PCM® marine engines

PREMIER DEALER

WORLDWIDE

PCM E-TRAIN PROGRAM

Course 2

Reference Material

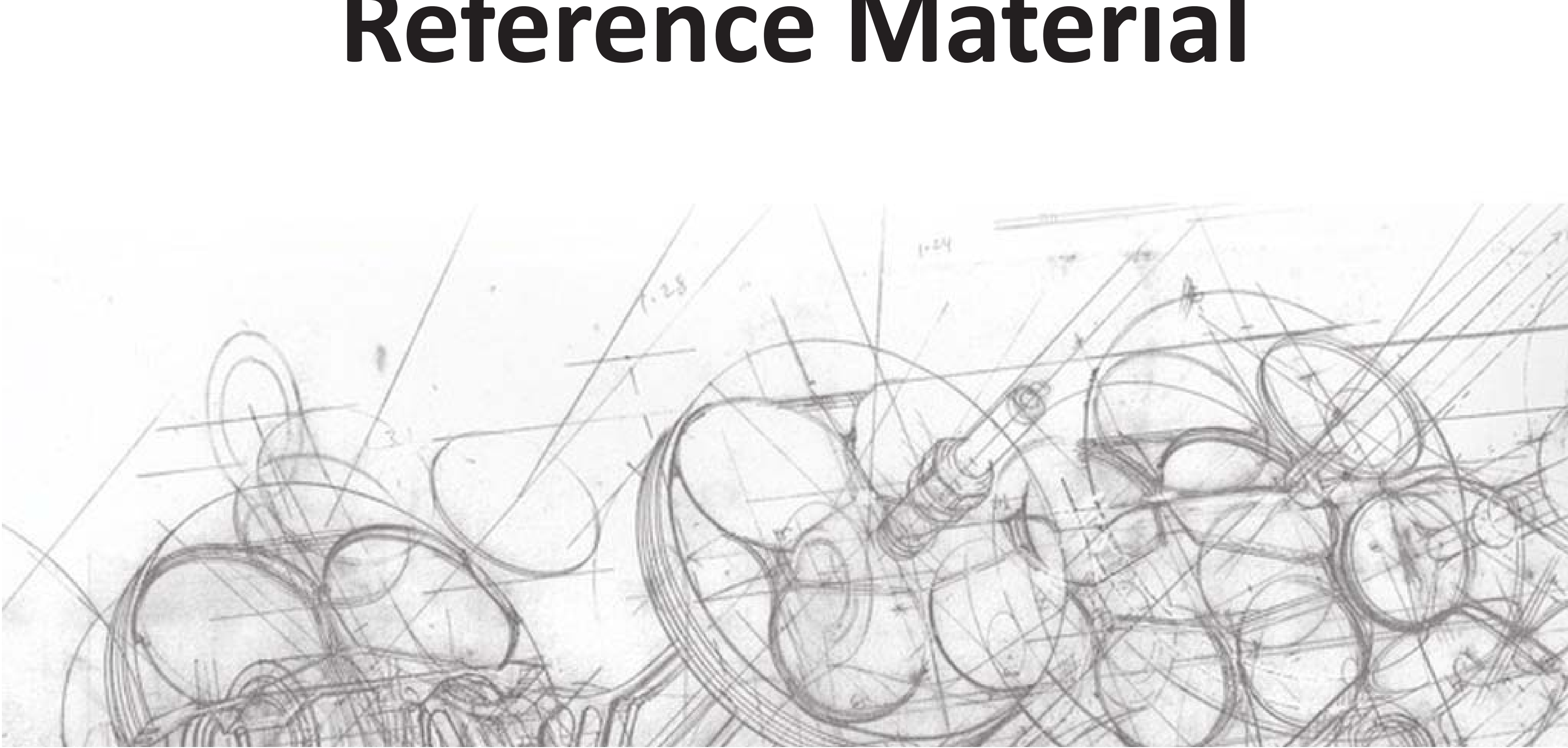


TABLE OF CONTENTS

NOTE: All other publications can be quickly referenced, downloaded or printed conveniently from your PCM Premier Dealer Website. Use your assigned Dealer ID and Password to access this information.

WELCOME

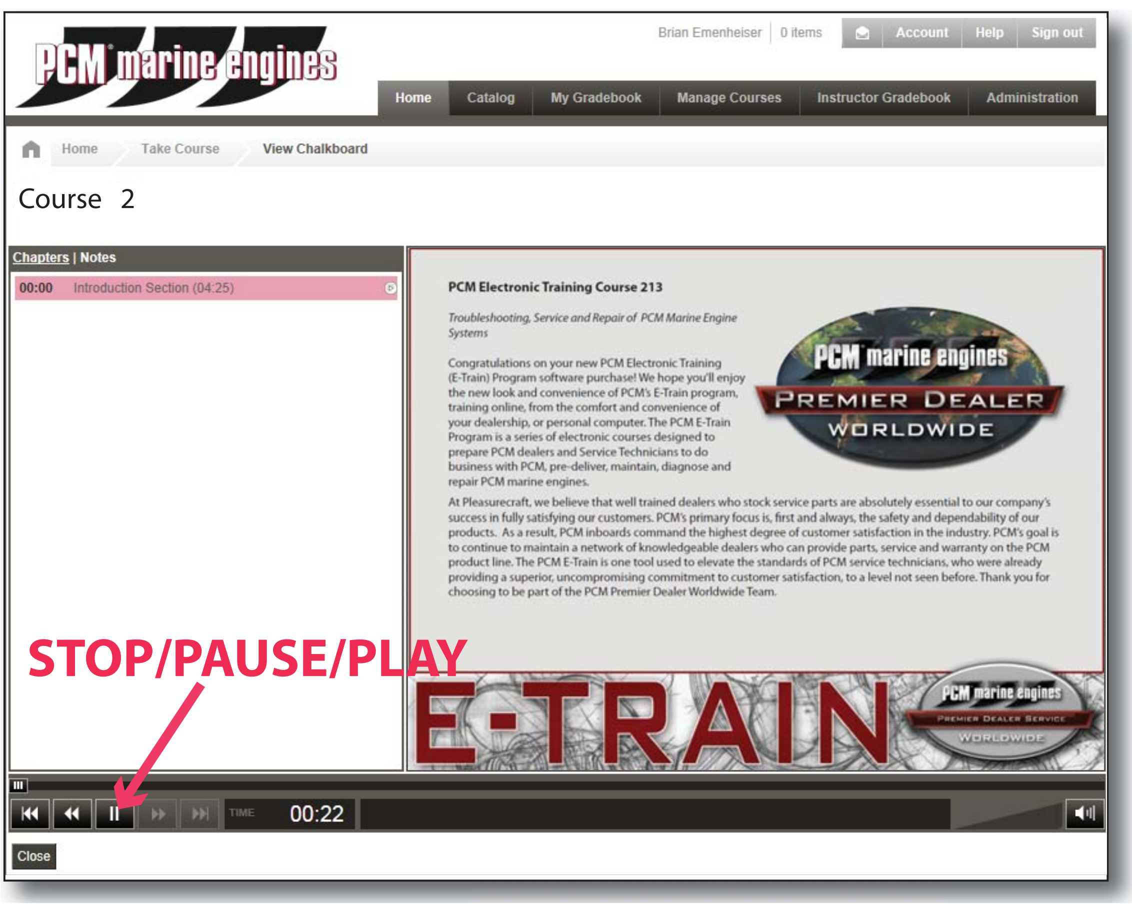
Congratulations on your new PCM Electronic Training (E-Train) Program purchase! We hope you'll enjoy the new look and convenience of PCM's E-Train program, training online, from the comfort and convenience of your dealership, or personal computer. The PCM E-Train Program is a series of electronic courses designed to prepare PCM dealers and Service Technicians to do business with PCM, pre-deliver, maintain, diagnose and repair PCM marine engines.

At Pleasurecraft, we believe that well trained dealers who supply genuine PCM engines, parts and service are absolutely essential to our company's success in fully satisfying our customers. PCM's primary focus is, first and always, the safety and dependability of our products. As a result, PCM inboards command the highest degree of customer satisfaction in the industry. PCM's goal is to create a network of knowledgeable dealers who can provide parts, service and warranty on the PCM product line. The PCM E-Train is one tool used to elevate the standards of PCM service technicians, who were already providing a superior, uncompromising commitment to customer satisfaction, to a level not seen before. Thank you for choosing to be part of the PCM Premier Dealer Worldwide Team.

STOP / PAUSE / PLAY TRAINING SESSION

There are video controls at the lower left hand corner of the screen. These controls work the same as any other video controls. You can stop, pause and play the training session at your pace.

The training session will run continuously through each section or chapter, pausing for several seconds in between screens. You can use the controls to stop, or pause the screen if you need more time to make some notes. Once the Stop/Pause button is clicked on, the control changes to a Play button so you can resume the training session when you are done taking your notes. The only time the training session stops, or pauses automatically is at the end of each section, or chapter. See the following "Section Checkpoints" for further information so your training session does not timeout on you.



BOOKMARKING YOUR TRAINING SESSION

If for any reason you need to end your session before completing the training course, you will be able to finish the course at a later time, even from a different computer if needed.

To properly end your session and “bookmark” your location, you must

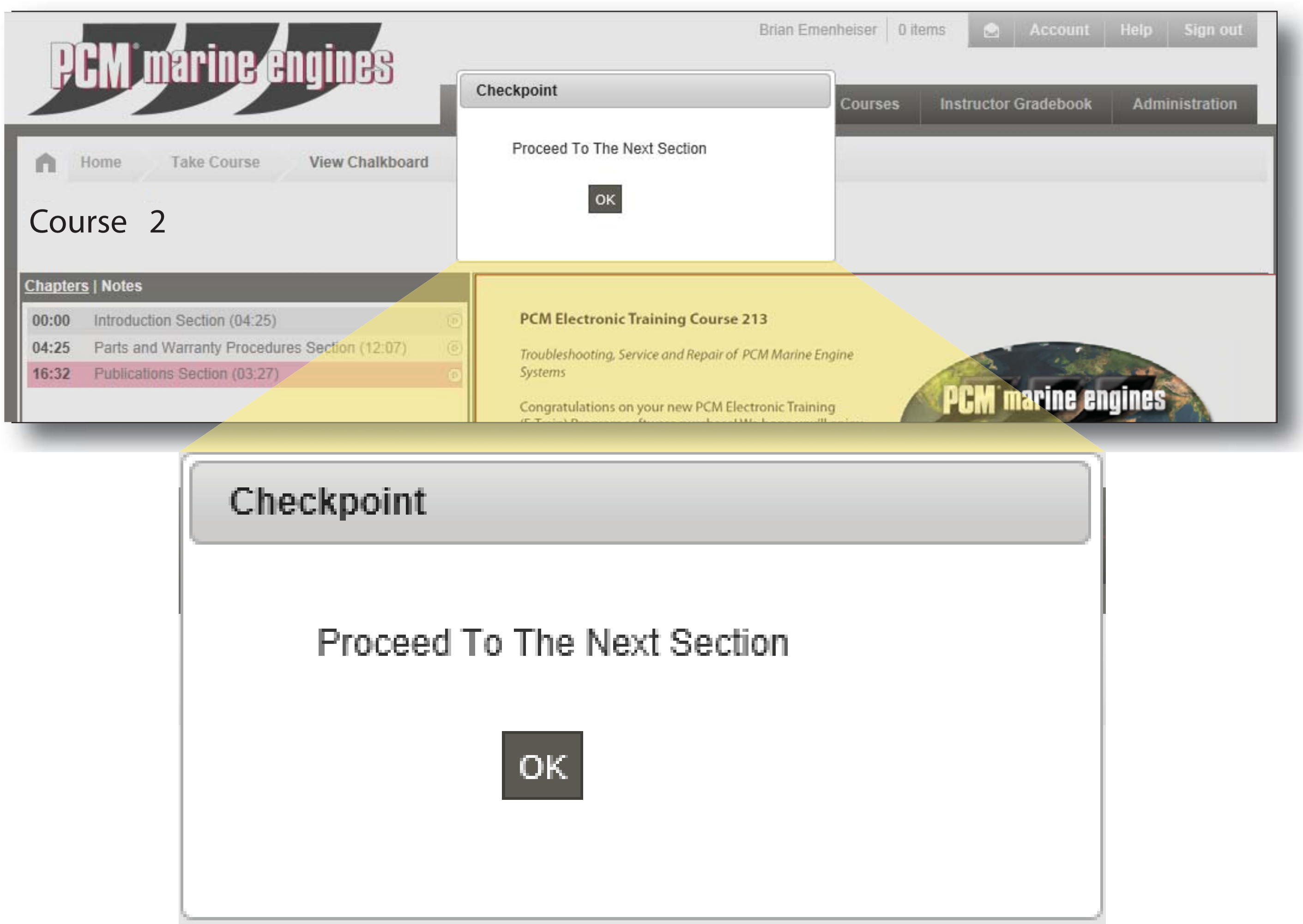
1. Click the STOP button on the lower left corner of the screen.
2. Click on CLOSE in order to properly close the session.
3. SIGN OUT.

Your training session has been bookmarked and can be resumed at a later time.

SECTION CHECKPOINTS

At the end of each section, or chapter, a Checkpoint dialogue box will appear. The Checkpoint requires you to click "OK" to proceed to the next section. You must click OK within one minute or the session will time out.

If you allow the session to time out this way, when you log back in you must start the course over from the beginning. BE SURE to stop the session and properly close out so a "bookmark" is established, and you can resume where you left off.



SAFETY PRECAUTIONS

PCM's primary focus is, first and always, the safety and dependability of our products. As a result, PCM inboards command the highest degree of customer satisfaction in the industry. The following is only a partial listing of the safety warnings that apply when working on the boat or the PCM product. It is required of all technicians performing service on the boat or the PCM product that all manuals be reviewed for the proper procedures and safety precautions, these include, but are not limited to, the boat manufacturer's Owner's Manual and the PCM Owner's Operation and Maintenance Manual.

NOTE: This is only a partial listing of the safety warnings that apply when working on a boat or PCM product. All applicable boat and engine manuals should be consulted before beginning work. Before attempting to perform any procedure, operation, or action on the boat or PCM product please read and observe all safety precautions:

1) Always refer to and follow the engine manufacturer's safety and service procedures to prevent personal injury and damage to the equipment.

2) Always refer to and follow the boat manufacturer's safety and service procedures to prevent personal injury and damage to the equipment.

3) Always refer to and follow all test equipment manufacturer's safety and service procedures to prevent personal injury and damage to the equipment.

4) The technician should review all owner's manuals, boat manufacturer and PCM, to become fully aware of all safety and operational warnings, before performing any procedure on the boat or engine.

5) The boat operator must be qualified and aware of his or her surroundings in order to safely perform the following operations. He/she must be fully familiar with all the safety and operational warnings provided by the boat manufacturer for the craft being tested.

6) Prior to starting the engine, carefully follow the boat manufacturer's starting procedures, including operation of the blower, etc., to ensure safe operation.

7) Fuel and oil are the most dangerous items onboard any boat. A small oil or fuel line leak may cause a fire or explosion. It is imperative that all fuel and oil lines be checked for leaks and corrected prior to delivery to our customer.

8) Over- or under-filling, or using oils not recommended by PCM, may cause engine or transmission damage which will not be covered under the PCM warranty.

9) When working near batteries never use any device that is capable of producing a spark, high temperature or open flame. Batteries contain sulfuric acid and produce highly explosive gasses that may ignite. To prevent serious injury always observe this precaution along with the safety precautions provided by the engine, boat, and battery manufacturers.

10) Always test and service a running engine in a well ventilated area.

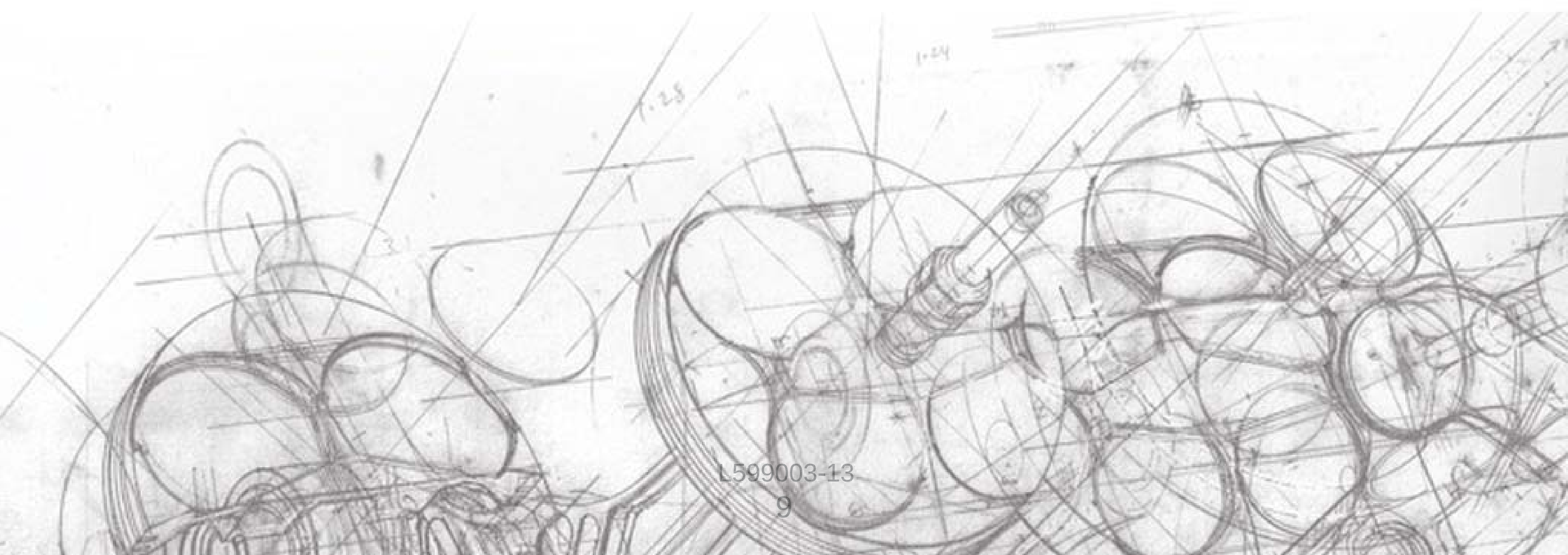
11) Always wear approved eye protection.

It is important that you recognize the potential danger to yourself, others around you and/or property that may be damaged if an accident should occur. It is impossible for PCM to foresee all the potential for accidents that are present at the numerous locations and under varying circumstances existing at those locations. Therefore, **IT IS YOUR RESPONSIBILITY** to determine if you are able to proceed safely in performing repairs at your location.

NOTES

NOTES

Section 2
PCM Drivability Checklist



PCM DRIVABILITY CHECKLIST - 2

Basic Troubleshooting Approach

In this section we will look at a basic troubleshooting approach and some service techniques for isolating various engine systems from the boat systems.

Proper engine operation depends on numerous systems and components functioning together. This of course, makes any one system dependant upon the proper operation of all the other systems.
When troubleshooting an electronic engine management system it is necessary that:

- o the Engine Mechanical Components,
- o the Engine Fuel System Components,
- o the Engine Cooling System Components, and
- o the Main Engine Electrical System Components

are all functioning as designed prior to troubleshooting the engine management system. The PCM Drivability Checklist is designed to help you ensure those requirements are met.

Most engine management circuit failures cause stored diagnostic trouble codes which have a diagnostic and repair procedure designed to resolve the problem causing the code. These codes identify specific failures and will be resolved using the diagnostic manual. Isolating, analyzing and resolving engine management failures is made even easier using the PCM Drivability Checklist.

Diagnostic Trouble Codes (DTC) have assigned numbers associated with each code. DTC 117 is ECT Sensor Circuit Low Voltage.

The DTC's also have both a Failure Mode Indicator (FMI) and Suspect Parameter Number (SPN). Each DTC has both a FMI and SPN in order to identify the exact circuit failure.

NOTE: Diacom only displays the FMI and SPN numbers. Be sure to have both these numbers for each fault displayed.

NOTE: If you need training on connecting Diacom or checking for trouble codes, refer to www.rinda.com/training for some short "How-To" videos to assist you.

Failures which do not set trouble codes must be resolved using the symptoms that are present. Some symptoms are easily recognized such as "the engine overheated". Other symptoms can be vague because one person's description of hesitation may be another person's stumble. Basically, you are dealing with conditions where the engine/boat package is no longer performing as it once did. This may be relayed to you as a loss of rpm at wide open throttle, or the boat doesn't "feel" as strong as it once did.

The PCM Drivability Checklist is based on seven basic steps. Performing these steps, in the order provided, will help you to isolate, identify and repair problems more effectively.

Refer to Figure 2-1. Successful problem diagnosis requires the following approach to be applied to all reported problems. There are seven basic steps to this approach. These seven basic steps are the basis for the PCM Drivability Checklist.

1. Obtain a detailed description of the problem.
2. Check for Service Updates.
3. Perform a detailed visual inspection.
4. Verify the problem.
5. Perform the On-Board Diagnostics
6. Isolate and Repair the problem
7. Verify the problem has been corrected.

You probably use most of these steps every day when you analyze a problem. Using the Drivability Checklist will help you to remember to do all the steps, for every problem.

NOTE: Not all problems reported as engine problems may actually be problems with the engine. Using the PCM Drivability Checklist will help you distinguish between boat and engine problems.

The PCM Drivability Checklist is a guide designed to give you a list of items and procedures often overlooked when troubleshooting a problem. Remember that the objective is to repair the reported problem. The PCM Drivability Checklist is especially useful for troubleshooting those more difficult problems when it is unclear where the problem may lie. Even for easily identified problems, such as an overheat condition, the checklist can keep you from overlooking or spending an unreasonable amount of time on conditions known to PCM. Known problems will have Service Updates issued to address problems such as the overheat example cited above. Service Updates are designed to quickly resolve and prevent a reoccurrence of the problem.

In most cases, performing the PCM Drivability Checklist will help you identify the problem so that you can repair it. In those instances where you are unable to locate the problem, the data you have collected on the completed PCM Drivability Checklist will allow you to work with your PCM Technical Service representative to more quickly isolate and resolve the problem.

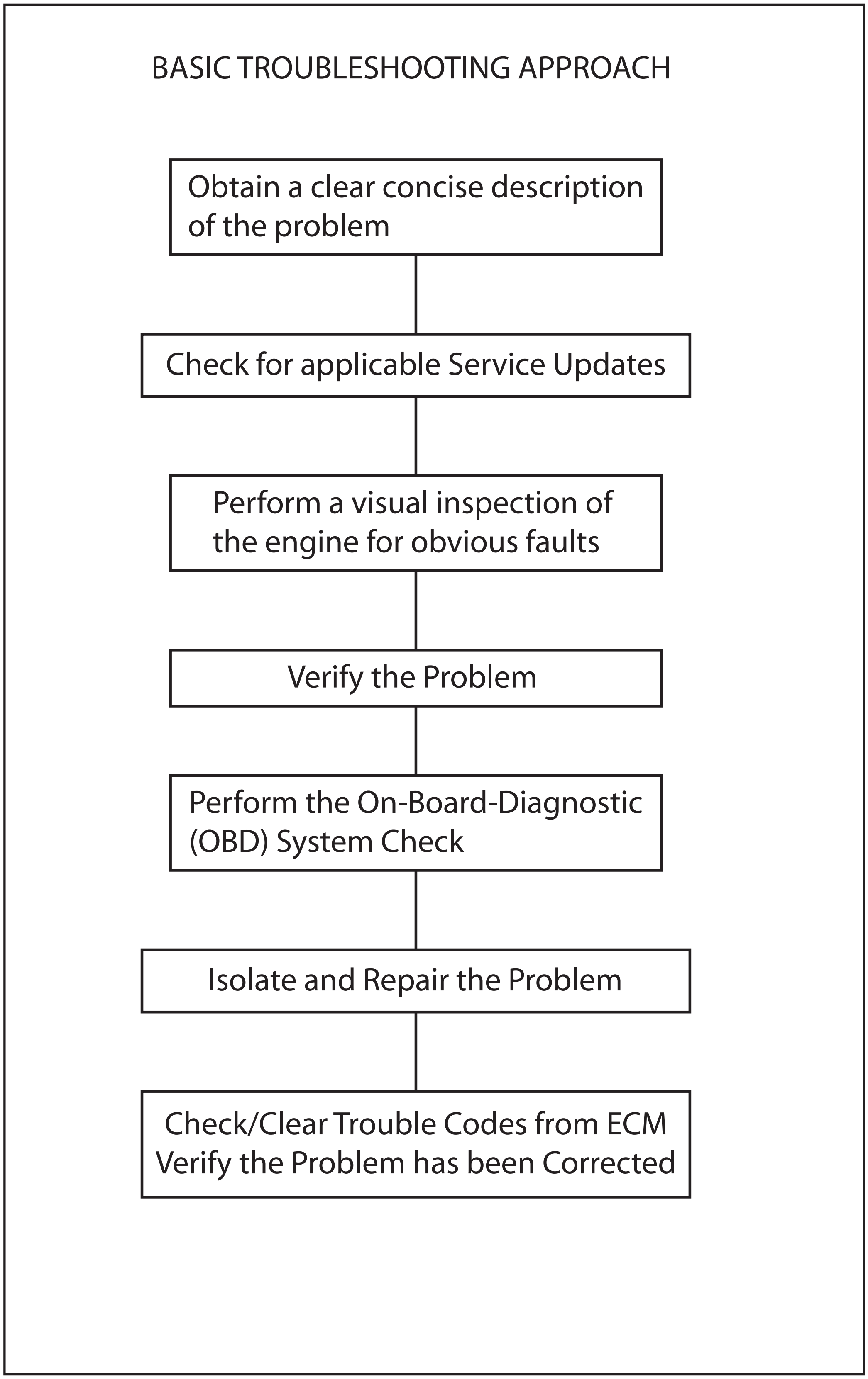


Figure 2-1 Basic Troubleshooting Approach Tree

PCM DRIVABILITY CHECKLIST

ENGINE SERIAL NUMBER: _______________

Date: _______________ **Dealership Name:** ____________________________________

Technician's Name:_____________________________ **Technician's Contact Phone #:** _________________________

Owner/Operator Name: ________________________________

Person Reporting the problem (if different from owner/operator): _____________________________

Service Writer or Person that took the problem report: ______________________________________

1) PROBLEM OR SYMPTOM: ____

Who first observed the symptom?___________________When did the symptom first occur? _______________________
Any recent change or service work prior to symptom occurring - replaced belts or impeller, major engine or boat repairs, recently refueled, etc.? ____ Has someone, other than yourself, tried to correct the current symptom? _________ If yes, what work was done?____

Accessories Added Recently? __________________________________Is the symptom currently present? ___________

Special conditions (if any) required to duplicate the symptom: ____

Use an additional sheet of paper if more space is required for symptoms or descriptions.

2) CHECK FOR SERVICE UPDATES:

ENGINE SERIAL NUMBER: _______________ **ENGINE MODEL NUMBER:** _______________ **ENGINE HOURS:** ____

HULL NUMBER: __________________

ENGINE: None Apply: __ Performed: ____________________________

BOAT: None Apply: __ Performed: ____________________________

3) VISUAL INSPECTION:

Inspection	YES	NO
Evidence of an over-heat:		
Engine Harness connectors connected properly:		
Physical Damage - wiring, connectors, assemblies, and **Remove Spark Plugs and inspect for fluids.**		
Corrosion:		
Hull-clean and free of excessive growth:		

Inspection	YES	NO
Evidence of or Excessive Water in the Bilge:		
Fluid levels checked:		
Leaking Fluids:		
Firing order correct:		
Correct size propellers installed:		
Underwater gear is undamaged:		
Accessories added? If yes, check items		

4) VERIFY THE PROBLEM

	YES	NO	
Does the engine start and continue to run?	**go to 3 below**	**go to 1 below**	
1) Key-ON-Engine-OFF (KOEO)	**YES**	**NO**	**Fuel Press.**
Both Fuel Pumps run 2-4 seconds:			
Fuel Pressure near wot specification - when pumps run:			
2) Key-ON-Engine-Running (KOER)	**YES**	**NO**	**Fuel Press.**
Engine cranks:			
Fuel Pressure near wot specification - engine cranking:			
Engine Starts and continues to run:		go to	(3) Water Test
3) WATER TEST	**YES**	**NO**	**Fuel Press.**
Verify reported symptom:			
Fuel Pressure - idle:			
Fuel Pressure - under load, @ WOT:			

Check Accessories Added:

- ☐ Heater
- ☐ Shower
- ☐ Hot Water Tank
- ☐ Flush Kit
- ☐ Multi-Function Display
- ☐ Synchronizer
- ☐ After-Market Stereo Equipment
- ☐ After-Market Depth/Fish Finder
- ☐ After-Market Navigational Equipment, such as GPS, Radar, Sonar, Auto-pilot systems
- ☐ After-Market Radio Equipment
- ☐ Lights
- ☐ Other - (please list)

4A) Revised or additional symptom found?: ____

1

Figure 2-2 Drivability Checklist

PCM DRIVABILITY CHECKLIST

5) PERFORM THE OBD SYSTEM CHECK

CODE(S) PRESENT: _______________ DIAGNOSTIC PROCEDURE USED: _______________ **Continue to Step 6**

6) ISOLATE AND REPAIR THE PROBLEM.

Were you able to isolate and repair the problem? If ***YES***, continue to **Step 7.**
If ***NO***, complete the Drivability Checklist for No Codes, step 6A below. If the problem is still not resolved, then call for factory technical assistance.

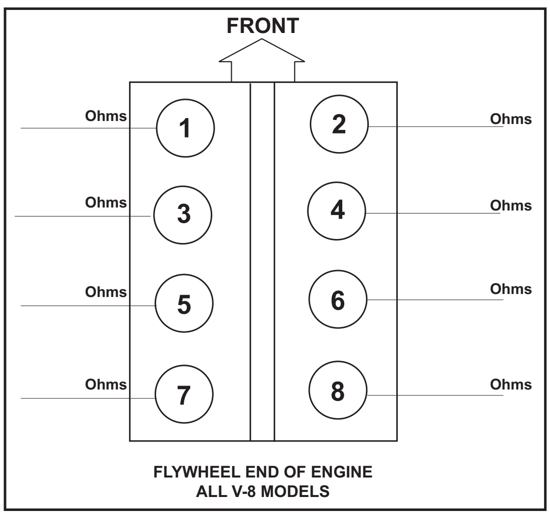
6A) NO CODES - ENGINE RUNS - DRIVABILITY SYMPTOM STILL PRESENT

Inspection or Check	YES	NO
1) Review Steps **1** thru **5**:		
2) Inspect fuel for contamination:		
3) Electrically isolate engine from boat:		
4) Powertrain is aligned:		
5) Remove and Inspect Distributor Cap and Rotor (5.0/5.7L only):		
6) Check&**record** Ignition wire resistance:		
7) Remove and Inspect each spark plug:		
8) Perform a Compression Check on all 8 cylinders: **Record below.**		

Inspection or Check	YES	NO
WATER TEST		
9) Verify CAM Retard** (5.0/5.7L only):		
10) Performance verified against a similar boat w/same engine. package, if available		
11) Perform the Diacom Power Balance Check; under load, @ 1600-1800rpm:		
12) Perform the harness 'Wiggle Test':		
13) Diacom recording-Pre-Delivery test:		

7) VERIFY REPAIR HAS CORRECTED THE PROBLEM. Check for and clear all codes from the ECM memory. **Water test the boat.** Run the engine for a minimum of two (2) minutes, then verify that no codes have returned. Continue with your water test long enough to verify that the problem has been corrected.

**** CAM Retard - '02 thru '06 = 43-47 degrees**
'07 - SN 485993 = 0 - 4 degrees/CES and SN 485994↑ = 15 ± 2 degrees



IGNITION WIRE RESISTANCE CHECK
Less than 10,000 ohms/ft

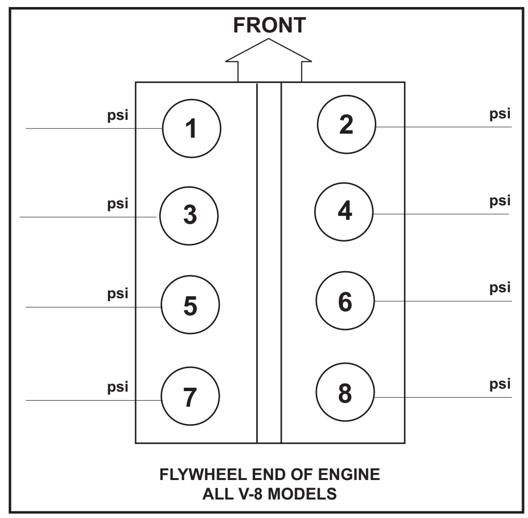
COMPRESSION PRESSURE:

5.0/5.7L - 130-215 psi

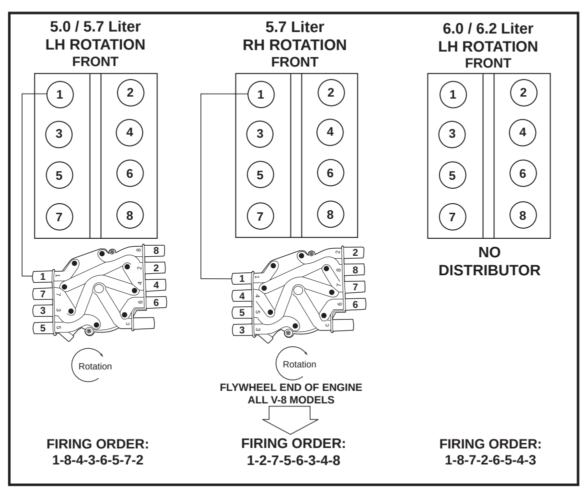
6.0L - 130-215 psi

6.2L - 130-215 psi

Lowest pressure should be within 70% of highest pressure. Minimum cylinder pressure - 100 psi.



COMPRESSION CHECK



REFERENCES:

Master Engine Specification Sheets

L510030 - GCP / 4G Diagnostic Service Manual

L510015 - 5.0/5.7L Engine Mechanical Service Manual

L510016 - 6.0L Engine Mechanical Service Manual

PCM Premier Dealer Website - All the Latest Publications

2

Figure 2-2 Drivability Checklist

PCM DRIVABILITY CHECKLIST - 2

Using the PCM Drivability Checklist will help you to remember to do all the steps for every problem.

The PCM Drivability Checklist

The following seven checks are the basis for the PCM Drivability Checklist, Figure 2-2. The seven steps of the Basic Troubleshooting Approach can be applied to every problem that you encounter.

1. Obtain a clear, concise description of the problem. Whenever possible, interview the owner/operator and understand any conditions leading up to, and during, the problem occurring. Understanding if recent service has been performed, or a recent abnormal event has happened, can greatly aid you in your troubleshooting effort.

Often, an owner/operator provides only information about the symptom that is currently present. Find out if any recent work was performed on the engine, such as a broken belt or failed raw water pump impeller.

- Has someone already tried to correct the current problem?
- Have any new accessories been added lately?
- Did the problem occur shortly after the last time he refueled?
- Did the problem occur after a recent repair such as a hull repair where the underwater gear was replaced?

As you can see, there are numerous questions that could be asked based on the symptom and the owner/operator's responses. Some of the more important questions to ask are detailed on the PCM Drivability Checklist, Figure 2-2, Step 1.

Based on the symptom you receive from the owner/operator, you may already know where to begin your troubleshooting. Many symptoms provide you that quick and easy insight to the problem. Some examples would be:

1. Over or Under Temperature problems – Troubleshoot the Cooling System
2. Various electrical issues such as no or slow cranking, dead battery, low or high voltage reading at the dash, etc. – Troubleshoot the Main Electrical System.
3. Malfunction Indicator Lamp (MIL) or Check Gauges Lamp (CGL) is illuminated on the dash – troubleshoot the engine management system.

NOTE: The MIL or CGL normally lights when the ECM stores a trouble code. Some boat manufacturers utilize a digital dash display to indicate these faults. Check your boat owners manual for each application.

Remember to closely follow the PCM Drivability Checklist so a problem, or cause of a problem, is not overlooked.

2. Check for applicable Service Updates. Before you begin work on an engine, always check for Service Updates that may apply to the engine being serviced. Service Updates must be performed prior to proceeding with any troubleshooting procedure.

Record your engine serial number, model number and engine hours on the PCM Drivability Checklist. This information is necessary to locate applicable Service Updates. With very little time and effort, the reported symptom may be identified as an issue that a Service Update corrects. Always check for Service Updates before proceeding.

Go to your PCM Premier Dealer website to search applicable Service Updates.

3. Perform a visual inspection of the engine for obvious faults. One of the most important, yet least performed, functions when troubleshooting is a detailed visual inspection. Always visually and physically inspect the engine wiring harness for damage caused by misrouting, chaffing, pinched wires or excessive heat. Check suspect connections for any that may be loose or broken. Inspect terminals for corrosion or being properly seated into connector.

Pay close attention to the power and ground connections for corrosion and/or accessory devices added in. Improperly added accessories can adversely affect engine operation. Inspect the engine and its assemblies for signs of damage or failure. Visually inspect for signs of arcing, fluid leaks, excessive water in the bilge, cracked or damaged assemblies and signs of excessive heat such as melted or deformed parts and discolored paint.

When you perform a visual inspection you are looking for obvious conditions that could cause the reported symptom. If an overheat is reported you look for discolored paint and other heat related damage. When you have a performance issue reported; include the often overlooked inspections of the boat, for conditions that may affect performance such as hull damage or growth, damaged underwater gear and if the correct propeller is installed.

Referring to the PCM Drivability Checklist, you can see there are a number of inspections listed, such as discolored paint from excessive heat, fluid leaks, fluid levels, etc. Most of the inspections listed are items easily seen as faults. When you have a performance issue, be sure to include in your inspection a check of the ignition wires and spark plugs to include:

1. Proper routing,
2. Correct firing order, and
3. Inspect spark plugs for broken or cracked insulators.

Be alert as you perform the visual inspection. You may repair the reported problem by reconnecting a wiring connector, or cleaning the corrosion away from the power and ground terminals of the battery.

Samples of some observations that would need attention before attempting to run the engine are:

1. **Melted, skinned or burnt wiring** – You will need to repair the wiring. The condition of the wiring may have been caused by a Cooling System failure or a Main Electrical System failure.
2. **Oil level excessively high on the dipstick** – This may indicate a foreign liquid in the oil or an over-fill condition exists. Investigate and correct a high oil level condition before proceeding. Symptoms of too much oil in the crankcase include a loss of power, a loss of top end rpm, a possible low oil pressure reading and the engine may be going into Power Derate Mode.
3. **Evidence of excessive water in the bilge** – A rust/water line on the starter/engine block is usually a good indication; if the water is not still covering these items. Multiple electrical issues may remain. Most common is a failed starter. High water may short out the battery and other electrical devices. As mentioned above, you may have water in the engine oil or transmission.

The results of a good visual inspection will help you determine where you will concentrate your troubleshooting efforts.

4. Verify the problem. At this point you must verify the problem or symptom you are trying to repair. In order to verify the problem, you will need to connect your Diacom scan tool and Fuel Pressure gauge to the engine. You should also have your Digital Multi-Meter (DMM) available.

Always verify, for yourself, that the problem you are about to troubleshoot is the same problem reported to you in Step 1 of the PCM Drivability Checklist. Verifying the problem may require you to water test the boat and trying to recreate the conditions under which the failure occurred.

Refer to Figure 2-2, Step 4. Step 4 is a series of checks leading up to verifying the reported problem. Remember that the PCM Drivability Checklist is to be used to help you locate a problem.

Refer to the Troubleshooting Tree for Step 4 of PCM Drivability Checklist, Figure 2-3. This diagram will take you through a step by step approach to troubleshoot and repair the problem.

Refer to Figure 2-3. This diagram is a troubleshooting tree for Step 4 of PCM Drivability Checklist. As you can see from Figure 2-3, if an action performed fails you may have a new branch to follow to troubleshoot and repair the problem.

NOTE: For illustrative purposes each test presumes the problem has not been resolved. Therefore, you proceed to the next step. In actual troubleshooting, if any step corrects the problem, there would be no reason to proceed further. You would verify your repair, Step 7 of the PCM Drivability Checklist.

We want to perform some basic checks before we go for a water test and verify the problem. You are going to need your senses: sight, hearing and touch, as much as you will need your tools. A Digital Multi-Meter (DMM), Diacom and Fuel Pressure Gauge will be used while performing these checks. This will be your first look at the various engine systems, with a focus on troubleshooting the problem. Within a few minutes of testing you may know the direction of your troubleshooting efforts.

Try to start the engine. If the engine starts and continues to run, you would go to the Water Test and verify:

1. The reported problem and
2. The fuel pressure at wide-open-throttle.

If we have a no crank condition we would troubleshoot the Main Electrical System and the Starter circuit.

For any other conditions, long crank, hard start, stalling, etc., we want to continue with our testing and perform the Key-On-Engine-Off (KOEO) test.

Key-On-Engine-Off (KOEO) Test. This test may be used to determine the condition of the engine's Electrical, Fuel and Engine Management systems:

Place the ignition switch in the Key-ON-Engine-OFF (KOEO) position. Ensure the boat's safety lanyard is properly connected. You should listen, feel and observe that the following actions take place:

1. Both fuel pumps run for 2-4 seconds. Listen for each pump and place your hand on each pump to verify that it is indeed running. Diacom can be used to cycle the fuel pumps as necessary.

NOTE: You can unplug the low pressure fuel pump (mounted to outside of FCC) electrical connector and cycle the ignition to listen and feel whether the high pressure fuel pump (located inside FCC) runs.

2. Observe the Fuel Pressure Gauge; fuel pressure should rise to the proper specification while the fuel pumps run.

You have learned a lot about the engine systems when you turned the ignition ON. The simple action of turning the key to the ON position has allowed you to check three engine systems simultaneously - Electrical, Fuel and Engine Management. If the actions described in the previous frame occur, then you have verified the:

1. Boat's Ignition Switch,
2. Boat's Safety Lanyard circuit,
3. Low and High Pressure Fuel pumps,
4. Relays - System and Fuel Pump,
5. Fuse Block fuses and 100A Fuse,
6. ECM powered up and functioned to turn on the fuel pumps,
7. Battery voltage is at least 9.6 vdc, and
8. Power and ground circuits and related components are functioning.

NOTE: ECM will not power up if the battery voltage is less than 9.6 vdc.

NOTE: If the actions described do not occur, verify the shift lever is in neutral. Verify the battery voltage, system power and ground connections starting at the battery.

If the previously mentioned actions do not take place, you can see on Figure 2-3 that you would move to a new branch of the troubleshooting tree. Here you will be troubleshooting the fuel pumps for a no run condition, or fuel pressure for an abnormal condition.

Each step or action you take will help resolve the problem that is present. If the pumps run and the fuel pressure rises, the next step is the Key-ON-Engine-Running (KOER) test.

Key-ON-Engine-Running (KOER) Test. Do Not turn the key to "OFF" between the Key-ON-Engine-OFF test and this test. Place the ignition switch in the START position to crank, or roll over, the engine. You should observe the following actions:

Warning: Most engines utilize an "auto-crank" feature. This feature allows the engine to crank up to 5 seconds, or until the engine starts.

1. The engine cranks or rolls over for at least 5 seconds,
2. The Fuel Pressure Gauge reading should rise to the same level observed during the Key-On-Engine-Off test. Fuel pressure rising is your indication that the fuel pumps are running.
3. The engine starts and continues to run.
4. If the engine does not start, the fuel pumps should run for 2-4 seconds after engine stops cranking. If the fuel pumps do not run for 2-4 seconds after the engine stops cranking, the ECM did not turn the pumps on. Perform the On-Board Diagnostic System Check to troubleshoot this problem.

NOTE: Turning the key to the 'START' position resets the ECM which will enable the fuel pumps for 2-4 seconds for prime. If the engine is failing to start, be sure to crank the engine for a minimum of 5 seconds. You are checking to see if the ECM is receiving the Crankshaft Position Sensor (CKP) signal which enables the fuel and ignition circuits. It is the CKP signal that causes the pumps to run for 2-4 seconds after you stop cranking the engine. For troubleshooting, utilize the Diacom scan tool to observe Battery Voltage, Engine Speed and Fuel Pump Output status while the engine cranks.

Your action of turning the key "ON" then to the "START" position has allowed you to verify more of the operational capability of the three engine systems - Electrical, Fuel and Engine Management. The additional circuit and component functions verified are:

1. Main Electrical System – All of the Starter Circuits to include the starter relay, transmission neutral safety switch, starter, the associated power and grounds, the boat's ignition and safety lanyard circuits, and the Battery meets the minimum system voltage requirements.
2. Engine Management System – IF the fuel pumps run for 2-4 seconds after the engine stops cranking, the Crank Sensor signal is presumed to be present at the ECM enabling the ignition circuits and Fuel System.

Typically, at this point the engine will be running.

NOTE: If the actions described do not occur, verify the shift lever is in 'neutral'. Verify the battery voltage, system power and ground connections starting at the battery

At this point in our test process, typically, we know the engine will start and run. Complete Step 4 of the PCM Drivability Checklist by water testing the boat. During the Water Test, you will be verifying two things:

1. The reported problem from Step 1 is or is not present.
2. The fuel pressure under load, at Wide-Open-Throttle (WOT), remains at the proper specification.

Remember it is absolutely essential to verify fuel pressure under load, at wide-open-throttle. This is the only reading that verifies the integrity of the fuel system.

Refer to Figure 2-3. You can see that if an action failed we continue to another branch on the trouble tree.

If the engine cranks normally, but still fails to start, continue to Step 5, the On-Board Diagnostic (OBD) System Check of the PCM Drivability Checklist. The OBD System Check will guide you to the appropriate diagnostic procedure for no start and hard start conditions.

NOTE: Normal starter cranking RPM is 150-200 RPM. This can be observed on the Diacom display. If normal cranking RPM is not achieved, troubleshoot the starter for a slow crank condition.

STEP 4

- VERIFY THE PROBLEM -

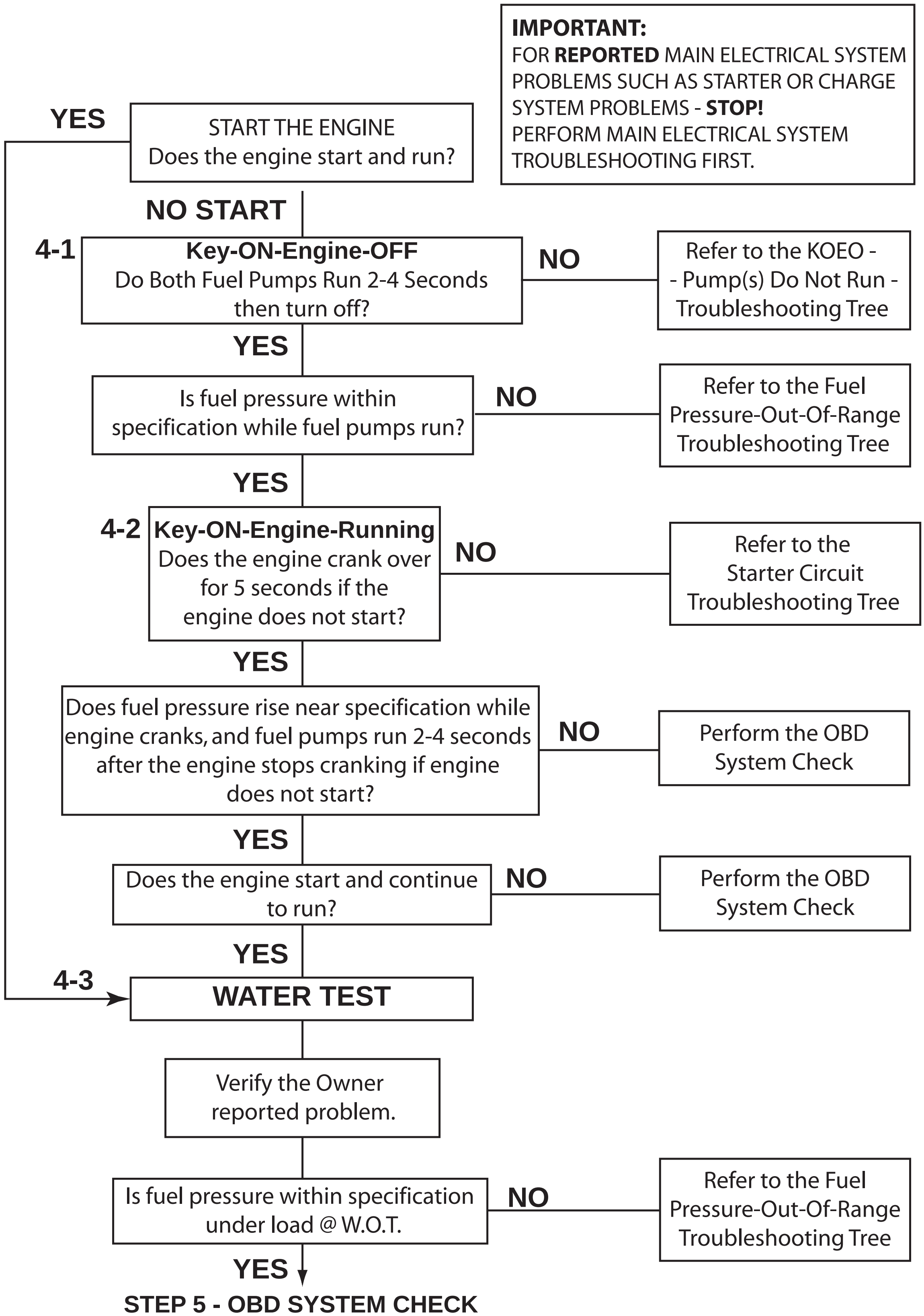


Figure 2-3 Verify the Problem

PCM DRIVABILITY CHECKLIST - 2

5. Perform the On-Board-Diagnostic (OBD) System Check. The On Board Diagnostic (OBD) System Check is an organized approach to identifying a problem created by an electronic engine control system malfunction. This check verifies the following:

1. The ECM power and ground circuits.
2. The ECM can communicate with the scan tool.
3. The ECM will allow the engine to start and continue to run.
4. The ECM has or has not stored Diagnostic Trouble Codes (DTC).

If DTC's are present, the OBD System Check will direct you to the next procedure you need to perform.

Details of the OBD System Check will be covered in the Engine Management section of this course. The OBD System Check will direct you to additional diagnostic procedures based on the results of each step.

6. Isolate and Repair the Problem. Utilize your resources. Obtain the Diagnostic manual for the problem you have encountered. Follow the procedures exactly as they are written. Do Not skip any steps. If you have reached a point in your testing where you have:

1. Checked all the components in a system,
2. Properly completed the PCM Drivability Checklist procedures through Step 5,
3. Completed Step 5 and did not find codes, or found and corrected code related problems but the symptom is still present,
4. An engine that starts and runs but still exhibits a symptom, and
5. Not resolved the problem.

You need to **STOP** and refer Figure 2-2 of the PCM Drivability Checklist, Step 6A. Step 6A is designed to check for a variety of problems known to affect drivability.

Refer to Figure 2-4, The Drivability Checklist - No Codes Troubleshooting Tree, for Step 6A of the PCM Drivability Checklist, Figure 2-2. This troubleshooting tree follows the items listed under Step 6A on the PCM Drivability Checklist.

Step 6A-1 is to review the data collected as you performed the first 5 steps of the checklist.

1. Review the symptom information the owner/operator provided when you questioned him/her on recent events or service.
2. Recheck the engine model and serial number.
3. Recheck the Service Updates.
4. Review your visual inspection.
5. Recheck for accessories added.
6. Review Step 4 "Verify The Problem".
7. Run another check for diagnostic trouble codes.

If a problem is found, correct that problem before proceeding. If you skipped any portion of the first 5 steps go back and perform those checks or inspections. After you verify that all steps, 1-5, have been properly completed, and the results properly analyzed, proceed to Step 6A-2.

Step 6A-2 - An extremely important test is to verify the quality of the fuel in the boat. Sample the gasoline for water, diesel fuel and/or other contaminants. This can be done by draining the FCC fuel bowl into an approved container for inspection.

If you suspect fuel system contamination, connect your auxiliary fuel tank to the engine, drain the FCC and retest the boat. If performance returns to normal, you know you have a fuel quality and/or fuel availability problem. This test analyzes two problems; fuel quality and fuel availability at the same time. Be careful not to misinterpret the results.

Important: Caution must be taken when using the remote fuel tank. The tank must be properly strapped down. The lines and fittings must be secure and away from heat and moving components.

Remember that proper fuel pressure verifies the components of the fuel system, not the quality of the fuel. Always inspect for fuel quality and utilize your auxiliary fuel tank to confirm your findings.

Step 6A-3 - Improper powertrain alignment may affect boat and engine performance. The powertrain cannot be properly aligned if there is damage to the strut or shaft. When you performed the Visual Inspection, Step 3 of the PCM Drivability Checklist, you should have inspected the boat for damage that may cause a loss of engine or boat performance. If you did not perform those inspections do so before performing this step.

Steps 6A-4 – 6A-8 are a series of inspections involving the ignition circuits.

Step 6A-4 - On 5.0/5.7L engines only, remove the distributor cap and inspect the cap and rotor for abnormal conditions.

Step 6A-5 - Check and record the resistance of each spark plug wire. Ignition wire resistance should not be greater than 10,000 ohms per foot. Record the results in the space provided on the PCM Drivability Checklist, Figure 2-2. Leave the plug wires disconnected.

Step 6A-6 - Remove each spark plug and inspect for abnormal conditions such as: wrong type, size, reach or heat range of the spark plug installed, improper gap, fouling or physical damage.

Step 6A-7 - With all eight spark plugs removed, perform a compression check on all 8 cylinders. Record the results of the compression check in the space provided on the PCM Drivability Checklist. Re-install the spark plugs and ensure the ignition wires are all connected and routed properly.

Step 6A-8 (5.0L/5.7L Engines Only) - Using your Diacom scan tool with the engine running at idle, verify CAM Retard is within specifications. Adjust as required to set to the proper specification.

Refer to Steps 6A-9 – 6A-12 - The final series of checks will be made with the boat in the water.

Step 6A-9 - Whenever practical, if another boat of similar size, with the same engine package is available, use it to verify and compare engine parameters for performance issues.

Step 6A-10 - Perform a Power Balance Test on the engine. The Power Balance Test is accessed using your Diacom scan tool. For best results, perform this test with the engine under load, running between 1600 - 1800 RPMs. This test can isolate a coil/ignition module circuit and/or fuel injector circuit problem to a specific cylinder. This will help determine what cylinder(s) to focus your diagnostic efforts on.

NOTE: The Diacom Power Balance Test should be performed with the engine under load. This provides for easier viewing and pitch change recognition when a cylinder is shut off. The Diacom Power Balance Test will be discussed in detail in the PCM Engine Management System Section, under Diacom Tests.

Step 6A-11- Perform the engine harness “Wiggle Test”. With the engine running, start at the boat/engine harness connectors and wiggle the harness. Move forward along the starboard side wiggling the harness at sensor, injector and coil connections. Then repeat for the port side of the harness. A change in engine operation indicates a wiring defect in the area where the wires were wiggled. Repair wiring or connections as required.

Warning: Take ALL Safety Precautions into consideration since you will be working around a HOT running engine with moving components.

Step 6A-12 - The final test will be a Diacom recording based on the Pre-Delivery test run. Compare this Diacom file to the Pre-Delivery recording of this engine if available, or to another new engine of the same model. Look for data that is out of range versus new engine data. Troubleshoot and repair circuits that read out of range. File this test and all relative information in the customer’s service and/or sales file.

NOTE: Keep your Diacom recording so that it may be emailed to the factory service representative if you are unable to resolve the problem.

Completing the steps on your PCM Drivability Checklist through step 6A will locate most symptomatic problems. Be sure to record all your findings as you perform the PCM Drivability Checklist.

If you have completed the PCM Drivability Checklist through Step 6A, and have not found and resolved the problem, **STOP** and call the PCM Technical Service Department for assistance. PCM Warranty and Service Department: 803-345-0050.

Have your completed PCM Drivability Checklist and Diacom recording readily available when you call the PCM Technical Service Department for assistance. You may be requested to fax or e-mail a copy of the checklist to the Technical Service Department during your discussion with the factory service representative.

DRIVABILITY CHECKLIST - NO CODES

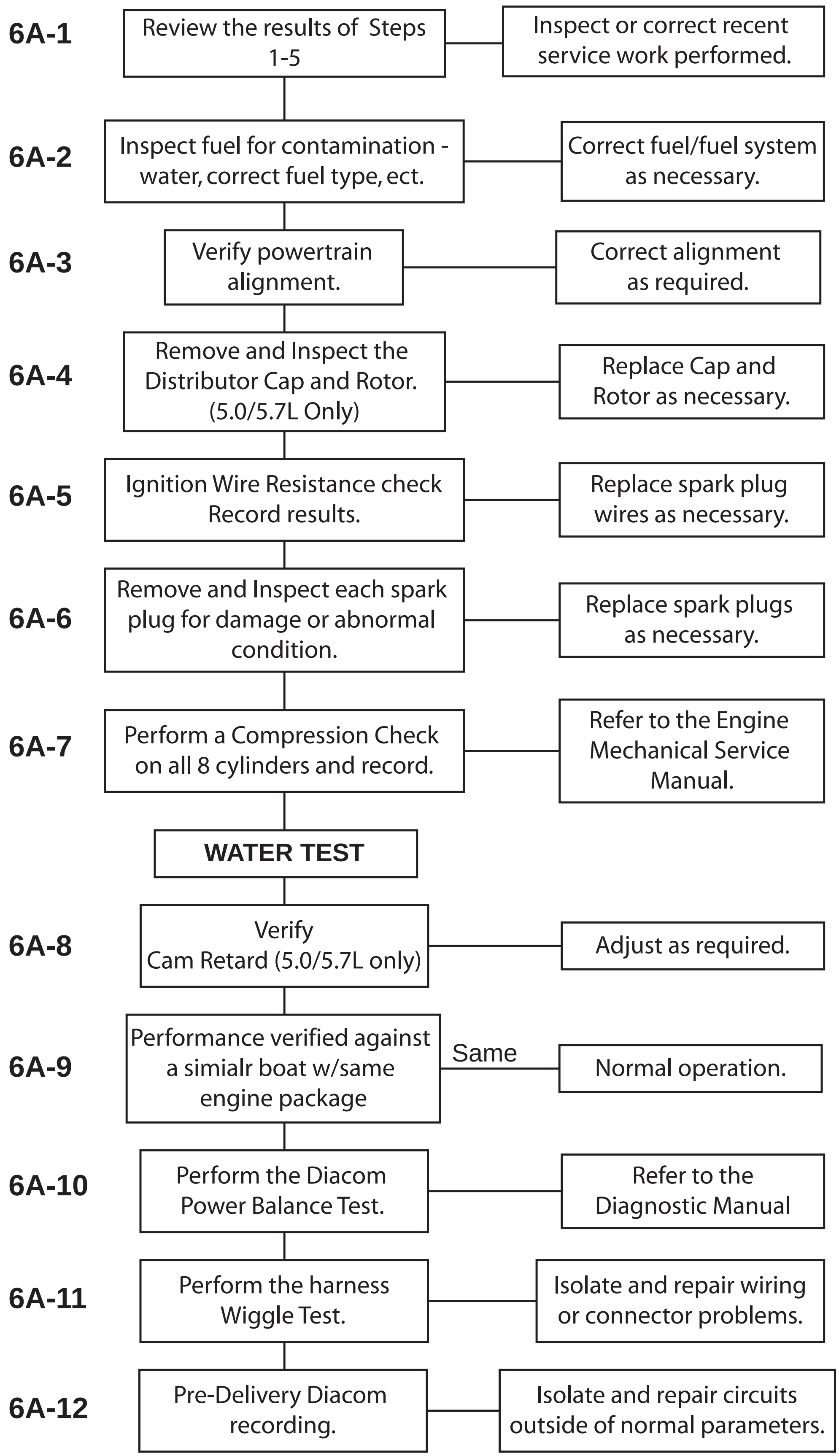


Figure 2-4 PCM Drivability Checklist - No Codes

7. Verify your repair action has corrected the problem.

Once you have completed a repair action, clear any codes from the ECM. If codes return after repairs are made or you had multiple codes listed in the ECM's memory return to Step 6, Isolate and Repair the Problem, and perform the procedure and repair action for the remaining code(s). Steps 6 and 7 will have to be performed for each stored code until the system is repaired and tests normally. Always retest to verify the engine is operating normally.

The original problem may have been caused by another system or event; ensure that you have corrected both the cause and the original problem. When you verify your repair action, be sure to test ***With the boat in the water***, and:

1) Run the boat a minimum of two (2) minutes to verify that no codes reset, and then

2) Run the boat long enough to verify your repair has corrected the problem.

PCM DRIVABILITY CHECKLIST - 2

SYSTEM POWER CHECK

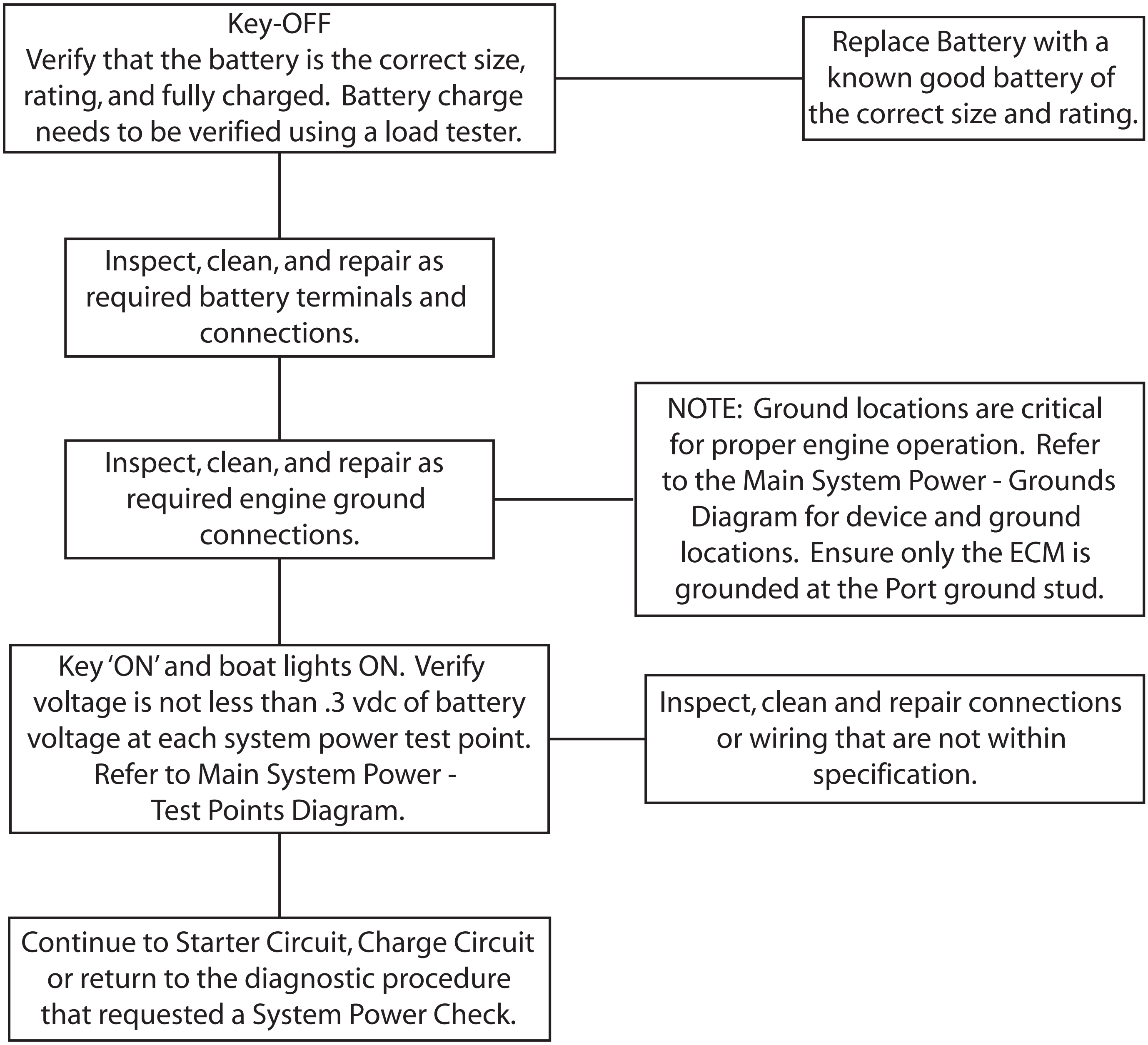


Figure 2-5 System Power Troubleshooting Tree

STARTER CIRCUIT TROUBLESHOOTING TREE

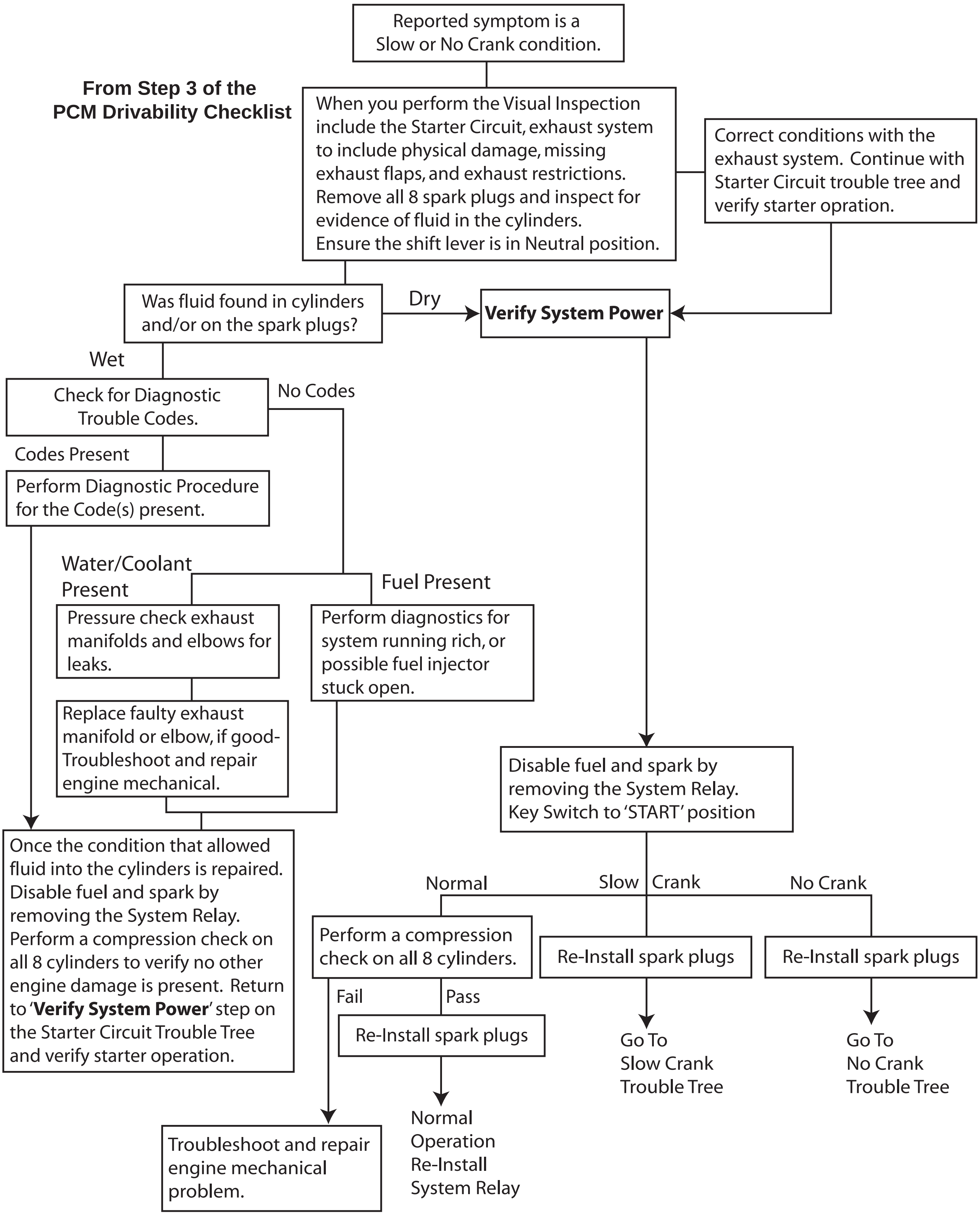
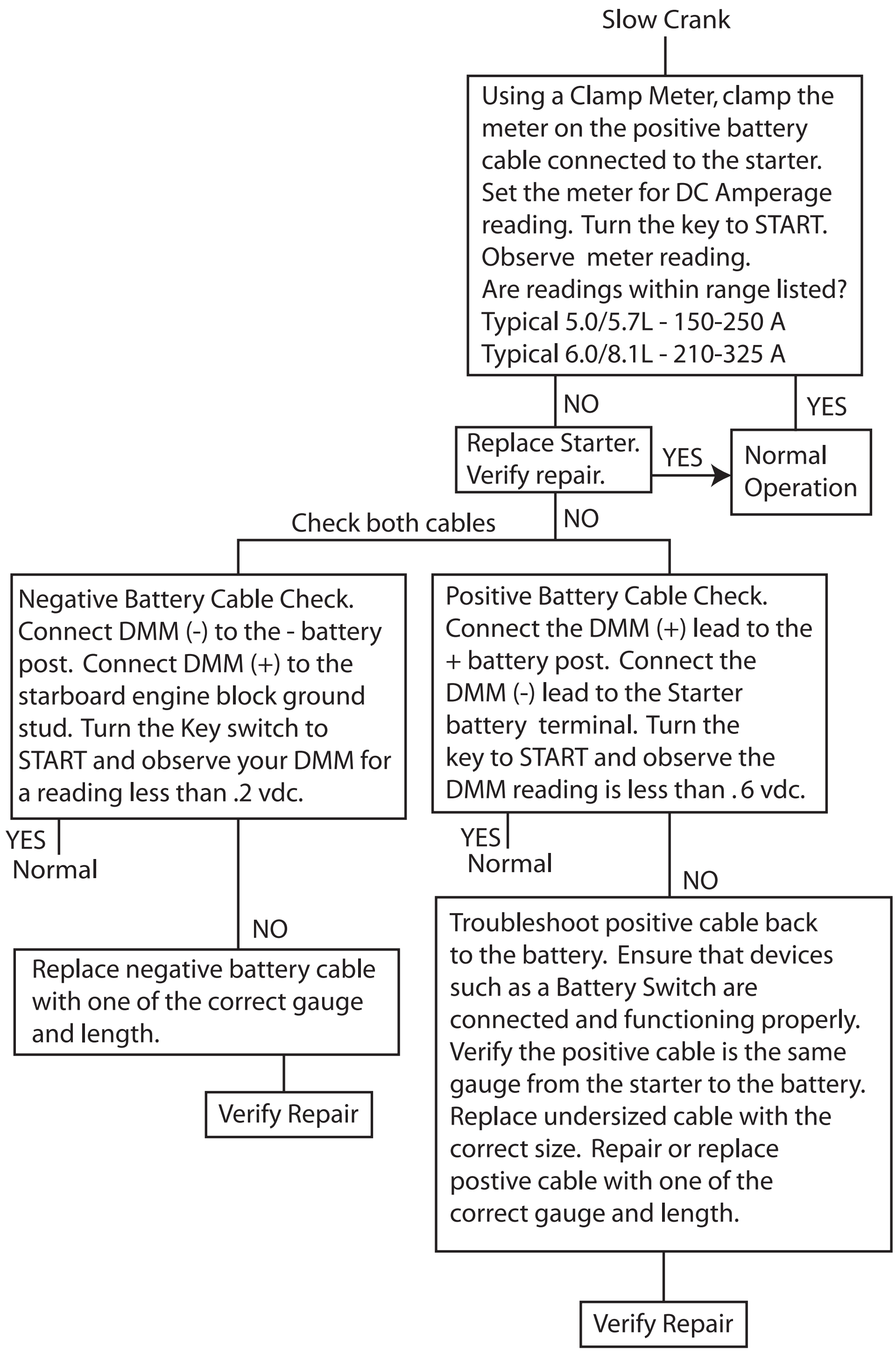


Figure 2-6 Starter Circuit Troubleshooting Tree

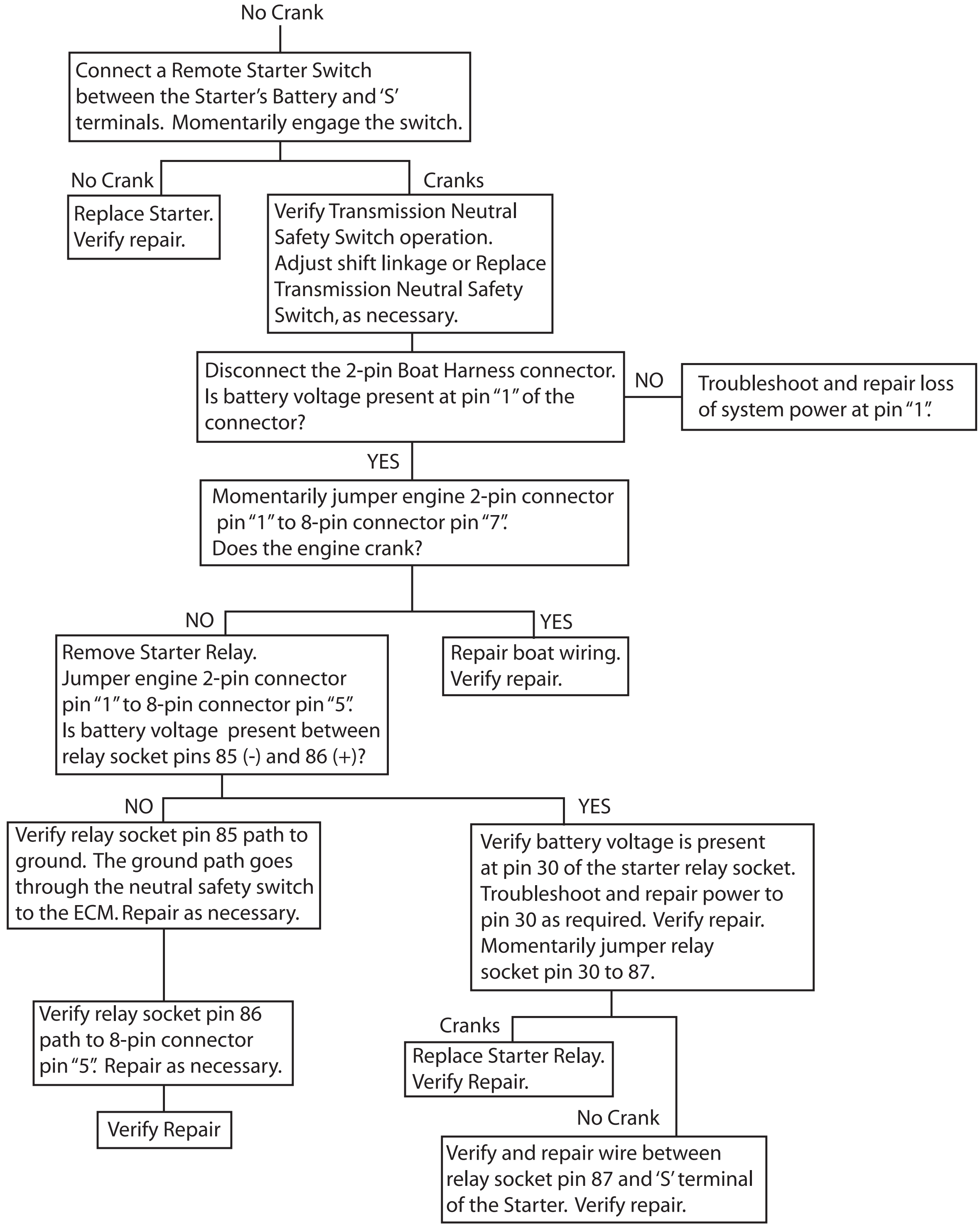
STARTER CIRCUIT
TROUBLESHOOTING TREE
SLOW CRANK CONDITION



******** IMPORTANT ********
When you have completed your troubleshooting and repair of the starter, be sure to Reinstall the System Relay, then verify the engine starts and runs.

Figure 2-7 Starter Circuit - Slow Crank

STARTER CIRCUIT
TROUBLESHOOTING TREE
NO CRANK CONDITION



******** IMPORTANT ********
When you have completed your troubleshooting and repair of the starter, be sure to Reinstall the System Relay, then verify the engine starts and runs.

Figure 2-8 Starter Circuit - No Crank

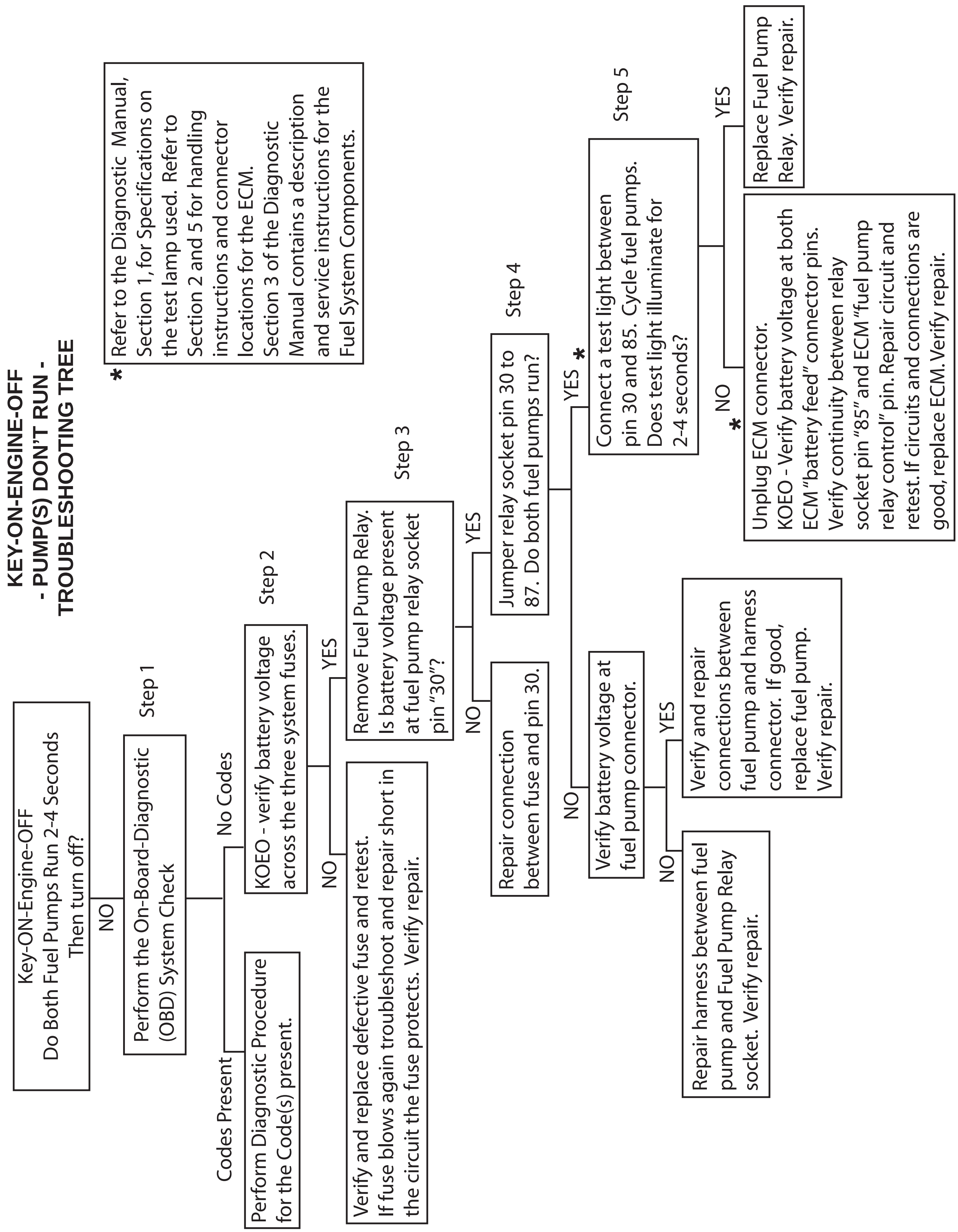


Figure 2-9 Fuel System - Fuel Pump(s) Do Not Run

KEY-ON-ENGINE-OFF
FUEL PRESSURE OUT OF RANGE - PUMPS RUN

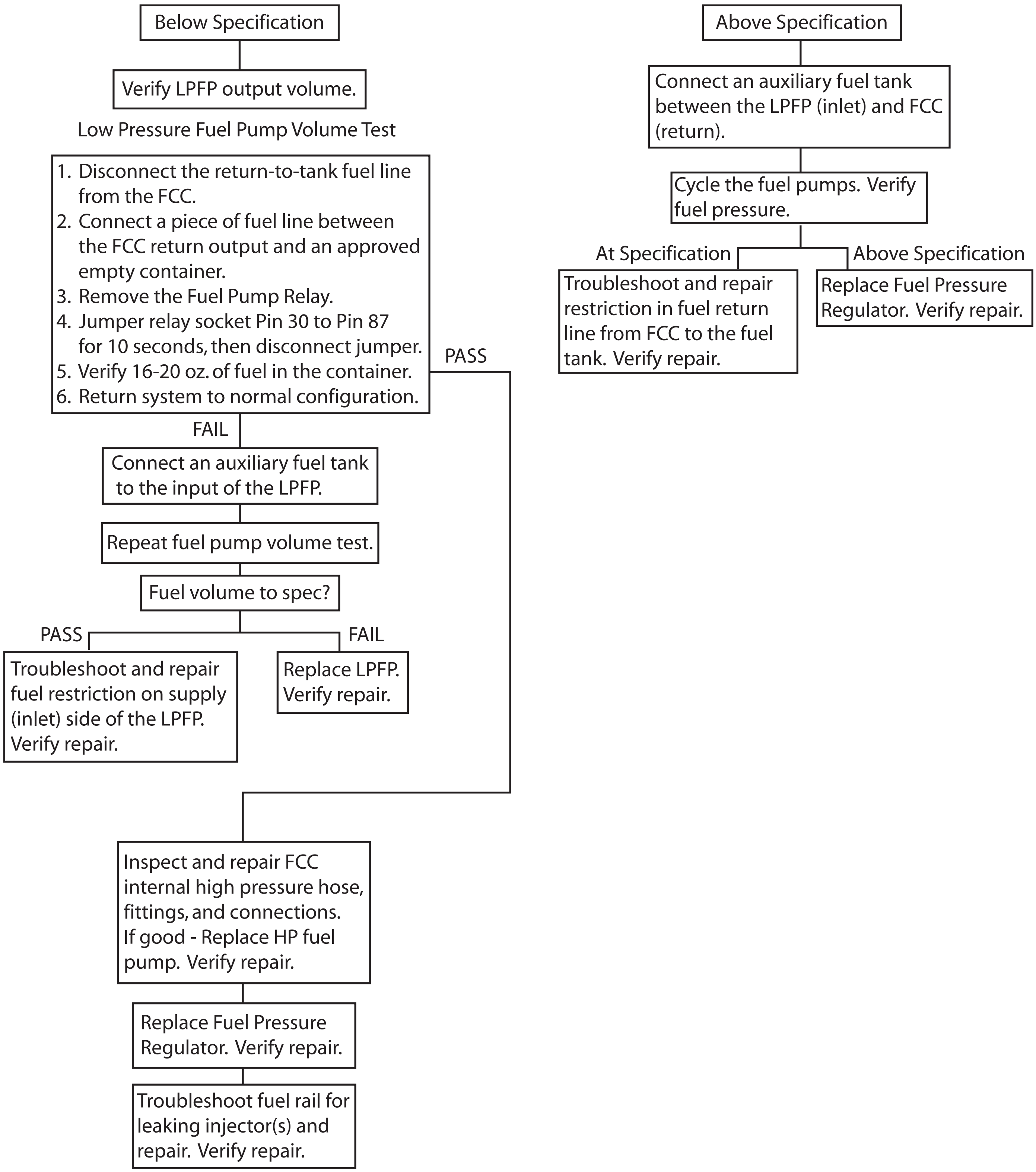


Figure 2-10 Fuel System - Fuel Pressure Out-Of-Range

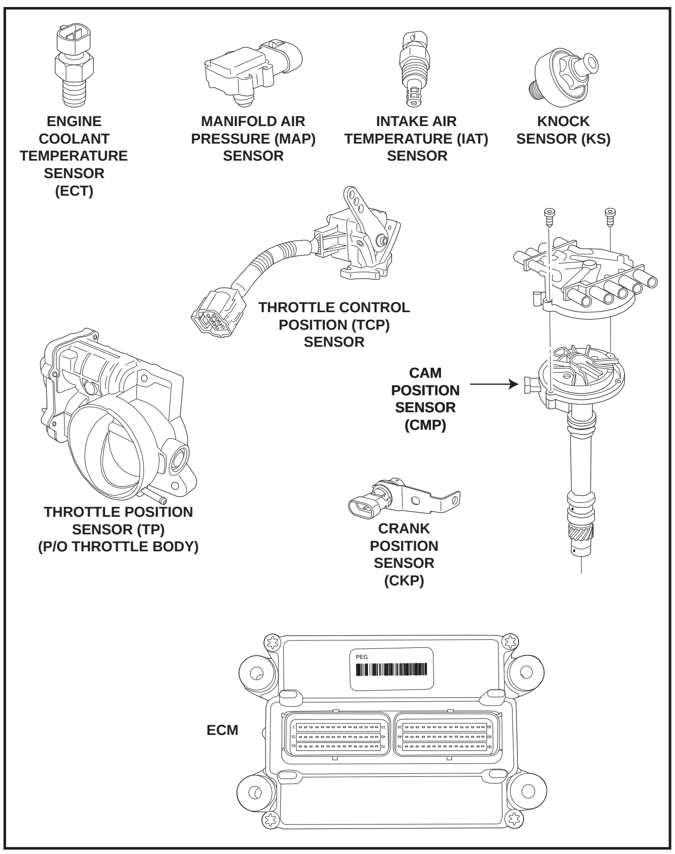
NOTES

Section 3 Engine Management System

Engine Management System - Overview

The ECM (Engine Control Module) is the brain of the Engine Management System. The ECM is responsible for maintaining the proper spark and fuel delivery for all operating conditions of the engine. To provide optimum drivability and emissions, the ECM monitors various input or sensor signals in order to calculate ignition control and fuel delivery. The following devices provide these inputs to the ECM:

- ECT, the Engine Coolant Temperature sensor,
- IAT, the Intake Air Temperature sensor
- TP, the Throttle Position sensor,
- KS, the Knock Sensor(s),
- MAP, the Manifold Absolute Pressure sensor,
- TCP, the Throttle Control Position sensor,
- HO2, the Heated Oxygen sensors,
- CKP, the crankshaft sensor, and
- CMP, the camshaft sensor.



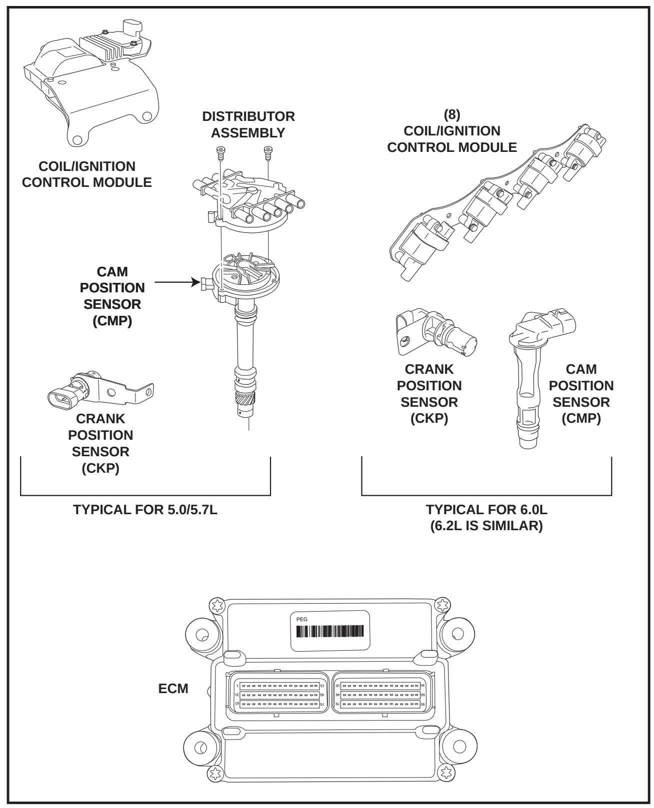
Refer to Section 2 of the Diagnostic Manual for a detailed description of the sensors and ECM.

To control spark and ignition timing the ECM controls one of two ignition systems. Both systems utilize a crankshaft sensor (CKP) to create Ignition Control (IC) signals. The ECM uses these inputs to trigger the ignition coil(s) and fuel injector circuits.

5.0/5.7L engines use the Distributor Ignition system. This system uses a Distributor to route spark to each cylinder from a single ignition control (IC) circuit and coil.

The 5.0/5.7L engines use a Camshaft (CMP) sensor to generate a signal named CAM Retard. The CAM Retard specification in degrees ensures proper rotor to cap positioning to prevent ignition crossfire. Refer to the Master Specifications for each model year engine for the correct setting.

6.0/6.2L engines use the Electronic Ignition system. This system uses eight individual ignition control (IC) circuits and coils. When starting the 6.0/6.2L engines, the ECM fires two coils for each IC signal until #1 cylinder can be located by the ECM. The 6.0/6.2L engines use a Camshaft (CMP) sensor to identify the compression stroke of TDC position of #1 cylinder, allowing the ECM to fire individual cylinders in the firing order sequence.



The failure of critical system components and/or circuits monitored by the ECM will generate and store Diagnostic Trouble Codes (DTCs) and illuminate the Malfunction Indicator Lamp (MIL) or Check Gauges Lamp (CGL) on the dash panel of boats.

Refer to Section 4 of the Diagnostic Manual for a detailed description of the ignition components used.

The MIL or CGL will stay illuminated when the engine is running as long as the failure is present. If the problem is intermittent, or has been repaired, the MIL or CGL will stay illuminated for up to 3 ignition cycles after the problem is corrected.

NOTE: When the DTC's are cleared using the Diacom scan tool (and the fault is not present), the MIL or CGL will immediately go out with the engine running.

NOTE: The Malfunction Indicator Lamp (MIL) is AMBER in color and the Check Gauges Lamp (CGL) is RED in color. Over-temperature and oil pressure faults illuminate the CGL, all other faults illuminate the MIL. Many manufacturers use digital displays for instrumentation. Faults are indicated through these displays, and DO NOT use separate lamps.

The DTCs are accessed using Diacom when you check the ECM for stored codes.

Diagnostic Manual

One of your most important tools for troubleshooting an Engine Management System problem will be the Diagnostic Manual. Take some time and familiarize yourself with the location and information that is contained in each of the sections. The manual is divided into several sections.

- Section 1 is General Information on the system, special tools, an abbreviation definition table and service instructions for engine harness and connector problems.

Section 1 not only lists the special tools required when working on an engine management system, but also specifies requirements for common tools you may already be using. A test light used for troubleshooting must pass the test requirements specified in Section 1. A Digital Multi-Meter must have a minimum input impedance of 10 mega ohms.

- Section 2 provides a description and service instructions for the Engine Control Module (ECM) and sensors.
- Section 3 describes how the fuel metering system operates, and provides a description and service instructions for the different fuel systems on the engines.
- Section 4 provides a description and service instructions for the two Ignition Systems used on the engines.
- Section 5 is the Diagnostic section and provides you with the procedures, schematic diagrams and definitions for troubleshooting an engine management problem.

Section 5 contains your primary diagnostic information, definitions, diagnostic procedures and wiring diagrams. While all the information contained in the manual is important, Section 5 will be your most widely used section of the manual. You should thoroughly familiarize yourself with the information contained in this section.

- Section 6 provides a description and service instructions for the Positive Crankcase Ventilation (PCV) System.
- Section 7 provides you with symptom diagnostics, using the PCM Drivability Checklist, for various malfunctions that do not generate a trouble code.

Diagnostic Trouble Codes (DTC)

Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI)

Diagnostic Trouble Codes (DTC) will be set and stored in the ECM whenever the ECM detects an engine management failure. These failures, when active, are reported to the operator through either lamps/buzzers or through a warning on the digital display.

DTC's have been commonized through Federal Regulations. This means that all engine manufacturers have the same identification numbers for each emission failure. Failures are now identified by a Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI). Both of these numbers are required in order to identify the exact failure detected.

NOTE: Diacom only displays the FMI and SPN numbers. Be sure to have both these numbers for each fault displayed. Diacom does not report the DTC number.

OBD System Check

During a previous discussion on the PCM Drivability Checklist, it was noted the reported problem may be found and corrected during any step of the checklist. During Step 4, refer to Figure 3-1; you checked for both system power and starting capabilities of the engine. You did this when you turned the key to the ON and then START positions. If the actions described did not occur, you would have begun troubleshooting and repair of the Main Electrical System, Engine Mechanical System or the Fuel System. If we completed Step 4, then we have determined the basic engine condition to be normal at this point in our testing.

Step 5 of the Drivability Checklist, OBD System Check, is the first diagnostic procedure you will perform for any remaining drivability issue with the engine.

Important: Starting issues are not the same as starter issues. If the engine has a cranking problem, diagnose that problem first, through the Main Electrical system troubleshooting. If the engine cranks normally (150-200 rpm) but will not start, then you would perform Step 5 of the PCM Drivability Checklist, the OBD System Check.

While it may seem that almost all problems encountered with the engine are Engine Management System problems, in reality, very few actually are. This perception exists because we are conditioned to begin troubleshooting by connecting the scan tool and checking the ECM for trouble codes. What needs to be realized; this is more a check to eliminate the engine management system from the troubleshooting effort. When you check the ECM for stored codes there are basically three results that may occur:

1. **The Diacom scan tool cannot communicate with the ECM.**

This may be the result of:

(1) a system power failure,

(2) a blown fuse,

(3) a faulty System Relay,

(4) a defective ECM,

(5) a damaged engine harness,

(6) an accessory device connected improperly into the CAN BUS data circuits.

(8) Diacom improperly installed, or

(9) a defective/out-of-date Diacom interface cable.

While some of these examples are definitely engine management system problems, most are outside conditions or other system failures that appear through the engine management system.

2. **There is a stored Diagnostic Trouble Code (DTC).**

This may be the result of:

(1) a failed electronic circuit,

(2) low system voltage, or any other condition which could cause an interruption in system power, such as a defective ignition switch or corroded or loose power and ground connections,

(3) improper shut down of the engine, such as using the battery switch instead of the ignition switch,

(4) a defective engine or boat harness, or

(5) a improperly connected device.

3. **There are no stored DTC's.**

Any abnormal condition, from system power to an engine mechanical problem, can affect the performance and drivability of the engine.

The fact is, none of these results clearly indicate an engine management system problem. This is why just checking for codes is an insufficient check. Stay on track by using the PCM Drivability Checklist and perform Steps 1-4 completely prior to Step 5, the OBD System Check. Finding or not finding a trouble code and jumping to a conclusion could waste valuable time in your troubleshooting effort.

The OBD System Check is followed by multiple Diagnostic Procedures. These diagnostic procedures all support and ensure the successful completion of the OBD System Check. All the engine management and drivability troubleshooting procedures will require the successful completion of the OBD System Check before proceeding to the next Diagnostic Procedure. If your OBD System Check fails, you will be referenced to one or more of these Diagnostic Procedures.

PCM DRIVABILITY CHECKLIST

ENGINE SERIAL NUMBER: _______________

Date: _______________ **Dealership Name:** ____________________________________

Technician's Name:_____________________________ **Technician's Contact Phone #:** _________________________

Owner/Operator Name: ________________________________

Person Reporting the problem (if different from owner/operator): _____________________________

Service Writer or Person that took the problem report: ______________________________________

1) PROBLEM OR SYMPTOM: ____

Who first observed the symptom?___________________When did the symptom first occur? ____________

Any recent change or service work prior to symptom occurring - replaced belts or impeller, major engine or boat repairs, recently refueled, etc.? ____ Has someone, other than yourself, tried to correct the current symptom? _________ If yes, what work was done?__________________________

Accessories Added Recently? ___________________________________Is the symptom currently present? ___________

Special conditions (if any) required to duplicate the symptom: ______________________________________

Use an additional sheet of paper if more space is required for symptoms or descriptions.

2) CHECK FOR SERVICE UPDATES:

ENGINE SERIAL NUMBER: _______________ **ENGINE MODEL NUMBER:** _______________ **ENGINE HOURS:** ____

HULL NUMBER: __________________

ENGINE: None Apply: __ Performed: _____________________________

BOAT: None Apply: __ Performed: _____________________________

3) VISUAL INSPECTION:

Inspection	YES	NO
Evidence of an over-heat:		
Engine Harness connectors connected properly:		
Physical Damage - wiring, connectors, assemblies, and **Remove Spark Plugs and inspect for fluids.**		
Corrosion:		
Hull-clean and free of excessive growth:		

Inspection	YES	NO
Evidence of or Excessive Water in the Bilge:		
Fluid levels checked:		
Leaking Fluids:		
Firing order correct:		
Correct size propellers installed:		
Underwater gear is undamaged:		
Accessories added? If yes, check items		

4) VERIFY THE PROBLEM

	YES	NO	
Does the engine start and continue to run?	**go to 3 below**	**go to 1 below**	
1) Key-ON-Engine-OFF (KOEO)	**YES**	**NO**	**Fuel Press.**
Both Fuel Pumps run 2-4 seconds:			
Fuel Pressure near wot specification - when pumps run:			
2) Key-ON-Engine-Running (KOER)	**YES**	**NO**	**Fuel Press.**
Engine cranks:			
Fuel Pressure near wot specification - engine cranking:			
Engine Starts and continues to run:		go to	(3) Water Test
3) WATER TEST	**YES**	**NO**	**Fuel Press.**
Verify reported symptom:			
Fuel Pressure - idle:			
Fuel Pressure - under load, @ WOT:			

Check Accessories Added:

- ☐ Heater
- ☐ Shower
- ☐ Hot Water Tank
- ☐ Flush Kit
- ☐ Multi-Function Display
- ☐ Synchronizer
- ☐ After-Market Stereo Equipment
- ☐ After-Market Depth/Fish Finder
- ☐ After-Market Navigational Equipment, such as GPS, Radar, Sonar, Auto-pilot systems
- ☐ After-Market Radio Equipment
- ☐ Lights
- ☐ Other - (please list)

4A) Revised or additional symptom found?: ____

1

Figure 3-1 PCM Drivability Checklist
L599003-13

PCM DRIVABILITY CHECKLIST

5) PERFORM THE OBD SYSTEM CHECK

CODE(S) PRESENT: _______________ DIAGNOSTIC PROCEDURE USED: _______________ **Continue to Step 6**

6) ISOLATE AND REPAIR THE PROBLEM.

Were you able to isolate and repair the problem? If ***YES***, continue to **Step 7.**
If ***NO***, complete the Drivability Checklist for No Codes, step 6A below. If the problem is still not resolved, then call for factory technical assistance.

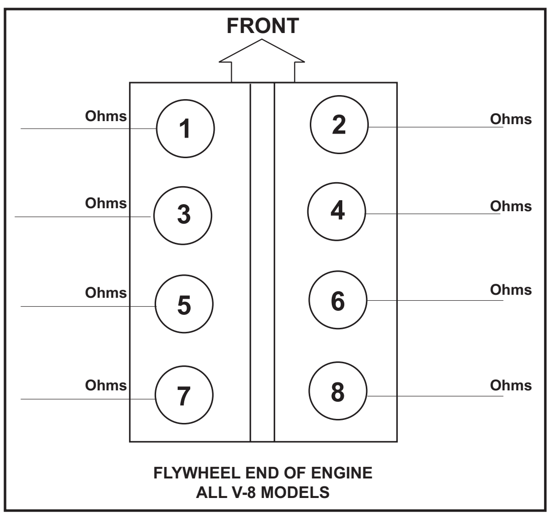
6A) NO CODES - ENGINE RUNS - DRIVABILITY SYMPTOM STILL PRESENT

Inspection or Check	YES	NO
1) Review Steps **1** thru **5**:		
2) Inspect fuel for contamination:		
3) Electrically isolate engine from boat:		
4) Powertrain is aligned:		
5) Remove and Inspect Distributor Cap and Rotor (5.0/5.7L only):		
6) Check&**record** Ignition wire resistance:		
7) Remove and Inspect each spark plug:		
8) Perform a Compression Check on all 8 cylinders: **Record below.**		

Inspection or Check	YES	NO
WATER TEST		
9) Verify CAM Retard** (5.0/5.7L only):		
10) Performance verified against a similar boat w/same engine. package, if available		
11) Perform the Diacom Power Balance Check; under load, @ 1600-1800rpm:		
12) Perform the harness 'Wiggle Test':		
13) Diacom recording-Pre-Delivery test:		

7) VERIFY REPAIR HAS CORRECTED THE PROBLEM. Check for and clear all codes from the ECM memory. **Water test the boat.** Run the engine for a minimum of two (2) minutes, then verify that no codes have returned. Continue with your water test long enough to verify that the problem has been corrected.

**** CAM Retard - '02 thru '06 = 43-47 degrees**
'07 - SN 485993 = 0 - 4 degrees/CES and SN 485994↑= 15 ± 2 degrees



IGNITION WIRE RESISTANCE CHECK
Less than 10,000 ohms/ft

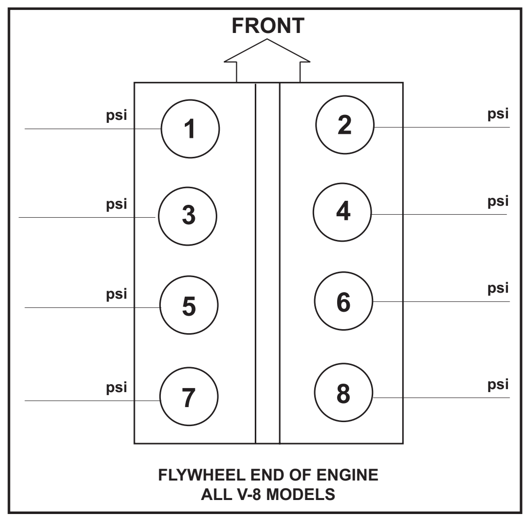
COMPRESSION PRESSURE:

5.0/5.7L - 130-215 psi

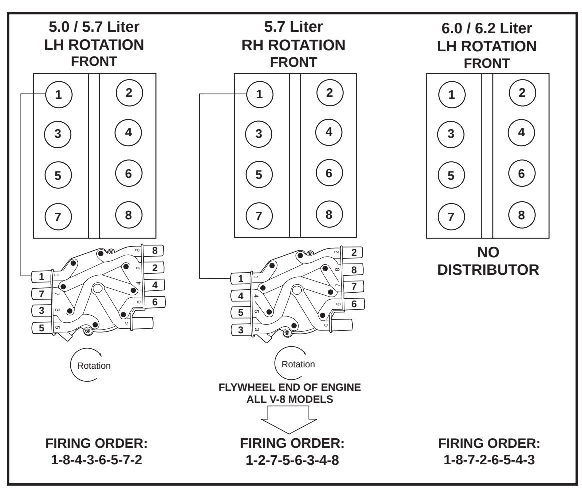
6.0L - 130-215 psi

6.2L - 130-215 psi

Lowest pressure should be within 70% of highest pressure. Minimum cylinder pressure - 100 psi.



COMPRESSION CHECK



REFERENCES:

Master Engine Specification Sheets

L510030 - GCP / 4G Diagnostic Service Manual

L510015 - 5.0/5.7L Engine Mechanical Service Manual

L510016 - 6.0L Engine Mechanical Service Manual

PCM Premier Dealer Website - All the Latest Publications

2

Figure 3-1 PCM Drivability Checklist
L599003-13

OBD SYSTEM CHECK

Step 5 of the PCM Drivability Checklist

The OBD System Check procedure provides 5 areas of testing as follows:

- Checks the ECM's ability to transmit data.
- Malfunction Indicator Lamp circuit.
- Tests the ability of the engine management system to allow the engine to start and run and/or set trouble codes.
- Checks for trouble codes and then directs you to the next diagnostic procedure.
- Diagnostic troubleshooting steps.

As you can see from the descriptions, you have accomplished much of the OBD System Check when you connected the scan tool and checked for trouble codes. Be sure to do the complete OBD System Check for any engine management or drivability concerns. Remember that skipping steps may cause you to skip over the cause of a problem.

It is not practical to cover every Diagnostic Procedure in the diagnostic manual. The layout of the On-Board Diagnostic System Check is representative of each of the diagnostic procedures you will find in Section 5 of the Diagnostic Manual. Each diagnostic procedure incorporates the following:

- a schematic or drawing of the circuit under test,
- a Circuit Description,
- Diagnostic Aids,
- Test Description and
- Diagnostic Procedure.

The schematic and circuit description provided are a snap-shot of the circuit being tested. Diagnostic Aids are inspections and tests, in addition to the diagnostic procedure, that may help you better isolate the problem. Test Descriptions define or clarify Diagnostic Procedure steps. It is good shop practice to always:

- Review the schematic,
- Read the Circuit Description,
- Read the Diagnostic Aids, and
- Read the Test Descriptions that relate to the steps of the Diagnostic Procedure being performed prior to actually performing any of the tests.

NOTE: Not all diagnostic procedures, or steps in a diagnostic procedure have Test Descriptions.

Refer to the beginning of the OBD System Check diagnostic procedure.

You will always begin each diagnostic procedure at the top. You may or may not perform every step in a procedure. The action performed compared to the result will dictate your next step in the procedure.

Diagnostic procedures may specify actions, test set-ups, and/or a test procedure to perform as part of a single step.

Step 1 specifies a number of preliminary actions you must perform before the actual test. As part of Step 1, the OBD System Check incorporates three steps we discussed as part of the PCM Drivability Checklist (Figure 3-1). These include:

1. Review of Service Updates,
2. a Visual Inspection,
3. Condition of the Starter and System Power.

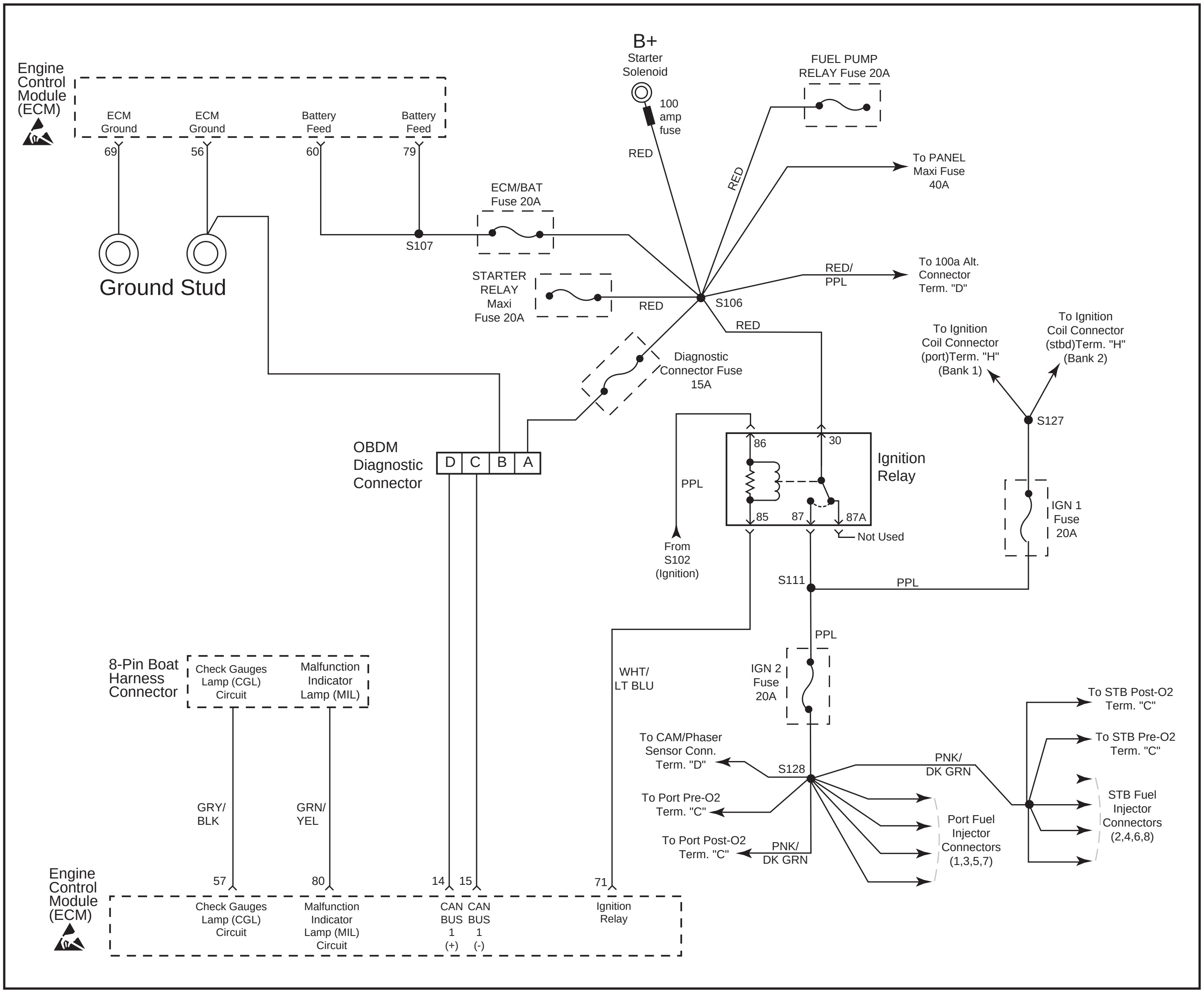
When you follow the PCM Drivability Checklist, these checks will have been accomplished before you begin this procedure.

When you complete an action or test sequence in a diagnostic procedure, the procedure will ask you a YES/NO question about the result. The OBD System Check Step 1 asks "Does the scan tool display 'ECM Data'?". The answer determines the correct path to proceed to in the procedure.

Some steps are diagnostic checks for communications problems of the ECM. One step of this procedure is an example of how the Test Descriptions can aid you in your troubleshooting. In this case, there is a Note referring you to the Test Descriptions. The Test Description for this provides you with conditions that can affect the transmission of CAN BUS data to the scan tool. One is a faulty scan tool; the other is an suspect auxiliary device(s) possibly wired into the CAN BUS circuit. Both are conditions that can affect the outcome of your test.

Even though some diagnostic steps do not have 'Test Descriptions', you should always read the Test Description information available for the step you are performing, prior to executing a diagnostic procedure. Test Description information can prevent you from coming to an erroneous result and spending unnecessary time troubleshooting a problem.

NOTE: A Note directing you to read the "Test Descriptions" is not always located in the test step. Always read "Test Descriptions" prior to performing the diagnostic procedure.



On-Board Diagnostic (OBD) System Check

Circuit Description

The on-board diagnostic system check must be the starting point for any drivability complaint diagnosis. Before using this procedure, you should perform a careful visual/physical check of the ECM and engine grounds for being clean and tight.

The on-board diagnostic system check is an organized approach to identifying a problem created by an electronic engine control system malfunction.

Diagnostic Aids

An intermittent may be caused by a poor connection, rubbed through wire insulation or a wire broken inside the insulation. Check for the following items:

- Inspect the ECM harness and connectors for improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wire connection and damaged harness.
- Conditions of the starting system that require repair before proceeding are no crank or slow crank conditions. Always verify battery condition and connections prior to troubleshooting starter issues. Crank with no start and hard start conditions are addressed by this procedure.
- The Malfunction Indicator Lamp data display should be “ON” steady with the ignition “ON,” engine “OFF.” If it is a steady “OFF”, DP A-1 should be used to isolate the malfunction. If the MIL is slowly blinking, this indicates a diagnostic trouble code is stored.
- Verify your Diacom Installation and cables on a known good engine.

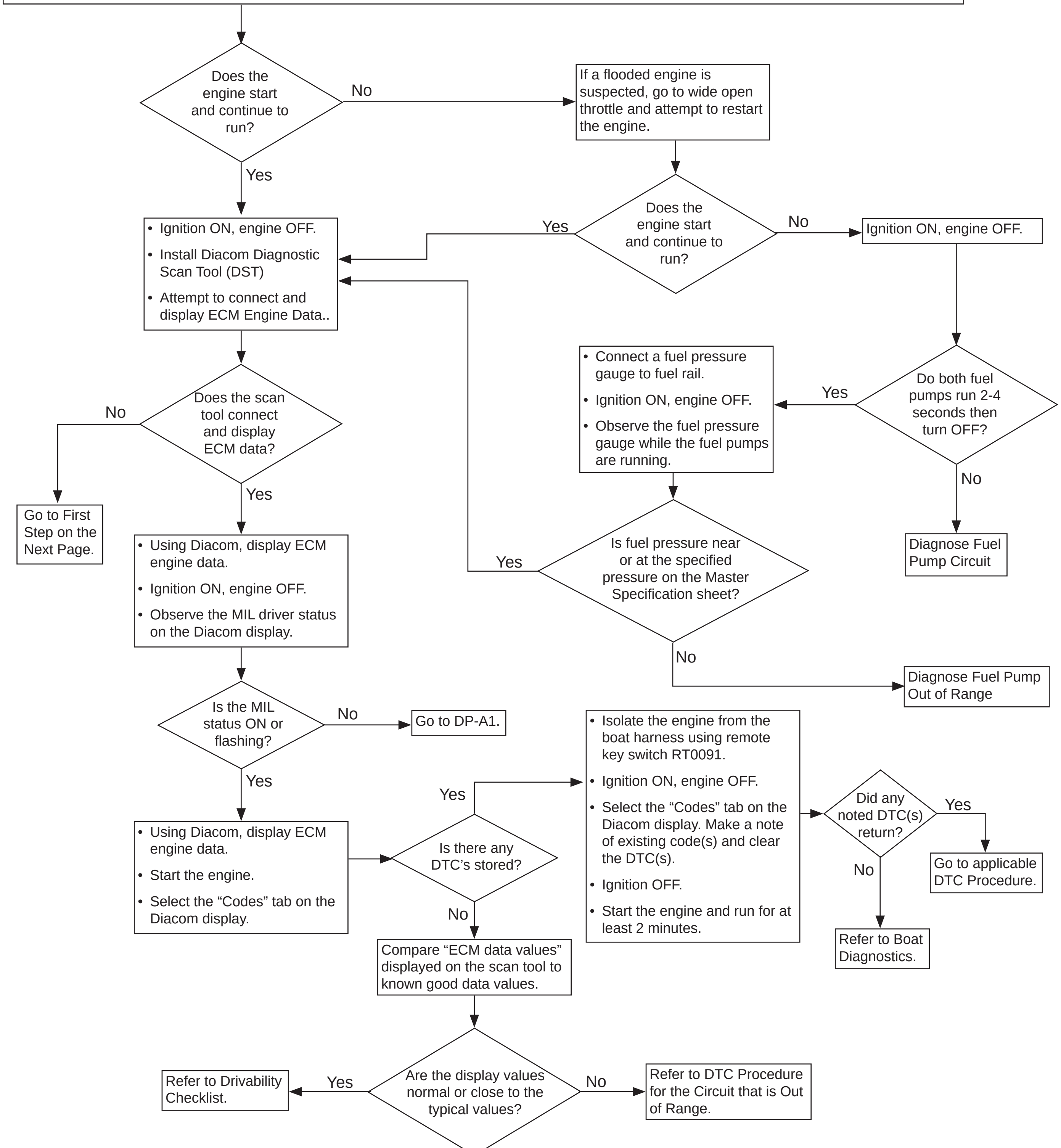
  b. Verify that no auxiliary devices are plugged into the CAN BUS circuit that could be affecting communications.

OBD System Check

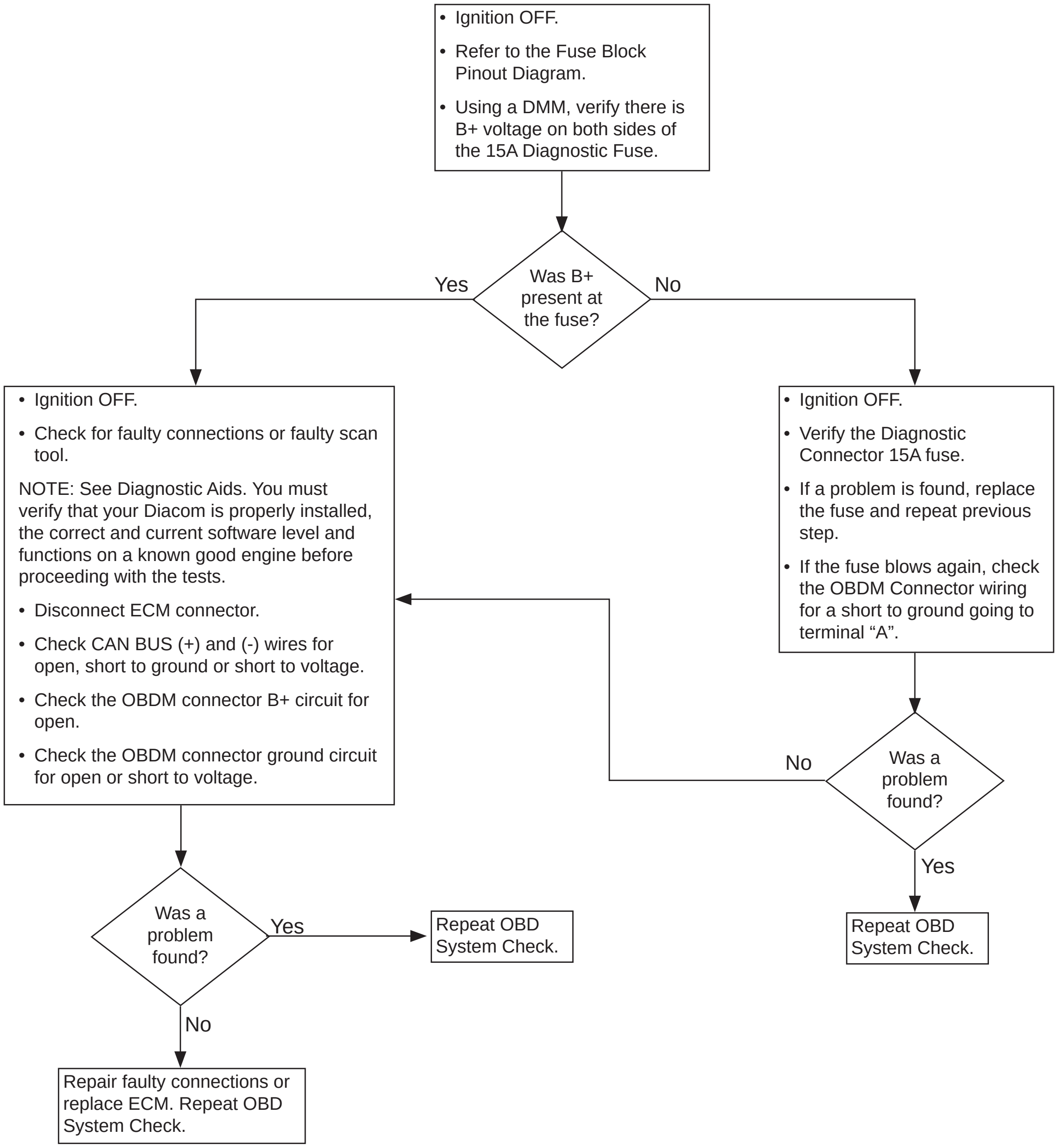
Important:

- **Do not perform this diagnostic if there is not a drivability concern, unless another procedure directs you to that diagnostic.**
- **Before you proceed with diagnosis, search for applicable service updates.**
- **Before you proceed with diagnosis, perform a visual inspection of the engine for damaged wiring, connections, assemblies or added accessories.**
- **If there is a condition with the Main Electrical System, such as a starter or charging system problem, repair that first.**
- **Ensure the battery has a full charge.**
- **Ensure the battery cables are clean and tight.**
- **Ensure the ECM grounds are clean, tight and in the correct location.**
- **Unless a diagnostic procedure instructs you, DO NOT clear the DTC's.**

Attempt to start the engine.



OBD System Check Continued



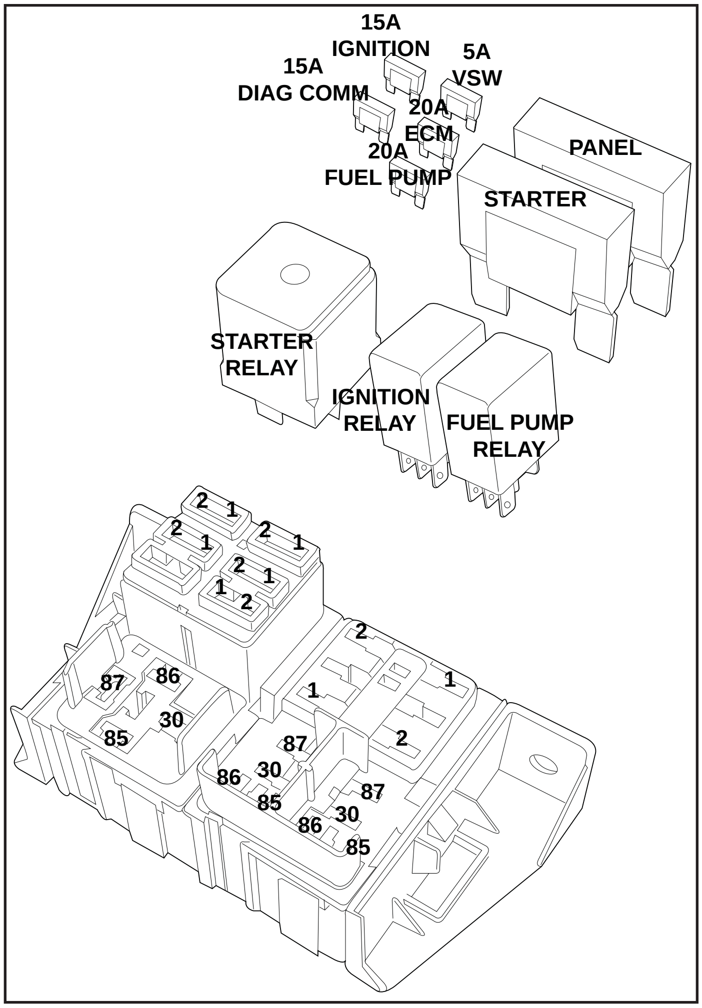


Figure 3-2 - FUSE BLOCK PIN-OUT DIAGRAM

When you successfully complete the OBD System Check you will have accomplished one of the following actions:

1. Identified and corrected the problem by performing one or more of the diagnostic procedures which supports the completion of the OBD System Check.
2. Identified and corrected the problem by performing the Diagnostic Procedure for a stored Diagnostic Trouble Code (DTC).
3. Completed the OBD System Check with no DTCs present, and the drivability symptom still present.

Items 1 and 2 above would require you to execute the additional diagnostic procedures you were directed to by the OBD System Check.

Item 3 requires you to complete the checks and inspections previously discussed as part of Step 6 of the PCM Drivability Checklist. Refer to Figure 3-1, the PCM Drivability Checklist, Step 6A and Figure 3-3, Drivability Checklist - No Codes Troubleshooting Tree.

Clearing Diagnostic Trouble Codes procedure is located in Section 5 Diagnostic manual. One of the most important items to note is that the ignition must be cycled OFF or the code may not be cleared from the ECM's memory.

It is important to note the conditions under which the ECM will or will not set a code. Occasionally, during troubleshooting you may wish to verify that a device or circuit will or will not set its code. Disabling or disconnecting the circuit and turning the ignition ON is not enough to set a code. The engine must be running to set most codes. Run times vary on when the ECM will recognize a fault and set a code. In general, the engine should run for at least two minutes at the specified criteria in order to set the code you are trying to induce, or to verify a successful circuit repair.

Clearing Diagnostic Trouble Codes

1. Install scan tool.
2. Start engine.
3. Link Diacom to the ECM.
4. Select "Codes" tab on the Diacom display.
5. Select "Erase Trouble Codes".

IMPORTANT: If the code(s) do not clear when you select "Erase Trouble Codes", then the code(s) is currently active. This indicates that the fault is still present in the system, you must trouble shoot the code(s) and correct the problem before the code can be cleared.

6. Turn ignition "OFF" for at least 5 seconds.
7. Turn ignition "ON" and read DTC's. If DTC's are still present, check "Notice" below and repeat procedure following from step 2.

It is important to note the conditions under which the ECM will or will not set a code. Occasionally, during troubleshooting you may wish to verify that a device or circuit will or will not set its code. Disabling or disconnecting the circuit and turning the ignition ON is not enough to set a code. The engine must be running to set most codes. Run times vary on when the ECM will recognize a fault and set a code. In general, the engine should run for at least two minutes at the specified criteria in order to set the code you are trying to induce, or to verify a successful circuit repair.

NOTICE: When clearing DTC's, the ignition must be cycled to the "OFF" position or the DTC's will not clear.

Malfunction Indicator Lamp (MIL) Trouble Codes

The majority of the trouble codes that the ECM stores are for emission related conditions. The AMBER Malfunction Indicator Lamp (MIL) is triggered for emission related faults. If the boat contains a Digital Display in the dash, in most cases the MIL is not used. All faults are displayed through the digital display.

Remember that DTC's have been commonized through Federal Regulations. This means that all engine manufacturers have the same identification numbers for each emission failure. Failures are now identified by a Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI). Both of these numbers are required in order to identify the exact failure detected.

NOTE: Diacom ONLY reports the SPN and FMI numbers. The scan tool does not report the DTC number.

The trouble codes help isolate the problem area to things such as: circuit short to ground, circuit open, circuit short to voltage or Bank 1 or 2 problem. These trouble codes also define sensor identification when multiple sensors are used such as knock sensors, O2 sensors or exhaust manifold water temperature sensors.

These trouble codes are diagnosed using the same logic previously stated as part of the PCM Drivability Checklist. Each trouble code has a corresponding Diagnostic Procedure. The Diagnostic Procedure will help determine if the condition was caused by:

1. A defective sensor or switch.
2. A faulty circuit or wiring.
3. A mechanical condition.

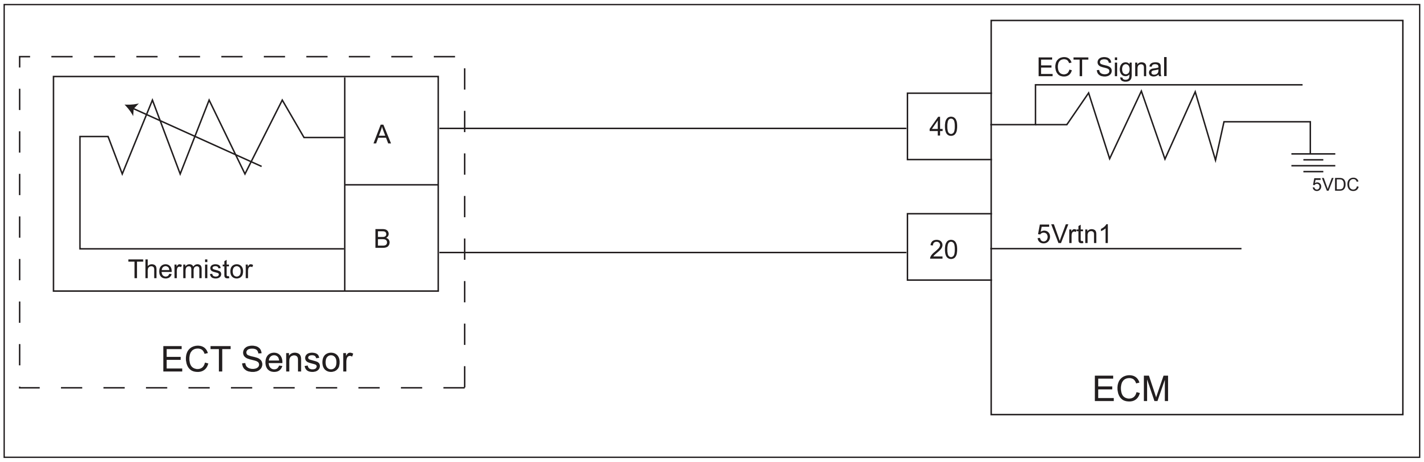
Once the cause has been determined, apply the procedures located in the service manual or troubleshooting tree that apply to the problem.

The following gives an example for the Engine Coolant Temperature (ECT) sensor Low Voltage. As you can see, the DTC is 0117; however, the important identification numbers that Diacom would display are SPN 110, FMI 4.

Using the Engine Coolant Temperature (ECT) sensor Low Voltage as an example, you can see the DTC is 0117; however, the important identification numbers that Diacom would display are SPN 110, FMI 4.

The facing page for each Diagnostic Procedure contains information that describes the fault condition to set this code. This information can be very useful when you are trying to recreate the problem or verify a repair. In many cases, the ECM will use a "default" value when a circuit failure has been detected. In this case, the ECM uses a default value of 165°F. Normally on this failure, the ECM would see a value from the ECT around 300°F. With that temperature, the ECM would not deliver near enough fuel to keep the engine running properly. The "default" value is what Diacom is displaying in this situation..

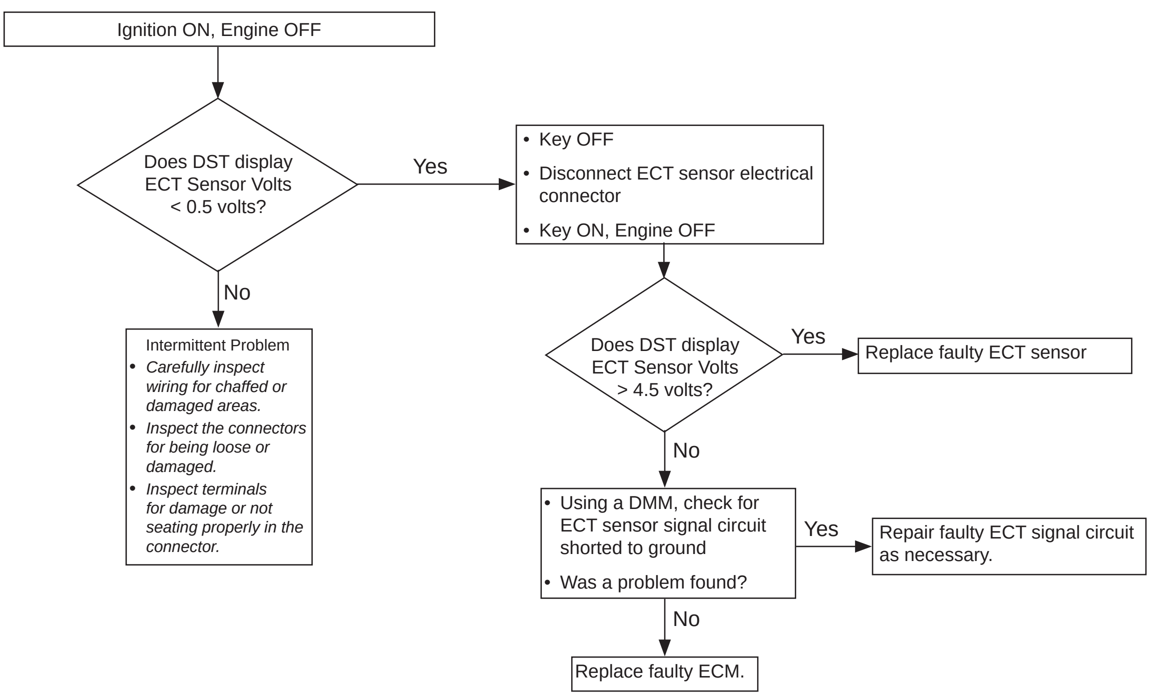
DTC 0117 - ECT Sensor Circuit Low Voltage
SPN - 110; FMI - 4



- Engine Coolant Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ECT sensor voltage less than 0.050 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. This is used for engine airflow calculation, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

This fault will set if the signal voltage is less than 0.050 volts. The ECM will use a default value for the ECT sensor in the event of this fault.



DRIVABILITY CHECKLIST - NO CODES

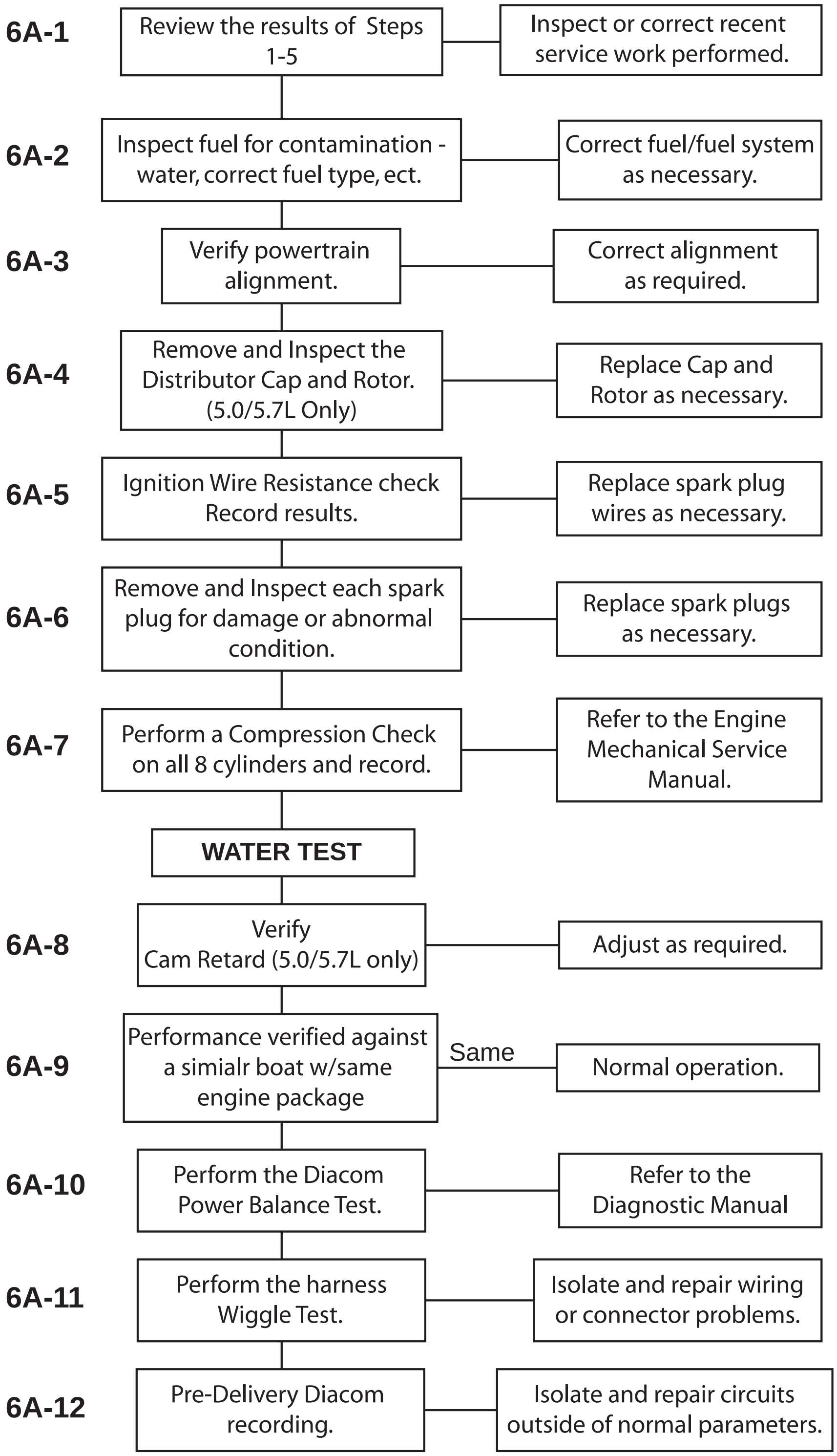


Figure 3-3 PCM Drivability Checklist - No Codes Troubleshooting Tree

L599003-13

Check Gauges Lamp (CGL) Trouble Codes

Most of the trouble codes that the ECM stores for conditions detrimental to the engine and/or transmission turn on a RED Check Gauges Lamp, if equipped. The AMBER Malfunction Indicator Lamp is triggered for emission related faults. If the boat contains a Digital Display in the dash, in most cases neither lamp is used. All faults are displayed through the digital display. The ECM may enter into Power Derate Mode should one of the following conditions occur:

- an engine overheats (Cooling System failure),
- low engine oil pressure (Engine Mechanical failure), and
- exhaust cooling system overheats (indicated by an Exhaust Manifold Water Temperature sensors located in each manifold on CES equipped engines).

Power Derate Mode is a reduced performance mode that will allow an owner/operator sufficient performance to seek service and repairs. Power Derate Mode limits the engine RPM at two different stages. When the cooling temperature or oil pressure indicates a reading exceeding the Stage 1 value, the ECM limits the throttle body to 35% maximum throttle. If the problem continues to get worse and reaches a reading exceeding Stage 2 values, the ECM limits the throttle body to an elevated idle speed.

Warning: The ECM never intentionally shuts the engine down. If the engine has low oil pressure or an over temp condition, the operator has to make the decision to shut the engine down or get to a safe location.

The following are good examples of problems reported through the Engine Management System that may be the result of another engine system failure. In these cases, the Engine Cooling System, the Exhaust Cooling System or the Engine Lubrication System may be the cause. By following the Diagnostic Procedures provided for each of the trouble codes, you will be able to distinguish the root cause of the reported failure. Your task is to determine if the condition was caused by:

- A mechanical condition.
- Improper fluid levels, under or over filled conditions.
- Fluid restrictions or lack of flow.

Once the cause has been determined, apply the procedure located in the service manual that applies to the problem.

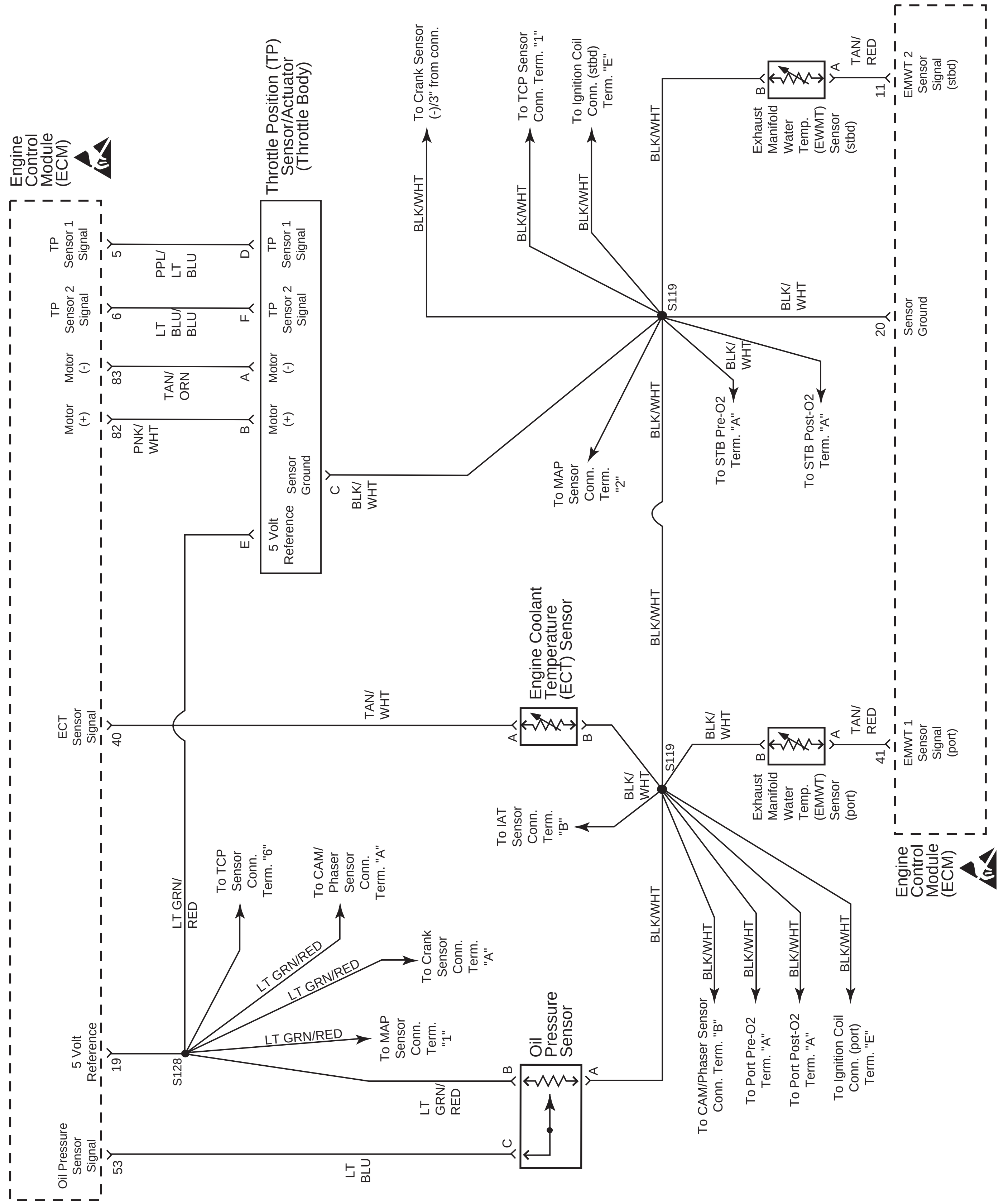


Figure 3-3 Sensor and Power Derate Circuits
L599003-13

TROUBLESHOOTING A POWER DERATE CONDITION

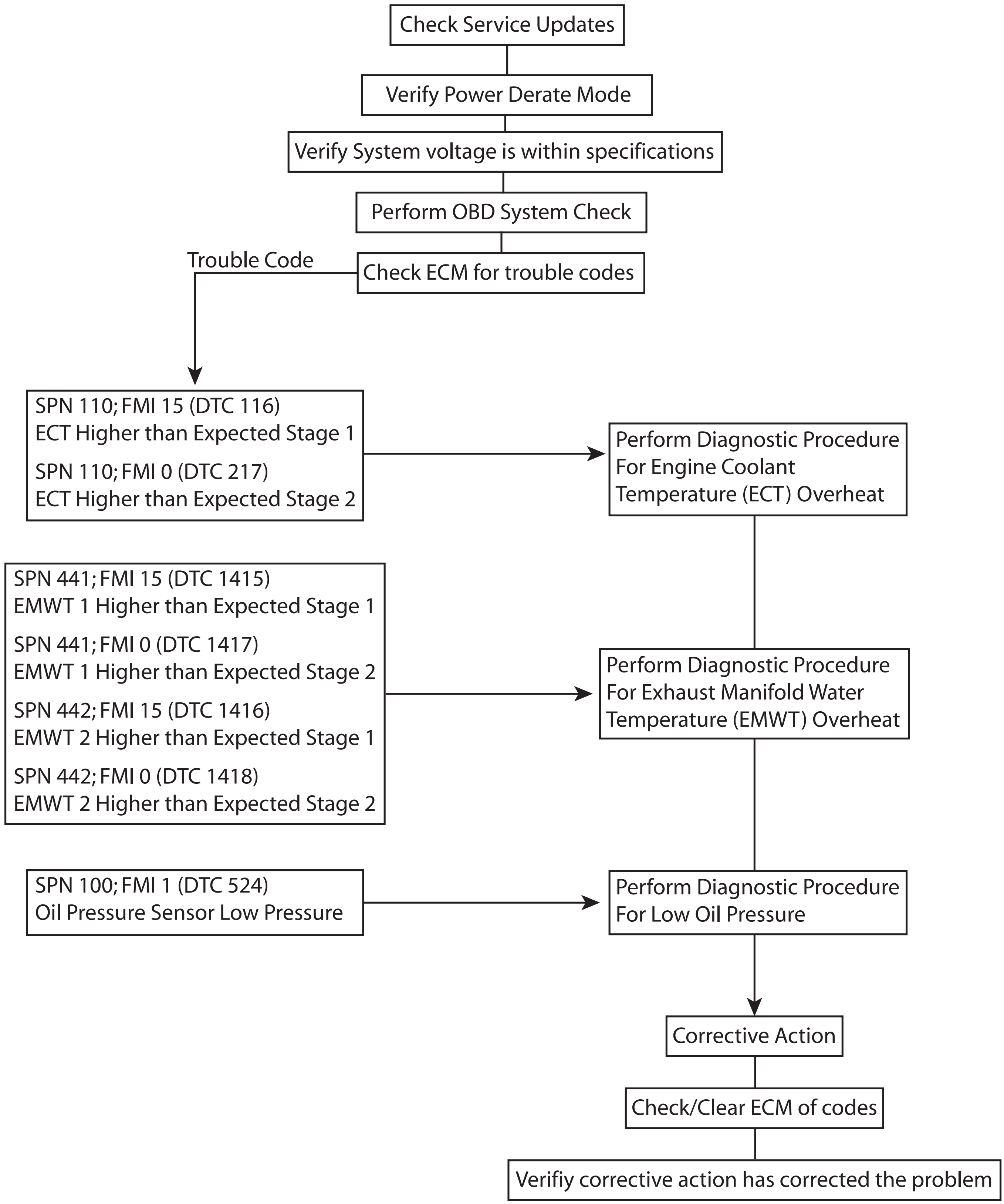


Figure 3-4 Power Reduction Mode Troubleshooting Tree

Engine Coolant Temperature (ECT) Higher than Expected Stage 1 / Stage 2 Set

Refer to Figure 3-5 and 3-6.

Engine Coolant Temperature (ECT) Higher than Expected Stage 1 / Stage 2 indicates that the ECM has detected an engine over-temperature condition. The ECT sensor provides the over-temperature reading to the ECM.

These trouble codes will be set and Power Derate Mode may be enabled when the ECT detects a coolant temperature in excess of 200°F (Stage 1) and 205°F (Stage 2). You would perform the Over-Temperature Troubleshooting Tree, Figure 3-6 of your Reference Material, which will be discussed in more detail in the Cooling System section of this course.

These trouble codes illuminate the Check Gauges Lamp (CGL). When equipped, the CGL is RED. In many models, these trouble codes are reported through a digital dash display.

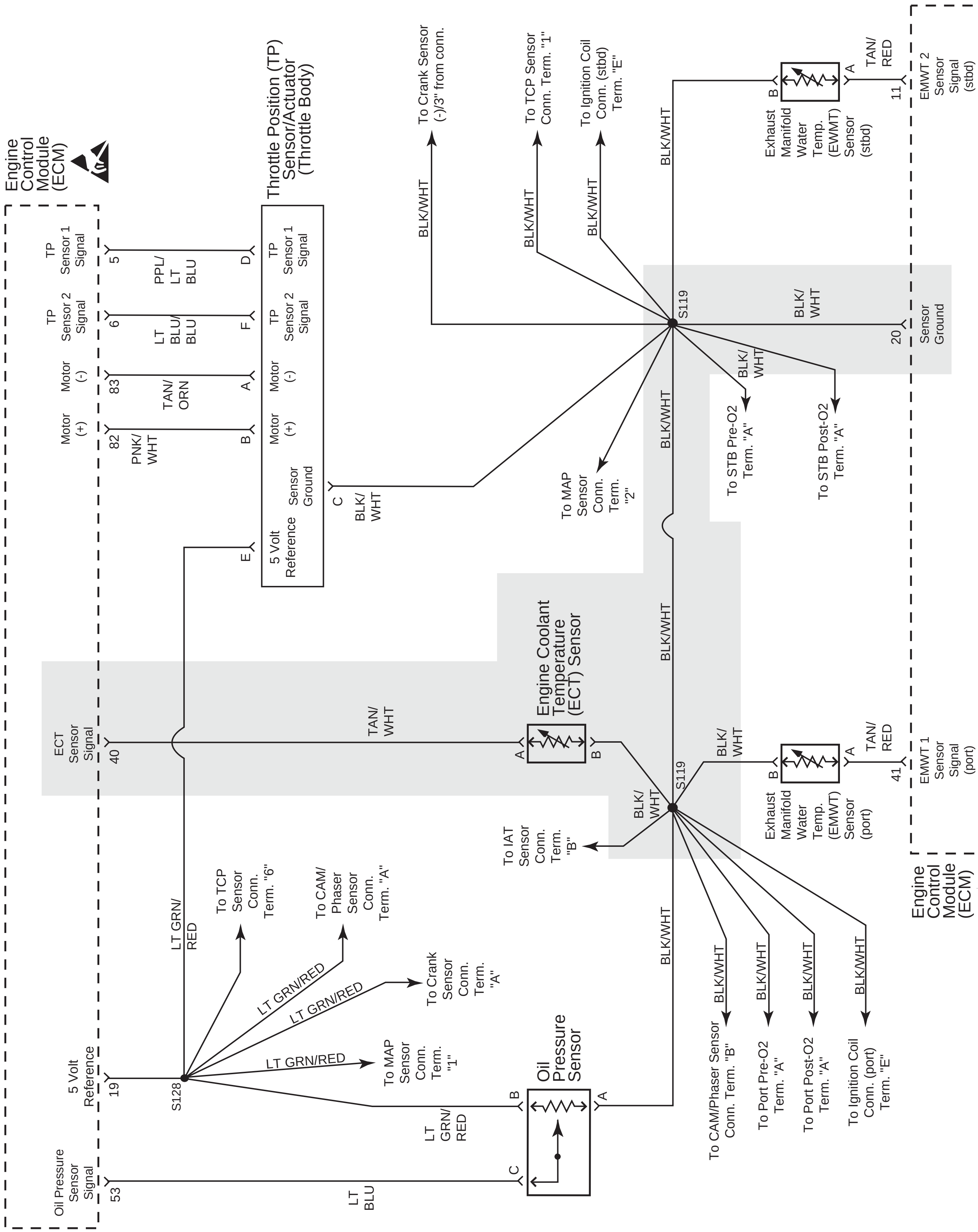


Figure 3-5 Power Derate Mode - ECT Circuit
L599003-13

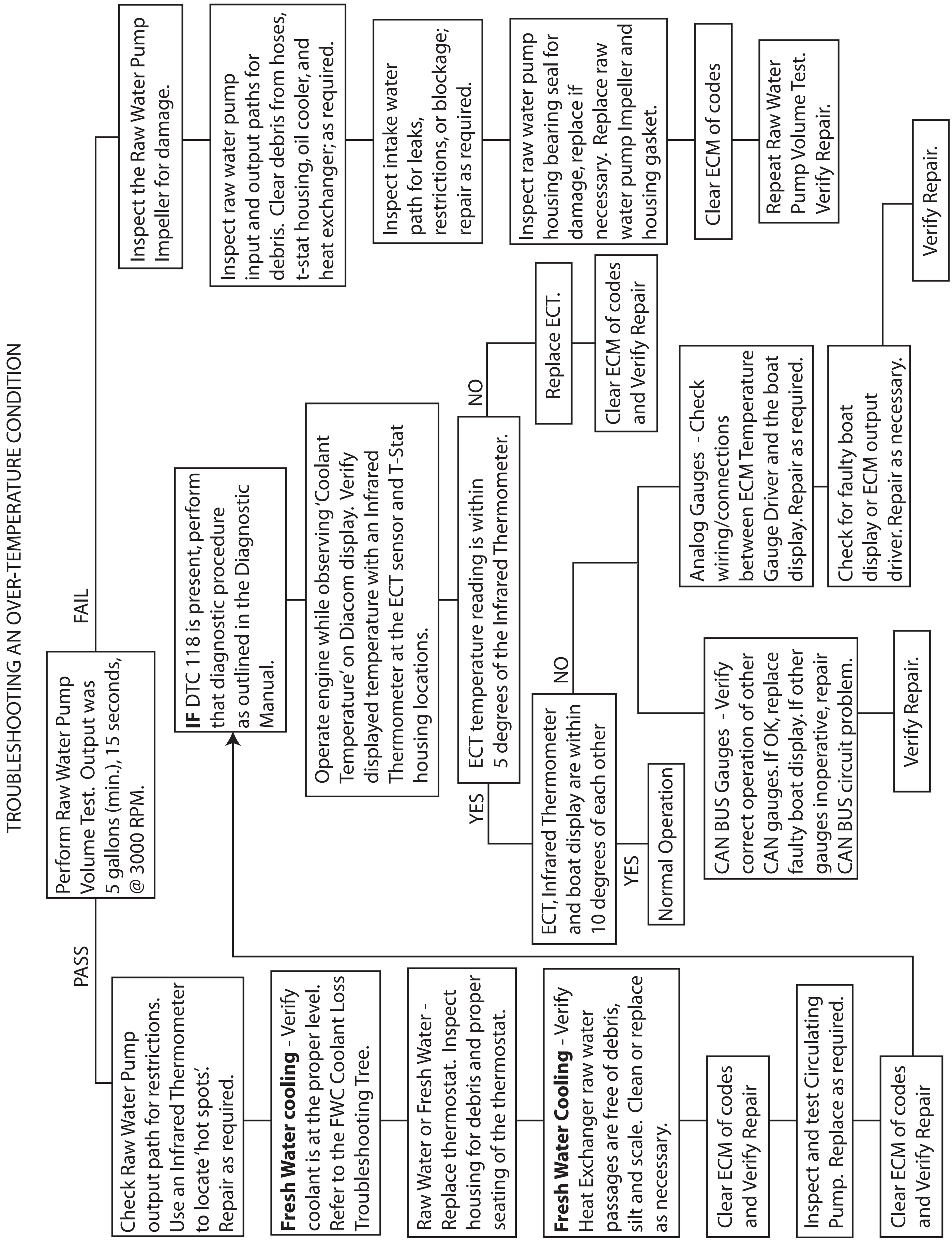


Figure 3-6 Engine Over Temperature - With Codes Troubleshooting Tree

Exhaust Manifold Water Temperature (EMWT) 1 and/or 2 Higher than Expected Stage 1 / Stage 2 Set

Refer to Figure 3-7 and 3-8.

Exhaust Manifold Water Temperature (EMWT) Higher than Expected Stage 1 / Stage 2 indicates that the ECM has detected an exhaust water over-temperature condition. The EMWT sensors provide the over-temperature reading to the ECM. There is an EMWT sensor in each exhaust manifold. EMWT 1 refers to the ODD cylinder (Left) side of the engine and EMWT 2 refers to the EVEN cylinder (Right) side of the engine.

These trouble codes will be set and Power Derate Mode may be enabled when either EMWT sensor detects a temperature in excess of 220°F (Stage 1) and 225°F (Stage 2). You would perform the EMWT Over-Temperature Troubleshooting Tree, Figure 3-8, which will be discussed in more detail in the Cooling System section of this course. These trouble codes illuminate the Check Gauges Lamp (CGL). When equipped, the CGL is RED. In many models, these trouble codes are reported through a digital dash display..

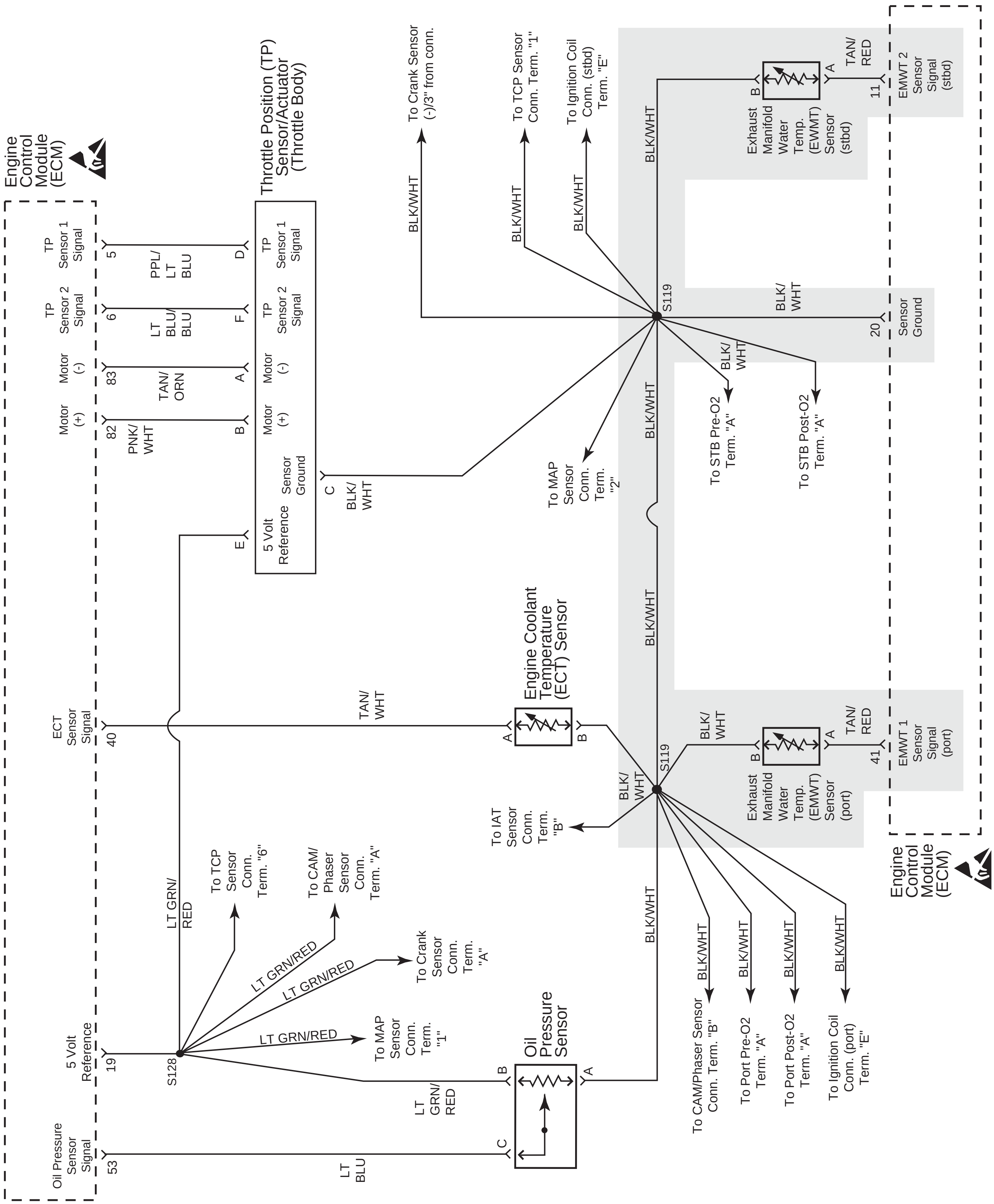


Figure 3-7 Power Derate Mode - EMWT Circuits

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TROUBLESHOOTING AN EXHAUST MANIFOLD WATER TEMPERATURE
HIGHER THAN EXPECTED STAGE 1/STAGE 2 CONDITION

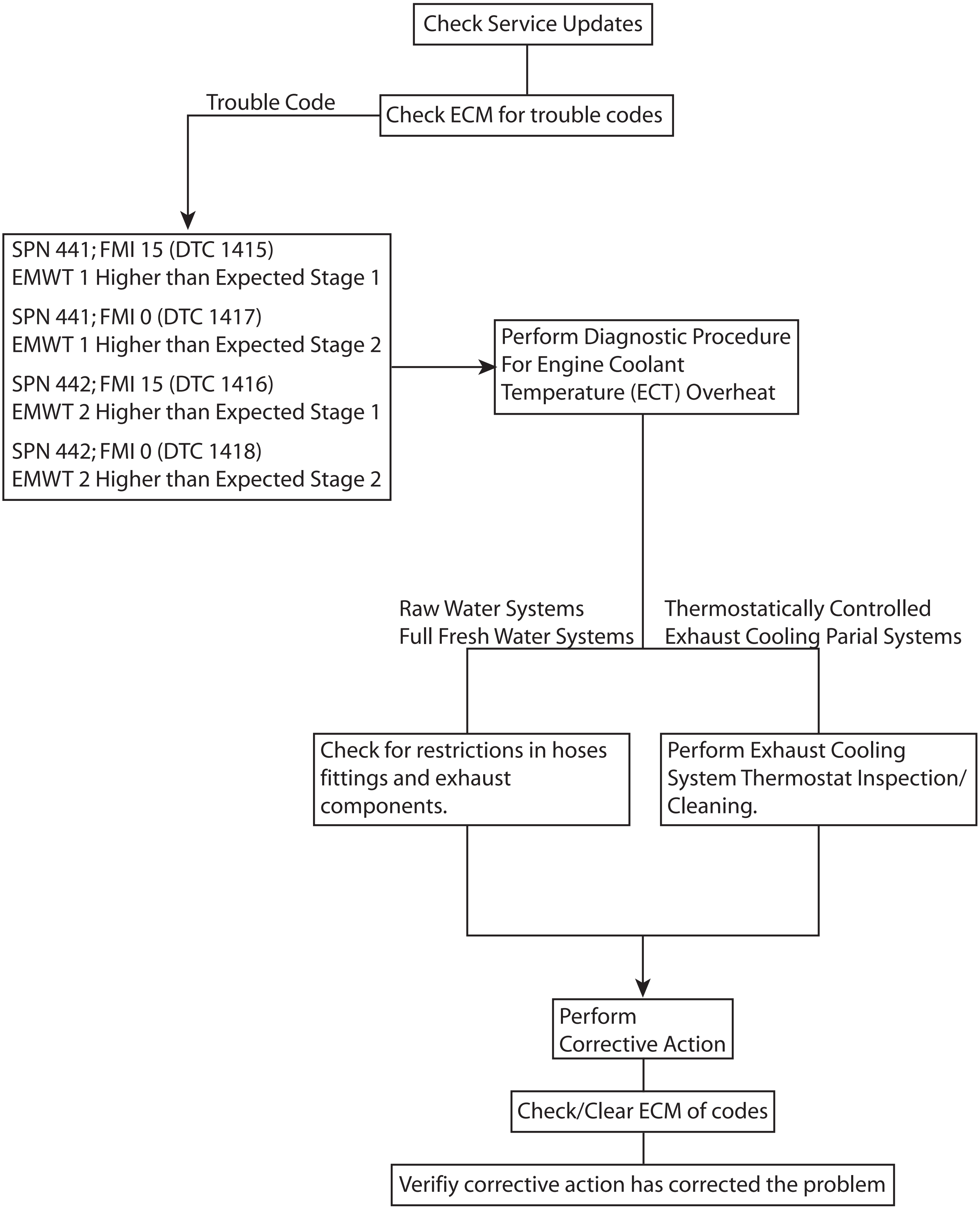


Figure 3-8 Exhaust Coolant Over Temperature - With Codes Troubleshooting Tree

Low Oil Pressure Telltale Set.

Refer to Figures 3-9 and 3-10.

The Low Oil Pressure trouble codes indicates the ECM has detected a low oil pressure condition. The oil pressure sensor provides the oil pressure information to the ECM.

This trouble code will be set and Power Derate Mode may be enabled when the oil pressure sensor detects an oil pressure less than 5 psi at idle or less than 24 psi at 4000 RPM. The diagnostics are linear between idle and 4000 RPM. This means if the engine was at 2000 RPM, the diagnostic limit would be less than 16 psi. Using a sensor instead of a switch allows for much better protection throughout the RPM range. You would perform the Low Oil Pressure Troubleshooting Tree, Figure 3-10. This trouble code illuminates the Check Gauges Lamp (CGL). When equipped, the CGL is RED. In many models, these trouble codes are reported through a digital dash display.

This is a good example of a problem reported through the Engine Management System that may be the result of another engine system failure. In this case the Engine Lubrication System. By following the Diagnostic Procedures provided for this trouble code, you will be able to distinguish between the system being monitored and a possible engine management system failure.

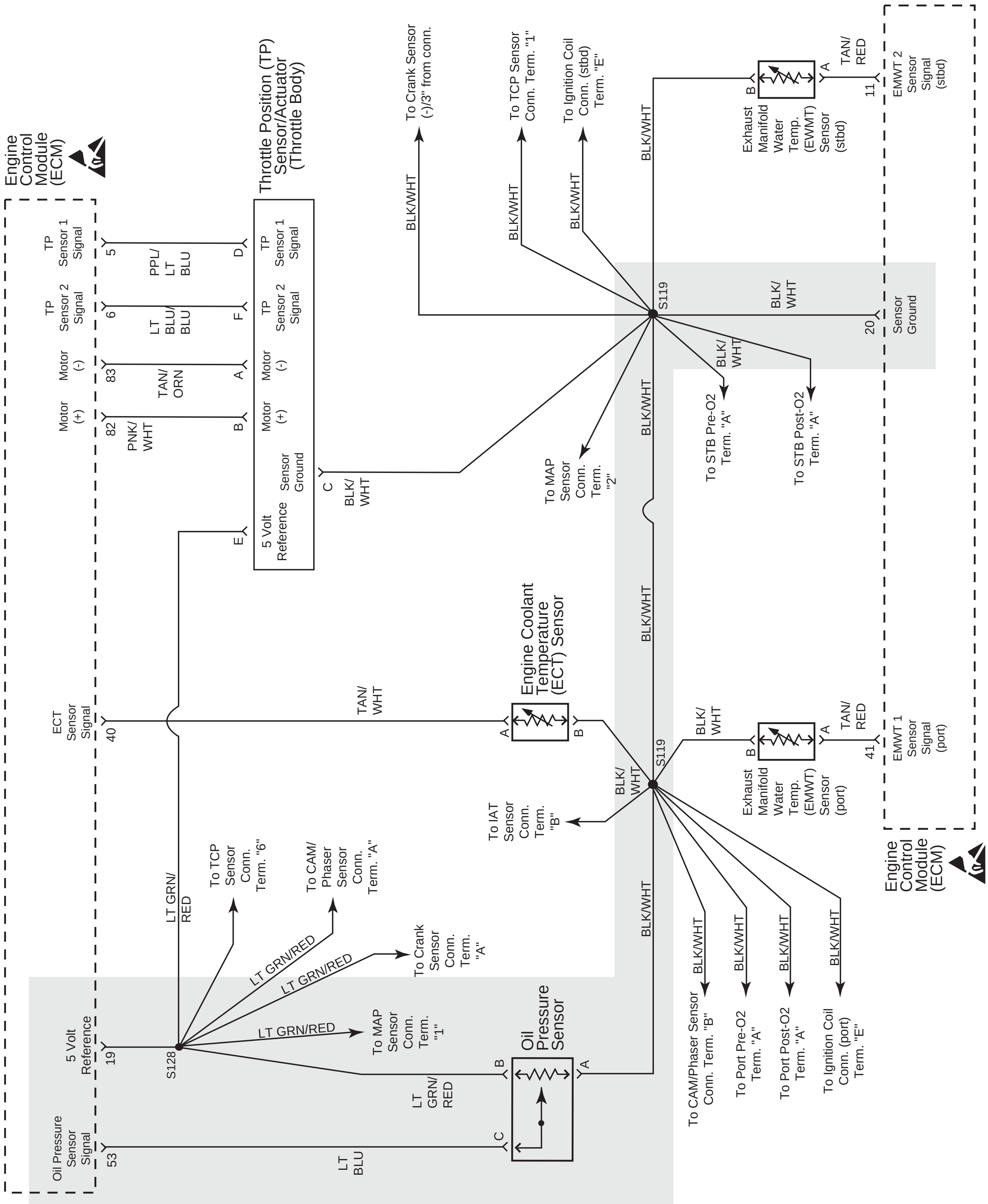


Figure 3-9 Power Derate Mode - Oil Pressure Circuit
L599003-13

TROUBLESHOOTING A POWER DERATE MODE
LOW OIL PRESSURE TROUBLE CODE SET

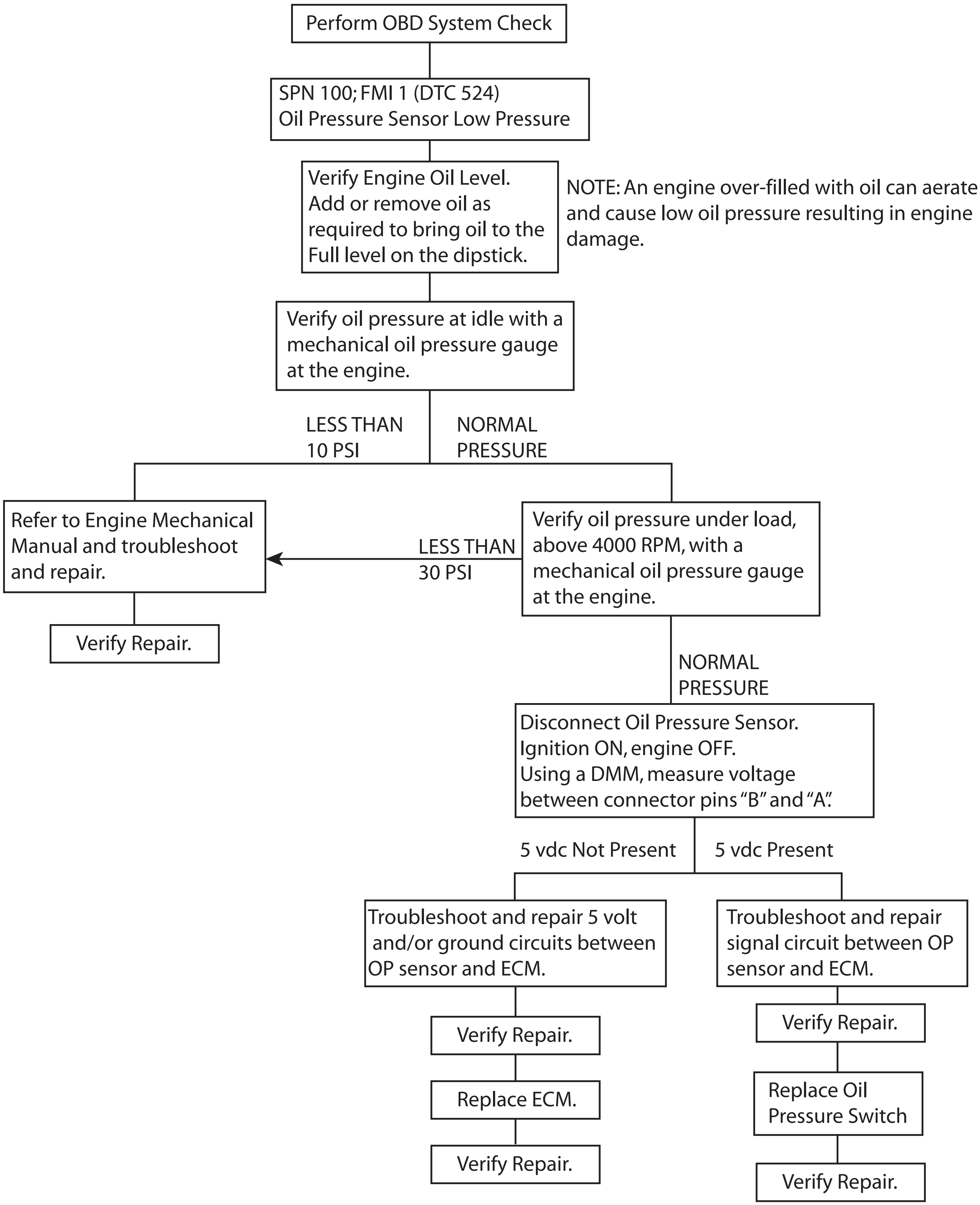
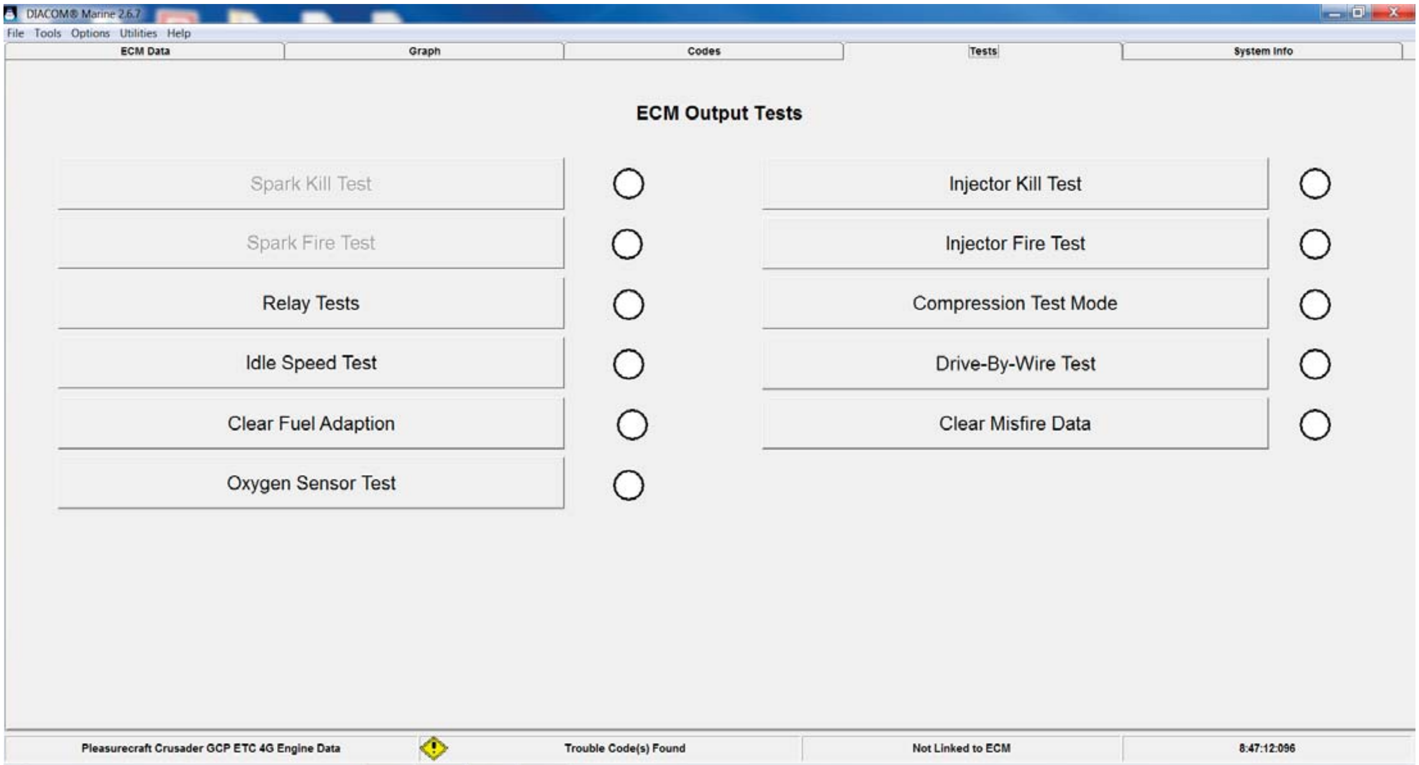


Figure 3-10 Low Oil Pressure - With Codes Troubleshooting Tree



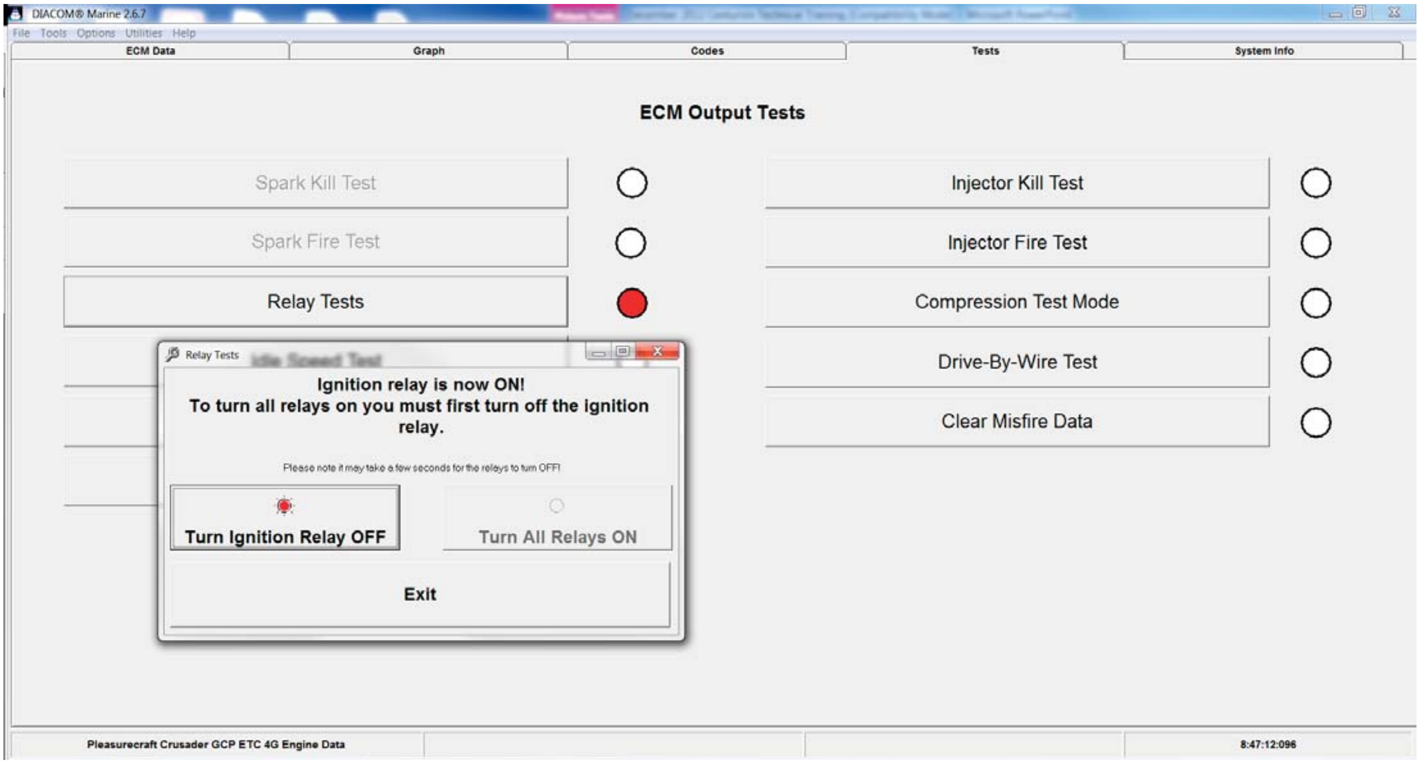
DIACOM TESTS

Your Diacom software package is much more than just a scan tool to read engine parameters and codes. Diacom, through its 'Tests' screen, provides you with control over various ECM functions. Utilizing these functions can allow you to test and/or control circuits to determine the source of a problem more efficiently. On your Diacom screen you will see a tab for 'Tests'. Left click on this tab to reveal the test screen. These tests can be used to assist in diagnosis, clear ECM data or run through an automated test cycle. Some of the more commonly used tests are:

- Relay Tests,
- Clear Fuel Adaption,
- Oxygen Sensor Test,
- Injector Kill Test,
- Compression Test Mode, and
- Clear Misfire Data.

The following is a brief description of these Diacom tests and how they may be used. For more information on these tests you should refer to your Diacom Help menu.

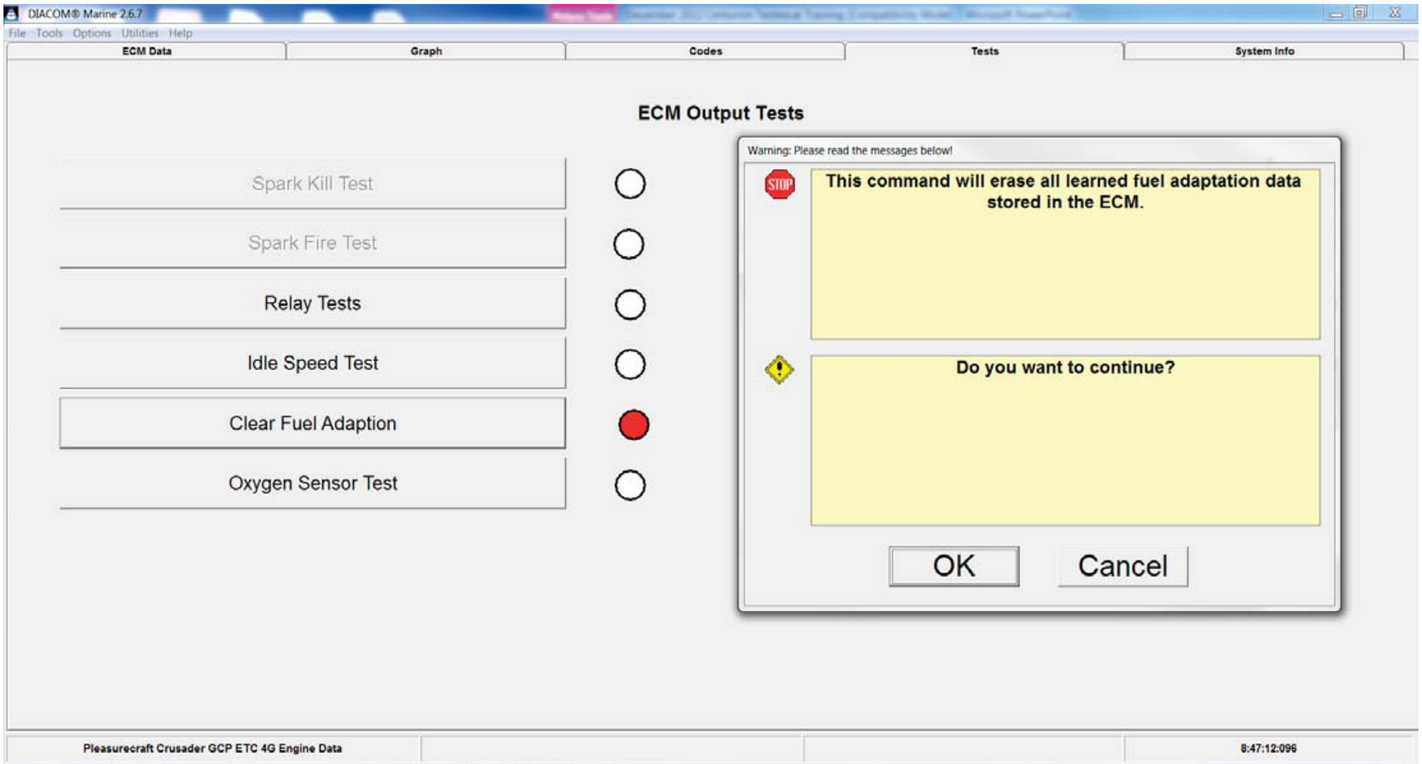
NOTE: The contents and appearance of the Test Screen will vary from system to system due to the fact that different ECMs have different capabilities.



Relay Tests

When selected this commands the ECM to activate the driver output for the Ignition Relay, or All Relays.

This command is very useful for troubleshooting engine management and/or fuel system problems. Once the ignition switch is in the ‘ON’ position, this command can be used to turn on the System Relay for electrical diagnosis. When the ignition is ON, engine OFF, the ECM turns the Ignition Relay ON for about 5 seconds. If the engine is not started, the ECM turns OFF the Ignition Relay. If you were diagnosing the 12 volt circuit supplied to injectors, ignition coils, O2 sensors or throttle body, you would turn on the Ignition Relay through Diacom. This would allow you to take the voltage measurements required without constantly cycling the ignition ON and OFF. If you need to turn ON the fuel pumps for priming and/or troubleshooting purposes, you would select “Turn ALL Relays ON.”



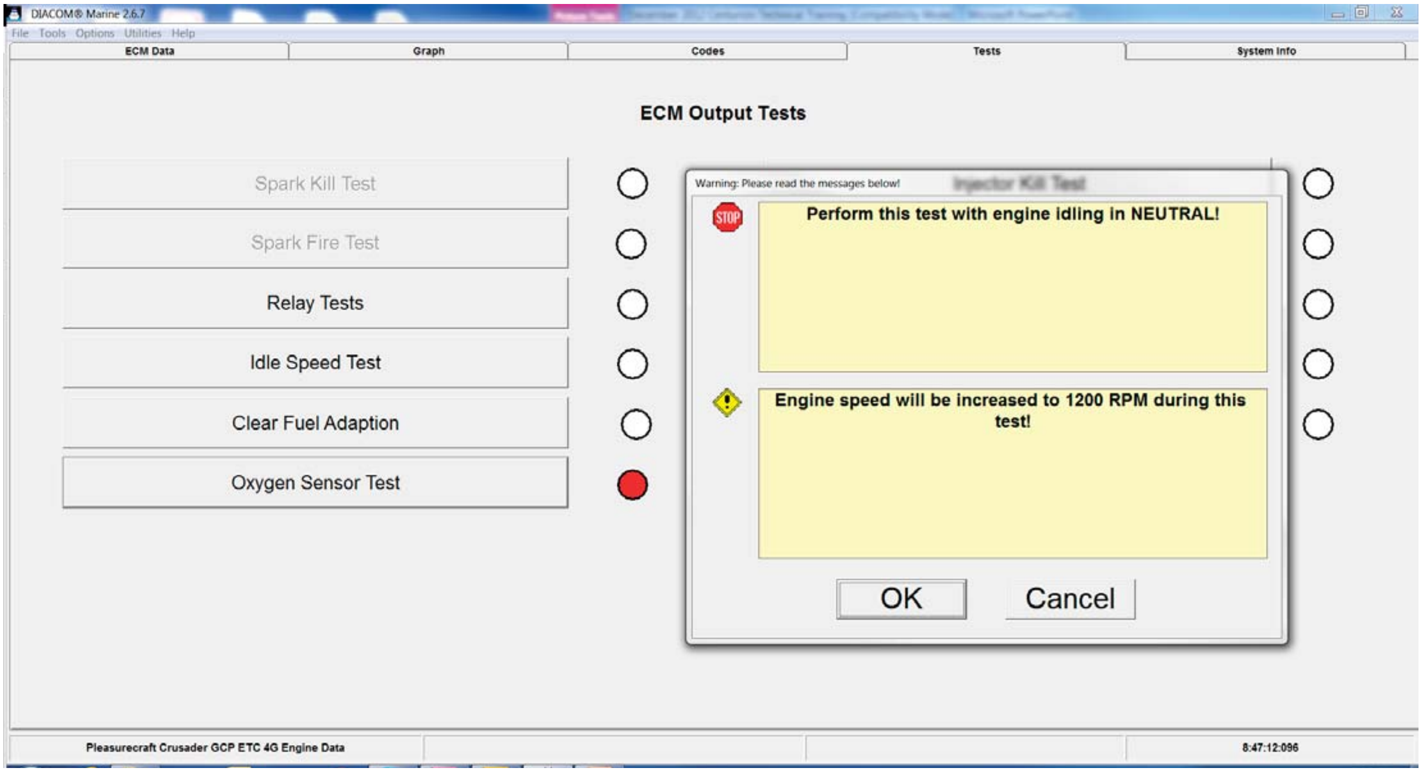
Clear Fuel Adaption

When selected this commands the ECM to erase all Learned Fuel Adaption data stored in the ECM.

The Engine Management System controls fuel in a "Closed Loop" fueling state most of the time. This means the ECM is taking feedback information from the Oxygen Sensors and adjusting the fuel delivery to constantly maintain a near stochiometric air/fuel ratio. This is done in order for the catalyst to be most affective. Open Loop fueling is when the engine is cold, during transients (accelerations/ decelerations) and near wide open throttle loads.

Under normal conditions, the ECM learns each application and populates a table based on engine speed and load. The adaptive learn allows the ECM to fine tune the fuel delivery based on variables such as backpressure. By fine tuning and populating the adaptive learn tables, the engine management system can precisely control the fuel delivery for optimal emission reduction.

This function would only be used after a repair is made. An example would be if a system has a restricted fuel filter causing fuel pressure to be down a few psi from specification. In this case, the system would want to run a little lean. The ECM learns that and adjusts the values for the adaptive learn. The problem is that it just populated the table based on a "lean" system. Therefore, once the filter is replaced and fuel pressure is back to specification, this function would "Clear the Adaptive Learn" tables and allow the ECM to relearn a normal system again.



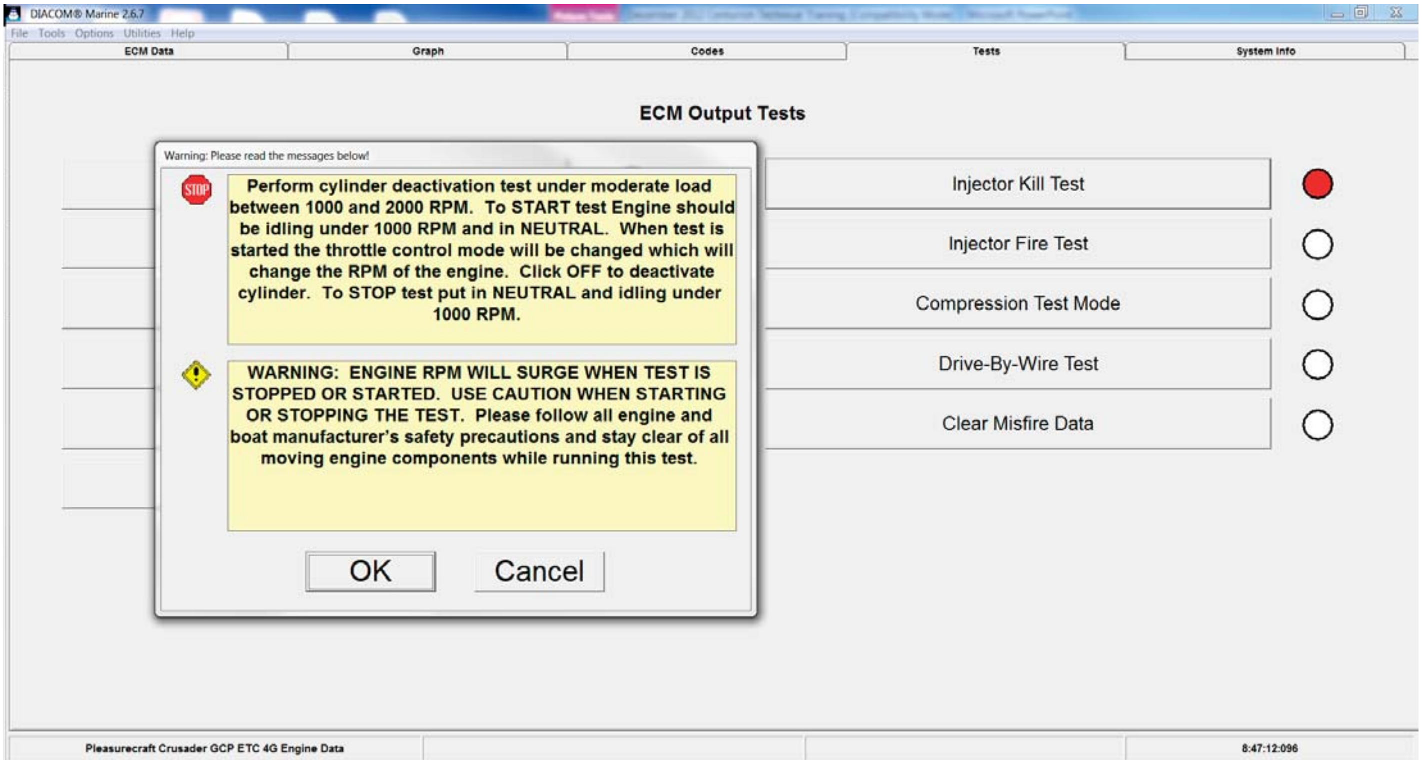
Oxygen Sensor Test

When selected this commands the ECM to enter into an "Automated Test Mode".

The Engine Management System controls fuel delivery based on Oxygen Sensor feedback. The system also monitors the efficiency of the catalyst system by monitoring Oxygen sensors prior to the catalyst substrate (pre O2 sensors) and Oxygen sensors after the catalyst substrate (post O2 sensors).

This test allows for the technician to run diagnostics on ALL four oxygen sensors. The test requires the engine to be idling in neutral. The test will automatically increase the RPM to about 1200 RPM. All four oxygen sensors are checked for the ability to report a lean air/fuel mixture, a rich air/fuel mixture or heater circuit control. The test usually takes several minutes.

This function can be used to help diagnose a faulty oxygen sensor circuit or to validate a repair to any of the four oxygen sensors or circuits.



Injector Kill Test

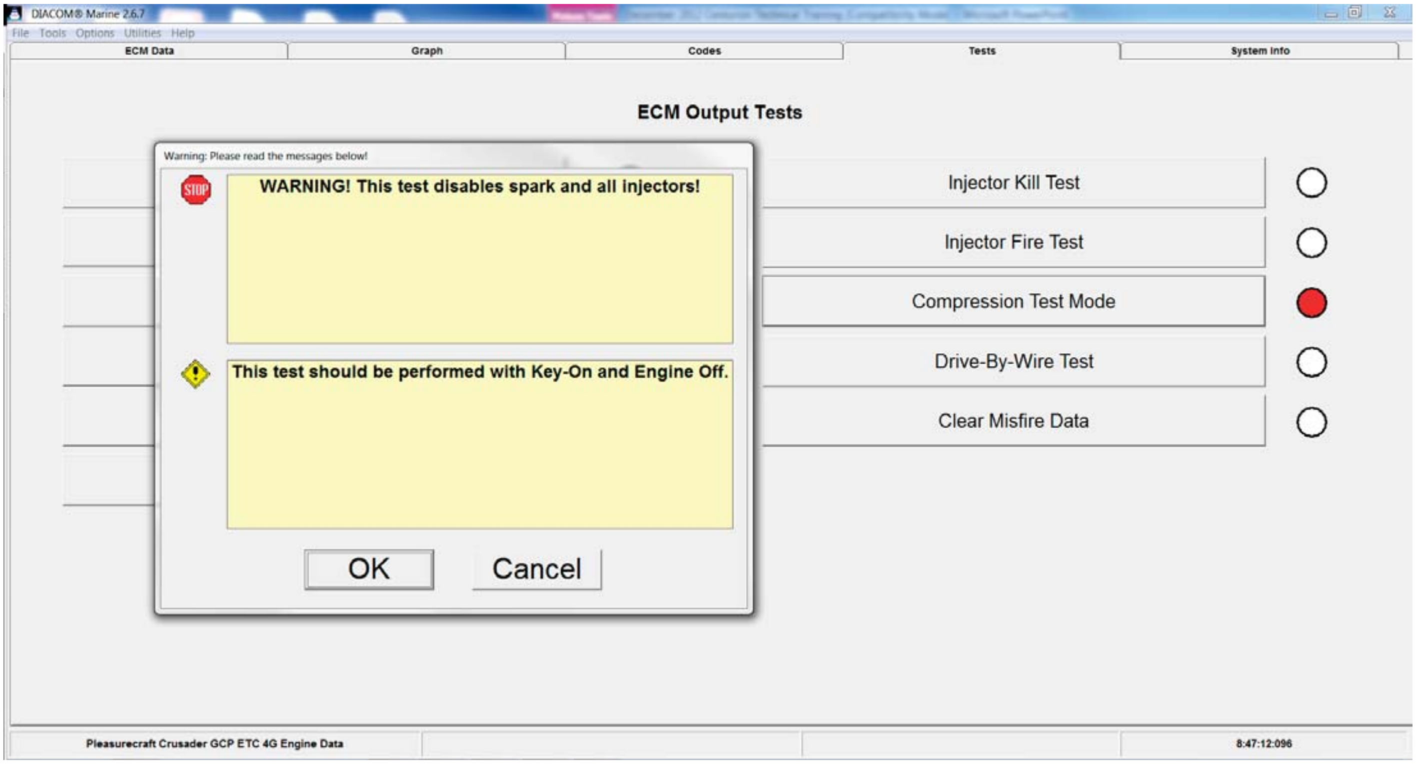
This is an extremely useful test for isolating ignition, fuel, and mechanical problems to a specific cylinder of the engine. This test is part of Step 6A, of the PCM Drivability Checklist, that has been previously discussed. You can use this test as a starting point when troubleshooting ignition problems, fuel system problems, and various symptomatic problems such as a misfire conditions, loss of power, and rough running.

The Injector Kill Test allows you to turn OFF the injector driver output to a selected cylinder which, in turn, will greatly aid you in determining if that particular cylinder is functioning properly. When you shut OFF an injector to a properly operating cylinder, the engine RPM or pitch will change, indicating that the cylinder was indeed shut off. Typically you will see a 150-200 RPM drop when a cylinder is shut off. If there is no change in RPM, you may have a cylinder malfunction. Cylinder malfunctions can be fuel, spark or mechanical in nature. Some of the more common causes for a cylinder not firing are:

- bad spark plug – fouled or broken
- bad spark plug wire – broken or too high in resistance
- bad distributor cap and rotor (5.0/5.7L only) or a coil/ignition module
- faulty wiring between a coil/module and ECM
- fuel injector failing to fire or leaking (bad injector or faulty wiring between the injector and ECM)
- bad cylinder – (a compression check of the cylinder will isolate this problem)

Best results are obtained when this test is performed with the engine under load (in gear), running between 1600-1800 RPM. RPM changes are more easily seen and heard when the engine is under load.

Warning: Please follow all engine and boat manufacturer's safety precautions and stay clear of all moving engine components while running this test.



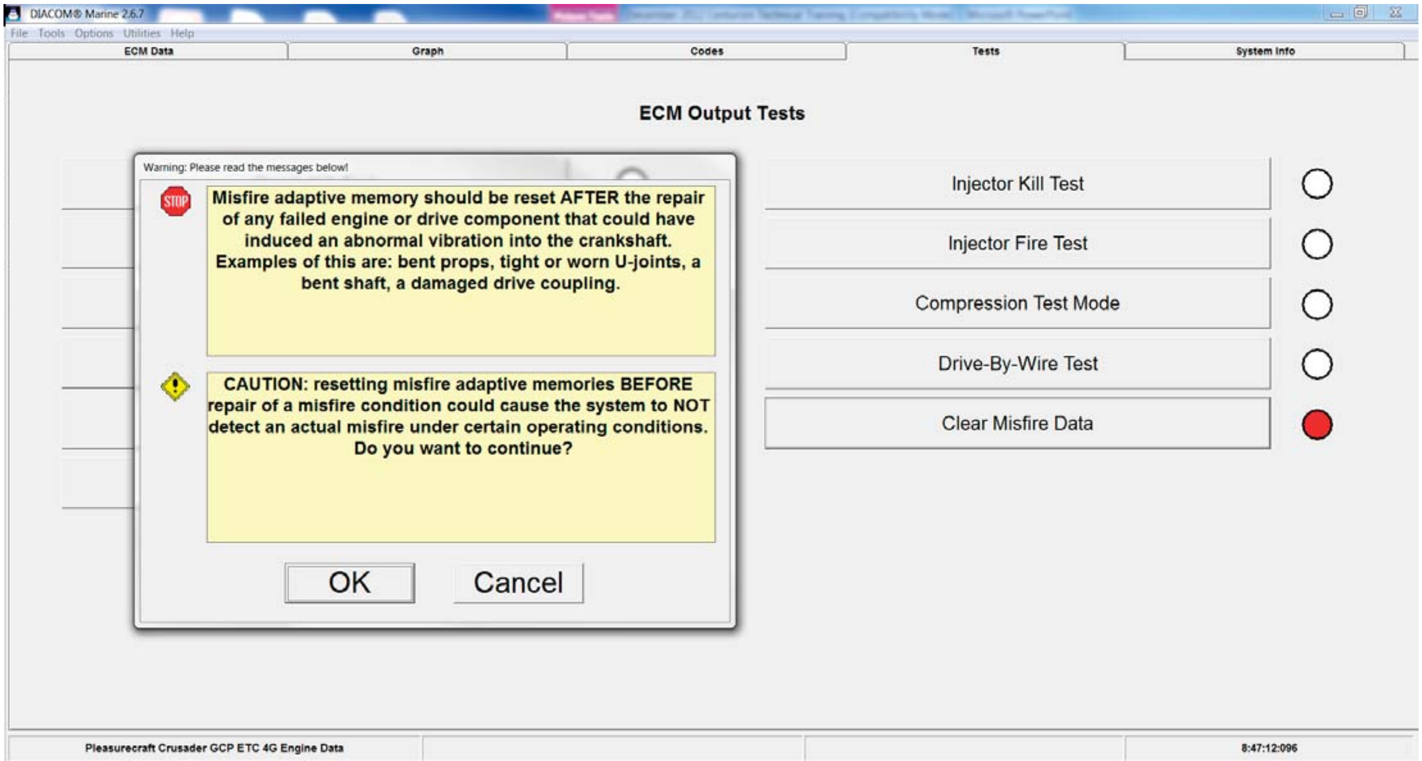
Compression Test Mode

The Compression Test is a special test mode that the ECM provides to allow a technician to safely perform a cylinder compression check. The Compression Test Mode is not really a “test” in itself, it is simply a mode or “state” the engine management system enters to allow a technician to manually perform a compression check without the possibility of the engine firing or starting.

Warning: This test commands the ECM to disable all spark and fuel injector outputs. The test must be properly exited from within Diacom in order to re-enable normal spark and fuel operation. Do not perform this test at sea.

The Compression Test should only be performed dockside or at a service facility since the engine will be disabled until the test is properly exited. If the Diacom’s communication cable is disconnected from the engine during the Compression Test, the engine will remain in a disabled state. You must reconnect Diacom, re-enter the Compression Test mode and then properly exit the test.

When the Compression Test is active, spark and fuel delivery functions will be disabled on the engine. When you have completed your compression test procedures simply click the Stop Test button.



Clear Misfire Data

When selected this commands the ECM to erase all Misfire data stored in the ECM.

The ECM constantly monitors various inputs to determine if a cylinder is misfiring. The ECM stores data every time a cylinder misfires. This data is stored for each cylinder. This data can be retrieved through the “System Info” tab using your Diacom.

Misfires can be damaging to the catalyst system if ignored. There are two levels of misfire trouble codes associated with the engine management system. There is “Cylinder Misfire” trouble codes for each cylinder and there is “Catalyst Damaging Misfire” trouble codes for each cylinder.

Abnormal vibrations to the crankshaft can also be induced by such things as: bent propshaft or bent prop.

This function would only be used after a repair is made. An example would be if an engine was diagnosed to have a bad spark plug wire on cylinder #3. In this case, the ECM has detected and accumulated misfire data on cylinder #3. Once the spark plug wire is replaced and the problem is corrected, this function would reset the ECM misfire data back to 0.

Caution: Resetting misfire data before a repair of a misfire condition can cause the system to NOT detect an actual misfire under certain operating conditions.

BASIC TROUBLESHOOTING APPROACH

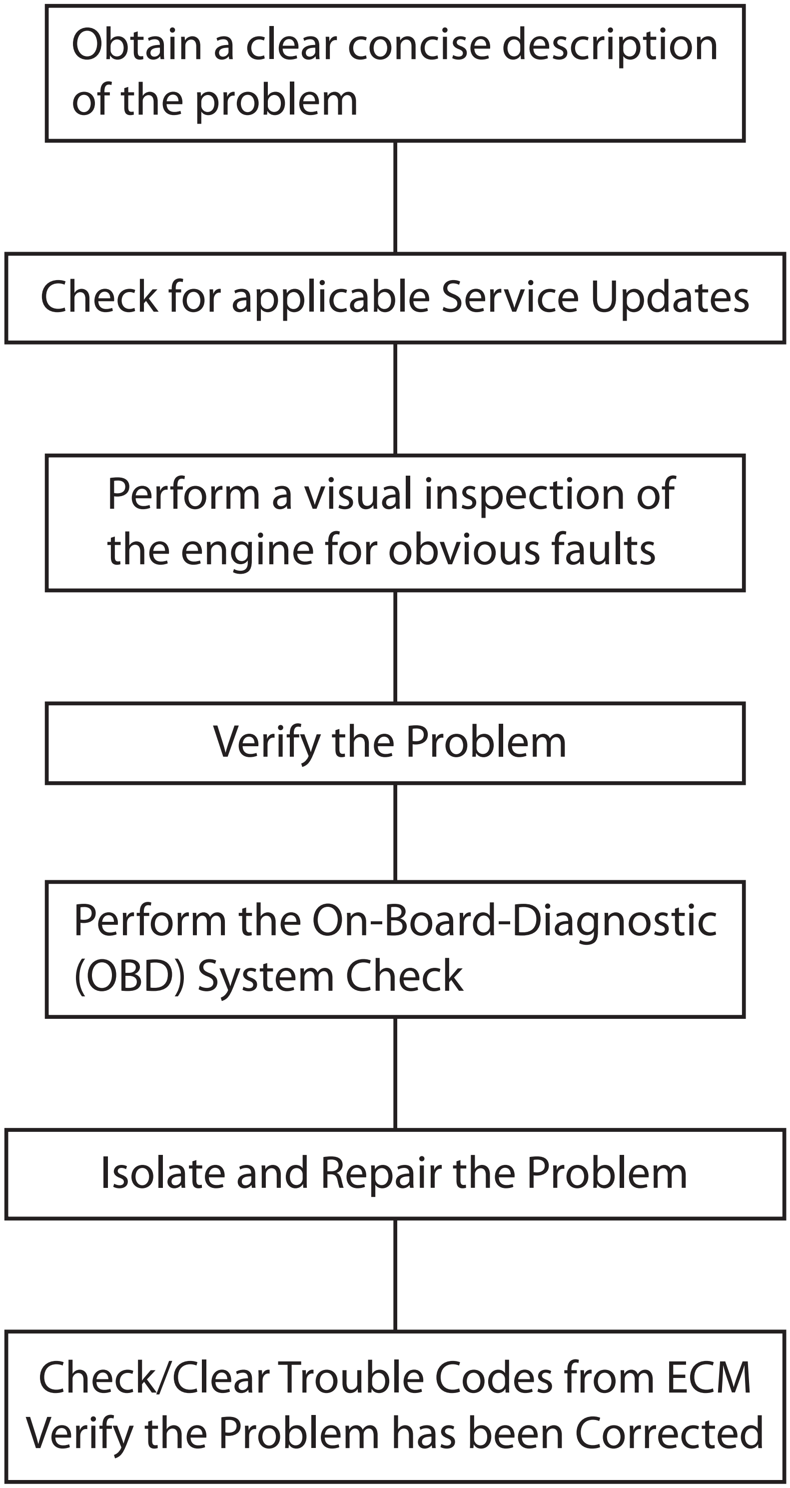


Figure 3-14 Basic Troubleshooting Approach Tree

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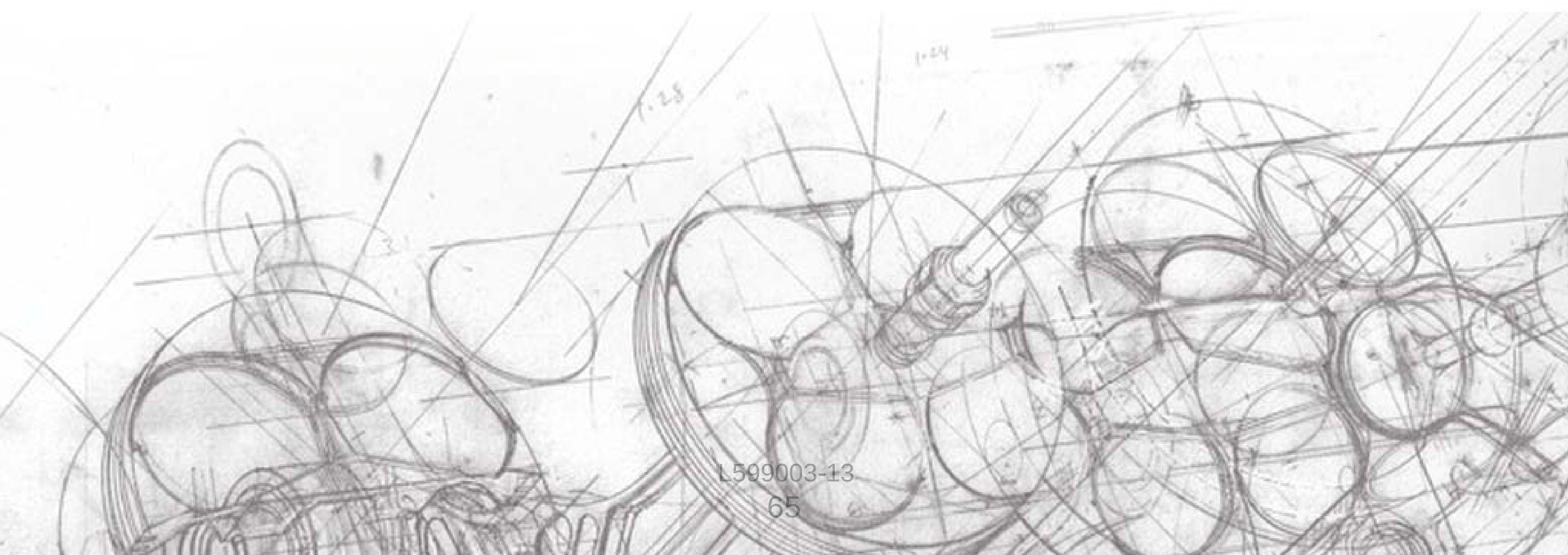
NOTES

NOTES

PCM® marine engines
PREMIER DEALER
WORLDWIDE

Section 4
Fuel
System



Fuel System

With the ever increasing sophistication of the engine's systems, the fuel system has had major changes over the years.

The Fuel System is comprised of two distinct sub-systems the Fuel Supply and the Fuel Metering Systems.

1. Fuel Supply System
    - Fuel Tank
    - Fuel Filters
    - Fuel Pumps
    - Fuel Lines
2. Fuel Metering System
    - Fuel Rail
    - Fuel Injectors
    - Fuel Pressure Regulator

The operation of the Fuel System and the precise delivery of fuel to the engine are controlled by the ECM.

Refer to Figure 4-1, Fuel System Diagrams. As you can see in the diagrams, the pressure regulator is located on the fuel rail on 5.0L and 5.7L applications. The pressure regulator is located in the Fuel Control Cell (FCC) on 6.0L and 6.2L applications.

Remember to always verify fuel pressure during a lake test, at wide-open-throttle, under load. This is the most accurate reading you can take on the fuel system. If the fuel pressure is correct under load, at wide-open-throttle, your fuel system is functioning correctly.

When troubleshooting a fuel system problem, your primary tool will be a Fuel Pressure Gauge. You should also have available:

1. Diacom
2. DMM
3. Auxiliary fuel tank
4. A graduated container

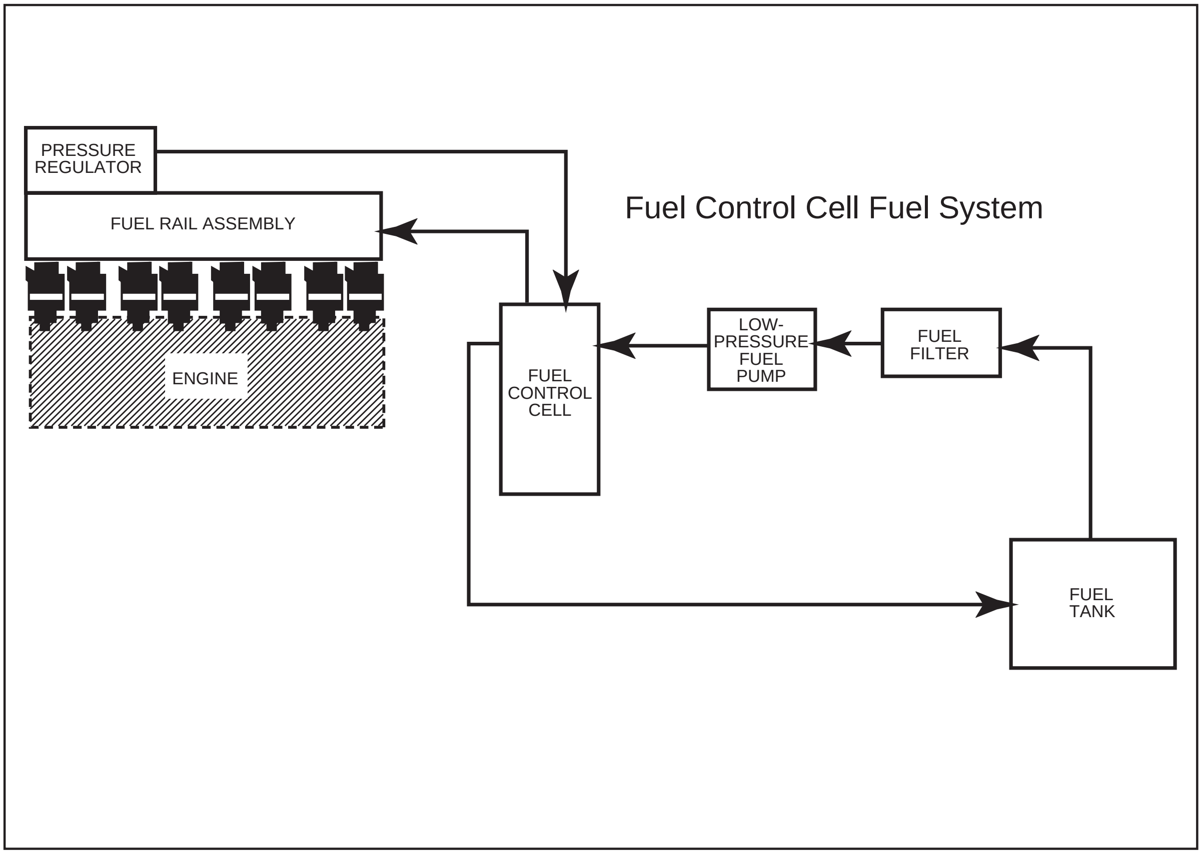
Previously we discussed the actions that occur when the ignition switch is placed in the 'ON' position, Step 4 of the PCM Drivability Checklist, Figure 4-2. While observing the fuel pressure rising to the required specification on the fuel pressure gauge, we were to listen to, and feel, both fuel pumps to verify that they were running.

Once the ignition is in the 'ON' position, you can use your Diacom 'Tests' screen to select and cycle the fuel pumps.

Using this test allows you to remain next to the engine and cycle the fuel pumps whenever a test procedure calls for:

- individually testing each fuel pump, and/or
- priming the fuel system.

NOTE: Diacom Relay test enables both fuel pumps. If testing an individual pump, the electrical connector for the other pump can be disconnected during testing.



FUEL SYSTEMS - TYPICAL

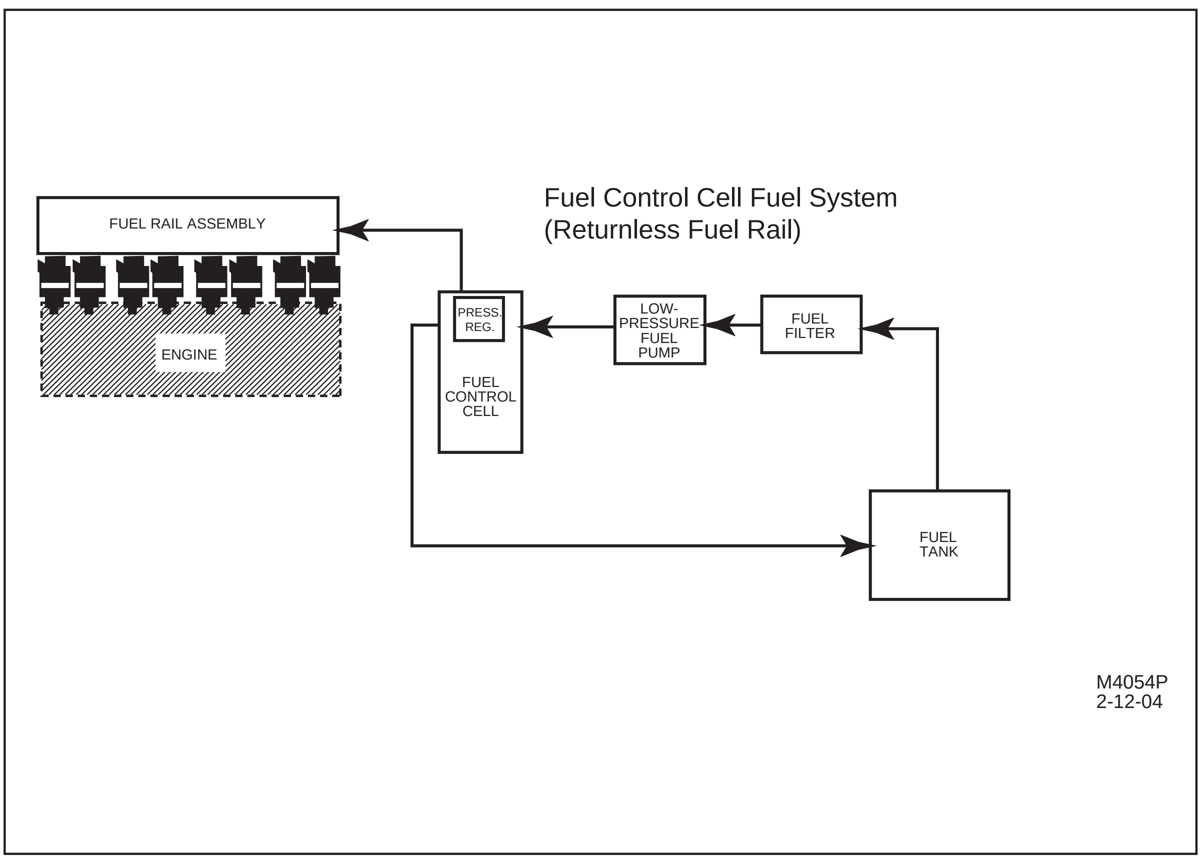


Figure 4-1 Typical Fuel System Configurations

PCM DRIVABILITY CHECKLIST

ENGINE SERIAL NUMBER: _______________

Date: _______________ **Dealership Name:** ___________________________________

Technician's Name:_____________________________ **Technician's Contact Phone #:** ________________________

Owner/Operator Name: ________________________________

Person Reporting the problem (if different from owner/operator): _____________________________

Service Writer or Person that took the problem report: ______________________________________

1) PROBLEM OR SYMPTOM: ____

Who first observed the symptom?__________________When did the symptom first occur? ________________
Any recent change or service work prior to symptom occurring - replaced belts or impeller, major engine or boat repairs, recently refueled, etc.? ____ Has someone, other than yourself, tried to correct the current symptom? _________ If yes, what work was done?____

Accessories Added Recently? __________________________________Is the symptom currently present? ___________

Special conditions (if any) required to duplicate the symptom: ____

Use an additional sheet of paper if more space is required for symptoms or descriptions.

2) CHECK FOR SERVICE UPDATES:

ENGINE SERIAL NUMBER: _______________ **ENGINE MODEL NUMBER:** _______________ **ENGINE HOURS:** ____

HULL NUMBER: __________________

ENGINE: None Apply: __ Performed: ____________________________

BOAT: None Apply: __ Performed: ____________________________

3) VISUAL INSPECTION:

Inspection	YES	NO
Evidence of an over-heat:		
Engine Harness connectors connected properly:		
Physical Damage - wiring, connectors, assemblies, and **Remove Spark Plugs and inspect for fluids.**		
Corrosion:		
Hull-clean and free of excessive growth:		

Inspection	YES	NO
Evidence of or Excessive Water in the Bilge:		
Fluid levels checked:		
Leaking Fluids:		
Firing order correct:		
Correct size propellers installed:		
Underwater gear is undamaged:		
Accessories added? If yes, check items		

4) VERIFY THE PROBLEM

	YES	NO	
Does the engine start and continue to run?	**go to 3 below**	**go to 1 below**	
1) Key-ON-Engine-OFF (KOEO)	**YES**	**NO**	**Fuel Press.**
Both Fuel Pumps run 2-4 seconds:			
Fuel Pressure near wot specification - when pumps run:			
2) Key-ON-Engine-Running (KOER)	**YES**	**NO**	**Fuel Press.**
Engine cranks:			
Fuel Pressure near wot specification - engine cranking:			
Engine Starts and continues to run:		go to	(3) Water Test
3) WATER TEST	**YES**	**NO**	**Fuel Press.**
Verify reported symptom:			
Fuel Pressure - idle:			
Fuel Pressure - under load, @ WOT:			

Check Accessories Added:

- ☐ Heater
- ☐ Shower
- ☐ Hot Water Tank
- ☐ Flush Kit
- ☐ Multi-Function Display
- ☐ Synchronizer
- ☐ After-Market Stereo Equipment
- ☐ After-Market Depth/Fish Finder
- ☐ After-Market Navigational Equipment, such as GPS, Radar, Sonar, Auto-pilot systems
- ☐ After-Market Radio Equipment
- ☐ Lights
- ☐ Other - (please list)

4A) Revised or additional symptom found?: ______________________________________

Figure 4-2 PCM Drivability Checklist

PCM DRIVABILITY CHECKLIST

5) PERFORM THE OBD SYSTEM CHECK

CODE(S) PRESENT: _______________ DIAGNOSTIC PROCEDURE USED: _______________ **Continue to Step 6**

6) ISOLATE AND REPAIR THE PROBLEM.

Were you able to isolate and repair the problem? If ***YES***, continue to **Step 7.**
If ***NO***, complete the Drivability Checklist for No Codes, step 6A below. If the problem is still not resolved, then call for factory technical assistance.

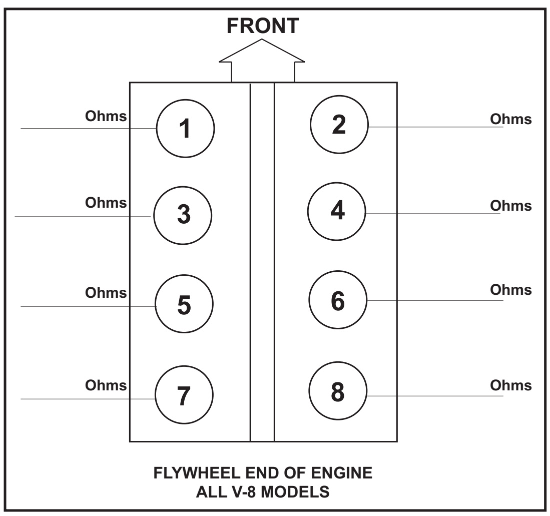
6A) NO CODES - ENGINE RUNS - DRIVABILITY SYMPTOM STILL PRESENT

Inspection or Check	YES	NO
1) Review Steps **1** thru **5**:		
2) Inspect fuel for contamination:		
3) Electrically isolate engine from boat:		
4) Powertrain is aligned:		
5) Remove and Inspect Distributor Cap and Rotor (5.0/5.7L only):		
6) Check&**record** Ignition wire resistance:		
7) Remove and Inspect each spark plug:		
8) Perform a Compression Check on all 8 cylinders: **Record below.**		

Inspection or Check	YES	NO
WATER TEST		
9) Verify CAM Retard** (5.0/5.7L only):		
10) Performance verified against a similar boat w/same engine. package, if available		
11) Perform the Diacom Power Balance Check; under load, @ 1600-1800rpm:		
12) Perform the harness 'Wiggle Test':		
13) Diacom recording-Pre-Delivery test:		

7) VERIFY REPAIR HAS CORRECTED THE PROBLEM. Check for and clear all codes from the ECM memory. **Water test the boat.** Run the engine for a minimum of two (2) minutes, then verify that no codes have returned. Continue with your water test long enough to verify that the problem has been corrected.

**** CAM Retard - '02 thru '06 = 43-47 degrees**
'07 - SN 485993 = 0 - 4 degrees/CES and SN 485994↑ = 15 ± 2 degrees



IGNITION WIRE RESISTANCE CHECK
Less than 10,000 ohms/ft

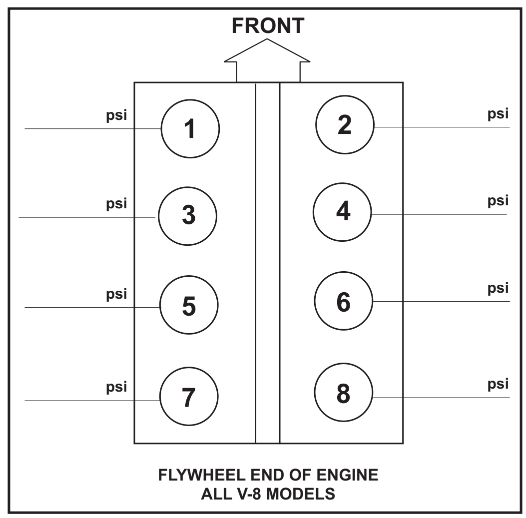
COMPRESSION PRESSURE:

5.0/5.7L - 130-215 psi

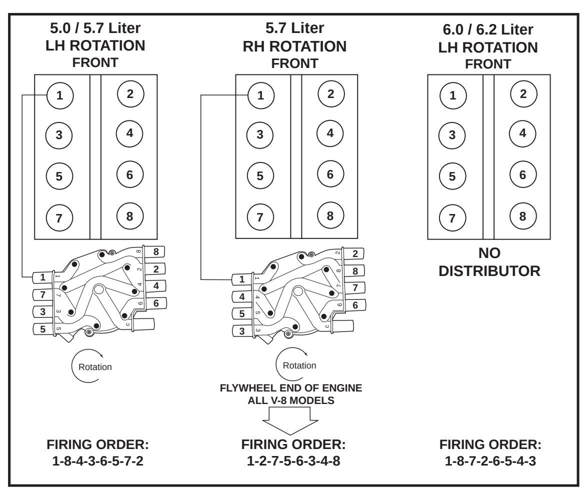
6.0L - 130-215 psi

6.2L - 130-215 psi

Lowest pressure should be within 70% of highest pressure. Minimum cylinder pressure - 100 psi.



COMPRESSION CHECK



REFERENCES:

Master Engine Specification Sheets

L510030 - GCP / 4G Diagnostic Service Manual

L510015 - 5.0/5.7L Engine Mechanical Service Manual

L510016 - 6.0L Engine Mechanical Service Manual

PCM Premier Dealer Website - All the Latest Publications

Figure 4-2 PCM Drivability Checklist

Refer to Figure 4-2. Step 4 of the Checklist was to Verify the Problem. During that step you performed a number of steps leading up to verifying the reported symptom. Figure 4-3 is a Troubleshooting Tree for these steps. As you can, see two of the tests and observations that you perform are directly related to the Fuel System.

When the ignition is in the ON position (first 2-4 seconds), or you cycle the pumps ON using Diacom, there are a number of possible outcomes that could occur. The best outcome is that both fuel pumps run and the fuel pressure rises near the WOT specification. The other possibilities are one or both pumps do not run, or the pumps run and fuel pressure is not to specification.

As you can see from Figure 4-3, if the pumps do not run you would use the KOEO Fuel Pumps Do Not Run Troubleshooting Tree, Figure 4-4, or the Fuel Pressure Out Of Range Troubleshooting Tree, Figure 4-7.

STEP 4

- VERIFY THE PROBLEM -

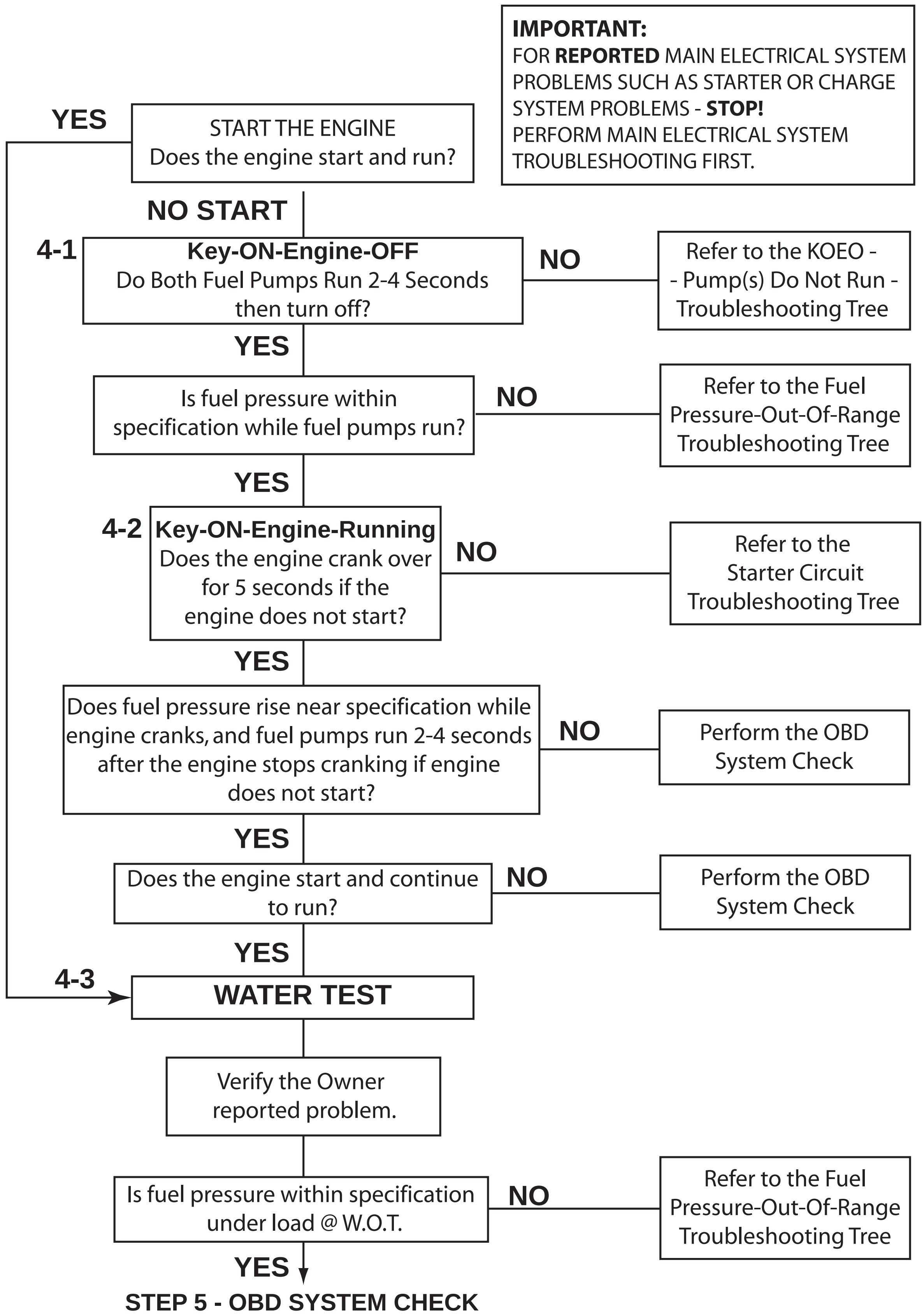


Figure 4-3 Verify the Problem

KOEO – Pump(s) Do Not Run

Refer to Figure 4-4, Key-On-Engine-Off Troubleshooting Tree. We need to determine the cause of the fuel pump failure. The cause of this condition could be electrical such as:

1. An open or shorted wiring circuit,
2. A faulty relay,
3. A bad fuel pump,
4. A blown fuse,
5. A control problem with the ECM .

Looking at the Troubleshooting Tree, you will see that the first step to perform is the On-Board Diagnostic (OBD) System Check. Perform this check to determine if the problem is located in the Fuel System or Engine Management System. If you find a Fuel Pump Relay Circuit Open, High or Short to Ground diagnostic trouble code, you will diagnose the Engine Management System problem first. If there are no trouble codes you will need to take a logical approach to isolating why the fuel pump or pumps do not run. Refer to the “No Code path”, Figure 4-4.

The second check is for battery voltage at the Fuel Pump Relay and ECM fuses. Looking at the main power diagram, we have picked a starting point for troubleshooting roughly in the middle of the circuit. When the key switch is in the ‘ON’ position, you can see that the fuses should have power across them. By taking a voltage reading between a known good ground and each fuse, you can then make a decision as to the direction of your troubleshooting path.

Refer to Figure 4-6. If voltage is not present across the fuses, the fuel pumps cannot run. If you find a fuse blown, typically the device or the wiring it protects has shorted causing too much current flow, and melts the fuse element open. This may have been caused by a temporary surge, and replacing the fuse corrects the problem, or the problem may be more serious.

To determine if the device the fuse protects, or the wiring caused the fuse to blow, you can disconnect the device, replace the fuse, and then reapply power and perform a wiggle test on the wiring. Be sure to wiggle the entire harness when checking to see if there is a short in the wiring. If during the wiggle test the fuse blows, you have a wiring problem at the point in the harness you were affecting when the fuse blew. If the fuse does not blow, then the device it is protecting may need to be replaced.

Refer to Figure 4-4 and 4-5, KOEO – Pumps Do Not Run Troubleshooting Tree and Main Power diagram. If the fuses are good, we will perform step 3, of the Troubleshooting Tree.

Step 3 requires the use of a non-powered test lamp.

CAUTION: Before you perform this step you should verify that your test lamp meets the requirement for circuit testing. Refer to the Diagnostic Manual for this requirement. The ECM can be damaged if the non-powered test lamp does not meet this requirement.

Using your test lamp connected to a know good ground, test for power at the Fuel Pump Relay socket. Looking at the main power diagram you can see that we are testing each device and harness connection on the way to the fuel pumps. If step 3 checks are good, continue to step 4 and verify the harness connections and power to the pumps.

Step 4 will verify the harness connections and power to the pumps. When you jumper pin 30 to pin 87 of the Fuel Pump Relay Socket, both fuel pumps should run.

1. Pumps Do Not Run - Verify battery voltage is present at both fuel pump connectors.
    - Battery Voltage Not Present - Diagnose and repair harness or connection problem between relay sockets and fuel pump(s).
    - Battery Voltage Present - Verify good ground circuit and repair as necessary. If OK, check connections and replace fuel pump(s).
2. Both Pumps Run - Verify battery voltage is present at both fuel pump connectors.
    - Battery Voltage Not Present - Diagnose and repair harness or connection problem between relay sockets and fuel pump(s).
    - Battery Voltage Present - Verify good ground circuit and repair as necessary. If OK, check connections and replace fuel pump(s).

Connect your test lamp between fuel pump relay socket pins 30 and 85. Cycle the fuel pumps, either with your Diacom or the ignition switch. The test lamp should illuminate for 2-4 seconds then go out.

1. Lamp Illuminates - Replace the Fuel Pump Relay.
2. Lamp Did Not Illuminate - Troubleshoot and repair the wiring between the ECM and the relay socket. If the wiring checks out good, replace the ECM.

Using the Troubleshooting Tree and the main power diagram, we have taken a logical step-by-step approach to solving this problem. Similar approaches can be used to solve most any problem you encounter with the engine. Let’s look at another fuel system example.

CAUTION: ***Refer to the Diagnostic Manual for handling and testing instructions for the ECM before you troubleshoot any harness problem. Never disconnect or connect the ECM connectors while power is applied. The ECM may be damaged.***

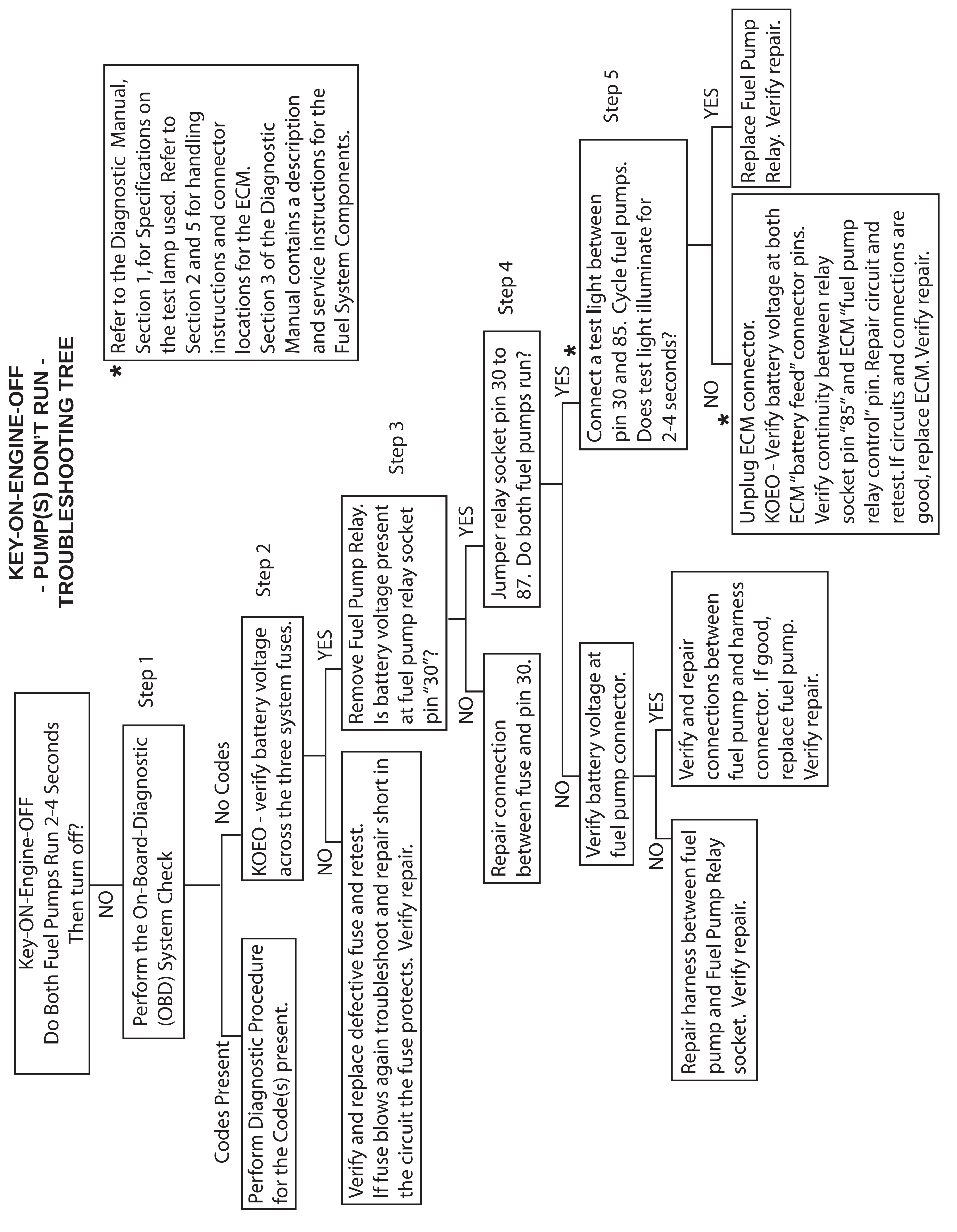


Figure 4-4 KOEO Pumps Do Not Run Troubleshooting Tree

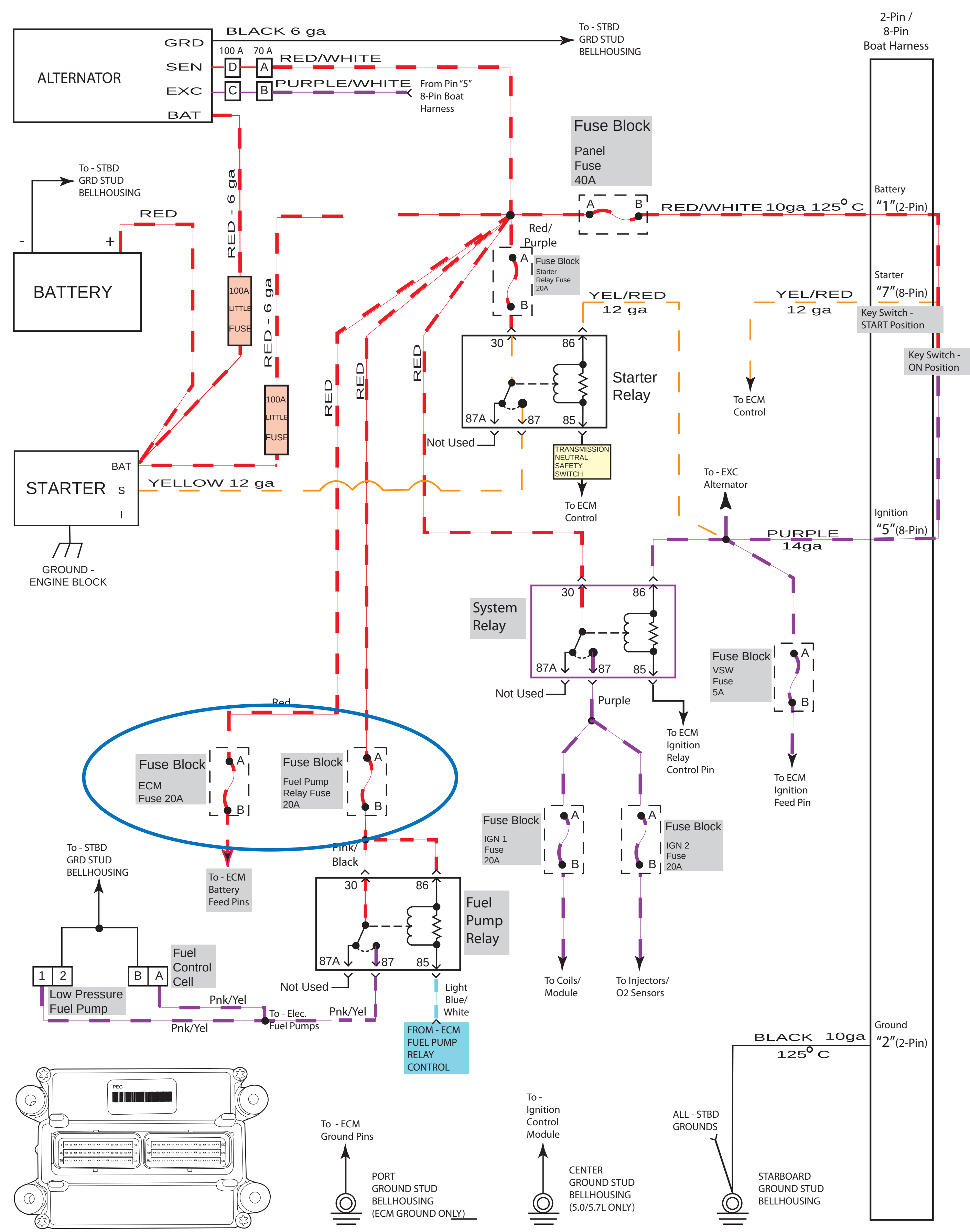


Figure 4-5 Main Power, Fuse Check
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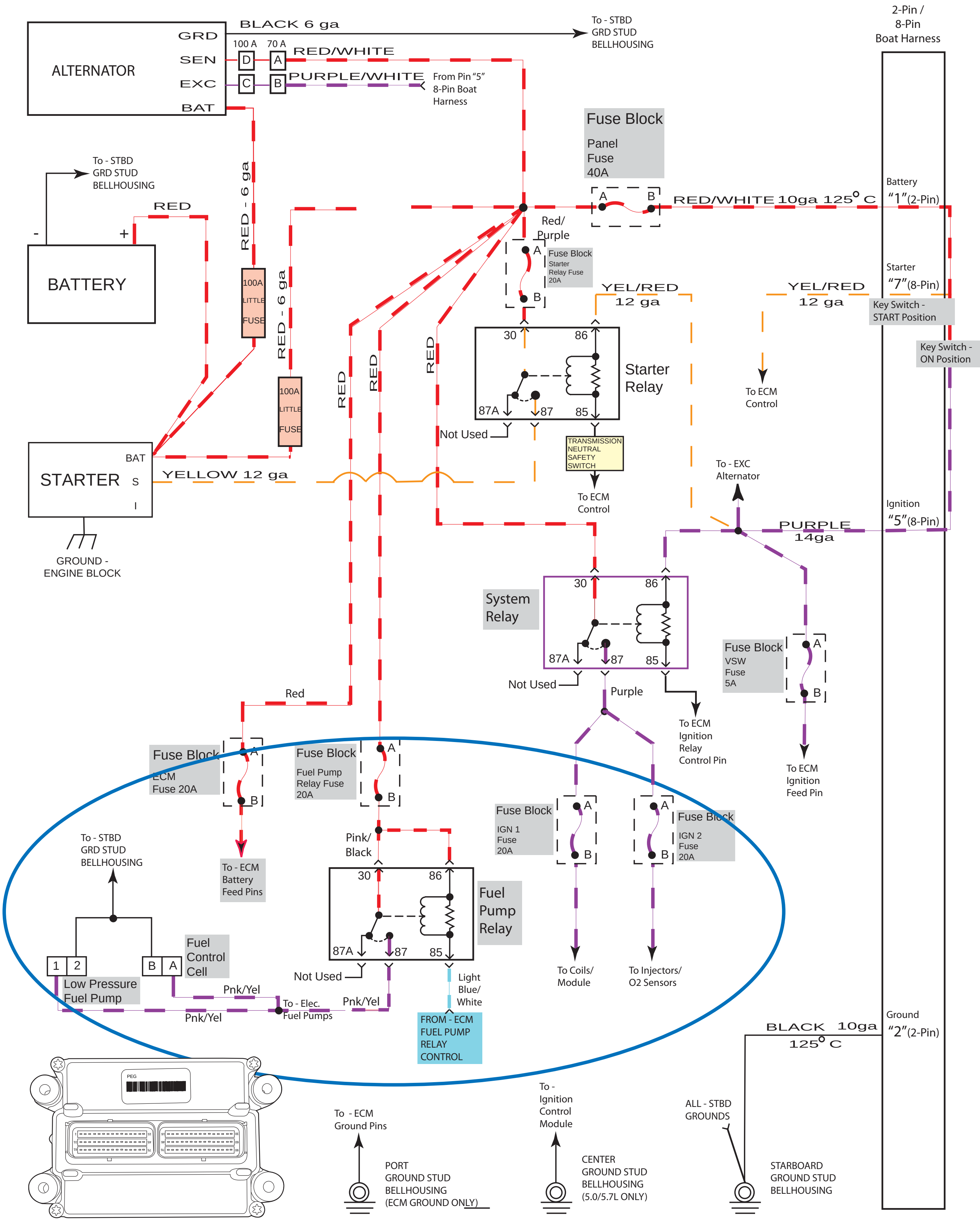


Figure 4-6 Main Power, Fuel Pumps Power Feed
L599003-13

Fuel Pressure is Out-of-RANGE

When we took our first look at the engine and turned the ignition to 'ON' our first observation was to listen and feel for the fuel pumps to run, and we've discussed the procedure that covers the condition when they do not. The second observation we needed to make was fuel pressure. Was the pressure near the WOT specification while the pumps ran?

Refer to Figure 4-7, the Fuel Pressure Out-Of-Range Troubleshooting Tree. Looking at the Troubleshooting Tree you will observe that this test sequence will require you to use an auxiliary fuel tank. The use of an auxiliary fuel tank allows you to isolate the boat's fuel system from the engine. The use of the auxiliary tank is a quick and extremely useful way to determine the source of a problem when fuel contamination or restriction is suspected. Some of the more common symptoms are:

- rough running,
- the engine cuts out,
- stalls,
- loses power at high speed, or
- fuel pressure problems.

NOTE: When using an auxiliary fuel source to test an engine with a FCC that returns fuel to the boat's fuel tank; the return fuel from the FCC must be redirected into the auxiliary fuel source.

Important: Caution must be taken when using the auxiliary fuel tank. The tank must be properly strapped down. The lines and fittings must be secure and away from heat and moving components.

Refer to Figure 4-7, the Fuel Pressure Out-Of-Range Troubleshooting Tree. You can see there are two distinct paths for fuel pressure problems. Pressure could be above the required specification, or below.

Fuel pressures above specification are uncommon occurrences. Symptoms of excessive fuel pressure may be similar to those associated with other engine problems such as a cold running engine or under temperature condition. The following is a partial list of symptoms:

Excessive fuel consumption.

Heavy black soot deposit on the transom.

Hard starts, especially on a warm or hot engine.

Erratic idle speed problems, that may include stalling warm or cold.

Fouled spark plugs, engine missing or backfires.

Owner reports great top end performance but cannot get through an idle zone without stalling.

Typically, the most common cause of a high fuel pressure condition will be a restriction in the return to tank fuel line, such as an anti-syphon valve installed at the tank instead of a straight through fitting. Less common will be a restriction in the fuel rail or a failed fuel pressure regulator. Using an auxiliary fuel tank will quickly isolate this problem.

The more common condition is fuel pressure below specification. Refer to Figure 4-7, the "Below Specification path". It would appear that pressure below specification is a complex problem to isolate. By making a couple of tests we can quickly isolate this problem.

The first test will be to verify an unrestricted supply of fuel. Without a sufficient supply of fuel, proper fuel pressure cannot be achieved.

Without a sufficient supply of fuel, the high pressure fuel pump cannot make or maintain pressure. This requires testing of the fuel delivery to the high pressure fuel pump located inside the FCC.

Disconnect the fuel return line from the FCC to the fuel tank and plug. Attach an adequate length approved fuel line to the return fitting on the FCC. This is where you will measure the amount of fuel required during the low pressure fuel pump volume test.

The Low Pressure Fuel Pump should output at least 16 to 20 ounces of fuel in 10 seconds. Be sure you use an approved container to capture the fuel output, and have a graduated measure to verify the quantity of fuel. A one-quart glass measuring cup is very useful for this. Not only can you accurately measure the fuel but you can also see if you have contamination in the fuel.

Low Pressure Fuel Pump Volume Test

1. Disconnect the return-to-tank fuel line from the FCC.
2. Connect a piece of fuel line between the FCC return output and an approved empty container.
3. Remove the Fuel Pump Relay.
4. Jumper relay socket Pin 30 to Pin 87 for 10 seconds, then disconnect jumper.
5. Verify 16-20 oz. of fuel in the container.
6. Return system to normal configuration.

If the result of the test is low output volume from the Low Pressure Fuel Pump, the Low Pressure Fuel Pump volume test will have to be repeated using your auxiliary fuel tank.

The auxiliary fuel tank is used to isolate the engine's fuel system from the boat. Restrictions in the fuel line, anti-siphon valve, in-line fuel filter, or in the fuel pick-up tube are some of the most common causes for the volume output of the Low Pressure Fuel Pump to be low.

Determining if the problem is on the boat side or engine side may be accomplished by connecting the auxiliary fuel tank. Remove the fuel line connection at the input to the Low Pressure Fuel Pump. Connect the auxiliary fuel tank directly to the Low Pressure Fuel Pump input and repeat the Low Pressure Fuel Pump output volume test.

If the Low Pressure Fuel Pump again fails the volume test, the fuel inlet or outlet is restricted or the pump is defective. Determine and resolve the problem and verify the repair.

Refer to Figure 4-7. Once the Low Pressure Fuel Pump output volume has been verified to be correct; the next check is an inspection of the high pressure pump and its output path. The result of that inspection will determine if we have a pump problem or a metering problem, such as the pressure regulator or defective fuel injector(s).

Inspect the FCC internal fittings and hoses for leaks and repair as required. If no problem is found, you will need to replace the high pressure pump. If the pressure is still low, replace the fuel pressure regulator.

The last step would be to troubleshoot and replace the faulty fuel injectors. It is important to note that if you have an injector or injectors stuck open causing a low fuel pressure problem, you will have multiple symptoms related to over fueling of the engine.

Some of the more common symptoms of over fueling are hard to start, possibly slow to crank, rough running at low RPM, evidence of heavy black soot on the transom and raw fuel in the exhaust. The Diacom Power Balance Test can be used to isolate this problem to the specific cylinder(s) being over fueled.

IMPORTANT: *Some additional causes for over-fueling of the engine include an engine coolant temperature (ECT) sensor that has shifted in value, a manifold absolute pressure (MAP) sensor that has shifted in value, system voltage out of range or a cooling system under-temperature condition.* <u>*Typically, the aforementioned conditions will not set a code in the ECM.*</u> *Be sure to complete the PCM Drivability Checklist verifying system power, cooling system operation and verifying system parameters by comparing a DIACOM recording of a known good engine against the DIACOM recording of the suspect engine.*

The Fuel pressure troubleshooting procedures discussed have approached the pressure problem from the stand point that the fuel pressure is out of tolerance under all conditions. Always verify fuel pressure is correct under load, at wide-open-throttle. If the pressure drops or varies at wide-open-throttle, use your auxiliary fuel tank to determine if the problem is in the engine's fuel system or the boat's supply components.

Always water test the boat. Verify fuel pressure is correct under load, at wide-open-throttle. If the pressure drops or varies at wide-open-throttle, use your auxiliary fuel tank to determine if the problem is in the engine's fuel system or the boat's supply components.

IMPORTANT: When you connect the auxiliary fuel tank to the FCC fuel system, always drain the FCC of any old fuel before you begin the test. The FCC holds sufficient fuel to perform a water test and you would not get to the fresh fuel in the auxiliary tank, thus invalidating your test.

If the engine operates normally with the auxiliary fuel tank, you know that the problem lies somewhere in the boat's fuel system such as contaminated fuel, fuel line restrictions or fuel tank problems.

If the problem persists, you know the problem lies in the engines fuel system and you would inspect for leaks, failing low pressure pump or failing high pressure pump.

KEY-ON-ENGINE-OFF
FUEL PRESSURE OUT OF RANGE - PUMPS RUN

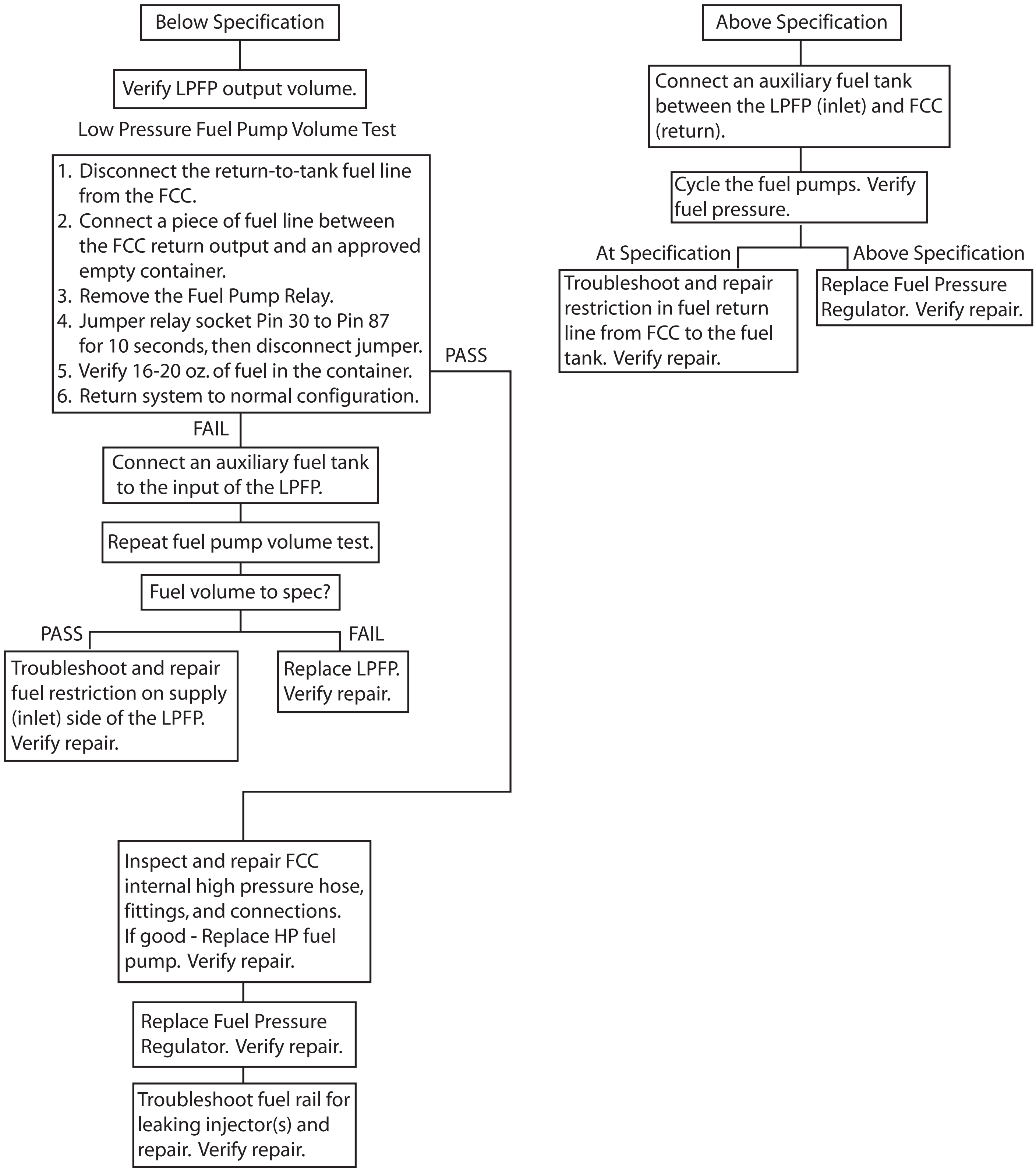
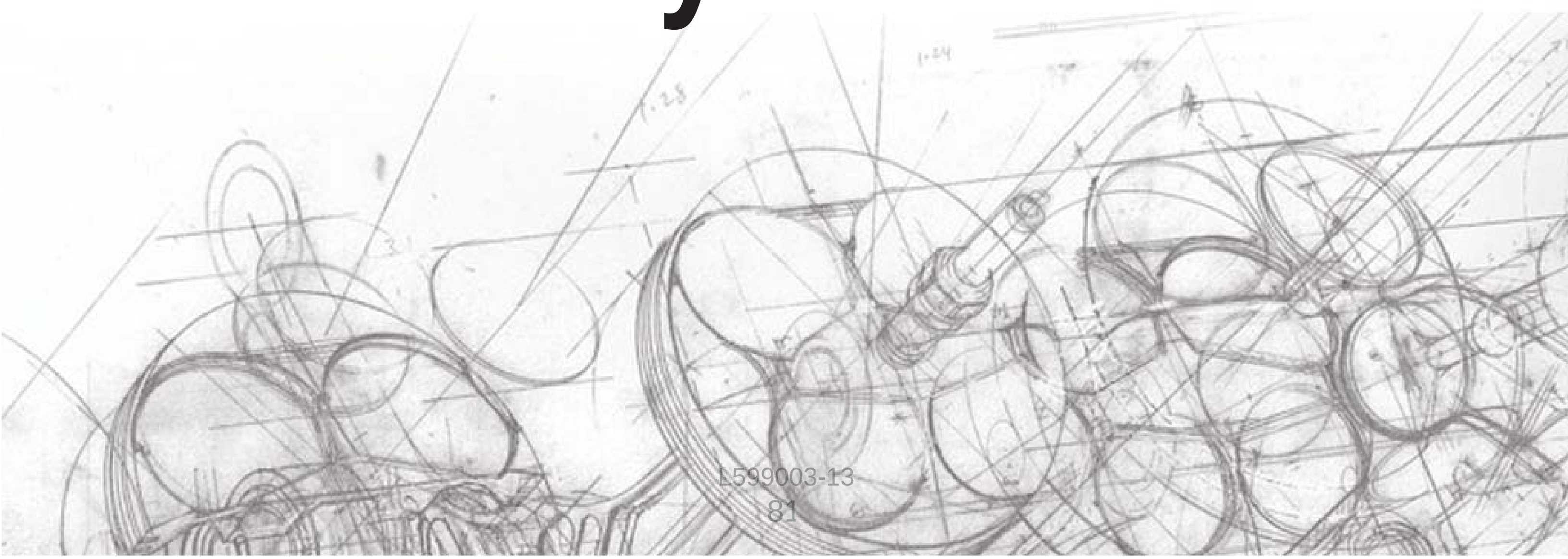


Figure 4-7 KOEO Fuel Pressure Out-Of-Range Troubleshooting Tree

NOTES

NOTES

Section 5
Main
Electrical
System



PCM DRIVABILITY CHECKLIST

ENGINE SERIAL NUMBER: ____________

Date: ____________ **Dealership Name:** ______________________________

Technician's Name:________________________ **Technician's Contact Phone #:** ____________________

Owner/Operator Name: ___________________________

Person Reporting the problem (if different from owner/operator): ________________________

Service Writer or Person that took the problem report: ________________________________

1) PROBLEM OR SYMPTOM: ____

Who first observed the symptom?________________When did the symptom first occur? ______________
Any recent change or service work prior to symptom occurring - replaced belts or impeller, major engine or boat repairs, recently refueled, etc.? __________________________________ Has someone, other than yourself, tried to correct the current symptom? ______ If yes, what work was done?________________________________

Accessories Added Recently? _____________________________Is the symptom currently present? ______

Special conditions (if any) required to duplicate the symptom: ____

Use an additional sheet of paper if more space is required for symptoms or descriptions.

2) CHECK FOR SERVICE UPDATES:

ENGINE SERIAL NUMBER: ____________ **ENGINE MODEL NUMBER:** ____________ **ENGINE HOURS:** ___

HULL NUMBER: ______________

ENGINE: None Apply: __ Performed: ________________________

BOAT: None Apply: __ Performed: ________________________

3) VISUAL INSPECTION:

Inspection	YES	NO
Evidence of an over-heat:		
Engine Harness connectors connected properly:		
Physical Damage - wiring, connectors, assemblies, and **Remove Spark Plugs and inspect for fluids.**		
Corrosion:		
Hull-clean and free of excessive growth:		

Inspection	YES	NO
Evidence of or Excessive Water in the Bilge:		
Fluid levels checked:		
Leaking Fluids:		
Firing order correct:		
Correct size propellers installed:		
Underwater gear is undamaged:		
Accessories added? If yes, check items		

4) VERIFY THE PROBLEM

	YES	NO	
Does the engine start and continue to run?	**go to 3 below**	**go to 1 below**	
1) Key-ON-Engine-OFF (KOEO)	**YES**	**NO**	**Fuel Press.**
Both Fuel Pumps run 2-4 seconds:			
Fuel Pressure near wot specification - when pumps run:			
2) Key-ON-Engine-Running (KOER)	**YES**	**NO**	**Fuel Press.**
Engine cranks:			
Fuel Pressure near wot specification - engine cranking:			
Engine Starts and continues to run:		go to (3) Water Test	
3) WATER TEST	**YES**	**NO**	**Fuel Press.**
Verify reported symptom:			
Fuel Pressure - idle:			
Fuel Pressure - under load, @ WOT:			

Check Accessories Added:

- ☐ Heater
- ☐ Shower
- ☐ Hot Water Tank
- ☐ Flush Kit
- ☐ Multi-Function Display
- ☐ Synchronizer
- ☐ After-Market Stereo Equipment
- ☐ After-Market Depth/Fish Finder
- ☐ After-Market Navigational Equipment, such as GPS, Radar, Sonar, Auto-pilot systems
- ☐ After-Market Radio Equipment
- ☐ Lights
- ☐ Other - (please list)

4A) Revised or additional symptom found?:

Figure 5-1 PCM Drivability Checklist

PCM DRIVABILITY CHECKLIST

5) PERFORM THE OBD SYSTEM CHECK

CODE(S) PRESENT: _______________ DIAGNOSTIC PROCEDURE USED: _______________ **Continue to Step 6**

6) ISOLATE AND REPAIR THE PROBLEM.

Were you able to isolate and repair the problem? If ***YES***, continue to **Step 7.**
If ***NO***, complete the Drivability Checklist for No Codes, step 6A below. If the problem is still not resolved, then call for factory technical assistance.

6A) NO CODES - ENGINE RUNS - DRIVABILITY SYMPTOM STILL PRESENT

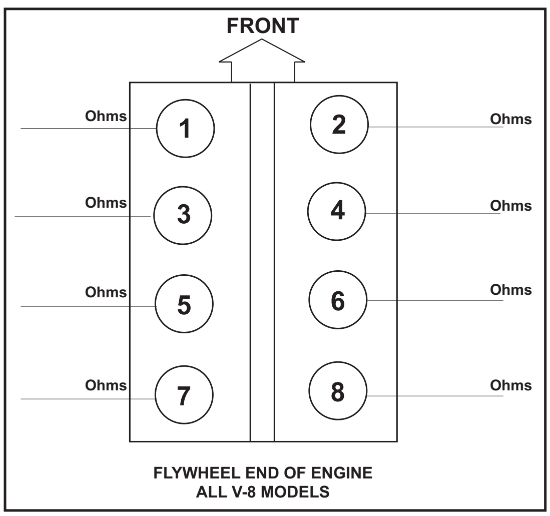
Inspection or Check	YES	NO
1) Review Steps **1** thru **5**:		
2) Inspect fuel for contamination:		
3) Electrically isolate engine from boat:		
4) Powertrain is aligned:		
5) Remove and Inspect Distributor Cap and Rotor (5.0/5.7L only):		
6) Check&**record** Ignition wire resistance:		
7) Remove and Inspect each spark plug:		
8) Perform a Compression Check on all 8 cylinders: **Record below.**		

Inspection or Check	YES	NO
WATER TEST		
9) Verify CAM Retard** (5.0/5.7L only):		
10) Performance verified against a similar boat w/same engine. package, if available		
11) Perform the Diacom Power Balance Check; under load, @ 1600-1800rpm:		
12) Perform the harness 'Wiggle Test':		
13) Diacom recording-Pre-Delivery test:		

7) VERIFY REPAIR HAS CORRECTED THE PROBLEM.

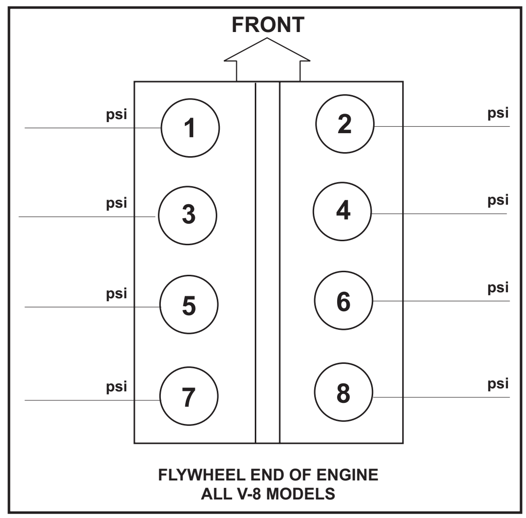
Check for and clear all codes from the ECM memory. **Water test the boat.** Run the engine for a minimum of two (2) minutes, then verify that no codes have returned. Continue with your water test long enough to verify that the problem has been corrected.

**** CAM Retard - '02 thru '06 = 43-47 degrees**
'07 - SN 485993 = 0 - 4 degrees/CES and SN 485994↑ = 15 ± 2 degrees

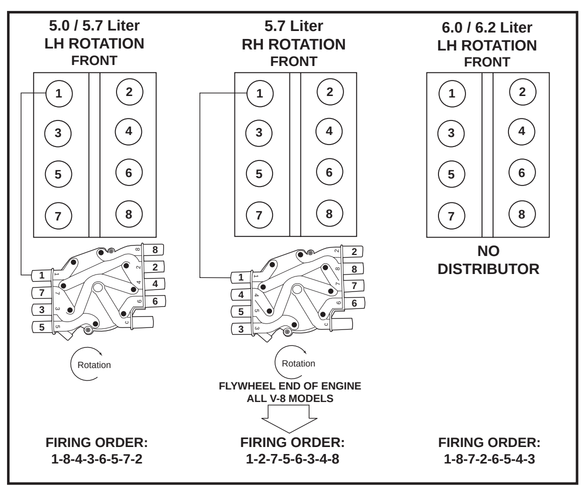


IGNITION WIRE RESISTANCE CHECK
Less than 10,000 ohms/ft

COMPRESSION PRESSURE:
5.0/5.7L - 130-215 psi
6.0L - 130-215 psi
6.2L - 130-215 psi
Lowest pressure should be within 70% of highest pressure. Minimum cylinder pressure - 100 psi.



COMPRESSION CHECK



REFERENCES:

Master Engine Specification Sheets

L510030 - GCP / 4G Diagnostic Service Manual

L510015 - 5.0/5.7L Engine Mechanical Service Manual

L510016 - 6.0L Engine Mechanical Service Manual

PCM Premier Dealer Website - All the Latest Publications

Figure 5-1 PCM Drivability Checklist

Main Electrical System

Engine reliability, performance and safety depend upon an electrical system that is functioning at peek efficiency. Marine engines are constructed from electrical components that meet strict safety and performance standards. These standards must be maintained to ensure that the performance and safety features engineered into PCM engines are not compromised.

This section covers the Main Electrical System. The primary functions of the Main Electrical System are to provide an uninterrupted source of constant power to all electrical sub systems, and to crank the engine for starting.

NOTE: The discussion that follows is for current production engines. Older models may have different configurations and illustrations. The following may not apply to these older models.

Refer to Figure 5-2. The Main Electrical System consists of three sub-systems.

1. System Power - The 12 volt Battery and its associated components and cables.
2. Starter Circuit - The Starter and its associated components and wiring.
3. Charge Circuit - The Alternator and its associated components and wiring.

It is necessary that a technician servicing PCM engines maintain the reliability, performance and safety built into our engines by:

1. Repairing electrical system components in a manner consistent with our design standards.
2. Replacing defective components with original equipment parts that meet all of our applicable marine safety and manufacturer design criteria.

Warning: All PCM electrical components are certified to meet Coast Guard requirements for ignition or explosion protection. DO NOT use electrical components that do not meet the Coast Guard requirements.

Symptoms of a malfunctioning Main Electrical System may not always be easily isolated to the Main Electrical System itself. Many of the symptoms reported could be interpreted as Engine Management or Fuel System problems, while others can be directly associated with the Main Electrical System. As shown in the procedures so far, verifying that you have sufficient power is one of the very first steps to perform. In all cases, whether performing the On-Board Diagnostic System Check or troubleshooting the Fuel System; having the correct voltage and current available is essential for proper operation.

We will begin troubleshooting Main Electrical System problems in the same manner we begin all of our troubleshooting exercises, by completing the PCM Drivability Checklist, Figure 5-1. Before you can complete Step 4 and beyond of the PCM Drivability Checklist, you must resolve all system power and starter issues. Low, or no power may not only keep you from starting the engine, but may cause the ECM to set false codes, cause improper operation of the engine's ignition and fuel systems and may cause erroneous instrument readings.

We will use the following procedures to troubleshoot the Main Electrical System.

This partial list contains some of the more common complaints associated with the Main Electrical System:

1. A dead battery
2. Over- or under-voltage displayed on the volt gauge
3. Slow cranking or no crank of the engine
4. The engine cranks but will not start
5. The engine stops and will not restart
6. The engine stops, but will restart
7. The engine cuts off and on, or stalls during operation.
8. The malfunction indicator light (MIL) and/or warning buzzer lights/sounds during cranking. No DTC codes are stored in the ECM's memory.
9. Scan Tool does not recognize the ECM.
10. Any similar complaint that may be caused by the loss of a power feed circuit.

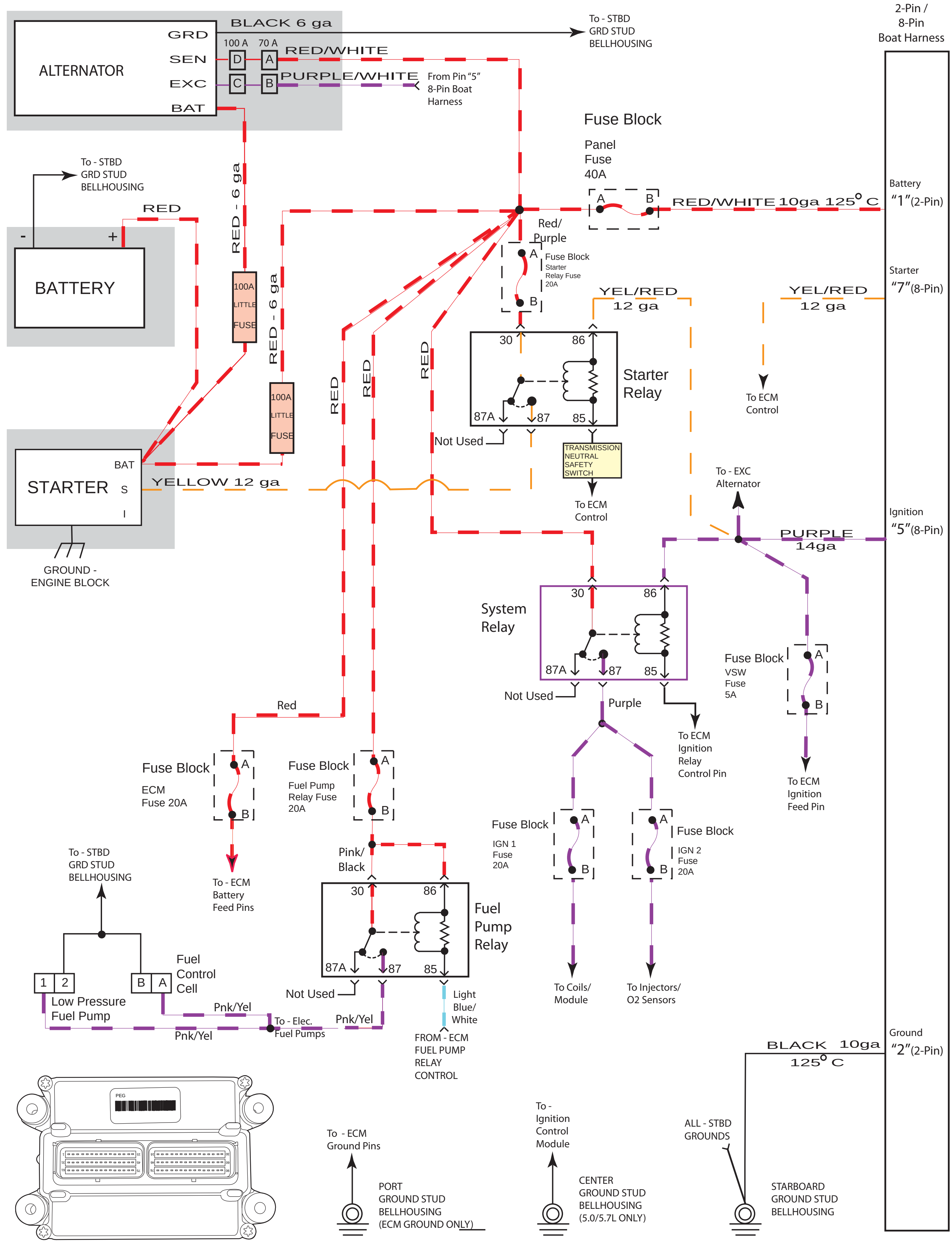


Figure 5-2 Main Electrical System Wiring Diagram
L599003-13

Isolating the Electrical System

The engine is designed to be controlled by the boat's mechanical and electrical controls. Problems in these areas may cause conditions that may be mistaken for engine defects.

Often it is necessary to determine if the boats electrical system is the cause of a reported engine problem. It will be necessary to separate the engine electrical system from the boats electrical system before testing begins. Some common symptoms that may indicate the need for this procedure are:

1. Intermittent crank or starts
2. No crank or no start
3. The engine cuts off and on during operation
4. Low voltage or dead battery
5. Perceived under- or over-charge conditions

Refer to Figure 5-3. Isolating the engine harness from the boat harness is easily done by disconnecting the boat harness at the engine/boat harness 8-pin and 2-pin connectors.

Once you have disconnected the boat harness connectors, verify that you have Battery voltage at Pin "1" of the engine's 2-pin connector. Troubleshoot System Power if voltage is not present.

You can then use a remote key switch, P/N RT0091, at the engine side of the two connectors to simulate Key 'ON' and 'START' functions that would normally take place through the boat harness and the ignition switch.

At the engine's 8-pin and 2-pin connectors, connect the remote key switch.

If the engine operates normally with the boat harness disconnected, you know the problem lies somewhere within the boat wiring or boat accessory devices. You would then troubleshoot and repair that problem. If the problem is still present in the engine, you can now focus your troubleshooting on the engine.

NOTE: The remote key switch test harness, P/N RT0091, can be purchased from the PCM Parts Department.

Figure 5-2 Remote Key Switch - P/N RT0091

System Power

Refer to Figure 5-3. You should have the following tools available when troubleshooting the Main Electrical System:

1. Diacom scan tool
2. DMM
3. Battery Load Tester

Your starting point for any Main Electrical System problem and most other troubleshooting problems will be the Battery. Low or no voltage at the ECM, Starter, and other devices will cause multiple faults and symptoms to occur.

Remember, voltage below 9.6 vdc at the ECM will cause the ECM to not power up, shut off or reset during cranking. This may cause an interruption in fuel and/or spark control, and cause starting or drivability issues. In other words, low voltage equals a loss of:

1. fuel
2. air
3. spark

Figure 5-3 Tools

System Power

Previously we discussed the OBD System Check. Part of the first step in that procedure was to ensure that:

1. The Battery is good, of the proper size and fully charged.
2. The Battery cables are clean, tight, properly connected and in the correct locations.
3. Excessive resistance is not present in the cable circuits.

These steps are the basis for the System Power Check. Let's take a detailed look at the System Power Check.

System Power – KEY OFF

1. Verify that the battery is the correct size and rating for the boat; and most importantly, fully charged.

Verify that the battery is the correct size and rating for the boat; and most importantly, fully charged. To verify the charge on a battery you will need a battery load tester. To load test a battery you must:

1. Disconnect both the negative and positive leads of the battery,
2. Connect your load tester and then load the battery, per your load tester instructions,
3. Under load, verify the battery voltage to be a minimum of 9.7 vdc.
4. If the battery check confirms the battery is good; inspect and clean your battery terminals and connectors then reconnect the battery.

Figure 5-4 Verify System Power

IMPORTANT – The ECM may reset if voltage drops below 9.6 vdc. This can cause false codes, and inaccurate display readings to occur. Always begin your troubleshooting procedures with a known good battery.

2. Refer to Figure 5-5. Inspect the engine power and ground locations. Clean and repair these connections as necessary. Proper ground connections are very important for engine operation. The flywheel housing's port ground stud should have only the ECM grounds from the main engine harness attached. The flywheel housing's starboard ground stud should be used for the battery, all other main engine harness grounds, and all accessory grounds.

NOTE: The 5.0/5.7L engines utilize the center bolt on the bell housing as a ground for the Ignition Coil/Module Assembly. This should be the only ground at this location.

System Power – KEY ON

3. Refer to Figure 5-6. After checking battery voltage and battery cable connections, Turn the ignition 'ON' and apply a load to the battery by turning ON the Navigation Lights and boat Courtesy Lamps. Verify that system power is not less than the battery voltage by more than 0.3 vdc at the test points shown. The test points are at junctions, connectors and fuses that are either routing points for system power or after major splices in the engine harness. As you take measurements at each of these points inspect for tightness of the connectors and inspect for corrosion. You should clean or repair connections as necessary. Turn the lights and ignition switch OFF when you have completed the test.

Example: Battery Voltage is 13.0 vdc; all test points should read 12.7 – 13.0 vdc. A reading outside of this range may indicate a bad splice, connection or broken wire which should be repaired before proceeding with any other troubleshooting.

NOTE: Test points are labeled on Figure 5-6 for easy reference. If battery voltage is not available at TP-2 (starter battery terminal). Ensure that the boat's Battery Switch (if equipped) is in the correct position before troubleshooting or replacing the cable.

Once you have verified that the proper voltage and grounds are available for System Power, you would return to the test procedure that requested a System Power check. If the problem you are troubleshooting is a starter problem or a charge system problem you would return to the Starter or Charge Circuit Troubleshooting Tree and complete the troubleshooting.

Always resolve system power, starter or charging, problems before you perform the On-Board Diagnostic System Check or any other Engine Management System troubleshooting procedure.

MAIN ELECTRICAL SYSTEM - 5

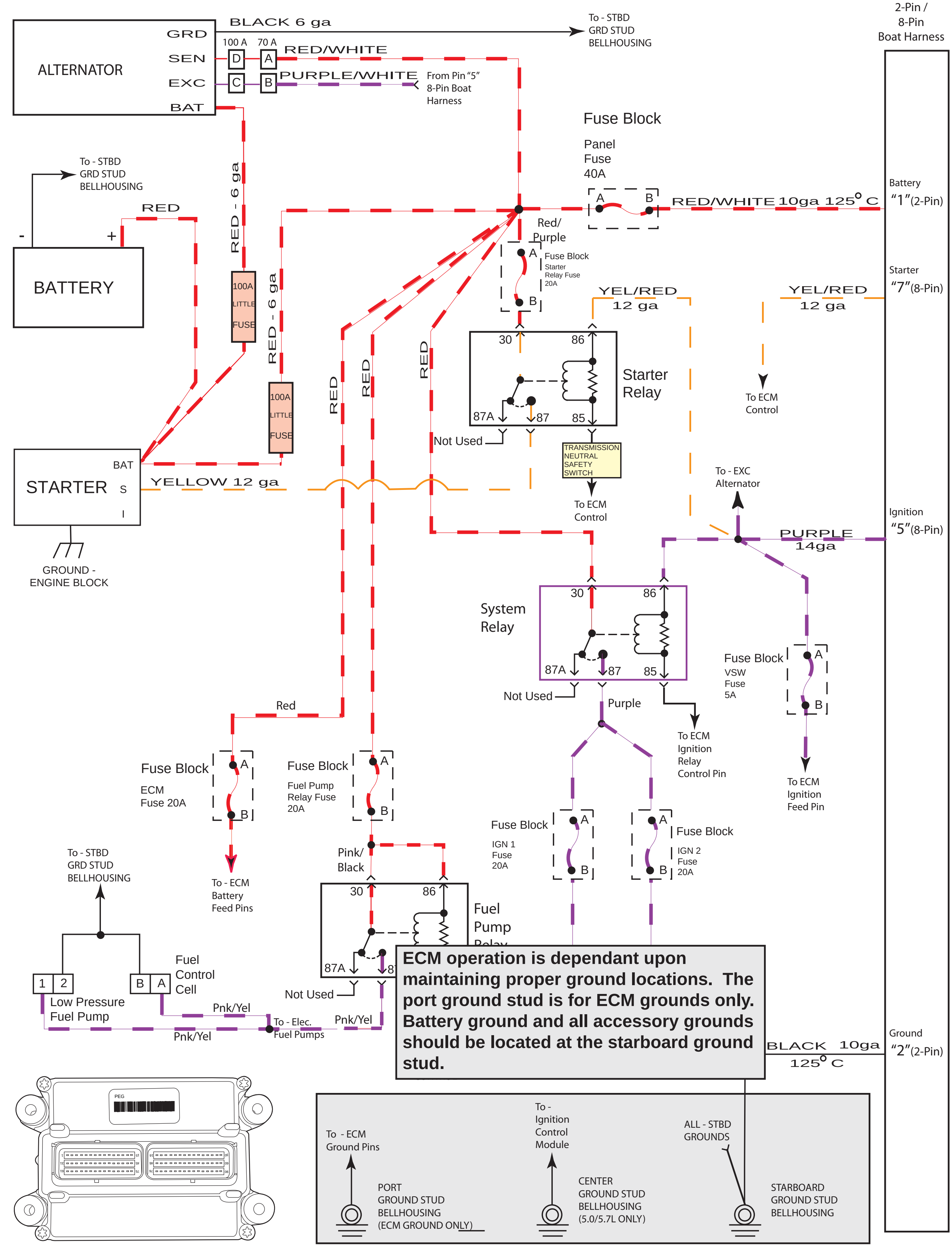


Figure 5-5 System Power Ground Locations

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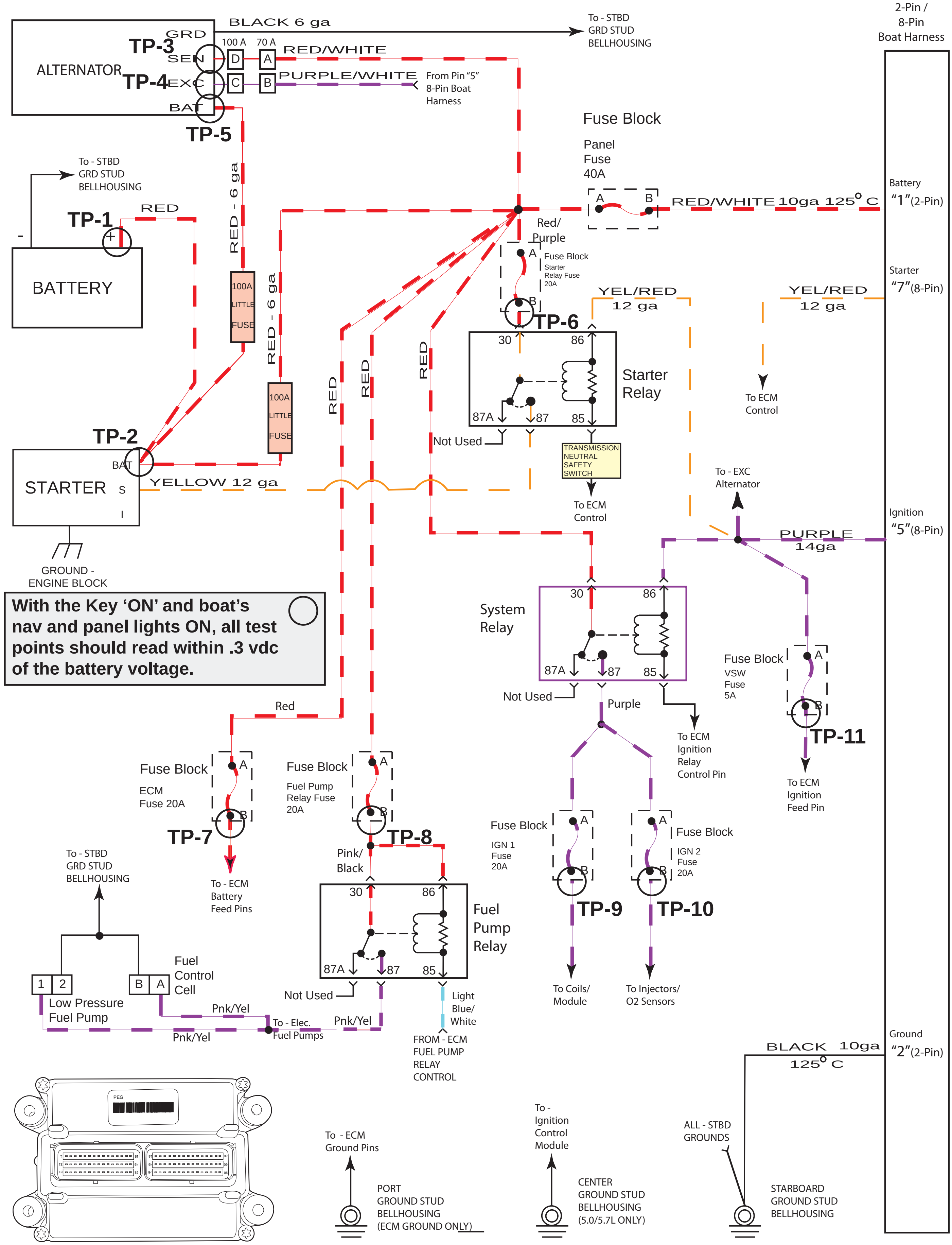

Figure 5-6 System Power Test Points
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Starter Circuit

NOTE: Starter problems are those associated with cranking the engine. Starting problems are those associated with making the engine run. Starter problems should be addressed before performing any other troubleshooting procedures.

The most common problems associated with the Starter Circuit will be:

1. A no crank
2. Slow crank condition

Typically, these conditions may be the result of:

1. A defective ignition switch or control
2. A failing battery
3. A failing starter
4. A faulty starter relay
5. A misadjusted or failed Transmission Neutral Safety Switch
6. An engine mechanical problem

Refer to Figure 5-7. The starter circuit path is from the battery positive (+) connection to the Starter BAT connection, through the 100A fuse to the 20A Starter Relay Maxi fuse. From the Maxi Fuse to pin “30” of the Starter Relay.

Power from Pin “1” of the 2-Pin connector is routed through the boat harness to the Ignition Key Switch. When the Key Switch is in the START Position power is routed back through the boat harness to pin “7” of the engine/boat harness 8-Pin connector to ECM Starter Circuit pin which energizes the relay. Ground for the Starter Relay is relay pin “85”, through the neutral safety switch to the ECM Starter Relay Control circuit pin.

When the Starter Relay closes, power from pin “30” is routed through the relay to pin “87”, then to the Starter Solenoid (S) contact causing the Starter to engage and crank the engine.

The Starter ground path is through the Starter’s case to the engine block through the starter mounting surface at the bell-housing. The engine block is grounded through the negative (-) battery cable back to the Battery negative (-) terminal or post.

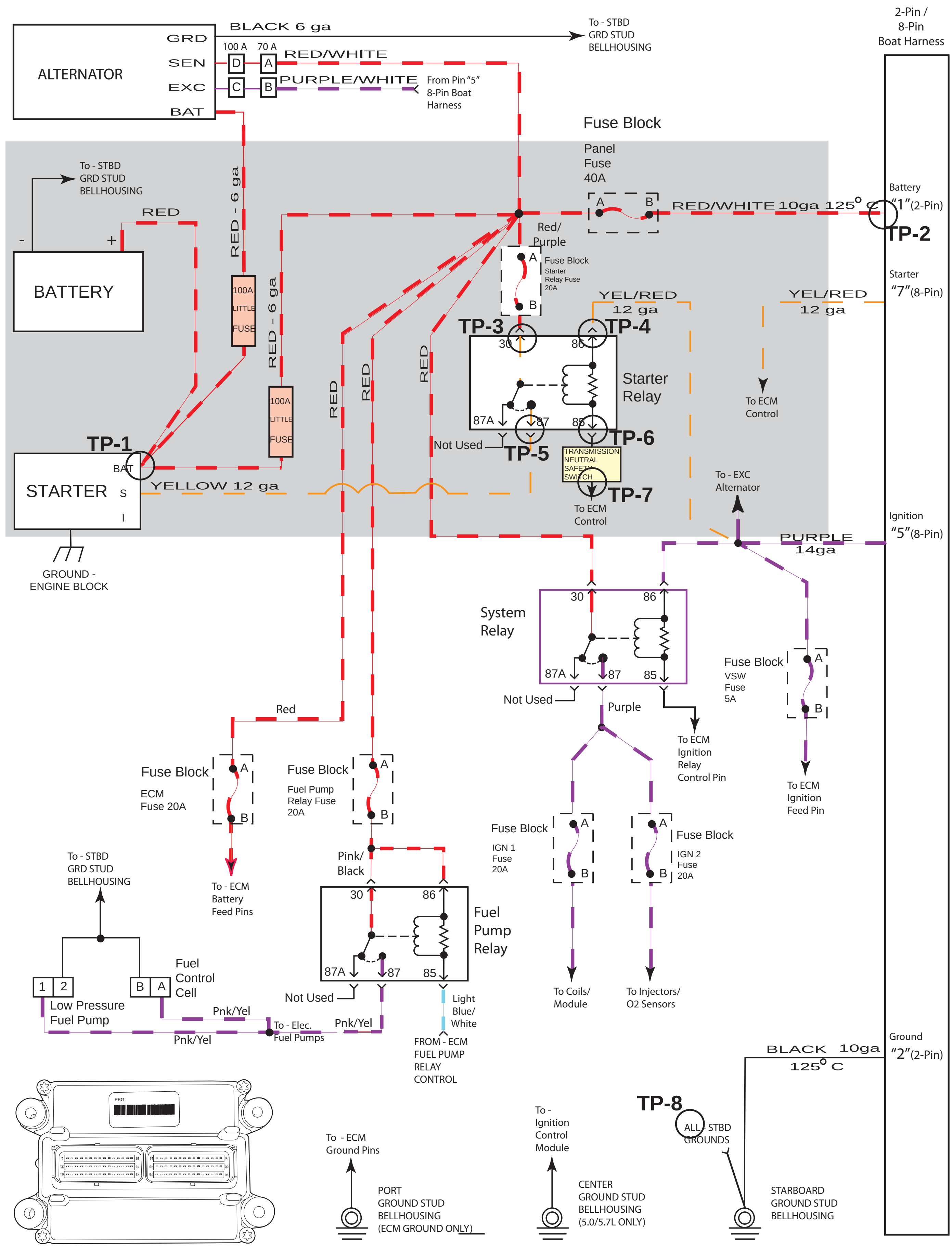

Figure 5-7 Starter Circuit Wiring Diagram
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Starter Circuit

Refer to Figure 5-8. The Starter Circuit Troubleshooting Tree lists the steps for troubleshooting starter problems, starting with:

1. A visual inspection
2. Verify there is no engine mechanical issue (Result of the spark plug inspection)
3. Check the ECM for a Fuel Injector code or Engine Overheat code
4. Verify System Power

The most difficult part about troubleshooting a starter problem will be NOT turning the key to the START position before the Starter Circuit Troubleshooting Tree instructs you.

Caution: When you have a reported slow or no cranking condition – Do Not attempt to crank the engine until you have performed a physical check of each spark plug for fluids in a cylinder. If water, coolant or fuel is in the cylinders, hydrostatically locking the engine, you may do major engine damage by attempting to crank the engine.

Always perform the System Power Check before troubleshooting a starter problem. A known good, fully charged battery is essential for proper testing. A weak or failing battery will give false test results.

Refer Figure 5-8. When you perform the Visual Inspection, Step 3 of the PCM Drivability Checklist, include in that inspection:

- All Starter wiring connections are tight and free of corrosion
- The Starter has no physical and/or water damage
- The exhaust flaps are present and there are no exhaust restrictions
- The spark plugs show no evidence of fluid in the cylinders
- The shift lever in the boat is in the Neutral position

NOTE: Starters used are permanent magnet starters and the magnet can be broken if the housing is pounded on. Also, “Marine” Starter means that the starter is “spark arrested” and safe to use in the bilge of the boat. It does not mean that the starter will operate under water.

Part of the Visual Inspection, Figure 5-1, will be to remove all eight spark plugs and inspect them for evidence of fluids. This check is done to eliminate a possible mechanical problem for a slow or no crank condition.

Caution: When you have a reported slow or no cranking condition – Do Not attempt to crank the engine until you have performed a physical check of each spark plug for fluids in a cylinder. If water, coolant or fuel is in the cylinders, hydrostatically locking the engine, you can do major engine damage by attempting to crank the engine.

The owner/operator may have already damaged the engine by continuing to attempt to crank an engine that has fluid in a cylinder(s). By doing this inspection before you attempt to crank the engine, you may find water, coolant or fuel in a cylinder before it is pumped out as the engine starts and runs. You would troubleshoot and repair the cause of the fluid in the cylinders, then verify the starter is operating properly.

If fluid is found in the engine cylinder(s) use your Diacom scan tool to check the ECM for a Fuel Injector Fault code or Engine Over Temperature code. If present, you may have found the starting issue. One or more cylinders may be filled with fuel from a defective injector circuit, or one or more cylinders may be filled with water from the engine dieseling after an overheat condition occurred.

Perform the Diagnostic Procedure for the trouble code present first. Return to the Starter Circuit Troubleshooting Tree and continue testing to ensure there are no other engine mechanical issues, and the starter issue is resolved.

If no codes are present, and there is evidence of fluid in the cylinders, there are two paths for troubleshooting:

1. If it is fuel, troubleshoot the injector circuit for that cylinder and repair the wiring or replace the injector.
2. If water or coolant is present, determine the source of the water or coolant by pressure testing the exhaust manifolds and elbows. Determine whether it is a failed exhaust component, or does the engine need diagnosed for a problem such as a failed head gasket.

Once you have corrected a fluid condition in the cylinder(s), be sure to perform a compression check of all 8 cylinders to check for indications of other engine damage. This test is not all conclusive, but may reveal internal engine damage that could cause major engine damage. Return to the Starter Circuit Troubleshooting Tree, at “Verify System Power,” and verify starter operation.

Refer Figure 5-8. If the spark plugs are dry, Verify System Power. You must have a known good source of system power to complete the Starter Circuit testing.

STARTER CIRCUIT TROUBLESHOOTING TREE

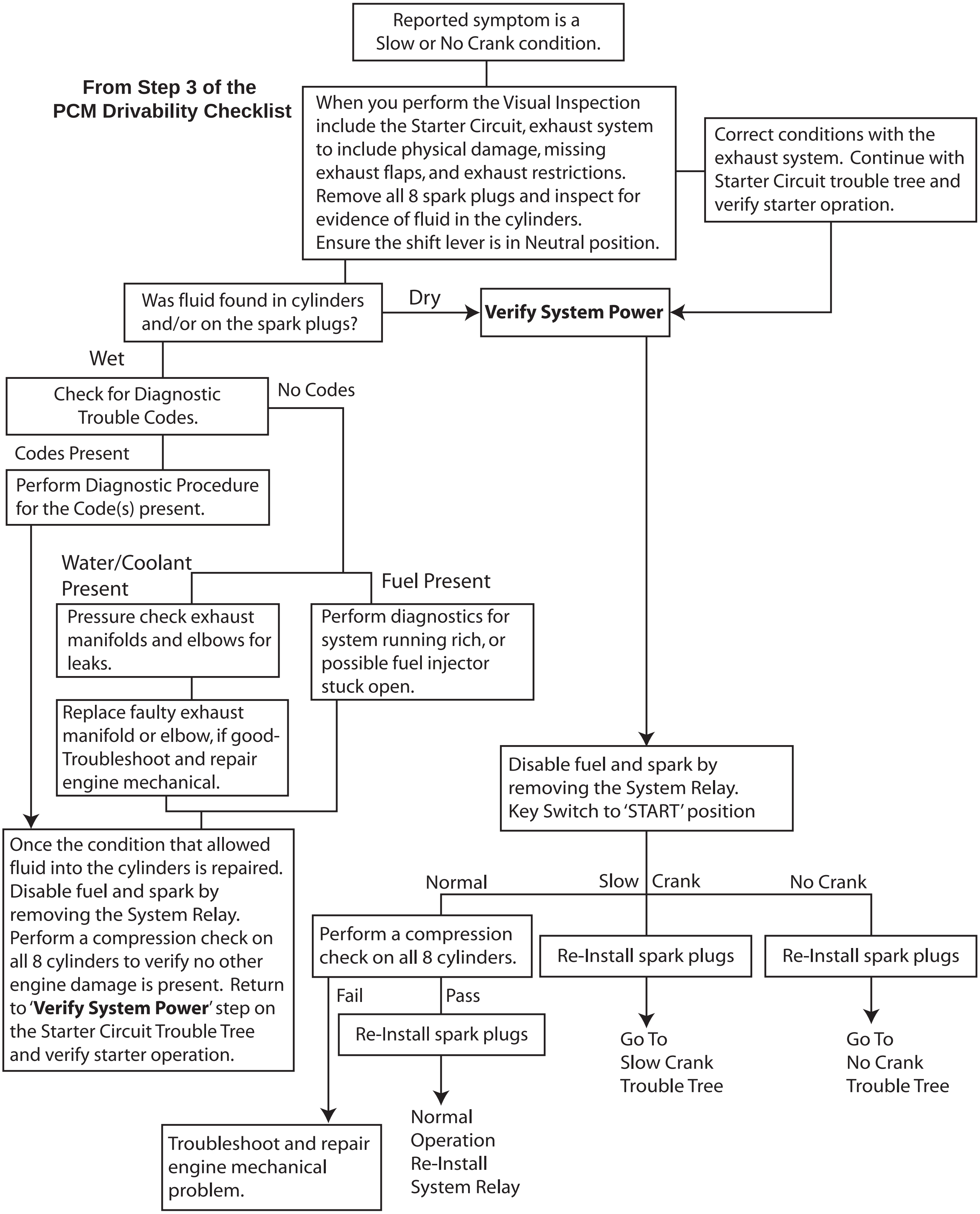

Figure 5-8 Starter Circuit Troubleshooting Tree

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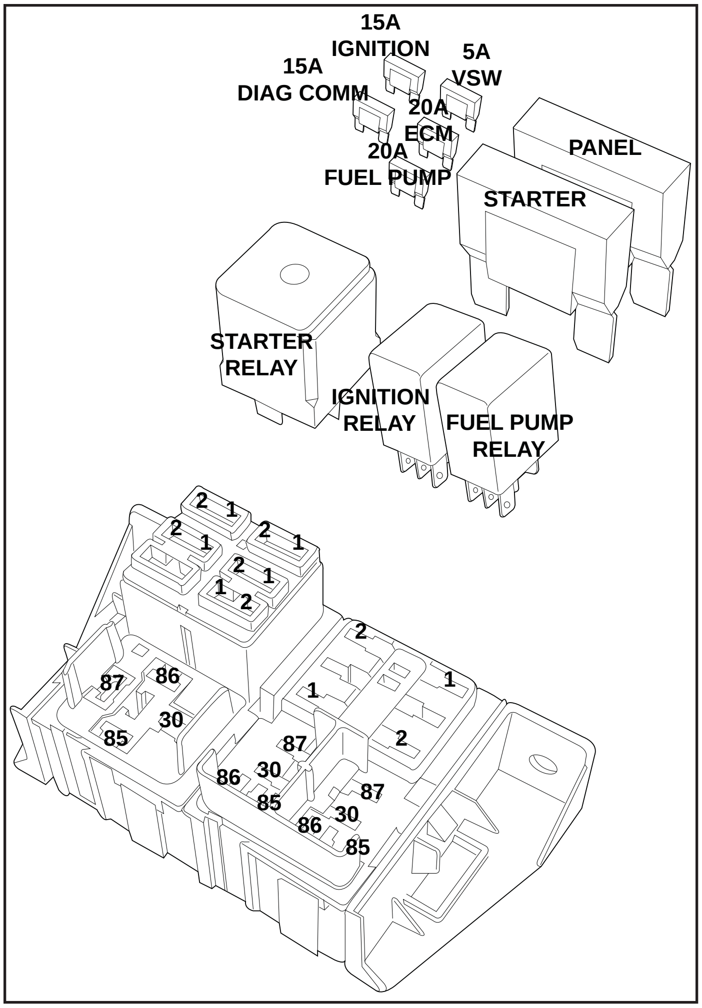


Next, disable the fuel and spark by removing the System Relay. Turn the ignition to the START position. There are three paths that may be followed based on the result of this test.

1. If the engine cranks normally, perform a compression test. The result of that test could locate an engine mechanical problem, or indicate normal engine condition.
2. If the engine cranks slowly, we will go to Figure 5-9, the Starter Circuit - Slow Crank Trouble Tree.
3. If the engine is a no crank, we will go to Figure 5-10, the Starter Circuit - No Crank Trouble Tree.

Starter Circuit Testing

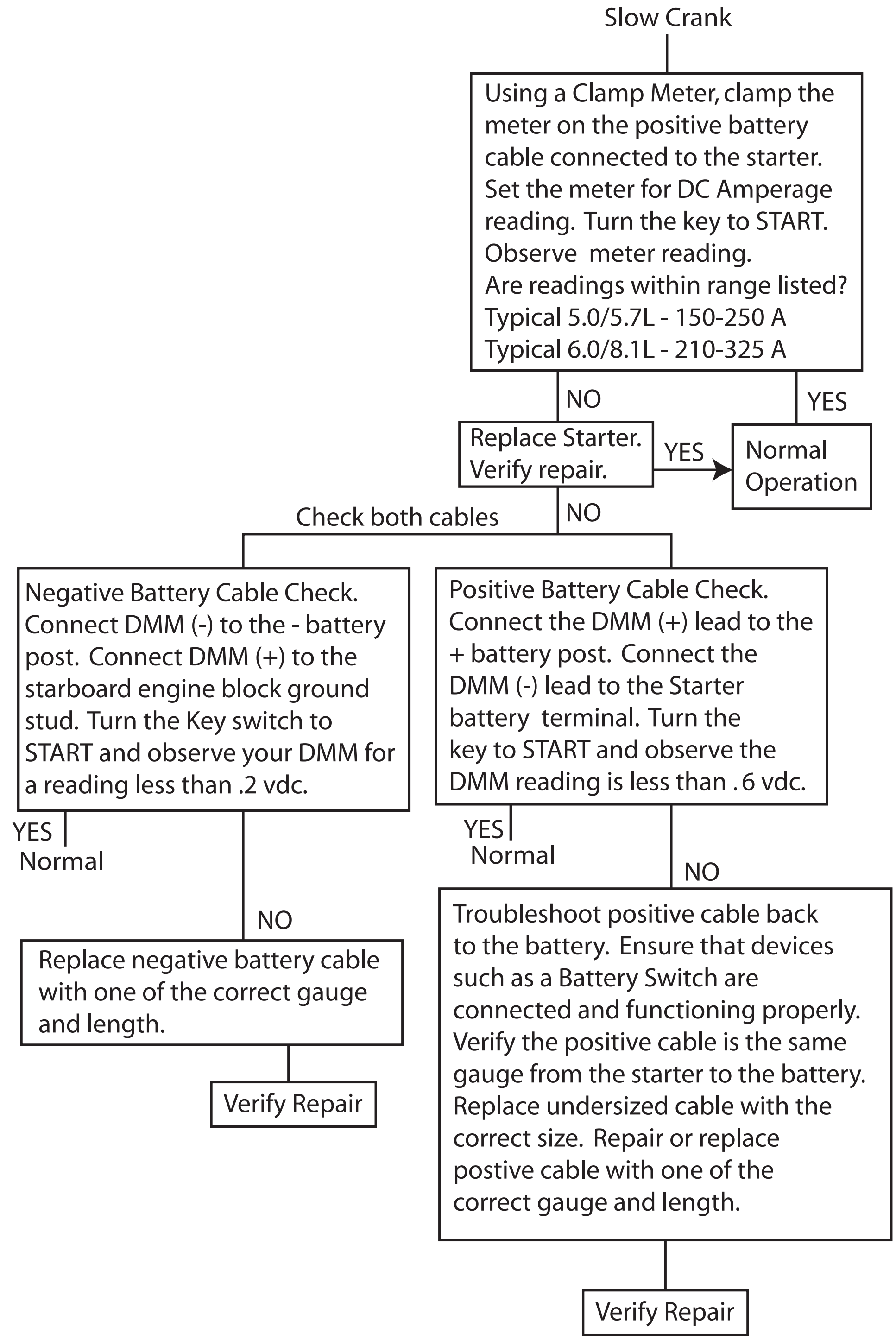
NOTE: Always perform the system power check before troubleshooting a starter problem. A known good, fully charged battery is absolutely essential for proper testing. A weak or failing battery will give false test results.

Slow Crank Condition

Refer to figure 5-9. For a slow crank condition, use a Clamp Meter to check the current draw of the starter. Clamp the meter on the positive battery cable connected to the starter and turn the ignition to the START position. Observe the meter reading as the engine cranks. Typical values will be in the range of 150 – 250 dc Amps for a 5.0/5.7L engine and 210 – 325 dc Amps for a 6.0/6.2L engine. An excessively high current draw could indicate a failing starter.

It is possible that you could still have a slow crank condition after replacing the starter due to defective or undersized battery cables. If this occurs, you would test each cable and repair or replace the cables as required. The positive cable may have multiple connection points between the battery and the starter because of the addition of Battery Switches, Power Panels or Isolators. Ensure that the same gauge cable is used throughout, and each connection or device is good between the battery and the starter.

STARTER CIRCUIT
TROUBLESHOOTING TREE
SLOW CRANK CONDITION



******** IMPORTANT ********

When you have completed your troubleshooting and repair of the starter, be sure to Reinstall the System Relay, then verify the engine starts and runs.

Figure 5-9 Starter Circuit - Slow Crank Troubleshooting Tree

Starter Circuit Testing

NOTE: Always perform the system power check before troubleshooting a starter problem. A known good, fully charged battery is absolutely essential for proper testing. A weak or failing battery will give false test results.

No Crank Condition

The No Crank condition is the more common starter problem. Testing will determine if the problem is in the boat or engine wiring, the relay or safety interlock, or the starter itself.

Refer to Figure 5-10, the Starter Circuit – No Crank Troubleshooting Tree. The first test to perform is at the starter. Using a remote starter switch connected between the Starter 'BAT' and 'S' terminals, we can verify right away if the problem is the starter or in the control circuit.

NOTE: Connecting a remote starter switch at the starter is not only useful for testing the starter but for any other test that requires the engine to crank without starting, such as a compression check.

If the engine cranks when the remote starter switch is engaged, you know the starter is good and the problem lies in the control circuit. If the engine does not crank, you have found the problem; replace the starter.

NOTE: For illustrative purposes each test presumes the problem has not been resolved. Therefore, you proceed to the next step. In actual troubleshooting if any step corrects the problem there would be no reason to proceed further.

Refer to Figure 5-10. The next series of steps verify the operation of the starter control circuit. Begin at the Transmission Neutral Safety Switch. Disconnect the wire from one side of the Transmission Neutral Safety Switch.

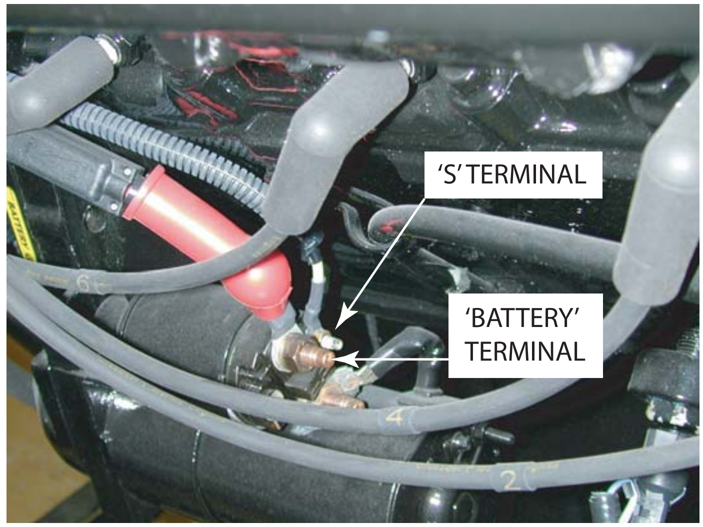
Use your DMM to verify continuity (0 ohms) when the Transmission Neutral Safety Switch is closed and the transmission is in neutral. When the transmission is shifted into gear, the switch should read open (infinite ohms or OL – out-of-limit on the meter).

Use your DMM to verify that the switch is opening and closing properly as the transmission is shifted into and out of gear. Be sure to check adjustment for both forward and reverse. Adjust the shift cable as necessary to ensure the switch is closed when the transmission is in neutral and open when the transmission is in gear.

Reconnect the wire removed to perform this test and proceed to the next test, Isolating the engine electrical system from the boat.

(Refer to Figure 5-3 for isolating the engine from the boat.)

The engine is designed to be controlled by the boat's mechanical and electrical controls. Problems in these areas may cause conditions that may be mistaken for engine defects.



Often it is necessary to determine if the boats electrical system is the cause of a reported engine problem. It will be necessary to separate the engine electrical system from the boats electrical system before testing begins. Some common symptoms that may indicate the need for this procedure are:

1. Intermittent crank or starts
2. No crank or no start
3. The engine cuts off and on during operation
4. Low voltage or dead battery
5. Perceived under- or over-charge conditions

Isolating the engine harness from the boat harness is easily done by disconnecting the boat harness at the engine/boat harness 8-pin and 2-pin connectors.

Once you have disconnected the boat harness connectors, verify that you have Battery voltage at Pin "1" of the engine's 2-pin connector. Troubleshoot System Power if voltage is not present.

You can then use a remote key switch, P/N RT0091, at the engine side of the two connectors to simulate Ignition ON and START functions that would normally take place through the boat harness and the ignition switch.

At the engine's 8-pin and 2-pin connectors, connect the remote key switch.

NOTE: The remote key switch test harness, P/N RT0091, can be purchased from the PCM Parts Department.

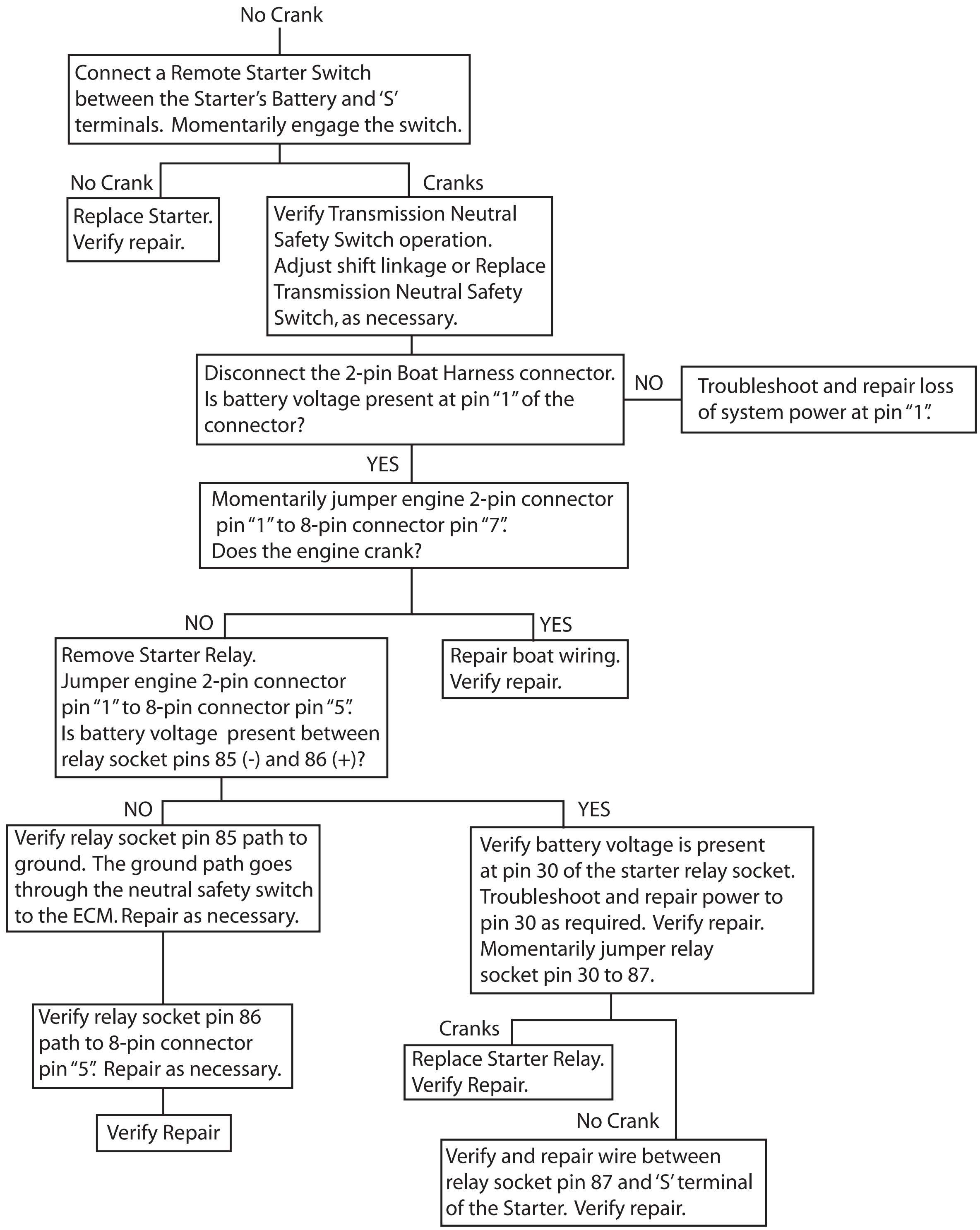
Battery voltage is present at pin "1" and a remote key switch is connected to the 2-pin and 8-pin connector. If the engine cranks, you know the issue is on the boat side of the circuit, such as wiring, a connection or the ignition switch.

If you still have a no crank condition you know that the problem lies on the engine side of the circuit., such as an ECM, wiring or the starter relay.

You have determined from the previous test that the problems lies somewhere in the engine wiring and circuits, the next check is for starter control voltage at the Starter relay socket.

1. Remove the Starter Relay from its socket.
2. Install a remote key switch to the 2-pin and 8-pin connector. Turn the Key to the START position. While the engine is cranking, measure battery voltage between socket pins 85 (ground, TP-6) and 86 (B+, TP-5).
    a. If the voltage is not present, troubleshoot the power and ground paths. Verify continuity (0 ohms) between relay socket pin 85 (TP-6) and the ECM Starter Relay control pin (TP-9). You have already verified the operation of the Transmission Neutral Safety Switch. Repair ground circuit as required.
    b. Verify ignition voltage from relay socket pin 86 (TP-5) back to pin “5” of the 8-Pin boat/engine harness connector. Look for a break in the wire or bad connection between pin 86 and the switch (TP-4), or between the switch (TP-3) and pin “7” of the 8-Pin boat/engine harness connector. Repair power circuit as required.
3. If the control voltage is present at the relay socket, you need to determine if the relay is defective or the wire between socket pin 87 (TP-8) to the starter ‘S’ terminal is defective.
4. Verify that battery voltage is present at pin 30 (TP-7) of the relay socket.
    a. If not, troubleshoot and repair the break in the wire between pin 30 and the main power circuit connection.
5. If voltage is present, jumper pin 30 (TP-7) to pin 87 (TP-8) of the relay socket. If the engine cranks, replace the starter relay.
    a. If the engine does not crank repair the wire between pin 87 of the relay socket and the ‘S‘ terminal of the starter.

STARTER CIRCUIT
TROUBLESHOOTING TREE
NO CRANK CONDITION



******** IMPORTANT ********
When you have completed your troubleshooting and repair of the starter, be sure to Reinstall the System Relay, then verify the engine starts and runs.

Figure 5-10 Starter Circuit - No Crank Troubleshooting Tree

Charge Circuit

The most common problems associated with the Charge Circuit are:

1. A dead battery
2. An over/under charge voltage reading on the instrument panel

These problems may be the result of:

1. An improperly tensioned drive belt
2. Failing battery
3. Failing alternator
4. An excessive current drain on the battery, or
5. Defective gauges and wiring

Refer to Figure 5-11. The charge path is from the BAT connection on the Alternator through the 100 Amp Fuse to the Starter BAT connection. From the Starter BAT connection to the Battery Positive (+) connection.

Ground is from the Alternator GND stud to the Starboard ground stud on the engine, back to the Battery Negative (-) connection.

MAIN ELECTRICAL SYSTEM - 5

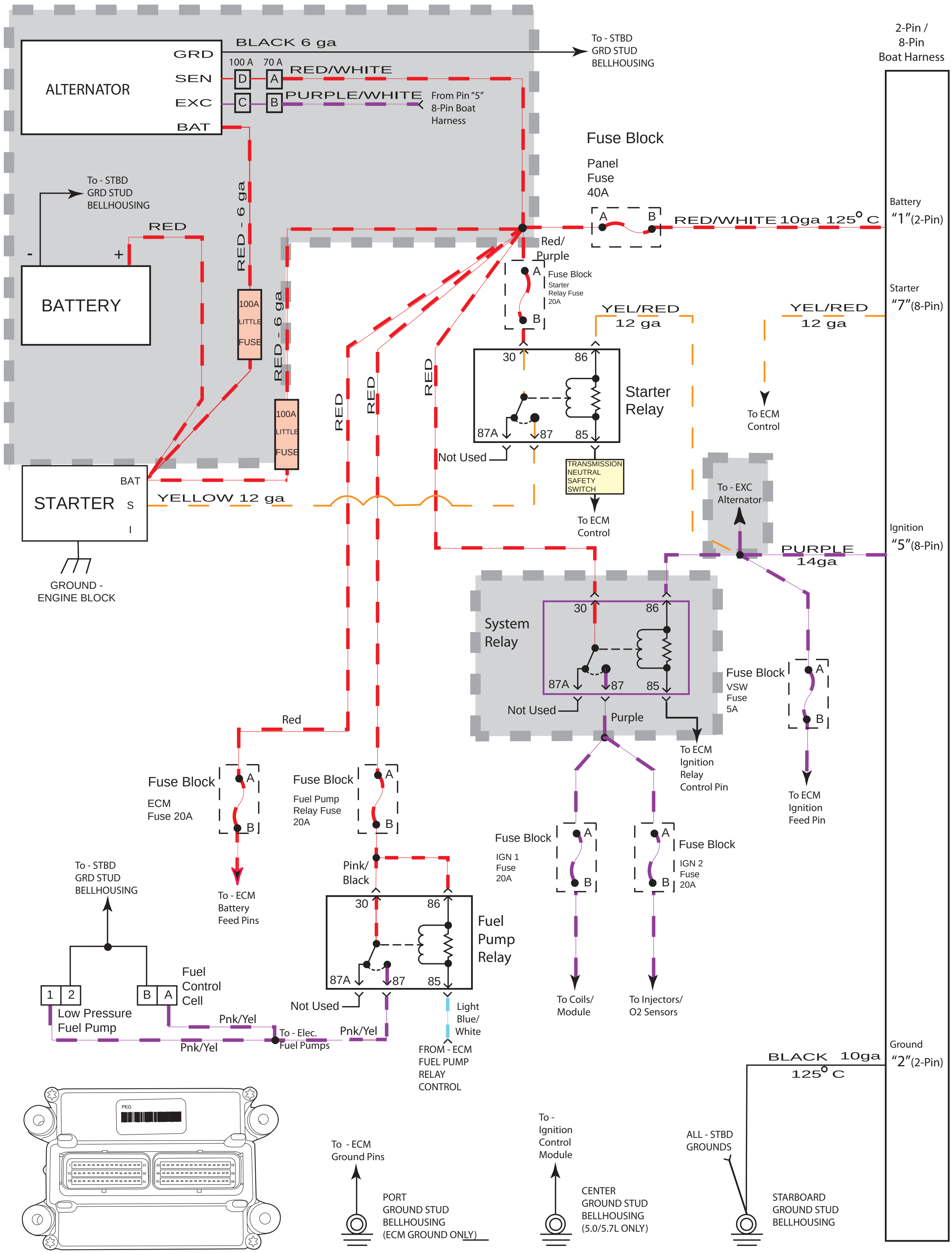


Figure 5-11 Charge Circuit Wiring Diagram

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Charge Circuit Testing

NOTE: Always perform the system power check before troubleshooting a charge circuit problem; a weak or failing battery can give false test results.

Refer to Figure 5-12, The Charge Circuit Troubleshooting Tree. The first two steps of the Charge Circuit Troubleshooting Tree will be to Verify System Power, then perform a Visual Inspection, which includes checking the drive belt for the proper adjustment.

When you perform your visual inspection, make sure all connections are tight and free of corrosion. Look for conditions that may cause an Alternator failure, such as a coolant leak above or near the alternator allowing fluids into the Alternator. Inspect the Alternator for physical damage. Pay close attention to the alternator wiring for scorched, melted or discolored wiring at the alternator. If you have damaged wiring, the next test to perform will be to check the alternator for evidence of an internal short. This must be done to prevent damaging the wires again.

NOTE: For illustrative purposes each test presumes the problem has not been resolved. Therefore, you proceed to the next step. In actual troubleshooting if any step corrects the problem there would be no reason to proceed further.

If there is no visible damage to the alternator wires, begin testing of the charge path by checking for any unusual current drain on the battery. A constant drain on the battery may be the cause of repeated low or dead battery issues and failure of the alternator. This test is done with the key 'OFF".

The current drain check is accomplished using the DMM set to the DC Amperage mode. Connect the DMM between the negative battery cable clamp and the battery's negative terminal. Normal readings will be .130 dc amps or less. It is normal to have a small draw on the battery due to various devices on the boat and engine, which have 'keep alive' circuits. Some examples of these devices are:

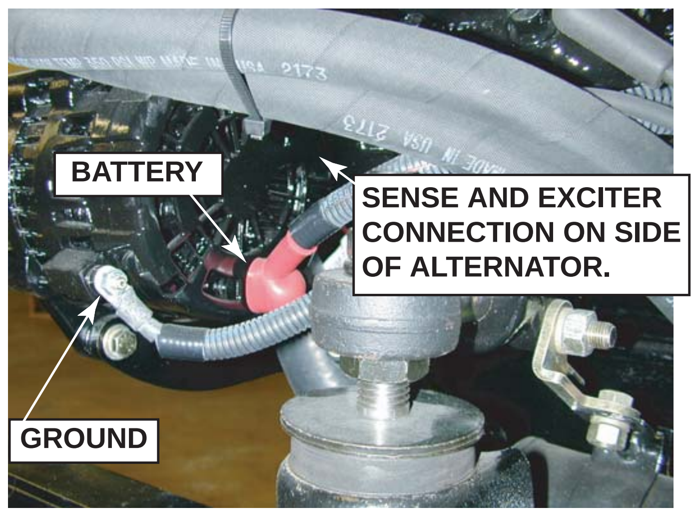
1. the ECM
2. automatic bilge pumps
3. stereo equipment

NOTE: When taking current readings allow sufficient time for devices to cycle on and resume their 'keep alive' state. Initial readings may be above the .130 dc amp specification while the device(s) warms up. Typically, this cycle will take 1-2 minutes.

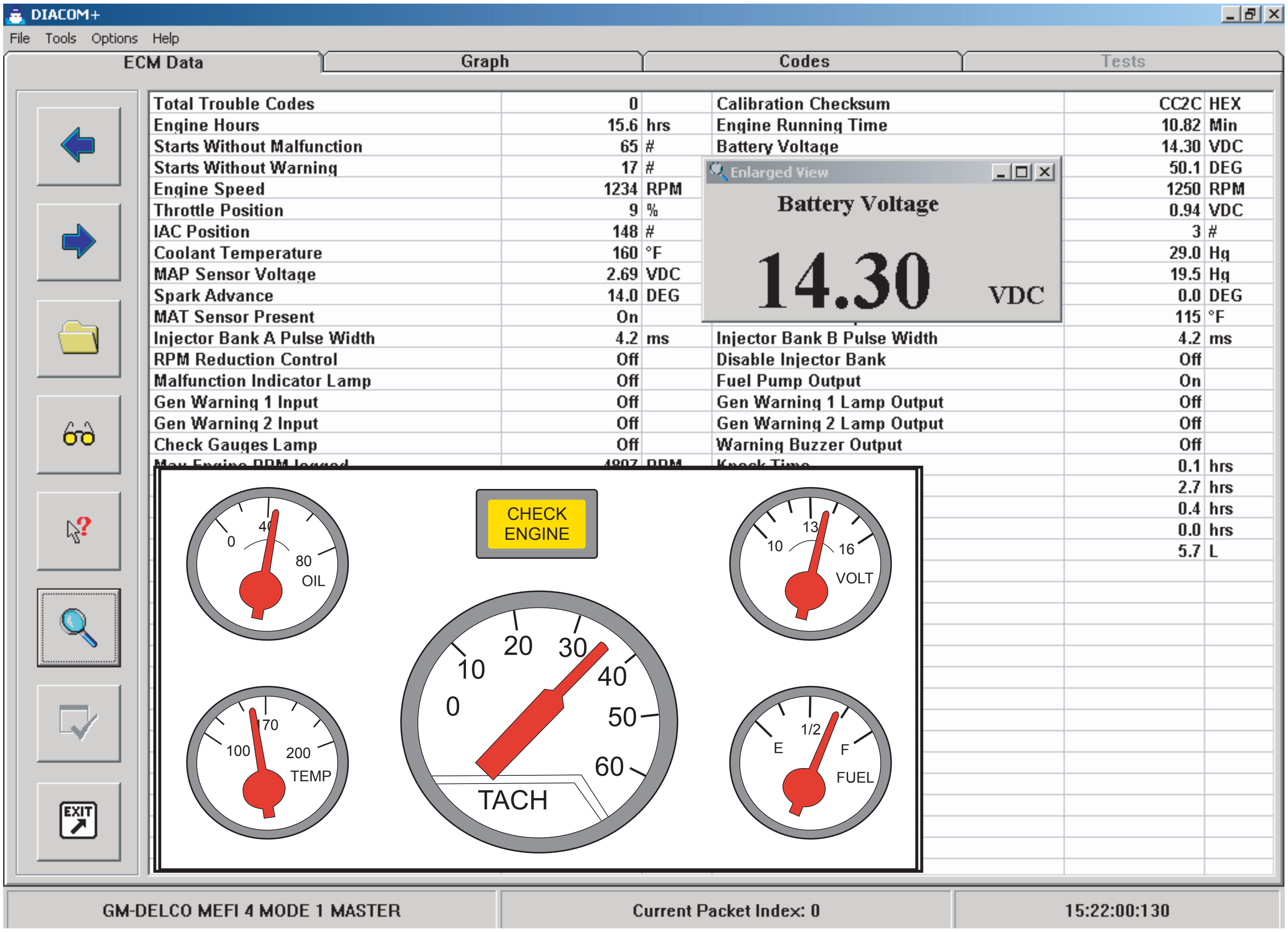
Refer to Figure 5-12. Refer to the Charge Circuit Troubleshooting Tree path for readings greater than .130 dc amps. You will need to disconnect devices connected directly to the battery's positive post one at a time. As a device is disconnected verify the current draw. If the current draw drops upon removal of a device, you now know the source of the drain on the battery. When only the starter is connected to the positive terminal of the battery, disconnect the boat harness from the engine/boat harness 2-pin connector and retest. This will complete the isolation of the current draw to either the engine or the boat. If your reading is less than .130 dc amps you know you have a problem in the boat and would troubleshoot the boat systems for a device that is drawing power from the engine/boat harness 2-Pin connector, pin "1". If the reading is still greater than .130 dc amps, you have a defective alternator. Replace the alternator and verify your repair.

Refer to the Charge Circuit Troubleshooting Tree path for a current reading of less than .130 dc amps. The next check of the charge system will be to verify that the alternator has the required inputs to function properly. Verify that you have reconnected the battery cable properly after the previous test was completed.

This test is a "KEY ON" Check. You will verify that battery voltage is present at the alternator Battery, Sense and Exciter inputs. The Exciter input is only available when the ignition switch is in the ON position. This voltage enables the alternator regulator circuit. If battery voltage is not present, troubleshoot and repair the connector or wire that is defective.



When troubleshooting a loss of voltage on the Exciter input, refer to Figure 5-11.



Refer to Figure 5-12. The final check on the charge circuit is the 'Run Test'. This will verify the operation of the alternator and its ability to maintain the battery at full charge. Connect your Diacom scan tool to the engine and with the key ON, link to the ECM. On the Diacom ECM Data display, locate the 'Battery Voltage' label. This is the current battery voltage reading. Start the engine and bring the engine to a fast idle between 1200 and 1500 RPM. Using your DMM verify the charge voltage at the alternator Battery terminal and at the battery's positive post.

NOTE: When you measure the Alternator voltage at the battery, ensure that the DMM test lead has a good connection on the battery's terminal post, not the battery cable clamp. A lower than expected reading may be the result of corrosion between the battery cable clamp and the battery post or a defective connection between the cable clamp and the battery cable. Inspect the cable to clamp bond and clean the clamp and battery post mating surfaces, reconnect and retest if a lower than expected reading is seen.

Your Diacom displayed voltage and the Alternator battery terminal reading should be within .3 vdc of the measured voltage at the battery's positive terminal and within the normal output range of the alternator, which is 12.5-14.0 vdc for normal charge or 14.0-15.2 vdc for normal high charge operation. Voltage readings above or below the specified ranges would require the replacement of the alternator.

Upon completion of the Run Test, you have verified the charge system for the engine.

If you have a discrepancy between your readings and the boat's instrument panel for a perceived over or under charging condition, refer to the boat's service and repair manual for troubleshooting.

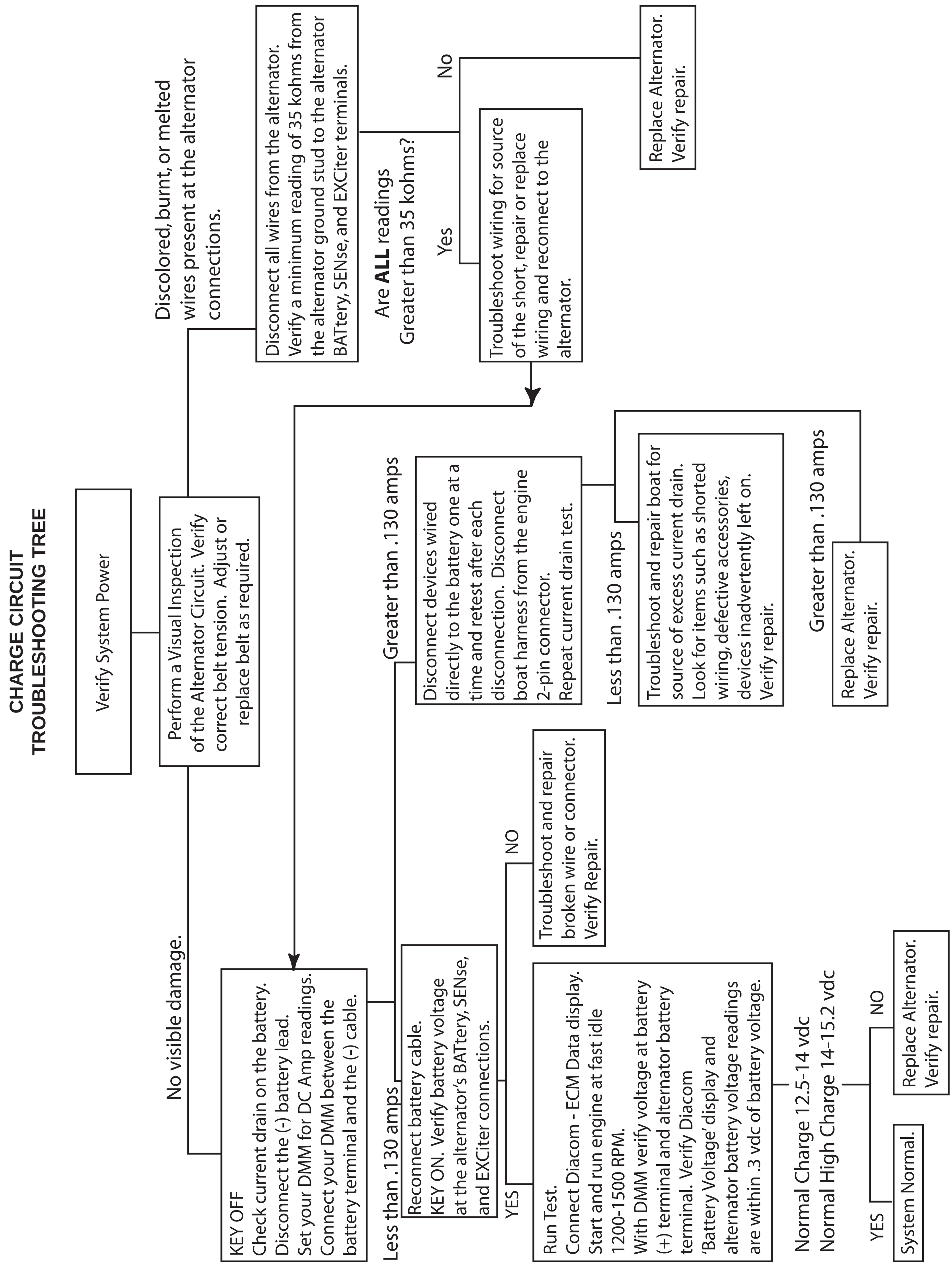


Figure 5-12 Charge Circuit Troubleshooting Tree

L599003-13

IMPORTANT: WHEN YOU INITIALLY CONNECT THE DMM CURRENT READINGS MAY BE HIGH AS DEVICES GO THROUGH A WARM UP CYCLE. WAIT 1-2 MINUTES FOR THE SYSTEMS TO STABILIZE, BEFORE RECORDING YOU READING.

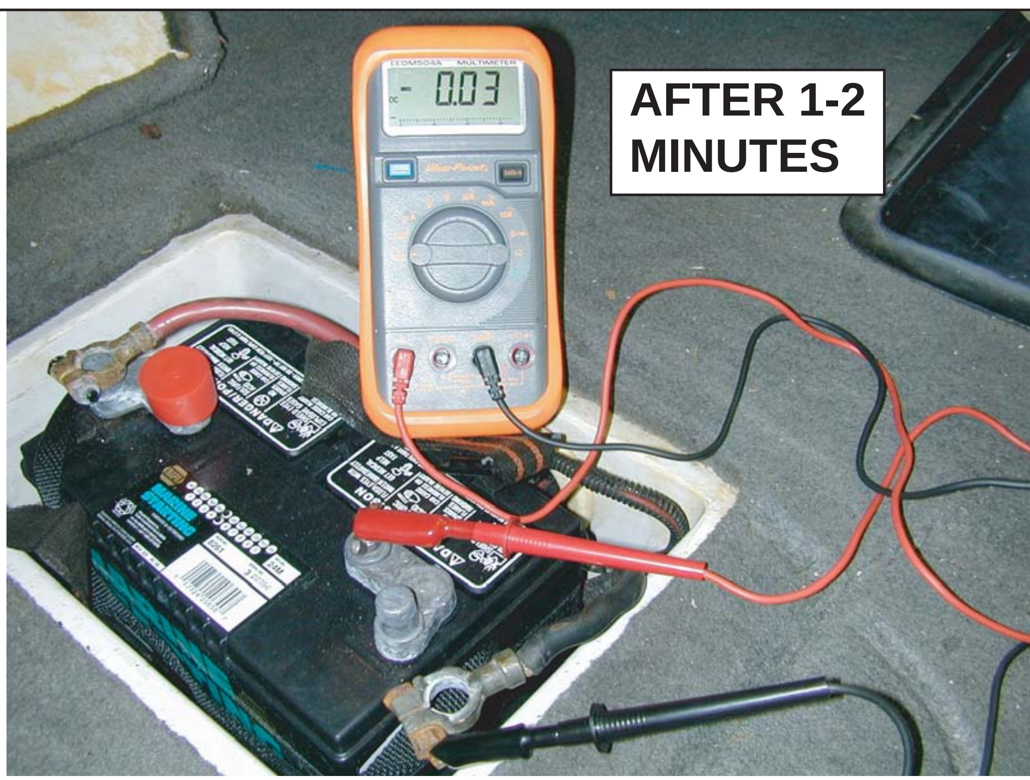


Figure 5-13 Current Drain Measurement
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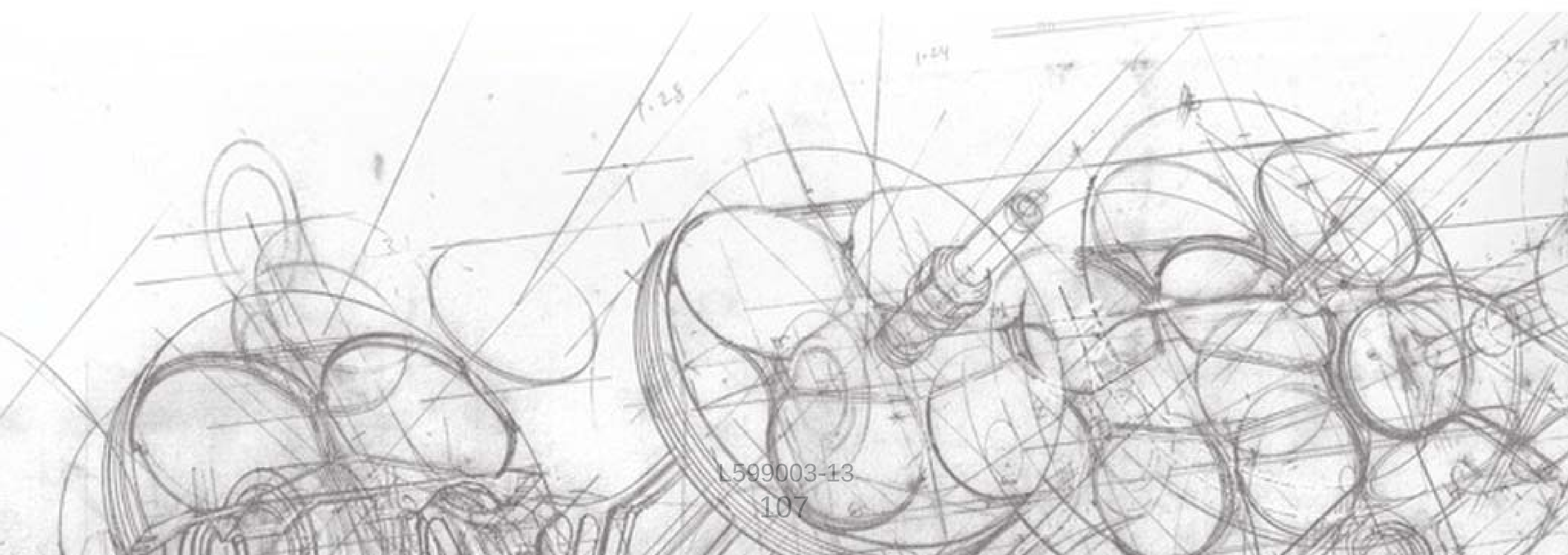
NOTES

NOTES

Section 6
Cooling
System



Cooling System

The engine Cooling System is comprised of the hull inlet, sea strainer, oil coolers, raw water pump, thermostat, circulating pump, hoses, exhaust manifolds, mufflers, exhaust hoses and elbows and heat exchanger (if equipped).

These components work together to keep the engine running at the desired operating temperature. The ability of the raw water pump to supply cooling water is essential to the proper operation of the Cooling System. Blockages, either before or after the pump, can greatly reduce the efficiency of the system, or cause the engine temperature to exceed normal readings.

There are basically two classifications of cooling systems used on a marine engine. Both systems require an endless supply of cool lake/sea water being constantly supplied to the engine for cooling.

A Raw Water Cooling System has no antifreeze, or coolant, in the system. This means there is no reason for a heat exchanger. Raw, or sea, water is pulled from the lake by the raw water pump. This sea water is circulated through the engine and expelled through the exhaust manifolds. A thermostat controls the sea water temperature in the engine to around 160°-170° F.

The Fresh Water Cooling System functions very much like your automobile. The engine block and cylinder heads, at minimal, are filled with an antifreeze solution (fresh water). This antifreeze solution is constantly circulated around the engine in a closed system. The antifreeze is cooled by circulating through the tubes of a Heat Exchanger.

The Heat Exchanger functions like a radiator. Instead of air blowing across the tubes, an endless supply of raw (sea) water is circulated through the tubes of the Heat Exchanger. This allows the heat to be removed from the antifreeze, which is circulating around the tubes. The raw water and heat are discharged through the exhaust system.

A Fresh Water Cooling System may be configured in several different setups. All Fresh Water Cooling systems circulate antifreeze through:

- The engine block and cylinder heads
- The heat exchanger

Refer to Figure 6-14. A “Partial” Fresh Water Cooling System may also include an exhaust system coolant thermostat. This allows the raw, or sea, water in the exhaust system to be thermostatically-controlled. This greatly reduces the possibility of condensation within the exhaust system.

The exhaust system thermostat filter must be inspected and cleaned as necessary at the 25-Hour Engine Inspection. The filter should then be inspected and cleaned every 50 hours or once a year. If the boat is operating in an area with high levels of sea grass, this inspection should be done more frequent.

Important: Any boat that has an engine equipped with an exhaust system coolant thermostat MUST have a sea-water strainer installed. The sea-water strainer must be an approved component from PCM or your boat manufacturer. Many sea-water strainers available severely restrict the overall system raw water flow. If you need to install a strainer, consult PCM, or your boat manufacturer, for the proper part and installation.

Important: The thermostat housing MUST be assembled and tightened as shown, in the vertical position. Failure to do so may cause the thermostat to improperly seat and result in a leak.

A “3/4” Fresh Water Cooling System circulates antifreeze through:

- The engine block and cylinder heads
- The heat exchanger
- The exhaust manifolds

A “Full” Fresh Water Cooling System circulates antifreeze through:

- The engine block and cylinder heads
- The heat exchanger
- The exhaust manifolds
- The exhaust corners

NOTE: Refer to the PCM Owner’s Operation and Maintenance manual to properly identify the cooling system you are working on. This is important to properly identify the raw water draining locations.

The raw water pump impeller should be serviced every 50 hours, or once a year, whichever occurs first. See Maintenance Schedule.

Locations “A” are access holes in order to loosen the raw water pump attaching bolts. The bolts are secured in the pump by O-rings, and will not fall out during removal.

Torque the raw water pump housing attaching bolts to 8.5-9 ft.lbs. (11.5-12 N-M), when re-installing the impeller.

NOTE: PCM Impeller Kit Part Number is RP061022 for all current modular (engine-mounted) raw water pumps.

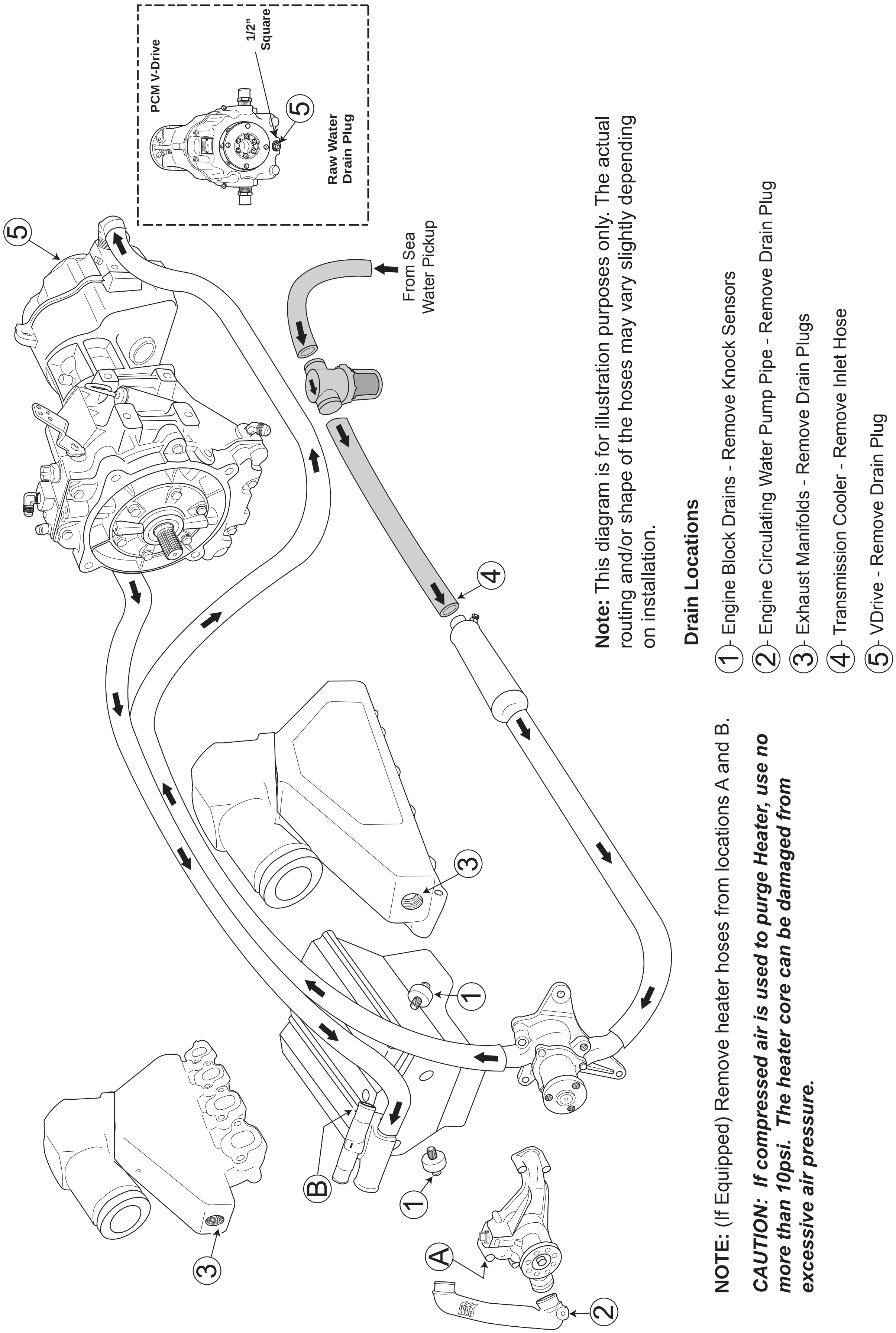
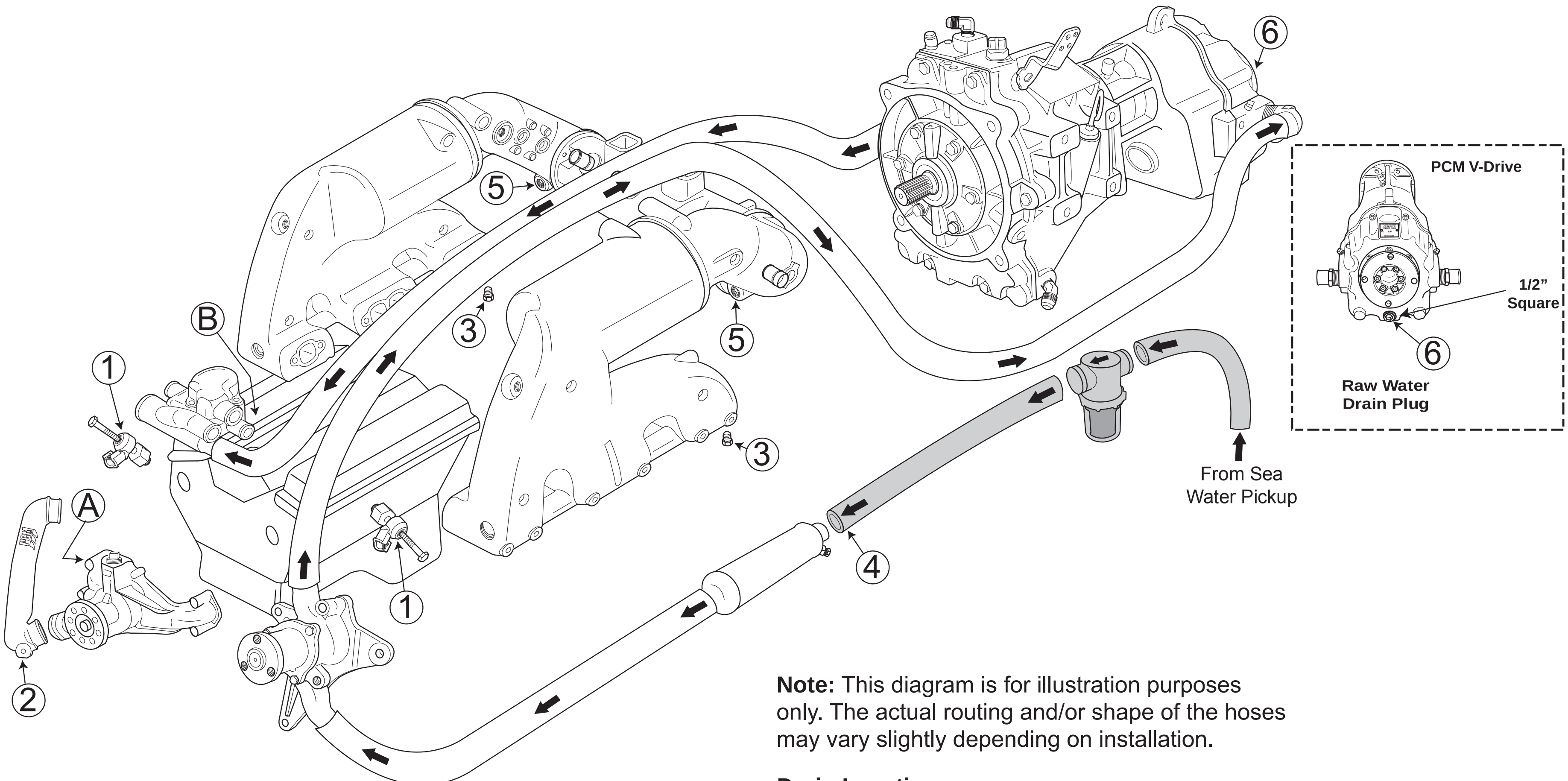


Figure 6-1 HO303 / EX343 Raw Water Cooling



Note: This diagram is for illustration purposes only. The actual routing and/or shape of the hoses may vary slightly depending on installation.

Drain Locations

1 - Engine Block Drains - Remove Knock Sensors

2 - Engine Circulating Water Pump Pipe - Remove Drain Plug

3 - Exhaust Manifolds - Remove Drain Plugs

4 - Transmission Cooler - Remove Inlet Hose

5 - Exhaust System Corners - Remove Drain Plugs

6 - VDrive - Remove Drain Plug

NOTE: (If Equipped) Remove heater hoses from locations A and B.

CAUTION: If compressed air is used to purge Heater, use no more than 10psi. The heater core can be damaged from excessive air pressure.

Figure 6-2 HO303 CES / EX343 CES Raw Water Cooling

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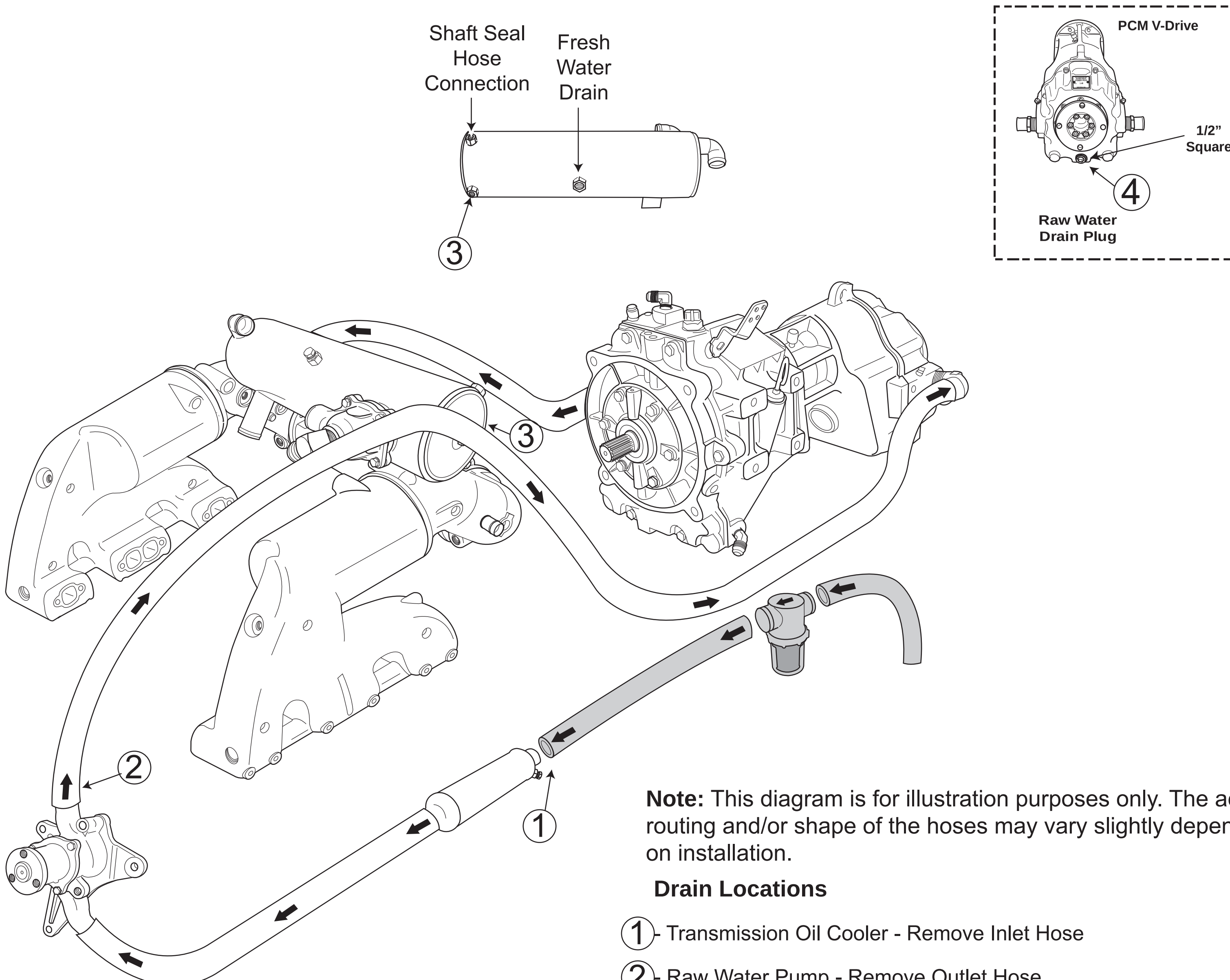
5.7L Catalyst (CES) CWS Raw Water Flow Diagram



Note: This diagram is for illustration purposes only. The actual routing and/or shape of the hoses may vary slightly depending on installation.

Drain Locations

1 - Transmission Oil Cooler - Remove Inlet Hose

2 - Raw Water Pump - Remove Outlet Hose

3 - Heat Exchanger - Remove Drain Plug/Zinc Anode

4 - VDrive - Remove Drain Plug

Figure 6-3 EX343 CES CWS Full Fresh Water Cooling

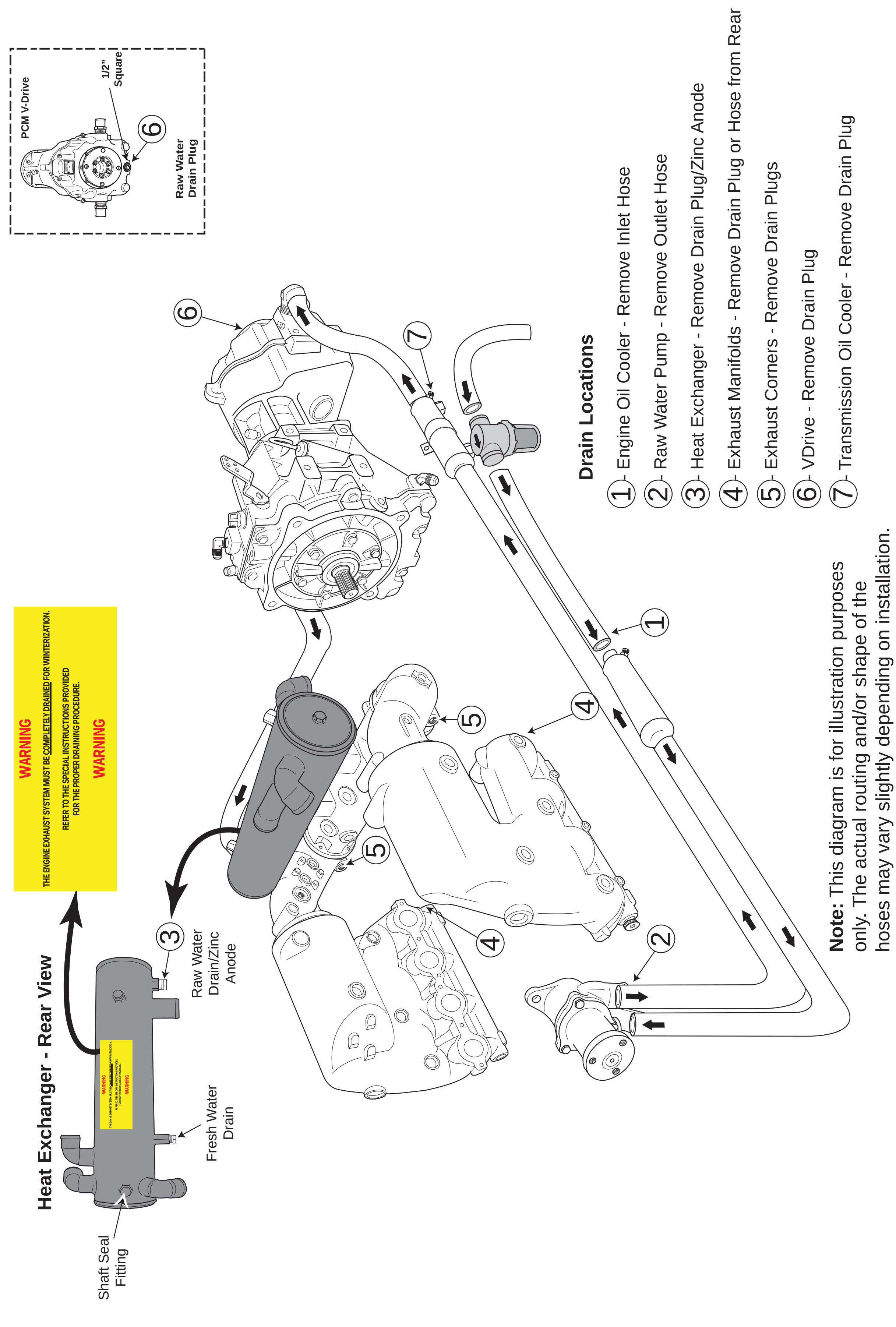


Figure 6-4 ZR409 CES / ZR450 CES Partial Fresh Water Cooling

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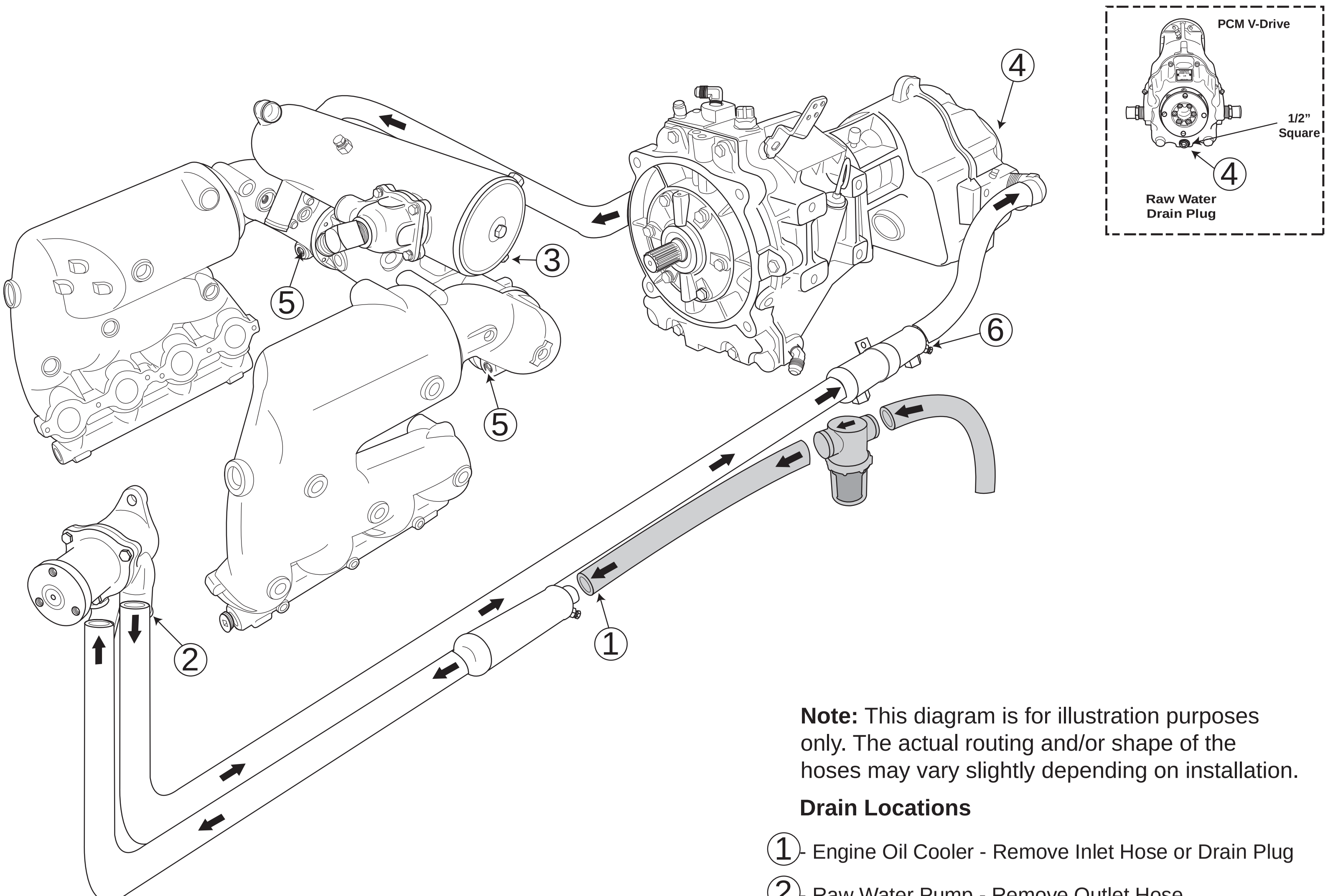
CWS409 CES / CWS450 CES VDrive Raw Water Draining Locations



Note: This diagram is for illustration purposes only. The actual routing and/or shape of the hoses may vary slightly depending on installation.

Drain Locations

1 - Engine Oil Cooler - Remove Inlet Hose or Drain Plug

2 - Raw Water Pump - Remove Outlet Hose

3 - Heat Exchanger - Remove Drain Plug/Zinc Anode

4 - VDrive - Remove Drain Plug

5 - Exhaust Corners - Remove Drain Plugs (Both)

6 - Transmission Oil Cooler - Remove Inlet Hose or Drain Plug

Figure 6-5 ZR409 CES CWS / ZR450 CES CWS 3/4 Fresh Water Cooling

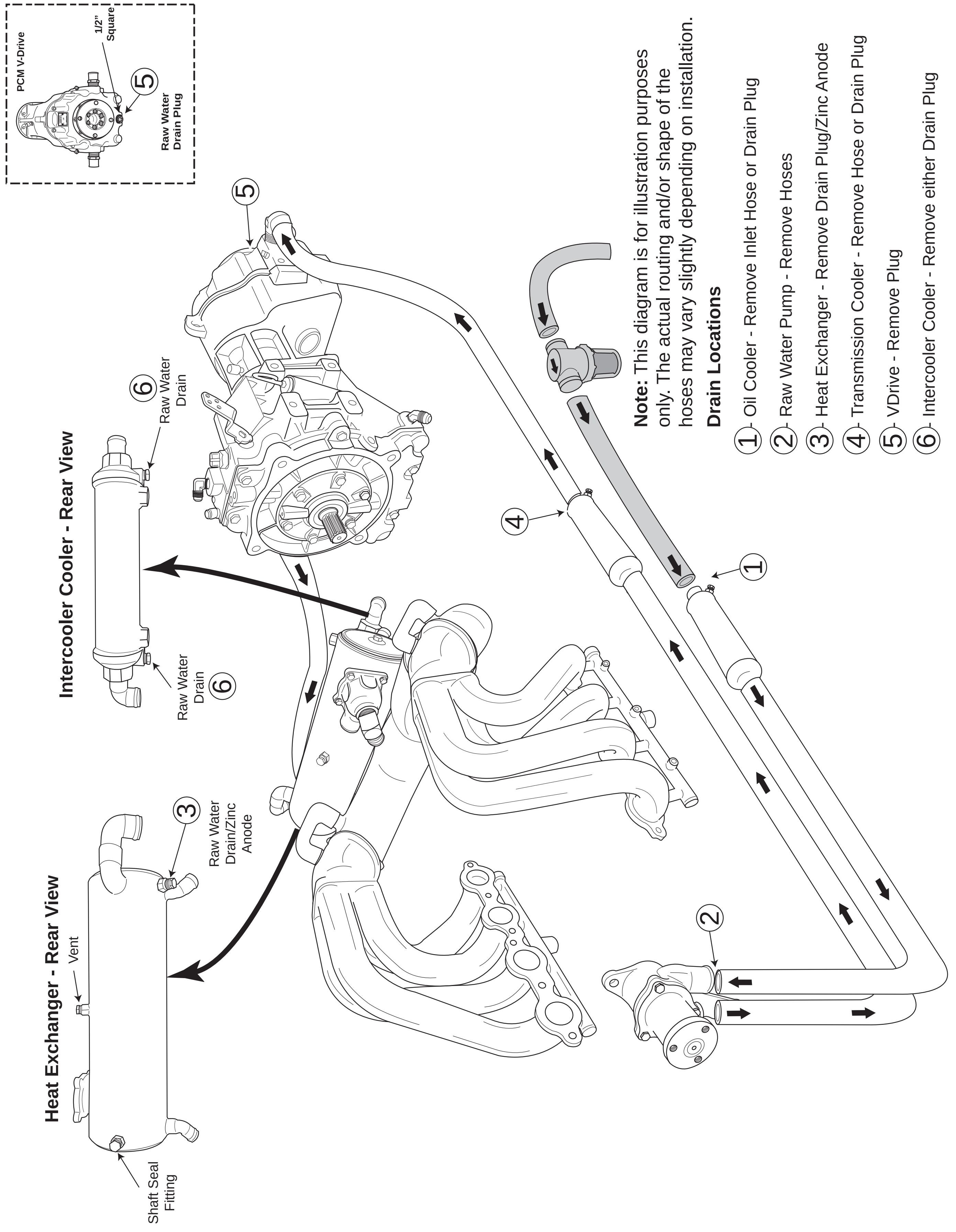


Figure 6-6 XS550 3/4 Fresh Water Cooling

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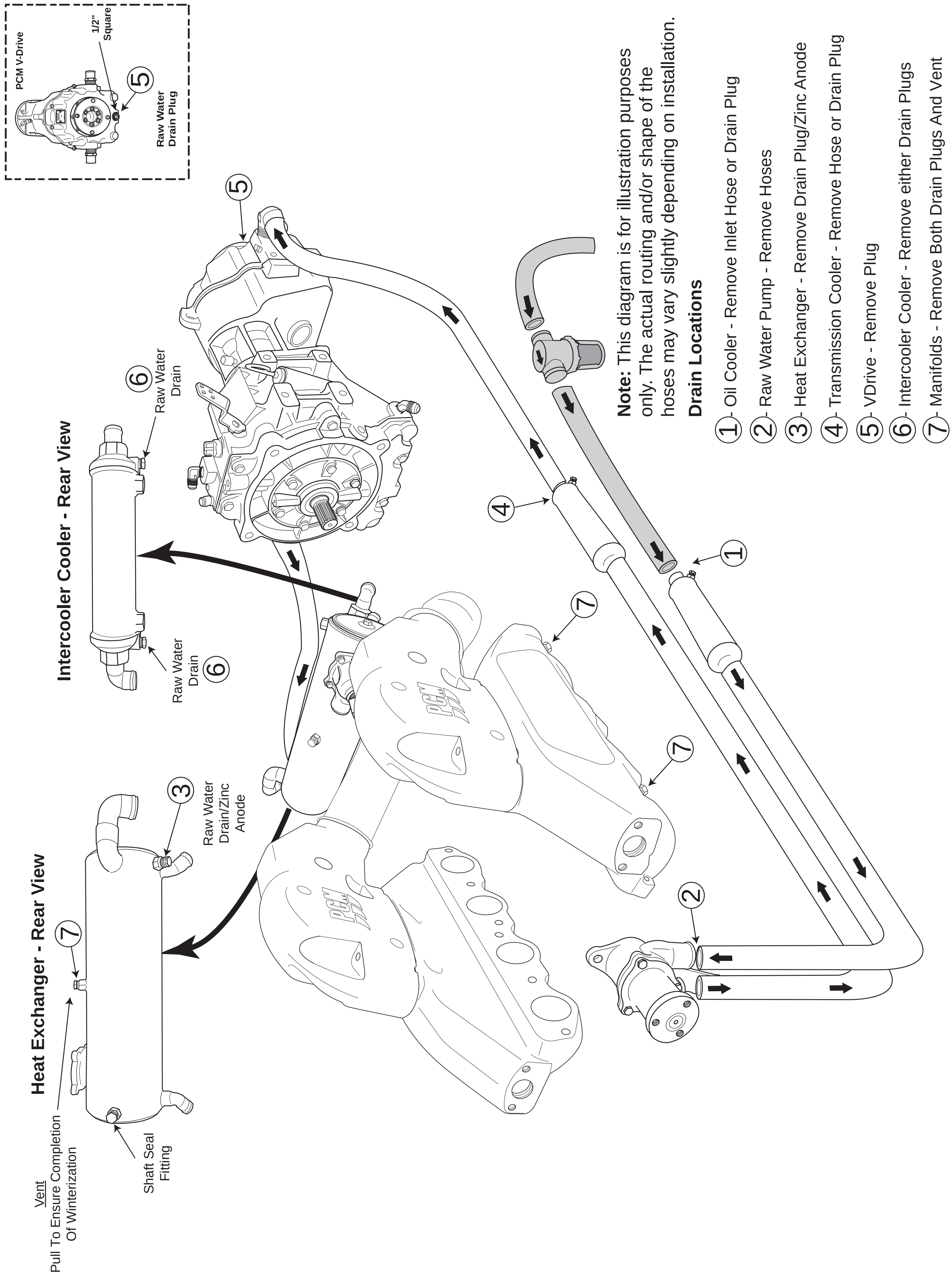


Figure 6-7 XR550 Partial Fresh Water Cooling

PCM DRIVABILITY CHECKLIST

ENGINE SERIAL NUMBER: ______________

Date: ______________ **Dealership Name:** ________________________________

Technician's Name:__________________________ **Technician's Contact Phone #:** ______________________

Owner/Operator Name: ____________________________

Person Reporting the problem (if different from owner/operator): __________________________

Service Writer or Person that took the problem report: __________________________________

1) PROBLEM OR SYMPTOM: ____

Who first observed the symptom?_________________When did the symptom first occur? _____________________
Any recent change or service work prior to symptom occurring - replaced belts or impeller, major engine or boat repairs, recently refueled, etc.? ____________________________________ Has someone, other than yourself, tried to correct the current symptom? ________ If yes, what work was done?____________________________________

Accessories Added Recently? _______________________________Is the symptom currently present? __________

Special conditions (if any) required to duplicate the symptom: ____

Use an additional sheet of paper if more space is required for symptoms or descriptions.

2) CHECK FOR SERVICE UPDATES:

ENGINE SERIAL NUMBER: ______________ **ENGINE MODEL NUMBER:** _____________ **ENGINE HOURS:** ____

HULL NUMBER: ________________

ENGINE: None Apply: __ Performed: _________________________

BOAT: None Apply: __ Performed: _________________________

3) VISUAL INSPECTION:

Inspection	YES	NO
Evidence of an over-heat:		
Engine Harness connectors connected properly:		
Physical Damage - wiring, connectors, assemblies, and **Remove Spark Plugs and inspect for fluids.**		
Corrosion:		
Hull-clean and free of excessive growth:		

Inspection	YES	NO
Evidence of or Excessive Water in the Bilge:		
Fluid levels checked:		
Leaking Fluids:		
Firing order correct:		
Correct size propellers installed:		
Underwater gear is undamaged:		
Accessories added? If yes, check items		

4) VERIFY THE PROBLEM

	YES	NO	
Does the engine start and continue to run?	**go to 3 below**	**go to 1 below**	
1) Key-ON-Engine-OFF (KOEO)	**YES**	**NO**	**Fuel Press.**
Both Fuel Pumps run 2-4 seconds:			
Fuel Pressure near wot specification - when pumps run:			
2) Key-ON-Engine-Running (KOER)	**YES**	**NO**	**Fuel Press.**
Engine cranks:			
Fuel Pressure near wot specification - engine cranking:			
Engine Starts and continues to run:		go to (3) Water Test	
3) WATER TEST	**YES**	**NO**	**Fuel Press.**
Verify reported symptom:			
Fuel Pressure - idle:			
Fuel Pressure - under load, @ WOT:			

Check Accessories Added:

- ☐ Heater
- ☐ Shower
- ☐ Hot Water Tank
- ☐ Flush Kit
- ☐ Multi-Function Display
- ☐ Synchronizer
- ☐ After-Market Stereo Equipment
- ☐ After-Market Depth/Fish Finder
- ☐ After-Market Navigational Equipment, such as GPS, Radar, Sonar, Auto-pilot systems
- ☐ After-Market Radio Equipment
- ☐ Lights
- ☐ Other - (please list)

4A) Revised or additional symptom found?: ______________________________________

Figure 6-8 PCM Drivability Checklist

PCM DRIVABILITY CHECKLIST

5) PERFORM THE OBD SYSTEM CHECK

CODE(S) PRESENT: _______________ DIAGNOSTIC PROCEDURE USED: _______________ **Continue to Step 6**

6) ISOLATE AND REPAIR THE PROBLEM.

Were you able to isolate and repair the problem? If ***YES***, continue to **Step 7.**
If ***NO***, complete the Drivability Checklist for No Codes, step 6A below. If the problem is still not resolved, then call for factory technical assistance.

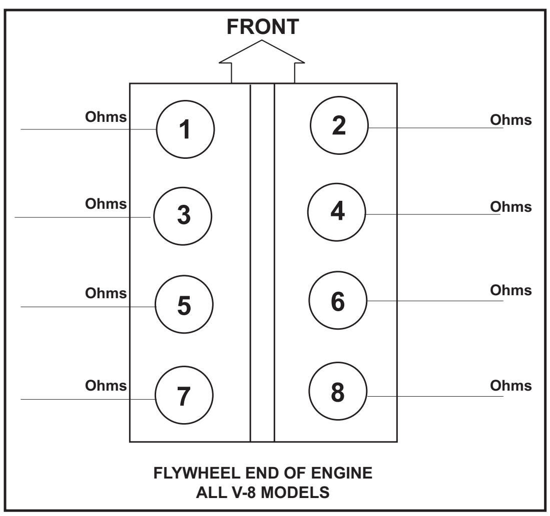
6A) NO CODES - ENGINE RUNS - DRIVABILITY SYMPTOM STILL PRESENT

Inspection or Check	**YES**	**NO**
1) Review Steps **1** thru **5**:		
2) Inspect fuel for contamination:		
3) Electrically isolate engine from boat:		
4) Powertrain is aligned:		
5) Remove and Inspect Distributor Cap and Rotor (5.0/5.7L only):		
6) Check&**record** Ignition wire resistance:		
7) Remove and Inspect each spark plug:		
8) Perform a Compression Check on all 8 cylinders: **Record below.**		

Inspection or Check	**YES**	**NO**
WATER TEST		
9) Verify CAM Retard** (5.0/5.7L only):		
10) Performance verified against a similar boat w/same engine. package, if available		
11) Perform the Diacom Power Balance Check; under load, @ 1600-1800rpm:		
12) Perform the harness 'Wiggle Test':		
13) Diacom recording-Pre-Delivery test:		

7) VERIFY REPAIR HAS CORRECTED THE PROBLEM. Check for and clear all codes from the ECM memory. **Water test the boat.** Run the engine for a minimum of two (2) minutes, then verify that no codes have returned. Continue with your water test long enough to verify that the problem has been corrected.

**** CAM Retard - '02 thru '06 = 43-47 degrees**
'07 - SN 485993 = 0 - 4 degrees/CES and SN 485994↑ = 15 ± 2 degrees



IGNITION WIRE RESISTANCE CHECK
Less than 10,000 ohms/ft

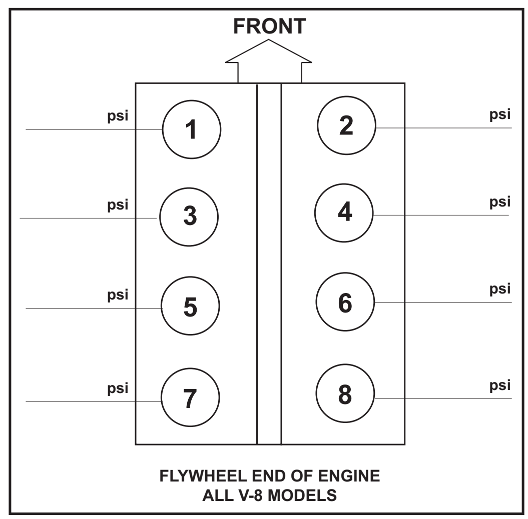
COMPRESSION PRESSURE:

5.0/5.7L - 130-215 psi

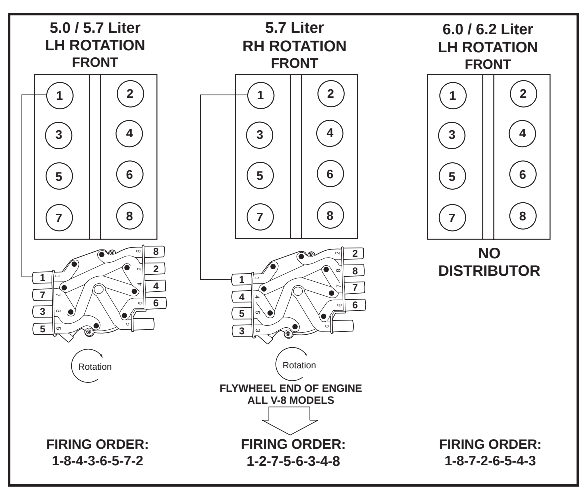
6.0L - 130-215 psi

6.2L - 130-215 psi

Lowest pressure should be within 70% of highest pressure. Minimum cylinder pressure - 100 psi.



COMPRESSION CHECK



REFERENCES:

Master Engine Specification Sheets

L510030 - GCP / 4G Diagnostic Service Manual

L510015 - 5.0/5.7L Engine Mechanical Service Manual

L510016 - 6.0L Engine Mechanical Service Manual

PCM Premier Dealer Website - All the Latest Publications

Figure 6-8 PCM Drivability Checklist

The most common problem associated with all cooling systems is an overheat condition. An overheat condition is usually caused by a raw water pump volume failure, or a defective thermostat. Other problems may be perceived conditions where the owner/operator reports an under/over temperature condition based on the temperature gauge or warning devices.

An additional cause for overheating, found only in fresh water systems, is a loss of engine coolant. Cooling flow diagrams are located in the PCM Owner's Operation and Maintenance Manual, which comes with each engine, and are Figures 6-1 through 6-7 in the Reference Material.

Begin troubleshooting cooling system problems in the same manner you begin all of your troubleshooting exercises, by completing the PCM Drivability Checklist.

Once the Checklist is completed, if the complaint has not been resolved, begin your Cooling System troubleshooting tests with the Raw Water Pump Volume Test.

Troubleshooting an Over-Temperature Condition

Refer to Figure 6-13 Trouble Tree - Over Temp Condition and the PCM Drivability Checklist, Figure 6-8.

When you receive an over temperature complaint, follow the PCM Drivability Checklist. When you get to Step 3, The Visual Inspection, you are not only looking for evidence that an overheat condition occurred, but for conditions that may have caused the overheat. One condition could be recently installed accessory items like a heater, shower or flush kit. Other conditions such as loose or missing hose clamps, or a blocked sea strainer, are easily identified and corrected. Continue with the Drivability Checklist until the overheat condition is completely resolved.

When you get to Step 4 of the PCM Drivability Checklist, Verify the Problem, you will want to begin your troubleshooting of the over temperature condition by following the Over-Temperature Troubleshooting Tree. The first step to perform will be the Raw Water Pump Volume Test.

Figure 6-9 Raw Water Pump Volume Test

The Raw Water Pump Volume Test

Refer to Figure 6-9. The Raw Water Pump Volume Test is the most important test you can use to troubleshoot Cooling System problems. This procedure is used on both raw water and fresh water systems. If you do not have a sufficient supply of raw water, the engine cannot cool properly. The raw water pump volume test must be accomplished with the boat in the water.

Use a container that will hold a minimum of 5 gallons of water.

1. Disconnect the hose connected to the output of the Raw Water Pump and connect a hose of sufficient length to reach your 5 gallon (minimum) container.
2. With the boat in the water, not on a trailer, start the engine and bring the engine RPMs quickly up to 3000. Hold 3000 RPM for 15 seconds, then slowly return to idle and shut off the engine.

Important: The output hose must be directed into the bilge or over the side of the boat when the engine is started. DO NOT put the hose into the 5 gallon container until you have brought the engine up to 3000 RPM. This MUST be done quickly as the engine is not getting cooling water at this time.

3. At the 15 second point in the test, verify you have at least 5 gallons of water in the container.

Note: Make sure the hose stays in the container during the test. The output of hose will be under sufficient pressure to 'blow' the hose out of the container.

Important: Most cooling systems require much more water flow than this static test creates. When the boat is underway, there is water being forced into the system due to "ram affect". This flow can only be measured with an inline water flow meter while the boat is underway.

Refer to Figure 6-13, the 'FAIL' path

If the Raw Water Pump Volume test results in less than 5 gallons of water, you know the problem lies somewhere between the hull inlet and the Raw Water Pump outlet. You would then check for a failed or fatigued impeller caused by:

1. A restriction in the Water Pump Inlet fitting
2. A leaking Raw Water Pump bearing housing seal
3. A pinched or defective Raw Water Pump housing gasket
4. A missing or leaking sea strainer gasket
5. A blocked sea strainer
6. A defective hose
7. Leaking hose connections
8. Blockage in an oil and/or transmission cooler (refer to the water flow diagrams 6-1 through 6-6 in Reference Material for the different configurations)
9. A blocked intake grate

The previously mentioned examples are problems that could cause an insufficient amount of water to flow through the Raw Water Pump. Additional problem areas include:

1. Loose hose clamps
2. Failing hoses
3. Heaters improperly installed, leaking, or blocked
4. Flush kits improperly installed or with failing check valves
5. Showers improperly installed or leaking
6. A seacock partially or completely closed
7. A failed raw water pump bearing seal
8. Starting and/or running the engine without a raw water supply

Refer to Figure 6-10. Generally when an impeller fails, small pieces of the impeller will be flushed out of the system and expelled with the water exiting the exhaust. Larger pieces may enter the hose attached to the inlet and outlet side of the raw water pump and can cause problems if they are not retrieved.

All engines will require inspection of the inlet side of the pump to determine if a restriction exists. Remove any restrictive material that is found.

Figure 6-10 Failed Raw Water Pump Impeller

On raw water systems further inspection of the outlet hose and the thermostat housing is required.

On fresh water systems inspect the outlet hose, the transmission cooler (if equipped) and the raw water section of the heat exchanger.

On fresh water partial systems equipped with an exhaust coolant system thermostat, the thermostat/screen assembly requires inspection/cleaning.

For raw or fresh water systems, ensure the restrictive material is located and removed.

Refer to Figures 6-1 through 6-7, water flow diagrams for specific differences in the raw water cooling flow path.

Refer to Figure 6-13, 'FAIL' path. Once you have completed your inspections of the input and output paths, replace the Raw Water Pump impeller. Clear the ECM of codes and perform the Raw Water Pump Volume Test again. Verify that you have corrected the raw water supply problem. Return the engine to its normal configuration and verify you have corrected the overheating condition.

If the overheating condition has not been corrected you will continue your troubleshooting of the cooling system by performing the tests for the 'PASS' path from the Raw Water Pump Volume Check.

Refer to Figure 6-13 'PASS' path

If the Raw Water Pump Volume test results in at least 5 gallons of water, you know the problem lies somewhere after the Raw Water Pump. You would then check for defects or restrictions in the output path to include:

1. Transmission cooler (only engines equipped with both an engine oil and transmission cooler, refer to Figure 6-4 in Reference Material for an example)
2. Hoses
3. The engine thermostat and its housing
4. The exhaust cooling thermostat/screen (if equipped)
5. Exhaust hoses
6. Muffler
7. The heat exchanger
8. The engine block

You are looking for any possible restrictions or debris that could block the flow of raw water. These are all examples of 'engine side' of the pump problems.

An infrared thermometer is useful for verifying the operating temperature at the thermostat housing, temperature sensor and other points along the engine block. Temperature readings from your infrared thermometer can aid you in locating 'hot spots', determining where to focus your troubleshooting efforts.

Refer to Figure 6-11. An often over-looked component of the output path is the exhaust manifolds, elbows, and hoses. With a severe overheat condition, the exhaust hoses may be damaged by the heat, and the exhaust manifold and elbow gaskets may need to be replaced. Remember that without the cooling water going through the exhaust system, exhaust temperatures can easily exceed 1200 degrees and burn out gaskets and melt, blister, and collapse the inner liner of the exhaust hose creating an exhaust restriction.

Always inspect the exhaust system after an overheat condition has occurred. Failed gaskets can let coolant, fresh or raw water, flow back into the engine causing severe damage. Collapsed, or severely blistered exhaust hoses can create excessive back pressure resulting in a loss of power and performance, and in severe cases cause water to back up into the engine causing major engine damage.

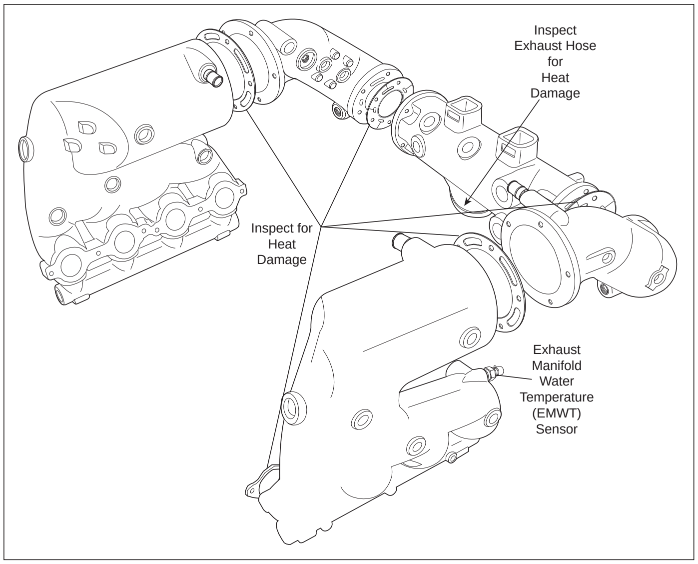


Figure 6-11 Exhaust System Inspection Points

Refer to Figure 6-13, 'PASS' path.

For Fresh Water Cooling Systems:

For Fresh Water Cooling systems:

1. Verify coolant level
2. Verify that coolant can be seen circulating through the degas bottle
3. Verify the coolant level rises and falls slightly as the engine maintains operating temperature

Fresh water systems may suffer a coolant loss as a result of an overheat condition; or a low coolant level may have been the cause of the overheat condition.

Troubleshooting a Fresh Water Coolant Loss

Refer to Figure 6-15. In many cases, the problem of coolant loss can be resolved by locating the leak and tightening a hose clamp, and/or properly filling the system.

As was mentioned previously, when you performed Step 3 of the PCM Drivability Checklist, you should be keenly aware of accessory devices added into the fresh water cooling system. The addition of an accessory device such as a heater, or recent service to change the coolant may have left the coolant level low. When the coolant was added, the level may have initially appeared to be full. After running, the system may have purged some air and became too low to cool properly. It is extremely important to get the air out of the system whenever the system is serviced.

NOTE: For illustrative purposes each test presumes the problem has not been resolved. Therefore, you proceed to the next step. In actual troubleshooting if any step corrects the problem there would be no reason to proceed further.

All current production Fresh Water Cooling Systems utilize a degas bottle. The cap on the degas bottle is a pressurized cap. Make sure the engine is cool before removing the cap to add coolant. When you begin service on a coolant loss problem, start with a cold engine.

For a partial fresh water cooled engine, you will fill the system cold. Run the engine with the cap off so you can verify circulation of the coolant in the Degas bottle. Top off the system and reinstall the cap. Observe that the coolant continues to circulate as the engine reaches normal operating temperature. You should observe a slight rise in the coolant level in the degas bottle when the engine reaches operating temperature.

For 3/4 and full fresh water cooled engines, you will fill the system completely when the engine is cold and NOT RUNNING. There are specific “air bleed” locations to allow the coolant to completely fill the system and purge the air without running. Consult the Full Fresh Water Coolant Fill Procedure on the PCM Premier Dealer website.

After you have completed the coolant fill procedure, you should shut the engine off and let it completely cool off. This may require you to come back to the engine the next day. On the cold engine verify that the coolant level is between the Min and Max level on the degas bottle. If it is, the system is operating normally. If it is not, repeat the coolant fill procedure and recheck the coolant level.

The low coolant level may be the result of:

1. Not getting the system full when an accessory device was added
2. Service performed such as a thermostat replacement
3. An overheat condition
4. Air trapped in the system during a service interval

If you have performed the coolant fill procedure, as specified, and return to the cold engine to find the coolant level has fallen outside of the specified range. You then have to look to the engine for the cause of the coolant consumption. Perform the following inspections on a cold engine. Running the engine before testing can temporarily remove the evidence of moisture, causing you to miss the source of the problem and perform unnecessary troubleshooting steps.

1. Inspect the engine oil for evidence of coolant.
2. Inspect each cylinder and spark plug for evidence of coolant. Carefully inspect the spark plugs for a white or gummy carbon like residue on them. This residue will be present if coolant or salt water is present in the cylinder.
3. Look for coolant standing on the pistons or a lack of carbon build-up on the pistons. Whenever evidence of coolant or moisture is present in any cylinder, and before performing expensive engine work, always pressure test the exhaust manifolds and elbows for evidence of a failure.

NOTE: Whenever evidence of coolant or moisture is present in any cylinder, and before performing expensive engine work, always pressure test the exhaust manifolds and elbows for evidence of a failure.

The next check for a coolant leak will be at the heat exchanger. Add a small amount of ‘marker dye’ to the engine coolant. You will need to water test the boat. Perform the following checks and/or inspections:

1. Verify that the engine has reached normal operating temperature.
2. Operate the boat under load; do not idle in the slip, operate under load, at approximately half throttle.
3. Inspect all hoses and connections on the engine for coolant leaks, correct as necessary.
4. Be vigilant in your observation of the water being expelled through the exhaust. If dye is present in the expelled water, you may have a defective heat exchanger, exhaust component, or an internal engine problem.

NOTE: Checks performed prior to this test will typically find a defective exhaust component or engine problem. At this point, the heat exchanger is the most likely defective component. However, before you replace the heat exchanger, always pressure check the heat exchanger, exhaust manifolds and elbows to verify no leaks exist. Perform a compression check to confirm no internal engine problem.

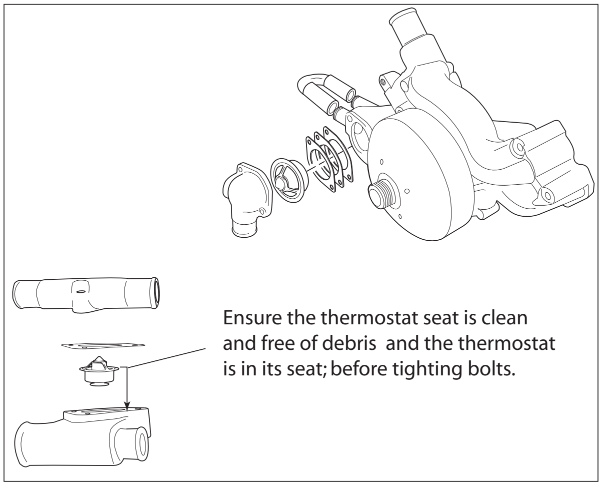


Figure 6-12 Thermostat Assembly

Refer to Figure 6-13, ‘PASS’ path and Figure 6-12

For raw and fresh water systems, the next action will be to replace the thermostat and retest.

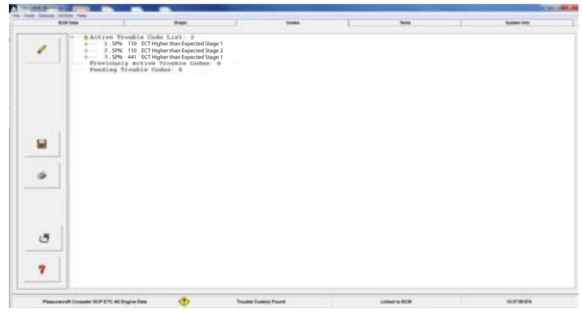
Whenever you replace a thermostat, ensure that the housing and thermostat seat are free of debris and scale. Ensure that the new thermostat is orientated and seated properly.

For freshwater systems, inspect the heat exchanger fresh water passages for scale and build up, and debris. If the heat exchanger cannot freely pass raw water, the engine will overheat.

If you have performed the aforementioned actions and the engine still overheats, inspect and test the circulating pump. Typically, a circulating pump failure will be characterized by a wobbly serpentine pulley and leakage around the pump shaft or housing.

Refer to Figure 6-13, ‘PASS’ path. After you have completed the mechanical inspections and tests for an overheat problem, you may find that you have a perceived overheat condition. Connect the Diacom scan tool and begin by checking for stored trouble codes.

The Engine Temperature Higher than Expected Stage 1 and/or Stage 2 trouble codes may be stored, indicating the Engine Coolant Temperature (ECT) sensor detected a high temperature condition in the engine. EMWT 1 and/or EMWT 2 Temperature Higher than Expected Stage 1 and/or Stage 2 trouble codes may be stored, indicating the exhaust manifold water temperature sensor(s) (if equipped) detected a high temperature condition in the exhaust manifold cooling system. Once you have corrected the cause of the overheat and cleared the ECM of codes, these codes should not return.



Make a note of any other code that may be present. You will have to return to the OBD System Check after you have corrected the cause of the over temperature condition and perform any remaining diagnostic procedures.

IMPORTANT: High temperature readings at the instrument panel may be caused by low system voltage. Be sure to perform a system power check and verify the voltage and wiring at the instrument panel. You may have to refer to the boat OEM service manual or the Instrument OEM’s service manual for detailed troubleshooting instructions.

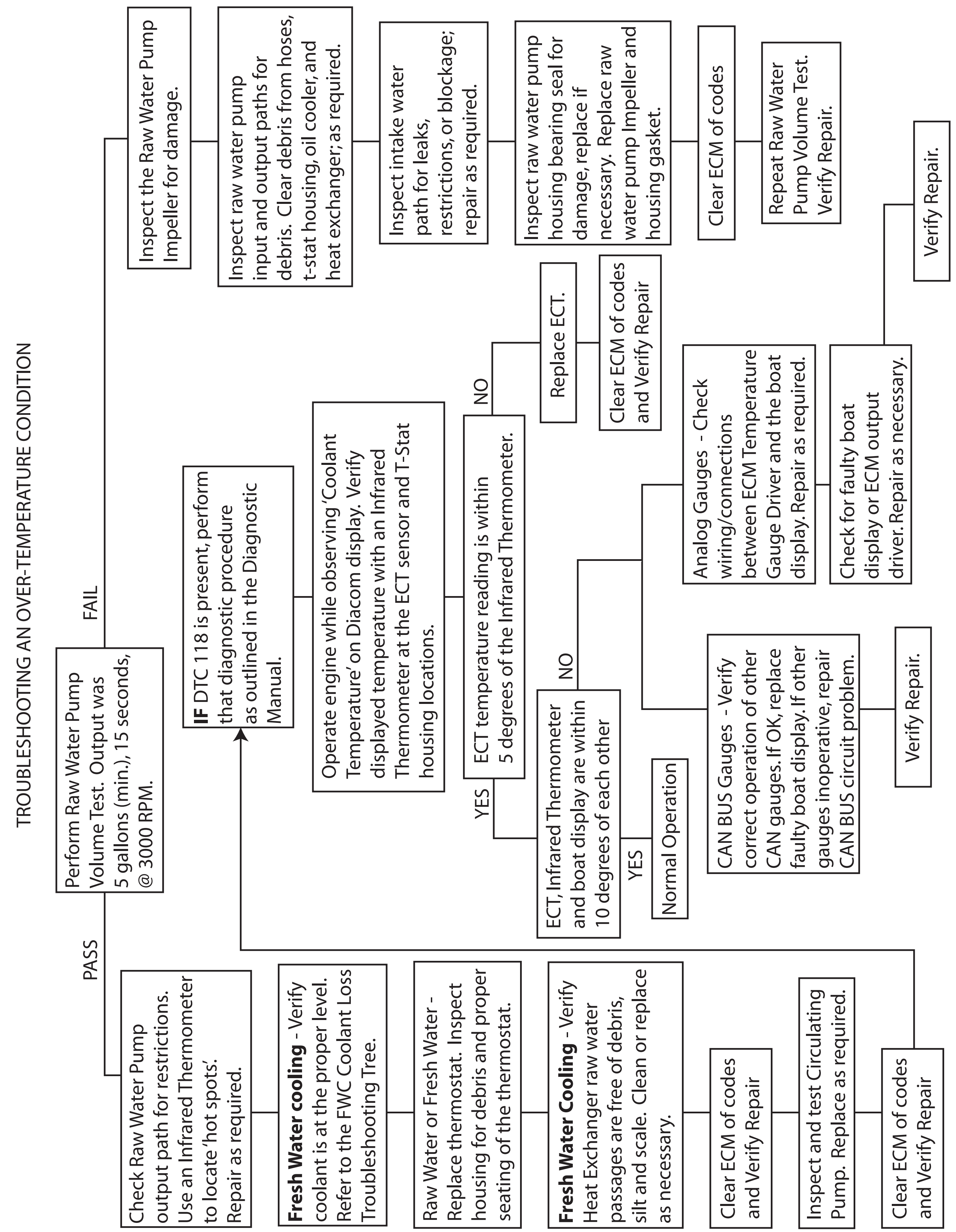
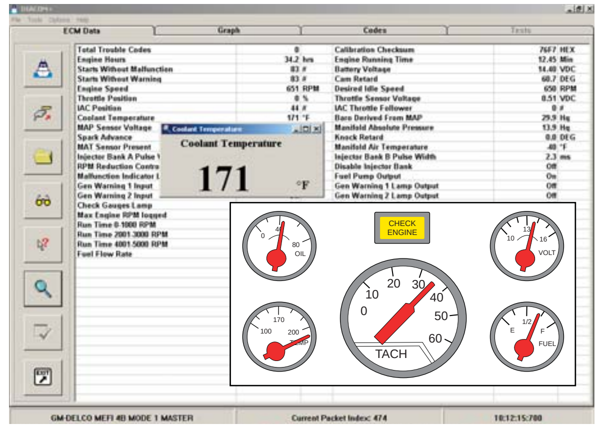


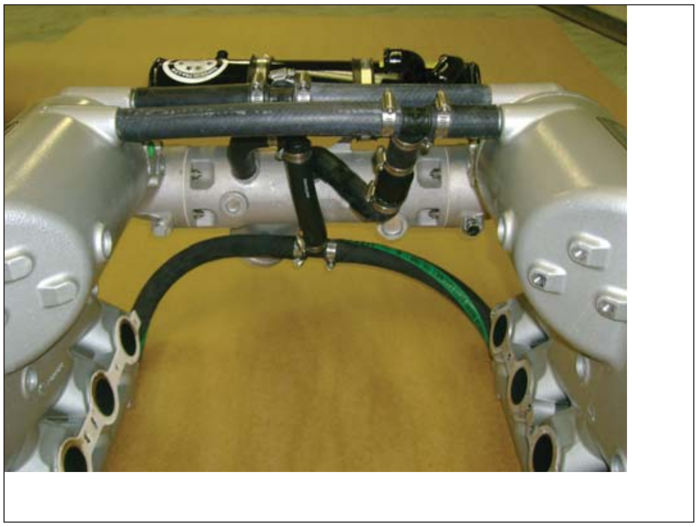
Figure 6-13 Troubleshooting Tree-Over Temperature Condition
L599003-13

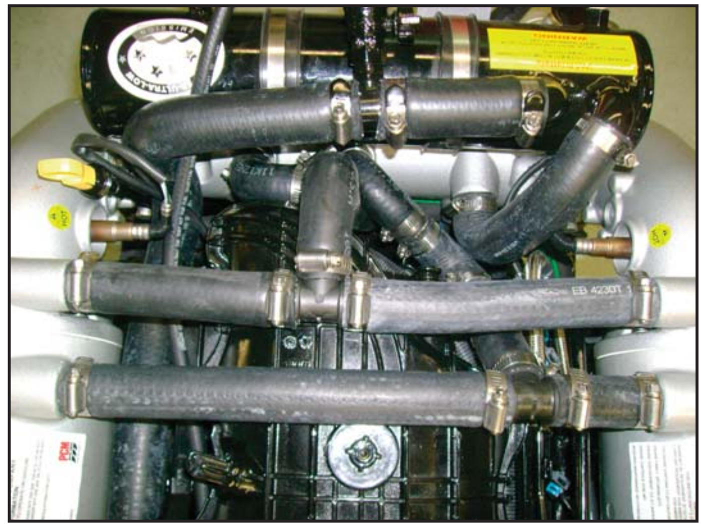


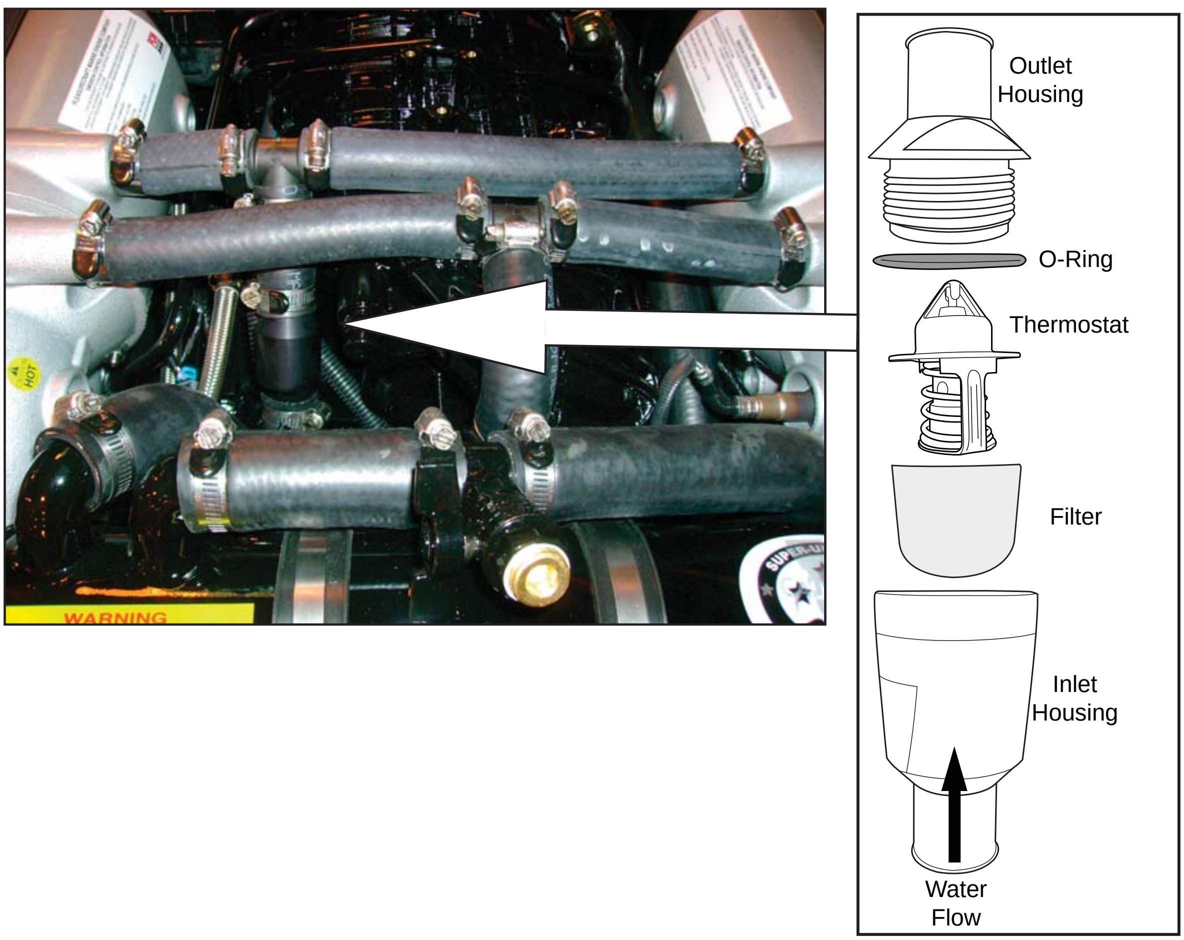
Refer to Figure 6-13, 'PASS' path. With the Diacom scan tool connected, operate the engine. Observe the ECT Sensor value on the Diacom screen. Using an infrared thermometer, verify the Diacom displayed temperature with the infrared temperature readings at the ECT, and at the Thermostat housing. The ECT's displayed temperature and thermometer readings should be within 5 degrees of each other. An ECT that has shifted in value, can cause a perceived overheat condition to occur, placing the engine into Power Derate Mode and set the Engine Temperature Higher than Expected code. If the readings are not close to each other replace the ECT then verify your repair.

If the infrared thermometer readings and the Diacom 'Coolant Temperature' display readings are within 5 degrees of each other, compare these readings to the boat's temperature display reading. The boat's engine temperature gauge typically receives engine temperature from the ECM. If your temperature readings and the boat's temperature gauge readings are within 10 degrees of each other, the system is operating normally. If not, troubleshoot the Temperature Gauge and its wiring. If that does not resolve the problem, refer to the boat or instrument manufacturers' troubleshooting procedures.

NOTE: Many applications today display the engine temperature on a digital display at the dash. This information is transmitted to the dash directly from the ECM via CAN BUS. In this case, the engine temperature on Diacom and on the digital display should be the same.







Part Number
RA026009

IMPORTANT
Thermostat housing MUST be assembled and tightened as shown, in the vertical position. Failure to do so may cause the thermostat to improperly seat and result in a leak.

This filter must be inspected and cleaned as necessary at your 25-Hour Engine Inspection. The filter should then be inspected and cleaned every 50 hours or once a year.

Figure 6-14 6.0L CES Exhaust System Thermostat

TROUBLESHOOTING A FWC - COOLANT LOSS CONDITION

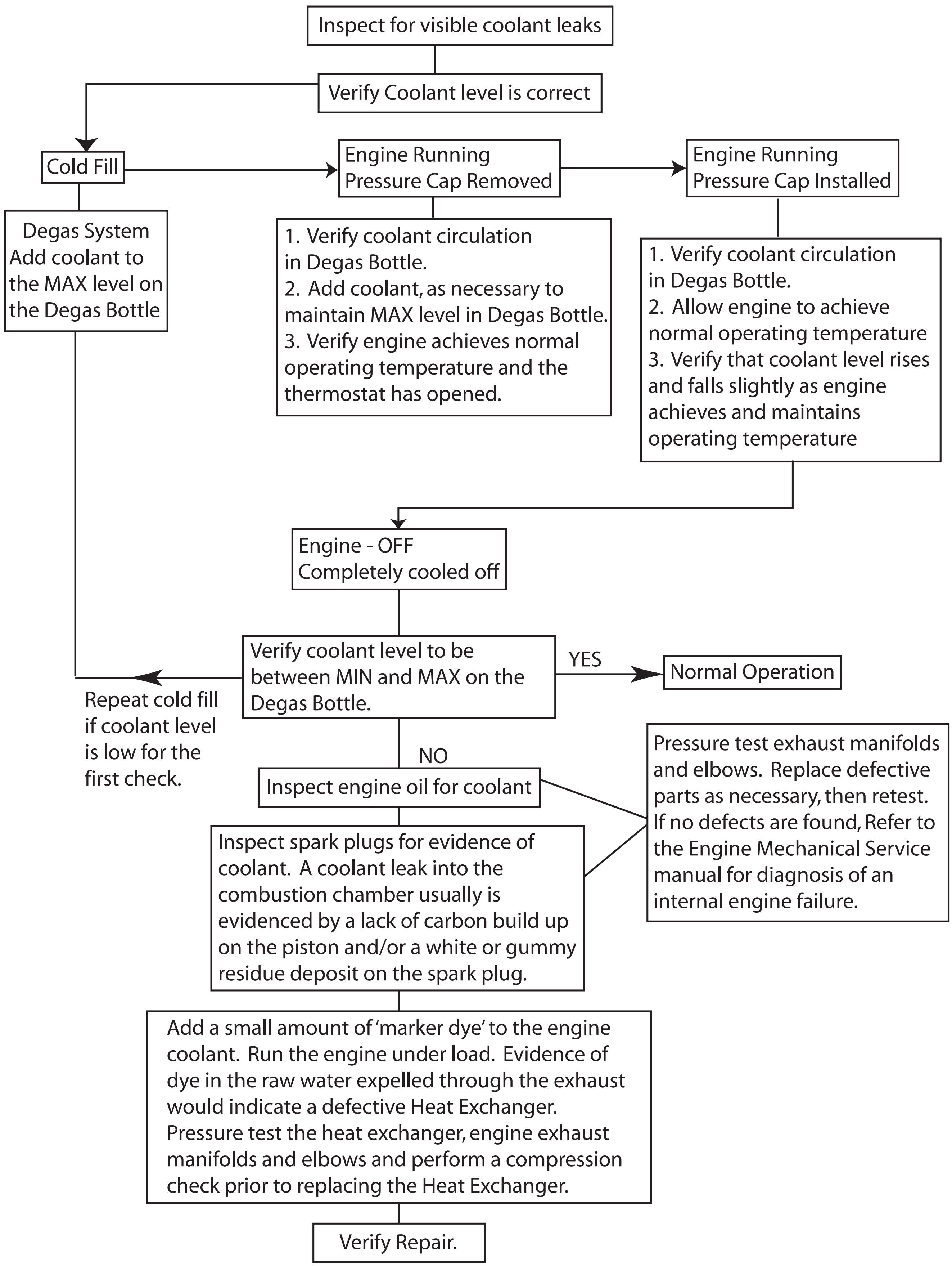


Figure 6-15 Troubleshooting Tree - Fresh Water Coolant Loss

Troubleshooting an Under-Temperature Condition

Refer to Figure 6-16. An under temperature condition will cause over-fueling of the engine under both cold and warm running conditions. The owner may or may not notice the build up of black soot on the transom and excessive fuel burn. The owner may or may not report the condition based on the soot, fuel burn and/or his temperature reading at the instrument panel.

IMPORTANT: Some additional causes for over-fueling of the engine include an engine coolant temperature (ECT) sensor that has shifted in value, a manifold absolute pressure (MAP) sensor that has shifted in value, system voltage out of range or a fuel system pressure out of range condition. Typically, the aforementioned conditions will not set a code in the ECM. Be sure to complete the PCM Drivability Checklist verifying system power, fuel system operation and verifying system parameters by comparing a DIACOM recording of a known good engine against the DIACOM recording of the suspect engine.

When troubleshooting all cooling system problems it is important to determine if added accessories are installed properly. This is particularly important on an engine that is operating in an Under-Temperature Condition. Properly completing the PCM Drivability Checklist (Visual Inspection, Step 3) will ensure that these accessories are not overlooked.

NOTE: For illustrative purposes each test presumes the problem has not been resolved. Therefore, you proceed to the next step. In actual troubleshooting if any step corrects the problem there would be no reason to proceed further.

Under temperature readings on the instrument panel may be the result of high system voltage. Be sure to perform the System Power check as part of Step 5, OBD System Check, on the PCM Drivability Checklist.

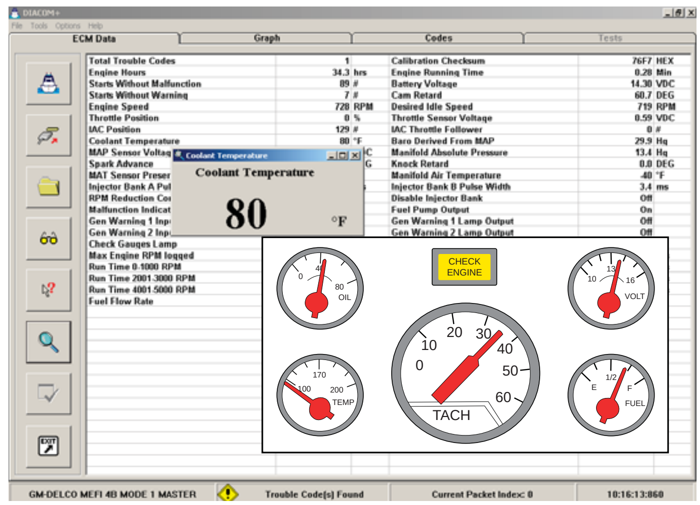
If codes were found during Step 5, of the PCM Drivability Checklist, perform the diagnostic and repair procedure in the diagnostic manual, then verify your repair. In most cases a code will not be present. You will have to determine the source of the problem by using Diacom, information from the PCM Drivability Checklist and the Troubleshooting Trees.

Check for real or perceived problems using Diacom and/or an infrared thermometer. The Under-Temperature Condition Troubleshooting Tree uses the same troubleshooting path as the over-temperature condition we discussed previously. Use Diacom to display the Coolant Temperature value from the ECT and verify the reading using an infrared thermometer. If the engine temperature is within normal parameters, the system should be operating normally. If so, there may be a defective Temperature Gauge, or an engine or boat wiring problem.

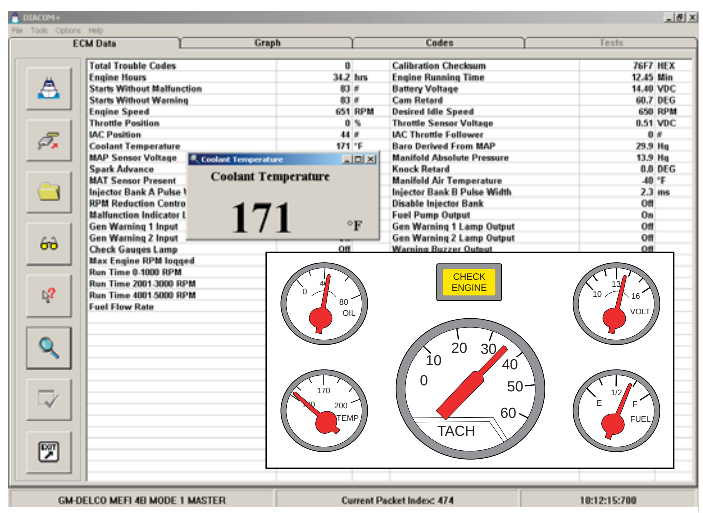
If the Diacom displayed value shows the engine to be running cold, typically this is the result of a defective thermostat. Verify that you do not have an ECT sensor shifted in value. Then replace the thermostat.

Before you replace the thermostat on a fresh water system, be sure to inspect the thermostat installation to verify the thermostat is seated properly. Fresh water systems that have the thermostat located in the heat exchanger can experience an under temperature condition if the thermostat comes off 'seat' in the housing.

Whenever you replace the thermostat, especially in a fresh water system heat exchanger, ensure that the thermostat housing fits tight against the thermostat before you tighten the clamps. If the thermostat is not held in place securely coolant will bypass the thermostat and the engine will run cold.



Real Under-Temp Condition



Perceived Under-Temp Condition

TROUBLESHOOTING AN UNDER-TEMPERATURE CONDITION

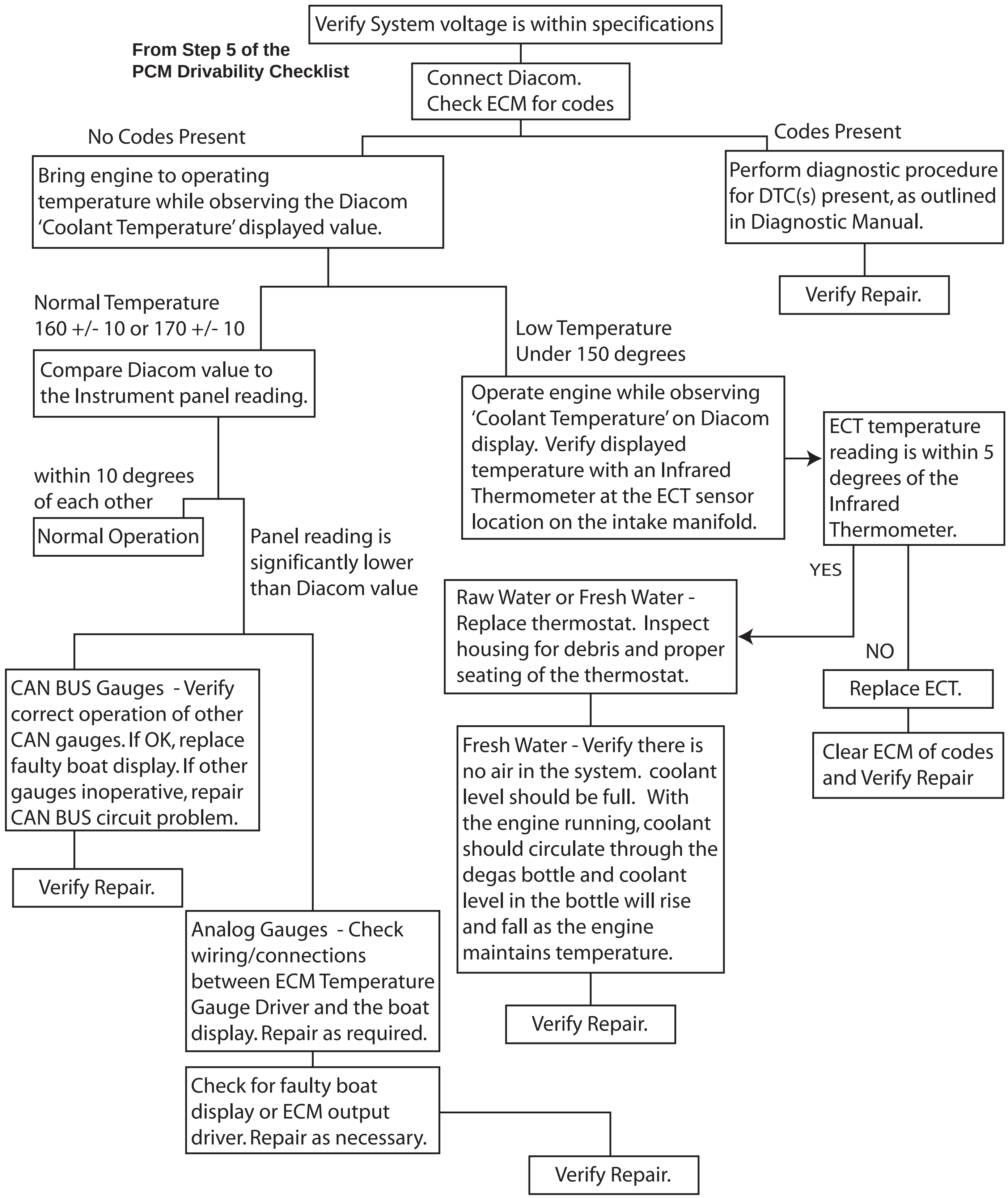


Figure 6-16 Troubleshooting Tree - Under Temperature

NOTES

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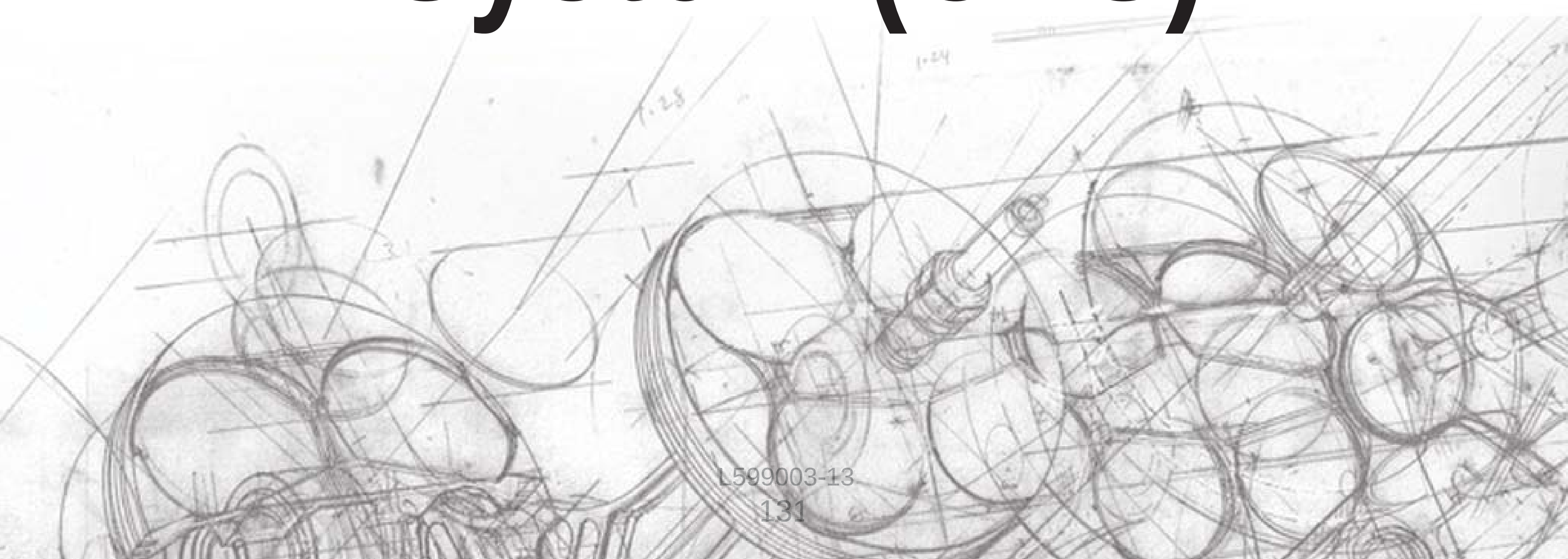
Section 7
Catanium Clean Exhaust System (CES)



CATANIUM CLEAN EMISSION SYSTEM (CES) - 7

Catanium Clean Emission System (CES) Overview

PCM's Catanium™ Clean Emission System is available to reduce emissions without diminishing performance. Catanium™ CES is patented catalyst technology which uses precious metals to create clean emissions and greatly reduce dangerous carbon monoxide gases.

PCM's Catanium CES is simply an emission reduction system added to an already sophisticated engine management system. PCM's CES consists of additional emission's components such as catalyst substrates, pre-oxygen sensors, post-oxygen sensors and Exhaust Manifold Water Temperature (EMWT) sensors.

PCM's CES exhaust components are comprised of five castings. Right and left exhaust manifolds each contain a catalyst substrate. The right and left exhaust corners, and the exhaust crossover tie the two exhaust manifolds together allowing for one exhaust outlet. This design greatly reduces backpressure associated with a catalyst system and does not compromise any performance from a non-catalyst application.

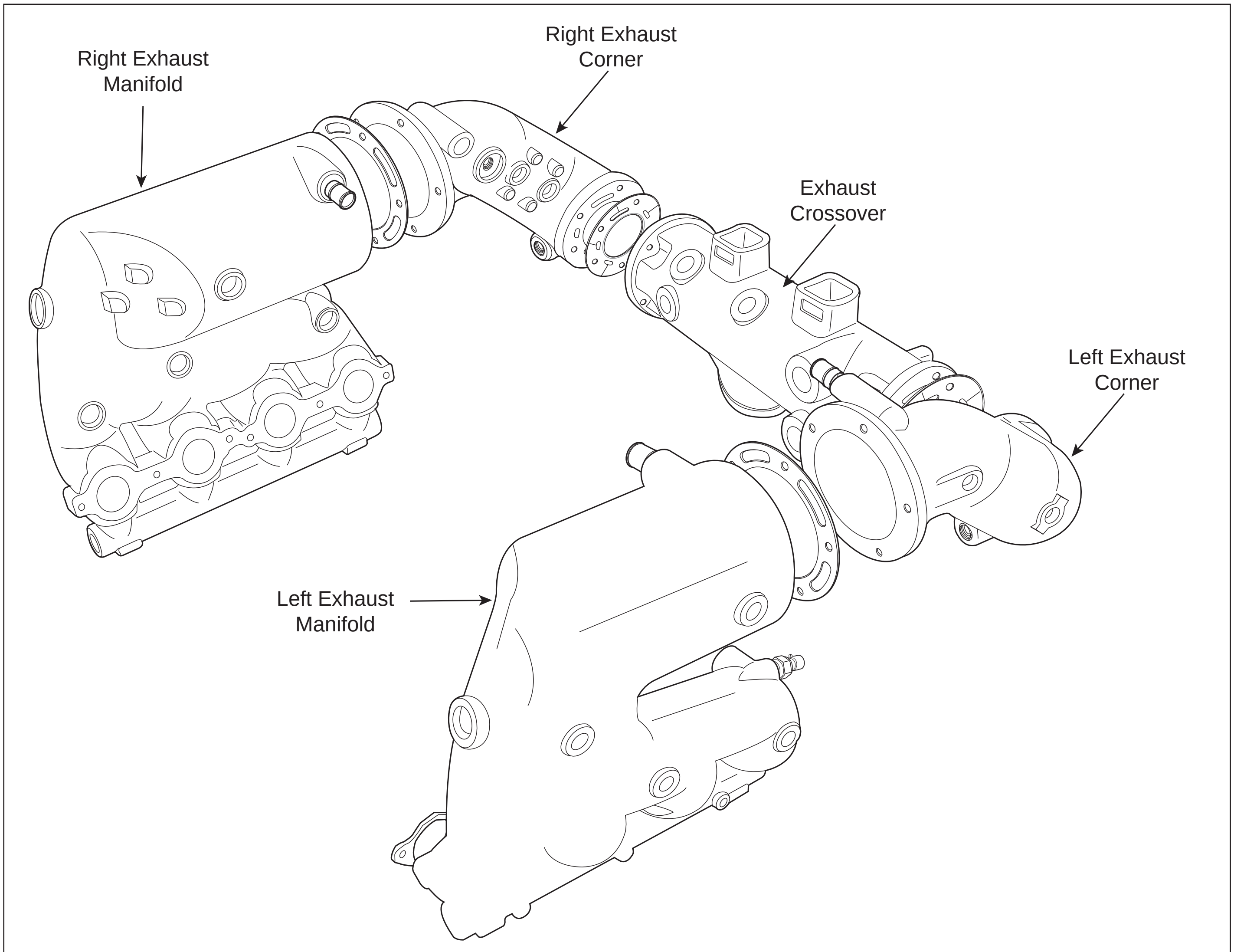


Figure 7-1 CES Exhaust Components

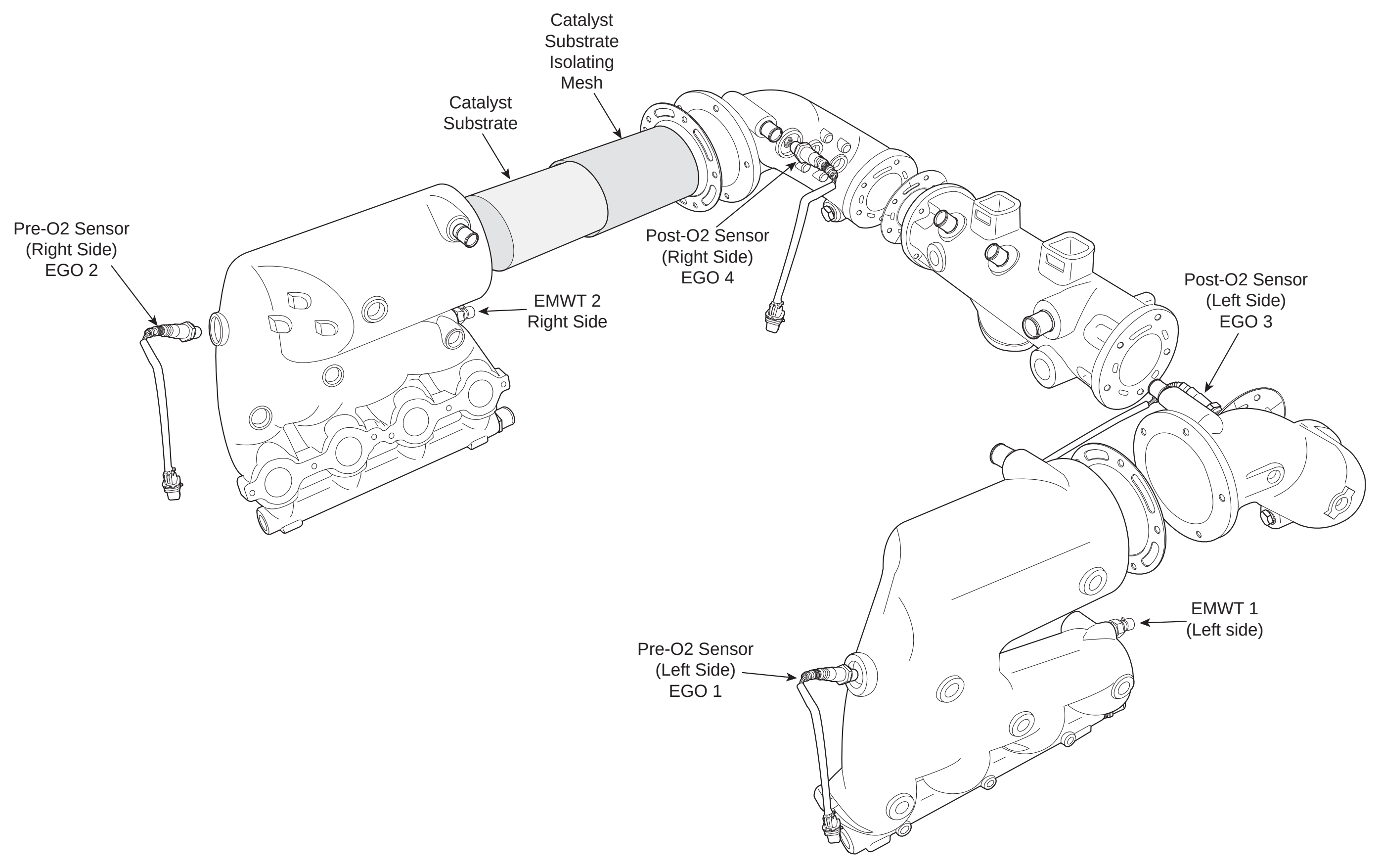


Figure 7-2 CES Catalyst and Sensor Components

Let's take a closer look at what makes this system different than a non-catalyst. We have discussed the additional components involved; now let's take a closer look at what these components do and how to diagnose them.

Pre and Post Oxygen Sensors

Traditional non-catalyst engines had an engine management system that electronically controlled fuel delivery. This fuel delivery method is known as "Open Loop" fuel control. This means that the ECM based fuel delivery strictly on a calibrated value at any given RPM and load. There is no "feedback" to the ECM validating the air/fuel ratio that was delivered. Although this method works fine for making power and good drivability, it does not control emissions very well.

A catalyst system requires the air/fuel ratio being delivered to the cylinders to be around 14.7:1 (stochiometric air/fuel ratio). This air/fuel ratio is required in order for the catalyst substrate to perform efficient emission reduction. Pre-Oxygen (O2) sensors are placed in the exhaust stream prior to the catalyst substrate. The Pre-O2 sensors provide feedback to the ECM, allowing the ECM to constantly fine tune the calibrated fuel delivery to maintain stochiometric air/fuel ratio. This system is referred to as "Closed Loop" fuel control.

Post Oxygen (O2) sensors are placed in the exhaust stream after the catalyst substrate. The primary function of the Post-O2 sensors is to monitor the exhaust gases and provide feedback to the ECM. With this information, the ECM can determine how efficient the catalyst substrate is reducing emissions. In the event that the catalyst substrate becomes inefficient, the Post-O2 sensor reports this information to the ECM and the ECM will then turn ON a warning and set a trouble code.

Catalyst Substrates

PCM's Catanium CES utilizes two catalyst substrates, one located in each exhaust manifold. The catalyst substrates are stainless steel "cans" that are coated with a certain "recipe" of precious metals. It is the precious metals interacting with the exhaust gases that cause a chemical reaction resulting in the reduction of emission gases such as hydrocarbons, carbon monoxide and nitrogen oxides.

Catalyst substrates require to be at extremely high temperatures in order to be effective. Catalyst substrate temperatures can reach in excess of 1500°F. Engine misfires can be damaging to the catalyst substrates. Engine Misfire is monitored on all Catanium CES applications.

Exhaust Manifold Water Temperature (EMWT) Sensors

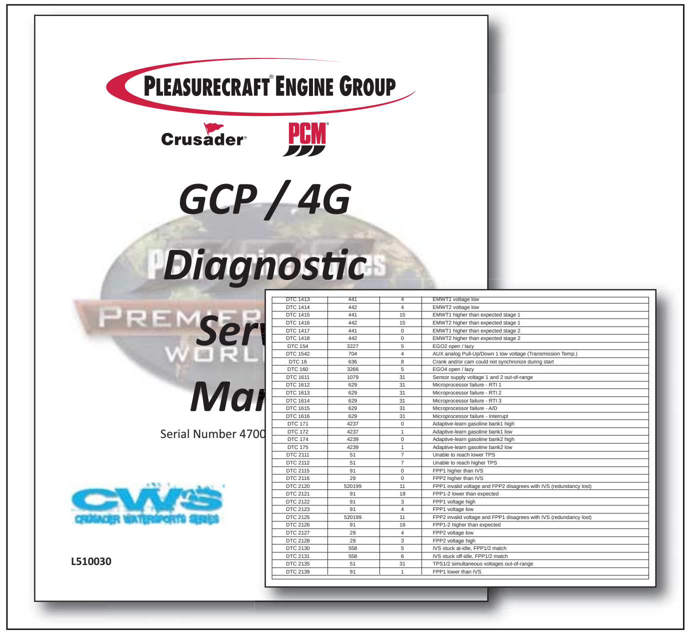
PCM's Catanium CES incorporates two Exhaust Manifold Water Temperature (EMWT) sensors, one located in each exhaust manifold. EMWT 1 refers to the sensor located on the left side of the engine (odd cylinder side) and EMWT 2 refers to the sensor located on the right side of the engine (even cylinder side). Each sensor is a two-wire thermistor that changes resistance with temperature. High and low voltage faults, and over temperature trouble codes are associated with each sensor. If either of these sensors report a temperature higher than expected, a trouble code will set and the engine will enter into Power Derate mode.

Diagnostic Trouble Codes Associated with Catanium CES

Each of the components used on the Catanium CES for controlling emissions, or for monitoring components, have diagnostic trouble codes associated with them. These trouble codes are diagnosed the same way as any other engine management fault. Performing the OBD System Check will determine if any of these faults are present.

If any of these faults are present, you are directed to the diagnostic manual to follow the Diagnostic Procedure associated with the trouble code(s) that is present.

Below is a breakdown of the trouble codes associated with the Catanium CES and a description of what they mean. Some of the trouble codes identify a particular circuit failure while others identify a system not operating correctly.



Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 1155	4236	0	Closed-loop gasoline bank1 high
DTC 1156	4236	1	Closed-loop gasoline bank1 low
DTC 1157	4238	0	Closed-loop gasoline bank2 high
DTC 1158	4238	1	Closed-loop gasoline bank2 low
DTC 171	4237	0	Adaptive-learn gasoline bank1 high
DTC 172	4237	1	Adaptive-learn gasoline bank1 low
DTC 174	4239	0	Adaptive-learn gasoline bank2 high
DTC 175	4239	1	Adaptive-learn gasoline bank2 low

The trouble codes above are associated with the overall engine management system. These trouble codes identify extremely rich or extremely lean conditions. As you can see, they are identified as Bank 1 and Bank 2. Bank 1 refers to the left side (odd cylinder side) of the engine and Bank 2 refers to the right side (even cylinder side) of the engine.

The issues that can set these faults more than likely has nothing to do with the Catanium CES components. Things like low fuel pressure, high fuel pressure, exhaust restrictions, leaking or stuck injector, other sensor failures, etc. can cause these trouble codes to set. Refer to the Diagnostic Procedure for a particular fault in the diagnostic manual for some diagnostic aids for diagnosing these faults.

Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 134	3217	5	EGO1 open / lazy
DTC 140	3256	5	EGO3 open / lazy
DTC 154	3227	5	EGO2 open / lazy
DTC 160	3266	5	EGO4 open / lazy

The trouble codes above are associated with the four oxygen sensors. These failures probably indicate a failure in the sensor, wiring or ECM circuits. Refer to the Diagnostic Procedure in the diagnostic manual for the organized approach to correcting the present fault(s).

EGO 1 - Left side (odd cylinder side) Pre-O2 Sensor

EGO 3 - Left side (odd cylinder side) Post-O2 Sensor

EGO 2 - Right side (even cylinder side) Pre-O2 Sensor

EGO 4 - Right side (even cylinder side) Post-O2 Sensor

Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 1411	441	3	EMWT1 voltage high
DTC 1412	442	3	EMWT2 voltage high
DTC 1413	441	4	EMWT1 voltage low
DTC 1414	442	4	EMWT2 voltage low

The trouble codes above are associated with the two Exhaust Manifold Water Temperature (EMWT) sensors. These failures probably indicate a failure in the sensor, wiring or ECM circuits. Refer to the Diagnostic Procedure in the diagnostic manual for the organized approach to correcting the present fault(s).

EMWT 1 - Left side (odd cylinder side)

EMWT 2 - Right side (even cylinder side)

Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 1415	441	15	EMWT1 higher than expected stage 1
DTC 1416	442	15	EMWT2 higher than expected stage 1
DTC 1417	441	0	EMWT1 higher than expected stage 2
DTC 1418	442	0	EMWT2 higher than expected stage 2

The trouble codes above are associated with the two Exhaust Manifold Water Temperature (EMWT) sensors. These failures indicate that the ECM has detected temperatures higher than expected. There are two different levels of temperature. Stage 1 puts the system into Power Derate and allows up to 35% maximum throttle. Stage 2 puts the system into Power Derate and allows only an elevated idle speed.

Failures setting these trouble codes may consist of, but not limited to, cooling system problem, raw water flow problem, restricted exhaust cooling system thermostat, etc. Refer to the Diagnostic Procedure in the diagnostic manual for the organized approach to correcting the present fault(s).

EMWT 1 - Left side (odd cylinder side)

EMWT 2 - Right side (even cylinder side)

Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 301	1323	31	Cylinder 1 emissions/catalyst damaging misfire
DTC 302	1324	31	Cylinder 2 emissions/catalyst damaging misfire
DTC 303	1325	31	Cylinder 3 emissions/catalyst damaging misfire
DTC 304	1326	31	Cylinder 4 emissions/catalyst damaging misfire
DTC 305	1327	31	Cylinder 5 emissions/catalyst damaging misfire
DTC 306	1328	31	Cylinder 6 emissions/catalyst damaging misfire
DTC 307	1329	31	Cylinder 7 emissions/catalyst damaging misfire
DTC 308	1330	31	Cylinder 8 emissions/catalyst damaging misfire

The trouble codes above are associated with engine misfire. The engine management system is constantly monitoring the crankshaft position sensor for engine misfire. Depending on the level of misfire, it can be damaging to the catalyst substrate. These trouble codes are set when the level reaches a potential catalyst damaging condition.

Some conditions that can cause misfire detection, but not limited to, are:

- faulty injector,
- faulty spark plug wire
- faulty spark plug,
- faulty ignition coil,
- faulty distributor cap,
- engine mechanical issue,
- wiring/connections.

Abnormal vibrations to the crankshaft can also be induced by such things as: bent propshaft or bent prop.

Refer to the Diagnostic Procedure for a particular fault in the diagnostic manual for some diagnostic aids for diagnosing these faults.

Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 420	3050	11	Catalyst inactive on gasoline (Bank 1)
DTC 430	3051	11	Catalyst inactive on gasoline (Bank 2)

The trouble codes above are associated with the efficiency of the catalyst substrate. As described earlier, the Post-O2 sensors are monitoring the integrity of the catalyst substrate. If the Post-O2 sensor feedback reaches a level in which the catalyst substrate is no longer reducing emissions to the level it was designed at, these trouble codes would set. This is a very uncommon failure due to the extreme engineering specifications that the catalyst substrates are built to. As described earlier, the catalyst substrates are constructed of stainless steel, not ceramic, and are very robust. The diagnostics for either of these codes is simply replace the inefficient catalyst substrate and verify repair.

NOTES