

Caterpillar 3126B HEUI Engines

The Caterpillar 3126B HEUI Engine introduces a new era of the diesel engine in the bus industry using the medium duty diesel engine. The basic engine takes advantage of the 3116's best features and years of experience and combines this with an electronically controlled fuel system, larger displacement, and other new features to produce the 3126B.

The fuel delivery system is controlled entirely by the Electronic Control Module, hereafter called the ECM. The actual delivery of the fuel into the combustion chambers is accomplished by the Hydraulic Electronic Unit Injector system (HEUI), which will be discussed later.

The ECM will identify short/open sensors or operating conditions out of the normal range. It will alert the driver/mechanic through the use of failure codes that are displayed on the dash.

At this point be advised that all subjects related to the operation and maintenance of the engine are covered in the 3100 HEUI manual provided with the chassis manual. Therefore no attempt is made herein to cover engine repairs. Service and operating instructions found in the Caterpillar manuals should be followed. When in need of information concerning the engine, contact your local Caterpillar dealer or distributor who is fully qualified and capable of handling all engine warranty and service repairs.

Those responsible for operating and maintaining the buses

powered by the 3126B engine are encouraged to read and study the Caterpillar Operation and Maintenance manual at the earliest opportunity. Certain operational characteristics should be discussed with the bus operators to familiarize them on how the ECM controls various functions.

Electronic Control Module

The ECM controls its various functions through signals from the following sensors:

- Injection Actuation Pressure
- Turbo Boost Pressure
- Engine Speed
- Engine Timing
- Coolant Temperature
- Air Intake Temperature
- Throttle Position
- Vehicle Speed

The ECM provides total electronic control of the start and duration of fuel injection. Data furnished by the sensors enable the ECM to control the fuel injected into each cylinder, which optimizes performance related to Normal and Cold weather starting, warm up, emissions, noise, fuel economy, and driveability.

Top Engine Limit

The ECM controls the top rpm of the engine, which is 2640 set at the factory, by limiting the fuel to the injectors. The engine does not have a mechanical governor.

Start-Up and Emission Control

White smoke is reduced by controlling injection timing and delivery during cold operation and acceleration. The ECM uses various sensor inputs to calculate timing and delivery that will not produce smoke.

Vehicle Speed Limit

Maximum road speed is predetermined by the owner/operator at

time of writing the specifications for the bus and is programmed into the ECM by the factory. When the programmed speed limit is reached the fuel to the injectors is limited, and will remain limited until the bus slows to a speed below the limited speed. Provisions have been made in the 3126B HEUI furnished by Thomas to allow for the fuel to be gradually reduced as maximum speed is approached, or about 2.5 mph before. This process, called Soft Vehicle Speed Limiting, prevents a sudden reduction of fuel at the top limit.

The soft vehicle speed limiting causes the engine to operate at a reduced rpm while maintaining the desired maximum road speed - a must if the best fuel economy is to be realized.

Engine Fast Idle

The engine is set to idle at 700 rpm by the factory; however, provisions can be made for a fast idle of 1000 rpm on buses operating in cold climates. This requires a dash mounted ON/OFF switch with an "Enabled Indicator Light" on the switch.

Note: All circuits powered by the ignition switch will remain HOT after the timer shuts OFF. To avoid draining the batteries the ignition switch must be turned OFF at that time.

Idle Shutdown Timer

The idle shutdown timer is designed to shut the engine OFF after a predetermined period of idling. This can be between 3 minutes and 60 minutes, depending on the initial programming.

The "Check Engine" light on the dash will begin to flash rapidly 90 seconds before the engine shuts down. The driver can override the timer by depressing the brake pedal, if necessary, by doing so while the light is flashing. This is only if idle shutdown timer has been programmed to be overridden.

Note: Excessive coolant temperature will not shut down the engine.

Engine Water Temperature Monitoring System

One of the features of the ECM system monitors the temperature of the coolant. At 225°F (107°C) the "Check Engine" lamp will come ON. If programmed, at that point the engine will gradually "derate" in horsepower to a minimum of 120 hp, and road speed will gradually reduce to 45 mph. This gives the operator ample time to get off the road and prevent damage to the engine. All drivers should be advised of this feature.

The ECM System Diagnostics

The ECM provides a flash code in the dash mounted "Check Engine" lamp in the event of malfunction in or of some component of the electronic control system. When the ECM detects a problem the "Check Engine" light will come ON, or is activated. At that time a failure diagnostic code will be entered and stored in the ECM memory. The failure code can be retrieved by 1) using the Caterpillar Electronic Control Service tool, or 2) using the "Check Engine" light if the bus is equipped with cruise control.

Check Engine Light Operation

When the ignition switch is turned ON, the lamp will illuminate for 5 seconds, which is a check to insure the lamp is working. The ECM can be programmed to notify the driver of an active fault or condition by blinking the lamp every 5 seconds after start-up.

The "Check Engine" lamp is also used to warn, by flashing rapidly, that the "Idle Shutdown Timer" will shut the engine down in 90 seconds. The driver can override the timer by depressing the brake pedal, if necessary, by doing so while the light is flashing. This is only if idle shutdown timer has been programmed to be overridden.

Retrieval of a Failure Code

If the bus is equipped with Cruise Control the failure code can be determined by the procedure outlined below. If not so equipped, it will be necessary to use an Electronic Control Service tool that is available from your Caterpillar dealer or from certain other major tool suppliers. Use of the service tool will enable the mechanic to retrieve codes stored in the ECM memory system for periods longer than a day.

Using the Cruise Control to Determine a Failure Code

1. Start the engine.
2. Turn the Cruise Control switch to the OFF position.
3. Move the SET/RESUME switch to either position and hold that position until the "Check Engine" lamp begins to

flash. The lamp will then flash to indicate a 2 digit code. Release the Cruise Control switch at this point. Count the first sequence of flashes to determine the first digit of the failure code. After a 2 second pause the second digit of the failure code will be flashed by the engine lamp.

If additional faults have occurred, the applicable failure code(s) will then be flashed after a short pause.

Flash code 55 signals "No Detected Faults" have occurred since the ignition switch was turned ON.

This subject is covered more in detail on pages 50 and 51 in the 3100 HEUI Operation and Maintenance Manual.

For various failure codes see the chart on page 13-11 for *Diagnostic Flash Codes/Engine Performance Relationship*.

Initial Start-Up

When coolant temperature is below 64⁰F (18⁰C) the ECM causes the engine to operate in a COLD MODE. During the COLD MODE operation the engine will operate at the predetermined FAST IDLE, 1000 rpm, horsepower is limited, and under certain conditions the AIR INLET Heater may operate. The engine should not be operated under full load until coolant temperature reaches 160⁰F (71⁰C), which will reduce the possibility of sticking valves due to a build-up of unburned fuel on the valve stems.

Inlet Air Heater and Lamp

The Inlet Air system incorporates an Inlet Air Heater in the intake manifold and a "MAN HTR" Lamp on the dash, connected in parallel. When the heater is ON, the dash lamp is ON at the same time.

The Inlet Air Heater is used to improve start ability in cold weather and reduce white smoke. The ECM controls the heater and lamp through a relay mounted beside the intake manifold. Heater operation is determined during three stages of engine operation: Power-up/Preheat, Cranking, and Engine Started cycle.

The ECM is "powered-up" when the ignition switch is turned ON. The heater lamp should glow for 2 seconds or so, regardless of coolant temperature. If the combination of coolant temperature and inlet air temperature is less than 77⁰F (25⁰C) the ECM will turn the Inlet Air Heater and lamp ON for 30 seconds as a preheat, and then go OFF. If the operator attempts to start the engine during the "preheat" cycle the ECM will take over control of the heater during the "cranking" cycle.

During the "cranking" cycle the heater will come ON if the combined temperatures of the coolant and the Inlet Air is less than 77⁰F (25⁰C) and will stay ON while cranking. If the engine fails to start, the heater will resume the 30 second "preheat" cycle.

After the engine has started the heater operation is still determined by the combined temperatures of the coolant and Inlet Air. The "engine started" cycle has two parts: a continuous mode, followed by an ON/OFF cycle.

The "continuous mode" lasts for a maximum of 7 minutes. The "ON/OFF" mode causes the heater to cycle ON and OFF at 10 second intervals. The "ON/OFF" mode can last up to 13 minutes.

Either of these modes can or will be interrupted when the combined temperatures of the coolant and inlet air reaches 95⁰F (35⁰C).

A failure or malfunction in either the inlet air sensor or the coolant temperature sensor will show up as a flash code on the "Check Engine" lamp.

Throttle/Fuel Control

The Electronic Control Module (ECM) controls the fuel flow to the cylinders. Instead of a direct rod/cable from the accelerator pedal to the fuel pump, the ECM receives a Pulse Width Modulation (PWM) from a throttle position sensor which incorporates a potentiometer. The sensor is located on the back side of the accelerator pedal.

The ECM supplies 8 volts as input voltage to the potentiometer,

not 12 volts from the chassis system. The throttle position sensor runs at a fixed frequency and amplitude. The 8 volts remain the same, as does the frequency, throughout the full range of pedal movement: the only thing that changes is the number of pulses within an extremely short period of time. The internal circuitry in the sensor causes a variation in the pulse width in the frequency, depending on the position of the accelerator pedal.

The output signal from the sensor to the ECM is referred to as the Duty Cycle or Pulse Width Modulation, and is expressed as a percentage between 3 and 100%.

At Low Idle the sensor will produce a duty cycle of 10-22%. At Full Throttle it will be 75-90%. This sensor-produced duty cycle is translated in the ECM which determines the timing and amount of fuel delivered to the cylinders.

Throttle Position Sensor Test Procedure

To test the TPS for being functional a meter that measures frequency and duty cycle is required, such as the FLUKE model 87. This particular meter is also a volt/ohm meter.

 **Caution:** DO NOT attempt to measure resistance of the TPS. To do so can cause catastrophic damage to the sensor.

1. Ignition switch must be OFF.
2. Disconnect the harness connector going to the throttle sensor, not any other connector. (This connector is located behind the left side windshield wiper motor access door.)
3. Install a "breakout" T harness between the sensor and the chassis harness.
4. Turn Ignition switch ON.
5. Set the meter to % Duty Cycle position. Measure the duty cycle across Ground (pin B) and Signal (pin C).
6. Closed throttle reading should be 10-22%. Full throttle should be 75-90%.

If the percentage figures fall within these ranges, the sensor is good.

The same test can be made using the Caterpillar Electronic Analyzer and Programmer tool, their model #8T9697 and tool #8C9801 PWM Signal Adapter.

To make up a "breakout" T harness:

1. Join three 12" 10 AWG wires in the center of each with a 6" 20 AWG wire, making sure of 100% bond.
2. Place male Deutch connector #DT 04-3P-E004 on one end of the three 12" wires.
3. Place a female Deutch connector on the opposite end and on the 6" lead.
4. Using Caterpillar crimping tool, #1U5804, crimp the terminals onto each wire. See **Figure 1**.

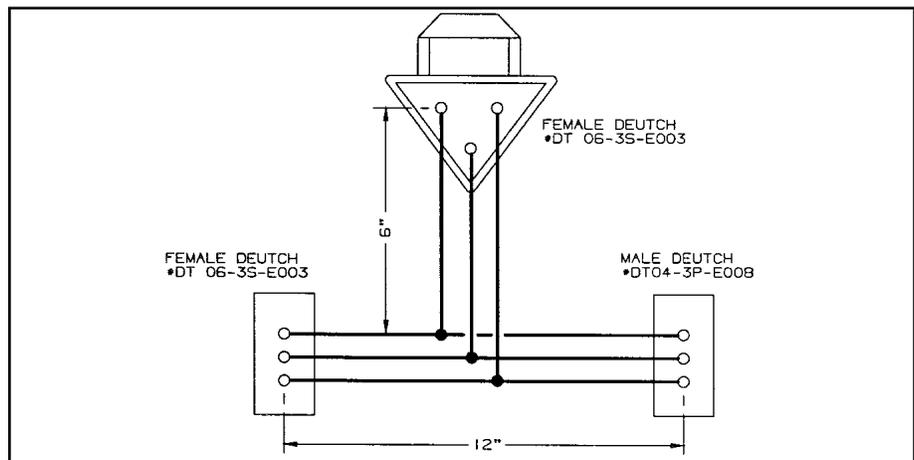


Figure 1

There may be times when it is more expedient to install a new sensor or a new ECM in a process of elimination, which means it would be wise to have one of each in stock.

Troubleshooting the Throttle Position Sensor System

Considerable training is required of the service technicians, and investment must be made in some new sophisticated test equipment, as well as, having on hand the appropriate service and troubleshooting manuals from Caterpillar. The most critical manual is Caterpillar Electronic Troubleshooting #7AS1-UP, available from your area Caterpillar dealer. This manual goes through a step-by-step sequence in checking any given fault code that appears on the dash light.

Other Items Related to Operating the 3126B HEUI Engine

As mentioned earlier, all who are involved in operating and servicing this engine are encouraged to study the 3100 HEUI

Operation and Maintenance Manual furnished with the bus. Most comments made herein are excerpts from that manual and are intended only to provide a broad overview of what the ECM does and how the 3126B differs from older engines, as far as the fuel system is concerned.

1. Operating units with winterfront/shutters - refer to the section related to the cooling system.
2. Fuel, lubricating oil, and coolant requirements are covered in the Caterpillar manual.
3. Jump starting - no special precautions need to be taken to protect the electronic system, other than what you would normally do in any jump starting operation.

Welding on the Chassis

Before welding on this bus equipped with an electronically controlled engine, the following precautions should be observed:

1. Disconnect all cables connected to the batteries.
2. Disconnect both electrical connectors at the ECM.
3. Do NOT use the ECM or engine ground stud for grounding the welder.

Customer Specifications

The customer determines certain parameters when writing the specifications for this bus. (See page 13-12.) At that time he or she was given the option of programming a password into the ECM. Unless the correct password is entered, it is impossible to change the maximum engine RPM originally programmed. The same thing applies to the Vehicle Maximum Speed limit and any other parameters that the customer specified. Certain features of the ECM system are controlled only by Caterpillar, consequently Caterpillar has its own password. However, customer passwords are not required for the engine to operate. The purpose is to prevent unauthorized alterations of the system as originally set up.

If the customer password(s) is (are) forgotten or misplaced, arrangements have to be made with the Caterpillar dealer to obtain the factory password if a change in one of the features is desired.

Tamper Resistance

One of the features of the ECM is a programmed tamper resistance. This prevents the vehicle from exceeding its preset maximum road speed in the event the vehicle speed signal is lost. Example: Assume the rear axle ratio would allow the vehicle to run 72 mph at 2400 rpm; however, management wants a maximum of 60 mph. This is programmed into the ECM by the factory, which means the engine would be turning over only 1600 rpm. (These are only figures used for the purpose of explaining how the Vehicle Speed Limit works.) IF the speed signal is lost, the bus would run 72 mph without the tamper resistance feature. With this feature, however, it will run only 60 mph, and under greatly reduced power.

Caterpillar Hydraulic Electronic Unit Injector System

The Caterpillar Hydraulic Electronic Unit Injector (HEUI) system uses the ECM to control the injection of fuel, using high pressure engine oil to provide the "muscle" instead of a cam shaft. In a conventional mechanical fuel system fuel injection pressures increases proportionally with engine speed, whereas the HEUI is electronically controlled independent of engine speed. Both the start and end of injection are electronically controlled. Plunger movement timing is NOT limited to the speed or shape of a camshaft. The next several pages describe how the HEUI system operates.

DIAGNOSTIC FLASH CODE/ENGINE PERFORMANCE RELATIONSHIP - 3100 HEUI DIESEL ENGINE

<u>DIAGNOSTIC FLASH CODE</u>	<u>EFFECT ON ENGINE PERFORMANCE</u>				<u>SUGGESTED DRIVER ACTION</u>		
	Engine Misfire	Low Power	Engine Speed Reduced	Engine Shutdown	Shutdown Vehicle	Service ASAP	Schedule Service
01 - Idle Shutdown Override							
15 - Injection Actuation Pressure Sensor Fault	X	*	*			*	
17 - Excessive Injection Actuation Pressure Fault (1)		*	*			*	
18 - Injection Actuation Pressure Control Valve Driver Fault	X	X	X	X		*	
19 - Injection Actuation Pressure System Fault	X	*	*			*	
21 - Sensor Supply Voltage Fault (1, 2)		*				X	*
25 - Boost Pressure Sensor Fault (1)		X					*
27 - Coolant Temperature Sensor Fault (1, 2)	X					X	*
28 - Check Throttle Sensor Adjustment			*			*	
31 - Loss of Vehicle Speed Signal			*				*
32 - Throttle Position Sensor Fault			*			*	
34 - Engine RPM Signal Fault				X		X	X
35 - Engine Overspeed Warning							
36 - Vehicle Speed Signal Fault			*				*
38 - Air Inlet Temperature Sensor Fault (1, 2)	*	*					*
41 - Vehicle Overspeed Warning							
47 - Idle Shutdown Occurrence				*			*
49 - Inlet Air Heater Driver Fault (1)							*
51 - Intermittent Battery Power to ECM	*			X		*	
55 - No Detected Faults							
56 - Check Customer/System Parameters		X	X			X	*
59 - Incorrect Engine Software				*		*	
61 - High/Very High Coolant Temperature Warning		X	X			*	
71 - Cylinder 1 Fault	*	*				*	
72 - Cylinder 2 Fault	*	*				*	
73 - Cylinder 3 Fault	*	*				*	
74 - Cylinder 4 Fault	*	*				*	
75 - Cylinder 5 Fault	*	*				*	
76 - Cylinder 6 Fault	*	*				*	
42 - Check Sensor Calibrations		X					*

NOTE: An X indicates that the effect on engine performance WILL occur if the code is active.

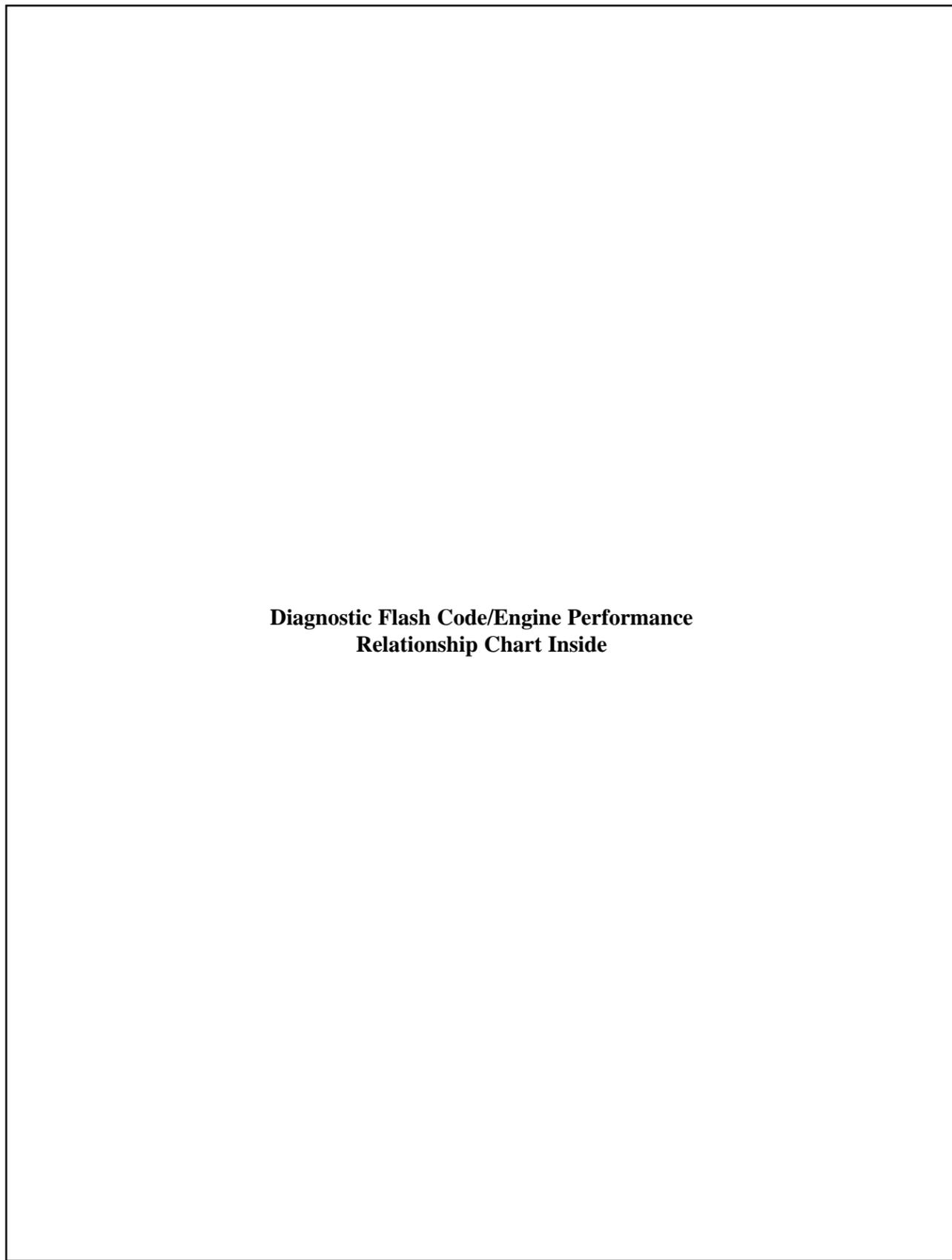
An asterisk (*) mark indicates that effect on engine performance MAY occur if the code is active.

1. These Diagnostic Flash Codes may affect the system only under specific environmental conditions such as cold weather start-up of engine or cold weather operation at high altitude.
2. These Diagnostic Flash Codes reduce the effectiveness of the engine monitoring feature when active.

Shutdown Vehicle: Drive the vehicle cautiously off the road and get immediate service. Severe engine damage may result.

Service ASAP: Driver should go to the nearest qualified service location.

Schedule: Driver should have problem investigated when convenient.



Diagnostic Flash Code/Engine Performance
Relationship Chart Inside

CAT 3126 CUSTOMER PARAMETER WORKSHEET

*To accompany each order or parameters will be defaulted.

<u>PARAMETER</u>	<u>PARAMETER SETTING</u>
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<p>Vehicle Speed Limiting If customer doesn't specify, speed will be set at 65 mph 105 km. Actual maximum speed depends on axle ratio. Seventy mph maximum speed allowed on school bus models.</p>	<p>_____ MPH</p> <p>or</p> <p>_____ KM</p>
---	--

Vehicle Speed Limiting Protection	Yes _____ No _____
--	--------------------

Idle Shutdown Timer	_____ Minutes 3 to 60 minutes
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Idle Shutdown Timer Override	Yes _____ No _____
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Maintenance Data PM Schedule	Choose One: _____ Hours or _____ Mileage/KM
--	---

Customer Password	_____ Up to 8 digits: letters or numbers
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Customer Name _____

Address _____

City, State _____

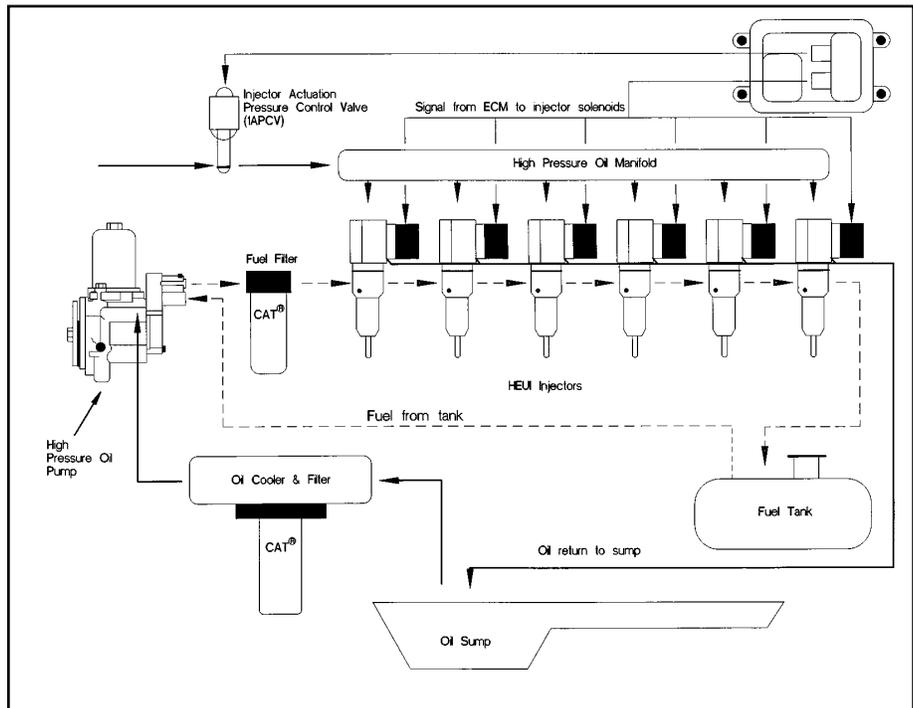
Selling Distributor _____

Distributor Order Number _____

Caterpillar 3126B Product News

Higher Injection Pressures

An intensifier piston in the HEUI injector multiplies hydraulic force on the plunger. By varying hydraulic input pressure, injection pressure can be controlled in a range from 5,000 to 21,000 psi. These high pressures are available at idle as well as high engine speeds. The higher injection pressures improve fuel economy, performance, and emission capabilities.



HEUI System Components

1. **Electronic Control Module (ECM):**
The ECM is a microprocessor based system which monitors various inputs and sensors from the vehicle and engine as it controls the operation of the entire fuel system. It contains information defining optimum fuel system operational parameters. The ECM also has many more external operational inputs than a mechanical governor such as engine speed, timing, rail pressure, boost pressure, etc. It can determine optimum fuel rate and injection timing for any condition. It sends a precisely controlled signal to energize the injector solenoid.