INTERNATIONAL®

VT 275 V6 ENGINE

model year 2006

WORKHORSE CUSTOM CHASSIS™

FEATURES AND DESCRIPTIONS FOR WORKHORSE CUSTOM CHASSIS APPLICATIONS

FORWARD

This publication is intended to provide technicians and service personnel with an overview of the technical features of the International® VT 275 Diesel Engine. The information contained in this publication is a supplement to information that is contained in available service literature. The photos and illustrations in this publication may vary from your particular vehicle. Consult the latest SERVICE and DIAGNOSTIC manuals for the latest information, before you conduct any service or repairs.

Safety Information

This manual provides general and specific service procedures and repair methods essential for your safety and the reliable operation of the engine. Since many variations in tools, procedures, and service parts are involved, advice for all of the possible safety conditions and hazards cannot be stated.

Departure from the instructions in this manual or disregard of warnings and cautions can lead to injury, death, or both, and damage to the engine or vehicle.

Read the safety instructions below before doing service and test procedures in this manual for the engine or vehicle. See related application manuals for more information.

Safety Instructions

Vehicle

Make sure the vehicle is in neutral, the parking brake is set, and the wheels are blocked before you perform any work or diagnostic procedures on the engine or vehicle.

Work Area

- Keep the work area clean, dry and organized.
- Keep tools and parts off the floor.
- Make sure the work area is ventilated and well lit.
- Make sure a First Aid Kit is available.

Safety Equipment

- Use the correct lifting devices.
- Use the proper safety blocks and stands.

Protective Measures

- Wear protective glasses and safety shoes (do not work in bare feet, sandals, or sneakers).
- Wear the appropriate hearing protection.
- Wear the correct clothing.
- Do not wear rings, watches, or other jewelry.
- Restrain long hair.

Tools

- Make sure all tools are in good condition.
- Make sure all standard electrical tools are grounded.
- Check for frayed power cords before using power tools.

Fire Prevention

NOTE: Check the classification of each fire extinguisher to ensure that the following fire types can be extinguished:

1. Type A - Wood, paper, textiles, and rubbish
2. Type B - Flammable liquids
3. Type C - Electrical equipment

- Make sure that charged fire extinguishers are in the work area.

Batteries

- Batteries produce highly flammable gas during and after charging.
- Always disconnect the main negative battery cable first.
- Always connect the main negative battery cable last.
- Avoid leaning over batteries.
- Protect your eyes.
- Do not expose batteries to open flames or sparks.
- Do not smoke in workplace.

Compressed Air

- Limit shop air pressure for blow gun to 207 kPa (30psi).
- Use approved equipment.
- Do not direct air at body or clothing.
- Wear safety glasses or goggles.
- Wear hearing protection.
- Use shielding to protect others in the work area.

Fluids Under Pressure

- Use extreme caution when working on systems under pressure.
- Follow approved procedures only.

Fuel

- Do not over fill fuel tank. Over fill creates a fire hazard.
- Do not smoke in the work area.
- Do not refuel the tank when the engine is running.

Removal of Tools, Parts, and Equipment

- Reinstall all safety guards, shields and covers after servicing the engine.
- Make sure all tools, parts, and service equipment are removed from the engine and vehicle after all work is done.

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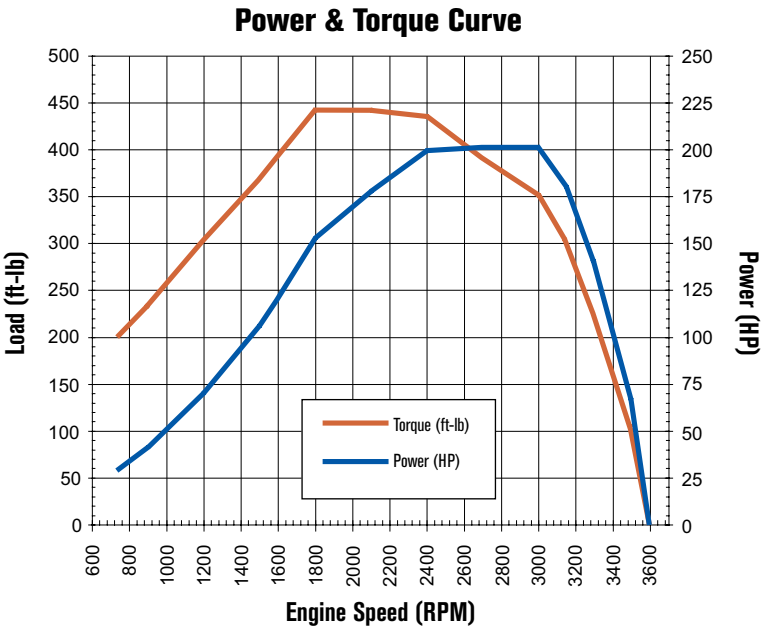
VT 275 FEATURES

- 90° V6
- Offset Crankpins
- Rear Gear Train
- Primary Balancer
- Regulated Two-Stage Turbocharging System
- Four Valves per Cylinder
- Cooled Exhaust Gas Recirculation
- Electro-Hydraulic Generation 2 Fuel Injection System
- Top Mounted Oil and Fuel Filters

VT 275 ENGINE SPECIFICATIONS

Engine Type	4-stroke, direct injection diesel
Configuration	V6, pushrod operated four valves / cylinder
Displacement	275 cu. in. (4.5 liters)
Bore	3.74 in. (95 mm)
Stroke	4.134 in. (105 mm)
Compression Ratio	18.0:1
Aspiration	Twin turbocharged and charge air cooled
Rated Power	200 hp @ 2700 rpm
Peak Torque	440 lb-ft @ 1800 rpm
Engine Rotation, Facing the Flywheel	Counterclockwise
Injection System	Electro-hydraulic generation 2 fuel injection
Cooling Sysytem Capacity (Engine Only)	11 quarts
Lube System Capacity (Engine Only)	15 quarts with oil filter



Horsepower and Torque

The VT 275 engine is offered with only one horsepower and torque rating for the 2005 model year. The engine creates 200 horsepower at 2700 rpm and 440 lb-ft of torque at 1800 rpm. The engine has a high idle speed of 2775 rpm with automatic transmission. The engine idle speed is set at 700 rpm and is not adjustable.

VT 275 OVERVIEW

Engine Serial Number

The Engine Serial Number (ESN) for the VT 275 is located on a machined surface at the left rear corner of the crankcase just below the cylinder head.

The ESN identifies the engine family, the build location, and the sequential build number.

Engine Serial Number Example:

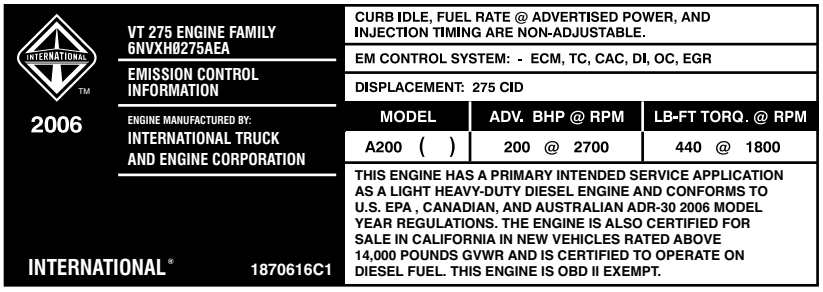
4.5HM2Y0135617

4.5 = Engine displacement
H = Diesel, Turbocharged
M2 = Motor Truck
Y = Huntsville
0135617 = Build Sequence

Emissions Label

The Environmental Protection Agency (EPA) emissions label is on top of the breather, toward the front, on the left valve cover. The label includes the following:

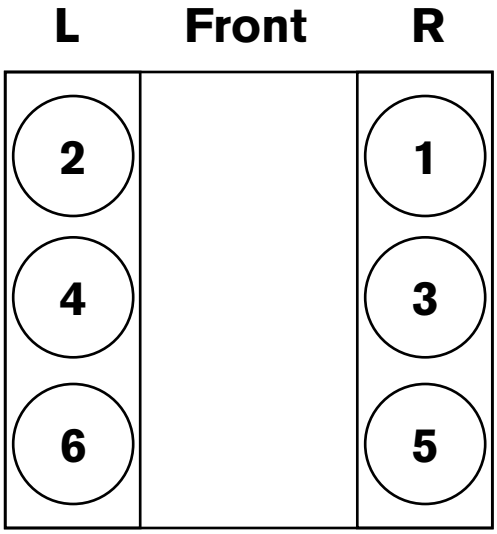
- Advertised horsepower rating
- Engine model code
- Service application
- Emission family and control system
- Year the engine was certified to meet EPA emission standards



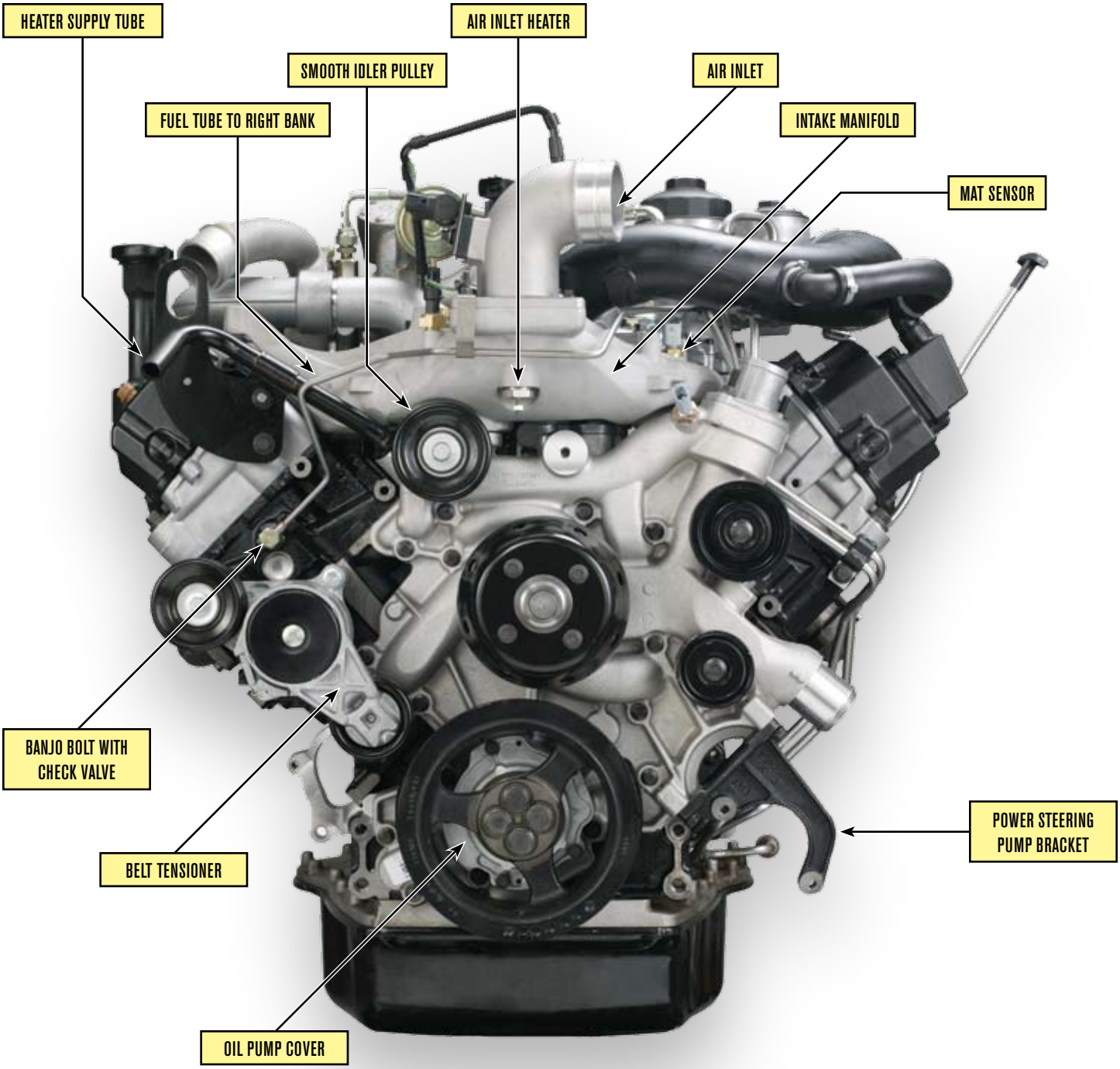
Cylinder Numbering

The cylinders on the VT 275 are numbered from the front of the right bank 1, 3, 5 and from the front of the left bank 2, 4 and 6.

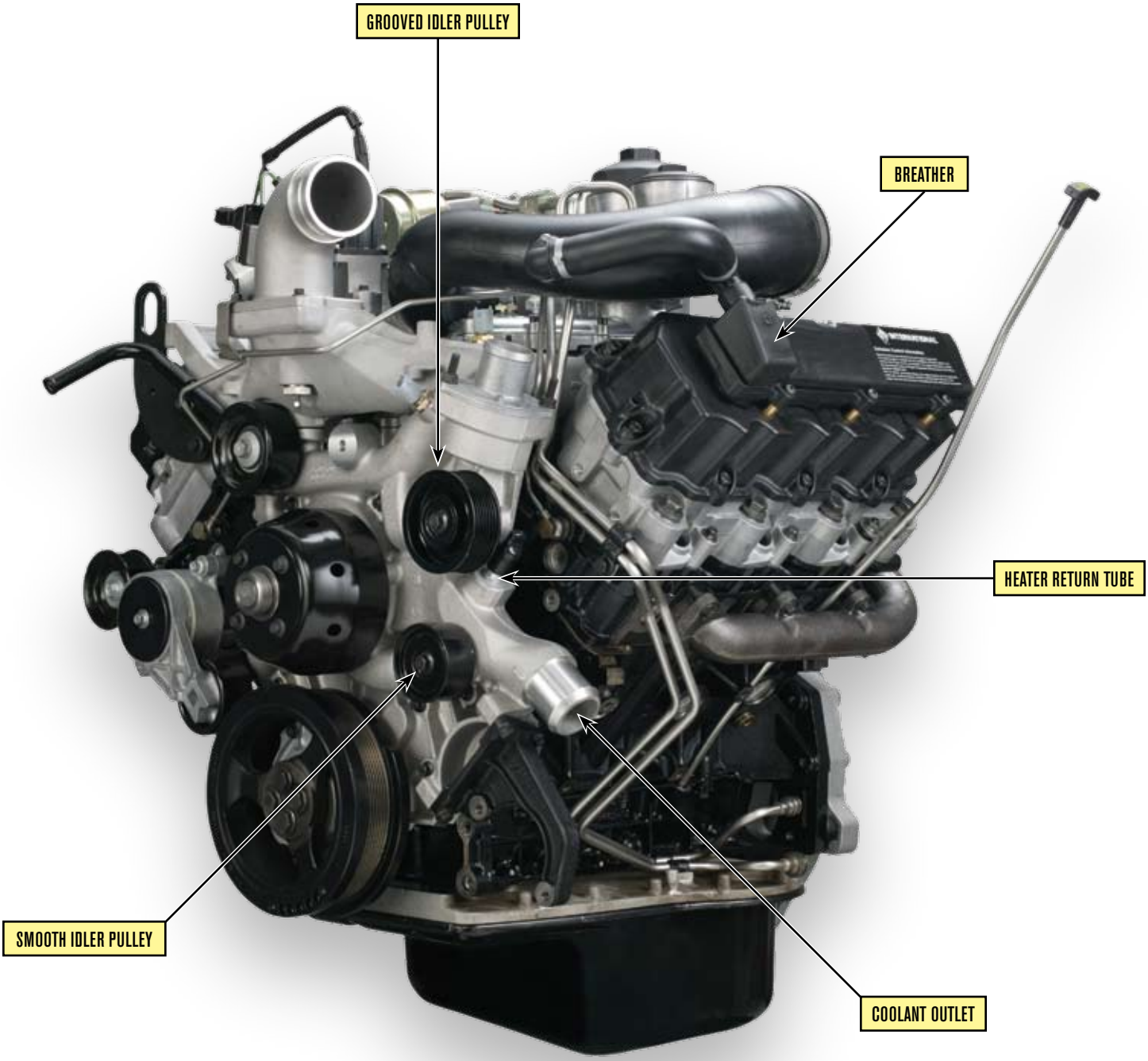
The engine firing order is 1-2-5-6-3-4



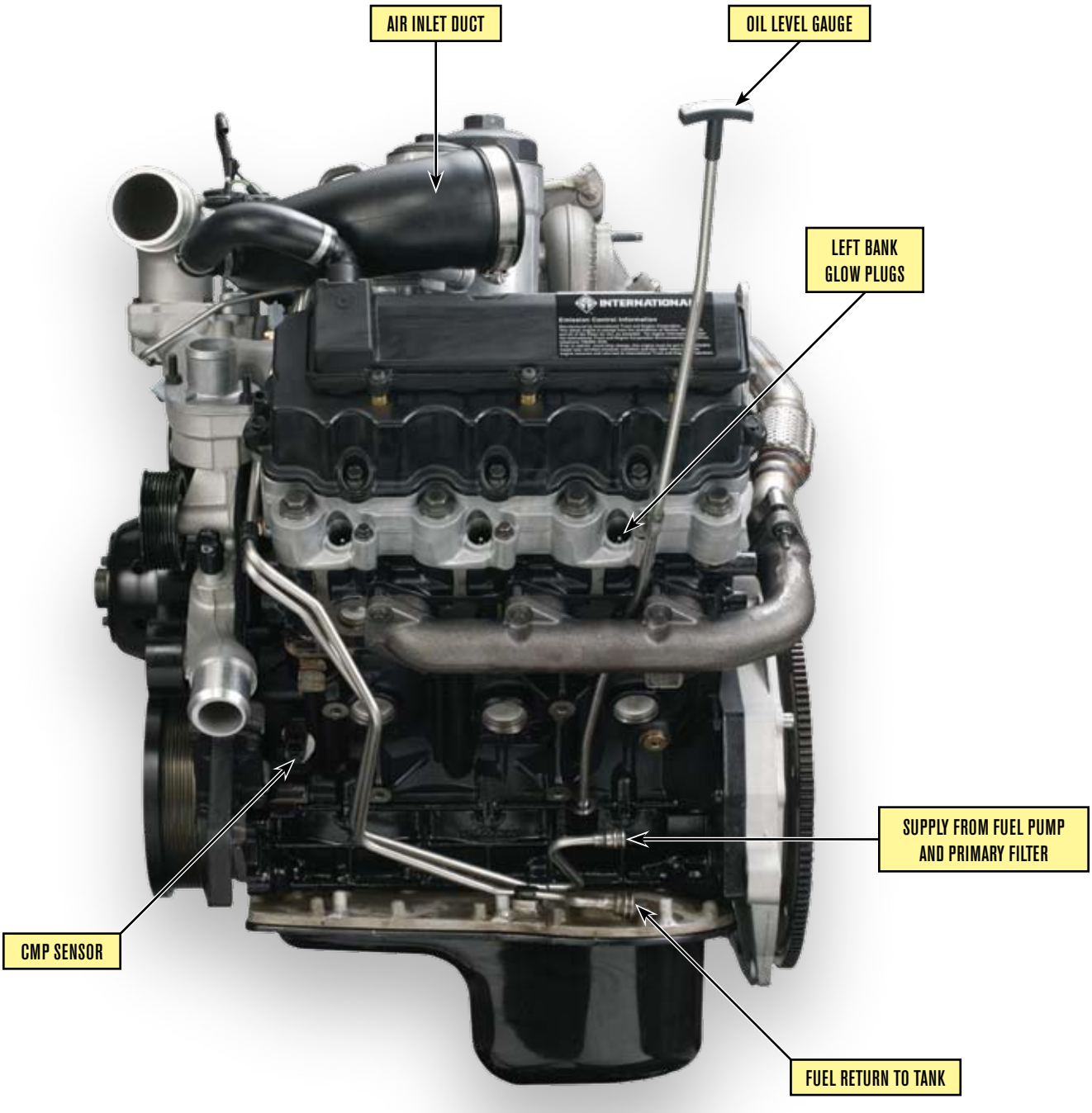
COMPONENT LOCATIONS - FRONT OF ENGINE



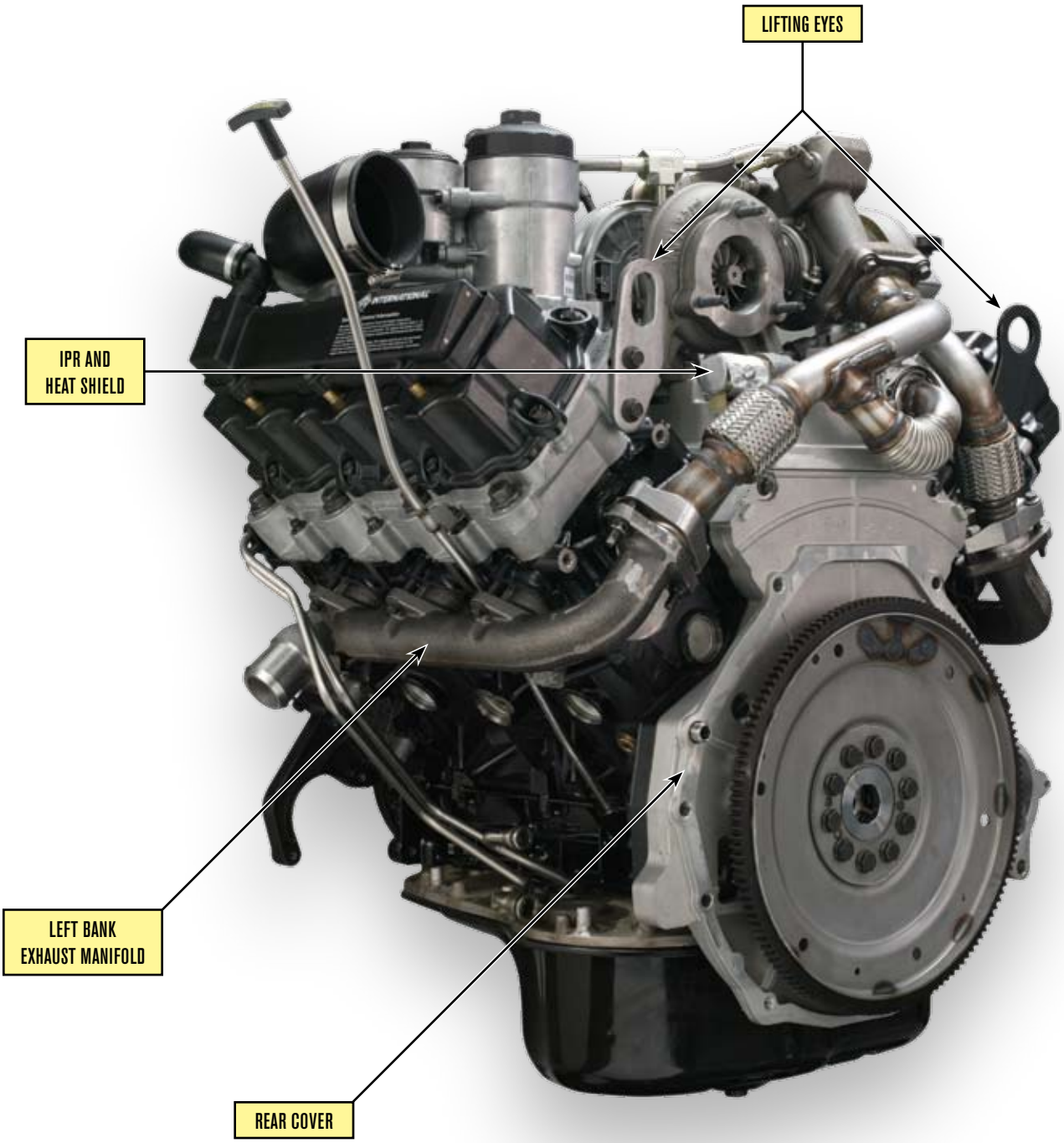
COMPONENT LOCATIONS - LEFT FRONT OF ENGINE



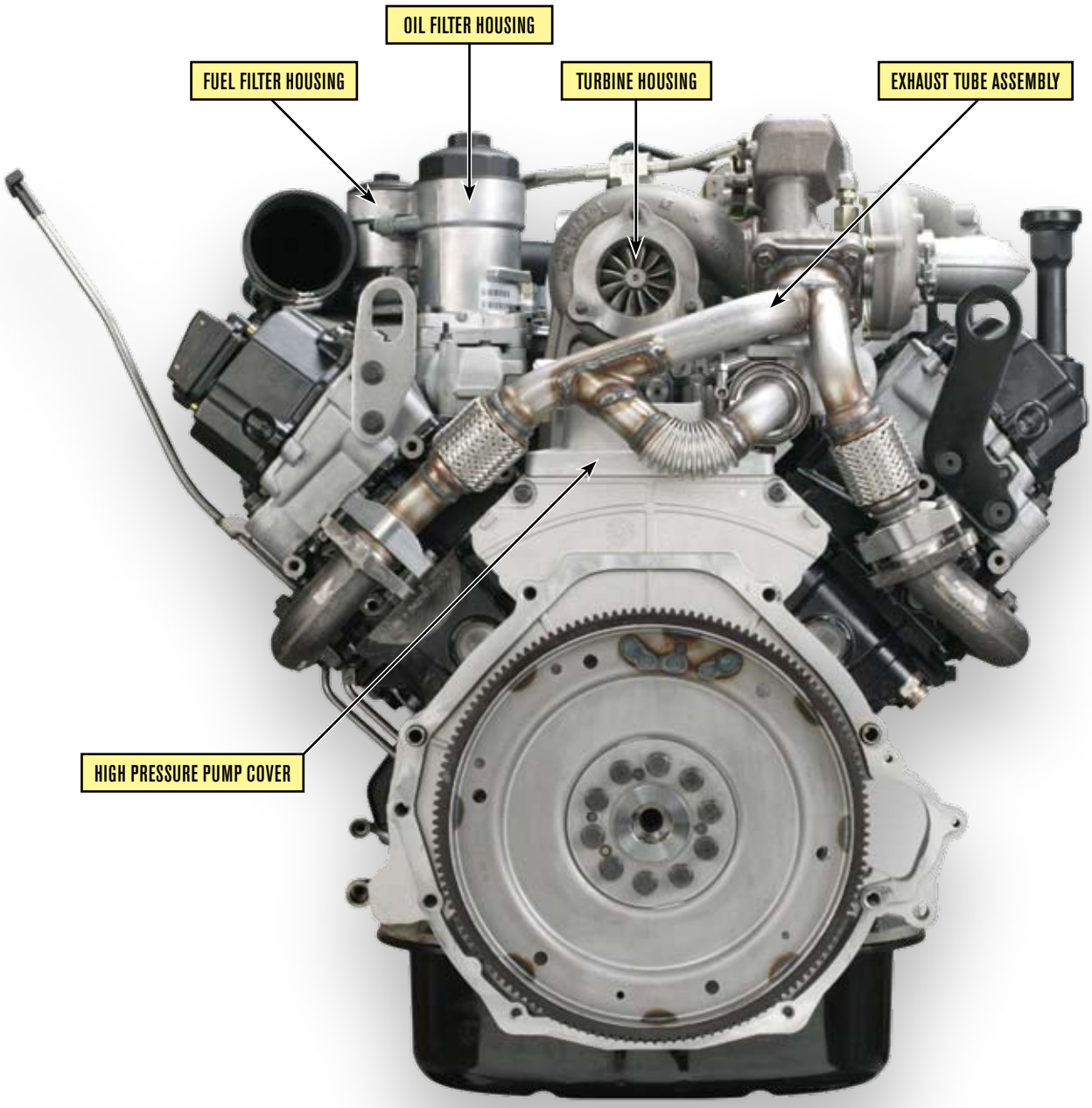
COMPONENT LOCATIONS - LEFT SIDE OF ENGINE



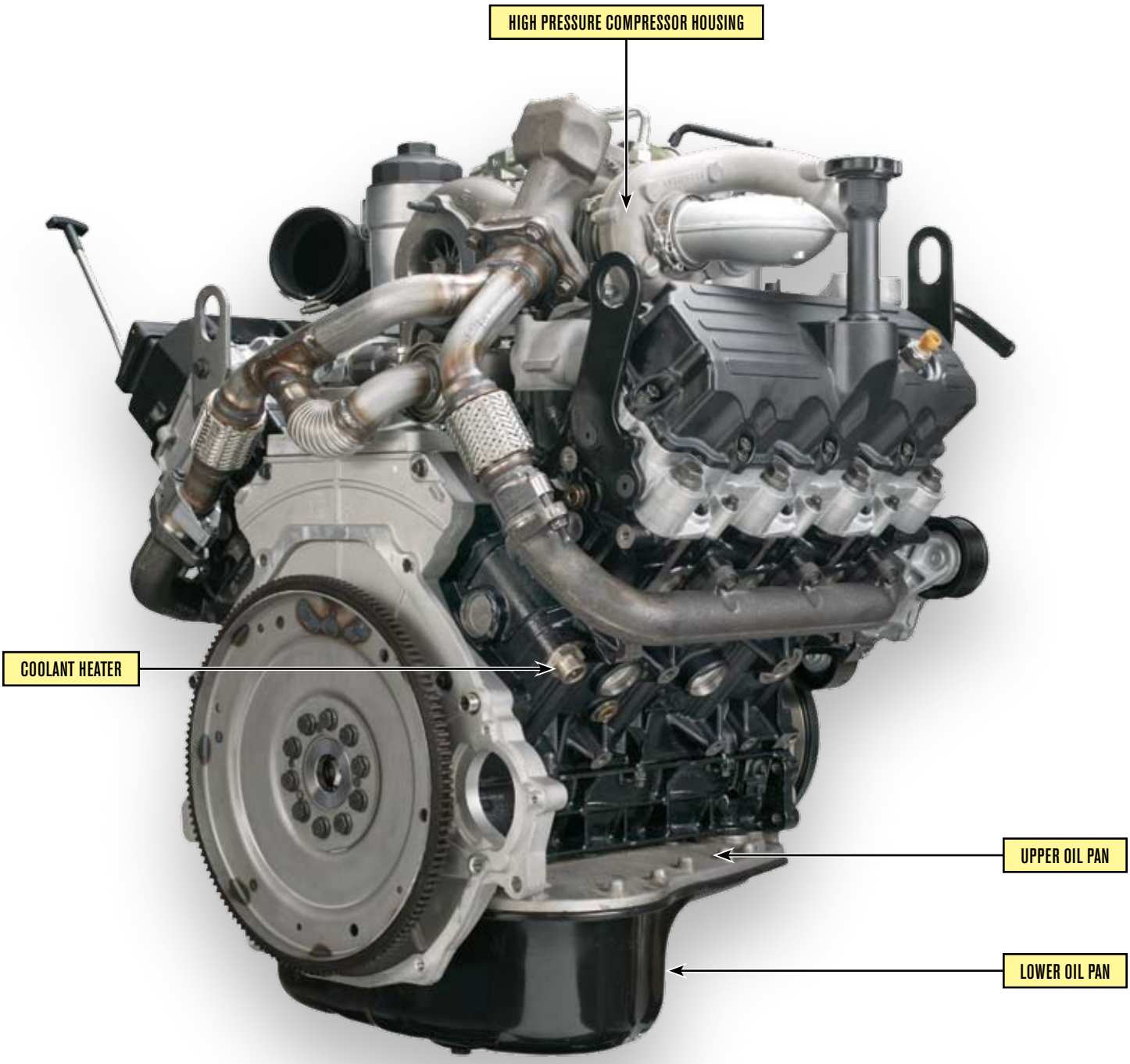
COMPONENT LOCATIONS - LEFT REAR OF ENGINE



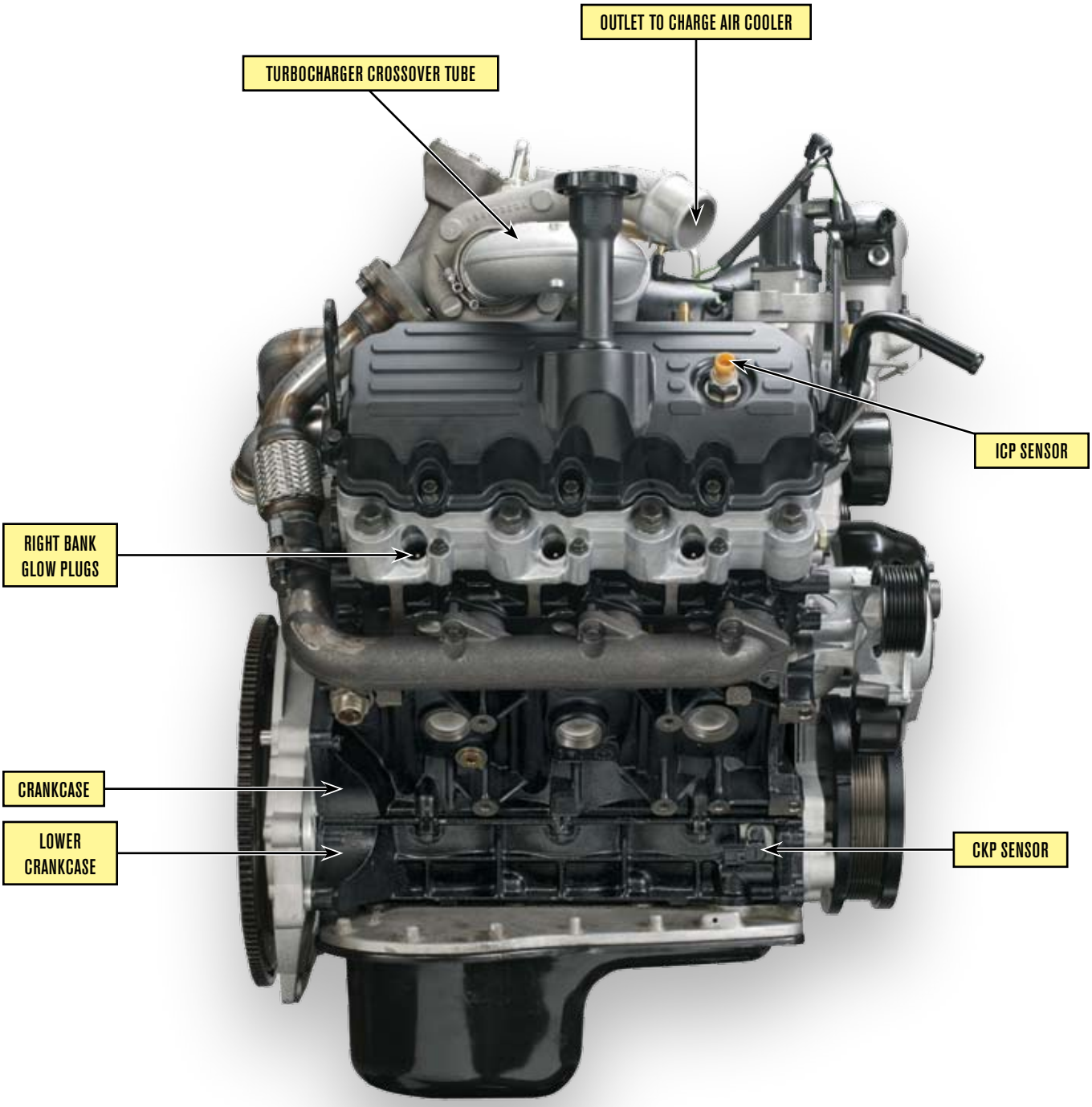
COMPONENT LOCATIONS - REAR OF ENGINE



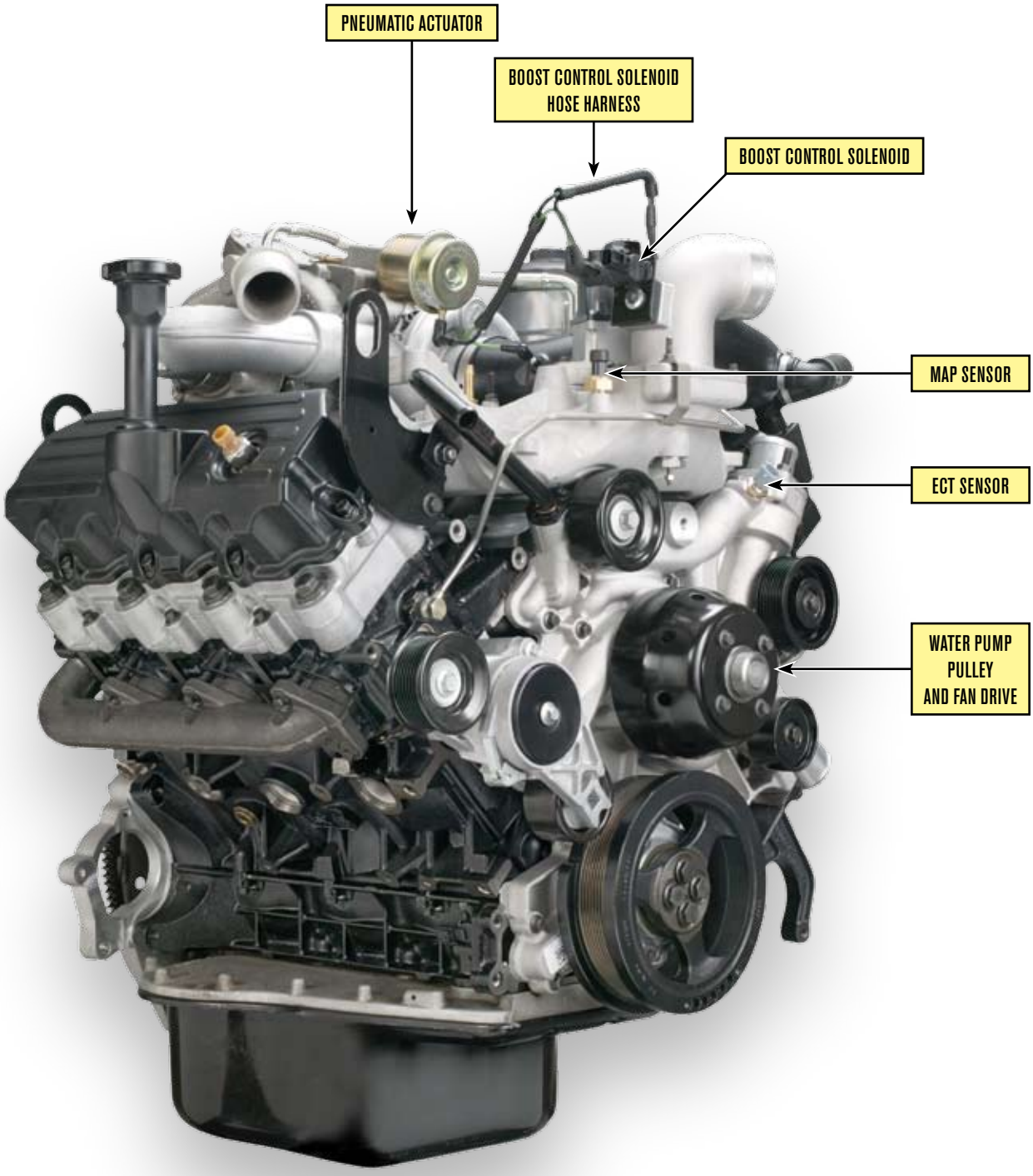
COMPONENT LOCATIONS - RIGHT REAR OF ENGINE



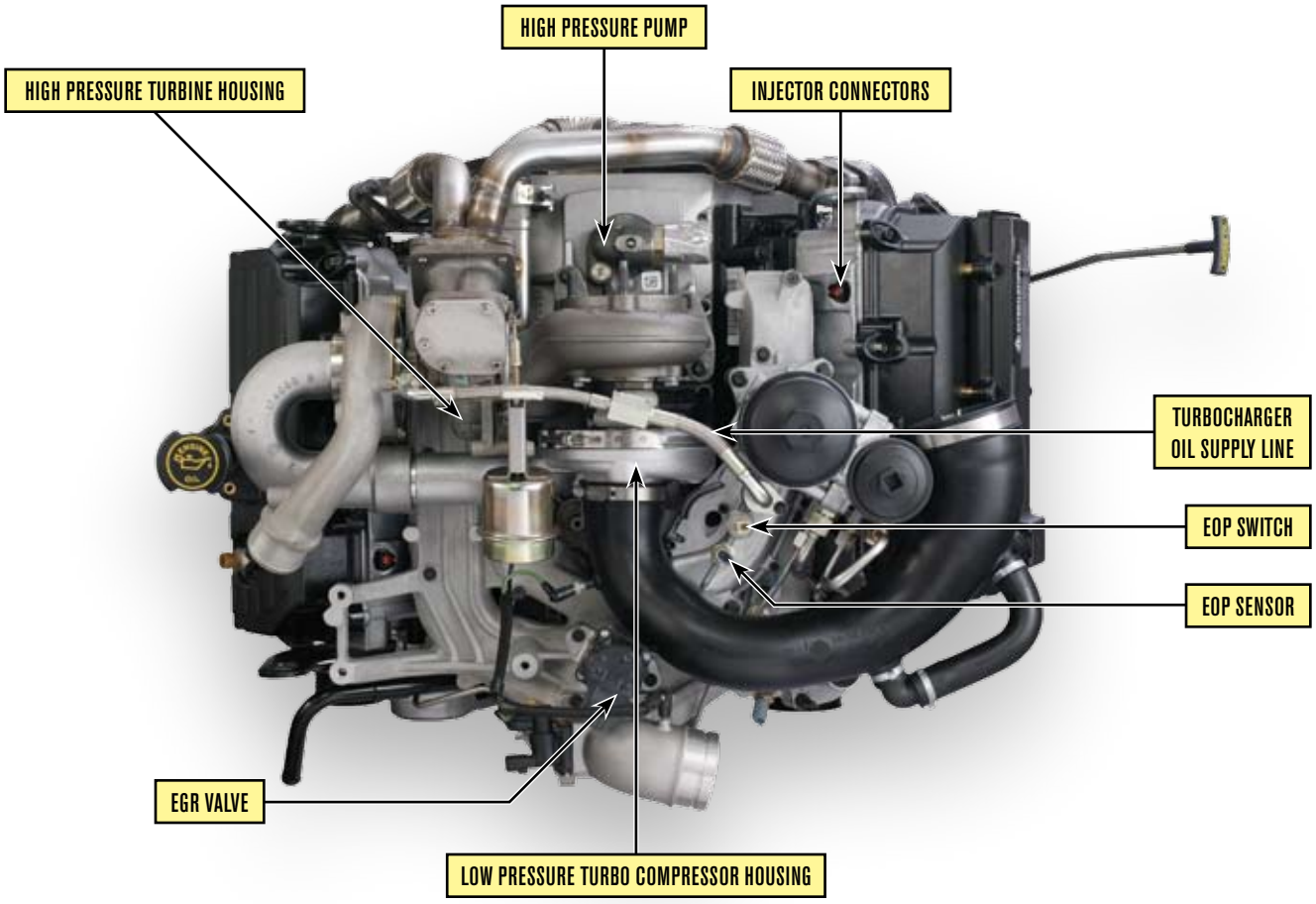
COMPONENT LOCATIONS - RIGHT SIDE OF ENGINE



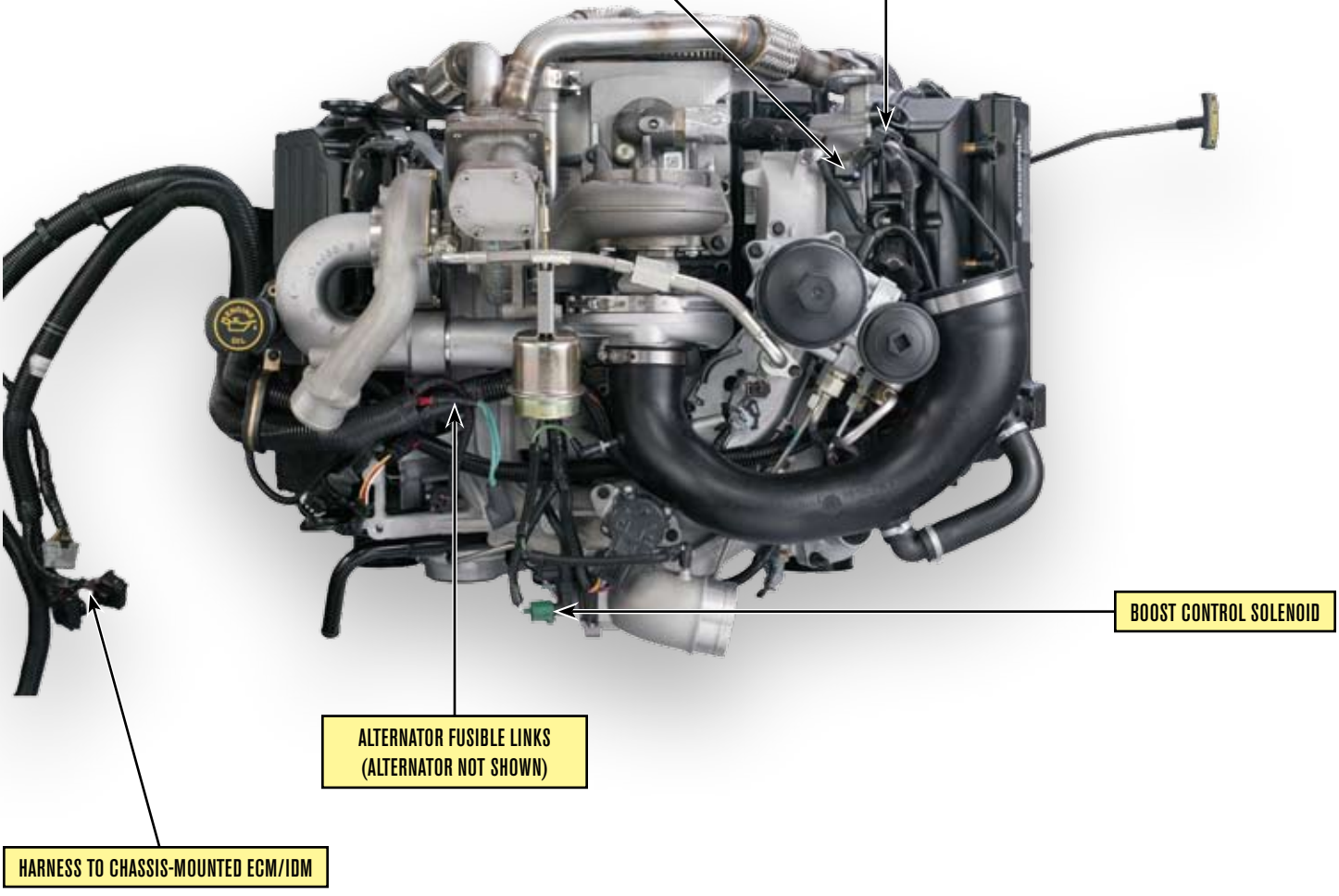
COMPONENT LOCATIONS - RIGHT FRONT OF ENGINE



COMPONENT LOCATIONS - TOP OF ENGINE WITHOUT HARNESS

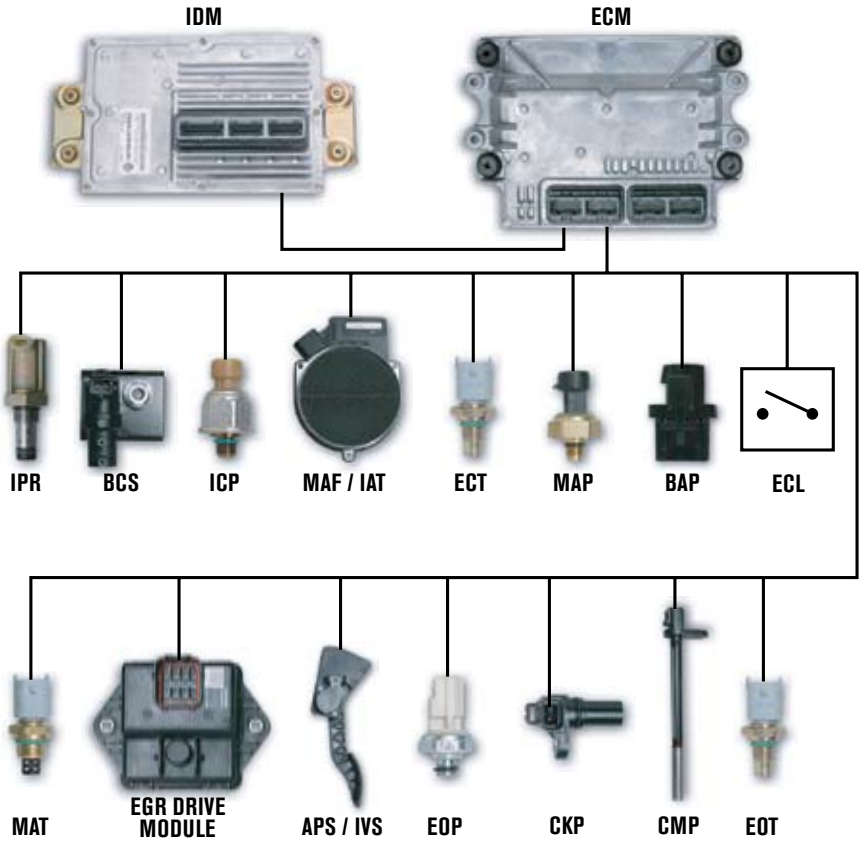


COMPONENT LOCATIONS - TOP OF ENGINE WITH HARNESS



ELECTRONIC CONTROL SYSTEM

- ECM and IDM control system
- Dual magnetic pick-up timing sensors
- Electric motor driven EGR valve
- ECM boost control



System Features

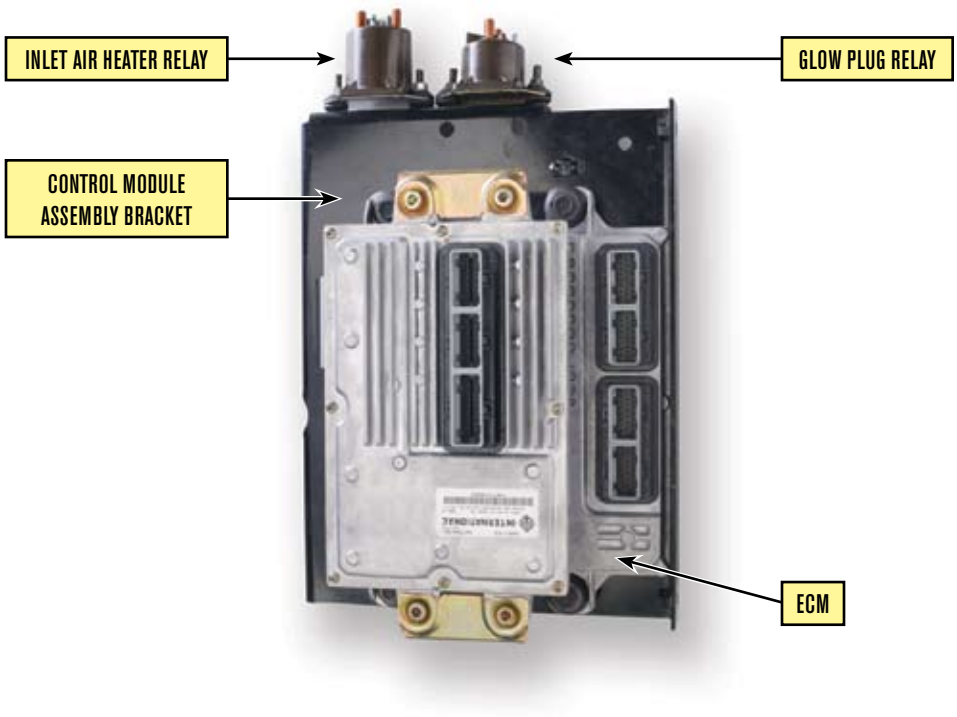
- The VT 275 engine uses the Diamond Logic™ II Control System. The electronic control system features an Engine Control Module (ECM) and an Injector Drive Module (IDM).
- The Exhaust Gas Recirculation (EGR) valve is positioned by an ECM controlled electric stepper motor. The system uses an EGR drive module to communicate commands from the ECM to the EGR valve.
- VT 275 engines use two magnetic pickup sensors to determine crankshaft speed and position and camshaft position. Magnetic pick-up sensors feature high reliability and accuracy.
- The VT 275 engine uses a twin turbocharger with ECM boost control.

ELECTRONIC CONTROL SYSTEM

ECM

- The ECM uses sensor inputs to control the Injection Pressure Regulator (IPR), the EGR valve, the boost control solenoid, the glow plug relay and the inlet air heater relay. The ECM also shares sensor data with the IDM over communication links between the two modules.

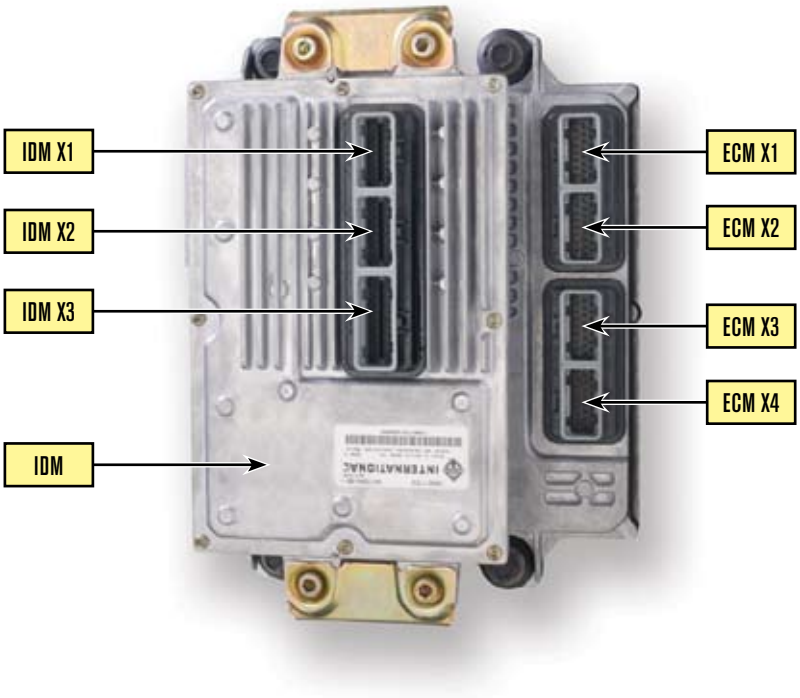
- The IDM is mounted on brackets cast into the ECM. The ECM and IDM are then mounted with vibration isolator grommets to the control module assembly bracket on the Power Distribution Center (PDC).



IDM

- The Injector Drive Module (IDM) receives sensor information from the ECM over three communication links: the CAN 2 link, the CMPO circuit, and the CKPO circuit. The IDM uses this information to calculate injection timing and duration. The IDM controls injector operation through 48-volt signals to the twin injector coils.

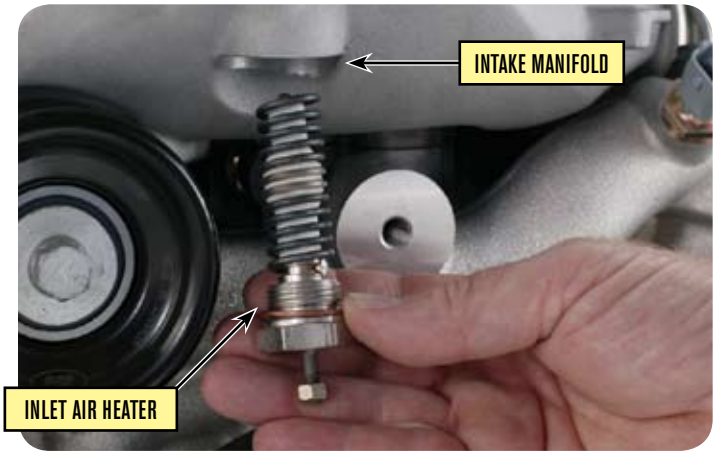
- The ECM has four connectors. The connectors are called X1 through X4 with ECM X1 being the top ECM connector as mounted on the truck. The IDM has three connectors with IDM X1 being the top connector as mounted on the truck. The ECM X1 and X2 connectors are for engine sensor inputs and X3 and X4 are for chassis inputs. The IDM X1 and X2 connectors are for injector operation and X3 is for chassis inputs and communication between the ECM and IDM.



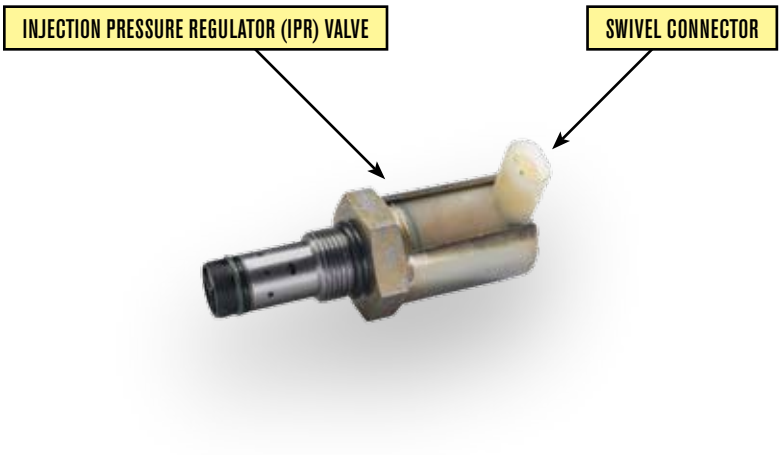
ELECTRONIC CONTROL SYSTEM

EGR Drive Module

- The EGR Drive Module receives the desired EGR valve position from the ECM over the engine CAN 2 link. The module then sends a series of voltage and ground signals to the Motor U, V, and W terminals of the EGR valve. The voltage signals are Pulse Width Modulated (PWM) to control current flow to the motor field coils.
- The module receives battery voltage and ground through the 12-way engine-to-chassis connector. The module supplies a reference voltage to three position sensors within the EGR valve. The drive module uses the sensor signals to determine the percent of valve opening.



- The Inlet Air Heater element is located in the lower side of the intake manifold and projects through the manifold and into the inlet air stream.
- The element warms the incoming air to aid cold start and reduce emissions during warm-up. The ECM turns the inlet air heater on for a predetermined amount of time, based on engine oil temperature, intake air temperature, and barometric air pressure. The inlet air heater can remain on while the engine is running to reduce white smoke during engine warm-up.



Injection Pressure Regulator (IPR) Valve

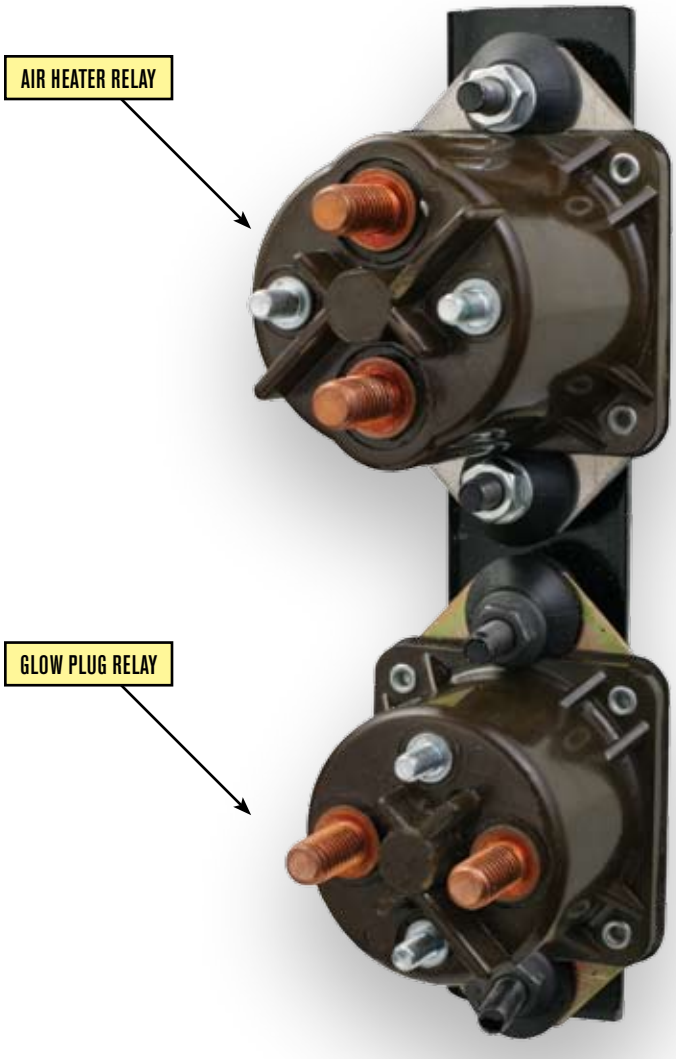
- The IPR mounts to the high-pressure pump and controls the amount of oil allowed to drain from the high-pressure system. When the ECM increases the IPR signal duty cycle, the valve blocks the oil's path to drain and pressure rises. When the ECM reduces the duty cycle, a larger volume of oil is allowed to drain from the system and pressure is reduced. The valve contains a pressure relief valve for the system that opens if system pressure reaches 4500 psi. The IPR is protected by a heat shield that must be reinstalled after servicing.

Inlet Air Heater Relay

- The Inlet Air Heater (IAH) element is used to improve cold start operation, reduce emissions and white smoke, and improve engine warm-up. The IAH relay is the taller of the two relays. The IAH relay receives battery power from the starter power-feed terminal and the normally open terminal connects to the element through the harness. One end of the relay coil is grounded through the engine 12-way connector. The relay closes when the coil receives voltage from the ECM.

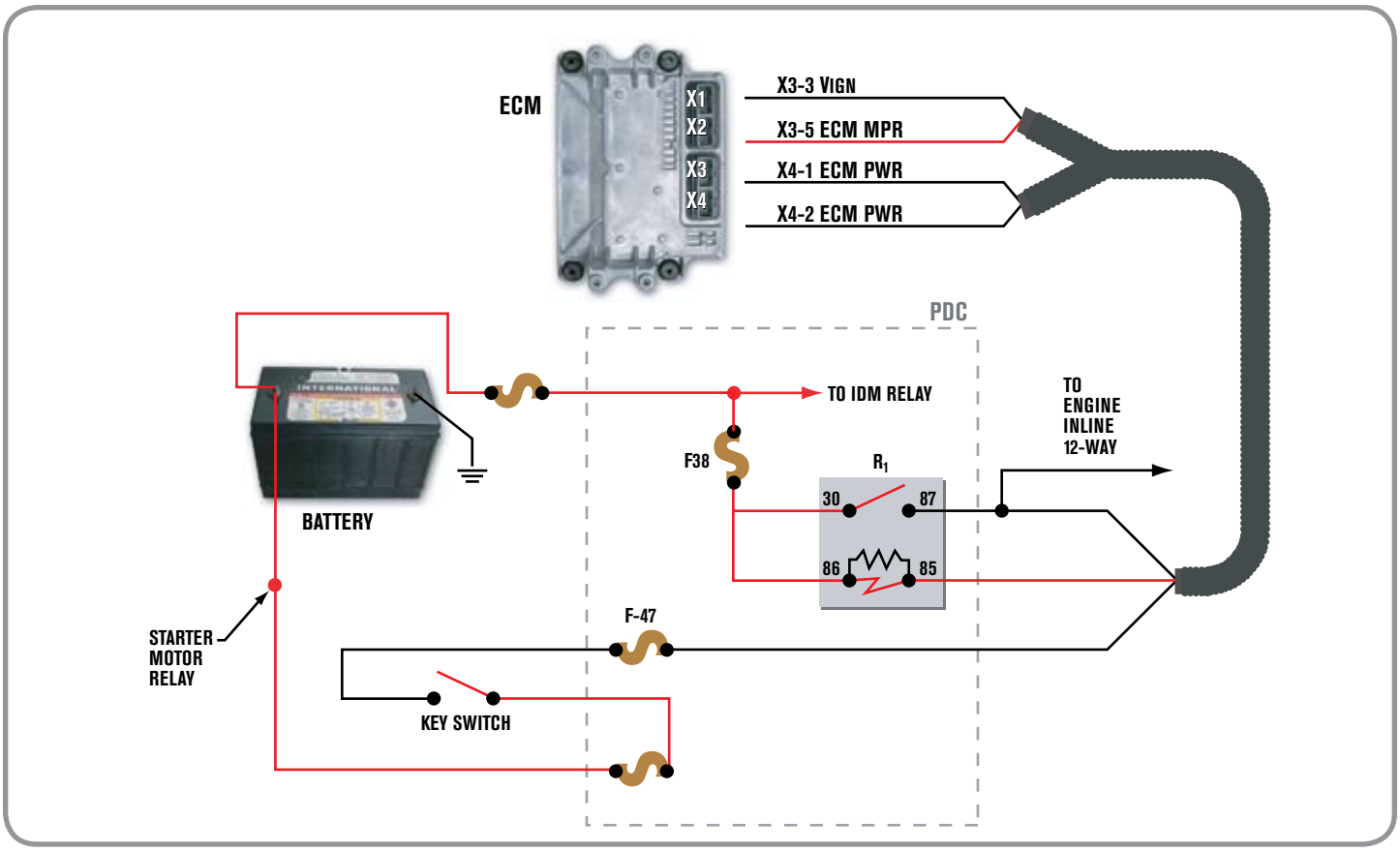
Glow Plug Relay

- Glow plugs are used to improve cold engine starting. Glow plug operation is controlled by the ECM through the glow plug relay. The relay common terminal is connected by jumper to the common terminal of the Inlet Air Heater relay. The normally open terminal connects to the glow plug harness. One end of the relay coil is grounded through the engine 12-way connector. The relay is closed when the other end of the coil receives voltage from the ECM.



Mass Air Flow (MAF) Sensor

- The Mass Air Flow (MAF) sensor is mounted with ductwork between the turbocharger inlet and the air filter element. The sensor applies voltage to a low resistance thermistor exposed to the fresh air portion of the intake charge. The MAF sensor circuitry measures the increase in voltage required to offset the cooling effect of the air flow over the thermistor. This voltage is then converted into a variable frequency that is sent to the ECM. The MAF value can be read with MasterDiagnostics® software in lb./min.



ECM Relay Circuit Operation

- The ECM controls its own power up and power down process. When the key is OFF, the ECM stays powered up for a brief period. The ECM then powers down after internal housekeeping functions have been completed.

Key Power

- The Run/Accessory position of the Key Switch receives battery voltage from the Power Distribution Center. When the key is ON, the switch supplies battery voltage through fuse F47 to ECM pin X3-3. Battery voltage is available at all times through fuse F38 to ECM relay pins 30 and 86.
- Pin 86 supplies voltage to the relay coil.
- Pin 85 connects the coil to pin X3-5 of the ECM.
- When the key is ON, voltage supplied to pin X3-3 signals the ECM that the operator is going to start the engine.

The ECM then supplies a ground circuit to pin X3-5. When this occurs, current flows through the ECM relay coil and creates a magnetic field causing the relay to latch. When latched, the relay connects pin 30 to pin 87 and supplies current to the ECM through pin X4-1 and X4-2.

Shut Down

- When the key is OFF and voltage is removed from ECM pin X3-3, the ECM shuts down the engine but keeps the ECM powered up briefly until the internal house keeping is completed.

ECM Power Relay

DTC 112 Electrical system voltage B+ out-of-range high
The ECM detects an alternator output greater than 23 volts at ECM Pin X3-3 for more than 0.5 seconds.

Possible causes:
- Voltage increases
- Jump starting the engine
- Incorrect external battery connections

DTC 113 Electrical system voltage B+ out-of-range low
The ECM detects less than 7 volts at ECM Pin X3-3 for more than 0.5 seconds.

Possible causes:
- Discharged batteries
- Increased resistance in the battery feed circuits
- Failed alternator or ECM power relay

DTC 626 Unexpected reset fault
Set when power is interrupted to the ECM or causes an ECM power down.

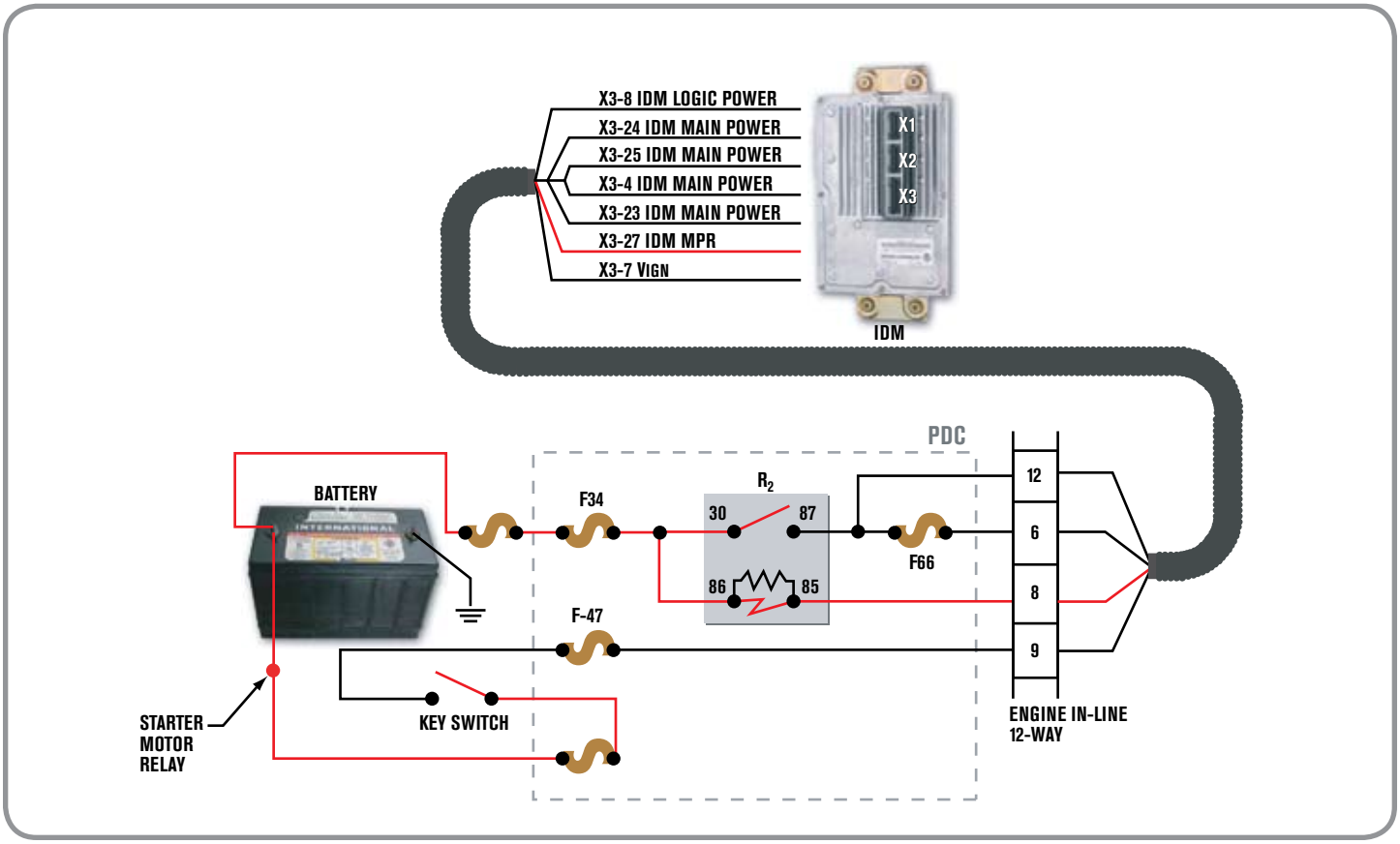
Possible causes:
- Loose or dirty connections at battery or ground cables
- Power feed wiring problems
- Low battery voltage

Voltage Checks - ECM Power Relay Socket

1. Turn Key Switch OFF.
2. Remove ECM relay and inspect for corroded terminals.
3. Connect relay breakout harness to relay and socket.
4. Measure voltage with Key Switch in the required test position.

TEST POINT	KEY SWITCH	SPECIFICATION	COMMENTS
85 to GND	ON	0.06 to 2 V	• If greater than 2 volts, check for open or short to B+.
85 to GND	OFF for open	B+	• If no voltage, check the fuse. • If fuse is good, check for open.
86 to GND	ON/OFF	B+	• If no voltage, check the fuse. • If fuse is blown, check for short to ground. • If fuse is good, check for open.
30 to GND	ON	B+	• If no voltage, check the fuse. • If fuse is blown, check for short to ground. • If fuse is good, check for open.
87 to GND	ON	B+	• If no voltage, check for failed relay.
87 to GND	OFF	O V	• If greater than 0 volts, check for short to B+.

If measurements are OK, send the vehicle to your International® dealer for further diagnostics.



IDM Relay Circuit Operation

- The IDM controls its own power up and power down process. When the key is OFF, the IDM stays powered up for a brief period. The IDM then powers down after internal housekeeping functions have been completed.

IDM Power Up

- The Key Switch receives battery voltage from the Power Distribution Center (PDC. When the key is ON, the switch supplies battery voltage through F-47 fuse and pin 9 of the engine 12-way connector to pin X3-7 of the IDM.

- Battery voltage is available through the PDC F-34 fuse to IDM relay pin 30 and 86 at all times. Pin 85 supplies voltage to the relay coil. Pin 85 takes that voltage through pin 8 of the engine 12-way connector to pin X3-27 of the IDM. When the key is ON, voltage supplied to pin X3-7 signals the IDM to provide a ground circuit to pin X3-27. When this occurs, current flowing through the IDM relay coil builds a magnetic field that causes the relay to latch. When latched, the relay connects pin 30 to pin 87 and supplies current through pin 12 of the engine in-line 12-way connector to pin X3-4, X3-23, X3-24, and X3-25 of the IDM. Four pins receive voltage to spread the current draw over multiple pins.

IDM Logic

- The IDM also requires voltage for the internal logic circuit. When the IDM relay latches, pin 87 of the relay supplies voltage to the IDM logic circuit through fuse F-66 in the PDC. The fuse feeds through pin 6 of the engine in-line 12-way connector to the IDM pin X3-8.

IDM Power Relay

DTC 523 IDM Vign Voltage Low
The ECM detects voltage from VIGN less than 7 volts.

Possible causes:
- Connections between the IDM Pin X3-7 and the VIGN

DTC 525 IDM fault
The ECM detects an internal IDM failure.

DTC 533 IDM relay voltage high
The ECM detects voltage from the IDM power relay greater than 16 volts.

Possible causes:
- When jump starting the engine
- Incorrect external battery connections
- Alternator voltage output of 16 volts or more

DTC 534 IDM relay voltage low
The ECM detects voltage from the IDM power relay less than 7 volts.

Possible causes:
- Discharged batteries
- Increased resistance in the battery feed circuits
- Failed IDM power relay or alternator

Voltage Checks - IDM Power Relay Socket

1. Turn Key Switch OFF.
2. Remove IDM relay and inspect for corroded terminals.
3. Connect relay breakout harness to relay and socket.
4. Measure voltage with Key Switch in required test position.

TEST POINT	KEY SWITCH	SPECIFICATION	COMMENTS
86 to gnd	ON	0.06 to 2 V	• If greater than 2 volts, check for open or short to B+.
86 to gnd	OFF	B+	• If no voltage, check the fuse. If fuse is good, check for open.
85 to gnd	ON / OFF	B+	• If no voltage, check the fuse. • If fuse is blown, check for short to ground. • If fuse is good, check for open.
30 to gnd	ON	B+	• If no voltage, check the fuse. • If fuse is blown, check for short to ground. • If fuse is good, check for open.
87 to gnd	ON	B+	• If no voltage, check for failed relay.
87 to gnd	OFF	0 V	• If greater than 0 volts, check for short to B+

CONTINUED ON THE NEXT PAGE ►

IDM Power Relay CONTINUED

Voltage Checks - 12-pin Connector

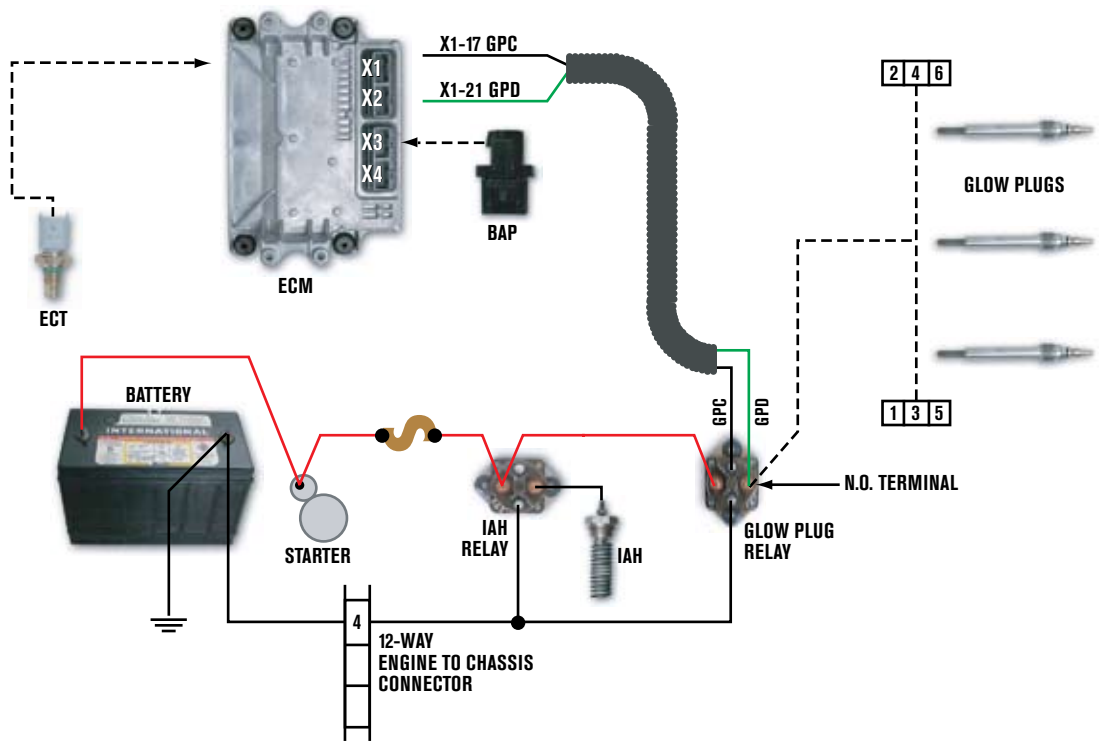
1. Turn Key Switch OFF.
2. Remove 12-pin connector.
3. Inspect for bent pins or corrosion.
4. Connect 12-pin breakout harness to chassis harness.
5. Turn Key Switch to the ON position.

TEST POINT	SPECIFICATION	COMMENTS
9 to gnd	B+	• If no voltage, check the fuse. • If fuse is blown, check for short to ground. • If fuse is good, check for open.
8 to gnd	0.06 to 2 V	• If greater than 2 volts, check for open.
12 to gnd	B+	• If no voltage, check for short to ground or open.
6 to gnd	B+	• If no voltage, check fuse. • If fuse is blown, check for short to ground. • If fuse is good, check for open.
1 to gnd	0 V	• If greater than 0 volts, check for open or high resistance (voltage readings indicate poor ground to battery).

Harness Resistance Checks

1. Turn Key Switch OFF.
2. Remove IDM relay and inspect for corroded terminals.
3. Install relay breakout harness to socket only.
4. Disconnect positive battery cable.
5. Use disconnected positive battery cable for B+ test point.

TEST POINT	SPECIFICATION	COMMENTS
30 to B+ cable	< 5 Ω	• If greater than 5 Ω, check fuses. • If fuses are good, check for open.
86 to B+ cable	< 5 Ω	• If greater than 5 Ω, check fuses. • If fuses are good, check for open.



Glow Plug System

- The VT 275 uses glow plugs to aid cold starts. The ECM turns on the glow plugs prior to engine cranking to increase the temperature of the cylinders. Glow plug operation is controlled by the ECM through the glow plug relay. The glow plugs have full voltage if battery voltage is normal, or pulse width modulated to control the current if battery voltage is above normal. The ECM calculates glow plug ontime based on coolant temperature and barometric pressure. The required time to warm up the cylinders decreases as engine coolant temperature increases. Warm up time decreases as barometric air pressure increases. The glow plugs may continue to be energized after start-up to reduce emissions.

Relay Operation

- The glow plug relay receives battery voltage to its common terminal from the starter power-feed terminal. The normally open terminal connects to the individual glow plugs through the glow plug harness. One end of the relay coil is always grounded through pin 4 of the engine 12-way connector. The ECM supplies 12 volts to the other end of the coil through ECM pin X1-17 in order to close the relay contacts.

Glow Plug Lamp

- The glow plug lamp is used as a wait-to-start indicator. The ECM lights the glow plug lamp at glow plug activation to signal the operator to wait for the cylinders to warm up.

- Both lamp operation and the glow plug operation are based on BAP and ECT values but are independent of each other.

- The glow plug operation may continue after the lamp is off.

Glow Plug Diagnostics

- Glow plug diagnostics are used to determine if the relay is operating correctly when commanded on. An additional wire on the relay's normally open terminal connects to ECM pin X1-21. This circuit, GPD, allows the ECM to monitor the relay operation.

- The glow plugs can be turned on using the KOEO Glow Plug/Inlet Air Heater Test. The test can only be activated twice per key cycle.

GPC (Glow Plug Control) Circuit

DTC 251 Glow Plug Control OCC self-test failed
Key On Engine Off Standard Test detects a fault in the glow plug relay control circuit.

Possible causes:
- Open or short in GPC signal circuit
- Open in actuator power ground
- Open glow plug relay coil

DTC 375 Glow Plug Relay Circuit Fault
The ECM does not see the expected relay output voltage value.

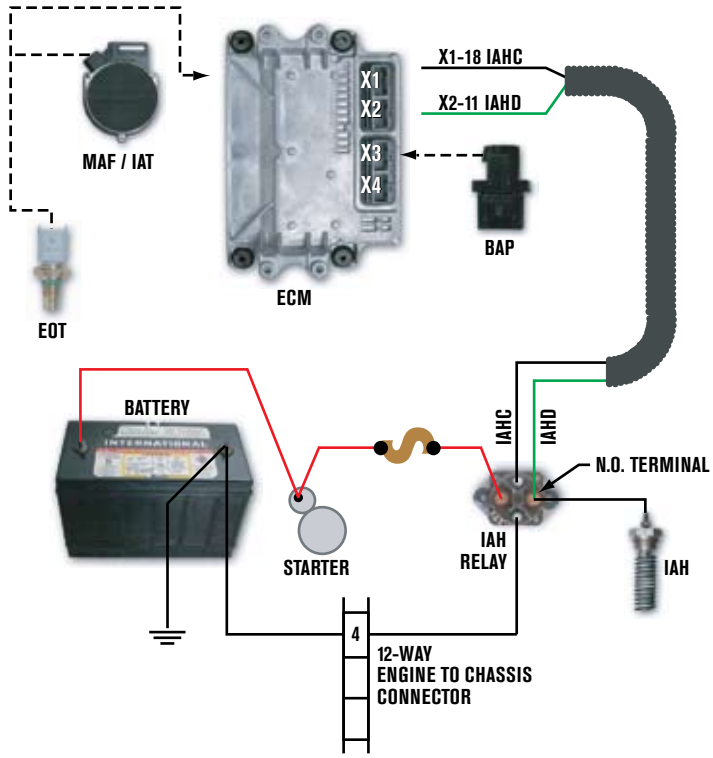
Possible causes:
- Open in the B+ supply circuit to glow plug relay
- Open or short in GPC circuit
- Failed glow plug relay

Note: If DTC 251 and DTC 375 are both set, repair DTC 251 first.

Voltage Checks - Relay

Measure voltage with Key Switch in the required test position (on-time is temperature dependent).

TEST POINT	KEY SWITCH	SPECIFICATION	COMMENTS
GP relay control terminal to GND	ON	B+	• If no voltage, check for short to ground or open.
GP relay control terminal to GND	OFF	0 V	• If greater than 0 V, check for short to power.
Actuator Pwr Gnd to gnd	OFF	0 V	• If greater than 0 V, check for open.
GP battery supply terminal to gnd	ON	B+	• If no voltage, check the fuse. • If fuse is blown, check for short to ground. • If fuse is good, check for open
GP relay output terminal to gnd	ON	B+	• If no voltage, check for failed relay.
GP relay output terminal to gnd	OFF	0 V	• If greater than 0 volts, check for short to B+ or check for failed relay



Inlet Air Heater Operation

- The VT 275 has an Inlet Air Heater (IAH) element mounted in the front of the intake manifold. The IAH is used to improve cold start operation, reduce emissions and white smoke, and improve engine warm-up. When the key is ON, the ECM determines if the element should be activated and for how long, based on barometric pressure and engine oil temperature. On time is limited to prevent heater element damage and to prevent damage to the intake manifold. The heater relay delivers full voltage to the element if battery voltage is normal, or the relay is pulsed by the ECM to control the current if battery voltage is above normal. If the battery voltage is so low that the starter motor operation may be affected, the inlet air heater is disabled.

Relay Operation

- The IAH relay receives battery power from the starter power feed terminal. The normally open terminal connects to the element through the harness. One end of the relay coil is always grounded through pin 4 of the engine 12-way connector. The other end of the coil receives 12 volts from ECM pin X1-18 to close the relay contacts.

Inlet Air Heater Diagnostics

- An additional wire on the normally open terminal connects to ECM pin X2-11. This diagnostic circuit allows the ECM to determine if the IAH relay is on when commanded on by the ECM.

- The Inlet Air Heater can be turned on using the KOEO Glow Plug/Inlet Air Heater Test. The test can only be activated twice per key cycle. The ECM will delay the Inlet Air Heater operation for three seconds after the test is activated.

IAH (Inlet Air Heater) Circuit

DTC 238 Inlet Air Heater Control OCC self-test failed
Key On Engine Off Standard test detects a fault in the inlet air heater control circuit.

Possible causes:
- Open or short in IAHC circuit
- Open in actuator power ground
- Open inlet in air heater relay coil

DTC 373 Inlet Air Heater relay circuit fault
The ECM does not see the expected relay output voltage value.

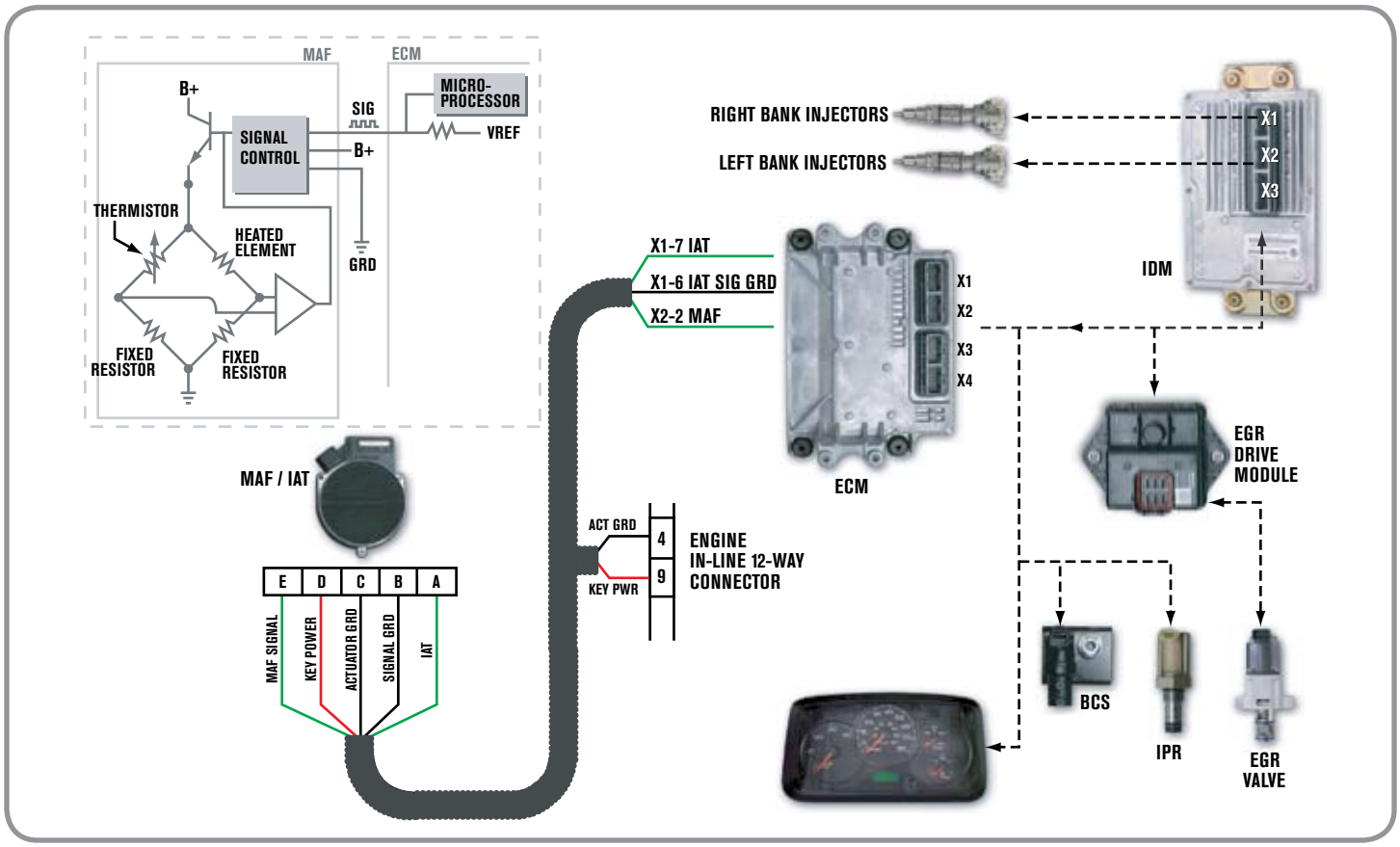
Possible causes:
- Open in the B+ supply circuit to inlet air heater relay
- Open or short in IAH control circuit
- Failed inlet air heater relay

Note: If DTC 238 and DTC 373 are both set, repair DTC 238 first.

Voltage Checks - Relay

Measure voltage with Key Switch in the required test position (on-time is temperature dependent).

TEST POINT	KEY SWITCH	SPECIFICATION	COMMENTS
IAH relay control terminal to gnd	ON	B+	• If no voltage, check for short to ground or open.
IAH relay control terminal to gnd	OFF	0 V	• If greater than 0 V, check for short to power.
Actuator Pwr Gnd to gnd	ON	0 V	• If greater than 0 V, check for open.
IAH battery supply terminal to gnd	ON	B+	• If no voltage, check the fuse. • If fuse is blown, check for short to ground. • If fuse is good, check for open
IAH relay output terminal to gnd	ON	B+	• If no voltage, check for failed relay.
IAH relay output terminal to gnd	OFF	0 V	• If greater than 0 volts, check for short to B+ or check for failed relay



Mass Air Flow (MAF) Sensor

- The MAF sensor is used to measure the mass of the fresh air portion of the intake air charge. To reduce Oxides of Nitrogen (NOx), a portion of the fresh air charge is displaced with cooled exhaust gases. The ECM calculates the total engine gas flow based on MAT, MAP and RPM. The ECM then determines the required EGR percent based on the current engine operating conditions. At this point, the ECM commands the exhaust portion of the total charge through the EGR valve while monitoring the fresh air portion through the MAF sensor.

Sensor Construction

- The sensor housing contains two sensors, the MAF sensor and the Intake Air Temperature (IAT) sensor. The MAF sensor contains a heated element placed in the air stream. The amount of electrical power needed to maintain the element at the proper temperature depends directly on the mass of air moving over the element.

Sensor Operation

- The MAF sensor is made up of two voltage divider circuits. A thermistor and a fixed resistor make up one voltage divider circuit, and the heated element and a fixed resistor make up the other voltage divider circuit. The two voltage divider circuits are combined into a bridge circuit with a common power supply and a common ground.

- During operation, when voltage is applied to the bridge, the temperature of the heated element increases and the resistance decreases. This affects the output of the divider circuit.

- The thermistor side is affected only by ambient air temperature. The divider voltages are compared and the input voltage to the bridge is increased or decreased until both divider voltages are equal.

- An increase or decrease in airflow will change the ratio between the divider voltages, which results in a change to the supply voltage.

- The signal controller circuit measures the voltage to the bridge and, based on that value, sends a frequency signal to the ECM.

MAF (Mass Air Flow) Sensor

DTC 148 MAF signal frequency out of range low
The ECM detects MAF frequency less than 200 Hz for 5 seconds.

Possible causes:
- Open or short to ground in the MAF signal circuit
- Open in VIGN circuit
- Open in ground circuit
- Failed MAF sensor

DTC 149 MAF signal frequency out of range high
The ECM detects MAF frequency more than 11,500 Hz for 5 seconds.

Possible causes:
- Short to voltage in the MAF signal circuit
- Failed MAF sensor

DTC 166 Mass air flow sensor in-range fault
The ECM detects MAF reading is above 20 gps at key-on-engine-off, MAF is not reading 15 +/- 5 gps at low idle (in Park or Neutral), or MAF is not reading 25 +/- 5 gps at low idle (in Drive).

Possible causes:
- Biased MAF/IAT sensor
- Plugged or leaking air intake or air filter
- Plugged exhaust system

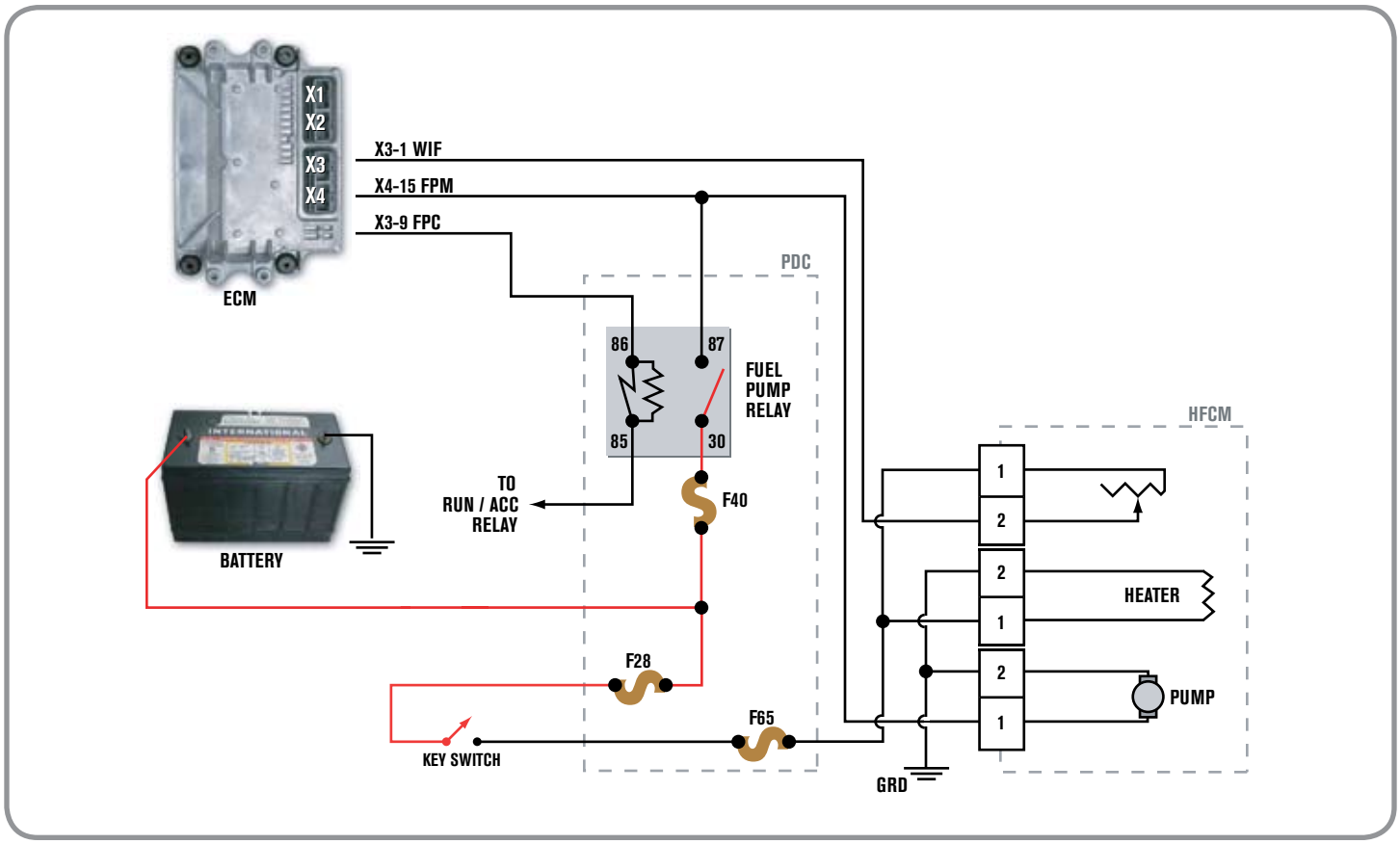
DTC 167 Excessive mass air flow
The ECM detects MAF readings above a calibrated set point based on engine rpm. MAF signal will be restricted to 300 gps.

Possible causes:
- Biased or disconnected MAF/IAT sensor
- Short to voltage in the MAF signal circuit

Voltage Checks - 12-Pin Connector

1. Turn Key Switch to OFF.
2. Disconnect the 12-Pin connector.
3. Inspect for bent pins or corrosion.
4. Connect 12-pin breakout harness.
5. Disconnect negative battery cable. Use negative battery cable as the ground test point.
6. Turn Key Switch to the ON position.

TEST POINT	SPECIFICATION	COMMENTS
Pin 4 (12pin) to gnd	0 V	• If greater than 0 volts, check for open.
Pin 9 (12pin) to gnd	B+	• If less than B+, check for short to ground or open.



Pump Operation

- The VT 275 has an ECM controlled chassis mounted electric fuel pump. At key-on, the ECM will operate the fuel pump for up to 60 seconds to prime the system. Priming allows the pump to pressurize the system and to allow air in the system to bleed out through an orifice between the filter housing and the fuel return circuit. When the engine is in run mode, the pump will operate continuously. If the engine dies or is shut down, or if it is not started within 60 seconds, the ECM will stop the pump.

Circuit Operation

- To operate the pump, the ECM provides a ground at ECM pin X3-9 to latch the fuel pump relay. The relay takes power from fuse F40 and provides it to pin 1 of the pump connector. The ECM monitors the relay's operation through ECM pin X4-15. Battery voltage should be present at X4-15 when the relay is commanded on. If the ECM does not detect the voltage, a DTC will be logged.

Fuel Heater

- The Horizontal Fuel Conditioning Module (HFCM) contains a fuel heater. When the key is ON, the key switch provides power to pin 1 of the heater connector through fuse 65. The heater element contains a thermostat that controls the heater operation.

Water-In-Fuel Sensor

- The pump module contains a Water-In-Fuel (WIF) sensor. The WIF sensor receives voltage from fuse 65. If the filter detects water, the sensor sends the voltage to ECM pin X3-1. The ECM then activates the dash WIF lamp.

Engine Coolant Level

- The Engine Coolant Level (ECL) sensor uses a floating ball and a magnetic switch. When the coolant level is full, the float will rise and the magnet will pull the ECL contacts open. When the level falls, the contacts close.
- ECM Pin X3-4 supplies a 5v signal to pin A of the ECL sensor. Pin B of the sensor connector is grounded through the chassis harness. When the level is OK, the switch is open and the ECM will see five volts on the circuit. If the level is low, the switch is closed and the circuit is grounded. With the circuit grounded the voltage goes to zero.
- The ECM can not detect an open or short circuit in the ECL system but does continuously monitors the circuit for in-range faults. When the ECM detects a voltage between 3.4 and 4.3 it is assumed there is a circuit failure and an in-range fault, DTC 236 will be set. This failure can be caused by a high resistance connection or an intermittent short to ground.

HFCM (Horizontal Fuel Conditioning Module) Fuel Pump

DTC 237 Fuel Pump Control OCC self-test failed
Key On Engine Off Standard Test detects a fault in the fuel pump relay control circuit.

Possible causes:
- Open or short to ground on FPC circuit
- Open or short to ground on VIGN circuit to the fuel pump relay
- Open fuel pump relay coil

DTC 374 Fuel Pump Relay Circuit failed
The ECM does not see the expected relay output voltage value.

Possible causes:
- Open in the B+ supply circuit to fuel pump relay
- Open or shorted FPC circuit
- Failed fuel pump relay

Note: If DTC 237 and DTC 374 are both set, repair DTC 237 first.

Voltage Checks - Relay

1. Turn Key Switch OFF.
2. Remove fuel pump relay and inspect for corrosion.
3. Connect relay breakout harness to relay and socket.
4. Measure voltage with Key Switch in the required test position (pump on-time is 60 seconds).

TEST POINT	KEY SWITCH	SPECIFICATION	COMMENTS
85 to gnd	ON	0 to 0.25 V	• If greater than 0.25 volts, check for open or short to B+.
85 to gnd	OFF	0 V	• If greater than 0 volts, check for short to B+.
86 to gnd	ON	B+	• If no voltage, check the fuse. • If fuse is blown, check for short to ground. • If fuse is good, check for open.
30 to gnd	ON	B+	• If no voltage, check the fuse. • If fuse is blown, check for short to ground. • If fuse is good, check for open
87 to gnd	ON	B+	• If no voltage, check for failed relay.
87 to gnd	OFF	0 V	• If greater than 0 volts, check for short to B+

Harness Resistance Checks - Relay to Ground

1. Turn Key Switch to OFF.
2. Remove fuel pump relay and inspect for corrosion.
3. Connect relay breakout harness to the socket only.
4. Disconnect negative battery cable. Use disconnected negative battery cable for ground test point.

TEST POINT	SPECIFICATION	COMMENTS
85 to gnd	> 1 kΩ	• If less than 1 kΩ, check for short to ground.
86 to gnd	> 1 kΩ	• If less than 1 kΩ, check for blown fuse or short to ground. • **Note:** If Key Switch is grounded when Key Switch OFF this will be less than 5 Ω.
30 to gnd	> 1 kΩ	• If less than 1 kΩ, check for blown fuse or short to ground.
87 to gnd	> 1 kΩ	• If less than 1 kΩ, check for blown fuse or short to ground.

CONTINUED ON THE NEXT PAGE ►

HFCM (Horizontal Fuel Conditioning Module) Fuel Pump CONTINUED

Harness Resistance Checks - Relay to VIGN

1. Turn Key Switch to OFF.
2. Remove fuel pump relay and inspect for corrosion.
3. Connect relay breakout harness to the socket only.
4. Disconnect negative battery cable. Use disconnected negative battery cable for ground test point.

TEST POINT	SPECIFICATION	COMMENTS
86 to VIGN	< 5 Ω	• If greater than 5 Ω, check VIGN and fuses, if OK check for open.

Harness Resistance Checks - Relay to Pump

1. Turn Key Switch to OFF.
2. Disconnect fuel pump connector.
3. Inspect for bent pins or corrosion.
4. Remove fuel pump relay and connect relay breakout harness to socket only.

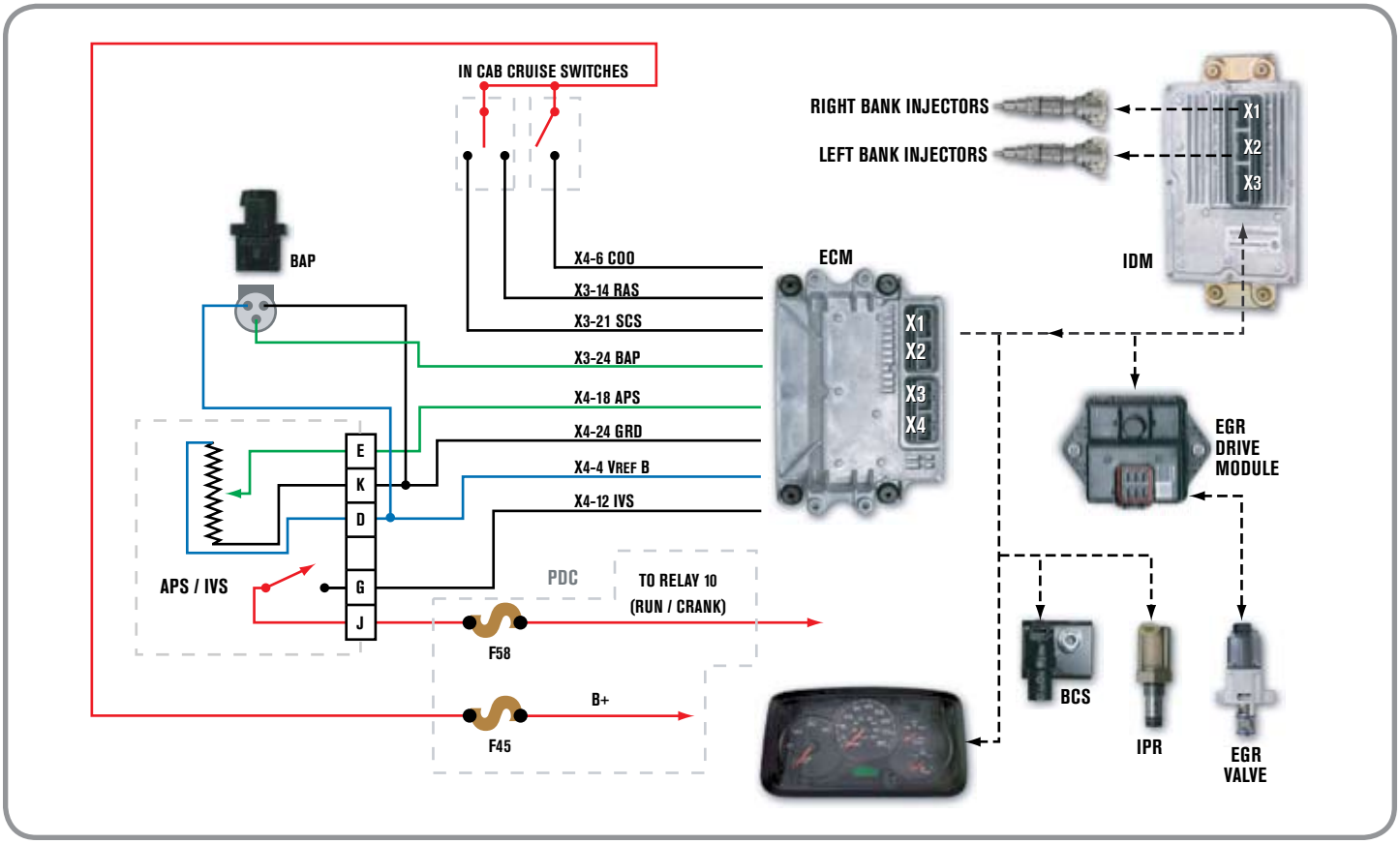
TEST POINT	SPECIFICATION	COMMENTS
87 to Pin 1	< 5 Ω	• If greater than 5 Ω, check for open.

Harness Resistance Checks - Fuel Pump Connector to Ground

1. Turn Key Switch to OFF.
2. Disconnect fuel pump connector.
3. Inspect for bent pins or corrosion.
4. Disconnect negative battery cable. Use disconnected negative battery cable for ground test point.

TEST POINT	SPECIFICATION	COMMENTS
Pin 1 to gnd	> 1 kΩ	• If less than 1 kΩ, check for short to ground.
Pin 2 to gnd	< 5 Ω	• If greater than 5 Ω, check for open.

ELECTRONIC CONTROL SYSTEM



Accelerator Pedal Position Sensor / Idle Validation Switch (APS/IVS)

- The APS/IVS sensor has two components built into one housing: the Accelerator Pedal Position Sensor (APS) and the Idle Validation Switch (IVS).

- The APS is a potentiometer type sensor. The ECM supplies a reference voltage (Vref) and ground to the potentiometer and the sensor sends a voltage signal back to the ECM indicating the pedal position. The idle validation switch receives 12 volts from the chassis harness and signals the ECM when the pedal is in the idle position. If the ECM detects an APS signal out of range high or low, the ECM will ignore the APS signal and operate at low idle.

- If a disagreement in the state of IVS and APS is detected by the ECM, and the ECM determines that the IVS is at fault, the ECM will allow a maximum of 50% of APS. If the ECM cannot determine that the IVS is at fault, the engine will be restricted to low idle only.

Barometric Absolute Pressure (BAP) sensor

- The BAP sensor is mounted in the cab. The BAP sensor provides altitude information to the ECM, so fuel quantity and timing, glow plug on time, intake heater on time, and the operation of the Boost Control Solenoid can be adjusted to compensate for air density changes.

Cruise Control

- Cruise control operation is controlled through the ECM. Two switches in the cab are used to signal the operator's intention for speed control. The Cruise On/Off (COO) switch sends a voltage signal to ECM pin X4-6. With the COO switch on, the operator can use the Set (SCS) and resume (RES) switch to control the vehicle speed.

Accelerator Pedal Position / Idle Validation Switch (APS/IVS)

DTC 131 APS Out of Range Low
The ECM detects less than 0.147 volts on the APS signal circuit. Engine rpm restricted to idle.

Possible causes:
- Short to ground or open in APS signal circuit
- Short to ground or an open in VREF circuit

DTC 132 APS Out of Range High
The ECM detects greater than 4.55 volts on the APS signal circuit. Engine rpm restricted to idle.

Possible causes:
- Short to VREF or B+ in APS signal circuit
- short to ground or an open in VREF circuit

DTC 133 APS Signal In-Range
The APS and IVS signals disagree, APS signal is at fault. Engine rpm will be restricted to idle.

DTC 134 APS and IVS signals disagree
The APS and IVS signals disagree, both signals are at fault. Engine rpm will be restricted to idle.

DTC 135 IVS Circuit Fault
The APS and IVS signals disagree, IVS is at fault. In this case the ECM limits the APS signal to 50% maximum.

Voltage Checks - Connector

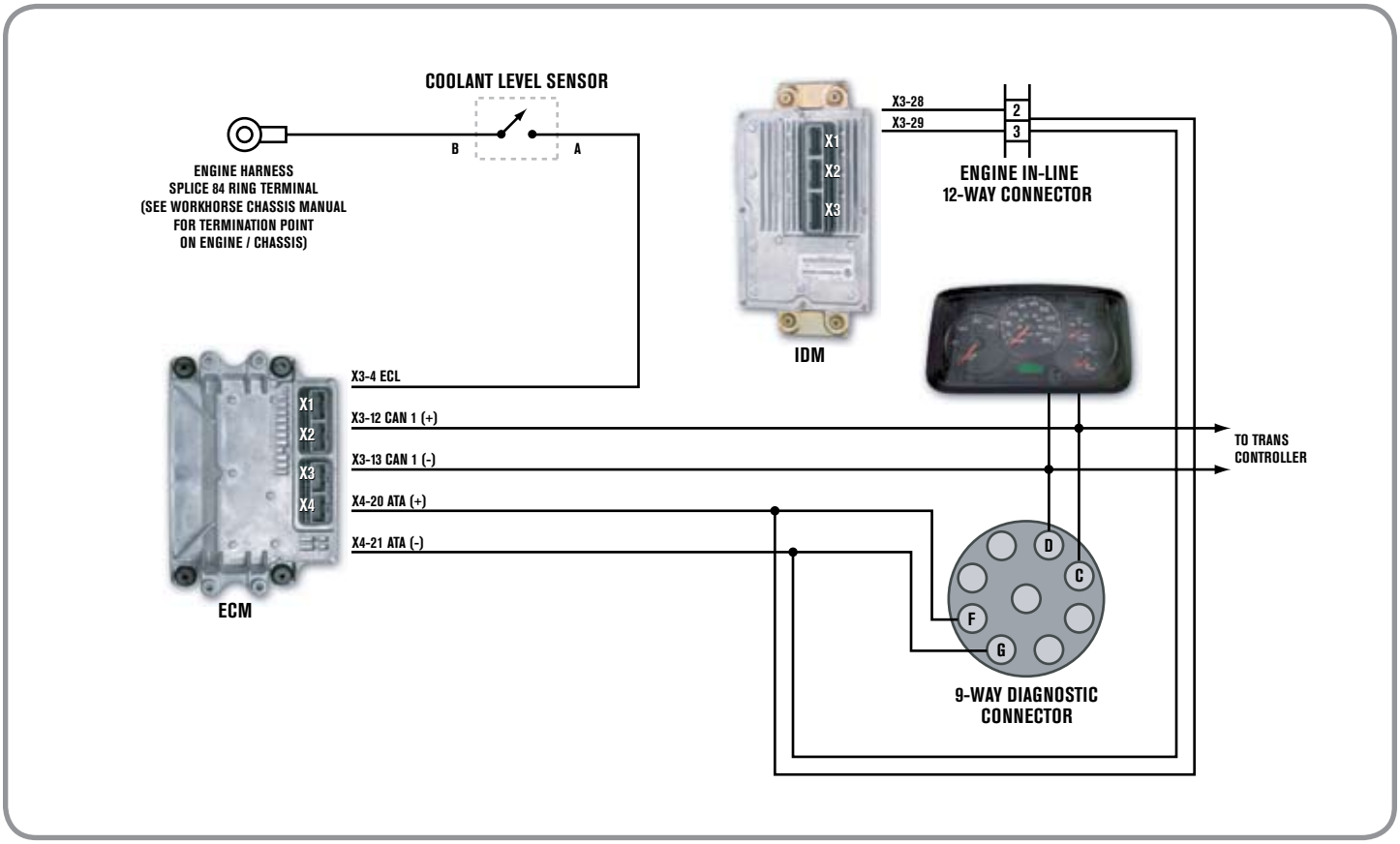
1. Turn Key Switch to OFF.
2. Disconnect harness from sensor.
3. Inspect for bent pins or corrosion.
4. Connect breakout harness to chassis harness only.
5. Turn Key Switch to ON.

TEST POINT	SPECIFICATION	COMMENTS
E to gnd	0 to 0.25 V	• If greater than 0.25 volts, check for short to VREF or B+.
K to gnd	0 V	• If greater than 0 volts, check for short to VREF or B+.
D to gnd	5 ± 0.5 V	• If greater than spec, check for short to B+. If less than spec, check for open or short to ground.
G to gnd	0 to 0.25 V	• If greater than 0.25 volts, check for short to VREF or B+.
J to gnd	B+	• If less than 10.5 volts, check for blown fuse, open, or high resistance.

Resistance Checks – Connector to Chassis Ground

1. Turn Key Switch to OFF.
2. Disconnect harness from sensor.
3. Inspect for bent pins or corrosion.
4. Disconnect negative battery cable. Use disconnected negative battery cable for ground test point.

TEST POINT	SPECIFICATION	COMMENTS
E to gnd	> 1 kΩ	• If less than 1 kΩ, check for short to ground.
K to gnd	< 5 Ω	• If greater than 5 Ω, check for open.
D to gnd	> 500 Ω	• If less than 500 Ω, check for short to ground.
G to gnd	> 1 kΩ	• If less than 1 kΩ, check for short to ground.
J to gnd	> 1 kΩ	• If less than 1 kΩ with fuse removed, check for short to ground.



Engine/Chassis Communications

- The ECM and IDM communicate over three independent communication links. The three links are CMPO, CKPO, and CAN 2. In addition to communications with the IDM, the ECM also sends engine information over the CAN 1 link to the vehicle's instrument cluster and the 9-pin Diagnostic connector.

Cam Position Output (CMPO)

- The CMPO signal is a 0-12V digital signal used to communicate the camshaft position to the IDM. The CMPO signal is a square wave signal derived from the information contained in the camshaft position sensor's AC voltage signal. The ECM generates the CMPO signal by pulling down (switching to ground) a single wire 12V circuit that originates in the IDM. The IDM reads the signal and uses it for injector timing calculations.

Crank Position Output (CKPO)

- The CKPO signal is a 0-12V digital signal used to communicate the crankshaft position and speed to the IDM. The CKPO signal is a square wave signal derived from the information contained in the crankshaft position sensor's AC voltage signal. The ECM generates the CKPO signal by pulling down (switching to ground) a single wire 12V circuit that originates in the IDM. CKPO is used by the IDM for injector timing and fuel quantity calculations.

American Trucking Association (ATA) Datalink

- The ATA link is a 0-5V signal that enables communications between the ECM and the Master-Diagnostics software. The data communication link also allows for programming of the ECM and IDM.

Engine Coolant Level

- The Engine Coolant Level (ECL) sensor uses a floating ball and a magnetic switch. When the coolant level is full, the float will rise and the magnet will pull the ECL contacts open. When the level falls, the contacts close.

- ECM Pin X3-4 supplies a 5v signal to pin A of the ECL sensor. Pin B of the sensor connector is grounded through the chassis harness. When the level is OK, the switch is open and the ECM will see five volts on the circuit. If the level is low, the switch is closed and the circuit is grounded. With the circuit grounded the voltage goes to zero.

- The ECM can not detect an open or short circuit in the ECL system but does continuously monitors the circuit for in-range faults. When the ECM detects a voltage between 3.4 and 4.3 it is assumed there is a circuit failure and an in-range fault, DTC 236 will be set. This failure can be caused by a high resistance connection or an intermittent short to ground.

ECM/IDM Communications

DTC 231 ATA data communication link error
The ECM can not access the ATA datalink. DTCs can only be retrieved using the cruise control feature.

Possible causes:
- Failed ATA device pulling signal to ground
- Open or shorted ATA+ or ATA-
- Exceeded limit on number of ATA devices
- Failed ECM

DTC 236 ECL switch circuit fault
The ECM detects a voltage between 3.4 and 4.3 volts at ECM Pin X3-4 for more than 2.0 seconds.

Possible causes:
- High resistance connection
- Intermittent short to ground

ATA Connector Diagnostics Voltage Checks

1. Turn Key Switch to ON (the engine shoud not be started).

TEST POINT	SPECIFICATION	COMMENTS
B to A	B+	• If no voltage, check for open or short on ground and power circuits.

ATA Connnector Diagnostics Harness Resistance Checks

1. Turn Key Switch to OFF.
2. Disconnect negative battery cable. Use disconnected battery cable for ground test point.

TEST POINT	SPECIFICATION	COMMENTS
B to fuse	$< 5\ \Omega$	• If greater than 5 Ω, check for open or short to ground.
A to gnd	$< 5\ \Omega$	• If greater than 5 Ω, check for an open.

Coolant Level Sensor Connector

1. Turn Key Switch to OFF.
2. Disconnect ECL sensor from harness. Inspect for bent pins or corrosion.
3. Check for FULL coolant level in surge tank.
4. Turn Key-Switch to ON.

TEST POINT	SPECIFICATION	COMMENTS
A to gnd	5 ± 0.5 V	• If less than 5 volts, check for open, short to ground, or failed ECM.
B to gnd	0 V	• If greater than 0 volts, check for short to power.

Resistance Checks - Coolant Level Sensor

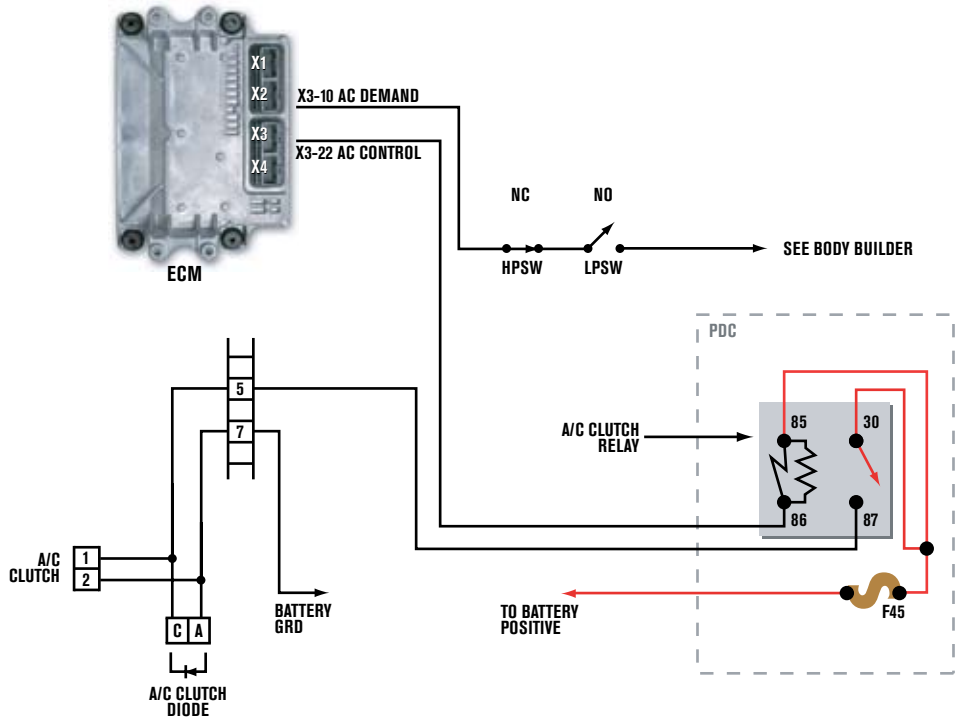
1. Disconnect ECL sensor connector and measure across sensor pins.

TEST POINT	SPECIFICATION	COMMENTS
A to B	> 1 k Ω	• If less than 1 k Ω, check for low coolant in surge tank or failed sensor.

Harness Resistance Checks - Coolant Level Sensor

1. Turn Key-Switch to OFF.
2. Disconnect ECL sensor from harness. Inspect for bent pins or corrosion.
3. Disconnect negative battery cable. Use disconnected battery cable for ground test point.

TEST POINT	SPECIFICATION	COMMENTS
B to gnd	$< 5\ \Omega$	• If greater than 5 Ω, check for open.



A/C Clutch Control

- The VT 275 ECM controls the A/C clutch. The ECM receives an A/C demand signal from the chassis, and engages the A/C clutch.

A/C Demand

- The A/C demand signal originates at the ECM as a reference voltage on X3-10. The ECM supplies 5 volts to pin 10 and considers clutch engagement when the voltage is pulled low (shorted to ground) by the A/C on/off switch in the dash located A/C Control Head. The low-pressure switch (LPSW), high-pressure switch (HPSW), and the thermostat switch (T-STAT SW) are in series in the A/C demand circuit. If the compressor head pressure rises above 430 psi, the high-pressure switch opens and the demand signal will be 5V. If pressure on the low side of the compressor goes below 7 psi, the low-pressure switch will open and the demand signal will be 5V. The last switch is the thermostat control in the A/C Control Head. If the thermostat is positioned so that in-cab temperature demands are satisfied, the thermostat will open and the demand signal will be 5V.

A/C Control

- If the A/C demand signal is pulled low, the ECM pulls the AC Control circuit low at pin X3-22. When pin 22 is low, a ground is provided for the A/C Clutch Relay. The relay latches and battery voltage is provided to the A/C clutch through pin 5 of the engine 12-way connector.

Switches

- The thermostatic switch (T-STAT SW) monitors evaporator core temperature to prevent freezing and to regulate cab temperatures.

- The low pressure switch (LPSW) prevents compressor damage in the event of a refrigerant leak. The high pressure cutoff Switch (HPSW) interrupts compressor operation in the event of high system pressures.

A/C Clutch Control

DTC 268 A/C Clutch Control OCC self-test failed
Key Switch ON, engine OFF. The standard test detects a fault in the A/C/ Clutch Control circuit.

Possible causes:
- Open or short to ground on A/C control circuit
- Open or short to ground on power circuit to the A/C clutch relay
- Open A/C clutch relay coil circuit

Voltage Checks - Relay (A/C Switch OFF)

1. Turn Key Switch to OFF.
2. Remove A/C clutch relay and inspect for corrosion.
3. Connect relay breakout harness to to relay and socket.
4. Measure voltage with the Key Switch in the required test position.

TEST POINT	KEY SWITCH	SPECIFICATION	COMMENTS
85 to gnd	ON / OFF	B+	• If no voltage, check the fuse. If fuse is blown, check for short to ground. If fuse is good, check for open.
30 to gnd	ON / OFF	B+	• If no voltage, check for short to ground or open.
86 to gnd	ON / OFF	B+	• If no voltage, check for failed relay.
87 to gnd	ON / OFF	0 V	• If greater than 0 volts, check for short to B+ or failed relay.

Voltage Checks - Relay (A/C Switch ON)

1. Turn Key Switch to OFF.
2. Remove A/C clutch relay and inspect for corrosion.
3. Connect relay breakout harness to to relay and socket.
4. Measure voltage with the Key Switch ON.
5. A/C system must be charged to specifications with the engine running and the A/C demand switch ON. (A/C Demand Signal at ECM X3-10 must be set low during these tests.)

TEST POINT	KEY SWITCH	SPECIFICATION	COMMENTS
86 to gnd	ON	0 to 0.25 V	• If greater than 0.25 volts, check for open or short to B+.
87 to gnd	ON	B+	• If no voltage, check for failed relay.

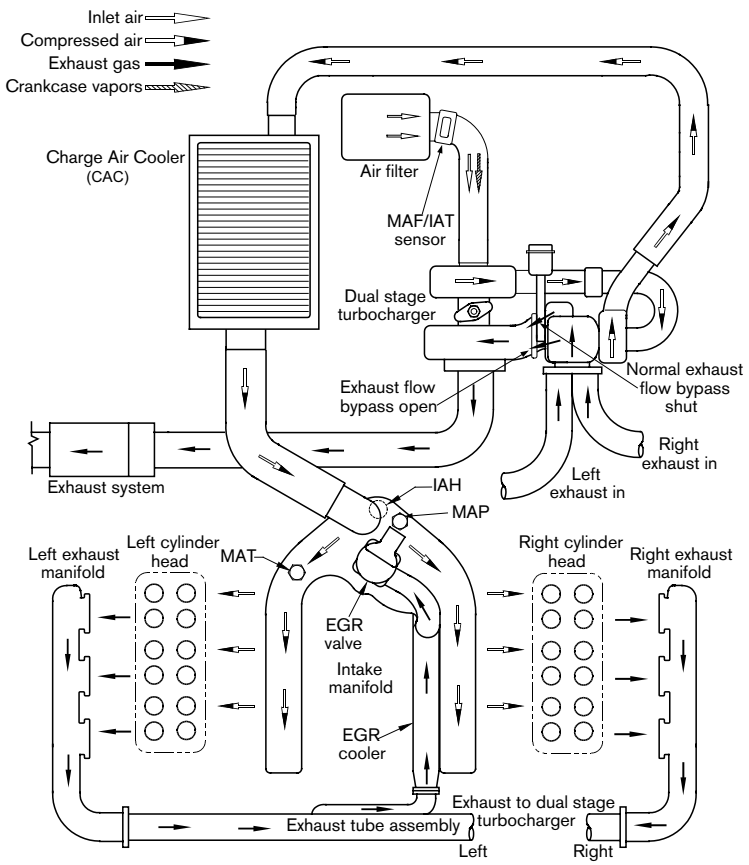
Voltage Checks - 12-pin Connector

1. Turn Key Switch to OFF.
2. Remove the 12-pin connector.
3. Inspect for bent pins or corrosion.
4. Connect 12-pin breakout harness to chassis harness.
5. Disconnect the A/C clutch connector.
6. Turn Key Switch ON.
7. A/C system must be charged to specifications with the engine running and the A/C demand switch ON.

TEST POINT	SPECIFICATION	COMMENTS
5 to gnd	B+	• If no voltage, check for short to ground or open.
7 to gnd	0 to 0.25 V	• If greater than 0.25 volts, check for open or short to B+.

AIR MANAGEMENT SYSTEM

- Regulated two-stage turbocharger
- Cooled exhaust gas recirculation
- Intake air heater



System Features

- The Air Management System consists of the air filter, two-stage turbocharger, charge air cooler, intake manifold, Exhaust Gas Recirculation (EGR) cooler and EGR valve. The mass air flow sensor, the intake air temperature sensor, the manifold air temperature sensor, the manifold absolute pressure sensor, and the EGR valve position sensors within the EGR valve are all inputs from the system to the ECM. The ECM controls the system through the EGR valve, and the turbocharger boost control solenoid.

System Operation

- The VT 275 uses a regulated two-stage turbocharger to boost the volume of air flowing into the cylinders. The system consists of two turbochargers with exhaust flow through the units controlled by the turbocharger boost control solenoid. The smaller of the two turbochargers is identified as the high-pressure turbocharger and is sized to provide boost for low to medium speeds. The larger turbo-

charger is the low-pressure turbo and is sized to work in tandem with the high-pressure unit to provide the boost and air flow needed for high-speed, high-load engine conditions.

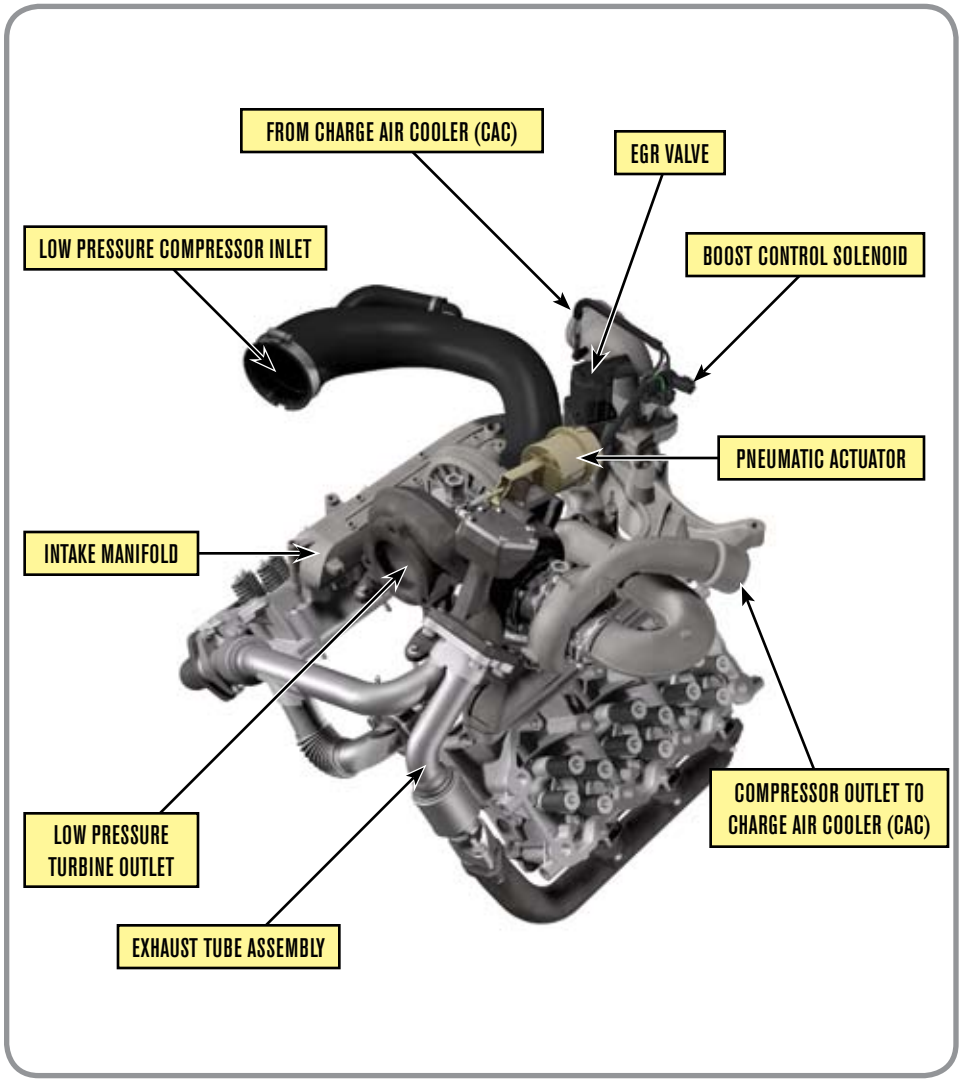
- Air passes through the air filter element and the mass air flow sensor to enter the compressor of the low-pressure turbocharger. Air that leaves the low-pressure compressor flows through the crossover tube to the compressor inlet of the high-pressure turbocharger. Air from the compressor goes to the Charge Air Cooler (CAC).

- The CAC is mounted in front of the radiator. The cooler is an air-to-air heat exchanger that uses airflow to remove heat energy from the pressurized intake charge. Reducing the temperature of the air increases the charge density, which results in a more efficient engine with quicker engine response and reduced emissions.

- After the CAC, the air flows through piping to the intake manifold where it is distributed to the cylinders.

- Exhaust flow from the cylinders exits the exhaust manifolds and spools up the high-pressure turbine. The exhaust passes through the high-pressure turbine and enters the low-pressure turbine. The exhaust gases then exit the turbine and flow out the exhaust system.

- A bypass valve controls the exhaust flow through a passage that allows a portion of the exhaust to bypass the high-pressure turbine and go directly to the low-pressure turbine. Part of the exhaust gas that leaves the left bank exhaust manifold is diverted to the EGR cooler. Heat energy is removed from the exhaust while in the cooler and transferred to the engine's coolant. The cooled exhaust gases then flow through a short internal passage in the intake manifold to the EGR valve. The EGR valve meters a portion of the cooled exhaust gases into the intake manifold where the exhaust displaces a portion of the fresh air charge.



Air Filter Restriction Gauge

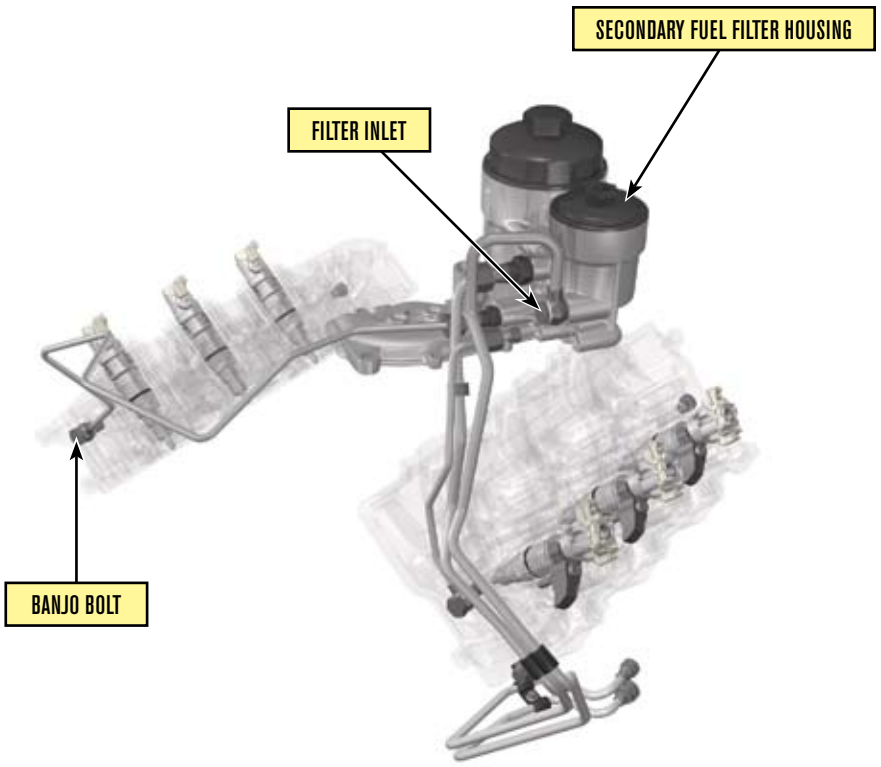
- The filter restriction gauge is mounted on the air filter housing. The gauge allows the operator to check the condition without removing the filter. The restriction gauge can be reset by pushing the yellow button on the end.

- **Note:** The filter restriction gauge bellows will lock in position if restriction exceeds 26 inches of water. The filter should be replaced and the gauge reset.

- The filter element should be replaced if restriction passes 12.5 inches of H_2O when tested at high-idle, no-load with a magnehelic gauge.

FUEL SUPPLY SYSTEM

- Chassis-mounted electric fuel pump
- Water-in-fuel detection
- Electric fuel heater
- Chassis-mounted primary fuel filter
- Engine-mounted secondary fuel filter element



System Features

- The VT 275 uses a chassis-mounted electric fuel pump. The pump is mounted with the fuel heater and primary filter in the Horizontal Fuel Conditioning Module (HFCM). The fuel pump relay, which is located in the Power Distribution Center (PDC), is controlled and monitored by the ECM.
- Water separated from the fuel in the HFCM is detected by the Water-in-Fuel (WIF) sensor. The sensor is an input to the ECM, which controls the WIF dash lamp through the CAN 1 link.
- The HFCM has both an electric fuel heater and a temperature controlled recirculation valve. The valve regulates recirculation through the system to assist the heater in warming the fuel. The secondary filter and fuel pressure regulator valve are mounted on the engine.

FUEL SUPPLY SYSTEM

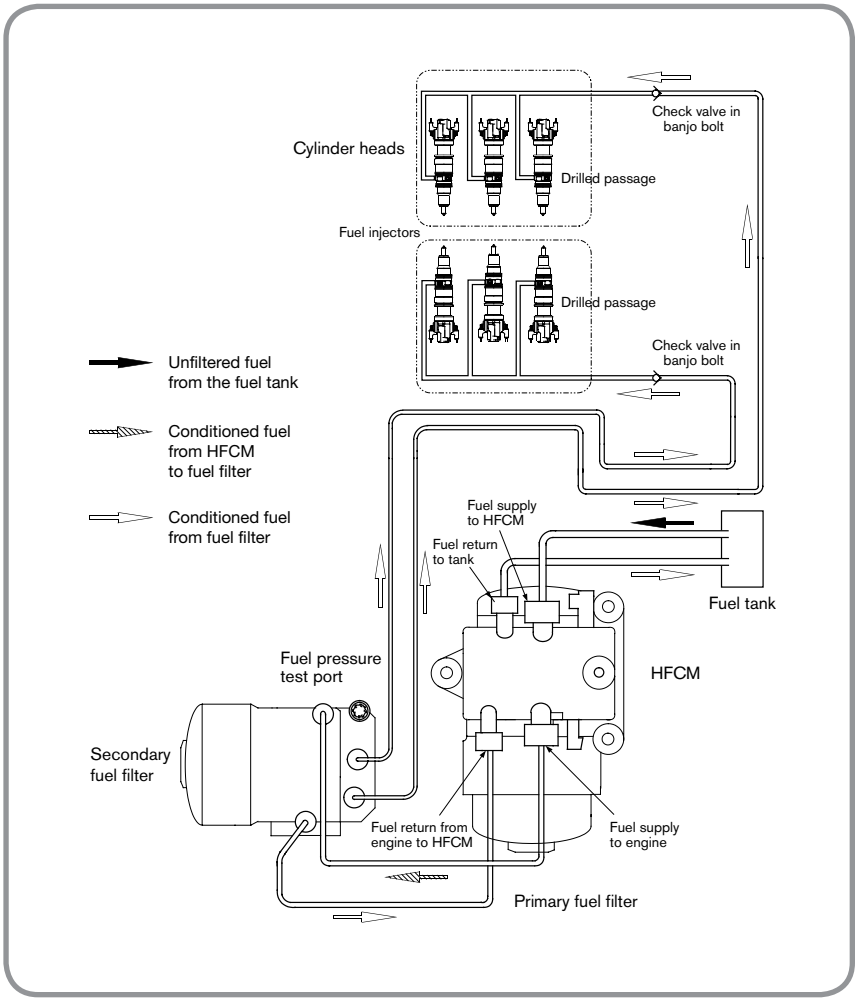
System Operation

- The fuel pump, fuel heater, pressure relief valve, Water-in-Fuel (WIF) sensor, recirculation valve, water drain and primary filter are all located in the Horizontal Fuel Conditioning Module (HFCM). The secondary filter, pressure regulator and banjo bolts are mounted on the engine.

- The ECM uses the fuel pump relay to activate the fuel pump at key-on. Fuel drawn from the tank contacts the electric fuel heater, passes through the one-way check valve, and enters the filter where water is separated. Fuel passes through the filter media and enters the pump inlet while water settles to the bottom of the housing until the level of water activates the WIF sensor. Pressurized fuel from the pump is routed to the engine-mounted filter. Fuel flows through the filter, then through individual steel lines to the cylinder heads. Each line is attached to the cylinder head with a banjo bolt. Each bolt contains an orifice and a check valve. Once in the head passages, fuel is distributed to the injectors.

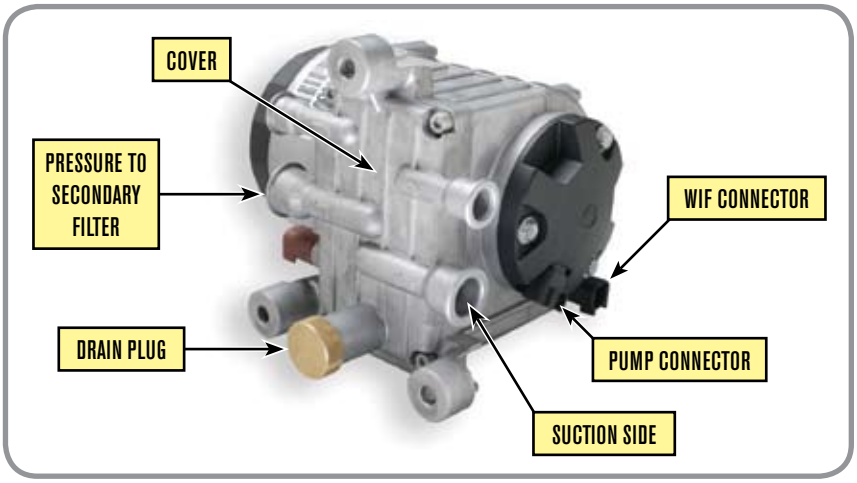
- Fuel is exposed to the pressure regulator in the secondary filter housing. The regulator returns excess fuel to the HFCM where it is directed to either the fuel tank or the pump inlet, depending on fuel temperature.

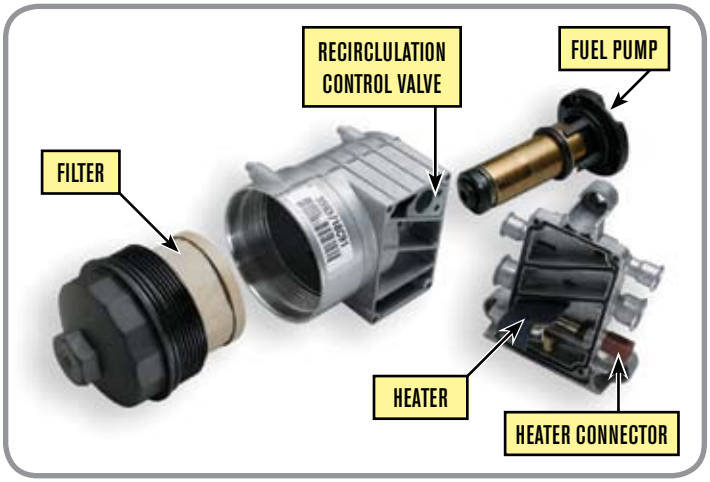
- Both filter elements push open a fuel passage valve when inserted into their respective housings. Without the filter in place, fuel will not flow through the system. The engine could start without the filter, but will not run properly.



Horizontal Fuel Conditioning Module (HFCM)

- The Horizontal Fuel Conditioning Module contains the fuel pump, fuel filter, WIF sensor, heater and the recirculation control valve. The water drain valve and all fuel connections are mounted on the module cover. The lower connection on the pump end of the module is the suction side to the tank and the lower connection on the filter side is pressure to the engine-mounted filter.

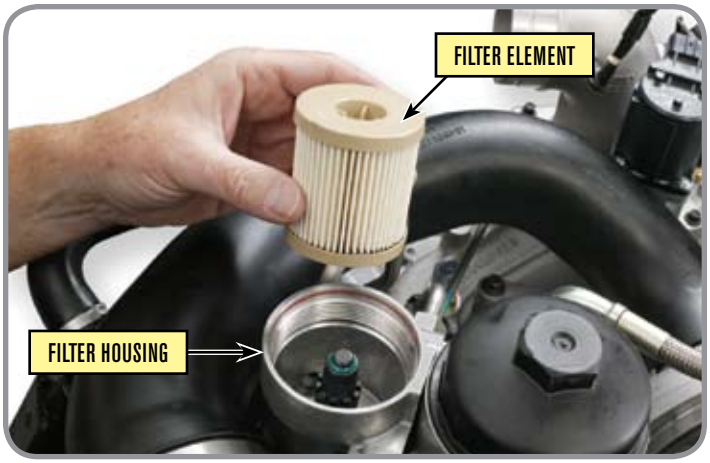




Primary Fuel Filter and Fuel Heater

- The HFCM contains a 10-micron primary fuel filter. The replaceable filter element opens a fuel passage in the end of the pump when the filter is inserted into the housing. Without the filter in place, sufficient fuel will not pass through the system for correct engine operation.

- Fuel from the tank is exposed to the electric fuel heater as it enters the HFCM module. The heater is controlled by the Key Switch start/run circuit and is selfregulating. The heater comes on when fuel temperature is below 50°F (10°C) and goes off at 80°F (27°C). Return fuel from the engine is recirculated to the suction side of the filter until the fuel temperature is sufficient to cause the recirculation valve to close. After the valve closes, all returned fuel is directed back to the tank.



Secondary Fuel Filter

- The secondary filter is a top-loaded, engine-mounted fuel filter. Fuel enters the filter housing under pressure from the fuel pump through the inlet line and banjo bolt. Fuel passes through the 4-micron filter element and through the filter stand pipe to enter the two fuel lines to the cylinder heads.

- The filter standpipe contains a valve that is opened by the filter when it is installed in the housing. Without the filter in place, sufficient fuel will not pass through the system for correct engine operation.

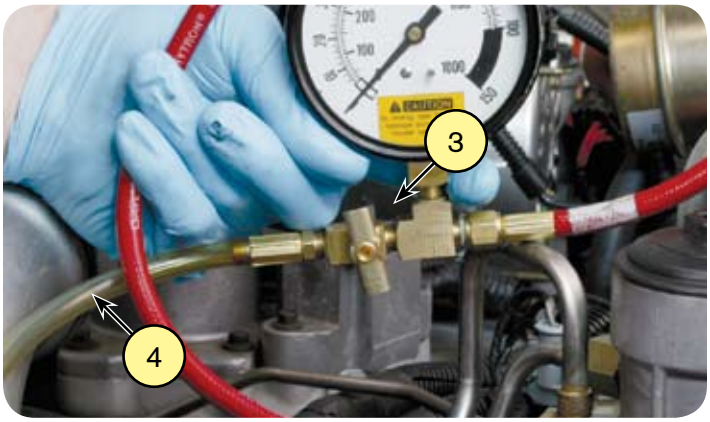
Measure Fuel Pressure

- The engine will not perform correctly with low fuel pressure. Fuel pressure can be measured at the secondary filter housing by removing the fuel pressure test port plug and install the ICP System Test Adapter (ZTSE4594) (1). Connect the Fuel Pressure Gauge (ZTSE4681) (2) to the ICP System Test Adapter. Turn the Key Switch to the **ON** position and measure the fuel pressure. The following pressure minimums should be met:

Cranking	20 psi
Idle	50 psi
High Idle/No load	50 psi
Full load @ rated speed	50 psi

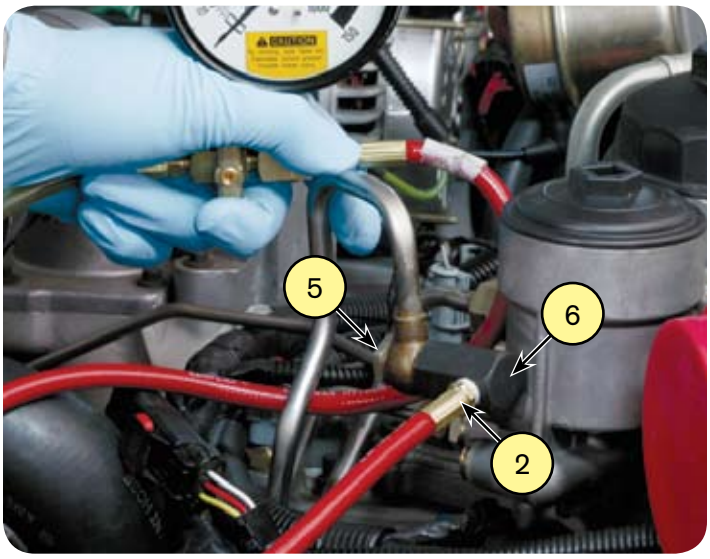
- If fuel pressure does not meet the minimum, verify there is fuel in the tank and the pump is running. Then check for fuel aeration, primary and secondary filter condition, pump inlet restriction, pump deadhead pressure, and pressure regulator operation.

Check for Fuel Aeration



- The engine will not operate correctly with aerated fuel. Aeration can be checked visually using a clear hose and valve.
- With the Key Switch in the **ON** position, open the valve (3) to allow fuel to flow into a clean container. Observe the fuel flow (4). Opening the system to install the hose will allow some air to enter the system. This air will be visible in the fuel flow initially but should clear within a few seconds.
- If the fuel continues to show signs of aeration, check the suction side of the system for air leaks.

Measure Fuel Pump Discharge Pressure



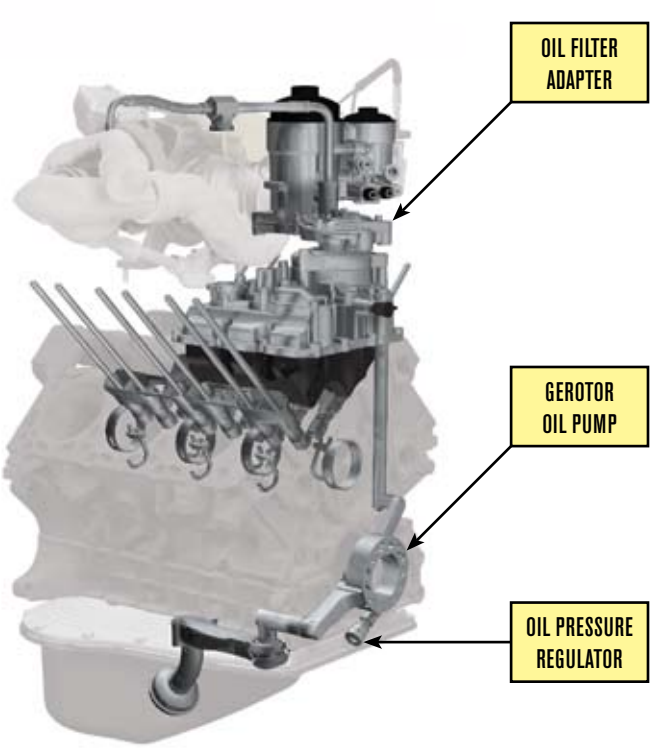
- Determine the ability of the fuel pump to develop pressure by isolating the fuel pump from the engine-mounted regulator.
- Remove the banjo bolt (5) on the pressure line at the secondary fuel filter and insert the bolt through the back of the fitting so that the bolt faces away from the engine. Install the Fuel Pressure Test Adapter (ZTSE4696) (6) and tighten the bolt. Attach a 0-160 psi Fuel Pressure Gauge (ZTSE4681) (2) to the test adapter. The fuel pump and its internal pressure regulator are now isolated from the engine-mounted fuel pressure regulator.
- Turn the Key Switch to the **ON** position and measure the fuel pressure while the pump is running. Pump discharge pressure should reach 80 psi. If the pressure is low, check for a plugged primary filter and/or high pump inlet restriction.

Measure Fuel Inlet Restriction

- High inlet restriction can starve the suction side of the fuel pump and cause low fuel pressure.
- With the Key Switch in the **OFF** position, remove the water drain plug from the fuel pump. Install the Fuel Inlet Restriction Adapter (ZTSE4698) in place of the plug. Connect the 0-30 in/hg pressure gauge to the adapter with a shut off valve in the **OFF** position between the pump and the Fuel Pressure Gauge (ZTSE4681).
- Turn the Key Switch to the **ON** position. With the fuel pump running, open the valve to the 0-30 in/hg pressure gauge and record the restriction.
- If inlet restriction causes a gauge reading of greater than 6 in/Hg, check the lines from the fuel tank to the pump for restrictions.

LUBRICATION SYSTEM

- Crankshaft driven lube oil pump
- Integrated oil cooler
- External oil pressure regulator
- Easy access canister oil filter
- Piston cooling jets



System Features

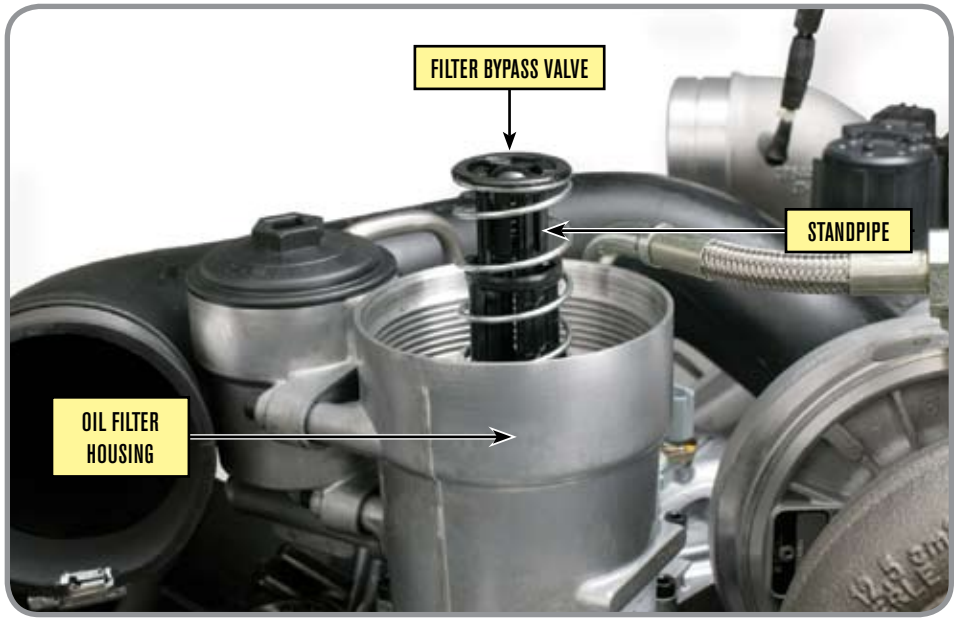
- The crankshaft driven oil pump is located behind the vibration damper and is integrated into the front cover.
- The oil pressure regulator valve is located in the front cover below the oil pump. The oil pressure regulator valve is accessed by removing the pressure regulator end plug.
- The oil cooler is located under the oil cooler cover within the engine's Vee. The cooler occupies a portion of the space within the high-pressure reservoir.
- The oil filter is a canister style filter located on top of the engine.

System Operation

- Oil that is sprayed through the piston cooling jets is used in order to reduce the piston crown temperatures.
- Oil discharged from the oil pump enters the oil cooler cover. If the oil is cold and thick the cooler bypass valve directs the oil directly to the oil filter. After passing through the filter, oil returns to the cooler cover assembly and is directed to the crankcase passages where oil is directed to the crankshaft main bearings, camshaft, lifters, piston cooling jets, and the valve train components.

Oil Filter Bypass

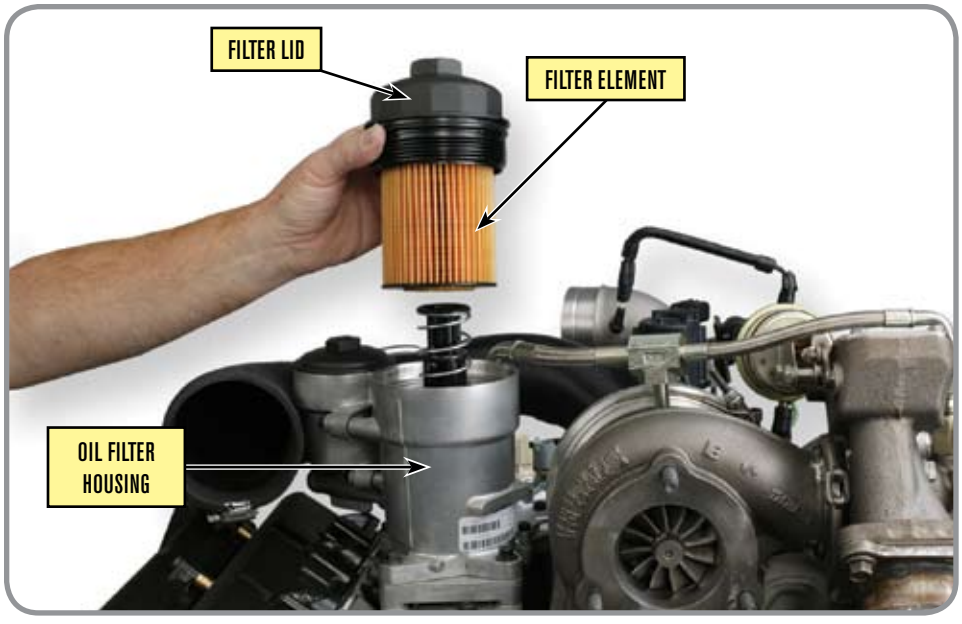
- The filter bypass valve is located at the top of the filter standpipe. The top of the oil filter element has a hole that matches the location of the valve. Unfiltered oil surrounds the filter, including the top of the filter and the bypass valve. The valve opens if there is a pressure difference of 32 psi between the outside of the paper filter material, which is unfiltered oil, and the inside of the filter paper.



Oil Filter

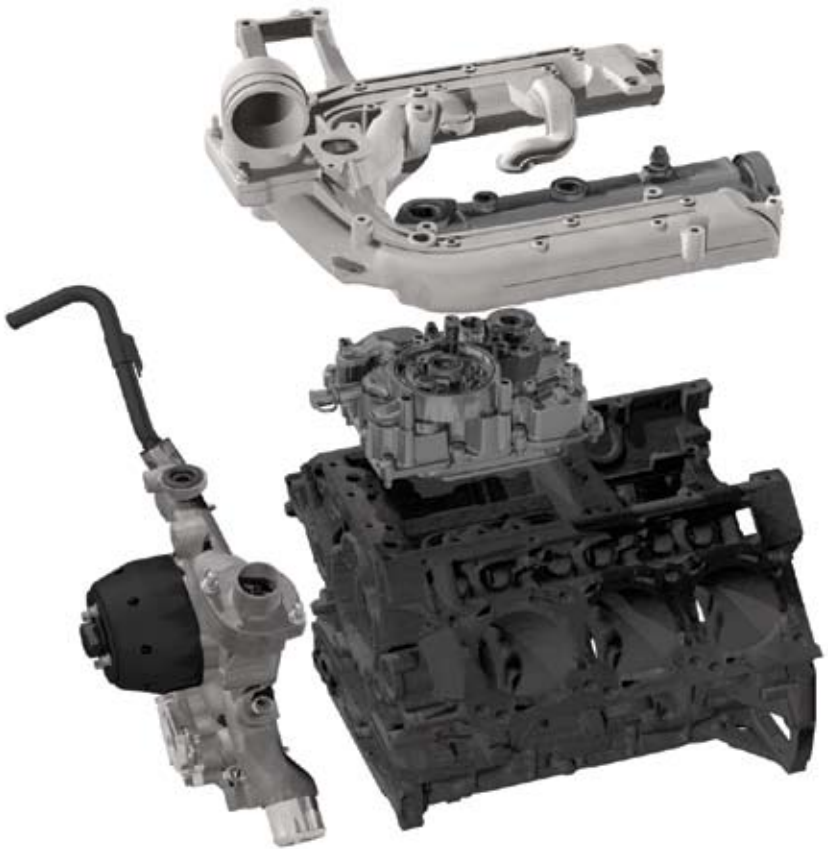
- The VT 275 uses a cartridge style oil filter located on top of the engine.

- When the oil filter is removed, the oil filter drain valve opens to allow oil to drain from the filter housing, through the adapter, and back to the oil pan. The oil filter element snaps onto the lid. This allows the filter element to be extracted without contact with the element.
- **Note:** The oil filter lid should be removed before draining the oil from the oil pan so that the oil can drain from the filter housing into the oil pan.



COOLING SYSTEM

- Modular water pump
- Stainless steel injector sleeves
- Stainless steel glow plug sleeves
- Extended life coolant



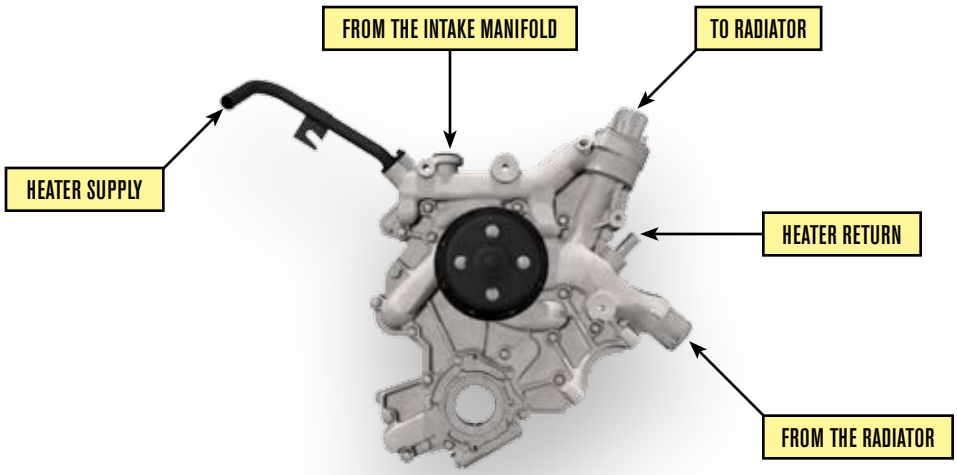
System Features and Flow

- The modular water pump mounts in the front cover and draws coolant from the radiator via the coolant inlet on the front cover. The water pump pushes coolant through two ports on the front cover to matching ports on the crankcase. Coolant flows through the crankcase and cylinder passages, then returns to the front cover. Coolant is then directed to the thermostat where coolant flows to either the bypass port or the radiator, depending on the coolant temperature. Coolant leaving the water pump is also directed to the oil cooler where it travels between the plates of the oil cooler and then to the EGR cooler.

COOLING SYSTEM

Front Cover Flow

- Coolant is drawn into the water inlet by the water pump. Coolant is discharged from the pump to the crankcase coolant jackets. Coolant is also routed from the front cover through a crankcase passage to the oil cooler cover.
- Return coolant from the crankcase coolant jackets is directed to the thermostat by the front cover. If the thermostat is open, coolant flows to the radiator to be cooled. If the thermostat is closed, coolant is returned to the water pump via a bypass circuit in the front cover.



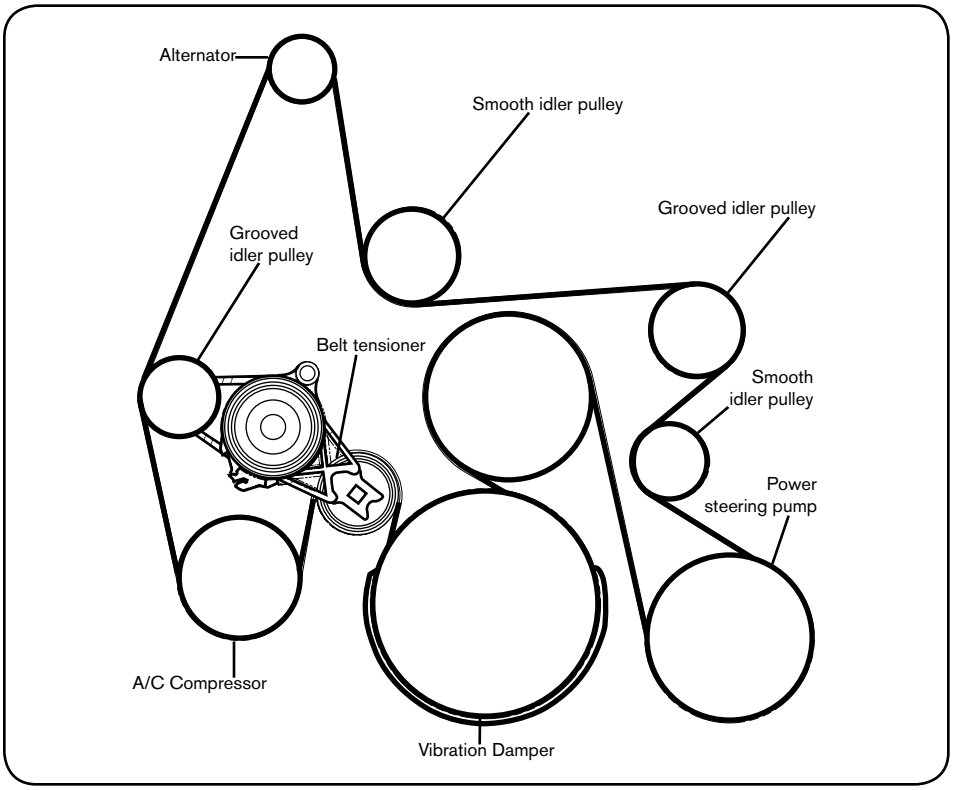
Service Intervals

- The VT 275 is designed to use Extended Life Coolants.
- Extended life coolant can be identified by its red/orange color in contrast to conventional green or blue antifreeze.
- The service interval is 5 years, 300,000 miles or 12,000 hours if the chemical extender is added at 30 months, 150,000 miles, or 6000 hours.
- **Note:** Do not add supplemental coolant additives like DCA4 to long-life coolant.

Service Intervals for the VT 275 Engine	
Change Oil and Filter	***7,500 mi., or 6 months**
Primary and Secondary Fuel Filter	***22,500 mi., or 18 months**
Coolant (Extended Life Coolant)	**300,000 miles / 12,000 hours / 5 years** (if extender is added at 30 months, 150,000 miles, or 6,000 hours)

Belt Routing

- The VT 275 uses one accessory drive belt. The belt must be routed correctly for the proper operation of the cooling fan, alternator, water pump and power steering pump.
- The engine uses a combination of grooved and smooth idler pulleys. The large diameter smooth pulley is located to the left of the engine's center when viewed from the front.
- The smaller smooth pulley is the lower idler on the right side of the front cover when viewed from the front of the engine.



SPECIAL TOOLS

ZTSE4698

- Fuel Inlet Restriction Adapter

ZTSE4693

- Relay Breakout Harness (ECM)

ZTSE4755

- Relay Breakout Harness (IDM)

ZTSE4754

- APS Harness

ZTSE4665

- 12-Pin Breakout Harness

ZTSE7559

- Vacuum Pump and Gauge

ZTSE4526

- Fuel / Oil Pressure Test Coupler

ZTSE4542

- Fuel Pressure Test Fitting

  (used for oil pressure measurement)

ZTSE4594

- ICP System Test Adapter

ZTSE4681

- Fuel Pressure Gauge

ZTSE4696

- Fuel Pressure Test Adapter

- Digital Multimeter

HARD START / NO START and PERFORMANCE DIAGNOSTICS

= Hard Start / No Start Diagnostics

= Performance Diagnostics

- Initial Ignition Key-ON
- Engine Cranking
- Diagnostic Trouble Codes
- Key-OFF Engine-OFF (KOEO) Standard Test
- Visual Inspection
- Engine Oil
- Fuel Supply System
- Main Power Relay Voltage to the ECM
- Main Power Relay Voltage to the IDM
- Glow Plug System
- Inlet Air Heater

WARNING: To avoid personal injury, death, or vehicle damage, refer to the safety Information in the beginning of this book before working on the vehicle.

CAUTION: Do the following checks in sequence unless stated otherwise. Doing a check or test out of sequence could cause incorrect results.

Initial Ignition Key-ON

Purpose: Verify that the ECM and IDM are receiving battery power.

Tools: None.

WARNING: To avoid personal injury, death, or vehicle damage, refer to the Safety Information in the beginning of this book before working on the vehicle.

1. Verify ECM Power

1. Turn the Key Switch to the **ON** position.
2. Check the WAIT TO START dash lamp. The dash lamp should come on before the other dash lamps self test. Check for the following if the lamp does not operate correctly:
   - No key power (VIGN) to the ECM.
   - Failed ECM ground circuit.
   - No power from main power relay to the ECM.
   - The CAN1 link is not working (will not cause hard start or no start).
   - ECM failure.
   - WAIT TO START lamp is defective (will not cause hard start or no start).

2. Verify IDM Power

1. Turn the Key Switch to the **ON** position and listen for the injector pre-cycle (All the injectors should buzz together when the Key Switch is first turned on). Check for the following if the pre-cycle does not occur:
   - No key power (VIGN) to the IDM or ECM.
   - Failed IDM or ECM ground circuit .
   - No power from main power relay to the IDM.
   - CAN2 link is not working.
   - IDM failure.
   - ECM has a power or ground problem.

3. Check for Water In Fuel

1. Turn the Key Switch to the **ON** position.
2. Check the WATER-IN-FUEL dash lamp. The lamp should not stay on after the dash self test is completed. Check for the following if the lamp is illuminated:
   - Water in fuel.
   - Corroded housing or connectors (will not cause hard start or no start).
   - Circuit failure (will not cause hard start or no start).

4. Check for Fuel Pump Operation

1. Turn the Key Switch to the **ON** position. Listen for a hum or buzz from the electric fuel pump after initial key on; the pump should stay on for 60 seconds then cycle off if the engine was not started. Check for the following if the pump does not operate:
   - Faulty fuel pump relay or fuse.
   - Fuel pump failure.
   - No key power (VIGN) to the ECM.
   - Wiring failure from ECM to relay.
   - Wiring failure from relay to pump.
   - ECM failure.

Engine Cranking

Purpose: Verify the engine cranking speed is sufficient to start the engine.

Tools:

- EST with MasterDiagnostics® software (optional).
- EZ-Tech® interface cable (optional).

WARNING: To avoid personal injury, death, or vehicle damage, refer to the Safety Information in the beginning of this book before working on the vehicle.

See "Appendix A: VT 275 Performance Specifications" for specifications, and enter data in "Spec" column for rpm.

1. Check for Crankshaft Rotation

1. Turn the Key Switch to the **START** position. Monitor the rpm on the instrument panel and the Electronic Service Tool (EST) if available. If the engine cranking speed is below the specification, do not continue with additional testing until that problem is corrected. Check for the following if cranking speed is below specification:
    - Low or no battery power.
    - Insufficient power to ECM.
    - Starting system failure.
    - Circuit fault for Engine Crank Inhibit (ECI).
    - Cylinder hydraulic lock.
    - Incorrect oil viscosity.
    - Cold temperature.

2. Check for Exhaust Smoke

1. Check for exhaust smoke while trying to start the engine. Observe the tail pipe and note the color of any exhaust smoke. Check for the following if excessive smoke occurs while cranking:
    - Glow plug system failure.
    - Failed air heater system.
    - Poor fuel quality.
    - Excessive air inlet or exhaust restriction.
    - Low cylinder temperature.
    - Loose injector.
    - Low compression.

NOTE: If smoke is seen, typically excess fuel is getting in the cylinders.

NOTE: The engine may run rough and produce white smoke after the fuel filter has been serviced or the fuel system opened. This occurs because air has entered the fuel system. This is normal and should stop after a short time.

Diagnostic Trouble Codes

Purpose: Verify there are no active DTCs.

Tools:

- EST with MasterDiagnostics® software (optional).
- EZ-Tech® interface cable (optional).

WARNING: To avoid personal injury, death, or vehicle damage, refer to the Safety Information in the beginning of this book before working on the vehicle.

1. Access DTCs

1. Set the parking brake
2. Turn the Key Switch to the **ON** position.
3. Move the cruise switch slide switch from **OFF** to **R/A**, and then release within 3 seconds.
4. DTCs will flash on the red and amber lamps in the instrument panel.

2. Reading DTCs

1. Two types of DTCs are displayed; active and inactive. Both are three digit codes. The red lamp will flash once to indicate the beginning of the active DTCs, and then the amber lamp will flash the first digit of the first DTC. The number of amber flashes is the first digit. After the first digit there will be a short pause then the lamp will flash the second digit.

   Example: Two amber flashes, a pause, three amber flashes, a pause, and two amber flashes and a pause indicates a DTC 232.

2. If there is more than one active DTC, the red lamp will flash once indicating the beginning of another active DTC.
3. After all the active DTCs have been displayed, the red lamp will flash twice to indicate the start of inactive DTCs.
4. After all DTCs have been flashed the red lamp will flash 3 times.

   - Active DTCs: Active indicates a DTC for a condition currently in the system.
   - Inactive DTCs: Inactive indicates a DTC for a condition during a previous key cycle.
   - Active/Inactive: Active/inactive indicates a DTC that is active now and was present in the last key cycles if the codes were not cleared.

Key-OFF Engine-OFF (KOEO) Standard Test

Purpose: Verify there are no active DTCs after the KOEO Standard test.

Tools:

- EST with MasterDiagnostics® software (optional)
- EZ-Tech® interface cable (optional)

WARNING: To avoid personal injury, death, or vehicle damage, refer to the Safety Information in the beginning of this book before working on the vehicle.

1. Perform Standard Test using MasterDiagnostics®

1. Set parking brake.
2. Turn Key Switch to **ON**. (Do not crank engine.)
3. Select ***Diagnostics*** from the menu bar.
4. Select ***Key-On Engine-Off Tests*** from the drop down menu.
5. From the KOEO Diagnostics menu, select ***Standard***, then select ***Run*** to start the test. When the test is completed, the DTC window will show DTCs if a problem has been detected.

2. Perform standard test using the cruise switches

Use the following method to check the DTCs if MasterDiagnostics® is not available:

1. Set the parking brake.
2. Turn Key Switch to **ON**. (Do not crank the engine.)
3. Move slide switch from **OFF** to **R/A** and then release.
4. Move slide switch to **R/A** within three seconds and standard test will run.
5. DTCs will be displayed through the red and amber engine dash lamps.

Note: The following actuators are tested during the Standard test:

- 241 Injection Pressure Regulator (IPR) solenoid or IPR control circuit.
- 238 Inlet Air Heater (IAH) relay coil or relay control circuit.
- 251 Glow plug relay coil or relay control circuit.
- 237 Fuel pump relay coil or relay control circuit.

Visual Inspection

Purpose: Verify that there is no visible damage to the engine systems.

Tools:
- Inspection lamp

WARNING: To avoid personal injury, death, or vehicle damage, refer to the Safety Information in the beginning of this book before working on the vehicle.

1. **Check for fuel, oil, and coolant leaks that may indicate more extensive engine damage.**

2. **Check the Electrical System**
    1. Check the relays and control module connections. All connections must be seated, in good condition, and free of damage or corrosion.
    2. Check the glow plug relay and IAH relay for corrosion.
    3. Check battery cable connections for corrosion. All connections must be seated, in good condition, and free of damage or corrosion.
    4. Check engine wiring harness for correct routing and protection against rubbing or chaffing.

3. **Check the Engine Sensors and Actuators**
   The engine will not start if the following components are disconnected or damaged:
    - Injection Pressure Regulator (IPR) valve
    - Camshaft Position (CMP) sensor
    - Crankshaft Position (CKP) sensor

4. **Check the Filter Minder**
    1. When the filter element reaches maximum allowable restriction, the indicator will reach the top of the window and automatically lock in this position.

5. **Inspect the following parts for restriction, damage or incorrect installation:**
    - Air filter inlet and duct.
    - Air inlet hoses and clamps.
    - Air filter housing, filter element, and gaskets.
    - Boost control solenoid hose harness
    - Exhaust pipes.
    - Chassis mounted CAC and piping.
    - Air filter restriction indicator (if equipped).

    NOTE: Unfiltered air will cause accelerated engine wear.

    If leaks in the air induction system are suspected, check for air filter element end seal movement inside the housing. End seal movement is indicated, if the seal contact area is polished.

    NOTE: Intake restriction should be below 6.2 kPa (25 in H_2O) at full load condition. Intake restriction performed for this test at high idle should be below 3.1 kPa (12.5 in H_2O).

6. **Check for exhaust system restriction**
    1. Inspect the entire exhaust system for bent, damaged, or kinked exhaust pipes. The following can cause a no-start condition:
        - Tailpipe or muffler may be damaged or collapsed.
        - Plugged or restricted Catalytic converter - if equipped.

Engine Oil

Purpose: Verify the engine has the correct oil level for injector operation.

Tools: None.

WARNING: To avoid personal injury, death, or vehicle damage, refer to the Safety Information in the beginning of this book before working on the vehicle.

NOTE: Never check the oil level when the engine is running or immediately after engine shutdown; the reading will be inaccurate. Allow 15 minute drain down time, before checking oil level.

NOTE: If the oil level is too low, the fuel injectors will not work correctly. If the oil level is above the operating range, the engine has been incorrectly serviced, fuel is in the oil, or coolant is in the oil.

1. Check Engine Oil

1. Check the engine oil level with the vehicle on parked on level ground after the engine has been off for at least 15 minute. Check for the following if the oil level is incorrect:
    - Low oil level.
    - Oil leak.
    - Oil consumption.
    - Incorrect servicing.
    - High oil level.
    - Fuel in oil.
    - Coolant in oil.
    - Incorrect oil level gauge.

2. Check Oil for Contamination

1. Check the oil for the thickening. Oil contaminated with long life coolant will cause thickening or coagulation.
2. Does oil have a diesel fuel odor?
3. Check engine service records for correct oil grade and viscosity for ambient operating temperatures.
4. See "Lubrication Requirements" in the Engine Operation and Maintenance Manual (for engineís model number and model year). Confirm that oil meets correct API category.

CAUTION: Do not use 15W-40 oil below -7 °C (20 °F). Long oil drain intervals can increase oil viscosity; thicker oil will make engine cranking and starting more difficult below freezing temperatures.

Fuel Supply System

Purpose: Verify that the fuel system is producing the correct pressure.

Tools:

- 0-160 psi gauge
- ICP System Test Adapter
- In-line shut off valve
- 3/8 inch clear sample line
- Clear container with a wide opening

WARNING: To avoid personal injury, death, or vehicle damage, refer to the Safety Information in the beginning of this book before working on the vehicle.

See EGES 305-1 "Appendix A: VT 275 Performance Specifications" (page 579) for fuel pump pressure specification and record on Diagnostic Form.

1. Verify the Fuel Quantity

1. Check the fuel level in fuel tank. Check the fuel tank for odors of kerosene, alcohol, or gasoline.

2. Verify Fuel Pump Operation

1. Turn the Key Switch to the **ON** position; listen for a hum coming from the fuel pump. The ECM turns the pump on; it should run for 60 seconds. After 60 seconds the ECM turns the pump off unless the engine is running. See page 35 for additional diagnostic steps if the pump cannot be heard running.

NOTE: The engine may run without the fuel pump, but damage to the injectors could occur.

3. Taking a Fuel Sample

1. Place a container under the secondary fuel filter test port plug.
2. Remove the plug.
3. Use the ICP System Test Adapter to attach the 160 psi pressure gauge to the port.
4. Run the clear test line to a clear container, and then turn the Key Switch to the **ON** position.
5. Open the in-line shut off valve to collect the fuel sample.
6. Check the test line for air bubbles while the pump is operating.
7. Check the sample for contamination.

NOTE: Breaking any fuel system joints will induce air in the fuel system. The air bubbles should stop shortly. A continuous flow of bubbles can indicate a leak on the suction side of the system.

4. Measure Engine Fuel Pressure

1. Close the in-line shut off valve.
2. Turn the Key Switch to the **ON** position and check the fuel pressure gauge when the pump starts:
    - If fuel pressure is below specification, replace both the primary and secondary fuel filters and retest.
    - If the engine fuel pressure is still below specification, measure the fuel pump's discharge pressure.

Fuel Supply System CONTINUED

5. Measuring Fuel Pump Discharge Pressure

1. Place a suitable container under the secondary fuel filter housing banjo bolt (2).
2. Remove the bolt and connect the Fuel Pressure Test Adapter to the fuel supply line, using the banjo bolt and original copper gaskets.

   NOTE: Use existing copper gaskets from the banjo bolt for testing. Replace the copper gaskets when testing is over and repairs have been made.

3. Turn the Key Switch to the **ON** position.
4. Read the fuel pressure gauge.

   - If the pump discharge pressure is within specifications, the fuel pump is good. The low engine fuel pressure is the result of a restricted line from the pump to the engine or the pressure regulator valve in the secondary filter housing is stuck open.
   - If the pump discharge pressure is low, check the pump inlet restriction.

6. Measuring Pump Inlet Restriction

1. Put a clean drain pan under the fuel pump drain plug.
2. Clean the drain plug and the area around the plug.
3. Open the drain plug and drain the pump.
4. Install the fuel inlet restriction adapter hand tight.
5. Connect a 0-30 in. Hg Gauge to the adapter through an in-line shut off valve.
6. Close the valve.
7. Turn the Key Switch to the **ON** position and open the shutoff valve.
8. Check the gauge reading:
   - If the reading is above 6 in. Hg, check for a restriction in the fuel line between the pump and the tank pick-up opening.
   - If reading is below the specification when the fuel pump discharge pressure is low, the fuel pump is faulty.

Main Power Relay Voltage to the ECM

Purpose: Verify that the ECM is receiving a minimum of seven volts.

Tools:

- 12-Pin Breakout Harness
- Digital Multi-Meter (DMM)

WARNING: To avoid personal injury, death, or vehicle damage, refer to the Safety Information in the beginning of this book before working on the vehicle.

NOTE: Batteries must be fully charged before performing the following tests.

1. Measure Voltage supplied to the ECM
    1. Turn the Key Switch to **OFF**.
    2. Remove the ECM relay from the power distribution center.
    3. Install the ECM Relay Breakout Harness between the main power relay and the power distribution center.
    4. Connect the positive DMM lead to pin 87 and the DMM negative lead to a good ground.
    5. Measure the voltage while cranking the engine for 20 seconds. The Voltage should not go below 7 volts. Check for the following if the relay provides less than 7 volts to the ECM:
        - Discharged batteries.
        - Corroded or loose connections.
        - Failed batteries.
        - High-resistance at battery cable connections.
        - The ECM main power fuse in the power distribution center may be open.
        - High-resistance or an open power feed circuit to the ECM or ECM power relay.
        - Failed ECM main power relay.
        - Key Switch circuit problem failed fuse.
        - Low or no battery voltage to the ECM.
        - Failed ECM.

2. If the voltage is low, go to "ECM Power Relay" diagnostics, page 25.

Main Power Relay Voltage to the IDM

Purpose: Verify that the IDM is receiving a minimum of seven volts.

Tools:

- 12-Pin Breakout Harness
- Digital Multi-Meter (DMM)

WARNING: To avoid personal injury, death, or vehicle damage, refer to the Safety Information in the beginning of this book before working on the vehicle.

NOTE: Batteries must be fully charged before performing the following tests.

1. Measure the Voltage supplied to the IDM
    1. Turn the Key Switch **OFF**.
    2. Disconnect the 12-pin chassis harness to engine harness connector.
    3. Connect the 12-Pin Breakout harness between both connectors.
    4. Connect the DMM positive lead to Pin 12 (IDM PWR) and the negative lead to pin 1(IDM GND).
    5. Measure the voltage while cranking the engine for 20 seconds. The voltage should not go below 7 volts.
    6. Check the following if the IDM relay supplies less that 7 volts to the IDM:
        - High-resistance at battery cable connections.
        - Low battery voltage.
        - Corroded or loose connections.
        - Open Wiring to the IDM.
        - The IDM fuse open.
        - Failed IDM relay.
        - Failed IDM.

2. If the voltage is low, go to "IDM Power Diagnostics", page 27.

Glow Plug System

Purpose: Verify that the glow plug system is operating correctly.

Tools:

- EST with MasterDiagnostics® software (optional)
- EZ-Tech® interface cable (optional)
- Digital Multi-Meter (DMM)
- Amp Clamp

WARNING: To avoid personal injury, death, or vehicle damage, refer to the Safety Information in the beginning of this book before working on the vehicle.

1. **Measure the left bank AMP draw**
    1. Install the inductive lead of an ammeter or Amp Clamp around the feed wire loom for the left bank glow plugs.
    2. Turn the Key Switch to the **ON** position.
    3. After 40 seconds, measure the amperage.
    4. Turn the Key Switch **OFF**. The amp draw should be 24-42 amps.

2. **Measure the Right bank AMP draw**
    1. Install the inductive lead of an ammeter or Amp Clamp around the feed wire loom for the right bank glow plugs.
    2. Turn the Key Switch to the **ON** position.
    3. After 40 seconds, measure the amperage. The amp draw should be 24-42 amps:
        - If the amperage on both banks is to specification and no glow plug related DTCs were set, the glow plug system is working correctly and is not the starting problem.
        - If the amperage is low, measure the resistance of each glow plug on the low bank.

3. **Measure individual glow plug resistance**
    1. Disconnect the three pin connector from the bank with low amperage draw.
    2. Use a DMM to measure the resistance of each pin through the glow plug to ground.
        - If a circuit has more than 6 ohms, disconnect the harness from the glow plug and check the resistance from the glow plug to ground.
        - If a glow plug has more than 6 ohms, the plug is defective

4. **The following are possible causes of low amperage draw:**
    - Poor wiring harness connection.
    - Poor ground connection.
    - Failed glow plug relay.
    - Failed glow plugs.
    - Failed ECM.

Inlet Air Heater

Purpose: Verify that the Inlet Air Heater system is operating correctly

Tools:

- EST with MasterDiagnostics® software (optional)
- EZ-Tech® interface cable (optional)
- Digital Multi-Meter (DMM)
- Amp Clamp

WARNING: To avoid personal injury, death, or vehicle damage, refer to the Safety Information in the beginning of this book before working on the vehicle.

1. Measure Inlet Air Heater amperage draw

1. Install the inductive lead of an ammeter or Amp Clamp around the lead to the Inlet Air Heater element.
2. Turn Key Switch to the **ON** position.
3. After 5 seconds, measure the amperage:
   - If amperage is 50+/- 5 amps and no inlet air heater DTCs were set, the IAH system is working correctly and is not the starting problem.
   - If the amperage is not to specification, measure the voltage at the element.

2. Measure element voltage during operation

1. Connect the DMM positive lead to IAH element terminal.
2. Connect the DMM negative lead to the alternator ground.
3. Turn Key Switch to the **ON** position. The element should have approximately battery voltage:
   - If the amperage draw is low and the voltage is OK, the element is at fault.
   - If the amperage is low and the voltage is low, check for high resistance in the circuit supplying the element.

3. The following are possible causes of low amperage draw:

- Poor wiring harness connection.
- Poor ground connection.
- Failed relay.
- Failed element.
- Failed ECM.

DIAGNOSTIC TROUBLE CODES for WORKHORSE CHASSIS APPLICATIONS

Consult service literature for latest information before attempting any repairs.

● = Code is applicable to Workhorse Chassis

W	DTC	CIRCUIT	CONDITION DESCRIPTION	COMMENTS	PROBABLE CAUSES
●	111	ECM	No errors - flash code only	Instrument panel code only, retrieving DTCs using cruise switches	No faults detected by the ECM
●	112 ✓	ECM PWR	Electrical system voltage B+ out of range high	ECM voltage continuously > 23.2v	Charging system fault
●	113 ✓	ECM PWR	Electrical system voltage B+ out of range low	ECM voltage < 7v - cause of no start/rough idle	Low VBAT, loose connection/resistance in circuit
	114 *	ECT	Engine Coolant Temperature signal out of range low	Default 180 °F / 82 °C - no fast idle, < 0.127v	ECT circuit short to GND, failed sensor
	115 *	ECT	Engine Coolant Temperature signal out of range high	Default 180 °F / 82 °C - no fast idle, < 4.6v	ECT circuit OPEN or short to PWR, failed sensor
	121 *	MAP	Intake Manifold Absolute Pressure signal out of range high	Default inferred MAP - low power, slow acceleration, > 4.9v	MAP circuit short to PWR, failed sensor
	122 *	MAP	Intake Manifold Absolute Pressure signal out of range low	Default inferred MAP - low power, slow acceleration, < 0.039v	MAP circuit OPEN or short to GND, failed sensor
	123 *	MAP	Intake Manifold Absolute Pressure signal in-range fault	Default inferred MAP - low power, slow acceleration	MAP sensor plugged, failed sensor
	124 *	ICP	Injection Control Pressure signal out of range low	Default open loop control - under run at idle, < 0.039v	ICP circuit OPEN or short to GND, failed sensor
	125 *	ICP	Injection Control Pressure signal out of range high	Default open loop control - under run at idle, > 4.9v	ICP circuit short to PWR, failed sensor
	126 *	BCP	Engine Brake Control Pressure signal out of range low	Engine Brake disabled, < 0.039v	BCP circuit OPEN or short to GND, failed sensor
	127 *	BCP	Engine Brake Control Pressure signal out of range high	Engine Brake disabled, > 4.9v	BCP circuit short to PWR, failed sensor
●	131 * ✓	APS/IVS	Accelerator Position Sensor signal out of range low	Engine idle only, < 0.147v	APS circuit OPEN or short to GND, defective sensor
●	132 * ✓	APS/IVS	Accelerator Position Sensor signal out of range high	Engine idle only, > 4.55v	APS circuit short to PWR, engine VREF concern, defective sensor
●	133 * ✓	APS/IVS	Accelerator Position Sensor signal in-range fault	Engine idle only, APS / IVS conflict	Failed APS signal
●	134 * ✓	APS/IVS	Accelerator Position Sensor signal and Idle Validation switch disagree	Engine idle only, APS / IVS conflict	Both APS and IVS signal failure
●	135 * ✓	APS/IVS	Idle Validation Switch circuit fault	50% APS only, APS / IVS conflict	Failed IVS signal
	136	EFP	Engine Fuel Pressure signal out of range low	Fuel Filter restriction indication disabled, < 0.039v	EFP circuit OPEN or short to GND, failed sensor
	137	EFP	Engine Fuel Pressure signal out of range high	Fuel Filter restriction indication disabled, > 4.9v	EFP circuit short to PWR, failed sensor
●	141 ✓	VSS	Vehicle Speed Sensor signal out of range low	Speedo, cruise, PTO disabled - eng. RPM limited - signal frequency, < 0.048v	VSS circuit OPEN or short to GND
●	142 ✓	VSS	Vehicle Speed Sensor signal out of range high	Speedo, cruise, PTO disabled - eng. RPM limited - signal frequency, > 0.048v	VSS circuit short to PWR or engine VREF concern
	143	CMP	Incorrect CMP signal signature	CMP signal intermittent	Poor connection, failed sensor, electrical noise
	145	CMP	CMP signal inactive	No start, No CMP signal, while CKP signal active and/or ICP signal above engine specific set point	CMP circuit OPEN, short to GND or PWR, failed sensor
	146	CMP	CMP signal inactive	No start, No CMP signal, while CKP signal active and/or ICP signal above engine specific set point	CMP circuit OPEN, short to GND or PWR, failed sensor

✓ See Chassis Circuit Diagrams and Engine Diagnostics Manual for more information.
* Indicates Amber ENGINE lamp on when a Diagnostic Trouble Code (DTC) is set.
** Indicates Red ENGINE lamp on when Engine Warning Protection System (EWPS) is enabled and a DTC is set.

DIAGNOSTIC TROUBLE CODES for WORKHORSE CHASSIS APPLICATIONS

W	DTC	CIRCUIT	CONDITION DESCRIPTION	COMMENTS	PROBABLE CAUSES
	147	CKP	Incorrect CKP signal signature	CKP signal intermittent	Poor connection, failed sensor, electrical noise
●	148 *	MAF	Mass Air Flow signal frequency out of range low	Default inferred MAF, EGR disabled, < 200Hz	MAF circuit OPEN or short to GND
●	149 *	MAF	Mass Air Flow signal frequency out of range high	Default inferred MAF, EGR disabled, > 11500Hz	MAF sensor defective, noise interference
●	152 * ✓	BAP	Barometric Absolute Pressure signal out of range low	Default 101 kPa, < 1.0v	BAP circuit OPEN or short to GND, defective sensor
●	153 ✓	WIF	Water In Fuel Sensor signal out of range high	Water in Fuel lamp disabled, >4.5v	WIF circuit short to PWR
●	154 * ✓	IAT	Intake Air Temperature signal out of range low	Default 77 °F / 25 °C, < 0.127v	IAT circuit short to GND, defective sensor
●	155 * ✓	IAT	Intake Air Temperature signal out of range high	Default 77 °F / 25 °C, > 4.6v	IAT circuit OPEN or short to PWR, defective sensor
	161 *	MAT	Manifold Air Temperature signal out of range low	EGR disabled, < 0.098v	MAT circuit short to GND, failed sensor
	162 *	MAT	Manifold Air Temperature signal out of range high	EGR disabled, > 4.6v	MAT circuit OPEN or short to PWR, failed sensor
	163 *	EGR	Exhaust Gas Recirculation valve position signal out of range low	EGR disabled (2002-03 VT 365 only, < 0.3v), All 2004-up error message position	EGRP circuit OPEN or short to GND, failed sensor - position PWR or GND
	164	EGR	Exhaust Gas Recirculation valve position signal out of range high	EGR disabled (2002-03 VT 365 only, > 4.8v)	EGRP circuit short to VREF or VBAT, failed sensor
●	166 *	MAF	Mass Air Flow Sensor signal in-range fault	MAF signal above calibrated limit KOEO, MAF sensor out of calibrated limit KOER	Plugged or leaking intake or exhaust, biased MAF sensor
●	167 *	MAF	Excessive Mass Air Flow	MAF signal setpoint above excessive calibrated limit	MAF circuit OPEN, short to GND or PWR, biased MAF sensor
	211 *	EOP	Engine Oil Pressure signal out of range low	EWPS disabled, default 50 psi, < 0.039v	EOP circuit OPEN or short to GND, failed sensor
	212 *	EOP	Engine Oil Pressure signal out of range high	EWPS disabled, default 50 psi, > 4.9v	EOP circuit short to PWR, failed sensor
●	215 ✓	VSS	Vehicle Speed Sensor signal out of range high	Speedo, cruise, PTO disabled - eng. RPM limited - signal frequency, > 4365 Hz	Misadjusted/defective speed sensor, electrical noise
●	221 ✓	SCCS	Speed Control Command Switches - cruise-PTO circuit fault	SCCS signal incorrect, voltage signal wrong for switch state	Short or resistance in SCCS circuit or CAN message fault
●	222 ✓	BRAKE	Brake switch circuit fault	Voltage at ECM (BNO1) and (BNO2) are different	Fault / misadjusted switch, unsuccessful start after 20 seconds
	224	Flash	Flash memory fault	Internal Proprietary Flag	Internal Proprietary Flag
●	225	EOP	Engine Oil Pressure signal in-range fault	EWPS disabled, EOP signal above spec. with KOEO, > 26 psi/1.90v	EOP circuit OPEN or short to GND, defective sensor
●	231	ATA	ATA data communication link error	EST communication disabled	ATA defective grounded or overloaded
●	236 ✓	ECL	Engine Coolant Level switch circuit fault	EWPS disabled, < 4.3v tank full, > 3.4v tank empty	ECL circuit, high resistance, defective sensor
●	237 ✓	FPC	Fuel Pump Control OCC self test failed	FPC output circuit check - engine off test only, engine power loss	FPC circuit OPEN or short to GND, high resistance
●	238 ✓	IAH	Inlet Air Heater Control (V6) OCC self test failed	IAH output circuit check - engine off test only, starting concern	IAH circuit OPEN or short to GND, high resistance
	241 ✓	IPR	Injection Control Pressure Regulator OCC self-test failed	IPR output circuit check - engine off test only; starting concern	IPR circuit OPEN, short to GND or PWR, failed IPR

✓ See Chassis Circuit Diagrams and Engine Diagnostics Manual for more information.
* Indicates Amber ENGINE lamp on when a Diagnostic Trouble Code (DTC) is set.
** Indicates Red ENGINE lamp on when Engine Warning Protection System (EWPS) is enabled and a DTC is set.

DIAGNOSTIC TROUBLE CODES for WORKHORSE CHASSIS APPLICATIONS

W	DTC	CIRCUIT	CONDITION DESCRIPTION	COMMENTS	PROBABLE CAUSES
●	246 ✓	EFAN	Engine Fan - OCC self test fault	Fan relay - output circuit check - engine off test only	EFAN circuit OPEN, short to GND or PWR, defective relay
●	247 ✓	BSV	Engine Brake Enable OCC self-test failed	Brake Shut Off Valve output circuit check - engine off test only	Brake Shut Off Valve circuit OPEN or short to GND, high resistance
●	251 ✓	GPC/IAH	Glow Plug (V8 & V6) Inlet Air Heater (I6) control OCC self test failed	GP/IAH relay - OCC test only - starting concern	Relay circuits OPEN, short to GND or PWR, failed relay
●	256 ✓	RSE	Radiator Shutter Enable OCC self test failed	Shutter relay - output circuit check - engine off test only	RSE circuit OPEN, short to GND or PWR, defective relay
●	259 ✓	TCM	TCM transmitted OSS fault	TCM fault message received	See diagnostic manual for transmission
	261 ✓	VGT	Variable Geometry Turbo control OCC self-test failed	VGTC - output circuit check - engine off test only	VGT circuits OPEN, short to GND or PWR, failed VGT module
●	263 ✓	OWL	Oil/Water Lamp OCC self test failed	Oil/Water Lamp - output circuit check - engine off test only	Oil/Water Lamp circuit OPEN or short to GND, high resistance or failed lamp
	264	EGR	Exhaust Gas Recirculation OCC self-test failed	EGRC output circuit check - engine off test only (2002-03 VT 365 only)	EGRC circuit OPEN or short to GND or PWR, failed sensor
●	266 ✓	WEL	Warn Engine Lamp OCC self test failed	Warn Engine Lamp - output circuit check - engine off test only	Warn engine lamp circuit OPEN or short to GND, high resistance or failed lamp
●	268 ✓	ACC	Air Conditioner Control OCC self test failed	ACC - output circuit check - engine off test only	ACC circuit OPEN, short to GND or PWR, high resistance
	311 *	EOT	Engine Oil Temperature signal out of range low	Default 212 °F / 100 °C, no fast idle < 0.2v	EOT circuit short to GND, failed sensor
	312 *	EOT	Engine Oil Temperature signal out of range high	Default 212 °F / 100 °C, no fast idle > 4.78v	EOT circuit OPEN or short to PWR, failed sensor
●	313 **	EWPS	Engine Oil Pressure below warning level	ECM detects low oil pressure, engine (red) lamp	EOP circuit fault, defective switch/sensor, low oil pressure
●	314 **	EWPS	Engine Oil Pressure below critical level	ECM detects low oil pressure, engine (red) lamp; shutdown (if equipped)	EOP circuit fault, defective switch/sensor, low oil pressure
●	315 * ✓	EWPS	Engine speed above warning level	ECM recorded excessive engine speed - engine specific	Transmission improperly downshifted
●	316	EWPS	Engine Coolant Temperature unable to reach commanded set point	Enabled only when cold ambient protection enabled	Cooling system concern
●	321 **	EWPS	Engine Coolant Temperature above warning level	ECM detects high coolant temp, engine (red) lamp; temp engine specific	Cooling system concern
●	322 **	EWPS	Engine Coolant Temperature above critical level	ECM detects high coolant temp, engine (red) lamp; temp engine specific, shutdown (if equipped)	Cooling system concern
●	323 **	EWPS	Engine Coolant Temperature belo warning/critical level	ECM detects high coolant level, engine (red) lamp; shutdown (if equipped)	Low coolant level, ECL circuit short to GND
●	324 **	IST	Idle Shutdown Timer enabled engine shutdown	Engine shutdown, engine (red) lamp, only when enabled	Engine at low idle longer than IST programmed value
●	325	EWPS	Power reduced, matched to cooling system performance	ECM detects high coolant temperature; temp engine specific, power reduced	Cooling system concern
	331 *	ICP SYS	Injection Control Pressure above system working range	Default inferred ICP, max ICP range is engine specific	See diagnostic manual - ICP system
	332 *	ICP	Injection Control Pressure above spec. with KOEO	ICP signal volt higher than expected with KOEO, default inferred ICP	ICP signal GND circuit OPEN, failed sensor

✓ See Chassis Circuit Diagrams and Engine Diagnostics Manual for more information.
* Indicates Amber ENGINE lamp on when a Diagnostic Trouble Code (DTC) is set.
** Indicates Red ENGINE lamp on when Engine Warning Protection System (EWPS) is enabled and a DTC is set.

DIAGNOSTIC TROUBLE CODES for WORKHORSE CHASSIS APPLICATIONS

W	DTC	CIRCUIT	CONDITION DESCRIPTION	COMMENTS	PROBABLE CAUSES
	333 *	ICP SYS	Injection Control Pressure above/below desired level	ICP desired does not = ICP signal, (difference is engine specific), default inferred ICP	See diagnostic manual - ICP system
	334	ICP SYS	ICP unable to achieve setpoint in time (poor performance)	ICP desired does not = ICP signal, (difference is engine specific), default inferred ICP	See diagnostic manual - ICP system
	335	ICP SYS	ICP unable to build pressure during cranking	No start (Min ICP is engine specific)	See diagnostic manual - ICP system
	341 *	EBP	Exhaust Back Pressure signal out of range low	EGR disabled, default inferred VGT < 0.039v	EBP circuit OPEN or short to GND, failed sensor
	342 *	EBP	Exhaust Back Pressure signal out of range high	EGR disabled, default inferred VGT > 4.9v	EBP circuit short to PWR, failed sensor
●	343 *	AMS	Excessive Exhaust Back Pressure (gauge)	EGR disabled (Max pressure is engine specific)	See diagnostic manual - Air Management System **Note:** No sensor
	344 *	EBP	Exhaust Back Pressure above spec. when engine off	EGR disabled, default inferred VGT	EBP signal GND circuit OPEN, failed sensor
	345	AMS	Faults detected during VGT portion of the AMS Test	ECM did not detect expected change in EBP, VGT portion of AMS test only	See diagnostic manual - Air Management System
	346	AMS	Faults detected during EGR portion of the AMS Test	ECM did not detect expected change in EBP, EGR portion of AMS test only	See diagnostic manual - Air Management System
	347	EBP	Exhaust Back Pressure not responsive	Sensor is not responsive due to icing	Engine concern, plugged tube, failed sensor
	351 *	AMS	Exhaust Back Pressure did not change when expected	Delta pressure is insufficient between KOEO and KOER minimum set point	Plugged EBP tube, stuck open EGR valve, exhaust system leak, bias
	353 *	AMS	Variable Geometry Turbo control over duty cycle	ECM overcompensates by increasing duty cycle offset	See diagnostic manual - Air Management System
	354 *	AMS	Variable Geometry Turbo control under duty cycle	ECM overcompensates by decreasing duty cycle offset	See diagnostic manual - Air Management System
	355	AMS	Variable Geometry Turbo overspeed	Inferred overspeed based off of BAP, RPM and MAP	See diagnostic manual - Air Management System
	361 *	AMS	VGT control circuit (MAP/EBP) above / below desired level	MAP /EBP actual does not = MAP / EBP desired	See diagnostic manual - Air Management System
	365 *	AMS	EGR Valve Position above/below desired level	EGR disabled, EGRP actual does not = EGRP desired	See diagnostic manual - Air Management System
	367	AMS	Improper position signal when EGR valve is expected closed	EGR disabled, > 2.5 with key on engine off (2002-03 VT 365 only) should not see after programming	See diagnostic manual - Air Management System See FAQ/TSI
	368 ✓	AMS	EGR Drive Module/ECM2 communication fault	ECM lost communication from the EGR Drive Module	EGR D-Module check circuits for OPEN or short to GND or PWR
	371	EFP	Engine Fuel Pressure is above normal operating range	Will not illuminate any lamp - Speed and load dependent	See diagnostic manual - Fuel Pressure
	372	EFP	Engine Fuel Pressure is below normal operating range	Will illuminate FUEL FILTER lamp - Speed and load dependent	Restricted fuel filter - See diagnostic manual - Fuel Pressure
●	373 ✓	IAH	Inlet Air Heater relay circuit fault	IAH relay output does not match desired	IAH PWR feed circuit OPEN or high resistance, IAH diagnostic wire OPEN or high resistance
●	374 ✓	FPC	Fuel Pump relay circuit fault	FPC relay output does not match desired	FPC PWR feed circuit OPEN or high resistance, FPC diagnostic wire OPEN or high resistance

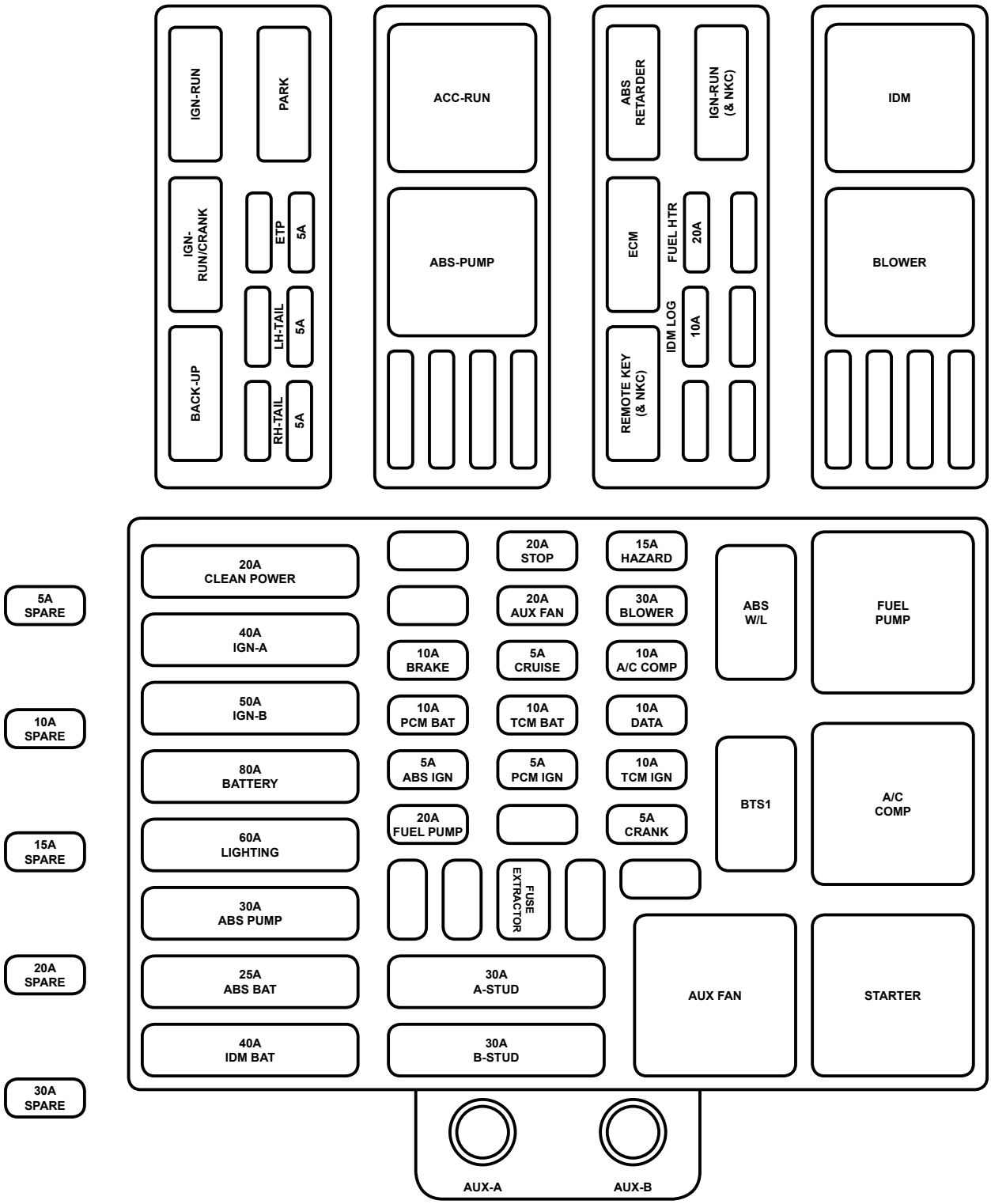
✓ See Chassis Circuit Diagrams and Engine Diagnostics Manual for more information.
* Indicates Amber ENGINE lamp on when a Diagnostic Trouble Code (DTC) is set.
** Indicates Red ENGINE lamp on when Engine Warning Protection System (EWPS) is enabled and a DTC is set.

DIAGNOSTIC TROUBLE CODES for WORKHORSE CHASSIS APPLICATIONS

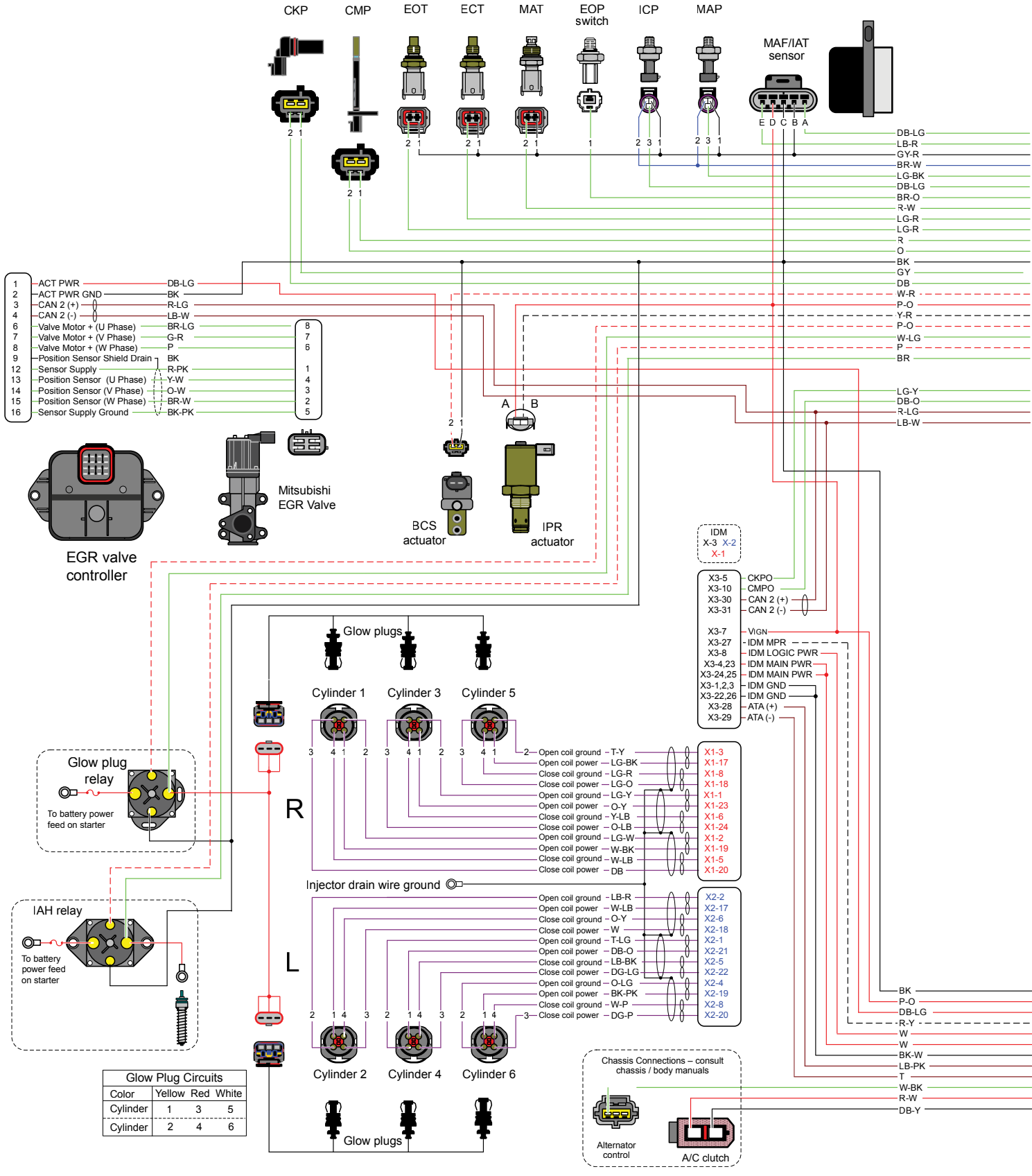
W	DTC	CIRCUIT	CONDITION DESCRIPTION	COMMENTS	PROBABLE CAUSES
●	375 ✓	GPC	Glow Plug relay circuit fault	Glow Plug relay output does not match desired	GPC PWR feed circuit OPEN or high resistance, FPC diagnostic wire OPEN or high resistance
	421 - 428	INJ	High side to low side open (cylinder number indicated)	IDM detected an open injector circuit	Injector circuit OPEN, failed injector
	431 - 438	INJ	High side shorted to low side open (cylinder number indicated)	IDM detected a short in an injector circuit from high to low	Injector circuit short high to low, failed injector
	451 - 458	INJ	High side short to GND or PWR (cylinder number indicated)	IDM detected a short in an injector circuit to GND or PWR	Injector circuit short to GND or PWR, failed injector
●	523 ✓	IDM	IDM KEY PWR voltage low	IDM detects KEY PWR low < 7v	Low batteries, loose connections / resistance in circuit, defective relay
●	525 *	IDM	IDM fault	internal IDM fault	Defective IDM
●	533 ✓	IDM	IDM relay voltage high	IDM detects excessive voltage > 16v	Charging system fault
●	534 ✓	IDM	IDM relay voltage low	IDM detects logic PWR low, < 7v	Low batteries, loose connections / resistance in circuit, defective relay
●	543 *	ECM/IDM	ECM/IDM communications fault	Loss of communication between ECM and IDM	IDM power concern, CAN2 circuit OPEN, short to GND or PWR
	546 *	BSV/BCP	Engine Brake Control Pressure is below expected range	BCP is less than ICP, difference of 580 psi / 4 MPa	See diagnostic manual - Brake Shut-Off Valve and BCP sensor
	547 *	BSV/BCP	Engine Brake Control Pressure is above expected range	BCP is greater than BCP desired, difference of 653 psi / 4.5 MPa	See diagnostic manual - Brake Shut-Off Valve and BCP sensor
	551	ECM/IDM	IDM CMPO signal inactive	No CMPO signal, while CKPO signal active	CMPO circuit OPEN, short to GND or PWR, logic power low
	552	ECM/IDM	IDM incorrect CMPO signal signature	CMPO signal intermittent or incorrect	Poor connection between ECM and IDM
	553	ECM/IDM	IDM CKPO signal inactive	No CKPO signal, while CMPO signal active	CKPO circuit OPEN, short to GND or PWR, logic power low
	554	ECM/IDM	IDM incorrect CKPO signal signature	CKPO signal intermittent or incorrect	Poor connection between ECM and IDM
	613 *	ECM	ECM/IDM software not compatible	Components changed in field not compatible	Components changed in field not compatible
	614 *	ECM	EFRC/ECM configuration mismatch	Programming problem	FRC not programmed properly
	621 *	ECM	Engine using mfg. default rating program engine	Engine operates at a default engine specific HP	ECM not programmed
	622 *	ECM	Engine using field default rating	Engine limited to lowest hp in family, options not available	Calibration does not match EFRC
	623 *	ECM	Invalid Engine Family Rating Code	ECM not programmed properly	ECM not programmed properly
	624	ECM	Field default active	EFRC not supported in ECM	programming concern / internal ECM concern
●	626 ✓	ECM PWR	Unexpected reset fault	ECM power reset	ECM power concern, low battery charge
	631	ECM	Read Only Memory (ROM) self test fault	ECM failure	Failed ECM
	632	ECM	Random Access memory (RAM) CPU self-test fault	ECM failure	Failed ECM
	655	ECM	Programmable parameter list level incompatible	Programming concern / ECM memory concern	Programming concern
	661	ECM	RAM programmable parameter list is corrupt	Programming concern / ECM memory concern	Programming concern / internal ECM concern
	664	ECM	Calibration level incompatible	Programming concern	Programming concern
	665	ECM	Programmable parameter memory content corrupt	ECM failure	Failed ECM

✓ See Chassis Circuit Diagrams and Engine Diagnostics Manual for more information.
* Indicates Amber ENGINE lamp on when a Diagnostic Trouble Code (DTC) is set.
** Indicates Red ENGINE lamp on when Engine Warning Protection System (EWPS) is enabled and a DTC is set.

POWER DISTRIBUTION CENTER



ENGINE & CHASSIS SCHEMATIC

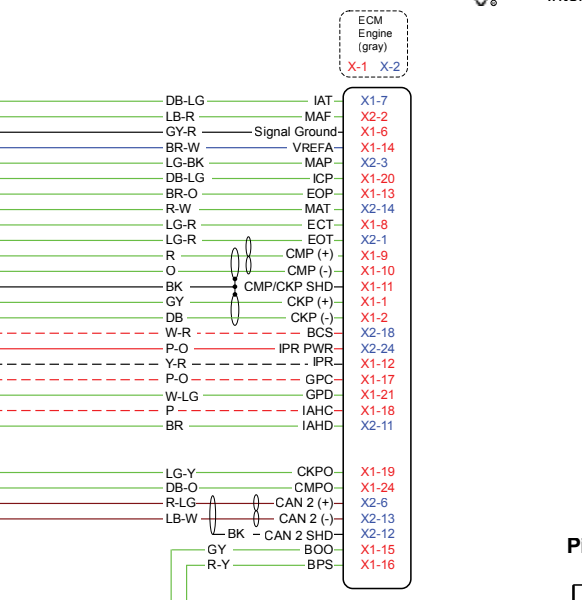


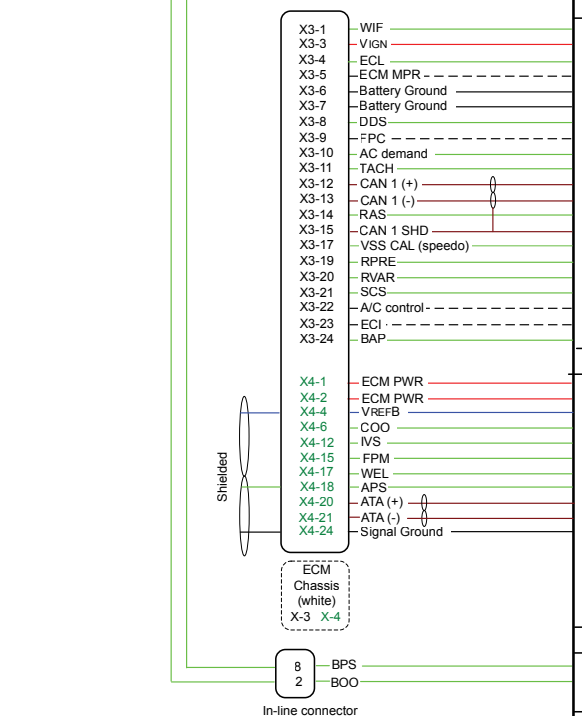
Glow Plug Circuits			
Color	Yellow	Red	White
Cylinder	1	3	5
Cylinder	2	4	6

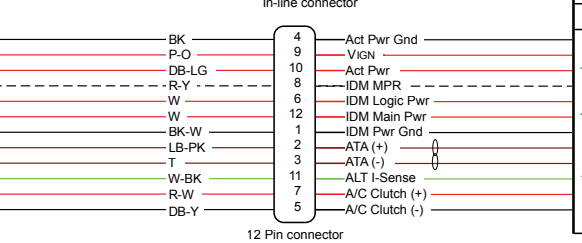
ENGINE MOUNTED COMPONENTS

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

International® VT 275







WARNING

To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of *Engine Diagnostics Manual* EGES-305 before doing diagnostic procedures.

Notes

- Colored lines on this schematic go to connector terminals for sensors and actuators.

Color code for schematic lines	Schematic Line description
Red	12 Volts (VBAT)
Red	High side driver control
Purple	Injectors (48 Volts)
Blue	VREF (5 Volts)
Green	Signal circuit
Brown	Data Communication Link
Black	Ground circuit
Black	Low side driver control

Pin	Circuit	Key ON Signal	Operating Range	Comments
X3 CHASSIS CONNECTOR (WHITE)				
1	Water In Fuel	0V – 7V	0V – B+	0V = No water, 7V = water in fuel, EST – No/Yes
3	ECM Switch Ignition voltage	B+	0V – B+	Switched Ignition power key On = B+, Key Off = 0V
4	Engine Coolant Level	0V Low – 5V Full	0V – 5V	0V = Low Coolant 5V = Full Coolant
5	ECM Main Power Relay Control	0.6V – 1V	0.6V – 1V/B+	0.6V – 1V = MPR On / B+ = MPR Off
6	Battery Ground	0V	0V	ECM Ground
7	Battery Ground	0V	0V	ECM Ground
8	Driveline Disengagement Switch	0V – B+	0V – B+	Key On = 0V in gear / B+ = Park and neutral
9	Fuel Pump control	0V Off – B+ On	0V – B+	B+ = FPC On, 0V = FPC Off, EST – Output State Test
10	Air Conditioner Demand	0V	0V – 5V	5V with A/C switch on, freon switches closed. 0V Off
11	Tachometer Output			Chassis body builder option only
12	CAN 1 (Public)	1V – 4V	1V – 4V	Digital signal communication
13	CAN 1 (Public)	1V – 4V	1V – 4V	Digital signal communication
14	Resume Accel Switch	0V Off – B+ On	0V – B+	Momentary switch 0V at normal state / B+ depressed
15	CAN 1 Shield	0V	0V	Ground shield for CAN 1
17	Vehicle Speed Signal			Chassis body builder option only
19	Remote Preset (PTO)			Chassis body builder option only
20	Remote Variable (PTO)			Chassis body builder option only
21	Speed Control Switch	0V Off – B+ On	0V Off – B+ On	Momentary switch 0V at normal state / B+ depressed
22	Air Conditioner Control	B+	0V Off – B+ On	B+ A/C command Off, 0V A/C command On
23	Engine Crank Inhibit	0V / 4V – 5V	0V – 4 to 5V	0V allows cranking / 4 – 5V inhibits cranking
24	Barometric Pressure	Alt. Depend.	0V – 5V	DMM set to V, EST – Continuous Monitor session
X4 CHASSIS CONNECTOR (WHITE)				
1	ECM Power	B+	0V – 5V	ECM B+ from ECM relay
2	ECM Power	B+	0V – 5V	ECM B+ from ECM relay
4	Voltage Reference B (Chassis)	5V ± 0.5	5V ± 0.5V	5V voltage reference for chassis sensors
6	Cruise ON / OFF Switch	0V Off – B+ On	0V Off – B+ ON	Cruise control On/Off switch
12	Idle Validation Switch	0V Off	0V – B+	0V at normal state, B+ pedal depressed
15	Fuel Pump Monitor	0V Off – B+ On	0V – B+	B+ = FPC On, 0V = FPC Off, EST – Output State Test
17	Warn Engine Lamp			Chassis body builder option only
18	Accelerator Position Sensor	0.7V – 4.2V	0V – 5V	0.7V = 10% / 4.2V = 102%
20	Communication Link	0.1V – 1.2V	0V – 5V	Diagnostic / Programming
21	Communication Link	0.0V – 4.2V	0V – 5V	Diagnostic / Programming
24	Signal Ground	0V	0V	Ground for chassis sensors
IN-LINE CONNECTOR				
8	BPS	B+	0V – B+	B+ at normal state, 0V pedal depressed
2	BOO	0V	0V – B+	0V at normal state, B+ pedal depressed
12 PIN CONNECTOR (BLACK)				
4	Battery ground	0V Off - B+ On	0V Off - B+ On	Diagnostic / Programming
9	Switch Ignition Voltage	0.1V - 1.2V	0V - 5V	Diagnostic / Programming
10	Actuator Power	0.0V - 4.2V	0V - 5V	0.7V = 10% / 4.2V = 102%
8	IDM Main Power Relay Control	0.7V - 4.2V	0V - 5V	B+ = FPC On. 0V = FPC Off, EST - Output State Test
6	IDM Logic Power	0V Off - B+ On	0V - B+	Ground for chassis sensors
12	IDM Main Power	0V	0V	IDM Ground
1	Battery Ground	0V	0V	Diagnostic / Programming
2	Communication Link	0.1V - 1.2V	0V - 5V	Diagnostic / Programming
3	Communication Link	0.0V - 4.2V	0V - 5V	Chassis body builder option only
11	Alternator Charge Warning			Chassis body builder option only
7	A/C Clutch Relay			0V at normal state, B+ pedal depressed
5	Battery Ground	0V Off	0V - B+	

GLOSSARY

Accelerator Position Sensor (APS)
A potentiometer sensor that indicates the position of the throttle pedal.

Actuator
A device that performs work in response to an electrical input signal.

Aeration
The entrainment of gass (air or combustion gas) in the coolant or lubricant.

American Trucking Association (ATA) Datalink
A serial datalink specified by the American Trucking Association and the SAE.

Barometric Absolute Pressure (BAP) Sensor
A variable capacitance sensor which, when supplied with a 5 volt reference signal from the ECM, produces a linear analog voltage signal indicating atmospheric pressure.

Boost Control Solenoid Harness
The hose harness that is used to transfer boost pressure from the intake manifold to the Boost Control Solenoid and the Pneumatic Actuator.

Boost Pressure
The pressure of the charge air leaving the turbocharger.

Camshaft Position (CMP) Sensor
A magnetic pickup sensor that indicates engine speed and camshaft position.

CAN 1
A data link between the vehicle modules and ECM.

CAN 2
The private link between the ECM and IDM.

Catalytic Converter
An antipollution device in the exhaust system that contains a catalyst for chemically converting some pollutants in the exhaust gases (carbon monoxide, unburned hydrocarbons, and oxides of nitrogen) into harmless compounds.

Charge Air
Dense, pressurized, heated air discharged from the turbocharger.

Controller Area Network (CAN)
A J1939 high speed communication link.

Coolant
A fluid used to transport heat from the engine to the radiator.

Crankcase
The housing that encloses the crankshaft, connecting rods, and associated parts.

Crankshaft Position (CKP) Sensor
A magnetic pickup sensor that determines crankshaft position and speed.

Duty Cycle
A control signal that has a controlled on/off time measurement from 0 to 100%. Normally used to control solenoids.

Electronic Control Module (ECM)
An electronic processor that monitors and controls the engine.

EGR Cooler
A cooler that allows heat to dissipate from the exhaust gasses before they enter the EGR Valve.

EGR Valve
A valve that regulates the flow of exhaust gasses into the intake manifold.

Engine Oil Pressure Switch (EOPS)
A switch that senses oil pressure.

Engine Oil Temperature (EOT) Sensor
A thermistor sensor that senses engine oil temperature.

Exhaust Gas Recirculation
A system used to recirculate a portion of the exhaust gases into the intake air charge in order to reduce oxides of nitrogen (NOx).

Injection Control Pressure (ICP)
High lube oil pressure generated by a high pressure pump/pressure regulator used to hydraulically actuate the fuel injectors.

Injection Control Pressure (ICP) Sensor
A sensor that measures injection control pressure.

Injection Pressure Regulator (IPR)
An ECM regulated valve that varies injection control pressure.

Injector Drive Module (IDM)
An electronic processor that calculates injection timing and fuel quantity and is the power supply for the injectors.

Intake Air Temperature (IAT) Sensor
A thermistor sensor that senses intake air temperature.

Manifold Absolute Pressure (MAP)
Boost pressure in the manifold that is a result of the turbocharger.

Manifold Absolute Pressure (MAP) Sensor
A variable capacitance sensor that measures boost pressure.

Manifold Air Temperature (MAT) Sensor
A thermistor style sensor used to indicate air temperature in the intake manifold.

Mass Air Flow (MAF) Sensor
A sensor that measures the air flow into the engine.

Magnehelic Gauge
A gauge that measures pressure in inches of water (in H2O).

Magnetic Pickup Sensor
A sensor that creates an alternating current current voltage when a magnetic field is broken.

Oxides of Nitrogen (NOx)
Oxides of nitrogen form by a reaction between nitrogen and oxygen at high temperatures.

Potentiometer
An electro-mechanical device that senses the position of a mechanical component.

Reference Voltage (VREF)
A 5 volt reference supplied by the ECM to operate the engine sensors.

Thermistor
A semiconductor device that changes resistance as temperature changes.

Turbocharger
A turbine driven compressor mounted to the exhaust manifold. The turbocharger increases the pressure, temperature and density of the intake air.

VT 275

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