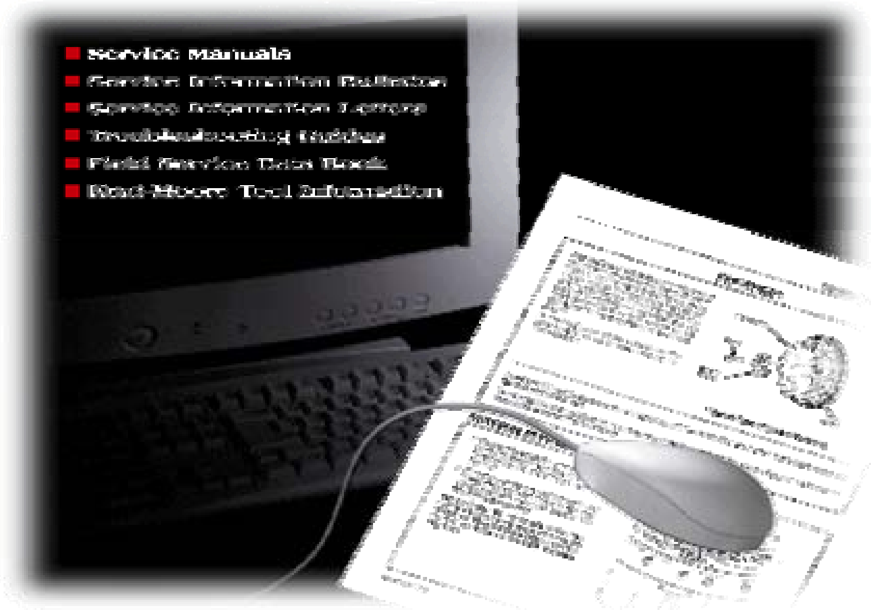
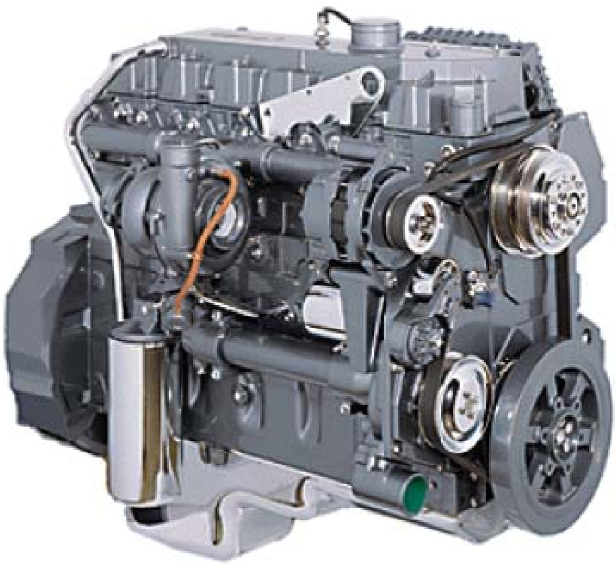
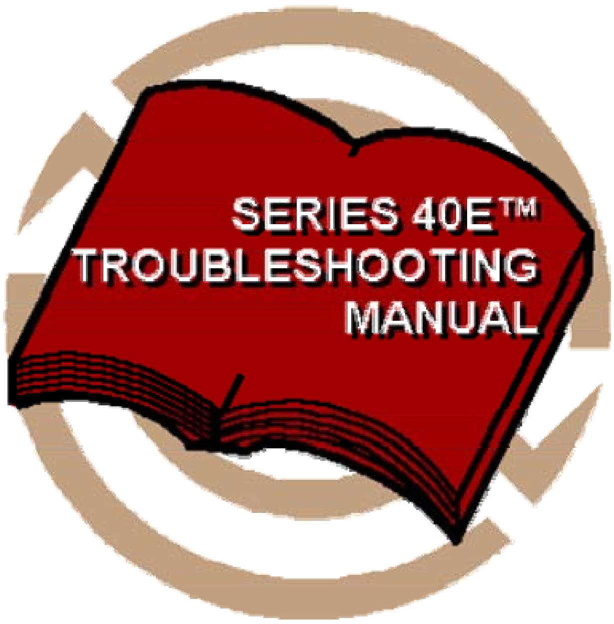
DETROIT DIESEL

Electronic Service Information



POWER Service LITERATURE





ENGINE SERIES 40™

INTRODUCTION

INTRODUCTION

Detroit Diesel Corporation is the world leader in diesel engine electronics. DDC has made technological leaps in engine performance and fuel economy. Today, we build the most dependable electronically controlled diesel engine in the industry.

Our goal at Detroit Diesel is to be the most customer focused and most responsive engine manufacturer in the world.

SERVICE DIAGNOSIS

Service diagnosis is a systematic procedure of investigation to be followed to locate and correct an engine problem. The engine is first considered as a complete unit in its specific application and then the problem is localized to components or systems; intake, exhaust, cooling, lubrication or injection. Testing procedures will then help analyze the source of the problem.

Prerequisites for effective diagnosis include:

1. Knowledge of the principles of operation for both the engine and application systems.
2. Knowledge to perform and understand all procedures in the diagnostic and service manuals.
3. Availability of and the ability to use gages and diagnostic test equipment.
4. Have available the current information for the engine application.

Although the cause of an engine failure may be apparent, very often the real cause is not found until a repeat failure occurs. This can be prevented if specific diagnostic action is taken prior to, during and after engine disassembly and during engine reassembly.

It is also very important that specific diagnostic tests follow engine reassembly prior to and after the engine is placed back into service.

Identification of the symptoms that lead to engine failure is the result of proper service diagnosis. Effective service diagnosis requires use of the following references:

1. Series 40E Service Manual, 6SE0242
2. Hard Start / No Start (**refer to section**
) and Performance Engine Diagnostics (**refer to section**
)
3. Electronic Control System Diagnostics **refer to section**
4. Service Bulletins

ABBREVIATIONS / ACRONYMS

A/C—Air Conditioning

AC—Alternating Current

ACC—Accessory

A/D—Analog to Digital

AMP—Ampere

ASCII—American Standard Code for Information Interchange

AT/MT—Allison AT.MT automatic transmission

ATA—American Trucking Association

AWG—American Wire Gauge

BARO—Barometric Pressure Sensor

BAT/BATT—Battery

BNO—Brake Normally Open

C—Celsius / Centigade

CAP—Cold Ambient Protection system

CEL—Check Engine Light

CLS—Coolant Level Switch

CMP—Camshaft Position Sensor; also referred to as TRS

COL—Change Oil Lamp

CYL—Cylinder

DC—Direct Current

DDC—Detroit Diesel Corporation

DDS—Driveline Disengagement Switch

DDR—Diagnostic Data Reader

DVOM—Digital Volt Ohm Meter

EFPA—Electronic Foot Pedal

EFRC—Engine Family Rating Code

ECI—Engine Crank Inhibit

ECL—Engine Coolant Level System

ECM—Electronic Control Module

ECM_PWR—Electronic Control Module Power Supply

ECT—Engine Coolant Temperature Sensor

EDL—Engine Data Line

EFAN—Engine Fan

ENG—Engine

EST—Electronic Service Tool

EOP—Engine Oil Pressure Sensor

EOT—Engine Oil Temperature Sensor

EWPS—Engine Warning and Protection System

F—Fahrenheit

FMI—Failure Mode Identifier

FUNC—Function

HEUI—Hydraulically Actuated Electronically Controlled Unit Injection

Hg—Mercury

HP—Horsepower

IAT—Intake Air Temperature Sensor

ICP—Injection Control Pressure Sensor

IGN—Ignition

INJ—Injector Drive Circuits

IPR—Injection Pressure Regulator

IPR_SYS—Injection Pressure Regulation System

IST—Idle Shutdown Timer

IVS—Idle Validation Switch

KOEO—Key Off Engine Off test

m—Meters

MAP—Manifold Absolute Pressure Sensor

MID—Message Identification (ID)

mm—Millimeter

MPH—Miles per Hour

OCC—Output Circuit Check

OEM—Original Equipment Manufacturer

OWL—Oil / Water Lamp

P/N—Part Number

PGS—Pressure Sensor Governor

PID—Parameter Identification (ID)

RAM—Random Access Memory

RESUME / ACCEL—Resume / Accelerate switch

r/min—Revolutions per minute

ROM—Read Only Memory

RPS—Remote Accelerator Pedal Sensor

RSE—Radiator Shutter Enable

SCCS—Speed Control Command Switches

SEL—Stop Engine Light

SID—Subsystem Identification (ID)

SPDT—Single Pole Double Throw

SPST—Single Pole Single Throw

STI—Self Test Input

STI / WARN—Self Test Input Switch and Engine Warn Light

TACH—Tachometer Input Circuits

TDC—Top Dead Center

TSA—Two-Speed Axle Input Circuit

TRS—Timing Reference Sensor

VAC—Volts, Alternating Current

VDC—Volts, Direct Current

VIH—Vehicle Interface Harness

VIN—Vehicle Identification Number

VRE—Vehicle Retarder

VREF—Voltage Reference Circuits

VSS—Vehicle Speed Signal

WTEC—Allison MD WTEC transmission

ATA COMMUNICATIONS

SIGNAL FUNCTIONS

The signal functions include the Data Communication Link and the ATA Diagnostic/Programming Link. **See Figure** .

1

Data Communication Link — The signal is a 0 to 5 volt variable width square wave form signal that enables communication between the electronic service tool (EST) and the ECM. It is used for communication of diagnostic and calibration data. For data link wiring, **see Figure** .

2

ATA Diagnostic/Programming Link — The ATA signal is a 0 to 5 volt width square wave form signal that enables communication between the ECM and the EST. It is used for communication of calibration, programming and diagnostic information.

Dash Board Information — Information on the ATA communication link is used to operate five different functions on the instrument cluster. They include:

1. Oil Pressure
2. Tachometer (Engine Speed)
3. Speedometer
4. Coolant Temperature
5. Battery Voltage

Fault Detection/Management

On a continuous basis, the ECM can detect an open, short or intermittent connection on the ATA lines. If an active fault occurs on the ATA lines, the instrument cluster and/or the EST

will not display data. A typical 31–pin connector is shown below. Connection descriptions are **listed in Table**
.

To VIH 31-pin	Description	To ECM 60-pin	To VIH 31-pin	Description	To ECM 60-pin		
1	A	Ignition Run Power	-	19	V	Vehicle Speed Control Throttle Device Ref	3
2	B	Data Link (+)	16	20	W	Engine Speed Control Throttle Device Ground	6
3	C	Data Link (-)	17	21	X	Variable Engine Speed Control Throttle Signal	30
4	D	Diagnostic Request	34	22	Z	Engine Speed Control Throttle Device Ref	5
5	E	Stop Engine Light (SEL) and Alarm	54	23	a	Required Stationary Signal No. 2 or Driveline Status	26
6	F	Check Engine Light (CEL)	55	24	b	Crank Inhibit Signal	46
7	G	Service Interval Lamp	45	25	c	Ignition Crank Power to Crank Inhibit Relay	-
8	H	Tachometer	59	26	d	Vehicle Speed No. 1 (+)	39
9	J	Cruise ON/OFF	35	27	e	Vehicle Speed No. 2 (-)	40
10	K	Cruise Resume/Accel, PTO Preset No. 2 or Fast Idle No. 2	31	28	f	OEM Discretionary for 31-pin Design	-
11	L	Cruise Set/Coast, PTO Preset No. 1, or Fast Idle No. 1	32	29	g	OEM Discretionary for 31-pin Design	-
12	M	PTO ON/OFF	36	30	h	Vehicle Retarder Output	47
13	N	PTO Preset ON/OFF or Fast Idle ON/OFF	37	31	j	Vehicle Retarder ON/OFF	
14	P	Required Stationary Signal No. 1 or Brake Status No. 1	43				
15	R	Required Stationary Signal No. 3 or Brake Status No. 2	44				

16	S	Idle Validation	27
17	T	Vehicle Speed Control Throttle Device Ground	11
18	U	Variable Speed Control Throttle Signal or .25 V Engine Speed Control Signal	8

Recommended 31–pin Connector Pin Definitions

Key ON, Engine Off voltage checks at the EST connector are **listed in Table** . Check with the breakout box installed and the ignition key ON, engine OFF.

+ Test Points	Spec.	Signal	Comments
C to E	B+	Power	Should be power at C at all times. If no power, check ground and power circuits

Voltage Checks at EST Connector

EST connector checks to ground are **listed in Table** . Check with the positive battery cable disconnected and the ignition key OFF. (If applicable, check with the dash connector unplugged.)

Test Points	Spec.	Signal	Comments
EST			
A to Grd.	>1,000 Ω	ATA +	Less than 1,000 Ω indicates a short to ground either thru the harness or internal in the ECM. Disconnect the ECM and measure to ground again. If the short is still present, repair the harness.
B to Grd.	>1,000 Ω	ATA -	
C to Grd.	>1,000 Ω	PWR	With Fuse F11 removed, a reading less than 1,000 Ω indicates a short to ground.
E to Grd.	<5 Ω	GRD	More than 5 Ω indicates an open circuit and will cause the EST tool not to power up.

EST Checks to Ground

EST resistance checks are **listed in Table** . Check with the breakout box installed and the ignition key OFF.

Test Points	Spec.	Signal	Comments
EST Connector			
A to No. 16	<5 Ω	ATA+	Resistance from ECM chassis connector (black) to EST connector
B to No. 17	<5 Ω	ATA-	Resistance from ECM chassis connector (black) to EST connector
C	<5 Ω	PWR	Resistance from EST connector to power fuse
E to Grd.	<5 Ω	GRD	More than 5 Ω indicates an open circuit and will cause the EST tool not to power up.

Electronic Service Tool Resistance Checks

Fault Code Descriptions: 231 = ATA Common Fault — ATA wiring or connector faults, interference on data bus (e.g. dash or WTEC controller), faulty ECM.

1. No data stream or Fault Codes displayed on EST or EST will not power up.
2. If applicable, the dash display for speedometer, tachometer, oil pressure, coolant temperature and battery voltage does not function.

ATA Communication

The ATA circuit uses a twisted wire pair. All repairs to this pair must maintain one complete twist per inch along the entire length of the circuit. This circuit is polarized (one positive and one negative) and reversing the polarity of this circuit will disrupt communications.

The ATA data link is defined by SAE recommended practices J1708 and J1587. This link and connector were adopted by the Recommended Practices 1201 and 1202.

All communications between the EST and the engine control system pass through the EST connector. **See Figure** . This communication link supports:

1. Displaying fault codes and operating conditions on the EST
2. Performing proprietary diagnostic tests programmed into the cartridge
3. Clearing fault codes
4. Programming performance parameter values
5. Programming calibrations and strategies

The EST connector 384, has six pins labeled A through F. Fused battery power is provided to Pin C to provide battery power for electronic service tools. Pin E provides a battery ground for the EST.

3

EST Connector 384

The engine control system does not detect faults in the power or ground circuits to EST connector 384. If the service tool does not power up when connected, try the service tool on another vehicle if one is available to determine if the service tool is working properly. If the service tool is okay, then check the power and ground circuits at the ATA connection.

EST Displays

Should the EST display NO DATA, the ATA data link circuit from the EST connector to the ECM may be disrupted. Verify that the key is ON and then perform diagnostic steps.

Fault Code

Flash Code 231

ATA Code SID 250 FMI 2

ECM: ATA COMMON FAULT

Symptom

Code 231 does not turn the Engine Warning light ON. This code can occur when the ECM cannot access the ATA data link. If this occurs, there will not be any ATA data available with the EST. The fault code may be flashed using the STI switch located on the instrument panel.

Wiring Causes

ATA positive or negative circuits between EST and ECM and any other electronic devices (transmissions, brakes, etc.) using the ATA bus: Shorted (high or low), open, or busy (too many devices).

Note: On vehicles equipped with the WTEC transmission, this code may be present when attempting to program the ECM. The WTEC controller must be disconnected when programming the engine ECM.

System Causes

System causes can include:

1. A defective ATA device (e.g. transmission controller or antilock brake controller) connected to the ATA bus is pulling the signal to ground.
2. Too many ATA devices, although this would be rare.
3. If no system causes are present, replace the ECM with a known good ECM.

Instrument Cluster Display

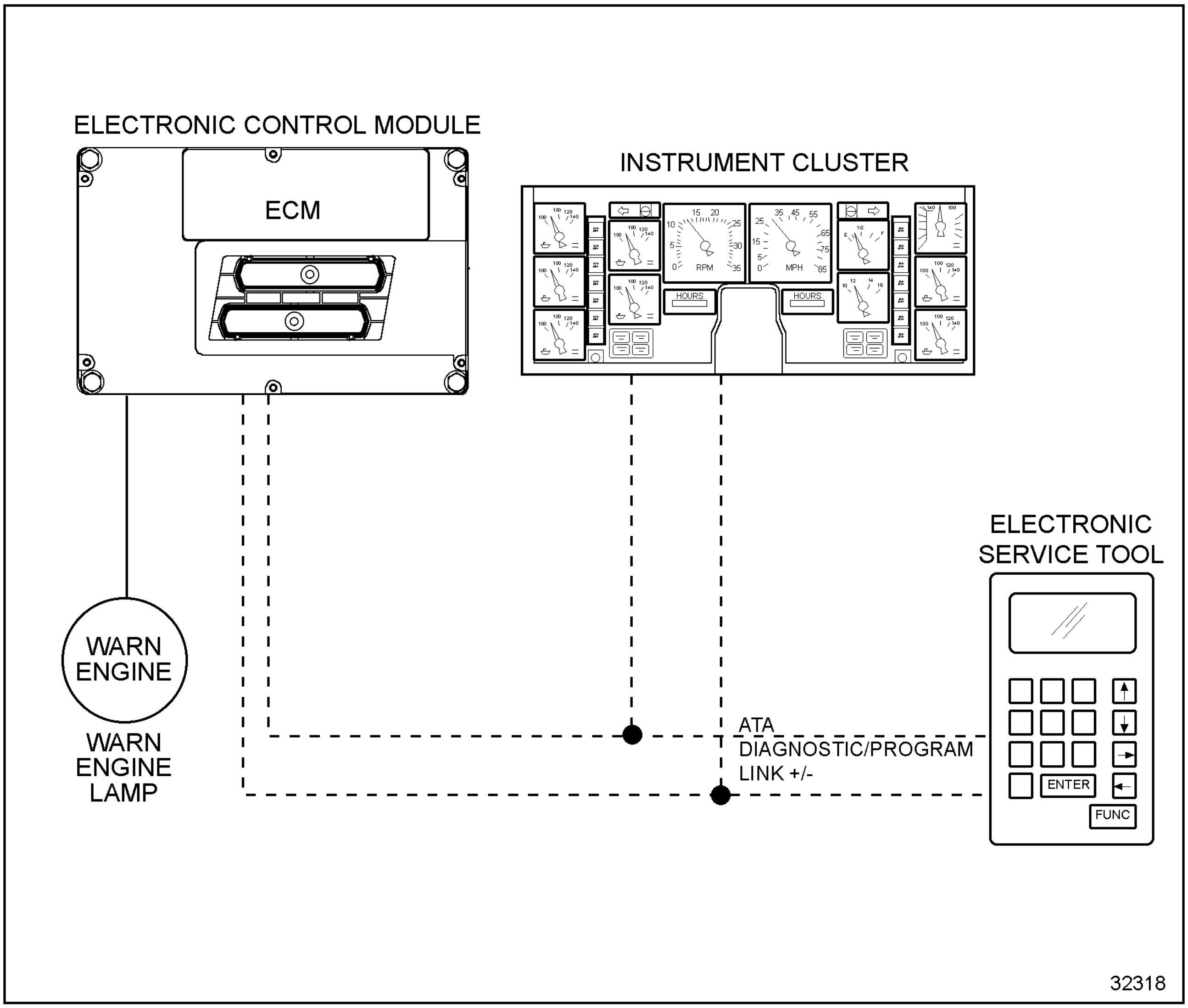
The instrument cluster utilizes data on the ATA lines for the display of:

1. Oil pressure

2. Tachometer (engine speed)
3. Speedometer
4. Coolant temperature
5. Battery voltage

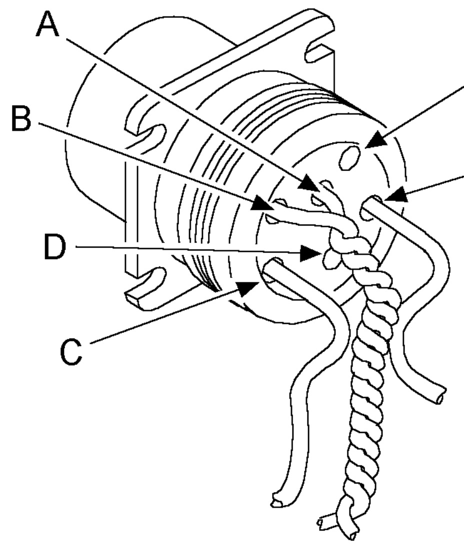
The data is transmitted on the same ATA link that supplies information to the EST and the WTEC transmission controller. A microprocessor in the instrument cluster converts the ATA data into signals that will drive the various gages in the dash.

1



ATA Communications Function Diagram

2



WIRE NO.	CAVITY	LABEL
900	A	J 1708/J 1587 DATA LINK (+)
901	B	J 1708/J 1587 DATA LINK (-)
440	C	+ 12 VDC
—	D	PLUG P/N: 23507136
953	E	BATTERY GROUND
—	F	PLUG P/N: 23507136

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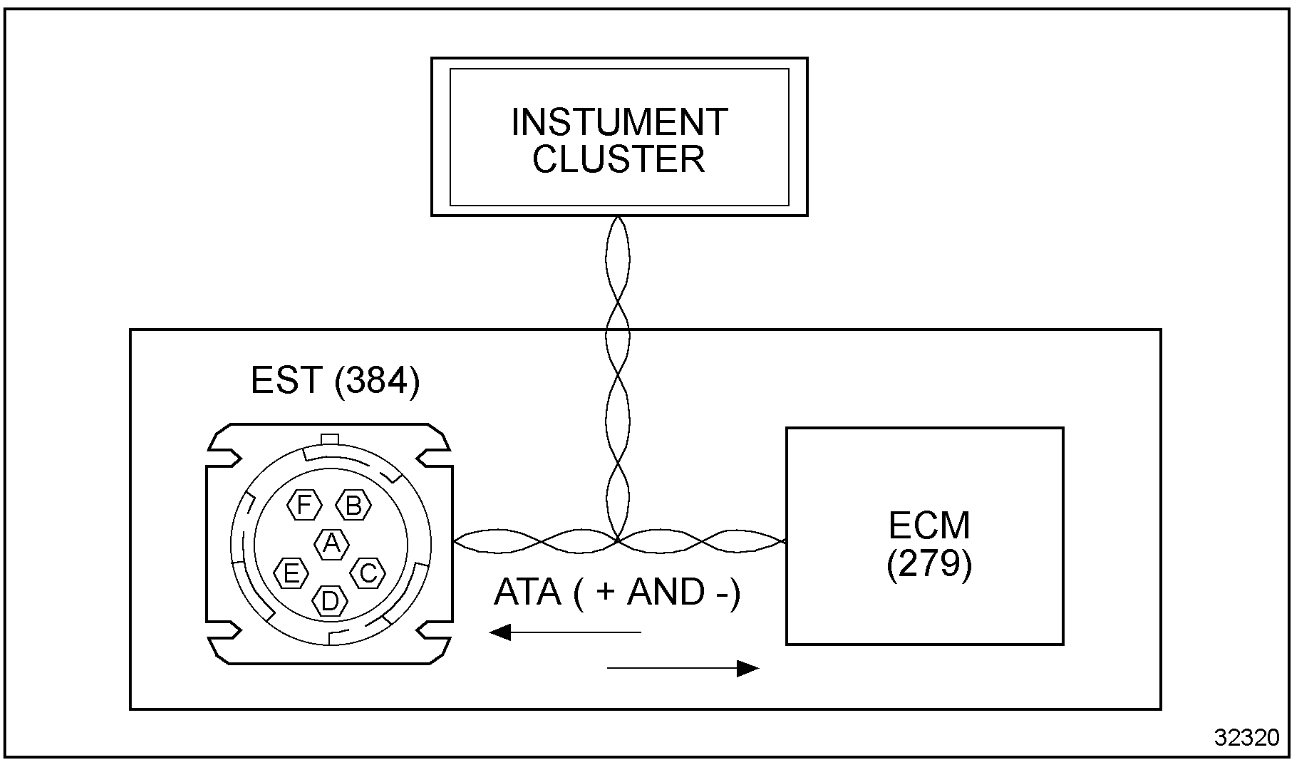
Data Link

3



ATA Communication

SENSOR OPERATION

INPUT SIGNALS

Engine and vehicle sensors transmit input signals to the ECM by either:

1. Controlling a reference voltage to produce an analog or digital signal (i.e. ICP, EOT)
2. Generating an analog or digital signal voltage i.e. CMP, VSS
3. Switching an analog 12 volt signal i.e. IVS, DDS

Reference Voltage Sensors

Reference voltage sensors are supplied with a constant 5 V regulated voltage supplied by the ECM. A voltage regulator supplies the reference voltage (VREF) to these sensors. This voltage is changed by the sensor and the resultant signal is relayed back to the ECM. The ECM then compares the supplied VREF with the returned signal and determines the value of the variable being measured by matching the signal value with its internal programmed tables.

TYPES OF SENSORS

A description of the types of sensors follows.

Thermistor

A thermistor is a type of sensor that changes its electrical resistance with temperature to which it is being exposed. The electrical resistance of the thermistor decreases as temperature increases and increases as temperature decreases. The sensor, in conjunction with a current limiting resistor in the ECM, forms a voltage divider network that provides a voltage signal that will be matched with a particular temperature value.

The top half of the voltage divider is the current limiting resistor internal to the ECM. A thermistor sensor has two electrical connections, signal return and ground. The output of a thermistor sensor is non linear analog signal. Examples are:

1. EOT, Engine Oil Temperature
2. ECT, Engine Coolant Temperature Sensor
3. IAT, Intake Temperature Sensor

Potentiometer

A potentiometer is a variable voltage divider used to sense the position of a mechanical component. A reference voltage is applied to one end of the potentiometer. Mechanical motion connected to the wiper causes it to move along the resistance material in a rotary fashion. The voltage on the wiper changes at each point along the resistive material. This voltage is proportional to the amount of mechanical movement. An example is:

1. APS, Accelerator Position Sensor

Variable Capacitance Sensor

Variable capacitance sensors are used to measure pressure. The pressure that is to be measured is applied to a ceramic material. The pressure forces the ceramic material closer to a thin metal disk. This action changes the capacitance of the sensor.

These sensors are connected to the ECM by three wires: VREF, signal return and signal ground.

The sensor receives the VREF and returns an analog signal voltage to the ECM. The ECM compares the voltage with pre-programmed values to determine the pressure.

The operational range of the sensor is linked to the thickness of the ceramic disk. The thicker the ceramic disk, the more pressure the sensor can measure. Examples are:

1. EOP, Engine Oil Pressure Sensor
2. ICP, Injection Control Pressure Sensor
3. MAP, Manifold Absolute Pressure Sensor

Hall Effect Sensor

The Hall Effect Sensor is an electronic device that generates voltage. The shape and frequency of this signal depend on how the magnetic field of this sensor is disturbed.

The camshaft position sensor is an example of a hall effect sensor. It contains a permanent magnet, transducer, signal conditioner, and a switching transistor. The permanent magnet of the sensor generates a magnetic field around the transducer and the timing sensor disk mounted to the camshaft gear. As the magnetic field is disturbed by the rotation of the timing disk (vanes and windows), the transducer generates a signal that is filtered and conditioned by the internal CMP sensor signal conditioner.

Once the signal has been conditioned, it is applied to the base of the switching transistor that causes the transistor to switch on and ground the 5 volt line from the ECM. At this time, the ECM no longer senses the 5 volt reference signal.

Each time a vane passes, no signal is generated by the transducer. This action causes the transistor to shut off and allows the ECM to see its 5 volt reference signal.

This switching action allows the ECM to determine crankshaft position and engine speed that is required by the ECM to control engine operating parameters such as injector timing, duration (injection pulse width) and injection control pressure.

This sensor is connected to the ECM by three wires: a 5 volt signal supply, a 5 volt power feed for the signal conditioner VDREF and signal ground.

Magnetic Pickup

A magnetic pickup is a sensor used to generate an alternating frequency that indicates speed. Magnetic pickups normally have a two-wire connection for signal and ground. This sensor is constructed with a permanent magnetic core surrounded by a wire coil. The signal frequency is generated by the rotation of gear teeth that disturbs the magnetic field created by the magnet. For example: See Figure .

1. VSS, Vehicle Speed Sensor

1

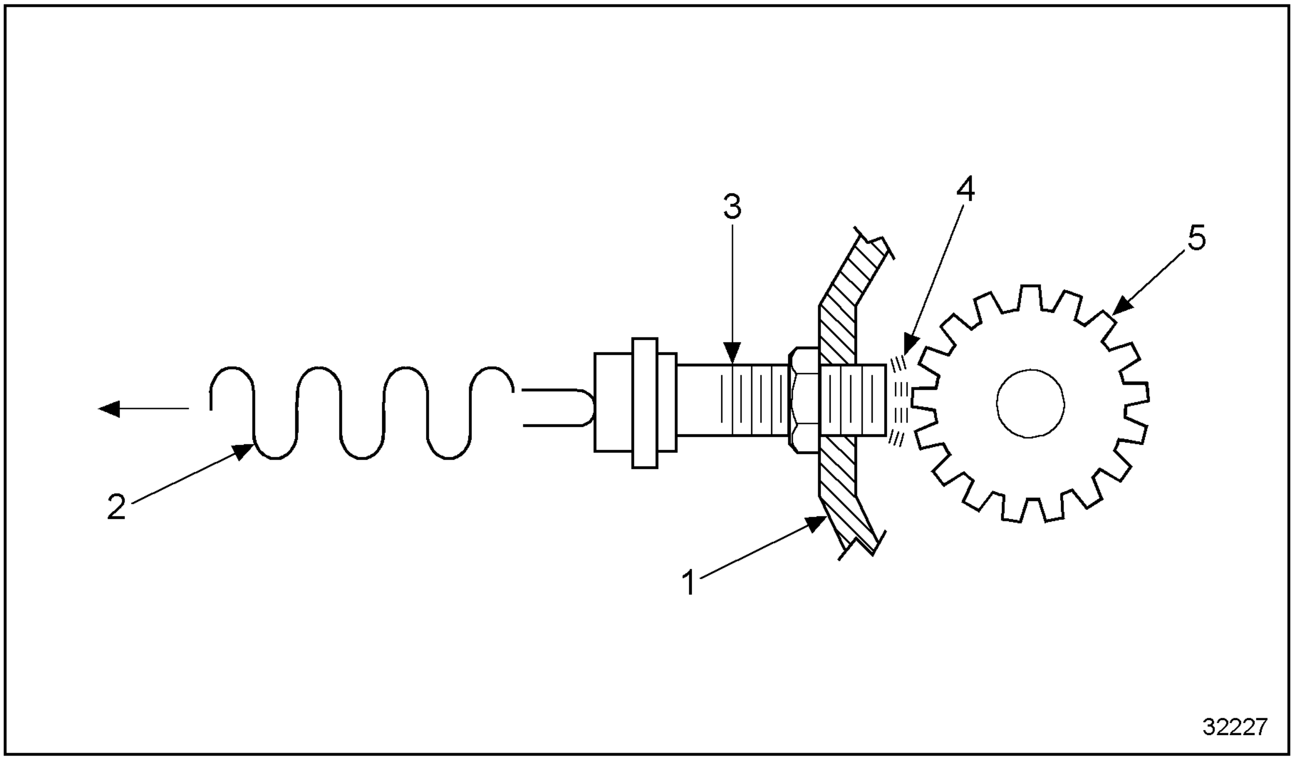
Switch Sensors

Switch sensors are used to indicate positions. They operate either open or closed, allowing or preventing the flow of current. A switch sensor can be either a voltage input type switch or a grounding type switch. A voltage input type switch will supply the ECM with a voltage when it is closed, while a grounding type switch will ground the circuit closed, causing a zero voltage signal. Grounding type switches are usually installed in series with a current limiting resistor.

This sensor is connected to the ECM by two wires: a 12 volt signal and a signal ground. These sensors are considered to be a low speed digital input. Examples are:

1. IVS, Idle Validation Switch
2. BNO, Brake Normally Open
3. CLS, Coolant Level Switch
4. DDS, Driveline Disengagement Switch

1



1. Transmission Case	4. Permanent Magnet Field
2. Output Signal	5. 16-teeth Speedometer Gear
3. Magnetic Pickup Sensor	

Magnetic Pickup (Vehicle Speed Sensor)

ENGINE COOLANT TEMPERATURE SENSOR

SIGNAL FUNCTIONS

The Engine Coolant Temperature (ECT) sensor is a thermistor type sensor that has a variable resistance that changes when exposed to different temperatures. When interfaced with the ECM it produces a 0 to 5 volt analog signal that indicates temperature. **See Figure**
.

1

Coolant Temperature Compensation — At coolant temperatures greater than 214°F (101°C) full load fuel quantity is reduced by approximately 6% for each degree of temperature, until the engine temperature reaches 218°F (103°C). Above 218°F (103°C), fuel is reduced by 3% for each °C increase in temperature.

Idle Speed — At temperatures below 158°F (70°C), low idle is incrementally increased to a maximum of 875 r/min.

Engine Warning and Protection — Optional feature when enabled will warn driver of overheat condition and can be programmed to shut the engine down.

Fault Detection/Management

An ECT signal that is detected out of range high or low by the ECM will cause the ECM to ignore the ECT signal and assume an engine coolant temperature of –29°F (–20°C), for starting and a temperature of 180°F (82°C) for engine running conditions. The warning lamp will also be illuminated as long as the fault condition exists. **See Figure**
.2

Note: After removing connectors, always check for damaged pins, corrosion, loose terminals, etc.

Connector voltage checks are made with the sensor connector disconnected and the ignition key ON. Checks are **listed in Table** .

Test Points	Spec.	Comments
B to Grd	4.6 - 5.0v	Pull up voltage. If no or low voltage, circuit has open or high resistance or short to ground.
A to Grd	0 - 0.25v	If greater than 0.25 volts, wire is shorted to VREF or battery.

Connector Voltage Checks

Connector checks to chassis ground are made with the sensor connector disconnected, the positive battery cable disconnected, and the ignition key OFF. Checks are **listed in Table** .

Test Points	Spec.	Comments
A to Grd	< 5 Ω	Resistance to chassis ground, check with key off, > 5 Ω, the harness is open.
B to Grd	> 1,000 Ω	Resistance less than 1,000 Ω, indicates a short to ground.

Connector Checks to Chassis Ground

Harness resistance checks are made with the breakout box installed on the engine harness only. Checks are **listed in Table** .

Test Points	Spec.	Comments
#19 to A	< 5 Ω	Resistance from harness connector to 60-pin connector - Signal ground.
#13 to B	< 5 Ω	Resistance from harness connector to 60-pin connector - ECT signal.

Harness Resistance Checks

Operational signal checks are made with the breakout box installed on the ECM and engine (Gray) harness. Checks are **listed in Table**
.

Test Points (+) #13 to (–) #19	Operational Signal Checks			
Voltage	Temp °F	Temp °C	Resistance	Comments
0.356v	230	110	1.19 K Ω	
0.552v	209	99	2 K Ω	
.648	199	93	3.84 K Ω	
3.87v	32	0	69.2 K Ω	
4.33v	–5	–20	131 K Ω	

Operational Signal Checks

Fault code descriptions are **listed in Table** .

Circuit Faults	
114	Signal was less than 0.127 volts for more than 0.1 seconds. (Probable short to ground.)
115	Signal voltage was greater than 4.6 volts for more than 0.1 seconds. (Probable open circuit.)
Cooling System Faults	
316	Engine temp has not warmed above spec after 120 minutes of operation. (Only on engines with cold ambient protection turned on.)
321	Engine Coolant Temperature above WARN level 228°F (109°C).
322	Engine Coolant Temperature above Critical level 234°F (112.5°C).
325	Coolant Temperature Compensation enabled. (Reduces fuel quantity 6% for each °C above 225°F (107°C).

Fault Code Descriptions

Function of Extended System

The DDC engine control system includes an Engine Coolant Temperature sensor. The ECM measures the engine coolant temperature signal and uses this information for coolant temperature compensation and optional high temperature warning and shut down systems.

Coolant Temperature Compensation protects the engine if the coolant temperature is too high. The ECM monitors the ECT signal to determine the coolant temperature. If the coolant reaches 214°F (101°C), the ECM will reduce the fuel delivery by 6% for each Celsius degree of temperature increase. If the coolant temperature increases to 218°F (104°C), fuel quantity will be reduced 3% for each Celsius degree of temperature increase. Coolant temperature compensation can be programmed to be inoperative in certain applications where full engine performance is required over the protection of the engine.

On engines equipped with an engine warning system, the ECM will activate the audible warning alarm and illuminate the red Oil/Water warning light when the engine coolant temperature reaches 225°F (107°C).

On engines equipped with an engine shutdown system, the ECM will shut the engine off when the coolant temperature reaches 235°F (112.5°C). The vehicle operator may restart the engine by turning the ignition key OFF and then restarting it. Upon restart, the ECM will allow the engine to run for an additional 30 seconds before shutting off the engine again.

Operation

The ECT sensor is a thermistor type sensor that changes resistance when exposed to different temperatures.

When the temperature of the coolant is decreased, the resistance of the thermistor increases which causes the signal voltage to increase. As the temperature of the coolant is increased, the resistance of the thermistor decreases, which causes the signal voltage to decrease.

The ECT sensor is supplied a regulated 5 volt reference voltage from the ECM. The sensor is grounded at terminal A through the signal return terminal at the ECM. As the coolant temperature increases or decreases, the sensor changes resistance and provides the ECM with the coolant temperature signal voltage at the ECM. This signal voltage is then read by the ECM to determine the temperature of the coolant.

ECM Diagnostics

With the ignition key ON, the ECM continuously monitors the ECT circuit for expected voltages. If the signal voltage is less than or more than expected, the ECM will set a fault code.

If the ECM detects a fault in the ECT signal, the ECM will disregard the signal and default to a temperature of 180°F (82°C) for engine running operation and –29°F (–33.9°C) for starting the engine. If the fault is no longer present, the ECM will once again return to normal operation using the ECT signal for processing.

Faults in the ECT signal can be retrieved using the Self Test Input Switch (STI) or the Electronic Service Tool (EST). If the fault is no longer present, it will be stored as an inactive code.

Flash Codes

The following flash codes could result from ECT sensor problems:

Flash Code 114

ATA Code PID 110 FMI 4

Out of Range LOW

An out of range low code will be set if the ECM detects a voltage less than .127 volts for more than 0.1 seconds. If this fault is active, the ECM will use the default value of 180°F (82°C).

Flash Code 114 may be caused by a short to ground or a shorted or biased sensor.

Flash Code 115

ATA Code PID 110 FMI 3

ECT: Out of range HIGH

An out of range high code will be set if the ECM detects a voltage greater than 4.6 volts for more than 0.1 seconds. If this fault is active, the ECM will use the default value of 180°F (82°C).

Flash Code 115 may be caused by an open circuit, an open sensor, or a short to another voltage source.

Flash Code 321

ATA Code PID 110 FMI 0

Engine coolant temperature above warning level.

Flash Code 321 will be set if the ECM detects engine coolant temperature above 225°F (107°C). When this occurs, the ECM illuminates the OIL/WATER warning light and sounds the audible alarm (if equipped), alerting the operator that a potential for engine damage exists.

If the temperature drops below 225°F (107°C), the code will become inactive and the ECM will return to normal operation.

Flash Code 322

ATA Code PID 110 FMI 7

Engine coolant temperature above critical level.

Flash Code 322 will be set if the ECM detects engine coolant temperature above 235°F (112.5°C). When this occurs, the OIL/WATER warning light illuminates and the audible alarm sounds (if equipped) alerting the operator that the temperature is increasing (having set code 321) indicating a potential for engine damage. With code 322 active, the engine will shut down. At the same time a fault code, current engine hours and odometer reading, will be recorded in the ECM as an Engine Event.

If the temperature drops below 235°F (112.5°C), the code will become inactive and the ECM will return to normal operation. Should the engine shut down, it can be restarted to move the vehicle to a safe place.

Flash Code 325

ATA Code PID 110 FMI 14

Power reduced, matched to cooling system performance.

Flash Code 325 will be set if the cooling system temperature exceeds 214°F (101°C). At this temperature the ECM will reduce the fuel delivered to the engine. For each one Celsius degree of temperature, the fuel will be reduced 6%. This reduces the heat produced by the engine, thereby reducing the burden on the engine cooling system. It will also slow the vehicle speed encouraging the operator to downshift, thus increasing the efficiency of the cooling system.

As the temperature is reduced, the compensation level is reduced, until the temperature drops below 214°F (101°C), at which normal operation is resumed.

Flash Code 316

ATA Code PID 110 FMI 1

CAP fault code — unable to warm engine.

Flash Code 316 will only be set with engines that have CAP (Cold Ambient Protection) strategy enabled. This code is set after the engine has run for greater than 120 minutes and has not exceeded the following specifications for engine coolant temperature. This code can be cleared with the EST.

1. DT 466E / 530E
2. Manual Transmission 142°F / 61°C
3. Automatic Transmission 106°F / 41°C

Note: This code only indicates that the engine has not been able to reach operating temperature. It does not indicate an electronic fault.

Possible System Faults include:

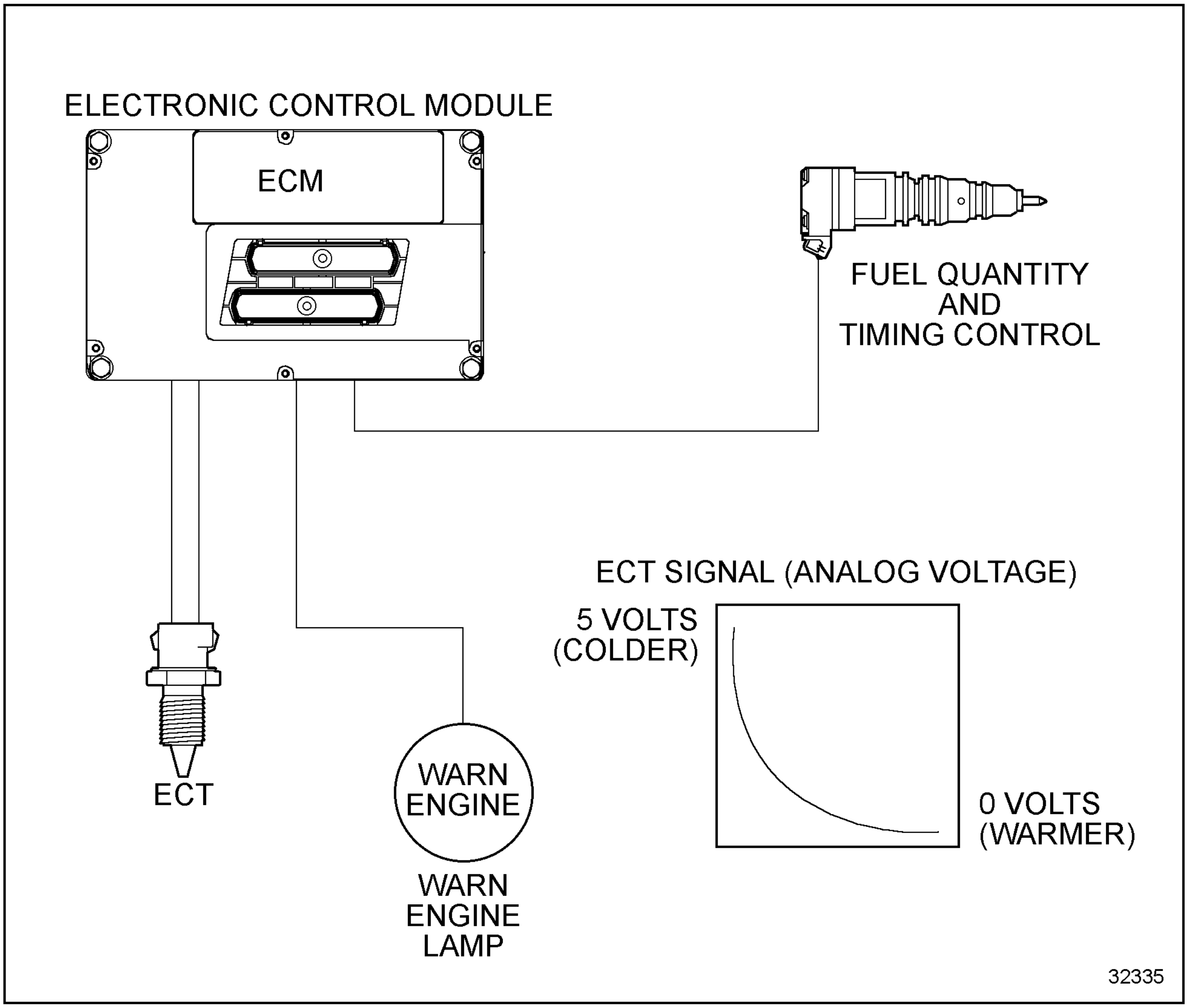
1. Extended idle time
2. Cold ambient temperatures (may require use of winter front)
3. Thermostat stuck in open position
4. Mis-plumbed cooling system (thermostat bypassed)
5. Auxiliary heater cores cooling off engine (school bus application)
6. Fan clutch locked on

Recommended actions are **listed in Table**.

Condition	Action
Extended idle time.	Recommend to reduce idle time or increase idle speed.
Cold ambient temperatures (may require use of winter front).	Recommend use of winter front.
Thermostat stuck in open position.	Perform thermostat tests per service manual.
Mis-plumbed cooling system.	Verify correct cooling system routing.
Auxiliary heater cores cooling off engine.	Reduce flow to heater cores or slow down fan speed of heater.
Fan clutch locked on.	Verify proper fan clutch operation.

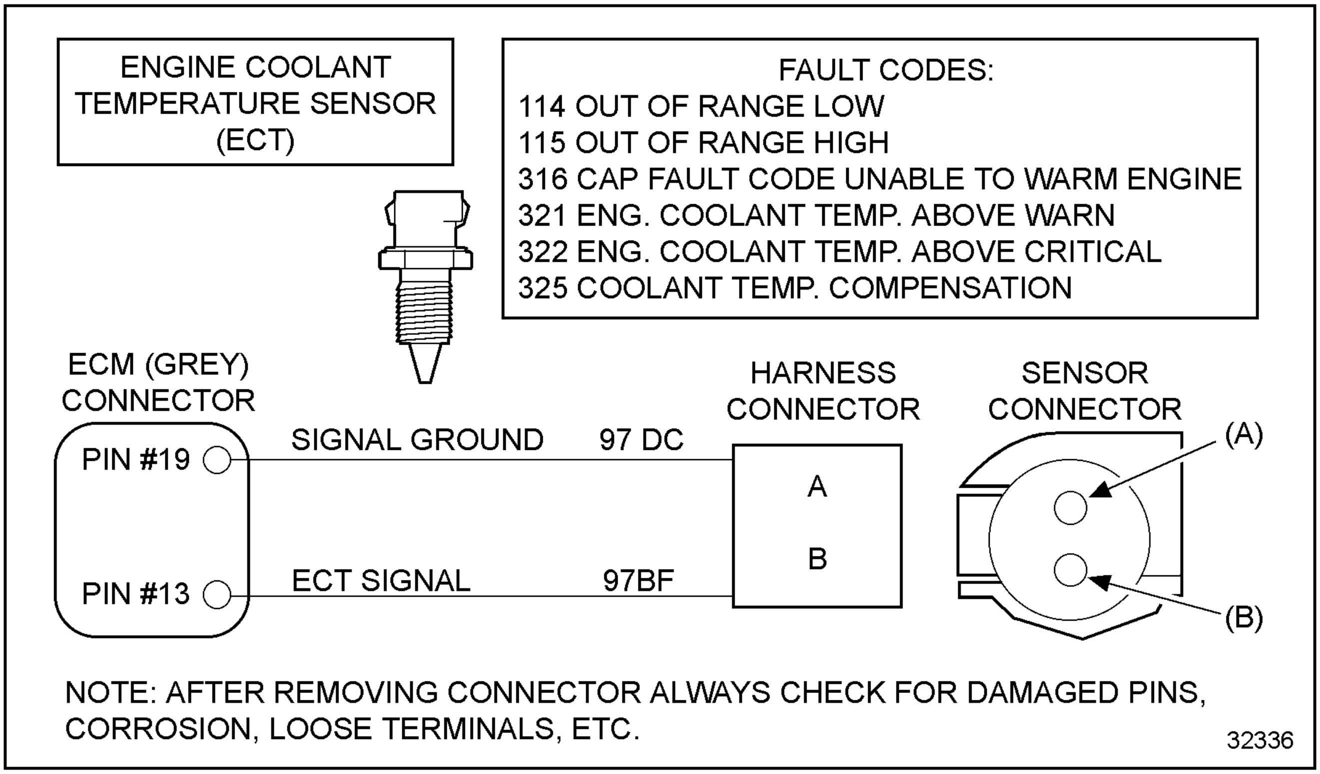
System Faults

1



Engine Coolant Sensor Function Diagram

2



Connector Voltage Checks

BAROMETRIC PRESSURE SENSOR

SIGNAL FUNCTIONS

The BARO (Barometric Pressure) sensor is a variable capacitance sensor that, when supplied with a 5 volt reference signal from the ECM, produces a linear analog voltage signal that indicates pressure.

For the Barometric Pressure Sensor function diagram, **See Figure**
.
1

Timing Control — The BARO signal is used to determine altitude to adjust the timing and fuel quantity to optimize engine operation and control smoke throughout all altitude conditions.

Fault Detection Management

A BARO signal that is detected out of range high or low by the ECM will cause the ECM to ignore the BARO signal and use the MAP (Manifold Absolute Pressure) signal generated at low idle as an indication of barometric pressure. If a MAP fault is also detected, the BARO will default to 29.6 in. Hg of barometric pressure. **See Figure** .

2

Connector voltage checks are **listed in Table** . Check with the sensor connector 406 disconnected, the ignition key ON and all accessories OFF.

Test Points	Spec	Comments
1 to Grd	< 0.25v	If voltage is greater than 0.25v signal wire is shorted to VREF or battery.
2 to Grd	5 ± 0.5 volts	VREF, check with key ON; if voltage not in spec, see VREF circuit.
2 to Grd	< 0.25v	If voltage is greater than 0.25v, signal wire is shorted to VREF or battery.

Connector Voltage Checks

Connector checks to chassis ground are **listed in Table**
. Check with the sensor connector 406 disconnected, the positive battery cable disconnected and the ignition key OFF.

Test Points	Spec	Comments
1 to Grd	< 5 Ω	Resistance to chassis ground, check with key off; > 5 Ω, the harness is open.
2 to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.
3 to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.

Connector Checks to Chassis Ground

Harness resistance checks are **listed in Table** . Check with the breakout box installed on the chassis harness only.

Test Points	Spec	Comments
#11 to 1	< 5 Ω	Resistance from sensor connector to 60-pin connector - signal ground
#3 to 2	< 5 Ω	Resistance from sensor connector to 60-pin connector - VREF
#29 to 3	< 5 Ω	Resistance from sensor connector to 60-pin connector - BARO signal

Harness Resistance Checks

Operational voltage checks are **listed in Table** . The test points are + No. 29 to —No. 11. Check with the breakout box installed in line with the ECM.

Voltage	In. Hg	kPa	Comments
4.89	31.0905	105	High atmospheric pressure
44.60	29.61	100	Normal atmospheric pressure at sea level
2.60	17.766	60	Normal atmospheric pressure at 10,000 feet

Operational Voltage Checks

Fault code descriptions are **listed in Table** .

Fault Code	Description
151	Signal voltage was greater than 4.95 volts for more than 1.0 seconds.
152	Signal voltage was less than 1.0 volts for more than 1.0 seconds.

Fault Codes

Barometric Pressure Sensor Operation

The ECM sends a regulated 5 volt signal from the ECM (black) chassis connector terminal 3 to the BARO connector terminal 2. The BARO sensor returns a variable voltage signal (represents atmospheric pressure) from the BARO connector terminal 3 to the ECM at terminal 29. The BARO sensor is grounded from the BARO connector terminal 1 to the ECM signal ground terminal 11.

ECM Diagnostics

The ECM continuously monitors the signal from the BARO sensor to the ECM terminal 29. If the signal is out of the expected range, a fault is logged (warning light does NOT turn on) and the ECM uses the MAP signal generated at low idle to determine barometric pressure.

Flash Codes

Flash Code 151

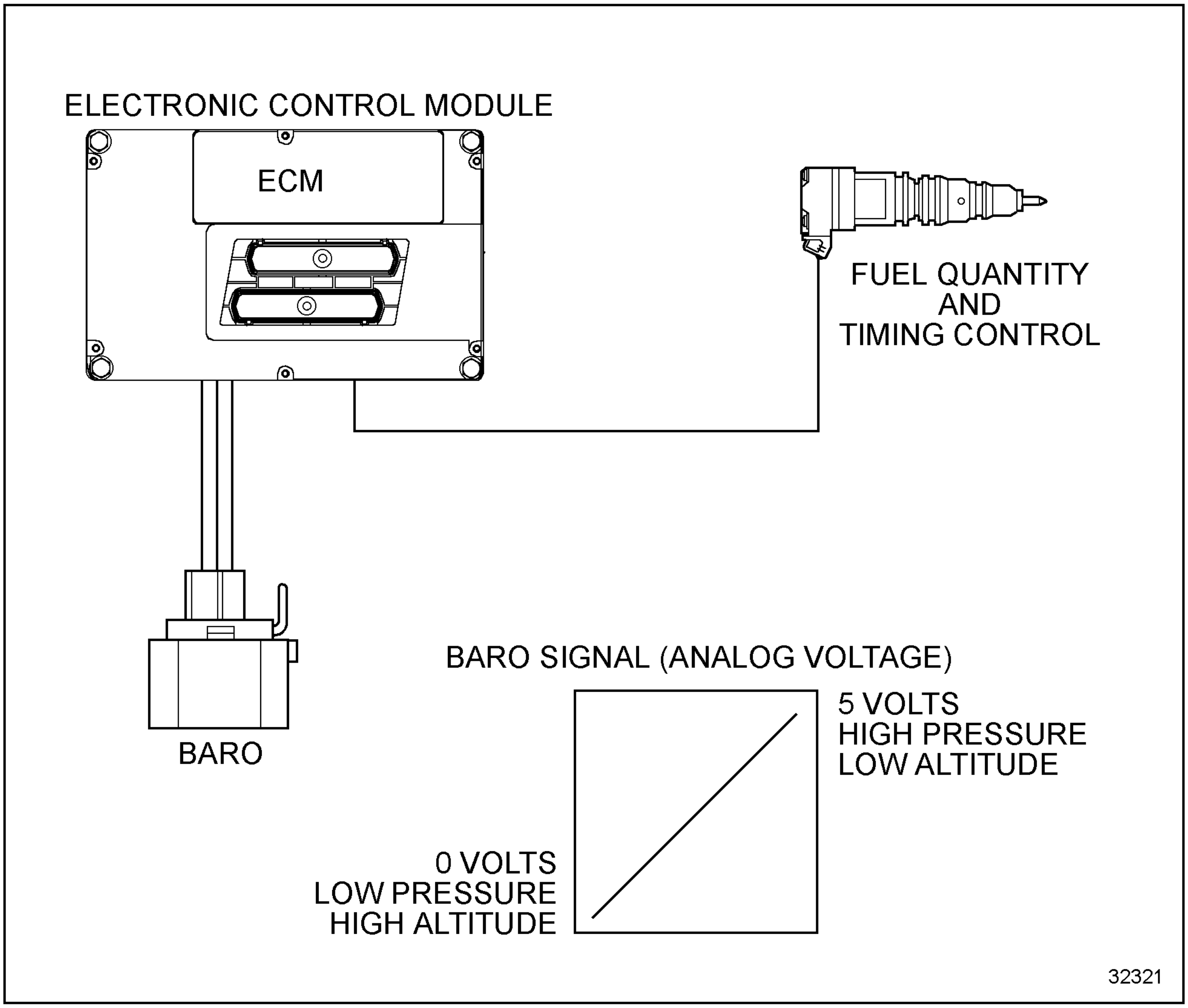
ATA Code PID 108 FMI 3

ECM: BARO signal out of range high; the BARO signal is greater than 34.95 volts for more than one second.

Flash Code 152

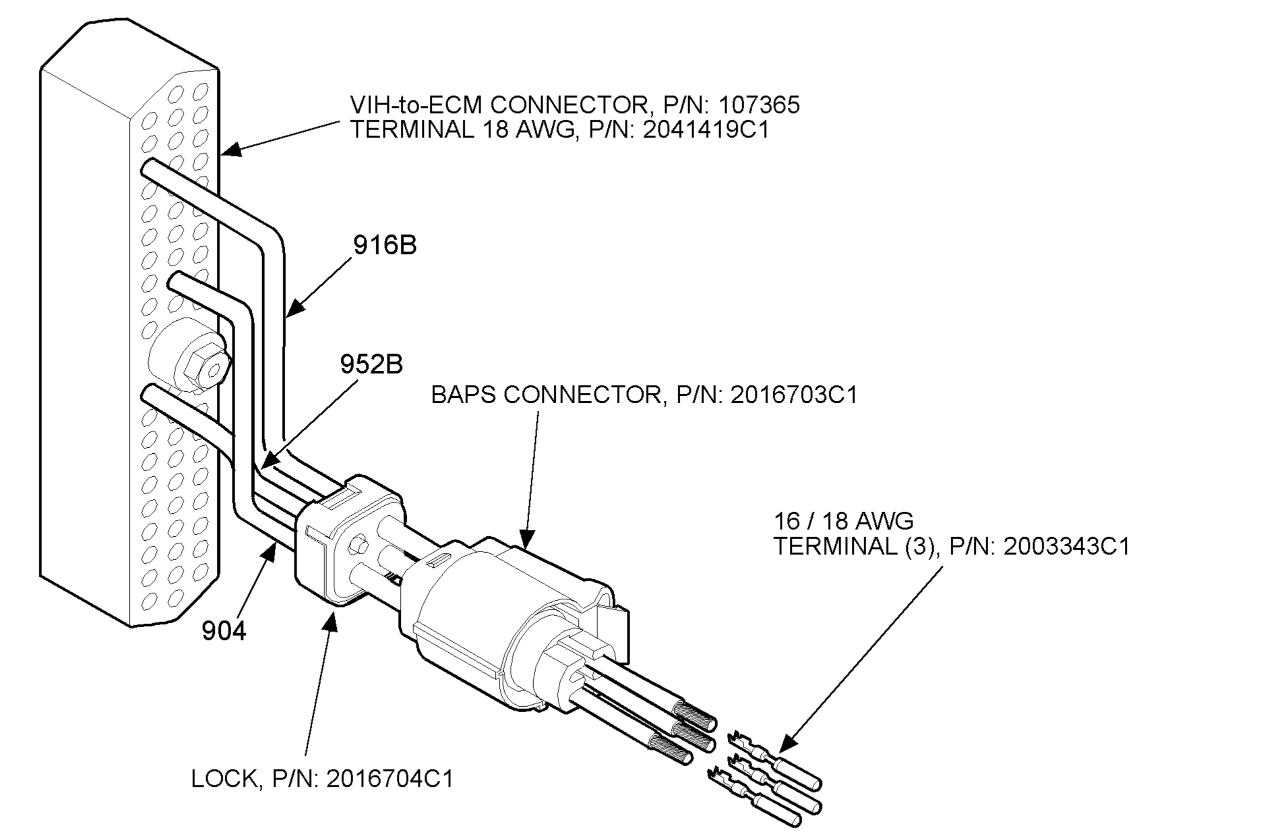
ATA Code PID 108 FMI 4

ECM: BARO signal out of range low; the BARO signal is less than 1.0 volt for more than one second.



Barometric Pressure Sensor Function Diagram

2



LABEL	WIRE NO.	WIRE GAUGE	VIH-to-ECM CONNECTOR CAVITY	WIRE COLOR	BAPS CONNECTOR CAVITY
SENSOR RETURN	952B	18	11	GRAY	1
SENSOR SUPPLY	916B	18	3	GRAY	2
BAROMETRIC AIR PRESSURE	904	18	29	GRAY	3

NOTE: AFTER TERMINALS ARE PUT ON WIRES, PULL INTO CONNECTOR TO LOCK

28791

Recommended Wiring for the Barometric Air Pressure Sensor

MANIFOLD ABSOLUTE PRESSURE SENSOR

SIGNAL FUNCTIONS

The Manifold Absolute Pressure (MAP) sensor is a variable capacitance sensor that operates on a 5 volt reference signal from the ECM to produce a linear analog voltage signal that indicates pressure. For the MAP sensor function diagram, see Figure .

1

Smoke Control — The MAP signal is used to control smoke by limiting fuel quantity during acceleration until a specified boost pressure is obtained.

Dynamic Injection Timing — Optimizes injection timing for boost pressure measured.

Fault Detection / Management

A MAP signal that is detected by the ECM to be out of range or at an incorrect value for specific conditions will cause the ECM to ignore the MAP signal and will operate the engine with the values from estimated MAP. Operate from a calculated boost pressure signal.

For MAP sensor, see Figure .
2

Connector voltage checks are listed in Table . Checks are made with the sensor connector disconnected and the ignition key ON.

Test Points	Spec	Comments
A to Grd	0 - 0.25 volts	If greater than 0.25 volts, signal ground wire is shorted to VREF or battery.
B to Grd	5 volts ± .5	VREF check with key ON; if voltage not in spec, see VREF circuit.
C to Grd	0 - 0.25 volts	If greater than 0.25 volts, signal ground wire is shorted to VREF or battery.

Connector Voltage Checks

Connector checks to chassis ground are **listed in Table**
. Checks are made with the sensor connector disconnected, the positive battery cable disconnected, and the ignition key OFF.

Test Points	Spec	Comments
A to Grd	< 5 Ω	Resistance to chassis ground, check with key OFF; if > 5 Ω, the harness is open.
B to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.
C to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.

Connector Checks to Chassis Ground

Harness resistance checks are **listed in Table** . Checks are made with the breakout box installed on the engine harness only.

Test Points	Spec	Comments
No. 19 to A	< 5 Ω	Resistance from sensor connector to 60-pin connector - Signal ground.
No. 40 to B	< 5 Ω	Resistance from sensor connector to 60-pin connector - VREF.
No. 30 to C	< 5 Ω	Resistance from sensor connector to 60-pin connector - MAP signal.

Harness Resistance Checks

Operational voltage checks are **listed in Table** .

Test Points (+) No. 30 to (-) No. 19	Operational Voltage Checks (Breakout box installed in line with ECM)		
Voltage	PSI	kPa	Comments
0.039 v	N/A	N/A	Out of range low limit.
0.92 v	0	0	Voltage with key ON, engine OFF. Atmospheric pressure dependent on altitude and barometric pressure.
1.73 v	8.0	56	
2.72 v	18.0	124	

Operational Voltage Checks

Fault code descriptions are **listed in Table** .

Circuit Faults	Descriptions
121	Signal voltage was greater than 4.9 volts for more than 0.1 seconds.
122	Signal voltage was less than 0.039 volts for more than 0.1 seconds.
System Faults	Descriptions
123	Detected high boost (above 16.7 psi / 115 kPa) signal at low idle.

Fault Code Descriptions

Function

The engine control system includes a Manifold Absolute Pressure (MAP) sensor. The ECM measures the signal from the MAP sensor to determine intake manifold (Boost) pressure. From this information, the ECM can optimize control of fuel rate and injection timing for all engine operating conditions.

Operation

The MAP sensor is a variable capacitance sensor located on the intake manifold that produces a linear analog voltage signal output. The MAP sensor is supplied 5 volts from ECM pin 19 to terminal A of the sensor. A return circuit (ground) is supplied from ECM pin 40 to terminal B of the sensor. Pressure applied to the MAP sensor changes the capacitance of the sensor that varies the signal voltage sent to the ECM. As boost pressure increases, the voltage signal increases.

ECM Diagnostics

The ECM monitors the MAP sensor output signal for expected values. If the ECM detects the MAP signal is greater than or less than the desired value, the ECM will set a fault code.

If an active MAP sensor fault code is set, the ECM will ignore the MAP signal. It will operate the engine using programmed default values. Active faults for the MAP sensor will cause the ECM to illuminate the Engine Warning light. These faults can be retrieved using the Self Test Input diagnostic switch located on the vehicle dash or the EST (Electronic Service Tool). If the ignition key is turned off, the fault code will be stored as an Inactive code.

Flash Codes

The following flash codes are possible when troubleshooting the MAP:

Flash Code 121

ATA Code PID 102 FMI 8

MAP signal out of range HIGH.

Flash Code 121 will be set if the ECM detects a MAP signal voltage greater than 4.9 volts for more than 0.1 seconds.

If Flash Code 121 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values. The ECM will illuminate the Engine Warning light when this code is active.

Flash Code 122

ATA Code PID 102 FMI 11

MAP signal is out of range LOW.

Flash Code 122 will be set if the ECM detects a MAP signal voltage less than .039 volts for more than 0.1 seconds.

When code 122 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values. The ECM will illuminate the Engine Warning light when this code is set.

Possible causes: A defective MAP sensor or MAP sensor signal circuits may be open or shorted to ground.

Flash Code 123

ATA Code PID 102 FMI 2

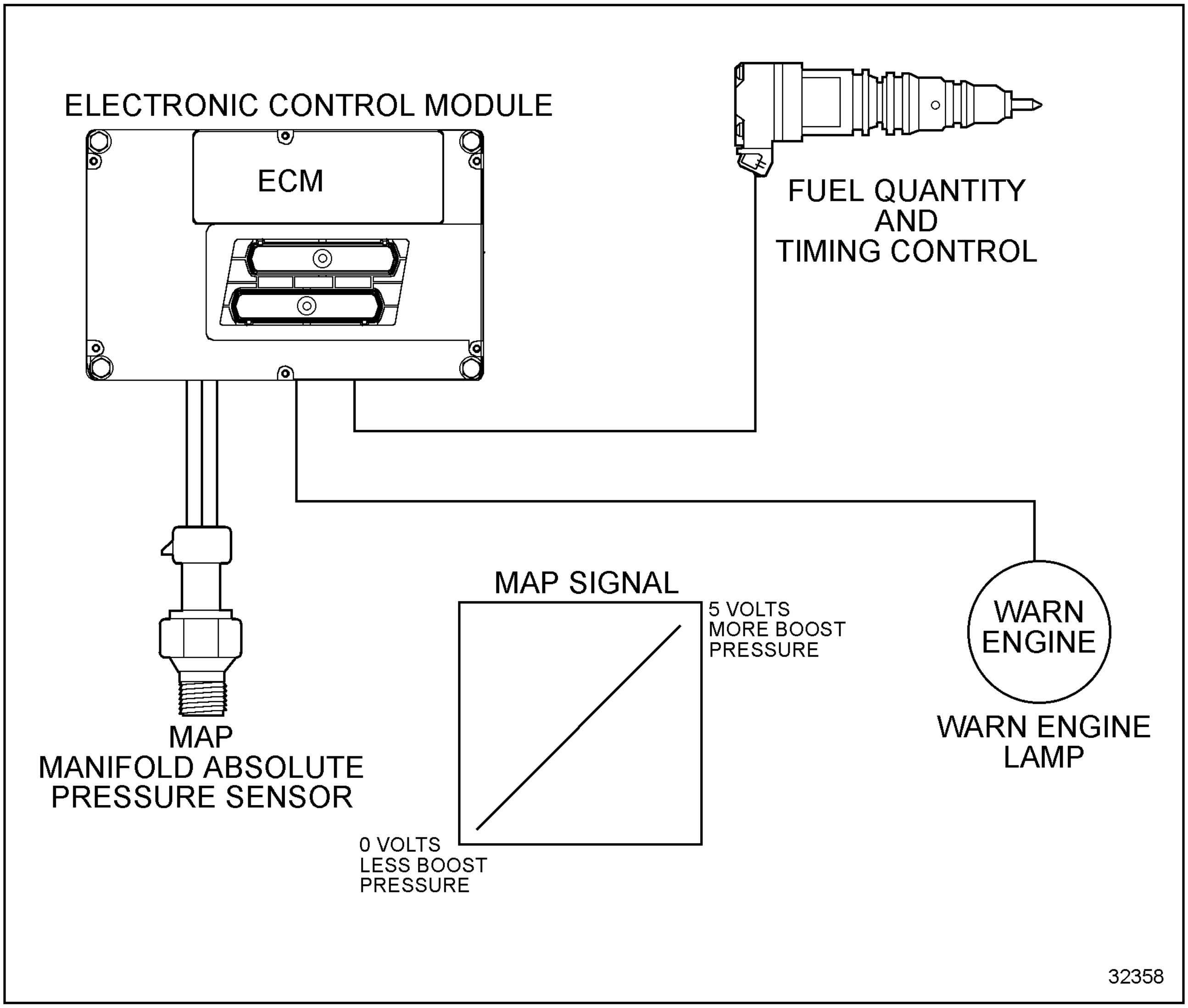
MAP signal above specified level at low idle.

Flash Code 123 is set when the MAP signal is greater than 16.7 psi (115 kPa) Absolute at low idle.

When code 123 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values. The ECM will illuminate the Engine Warning light when this code is set.

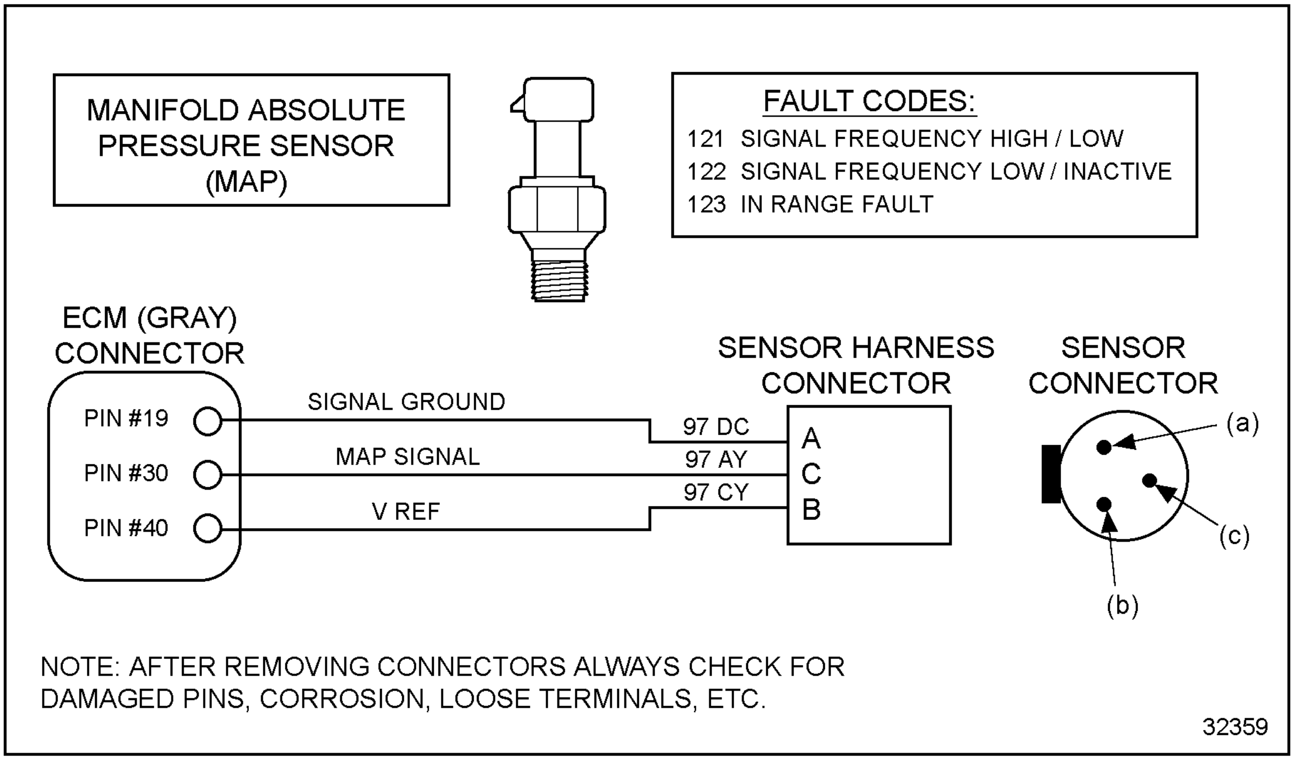
Possible causes: Restricted or plugged sensor inlet or a defective MAP sensor.

1



Manifold Absolute Pressure Sensor Function Diagram

2



Manifold Absolute Pressure Sensor

ENGINE OIL PRESSURE SENSOR

SIGNAL FUNCTIONS

The Engine Oil Pressure (EOP) sensor is a variable capacitance sensor, that when supplied with a 5 volt reference signal from the ECM, produces a linear analog voltage signal that indicates engine oil pressure. For the EOP sensor function diagram, **see Figure** .

1

Engine Warning and Protection — An optional feature that, when enabled, will warn the driver of low engine oil pressure condition and can be programmed to shut the engine down.

Instrument Cluster Display — The ECM transmits sensed engine oil pressure information on the ATA data link that is for display on the instrument cluster.

Fault Detection / Management

An EOP signal that is detected out of range high or low by the ECM will cause the engine to ignore the EOP signal and disable Engine Warning and Protection. For details of the engine oil pressure sensor, **see Figure**

.

2

Connector voltage checks are **listed in Table** . Checks are made with the sensor connector disconnected and the ignition key ON.

Test Points	Spec	Comments
A to Grd	0 volts	Signal ground; no voltage expected.
B to Grd	5 volts ± .5	VREF check with key ON; if voltage not in spec, see VREF circuit.
C to Grd	< .75 volts	If greater than 0.75 volts, signal ground wire is shorted to VREF or battery.

Connector Voltage Checks

Connector checks to chassis ground are **listed in Table**
. Checks are made with the sensor connector disconnected, the positive battery cable disconnected, and the ignition key OFF.

Test Points	Spec	Comments
A to Grd	< 5 Ω	Resistance to chassis ground, check with key OFF; if > 5 Ω, the harness is open.
B to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.
C to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.

Connector Checks to Chassis Ground

Harness resistance checks are **listed in Table** . Checks are made with the breakout box installed on the engine harness only.

Test Points	Spec	Comments
#19 to A	< 5 Ω	Resistance from sensor connector to 60-pin connector - Signal ground.
#40 to B	< 5 Ω	Resistance from sensor connector to 60-pin connector - VREF.
#14 to C	< 5 Ω	Resistance from sensor connector to 60-pin connector - EOP signal.

Harness Resistance Checks

Operational signal checks are **listed in Table** . Checks are made with the breakout box installed in line with the ECM.

Test Points (+) #14 to (-) #19	Operational Signal Checks Check with breakout box installed in line w/ECM		
Voltage	PSIG	kPa	Comments
.89v	5	34	Pressure will vary with engine speed and temperature.
1.15v	10	69	
2.40v	35	241	
3.61v	60	414	

Operational Signal Checks

Fault code descriptions are **listed in Table** .

Circuit Faults	Description
211	Signal was less than .039 volts for more than 0.1 seconds.
212	Signal voltage was greater than 4.9 volts for more than 0.1 seconds.
225	Engine oil pressure was sensed greater than 40 psi with the ignition key ON, engine OFF.
Oil Pressure Faults	Description
313	Engine oil pressure < 5 psi (34 kPa) @ 700 r/min or 10 psi (69 kPa) @ 1400 r/min or 20 psi (138 kPa) @ 2,000 r/min.
314	Engine oil pressure < 2 psi (14 kPa) @ 700 r/min or 5 psi (34 kPa) @ 1,400 r//min or 12 psi (152 kPa) @ 2,000 r/min.

Fault Code Descriptions

Function

The Engine Oil Pressure sensor (EOP) is standard in the engine control system. Engine shutdown and protection is an option that can be ordered with the vehicle or activated at the dealer.

The ECM measures the EOP signal to monitor the oil pressure during engine operation. If the oil pressure drops below 5.0 psi (34 kPa) @ 700 r/min or 10.0 psi (69 kPa) @ 1,400 r/min or 20.0 psi (138 kPa) @ 2,000 r/min, the ECM will illuminate the OWL (oil/water light) and sound the audible warning alarm. If the vehicle is equipped with the Engine Shutdown system and the oil pressure drops to 2.0 psi (14 kPa) @ 700 r/min or 5.0 psi (34 kPa) @ 1,400 r/min or 12.0 psi (152 kPa) @ 2,000 r/min, the ECM will shut the engine OFF.

Operation

The EOP sensor is a variable capacitance sensor. When pressure is applied to the sensor, the capacitance changes in relation to the pressure.

The ECM supplies a regulated 5 volt signal to terminal B of the EOP sensor from terminal 40 of the ECM. The EOP sensor is supplied a signal return (ground) at terminal A to terminal 19 of the ECM.

During engine operation, oil pressure acting on the sensor causes the sensor's capacitance to vary which changes the incoming 5 volt reference signal in relation to pressure. The sensor's oil pressure signal at terminal C is sent to terminal 14 of the ECM. This signal increases equally in proportion to an increase in pressure up to a maximum of 85.3 psi (588 kPa).

ECM Diagnostics

The ECM continuously monitors the signal from the EOP sensor to ensure the signal is within the correct operating range. If the signal is lower or higher than required, the ECM will set a fault code. This fault code is retrieved using the EST or by reading the flash code using the STI diagnostic switch. If the ignition key is shut off, the code will be stored as an inactive code.

During engine operation, the ECM also monitors the engine speed signal. It compares the expected oil pressure specification versus engine speed. If the ECM detects that the oil pressure is lower for a given engine speed the ECM will set a fault code. If the pressure is lower than the critical level, the ECM will automatically record this as a low oil pressure “Event” that is stored in the ECM memory and cannot be erased using the EST. This becomes a record of operation of the engine.

Flash Codes

The following fault codes could result form troubleshooting the EOP:

Flash Code 211

ATA Code PID 100 FMI 4

Engine oil pressure signal out of range LOW.

An out of range LOW code will be set if the ECM detects a voltage less than .039 volts for more than 0.1 seconds. If this fault code is set, the ECM will ignore the EOP signal and continue to operate normally. However, if the fault is Active, the ECM will turn on the Engine Warning light.

Flash Code 211 may be caused by an open VREF feed, open signal circuit, or a defective sensor.

Flash Code 212

ATA Code PID 100 FMI 3

Engine oil pressure signal out of range HIGH.

An out of range HIGH code will be set if the ECM detects a voltage more than 4.9 volts for more than 0.1 seconds. If this fault code is set, the ECM will ignore the EOP signal and continue to operate normally. If this fault is active, the ECM will illuminate the Engine Warning light.

Flash Code 212 may be caused by an open signal return circuit, a short to a voltage source, or a defective sensor.

Flash Code 225

ATA Code PID 100 FMI 0

Engine oil pressure sensor signal in range fault.

Flash Code 225 will be set by the ECM if the signal from the EOP sensor is higher than expected with the key ON and the engine OFF (a signal that indicates 40 psi). If the ECM detects this fault, it will ignore the EOP signal and illuminate the Engine Warning lamp. This code most likely will be set because of a defective EOP sensor or a biased circuit.

Flash Code 313

ATA Code PID 100 FMI 1

Engine oil pressure below warning level.

Flash Code 313 indicates that the oil pressure has dropped below the warning level. The specification for the warning level is 5.0 psi (34 kPa) @ 700 r/min or 10.0 psi (69 kPa) @ 1,400 r/min or 20.0 psi (138 kPa) @ 2,000 r/min.

Flash Code 313 may be caused by a defective sensor sending an incorrect signal. To confirm this, compare actual oil pressure (with a mechanical gauge) to the reading on the data list of the EST. Low oil pressure due to defective mechanical components will also set this code.

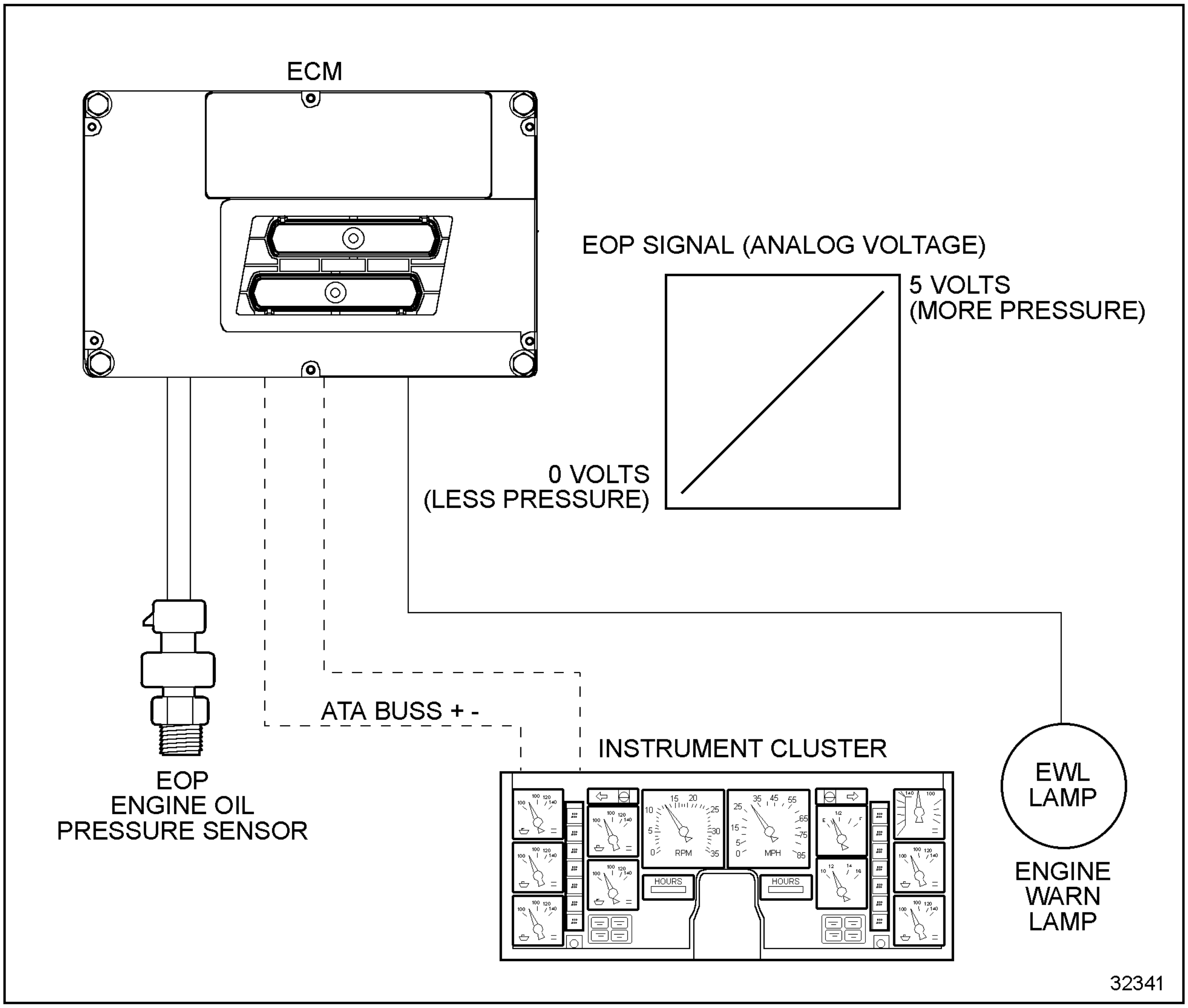
Note: It may be possible to set this code at start up, especially if the oil was just changed, or after a rebuild until the oil system is primed.

Flash Code 314

ATA Code PID 100 FMI 7

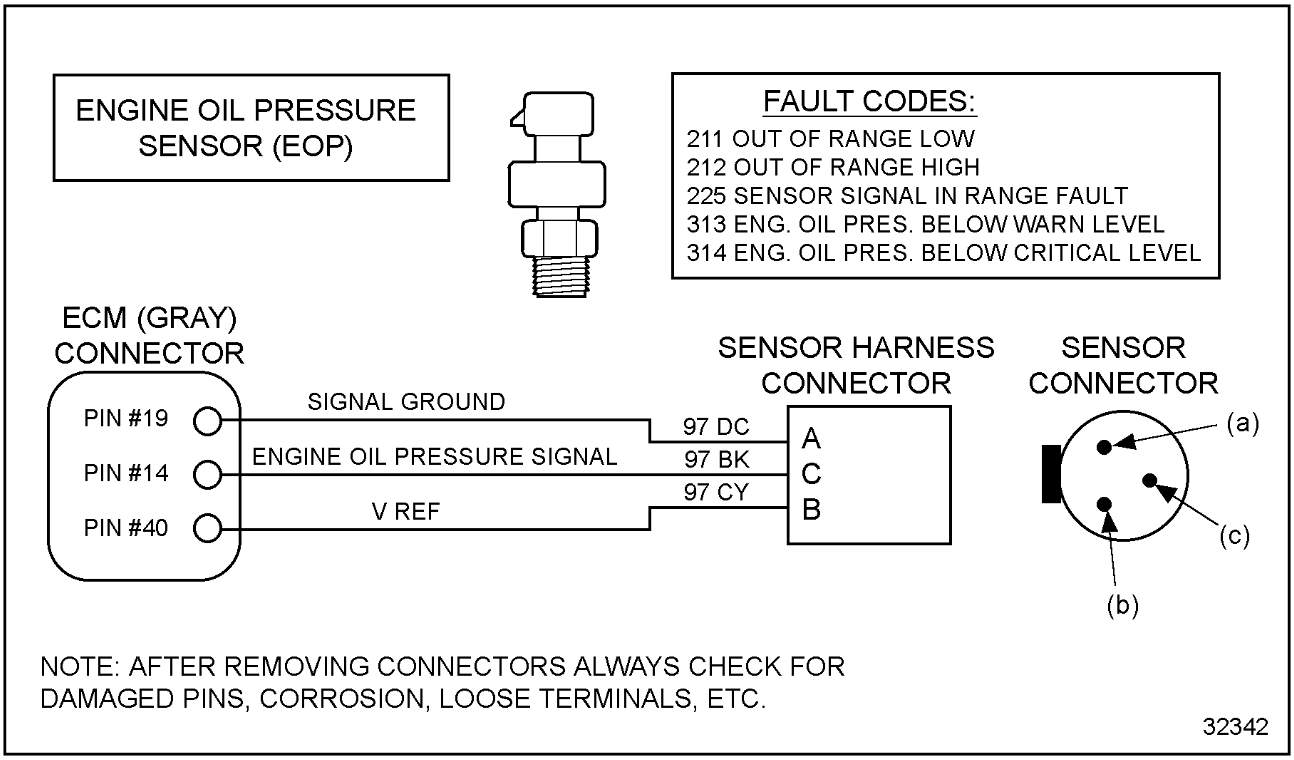
If Flash Code 314 is set, the oil pressure has dropped below the critical level. The specification for the critical level is 2.0 psi (14 kPa) @ 700 r/min or 5.0 psi (34 kPa) @ 1,400 r/min or 22.0 psi (152 kPa) @ 2,000 r/min.

Flash Code 314 may be caused by a defective sensor sending an incorrect signal. To confirm this, compare the actual oil pressure with a mechanical gauge installed, to the reading on the data list of the EST. Low oil pressure due to defective mechanical components will also set this code.



Engine Oil Pressure Sensor Function Diagram

2



Engine Oil Pressure Sensor

ENGINE OIL TEMPERATURE SENSOR

SIGNAL FUNCTIONS

The Engine Oil Temperature (EOT) sensor is a thermistor type sensor that has a variable resistance that changes when exposed to different temperatures. When interfaced with the ECM, it produces a 0 to 5 volt analog signal that indicates temperature. For the EOT sensor function diagram, **see Figure**
.

1

Cranking Fuel Quantity/Timing Control — The EOT signal is used to determine the timing and quantity of fuel required to optimize starting over all temperature conditions.

Temperature Compensation — Fuel quantity and timing is controlled throughout the total operating range to compensate for oil viscosity changes due to temperature variations and ensure that adequate torque and power is available.

Fault Detection/Management

An EOT signal that is detected out of range high or low by the ECM will cause the ECM to ignore the EOT signal and default to the engine coolant temperature (ECT) sensor. The Warn Engine lamp will also be illuminated as long as the fault condition exists. If both the EOT and ECT sensors are not functioning, the ECM will assume a 212°F (100°C) value for engine oil temperature. For the EOT sensor, **see Figure** .

2

Note: After removing connectors always check for damaged pins, corrosion, loose terminals, etc.

Connector voltage checks are **listed in Table** . These checks are performed with sensor connector disconnected and the ignition key ON.

Test Points	Spec	Comments
B to Grd	4.8 - 5.0v	Pull up voltage; if no or low voltage, circuit has open or high resistance or short to ground.
A to Grd	0 - 0.25v	If greater than 0.25 volts, signal ground wire is shorted to VREF or battery.

Connector Voltage Checks

Connector checks to chassis ground are **listed in Table**
. These checks are performed with the sensor connector disconnected, the ignition key OFF, and the positive battery cable disconnected.

Test Points	Spec	Comments
A to Grd	< 5 Ω	Resistance to chassis ground, check with key OFF; if > 5 Ω, the harness is open.
B to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.

Connector Checks to Chassis Ground

Harness resistance checks are **listed in Table** . These checks are performed with the breakout box installed on the engine harness only.

Test Points	Spec	Comments
#19 to A	< 5 Ω	Resistance from sensor connector to 60-pin connector - Signal ground.
#12 to B	< 5 Ω	Resistance from sensor connector to 60-pin connector - EOT signal.

Harness Resistance Checks

Operational signal checks are **listed in Table** . These checks are performed with the breakout box installed in line with the ECM.

Test Points (+) #12 to (-) #19	Operational Signal Checks (Check with breakout box installed in line w/ECM)			
Voltage	Temp °F	Temp °C	Resistance	Comments
0.53v	248	120	1.19 K Ω	
0.96v	205	96	2 K Ω	
1.45v	176	80	3.84 K Ω	
4.36v	32	0	69.2 K Ω	
4.64v	-5	-20	131.0 K Ω	

Operational Signal Checks

Fault code descriptions are **listed in Table** .

Circuit Faults	Descriptions
311	Signal was less than 0.2 volts; more than 0.1 seconds.
312	Signal voltage was greater than 4.78 volts for more than 0.1 seconds.

Fault Code Descriptions

Function

The engine control system includes an Engine Oil Temperature (EOT) sensor. The ECM monitors engine oil temperature via the EOT sensor signals to control fuel quantity and timing throughout the operating range of the engine. The EOT signal allows the ECM to compensate for oil viscosity variations due to temperature changes in the operating environment. This ensures that adequate power and torque are available under all operating conditions.

Operation

The EOT sensor is a thermistor type sensor that changes resistance when exposed to different oil temperatures.

When the temperature of the oil is decreased, the resistance of the thermistor increases, which causes the signal voltage to increase. As the temperature of the oil is increased, the resistance of the thermistor decreases, causing the signal voltage to decrease.

The EOT sensor is supplied a regulated 5 volt reference signal at terminal B from the ECM. A return circuit (ground) is supplied at terminal A from the ECM. As the oil temperature increases or decreases, the sensor changes resistance and provides the ECM with the oil temperature signal voltage. This signal voltage is then read by the ECM to determine the temperature of the oil.

ECM Diagnostics

With the ignition key ON, the ECM continuously monitors the EOT signal to determine if it is within expected values. If the signal voltage is above or below the expected levels, the ECM will set a fault code.

If the ECM detects a fault, it will use the value of the Engine Coolant Temperature signal, in place of the EOT signal. If the ECT sensor is not sending a correct signal, the ECM will default to 29°F (-1.7°C) for starting or 212°F (100°C) for engine running operation.

EOT sensor faults can be retrieved using the EST or by reading the flash codes from the warning light using the STI diagnostic switch located on the vehicle dash. If the ignition key is shut off, the code will become an inactive code. EOT codes will cause the Engine Warning light to be illuminated.

Flash Codes

The following flash codes could display when troubleshooting the EOT.

Flash Code 311

ATA Code PID 175 FMI 4

Engine Oil Temperature signal out of range LOW.

Flash Code 311 out of range low will be set if the signal voltage was less than 0.2 volts for longer than 0.1 seconds. If this code is set, the ECM will default to ECT temperature or a default value of –4°F (–20°C) for starting or 212°F (100°C) for engine running operation. This code will cause the ECM to illuminate the engine warning light.

Flash Code 311 may be set due to a short to ground in the signal circuit or a defective sensor.

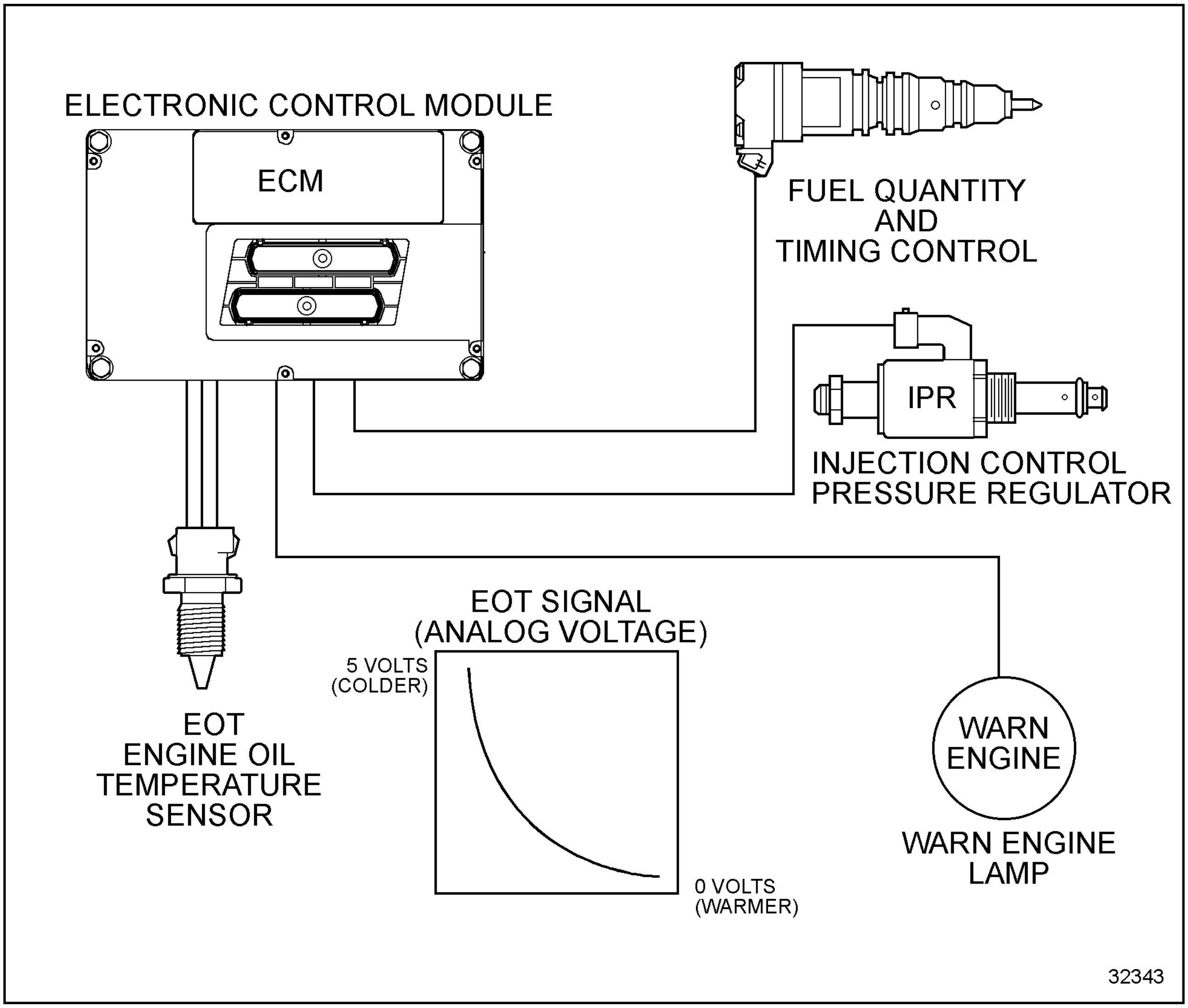
Flash Code 312

ATA Code PID 175 FMI 3

Engine Oil Temperature signal out of range HIGH.

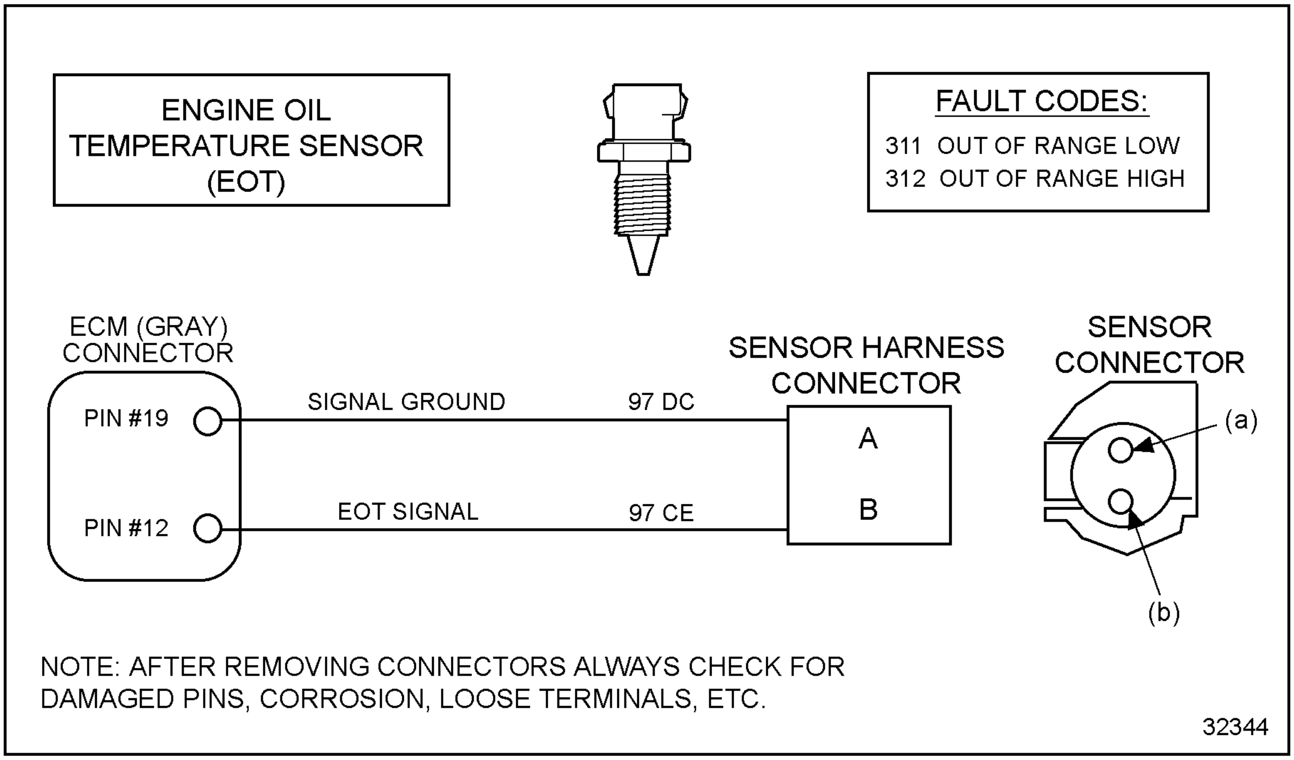
Flash Code 312 out of range high will be set if the signal voltage is more than 4.8 volts for more than 0.1 seconds. If this code is set, the ECM will default to ECT temperature or a default value of –4°F (–20°C) for starting or 212°F (100°C) for engine running operation. This code will cause the ECM to illuminate the engine warning light.

Flash Code 312 may be set due to an open signal circuit between the ECM and the sensor or a short to a voltage source. A defective sensor may also cause Flash Code 312 to be set.



Engine Oil Temperature Sensor Function Diagram

2



Engine Oil Temperature Sensor

INJECTION CONTROL PRESSURE SENSOR

SIGNAL FUNCTIONS

The Injection Control Pressure (ICP) sensor is a variable capacitance sensor that, when supplied with a 5 volt reference signal from the ECM, produces a linear analog voltage signal that indicates pressure.

The ICP sensor's primary function is to provide a feedback signal to indicate injection control pressure to enable the ECM to command the correct injector timing and pulse width, and the correct injection control pressure for proper fuel delivery at all speed and load conditions. For ICP sensor function diagram, **see Figure** .

1

Fault Detection/Management

If the ECM detects a malfunctioning ICP sensor or a problem in the ICP sensor circuit, the WARN lamp will illuminate. The ECM will go to open loop control of injection control pressure. (Operate from an estimated ICP pressure.) For Injection Control Pressure Sensor (ICP), **see Figure** .

2

Connector voltage checks are **listed in Table** . Checks are made with the sensor connector disconnected and the ignition key ON.

Test Points	Spec	Comments
A to Grd	0 volts	Signal ground; no voltage expected.
B to Grd	5 volts ± .5	VREF check with key ON; if voltage not in spec, see VREF circuit.
C to Grd	< 0.25 volts	If greater than 0.25 volts, signal ground wire is shorted to VREF or battery.

Connector Voltage Checks

Connector checks to chassis ground are **listed in Table**
. Checks are made with the sensor connector disconnected, the positive battery cable disconnected, and the ignition key OFF.

Test Points	Spec	Comments
A to Grd	< 5 Ω	Resistance to chassis ground, check with key OFF; if > 5 Ω, the harness is open.
B to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.
C to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.

Connector Checks to Chassis Ground

Harness resistance checks are **listed in Table** . Checks are made with the breakout box installed on the engine harness only.

Test Points	Spec	Comments
#19 to A	< 5 Ω	Resistance from sensor connector to 60-pin connector - Signal ground.
#40 to B	< 5 Ω	Resistance from sensor connector to 60-pin connector - VREF.
#16 to C	< 5 Ω	Resistance from sensor connector to 60-pin connector - ICP signal.

Harness Resistance Checks

Operational signal checks are **listed in Table** . Checks are made with the breakout box installed on the ECM and engine (Gray) harness.

Test Points (+) #16 to (-) #19	Operational Voltage Checks (Check with breakout box installed on ECM and Engine (Gray) Harness		
Voltage	PSI	MPA	Comments
.15 - .30v	0	0	Atmospheric pressure with key ON, engine OFF. (Altitude dependent)
1.0v	580	4	Minimum required at engine cranking speed 150 r/min.
.74 - .81v	425 - 475	2.9 - 3.2	Normal warm idle voltage signal (Check performance specs.)
1.34 - 1.68v	865 - 1157	6.0 - 8.0	Normal high idle voltage signal (Check performance specs.)
3.334v	2550	17.6	Snap accel or full load pressure signal.

Operational Voltage Checks

Fault code descriptions are **listed in Table** .

Circuit Faults	Descriptions
124	Signal voltage was less than 0.039 volts for more than 1.0 seconds.
125	Signal voltage was greater than 4.90 volts for more than 1.0 seconds.
332	Signal above 1.625 volts with engine off. (1160 psi, 8 MPa).

Fault Code Descriptions

Function

The engine control system includes an Injection Control Pressure (ICP) sensor. The ECM measures the signal from the ICP sensor to determine the injection control pressure as the engine is running to modulate the ICP regulator. This is a closed loop function that means the ECM continuously monitors and adjusts for ideal ICP determined by operating conditions such as load, speed and temperature.

The ECM monitors the ICP signal to determine if the performance of the hydraulic system is satisfactory. During engine operation, if the ECM recognizes that the pressure reading is lower or higher than the value that was commanded, the ECM will set a fault code. This strategy is also used during the On Demand tests, commanded by the EST and referred to as the Engine Running tests.

Operation

The ICP sensor is a variable capacitance sensor that is supplied with a 5 volt reference voltage at terminal B by the ECM from terminal 40. The ICP sensor is also supplied with a return circuit (ground) at terminal A from ECM terminal 19. The ICP sensor sends a signal from terminal C of the sensor to ECM terminal 16.

The ICP signal voltage increases or decreases equally in proportion to an increase or decrease in injection control pressure.

ECM Diagnostics

The ECM continuously monitors the signal of the ICP sensor to determine if the signal is within an expected range. If the signal voltage is higher or lower than expected, the ECM will set a fault code. The ECM will then ignore the ICP sensor signal and will use a preset value determined by engine operating conditions. If the ignition key is shut off, the code will become an inactive code.

ICP faults can be retrieved using the EST or by reading the flash codes from the warning light using the STI diagnostic switch located on the vehicle dash.

If the ignition key is shut off, the code will become an inactive code. ICP codes will cause the Engine Warning light to illuminate.

Flash Codes

Flash codes that could display when troubleshooting the ICP include:

Flash Code 124

ATA Code PID 164 FMI 4

ICP signal out of range LOW.

An out of range low code 124 will be set by the ECM if the signal voltage is less than 0.039 volts for more than 1.0 seconds.

Flash Code 124 may be set due to an open or short to ground on the signal circuit, a defective sensor, or an open VREF circuit at the sensor.

Flash Code 125

ATA Code PID 164 FMI 3

ICP signal out of range HIGH.

An out of range high code 125 will be set by the ECM if the signal voltage is greater than 4.9 volts for more than 1.0 seconds.

Flash Code 125 may be set by an open return circuit, short to a voltage source on the ICP signal circuit or a defective sensor.

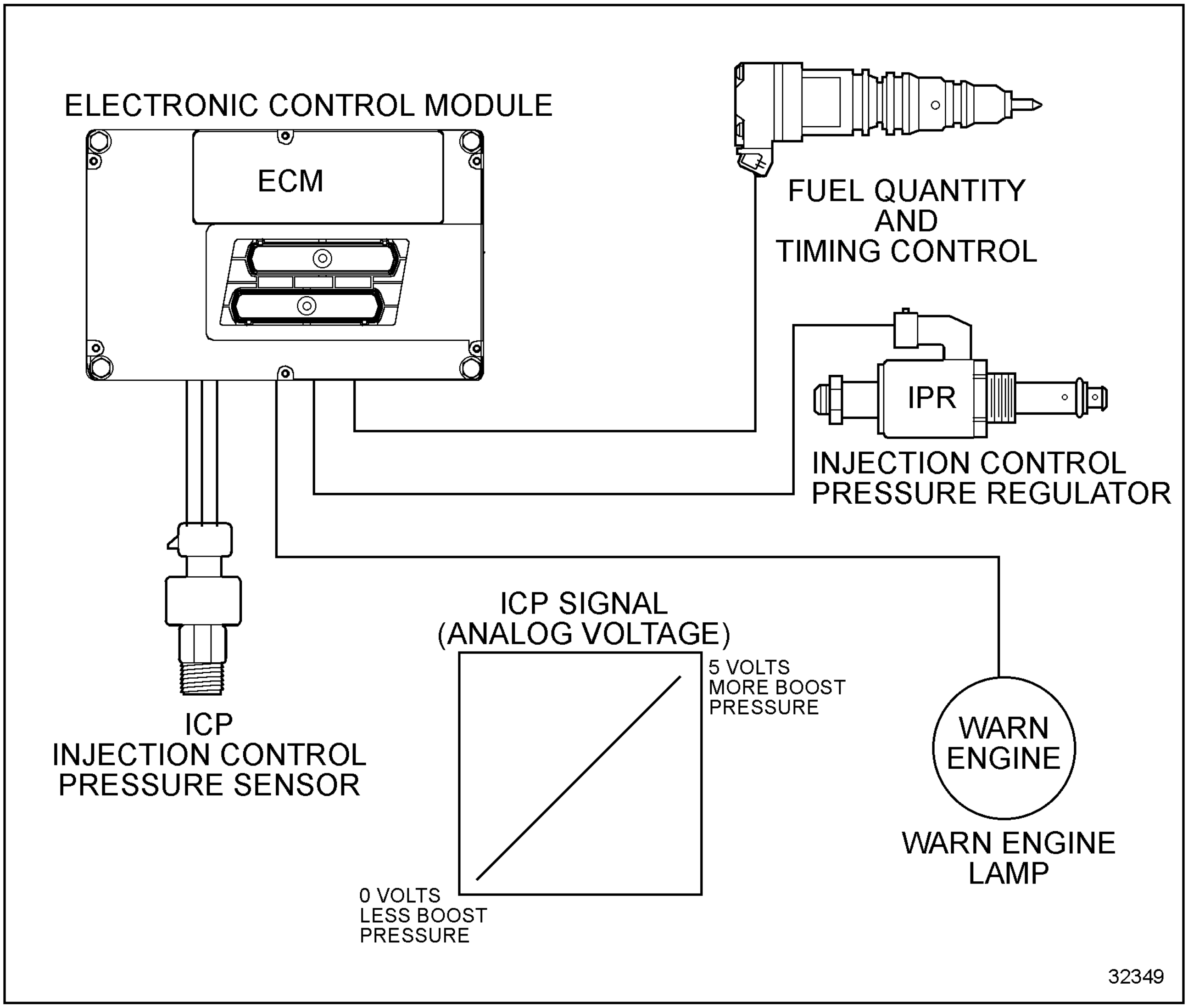
Flash Code 332

ATA Code PID 164 FMI 13

ICP pressure above specification with engine off.

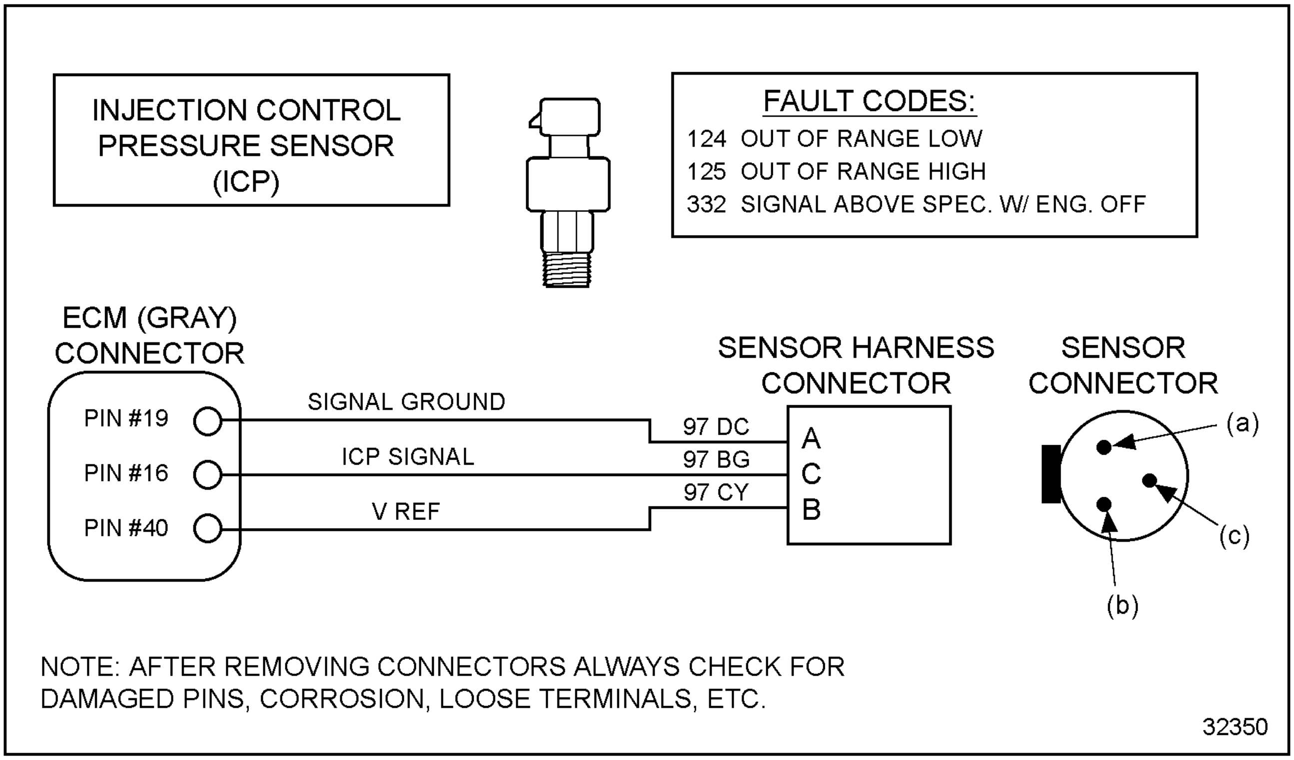
Flash Code 332 will be set by the ECM if the signal from the ICP sensor is higher than expected with the engine not running. If the ECM detects this fault, the ECM will ignore the ICP signal and will operate the IPR with fixed values determined from engine operating conditions.

Flash Code 332 may be caused by a defective sensor or a biased circuit.



Injection Control Pressure Sensor Function Diagram

2



Injection Control Pressure Sensor

INTAKE AIR TEMPERATURE SENSOR

SIGNAL FUNCTIONS

The Intake Air Temperature (IAT) sensor is a thermistor type sensor that has a variable resistance that changes when exposed to different temperatures. When interfaced with the ECM, it produces a 0–5 volt analog signal that will deduce temperature. For IAT sensor function diagram, **see Figure**

.

1

Timing and Fuel Rate — The primary function of the IAT sensor is to measure intake air temperature to control timing and fuel rate while starting the engine in cold weather to limit smoke emissions.

Fault Detection Management

An IAT signal that is detected out of range high or low by the ECM will cause the engine to ignore the IAT signal, and assume an ambient temperature of 77°F (25°C). For IAT sensor, **see Figure** .

2

Connector voltage checks are **listed in Table** . These checks are performed with sensor connector disconnected and the ignition key ON.

Test Points	Spec	Comments
A to Grd	0 - .25v	If greater than 0.25 volts, signal ground wire is shorted to VREF or battery.
B to Grd	4.8 - 5.0v	Pull up voltage; if no voltage, circuit has open or high resistance or short to ground.

Connector Voltage Checks

Connector checks to chassis ground are **listed in Table**

. These checks are performed with the sensor connector disconnected, the ignition key OFF, and the positive battery cable disconnected.

Test Points	Spec	Comments
A to Grd	< 5 Ω	Resistance to chassis ground, check with key OFF; if > 5 Ω, the harness is open.
B to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.

Connector Checks to Chassis Ground

Harness resistance checks are **listed in Table** . These checks are performed with the breakout box installed on the chassis harness only.

Test Points	Spec	Comments
#11 to A	< 5 Ω	Resistance from sensor connector to 60-pin connector - Signal ground.
#12 to B	< 5 Ω	Resistance from sensor connector to 60-pin connector - IAT signal.

Harness Resistance Checks

Operational signal checks are **listed in Table** . These checks are performed with the breakout box installed in line with the ECM.

Test Points (+) #12 to (-) #19	Operational Signal Checks (Check with breakout box installed in line w/ECM)			
Voltage	Temp °F	Temp °C	Resistance	Comments
1.72v	122	50	10.9 K Ω	Resistance checks must be taken across sensor only with the battery disconnected.
3.09v	68	20	37.34 K Ω	
3.897v	32	0	68.75 K Ω	
4.33v	0	-18	120.9 K Ω	
4.53v	-40	-40	194.3 K Ω	

Operational Signal Checks

Fault code descriptions are **listed in Table** .

Circuit Faults	Descriptions
154	Signal voltage was less than .127 volts; more than 0.2 seconds.
155	Signal voltage was greater than 4.6 volts for more than 0.2 seconds.

Fault Code Descriptions

Function

The engine control system includes an Intake Air Temperature sensor (IAT). The ECM measures the signal from the IAT sensor to determine the temperature of the air entering the engine. The ECM uses this data to adjust timing and fuel rate for starting in cold weather, to limit smoke emissions.

Operation

The IAT is a thermistor type sensor that changes resistance when exposed to different air temperatures.

When the temperature of the intake air decreases, the resistance of thermistor increases, which causes the signal voltage to increase. When the air temperature increases, the resistance of the thermistor decreases causing the signal voltage to decrease.

The IAT sensor is supplied a regulated 5 volt reference signal at terminal B from the ECM. A return circuit (ground) is supplied at terminal A from the ECM. As the air temperature increases or decreases, the sensor changes resistance and provides the ECM with the air temperature signal voltage reading.

ECM Diagnostics

With the ignition key ON, the ECM continuously monitors the IAT signal to determine if it is within expected values. If the signal voltage is above or below the expected levels, the ECM will set a fault code.

If the IAT sensor is not sending a correct signal, the ECM will default to 77°F (25°C).

IAT faults can be retrieved using the EST or by reading the flash codes from the warning light using the STI diagnostic switch located on the vehicle dash. If the ignition key is shut off, the code will become an inactive code. IAT codes will cause the Engine Warning light to be illuminated.

Flash Codes

While troubleshooting the Intake Air Temperature sensor, the following codes could set.

Flash Code 154

ATA Code PID 171 FMI 4

Intake Air Temp Signal out of range LOW.

An out of range low code will be set if the ECM detects the signal voltage to be less than 0.127 volts for more than 0.2 seconds. If this fault is active, the ECM will default to a value of 77°F (25°C) for starting.

Flash Code 154 may be set to a short to ground in the signal circuit or a defective sensor.

Flash Code 155

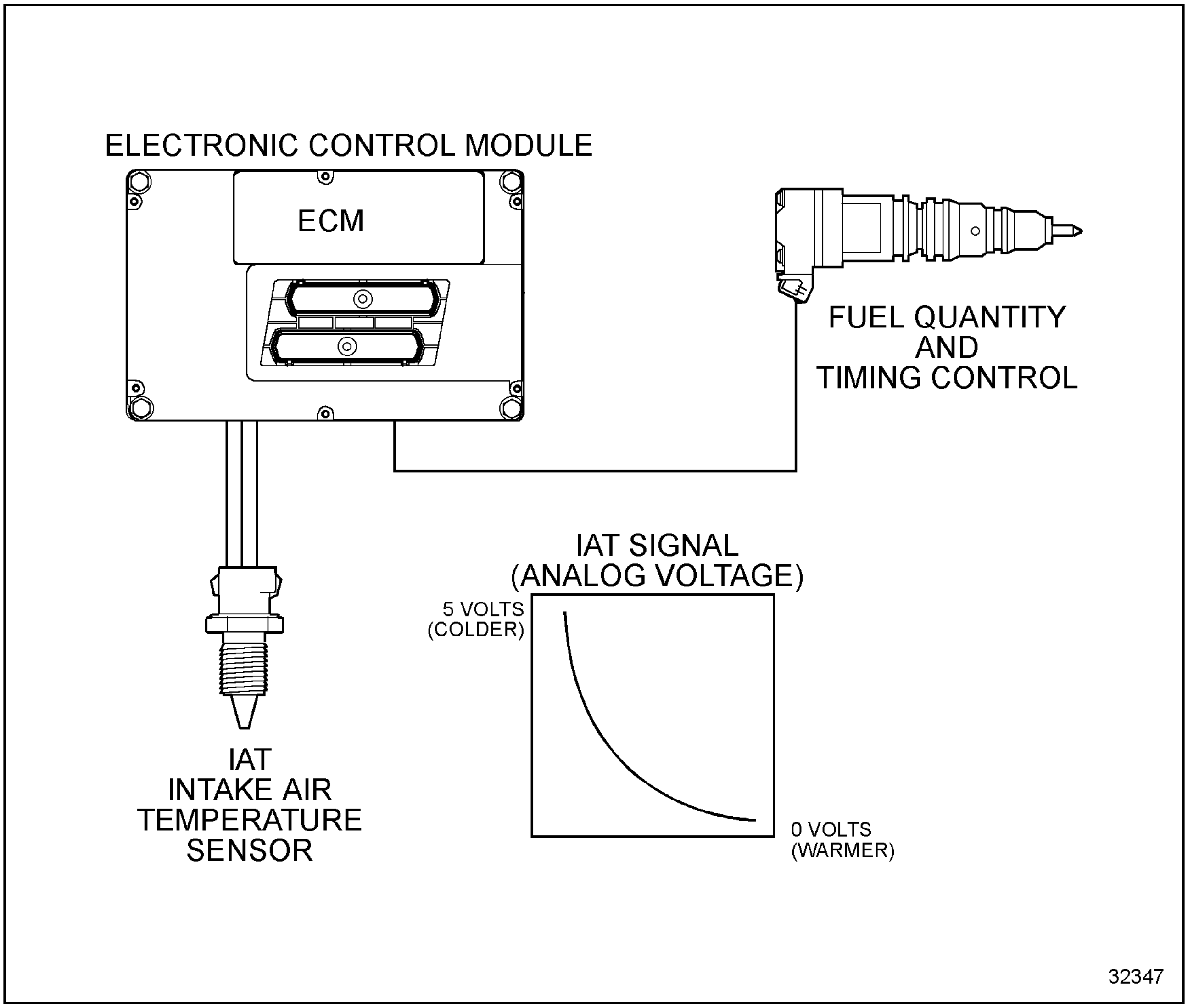
ATA Code PID 171 FMI 3

Intake Air Temp Signal out of range HIGH.

An out of range high code will be set if the ECM detects the signal voltage to be more than 4.6 volts for more than 0.2 seconds. If this fault is active, the ECM will default to a value of 77°F (25°C) for starting.

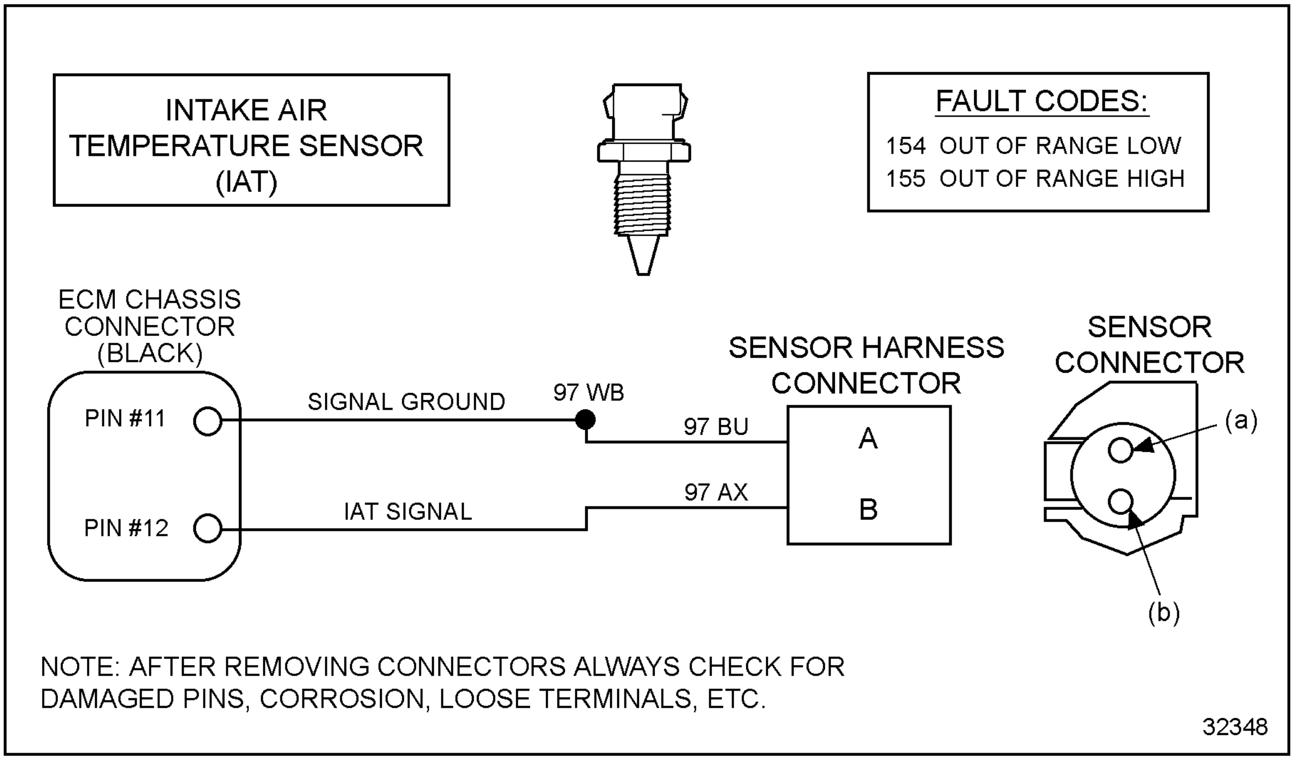
Flash Code 155 may be set due to an open signal circuit between the ECM and the sensor or a short to a voltage source. A defective sensor may also cause Code 155 to set.

1



Intake Air Temperature Sensor Function Diagram

2



Intake Air Temperature Sensor

ELECTRONIC FOOT PEDAL ASSEMBLY AND IDLE VALIDATION

ELECTRONIC FOOT PEDAL ASSEMBLY AND IDLE VALIDATION

Follow these procedures to diagnose and correct the Electronic Foot Pedal Assembly and Idle Validation Sensor.

Signal Functions

The accelerator position sensor is a potentiometer type sensor that, when supplied with a 5 volt reference signal from the ECM provides a linear analog voltage signal that indicates the driver's demand for power. **See Figure**

.

1

The Idle Validation Switch (IVS) is a 0/12 volt switch that provides the ECM with a redundant signal to verify when the pedal is in the idle position.

Fuel Quantity and Timing Control — The accelerator position sensor signal is used in calculating desired fuel quantity and injector timing.

Injection Control Pressure — Accelerator pedal position is one of the controlling variables in the calculation of desired injection control pressure.

Fault Detection Management

Any detected malfunction of the accelerator position sensor or IVS sensor circuit will illuminate the WARN ENGINE lamp.

An accelerator position sensor signal that is detected out of range high or low by the ECM will cause the engine to ignore the signal and will only allow the engine to operate at low idle.

If a disagreement in the state of the IVS and accelerator position sensors is detected by the ECM and the ECM determines that it is an IVS fault, the ECM will only allow a maximum of 50% of the accelerator position sensor to be commanded.

If a disagreement in the state of IVS and the accelerator position sensor is detected by the ECM and the ECM cannot discern if it is an accelerator position sensor or IVS fault, or if it is an EFPA fault, the engine will be allowed to operate at low idle only.

For recommended wiring for the EFPA/Hand Throttle to control vehicle speed, **see Figure** . For recommended wiring for the Idle Validation Switch, **see Figure**
.
23

Connector voltage checks are **listed in Table** . These checks are performed with the sensor connector disconnected and the ignition key ON.

Test Points	**Specifications**	**Comments**
A to Grd	0 – 0.25 volts	If greater than 0.25 volts, signal ground wire is shorted to VREF or battery.
B to Grd	0 volts	Signal ground no voltage expected.
C to Grd	5 ± 0.5 volts	VREF check key on; if VREF not present, check open/short to ground; see VREF circuit.
D to Grd	0 – 0.25 volts	If greater than 0.25 volts, signal ground wire is shorted to VREF or battery.
F to Grd	12 ± 1.5 volts	< 10.5 v check for poor connection; 0 v check for open/short to ground circuit or blown fuse.

Connector Voltage Checks

Connector checks to chassis ground are **listed in Table**
. These checks are performed with the sensor connector disconnected, the positive battery cable disconnected, and the ignition key OFF.

Test Points	**Specifications**	**Comments**
A to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.
B to Grd	< 5 Ω	Resistance to chassis ground, check with key off, > 5 Ω, harness is open.
C to Grd	> 500 Ω	Resistance less than 500 Ω indicates a short to ground.
D to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.
F to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground, with Fuse F17 removed.

Connector Checks to Chassis Ground

Harness resistance checks are **listed in Table** . These checks are performed with the breakout box installed on the chassis harness only.

Test Points	Specifications	Comments
#8 to A	< 5 Ω	Resistance from 60-pin connector to harness connector - accelerator position sensor signal
#11 to B	< 5 Ω	Resistance from 60-pin connector to harness connector - signal ground
#3 to C	< 5 Ω	Resistance from 60-pin connector to harness connector - VREF
#27 to D	< 5 Ω	Resistance from 60-pin connector to harness connector - 60-pin connector to harness connector - IVS signal
4390 to G	< 5 Ω	Resistance from V IGN power to harness connector

Harness Resistance Checks

Operational voltage checks are **listed in Table** . These checks are performed with the breakout box and the EST installed key ON.

	EFPA Test Points (+) #8 to (-) #11	IVS Test Points (+) #27 to (-) #11	Operational Voltage Checks		
Position	Voltage	% EFPA	Voltage	% EFPA	Comments
Low Idle	0.25 to 0.8V	0 %	0 Volts	0 %	IVS voltage should toggle just off low idle position
High Idle	3 to 4.4V	98 - 102%	12 ± 1.5 volts	98 - 102%	If EFPA measures only 50% and voltage signal in spec, IVS fault detected

Fault code descriptions are **listed in Table** . If Fault Codes 131, 132, 133 or 134 are set, the engine operation will default to run at low idle speed only.

Fault Code	Fault Code Descriptions
131	EFPA signal was less than 0.148 volts for more than 0.5 seconds*
132	EFPA signal was greater than 4.55 volts for more than 0.5 seconds*
133	EFPA signal in-range fault*
134	EFPA and IVS disagree*
135	Idle validation switch circuit fault - 50% accelerator position sensor only

* If a fault code is set, engine operation will default to run at low idle speed only.

EFPA/IVS Extended System Description

Detroit Diesel electronic engines use an electronic foot pedal assembly that includes an accelerator position sensor and IVS. These two functions are integrated into one component mounted on the pedal. The accelerator pedal assembly is serviceable to the extent that the position sensor/IVS switch can be replaced without replacing the complete assembly.

The engine ECM determines the position of the accelerator pedal by processing the input signals from the accelerator position sensor and IVS.

Accelerator Position Sensor

The ECM sends a regulated 5 volt signal through the ECM chassis connector (black) terminal three to the accelerator position sensor connector terminal C. The position sensor then returns a variable voltage signal (depending on the pedal position) from the accelerator position sensor connector terminal A to the ECM at terminal 8. The position sensor is grounded from the connector terminal B to the ECM signal ground terminal 11.

Auto-Calibration

The ECM learns the lowest and highest pedal positions by reading and storing the minimum and maximum voltage levels from the accelerator position sensor. In this manner the ECM auto-calibrates the system to allow maximum pedal sensitivity. The ECM auto-calibrates as the key is ON, but when the key is turned on again, this process starts over. When the pedal is disconnected (or new one installed), the pedal does not need to be calibrated as the calibration happens when the key is turned on.

Idle Validation Switch

The ECM expects to receive one of two signals through the ECM chassis connector (black) terminal 27 from the accelerator position sensor/IVS connector terminal D:

1. 0 volts when the pedal is at the idle position
2. 12 volts when the pedal is depressed

The IVS receives 12 volt ignition voltage from the switched ignition fuse in the fuse box. When the pedal is not in the idle position (throttle applied), the IVS supplies a 12 volt signal to the ECM.

The ECM compares the inputs it receives at terminals 8 and 27 from the EFPA to verify the pedal is in the idle position. If the signal at terminal 8 indicates the throttle is being applied, then the ECM expects to see 12 volts at IVS terminal 27. If the signal at terminal 8 indicates throttle is not applied, then the ECM expects to see 0 volts at the IVS terminal 27. The timing process is critical between the accelerator position sensor and the IVS sensor. For this reason, it is very difficult to determine if the EFPA is working properly using a volt-ohmmeter.

ECM Diagnostics

When the key is ON, the ECM continuously monitors the accelerator position sensor and IVS circuits for expected voltages. It also compares the accelerator position sensor and IVS signals for conflict. If the signals are not what the ECM expects to see, Fault Codes will be set.

Flash Codes

The following Flash Codes are possible with the EFPA/IVS faults.

Flash Code 131

ATA Code PID 91 FMI 4 —

ECM: Accelerator Position Sensor out of range LOW

The ORL (out of range low) Flash Code 131 is set if the ECM detects a voltage lower than 0.146 volts at terminal 8. Possible causes include a short to ground or an open in circuit 417. This code is displayed by either the EST or the Engine Warning Light when used to flash codes.

When Flash Code 131 is active, the ECM restricts the engine speed to idle and turns the Engine Warning Light ON. If the condition causing code 131 is intermittent, and the condition is no longer present, the code will become inactive and normal engine operation will resume.

Flash Code 132

ATA Code PID 91 FMI 3 —

ECM: Accelerator Position Sensor out of range HIGH

The ORH (out of range high) Flash Code 132 is set if the ECM detects a voltage greater than 4.55 volts at terminal 8. Possible cause is a short to VREF or 12 volts in circuit 417. This code is displayed by either the EST or the Engine Warning Light when used to flash codes.

When Flash Code 132 is active, the ECM restricts engine speed to idle and turns the Engine Warning Light ON. If the condition causing code 132 is intermittent and the condition is no longer present, the code will become inactive and normal engine operation will resume.

Flash Code 133, 134 and 135

Accelerator Position Sensor in range faults

The ECM checks the voltage output of the accelerator position sensor by comparing that signal with the IVS signal. These two signals can disagree in two cases:

1. The accelerator position sensor signal indicates the pedal is pressed down to accelerate, but the IVS signal indicates idle position.
2. The accelerator position sensor signal indicates the pedal has been released to allow the engine to return to idle, but the IVS signal indicates off-idle position of the pedal.

If the ECM detects either of the above conditions, the ECM attempts to isolate the source of conflict and set the appropriate fault code.

Flash Code 133

ATA Code PID 91 FMI 2 —

ECM: Accelerator position sensor in range fault

If the IVS signal is changing and the accelerator position sensor signal is constant, the ECM assumes the accelerator position sensor is the conflict source and sets Flash Code 133. Engine r/min is restricted to idle and the Engine Warning Light is turned ON.

Flash Code 134

ATA Code PID 91 FMI 2 —

ECM: Accelerator position sensor and IVS disagree

If neither the accelerator position sensor or the IVS is changing, or both are changing, or the ECM cannot determine the faulty code in specified time, then Flash Code 134 is set; the engine r/min is restricted to idle and the Engine Warning Light is turned ON.

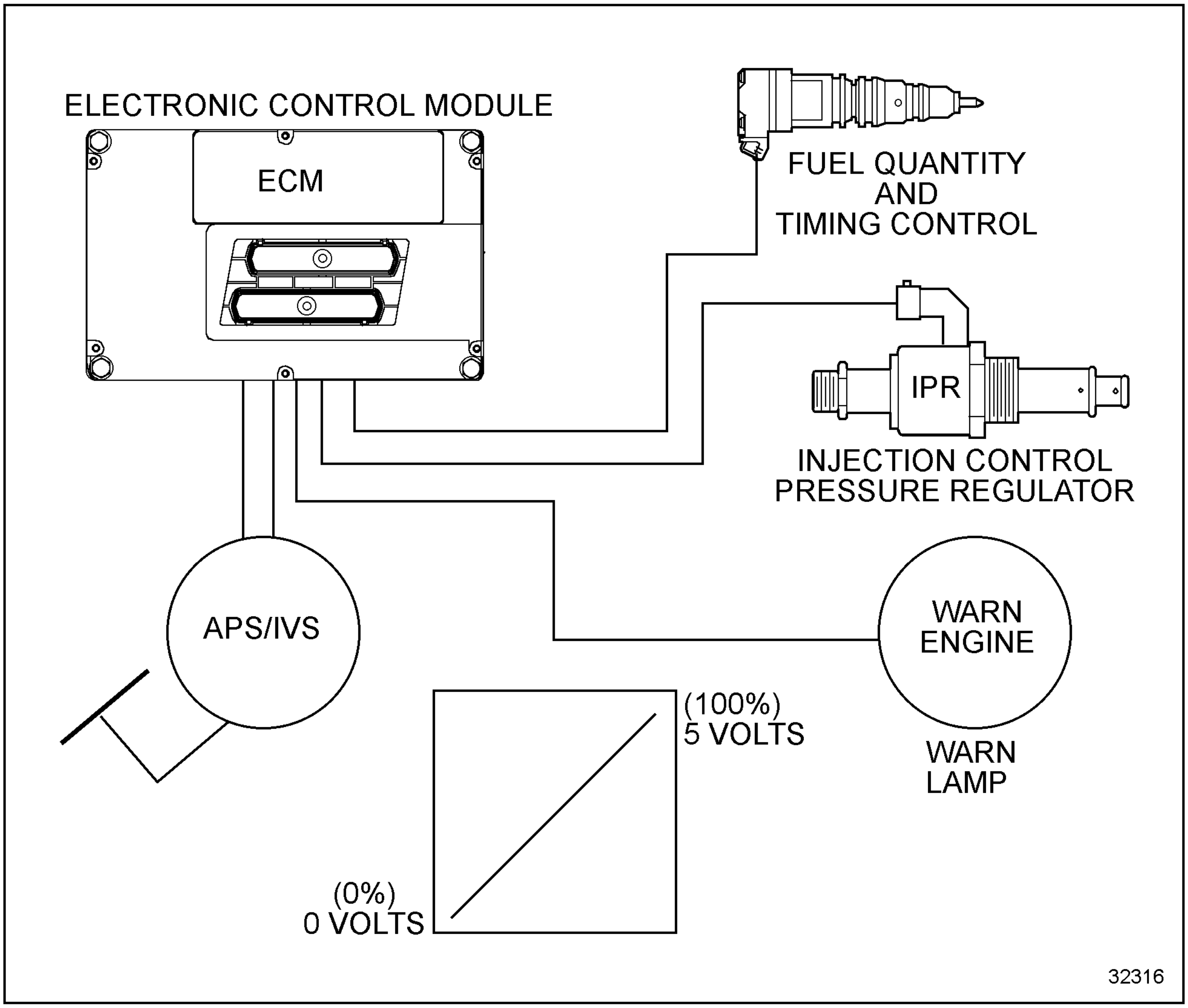
Flash Code 135

ATA Code SID 230 FMI 11 —

ECM: IVS circuit fault

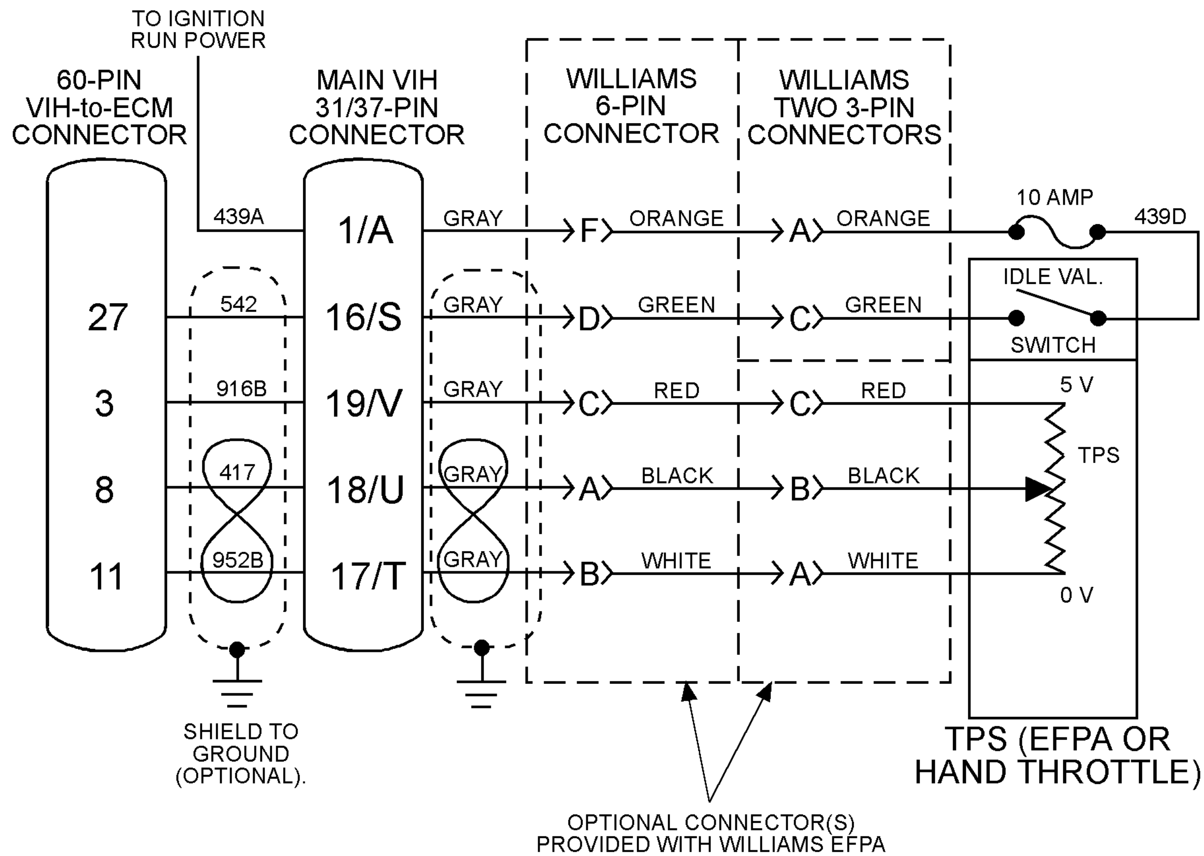
If the accelerator position sensor is changing and the IVS is constant, the ECM assumes the IVS is the conflict source and sets the Flash Code 135. In this case, the ECM limits the APS signal to a lower value that provides less than full r/min, but does not limit the engine r/min to idle. The Engine Warning Light is not turned ON.

Note that Flash Codes 133, 134 and 135 are caused by an intermittent condition. The codes remain active until the vehicle has been shut down and restarted. They do not recover without cycling the key switch.



EFPA/IVS Function Diagram

2



NOTE: BLUE WIRES ARE NOT USED.

LABEL	WIRE NO.	WIRE GAUGE	VIH-to-ECM CONNECTOR CAVITY	WIRE COLORS	6-PIN TPS / IVS CONNECTOR CAVITY	TWO 3-PIN TPS / IVS CONNECTORS CAVITY
SENSOR SUPPLY (5 VDC)	916B	18	3	GRAY& RED	C	C
TPS SIGNAL	417	18	8	GRAY & BLACK	A	B
TPS / IVS RETURN	952B	18	11	GRAY & WHITE	B	A
IVS SIGNAL	542	18	27	GRAY& GREEN	D	C
FUSED IGNITION 'RUN' POWER	439D	16	–	GRAY & ORANGE	F	A
FUSED IGNITION 'RUN' POWER	439A	16	–	GRAY	–	–

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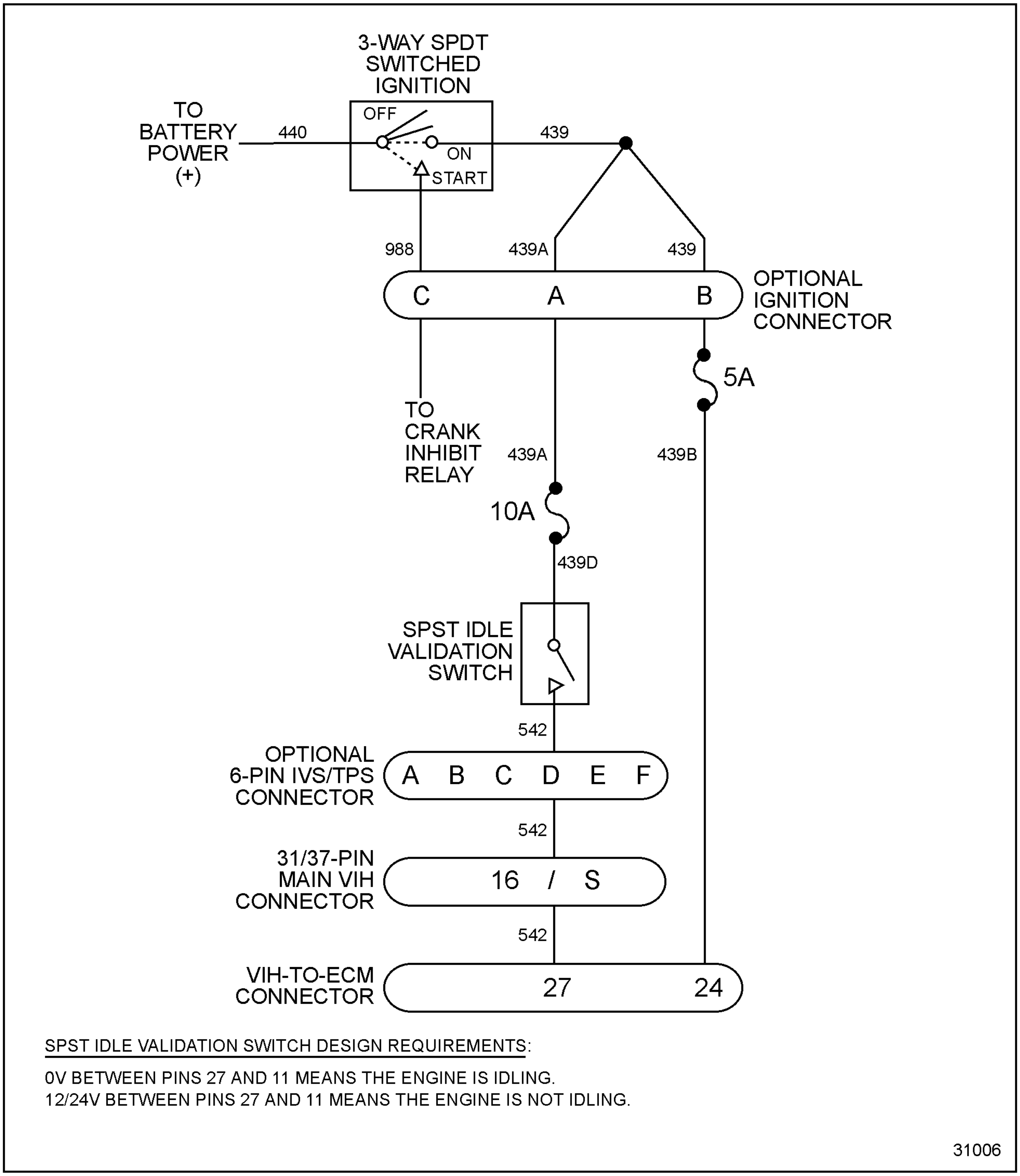
Recommended Wiring for the Electronic Foot Pedal Assembly/Hand Throttle



Recommended Wiring for Idle Validation Switch

REMOTE ACCELERATOR PEDAL SENSOR

SIGNAL FUNCTION

The purpose of the Remote Accelerator Pedal Sensor (RPS) is to allow an operator to adjust engine speed from a remote location. The RPS functions similar to the Accelerator Position Sensor. For the RPS function diagram, **see Figure** .

1

Note: The RPS sensor, ON/OFF switch and circuit are supplied by the body builder.

Remote Accelerator Pedal Sensor

The RPS is a potentiometer that sends a variable analog voltage signal to the ECM that indicates a desired speed. In order for the RPS to function, the control module must be programmed for remote RPS enable. To activate the RPS, the remote variable terminal of the ECM must receive a 12 volt signal.

Pedal Operation

The pedal receives a 5 volt reference signal and a signal return through the body builder connections. By depressing the pedal, the RPS signal voltage increases, indicating a request to increase engine speed.

Fault Detection Management

The ECM monitors the voltage at the RPS terminal for voltage to determine if the signal is in range. A minimum voltage level is established to verify that the circuit is not open and a maximum voltage level is established to verify that the signal is not shorted to a voltage source. When the ECM detects a voltage out of range, the pedal will be disabled and Flash

Code 213 for out of range LOW, or Flash Code 214 for out of range HIGH will be set.

For the RPS function diagram, **see Figure** .
2

RPS connector voltage checks are **listed in Table** . Checks are made with the RPS disconnected and the ignition key ON.

Test Points	Spec	Comments
A to Grd	0v	A positive voltage reading indicates a short to another circuit.
B to Grd	0v	A positive voltage reading indicates a short to another circuit.
C to Grd	5 ± .5v	Voltage out of specification indicates an open circuit or short to ground.
451A to Grd	12v	ON/OFF switch voltage when switch is in the ON position.

Remote Pedal Sensor Connector Voltage Checks

RPS connector resistance checks are **listed in Table**
. Checks are made with the RPS disconnected, ignition key OFF and all accessories OFF.

Test Points	Spec	Comments
A to Grd	> 1,000 Ω	Less than 1,000 Ω indicates a short to ground.
B to Grd	> 1,000 Ω	Less than 1,000 Ω indicates a short to ground.
C to Grd	< 5 Ω	Greater than 5 Ω indicates circuit is open.
439C to Grd	> 1,000 Ω	Less than 1,000 Ω indicates a short to ground with switch closed.

Remote Pedal Sensor Connector Resistance Checks

Harness resistance checks are **listed in Table** . Checks are made with the breakout box installed on the chassis harness only, and the sensor connector disconnected.

Test Points	Spec	Comments
5 to B	< 5 Ω	More than 5 Ω indicates a high resistance or an open circuit.
6 to C	< 5 Ω	More than 5 Ω indicates a high resistance or an open circuit.
30 to A	< 5 Ω	More than 5 Ω indicates a high resistance or an open circuit.
36 to 439C	< 5 Ω	More than 5 Ω indicates a high resistance or an open circuit with the switch closed.

Harness Resistance Checks

Operational voltage checks are **listed in Table** . These checks are made with the breakout box installed and the RPS sensor connected to the connector.

Test Points	Spec	Comments
30 to 6	.5 to 4v	Voltage should be low at idle position and should increase by depressing the pedal. Voltage reading should change smoothly and there should be no position that causes a sudden increase or decrease in voltage.
36 to Grd	12v or 0v	ON / OFF switch voltage: 12v when ON, 0 volts when OFF.

Operational Voltage Checks

Fault code descriptions are **listed in Table** .

Fault Code	Description
213	RPS signal was less than 0.488 volts. Circuit open or shorted to ground.
214	RPS signal was more than 3.91 volts. Sensor shorted internally or short to VBAT or VREF.

These values are for software version AF. **Refer to section**
, for further Flash Code information.

Fault Code Descriptions

System Description

The remote accelerator pedal sensor is used for engine speed control outside of the vehicle cab. As part of the PTO engine speed control, connections for the RPS are supplied through the body builder connections.

To operate the RPS a 5 volt reference voltage is supplied by the ECM from pin 5 through the body builder connection circuit 916C. Signal return for the RPS is supplied by a dedicated terminal number 6 through the body builder connection circuit 952A. The remote pedal sensor is a potentiometer that uses the 5 volt reference voltage and signal return to supply an analog voltage to terminal 30 through the body builder connection circuit 510. In the idle position, the voltage signal from the RPS is low. As the pedal is depressed, the voltage increases, indicating an increase in demand for speed from the operator.

Before the RPS is operational, the ECM must first have a 12 volt signal at pin 36. This is supplied through the body builder connection circuit 451 to enable the operation of the RPS.

To interrupt the operation of the PTO speed control, if the Remote Variable circuit is open, the engine will return to idle. Or, if the brake or clutch pedal is depressed, or with an automatic transmission the transmission is placed in gear, the engine will return to idle. If the option has been programmed in the ECM for PTO operation, disabling the brake, clutch or transmission will not interrupt the PTO speed control. Also, if the ECM receives a signal from the vehicle speed sensor, the engine will return to idle. Remote PTO speed control will not function if the brake or VSS circuits are in fault. The RPS will not operate if the RPS system has an active fault present.

Programming

The ECM must be programmed to enable the operation of the RPS. From the programmable parameters menu under the option PTO controls, select RPS and program for enable. If it is desired that the cab controls (APS brake and clutch) not affect the operation of the PTO speed control, select the option PTO Operation Disable and select Enable.

PTO mode must be programmed to remote. If the RPS is enabled and there is no pedal signal present, the ECM will log a fault code. The PTO Maximum Engine Speed will allow programming for the maximum engine speed allowed when in PTO mode.

Fault Detection Management

The ECM monitors the voltage at the RPS terminal to determine if the signal is in range. A minimum voltage level is established to verify that the circuit is not open, and a maximum voltage level is established to verify that the signal is not shorted to a voltage source. When the ECM senses the voltage is out of range, the pedal will be disabled and a Flash Code 213 for out of range LOW, or 214 for out of range HIGH is set. If the ignition is shut off, the flash code will be recorded as an inactive code.

Flash Codes

The following flash codes could display when troubleshooting the RPS:

Flash Code 213

ATA Code SID 29 FMI 4

Remote throttle signal out of range LOW.

Flash Code 213 indicates that the ECM pin 30 voltage was less than .25 volts. (If this is the AF software version, the ECM pin 30 voltage was less than 3.99 volts.) This indicates an open circuit for the VREF supply from ECM pin 5 or in the RPS signal circuit to pin 30 from the RPS. It may also result from a defective (open) remote pedal sensor.

Flash Code 214

ATA Code SID 29 FMI 3

Remote throttle signal out of range HIGH.

Flash Code 214 indicates the ECM pin 30 voltage was greater than 4.5 volts. (If this is the AF software version, the ECM pin 30 voltage was greater than 3.91 volts.) This indicates a possible open circuit in RPS return to pin 6 or a short to another voltage supply on the RPS signal circuit. It may also result from a defective (shorted) remote pedal sensor.

Troubleshooting

The EST ProLink can be used to monitor the status of the PTO controls. Comparing the data list reading to actual operation will indicate if the controls are operating properly. Using the menu option of programmable parameters, the programming can be verified to be sure the ECM is programmed properly for the application. The data list can be used to monitor the parameters that cause the interruption of PTO speed control. Use the Diagnostic Code menu to read fault codes.

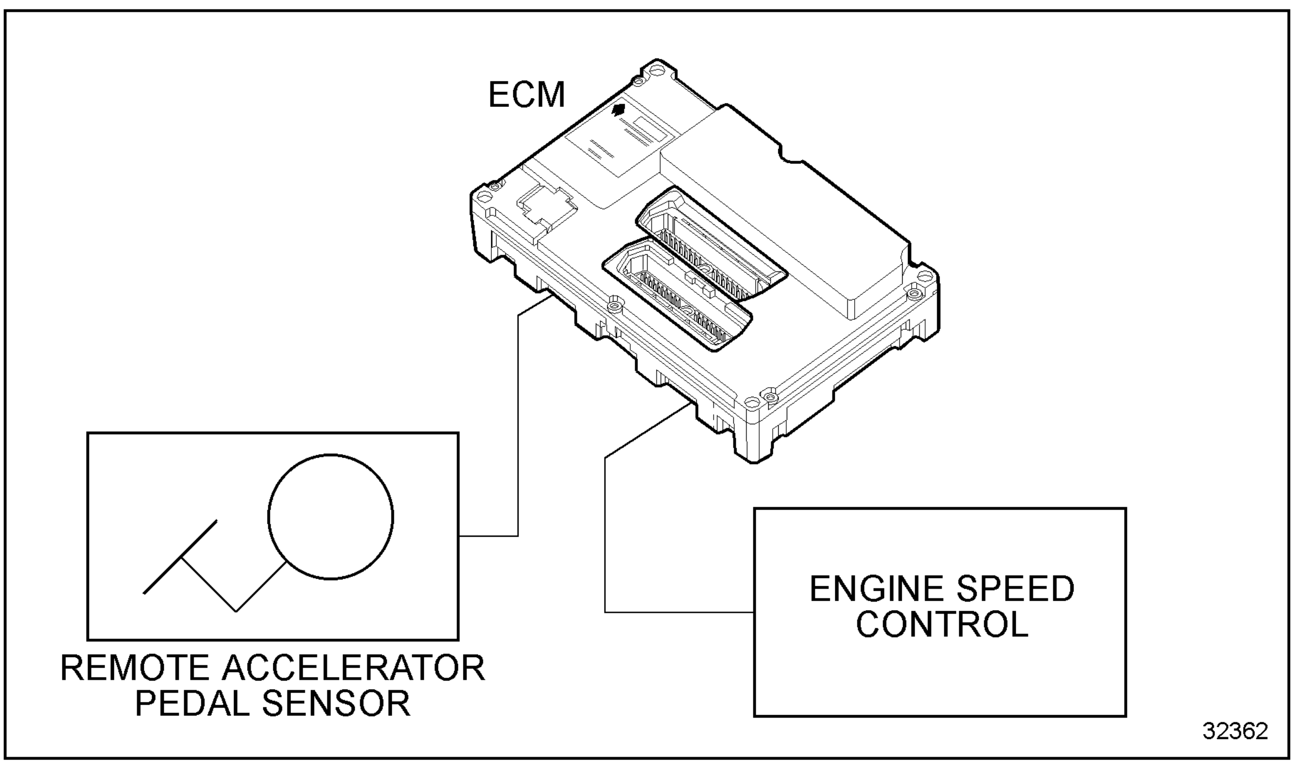
Before Troubleshooting

Before troubleshooting, ensure the batteries are fully charged. Check the battery connections and grounds for clean, tight connections, free of damage. The voltage test will give misleading results if the batteries are not fully charged.

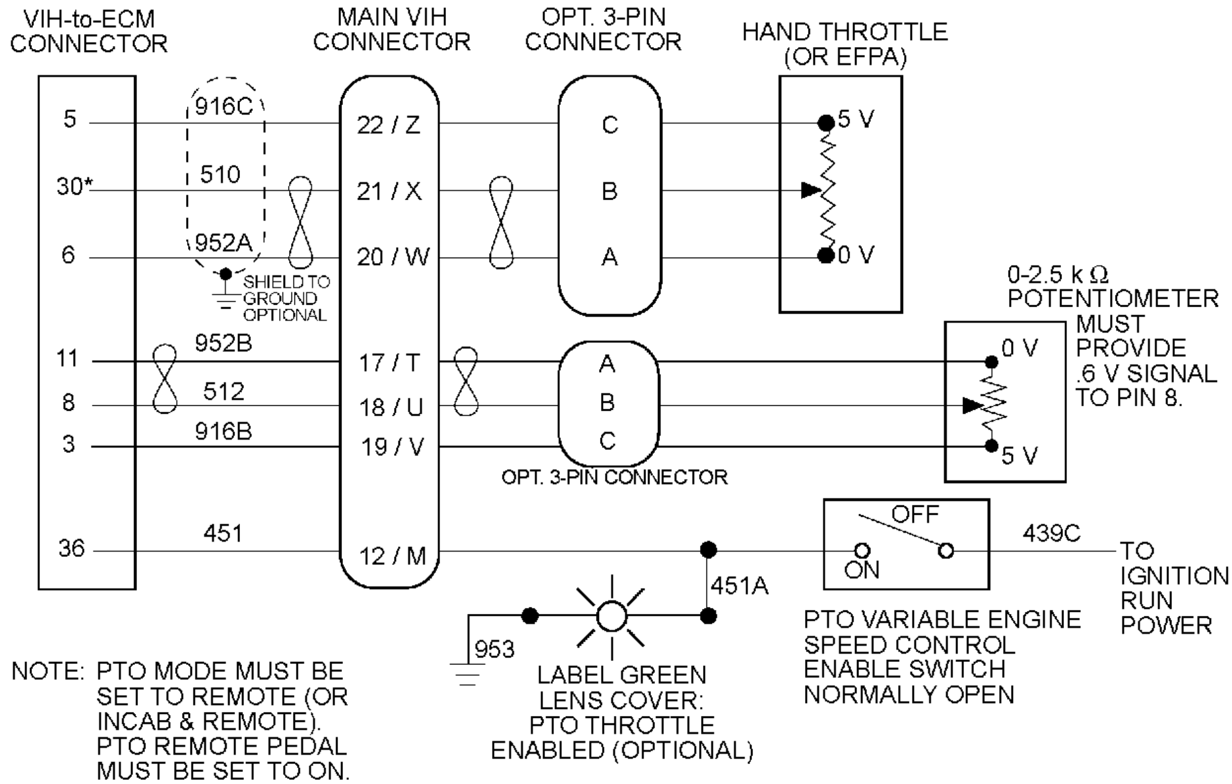
Before troubleshooting, inspect the circuit connectors for pushed back, loose or damaged (spread or bent) terminals or wires with cut strands, etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present and must be removed.

Before troubleshooting, inspect suspect circuit grounds for clean, tight connections, free of damage.

1



Remote Accelerator Pedal Sensor Function Diagram



LABEL	WIRE NO.	WIRE GAUGE	VIH-to-ECM CONNECTOR CAVITY	WIRE COLOR
SENSOR SUPPLY (5 VDC)	916C	18	5	GRAY
VARIABLE THROTTLE SIGNAL	510	18	30	GRAY
TPS RETURN	952A	18	6	GRAY
.6 V FIXED THROTTLE SIGNAL	512	18	8	GRAY
SENSOR SUPPLY (5 VDC)	916B	18	3	GRAY
FUSED IGNITION 'RUN' POWER	439C	16	–	GRAY
VARIABLE ENGINE SPEED CONTROL (ON/OFF)	451	18	36	GRAY
TPS SIGNAL GROUND RETURN	952B	18	11	GRAY

DESIGN REQUIREMENTS:

12 V AT PIN 36 ENABLES VARIABLE ENGINE SPEED CONTROL, IF THE PROGRAMMABLE REMOTE THROTTLE POSITION SENSOR VALUE IS ENABLED.
0 V AT PIN 36 DISABLES VARIABLE ENGINE SPEED CONTROL.

* SIGNAL MUST BE BETWEEN 0.5 AND 3.9 V.
SIGNALS LESS THAN 0.488 V WILL ACTIVATE FAULT CODE 213.
SIGNALS MORE THAN 3.91 V WILL ACTIVATE FAULT CODE 214.

29010

Engine Speed Without Vehicle Speed Control

CAMSHAFT POSITION SENSOR

FUNCTIONS

Follow these procedures to diagnose and correct Camshaft Position Sensor (CMP) faults.

Signal Functions

The CMP sensor is a Hall Effect type sensor that generates a digital frequency as windows on the timing disk pass through its magnetic field. The frequency of the windows passing by the sensor as well as the width of selected windows allow the ECM to detect engine speed and position. See Figure
.

1

1. Engine Speed — Determined by counting 24 windows on the timing sensor disk each camshaft revolution.
2. Fuel Timing Control — the position of the cylinder No. 1 is determined by distinguishing a narrow vane on the camshaft timing sensor disk.
3. Engine Mode Selection — Allows the ECM to discern when the engine is in the OFF, crank or run mode.
4. Injection Control Pressure — Engine speed is one of the controlling variables in the calculation of desired injection control pressure.
5. Fuel Quantity Control/ Torque Limiting — Engine torque and fuel is controlled and is dependent on engine speed. Fuel quantity is determined by engine speed.

Fault Detection / Management

An inactive CMP signal during cranking is detectable by the ECM. An inactive CMP signal will cause a no start condition. Electrical noise can also be detected by the ECM; if the level is sufficient to affect engine operation a corresponding fault code will be set. The engine will not operate without a functioning CMP signal. **See Figure** .

2

Connector voltage checks are **listed in Table** . These checks are performed with the sensor connector disconnected, the ignition key ON and all accessories OFF.

Test Points	Spec.	Comments
A to Grd.	0 volts	No voltage expected.
B to Grd.	5 ± 5 volts	VREF, check key ON, VREF not present check open/short to ground No. 40 to B, see VREF circuit
C to Grd.	5 ± 5 volts	If < 4.5v check for poor connection; if 0v check for open/short to ground circuit.

Connector Voltage Checks

Connector checks to chassis ground are **listed in Table**
. These checks are performed with the sensor connector (406) disconnected, the positive battery cable disconnected and the ignition key OFF.

Test Points	Spec.	Comments
A to Grd	< 5 Ω	Resistance to chassis ground, check with key OFF, > 5 Ω the harness is open.
B to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.
C to Grd	> 1,000 Ω	Resistance less than 1,000 Ω indicates a short to ground.

Connector Checks to Chassis Ground

Harness resistance checks are **listed in Table** . These checks are performed with the breakout box installed on the engine harness only, and ignition key OFF.

Test Points	Spec.	Comments
#53 to A	< 5 Ω	Resistance from harness connector to 60-pin connector - Signal grd has dedicated ground ckt.
#40 to B	< 5 Ω	Resistance from harness connector to 60-pin connector - VREF
#51 to C	< 5 Ω	Resistance from harness connector to 60-pin connector - CMP signal

Harness Resistance Checks

Operational voltage checks are **listed in Table** . These checks are performed with the breakout box installed in line with the ECM and the ignition key ON.

Test Points (+) #51 to (–) #53	Voltage Checks	
Voltage	Position	Comments
5 ± .5v	Vane	With the breakout box installed, the CMP sensor and ECM connected, bar engine by hand.
.2 to 2v	Window	The CMP signal voltage should change voltage state as timing wheel on cam is rotated.

Operational Voltage Checks

Fault Code descriptions are **listed in Table** .

Flash Code	Descriptions
143	Incorrect number of sync to transition counts detected; possible intermittent CMP sensor/circuit fault.
144	Electrical noise detected; check wire routing and grounds.
145	Inactive CMP signal detected during engine cranking when ICP pressure was sufficient for starting.
612	ECM/target disk mismatch detected (wrong ECM Programming/Installed).
315	Engine RPM exceeded 3,000 RPM.

Fault Code Descriptions

Function of the Extended System

The Series 40E engine control system includes a CMP. This sensor provides the ECM with a signal that indicates camshaft position and engine speed.

The CMP sensor signal is used by the ECM to synchronize piston position to injector firing sequence. The injector firing order sequence begins when the ECM detects the narrow vane on the timing disk indicating No. 1 cylinder. Engine position for each cylinder is then continuously calculated as each vane on the timing disk passes by the CMP sensor. This information is processed by the ECM and used for injection timing and fuel delivery control. The ECM can then initiate the beginning of firing.

Operation

The CMP is a Hall Effect type sensor that generates a digital frequency as windows on the timing disk pass through its magnetic field. The frequency of the windows passing by the sensor as well as the width of selected windows allow the ECM to detect engine speed and position. When the narrow vane passes the CMP, the signal on time is less than when the other vanes pass the sensor. This produces a signal that the ECM uses to indicate engine position.

Engine speed is detected by the ECM by counting the frequency of the 24 signal pulses for each camshaft revolution.

ECM Diagnostics

Once the ECM has recognized the narrow vane (wide window) it will synchronize the engine firing order to the timing of the CMP signal. Every two crankshaft revolutions, it will verify that synchronization. If the ECM receives too many or too few pulses for the number of engine revolutions, it will set a fault code.

The engine will not operate without a functioning CMP signal. However, the ECM will attempt to determine the cause of an invalid signal and identify it with a fault code.

CMP codes that are set will become inactive codes if the key is turned off. These codes can be retrieved using the Self Test Input (STI) switch located on the vehicle dashboard or the EST (electronic service tool).

Flash Codes

Several flash codes are connected to the CMP diagnostics:

Flash Code 143

ATA code SID 21 FMI 2

Wrong number of CMP signal transitions per camshaft revolution.

Flash Code 143 indicates the ECM has received CMP signals with the wrong number of transitions. This indicates that the ECM has counted the voltage transitions and found less than the specified number of pulses from the sensor. When this problem is continuous, the engine will stop running and the ECM will log an active code. If the key is shut off, the code will become an inactive code. This code will not turn the warning light on.

Possible causes for code 143: Intermittent CMP signal caused by an intermittent circuit, defective CMP sensor, or incorrect CMP sensor to timing disk clearance.

Flash Code 144

ATA code SID 21 FMI 2

CMP signal noise detected.

Flash Code 144 indicates that the ECM has detected voltage spikes or transitions other than the CMP signal. If this problem is continuous, the engine could stop running and the ECM will log an active code. If the key is shut off, the code will become an inactive code. This code will not cause the warning light to illuminate.

Flash Code 144 may be due to poor ground connections for CMP or other electronic components; wire harness shielding missing or incorrectly installed on the engine harness; or outside components that could induce voltage signals.

Flash Code 145

ATA code SID 21 FMI 12

CMP signal inactive while ICP has increased.

Flash Code 145 indicates that the ECM does not detect a CMP signal. This code would set if the engine was rotating and the ECM detected a rise in ICP pressure, but did not detect a CMP signal. To set this code, the engine must be rotated long enough for the ICP to increase. When this code is set, the engine will not operate. This code will not cause the warning light to illuminate.

Possible causes for flash code 145: defective CMP sensor; faulty sensor circuitry; or improper air gap between sensor and camshaft timing disk.

Flash Code 612

ATA code SID 21 FMI 7

Incorrect ECM installed for CMP timing disk.

Flash Code 612 indicates that the ECM has monitored the CMP signal and the signal is incorrect for the programming in the ECM. This means that the ECM does not recognize the signal generated from the timing disk and CMP sensor.

Possible causes: ECM has been accidently replaced with an incorrect ECM for the particular engine application; incorrect signal due to a defective CMP sensor or incorrect air gap between the CMP sensor and the timing disk.

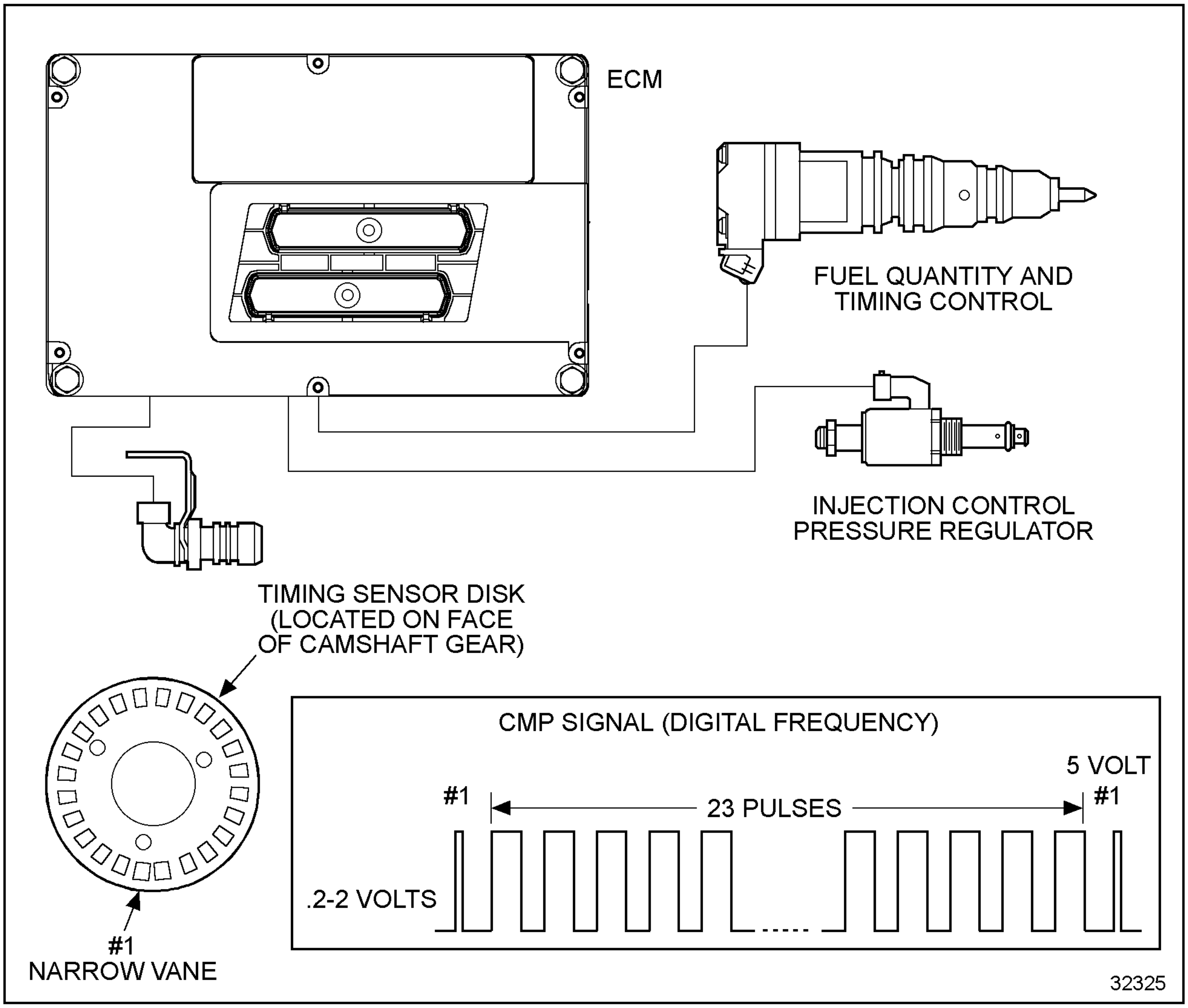
Flash Code 315

ATA code PID 190 FMI 0

Engine speed above warning level.

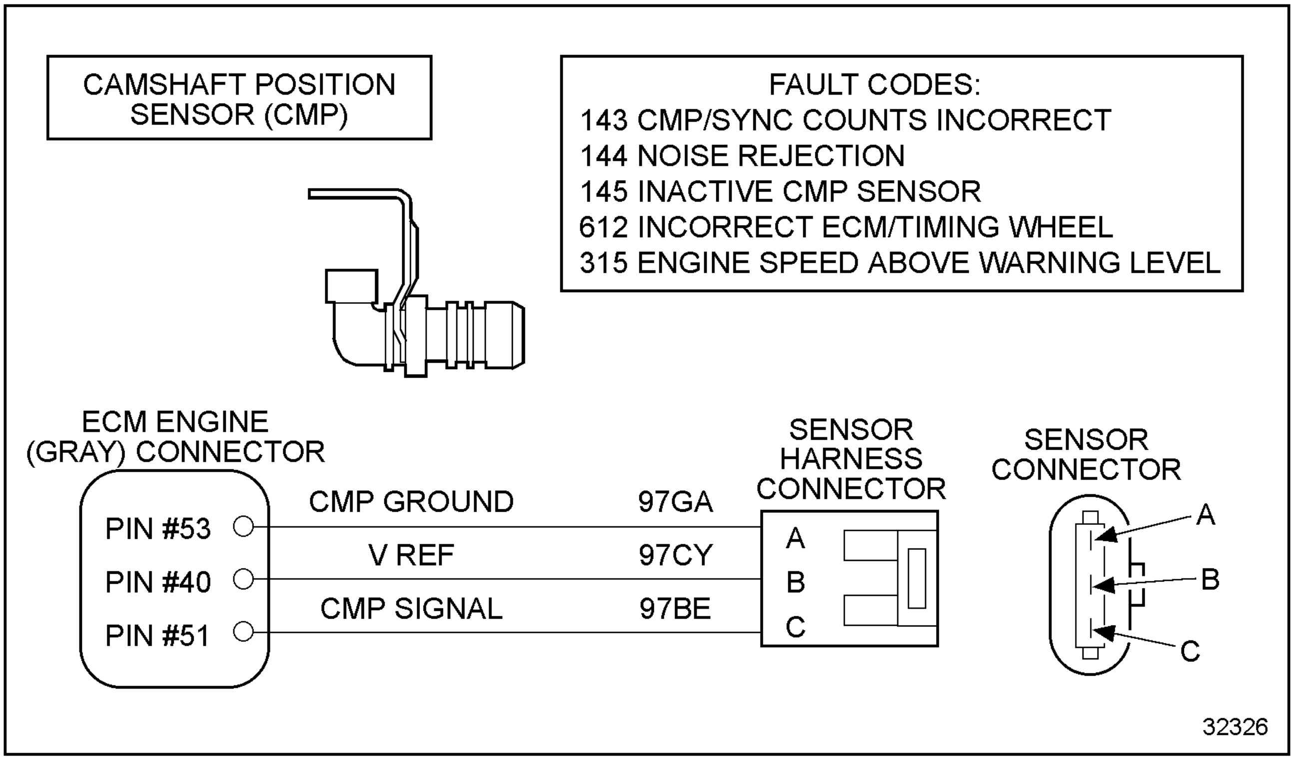
Flash Code 315 indicates that the ECM has detected an engine speed above 3,000 r/min. The most likely cause of the excessive engine speed is an unintended downshift, steep acceleration down a hill without correct brake application, or an external fuel source being ingested into the air intake system. The engine hours and miles of the last two over speed occurrences will be recorded in the Engine Event Log. Code 315 will cause the WARN lamp to illuminate.

1



Camshaft Position Sensor Functions

2



Camshaft Position Sensor

SENSOR AND ACTUATOR DIAGNOSTICS

SENSOR AND ACTUATOR DIAGNOSTIC PROCEDURES

Follow these procedures to diagnose problems with the sensor or actuator circuits.

Basic Procedure

The basic diagnostic procedure recommended for most sensor and actuator circuits is to disconnect the harness at the connector and inspect for corrosion, bent pins, spread pins, or any condition that could cause a loose or intermittent connection. **See Figure** .

1

Connector Voltage Checks

Turn the ignition key to the ON position and measure if the expected voltages are present at the connector. On circuits with expected voltages, this test will verify the integrity of that circuit. On circuits without an expected voltage, this test will determine if that circuit is shorted or miswired to a voltage source.

1. Signal return (marked “A” on all engine sensor harness connectors) should measure less than 0.25 volts.
2. VREF should measure 5.00 volts ± 0.50 volts. If this is higher or lower than expected, disconnect sensors one at a time to determine if a sensor is biasing the circuit and refer to VREF procedures. **See Figure** .
3. Sensor signal lines will measure 0 to 0.25 volts if the circuit is designed to pull down when disconnected, or a higher voltage (normally 4.6 to 5, or 12 volts) if it is designed as a pull up circuit. A pull up signal circuit that measures the expected value normally indicates a good circuit.
4. Actuator circuits may be either on/off type circuits (normally 12 volts) or pulse width

modulated circuits (12 volts controlled by a percent duty cycle.

2

Connector Checks to Ground (B-)

Next, measure the resistance of all wiring harness connectors to ground (preferably the negative battery cable) to determine if a short to ground condition is present. It is important that during this test all accessories including the dome light be turned off. Current flow in the system will affect resistance readings. If the reading is fluctuating greatly, disconnect the positive battery cable and measure to the negative battery cable.

1. Signal ground (marked "A" on all engine sensor harness connectors) should measure less than 5 Ω. Signal ground on vehicle sensor connectors vary. **See Figure** .
2. The VREF and signal lines, with the processor connected, will normally measure greater than 1,000 Ω.

Note: The symbols < (less than) and > (greater than) are used on each diagnostic circuit page. e.g. < 5 Ω is less than 5 Ω; > 5 Ω is more than 5 Ω.

3. Power ground on an actuator circuit should measure less than 5 Ω. The control side of an actuator circuit will normally measure greater than 1,000 Ω.

3

Harness Resistance Tests

The harness resistance tests are performed when a circuit is suspected of having high resistance or being open. These tests are performed with the breakout box connected and by measuring resistance from the sensor connector end to the processor connector. If an open circuit or high resistance is encountered, the problem is easily isolated by separating the circuit at the interim connectors (normally the Deutsch connector on the valve cover or the Packard 22 pin on the cowl) and measuring resistance through both halves of the circuit.

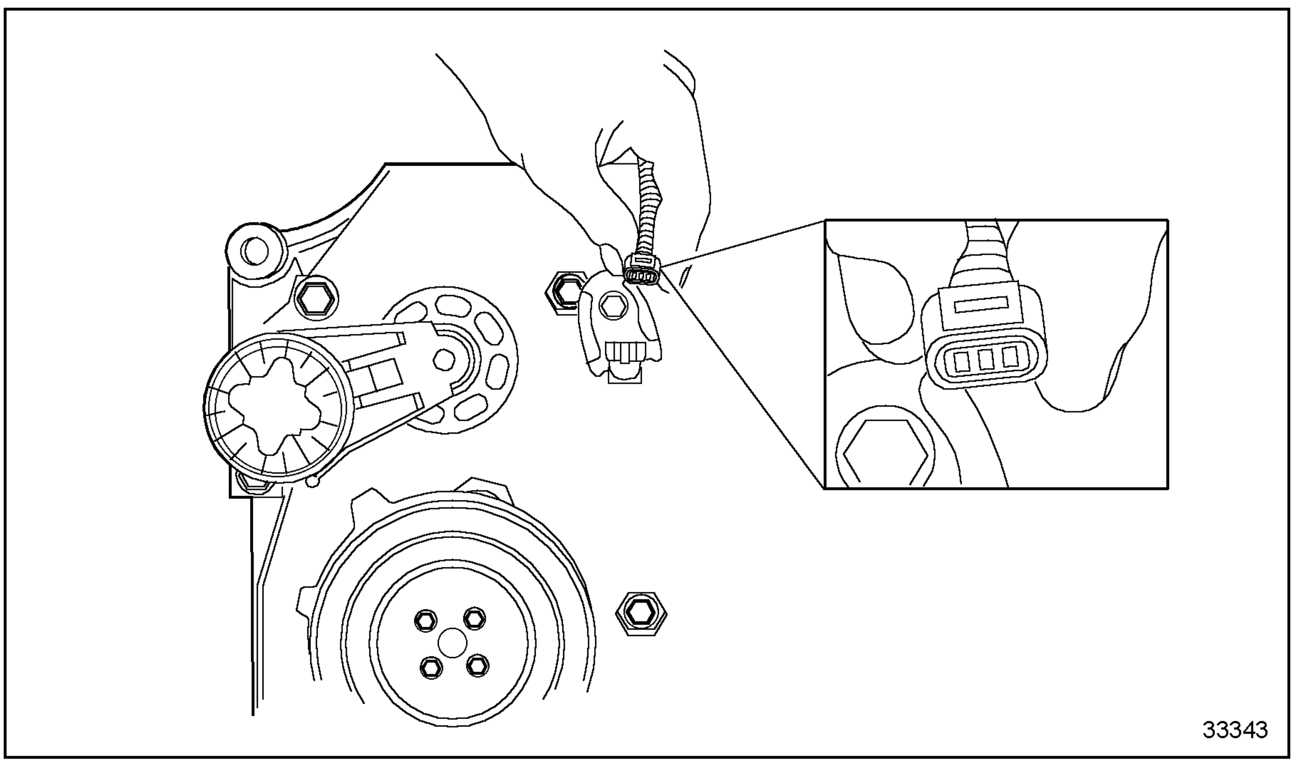
Operational Signal Checks

These checks are made with the breakout box installed and are normally measuring a signal voltage or frequency. They are useful for determining an in-range type fault or an intermittent connection.

If an intermittent fault is detected, monitoring a suspected circuit and recreating the environmental or physical conditions that caused the complaint will help verify if a problem is in a particular circuit.

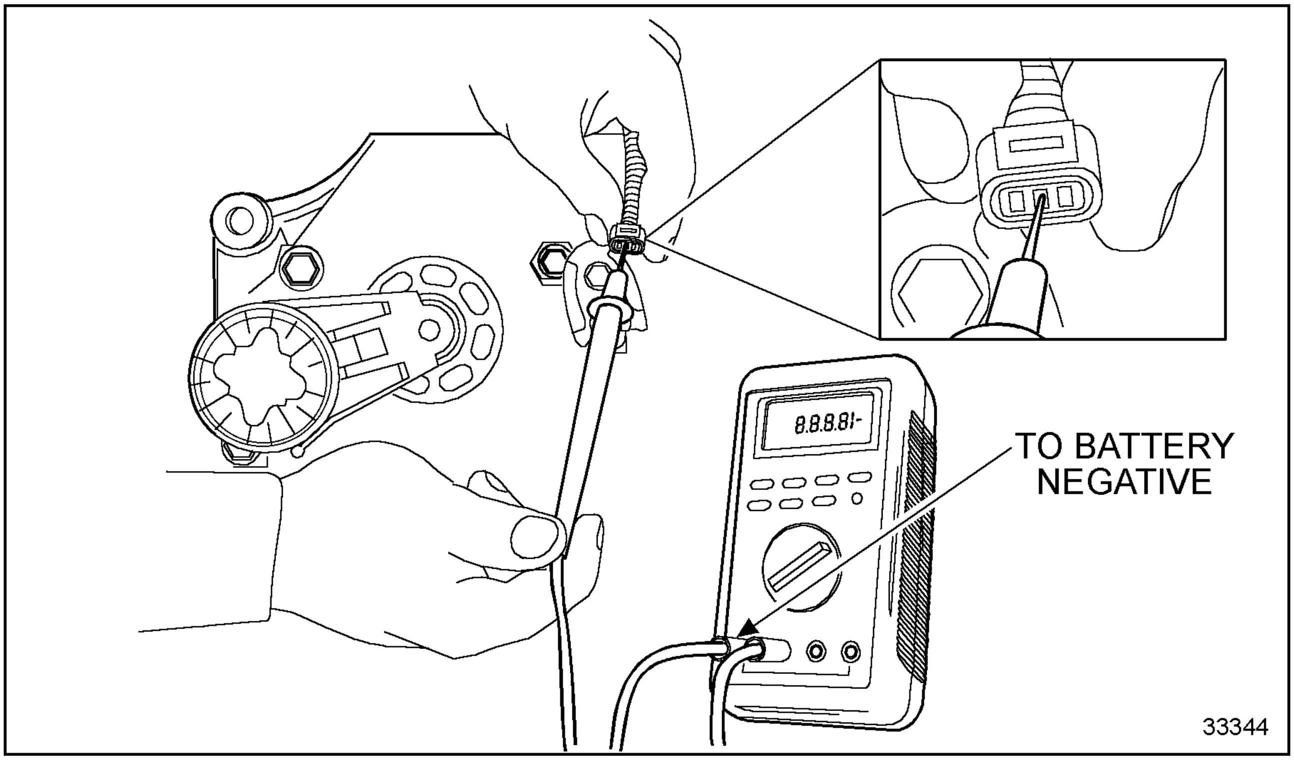
It is critical when measuring the signal level of a circuit to understand its function and whether it is an analog voltage, digital frequency, sine wave or digital communication signal. A standard Digital Volt Ohm Meter (DVOM) has certain limitations in measuring any circuit that has a frequency.

1



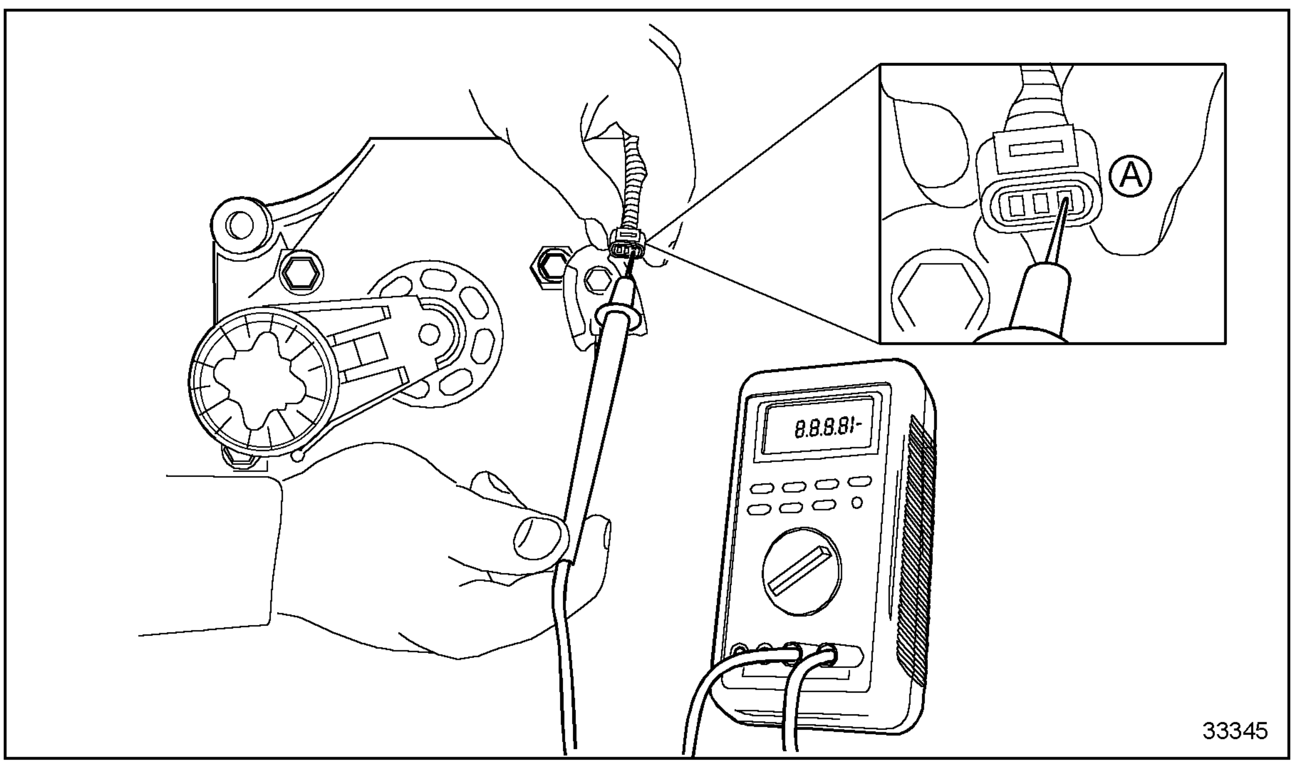
Connector Removal

2



Measuring VREF Voltage

3



Measuring Resistance to Ground

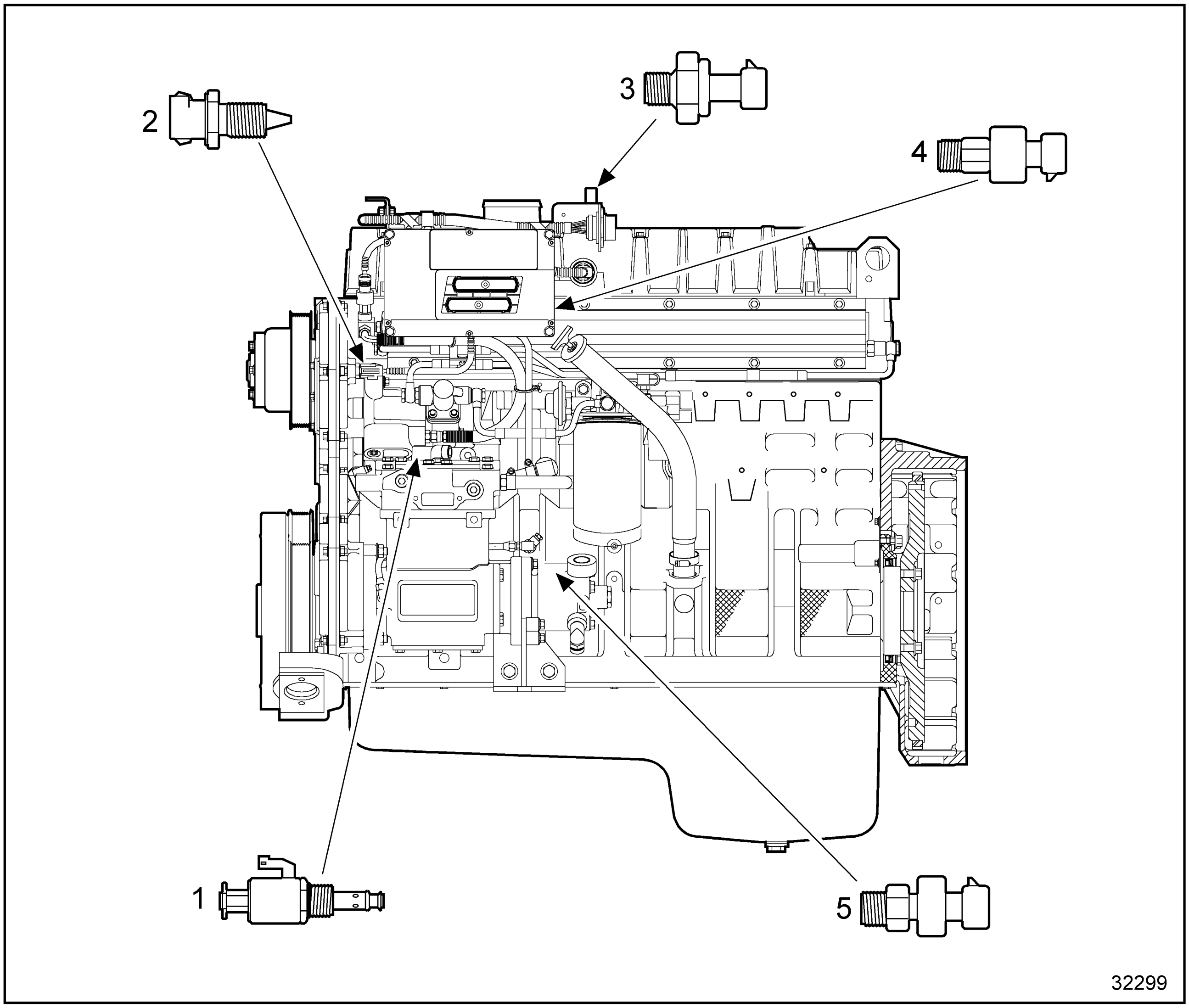
SENSOR AND ACTUATOR LOCATIONS

SENSOR AND ACTUATOR LOCATIONS

For location of sensors, **see Figure** , and **see Figure** .

12

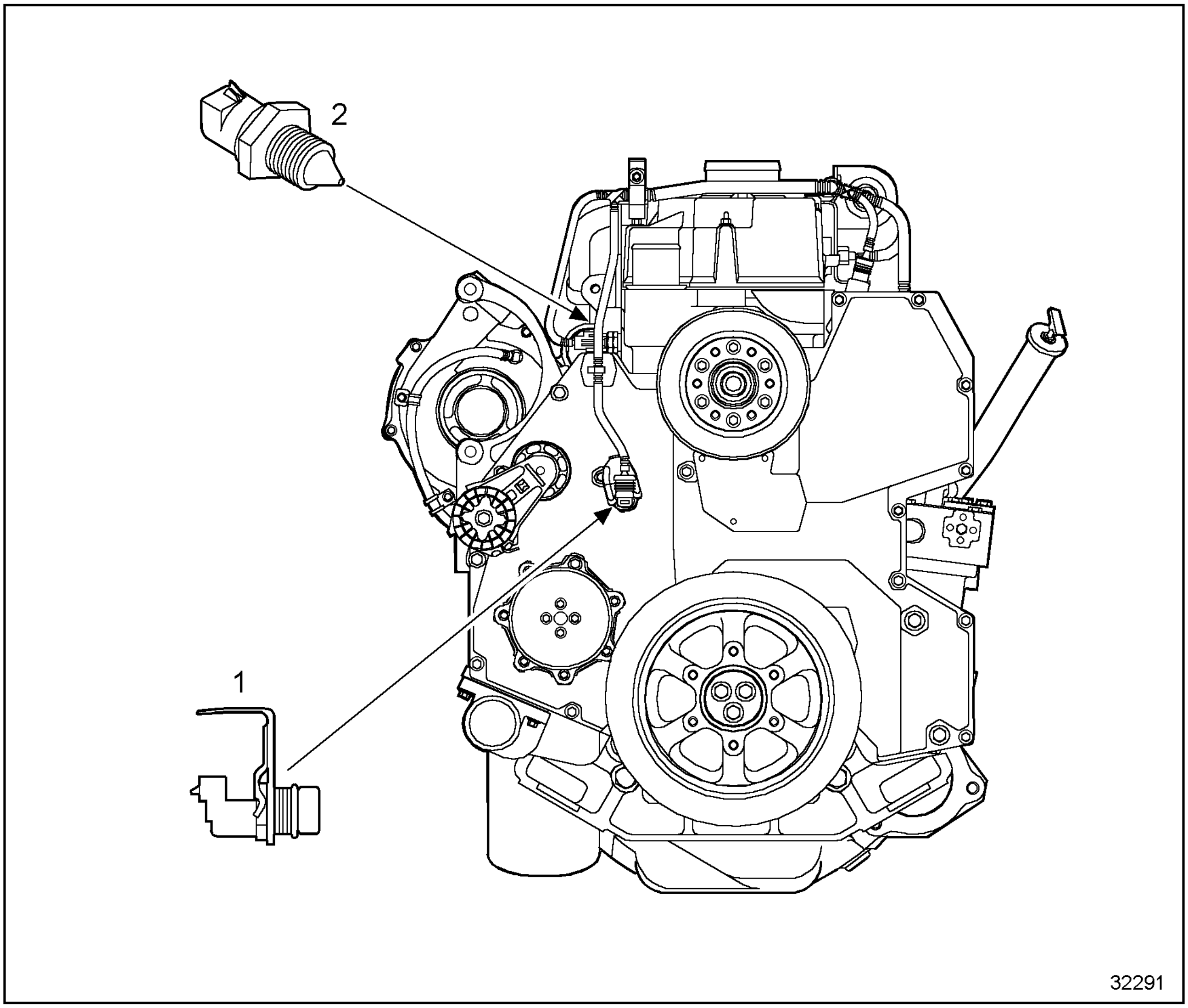
1



1. Injection Pressure Regulator	4. Injection Control Pressure Sensor
2. Engine Oil Temperature Sensor	5. Engine Oil Pressure Sensor
3. Manifold Absolute Pressure Sensor	

Sensor and Actuator Locations on the Engine

2



1. Camshaft Position Sensor	2. Engine Coolant Temperature Sensor

Sensor and Actuator Locations on the Engine

TACHOMETER INPUT CIRCUITS

CIRCUIT FUNCTION

For the tachometer input circuit function, **see Figure**
. The ECM provides an output for a remote tachometer with a 0 — 12 volt digital signal that indicates engine speed. The frequency sent by the ECM is 1/5th of the actual engine r/min.

1

Fault Detection Management

No fault detection is available for communication between the ECM and the remote tachometer.

For the tachometer input diagram, **see Figure** .
2

Key on, engine off voltage checks at the ECM are **listed in Table**
. These checks are performed with the breakout box installed and the ignition key ON, engine OFF.

Test Points	Spec	Signal	Comments
60 to 11	5 ± 1.5v	Tach B	The signal is pulled up by the ECM with the key ON, engine OFF.
59 to 11	5 ± 1.5v	Tach A	

Key ON Engine OFF Voltage Checks at ECM

Connector checks to Ground at the ECM are **listed in Table**
. These checks are performed with the breakout box installed and the ignition key in the OFF position.

Test Points	Spec	Signal	Comments
60 to 11	> 1,000 Ω	Tach B	Less than 1,000 Ω indicates a short to ground either through the harness or internal in the ECM. Disconnect the ECM from the breakout box and measure to ground again. If the short is still present, repair the harness.
59 to 11	> 1,000 Ω	Tach A	

Connector Checks to Ground at ECM

Harness resistance checks are **listed in Table** . These checks are performed with the breakout box installed and the ignition key in the OFF position.

Test Points	Spec	Signal	Comments
60 to C4	< 5 Ω	Tach	Resistance from 60-pin connector to 31-pin connector - Tach signal.
C4 to Tach	< 5 Ω	Tach	Resistance from ECM connector to Tach input at instrument panel - Dash Tach.
59 to Tach	< 5 Ω	Tach	Resistance from ECM connector to Tach input - Optional Owner/Operator Tach.

Harness Resistance Checks

Key on, engine running signal checks are **listed in Table**
. These checks are performed with the breakout box installed.

Test Points	Spec	Comments
60 to 11	5 to 7v / 140 to 540 Hz	Tach signal from the ECM is a frequency that is engine r/min + 5.
59 to 11	5 to 7v / 140 to 540 Hz	Tach signal from the ECM is a frequency that is engine r/min + 5.

Key On Engine Running Signal Checks — Tachometer

Fault Code Descriptions = NONE.

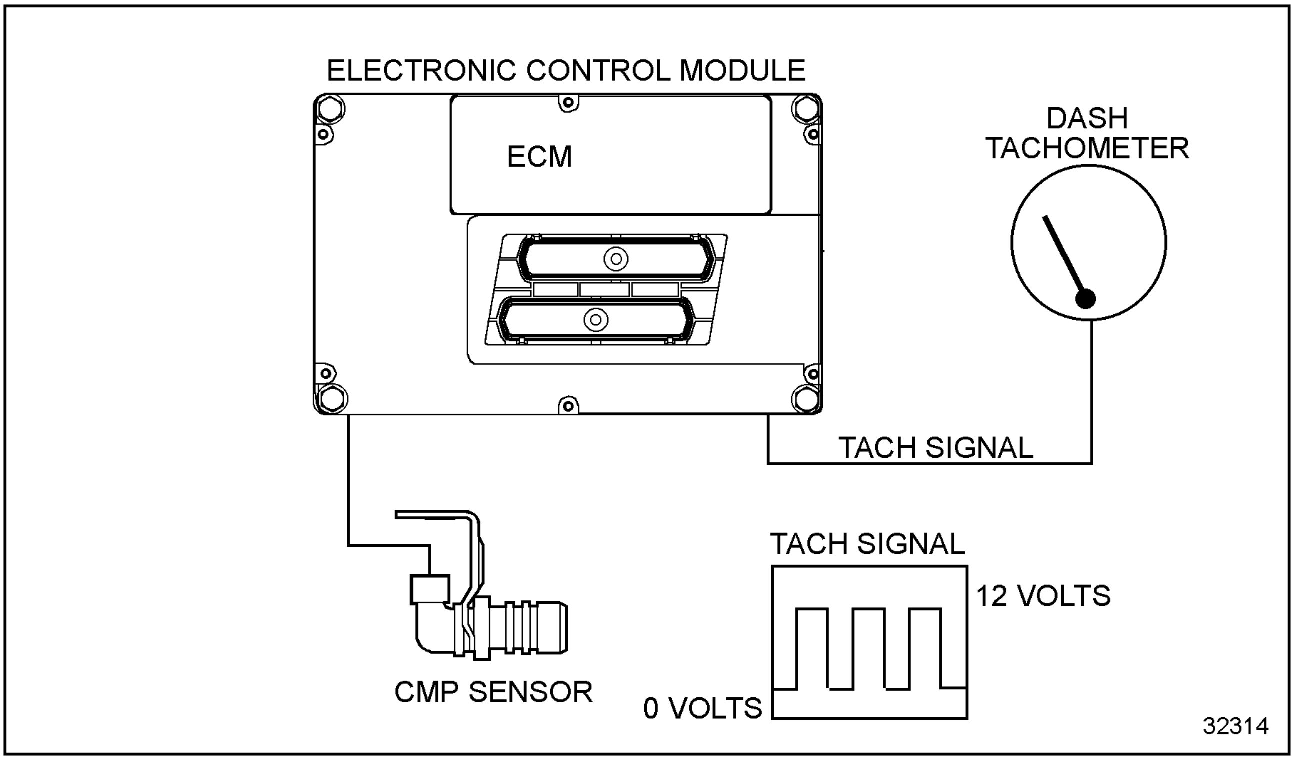
Note: The instrument cluster tachometer does not use these outputs. See the ATA communication for instrument cluster tachometer diagnostics.

Tachometer Input Signal

The following information is only for auxiliary tachometers installed by the body builder or vehicle owner. It does not apply to the instrument cluster tachometer that is operated from the ATA data line.

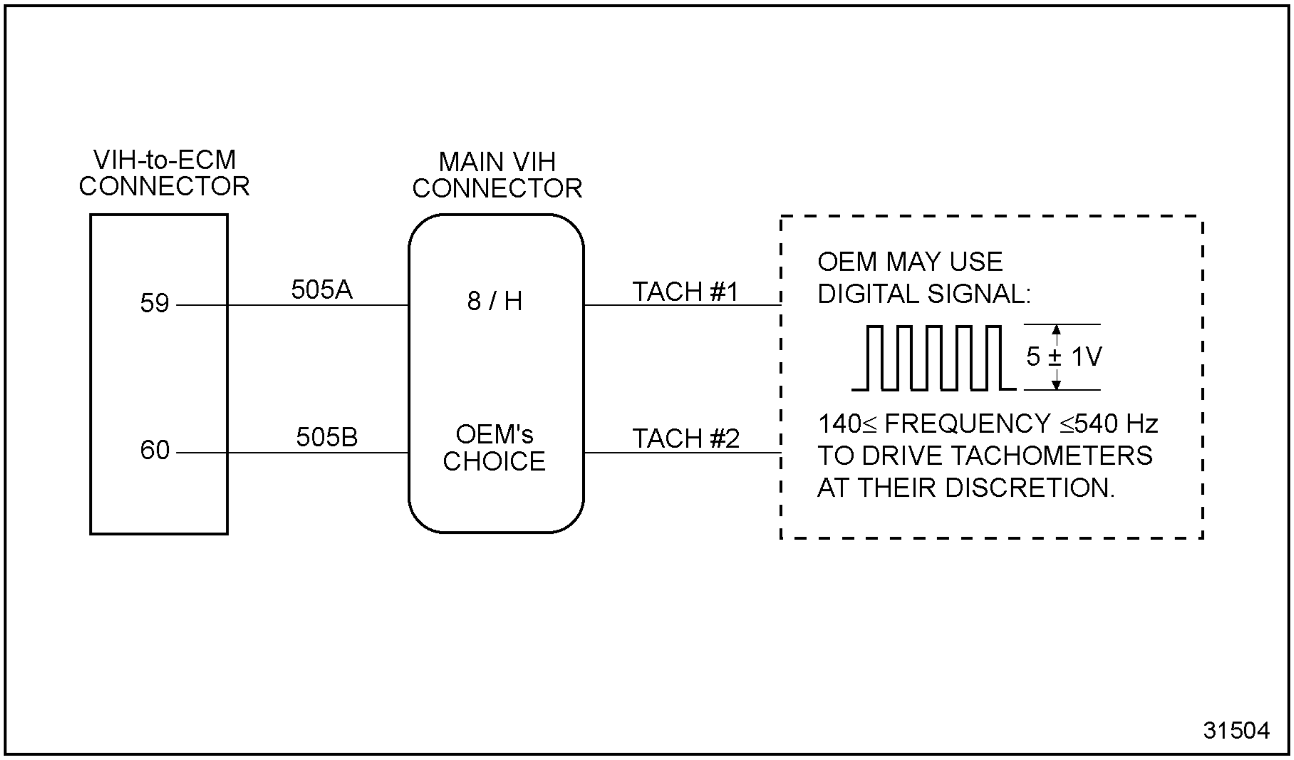
The ECM receives a signal from the CMP sensor and calculates engine speed (rpm). The ECM sends the calculated engine speed as a digital buffered tach signal from the ECM connector to the owner installed tachometer.

1



Tachometer Input Circuit Function

2



Tachometer Input

VOLTAGE REFERENCE CIRCUITS

CIRCUIT FUNCTIONS

For the Voltage Reference Circuits (VREF) function diagram, **see Figure**
.

1

The VREF circuit is a 5 ± .5 volt power supply from the ECM that provides power to the three wire engine and vehicle sensors and provides a benchmark or reference voltage for the ECM.

There are three separate VREF circuits in this system:

1. VREF B — for chassis sensors
2. VREF C — for body builder sensors
3. VREF D — for engine sensors

Fault Detection/Management

There is no fault detection specifically for the VREF signal directly, but if there is a VREF circuit fault, the sensor(s) in the section of the circuit affected may set an out of range high or low code. Multiple high or low codes are usually an indication of a VREF or, in some instances, a Signal Ground fault condition.

A VREF signal shorted to ground will cause the ECM to reset, causing either a stumble or no start condition.

For the Voltage Reference Circuits, **see Figure**.
2

Connector VREF voltage checks are **listed in Table** . If multiple faults are set, remove and measure the VREF at suspected sensor circuits.

Sensor	Test Points	Spec	Comments
ICP	B to Grd	5 ± .5v	Check VREF at suspected sensors one at a time. Identifying which sensors do not have VREF and which ones share common VREF feed will more quickly help isolate the area of a short or open circuit. If disconnecting a sensor causes VREF to be present at a circuit that had previously lost VREF, it is likely that the disconnected sensor had shorted VREF to ground.
CMP	B to Grd	5 ± .5v	
MAP	B to Grd	5 ± .5v	
APS/IVS	C to Grd	5 ± .5v	
BARO	B to Grd	5 ± .5v	

Connector VREF Voltage Checks

Connector checks to chassis ground are **listed in Table**
. Check with the sensor connectors disconnected and the ignition key OFF; all accessories OFF.

Sensor	Test Points	Spec	Comments
ICP	B to Grd	> 1000 Ω	Resistance less than 1000 Ω indicates a short to ground. If a short to ground condition is identified, remove all sensor connectors that are connected to VREF and ECM to determine if the short is in a sensor, ECM or wire harness. If the short is identified in the harness, remove the intermediate Deutsch connectors and measuring to ground will identify in which part of the harness the short is located.
CMP	B to Grd	> 1000 Ω	
MAP	B to Grd	> 1000 Ω	
APS/IVS	C to Grd	> 1000 Ω	
BARO	B to Grd	> 1000 Ω	

Connector Checks to Chassis Ground

Connector checks to chassis ground are **listed in Table**
. Check with the sensor connectors disconnected and the ignition key OFF; all accessories OFF.

Sensor	Test Points	Spec	Comments
ICP	B to No. 19	< 5 Ω	The measurement is taken from the sensor connector to the ECM 60-pin connector. Resistance greater than 5 Ω indicates high resistance or an open in the VREF supply circuit.
CMP	B to No. 19	< 5 Ω	
MAP	B to No. 19	< 5 Ω	
APS/IVS	C to Grd	< 5 Ω	
BARO	B to Grd	< 5 Ω	

Connector Checks to Chassis Ground

Function

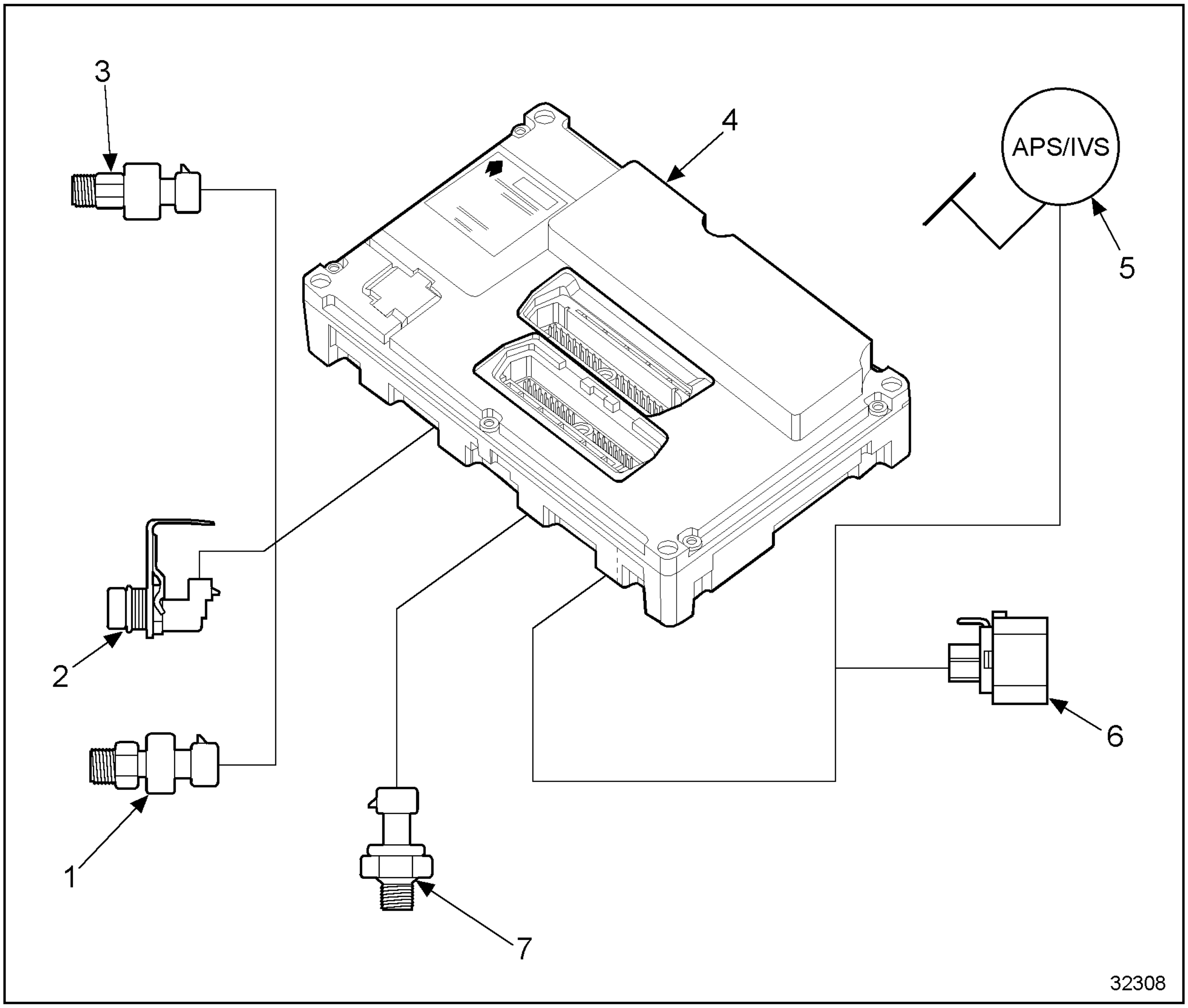
The ECM contains a regulated 5 volt DC voltage reference source to power engine and vehicle control sensors. The sensor signals are compared to the VREF to determine actual sensor output signal values. These values are processed by the ECM for engine operation.

Operation

The ECM is supplied with Battery Voltage when the ignition key is ON at terminals 40 for the engine (gray connector) and terminals No. 3, and No. 5 for the chassis and body builder connections (black connector).

ECM Voltage Reference Diagnostics

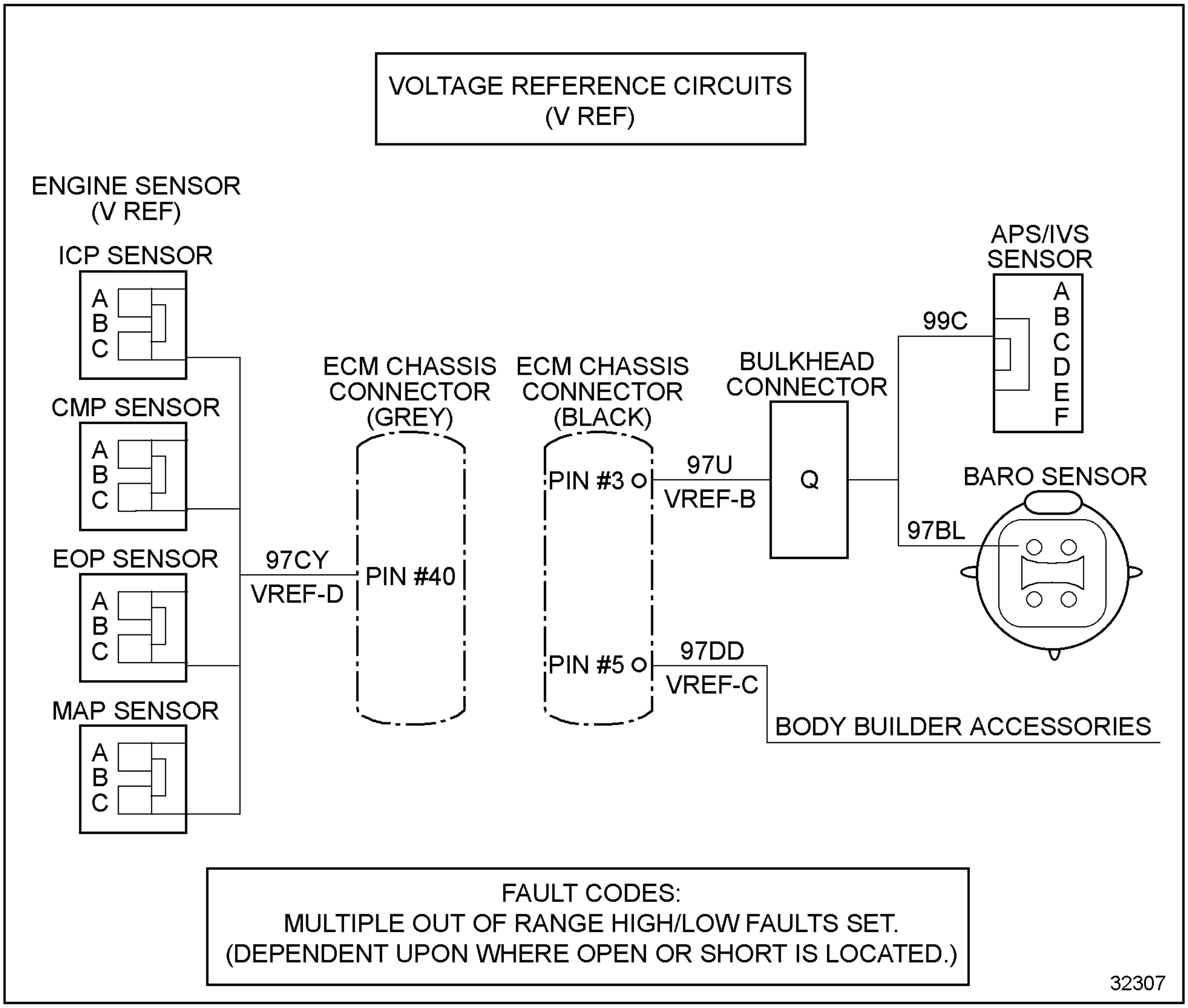
If multiple sensor codes are set, it is possible that the VREF signal circuit is open or the return signal circuit is open. Follow troubleshooting procedures to determine if VREF circuits are at fault. The engine will not run without a valid VREF signal.



1. Engine Oil Pressure Sensor	5. Accelerator Position/Idle Validation
2. Camshaft Position Sensor	6. Barometric Pressure Sensor
3. Injection Control Pressure Sensor	7. Manifold Absolute Pressure Sensor
4. ECM	

Voltage Reference Circuits Function Diagram

2



Voltage Reference Circuits

CHANGE OIL LAMP

CHANGE OIL LAMP

Follow these procedures to diagnose and correct faults with the Change Oil Lamp.

System Functions

The amber Change Oil Lamp will be illuminated when a customer programmable service interval has been exceeded. These limits may be set up in terms of vehicle miles, hours or calculated fuel consumption. These service interval limits may be adjusted or the Change Oil Lamp feature may be turned on or off using the EST. **See Figure** .

1

Fault Detection/Management

The ECM can detect an open COL lamp circuit during a Standard Engine Off test which automatically performs an output circuit check. For service interval light wiring, **see Figure** .

2

Key ON, Engine OFF voltage checks are **listed in Table**
. Check with the ECM chassis connector (black) unplugged, the breakout box installed, the ignition key ON and the engine OFF.

Test Points	Spec.	Comments
439L to Grd	12 v	Fuse for instrument cluster and COL lamp.
45 to Grd	12 v	Battery voltage should be present from lamp circuit to ECM. If no voltage is present, check the circuit for open or short. Check the fuse.

Voltage Checks, Key ON, Engine OFF

Harness resistance checks are**listed in Table** .

Test Points	Spec.	Comments
45 to COL	< 5 Ω	Continuity from ECM to cluster connector for COL lamp. (Pin No. 11 in cluster connector.)
COL to 439L	< 5 Ω	Continuity from instrument cluster connector to fuse. (Pin No. 5 in cluster connector.)

Harness Resistance Checks

Functional Checks

Physical Circuit Check — The physical check, with breakout box installed, momentarily ground the ECM chassis pin No. 45 . The COL lamp should illuminate if the COL circuit is good.

Output State Check — Request an Output State Check with the EST and the COL lamp can be commanded on for test purposes.. If the COL circuit checks out good to this point, and does not turn on when an Output State Check is commanded, either the ECM is bad or the feature is not turned on.

Fault Code Description — Fault Code 262, COL Output Circuit Check fault detected during a key ON, engine OFF Standard Test; possible open or short in COL circuit.

Change Oil Lamp Description

The Change Oil Lamp (COL) is cycled momentarily ON, at every key on cycle as part of a visual bulb check. It is mounted in the instrument cluster and receives 12 volt power from the cluster. The lamp is illuminated when the ECM completes the path to ground.

Service Interval Limits

The limits listed below are the maximum and default values for the service internal function. Through the use of the EST, these limits can be adjusted downward for specific customer needs, but not above the recommended factory service interval.

Service Interval Parameters

This group of parameters customizes the Service Interval feature. Service Interval allows the vehicle owner to customize when his vehicle requires servicing as in changing oil. When the programmed distance or engine hour has been reached, the Change Oil Lamp will illuminate to indicate it is time for maintenance and service.

1. Service Interval Mode — This parameter indicates to the on-board electronics if this vehicle has the service interval feature.
2. Fuel Interval — This parameter allows the customer to program the amount of fuel used since the last service before lighting the Change Oil Lamp.
3. Hour Interval — This parameter allows the customer to program the amount of Engine Hours since the last service before lighting the Change Oil Lamp.
4. Distance Interval — This parameter allows the customer to program the amount of Distance miles/kilometers since the last service before lighting the Change Oil Lamp.
5. Fuel Used Starting Value — This parameter indicates when the last service was performed.
6. Engine Hour Staring Value — This parameter indicates when the last service was performed.
7. Vehicle Distance Starting Value — This parameter indicates when the last service was performed.
8. Service Soon Percent — This parameter indicates at what percentage of the service intervals should the Change Oil Lamp begin to flash as a warning.
9. Change Oil Lamp On Mode — This parameter indicates if the Change Oil Lamp is to be always on after an engine start. This parameter also indicates how long to

activate the Change Oil Lamp after an engine start, if it is not always on.

10. Service Interval Reset Request — This parameter indicates to the on-board electronics if the vehicle has been serviced and the starting values are to be reset.

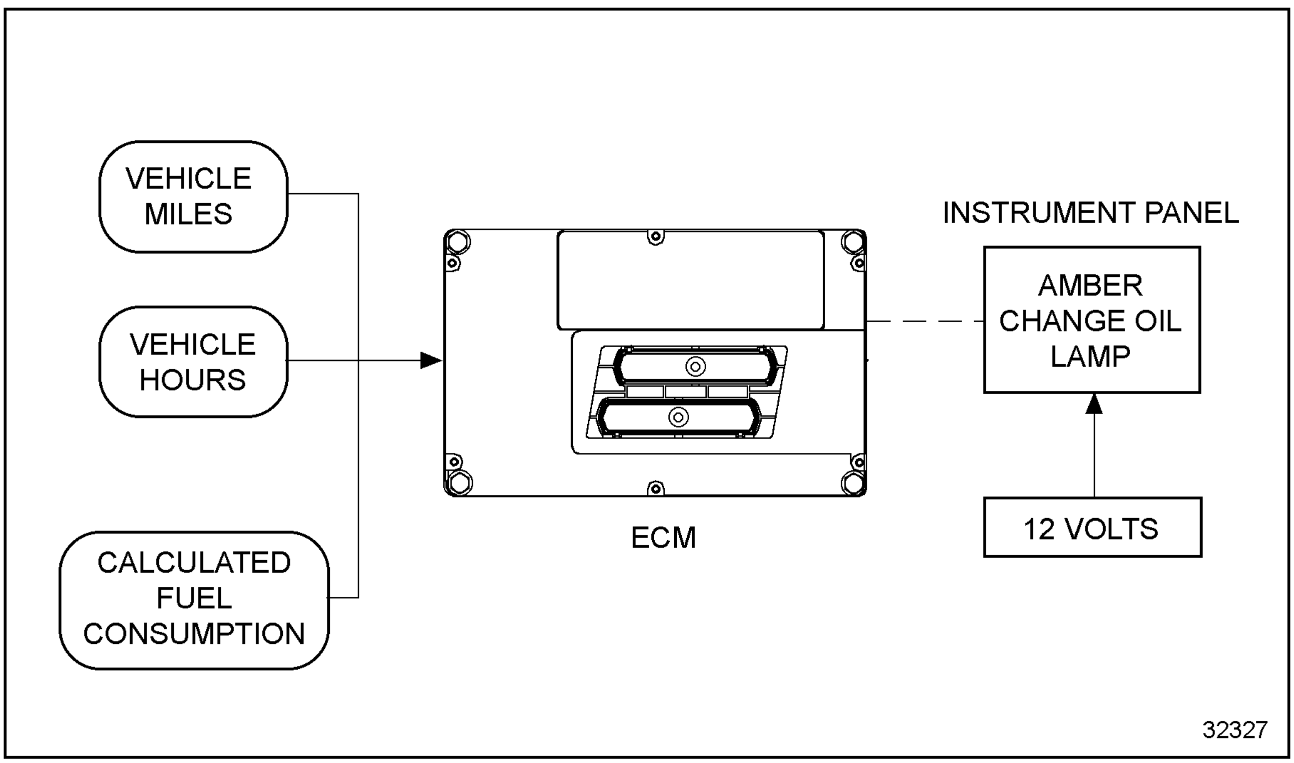
Flash Code 262

ATA code SID 54 FMI 11

Change Oil Lamp OCC self test fail

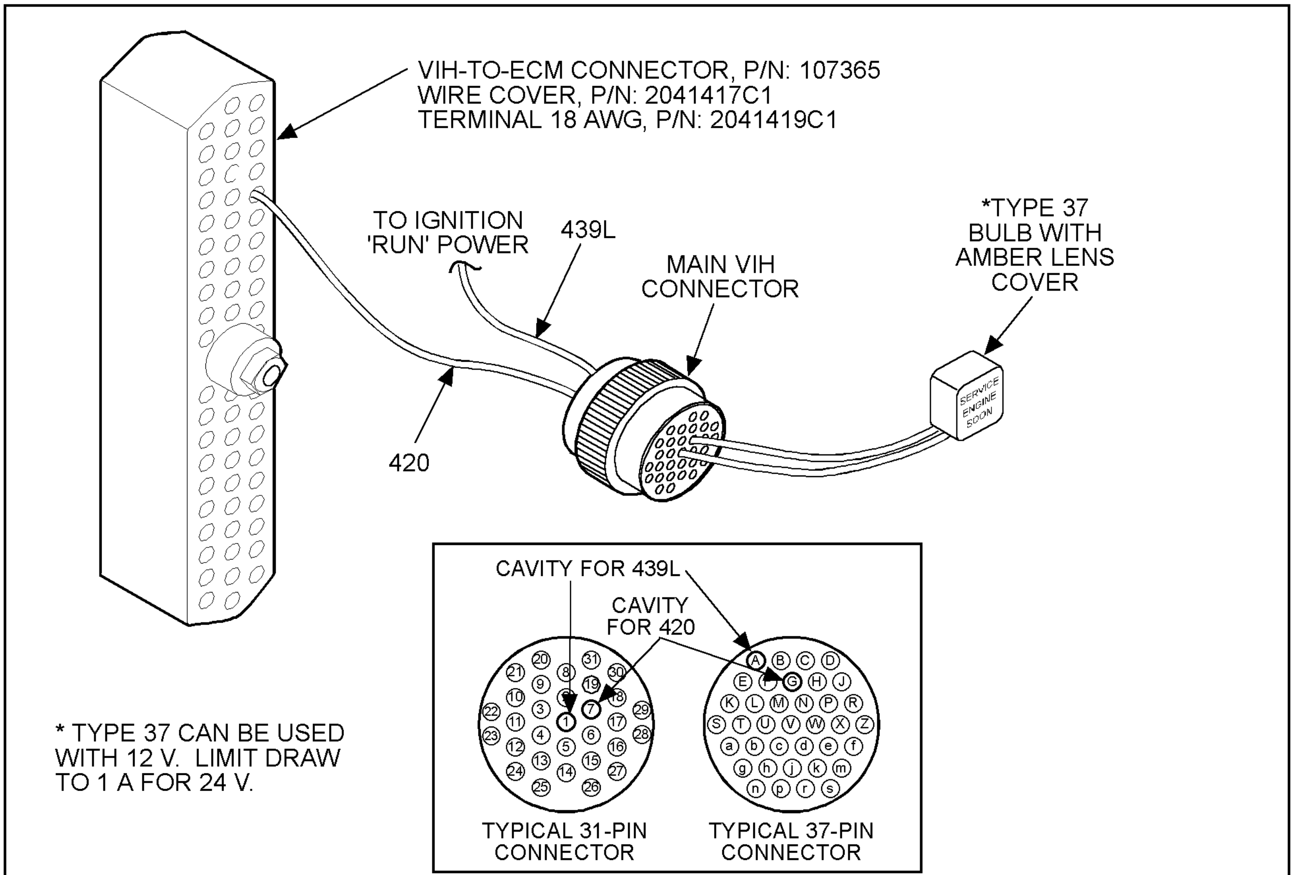
Flash code 262 is caused by an open or short to ground or power in the Change Oil Lamp circuit. It is detected during a Standard Engine Off test when an Output Circuit Check is automatically performed. The Engine standard test may be requested with the EST or displayed as a flash code if the diagnostic button is pressed in and the ignition key is turned to the ON position.

1



Change Oil Lamp Function Diagram

2



LABEL	WIRE NO.	WIRE GAUGE	VIH-to-ECM CONNECTOR CAVITY	MAIN VIH CONNECTOR CAVITY	WIRE COLOR
SERVICE INTERVAL LIGHT	420	18	45	G/7	GRAY
FUSED IGNITION 'RUN' POWER	439L	16	–	A/1	GRAY

28945

Service Interval Light Wiring

ELECTRONIC CONTROL MODULE

OPERATION AND FUNCTION

The Electronic Control Module (ECM) monitors and controls engine performance to ensure maximum performance and adherence to emissions standards. The ECM is also able to monitor and control vehicle features such as cruise control, transmission control, starter engagement, etc. **See Figure**

.

To understand how the ECM functions and how it can monitor input signals and exert control over the actuators, it is necessary to view the four primary functions of the ECM.

1

Reference Voltage

The ECM supplies a 5 volt reference signal to many of the input sensors in the control system. The ECM is able to determine pressures, speeds, positions and many other variables that are important to engine and vehicle functions by comparing the regulated 5 volts sent to the sensors with their respective returned signals.

The VREF (voltage reference) signal is supplied by the ECM by three separate and independent circuits. **See Figure** .

1. VBRef for the cab sensors
2. VCRef for the body builder sensors
3. VDRef for the engine sensors

2

Different VREF signal supplies make the system more robust against VREF circuit failures. A current limiting resistor protects the microprocessor of the ECM in the event of an external short to ground of the VREF signal.

Signal Conditioner

The signal conditioner conditions the input signals for the internal microprocessor by converting analog signals to digital signals, squaring up sine wave signals or amplifying low intensity signals to a level that the ECM microprocessor can process. See Figure .

3

Microprocessor

The ECM contains an internal microprocessor. The processor stores operating instructions (control strategies) and tables of values (calibration parameters). It compares these stored instructions and values to conditioned input values to determine the correct operating strategy for any given engine operating condition. Calculations in the ECM occur at two different levels or speeds referred to as the foreground and the background calculations. These calculations are performed on a continuous loop basis.

Diagnostic strategies (instructions) are also programmed into the ECM. Some instructions monitor inputs on a continuous basis and command the necessary outputs to achieve the correct performance of the engine.

The microprocessor of the ECM is equipped with two types of memory. They are Random Access Memory (RAM) and Read Only Memory (ROM). They allow the processor to store the necessary instructions, calibration tables and input values to control the engine. See Figure .
4

These strategies will instruct the ECM to continuously perform certain diagnostic procedures and other diagnostic tests upon the demand of the technician.

Diagnostic codes can be generated by the microprocessor in the event of any inputs or conditions not complying with pre-programmed expected values. Calculations in the ECM occur at two different levels or speeds referred to as the foreground and the background calculations. These calculations are performed on a continuous loop basis.

Foreground calculations occur at a much faster rate than the background calculations and are normally the more critical functions to engine operation. Engine speed control is an example of foreground calculations.

Background calculations are normally variables that change at a slower rate such as engine temperature.

The microprocessor of the ECM is equipped with two types of memory, Random Access (RAM) and Read Only (ROM) memory. These memories allow the processor to store the necessary instructions, calibration tables and input values necessary to control the engine.

ROM

Read Only Memory is the memory where calibration tables and operating strategies are stored. Information in the ROM is permanent. It cannot be changed or lost by turning the engine off or disconnecting the batteries.

All the information regarding the engine rating are stored in this memory. Vehicle and engine personality information are also stored in this memory and can be modified with the EST to comply with the needs of each individual customer. This includes truck configuration, available features, warning and protection modes and many other parameters that will be described in more detail in this manual.

RAM

Random Access Memory is a temporary storage memory for current events such as current engine temperature, engine r/min, pedal position, etc. It is the memory to which information is temporarily stored so that it can be compared to the information in the ROM. Unlike the ROM, information stored in the RAM is lost every time the key is turned off or when power is interrupted to the ECM.

ACTUATOR CONTROL

The ECM controls the actuators by applying a (low level) signal to the base of the transistor output drivers. These drivers, when switched on, will complete the ground circuit of each actuator.

The actuators are controlled through a duty cycle (% time on/off), a controlled pulse width, or simply switched on or off as determined by the type of actuator being controlled. **See Figure** .

5

Electronic Distributor for the Injectors

The ECM monitors the engine speed and cylinder positions by constantly monitoring the camshaft position signal. When the ECM senses the narrow vane of the trigger wheel through the CMP signal, it locates the position of the piston on cylinder No. 1 and based on that cylinder, the rest of the pistons. **See Figure** .

6

Ground Source

The ECM provides a constant ground path to all the injectors. **See Figure**

.

7

Power Source and Output Drivers

By using output driver transistors, the ECM supplies 115+ volts DC to each injector following the firing order. The ECM contains an individual output driver for each of the injectors. **See Figure** .

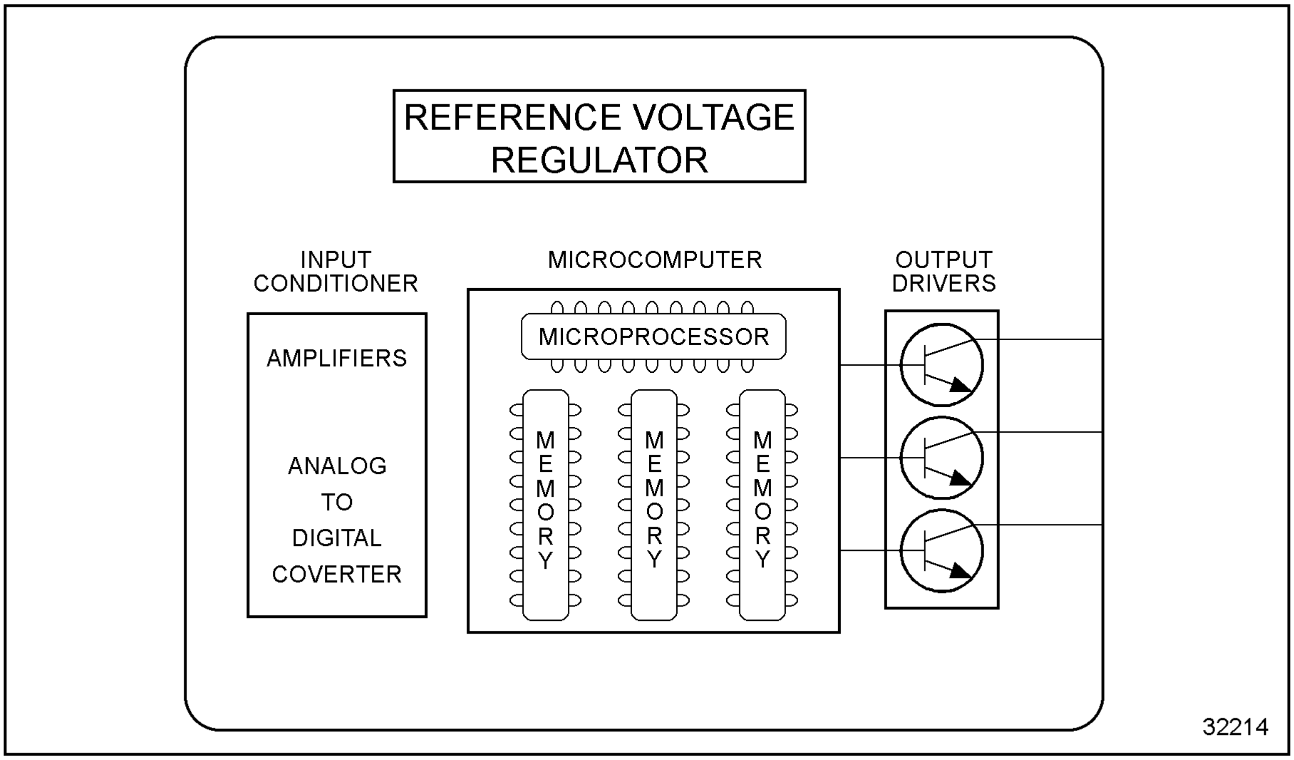
The processor of the ECM determines the following:

1. The correct firing sequence
2. The timing of the injectors
3. The duration of the injection

Note: The 115+ volt DC supply is created by the ECM by making and breaking a 12 volt source across an

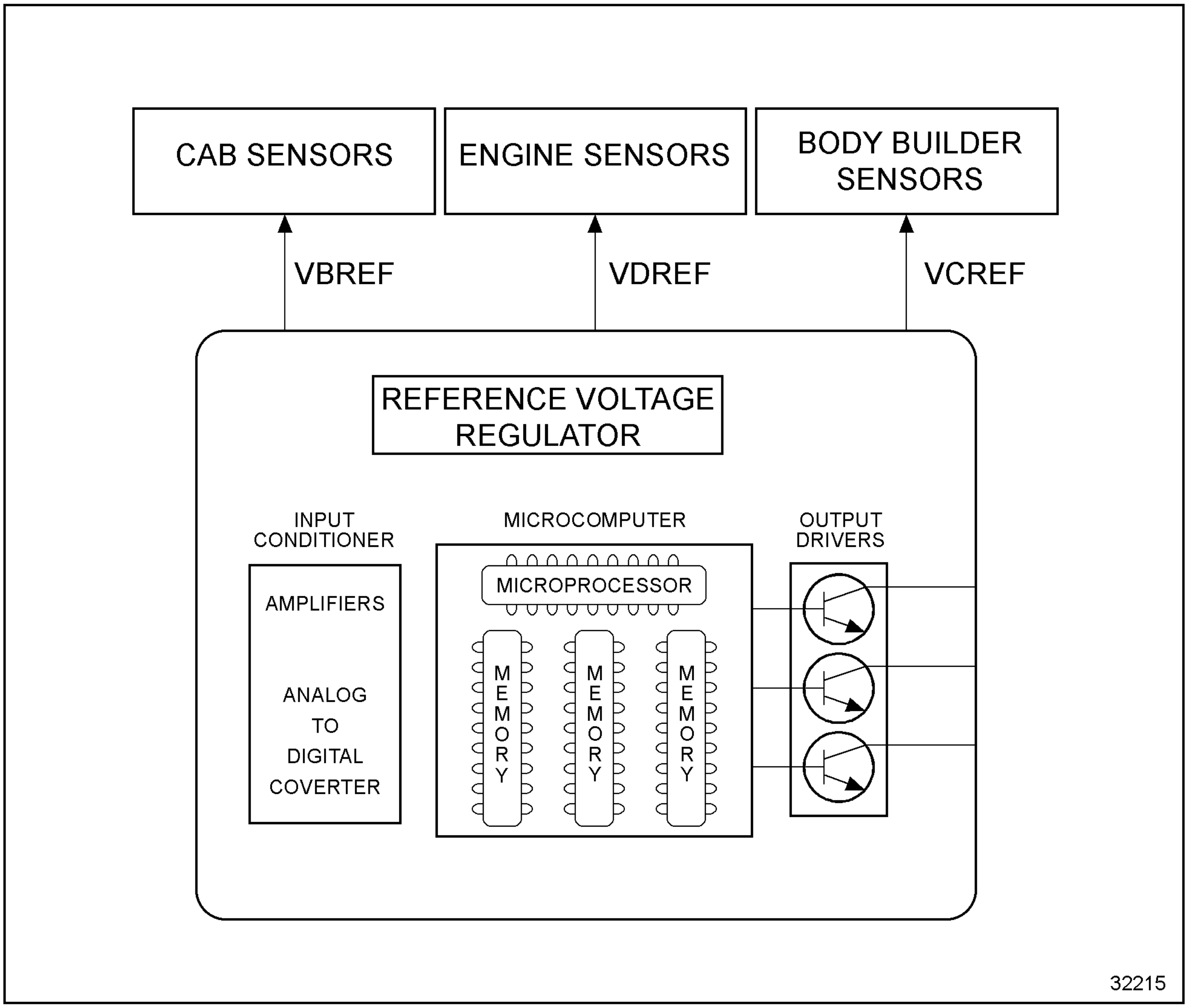
internal coil, based on the same principle as the automotive ignition coil.
8

1



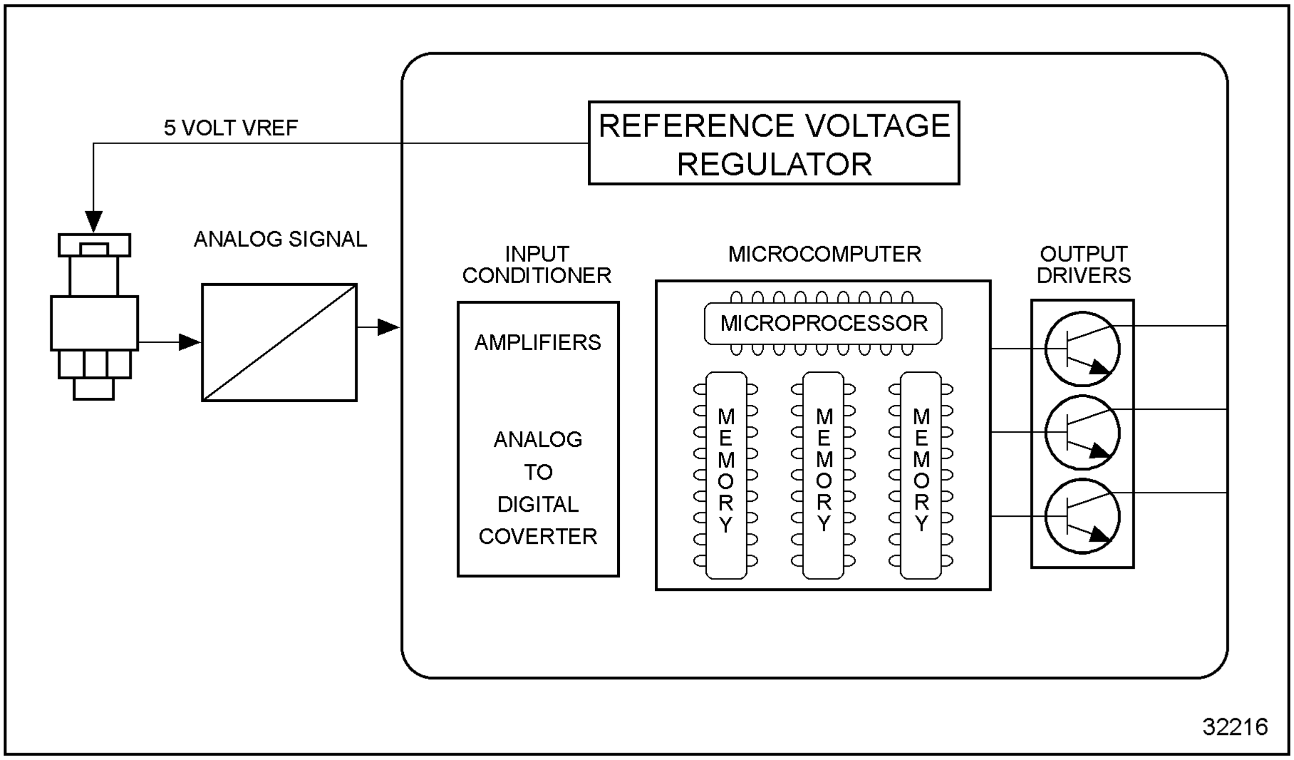
Electronic Control Module

2



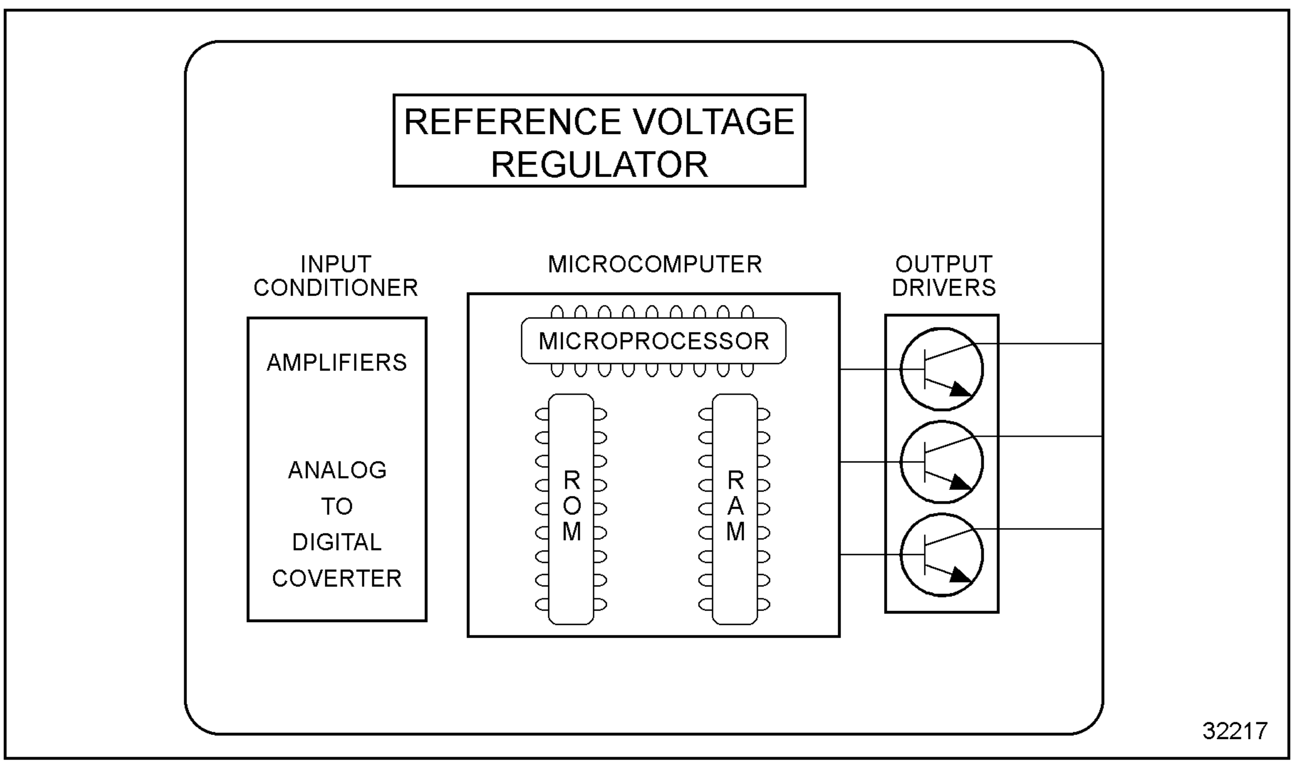
Electronic Control Module 5 Volt Reference

3



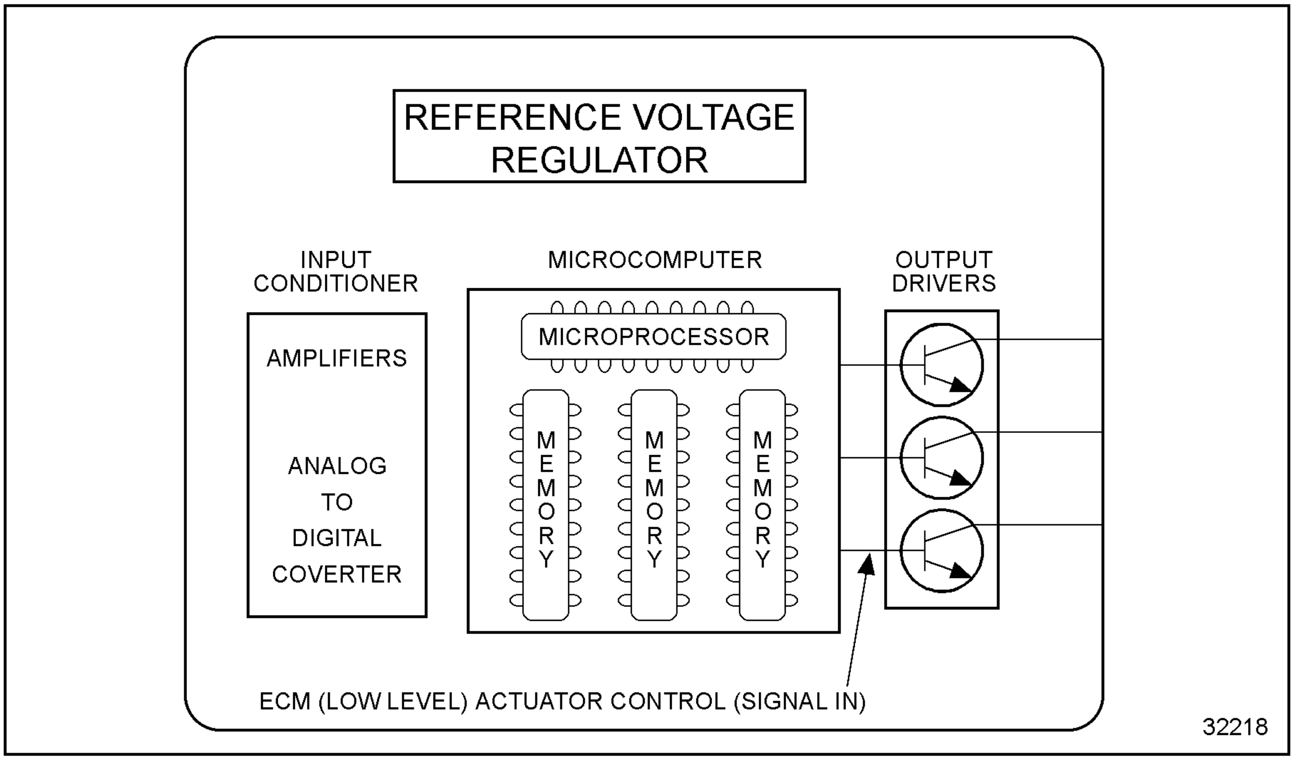
Electronic Control Module Signal Conditioning

4



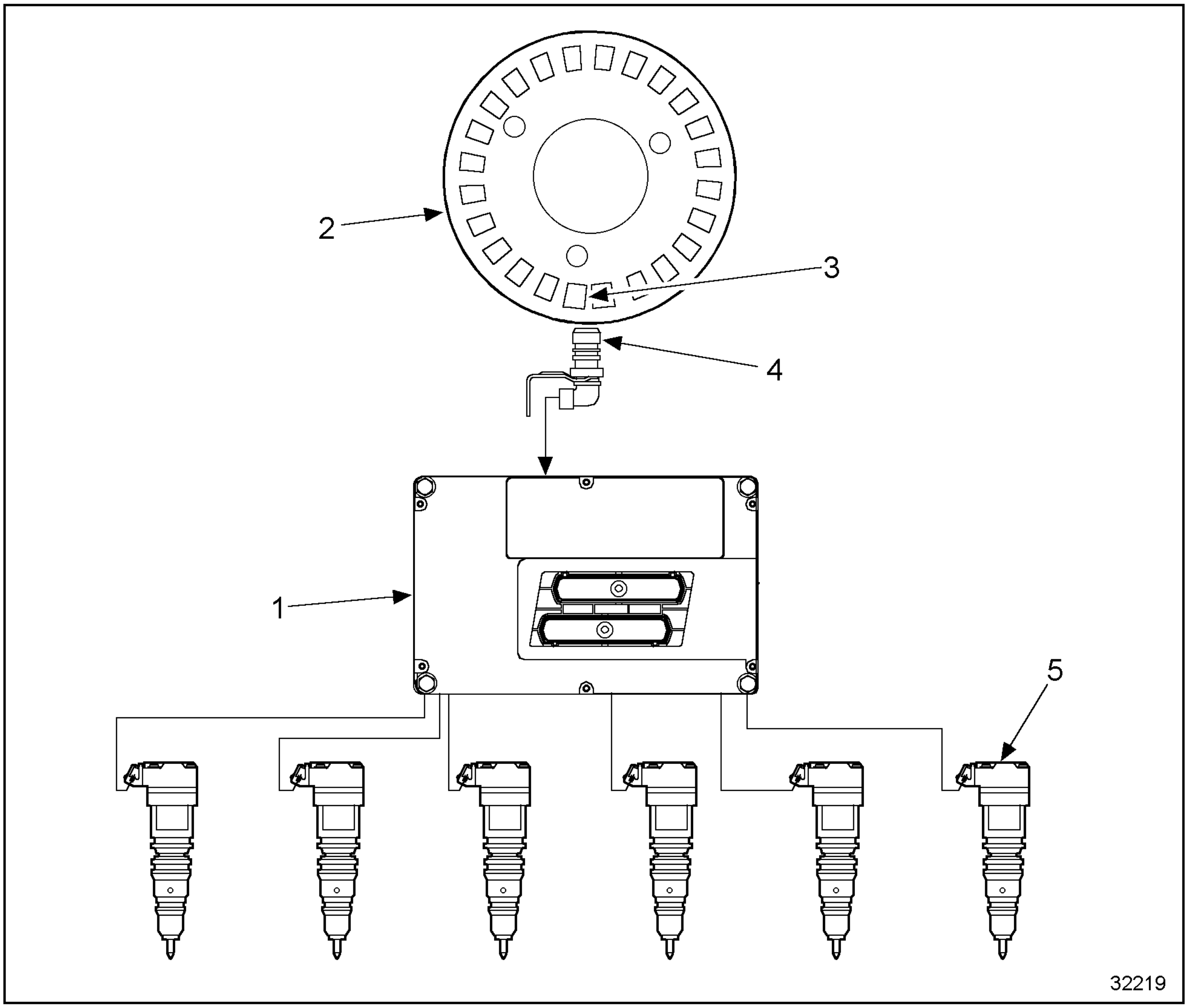
Electronic Control Module Microprocessor Memory

5



Electronic Control Module Actuator Control

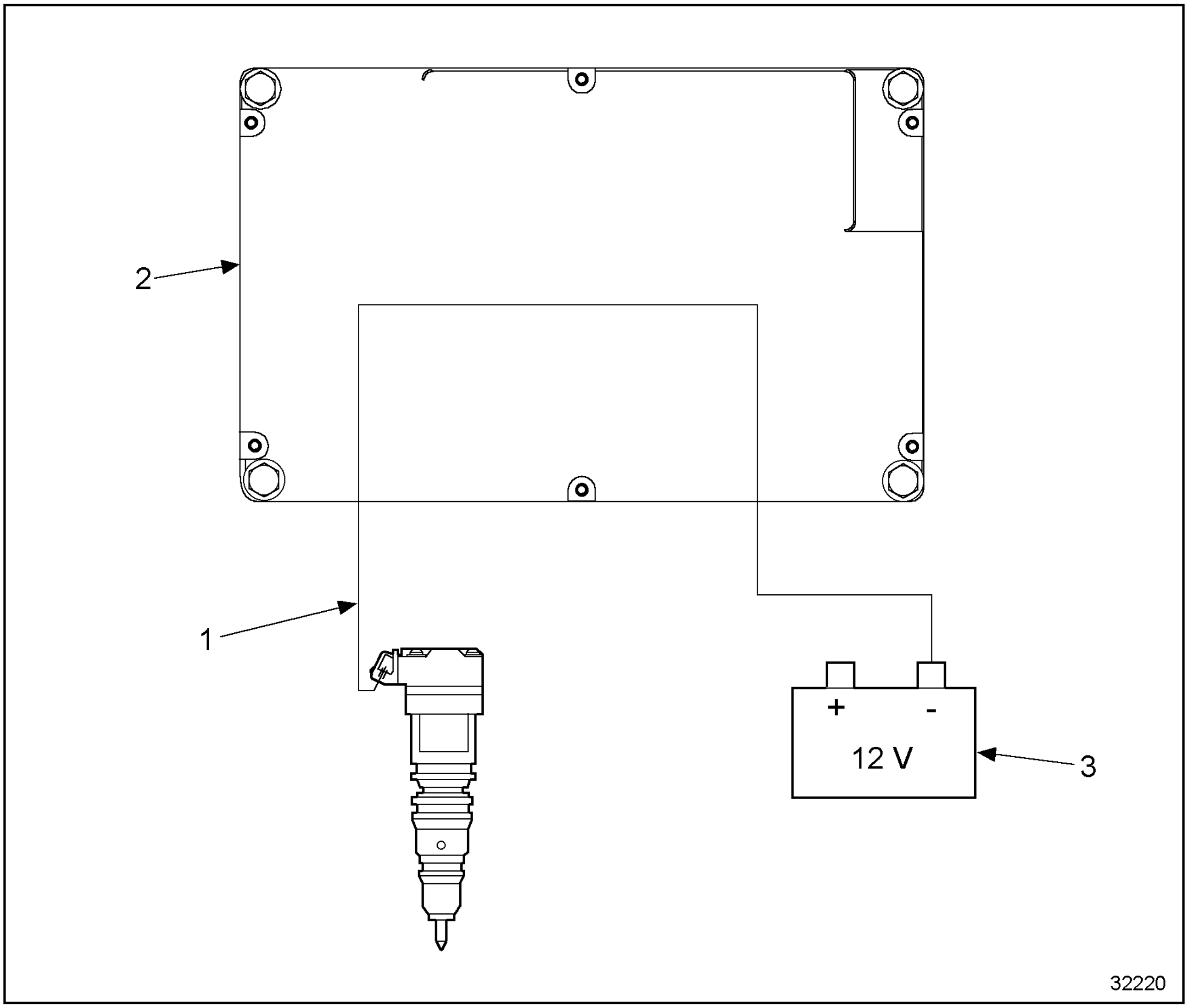
6



1. ECM	4. CMP Sensor
2. Timing Sensor Disk	5. Injectors
3. Narrow Vane	

Electronic Distributor For Injectors

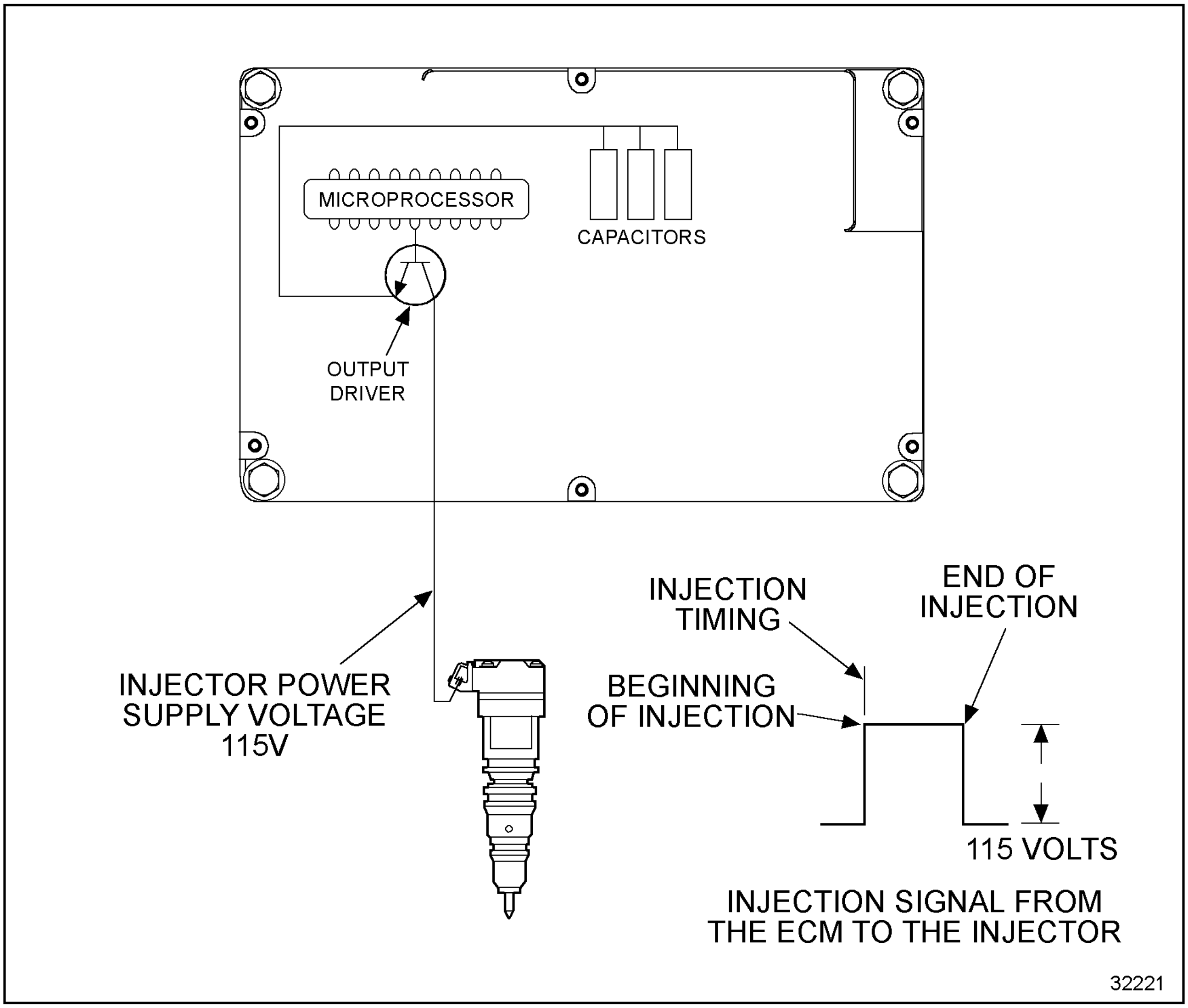
7



1. Supply Ground	3. Battery Voltage
2. ECM	

Injector Ground Supply

8



Injector Control High Side

DIAGNOSTICS FORMS

INTRODUCTION

Almost any mechanical problem can be accurately diagnosed under ideal conditions; but, accurate diagnosis can become the norm under everyday conditions. Much of the long term success and acceptance of an engine is actually determined by the efficiency of thousands of shop foremen and technicians.

The purpose of engine diagnostic forms is to provide the customer with satisfaction and assist the technician in troubleshooting. Diagnostic forms provide a guide to finding problems quickly and easily, avoiding unnecessary repairs and expense. Engine diagnostic forms should not remain buried in a book in the service library. They should be taken right to the job and used in providing a systematic and time saving method of diagnosing engine problems.

Engine diagnostic forms begin with the basics progressing to the tests that are more difficult. This leads the technician in a path of diagnosis to check the more common problems first, then proceed to the less likely problems. The form should be followed in sequence, starting at test number one and continuing through to the final test. The order of the tests should be followed because some components depend on the function of other components for proper operation. Performing the tests out of order could cause an incorrect conclusion.

Two diagnostic forms are required to properly diagnose Series 40E diesel engines. The first form, Hard Start/No Start and Performance Engine Diagnostics, guides the technician through hard start or no start conditions in which the engine does not start or is difficult to start. The Performance Engine Diagnostics portion guides the technician through conditions in which the engine is running with some type of performance problem. An example would be a low power complaint. Illustrations when applicable are located on the reverse side of the form. They show the location of test points and how to hook up test equipment at each point.

The second form, Electronic Control System Diagnostics, lists all engine and vehicle related fault codes on the front side. A circuit index adjacent to each fault code is provided to assist the technician in quickly referring to the appropriate section of the manual for each fault code. Fault code descriptions, comments and probable causes are listed for each fault code on the list. This information will allow the technician to understand what the fault code is and the problem associated with it.

The reverse side of this form contains a schematic wiring diagram of the engine and chassis-mounted electronic controls. A chart is supplied that describes the ECM engine —mounted versus chassis-mounted expected signal values under specified conditions. The chart will enable the experienced technician to quickly identify and repair the problem.

INSTRUCTIONS

Before performing any of the diagnostic procedures, fill in the information requested at the top of the diagnostic forms. Proper information is required.

The date, miles and hours are important information for warranty purposes.

The engine serial number and vehicle identification number (VIN) are important information for ordering parts and referencing service information. The engine serial number is located on a machined pad next to the rear of the fuel filter on the left side of the engine block. The VIN is located on the driver side door jamb.

The engine horsepower and emissions information and the engine family rating code (EFRC) is important information to determine if the engine is the correct horsepower for the application and if the ECM is calibrated to the correct horsepower and emissions level. The engine horsepower and emissions information is located on the emission label located on the intake manifold/valve cover. The engine family rating code can only be accessed with the EST (Electronic Service Tool).

To read the EFRC, follow these steps:

1. Select NAVPAK MENU™ and press ENTER.
2. Select PROGRAMMABLE PARMS MENU and press ENTER.
3. Select ENG/TRANS SELECT MENU and press ENTER.
4. Scroll to the ENGINE RATING CODE and it will be displayed on the EST. **See Figure.** .

1

DIAGNOSTIC FORM INSTRUCTIONS

Record the test data in the actual box of the EST Tool — Data List. If there are any differences between the Specification column and the Actual column, correct as necessary and repeat the checks. Retain this information for future operating analysis. **See Figure** .

2

1

Date:	Mile	Hours	Technician	Injector P/N	Turbocharger P/N
Eng. S/N	VIN		Unit #	Engine Family Rating Code	
Eng. HP	Ambient Temp.	Coolant Temp.		Complaint	

33235

Diagnostic Form

2

8. EST TOOL - DATA LIST

- Select and enter the following data as the first 3 lines in a custom data list.
- Monitor the data while cranking the engine for 20 seconds minimum.

Data	Specification	Actual
Battery voltage	7 volts minimum	
Engine rpm	130 rpm minimum	
ICP pressure	500 psi minimum	

☐ If voltage is low, refer to ECM PWR diagnostics

☐ If no RPM is noted, recheck fault codes

☐ If ICP pressure is low, refer to Test 10

33236

Diagnostic Form

CODIGOS DE FALLAS MOTOR DETROIT DIESEL SERIES 40 E

Series 40 E Electronic Control System Diagnostics

Flash Codes	Circuit	Code Description	Comments	Probable Causes
111	ECM	No Errors Detected - Flash Code Only	No Errors Detected by The ECM	
112	ECM PWR	Electrical System Voltage B+ Out of Range HIGH	ECM Voltage Is continuously More Than 18 Volts	Charging Sistem Fault
113	ECM PWR	Electrical System Voltage B+ Out of Range LOW	ECM Voltage Less Than 6.5 - Cause of No start / Misfire	¨Lo Batt, Poor Connections or Resistance in Circuit
114*	ECT	Engine Coolant Temperature Signal Out of Range HIGH	¨Default 180° F / 82°C,No Fast Idle. ,0.127 v¨	ECT Signal Circuit or Sensor Shorted to Ground
115*	ECT	Engine Coolant Temperature Signal Out of Range LOW	¨Default 180° F / 82°C,No Fast Idle. ,4.595 v¨	ECT Circuit or Sensor Open
121*	MAP	Intake Manifold Abs. Press. Signal Out of Range HIGH	¨Default Inferred MAP - Low Power, Slow Acceleration	¨MAP Circuit Shorted High, Defective Sensor¨
122*	MAP	Intake Manifold Abs. Press. Signal Out of Range LOW	¨Default Inferred MAP - Low Power, Slow Acceleration	MAP Circuit Short Low or Open
123*	MAP	Intake Manifold Abs. Press. In Range Fault	¨Default Inferred MAP - Low Power, Slow Acceleration	Hose or MAP Sensor Plugged
124*	ICP	Injection Control Press. Signal Out of Range LOW	Default Open Loop Control - Underrun At. Idle - 0.039 v	¨Circuit Short Low, Open. Defective Sensor
125	ICP	Injection Control Press. Signal Out of Range HIGH	Default Open Loop Control - Underrun At. Idle - 4.897 v	¨Circuit Short High, Defective Sensor¨
131*	APS/VS	Accelerator Position Signal Out of Range LOW	Signal Voltage Lower Than .152 Volts - Eng. Idle. Only	¨Short to Grd or Open in Circuit, Defective Sensor¨
132*	APS/VS	Accelerator Position Signal Out of Range HIGH	Signal Voltage Higher Than 4.55 Volts - Eng. Idle. Only	¨Short to Vref or 12 Volt, Defective Sensor¨
133*	APS/VS	Accelerator Position Signal In Range Fault	APS / IVS Conflict - Limited to 0% APS	Failed APS Signal
134*	APS/VS	Accelerator Position and Idle Validation Disagree	APS / IVS Conflict - Limited to 0% APS	Both APS And IVS Signal Failure
135*	APS/VS	Idle Validation Switch Circuit Fault	APS / IVS Conflict - Limited to 50% APS	Failed IVS Signal
141	VSS	Vehicle Speed Signal Out of Range LOW	VSS sig at OMPH .048v - Cruise/ PTO disabled - Eng RPM limited	VSS Circuit Open or Shorted to Ground
142	VSS	Vehicle Speed Signal Out of Range HIGH	VSS sig at OMPH 4.492v - Cruise/ PTO disabled - Eng RPM limited	VSS Circuit Shorted to Vref or 12 Volts
143	CMP	Wrong Number of CAMP Signal Transitions per Can Rev	CMP Signal Intermittent	¨Poor Connection. Defective Sensor¨
144	CMP	CMP Signal Noise Detected	ECM Detects electrical noise in circuit	¨Electrical Noise, inyector voltage shorted to ground
145	CMP	CMP Signal Inactive While ICP has Increased	No CMP Signal While ICP Signal Increased	¨Short High Low or Open, Defective Sensor¨
151	BARO	Barometric Press Signal Out of Range HIGH	BARO Signal Voltage above 4.9 v for 1.0 sec	BARO circuit Short High or Open Circuit
152	BARO	Barometric Press Signal Out of Range LOW	BARO Signal Voltage below 1.0 v for 1.0 sec	BARO circuit Short Low
154	IAT	Air Inlet Temperature Signal Out of Range LOW	IAT Signal Voltage Low - Defaults to 77° C	IAT Signal Circuit or Sensor Shorted to Ground
155	IAT	Air Inlet Temperature Signal Out of Range HIGH	IAT Signal Voltage Low - Defaults to 77° C	IAT Circuit or Sensor Open
161	AC	A/C Demand Pressure Signal Out of Range LOW	A/C Sensor Circuit Short	Low or Open
162	AC	A/C Demand Pressure Signal Out of Range HIGH	¨A/C Circuit Chorted High, Defective Sensor¨	
211*	EOP	Engine Oil Press Signal Out of Range LOW	¨EOP Signal Voltage Low, below 0.039 v¨	EOP Circuit Short Low
212*	EOP	Engine Oil Press Signal Out of Range HIGH	¨EOP Signal Voltage High, above 4.897 v¨	EOP Circuit Short High or Open
213	SCCS	Remote Throttle Signal Out of Range LOW	Remote APS Signal Lower Than 249 mv	Open APS Circuit
214	SCCS	Remote Throttle Signal Out of Range HIGH	Remote APS Signal Higher Than 4.50 volts	Shorted APS Circuit
215	VSS	Vehicle Speed Signal Freg Out of Range HIGH	¨Speed,cruise,PTO disabled - Eng RPM limited - Sig freq 4375Hz	¨Misadjusted / faulty spedd sensor, electrical noise on circuit¨
216	HPS	Hydraulic Pressure Signal Out of Range LOW	HPS Signal voltage below .039 v	¨Circuit Open, Short to ground, Defective Sensor¨
221	SCCS	Cruise - PTO Control Switch Circuit Fault	SCCS Signal Incorrect Voltage Signal Wrong for Switch State	Short or Resistance in SCCS Circuit
222	BRAKE	Brake Switch Circuit Fault	Voltage at ECM (BNO) And (BNC) Are The Same	Faulty / Misadjusted Switch
225	EOP	EOP Sensor Signal In-Range Fault	EOP Signal above spec. With engine off key on	Disables engine protection
226	HPS	Hydraulic Pressure Sensor Signal Out of Range High	HPS Signal above 4.9 volts	¨Circuit Short High, Defective Sensor¨
231	ATA	ATA Data Communication Link Error	¨ATA Link Open or Shorted, WTEC controller interference¨	ATA Device Grounded or Overloaded
236	ECLECL	Switch Circuit Fault	Engine coolant level switch circuit fault	Open or Short Circuits
241	IPR	Injection Cntrl. Press. Regulator OCC Self Test Failed	IPR - Output Circuit Check - Engine Off Test Only	Short High or Low or Open
244	EDL	Engine to Trans. Data Line OCC Self Test Failed	EDL Relay - Output Circuit Check - Engine Off Test Only	Open or Short Circuits
246	FAN	Engine Fan OCC Self Test Fault	Fan Relay - Output Circuit Check - Engine Off Test Only	Open or Short Circuits
256	RSE	Radiator Shutter Enable OCC Fault	Shutter Relay - Output Circuit Check - Engine Off Test Only	Open or Short Circuits

* Indicates WARN Lamp on when Fault Set

** Faults only Available if engine Protection is enabled

DDC Diagnostic Form

CODIGOS DE FALLAS MOTOR DETROIT DIESEL SERIES 40 E

Series 40 E Electronic Control System Diagnostics

Flash Codes	Circuit	Code Description	Comments	Probable Causes
262	COL	Change Oil Lamp OCC Fault	Change Oil Lamp - Output Circuit Check - Engine Off Test Only	"Open or Short Circuits, failed bulb"
263	OWL	Oil Water Lamp OCC Fault	Oil Water Lamp - Output Circuit Check - Engine Off Test Only	"Open or Short Circuits, failed bulb"
265	VRE	Vehicle Retarder Relay OCC Fault	Vehicle Retarder Relay - Output Circuit Check - Engine Off Test Only	Open or Short Circuits
266	WEL	Engine Warning Lamp OCC Fault	Engine Warning Lamp - Output Circuit Check - Engine Off Test Only	"Open or Short Circuits, failed bulb"
311*	EOT	Engine Oil Temp. Signal Out of Range Low	"Default 212° F / 100° C, No Fast Idle, EOT above 4.78 v"	EOT Signal Circuit or sensor shorted to Ground
312*	EOT	Engine Oil Temp. Signal Out of Range High	"Default 212° F / 100° C, No Fast Idle, EOT below 0.2 v"	EOT Circuit or sensor Open
313	EOP**	Engine Oil Pres Below Warning Level	"Engine Monitor of Low Oil Press, Oil Light On"	"No or low oil, sticking oil pressure regulator, pickup"
314	EOP**	Engine Oil Pres Below Critical Level	"Engine Monitor of Low Oil Press, Shutdown (if Equipped)"	"Pick-up tube blocked or cracked, worn bearings or oil pump"
315*		Engine Speed Above Warning Level	ECM Recorded Excessive Engine Speed	Transmission Improperly Downshifted
316		Engine Coolant Temp. Unable to Reach commarded set point	Enabled only when Cold Ambient Protection Enabled	"Leaking thermostat, cooling system problems"
321	ECT**	Engine Coolant Temp. Above Warning Level	Coolant Temperature Greater Than 224.6° F (107° C)	Cooling system problem
322	ECT**	Engine Coolant Temp. Above Critical Level	Coolant Temperature Greater Than 233.6° F (112.5° C)	
323	ECL	Engine Coolant Below Warning / Critical Level	ECM Detects Low Coolant Level	Check coolant Level if low Check For Leaks
324	ECT	Idle Shutdown Timer Enabled Engine Shutdown	Enabled only when idle Shutdown Enabled	
325	ECT	"Power Reduced. Matched to Cooling Sys Perfomance"	Engine Power Reduced Due Monitoring System	Repair low Coolant Level or coolant Overtemp
331*	IPR	Injection Crtrl Press Above System Working Range	ICP Above 3675 Psi (25 Mpa)	"Grounded IPR Circuit, Stuck IPR Valve"
332*	ICP	Injection Control Pres Above Spec With Engine off	ICP Sig. Volt Higher Than Expected W/Eng Not Running	"Circuit Shorted to Voltage, Defective sensor"
333*	IPR	Injection Control Pres Above/Below Desired Level	ICP desired does not = ICP signal (long period of time)	"Air in oil, wrong oil, stuck or wrong IPR, leaking injector"
334	IPR SYS	ICP unable to achieve setpoint in time (poor performance)	ICP desired does not = ICP signal (short period of time)	"rings. ICP sensor, High pressure pump (See manual)
335	IPR SYS	ICP unable to build pressure during cranking	Less than 725 psi ICP pressure after 10 sec. Of cranking	"Air in oil, injection pressure problem(See manual)
336	HGE		Hydraulic pressure unable to achieve commanded set point	
421 - 426	INJ	High Side to Low Side Open (Cyl Number Indicated)	ECM Detectec A Open Circuit For Injector circuit	Individual injector Harness Open
431 - 436	INJ	High Side Shorted to Low Side (Cyl Number Indicated)	ECM Detectec A Short Circuit For an Injector	Injector or Harness Shorted Low side to high Side
451 - 456	INJ	High Side Shorted to Ground or V Bat (Cyl Number Indicated)	ECM Detectec Inj. Low side shorted to Grd - 1 bank run	Inj Harness shorted On Low (Control) Circuit to Grd.
461 - 466	Perf. Diag.	Cylinder Contrib. Test Failed (Cyl Number Indicated)	ECM Fiads Cylinder Contribution insufficient	Refer to Performance Diagnostics
513*	INJ	Low Side to Bank 1 Open	High Voltage Supply Open	Open Circuit Bank # 1
514*	INJ	Low Side to Bank 2 Open	High Voltage Supply Open	Open Circuit Bank # 2
515*	INJ	Bank 1 Low Side Short to Ground or B+	Right Side High Voltage Circuit Shorted	Harness to Right side of Engine Shorted
521*	INJ	Bank 2 Low Side Short to Ground or B+	Left Side High Voltage Circuit Shorted	Harness to Left side of Engine Shorted
525	ECM	Inyector Driver Circuit Fault	ECM unable to supply sufficient voltage to injectors	Injector wiring Open or Shorted
612*	CMP	Incorrect ECM installed For CMP Timing Wheel	Mismatch Between ECM And CMP Sensor	Incorrect ECM
614*	ECM	EFRC/EECM configuration mismatch	Components Changed in The Field Not Available	
621*	ECM	Engine Using Mfg. Default Rating Program Engine	Engine Operates At 25 HP Default	ECM Not Programmed But Installed On Truck
622*	ECM	Engine Using Field Default Rating	"Engine Limited to 160 HP, Options Not Available"	
623*	ECM	Invalid Engine Rating Code; ECM Programming	ECM Not Programmed Properly	
624	ECM	Field Default Active	Programming problem	Programming problem / Internal ECM problem
626	ECM	Unexpected Reset Fault	Internal ECM power reset	Poor Batt. Connections
631	ECM	ROM (Read Only Memory) Self Test Fault	ECM Failure	Replace ECM
632	ECM	Ram Memory - CPU Self Test Fault	ECM Failure	Replace ECM
655	ECM	Programmable Parameter list corrupt	Programming problem / ECM memory problem	Programming problem
661	ECM	RAM Programmable Parameter list corrupt	Programming problem / ECM memory problem	Programming problem / Internal ECM problem
664	ECM	Calibration level incompatible	Programming problem	Programming problem
665	ECM	Programmable Parameter memory content corrupt	ECM Failure	Replace ECM

* Indicates WARN Lamp on when Fault Set

** Faults only Available if engine Protection is enabled

DDC Diagnostic Form

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

GENERAL INSTRUCTIONS

This section contains the supporting information for the Electronic Control Diagnostic Form.

This section contains the supporting information for the Electronic Control System diagnostic form. It includes engine and vehicle recommended diagnostic procedures, a description of each control circuit's function and a detailed drawing with specifications for each circuit. The technician can be directed to the appropriate control circuit through the Circuit Index column on the Diagnostic Form.

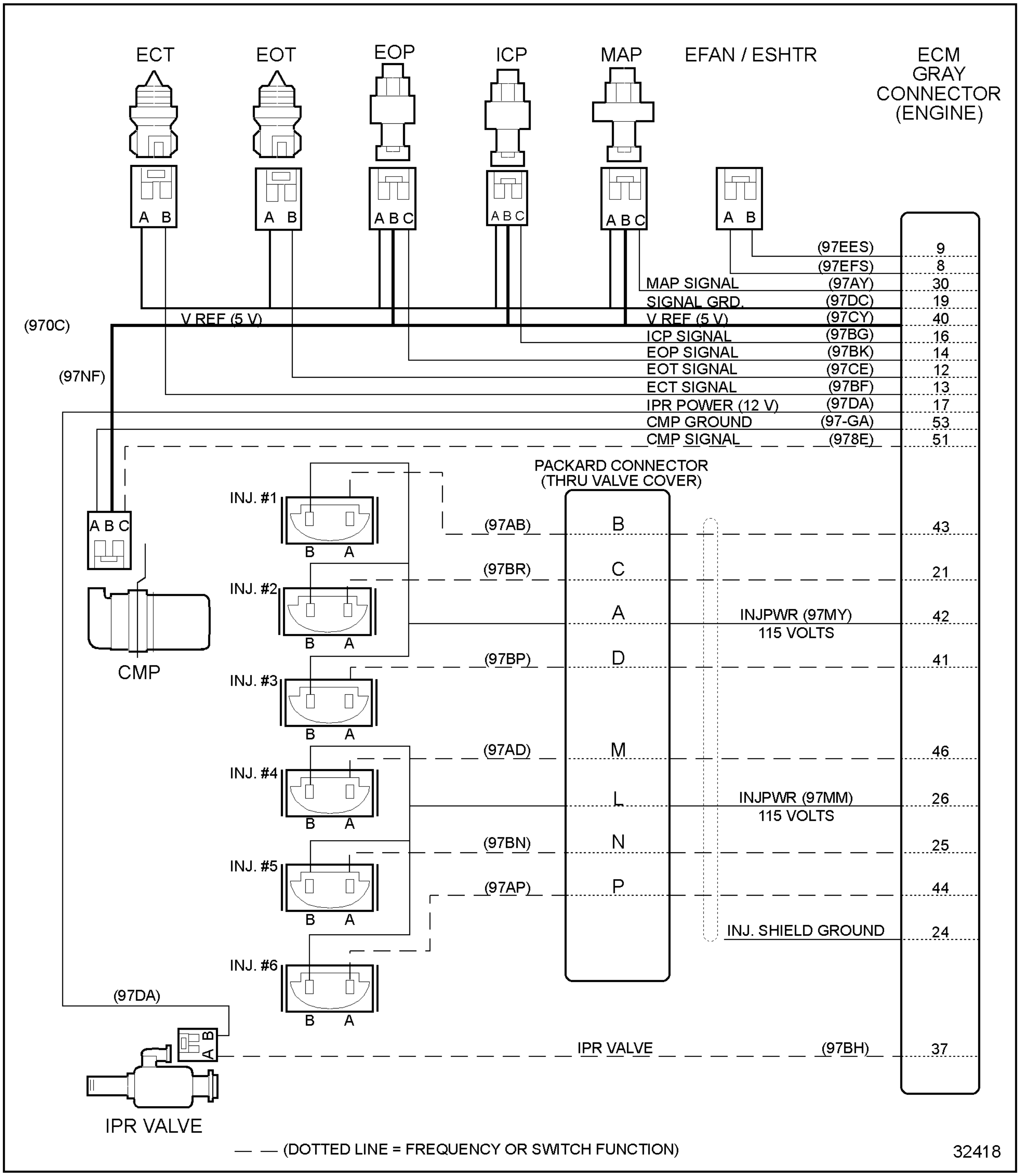
Engine and vehicle electronic diagnostics are indexed by circuit acronyms listed on the Electronic Control System Diagnostic Form. The Section Index lists the acronyms to quickly locate the circuits requiring diagnostics. The diagnostic information is structured as described:

1. The function pages for each circuit are intended to give a technician a brief description of what that circuit does, and what faults the control system can detect.
2. The diagnostic pages for each circuit are intended to give the technician information required to test that circuit and determine if it is functioning correctly.

See Figure . **See Figure** . **See Figure** . **See Figure** .

1234

1



DDC Diagnostic Form — Engine Mounted Components

2

Signal Values Series 40E (All values with breakout box installed on ECM and Harness)

Pin Number	Acronym	Circuit Number	Circuit On	Key	Low Idle Signal	Low Idle Data List	High Idle Signal	High Idle Data List	Operating Range	Comments
1	EBP	Exhaust Back Pressure	97BD							
8	EFAN	Fan	97EFS	4.48	4.48		4.48			0V: relay on (fan off) 12V/open: relay off (fan on)
9	ESHTR	Shutters	97EE	4.48	4.48		4.48			
12	EOT	Engine Oil Temperature	97CE	Temperature Dependent					1.19 v = 194°F	4.75 v = -40°F .669 v = 230°F
13	ECT	Engine Coolant Temperature	97BF	Temperature Dependent					.65 v = 199°F	4.53 v = -40°F .356 v = 230°F
14	EOP	Engine Oil Pressure	97BK	0.61 v	2.6 v	39 psi	3.60 v	60 psi	0.5 v - 4.64 v	.5 v = 0 psi 4.64 v = 80 psi
16	ICP	Injection Control Pressure Sensor	97BG	.2 v	0.48 v	431 psi	1.97 v	1370 psi	.3 v - 4.5 v	.84 v = 444 psi 3.8 v = 3000psi
17	IPR OUTPUT	Injection Pressure Reg. Pwr.	97DA	B +	B +	-	B +	-	B +	Power supply for IPR valve
19	Sig_Grd D	Signal Ground D	97DC	0 v	0 v	-	0 v	-	0 v	Ground for engine sensors
21	INJ_5	Injector #5	97BR							High voltage pulse width signal
22	INJ_GRD	Injector Ground (#5 & #7)	97MV							Injector ground to ECM
23	INJ_7	Injector #7	97AN							High voltage pulse width signal
24	INJ_SHD	Injector Shield Ground	97DW							
25	INJ_2	Injector #2	97BN							High voltage pulse width signal
26	INJ_GRD	Injector Ground (#6 & #8)	97MM							Injector ground to ECM
27	INJ_8	Injector #8	97BS							High voltage pulse width signal
28	HSO_GRD	Ground for EPR and GPR	97GR							
29	EPR_CNTRL	Exhaust Backpressure Reg. Cntrl	97BC							
30	MAP	Manifold Absolute Pressure	97AY	.88 v	.96 v	.5 psi	1.36	3.75 psi	85 v - 4.56 v	0.88 v = 0 psi 4.13 v =32 psi
37	IPR_CNTRL	Injection Pressure Reg. Control	97BH	10.5 v	13 v	-	10.75 v	-	10v - 14 v	Duty Cycle Duty Controlled
38	GPR	Glow Plug Relay Control	97CH							
40	VREF_D	Voltage Reference - D	97CY	5 ±.5 v	5 ±.5 v		5 ±.5 v		5 ±.5 v	V-Ref for engine sensors
41	INJ_3	Injector #3	97BP							High voltage Pulse width signal
42	INJ_GRD	Injector Ground (#1& #3)	97MY							Injector ground to ECM
43	INJ_1	Injector #1	97AB							High voltage Pulse width signal
44	INJ_4	Injector #4	97AP							High voltage Pulse width signal
45	INJ_GRD	Injector Ground (#2 & #4)	97MS							Injector ground to ECM
46	INJ_6	Injector #6	97AD							High voltage Pulse width signal
51	CMP	700 - 3000 RPM Hz vary with RPM								
53	CMP Grd.	Camshaft sensor ground	97GA	0 v	0 v	-	0 v	-	0 vCMP sensor ground	Chassis Connector (Black)
1	DC/DC GND	Pwr Ground for injector drivers	11GW	0 v	0 v	-	0 v	-	0 v	
2	DC/DC GND	Pwr Ground for injector drivers	11GX	0 v	0 v	-	0 v	-	0 v	
3	VREF_B	Voltage reference B	97U	5 ±.5 v	5 ±.5 v	-	5 ±.5 v	-	5 ±.5 v	V-Ref for cab mounted sensors
4	HG	Hydraulic Governor	97HE	Feature not yet functional						Input for hid pressure governor
5	VREF_C	Voltage reference C	97DD	5 ±.5 v	5 ±.5 v				5 ±.5 v 5 ±.5 v	V-Ref for body builder sensors
6	RPS_GRD	Remote pedal sensor ground	97HM	0 v	0 v	-	0 v	-	0 v	Remote accel. pedal sensor grd
7	Sig_Grd C	Signal ground C	97WA	0 v	0 v	-	0 v	-	0 v	Signal grd body builder sensors
8	APS	Accelerator Pedal Sensor	99B	.47 v	.47 v	0%	3.74 v	102%	.47v - 3.74 v	APS signal (min 3.65 v reqd. for 102 %)
10	CLS	Coolant Level Switch	34B	Dependent upon coolant level					0 v / 5 v	0 v = Low Coolant 5 v = Full Coolant
11	Sig_Grd B	Signal ground B	97BW	0 v	0 v	-	0 v	-	0 v	Signal grd. cab mounted sensors
12	IAT	Intake Air Temperature	97AX	Temperature Dependent					3 v = 68°F	3.87 v = 32°F 2.29 v = 99°F
13	HPS	Hydraulic Pressure Gov. Sensor	97EA	Feature not yet functional						49 v = 10psi 4.88 v = 510 psi
16	ATA (+)	Communication Link (Red)	98A	Digital data signal - No signal no EST data display						Dash / Diagnostic / Programming
17	ATA (-)	Communication Link (Blue)	98C	Digital data signal - No signal no EST data display						Dash / Diagnostic / Programming
21	DC/DC PWR	Pwr Supply for injector drivers	97CL	B +	B +	B +	B +	B +	B +	Pwr from ECM power relay
22	DC/DC PWR	Pwr Supply for injector drivers	97CK	B +	B +	B +	B +	B +	B +	Pwr from ECM power relay
23	ECM GRD	ECM Ground	11GY	0 v	0 v	-	0 v	-	0 v	
24	VIGN (+)	ECM Ignition voltage	97BCR	B +	B +	B +	B +	B +	B +	Pwr from ignition circuit
25	ECM_CNTL	ECM power relay control	97AH	1.15 v	1.15 v	-	1.15 v	-	B + / 1.15 v	1.15v = ECM relay on B+ = ECM relay off
26	DDS	Driveline disengagement	97A	0v = clutch pedal down 12v = clutch pedal up I 0v = trans in gear 12v = trans in neutral						
27	IVS	Idle Validation Switch	99D	0v / 12v	0 v	-	12 v	-	0 v / 12	0v = APS at idle 12v = APS off idle
28	TSA	Two Speed Axle Switch	93A							0 v = high axle range 12 v = low axle range
29	BARO	Barometric Pressure Sensor	97CDsi	4.6 v	4.6 v	14.7 psi	4.6 v	14.7 psi	2.55 v - 4.8 v	"4.6v = sea level 2.6v =10,000 ft. (approx.)"
30	RPS	Remote Pedal Sensor	99F0	??			0%	102%	47v - 3.74 v	RPS signal (min 3.799v reqd. for 102 %)
31	RAS	Resume / Accelerate Switch	97DK	0v = switch normal 12v = switch depressed (accel or resume) note: signal only when COO on						
32	SET	Cruise Set Switch	97DJ	0v = switch normal 12v = switch depressed (cruise/PTO set) note: signal only when COO on						
34	STI	Self Test Input	98	4.7 v	4.7 v	-	4.7	-	4.5v - 5.02 v	Diagnostic button grds circuit
35	COO	Cruise On / Off Switch	97CF	12v/0v	12v/0v	On/ Off	12v/0v	On/ Off	12v/0v	0v = Cruise/PTO off 12v = Cruise/PTO on
36	RVAR	Remote Variable PTO	97CC	12v = PTO On 0v= PTO Off						Remote Variable PTO On/Off switch
37	RPRE	Remote Preset PTO	97CB	12v = PTO On 0v= PTO Off						Remote Preset PTO On/Off switch
38	PBA	Parking Brake Applied Switch	44D							Feature not yet functional ??
*39	VSS	Vehicle Speed Input	47	Digital signal from WTEC module on transmission						* Allison World Class trans. only
39	VSS (+)	Vehicle Speed Sensor +	47	3.25 v	2-14vac	MPH	2-14vac	MPH	2v 14 vac	Manual and mechanical transmissions
40	VSS (-)	Vehicle Speed Sensor -	47A	3.25 v	2-14vac	MPH	2-14vac	MPH	2v 14 vac	VSS signal is an AC sine wave
41	ECM_PWR	Voltage from ECM_PWR relay	97AL	B +	B +	B +	B +	B +	B +	Pwr from ECM power relay
42	ECM_GRD	ECM Ground	11 GZ	0 v	0 v	-	0 v	-	0 v	
43	BNO_1	Brake Switch #1	97N	0v/12v	0v/12v	Off/On	v/12v	Off/On	0v/12v	0v = brake released
44	BNO_2	Brake Switch #2	97M	0v/12v	0v/12v	Off/On	0v/12v	Off/On		0v/12v12v = brake depressed
45	COL	Change Oil Lamp	97AA	12v/.6v	12v/.6v	-	12v/.6v	-	12v/.6v	12v = Lamp Off .6v = Lamp On
46	ECI	Engine Crank Inhibit Relay	97H	0v	12v (4.5v)	-	12v (4.5v)	-	0v/12v	0v = allow crank 12v = Inhibits crank
47	VRE	Vehicle Retarder Output	24A							Feature not yet functional
53	GPL	Glow Plug Lamp	18G	12v/.6v	12v/.6v	-	12v/.6v	-		12v/.6v 12v = Lamp Off .6v = Lamp On
54	OWL	Oil/ Coolant Warning Lamp	97AF	12v/.6v	12v/.6v	-	12v/.6v		12v/.6v	12v = Lamp Off .6v = Lamp On
55	WARN	Engine Warning Lamp	97T	12v/.6v	12v/.6v	-	12v/.6v		12v/.6v	12v = Lamp Off .6v = Lamp On
56	EDL	Engine Data Line	92F	0v = normal shift 12v = elevated shift schedule						Automatic Transmission Relay
57	VSSCALB	Vehicle Speed Output	47D	Digital frequency 0v - 12v signal (Not truck Production)						Varies with vehicle speed
60	TACB	Tachometer Output	97AP	Digital frequency 0v - 12v signal (Not truck Production)						Varies with engine RPM Hz =(RPM/5)

33340

DDC Diagnostic Form

3

Series 40E Electronic Controls System Diagnostics

Flash Codes	Circuit	Code Description	Comments	Probable Causes
111	ECM	No Errors Detected - Flash Code Only	No Errors Detected by The ECM	
112	ECM_PWR	Electrical System Voltage B+ Out of Range HIGH	ECM Voltage Is Continuously More Than 18 Volts	Charging System Fault
113	ECM_PWR	Electrical System Voltage B+ Out of Range LOW	ECM Voltage Less Than 6.5 - Cause of No start / Misfire	"Lo Batt, Poor Connections or Resistance In Circuit"
114*	ECT	Engine Coolant Temperature Signal Out of Range LOW	"Default 180° F /82°C, No Fast Idle , < ,0.127 v"	ECT Signal Circuit or Sensor Shorted to Ground
115*	ECT	Engine Coolant Temperature Signal Out of Range HIGH	"Default 180° F /82°C, No Fast Idle, > 4.595 v "	ECT Circuit or Sensor Open
121*	MAP	Intake Manifold Abs. Press. Signal Out of Range HIGH	"Default Inferred MAP - Low Power, Slow Acceleration"	"MAP Circuit Shorted High, Defective Sensor"
122*	MAP	Intake Manifold Abs. Press. Signal Out of Range LOW	"Default Inferred MAP - Low Power, Slow Acceleration"	MAP Circuit Short Low or Open
123*	MAP	Intake Manifold Abs. Press. Inrange Fault	"Default Inferred MAP - Low Power, Slow Acceleration"	Hose or MAP Sensor Plugged
124*	ICP	Injection Control Press. Signal Out of Range LOW	Default Open Loop Control - Underrun At Idle - < 0.039 v	"Circuit Short Low, Open, Defective Sensor"
125	ICP	Injection Control Press. Signal Out of Range HIGH	Default Open Loop Control - Underrun At Idle - > 4.897 v	"Circuit Short High, Defective Sensor"
131*	APS/IVS	Accelerator Position Signal Out of Range LOW	Signal Voltage Lower Than .152 Volts - Eng. Idle Only	"Short to Grd or Open In Circuit, Defective Sensor"
132*	APS /IVS	Accelerator Position Signal Out of Range HIGH	Signal Voltage Higher Than 4.55 Volts - Eng. Idle Only	"Short to Vref or 12 Volt, Defective Sensor"
133*	APS /IVS	Accelerator Position Signal Inrange Fault	APS / IVS Conflict - Limited to 0% APS	Failed APS Signa
134*	APS /IVS	Accelerator Position and Idle Validation Disagree	APS / IVS Conflict - Limited to 0% APS	Both APS And IVS Signal Failure
135*	APS /IVS	Idle Validation Switch Circuit Fault	APS / IVS Conflict - Limited to 50% APS	Failed IVS Signal
141	VSS	Vehicle Speed Signal Out of Range LOW	VSS sig at 0MPH < .048v - Cruise/PTO disabled - Eng RPM limited	VSS Circuit Open or Shorted to Ground
142	VSS	Vehicle Speed Signal Out of Range HIGH	VSS sig at 0MPH >4.492v Cruise/PTO disabled - Eng RPM limited	VSS Circuit Shorted to Vref or 12 Volts
143	CMP	Wrong Number of CAMP Signal Transitions per Cam Rev	CMP Signal Intermittent	"Poor Connection, Defective Sensor"
144	CMP	CMP Signal Noise Detected	ECM Detects electrical noise in circuit	"Electrical Noise, injector voltage shorted to ground"
145	CMP	CMP Signal Inactive While ICP has Increased	No CMP Signal While ICP Signal Increased	"Short High, Low or Open, Defective Sensor"
151	BARO	Barometric Press. Signal Out of Range HIGH	BARO Signal Voltage above 4.9 v for 1.0 sec	BARO circuit Short High or Open Circuit
152	BARO	Barometric Press. Signal Out of Range LOW	BARO Signal Voltage below 1.0 v for 1.0 sec	BARO circuit Short Low
154	IAT	Air Inlet Temperature Signal Out of Range LOW	IAT Signal Voltage Low - Defaults to 77° C	IAT Signal Circuit or Sensor Shorted to Ground
155	IAT	Air Inlet Temperature Signal Out of Range HIGH	IAT Signal Voltage Low - Defaults to 77° C	IAT Circuit or Sensor Open
161	AC	A/C Demand Pressure Signal Out of Range Low	A/C Sensor Circuit Short	Low or Open
162	AC	A/C Demand Pressure Signal Out of Range High	"A/C Circuit Shorted High, Defective Sensor"	
211*	EOP	Engine Oil Press. Signal Out of Range LOW	"EOP Signal Voltage Low, below 0.039 v"	EOP circuit Short Low
212*	EOP	Engine Oil Press. Signal Out of Range HIGH	"EOP Signal Voltage High, above 4.897 v"	EOP circuit Short High or Open
213	SCCS	Remote Throttle Signal Out of Range LOW	Remote APS Signal Lower Than 249 mv	Open APS Circuit
214	SCCS	Remote Throttle Signal Out of Range HIGH	Remote APS Signal Higher Than 4.50 Volts	Shorted APS Circuit
215	VSS	Vehicle Speed Signal Freq. Out of Range HIGH	"Speedo,cruise,PTO disabled - Eng RPM limited - sig. freq > 4375 Hz"	"Misadjusted / faulty speed sensor, electrical noise on circuit"
216	HPS	Hydraulic Pressure Signal Out of Range Low	HPS signal voltage below .039v	"Circuit Open, Short to ground, Defective Sensor"
221	SCCS	Cruise-PTO Control Switch Circuit Fault	SCCS Signal Incorrect Voltage Signal Wrong for Switch State	Short or Resistance In SCCS Circuit
222	BRAKE	Brake Switch Circuit Fault	Voltage at ECM (BNO) And (BNC) Are The Same	Faulty / Misadjusted Switch
225	EOP	EOP Sensor Signal In-Range Fault	EOP signal above spec. with engine off key on	Disables engine protection
226	HPS	Hydraulic Pressure Sensor Signal Out of Range High	HPS signal above 4.9 volts	"Circuit Short High, Defective Sensor"
231	ATA	ATA Data Communication Link Error	"ATA Link Open or Shorted, WTEC controller interference"	ATA Device Grounded or Overloaded
236	ECLECL	Switch Circuit Fault	Engine coolant level switch circuit fault	Open or Short Circuits
241	IPR	Injection Cntrl. Press. Regulator OCC Self Test Failed	IPR - Output Circuit Check - Engine Off Test Only	Short High or Low or Open
244	EDL	Engine to Trans. Data Line OCC Self Test Failed	EDL Relay - Output Circuit Check - Engine Off Test Only	Open or Short Circuits
246	FAN	Engine Fan - OCC Self Test Fault	Fan Relay - Output Circuit Check - Engine Off Test Only	Open or Short Circuits
256	RSE	Radiator Shutter Enable OCC Fault	Shutter Relay - Output Circuit Check - Engine Off Test Only	Open or Short Circuits

33341

DDC Diagnostic Form

4

Series 40E Electronic Controls System Diagnostics

262	COL	Change Oil Lamp OCC Fault	Change Oil Lamp - Output Circuit Check - Engine Off Test Only	"Open or Short Circuits, failed bulb"
263	OWL	Oil Water Lamp OCC Fault	Oil Water Lamp - Output Circuit Check - Engine Off Test Only	"Open or Short Circuits, failed bulb"
265	VRE	Vehicle Retarder Relay OCC Fault	Vehicle Retarder Relay- Output Circuit Check - Engine Off Test Only	Open or Short Circuits
266	WEL	Engine Warning Lamp OCC Fault	Engine Warning Lamp- Output Circuit Check - Engine Off Test Only	"Open or Short Circuits, failed bulb"
311*	EOT	Engine Oil Temp. Signal Out of Range Low	"Default 212° F /100°C, No Fast Idle , EOT above 4.78 v"	EOT Signal Circuit or Sensor Shorted to Ground
312*	EOT	Engine Oil Temp. Signal Out of Range High	"Default 212° F /100°C, No Fast Idle , EOT below 0.2 v"	EOT Circuit or Sensor Open
313	EOP**	Engine Oil Pres Below Warning Level	"Engine Monitor of Low Oil Press. Oil Light On"	"No or low oil, sticking oil pressure regulator, pickup "
314	EOP**	Engine Oil Pres Below Critical Level	"Engine Monitor of Low Oil Press, Shutdown (if Equipped)"	"Pick-up tube blocked or cracked, worn bearings or oil pump"
315*		Engine Speed Above Warning Level	ECM Recorded Excessive Engine Speed	Transmission Improperly Downshifted
316		Engine Coolant Temp.Unable to Reach commanded set point	Enabled only when Cold Ambient Protection Enabled	"Leaking thermostat, cooling system problems"
321	ECT**	Engine Coolant Temp. Above Warning Level	Coolant Temperature Greater Than 224.6°F (107°C)	Cooling system problem
322	ECT**	Engine Coolant Temp. Above Critical Level	Coolant Temperature Greater Than 233.6°F (112.5°C)	
323	ECL	Engine Coolant Below Warning / Critical Level	ECM Detects Low Coolant Level	Check Coolant Level If Low Check For Leaks
324	ECT	Idle Shutdown Timer Enabled Engine Shutdown	Enabled only when Idle Shutdown Enabled	
325	ECT	"Power Reduced, Matched to Cooling Sys Performance"	Engine Power Reduced Due Monitoring System	Repair Low Coolant Level or Coolant Overtemp
331*	IPR	Injection Cntrl Press Above System Working Range	ICP Above 3675 Psi (25 Mpa)	"Grounded IPR Circuit, Stuck IPR Valve"
332*	ICP	Injection Control Pres Above Spec With Engine off	ICP Sig. Volt. Higher Than Expected W/Eng Not Running	"Circuit Shorted to Voltage, Defective Sensor"
333*	IPR	Injection Control Pres Above/Below Desired Level	ICP desired does not = ICP signal (long period of time)	"Air in oil, wrong oil, stuck or wrong IPR, leaking injector ""O"""
334	IPR_SYS	ICP unable to achieve setpoint in time (poor performance)	ICP desired does not = ICP signal (short period of time)	"rings, ICP sensor, High pressure pump (See manual)"
335	IPR_SYS	ICP unable to build pressure during cranking	Less than 725 psi ICP pressure after 10 sec. of cranking	"Air in oil, injection pressure problem (See manual)"
336	HGE		Hydraulic pressure unable to achieve commanded set point	
421-426	INJ	High Side to Low Side Open (Cyl Number Indicated)	ECM Detected A Open Circuit For Injector Circuit	Individual Injector Harness Open
431-436	INJ	High Side Shorted to Low Side(Cyl Number Indicated)	ECM Detected A Short Circuit For an Injector	Injector or Harness Shorted Low Side to High Side
451-456	INJ	High Side Shorted to Ground or V Bat (Cyl Number Indicated)	ECM Detected Inj. Low Side Shorted to Grd -1 bank run	Inj Harness Shorted On Low (Control) Circuit to Grd.
461-466	Perf. Diag.	Cylinder Contrib. Test Failed(Cyl Number Indicated)	ECM Finds Cylinder Contribution Insufficient	Refer to Performance Diagnostics
513*	INJ	Low Side to Bank 1 Open	High Voltage Supply Open	Open Circuit Bank #1
514*	INJ	Low Side to Bank 2 Open	High Voltage Supply Open -	Open Circuit Bank #2
515*	INJ	Bank 1 Low Side Short to Ground or B+	Right Side High Voltage Circuit Shorted	Harness to Right Side of Engine Shorted
521*	INJ	Bank 2 Low Side Short to Ground or B+	Left Side High Voltage Circuit Shorted	Harness to Left Side of Engine Shorted
525	ECM	Injector Driver Circuit Fault	ECM unable to supply sufficient voltage to injectors	Injector wiring Open or Shorted
612*	CMP	Incorrect ECM Installed For CMP Timing Wheel	Mismatch Between ECM And CMP Sensor	Incorrect ECM
614*	ECM	EFRC/EECM configuration mismatch	Components Changed In The Field Not Compatible	
621*	ECM	Engine Using Mfg. Default Rating Program Engine	Engine Operates At 25 HP Default	ECM Not Programmed But Installed On Truck
622*	ECM	Engine Using Field Default Rating	"Engine Limited to 160 HP, Options Not Available"	
623*	ECM	Invalid Engine Rating Code; ECM Programming	ECM Not Programmed Properly	
624	ECM	Field Default Active	Programming problem	Programming problem / Internal ECM problem
626	ECM	Unexpected Reset Fault	Internal ECM power reset	Poor Batt. connections
631	ECM	ROM(Read Only Memory) Self Test Fault	ECM Failure	Replace ECM
632	ECM	Ram Memory-CPU Self Test Fault	ECM Failure	Replace ECM
655	ECM	Programmable Parameter list level incompatible	Programming problem / ECM memory problem	Programming problem
661	ECM	RAM Programmable Parameter list corrupt	Programming problem / ECM memory problem	Programming problem / Internal ECM problem
664	ECM	Calibration level incompatible	Programming problem	Programming problem
665	ECM	Programmable Parameter memory content corrupt	ECM Failure	Replace ECM

* Indicates WARN Lamp on When Fault Set

** Faults only available if Engine Protection is enabled

33342

DDC Diagnostic Form

ECM SELF DIAGNOSTICS

SIGNAL FUNCTIONS

The ECM monitors and controls engine/vehicle operation and performance, enables vehicle features such as PTO and cruise control to function, communicates engine/vehicle information to the instrument cluster transmission (on vehicles equipped with electronically controlled transmissions) and diagnostic/programming tools. For the ECM, see Figure .

1

Fault Detection/Management

During normal operation, the ECM automatically performs diagnostic checks upon itself and the total electronic control system. The ECM self tests include memory checks, programming checks, and internal power supply checks for power to the injectors. The ECM is capable of internal fault detection and dependent upon the severity of the problem, can provide fault management strategies to allow limited engine/vehicle operation.

Pass Code — Flash Code Only

The following flash codes could display as part of the self diagnostics:

Flash Code 111

ATA code: None

Condition Description: No fault conditions detected.

Note: Can only determine if ECM has detected continuous faults or faults detected during an Output Circuit

Check. Faults generated during an On-Demand Test such as Cylinder Contribution Tests can only be accessed by an EST.

Flash Code 525, Injector Drive Diagnostics

ATA code: SID 254 FMI 6

Condition Description: Injector driver circuit fault.

Symptoms: Possible hard start/no start or low power condition.

Possible Causes: Shorted engine harness, injector harness or defective ECM.

Actions: Perform injector harness checks in INJ circuit diagnostics; if no defects found, replace ECM and test again.

Flash Code 614, ECM Memory/Programming Diagnostics

ATA code: SID 252 FMI 13

Condition Description: EFRC/EECM ING Configuration mismatch.

Symptoms: Possible hard start/no start or low power condition.

Possible Causes: Wrong EFRC (Engine Family Rating Code) selected for the ECM strategy programmed in the module.

Actions: Check EFRC and verify it matches ECM strategy level. Reprogram ECM or change EFRC as necessary.

Flash Code 621

ATA code: SID 253 FMI 1

Condition Description: Manufacturing defaults selected.

Symptoms: Very low power (25 hp)

Possible Causes: Programmable parameters for ECM never programmed in module. Most likely to occur in new vehicle or new module.

Actions: Program programmable parameters.

Flash Code 622

ATA code: SID 253 FMI 0

Condition Description: Engine using Field Default Rating.

Symptoms: Low power (lowest rating in engine class) and vehicle features not working.

Possible Causes: Programmable parameters for ECM module incorrectly programmed in module.

Actions: Program programmable parameters.

Flash Code 623

ATA code: SID 253 FMI 13

Condition Description: Invalid EFRC (Engine Family Rating Code)

Symptoms: Possible hard start/no start or low power condition.

Possible Causes: Wrong EFRC selected for the ECM strategy programmed in the module.

Actions: Check EFRC and verify it matches ECM strategy level. Reprogram ECM or change EFRC as necessary.

Flash Code 624

ATA code: SID 240 FMI 14

Condition Description: Field Defaults Active

Symptoms: Low power (lowest rating in engine class) and vehicle features not working.

Possible Causes: Programmable parameters for ECM module incorrectly programmed in module.

Actions: Program programmable parameters.

Flash Code 631

ATA code: SID 240 FMI 2

Condition Description: Read Only Memory (ROM) Self Test Fault.

Symptoms: No start.

Possible Causes: Internal ECM problem.

Actions: Replace ECM.

Flash Code 632

ATA code: SID 254 FMI 12

Condition Description: RAM Memory — CPU Self Test Fault

Symptoms: No start.

Possible Causes: Internal ECM problem.

Actions: Replace ECM.

Flash Code 655

ATA code: SID 240 FMI 13

Condition Description: Programmable Parameter List level incompatible.

Symptoms: No start or run in field defaults.

Possible Causes: Programming problem or internal ECM problem.

Actions: Attempt to program ECM; if does not help, replace the ECM.

Flash Code 661

ATA code: SID 240 FMI 11

Condition Description: RAM Programmable Parameter list corrupt.

Symptoms: No start or run in field defaults.

Possible Causes: Internal ECM problem.

Actions: Replace ECM.

Flash Code 664

ATA code: SID 253 FMI 14

Condition Description: Calibration level incompatible.

Symptoms: No start or run in field defaults.

Possible Causes: Programming problem or internal ECM problem.

Actions: Attempt to program ECM; if does not help, replace the ECM.

Flash Code 665

ATA code: SID 252 FMI 14

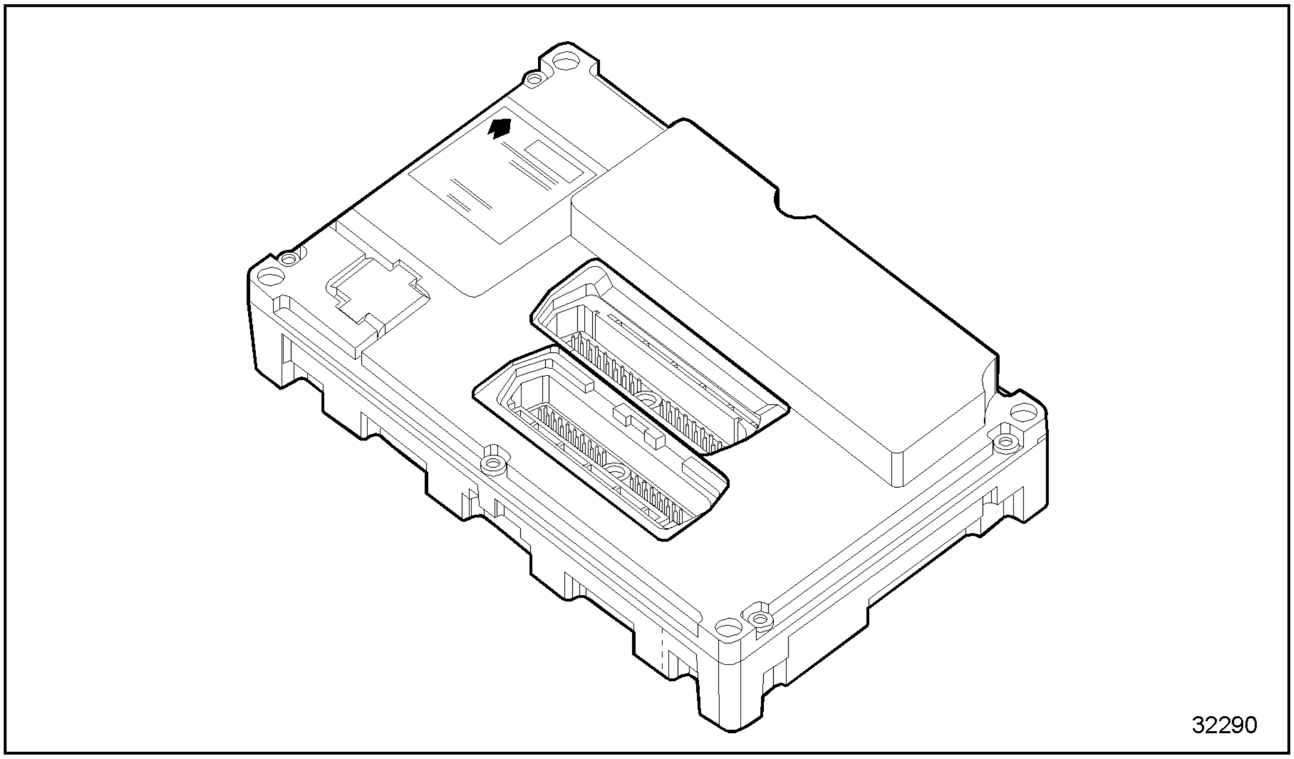
Condition Description: Programmable Parameter Memory content corrupt.

Symptoms: No start or run in field defaults.

Possible Causes: Internal ECM problem.

Actions: Replace ECM.

1



Electronic Control Module

ECM POWER SUPPLY

CIRCUIT FUNCTIONS

The ECM requires a 12 volt source of power to perform its functions. It receives this operating power directly from the vehicle batteries via the ECM relay contacts each time the ignition key switch is turned to the on position. Turning the ignition key switch ON causes the ECM to provide an internal ground to the coil side of the ECM relay. This causes the relay to close its contacts and provide the ECM with the power necessary to perform its various functions. For ECM Power Supply Diagram, **see Figure**

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1

Fault Detection Management

The ECM internally monitors battery voltage. If the ECM continuously receives less than 6.5 volts or more than 18 volts, a fault code will be set. The fault code will not cause the warning light to turn ON. If the condition is intermittent, the code will be logged as an inactive code. The ECM will not operate at voltages continuously below 6.5 or above 18 volts. **See Figure**

.

2

Perform the following checks with the ECM relay removed and the ignition key ON, engine OFF. Voltage checks at the ECM Power Relay Socket are **listed in Table**

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+Test Points	Spec	Comments
85 to Grd	12v ± 1.5v	Voltage present at all times. If no voltage, check ground and power circuits from chassis connectors.
30 to Grd	12v ± 1.5v	Voltage present at all times. If no voltage, check ground and power circuits to battery circuits.
86 to Grd	0.6 to 2v	ECM grounds relay through internal transistor. Expect 1.2v with key ON relay removed.
87 to Grd	0v	No voltage present when relay is removed.

Key ON Engine OFF — Voltage Checks at ECM Power Relay Socket

The following checks are to be made with the breakout box installed, the ECM power relay installed, and the ignition key ON. Voltage checks at the ECM are **listed in Table** .

+Test Points	Spec	Comments
21 to Grd	12v ± 1.5v	Power from relay to ECM.
22 to Grd	12v ± 1.5v	Power from relay to ECM.
41 to Grd	12v ± 1.5v	Power from relay to ECM.
25 to Grd	0.6 to 2v	ECM grounds relay through internal transistor. Expect 1.2v with key ON.

Key ON Engine OFF — Voltage Checks at ECM

Circuit resistance checks are made with the breakout box installed, the ECM power relay installed and the ignition key OFF. These checks are **listed in Table** .

+Test Points	Spec.	Comments
240 to 25	60-120 Ω	Measure resistance across the relay coil; remove fuse 240 to test.
30 to 564A	< 5 Ω	Power from the relay to the ECM (Remove relay to test, and test at location 30 in relay socket.)

Circuit Resistance Checks

Fault code descriptions are **listed in Table** .

Fault Code	Descriptions
112	Internal ECM voltage was detected above 18 volts.
113	Internal ECM voltage was detected below 6.5 volts.
626	ECM detected intermittent power loss through the ECM relay.

Fault Code Descriptions

Description

The ECM receives its power directly from the vehicle batteries when the ECM power relay is energized. This allows maximum power transfer from the batteries to the ECM with a minimum amount of power loss. The wire harness that supplies ECM power is fused at the battery to protect it from short circuits.

When the key switch is turned ON, ignition power from the fuse is supplied to the cavity of the ECM through the connector. This indicates to the ECM that the ignition switch is ON, and it is time to enable the ECM power relay.

Power to the ECM power relay control coil (terminal 85) is provided by circuit 564B from the battery feed stud through the 31–pin connector. The ECM will enable the ECM power relay by completing the ground circuit (internally) to the relay at ECM pin 25.

When the ECM power relay is enabled, power at terminal 30 from the vehicle batteries is switched directly to the ECM from terminal 87 of the relay to pins 21, 22 and 41 of the ECM. The vehicle battery power for this relay to switch is supplied directly from the battery to terminal 30 of the relay.

ECM Diagnostics

If the ECM detects more than 18 volts at pins 21, 22 and 41, it will set Flash Code 112. A voltage of less than 6.5 volts detected by the ECM will set Flash Code 113. The ECM is capable of detecting an intermittent interruption of power or ground circuits. Flash Code 626 will be set indicating an unexpected reset has occurred.

Flash Codes

The following ECM Power Supply faults can occur:

Flash Code 112

ATA Code PID 168 FMI 35

ECM: Internal voltage power out of range HIGH.

Flash Code 112 can be caused by:

1. Defective alternator causing an alternator output voltage in excess of 18 volts.
2. Additional voltage provided while attempting to jump start engine or improper external battery connections that could cause the additional voltage increase.

If the condition causing Flash Code 112 is intermittent, the code will change from active to inactive status. Code 112 does not cause the Engine Warning Light to turn ON.

Flash Code 113

ATA Code PID 168 FMI 36

ECM: Internal voltage power out of range LOW.

Code 113 can be caused by consistently less than 6.5 volts being applied to ECM pins 21, 22 and 41. This can be caused by a defective alternator or ECM power relay, discharged batteries, and/or increased resistance in the battery feed circuits. Code 113 does not turn the Engine Warning Light ON. If the condition causing Code 113 to set is an intermittent condition, when the condition is no longer present, the code status will change from active to inactive.

Flash Code 626

ATA Code PID 254 FMI 56

ECM: Unexpected reset fault.

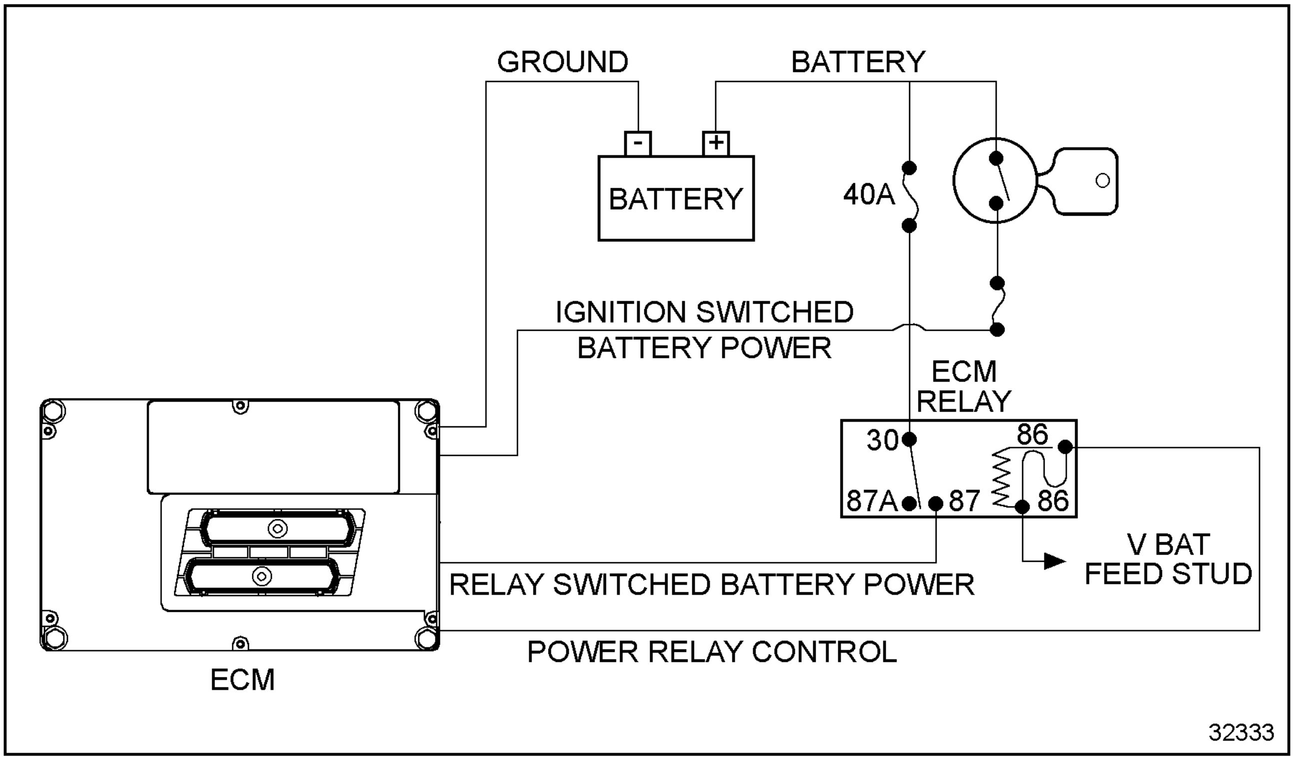
Any time power is interrupted to the ECM due to intermittent power feed circuits caused by loose or dirty connections at the batteries or at ground cables, the ECM may power down. When the power or ground circuit becomes intact again, the ECM will reboot itself. This may cause erratic engine operation. Flash Code 626 will be set anytime the flow of power is interrupted to the ECM. Turning the ignition key OFF and then ON again causes the code to change from an active to an inactive code status. Code 626 will not cause the Engine Warning Light to illuminate.

Before Performing Tests

Inspect the ECM power relay circuit connectors for pushed back, damaged, corroded or dirty terminals as well as ensuring the terminals and wires are properly crimped. Ensure connectors are properly joined together. Also, check for damage to wiring, and check for clean, tight battery and ground connections.

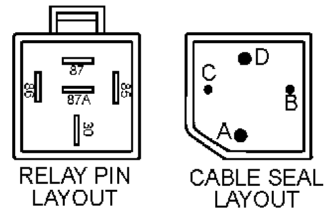
Troubleshooting

If Flash Code 626 is active, the voltage at pins 21, 22 and 41 of the ECM should be monitored while looking for an intermittent connection in the power feed wiring. The EST may be used to indicate any fault codes as well as displaying the voltage as measured by the ECM.

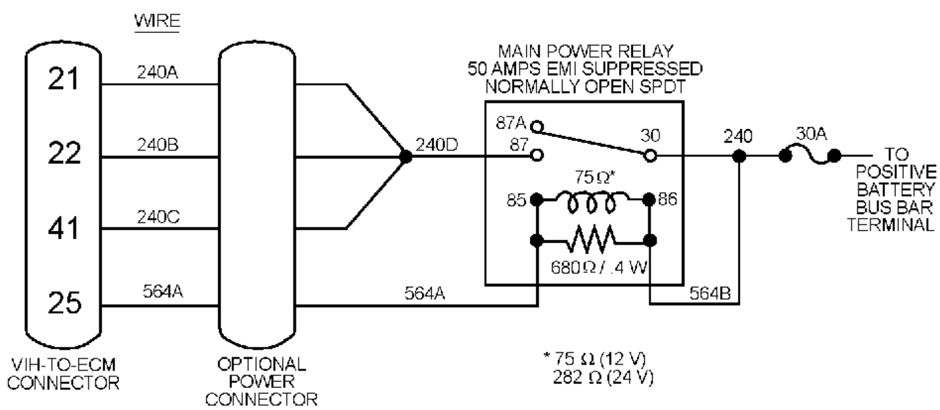


ECM Power Supply Diagram

2



SEAL HOLE	RELAY CAVITY	CIRCUIT
A	87	240D
B	86	564B
C	85	564A
D	30	240



MAIN POWER RELAY KIT AVAILABILITY	
DESCRIPTION	PART NO.
MAIN POWER RELAY (12 V)	23523006
MAIN POWER RELAY (24 V)	23523455

CIRCUIT DESCRIPTION	CIRCUIT NUMBER	VIH-TO-ECM CONNECTOR CAVITY ASSIGNMENT	POWER CONNECTOR CAVITY ASSIGNMENT	WIRE SPECIFICATIONS GAGE (AWG) AND TYPE
BATTERY POWER TO MAIN RELAY TERMINAL 30	240	–	–	10 TXL
BATTERY POWER TO ECM	240A	21	OEM DISCRETION	14 TXL
BATTERY POWER TO ECM	240B	22	OEM DISCRETION	14 TXL
BATTERY POWER TO ECM	240C	42	OEM DISCRETION	14 TXL
ECM-TO-MAIN POWER RELAY COIL	564A	25	OEM DISCRETION	18 GXL
MAIN POWER RELAY SIGNAL	564B	–	–	18 GXL
SWITCHED RELAY CONTROL CURRENT TO ECM FROM PIN 87	240D	–	–	10 TXL

NOTE: POWER CIRCUITS MAY NOT BE SPLICED, EXCEPT AS SHOWN.

31235

Main Power Relay Wiring

PERFORMANCE DIAGNOSTICS

ENGINE OIL LEVEL CHECK

[1]The following procedure will lead you through the engine oil level check. For a reproduction of the applicable portion of the diagnostic form, see Figure .

Purpose

The engine oil level check will determine if the crankcase and oil reservoir contain engine oil of sufficient quantity and quality to enable the injection control pressure system to function properly.

Test Procedure

Follow this procedure to check for sufficient quantity and quality of engine oil

1. Park the vehicle on level ground. Check the oil level with the oil level gage. If there is no oil or very little oil in the crankcase, the fuel injectors will not operate.

If the oil level on the gage is over full, it is possible the engine was incorrectly serviced or fuel is diluting the oil and filling the crankcase. If a substantial amount of fuel is in the oil, it will have an odor.

2. Inspect the oil for color. A milky white oil indicates possible coolant contamination and will have an ethylene glycol odor.
3. Check service records for correct oil type and viscosity for the temperature (environment) in which the vehicle is being operated. Single weight or 15W40 oil is not recommended for cold ambient temperatures. Oil that has had extended drain intervals will have increased viscosity (become thicker) and will make engine cranking more difficult. Starting will also be less reliable at temperatures below

freezing. Refer to the lubrication oil chart in the ***Series 40E Engine Operator's Guide***, 6SE0240, for the correct oil selection for temperature conditions.

Possible Causes

Possible Causes for the oil level problem include:

1. Oil level low — oil leak, oil consumption, incorrect servicing
2. Oil level high — incorrect servicing, fuel dilution from lift pump or defective injector O-rings
3. Oil contamination with coolant — oil cooler, head gasket, porosity, (accessories i.e. water cooled air compressors)

Tools Required

None

SUFFICIENT FUEL / PRESSURE

[2]Follow these steps to diagnose the sufficient fuel/fuel pressure problem. For a reproduction of the applicable portion of the diagnostic form, **see Figure** .

Purpose

This procedure will determine if the fuel system is getting sufficient clean fuel at the proper pressure to start and operate the engine.

Sufficient/Clean Fuel Test Procedure

Follow these steps to check for sufficient clean fuel.

1. Obtain fuel sample from the fuel tank.

Note: Fuel must be of proper grade, clean and undiluted.

2. Inspect fuel in the container. It must be clean and free of air, contaminants, water, icing or clouding. The fuel should be straw colored. Fuel dyed red or blue indicates an off-highway fuel.
3. Check fuel odor for the presence of other fuels such as gasoline or kerosene.

If engine oil is present in the fuel, it may indicate an injector O-ring leak and subsequent loss of injection control pressure. **Refer to section**
, for Low ICP Pressure and the Leakage Test for determining the cause of oil present in the fuel. After the cause has been determined and the repair made, drain the fuel tank(s) and dispose of the contaminated fuel properly.

Fuel Pressure Test Procedure

To test fuel pressure, follow these steps:

1. Remove the air bleed valve on the fuel filter header. **See Figure** .
3

2. Install 1/8 in. (3 mm) pipe fitting in place of the bleed valve.
3. Connect a line from the fitting to the Engine Field Test Kit, **J 39257**
. **See Figure** .
4

4. Measure the fuel pressure at high idle. Record the pressure on the diagnostic form and compare to the specifications. If fuel pressure is low, replace fuel filter, clean fuel strainer and test again. If pressure is low on the second test, perform the following steps:

   a. Remove the fuel return line and install the plug (to prevent fuel from exiting) into fuel return opening.

   b. Crank the engine and observe fuel pressure gage. If pressure rises, replace the fuel return valve and check the fuel pressure again. If there is no increase in fuel

pressure while the return line is plugged, perform the Transfer Pump Restriction Test. **Refer to section**
.

Note: Perform Fuel Pressure (Full Load) Test before removing the pressure test equipment. **Refer to section**
.

Low or No Fuel Pressure Possible Causes

The following are possible causes for the low or no fuel pressure condition:

1. No fuel in tank.
2. If equipped with an inline fuel valve, check it is not shut off.
3. The fuel supply line from the tank(s) could be broken or crimped.
4. Fuel could be waxed or jelled (most likely in cold weather with No. 2 fuel); the pickup tube in the tank could be clogged or cracked. If there is excessive water in the tank, it could freeze, preventing the fuel from being drawn to the engine.
5. If the vehicle is equipped with supplemental filters or water separators, check for plugged filters or leakage that could allow the fuel system to draw air.
6. Cloudy fuel indicates that the fuel may not be a suitable grade for cold temperatures. Excessive water or contaminants in the fuel may indicate that the tank and fuel system may need to be flushed and cleaned.

Tools Required

Clear container, approximately one quart; Engine Field Test Kit **J 39257**
; and appropriate line with 1/8 in. NPT fitting.

TRANSFER PUMP RESTRICTION

[5]Follow these steps to check for a restriction in the transfer pump. For a reproduction of the applicable portion of the diagnostic form, **see Figure** .

Purpose

The purpose of this test procedure is to determine if low fuel pressure is caused by excessive restriction in the fuel supply line from the fuel tank(s) to the transfer pump inlet.

Test Procedure

Follow this procedure to check for a restriction:

1. Connect a tee between the fuel filter inlet and the fuel supply line. Connect a line from the tee to the 0–30 in. Hg. vacuum gage of the Pressure Test Kit.
2. Measure fuel inlet restriction at high idle and record the reading on the diagnostic form.
3. If the restriction exceeds 8 in. Hg, locate the restriction on the suction side of the fuel system and correct. If the restriction is within specifications or very low, perform the following:

   c. Remove the fuel supply line; connect a clear plastic line to the fuel inlet fitting; and connect the fuel supply line to clear the plastic line.

   d. Check for air bubbles in the clear plastic line while the engine is running at high idle. If air bubbles are visible, inspect the fuel system for suction leak(s) and repair. If air bubbles were not present in the clear line, remove the clear plastic line.

   e. Install a plug to seal off the fuel inlet. Start the engine and run at high idle. Vacuum reading should be greater than 22 in. Hg. If less, check for air ingestion from the vacuum gage to the transfer pump. If no leak is found, replace the transfer pump.

Note: If no leaks are found on the inlet side of the fuel system, and the transfer pump is providing > 22 in. Hg vacuum, replace the fuel return valve. Check the fuel pressure again to verify the valve was defective.

Possible Causes

Possible causes for a transfer pump restriction include:

1. A fuel filter could cause high restriction and low fuel pressure because of dirt or fuel jelling in cold ambient temperatures. Change filter and test again.
2. Primary fuel filter or fuel/water separator clogged.
3. A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and therefore low fuel pressure.
4. A loose fuel line on the suction side of the fuel system could cause air to be ingested into the system and cause low fuel pressure.
5. Primary fuel filter or fuel/water separator may be ingesting air into fuel system via loose connections, etc.
6. Fuel return valve defective or stuck open due to debris.
7. Defective fuel transfer pump.

Tools Required

Engine Field Test Kit **J 39257**
, tee or reworked hollow screw fitting, NPT pipe adaptor, and appropriate fuel lines.

EST TOOL — FAULT CODES

[6]To check fault codes, follow this procedure. For a reproduction of the applicable portion of the diagnostic form, **see Figure** .

Purpose

The purpose of the EST — Fault Codes check is to determine if the ECM has detected any fault conditions that would cause a hard start or no start condition.

Test Procedure

Before starting this procedure, turn all accessories and the ignition off before connecting the EST tool to the ATA diagnostic connector.

A Diagnostics Flowchart follows: **See Figure** ; and **see Figure** .
78

Connect the EST to the American Trucking Association (ATA) diagnostic connector. If the engine is installed in a truck, the connector is located on the lower left kick panel inside the cab. Body builders could locate this connector in other places. The screen of the reader should light up as soon as the tool is plugged in. **See Figure** .

9

Note: The ATA connector supplies power to operate the EST. The EST will automatically power up as soon as it is plugged into the ATA connector.

Turn the ignition switch to the ON position, but do not start the engine. This will allow the EST to receive data from the electronic control components. Press enter for NAVPAK menu. The information received will be data showing the current status of the engine. **See Figure** .

10

To access the fault codes, press the FUNC key to switch to the main menu. **See Figure** .11

From the main menu press the ↓ arrow down key to select Diagnostic Codes. The selection will have the ↑↓ symbol on the screen, indicating there are other selections available. By pressing the ↓ key, the other selections will display on the screen. Press ↓ key until Diagnostic Codes displays on the screen.

Next press enter. You are now in the diagnostic codes selection of the tool. From this point, diagnostic codes can be accessed. **See Figure**
.12

The first option that will appear is ACTIVE CODES. By selecting this option, the fault codes that have been detected on the current (ignition) key ON cycle will be displayed.

Press enter. If there are any active codes, the first one will appear on the screen along with

a description of the code. The number in the upper left hand corner represents the Flash Code number. This flash code number is referenced on the electronic diagnostic form. The numbers at the bottom of the screen represent the SAE codes. Press ↓ key to access the additional codes. If there are not any codes active, EMPTY will display on the screen. See Figure
.13

To access Inactive Codes press the FUNC key. This will access the last prior menu selection. Then press the ↓ key to select INACTIVE CODES. Press the enter key. See Figure .14

Inactive codes are faults that have occurred in the previous (ignition) key ON cycles and are now stored in memory. An active code will become an inactive code when the ignition (key) is shut off.

Record all fault codes and refer to Electronic Diagnostics Form.

Note: All current fault codes must be repaired and cleared before proceeding with further diagnostic testing.

Possible Causes

ECM detectable faults that will cause this condition are:

1. Camshaft position (CMP) sensor inactive faults
2. Injection pressure regulator (IPR) output circuit check fault

Tools Required

Pro-Link 9000, J 38500–100
.

Supplemental Diagnosis

If fault codes are set, refer to Electronic Diagnostic form and the fault code diagnostics. Refer to section

.

EST TOOL — ENGINE OFF TESTS

[15]Follow these procedures to access the EST — Engine Off Tests. Access Diagnostic Codes menu in the EST and clear all fault codes before performing the Engine Off Tests. For a reproduction of the applicable portion of the diagnostic form, **see Figure**

.

Purpose

The EST Tool — Engine Off Tests are used to determine if there are any electrical malfunctions that can be detected by the ECM Output Circuit Check self test.

Test Procedure

Access the Engine Off Tests in the Diagnostic Tests section of the EST (Electronic Service Tool).

Press the FUNC key repeatedly, until the main menu displays on the screen, **see Figure** . [16]

Next, select the Diagnostic Tests menu by pressing the ↓ key until DIAGNOSTIC TESTS is displayed on the screen. Press enter to make this selection, **see Figure** . [17]

Press the ↓ key until ENGINE OFF TESTS is displayed on the screen. At this point, press enter; **see Figure** . [18]

After the enter key is pressed, the EST will command the ECM to perform an Output Circuit Check self test.

When the test is complete, the screen will display the number of faults found in the self test. If there are any additional faults found, press enter and the faults will be displayed. Press the ↓ key to access any additional faults. The test is repeated by selecting STANDARD TEST under the Engine Off Tests menu. Only new faults found will be displayed as Faults

Found.

Note: To repeat Engine Off Tests, select STANDARD TEST in the Engine Off Test menu.

Possible Causes

The following are possible causes for this condition:

1. Defective electrical components or circuitry.
2. Injection Pressure Regulator (IPR) output circuit check fault.

Tools Required

Pro-Link 9000, **J 38500–100**

.

EST TOOL — INJECTOR BUZZ TEST

[19]The following procedure will lead you through the Injector Buzz Test. For a reproduction of the applicable portion of the diagnostic form, **see Figure**.

Purpose

This test will determine if the injectors are functioning correctly electronically, by energizing each injector in a programmed sequence. The ECM will monitor this test and transmit fault codes if any injector(s) or electrical circuitry are not functioning properly.

Test Procedure

Access Diagnostic codes menu in EST and clear all fault codes.

Note: Engine OFF standard test must be performed first in order to access the Injector Buzz Test. Press enter to begin the test.

After the Engine OFF standard tests have been completed, press the ↓ key to access the INJECTOR TEST. If the tool is not on a menu screen, i.e. displaying the fault codes, etc., press the FUNC key. This will access the ENGINE OFF TESTS menu. Press enter to begin the test. **See Figure.**

.20

During this test, the injector solenoids will produce an audible clicking sound when actuated. It is possible to detect a malfunctioning injector by listening for the absence of the solenoid clicking sound.

Note: If fault codes were cleared before the Injector Buzz Test, fault codes displayed will be actual faults found during the test. If codes were not cleared before testing, access INACTIVE FAULT CODES from the EST menu to retrieve faults found during this test.

At the completion of the injector test, any faults that have been detected will be displayed. Additional faults can be accessed by pressing the ↓ key.

Record any faults found and **refer to section**

.

Possible Causes

Possible causes for the performance include:

1. Bad wiring harness connection at the injector solenoid
2. Open or shorted engine wiring harness to the injectors
3. Defective injector solenoids
4. Defective ECM

Tools Required

Pro-Link 9000, **J 38500–100**

.

Supplemental Diagnostics

If fault codes are set, refer to the Electronic Diagnostic Form; **refer to section**
, and fault code diagnostics.

STI BUTTON — FLASH CODES

[21]The following procedure will lead you through the Self Test Input (STI) to read faults. For a reproduction of the applicable portion of the diagnostic form, **see Figure**
.

Purpose

The purpose of the STI is to read faults detected by the ECM if the Electronic Service Tool (EST) is not available, or the EST cannot receive STI data due to communications or component failures.

Depressing the STI switch while turning the ignition switch to the ON position, will signal the ECM to perform an Output Circuit Check self test. If any faults are detected, the ECM will flash the Warn Engine light to indicate which faults have been detected.

Test Procedure

Depress and hold the STI switch. Turn the ignition switch to the ON position. Do not start the engine. The ECM will begin to perform the self test to check the output circuits.

When the test is completed, the ECM will flash the red Oil/Water light and amber Warn Engine light to signal the fault codes.

Note: Fault codes can be accessed at any time by depressing and holding the STI switch while turning the ignition switch to the ON position. Do not start the engine.

To read the fault codes, it will be necessary to count the number of times the Engine Warn light flashes. The following sequence of events occurs each time the STI switch is depressed to obtain the fault codes.

1. The Oil/Water light will flash one time to indicate the beginning of active fault codes.
2. The Warn Engine light will flash repeatedly signaling the active fault codes.

Note: All fault codes are three digits and code 111 indicates no faults have been detected.

3. Count the number of flashes in sequence. At the end of each digit of the code, there will be a short pause. Three flashes and a pause would indicate the number 3. Therefore, two flashes, a pause, three flashes and a pause, and two flashes and a pause would indicate the code 232. If there is more than one fault code, the Oil Water light will flash once indicating the beginning of another active fault code.

After all the active codes have been flashed, the Oil/Water light will flash twice to indicate the beginning of inactive codes. Count the number of flashes from the Warn Engine light. If there is more than one inactive code, the Oil/Water light will flash once in between each fault code.

After all codes have been sent, the Oil/Water light will flash three times indicating END OF MESSAGE.

To repeat transmission of fault codes, depress the Engine Diagnostics switch to signal the ECM to send all stored fault codes again.

If fault codes are set, refer to the Electronic Diagnostic Form; **refer to section**
, and fault code diagnostics.

Possible Causes

The possible cause of the problem is an electronic component or circuitry failure.

Tools Required

None.

INTAKE RESTRICTION

[22]Follow this procedure to determine if an intake/air cleaner restriction is excessive. For a reproduction of the applicable portion of the diagnostic form, see Figure.

Purpose

Often a low power and poor fuel economy complaint is simply due to a dirty air cleaner element. In this test, the gage is inserted into the air cleaner housing. As the air cleaner element accumulates dirt, restriction to airflow increases. If restriction exceeds specifications, replace the air cleaner element or elements.

Note: A high intake restriction may cause a considerable amount of black or blue smoke when starting the engine.

Air Intake Restriction Indicator

Inspect the air intake restriction indicator.

1. Refer to appropriate OEM guides for air cleaner information.
2. Inspect the element(s) for damaged gaskets or dents. If they exhibit either, they should be replaced.
3. Inspect inlet piping for debris.

Single Element Air Cleaner

Measure air cleaner restriction as follows:

1. Attach the restriction test gage at the air cleaner housing tap location. See Figure .
23
2. Run engine at high idle r/min.
3. Replace the air cleaner element when the test gage measures a restriction greater than 12.5 in. H_2O (3.13 kPa).

Note: The true maximum air cleaner restriction can only be obtained when operating the engine at full load and rated speed. The vehicle mounted indicator or vacuum gage will sense maximum restriction. When 25 in. H_2O (6.22 kPa) is sensed on the vehicle mounted gages, replace the air cleaner element. For convenience, air cleaner restriction can be measured at high idle (no load). However, the element must be replaced when 12.5 in. H_2O (3.13 kPa) is measured at no load.

Note: High air cleaner restriction can cause turbocharger seals to unseat, causing oil to be drawn through the seals and into the engine.

Dual Element Air Cleaner

The dual element air cleaner provides a large primary (outer) filter element and an optional small, secondary (inner) filter element. The secondary element should be used in dusty environments.

The dual element air cleaner assembly restriction connection is located between the primary and the secondary element in the bottom of the air cleaner housing. This arrangement allows only the primary (outer) element to be sensed by the restriction indicator or dash-mounted vacuum gage. The inner element is not recorded on the restriction indicator or dash-mounted vacuum gage. See Figure . See Figure .
2425

To determine inner element restriction, use the visual check procedure.

Visually inspect the restriction indicator built into the inner element or inner element retaining nut.

Note: Two different indicators are the result of two different suppliers. Replace the element when the green dot disappears from the element or from the window in the retaining nut. Each supplier's retaining nut requires a different torque. **See Figure** . **See Figure** .

Possible Causes

Possible causes for the problem include:

1. Dirty air cleaner element.
2. Snow, plastic bags or other foreign material may restrict airflow at the air cleaner inlet. On engines recently repaired, rags or cap plugs may have been inadvertently left in the intake system.

Tools Required

Engine Field Test Kit **J 39257**
, and magnehelic gauge or water manometer

EST TOOL — ENGINE RUNNING TEST

[26]The EST (Electronic Service Tool) is used to signal the ECM to perform the Engine Running Test. The ECM will exercise the actuators and monitor sensor feedback signals. If a sensor or actuator problem exists, the ECM will transmit fault code(s) to the EST. For a reproduction of the applicable portion of the diagnostic form, **see Figure**
.

Purpose

The purpose of the Engine Running Test is to verify the electronic sensors and actuators of the engine are operating properly within their specified operating ranges.

Test Procedure

Before running this test, apply the parking brake and ensure the transmission is in neutral.

1. Start and run the engine until it reaches 160°F (71°C) minimum.

Note: The engine must be at least 160°F (71°C) to allow the ECM to perform an accurate test of the engine sensors and actuators. If the engine coolant temperature is below self test range, the EST tool will display an "ECT out of self test range" message.

2. Access the Engine Running Test from the DIAGNOSTIC TESTS menu by pressing the ↓ key until ENGINE RUNNING TEST displays on the screen. Then press the enter key. **See Figure** .
27

The ECM will conduct the test. It will command the engine to accelerate to a predetermined engine r/min and operate the Injection Pressure Regulator (IRP) valve.

The ECM will measure the effects of the IPR valve movement via the ICP sensor. At the completion of the test, the EST screen will display 00 FAULTS, if no faults were detected. If the EST indicates faults have been detected, press the enter key to display the fault codes. Record the fault codes and refer to the Electronic Diagnostic Form for fault codes that were detected. **Refer to section**
.

Possible Causes

Possible causes of fault codes from the engine running test include:

1. Defective or inoperative ICP sensor or IPR valve
2. Injection Control System high pressure oil leakage
3. Defective high pressure pump
4. Open or shorted wiring harness to sensors or actuators
5. Loose or corroded engine wiring harness connections at sensors or actuators

EST TOOL — INJECTOR TEST

[28]The Engine Running Test must be performed first to access the INJECTOR TEST. For a reproduction of the applicable portion of the diagnostic form, **see Figure** .

Purpose

The Engine Running Test will verify that all power cylinders are contributing equally.

Test Procedure

After the Engine Running Test has been completed, press the ↓ key from the ENGINE RUNNING TESTS screen to access the INJECTOR TEST. Then press enter. **See Figure** [29]

Note: The engine will run rough during the test.

The EST will signal the ECM to actuate each injector in a programmed sequence and then measure the power cylinder performance.

At the completion of the test, the EST screen will display 00 FAULTS", if no injector faults occurred. If the EST indicates faults have been detected, press enter to display the fault codes. Record the fault codes and refer to the Electronic Diagnostic Form; **refer to section** , for fault codes that were detected.

Possible Causes

Possible causes for this condition follow:

1. Broken compression rings, leaking or bent valves, bent pushrods or connecting rods
2. Open or shorted engine wiring harness to injectors

3. Defective injectors or solenoids

Tools Required

Pro-Link 9000, **J 38500–100**

.

Supplemental Diagnostics

For further diagnostics, **refer to section**

.

FUEL PRESSURE FULL LOAD

[30]The Fuel Pressure Full Load Test, ICP Pressure Test and Boost Pressure Test may be performed simultaneously at full load conditions. **Refer to section**

. **Refer to section**

. Follow this procedure for the Fuel Pressure Full Load test. For a reproduction of the applicable portion of the diagnostic form, **see Figure .**.

Purpose

The purpose of this test is to determine if the fuel system is supplying the engine with the proper fuel quantity and pressure at full load conditions.

Test Procedure

If the fuel filter is equipped with a water-in-fuel probe, check with the vehicle operator to determine if the water-in-fuel lamp has been illuminated during vehicle operation. Then proceed with the following test procedure.

1. If the pressure gage was not connected to the fuel system in Test 2, Sufficient Fuel/Pressure Test, remove the air bleed valve on the fuel filter header. **See Figure** .

31

2. Install a 1/8 in. (3 mm) pipe fitting in place of the bleed valve.
3. Connect a line from the fitting to the 0–160 lb/in.^{2} (psi), gage of the Pressure Test Kit. Start the engine and run at low idle to check for fuel leaks in the line to the pressure gage. **See Figure** .

Note: Bleed the air from the fuel line to ensure an accurate reading.

32

4. Drive the vehicle on the road until the engine reaches operating temperature. Find an open section of the road and select a suitable gear. Depress the accelerator pedal (full depression) to the floor and accelerate to rated speed and 100% load.

Note: Driving the vehicle uphill or fully loaded will facilitate efforts of reaching the proper engine loading at the rated engine speed.

5. Measure fuel pressure and record on the diagnostic form. If pressure is not within specifications, replace the fuel filter, clean the fuel strainer and check fuel pressure again.

Note: It may take a number of crank cycles to purge the air out of the fuel system after replacing the fuel filter.

If the fuel pressure remains low after replacing the filter, perform the Transfer Pump Restriction Test. **Refer to section**
.

Possible Causes

The following conditions are possible causes of fuel pressure problems:

1. A fuel filter or clogged fuel strainer could cause high restriction and low fuel pressure because of dirt or fuel jelling in cold ambient temperatures. Replace the fuel filter; clean the strainer and test again.

2. Debris in the fuel regulator valve will cause low fuel pressure. **Refer to section**
.
3. A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and, therefore, low fuel pressure. **Refer to section**
.
4.

loose fuel line on the suction side of the fuel system could cause air to be ingested into the system and cause low fuel pressure. **Refer to section**

5. The fuel pump could have internal damage, e.g. seized plunger or leaking check valves.

Tools Required

Engine Field Test Kit, **J 39257**
, and appropriate line with 1/8 in. NPT fitting.

ICP PRESSURE

[33]The ICP Pressure test should be performed at full load in conjunction with Fuel Pressure Full Load and Boost Pressure Tests. **Refer to section**
. **Refer to section**
. For a reproduction of the applicable portion of the diagnostic form, **see Figure above.**.

Purpose

The purpose of this test is to determine if the high pressure lube oil system is providing sufficient hydraulic pressure to operate the injectors.

Test Procedure

Before connecting the EST tool to the ATA diagnostic connector, turn off all accessories and turn off the ignition.

1. Connect the EST (Electronic Service Tool) to the ATA (American Trucking Association) data link connector. **See Figure**

.
34

2. Press the ↓ key on the EST until NAVPAK™displays on the screen. Press enter. Press the ↓ key until NAVPAK DATA LIST displays. Press enter. Press the ↓ key until INJ CONTROL PSI displays. **See Figure ..**.

35

3. Drive the vehicle on the road until the engine reaches operating temperature. Find an open section of road and select a suitable gear. Depress the accelerator pedal (full depression) to the floor, and accelerate to the rated speed and 100% load.

Note: Driving the vehicle uphill or fully loaded will facilitate efforts to reach the proper engine loading at rated engine speed.

4. Read ICP pressure (voltage) and record on the diagnostic form.
5. Stop the vehicle to read low and high idle ICP pressures (voltage) and record on the diagnostic form.

Alternate Method of Measuring ICP Using Breakout Tee

With a breakout Tee, use the following method to measure the ICP:

1. Remove the engine harness connector at the ICP sensor.
2. Connect the breakout Tee, J 43102, to the removed engine harness connector and the ICP sensor. **See Figure** .

36

3. Place the DVOM in the cab of the vehicle (if applicable) and connect a set of long

leads (+Green, —Black) to the breakout Tee.

4. Operate the vehicle under load as follows. Drive the vehicle on the road until the engine reaches operating temperature. Find an open section of road and select a suitable gear. Depress the accelerator pedal (full depression) to the floor, and accelerate to the rated speed and 100% load.

Possible Causes

Low injection pressure (voltage) indicates the injectors are not receiving sufficient oil pressure to properly operate the fuel injectors. (Perform the ICP Leakage test.) This may be caused by:

1. Defective IPR valve
2. Defective high pressure pump
3. Injection control pressure (ICP) system leakage
4. ECM commanding the IPR valve to reduce injection control pressure due to:
   f. Low boost pressure
   g. Incorrect APS (Accelerator Position Sensor) feedback signal
   h. Incorrect ICP sensor feedback signal.

Tools Required

Pro-Link 9000, **J 38500–100**
, or DVOM and Breakout Tee, **J 43103**
.

Supplemental Diagnostics

For ICP diagnostics, **refer to section**
. For IPR diagnostics, **refer to section**
.

BOOST PRESSURE

[37]Follow this procedure to diagnose boost pressure. For a reproduction of the applicable portion of the diagnostic form, **see Figure** .

Purpose

The purpose of this test is to determine if the engine can develop sufficient boost pressure to obtain specific power.

Test Procedure

This test should be performed at full load in conjunction with the Fuel Pressure Full Load and the ICP Pressure tests. **Refer to section**
. **Refer to section**
.

Note: Turn off all accessories and turn off the ignition before connecting the EST to the ATA connector.

1. Connect the EST to the ATA connector.
2. Turn the ignition switch to ON.
3. Access the data list and press the ↓ key until BOOST PSI is displayed on the screen. **See Figure** .

38

4. Drive vehicle on the road until the engine reaches operating temperature. Find an open section of the road and select a suitable gear. Depress the accelerator pedal (full depression) to the floor and accelerate to rated speed and 100% load.

Note: Driving the vehicle uphill or fully loaded will facilitate efforts of reaching the proper engine loading at the rated engine speed.

5. Record intake manifold boost at full load rated engine speed.

Alternate Test Procedure

This is the alternate procedure to test for boost pressure.

1. Remove the plug from the boost pipe. Install adaptor fitting and connect a line. **See Figure** . If no plug is provided on the boost pipe, remove the MAP (Manifold Absolute Pressure) sensor at the intake manifold/valve cover. Install a tee-fitting and install the MAP sensor again; install the test line to the fitting.

Note: The MAP sensor must be connected during the boost pressure test.
39

2. Route the line ensuring it is not crimped or in contact with a hot engine surface inside the cab of the vehicle.
3. Temporarily install the Engine Field Test Kit, **J 39257** , in the cab of the vehicle (if applicable). Connect the line routed from the boost pipe or tee at the MAP sensor to the appropriate pressure gage.
4. Drive vehicle on the road until the engine reaches operating temperature. Find an open section of the road and select a suitable gear. Depress the accelerator pedal (full depression) to the floor and accelerate to rated speed and 100% load.

Note: Driving the vehicle uphill or fully loaded will facilitate efforts of reaching the proper engine loading at the rated engine speed.

5. Record intake manifold boost at full load rated engine speed.

Note: If boost pressure is within specifications, the engine is functioning properly. There may be chassis or application concerns.

Possible Causes

Possible causes for boost pressure problems are:

1. Restricted intake or exhaust
2. Low fuel pressure
3. Low injection control pressure

4. Control system faults
5. Defective injectors
6. Defective turbocharger
7. Base engine failure

Tools Required

Pro-Link 9000, **J 38500–100**
, or Engine Field Test Kit **J 39257**
, and a Tee-fitting.

CRANKCASE PRESSURE

[40]Use this procedure to check crankcase pressure. For a reproduction of the applicable portion of the diagnostic form, **see Figure** .

Purpose

The purpose of the crankcase pressure test is to measure the power cylinder condition.

Test Procedure

Follow these steps to test the crankcase pressure.

1. Park the vehicle on level ground.
2. Ensure the breather tube is free of dirt and the valve cover/intake manifold is tight.
3. Ensure the engine oil level is not above the full mark and the dipstick is securely in place.
4. Connect a line from the restrictor tool to a water manometer or the magnehelic

gage of the Engine Field Test Kit, **J 39257**
. **See Figure**
.
41

5. Run the engine to attain normal engine operating temperature before measuring crankcase pressure.
6. Perform the engine crankcase pressure test with the engine at high idle (no load) r/min. Allow the gage reading to stabilize before taking the pressure reading.
7. Record crankcase pressure on the diagnostic form. **Refer to section**
.

NOTICE:
Do not plug the breather tube during the crankcase pressure test. Restricting the tube can cause crankshaft and turbocharger seals to leak.

Possible Causes

Excessive crankcase pressure ***with*** oil consumption trend data indicates:

1. Dirt entering the air induction system; perform the Air Induction System pressure test; **refer to section**
2. Badly worn or broken rings
3. Badly worn or scored cylinder sleeves
4. Leaking valve seals or worn valve guides
5. A restricted breather tube

Excessive crankcase pressure ***without*** significant oil consumption trend data indicates:

1. Leaking intake manifold/valve cover gasket
2. Air compressor affecting the crankcase pressure; remove the compressor discharge line to remove its influence.

Tools Required

Magnehelic Gage on Engine Field Test Kit, **J 39257**
, and orifice restriction tool, **J 39267**

WASTEGATE ACTUATOR TEST

[42]The following procedure will lead you through the Wastegate Actuator Test. For a reproduction of the applicable portion of the diagnostic form, **see Figure** .

Purpose

This procedure will determine the operation of the actuator in conjunction with the turbocharger operation.

Test Procedure

Follow these steps to test the operation of the actuator:

1. Remove the actuator boost line from the turbo compressor housing.
2. Connect an air regulator with an 0–60 PSI gage to the actuator boost line. **See Figure** .
43
3. Mark the actuator shaft with the paint pen. Spray leak detector or soap solution around the actuator housing.
4. Spray the leak detector around the actuator housing and slowly apply air pressure to the actuator. The actuator (shaft) movement (indicated by the position of the paint mark, should begin to occur between 28 ± 2 psi.

If a significant amount of actuator shaft movement occurs and no air leaks are detected at the actuator housing, the actuator is okay. If little or no shaft movement occurs or air leaks are present at the actuator housing, the turbocharger must be removed from the engine. Refer to the ***Series 40E Service Manual***, 6SE0242, for further wastegate diagnosis.

Possible Causes

Possible causes for the problem include:

1. Sticky flapper valve
2. Ruptured actuator diaphragm
3. Leaky canister
4. Leaky hose to actuator

Tools Required

Air pressure regulator, 0–60 psi gage and paint marker (Alternative, a Dial Indicator)

EXHAUST RESTRICTION

[44]The following procedure will lead you through the Exhaust Restriction Test. For a reproduction of the applicable portion of the diagnostic form, see Figure.

Purpose

This test will determine if an excessive restriction exists in the exhaust system that would cause an engine performance problem.

Test Procedure

Follow these steps to test for an excessive exhaust restriction:

1. Drill and braze on a 1/8 in. NPT male connector in a straight section of exhaust pipe, approximately 3 to 6 in. after the bend in the exhaust pipe. **See Figure** .
45
2. Connect a minimum of one foot coiled copper tubing to the connector before attaching the plastic tubing from the Gage Bar.

Note: The coiled copper tubing prevents the plastic tubing from melting.

3. Connect the other end of the plastic tubing to the magnehelic gage on the Gage Bar or a water manometer.
4. Obtain the data at rated speed on a chassis dynamometer or fully loaded on the highway. The engine must be at normal operating temperature.
5. Pressures that exceed specification indicate a restriction in the exhaust system that can cause a reduction in engine power. Reduce restriction by replacing the muffler or exhaust piping as required.

Possible Causes

The following conditions are possible causes of exhaust restriction:

1. Collapsed exhaust piping
2. Restricted exhaust piping
3. Damaged muffler

Tools Required

Engine Field Test Kit, **J 39257**

, or a water manometer

VALVE CLEARANCE

[46]The following procedure will lead you through the Valve Clearance Test. For a reproduction of the applicable portion of the diagnostic form, **see Figure** .

Purpose

The purpose of the valve clearance test is to determine if the valve clearance is correct.

Test Procedure

Follow these steps to test the valve clearance:

1. Remove the valve cover/intake manifold.
2. Rotate the crankshaft until the No. 1 piston is on the compression stroke and the timing mark on the damper pulley is aligned with the TDC mark on the timing indicator.

Note: Confirm that the No. 1 piston is on the compression stroke by turning both pushrods by hand to verify both valves are closed. The valves are closed when the pushrods are loose and can be turned easily.

3. Check the valve lash by inserting the feeler gage between the rocker arm and valve step tip. If adjustment is required, loosen the locknut and turn the valve adjustment screw until the valve lever can support the feeler gage. **See Figure** .

47

4. Tighten the locknut once the adjustment is set and remove the feeler gage. Continue checking and adjusting valves (if necessary) following the valve sequence shown. **See Figure** .

Note: Six valves are adjusted when the No. 1 piston is at TDC (compression stroke) and the remaining six are adjusted when the No. 6 piston is at TDC (compression stroke).

4849

5. For valve lash adjustments, **see Figure**

. Install the valve cover/intake manifold on the cylinder head. Tighten the mounting bolts to 13 lb·ft. (18 N·m). **See Figure** .

50

Possible Causes

Possible causes for valve lash problems are:

1. Worn valve train
2. Valve seat or face wear

Tools Required

Feeler Gage

1

1. CHECK ENGINE OIL LEVEL

- Check engine crankcase oil level
- Check for contaminants (fuel, coolant)
- Correct grade / Viscosity

Method	Check
Visual	

33267

Diagnostic Form

2

2. SUFFICIENT FUEL/PRESSURE

- Drain sample from tank(s)
- Inspect fuel for contamination
- Measure fuel pressure at fuel filter bleeder
- Measure pressure at high idle

Instrument	Specification	Actual
0-160 PSI Gauge	30 PSI min. @ high idle	

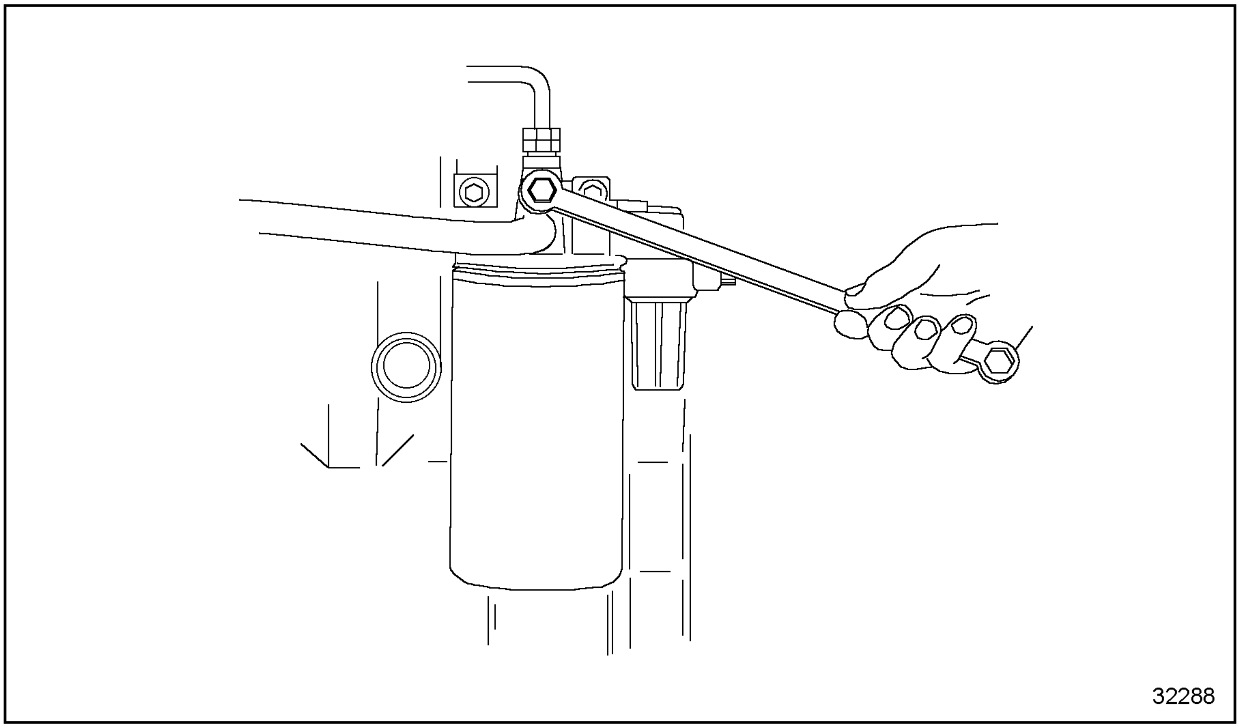
☐ If pressure is low, replace fuel filter, clean fuel strainer and retest.

☐ If pressure is still low, proceed with step 2B

33268

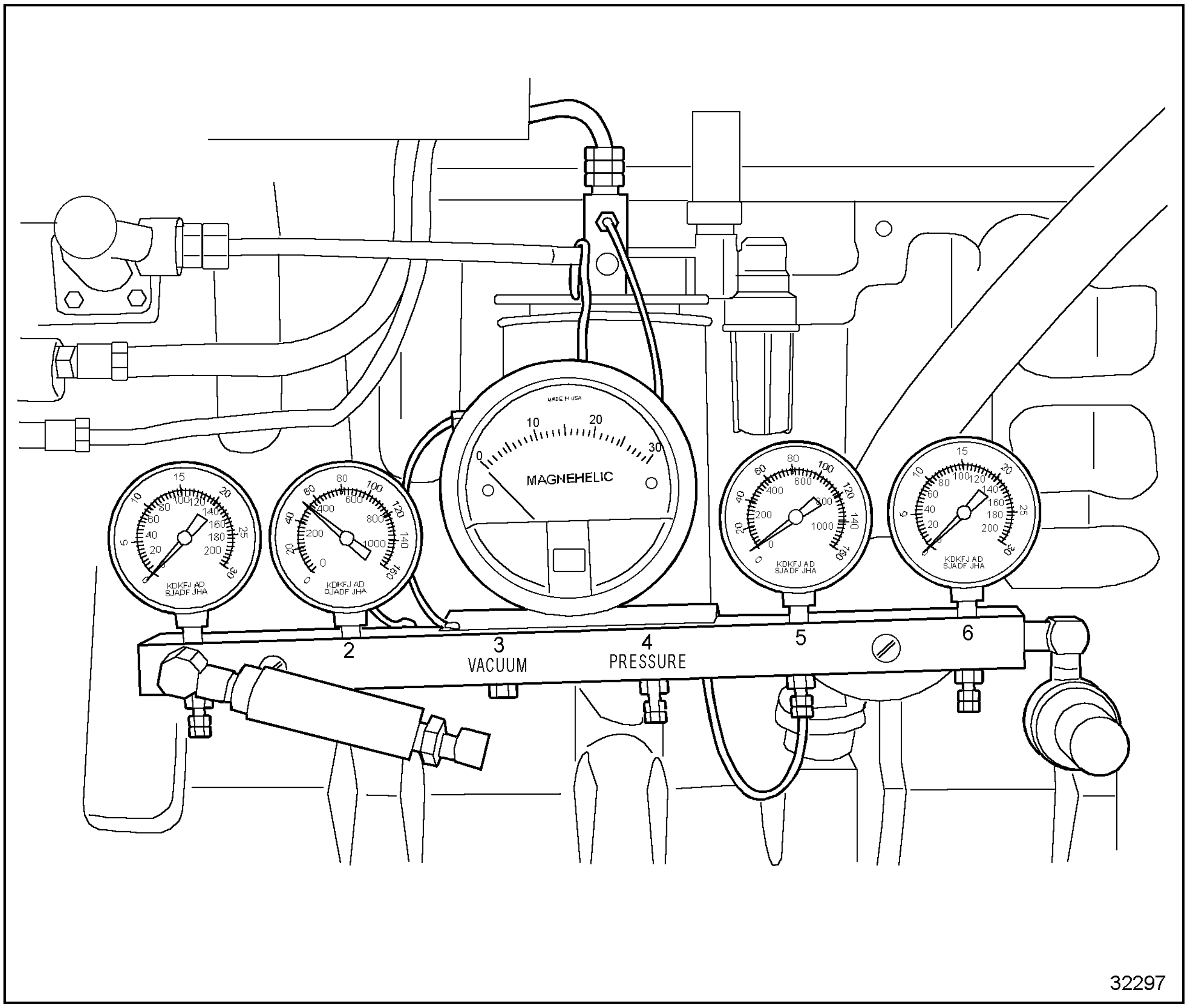
Diagnostic Form

3



Air Bleeder Valve Removal

4



Measuring Fuel Pressure with Pressure Test Kit

5

2b. TRANSFER PUMP RESTRICTION

NOTE: Perform this test only if fuel pressure is low.

- Measure at fuel filter inlet @ High idle

Instrument	Specification	Actual
0-30" Hg. Vacuum Gauge	Less than 8" Hg.	

- If restriction is high, check for blockage between pump and fuel tank.

33269

Diagnostic Form

6

3. EST TOOL - FAULT CODES

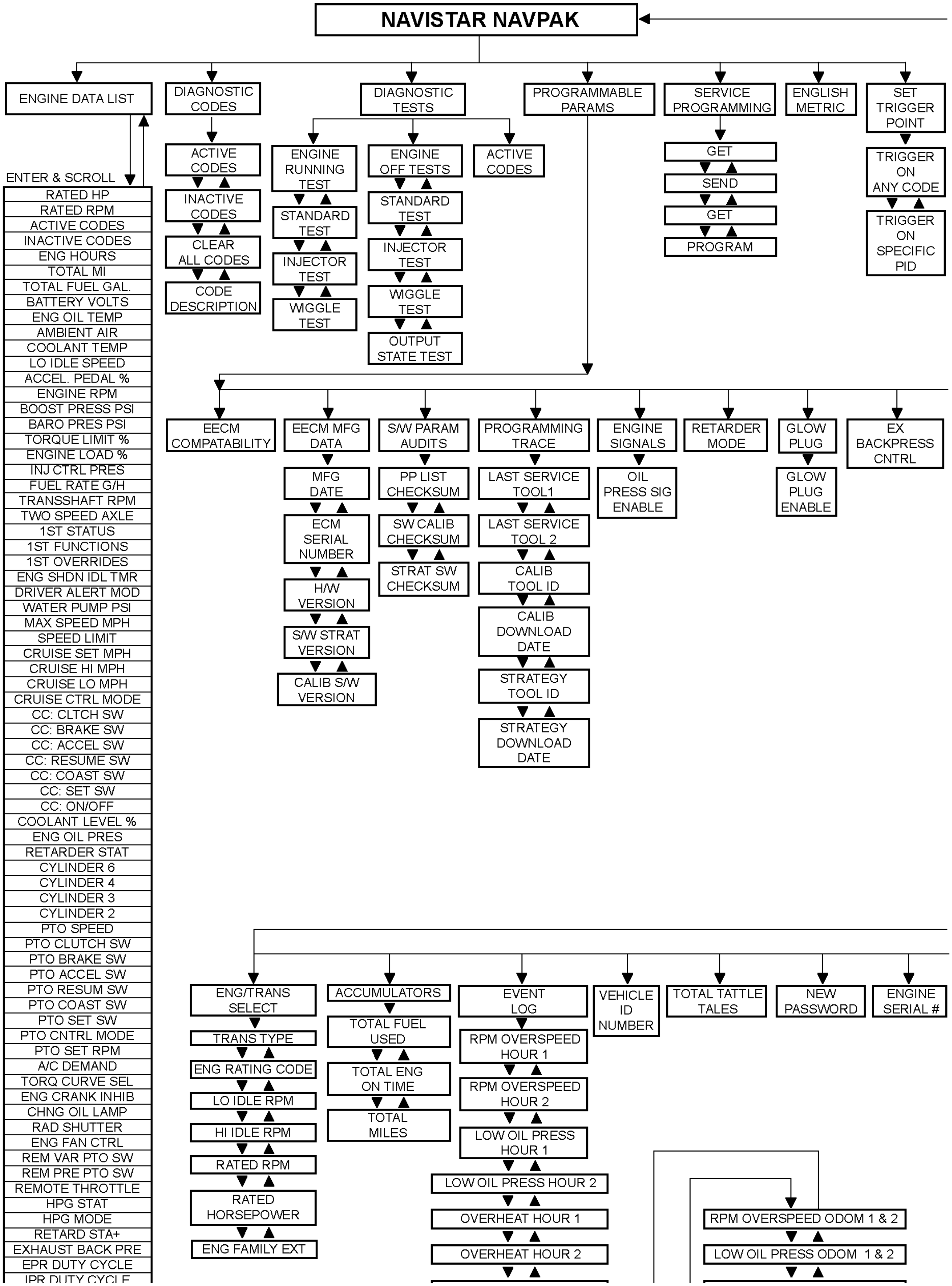
• Install Electronic Service Tool

Active	
Inactive	

□ See Electronic Diagnostic Form for codes

33273

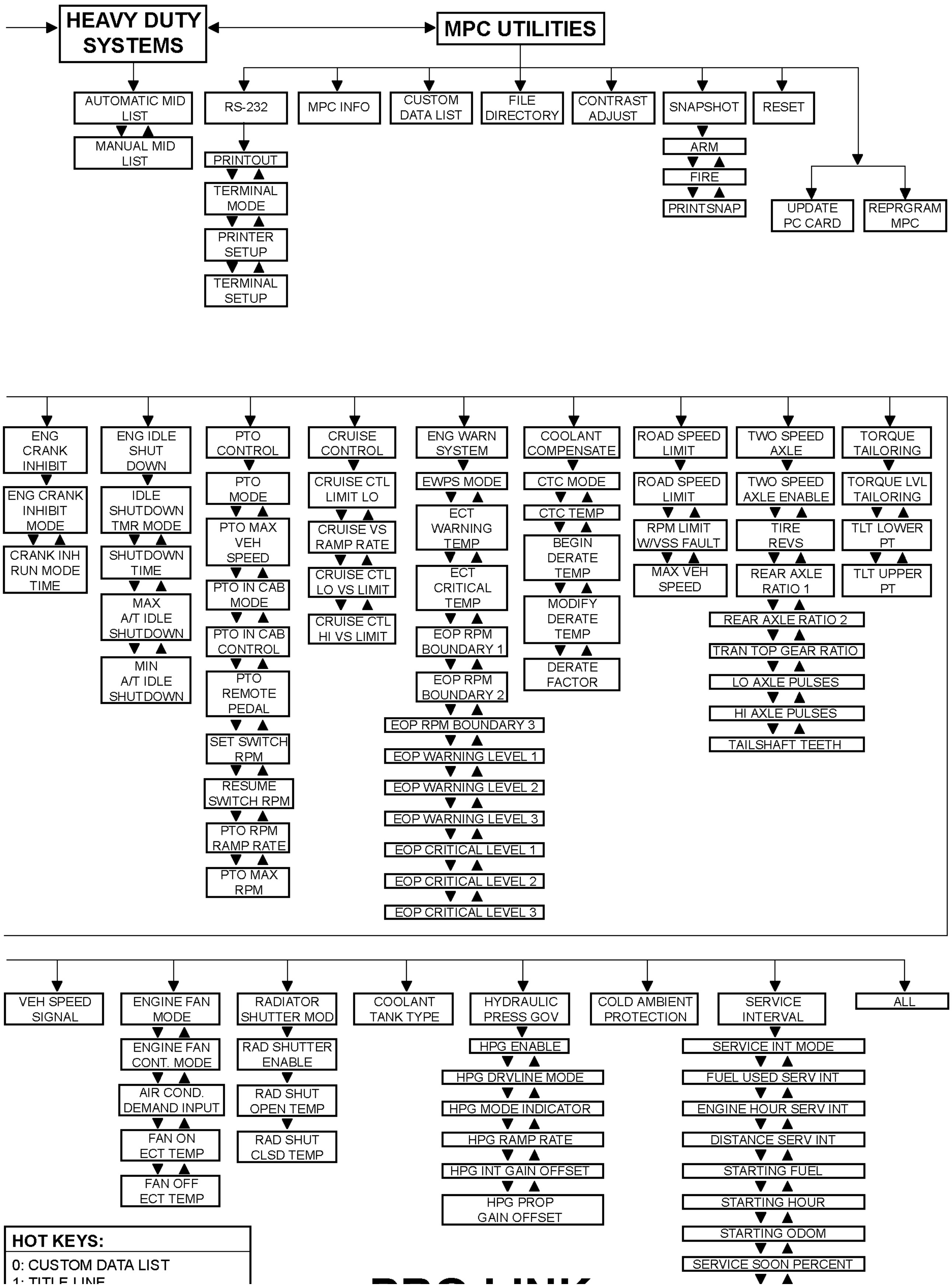
Diagnostic Form



NAVISTAR NAVPAK
ENGINE DATA LIST
ENTER & SCROLL
RATED HP
RATED RPM
ACTIVE CODES
INACTIVE CODES
ENG HOURS
TOTAL MI
TOTAL FUEL GAL.
BATTERY VOLTS
ENG OIL TEMP
AMBIENT AIR
COOLANT TEMP
LO IDLE SPEED
ACCEL. PEDAL %
ENGINE RPM
BOOST PRESS PSI
BARO PRES PSI
TORQUE LIMIT %
ENGINE LOAD %
INJ CTRL PRES
FUEL RATE G/H
TRANSSHAFT RPM
TWO SPEED AXLE
1ST STATUS
1ST FUNCTIONS
1ST OVERRIDES
ENG SHDN IDL TMR
DRIVER ALERT MOD
WATER PUMP PSI
MAX SPEED MPH
SPEED LIMIT
CRUISE SET MPH
CRUISE HI MPH
CRUISE LO MPH
CRUISE CTRL MODE
CC: CLTCH SW
CC: BRAKE SW
CC: ACCEL SW
CC: RESUME SW
CC: COAST SW
CC: SET SW
CC: ON/OFF
COOLANT LEVEL %
ENG OIL PRES
RETARDER STAT
CYLINDER 6
CYLINDER 4
CYLINDER 3
CYLINDER 2
PTO SPEED
PTO CLUTCH SW
PTO BRAKE SW
PTO ACCEL SW
PTO RESUM SW
PTO COAST SW
PTO SET SW
PTO CNTRL MODE
PTO SET RPM
A/C DEMAND
TORQ CURVE SEL
ENG CRANK INHIB
CHNG OIL LAMP
RAD SHUTTER
ENG FAN CTRL
REM VAR PTO SW
REM PRE PTO SW
REMOTE THROTTLE
HPG STAT
HPG MODE
RETARD STA+
EXHAUST BACK PRE
EPR DUTY CYCLE
IPR DUTY CYCLE
DIAGNOSTIC CODES
ACTIVE CODES
INACTIVE CODES
CLEAR ALL CODES
CODE DESCRIPTION
DIAGNOSTIC TESTS
ENGINE RUNNING TEST
STANDARD TEST
INJECTOR TEST
WIGGLE TEST
ENGINE OFF TESTS
STANDARD TEST
INJECTOR TEST
WIGGLE TEST
OUTPUT STATE TEST
ACTIVE CODES
PROGRAMMABLE PARAMS
SERVICE PROGRAMMING
GET
SEND
GET
PROGRAM
ENGLISH METRIC
SET TRIGGER POINT
TRIGGER ON ANY CODE
TRIGGER ON SPECIFIC PID
EECM COMPATABILITY
EECM MFG DATA
MFG DATE
ECM SERIAL NUMBER
H/W VERSION
S/W STRAT VERSION
CALIB S/W VERSION
S/W PARAM AUDITS
PP LIST CHECKSUM
SW CALIB CHECKSUM
STRAT SW CHECKSUM
PROGRAMMING TRACE
LAST SERVICE TOOL1
LAST SERVICE TOOL 2
CALIB TOOL ID
CALIB DOWNLOAD DATE
STRATEGY TOOL ID
STRATEGY DOWNLOAD DATE
ENGINE SIGNALS
OIL PRESS SIG ENABLE
RETARDER MODE
GLOW PLUG
GLOW PLUG ENABLE
EX BACKPRESS CNTRL
ENG/TRANS SELECT
TRANS TYPE
ENG RATING CODE
LO IDLE RPM
HI IDLE RPM
RATED RPM
RATED HORSEPOWER
ENG FAMILY EXT
ACCUMULATORS
TOTAL FUEL USED
TOTAL ENG ON TIME
TOTAL MILES
EVENT LOG
RPM OVERSPEED HOUR 1
RPM OVERSPEED HOUR 2
LOW OIL PRESS HOUR 1
LOW OIL PRESS HOUR 2
OVERHEAT HOUR 1
OVERHEAT HOUR 2
VEHICLE ID NUMBER
TOTAL TATTLE TALES
NEW PASSWORD
ENGINE SERIAL #
RPM OVERSPEED ODOM 1 & 2
LOW OIL PRESS ODOM 1 & 2

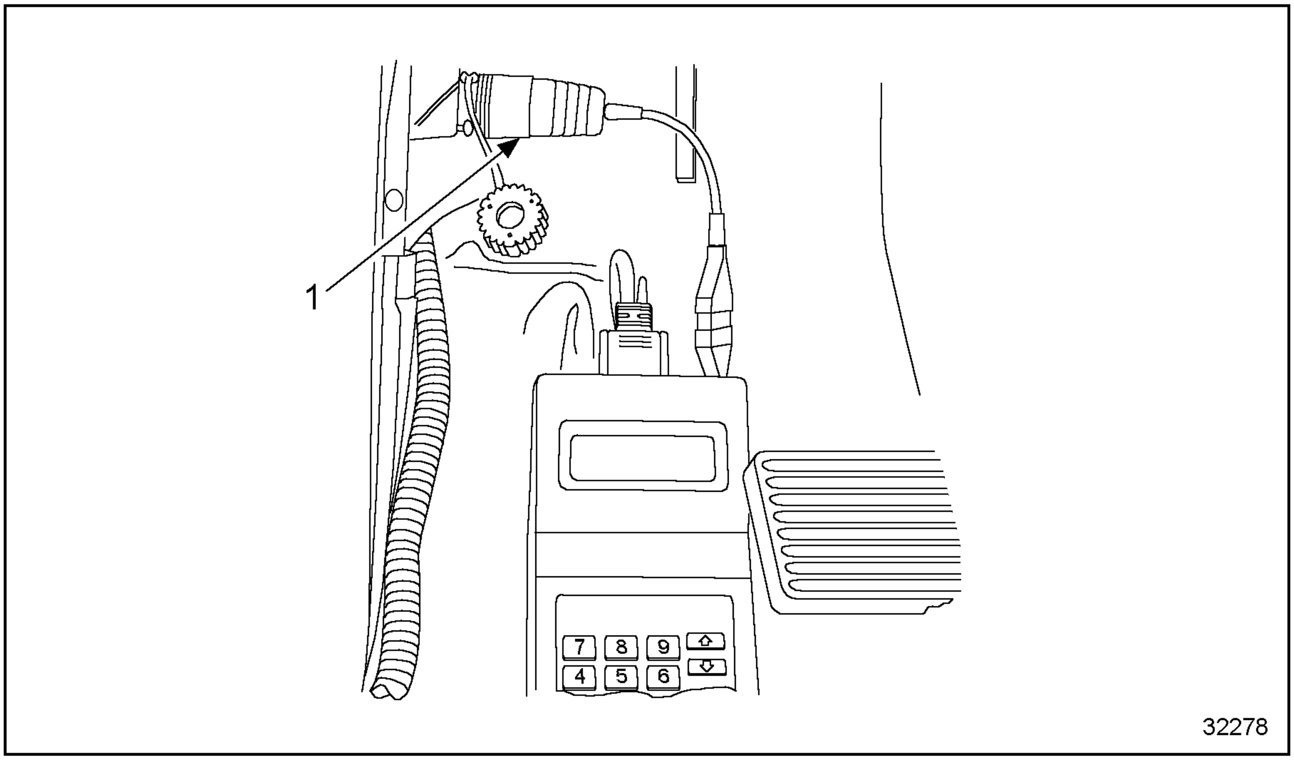
Diagnostic Flowchart

8


HEAVY DUTY SYSTEMS
MPC UTILITIES
AUTOMATIC MID LIST
MANUAL MID LIST
RS-232
PRINTOUT
TERMINAL MODE
PRINTER SETUP
TERMINAL SETUP
MPC INFO
CUSTOM DATA LIST
FILE DIRECTORY
CONTRAST ADJUST
SNAPSHOT
ARM
FIRE
PRINTSNAP
RESET
UPDATE PC CARD
REPRGRAM MPC
ENG CRANK INHIBIT
ENG CRANK INHIBIT MODE
CRANK INH RUN MODE TIME
ENG IDLE SHUT DOWN
IDLE SHUTDOWN TMR MODE
SHUTDOWN TIME
MAX A/T IDLE SHUTDOWN
MIN A/T IDLE SHUTDOWN
PTO CONTROL
PTO MODE
PTO MAX VEH SPEED
PTO IN CAB MODE
PTO IN CAB CONTROL
PTO REMOTE PEDAL
SET SWITCH RPM
RESUME SWITCH RPM
PTO RPM RAMP RATE
PTO MAX RPM
CRUISE CONTROL
CRUISE CTL LIMIT LO
CRUISE VS RAMP RATE
CRUISE CTL LO VS LIMIT
CRUISE CTL HI VS LIMIT
ENG WARN SYSTEM
EWPS MODE
ECT WARNING TEMP
ECT CRITICAL TEMP
EOP RPM BOUNDARY 1
EOP RPM BOUNDARY 2
EOP RPM BOUNDARY 3
EOP WARNING LEVEL 1
EOP WARNING LEVEL 2
EOP WARNING LEVEL 3
EOP CRITICAL LEVEL 1
EOP CRITICAL LEVEL 2
EOP CRITICAL LEVEL 3
COOLANT COMPENSATE
CTC MODE
CTC TEMP
BEGIN DERATE TEMP
MODIFY DERATE TEMP
DERATE FACTOR
ROAD SPEED LIMIT
ROAD SPEED LIMIT
RPM LIMIT W/VSS FAULT
MAX VEH SPEED
TWO SPEED AXLE
TWO SPEED AXLE ENABLE
TIRE REVS
REAR AXLE RATIO 1
REAR AXLE RATIO 2
TRAN TOP GEAR RATIO
LO AXLE PULSES
HI AXLE PULSES
TAILSHAFT TEETH
TORQUE TAILORING
TORQUE LVL TAILORING
TLT LOWER PT
TLT UPPER PT
VEH SPEED SIGNAL
ENGINE FAN MODE
ENGINE FAN CONT. MODE
AIR COND. DEMAND INPUT
FAN ON ECT TEMP
FAN OFF ECT TEMP
RADIATOR SHUTTER MOD
RAD SHUTTER ENABLE
RAD SHUT OPEN TEMP
RAD SHUT CLSD TEMP
COOLANT TANK TYPE
HYDRAULIC PRESS GOV
HPG ENABLE
HPG DRVLINE MODE
HPG MODE INDICATOR
HPG RAMP RATE
HPG INT GAIN OFFSET
HPG PROP GAIN OFFSET
COLD AMBIENT PROTECTION
SERVICE INTERVAL
SERVICE INT MODE
FUEL USED SERV INT
ENGINE HOUR SERV INT
DISTANCE SERV INT
STARTING FUEL
STARTING HOUR
STARTING ODOM
SERVICE SOON PERCENT
ALL
HOT KEYS:
0: CUSTOM DATA LIST

Diagnostic Flowchart

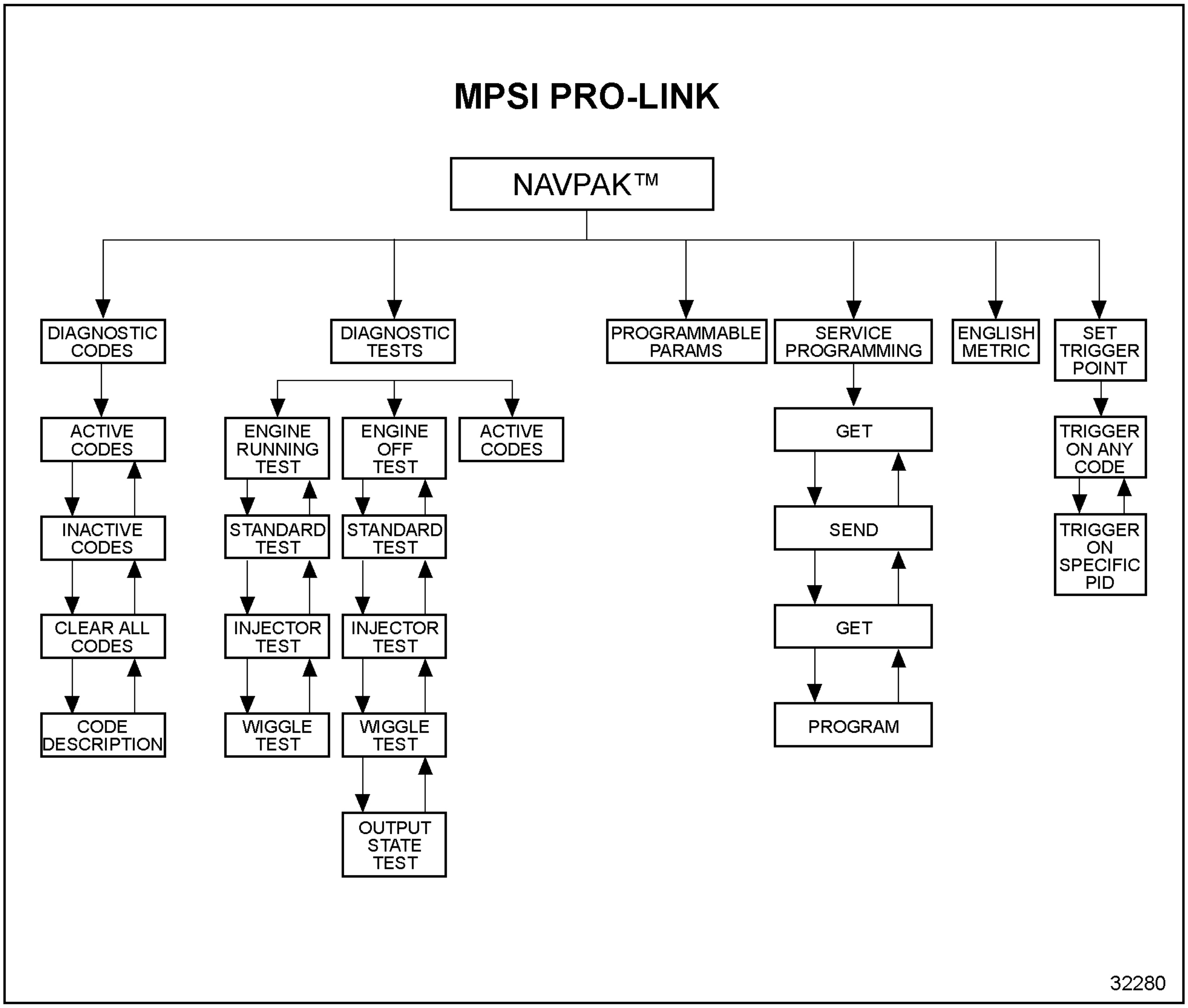
9



1. ATA Connector	

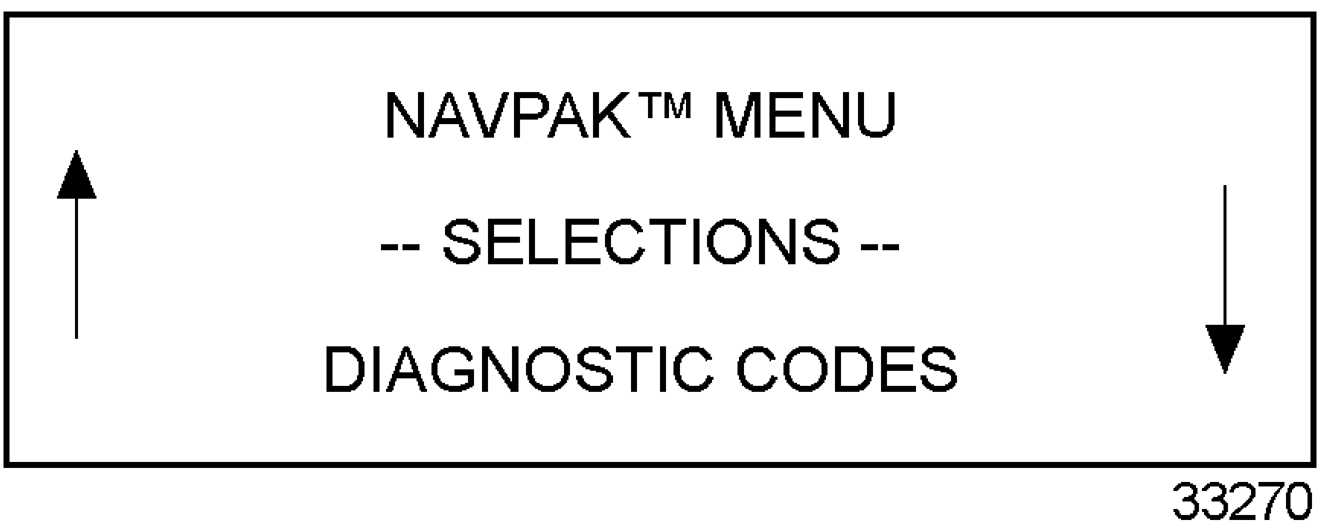
Electronic Service Tool / ATA Connector Location

10



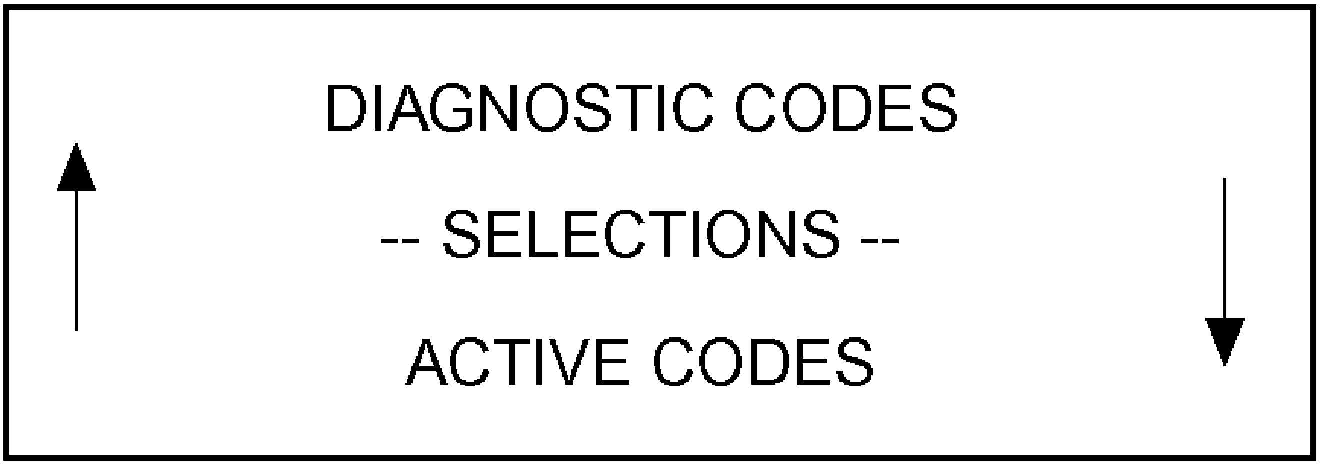
MPSI Pro-Link

11



Main Menu

12



33244

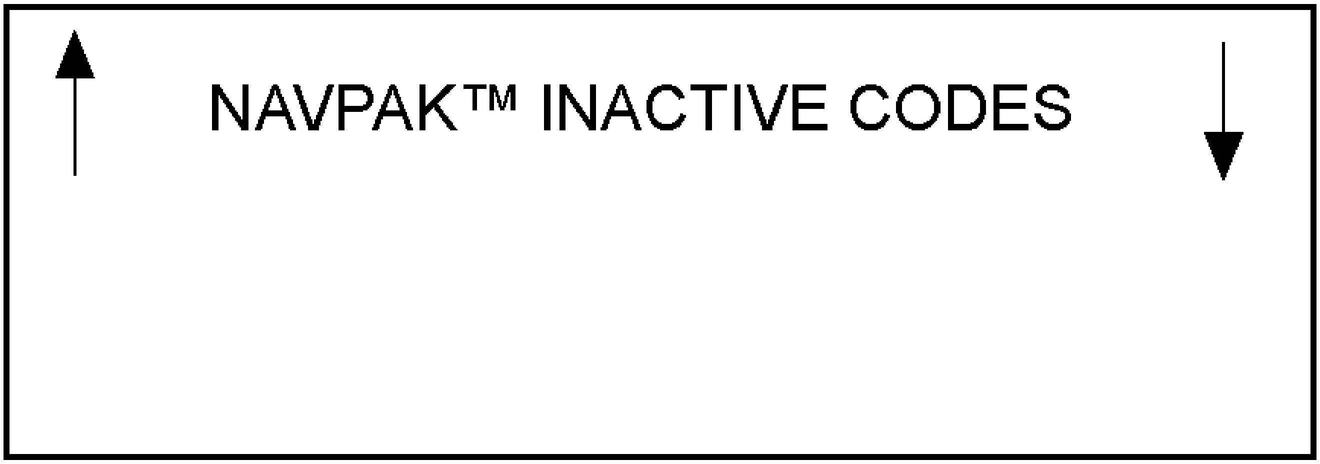
Diagnostic Codes

13

33271

Active Codes

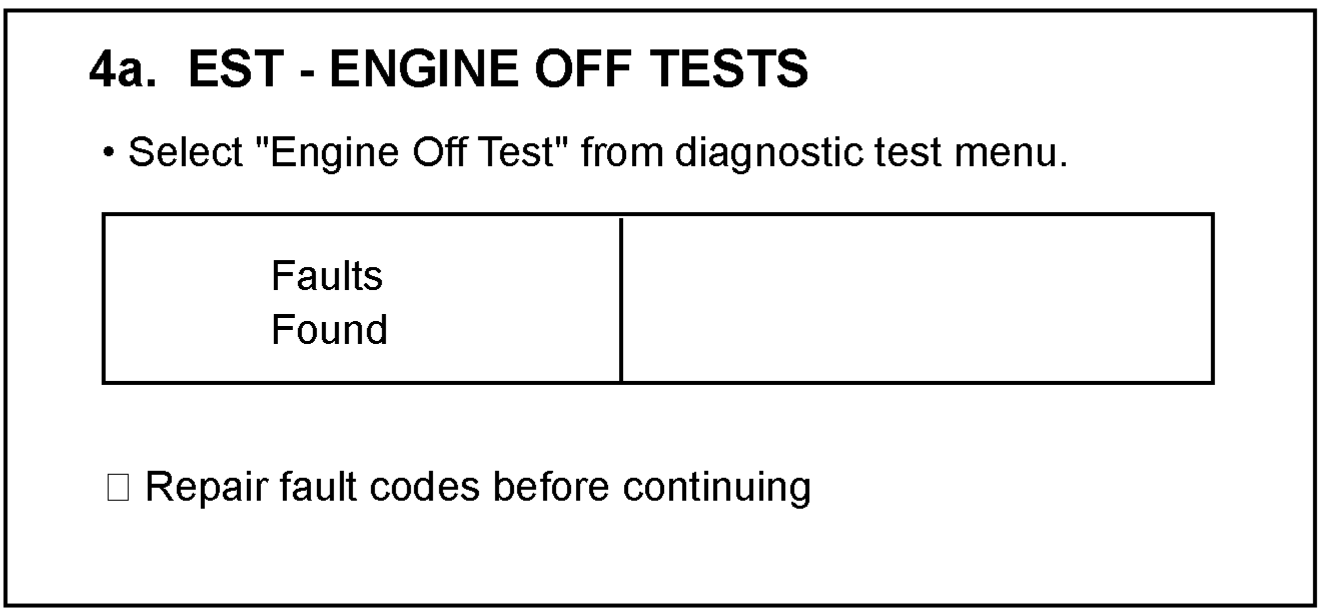
14



33272

Inactive Codes

15



33274

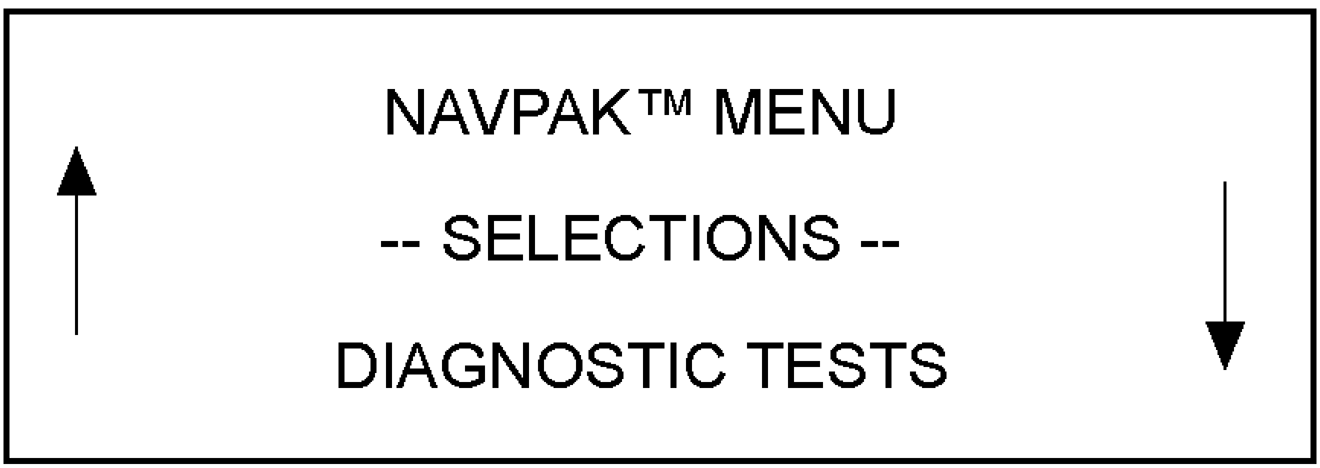
Diagnostic Form

16

33247

MPSI Menu

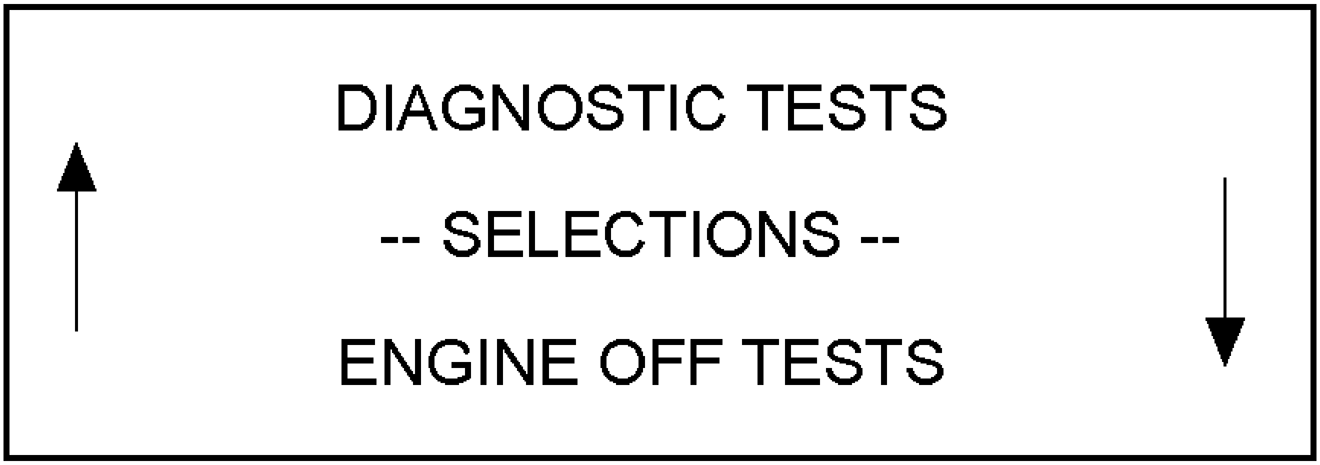
17



33248

Navpak Menu

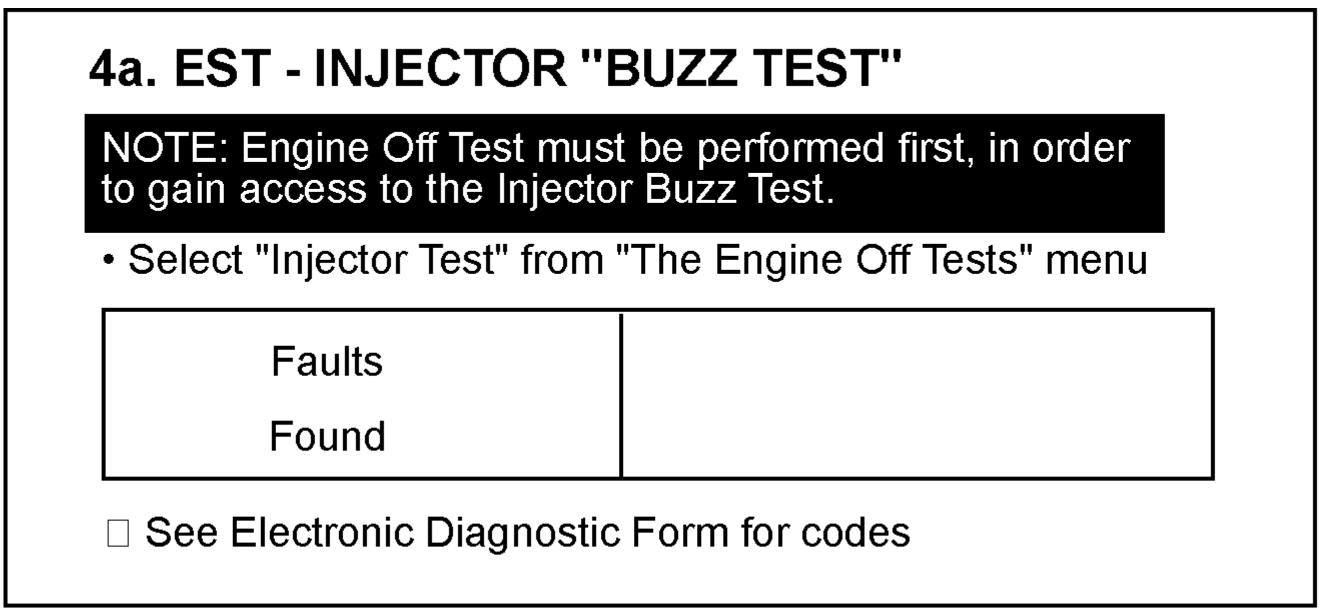
18



33249

Diagnostic Tests Menu

19



4a. EST - INJECTOR "BUZZ TEST"

NOTE: Engine Off Test must be performed first, in order to gain access to the Injector Buzz Test.

• Select "Injector Test" from "The Engine Off Tests" menu

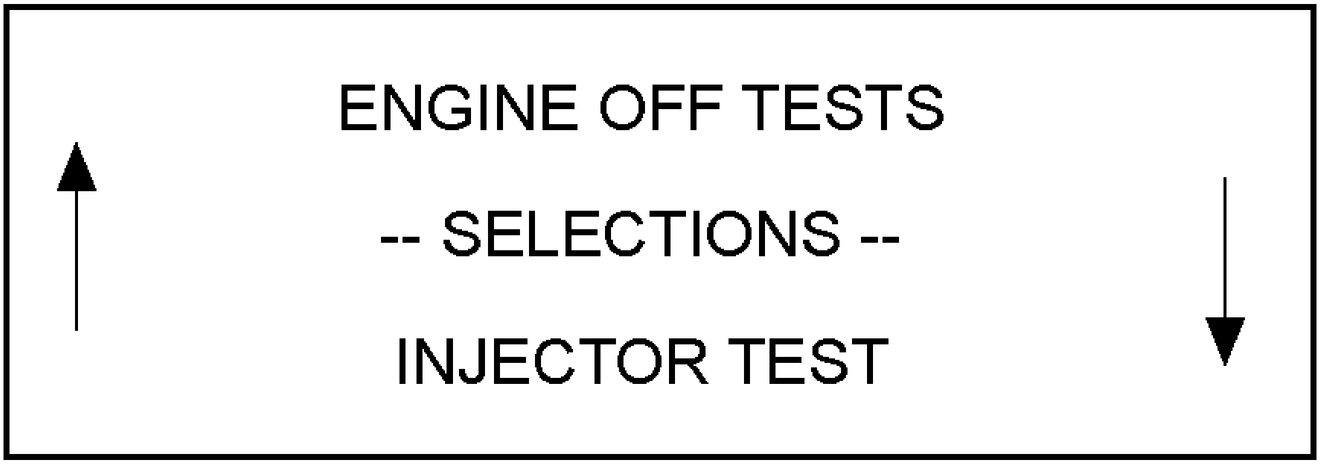
Faults Found	

☐ See Electronic Diagnostic Form for codes

33275

Diagnostic Form

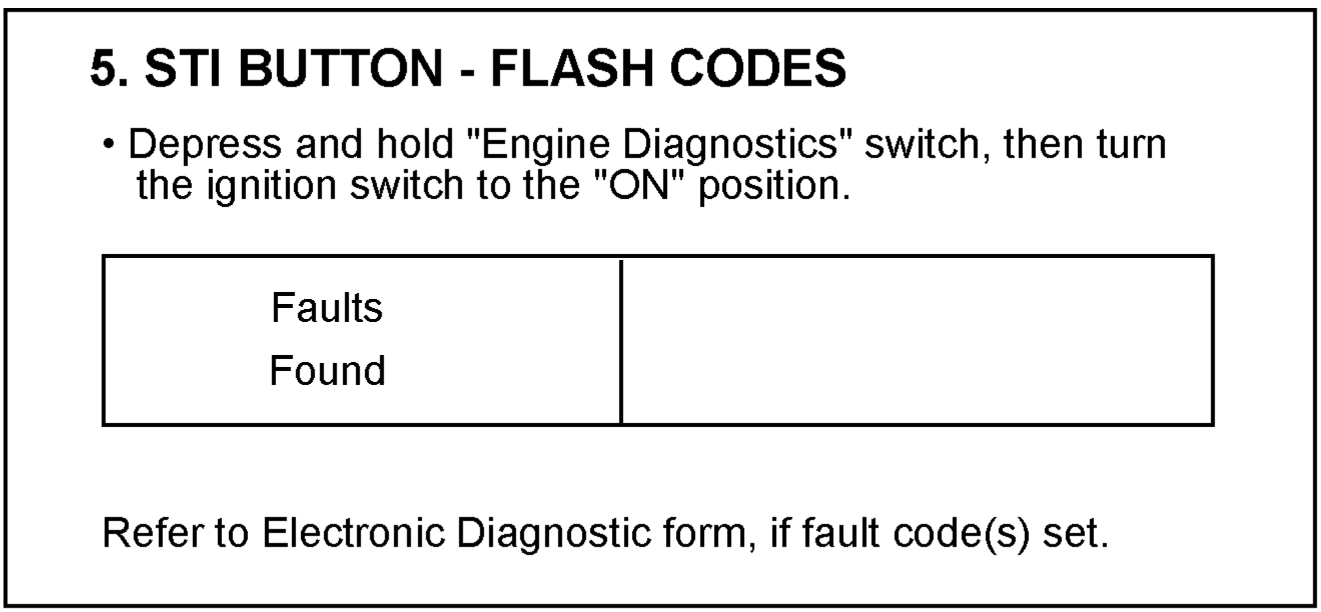
20



33251

Diagnostic Tests Menu

21



33276

Diagnostic Form

22

6. INTAKE RESTRICTION

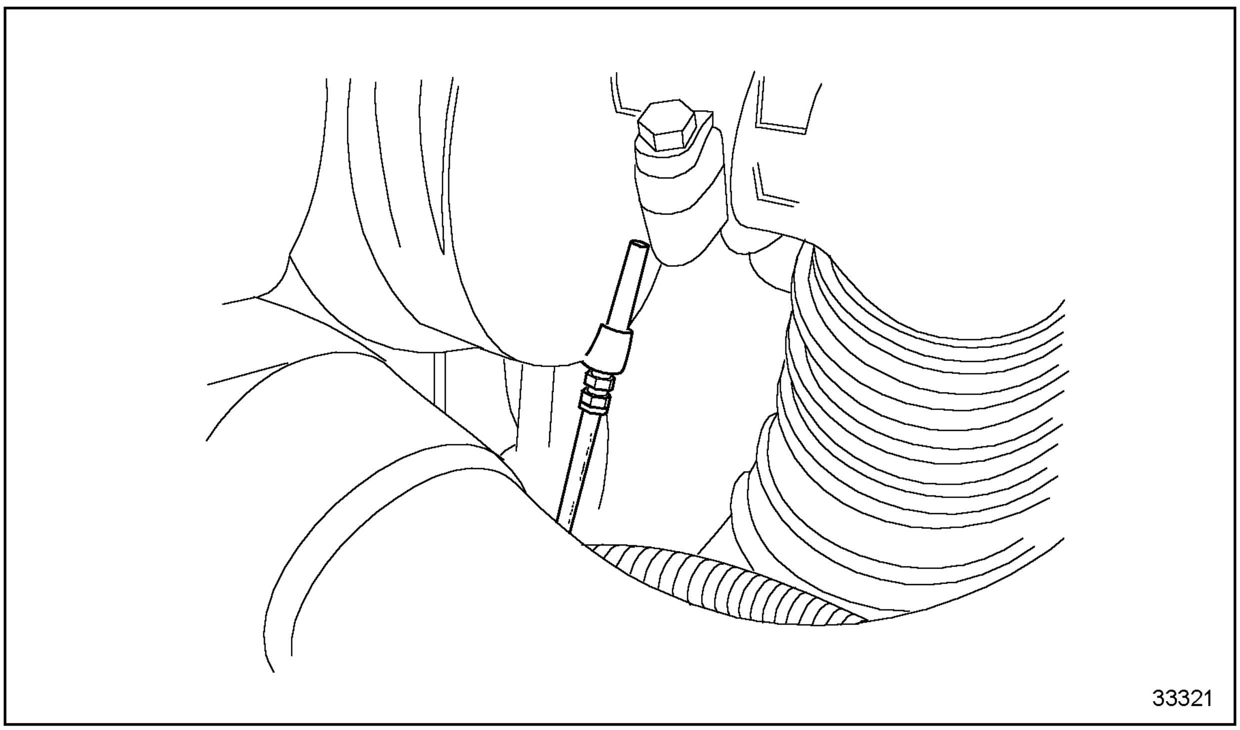
- Measure at High idle & no load.
- Use manometer or magnehelic gauge.

Instrument	Specification	Actual
Manometer or Magnehelic Gauge	12.5" H20 Max.	

33277

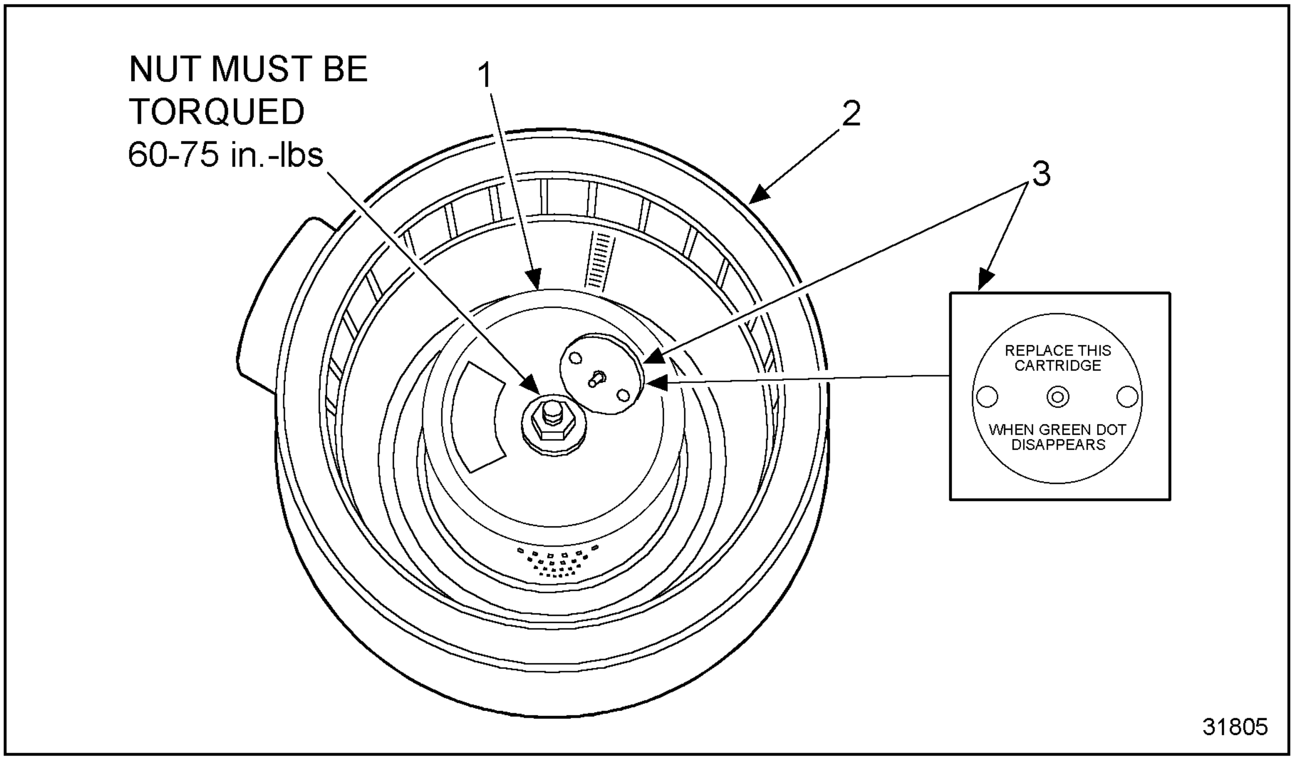
Diagnostic Form

23



Restriction Test, Tap Location

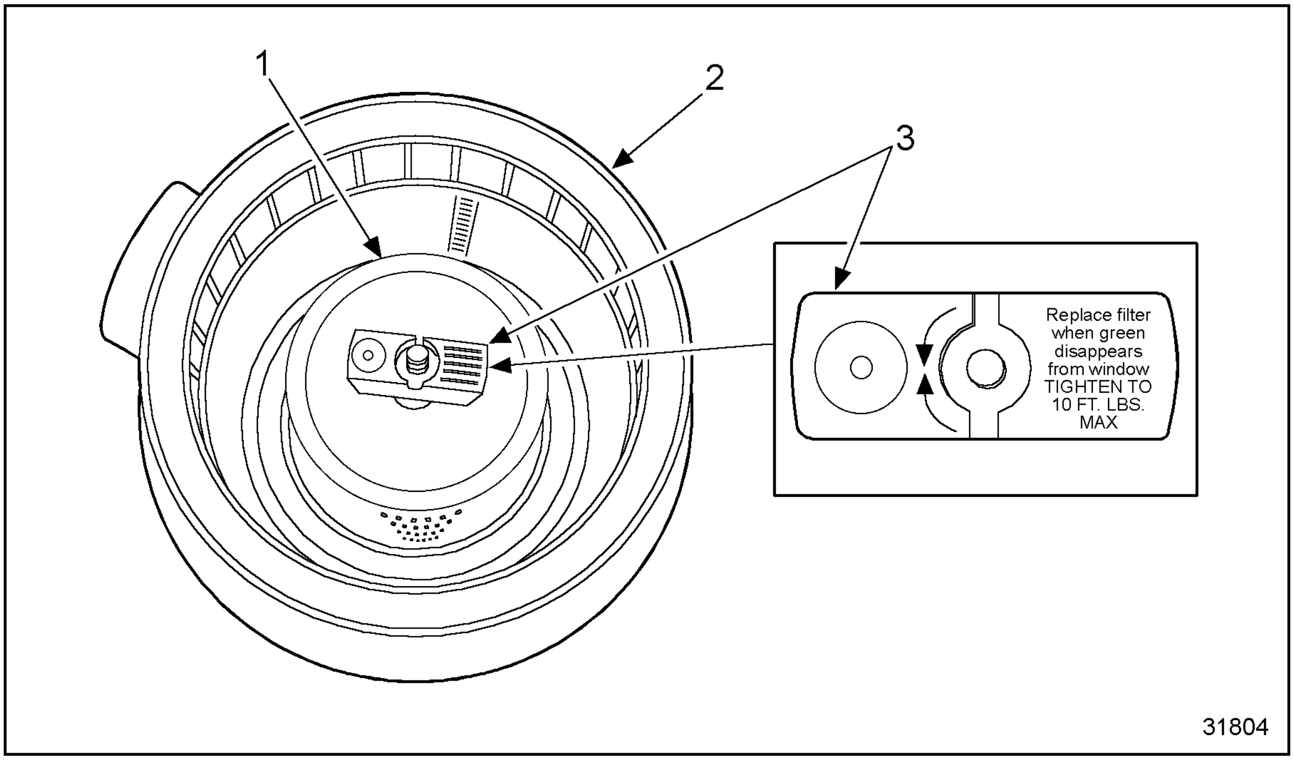
24



1. Secondary (Inner Element)	3. Inner Element Restriction Indicator
2. Air Cleaner Housing	

Dual Element Air Cleaner with Indicator in End Cap

25



1. Secondary (Inner Element)	3. Inner Element Retaining Nut with Restriction Indicator
2. Air Cleaner Housing	

Dual Element Air Cleaner Retaining Nut Indicator

26

7a. EST - ENGINE RUNNING TEST

- Select "Engine Running" test from the diagnostic tests menu.

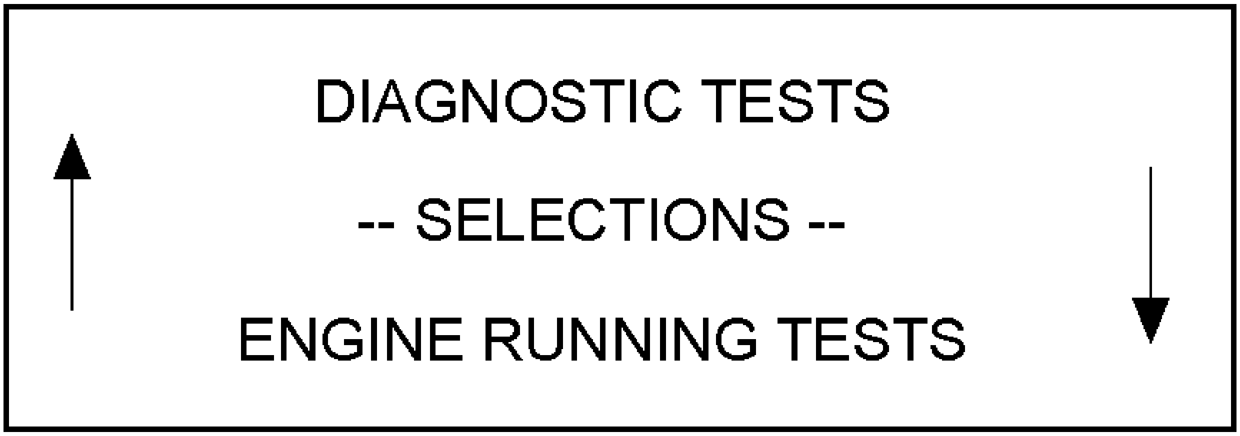
Faults Found	

Refer to Electronic Diagnostic form if fault code(s) set

33278

Diagnostic Form

27



33279

Diagnostic Form

28

7b. EST TOOL - INJECTOR TEST

NOTE: "Engine Running Test" must be performed first, in order to gain access to the "Injector Test".

- Select "Injector Test" from Engine Running test menu.

Faults Found	

☐ Refer to Electronic Diagnostic form if fault code(s) set.

33280

Diagnostic Form

29

ENGINE RUNNING TESTS

-- SELECTIONS --

INJECTOR TEST

33281

Diagnostic Form

30

8. FUEL PRESSURE FULL LOAD

- Measure fuel pressure at fuel filter bleeder
- Measure pressure at full load rated speed

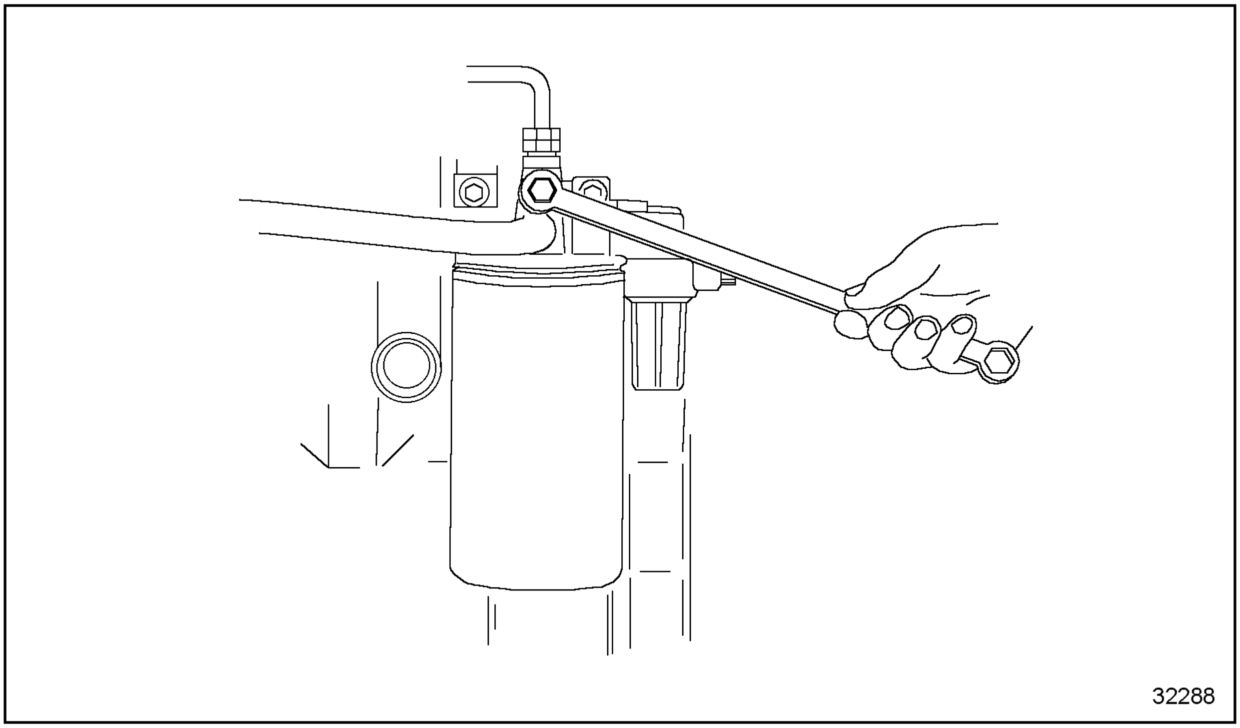
Instrument	Specification	Actual
0-160 PSI Gauge	30 PSI minimum	

- ☐ If pressure is low, replace fuel filter, clean fuel strainer and retest.
- ☐ If pressure is still low, perform Test 2b

33282

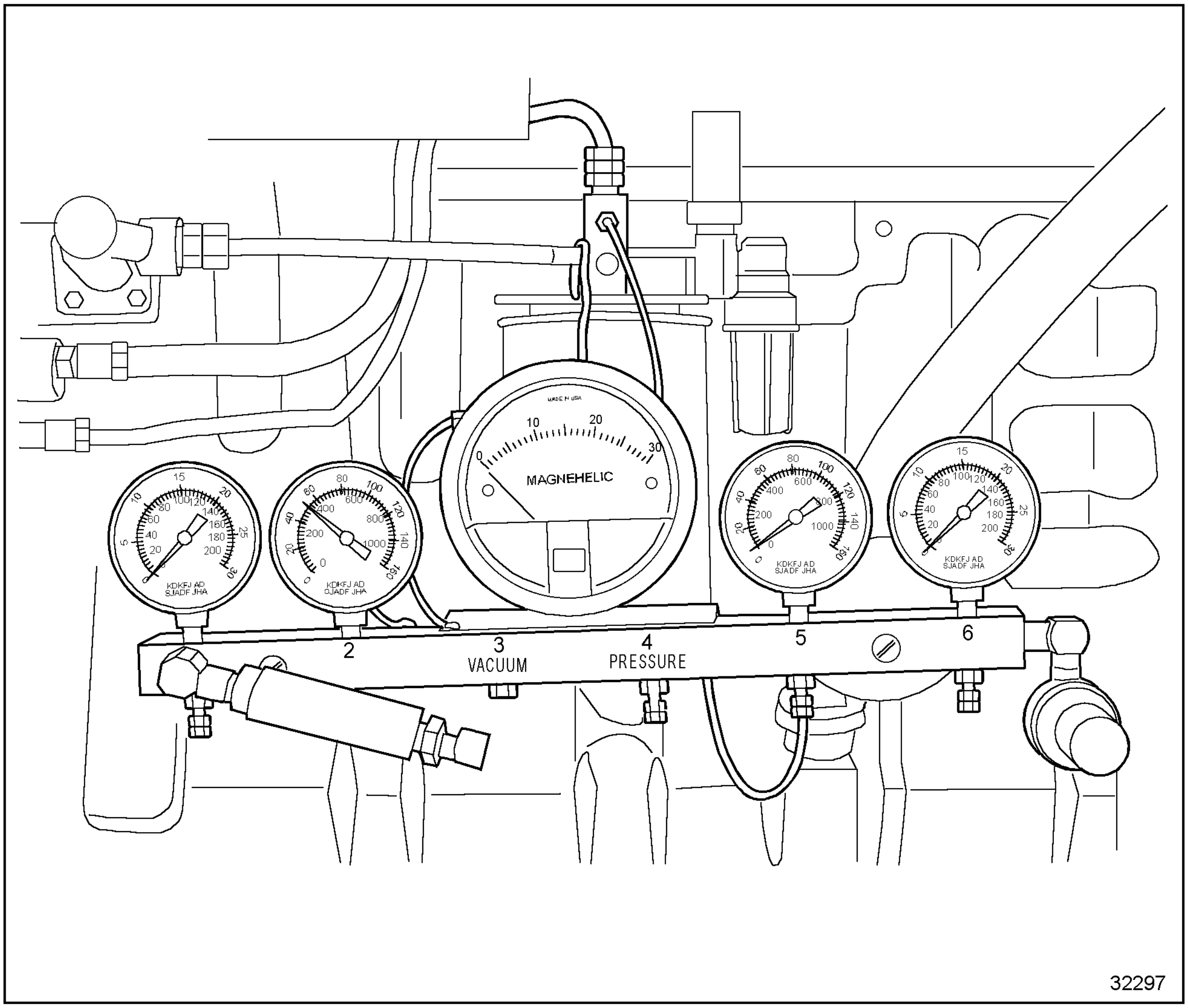
Diagnostic Form

31



Fuel Pressure Tap Location

32



Measuring Fuel Pressure with Pressure Test Kit

33

9. ICP PRESSURE

- Monitor ICP pressure and engine RPM with the EST tool in data list mode.

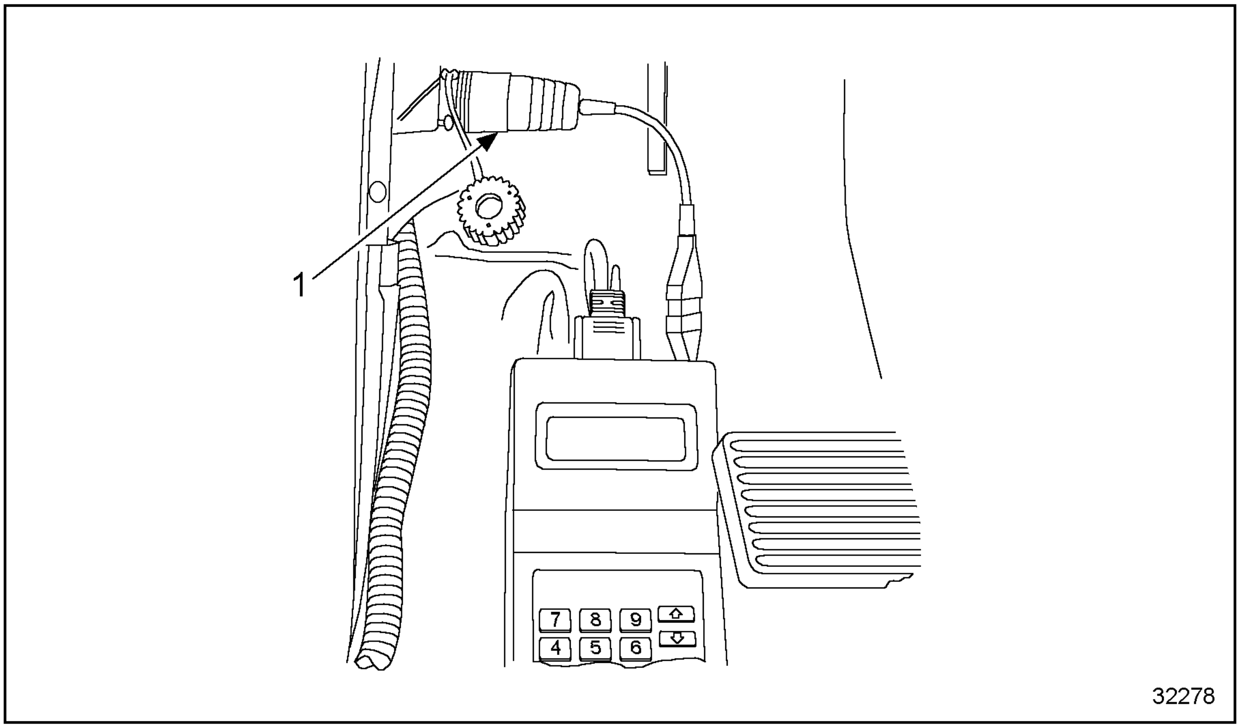
Data	Specification	Actual
Low idle	PSI / volts	
High idle	PSI / volts	
Full load	PSI / volts	

- ☐ If pressure is low or unstable, disconnect ICP sensor and retest.
- ☐ If problem is resolved, refer to ICP diagnostics.
- ☐ If pressure is still low or unstable, replace IPR and retest.

33283

Diagnostic For

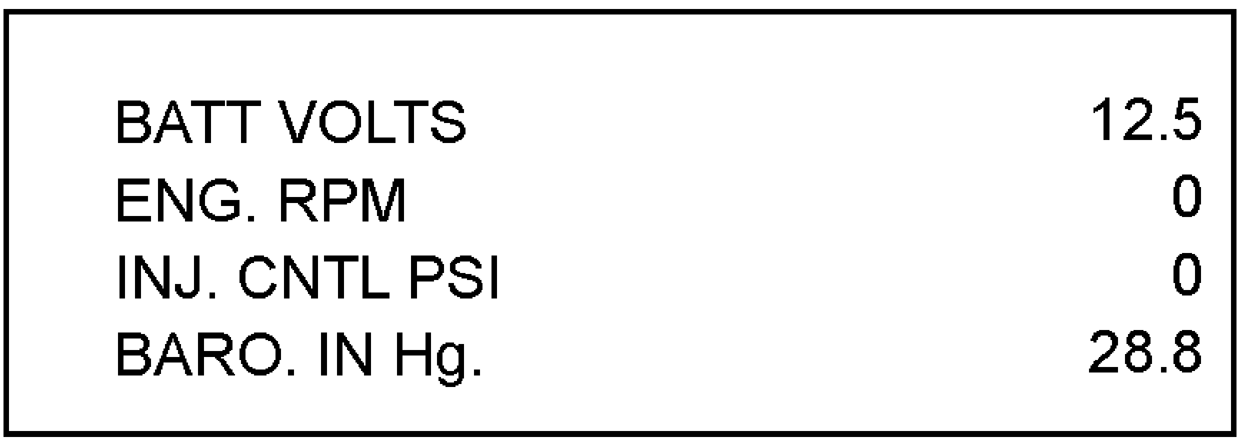
34



1. ATA Connector	

ATA Connector Location

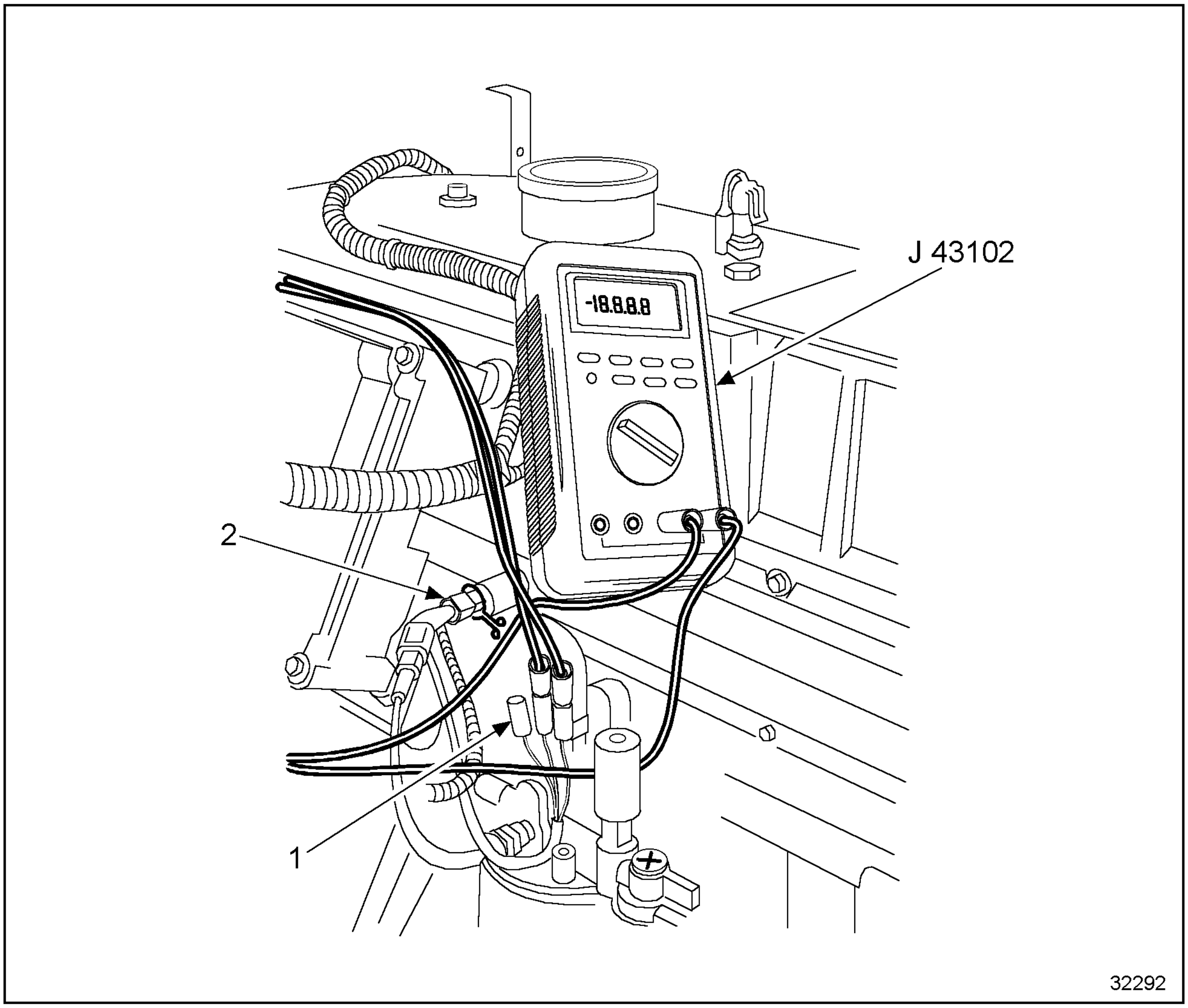
35



33284

Diagnostic For

36



1. Breakout Tee	2. ICP Sensor

Measuring Injection Control Pressure with Breakout Tee

37

10. BOOST PRESSURE

- Monitor boost pressure and engine RPM with the EST tool in data list mode or use dash tach and 0-30 PSI gauge and "T" if EST tool is not available.
- Measure pressure at full load rated speed.

Specification	Actual
PSI @ RPM	

33285

Diagnostic Form

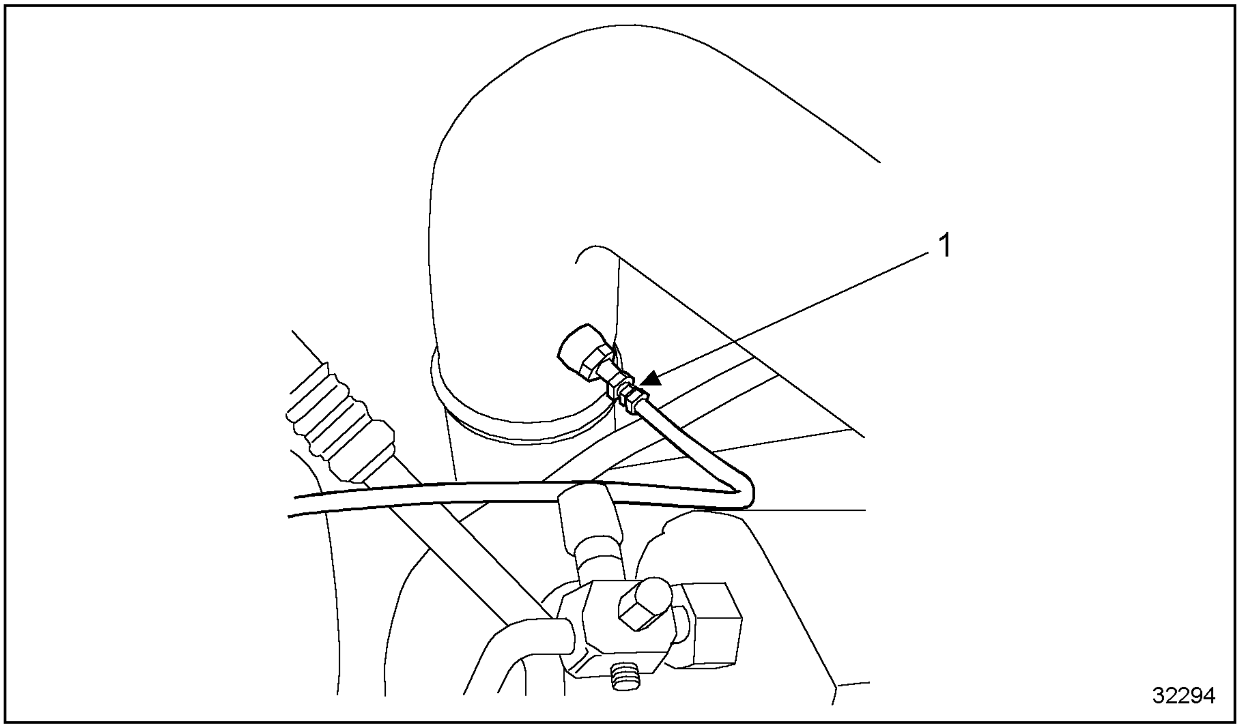
38

BATT VOLTS	12.5
ENGINE RPM	0
BOOST PSI	0

33286

Diagnostic For

39



1. Tap Location	

Boost Pressure Tap Location

40

11. CRANKCASE PRESSURE

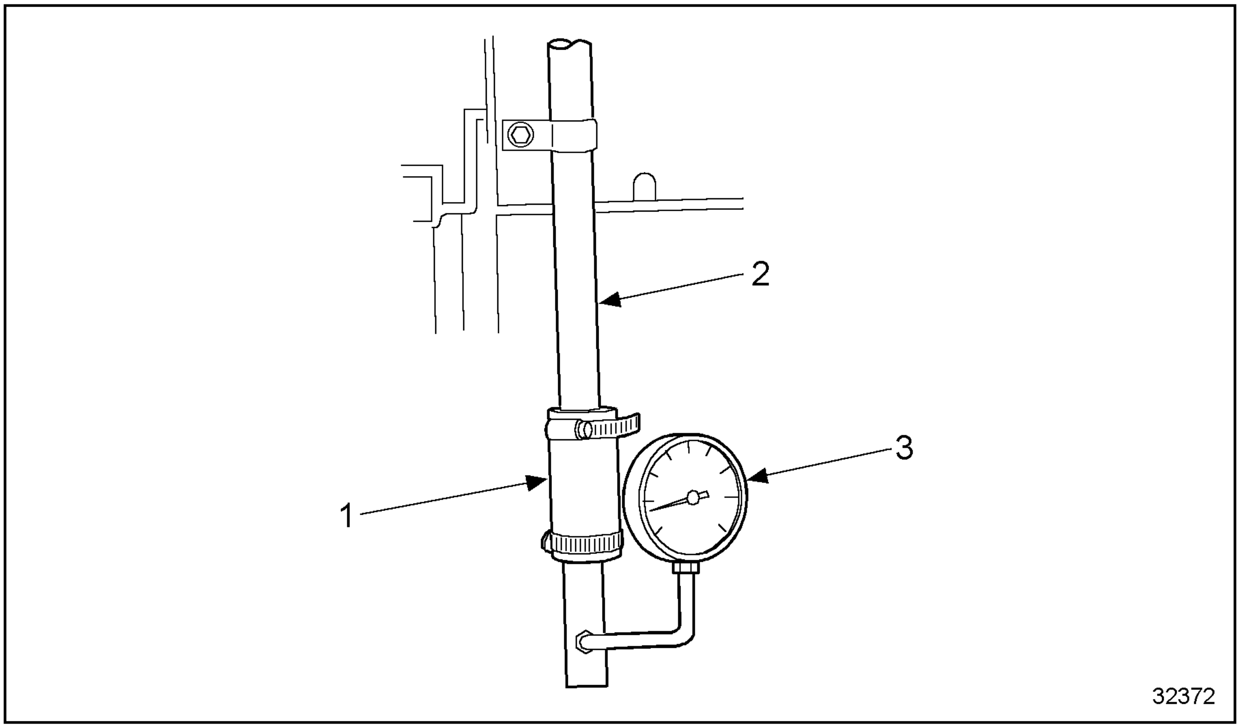
- Measure at road draft tube with orifice restrictor tool J 39267
- Measure at High idle no load RPM.

Instrument	Specification	Actual
0-60" H2O Gauge	< 8" H2O	

33287

Diagnostic For

41



1. Crankcase Breather	3. Breather Tube Restrictor
2. Water Manometer or Magnehelic Gage	

Crankcase Pressure Test

42

12. WASTEGATE ACTUATOR TEST

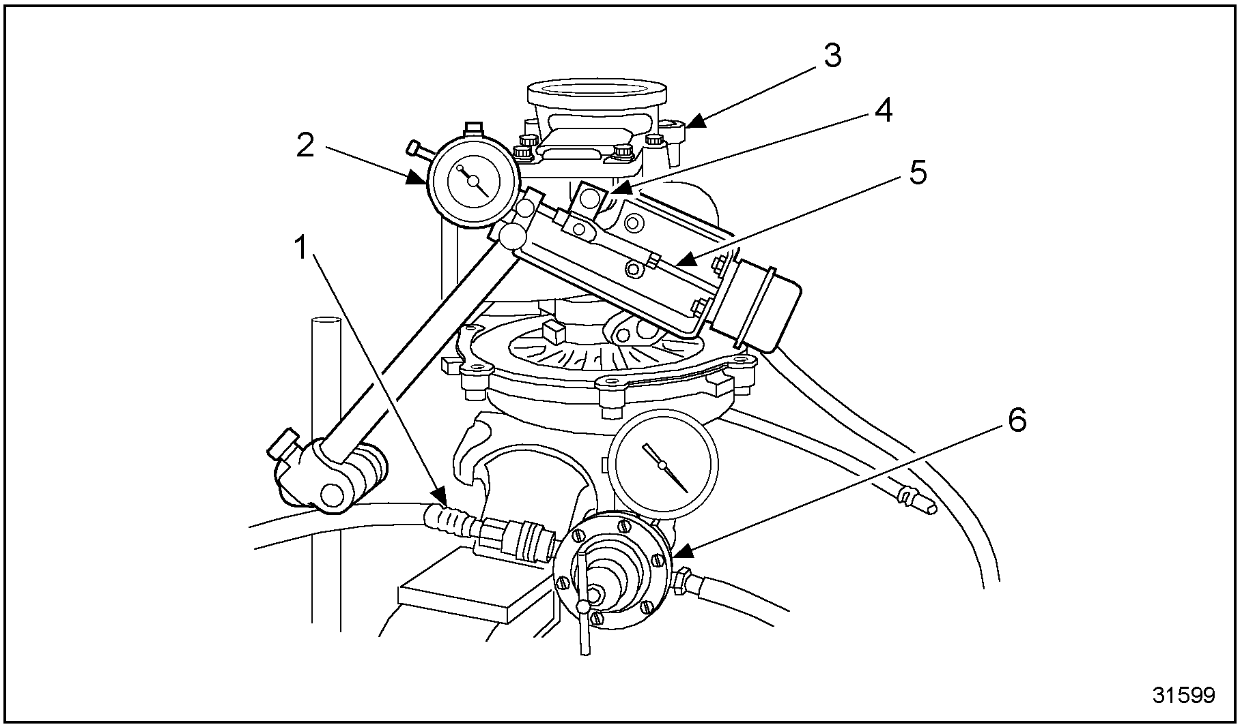
- Apply regulated air to actuator.
- Inspect for leakage
- Inspect actuator for movement.

Instrument	Specification	Actual
0-60 PSI Gauge	28 ± 2 PSI	

33288

Diagnostic Form

43



1. Air Hose	4. Wastegate Housing
2. Dial Indicator	5. Wastegate Actuator Rod
3. Turbine Housing	6. Air Pressure Regulator

Wastegate Actuator Test

13. EXHAUST RESTRICTION

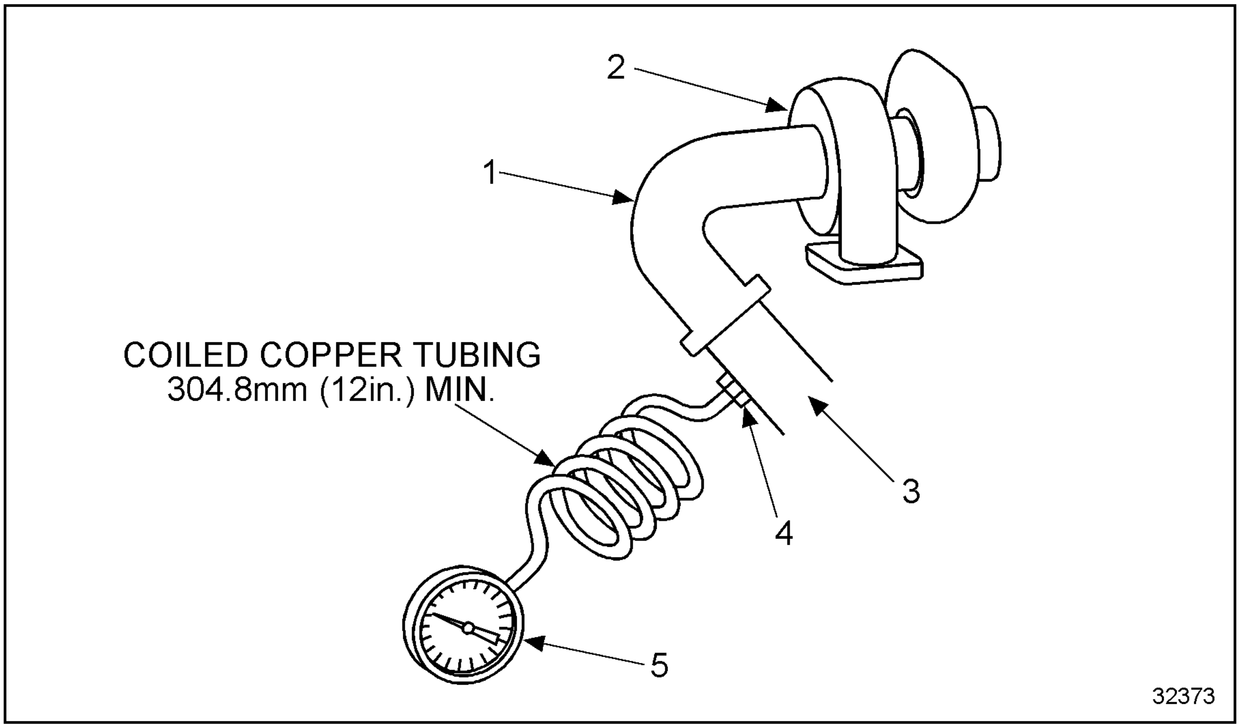
- Visually inspect exhaust system for damage
- Measure at a point 3 to 6 inches after turbo outlet
- Measure at full load and rated speed

Instrument	Specification	Actual
Manometer or Magnehelic Gauge	0-33" H20	

33289

Diagnostic Form

45



1. Exhaust Elbow	4. Drill and Braze on Connector
2. Turbine	5. Water Manometer or Magnehelic Gage
3. Exhaust Pipe	

Exhaust Back Pressure Test Location

46

14. VALVE CLEARANCE

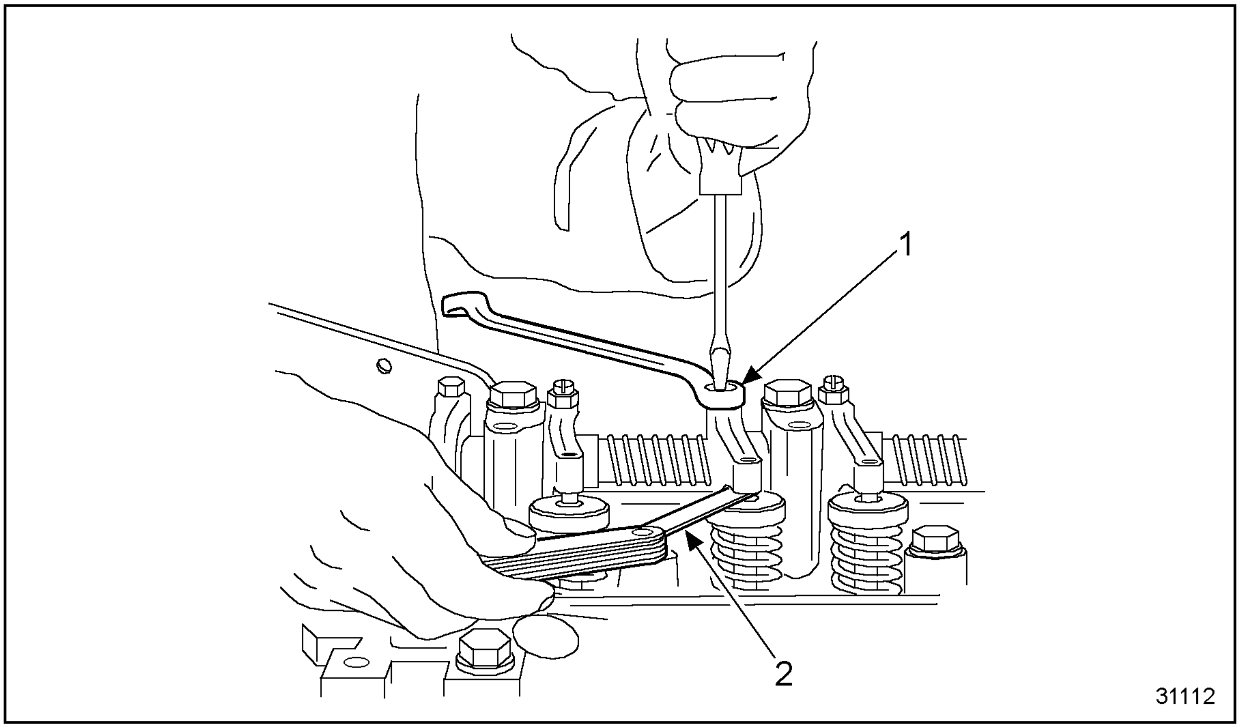
- Engine off: Hot or cold

Instrument	Specification	Actual
Feeler Gage		

33290

Diagnostic Form

47

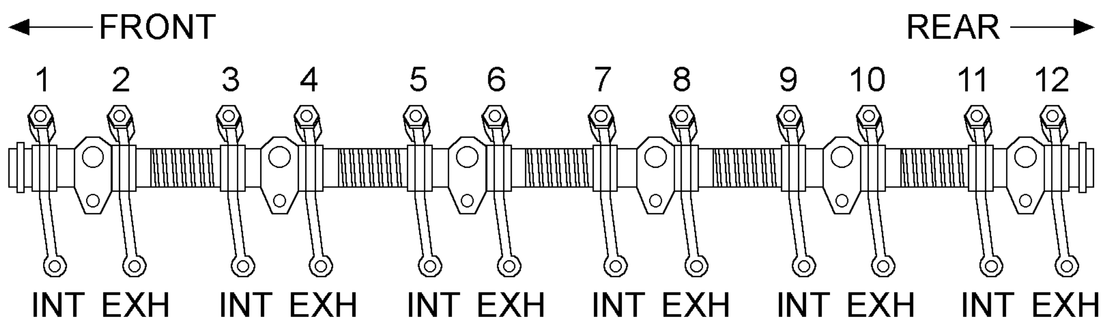


1. Locknut	2. Feeler Gage Insertion

Valve Lash Check

48

WITH	ADJUST VALVES											
NO. 1 PISTON AT TDC (COMPRESSION)	INT 1	EXH 2	INT 3			EXH 6	INT 7			EXH 10		
NO. 6 PISTON AT TDC (COMPRESSION)				EXH 4	INT 5			EXH 8	INT 9		INT 11	EXH 12



31114

Valve Lash Adjustment Sequence

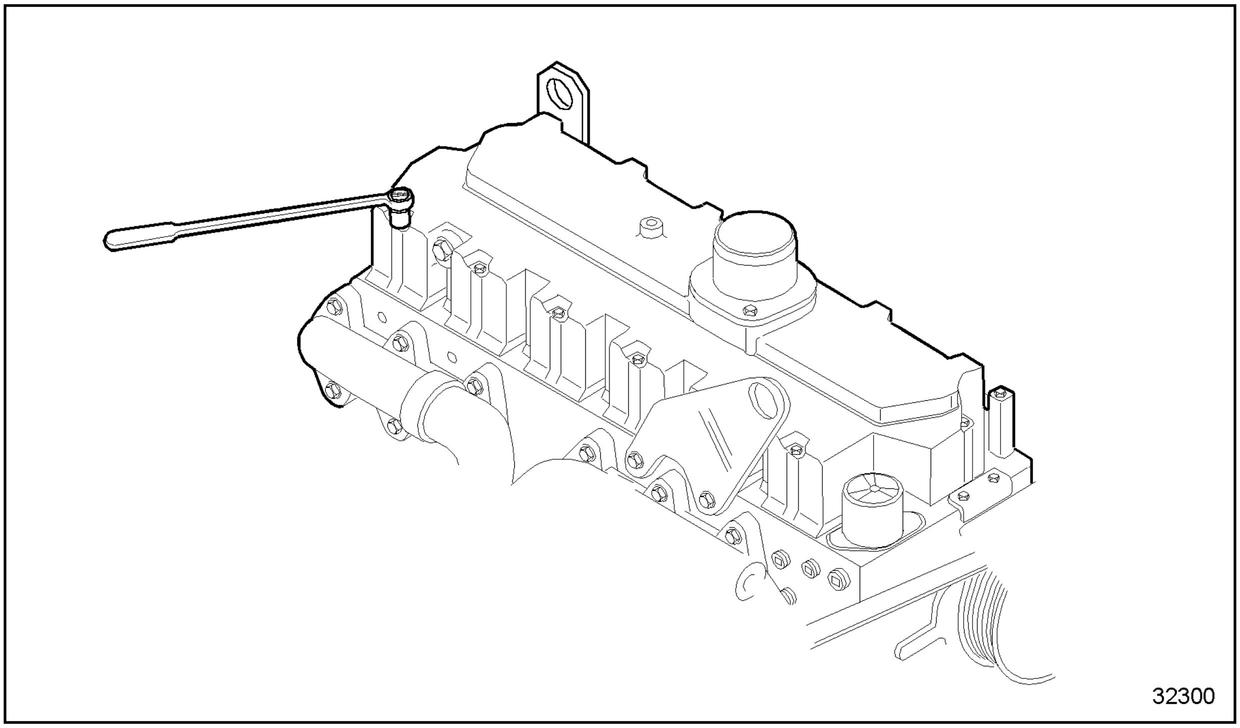
49

VALVE LASH ADJUSTMENT CHART		
ENGINES	INTAKE - in. (mm)	EXHAUST - in. (mm)
ALL SERIES 40E	0.025 (.635)	0.025 (.635)

33346

Diagnostic Form

50



Torque Valve Cover / Intake Manifold

OIL WATER LAMP / ENGINE WARNING AND PROTECTION

SIGNAL FUNCTIONS

The red Oil and Water Lamp (OWL) and the Engine Alarm Buzzer are intended to be turned on when conditions are present that will cause impending damage to the engine. The level of protection is dependent upon which Engine Warning and Protection System (EWPS) is turned on in the ECM. When the ignition switch is in the ON position, power is available at the OWL and alarm. The lamp and the alarm are turned ON when the ECM provides a path to ground. For the OWL / EWPS functions **see Figure** .

1

Fault Detection / Management

An open or short to ground can be detected in the OWL circuit during an On Demand Engine Standard Test by the technician. A momentary bulb check can also be visually observed each time the ignition switch is turned on by the operator. For the stop engine light and alarm **see Figure**

.

2

Key ON, Engine OFF voltage checks are **listed in Table**

. Checks are made with the ECM chassis connector (black) unplugged, the breakout box installed, the ignition key ON and the engine OFF.

Test Points	Spec	Comments
439L to Grd	12 volts	Fuse for instrument cluster and OWL lamp.
B to Grd	12 volts	Battery voltage should be present from 439L to buzzer; if no voltage present, check circuit for open or short.
54 to Grd	12 volts	Battery voltage should be present from lamp circuit to ECM; if no voltage present, check circuit for open or short.

Key ON Engine OFF — Voltage Checks

Harness resistance checks are **listed in Table** . Checks are made with the ECM chassis connector (black) unplugged, the instrument cluster connector unplugged, and the ignition key OFF.

Test Points	Spec	Comments
54 to C	< 5 Ω	Continuity for ECM to Buzzer connector.
B to 439L	< 5 Ω	Continuity from Buzzer to fuse.

Harness Resistance Checks

Functional Checks:

1. Physical Circuit Check — With breakout box installed momentarily ground the ECM chassis pin No. 54; the OWL lamp should illuminate if the OWL circuit is good.
2. Output State Check — The OWL lamp can be commanded on for test purposes with the EST by requesting an Output State Check; if the OWL circuit checks out good to this point, and does not turn on when an Output State Check is commanded, either the ECM is bad or the feature is not turned on.

Fault Code Description:

Flash Code 263 = OWL Output Circuit Check Fault detected during a key ON, engine OFF, Standard Test; possible open or short in OWL.

Engine Warning and Protection System Description

This group of parameters customizes the engine warning and protection (EWPS) feature. The EWPS safeguards the engine from undesirable operating conditions in order to prevent engine damage and to prolong engine life. When a warning condition is detected, the on-board electronics will light up the OWL and the warning buzzer is activated.

When a critical condition is detected, the on-board electronics will shut down the engine if the EWPS has the protection feature enabled. After an engine shutdown, the operator may start the engine again for a 30 second run time, if desired.

The event logging feature will also record when an excessive (i.e. critical) engine event has occurred in both engine hours and odometer readings. Currently there are four states of electronic operation.

1. Standard
2. Three–way Warning
3. Three–Way Protection
4. Two–Way Warning

EWPS Mode

This parameter indicates to the on-board electronics the desired mode of operation for the engine warning and protection feature.

Standard Warning (RPM)

Engine overspeed and engine overheat are provided as the default operating mode. No engine shutdown is available.

Three-Way Warning (RPM, ECT, EOP, ECL)

Engine overspeed, engine overheat, engine oil pressure low, and loss of engine coolant are provided as the engine warning operating mode. No engine shutdown is available.

Three-Way Protection (RPM, ECT, EOP, ECL)

Engine overspeed, engine overheat, engine oil pressure low, and loss of engine coolant are provided as the engine warning operating mode. Engine shutdown is available if an engine critical condition is detected. Critical engine conditions include overheat, low oil pressure and low coolant level.

Two-Way Warning (RPM, ECT, EOP)

Engine overspeed, engine overheat, and engine oil pressure low, are provided as the engine warning operating mode. No engine shutdown is available.

ECT Warning Temperature

This parameter indicates when an engine overheat condition warrants the OWL to be illuminated and the warning buzzer to be activated.

ECT Critical Temperature

This parameter indicates when an engine overheat condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

EOP RPM Boundary 1

This parameter indicates the RPM range for which engine oil pressure level 1 is to be used for the loss of engine oil pressure detection.

EOP RPM Boundary 2

This parameter indicates the RPM range for which engine oil pressure level 2 is to be used for the loss of engine oil pressure detection.

EOP RPM Boundary 3

This parameter indicates the RPM range for which engine oil pressure level 13 is to be used for the loss of engine oil pressure detection.

EOP Warning Level 1

This parameter indicates when a loss of engine oil pressure condition warrants the OWL to be illuminated and the warning buzzer to be activated.

EOP Warning Level 2

This parameter indicates when a loss of engine oil pressure condition warrants the OWL to be illuminated and the warning buzzer to be activated.

EOP Warning Level 3

This parameter indicates when a loss of engine oil pressure condition warrants the OWL to be illuminated and the warning buzzer to be activated.

EOP Critical Level 1

This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred, in both engine hours and odometer readings.

EOP Critical Level 2

This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred, in both engine hours and odometer readings.

EOP Critical Level 3

This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred, in both engine hours and odometer readings.

ECM Diagnostics

The following flash code could set when troubleshooting the OWL:

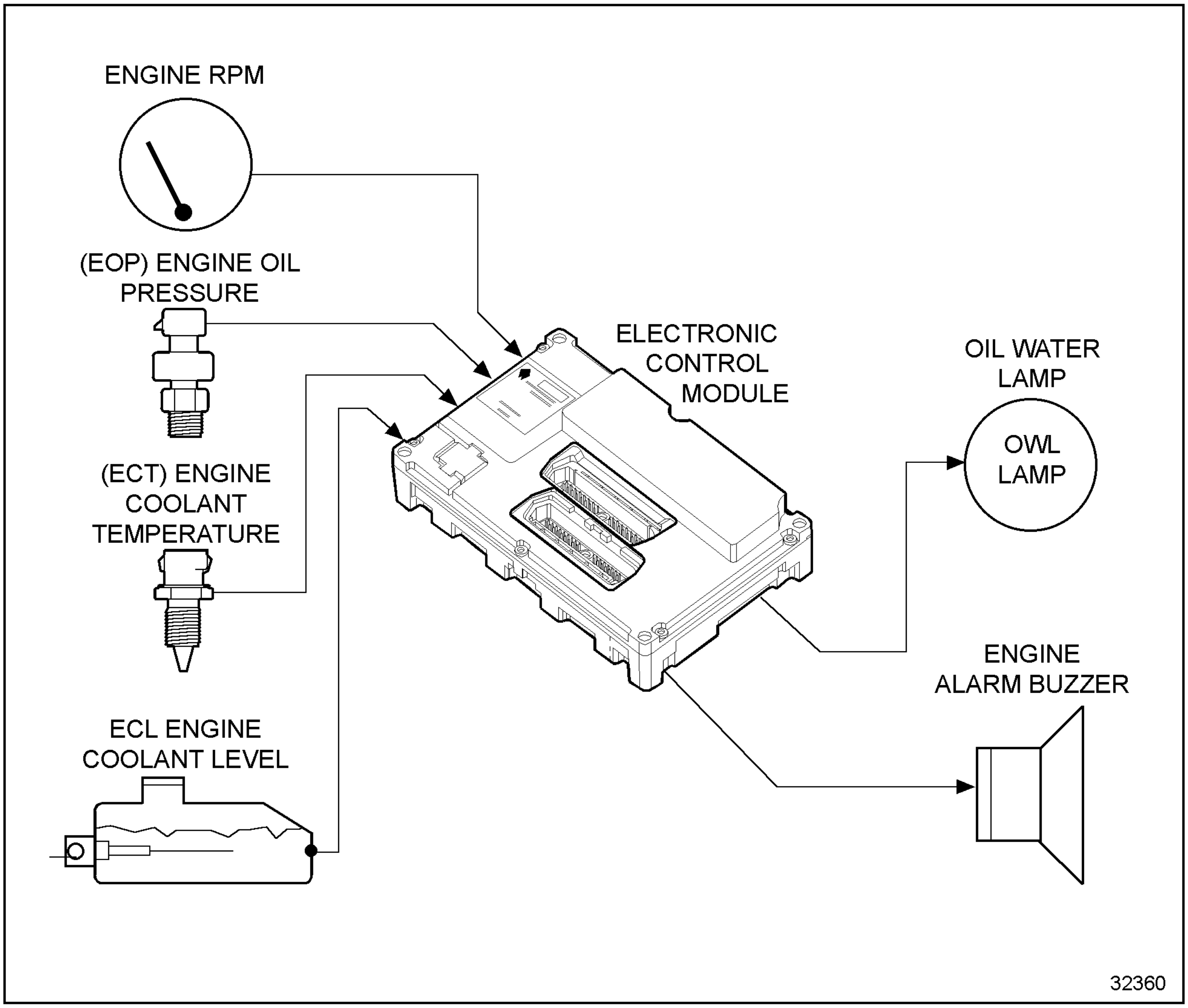
Flash Code 263

ATA Code SID FMI 11

Oil Water Lamp OCC Fault.

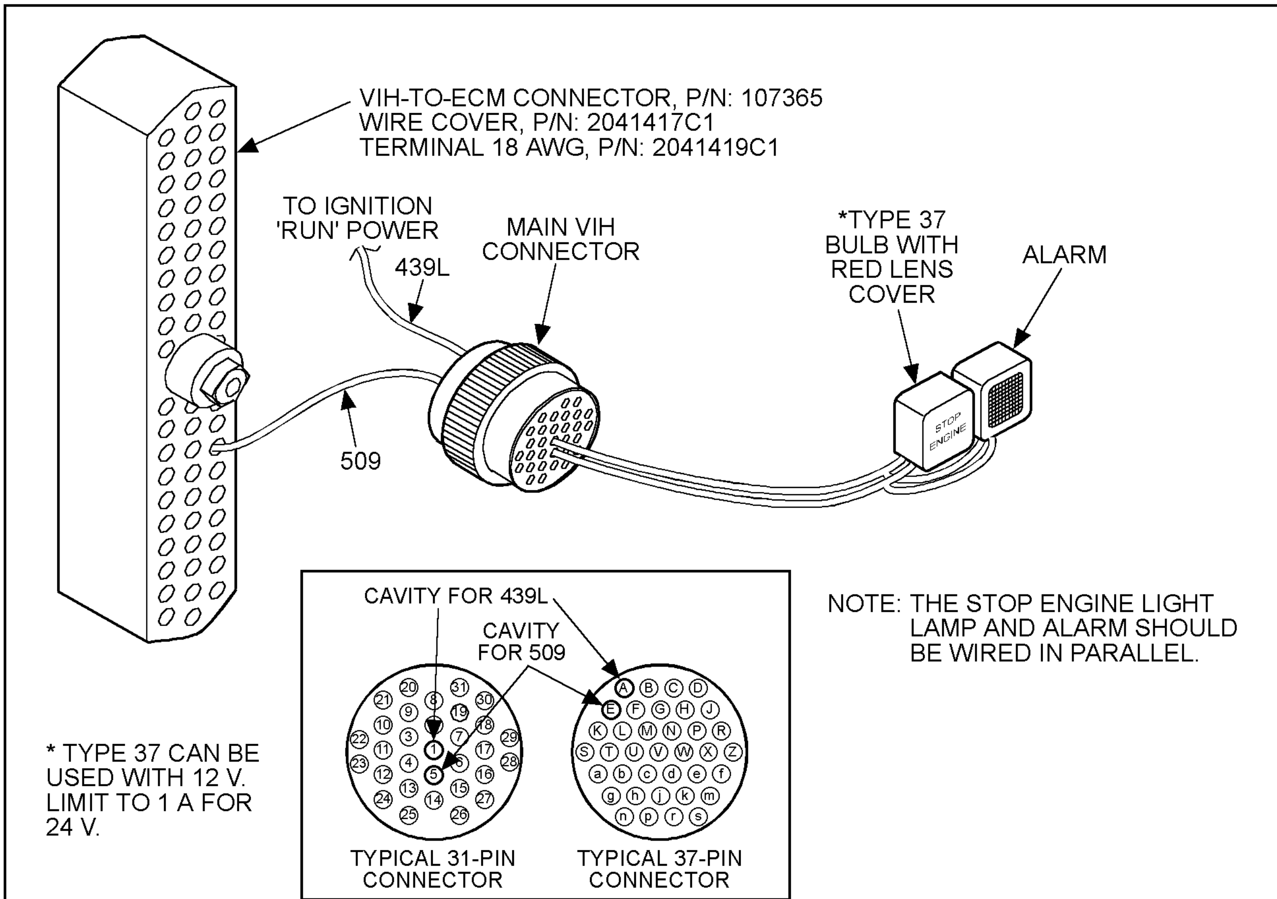
The Output Circuit Test, performed during an On Demand Engine Standard Test, will test the OWL circuit for an open or short condition. If an out of range condition exists, a Flash Code 263 will be set.

1



Oil Water Lamp / Engine Warning and Protection System Functions

2



LABEL	WIRE NO.	WIRE GAUGE	VIH-to-ECM CONNECTOR CAVITY	MAIN VIH CONNECTOR CAVITY	WIRE COLOR
STOP ENGINE LIGHT & ALARM	509	18	54	E/5	GRAY
FUSED IGNITION 'RUN' POWER	439L	16	–	A/1	GRAY

28947

Stop Engine Light and Alarm Wiring

SELF TEST INPUT SWITCH AND ENGINE WARNING LIGHT

SIGNAL FUNCTION

For the self test input switch function diagram, **see Figure**

.

1

Self Test Input Switch

The Self Test Input (STI) switch runs the Key On Engine OFF (KOEO) Standard Tests. (STI is sometimes referred to as the EST.) Faults detected during the test result in active fault codes that are transmitted as flash codes with the warning light. If no faults are detected, the ECM will flash Code 111, indicating no faults detected.

ECM pin 34 has 12 volts with the key ON and engine OFF. Depressing the STI switch grounds pin 34, causes it to change from 12 volts to 0 volts, signaling the ECM to start the KOEO Standard Tests.

Engine Warning Light WARN

When the key switch is turned to ON, the amber Engine Warning Light turns ON and stays ON. The ECM runs normal start-up tests and then turns OFF. If the ECM detects a problem, the WARN remains ON.

Ignition power is applied to the WARN lamp. The ground side of the WARN lamp is connected to ECM pin 55, a ground switch. The ECM applies 5 volts to pin 55 (light OFF) or 0 volts (light ON), in response to engine conditions.

Fault Detection Management

The ECM can detect an open WARN lamp circuit during a Standard Engine OFF Test during which an output circuit test is automatically performed. There are no ECM diagnostics for the STI circuits.

For the self test input switch, **see Figure** .
2

The STI switch is tested with the ignition key OFF. Checks are **listed in Table** .

Test Points	Spec	Comments
Across Switch Terminals	> 1,000 Ω open position	Less than 1,000 Ω, replace the switch.
Across Switch Terminals	< 5 Ω closed position	Greater than 5 Ω, replace the switch.

Self Test Input Switch Test

The STI switch connection is tested with the ignition key OFF. Checks are **listed in Table** .

Test Points	Spec	Comments
98 to Grd	> 1,000 Ω open position	Less than 1,000 Ω, locate short to ground.

Self Test Input Switch Connection Test, Key OFF

The STI switch connection is tested with the ignition key ON. Checks are **listed in Table** .

Test Points	Spec	Comments
98 to Grd	5 ± .5 volts	Less than 4.5v, check connections; if 0 volts, check for open/short to ground in circuit 98.
98 to 98 - Grd	5 ± .5 volts	Less than 4.5v, check connections; if 0 volts, check for open in ground circuit.

Self Test Input Switch Connection Test, Key ON

Key ON, No Warning Light

If the warning light does not turn on when the key is turned ON:

1. Check the fuse and bulb condition.
2. Disconnect 379 from the ECM and install the breakout box to harness; jumper terminal 17 to ground; note if light is ON.
   a. If the light is ON, the ECM is defective.
   b. If the light does not turn ON, check the circuit for an open condition.
   c. If the light goes OFF, the ECM is defective.

Warning Light STAYS ON

If the warning light stays ON after the self test:

1. Check for active fault conditions (use EST or STI flash codes).
   d. If active fault conditions are present, correct the faults.
   e. If no fault conditions are present, go to the next step.
2. Disconnect 379 from the ECM and note if light stays ON.
   f. If light stays ON, check for short to ground in circuit.

Fault Code Descriptions

Fault Code 266 = Output Circuit Check detected during the Standard Test; indicates high or low resistance in Warn Lamp circuit.

STI Switch

The STI switch (or EST) can be used to run the KOEO Standard Tests. Faults detected during this test result in active fault codes that are transmitted as flash codes with the Warning Light. If no faults are detected, the ECM will flash Code 111, indicating no faults detected.

Depressing the STI switch with the key ON and engine OFF starts the test cycle. KOEO Standard Tests include the ECM Internal Tests and the Output Circuit Check (OCC) tests.

The normally open switch has one pole connected through circuit 98 and the ECM connector 379 to the ECM STI pin 34. The other switch pole is connected (circuit 98–G/11–GA) to the G2 ground stud.

The ECM pin 34 has 5 volts with the key ON and the engine OFF. Depressing the STI switch grounds pin 34, causing it to change from 5 volts to 0 volts, signaling the ECM to start the KOEO Standard Tests.

Engine Warning Light WARN

When the key switch is turned to ON, the amber Engine Warning Light turns ON and stays ON, while the ECM runs normal start-up tests, and then turns OFF. If the ECM detects a problem, the WARN remains ON.

Ignition power WARN is applied to the Engine Warning Light. The ground side of the WARN is connected to ECM pin 55, which is a ground switch. The ECM applies 12 volts to terminal 17 (light OFF) or 0 volts (light ON), in response to engine conditions.

ECM Diagnostics

There are no ECM diagnostics for the STI or Warning Light circuits.

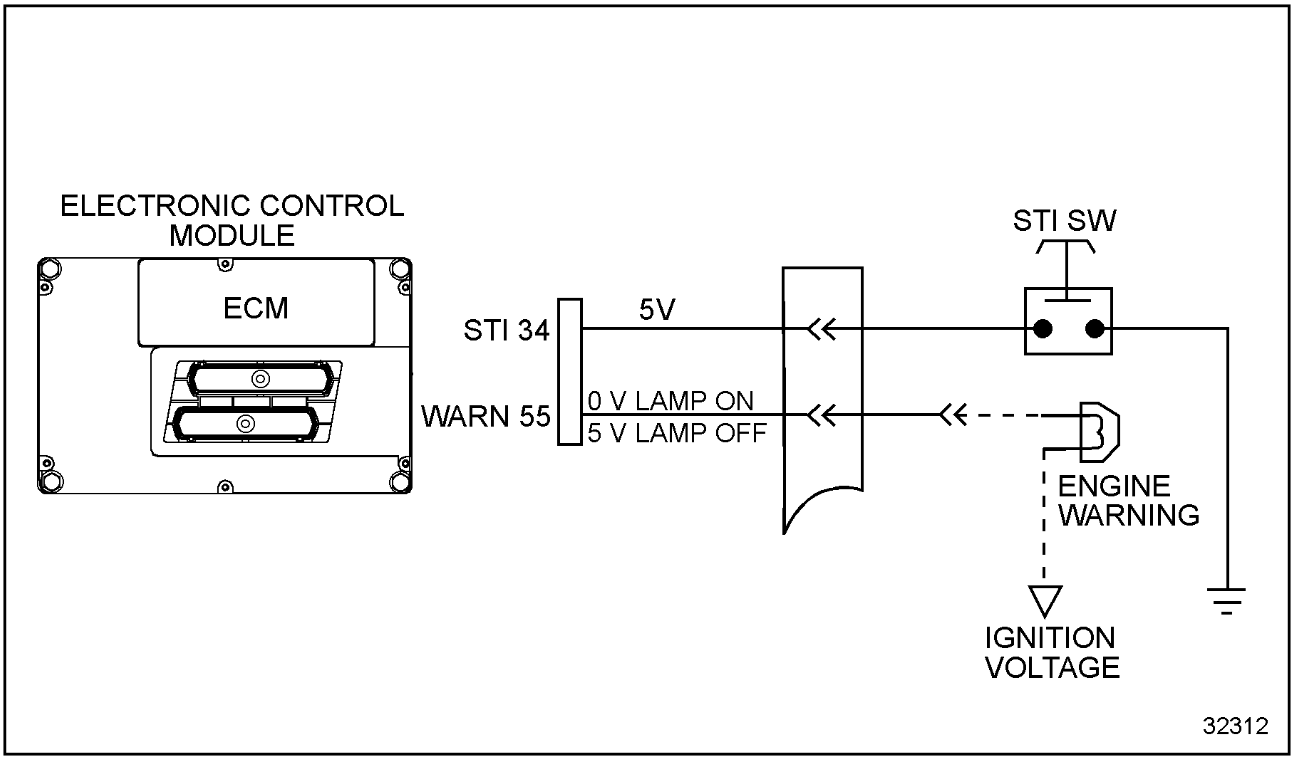
Before Troubleshooting

Before troubleshooting, ensure that the batteries are fully charged. Check the battery connections and grounds for clean, tight connections free of damage. Voltage tests will give misleading results if the batteries are not fully charged.

Before troubleshooting, inspect circuit connectors for pushed back, loose, or damaged (spread or bent) terminals, or wires with cut strands, etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present and must be removed.

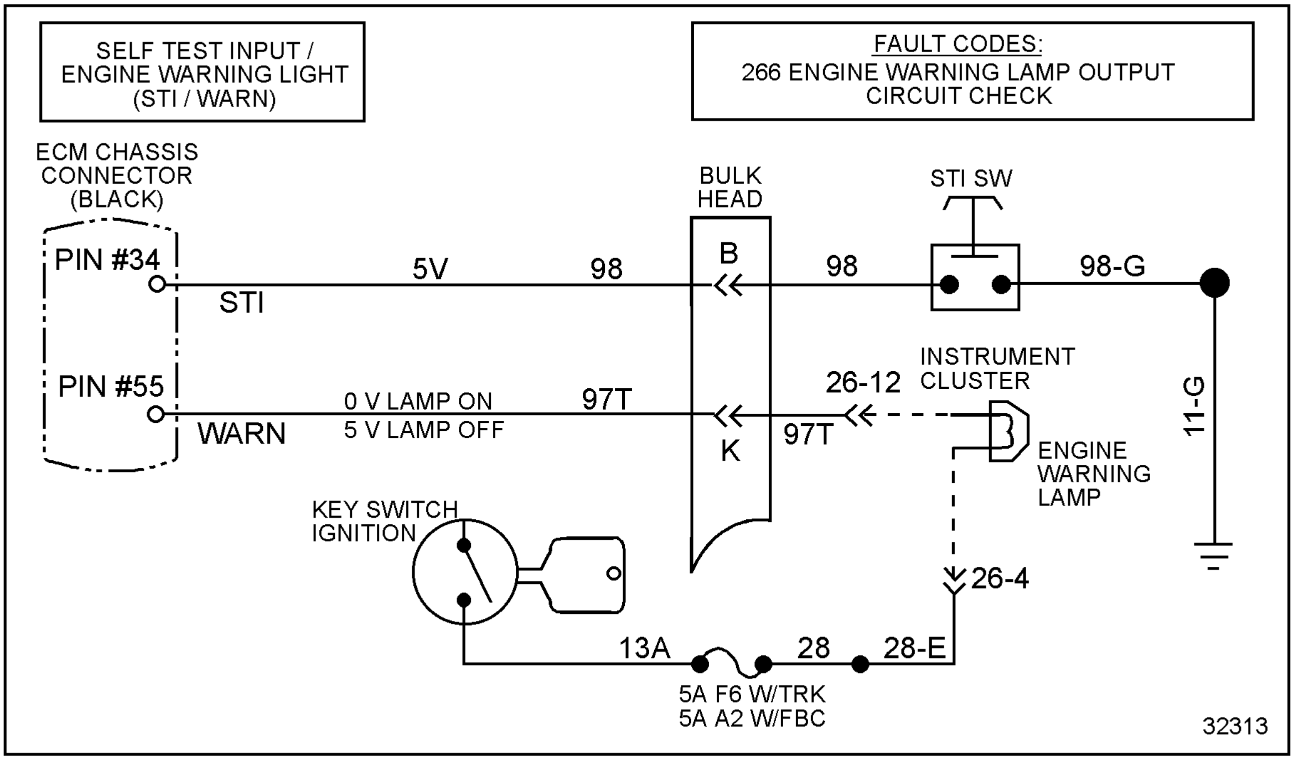
Before troubleshooting, inspect the suspect circuit grounds for clean, tight connections, free of damage.

1



Self Test Input Switch Function Diagram

2



Self Test Input Switch

SELF TEST OPERATION

DIAGNOSTIC SOFTWARE TEST

The following flow chart will enable diagnostic fault code detection: **See Figure** .

1

CONTINUOUS MONITOR

Diagnostics are performed by the ECM continuously to detect out of range rationality and system faults.

During the time that the key is ON, if an input signal is out of range, meaning the signal is either greater or lesser than what the signal range should be during normal operation, the ECM will record a fault. It will also monitor the operation of systems and will determine if they are working within a normal operational range (rationality fault detection). If the ECM detects that a system falls outside a predetermined range, it will record and set a fault code.

During normal engine operation, the ECM automatically performs several tests to detect faults. When it has detected a fault, the ECM often invokes a fault management strategy to allow continued, though sometimes degraded, vehicle operation.

The ECM can also set codes associated with the injection control system on a continuous basis that is an improvement from previous systems in which specific diagnostic tests had to be performed in order to get the codes.

A Fault is an indication of a malfunction measured or monitored electronically. Sometimes faults are referred to as Codes.

Codes are three digit numbers assigned to faults to indicate the source of the malfunction. Most codes will indicate the source and the Mode of failure. The Failure Mode will indicate the signal reading, i.e. out of range high, out of range low, or in range fault.

With the engine running, the ECM memory will also record Event Engine Hours. This feature records if the engine has been operated beyond maximum r/min, overheated (coolant temperature), low on coolant, or experienced low oil pressure.

The standard Engine Events are overspeed (Over RPM) of the engine and excessive coolant temperature. Low oil pressure and low coolant level operation will also be monitored and recorded as Event Engine Hours, if the engine is equipped with the optional engine warning/shutdown system.

Engine events logged into the ECM memory are permanent and can be retrieved with the Electronic Service Tool (EST).

OPERATOR ON DEMAND TESTS, ENGINE OFF

The following tests are performed with the engine OFF:

Standard Test (KOEO Test)

Key Off Engine Off Tests (KOEO) are standard tests performed by the ECM. These tests are commanded by the technician using the Electronic Service Tool (EST) or using the Self Test Input (STI) push-button switch.

To perform the test using the EST, access the Engine Menu and select Diagnostic Tests. Then select Engine Off Tests. Depressing the Enter key will initiate the test.

To use the STI diagnostic push-button switch, depress the switch and hold in while turning the ignition switch to the ON position. Release the STI button after the key is in the ON position. **Do not start the engine.**

When the operator signals the test to begin, the ECM will perform internal tests of its processing components and internal memory.

It will automatically proceed to Output Circuit Check (OCC). This test checks output circuits to detect shorts or opens in the ECM, the harnesses or the actuators by operating the ECM output circuits and measuring each individual circuit response. If a circuit fails the test, a fault code will be logged in the memory.

The following circuits are checked by the ECM during the test:

1. Engine Crank Inhibit (relay)

2. Engine to Transmission Data Link
3. Injection Pressure Regulator (IPR)
4. Engine Fan
5. Radiator Shutters
6. Change Oil Light
7. Oil/Water Light
8. Engine Warning Light
9. Vehicle Retarder Relay (VRE)

The output circuits check test only evaluate the electrical condition of the circuits involved and can only be performed by commanding the KOEO test. It does not evaluate the mechanical or hydraulic performance of any of the systems involved.

When the test is complete, the EST will display any faults that were found during the test. If the STI diagnostic switch was used to perform the test, the faults will be transmitted as Flash Codes, using the Oil Warning and Engine Warning lights.

The fault codes are read by counting the number of light flashes. The following sequence occurs.

1. The Oil/Water light will flash one time. This indicates the beginning of Active fault codes.
2. The Warn Engine light will flash repeatedly signaling the active fault codes. All codes are three digits. The number of flashes should be counted in sequence.
3. At the end of each digit of the code there will be a short pause. For example, the code 232 will be sent as two flashes, a pause, three flashes, a pause, and two flashes.
4. After each active code is displayed, the Oil/Water light will flash once to indicate the next active code.
5. Once all active codes have been displayed, the Oil/Water will flash twice to indicate the beginning of Inactive codes.
6. Inactive codes will be displayed in the same manner as active codes.
7. Once the Inactive codes have been displayed, the Oil/Water will flash three times to indicate that all the stored fault codes have been displayed, END OF MESSAGE.

If it is necessary to repeat transmission of fault codes, press the STI button and all stored codes will be transmitted again, as described previously.

The STI button can be utilized to clear the Diagnostic Codes by:

1. Depressing and holding the STI button
2. Turning the ignition key ON
3. Depressing and releasing the accelerator pedal three times
4. Releasing the STI button

Injector BUZZ Test, Engine Off

The purpose of the Engine Off Injector BUZZ Test is to diagnose electrical problems with the fuel delivery components. This test can only be accessed with the EST and only after an Engine Off Test or Standard Test has been performed.

Note: Before running this test, fault codes should be accessed, noted and erased. This will allow the faults found in this test to be displayed as Active Codes.

During the test, the ECM will actuate the injectors in numerical order, 1 through 6, ***not in firing order.***

The ECM will monitor the electrical circuit operation of each injector and evaluate the performance of the injector's solenoid and the electrical circuit operation. If an electronic component in the fuel system fails the expected parameters, an inactive fault code will be logged and transmitted tot he EST at the end of the test.

Note: The technician can monitor injector operation by listening to the sound each injector produces as it is activated by the ECM. However, in a hard start/no start condition where the oil may be very cold or thick, injectors may not be audible.

If the faults were not erased before this test, the faults found during this test will be displayed as Inactive Codes.

To read these fault codes after the test has been completed, access the Diagnostic Codes menu and read both active and inactive Codes.

Output State Tests, Engine OFF

The Output State Test diagnoses the operation of the output signals and actuators. This test can only be performed by using the EST.

To run this test, select the Output State Test from the EST Engine Off Test menu. The test consists of two modes of operation.

In the OUTPUTS ARE LOW mode, the ECM will pull down the output voltage to their low state. This will actuate the output components that are controlled by the ECM grounding the circuits. The message: OUTPUTS ARE LOW will be displayed on the screen during this test.

In the OUTPUTS ARE HIGH mode, the ECM will pull up the output voltage to their high state. This will actuate the output components that are controlled by the ECM energizing the control circuits. During this test, OUTPUTS ARE HIGH will be displayed on the screen.

During this test, the output of the circuit in question can be monitored with a DVOM. The DVOM will measure a High or Low voltage state condition as the outputs are toggled. The actual voltage will vary with the circuit tested.

Note: The EST will only display OUTPUTS ARE HIGH or OUTPUTS ARE LOW. It will not display any voltages, etc. A breakout box and DVOM are required to monitor the suspected problem circuit or actuator.

Note: Faults will not be set by the ECM during this test.

The following actuators and signals are toggled high and low during the test:

1. Engine Crank Inhibit (relay)
2. Engine to Transmission Data Link
3. Injection Pressure Regulator (IPR)
4. Engine Fan
5. Radiator Shutters
6. Change Oil Light
7. Oil/Water Light
8. Engine Warning Light
9. Vehicle Retarder Relay (VRE)

OPERATOR ON DEMAND TESTS, ENGINE RUNNING

The following tests are performed with the engine running:

Standard Test, Engine Running

During the test, the ECM controls the Injection Pressure Regulator (IPR) following a pre-programmed testing sequence to evaluate the performance of the high pressure oil pump, the IPR and the injection control pressure system as a whole, both from an electrical and a hydraulic perspective.

The ECM monitors the feedback signal values from the Injection Control Pressure (ICP) sensor and compares them to the expected values. At the end of the test, the ECM will return the engine to the normal operating mode and transmit any fault codes that may have been set during the test.

Test Procedure

Select Engine Running Test from the Diagnostic Test menu in the EST and press enter to begin the test.

The ECM will begin to raise the engine idle speed to a predetermined value. It will then command the IPR valve to set the injection control pressure to rated speed pressure. If the performance of the IPR is acceptable, the ECM will control the IPR valve to reduce the pressure in steps while continuing to monitor the performance of the injection control pressure system.

Note: To perform this test, the following conditions should be present: The engine coolant temperature must be at least 160°F (71°C); battery voltage must be higher than 12.5 volts; no vehicle speed sensor (VSS) signal should be present.

Note: If active fault codes are present, they must be repaired and cleared prior to running this test.

After the test is completed, normal engine operation is restored by the ECM and fault codes will be transmitted as previously described.

Injector Cylinder Contribution Test, Engine Running

The Injector Test is designed to detect problems with injection and combustion events. This test will not only detect injector problems, but it will detect any problem that could affect the overall performance of the power cylinder, i.e. valves, pushrods, pistons, rings, etc.

During this test the ECM will control fuel delivery and determine the power contribution of each cylinder. If a cylinder is not performing satisfactorily, a fault code will be set.

Test Procedure

Select Injector Test from the Engine Running Test menu and press enter to begin the test.

The ECM will increase the normal amount of fuel delivery (overfuel) to the injector of the cylinder being tested, and monitor the reduction of fuel required to operate the remaining injectors to maintain a constant engine speed. If the reduction in fuel delivery to the other cylinders is not what the ECM expects, it will set a fault code identifying the noncontributing cylinder.

Note: The engine running standard test must be performed first to gain access to the Injector (engine running) Test.

When testing is completed, normal engine operation is restored and fault codes will be transmitted to the Electronic Service Tool (EST).

Wiggle Test

The purpose of the Wiggle Test is to troubleshoot intermittent connections at sensors and actuators. It may be performed with the engine off or running.

The EST is used to monitor the following circuits during the Wiggle Test.

1. Accelerator Position Sensor (APS)

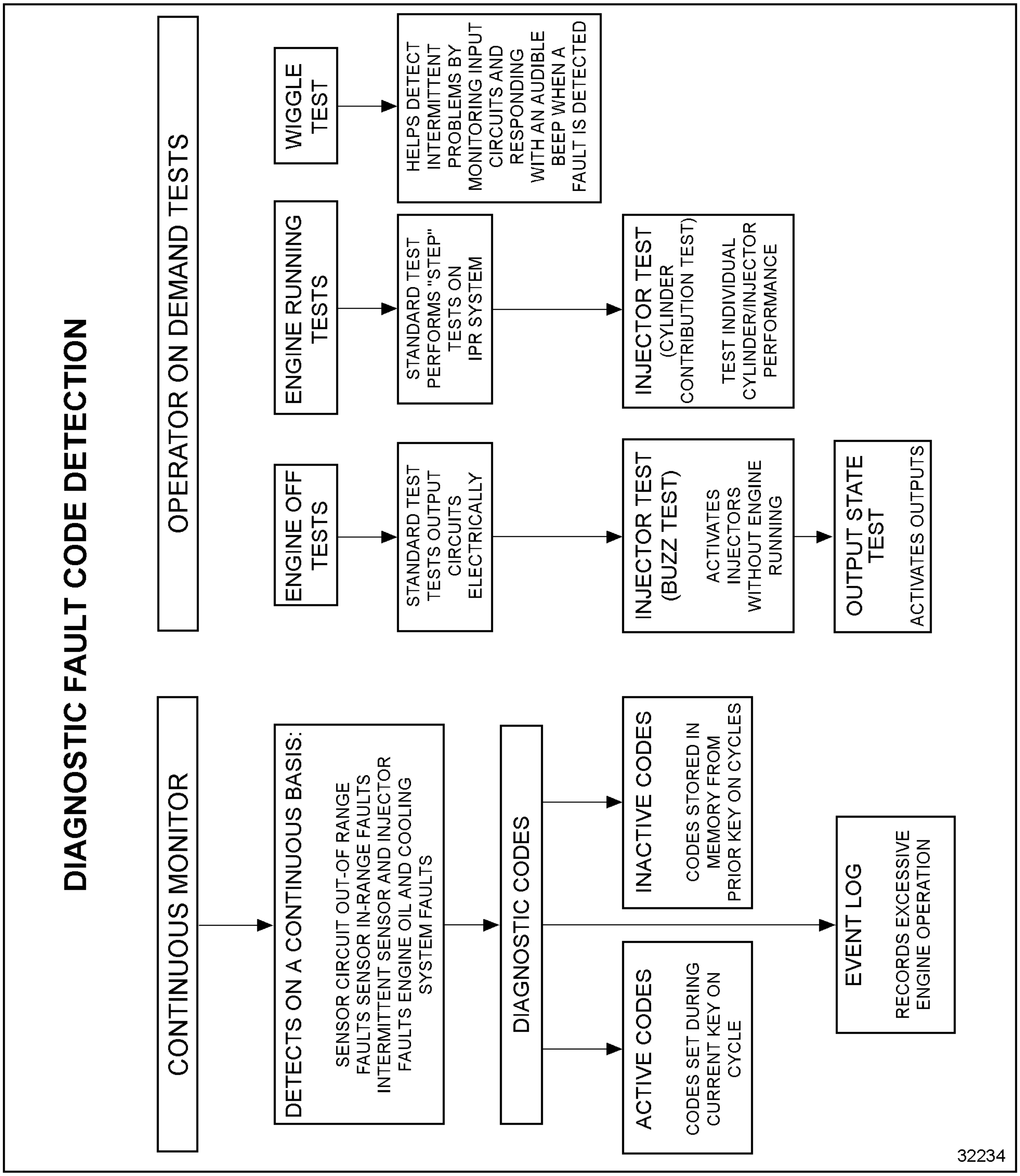
2. Intake Air Temperature Sensor (IAT)
3. Camshaft Position Sensor (CMP)
4. Data Communication Link (DCL)
5. Engine Coolant Temperature (ECT)
6. Engine Oil Pressure (EOP)
7. Injection Control Pressure (ICP)
8. Manifold Absolute Pressure (MAP)
9. Remote Accelerator Pedal Sensor (RPS)
10. Engine Oil Temperature (EOT)
11. Barometric Pressure Sensor (BARO)

Test Procedure

Select the Wiggle Test from the Diagnostic Test menu in the EST and press ENTER to begin the test.

The technician should wiggle connectors and wires at all suspected problem locations. The EST will beep if the circuit continuity is interrupted and will display all fault codes related to the condition.

1



Diagnostic Software Test Chart

HARD START / NO START DIAGNOSTICS

INTRODUCTION

The following pages have supporting information and instructions for the combined Hard Start/No Start diagnostics. Detailed instructions are included on how to perform each test and how to use any specialized equipment. **See Figure** . **See Figure** .

12

SUFFICIENT CLEAN FUEL

[3]The sufficient clean fuel procedure determines if the fuel system is getting sufficient clean fuel to start and operate the engine. For a reproduction of the applicable portion of the diagnostic form, **see Figure**, above.

Test Procedure

Follow this procedure to check for sufficient clean fuel to start and operate the engine:

1. Obtain fuel sample from the fuel tank.

Note: Fuel must be of proper grade, clean and undiluted.

2. Check for air in fuel: Check for leaks in the supply line from the tank to the fuel transfer pump. If in doubt, connect a piece of clear plastic tubing from the filter to the transfer pump inlet. Run the engine and watch for air bubbles. No air bubbles should be present.

Note: Cold weather can cause fuel waxing of certain grades of diesel fuel. This could result in fuel filter plugging.

3. Check fuel odor for the presence of other fuels such as gasoline or kerosene.
4. If engine oil is present in the fuel, it may indicate an injector O-ring leak and

subsequent loss of injection control pressure. If that is suspected, perform the following:

a. Drain some fuel from the fuel filter and check the color of the fuel. If the fuel appears darker in color, compare the fuel to a small quantity of newly purchased fuel to confirm contamination.

b. If comparing the fuel is impossible or inconclusive, remove the fuel filter and cut the filter can using a filter cutter. If the filter element appears black, oil may have entered the fuel system past the injector O-rings.

5. Check the injection control pressure during engine cranking. Use the Electronic Service Tool (EST) or follow the procedure outlined in part 9c of the Diagnostic Form. **Refer to section**

.**Refer to section**

.

Note: If fuel quality is okay and the engine does not start, depress the priming valve plunger. If the plunger offers no resistance, it is an indication that fuel is not present in the system. Perform the fuel pump pressure test as outlined in 11 of the Diagnostic Form to check for fuel pressure. **Refer to section**

.

Low or No Fuel Possible Causes

Causes for low or no fuel follow:

1. No fuel in tank.
2. If equipped with an inline fuel valve, it is shut off.
3. Fuel supply line from the tank(s) is broken or crimped.
4. Fuel is waxed or jelled (most likely in cold weather with No. 2 fuel), the pickup tube in the tank is clogged or cracked. If there is excessive water in the tank, it is likely to freeze, preventing the fuel from being drawn to the engine.
5. If the vehicle is equipped with supplemental filters or water separators, check for plugged filters or leakage that is allowing the fuel system to draw air.
6. Cloudy fuel indicates that the fuel may not be a suitable grade for cold temperatures. Excessive water or contaminants in the fuel may indicate the tank and fuel need to be flushed and cleaned.

Tools Required

Clear container, approximately 1 quart.

VISUAL INSPECTION

[4]Visually inspect the general condition of the engine and look for obvious causes of hard or no start conditions. For a reproduction of the applicable portion of the diagnostic form, **see Figure**
, above.

Test Procedure

Follow this procedure to visually check the general condition of the engine:

1. Inspect entire fuel system for leaks including the tank and lines. Inspect fuel lines for damage (kinks and bends).
2. Check high pressure oil line from high pressure pump to high pressure oil supply manifold for major oil leaks.
3. Inspect entire cooling system, (coolant level in reservoir, hoses, water pump and radiator) for coolant leaks. Check for residue that may have been caused from prior leakage.
4. Check air induction system for leaks. **Refer to section**
.
5. Inspect engine wiring harness for correct routing and ensure that no rubbing or chaffing has occurred Check connections to sensors, relays and control modules. Inspect battery cable connections for corrosion. Check the fuses at the battery. All connections should be seated and in good condition, free from damage and corrosion.

Note: Harness connections fastened to the ECM must be torqued to 35 lb·in.

Possible Causes

The following are possible causes of the hard start/no start condition:

1. Loose or leaking fuel supply lines could cause the fuel system to lose prime.
2. Kinked or blocked fuel supply lines will create restriction to fuel flow.
3. Massive fuel or oil leaks may contribute to no start conditions.
4. Coolant leaks could indicate serious engine problems.
5. Electronic connectors may be damaged or not installed properly, causing a no start condition.

Note: The Camshaft Position sensor (CMP) and the Injection Pressure Regulator valve (IPR) are the two most critical electronic components to inspect when the engine fails to start.

Tools Required

Inspection light.

AIR INDUCTION SYSTEM

The air induction system must be visually inspected.

Air Induction System Inspection

Follow this procedure to inspect the Air Induction System.

1. Inspect the air cleaner housing externally for damage or distortion that could allow unfiltered air to enter the engine.

NOTICE:
Unfiltered air leakage into the induction system can cause accelerated engine wear.

2. Inspect the air cleaner housing internally for end seal movement indicated by polishing where the end seal contacts the air cleaner housing. End seal movement indicates dirt may have passed the air cleaner element and entered the engine.
3. Inspect the air cleaner element for holes, damaged seals, element sooting, end cap denting because of overtightening or damage during servicing.
4. Inspect the air intake hoses and clamps for tightness and positioning over sealing beads.
5. Inspect the chassis mounted air charge cooler and piping.

Air Induction System Pressure Test

Conduct the air induction system pressure test as follows:

1. Mask off the outer diameter of the air cleaner element air inlet with duct tape and plug the air cleaner canister drain.
2. Remove the air cleaner restriction indicator or tubing at the air cleaner. Install a plug to seal the opening.
3. Locate the tap on the cold air discharge pipe that contains a plug. Remove the plug and connect a manually regulated air supply with a pressure gage to the tap opening. **See Figure** .

5

4. Apply 5–8 lb/in.

2

(psi) of air pressure with regulator to pressurize the air induction system. A constant supply of air is needed to compensate for the air loss through opened intake valves.
5. Coat the following areas with the soap solution and check for leaks. Leaks will cause air bubbles to form. **See Figure**

.

c. Air cleaner body surface around the outlet pipe.

d. Air cleaner outlet pipe to air cleaner body junction.

e. All clamped hose and gasket connections between air cleaner outlet and intake manifold valve/valve cover. This includes the connections at the turbocharger.

f. Surface of all air induction piping and hoses between air cleaner and intake manifold/valve cover.

g. When applicable, the air compressor air inlet piping from the air cleaner tube to and including the fitting and the gasket.

h. Piping to the air charge cooler.

6. No leakage is permitted between the air cleaner and the turbocharger (suction side). If leakage at the joints is detected, tighten the hose clamps. If leakage persists, remove the parts to determine the cause. Replace the parts as necessary, using the latest clamps and torques specified. Retest the corrected area.

6

NOTICE:
Any leaks found in the air induction system could have allowed dirt to enter the engine. Dirt entering the engine can cause piston rings to wear abnormally or break (causing high oil consumption), excessive blue smoke, turbocharger compressor wheel pitting and erosion.

ENGINE OIL LEVEL CHECK

[7]The engine oil level check determines if the crankcase contains engine oil of sufficient quantity and quality to enable the injection control pressure system to function properly. For a reproduction of the applicable portion of the diagnostic form, **see Figure**
, above.

Test Procedure

Follow this procedure to check engine oil level:

1. Park the vehicle on level ground. Check the oil level with the oil level gage. If there is no oil or very little oil in the crankcase, the fuel injectors will not operate.

Note: If the oil level on the gage is over the full level, it is possible the engine was incorrectly serviced or fuel is diluting the oil and filling the crankcase. If a substantial amount of fuel is in the oil, the oil will have a fuel odor.

2. Inspect the oil for color. A milky white oil indicates possible coolant contamination and will have an ethylene glycol odor.
3. Check service records for correct oil type and viscosity for the temperature (environment) in which the vehicle is operating. Single weight or 15W40 oil is not recommended for cold ambient temperatures. Oil that has had extended drain intervals will have increased viscosity (become thicker) and will make engine cranking more difficult and starting less reliable at temperatures below freezing. Refer to the lubrication oil chart in the engine operators manual, ***Series 40E Engine Operator's Guide***, 6SE0240, for the correct oil selection for temperature conditions.

Possible Causes

Possible causes for the hard start/no start diagnosis include the following:

1. Oil level low — Oil leak, oil consumption, incorrect servicing
2. Oil level high — Incorrect servicing, fuel dilution from transfer pump or defective injector and defective O-rings
3. Oil contamination with coolant — Oil cooler, head gasket, porosity (accessories i.e. water-cooled air compressors)

INTAKE AND EXHAUST RESTRICTION

[8]A visual inspection of the intake/exhaust restriction will determine if this component is contributing to a no start or hard start condition. For a reproduction of the applicable portion of the diagnostic form, **see Figure** , above.

Note: A high intake or exhaust restriction may cause a considerable amount of black or blue smoke when starting the engine.

Inspection of Intake and Exhaust Restriction

Use the following procedure to visually inspect the intake/exhaust restriction:

1. Air cleaner inlet and ducting to assure that it is not restricted or collapsed.
2. Air cleaner housing, filter element and gaskets for proper installation.
3. Filter-minder to assure the intake restriction is below 25 inches H
2
O. When the filter element reaches maximum allowable restriction, the yellow indicator reaches the top of the window and automatically locks in this position. **See Figure** and **see Figure** .
4. Exhaust system for damaged or restricted pipes.

910

Possible Causes

Possible causes for the hard start/no start diagnosis include the following:

1. Snow, plastic bags or other foreign material may restrict air flow at the air cleaner inlet. On engines recently repaired, rags or cap plugs may have been inadvertently left in the intake system.
2. The tailpipe or muffler may have been damaged or collapsed.
3. Restricted catalytic converter (if equipped).

Tools Required

None required.

EST TOOL — FAULT CODES

[11]For a reproduction of the applicable portion of the diagnostic form, **see Figure** above.

Purpose

The purpose of the EST — Fault Codes check is to determine if the ECM has detected any fault conditions that would cause a hard or no start condition.

Test Procedure

Before starting this procedure, turn all accessories and the ignition off. Then connect the EST tool to the ATA diagnostic connector.

Connect the EST to the American Trucking Association (ATA) diagnostic connector. If the engine is installed in a truck, the connector is located on the lower left kick panel inside the cab. Body builders could locate this connector in other places. The screen of the reader should light up as soon as the tool is plugged in. **See Figure** .
12

Note: The ATA connector supplies power to operate the EST. The EST will automatically power up as soon as it is plugged into the ATA connector.

Turn the ignition switch to the ON position, but do not start the engine. **See Figure** . This will allow the EST to receive data from the electronic control components. Press enter for NAVPAK menu. [13]To access the fault codes, press the ↓ down arrow key to switch to the Diagnostic Codes menu. **See Figure**
.[14]

From the main menu press the ↓ arrow down key to select Diagnostic Codes. The selection will have the ↑↓ symbol on the screen, indicating there are other selections available. By pressing the ↓ key, the other selections will display on the screen. Press ↓ key until Diagnostic Codes displays on the screen. **See Figure** .[15]

Next press enter. You are now in the diagnostic codes selection of the tool. From this point, diagnostic codes can be accessed.

The first option that will appear is ACTIVE CODES. By selecting this option, the fault codes that have been detected on the current (ignition) key ON cycle will be displayed. **See Figure** .16

Press enter. If there are any active codes, the first one will appear on the screen along with a description of the code. The number in the upper left hand corner represents the Flash Code number. This flash code number is referenced on the electronic diagnostic form. The numbers at the bottom of the screen represent the SAE codes. Press ↓ key to access the additional codes. If there are not any codes active, EMPTY will display on the screen.

To access Inactive Codes press the FUNC key. This will access the last prior menu selection. Then press the ↓ key to select INACTIVE CODES. Press the enter key. **See Figure** .17

Inactive codes are faults that have occurred in the previous (ignition) key ON cycles and are now stored in memory. An active code will become an inactive code when the ignition (key) is shut off.

Record all fault codes and refer to the Electronic Diagnostic Form. **Refer to section** , and fault code diagnostics.

Note: All current fault codes must be repaired and cleared before proceeding with further diagnostic testing.

Possible Causes

ECM detectable faults that will cause a no start or hard start condition are:

1. Camshaft position (CMP) sensor inactive faults
2. Injection pressure regulator (IPR) output circuit check fault

Tools Required

Pro-Link 9000, **J 38500–100** .

EST TOOL— ENGINE OFF TESTS

[18]Follow these procedures to access the Electronic Service Tool (EST) — Engine Off Tests. Access Diagnostic Codes menu in the EST and clear all fault codes before performing the Engine Off Tests. For a reproduction of the applicable portion of the diagnostic form, **see Figure**
.

Purpose

The EST Tool — Engine Off Tests are used to determine if there are any electrical malfunctions that can be detected by the ECM Output Circuit Check self test.

Test Procedure

Access the Engine Off Tests in the Diagnostic Tests section of the EST.

Press the FUNC key repeatedly, until the main menu appears on the screen. **See Figure** .[19]

Next, select the Diagnostic Tests menu by pressing the ↓ key until DIAGNOSTIC TESTS is displayed on the screen. Press enter to make this selection. **See Figure** .[20]

Press the ↓ key until ENGINE OFF TESTS is displayed on the screen. At this point, press enter. **See Figure** .[21]

After the enter key is pressed, the EST will command the ECM to perform an Output Circuit Check self test.

When the test is complete, the screen will display the number of faults found in the self test. If there are any additional faults found, press enter and the faults will be displayed. Press the ↓ key to access any additional faults. The test is repeated by selecting STANDARD TEST under the Engine Off Tests menu. Only new faults found will be displayed as Faults Found.

Note: To repeat Engine Off Tests, select STANDARD TEST in the Engine Off Test menu.

Possible Causes

The following are possible causes for the hard start/no start condition:

1. Defective electrical components or circuitry.
2. Injection Pressure Regulator (IPR) output circuit check fault.

Tools Required

Pro-Link 9000, **J 38500–100**
.

Supplemental Diagnostics

If fault codes are set, refer to the Electronic Diagnostic Form; **refer to section**
, and fault code diagnostics.

EST — INJECTOR BUZZ TEST

[22]The following procedure will lead you through the Injector Buzz Test. For a reproduction of the applicable portion of the diagnostic form, **see Figure** .

Purpose

This test will determine if the injectors are functioning correctly electronically, by energizing each injector in a programmed sequence. The ECM will monitor this test and transmit fault codes if any injector(s) or electrical circuitry are not functioning properly.

Test Procedure

Access Diagnostic codes menu in EST and clear all fault codes.

Note: Engine OFF standard test must be performed first in order to access the Injector Buzz Test. Press enter to begin the test.

After the Engine OFF standard tests have been completed, press the ↓ key to access the INJECTOR TEST. If the tool is not on a menu screen, i.e. displaying the fault codes, etc., press the FUNC key. This will access the ENGINE OFF TESTS menu. Press enter to begin the test. **See Figure**

.23

During this test, the injector solenoids will produce an audible clicking sound when actuated. It is possible to detect a malfunctioning injector by listening for the absence of the solenoid clicking sound.

Note: If fault codes were cleared before the Injector Buzz Test, fault codes displayed will be actual faults found during the test. If codes were not cleared before testing, access INACTIVE FAULT CODES from the EST menu to retrieve faults found during this test.

At the completion of the injector test, any faults that have been detected will be displayed. Additional faults can be accessed by pressing the ↓ key.

Record any faults found and **refer to section**

.

Possible Causes

Possible causes for the hard start or no start diagnosis include:

1. Bad wiring harness connection at the injector solenoid
2. Open or shorted engine wiring harness to the injectors
3. Defective injector solenoids
4. Defective ECM

Tools Required

Pro-Link 9000, **J 38500–100**

.

Supplemental Diagnostics

If fault codes are set, refer to the Electronic Diagnostic Form; **refer to section**

, and fault code diagnostics.

STI BUTTON — FLASH CODES

[24]The following procedure will lead you through the Self Test Input (STI) to read faults. **See Figure**

.

Purpose

The purpose of the STI is to read faults detected by the ECM if the Electronic Service Tool (EST) is not available, or the EST cannot receive STI data due to communications or component failures.

Depressing the STI switch while turning the ignition switch to the ON position, will signal the ECM to perform an Output Circuit Check self test. If any faults are detected, the ECM will flash the Warn Engine light to indicate which faults have been detected.

Test Procedure

Depress and hold the STI switch. Turn the ignition switch to the ON position. Do not start the engine. The ECM will begin to perform the self test to check the output circuits.

When the test is completed, the ECM will flash the red Oil/Water light and amber Warn Engine light to signal the fault codes.

Note: Fault codes can be accessed at any time by depressing and holding the STI switch while turning the ignition switch to the ON position. Do not start the engine.

To read the fault codes, it will be necessary to count the number of times the Engine Warn light flashes. The following sequence of events occurs each time the STI switch is depressed to obtain the fault codes.

1. The Oil/Water light will flash one time to indicate the beginning of active fault codes.
2. The Warn Engine light will flash repeatedly signaling the active fault codes.

Note: All fault codes are three digits and code 111 indicates no faults have been detected.

3. Count the number of flashes in sequence. At the end of each digit of the code, there will be a short pause. Three flashes and a pause would indicate the number 3. Therefore, two flashes, a pause, three flashes and a pause, and two flashes and a pause would indicate the code 232. If there is more than one fault code, the Oil Water light will flash once indicating the beginning of another active fault code.

After all the active codes have been flashed, the Oil/Water light will flash twice to indicate the beginning of inactive codes. Count the number of flashes from the Warn Engine light. If there is more than one inactive code, the Oil/Water light will flash once in between each fault code.

After all codes have been sent, the Oil/Water light will flash three times indicating END OF MESSAGE.

To repeat transmission of fault codes, depress the Engine Diagnostics switch to signal the ECM to send all stored fault codes again.

If fault codes are set, refer to the Electronic Diagnostic Form; **refer to section**
, and fault code diagnostics.

Possible Causes

The possible cause of the hard start/no start diagnostics is an electronic component or circuitry failure.

Tools Required

None.

EST TOOL — DATA LIST

[25]The following procedure will lead you through the EST Tool Data List. The test must be performed with fully charged batteries. For a reproduction of the applicable portion of the diagnostic form,see Figure .

Purpose

The purpose of the EST Data List procedure is to determine if the components needed for starting the engine are operating within specifications.

Test Procedure

To measure engine cranking speed, battery voltage and Injection Control Pressure (ICP), it may be possible to read the data on the EST Data List while the engine is cranking. If the voltage drops below 7 volts while cranking, the EST will reset back to start-up. If this occurs, the tool can be used to perform this test by setting a Custom Data List. Refer to section
. Or, refer to section
, to conduct a testing voltage rpm and ICP individually using the Fluke 88 DVOM as an alternative. Also refer to section
.

Note: Turn all accessories and the ignition OFF before connecting the EST tool to the ATA (American Trucking Association) diagnostic connector.

Connect the EST to the ATA diagnostic connector. The screen of the reader should light up as soon as the tool is plugged in.

Turn the ignition switch to the ON position. Do not start the engine. This will allow the EST to receive data from the electronic control components on the unit. The information received will be data indicating the current status of the engine. **See Figure** .[26]

Press the ↓ key until BATT VOLTS displays on the screen. Continue to press the ↓ key until the black dot is on BATT VOLTS. Pressing the number “0” key will add BATT VOLTS to the custom data list. Press FUNC to return to NAVPAK Standard Data List.**See Figure** .[27]

Now press the ↓ key until the black dot is on ENGINE RPM. Press the “0” key to add ENGINE RPM to the custom data list. **See Figure** .[28]

Press the FUNC key to return to the NAVPAK data list. Continue to press the ↓ key until INJ CNTL PSI is highlighted with the black dot. Then press the number “0” key to add INJ CNTL PSI to the Custom Data List. **See Figure** .[29]

The EST is now ready to read data. Crank the engine while observing the data on the screen.

Creating a Custom Data List

From the main menu, select Engine Data List and press enter. **See Figure** .[30]

Press the ↓ key until the black dot displays on the PID to be added to the Custom Data List. Then press the number “0” key. The selected PID will now be added to the bottom of the Custom Data List. **See Figure** .[31]

Pressing the FUNC key one time will toggle back to NAVPAK Data List. **See Figure** .[32]

Using the ↓ or ↑ key to highlight the next PID for the Custom Data List with the black dot, depress the number “0” key to add PID to the bottom of the Custom Data List. **See Figure** .[33]

To remove a PID from the Custom Data List, move the black dot with the ↑↓ key to the desired PID and press the number “0” key. This will remove the PID from the Custom Data List.

Select BATT VOLTS for the first line. Select Engine rpm for the second line and ICP pressure for the third line. The order of the data list will display BATT VOLTS, ENG. RPM and ICP as the first three items on the list.

If the tool cycles on and off due to low voltage, it will now return to the screen START NEW SESSION as displayed below.

Press the → key to move brackets to NO. Pressing ENTER will cause the EST to toggle back to the Custom Data List. **See Figure**
.34

The battery voltage must be 7 or more volts. If the voltage to the ECM drops below 7 volts, the ECM will not remain powered up. If the ECM is not receiving power via the ECM relay, the engine cannot be started.

Engine cranking rpm must be sufficient to generate the required injection control pressure to operate the fuel injectors and to create enough compression heat to ignite the fuel.

A rpm indication of “0” on the EST during engine cranking, indicates the ECM may not be receiving a signal from the Camshaft Position sensor (CMP). Refer to CMP sensor diagnostics. **Refer to section**
.

If the CMP sensor is inoperative, it must be repaired before continuing with troubleshooting. The ECM will not allow the Injector Pressure Regulator (IRP) valve to fully activate without a CMP signal.

If the EST indicates little or no injection control pressure, check the oil level in the oil reservoir (located on the front cover) by:

1. Removing the engine harness connector from the Engine Oil Temperature (EOT) sensor.
2. Loosen and carefully remove the EOT sensor from the front cover. The sensor is positioned below the oil level in the oil reservoir. Removing the sensor will allow the oil in the reservoir to drain out of the opening. If little or no oil is present, refill the reservoir and reinstall the EOT sensor and harness connector.

If the oil reservoir continues to lose its oil level, the engine may not be pumping oil to the reservoir.

Note: The test must be performed with fully charged batteries.

Possible Causes

The following are possible causes of the hard start/no start problem:

1. Low battery voltage due to bad batteries, high resistance at the battery cable connections or in the wiring to the ECM.
2. Defective ECM power relay.
3. Blown 40A inline fuse (located in battery box) that supplies battery power (voltage) to the ECM.
4. Low cranking rpm that may be caused by electrical system malfunctions, incorrect oil or extended oil change intervals in cold ambient temperatures.
5. No engine rpm indication on EST while cranking the engine, a condition possibly caused by CMP sensor or faulty circuitry to the ECM. Check again for fault codes after cranking the engine.
6. Low ICP pressure that may indicate a leak in the high pressure oil system, or a defective CMP sensor. **Refer to section**

   .
7. A defective high pressure oil pump or pump drive will prevent proper injection control pressure. A defective IPR, or electronic controls for the regulator will cause low injection control pressure.

Tools Required

Pro-Link 9000, **J 38500–100**

.

Supplemental Diagnostics

The hard start/no start diagnosis may also be caused by:

1. Low voltage at the ECM. **Refer to section**
.
2. No engine rpm indication during engine cranking. Refer to CMP sensor diagnostics.**Refer to section**
.
3. No injection control pressure. Refer to the ICP sensor found in IPR valve diagnostics. **Refer to section**
.
4. No or low injection control pressure and no electronic faults. **Refer to section**
.

ECM VOLTAGE

[35]Sufficient voltage and current is needed to operate the ECM. For a reproduction of the applicable portion of the diagnostic form,**see Figure** , above.

Purpose

The ECM requires 7 volts minimum to operate and drive the injectors. This is an alternate method to be used if the EST is unavailable or fails to function properly. Insufficient electrical power from the batteries or an electronic failure may inhibit the EST from receiving diagnostic data.

Test Procedure

All tests must be performed with fully charged batteries.

Voltage Measurement at Battery

Use the following procedure to measure voltage at the battery:

1. Turn all accessories off and connect a DVOM (Digital Volt Ohm Meter) across the battery terminals.
2. Crank the engine.

Record the lowest voltage obtained during engine cranking. If the voltage is below 7 volts, the ECM power relay may be resetting due to the lack of voltage and current from the batteries, or a problem exists in the starting system.

If voltage is within specification, perform the voltage measurement at the ECM with a breakout box. **Refer to section**
.

Voltage Measurement at ECM With Breakout Box

Follow these steps to measure voltage at the ECM with a breakout box:

1. Remove the 60–way chassis (lower) connector harness from the ECM.
2. Install the breakout box adaptor connectors to the chassis female connections on the ECM. Again connect the chassis harness connector to the breakout box adaptor connector. Torque the connector to ECM to 35 lb·in. **See Figure** .
36
3. Connect the leads of the voltmeter to each of the three separate test points {(21+ & 1–), (22+ & 2–), (24+ & 23–)} on the breakout box.
4. Record the lowest voltage observed at each of the test points while cranking the engine. **See Figure** .
37
5. If voltage is lower than 7 volts, repair the ECM power feed circuit. **Refer to section**
.

Possible Causes

Possible causes for the hard start/no start diagnosis are:

1. Low battery voltage
2. Bad batteries, high resistance at the battery cable connections or a defective starter
3. Low or no battery voltage to the ECM that may be due to high resistance or an open circuit in the power feed circuit to the ECM, or its power relay. The ECM power circuit fuse located in the battery box may be open or the ECM power relay may be defective.

Tools Required

DVOM and breakout Box, J 43102

Supplemental Diagnostics

Refer to section
, for power circuit diagnostics.

ENGINE CRANKING RPM

[38]The Engine Cranking RPM check determines if engine cranking speed is high enough to start the engine and confirms that the CMP (Camshaft Position) sensor is functioning properly. For a reproduction of the applicable portion of the diagnostic form, see Figure .
, above.

Purpose

This is an alternate method to use if the EST is unavailable or fails to function properly. Insufficient electrical power from the batteries or an electronic failure may inhibit the EST from receiving diagnostic data.

Test Procedure

The following test must be performed with fully charged batteries.

Engine cranking rpm must be sufficient to generate the required injection control pressure to operate the fuel injectors and to create enough compression heat to ignite the fuel.

The following procedure checks cranking rpm with the breakout box.

1. Remove the 60–way engine (upper) connector from the ECM.
2. Install the breakout box adaptor connectors to the engine and chassis female connections on the ECM. Reconnect the engine harness connector to the breakout box adaptor connector. Torque the connector to ECM to 35 lb·in.
3. Connect the +lead of the Fluke 88 to terminal 51, and the —lead to terminal 19. Select the DC voltage scale and press the RPM button. **See Figure** .

39

4. Crank the engine while observing the Fluke 88. A minimum of 130 rpm (26 Hz) is necessary to start the engine.
5. Record the cranking engine rpm on the diagnostic form.

A “0” frequency indication on the Fluke 88 during engine cranking may indicate the ECM is not receiving a signal from the CMP sensor. **Refer to section**
.

If the CMP sensor is inoperative, it must be repaired before continuing. The ECM will not allow the IPR (Injector Pressure Regulator) valve to fully activate without a CMP signal.

Note: If no frequency/engine rpm is measured with the Fluke 88, check for additional fault codes. **Refer to section**
. Also **refer to section**
for Test 5; and **refer to section**
for Test 7.

Possible Causes

Possible causes for the hard start/no start diagnosis include:

1. Low cranking rpm — The starting system electrical malfunctions. Incorrect oil type or extended oil change intervals in cold ambient temperature conditions.
2. No engine rpm — Poor electrical connection at the CMP sensor wiring harness connector, wiring harness to sensor open or shorted. or a defective CMP sensor causing an “0” frequency/engine rpm indication.

Tools Required

Fluke 88 DVOM, **J 34520A**
, and breakout box, **J 43102**
.

Supplemental Diagnostics

Refer to section
, for CMP sensor diagnostics.

INJECTION CONTROL PRESSURE

40 The injection control pressure troubleshooting as it relates to the hard start/no start problem, follows. For a reproduction of the applicable portion of the diagnostic form, **see Figure**
.

Purpose

The purpose of the ICP system check is to determine if the system is supplying sufficient oil pressure to start and operate the engine. This is an alternate method to be used if the EST is unavailable or fails to function properly. Insufficient electrical power from the batteries or an electronic failure may inhibit the EST from receiving diagnostic data.

Test Procedure

There are two methods to measure injection control pressure, with a breakout box or with a breakout T.

Breakout Box Method

To measure injection control pressure using the breakout box, **See Figure**
, and follow this procedure.

41

1. Remove the 60–way connector engine (upper) harness from the ECM.
2. Install the breakout box adaptor connector to the engine connector on the ECM. Reconnect the engine harness connector to the breakout box adaptor connector. Torque the connector to ECM to 35 lb·in.
3. Connect the positive lead of the DVOM to terminal 16 and the negative lead to terminal 19.
4. Crank the engine while observing the DVOM and record the injection control pressure voltage signal on the diagnostic form. If injection control pressure is low, **refer to section**
, Low ICP Pressure Test.

Breakout T Method

Measure the injection control pressure using a breakout T.

1. Remove the engine harness connector at the ICP sensor.
2. Connect the breakout T to the removed engine harness connector and the ICP

sensor.

3. Connect the DVOM leads (+Green, —Black) to the breakout T as shown. **See Figure** .

4. Crank the engine and observe the DVOM voltage reading. Record the reading on the diagnostic form. If voltage is low, check the oil level in the reservoir (at EOT sensor) again to confirm the reservoir contains a sufficient supply of oil to enable the injection control system to function properly. If the oil level is okay, proceed to the Low ICP pressure test, **refer to section**

.

42

Possible Causes

Low injection pressure (voltage) indicates the injectors are not receiving sufficient oil pressure to properly operate the fuel injectors. This may be caused by:

1. No oil in the engine
2. Oil reservoir leak down (possibly through high pressure pump check valve)
3. Defective high pressure pump
4. Injector O-ring leak
5. Injector body leak
6. IPR valve stuck open
7. Pump drive gear loose or damaged

Tools Required

Pro-Link 9000, **J 38500–100**
, or DVOM and ICP sensor Breakout T, **J 43103**
.

Supplemental Diagnostics

Refer to section
, for IPR diagnostics.

LOW INJECTION CONTROL PRESSURE TEST

[43]Use this procedure to troubleshoot the low injection control pressure. For a reproduction of the applicable portion of the diagnostic form, **see Figure** , above.

Purpose

The purpose of this procedure is to isolate the cause of low ICP pressure that prevents the engine from starting.

Test Procedure

Before performing this test, repair all previously detected faults.

1. Remove the engine harness connector from the EOT (Engine Oil Temperature) sensor located on the left rear of the front cover.
2. Remove EOT sensor by loosening and carefully removing the sensor from the front cover. **See Figure** . The sensor is positioned below the oil level in the reservoir. Removing the sensor will allow the oil in the reservoir to drain out of the opening. If little or no oil is present, refill the reservoir and install the EOT sensor and harness connector again. Crank the engine over to determine if it will start. If the engine does not start, proceed to the next step.

44

3. Disconnect the high pressure oil hose from the high pressure oil manifold and

install the adaptor from the Hydraulic Fitting Kit, J 43104, into the end of the hose.
See Figure .
45

4. Disconnect the engine harness connector from the ICP sensor located in the center of the high pressure oil manifold and remove the ICP sensor.
5. Install the sensor into the adaptor located in the disconnected end of the high pressure oil hose.

Note: If the EST is to be used for measuring ICP pressure, connect the ICP engine harness connector to the ICP sensor again. Monitor and record the ICP pressure while cranking the engine.

Note: If the EST is unavailable, follow the remaining steps outlined below to perform the test.

6. Install the Breakout T, J 43103, between the ICP sensor and the ICP engine harness connector.
7. Connect the (+) lead of the DVOM to the green terminal and the (-) lead to the black terminal of the Breakout T.
8. Monitor ICP pressure (signal voltage) while cranking the engine, and record on the diagnostic form.

If the ICP pressure is less than 500 lb/in.
2
(psi) or 1 volt, perform the ICP Leakage Test. **Refer to section**
. If the ICP pressure remains low, perform the following steps:

1. Remove the three cap screws that secure the transfer pump to the housing and pull the transfer pump away from the housing.
2. Crank the engine and observe the transfer pump camshaft for rotation inside the housing. If the transfer pump camshaft is not rotating, remove the high pressure pump and tighten the loose drive gear. Install the high pressure pump again. Check the ICP pressure while cranking the engine, again.
3. If the pressure is still low, replace the IPR valve and check the ICP pressure again.
4. If pressure is still low, replace the high pressure oil pump.

ICP Leakage Test

Perform the leakage test using the following procedure:

1. Remove intake manifold/valve cover.
2. Remove ICP sensor and adaptor plug (used previously) from the high pressure hose. Attach the hose to the oil manifold. Remove the other end of the hose from the high pressure pump and connect an air pressure regulator to the (removed) hose as shown. **See Figure**

.
46

3. Apply 100 lb/in.
2
of air pressure to the oil manifold.
4. Inspect for leakage around the injectors.
5. With the fuel lines removed from the fuel manifold, inspect for oil leakage out of each end of the fuel manifold.

If leakage is observed at an injector, remove and inspect the injector for obvious damage or worn O-rings.

If no leakage is present, perform Injector Buzz Test with air pressure still applied. Observe oil discharge from each of the injectors. Oil discharge should be equal from all injectors. If excess oil is discharged from an injector(s), the injector(s) may be defective.

If it is difficult to distinguish which injector(s) are leaking, remove the air supply and the regulator from the high pressure hose and:

1. Connect an automotive cylinder leak tester to the high pressure hose and apply air pressure via the cylinder leak tester.
2. Conduct an Injector Buzz Test and observe the percent of cylinder leakage while each injector is actuated. Remove and inspect injectors that exhibit a greater amount of leakage compared to the others.
3. If none of the injectors indicate an excessive amount of leakage, remove all injectors. Inspect all O-rings for wear and damage. All O-rings should be replaced.

If oil was entering the fuel system drain the fuel tanks and dispose of the contaminated fuel properly.

Possible Causes

Low injection pressure (voltage) indicates the injectors are not receiving sufficient oil pressure to operate properly. This may be caused by:

1. No oil in the engine
2. Oil reservoir leak down (possibly through high pressure pump check valve)
3. Defective high pressure pump
4. Injector O-ring leak
5. Injector body leak
6. IPR valve stuck open
7. Pump drive gear loose or damaged

Tools Required

Pro-Link 9000 or DVOM and ICP sensor breakout Tee, **J 43103**
, and an ICP adaptor fitting from the Hydraulic Fitting Kit, **J 43104**
.

Supplemental Diagnostics

Camshaft Position sensor diagnostics, **refer to section**
.

FUEL PUMP PRESSURE

[47]Use the following procedure to check the fuel pump pressure. For a reproduction of the applicable portion of the diagnostic form, **see Figure**, above.

Purpose

The purpose of this check is to determine if fuel pressure is sufficient to start and operate the engine.

Note: If the vehicle is equipped with an optional fuel/water separator and a water-in-fuel probe, check with the vehicle operator to determine if the water-in-fuel lamp has been illuminated during vehicle operation.

Test Procedure

Follow this procedure to test the fuel pump pressure.

1. Remove the air bleed valve on the fuel filter header. **See Figure** .
48
2. Install 1/8 in. (3 mm) pipe fitting in place of the bleed valve.
3. Connect a line from the fitting to the Engine Field Test Kit, J 39257. **See Figure** .
49
4. Measure fuel pressure by cranking the engine for 20 seconds and observing maximum pressure. Record the pressure on the diagnostic form, and compare to specifications. If fuel pressure is low, replace fuel filter, clean fuel strainer and test again. If pressure is low on the test the second time, perform the following:

   i. Remove fuel return line and install the plug (to prevent fuel from exiting) into fuel return opening.

   j. Crank engine and observe fuel pressure gage. If pressure rises, replace fuel return valve and check the fuel pressure again. If there is no increase in fuel pressure while the return line is plugged, perform the Transfer Pump Restriction Test. **Refer to section**
   .

Note: It may take a number of crank cycles to purge the air out of the fuel system.

Low Fuel Pressure Possible Causes

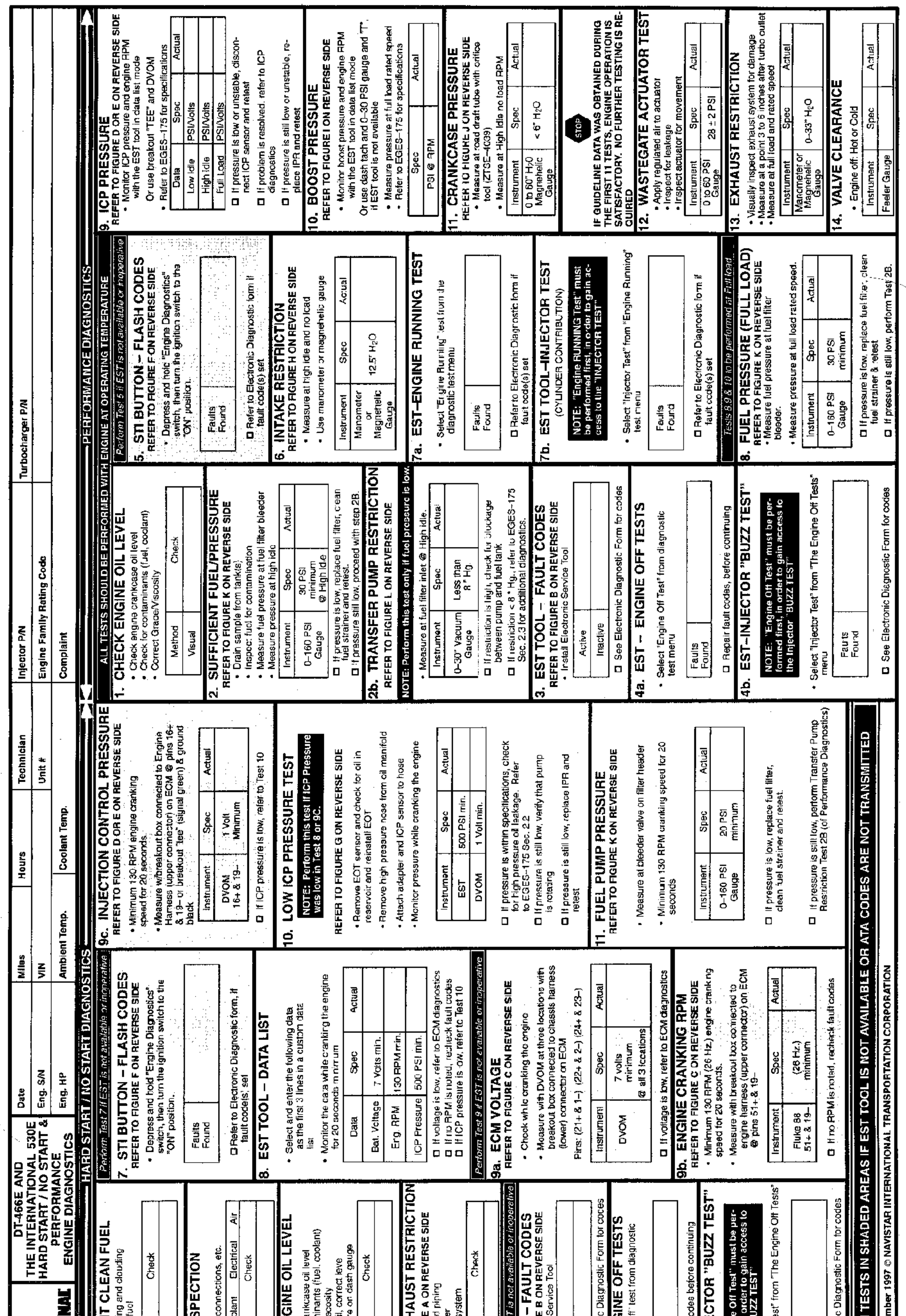
Possible causes for low fuel pressure include:

1. No fuel in tank.
2. A fuel filter or strainer could cause high restriction and low fuel pressure because dirt or fuel could jell in cold ambient temperatures. Replace the fuel filter clean fuel strainer and retest.
3. Debris in the fuel regulator valve may be the cause of low fuel pressure.
4. A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and, therefore, low fuel pressure.
5. A loose fuel line on the suction side of the fuel system could cause air to be ingested into the system and cause low fuel pressure.
6. Defective fuel transfer pump.

Tools Required

Engine Field Test Kit, **J 39257**

1



INTERNATIONAL

DT-466E AND THE INTERNATIONAL 530E HARD START / NO START & PERFORMANCE ENGINE DIAGNOSTICS

Date	Miles	Hours	Technician	Injector P/N	Turbocharger P/N
Eng. S/N	VIN		Unit #	Engine Family Rating Code	
Eng. HP	Ambient Temp.	Coolant Temp.		Complaint	

HARD START / NO START DIAGNOSTICS

1. SUFFICIENT CLEAN FUEL
- Free of Water–Icing and clouding
- Correct grade of fuel

Method	Check
Visual	

2. VISUAL INSPECTION
- Inspect for leaks
- Inspect for loose connections, etc.

Fuel Oil Coolant Electrical Air	
Method	Check
Visual	

3. CHECK ENGINE OIL LEVEL
- Check engine crankcase oil level
- Check for contaminants (fuel, coolant)
- Correct Grade/Viscosity
- Miles/Hours on oil, correct level
- Check oil pressure on dash gauge

Method	Check
Visual	

4. INTAKE/EXHAUST RESTRICTION
REFER TO FIGURE A ON REVERSE SIDE
- Inspect hoses and piping
- Check filter minder
- Inspect exhaust system

Method	Check
Visual	

Perform Test 7 if EST is not available or inoperative

5. EST TOOL – FAULT CODES
REFER TO FIGURE B ON REVERSE SIDE
- Install Electronic Service Tool

Active	
Inactive	

☐ See Electronic Diagnostic Form for codes

6a. EST – ENGINE OFF TESTS
- Select "Engine Off" test from diagnostic test menu

Faults Found	

☐ Repair fault codes before continuing

6b. EST–INJECTOR "BUZZ TEST"

NOTE: "Engine Off Test" must be performed first, in order to gain access to the Injector "BUZZ TEST"

- Select "Injector Test" from "The Engine Off Tests" menu

Faults Found	

☐ See Electronic Diagnostic Form for codes

Perform Test 7 if EST is not available or inoperative

7. STI BUTTON – FLASH CODES
REFER TO FIGURE F ON REVERSE SIDE
- Depress and hold "Engine Diagnostics" switch, then turn the ignition switch to the "ON" position.

Faults Found	

☐ Refer to Electronic Diagnostic form, if fault code(s) set

8. EST TOOL – DATA LIST
- Select and enter the following data as the first 3 lines in a custom data list
- Monitor the data while cranking the engine for 20 seconds minimum

Data	Spec	Actual
Bat. Voltage	7 Volts min.	
Eng. RPM	130 RPM min.	
ICP Pressure	500 PSI min.	

☐ If voltage is low, refer to ECM diagnostics
☐ If no RPM is noted, recheck fault codes
☐ If ICP pressure is low, refer to Test 10

Perform Test 9 if EST is not available or inoperative

9a. ECM VOLTAGE
REFER TO FIGURE C ON REVERSE SIDE
- Check while cranking the engine
- Measure with DVOM at three locations with breakout box connected to chassis harness (lower) connector on ECM

Pins: (21+ & 1–) (22+ & 2–) (24+ & 23–)

Instrument	Spec	Actual
DVOM	7 volts minimum @ all 3 locations	

☐ If voltage is low, refer to ECM diagnostics

9b. ENGINE CRANKING RPM
REFER TO FIGURE C ON REVERSE SIDE
- Minimum 130 RPM (26 Hz.) engine cranking speed for 20 seconds.
- Measure with breakout box connected to engine harness (upper connector) on ECM @ pins 51+ & 19–

Instrument	Spec	Actual
Fluke 88 51+ & 19–	(26 Hz.) minimum	

☐ If no RPM is noted, recheck fault codes

9c. INJECTION CONTROL PRESSURE
REFER TO FIGURE D OR E ON REVERSE SIDE
- Minimum 130 RPM engine cranking speed for 20 seconds.
- Measure w/breakout box connected to Engine Harness (upper connector) on ECM @ pins 16+ & 19– or breakout "tee" (signal green) & ground black

Instrument	Spec	Actual
DVOM 16+ & 19–	1 Volt Minimum	

☐ If ICP pressure is low, refer to Test 10

10. LOW ICP PRESSURE TEST

NOTE: Perform this test if ICP Pressure was low in Test 8 or 9C.

REFER TO FIGURE G ON REVERSE SIDE
- Remove EOT sensor and check for oil in reservoir and reinstall EOT
- Remove high pressure hose from oil manifold
- Attach adapter and ICP sensor to hose
- Monitor pressure while cranking the engine

Instrument	Spec	Actual
EST	500 PSI min.	
DVOM	1 Volt min.	

☐ If pressure is within specifications, check for high pressure oil leakage. Refer to EGES-175 Sec. 2.2
☐ If pressure is still low, verify that pump is rotating
☐ If pressure is still low, replace IPR and retest

11. FUEL PUMP PRESSURE
REFER TO FIGURE K ON REVERSE SIDE
- Measure at bleeder valve on filter header
- Minimum 130 RPM cranking speed for 20 seconds

Instrument	Spec	Actual
0–160 PSI Gauge	20 PSI minimum	

☐ If pressure is low, replace fuel filter, clean fuel strainer and retest.
☐ If pressure is still low, perform Transfer Pump Restriction Test 2B (of Performance Diagnostics)

PERFORM TESTS IN SHADED AREAS IF EST TOOL IS NOT AVAILABLE OR ATA CODES ARE NOT TRANSMITTED

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PERFORMANCE DIAGNOSTICS

ALL TESTS SHOULD BE PERFORMED WITH ENGINE AT OPERATING TEMPERATURE

1. CHECK ENGINE OIL LEVEL
- Check engine crankcase oil level
- Check for contaminants (fuel, coolant)
- Correct Grade/Viscosity

Method	Check
Visual	

2. SUFFICIENT FUEL/PRESSURE
REFER TO FIGURE K ON REVERSE SIDE
- Drain sample from tank(s)
- Inspect fuel for contamination
- Measure fuel pressure at fuel filter bleeder
- Measure pressure at high idle

Instrument	Spec	Actual
0–160 PSI Gauge	30 PSI minimum @ High Idle	

☐ If pressure is low, replace fuel filter, clean fuel strainer and retest.
☐ If pressure still low, proceed with step 2B.

2b. TRANSFER PUMP RESTRICTION
REFER TO FIGURE L ON REVERSE SIDE

NOTE: Perform this test only if fuel pressure is low.

- Measure at fuel filter inlet @ High idle.

Instrument	Spec	Actual
0–30" Vacuum Gauge	Less than 8" Hg.	

☐ If restriction is high, check for blockage between pump and fuel tank
☐ If restriction < 8" Hg., refer to EGES-175 Sec. 2.3 for additional diagnostics.

3. EST TOOL – FAULT CODES
REFER TO FIGURE B ON REVERSE SIDE
- Install Electronic Service Tool

Active	
Inactive	

☐ See Electronic Diagnostic Form for codes

4a. EST – ENGINE OFF TESTS
- Select "Engine Off Test" from diagnostic test menu

Faults Found	

☐ Repair fault codes, before continuing

4b. EST–INJECTOR "BUZZ TEST"

NOTE: "Engine Off Test" must be performed first, in order to gain access to the Injector "BUZZ TEST"

- Select "Injector Test" from "The Engine Off Tests" menu

Faults Found	

☐ See Electronic Diagnostic Form for codes

Perform Test 5 if EST is not available or inoperative

5. STI BUTTON – FLASH CODES
REFER TO FIGURE F ON REVERSE SIDE
- Depress and hold "Engine Diagnostics" switch, then turn the ignition switch to the "ON" position.

Faults Found	

☐ Refer to Electronic Diagnostic form if fault code(s) set

6. INTAKE RESTRICTION
REFER TO FIGURE H ON REVERSE SIDE
- Measure at high idle and no load
- Use manometer or magnehelic gauge

Instrument	Spec	Actual
Manometer or Magnehelic Gauge	12.5" H_2O	

7a. EST–ENGINE RUNNING TEST
- Select "Engine Running" test from the diagnostic test menu

Faults Found	

☐ Refer to Electronic Diagnostic form if fault code(s) set

7b. EST TOOL–INJECTOR TEST
(CYLINDER CONTRIBUTION)

NOTE: "Engine RUNNING Test" must be performed first, in order to gain access to the "INJECTOR TEST"

- Select "Injector Test" from "Engine Running" test menu

Faults Found	

☐ Refer to Electronic Diagnostic form if fault code(s) set

Tests 8,9 & 10 to be performed at Full load

8. FUEL PRESSURE (FULL LOAD)
REFER TO FIGURE K ON REVERSE SIDE
- Measure fuel pressure at fuel filter bleeder.
- Measure pressure at full load rated speed.

Instrument	Spec	Actual
0–160 PSI Gauge	30 PSI minimum	

☐ If pressure is low, replace fuel filter, clean fuel strainer & retest
☐ If pressure is still low, perform Test 2B.

9. ICP PRESSURE
REFER TO FIGURE D OR E ON REVERSE SIDE
- Monitor ICP pressure and engine RPM with the EST tool in data list mode

Or use breakout "TEE" and DVOM
- Refer to EGES-175 for specifications

Data	Spec	Actual
Low Idle	PSI/Volts	
High Idle	PSI/Volts	
Full Load	PSI/Volts	

☐ If pressure is low or unstable, disconnect ICP sensor and retest
☐ If problem is resolved, refer to ICP diagnostics
☐ If pressure is still low or unstable, replace IPR and retest

10. BOOST PRESSURE
REFER TO FIGURE I ON REVERSE SIDE
- Monitor boost pressure and engine RPM with the EST tool in data list mode

Or use dash tach and 0–30 PSI gauge and "T", if EST tool is not available
- Measure pressure at full load rated speed
- Refer to EGES-175 for specifications

Spec	Actual
PSI @ RPM	

11. CRANKCASE PRESSURE
REFER TO FIGURE J ON REVERSE SIDE
- Measure at road draft tube with orifice tool (ZTSE-4039)
- Measure at High Idle no load RPM

Instrument	Spec	Actual
0 to 60" H_2O Magnehelic Gauge	< 6" H_2O	

STOP

IF GUIDELINE DATA WAS OBTAINED DURING THE FIRST 11 TESTS, ENGINE OPERATION IS SATISFACTORY. NO FURTHER TESTING IS REQUIRED

12. WASTEGATE ACTUATOR TEST
- Apply regulated air to actuator
- Inspect for leakage
- Inspect actuator for movement

Instrument	Spec	Actual
0 to 60 PSI Gauge	28 ± 2 PSI	

13. EXHAUST RESTRICTION
- Visually inspect exhaust system for damage
- Measure at a point 3 to 6 inches after turbo outlet
- Measure at full load and rated speed

Instrument	Spec	Actual
Manometer or Magnehelic Gauge	0–33" H_2O	

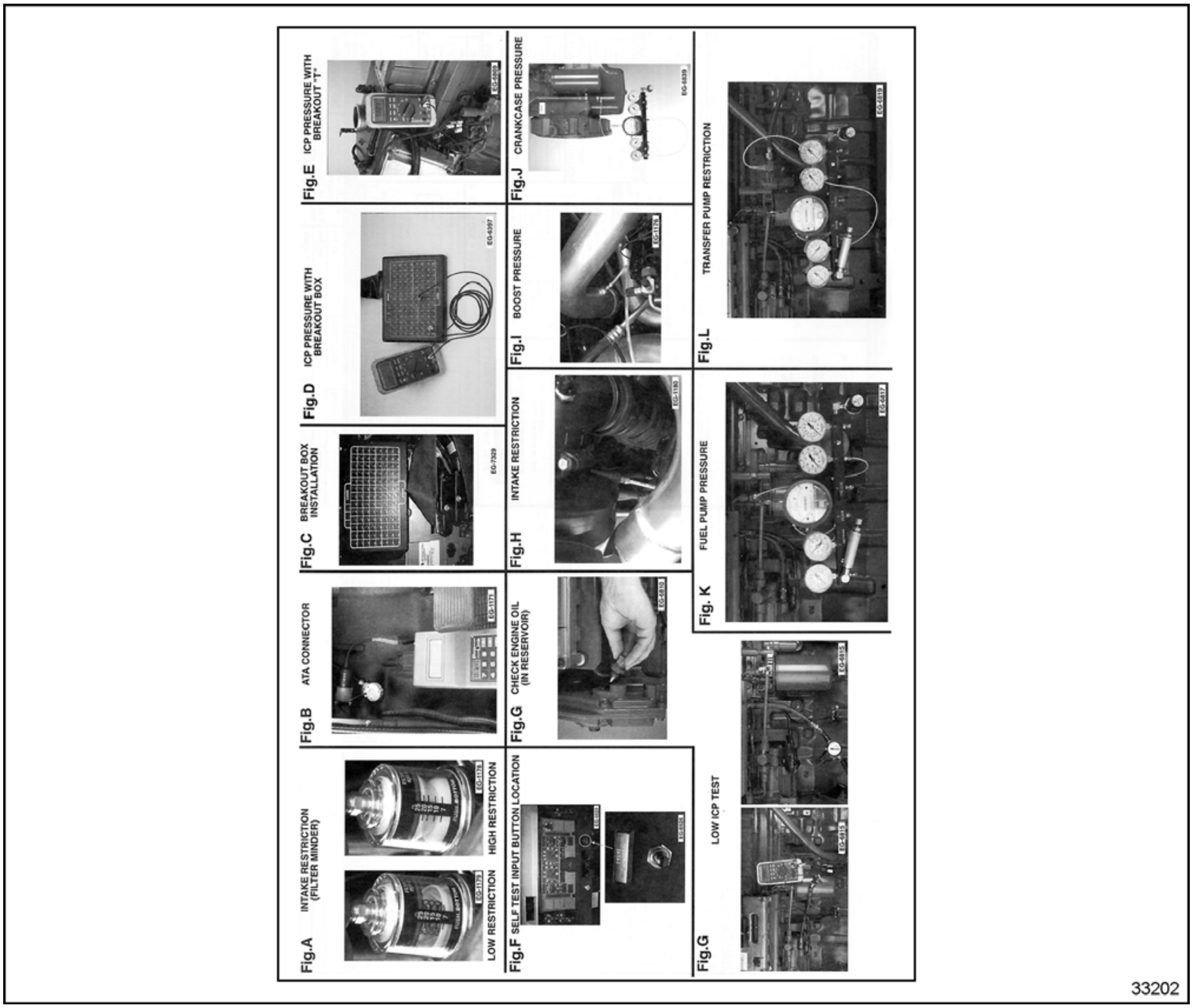
14. VALVE CLEARANCE
- Engine off: Hot or Cold

Instrument	Spec	Actual
Feeler Gauge		

33201

Hard Start No/Start Diagnostic Form (Side One)

2



Hard Start No/Start Diagnostic Form (Side Two)

3

1. SUFFICIENT CLEAN

- Free of Water - Icing and Clouding
- Correct grade of fuel

Method	Check
Visual	

33237

Diagnostic Form

4

2. VISUAL INSPECTION

- Inspect for leaks
- Inspect for loose connections, etc.

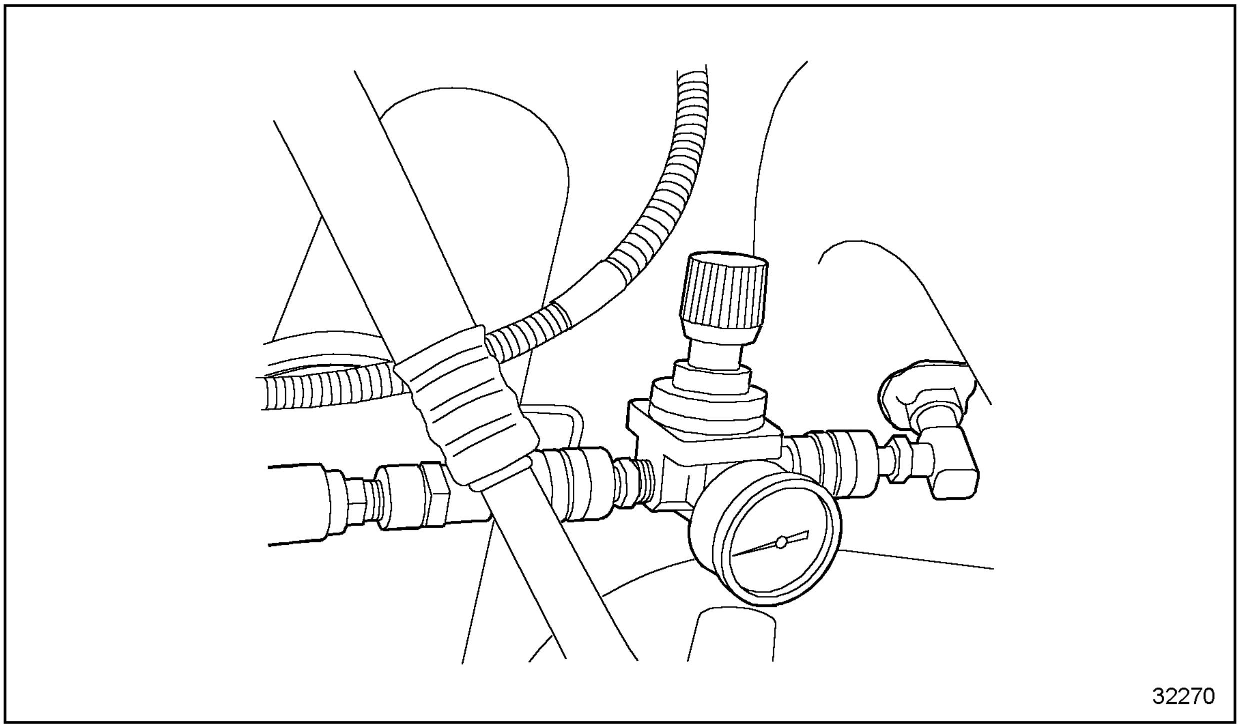
Fuel	Oil	Coolant	Electrical	Air

Method	Check
Visual	

33238

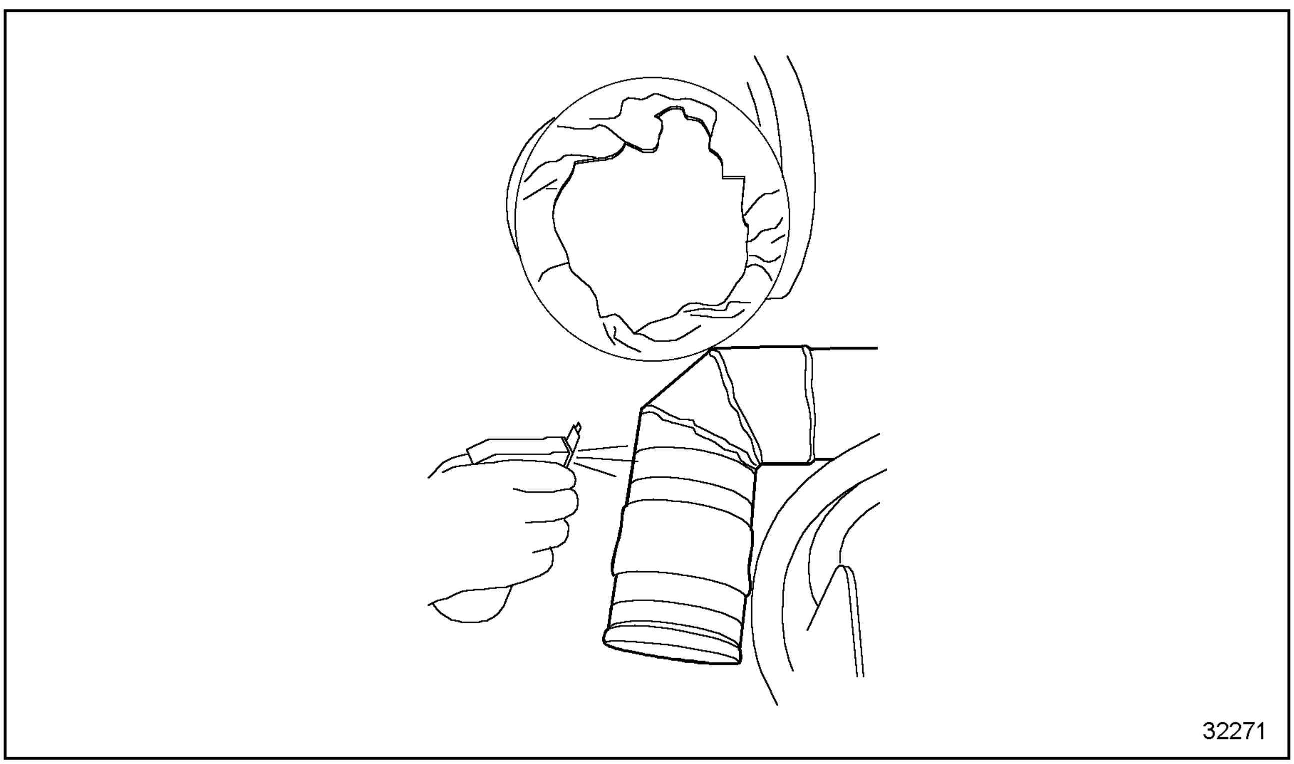
Diagnostic Form

5



Regulated Air Supply

6



Air Induction System Leakage

7

3. CHECK ENGINE OIL LEVEL

- Check engine crankcase oil level
- Check for contaminants (fuel, coolant)
- Correct grade/Viscosity
- Miles/Hours on oil, correct level
- Check oil pressure on dash gauge

Method	Check
Visual	

33239

Diagnostic Form

8

4. INTAKE / EXHAUST RESTRICTION

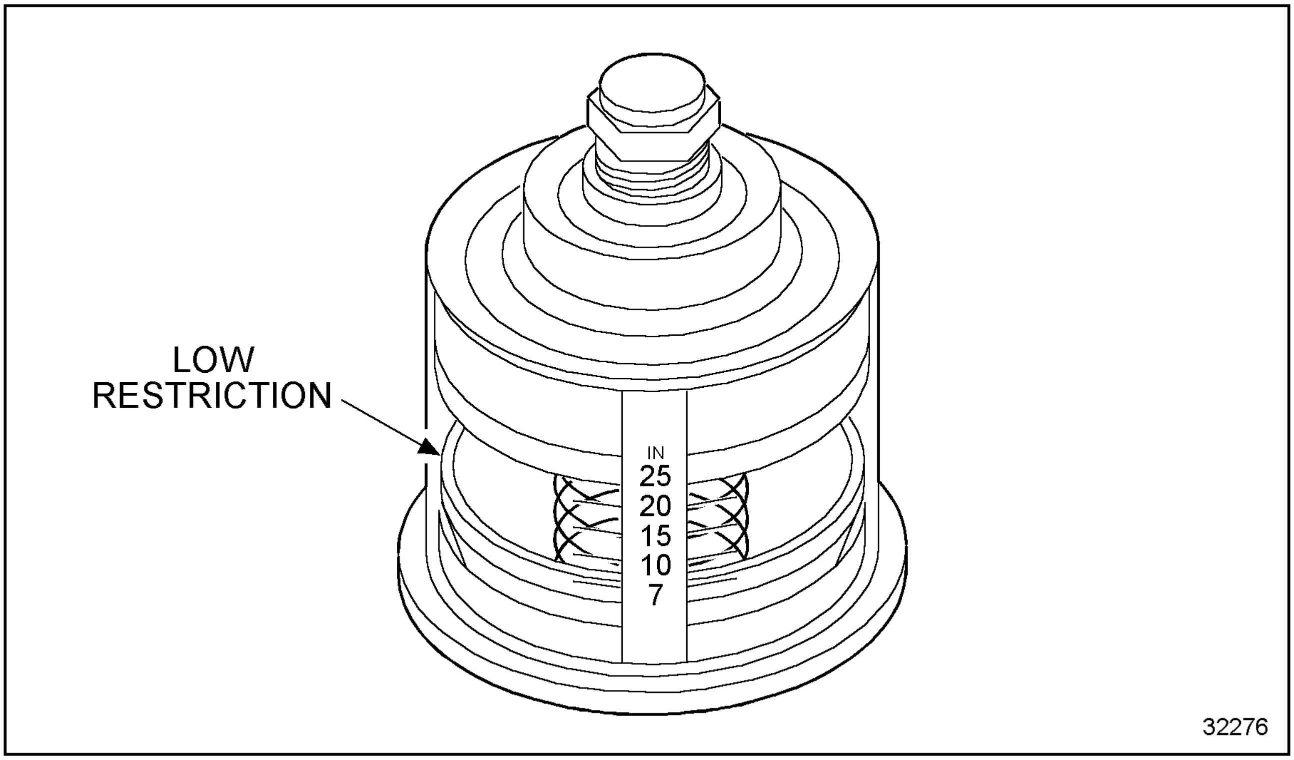
- Inspect hoses and piping
- Check filter minder
- Inspect exhaust system

Method	Check
Visual	

33240

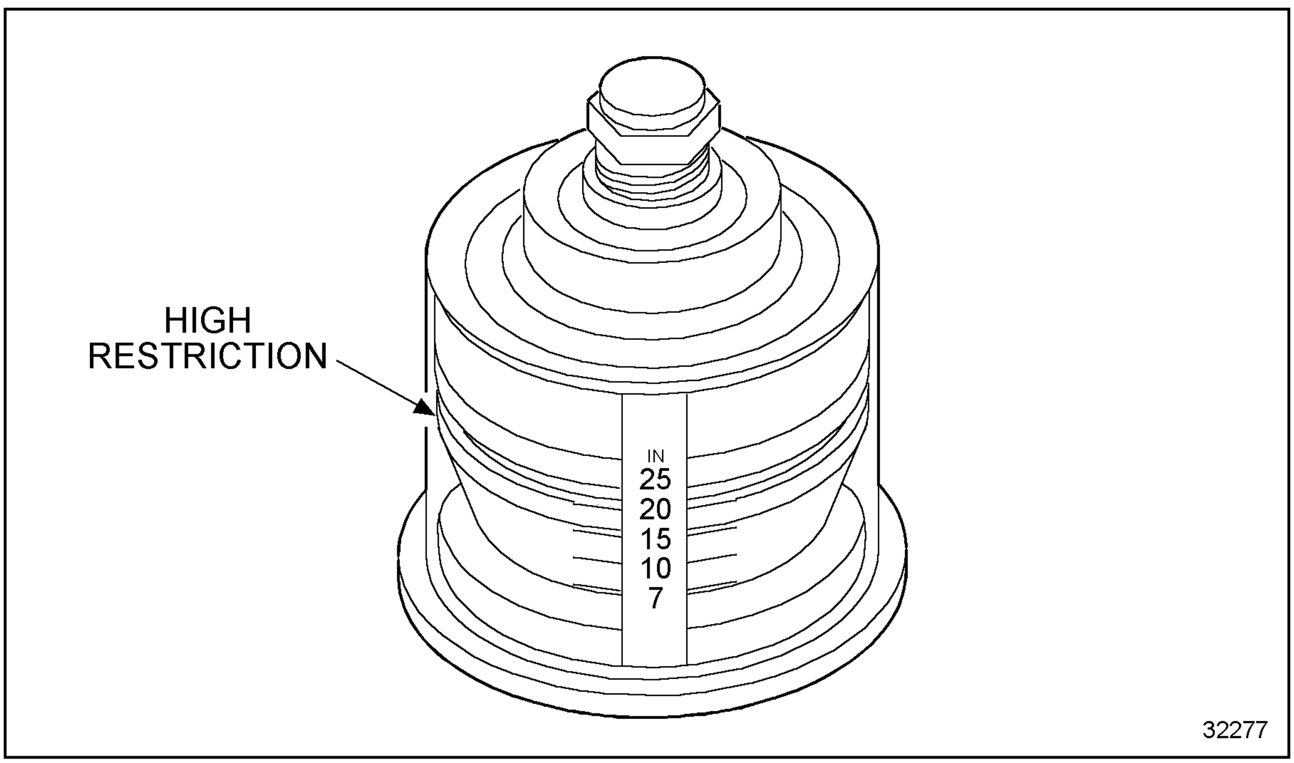
Diagnostic Form

9



Low Restriction

10



High Restriction

11

3. EST TOOL - FAULT CODES

• Install Electronic Service Tool

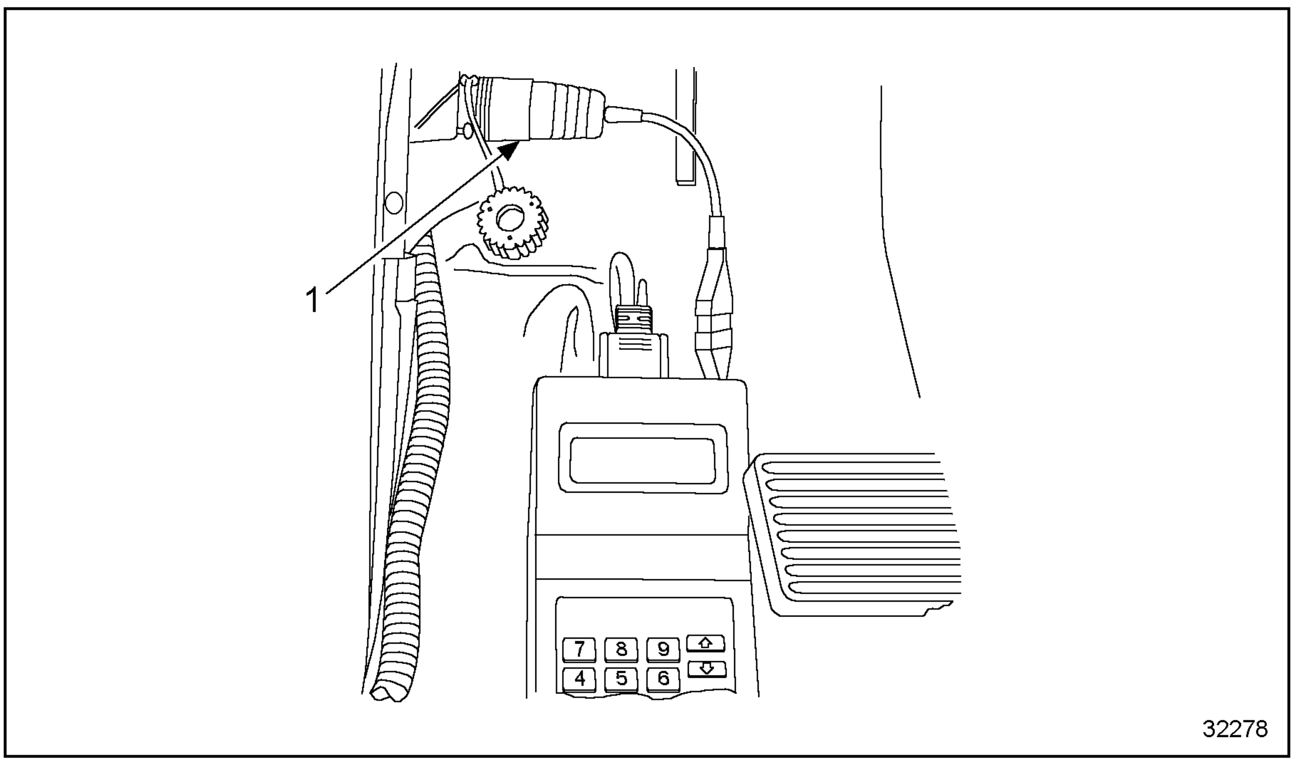
Active	
Inactive	

☐ See Electronic Diagnostic Form for codes

33273

Diagnostic Form

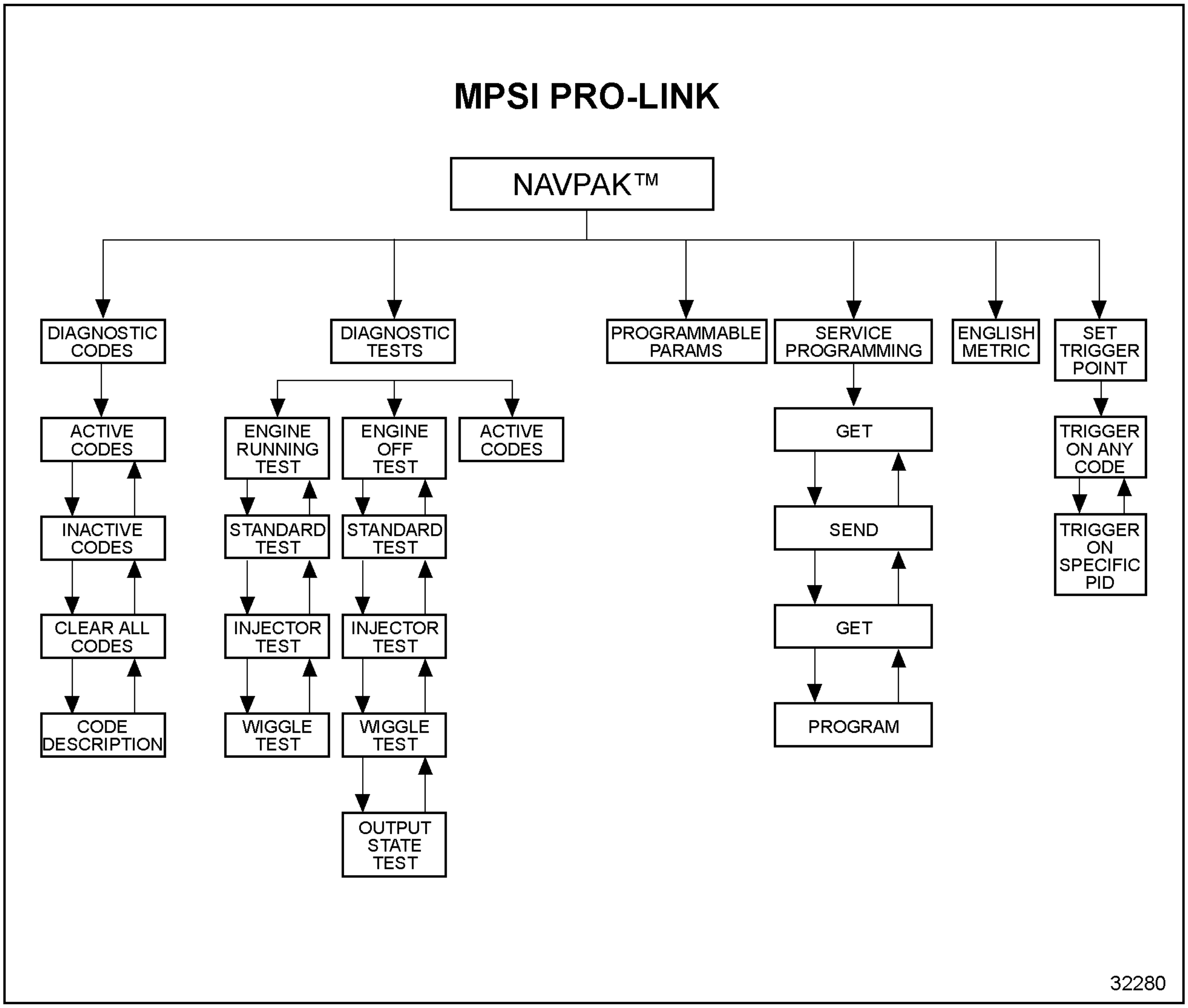
12



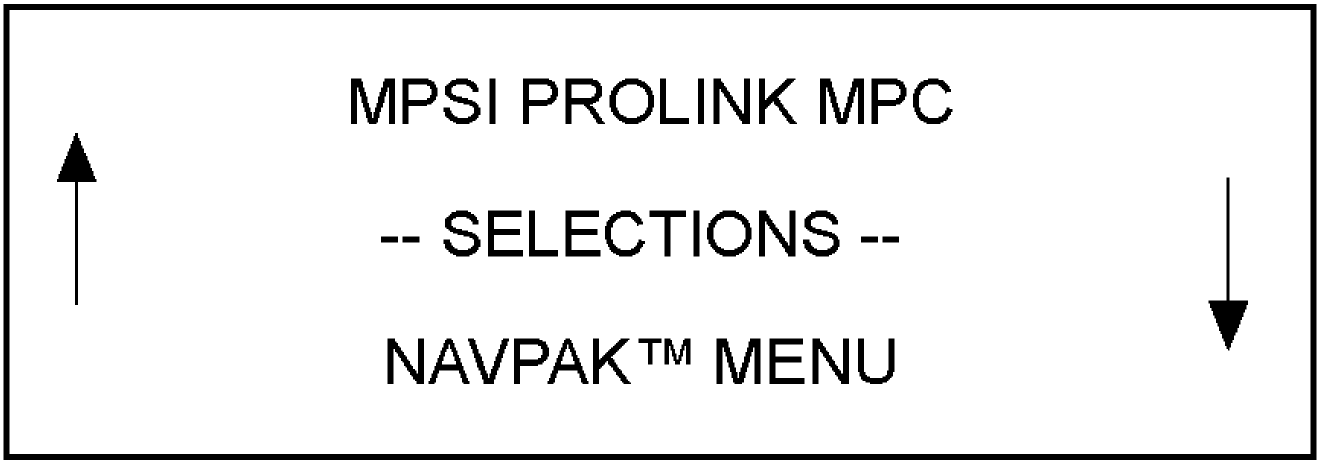
1. ATA Connector	

Electronic Service Tool / ATA Connector Location

13



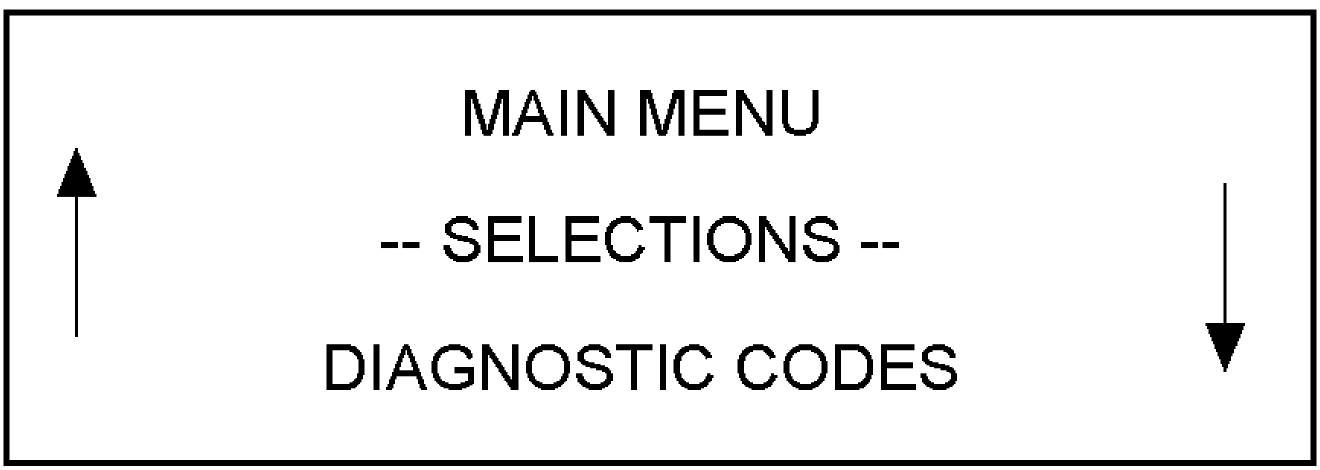
MPSI Pro-Link



33242

MPSI Menu

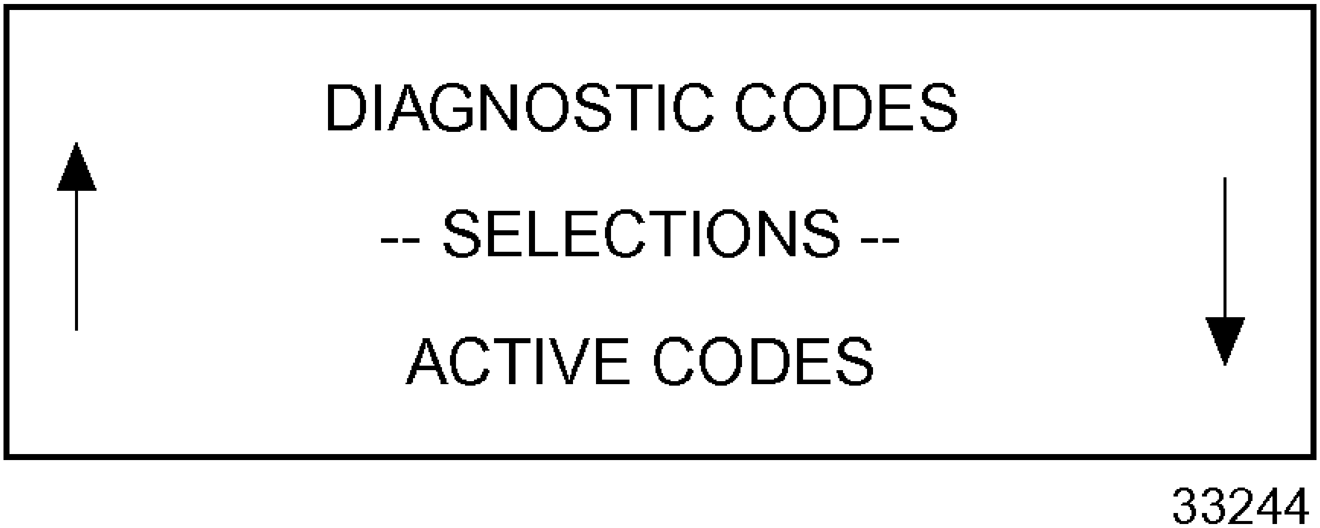
15



33243

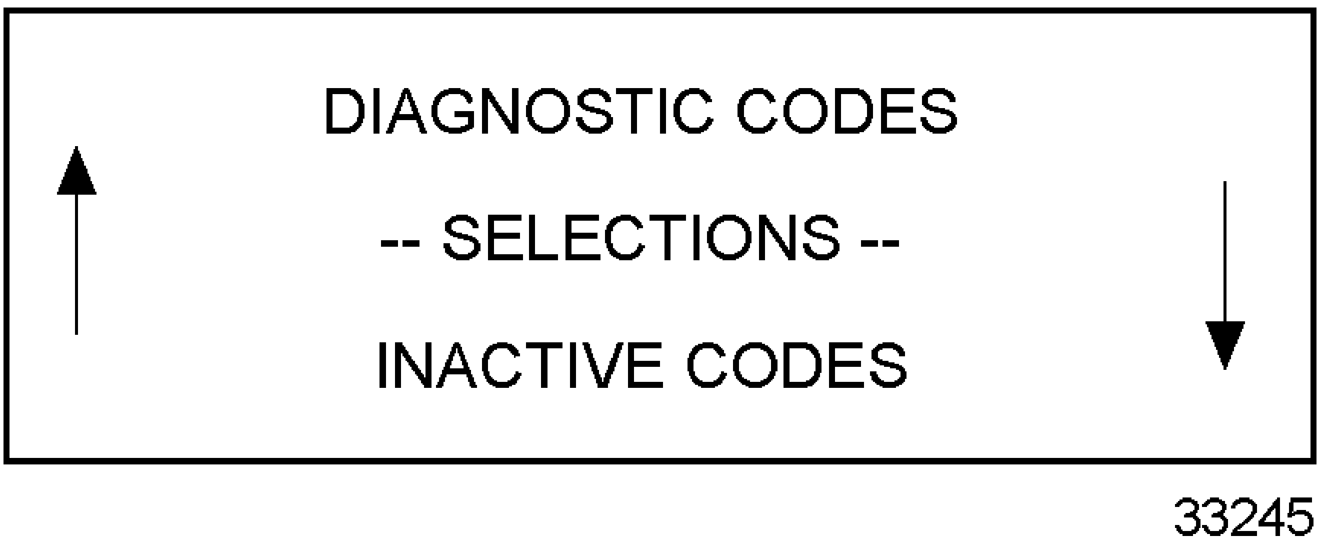
Main Menu

16



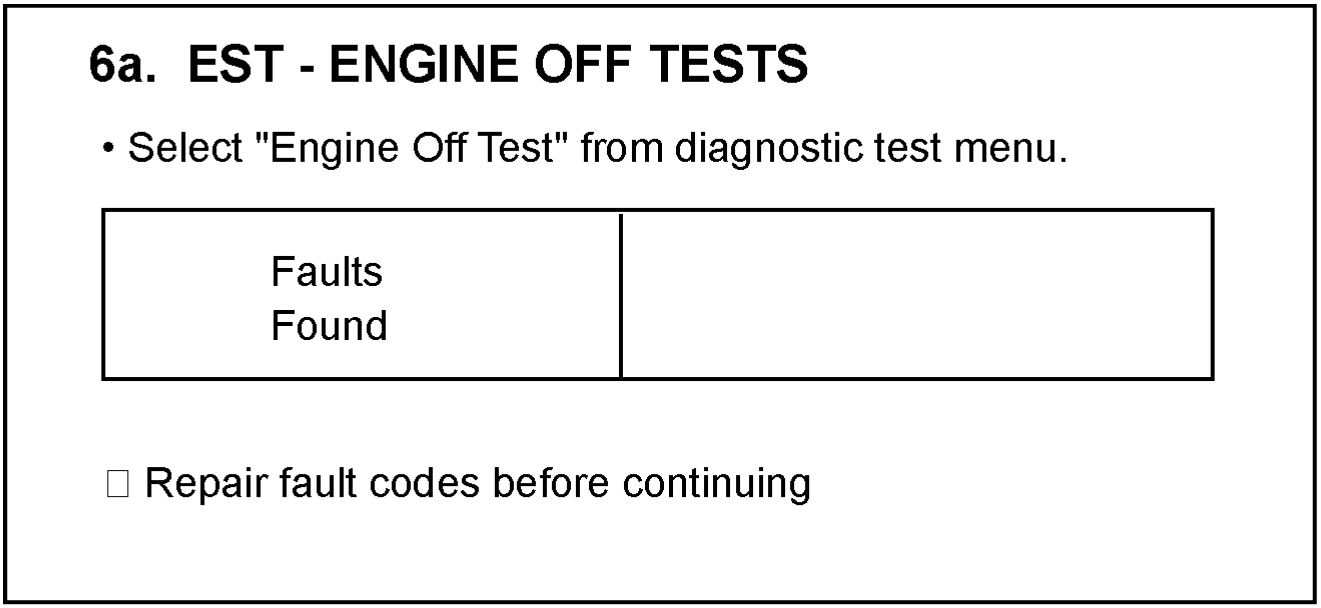
Diagnostic Codes Menu

17



Diagnostic Codes Menu

18



6a. EST - ENGINE OFF TESTS

- Select "Engine Off Test" from diagnostic test menu.

Faults Found	

☐ Repair fault codes before continuing

33246

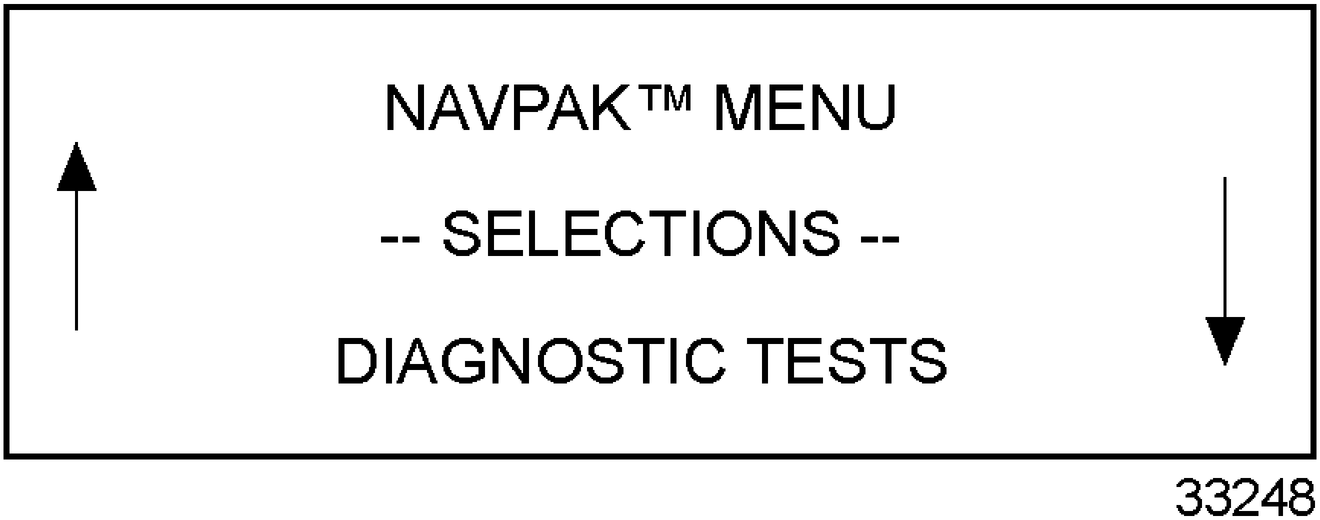
Diagnostic Form

19

33247

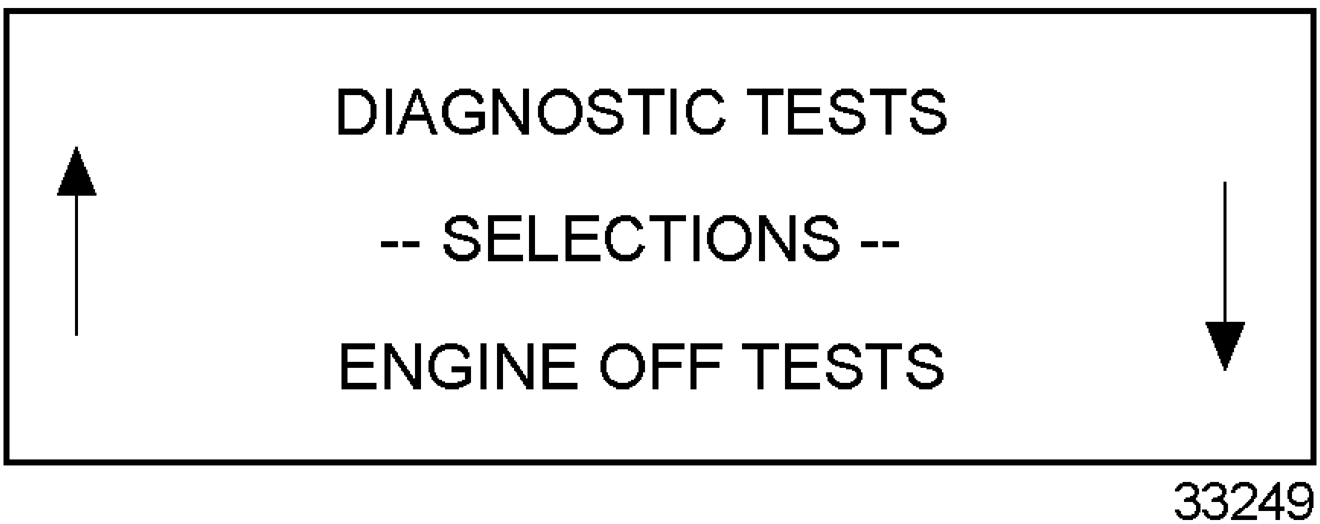
MPSI Menu

20



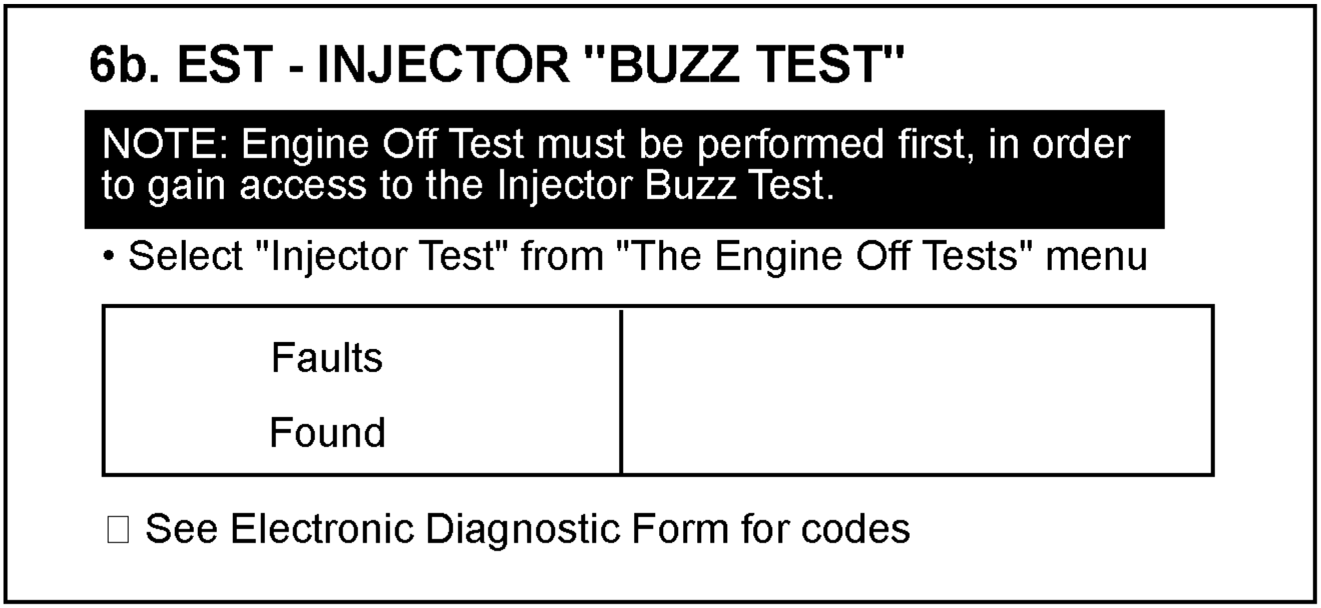
Navpak Menu

21



Diagnostic Tests Menu

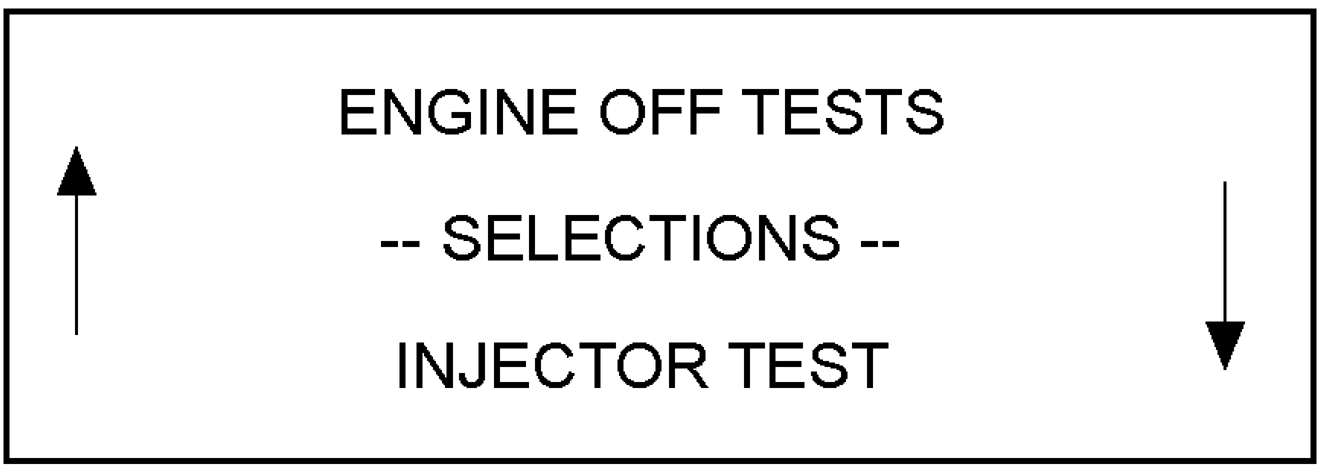
22



33250

Diagnostic Form

23



33251

Engine OFF Tests Menu

24

7. STI BUTTON - FLASH CODES

• Depress and hold "Engine Diagnostics" switch, then turn the ignition switch to the "ON" position.

Faults Found	

Refer to Electronic Diagnostic form, if fault code(s) set.

33252

Diagnostic Form

25

8. EST TOOL - DATA LIST

- Select and enter the following data as the first 3 lines in a custom data list.
- Monitor the data while cranking the engine for 20 seconds minimum.

Data	Specification	Actual
Battery voltage	7 volts minimum	
Engine rpm	130 rpm minimum	
ICP pressure	500 psi minimum	

☐ If voltage is low, refer to ECM PWR diagnostics

☐ If no RPM is noted, recheck fault codes

☐ If ICP pressure is low, refer to Test 10

33236

Diagnostic Form

26

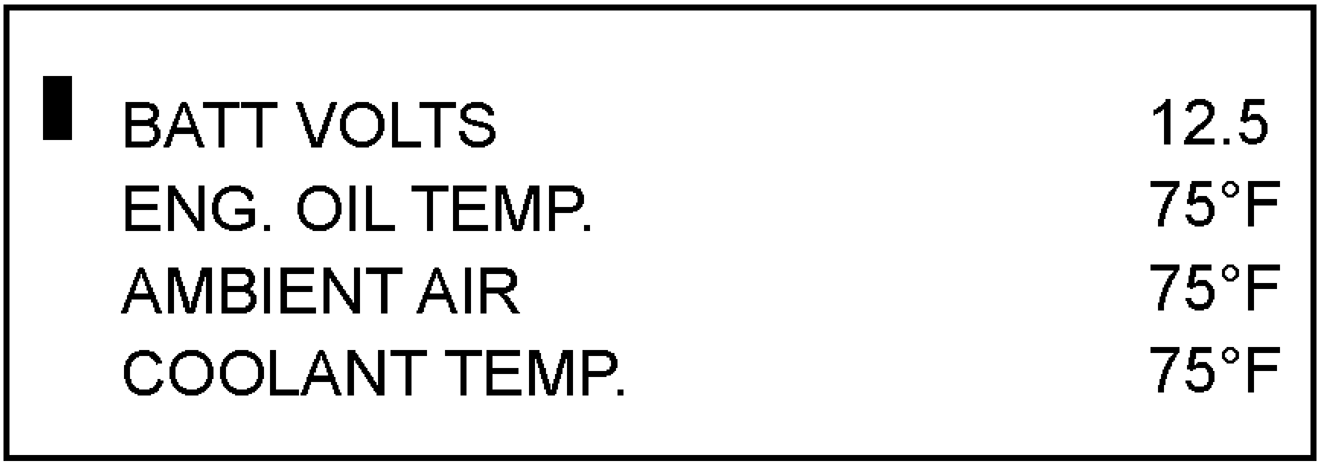
NAVPAK™ DATA LIST

RATED HP	175
RATED RPM	2300
ACTIVE CODES	NO
INACTIVE CODES	NO

33253

Data List

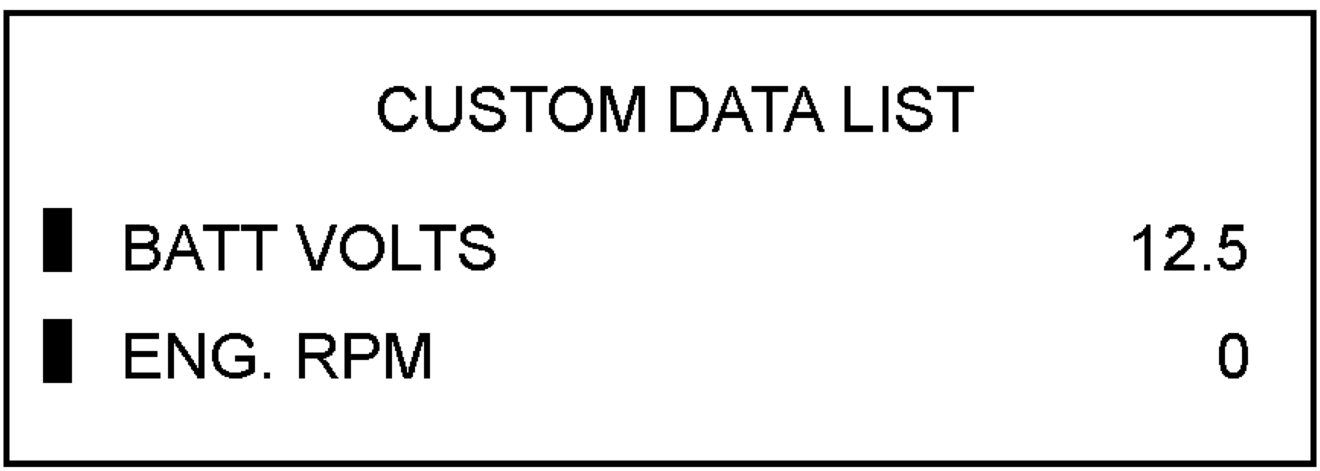
27



33254

Data List

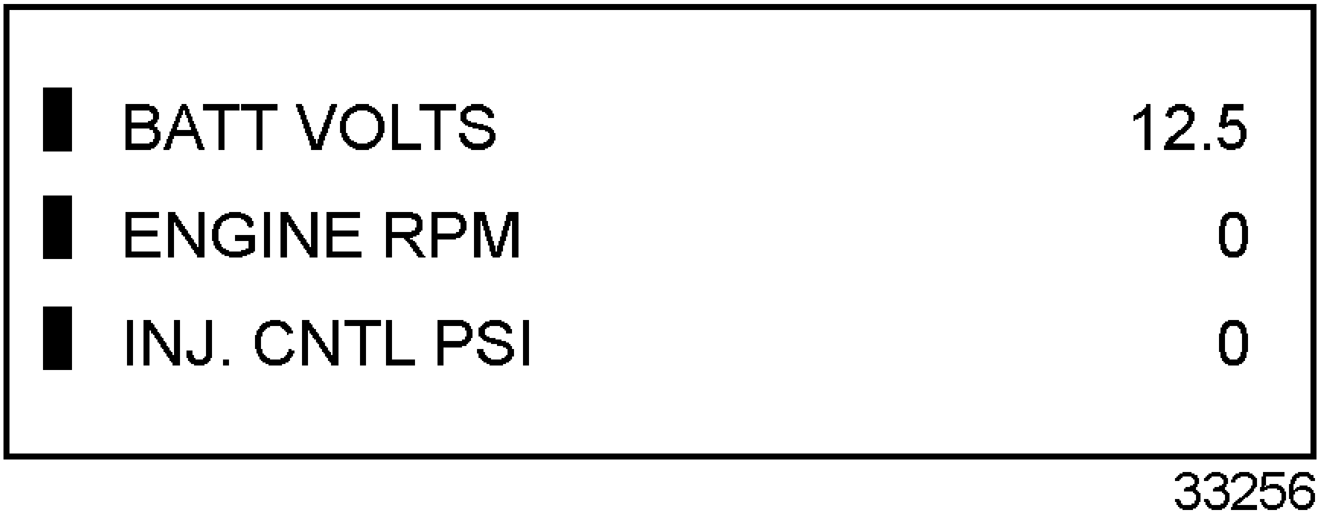
28



33255

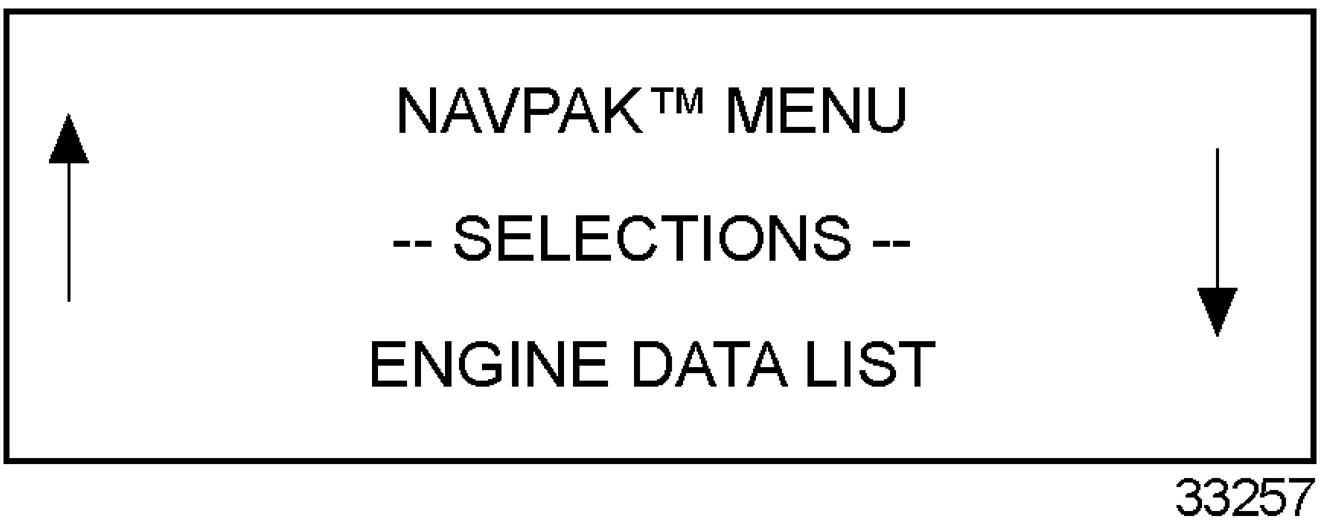
Data List

29



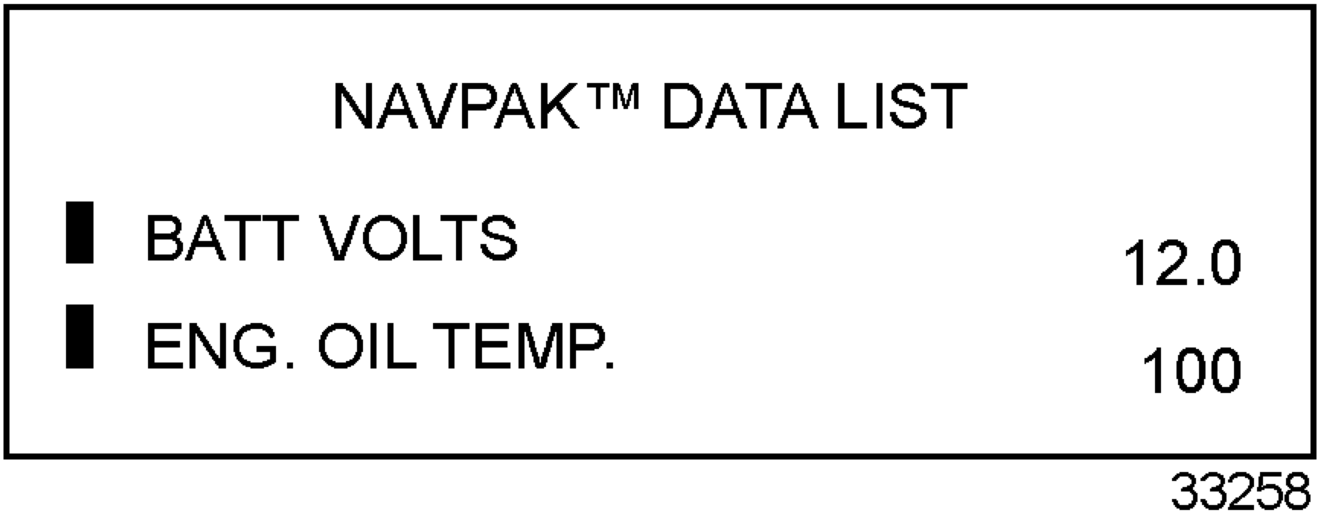
Data List

30



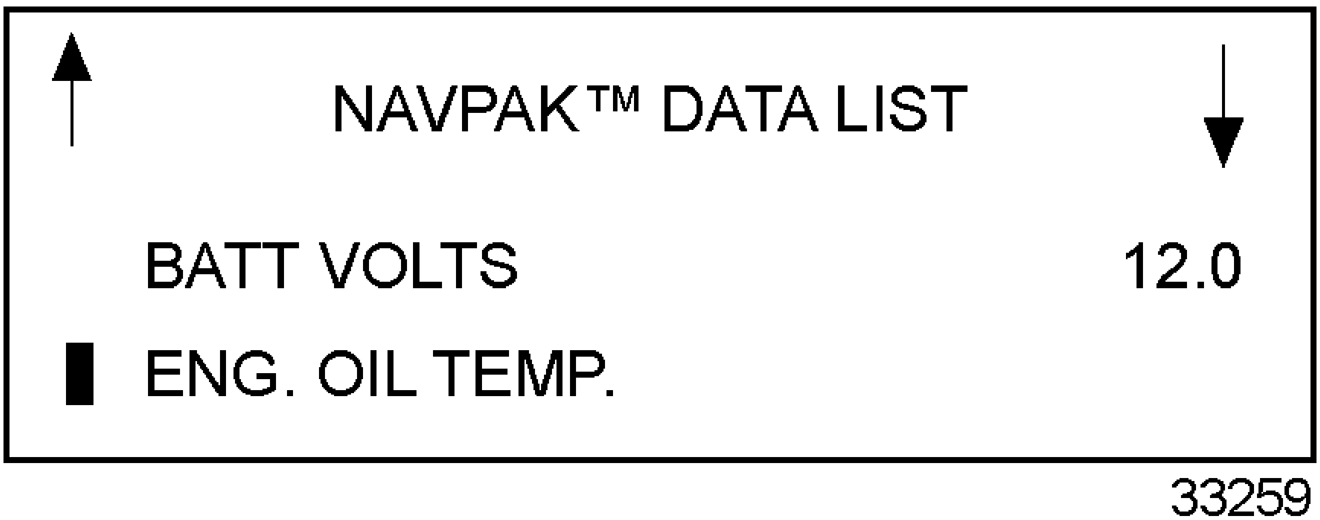
Main Menu

31



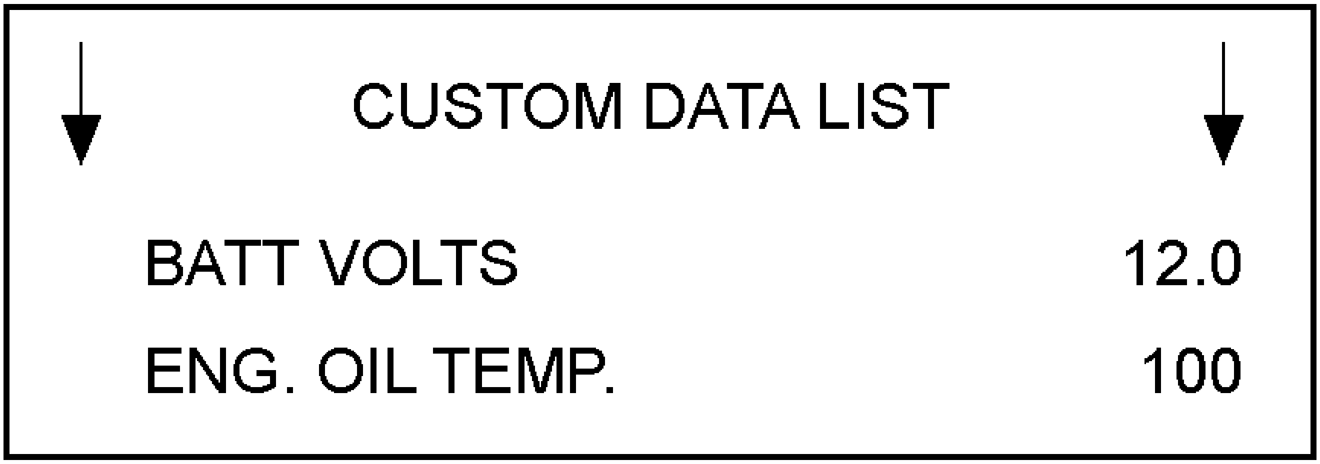
Data List

32



Data List

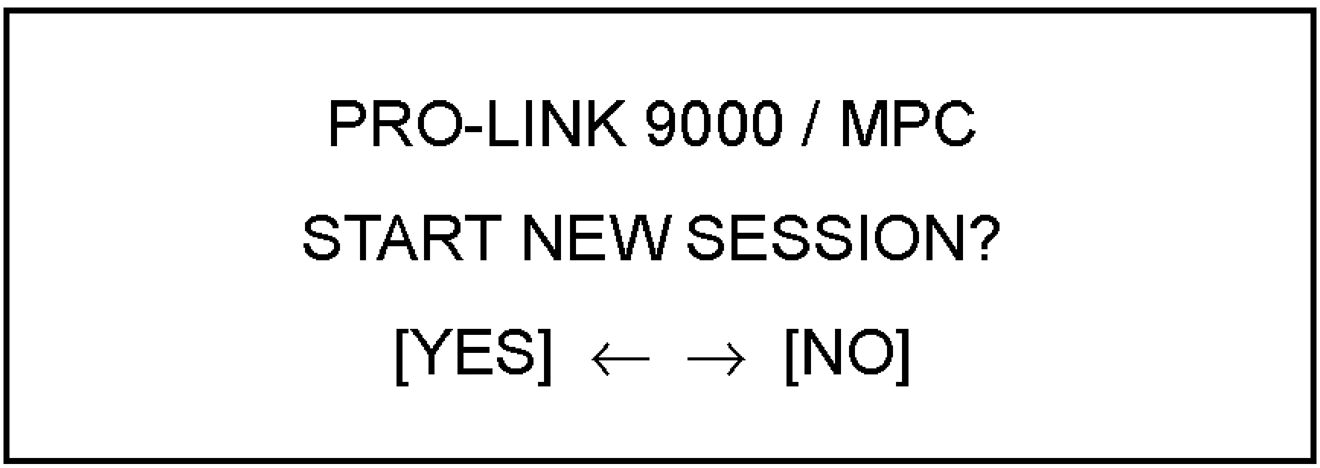
33



33260

Data List

34



33261

Data List

35

9a. ECM VOLTAGE

- Check while cranking engine
- Measure with DVOM at three locations with breakout box connected to Chassis Harness (lower) connector on ECM

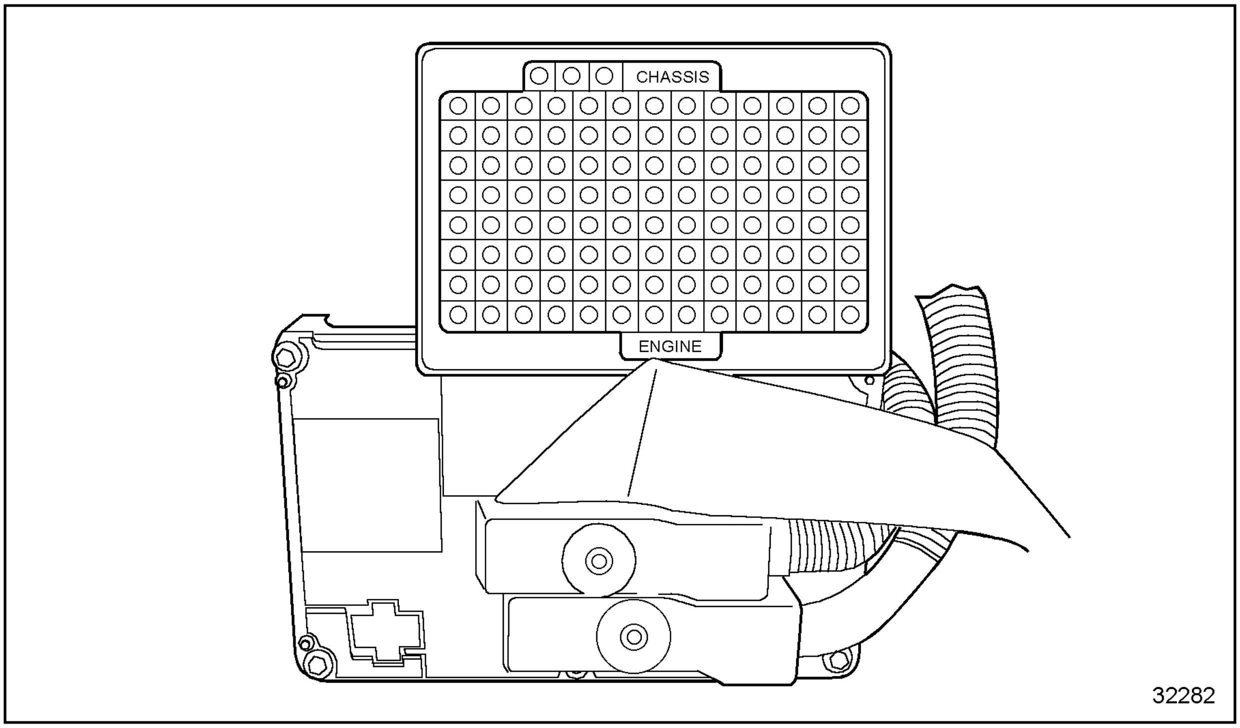
Pins (21+ & 1-) (22+ & 2-) (24+ & 23-)

Instrument	Specification	Actual
DVOM	7 volts minimum @ all 3 locations	

□ If voltage is low, refer to ECM diagnostics

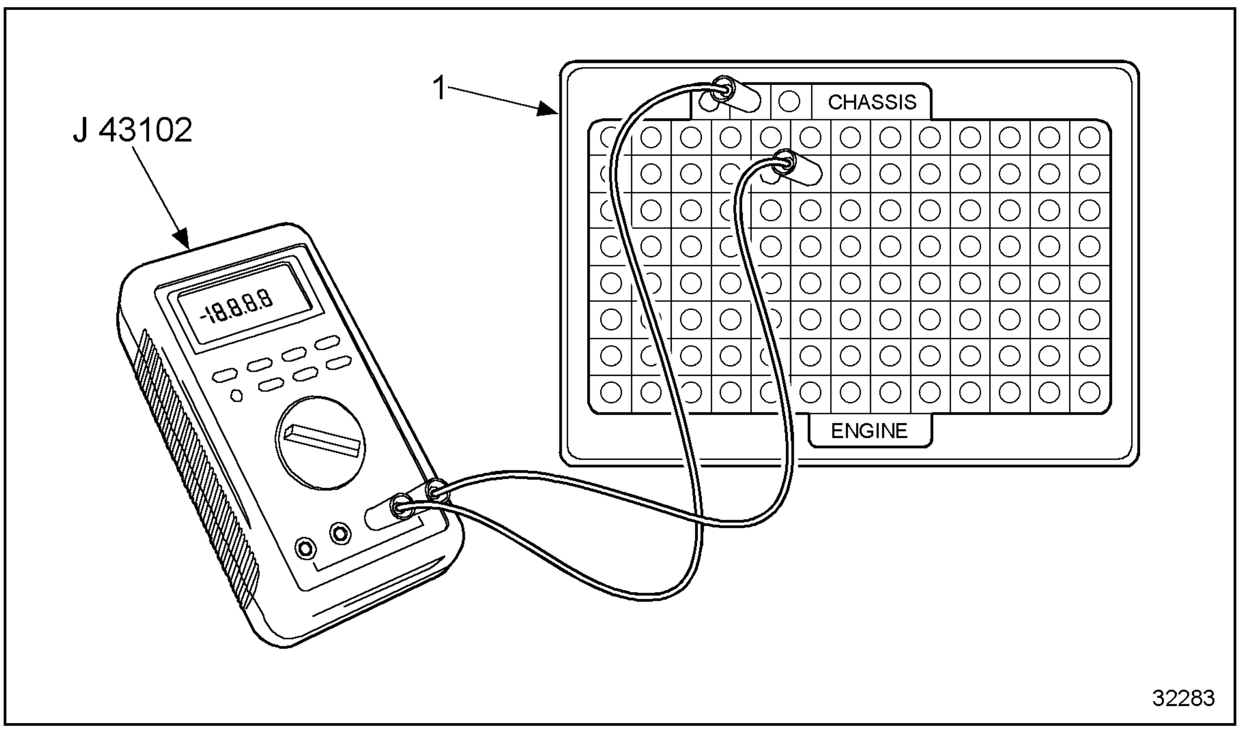
33262

Diagnostic Form



Breakout Box Connection

37



1. Breakout Box	

Measuring ECM Voltage with Breakout Box

38

9b. ENGINE CRANKING RPM

- Minimum 130 rpm (26 Hz.) engine cranking speed for 20 seconds
- Measure with breakout box connected to Engine Harness (upper connector) on ECM @ pins 51+ & 19-

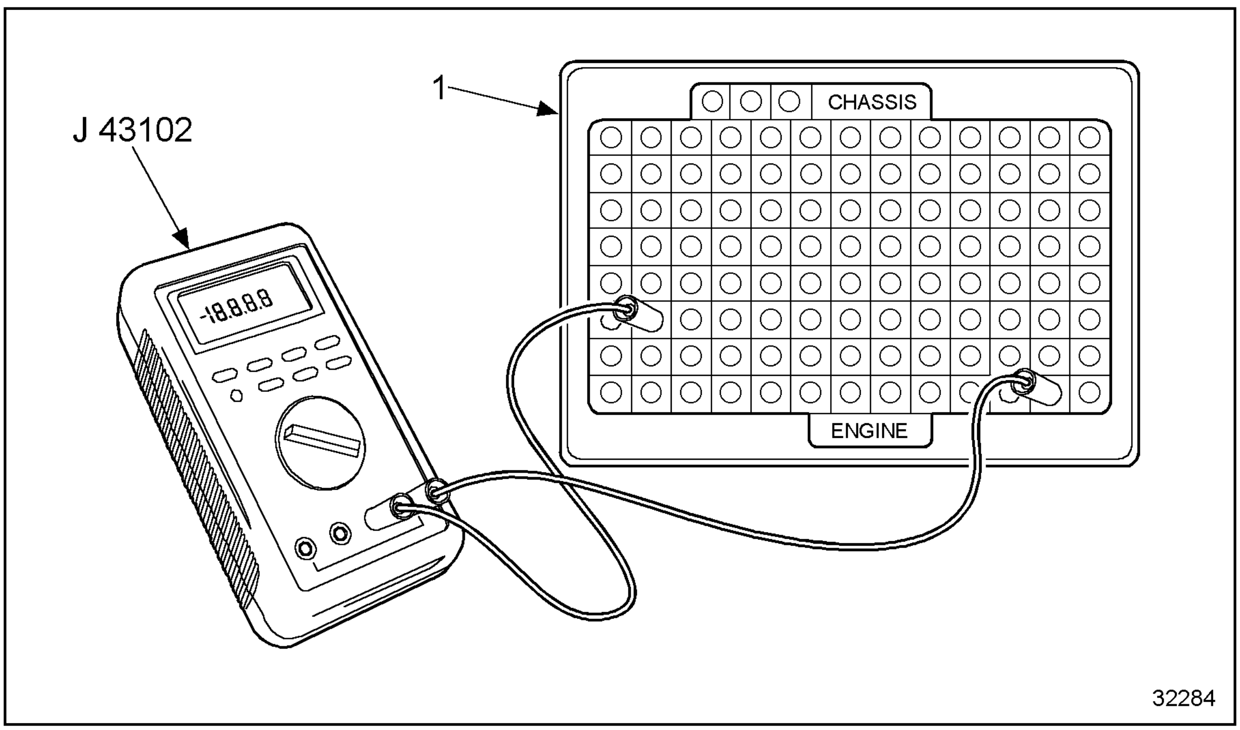
Instrument	Specifications	Actual
Fluke 88 51+ & 19-	(26 Hz.) minimum	

☐ If no RPM is noted, recheck fault codes

33263

Diagnostic Form

39



1. Breakout Box	

Measuring Engine Cranking RPM with Breakout Box

40

9c. INJECTION CONTROL PRESSURE

- Minimum 130 rpm engine cranking speed for 20 seconds
- Measure with breakout box connected to Engine Harness (upper connector) on ECM @ pins 16+ & 19- or breakout "tee" signal (green) & ground (black)

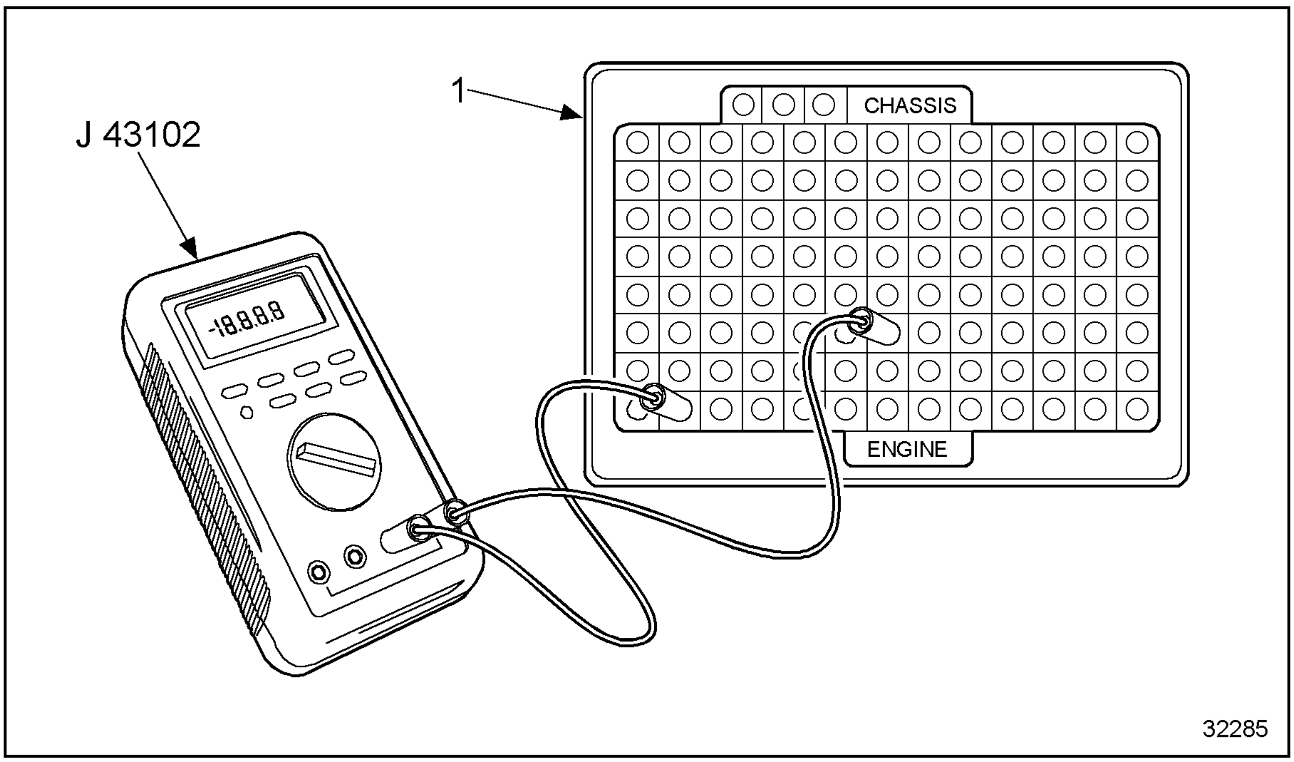
Instrument	Specifications	Actual
DVOM 16+ & 19-	1 Volt minimum	

☐ If ICP pressure is low, refer to Test 10

33264

Diagnostic Form

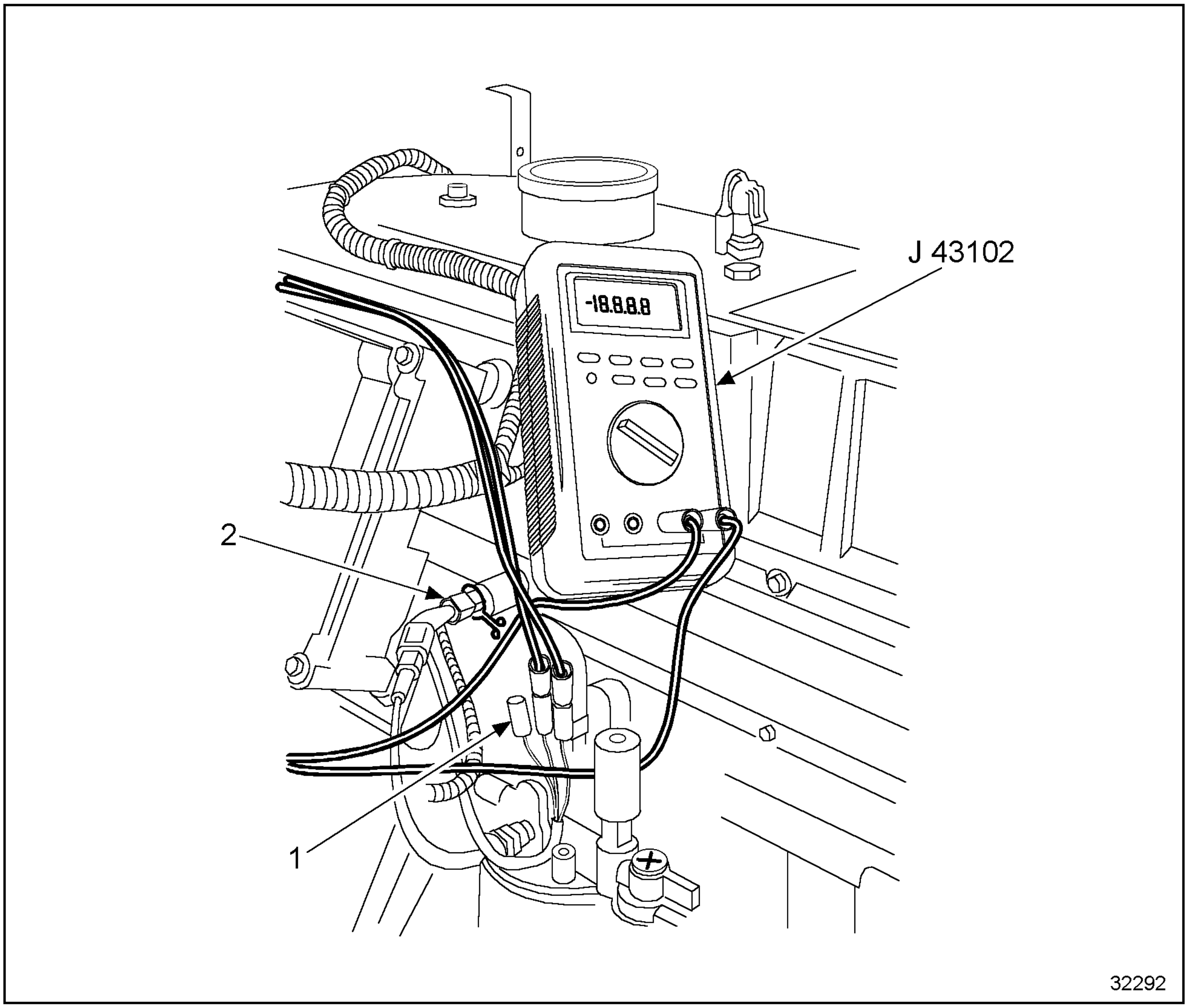
41



1. Breakout Box	

Measuring Injection Control Pressure with Breakout Box

42



1. Breakout Tee	2. ICP Sensor

Measuring Injection Control Pressure (Voltage)

43

10. LOW ICP PRESSURE TEST

NOTE: Perform this test if ICP pressure was low in Test 8 or 9c.

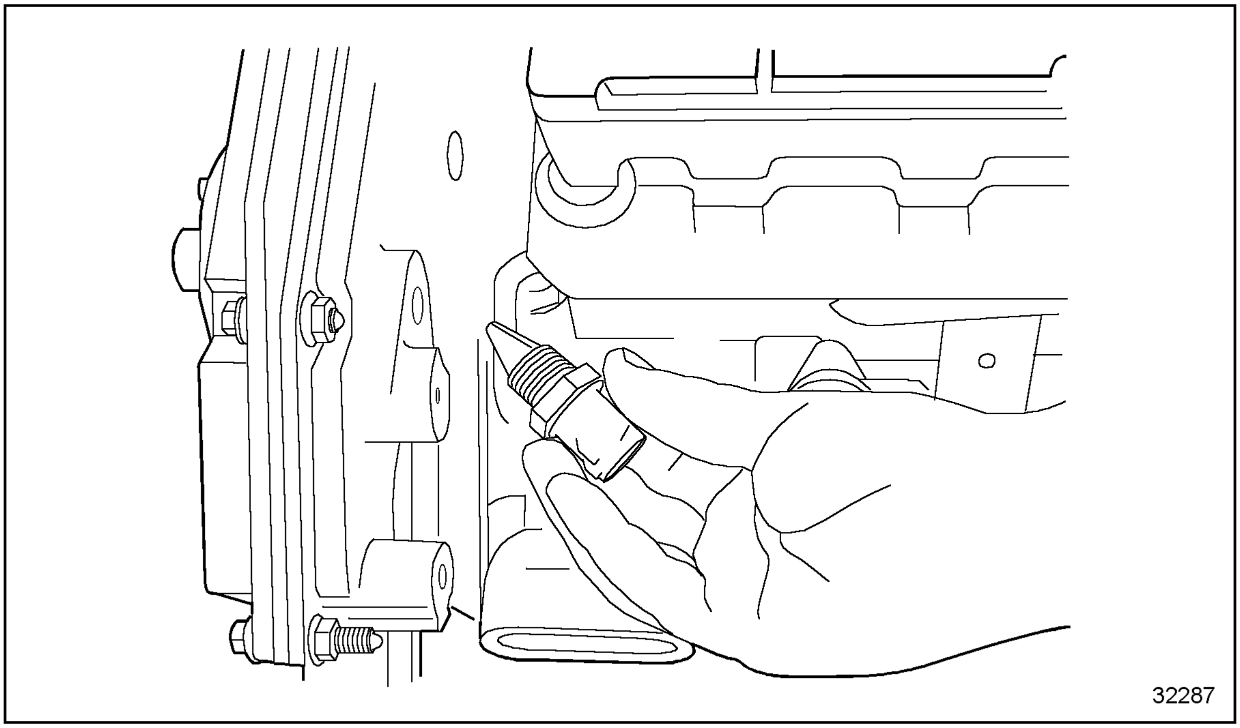
- Remove EOT sensor and check for oil in reservoir and reinstall EOT
- Remove high pressure hose from oil manifold
- Attach adaptor and ICP sensor to hose
- Monitor pressure while cranking engine

Instrument	Specification	Actual
EST	500 psi minimum	
DVOM	1 volt minimum	

- If pressure is within specifications, check for high pressure oil leakage.
- If pressure is still low, verify that pump is rotating
- If pressure is still low, replace IPR and retest

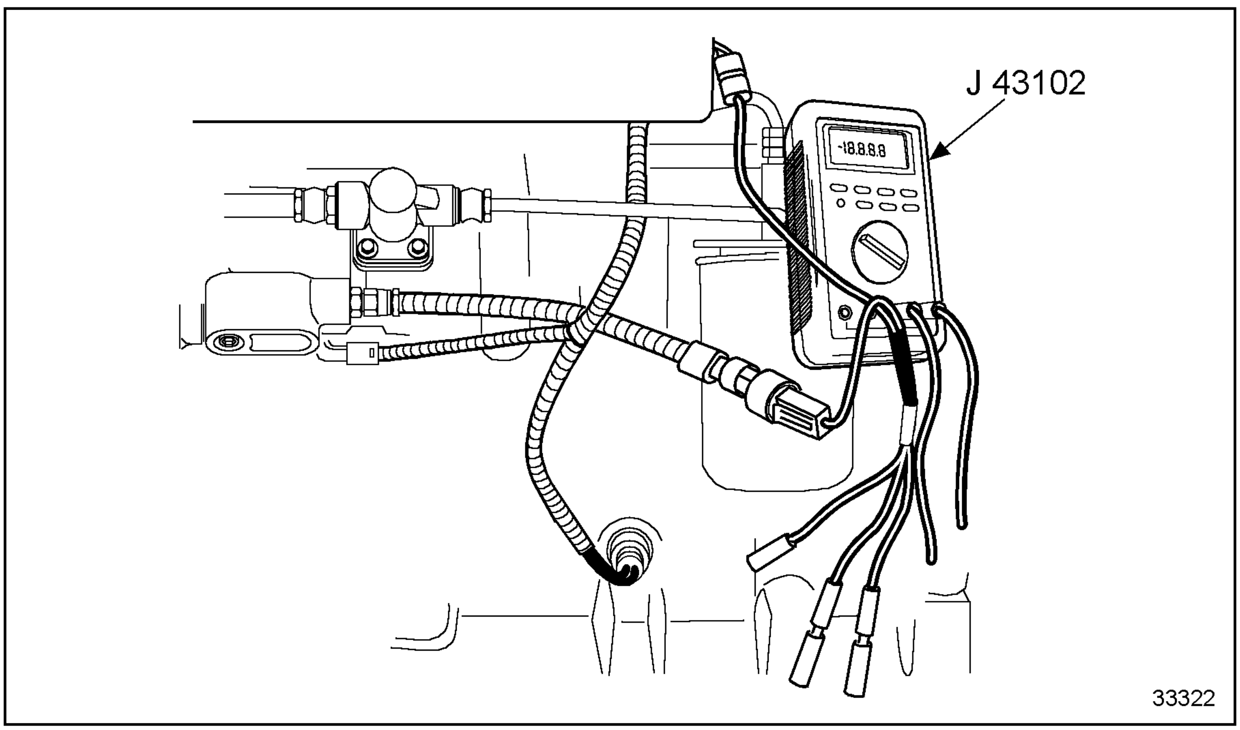
33265

Diagnostic Form



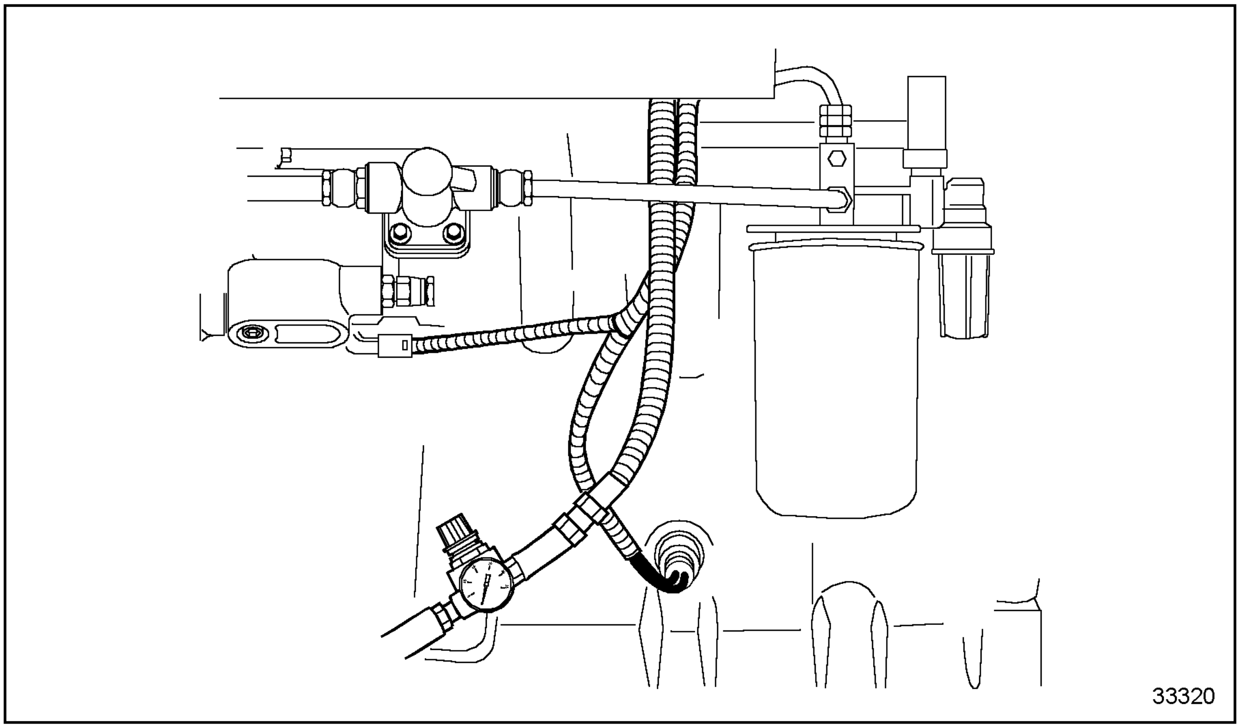
Checking Oil Level in Oil Reservoir

45



Low ICP Pressure Test

46



ICP Leakage Test

47

11. FUEL PUMP PRESSURE

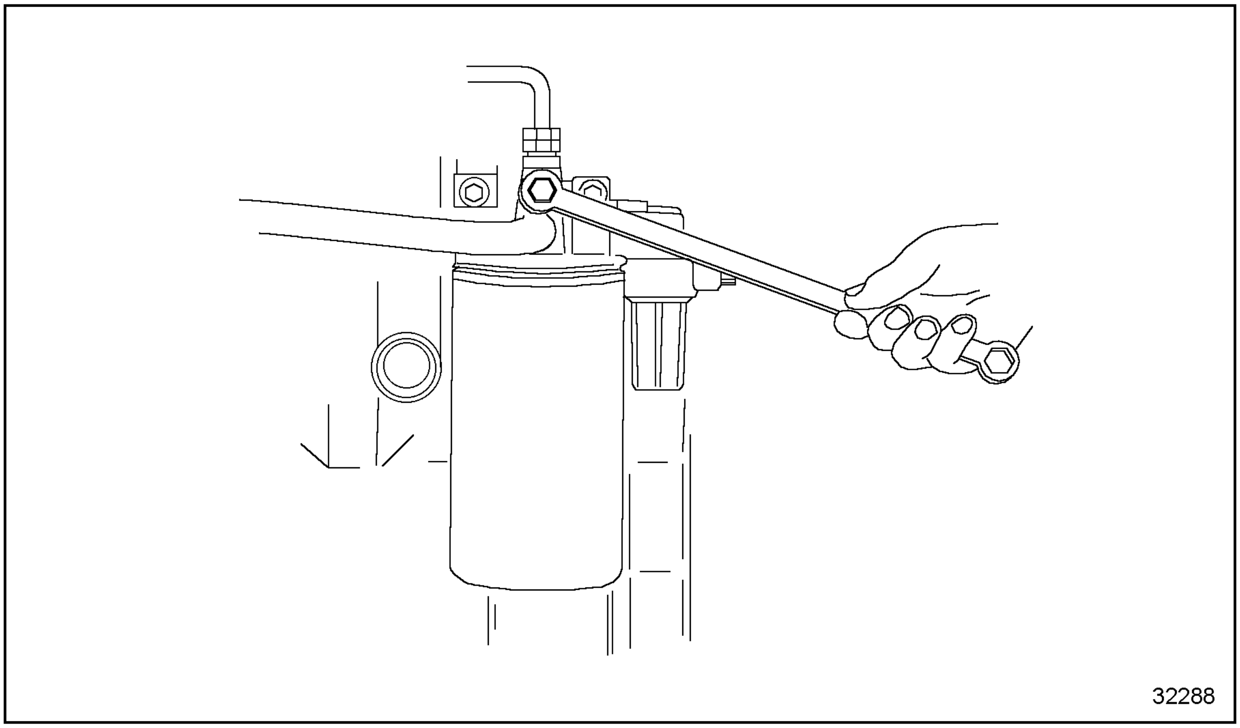
- Measure at bleeder valve on filter header
- Minimum 130 rpm cranking speed for 20 seconds

Instrument	Specification	Actual
0-160 PSI Gauge	20 PSI minimum	

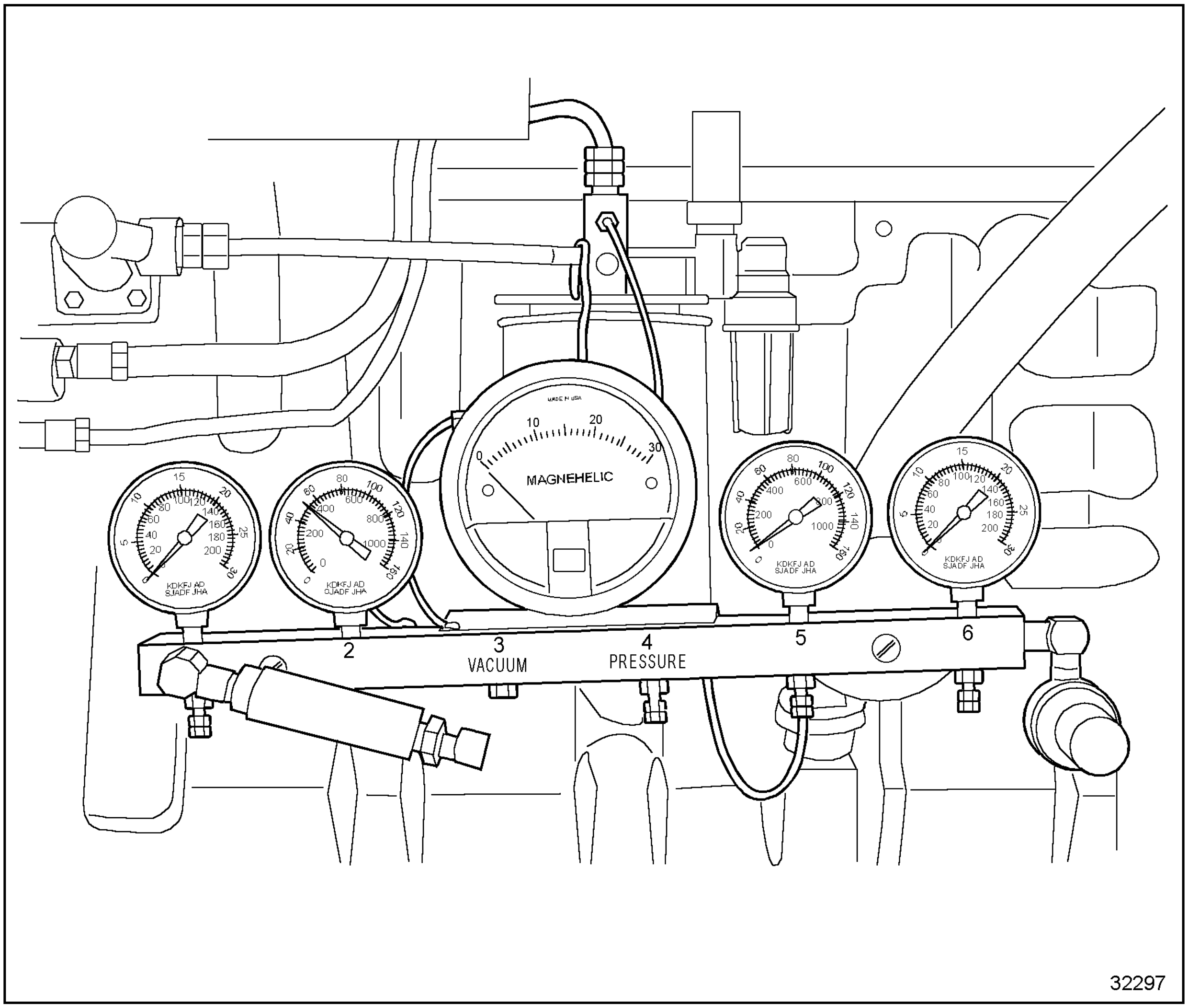
- If pressure is low, replace fuel filter, clean fuel stainer and retest.
- If pressure is still low, perform Transfer Pump Restriction Test 2B (of Performance Diagnostics).

33266

Diagnostic Form



Air Bleeder Valve Removal



Measuring Fuel Pump Pressure with Pressure Test Kit

IDLE SHUTDOWN TIMER

SYSTEM FUNCTION

The Idle Shutdown feature is an optional feature that allows the ECM to shut off the engine if an idle condition has been detected for more than a customer specified programmed period (2 to 120 minutes). Prior to engine shutdown, the Oil/Water Lamp (red) will flash for 30 seconds to warn the driver of the pending shutdown. The idle time is measured from the last clutch or break pedal transition. The engine must be out of gear for the idle shutdown timer to be initiated. This feature can be programmed to only operate at specific ambient air temperatures to allow prolonged engine operation in cold or hot weather operation. For PTO applications, this feature can also be programmed not to be turned on under specific load levels, or when the PTO switches are on. For the Idle Shutdown Timer function diagram, **see Figure**
.
1

Fault Detection / Management

The Idle Shutdown feature is internal to the ECM. All subsystems that input the idle shutdown strategy have their own fault detection and management strategy, e.g. IAT temperature sensor circuit. A fault code will be set if the idle shutdown timer has been activated, but this is not a system fault. Its only purpose is to indicate to the technician, driver or owner that the idle shutdown timer has been activated and the engine has been shut down.

For Idle Shutdown Timer (IST), **see Figure** .
2

Note: This fault code does not indicate any system or circuit faults. No diagnostics are necessary. If the IST programming parameters need to be changed, follow the extended description.

Fault Code 324 = Idle Shutdown time has been exceeded and the engine has been shut down.

Extended Description

The following list of parameters are those essential to setting the IST function to meet the customer's needs and expectations. They are accessible by using the EST (Electronic Service Tool).

Engine Idle Shutdown Control Parameters

This group of parameters customizes the prolonged engine idle automatic shutdown feature. The purpose of this feature is to shut the engine down after a programmable period of idle time has been exceeded. This allows fuel conservation, a reduction of engine wear and emissions. Thirty seconds before an automatic engine shutdown, the operator will be warned via the red Oil / Water Lamp. This lamp will begin flashing until the engine is shut down. The operator may override the electronics at any time. After an engine shutdown occurs, the Oil / Water Lamp will stop flashing and a diagnostic code (324) will be recorded. The diagnostic code is recorded to assist in diagnosing possible service complaints of the engine shutting down.

Currently there are four states of electronic operation:

1. OFF
2. PTO available
3. No engine load
4. Tamper proof

Idle Shutdown Timer

This parameter indicates to the on-board electronics if this vehicle has the Idle Shutdown timer feature.

OFF: Feature is turned OFF at all times.

PTO Available: Feature allows prolonged engine idle shutdown only when the engine is in the low idle, no load condition and PTO operation is OFF.

No Engine Load: Feature allows prolonged engine idle shutdown when the engine is in the low idle, no load condition.

Tamper Proof: Feature is tamper proof from operator override.

Idle Shutdown Time

This parameter indicates the length of engine idle time before the engine may be shut down.

Max IAT for Idle Shutdown

This parameter indicates the maximum ambient air temperature that the on-board electronics may shut down a prolonged idling engine. This temperature is used to circumvent the shutting down of an engine when it is running because the air conditioning may be turned on.

MIN IAT for Idle Shutdown

This parameter indicates the minimum ambient air temperature that the on-board electronics may shut down a prolonged idling engine. This temperature is used to circumvent the shutting down of an engine when it is running because of cold ambient temperature.

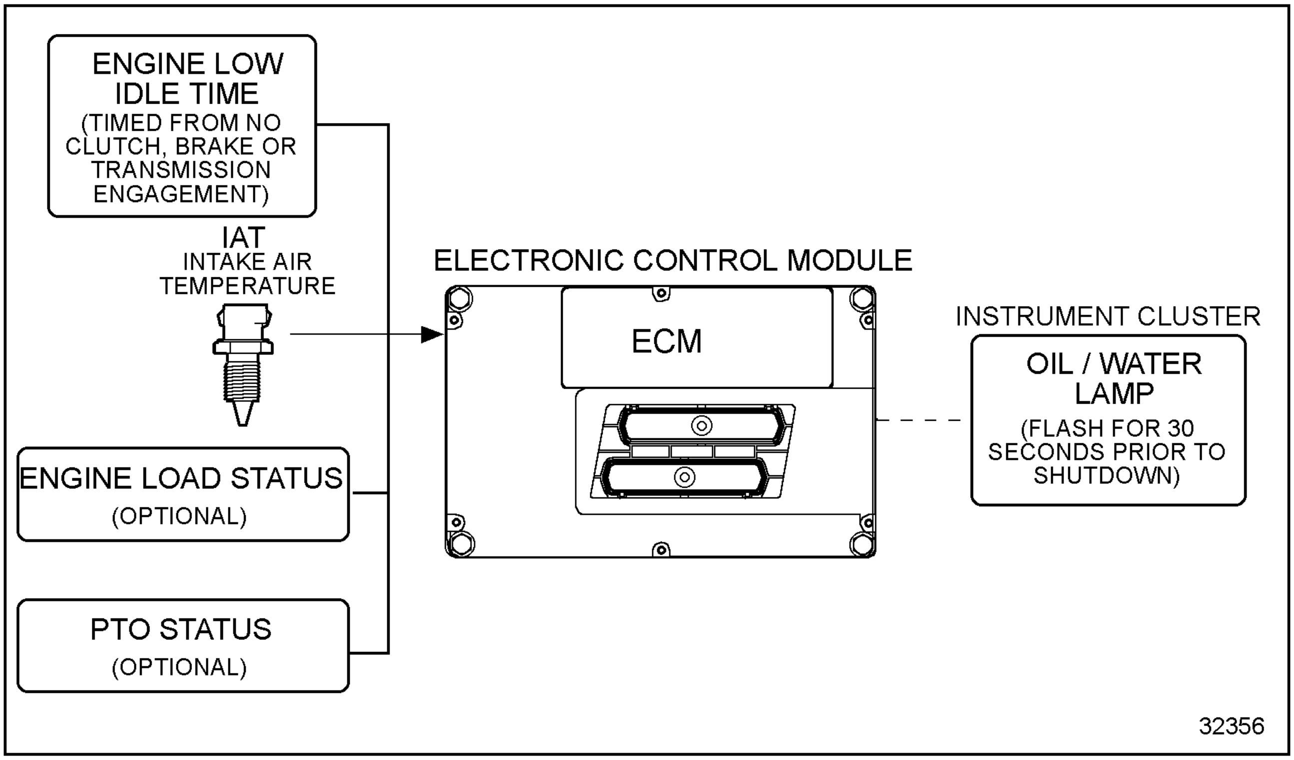
Flash Code 324

ATA Code PID 71 FMI 14

Idle Shutdown Timer enabled engine shutdown.

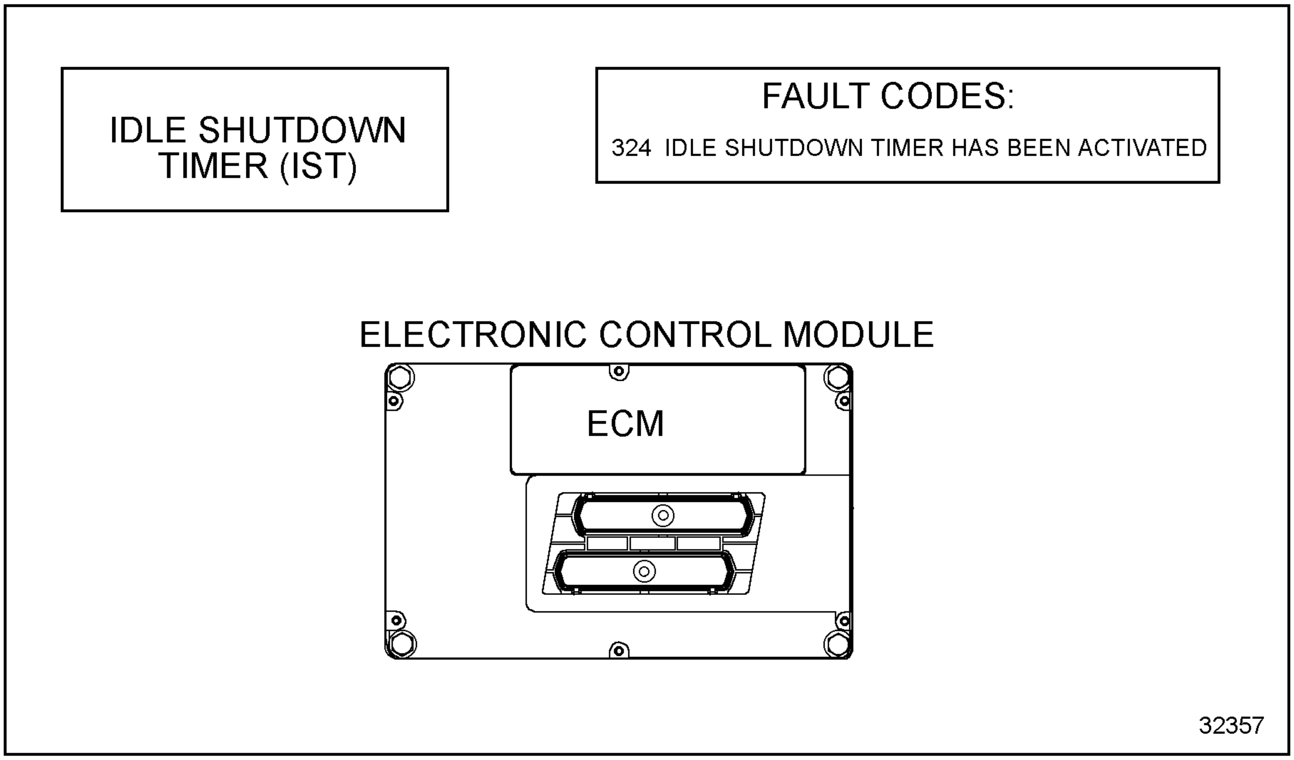
This flash code is set when the engine has been shut off by the ECM because the idle time criteria has been exceeded. The idle shutdown feature must be turned on for this fault code to display. This fault code can be cleared with the EST.

1



Idle Shutdown Timer Function Diagram

2



Idle Shutdown Timer

ENGINE COOLANT LEVEL SYSTEM

SIGNAL FUNCTION

The purpose of the Engine Coolant Level (ECL) monitoring system is to signal the driver in the event of a low coolant situation. Depending on the programming of the control module it is also capable of shutting off the engine to prevent damage to the engine due to low coolant level. **See Figure**
.

1

Coolant Level Sensor

There are two types of coolant level sensors:

1. Magnetic switch
2. Conductive probe

The magnetic switch type sensor is used and located in plastic surge tanks. The magnetic switch will be open when the coolant level in the tank is full.

The conductive probe type sensor is used and located in steel surge tanks. The conductive probe is grounded when the coolant level in the tank is full. **See Figure** .
2

For coolant level sensor wiring troubleshooting, **see Figure**
.

3

Fault Detection Management

There are no ECM diagnostics for the ECL system. Flash Code 323 will be active when a low coolant situation is present, and the Pro-Link will indicate engine coolant below warning/critical level. After the coolant has been restored to proper levels, Flash Code 323 will remain as an inactive code and the ECM will log the engine hours of the occurrence. Fault code descriptions are **listed in Table** .

Code	Fault Code Description
236	ECM has detected an open or shorted circuit on the ECL circuit.
323	The 5 volt circuit at pin #10 of the ECM has been pulled to ground, indicating low coolant. Check the cooling system.

Fault Codes

Description

The ECL sensor is used with the optional engine warning and protection feature. The purpose of the coolant level system is to monitor the level of the coolant in the surge tank to protect the engine from damage due to operating the engine when the coolant level is low. Since this is an optional feature, the system functions by programming three-way warning or three-way engine shutdown in the control module.

Coolant Level Sensor

There are two different types of sensors used in the coolant level monitoring system. One type is used in plastic surge tanks, and the other in steel surge tanks.

Plastic Surge Tanks

Plastic surge tanks use a floating ball with a magnet and magnetic switch. With the coolant level full, the float will raise and the magnet will pull the level switch open. This will allow 5 volts to be present at pin No. 10 of the ECM. If the level should go low, the switch will close and pin No. 10 of the ECM would go to 0 volts. The ECM must be programmed for a plastic tank for this coolant level switch to operate properly.

Steel Surge Tanks

Steel surge tanks use a conductive probe that allows the probe to be grounded when the coolant level is full. This causes the voltage at pin No. 10 to be 0 volts. If the coolant level is low, the probe circuit is open and a 5 volt signal is present at pin No. 10 of the ECM, indicating low coolant. If using a steel surge tank, it is necessary for the ECM to be programmed for a steel tank.

Programming

Coolant level monitoring is a customer programmable feature that may be programmed by the EST using the customer password. Coolant level feature is operational if programmed for three-way warning or three-way shutdown. However, if not pre-programmed for three-way shutdown at the factory, it will not be possible to enable the shutdown feature.

Flash Codes

The following flash codes could display when troubleshooting the ECL system.

Flash Code 236

ATA Code PID 111 FMI 33

ECM: Engine coolant below warning/critical level

Flash Code 236 will be active when the ECM detects an in-range voltage error in the ECL circuit. The probable cause for this condition will be a high resistance connection or intermittent short to ground in the circuit.

Flash Code 323

ATA Code PID 111 FMI 33

ECM: Engine coolant below warning/critical level

Flash Code 323 will be active when a low coolant situation is present and the EST will indicate COOLANT LOW. After the coolant has been restored to proper levels, Flash Code 323 will remain as an inactive code and the ECM will log the engine hours and odometer reading at the time of the occurrence.

Troubleshooting

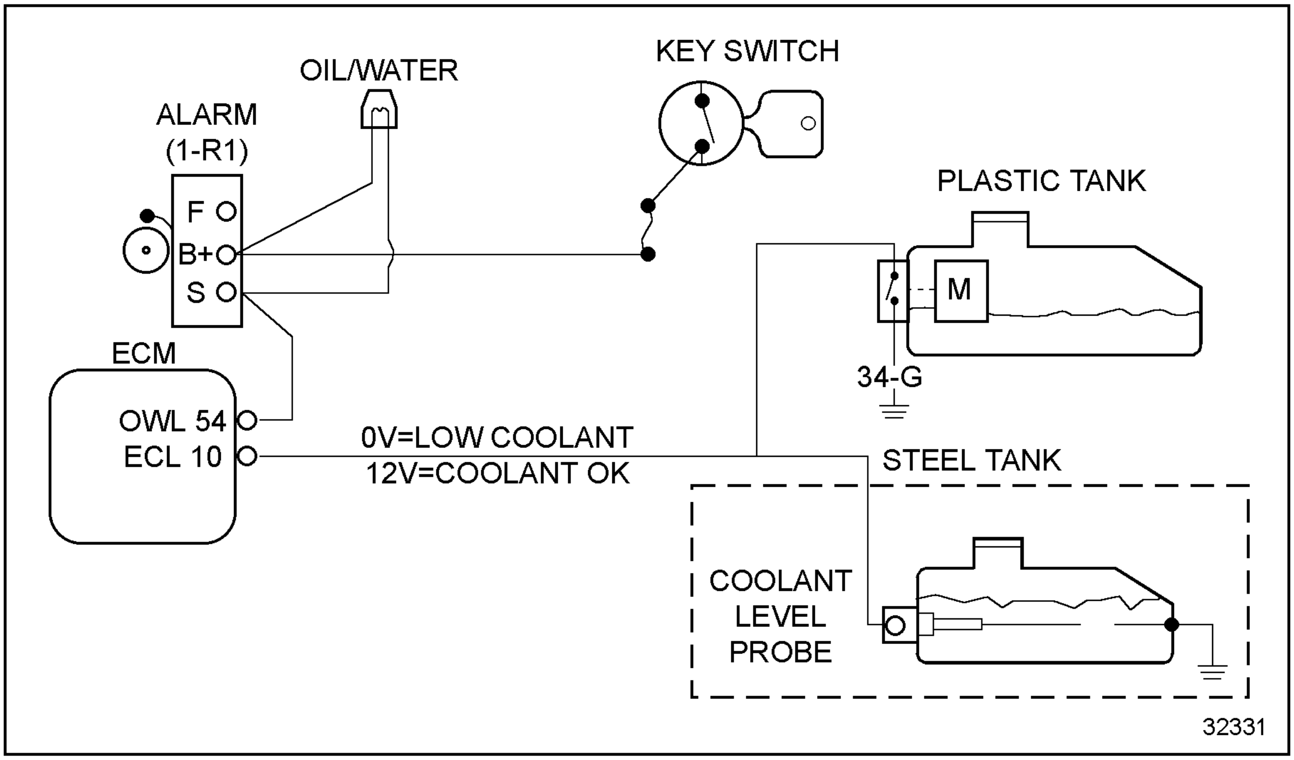
Use the EST to monitor the coolant level on the data list or to retrieve fault codes from the fault code list. Also prior engine events can be retrieved using the EST in the calibration data screen under the Event Log. This will display the total number of times the event has taken place, the engine hours, the odometer reading at which the last two events have taken place.

Before Troubleshooting

Perform these steps before troubleshooting the ECL system:

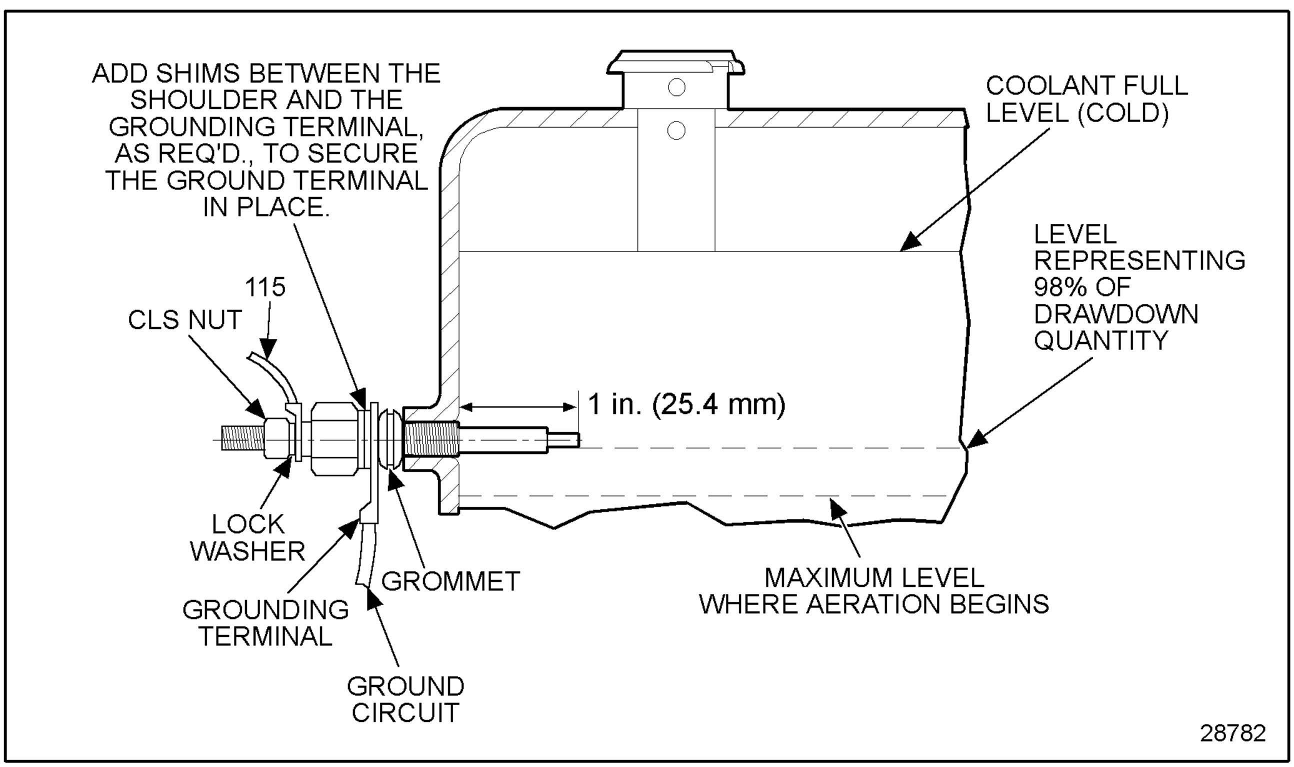
1. Ensure the batteries are fully charged. Check the battery connections and grounds for clean, tight connections, free of damage. Voltage tests will give misleading readings if batteries are not fully charged.
2. Before troubleshooting a particular circuit, inspect connectors for pushed back, loose or damaged (spread or bent) terminals or wires with cut strands, etc. The wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present. This must be removed.
3. Inspect suspect circuit grounds for clean, tight connections, free of damage.

1

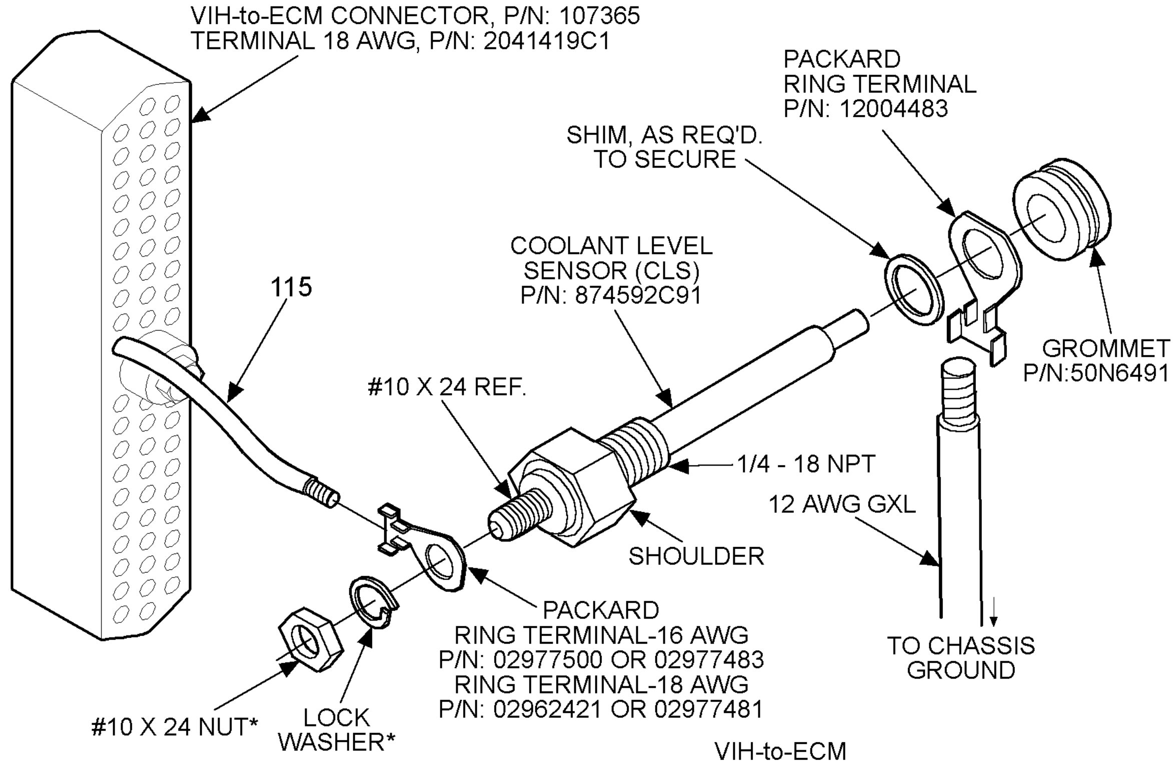


Engine Coolant Level System Function

2



Coolant Level Sensor in Coolant Tank



LABEL	WIRE NO.	WIRE GAUGE	VIH-to-ECM CONNECTOR CAVITY	WIRE COLOR
COOLANT LEVEL	115	18	10	GRAY

* INCLUDED WITH CLS P/N: 874592C91

28792

Recommended Wiring for the Coolant Level Sensor

HEUI INJECTOR OPERATION

INJECTOR OPERATION

The injection operation is divided into three stages or cycles:

1. Fill stage
2. Injection stage
3. End of injection

During the fill stage, the solenoid is de-energized and the poppet valve is in the closed position preventing the flow of high pressure oil to the intensifier piston. At this point the intensifier piston is in the upper position allowing the fuel supply to enter and fill the nozzle of the injector.

Once the ECM commands injection, the solenoid is energized and the injection stage is initiated. Such action rapidly lifts the poppet valve from its seat, allowing the high pressure oil to enter the injector. At the intensifier piston, the pressure is transmitted from the high pressure oil to the fuel and multiplied 6 to 7 times creating fuel injection pressures of up to 21,000 lb/in.2.

As the fuel pressure increases, check valves prevent the fuel from flowing back to the supply manifold. Once the pressure is high enough to lift the needle valve, high pressure fuel is atomized into the combustion chamber.

Once injection is completed, the ECM de-energizes the solenoid; the poppet valve and the intensifier piston return to the closed position; and the injector returns to the fill stage. **See Figure** .
1

SPLIT-SHOT INJECTORS

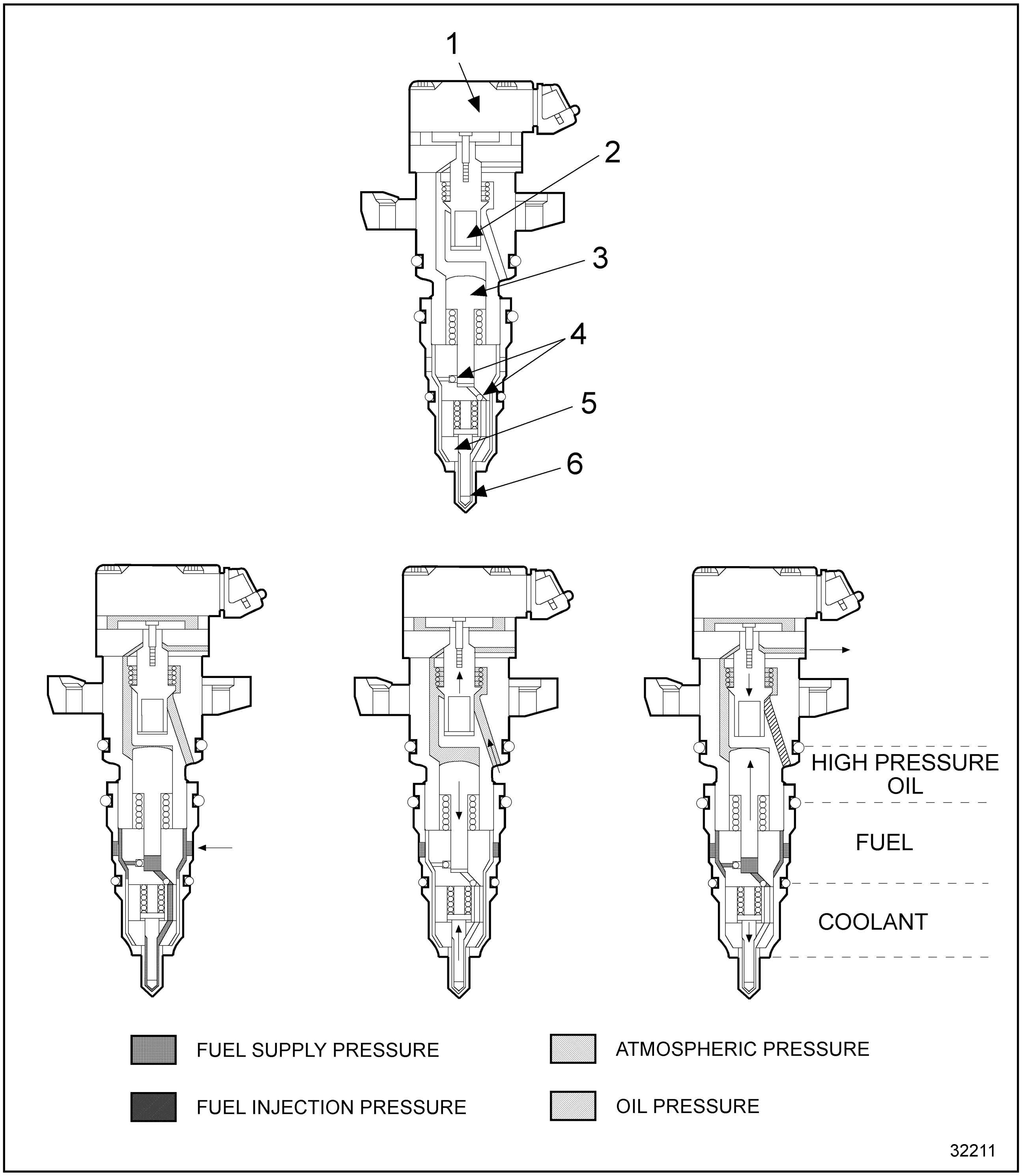
Some Series 40E electronic engines are equipped with split-shot injectors. On these injectors the injection cycle is executed in two stages. Some fuel is pre-injected into the combustion chamber to initiate the combustion and, once initiated, the primary injection takes place. This feature reduces emission levels at light load operations. It also reduces light load engine noise.

Both the electrical and the hydraulic portions of the split-shot injector operate identically to the regular HEUI injector, but the fuel distribution is different.

The barrel and plunger were redesigned and a spill port was incorporated. When injection is initiated, the first shot of fuel is pre-injected into the combustion chamber until the spill port of the plunger coincides with the slot on the barrel.

At this time some fuel is allowed to return back to the fuel supply port until the spill port slot is blocked again by the plunger and the primary injection stroke takes place. **See Figure** .
2

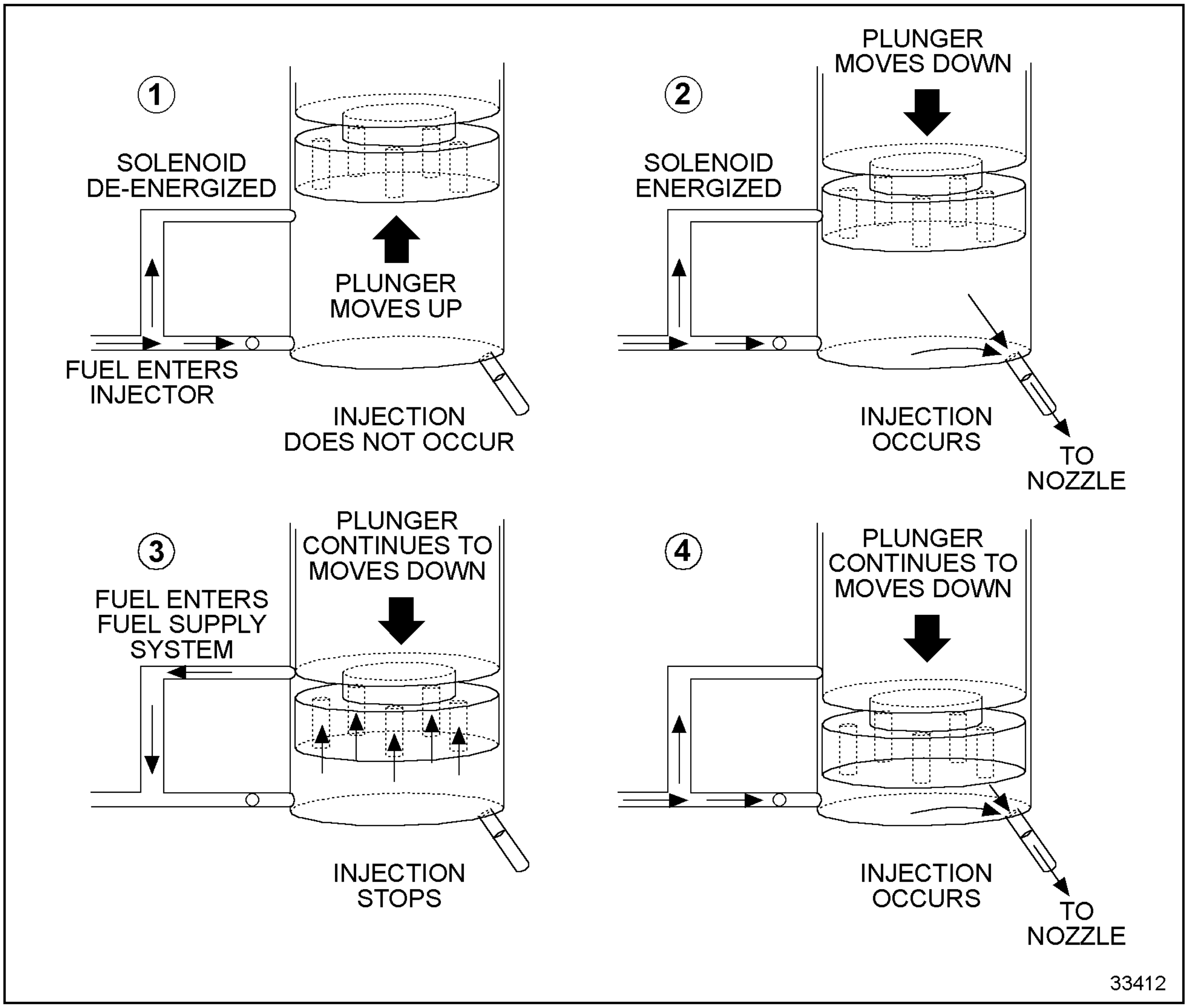
1



1. Fuel Inlet	4. Oil Inlet
2. Amplifier Piston Return Spring	5. Poppet Valve Return Spring
3. Amplifier Piston	6. Poppet Valve

HEUI Injector Stages of Operation

2



HEUI Split-Shot Injector Operation

FUEL SUPPLY SYSTEM

FUEL SYSTEM DESCRIPTION

The fuel system consists of three major subsystems:

1. Fuel Supply System
2. Injection Control Pressure System
3. Fuel Injector

These subsystems work together to inject pressurized fuel into the combustion chambers. The function of the fuel supply system is to deliver fuel to the injectors. The injection control pressure system supplies the injectors with high pressure oil and the Electronic Control System controls the moment and duration of the injection.

All three systems converge into the Hydraulically Actuated Electronically Controlled Unit Injector (HEUI).

The function of the fuel supply system is to deliver fuel from the fuel tanks to the injectors. The components involved in this task are:

1. Fuel tanks
2. Fuel supply lines
3. Fuel strainer
4. Fuel filter
5. Priming (hand) pump
6. Fuel supply pump
7. Fuel/oil supply manifold
8. Fuel passages from the fuel supply manifold to the cylinder head that feeds the injectors
9. Fuel pressure regulator
10. Fuel return lines

FUEL FLOW

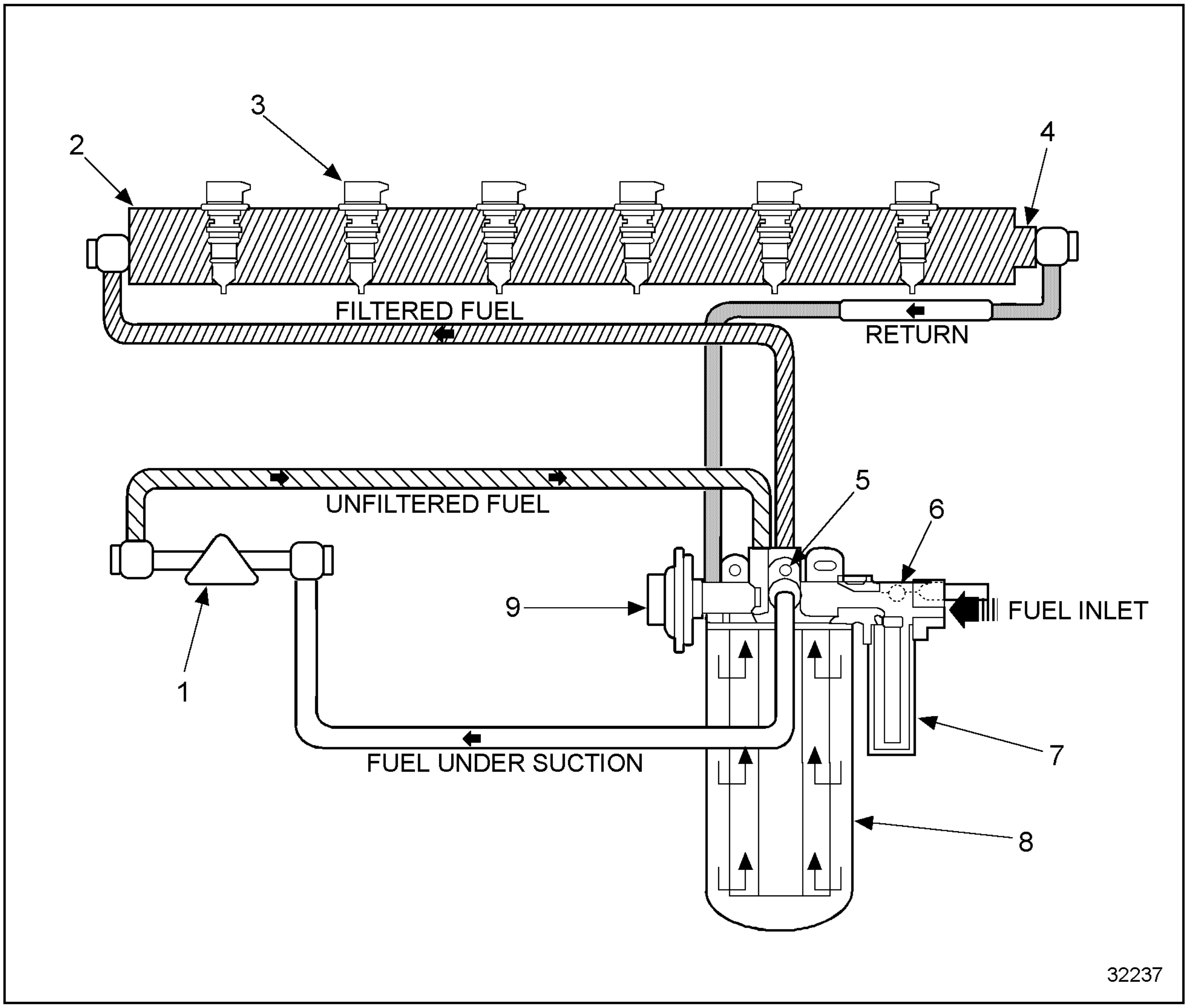
The fuel supply pump produces the necessary vacuum to draw the fuel from the fuel tanks. See Figure . Fuel from the tanks flows through the strainer that filters out any large contaminants that may be present in the fuel. From the strainer the fuel flows to the supply pump. This pump increases the pressure to approximately 65 $lb/in.^2$ (448 kPa). Once the fuel has been pressurized, it flows to the fuel supply manifold and to the injectors via passage ways in the cylinder head.

1

In the injectors, the fuel pressure is increased to injection pressures of approximately 18,000 $lb/in.^2$ (124,106 kPa).

The fuel rail pressure is controlled to 65 $lb/in.^2$ by a fuel pressure regulator mounted to the rear of the manifold. After the pressure regulator, excess fuel is returned to the tanks.

1



1. Supply Pump	6. Check Ball
2. Fuel Manifold	7. Strainer
3. Injector	8. Filter
4. Regulator	9. Hand Primer Pump
5. Bleed Valve	

Fuel System Diagram

INJECTOR DRIVE CIRCUITS

SIGNAL FUNCTIONS

Signal functions include High Side Drive Outputs and Low Side Drive Return. For the Injector Drive Circuit (INJ) function diagram, **see Figure**
.

1

High Side Drive Outputs — The high side drive outputs control the individual injector on-time, injection timing and sequencing (firing order). The ECM controls each individual injector by providing current to each individual injector solenoid. Sufficient injection control pressure and a valid CMP signal must be received by the ECM before an injector will be allowed to fire.

Low Side Drive Return — The two low side drive circuits (one for cylinders 1, 2 and 3, one for 4, 5 and 6) provide a ground path for the injectors through the ECM and also allows the ECM to perform diagnostic measurements on injector performance.

Fault Detection/Management

The ECM is capable of detecting, while the engine is running, individual injector circuit open and short conditions to either ground or power. If individual injector faults are detected while the engine is operating, the ECM can command an individual injector or a bank of injectors to turn off to enhance engine running and life, as well as provide a limp home capacity.

CAUTION
Do not perform voltage checks with the engine running. The injector solenoid operating voltage, 115 volts DC @ 10 amps is present on the injector circuits and could cause bodily injury.

A number of special On-Demand service bay tests can be commanded by the operator to verify injector circuit continuity as well as injector operation while the engine is operating in a test mode. For injector drive circuits (INJ), **see Figure** .

2

Engine harness connector checks are **listed in Table**
. The checks are made through the connector with test pin, ignition key OFF.

+Test Points-	Spec	Comments
43 to Grd	> 1,000 Ω	Injector #1 high side power supply.
21 to Grd	> 1,000 Ω	Injector #2 high side power supply.
41 to Grd	> 1,000 Ω	Injector #3 high side power supply.
42 to Grd	> 1,000 Ω	Low side voltage return injectors #1, #2, #3.
46 to Grd	> 1,000 Ω	Injector #4 high side power supply.
25 to Grd	> 1,000 Ω	Injector #5 high side power supply.
44 to Grd	> 1,000 Ω	Injector #6 high side power supply.
26 to Grd	> 1,000 Ω	Low side voltage return injectors #4, #5, #6.
If less than 1,000 Ω, check engine harness, under valve cover harness, and injector circuits for short to ground.		

Engine Harness Connector Check to Chassis Ground

The injector, under valve cover harness, engine harness circuit continuity checks are **listed in Table** . The checks are made through the connector with test pin, ignition key OFF.

+Test Points-	Spec	Comments
43 to 42	3.4 ± 2 Ω	Injector circuit #1
21 to 42	3.4 ± 2 Ω	Injector circuit #2
41 to 42	3.4 ± 2 Ω	Injector circuit #3
46 to 26	3.4 ± 2 Ω	Injector circuit #4
25 to 26	3.4 ± 2 Ω	Injector circuit #5
44 to 26	3.4 ± 2 Ω	Injector circuit #6
Resistance measured through complete injector circuit, including injector solenoid. If resistance is high or circuit is open, isolate problem to harness, connector or injector solenoid.		

Injector, Under Valve Cover Harness, Engine Harness — Circuit Continuity Check

Function System Description

The Series 40E engine control system consists of a single ECM that provides the voltage and current required by the injectors to fuel the engine.

Fuel quantity, fuel rate and timing are all controlled by the single engine mounted ECM. The desired fuel and timing are calculated and controlled by the ECM from the input of various engine and vehicle sensors as well as the limits programmed into its internal memory.

ECM Injector Diagnostics

The ECM monitors the voltage on each of the individual injector circuits, and is capable of detecting an open or shorted circuit. If the ECM detects a short to ground or a multiple fault in an injector circuit, it is capable of disabling an individual injector or a bank of three injectors, allowing the engine limp home capabilities on the remaining three cylinders. The Engine Warning Lamp will be illuminated when an injector circuit fault is present.

Note: The last digit of the flash code indicates the affected cylinder number. For example, Code 421 indicates cylinder No. 1 has an open circuit between the IDM high side driver and the low side (signal return) to the IDM. The SID numbers 1–6 indicate cylinder numbers in a similar manner.

Flash Codes

The following Flash Codes could display when troubleshooting the injector drive circuits.

Flash Codes 421 through 426

ATA Code SID 1 through 6 FMI 5

High side to low side open.

Flash codes for high side to low side open indicate an open circuit between the ECM high side driver and the low side (signal return) to the ECM.

The ECM will compensate for engine misfire to keep the engine operating. The ECM will not illuminate the engine warning light when this situation occurs.

Possible causes: Open wire in the injector harness; open injector return circuit or injector solenoid.

Flash Codes 431 through 436

ATA Code SID 1 through 6 FMI 4

High side to low side short.

Flash codes for high side shorted to low side indicate the return voltage is too high due to a short circuit between the high side driver and return circuit.

The ECM will compensate for engine misfire to keep the engine operating. The ECM will not illuminate the engine warning light when this situation occurs.

Possible causes: Shorted injector solenoid or wiring harness.

Flash Codes 451 through 456

ATA Code SID 1 through 6 FMI 6

High side shorted to ground or VBat.

Flash codes for high side shorted to ground or VBat indicate the return circuit shorted to ground.

If the ECM detects this fault, it will disable the entire bank of cylinders associated with the cylinder indicated. The ECM will not illuminate the engine warning lamp when this occurs.

Possible causes: Shorted injector solenoid or wiring harness to ground.

Flash Code 513

ATA Code SID 151 FMI 5

Low side to Bank 1 open.

With the low side to Bank 1 open, the ECM has detected an open circuit to the injectors on the cylinders 1 through 3.

With Flash Code 513 active, the drivers for cylinders 1 through 3 are inoperative. The ECM will compensate for misfire to keep the engine operating and will illuminate the engine warning light.

Flash Code 514

ATA Code SID 151 FMI 5

Low side to Bank 2 open.

With the low side to Bank 2 open, the ECM has detected an open circuit to the injectors on cylinders 4 through 6.

With Flash Code 514 active, the drivers for cylinders 4 through 6 are inoperative. The ECM will compensate for misfire to keep the engine operating and will illuminate the engine warning light.

Flash Code 515

ATA Code SID 151 FMI 6

Bank 1 low side short to ground or B+.

Flash Code 515 indicates the ECM has detected the low side driver for cylinders 1 through 3 has excessive current draw.

With Flash Code 515 active, the driver for cylinders 1 through 3 will be disabled. The ECM will compensate for engine misfire to keep the engine running. This code will cause the engine warning light to illuminate.

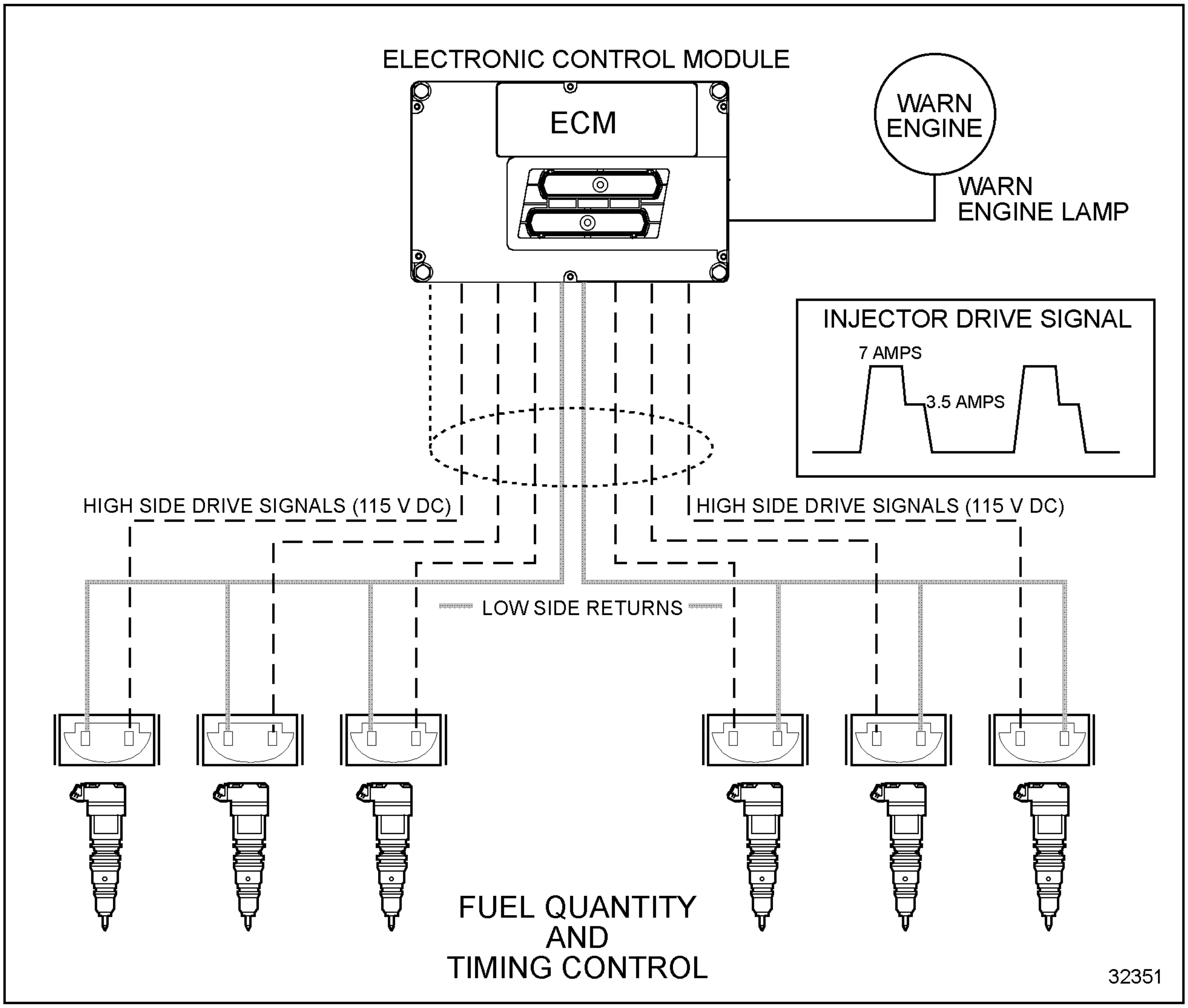
Flash Code 521

ATA Code SID 152 FMI 6

Bank 2 low side short to ground or B+.

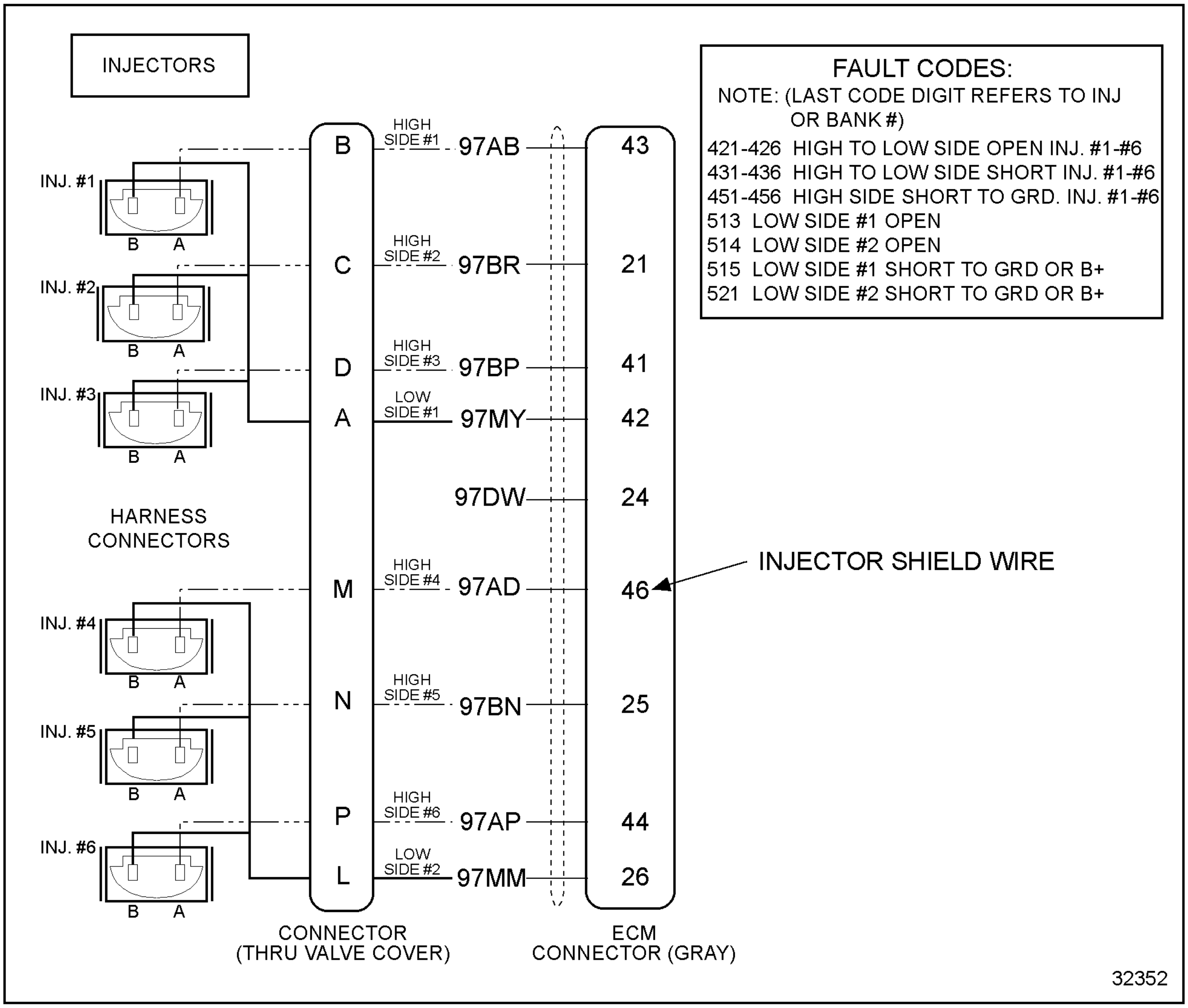
Flash Code 521 indicates the ECM has detected excessive current draw on the low side driver for cylinders 4 through 6.

With Flash Code 521 active, the driver for cylinders 4 through 6 will be disabled. The ECM will compensate for engine misfire to keep the engine operating and will illuminate the engine warning light.



Injector Drive Circuit Function Diagram

2



Injector Drive Circuits

INJECTION PRESSURE REGULATOR

INJECTION PRESSURE REGULATOR

The Injector Pressure Regulator (IPR) is a variable position valve that controls injection control pressure. The ECM uses many input variables to determine the desired injection control pressure. For the IPR function diagram, **see Figure** .

1

Output Functions

Battery voltage is supplied to the IPR when the ignition key is in the ON position. Valve position is controlled by switching the output signal circuit to ground inside the ECM. ON and OFF time is modulated from 0 — 60% dependent upon the desired injection control pressure.

Fault Detection / Management

An open or a short to ground control circuit can be detected by an on demand output circuit check performed during the engine off test.

The ECM is capable of detecting, while the engine is running, if desired injection control pressure is equal to measured injection control pressure. If the measured injection control pressure does not reasonably compare to the desired injection control pressure, the ECM ignores the measured ICP signal and attempts to control the engine with the desired value. (If the problem was in the sensor circuit, this strategy causes little performance deterioration. If the problem is in the control circuit, engine performance will probably still be unsatisfactory.

A faulty IPR or problem with the high pressure oil system can be detected by the engine running test during the injection control pressure step test. During this test, the ECM commands and measures two specific pre-programmed pressures. A fault code is set if the pressures cannot be maintained.

For the IPR function diagram, **see Figure** .
2

Note: The engine will not operate with an IPR circuit that is not functioning.

The IPR voltage checks are **listed in Table** . Checks are performed with the regulator connector disconnected and the ignition key ON.

Test Points	Spec	Comments
A to Grd	B+	IPR power voltage from the ECM.
B to Grd	0 - 0.25v	If greater than 0.25 volts, the signal wire is shorted to VREF or battery.

IPR Voltage Check

The connector checks to ground are **listed in Table** . Checks are performed with the IPR connector disconnected and the ignition key OFF; the positive battery cable disconnected.

Test Points	Spec	Comments
A to Grd	> 1,000 Ω	Resistance to chassis ground. If less than 1,000 Ω, check for short to ground in circuit. Remove fuse F5 in fuse box prior to measuring resistance.
B to Grd	> 1,000 Ω	

Connector Checks to Ground (B+)

The harness resistance checks are **listed in Table** . Checks are performed with the breakout box installed on the engine harness only.

Test Points	Spec	Comments
#17 to #37	5 to 20 Ω	Resistance through entire IPR circuit including regulator; check with regulator connector connected to IPR.
#17 to A	< 5 Ω	
37 to B	< 5 Ω	Resistance from 60-pin connector to regulator connector.

Harness Resistance Checks

Fault code descriptions are **listed in Table** .

Flash Code	Description
241	Output circuit check detected during Standard Test, indicates high or low resistance in circuit.
331	ICP pressure was greater than 3675 psi (25 MPA) for 1.5 seconds. (Possible grounded IPR control circuit.) Refer to injection control pressure diagnostics if not an electronic fault.

Fault Code Descriptions

Function

The engine control system includes an IPR valve that controls oil pressure in the high pressure injection control system that actuates the injectors.

The IPR valve consists of a solenoid, poppet and spool valve assembly and is mounted in the high pressure oil pump. The ECM regulates injection control pressure by controlling the duty cycle or ON/OFF time of the injection control pressure solenoid. This increase or decrease of ON/OFF time positions a poppet valve and spool valve internal to the IPR, which in turn, either maintains pressure in the injection control pressure system or vents pressure to the oil sump via the front cover.

For a more complete description of the IPR operation and function, **refer to section** .

Operation

The IPR valve is supplied with voltage at terminal A of the IPR connector when the ignition key is turned on through the ECM. Control of the injection control system is accomplished by the ECM grounding the IPR circuit from terminal B of the IPR valve through pin No. 37 of the ECM. Precise control is accomplished by varying the pulse width or percentage of ON/OFF time of the IPR solenoid. The frequency of the pulse width to the IPR is 400 Hz. Normal ON/OFF times vary from 8% to 60%.

A high duty cycle indicates a high amount of injection control pressure being commanded; a low duty cycle is an indication of less pressure being commanded.

ECM Diagnostics

The ECM monitors the injection control pressure while the engine is in operation. If the actual pressure is greater or less than the desired pressure, the ECM will set a fault code. When this occurs, the ECM will ignore the ICP sensor and control the engine using pre-programmed values for the IPR.

The EST is used to perform the Engine Running Standard Test that enables the ECM to vary the command signal to the IPR and monitor the performance of the Injection Control Pressure System. If the system does not respond within the specified parameters, the ECM will set a fault code.

Fault codes can be retrieved using the EST or the Self Test Input diagnostic switch located on the vehicle dash. If the ignition key is shut off, the code will be stored as an inactive code.

Flash Codes

The following flash codes could be set while troubleshooting the IPR.

Flash Code 241

ATA Code SID 42 FMI 11

Injection control pressure regulator OCC Self Test failed.

Flash Code 241 is set only during the Engine OFF Standard Output Circuit Check. This test indicates the ECM has performed an output circuit test, measured the voltage drop across the IPR circuit, and determined it is below or above specification.

If this fault is present, the engine will not run. The ECM will not illuminate the engine warning light if this code is active. However, this code will be transmitted at the completion of the Output Circuit Check, using the STI switch or the EST.

Flash Code 331

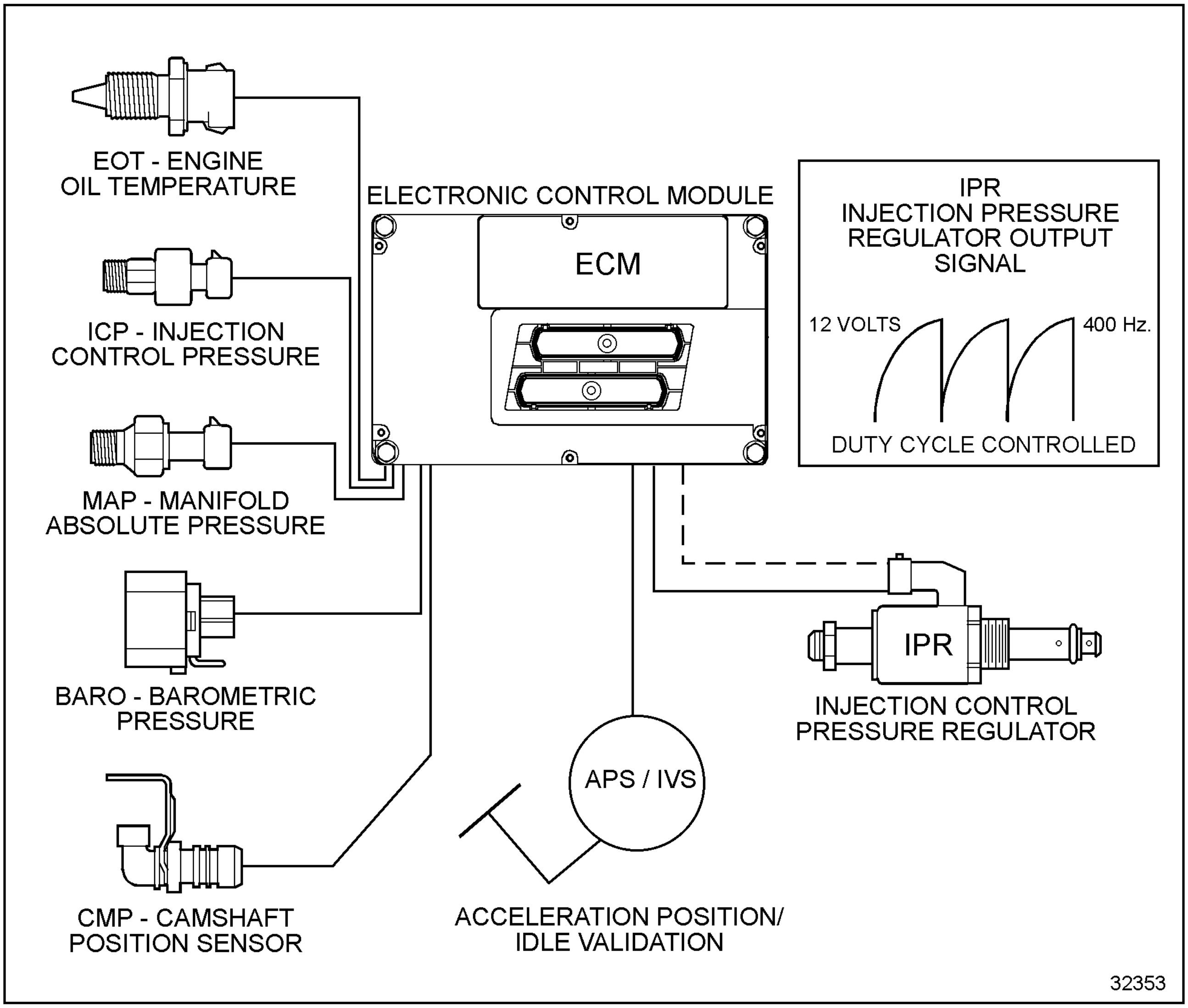
ATA Code PID 164 FMI 0

Injection control pressure above system working range.

Flash Code 331 indicates the ECM has detected injection control pressure greater than 3675 psi (25 MPA) which is greater than the maximum allowable working pressure.

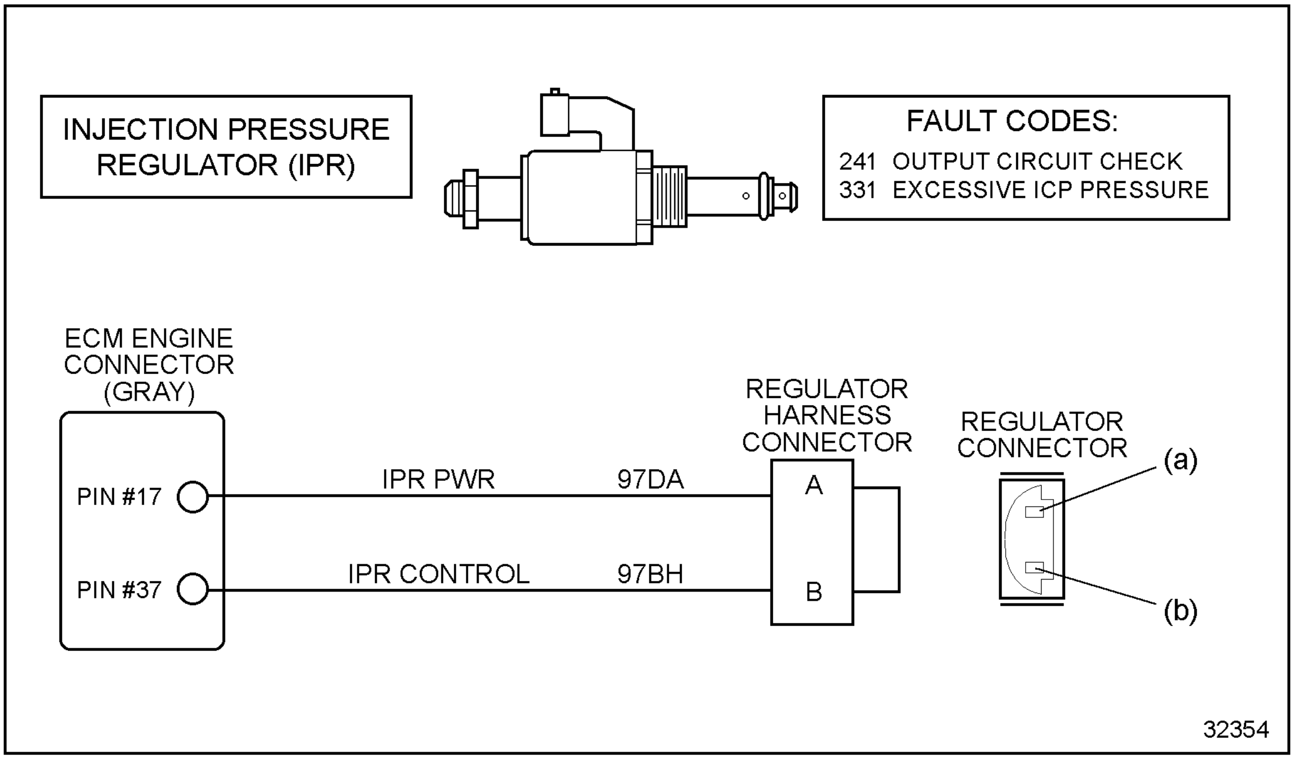
When this code is active, the ECM will illuminate the engine warning light.

Possible causes for this condition include incorrect ICP signal due to faulty circuits or sensor, grounded IPR signal circuit, a malfunction in the injection control pressure system, or a sticking or blocked IPR valve.



Injection Pressure Regulator Function Diagram

2



Injection Pressure Regulator

INJECTION CONTROL PRESSURE SYSTEM

INJECTION CONTROL PRESSURE SYSTEM OPERATION

The Injection Control Pressure system provides the necessary energy to hydraulically actuate the HEUI injector. Engine oil is the hydraulic fluid used by this system for this purpose.

Oil is drawn from the oil pan through the pick-up tube by the engine oil lubrication pump. The lubrication pump is a gerotor type pump driven by the crankshaft. Filtered oil is fed through passages in the front cover to the oil reservoir which is an integral part of the front cover. **See Figure**

.
1

The reservoir makes available a constant supply of oil to a high pressure hydraulic pump mounted to the front cover. The high pressure pump is a gear driven swash plate pump. High pressure oil is delivered by the high pressure pump to the high pressure oil supply manifold and into the oil passages machined into the cylinder head.

This high pressure oil is utilized by the HEUI injector when the solenoid is energized to pressurize and atomize the fuel into the combustion chamber. After injection is completed, the solenoid is de-energized and the oil inside the injector is vented through the top portion of the injector, splashed on the valve train and allowed to drain back into the oil pan.

Injection control pressure is governed by the Electronic Control Module (ECM) depending upon the operating conditions and the driver's demand for power. The injection pressure regulator (IPR) is utilized by the ECM for this purpose.

The IPR is a pressure regulator valve that is electrically controlled by the ECM to control the pressure of the entire injection control pressure system. The IPR valve is mounted on the high pressure pump and achieves injection control pressure regulation by dumping excess oil into the front cover and back to the oil pan.

The injection control pressure sensor provides pressure information in the form of an analog voltage signal to the ECM at any time.

The injection control pressure ranges from 3.4 to 20 kPa (500 to 3000 $lb/in.^2$), depending on the engine family.

INJECTION PRESSURE CONTROl

The ECM controls the injection control pressure by operating the injection control pressure regulator (IPR). **See Figure** . The result of this control is continuously monitored by the ECM using the injection control pressure sensor (ICP). The pressure signal obtained from the ICP allows the ECM to know the actual injection control pressure at all times of engine operation or even during cranking mode. This operation is known as closed loop. **See Figure** .

2

Diagnostic codes can be set by the ECM if the ICP electrical signal is out of range or if the ICP signal received corresponds to an out of range value for the injection control pressure at a given operating condition.

Should these occur, the ECM will ignore the ICP signal and control the IPR valve operation from pre-programmed default values. This condition is known as open loop.

3

IPR VALVE OPERATION

The injection control pressure regulator valve is a pulse width (Duty cycle %) modulated valve operating at 400 Hz. The pulse width is modulated between 8 to 60% to control ICP pressure in the range of 3.4 to 20 kPa (500 to 3000 $lb/in.^2$). The regulator is mounted in the high pressure pump and maintains desired injection control pressure by dumping excess oil through a (internal shuttle) spool valve into the front cover and back to the oil pan.

As the demand for injection control pressure increases, the ECM increases the pulse width (duty cycle %) over the IPR solenoid. This action forces the poppet against the drain orifice increasing the pressure behind the spool valve.

As oil pressure increases behind the spool valve, it moves forward and blocks the drain ports on the sides of the IPR valve. **See Figure**

. When the demand for injection control pressure decreases, the ECM decreases the duty cycle %) over the solenoid allowing oil to drain out of the drain orifice. This action is accomplished by relieving the pressure behind the spool valve that allows it to partially open the relief port, decreasing the injection control pressure. **See Figure**

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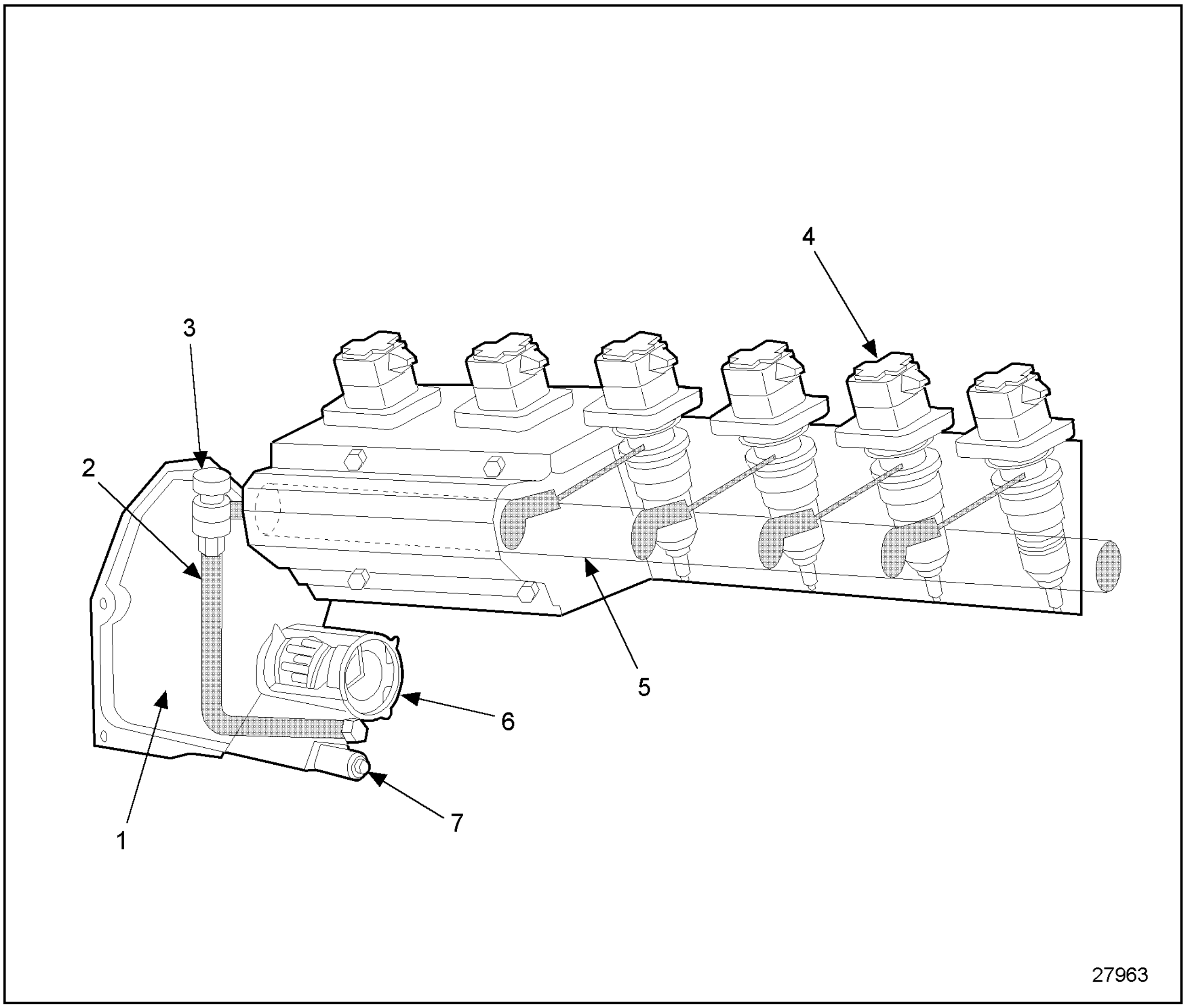
The described operation allows the IPR to continuously adjust injection control pressure commanded by the ECM. (The Injection Control Pressure Sensor is referred to as both the ICP and the IPS sensor. Both are correct.)

45

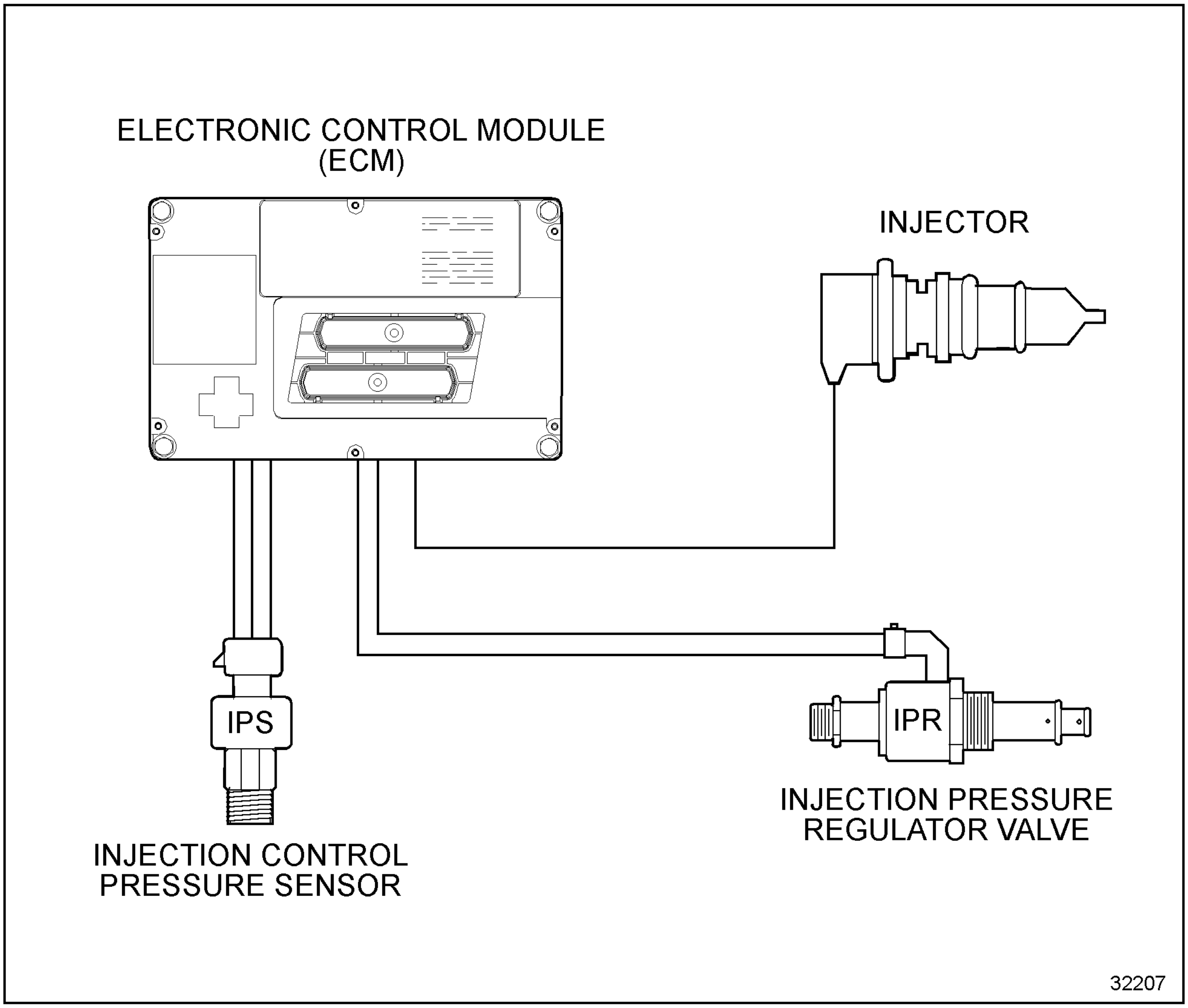
1



1. Oil Reservoir	5. Oil Manifold
2. Hose	6. High Pressure Oil Pump
3. Injection Control Pressure Sensor	7. Injector Pressure Regulator Valve
4. Injectors	

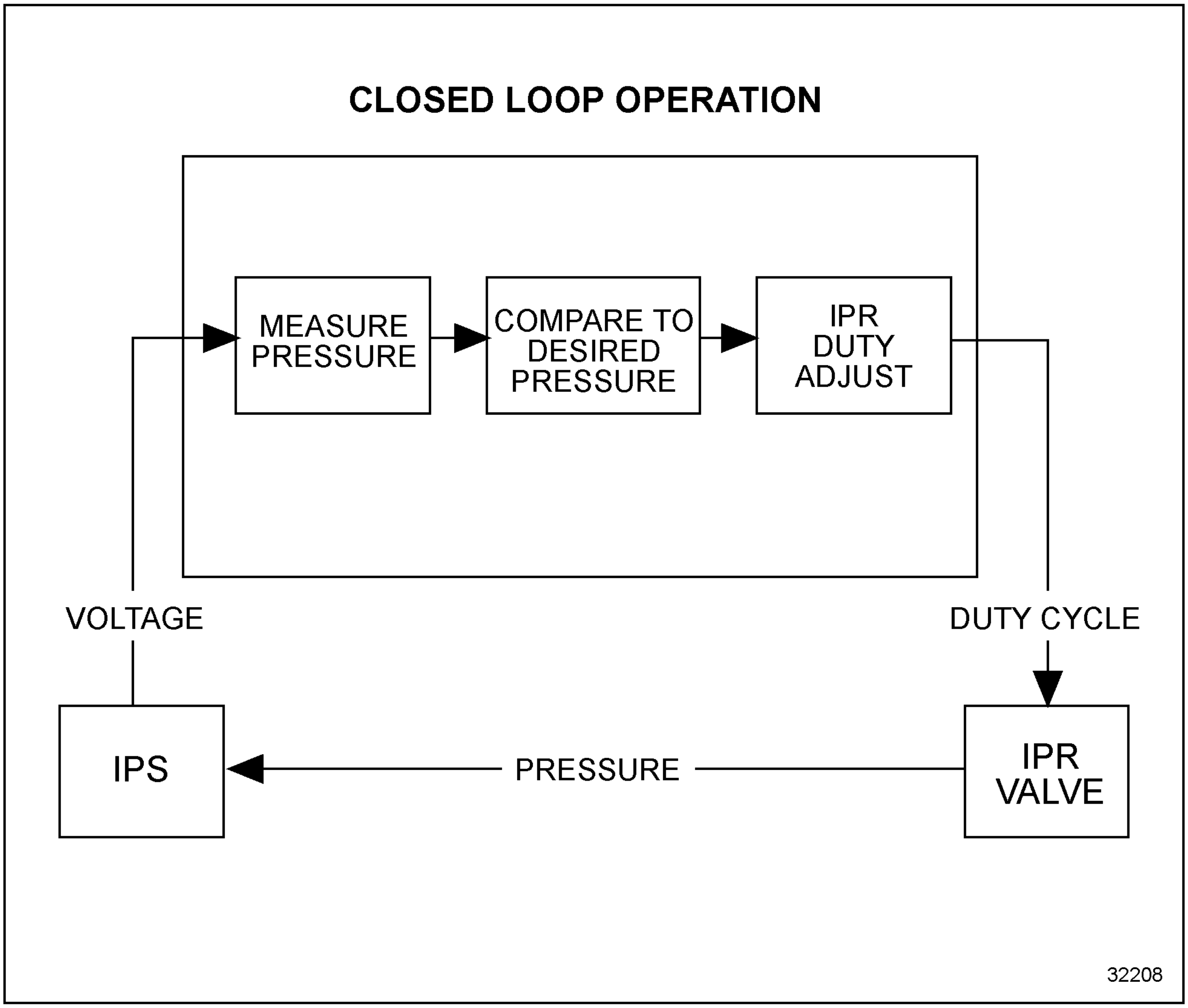
Injection Control Pressure System

2



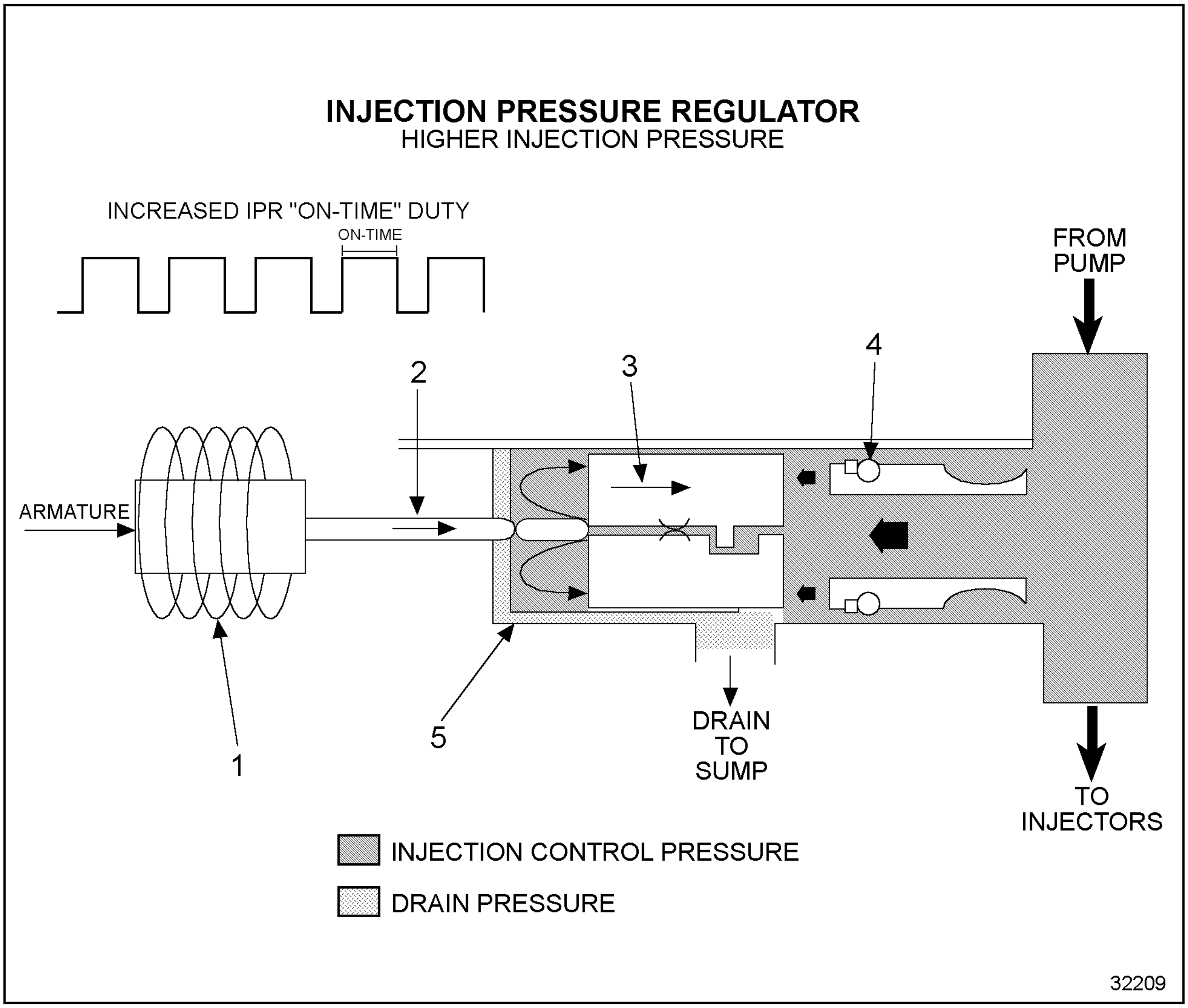
Injection Control System

3



Closed Loop Operation

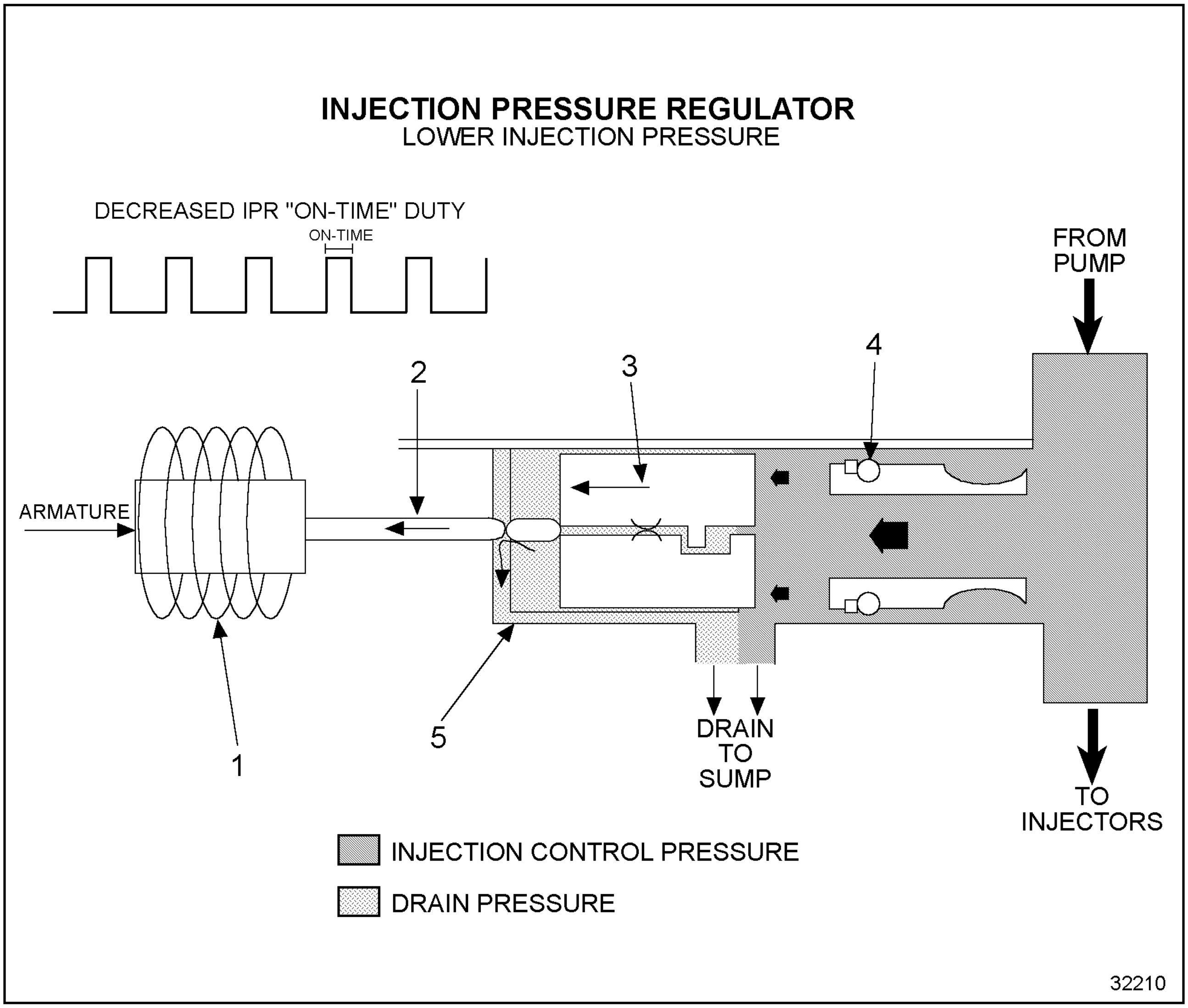
4



1. Solenoid Windings	4. O-rings
2. Poppet Valve	5. Spool Chamber Drain
3. Spool Valve	

IPR Higher Injection Pressure

5



1. Solenoid Windings	4. O-rings
2. Poppet Valve	5. Spool Chamber Drain
3. Spool Valve	

IPR Lower Injection Pressure

INJECTION PRESSURE REGULATION SYSTEM

INJECTION PRESSURE REGULATION SYSTEM OVERVIEW

The Injection Control Pressure Regulation System (IPR_SYS) consists of the low pressure oil lubrication system, passages in the front cover and reservoir, high pressure oil pump, high pressure oil line, as well as the high pressure oil rail that is mounted on the side of the cylinder head. The system also includes the injectors and their sealing O-rings, the IPR valve and the ICP sensor (Injection Control Pressure) and associated wiring. For an exploded view of the IPR_SYS, **see Figure** .

1

System Functions

The function of the IPR_SYS is to develop, maintain and control the high pressure injection control pressure to provide the force to actuate the injectors and provide fuel to the engine.

Fault Detection / Management

The fault codes associated with this system may indicate an electrical or electronic control system failure, but most likely will indicate a mechanical or hydraulic problem with the IPR_SYS.

The ECM constantly monitors the ICP in the system to assure the control system is providing the proper control pressure at all times. If the oil pressure feedback provided by the ICP sensor does not meet the programmed desired values of the ECM, the ECM will set a fault code. It will also illuminate the WARN lamp and control the operation of the injection control system by calculating the correct oil pressure for all engine operating conditions until the system is diagnosed and repaired.

The ECM also monitors the ICP developed while cranking the engine. If pressure does not develop within the expected time limit of the ECM, it will set an appropriate fault code that will aid the technician in diagnosing the no start or hard start condition.

The Electronic Service Tool (EST) may be used by the technician to command the ECM to perform an engine running test on the ICP system. The ECM controls the pressure regulator in a programmed sequence to evaluate system performance. At the end of the test, the ECM will transmit any fault codes if system performance is unsatisfactory.

ECM Diagnostics

The following flash codes could display when troubleshooting the IPR_SYS:

Flash Code 333

ATA Code PID 164 FMI 10

ICP above/below desired level.

Flash Code 333 may be set during normal engine operation through the continuous monitor function or during the Engine Running Standard Test. It indicates that the measured pressure does not match the pressure value that the ECM expects. Flash Code 333 will be set if the measured value is greater or less than 362 psi (2.5 MPA) of desired injection control pressure for a period greater than seven seconds. When this code is active, the ECM will ignore feedback from the ICP sensor and control the IPR valve to control the pressure in the system from pre-programmed default values. When this occurs, it will illuminate the engine WARN lamp to notify the driver.

Flash Code 333 is usually associated with poor engine performance. Symptoms are slow acceleration time, low power at full load, and possible engine under run.

Possible Causes:

1. Low oil level, contaminated or aerated engine oil.
2. Trapped air in the ICP system, particularly after an injector or high pressure pump replacement.
3. Defective or stuck injection pressure regulator.
4. Intermittent IPR valve wiring connection. Spread IPR harness terminals at valve,

poorly crimped terminals or pulled back pins.

5. Leaking injector O-rings.
6. Problem with ICP sensor and sensor circuit; system biased high or low.

Recommended actions are **listed in Table** .

Test	Comments
Check repair history - Determine if air entrapment could be caused by ICP system disassembly.	If system was disassembled, ensure vehicle is operated 15 to 20 miles after injection control system has been serviced.
Check oil level and quality.	Check for level and contamination and correct API classification.
Check active and inactive faults.	Repair any ICP sensor codes first.
Perform a Key ON Engine OFF Standard Test.	Test will verify IPR valve circuit continuity.
Perform a Key ON Engine Running Test.	ICP step test will verify a gross ICP system failure.
Perform Engine Running wiggle test, Intermittent fault detection test.	When engine is running enable test, pull/wiggle wires on ICP sensor and IPR valve as well as all pass through connectors. If fault is set or engine dies, inspect wires at point of connection; check codes.
Perform ICP Pressure Test - Performance Diagnostic Form (Oil aeration).	Will verify oil is aerated at high idle, Step #9 on the Performance Diagnostic Form.
Test high pressure (ICP system) for leaks.	For ICP Leakage Tests, **refer to section** .

Recommended Actions

Flash Code 334

ATA Code PID 164 FMI 7

ICP unable to reach set point — poor performance.

The purpose of Flash Code 334 is to determine if a rapid increase in ICP can be developed when commanded by the operator while the engine is running.

Flash Code 334 is an ICP system response time fault that compares measured injection control pressure to desired injection control pressure, and looks for a large pressure difference- 1300 psi (9 MPA) for a short period of time (three seconds). Its primary function is to detect injection control pressure system faults.

When this code is active, the engine warning lamp will illuminate and the ECM will ignore the ICP sensor and control IPR valve operation from pre-programmed default values.

An active Flash Code 334 is usually associated with poor engine performance conditions, including slow time to acceleration and lower power concerns.

Possible Causes:

1. Low oil level, contaminated or aerated engine oil.
2. Trapped air in the ICP system, particularly after an injector or high pressure pump replacement.
3. Defective or stuck injection pressure regulator.
4. Intermittent IPR valve wiring connection. Spread IPR harness terminals at valve, poorly crimped terminals or pulled back pins.
5. Leaking injector O-rings.
6. Problem with ICP sensor and sensor circuit; system biased high or low.

Recommended actions are **listed in Table** .

Test	Comments
Check repair history - Determine if air entrapment could be caused by ICP system disassembly.	If system was disassembled, ensure vehicle is operated 15 to 20 miles after injection control system has been serviced.
Check oil level and quality.	Check for level and contamination and correct API classification.
Check active and inactive faults.	Repair any ICP sensor codes first.
Perform a Key ON Engine OFF Standard Test.	Test will verify IPR valve circuit continuity.
Perform a Key ON Engine Running Test.	ICP step test will verify a gross ICP system failure.
Perform Engine Running wiggle test, Intermittent fault detection test.	When engine is running enable test, pull/wiggle wires on ICP sensor and IPR valve as well as all pass through connectors. If fault is set or engine dies, inspect wires at point of connection; check codes.
Perform ICP Pressure Test - Performance Diagnostic Form (Oil aeration).	Will verify oil is aerated at high idle, Step #9 on the Performance Diagnostic Form.
Test high pressure (ICP system) for leaks.	For ICP Leakage Tests, **refer to section** .

Recommended Actions

Flash Code 331

ATA Code PID 164 FMI 10

ICP above working system range.

The purpose of Flash Code 331 is to detect when the ICP is above its normal working range (3675 psi or 25 MPA). This code may indicate a mechanical injection control pressure system problem or a wiring or ICP sensor problem. When this code is set, the engine warning lamp is illuminated and the ECM ignores the ICP sensor signal and uses estimated ICP values to operate the engine.

Note: If the engine still performs well when this code is set, the problem is more likely in the ICP sensor circuit.

Possible Causes:

1. Contaminated or improper grade of engine oil.
2. Defective or stuck injection pressure regulator (IPR) valve.
3. Improperly matched parts (IPR valve, high pressure pump, front cover).
4. Grounded IPR control wire.
5. Problems with ICP sensor or circuit causing signal to be biased high.

Flash Code 335

ATA Code PID 164 FMI 1

ICP unable to build pressure during cranking.

The purpose of Flash Code 335 is to determine if injection control pressure is being developed during engine cranking. It is an ICP system check and will be set after 8 to 10 seconds of engine cranking time with less than 725 psi (5 MPA) of injection control pressure detected. The period of engine cranking time before Fault Code 335 is set varies with engine temperature. Engine cranking speed must be greater than 130 r/min before fault detection begins.

An active Flash Code 335 is normally associated with a long time to start or no start engine condition.

Possible Causes:

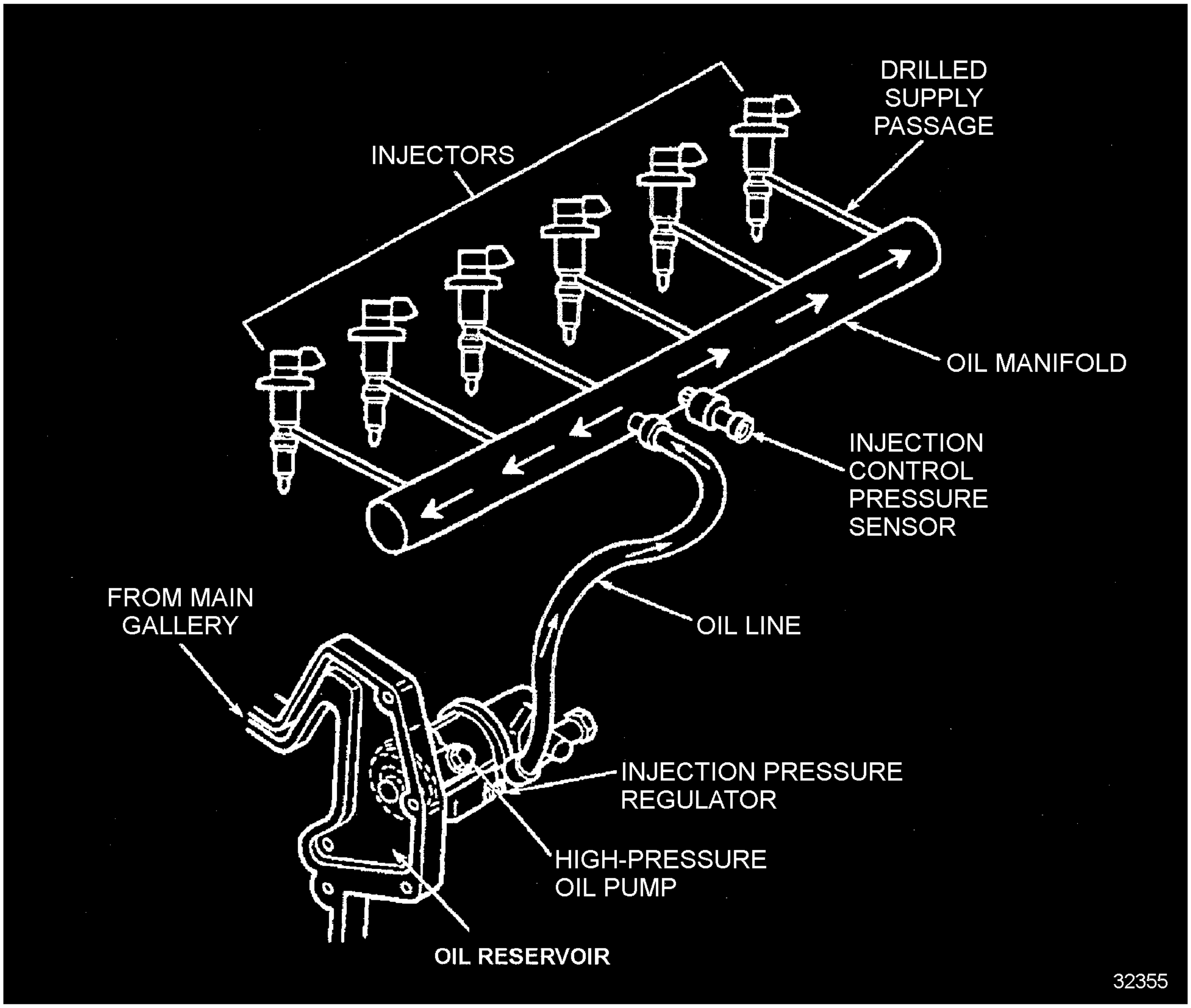
1. No oil or insufficient oil in the engine.
2. Air in the injection control pressure system, particularly after an injector or high pressure pump replacement.
3. Defective or stuck injection pressure regulator.
4. Leaking injector O-rings.
5. Loose high pressure pump gear.
6. Defective high pressure pump.

Recommended actions are **listed in Table** .

Test	Comments
Visual inspection	Check to see if IPR regulator and ICP sensor wiring is connected; check for oil leaks; check to see if injection control system recently disassembled (air entrapment); ensure vehicle is operated a minimum of 15 to 20 miles if symptom is hard start and evidence of recent disassembly of injection control system.
Check oil level, quality, pressure	Check for level and contamination; check for oil in the oil reservoir; verify lube oil pressure during engine cranking.
Check active and inactive faults.	Repair any ICP and CMP sensor codes first.
Perform a Key ON Engine OFF Standard Test.	Test will verify IPR valve circuit continuity.
Perform Engine Running wiggle test, Intermittent fault detection test. — Hard Start Only.	When engine is running enable test, pull/wiggle wires on ICP sensor and IPR valve as well as all pass through connectors. If fault is set or engine dies, inspect wires at point of connection; check codes.
Perform ICP Pressure Test - Hard Start/No Start Diagnostic Form.	Will verify oil is aerated at high idle, Step #9 on the Performance Diagnostic Form.
Test high pressure (ICP system) for leaks.	For ICP Leakage Tests, **refer to section** .

Recommended Actions

1



Injection Pressure Regulation System

ENGINE CRANK INHIBIT

SIGNAL FUNCTION

The Engine Crank Inhibit (ECI) feature of the ECM is used to control the operation of the cranking motor. The ECM prevents the cranking motor from being engaged when the engine is running. The transmission neutral safety switch or clutch switch will prevent the cranking motor from being engaged when the transmission is in gear or when the clutch pedal is not depressed.

For Engine Crank Inhibit Relay with a driveline status switch Type I, **see Figure**.

1

For Engine Crank Inhibit Relay with a driveline status switch Type II, **see Figure**.

2

For Engine Crank Inhibit Relay without a driveline status switch, **see Figure**.

3

ECM

The ECM prevents the engine from being cranked if the engine is already running. It does this by not allowing the ECI relay to be enabled.

Engine Crank Inhibit Relay

The ECI relay controls the start relay. The ECI relay receives signals from the ignition switch and ECM to close the relay. Current to the relay is supplied from the neutral safety switch with automatic transmission or clutch with manual transmission.

Start Relay

The start relay switches battery power to the crank motor solenoid when the crank inhibit relay is energized. With thermal overcrank protection, the relay is also controlled by the overcrank thermocouple.

Clutch Switch

On vehicles equipped with manual transmissions, the clutch switch supplies switched power to the ECI relay and provides a signal to the ECM that indicates the driveline is disengaged. On vehicles programmed for manual transmissions, a 0 volt signal on the DDS circuit indicates that the clutch is disengaged (clutch pedal down); a 12 volt signal indicates that the clutch is engaged (clutch pedal up). When the clutch pedal is up, no power is available to the ECI relay.

Neutral Switch

On vehicles equipped with mechanical automatic transmissions (Allison AT/MT), the neutral position switch supplies switched power to the ECI relay and provides a signal to the ECM that indicates the driveline is disengaged. On vehicles programmed for Allison AT/MT transmissions, a 12 volt signal on the DDS circuit indicates that the transmission is out of gear; a 0 volt signal indicates that the transmission is in gear. When the transmission is in gear, no power is available to the ECI relay.

WTEC VIM Relay

On vehicles equipped with the electronic Allison MD WTEC transmission, the transmission controller provides a signal to a relay in the VIM module that supplies switched power to the ECI relay and provides a signal to the ECM to indicate that the driveline is disengaged.

On vehicles programmed for Allison MD transmissions, a 12 volt signal on the DDS circuit indicates that the transmission is out of gear; a 0 volt signal indicates that the transmission is in gear. When the transmission is in gear, no power is available to the ECI relay.

Fault Detection Management

The ECM does not monitor the cranking system circuits. There are no fault codes for this system.

Before testing the ECI or cranking circuits, verify that batteries are fully charged. Check battery connections at battery, frame and starter.

Start relay voltage and resistance checks with the start relay removed are .

<table>
<tr><th>Test Points</th><th>Specs.</th><th>Comments</th></tr>
<tr><td>86 to Grd</td><td>12v ± 1.5v</td><td>Check with relay unplugged and starter switch (key or button) engaged. If no voltage present, troubleshoot the clutch or transmission switch, the ECI circuit or ignition crank circuit.</td></tr>
<tr><td>85 to Grd</td><td>< 5 Ω</td><td>An open to ground will cause the relay not to energize. (Check the thermal overcrank switch.)</td></tr>
<tr><td colspan="3">Crank Circuit Test - With the transmission out of gear and the clutch depressed with wheels blocked, momentarily insert a jumper wire between socket pins #30 and #87 of the Start Relay.

NOTE: If the cranking circuit is functional, the engine will crank.

If the engine cranks and voltage is present at #86 and ground at #85, the relay is bad.</td></tr>
</table>

Start Relay Voltage and Resistance Checks — Start Relay Removed

ECI relay voltage and resistance checks with the ECI relay removed are .

Test Points	Specs.	Comments
85 to Grd	12v ± 1.5v	Check with relay unplugged and starter switch (key or button) engaged. If no voltage present, troubleshoot ignition crank circuit.
30 to Grd	12v ± 1.5v	If no voltage present when clutch is depressed or automatic transmission in neutral, troubleshoot clutch switch or neutral switch circuit.
86 to Grd	4 to 5v	ECM will pull circuit up to 4 to 5 volts with key ON; will go to 0 volts with clutch depressed or transmission in neutral.
ECI Circuit Test - With the transmission out of gear, and the clutch depressed, wheels blocked, insert a jumper wire between socket pins #85 and #87 of the ECI relay. If the engine cranks when the start switch is engaged, either the ECI relay is bad or there is a problem with the ECM or ECM wiring.		

ECI Relay Voltage and Resistance Checks — ECI Relay Removed

Engine Crank Inhibit Description

The engine starting system is controlled by the ECM. This is to prevent cranking motor operation while the engine is running, causing damage to the starter pinion and ring gear. In series with the ECI relay is a clutch switch or transmission neutral switch. These switches prevent the cranking motor from being engaged unless the transmission is in neutral or the clutch is depressed.

Components of the system are:

1. Ignition switch
2. Push button start switch (optional)
3. Engine Crank Inhibit (ECI) Relay
4. Start relay
5. Crank motor and solenoid
6. Batteries and cables
7. Neutral safety switch (with AT/MT automatic transmission)
8. Clutch switch (with manual transmission)
9. VIM relay module (with MD automatic transmission.

System Operation

When the ignition switch is turned to the start position, with the ignition switch on and the pushbutton start switch depressed, current flows to the ECI relay. The relay is then enabled if the ECM supplies the ground circuit for the relay control windings.

Closing this relay allows current to pass from the ignition switch through the fuse, through the neutral safety switch (jumped if manual transmission), and through the clutch switch normally closed (jumped if automatic transmission). With the relay closed, current then passes through the relay and will energize the start relay. The ground circuit for the start relay is through the overcrank protection fuse in the crank motor, or directly to ground if not equipped with overcrank protection. When the relay is closed, the current can then pass from the crank motor battery terminal through the relay and to the crank motor solenoid, start terminal. This closes the crank solenoid to engage the starter.

ECM

When the ECM recognizes that the engine is not running, the ECM will ground terminal 46. This provides the current path for the ECI relay to close when the start switch is engaged or the starter button is depressed. When the ECM recognizes that the engine is running, the ECM will open terminal 46. This will prevent the ECI relay from closing, thus preventing the starter motor from engaging.

Engine Crank Inhibit Relay

The ECI relay controls the current to the start relay. Turning the ignition key to the start position supplies current to energize the relay at terminal 85. If the engine is not running, the ECM terminal 46 will enable the relay by supplying a ground circuit to terminal 86 of the relay. Current for the start relay is supplied through the neutral safety switch if the transmission is in neutral with an automatic transmission to terminal 30. Or, if the vehicle is equipped with a manual transmission, current will be supplied to the relay through the clutch switch if the clutch pedal is depressed. With the relay closed, current can then pass through the relay to terminal 86 to power the start relay.

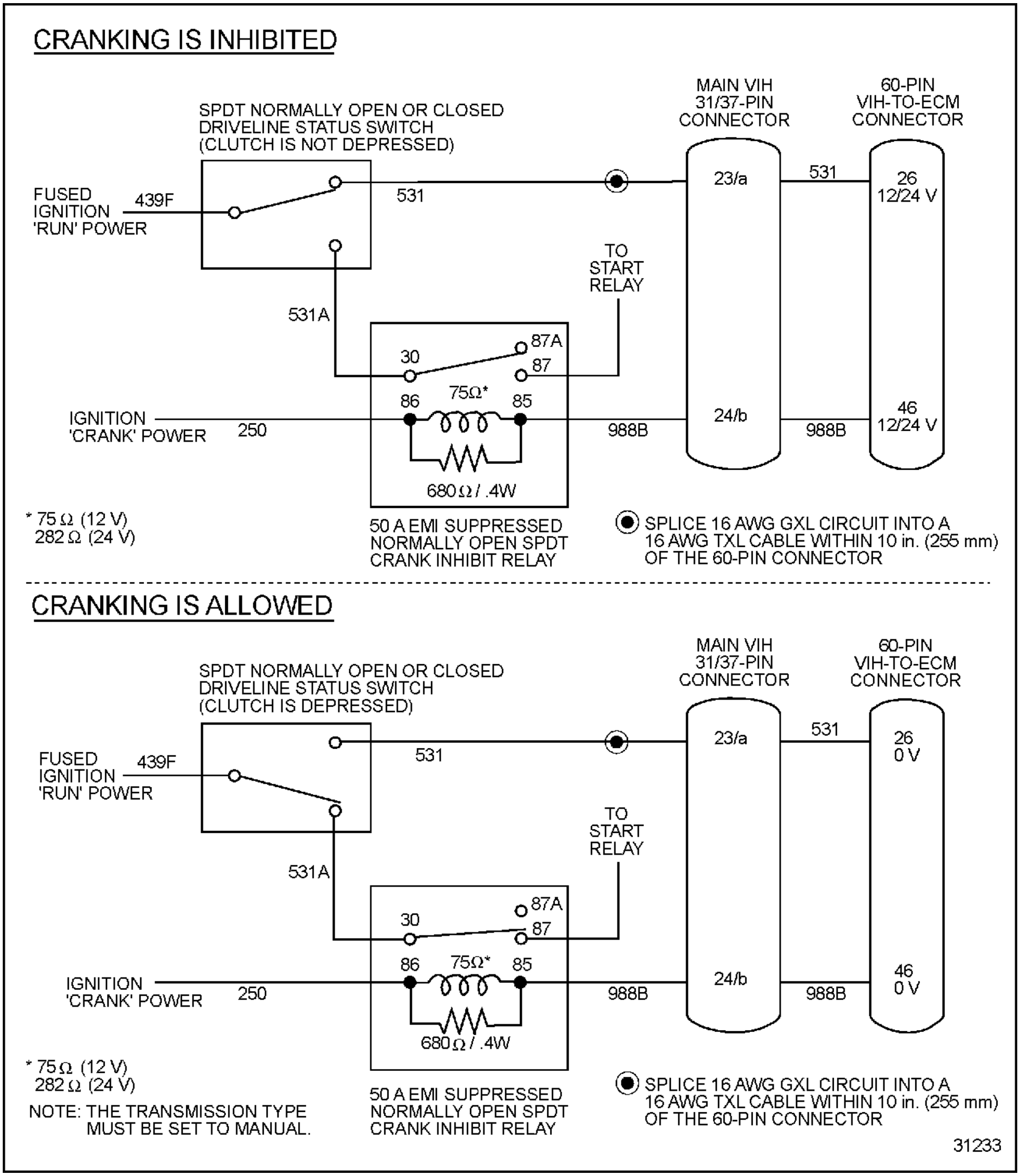
Start Relay

The start relay switches battery power to the crank motor solenoid when the crank inhibit relay is energized. Then the ECI relay is closed, current is supplied to the start relay terminal to energize the relay. The start relay control is grounded through the starter thermal overcrank protection thermocouple, if equipped. Or, if not, the relay is grounded directly to the ground stud on the starter. With the start relay energized, battery voltage is supplied to the start relay, and then switched to the crank motor solenoid to crank the engine.

Before troubleshooting, ensure the batteries are fully charged. Check the battery cables and grounds for clean and tight connections, free of damage. Voltage readings will not be accurate if the batteries are not fully charged.

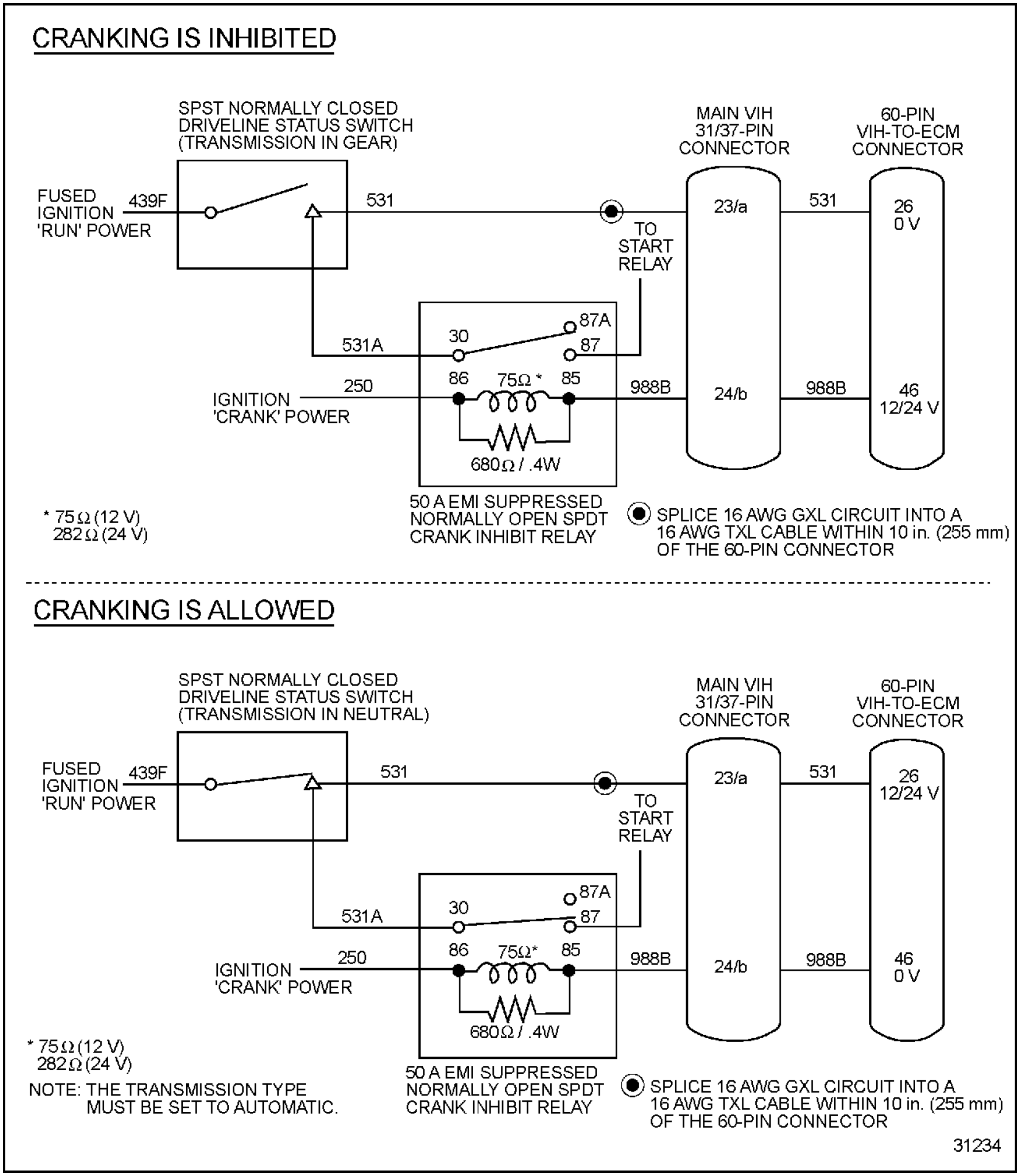
Before troubleshooting, inspect circuit connectors for pushed back, loose or damaged (spread or bent) terminals, or wires with cut strands, etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present and must be removed.

Before troubleshooting, inspect the suspect circuit ground for clean, tight connections, free of any damage.



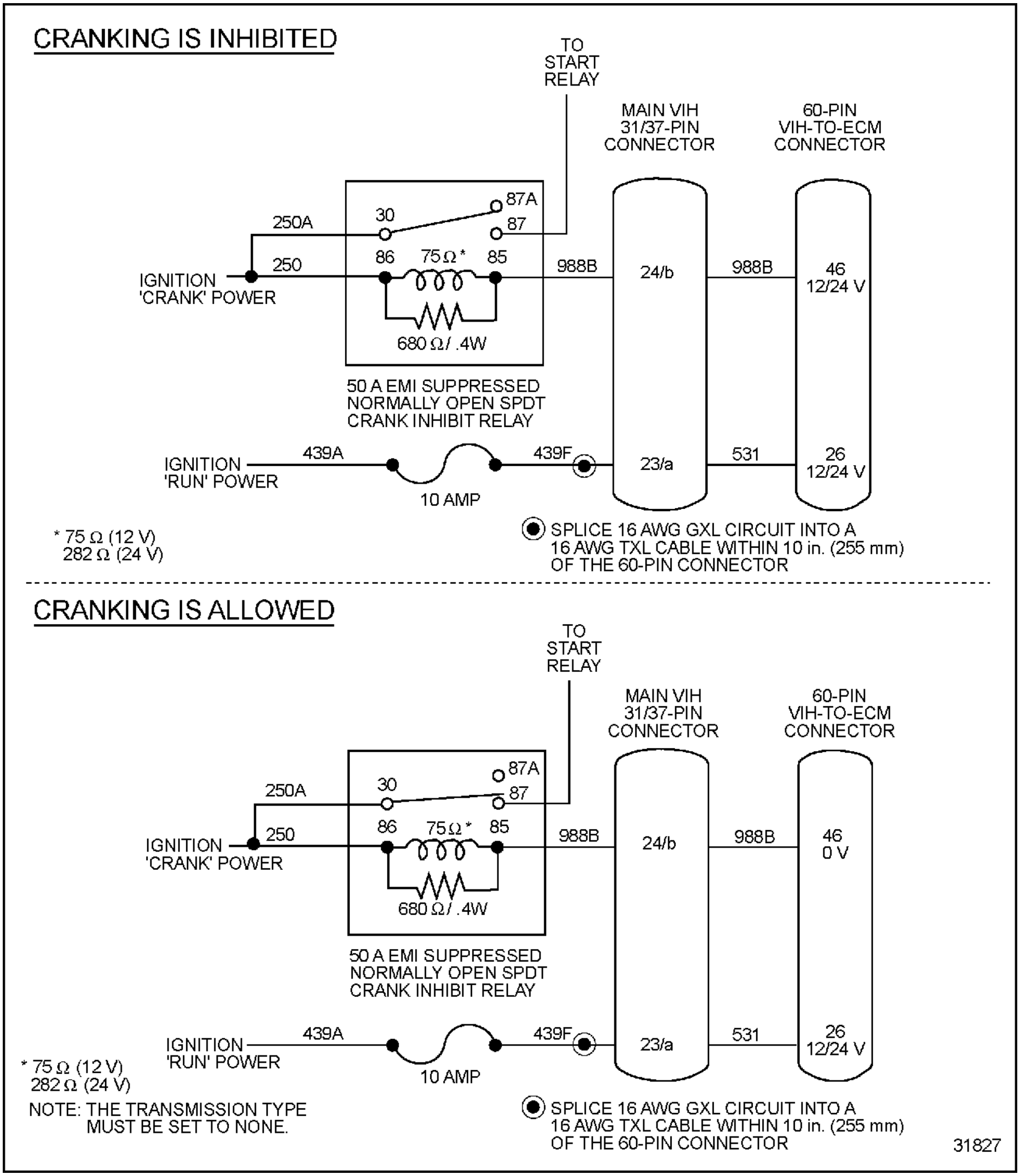
Wiring a Crank Inhibit Relay with a Driveline Status Switch Type I

2



Wiring a Crank Inhibit Relay with a Driveline Status Switch Type II

3



Wiring a Crank Inhibit Relay without a Driveline Status Switch

BRAKE SWITCH CIRCUITS

FUNCTION

The service brake circuit function is to signal the ECM when the brakes are applied. This information is used to disengage the cruise control and PTO functions. The signal is also used for ECM control of the Vehicle Retarder and exhaust brake enabling. The brake signal will interrupt the Cold Ambient Protection feature and will reset the time interval for the Idle Shutdown feature. **See Figure** .1

Service Brake Switches

The service brake switches send a 12 volt signal to the ECM when the brakes are applied. Both signals are normally open.

Fault Detection Management

The ECM continuously monitors terminals 43 and 44 for voltage. Should there be a voltage at one of the terminals and not at the other, the ECM will set a fault code.

When Flash Code 222 is active, all features using brake signal inputs will be disabled.

This code will not cause the Warn Engine Light to illuminate. **See Figure** .
2

Connector voltage checks are **listed in Table** .

Test Points	Specification	Comments
439G to Grd	12v ± 1.5v	Open fuse F9 or open circuit 70 (Hydraulic and Air)
439C to Grd	12v ± 1.5v	Open fuse F33 or open circuit 90C (Hydraulic brake only)
523 to Grd	0	Circuit 523 shorted to another circuit
543 to Grd	0	Circuit 543 shorted to another circuit or ...with hydraulic brakes shorted diode assembly or defective brake module...with air brakes defective brake relay.

Connector Voltage Checks

ECM connector checks with the breakout box installed, ignition switch ON and the brakes not depressed, are **listed in Table** .

Test Points	Specification	Comments
43+ to 42–	0	Circuit 423 shorted to another circuit or (with hydraulic brakes) defective brake module
44+ to 42–	0	Circuit 543 shorted to another circuit or (with hydraulic brakes) defective brake module or shorted diode assembly.
Apply brakes (with air brakes, ensure sufficient air pressure is available)		
43+ to 42–	12v ± 1.5v	If the brake switch connector test is within spec, then possible open ckt 523 or defective brake switch
44+ to 42–	12v ± 1.5v	If the brake switch connector test is within spec, then possible open ckt 543 or defective brake switch

ECM Connector Check

Fault code descriptions are **listed in Table** .

Fault Code	Description
222	Brake switch circuit fault
Indicates ECM has detected that voltage at terminal 43 is not equal to voltage at terminal 44	

Fault Codes

Extended Description

The service brake circuit function is to signal the ECM when the brake pedal is applied. This information is used to disengage the cruise control and PTO functions. This signal is also used for ECM control of the Vehicle Retarder and compression brake enabling. The brake signal will interrupt the Cold Ambient Protection feature and will reset the time interval for the Idle Shutdown feature.

Four systems are used for the service brake signal.

Hydraulic Brakes

With hydraulic brakes a double pole single throw switch is used. The switch is a self adjusting switch mounted at the brake pedal. When the brake is not applied, the brake pedal holds the switch in the open state. Current is supplied by fuse to the primary side of the switch and by fuse to the secondary side of the switch. Applying the brakes closes the switch to supply current to circuits 543 and 523.

Circuit 523 supplies voltage to:

1. Operate the turn signal switch relay for brake light operation.
2. Circuit 523 to signal the ECM at terminal 43 to indicate the brakes have been applied.

Circuit 543 supplies voltage to the brake module and to the ECM at terminal 44 as a redundant signal to verify brake application.

Service Brake Switch(s)

The following apply to the service brake switch:

1. With tractor air brakes, a single normally open switch is used. Air pressure closes

the switch with the brakes applied.

2. With air brakes, two normally open air-operated switches are in parallel circuits.
3. With hydraulic brakes, two mechanical switches are used, but only one of the switches is linked to the ECM. The switches are activated by the brake pedal arm.

Flash Code

Flash Code 222

SID 247 FMI 2

ECM: Brake Switch Circuit Fault

The ECM continuously monitors terminals 43 and 44 for voltage. Should there be voltage present at one of the terminals and not at the other, the fault detection will set a fault code.

When flash code 222 is active, all features using brake signal inputs will be disabled. This code will not cause the Warn Engine Light to illuminate.

Possible Causes

If an open circuit exists due to a defective fuse, switch or an open wire, voltage may not be present at either terminal 43 or 44. This would cause the fault code to be set.

Before Troubleshooting

Before troubleshooting, ensure the batteries are fully charged.

Check the battery cables and grounds for clean and tight connections, free of damage. Voltage readings will not be accurate if the batteries are not fully charged.

Inspect circuit connectors for pushed back, loose or damaged (spread or bent) terminals, or wires with cut strands, etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present and must be removed.

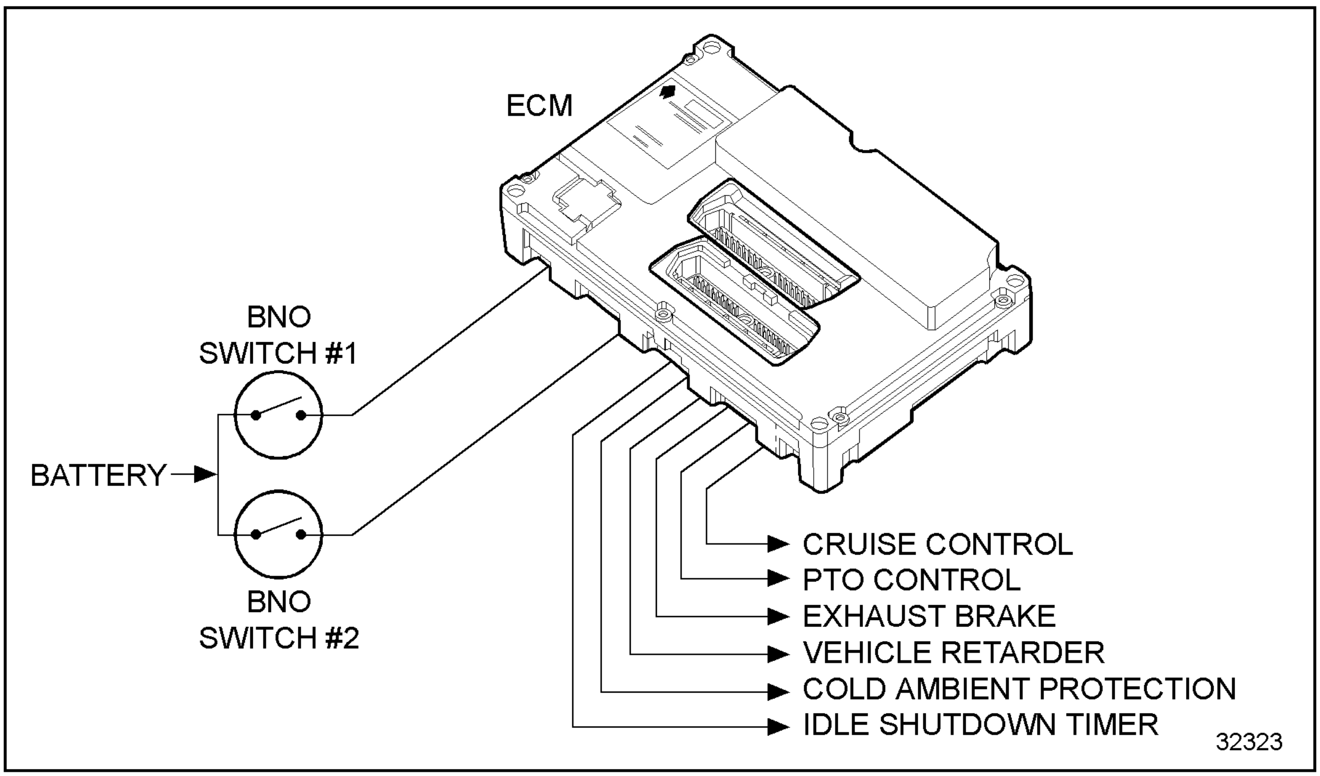
Inspect the suspect circuit ground for clean, tight connections free of damage.

Troubleshooting

The EST service tool can be used to retrieve a fault code that has been set in the ECM. The EST may also be used to clear these fault codes once the problem has been resolved.

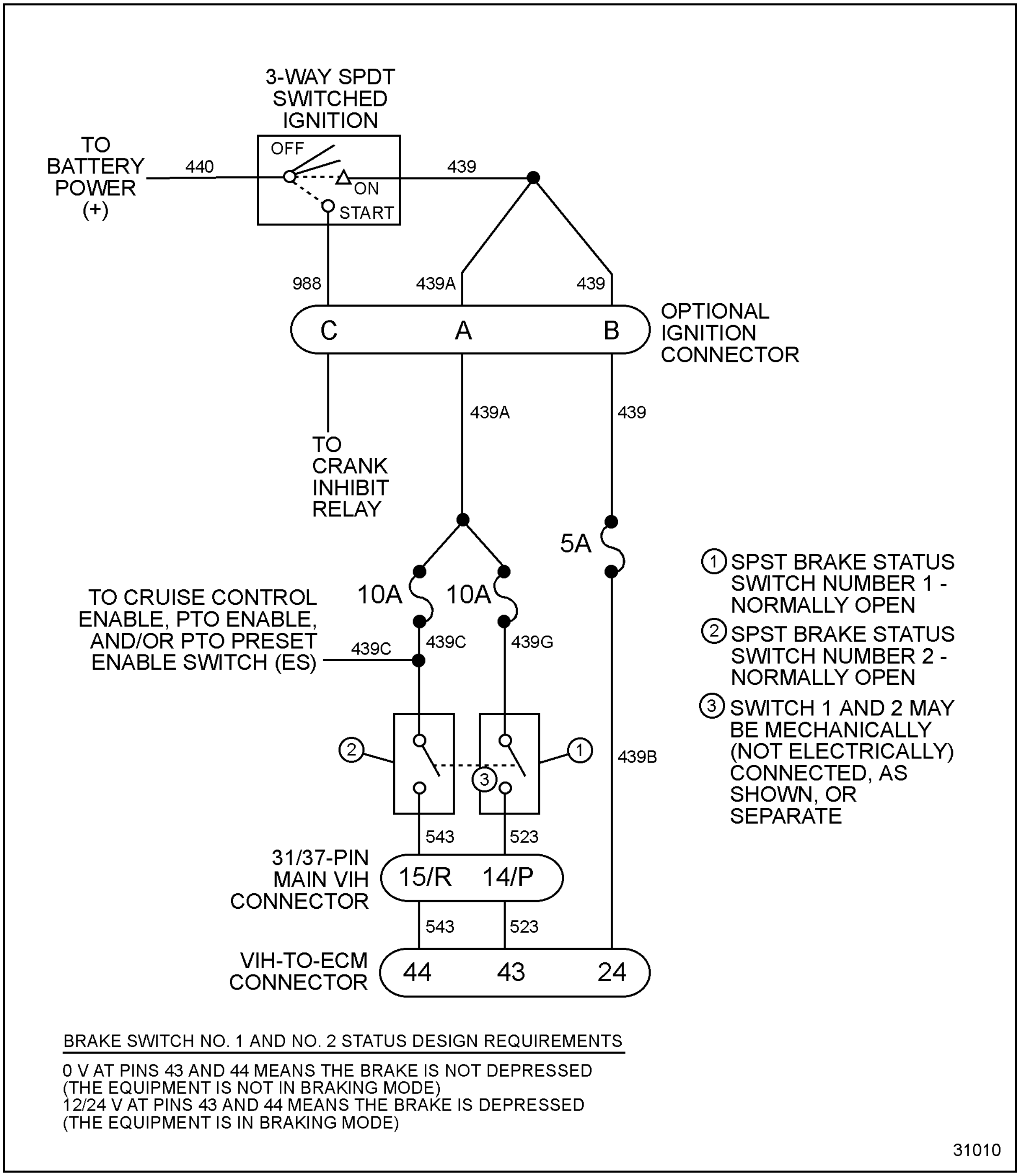
To determine the operation of the brake switch circuit it is possible to monitor the EST data list and the brake status will be displayed.

1



Service Brake Circuit Function

2



Circuit 523 and 543 Wiring Recommendation (Brake Switches)

RADIATOR SHUTTER ENABLE

SIGNAL FUNCTIONS

The purpose of Radiator Shutter Enable (RSE) circuit is to provide control to open or close the radiator shutters (energize or de-energize a solenoid). The purpose of this device is to keep the engine warm during cold weather operation. When the ignition switch is in the ON position, power is available to the shutter solenoid. The solenoid is energized and the shutters are closed when the engine coolant temperature is below 181.5°F, 83°C, and de-energized (allowing the shutters to open) when cooling temperature gets above 185°F, 85°C. The ECM controls the shutter solenoid by providing a path to ground for the solenoid coil.**see Figure** .

Note: This circuit has many applications and can be wired in many configurations. The applicable wiring diagram for the correct application must be used for troubleshooting this circuit.

1

Fault Detection / Management

An open or short to ground can be detected in the RSE circuit during an On Demand Engine Standard Test performed by the technician.

see Figure .

2

RSE connector voltage checks are **listed in Table** . Checks are made with the RSE solenoid disconnected and the ignition key ON, Engine OFF.

+Test Points-	Spec	Comments
A to Grd	12 ± 1.5v	Power should be available with key ON check fuse and/or circuit or open/shorts.
B to Grd	0-1v	If voltage present, check for short to power.

Voltage Checks at Radiator Shutter Enable Connector

RSE solenoid continuity checks are **listed in Table** . Checks are made with the RSE solenoid disconnected; resistance is measured through the solenoid.

+Test Points-	Spec	Comments
(B) to Grd	> 100 Ω	If less than 100 Ω, check for short to ground.
(A) to Grd	> 100 Ω	If less than 100 Ω, check for short to ground.
(B) to (A)	10 to 30 Ω	Expected coil resistance of solenoid.

Radiator Shutter Enable Solenoid Continuity Checks

Harness resistance checks are **listed in Table** . Checks are made with the RSE solenoid disconnected; battery positive cable disconnected; and breakout box installed.

+Test Points-	Spec	Comments
9 to B	< 5 Ω	If greater than 5 Ω, check for open circuit.
F4 to A	< 5 Ω	If greater than 5 Ω, check for open circuit.
9 to Grd	> 100 Ω	If less than 100 Ω, check for short to ground.
B to Grd	> 100 Ω	If less than 100 Ω, check for short to ground.

Harness Resistance Check

Operational checks are **listed in Table** . Checks are made with the RSE solenoid connected and breakout box installed.

Note: Perform this test only where there are no ECT faults present. Monitor the ECT temperature and voltage at the ECM engine pin No. 9 while the engine or vehicle is in operation.

+Test Points-	Spec	Comments
9 to 19	0 volts	Solenoid energized; shutters closed; ECT temperature less than 181.5°F, 83°C.
9 to 19	12 volts	Solenoid de-energized; shutters open; ECT temperature more than 185°F, 85°C.

Operational Checks

Fault Code Description:

Flash Code 256 = The RSE control solenoid failed the output circuit check during a Key ON, Engine OFF Standard Test.

Function

The purpose of the RSE feature is to provide the proper logic to open or close the radiator shutters (energize or de-energize a solenoid). Closing the shutters will keep the engine warm during cold weather operation. This will provide faster warm-up of the passenger cab, thereby enabling faster defrost of the windshield.

Radiator Shutter

This parameter indicates to the on-board electronics if the vehicle has the electronically controlled radiator shutter.

OFF: Feature is turned off at all times.

ON: Feature is enabled and the radiator shutter is electronically controlled.

185°F, 85°C — Open; de-energize solenoid.

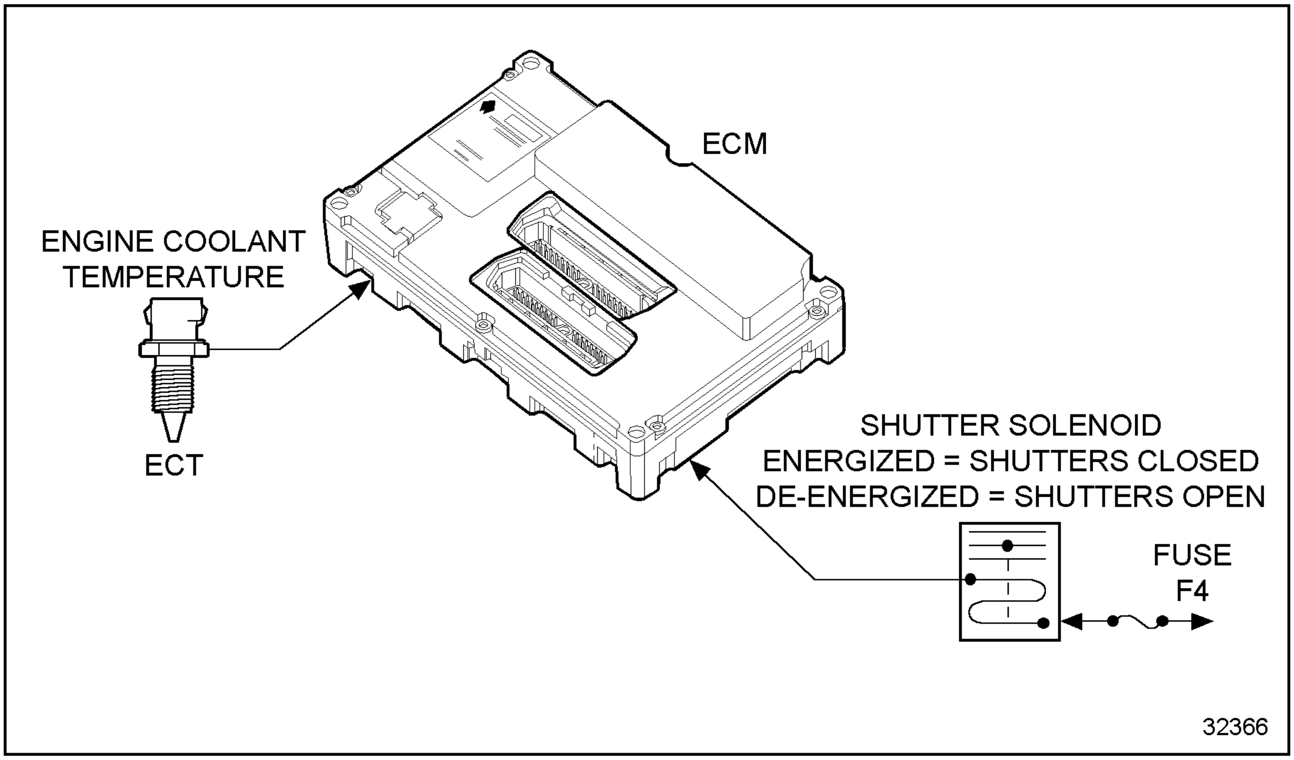
181.5°F, 83°C — Close; energized.

Flash Code 256

ATA Code SID 55 FMI 11

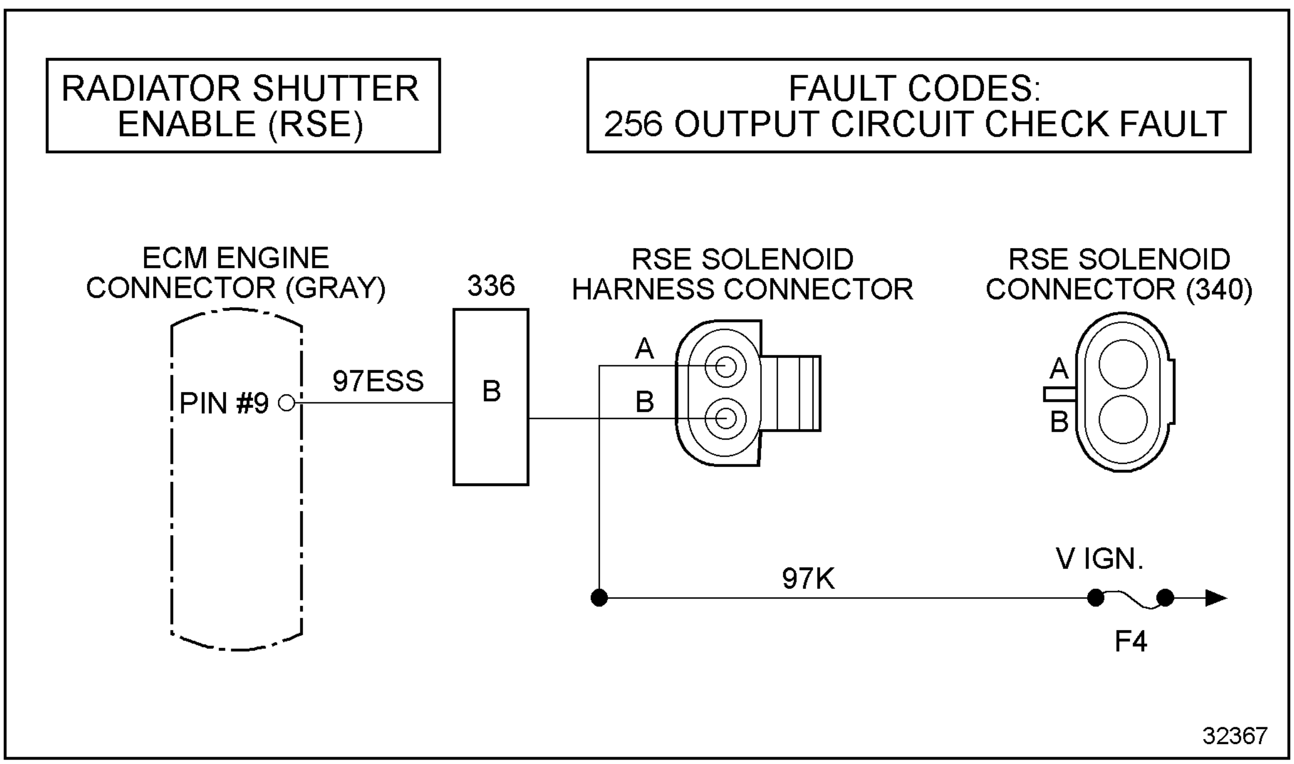
Radiator Shutter Enable OCC fault.

The Output Circuit Test, performed during an On Demand Engine Standard Test, will test the RSE solenoid circuit for an open or short condition. If an out of range condition exists, a Flash Code 256 will be set.



Radiator Shutter Enable

2



Radiator Shutter

SPEED CONTROL COMMAND SWITCHES

COMMAND SWITCHES

Speed Control command Switches (SCCS) include cruise control, PTO, and the hand throttle system, see Figure.

1

Cruise Control

The ECM will control the engine speed to maintain a constant road speed with cruise control. Depressing the set switch when the vehicle is at the desired speed with the cruise switch in the ON position activates the cruise control. Speed is increased or decreased by depressing Accel or Coast. The cruise control is deactivated by depressing the OFF switch, brake pedal, clutch pedal or on vehicles equipped with automatic transmissions by placing the transmission in neutral.

PTO Control

Engine speed can be controlled by the SCCS switches if the PTO option has been programmed into the ECM and the vehicle is stationary. Variable as well as preset speeds are available dependent upon programming. The PTO function is turned ON by switching the cruise switch on. Depressing the Set/Coast or Resume/Accel switch will increase or decrease speed dependent upon PTO programming.

Fault Detection Management

The ECM monitors the SCCS signals for proper voltages and will set Flash Code 221. If the ignition switch is turned off, the fault will be recorded as an inactive fault. For circuit 541 and

545 wiring recommendations, **see Figure**
. For circuit 544 wiring recommendations, **see Figure** .

23

In cab control switch circuit voltage checks are made with the switch assembly removed from the dash panel. Test from the rear of the connector body. Cruise PTO ON/OFF Switch checks are **listed in Table** . Cruise PTO SET/RESUME Switch checks are made with the COO switch on and are **listed in Table** .

Test Points	Spec	Comments
439C to Grd	12v ± 1.5v	Switch in OFF position - possible open fuse F6 or open circuit.
544 to Grd	12v ± 1.5v	Switch in ON position - no voltage; possible defective switch.

Cruise PTO ON/OFF Switch

Test Points	Spec	Comments
544 to Grd	12v ± 1.5v	Possible defective switch or open circuit.
541 to Grd	12v ± 1.5v	Switch held in set position - possible defective switch or open circuit.
545 to Grd	12v ± 1.5v	Switch held in resume position - possible defective switch or open circuit.

Cruise PTO SET/RESUME Switch (COO Switch ON)

Voltage circuit checks are performed at the ECM connector with the breakout box installed and the ignition key ON. The cruise switch circuit checks are **listed in Table** .

Test Points	Spec	Comments
35 to 42	12v ± 1.5v	Switch in ON position - no voltage, open circuit.
35 to 42	0	Switch in OFF position - voltage; short to power.

Cruise PTO ON/OFF Switch Circuit

The set switch circuit checks are **listed in Table** .

Test Points	Spec	Comments
32 to 42	12v ± 1.5v	Switch held in SET position - no voltage, open circuit.
32 to 42	0	Switch in Middle position - voltage; short to power.

Set Switch Circuit

The resume switch circuit checks are **listed in Table**
.

Test Points	Spec	Comments
31 to 42	12v ± 1.5v	Switch held in RESUME position - no voltage, open circuit.
31 to 42	0	Switch in Middle position - voltage; short to power.

Resume Switch Circuit

Fault Code Descriptions

Flash Code 221 = SCCS or PTO switch signal, incorrect voltage signal; wrong for switch state.

Cruise Control Description

Cruise control allows the ECM to control the engine's power delivery to maintain a constant speed. The speed set point is determined by the driver. High and low set points are programmed into the ECM. These are the cruise high set limit and cruise low set limit. Also, the minimum engine speed at which the cruise control can be engaged, is programmed into the ECM.

Placing the cruise control ON/OFF switch in the on position supplies 12 volts to the ECM pin 35 to enable the cruise control. When the ON/OFF switch is in the ON position, it supplies the voltage for the Set/Resume switch. Depressing the Set switch will supply a 12 volt signal at the ECM pin 32 to reactivate the cruise set speed to the last active set speed. Or, if the cruise is active, depressing the resume (accel) switch will cause the set speed to increase.

Depressing the OFF switch, brake, clutch or placing the automatic transmission in neutral, will deactivate the cruise control. Cruise control will not be functional if the VSS signal is in fault.

PTO (Engine Speed) Control

PTO speed control allows an operator to set a fixed engine speed, either in the cab, or remotely. In cab PTO uses the same switches on the dash as are used for the cruise control. Remote PTO uses switches that are installed by a body builder and are wired into the wiring harness of the vehicle at the body builder connections. There are two features that utilize the PTO speed controls — remote accelerator pedal and hydraulic pressure governing.

In Cab PTO

In cab PTO has three different modes of operation. These modes are selected by programming the ECM in cab PTO mode. These modes are:

1. In cab Preset
2. In cab Variable
3. In cab Mobile

In Cab Preset

In Cab Preset is selected by programming the ECM programmable parameters for In Cab Mode to In Cab Preset. This allows the operator to select one of the two pre-programmed values for engine speed. To operate, turn the On/Off switch to the ON position. This sends a 12 volt signal to pin 35 of the ECM. The, depress either the Set or Resume switch. Depressing the Set switch sends a 12 volt signal to pin 32 of the ECM. This will cause the engine speed to run at the value programmed into PTO Set Speed.

Depressing the OFF switch, brake pedal, clutch pedal, or placing the automatic transmission in gear, as well as a signal from the VSS, unless programmed for mobile operation, will deactivate the PTO speed control. PTO speed control will not be functional if the VSS or brake signal is in fault.

In Cab Variable

In Cab Variable is selected by programming the ECM programmable parameters for In Cab Mode to In Cab Variable. This option allows the driver to set the engine speed to a desired value. The control module will then maintain this speed over varying load conditions up to the rated power of the engine in the selected speed range.

To enable, turn the On/Off switch to the ON position. This sends a 12 volt signal to pin 35 of the ECM. Speed may be adjusted two ways. First the operator may adjust the engine speed with the accelerator and then depress the Set switch. This sends a 12 volt signal to pin 32 of the ECM. Or, the operator may depress the Resume/Accel switch, sending a 12 volt signal to pin 31 of the ECM to increase the speed incrementally. Also the operator may depress the Set/Coast switch to decrease engine speed.

Engine set speed will be limited to the value programmed in the ECM for maximum PTO speed.

Depressing the Off switch, brake pedal, clutch pedal, or placing the automatic transmission in gear, as well as a signal from the VSS, unless programmed for mobile operation, will deactivate the PTO Speed control. PTO speed control will not be functional if the VSS or Brake signal is at fault.

In Cab Mobile

In Cab Mobile is selected by programming the ECM programmable parameters for the In Cab Mode to In Cab Mobile. This allows the operator to use the engine speed control the same as In Cab Variable. However, in this mode, the vehicle can be moving while the mode is active. Refer to In Cab Variable for more details. The maximum speed of the vehicle is programmable up to 20 mph. Disabling this mode is the same as In Cab Variable. A speed signal will not disable the speed control until the pre-programmed maximum speed is achieved.

Remote PTO

Remote PTO can be enabled by two means. Operation of the speed control depends on which signal is enabled.

Remote Preset

Enabling the remote preset signal allows for the engine to maintain a pre-programmed speed. When in the preset mode, a signal at the set terminal will cause the engine to run at the pre-programmed set speed. A signal at the resume terminal will allow the engine to run at the pre-programmed resume speed.

To operate, a 12 volt signal is sent to ECM pin 37. With the remote preset enabled, the speed is adjusted as with In Cab Preset.

Opening the switch to pin 37, or depressing the brake pedal, clutch pedal, or placing the automatic transmission in gear, as well as a signal from the VSS will deactivate the PTO speed control. However, the pre-programmed option of PTO Operation Disable will prevent the clutch and brake signals from interrupting the PTO speed control, as well as cause the APS to be inoperative. PTO speed control will not be functional if the VSS or brake signal is in fault.

Remote Variable

Enabling the remote variable signal allows for the engine speed to be adjusted to the desired level. A signal to the resume (accel) terminal will cause the engine speed to increase; a signal to the set (coast) terminal will cause the engine speed to decrease.

To operate, a 12 volt signal is sent to the ECM pin 36. With the remote variable enabled, the speed is adjusted as with In Cab Variable above. **Refer to section**
.

Opening the switch to pin 37 or depressing the brake pedal or clutch pedal or placing the automatic transmission in gear, as well as a signal from the VSS will deactivate the PTO speed control. However, the pre-programmed option of PTO Operation Disable will prevent the clutch and brake signals from interrupting the PTO speed control, as well as cause the APS to be inoperative. PTO speed control will not be functional if the VSS or brake signal is in fault.

PTO Speed Ramp Rate

The rate at which the speed of the engine will change will depend on load conditions and on a pre-programmed value called PTO speed ramp rate. A higher value will cause the engine to change speed more quickly.

Fault Detection Management

The ECM monitors the signals for proper voltages and will set Flash Code 221. If the ignition switch is turned off, the fault will be recorded as an inactive fault.

Flash Code 221

ATA Code SID 244 FMI 2

ECM: SCCS Switch or circuit fault.

The ECM monitors the cruise control and PTO inputs. If the expected value for each input does not match the expected status, a fault code is set.

Troubleshooting

The EST can be used to monitor the status of the PTO controls. Comparing the data list reading to actual operation will indicate if the controls are operating properly. Using the menu option of programmable parameters, the programming can be verified to ensure the ECM is programmed properly for the application. Also the data list can be used to monitor the parameters that cause the interruption of PTO speed control. Use the Diagnostic Code menu to read fault codes.

Before Troubleshooting

Before troubleshooting, ensure the batteries are fully charged. Check battery connections and grounds for clean, tight connections, free of damage. Voltage test will give misleading results if the batteries are not fully charged.

Before troubleshooting, inspect circuit connectors for pushed back, loose or damaged (spread or bent) terminals, or wires with cut strands, etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present and must be removed.

Before troubleshooting, inspect suspect circuit grounds for clean, tight connections, free of damage.

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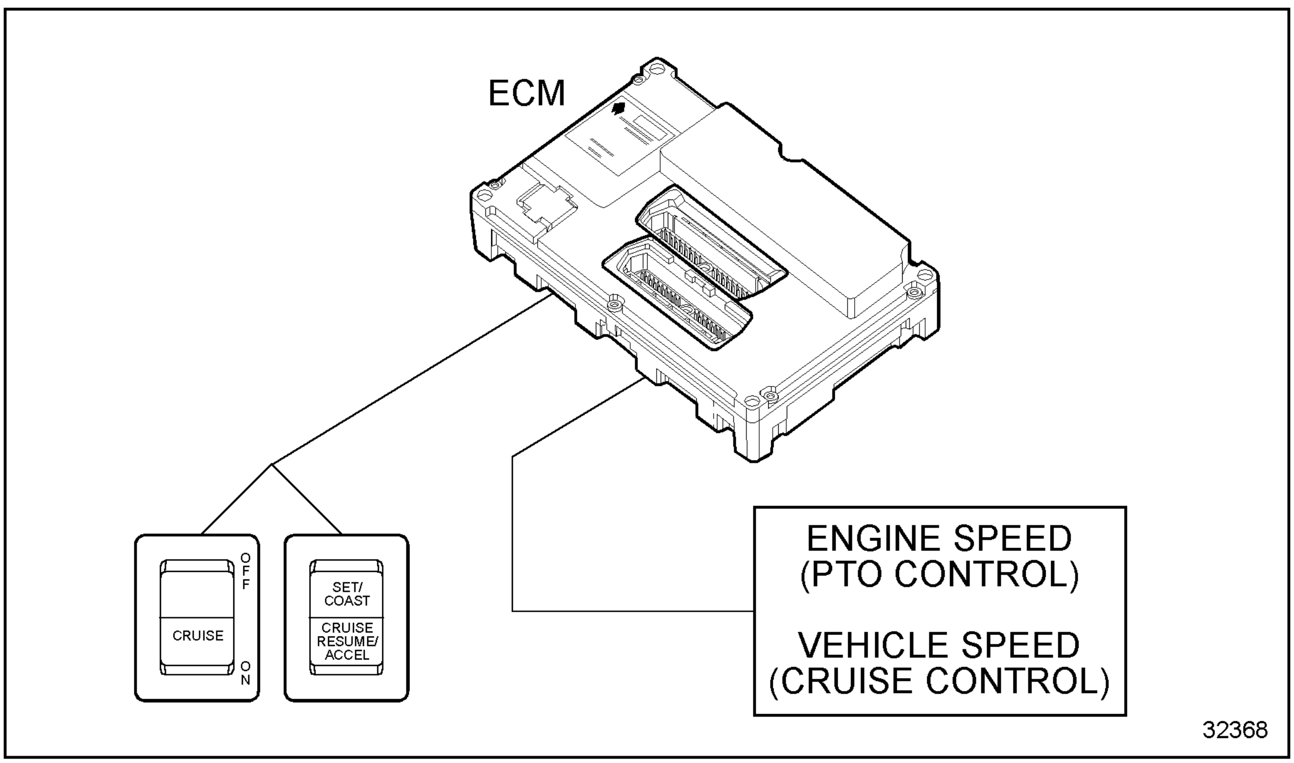
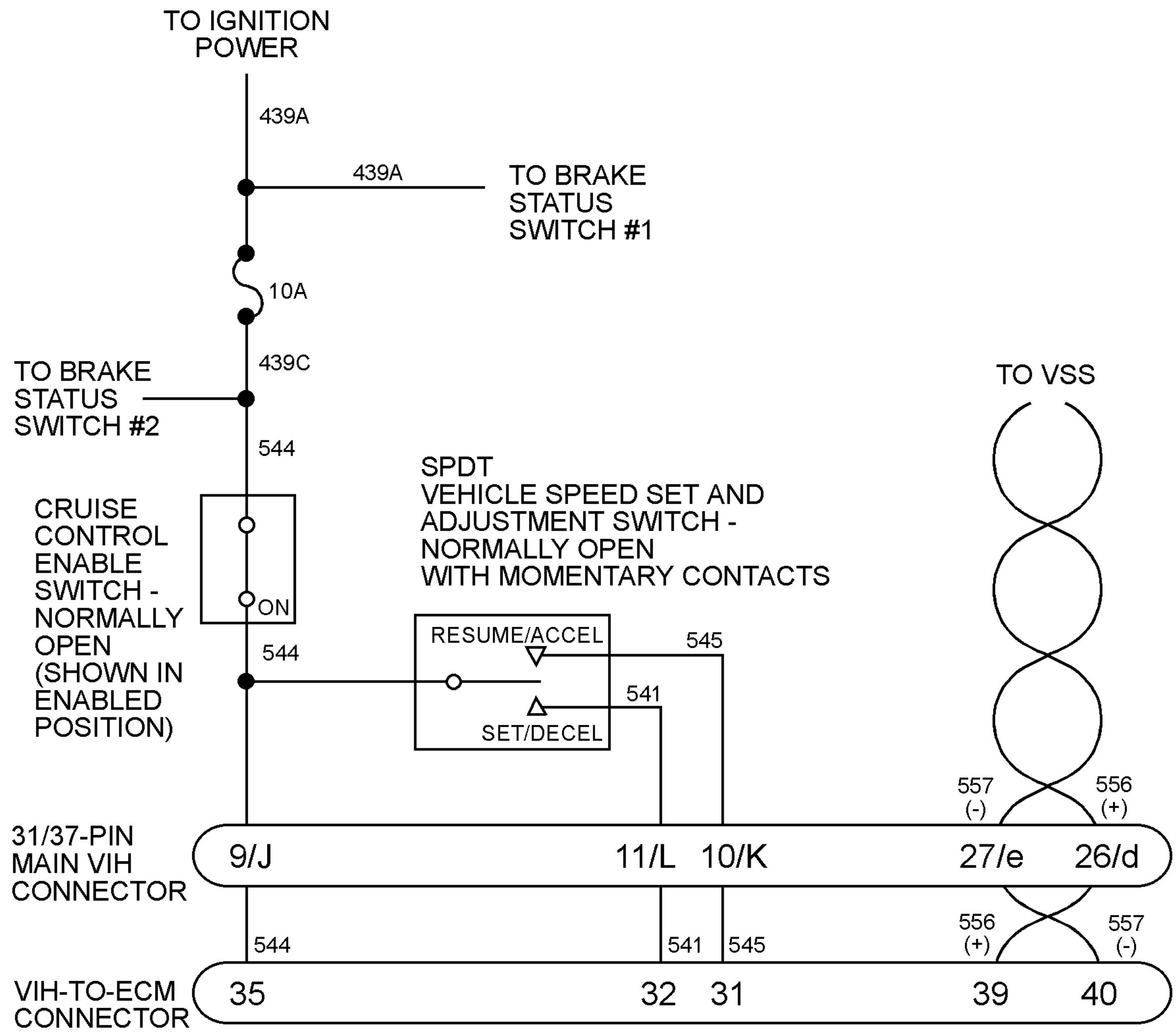


Speed Control Command Switches Function Diagram

2

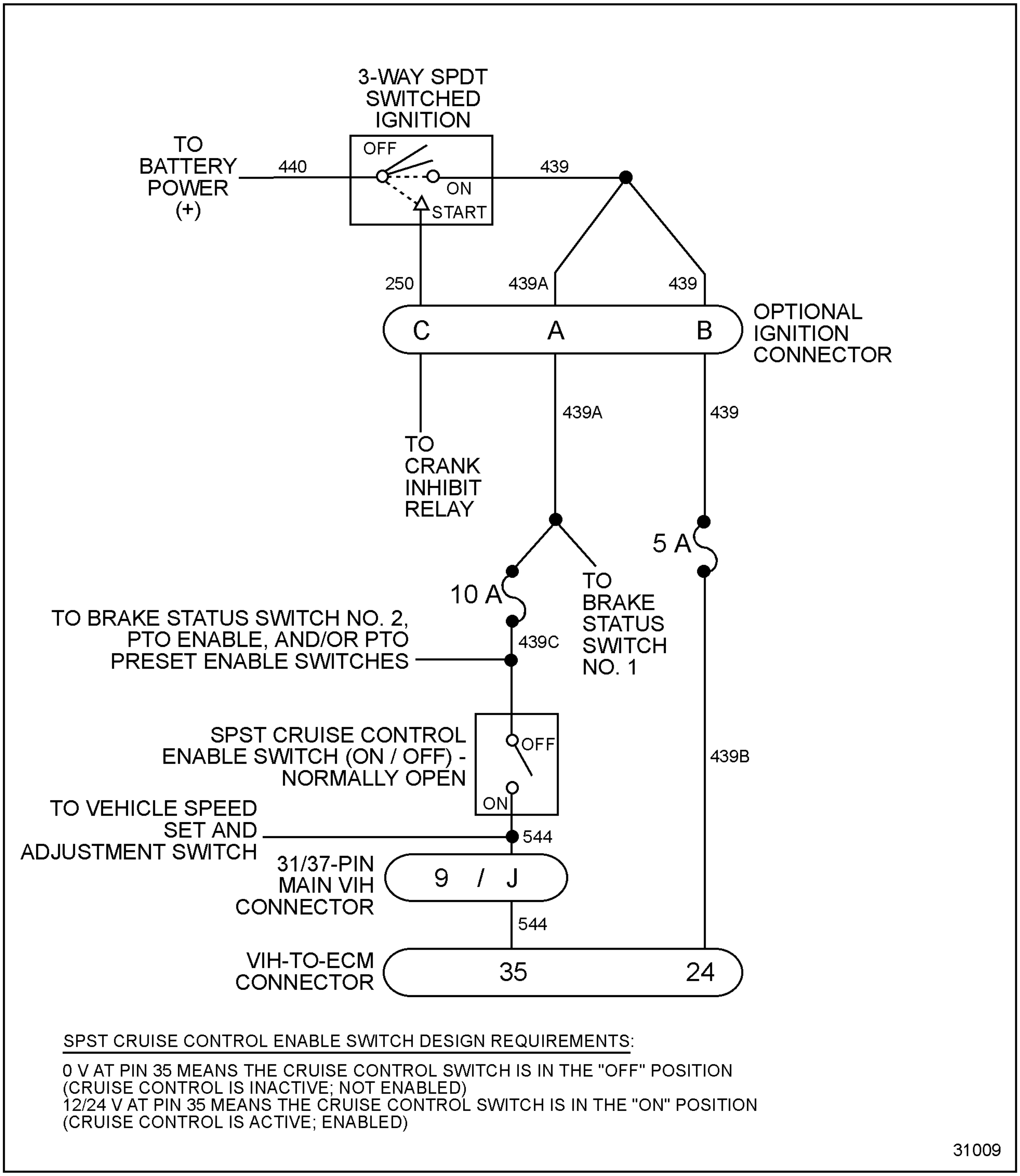


VEHICLE SPEED SET AND ADJUSTMENT SWITCH DESIGN REQUIREMENTS:

12/24 V (SINGLE, MOMENTARY CONTACT) AT ECM PIN 32 WILL SET VEHICLE SPEED WHEN CRUISE CONTROL IS IN "ON" POSITION.
12/24 V (SINGLE OR CONTINUOUS CONTACT) AT ECM PIN 31 WILL INCREASE VEHICLE SPEED, AFTER CRUISE CONTROL SPEED HAS BEEN SET, UNTIL SWITCH IS RELEASED.
12/24 V (SINGLE OR CONTINUOUS CONTACT) AT ECM PIN 32 WILL DECREASE VEHICLE SPEED, AFTER CRUISE CONTROL SPEED HAS BEEN SET, UNTIL SWITCH IS RELEASED.

31017

Circuit 541 and Circuit 545 Wiring Recommendation



Circuit 544 Wiring Recommendation

1

TWO SPEED AXLE INPUT CIRCUIT

SIGNAL FUNCTIONS

For the Two Speed Axle (TSA) circuit function diagram, **see Figure**
. The ECM is programmed with the high and low rear axle ratios. The ratios are used to calculate the speedometer signal, depending on which mode the switch is in. The ECM uses the high ratio unless voltage is applied to ECM pin 28, indicating the two speed selector switch is in the low range.

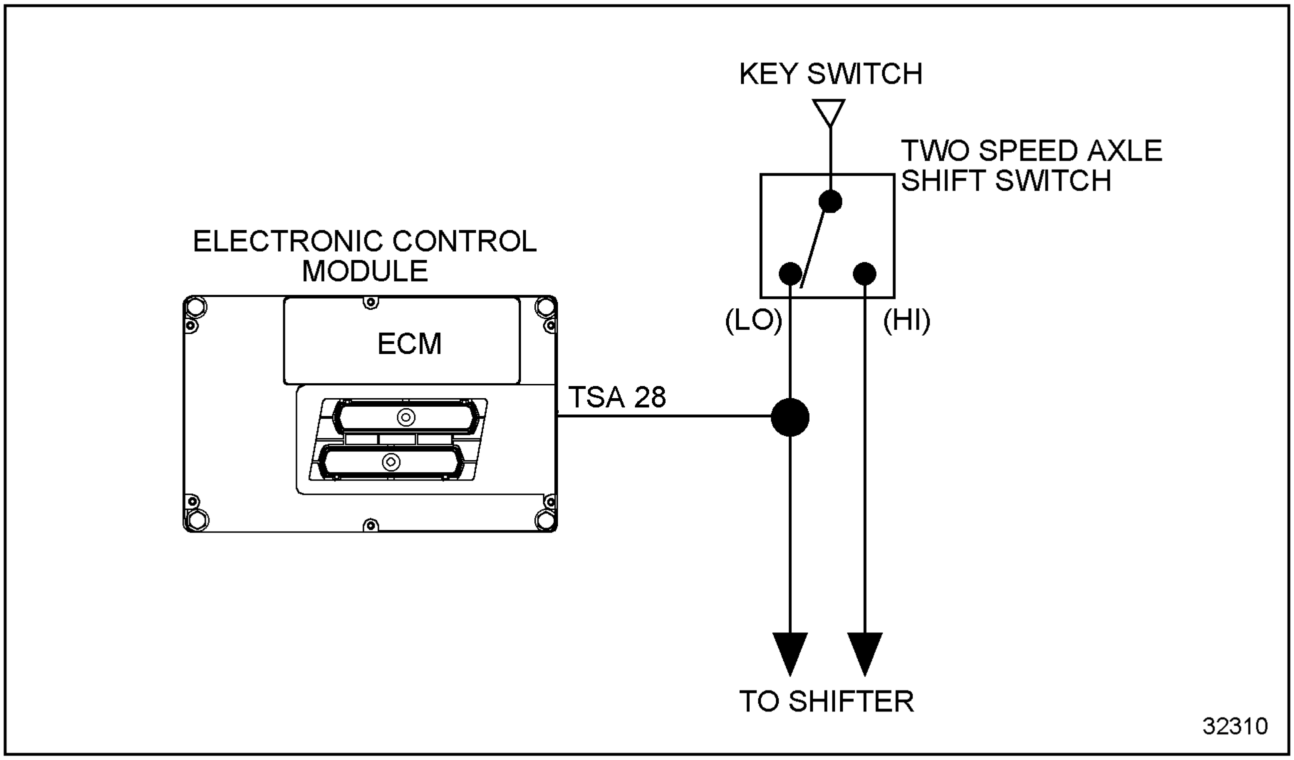
1

The two speed switch applies 12 volts to the ECM at pin 28 (and to the shifter) when the switch is in the low position.

Fault Detection Management

There are no ECM diagnostics for the two speed circuits.

1



Two Speed Axle Circuit Function Diagram

VEHICLE FEATURES

STANDARD FEATURES

This section covers standard features of the Series 40E engines.

Electronic Governor Control

The Series 40E engines are fully electronically governed over all operating ranges.

American Trucking Association Data Link Provisions

Vehicles are equipped with an American Trucking Association (ATA) data link connector that allows communication between the electronic engine control system of the engine and the Pro-Link® 9000 Electronic Service Tool (EST).

The data link provides communication capabilities for:

1. Engine parameter data transmission
2. Diagnostics and troubleshooting
3. Customer programming
4. Production line programming of vehicle features
5. Field programming

Service Diagnostics

The Electronic Service Tool (EST) provides means for obtaining diagnostic information using the ATA data link. The recommended electronic service tool is the Pro-Link 9000 with cartridge.

Sensor, actuator, electronic component and engine system faults can be detected by the ECM and transmitted to the EST so proper diagnostics can be performed. The engine control system also provides service diagnostic information via flash codes emitted by the engine warning lamp located on the dash of the vehicle. Diagnostic literature is indexed according to the flash codes.

Electronic Speedometer and Tachometer Provisions

The Engine Control System calibrates vehicle speed to 30,000 pulses/mile. Dip switches no longer need to be changed when components affecting speed calibration are changed. However, the new speed calibration information must be programmed through the EST.

The tachometer signal is generated by the ECM by computing the camshaft position (CMP) sensor signal. The result of this calculation is transmitted to both the instrument dash cluster and the EST via the ATA Data Link for service purposes.

Engine Over Temperature Protection System

The Engine Over Temperature Protection System (coolant temperature compensation) feature reduces fuel delivery when the engine coolant temperature is above the cooling system design target value. Fueling is reduced proportionally to the extent the design limit is exceeded. The reduction is calibrated to a maximum of 40% before standard engine warning and/or optional warning/shutdown systems engage. If this feature is activated, a fault code is stored in the ECM memory to explain low power complaints.

This feature may be omitted on emergency vehicle applications that require 100% power on demand.

Event Logging System

The Event Logging System records if the engine was operated beyond maximum r/min, over heated (coolant temperature), low on coolant and/or experienced low oil pressure. This information and the odometer and hourmeter reading at the time the event took place are stored in the ECM memory and may be accessed through the use of the EST.

Engine Crank Inhibit

The Engine Crank Inhibit System will not allow the starting motor to crank when the engine is running or when the automatic transmission is not in neutral. Engine crank inhibit is also available as an optional feature on vehicles equipped with a manual transmission.

Electronic Accelerator Pedal

The Electronic Accelerator Pedal eliminates the mechanical linkage used with the conventional accelerator pedals. An accelerator position sensor built within the accelerator pedal assembly provides the ECM with an analog voltage signal representing the demand of the driver for power. **See Figure**

.

1

Cold Ambient Protection

The Cold Ambient Protection (CAP) System safeguards the engine from damage that can result from prolonged periods of idle time with no load in cold weather conditions. Additionally, CAP will enhance cab warm-up.

This feature maintains the engine coolant temperature by increasing the engine speed to a pre-programmed value when the ambient air temperature is below 0°C (32°F), the engine coolant temperature is below 65°C (149°F) and the engine has been idling with no load for more than five minutes.

This is a standard feature available on all trucks equipped with a clutch switch (manual transmissions) or a neutral safety switch (automatic transmissions) and not equipped with the Idle Shutdown Timer feature.

Change Oil Light

The Change Oil Light (COL) timer can be reset with the STI button. To utilize this feature, the following steps must be followed:

1. Depress and hold the STI button.
2. Turn the ignition key on.
3. Depress and release the accelerator pedal five times.
4. Release the STI button.

OPTIONAL FEATURES

Optional features on the Series 40E engine include the following:

Cruise Control

Cruise Control provides vehicle speed using automotive style On, Off, Set/Coast, and Resume/Accel switches. Speed control is disabled when the service brakes are applied, the clutch pedal is depressed, or an automatic transmission is placed in neutral. The accelerator pedal can be used to provide a speed increase from the cruise speed selected. **See Figure**

.

2

Throttle Control

The Series 40E engines are compatible with both stationary and mobile PTO applications. Remote and in-cab throttle control locations are available. Also, the throttle control feature can be used as an electronic hand throttle to be used during warm-up procedures or cold weather idle operation. **See Figure**

.

3

Road Speed Limiting/Governor

The Road Speed Limiting/Governor limits vehicle speed to an owner/operator programmable maximum speed.

Body Equipment Manufacturer Provisions

Additional circuits and connector junction blocks are provided in the engine compartment on the left side of the cowl. These circuits include provisions for:

1. Remote engine speed control
2. Remote PTO (engine speed) control commands
3. Additional power and control circuits for aftermarket added equipment

The standard electrical system will provide breakout connector access to the speed control circuits.

Engine Warning System

The Engine Warning System illuminates the red Stop Engine lamp, and actuates a buzzer when warning thresholds for coolant temperature, engine coolant level and/or engine oil pressure (low) are exceeded. **See Figure** .

4

Engine Shutdown System

The Engine Shutdown System shuts down the engine after 30 seconds of operation beyond the critical threshold values for coolant temperature and/or oil pressure. The above mentioned warning system is included with this shutdown system. The engine may be restarted after shutdown if it is mechanically capable of starting. See Figure .

5

Idle Shutdown

The Idle Shutdown feature provides automatic engine shutdown after a 2 to 120 minute idle time has been exceeded.

The allowed idle time can be customized to the maximum or minimum intake air temperatures at which extended idle would be allowed, or to whatever the owner desires.

In the event that the idle shutdown feature is triggered, the ECM will flash the Oil/Water light on the dash and sound the buzzer 30 seconds before the engine shuts down, indicating the condition. A fault code will also be set after the shutdown is completed.

When this feature is selected, the Cold Ambient Protection feature is automatically disabled.

Hydraulic Pressure Governor

The optional Hydraulic Pressure Governor can be used on special trucks (firetrucks) equipped with hydraulic pumps where output pressure is controlled by adjusting the engine r/min.

Body builder connections are provided and the ECM can be programmed for this purpose on request.

This feature can be programmed to fit the operator needs. Engine r/min ramp rate and hydraulic pressure governor gain adjustments are among the available variables that allow this feature to be such a versatile tool.

Engine Fan

The engine fan allows the ECM to control the engagement and disengagement of the engine fan, depending on the Engine Coolant Temperature (ECT) or air conditioner demand.

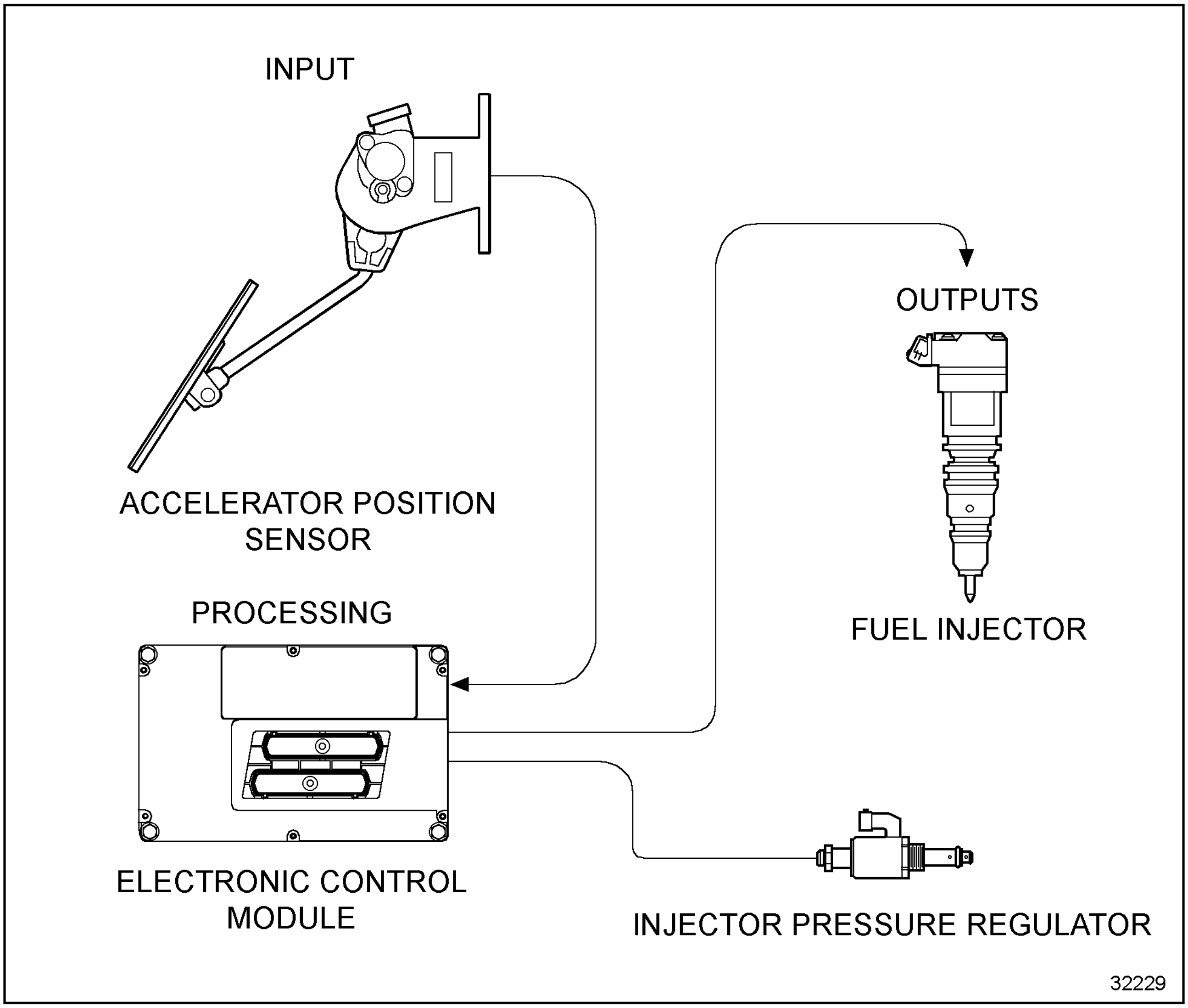
The ECM can also be programmed to utilize the engine fan as an engine retarder device.

Radiator Shutters

Electronically controlled radiator shutters can also be controlled by the ECM to maintain a proper engine coolant temperature during cold weather operation. This improves the performance of the engine and benefits the operation of cab accessories such as the heater and the windshield defroster.

Fuel mileage can also be benefited from this feature.

1



Electronic Accelerator Pedal System

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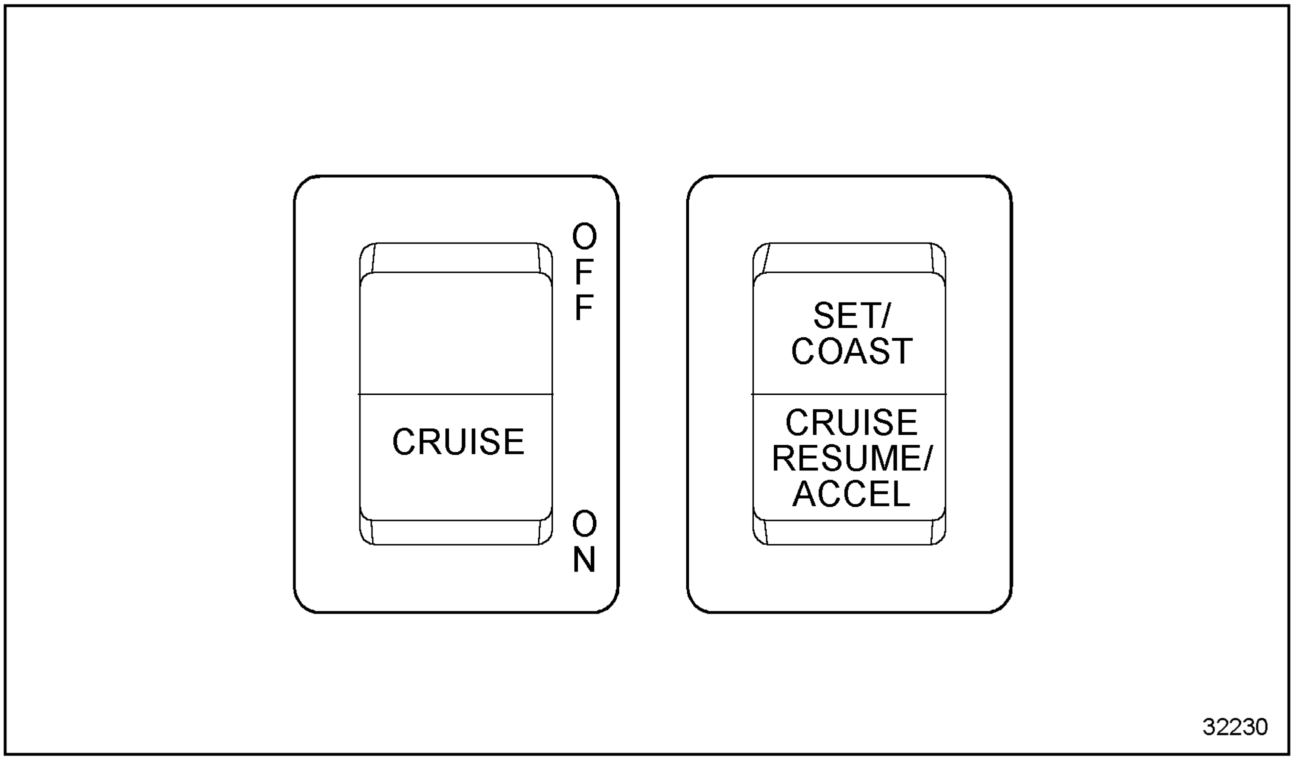
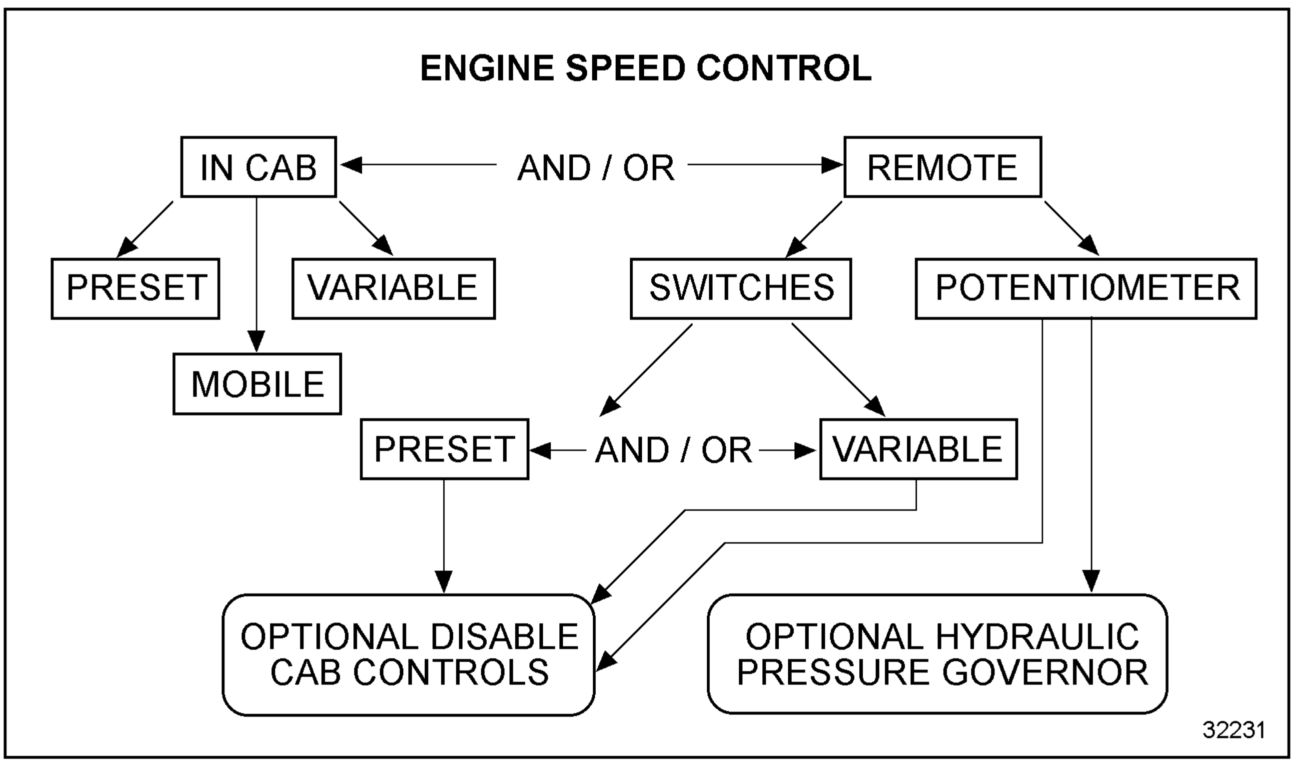


Cruise Control Switches

3



Engine Speed Control

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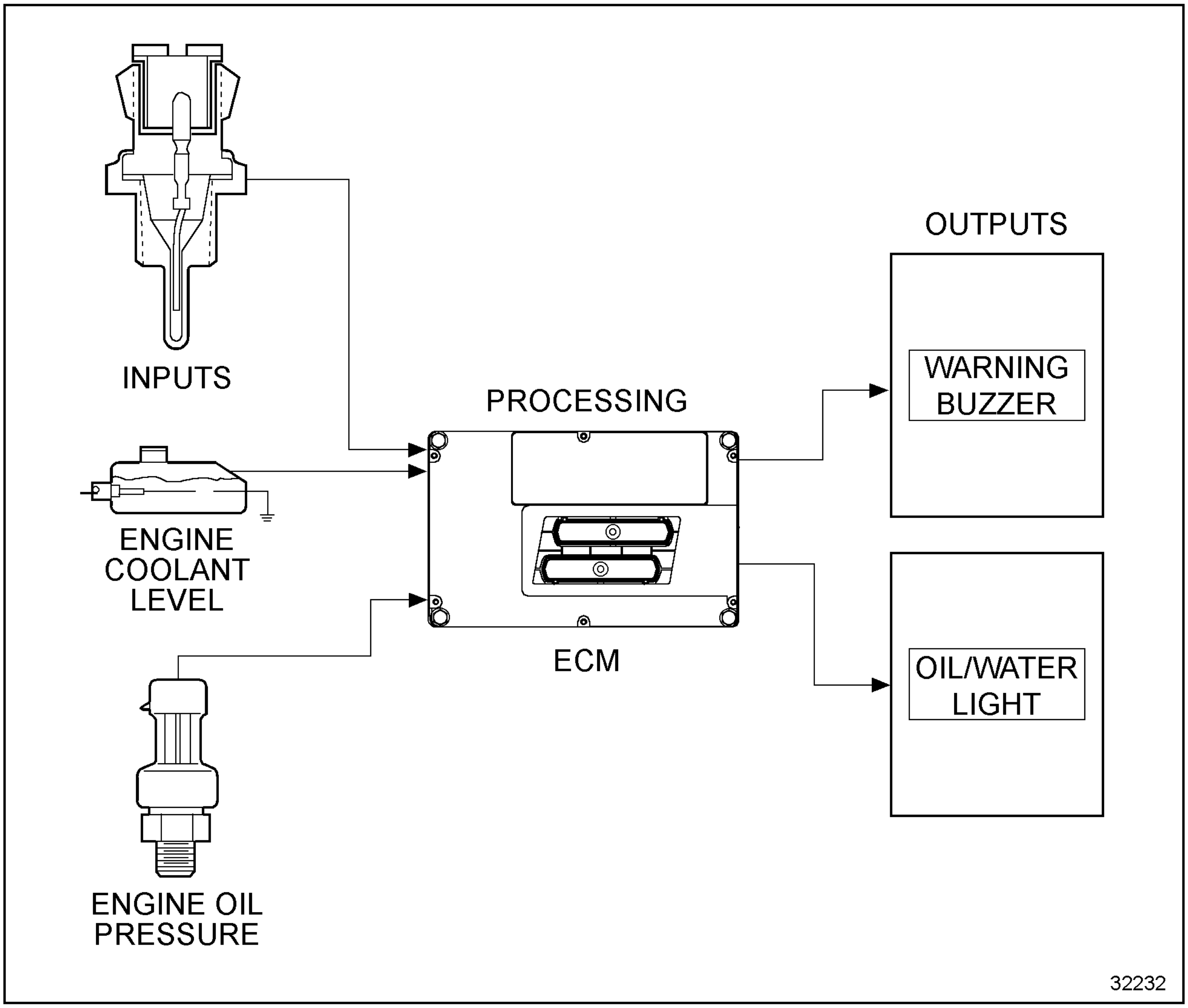
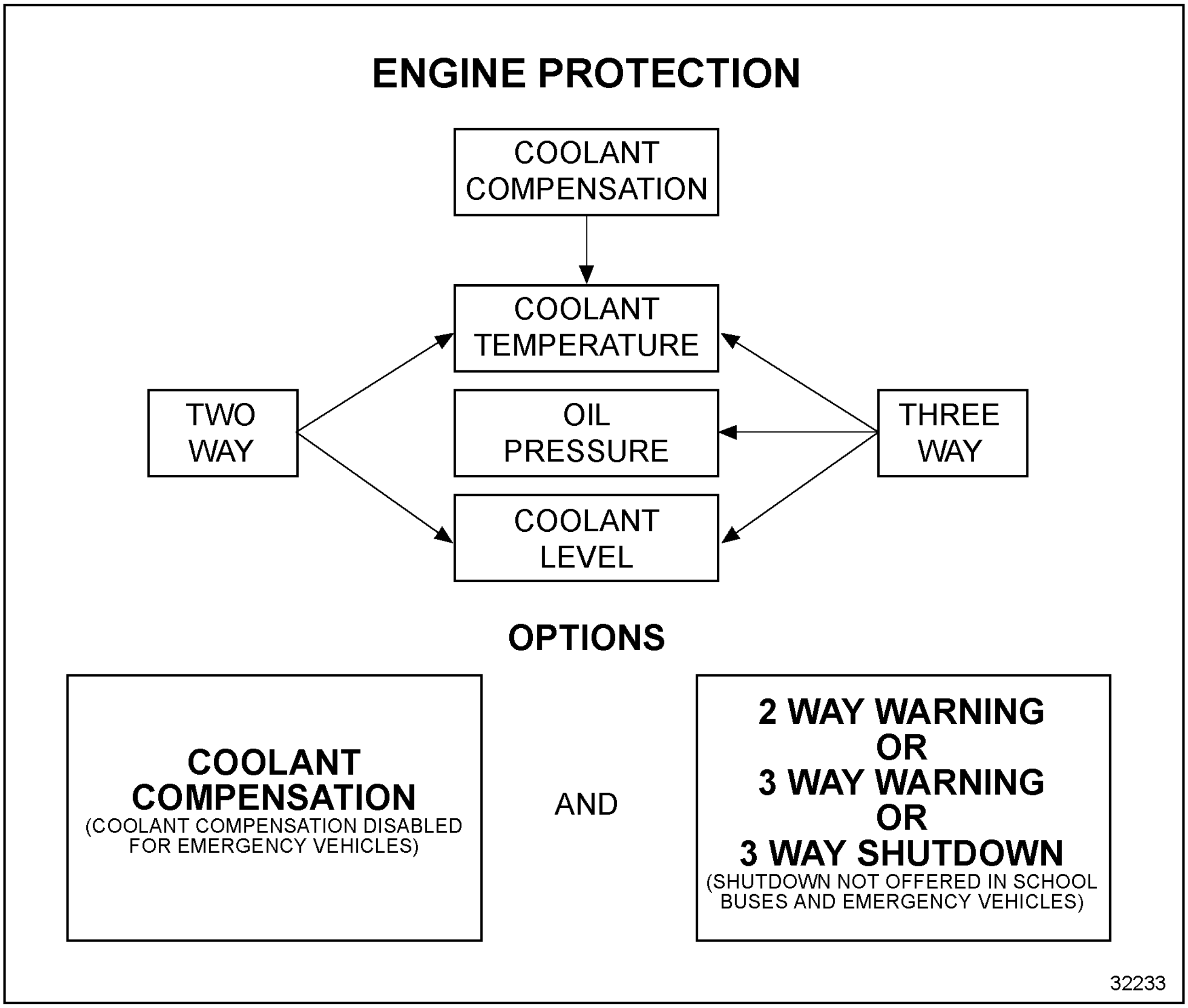


Engine Warning System

5



Engine Protection System

1

VEHICLE RETARDER

CIRCUIT FUNCTIONS

For the Vehicle Retarder function diagram, **see Figure**
.

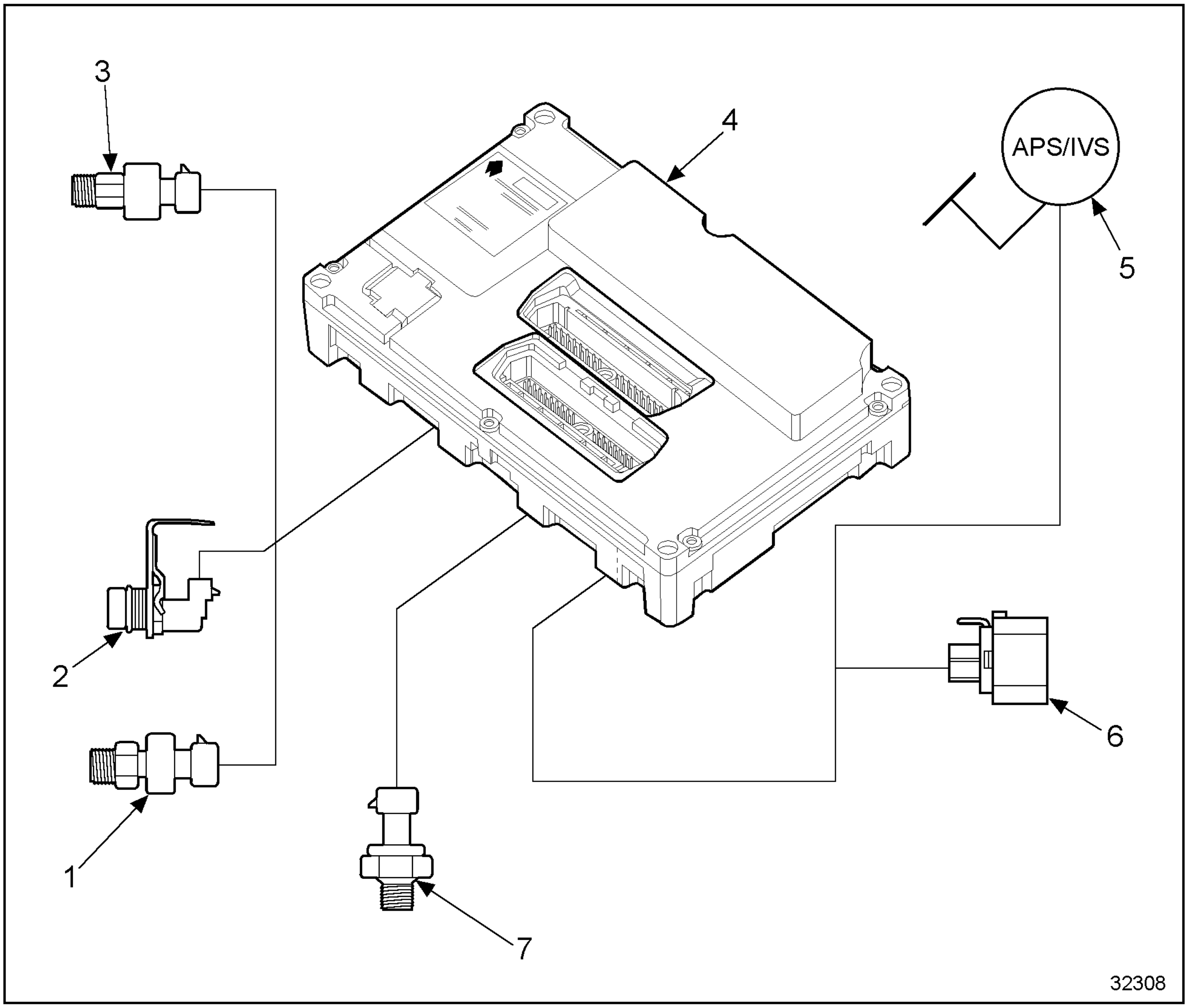
1

On engines or vehicles equipped with an engine brake or a transmission retarder, the Vehicle Retarder Circuit (VRE) function is to control the relay or solenoids that turn the brake or retarder on and off. This circuit has many applications and can be wired in many configurations.

Fault Detection and Management

An open or short to ground can be detected on the coil side of the engine brake relay during an On Demand Engine Standard Test by the technician.

1



1. Engine Oil Pressure Sensor	5. Accelerator Position/Idle Validation
2. Camshaft Position Sensor	6. Barometric Pressure Sensor
3. Injection Control Pressure	7. Manifold Absolute Pressure Sensor
4. ECM	

Vehicle Retarder Function Diagram

VEHICLE SPEED SIGNAL

VEHICLE SPEED SENSOR SIGNAL

For the Vehicle Speed Sensor (VSS) function diagram, **see Figure**
.

1

Signal Function

Transmission tail-shaft speed is detected by a magnetic pickup mounted on the transmission that senses the rotation of a 16–toothed gear installed on the rear of the transmission. The resultant AC (alternating current) sine wave signal is received by the ECM and is utilized along with tire size and axle ratio, to calculate vehicle speed. Calculated vehicle speed is transmitted to the instrument cluster on the ATA (American Trucking Association) data link to operate the speedometer in the instrument cluster. Calculated vehicle speed is also utilized in the control strategies that control features such as Cruise Control, PTO operation and Road Speed Limiting.

W TEC MD transmissions utilize an internal VSS sensor that sends a signal to the W TEC ECM. The W TEC ECM buffers the signal and sends a square wave signal to the engine ECM.

Fault Detection Management

When the ECM determines that the vehicle is operating at 0 mph, the ECM performs diagnostic checking on the VSS circuitry. A voltage signal is transmitted on the VSS circuitry by the ECM and will detect if the return voltage is out of range high or low.

An out of range low code normally indicates an open, short to ground condition. An out of range high code normally indicates a short to voltage condition. When a VSS fault condition is detected, the ECM disables cruise control, PTO operation, and if road speed limiting is enabled, will limit the engine r/min in all gears.

On vehicles equipped with MD (W TEC) transmissions, no fault codes will be sent in the event of a VSS sensor circuit failure. Any VSS faults set with vehicles equipped with MD transmissions only diagnose the communication circuit between the engine ECM and the transmission ECM. Refer to the Allison W TEC Maintenance/Diagnostic Manual to diagnose any MD VSS sensor problems.

For the Vehicle Speed Sensor, **see Figure** .

2

For the Vehicle Speed Sensor recommended wiring **see Figure**

; **see Figure**

.

34

The voltage checks at the VSS connector with key ON, engine OFF, are **listed in Table** . Checks are made with the VSS sensor connector disconnected.

+Test Points-	Spec	Comments
B to Grd	2 to 3 v	ECM pull up voltage when sensor disconnected. If no voltage present check for open or shorts
A to Grd	2 to 3 v	

Key ON, Engine OFF — Voltage Checks at Vehicle Speed Signal Connector

The VSS sensor continuity checks are **listed in Table**

. Checks are made with the VSS sensor disconnected. Measure resistance through the sensor.

+Test Points-	Spec	Comments
B to Grd	> 100 Ω	If less than 100 Ω, check for short to ground.
B to Grd	> 100 Ω	If less than 100 Ω, check for short to ground.
B to A	600-800 Ω	Manual Transmission.
B to A	1200-1450 Ω	Automatic transmission (mechanical) AT/MT.
B to A	See W TEC manual	Automatic transmission (electronic) MD.

Vehicle Speed Signal Sensor Continuity Checks

The harness resistance checks are **listed in Table** . Checks are made with the VSS sensor disconnected, the battery disconnected and the breakout box installed.

+Test Points-	Spec	Comments
40 to B	< 5 Ω	If greater than 5 Ω, check for open circuit.
39 to A	< 5 Ω	If greater than 5 Ω, check for open circuit.
40 to Grd	> 100 Ω	If less than 100 Ω, check for short to ground.
39 to Grd	> 100 Ω	If less than 100 Ω, check for short to ground.

Harness Resistance Checks

The operational check is **listed in Table** . Checks are made with the VSS sensor connected, the battery disconnected and the breakout box installed. Place the rear axles on jack stands with the front wheels blocked. Measure with the transmission in high gear and the engine at low idle.

+Test Points-	Spec	Comments
40 to 39	> 2v AC	If less than 2v AC, check sensor adjustment or replace defective sensor.

Operational Check

Note: To adjust sensor clearance, turn sensor in clockwise direction until contact is made on tail-shaft gear; then back out one full turn and tighten locknut. Ensure the sensor tip is free of metal chips prior to installation.

Fault code descriptions are **listed in Table** .

Fault Code	Description
141	ECM detected low test voltage across VSS circuit for greater than .5 seconds. Possible open or short to ground.
142	ECM detected high test voltage across VSS circuit for greater than .5 seconds. Possible internal sensor short or short to power.
215	ECM detected a VSS frequency signal > 4365 Hz.

Fault Code Descriptions

Extended Description

The Vehicle Speed Sensor (VSS) is located on the transmission and sends an AC signal to the ECM. The VSS sensor contains a permanent magnet that creates a magnetic field. The AC signal is created when the 16–tooth transmission speedometer gear rotates breaking the magnetic field created by the sensor. The ECM processes the AC signal and transmits vehicle speed data on the ATA Data Link and utilizes it for various engine and vehicle control strategies.

On a manual transmission, the VSS sensor is mounted at the rear of the transmission. With an Allison AT/MT transmission, the VSS sensor is installed in the lower right side of the transmission.

ECM Diagnostics — Flash Codes

The following flash codes could set when troubleshooting the VSS:

Flash Code 141

ATA Code PID 84 FMI 4

VPM: VSS out of range low

Fault Code 141 is set when the ECM detects an out of range low condition in the VSS circuit. This is a continuous monitor code and can be set any time the vehicle is operating. It may be displayed as an active or inactive fault. When this code is set, the WARN lamp will not be illuminated.

Possible Causes: Open sensor wiring; open sensor; short to ground in wiring or sensor.

Flash Code 142

ATA Code PID 84 FMI 3

VPM: VSS out of range high

Fault Code 142 is set when the ECM detects an out of range high condition in the VSS circuit. This is a continuous monitor code and can be set any time the vehicle is operating. It may be displayed as an active or inactive fault. When this code is set, the WARN lamp will not be illuminated.

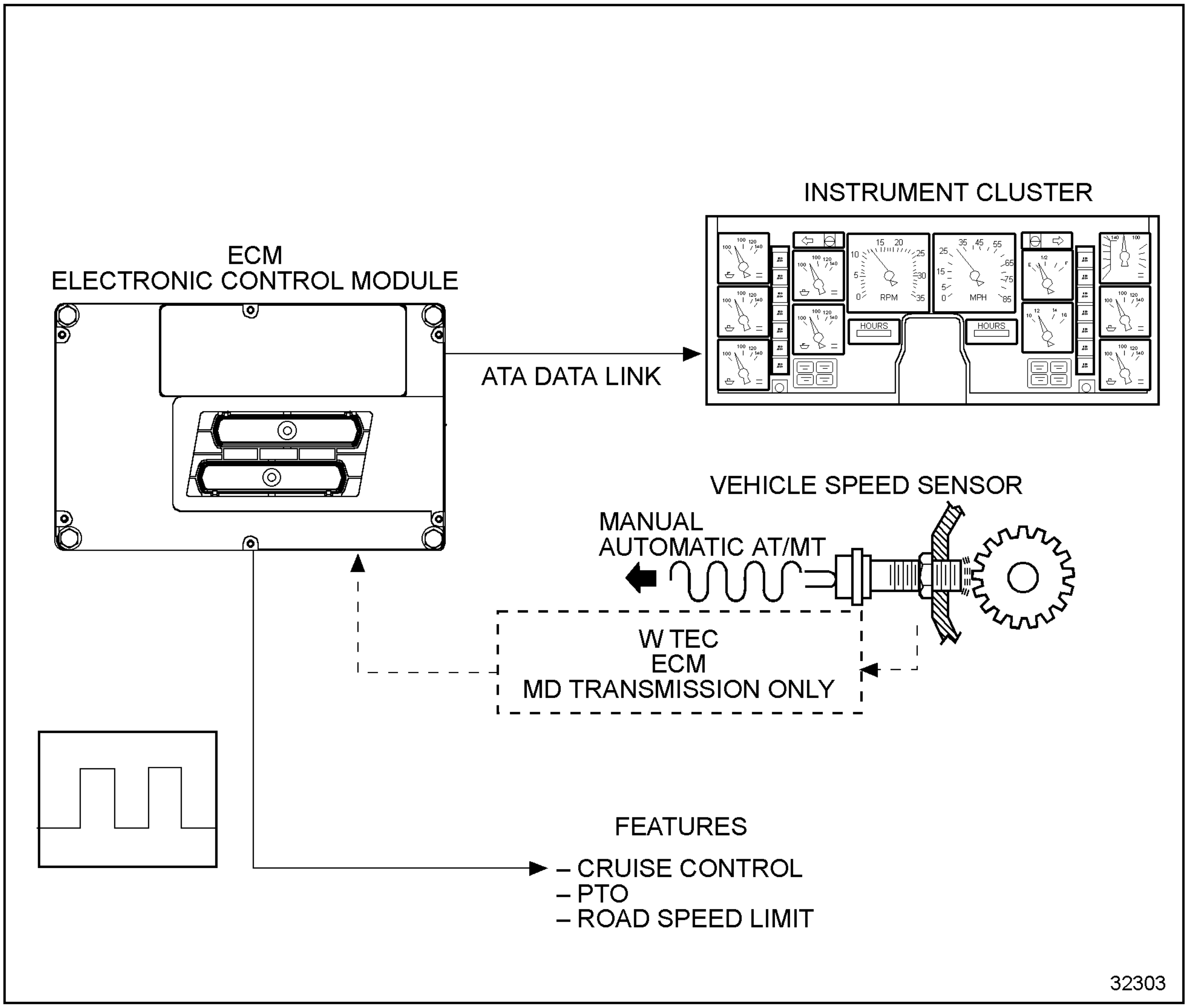
Possible Causes: Wiring short to power (VREF or battery); internal short in the VSS sensor.

Before Troubleshooting

Before troubleshooting, ensure the batteries are fully charged. Check the battery connections and grounds for clean, tight connections, free of damage. Voltage tests will give misleading results if the batteries are not fully charged.

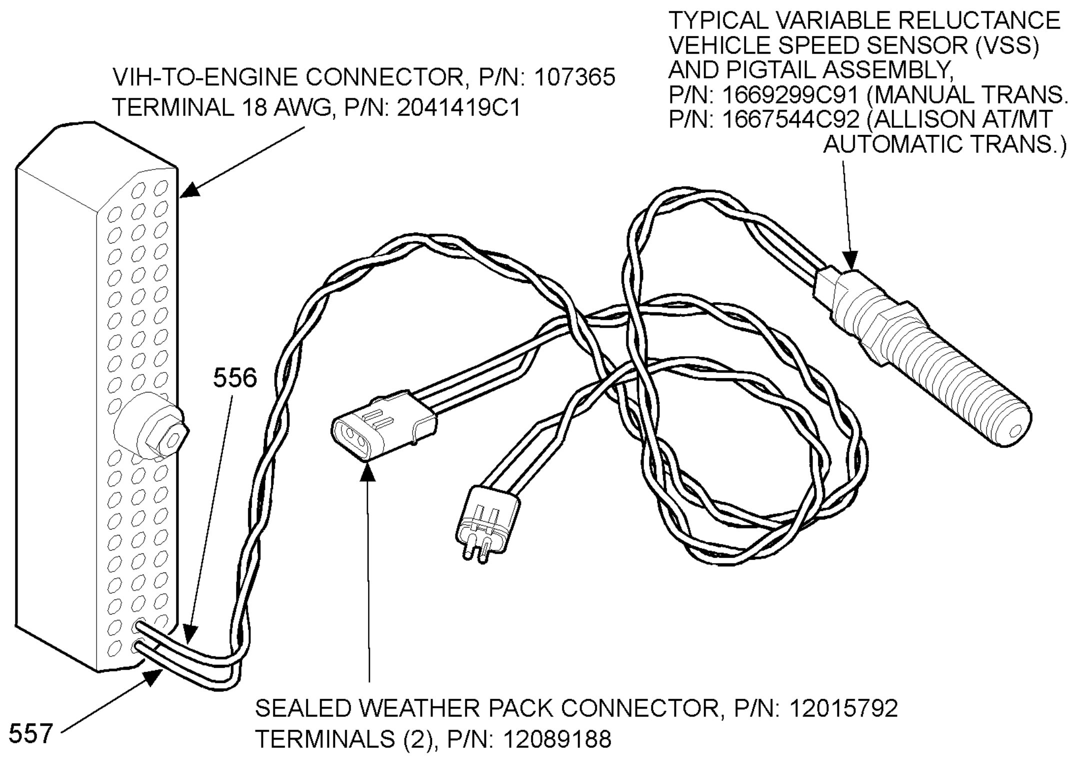
Before troubleshooting, inspect the circuit connectors for pushed back, loose, or damaged (spread or bent) terminals, or wires with cut strands, etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present, and must be removed.

Before troubleshooting, inspect the suspect circuit grounds for clean, tight connections, free of damage.



Vehicle Speed Sensor Function Diagram

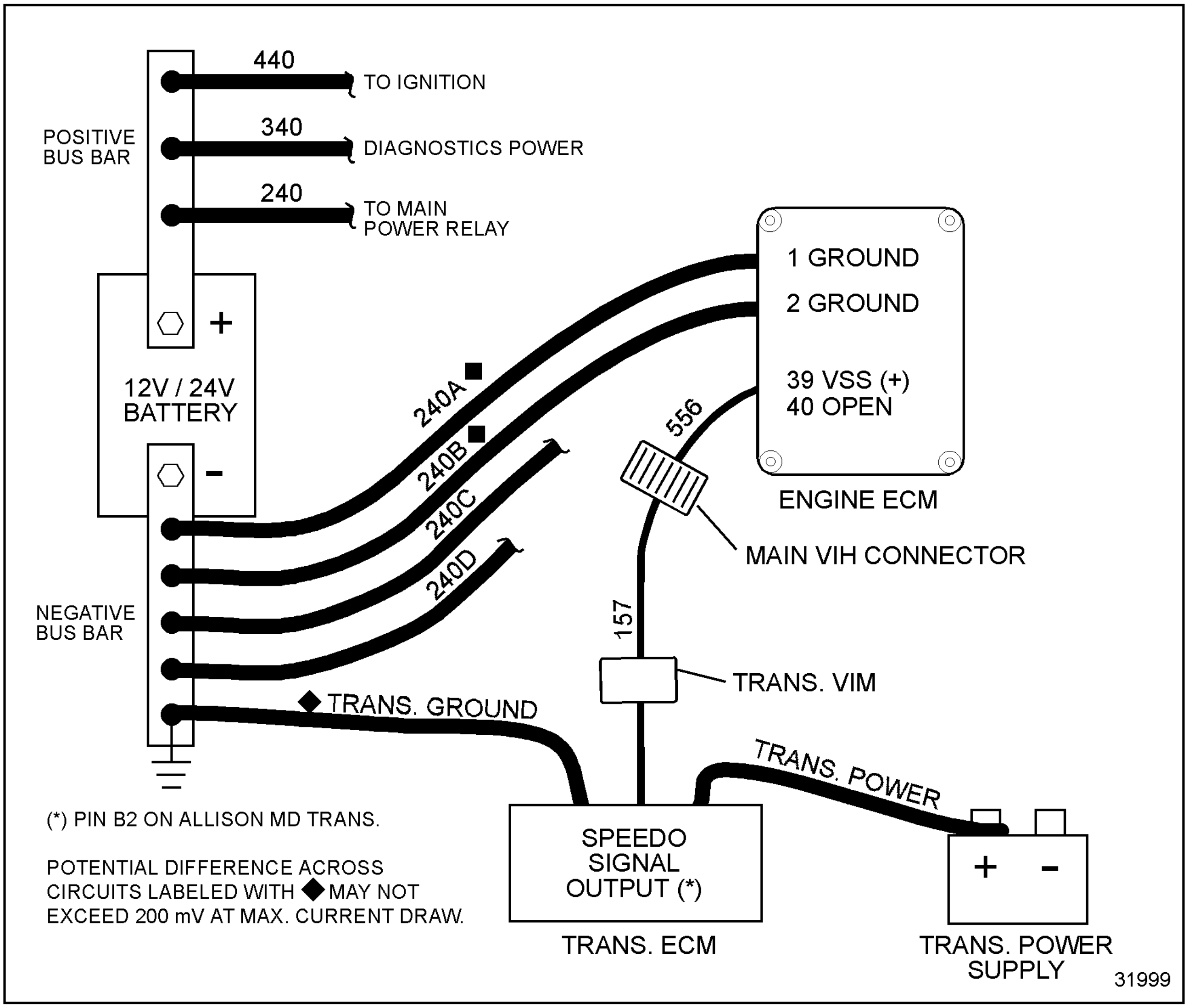
2



LABEL	WIRE NO.	WIRE GAUGE	VIH CONNECTOR CAVITY	WIRE COLOR	VSS CONNECTOR CAVITY
VEHICLE SPEED SENSOR (+)	556	18	39	GRAY	SIGNAL
VEHICLE SPEED SENSOR (-)	557	18	40	GRAY	RETURN

24457

Vehicle Speed Sensor



Recommended Wiring for a Digital Vehicle Speed Input Signal — Common Ground Architecture

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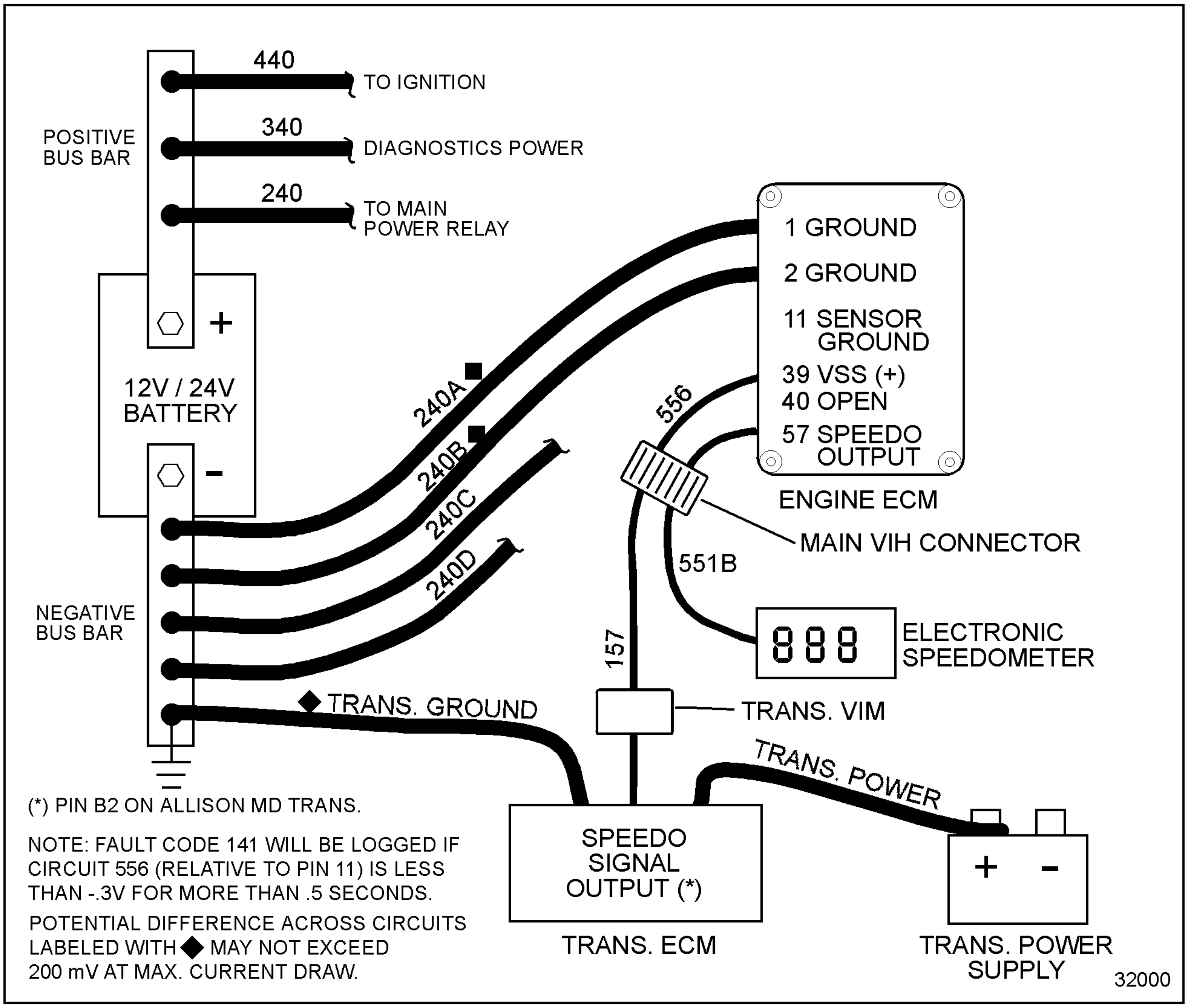


Recommended Wiring for a Digital Vehicle Speed Input Signal and Optional Speedometer Output

ENGINE DATA LINE WITH ALLISON AT/MT TRANSMISSION

ENGINE DATA LINE

For the Engine Data Line (EDL) Diagram, see Figure .

1

Circuit Functions

The ECM is programmed with two shift schedules — the Closed Throttle Mode and the Wide Open Throttle Mode.

1. Closed Throttle Mode is for situations with moderate engine load. ECM pin 56 will be LOW (0 volts). This energizes the relay, turning off power to the solenoid, causing the transmission to shift at approximately 65% of the engine load.
2. Wide Open Throttle Mode is for heavy load situations. The ECM pin 56 will be HIGH (12 volts). This de-energizes the relay causing 12 volts to be applied to the solenoid. In this mode, the ECM has shift schedules that occur at 80% of engine load.

When the engine is operating at less than the load shift point, ignition voltage is not applied to the shift solenoid. When the ECM commands a transmission shift, the relay coil ground is opened by the ECM, which de-energizes the relay, turning ON the power to the shift solenoid, causing it to shift.

Fault Detection

The EST is used to initiate the KOEO Output Circuit Tests. This will test the enabling circuit between the key switch, through the relay coil and circuit to ECM pin 56. If an open or short (high or low) is found in this circuit, Flash Code 244 will be set.

Note that the test does not check relay function or the circuit to the shift solenoid. For transmission shift modulation wiring diagram, **see Figure**

.

2

Key ON engine OFF voltage checks at the EDL relay socket are **listed in Table**

.

+Test Points–	Spec	Comments
85 to Grd	12v ± 1.5v	Should be power when key ON. If no power, check ground and power circuits from key switch; fuse F2.
30 to Grd	12v ± 1.5v	Should be power when key ON. If no power, check ground and power circuits from key switch; fuse F2.
87A to 30	> 10v	If no voltage present, open circuit or high resistance through shift solenoid, see OEM transmission information.
86 to Grd	0v	No voltage present when relay removed.

Voltage Checks at Engine Data Line Relay Socket

Key ON engine OFF voltage checks at the ECM are **listed in Table**

.

+Test Points–	Spec	Comments
+56 to –23	12v ± 1.5v	With EST tool enter OUTPUT STATE TEST set outputs HIGH (12v = shift modulator energized.)
+56 to –23	0v	With EST tool enter OUTPUT STATE TEST set outputs LOW (0v = shift modulator de-energized.)
If voltage states are correct the relay circuit is functioning correctly; if not, check relay, circuit from relay to ECM, or ECM programming.		

Voltage Checks at ECM

Circuit Resistance Checks are performed with the breakout box installed, the ECM power relay installed and the key to ON. Checks are **listed in Table**

.

+Test Points–	Spec	Comments
56 to 86	< 5 Ω	Resistance from ECM to EDL relay.
85 to 86	80 - 120 Ω	Measure resistance across relay coil.
30 to 439K	< 5 Ω	Power from relay to fuse 439K.

Circuit Resistance Checks

Fault Code Descriptions:

Fault Code 244 = High or low resistance detected in relay or relay coil during an Engine OFF test (Output Circuit Check).

Extended Description

Engine Data Line (EDL) output from the ECM controls the Transmission Modulator Shift Solenoid Control Relay which in turn controls the Transmission Modulator Shift solenoid.

The ECM is programmed with two shift schedules: Closed Throttle Mode and Wide Open Throttle Mode. The Closed Throttle Mode schedule for a transmission is for situations with a moderate engine load. The transmission will shift at approximately 65 percent of engine load. The Wide Open Throttle Mode shift schedule has shift points that occur at 80 percent of engine load. This provides increased power in heavy load situations for passing or faster acceleration.

The ECM analyzes engine operating data and determines which mode is most appropriate for current operation. The physical Allison transmission uses EDL output from ECM connector pin 56 to select the most appropriate shift schedule depending upon engine loads.

When ECM pin 56 is LOW (0 volts), the transmission operates in the Closed Throttle Mode (normal shift schedule). When the ECM pin 56 is HIGH (12 volts), the transmission operates in the Wide Open Throttle Mode.

Wide Open Throttle Mode Operation

In the Wide Open Throttle Mode, ECM pin 56 is HIGH (12 volts) and the XMSN Shift

Modulator is energized. The Transmission Modulator Shift Solenoid Control Relay receives ignition power at common terminal 30 and control coil terminal 86. When ECM pin 56 is HIGH (12 volts), the relay does not energize. The ignition power on circuit 439K goes through the normally closed (N.C.) contacts (30 to 87A) to the Transmission Modulator Shift Solenoid, causing the shift solenoid to energize.

Closed Throttle Mode Operation

In the closed Throttle Mode, ECM pin 56 is LOW (0 volts) and the Transmission Shift Modulator is not energized. When the ECM pin 56 is LOW (0 volts), circuit 150C grounds the Modulator Shift Control Relay control coil causing the relay to energize, opening the normally closed (N.C.) contacts (30 to 87A) in relay, turning OFF the power to the Transmission Modulator Shift Solenoid, which is de-energized.

ECM Diagnostics

The ECM does not continuously monitor the EDL circuits. To check these circuits, use the ProLink EST to perform the KOEO — Output Circuit Checks (OCC).

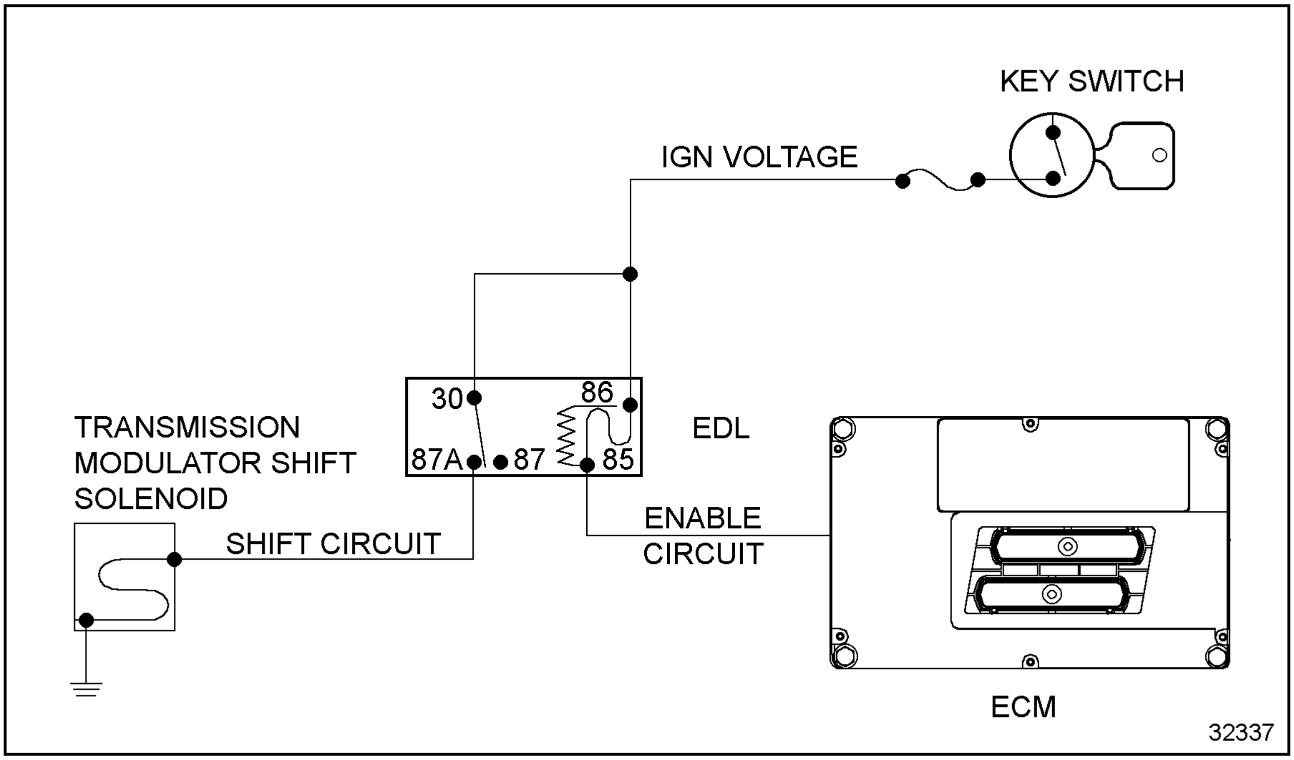
Flash Code 244

ATA Code SID 248 FMI 11

ECM: EDL OCC Fault

The OCC Test checks the relay control coil circuits and the relay control coil for opens or shorts (high or low). If a defect is noted, Flash Code 244 will be set. The Engine Warning light does not turn ON.

Note that the ECM diagnostics do not check the actual operation of the Modulator Shift Solenoid Control relay or the Modulator Shift Solenoid. For these reasons, it is possible for the Allison AT/MT transmission Modulator Shift Solenoid not to function, without a fault code.



Engine Data Line Diagram

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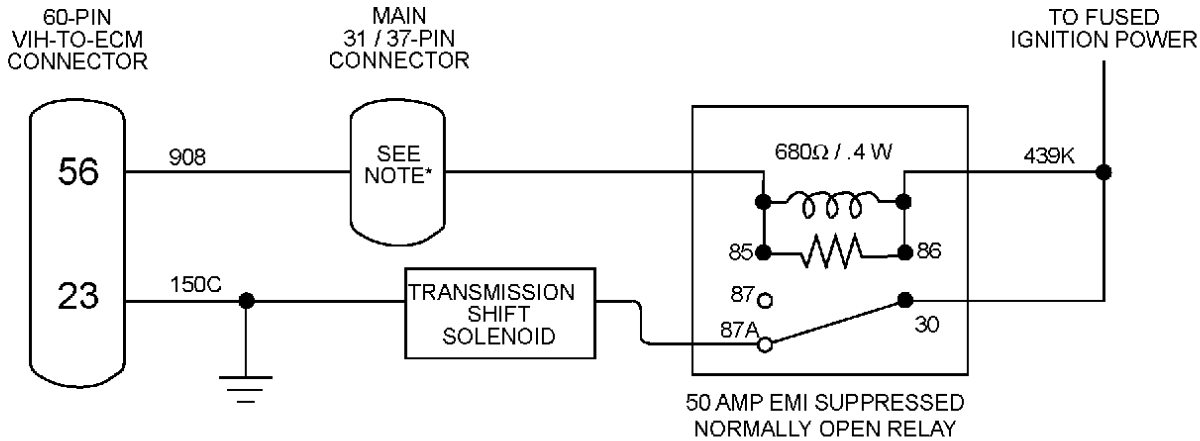

DESIGN REQUIREMENTS:

12 V BETWEEN PINS 56 & 23 ENERGIZES THE RELAY AND DE-ENERGIZES THE SHIFT SOLENOID.
0 V BETWEEN PINS 56 & 23 DE-ENERGIZES THE RELAY AND ENERGIZES THE SHIFT SOLENOID.

*NOTE:

PIN SELECTION IS LEFT TO THE DISCRETION OF THE OEM.

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Transmission Shift Modulation — Wiring Diagram