Fuel System

Section 5F - ECS Diagnostics

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Service Precautions

Service Precautions

⚠ WARNING

Failure to comply with regulations can result in injury from fire or explosion. Electrical system components on this engine are not rated as external ignition–protected (EIP). Do not store or use gasoline on boats equipped with these engines, unless provisions have been made to exclude gasoline vapors from the engine compartment (REF: 33 CFR).

⚠ WARNING

Performing service or maintenance without first disconnecting the battery can cause product damage, personal injury, or death due to fire, explosion, electrical shock, or unexpected engine starting. Always disconnect the battery cables from the battery before maintaining, servicing, installing, or removing engine or drive components.

⚠ WARNING

Fuel leakage is a fire or explosion hazard, which can cause serious injury or death. Periodically inspect all fuel system components for leaks, softening, hardening, swelling, or corrosion, particularly after storage. Any sign of leakage or deterioration requires replacement before further engine operation.

⚠ WARNING

Fuel is flammable and explosive. Ensure the key switch is off and the lanyard is positioned so that the engine cannot start. Do not smoke or allow sources of spark or open flame in the area while servicing. Keep the work area well ventilated and avoid prolonged exposure to vapors. Always check for leaks before attempting to start the engine and wipe up any spilled fuel immediately.

⚠ WARNING

Fuel vapors trapped in the engine compartment may be an irritant, cause difficulty breathing, or may ignite resulting in a fire or explosion. Always ventilate the engine compartment before servicing the power package.

⚠ CAUTION

Failure to release pressure from the fuel system will result in fuel spraying out, which can cause a fire or explosion. Allow the engine to cool completely and release all fuel pressure before servicing any part of the fuel system. Always protect eyes and skin from pressurized fuel and vapors.

NOTICE

Without sufficient cooling water, the engine, the water pump, and other components will overheat and suffer damage. Provide a sufficient supply of water to the water inlets during operation.

IMPORTANT: Adhere to the following information when working on the fuel system:

- **Always keep a dry chemical fire extinguisher at the work area.**
- **Do NOT replace fuel pipe with fuel hose.**
- **Do NOT attempt any repair to the fuel system until instructions and illustrations relating to the repair are thoroughly understood.**
- **Observe all precautions and notes.**

Replacement Parts Warning

⚠ WARNING

Avoid fire or explosion hazard. Electrical, ignition, and fuel system components on Mercury Marine products comply with federal and international standards to minimize risk of fire or explosion. Do not use replacement electrical or fuel system components that do not comply with these standards. When servicing the electrical and fuel systems, properly install and tighten all components.

General Information

Follow these instructions to ensure safe and proper service and repair of all Cummins MerCruiser Diesel Electronic Control System (ECS) engines.

- Observe all Warnings, Cautions, and Notices within this manual.
- Replace parts with those recommended by Cummins MerCruiser Diesel. Ensure that the replacement has an identical part number as the original.
- Use only special tools as listed in the document.

IMPORTANT: Using replacement parts, service procedures, or tools not recommended by Cummins MerCruiser Diesel can compromise personal safety or engine operation.

Introduction

The following text describes proper diagnosis and service of the Cummins MerCruiser Diesel Electronic Control System (ECS) for the diesel fuel injection system with a high-pressure fuel pump and a common fuel rail (sometimes referred to as an accumulator).

All information is based on the latest product information available at the time of publication. We reserve the right to make changes without notice.

This manual and any subsequent publication provides information required to properly maintain the Cummins MerCruiser Diesel engine control system.

Service Precautions

Observe the following when working on ECS equipped engines:

- Before removing any ECM system component, disconnect the negative battery cable.
- Never start the engine without the battery cable terminal ends being solidly connected.
- Never separate the battery from the on-board electrical system while the engine is operating.
- Never separate the battery feed wire from the charging system while the engine is operating.
- When charging the battery, disconnect it from the boat's electrical system.
- Ensure that all cable harnesses are connected solidly and that battery connections are thoroughly clean.
- Never connect or disconnect the wiring harness at the ECM when the ignition is switched on.

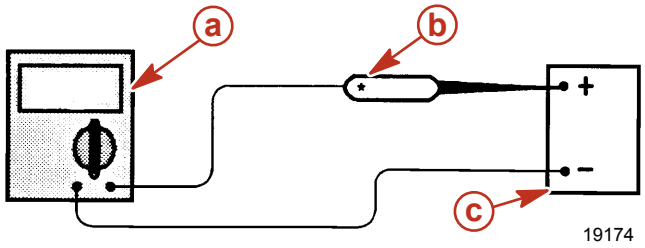
- Before attempting any electric arc welding, disconnect the battery leads, the ECM connectors, and any bonding connections between the engine and the boat.
- When steam cleaning engines, do not direct the steam cleaning nozzle at ECM system components. If this happens, corrosion of the terminals or damage of components can take place.
- Use only the test equipment specified in the diagnostic charts; other test equipment may either give incorrect results or damage good components.
- All voltage measurements using a voltmeter require a digital voltmeter with a rating of 10 mega-ohms input impedance.

ECS and Test Light Compatibility

IMPORTANT: Perform the following test to ensure that a test light is safe for use with this ECS.

When a test light is specified, a low-power test light must be used. Do not use a high-wattage test light. While a particular brand of test light is not suggested, a simple test on any test light, as shown below, will ensure it to be safe for system circuit testing.

1. Connect an accurate ammeter (such as the high impedance digital multimeter) in series with the test light and power the test light-ammeter circuit with the battery.
2. If the ammeter indicates less than 0.3 A (300 mA) current flow, the test light is safe to use.
3. If the ammeter indicates more than 0.3 A (300 mA) current flow, the test light is not safe to use.



a - Ammeter
b - Test light
c - 12 volt battery

NOTE: *Using a test light with 100 mA or less rating may show a faint glow when test indicates no light.*

Turn the ignition off each time a DVOM is connected to a circuit to perform voltage measurements or is disconnected.

Basic Knowledge and Tools Required

To use the information in this manual most effectively you should be familiar with wiring diagrams; the meaning of volts, ohms and amperes; and the basic theories of electricity and electrical diagnostics. System diagnosis requires specialized equipment. Become acquainted with the tools and their use before attempting to diagnose the system. Any special tools required for ECS service are listed in this manual.

Visual and Physical Inspection

IMPORTANT: A careful visual and physical inspection must be performed as part of any diagnostic procedure and may reveal a solution that eliminates the need for further diagnosis.

Inspect all wiring for proper connections, signs of burning, chafing, and pinched or cut wires.

Electrostatic Discharge Damage

Control system electronics operate at a low voltage and are susceptible to damage caused by electrostatic discharge. Less than 100 volts of static electricity can cause damage to electronic components. By comparison, it takes as much as 4,000 volts for a person to feel a static discharge.

A person can become statically charged in several ways, the most common methods are by friction and by induction. An example of charging by friction is a person sliding across a seat which can build up a charge of as much as 25,000 volts. Charging by induction occurs when a person with well-insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges of either type can cause damage. Use caution when handling and testing electronic components.

Diagnostic Information

The diagnostic information and functional checks in **Section 5F** of this manual are designed to locate a faulty circuit or component through the process of elimination. The information assumes that the system functioned correctly at the time of assembly and that there are not multiple failures.

Abbreviations

BARO	Barometric Pressure
BAT	Battery Positive Terminal, Battery or System Voltage
B+	Battery Positive
CKT	Circuit
CONN	Connector
CYL	Cylinder
DEG	Degrees
DIAG	Diagnostic
DLC	Data Link Connector
DTC	Diagnostic Trouble Code
DVOM	Digital Volt Ohmmeter
ECM	Engine Control Module
ECT	Engine Coolant Temperature
EEPROM	Electronic Erasable Programmable Read Only Memory
EMI	Electromagnetic Interference
ENG	Engine
GND	Ground
GPH	Gallons Per Hour
IAT	Intake Air Temperature
in.hg	Inches Of Mercury
INJ	Injection
IGN	Ignition
kPa	Kilopascal
KV	Kilovolts
LDF	MAP or Boost Pressure Sensor
LGS	Low Idle Switch
MAP	Manifold Absolute Pressure

MIL	Malfunction Indicator Lamp
msec	Millisecond
mV	Millivolt
N/C	Normally Closed
N/O	Normally Open
PID	Packet of Informational Data
PROM	Programmable Read Only Memory
RAM	Random Access Memory
REF HI	Reference High
REF LO	Reference Low
ROM	Read Only Memory
SRC	Signal Range Check
SW	Switch
TACH	Tachometer
TERM	Terminal
TP	Throttle Position Sensor
V	Volts
VAC	Vacuum
WOT	Wide Open Throttle

Diagnostic Information

The diagnostic information and functional checks in this manual are designed to locate a faulty circuit or component through logic based on the process of elimination. The information was prepared with the requirement that the system functioned correctly at the time of assembly and that there are no multiple failures.

Abbreviations

ADF	Atmospheric Pressure Sensor
BARO	Barometric Pressure
BAT	Battery positive terminal, battery or system voltage
B+	Battery Positive
CKT	Circuit
CONN	Connector
CYL	Cylinder
DEG	Degrees
DIAG	Diagnostic
DLC	Data Link Connector
DTC	Diagnostic Trouble Code
DVOM	Digital Volt/Ohmmeter
ECM	Engine Control Module
ECT	Engine Coolant Temperature
EEPROM	Electronic Erasable Programmable Read Only Memory
EMI	Electromagnetic Interference
ENG	Engine
GND	Ground

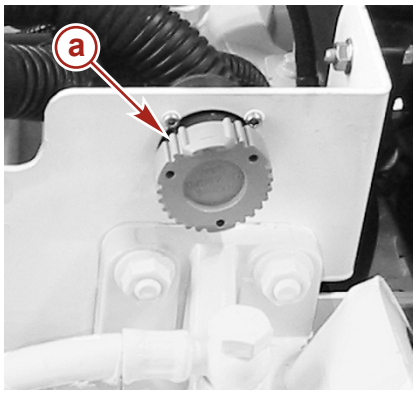
GPH	Gallons per hour
IAT	Intake Air Temperature
in. Hg.	Inches of Mercury
INJ	Injection
IGN	Ignition
kPa	Kilopascal
KV	Kilovolts
LDF	Boost Pressure Sensor (See MAP)
LGS	Low Idle Switch
MAP	Manifold Absolute Pressure
MIL	Malfunction Indicator Lamp
msec	Millisecond
NBF	Instrumented Injector
N/C	Normally Closed
N/O	Normally Open
PID	Packet of Information Data
PROM	Programmable Read Only Memory
PWG	Throttle Position Sensor
RAM	Random Access Memory
REF HI	Reference High
REF LO	Reference Low
ROM	Read Only Memory
SRC	Signal Range Check
SW	Switch
TACH	Tachometer
TERM	Terminal
TPS	Throttle Position Sensor
V	Volts
VAC	Vacuum
WOT	Wide Open Throttle

ECM Self-Diagnostics

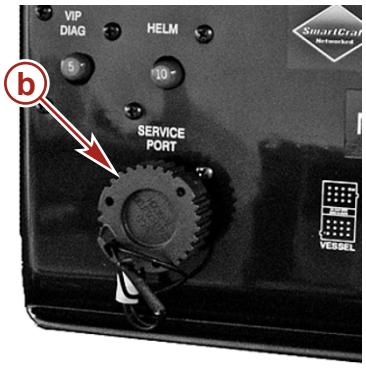
The ECM performs a continual self-diagnosis on certain control functions. This diagnostic capability is complemented by the diagnostic procedures contained in this manual. The ECM's language for communicating the source of a malfunction is a system of fault codes which can be read using the Computer Diagnostic System (CDS) tool.

Reading the Codes

Two 9-pin engine diagnostic connectors allow diagnostic equipment to communicate with the ECM. One connector is attached to a mounting plate on the ECM-side of the engine and is part of the ECS engine interface wiring harness. The second diagnostic connector is located on the front of the Vessel Interface Module (VIP).



Engine Diagnostic Connector



VIP Diagnostic Connector

a - Engine diagnostic port
b - VIP diagnostic port

Computer Diagnostic System (CDS) Tool

IMPORTANT: If using a scan tool other than CDS, follow the manufacturers instructions.

The information displayed by the CDS tool provides access to data that can not be accessed, or is difficult to obtain with other equipment. The CDS tool can isolate the location of a problem in a particular circuit speeding the diagnostic process, frequently eliminating the need to consult diagnostic flow charts and limiting the likelihood of unnecessarily replacing parts.

The CDS tool can be used to:

- Find intermittently shorted or open circuits by monitoring CDS tool data while manipulating wiring harnesses or other components with the engine off
- Check circuits and monitor data streams under operating conditions
- Observe and record various circuits over time
- Compare the operating parameters of a poorly performing engine with those of a know good engine

Clearing Codes with the CDS Tool

NOTE: *Refer to the CDS manual for in-depth information concerning CDS tool usage.*

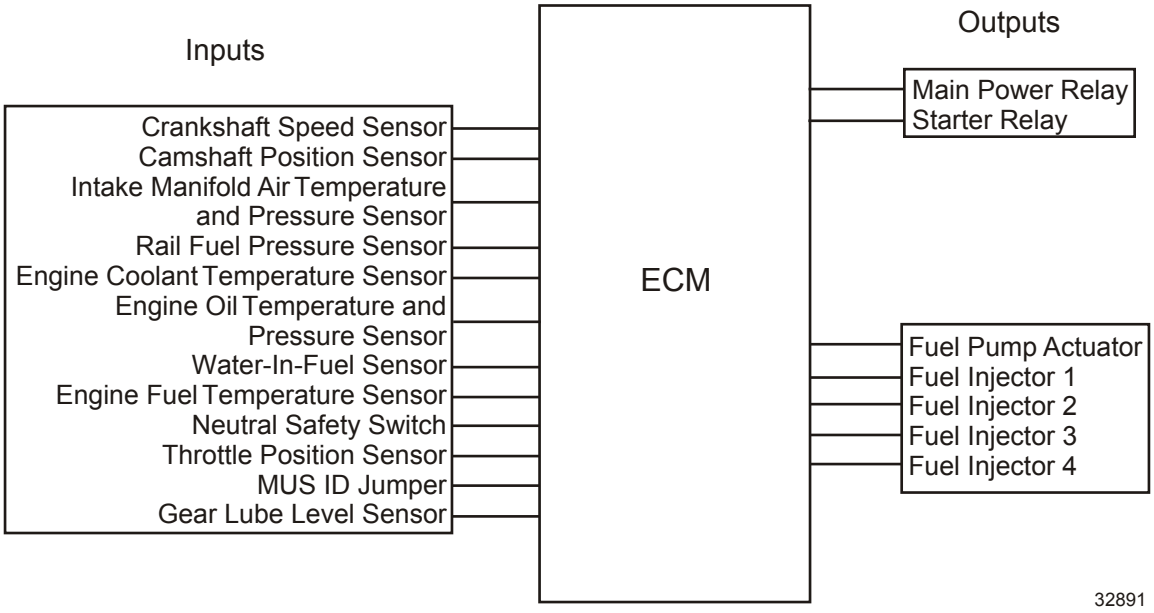
1. Turn the key on.
2. Connect to the ECM using the CDS tool.
3. Click on the **Toolbox** icon.
4. Click on the **Fault Status** icon.
5. Click on the **Freeze Frame** tab.
6. Click on the **Clear Faults** button.
7. If codes are still present, a real system fault exists. Refer to the appropriate troubleshooting and diagnostics section.

Diagnosis of Performance Concerns

If a performance concern still exists after following the troubleshooting and diagnostic circuit checks, an out-of-range sensor may be at fault. The ECM has default fail-safe sensor values to replace an out of range sensed value in the case of a sensor malfunction or a sensor wiring issue. This allows limited engine performance until the vessel is repaired. A basic understanding of sensor operation is necessary to diagnose an out-of-range sensor.

ECM Input and Sensor Diagram

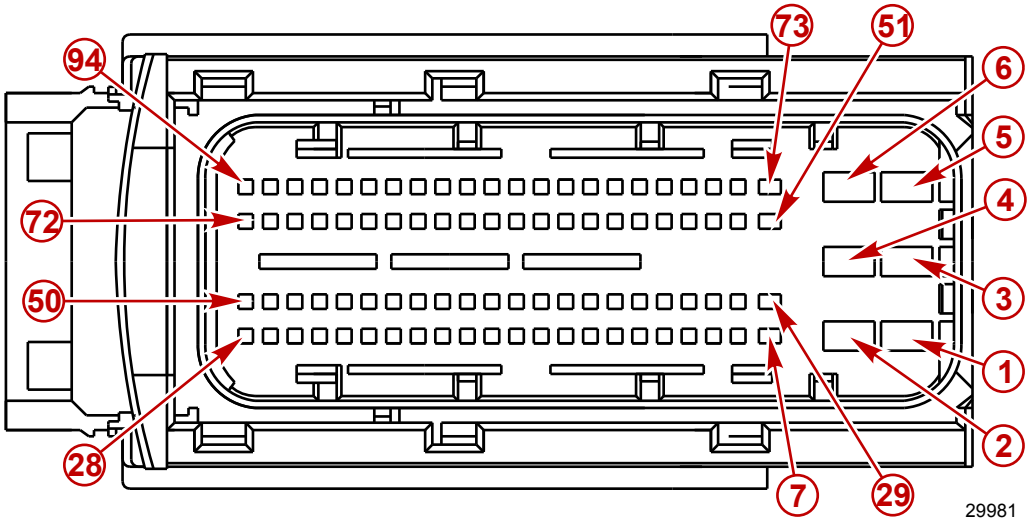
The following shows the sensors, switches, and other inputs and outputs used by the ECM to control its various systems.



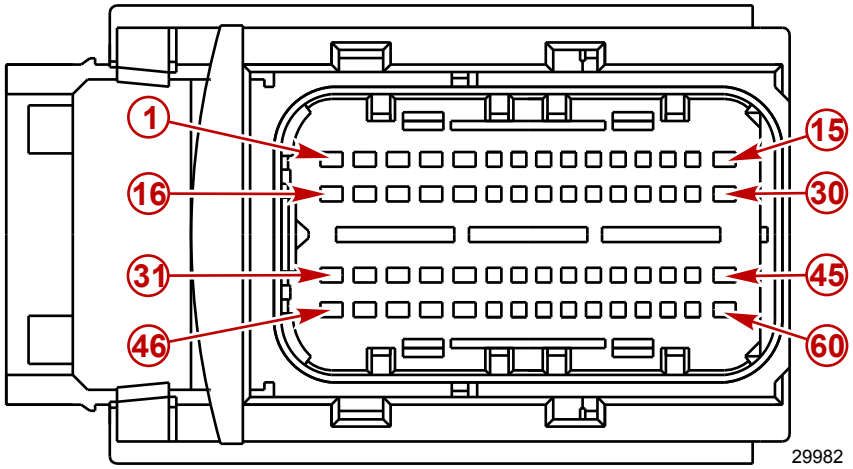
ECM input and sensor diagram

ECM Connector Pin Layout

All related wiring attaches to the ECM with one 60 pin-wiring harness connector (ECM Connector A) and one 94-pin wiring harness connector (ECM Connector K). These connectors are represented by the following diagram. The numbering orientation of the connectors is as shown. For a circuit designation, see **Connector Chart**.



ECM engine interface harness 94-pin connector K



ECM injection harness 60-pin connector A

Connector Chart

The following charts will aid in identification and diagnosis of wiring circuits that are attached to the ECM through the 60-pin connector "A" and 94-pin connector "K".

IMPORTANT: Improper probing of wires and connectors may result in damage to the electrical system. Use caution when installing or servicing electrical system components.

NOTE: *Clear each code after disconnecting and reconnecting each sensor. Failure to do so may result in an incorrect diagnosis of the problem.*

Injection Harness Connector A (60-Pin)

Position	Circuit Designation	Wire Color Abbreviation
1	Injector cylinder number 3 driver	LT BLU/GRY
2	Injector cylinder number 2 driver	ORN/BLK
7	Crankshaft speed sensor shield	SHIELD
8	Rail fuel pressure return	BLK/PUR
11	Camshaft position sensor +5V Supply	YEL/RED
12	Crankshaft speed (–) Signal	WHT
13	Intake manifold air pressure sensor +5V Supply	WHT/ORN
16	Injector cylinder number 1 driver	BLU/RED
17	Injector cylinder number 4 driver	BRN/WHT
19	Fuel pump actuator signal 1	BLK/PNK
20	Camshaft position sensor return	PUR
22	Engine oil temperature and pressure sensor return	BRN
23	Intake manifold air temperature and pressure sensor return	BRN/RED
25	Engine oil pressure sensor +5V supply	ORN
27	Crankshaft speed (+) signal	BRN
28	Rail fuel pressure sensor +5V supply	LT BLU
31	Injector cylinder number 2 return	ORN/BLU
33	Injector cylinder number 4 return	BRN/BLK
40	Intake manifold air pressure signal	WHT/RED
41	Engine coolant temperature sensor return	GRY/GRN
43	Rail fuel pressure signal	YEL
46	Injector cylinder number 3 return	LT BLU/ORN

Position	Circuit Designation	Wire Color Abbreviation
47	Injector cylinder number 1 return	BLU/BLK
49	Fuel pump actuator signal 2	ORN/GRN
50	Camshaft position signal	GRY/WHT
52	Engine oil temperature signal	WHT/BLK
53	Intake manifold air temperature signal	WHT/GRN
56	Engine oil pressure signal	GRN/BLK
58	Engine coolant temperature signal	PNK

Engine Interface Harness Connector K (94-Pin)

Position	Circuit Designation	Wire Color Abbreviation
1	ECM battery (+) from main relay	RED/BRN
2	ECM battery (–)	BLK
4	ECM battery (–)	BLK
5	ECM battery (+) from main relay	RED/BLU
6	ECM battery (–)	BLK
8	Throttle position 2 return	GRN
9	Throttle position 1 signal	WHT
10	Fuel temperature sensor return	GRY/WHT
11	Fuel temperature signal	GRY/BLK
25	KWP2000 engine datalink	PUR/BLK
28	Key switch Input signal	PUR/YEL
30	Throttle position 1 return	BRN
31	Throttle position 2 signal	YEL
38	MUS ID number 1 signal	BRN/WHT
40	Neutral safety signal	PUR/WHT
45	Throttle position 1 +5V supply	PNK
46	Throttle position 2 +5V supply	GRY
55	Starter relay Hi signal	PNK/BLU
56	MUS ID number 2 signal	BRN/BLK
57	Water in fuel signal	GRY/BLU
58	Crank signal	YEL/RED
61	J1939 CAN L	GRN
62	J1939 CAN H	WHT
72	main relay enable signal	WHT/BLK
73	Starter relay Lo signal	PNK/BLK
78	MUS ID number 3 signal	BRN/GRN
83	J1939 CAN L	GRN
84	J1939 CAN H	WHT
93	Not used - glow plug signal	BLU/BLK

Troubleshooting ECS System

Diagnostic Trouble Code (DTC) Readouts

The following chart will provide cross-reference information to correlate between DTCs and the associated CDS tool fault code text description.

DTC	CDS Tool Fault Code Text	See
P0016	Crankshaft / camshaft sensor correlation	**Crankshaft Speed Sensor** or **Camshaft Speed Sensor**
P0087	Fuel rail pressure low warning	**Rail Fuel Pressure Sensor**
P0088	Fuel rail pressure higher than commanded	
P0090	Fuel rail pressure high warning	
P0091	Fuel rail pressure lower than commanded	
P0092	Fuel rail pressure data invalid	
P0110	Intake air temperature sensor voltage out of range	**Intake Air Temperature (IAT) Sensor**
P0113	Intake air temperature high warning	
P0115	Coolant temperature sensor voltage out of range	**Engine Coolant Temperature (ECT) Sensor**
P0118	Coolant temperature high warning	
P0120	Throttle position sensor 1 voltage out of range	**Throttle Position (TP) Sensor**
P0180	Fuel temperature sensor voltage out of range	**Engine Fuel Temperature (EFT) Sensor**
P0190	Fuel rail pressure sensor voltage out of range	**Rail Fuel Pressure Sensor**
P0195	Oil temperature sensor voltage out of range	**Engine Oil Temperature (EOT) Sensor**
P0198	Oil temperature high warning	
P0201	Cylinder 1 - injector open circuit	**Injector Fault**
P0202	Cylinder 2 - injector open circuit	
P0203	Cylinder 3 - injector open circuit	
P0204	Cylinder 4 - injector open circuit	
P0220	Throttle position sensor 2 voltage out of range	**Throttle Position (TP) Sensor**
P0221	Throttle position sensor voltage out of sync	
P0235	Boost pressure sensor voltage out of range	**Manifold Air Pressure (MAP) Sensor**
P0238	Boost pressure high warning	
P0252	Fuel pressure solenoid open circuit	**Fuel Pressure Solenoid**
P0253	Fuel pressure solenoid shorted low	
P0254	Fuel pressure solenoid shorted high	
P0262	Cylinder 1 - injector circuit shorted	**Injector Fault**
P0265	Cylinder 2 - injector circuit shorted	
P0268	Cylinder 3 - injector circuit shorted	
P0271	Cylinder 4 - injector circuit shorted	
P0335	Crankshaft speed sensor data error	**Crankshaft Speed Sensor**
P0338	Engine overspeed warning	
P0340	Camshaft position sensor data error	**Camshaft Position Sensor**

DTC	CDS Tool Fault Code Text	See
P0520	Oil pressure sensor voltage out of range	**Engine Oil Pressure (EOP) Sensor**
P0522	Oil pressure critical low warning	
P0524	Oil pressure low warning	
P0560	ECM battery voltage out of range	**Battery and Main Relay**
P0606	ECM internal malfunction	**ECM Internal Error**
P0616	Starter relay low-side shorted	**Starter Circuit**
P0617	Starter relay high-side shorted	
P0641	Sensor supply 1 voltage out of range	**Camshaft Position Sensor** or **Throttle Position (TP) Sensor**
P0651	Sensor supply 2 voltage out of range	**Manifold Air Pressure (MAP) Sensor**, **Rail Fuel Pressure Sensor**, or **Throttle Position (TP) Sensor**
P0685	Main relay control timing error	**Battery and Main Relay**
P0697	Sensor supply 3 voltage out of range	**Engine Oil Pressure (EOP) Sensor**
P1605	Keyswitch signal circuit error	**Keyswitch Circuit**
P1606	Crank signal circuit error	**Starter Circuit**
P1628	ECM dataset variant coding error	**ECM Dataset Variant Coding Error**
P2148	Injector bank 1 circuit error	**Injector Fault**
P2151	Injector bank 2 circuit error	
P2226	Atmospheric pressure sensor voltage out of range	**Atmospheric Pressure (BARO) Sensor**
P2269	Water in fuel detected warning	**Water In Fuel (WIF) Sensor**
P2293	Fuel rail pressure relief valve error	**Rail Fuel Pressure Sensor** or **Fuel Rail Pressure Relief Valve**
U0101	CAN communication error	**CAN Communication Error**
U1001	No DTS CAN message or throttle lever signal present	**DTS CAN Communication Error**
U1002	DTS CAN message error (if DTS installed)	

SmartCraft Display Fault Readouts

The following chart correlates between SmartCraft display device reported faults and the equivalent diagnostic trouble codes they represent.

Smartcraft Display Text	DTC	CDS Tool Fault Code Text
122 Sensor Boost High	P0235	Boost pressure sensor voltage out of range
123 Sensor Boost Low		
2973 Snsr Boost InRange Error		
124 Boost Press High	P0238	Boost pressure high warning
131 Sensor Throt High	P0120	Throttle position sensor 1 voltage out of range
132 Sensor Throt Low		
131 Sensor Throt High	P0220	Throttle position sensor 2 voltage out of range
132 Sensor Throt Low		
135 Sensor Oil Press High	P0520	Oil pressure sensor voltage out of range
141 Sensor Oil Press Low		
143 Oil Press Low	P0524	Oil pressure low warning
144 Sensor Cool T High	P0115	Coolant temperature sensor voltage out of range
145 Sensor Cool T Low		

Smartcraft Display Text	DTC	CDS Tool Fault Code Text
151 Cool T High	P0118	Coolant temperature high warning
153 Sensor IMT High	P0110	Intake air temperature sensor voltage out of range
154 Sensor IMT Low		
155 IMT High	P0113	Intake air temperature high warning
212 Sensor Oil T High	P0195	Oil temperature sensor voltage out of range
213 Sensor Oil T Low		
214 Oil Temperature High	P0198	Oil temperature high warning
221 Snsr Amb Air Press High	P2226	Atmospheric pressure sensor voltage out of range
222 Snsr Amb Air Press Low		
2249 Low Fuel Press2	P0087	Fuel rail pressure low warning
234 Engine Overspeed	P0338	Engine overspeed warning
271 IMV Shorted Low	P0253	Fuel pressure solenoid shorted low
272 IMV Shorted High	P0254	Fuel pressure solenoid shorted high
322 Injector 1 Error	P0201	Cylinder 1 - injector open circuit
	P0262	Cylinder 1 - injector circuit shorted
324 Injector 3 Error	P0203	Cylinder 3 - injector open circuit
	P0268	Cylinder 3 - injector circuit shorted
331 Injector 2 Error	P0202	Cylinder 2 - injector open circuit
	P0265	Cylinder 2 - injector circuit shorted
332 Injector 4 Error	P0204	Cylinder 4 - injector open circuit
	P0271	Cylinder 4 - injector circuit shorted
415 Oil Pressure Low	P0522	Oil pressure critical low warning
418 Water In Fuel	P2269	Water in fuel detected warning
449 Fuel Press Very High	P0090	Fuel rail pressure high warning
451 Sensor Fuel P High	P0190	Fuel rail pressure sensor voltage out of range
452 Sensor Fuel P Low		
553 High Fuel Pressure	P0088	Fuel rail pressure higher than commanded
554 Fuel Pressure InRange Error	P0092	Fuel rail pressure data Invalid
559 Low Fuel Pressure	P0091	Fuel rail pressure lower than commanded
115 Main EPS Error	P0335	Crankshaft speed sensor data error
689 Main/Crank EPS Error		
121 Bkup/Cam EPS Error	P0340	Camshaft position sensor data error
778 Bkup/Cam EPS Error		
ECM Hi Battery Volts	P0560	ECM battery voltage out of range
ECM Lo Battery Volts		

Preliminary Checks

Before using the troubleshooting charts:

- Ensure that the ECM is operating properly.
- Verify that there are no diagnostic trouble codes stored.

Visual and Physical Check

Several of the symptom or condition lists call for careful visual and physical checks. These checks are importance can and save valuable time. Check that:

- All electrical terminals and connectors are clean, tight, free from corrosion, and in the proper location
- All fuel lines and hoses are properly connected and inspect for leaks and restriction
- There are no intake manifold leaks
- The engine is in good mechanical condition

Intermittent Problems

An intermittent problem is a problem that occurs randomly. An intermittent problem may, or may not, store a diagnostic trouble code (DTC). Do not use the diagnostic trouble code charts for intermittent problems unless instructed to do so. Incorrect diagnosis may result in the replacement of good parts.

Most intermittent problems are caused by faulty electrical connections or wiring. Carefully check the suspected circuits for the following problems:

- Poor mating of the connector halves or terminals that are not fully seated in the connector body.
- Improperly formed or damaged terminals and or connectors. All connector terminals and connectors in problem circuit should be carefully reformed or replaced to insure proper contact tension.
- Poor terminal to wire connection (crimping).

The following conditions may also cause an intermittent problem:

- Electrical system interference caused by a sharp electrical surge. Normally, the problem will occur when the faulty component is operated.
- Improper installation of electrical options, such as lights, ship to shore radios, sonar, and so on.
- Improperly routed wires. Wires should be routed away from charging system components.
- An electrical arc at part of internal circuitry shorted to ground such as in starters, relays and alternators.

If visual and physical checks do not find the cause of the problem, test the ECS system with a voltmeter or a scan tool while observing the suspected circuit. An abnormal reading when the problem occurs indicates the problem may be in that circuit.

Symptoms

When troubleshooting a customer complaint based on a symptom or condition, do the following:

- Verify the customer complaint.
- Locate the correct symptom under the condition column in the **Troubleshooting Charts**.
- Check the list of possible causes and corrections under that symptom or condition.

Troubleshooting Charts

Engine Will Not Crank or Cranks Slowly

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Engine will not crank or cranks slowly	Starter motor operating, but not cranking the engine	Remove the starter motor. Check for broken flywheel teeth or broken starter motor spring.
	Crankshaft rotation restricted	Rotate the engine to check for rotational resistance.
	Starting circuit connections loose or corroded	Clean and tighten connections. Reapply liquid neoprene, when required.
	Neutral safety switch or starter relay inoperative	Check starter relay supply voltage and proper operation of the neutral safety switch (if equipped). Replace defective parts.
	Battery charge low	Check battery voltage. Replace battery if a charge cannot be held.
	No voltage to starter solenoid	Check voltage to the solenoid. If necessary, replace the solenoid.
	Solenoid or starter motor inoperative	Replace starter motor.

Engine Cranks but Will Not Start

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

NOTE: *The SmartStart feature ends the start cycle after three seconds if no crankshaft speed is reported to the ECM or if engine RPM does not exceed 500 RPM within five seconds of the initiation of a start cycle.*

Condition	Possible Causes	Correction
Engine cranks but will not start. No smoke.	No fuel in supply tank	Add fuel.
	Air intake or exhaust plugged	Remove the obstruction.
	Fuel filter plugged	Drain fuel and water separator and replace fuel filter.
	Excessive fuel inlet restriction	Check fuel inlet restriction. Correct cause.
	High pressure fuel pump not getting fuel or fuel is aerated	Check fuel flow and flow and bleed fuel system.
	One or more injectors worn or not operating properly	Check and replace bad or improperly operating injectors.
	Worn or inoperative injection pump	Visually check delivery with externally connected injector to one of the pump outlets. Repair or replace as needed after testing, if fuel is not being delivered.
	Incorrect camshaft timing	Check and correct gear train timing alignment.
	Open lanyard or E-stop circuit	Correct switch position or short in circuit.
	Fuel pump fuel pressure solenoid not responding	Correct wiring defect or replace solenoid as needed.
	Incorrect fuel rail fuel pressure	Check fuel rail pressure sensor and relief valve operation.

Engine Hard to Start or Will Not Start

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Engine hard to start or will not start. Smoke from exhaust.	Incorrect starting procedure	The fuel shut-off solenoid control must be in the run position. Ensure that the proper procedure is being used.
	Cranking speed too slow	Verify that the drive or transmission is not engaged.
		Check the battery and starter motor and look for loose or corroded wiring connections.
	Insufficient intake air	Inspect or replace the filter and check for any obstruction to the air supply.
	Air in the fuel system or the fuel supply is inadequate	Check the flow through the filter and bleed the system. Locate and eliminate the air source.
	TP sensor, throttle cable, or both, are loose or damaged	Scan and visually inspect the TP sensor, throttle cable and mounting. Adjust or replace, if necessary.
	Contaminated fuel	Verify by operating the engine with clean fuel from a temporary tank. Check for presence of gasoline. Drain and flush supply tank. Replace the water-separating fuel filter.
	Fuel screen plugged	Check fuel screen.
	One or more injectors plugged or not operating properly	Check and replace improperly operating injectors.
	Malfunctioning, worn, or inoperative injection pump	Scan, repair, or replace components as needed.
	Fuel injectors out of time	Check injector feedback data and wiring.
	Engine compression low	Check compression to identify the problem.
	Incorrect fuel rail fuel pressure	Check fuel rail pressure sensor and relief valve operation.

Rough Idle (Irregularly Firing or Engine Shaking)

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Rough idle (irregularly firing or engine shaking)	Idle speed, fuel quantity, or both, too low for the accessories	Adjust the idle speed.
	Engine mounts damaged or loose	Repair or replace the mounts.
	High pressure fuel leaks	Correct leaks in the high-pressure lines, fittings, or delivery valves.
	Air in the fuel system	Bleed the fuel system and eliminate the source of the air.
	Sticking needle valve in an injector	Check and replace the injector with the sticking needle valve.
	Incorrect fuel rail fuel pressure	Check fuel rail pressure sensor and relief valve operation.

Engine Operates Rough

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Engine operates rough	Fuel injection lines leaking	Correct leaks in the high-pressure lines, fittings, injector sealing washers or delivery valves.
	Air in the fuel or fuel supply is inadequate	Check the flow through the fuel filter and bleed the system. Locate and eliminate the air source.
	Contaminated fuel	Verify by operating the engine with clean fuel from a temporary tank. Check for presence of gasoline. Drain and flush supply tank. Replace the water separating fuel filter.
	Incorrect valve operation	Check for a bent push-rod or damaged roller lifter. Replace parts if necessary.
	Improperly operating injectors	Replace defective injectors.
	Defective high pressure fuel pump (fuel quantity or solenoid valve)	Scan, repair, or replace injection pump.
	Camshaft out of time	Check and correct gear train timing alignment.
	Damaged camshaft or tappets	Inspect camshaft valve lift. Replace camshaft and tappets.
	Automatic timing advance not operating	Check injection pump and instrumented injector at number 1 cylinder.
	Incorrect fuel rail fuel pressure	Check fuel rail pressure sensor and relief valve operation.

Engine Starts, But Will Not Keep Operating.

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Engine starts, but will not keep operating.	Low fuel rail fuel pressure	Check fuel rail pressure sensor and relief valve operation.
	Idle speed or fuel quantity too low for accessories	Adjust the idle speed.
	Intake air or exhaust system restricted	Visually check for exhaust restriction and inspect the air intake. Repair or replace the defective parts.
	Air in the fuel or fuel supply is inadequate	Check the flow through the fuel filter and bleed the system. Locate and eliminate the air source.
	Fuel waxing due to extremely cold weather	Verify by inspecting the fuel filter. Clean the system and use the proper seasonal blend of fuel. Replace water-separating fuel filter. Check fuel filter for proper operation, if equipped.
	Contaminated fuel	Verify by operating the engine with clean fuel from a temporary tank. Check for presence of gasoline. Drain and flush supply tank. Replace water-separating fuel filter.

Surging (Speed Change)

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Surging (speed change)	If the condition occurs at idle, the idle speed is set too low for accessories	Adjust the idle speed.
	High-pressure fuel leak	Inspect and correct leaks in the high-pressure lines, fittings, and delivery valve sealing washers.
	One or more injectors worn or not operating properly	Check and replace the inoperative injector.
	Improperly operating injection pump	Replace the injection pump.
	Incorrect fuel rail fuel pressure	Check fuel rail pressure sensor and relief valve operation.

Engine RPM Will Not Reach Rated Speed.

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Engine RPM will not reach rated speed.	Engine overload	Verify high idle speed without load. Investigate operation to ensure correct gear and propeller are being used.
	Improperly operating tachometer	Verify engine speed with a hand tachometer. Correct as required.
	Throttle linkage worn or incorrectly adjusted	Adjust linkage for stop to stop fuel lever travel. Replace linkage if necessary.
	Inadequate fuel supply	Check the fuel flow through the system to locate the reason for inadequate fuel supply. Correct as required.
	Air and fuel controls leak	Check and repair leak. Check AFC tubing for obstruction.
	Improperly operating high pressure fuel pump	Repair or replace injection pump.
	Incorrect ECM part number	Ensure ECM part number is correct for your model; some de-rated ECMs are for dual installations in emission regulated countries.
	Incorrect fuel rail fuel pressure	Check fuel rail pressure sensor and relief valve operation.

Low Power

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Low power	Throttle cable not moving to full throttle	Check and correct for stop-to-stop travel.
	High oil level	Check and correct oil level.
	Engine overloaded	Check for added loading from accessories or driven units, brakes dragging, and other changes in vehicle loading. Repair or replace as needed.
	Slow throttle response caused by leaking or obstructed air control tube or improperly operating injection pump	Check for leaks and obstructions. Tighten the fittings. Repair or replace the pump if scan or check determines the pump is not functioning.
	Inadequate intake air flow	Inspect or replace air cleaner element. Look for other restrictions.
	Inadequate fuel supply. Air in the fuel.	Check the flow through the filter to locate the source of the restriction. Check fuel pressure and inlet restriction.
	Excessive exhaust restriction	Check and correct the restriction in the exhaust system.
	High fuel temperature	Verify that the fuel heater, if equipped, is off when the engine is warm. Check for restricted fuel return lines. Repair or replace as needed.
	Poor quality fuel or fuel contaminated with gasoline	Verify by operating with a temporary tank with good fuel. Check for presence of gasoline. Replace water separating fuel filter.
	Air leak between the turbocharger and aftercooler	Check and correct leaks in hoses, gaskets, aftercooler, and around mounting cap screws or through holes in the cooler and end caps.
	Exhaust leak at the manifold and turbocharger	Check and correct leaks in the manifold or turbocharger gaskets. If the manifold is cracked, replace the manifold.
	Improperly operating turbocharger	Inspect or replace turbocharger.
	Wastegate operation	Check wastegate operation.
	Valve not operating	Check for bent push-rod or faulty hydraulic lifter. Replace if necessary.
	Worn or improperly operating injectors	Check or replace injectors.
	Improperly operating high pressure fuel pump	Repair or replace injection pump.
	Incorrect fuel rail fuel pressure	Check fuel rail pressure sensor and relief valve operation.

Excessive Exhaust Smoke

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Excessive exhaust smoke	Engine operating too cold (white smoke)	Refer to troubleshooting for coolant temperature below normal (See Cooling System). Inspect glow plugs for proper operation.
	Improper starting procedure (white smoke)	Use proper starting procedures.
	Fuel supply inadequate	Check fuel supply pressure and inlet restriction.
	Injection pump timing	Scan or check pump timing.
	Inadequate air intake	Inspect or change air filter. Look for other restriction. Check charge air cooler for obstructions.
	Air leak between turbocharger and intake manifold	Check and correct air leaks in the air crossover tube, hoses, gaskets, mounting cap screws or through holes in the manifold cover.
	Exhaust leak at the manifold or turbocharger	Check and correct leaks in the manifold or turbocharger gaskets. Replace component if a crack is found.
	Improperly operating turbocharger	Inspect or replace turbocharger.
	Improperly operating injectors	Check and replace any defective injectors.
	Improperly operating or over fueled injector pump	Repair or replace injection pump.
	Piston rings not sealing (blue smoke)	Perform compression and blow-by check. Correct as required.
	Incorrect fuel rail fuel pressure	Check fuel rail pressure sensor and relief valve operation.

Engine Will Not Shut Off

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Engine will not shut off	Engine operating on fumes drawn into the air intake	Check the air intake ducts for the source of the fumes.
	Fuel injection pump or fuel shut-off valve malfunction	Repair or replace the fuel injection pump.

Coolant Temperature Above Normal

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Coolant temperature above normal	Low coolant level	Check coolant level. Add coolant, if necessary. Locate and correct the source of the coolant loss. (See **Closed Cooling System**).
	Incorrect or improperly operating pressure cap	Replace the cap with the correct rating for the system.
	Loose drive belt on the water pump	Check or replace belt or belt tensioner .
	Improperly operating temperature sensor or gauge	Verify that the the gauge and temperature sensor are accurate. Replace the gauge or sensor if either is defective.
	Obstructed or restricted seawater pump inlet	Remove the obstruction or restriction.
	Improperly operating thermostat. Incorrect or no thermostat	Check and replace thermostat.
	Air in the cooling system	Ensure that the fill rate is not being exceeded and that the correct vented thermostat is installed.
		Check for loose hose clamps. Tighten if loose.
		If aeration continues, check for a compression leak through the head gasket.
	Inoperative water pump	Check and replace the water pump.
	Incorrect injection pump timing	Verify that the pump timing marks are aligned. Check and, if necessary, time the injection pump. See **Fuel System**.
	Over-fueled injection pump	Repair or replace the injection pump.
	Plugged cooling passages in the coolers, heat exchanger, cylinder head, head gasket, or engine block	Flush the cooling system and refill with clean coolant.
	Engine overloaded	Verify that the engine load rating is not being exceeded.

Coolant Temperature Below Normal

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Coolant temperature below normal	Incorrect thermostat or contamination in the thermostat	Check and replace the thermostat.
	Temperature sensor or gauge inoperative	Verify that the gauge and sensor are accurate. If not, replace the gauge or sensor.
	Coolant not flowing by the temperature sensor	Check and clean the coolant passages.

Lubricating Oil Pressure Low

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Lubricating oil pressure low	Low oil level	Check and fill with clean engine oil.
		Check for a severe external oil leak that could reduce pressure.
	Oil viscosity thin, diluted, or incorrect specification	Verify that the correct oil is being used. Check for oil dilution. See Engine Mechanical).
	Improperly operating pressure switch or gauge	Verify that the pressure switch is functioning properly. Replace the gauge or pressure switch as required.
	Relief valve stuck open	Check or replace the valve.
	Plugged oil filter	Change the oil filter. Oil filter change interval may need to be revised.
	If cooler was replaced, shipping plugs remain in the cooler	Check and remove the shipping plugs.
	Worn oil pump	Check and replace the oil pump.
	Suction tube loose or tube seal leaking	Check and replace the seal.
	Loose main bearing cap	Check and install new main bearing and tighten main bearing cap to specification.
	Worn bearings or incorrect bearings installed	Inspect and replace main bearings or connecting rod bearings. Check and replace the piston cooling nozzles.
	Oil jet under the piston is a bad fit into the main carrier	Check oil jet position.

Lubricating Oil Pressure Too High

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Lubricating oil pressure too high	Pressure switch or gauge not operating properly	Verify that the pressure switch is functioning properly. If not, replace the switch or gauge, or both.
	Engine operating too cold	See "Coolant Temperature Below Normal" troubleshooting chart.
	Oil viscosity too thick	Make sure that the correct oil is being used. See **Maintenance**.
	Oil pressure relief valve stuck closed or binding	Check and replace the relief valve.

Lubricating Oil Loss

Condition	Possible Causes	Correction
Lubricating oil loss	External leaks	Visually inspect for oil leaks. Repair as required.
	Crankcase overfilled	Verify that the correct dipstick and/or the correctly marked dipstick is being used.
	Incorrect oil specification or viscosity	Ensure that the correct oil is being used.
		Look for reduced viscosity resulting from dilution by fuel.
		Review and reduce the interval between oil changes.
	Oil cooler leak	Check and replace the oil cooler.
	High blow-by forcing oil out through the breather	Check the breather tube area for signs of oil loss. Repair as required.
	Turbocharger leaking oil into the air intake	Inspect aftercooler for evidence of oil transfer. Repair as required.
	Piston rings not sealing; Oil being consumed by the engine	Perform compression check. Repair as required.

Compression Knocks

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Compression knocks	Air in the fuel system	Bleed the fuel system.
	Poor quality fuel or contaminated fuel (water or gasoline in fuel)	Verify by operating from a temporary tank with good fuel. Clean and flush the fuel supply tanks. Replace the water separating fuel filter.
	Engine overloaded	Verify that the engine load rating is not being exceeded.
	Incorrect injection pump timing	Scan and check the injection pump timing.
	Improperly operating injectors	Check and replace the inoperative injectors.

Excessive Vibration

Condition	Possible Causes	Correction
Excessive vibration	Loose or broken engine mounts	Replace engine mounts.
	Damaged or improperly operating accessories	Check and repair or replace the vibrating accessory.
	Improperly operating vibration damper	Inspect and replace the vibration damper.
	Worn or damaged alternator bearing	Check and, if necessary, replace the alternator.
	Flywheel housing misaligned	Check and correct the flywheel housing alignment.
	Loose or broken power component	Inspect the crankshaft and connecting rods for damage that causes an imbalance. Repair or replace as required.
	Worn or unbalanced drive line components	Check and repair drive line components.

Excessive Engine Noise

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Excessive engine noise	Drive belt squeal from insufficient tension or abnormally high loading	Inspect the drive belt and check the drive belt tension.
	Intake air or exhaust leaks	See **Excessive Exhaust Smoke** (Engine Diagnosis-Performance).
	Excessive valve lash	Ensure that the push rods are not bent and that the rocker levers are not severely worn. Replace as necessary.
	Turbocharger noise	Check turbocharger impeller and turbine wheel for housing contact. Repair or replace as required.
	Gear train noise	Visually inspect and measure the gear backlash. Replace gears as required.
	Power function knock	Check and replace, if necessary, main and connecting rod bearings.

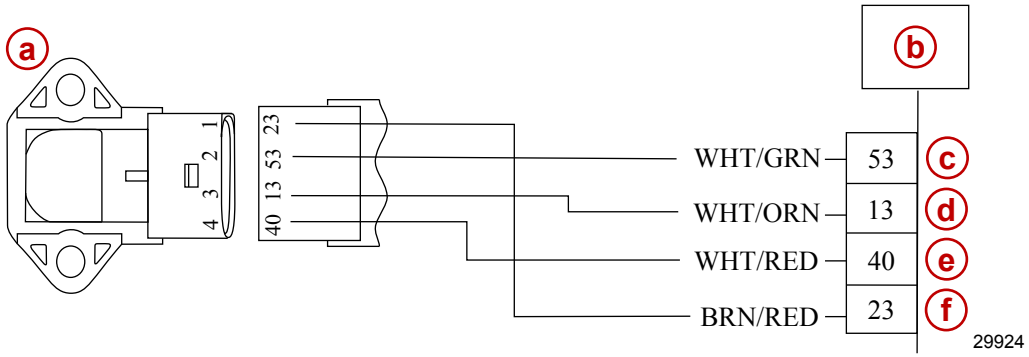
Alternator Not Charging or Insufficient Charging

IMPORTANT: Check for active fault codes at the beginning of any diagnostic process.

Condition	Possible Causes	Correction
Alternator not charging or insufficient charging	Loose or corroded battery terminals	Clean and tighten battery cable connections.
	Alternator belt slipping	Check and replace and/or adjust the alternator belt.
	Alternator pulley loose on the shaft	Tighten the alternator pulley.
	Improperly operating alternator	Check and, if necessary, replace alternator.

Manifold Air Pressure Sensor

Manifold Air Pressure (MAP) Sensor



a - MAP and IAT sensor assembly
b - ECM 60-pin connector "A"
c - IAT signal
d - 5-volt reference signal
e - MAP signal
f - Sensor ground

Circuit Description

The MAP sensor and Intake Air Temperature (IAT) sensor form an assembly. The MAP sensor portion of this assembly is a pressure transducer that measures changes in the intake manifold pressure. The pressure changes as a result of engine load and speed changes. The MAP sensor converts pressure changes to a voltage output signal.

NOTE: *This component may be referred to as a boost pressure sensor due to the presence of a turbocharger.*

The ECM sends a 5 volt reference signal to the MAP sensor. As the manifold pressure changes, the electrical resistance of the MAP sensor also changes. By monitoring the sensor output voltage, the ECM knows the manifold pressure. A higher pressure, low vacuum (high voltage) requires more fuel, while a lower pressure, higher vacuum (low voltage) requires less fuel.

A faulty MAP sensor circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P0235	Boost pressure sensor voltage out of range. The MAP sensor output voltage is above the upper limit or below the lower limit or there is an implausibility with the barometric pressure sensor.	No effect on the engine.	>4848.48 mV <337.2 mV difference between atmospheric sensor >150 hPa
P0238	High boost pressure warning. Intake manifold pressure signal indicates the intake manifold pressure has exceeded the maximum limit for the given engine rating.	The engine torque limitation will limit the engine speed to 3600 RPM.	>3300 hPa
P0651	Sensor supply 2 voltage out of range. The sensor supply 2 circuit output voltage is above the upper limit or below the lower limit. This circuit supplies power to the throttle position 2 sensor, the fuel rail pressure sensor, and the boost pressure sensor.	The engine fuel quantity limitation will limit the engine speed to 3000 RPM.	>5.2 V <4.8 V

ECM 60-Pin Connector "A" CKT pin	Name
40	MAP signal
13	5-volt reference signal
23	Sensor ground (–)

Test Description

Verify continuity between the following pins:

ECM 60-Pin Connector "A"	4-terminal connector at MAP
40	4
13	3
23	1

Verify the sensor voltage on pin 40 of the ECM 60-pin connector "A" or on pin 4 of the MAP sensor as a function of pressure.

Pressure (mm Hg)	Pressure (Hg)	Pressure (PSI)	Voltage (VDC)
0	0	0	0.09–0.10
381	15	7	0.83–0.91
635	25	12	1.31–1.45
1549	61	30	3.07–3.39
2057	81	40	4.04–4.47

Diagnostic Help

Check for the following:

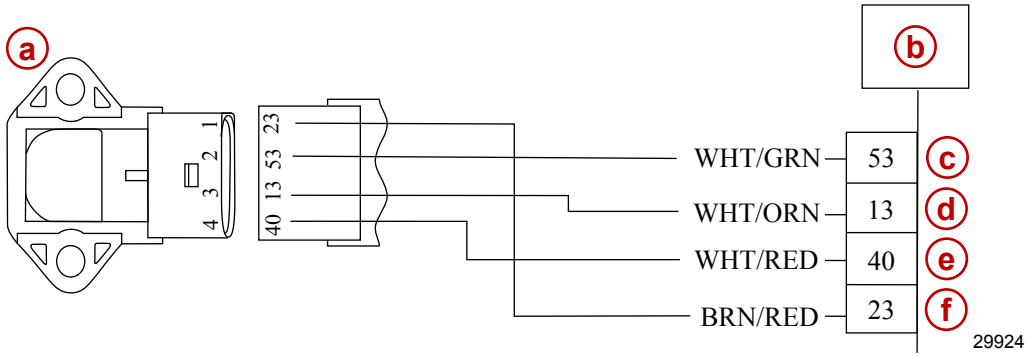
- Open or shorted circuits in pins 40, 13, or 23 (causes a low amount of smoke)
- Loose sensor assembly or a damaged O-ring seal (causes a high amount of smoke)
- A terminal or pin at the MAP connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals a cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- A defective MAP sensor
- A defective ECM

IMPORTANT: Replace the O-ring seal whenever removing the MAP and IAT sensor. Tighten the sensor to specification.

Description	Nm	lb. in.	lb. ft.
Intake manifold pressure sensor screw	3.3	29	–

Intake Air Temperature Sensor

IAT (Intake Air Temperature) Sensor



a - MAP and IAT sensor assembly
b - ECM 60-pin connector "A"
c - IAT signal
d - 5-volt reference signal
e - MAP signal
f - Sensor ground

Circuit Description

The IAT sensor and MAP sensor form an assembly. The IAT portion of the assembly is a thermistor (a resistor that changes value based on temperature). Low temperature produces a high resistance, while high temperature causes a low resistance. The ECM supplies a 5-volt signal to the sensor through a resistor in the ECM and measures the voltage divider output. The ECM monitors the voltage on the signal pin and converts this to a temperature value. The ECM voltage will be high when the intake air is cold and low when the intake manifold air is hot.

A faulty IAT sensor circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P0110	Intake air temperature sensor voltage out of range. The intake manifold air temperature sensor output voltage is above the upper limit or below the lower limit.	No effect on the engine.	>4941.35 mV <166.18 mV
P0113	High intake air temperature warning. Intake air temperature signal indicates the intake manifold air temperature is above the engine protection critical limit.		>95° C

ECM 60-Pin Connector "A" CKT pin	Name
23	Sensor ground
53	IAT signal

Test Description

Verify continuity between the following pins:

ECM 60-Pin Connector "A"	4-terminal connector at IAT
23	1
53	2

Verify the sensor resistance between the two IAT sensor terminals as a function of temperature:

NOTE: *Stabilization time before each measurement in the test medium is a minimum of 10 minutes.*

Temperature °C (°F)	Resistance (kOhm)
–10 (14)	8.95–9.90
0 (32)	5.61–6.17
20 (68)	2.40–2.62
40 (104)	1.15–1.25
70 (158)	0.431–0.462

Diagnostic Help

Check for the following:

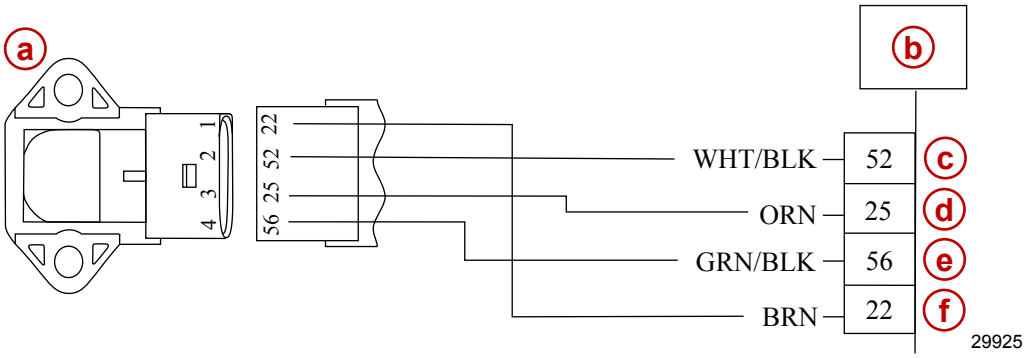
- An open circuit or a short circuit in CKT pins 23 or 53
- A terminal or pin at the IAT connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins

- A defective IAT sensor
- A defective ECM

IMPORTANT: Replace the O-ring seal whenever removing the IAT and MAP sensor. Tighten the sensor to specification.

Description	Nm	lb. in.	lb. ft.
Intake manifold air temperature sensor screw	3.3	29	–

Engine Oil Pressure Sensor



a - EOP and EOT sensor assembly
b - ECM 60-pin connector "A"
c - EOT signal
d - 5-volt reference signal
e - EOP signal
f - Sensor ground

Circuit Description

The Engine Oil Pressure sensor (EOP) and the Engine Oil Temperature (EOT) sensor form an assembly. The EOP sensor portion of this assembly is a pressure transducer that measures the changes in the engine oil pressure. The pressure changes as a result of engine load and speed change, and the EOP sensor converts this to a voltage output signal.

The ECM sends a 5 volt reference signal to the EOP sensor. Changes in the engine oil pressure change the resistance of the EOP sensor. By monitoring the sensor output voltage, the ECM knows the engine oil pressure. A higher pressure results in a higher voltage while a lower pressure results in a lower voltage. The ECM uses the EOP sensor to monitor engine protection limits.

A faulty EOP sensor circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P0520	Oil pressure sensor voltage out of range. The engine oil pressure sensor output voltage is above the upper limit or below the lower limit.	No effect on the engine.	>4838.7 mV <254.1 mV
P0522	Critical low oil pressure warning. Engine oil pressure signal indicates engine oil pressure is well below engine protection limit.	The engine torque limitation will limit the engine speed to 3600 RPM.	<180 kPa
P0524	Low oil pressure warning. Engine oil pressure signal indicates engine oil pressure is below engine protection limit.		<210 kPa
P0697	Sensor supply 3 voltage out of range. The sensor supply 3 circuit output voltage is above the upper limit or below the lower limit. This circuit supplies power to the oil pressure sensor.		>5.2 V <4.8 V

ECM 60-Pin Connector "A" CKT pin	Name
56	EOP signal
25	5-volt reference signal
22	Sensor ground (–)

Test Description

Verify continuity between the following pins:

ECM 60-Pin Connector "A"	4-terminal connector at EOP
56	4
25	3
22	1

Verify the sensor supply voltage between terminals 1 and 3 of the sensor connector on the engine harness with the sensor disconnected and the keyswitch on:

Voltage (V)	Measurement
5	4.75–5.25

Verify the sensor voltage on pin 56 of the ECM 60-pin connector "A" or on pin 4 of the MAP sensor as a function of pressure.

Pressure kPa (PSI)	Voltage (VDC)
101 (15)	0.68–0.75
274 (40)	1.37–1.52
446 (65)	2.06–2.28
584 (85)	2.61–2.89
722 (105)	3.16–3.50
860 (125)	3.71–4.11
1000 (145)	4.27–4.73

Diagnostic Help

Check for the following:

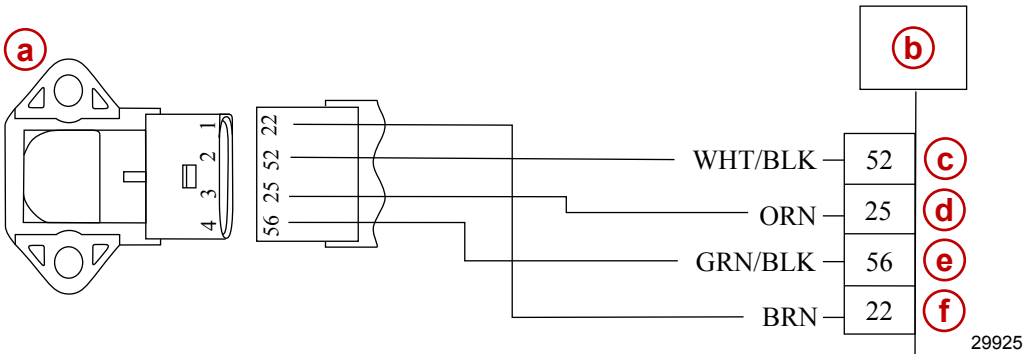
- An open circuit or a short circuit in CKT pins 56, 25, or 52

- A loose assembly on the oil pressure mounting location on the block or a damaged O-ring seal will cause an improper signal
- A terminal or pin at the MAP connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- A defective EOP sensor
- A defective ECM

IMPORTANT: Replace the O-ring seal whenever removing the EOP and EOT sensor. Torque the sensor to specification when replacing.

Description	Nm	lb. in.	lb. ft.
Engine oil pressure sensor screw	11.5	102	–

Engine Oil Temperature Sensor



a - EOP and EOT sensor assembly
b - ECM 60-pin connector "A"
c - EOT signal
d - 5-volt reference signal
e - EOP signal
f - Sensor ground

Circuit Description

The Engine Oil Temperature (EOT) sensor and the Engine Oil Pressure (EOP) sensor form an assembly. The EOT portion of the assembly is a thermistor (a resistor that changes value based on temperature). Low temperature produces a high resistance, while high temperature causes a low resistance. The ECM supplies a 5 volt signal to the sensor through a resistor in the ECM and measures the voltage divider output.

The ECM monitors the voltage on the signal pin and converts this to a temperature value. The ECM voltage will be high when the engine oil is cold and low when the engine oil is hot. A faulty EOT sensor circuit can generate the following diagnostic trouble codes:

DTC	Reason	Effect	Condition
P0195	Oil temperature sensor voltage out of range. The engine oil temperature signal output voltage is above the upper limit, below the lower limit, or there is an implausibility with the coolant temperature sensor.	No effect on the engine.	>4799.609 mV <141.74 mV
P0198	High oil temperature warning. Engine oil temperature signal indicates the engine oil temperature is above the engine protection critical limit.	The engine torque limitation will limit the engine speed to 3600 RPM.	>120° C

ECM 60-Pin Connector "A" CKT pin	Name
22	Sensor ground
52	EOT signal

Test Description

Verify continuity between the following pins:

ECM 60-Pin Connector "A"	4-terminal connector at EOT
22	1
52	2

Verify the sensor resistance between the two EOT sensor terminals as a function of temperature:

NOTE: *Stabilization time before each measurement in the test medium is a minimum of 10 minutes.*

Temperature °C (°F)	Resistance (kOhm)
0 (32)	5.670–6.120
25 (77)	1.990–2.120
50 (122)	0.811–0.857
75 (167)	0.365–0.383
100 (212)	0.183–0.190

Diagnostic Help

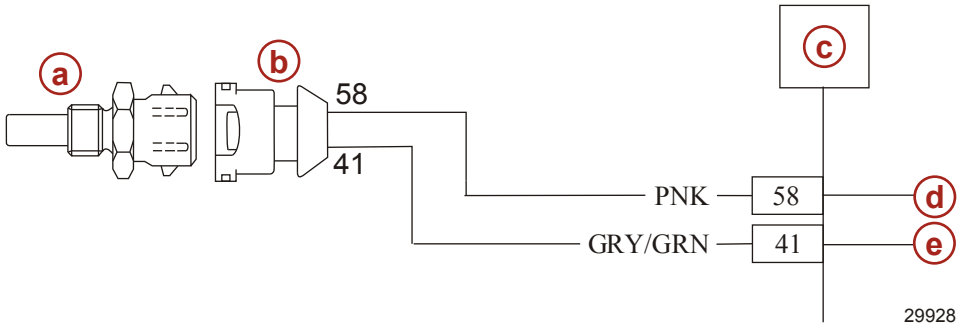
Check for the following:

- An open circuit or a short circuit in CKT pins 22 or 52
- A terminal or pin at the EOT connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- A defective EOT sensor
- A defective ECM

IMPORTANT: Replace the O-ring seal whenever removing the EOP and EOT sensor. Torque the sensor to specification when replacing.

Description	Nm	lb. in.	lb. ft.
Engine oil temperature sensor screw	11.5	102	–

Engine Coolant Temperature Sensor



a - ECT sensor
b - ECT connector
c - ECM 60-pin connector "A"
d - 5-volt reference signal
e - Sensor return signal

Circuit Description

The engine coolant temperature (ECT) sensor is a thermistor (a resistor that changes value based on temperature) immersed in the engine coolant stream. Low coolant temperature produces a high resistance, while high temperature causes low resistance. The ECM supplies a 5 volt signal to the ECT through a resistor in the ECM and measures the voltage divider output. The voltage is high when the engine is cold and low when the engine is hot. The ECM monitors the voltage on the signal pin and converts this to a temperature value. The engine coolant temperature value is used by the ECM for the engine protection system and engine emissions control.

A faulty ECT sensor circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P0115	Coolant temperature sensor voltage out of range. The engine coolant temperature sensor output voltage is above the upper limit, below the lower limit, or there is an implausibility with the oil temperature sensor.	The setting of this DTC has no effect on engine operation.	>4960.89 mV <205.279 mV
P0118	High coolant temperature warning. The engine coolant temperature signal indicates the engine coolant temperature is above the engine protection critical limit.	The engine torque limitation will limit the engine speed to 3600 RPM.	>105° C

ECM 60-Pin Connector "A" CKT pin	Name
58	Engine Coolant Temperature Sensor (ECT) signal
41	Sensor ground (–)

Test Description

Verify continuity between the following pins:

ECM 60-Pin Connector "A"	2-terminal connector at ECT
58	1
41	2

Verify the sensor resistance between the ECT signal and ground terminals as a function of temperature. Check the sensor resistance falls within the range shown in the following table.

NOTE: *Stabilization time before each measurement in the test medium is a minimum of 10 minutes.*

Temperature °C (°F)	Resistance (kOhm)
0 (32)	5.470–6.330
25 (77)	1.940–2.170
60 (140)	0.573–0.618
80 (176)	0.313–0.332
100 (212)	0.182–0.191

Diagnostic Help

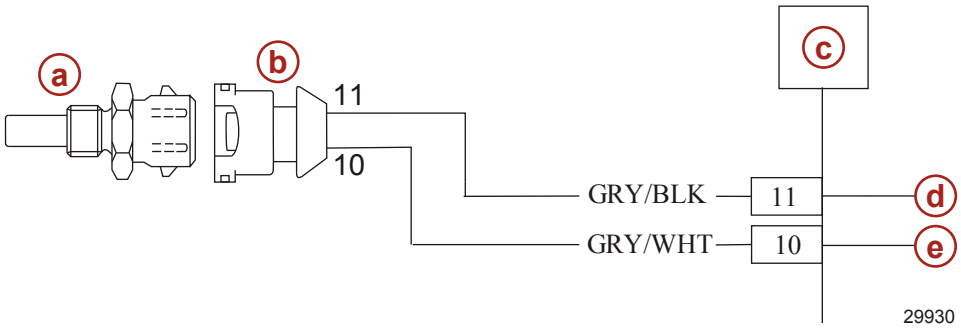
Check for the following:

- An open circuit or a short circuit in CKT pins 58 or 41
- A terminal or pin at the ECT connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- A defective ECT sensor
- A defective ECM

IMPORTANT: Torque the ECT sensor to specification when replacing.

Description	Nm	lb. in.	lb. ft.
Coolant temperature sensor	22	195	–

Engine Fuel Temperature Sensor



a - EFT sensor
b - EFT connector
c - ECM 94-pin connector "K"
d - 5-volt reference signal
e - Sensor return signal

Circuit Description

The engine fuel temperature (EFT) sensor is a thermistor (a resistor that changes value based on temperature). Low temperature produces a high resistance, while high temperature causes a low resistance. The ECM supplies a 5 volt signal to the sensor through a resistor in the ECM and measures the voltage divider output. The ECM monitors the voltage on the signal pin and converts this to a temperature value. The ECM voltage will be high when the fuel temperature is cold and low when the fuel temperature is hot. The ECM uses the EFT sensor to monitor engine protection limits.

A faulty EFT sensor circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P0180	Fuel temperature sensor voltage out of range. The fuel temperature signal output voltage is above the upper limit or below the lower limit.	No effect on the engine.	>4936.5 mV <132 mV

ECM 94-Pin Connector "K" CKT pin	Name
11	Engine fuel temperature sensor (EFT) signal
10	Sensor ground (–)

Test Description

Verify continuity between the following pins:

ECM 94-Pin Connector "K"	2-terminal connector at EFT
11	1
10	2

Verify the sensor resistance between the EFT signal and ground terminals as a function of temperatures. Check the sensor resistance falls within the range in the following table.

NOTE: *Stabilization time before each measurement in the test medium is a minimum of 10 minutes.*

Temperature °C (°F)	Resistance (kOhm)
–30 (–22)	23.5–28.7
0 (32)	5.47–6.33
25 (77)	1.94–2.17
60 (140)	0.57–0.62
100 (212)	0.18–0.19
110 (230)	0.14–0.15

Diagnostic Help

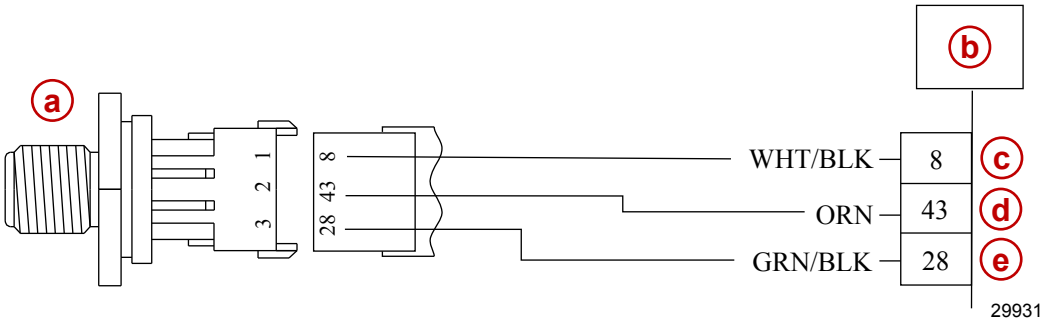
Check for the following:

- An open circuit or a short circuit in CKT pins 11 or 10
- A terminal or pin at the EFT connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- A defective EFT sensor
- A defective ECM

IMPORTANT: Torque the EFT sensor to specification when replacing.

Description	Nm	lb. in.	lb. ft.
Fuel temperature sensor	35	–	26

Rail Fuel Pressure Sensor



a - RFP sensor
b - ECM 60-pin connector "A"
c - Sensor ground
d - RFP signal
e - 5-volt reference signal

Circuit Description

The rail fuel pressure (RFP) sensor is a pressure transducer that measures the changes in the fuel rail pressure. The pressure changes as a result of engine load and speed change, and the RFP sensor converts this to a voltage output signal to the ECM.

The ECM sends a 5 volt reference signal to the RFP sensor. As the fuel rail pressure changes, the electrical signal of the RFP sensor also changes. The ECM monitors the sensor output voltage signal and converts this to a pressure value. A higher pressure results in a higher voltage while a lower pressure results in a lower voltage. The ECM uses the RFP sensor to monitor fuel delivery to the common rail fuel system.

A faulty RFP sensor circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition		
P0087	Fuel rail pressure low warning. Fuel rail pressure signal indicates that fuel pressure is below the minimum limit for the given engine rating.	No effect on the engine.	400–800 RPM		120 bar (1740 psi)
			1000–2800 RPM		150 bar (2175 psi)
			3200–4500 RPM		200 bar (2900 psi)
P0088	Fuel rail pressure higher than commanded. The ECM detects the fuel rail pressure is higher than the commanded pressure.	The engine fuel quantity limitation will limit the engine speed to 3000 RPM.	QSD 2.0L	400 RPM	500 bar (7251 psi)
				500 RPM	350 bar (5076 psi)
				630 RPM	300 bar (4351 psi)
				800–1800 RPM	200 bar (2900 psi)
				2000–3400 RPM	180 bar (2610 psi)
				3800–4000 RPM	170 bar (2465 psi)
P0090	Fuel rail pressure high warning. Fuel rail pressure signal indicates that fuel pressure has exceeded the maximum limit for the given engine rating.	No effect on the engine.	1750 bar (25381 psi)		
P0091	Fuel rail pressure lower than commanded. The ECM detects the the fuel rail pressure is lower than commanded pressure.	The engine fuel quantity limitation will limit the engine speed to 3000 RPM.	QSD 2.0L	400–1000 RPM	–300 bar (–4351 psi)
				1200–2400 RPM	–250 bar (–3625 psi)
				3200–4000 RPM	–200 bar (–2900 psi)
P0092	Fuel rail pressure data invalid. The ECM detects the rail fuel pressure is not changing with fuel flow correctly.	No effect on the engine.	No condition exists.		
P0190	Fuel rail pressure sensor voltage out of range. The fuel pressure signal output voltage is above the upper limit or below the lower limit.	The engine fuel quantity limitation will limit the engine speed to 3000 RPM.	>4750.7 mV <254 mV		

DTC	Reason	Effect	Condition
P0651	Sensor supply 2 voltage out of range. The sensor supply 2 circuit output voltage is above the upper limit or below the lower limit. This circuit supplies power to the throttle position 2 sensor, the fuel rail pressure sensor, and the boost pressure sensor.		
P2293	Fuel rail pressure relief valve error. The ECM detects the fuel rail pressure relief valve is not responding correctly.	No effect on the engine.	No condition exists.

ECM 60-Pin Connector "A" CKT pin	Name
43	RFP signal
28	5-volt reference signal
8	Sensor ground (–)

Test Description

Verify continuity between the following pins:

ECM 60-Pin Connector "A"	3-terminal connector at RFP
43	2
28	3
8	1

Verify the sensor supply voltage between terminals 1 and 3 of the sensor connector on the engine harness with the sensor disconnected and the keyswitch on:

Voltage (V)	Measurement
5	4.75–5.25

Verify the sensor voltage on pin 43 of the ECM 60-pin connector "A" or on pin 2 of the RFP sensor as a function of pressure.

Pressure	Voltage (VDC)
0 bar (0 PSI)	0.50
400 bar (2801 PSI)	1.39
700 bar (10153 PSI)	2.06
1000 bar (14504 PSI)	2.72
1400 bar (20305 PSI)	3.61
1800 bar (26107 PSI)	4.50

Diagnostic Help

Check for the following:

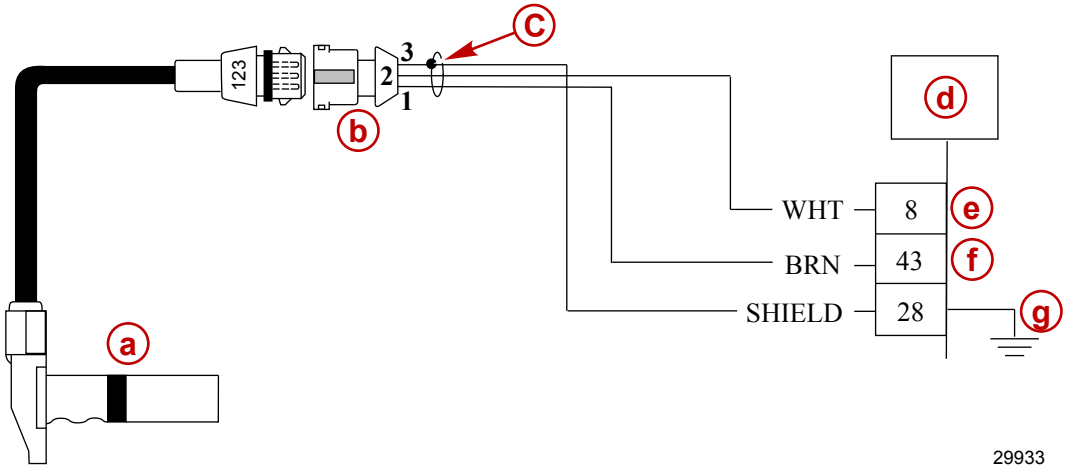
- An open or short circuit in CKT pins 43, 28, or 8 (causes a loss of engine power)
- A loose assembly on the fuel rail or a damaged O-ring seal (causes an improper signal and a possible loss in fuel rail pressure)
- A terminal or pin at the RFP connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage

- Dirt, debris, or moisture in or on the connector pins
- A defective RFP sensor
- A defective ECM

IMPORTANT: Replace the O-ring seal and torque the sensor to specification when installing.

Description	Nm	lb. in.	lb. ft.
Rail Fuel Pressure Sensor	70	–	51.6

Crankshaft Speed Sensor



a - Crankshaft speed sensor
b - Harness connector
c - Symbol for shielded twisted pair
d - ECM 60-pin connector "A"
e - Sensor ground (–)
f - Sensor ECM input signal
g - Shield ground

Circuit Description

The Crankshaft Speed sensor is an induction-type pulse generator that mounts close the leading edge of the flywheel. Four notches (drilling) serve to sense the engine speed. The resulting change in magnetic flux induces an AC voltage signal that the ECM evaluates. The ECM processes the signal to establish TDC and the crankshaft position relative to TDC. This sensor is commonly referred to as the RPM engine speed sensor.

A faulty engine speed sensor circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P0016	Crankshaft and camshaft sensor correlation. The ECM detects the engine speed sensor data is inconsistent.	No effect on the engine.	OFFSET > 24°
P0335	Crankshaft speed sensor data error. The crankshaft speed sensor data is lost, erratic, intermittent, or incorrect.	The engine will shut off.	No condition exists.
P0338	Engine overspeed warning. The engine speed signal indicates engine speed above engine protection limit.	The engine torque limitation will limit the engine speed to 3600 RPM.	>4300 RPM

ECM 60-Pin Connector "A" CKT Pin	Name
27	ECM input signal from crankshaft speed sensor
12	Sensor ground (Digital –)
7	Shield ground

Test Description

Verify continuity between the following:

ECM 60-Pin Connector "A"	3-Terminal Connector
27	1
12	2
7	3 (shield wire)

Verify the resistance between terminals 1 and 2 of the sensor:

Resistance (Ohm)	Maximum Measurement
1000	1000 ohm

Diagnostic Help

Check for the following:

- An open circuit or a short circuit in CKT pins 22 or 52
- A terminal or pin at the crankshaft speed sensor connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- A defective crankshaft speed sensor sensor
- A defective ECM

FAULT CODE 115

Attempting to start the engine while there is an open circuit in the crankshaft speed sensor circuit will trigger fault code 115. Correct the fault by repairing the open circuit and then use the following procedure to clear the fault code.

IMPORTANT: The timing in this procedure is extremely important.

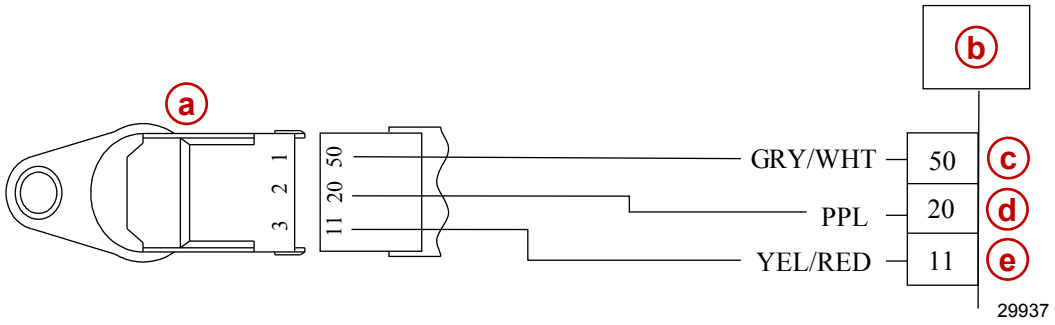
1. Shut the engine down and wait 10 seconds.

NOTE: *Fault code 115 is present on the SmartTach as long as the key switch is on, or the engine is running.*

2. Restart the engine.
3. Shut the engine down, turn the key switch to "OFF" for 10 seconds.
4. Turn the key switch to "ON."
5. Wait 3–5 seconds, when the ‘OKAY’ screens appear on the tachometer, start the engine.

Camshaft Position Sensor

QSD 2.0 Camshaft Position Sensor



a - Camshaft position sensor
b - ECM 60-pin connector "A"
c - Camshaft position signal
d - Sensor ground
e - 5-volt reference signal

Circuit Description

The camshaft position sensor is a hall-effect sensor and is used as a reference to time the sequential fuel injection. As the engine rotates the sensor will signal to the ECM the engine is approaching number 1 and the timing of the injection pulse is determined.

A faulty camshaft position sensor circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P0016	Crankshaft and camshaft sensor correlation. The ECM detects the engine speed sensor data is inconsistent.	No effect on the engine.	Offset > 24°
P0340	Camshaft position sensor data error. The camshaft position sensor data is lost, erratic, intermittent, or incorrect.	No effect on the engine.	No condition exists.
P0641	Sensor supply 1 voltage out of range. The sensor supply 1 circuit output voltage is above the upper limit or below the lower limit. This circuit supplies power to the throttle position 1 sensor and the camshaft position sensor.	The engine torque limitation will limit the engine speed to 3600 RPM.	>5.2 V <4.8 V

ECM 60-Pin Connector "A" CKT Pin	Name
50	ECM input signal from Camshaft Position sensor
11	5-volt reference signal
20	Sensor ground

Test Description

Verify continuity between the following:

QSD 2.0

ECM 60-Pin Connector "A"	3-Terminal Connector
50	1
11	3
20	2

Verify the sensor supply voltage between terminals 2 and 3 of the sensor connector on the engine harness with the sensor disconnected and the keyswitch on:

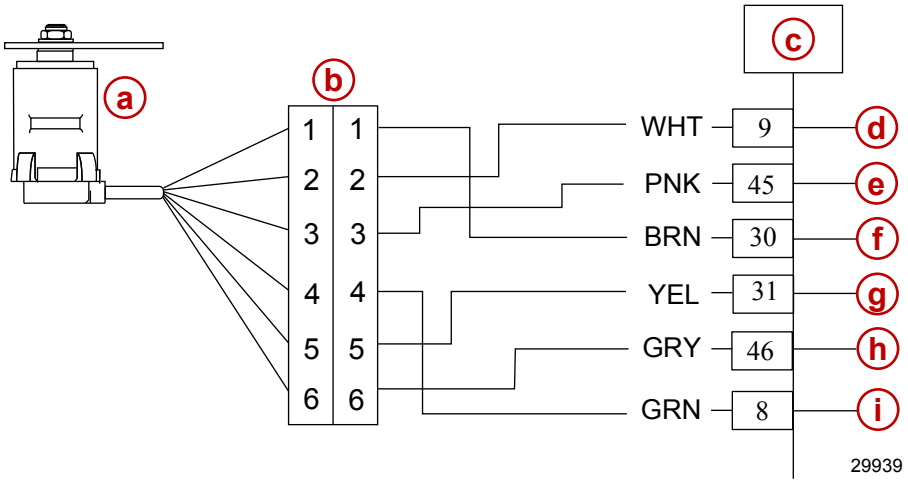
Voltage (V)	Minimum and Maximum Measurement
5	4.75 V–5.25 V

Diagnostic Help

Check for the following:

- An open circuit or a short circuit in CKT pins 50, 11, or 20
- A terminal or pin at the camshaft position sensor connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- Sensor mounting is improper
- A defective camshaft position sensor
- A defective ECM

Throttle Position Sensor



a - TP sensor
b - Harness connector
c - ECM 94-pin connector "K"
d - TP sensor TP1 signal
e - 5-volt TP1 reference signal
f - TP1 sensor ground (–)
g - TP sensor TP2 signal
h - 5-volt TP1 reference signal
i - TP1 sensor ground (–)

Circuit Description

The throttle position (TP) sensor translates throttle position into a set of voltage signals the ECM interprets. The TP sensor is a pair of linear potentiometers, TP1 and TP2. These potentiometers are supplied as a pair to offer redundancy for the throttle signal. The ECM supplies 5 volts to the sensor and processes the returning voltage signals to calculate throttle percentage. The TP output voltages varies from idle–WOT. As the throttle position changes the output increases, so that at WOT, the output voltage is near 3.65 V for TP1 and 1.6 V for TP2. By monitoring the TP sensor output voltages, the ECM determines fuel delivery based on the throttle position (operator demand).

A faulty TP sensor circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P0120	Throttle position sensor 1 voltage out of range. The throttle position 1 sensor output voltage is above the upper limit or below the lower limit.	No effect on the engine.	>4800 mV <200 mV
P0220	Throttle position sensor 2 voltage out of range. The throttle position 2 sensor output voltage is above the upper limit or below the lower limit.		>2424.242 mV <97.752 mV
P0221	Throttle position sensor voltage out of sync. The throttle position sensor output voltages are not consistent with each other.		DEVIATION > 190.616 mV
P0641	Sensor supply 1 voltage out of Range. The sensor supply 1 circuit output voltage is above the upper limit or below the lower limit. This circuit supplies power to the throttle position 1 sensor and the camshaft position sensor.	The engine torque limitation will limit the engine speed to 3600 RPM.	>5.2 V <4.8 V
P0651	Sensor supply 2 voltage out of range. The sensor supply 2 circuit output voltage is above the upper limit or below the lower limit. This circuit supplies power to the throttle position 2 sensor, the fuel rail pressure sensor, and the boost pressure sensor.	The engine fuel quantity limitation will limit the engine speed to 3000 RPM.	>5.2 V <4.8 V

ECM 94-Pin Connector "K" CKT Pin	Name
9	TP 1 sensor signal
31	TP 2 sensor signal
45	5-volt TP 1 reference signal
46	5-volt TP 2 reference signal
30	Sensor TP 1 ground (–)
8	Sensor TP 2 ground (–)

Test Description

NOTE: *Observe constant voltage at the very first part and the very last part of the TP's rotation.*

Verify continuity between the following:

ECM 94-Pin Connector "K"	6-terminal connector
9	2
31	5
45	3
46	6
30	1
8	4

Verify supply voltage to the TP sensor with the 6-terminal connector unplugged and the keyswitch on. Measure between terminals 1 and 3 as well as 4 and 6 of the TP sensor connector on the engine harness:

Volts (V)	Minimum and Maximum Measurement
5	4.75–5.25 V

With the key off and the 6-terminal connector unplugged, verify that the TP sensor potentiometer resistance between terminals 1 and 3 for U1 and 4 and 6 for U2 of the sensor connector:

Condition	Resistance (Ohm)	Minimum and Maximum Measurement
TP U1 at idle position	1050	± 100
TP U1 at WOT position	1650	
TP U2 at idle position	1400	
TP U2 at WOT position	2000	

Verify the signal voltage on pin 9 (TP1 output signal) or pin 31 (TP2 output signal) of the ECM 94-pin connector "K" of the Throttle Position Sensor as a function of percent throttle.

Throttle (%)	TP1 Vout Voltage (VDC)	TP2 Vout Voltage (VDC)
0 (Idle)	0.88	0.56
10	1.16	0.67
20	1.43	0.77
30	1.71	0.87
40	1.98	0.98
50	2.25	1.08
60	2.53	1.19
70	2.8	1.29
80	3.07	1.39
90	3.35	1.5
100 (WOT)	3.62	1.6

Diagnostic Help

Check for the following:

- An open circuit or a short circuit in CKT pins 2, 5, 3, 6, 4, or 1
- A terminal or pin at the TP connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- A defective TP sensor
- A defective ECM

IMPORTANT: Torque the TP sensor to specification when replacing.

Description	Nm	lb. in.	lb. ft.
Throttle position sensor screw	10.8	95	–

Atmospheric Pressure Sensor

29940

ECM

Circuit Description

The atmospheric pressure (BARO) sensor is located inside the ECM. It is not serviceable or replaceable individually. Replace the ECM to repair a faulty BARO sensor.

A faulty BARO sensor circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P2226	Atmospheric pressure sensor voltage out of range. The barometric pressure sensor output voltage is above the upper limit, below the lower limit, or there is an implausibility with the boost pressure sensor.	No effect on the engine.	>4750.7 mV <2170.1 mV

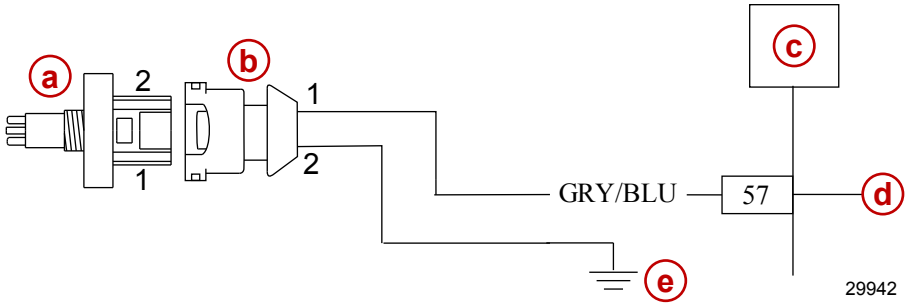
Test Description

Verify failure using either the CDS tool or a SmartCraft display device. There are no individual circuits to be tested. All BARO sensor circuits are located inside the ECM and are not serviceable.

Diagnostic Help

The BARO sensor is integrated in, and serviced with the ECM.

Water In Fuel Sensor



29942

a - WIF sensor
b - WIF sensor connector
c - ECM 94-pin connector "K"
d - WIF signal
e - Sensor ground (–)

Circuit Description

The water in fuel (WIF) sensor acts as a switch depending on the medium it is immersed in. The WIF sensor provides a closed circuit to ground when water is detected in the fuel filter assembly.

A faulty WIF sensor circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P2269	Water in fuel detected warning. Water is detected in the fuel filter.	The engine torque limitation will limit the engine speed to 3600 RPM.	No conditions exist.

ECM 94-Pin Connector "K" CKT Pin	Name
57	WIF sensor signal
2	Sensor ground (–)
4	
6	

Test Description

Verify continuity between the following:

ECM 94-Pin Connector "K"	2-terminal connector
57	2
2	1
4	
6	

If there is no water in the fuel-water separator bowl verify the circuit state across the WIF sensor connector terminals 1 and 2 with the harness unplugged.

Condition	Circuit State
No Water Detected	Open
Water detected	Close

Diagnostic Help

NOTE: *If there is debris on the WIF sensor probes themselves, clean the probes. If corrosion has occurred to the WIF sensor tips replace the WIF sensor.*

Check for the following:

- An open circuit or a short circuit in CKT pins 1 or 2
- A debris build up or corrosion on the WIF sensor probes
- A terminal or pin at the WIF connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- A defective WIF sensor
- A defective ECM

Fuel Injector Faults

30013

Fuel injector

Circuit Description

The injector solenoid valves control fueling quantity and injection timing. The ECM energizes the solenoid by closing a high-side and a low-side switch On a 4-cylinder engine the injectors for cylinders 1 and 4 (front bank) share a single high-side switch that connects the injector circuit to the source of high voltage inside the ECM. Likewise, the injectors for cylinders 2 and 3 (rear bank) also share a single high-side switch. Each injector circuit has a dedicated low-side switch that completes the circuit path to ground inside the ECM. The ECM senses current as each injector is actuated. If multiple injector fault codes occur in the same bank a short circuit exists. The ECM can also detect when unintended fuel injection occurs by monitoring fuel rail pressure and engine speed.

A faulty injector circuit can generate the following diagnostic trouble codes.

<table>
<tr><th>DTC</th><th>Reason</th><th colspan="3">Effect</th><th>Condition</th></tr>
<tr><td>P0201</td><td rowspan="4">Injector open circuit. High resistance detected in the specified injector circuit or no current detected at the specified injector driver or return pin when voltage supplied.</td><td rowspan="4">Injector</td><td>1</td><td rowspan="4">The ECU fuel quantity limitation is lower than the mechanical limit due to the loss of injector. The engine will shut off.</td><td rowspan="4">Injector open circuit.</td></tr>
<tr><td>P0202</td><td>2</td></tr>
<tr><td>P0203</td><td>3</td></tr>
<tr><td>P0204</td><td>4</td></tr>
<tr><td>P0262</td><td rowspan="4">Injector circuit shorted. The ECM detects a short circuit on low-side to battery, a general short circuit, or a short circuit from low-side to high-side on the injector solenoid driver in the specified cylinder circuit.</td><td rowspan="4">Cylinder</td><td>1</td><td rowspan="4">The engine will shut off.</td><td rowspan="7">No conditions exist.</td></tr>
<tr><td>P0265</td><td>2</td></tr>
<tr><td>P0268</td><td>3</td></tr>
<tr><td>P0271</td><td>4</td></tr>
<tr><td>P0611</td><td>Injector energizing time error. The ECM detects the injector did not energize within the specified window of time.</td><td colspan="3">Not applied.</td></tr>
<tr><td>P2148</td><td rowspan="2">Injector bank circuit error. The ECM detects a short circuit on low-side to ground or a general short circuit on the specified injector bank circuit.</td><td>Injector Bank 1</td><td rowspan="2">The engine will shut off.</td></tr>
<tr><td>P2151</td><td>Injector Bank 2</td></tr>
</table>

ECM 60-PIN CONNECTOR "A"

ECM 60-Pin Connector "A" CKT Pin	Name			
16	Injector	1	Bank 1	Power
17		4		
1		3	Bank 2	
2		2		
47		1	Return	
46		4		
33		3		
31		2		

Test Description

Verify continuity between the following:

ECM 60-Pin Connector "A"	2-terminal connector
16	1 - Injector 1 connector
47	2 - Injector 1 connector
17	1 - Injector 4 connector
33	2 - Injector 4 connector
1	1 - Injector 3 connector
46	2 - Injector 3 connector
2	1 - Injector 2 connector
31	2 - Injector 2 connector

With the key off and the 2-terminal harness connector unplugged from the injector in question, verify that the injector solenoid resistance between terminals 1 and 2 is the following:

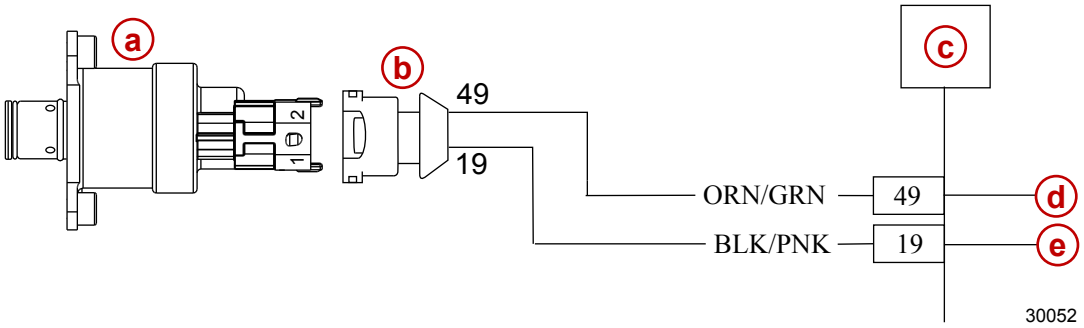
Condition Resistance (Ohm)	Minimum and Maximum measurement
0.255	0.215–0.295

Diagnostic Help

Check for the following:

- An open circuit or a short circuit in CKT 60-pin ECM connector A harness or pins 1 or 2.
- A terminal or pin at the injector connection or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed.
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector.
- Wire insulation damage.
- Dirt, debris, or moisture in or on the connector pins
- A defective injector.
- A defective ECM.

Fuel Pressure Solenoid



a - Fuel pressure solenoid
b - Harness connector
c - ECM 60-pin connector "A"
d - Fuel pressure solenoid 2
e - Fuel pressure solenoid 1

Circuit Description

The fuel pressure solenoid circuit is enabled by a pulse width modulation driver from the ECM. The ECM varies the PWM signal to this solenoid in order to set the fuel flow by the fuel pump actuator based on engine operating conditions. PWM duty cycle to the fuel pressure solenoid depends on the difference between desired rail pressure and sensed rail pressure.

A faulty Fuel Pressure Solenoid circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P0252	Fuel Pressure Solenoid Open Circuit. The ECM has detected no load, excess temperature, or open circuit on the fuel pressure solenoid circuit.	The engine fuel quantity limitation will limit the engine speed to 3000 RPM.	No conditions exist.
P0253	Fuel Pressure Solenoid Shorted Low. The fuel pressure solenoid output voltage is below normal or shorted to a low source.	The engine will shut off.	
P0254	Fuel Pressure Solenoid Shorted High. The fuel pressure solenoid output voltage is above normal or shorted to a high source.	The engine fuel quantity limitation will limit the engine speed to 3000 RPM.	

ECM 60-Pin Connector "A" CKT Pin	Name
19	Fuel Pressure Solenoid 1
49	Fuel Pressure Solenoid 2

Test Description

Verify continuity between the following:

ECM 60-Pin Connector "A"	2-terminal connector
19	1
49	2

Verify the actuator's resistance between terminals 1 and 2 of the Fuel Pump Actuator.

Resistance (Ohm)	Minimum and Maximum (Ohm)
2.88	2.6–3.15

Verify the supply voltage to the fuel pump actuator with the 2-terminal engine harness connector unplugged and the keyswitch on. Measure the voltage between terminals 1 and 2 of the fuel control actuator connector on the engine harness.

Volts	Minimum and Maximum
12	Battery voltage

Diagnostic Help

Verify the following:

1. Open or short on CKT pin 1 or CKT pin 2
2. Bent, corroded, broken, expanded, poorly crimped or recessed terminal or pin at the fuel pump actuator connection or ECM
3. Missing or damaged connector seals, loose connector, cracked or broken connector shell, wire insulation damage, or dirt, debris or moisture in or on the connector pins
4. Defective fuel pump actuator
5. Defective ECM

Fuel Rail Pressure Relief Valve

Circuit Description

The fuel rail pressure relief valve is a mechanical relief valve which is normally closed. In the event of critical high rail pressure this valve opens in order to relieve fuel pressure and dump fuel back to tank. The ECM monitors this valve closely using the rail pressure sensor and will flag a fault if it sees a condition which indicates a malfunctioning valve. These conditions include a valve that did not open at the required pressure, a valve that has opened too many times, or a valve that was open longer than the specification allows.

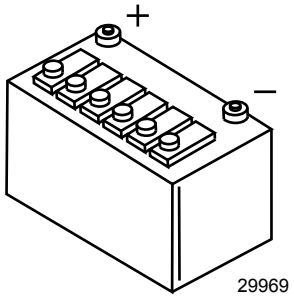
A faulty fuel rail pressure relief valve can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P2293	Fuel Rail Pressure Relief Valve Error. The ECM has detected that the fuel rail pressure relief valve is not responding correctly.	No effect on the engine.	No conditions exist.

Diagnostic Help

The fuel pressure relief valve is not serviceable and must be replaced if defective.

Battery and Main Relay



Circuit Description

The electronic control module (ECM) receives a constant voltage supply through the unswitched power harness which is connected directly to the battery. The ECM receives switched battery input when the key switch is turned to "RUN." If the ECM battery voltage drops below 9 V an ECM fault is triggered by the low battery voltage condition. If the battery voltage drops from 6–9 V the fuel pump actuator begins to work improperly. The ECM stops working when the battery voltage drops below 6 V. The ECM also flags a fault in a high battery voltage condition where the voltage exceeds 20 VDC. The ECM also monitors the condition of the main relay and verifies if it is responding correctly.

ECM battery voltage or main relay circuits can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P0560	ECM battery voltage out of range. The ECM supply voltage is above the maximum limit or below the minimum limit.	No effect on the engine.	>18 V <7.5 V
P0685	Main relay control timing error. The ECM detects that the main relay did not energize within the specified window of time.		No conditions exist.

ECM 94-Pin Connector "K" CKT Pin	Name
1	Battery (+) to ECM from 10 Amp CB
5	Battery (+) to ECM from 15 Amp CB
2	Battery (-) to ECM from 4-pos power connector
4	
6	
72	Main Relay Enable

Test Description

Verify continuity between the following:

ECM 94-Pin Connector "K"	Main Relay Connector
1	87
5	
72	85

Main Relay	4-terminal power connector
30 and 86	3 and 4

Battery	4-terminal power connector
Battery (–)	1
	2
Battery (+)	3
	4

ECM 94-Pin Connector "K"	4-terminal power connector
2,4, and 6	1 and 2

Diagnostic Help

Check for the following:

- A terminal or pin at the Battery, circuit breakers, 4-pos engine power connector, main relay, or ECM 94-pin connector "K" that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- Battery voltage that does not fall below threshold even when cranking
- Incorrect serpentine belt tension
- An energizing time fault in the main relay
- Unswitched Battery supply to engine power connector blown fuses
- Open circuit in the battery supply (+) or ground (–) circuits
- The voltage, using a multimeter, at CKT pins 1 and 5 is battery voltage
- Unswitched battery was not disconnected for 30 seconds after key off
- Intermittent short circuit or open circuit on the battery supply to the ECM 94-pin connector "K" in CKT pin 1, 5, or 72 to main relay
- 10 and 15 amp battery (+) to ECM CB's tripped
- A defective alternator
- A defective main relay or circuit breaker
- A defective ECM

Keyswitch Circuit

Circuit Description

The keyswitch signal is supplied to the ECM through a single circuit. When turned to "RUN," the keyswitch provides an input voltage to the ECM which turns the control system on or off. The ECM does this by energizing the main relay by pulling the relay coil to ground when a valid keyswitch signal is registered.

A faulty keyswitch circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P1605	Keyswitch signal circuit error. The ECM detects an error in the keyswitch circuit signal.	No effect on the engine.	No conditions exist.

ECM 94-Pin Connector "K" CKT Pin	Name
28	Keyswitch input signal

Test Description

Verify continuity between the following:

ECM 94-Pin Connector "K"	12-pos Engine Connector
28	4

Verify the keyswitch supply voltage to the ECM with the ECM 94-Pin Connector "K" disconnected and the keyswitch on. Measure the voltage between terminals 28 and 2, 4, or 6 of the ECM 94-Pin Connector "K."

Volts	Minimum and Maximum
12	Battery voltage

Diagnostic Help

Check for the following:

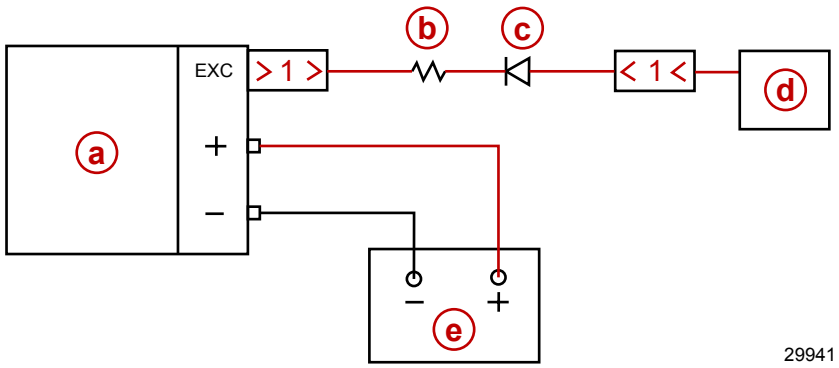
- An open circuit in CKT pin 28 from the ignition switch or keyswitch (10-Amp CB tripped)
- A terminal or pin at the 12-pos engine connection, keyswitch CB, or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- A defective ignition switch or circuit breaker
- An internal ECM system failure. A defective ECM

Alternator Excitation Circuit

Circuit Description

The alternator excitation circuit is powered directly by the key switch circuit, which is diode protected from the alternator. The diode is contained in a jumper harness that connects the alternator to the key switch circuit. **If the alternator excitation jumper is modified to route around the diode, the key switch circuit connects directly to unswitched battery power. The control system can not be shut down with the key switch if this occurs.**

Circuit Diagram



a - Alternator
b - 82-Ohm resistor
c - 3-Amp, 200-volt diode
d - Keyswitch
e - Battery

Starter Circuit

Circuit Description

The starter circuit incorporates smart start capability. If a crank signal is registered by the system integration module (SIM) the engine will crank over for 3 seconds if no engine RPM is seen and 5 seconds if engine RPM is present. This feature allows greater longevity from engine and starter components. If a crank signal command is sent to the SIM when the engine is already running, the engine will shut down. Upon receiving a valid crank signal from the SIM, the ECM provides both a Hi and Lo signal to the starter relay coil to initiate cranking.

A faulty starter circuit can generate the following diagnostic trouble codes.

DTC	Reason	Effect	Condition
P0616	Starter relay low-side shorted. No load or short circuit to ground or battery detected at low-side starter relay circuit.	The engine will not start "mechanically."	No conditions exist.
P0617	Starter relay high-side shorted. Short circuit to ground or battery detected at high-side starter relay circuit.		
P1606	Crank signal circuit error. The ECM detects the crank signal is always active.	No effect on the engine.	

ECM 94-Pin Connector "K" CKT Pin	Name
58	Crank input signal
55	Starter relay enable Hi signal
73	Starter relay enable Lo signal

Test Description

Verify continuity between the following:

ECM 94-Pin Connector "K"	12-pos Engine Connector
58	5

ECM 94-Pin Connector "K"	4-pos Starter Relay Connector
55	86
73	85

When troubleshooting a no-crank issue, verify the control handles are in neutral, the lanyard switch is correctly installed and not in the off position.

Verify the crank signal to the ECM by first checking terminal 5 of the 12-pin engine connector. The crank signal is approximately +12V and is only active when the keyswitch is held in the crank position or the start/stop button is pressed.

If a crank signal is continually present with or without the keyswitch in "START" or the start/stop button engaged, there is a short circuit to the battery on the crank signal circuit or a defective SIM.

Verify the SIM is transmitting a crank signal by checking the voltage of pin 58 on the ECM 94-pin connector "K." If a crank signal is present, the voltage will be +12V.

Check that the ECM is controlling the starter relay correctly by verifying there is a +12V signal on the 4-pos starter relay connector pin 86. Verify there is a ground (–) supply on the 4-pos starter relay connector pin 85.

If the starter enable signals are correct, verify the starter relay is a +12V output on relay pin 87, which is connected to the starter solenoid. A +12V signal present on the starter solenoid connection point, can damage the starter.

Diagnostic Help

Check for the following:

- A short circuit on the SIM crank signal output
- Starter Relay enable circuits shorted high, low or to each other
- A terminal or pin at the keyswitch, 12-pos engine connector, starter relay connector, or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed

- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- A defective starter solenoid or starter motor
- A defective ECM
- A defective SIM

ECM Internal Error

29940

ECM

Circuit Description

The ECM is capable of determining if failures have occurred to circuits within the ECM through self-diagnosis. If the ECM detects an error regarding internal circuitry or components it will set the following diagnostic trouble code.

DTC	Reason	Effect	Condition
P0606	ECM internal malfunction. ECM internal error related to memory hardware failures, internal voltage supply, or communication circuits.	No effect on the engine.	Internal condition.

Diagnostic Help

The ECM is not serviceable and must be replaced when defective.

CAN Communication Error

Circuit Description

The ECM monitors activity over the CAN communication bus. CAN bus errors arise due to CAN message time-outs, a bus wiring short or open, and communication issues.

A CAN communication error generates the following diagnostic trouble code.

DTC	Reason	Effect	Condition
U0101	CAN communication error. SAE J1939 ECM network communication data erratic, intermittent, or incorrect.	No effect on the engine.	No condition exists.

Diagnostic Help

Check for the following:

- Continuity on all CAN bus circuits across CAN Hi (+) and CAN Low (–)

- No intermittent shorts to ground, battery, or from CAN Hi (+) to CAN Low (–)
- A terminal or pin at the 12-pos engine connector, VIP, or ECM that is bent, corroded, broken, expanded, poorly crimped, or recessed
- Missing or damaged connector seals, cracked or broken connector shell, or a loose connector
- Wire insulation damage
- Dirt, debris, or moisture in or on the connector pins
- Termination resistors are placed correctly on the network
- A defective ECM if there is no communication possible

DTS CAN Communication Error

Circuit Description

The ECM can use a digital throttle and shift (DTS) system in place of the mechanical cable throttle and shift. It uses a CAN message for throttle commands rather than the throttle position sensor. The ECM will monitor these messages and display a fault code if an error exists.

DTS CAN communication errors may generate the following diagnostic trouble codes.

IMPORTANT: DTC U1002 may be set in non-DTS applications. Ignore the code if this is the case.

DTC	Reason	Effect	Condition
U1001	No DTS CAN message or throttle lever signal present. The ECM is not receiving throttle information.	No effect on the engine.	No conditions exist.
U1002	DTS CAN message error (if DTS is installed). The output command from the multiplexed throttle is incorrect or the ECM did not receive the digital throttle commands in time.		

Diagnostic Help

Check for the following:

- There is a system DTS throttle source signal
- The control head is powered on and there is communication present
- Replace the ECM

ECM Dataset Variant Coding Error

29940

ECM

Circuit Description

The ECM dataset variant coding error appears as a result of an ECM calibration failure. The EEPROM reads and interprets the defect memory at startup. If an error or implausibility exists the ECM registers the following fault.

DTC	Reason	Effect	Condition
P1628	ECM dataset variant coding error. The dataset variant coding is invalid or not set.	No effect on the engine.	No conditions exist.

Diagnostic Help

The ECM is not serviceable and must be replaced when defective.

Notes: