

Operation & Maintenance Manual

3114, 3116, and 3126 Industrial and EPG Diesel Engines

5EF1-UP
6AF1-UP
1ZG1-UP
2SG1-UP
2WG1-UP

4PG1-UP
5JG1-UP
1NJ1-UP
5EN1-UP
2MR1-UP

4KR1-UP
9ZR1-UP
6MS1-UP

Engines Equipped With Mechanical Unit Injectors (MUI)



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Foreword

Literature Information

This manual contains safety, operation instructions, lubrication and maintenance information.

Some photographs or illustrations in this publication show details or attachments that may be different from your engine. Guards and covers may have been removed for illustrative purposes.

Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this publication. Read – study – and keep this manual with the engine.

Whenever a question arises regarding your engine, or this publication, please consult your Caterpillar dealer for the latest available information.

Safety

The safety section lists basic safety precautions. In addition, this section identifies the text and locations of warning labels used on the engine.

Read and understand the basic precautions listed in the safety section before operating or performing lubrication, maintenance and repair on this product.

Operation

The operation section is a reference for the new operator and a refresher for the experienced one. This section includes a discussion of gauges, switches and engine controls.

Photographs and illustrations guide the operator through correct procedures of inspecting, starting, operating and stopping the engine. This section also includes a discussion of maintenance specifications, lifting and storage information.

Operating techniques outlined in this publication are basic. Skill and techniques develop as the operator gains knowledge of the engine and its capabilities.

Maintenance

The maintenance section is a guide to engine care. The illustrated, step-by-step instructions are grouped by preventive maintenance intervals. Items in the Maintenance Schedule are referenced to detailed instructions that follow.

The Maintenance Schedule items are organized for a Preventive Maintenance Program.

If the preventive Maintenance Management program is followed, a periodic tune-up is not required. The implementation of a preventive Maintenance Management program should minimize operating costs resulting from reductions in unscheduled downtime and failures.

Maintenance Intervals

Use the fuel consumption figures to determine maintenance intervals. Calendar intervals and service hour units can be used instead of fuel consumption intervals if they provide more convenient maintenance schedules and approximate the indicated fuel consumption figures. Recommended maintenance should always be performed at the interval that occurs first.

The maintenance interval for each item listed in the Maintenance Schedule is primarily based on the item and its relationship to either engine speed (rpm) or load.

Under extremely severe, dusty or wet operating conditions, more frequent lubrication than is specified in the Maintenance Schedule might be necessary.

We recommend that these schedules be reproduced for ease of inspection. We also recommend that a maintenance record be maintained as part of the engine's permanent record.

Perform maintenance on items at multiples of the original requirement. For example, at Every 2000 Hours, also service those items listed under Every 1000 Hours and Every 250 Hours.

See the Maintenance Log and Maintenance Records topics in this publication for information regarding documents that are generally accepted as proof of maintenance or repair.

Your Caterpillar dealer can assist you in tailoring your schedule to meet the needs of your operating environment.

Engine Description

The engines described in this publication are the 3114, 3116, and 3126 Industrial and EPG diesel engines.

They are designed primarily for stationary and mobile industrial, agricultural, and petroleum applications, and electrical prime and standby power generation.

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.

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

Safety

Warning Signs and Labels

There may be several specific safety signs on your engine. Please take the time to familiarize yourself with the location and the information stated on the safety signs.

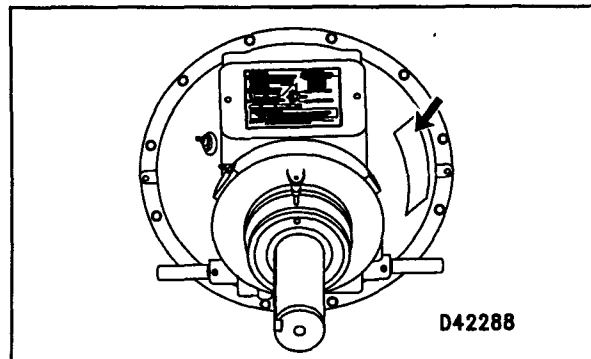
Make sure that you can read all safety signs. Clean or replace these if you cannot read the words or see the pictures. When cleaning the labels use a cloth, water and soap. Do not use solvents, gasoline, etc., to clean safety signs. The use of solvents, gasoline, etc., could loosen the sign's adhesive and cause the sign to fall off.

You must replace a label if it is damaged, missing or cannot be read. If a label is on a part that is replaced, make sure a new label is installed on the replaced part. See your Caterpillar dealer for new labels.

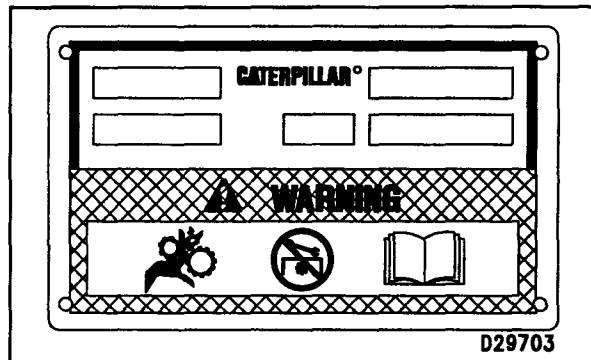
Do not operate or work on this engine unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings could result in injury or death. Contact any Caterpillar dealer for replacement manuals.

WARNING

Rotating gears— finger or hand entanglement. Do not service until reading the operator's manual.



The clutch warning sign is located on the clutch housing (if equipped).

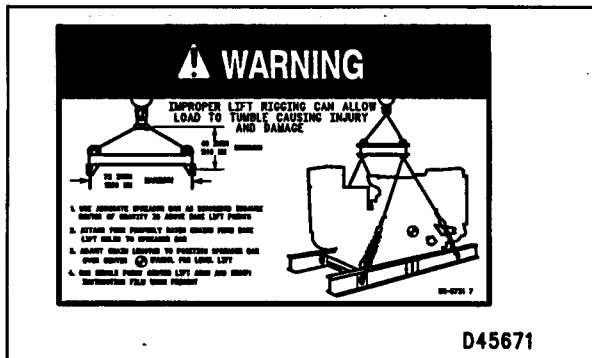


Clutch warning sign.

WARNING

Improper lift rigging can allow load to tumble causing injury and damage.

1. Use adequate spreader bar as described because center of gravity is above base lift points.
2. Attach four properly rated chains from base lift holes to spreader bar.
3. Adjust chain lengths to position spreader bar over center symbol for level lift.
4. Use single point center lift arch and 5N2171 Instruction Film when present.



Located on the mounting base (if equipped) near the lifting holes.

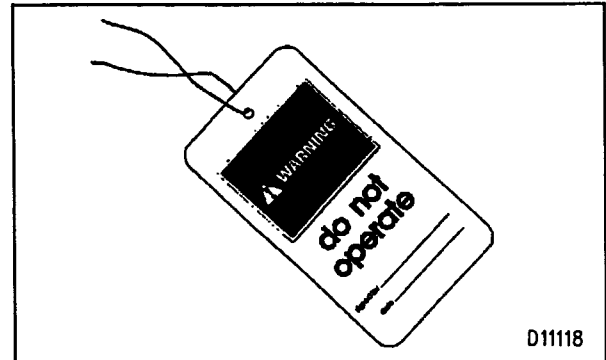
Located near batteries (if equipped):

WARNING

Improper jumper cable connections can cause an explosion resulting in personal injury.

Batteries may be located in separate compartments. When using jumper cables, always connect positive (+) cable to positive (+) terminal of battery connected to starter solenoid and negative (-) cable from external source to starter negative (-) terminal (if machine not equipped with starter negative terminal, connect to engine block.) Follow procedure in the operation manual.

General Hazard Information



Attach a "DO NOT OPERATE" or similar warning tag to start switch or controls before servicing or repairing the engine. These tags, Form SEHS7332, are available from your Caterpillar dealer.

Do not allow unauthorized personnel near the engine when maintenance or repair is being performed.

Ensure protective locks or controls are in the applied position.

If the generator is connected in series to a utility electrical distribution system, it must be isolated from that distribution system by

- Opening the main switch in the case of a portable generator temporarily connected to the system, or . . .
- Utilizing a double throw (transfer) switch in the case of a permanent connection to the distribution system.

Wear a hard hat, protective glasses and other protective equipment as required by job conditions.

Wear ear protective devices to prevent hearing damage if working inside an enclosed area with engines running.

Do not wear loose clothing or jewelry that can catch on controls or other parts of the engine.

Make certain all protective guards and covers are secured in place.

Use all cleaning solutions with care.

Never put maintenance fluids into glass containers since glass containers can break.

Report all needed repairs.

Do not attempt repairs you do not understand. Do not use tools or equipment you do not know how to use.

Unless Instructed Differently, Perform All Maintenance as Follows:

- Stop the engine. Do not attempt any repairs or adjustments to the engine or driven equipment while it is in operation.
- Lock out all electrical panels associated with the generator set being serviced.
- Ensure the protective locks or controls are in the applied position.
- Disconnect the batteries before performing maintenance on the electrical system.
- Do NOT attempt repairs you do not understand.
- Use proper tools; replace or repair broken or damaged equipment.
- Start the engine only from the operator's station. Never short across the starter terminals or the batteries as this could bypass the engine neutral-start system as well as damage the electrical system.
- In case there is an overspeed on start-up when starting an engine after repairs have been made to the fuel system, be prepared to shut off the engine's inlet air or fuel supply to stop the engine.

Pressure Air and Water

Pressure air can cause personal injury. When using pressure air for cleaning, wear a protective face shield, protective clothing and protective shoes.

The maximum air pressure must be below 205 kPa (30 psi) for cleaning purposes.

Wear eye protection at all times when cleaning the cooling system. Pressurized water could cause debris and/or hot water to be blown and result in personal injury.

Fluid Penetration

Always use a board or cardboard when checking for a leak. Escaping fluid under pressure, even a pin-hole size leak, can penetrate body tissue, causing serious injury or possible death.

If fluid is injected into your skin, it must be treated by a doctor familiar with this type of injury immediately.

Asbestos Information

Caution should be used to avoid breathing dust that may be generated when handling components containing asbestos fibers. If this dust is inhaled, it can be hazardous to your health.

Components in Caterpillar products that may contain asbestos fibers are brake pads, brake band and lining assemblies, clutch plates and some gaskets.

The asbestos used in these components is usually bound in a resin or sealed in some way. Normal handling is not hazardous as long as airborne dust which contains asbestos is not generated.

If dust is present, which may contain asbestos, there are several common sense guidelines that should be followed.

- Never use compressed air for cleaning.
- Avoid brushing or grinding of asbestos containing materials.
- For clean up, use wet methods or a vacuum equipped with a high efficiency particulate air (HEPA) filter.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place. (For example in the U.S.A., OSHA requirements as set forth in 29 CFR 1910.1001).
- Follow environmental rules and regulations for disposal of asbestos.
- Avoid areas where airborne asbestos particles may be present.

Lines, Tubes and Hoses

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. Do not use your bare hands to check for leaks. Tighten all connections to the recommended torque.

Check for the following:

- End fittings displaced, damaged or leaking.
- Outer covering chafed or cut and wire reinforcing exposed.
- Outer covering ballooning locally.
- Evidence of kinking or crushed areas of the flexible part of the hose.
- Armoring embedded in the outer cover.

Burn Prevention

Do not touch any part of an operating engine. Allow the engine to cool before any repair or maintenance is performed on the engine.

Relieve all pressure in air, oil, fuel or cooling systems before any lines, fittings or related items are disconnected or removed.

Coolant

To prevent personal injury, do not step up on engine to remove the filler cap, if applicable. Use an adequate ladder.

At operating temperature, the engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot water. When pressure is relieved rapidly, this hot water can turn into steam.

Radiators must be kept clean and free from trash to prevent possible overheating.

Any contact with hot water or steam can cause severe burns. Allow cooling system components to cool before draining.

Check the coolant level only after the engine has been stopped and the filler cap is cool enough to remove with your bare hand.

Remove the cooling system filler cap slowly to relieve pressure.

Cooling system supplemental coolant additive contains alkali. To prevent personal injury, avoid contact with the skin and eyes and do not drink.

Oils

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

Batteries

Battery electrolyte contains acid and can cause injury. Avoid contact with the skin and eyes.

Wash hands after touching batteries and connectors. Use of gloves is recommended.

Batteries give off flammable fumes which can explode.

Do not smoke when observing the battery electrolyte levels.

Always wear protective glasses when working with batteries.

Fire or Explosion Prevention

Determine whether the engine will be operated in an environment in which combustible gases could be drawn through the air inlet system. These gases could cause the engine to overspeed, which in turn could destroy the engine and result in bodily injury or property damage.

If your application involves the presence of combustible gases, consult your Caterpillar dealer to obtain additional information concerning protection devices (i.e. air inlet shutoff) suitable for the application involved.

A manual shutdown device such as an air inlet shutoff is recommended to be installed in the air inlet piping for engines handling flammable gases or working in an area where escaping flammable gases could be encountered. This will prevent possible engine runaway or possible engine explosion.

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

Diesel fuel is flammable. Gasoline is flammable. The mixture of diesel and gasoline fumes are extremely explosive.

Do not smoke while refueling or in a refueling area.

Do not smoke in areas where batteries are charged, or where flammable materials are stored.

Batteries give off flammable fumes which can explode.

Keep all fuels and lubricants stored in properly marked containers and away from unauthorized people.

Store oily rags or other flammable material in a protective container, in a safe place, away from sparks and open flames.

Do not weld or flame cut on pipes or tubes that contain flammable fluids. Clean them thoroughly with nonflammable solvent before welding or flame cutting on them.

Remove all flammable materials such as fuel, oil and other debris before they accumulate on the engine.

Do not expose the engine to flames, burning brush, etc., if at all possible.

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

When starting from an external source, always connect the positive (+) jumper cable to the POSITIVE (+) terminal of the battery of the engine to be started.

To prevent potential sparks from igniting combustible gases produced by some batteries, attach the negative (-) boost ground cable last, to the starter NEGATIVE (-) terminal (if equipped) or to the engine block.

See the Operation Section of this manual for specific starting instructions.

If the engine is equipped with an emergency starting receptacle, use a jumper cable with a plug that will mate with the receptacle.

Clean and tighten all electrical connections. Check daily for loose or frayed electrical wires. Have all loose or frayed electrical wires tightened, repaired or replaced before operating the engine.

Fire Extinguisher

Have a fire extinguisher available and know how to use it. Inspect and have it serviced as recommended on its instruction plate.

Crushing or Cutting Prevention

Support equipment and attachments properly when working beneath them.

Never attempt adjustments while the engine is running unless otherwise specified in this manual.

Stay clear of all rotating and moving parts. Guards should be in place whenever maintenance is not being performed.

Keep objects away from moving fan blades. They will throw or cut any object or tool that falls or is pushed into them.

Wear protective glasses when striking objects to avoid injury to your eyes.

Chips or other debris can fly off objects when struck. Make sure no one can be injured by flying debris before striking any object.

Mounting and Dismounting

Mount and dismount the engine only where steps and/or handholds are provided. Do not climb on the engine. Use an adequate ladder.

Inspect, and when necessary, have repairs made and clean steps, handholds and platform areas of the engine installation you will be working on or around.

Maintain a three point contact, (two feet and one hand or one foot and two hand contact) with the steps and handholds.

Do not jump on around or off the engine platform or base. Always use proper steps and handholds when mounting and dismounting.

Do not try to climb on or off the engine when carrying tools or supplies. Use a hand line to pull equipment and tools up onto the engine.

Do not use any controls as handholds when entering or leaving the engine area.

Before Starting the Engine

Inspect the engine for potential hazards by using the Walk-Around Inspection procedure listed in this manual.

Be sure all protective guards and covers are installed if an engine must be started to make adjustments or checks. To help prevent an accident caused by parts in rotation, work carefully around them.

Never start an engine with the governor linkage disconnected.

Do not disable or bypass automatic shutoff circuits unless otherwise instructed in this manual. They are provided to prevent personal injury and equipment damage.

Make provisions for shutting off the air supply to stop the engine if there is an overspeed on start-up after performing repair or maintenance to the engine.

Engine Starting

Do not start the engine or move any of the controls if there is a warning tag attached to the controls. Check with the person who attached the tag before starting the engine.

Make sure no one is working on, or close to the engine or engine driven components before starting it. Always make an inspection of the engine before and after starting.

Diesel 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 and be sure the venting systems are correctly installed and in proper working order.

Start the engine only from the operator's station. Never short across the starter terminals as this could bypass the engine neutral-start system as well as damage the electrical system.

Starting Aids (if used)

Ether and other starting aids are poisonous and flammable. Do not smoke while changing ether cylinders.

Use ether only in well ventilated areas.

Keep ether cylinders out of the reach of unauthorized persons.

Do not store replacement ether cylinders in living areas or in the engine installation area.

Do not store ether cylinders in direct sunlight or at temperatures above 39°C (102°F). Discard cylinders in a safe place. Do not puncture or incinerate the cylinders.

Engine Stopping

Stop the engine according to the "Engine Stopping" instructions in the Operation Section to avoid overheating and accelerated wear of the engine components.

Only use the Emergency Stop knob in an emergency situation. DO NOT start the engine until the problem necessitating the emergency stop has been located and corrected.

Customer Service

North America Only

When a problem arises concerning the sale, operation or service of your engine, it will normally be handled by the dealer in your area. The service facility nearest you can be located twenty-four hours a day by calling the phone number below.

In U.S. and Canada: 1 (800) 447-4986.

Your satisfaction is a primary concern to Caterpillar and its dealers. If you have a problem that has not been handled to your complete satisfaction, we suggest the steps that follow.

Step One

Discuss your problem with a member of management from the dealership.

Step Two

When it appears that your problem cannot be readily resolved at the dealer level without additional assistance, use the above telephone numbers and ask to talk to a Field Service Coordinator. Regular Monday through Friday business hours are from 8:00 a.m. to 4:30 p.m. Central Standard Time (CST).

Step Three

If you are still not satisfied, present the engine matter in writing to: Caterpillar Inc.
Manager, Customer Service, Engine Division
Mossville Bldg. A
P.O. Box 600
Peoria, Illinois 61552-0600

When contacting the Manager, Customer Service, please keep in mind that ultimately your problem will likely be resolved at the dealership, using their facilities, equipment, and personnel. Therefore, it is suggested that you follow the above steps in sequence when experiencing a problem.

Outside North America

If a problem arises outside North America, and cannot be resolved at the dealer level, contact the appropriate Caterpillar subsidiary office.

Central/South America (except Brazil)

Caterpillar Americas Co.
100 NE Adams Street
Peoria, Illinois 61629 U.S.A.
Phone: 309-675-5876
Fax: 309-675-5384

Brazil

Caterpillar Americas Co.
Edificio Brasil Interpart
Rua Guararapes, 2064 5.0 andar, cj.2
04561-004 - Sao Paulo-SP-Brazil
01.000-Sao Paulo-SP-Brazil
Phone: 011-536-3388
Fax: 011-505-1647

Far East (except Japan and Australia)

Caterpillar Far East Limited
28th Floor, Sun Hung Kai Centre
30 Harbour Road
G.P.O. Box 3069
Wanchai, Hong Kong
Cable Address: CATFAREAST HKG
Telex No.: HX73305 CFEL
Phone: 5-8326333

Australia and New Zealand

Caterpillar of Australia Ltd.
1 Caterpillar Drive
Private Mail Bag 4
Tullamarine, Victoria 3043
Australia
Telex: AA30240
Cable: CATERPILLAR MELB
Phone: (03) 339-9333
Fax: (03) 335-3366

Japan

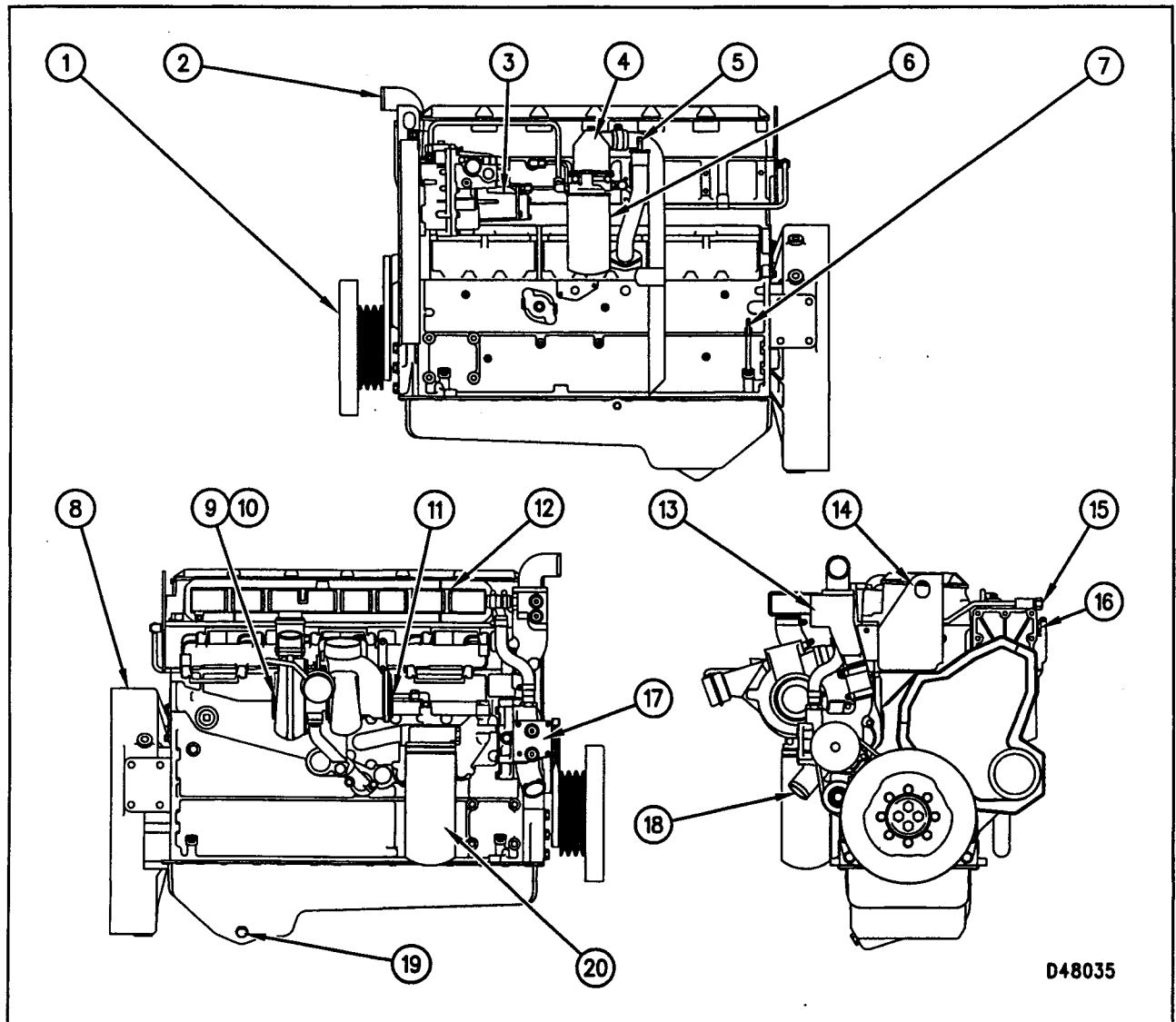
Caterpillar Mitsubishi Ltd.
3700, Tana, Sagamihara-shi
Kanagawa-ken, 229
Japan
Telex No.: 2872-261CM HAJ
Cable Address: CATERBISHICO SAGAMIHARA
Phone: Sagamihara (0427) 62-1121
Fax: (0427) 62-8542

Europe, Africa, and Middle East

Caterpillar Overseas S.A./Power Systems
YA50 76, Route de Frontenex
P.O. Box 6000
1211 Geneva 6
Switzerland
Cable Address: CATOVERSEA
Telex No.: 413323
Phone: (022) 849-4444
Telecopier: (022) 849-4984
Fax: (022) 849-4544

Model Views

The sample model view drawings show various typical Caterpillar 3100 Engine features. The drawings are generic and do not reflect all available options.



3116 Engine Shown: Crankshaft Vibration Damper (1), Water Outlet (2), Governor (3), Crankcase Breather (4), Oil Filler Cap (5), Fuel Filter (6), Oil Level Gauge (Dipstick, 7), Flywheel Housing (8), Air Inlet (9), Turbocharger (10), Exhaust Outlet (11), Aftercooler (12), Water Temperature Regulator (Thermostat) Housing (13), Lifting Eye (14), Excess Fuel Return (15), Fuel Inlet (16), Water Pump (17), Water Inlet (18), Oil Drain Plug (19), and Oil Filter (20).

Engine Information

Engine Specifications

3114 Engine

The Caterpillar 3114 Industrial and EPG Engine is a four stroke cycle, in-line 4 cylinder with direct injection.

3114 ENGINE SPECIFICATIONS	
Operating Range (rpm)	1500 - 2800 ¹
Number of Cylinders	4 In Line
Bore	105 mm (4.13 in)
Stroke	127 mm (5.0 in)
Displacement	4.4 liter (268 cu in)
Firing Order	1-3-4-2
Rotation (viewed from flywheel)	CCW

¹ Operating rpm is dependent on engine rating and application.

3116 Engine

The Caterpillar 3116 Industrial and EPG Engine is a four stroke cycle, in-line 6 cylinder with direct injection.

3116 ENGINE SPECIFICATIONS	
Operating Range (rpm)	1800 - 2600 ¹
Number of Cylinders	6 In Line
Bore	105 mm (4.13 in)
Stroke	127 mm (5.0 in)
Displacement	6.6 liter (403 cu in)
Firing Order	1-5-3-6-2-4
Rotation (viewed from flywheel)	CCW

¹ Operating rpm is dependent on engine rating and application.

3126 Engine

The Caterpillar 3126 Industrial and EPG Engine is a four stroke cycle, in-line 6 cylinder with direct injection.

3126 ENGINE SPECIFICATIONS	
Operating Range (rpm)	2200 - 2600 ¹
Number of Cylinders	6 In Line
Bore	110 mm (4.33 in)
Stroke	127 mm (5.0 in)
Displacement	7.2 liter (450 cu in)
Firing Order	1-5-3-6-2-4
Rotation (viewed from flywheel)	CCW

¹ Operating rpm is dependent on engine rating and application.

Engine Information

The 3100 Family of Engines has a rated rpm ranging from 1800 to 2600 in industrial applications (depending on the turbocharged or turbocharged and aftercooled intermittent rating). Continuous ratings may have a rated rpm of 2200 or below. Generator set engines may be rated for prime power or standby power.

A full range hydramechanical governor and high pressure unit injection fuel system controls output to maintain the engine rpm selected by the operator and provide good engine response and fuel economy.

The engine oil cooler is a plate type unit which utilizes cooling water directly from the engine water pump.

The engine water pump is belt driven by a single vee belt and idler pulley for belt tensioning. The pump speed to engine speed ratio can be varied to adapt to high and low speed engine ratings. A thermostat regulates the engine coolant water temperature to the oil cooler from the radiator, incorporating a shunt system.

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

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

Follow the recommended Maintenance Schedule with emphasis on emission related components, air cleaner, lubrication oil, oil filter, fuel, fuel filter, and cooling system maintenance found in this publication.

Engine Identification

Caterpillar engines are identified with serial numbers, fuel system setting numbers and arrangement numbers. In some cases modification numbers are also used. These numbers are shown on the serial number plate mounted on the engine.

Caterpillar dealers need all of these numbers to determine which components were included on the engine when it was assembled at the factory. This permits accurate identification of replacement part numbers.

Serial Number, Information Plate and Reference Numbers

Serial Number Plate

CATERPILLAR		CH	CAT
SERIAL NUMBER		ARRANGEMENT NUMBER	
ENGINE MODEL			
(ALWAYS TYPE ALL NUMBERS)			
D35477			

Located on the left side of the block near the rear face.

Information Plate

CAT		CORE NO.	DATE DELIVERED	SER. CODE
SER. NO.	MODIFICATION NO.	PER. SPEC.		WAT. ALT.
AR. OEN NO.				
FULL LOAD STATIC FUEL POWER	HP	FULL TORQ. STATIC FUEL	hp	A/T RATIO DYNAMIC
BARE ENG. HT. IDLE RPM		FULL LOAD RPM		FUEL TIMING
9L-6531 17				
D48703				

Located on top of the valve cover or on the valve cover base forward of the breather.

Reference Numbers

Engine Model_____

Engine Serial No._____

Engine Arrangement No._____

Engine Power Rating _____kW, _____hp

Engine Full Load rpm_____

Performance Specification No._____

Governor Group No._____
(located on Governor Plate)

Fuel Filter Element No._____

Lubrication Oil Filter Element No._____

Auxiliary Oil Filter Element No._____

Lubrication Oil System Capacity_____

Supplemental Coolant Additive (SCA) Maintenance Element No._____

Supplemental Coolant Additive Precharge Element No._____

Cooling System Capacity_____

Air Cleaner Element No._____

Fan Drive Belt Set No._____

Alternator Belt No._____

Ordering Parts

Quality Caterpillar replacement parts are available from Caterpillar dealers throughout North America and the world. Their parts stocks are up to date and include all parts normally required to protect your investment in Caterpillar engines.

When ordering parts, your order should specify the quantity, part number, part name and serial number, arrangement number and modification number of the engine for which the parts are needed. If in doubt about the part number, please provide your dealer with a complete description of the needed item.

When service is needed for your Caterpillar engine, be prepared to give the dealer all the information that is provided on the 9L6531 Information Plate located on the cylinder block or valve cover.

Discuss the problem with the dealer, such as; when it occurs, what happens, etc. This will help the dealer in troubleshooting and solving the problem faster.

Gauges

Gauges provide a "look" inside the engine. Be sure they are in good working order. You can determine what is the "normal" operating range by observing the gauges over a period of time.

Noticeable changes in gauge readings are indicative of potential gauge or engine problems. This also applies to gauge readings that have changed significantly but are still within specifications. The cause of any sudden or significant change in the readings should be determined and corrected. Contact your Caterpillar dealer for assistance as needed.

The oil pressure will be higher after starting a cold engine. When the engine is running at rated engine speed, with SAE 10W30 oil, at operating temperature, normal oil pressure will be between 240 and 480 kPa (35 and 70 psi). A lower pressure is normal at low idle speed.

NOTICE

If no pressure is indicated, stop the engine. Engine damage can result.



Jacket Water Temperature – Indicates engine coolant temperature. It should normally indicate between 71 and 99°C (160 to 210°F). Maximum allowable temperature is 102°C (215°F) with the cooling system pressurized.



Voltmeter – Indicates the condition of the battery charging circuit.

With the engine running, during normal operation, if the indicator is constantly to the negative (left) side of "0" (zero) or shows excessive charge, have the charging system checked for malfunction.



Tachometer – Indicates engine rpm (speed). The engine can be operated at high idle without damage, but should not be allowed to overspeed. Overspeeding can result in serious damage to your engine.

NOTICE

Do not exceed "bare engine high idle" rpm in any situation.



Fuel Level – Indicates fuel level in the fuel tank. Electrically operated, it registers only when the START/STOP switch is ON.



Fuel Pressure – Indicates fuel pressure to the injectors. An orifice in the fuel return line produces a fuel pressure of 200 to 400 kPa (29 to 58 psi) for the injectors in the cylinder head gallery at rated rpm and a minimum pressure of 50 kPa (7 psi) at low idle rpm.

Low fuel pressure can be an indication of a plugged fuel filter or fuel inlet screen. If fuel pressure is low, replace the fuel filter and clean the fuel inlet screen located on the suction side of the fuel transfer pump.



Service Hour Meter – Indicates the total number of clock hours the engine has operated.

Engine Protection Devices

Shutoff and Alarm Systems

Shutoff and alarm systems are electrically operated. The operation of all electric shutoffs and alarms utilize components which actuate switches in a sensing unit.

Shutoff switches are set at a more critical operating temperature, pressure, level or speed than the alarm components. A shutoff switch opens or closes the circuit to the fuel shutoff solenoid. Opening the circuit to the fuel shutoff solenoid moves the fuel rack to the fuel OFF position. The particular shutoff may require resetting before the engine will start.

When any sensing switch shuts the engine down, the problem causing the shutdown must be corrected before attempting to restart the engine.

Familiarize yourself with the

- types and locations of the shutoff controls
- conditions which cause each control to function
- resetting procedure required to restart your engine

Alarm switches consist of a sensor and contactor. Sensors are wired to contactors. The contactors activate alarm circuits in the Annunciator Panel.

Alarm switches are set at a less critical operating temperature, pressure, level, or speed than the shutoff components. The purpose of the alarm switches is to warn the operator that an unsafe operating condition is beginning to occur.

When an alarm is activated, corrective measures must be taken, **before the situation becomes an emergency**, to avoid possible engine damage.

If corrective measures are not taken within a reasonable time, engine damage could result. Alternatively, a corresponding shutdown device (if equipped) will stop the engine.

The alarm will continue until the condition is corrected or the alarm is reset by the operator. The alarm circuits merely warn the operator, they do not shut the engine down to protect it from damage.

A switch may be installed in the alarm circuit for silencing the alarm while the engine is stopped for repairs. Before starting, be sure the switch is moved to the closed (ON) position and the warning lights are illuminated.

If the switch is left in the open (OFF) position when the engine is started, the engine will not be protected.

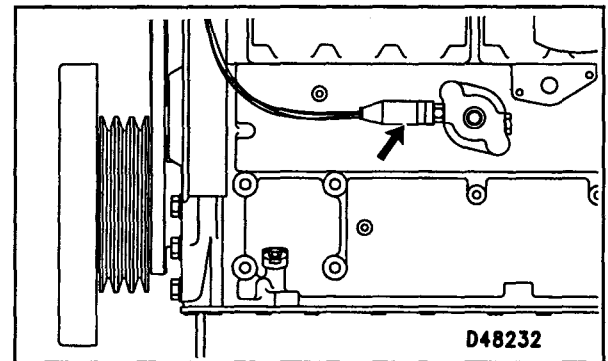
NOTICE

Always determine the cause of the engine shutdown. Make necessary repairs before attempting restarting the engine.

Fuel Shutoff Solenoid

This solenoid is located on the governor or the fuel injection pump. When the solenoid is activated, the solenoid moves the fuel rack (either directly or through the governor) to the fuel OFF position.

Oil Pressure

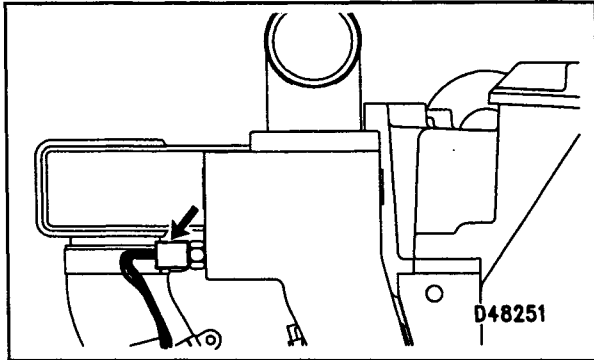


This oil pressure switch is mounted on the left side of the engine.

An oil pressure switch may be mounted in the side of the engine. An oil pressure switch has wires connected to the electrical system for alarm or shutoff functions. The oil pressure switch senses oil pressure at the bearing oil gallery. If sufficient oil pressure is not achieved after engine starting, or if the engine has been running normally and then loses oil pressure, the fuel shutoff solenoid is energized to shut the engine off. No resetting procedure is required.

NOTE: Switches may close at 48 to 62 kPa (7 to 9 psi) below actual trip point.

Water Temperature Contactor Switch



The water temperature contactor switch is located in the water temperature regulator (thermostat) housing. High water temperature closes the switch to activate an alarm or fuel shutoff. No resetting is required. The switch opens as the coolant cools.

NOTICE

The sensing element must be submerged in the coolant to operate. Be sure to have an adequate water supply in the jacket water system, or engine damage could result.

Shutoff and Alarm System Testing

The Engine Protective Devices shutdown controls and alarms on the engine should be tested every 1000 service hours or twice a year for proper operation by authorized Caterpillar service personnel or other experienced mechanics.

NOTICE

During testing, abnormal operating conditions must be simulated. Perform the tests correctly to prevent possible damage to the engine.

Refer to the Service Manual or consult with your Caterpillar dealer for the testing procedures.

Before Starting the Engine

Walk-Around Inspection

For maximum service life of your engine, make a thorough inspection before starting the engine. Look for items such as oil or coolant leaks, loose bolts, worn fan belts and trash build-up. Remove trash build-up and have repairs made as needed.

Perform required periodic maintenance before starting the engine. Make a walk-around inspection of the installation. It only takes a few minutes to make minor corrections. This can prevent major repairs at a later date.

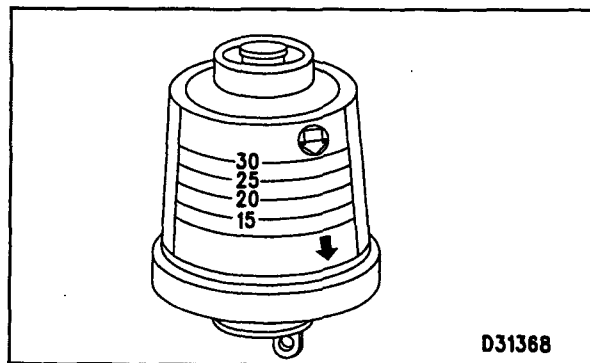
Look for such items as fuel, coolant or oil leaks, loose bolts, worn vee belt(s), frayed wiring, and trash build-up.

NOTICE

Accumulated grease and oil on an engine or platform is a fire hazard. Remove this debris with steam cleaning or high pressure water, at least every month or each time any significant quantity of oil (or other fluid) is spilled on or near an engine and working area.

Wipe clean all fittings, caps and plugs before servicing.

Air Inlet System



Typical air cleaner service indicator.

- Observe the air cleaner service indicator (if equipped). Service the air cleaner when the yellow diaphragm enters the red zone or the red piston locks in the visible position.

If your air cleaner is not equipped with an indicator, you can obtain one at your Caterpillar dealer. Make sure the air inlet piping is secured and air filters are in place.

- Inspect the air inlet system hoses or piping, elbows and gaskets for cracks or damage. Replace items as needed. Check for loose clamps and tighten if necessary.

Cooling System

- Inspect the cooling system for leaks and trash build-up.
- Inspect the water pump for leaks.

NOTE: The water pump seal is lubricated by coolant in the cooling system. It is not unusual for a small amount of leakage to occur as the engine cools down and parts contract.

- Inspect the system hoses for cracking and loose clamps.
- Inspect the fan and accessory drive belts for cracks, breaks or other damage. Check for proper belt tension.

Belts for multiple groove pulleys are sold in matched sets.

NOTE: Belts for multiple groove pulleys must be replaced as matched sets. If only one belt of a two or three belt set is replaced, it will carry more of a load than the belts not replaced since the older belts are stretched. The additional load on the new belt could cause it to break.

Electrical System

Wiring must be kept in good condition, properly routed and firmly attached. Routinely inspect wiring for wear or deterioration. Loose, unattached, or unnecessary wiring must be eliminated. All wires and cables must be of the recommended gauge and fused if necessary. Do not use smaller gauge wire or bypass fuses.

Tight connections, recommended wiring and cables properly cared for will help prevent arcing or sparking which could cause a fire.

- Inspect wiring for loose connections and worn or frayed wires.
- Inspect engine-to-frame rail ground strap for good connection and condition.
- Disconnect any battery chargers that are not protected against the high current drain created when the electric starter engages. Check electrical cables and the battery for poor connections and corrosion.

Fuel and Lube Systems

- Make sure fuel lines are properly clamped and tight. Check for loose fittings or leaks.
- Drain water from the water separator (if equipped).
- Inspect the crankcase breather hose for cracking and loose clamps.
- Check for lubrication leaks, such as the front and rear crankshaft seals, crankcase, oil filter, oil gallery plugs, sensors and valve covers.

NOTE: If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more frequently than the recommended service intervals prescribed in this publication until a leak is found or fixed, or until the suspicion for a leak has been proven to be unwarranted.

Pre-Start Checks

- All guards must be in place. Repair or replace all guards that are damaged or missing.
- Check the oil level. Maintain the oil level between the ADD and FULL marks.
- Check the oil level(s) on driven equipment.
- Check the coolant level with the engine stopped and cold. Remove the filler cap slowly to relieve pressure. Maintain the coolant level to within 13 mm (½ in) of the bottom of the fill pipe. Install the filler cap.
- If equipped with a sight glass, maintain the coolant to the proper level.

NOTICE

To prevent engine damage, never add coolant to an overheated engine. Allow the engine to cool first.

- Open the circuit breaker on a generator set. Disconnect any battery chargers that are not protected against the starter current drain.

Engine Starting

WARNING

Diesel 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.

Do not start the engine or move any of the controls if there is a "DO NOT OPERATE" or similar warning tag attached to the start switch or controls.

The operator must be satisfied that no one will be endangered before starting the engine.

If the engine has not been run for several weeks, fuel may have drained and allowed air into the filter housing. Also, when fuel filters have been changed, some air space will be left in the housing.

In these instances, prime the fuel system.

NOTICE

Do Not engage starter when flywheel is turning.

Do Not start engine under load.

Starting, Operating, and Stopping EPG Engines Equipped With Control Panels

Refer to SEBU6150, the Operation and Maintenance Manual for Caterpillar SR4 Generators and Control Panels (if equipped). Additional information and programming instructions are provided in the service manual for specific control panels.

Electric Starting

NOTE: Startability will be improved at temperatures below 16°C (60°F) by the use of a starting aid and/or use of a jacket water (coolant) heater or other means to heat the cylinder block.

Start the engine using the following procedure:

1. Open the fuel supply valve. Open the fuel return line to prevent engine damage.
2. Place machine controls in starting position. Disengage the clutch, or transmission, or open the main electrical circuit breaker on generator sets.

NOTICE

Do not crank the engine for more than 30 seconds. Allow the starter to cool for two minutes before cranking again.

Turbocharger damage can result if the engine rpm is not kept low until the engine oil light or gauge verifies the oil pressure is sufficient.

NOTICE

If oil pressure does not rise within 15 seconds after the engine starts, stop the engine and make necessary troubleshooting corrections before restarting.

3. Turn the starter switch to the START position. Turn the battery disconnect switch (if equipped) to the ON position. Crank the engine. While cranking, move the throttle to the full on (high idle) position, then back to low idle, and then advance to the ½ to ⅓ fuel position. Release the start switch as soon as the engine starts, and return the throttle to low idle. Oil pressure should rise within 15 seconds after the engine starts. Do not apply load to the engine or increase engine speed until the oil pressure gauge indicates normal.

4. Allow the engine to idle. After the engine is idling smoothly, load and speed may be gradually increased until normal operating temperature is achieved.

5. Operate the engine at low load and rpm until the coolant temperature is normal. Monitor all gauge readings during this warm-up period.

Starting At Temperatures Below 0°C (32°F)

For starting below -18°C (0°F), use of optional cold weather starting aids is recommended. A coolant heater, air inlet heater, or extra battery capacity may be required.

For temperatures below -23°C (-10°F) consult your Caterpillar dealer.

Starting With Starting Fluid

WARNING

When using starting fluid, follow the manufacturer's instructions carefully, use it sparingly and spray it only while cranking the engine. Failure to do so, could result in an explosion and/or fire and possible personal injury.

WARNING

If equipped with an air inlet heater (AIH) for cold weather starting, do not use aerosol types of starting aids such as ether. Such use could result in explosion or personal injury.

At temperatures below 0°C (32°F), it may be necessary to spray starting fluid into the air cleaner inlet. Additional injections of ether may be required to start and/or achieve low idle speed.

Follow the Electric Starting procedure. After cranking begins, push the starting fluid control switch and release immediately. Use additional starting fluid about every two seconds until the engine is running smoothly.

NOTICE

Excessive ether can cause piston and ring damage. Use ether for cold starting purposes only. Do not use excessive starting fluid during starting or after the engine is running.

If the engine fails to start within 30 seconds, release the starter switch and wait two minutes to allow the starter motor to cool before using it again.

Starting With An Air Inlet Heater (If Equipped)

WARNING

If equipped with an air inlet heater (AIH) for cold weather starting, do not use aerosol types of starting aids such as ether. Such use could result in explosion or personal injury.

The air inlet heater (AIH) is an available option for assisting cold weather starting. Allow the AIH sufficient time (30 seconds maximum) to heat before starting.

Engine Starting With Jumper Cables

WARNING

Batteries give off flammable fumes that can explode.

Improper jumper cable connections can cause an explosion resulting in personal injury.

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

Do not smoke when observing the battery electrolyte levels.

Always wear protective glasses when working with batteries.

Electrolyte is an acid and can cause personal injury if it contacts skin or eyes.

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

To prevent electrical discharge damage, check to make sure the engine's electrical system has a separate engine-to-frame rail ground strap. For engines which have the alternator connected to an engine component, the ground strap must connect that component to the frame.

Some engines have starter-to-frame ground straps. But many of these starters are not electrically grounded to the engine. They have electrical insulation systems. For this reason, the starter-to-frame ground strap may not be an acceptable engine ground.

When boost starting, refer to the instructions that follow to properly start the engine.

NOTICE

When using an external electrical source to start your engine, turn the START switch OFF and turn off all electrical accessories before attaching cables.

Your engine may be equipped with a 12 or 24 volt starting system. Use only the same voltage for boost starting. Use of a welder or higher voltage will damage the electrical system.

When using jumper cables always connect POSITIVE (+) cable to POSITIVE (+) terminal of battery which is connected to starter solenoid and NEGATIVE (–) cable from external source to starter NEGATIVE (–) terminal. If not equipped with a starter NEGATIVE terminal, connect to the engine block.

Do not reverse the battery cables. The alternator can be damaged.

Attach ground cable last and remove first.

1. Connect one end of the cable to the POSITIVE (+) terminal of the battery being started. Connect the other end to the POSITIVE (+) terminal of the power source.
2. Connect one end of the other cable to the NEGATIVE (–) terminal of the power source. Connect the other end to the starter NEGATIVE (–) terminal or to the engine block. This prevents potential sparks from igniting combustible gases produced by some batteries.
3. Begin cranking engine to start and achieve idle speed.
4. After the engine starts, disconnect the cable from the starter NEGATIVE (–) terminal or engine block. Disconnect the other end from the NEGATIVE (–) terminal of the power source.
5. Disconnect the cable from the POSITIVE (+) terminal of the battery on the engine being started. Disconnect the cable from the POSITIVE (+) terminal of the power source.

Engine Operation

Proper operation and maintenance are key factors in obtaining the maximum life and economy of the engine. Following the directions in this manual will lower operating costs.

The engine will reach normal operating temperature faster when operated at low speed and low power demand than when idled at no load.

Governors

Mechanical Governor

This governor has a manual control lever which allows the operator to control engine speed. The control lever is basic equipment with the Electro-mechanical Control Panel and a mechanical governor.

Applying the Load

To engage driven equipment before applying the load:

1. Operate the engine at $\frac{1}{2}$ rated speed.
2. Engage the driven equipment without a load on the equipment.

Interrupted starts put excessive stress on the drive train and waste fuel. To get the driven equipment in motion, engage the clutch smoothly, with no load on the equipment. This should result in a smooth, easy start without increasing the engine speed or excessively slipping the clutch.

To apply the load:

1. Make sure the engine gauges register in normal ranges with the engine operating at $\frac{1}{2}$ rated speed. If the driven equipment is already engaged without load, make sure any equipment gauges register in normal ranges.
2. Begin operating the engine at low load. Check the gauges and equipment for proper operation. After normal oil pressure is reached and the temperature gauge is normal, the engine may be operated at full load.

If the load varies, or is cyclic, the governor will adjust the engine speed as required.

Extended operation at low idle or reduced load may cause increased oil consumption and carbon build-up in the cylinders. This carbon build-up results in loss of power and/or poor performance. When operating at reduced load, the engine should be fully loaded to burn excess carbon from the cylinders at least every four hours. Check the gauges and equipment frequently while operating under load.

Engine Stopping

NOTICE

Stopping the engine immediately after it has been working under load can result in overheating and accelerated wear of the engine components. Follow the stopping procedure, outlined below, to allow the engine to cool. Excessive temperatures in the turbo-charger center housing could cause oil coking problems.

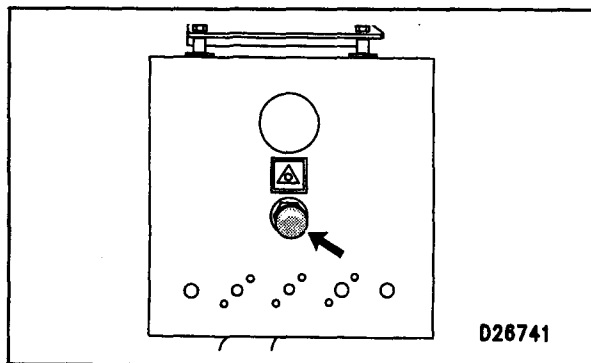
Emergency Stopping

NOTICE

Emergency shutoff controls are for **EMERGENCY** use **ONLY**. **DO NOT** use Emergency shutoff devices or controls for normal stopping procedure.

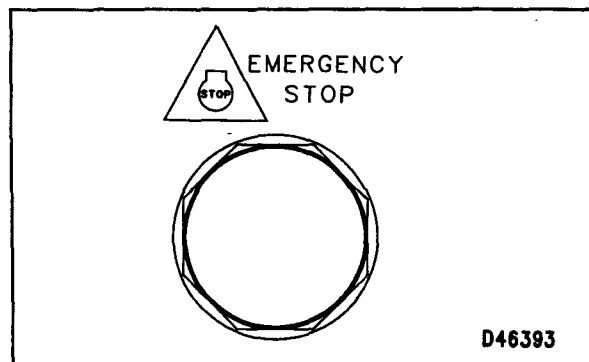
Make sure that any external system components that have been operating to support engine operation are secured after any stop.

Emergency Stop Buttons

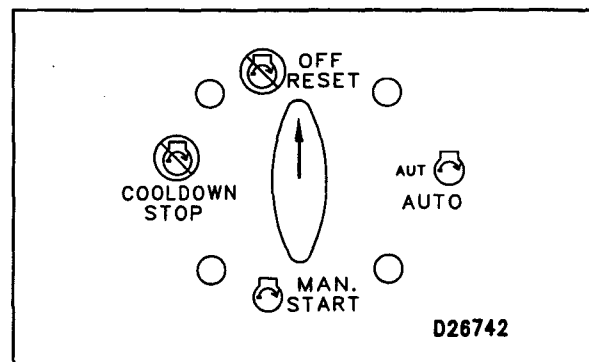


Emergency Stop Button, shown mounted on a junction box.

Emergency stops may be made by pushing the Emergency Stop Button located on the junction box (if equipped). The button requires resetting before the engine will start.

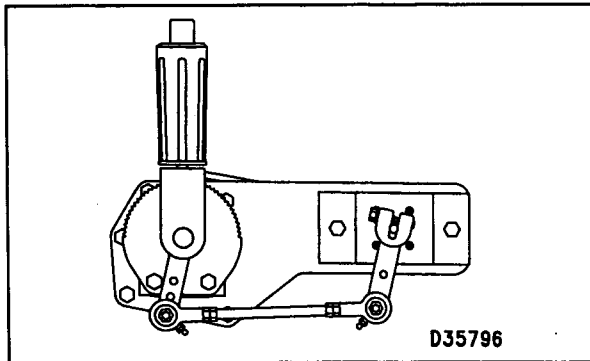


Control Panel Emergency Stop Button.



Engine Control Switch (ECS) in OFF/RESET position.

If equipped with a Control Panel, press the Emergency Stop Button for an emergency stop. The Engine Control Switch must be reset before resuming operation. Move the ECS to the OFF/RESET position.



Typical Mechanical Governor Control

If equipped with a Mechanical Governor Control, move the control to the FUEL OFF position. Hold the lever at the FUEL OFF position until the engine stops.

Manual Stop Procedure

There may be several ways to shut off your engine. Make sure the shutoff procedures are understood. Use the following general guidelines for stopping the engine.

1. Disengage any driven equipment or remove the load from engine.
2. Allow the engine to run at rated speed for one to two minutes with no load.
3. Run the engine at $\frac{1}{2}$ rated speed for one to two minutes with no load.
4. Reduce the engine speed to low idle for one to two minutes.
5. Shut the engine off by turning the start/stop switch to the stop or off position.

After Stopping the Engine

Turn the disconnect switch off when the engine is stopped to prevent battery discharge.

1. After the engine cools, fill the fuel tank to prevent accumulation of moisture in the fuel.
2. Check the coolant level. Allow the engine to cool. Open the filler cap slowly to relieve any pressure. Maintain the cooling system to 13 mm ($\frac{1}{2}$ in) from bottom of the fill pipe.

If freezing temperatures are expected, check the coolant water system for proper antifreeze protection. The system must be protected against freezing to the lowest expected outside temperature.

Add the proper coolant mix. Refer to the Cooling System Specification section of this publication for all information pertaining to acceptable water and antifreeze concentrations to use.

3. Check the crankcase oil level. Maintain the oil level between the ADD and FULL marks on the ENGINE STOPPED side of the oil level gauge (dipstick).
4. Repair any leaks, perform minor adjustments, tighten loose bolts, etc.
5. Observe the service meter reading. Perform periodic maintenance as indicated in the Maintenance Schedule of this manual.

Fuel Problems In Cold Weather Operation

Caterpillar Diesel Engines can operate effectively in cold weather, however, engine operation in cold weather is dependent on the type of fuel used and how well the fuel moves through fuel related components. The purpose of this section is to explain some of the problems and steps that can be taken to minimize fuel problems during cold weather operation when the engine area is colder than 5°C (40°F).

Fuel and the Effect from Cold Weather

The two types of diesel fuel available for your engine are typically grades No.1 and No.2. Although No.2 diesel fuel is the most commonly used fuel, No.1 diesel fuel is the fuel that is best suited for cold weather operation.

During cold weather operation, it may be necessary for you to use No.2 diesel fuel since quantities of No.1 diesel fuel are limited and generally are only available during the winter months and in the colder climates.

There are two major differences between No.1 and No.2 diesel fuel. No.1 diesel fuel has a lower cloud point and a lower pour point.

The cloud point is the temperature at which a cloud or haze of wax crystals will begin to form in the fuel and cause fuel filters to plug. The pour point is the temperature which diesel fuel will begin to thicken and be more resistant to flow through fuel pumps and lines.

Be aware of these fuel values when purchasing your diesel fuel and anticipate the average outside (ambient) temperature for the area your engine will be operating. Engines fueled in one climate may not operate satisfactorily if moved to another because of problems that result from cold weather.

NOTE: The average No.1 diesel fuel has a lower kJ (BTU) (heat content) rating per unit volume of fuel than the average No.2 diesel fuel. When using No.1 diesel fuel, you may notice a drop in power and fuel efficiency, but should not experience any other operating effects.

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

Fuel heating attachments are available from your Caterpillar dealer to minimize these problems.

The use of starting aids, engine oil pan heaters, engine coolant heaters, fuel heaters and fuel line insulation also provide a means of minimizing starting and fuel problems in cold weather when No.2 diesel fuel is used.

Fuel Related Components in Cold Weather

Fuel Heaters

Fuel heaters prevent plugging of the fuel filters in cold weather due to waxing. Non-thermostatically controlled fuel heaters can heat the fuel in excess of 65°C (150°F). High fuel temperatures reduce engine performance and reliability.

A fuel heater should be installed so that the fuel is heated before it enters the fuel filter.

Use a fuel heater that is mechanically simple, yet adequate for the application. The fuel heater should also prevent overheating of the fuel. Choose a fuel heater with as large a heating surface as practical. Small heaters can be too hot in their limited surface area.

Disconnect or deactivate the fuel heater in warm weather. A loss of engine power can occur if the fuel supply temperature exceeds 30°C (85°F).

NOTE: Heat exchanger-type fuel heaters should have a bypass provision to prevent overheating of the fuel in warm weather operation.

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

7C3557 Fuel Filter Heater

7C3558 Heater Kit

For further information on fuel heaters, contact your Caterpillar dealer.

Fuel Filters

The use of a water separator is recommended between the fuel tank and the engine mounted fuel filter. The micron rating and location of a water separator is important in cold weather operation. The water separator and its fuel supply line are the most common components affected by cold fuel.

The micron rating of the water separator should only be fine (low) enough to protect the fuel transfer pump. A very fine (low micron rating) water separator, can be more easily plugged by wax in cold weather.

The best location for the water separator is in the engine compartment, where it will benefit from the radiant heat of the engine. If it is mounted outside the frame rails, or any location exposed to wind, it can be a persistent problem in cold weather.

Radiator Restrictions

Caterpillar discourages the use of air flow restriction devices mounted in front of radiators with air-to-air aftercooled (ATAAC) engines. Air flow restriction can cause higher exhaust temperatures, power loss, excessive fan usage, and a reduction in fuel economy.

If an air flow restriction device must be used, the device should have a permanent opening directly in line with the fan hub. The device must have a minimum opening dimension of at least 770 cm² (120 in²).

A centered opening, directly in line with the fan hub, is specified to provide sensing when viscous fan drives are used and/or to prevent an interrupted air flow on the fan blades. Interrupted air flow on the fan blades could cause a fan failure.

Caterpillar recommends that a package include an inlet manifold temperature device, such as a light indicator, buzzer, etc., set at 65°C (150°F) and/or installation of an inlet air temperature gauge. For the ATAAC engines, air temperature in the inlet manifold should not exceed 65°C (150°F). Temperatures exceeding this limit can cause power loss and potential engine damage.

This temperature provides engine protection for full restriction device closure. This temperature can also serve as a diagnostic tool for a malfunction of the charge air cooling system. It is not anticipated that a temperature of 65°C (150°F) will be encountered under normal operating conditions.

The radiator shutter thermostat should open the shutters at a temperature that is 5.6°C (10°F) higher than the opening temperature of the engine thermostat.

On/off fan thermostats should open at a temperature that is 2.8° to 5.6°C (5° to 10°F) higher than the temperature setting of the shutters. The sequence of these events is important to maintain engine temperature and obtain optimum fuel economy.

If shutters are not used, fan temperature operation is typically 5.6° to 8.4°C (10° to 15°F) above the thermostat temperature.

Engine Lifting and Storage

Engine Lifting

NOTICE

When it is necessary to remove a component on an angle, remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90°. Eye Bolts and brackets should never be bent and should only be loaded in tension.

Use a hoist to remove heavy components. Lift the engine by using an adjustable lifting beam. All supporting members (chains and cables) should be parallel to each other, and as near perpendicular as possible to the top of the object being lifted.

Some removals require the use of lifting fixtures to obtain proper balance and to provide adequate handling.

To remove the engine ONLY, use the two lifting eyes equipped with the engine. Refer to the Model Views for the engine lifting eye locations.

Lifting eyes are designed for the arrangement as sold. Alterations to lifting eyes and/or arrangement weight make the lifting eyes obsolete.

If you make alterations, you are responsible for providing adequate lifting devices.

See your Caterpillar dealer for information regarding fixtures for proper lifting of your engine package.

Engine Storage

If the engine is not started for several weeks, the lubricating oil will drain from the cylinder walls and piston rings. Rust can form on the cylinder liner surface, which will increase engine wear and result in shorter engine life.

To prevent excessive engine wear:

- Be sure all Maintenance Schedule lubrication recommendations are completed.
- If freezing temperatures can be expected, check the cooling system for adequate protection against freezing. A 50/50 solution of Caterpillar permanent-type antifreeze and approved water will give protection below -37°C (-34°F).

If an engine remains out of service and its use is not immediately planned, special precautions should be taken.

Refer to SEHS9031, Storage Procedures For Caterpillar Products, for detailed information on engine storage.

Engine Lifting With Generator

To remove the engine and generator together, refer to the lifting decals and use the proper lifting eyes on the package.

Generator Storage

When a generator is in storage for any length of time, moisture condenses in the windings. Minimize the condensation by use of a dry storage space and space heaters.

Refer to SENR3985, the Service Manual for SR4 Generators, or SEHS9124, Cleaning and drying of Caterpillar Electric Set Generators, or consult with your Caterpillar dealer.

Torque Specifications

Torque for Standard Bolts, Nuts and Taperlock Studs

NOTICE

The following charts give general torques for bolts, nuts, and taperlock studs. For torque specifications not included in this section, refer to Torque Specifications, SENR3130, available from your Caterpillar dealer.

Torques for Bolts and Nuts With Standard Threads

Thread Size Inch	Standard Bolt & Nut Torque	
	N·m ¹	lb ft
1/4	12 ± 3	9 ± 2
5/16	25 ± 6	18 ± 4.5
3/8	47 ± 9	35 ± 7
7/16	70 ± 15	50 ± 11
1/2	105 ± 20	75 ± 15
9/16	160 ± 30	120 ± 20
5/8	215 ± 40	160 ± 30
3/4	370 ± 50	275 ± 37
7/8	620 ± 80	460 ± 60
1	900 ± 100	660 ± 75
1 1/8	1300 ± 150	950 ± 100
1 1/4	1800 ± 200	1325 ± 150
1 3/8	2400 ± 300	1800 ± 225
1 1/2	3100 ± 350	2300 ± 250

¹ 1 Newton meter (N·m) is approximately the same as 0.1 mkg.

Torques for Taperlock Studs

Thread Size Inch	Standard Taperlock Stud Torque	
	N·m ¹	lb ft
1/4	8 ± 3	6 ± 2
5/16	17 ± 5	13 ± 4
3/8	35 ± 5	26 ± 4
7/16	45 ± 10	33 ± 7
1/2	65 ± 10	48 ± 7
5/8	110 ± 20	80 ± 15
3/4	170 ± 30	125 ± 22
7/8	260 ± 40	190 ± 30
1	400 ± 60	300 ± 45
1 1/8	525 ± 60	390 ± 45
1 1/4	750 ± 80	550 ± 60
1 3/8	950 ± 125	700 ± 92
1 1/2	1200 ± 150	890 ± 110

¹ 1 Newton meter (N·m) is approximately the same as 0.1 mkg.

NOTE: Use these standard torque values for all fasteners, unless otherwise specified in this manual or in the Service Manual.

Torque for Metric Fasteners

NOTICE

Be very careful never to mix metric with customary (SAE standard) fasteners. Mismatched or incorrect fasteners will cause engine damage or malfunction and may even result in personal injury.

Original fasteners removed from the engine should be saved for reassembly whenever possible. If new fasteners are needed, they must be of the same size and grade as the ones that are being replaced.

Material strength identification is usually shown on the bolt head by numbers (8.8, 10.9, etc.). The following chart gives general torque values for bolts and nuts. Use these standard torque values unless otherwise specified in this publication.

NOTE: Metric hardware must be replaced with metric hardware. Check Parts Manual for proper replacement.

Torques for Bolts and Nuts with Metric Threads

METRIC ISO ² THREAD		
Thread Size Metric	Standard Torque	
	N•m ¹	lb ft
M6	12 ± 3	9 ± 2
M8	28 ± 7	20 ± 5
M10	55 ± 10	40 ± 7
M12	100 ± 20	75 ± 15
M14	160 ± 30	120 ± 20
M16	240 ± 40	175 ± 30
M20	460 ± 60	340 ± 40
M24	800 ± 100	600 ± 75
M30	1600 ± 200	1200 ± 150
M36	2700 ± 300	2000 ± 225

¹ 1 Newton meter (N•m) is approximately the same as 0.1 mkg.

² ISO—International Standard Organization.

Torque for Standard Hose Clamps—Worm Drive Band Type

NOTE: The following chart gives the torques for initial installation of hose clamps on new hose and for reassembly or tightening of hose clamps on existing hose.

Clamp Width	Initial Installation Torque on New Hose	
	N•m ¹	lb in
16 mm (.625 in)	7.5 ± 0.5	65 ± 5
13.5 mm (.531 in)	4.5 ± 0.5	40 ± 5
8 mm (.312 in)	0.9 ± 0.2	8 ± 2
Clamp Width	Reassembly or Retightening Torque	
	N•m ¹	lb in
16 mm (.625 in)	4.5 ± 0.5	40 ± 5
13.5 mm (.531 in)	3.0 ± 0.5	25 ± 5
8 mm (.312 in)	0.7 ± 0.2	6 ± 2

¹ 1 Newton meter (N•m) is approximately the same as 0.1 mkg.

Torque for Constant Torque Hose Clamps

NOTICE

Due to extreme temperature changes, hose will heat set. Heat setting causes hose clamps to loosen. Loose hose clamps can result in leaks. There have been reports of component failures caused by hose clamps loosening. The new constant torque hose clamp will help prevent these failures. A constant torque hose clamp can be used in place of any standard hose clamp. Make sure the constant torque hose clamp is the same size as the standard clamp.

Installation

Each installation application can be different depending on the type of hose, fitting material, and anticipated expansion or contraction of the hose and fittings. A torque wrench should be used for proper installation of constant torque hose clamps. Constant torque hose clamps should be installed as follows:

- To allow for maximum expansion, install clamps at 5.7 N•m (50 lb in).
- To allow for equal expansion and contraction, install clamps at 10.2 N•m (90 lb in).
- To allow for maximum contraction, install clamps at 14.1 N•m (125 lb in).

Cooling System Specifications

General Coolant Information

Several industry sources claim that forty percent of all engine failures are due to cooling system problems. Many of these failures could be avoided with proper cooling system maintenance. Cooling system maintenance is as important as fuel and lubricating system maintenance. Coolant quality is as important as the quality of fuel and lubricating oil.

The three main coolant functions provide:

- adequate heat transfer and anti-boil protection,
- cavitation erosion and corrosion protection,
- anti-freeze protection.

Coolant is normally composed of three elements:

- Water
- Additives
- Glycol

A brief discussion of each of these elements follows.

Water

Distilled or deionized water is recommended for use in cooling systems. DO NOT use hard, tap water or salt softened tap water in engine cooling systems. If Distilled or deionized water is NOT available, use water that meets the Minimum Acceptable requirements listed in the following chart.

MINIMUM ACCEPTABLE WATER	
Water Content	Limits mg/L or ppm (grains/US gal)
Chlorides	2.4 (40) maximum
Sulfates	5.9 (100) maximum
Total Hardness	10 (170) maximum
Total Solids	20 (340) maximum
Acidity (pH)	5.5 to 9.0

ppm = parts per million

NOTICE

Water that does not meet the Minimum Acceptable limits will reduce engine service life when used in cooling systems.

If you are not sure of your water's contents, contact your Caterpillar dealer, your local water department, agricultural agent, or an independent laboratory to analyze the water.

Additives

Additives must be included in all coolant mixtures. Additives help prevent the formation of rust, scale and mineral deposits. Additives protect metals from corrosion, prevent liner cavitation, and contain anti-foaming agents. Additives deplete during engine operation and need to be replenished. This is done through the addition of supplemental coolant additives (SCAs, with conventional coolants) or Extender (with Caterpillar Long Life Coolant/Antifreeze).

Nitrites or nitrite and molybdate additives protect the cylinder liner from cavitation corrosion. Nitrites deplete, creating the need for SCAs or Extender. SCAs and Extender also contain other inhibitors that deplete from cooling systems.

Under-concentration of additives does not provide the protection required for cooling systems. Over-concentration can cause additives to drop out of solution, deposit inside the cooling system, or form a gel in the radiator. Deposits can be in the form of sludge and scale which accumulate on hot engine surfaces, reducing cooling system effectiveness, or causing water pump leaks.

To maintain conventional cooling system protection, it is necessary to monitor SCA concentration. Incorrect SCA concentration requires action to return proper additive levels to the cooling system.

Glycol

Engine coolant glycol is normally one of two varieties, ethylene or propylene. Glycol raises the boiling point of water to help prevent boil-over, provides freeze protection, helps prevent water pump cavitation, and reduces cylinder liner pitting.

NOTICE

For ambient temperatures requiring lower freeze protection (higher than 50 percent glycol), use ethylene glycol. DO NOT use propylene glycol.

Proper anti-freeze/boil protection requires the proper ratio of glycol and Acceptable water. Use the following charts to determine glycol concentrations to mix with Acceptable water.

PROPYLENE GLYCOL		
Concentration % Glycol/% Water	Protection	
	Anti-Freeze °C (°F)	Anti-Boil °C (°F)
30/70	-15° (5°)	102° (216°)
40/60	-23° (-9°)	104° (219°)
50/50	-37° (-34°)	106° (222°)

ETHYLENE GLYCOL		
Concentration % Glycol/% Water	Protection	
	Anti-Freeze °C (°F)	Anti-Boil °C (°F)
30/70	-15° (5°)	104° (219°)
40/60	-24° (-12°)	106° (222°)
50/50	-37° (-34°)	108° (226°)
60/40	-57° (-62°)	111° (231°)

Check the coolant solution periodically to ensure adequate anti-freeze/boil protection. Use the 1U7298 (°C) or the 1U7297 (°F) Refractometer. The Refractometers give immediate, accurate readings and can be used with ethylene or propylene glycol.

NOTE: For more detailed specifications, refer to: Know Your Cooling System, SEBD0518, and Coolant and Your Engine, SEBD0970, or contact your Caterpillar dealer.

Caterpillar Coolant Recommendations

- Preferred- Caterpillar Long Life Coolant/Antifreeze (LLCA).

Conventional Antifreeze/Coolant

- Recommended- Caterpillar Diesel Engine Antifreeze/Coolant (DEAC).
- Acceptable- Any low silicate coolant that meets Truck Maintenance Council (TMC) Recommended Practice (RP) 329, TMC RP330, or ASTM D4985 requirements when used with SCAs.
- Permitted- A mixture of Acceptable Water and SCA, where freeze protection is not necessary.
- Unacceptable- ANY high silicate coolant that is classified as meeting ASTM D3306.

NOTICE

Most commercial engine coolant/antifreezes are formulated for gasoline engine applications and have high silicate content. High silicates provide conditions favoring cylinder liner cavitation and corrosion. Caterpillar DOES NOT recommend these antifreezes.

NOTE: Due to individual engine applications, engine cooling system maintenance practices may need periodic re-evaluation.

NOTICE

Never operate without thermostats in the cooling system. Thermostats maintain the engine coolant at the proper operating temperature. Cooling system problems can arise without thermostats.

NOTICE

Never add coolant water to an overheated engine- engine damage can result. Allow the engine to cool first. Do not add coolant water too quickly. Filling the cooling system at over 19 L (5 US gal) per minute can create air pockets in the cooling system.

When filling or adding to the coolant to the system, premix the coolant solution prior to pouring it into the cooling system. Pure undiluted glycol will freeze at -23°C (-10°F). Use a mixture in a range which will provide protection to the lowest expected outside (ambient) temperature and provide the required boil-over protection.

Caterpillar Long Life Coolant/Antifreeze (LLCA)

Caterpillar's Long Life Coolant/Antifreeze (LLCA) anti-corrosion package is totally different from the conventional antifreezes that have been in use. Caterpillar LLCA is an ethylene glycol based coolant/antifreeze containing organic corrosion inhibitors and anti-foam agents with fewer nitrites than conventional coolants.

LLCA was specifically designed for cooling systems in diesel and natural gas engines. LLCA may also be used in automotive applications

LLCA extends coolant life to 6,000 service hours or four years, whichever comes first. The only maintenance required for cooling systems filled with LLCA is one addition of Caterpillar Extender.

Major LLCA advantages:

- twice the coolant life.
- considerably less maintenance.
- improved corrosion protection.
- better aluminum protection.
- better liner protection.
- fewer additives (chemicals) and no chemical drop out.
- longer radiator life.
- increased water pump seal life.

LLCA is available premixed 50/50 with deionized water, or in concentrate, in the following quantities.

CATERPILLAR LONG LIFE COOLANT/ANTIFREEZE QUANTITIES AVAILABLE		
Type	Size	Part No.
Pre-mix ¹	Bulk	119-5148
	208.5 L (55 US gal)	101-2845
	3.8 L (1 US gal)	101-2844
Concentrate ²	3.8 L (1 US gal)	119-5150

¹ 50 percent Long Life Coolant/Antifreeze and 50 percent water.

² LLCA Concentrate is available ONLY to lower freeze protection. The Concentrate is not intended to be used as a mix.

NOTE: A 50/50 LLCA/water solution provides freeze protection to -37°C (-34°F) and anti-boil protection to 108°C (226°F). DO NOT use LLCA at reduced concentrations (less than 50 percent), since the additives would be reduced along with the antifreeze. LLCA concentrate is available to lower the freeze point for arctic conditions. LLCA concentration can be increased to 60 percent for -52°C (-62°F) freeze protection.

Extender

LLCA Extender is a liquid that is poured into the cooling system halfway through the LLCA service life.

The cooling system should be treated with Extender at the 3,000 service hour interval or two years, whichever comes first. Use the following table to determine the recommended amount of Extender to add to LLCA.

RECOMMENDED AMOUNT OF EXTENDER BY COOLING SYSTEM CAPACITY	
Cooling System Capacity	Recommended Amount of Extender
22 to 30 L (6 to 8 US gal)	0.57 L (20 oz)
30 to 38 L (8 to 10 US gal)	0.71 L (24 oz)
38 to 49 L (10 to 13 US gal)	0.95 L (1 qt)
49 to 64 L (13 to 17 US gal)	1.2 L (40 oz)

LLCA Cooling System Maintenance

NOTICE

Use only Caterpillar products or commercial products that have passed the CAT EC-1 specification for pre-mixed or concentrate coolants.

Use only Caterpillar Extender with LLCA.

Mixing LLCA with other products reduces the LLCA service life. Failure to follow the recommendations can reduce cooling system component life unless appropriate corrective action is performed.

Due to the balance of antifreeze and additives, care should be taken to maintain the proper LLCA concentration. Lowering the proportion of antifreeze lowers the proportion of additive, thus lowering the coolant's ability to protect the system from pitting, cavitation, erosion, and deposits.

Make Proper LLCA Additions

NOTE: DO NOT add LLCA Concentrate as a makeup solution for routine cooling system top-off. Adding concentrated LLCA increases the concentration of glycol in the cooling system.

During normal maintenance, use pre-mixed LLCA as a top-off to the system to bring the coolant up to the proper level. Use LLCA or a coolant that meets Caterpillar's EC-1 specification. If a coolant that meets EC-1 is not available, use distilled or de-ionized water as a make-up. Check the systems glycol level with the 1U7298 (°C) or the 1U7297 (°F) Refractometer. Use LLCA Concentrate to restore the proper glycol concentration before the engine is exposed to freezing temperatures.

NOTICE

Do not use conventional coolant to top off a cooling system using LLCA.

Do not use supplemental coolant additives (SCA's) in cooling systems filled with LLCA.

If the LLCA cooling system has been topped off with a small amount of conventional coolant or if SCA was added to the system by mistake, the system will not be harmed.

Should the system become contaminated with conventional coolant or SCA exceeding 10 percent of the system's total capacity, either:

- drain the system and refill with LLCA, or
- maintain the system as if the system is filled with conventional coolant.

LLCA Cooling System Cleaning

NOTE: No cleaning agents are to be used when a system ALREADY using LLCA is drained, flushed, and refilled.

CLEAN WATER is the only system cleaning/flushing agent required when LLCA is drained from the cooling system.

LLCA can be recycled. The drained coolant mixture can be "distilled" to remove the ethylene glycol and water for reuse. Contact your Caterpillar dealer for more information.

After draining and refilling the cooling system, operate the engine with the radiator filler cap removed until the coolant reaches normal operating temperature and coolant level stabilizes. Add coolant mixture as necessary to fill the system to the proper level.

Changing the Cooling System From Conventional Coolant To LLCA

NOTE: When the coolant is switched from conventional coolant to LLCA, Caterpillar cleaner should be used. After the use of Caterpillar cooling system cleaners, the system MUST be thoroughly flushed with clean water.

To switch from conventional coolant to LLCA, perform the following steps:

1. Drain the coolant.
2. Flush the system with clean water to remove any debris.
3. Use Caterpillar cleaner to clean the system. Follow the instructions on the label. Caterpillar cleaner is available from your Caterpillar dealer.
4. Drain the cleaner, and flush the cooling system with clean water.
5. Fill the cooling system with clean water. Operate the engine until the cooling system temperature is 49° to 66°C (120° to 150°F).
6. Drain and flush the cooling system with clean water.
7. Repeat steps five and six.
8. Fill the cooling system with LLCA.
9. Attach a label to the cooling system to indicate the system has been switched over to LLCA.

Recommended– Caterpillar Diesel Engine Antifreeze/Coolant (DEAC)

NOTE: The following information and recommendations are for Caterpillar DEAC only.

Caterpillar DEAC was specifically designed for diesel and natural gas engine cooling systems. Caterpillar DEAC is an alkaline type, ethylene glycol based formula containing inorganic corrosion inhibitors and anti-foam agents. Caterpillar DEAC was formulated with the correct additive levels to protect metal parts in diesel engines. Caterpillar DEAC will furnish adequate corrosion, anti-foam, and cylinder liner/block pitting protection in a 30/70 DEAC/Acceptable water and SCA solution.

Major advantages of Caterpillar DEAC:

- minimal silicate content. High silicate coolants, used with SCAs, can cause a build-up of solids over a period of time. Build-up of solids can cause plugging, loss of heat transfer, and water pump seal damage. Caterpillar DEAC significantly reduces solid residue buildup that causes inhibitor dropout and water pump seal damage.
- no need to add SCA on initial fill, which must be done with other commercially available coolants.

Caterpillar DEAC is available from your Caterpillar dealer in the following quantities:

CATERPILLAR ANTIFREEZE/COOLANT CONCENTRATE	
Part Number	Size
8C3684	3.8 L (1 US gal)
8C3686	208 L (55 US gal)

Proper Antifreeze Concentrations

Use the following chart to determine concentrations of Caterpillar DEAC to mix with Acceptable water and SCA.

ANTIFREEZE CONCENTRATIONS (GLYCOL)	
Protection Temperature	Concentration
Protection to –15°C (5°F)	30% antifreeze and 70% water
Protection to –23°C (–9°F)	40% antifreeze and 60% water
Protection to –37°C (–35°F)	50% antifreeze and 50% water
Protection to –51°C (–60°F)	60% antifreeze and 40% water

Acceptable Antifreeze/Coolant

Any low silicate coolant that meets Truck Maintenance Council (TMC) Recommended Practice (RP) 329, TMC RP330, or ASTM D4985 requirements when used with SCAs.

Caterpillar recommends a minimum of 30 percent glycol to 70 percent water and SCA for corrosion protection. All Caterpillar engines with air-to-air after cooling (ATAAC) require a minimum concentration of 30 percent glycol to prevent water pump cavitation.

While 30 percent glycol is the minimum acceptable volume, Caterpillar prefers a 50/50 glycol/water-SCA coolant mixture for optimum performance.

When using Caterpillar DEAC, no SCA is necessary on initial fill because SCA is in the DEAC. SCA must be added with commercial coolants meeting ASTM D4985 at initial fill. SCA must be replenished with both Caterpillar DEAC and other commercial coolants at regular service intervals. Refer to the following chart for quantities of Caterpillar Liquid SCA to mix with ASTM D4985 commercial coolants at initial fill.

LIQUID SUPPLEMENTAL COOLANT ADDITIVE REQUIRED BY CAPACITY		
Cooling System Capacity Liters (US gal)	Amount At Initial Fill ¹ Quantity ² Or	Amount At 250 Hour Maintenance ²
22 to 30 (6 to 8)	3P2044 (1)	6V3542 (1)
30 to 38 (8 to 10)	3P2044 (1) 6V3542 (1)	111-2372 (1)
38 to 49 (10 to 13)	3P2044 (1) 8T1589 (1)	111-2372 (1)
49 to 64 (13-17)	3P2044 (2)	8T1589 (1)
64 to 83 (17 to 22)	3P2044 (2) 8T1589 (1)	3P2044 (1)
83 to 114 (22 to 30)	3P2044 (3) 8T1589 (1)	3P2044 (1)
114 to 163 (30 to 44)	3P2044 (5)	3P2044 (1) 6V3542 (1)
163 to 243 (44 to 64)	3P2044 (8)	3P2044 (2)

Number in brackets () indicates quantity required.

¹ Use only when not using Caterpillar DEAC on initial fill or refill.

² Do not exceed six percent maximum SCA concentration. Check concentration with SCA test kit.

Supplemental Coolant Additive (SCA)

WARNING

Supplemental cooling system additive contains alkali. To prevent personal injury, do not drink, avoid contact with the skin and eyes.

NOTICE

The cooling system **MUST** contain supplemental coolant additive (SCA) for proper engine protection, regardless of antifreeze concentration.

NOTICE

DO NOT mix Caterpillar SCA or coolant additive elements with another manufacturer's products; select a cooling system treatment and use it exclusively.

SCA is necessary for proper conventional coolant maintenance. Most coolant solutions **DO NOT** contain sufficient SCA for diesel engine application.

NOTICE

Do not exceed the recommended six percent SCA concentration. Excessive SCA 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 SCA concentration could also result in radiator tube blockage, overheating, and/or accelerated water pump seal wear. Never use both liquid SCA and the spin-on element (if equipped) at the same time. The use of those additives together could result in SCA concentration exceeding the recommended six percent maximum.

Use liquid SCA or a SCA element (if equipped) to maintain a three to six percent SCA concentration in the coolant.

NOTE: Caterpillar Test Kits check for concentration of nitrites in the coolant solution. Some manufacturers' SCA are phosphate based. Caterpillar Test Kits provide inaccurate results with phosphate based SCA. Commercial SCA products must contain silicates and a minimum of 1200 mg/L or 1200 ppm (70 grains/US gal) nitrites. If another manufacturer's SCA is used, use that manufacturer's test kit. Follow the manufacturer's recommendations for cooling system treatment and test evaluation.

Test the coolant periodically to monitor SCA levels. Use the 4C9301 Test Kit to check for Caterpillar SCA concentration. The Kit also provides cooling system maintenance recommendations. This kit is specifically for use with Caterpillar SCA's. The 8T5296 Test Kit can also to check for Caterpillar SCA concentration.

The following charts lists the part numbers and quantities of SCA (liquid and solid) available from your Caterpillar dealer. Follow the instructions on the label.

LIQUID SUPPLEMENTAL COOLANT ADDITIVE REQUIRED BY CAPACITY	
Cooling System Capacity Liters (US gal)	Amount At 250 Hour Maintenance ¹
22 to 30 (6 to 8)	6V3542 (1)
30 to 38 (8 to 10)	111-2372 (1)
38 to 49 (10 to 13)	111-2372 (1)
49 to 64 (13 to 17)	8T1589 (1)
64 to 83 (17 to 22)	111-2372 (1) 6V3542 (1)
83 to 114 (22 to 30)	3P2044 (1)
114 to 163 (30 to 44)	3P2044 (1) 6V3542 (1)
163 to 242 (44 to 64)	3P2044 (2)

¹ Numbers in parenthesis () are quantities required. Do not exceed six percent maximum concentration. Check concentration with SCA test kit.

SUPPLEMENTAL COOLANT ADDITIVE ELEMENTS REQUIRED BY CAPACITY	
Cooling System Capacity Liters (US gal)	Amount At 250 Hour Maintenance ¹
22 to 30 (6 to 8)	111-2370 (1)
30 to 49 (8 to 13)	111-2369 (1)
49 to 64 (13 to 17)	9N3368 (1)
64 to 83 (17 to 22)	111-2371 (1)
83 to 114 (22 to 30)	9N3718 (1)
114 to 163 (30 to 44)	111-2371 (2)
163 to 242 (44 to 64)	9N3718 (2)

¹ Do not use SCA element and SCA liquid at the same time.

Permitted-Water/SCA Coolant

NOTICE

Never use water alone without SCA. Water alone is corrosive at engine operating temperatures.

NOTICE

A mixture of water and SCA does not protect against freezing or boiling.

NOTICE

A coolant mixture of water and SCA will cool and provide some protection to engine components, but it will NOT provide normal engine service life.

NOTICE

Caterpillar's recommendation for proper coolant is a minimum concentration of 30 percent glycol and 70 percent Acceptable water and SCA (3 percent of the total mixture). This recommendation will maintain cooling system corrosion protection.

In applications where freeze protection is not required, or where antifreeze is not available, a coolant mixture of Acceptable water and SCA can be used. A Water/SCA system should maintain a six to eight percent SCA concentration. DO NOT exceed eight percent maximum SCA concentration. SCA concentration levels must be monitored.

The 8T5296 Test Kit can be used to evaluate the SCA concentration in Water/SCA coolant, with the following modifications to label instruction Step 3 and Step 5.

STEP 3. - Add tap water to the vial up to the 20 ml mark.

STEP 5. - With the defined procedure, the six to eight percent concentration will yield a 20 to 27 drop range. Fewer drops indicate under-concentration of SCA and more drops indicate over-concentration. Adjust the concentration appropriately.

If the SCA concentration is greater than the maximum of eight percent: drain some of the coolant, refill the system with acceptable water, and re-test the concentration level.

Conventional Cooling System Maintenance

Check the antifreeze solution frequently in cold weather to ensure adequate freeze protection. Test the concentration or a submit a coolant sample to your Caterpillar dealer to monitor the SCA concentration in your engine's coolant mixture Every 250 Service Hours. SCA or a maintenance additive element (if equipped) may be needed Every 250 Service Hours.

NOTICE

To prevent over-inhibiting the engine's cooling system, NEVER use both SCA liquid AND an SCA element (if equipped) at the same time. Use one method or the other exclusively.

When using Caterpillar DEAC and SCA, the cooling system should be drained, cleaned, flushed, and filled with new coolant Every Two Years. Refer to the Maintenance Schedule in this manual.

When NOT using Caterpillar DEAC and SCA, the drain/flush period must be performed at least Every Year.

After draining and refilling the cooling system, operate the engine with the radiator filler cap removed until the coolant reaches normal operating temperature and the coolant level stabilizes. Add coolant mixture as necessary to fill the system to the proper level.

Cooling System Cleaning

Draining, cleaning and flushing the cooling system removes small particles, undesirable chemicals, scale, and other deposit formations. Not performing maintenance on the cooling system can eventually cause engine overheating problems that could result in severe damage to engine and components.

Clean the cooling system if the system becomes contaminated, the engine overheats, or foaming is observed.

Caterpillar Fast Acting Cooling System Cleaner is designed to clean the system of harmful scale and corrosion. The Cleaner dissolves mineral scale, corrosion products, light oil contamination, and sludge.

Caterpillar Fast Acting Cooling System Cleaner is available from your Caterpillar dealer in the quantities listed below. Follow the product label directions for proper use.

CATERPILLAR COOLING SYSTEM FAST ACTING CLEANER	
Part No.	Size
4C4609	0.47 L (1 pt)
4C4610	0.95 L (1 qt)
4C4611	3.8 L (1 US gal)
4C4612	19 L (5 US gal)
4C4613	208.5 L (55 US gal)

Fuel Specifications

Fuel Recommendations

NOTICE

Fill the fuel tank at the end of each day of operation to drive out moist air and prevent condensation. Maintain a fairly constant level in the day tank (near the top) to avoid drawing moisture into the tank as the level decreases.

Do not fill the tank to the top. Fuel expands as it warms, and may overflow.

Do not fill fuel filters with fuel before installing them. Contaminated fuel causes accelerated wear to fuel system parts.

Use fuel only as recommended in this section. Fuel grades recommended for use in Caterpillar diesel engines are: No.2-D diesel fuel with low sulfur (0.05 percent maximum), or regular sulfur (0.5 percent maximum). No.1 grades are acceptable.

The following chart lists worldwide fuel standards which meet Caterpillar requirements.

WORLDWIDE FUEL SPECIFICATIONS—DIESEL ENGINES	
Specifications	Fuel Designation
U.S. STANDARDS ASTM D975 ASTM D396 ASTM D2880	No.1-D, No.2-D & No.4 Diesel Fuel Low Sulfur No.1 & No.2 Diesel Fuel No.1-GT & No.2-GT Gas Turbine Fuels
BRITISH STANDARDS BS 2869	Classes A1, A2 & B1 Engine Fuels Classes C2 & D Burner Fuels
GERMAN STANDARDS DIN 51601 DIN 51603	Diesel Fuel Heating Oil EI
AUSTRALIAN STANDARD AS 3570	Automotive Diesel Fuel
JAPANESE STANDARD JIS K2204	Types 1 (spl), 1, 2, 3 & 3 (spl) Gas Oil
U.S. GOVERNMENT VV-F-800C VV-F-815C	DF-1,DF-2 & DF-20 Con. U.S. Diesel Fuel FS1 & FS2 Burner Fuel Oil
U.S. MILITARY MIL-F-16884G	Marine Oil

Aviation kerosene-type fuels meeting acceptable limits may also be used as an engine fuel. The following chart lists some of the acceptable kerosene-type fuels.

ACCEPTABLE KEROSENE-TYPE FUELS	
Standard	Description
ASTM D 1655-80	Aviation Turbine Fuel (JET A-1)
MIL-T-5624L	Aviation Turbine Fuel (JP-5) (NATO Code No.F-44)
MIL-T-83133B	Aviation Turbine Fuel (JP-8) (NATO Code No.F-34)
VV-F-800F1	Grade DF-A (Arctic)

Fuel viscosity is a major concern with aviation fuels. A minimum viscosity of 1.4 cSt at 38°C (100°F) is required to properly lubricate Caterpillar fuel system components. These kerosene-type fuels have a lower viscosity for low temperature operation.

The kerosene-type fuels have less energy per unit volume than diesel fuels, producing less peak power. More kerosene-type fuel is needed than diesel fuel to do the same amount of work.

Caterpillar Diesel Engines are capable of burning a wide range of distillate fuels. Burning clean, stable blends of distillate fuel meeting the following requirements will provide quality engine service life.

DISTILLATE FUEL RECOMMENDATIONS—DIESEL ENGINES	
Specifications	Requirements ¹
Aromatics (ASTM D1319)	35% Max.
Ash (ASTM D482)	0.02% Weight Max.
Cetane Number (ASTM D613)	40 Minimum
Cloud Point (ASTM D97)	Not Above Lowest Expected Ambient Temperature
Gravity API (ASTM D287)	30 Min. and 45 Max.
Pour Point (ASTM D97)	6°C (10°F) Below Ambient Minimum
Sulfur (ASTM D2788, D3605 or D1552)	0.5% Max. (See Sulfur Topic)
Viscosity, Kinematic @ 38°C (100°F) (ASTM D445)	20.0 cSt Max. 1.4 cSt Min.
Water & Sediment (ASTM D1796)	0.01% Max.

¹ As delivered to fuel system

NOTE: When economics or fuel availability dictate, other fuel types may be burned in the engine. Consult your Caterpillar dealer for more information and advice on any specific fuel.

Cetane Number

Under average starting conditions, direct injection engines require a minimum cetane number of 40. A higher cetane value may be required for high altitude or cold weather operation.

Filterability

Clean fuels should have no more than 0.1 percent of sediment and water. Fuel stored for extended periods of time may oxidize and form solids, causing filtering problems.

Pour Point

Fuel pour point should be at least 6°C (10°F) below the lowest ambient temperature at which the engines must start and operate. Lower pour points of No.1 or No.1-D fuel may be necessary in extremely cold weather.

Cloud Point

The cloud point should be below the lowest ambient temperature at which the engines must start and operate, to prevent the fuel filter elements from plugging with wax crystals. Refer to Fuel Problems in Cold Weather Operation for additional information.

Viscosity

Fluid viscosity is a measure of resistance to flow. Fuel viscosity is important because it effects lubrication of fuel system components, and fuel atomization. The provided viscosity limits address both of those effects.

Additives

Fuel additives are generally not recommended or needed for the specified fuels listed. Cetane improvers can be used as necessary for direct injection engine requirements. Biocides may be needed to eliminate microorganism growth in storage tanks. In cold conditions, treatment for entrained water may also be necessary.

Consult your fuel supplier about the use of additives to prevent incompatibility among additives already in the fuel and the additives to be used.

Fuel Sulfur

The percentage of sulfur in fuel affects engine oil recommendations. Fuel sulfur can change chemically during combustion, forming both sulfurous and sulfuric acids. The acids attack metal surfaces and cause corrosive wear. Sulfur oxides formed during combustion also produce particulate exhaust emissions.

Some lubricating oil additives contain alkaline compounds to neutralize acids in combustion gases and minimize corrosive wear. Reserve alkalinity in lubricating oil is measured and defined with a Total Base Number (TBN).

Periodically request fuel sulfur content information from your fuel supplier. Fuel sulfur content can change with each bulk delivery.

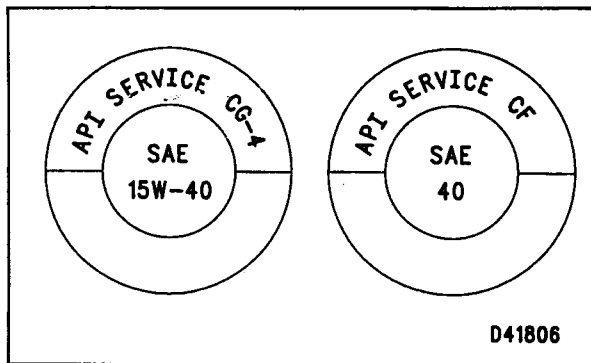
More information concerning fuel sulfur and lubrication can be found in the Lubricant Specifications section of this manual.

Refer to Diesel Fuels and Your Engine, SEBD0717, or contact your Caterpillar dealer for more information on fuel selection and fuel properties.

Lubricant Specifications

General Information

Caterpillar recognizes and supports the American Petroleum Institute (API) "Engine Oil Licensing and Certification System" for engine oils. The API publication No. 1509, 13th edition, contains the detailed information concerning this system. Engine oils bearing the API symbol are licensed by the API.



Examples of the API symbol.

Diesel engine oil classifications CD, CD-2 and CE will not be API licensed categories after January 1, 1996. Caterpillar will only reference those categories that are licensed by the API. The following chart summarizes the status of the categories.

OIL CLASSIFICATION STATUS	
Obsolete	Current
CC, CD	CF
CD-2 ¹	CF-2 ¹
CE	CF-4, CG-4

¹ CD-2 and CF-2 are oil categories for two cycle diesel engines. These oils are NOT recommended for Caterpillar engines.

Engine Lubricant Specifications

Caterpillar Oil

Caterpillar Oils have been developed, tested, and approved by Caterpillar to provide the performance and life that has been designed and built into Caterpillar diesel engines. Caterpillar Oils are used for engine development and factory fill. They are available from Caterpillar dealers. Due to significant variations in the quality and performance of commercially available oils, Caterpillar recommends the following.

Caterpillar Diesel Engine Oil (DEO) (multi-grade)

Caterpillar DEO multi-grade oils are formulated with detergents, dispersants, and sufficient alkalinity to provide superior performance in Caterpillar diesel engines. DEO multi-grade oils are blended in two viscosity grades: SAE 10W30 and SAE 15W40. Refer to the lubricant viscosity chart to choose the correct viscosity grade based on ambient temperatures. Multi-grade oils provide the correct viscosity for a broad range of operating temperatures and for cold engine starts. Multi-grade oils are also effective in maintaining low oil consumption and low levels of piston deposits.

Caterpillar DEO multi-grade oils are also qualified for use in other diesel engines and in gasoline engines. Consult the engine manufacturer's guide for the recommended specifications, and compare to the specifications of Caterpillar DEO multi-grade. The current Caterpillar DEO industry specifications are listed on the label and on the product data sheets.

Commercial Diesel Engine Oils

The performance of commercial diesel engine oils are based on API categories. These API categories are developed to provide commercial lubricants for a wide variety of diesel engines that operate at various conditions.

If Caterpillar DEO (multi-grade) is not used, the following multi-grade commercial oils are recommended.

- API CG-4 Preferred
- API CF-4 Allowed

API CG-4 oils are preferred for Caterpillar engines because of the fuel sulfur level. API CG-4 is the only oil category that evaluates oils with engine tests utilizing 0.05 percent sulfur fuel.

The following explanations of these API categories can be used to make the proper choice of a commercial oil.

CG-4: This is the newest oil category. CG-4 oils were primarily developed for diesel engines that are operating on 0.05 percent sulfur diesel fuel. All of the laboratory engine tests for this category were run with 0.05 percent sulfur diesel fuel. This category also defines oils that have superior soot dispersancy. CG-4 oils will provide improved viscosity control and improved crankcase cleanliness in applications where oil soot is a problem. CG-4 oils should also be used in engines that contain hydraulically actuated fuel injection pumps: these are the first oils to pass industry tests for foam control and viscosity shear loss. CG-4 oils must also pass recently developed tests for metals corrosion, and wear. CG-4 oils can be used in all Caterpillar engines where CF-4 oils are recommended.

CF-4 oils service a wide variety of modern diesel engines. This oil classification was developed with 0.40 percent sulfur diesel fuel. The fuel used in the CF-4 tests represents the type of diesel fuels commonly available world wide. CF-4 oils provide improved piston deposit control and improved oil control when compared to the CE category oils. CF-4 oils also provide improved soot dispersancy compared to CD or CF category oils.

Some commercial oils meeting these API specifications may require shortened oil change intervals as determined by close monitoring of oil condition and wear metals (Caterpillar's S•O•S Oil Analysis Program preferred).

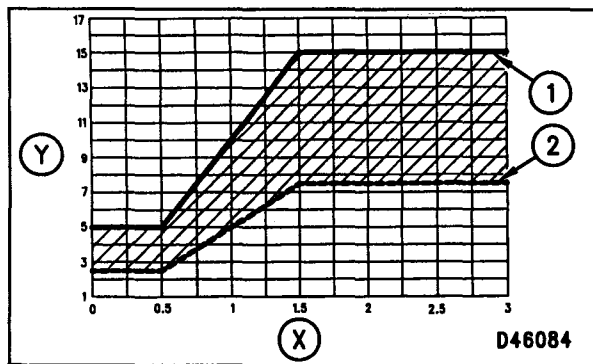
Consult with your Caterpillar dealer for the latest oil recommendations or refer to the following Caterpillar Supplements: SEBU6250, SEBU6251, and SEBU6385.

NOTICE

Failure to follow these oil recommendations can cause shortened engine life due to deposits and or excessive wear.

Total Base Number (TBN) and Fuel Sulfur Levels For Caterpillar Diesel Engines**Caterpillar Direct Injection Diesel Engines**

For direct injection engines running on distillate diesel fuel, the minimum new oil TBN (by ASTM D 2896) must be 10 times the fuel sulfur level, and the minimum TBN is 5 regardless of low fuel sulfur level, see the chart below.



Y = oil TBN shown by ASTM D2896.

X = percent of fuel sulfur by weight.

New oil TBN (1).

Change oil when the used oil TBN limit (2) is reached.

In areas where the fuel sulfur exceeds 0.5 percent, choose an oil with the highest TBN that is within the API CF-4 or CG-4 categories, and shorten the oil change period based on oil analysis. The oil analysis should evaluate oil condition and wear metals. High TBN oils that are not within the API CF-4 or CG-4 categories can produce excessive piston deposits leading to a loss of oil control and bore polishing.

NOTICE

Operation at fuel sulfur levels over 0.5 percent may require shortened oil change periods to maintain adequate wear protection.

Lubricant Viscosity Recommendations

The proper SAE viscosity grade oil is determined by the minimum outside temperature at cold engine start up, and the maximum outside temperature during engine operation. Use the minimum temperature column on the chart to determine the oil viscosity required for starting a "cold soaked" engine. Use the maximum temperature column on the chart to select the viscosity for operation at the highest temperature anticipated. In general, use the highest viscosity oil available that still meets the start up temperature requirements.

ENGINE OIL VISCOSITY PROTECTION		
Engine Oil Viscosity Grade	Ambient Temperature	
	Minimum °C (°F)	Maximum °C (°F)
SAE 0W20	-40° (-40°)	10° (50°)
SAE 5W30	-30° (-22°)	30° (86°)
SAE5W40	-30° (-22°)	40° (104°)
SAE 10W30	-20° (-4°)	40° (104°)
SAE 15W40	-15° (5°)	50° (122°)

Synthetic Base Stock Oils

Synthetic base stock oils are acceptable for use in Caterpillar engines and machines if these oils meet the performance requirements specified by Caterpillar for a particular compartment.

Synthetic base stock oils generally outperform non-synthetics in two areas:

1. Improved low temperature viscosity characteristics, especially in Arctic conditions.
2. Improved oxidation stability, especially at high operating temperatures.

Some synthetic base stock oils have performance characteristics that enhance the useful life of the oil. However, Caterpillar does NOT recommend the automatic extension of oil drain intervals for any oil, including synthetic base stock oils. For Caterpillar diesel engines, oil drain intervals can only be adjusted through an oil analysis program that contains the following elements: oil condition and wear metals (Caterpillar's S•O•S Oil Analysis preferred), trend analysis, fuel consumption, and oil consumption.

Re-Refined Base Stock Oils

Re-refined base stock oils are acceptable for use in Caterpillar engines and machines if these oils meet the performance requirements specified by Caterpillar for a particular compartment. Re-refined oils can be used exclusively in a finished oil or in combination with new base stocks. The US Military and other heavy equipment manufacturers have also accepted the use of re-refined base stock oils with the same criteria.

The re-refining process should be adequate to remove all wear metals and oil additives that were present in the used oil. This type of re-refining is generally accomplished by vacuum distillation and hydrotreating the used oil. Filtering alone is inadequate for producing a high quality re-refined base stock from used oil.

After-Market Oil Additives

Caterpillar does NOT recommend the use of after-market oil additives. After-market oil additives are not necessary to achieve life predictions or to achieve rated performance. Fully formulated finished oils are made up of base stocks and commercial additive packages. These additive packages are blended into the base stocks at precise percentages to provide finished oils with performance characteristics that meet lubricant industry standards.

Lubricant industry standard tests do not exist to evaluate the performance of after-market oil additives. There are also no lubricant industry standard tests to evaluate the compatibility of these after-market additives in a finished oil. After-market additives could be incompatible with the finished oil additive package, and lower the performance of the finished oil. The after-market additive could fail to mix with the finished oil, and produce a sludge in the crankcase. Caterpillar discourages the use of after-market additives in finished oils.

To achieve all the performance that was built into a Caterpillar engine, follow these guidelines:

- Select the proper Caterpillar oil or commercial oil that meets the compartment specifications.
- Select the proper oil viscosity based on the Engine Oil Viscosity Chart in this manual.
- Service the engine at the specified interval with new oil and oil filter.
- Perform maintenance at the intervals specified by the Operation and Maintenance Manual.

Caterpillar Lubricating Grease

The National Lubricating Grease Institute (NLGI) classifies grease, based on ASTM D217-68 Worked Penetration characteristics. Grease characteristics are given a defined consistency number.

Caterpillar has grease and lubricants for all applications. Your Caterpillar dealer can provide you with complete information regarding all of the different types and sizes of Caterpillar lubrication and special application products.

CATERPILLAR LUBRICATING GREASE		
Part No.	Item	Size
2S3230	Bearing Lubricant ¹	411 g (14.5 oz)
5P0960	Molybdenum Grease ²	411 g (14.5 oz)
1P0808	All-Purpose Lubricant ³	411 g (14.5 oz)
4C4774	Water & Temperature Resistant Grease ⁴	454 g (16 oz)

¹ NLGI No. 2 Grade, services heavily loaded ball and roller bearings operating at high speeds, extreme pressure, and temperatures from -34 to 163°C (-18 to 300°F). Use for bearings in electric motors, fan drives, starting motors, alternators/generators and to pack similar bearings in many other applications.

² NGLI No. 2 Grade, three to five percent molybdenum disulfide, multi-purpose grease with an operating temperature range from -28 to 149°C (-18 to 300°F).

³ NGLI No. 2 Grade lithium grease has mechanical stability, resists oxidation, protects from rust, excellent breakaway torque. For light-duty automotive-type applications and temperatures up to 175°C (350°F).

⁴ This NLGI No 2 Grade has exceptional water resistance, meets ASTM D-1264 Water Washout Test. This low and high temperature resistant grease has a starting torque at -40°C (-40°F), and is still not fluid at 316°C (600°F).

Caterpillar Specialty Lubricants

CATERPILLAR SPECIALTY LUBRICANTS		
Part No.	Item	Size
6V4876	Molykote Paste Lubricant ¹	500 g (17.6 oz)
5P3931	High Temperature Anti-Seize ²	150 g (5.3 oz)

¹ Recommended for typical uses such as on head bolt threads and washers.

² Recommended for connectors such as exhaust manifold studs and nuts.

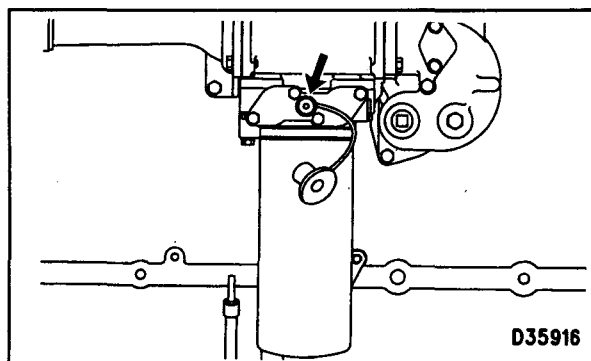
Caterpillar's Scheduled Oil Sampling (S•O•S) Analysis

Caterpillar's Scheduled Oil Sampling (S•O•S) analysis is the best indicator for determining what is happening inside your engine.

S•O•S analysis is a diagnostic tool used to determine oil performance and component wear rates with a series of tests designed to identify and measure contamination such as soot, sulfur, etc. and degradation such as the presence of fuel, water and antifreeze in a sample of oil.

The tests also determine the amount of wear metals present in the oil sample, which is compared to established Caterpillar norms to determine acceptability. To be effective as an indicator, S•O•S analysis must be performed on a continuing basis. Intermittent sampling will not allow wear rate trend lines to be established.

S•O•S INTERVAL CHART	
Compartment	Interval
Engine Crankcase	Every 250 Hours



Typical sampling valve.

Obtain Every 250 Hour Interval.

Obtain oil samples at regularly scheduled intervals to monitor the condition and maintenance requirements of your engine. Each oil sample should be taken when the oil is warm and well mixed to ensure that the sample is representative of the oil in the engine crankcase.

Consult your Caterpillar dealer for complete information and assistance in establishing an S•O•S oil analysis program for your engine(s).

S•O•S Oil Analysis

S•O•S oil analysis is composed of three basic tests:

- Wear Analysis
- Chemical and Physical Tests
- Oil Condition Analysis

Wear analysis is performed with an atomic absorption spectrophotometer to monitor component wear by identifying and measuring concentrations, in parts per million, of wear elements present in the oil. Based on known normal concentration data, maximum limits of wear elements are established. Impending failures can be identified when test results deviate from concentration levels established as acceptable, based on normal wear.

Chemical and physical tests detect the presence of water, fuel and glycol (antifreeze) in the oil and determine whether or not their concentrations exceed established maximum limits.

Oil condition is evaluated with infrared analysis. This test determines the presence and measures the amount of contaminants such as soot, sulfur products, oxidation, and nitration products in the oil. Infrared analysis can also assist in customizing (reducing, maintaining or extending) oil change intervals for particular conditions and applications.

Infrared analysis should always be accompanied by wear element analysis and chemical and physical tests to assure accurate diagnosis.

NOTE: Infrared analysis must be used to determine oil change intervals.

The test results of the oil samples will then be used as a basis for determining the oil change interval for your engine, giving you the ultimate time between oil changes without the risk of engine damage.