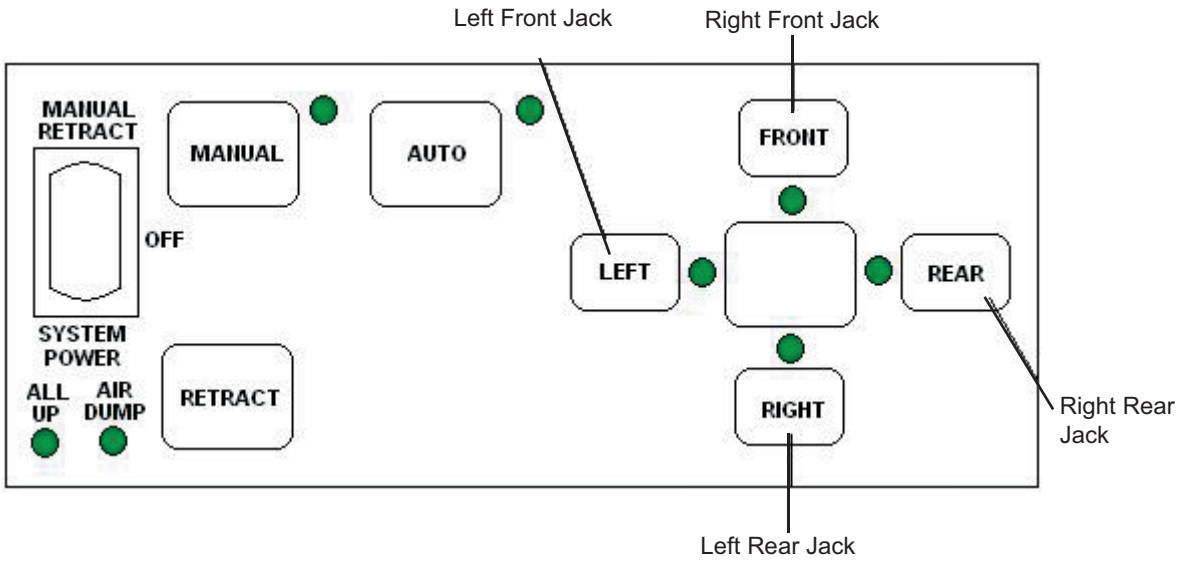
4-19.1.2 Manual Mode or Extending Stabilizers Individually



1. Push and hold manual button until indicator light is illuminated indicating system is in manual mode. (See figure above).
2. Press buttons on the four-button side panel individually to extend stabilizers.

IMPORTANT NOTE: Make certain to run jacks in pairs by pushing the following button pairs together (see chart below). If the jacks are not operated in pairs, this could twist the body structure and affect slideout room operation by distorting the slideout opening.

Button Pairs	Action
Left & Front	Raises Front
Right & Rear	Raises Rear
Left & Right	Raises Left Side
Front & Rear	Raises Right Side
Left & Front	**NO - Twists Body**
Rear & Front	**NO - Twists Body**

4-19.1.3 To Operate Manually

To level manually extend two stabilizers at a time by pushing jacks in pairs. For example, either by pushing the front and left together or the right and rear together.

4-19.2 Maintenance Guide

One advantage of owning a Big Foot Stabilizing System from Quadra Mfg. is that your system requires very little in the way of maintenance. Here is a guide to follow for years of carefree service.

NOTE: Maintenance related problems and maintenance service are not covered by warranty.

Check the fluid level at least once a year:

- Remove the red fill cap at each stabilizer pump and use a wire-tie as a dipstick (not provided) to check the fluid level. The correct level is ¾" from the top of the reservoir.
- If needed, fill with Dexron II or III transmission fluid. The standard reservoir holds 54 oz. And the deep reservoir holds 141 oz.

Under mild to normal weather conditions:

- Extend stabilizers and spray the rams of the hydraulic cylinders with silicone* spray twice a year. Let the spray dry and retract the stabilizers.

If you leave your stabilizers extended over a period of time:

- When camping or storing your vehicle for the winter, be sure to spray the rams of the hydraulic cylinders with silicone spray before retracting your stabilizers to avoid tearing the cylinder's seal.

Under severe weather conditions:

- The above procedure should be followed on a monthly basis if conditions exist that result in your stabilizers being exposed to high amounts of salt, dirt and wind.

Limit pins:

- Clean with brake cleaner and then spray with clear silicone twice a year.

Routinely check your footpads:

- The bolt should be tightened with a 15/16 socket or an impact wrench and a 1-1/8" narrow head wrench.
- Torque footpad to 120 lbs. Over time, vibration may work footpads loose.

**Use ONLY silicone spray*

4-19.3 Troubleshooting

PANEL:

Power On button is pushed but no indicators are lit on panel –

- Fuse on the back of the panel is blown.
- White wire on the four-wire pigtail is not getting constant power.
- Ground wire may not be getting a good ground.
- White or black wire on pigtail may be pushed back in the plug.

Vehicle is started and stabilizers are down but the warning alarm does not sound –

- Yellow wire is not getting power when the key is turned forward.
- Yellow wire may be pushed back in the plug.

Cylinders will not retract and the red indicator light is not lit –

- Limit pin on the cylinder may be stuck.
- Limit pin wire on the main wire harness may be pushed back in the plug.
- Limit switch ground wire on the tank assembly may not be grounding properly.

Cylinders will not extend or retract –

- The 120 amp breaker has been tripped.
- Wires on the tank solenoids have a break or are not making a good connection.

CYLINDERS:

Cylinders do not fully extend or retract –

- Air trapped in the cylinder.
- Hydraulic lines are plumbed backwards.
- There is no fluid or low fluid in the tank reservoir.

Cylinder continues to run after the panel button has been released –

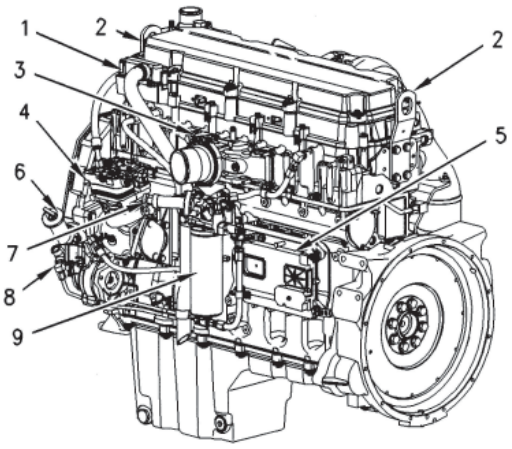
- Tank solenoids may be sticking.
- Panel switch may be sticking.

Cylinder will not lift or hold the weight of the motor home –

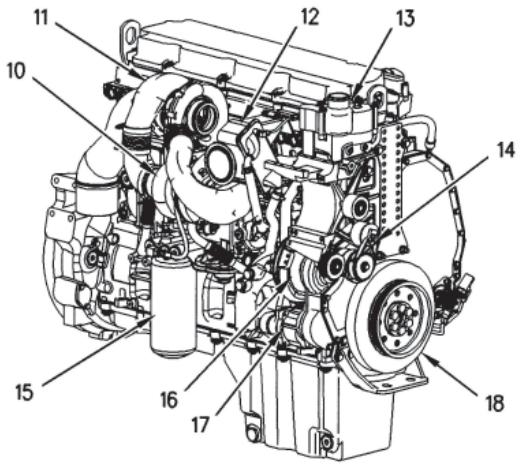
- Lines may be plumbed backwards.
- Back pressure circuit in hydraulic pump is bad
- Damaged piston seal inside cylinder

5-1 Caterpiller C-13 Engine

The 450 LXi is equipped with the Caterpillar C-13 Engine. Basic operating instructions are as follows: Maintenance procedures can be found in the *5-3 Engine Maintenance* Section of this manual.



(1) Engine crankcase breather
(2) Lifting eyes
(3) Inlet air manifold
(4) Air compressor
(5) Engine control module (ECM)
(6) Engine oil fill neck
(7) Fuel priming pump
(8) Fuel transfer pump
(9) Fuel filter



(10) High pressure turbocharger
(11) Low pressure turbocharger
(12) Air precooler
(13) Water temperature regulator
(14) Spring loaded belt tensioner
(15) Engine oil filter
(16) Water pump
(17) Engine oil pump
(18) Vibration damper

5-1.1 General Hazard Information

The following paragraphs cover basic safety, hazard and operating information. In addition, this section identifies hazardous, warning situations. Read and understand the precautions listed in the safety section before operating or performing lubrication, maintenance and repairs on the engine. The operating techniques outlined in this manual are basic. They assist with developing the skills and techniques required to operate the engine more efficiently and economically. Skill and techniques develop as the operator gains knowledge of the engine and its capabilities.

The operation section is a reference for operators. Photographs and illustrations guide the operator through procedures of inspecting, starting, operating and stopping the engine. This section also includes a discussion of electronic diagnostic information. Information on the Engine Messenger System can be found in *Section 5-2 Engine Messenger System* of this Owner's Manual.

5-1.1.1 Overhaul

Major engine overhaul details are not covered in the Operation and Maintenance sections of this manual except for the maintenance intervals and the maintenance items in that interval. Major repairs are best left to trained personnel or an authorized Caterpillar dealer. Your Caterpillar dealer offers a variety of options regarding overhaul programs. If you experience a major engine failure, there are also numerous after failure overhaul options available from your Caterpillar dealer. Consult with your dealer for information regarding these options.

5-1.1.2 California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

Battery posts, terminals and related accessories contain lead and lead compounds. ***Wash hands after handling.***

5-1.2 Safety Section

5-1.2.1 Safety Messages

There may be several specific warning stickers on your engine. The exact location and a description of the warning stickers are reviewed in this section. These stickers are on the engine to protect the customer, please become familiar with all warning stickers.

Ensure that all of the warning stickers are legible. Clean the warning stickers or replace the warning stickers if the words cannot be read or if the illustrations are not visible. Use a cloth, water, and soap to clean the warning stickers. Do not use solvents, gasoline, or other harsh chemicals. Solvents, gasoline or harsh chemicals could loosen the adhesive that secures the warning stickers. The warning stickers that are loosened could drop off of the engine.

Replace any warning sticker that is damaged or missing. If a warning sticker is attached to a part of the engine that is replaced, install a new warning sticker on the replacement part. Your Caterpillar dealer can provide new warning stickers.

5-1.2.2 Universal Warning

One warning label for the Universal Warning is located on the valve cover base on the left side of the engine. The label is on the fourth flat surface from the rear of the engine.

⚠ WARNING

Do not operate or work on this equipment unless you have read and understand the instructions and warnings in the Operation and Maintenance Manuals. Failure to follow the instructions or heed the warnings could result in serious injury or death.

The other warning label for the Universal Warning is located on the vertical surface of the water temperature regulator housing just below the round boss that is cast into the housing.

5-1.2.3 General Hazard Information

Attach a **"Do Not Operate"** warning tag or a similar warning tag to the start switch or to the controls before the engine is serviced or before the engine is repaired. These warning tags (Special Instruction, SEHS7332) are available from your Caterpillar dealer. Attach the warning tags to the engine and to each operator control station. When it is appropriate, disconnect the starting controls.

Do not allow unauthorized personnel on the engine or around the engine when the engine is serviced.

- Tampering with the engine installation or tampering with the OEM supplied wiring can be dangerous. Engine damage, personal injury and/or death could result.
- Vent the engine exhaust to the outside when the engine is operated in an enclosed area.
- If the engine is not running, do not release the secondary brake or the parking brake systems unless the coach is blocked or unless the coach is restrained.
- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.

- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

Unless other instructions are provided, perform the maintenance under the following conditions:

- The engine is stopped.
- The protective locks or the controls are in the applied position.
- Engage the secondary brakes or parking brakes.
- Block the coach or restrain the coach before maintenance or repairs are performed.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- Disconnect the connector for the unit injector that is located on the valve cover base. This will help prevent personal injury from the high voltage to the unit injectors. Do not come in contact with the unit injector terminals while the engine is operating.
- Do not attempt any repairs or any adjustments to the engine while the engine is operating.
- Do not attempt any repairs if not completely sure how to complete the procedure. Use the proper tools. Replace any equipment that is damaged or repair the equipment.
- For initial start-up of a new engine or for starting an engine that has been serviced, make provisions to stop the engine if an overspeed occurs. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.
- Start the engine from the operator's station (cab). Never short across the starting motor terminals or the batteries. This could bypass the engine neutral start system and/or the electrical system could be damaged.

5-1.2.4 Pressure Air and Water

Pressurized air and/or water can cause debris and/or hot water to be blown out. This could result in personal injury. When pressure air is used for cleaning, wear a protective face shield, protective clothing, and protective shoes. The maximum air pressure for cleaning purposes must be below 205 kPa (30 psi). The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi). Always wear eye protection for cleaning the cooling system.

5-1.2.5 Fluid Penetration

Always use a board or cardboard when the engine components are checked for leaks. Leaking fluid that is under pressure can cause serious injury or possible death. This includes leaks that are the size of a pin hole. If fluid is injected into the skin, seek treatment immediately. Seek treatment from a doctor that is familiar with this type of injury.

5-1.2.6 Fluid Spillage

Care must be used in order to ensure that the fluids are contained during the inspection, the maintenance, the testing, the adjusting, and the repair of the engine. Make provisions to collect the fluid with a suitable container before any compartment is opened or before any component is disassembled. This publication explains the items that are needed for collecting and for containing fluids that are used in Caterpillar engines. Dispose of fluids according to local regulations.

5-1.2.7 Asbestos Information

Caterpillar equipment and replacement parts that are shipped from Caterpillar are asbestos free. Caterpillar recommends the use of only genuine Caterpillar replacement parts.

5-1.2.8 Burn Prevention

Do not touch any part of an operating engine. Allow the engine to cool before any maintenance is performed on the engine. Relieve all pressure in the air system, in the hydraulic system, in the lubrication system, in the fuel system, or in the cooling system before any lines, fittings or related items are disconnected.

5-1.2.9 Coolant

When the engine is at operating temperature, the engine coolant is hot. The coolant is also under pressure. The radiator and all lines to the heaters or to the engine contain hot coolant.

Any contact with hot coolant or with steam can cause severe burns. Allow cooling system components to cool before the cooling system is drained.

Check the coolant level after the engine has stopped and the engine has been allowed to cool.

Ensure that the filler cap is cool before removing it. The filler cap must be cool enough to touch with a bare hand. Remove the filler cap slowly in order to relieve pressure.

Cooling system conditioner contains alkali. Alkali can cause personal injury. Do not allow alkali to come in contact with the skin, the eyes, or the mouth.

5-1.2.10 Oils

Hot oil and hot lubricating components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

5-1.2.11 Batteries

Electrolyte is an acid. Electrolyte can cause personal injury. Do not allow electrolyte to contact the skin or eyes. Always wear protective glasses for servicing batteries. Wash hands after touching the batteries and connectors. Use of gloves is recommended.

5-1.2.12 Fire and Explosion Prevention

All fuels, most lubricants, and some coolant mixtures are flammable.

Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire. Fire may cause personal injury and property damage.

A flash fire may result if the covers for the engine crankcase are removed within fifteen minutes after an emergency shutdown.

Determine whether the engine will be operated in an environment that allows combustible gases to be drawn into the air inlet system. These gases could cause the engine to overspeed. Personal injury, property damage, or engine damage could result.

If the application involves the presence of combustible gases, consult your Caterpillar dealer for additional information about suitable protection devices.

Remove all flammable materials such as fuel, oil, and debris from the engine. Do not allow any flammable materials to accumulate on the engine.

Store fuels and lubricants in properly marked containers away from unauthorized persons. Store oily rags and any flammable materials in protective containers. Do not smoke in areas that are used for storing flammable materials.

Do not expose the engine to any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in case of a line, a tube, or a seal failure. Exhaust shields must be installed correctly.

Do not weld on lines or tanks that contain flammable fluids. Do not flame cut lines or tanks that contain flammable fluid. Clean any such lines or tanks thoroughly with a nonflammable solvent prior to welding or flame cutting.

Wiring must be kept in good condition. All electrical wires must be properly routed and securely attached. Check all electrical wires daily. Repair any wires that are loose or frayed before you operate the engine. Clean all electrical connections and tighten all electrical connections.

Eliminate all wiring that is unattached or unnecessary. Do not use any wires or cables that are smaller than the recommended gauge. Do not bypass any fuses and/or circuit breakers.

Arcing or sparking could cause a fire. Secure connections, recommended wiring, and properly maintained battery cables will help to prevent arcing or sparking.

Inspect all lines and hoses for wear or for deterioration. The hoses must be properly routed. The lines and hoses must have adequate support and secure clamps. Tighten all connections to the recommended torque. Leaks can cause fires.

Oil filters and fuel filters must be properly installed. The filter housings must be tightened to the proper torque.

Use caution when you are refueling an engine. Do not smoke while you are refueling an engine. Do not refuel an engine near open flames or sparks. Always stop the engine before refueling.

Gases from a battery can explode. Keep any open flames or sparks away from the top of a battery. Do not smoke in battery charging areas.

Never check the battery charge by placing a metal object across the terminal posts. Use a voltmeter or a hydrometer.

Improper jumper cable connections can cause an explosion that can result in injury. Refer to the *Operation* Section of this manual for specific instructions.

Do not charge a frozen battery. This may cause an explosion.

The batteries must be kept clean. The covers (if equipped) must be kept on the cells. Use the recommended cables, connections, and battery box covers when the engine is operated.

5-1.2.13 Fire Extinguisher

Make sure that a fire extinguisher is available. Be familiar with the operation of the fire extinguisher that is supplied in your coach. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate.

5-1.2.14 Ether (if equipped)

Ether is flammable and poisonous.

Use ether in well ventilated areas. Do not smoke while you are replacing an ether cylinder or while you are using an ether spray.

⚠ WARNING

DO NOT USE ETHER (starting fluids) unless specifically instructed to do so. If the engine is equipped with an Air Inlet Heater (electrically or fuel ignited manifold heater), DO NOT use ether (starting fluids) at any time. The use could result in engine damage and/or personal injury.

Do not store ether cylinders in living areas or in the engine compartments.

Do not store ether cylinders in direct sunlight or in temperatures above 49 °C (120 °F). Keep ether cylinders away from open flames or sparks.

Dispose of used ether cylinders properly. Do not puncture an ether cylinder. Keep ether cylinders away from unauthorized personnel.

Do not spray ether into an engine if the engine is equipped with a thermal starting aid for cold weather starting.

5-1.2.15 Lines, Tubes and Hoses

Do not blend high pressure lines. Do not strike high pressure lines. Do not install any lines that are bent or damaged.

Repair any lines that are loose or damaged. Leaks can cause fires. Consult your Caterpillar dealer for repair or for replacement parts.

Check lines, tubes and hoses carefully. Do not use your bare hand to check for leaks. Use a board or cardboard to check for leaks. Tighten all connections to the recommended torque.

Replace the parts if any of the following conditions are present:

- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.
- Flexible part of the hoses are kinked.
- Outer covers have embedded armoring.
- End fittings are displaced.

Make sure that all clamps, guards, and heat shields are installed correctly. During engine operation, this will help to prevent vibration, rubbing against other parts, and excessive heat.

5-1.2.16 Crushing and Cutting Prevention

Support the component properly when working beneath the component.

Unless other maintenance instructions are provided, never attempt adjustments while the engine is running.

Stay clear of all rotating and moving parts. Leave the guards in place unless maintenance is being performed. Remove guards prior to performing maintenance. After the maintenance is completed, reinstall the guards.

Keep objects away from moving fan blades. The fan blades will throw or cut objects. Do not attempt to stop a fan by bare hand even though it appears to be moving very slowly. Do not hit a fan blade. Fan blades are made out of plastic and can break immediately, or become unbalanced and fail later on or they can crack or fracture and fail later on.

Chips or other debris may fly off objects when objects are struck. Make sure no one is close enough to be injured by flying debris.

NOTE: When working around engine always wear protective glasses to protect against eye injury.

5-1.2.17 Mounting and Dismounting

Inspect the stops, the handholds, and the work area before mounting the engine. Keep these items clean and in good repair.

Mount and dismount the engine only at locations that have steps and/or handholds. Do not climb or jump off the engine.

Face the engine in order to mount or dismount the engine. Maintain a three-point contact with the steps and handholds. Use two feet and one hand or use one foot and two hands. Do not use any controls as handholds.

Do not stand on components which cannot support your weight. Use an adequate ladder or use a work platform. Secure the climbing equipment so that the equipment will not move.

Do not carry tools or supplies when you mount or dismount the engine. Use a hand line to raise and lower tools or supplies.

5-1.3 Starting the Engine - Safety

5-1.3.1 Before Starting Engine

Inspect the engine for potential hazards.

Before starting the engine, ensure that no one is on, underneath, or close to the engine. All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Do not bypass or disable the automatic shut off circuits. The circuits are provided in order to help prevent personal injury and help prevent engine damage.

On the initial start-up of a new engine or an engine that has been serviced, prepare to stop the engine if an overspeed condition occurs. This may be accomplished by shutting off the fuel supply to the engine and/or shutting off the air supply to the engine.

5-1.3.2 Engine Starting - Safety

If a warning tag is attached to the engine start switch or to the controls, do not start the engine or move the controls. Also, do not disengage the parking brakes. Consult with the person that attached the warning tag before the engine is started.

All protective guards and covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Start the engine from the operator's station (cab). Never short across the starting motor terminals or the batteries. This could bypass the engine neutral start system and/or the electrical system could be damaged.

Always start the engine according to the procedure that is described in this manual. Knowing the correct procedure will help to prevent major damage to the engine components. Knowing the procedure will also help to prevent personal injury.

To ensure that the jacket water heater (if equipped) and/or the lube oil heater (if equipped) is working properly, check the water temperature gauge and the oil temperature gauge during the heater operation.

Engine exhaust contains products of combustion that can be harmful to your health. Always start the engine and operate the engine in a well ventilated area. If the engine is started in an enclosed area, vent the engine exhaust to the outside.

5-1.3.3 Ether (if equipped)

⚠ WARNING

DO NOT USE ETHER (starting fluids) unless specifically instructed to do so. If the engine is equipped with an Air Inlet Heater (electrically or fuel ignited manifold heater), DO NOT use ether (starting fluids) at any time. The use could result in engine damage and/or personal injury.

Ether is poisonous and flammable. Do not inhale ether, and do not allow ether to contact the skin. Personal injury could result. Do not smoke while ether cylinders are changed. Use ether in well ventilated areas.

Keep ether cylinders out of the reach of unauthorized persons. Store ether cylinders in authorized storage areas only. Do not store ether cylinders in direct sunlight or at temperatures above 39°C (102°F). Discard the ether cylinders in a safe place. Do not puncture or burn the ether cylinders.

5-1.3.4 Engine Stopping

Stop the engine according to the procedure in this manual in order to avoid overheating of the engine and accelerated wear of the engine components.

Use the Emergency Stop Button (if equipped) ONLY in an emergency situation. Do not use the Emergency Stop Button for normal engine stopping. After an emergency stop, DO NOT start the engine until the problem that caused the emergency stop has been corrected.

Stop the engine if an overspeed condition occurs during the initial start-up of a new engine or an engine that has been overhauled. This may be accomplished by shutting off the fuel supply to the engine and/or shutting off the air supply to the engine.

To stop an electronically controlled engine, cut the power to the engine.

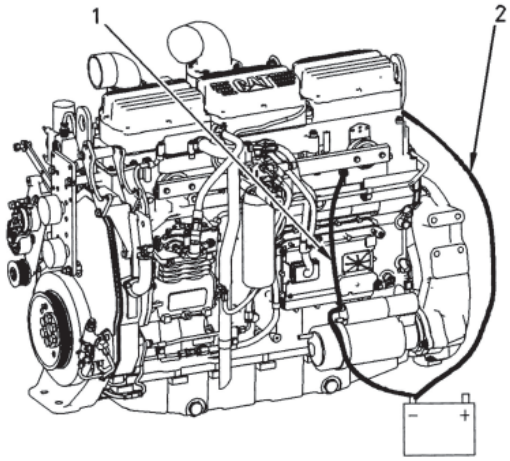
5-1.3.5 Electrical System

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.

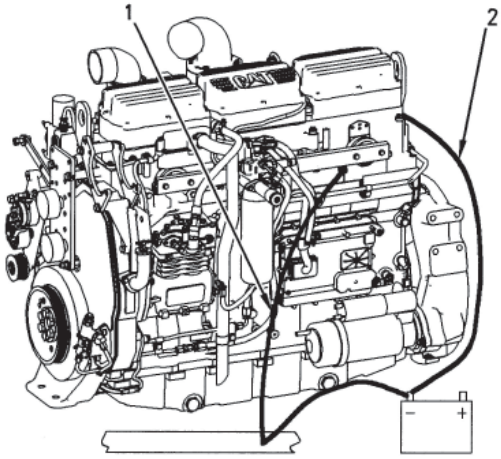
To help prevent sparks from igniting combustible gases that are produced by some batteries, the negative "-" jump start cable should be connected last from the external power source to the negative "-" terminal of the starting motor. If the starting motor is not equipped with a negative "-" terminal, connect the jump start cable to the engine block.

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before the engine is started. Repair all frayed electrical wires before the engine is started. See specific instructions found later in this manual.

5-1.3.6 Grounding Practices



Typical Example - Engine Ground
(1) Recommended Connections
(2) Alternate Connections



Typical Example - Frame Ground
(1) Recommended Connections
(2) Alternate Connections

Proper grounding for the engine electrical system is necessary for optimum engine performance and reliability. Improper grounding will result in uncontrolled electrical circuit paths and in unreliable electrical circuit paths.

Uncontrolled electrical circuit paths can result in damage to main bearings, to crankshaft bearing journal surfaces, and to aluminum components.

Engines that are installed without engine-to-frame ground straps can be damaged by electrical discharge.

To ensure that the engine and the engine electrical systems function properly, an engine-to-frame ground strap with a direct path to the battery must be used. This path may be provided by way of a starting motor ground, a starting motor ground to the frame, or a direct engine ground to the frame.

All grounds should be tight and free of corrosion. The engine alternator must be grounded to the negative "-" battery terminal with a wire that is adequate to handle the full charging current of the alternator.

5-1.3.7 Engine Electronics

⚠ WARNING

Tampering with the electronic system installation or the OEM wiring installation can be dangerous and could result in personal injury or death and/or engine damage.

This engine has a comprehensive, programmable Engine Monitoring System. The Engine Control Module (ECM) has the ability to monitor the engine operating conditions. If any of the engine parameters extend outside an allowable range, the ECM will initiate an immediate action.

The following actions are available for engine monitoring control: WARNING, DERATE, and SHUTDOWN. These engine monitoring modes have the ability to limit engine speed and/or the engine power.

Many of the parameters that are monitored by the ECM can be programmed for the engine monitoring functions. The following parameters can be monitored as a part of the Engine Monitoring System.

- Operating Altitude
- Engine Coolant Level
- Engine Coolant Temperature
- Engine Oil Pressure
- Engine Speed
- Fuel Temperature
- Intake Manifold Air Temperature
- System Voltage

The Engine Monitoring package can vary for different engine models and different engine applications. However, the monitoring system and the engine monitoring control will be similar for all engines.

NOTE: Many of the engine control systems and display modules that are available for Caterpillar engines will work in unison with the Engine Monitoring System. Together, the two controls will provide the engine monitoring function for the specific engine application.

5-1.4 Engine Description

C13 (S/N: KCB) On-highway Engine Specifications	
Cylinders and Arrangement	In-line six cylinder
Bore	130 mm (5.2 inch)
Stroke	157 mm (6.2 inch)
Displacement	12.5 L (763 in^3)
Firing Order	1-5-3-6-2-4
Rotation (flywheel end)	Counterclockwise

The electronic on-highway engines that are covered by this manual have the following characteristics: direct fuel injection, electronic unit injection that is mechanically actuated, turbocharged, and air-to-air aftercooled (ATAAC).

The electronic engine control system provides the following functions: electronic governing, automatic air to fuel ratio control, torque rise shaping, injection timing control, and system diagnostics.

Several programmable features are included in the electronic control: cruise control, governing the PTO, vehicle speed limiting, rpm limit for high gears, rpm limit for low gears, top engine limit, idle shutdown timer, and control for the engine retarder (compression brake).

Additional benefits provide engine fuel economy, serviceability, and operator comfort. The additional benefits include the following features: improved cold starting capability, resistance to tampering, diagnostics, progressive shift engine speed control, data link (SAE J1587) for the American Trucking Association (ATA), and optional Engine Monitoring Package.

An electronic governor controls the output of the unit injectors in order to maintain the engine rpm that is desired. The functions of the governor include a programmable low idle and a 20 rpm to 200 rpm governor overrun.

Very high injection pressures are produced by electronically controlled, mechanically actuated unit injectors. The injectors combine the pumping and the electronic fuel metering (duration and timing) during injection. The unit injectors accurately control smoke limiting, white smoke, and engine acceleration rates.

Each cylinder has one unit injector. Individual unit injectors meter the fuel. The individual unit injectors also pump the fuel. The metering and the pumping is done under high pressure. High injection pressures help to reduce fuel consumption and emissions. The use of this type of unit injector provides total electronic control of injection timing. The injection timing varies with engine operating conditions. The engine performance is optimized in the following areas:

- Starting
- Emissions
- Noise
- Fuel Consumption
- Driveability

The timing advance is achieved through precise control of the injector firing. Engine speed is controlled by adjusting the firing duration. The information is provided to the Engine Control Module (ECM) by an engine speed/timing sensor. The information is for detection of cylinder position and engine speed.

The engines have built-in diagnostics in order to ensure that all of the components are functioning and operating properly. In the event of a system component deviation from the programmed limits, the operator will be alerted to the condition by a CHECK ENGINE/DIAGNOSTIC lamp that is mounted on the dashboard. An electronic service tool that is provided by Caterpillar or the cruise control switches (if equipped) may be used to read the numerical code of the diagnostic flash code. There are three types of diagnostic codes: ACTIVE, LOGGED, and EVENT. These codes are logged and stored in the ECM. Refer to *"Engine Diagnostics"* section of this manual for additional information.

The cooling system consists of the following items: a centrifugal pump that is driven by a gear, water temperature regulator, an oil cooler, and an OEM supplied radiator that incorporates a shunt system.

The engine lubricating oil is supplied by a gear type pump. The engine lubricating oil is cooled and filtered. Bypass valves provide unrestricted flow of lubrication oil to the engine parts when the oil viscosity is high or if either of the oil cooler or the oil filter elements (paper cartridge) become plugged.

Engine efficiency, efficiency of emission controls, and engine performance depend on adherence to proper operation and maintenance recommendations. This includes the use of recommended fuels, coolants and lubrication oils.

5-1.4.1 Multitorque Rating (If Equipped)

The Multitorque ratings provide additional torque as engine load increases. This feature provides higher torque levels. This feature also provides better driveability while the vehicle is only in the top gears. The engine electronics are able to determine when the vehicle is in the top gears by calculating the engine rpm/vehicle speed ratio.

With the additional torque, the following benefits are provided: less shifting in rolling terrain, less wear on drive line components, more responsive, and better engine performance.

5-1.4.2 Aftermarket Products and Caterpillar Engines

NOTICE: In order to maximize fuel system life and prevent premature wear out from abrasive particles in the fuel, a two micron absolute high efficiency fuel filter is required for all Caterpillar Hydraulic Electronic Unit Injectors. Caterpillar High Efficiency Fuel Filters meet these requirements. Consult your Caterpillar dealer for the proper part numbers.

When auxiliary devices, accessories, or consumables (filters, additives, catalysts, etc.) which are made by other manufacturers are used on Caterpillar products, the Caterpillar warranty is not affected simply because of such use.

However, failures that result from the installation or use of other manufacturers' devices, accessories, or consumables are NOT Caterpillar defects. Therefore, the defects are NOT covered under the Caterpillar warranty.

5-1.5 Product Identification Information

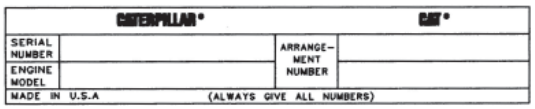
5-1.5.1 Engine Identification

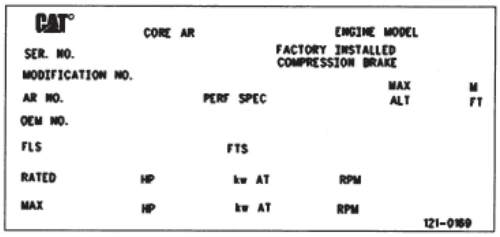
Caterpillar engines are identified with serial numbers, with performance specification numbers, and with arrangement numbers. In some of the cases, modification numbers are used. These numbers are shown on the Serial Number Plate and the Information Plate that are mounted on the engine.

Caterpillar dealers need these numbers in order to determine the components that were included with the engine. This permits accurate identification of replacement part numbers.

5-1.5.2 Serial Number Plate

C11 and C13 the Serial Number Plate is located on the left side of the cylinder block near the rear of the engine.





5-1-5.3 Information Plate

On C11 and C13 engines the Information Plate is located on the right side of the engine. The information plate is on the front half of the inlet manifold

5-1.5.4 Reference Numbers

Information for the following items may be needed to order parts. Locate the information for your engine. Record the information in the appropriate space. Make a copy of this list for your records. Retain this information for further reference.

Record for Reference

Chassis Serial Number: _____

Engine Model: _____

Engine Serial Number: _____

Engine Arrangement Number: _____

Modification Number: _____

Engine Low Idle RPM: _____

Engine Full Load RPM: _____

Performance Specification Number: _____

Engine HP: _____

Primary Fuel Filter Number: _____

Water Separator Element Number: _____

Secondary Fuel Filter Element Number: _____

Lubrication Oil Filter Element Number: _____

Auxiliary Oil Filter Element Number: _____

Supplemental Coolant Additive Maintenance Element Number: (Optional) _____

Total Lubrication System Capacity: _____

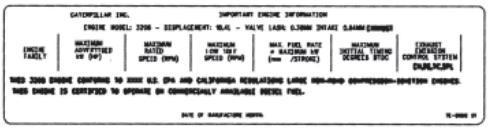
Total Cooling System Capacity: _____

Air Cleaner Element Number: _____

Fan Drive Belt Number: _____

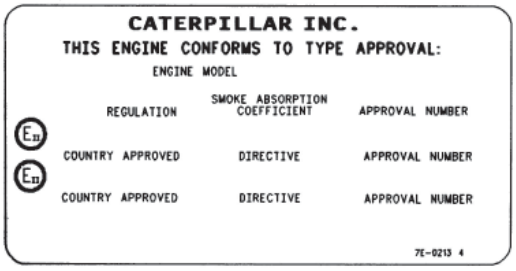
Alternator Belt Number: _____

5-1.5.5 Emissions Certification Film



EPA Emissions Certification Film

The EPA Emissions Certification Film (if equipped) and/or the European Emissions Certification Film (if equipped) is located on the side of the engine.



European Emissions Certification Film

5-1.5.6 Customer Specified Parameters

To record programmed specifications, use the following chart.

Customer Passwords

- "Customer Password #1" _____
- "Customer Password #2" _____

Selected Engine Rating

- "Rating Number" _____
- "Rating Type" _____
- "Multi-Torque Ratio" _____
- "Advertised Power" _____
- "Governed Speed" _____
- "Rated Peak Torque" _____
- "Top Engine Speed" _____
- "Test Spec" _____
- "Test Spec with Brake Saver" _____

ECM Identification Parameters

- "Vehicle ID" _____
- "Engine Serial Number" _____
- "ECM Serial Number" _____
- "Personality Part Number" _____
- "Personality Module Release Date" _____

Security Parameters

- "Total Tattletale" _____
- "Last Tool to Change Customer Parameters" _____
- "Last Tool to Change System Parameters" _____
- "ECM Wireless Communications Enable" _____

Customer Specified Parameters - Continued

Vehicle Speed Parameters

- "Vehicle Speed Calibration" _____ pulses per km or pulses per mile
- "Vehicle Speed Limit" _____ km per hr or miles per hr
- "Vehicle Speed Limit Protection" _____
- "Tachometer Calibration" _____ pulses per revolution
- "Soft Vehicle Speed Limit" _____
- "Low Speed Range Axle Ratio" _____
- "High Speed Range Axle Ratio" _____
- "Vehicle Speed Cal (J1939-Trans)" _____
- "Vehicle Speed Cal (J1939-ABS)" _____

Cruise Control Parameters

- "Low Cruise Control Speed Set Limit" _____ km per hr or miles per hr
- "High Cruise Control Speed Set Limit" _____ km per hr or miles per hr
- "Engine Retarder MODE" _____
- "Engine Retarder Minimum VSL Type" _____
- "Engine Retarder Minimum Vehicle Speed" _____
- "Auto Retarder in Cruise" _____
- "Auto Retarder in Cruise Increment" _____
- "Cruise/Idle/PTO Switch Configuration" _____
- "Soft Cruise Control" _____
- "Adaptive Cruise Control Enable" _____

Idle Parameters

- "Idle Vehicle Speed Limit" _____ km per hr or miles per hr
- "Idle RPM Limit" _____
- "Idle/PTO Engine Speed Ramp Rate" _____ rpm/sec
- "Idle/PTO Bump RPM" _____

PTO Parameters

- "PTO Configuration" _____
- "PTO Top Engine Limit" _____
- "PTO Engine RPM Set Speed" _____

Customer Specified Parameters - Continued

- "PTO to Set Speed" _____
- "PTO Cab Controls RPM Limit" _____
- "PTO Kickout Vehicle Speed Limit" _____
- "Torque Limit" _____N • m or lb ft
- "PTO Shutdown Time" _____
- "PTO Activation of Cooling Fan (If Equipped)" _____
- "PTO Engine RPM Set Speed" _____
- "PTO Engine RPM Set Speed A" _____
- "PTO Engine RPM Set Speed B" _____
- "Maximum PTO Enable Speed" _____
- "PTO Shutdown Timer Maximum RPM" _____

"Engine/Gear Parameters"

- "Lower Gears Engine RPM Limit" _____
- "Lower Gears Turn Off Speed" _____km per hr or miles per hr
- "Intermediate Gears Engine RPM Limit" _____
- "Intermediate Gears Turn Off Speed" _____km per hr or miles per hr
- "Gear Down Protection RPM Limit" _____
- "Gear Down Protection Turn On Speed" _____km per hr or miles per hr
- "Top Engine Limit" _____
- "Top Engine Limit with Droop" _____
- "Low Idle Engine RPM" _____
- "Transmission Style" _____
- "Eaton Top 2 Override with Cruise Switch" _____
- "Top Gear Ratio" _____
- "Top Gear Minus One Ratio" _____
- "Top Gear Minus Two Ratio" _____
- "Governor Type" _____

Smart Idle Parameters

- "Battery Monitor and Engine Control Voltage" _____

Customer Specified Parameters - Continued

Timer Parameters

- "Idle Shutdown Time" _____
- "Idle Shutdown Timer Maximum RPM" _____
- "Idle Shutdown Override Allowance" _____
- "Minimum Idle Shutdown Outside Temp" _____
- "Maximum Idle Shutdown Outside Temp" _____
- "A/C Pressure Switch Fan On - Time (If Equipped)" _____
- "Fan with Engine Retarder in High Mode (If Equipped)" _____
- "Engine Retarder Delay" _____

Engine Monitoring Mode

- "Warning" _____
- "Warning/Derate" _____
- "Warning/Derate/Shutdown" _____
- "Engine Monitoring Lamps" _____
- "Coolant Level Sensor Type" (If Equipped) _____
- "Coolant Temperature Derate" _____

Maintenance Indicator Parameters

- "Maintenance Indicator Mode" _____
- "PM 1 Interval" _____
- "Engine Oil Capacity" _____

Dash Display Access Parameters

- "Fuel Correction Factors" _____
- "Dash - Change Fuel Correction Factor" _____
- "Dash - PM1 Reset" _____
- "Dash - Fleet Trip Reset" _____
- "Dash - State Selection" _____
- "Theft Deterrent System Control" _____
- "Theft Deterrent Password" _____
- "Quick Stop Rate" _____
- "Vehicle Overspeed Threshold" _____

Customer Specified Parameters - Continued

Vehicle Activity Report

- "Minimum Idle Time" _____

Driver Reward

- "Driver Reward Enable" _____

Data Link Parameters

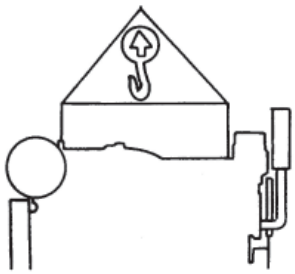
- "Powertrain Data Link" _____

5-1.6 Operation

5-1.6.1 Engine Lifting

NOTICE: Never bend the eyebolts and the brackets. Only load the eyebolts and the brackets under tension. Remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees.

When it is necessary to remove a component at an angle, only use a link bracket that is properly rated for the weight.



Use a hoist to remove heavy components. Use an adjustable lifting beam to lift the engine. All supporting members (chains and cables) should be parallel to each other. The chains and cables should be perpendicular to the top of the object that is being lifted.

Some removals require lifting the fixtures in order to obtain proper balance and safety.

To remove the engine ONLY, use the lifting eyes that are on the engine. If the lifting eyes are missing, consult a Caterpillar dealer for the proper lifting eyes and bolts.

Lifting eyes are designed for the specific engine arrangement. These lifting eyes are installed when the engine is manufactured. Alterations to the lifting eyes and/or the engine make the lifting eyes and the lifting fixtures obsolete. If alterations are made, ensure that proper lifting devices are provided. Consult your Caterpillar dealer for information regarding fixtures for proper engine lifting.

5-1.6.2 Engine Storage

If the engine will not be started for several weeks, the lubricating oil will drain from the cylinder walls and from the piston rings. Rust can form on the cylinder liner surface. Rust on the cylinder liner surface will cause increased engine wear and a reduction in engine service life.

To help prevent excessive engine wear, use the following guidelines:

- Complete all of the lubrication recommendations that are listed in the "*Maintenance Interval Schedule*" (Maintenance Section) of this manual.
- If freezing temperatures are expected, check the cooling system for adequate protection against freezing. See the "*General Coolant Information*" found in this manual for more information.

If an engine is out of operation and if use of the engine is not planned, special precautions should be made. If the engine will be stored for more than one month, a complete protection procedure is recommended.

Your Caterpillar dealer can assist in preparing the engine for extended storage periods.

5-1.6.3 Gauges and Indicators

The engine may not have the same gauges or all of the gauges that are described. For descriptions of the gauges that are supplied with this engine, see *2_1 Dash and Monitors* section found earlier in this manual.

Gauges provide indications of engine performance. Ensure that the gauges are in good working order. Determine the normal operating range by observing the gauges over a period of time.

Noticeable changes in gauge readings indicate potential gauge or engine problems. Problems may also be indicated by gauge readings that change even if the readings are within specifications. Determine the cause of any significant change in the readings. Then, correct any cause of any significant change in the readings. Consult your Caterpillar dealer for assistance.

Electronically controlled engines require one lamp in addition to the gauge package that is normally provided.

The “Diagnostic” lamp is yellow or amber. The “Diagnostic” lamp will communicate the status of the engine’s electronic system.

An optional “Warning” lamp is available. This red “Warning” lamp warns the operator of engine problems.

The following conditions are some examples of the problems:

- Low oil pressure
- High coolant temperature
- Low coolant level
- High inlet air temperature

Engine Oil Pressure - Typical oil pressure for an engine at rated speed with SAE 10W30 or with SAE 15W40 is 207 to 310 kPa (30 to 45 psi) for the C-10 and the C-12. Typical oil pressure for an engine at rated speed with SAE 10W30 or with SAE 15W40 is 276 to 606 kPa (40 to 88 psi) for the 3406E, C-15, and C-16.

A higher oil pressure is normal with cold oil when the engine is started. A lower oil pressure is normal at low idle. If the load is stable and the gauge reading changes, perform the following procedure:

1. Remove the load.
2. Reduce engine speed at low idle.
3. Check the oil level. Maintain the oil level at the proper amount.

The diagnostic lamp will turn on if the oil pressure drops below 35 kPa (5 psi) at low idle rpm. The diagnostic code will be logged in the Engine Control Module (ECM).

Engine Oil Temperature - This gauge indicates the engine oil temperature. An oil temperature that is higher than normal indicates a heat problem in the lubrication system and/or the cooling system. This problem can damage the cylinder heads, the cylinder liners, the pistons, and the crankshaft bearings.

Jacket Water Coolant Temperature - Typical temperature range is 87 to 98 °C (189 to 208 °F). The maximum allowable temperature with the pressurized cooling system is 102 °C (216 °F) for the C-10 and the C-12, for C-13 104 °C (220 °F).

The maximum allowable temperature with the pressurized cooling system is 107 °C (225 °F) for the 3406E, C-15, and C-16. Higher temperatures may occur under certain conditions. The water temperature reading may vary according to load. The reading should never exceed the boiling point for the pressurized system that is being used.

If the engine is operating above the normal range and steam becomes apparent, perform the following procedure:

1. Reduce the load and the engine rpm.
2. Inspect the cooling system for leaks.
3. Determine if the engine must be shut down immediately or if the engine can be cooled by reducing the load.

NOTICE: Do not exceed 2300 rpm in any situation or 2100 rpm if equipped with an auxiliary engine brake system.

Tachometer - This gauge indicates engine speed. The engine can be operated at high idle without damage, but the engine should not be allowed to overspeed. The engine can overspeed by downshifting or by going downhill. An overspeed can result in serious damage to the engine.

NOTE: The high idle rpm and the full load rpm are stamped on the Information Plate.

Ammeter - This gauge indicates the amount of charge or discharge in the battery charging circuit. Operation of the indicator should be to the right side of "0" (zero). The charging system should be checked for a malfunction if the indicator is constantly to the left side of "0" (zero) or if the indicator shows an excessive charge during normal operation. Correct any problems.

Service Hour Meter - This gauge indicates the total number of clock hours that the engine has operated. Hours of operation are logged in the ECM. A service tool is needed to retrieve the hours from the ECM. A Service Hour Meter may be installed on the engine.

Fuel Pressure - This gauge indicates fuel pressure to the electronic unit injectors from the fuel filter. The indicator should indicate the "NORMAL" range. A decrease in fuel pressure usually indicates a plugged fuel filter.

Fuel Level - This gauge indicates the level of fuel in the fuel tank. The fuel level gauge registers the fuel level only when the ignition switch is in the ON position.

5-1.7 Features and Controls

5-1.7.1 Monitoring System

WARNING!! If the Shutdown mode has been selected and the warning indicator activates, engine shutdown may take as little as 20 seconds from the time the warning indicator is activated. Depending on the application, special precautions should be taken to avoid personal injury. The engine can be restarted following shutdown for emergency maneuvers, if necessary.

NOTICE: The Engine Monitoring System is not a guarantee against catastrophic failures. Programmed delays and moderate schedules are designed to minimize false alarms and provide time for the operator to stop the engine.

Programmable features monitor the following conditions:

- Coolant temperature
- Oil pressure
- Inlet manifold air temperature
- Cooling system level (if equipped)

5-1.7.2 Coolant Level Sensor (If Equipped)

NOTICE: The coolant level sensor is an optional feature.

The system can be programmed with one of the following options:

ENABLED - The system will monitor the input from the coolant level sensor. The system is programmed to this value when the engine is shipped by Caterpillar.

DISABLED - The system will not monitor the input from the coolant level sensor.

5-1.7.3 Programmable Options and Systems Operation

WARNING!! If the Warning/Derate/Shutdown mode has been selected and the warning indicator activates, bring the engine to a stop whenever possible. Depending on the application, special precautions should be taken to avoid personal injury.

The engine can be programmed to the following modes:

- "OFF"
- "Warning"
- "Warning/Derate"
- "Warning/Derate/Shutdown"

"Warning"

The "DIAGNOSTIC" lamp and the warning signal (red lamp or buzzer) turn "ON" and the warning signal is activated continuously in order to alert the operator that one or more of the engine parameters is not within normal operating range.

"Warning/Derate"

The "DIAGNOSTIC" lamp turns "ON" and the warning signal (red lamp or buzzer) is activated. After the warning, the engine will derate rpm and power. The warning lamp will begin to flash when the derating occurs.

When the engine is fully derated, the engine power is limited to 120 kW (160 hp). During a low oil pressure condition, the engine can be limited to 1350 rpm.

"Warning/Derate/Shutdown"

The "DIAGNOSTIC" lamp turns "ON" and the warning signal (red lamp or buzzer) is activated. After the warning, the engine will derate rpm and power. The engine will continue to derate rpm until a shutdown of the engine occurs. The engine can be restarted after a shutdown for use in an emergency.

A shutdown of the engine may occur in as little as 20 seconds. The engine can be restarted after a shutdown for use in an emergency. However, the cause of the initial shutdown may still exist. The engine may shut down again in as little as 20 seconds.

If there is a signal for coolant loss, there will be a 10 second delay in order to verify the condition. The system will derate the engine rpm for 40 seconds before the engine will shut down if the engine has been programmed to shut down.

If there is a signal for low oil pressure or for coolant temperature, there will be a two second delay in order to verify the condition. The system will derate the engine rpm for 30 seconds before the engine will shut down if the engine has been programmed to shutdown.

For more information or assistance for repairs, consult your Caterpillar dealer.

NOTE: The Customer Specified Parameters may be secured by customer passwords. The engine may have all of the parameters that are programmed or any combination of the parameters that are programmed. Refer to *"Customer Specified Parameters"* section in this manual for more information on the programmed parameters of the engine. Refer to the *Electronic Troubleshooting* for more information.

5-1.7.4 Cold Start Strategy

These engines use a cold start strategy that limits power until the coolant temperature reaches 28°C (82°F). This cold start strategy is called cold mode. The electronic system will automatically idle the C13 engine at 800 RPM. Cold mode will also vary the fuel injection amount, the timing for the maximum start-up, and the timing for the control of white smoke. Cold mode will provide reduced emissions and reduced warm-up times. Cold mode will be disabled and the engine rpm will drop to the programmed low idle speed if the throttle, the service brake, or the clutch is depressed.

The engine should be operated at low rpm and low power demand until the engine reaches normal operating temperature. The engine will reach normal operating temperature faster when the engine is operated at low rpm and low power demand instead of idling the engine until the engine reaches normal operating temperature.

NOTICE: A coach should not be moved until it is out of the cold mode. If the coach is operated while in cold mode, power will be noticeably reduced.

5-1.8 Engine Diagnostics

5-1.8.1 Self-Diagnostics

Caterpillar Electronic Engines have the capability to perform a self-diagnostics test. When the system detects an active problem, the “DIAGNOSTIC” lamp is activated. Diagnostic codes will be stored in permanent memory in the Electronic Control Module (ECM). The diagnostic codes can be retrieved by using the following components:

- Caterpillar electronic service tools
- “DIAGNOSTIC” lamp

NOTICE: The “DIAGNOSTIC” lamp must be installed by the OEM or by the customer.

Some installations have electronic displays that provide direct readouts of the engine diagnostic codes.

Active codes represent problems that currently exist. These problems should be investigated first. If a code is active, the “DIAGNOSTIC” lamp will flash the flash code at five second intervals.

Logged codes represent the following items:

- Intermittent problems
- Recorded events
- Performance history

The problems may have been repaired since the logging of the code. These codes do not indicate that a repair is needed. The codes are guides or signals when a situation exists. Codes may be helpful to troubleshoot problems.
When the problems have been corrected, the corresponding logged fault codes should be cleared.

5-1.8.2 Diagnostic Lamp

The “DIAGNOSTIC” lamp is used to indicate the existence of a fault by flashing codes. The “DIAGNOSTIC” lamp that is on the dashboard is usually “YELLOW”.

When the ignition switch is first turned on, the “DIAGNOSTIC” lamp will go through the following procedure:

1. The “DIAGNOSTIC” lamp will illuminate for five seconds.
2. The “DIAGNOSTIC” lamp will turn off.

Whenever the Engine Control Module (ECM) detects an active fault or condition the lamp will flash at five second intervals. If the lamp turns on and if the lamp stays on after initial start-up, the ECM has detected a system problem.

The “DIAGNOSTIC” lamp is also used for the Idle Shutdown Timer. The lamp will start to flash at a rapid rate 90 seconds before the programmed idle time expires. The engine will shut down after the 90 second interval. To disable the Idle Shutdown Timer, the “ALLOW IDLE SHUTDOWN OVERRIDE” must be programmed to “YES”. The clutch pedal or the service brake pedal must be depressed during the final 90 seconds while the “YELLOW” lamp is flashing. A diagnostic “EVENT” code or Override of the Idle Shutdown Timer will be logged in the ECM.

5-1.9 Diagnostic Flash Code Retrieval

5-1.9.1 "Diagnostic" Lamp

Use the "DIAGNOSTIC" Lamp or a Caterpillar electronic service tool to determine the diagnostic flash code.

Use the following procedure to retrieve the diagnostic codes if the engine is equipped with a "DIAGNOSTIC" lamp:

1. Turn the cruise control ON/OFF switch to the OFF position.
2. Move the SET/RESUME switch to either position. Hold that position until the "YELLOW" lamp begins to flash.

The "YELLOW" lamp will flash in order to indicate a two digit flash code and the SET/RESUME switch may be released. The sequence of flashes represents the system diagnostic message. Count the first sequence of flashes in order to determine the first digit of the diagnostic code. After a two second pause, the second sequence of flashes will identify the second digit of the diagnostic code.

Any additional diagnostic codes will follow after a pause. The additional diagnostic codes will be displayed in the same manner. Flash Code 55 signals that No Detected Faults have occurred since the ignition key switch has been turned to the ON position.

The electronic diagnostic codes are listed and described in the following Diagnostic Flash Code Chart Table.

NOTE: Diagnostic Flash Code Chart indicates the potential effect on engine performance with "ACTIVE" flash codes.

Some codes record events or some codes indicate that a mechanical system needs attention rather than indicating a performance problem. Troubleshooting is not required for codes "35", "41", "47" and "55". Code "01" will not flash. Some codes will limit the operation or the performance of the engine.

The Diagnostic Flash Code Chart indicates the potential effect on the engine performance with active flash codes. This table also forms a list of Electronic diagnostic codes and descriptions.

Diagnostic Flash Code or Engine Performance Relationship

Diagnostic Flash Code		Effect on Engine Performance (1)				Suggested Acton of the Operator		
		Engine Misfire	Low Power	Reduced Engine Speed	Engine Shutdown	Shut Down the Engine(2)	Service (3)	Schedule for Service ASAP (4)
01	Idle Shutdown Override							
12	Coolant Level Sensor Fault (5)							X
13	Fuel Temperature Sensor Fault							X
14	Retarder Solenoid Fault							X
21	Sensor Supply Voltage Fault (5)(6)		X					X
24	Oil Pressure Sensor Fault(5)							X
25	Boost Pressure Sensor Fault(6)		X					X
26	Barametric Pressure Sensor Fault(6)							X
27	Coolant Temperature Sensor Fault(5)(6)							X
28	Accelerator Pedal Position Out of Calibration							X
29	PTO Throttle Position Sensor Fault			X			X	
31	Loss of Wheel-Based Vehicle Speed Signal			X				X
32	Accelerator Pedal Position Invalid			X			X	
34	Engine RPM Signal Fault	X		X	X		X	
35	Engine Overspeed Warning							
36	Wheel-Based Vehicle Speed Signal Fault			X				X
38	Intake ManifoldAir Temperature Sensor Fault(5)(6)							X

Diagnostic Flash Code or Engine Performance Relationship - Continued								
Diagnostic Flash Code		Effect on Engine Performance (1)				Suggested Acton of the Operator		
		Engine Misfire	Low Power	Reduced Engine Speed	Engine Shutdown	Shut Down the Engine(2)	Service (3)	Schedule for Service ASAP (4)
41	Wheel-Based Vehicle Overspeed Warning							
42	Check Engine Speed Sensor Calibrations		X					X
46	Low Oil Pressure Warning		X	X	X	X	X	
47	Idle or PTO Shutdown Occurrence				X			
51	Intermittent Battery Power to ECM	X	X		X		X	
55	No Detected Faults							
56	Check Customer or System Parameters		X	X				X
	Check Transmission Customer Parameters							
59	Incorrect Engine Software							X
61	High Coolant Temperature Warning		X		X		X	
62	Low Coolant Level Warning		X		X		X	
64	High Intake Manifold Air Temperature Warning							X
65	High Fuel Temperature Warning							X
66	Auxiliary Output #6 Fault							X
67	Auxiliary Output #7 Fault							X
68	Transmission Not Responding							X
69	Malfunction No. 1 Output Fault							X
71	Ignition Key Switch Fault							X
72	Cylinder 1 or 2 Fault	X	X				X	
73	Cylinder 3 or 4 Fault	X	X				X	
74	Cylinder 5 to 6 Fault	X	X				X	
92	Intake Valve Actuator 1 or 2 Fault						X	
93	Intake Valve Actuator 3 or 4 Fault						X	
94	Intake Valve Actuator 5 or 6 Fault						X	
95	Intake Valve Actuation Oil Pressure Voltage Fault							X
97	Intake Valve Actuation System Oil Pressure Solenoid Current Fault							X
98	Engine Coolant Diverter Solenoid Fault							X

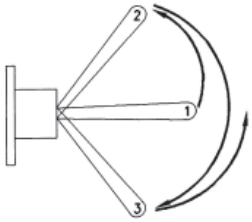
(1) An “X” indicates that the effect on engine performance may occur, if the code is active. This depends on the exact failure.
(2) Shut Down the Engine: Operate the engine cautiously. Get immediate service. Severe engine damage may result.
(3) Service: The operator should go to the nearest qualified service facility.
(4) Schedule Service: When it is convenient for the operator, the problem should be investigated.
(5) When the diagnostic flash code is active, the effectiveness of the Engine Monitoring feature is reduced.
(6) The system may be affected by these Diagnostic Flash Codes, only under specific environmental conditions. This includes engine start-up at cold temperature, cold weather operation at high altitudes, etc.

For further information or assistance for repair, consult an authorized Caterpillar dealer

5-1.10 ECM Snapshot

The ECM can record a snapshot of the engine parameters and vehicle parameters. The snapshot records the parameters for a period of 13 seconds that surrounds the event, 9 seconds before the trigger and 4 seconds after the trigger. A technician can use a service tool in order to view this snapshot information.

5-1.10.1 Triggering Snapshot Information



An operator can aid in the troubleshooting of intermittent problems by taking a “snapshot” when the problem is experienced. A snapshot can be triggered by using the Cruise Control Set/Resume Switch. Use the following procedure in order to perform this function:

1. Toggle the switch quickly from the OFF position (1) to the SET position (2).
2. Toggle the switch quickly from the SET position (2) to the RESUME position (3).
3. Toggle the switch quickly from the RESUME position (3) back to the OFF position (1).

NOTE: The switch must be toggled within a one second time period in order to take a snapshot of the engine parameters. The procedure can also be performed in the reverse order.

5-1.10.2 Storage of Snapshots in the ECM

The ECM can store a maximum of four snapshots that are triggered manually. The newest snapshot will replace the oldest snapshot if a fifth snapshot that is triggered manually is taken.

Snapshots are automatically cleared by the ECM after 100 hours of operation. Also, the snapshots can be cleared manually by using an Electronic Service Tool.

5-1.10.3 Fault Logging

The system provides the capability of Fault Logging. When the Electronic Control Module (ECM) generates an active diagnostic code, the code will be logged in the memory of the ECM. The codes that have been logged in the memory of the ECM can be retrieved with Caterpillar electronic service tools. The codes that have been logged can be cleared with Caterpillar electronic service tools. The codes that have been logged in the memory of the ECM will be automatically cleared from the memory after 100 hours. The following faults can not be cleared from the memory of the ECM without using a factory password: overspeed, low engine oil pressure, and high engine coolant temperature.

5-1.11 Engine Operation with Active Diagnostic Codes

If the diagnostic lamp stays on during normal engine operation, the system has identified a situation that is not within the specification. Use Caterpillar electronic service tools to check the active diagnostic codes.

NOTE: If the customer has selected “DERATE” and if there is a low oil pressure condition, the Electronic Control Module (ECM) will limit the engine power until the problem is corrected. If the oil pressure is within the normal range, the engine may be operated at the rated speed and load. However, maintenance should be performed as soon as possible. Refer to *“Diagnostic Flash Code Retrieval”* section in this manual for more information on flash codes.

The active diagnostic code should be investigated. The cause of the problem should be corrected as soon as possible. If the cause of the active diagnostic code is repaired and there is only one active diagnostic code, the diagnostic lamp will turn off.

Operation of the engine and performance of the engine can be limited as a result of the active diagnostic code that is generated. Acceleration rates may be significantly slower. Refer to this manual for more information on the relationship between these active diagnostic codes and engine performance.

5-1.11.1 Engine Operation with Intermittent Diagnostic Codes

If the diagnostic lamp illuminates during normal engine operation and the diagnostic lamp shuts off, an intermittent fault may have occurred. If a fault has occurred, the fault will be logged into the memory of the Electronic Control Module (ECM).

In most cases, it is not necessary to stop the engine because of an intermittent code. However, the operator should retrieve the logged fault codes and the operator should reference the appropriate information in order to identify the nature of the event. The operator should log any observation that could have caused the lamp to light.

- Low power
- Limits of the engine speed
- Excessive smoke, etc.

This information can be useful to help troubleshoot the situation. The information can also be used for future reference. For more information on diagnostic codes, refer to *Troubleshooting Guide* for this engine.

5-1.11.2 Customer Specified Parameters

Customer specified parameters that will enhance the fuel efficiency and the operator's convenience can be programmed into the Electronic Control Module (ECM). Some parameters may affect engine operation. This may lead to complaints from the operator about power or about performance. Certain engine parameters may be programmed by the customer by using Caterpillar electronic service tools in order to influence the operation of the engine:

The customer specified parameters can be changed as often as needed. Password protection is provided so that the customer can change the parameters. The customer can authorize someone else to change the parameters. Ensure that a record of the parameters is kept in this manual in the "*Customer Specified Parameters*" section. For detailed instructions on programming the engine for optimum performance and for optimum fuel economy, consult your Caterpillar dealer.

5-1.12 Engine Starting

WARNING!! Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

5-1.12.1 Under-the-Hood Inspection

Perform the required daily maintenance and other periodic maintenance before the engine is started. Inspect the engine compartment. This inspection can help prevent major repairs at a later date. Refer to the *"Walk-Around Inspection"* section in this manual for more information.

- For the maximum service life of the engine, make a thorough inspection before starting the engine. Look for the following items: oil leaks, coolant leaks, loose bolts, and trash buildup. Remove trash buildup and arrange for repairs, as needed.
- Inspect the cooling system hoses for cracks and for loose clamps.
- Inspect the alternator and accessory drive belts for cracks, breaks, and other damage.
- Inspect the wiring for loose connections and for worn wires or frayed wires.
- Check the fuel supply. Drain water from the water separator (if equipped). Open the fuel supply valve.
- Do not start the engine or move any of the controls if there is a "DO NOT OPERATE" warning tag or similar warning tag attached to the start switch or to the controls.
- Ensure that the areas around the rotating parts are clear.
- All of the guards must be put in place. Check for damaged guards or for missing guards. Repair any damaged guards. Replace damaged guards and/or missing guards.
- Disconnect any battery chargers that are not protected against the high current drain that is created when the electric starting motor (if equipped) is engaged. Check electrical cables and check the battery for poor connections and for corrosion.

- Reset all of the shutoffs or alarm components.
- Check the engine lubrication oil level. Maintain the oil level between the “ADD” mark and the “FULL” mark on the oil level gauge.
- Check the coolant level. Observe the coolant level in the coolant recovery tank (if equipped). Maintain the coolant level to the “FULL” mark on the coolant recovery tank.
- If the engine is not equipped with a coolant recovery tank maintain the coolant level within 13 mm (.5 inch) of the bottom of the filler pipe.
- Observe the air cleaner service indicator (if equipped). Service the air cleaner when the yellow diaphragm enters the red zone, or when the red piston locks in the visible position.
- Ensure that any driven equipment has been disengaged. Remove any electrical loads.

5-1.12.1 Cold Weather Starting

Starting the engine and operation in cold weather is dependent on the type of fuel that is used, the oil viscosity, and other optional starting aids. For more information see *“Cold Weather Operation”* section in this manual.

5-1-12.2 Starting the Engine

WARNING!! DO NOT USE ETHER (starting fluids) unless specifically instructed to do so. The use could result in engine damage and/or personal injury.

When using starting fluid, follow the manufacturer’s instructions carefully. Use starting fluid sparingly and spray it ONLY WHILE CRANKING THE ENGINE. Excessive ether can cause piston and ring damage. Use ether for cold weather starting purposes only.

Use the following procedure in order to start the engine:

1. Engage the parking brake. Place the transmission in NEUTRAL.
2. Turn the ignition key switch to the ON position. The “CHECK ENGINE/DIAGNOSTIC” lamp will illuminate for 5 seconds when the ignition key switch is first turned on. If the lamp fails to illuminate, notify your authorized Caterpillar dealer. If the lamp continues to stay on, the ECM has detected a problem in the system. Refer to “*Engine Diagnostics*” in this manual.

NOTICE: Do not engage the starting motor when flywheel is turning. Do not start the engine under load.

If the engine fails to start within 30 seconds, release the starter switch or button and wait two minutes to allow the starting motor to cool before attempting to start the engine again.

3. Turn the ignition key switch to the START position in order to crank the engine. Do not push the throttle or hold the throttle downward while the engine is cranked. The system will automatically provide the correct amount of fuel in order to start the engine. If the engine does not start after 30 seconds of cranking, release the ignition key switch. Turn the ignition key switch to the OFF position. Allow the starting motor to cool for two minutes. Repeat Steps 2 and 3.

NOTICE: Oil pressure should rise within 15 seconds after the engine starts. Do not increase engine speed until the oil pressure gauge indicates normal. If oil pressure is not indicated in the gauge within 15 seconds. DO NOT operate the engine. STOP the engine, investigate and correct the cause.

4. Release the ignition key switch to the ON or RUN position immediately after the engine starts. After the engine starts, ensure that the transmission is still in the NEUTRAL position and release the clutch pedal (manual transmission). Once a normal engine oil and air pressure is reached, the vehicle may be operated at a light load and low speed.

5-1.12.3 Starting Problems

An occasional starting problem may be caused by one of the following items:

- Low battery charge
- Lack of fuel
- Problem with the wiring harness

If the engine fuel system has been run dry, fill the fuel tank and prime the fuel system. Refer to *"Fuel System - Prime"* in this manual.

If the other problems are suspected, perform the appropriate procedure in order to start the engine.

5-1.12.4 Problems with the Wiring Harness

Locate the ECM. Two harness connectors are attached to the ECM. The left connector is the engine harness and the right connector is the chassis harness. Check the connectors in order to ensure that the connectors are secure. Lightly pull each of the wires in the chassis harness.

1. Pull each wire with approximately 4.5 kg (10 lb) of force. The wire should remain in the connector.
2. If a wire is loose, push the wire back into the connector. Pull the wire again in order to ensure that the wire is secure.
3. Start the engine. If the engine does not start, consult the nearest Caterpillar dealer for assistance.

5-1.12.5 Starting with Jump Start Cables

WARNING!! Improper jump start cable connections can cause an explosion resulting in personal injury.

Prevent sparks near the batteries. Sparks could cause vapors to explode. Do not allow jump start cable ends to contact each other or the engine.

If the installation is not equipped with a backup battery system, it may be necessary to start the engine from an external electrical source.

First, determine the reason that it is necessary to start with power from an external source.

Many batteries which are considered unusable are still rechargeable. After jump starting, the alternator may not be able to fully recharge batteries that are severely discharged. The batteries must be charged to the proper voltage with a battery charger. For information on charging and testing see your Caterpillar dealer.

NOTICE: Using a battery source with the same voltage as the electric starting motor. Use ONLY equal voltage for jump starting. The use of higher voltage will damage the electrical system.

Do not reverse the battery cables. The alternator can be damaged. Attach ground cable last and remove first. When using an external electrical source to start the engine, turn the engine control switch to the "OFF" position. Turn all electrical accessories OFF before attaching the jump start cables.

Ensure that the main power switch is in the OFF position before attaching the jump start cables to the engine being started.

1. Turn the start switch on the stalled engine to the OFF position. Turn off all accessories.
2. Connect one positive end of the jump start cable to the positive cable terminal of the discharged battery. Connect the other positive end of the jump start cable to the positive cable terminal of the electrical source.
3. Connect one negative end of the jump start cable to the negative cable terminal of the electrical source. Connect the other negative end of the jump start cable to the engine block or to the chassis ground. This procedure helps to prevent potential sparks from igniting combustible gases that are produced by some batteries.
4. Charge the batteries. The engine will not continue to run after starting if the batteries have not been charged.
5. Start the engine.
6. Immediately after the stalled engine is started, disconnect the jump start cables in reverse order.

Refer to the Electrical Schematic for your engine. Consult your Caterpillar dealer for more information.

5-1.13 Engine Operation

5-1.13.1 Engine Operation

Proper operation, driving techniques and maintenance are key factors in obtaining the maximum service life and economy of Caterpillar engines. The recommendations in this manual will help to lower operating costs. For more information see your Caterpillar dealer.

5-1.13.2 Idling

Idle speed is adjustable on Caterpillar electronic engines. Consult your Caterpillar dealer for information. The idle rpm is preset at 600 rpm.

Avoid excess idling. If the vehicle is parked for more than five minutes, stop the engine. An engine can burn from 2.8 L (.7 US gal) to 5.7 L (1.5 US gal) of fuel per hour while the engine is idling. Excessive idling can cause carbon buildup and/or excessive idling can cause the engine to slobber. This is harmful to the engine.

If extended idle time is required, control the engine rpm to 1000 rpm or above 1000 rpm. Ensure that the coolant temperature exceeds 82°C (180°F) Consult your Caterpillar dealer for assistance.

Fast idle can be programmed within the range of 700 rpm to the top engine limit. Fast idle requires an “ON/OFF” switch on the dashboard. Consult your Caterpillar dealer for assistance.

5-1.13.3 Idle Shutdown Timer

The idle shutdown timer can be programmed in order to shut down the engine after a specific time period of idling. The idle time can be programmed from three minutes to 1440 minutes (24 hours). If the idle shutdown timer is set to 0 minutes, the idle shutdown feature is disabled. If the setting of the timer is unknown, allow the engine to idle. Observe the time that elapses before the engine shuts down. The following conditions must be met in order to activate the idle shutdown timer:

- The idle shutdown feature must be selected.
- No vehicle speed is detected by the Electronic Control Module (ECM).
- The engine is not under load.
- The engine is at operating temperature. The engine is not in Cold Mode.

After the vehicle is stationary, the idle shutdown timer begins. The engine can be operating at low idle or at an idle or at an idle rpm that is selected by the idle governor. The “*CHECK ENGINE/DIAGNOSTIC*” lamp will flash rapidly for 90 seconds prior to shutdown. Movement of the vehicles automatically resets the idle shutdown timer to the programmed setting.

The following conditions must be met in order to override the idle shutdown timer:

1. Program the “ALLOW IDLE SHUTDOWN OVERRIDE” to “YES”.
2. The “CHECK ENGINE/DIAGNOSTIC” lamp will flash rapidly for 90 seconds prior to shutdown. Depress the service brake or the clutch pedal during the 90 seconds when the “CHECK ENGINE/DIAGNOSTIC” lamp flashes.

After an idle shutdown, the engine can be restarted without turning the ignition switch to the OFF position.

The override function is disabled if the “ALLOW IDLE SHUTDOWN OVERRIDE” is programmed to “NO”.

5-1.13.4 Cold Mode Operation

Cold mode is initiated if the coolant temperature is below 28°C (82°F). Engine power is decreased until the coolant temperature reaches the above value. In cold mode, the idle is 800 rpm for the C11 and the C13. The strategy for cold mode provides reduced smoke emission and faster warm-up time.

After the cold mode is completed, the engine should be operated at low rpm and low load until normal operating temperature is reached. The engine will reach normal operating temperature faster when the engine is operated at low rpm and low power demand. This method is faster than trying to reach operating temperature by idling with no load.

NOTICE: It is not recommended that the vehicle be moved until the engine is out of cold mode. Power may be noticeably reduced if the vehicle is operated when the engine is in cold mode. At a speed above 8 km/h (5 mph), the low idle speed will be reduced to the customer programmed low idle speed. The power will still be reduced.

Cold mode is disabled if the throttle, the service brake, or the clutch (if equipped) is depressed. The rpm for cold mode operation drops to the programmed low idle speed in order to allow the transmission to be put into gear.

5-1.13.5 Getting Started

Caterpillar electronic engines do not require long warm-up periods that needlessly waste fuel. Typically, the engine should be at normal operating temperature in a few minutes. Begin operating the engine at low load. After normal oil pressure is reached and the temperature gauges begin to rise, the engine may be operated at full load.

To get the vehicle in motion, use a gear that will result in a smooth start. Move the load without increasing the engine rpm above low idle or without slipping the clutch. Engage the clutch smoothly. Slipping the clutch and engaging the clutch can cause stress to occur on the drive train. This can also cause fuel to be wasted.

Use progressive shifting techniques. Progressive shifting is using only the rpm that is required in order to upshift into the next gear. Progressive shifting improves fuel economy.

- Keep the engine rpm to a minimum. Use an rpm that is from 1200 to 1600 rpm.
- Use only enough rpm to pick up the next gear.

Progressive shifting also reduces the acceleration rate. Top gear is reached sooner because less time is needed to synchronize the gears during shifting. In addition, the engine is operating at the highest range of torque.

The amount of rpm that is required to upshift increases as the vehicle speed increases, unless upshifts are made on upgrades. Experience with the vehicle will show the amount of rpm that is required to upshift under various conditions.

NOTE: These engines may be programmed to encourage progressive shifting. The acceleration rate may slow down at certain rpm in lower gears. If this occurs, progressive shift parameters may have been programmed into the ECM. Progressive shift parameters will limit the rpm when the vehicle is driven in higher gears. These parameters are protected by customer passwords. If the vehicle can be operated in a higher gear at a vehicle speed that is desired, select the highest gear that is available to pull the load. This recommendation will help to obtain fuel economy. The engine will be operating at the lowest rpm that is required to pull the load.

5-1.13.6 Vehicle Efficiency

An efficient vehicle performs the desired amount of work while the power demand on the engine is minimized. The following factors are major contributors to power demand:

- Aerodynamic drag (wind resistance)
- Rolling resistance of the tires
- Gross weight of the vehicle
- Losses in the drive train and the load from the engine driven accessories

For more information about vehicle efficiency, consult the Caterpillar website http:///www.caterpillar.com or consult your Caterpillar dealer.

5-1.13.7 Fuel Economy

Fuel is the largest single operating cost of today's on-highway engines. Improved fuel economy can have a substantial impact on operating profit. The following items are the most significant factors that influence vehicle fuel economy:

- Driver techniques
- Vehicle efficiency
- Operating conditions
- Engine efficiency

A No. 1 grade of fuel contains less energy per volume and increases fuel consumption. A greater volume of fuel must be injected in order to yield the same amount of work as a No. 2 fuel. The difference in the fuel economy between the two grades of fuel can be as great as 0.2 km/L (.5 mpg) to 0.3 km/L (.7 mpg).

For more information about fuel economy consult the Caterpillar website at http://www.caterpillar.com or see your Caterpillar dealer.

Rolling hills provide a great opportunity to reduce fuel consumption. Avoid downshifting on small hills. The vehicle should not be downshifted even if the engine must be lugged down to an rpm that is below the peak torque rpm. When the vehicle is going down a hill, use gravity instead of the engine's power to regain vehicle speed.

On grades that require more than one downshift, allow the engine to lug to peak torque rpm. If the engine is running at peak torque rpm or above peak torque rpm and the rpm stabilizes, remain in that gear.

Long steep down grades should be anticipated. Reduce the speed of the vehicles before you crest the top of a hill and before you proceed down a long, steep grade. Minimize the amount of braking that is used in order to maintain a safe speed for maximizing fuel efficiency.

The engine's ability to hold the vehicle back increases with engine rpm. Select a gear that runs the engine near the high engine rpm limit for long steep hills when braking is required.

Speed reductions and future stops should be anticipated. Downshifts should be avoided. The amount of braking should be minimized in order to improve fuel consumption. By coasting to a stop, a vehicle can travel a considerable distance without consuming any fuel.

5-1.13.8 Cruising

Vehicles that are driven faster consume more fuel. Increasing the cruising speed from 88 km/h (55 mph) to 104 km/h (65 mph) will increase the fuel consumption of a typical Class 8 vehicle by approximately 0.4 km/L (1 mpg). When a vehicle is driven fast in order to allow more time for stops, the stops become very expensive. Cruising allows the engine to operate in the most efficient rpm range (1100 to 1500 rpm).

5-1.13.9 Cruise Control

The cruise control function is explained earlier in this manual in *Section 2_1 Instruments and Controls - Dash and Monitor Panels*. Please refer to this section for instructions on use.

5-1.14 Engine Stopping

5-1.14.1 Stopping the Engine

NOTICE: Stopping the engine immediately after it has been working under load can result in overheating and accelerated wear of the engine components.

If the engine has been operating at high rpm and/or high loads, run at low idle for at least three minutes to reduce and stabilize internal engine temperature before stopping the engine.

Avoiding hot engine shutdowns will maximize turbocharger shaft and bearing life.

Prior to stopping an engine that is being operated at low loads, operate the engine at low idle for 30 seconds before stopping. If the engine has been operating at highway speeds and/or at high loads, operate the engine at low idle for at least three minutes. This procedure will cause the internal engine temperature to be reduced and stabilized.

Ensure that the engine stopping procedure is understood. Stop the engine according to the shutoff system on the vehicle.

- To stop the engine, turn the ignition key switch to the OFF position.

5-1.14.2 After Stopping the Engine

- Check the crankcase oil level. Maintain the oil level between the “ADD” mark and the “FULL” mark on the oil level gauge.
- If necessary, perform minor adjustments. Repair any leaks and tighten any loose bolts.
- Note the service hour meter reading. Perform the maintenance that is in the *“Maintenance Interval Schedule”* section of this manual.
- Fill the fuel tank in order to help prevent accumulation of moisture in the fuel. Do not overfill the fuel tank.

NOTICE: Only use antifreeze/coolant mixtures recommended in the *Coolant Specifications* of this manual. Failure to do so can cause engine damage.

- Allow the engine to cool. Check the coolant level. Maintain the cooling system at 13 mm (.5 inch) from the bottom of the pipe for filling.
- If freezing temperatures are expected, check the coolant for proper antifreeze protection. The cooling system must be protected against freezing to the lowest expected outside temperature. Add the proper coolant/water mixture, if necessary.
- Perform all required periodic maintenance on all driven equipment.

5-1.15 Cold Weather Operation

5-1.15.1 Radiator Restrictions

Caterpillar discourages the use of airflow restriction devices that are mounted in front of radiators. Airflow restriction can cause the following conditions:

- High exhaust temperatures
- Power loss
- Excessive fan usage
- Reduction in fuel economy

Shutters can be properly used for parking overnight, very cold temperatures, and high winds. In those particular cases, the coolant temperature and the inlet manifold temperature must be carefully monitored and controlled.

NOTICE: Failure to open the winter fronts in the morning could cause engine damage and/or loss of fuel economy.

5-1.15.2 Fuel and the Effect from Cold Weather

The following fuels are in the grades that are available for Caterpillar engines:

- No. 1
- No. 2
- Blend of No. 1 and No. 2

No. 2 diesel fuel is the most commonly used fuel. Either No. 1 diesel fuel or a blend of No. 1 and No. 2 is best suited for cold weather operation.

Quantities of No. 1 diesel fuel are limited. No. 1 diesel fuels are usually available during the months of the winter in the colder climates. During cold weather operation, if No. 1 diesel fuel is not available, use No. 2 diesel fuel, if necessary.

There are three major differences between No. 1 and No. 2 diesel fuel. No. 1 diesel fuel has the following properties:

- Lower cloud point
- Lower pour point
- Lower rating of BTU per unit volume of fuel

When No. 1 diesel fuel is used, a decrease in power and in fuel efficiency may be noticed. Other operating effects should not be experienced.

The cloud point is the temperature when a cloud of wax crystals begins to form in the fuel. These crystals can cause the fuel filters to plug. The pour point is the temperature when diesel fuel will thicken. The diesel fuel becomes more resistant to flow through fuel pumps and through fuel lines.

Be aware of these values when diesel fuel is purchased. Anticipate the average ambient temperature of the area that the engine will be operated. Engines that are fueled in one climate may not operate well if the engines are moved to another climate. Problems can result due to changes in temperature.

Before troubleshooting for low power or for poor performance in the winter, check the type of fuel that is being used.

When No. 2 diesel fuel is used the following components provide a means of minimizing problems in cold weather:

- Starting aids
- Engine oil pan heaters
- Engine coolant heaters
- Fuel heaters
- Fuel line insulation

5-1.15.3 Fuel Related Components in Cold Weather

Fuel Tanks

Condensation can form in partially filled fuel tanks. Top off the fuel tanks after operating the engine.

Fuel tanks should contain some provision for draining water and sediment from the bottom of the tanks. Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe.

Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Drain the water and sediment from any fuel storage tank at the following intervals:

- Weekly
- Oil Changes
- Refueling of the Fuel Tank

This will help prevent water and/or sediment from being pumped from the fuel storage tank and into the engine fuel tank.

Fuel Filters

A primary fuel filter and/or a water separator is installed between the fuel tank and the engine mounted fuel filter. The primary fuel filter and the fuel supply line are commonly affected by cold fuel. The primary fuel filter is mounted in the engine compartment. The primary fuel filter will benefit from the radiant heat of the engine.

Fuel Heaters

Fuel heaters help to prevent fuel filters from plugging in cold weather due to waxing. If coach is going to be driven extensively in cold weather a fuel heater may want to be considered. If a fuel heater is purchased it should be installed so that the fuel is heated before the fuel enters the primary fuel filter.

To select a fuel heater, contact your Caterpillar dealer.

The following fuel heaters are recommended for use with Caterpillar engines:

- 7C-3557 Fuel Heater Group
- 7C-3558 Heater Kit

Your Caterpillar dealer can give you full information on the benefits of fuel heaters and which type would be best for you.

NOTES:

5-2 Engine Messenger Display System

5-2.1 Introduction

This display is intended to allow the driver to monitor the vehicle and engine information while the vehicle is being operated. The display may also display stored trip information. When possible, the driver should select the proper display screen before operating the vehicle.

CAUTION!! Select the desired display prior to moving the vehicle. Do not manipulate the display while the vehicle is moving. This could divert attention from driving efforts and result in personal injury or equipment damage.

Do not perform any procedure that is outlined in this manual until you have read the information and you understand the information.

5-2.2 Features of Messenger Display

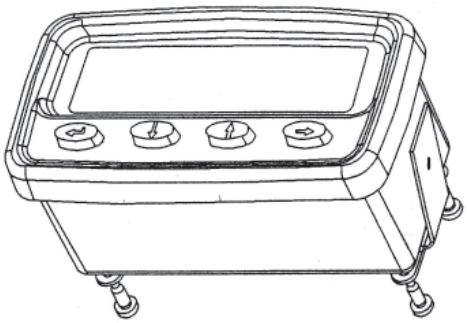


Figure 1 - Messenger Display

The Messenger display may show information for the engine and the vehicle. For detailed operating information, see the *Operation* Section later in this manual. The driver should review the information in this manual prior to driving. Before driving, the driver should review the Messenger Screen Map in order to select the most important information for the trip. This will avoid the entry of data during the operation of the vehicle.

NOTICE: The electronic service tool may be used to make changes to the display. Power to the display must be cycled in order for the changes to be viewed. The display may be used to make changes to options of the display. Changes may be viewed on the screen after the display is returned to the title screen of each column.

5-2.2.1 Engine Operating Information

The Messenger display provides information on cruise control set speed, PTO engine rpm set speed, fuel temperature to the engine, boost and oil pressure, coolant temperature, and intake manifold temperature.

5-2.2.2 Vehicle Trip Information

The Messenger display provides information concerning the quantity of fuel that has been used, the fuel economy, the average vehicle speed, idle time, PTO time, percent idle hour, idle fuel, and PTO fuel. These parameters may relate to trip segments or to the engine history. A Driver and a Fleet Trip Segment is available for the C13 engine. For the Driver Trip Segment, the driver determines the start and stop points. For the Fleet Trip Segment, the vehicle owner determines the start and stop points. The vehicle may be operated in separate states. The Fleet Trip Segment may be tied to each of these states. The Fleet Trip Segment may be split between two drivers and two ID codes.

5-2.2.3 Maintenance Information

The last oil change may be entered. This allows the display to indicate when the next oil change is due.

5-2.2.4 Diagnostic Data

Engine diagnostic codes may be displayed for the driver. The Messenger display will automatically display potentially serious engine problems. When one of these codes appears, the driver should bring the vehicle to a safe stop. After the display of a serious diagnostic code, the engine may shut down within 20 seconds. Refer to the *Diagnostic Codes Chart* for a list of these codes.

5-2.2.5 Theft Deterrent

Messenger provides the capability to allow the engine to start or the capability to prevent the engine from starting. The Messenger display can shut down the engine after entering a password with four characters into the display when the engine is at idle.

5-2.2.6 Fuel Correction Adjustment

Messenger provides the capability to adjust the Fuel Correction Factor of the ECM.

5-2.2.7 Configuration of the Display

Messenger can provide information in either English, French or Spanish. Units of measure can be displayed in English (miles per hour, US gallons, psi, and °F), English (miles per hour, Imperial gallons, psi, and °F), or Metric units (kilometer per hour, liters, kPa, and °C). The French or Spanish manuals may be ordered by contacting a Caterpillar dealer.

Units		
Parameter Identifier	**English Unit Abbreviation**	**Metric Unit Abbreviation**
“Distance”	Miles - MI	Kilometers - KM
“English Speed”	Revolutions per minute - RPM	Revolutions per minute - RPM
“Fuel Economy”	Miles per gallon - MPG	Kilometers per liter (“KPL”) Liters per 100 - KM
“Fuel Quantity”	Gallons (US or Imperial Gallons) - GAL	Liters - LTR
“Fuel Rate”	Gallons Per Hour - GPH	Liters per hour - LPH
“Pressure”	Pounds Per Square Inch - PSI	Kilopascals - kPa
“Speed”	Miles Per Hour - MPH	Kilometers Per Hour - KPH
“Temperature”	Degrees Fahrenheit - F	Degrees Celsius - C
“Time”	Hours - HR	Hours - HR

5-2.2.8 Driver ID Entry

The Messenger display provides the capability to enter the ID of multiple drivers. This allows the ECM to log information for multiple drivers. This is useful in driving applications that involve several drivers.

5-2.2.9 State Crossing

Messenger allows the driver to enter the current state.

5-2.2.10 Access to Parameters

The availability of parameters is determined by the engine manufacturer, the model year of the engine, and the ECM settings for the Customer Programmable Parameters.

Table 2

Parameter Programming by Engine Model	
Engine	**Access**
C13	All 3176B, 3176C, 3406E, C-10, C11, C-12, C13, C15, C-15, and C-16 functions.

5-2.2.11 Display Functions

Functions of Buttons on the Display - Simultaneously pressing and releasing the two center buttons (Down and Up) will cause the display screen to return to the title screen (Instantaneous Data) of the display.

Adjusting the Brightness of the Display - The display will automatically be dimmed when the headlights are turned ON and the display is connected to the lighting circuit. The illumination of the display may be adjusted manually.

1. The contrast may be adjusted by pressing and releasing the Right arrow button and the Left arrow button from the Adjust Contrast screen. The characters may be lightened by pressing and releasing the Left arrow button until the illumination is satisfactory. The background may be darkened by pressing and releasing the Right arrow until the background is satisfactory.
2. The Down arrow button may be used in order to change the backlight. The backlight may be turned off by pressing and releasing the Left arrow button. The backlight may be turned on by pressing and releasing the Right arrow button.
3. The backlight may be adjusted by pressing the Down arrow button. Pressing and releasing the Left arrow button will decrease the backlight. Pressing and releasing the Right arrow button will increase the backlight.

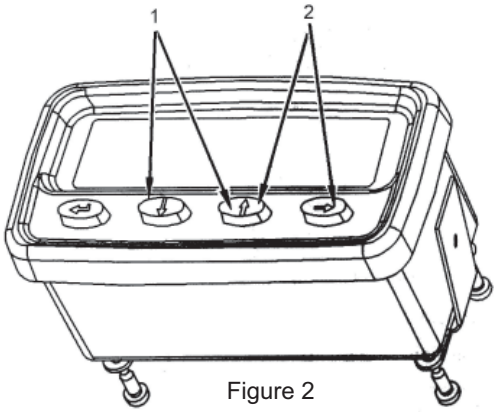


Figure 2

Front view of Messenger display
(1) Home buttons
(2) Display dimming buttons

NOTE: The automatic dim feature will not function if the display has been placed in a manual dim mode. To reactivate the automatic dim feature, turn the power to the display OFF, then back ON.

5-2.2.12 Additional Features

The Messenger display may be mounted in or on the dash.

The display allows an inside view of the engine's operation. The Messenger's display provides information to the driver from the engines Electronic Control Module (ECM) through the J1708 Data Link.

The Messenger screen has a LCD display.

5-2.3 Messenger Display Screen Map

In order to view specific information, a Messenger Display Screen Map is provided in this manual. Arrows are attached to each block of the Screen Map. The arrows indicate the actual arrow buttons that are available with each screen. Pressing an arrow that is not shown will have no effect. The display will remain at the same screen.

The first row of the screen map indicates the title screen for each of the columns on the screen map. The farthest title screen to the right and the "INSTANTANEOUS DATA" title screen in column 1 are adjacent in operation. Pressing the right arrow button from the farthest right title screen moves to the "INSTANTANEOUS DATA" title screen in column 1.

Movement between the columns of information is permitted when the title screen can be viewed. The exception is movement between the "Fleet Trip", "Driver Trip", and "Lifetime Total" columns. These columns are available with 3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, C-16, and 3406E engines.

The Up and Down arrow buttons allow movement up and down through the columns. When the bottom screen of a column is being viewed, press the Down arrow button in order to view the title screen at the top of the column. You cannot press the Up arrow button from the title screen to get the to the bottom screen.

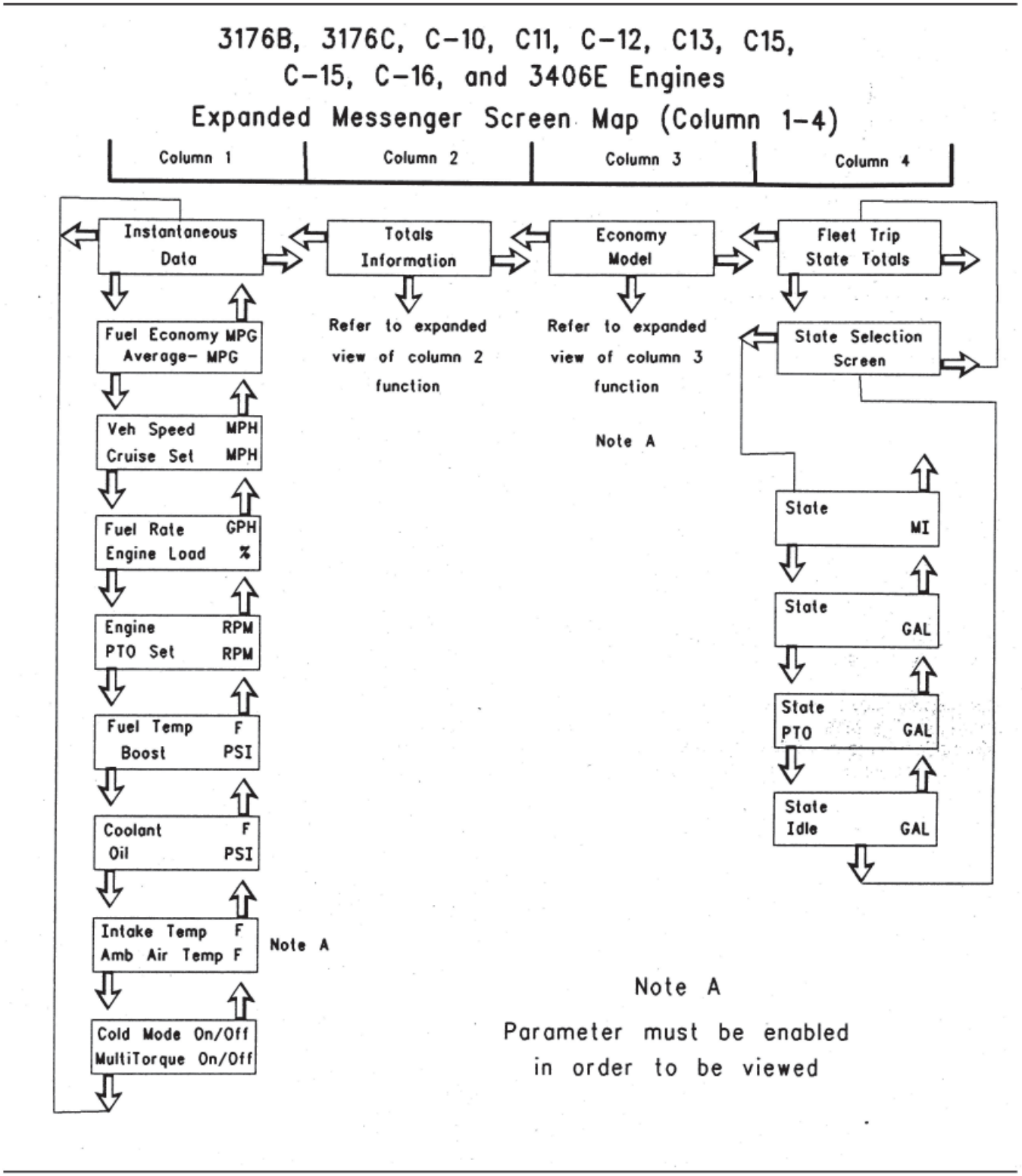


Figure 3 - “Screen maps for the heavy duty truck engine (columns 1-4)”

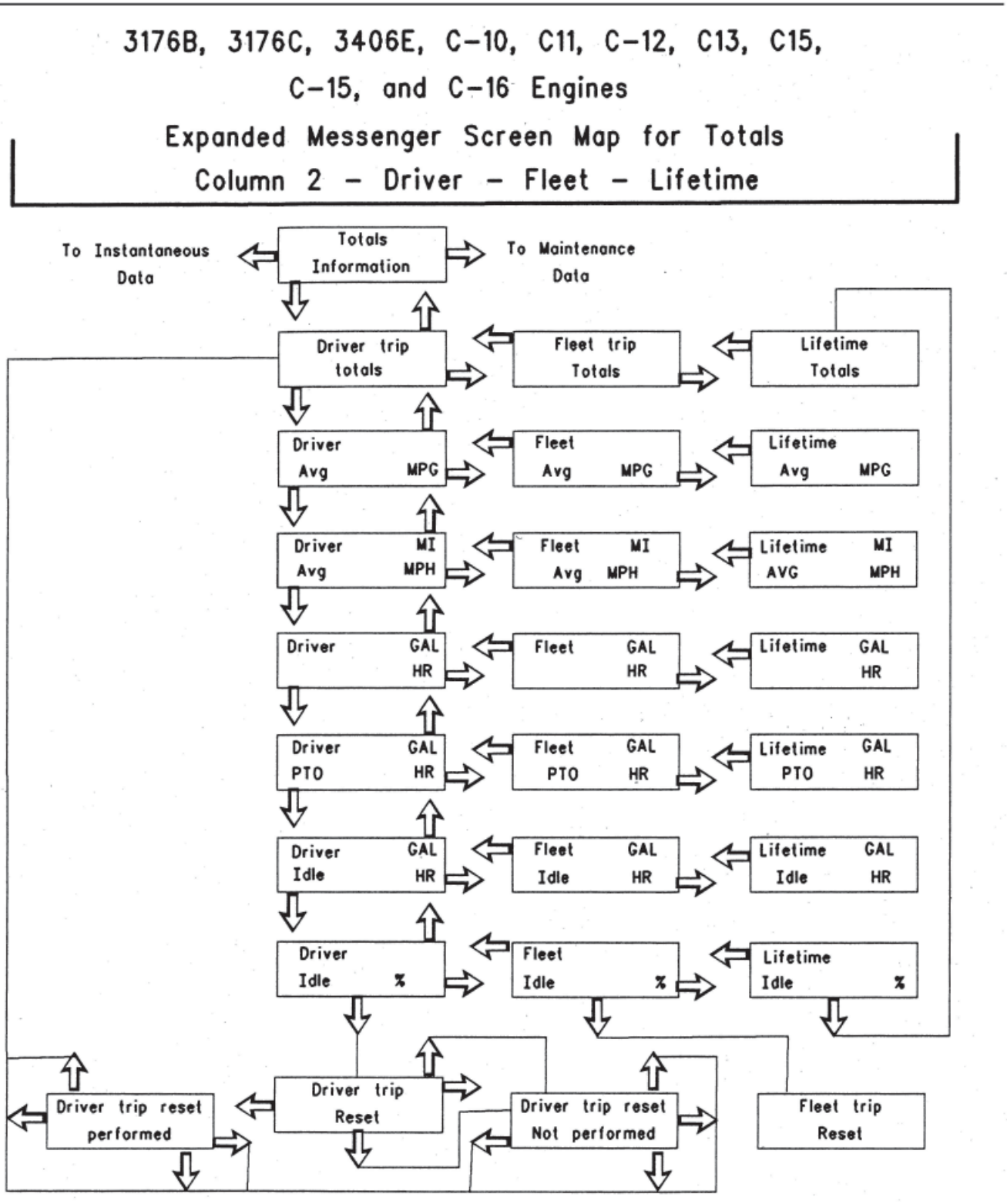


Figure 4 - "Screen map for the heavy duty truck engine (column 2-driver-fleet-lifetime)"

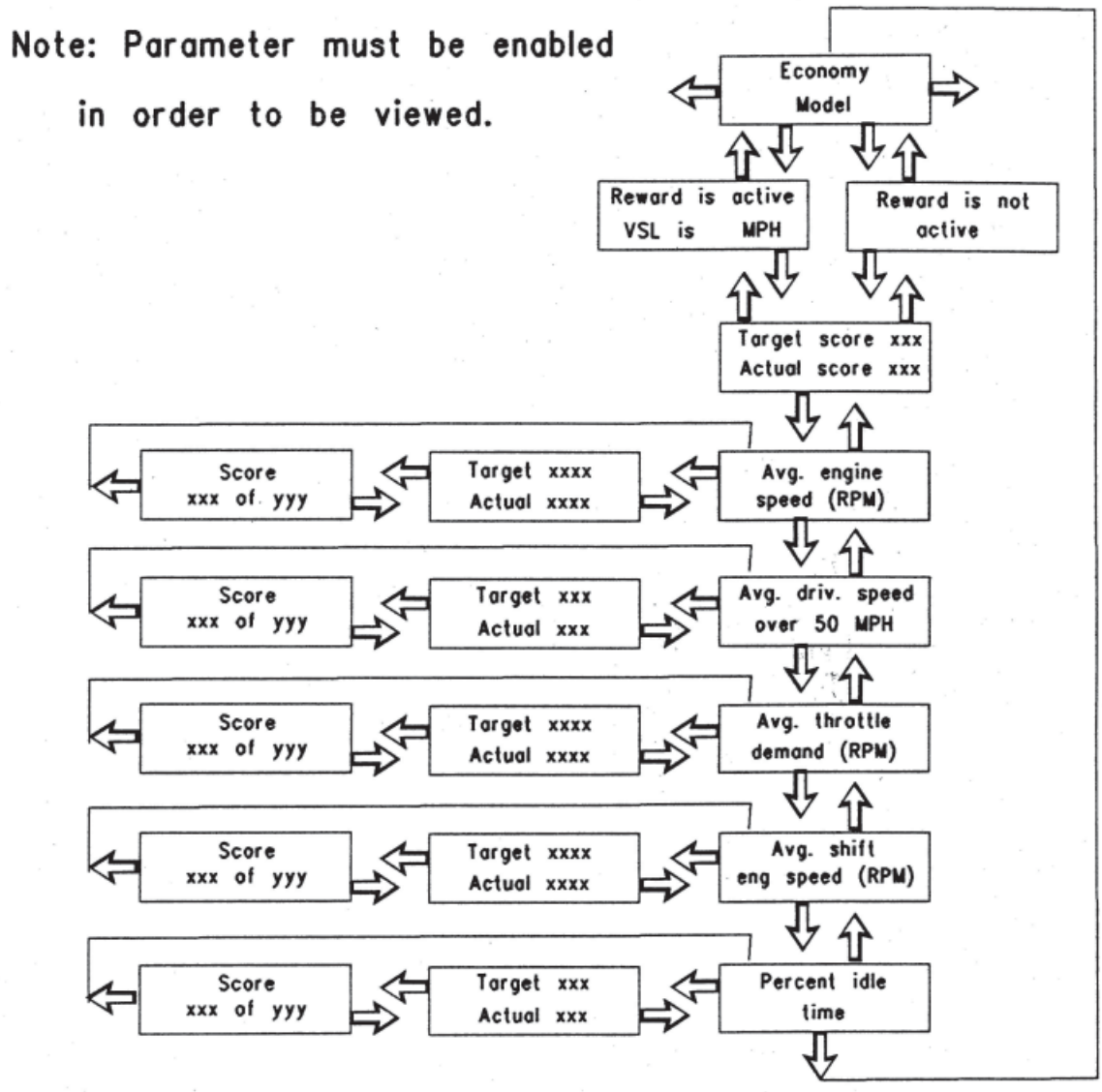


Figure 5 - “Screen map for the heavy duty truck engine screen map (column 3)”

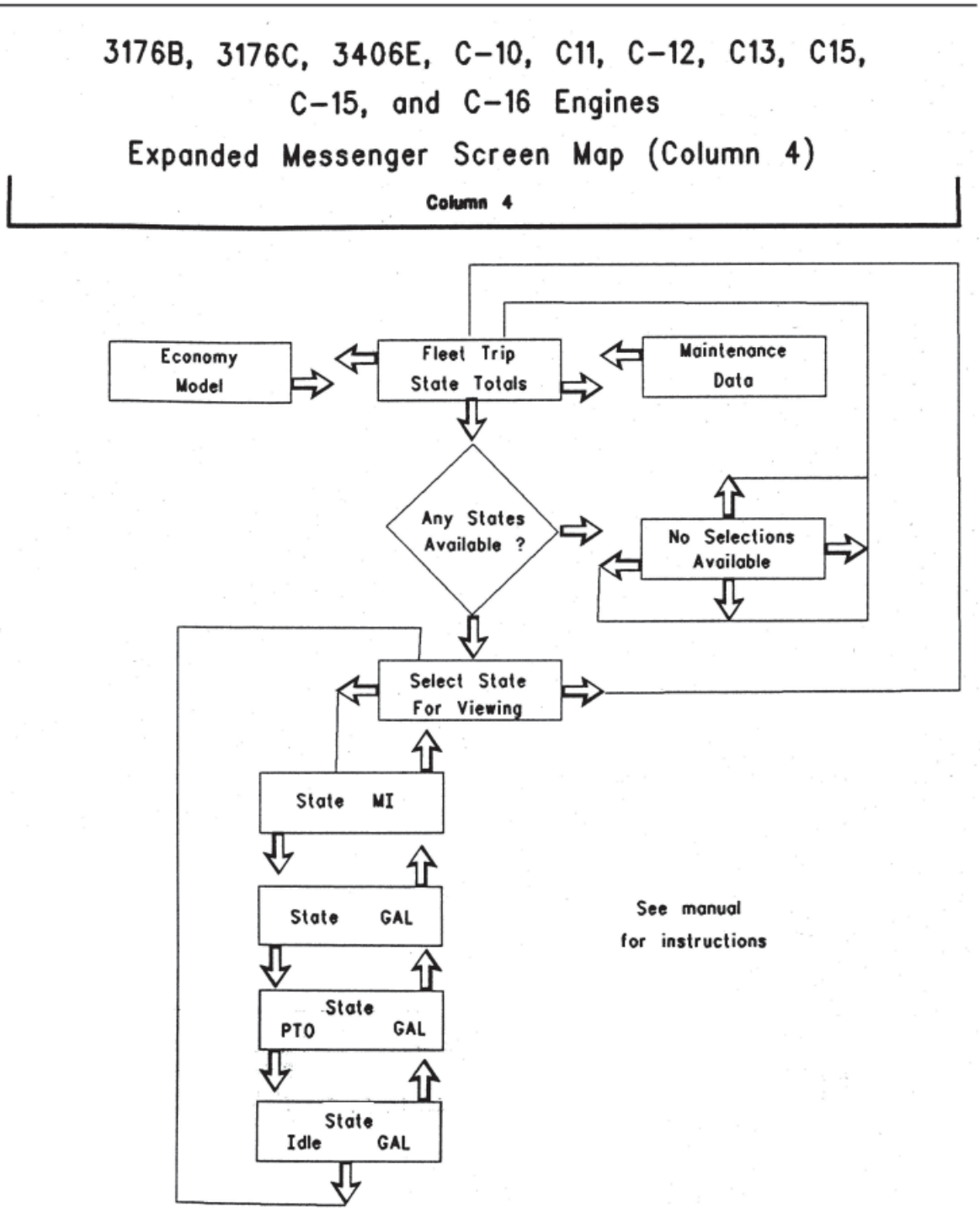


Figure 6 - “Screen map for the heavy duty truck engine (column 4)”

3176B, 3176C, 3406E, C-10, C11, C-12, C13

C15, C-15, and C-16 Engines

Expanded Messenger Screen Map (Column 5)

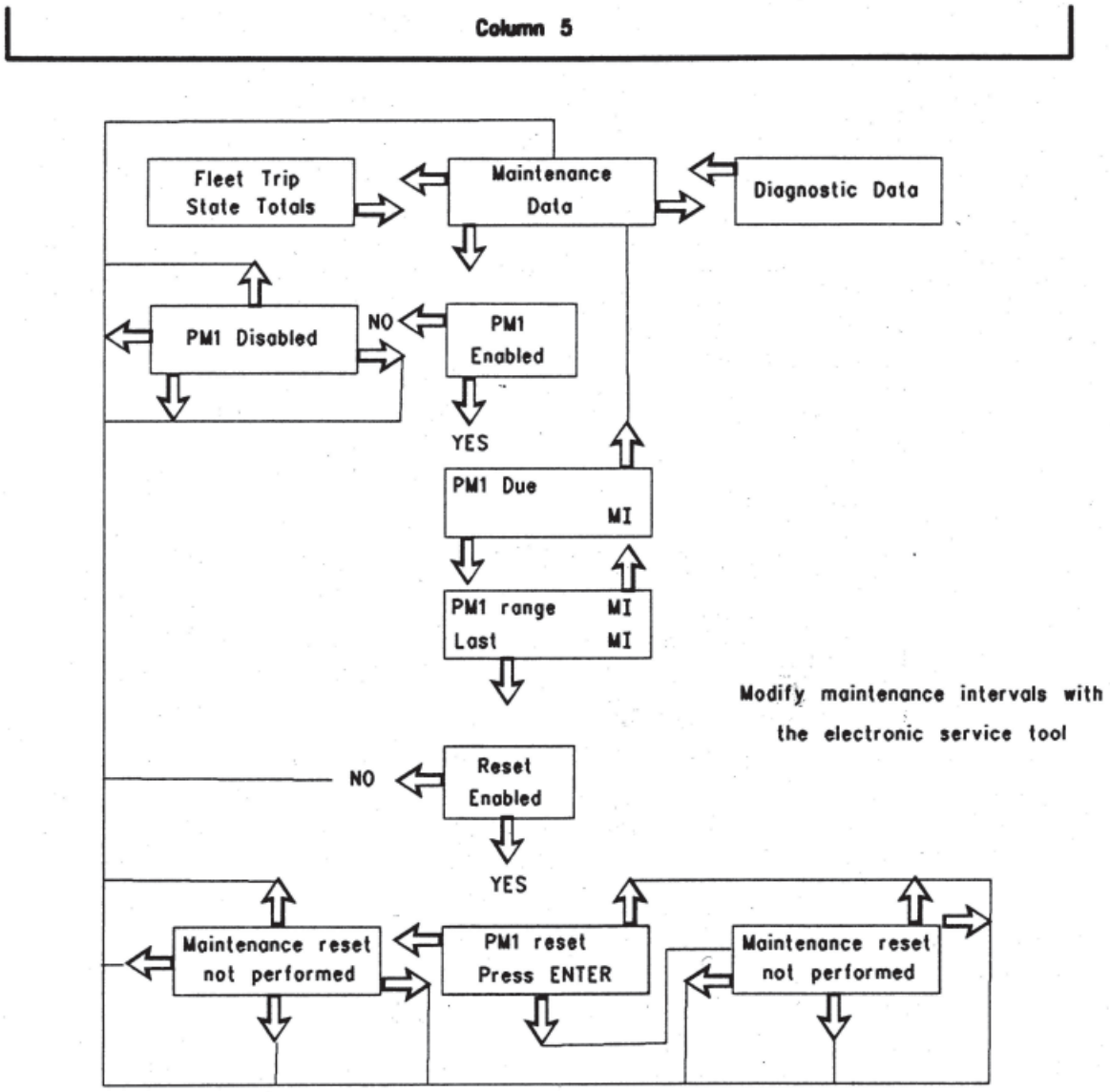


Figure 7 - “Screen map for the heavy duty truck engine (column 5)”

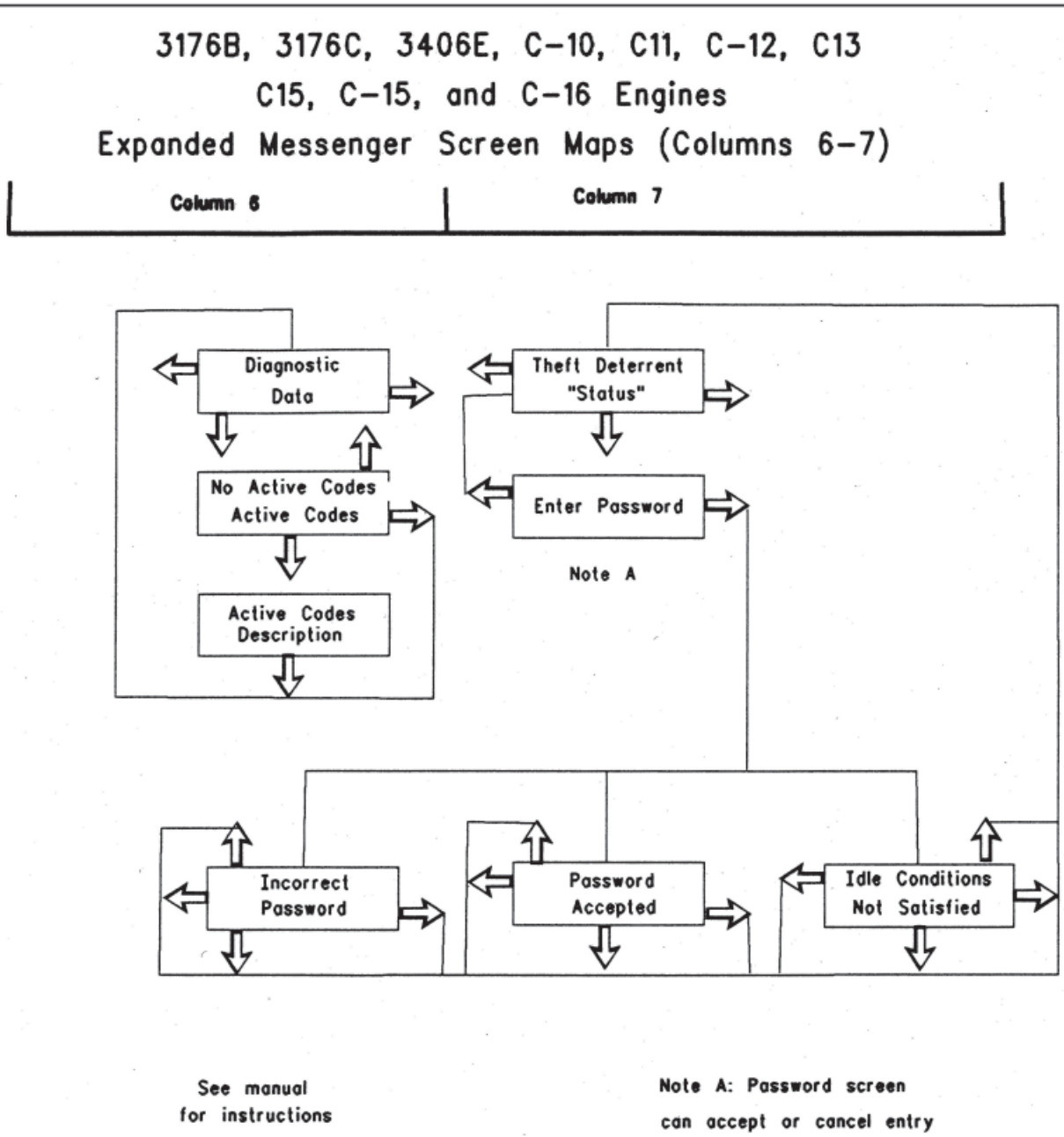


Figure 8 - “Screen maps for the heavy duty truck engine (columns 6-7)”

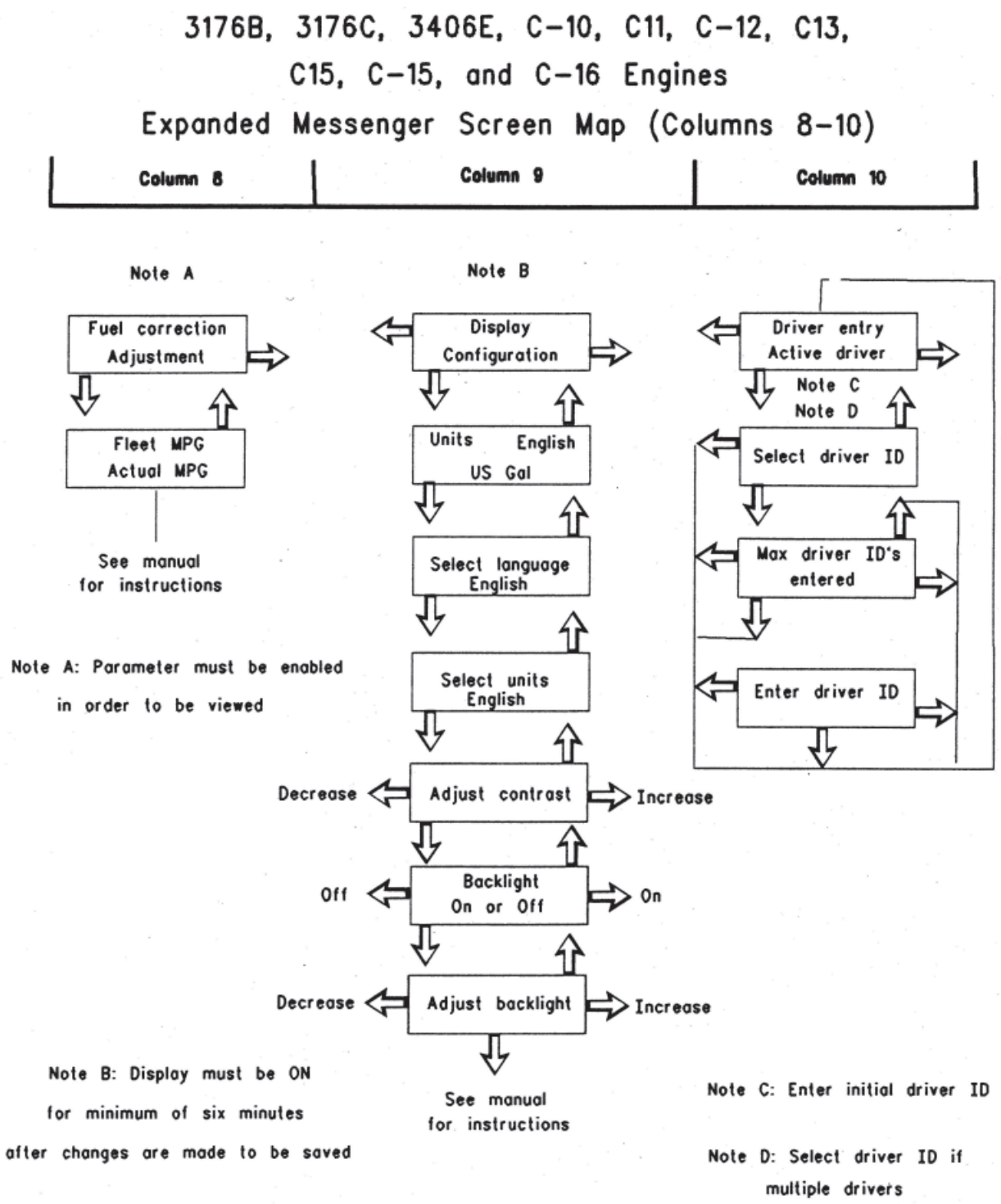


Figure 9 - “Screen maps for the heavy duty truck engine (columns 8-10)”

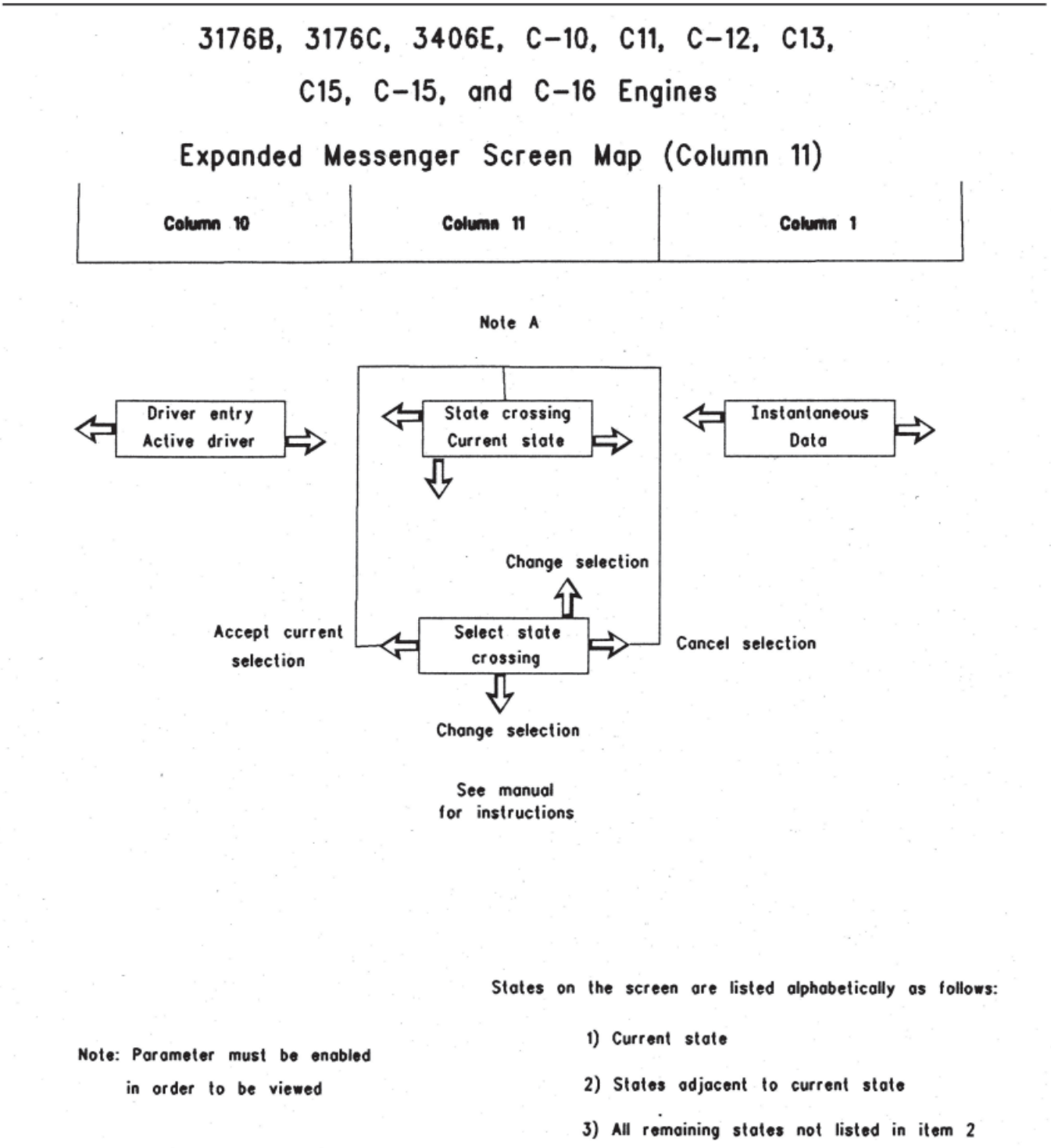


Figure 10 - “Screen maps for the heavy duty truck engine (column 11)”

5-2.4 “Instantaneous Data” Screens

The display can indicate the status of sixteen engine and vehicle operating conditions. The “INSTANTANEOUS DATA” can include “Current Fuel Economy”, “Fleet Trip Segment Fuel Economy”, “Vehicle Speed”, “Cruise Set Speed”, “Fuel Rate”, “Engine Load”, “Engine Speed”, “PTO Set Engine Speed”, “Fuel Temperature Boost Pressure”, “Coolant Temperature”, “Oil Pressure”, “Intake Manifold Temperature”, “Ambient Air Temperature”, “Cold Mode Status”, and “Multi-Torque Status”.

Remember that not all engines support all of the “INSTANTANEOUS DATA” parameters. The parameters that are supported depend on the type of engine. For example, 3126B engines only support 11 of the 16 possible “INSTANTANEOUS DATA” parameters. View the appropriate screen map for the particular engine for a complete listing of “INSTANTANEOUS DATA” parameters.

NOTE: The engine parameters use the EC as the source of information for the display. The Messenger display and the instrument panel gauges may indicate different values. The display may respond differently to changing conditions as the vehicle operates. The readings between the gauges and display may be different. This does not indicate that the components are faulty.

5-2.4.1 “Instantaneous Data” Screens for the 3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, C-16, and 3406E Engines

Table 3

Screen	Parameter	Description
Instantaneous Data	Instantaneous Data Title Screen	– The display will return to this screen at any time during operation by pressing the Down button and Up button at the same time. – Press the Right arrow button in order to move the column of the display to the right. – Press the Left arrow button in order to move the column of the display to the left. – Press the Down arrow button in order to view the “FUEL ECONOMY-MPG/ AVERAGE FUEL ECONOMY-MPG”.
Fuel Economy “MPG” Average MPG	Current Fuel Economy. The Average Fuel Economy of the Fleet Trip Segment	– With a vehicle speed of zero, the fuel economy is zero. – Data is available for 1994 or newer 3176B, 3176C, or 3406E engines only. – Press the Down arrow button to view “VEHICLE SPEED-MPH/CRUISE SET SPEED -MPH”. – Press the Up arrow button to view “INSTANTANEOUS DATA”.
Vehicle Speed MPH Cruise Set Speed MPH	Vehicle Speed Cruise Control Set Speed	– The screen shows the vehicle speed that the ECM is using for cruise control and PTO operation. – The screen shows the current cruise control speed that is set. The value will be zero if a cruise set speed has not been entered. – Press the Up arrow button in order to view “FUEL ECONOMY-MPG/AVERAGE-MPG”. – Press the Down arrow button in order to view “FUEL RATE/ENGINE LOAD”.
Fuel Rate GPH Engine Load %	Instantaneous Fuel Rate Percent Load on the Engine	– The fuel consumption per hour – This is a measure of the load demand on the engine. A higher value indicates that the engine is operating with a heavy load or the vehicle is being driven hard. – Press the Up arrow button in order to view “VEHICLE SPEED/CRUISE SET SPEED”. – Press the Down arrow button in order to view “/ENGINE SPEED/PTO SPEED”.

5-2.4.1 "Instantaneous Data" Screens for the 3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, C-16, and 3406E Engines continued

Table 3 - Continued

Screen	Parameter	Description
Engine RPM PTO Set RPM	Engine Speed PTO Set RPM	– This screen displays the current engine speed and the engine speed is expressed in revolutions per minute (RPM). – This screen displays the engine speed set point while the engine is in PTO operation or extended idle. The value will be zero if a PTO set speed has not been entered. – Press the Up arrow button in order to view "FUEL RATE/ENGINE LOAD". – Press the Down arrow button in order to view "FUEL TEMP/BOOST PRESSURE".
"Fuel Temp" (F) Boost (PSI)	Fuel Temperature Boost Pressure	– Fuel Temperature – Intake Manifold Air Pressure – Press the Up arrow button in order to view "ENGINE RPM/PTO SET". – Press the Down arrow button in order to view "COOLANT TEMP/OIL PSI".
Coolant F Oil PSI	Coolant Temperature Oil Pressure	– Engine coolant temperature – Oil pressure – Press the Up arrow button in order to view "FUEL TEMP/BOOST PSI". – Press the Down arrow button in order to view "INTAKE AIR TEMP/AMB AIR TEMP".
"Intake Temp" (F) "Amb Air Temp" (F)	"Intake Air Temp" "Ambient Air Temp"	– Temperature of the air in intake manifold – Temperature of the ambient air – Press the Up arrow button in order to view "COOLANT TEMP/OIL PSI". – Press the Down arrow button in order to view "COLD MODE/MULTI-TORQUE"
"Cold Mode On/Off" "Multi-Torque" On/Off	Code Mode "Multi-Torque"	– The engine is operating in Cold Mode. – The engine is operating in "Multi-Torque" mode. – Press the Up arrow button in order to view "INTAKE TEMP/AMB AIR TEMP". – Press the Down arrow button in order to view "INSTANTANEOUS DATA".

5-2.5 Screen Display Information

5-2.5.1 Trip Segments

The Messenger display will provide operating data on the engine in a variety of ways. The Messenger display provides the method in order to label information for both driver and the vehicle owner. With the 3176B, 3176C, 3406E, C-10, C11, C-12, C13, C15, C-15, and C-16 engines, the Messenger display records information in three separate ways. Lifetime Totals, a Fleet Trip Segment, and a Driver Trip Segment are recorded.

5-2.5.2 Lifetime Totals

Lifetime totals are permanently stored in the ECM on the engines. The information is recorded throughout the life of the engine. The Lifetime Totals cannot be reset under normal operation. The Lifetime Totals cannot be deleted under normal operation. The Lifetime Totals are shown on the screen map for the Messenger Display.

5-2.5.3 "Totals Information" (3176B, 3176C, 3406E, C-10, C11, C-12, C13, C15, C-15, and C-16 Engines)

The "Total Information" column facilitates access to the "Driver Trip", "Fleet Trip", and "Lifetime Totals" columns. Press the Down arrow button on the "Totals Information" title screen in order to access the three totals.

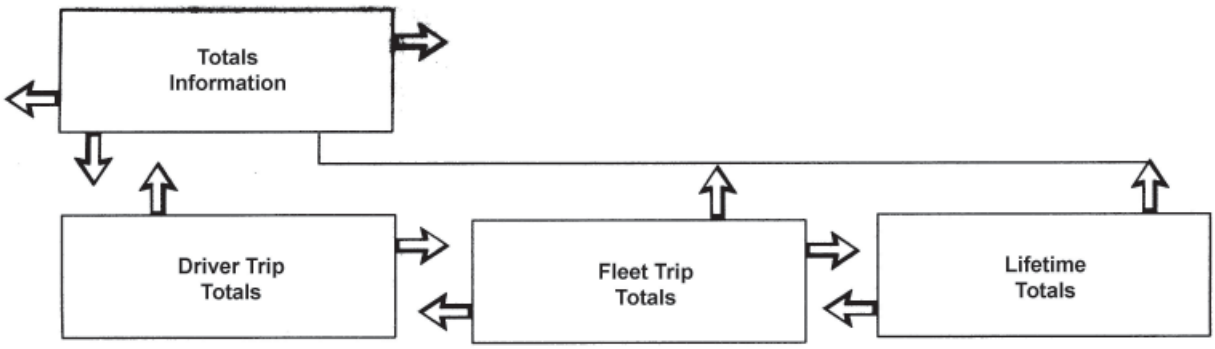


Figure 11 - "Totals Information Column"

5-2.5.4 Fleet Trip Segment

The information is intended for the fleet owner or owner driver. The ability to reset the information from the Messenger display depends on the software program. The Fleet Trip Segment may be reset with the electronic service tool and the appropriate passwords. Resetting the Fleet Trip Segment does not affect the Driver Trip Segment or the Lifetime Totals. The Fleet Trip Segment is shown on the Messenger screen map. The Messenger display provides the capability to enter the information for two drivers for the Fleet Trip Segment. The Messenger display provides the driver with the capability to enter the current state. The information on the state is part of the Fleet Trip Segment. The Messenger display provides the capability to enter the information for two drivers for the Fleet Trip Segment. The Fleet Trip Segment can be sorted for the two drivers by the Messenger software. The information on the state is shown on the screen map for the Messenger display. Entering the State Cross and DRIVER ID is explained further in this manual. Resetting the Fleet Trip Segment will clear the Fleet Trip DRIVER IDs. Resetting the Fleet Trip Segment will clear the Fleet Trip State Totals.

5-2.5.5 Driver Trip Segment

The Driver Trip Segment is intended for the driver and the Driver Trip segment is controlled by the driver. The Driver Trip Totals are shown on the screen map for the Messenger display in column 2. Resetting the Driver Trip Segment does not affect the Fleet Trip Segment or Lifetime Totals. Resetting the Driver Trip Segment does not affect the State Totals or the DRIVER IDs.

5-2.5.6 Example of Trip Segments and Lifetime Totals

The “Explanation of Trip Segment” shows the effect of entering the State Crossing, DRIVER ID, Fleet Trip Segment, and the Driver Trip Segment.

Table 4 - Example of the Trip Segment

Miles	Event	Driver Totals	Mileage Totals
0	New engine	“DRIVER ID1=0 miles” “DRIVER ID2=0 miles”	0
500	“State crossing entered”	“DRIVER ID1=500 miles” “DRIVER ID2=0 miles”	“State 1=500 miles”
1000	“DRIVER ID2 entered as driver”	“DRIVER ID1=1000 miles” “DRIVER ID2=0 miles”	“State 1=500 miles” “State 2=500 miles”
2000	“State crossing entered”	“DRIVER ID1=1000 miles” “DRIVER ID2=1000 miles”	“State 1=500 miles” “State 2=1500 miles” “State 3=0 miles”
2800	“Driver trip segment reset”	“DRIVER ID1=1000 miles” “DRIVER ID2=1800 miles”	“State 1=500 miles” “State 2=1500 miles” “State 3=800 miles”
3300	“DRIVER ID1 entered as driver”	“DRIVER ID1=1000 miles” “DRIVER ID2=2300 miles”	“State 1=500 miles” “State 2=1500 miles” “State 3=1300 miles”
3800	“State crossing entered”	“DRIVER ID1=1500 miles” “DRIVER ID2=2300 miles”	“State 1=500 miles” “State 2=1500 miles” “State 3=1800 miles”
5000	“Fleet trip segment reset” “DRIVER ID’s cleared-must be re-entered.”	“DRIVER ID1=2700 miles” “DRIVER ID2=2300 miles”	“State 1=500 miles” “State 2=2700 miles” “State 3=1800 miles”

Table 5 - Example of the Trip Segment

Miles	“Driver Trip Miles”	“Fleet Trip Miles”	“Lifetime Trip Miles”
0	0	0	0
500	500	500	500
1000	1000	1000	1000
2000	2000	2000	2000
2800	0	2800	2800
3300	500	3300	3300
3800	1000	3800	3800
5000	2200	0	5000

NOTE: The fleet trip segment includes State Information and DRIVER ID information.

Table 6 - “Trip Segment Example”

Miles	Description
500	A state crossing is entered and the vehicle operation is now recorded for State 2. The data for State 1 is stored.
1000	Driver 2 begins driving and the vehicle operation is now recorded for Driver 2. The data for Driver 1 is stored.
2000	A third state crossing is entered and the vehicle operation is now recorded for State 3. The data for State 1 and State 2 is stored.
2800	The Driver Trip Segment is reset. The Fleet and “Lifetime” information is not affected.
3300	Driver 1 returns as the driver. New information is now added to the previous Driver 1 records. The records for Driver 2 are stored.
3800	The vehicle has re-entered State 2. Operational information is now added to the State 2 records. The information for State 1 and State 3 are still stored.
5000	The Fleet Trip is reset. This clears the State and DRIVER ID records. Driver Trip and Lifetime Totals are unaffected.

5-2.6 The Driver Totals Information for the 3176B, 3176C, 3406E, C-10, C11, C-12, C13, C15, C-15, and C-16 Engines

The Driver Trip Segment is set by the driver. The driver sets the point to begin and the driver sets the point to end. The procedure is similar to setting a trip odometer. The Driver Trip Segment Totals are independent of the DRIVER ID. If a new driver begins operating the vehicle, resetting the DRIVER ID will not reset the Driver Trip Segment. The screen for the Driver Trip segment has ten parameters. The parameters are “Average Fuel Economy”, “Distance Traveled”, “Average Speed”, “Fuel Used”, “Engine Run Hours”, “PTO Fuel Used”, “PTO Hours”, “Idle Fuel Used”, “Idle Hours”, and “Percent Idle Time”.

5-2.6.1 Accessing the Driver Trip Screens

The display may be moved Up or Down from Column 2 of the screen map from any of the Driver Trip Screens. The “FLEET TRIP” screen may also be navigated in the same way as the “DRIVER TRIP” screen. The Down, Up, and Right arrow buttons are available from any of the “DRIVER TRIP DATA” screens. Moving to the corresponding “FLEET TRIP” information allows the driver to compare current “DRIVER TRIP” data to “FLEET TRIP” data. The desired screen should be selected prior to driving.

Table 7 - Driver Trip Screens

Screen	Parameter	Description
Driver Trip Totals	"Drive Trip Totals" Screen	– "Down arrow-View Driver Trip Data." – "Left arrow-Moves one column to the left." – "Right arrow-Moves one column to the right."
"DRV - AVG MPG"	"Driver Trip Segment" "Average Fuel Economy"	– "Shows Driver Trip Average Fuel Economy." – "Right arrow-Fleet Trip Average Fuel Economy." – "Down arrow-Driver Trip Distance Traveled and Average Vehicle Speed." – "Up arrow-DRIVER TRIP TOTALS title screen."
"DRV - MI" "AVG - MPH"	"Driver Trip Segment Distance Traveled" "Driver Trip Segment Average Vehicle Speed"	– "Shows Distance Traveled for the current Driver Trip Segment. Shows Average Vehicle Speed for the current Driver Trip Segment." – "Up arrow-Driver Trip Average Fuel Economy screen." – "Down button-Driver Trip Segment Fuel Used and Engine Hours." – "Right arrow-Fleet Trip Distance Traveled and Average Speed."
"DRV - GAL" "HR"	"Driver Trip Segment Fuel Used" "Driver Trip Segment Engine Hours"	– "Shows fuel used during the current Driver Trip Segment. Shows Driver Trip Segment Engine Hours." – "Up arrow-Driver Trip Segment Distance and Average Vehicle Speed." – "Down arrow-Driver Trip Segment PTO Fuel and PTO Time." – "Right arrow-Fleet Trip Fuel and Engine Hours."
"DRV - GAL" "PTO" "HR"	"Driver Trip Segment PTO Fuel Used" "Driver Trip Segment PTO Time"	– "Shows PTO fuel during the current Driver Trip Segment. Shows Driver Trip Segment PTO time." – "Up arrow-Driver Trip Segment Fuel Used and Engine Hours." – "Down arrow-Driver Trip Percent Idle Time." – "Right arrow-Fleet Trip Idle Fuel and Idle Hours."
"DRV - GAL" "IDLE" "HR"	"Driver Trip Segment Idle Fuel Used" "Driver Trip Segment Idle Time"	– "Shows Idle Fuel during the current Driver Trip Segment. Shows Driver Trip Segment Idle Time." – "Up arrow-Driver Trip Segment Fuel Used and Engine Hours." – "Down arrow-Driver Trip Segment Idle Fuel and Idle Time." – "Right arrow-Fleet Trip PTO Fuel and PTO Hours."
"DRV - IDLE" "%"	"Driver Percent Idle Time"	– "A value for the percent of time the driver was idling, calcuated from: (Driver Idle Hours divided by Total Driver Hours)." – "Right arrow-Fleet Percent Idle Time." – "Up arrow-Driver Trip Segment Idle Fuel and Idle Time." – "Down arrow-Driver Trip Reset screen."
"DRV - RESET" "TRIP TOTALS"	"Driver Trip Reset"	– "To reset the Driver Trip Segment, press the Left arrow button." – "Up arrow-Driver Trip Percent Idle Time." – "Down arrow-Driver Trip Segment title screen."
"DRIVER TRIP" "RESET PERFORMED"	"Driver Trip Reset Completed"	– "Indicates the Driver Trip Segment has been reset." – "Pressing any buton will return display to the Driver Trip Segment title screen."

5-2.6.2 “Fleet Trip Totals” Screens

The screen for the Fleet Trip Segment has ten parameters. The parameters are “Average Fuel Economy”, “Distance Traveled”, “Average Speed”, “Fuel Used”, “Engine Run Hours”, “PTO Fuel Used”, “PTO Hours”, “Idle Fuel Used”, “Idle Hours”, and “Percent Idle Time”. The information for the Fleet Trip Segment is controlled by the fleet owner. The information may be controlled by the driver if the ECM has been programmed to allow the driver to reset the display on the Fleet Trip Segment.

5-2.6.3 Accessing the “Fleet Trip” Screens

The display may be moved Up or Down from any of the “Fleet Trip” Screens. The “Driver Trip” screen and the “Lifetime Total” screen may also be navigated in the same way as the “Fleet Trip” screen. The Left Down, Up, and Right arrow buttons are available from any of the “Fleet Trip Data” screens. Moving to the corresponding “Driver Trip Segment” or “Lifetime Total” information allows the driver to compare current “Fleet Trip Data” to the “Driver Trip” data or “Lifetime Total data. The desired screen should be selected prior to driving.

5-2.6.4 Reset Protection of Fleet Trip Totals

The “Fleet Trip Totals” may be reset with the Messenger display or the “Fleet Trip Totals” may be reset with an electronic service tool by the Fleet Owner. Resetting is controlled by a Customer Programmable Parameter that is programmed into the engine ECM by the Fleet Owner. The parameter must first be programmed into the ECM. The power to the display must be turned OFF and ON In order for the display to recognize the change.

Fleet Owner Control for Reset of the Fleet Trip Segment

The Fleet Trip Reset may be controlled by the Fleet Owner. The display may be reset with Caterpillar Fleet Information Software or with an electronic service tool.

ECM Allows the Messenger Display to Reset the Fleet Trip Segment

The Fleet Trip Reset may be controlled by the driver. The display is reset with the dash display, with Caterpillar Fleet Information Software, or with an electronic service tool.

All Data Has Been Cleared and the Fleet Trip Segment is Reset

A Fleet Trip Reset will clear all “Fleet Trip Totals”, “Fleet Trip State Totals”, “DRIVER ID”, and “State Crossings”. No other information is affected.

Table 8 - “Fleet Trip” Screens

Screen	Parameter	Description
“FLEET TRIP TOTALS”	“Fleet Trip Totals Title Screen”	– “Down arrow-View Fleet Trip Fuel Economy Data.” – “Left arrow-Moves one column to the left.” – “Right arrow-Moves one column to the right.”
“FLT” “AVG-MPG	“Fleet Trip Segment Average Fuel Economy”	– “Shows average fuel economy and distance traveled during the current Fleet Trip Segment.” – “Left arrow-Driver Trip Average Fuel Economy.” – “Right arrow-Lifetime Average Fuel Economy.” – “Down arrow-Fleet Trip Fuel Used and Gallons Used Per Hour.” – “Up arrow-Fleet Trip Totals title screen.”
“FLT” “AVG - MPH”	“Fleet Trip Segment Average Speed”	– “Shows average vehicle speed during the current Fleet Trip Segment.” – “Left arrow-Driver Trip Average Speed.” – “Right arrow-Lifetime Average Speed.” – “Down arrow-Fleet Fuel Used and Engine Hours during current trip.” – “Up arrow-Fleet Trip Fuel Economy title screen.”

Table 8 - “Fleet Trip” Screens - Continued

Screen	Parameter	Description
“FLT - GAL - HR”	“Fleet Trip Segment Fuel Used” “Fleet Trip Segment Engine Hours”	– “Shows Fuel Used during the current Fleet Trip Segment. Shows Fleet Trip Segment Engine Hours.” – “Left arrow-Driver Trip Segment Fuel Used and Engine Hours.” – “Right arrow-Lifetime Fuel Used and Engine Hours.” – “Up arrow-Fleet Trip Segment Fuel Used Per Hour.” – “Down arrow-Fleet Trip Segment PTO Fuel and PTO Time.”
“FLT - GAL” “PTO” “HR”	“Fleet Trip Segment PTO Fuel Used” “Fleet Trip Segment PTO Time”	– “Shows PTO fuel during the current Driver Trip Segment. Displays Fleet Trip Segment PTO time.” – “Left arrow-Driver Trip Segment PTO Time and PTO Fuel Used.” – “Right arrow-Lifetime PTO Time and PTO Fuel Used.” – “Up arrow-Fleet Fuel Used and Engine Hours during current trip.” – “Down arrow-Fleet Trip Segment Idle Fuel and Idle Time.”
“FLT - GAL” “IDLE” “HR”	“Fleet Trip Segment Idle Fuel Used” “Fleet Trip Segment Idle Time”	– “Shows Idle Fuel Used during the current Fleet Trip Segment. Shows Fleet Trip Segment Idle Time.” – “Left arrow-Driver Trip Segment Idle Time and Idle Fuel Used.” – “Right arrow-Lifetime Idle Time and Idle Fuel Used.” – “Up arrow-Fleet Trip Segment PTO Fuel and PTO Hours.” – “Down arrow-Fleet Percent Idle Time.”
“FLT - IDLE” “%”	“Fleet Percent Idle Time”	– “A value for the percent idle time of the fleet, calculated from: (Fleet Idle Hours divided by Total Fleet Hours).” – If the 3176B, 3176C, 3406E, C-10, C11, C-12, C13, C15, C-15 and C-16 engine ECM has been programmed to allow the Fleet Trip Reset, the Down button displays the “Fleet Trip Reset” screen. If the Fleet Trip Reset has not been programmed, the Down button returns to the “Fleet Trip” title screen. – “Left arrow-Driver Percent Idle Time.” – “Right arrow-Lifetime Percent Idle Time.” – “Up arrow-Fleet Trip Segment Idle Fuel and Idle Time.”
“FLT RESET” “TRIP TOTALS”	“Fleet Trip Reset”	– “To Reset the Fleet Trip Segment, press the Left arrow button.” – “Up arrow-Fleet Trip Percent Idle Time.” – “Down arrow-FLEET TRIP SEGMENT title screen.” – (f the 3176B ECM, 3176C ECM, 3406E ECM, C-10 ECM, C11 ECM, C-12 ECM, C13 ECM, C15 ECM, C-15 ECM, or the C-16 ECM has not been programmed to allow the Fleet Trip Reset by the driver, this screen is not available.)
“FLEET TRIP” “RESET PERFORMED”	“Fleet Trip Reset Completed”	– “Indicates the Fleet Trip Segment has been reset. Pressing any button will return display to the FLEET TRIP SEGMENT title screen.” (The 3176B ECM, 3176C ECM, 3406E ECM, C-10 ECM, C11 ECM, C-12 ECM, C13 ECM, C15 ECM, C-15 ECM, or the C-16 ECM must be programmed in order to allow the “Fleet Trip Reset” by the driver.)

5-2.6.5 “Lifetime Totals” Screens

The screen for the “Lifetime Totals” has ten parameters. The parameters are “Average Fuel Economy”, “Distance Traveled”, “Average Speed”, “Fuel Used”, “Engine Run Hours”, “PTO Fuel Used”, “PTO Hours”, “Idle Fuel Used”, “Idle Hours”, and “Percent Idle Time”. This information is maintained by the engine ECM for the life of the engine.

5-2.6.6 Accessing The Lifetime Totals Screens

The display may be moved Up or Down from Column 2 of the screen map from any of the Lifetime Totals Screens. The "Driver Trip" screen and the "Lifetime Total" screen may be navigated in the same way as the "Fleet Trip" screen when the vehicle has the 3176B, 3176C, 3406E, C-10, C11, C-12, C13, C15, C-15, or C-16 engines. The Left, Down, Up, and Right arrow buttons are available from any of the "Lifetime Totals Data" screens. Moving to the corresponding "Fleet Trip" information allows the driver to compare current "Lifetime Totals" to the "Fleet Trip" data. The desired screen should be selected prior to driving.

Table 9 - "Lifetime" Screens

Screen	Parameter	Description
"LIFETIME TOTALS"	"Lifetime Totals Title Screen"	– "Down arrow-View Lifetime Totals Data." – "Left arrow-Moves one column to the left." – "Right arrow-Moves one column to the right."
"LFT" "AVG MPG"	"Lifetime Total Segment" "Average Fuel Economy"	– "Shows Lifetime Total Average Fuel Economy." – "Left arrow-Fleet Trip Average Fuel Economy." – "Down arrow-Lifetime Total Fuel Used and Engine Hours." – "Up arrow-Lifetime Totals title screen."
"LIF MI" "AVG MPH"	"Lifetime Mileage" "Lifetime Average Speed"	– "Shows Distance Traveled for the engine to date. Shows Average Vehicle Speed for the engine to date." – "Left arrow-Fleet Trip Segment Distance Traveled and Average Vehicle Speed." – "Up arrow-Lifetime total miles and average fuel economy screen." – "Down arrow-Lifetime Total Fuel Used and Gallons per Hour."
"LIF - GAL - HR"	"Lifetime Total Fuel Used" "Lifetime Total Segment Engine Hours"	– "Shows Fuel Used for the engine to date. Shows Engine Hours for the engine to date." – "Left arrow-Fleet Trip Segment Fuel Used and Engine Hours." – "Up arrow-Lifetime Total Fuel and Hours." – "Down arrow-Lifetime Total PTO Fuel and PTO Time."
"LIF PTO GAL" "PTO HR"	"Lifetime Total PTO Fuel Used" "Lifetime Total PTO Time"	– "Shows Fuel Used for the engine to date. Shows Engine Hours for the engine to date." – "Left arrow-Fleet Trip Segment Fuel Used and Engine Hours." – "Up arrow-Lifetime Total Distance and Average Vehicle Speed." – "Down arrow-Lifetime Total PTO Fuel and PTO Time."
"LIF IDLE GAL" "HR"	"Lifetime Total Idle Time" "Lifetime Total Idle Fuel Used"	– "Shows Idle Fuel Used for the engine to date. Shows Idle Time for the engine to date." – "Left arrow-Fleet Trip Segment Idle Time and Idle Fuel Used." – "Up arrow-Lifetime Total PTO Fuel Used and PTO Hours." – "Down arrow-Lifetime percent idle time screen."
"LIF IDLE" "%"	"Lifetime Percent Idle Time"	– "Shows a value for the percent of total operating time idling, calculated from: (Lifetime Idle Hours divided by Total Lifetime Hours)." – "Left arrow-Fleet Percent Idle Time." – "Up arrow-Lifetime Total Idle Fuel and Idle Time." – "Down arrow-LIFETIME TOTALS title screen."

5-2.7 “Fleet Trip State Totals” Screens

5-2.7.1 The 3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, C16, and 3406E Engines only

The ECM for the Caterpillar 3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, C-16 and 3406E will store the data for the distance that is driven, the total fuel consumption number, the idle fuel that has been used, and the PTO fuel that has been used for each state. More than one state may be selected during a “Fleet Trip Segment” up to a maximum of 50 states. Before the data is stored, the current state must be entered into the display.

5-2.7.2 Accessing “Fleet Trip State Totals”

ECM Customer Programmable parameters determine the access to this function of the display. If the “State Information” is programmed OFF in the ECM, the entire “Fleet Trip State Totals” column will not be shown. Press the Right arrow button of the “LIFETIME TOTALS” screen. This will cause the display to skip the “FLEET TRIP STATE TOTALS” screen. Press the Left arrow button of the “MAINTENANCE DATA” title screen. This will cause the display to skip the “FLEET TRIP STATE TOTALS” title screen.

After programming the parameters in the ECM, the power must be turned OFF and the power turned ON again in order for the display to recognize the change.

Table 10 - “Fleet Trip State Totals” Screens

Screen	Parameter	Description
“FLEET TRIP STATE TOTALS”	“Fleet Trip State Totals Title Screen”	– The Down arrow button selects a state and the data for that state. – If “State Crossing” has not been entered, the message “NO SELECTIONS AVAILABLE” will appear. – Press any button in order for the display to return to the “FLEET TRIP STATE TOTALS” title screen. – From the title screen, the Left arrow button moves to the “LIFETIME TOTALS” title screen. The Right arrow button moves to the “MAINTENANCE DATA” title screen.
“STATE 1”	“Select A State To View State Trip Data”	– Press the Left arrow button in order to begin viewing “Fleet Trip State” information. – Press the Down arrow button in order to view other states, if other states are available. – If more than one state is available, use the Down and Up arrow buttons to review the list of states with recorded data.
“STATE 1” “MI”	“Fleet Trip State Distance Traveled For Selected State”	– The display shows the distance that has been driven in the selected state for the current “Fleet Trip”. – The selected state will be shown as “State 1”. – The Up arrow button returns to “STATE SELECTION” screen. – The “Down” arrow button will display the fuel that has been used in the selected state.
“STATE 1” “GAL”	“Fleet Trip State Fuel Used For Selected State”	– The display shows the “Fuel Used” in a selected state for the current “Fleet Trip”. – The selected state will be shown as “State 1”. – The Up arrow button returns to “STATE DISTANCE TRAVELED” screen. – The Down arrow button displays “PTO Fuel Used” in the selected state.
“STATE 1” “PTO GAL”	“Fleet Trip State PTO Fuel Used For Selected State”	– The display shows the “PTO Fuel Used” in a selected state for the current “Fleet Trip”. – The selected state will be shown as “State 1”. – The Up arrow button returns to “Fuel Used” for this state. – The Down arrow button displays “Idle Fuel Used” in the state that is selected.
“STATE 1” “IDLE GAL”	“Fleet Trip State Idle Fuel Used For Selected State”	– The display shows the “Idle Fuel Used” in a selected state for current “Fleet Trip”. – The selected state will be shown as “State 1”. – The Up arrow button returns to the “PTO Fuel Used” for this state. – The Down arrow button returns the display to the screen that shows the state that is selected, in this example “State 1”.

5-2.8 “Economy Model” Screens

5-2.8.1 Information for the 3176B, 3176C, 3406E, C-10, C11, C-12, C13, C15, C-15, and C-16 Engines

The Messenger display can display information regarding the “Economy Model” feature of the ECM. This information includes the current “Driver Bonus” and this information includes the current “Target vs. Actual” totals. Refer to the “Screen Maps” of the Messenger display for additional information.

Table 11 - “Economy Model” Screens

Screen	Parameter	Description
THE REWARD IS ACTIVE OR THE REWARD IS NOT ACTIVE.	The Reward is not active.	– This screen will indicate if the reward is active and the driver “VSL bonus” is active. The reward will be active if the overall Driver Incentive score is above the programmed threshold score.
	The Reward is active.	– If the reward is active, the second line of the display will indicate the current “Driver Bonus” reward that is available.
“TARGET SCORE XXX” “ACTUAL SCORE XXX”	“Target vs. Actual” “XXX”	– The screen will display the threshold score. This is referred to as the target score. This may be viewed on the top line. – The bottom line of the display will indicate the current overall “actual score”. – If the “actual score” is higher than the target score, the reward will be active and the driver will receive a “Driver Bonus”.
“AVG ENGINE SPEED (RPM)”	“Parameter Information Screens” “Average Engine Speed (RPM)” “Average Driving Speed Over 50 MPH” “Average Throttle Demand (RPM)” “Average Shift Engine Speed (RPM)” “Percent Idle Time”	– The driver can use the screens for parameter information to obtain information on each of the five parameters of the “Economy Model” feature. As an example, follow the steps in order to obtain information on “Percent Idle Time”. a. Press the Down arrow button to the “PERCENT IDLE TIME” screen. b. Press the Left arrow button. c. View the specific information on “target vs. Actual Percent Idle Time Values”. d. Press the Left arrow button in order to view the “SCORE” screen. The “score” is shown on the screen as “XXX” of “YYY”. “XXX” is the actual “score” and “YYY” is the maximum “score” for that parameter. The maximum “score” will depend on the parameter value in the ECM.

5-2.9 "Maintenance Data" Screens

The display can indicate the service history for the maintenance that was performed on the oil and the oil filter (PM1). The display may indicate when the next scheduled PM 1 maintenance is due. The maintenance data is displayed in distance or hours. This is determined by the Customer Programmable Parameters that are programmed into the ECM. The ECM can be programmed to the OFF position, which will prevent the recording of maintenance data from the ECM. After programming the parameters in the ECM, the power must be turned OFF and the power turned ON again in order for the display to recognize the change.

Table 12 - "Maintenance" Screens

Screen	Parameter	Description
"MAINTENANCE DATA"	"Maintenance Data title screen" The Reward is active.	Press the Down arrow button in order to view maintenance data. Press the Left arrow button in order to move one column to the left. Press the Right arrow button in order to move one column to the right.
PM 1-DUE "MI or HR"	PM 1 "Maintenance Due Data"	The display shows when the PM 1 Maintenance should next be performed. This screen will be shown automatically when the display is first turned on and the PM 1 maintenance is due within 3000 miles or 60 hours. This screen will be viewed until an arrow button is pressed. Press the Down arrow button in order to view the maintenance interval and the last performed maintenance interval. Press the Up arrow button in order to view the "MAINTENANCE DATA" title screen. The display will show "PM 1 Disabled" on this screen if the ECM has not been programmed to record PM 1.
PM 1 "RANGE" "MI or HR" "LAST" "MI or HR"	PM 1 "Maintenance Due Data"	This screen shows the PM 1 Maintenance Interval. The screen also shows the previous PM 1 Maintenance that was performed. Press the Up arrow button in order to return to the screen that indicates when the next PM 1 Maintenance is due. This may be performed if the 3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, C-16, or 3406E has been programmed to allow the PM 1 Maintenance Data to be reset from the display. Press the Down arrow button in order to display the "MAINTENANCE DATA RESET" screen. Press the Down arrow button in order to return to the "Maintenance Data" title screen. This may be performed if the 3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, C-16 or 3406E has been programmed to not allow the PM 1 Maintenance Data to be reset from the display.
PM 1 "RESET"	PM 1 "Maintenance"	Press the Left arrow button in order to reset the PM 1 Maintenance Data. Press the Up arrow button in order to view the PM 1 Maintenance Interval. Press the Up arrow button in order to view the PM 1 Maintenance screen. Press the Down arrow button in order to view the "Maintenance Data" title screen.
PM 1 "RESET PERFORMED"	PM 1 "Maintenance Reset Completed"	This screen indicates that PM 1 has been successfully reset. Press any button in order to return to the "MAINTENANCE DATA" title screen.
PM 1 "PAST DUE" "MI or HR"	PM 1 "Maintenance Overdue"	This screen indicates that the PM 1 maintenance interval has been exceeded without a reset. This message will be shown when the display is first turned On. This message will be shown when PM 1 is On. This message will be shown when PM 1 maintenance is due within 3000 miles or maintenance is due within 60 hours. This screen will also be shown if the maintenance interval has been exceeded.

5-2.10 Diagnostic Data" Screens

The display will automatically indicate certain diagnostic codes as the codes occur. The "DIAGNOSTIC DATA" screens provide the advantage of indicating the reason that the Check Engine lamp has come on. The codes will be displayed with the PID-FMI diagnostic code (Parameter Identifier and Failure Mode Identifier) and a brief text description. If more than one code is active, pressing the Down arrow button will scroll through the remaining codes. An active diagnostic code that becomes inactive will disappear from the screen. Press the Right arrow button in order to return to the title screen. The display will indicate other codes or "No Active Codes".

Table 13 - Automatically Displayed Diagnostic Codes

PID-FMI	"Code Description"
100-11	"Very Low Oil Pressure"
110-11	"Very High Coolant Temperature"
111-11	"Very Low Coolant Level"
100-01	"Low Oil Pressure Warning"
110-00	"High Coolant Temperature Warning"
111-01	"Low Coolant Level Warning"
105-00	"High Inlet Manifold Temp Warning"
105-11	"Very High Inlet Manifold Temp"

The diagnostic codes in the above table (table 13) will be displayed whenever the codes are active. The display will continue to show these codes until any button is pressed. The display will continue to show these codes until the diagnostic goes from an active state to an inactive state. If no other codes are active, the Messenger display will return to the screen that was displayed before the diagnostic event.

The diagnostic codes may alert the driver to conditions that may damage engine components. The diagnostic codes 100-11 "Very Low Oil Pressure", 111-11 "Very Low Coolant Level", and 110-11 "Very High Coolant Temperature" indicate that the engine is experiencing a serious problem.

NOTE: Depending on the engine configuration, the engine may shut down when a potentially serious engine problem diagnostic code becomes active. The driver will be provided a warning before engine shutdown.

5-2.10.1 Procedure to Address the Occurrence of Codes

Whenever a diagnostic code occurs, try to note all operating conditions of the vehicle. It is especially critical to take note of the operating conditions for intermittent codes. This information provides the technicians with the operating conditions at the time of the intermittent code. This will enhance the technician's ability to produce the code again. This will also enhance the technician's ability to diagnose the problem. The codes are recorded in the ECM and the codes may be recovered with the electronic service tool.

5-2.10.2 Diagnostic Code Chart

The following table (Table 14) is provided in order to help determine the action that should be taken if a particular diagnostic code is active. The chart is intended as a general guideline. The current operating conditions will determine the reaction of the driver to the codes. As an example, only intermittent service codes that are a persistent problem should be serviced.

Table 14 - "Suggested Driver Action for Diagnostic Codes
(3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, and the 3406E Engines)"

Code	Description	"Shutdown" "Vehicle"(1)	"Service ASAP" (2)	"Schedule Service" (3)
1-11	Cylinder 1 Fault		X	
2-11	Cylinder 2 Fault		X	
3-11	Cylinder 3 Fault		X	
4-11	Cylinder 4 Fault		X	
5-11	Cylinder 5 Fault		X	
6-11	Cylinder 6 Fault		X	
22-11	"Cam Sensor to Crank Sensor Calibration"			X
22-13	"Check Timing Sensor Calibration"			X
30-08	Invalid PTO Throttle Signal			X
30-13	"PTO Throttle Sensor Calibration"			X
32-05	"Turbo Wastegate Solenoid Output Open Circuit"		X	
32-06	"Turbo Wastegate Solenoid Short Circuit"		X	
32-11	"Turbo Wastegate Solenoid Output Short to +Batt"		X	
41-03	"8 Volt Supply Above Normal"		X	
41-04	"8 Volt Supply Below Normal"		X	
43-02	"Ignition Button Switch Fault"		X	
52-11	"Air Inlet Shutoff Shutdown"			X
54-05	"Output #6 Open Circuit"		X	
54-06	"Output #6 Short Circuit"		X	
55-05	"Output #7 Open Circuit"		X	
55-06	"Output #76 Short Circuit"		X	
64-12	"Loss of Engine Cam Sensor RPM Signal"			X
71-00	"Idle Shutdown Override" (4)			
71-01	"Idle Shutdown Occurence" (4)			
71-14	"PTO Shutdown Timer Occurence"			X
84-00	"Vehicle Over Speed Warning" (4)			
84-01	"Loss of Vehicle Speed Signal"			X
84-02	"Invalid Vehicle Speed Signal"			X
84-08	"Vehicle Speed Out of Range"			X
84-01	"Vehicle Speed Rate of Change"			X

(1) The "Shutdown Vehicle" code indicates the presence of a condition that could potentially damage the engine. The driver should bring the vehicle to a stop off the road and out of traffic.
(2) The "Service ASAP" code indicates that the driver should go to the nearest qualified location for service if vehicle performance is adversely affected.
(3) The "Schedule Service" code should be addressed at the next convenient opportunity if vehicle operation is adversely affected.
(4) "No action required"

Table 14 - "Suggested Driver Action for Diagnostic Codes
(3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, and the 3406E Engines)" continued

Code	Description	"Shutdown" "Vehicle"(1)	"Service ASAP" (2)	"Schedule Service" (3)
84-14	"Quick Stop Occurrence:"(4)			
91-08	"Invalid Throttle Signal"		X	
91-13	"Throttle Sensor Calibration"		X	
100-01	"Low Oil Pressure Warning"		X	
100-03	"Oil Pressure Sensor Open Circuit"			X
100-04	"Oil Pressure Sensor Short Circuit"			X
100-11	"Very Low Oil Pressure"	X		
102-00	"Boost Pressure Reading Stuck High" (4)			X
102-01	"Boost Pressure Reading Stuck Low" (4)			X
102-02	"Erratic Boost Pressure"		X	
102-03	"Boost Pressure Sensor Open Circuit"			X
102-04	"Boost Pressure Sensor Short Circuit"			X
102-07	"Excessive Boost Pressure"		X	
103-00	"High Turbo Speed Derate"		X	
103-11	"Very High Turbo Speed Derate"		X	
105-00	"High Intake Manifold Air Temperature Warning"		X	
105-03	"Intake Manifold Air Temperature Sensor" "Open Circuit"			X
105-04	"Intake Manifold Air Temperature Sensor" "Short Circuit"			X
105-11	"Very High Intake Manifold Air Temperature"		X	
108-03	"Atmospheric Pressure Sensor Open Circuit"			X
108-04	"Atmospheric Pressure Sensor Short Circuit"			X
110-00	"High Coolant Temperature Warning"		X	
110-03	"Coolant Temperature Sensor Open Circuit"			X
110-04	"Coolant Temperature Sensor Short Circuit"			X
110-11	"Very High Coolant Temperature"	X		
111-01	"Low Coolant Level Warning"		X	
111-02	"Coolant Level Sensor Fault"			X
111-03	"Coolant Level Sensor Open Circuit"			X
111-04	"Coolant Level Sensor Short Circuit"			X
111-11	"Very Low Coolant Level"	X		

(1) The "Shutdown Vehicle" code indicates the presence of a condition that could potentially damage the engine. The driver should bring the vehicle to a stop off the road and out of traffic.
(2) The "Service ASAP" code indicates that the driver should go to the nearest qualified location for service if vehicle performance is adversely affected.
(3) The "Schedule Service" code should be addressed at the next convenient opportunity if vehicle operation is adversely affected.
(4) "No action required"

Table 14 - "Suggested Driver Action for Diagnostic Codes
(3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, and the 3406E Engines)" continued

Code	Description	"Shutdown" "Vehicle"(1)	"Service ASAP" (2)	"Schedule Service" (3)
111-14	"Early Hour Low Coolant Level"			X
121-05	"Retarder Solenoid Low/High Open Circuit"			X
121-06	"Retarder Solenoid Low/High Short Circuit"			X
122-05	"Retarder Solenoid Med/High Open Circuit"			X
122-06	"Retarder Solenoid Med/High Short Circuit"			X
166-11	"Rated Engine Power Derate"			X
168-02	"Intermittent Battery"		X	
171-03	"Outside Air Temp Sensor Open Circuit"			X
171-04	"Outside Air Temp Sensor Short Circuit"			X
171-11	"No Ambient Air Temperature Data"			X
173-00	"High Exhaust Gas Temperature Derate"		X	
173-03	"Exhaust Gas Temperature Open Circuit"			X
173-04	"Exhaust Gas Temperature Short Circuit"			X
173-11	"Very High Exhaust Gas Temperature Derate"	X		
174-00	"High Fuel Temperature Warning"			X
174-03	"Fuel Temperature Sensor Open Circuit"			X
174-04	"Fuel Temperature Sensor Short Circuit"			X
190-00	"Engine Over Speed Warning" (4)			
190-12	"Loss of Engine Crank Sensor RPM Signal"			X
191-07	"Transmission Not Responding"		X	
224-11	"Theft Deterrent Active" (4)			
224-14	"Engine Cranking with Theft Deterrent Active" (4)			
231-02	"J1939 Required Data Not Received"			X
231-12	"J1939 Device Not Responding"			X
232-03	"5 Volt Supply Above Normal"			X
232-04	"5 Volt Supply Below Normal"			X
246-11	"Brake Switch #1"			X
247-11	"Brake Switch #2"			X
249-11	"J1922 Data Link Fault"			X
252-11	"Incorect Engine Software"		X	
253-02	"Check Customer or System Parameters"			X
253-11	"Check Transmission Customer Parameters		X	

(1) The "Shutdown Vehicle" code indicates the presence of a condition that could potentially damage the engine. The driver should bring the vehicle to a stop off the road and out of traffic.
(2) The "Service ASAP" code indicates that the driver should go to the nearest qualified location for service if vehicle performance is adversely affected.
(3) The "Schedule Service" code should be addressed at the next convenient opportunity if vehicle operation is adversely affected.
(4) "No action required"

5-2.11 “Theft Deterrent” Screens

5-2.11.1 Theft Deterrent

The Messenger display provides the capability to allow the engine to start, the capability to prevent the engine from starting, or the capability to shut down the engine. This may be done by entering a customer password with four characters into the display when the engine is at idle.

In the powerup sequence, the display will indicate if the “Theft Deterrent System” is enabled, automatically enabled, or disabled. The “Theft Deterrent System” may be enabled or the system may be automatically enabled. The engine will not start until the customer password with four characters is successfully entered into the display. If the system is disabled, the engine will start without the password. To enable the system, the customer password must be successfully entered. The passwords that are entered will not be accepted if the engine is not at idle condition. In order to automatically enable the system, the vehicle needs to be shut off in a normal manner. The “Theft Deterrent” parameter needs to be programmed in order to be in the “Automatically Enable” mode.

5-2.11.2 “Accessing Theft Deterrent”

ECM Customer Programmable parameters determine the access to this function of the dash display and the Theft Deterrent password. The ECM must be programmed to allow access to this screen. The ECM must be programmed or the entire “Theft Deterrent” column of the screen map will not be shown. Pressing the Right arrow button on the “DIAGNOSTIC DATA” title screen will cause the display to pass over the “THEFT DETERRENT” title screen.

After the parameters are programmed in the ECM, the power must be turned OFF and the power turned ON again in order for the display to recognize the charge.

Table 15 - “Theft Deterrent” Entry Screens

Screen	Parameter	Description
“Theft Deterrent Status”	“Theft Deterrent Title Screen”	The screen shows the current status of the “Theft Deterrent” system when “STATUS” text is indicated. The system may be “ENABLED” and the engine will not start until the correct password is entered. The system may be “DISABLED” and the “Theft Deterrent” system is not active. The engine may be started if the “Theft Deterrent” system is “Disabled”. This screen is shown when the display is first powered up and the “Theft Deterrent” system is programmed to be active. Press the Left arrow button in order to move one column to the left. Press the Right arrow button in order to move one column to the right. Press the Down arrow button in order to move to the “ENTER PASSWORD” screen.
“Enter Password” “4 Characters”	“Enter Theft Deterrent Password”	Press the “Up” arrow button or the “Down” arrow button in order to scroll through numbers 0 to 9. Press the “Up” arrow button or the “Down” arrow button in order to scroll through letters A to Z. Press the Right arrow button and the Left arrow button in order to move between locations of the characters.
“4 Characters If Correct”	“Accept Entered Password”	This screen shows the password that has been entered. If the password is correct, the text message “PASSWORD ACCEPTED” will be displayed. The display will then return to the “THEFT DETERRENT” title screen in order to show the status. If the password is not accepted, the following message will be displayed “PASSWORD INCORRECT”. The display will then return to the “THEFT DETERRENT” title screen and the status will not have changed. Press the Left arrow button in order to enter the password. Press the Up, Down, and Right arrow button in order to return the display to the “THEFT DETERRENT” title screen. This will clear the password that was just entered.

5-2.12 "Fuel Correction Adjustment" Screens

5-2.12.1 The 3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, C-16, and 3406E Engines Only

The "Fuel Correction Adjustment" allows the fine tuning of data on future fuel usage that is based on the past differences of values. The values are stored in the ECM and the recorded fuel usage.

5-2.12.2 Accessing "Fuel Correction Adjustment"

An ECM Customer Programmable Parameter determines access to this function of the dash display. If the ECM is not programmed to allow access to this screen, the entire "Fuel Correction Adjustment" column of the "Screen Map" will not be shown. Press the Right arrow button from the "THEFT DETERRENT" title screen or press the Left arrow button from the "DISPLAY CONFIGURATION" title screen in order to pass over the "FUEL CORRECTION ADJUSTMENT" title screen. After the parameters are programmed in the ECM, power to the display must be turned OFF and the power turned ON again in order for the display to recognize the change.

"Fuel Correction Adjustments" should be made following extensive operation of the vehicle. During this period, the vehicle should be operated in the usual manner. The "Fuel Correction Adjustment" affects all future "Fuel Used" data, "Instantaneous", "Driver Trip", "Fleet Trip", and "Lifetime Totals". The "Fuel Correction Adjustment" should be made when the vehicle is not moving.

5-2.12.3 "Adjusting Fuel Correction"

Determining Actual Fuel Economy

The actual fuel usage and travel distance must be recorded in order to make an accurate adjustment. The display uses the "Fleet Trip Segment" as a basis for "fuel correction adjustment". The actual fuel usage and the travel distance should be recorded immediately after a "Fleet Trip Segment Reset". Calculate the "Actual Fuel Economy" after driving on a typical route for an extended period of time. Calculate the fuel economy from the "Fuel Used" and "Distance Traveled" per the following formula.

$$\frac{\text{Actual Distance Traveled}}{\text{Actual Fuel Used}}$$

Entering Actual Fuel Economy

1. From the "FUEL CORRECTION ADJUSTMENT" title screen, press the Down arrow button. The display will show the current "Fleet Fuel Economy" on the top line. The display will show a flashing cursor near the left digit next to the word "ACTUAL" on the second line of the display.
2. Pressing the Down arrow button scrolls through numbers 0 to 9 beginning with 9. Pressing the Up arrow button begins with the number 1. If the first position is not needed, press the Right arrow button. The space for the second digit will be highlighted. When the appropriate number is viewed, press the Right arrow button and select the digit after the decimal point. When the last digit is successfully selected, press the Right arrow button. The display will indicate the "Actual Fuel Economy" that was entered. If the number is correct, press the Left arrow button.
3. If the "Actual Fuel Economy" is correct, press the Left arrow button. A message will appear to verify the "fuel correction adjustment". If the value for "Actual Fuel Economy" was entered incorrectly, press the Down, Up, or Right arrow button. The display will return to the "FUEL CORRECTION ADJUSTMENT ENTRY" screen. The numbers that were previously entered will be deleted from the screen. The display will allow the value for the "Actual Fuel Economy" to be re-entered on the screen.

"Fuel Correction Out-of-Range" Message

The "FUEL CORRECTION OUT OF RANGE" message will be displayed if the value for the "Fuel Rate Correction" exceeded the allowable limits. Press any button in order for the display to return to the "FUEL CORRECTION ADJUSTMENT" title screen.

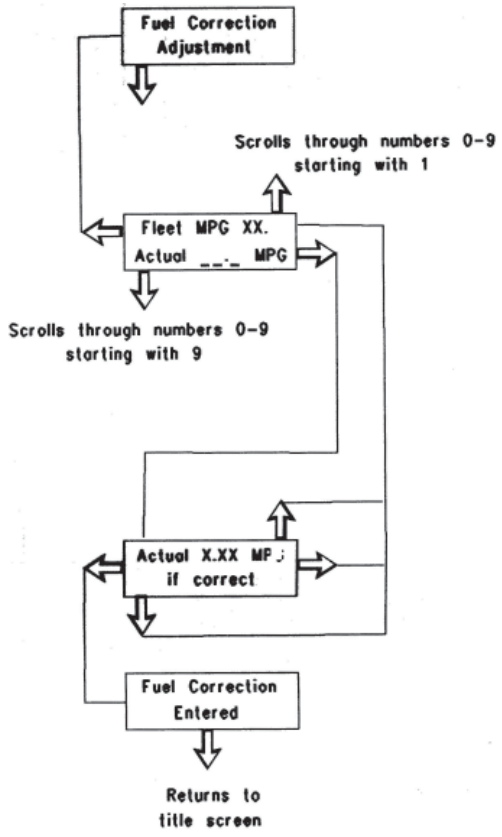


Figure 12

5-2.13 "Display Configuration" Screens

The language for the display can be selected by the driver. The three languages are English, French, or Spanish.

The units of measure for the display may be selected by the driver. There are four groups of units:

- English units ("miles", "US gallons", "psi", and "°F")
- English units ("miles", "Imperial gallons", "psi", and "°F")
- Metric units ("kilometers/liters", "kPa", and "°C")
- Metric units ("liters/100 kilometers", "liters", "kPa", and "°C")

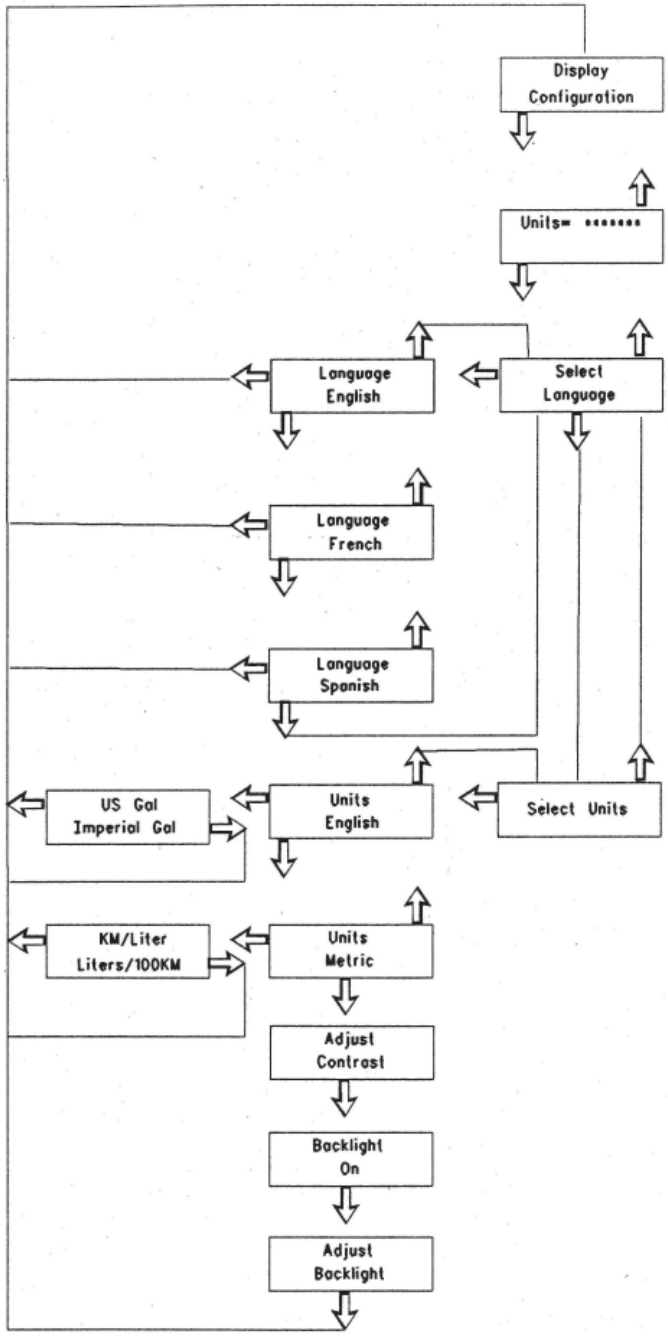


Figure 13 - Seeking Display Units

5-2.13.1 Units of Measure

From the “DISPLAY CONFIGURATION” title screen, press the Down arrow button. This screen displays the current units for the measurements.

Select the Display Language from the “DISPLAY CONFIGURATION” title screen. Press the Down arrow button two times. Once the “Select Language” screen appears, press the Left arrow button one time.

If the English language is desired, press the Left arrow button.

Press the Down arrow button from the “English” screen to go to the “French” screen. Now press the Left arrow button from this screen.

Press the Down arrow button twice from the “English” screen to go to the “Spanish” screen. Now press the Left arrow button from this screen.

5-2.13.2 Selecting the Display Units

From the “Display Configuration” title screen, press the Down arrow button three times. Once the “Select Units” screen appears, press the Left arrow button one time.

If English units are desired, press the Left arrow button and select the desired unit of measure (“US gallons” or “Imperial gallons”). If “Imperial Gallons” is selected, then an “IG” will be displayed to the driver. As an example, the display will show “MPIG”, “IGAL”, etc.

If Metric units are desired, press the Down arrow button from the “Units English” screen. Now, press the Left arrow button from this screen and select the desired units (“kilometers/liter” or “liters/100 kilometers”).

5-2.13.3 Adjusting the Brightness of the Display

The contrast may be adjusted by pressing and releasing the Right arrow button or the Left arrow button from the Adjust Contrast screen. The characters may be lightened by pressing and releasing the Left arrow button until the illumination is satisfactory. The background may be darkened by pressing and releasing the Right arrow until the background is satisfactory.

The Down arrow button may be used in order to change the backlight. The backlight may be turned off by pressing and releasing the Left arrow button. The backlight may be turned on by pressing and releasing the Right arrow button.

The backlight may be adjusted by pressing and releasing the Right arrow button or the Left arrow button. Pressing and releasing the Left arrow button will decrease the backlight. Pressing the releasing the Right arrow button will increase the backlight.

NOTE: The automatic dim feature will not function if the display has been placed in a manual dim mode. To reactivate the automatic dim feature, turn the power to the display OFF, then back ON.

5-2.14 “Driver Entry” Screens for the 3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, C-16, and 3406E Engines Only

5-2.14.1 Two Different DRIVER IDs

The Caterpillar 3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, C-16, and 3406E ECM can maintain information for two different DRIVER IDs at the same time. The ECM will separately store “Fleet Trip” information for each of the two drivers. This function is especially suited for slip seat or more than one driver per the vehicle. This function could also be used by the same driver to record vehicle operation over two legs of a trip. A single driver would use two different DRIVER IDs to identify each different leg of the trip. The DRIVER IDs should be chosen prior and entered into the display prior to operating the vehicle.

The Messenger display will indicate the last driver as the active driver in the system. If the Fleet Trip Segment has been reset, the display will indicate “NO ACTIVE DRIVER”. Press any button in order to continue.

The “Fleet Trip” information is unavailable for display on the Messenger display to either driver. This information is only available through use of the “Caterpillar Fleet Information Software” program.

5-2.14.2 Entering a New Driver ID

A maximum of two different DRIVER IDs may be used for each “Fleet Trip Segment”. If a third DRIVER ID is desired, the “Fleet Trip Segment” must be reset. After the “Fleet Trip Segment” has been reset, the previous DRIVER IDs are cleared. The two new DRIVER IDs may now be added to the next “Fleet Trip Segment”. Press the Up arrow button or press the Down arrow button in order to scroll through the letters A to Z. Press the Right arrow button and the Left arrow button in order to move between locations of the characters. Press the Up arrow button or the Down arrow button in order to scroll through numbers 0 to 9.

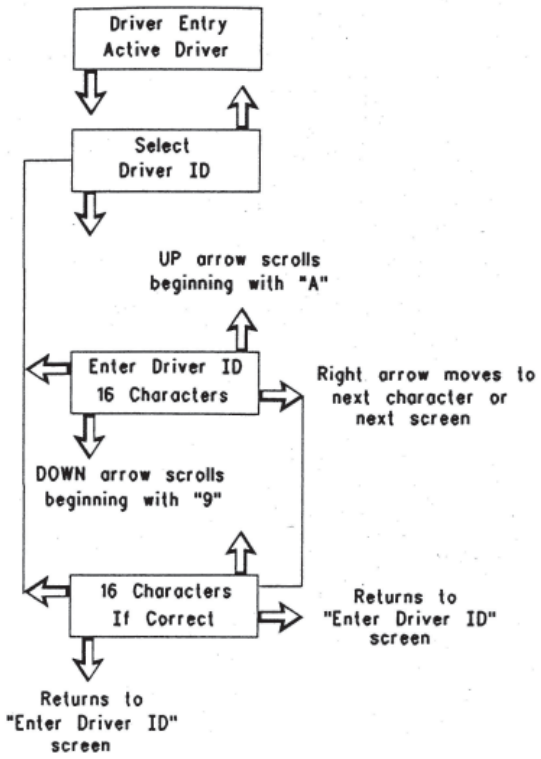


Figure 14 - Enter Identification of the driver.

5-2.14.2 “Selecting a Previously Entered DRIVER ID”

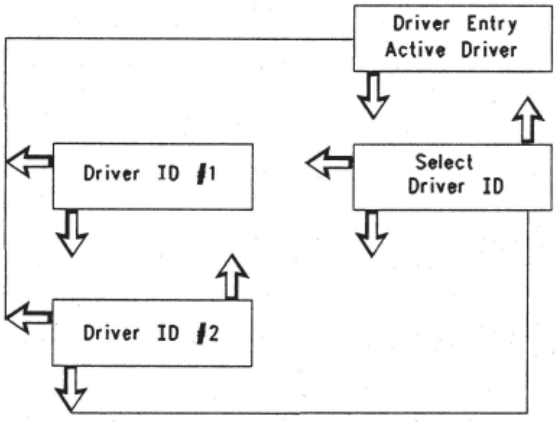


Figure 15 - Select the driver.

Only the DRIVER IDs that have been entered during the current “Fleet Trip Segment” may be viewed. The DRIVER ID may be toggled between drivers per the following instructions. Press the Down arrow button from the “Driver Entry” screen. The “SELECT DRIVER ID” screen will be shown. Press the Left arrow button. One of the two DRIVER IDs that were previously entered will be shown. A “NO DRIVER ID ENTERED!” message will appear if a DRIVER ID has not been entered. Pressing and releasing the Down arrow button will show any other DRIVER ID. Press and release the Left arrow button in order to select a DRIVER ID as the active driver.

Table 16 - “Driver Entry Screens Table”

Screen	Parameter	Description
“Driver Entry” “Active Driver”	“Driver Entry Title Screen”	This screen shows the current DRIVER IDs whenever the text for “ACTIVE DRIVER” is indicated. This is the second screen after the display is first powered up. This is shown automatically. Pressing any button will display the next screen in the power up sequence. Press the Left arrow button in order to move one column to the Left. Press the Down arrow button in order to select the DRIVER ID screen. If the “Fleet Trip” has been reset, the screen will indicate “NO ACTIVE DRIVER” when the “ACTIVE DRIVER” text is indicated.
“Select “ “DRIVER ID’”	“Select Previously Entered DRIVER ID”	Press the Left arrow button in order to select one of the two DRIVER IDs. The first DRIVER ID will be shown. If no DRIVER IDs have been entered, a message “NO DRIVER IDs ENTERED!” will appear. Press any button to go back to the “DRIVER ENTRY” title screen.
“DRIVER ID” #1	“Select DRIVER ID #1”	This screen shows the first DRIVER ID. The screen will indicate “DRIVER ID 1”. Press the Left arrow button in order to enter the ID code as the current driver. The display will begin recording information for this driver. Display returns to “DRIVER ENTRY” title screen.
“DRIVER ID” #2”	“Select DRIVER ID #2”	This screen shows the second DRIVER ID that was entered. Press the Left arrow button in order to enter this ID code as the current driver. The display will begin to record information on the second driver. Display returns to “DRIVER ENTRY” title screen.
“Enter DRIVER ID”	“Enter New DRIVER ID”	Press the Down arrow button or the Up arrow button in order to scroll through numbers 0 to 9. Press the Down arrow button or the Up arrow button in order to scroll through letters A to Z. The Right arrow button and Left arrow button move between locations for the characters. A space may be entered by moving through a space for a character without selecting a character. Press the Down arrow button and release the Down arrow button in order to scroll through the available characters. Press the Up arrow button and release the Up arrow button in order to scroll through the available characters. If two DRIVER IDs have been entered, a “MAX DRIVER IDs ENTERED!” message will appear. Press any button in order to return to the “DRIVER ENTRY” title screen. If no characters have been entered a message will appear. The display will show “A CHARACTER MUST BE ENTERED!” on the screen.
“If DRIVER ID Correct”	“Accept New DRIVER ID”	This screen shows the DRIVER ID that was entered. Press the Left arrow button in order to enter this DRIVER ID and return the display to the “DRIVER ENTRY” title screen. This ID code will be shown as the “Current Driver”. All vehicle data will be recorded to this driver. Press the Up, Down, or Right arrow button in order to return the display to the “ENTER NEW DRIVER ID” screen. This may be done in order to clear the DRIVER ID that was just entered.

5-2-15 State Crossing Screens

5-2.15.1 The 3176B, 3176C, C-10, C11, C-12, C13, C15, C-15, C-16, and 3406E Engines Only

The Messenger display will record information for the “Distance Traveled”, “Fuel Used”, “PTO Fuel Used”, and “Idle Fuel Used” in the United States or in Canada. The state must be entered in order for the display to record the information for the vehicle. The screen will show the last state that was entered into the display. This information is reset with the “Fleet Trip Segment”. The state selection should be performed when the vehicle is not moving. All fifty US states and twelve Canadian provinces are provided in this display.

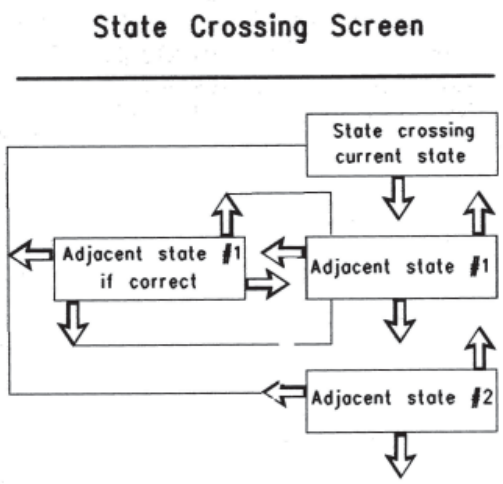
5-2.15.2 Accessing State Crossings

"ECM Customer Programmable Parameters" determine the access to this function of the dash display. If information for the state is programmed OFF, the entire "State Crossing" column will not be shown. Press the Right arrow button from the "DRIVER ENTRY" title screen. Press the Left from the "INSTANTANEOUS DATA" title screen. This will cause the display to skip the STATE CROSSING screen.

After programming the parameters in the ECM, the power must be turned OFF and the power turned ON again in order for the display to recognize the change.

5-2.15.3 Selecting a State

The STATE CROSSING title screen displays the currently selected state. This is illustrated as the "CURRENT STATE" in Figure 16. Press the Down arrow button in order to show more states. The display will list all adjacent states to the current state first. The display will list all adjacent states in an alphabetical order to the current state. Press the Up and Down arrow buttons in order to scroll through the list.



Available states are listed alphabetically
Figure 16

Continue to scroll through the list of adjacent states in order to select a state that is not adjacent to the current state. The list will start with a full alphabetical list of all available states and provinces.

When the desired state is displayed, press the Left arrow button. The display will again show the selected state. Press the Left arrow button in order to enter the displayed state as the current state. Press any other button in order to select a different state.

Table 17 - "State Entry Screens"

Screen	Parameter	Description
"State Crossing" "Current State"	State Crossing Title Screen	This screen shows the "Current State" of operation. If a state has not been entered, the message "No Active State" will appear. The "No Active State" will occur only with a new display until one state is entered. The screen will be automatically shown when the display is first powered up. This screen will be shown after the "Active Driver" screen. Press any button in order to show the next screen in the power up sequence. If the "Fleet Trip" information has been reset, the current state is maintained. Press the Left arrow button in order to move one column to the Left. Press the Right arrow button in order to move one column to the Right. Press the Down arrow button in order to select another state. Fifty entries for "State Crossing" are the maximum number that is allowed until the display is reset. A "STATES ALLOWED EXCEEDED!" message will appear after the entry of fifty. Press any button in order to return to the STATE CROSSING title screen. The display will not allow the addition of any additional "State Crossings" until the "Fleet Trip" has been reset.
"Adjacent State #1"	"Select a different state"	Press the Up arrow button or press the Down arrow button in order to scroll through the list of states. The display will list all adjacent states to the current state first. The display will list all adjacent states in an alphabetical order to the current state. When adjacent states are exhausted, the display begins listing all states in alphabetical order. Press the Left arrow button in order to select the desired state. The Up and Down arrow buttons will scroll forward and backward through the list.
"Adjacent State #1 if Correct"	"Enter selected state"	This screen shows the state that was just selected. If this state is desired, press the Left arrow button and display returns to STATE CROSSING title screen with this state as the "Current State". If this state is incorrect, press any arrow button in order to return to the list of states.

5-2.16 Troubleshooting

The following is a list of possible problems that may occur.

1. Unable to Read Characters on the Display

Probable Cause

- Portions of the display may not light. Part of a character is missing, etc. The unit must be replaced.

2. The Display May Not Have Power

Probable Cause

- Make sure that the ON button has been pressed.
- Loose power or loose ground connections to the display.
- The vehicle battery is dead.
- After checking the above items, if condition still exists refer to Step 1 of Diagnostic Test.

3. No Data Link Communication

Probable Cause

- No connection or an intermittent connection in one of the two Data Link lines to the engine ECM
- Connection to the J1922 Data Link or the J1939 Data Link instead of the J1708 ATA Data Link
- The data link lines must be the twisted pair.
- The engine has no power, intermittent power, or poor ground connections to the engine ECM. After checking the above items, if a condition still exists refer to Step 4 of the Diagnostic Test.

4. All Data Except Lifetime Totals Has Been Reset

Probable Cause

- The unswitched battery connection to the engine ECM is disconnected. This is possibly due to vehicle service or a battery disconnect switch.
- The data has been intentionally reset with the display. “Caterpillar Fleet Information Software”, or the electronic service tool. Determine the reason for the reset and avoid the conditions that caused this event. If a different system problem is suspected, consult a qualified service center.

5. The Fleet, Driver Trip Data, and Lifetime Totals Have Been Reset

Probable Cause

- The engine ECM was recently replaced. Determine the reason for the reset and avoid the conditions that caused this event. If a different system problem is suspected, consult a qualified service center.

6. The Driver is unable to adjust the Fleet Trip or unable to reset the maintenance. The driver is unable to reset the “Fuel Correction”.

Probable Cause

- The ECM parameters are programmed to prevent the reset of these parameters by the customer. The electronic service tool and authorization from the owner will be necessary to reset the ECM. This will allow access to these functions from the display.
- The power to the display was turned OFF and the power was turned ON in order for the display to recognize the charge.

7. The Driver is unable to access the “Fleet Trip State Totals” and “State Crossing” Information.

Probable Cause

- The ECM parameters are programmed OFF in order to prevent access to this information. The electronic service tool and authorization from the owner will be necessary to reset the ECM. This will allow access to this information.
- The power must be turned OFF and the power turned ON in order for the display to recognize any changes to the ECM.

8. Certain “Instantaneous Data” Parameters Appear to be Unavailable.

- This information is not available on the data link. Verify that the appropriate sensors are installed. For example, if Ambient Air Temperature is not shown by the display, verify that an Ambient Air Sensor is installed on the vehicle.

9. The Display Will Not Become Dim on the Circuit for the Panel Dimmer

- The dimmer circuit on the vehicle is not a Pulse Width Modulated (PWM) circuit. Contact the vehicle manufacturer in order to determine if the vehicle has a PWM dimmer circuit.

Table 18

"Parameter"	Available Range or Options	Default
"SELECTED ENGINE RATING"		
"Rating Number"	Dependent on engine power	
"Multitorque Ratio"	Unavailable (Standard Ratings) "MT-A" "MT-B" "MT-C"	Unavailable (Standard Ratings) "MT-A" (Multitorque Ratings)
"ECM IDENTIFICATION PARAMETERS"		
"Vehicle ID"	17 Digits Available characters are dependent on the service tools	all zeroes
"SECURITY ACCESS PARAMETERS"		
"ECM Wireless Communication Enable"	"No" "Yes"	"No"
"SECURITY ACCESS PARAMETERS"		
"Vehicle Speed Calibration"	2485 to 93226 PPKM (4000 to 150000 PPM)	Not Programmed
"Vehicle Speed Cal (J1939 - Trans)"	0 to 430000 revolutions per km (0 to 65000 revolutions per mile)	Not Programmed
"Vehicle Speed Cal (J1939 - ABS)"	0 to 6.550	Not Programmed
"Vehicle Speed Limit"	48 to 204 km/h (30 to 127 mph)	204 km/h (127 mph)
"VSL Protection"	1000 to TEL rpm	TEL rpm
"Tachometer Calibration"	12.0 to 500.0 pulses per revolution	113.0 pulses per revolution
"Soft Vehicle Speed Limit"	"No" "Yes"	"No"
"Two Speed Axle - Low Speed Range Axle Ratio"	1.00 to 19.99	1.00
"Nominal Axle Ratio - High Speed Range Axle Ratio"	1.0 to 9.99	1.00
"CRUISE CONTROL PARAMETERS"		
"Low Cruise Control Speed Set Limit"	24 to 204 km/h (15 to 127 mph)	204 km/h (127 mph)
"High Cruise Control Speed Set Limit"	48 to 204 km/h (30 to 127 mph)	204 km/h (127 mph)
"Engine Retarder Mode"	"Coast" "Latch" "Manual"	"Manual"
"Engine Retarder Minimum VSL Type"	"Hard Limit" "Soft Limit"	"Hard Limit"
"Engine Retarder Minimum Vehicle Speed"	0 to 204 km/h (0 to 127 mph)	0 km/h (0 mph)
"Auto Retarder in Cruise (0 - Off)"	0 to 16 km/h (0 to 10 mph)	0 km/h (0 mph)
"Auto Retarder in Cruise Increment"	0 to 8 km/h (0 to 5 mph)	3 km/h (2 mph)
"Cruise/ Idle/PTO Switch Configuration"	"Set/Accel-Res/Decel" "Set/Decel-Res/Accel"	"Set/Accel-Res/Decel"
"Soft Cruise Control"	"No" "Yes"	"Yes"
"Adaptive Cruise Control Enable"	"Disabled" "Enabled"	"Disabled"

Table 18 - Continued

"Parameter"	Available Range or Options	Default
"IDLE PARAMETERS"		
"Idle Vehicle Speed Limit"	2 to 24 km/h (1 to 15 mph)	2 km/h (1 mph)
"Idle RPM Limit"	Low Idle to 2120 rpm	2120 rpm
"Idle/PTO RPM Ramp Rate"	5 to 1000 rpm/sec	50 rpm/sec
"Idle/PTO Bump RPM"	5 to 500 rpm	20 rpm
"DEDICATED PTO PARAMETERS"		
"PTO Configuration"	"Cab Switches" "Off" "Remote Switches" "Remote Throttle"	"Off"
"PTO Top Engine Limit"	Low Idle to 2120 rpm	2120 rpm
"PTO Engine RPM Set Speed (0 - Off)"	Low Idle to PTO TEL rpm	0
"PTO Engine RPM Set Speed A"	Low Idle to PTO TEL rpm	0
"PTO Engine RPM Set Speed B"	Low Idle to PTO TEL rpm	0
"PTO to Set Speed"	"No" "Yes"	"No"
"Maximum PTO Enable Speed"	Low Idle to PTO TEL rpm	PTO TEL rpm
"PTO Cab Controls RPM Limit"	"Low Idle" "TEL" "PTO TEL"	"TEL"
"PTO Kickout Vehicle Speed Limit"	2 to 204 km/h (1 to 127 mph)	2 km/h (1 mph)
"Max PTO Vehicle Speed"	24 to 204 km/h (15 to 127 mph)	204 km/h (127 mph)
"Torque Limit"	270 N•m (200 lb ft) to Rated Torque	3400 N•m (2500 lb ft)
"PTO Shutdown Time (0 - Off)"	3 to 1440 minutes	0
"PTO Shutdown Timer Maximum RPM"	600 to PTO TEL rpm	PTO TEL rpm
"PTO Activates Cooling Fan"	"Continuous" "Normal"	"Normal"
"ENGINE/GEAR PARAMETERS"		
"Lower Gears Engine RPM Limit"	1100 to TEL rpm	TEL rpm
"Lower Gears Turn Off Speed"	5 to 48 km/h (3 to 30 mph)	5 km/h (3 mph)
"Intermediate Gears Engine RPM Limit"	1100 to TEL rpm	TEL rpm
"Intermediate Gears Turn Off Speed"	8 to 80 km/h (5 to 50 mph)	8 km/h (5 mph)
"Gear Down Protection RPM Limit"	1300 to TEL rpm	TEL rpm
"Gear Down Protection Turn On Speed"	48 to 204 km/h (30 to 127 mph)	204 km/h (127 mph)
"Low Idle Engine RPM"	600 to 750 rpm	600 rpm
"Transmission Style"	"Automatic Option 1" "Automatic Option 2" "Automatic Option 3" "Automatic Option 4" "Eaton Top 2" "Manual Option 1"	"Manual Option 1"

Table 18 - Continued

"Parameter"	Available Range or Options	Default
"ENGINE/GEAR PARAMETERS" - Continued		
"Eaton Top 2 Override with Cruise Switch"	"No" "Yes"	"No"
"Top Gear Ratio"	0.000 to 3.750	0.000
"Top Gear Minus One Ratio"	0.000 to 3.750	0.000
"Top Gear Minus Two Ratio"	0.000 to 3.750	0.000
"Governor Type"	"Full Range" "Min/Max" "Min/Max with Speed Control"	"Full Range"
"TIMER PARAMETERS"		
"Idle Shutdown Time (0 - Off)"	3 to 1440 minutes	0 minutes
"Idle Shutdown Timer Maximum RPM"	Low Idle to 2120 rpm	2120 rpm
"Allow Idle Shutdown Override"	"J1587 Outside Temp Based" "No" "Outside Temperature Based" "Yes"	"Yes"
"Minimum Idle Shutdown Outside Temp"	-40° to 49°C (-40° to 120°F)	49°C (120°F)
"Maximum Idle Shutdown Outside Temp"	-40° to 49°C (-40° to 120°F)	49°C (120°F)
"A/C Switch Fan On - Time (0 - Off)"	1 to 600 seconds	0 seconds
"Fan with Engine Retarder in High Mode"	"No" "Yes"	"No"
"Engine Retarder Only"	0.0 to 3.0 seconds	0.0 seconds
"SMART IDLE PARAMETERS"		
"Battery Monitor and Engine Control Voltages"	0 to 25.5 volts	0.0 volts
"ENGINE MONITORING PARAMETERS"		
"Engine Monitoring Mode"	"Derate" "Shutdown" "Warning"	"Warning"
"Engine Monitoring Lamps"	"Option 1" "Warning Lamp"	"Warning Lamp"
"Coolant Level Sensor"	"2-wire Float Sensor" "4-pin" "No"	"No"
"Engine Coolant Temperature Derate Enable Status"	"Disabled" "Enabled"	"Disabled"

Table 18 - Continued

"Parameter"	Available Range or Options	Default
"MAINTENANCE PARAMETERS"		
"Maintenance Indicator Mode"	"Automatic Distance" "Automatic Hours" "Manual Distance" "Manual Hours" "Off"	"Off"
"PM 1 Interval (Manual Maintenance Indicator Mode)"	8050 to 56325 km (5000 to 35000 miles) 100 to 750 hours	2140 km (15000 miles) 250 hours
"Engine Oil Capacity"	19 to 57 L (20 to 60 qt)	C11, C13, 34 L (36 qt)
"TRIP PARAMETERS"		
"Fuel Correction Factor"	-63 to 63.5%	0%
"Dash-Change Fuel Correction Factor"	"No" "Yes"	"No"
"Dash-PM 1 Reset"	"No" "Yes"	"No"
"Dash-Fleet Trip Reset"	"No" "Yes"	"No"
"Dash-State Selection"	"No" "Yes"	"Yes"
"Theft Deterrent System Control"	"Auto-Enable" "No" "Yes"	"No"
"Theft Deterrent Password"	Four Characters	0000
"Quick Stop Rate"	5 to 24 km/h per sec (3 to 15 mph per sec)	0 km/h per sec (0 mph per sec)
"Vehicle Overspeed Threshold"	48 to 204 km/h (30 to 127 mph)	204 km/h (127 mph)
"VEHICLE ACTIVITY REPORT PARAMETERS"		
"Minimum Idle Time (0 - Off)"	0 to 1440 minutes	0 minutes
"DRIVER REWARD"		
"Driver Reward Enable"	"Disabled" "Enabled"	"Enabled"
"INPUT SELECTIONS"		
"Fan Override Switch"	"J1/P1:46" "J1/P1:47" "J1/P1:6" "J1/P1:7" "J1939 - Body Controller" "J1939 - Cab Controller" "J1939 - Instrument Cluster" "None"	"None"
"Transmission Neutral Switch"	"None" "J1939" "J1/P1:62"	"None"
"Ignore Brake/Clutch Switch"	"J1/P1:7" "None"	"None"

Table 18 - Continued

"Parameter"	Available Range or Options	Default
"INPUT SELECTIONS" - Continued		
"Torque Limit Switch"	"J1/P1:7" "None"	"None"
"Diagnostic Enable"	"J1/P1:7" "J1939 - Body Controller" "J1939 - Cab Controller" "J1939 - Instrument Cluster" "None"	"None"
"PTO On/Off Switch"	"J1/P1:56" "J1939 - Cab Controller" "J1939 - Body Controller" "J1939 - Instrument Cluster" "None"	"J1/P1:56"
"Remote PTO Set Switch"	"J1/P1:58" "J1939 - Body Controller" "J1939 - Cab Controller" "J1939 - Instrument Cluster" "None"	"J1/P1:58"
"Remove PTO Resume Switch"	"J1/P1:60" "J1939 - Body Controller" "J1939 - Cab Controller" "J1939 - Instrument Cluster" "None"	"J1/P1:60"
"PTO Engine RPM Set Speed Input A"	"J1/P1:46" "J1/P1:58" "J1/P1:6" "J1/P1:60" "J1939 - Body Controller" "J1939 - Cab Controller" "J1939 - Instrument Cluster" "None"	"None"
"PTO Engine RPM Set Speed Iput B"	"J1/P1:46" "J1/P1:58" "J1/P1:6" "J1/P1:60" "None"	"None"
"Starting Aid On/Off Switch"	"J1/P1:46" "J1/P1:47" "J1/P1:6" "J1/P1:7" "None"	"None"
"Two-Speed Axle Switch"	"J1/P1:6" "J1939 - Body Controller" "J1939 - Cab Controller" "J1939 - Instrument Cluster" "None"	"None"
"Cruise Control On/Off Switch"	"J1/P1:59" "J1939 - Body Controller" "J1939 - Cab Controller" "J1939 - Instrument Cluster"	"J1/P1:59"

Table 18 - Continued

"Parameter"	Available Range or Options	Default
"INPUT SELECTIONS" - Continued		
"Cruise Control Set/Resume/Accel/ Decel Switch"	"J1/P1:35 & 44" "J1939 - Cab Controller" "J1939 - Body Controller" "J1939 - Instrument Cluster"	"J1/P1:35 & 44"
"Cruise Control Pause Switch"	"J1939 - Body Controller" "J1939 - Cab Controller" "J1939 - Instrument Cluster" "None"	"None"
"Clutch Pedal Position Switch"	"J1/P1:22" "J1939 - Body Controller" "J1939 - Cab Controller" "J1939 - Instrument Cluster"	"J1/P1:22"
"Retarder Off/Low/Medium/High Switch"	"J1/P1:23 & 40" "J1939 - Body Controller" "J1939 - Cab Controller" "J1939 - Instrument Cluster"	"J1/P1:23 & 40"
"Service Brake Pedal Position Switch #1"	"J1/P1:45" "J1939 - Body Controller" "J1939 - Cab Controller" "J1939 - Instrument Cluster"	"J1/P1:45"
"Accelerator Pedal Position"	"J1/P1:66"	"J1/P1:66"
"Vehicle Speed Input"	"J1/P1:32 & 33" "J1939 - ABS" "J1939 - Trans"	"J1/P1:32 & 33"
"OUTPUT SELECTIONS"		
"Engine Running Output"	"J1/P1:10" "J1/P1:12" "J1/P1:13" "None"	"None"
"Engine Shutdown Output"	"J1/P1:10" "J1/P1:12" "J1/P1:13" "None"	"None"
"Auxiliary Brake"	"J1/P1:12" "None"	"None"
"Starting Aid Output"	"J1/P1:10" "J1/P1:12" "J1/P1:13" "None"	"None"
"Air Inlet Shutoff Relay Control"	"J2/P2:13" "None"	"None"

Table 18 - Continued

"Parameter"	Available Range or Options	Default
"OUTPUT SELECTIONS" - Continued		
"Fan Control Type"	"None" "On/Off PWM" "On/Off DC" "Three-Speed Fan PWM" "Three-Speed Fan DC" "Variable Speed Fan Option S"	"None"
"PTO Active Output"	"J1/P1:19" "None"	"None"
"CUSTOMER PASSWORDS"		
"Customer Password #1"	8 Digits Available characters are dependent on the service tools.	Not Programmed
"Customer Password #2"		
"DATA LINK PARAMETERS"		
"Power Train Data Link"	"J1939" "None"	"J1939"

Customer Specified Parameters Worksheet

Table 19

"SELECTED ENGINE RATING"	
"Rating Number"	
"Rating Type"	
"Multitorque Ratio"	
"Advertised Power"	
"Governed Speed"	
"Rated Peak Torque"	
"Top Engine Speed Range"	
"Test Spec"	

Table 20

"ECM IDENTIFICATION PARAMETERS"	
"Vehicle ID"	
"Engine Serial Number"	
"ECM Serial Number"	
"Personality Module Part Number"	
Personality Module Release Date"	

Table 21

"SECURITY ACCESS PARAMETERS"	
"Total Tattletale"	
"Last Tool to change Customer Parameters"	
"Last Tool to change System Parameters"	
"ECM Wireless Communication Enable"	

Table 22

"SECURITY ACCESS PARAMETERS"	
"Vehicle Speed Calibration"	
"Vehicle Speed Cal (J1939) - Trans)"	
"Vehicle Speed Cal (J1939) - ABS"	
"Vehicle Speed Limit" (VSL)	
"VSL Protection"	
"Tachometer Calibration"	
"Soft Vehicle Speed Limit"	
"Two Speed Axle - Low Speed Range Axle Ratio"	
"Nominal Axle Ratio - High Speed Range Axle Ratio"	

Table 23

"CRUISE CONTROL PARAMETERS"	
"Low Cruise Control Speed Set Limit"	
"High Cruise Control Speed Set Limit"	
"Engine Retarder Mode"	
"Engine Retarder Minimum VSL Type"	
"Engine Retarder Minimum Vehicle Speed"	
"Auto Retarder in Cruise (0 - Off)"	
"Auto Retarder in Cruise Increment"	
"Cruise/Idle/PTO Switch Configuration"	
"Soft Cruise Control"	
"Adaptive Cruise Control Enable"	

Table 24

"IDLE PARAMETERS"	
"Idle Vehicle Speed Limit"	
"Idle RPM Limit"	
"Idle/PTO RPM Ramp Rate"	
"Idle/PTO Bump RPM"	

Table 25

"DEDICATED PTO PARAMETERS"	
"PTO Configuration"	
"PTO Top Engine Limit"	
"PTO Engine RPM Set Speed (0 - Off)"	
"PTO Engine RPM Set Speed"	
"PTO Engine RPM Set Speed A"	
"PTO Engine RPM Set Speed B"	
"PTO to Set Speed"	
"Maximum PTO Enable Speed"	
"PTO Cab Controls RPM Limit"	
"PTO Kickout Vehicle Speed Limit"	
"Max PTO Vehicle Speed"	
"Torque Limit"	
"PTO Shutdown Time (0 - Off)"	
"PTO Shutdown Timer Maximum RPM"	
"PTO Activates Cooling Fan"	

Table 26

"ENGINE/GEAR PARAMETERS"	
"Lower Gears Engine RPM Limit"	
"Lower Gears Turn Off Speed"	
"Intermediate Gears Engine RPM LImit"	
"Intermediate Gears Turn Off Speed"	
"Gear Down Protection RPM Limit"	
"Gear Down Protection Turn On Speed"	
"Low Idle Engine RPM"	
"Transmission Style"	
Eaton Top 2 Override with Cruise Switch	
"Top Gear Ratio"	
"Top Gear Minus One Ratio"	
"Top Gear Minus Two Ratio"	
"Governor Type"	

Table 27

"TIMER PARAMETERS"	
"Idle Shutdown Time (0 = Off)"	
"Idle Shutdown Timer Maximum RPM"	
"Allow Idle Shutdown Override"	
"Minimum Idle Shutdown Outside Temp"	
"Maximum Idle Shutdown Outside Temp"	
"A/C Switch Fan On-Time (0 = Off)"	
"Fan with Engine Retarder in High Mode"	
"Engine Retarder Delay"	

Table 28

"SMART IDLE PARAMETERS"	
"Battery Monitor and Engine Control Voltage"	

Table 29

"ENGINE MONITORING PARAMETERS"	
"Engine Monitoring Mode"	
"Engine Monitoring Lamps"	
"Coolant Level Sensor"	
"Engine Coolant Temperature Derate Enable Status"	

Table 30

"MAINTENANCE PARAMETERS"	
"Maintenance Indicator Mode"	
"PM 1 Interval"	
"Engine Oil Capacity"	

Table 31

"TRIP PARAMETERS"	
"Fuel Correction Factor"	
"Dash - Change Fuel Correction Factor"	
"Dash - PM 1 Reset"	
"Dash - Fleet Trip Reset"	
"Dash - State Selection"	
"Theft Deterrent System Control"	
"Theft Deterrent Password"	
"Quick Stop Rate"	
"Vehicle Overspeed Threshold"	

Table 32

"VEHICLE ACTIVITY REPORT PARAMETERS"	
"Minimum Idle Time (0 = Off)"	

Table 33

"DRIVER REWARD"	
"Driver Reward Enable"	

Table 34

"INPUT SELECTIONS"	
"Fan Override Switch"	
"Transmission Neutral Switch"	
"Ignore Brake/Clutch Switch"	
"Torque Limit Switch"	
"Diagnostic Enable"	
"PTO On/Off Switch"	
"Remote PTO Set Switch"	
"Remote PTO Resume Switch"	
"PTO Engine RPM Set Speed Input A"	
"PTO Engine RPM Set Speed Input B"	
"Starting Aid On/Off Switch"	
"Two Speed Axle Switch"	
"Cruise Control On/Off Switch"	
"Cruise Control Set/Resume/Accel/ Decel Switch"	
"Cruise Control Pause Switch"	
"Clutch Pedal Position Switch"	
"Retarder Off/Low/Medium/High Switch"	
"Service Brake Pedal Position Switch #1"	
"Accelerator Pedal Position"	
"Vehicle Speed Input"	

Table 35

"OUTPUT SELECTIONS"	
"Engine Running Output"	
"Engine Shutdown Output"	
"Auxiliary Brake"	
"Starting Aid Output"	
"Air Inlet Shutoff Relay Control"	
"Fan Control Type"	
"PTO Active Output"	

Table 36

"CUSTOMER PASSWORDS"	
"Customer Password #1"	
"Customer Password #2"	

Table 37

"DATA LINK PARAMETERS"	
"Powertrain Data Link	

Lifetime Totals Worksheet

Table 38

"LIFETIME TOTALS WORKSHEET"	
Total Time	
Total PTO Time	
Total Idle Time	
Total Distance	
Total Fuel	
Total PTO Fuel	
Total Idle Fuel	
Total Maximum Fuel	
Average Load Factor	

5-2.17 Diagnostic Test

Table 39

"Test"	"Result"	"Action"
"Check Electrical Connectors and Wiring" Follow the wiring harness for the display and locate the connector from the display to the vehicle. Inspect the wiring harness for evidence of wear through the harness bundle. Check the harness connector. Ensure that the connector is properly locked. Pull on each of the wires in the connector. Refer to Troubleshooting "Electrical Connectors-Inspect" for additional information.	**"OK"**	**"Proceed to next step."**
	"Not OK"	**Repair the problem. If conditions are not resolved then proceed to next step.**
"Check Battery Voltage at Vehicle Connector" Turn the ignition key OFF and disconnect the dash display connector. Turn the ignition key ON and measure the DC voltage. Use a voltmeter in order to measure the DC voltage from pin 3 (red wire from display) to pin 4 (black wire from display) of the vehicle connector. The battery voltage should be 11 to 13.5 Volts DC. Pull on each of the wires in the connector. Inspect batteries, wiring, and connectors.	**"OK"**	**"Proceed to next step."**
	"Not OK"	**Repair the problem. If conditions are not resolved then proceed to next step.**
"Connect Display to 12 Volt Power Source" Disconnect display from vehicle wiring and connect to another 12 Volt DC power source. Connect pin 3 (red wire from display) to the positive terminal (+ Battery) of the power source. Connect pin 4 (black wire from display) to the negative terminal "(-Battery)" of the power source. The display should illuminate. The display will not communicate until the display is connected to the data link. Check wiring, connectors, or the vehicle battery for damage.	**"OK"**	**Repair the components or replace the components, as required, proceed to next step.**
	"Not OK"	**Display is fault.**
"Connect Display to Another Data Link Connector" Disconnect display from the vehicle wiring harness. Connect the display to the other data link connector. The display will activate when the display is connected to the proper data link. The display will communicate when the display is connected to the proper data link. Connect the electronic service tool to the cab Data Link connector. Turn the ignition key ON in order to verify that the data link is functional. . .Verify that the connections to the display are not connected to the J1922 Data Link or the J1939 Data Link. If a cab data link connector is not available, connect the electronic service tool directly to the engine ECM. Verify that the electronic service tool functions. Configure a harness adapter to go from the Data Link connector for the display to the appropriate data link connector. Refer to the "Harness Adapter Diagrams" in order to view the pin-out for some common Data Link connectors. Check the display's wiring or connectors for damage.	**"OK"**	**Repair the components or replace the components, as required.**
	"Not OK"	**Proceed to the next step.**

5-2.18 General Information

5-2.18.1 Components for the Messenger Display

Table 40

Callout	Description	Quantity
1	Messenger Display	1
2	Buttons	1
3	Mounting Bracket	2
4	#6 Pan Head Screw	4
5	Gimbal Mounting Bracket	1

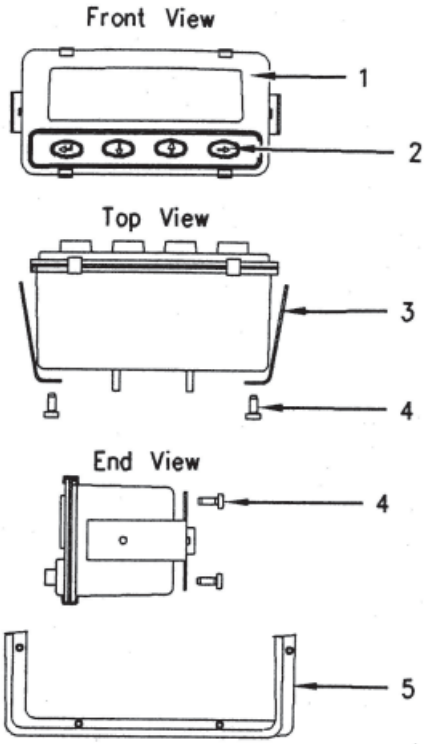


Figure 17

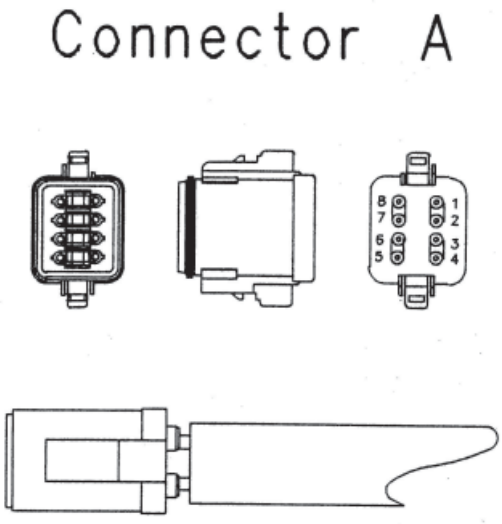


Figure 18

Table 41

"CONNECTOR A WIRE TABLE"		
"Signal ID"	Pin #	Color
CDL/ATA+	1	Yellow
CDL/ATA-	2	Lt. Blue
+Battery	3	Red
Battery Ground	4	Black
Dimmer	5	Purple
Plugged	6	*

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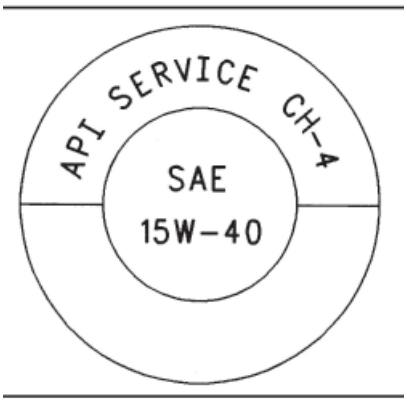
5-3 Engine Maintenance

5-3.1 Refill Capacities and Recommendations

5-3.1.1 Engine Oil



Typical API Symbol

API Oils

The Engine Oil Licensing and Certification System by the American Petroleum Institute (API) is recognized by Caterpillar. For detailed information about this system, see the latest edition of the “API publication No. 1509”. Engine oils that bear the API symbol are authorized by API.

Diesel engine oils, CC, CD, CD-2, and CE have not been API authorized classifications since January 1, 1996. The API Classification Table that follows summarizes the status of the classifications.

API Classifications	
Current	**Obsolete**
C1-4(1), CH-4(1), CG-4(2), CF-4(3)	CE
CF(4)	CC, CD
CF-2(5)	CD-2(5)

(1) API-CH-4 and CI-4 oils are acceptable if the requirements of Caterpillar’s ECF-1 (Engine Crankcase Fluid specifications-1) are met. CH-4 and CI-4 oils that have not met the requirements of Caterpillar’s ECF-1 Specification may cause reduced engine life.

(2) API CG-4 oils are acceptable for all Caterpillar diesel engines. When the API CG-4 oils are used, the oil drain interval should not exceed 75 Percent of the standard oil drain interval for your engine.

(3) API CF-4 oils are no longer recommended for Caterpillar on-highway diesel engines.

(4) API CF oils are not recommended for Caterpillar on-highway diesel engines.

(5) API CF-2 and CD-2 oils are classifications for two-cycle diesel engines. Caterpillar does not sell engines that utilize the CD-2 and the API CF-2 oils.

5-3.1.2 Caterpillar Diesel Engine Oil (DEO)

Caterpillar Oils have been developed and tested in order to provide the full performance and service life that has been designed and built into Caterpillar Engines. Caterpillar Oils are currently used to fill diesel engines at the factory. These oils are offered by Caterpillar dealers for continued use when the engine oil is changed. Consult your Caterpillar dealer for more information on these oils.

Due to significant variations in the quality and in the performance of commercially available oils, Caterpillar makes the following recommendations:

- Caterpillar Diesel Engine Oil (DEO) (10W-30)
- Caterpillar Diesel Engine Oil (DEO) (15W-40)

5-3.1.3 Lubricant Viscosity Recommendations

The proper SAE viscosity grade of oil is determined by the minimum ambient temperature during cold engine start-up, and the maximum ambient temperature during engine operation.

Refer the following table (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to this table in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

NOTE: Generally, use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

If ambient temperature conditions at engine start-up require the use of multigrade SAE 0W oil, SAE 0W-40 viscosity grade is preferred over SAE 0W-20 or SAE 0W-30.

NOTE: SAE 10W-30 is the preferred viscosity grade for the following diesel engines when the ambient temperature is above -18°C (0°F) and below 40°C (104°F).

Engine Oil Viscosities for Ambient Temperatures [1]

	Ambient Temperature	
Viscosity Grade	**Minimum**	**Maximum**
SAE 0W-20	-40°C (-40°F)	10°C (50°F)
SAE 0W-30	-40°C (-40°F)	30°C (86°F)
SAE 0W-40	-40°C (-40°F)	40°C (104°F)
SAE 5W-30	-30°C (-22°F)	30°C (86°F)
SAE 5W-40	-30°C (-22°F)	50°C (122°F)
SAE 10W-30	-18°C (0°F)	40°C (104°F)
SAE 10W-40	-18°C (0°F)	50°C (122°F)
SAE 15W-40	-9.5°C (15°F)	50°C (122°F)

NOTE: Supplemental heat is recommended below the minimum recommended ambient temperature.

5-3.1.4 S•O•S Oil Analysis

Caterpillar has developed a tool for maintenance management that evaluates oil degradation and the tool also detects the early signs of wear in internal components. The Caterpillar tool for oil analysis is called S•O•S Analysis and the tool is part of the S•O•S Services program. S•O•S Oil Analysis divides oil analysis into three categories:

- Wear Analysis
- Oil Condition
- Additional Tests

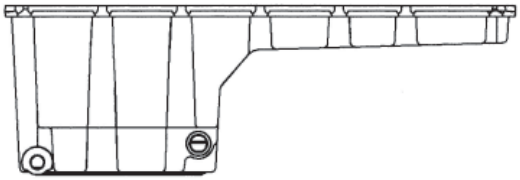
The wear analysis monitors metal particles, some oil additives, and some contaminants.

Oil condition uses infrared (IR) analysis to evaluate the chemistry of the oil. Infrared analysis is also used to detect certain types of contamination.

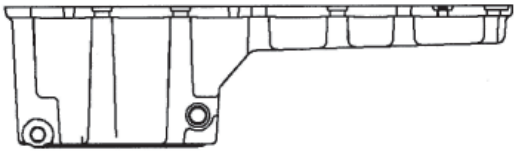
Additional tests are used to measure contamination levels from water, fuel, or coolant. Oil viscosity and corrosion protection can be evaluated, as needed.

5-3.1.5 Refill Capacities (Engine Oil)

The refill capacities for the engine crankcase reflect the approximate capacity of the crankcase or sump plus standard oil filters. Auxiliary oil filter systems will require additional oil.



C11 and C13 - 210-1745 Pan (Deep-Standard) This plan has an overall height of 335 mm (13.2 inch).



C11 and C13 - 240-3277 Pan (Shallow-Optional) This pan has an overall height of 278 mm (10.9 inch).

Approximate Refill Capacities of the Engine Lubrication System	
Compartment or System	**C13**
Standard-Deep Oil Sump (1)	40L (42 qt)
Shallow Oil Sump (1)	34L (36 qt)
Capacity of the Auxiliary Oil Filter System(2)	
Total Capacity of the Lubrication System(3)	

(1) Approximate sump capacity of the crankcase includes standard oil filters that are factory installed. Engines with auxiliary oil filters will require additional oil. Optional bypass oil filters that are supplied by Caterpillar require an additional 2.5 L (2.6 qt) of oil. If the engine is equipped with another type of auxiliary oil filter, refer to the OEM specifications for that capacity of the auxiliary oil filter.

(2) Fill in the capacity of the auxiliary oil filter system (if equipped) in the space that is provided.

(3) Fill in the total capacity of the lubrication system. Add the auxiliary oil filter system to the correct capacity of the oil sump in order to find the total capacity of the lubrication system.

5-3.1.6 Lubricating Grease

Caterpillar provides a range of moderate greases to extremely high performance greases in order to service the entire line of Caterpillar products that operate throughout the wide variety of climates. From this variety of Caterpillar grease products, you will find at least one of the Caterpillar greases that will meet or exceed the performance requirements for any machine or equipment application.

Before selecting a grease product for any application, the performance requirements must be determined. Consult the grease recommendations that are made by the OEM for the equipment when the equipment is operated in the expected conditions. Then, consult with your Caterpillar dealer for a list of greases and the following related characteristics.

- Performance specifications
- Available sizes of containers
- Part numbers

Always choose a grease that meets or exceeds the recommendations that are specified by the equipment manufacturer for the application.

If it is necessary to choose a single grease to use for all of the equipment at one site, always choose a grease that meets or exceeds the requirements of the most demanding application. Remember, products that barely meet the minimum performance requirements can be expected to barely protect minimum parts life. It is false economy to use grease that was purchased based on the lowest cost per pound. Instead, use the grease that yields the lowest total operating cost based on an analysis that includes the costs of parts, labor, and downtime, as well as the cost of the amount of grease that is actually used.

NOTES: Because some greases are not chemically compatible, it is generally recommended to purge all of the old grease from the joint when switching from one type of grease to another, and/or from one supplier to another. Consult your supplier in order to determine if the greases are compatible.
If in doubt, Purge!

All Caterpillar brand name greases are compatible with each other.

5-3.1.7 Fuel

Distillate Diesel Fuel

Caterpillar recommends that all distillate diesel fuel, including ULSD fuel (ie fuel ≤ 15 ppm sulfur using ASTM D 2622 or DIN 51400) meet the requirements of the Caterpillar Specifications for Distillate Diesel Fuel.

In North America, diesel fuel that is identified as No. 1-D or No. 2-D in "ASTM D975" generally meet the specifications. Caterpillar recommends diesel fuels that are distilled from crude oil. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

NOTE: Caterpillar recommends that fuel be filtered through a fuel filter with a rating of less than five (5) microns absolute at the point where the fuel is dispensed into the vehicle.

NOTICE: Operating with fuels that do not meet Caterpillar's recommendations can cause the following effects: starting difficulty, poor combustion, deposits in the fuel injectors, reduced service life of the fuel system, deposits in the combustion chamber, and reduced service life of the engine.

5-3.2 Coolant

NOTICE: Do not use a commercial coolant/antifreeze that only meets the ASTM D3306 specification. This type of coolant/antifreeze is made for light duty automotive applications.

The following two coolants are used in Caterpillar diesel engines:

Preferred - Caterpillar Extended Life Coolant (ELC) or a commercial extended life coolant that meets the Caterpillar EC-1 specification.

Acceptable - A Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) or a commercial heavy-duty coolant/antifreeze that meets "ASTM D4985", or "ASTM D6210" specifications.

NOTE: Caterpillar DEAC does not require a treatment with a SCA at the initial fill. A commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" or "ASTM D6210" specifications MAY require a treatment with an SCA at the initial fill. These coolants WILL require a treatment with an SCA on a maintenance basis.

Service Life Before Flushing and Before Refilling	
Coolant	Service Life (1) (2) (3)
Cat® ELC	965,606 kilometers (600,000 miles) or 12000 hours or 6 years
Commercial coolant that meets the Caterpillar EC-1 specification	482,803 kilometers (300,000 miles) or 6000 hours or 6 years
Cat® DEAC	321,869 kilometers (200,000 miles) or 3000 hours or 3 years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D4985" or "ASTM D6210"	241,402 kilometers (150,000 miles) or 3000 hours or 1 year

1) Whichever comes first
2) Refer to the specific engine OMM, "Maintenance Interval Schedule" for the interval for the Cooling System Water Temperature Regulator.
3) Cat truck engines with excessive idle time must reduce coolant drain intervals to one-half of the stated kilometers/miles recommendations, or base the coolant service life on the xtated hours. Engine hours of operation are reported in the ECM (Electronic Control Module). Two examples where engines may experience excessive idle time are engines that are normally operated in city pickup and delivery applications, and over the road truck applications where the engines are kept running in order to provide heat and/or air conditioning while the driver sleeps. Refer to the OMM for the specific engine for additional information.

NOTES: Add Cat ELC Extender at the half-life of the coolant drain interval.

These drain intervals are only achievable with annual Level 2 coolant analysis.

5-3.2.1 Glycol

Glycol in the coolant helps to provide protection against the following conditions:

- Boiling
- Freezing
- Cavitation of the water pump and cylinder liners

For optimum performance, Caterpillar recommends a 1:1 mixture of a water/glycol solution.

NOTE: Use a mixture that will provide protection against the lowest ambient temperature.

NOTE: 100 percent pure glycol will freeze at a temperature of -23°C (-9°F).

Refer to the following two tables for additional information.

Most conventional heavy-duty coolant/antifreezes use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. Refer to the following two tables for additional information.

Ethylene Glycol		
Concentration	Freeze Protection	Boil Protection
50 Percent	-37°C (-34°F)	106°C (223°F)
60 Percent	-51°C (-60°F)	111°C (232°F)

Propylene Glycol		
Concentration	Freeze Protection	Boil Protection
50 Percent	-32°C (-26°F)	106°C (223°F)

NOTICE: Do not use propylene glycol in concentrations that exceed 50 percent glycol because of propylene glycol's reduced heat transfer capability. Use ethylene glycol in conditions that require additional protection against boiling or freezing.

To check the concentration of glycol, use the 1U-7298 Coolant/Battery Tester (Degree Celsius) or use the 1U-7297 Coolant/Battery Tester (Degree Fahrenheit). The testers give readings that are immediate and accurate. The testers can be used with ethylene or propylene glycol.

NOTE: Propylene glycol coolant used in Caterpillar Diesel Engine cooling systems must meet "ASTM D6211-98a Fully-Formulated Propylene Glycol-Based Engine Coolant for Heavy-Duty Engines". When Propylene glycol is used in heavy-duty diesel engines, regular addition of Supplemental Coolant Additive (SCA) is required for liner cavitation protection. Consult your Caterpillar dealer for more information.

5-3.2.2 S•O•S Coolant Analysis

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
DEAC	Every 250 Hours	Yearly(1)
ELC	Not Required	Yearly

(1) The Level 2 Coolant Analysis should be performed sooner if a problem is identified by a Level 1 Coolant Analysis.

Testing the engine coolant is important to ensure that the engine is protected from internal cavitation and from corrosion. The analysis also tests the ability of the coolant to protect the engine from boiling and from freezing. The S•O•S Coolant Analysis can be done at your Caterpillar dealer. Caterpillar S•O•S Coolant Analysis is the best way to monitor the condition of your coolant and your cooling system. S•O•S Coolant Analysis is a program that is based on periodic samples.

5-3.2.3 Refill Capacity (Coolant System)

The total cooling system capacity will vary depending on the radiator that is installed in the coach. The table for the capacity of the cooling system is blank. The customer should fill in the table and keep for their records.

Approximate Capacity of the Cooling System		
Compartment or System	**Liters**	**Quarts**
Total Cooling System(1)		

(1) The total cooling system capacity includes the following components the engine block, the radiator, and all coolant hoses and lines.

5-3.3 Maintenance Interval Schedule for C13 Engines with Standard/Deep Oil Sumps

!!IMPORTANT: Ensure that the Safety Information, Warnings, and Instructions are read and understood before operation or maintenance procedures are performed.

NOTE: Use fuel consumption, service hours, or calendar time, whichever occurs first, in order to determine the maintenance intervals. Engines that operate in severe operating conditions may require more frequent maintenance.

Before each consecutive interval is performed, all of the maintenance requirements from the previous interval must be performed.

NOTE: Some maintenance items are for optional equipment.

Instructions for performing the following procedures may be found later in the manual after these schedules.

When Required	
Battery	Replace
Battery or Battery Cable	Disconnect
Engine Air Cleaner Element	Clean/Replace
Engine Oil Level Gauge	Calibrate
Fuel System	Prime
Severe Service Application	Check
Daily	
Cooling System Coolant Level	Check
Engine Air Cleaner Service Indicator	Inspect
Engine Oil Level	Check
Fuel System Primary Filter/Water Separator	Drain
Fuel System Water Separator	Drain
Walk-Around Inspection	Inspect

PM Level 1 - Every 48 000 km (30 000 miles) or 17 400 L (4600 US gal) of Fuel or 600 Service Hours	
Air Compressor Filter	Clean/Replace
Alternator	Inspect
Battery Electrolyte Level	Check
Belt	Inspect
Belt Tensioner	Inspect
Cooling System Supplemental Coolant Additive (SCA)	Test/Add
Cylinder Head Grounding Stud	Inspect/Clean/Tighten
Engine Crankcase Breather	Clean
Engine Oil Sample	Obtain
Engine Oil and Filter	Change
Fuel System Primary Filter	Clean/Replace
Fuel System Secondary Filter	Replace
Fuel Tank Water and Sediment	Drain
Hoses and Clamps	Inspect/Replace
Between 24 000 and 96 000 km (15 000 and 60 000 miles)	
Compression Brake	Inspect/Adjust
Electronic Unit Injector	Inspect/Adjust
Engine Valve Lash	Inspect/Adjust
Valve Actuators	Inspect/Adjust
PM Level 2 - Every 320 000 km (200 000 miles) or 125 000 L (33 000 US gal) of Fuel or 4000 Service Hours or 2 Years	
Aftercooler Core	Clean/Test
Cooling System Coolant (DEAC)	Change
Cooling System Water Temperature Regulator	Replace
Fan Drive Bearing	Lubricate
Radiator	Clean
PM Level 3 - Every 483 000 km (300 000 miles) or 190 000 L (50 000 US gal) of Fuel or 6000 Service Hours or 3 Years	
Air Compressor	Inspect
Compression Brake	Inspect/Adjust/Replace
Crankshaft Vibration Damper	Inspect
Electronic Unit Injector	Inspect/Adjust
Engine	Clean
Engine Valve Lash	Inspect/Adjust
Turbocharger	Inspect
Valve Actuators	Inspect/Adjust
Every 483 000 km (300 000 miles) or 3 Years	
Cooling System Coolant Extender (ELC)	Add
Every 966 000 km (600 000 miles) or 6 Years	
Cooling System Coolant (ELC)	Change
PM Level 4 - Every 966 000 km (600 000 miles) or 380 000 L (100 000 US gal) of Fuel or 12 000 Service Hours or 6 Years	
Compression Brake	Inspect/Adjust/Replace

5-3.4 Maintenance Interval Schedule for C13 Engines with Shallow/Optional Oil Sumps and 525 HP RV Ratings

!!IMPORTANT: Ensure that the Safety Information, Warnings, and Instructions are read and understood before operation or maintenance procedures are performed.

NOTE: Use fuel consumption, service hours, or calendar time, whichever occurs first, in order to determine the maintenance intervals. Engines that operate in severe operating conditions may require more frequent maintenance.

Before each consecutive interval is performed, all of the maintenance requirements from the previous interval must be performed.

NOTE: Some maintenance items are for optional equipment.

Instructions for performing the following procedures may be found later in the manual after these schedules.

When Required	
Battery	Replace
Battery or Battery Cable	Disconnect
Engine Air Cleaner Element	Clean/Replace
Engine Oil Level Gauge	Calibrate
Fuel System	Prime
Severe Service Application	Check
Daily	
Cooling System Coolant Level	Check
Engine Air Cleaner Service Indicator	Inspect
Engine Oil Level	Check
Fuel System Primary Filter/Water Separator	Drain
Fuel System Water Separator	Drain
Walk-Around Inspection	Inspect
PM Level 1 - Every 32 000 km (20 000 miles) or 11 700 L (3100 US gal) of Fuel or 400 Service Hours	
Air Compressor Filter	Clean/Replace
Alternator	Inspect
Battery Electrolyte Level	Check
Belt	Inspect
Belt Tensioner	Inspect
Cooling System Supplemental Coolant Additive (SCA)	Test/Add
Cylinder Head Grounding Stud	Inspect/Clean/Tighten
Engine Crankcase Breather	Clean
Engine Oil Sample	Obtain
Engine Oil and Filter	Change
Fuel System Primary Filter	Clean/Replace
Fuel System Secondary Filter	Replace
Fuel Tank Water and Sediment	Drain
Hoses and Clamps	Inspect/Replace

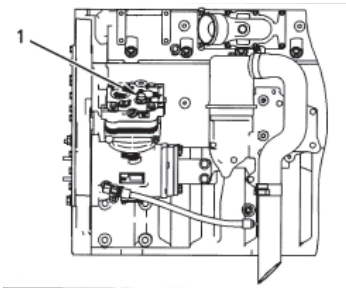
Between 24 000 and 96 000 km (15 000 and 60 000 miles)	
Electronic Unit Injector	Inspect/Adjust
Engine Valve Lash	Inspect/Adjust
Valve Actuators	Inspect/Adjust
PM Level 2 - Every 320 000 km (200 000 miles) or 125 000 L (33 000 US gal) of Fuel or 4000 Service Hours or 2 Years	
Aftercooler Core	Clean/Test
Cooling System Coolant (DEAC)	Change
Cooling System Water Temperature Regulator	Replace
Fan Drive Bearing	Lubricate
Radiator	Clean
PM Level 3 - Every 483 000 km (300 000 miles) or 190 000 L (50 000 US gal) of Fuel or 6000 Service Hours or 3 Years	
Air Compressor	Inspect
Crankshaft Vibration Damper	Inspect
Electronic Unit Injector	Inspect/Adjust
Engine	Clean
Engine Valve Lash	Inspect/Adjust
Turbocharger	Inspect
Valve Actuators	Inspect/Adjust
Every 483 000 km (300 000 miles) or 3 Years	
Cooling System Coolant Extender (ELC)	Add
Every 966 000 km (600 000 miles) or 6 Years	
Cooling System Coolant (ELC)	Change

5-3.5 Aftercooler Core - Clean/Test (Air-To-Air Aftercooler)

The air-to-air aftercooler is OEM installed in many applications. Please refer to the OEM specifications for information that is related to the aftercooler.

5-3.6 Air Compressor - Inspect

WARNING!! Do not disconnect the air line from the air compressor governor without purging the air brake and the auxiliary air systems. Failure to purge the air brake and the auxiliary air systems before removing the air compressor and/or the air lines could cause personal injury.



WARNING!! If the air compressor pressure relief valve that is mounted in the air compressor cylinder head is bypassing compressed air, there is a malfunction in the air system, possibly ice blockage. Under these conditions, your engine may have insufficient air for normal brake operation.
Do not operate the engine until the reason for the air bypass is identified and corrected. Failure to heed this warning could lead to property damage, personal injury, or death to the operator or bystanders.

The function of the pressure relief valve is to bypass air when there is a malfunction in the system for the air compressor.

The pressure relief valve for the air compressor releases air at 1723 kPa (250 psi). If the pressure relief valve for the air compressor exhausts, all personnel should be at a safe distance away from the air compressor. All personnel should also stay clear of the air compressor when the engine is operating and the air compressor is exposed.

Consult your Caterpillar dealer for assistance.

5-3.7 Air Compressor Filter - Clean/Replace (If Equipped)

One of the single most important aspects of preventative maintenance for the air compressor is the induction of clean air. The type of maintenance that is required for the air compressor and the maintenance interval depends on the type of air induction system that is used. Operating conditions (dust, dirt and debris) may require more frequent service.

5-3.8 Alternator - Inspect

Caterpillar recommends a scheduled inspection of the alternator. Inspect the alternator for loose connections and proper battery charging.

Check the alternator and the battery charger for proper operation. If the batteries are properly charged, the ammeter reading should be very near zero. All batteries should be kept charged. The batteries should be kept warm because temperature affects the cranking power. If the battery is too cold, the battery will not crank the engine. The battery will not crank the engine, even if the engine is warm. When the engine is not run for long periods of time or if the engine is run for short periods, the batteries may not fully charge. A battery with a low charge will freeze more easily than a battery with a full charge.

5-3.9 Battery - Replace

WARNING!! Batteries give off combustible gases which can explode. A spark can cause the combustible gases to ignite. This can result in severe personal injury or death.

Ensure proper ventilation for batteries that are in an enclosure. Follow the proper procedures in order to help prevent electrical arcs and/or sparks near batteries. Do not smoke when batteries are serviced.

WARNING!! The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Turn the key start switch to the OFF position. Remove the key and all electrical loads.
2. Turn OFF the battery charger. Disconnect the charger.
3. The NEGATIVE “-“ cable connects the NEGATIVE “-“ battery terminal to the ground plane. Disconnect the cable from the NEGATIVE “-“ battery terminal.
4. The POSITIVE “+” cable connects the POSITIVE “+” battery terminal to the starting motor. Disconnect the cable from the POSITIVE “+” battery terminal.

NOTE: Always recycle a battery. Never discard a battery. Return used batteries to an appropriate recycling facility.

5. Remove the used battery.
6. Install the new battery.

NOTE: Before the cables are connected, ensure that the key start switch is OFF.

7. Connect the cable from the starting motor to the POSITIVE “+” battery terminal.
8. Connect the cable from the ground plane to the NEGATIVE “-“ battery terminal.

5-3.10 Battery Electrolyte Level - Check

When the engine is not run for long periods of time or when the engine is run for short periods, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing. If batteries are properly charged, ammeter reading should be very near zero.

WARNING!! All lead-acid batteries contain sulfuric acid which can burn the skin and clothing. Always wear a face shield and protective clothing when working on or near batteries.

1. Remove the filler caps. Maintain the electrolyte level to the “FULL” mark on the battery.
2. If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.
3. Check the condition of the electrolyte with the 1U-7298 Coolant/Battery Tester (°C) or the 1U-7297 Coolant/Battery Tester (°F).
4. Keep the batteries clean.

   Clean the battery case with one of the following cleaning solutions.

   - A mixture of 0.1 kg (0.2 lb) of baking soda and 1 L (1 qt) of clean water
   - A mixture of 0.1 L (0.11 qt) of ammonia and 1 L (1 qt) of clean water

   Thoroughly rinse the battery case with clean water.

Use a fine grade of sandpaper to clean the terminals and the cable clamps. Clean the items until the surfaces are bright and shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to not fit properly. Coat the clamps and the terminals with 5N-5561 Silicone Lubricant, petroleum jelly or MPGM grease.

5-3.11 Battery or Battery Cable - Disconnect

WARNING!! The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Turn the start switch to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.
2. Disconnect the negative battery terminal at the battery that goes to the start switch. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, the negative side of two batteries must be disconnected.
3. Tape the leads in order to help prevent accidental starting.
4. Proceed with necessary system repairs. Reverse the steps in order to reconnect all of the cables.

5-3.12 Belt - Inspect

5-3.12.1 Inspection

Belt tension should be checked initially between the first 20 to 40 hours of engine operation.

After the initial check, the belt tension should be checked at Every PM Level 1 or Three Months.

To maximize the engine performance, inspect the belts for wear and for cracking. Replace belts that are worn or damaged.

For applications that require multiple drive belts, replace the belts in matched sets. Replacing only one belt of a matched set will cause the new belt to carry more load because the older belt is stretched. The additional load on the new belt could cause the new belt to break.

If the belts are too loose, vibration causes unnecessary wear on the belts and pulleys. Loose belts may slip enough to cause overheating.

If the belts are too tight, unnecessary stresses are placed on the pulley bearings and on the belts. This may shorten the service life of the components.

Remove the belt guard. Inspect the condition and adjustment of the alternator belts and accessory drive belts (if equipped).

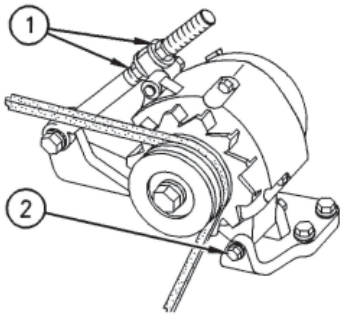
To check the belt tension, apply 110 N • m (25 lb ft) of force midway between the pulleys. A correctly adjusted belt will deflect 9 mm (0.35 inch) to 15 mm (0.59 inch).

If the belt does not require replacement or adjustment, install the belt guard. If the belt requires adjustment or replacement, perform the following procedure to adjust the belt tension.

- If the engine is equipped with a refrigerant compressor (air conditioner), the belt for the fan drive, the alternator, and the accessories will have an automatic belt tensioner.
- If the engine is not equipped with a refrigerant compressor, the alternator is used to adjust the belt tension.

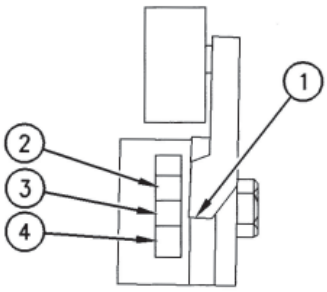
5-3.12.2 Adjustment

Alternator Belt



1. Slightly loosen mounting bolt (2) and adjusting nut (1).
2. Move the pulley in order to adjust the belt tension.
3. Tighten adjusting nuts (1) and mounting bolts (2). Refer to *"Torque Specifications"* section of this manual.
4. Install the belt guard.

If new belts are installed, check the belt tension again after 30 minutes of engine operation at the rated rpm.



Side view of the belt tensioner
(1) Indicator
(2) Upper red zone
(3) Green zone
(4) Lower red zone

5-3.13 Belt Tensioner - Inspect

It is essential to check the position of the belt tightener in order to maintain the proper belt tension. A film (decal) is located on the side of the belt tightener. The decal indicates when the belts have stretched beyond the belt tightener's ability.

If the pointer (1) is in green zone (3), the belt tension is correct. If the pointer (1) is in the upper red zone (2), the belt has stretched. The tension must be adjusted or the belt must be replaced. If the pointer (1) is in the lower red zone (4), the belt is too short. The belt must be replaced.

5-3.14 Compression Brake - Inspect/Adjust

S/N: BXS1-Up

The maintenance of the compression brake should be performed in conjunction with scheduled engine maintenance. The correct tune-up kit is required when parts are replaced on the compression brake.

NOTE: The slave piston lash adjustment must be performed after the engine valve lash adjustment is performed. Make the slave piston adjustment while the engine is stopped. Refer to the Systems Operation, Testing and Adjusting module for additional information.

Component	Required Maintenance
Wiring and Terminal Connections	Inspect
Clutch/Throttle/Buffer Screw	Adjust
Slave Piston Lash Adjusting Screw	Adjust/Inspect
Solenoid Valves	Inspect
Crosshead Bridges/Valve Stem Caps	Inspect
Injector/Exhaust Rocker Arm Screws	Inspect
Master Piston/Fork Assembly	Inspect
Slave pistons	Inspect
External Hose Assembly	Inspect
Housings	Inspect
Fuel Pipes	Inspect
Hold Down Bolts	Inspect
Accumulator Springs(1)	Inspect
Solenoid Harness(1)	Inspect
Solenoid Seal Rings(1)	Inspect
Control Valve Springs(1)	Inspect
Control Valves(1)	Inspect
Oil Seal Rings(1)	Inspect
Master Piston Return Springs(1)	Inspect
Terminal Lead Out(1)	Inspect
Crosshead Pin Assembly(1)	Inspect

5-3.15 Compression Brake - Inspect/Adjust/Replace

S/N: BXS1-Up

The maintenance of the compression brake should be performed in conjunction with scheduled engine maintenance. The correct tune-up kit is required when parts are replaced on the compression brake.

NOTE: The slave piston lash adjustment must be performed after the engine valve lash adjustment is performed. Make the slave piston adjustment while the engine is stopped. Refer to the *Systems Operation, Testing and Adjusting Module* for additional information.

Refer to the *Disassembly and Assembly Module* for instructions on replacing the components.

Component	Required Maintenance (300,000 miles)	Required Maintenance (600,000 miles)
Wiring and Terminal Connections	Inspect	Inspect
Clutch/Throttle/Buffer Screw	Adjust/Replace	Adjust/Replace
Slave Piston Lash Adjusting Screw	Adjust/Inspect	Adjust/Inspect
Solenoid Valves	Inspect	Replace
Crosshead Bridges/Valve Stem Caps	Inspect	Inspect
Injector/Exhaust Rocker Arm Screws	Inspect	Inspect
Master Piston/Fork Assembly	Inspect	Inspect
Slave pistons	Inspect	Inspect
External Hose Assembly	Inspect	Inspect
Housings	Inspect	Inspect
Fuel Pipes	Inspect	Inspect
Hold Down Bolts	Inspect	Replace
Accumulator Springs(1)	Replace	Inspect
Solenoid Harness(1)	Replace	Inspect
Solenoid Seal Rings(1)	Replace	Inspect
Control Valve Springs(1)	Replace	Inspect
Control Valves(1)	Replace	Inspect
Oil Seal Rings(1)	Replace	Inspect
Master Piston Return Springs(1)	Replace	Inspect
Terminal Lead Out(1)	Replace	Inspect
Crosshead Pin Assembly(1)	Replace	Inspect

5-3.16 Cooling System Coolant (DEAC) - Change

Clean the cooling system and flush the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming is observed.
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

NOTICE: Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

NOTE: Inspect the water pump and the water temperature regulator after the cooling system has been drained. This is a good opportunity to replace the water pump, the water temperature regulator and the hoses, if necessary.

5-3.16.1 Drain

WARNING!! ***Pressurized System*** **- Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.**

1. Stop the engine and allow the engine too cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.
2. Open the cooling system drain valve (if equipped). If the cooling system is not equipped with a drain valve, remove one of the drain plugs.

NOTE: If equipped, be sure to drain the heater and any related supply and return lines.

Allow the coolant to drain.

NOTICE: Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant or reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal and recycling of used coolant, consult your Caterpillar dealer or consult

Caterpillar Service Technology Group:
Outside Illinois: 1-800-542-TOOL
Inside Illinois: 1-800-541-TOOL
Canada: 1-800-523-TOOL

5-3.16.2 Flush

1. Flush the cooling system with clean water in order to remove any debris.
2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs.

NOTICE: Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add 0.5 L (1 pint) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the cooling system filler cap.
4. Start and run the engine at low idle for a minimum of 30 minutes. The coolant temperature should be at least 82°C (180°F).

NOTICE: Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. If equipped, be sure to flush the heater and any related supply and return lines. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs to the specified torque.

5-3.16.3 Cooling Systems with Heavy Deposits or Plugging

NOTE: For the following procedure to be effective, there must be some active flow through the cooling system components.

1. Flush the cooling system with clean water in order to remove any debris.

NOTE: If equipped, be sure to flush the heater and any related supply and return lines.

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs to the specified torque.

NOTICE: Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add 0.5 L (1 pint) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity. Install the cooling system filler cap.
4. Start and run the engine at low idle for a minimum of 90 minutes. The coolant temperature should be at least 82°C (180°F).

NOTICE: Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs to the specified torque.

5-3.16.4 Fill

NOTICE: Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

1. Fill the cooling system with coolant/antifreeze. Refer to *"Refill Capacities and Recommendations"* section of this manual for more information on cooling system specifications. Do not install the cooling system filler cap.
2. Start and run the engine at low idle. Increase the engine rpm to 1500 rpm. Run the engine at high idle for one minute in order to purge the air from the cavities of the engine block. Stop the engine.
3. Check the coolant level. Maintain the coolant level within 13 mm (0.5 inch) below the bottom of the pipe for fitting. Maintain the coolant level within 13 mm (0.5 inch) to the proper level on the sight glass (if equipped).
4. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system filler cap is not damaged, perform a pressure test. A 9S-8140 Pressurizing Pump is used to perform the pressure test. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

5-3.17 Cooling System Coolant (ELC) - Change

Clean the cooling system and flush the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming is observed.
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

NOTE: When the cooling system is cleaned, only clean water is needed when the ELC is drained and replaced.

NOTE: Inspect the water pump and the water temperature regulator after the cooling system has been drained. This is a good opportunity to replace the water pump, the water temperature regulator and the hoses, if necessary.

5-3.17.1 Drain

WARNING!! ***Pressurized System*** **- Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.**

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.
2. Open the cooling system drain valve (if equipped). If the cooling system is not equipped with a drain valve, remove the cooling system drain plugs.

   Allow the coolant to drain.

NOTICE: Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal and the recycling of used coolant, consult your Caterpillar dealer or consult

Caterpillar Service Technology Group:

• Outside Illinois: 1-800-542-TOOL • Inside Illinois: 1-800-541-TOOL • Canada: 1-800-523-TOOL

5-3.17.2 Flush

1. Flush the cooling system with clean water in order to remove any debris.

NOTE: If equipped, be sure to flush the heater and any related supply and return lines.

2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs to the specified torque.

NOTICE: Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

3. Fill the cooling system with clean water. Install the cooling system filler cap.
4. Start and run the engine at low idle until the temperature reaches 49 to 66°C (120 to 150°F).
5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs to the specified torque.

5-3.17.3 Fill

NOTICE: Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

1. Fill the cooling system with Extended Life Coolant (ELC). Refer to *"Refill Capacities and Recommendations"* section of this manual for more information on cooling system specifications. Do not install the cooling system filler cap.
2. Start and run the engine at low idle. Increase the engine rpm to high idle. Run the engine at high idle for one minute in order to purge the air from the cavities of the engine block. Stop the engine.
3. Check the coolant level. Maintain the coolant level within 13 mm (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (0.5 inch) to the proper level on the sight glass (if equipped.)
4. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system filler cap is not damaged, us a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cool cooling system filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

5-3.18 Cooling System Coolant Extender (ELC) - Add

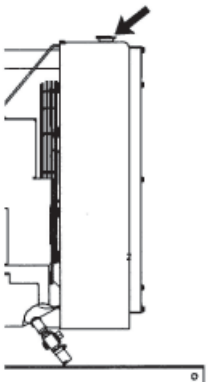
Caterpillar Extended Life Coolant (ELC) does not require the frequent Supplemental Coolant Additive (SCA) additions that are associated with the present conventional coolants. The Extender only needs to be added once.

Check the cooling system only when the engine is stopped and cool.

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.
2. It may be necessary to drain enough coolant from the cooling system in order to add the Extender.
3. Add Extender according to the requirements for your engine's cooling system capacity. Refer to the "*Refill Capacities and Recommendations*" section of this manual for the capacity of the cooling system for your engine.
4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets for the cooling system filler cap are damaged. Install the cooling system filler cap.

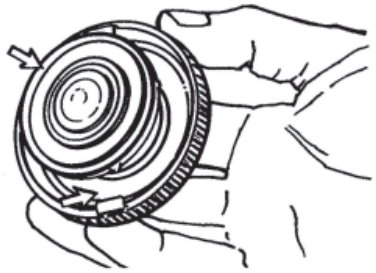
5-3.18 Cooling System Coolant Level - Check

Check the coolant level when the engine is stopped and cool.



WARNING!! ***Pressurized System*** **- Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.**

1. Remove the cooling system filler cap slowly in order to relieve pressure.
2. Maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level to the proper level in the sight glass.
3. Clean the cooling system filler cap and check the condition of the filler cap gaskets. Replace the cooling system filler cap if the filler cap gaskets are damaged. Reinstall the cooling system filler cap.
4. Inspect the cooling system for leaks.



5-3.19 Cooling System Supplemental Coolant Additives (SCA) - Test/Add

NOTICE: Cooling system coolant additive contains alkali. To help prevent personal injury, avoid contact with the skin and eyes. Do not drink cooling system coolant additive.

NOTE: Test the Supplemental Coolant Additive (SCA) or test the SCA concentration as part of the S•O•S Coolant Analysis.

5-3.19.1 Test the SCA Concentration

Coolant/Antifreeze and SCA

NOTICE: Do not exceed the recommended six percent supplemental coolant additive concentration.

WARNING!! **Cooling system coolant additive contains alkali. To help prevent personal injury, avoid contact with the skin and the eyes. Do not drink cooling system coolant additive.**

Use the 8T-5296 Coolant Conditioner Test Kit or use the 4C-9301 Coolant Conditioner Test Kit in order to check the concentration of the SCA.

5-3.19.2 Add the SCA, If Necessary

NOTICE: Do not exceed the recommended amount of supplemental coolant additive concentration. Excessive supplemental coolant additive concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components. Excessive supplemental coolant additive concentration could also result in radiator tube blockage, overheating, and/or accelerated water pump seal wear. Never use both liquid supplemental coolant additive and the spin-on element (if equipped) at the same time. The use of those additives together could result in supplemental coolant additive concentration exceeding the recommended maximum.

WARNING!! ***Pressurized System*** **- Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.**

1. Slowly loosen the cooling system filler cap in order to relieve the pressure. Remove the cooling system filler cap.

NOTE: Always discard drained fluids according to local regulations.

If necessary, drain some coolant from the cooling system into a suitable container in order to allow space for the extra SCA.

2. Add the proper amount of SCA.
3. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Install the cooling system filler cap.

5-3.20 Cooling System Water Temperature Regulator - Replace

Replace the water temperature regulator before the water temperature regulator fails. This is a recommended preventive maintenance practice. Replacing the water temperature regulator reduces the chances for unscheduled downtime.

A water temperature regulator that fails in a partially opened position can cause overheating or overcooling of the engine.

A water temperature regulator that fails in the closed position can cause excessive overheating. Excessive overheating could result in cracking of the cylinder head or piston seize problems.

A water temperature regulator that fails in the open position will cause the engine operating temperature to be too low during partial load operation. Low engine operating temperatures during partial loads could cause an excessive carbon buildup inside the cylinders. This excessive carbon buildup could result in an accelerated wear of the piston rings and wear of the cylinder liner.

NOTICE: Failure to replace your water temperature regulator on a regularly scheduled basis could cause severe engine damage.

Caterpillar engines incorporate a shut design cooling system and require operating the engine with a water temperature regulator installed.

If the water temperature regulator is installed incorrectly, the engine may overheat, causing cylinder head damage.

Ensure that the new water temperature regulator is installed in the original position. Ensure that the water temperature regulator vent hole is open.

Do not use liquid gasket material on the gasket or cylinder head surface.

Consult your Caterpillar dealer for the replacement procedure of the water temperature regulator.

NOTE: If only the water temperature regulators are replaced, drain the coolant from the cooling system to a level that is below the water temperature regulator housing.

5-3.21 Crankshaft Vibration Damper - Inspect

Damage to the crankshaft vibration damper or failure of the crankshaft vibration damper can increase torsional vibrations. This can result in damage to the crankshaft and to other engine components. A damper that is damaged can cause excessive gear train noise at variable points in the speed range.

The damper is mounted to the crankshaft which is located behind the belt guard on the front of the engine.

5-3.21.1 Visconic Damper

The visconic damper has a weight that is located inside a fluid filled case. The weight moves in the case in order to limit torsional vibration.

Inspect the damper for evidence of fluid leaks. If a fluid leak is found, determine the type of fluid. The fluid in the damper is silicone. Silicone has the following characteristics: transparent, viscous, smooth, and difficult to remove from surfaces.

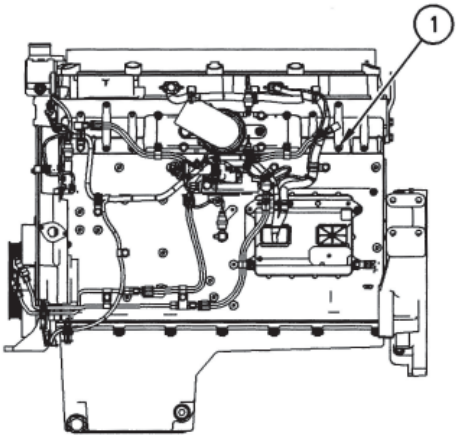
If the fluid leak is oil, inspect the crankshaft seals for leaks. If a leak is observed, replace the crankshaft seals.

Inspect the damper and repair or replacement the damper for any of the following reasons:

- The damper is dented, cracked, or leaking.
- The paint on the damper is discolored from heat.
- The engine has had a failure because of broken crankshaft.
- Analysis of the oil has revealed that the front main bearing is badly worn.
- There is a large amount of gear train wear that is not caused by a lack of oil.

Consult your Caterpillar dealer for information about damper replacement.

5-3.22 Cylinder Head Grounding Stud - Inspect/Clean/Tighten



(1) Cylinder head grounding stud

Inspect the OEM vehicle wiring harness for the following conditions:

- Connections that are loose or disconnected
- Mounting hardware that is missing
- Insulation that is chafed or cut
- Wires that are bare

The cylinder head grounding stud must have a wire ground to the battery. Tighten the cylinder head grounding stud at every oil change. Ground wires and straps should be combined at engine grounds. All grounds should be tight and free of corrosion.

1. Clean the cylinder head grounding stud and the terminals for the cylinder head ground strap with a clean cloth.
2. If the connections are corroded, clean the connections with a solution of baking soda and water.
3. Keep the cylinder head grounding stud and the strap clean and coated with MPGM grease or petroleum jelly.

5-3.23 Electronic Unit Injector - Inspect/Adjust

WARNING!! **Be sure the engine cannot be started while this maintenance is being performed. To prevent possible injury, do not use the starting motor to turn the flywheel.**

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting the unit injectors.

The electronic unit injectors use high voltage. Disconnect the unit injector enable circuit connector in order to prevent personal injury. Do not come in contact with the injector terminals while the engine is running.

WARNING!! **Electrical shock hazard. The electronic unit injector system uses 90-120 volts.**

Adjust the electronic unit injector at the same interval as the valve lash adjustment. The operation of Caterpillar engines with improper adjustments of the electronic unit injector can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

NOTICE: The camshafts must be correctly timed with the crankshaft before an adjustment of the lash for the fuel injector is made. The timing pins must be removed from the camshafts before the crankshaft is turned or damage to the cylinder block will be the result.

Inspect the adjustment of the lash for the electronic unit injector according to the Systems Operation/Testing and Adjusting *"Fuel System"* section. Adjust the lash for the electronic unit injector, if necessary.

5-3.24 Engine - Clean

WARNING!! **Personal injury or death can result from high voltage.**

Moisture can create paths of electrical conductivity.

Make sure that the electrical system is OFF. Lock out the starting controls and tag the controls "DO NOT OPERATE".

NOTICE: Accumulated grease and oil on an engine is a fire hazard. Keep the engine clean. Remove debris and fluid spills whenever a significant quantity accumulates on the engine.

Periodic cleaning of the engine is recommended. Steam cleaning the engine will remove accumulated oil and grease. A clean engine provides the following benefits:

- Easy detection of fluid leaks
- Maximum heat transfer characteristics
- Ease of maintenance

NOTE: Caution must be used in order to prevent electrical components from being damaged by excessive water when you clean the engine. Avoid electrical components such as the alternator, the starter, and the ECM.

5-3.25 Engine Air Cleaner Element - Clean/Replace

NOTICE: Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

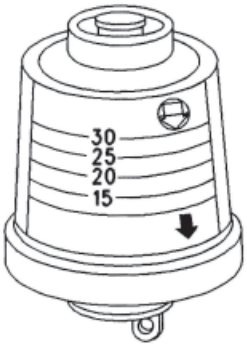
If the air cleaner element becomes plugged, the air can split the material out of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear.

- Operating conditions (dust, dirt and debris) may require more frequent service of the air cleaner element.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Replace the dirty paper air cleaner elements with clean air cleaner elements. Before installation, the air cleaner elements should be thoroughly checked for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

Your Caterpillar dealer has the proper air cleaner elements for your application. Consult your Caterpillar dealer for the correct air cleaner element or follow the instructions that are provided by the OEM.

5-3.26 Engine Air Cleaner Service Indicator - Inspect (If Equipped)



Typical service indicator

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The differential gauge for inlet air pressure displays the difference in the pressure that is measured before the air cleaner element and the pressure that is measured after the air cleaner element. As the air cleaner element becomes dirty, the pressure differential rises. If your engine is equipped with a different type of service indicator, follow the OEM recommendations in order to service the air cleaner service indicator.

The service indicator may be mounted on the air cleaner housing or in a remote location.

Observe the service indicator. The air cleaner element should be cleaned or the air cleaner element should be replaced when one of the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.

5-3.26.1 Test the Service Indicator

Service indicators are important instruments.

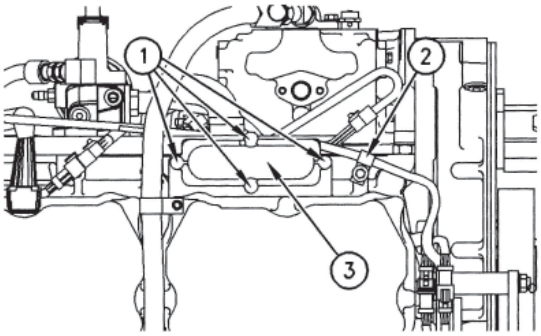
- Check for ease of resetting. The service indicator should reset in less than three pushes.
- Check the movement of the yellow core when the engine is accelerated to the engine rated speed. The yellow core should latch approximately at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the yellow core does not latch at the greatest vacuum, the service indicator should be replaced. If the new service indicator will not reset, the hole for the service indicator may be plugged.

The service indicator may need to be replaced frequently in environments that are severely dusty, if necessary. Replace the service indicator annually regardless of the operating conditions. Replace the service indicator when the engine is overhauled, and whenever major engine components are replaced.

NOTE: When a new service indicator is installed, excessive force may crack the top of the service indicator. Tighten the service indicator to a torque of 2 N•m (18 lb in).

5-3.27 Engine Crankcase Breather - Clean



(1) Bolts (2) Hose Clamp (3) Breather Cover

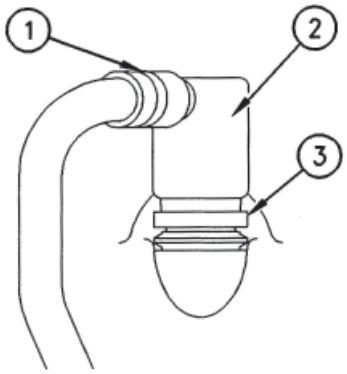
NOTICE: Perform this maintenance with the engine stopped.

If the crankcase breather is not maintained on a regular basis, the crankcase breather will become plugged. A plugged crankcase breather will cause excessive crankcase pressure that may cause crankshaft seal leakage.

1. Loosen hose clamp (2) and remove the hose from breather cover (3).
2. Loosen four bolts (1) for the breather cover and remove breather cover (3).
3. Remove the breather element and wash the breather element in solvent that is clean and nonflammable. Allow the element to dry.
4. Install a breather element that is clean and dry. Install breather cover (3) and install bolts (1).
5. Install the hose. Install hose clamp (2).

5-3.28 Engine Crankcase Breather - Clean

NOTICE: Perform this maintenance with the engine stopped.



Typical Example
(1) Hose Clamp
(2) Breather Assembly
(3) Retaining Clamp

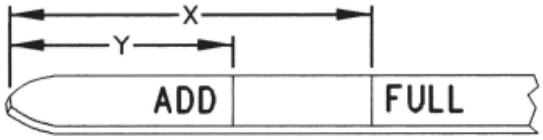
If the crankcase breather is not maintained on a regular basis, the crankcase breather will become plugged. A plugged crankcase breather will cause excessive crankcase pressure that may cause crankshaft seal leakage.

1. Loosen hose clamp (1) and remove the hose from breather assembly (2).
2. Loosen the retaining clamp (3). Remove breather assembly (2) and the seal.
3. Wash the breather element in solvent that is clean and nonflammable. Allow the breather element to dry before installation.
4. Install a breather element that is clean and dry. Install breather assembly and seal (2) and install (3) to the specified torque.
5. Install the hose. Install hose clamp (1) to the specified torque.

5-3.29 Engine Oil Level - Check

WARNING!! **Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.**

NOTE: The location of the oil level gauge and the oil filler cap will vary with the model.



(Y) “ADD” mark (X) “FULL” mark

NOTICE: Perform this maintenance with the engine stopped.

1. Maintain the oil level between “ADD” mark (Y) and “FULL” mark (X) on the oil level gauge. Do not fill the crankcase above “FULL” mark (X).

NOTICE: Engine damage can occur if the crankcase is filled above the “FULL” mark on the oil level gauge (dipstick).

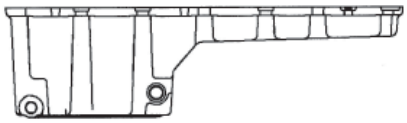
An overfull crankcase can cause the crankshaft to dip into the oil. This will reduce the power that is developed and also force air bubbles into the oil. These bubbles (foam) can cause the following problems: reduction of the oil’s ability to lubricate, reduction of oil pressure, inadequate cooling, oil blowing out of the crankcase breathers, and excessive oil consumption.

Excessive oil consumption will cause deposits to form on the pistons and in the combustion chamber. Deposits in the combustion chamber lead to the following problems: guttering of the valves, packing of carbon under the piston rings, and wear of the cylinder liner.

If the oil level is above the “FULL” mark on the oil level gauge, drain some of the oil immediately.

2. Remove the oil filler cap and add oil, if necessary. For the correct oil to use, see *“Engine Oil”* section in this manual. Do not fill the crankcase above “FULL” mark (X) on the oil level gauge. Clean the oil filler cap. Install the oil filler cap.
3. Record the amount of oil that is added. For the next oil sample and analysis, include the total amount of oil that has been added since the previous sample. This will help to provide the most accurate oil analysis.

5-3.30 Engine Oil Level Gauge - Calibrate (Optional-Shallow)



240-3277 Pan (Optional-Shallow) - This pan has an overall height of 278 mm (10.9 inch).

5-3.31.1 Check Calibration at the First Oil Change

The engine oil level will vary depending on the angle and the slant of the engine installation. The angle is the front to back tilt. The slant is the sideways tilt.

The oil level gauge markings must be verified in order to ensure that it is correct. Verify the oil level gauge markings at the first oil change.

Verify the “ADD” mark and verify the “FULL” mark that is on the oil level gauge. Use the following procedure.

NOTICE: The vehicle must be parked on a level surface in order to perform this maintenance procedure.

1. Operate the engine until normal operating temperature is achieved. Stop the engine. Remove the crankcase oil drain plugs. The oil drain plug from the deep portion of the oil pan should be removed. The oil drain plug from the shallow portion of the oil pan should be removed. This will allow all of the oil to drain. Drain the oil from the crankcase for 20 minutes.
2. Remove the used oil filter(s). Install the new oil filter(s). Install the oil drain plugs and tighten to 70± 15 N•m (50± 11 lb ft).

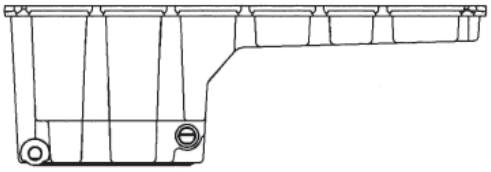
NOTE: Your engine may be equipped with auxiliary oil filters. The auxiliary oil filters require a different volume of oil. Refer to the OEM specifications for the auxiliary oil filter.

3. Pour 26 L (28 qt) of oil into the crankcase. Allow enough time for the oil to drain into the crankcase. Approximately 20 minutes should be allowed. Check the oil level. Wait for several minutes and check the oil level again. Proceed after the oil level stops changing.
4. Check the oil level on the oil level gauge. The oil level should be at the “ADD” mark. If the oil level is not at the existing “ADD” mark, grind off the “ADD” mark and engrave the new “ADD” level. Use an engraving pen in order to engrave the new “ADD” mark.
5. Pour 4 L (4 qt) of oil into the crankcase. Allow enough time for the oil to drain into the crankcase.
6. Check the oil level on the oil level gauge. The oil level should be at the “FULL” mark. If the oil level is not at the existing “FULL” mark, grind off the “FULL” mark. Use an engraving pen in order to engrave the new “FULL” mark.

NOTICE: Do not crank the engine for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking again.

7. Pour an additional 4 L (4 qt) of oil into the crankcase. Start the engine and run the engine enough to ensure that the lubrication system is filled. Inspect the engine for oil leaks.
8. Stop the engine and allow enough time for the oil to drain into the crankcase.
9. Check the oil level on the oil level gauge. If the oil level is not at the calibrated “FULL” mark, fill the crankcase to the calibrated “FULL” mark. Record the amount of oil that was added. The additional oil and the 34 L (36 qt) of oil that was in the crankcase is the oil capacity of the lubrication system. Record the oil capacity of the lubrication system for future oil changes.

5-3.32 Engine Oil Level Gauge - Calibrate (Standard-Deep)



210-1745 Pan (Standard-Deep) - This pan has an overall height of 335 mm (13.2 inch).

5-3.32.1 Check Calibration at the First Oil Change

The engine oil level will vary depending on the angle and the slant of the engine installation. The angle is the front to back tilt. The slant is the sideways tilt.

The oil level gauge markings must be verified in order to ensure that they are correct. Verify the oil level gauge markings at the first oil change.

Verify the “ADD” mark and verify the “FULL” mark that is on the oil level gauge. Use the following procedure.

NOTICE: The vehicle must be parked on a level surface in order to perform this maintenance procedure.

1. Operate the engine until normal operating temperature is achieved. Stop the engine. Remove the crankcase oil drain plugs. The oil drain plug from the deep portion of the oil pan should be removed. The oil drain plug from the shallow portion of the oil pan should be removed. This will allow all of the oil to drain. Drain the oil from the crankcase for 20 minutes.
2. Remove the used oil filter(s). Install the new oil filter(s). Install the oil drain plugs and tighten to 70 ± 15 N•m (50 ± 11 lb ft).

NOTE: Your engine may be equipped with auxiliary oil filters. The auxiliary oil filters require a different volume of oil. Refer to the OEM specifications for the auxiliary oil filter.

3. Pour 32 L (34 qt) of oil into the crankcase. Allow enough time for the oil to drain into the crankcase. Approximately 20 minutes should be allowed. Check the oil level. Wait for several minutes and check the oil level again. Proceed after the oil level stops changing.
4. Check the oil level on the oil level gauge. The oil level should be at the “ADD” mark. If the oil level is not at the existing “ADD” mark, grind off the “ADD” mark and engrave the new “ADD” level. Use an engraving pen in order to engrave the new “ADD” mark.
5. Pour 4 L (4 qt) of oil into the crankcase. Allow enough time for the oil to drain into the crankcase.
6. Check the oil level on the oil level gauge. The oil level should be at the “FULL” mark. If the oil level is not at the existing “FULL” mark, grind off the “FULL” mark. Use an engraving pen in order to engrave the new “FULL” mark.

NOTICE: Do not crank the engine for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking again.

7. Pour an additional 4 L (4 qt) of oil into the crankcase. Start the engine and run the engine enough to ensure that the lubrication system is filled. Inspect the engine for oil leaks.
8. Stop the engine and allow enough time for the oil to drain into the crankcase.
9. Check the oil level on the oil level gauge. If the oil level is not at the calibrated “FULL” mark, fill the crankcase to the calibrated “FULL” mark. Record the amount of oil that was added. The additional oil and the 40 L (42 qt) of oil that was in the crankcase is the oil capacity of the lubrication system. Record the oil capacity of the lubrication system for future oil changes.

5-3.33 Engine Oil Sample - Obtain

In addition to a good preventative maintenance program, Caterpillar recommends using S•O•S oil analysis at regularly scheduled intervals in order to monitor the condition of the engine and the maintenance requirements of the engine S•O•S oil analysis provides infrared analysis, which is required for determining nitration and oxidation levels.

5-3.33.1 Obtain the Sample and the Analysis

WARNING!! Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Before you take the oil sample, complete the Label, PEEP5031 for identification of the sample. In order to help obtain the most accurate analysis, provide the following information:

- Engine model
- Service hours on the engine
- The number of hours that have accumulated since the last oil change
- The amount of oil that has been added since the last oil change

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, well mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

Caterpillar recommends using the sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when the sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

The 169-8373 Fluid Sampling Bottle is recommended for use with the sampling valve. The fluid sampling bottle includes the part that is needed for obtaining oil samples. Instructions are also provided.

NOTICE: Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

If the engine is not equipped with a sampling valve, use the 1U-5718 Vacuum Pump. The pump is designed to accept sampling bottles. Disposable tubing must be attached to the pump for insertion into the sump.

5-3.34 Engine Oil and Filter - Change

WARNING!! Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Do not drain the engine oil when the engine is cold. As the engine oil cools, suspended waste particles settle on the bottom of the engine oil pan. The waste particles are not removed with the draining cold engine oil. Drain the crankcase while the engine is stopped. Drain the crankcase while the engine oil is warm. This draining method allows the waste particles that are suspended in the engine oil to be drained properly.

Failure to follow this recommended procedure will cause the waste particles to be recirculated through the engine lubrication system with the new engine oil.

5-3.34.1 Drain the Engine Oil

After the engine has been run at the normal operating temperature, stop the engine. Use one of the following methods to drain the engine crankcase oil.

WARNING!! Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

NOTICE: The vehicle must be parked on a level surface for this maintenance procedure.

- If the engine is equipped with a drain valve, turn the drain valve knob counterclockwise in order to drain the engine oil. After the engine oil has drained, turn the drain valve knob clockwise in order to close the drain valve.
- If the engine is not equipped with a drain valve, remove the oil drain plug in order to allow the engine oil to drain. If the engine is equipped with a shallow sump, remove the bottom oil drain plugs from both ends of the engine oil pan.

After the engine oil has drained, the oil drain plugs should be cleaned and installed. Tighten the oil drain plugs to the proper torque. Refer to the *Specifications Module "Engine Oil Pan"* topic for additional information.

5-3.34.2 Replace the Oil Filter

NOTICE: Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe engine damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Caterpillar.

1. Remove the oil filter with a 185-3630 Chain Wrench.
2. Cut the oil filter open with a 175-7546 Oil Filter Cutter. Break apart the pleats and inspect the oil filter for metal debris. An excessive amount of metal debris in the oil filter may indicate early wear or a pending failure.

Use a magnet to differentiate between the ferrous metals and the nonferrous metals that are found in the oil filter element. Ferrous metals may indicate wear on the steel and cast iron parts of the engine.

Nonferrous metals may indicate wear on the aluminum parts, brass parts or bronze parts of the engine. Parts that may be affected include the following items: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter. Consult your Caterpillar dealer in order to arrange for a further analysis if an excessive amount of debris is found in the oil filter.

3. Clean the sealing surface of the filter mounting base. Ensure that all of the oil filter gasket is removed.
4. Apply clean engine oil to the new oil filter gasket.

NOTICE: Do not fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil can cause accelerated wear to engine components.

5. Install the new oil filter. Tighten the oil filter until the oil filter gasket contacts the base. Tighten the oil filter by hand according to the instructions that are shown on the oil filter. Do not over tighten the oil filter.

5-3.34.3 Fill the Engine Crankcase

1. Remove the oil filler cap. Refer to "*Lubricant Specifications*" section of this manual for more information. Fill the crankcase with the proper amount of engine oil. Refer to "*Refill Capacities*" section of this manual for more information.

NOTICE: If equipped with an auxiliary oil filter or system, extra oil must be added when filling the crankcase. Follow the OEM or filter manufacturer's recommendations. If the extra oil is not added, the engine may starve for oil.

NOTICE: To help prevent crankshaft or bearing damage, crank engine to fill all filters before starting. Do not crank engine for more than 30 seconds.

1. Start the engine and run the engine at "LOW IDLE" for two minutes. Perform this procedure in order to ensure that the lubrication system has oil and that the oil filters are filled. Inspect the oil filter for oil leaks.
2. Stop the engine and allow the oil to drain back to the sump for a minimum of ten minutes.
3. Remove the oil level gauge in order to check the oil level. Maintain the oil level between the "ADD" and "FULL" marks on the oil level gauge.

5-3.34.4 Oil Change Intervals

Many conditions affect the selection of an oil change interval. Some of the conditions that affect the selection of oil are listed: premium API CH-4 multigrade oil, oil analysis at 16,100 km (10,000 miles), and premium oil filters.

Proper oil change intervals are important for maintaining engine service life and engine performance and fully utilizing the lubricant. The engine oil must be able to control the following items: corrosion, oxidation, soot, and wear metals. The engine oil must be able to control the conditions during the time between oil changes. In some severe service applications, reducing the oil change interval may be necessary in order to maintain the integrity of the engine lubricant.

Fuel consumption and oil consumption are the most important factors that are used in order to calculate an oil change interval.

The rate of fuel consumption is a direct result of the load factor of the engine. An engine with a high fuel consumption rate is working harder than an identical engine with a lower fuel consumption rate.

5-3.34.5 Tables for Extended Oil Change Intervals

In order to understand the tables for maximum permissible oil change intervals, use the following procedures.

1. Determine the average fuel consumption of the vehicle.
2. Determine the gross vehicle weight (GVW) of the vehicle.
3. Determine the percent of idle time for the vehicle. A download of the histogram data from the ECM can provide a more accurate “percent idle time” measurement. Contact your nearest Caterpillar dealer for information on obtaining data from the ECM.
4. The intersection of the column and the row lists the maximum number of kilometers or miles between oil change intervals.

For example, a C13 Engine with an average fuel consumption of 3 km/L (7 mpg) in a light-duty application will have a maximum permissible oil change interval of 40,250 kilometers (25,000 miles) with a shallow oil sump. The maximum permissible oil change interval for the same situation with a Deep oil sump would be 64,350 km (40,000 miles).

For more information about optimizing oil change intervals, see your Caterpillar dealer.

NOTE: Metric units are listed before English units.

The following requirements must be met in order to use Tables 1 and 2:

- Use premium API CH-4 or API CI-4 multigrade oil only. API CH-4 and CI-4 oils are acceptable if the requirements of Caterpillar’s ECF-1 (Engine Crankcase Fluid Specification-1) are met. CH-4 and CI-4 oils that have not met the requirements of Caterpillar’s ECF-1 Specification may cause reduced engine life.
- DEO Caterpillar multigrade oil is recommended.
- S•O•S Oil analysis is taken at 16,100 km (10,000 mile) intervals and all oil change intervals. The oil analysis must evaluate oil condition, wear metals and soot. Caterpillar’s Oil Analysis is preferred. Caterpillar’s Oil Analysis is the only oil analysis program with wear tables and limits for soot and oxidation, that are approved by Caterpillar.
- Use premium oil filter(s). Caterpillar 1R-0716 Oil Filter or an oil filter with equivalent performance and durability is recommended.
- Use North American low sulfur diesel fuel (0.05% sulfur).

NOTE: Caterpillar cannot guarantee the performance of lubricants or filters that are not made by Caterpillar. Caterpillar cannot guarantee the performance of lubricants or filters that are not sold by Caterpillar. The performance guarantee of any commercially available lubricant is the responsibility of that oil company. The performance guarantee of any commercially available filter is the responsibility of the filter manufacturer.

Table 1

Maximum Permissible Oil Change Intervals for On-Highway C11 and C13 Engines with Optional Shallow Sumps			
	Severe Duty	**Normal Duty**	**Light Duty**
Fuel Consumption Kilometers Per Liter (Miles Per Gallon)	Less than 2.6 km/L (6 MPG)	2.6 km/L (6 MPG) to 3 km/L (7 MPG)	Greater than 3 km/L (7 MPG)
Gross Vehicle Weight	More than 80,000 lb	80,000 lb or less	80,000 lb or less
Minimum Oil Sump Capacity(1)	34 L (36 qt)	34 L (36 qt)	34 L (36 qt)
Idle Time	More than 40%	20% to 40%	Less than 20%
Oil Classification	API CH-4 or API CI-4(2)		
Kilometers (Miles)	24,150 kilometers (15,000 miles)	32,200 kilometers (20,000 miles)	40,250 kilometers (25,000 miles)

1) If the oil sump capacity is greater than the oil sump capacity that is listed in Table 1, the oil change interval can be extended 1600 kilometers (1000 miles) for every 2 L (2 qt) increase in sump capacity.

2) API CH-4 and CI-4 oils are acceptable if the requirements of Caterpillar's ECF-1 (Engine Crankcase Fluid specification-1) are met. CH-4 and CI-4 oils that have not met the requirements of Caterpillar's ECF-1 Specification may cause reduced engine life.

Table 2

Maximum Permissible Oil Change Intervals for On-Highway C11 and C13 Engines with Deep Sumps (Standard)			
	Severe Duty	**Normal Duty**	**Light Duty**
Fuel Consumption Kilometers Per Liter (Miles Per Gallon)	Less than 2.6 km/L (6 MPG)	2.6 km/L (6 MPG) to 3 km/L (7 MPG)	Greater than 3 km/L (7 MPG)
Gross Vehicle Weight	More than 80,000 lb	80,000 lb or less	80,000 lb or less
Minimum Oil Sump Capacity(1)	40 L (42 qt)	40 L (42 qt)	40 L (42 qt)
Idle Time	More than 40%	20% to 40%	Less than 20%
Oil Classification	API CH-4 or API CI-4(2)		
Kilometers (Miles)	32,200 kilometers (20,000 miles)	48,300 kilometers (30,000 miles)	64,350 kilometers (40,000 miles)

1) If the oil sump capacity is greater than the oil sump capacity that is listed in Table 2, the oil change interval can be extended 1600 kilometers (1000 miles) for every 2 L (2 qt) increase in sump capacity.

2) API CH-4 and CI-4 oils are acceptable if the requirements of Caterpillar's ECF-1 (Engine Crankcase Fluid specification-1) are met. CH-4 and CI-4 oils that have not met the requirements of Caterpillar's ECF-1 Specification may cause reduced engine life.

5-3.35 Engine Valve Lash - Inspect/Adjust

The initial valve lash adjustment on new engines, rebuilt engines, or remanufactured engines is recommended at the first scheduled oil change. The adjustment is necessary due to the initial wear of the valve train components and to the seating of the valve train components.

This maintenance is recommended by Caterpillar as part of a lubrication and preventive maintenance schedule in order to help provide maximum engine life.

NOTICE: Only qualified service personnel should perform this maintenance. Consult your Caterpillar dealer for the complete valve lash adjustment procedure.

Operation of Caterpillar engines with improper valve adjustments can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

WARNING!! Ensure that the engine cannot be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/ adjusting valve lash clearance.

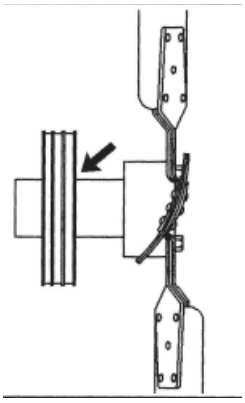
Ensure that the engine is stopped before measuring the valve lash. To obtain an accurate measurement, allow the valves to cool before this maintenance is performed.

The following components should be inspected and adjusted when the valves are inspected and adjusted.

- Valve Actuators
- Injectors
- Compression Brakes

5-3.36 Fan Drive Bearing - Lubricate

NOTE: In some applications, the fan drives are supplied by the OEM. Refer to the OEM specifications if the fan drive is not supplied by Caterpillar.



Lubricate the grease fitting that is on the fan drive bearing with Bearing Lubricant or the equivalent.

Inspect the fan drive pulley assembly for wear or for damage. If the shaft is loose, an inspection of the internal components should be performed.

5-3.37 Fuel System - Prime

5-3.37.1 C11 and C13 On-highway Engines

The Secondary Fuel Filter Has Been Replaced

WARNING!! **Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.**

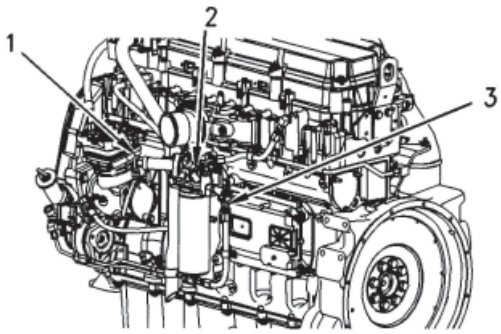
NOTICE: Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

NOTICE: Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

NOTE: Refer to "*Fuel System Secondary Filter - Replace*" section for more information on replacing the filter.

1. Turn the ignition switch to the "OFF" position.

NOTICE: Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.



(1) Fuel Priming Pump,
(2) Air Purge Screw, (3) Priming Valve (if equipped)

2. Start the engine. Operate the engine at 1000 to 1200 rpm until the engine runs smoothly in order to remove the residual air from the fuel system.
3. Once the engine runs smoothly, stop the engine. Turn the ignition switch to the OFF position.

NOTE: You may use the hand priming pump for the fuel filter (if equipped) instead of starting the engine and running the engine. Perform the following procedure when the hand priming pump is used:

a. Turn the priming valve (3) (if equipped) to the "Closed (Prime)" position in order to prime the fuel system.
b. Open the air purge screw (2) for the fuel filter by three full turns. Do not remove the air purge screw.
c. While you operate the hand priming pump (1), observe air purge screw (2). When a small drop of fuel appears at the threads of the air purge screw, close and tighten air purge screw (2).

NOTE: Failure to tighten all fittings could result in serious fuel leaks.

d. Clean any residual fuel from the engine components.
e. Continue to operate the fuel priming pump (1) until a strong resistance is felt. Listen for an audible click from the fuel manifold. The click will indicate that the valve has opened and the fuel system is pressurized. Lock the fuel priming pump (1).

NOTICE: Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.

f. Crank the engine. If the engine starts but the engine runs rough, continue to operate the engine at low idle until the engine runs smoothly.

NOTE: If the engine will not start, further priming is necessary. If the engine starts but the engine continues to misfire or smoke, further priming is necessary.

g. After the engine has operated smoothly for 30 seconds, turn the priming valve (3) to the “Open (Run)” position.

NOTE: Shortened injector life may occur if the priming valve (3) is left in the “Closed (Prime)” position.

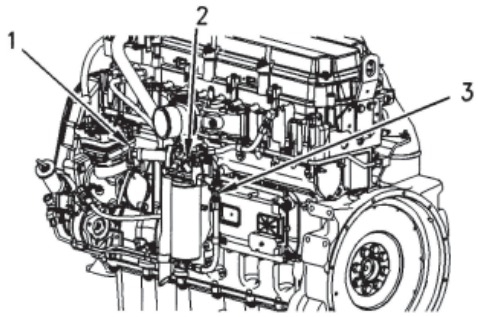
5-3.37.2 The Engine Has Been Run Out of Fuel

NOTICE: Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

NOTICE: Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

1. Turn the ignition switch to the “OFF” position.
2. Fill the fuel tank(s) with clean diesel fuel.
3. Turn the priming valve (3) (if equipped) to the “Closed (Prime)” position in order to prime the fuel system.
4. Open air purge screw (2) for the fuel filter by three full turns. Do not remove the air purge screw.

NOTICE: Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.



(1) Fuel Priming Pump,
(2) Air Purge Screw, (3) Priming Valve (if equipped)

5. Crank the engine for 30 seconds. Use a suitable container to catch the fuel while you crank the engine. Allow the starter motor to cool for 2 minutes.

NOTE: Most of the air should be purged from the system after four or five cranking cycles.

6. Crank the engine for 30 seconds. Allow the starter motor to cool for 2 minutes.
7. Repeat Step 6 until the engine starts and runs. If the engine runs rough, continue to operate the engine at low idle until the engine runs smoothly.
8. Observe air purge screw (2). When a small drop of fuel appears at the threads of the air purge screw, close and tighten air purge screw (2).

NOTE: Failure to tighten all fittings could result in serious fuel leaks.

9. After the engine has operated smoothly for 30 seconds, turn the priming valve (3) to the “Open (Run)” position.

NOTE: Shortened injector life may occur if the priming valve (3) is left in the “Closed (Prime)” position.

10. Clean any residual fuel from the engine components.
11. Once the engine runs smoothly, stop the engine. Turn the ignition switch to the “OFF” position.

NOTE: You may use the hand priming pump for the fuel filter (if equipped) instead of starting the engine and running the engine. Perform the following procedure when the hand priming pump is used:

a. Turn the priming valve (3) (if equipped) to the “Closed (Prime)” position in order to prime the fuel system.
b. Open air purge screw (2) for the fuel filter by three full turns. Do not remove the air purge screw.
c. While you operate the hand priming pump (1), observe air purge screw (2). When a small drop of fuel appears at the threads of the air purge screw, close and tighten air purge screw (2).

NOTE: NOTE: Failure to tighten all fittings could result in serious fuel leaks.

d. Clean any residual fuel from the engine components.
e. Continue to operate the fuel priming pump (1) until a strong resistance is felt. Listen for an audible click from the fuel manifold. The click will indicate that the valve has opened and the fuel system is pressurized. Lock the fuel priming pump (1).

NOTICE: Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.

f. Crank the engine. If the engine starts but the engine runs rough, continue to operate the engine at low idle until the engine runs smoothly.

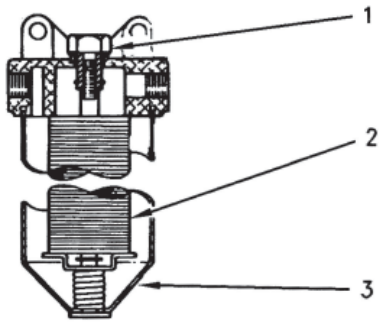
NOTE: If the engine will not start, further priming is necessary. If the engine starts but the engine continues to misfire or smoke, further priming is necessary.

g. After the engine has operated smoothly for 30 seconds, turn the priming valve (3) to the “Open (Run)” position.

NOTICE: Shortened injector life may occur if the priming valve (3) is left in the “Closed (Prime)” position.

5-3.38 Fuel System Primary Filter - Clean/Replace

WARNING!! Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.



(1) Bolt, (2) Element, (3) Case

1. Stop the engine.
2. Turn the start switch to the “OFF” position. Disconnect the battery.
3. Shut off the fuel tank supply valve to the engine.
4. If the primary fuel filter is equipped with a drain valve, open the drain valve in order to drain any fuel from the filter case. Close the drain valve.

NOTICE: Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

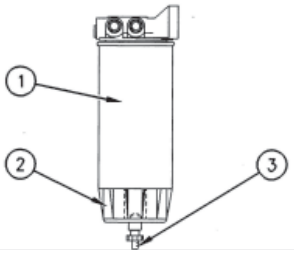
5. Loosen the bolt (1) that is on the filter housing. Remove the filter case (3).
6. Remove the element (2) and wash the element in clean, nonflammable solvent.

NOTICE: Do not fill the fuel filters with fuel before installing them. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

7. Install the element (2) and the filter case (3). Tighten the bolt (1) to a torque of 24 ± 4 N•m (18 ± 3 lb ft).

5-3.39 Fuel System Primary Filter/Water Separator - Drain

WARNING!! Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.



(1) Element, (2) Bowl, (3) Drain

NOTICE: Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

NOTICE: Do not fill the fuel filters with fuel before installing them. The fuel would not be filtered and could be contaminated. Contamination fuel will cause accelerated wear to fuel system parts.

Bowl (2) should be monitored daily for signs of water. If water is present, drain the water from the bowl.

1. Open drain (3). The drain is a self-ventilated drain. Catch the draining water in a suitable container. Dispose of the water properly.
2. Close drain (3).

NOTICE: The water separator is under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

5-3.40 Fuel System Secondary Filter - Replace

WARNING!! Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE: Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over any disconnected fuel system components.

NOTICE: Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

1. Stop the engine. Turn the ignition switch to the OFF position or disconnect the battery. Refer to "*Battery or Battery Cable - Disconnect*" section of this manual for more information. Shut off the fuel supply valve (if equipped).
2. Remove the used fuel filter and discard the used fuel filter.
3. Clean the gasket sealing surface of the fuel filter base. Ensure that all of the old gasket is removed.
4. Apply clean diesel fuel to the new fuel filter gasket.

NOTICE: Do not fill the secondary fuel filter with fuel before installing. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

NOTICE: In order to maximize fuel system life and prevent premature wear out from abrasive particles in the fuel, a two micron absolute high efficiency fuel filter is required for all Caterpillar Hydraulic Electronic Unit Injectors. Caterpillar High Efficiency Fuel Filters meet these requirements. Consult your Caterpillar dealer for the proper part numbers.

5. Install the new fuel filter. Spin the fuel filter onto the fuel filter base until the gasket contacts the base. Use the rotation index marks on the filters as a guide for proper tightening. Tighten the filter for an additional one turn (360 degrees) by hand. Do not overtighten the filter.
6. Open the fuel supply valve. Prime the fuel system. Refer to "*Fuel System - Prime*" section in this manual for more information. Start the engine and inspect the fuel system for leaks.

NOTICE: Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.

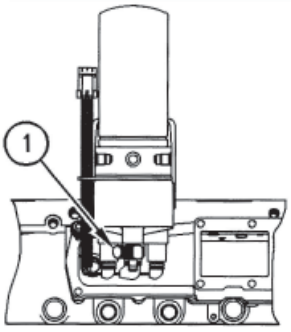
NOTE: There should be enough residual fuel in the cylinder head in order to start the engine. If the engine stops after starting, do not crank the engine for more than 30 seconds. Then allow the starting motor to cool for two minutes. Repeat this procedure until the engine starts and the engine operates.

5-3.41 Fuel System Water Separator - Drain

WARNING!! Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE: The water separator is not a filter. It separates water from the fuel.

The engine should never be allowed to run with the water level in the separator more than ½ full or engine damage may result.



(1) Drain

A water separator is recommended. The water separator should be installed between the fuel tank and the engine fuel inlet. Drain the water and sediment from the water separator on a daily basis.

1. Open drain (1). Catch the draining water in a suitable container. Dispose of the water properly.

NOTICE: The water separator is under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

2. Close drain (1).

5-3.42 Fuel Tank Water and Sediment - Drain

NOTICE: Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

5-3.42.1 Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system. Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel.

5-3.42.2 Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Check the fuel daily. Drain the water and sediment from the fuel tank after operating the engine or drain the water and sediment from the fuel tank after the fuel tank has been filled. Allow five to ten minutes before performing this procedure.

Fill the fuel tank after operating the engine in order to drive out moist air. This will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

5-3.42.3 Fuel Storage Tanks

Drain the water and the sediment from the fuel storage tank during the following conditions:

- Weekly
- Oil Change
- Refill of the Tank

This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank.

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

5-3.43 Hoses and Clamps - Inspect/Replace

Inspect all hoses for leaks that are caused by the following conditions:

- Cracking
- Softness
- Loose Clamps

NOTICE: Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Inspect all lines, tubes and hoses carefully. Tighten all connections to the recommended torque.

Check the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

A constant torque hose clamp can be used in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard clamp.

Due to extreme temperature changes, the hose will heat set. Heat setting causes hose clamps to loosen. This can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Each installation application can be different. The difference depends on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose
- Anticipated expansion and contraction of the fittings

5-3.41.1 Replace the Hoses and the Clamps

WARNING!! ***Pressurized System*** **- Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.**

1. Stop the engine. Allow the engine to cool.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

NOTE: Drain the coolant into a suitable, clean container. The coolant can be reused.

3. Drain the coolant from the cooling system to a level that is below the hose that is being replaced.
4. Remove the hose clamps.
5. Disconnect the old hose.
6. Replace the old hose with a new hose.

NOTE: Refer to the Specifications, SENR3130 in order to locate the proper torques.

7. Install the hose clamps with a torque wrench.

NOTE: For the proper coolant to use, see *"Coolant Recommendations"* section of this manual.

8. Refill the cooling system.
9. Clean the cooling system filler cap. Inspect the cooling system filler cap's gaskets. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.
10. Start the engine. Inspect the cooling system for leaks.

5-3.44 Radiator - Clean

NOTE: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the radiator for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the radiator, if necessary.

WARNING!! **Personal injury can result from air pressure.**
Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.
Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the fan's air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a "comb". Inspect these items for good condition: welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

5-3.45 Severe Service Application - Check

Operation and maintenance practices affect the service life of the components when the engine is operated in severe service applications.

The level of maintenance is crucial to the service life of the engine. Other major factors that affect service life are operating speed and loads.

The conditions that follow can indicate severe service operations:

- Operation above 36,320 kg (80,000 lb) gross vehicle weight (GVW) and other high load factor operations (such as off-highway)
- Frequent high altitude operation above 1525 m (5000 ft)
- Extended operation at low idle
- Arctic operation (regular cold starts at temperatures below -18°C (0°F))
- Extending maintenance beyond the recommended maintenance intervals
- Frequent hot shutdowns (minimum five minute cool down periods after high load factor operation)
- Use of fuels that are NOT recommended by Caterpillar in the Fuel Specifications
- Extreme ambient temperature conditions that may cause the lubricating properties of the fuel to diminish
- Frequent plugging of the fuel filter
- Extended maintenance intervals of the fuel system
- Inadequate maintenance of fuel storage tanks (excessive water, sediment, microorganism growth, etc.)

5-3.46 Turbocharger - Inspect

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side)

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel can cause additional damage to the pistons, the valves, and the cylinder head.

NOTICE: Turbocharger bearing failures can cause large quantities of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is repaired or replaced.

A periodic inspection of the turbocharger can minimize unscheduled downtime and the chance for potential damage to other engine parts.

NOTE: Turbocharger components require precision clearances with proper balancing in order to support high operating speeds. Severe Service Applications can accelerate component wear. Therefore, more frequent inspections of the cartridge are required.

5-3.46.1 Removal and Installation

For options regarding the inspection, removal, installation, repair and replacement, consult your authorized Caterpillar service center.

5-3.47 Valve Actuators - Inspect/Adjust

The valve actuators should be inspected and adjusted when adjustments to the following components occur.

- Valves
- Injectors
- Compression Brakes

Refer to the System Operation, Test and Adjust Manual for the proper adjustment procedure.

5-3.48 Walk-Around Inspection

5-3.48.1 Inspect the Engine for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, make a thorough inspection of the engine compartment before starting the engine. Look for items such as oil leaks or coolant leaks, loose bolts, worn belts, loose connections and trash buildup. Make repairs, as needed:

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

NOTICE: For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

NOTICE: Accumulated grease and/or oil on an engine or deck is a fire hazard. Remove the debris with steam cleaning or high pressure water.

- Ensure that the cooling lines are properly clamped and that the cooling lines are tight. Check for leaks. Check the condition of all pipes.
- Inspect the water pumps for coolant leaks.

NOTE: The water pump seal is lubricated by coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of water pumps and the installation of water pumps and/or seals, refer to your servicing dealer.

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the valve cover.
- Inspect the fuel system for leaks. Look for loose fuel line clamps or for loose fuel line tie-wraps.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps. Ensure that hoses and tubes are not contacting other hoses, tubes, wiring harnesses, etc.
- Inspect the alternator belt and the accessory drive belts for cracks, breaks or other damage.