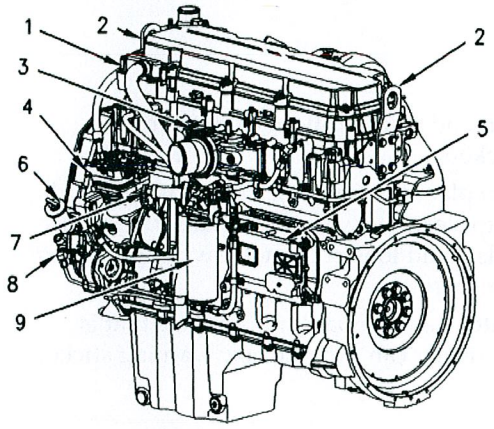
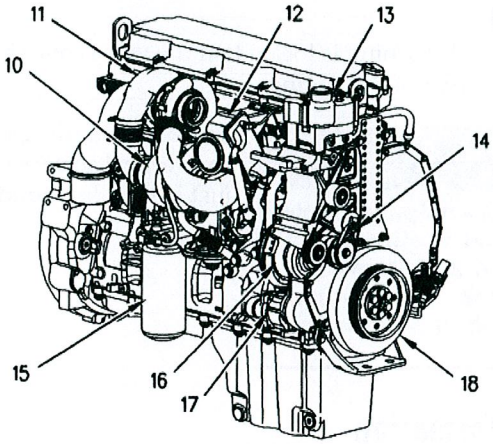
5-1 Engine Operation

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 6-1 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

This section describes the basic safety, hazard and operating information. The safety section lists basic safety precautions. In addition, this section identifies hazardous, warning situations. Read and understand the basic 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.

5-1.1.1 Overhaul

Major engine overhaul details are not covered in the Operation and Maintenance sections of this manual except for the interval 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. 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

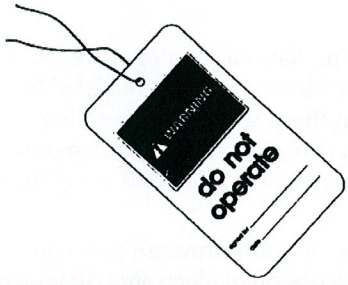
One warning label for the Universal Warning is located on the valve cover base on the left side of the engine. The label is on the fourth flat surface from the rear of the engine.

⚠ 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.

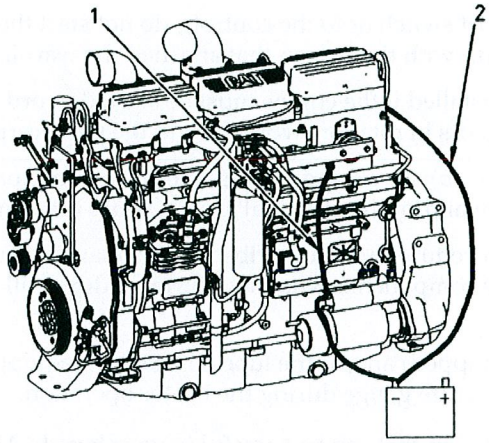
5-1.3.5 Electrical System

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.

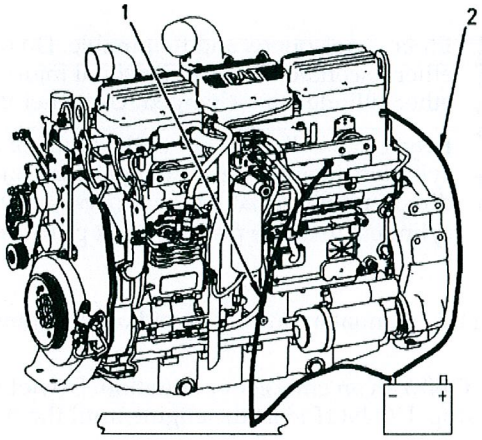
To help prevent sparks from igniting combustible gases that are produced by some batteries, the negative "-" jump start cable should be connected last from the external power source to the negative "-" terminal of the starting motor. If the starting motor is not equipped with a negative "-" terminal,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

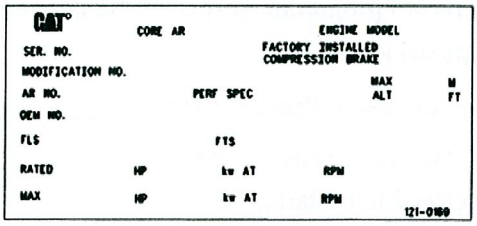
Caterpillar engines are identified with serial numbers, with performance specification numbers, and with arrangement numbers. In some of the cases, modification numbers are used. These numbers are shown on the Serial Number Plate and the Information Plate that are mounted on the engine.

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.

CATERPILLAR®		CAT®	
SERIAL NUMBER		ARRANGE-MENT NUMBER	
ENGINE MODEL			
MADE IN U.S.A	(ALWAYS GIVE ALL NUMBERS)		



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 a record. 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: _____

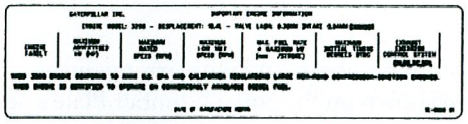
Total Cooling System Capacity: _____

Air Cleaner Element Number: _____

Fan Drive Belt Number: _____

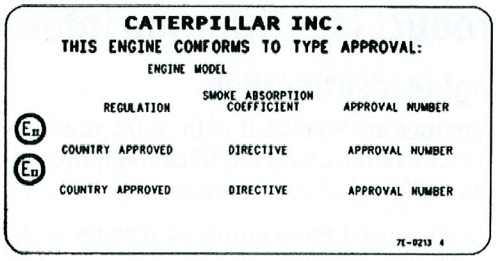
Alternator Belt Number: _____

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 blanks.

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

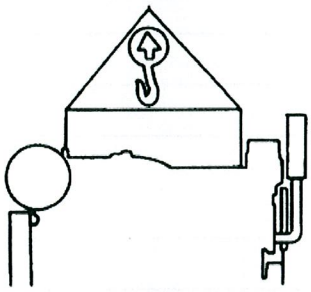
- "Powertrain Data Link" _____

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 esult 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)

NOTE: 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

NOTE: 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 Faulit[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

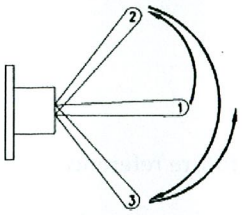
(1) An "X" indicates that the effect on engine performance may occur, if the code is active. This depends on the exact failure.
(2) Shut Down the Engine: Operate the engine cautiously. Get immediate service. Severe engine damage may result.
(3) Service: The operator should go to the nearest qualified 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.

5. 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.

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