshooting historic or logged codes, the system in question **is not** experiencing a failure at this time.
 - 1. Still check circuits for opens and shorts but you must wiggle wires and connections during tests in attempt to locate the poor connection.
 - a. Inspect for corroded connections and internal wire splices.
 - b. Make sure the male to female connections are not relaxed.
 - c. Reference intermitants for expanded information.
- D. If no faults are present, but you still have an observable symptom, then the problem is with a component or system that the ECM cannot monitor. Carefully perform and check for obvious things, such as incorrect fuel pressure, engine mechanical problems, exhaust blockage, etc.

Notes

1. The problem may be that a sensor is “out of calibration” or it may be that the problem has nothing to do with the EFI system (clogged fuel supply system, mechanical engine problems, etc.).

5. Repair and Verify the Fix.

- A. After the cause of the problem is located, repairs must be performed following recommended procedures in the service manual.
- B. Verify the system works by operating the system under the conditions documented in step 1. Customer Complaint.
- C. Carry out preventative measures to avoid comebacks. This might include lake testing with the customer.

Diagnosing Typical Two Wire Sensor General Theory

Notes

The ECM is dependable and should not be replaced before testing the sensor or wiring harness. The corrosive environment combined with vibration suggests that most problems occur with either the wiring or the sensor.

Note: This is general guide to aid in diagnosing a typical two wire and three wire sensor fault.

Diagnosing Two Wire Sensor

1. Disconnect the connector from the sensor being tested.
2. Perform a visual inspection of the pins at the sensor and the wires coming from the connector, look for broken, bent, or corroded pins at the sensor and loose, broken or corroded wires at the connector.
3. Turn the key switch to the RUN position and make sure the lanyard switch is in the RUN position. Do not start the engine.
4. Shake or move the harness and connector by hand as you perform the following tests. If the voltmeter readings vary during the tests, you should suspect a broken, loose or corroded wire is causing the failure.
5. Check for voltage at the two-pin connector on the harness between the 5 V signal wire and the BLK/ORN wire. If voltage is present, the wiring is good. Check the sensor for a open or a short.

Notes

Example	Description	Reading
	Connect meter leads between +5 V pin and the ground pin (BLK/ORN).	+5 V

6. If voltage is not present, check for voltage between the 5 V pin and engine ground. If this test results in voltage, trace the BLK/ORN wire back to its splice point and test for voltage to locate the fault. In addition to checking for opens don't forget to check for short to voltage.

Example	Description	Reading
	Connect meter leads between +5 V pin and engine ground.	+5 V

7. If the BLK/ORN ground is ok turn the key off, disconnect the PCM connector referencing the wiring diagram. Check the 5 v signal reference or signal wire from the PCM with ohmeter. Should have continuity if not check for open between the sender and PCM. Remember to check for short to voltage.

Diagnostic Tip: Two wire sensor can also suffer from OUT OF CALIBRATION problems. EXAMPLE: If the ECT sensor is indicating 125 degrees Fahrenheit but the engine is actually at 160 degrees Fahrenheit the ECM thinks the engine is cold. This will not set a code since the ECT voltage is not outside of its WINDOW. The engine will still run poorly due to the added fuel.

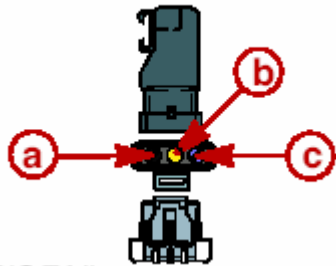
DC Volts	0.0	0.3	0.6	0.9	1.3	1.5	1.9	2.1	2.5	2.8	3.1	3.4	3.8	4.0
Deg. C	200	143	113	96	84	75	64	59	52	45	40	32	25	16
Deg. F	392	289	235	205	183	167	147	138	126	113	104	90	77	61
kΩ	0	.063	.136	.219	.351	.428	.612	.724	1.000	1.272	1.631	2.125	3.166	4.000

Diagnosing Three Wire Sensors General Theory

Notes

Condition: key switch to RUN and engine OFF.

1. Complete steps 1-4 under Diagnosing Typical Two Wire



- a** -Ground (BLK/ORN)
- b** -Signal Lead (YEL)
- c** -+ 5 volts (PPL/YEL)

2. The voltmeter should read 5 volts, if not, connect the voltmeter across the PPL/YEL wire and the engine ground. If the voltmeter indicates 5 volts, there is an open in the ground circuit (BLK/ORN).

Example	Description	Reading
	Connect meter leads between +5 V pin (PPL/YEL) and the ground pin (BLK/ORN).	+5 V

3. If the voltmeter does not indicate 5 volts, there is an open circuit between the ECM and the connector (PPL/YEL).

4. **High Circuit Fault** would indicate short in sensor circuit. The following conditions will store a typical three wire sensor HIGH FAULT:

A. Power Lead 5 volts (PPL/YEL)

- 1. If the power lead shorts to the signal lead, the signal lead will indicate 5 volts.

B. Ground Lead (BLK/ORN)

- 1. If the ground lead opens the signal lead will indicate 5 volts.

C. Signal Lead (YEL)

- 1. If the signal lead shorts to another 5 volt source, the ECM will read a 5 volt signal.
- 2. If the signal lead shorts to the power lead, the ECM will read 5 volts.

Notes

5. **Low Circuit Fault** would indicate open in the sensor circuits. The following conditions will store a typical three wire sensor LOW FAULT.

A. Power Lead 5 volts (PPL/YEL)

1. If the power lead opens, the signal lead will indicate 0 volts.
2. If the power lead shorts to a ground source the signal lead will indicate 0 volts.

B. Ground Lead (BLK/ORN)

1. If the ground lead shorts to the power lead, the signal lead will indicate 0 volts.
2. If the ground lead shorts to the signal lead, the signal lead will indicate 0 volts.

C. Signal Lead (YEL)

1. If the signal lead opens , the ECM will read 0 volt signal.
2. If the signal lead shorts to the ground lead, the ECM will read a 0 volt signal.
3. If the signal lead shorts to another ground source the ECM will read 0 volts.

Diagnostic Tip: Three wire sensors can also suffer form OUT OF CALIBRATION problems. EXAMPLE: If the MAP sensor was indicating 25 inches of mercury but the engine was actually operating at 15 inches of mercury the ECM would indicate that the engine was under a greater load than it actually is and would richen up the fuel delivery accordingly. The engine would be running to rich in this example. There would not be a fault since the voltage readings are still within the acceptable WINDOW for this sensor and calibration.

For specific faults listings reference: Outboard ECM/PCM Fault Listings at end of this section or:

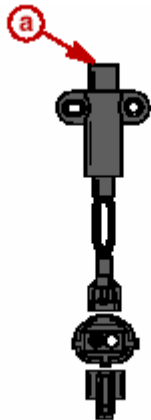
- SmartCraft DTS 10 Pin 90-895372
- SmartCraft DTS 14 Pin 90-895072
- SmartCraft DTS 14 Pin Version 2006 90-89770

Crankshaft Position Sensor

Condition: Key switch to RUN and engine OFF.

Model Referenced: FourStroke ECM/PCM 555

1. Complete steps 1-5 under diagnosing Typical Two Wire Sensor High/Low Circuit Fault. Perform a visual inspection of the sensor. The tip of the sensor must be flush and centered across the end, if not, replace the sensor.
2. Inspect magnet make sure on center. Important the magnet and entire sensor is secure.



a -Sensor Tip

3. Inspect the flywheel for:
 - A. Excessive corrosion.
 - B. The teeth on the rotor should have square edges
 - C. Inspect the flywheel key.
4. Diagnose without scanner: Disconnect the connector from the sensor. Measure the resistance across the connector pins. Resistance should be between 300 and 350 Ohms, if not, replace the sensor
5. Diagnose with scanner: Crank engine over while monitoring **engine speed** should show crank RPM if not continue with step six.
6. Reconnect the harness to the sensor. Disconnect the Starboard (A) conector from the ECM and measure the resistance across pins 5 and 6. Resistance should be between 300 and 350 Ohms, if not, repair the wiring between the ECM and the sensor.

Notes

Notes

Intermittent Faults

IMPORTANT: DO NOT use the Diagnostic Trouble Code (DTC) tables for intermittent problems. The fault must be present to locate the problem.

Most intermittent problems are caused by faulty electrical connections or wiring. Perform careful visual/physical check. Check for the following conditions:

1. Harness and Connectors
 - a. Many intermittent open or shorted circuits are affected by harness/connector movement that is caused by vibration, engine torque, bumps/rough water, etc.
2. Poor mating of the connector halves, or a terminal not fully seated in the connector body (backed out or loose).
3. Improperly formed or damaged terminals and/or connectors.
4. All connector terminals in the problem circuit should be carefully checked for proper contact tension.
5. Poor terminal to wire connection (crimping).

The vessel may be driven with a Digital Multimeter connected to a suspected circuit. An abnormal voltage when malfunction occurs is a good indication that there is a fault in the circuit being monitored. The record (or min/max) function of the DMT 2004 (or equivalent) multimeter can also be used to monitor and record the voltage signals on the suspect circuit. Use the SPX MM-46523 Jumper Lead Set (or equivalent) to connect the meter to the suspect sensor's signal lead. Sensor signals must never be 0.0 or 5.0 volts. A multimeter can catch glitches as quick as a micro-second.

A scan tool (see "Special Tools" for part numbers) can be used to help detect intermittent conditions. Keep in mind that the refresh rate of the scan tool is relatively slow (every 50 milliseconds or so). The scan tools have several features that can be used to locate an intermittent condition. The following features can be used in finding an intermittent fault:

Freeze frame displays captured set of data the corresponds to the exact moment in time the fault was set.

The "Record" feature or choosing not to erase data can be triggered to capture and store engine parameters within the scan tool when the malfunction occurs. This stored information can then be reviewed by the service technician to see what caused the malfunction.

To check loss of fault memory, disconnect TPS sensor and idle engine until the fault comes "ON." A trouble code should be stored and kept in memory when ignition is turned "OFF." If not, the ECM/PCM is faulty. When this test is completed, make sure that you clear the codes from memory.

Notes

- [illegible]

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Electrical Connections or Wiring	Poor electrical connections, terminal tension or wiring problems cause most intermittents • Inspect for poor mating of the connector halves, or terminals improperly seated in the connector body. • Inspect for improperly formed or damaged terminals. Test for poor terminal tension. • Inspect for poor terminal to wire connections including terminals crimped over insulation. This requires removing the terminal from the connector body. • Inspect for corrosion/water intrusion. Pierced or damaged insulation can allow moisture to enter the wiring. The conductor can corrode inside the insulation, with little visible evidence. Look for swollen and stiff sections of wire in the suspect circuits. • Inspect for wires that are broken inside the insulation. • Inspect the harness for pinched, cut or rubbed through wiring. • Ensure that the wiring does not come in contact with hot exhaust components.
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ECM Power and Grounds	Poor power or ground connections can cause widely varying symptoms. • Test all control module or ECM power supply circuits. Many vessels have multiple circuits supplying power to the control module. Other components in the system may have separate power supply circuits that may also need to be tested. Inspect connections at the module/component connectors, fuses, and any intermediate connections between the power source and the module/component. A test lamp or a digital meter may indicate that voltage is present, but neither tests the ability of the circuit to carry sufficient current. Ensure that the circuit can carry the current necessary to operate the component. • Test all ECM or control module grounds and system ground circuits. The control module may have multiple ground circuits. Other components in the system may have separate grounds that may also need to be tested. Inspect grounds for clean and tight connections at the grounding point. Inspect the connections at the component and in splice packs, where applicable.
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Temperature Sensitivity	• An intermittent condition may occur when a component/connection reaches normal operating temperature. The condition may occur only when the component/connection is cold, or only when the component/connection is hot. • Freeze Frame, Failure Records and recorded data may help with this type of intermittent condition, where applicable. • If the intermittent is related to heat, review the data for a relationship with the following: ○ High ambient temperatures ○ Under cowl engine generated heat ○ Circuit generated heat due to a poor connection, or high electrical load ○ Higher than normal load conditions, towing, etc. • If the intermittent is related to cold, review the data for the following conditions: ○ The condition only occurs on a cold start. ○ The condition goes away when the vessel warms up. • Information from the customer may help to determine if the trouble follows a pattern that is temperature related.
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Electromagnetic Interference (EMI) and Electrical Noise	Some electrical components/circuits are sensitive to EMI or other types of electrical noise. Inspect for the following conditions: • A misrouted harness that is too close to high voltage/high current devices such as secondary ignition components, motors, generator etc. These components may induce electrical noise on a circuit that could interfere with normal circuit operation. • Electrical system interference caused by a malfunctioning relay, or a ECM driven solenoid or switch. These conditions can cause a sharp electrical surge. Normally, the problem will occur when the malfunctioning component is operating. • Improper installation of non-factory or aftermarket add on accessories such as lights, 2-way radios, amplifiers, electric motors, remote starters, alarm systems, cell phones, etc. • Test the generator or alternator for a bad rectifier bridge that may be allowing AC noise into the electrical system.
Duplicating Failure Conditions	• If none of the previous tests are successful, attempt to duplicate and/or capture the failure conditions. • Freeze Frame and Saved Events Records data, where applicable, contains the conditions that were present when the fault set. 1. Review and record Freeze Frame and Saved Event Records for future use. 2. Clear the faults using the scan tool. 3. Turn the key to OFF and wait 15 seconds. 4. Operate the vessel under the same conditions that were noted in Freeze Frame or Saved Event data, as closely as possible.

ECM 555 FourStroke Pin Identification

Pin	ECM555OB	Color Code	Pin	ECM555OB	Color Code
A1	Fuel Injector #3	PNK/ORN	B1	Sender Ground	BLK/ORN
A2	Fuel Injector #2	PNK/RED	B2	MAT Signal	TAN
A3	Empty		B3	MAP Signal	YEL
A4	CAN 1 (+)	WHT	B4	Empty	Empty
A5	Scan (-)	WHT/BLU	B5	CPS (merc)	RED
A6	Empty		B6	CPS (merc)	WHT
A7	Empty		B7	Oil Pressure Switch	LT-BLU
A8	Empty		B8	Empty	Empty
A9	Warning Horn	BRN/LT-BLU	B9	Empty	Empty
A10	Tach Sig Out	GRY	B10	Empty	Empty
A11	CAN 1 (-)	DK-BLU	B11	Empty	Empty
A12	Scan (+)	BLU/WHT	B12	Empty	Empty
A13	Empty		B13	Empty	Empty
A14	Empty		B14	ECT Signal	TAN/BLK
A15	E-Stop (thru CAN)	BLK/YEL	B15	EST coil #3	GRN/ORN
A16	Ground	BLK	B16	EST coil #4	GRN/YEL
A17	Fuel Injector #1	PNK/BRN	B17	EST return	BLK/GRN
A18	Fuel Injector #4	PNK/YEL	B18	Wakeup	PPL
A19	Fuel Pump Driver	BLK/BLU	B19	Empty	Empty
A20	IAC Valve Control	WHT/ORN	B20	TPS Sig	LT-BLU/WHT
A21	Empty		B21	Sender Power	PPL/YEL
A22	MPR control	YEL/PPL	B22	Empty	Empty
A23	MPR Output (to ECM)	RED/BLU	B23	EST coil #1	GRN/BLK
A24	Ground	BLK	B24	EST coil #2	GRN/RED

Injector Balance Test

Note: To prevent flooding, the entire test should not be repeated more than once without running the engine. (This includes any retest on faulty injectors)

WARNING

Gasoline is extremely flammable and highly explosive under certain conditions. Be sure that ignition key is OFF. DO NOT smoke or allow sources of spark or open flame in area when cleaning flame arrestor and crankcase ventilation hose.

WARNING

Be sure that the engine compartment is well ventilated and that no gasoline vapors are present to avoid the possibility of fire.

CAUTION

Fuel pressure MUST BE relieved before servicing high pressure component in the fuel system.

CAUTION

DO NOT operate engine without cooling water being supplied to water pickup holes in gear housing, or water pump impeller will be damaged and subsequent overheating damage to engine may result.

Injector Testing Tool Specifications

- Must be capable of an injector pulse width within 0-1000 milliseconds (mSec) or CDS version 5.09 or greater. See tool section for CDS part numbers.
- Must drop the fuel rail pressure to half of its normal operating pressure.
- Will turn the injector ON for a precise amount of time.
- Will spray a measured amount of fuel into the manifold.
- Will cause a drop in the fuel rail pressure to be recorded and injectors compared.

Any injector with a pressure drop that is 1.5 PSI (10kPa) (or more) greater or less than the average drop of the other injectors should be considered faulty and replaced.

Test Procedure

1. Allow engine to cool down for ten minutes to avoid irregular readings due to “hot soak” fuel boiling.
2. Relieve fuel pressure.
3. Remove plenum if necessary to gain access to the fuel pressure schrader valve test port.
4. With ignition OFF, connect fuel pressure gauge to fuel pressure tap.
5. Disconnect harness connectors from all injectors, and connect injector tester to one injector.
 - a. Ignition must be OFF at least ten seconds to complete ECM shutdown cycle.
 - b. Fuel pump should run about two-five seconds after ignition is turned ON.
6. Attach clear tubing to the vent valve and insert it into a suitable container. Bleed initial air pocket from gauge and hose to ensure accurate gauge operation.
7. Turn ignition OFF for ten seconds and then ON again several times to get fuel pressure to its maximum. Record this initial pressure reading and make sure the fuel pressure is steady. **Note: If the fuel pressure continues to drop you should not continue the test until leak is repaired**
8. Energize tester one time and note pressure drop at its lowest point. **(Disregard any slight pressure increase after drop hits low point.)**
9. Subtract this second pressure reading from the initial pressure to get the actual amount of injector pressure drop.
10. Repeat Steps 5 through 9 on each injector and compare the amount of drop between injectors. Usually, good injectors will have virtually the same drop.

Notes

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11. Retest any injector that has a pressure difference of 1.5 PSI (10 kPa), either more or less than the average of the other injectors. Replace any injector that also fails the retest.
12. If the pressure drop of all injectors is within 1.5 PSI (10 kPa) of the average, the injectors appear to be flowing properly.

Injector Pressure Test Example

Cylinder	1	2	3	4	5	6	7	8
1st. Reading	38 PSI (262 kPa)	38 PSI (262 kPa)	38 PSI (262 kPa)	38 PSI (262 kPa)	38 PSI (262 kPa)	38 PSI (262 kPa)	38 PSI (262 kPa)	38 PSI (262 kPa)
2nd Reading	19 PSI (131 kPa)	17 PSI (117 kPa)	21 PSI (145 kPa)	19 PSI (131 kPa)	19 PSI (131 kPa)	19 PSI (131 kPa)	19 PSI (131 kPa)	19 PSI (131 kPa)
Amount of Drop	19 PSI (131 kPa)	21 PSI (145 kPa)	17 PSI (117 kPa)	19 PSI (131 kPa)	19 PSI (131 kPa)	19 PSI (131 kPa)	19 PSI (131 kPa)	19 PSI (131 kPa)
	OK	Rich (Too Much Fuel Drop)	Lean (Too Little Fuel Drop)	OK	OK	OK	OK	OK

Outboard 555 ECM/PCM Fault Listing

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
1	Battery Voltage High	BATT VOLT HI	BATT VOLT HI	Battery voltage above allowable threshold. The further threshold is exceeded, the more Guardian reduces power.	Alternator. Alternator sense wire. Short to +24VDC trolling motor harness.
2	Battery Voltage Low	BATT VOLT LO	BATT VOLT LO	Battery voltage below allowable threshold. The further threshold is exceeded, the more Guardian reduces power.	Alternator. Belt slipping. Defective battery (shorted cells) Too much electrical load.
3	Block Water Pressure is Low	WATER PRES LO	WATER PRES LO	Water pressure in engine block low. Guardian is active. Variable power limit depends on block pressure, port and starboard coolant temperature, and RPM	Blockage at gearcase inlets. Failed water pump. Failed water tube. Leak between block and sensor. Sensor bad but not open or short.
4	Air Compressor Overheat	COMP TMP OVRHT	COMP TMP OVRHT	Air compressor temperature high.	Water cooling path blocked (usually at telltale). Failed temperature sensor.
5	ETC Loss of Control	ETC CONTROL	ETC CONTROL	Feedback from ETC indicates actual throttle blade position does not match ERC position.	Faulty ETC - check TPS voltage readings with DDT or CDS. Check connection to ETC. Faulty ERC.
6	ETC Sticking	ETC STICKING	ETC STICKING	Throttle blade not responding to ETC. Blade is stuck or obstructed.	ETC failed. Obstruction in throttle bore. Wiring problem.
9	Guardian Strategy	GUARDIAN	GUARDIAN	Guardian is trying to protect engine by reducing power.	Check for other faults. The Guardian is a result of other faults. Failed sensor.
10	Knock Sensor 1	KNOCK SENSOR1	KNOCK SENSOR1	The knock sensor is expected to sense a minimum amount of vibration. Too little of a signal will cause this fault. Too much and the knock control becomes active.	Failed sensor. Bad wiring. Poor mounting.
11	Knock Sensor 2	KNOCK SENSOR2	KNOCK SENSOR2	The knock sensor is expected to sense a minimum amount of vibration. Too little of a signal will cause this fault. Too much and the knock control becomes active.	Failed sensor. Bad wiring. Poor mounting.
12	Oil Pressure is Low	OIL PRES LO	OIL PRES LO	Oil pressure low. Guardian is active. Variable power limit depends on RPM.	Low oil level. Blockage in oil system. Sensor is bad but not open or short. Sensor is open or short.

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
13	Oil Level (remote) is Low	OIL LVL BOAT LO	OIL LVL BOAT LO	Oil level in boat mounted tank low (3 gallon oil tank). Typically next warning will be Oil Level Engine Low.	Oil consumed. Bad float. Leak in oil tank.
14	Oil Level (engine) is Low	RSVR OIL LO	RSVR OIL LO	Engine mounted tank. When horn sounds, Guardian becomes active. Oil usage is monitored until only a little is left in tank. At this point engine goes into forced idle.	Oil consumed. Bad float. Oil prime just performed and bottle has not refilled yet. Oil sensor bad.
15	MAP Sensor Circuit High	MAP CKT HI	MAP CKT HI	MAP circuit shorted. Airflow calculation is no longer valid. Power limit is active. Fueling level is a straight lookup based on demand (or TPI) and RPM.	Wiring problem. Sensor problem.
16	MAP Sensor Circuit Low	MAP CKT LO	MAP CKT LO	MAP circuit open. Airflow calculation is no longer valid. Power limit is active. Fueling level is a straight lookup based on demand (or TPI) and RPM.	Wiring problem. Sensor problem.
17	MAP Sensor Idle Fault	MAP IDLE ERR	MAP IDLE ERR	The engine is expected to pull a little vacuum on the inlet at idle. If there is no difference in PSI drop from key on to running, the MAP sensor may be bad or airflow disrupted in the intake system.	MAP sensor failed. Throttle bore missing or oversized. Wiring problem. Air flow disrupted in intake.
18	Oil Pump Output	OIL PUMP OUTPUT	OIL PUMP OUTPUT	Insufficient current draw at the oil pump.	Electrical connection to oil pump is open circuit. Open circuit oil pump coil.
19	Overspeed	OVERSPEED	OVERSPEED	Recommended RPM range exceeded. First, horn sounds. Second, cylinders stop firing. Third, more cylinders stop firing. Typically next fault is Overspeed1 which causes power limit.	Prop too small. Too much trim. Too high on transom. Too much vent in prop. Too much throttle in neutral. Gearcase problem.

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
20	Port Head Overheat	PRT COOL OVRHT	PRT COOL OVRHT	1. Water temperature in head high. Guardian is active. Variable power limit depends on block pressure, port and starboard coolant temperature, and RPM. 2. Engine coolant sensor exceeds a specified threshold.	Blockage at gearcase inlets. Failed water pump. Failed water tube. Blockage in head or thermostat dump. Sensor out of specification.
21	Starboard Head Overheat	STBD HEAD OVRHT	STBD HEAD OVRHT	1. Water temperature in head high. Guardian is active. Variable power limit depends on block pressure, port and starboard coolant temperature, and RPM. 2. Engine coolant sensor exceeds a specified threshold.	Blockage at gearcase inlets. Failed water pump. Failed water tube. Blockage in head or thermostat dump. Sensor out of specification.
22	Warning Horn Output	HORN OUTPUT	HORN OUTPUT	Warning horn in boat not operating. No audible alarm will be heard in event of engine malfunction.	Horn failed or missing. Horn not connected. Horn circuit open. Horn driver in ECM failed.
23	Water in Fuel	WATER IN FUEL	WATER IN FUEL	Sufficient water in the water separating fuel filter to complete a circuit.	Water in fuel.
24	Direct Injector 1 Open Circuit	DINJ1 OPEN	DINJ1 OPEN	Insufficient current draw on direct injector circuit.	Injector harness open. Bad direct injector.
25	Direct Injector 1 Shorted Circuit	DINJ1 SHORT	DINJ1 SHORT	Current draw direct injector has exceeded its limit.	Injector harness shorted. Bad direct injector.
26	Direct Injector 2 Open Circuit	DINJ2 OPEN	DINJ2 OPEN	Insufficient current draw on direct injector circuit.	Injector harness open. Bad direct injector.
27	Direct Injector 2 Shorted Circuit	DINJ2 SHORT	DINJ2 SHORT	Current draw direct injector has exceeded its limit.	Injector harness shorted. Bad direct injector.
28	Direct Injector 3 Open Circuit	DINJ3 OPEN	DINJ3 OPEN	Insufficient current draw on direct injector circuit.	Injector harness open. Bad direct injector.
29	Direct Injector 3 Shorted Circuit	DINJ3 SHORT	DINJ3 SHORT	Current draw direct injector has exceeded its limit.	Injector harness shorted. Bad direct injector.
30	Direct Injector 4 Open Circuit	DINJ4 OPEN	DINJ4 OPEN	Insufficient current draw on direct injector circuit.	Injector harness open. Bad direct injector.
31	Direct Injector 4 Shorted Circuit	DINJ4 SHORT	DINJ4 SHORT	Current draw direct injector has exceeded its limit.	Injector harness shorted. Bad direct injector.
32	Direct Injector 5 Open Circuit	DINJ5 OPEN	DINJ5 OPEN	Insufficient current draw on direct injector circuit.	Injector harness open. Bad direct injector.

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
33	Direct Injector 5 Shorted Circuit	DINJ5 SHORT	DINJ5 SHORT	Current draw direct injector has exceeded its limit.	Injector harness shorted. Bad direct injector.
34	Direct Injector 6 Open Circuit	DINJ6 OPEN	DINJ6 OPEN	Insufficient current draw on direct injector circuit.	Injector harness open. Bad direct injector.
35	Direct Injector 6 Shorted Circuit	DINJ6 SHORT	DINJ6 SHORT	Current draw direct injector has exceeded its limit.	Injector harness shorted. Bad direct injector.
36	Block Water Pressure Circuit High	H2O PRES CKT HI	H2O PRES CKT HI	Block pressure sensor circuit shorted.	Wiring problem. Sensor problem.
37	Block Water Pressure Circuit Low	H2O PRES CKT LO	H2O PRES CKT LO	Block pressure sensor circuit is open.	Wiring problem. Sensor problem.
38	Breakin Strategy Active	BREAKIN STR	BREAKIN STR	Factory break-in oiling period has not yet been completed.	Nothing wrong. Trim engine down and continue driving. Timer will not decrement under light load such as a bass boat trimmed out.
39	Intake Air Temp Circuit High	AIR TEMP CKT HI	AIR TEMP CKT HI	Air temperature sensor circuit open. Power limit is active.	Wiring problem. Sensor problem.
40	Intake Air Temp Circuit Low	AIR TEMP CKT LO	AIR TEMP CKT LO	Air temperature sensor circuit shorted. Power limit is active.	Wiring problem. Sensor problem.
41	Air Compressor Temp Circuit High	COMP TEMP CKT HI	COMP TEMP CKT HI	Compressor temperature sensor circuit open.	Wiring problem. Sensor problem.
42	Air Compressor Temp Circuit Low	COMP TEMP CKT LO	COMP TEMP CKT LO	Compressor temperature sensor circuit shorted.	Wiring problem. Sensor problem.
43	EST 1 Open Circuit	ECM_TRIG 1 OPEN	ECM_TRIG 1 OPEN	Ignition fault. Signal from ECM to ignition driver module open. Detectable only at zero RPM.	Wiring problem. Coil problem.
44	EST 1 Shorted Circuit	ECM_TRIG 1 SHORT	ECM_TRIG 1 SHORT	Ignition fault. Signal from ECM to ignition driver module shorted. Detectable only at RPM.	Wiring problem. Coil problem. May see this fault during overspeed as ignition trigger signal is being turned off.
45	EST 2 Open Circuit	ECM_TRIG 2 OPEN	ECM_TRIG 2 OPEN	Ignition fault. Signal from ECM to ignition driver module open. Detectable only at zero RPM.	Wiring problem. Coil problem.
46	EST 2 Shorted Circuit	ECM_TRIG 2 SHORT	ECM_TRIG 2 SHORT	Ignition fault. Signal from ECM to ignition driver module shorted. Detectable only at RPM.	Wiring problem. Coil problem. May see this fault during overspeed as ignition trigger signal is being turned off.

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
47	EST 3 Open Circuit	ECM_TRIG 3 OPEN	ECM_TRIG 3 OPEN	Ignition fault. Signal from ECM to ignition driver module open. Detectable only at zero RPM.	Wiring problem. Coil problem.
48	EST 3 Shorted Circuit	ECM_TRIG 3 SHORT	ECM_TRIG 3 SHORT	Ignition fault. Signal from ECM to ignition driver module shorted. Detectable only at RPM.	Wiring problem. Coil problem. May see this fault during overspeed as ignition trigger signal is being turned off.
49	EST 4 Open Circuit	ECM_TRIG 4 OPEN	ECM_TRIG 4 OPEN	Ignition fault. Signal from ECM to ignition driver module open. Detectable only at zero RPM.	Wiring problem. Coil problem.
50	EST 4 Shorted Circuit	ECM_TRIG 4 SHORT	ECM_TRIG 4 SHORT	Ignition fault. Signal from ECM to ignition driver module shorted. Detectable only at RPM.	Wiring problem. Coil problem. May see this fault during overspeed as ignition trigger signal is being turned off.
51	EST 5 Open Circuit	ECM_TRIG 5 OPEN	ECM_TRIG 5 OPEN	Ignition fault. Signal from ECM to ignition driver module open. Detectable only at zero RPM.	Wiring problem. Coil problem.
52	EST 5 Shorted Circuit	ECM_TRIG 5 SHORT	ECM_TRIG 5 SHORT	Ignition fault. Signal from ECM to ignition driver module shorted. Detectable only at RPM.	Wiring problem. Coil problem. May see this fault during overspeed as ignition trigger signal is being turned off.
53	EST 6 Open Circuit	ECM_TRIG 6 OPEN	ECM_TRIG 6 OPEN	Ignition fault. Signal from ECM to ignition driver module open. Detectable only at zero RPM.	Wiring problem. Coil problem.
54	EST 6 Shorted Circuit	ECM_TRIG 6 SHORT	ECM_TRIG 6 SHORT	Ignition fault. Signal from ECM to ignition driver module shorted. Detectable only at RPM.	Wiring problem. Coil problem. May see this fault during overspeed as ignition trigger signal is being turned off.
59	Fuel Injector 1 Open Circuit	FINJ1 OPEN	FINJ1 OPEN	Insufficient current draw on fuel injector circuit.	Open connection to injector on harness. Bad fuel injector.
60	Fuel Injector 1 Shorted Circuit	FINJ1 SHORT	FINJ1 SHORT	Current draw of fuel injector has exceeded its limit.	Shorted connection to injector on harness. Bad fuel injector.
61	Fuel Injector 2 Open Circuit	FINJ2 OPEN	FINJ2 OPEN	Insufficient current draw on fuel injector circuit.	Open connection to injector on harness. Bad fuel injector.
62	Fuel Injector 2 Shorted Circuit	FINJ2 SHORT	FINJ2 SHORT	Current draw of fuel injector has exceeded its limit.	Shorted connection to injector on harness. Bad fuel injector.

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
63	Fuel Injector 3 Open Circuit	FINJ3 OPEN	FINJ3 OPEN	Insufficient current draw on fuel injector circuit.	Open connection to injector on harness. Bad fuel injector.
64	Fuel Injector 3 Shorted Circuit	FINJ3 SHORT	FINJ3 SHORT	Current draw of fuel injector has exceeded its limit.	Shorted connection to injector on harness. Bad fuel injector.
65	Fuel Injector 4 Open Circuit	FINJ4 OPEN	FINJ4 OPEN	Insufficient current draw on fuel injector circuit.	Open connection to injector on harness. Bad fuel injector.
66	Fuel Injector 4 Shorted Circuit	FINJ4 SHORT	FINJ4 SHORT	Current draw of fuel injector has exceeded its limit.	Shorted connection to injector on harness. Bad fuel injector.
67	Fuel Injector 5 Open Circuit	FINJ5 OPEN	FINJ5 OPEN	Insufficient current draw on fuel injector circuit.	Open connection to injector on harness. Bad fuel injector.
68	Fuel Injector 5 Shorted Circuit	FINJ5 SHORT	FINJ5 SHORT	Current draw of fuel injector has exceeded its limit.	Shorted connection to injector on harness. Bad fuel injector.
69	Fuel Injector 6 Open Circuit	FINJ6 OPEN	FINJ6 OPEN	Insufficient current draw on fuel injector circuit.	Open connection to injector on harness. Bad fuel injector.
70	Fuel Injector 6 Shorted Circuit	FINJ6 SHORT	FINJ6 SHORT	Current draw of fuel injector has exceeded its limit.	Shorted connection to injector on harness. Bad fuel injector.
75	Fuel Level 1 Circuit High	FUEL LVL CKT HI	FUEL LVL CKT HI	Fuel level sensor circuit open. This is primary fuel tank if two tanks are used.	Wiring problem. Sensor problem. If sensor is not installed this is a normal fault message.
76	Fuel Level 1 Circuit Low	FUEL LVL CKT LO	FUEL LVL CKT LO	Fuel level sensor circuit shorted. This is primary fuel tank if two tanks are used.	Wiring problem. Sensor problem.
77	Camshaft Sensor Fault	HALL SENSOR	HALL SENSOR	Cam position sensor circuit is faulty. Fuel and ignition strategies will be modified.	Wiring problem. Sensor problem.
80	Main Power Relay Output	MPRLY OUTPUT	MPRLY OUTPUT	Keyswitch +12v and driver power do not agree within calibrated limits.	Low battery voltage. Poor battery connections or cables. Relay problem.
81	Main Power Relay Backfeed	MPRLY BACKFEED	MPRLY BACKFEED	Unintended voltage being supplied back to ECU. Fault declared if voltage regulator in ECU is off, but ECU senses voltage on driver power.	Wiring problem. Relay problem.
82	Oil Level Sensor Circuit High	OIL LVL CKT HI	OIL LVL CKT HI	Oil level sensor circuit open.	Wiring problem. Sensor problem. If sensor is not installed this is a normal fault message.
83	Oil Level Sensor Circuit Low	OIL LVL CKT LO	OIL LVL CKT LO	Oil level sensor circuit shorted.	Wiring problem. Sensor problem.

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
84	Oil Pressure Circuit High	OIL PRES CKT HI	OIL PRES CKT HI	Oil pressure sensor circuit shorted.	Wiring problem. Sensor problem.
85	Oil Pressure Circuit Low	OIL PRES CKT LO	OIL PRES CKT LO	Oil pressure sensor circuit open.	Wiring problem. Sensor problem.
89	Oil Temperature Circuit High	OIL TEMP CKT HI	OIL TEMP CKT HI	Oil temperature sensor circuit open.	Wiring problem. Sensor problem.
90	Oil Temperature Circuit Low	OIL TEMP CKT LO	OIL TEMP CKT LO	Oil temperature sensor circuit shorted.	Wiring problem. Sensor problem.
91	Oil Temperature Overheat	OIL TEMPERATURE	OIL TEMPERATURE	Engine oil temperature high. Reduce throttle demand.	Oil cooler restricted. Low oil level. Restricted water flow. Thermostat stuck.
92	Paddle Wheel Sensor Fault	PADDLE WHEEL	PADDLE WHEEL	Paddle wheel not operating properly.	Wiring problem. Sensor problem.
93	Pitot Pressure Circuit High	PITOT CKT HI	PITOT CKT HI	Pitot pressure sensor (used for boat speed) circuit shorted.	Wiring problem. Sensor problem.
94	Pitot Pressure Circuit Low	PITOT CKT LO	PITOT CKT LO	Pitot pressure sensor (used for boat speed) circuit open.	Wiring problem. Sensor problem.
95	Port Head Temp Circuit High	PRT TMP CKT HI	PRT TMP CKT HI	Port head coolant temperature sensor circuit open.	Wiring problem. Sensor problem.
96	Port Head Temp Circuit Low	PRT TMP CKT LO	PRT TMP CKT LO	Port head coolant temperature sensor circuit shorted.	Wiring problem. Sensor problem.
101	CAN Circuit Fault 1	CAN ERR1	CAN ERR1	CAN bus	Wiring problem on the CAN1 (primary control data) system.
102	CAN Circuit Fault 2	CAN ERR2	CAN ERR2	CAN bus	Wiring problem on the CAN2 system.
103	CAN Circuit Fault 3	CAN ERR3	CAN ERR3	CAN bus	Wiring problem on the CAN3 (redundant control data) system.
104	Lake/Sea Temp Circuit High	SEA TMP CKT HI	SEA TMP CKT HI	Boat mounted water temperature sensor circuit open.	Wiring problem. Sensor problem. If sensor is not installed this is a normal fault message.
105	Lake/Sea Temp Circuit Low	SEA TMP CKT LO	SEA TMP CKT LO	Boat mounted water temperature sensor circuit shorted.	Wiring problem. Sensor problem.
106	Shift Actuator Driver Overtemp	SHIFT DRV OVRHT	SHIFT DRV OVRHT	Shift actuator driver (within PCM) temperature high.	Wiring problem. Shift actuator faulty. Binding linkage.
107	Shift Actuator Feedback High	SHIFT POS CKT HI	SHIFT POS CKT HI	Shift position sensor circuit faulty.	Wiring problem. Sensor problem.
108	Shift Actuator Feedback Low	SHIFT POS CKT LO	SHIFT POS CKT LO	Shift position sensor circuit faulty.	Wiring problem. Sensor problem.
109	Shift Actuator No Adapt	SHIFT ADAPT ERR	SHIFT ADAPT ERR	Actuator stalled but not within a valid range.	Check linkage. Shift actuator faulty.

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
110	Shift Position Switch Fault	SHIFT SWITCH	SHIFT SWITCH	Shift switch/neutral switch faulty.	Wiring problem. Switch faulty. Check linkage.
111	Starboard Head Temp Circuit High	ECT TMP CKT HI	ECT TMP CKT HI	Starboard head coolant temperature sensor circuit open.	Wiring problem. Sensor problem.
112	Starboard Head Temp Circuit Low	ECT TMP CKT LO	ECT TMP CKT LO	Starboard head coolant temperature sensor circuit shorted.	Wiring problem. Sensor problem.
117	Start Solenoid Output	START SOLENOID	START SOLENOID	Open circuit to or insufficient current draw on start solenoid/relay.	Wiring problem between ECM and start solenoid/relay. Faulty solenoid.
120	TPS 1 Circuit High	TPI1 CKT HI	TPI1 CKT HI	TPI sensor circuit shorted.	Wiring problem. Faulty sensor inside of ETC.
121	TPS 1 Circuit Low	TPI1 CKT LO	TPI1 CKT LO	TPI sensor circuit open.	Wiring problem. Faulty sensor inside of ETC.
122	TPS 1 Range High	TPI1 RANGE HI	TPI1 RANGE HI	TPI above the normal expected range.	Faulty sensors inside of ETC.
123	TPS 1 Range Low	TPI1 RANGE LO	TPI1 RANGE LO	TPI below the normal expected range.	Faulty sensors inside of ETC.
124	TPS 1 No Adapt	TPI1 NO ADAPT	TPI1 NO ADAPT	Outside valid range when trying to adapt. Adapt occurs when exiting crank on way to run.	Faulty sensors inside of ETC.
125	TPS 2 Circuit High	TPI2 CKT HI	TPI2 CKT HI	TPI sensor circuit shorted.	Wiring problem to ETC connectors. Faulty sensor inside of ETC.
126	TPS 2 Circuit Low	TPI2 CKT LO	TPI2 CKT LO	TPI sensor circuit open.	Wiring problem. Faulty sensor inside of ETC.
127	TPS 2 Range High	TPI2 RANGE HI	TPI2 RANGE HI	TPI above the normal expected range.	Faulty sensors inside of ETC.
128	TPS 2 Range Low	TPI2 RANGE LO	TPI2 RANGE LO	TPI below the normal expected range.	Faulty sensors inside of ETC.
129	TPS 2 No Adapt	TPI2 NO ADAPT	TPI2 NO ADAPT	Outside valid range when trying to adapt. Adapt occurs when exiting crank on way to run.	Faulty sensors inside of ETC.
130	Trim Sensor Circuit High	TRIM CKT HI	TRIM CKT HI	Trim sensor circuit shorted.	Wiring problem. Sensor problem.
131	Trim Sensor Circuit Low	TRIM CKT LO	TRIM CKT LO	Trim sensor circuit open.	Wiring problem. Sensor problem.
132	Crank Position (VR) Sensor Fault	VR SENSOR	VR SENSOR	Variable reluctance sensor (crank position sensor).	With this failure, engine will not run. Wiring problem. Sensor problem.

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
133	Power 1 Volts (5VDC) Low	5 VDC PWR LO	5 VDC PWR LO	Supplies power to all sensors (+5v).	Excessive current draw on the +5 VDC circuit. Circuit/sensor shorted to ground.
134	Overspeed 1	OVERSPEED 1	OVERSPEED 1	Level 1 of overspeed exceeded.	Prop too small. Too much trim. Too high on transom. Too much vent in prop. Too much throttle in neutral. Gearcase problem. Prop damaged.
135	Overspeed 2	OVERSPEED 2	OVERSPEED 2	Level 2 of overspeed exceeded.	Prop too small. Too much trim. Too high on transom. Too much vent in prop. Too much throttle in neutral. Gearcase problem. Prop damaged.
136	Boost Bypass Valve Circuit High	BOOST BY CKT HI	BOOST BY CKT HI	Boost control valve circuit shorted.	Wiring problem. Faulty valve.
137	Boost Bypass Valve Circuit Low	BOOST BY CKT LO	BOOST BY CKT LO	Boost control valve circuit open.	Wiring problem. Faulty valve.
138	ECM Memory Fault	ECM MEMORY ERR	ECM MEMORY ERR	ECM memory is corrupted.	ECM faulty.
148	ESC and Neutral Switch Position Fault	ESC-NS POS DIFF	ESC-NS POS DIFF	ESC actuator's determination of its position and neutral switch position do not agree.	Harness connection to neutral switch faulty, or faulty neutral switch.
149	ETC Idle Range Fault	ETC IDLE RANGE	ETC IDLE RANGE	ETC out of range for the idle position.	Wiring problem. Debris in ETC. Faulty ETC. Air leak in induction system.
150	Dual Engine CAN Circuit Fault	DUAL CAN ERR	DUAL CAN ERR	Communication between System View and PCM has been lost. Discrepancy between CAN1 & CAN2	Wiring problem CAN1 & CAN2. Lost terminator connection.
151	Fuel Pump Circuit	FUEL PUMP RLY CKT	FUEL PUMP RLY CKT	Open circuit to fuel pump.	Wiring problem. Connector problem. Bad pump.
152	IAC Output	IAC OUTPUT	IAC OUTPUT	Open circuit to IAC.	Wiring problem. Connector problem. Bad IAC.
154	Mass Airflow Too High	AIRFLOW HI	AIRFLOW HI	Mass airflow calculation not correct.	Calibration problem.
163	CAN Circuit Fault 5	CAN ERR5	CAN ERR5	CAN bus.	Wiring problem on the CAN system.
176	Shift Actuator Position Sensor Fault	ESC-ERC POS	ESC-ERC POS	ESC actuator's determination of its position and commanded position do not agree.	Worn linkage. Faulty ESC. Faulty ERC.

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
180	MAP/TPI Difference Fault	MAP DIFF ERR	MAP DIFF ERR	Both TPI's are functioning, but MAP sensor calculations do not agree. Suspect MAP sensor to be faulty.	MAP sensor outside of expected operating range. Abnormal airflow in intake.
181	TPI Sensors (All)	TPI ALL ERR	TPI ALL ERR	MAP does not agree with either TPI. Power off the ETC.	Wiring problem to ETC. Sensor problem.
182	TPS 1 Difference Fault	TPI1 DIFF ERR	TPI1 DIFF ERR	MAP sensor range = TPI2, but TPI1 does not agree.	Wiring problem to ETC. Sensor problem.
183	TPS 2 Difference Fault	TPI2 DIFF ERR	TPI2 DIFF ERR	MAP sensor range = TPI1, but TPI2 does not agree.	Wiring problem to ETC. Sensor problem.
184	Trim Down Relay Output	TRIM DOWN SOL	TRIM DOWN SOL	Trim down circuit faulty.	Wiring problem. Faulty relay coil.
185	Trim Up Relay Output	TRIM UP SOL	TRIM UP SOL	Trim up circuit faulty.	Wiring problem. Faulty relay coil.
186	CAN Circuit Fault 7	CAN ERR7	CAN ERR7	CAN bus	Problem on the CAN system.
187	CAN Circuit Fault 8	CAN ERR8	CAN ERR8	CAN bus	Wiring problem on the CAN system.
188	Primary Demand to Redundant Diff	DEMAND DIFF	DEMAND DIFF	CAN1 not equal to CAN2 cross check failure.	Faulty pots in ERC.
189	Demand Cross Check Difference	XCHK DEMAND DIFF	XCHK DEMAND DIFF	Command module not equal to PCM cross check of demand value.	Incorrect positions used when configuring levers at command module, faulty command module or ECM.
190	Shift Cross Check Difference	XCHK SHIFT DIFF	XCHK SHIFT DIFF	Command module not equal to PCM cross check of shift position.	Incorrect positions used when configuring levers at command module, faulty command module or ECM.
191	Fuel Level 2 Circuit High	FUEL LVL2 CKT HI	FUEL LVL2 CKT HI	Secondary boat mounted fuel tank sensor circuit open.	Wiring problem. Sensor problem.
192	Fuel Level 2 Circuit Low	FUEL LVL2 CKT LO	FUEL LVL2 CKT LO	Secondary boat mounted fuel tank sensor circuit shorted.	Wiring problem. Sensor problem.
193	Shift Anticipate Switch Fault	SHIFT ANT SWITCH	SHIFT ANT SWITCH	Shift anticipate (interrupt) switch active at incorrect time.	Wiring problem. Mechanical linkage problem. Faulty shift switch.
194	ESC Timeout Fault	ESC TIMEOUT	ESC TIMEOUT	Shift actuator has not physically moved with respect to the control lever (demand) position.	Linkage problem. Faulty ESC. Wiring problem.
195	Thermostat Fault	THERMOSTAT FAULT	THERMOSTAT FAULT	Failure to reach operating temperature.	Thermostat may be stuck open.

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
197	Supercharger Temp Circuit High	SC TEMP CKT HI	SC TEMP CKT HI	Supercharger temperature sensor circuit open.	Wiring problem. Sensor problem.
198	Supercharger Temp Circuit Low	SC TEMP CKT LO	SC TEMP CKT LO	Supercharger temperature sensor circuit shorted.	Wiring problem. Sensor problem.
199	Supercharger Overheat	SC OVERHEAT	SC OVERHEAT	Supercharger overheating.	Excessive temperature. Reduce loads and throttle demand.
200	Boost Bypass Valve Fault	BOOST VALVE ERR	BOOST VALVE ERR	Feedback from boost valve.	Wiring problem. Faulty valve.
201	Head Temp Circuit High	HEAD TEMP CKT HI	HEAD TEMP CKT HI	Head temperature sensor circuit open.	Wiring problem. Sensor problem.
202	Head Temp Circuit Low	HEAD TEMP CKT LO	HEAD TEMP CKT LO	Head temperature sensor circuit shorted.	Wiring problem. Sensor problem.
203	Head Temp Overheat	HEAD OVERHEAT	HEAD OVERHEAT	Cylinder head overheat.	Loss of cooling water. Sensor problem.
204	Block Temp Circuit High	BLK TEMP CKT HI	BLK TEMP CKT HI	Block temperature sensor circuit open.	Wiring problem. Sensor problem.
205	Block Temp Circuit Low	BLK TEMP CKT LO	BLK TEMP CKT LO	Block temperature sensor circuit shorted.	Wiring problem. Sensor problem.
206	Block Temp Overheat	BLOCK OVERHEAT	BLOCK OVERHEAT	Cylinder block overheat.	Loss of cooling water. Thermostat malfunction. Sensor problem.
207	Lift Pump Timeout	LIFT PUMP TIMER	LIFT PUMP TIMER	VST did not fill in specified time.	Fuel restriction. No fuel in tank.
208	Lift Pump Output	LIFT PUMP OUT	LIFT PUMP OUT	Insufficient current draw at fuel lift pump.	Wiring problem. Faulty pump.
209	Drive Power Low	DRIVER POWER LO	DRIVER POWER LO	Supplies power to all drivers (+12v).	Faulty or low battery condition.
210	Overspeed in Neutral	NEUTRAL OVERSPD	NEUTRAL OVERSPD	Allowable overspeed limit in neutral exceeded.	Bad shift switch. Engine exceeded specified RPM in neutral.
211	Overspeed in Reverse	REVERSE OVERSPD	REVERSE OVERSPD	Allowable overspeed limit in reverse exceeded.	Engine exceeded specified RPM limit in reverse gear.
212	SmartStart Aborted	SMART START ERR	SMART START ERR	No engine RPM detected, no starter engagement.	Starter failed to engage. Weak battery. Open circuit to start solenoid. CPS circuit problem.
213	Fuel in Vent Canister	FUEL IN VENT	FUEL IN VENT	Vent canister switch active.	Excess fuel being vented from vapor separator or fuel system module.
214	Boost Diag. Circuit High at Keyup	SC DIAG CKT HI	SC DIAG CKT HI	Boost control valve shorted at key up.	Wiring problem. Valve problem.
215	CAN Circuit Fault 9	CAN ERR9	CAN ERR9	CAN bus	Wiring problem on the CAN system.

Fault #	CDS Fault Message	DDT Fault Status Message	System View Active Alarm	Fault Explanation	Possible Root Cause
216	CAN Circuit Fault 10	CAN ERR10	CAN ERR10	CAN bus	Wiring problem on the CAN system.
217	Power 2 (5 VDC) Volts Low	5 VDC PWR 2 LO	5 VDC PWR 2 LO	Supplies power to all SmartCraft sensors (+5v).	Excessive current draw on the +5 VDC circuit. Paddle wheel harness shorted. SmartCraft connector corroded.
218	Helm ADC Check	HELM ADC ERR	HELM ADC ERR	Discrepancy between DTS Command Module and PCM.	Wrong DTS Command Module for engine model. Bad DTS Command Module. Incorrect PCM hardware. Wiring problem.
219	ESC Loss of Control	ESC CONTROL LOST	ESC CONTROL LOST	ESC in gear position other than commanded by ERC.	Potentiometers in electronic shift actuator are questionable. Wiring to actuator could be bad. Engine manually put into gear.
220	Vent Float Switch High	VENT SW HI	VENT SW HI	Vent switch circuit shorted.	Fuel in vent canister. Wiring problem. Switch problem.
221	Lift Pump Float Switch High	LIFT PUMP SW HI	LIFT PUMP SW HI	Lift pump switch circuit shorted.	Wiring problem. Switch problem.
222	Lift Pump Flow Low	LIFT PUMP FLOW	LIFT PUMP FLOW	Fuel flow across injectors vs. lift pump on time.	Calibration problem.
226	CAN Circuit Fault 11	CAN ERR11	CAN ERR11	CAN bus	Communication problem on the CAN system.
236	Emergency Stop Activated	STOP CKT ACTIVE	STOP CKT ACTIVE	Emergency stop performed.	Re-attach lanyard and restart engine.
237	Excessive Knock Detected	EXCESSIVE KNOCK	EXCESSIVE KNOCK	Engine is in detonation control.	Reduce throttle demand.
238	Overspeed in Trailer Mode	TRIM OVERSPD	TRIM OVERSPD	Engine RPM above allowable limit in trailer position.	High RPM in trailer range. Lower trim.
239	Underwater Impact	TRIM IMPACT	TRIM IMPACT	Fast trim sensor movement.	There has been an underwater impact.
240	Low Battery	LOW BATTERY	LOW BATTERY	Low battery voltage.	Excessive battery draw. Corroded circuits. Failed alternator or battery.
241	Intake Air Temp Overheat	CHRG TMP OVRHT	CHRG TMP OVRHT	Charge air temperature above allowable limit.	Reduce throttle demand.
242	Fuel Vent Purge Valve	FUEL VENT VALVE	FUEL VENT VALVE	Fuel vent valve not opening.	Wiring problem. Faulty valve.

Mechanical Engine Noise

Notes

No definite rule or test will positively determine source of engine noise; therefore, use the following information only as a general guide to engine noise diagnosis.

1. The use of a stethoscope can aid in locating a noise source; however, because noise will travel to other metal parts not involved in the problem, caution must be exercised.
2. If you believe noise is confined to one particular cylinder, ground spark plug leads, one at a time. If noise lessens noticeably or disappears, it is isolated to that particular cylinder. Noise confined to one cylinder is normally connected to a problem with a wrist pin, rod bearing or piston slap.
3. Try to isolate the noise to location in engine: front to back, top to bottom. This can help determine which components are at fault.
4. Sometimes engine noises can be caused by other components transfer noise to powerhead. Examples are: flywheel torqued to specification; flywheel load wring in place, or exhaust tube loose rattling.
5. When noise is isolated to a certain area and component, removal and inspection will be required. Refer to proper sections of servicemanual for information required for service.
6. If noise cannot be distinguished between engine and gear case, on applications where the **driveshaft does not run the oil pump** remove gearcase. Run a water supply directly to engine. Run engine without the gearcase to determine if the noise is still there.

Notes

Compression Check

- 1) Remove spark plugs.
- 2) Install compression gauge in spark plug hole.
- 3) Hold throttle plate at W.O.T.
- 4) Crank the engine over until the compression reading peaks on the gauge. Record the reading.
- 5) Check and record compression of each cylinder. The highest and lowest reading recorded should not differ by more than 15% (see example chart below). A reading below 120 psi might indicate a total engine wear problem.

Example of compression test differences

Maximum (psi)	Minimum (psi)
180	153
150	127.5

- 6) Compression check is important because an engine with low or uneven compression cannot be tuned successfully to give peak performance. It is essential, therefore, that improper compression be corrected before proceeding with an engine tuneup.
- 7) Cylinder scoring: If powerhead shows any indication of overheating, such as discolored or scorched paint, visually inspect cylinders for scoring or other damage as outlined in Service Manual.

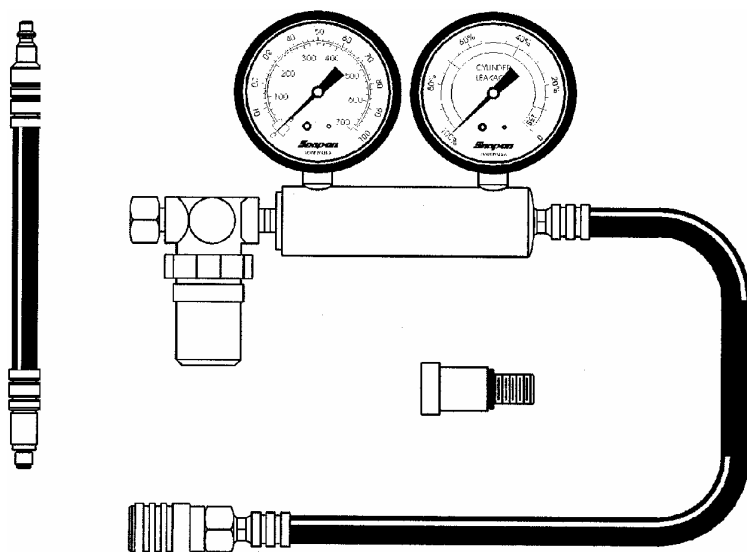
CAUTION

Compression/Cylinder Leakage Tests Must be performed with the ignition/injection system disabled. To do this, the lanyard stop switch MUST BE placed to the "OFF" position.

Cylinder Leakage Testing

NOTE: Cylinder leakage testing, along with compression testing, can help the mechanic pinpoint the source of a mechanical failure by gauging the amount of leakage in an engine cylinder. Refer to the manufactures tester instructions for proper testing procedures.

Cylinder Leakage Tester (Snap-On Tools EEPV309A)



Analysis

Due to standard engine tolerances and engine wear, no cylinder will maintain a 0% of leakage. It is important only that cylinders have somewhat consistent reading between them. Differences of 15 to 30% indicate excessive leakage. Larger engines tend to have a larger percentage of cylinder leakage than smaller engines.

If excessive leakage is present, first check that the piston is at top dead center of it's compression stroke. Leakage will naturally occur if the exhaust or intake valve is open.

Notes

To determine the cause of high percentage leaks, you must locate where the air is escaping from. Listen for air escaping thru the carburetor intake, adjacent spark plug holes, exhaust pipe, crankcase fill plug. Use the following table to aid in locating the source of cylinder leakage:

Air Escaping From:	Indicates Possible Defective:
Carburetor	Intake Valve
Exhaust System	Exhaust Valve
Crankcase Fill Plug	Piston and rings
Adjacent Cylinders	Head Gasket

NOTE: Prevent engine from rotating when performing leak down test to ensure accuracy.

Flywheel Retorque

NOTE: Refer to Service Bulletin 2001-6 for 115 Flywheel Retorque information.