

Operation & Maintenance Manual

G3408 & G3412 Industrial and Generator Set Engines

6NB1-UP
7DB1-UP
6RJ1-UP
3NK1-UP

**Includes Standard NA & TA, Low Gas Pressure
and Optional Fuel System Arrangements**

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Foreword

Literature Information

This manual contains safety, operation instructions, lubrication and maintenance information. This manual should be stored in the operator's area in a literature holder or literature storage area. Read, study, and keep it with the literature and engine information.

Some photographs or illustrations in this manual 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 manual. Whenever a question arises regarding your engine, or this manual, please consult your Caterpillar dealer for the latest available information.

Safety

The safety section lists basic safety precautions. In addition, this section identifies hazardous, warning situations. Read and understand the basic precautions listed in the safety section before operating or performing lubrication, maintenance, or repair on this product.

Operation

Operating techniques outlined in this manual are basic. Skills and techniques develop as the operator gains knowledge of the engine and the engines' capabilities.

The operation section is a reference for operators. Photographs and illustrations guide the operator through correct procedures of inspecting, starting, operating, and stopping the engine. This section also includes a discussion of gauges, switches, and engine control information.

Maintenance

The maintenance section is a guide to engine care. The illustrated instructions are grouped by maintenance servicing intervals. Items in the Maintenance Schedule are referenced to detailed instructions that follow and are organized for a preventive maintenance program. Recommended service should always be performed at the interval that occurs first.

Under extremely severe, dusty, wet, or frigid operating conditions, maintenance and lubrication checks more frequent than those specified in the Maintenance Schedule may be necessary. The implementation of a preventive maintenance program should minimize operating costs through cost avoidances resulting from reductions in unscheduled downtime and failures.

Maintenance Intervals

Perform maintenance on items at multiples of the original requirement. Each level and/or individual items in each level should be shifted ahead or back depending upon your specific maintenance practices, operation and application.

We recommend that the Maintenance Schedules be reproduced and displayed near the engine as a convenient reminder and for ease of inspection. We also recommend that a Maintenance Record be maintained as part of the engine's permanent record.

See the Maintenance Records section of this manual for information regarding documents that are generally accepted as proof of maintenance or repair. Your Caterpillar dealer can assist you in tailoring your Maintenance Schedule to meet the needs of your operating environment.

Overhaul

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

Engine Description

The engines described in this manual are the G3408 and the G3412 Industrial and Generator Set engines. They are designed for electrical power generation, gas compression, petroleum and auxiliary industrial applications.

Engine Storage

For general information, refer to the Engine Lifting & Storage topic. For complete engine storage information refer to Special Instruction, SEHS9031, Storage Procedure For Caterpillar Products.

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 safety signs.

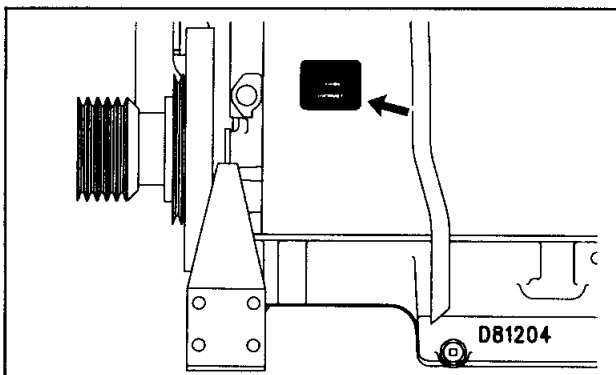
Make sure that you can read all safety signs. Clean or replace these if you cannot read the words or see the pictures. When cleaning the labels use a cloth, water, and soap. Do not use solvents, gasoline, etc, to clean safety signs. The use of solvents, gasoline, etc, could loosen the sign's adhesive 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 attached to a part, and that part is replaced, make sure a new label is installed on the replaced part. See your Caterpillar dealer for new labels.

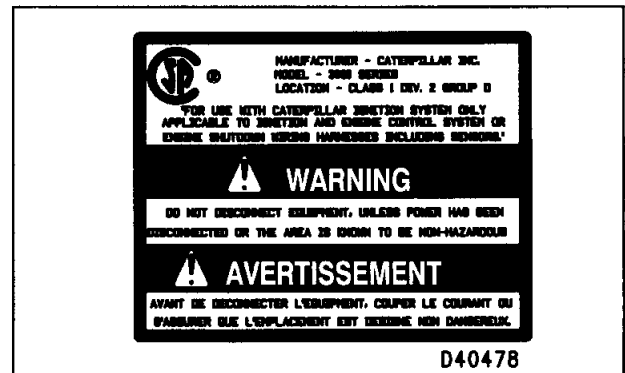
Hazardous Environment

WARNING

Do not disconnect equipment unless power has been disconnected or area is known to be non-hazardous.



The hazardous environment warning label is located on the left side of the engine block.

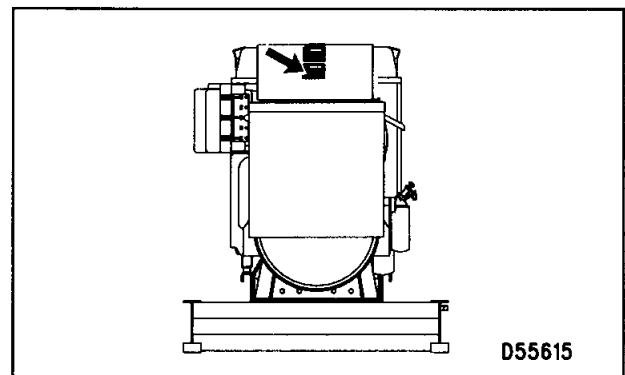


Hazardous environment warning label.

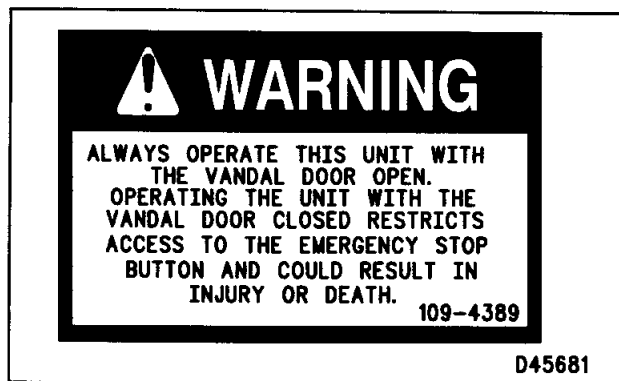
Emergency Stop

WARNING

Always operate this unit with the vandal door open. Operating the unit with the vandal door closed restricts access to the emergency stop button and could result in injury or death.

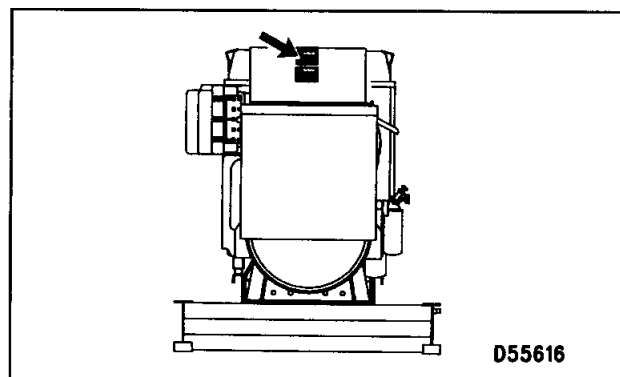
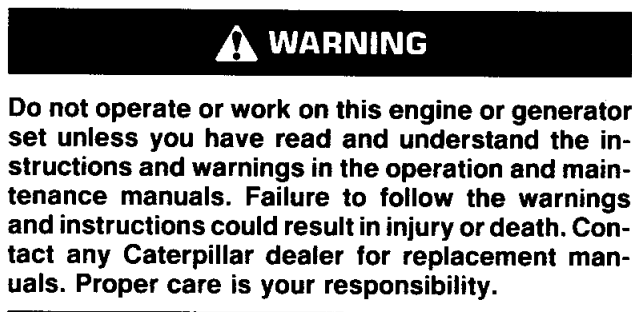


The emergency stop warning label is located on the outside of the control panel vandal door.

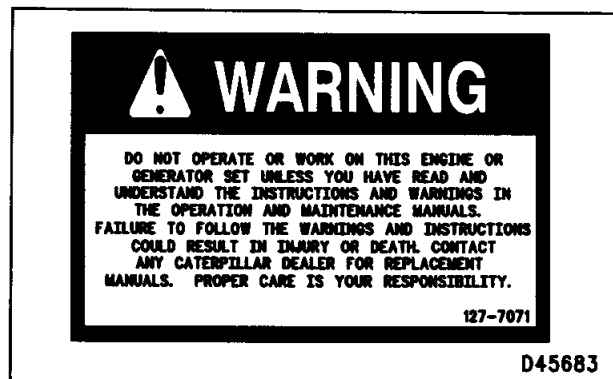


Emergency stop warning label.

Operation

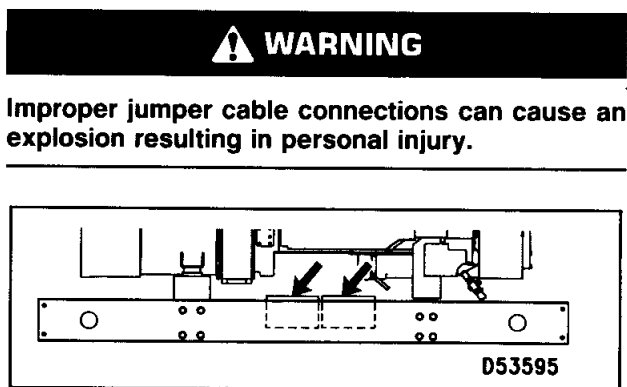


The operation warning label is located on the outside of the control panel vandal door, above the emergency stop warning.

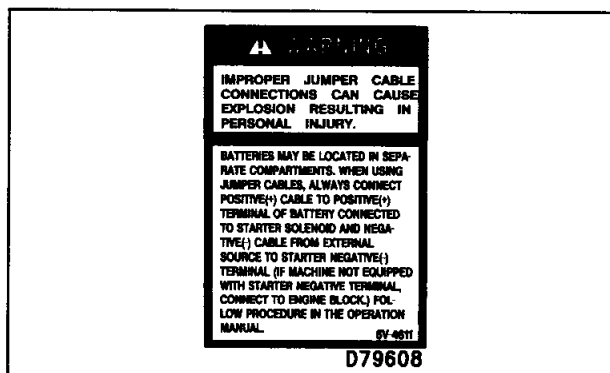


Operation warning label.

Batteries



The battery warning label is located near the batteries.

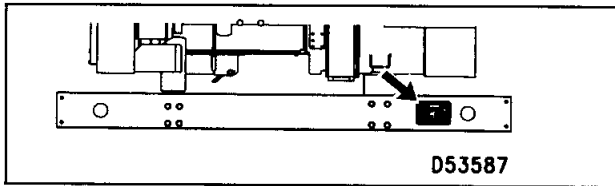


Battery warning label.

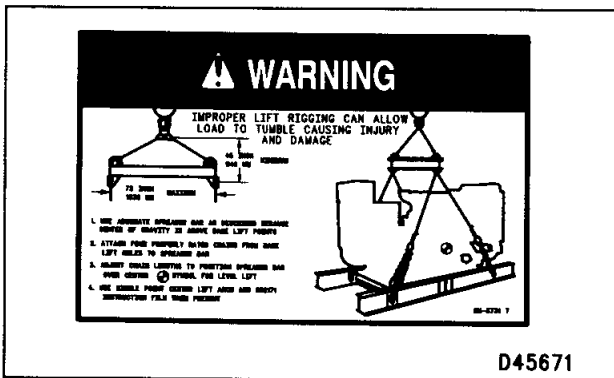
Lifting

WARNING

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



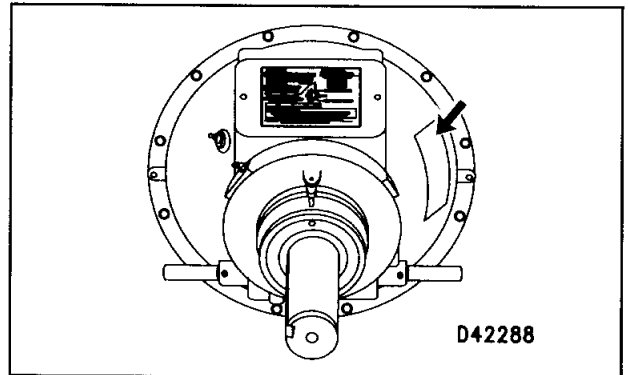
The lifting warning label is located on the mounting base near the lifting holes.



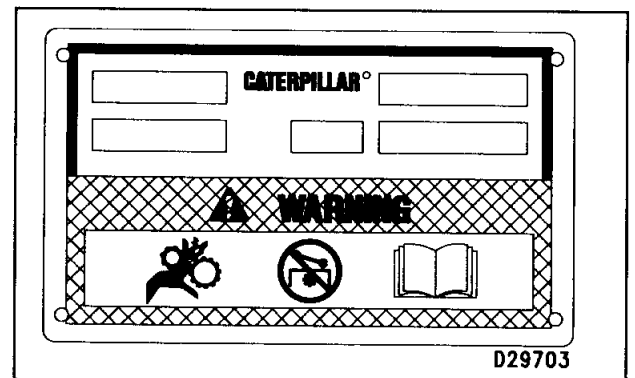
Lifting warning label.

Clutch

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



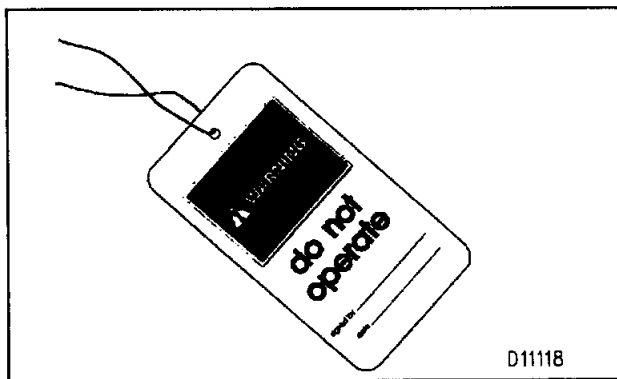
The clutch warning label is located on the clutch housing.



Clutch warning label.

General Hazard Information

Attach a **DO NOT OPERATE** or similar warning tag to the start switch or controls before performing maintenance or repairing the engine. These tags, SEHS7332, are available from your Caterpillar dealer. When appropriate, attach the tags at the engine and at each operator's position. Disconnect starting controls when appropriate.



Do not allow unauthorized personnel on, around or in the engine unit when it is being serviced.

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.

Use caution when removing cover plates. Gradually loosen (do not remove) the last two bolts or nuts located at opposite ends of the cover or device. Pry cover loose to relieve any spring or other pressure before removing the last bolts or nuts.

Use caution when removing filler cap, grease fittings, pressure taps, breathers or drain plugs. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure.

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

UNLESS INSTRUCTED DIFFERENTLY, PERFORM ALL MAINTENANCE AS FOLLOWS:

- Stop the engine.
- Ensure the protective locks or controls are in the applied position.
- Be sure the remote starting system is disabled and/or disconnect the starting system on the engine being serviced.
- Disconnect the batteries whenever performing any maintenance or before servicing the electrical system. If the engine has an electric starting motor, disconnect and tape the battery ground leads to prevent accidental starting.
- Do not attempt any repairs or adjustments to the engine or driven equipment while it is running.
- Do not attempt repairs you do not understand. Use proper tools; replace or repair broken or damaged equipment.
- When starting an engine after repairs have been made to the fuel system or governor, make provisions for shutting off the engine's ignition, the fuel supply, and/or inlet air supply (to stop the engine), in case there is an overspeed on start-up.
- Start the engine only from the operator's station. Never short across the starting motor terminals or the batteries as this could bypass the engine neutral start system as well as damage the electrical system.

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) and maximum water pressure must be below 275 kPa (40 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.

Fluid Spillage Containment

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the engine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to NENG2500, Tools And Shop Products Guide, for tools and supplies suitable to collect and contain fluids used in Caterpillar engines. Dispose of fluids according to local regulations and mandates.

Asbestos Information

This Caterpillar product and replacement parts shipped from the factory are asbestos free. Caterpillar recommends the use of only genuine Caterpillar replacement parts. If any replacement parts containing asbestos fibers are used, the following guidelines should be used in handling these parts and asbestos debris.

Asbestos used in 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.

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.

If dust, which may contain asbestos is present, there are several 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 USA, 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 damaged, leaking or displaced
- Outer covering chafed or cut and wire reinforcing exposed
- Outer covering ballooning locally
- Evidence of kinking or crushing of the flexible part of the hose
- Armoring embedded in the outer cover

Make sure that all clamps, guards and heat shields are installed correctly to prevent vibration, rubbing against other parts and excessive heat during operation.

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.

Make sure that all clamps, guards and heat shields are installed correctly in order to prevent vibration, rubbing against other parts, and excessive heat during operation.

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

Coolant

Use caution when removing filler cap, grease fittings, pressure taps, breathers or drain plugs. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure.

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.

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

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.

Coolant additive contains alkali. To prevent personal injury, avoid contacting the skin and eyes with coolant. Do not drink coolant.

Oils

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

Keep all exhaust manifold and turbocharger shields in place to protect hot exhaust from oil spray in the event of a line, tube or seal failure.

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. Ensure there is proper ventilation for batteries which are located in an enclosure.

Always thaw a frozen battery before jump starting. Frozen batteries can explode.

Do not smoke when servicing the batteries.

Always wear protective glasses when working with batteries.

Never disconnect any charging unit circuit or battery circuit cable from the battery when charging unit is operating. A spark can cause the flammable vapor mixture of hydrogen and oxygen to explode.

Fire or Explosion Prevention

Fire may result from lubricating oil or fuel sprayed on hot surfaces causing personal injury and property damage. Inspect all lines and tubes for wear or deterioration. They must be routed, supported or clamped securely. Tighten all connections to the recommended torque. Leaks can cause fires.

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 seriously damage 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.

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 all unauthorized persons.

Store all oily rags or other flammable material in a protective container, in a safe place.

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.

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.

Provide adequate and proper waste oil disposal. Oil and fuel filters must be properly installed and housing covers tightened to proper torque when being changed.

Batteries must be kept clean, covers kept on all cells, recommended cables and connections used and battery box covers kept in place when operating.

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 starting motor NEGATIVE (–) terminal (if equipped) or to the engine block. See the Operation Section of this manual for specific starting instructions.

Clean and tighten all electrical connections. Check regularly for loose or frayed electrical wires. Refer to maintenance schedules for interval. Have all loose or frayed electrical wires tightened, repaired or replaced before operating the engine.

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.

Fire Extinguisher

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

Electrical System

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the flammable vapor mixture of hydrogen and oxygen to explode.

To prevent potential sparks from igniting combustible gases produced by some batteries, attach the negative (–) boost ground cable last, to the starting motor NEGATIVE (–) terminal (if equipped) or to the engine block. Check regularly for loose or frayed electrical wires. Have all loose or frayed electrical wires tightened, repaired or replaced before operating the engine. See the Operation Section of this manual for specific starting instructions.

Grounding Practices

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

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

Engines installed without engine to frame ground straps can be damaged by electrical discharge. To prevent electrical discharge damage, check to make sure the engine's electrical system has an engine to frame 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 starting motor to frame ground straps. But many of these starting motors are not electrically grounded to the engine. They have electrical insulation systems. For this reason, the starting motor to frame ground strap may not be an acceptable engine ground.

To insure proper functioning of the engine and the engine electrical systems, an engine to frame ground strap with a direct path to the battery must be used. This may be provided by way of a starting motor ground, a frame to starting motor ground, or a direct frame to engine ground.

All grounds should be tight and free of corrosion. The engine alternator must be battery (–) grounded with a wire size adequate to handle full alternator charging current. The engine comes equipped with an alternator ground wire.

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

Do not climb on, or jump off the engine or stand on components which cannot support your weight. Use an adequate ladder. Always use steps and handholds when mounting and dismounting.

Clean steps, handholds and areas of the engine you will be working on or around.

Enclosure Doors

Strong winds may lift the enclosure doors off their hinge pins.

If strong winds threaten to lift the enclosure doors, the doors should be removed from their hinges to prevent damage.

Ignition Systems

Ignition systems can cause electrical shocks. Avoid contacting ignition components and wiring. DO NOT inspect valve mechanism or transformers while the engine is running. Personal injury or death may result.

Ignition system damage will occur when the cylinder head valve covers are removed with the engine running. The ignition system harness should be disconnected BEFORE removing valve covers or performing valve train maintenance.

Always have the Engine Control Switch (ECS) in the STOP or OFF/RESET position to immediately discharge the ignition system when the ignition harness is reconnected.

When the wiring harness is reconnected, and the ECS is in the AUTOMATIC or MANUAL START position, the ignition system may discharge and fire a spark plug. The plug will ignite any gas that has accumulated in that cylinder. The crankshaft and driven equipment can rotate, possibly causing personal injury or damage to equipment.

Gas that has accumulated in the exhaust system may also be ignited.

Before Starting the Engine

Inspect engine for potential hazards.

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.

Do not disable or bypass automatic shutoff circuits. They are provided to prevent personal injury and engine damage.

Never start an engine with the governor linkage disconnected.

Make provisions for shutting off the air and/or fuel supply, or shutting off the ignition system in order to stop the engine if there is an overspeed on start-up after performing repair or maintenance to the engine.

See the Service Manual for repairs.

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.

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.

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

Always start the engine according to the required Engine Starting procedure described in this manual to prevent major engine component damage and personal injury.

Make sure the engine is equipped with a lighting system as required by conditions.

Make sure all lights are working properly.

Check the jacket water and oil temperature gauges frequently during the operation of jacket water and/or lubrication oil heaters to ensure proper operation.

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.

Ether

Ether is poisonous and flammable.

Inhaling ether vapors or repeated contact of ether with skin can cause personal injury.

Do not smoke while changing ether cylinders.

Use ether only in well ventilated areas.

Use ether with care to avoid fires.

Keep ether cylinders out of the reach of unauthorized persons.

Do not store replacement ether cylinders in living areas or in the engine compartment or cab (if equipped).

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 burn cylinders.

Engine Stopping

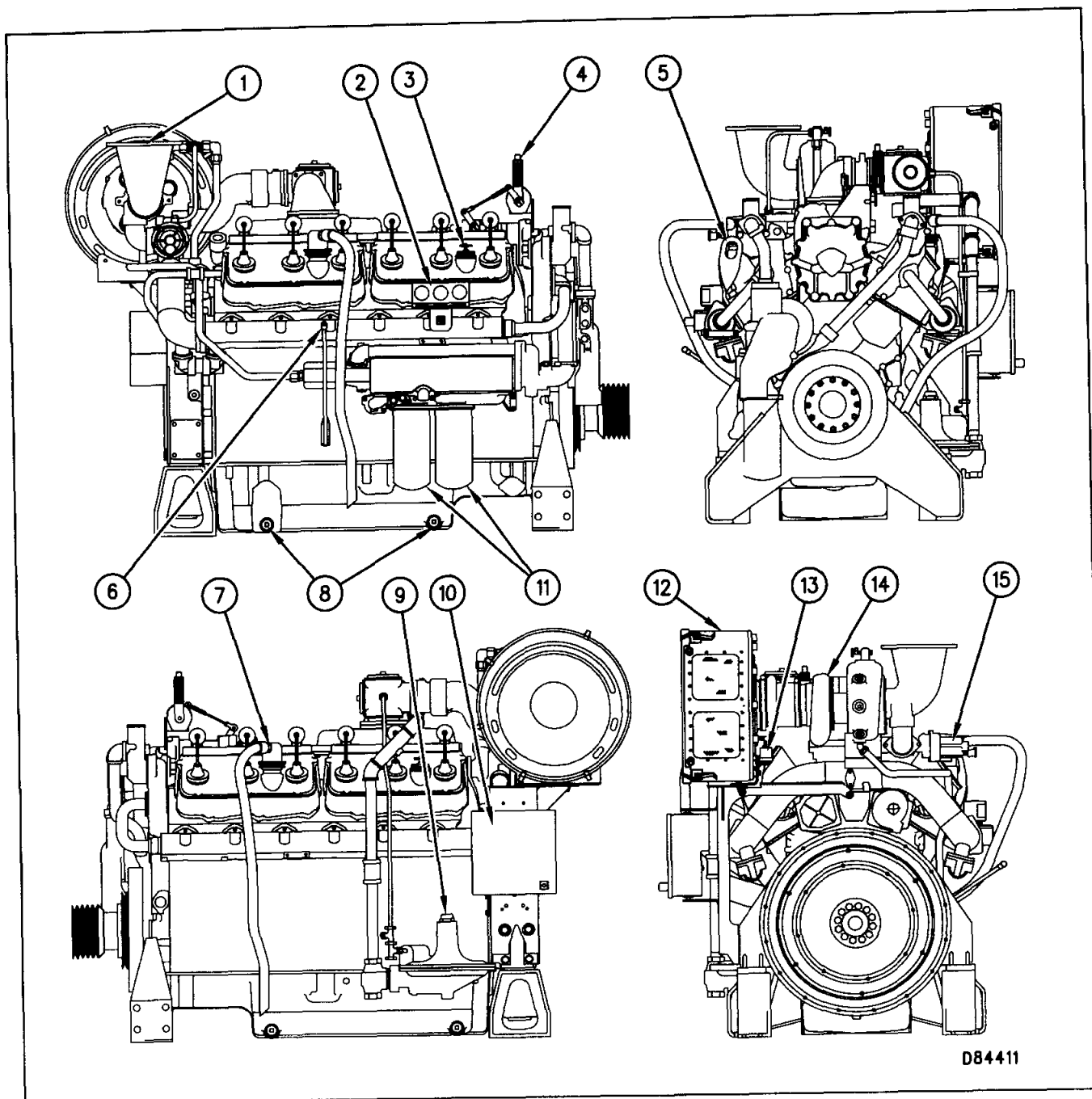
Stop the engine according to the Engine Stopping instructions in the Operation Section to avoid overheating and accelerated wear of the engine components.

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

On initial start-up or overhaul, be prepared to STOP the engine should an overspeed condition occur. This may be accomplished by cutting the ignition, the fuel supply, and/or the air supply to the engine.

Model Views

The sample model views show various typical G3400 Engine features. The illustrations are generic and do not reflect all available options. Because of individual applications, your engine may appear different from the illustrations.



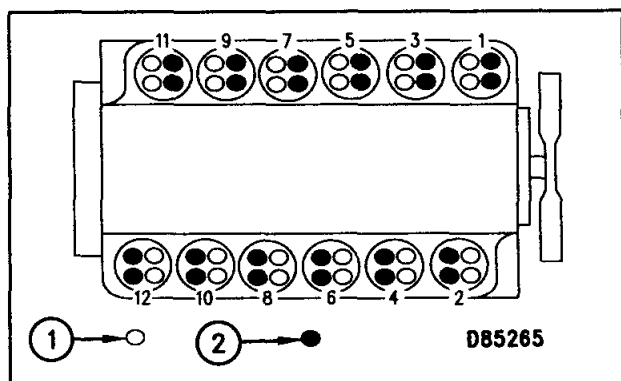
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G3412 Engine: Exhaust (1), Instrument Panel (2), Oil Filler Cap (3), Governor Control Lever (4), Lifting Eye (5), Oil Level Gauge (Dipstick) (6), Crankcase Breather (7), Oil Drain Plugs (8), Gas Regulator (9), Junction Box (10), Oil Filters (11), Air Cleaner (12), Service Indicator (13), Turbocharger (14), and Exhaust Bypass Valve (15).

G3412 Engine Specifications	
Rated Speed (rpm)	1000 to 1800
Number of Cylinders	12
Arrangement of Cylinders	65 degree Vee
Bore	137 mm (5.4 inch)
Stroke	152 mm (6.0 inch)
Compression Ratio	NA 9.7:1 TA 9.7:1 & 8.5:1 ¹
Aspiration	Natural Aspirated (NA) or Turbocharged (TA) with SCAC ²
Displacement	27.0 L (1649 cu in)
Firing Order	1-4-9-8-5-2-11-10-3-6-7-12
Rotation (viewed from flywheel)	Counterclockwise

¹ Alternate fuel system compression ratio 11.4:1.

² Turbocharger with aftercooler water supplied from a cooling system separate from the jacket water system equipped with 32°C (90°F) or 54°C (130°F) or 70°C (160°F) separate circuit aftercooler water.



G3412 cylinder numbers, inlet valves (1) and exhaust valves (2).

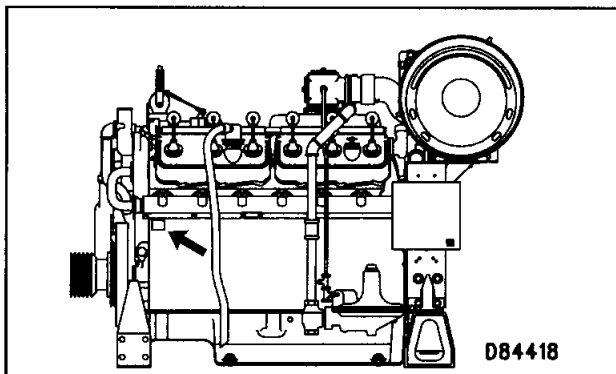
Product Identification

Engine Identification

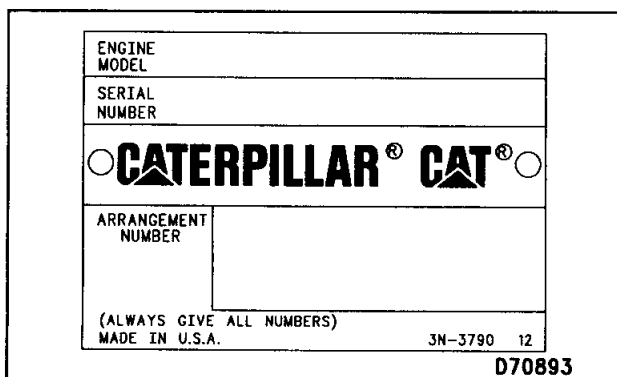
Caterpillar engines are identified with serial numbers, with fuel system setting numbers, and with arrangement numbers. In some cases, modification numbers are used. These numbers are shown on the Serial Number Plate and on the Information Plate which are mounted on the engine. The gas engines will also have a Gas Information Plate.

Caterpillar dealers need all of these numbers in order to determine which components were included on the engine when the engine was assembled at the factory. These numbers permit accurate identification of replacement part numbers.

Serial Number Plate



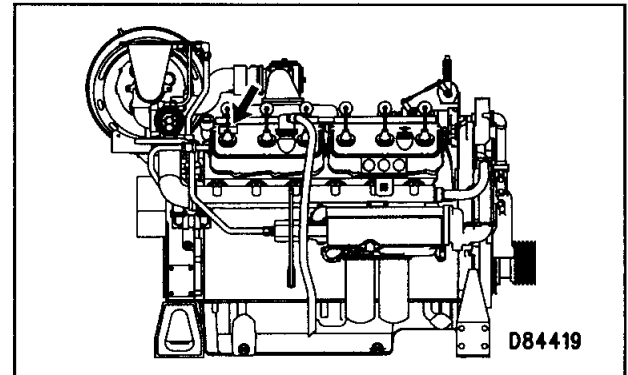
The Serial Number Plate is located on the left side of the cylinder block near the front of the engine.



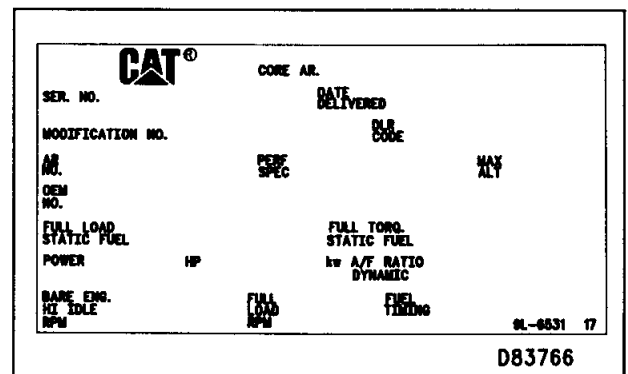
Typical Serial Number Plate.

The engine serial number, model, and arrangement number are stamped on the Serial Number Plate.

Information Plate



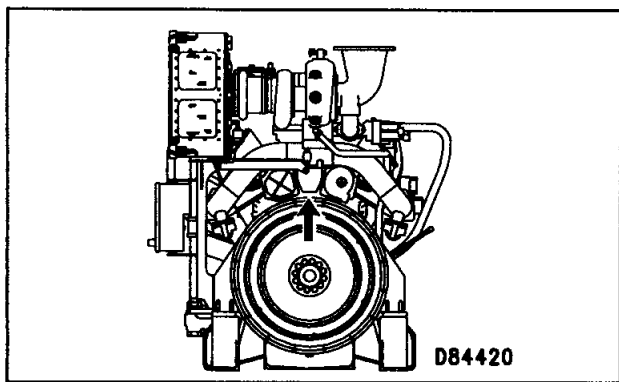
The Information Plate is located on the right side valve cover near the rear of the engine.



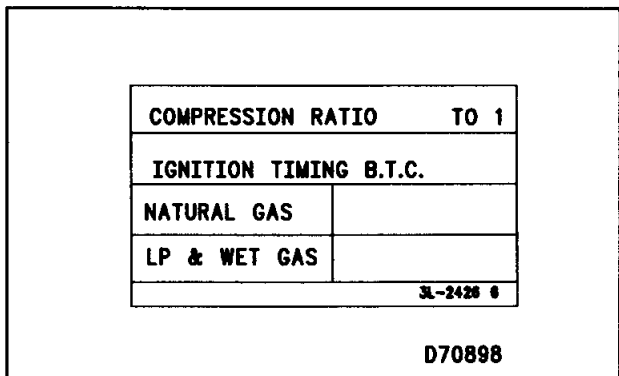
Typical Information Plate.

The engine's maximum altitude, horsepower, high idle, full load rpm, and other information is stamped on the Information Plate.

Gas Information Plate



The Gas Information Plate is located on the top of the flywheel housing.



Typical Gas Information Plate.

The compression ratio, ignition timing, and other information is stamped on the Gas Information Plate.

Reference Numbers and Ordering Parts

Reference Numbers

Information for the following listed items may be needed for ordering parts. Locate the information for your engine. Record the information on the appropriate line below. You may wish to make a copy of this record. Retain the information for future reference.

Engine Model_____

Engine Serial No._____

Engine Arrangement No._____

Modification No._____

Engine Power Rating_____

Engine Low Idle rpm_____

Engine Full Load rpm_____

Performance Specification No._____

Governor Group No._____

Lubrication Oil Filter Element No._____

Supplemental Coolant Additive
(Conditioner) Quantity_____

Supplemental Coolant Additive
Maintenance Element No._____

Supplemental Coolant Additive
Precharge Element No._____

Air Cleaner Element No._____

Fan Drive Belt Set No._____

Alternator Belt No._____

Lubrication System Capacity (Total)_____

Cooling System Capacity (Total)_____

Ordering Parts

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

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

When service or maintenance is needed for your Caterpillar engine, be prepared to give the dealer all of the information that is provided on the Information Plate.

Discuss the problem with the dealer, such as when it occurs, what happens, etc. This will help the dealer to troubleshoot and solve the problem faster.

Customer Service

USA and Canada

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: **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 following steps.

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 number 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 of the USA and Canada

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

Australia and New Zealand

Caterpillar of Australia Ltd.

1 Caterpillar Drive

Private Mail Bag 4

Tullamarine, Victoria 3043

Australia

Phone: (03) 9339-9333

Fax: (03) 9335-3366

Brazil, Bolivia, and Paraguay

Caterpillar Brasil, Ltda.

Edificio Brasil Interpart

Rua Guararapes, 2064-5 andar, conjunto 2

CEP 04561-004, Sao Paulo, SP

Brasil

Phone: (55) 11-5505-3388

Fax: (55) 11-5505-1647

Central America and Caribbean

Caterpillar Americas Co.

300 South Pine Island Road, Suite 308

Plantation, Florida 33324

USA

Phone: (954) 472-8204

Fax: (954) 472-4967

China

Caterpillar China Ltd.

One Pacific Place

88 Queensway, Level 8

G.P.O. Box 3069

Hong Kong

Phone: 852-2848-0333

Fax: 852-2848-0440

Ecuador, Colombia, Venezuela, Guyana, and Suriname

Caterpillar Americas Co.

300 South Pine Island Road, Suite 308

Plantation, Florida 33324

USA

Phone: (954) 475-7202 or 475-7203

Fax: (954) 474-9791

Europe, Africa, and Middle East

Caterpillar Overseas S.A.
76 Route de Frontenex
P.O. Box 6000
1211 Geneva 6
Switzerland
Phone: (22) 849-4444
Fax: (22) 849-4544

Far East

Caterpillar Asia Pte. Ltd.
7 Tractor Road
Jurong, Singapore 627968
Republic of Singapore
Phone: 65-662-8333
Fax: 65-662-8302

Japan

Caterpillar Mitsubishi Ltd.
3700, Tana, Sagamihara-shi
Kanagawa-ken, 229
Japan
Phone: Sagamihara (427) 62-2112
Fax: (427) 62-8542

Mexico

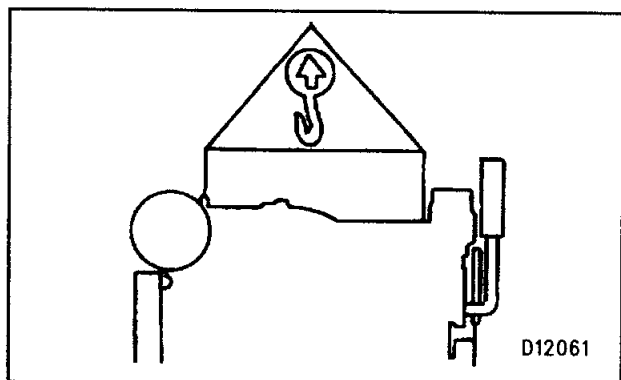
Grupo Financiero Caterpillar Mexico, S.A. de C.V.
Primer piso del Arco Oriente de Arco Bosques
Coporativa,
Bosques del Alisos 45A
Bosques de Las Lomas
Mexico, D.F. 05120
Phone (From within Mexico): 915-259-3389 or
259-3436
Phone (From within the USA): 011-525-259-3389 or
259-3436
Fax: (309) 675-5364

Peru, Chile, Argentina, and Uruguay

Caterpillar Americas Co.
Edificio Torre Santa Maria
Av. Los Conquistadores 1700
Piso 22B, Oficina B
Santiago, Chile
Phone: (011-562) 231-6354 or 231-0160
Fax: (011-562) 231-0159

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 degrees. Eyebolts and brackets should never be bent. Eyebolts and brackets should only be loaded under tension.

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

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

To remove the engine only, use the lifting eyes equipped with the engine.

The lifting eyes are designed for the engine arrangement as sold. Modifying the lifting eyes and/or modifying the engine arrangement weight renders the lifting eyes and the devices obsolete.

If you modify the lifting eyes and/or the engine arrangement weight, you are responsible for providing adequate lifting devices. Contact your Caterpillar dealer for information regarding fixtures for proper engine package lifting.

Engine Lifting With Generator

Lifting the engine and generator together requires special equipment and procedures. Contact your Caterpillar dealer for information regarding fixtures for proper lifting of your engine package.

Engine Lifting With Fuel Tank

Lifting the engine along with a mounted fuel tank requires special equipment and procedures. Do not lift the unit with fuel in the tank. Contact your Caterpillar dealer for information regarding proper engine and fuel tank lifting.

Engine Storage

When an engine is not started for several weeks, the lubricating oil drains from the cylinder walls and piston rings. Rust can then form on the cylinder liner surface, increasing engine wear and decreasing engine life.

To prevent excessive engine wear:

- Be sure all lubrication recommendations mentioned in the Maintenance Schedule intervals chart are completed.
- If freezing temperatures are 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 to -29°C (-20°F).

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

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

Your Caterpillar dealer will have instructions for preparing your engine for extended storage periods.

Generator Storage

WARNING

When servicing or repairing electric power generation equipment:

Make sure the unit is off-line (disconnected from utility and/or other generators power service), and either locked out or tagged DO NOT OPERATE. Remove all fuses.

**Make sure the generator engine is stopped.
Make sure all batteries are disconnected.
Make sure all capacitors are discharged.
Failure to do so could result in personal injury or death.**

Make sure residual voltage in the rotor, stator and the generator is discharged.

When a generator is stored, moisture may condense in the windings. Use a dry storage space and space heaters to minimize condensation.

Removing Moisture

NOTICE

Drying does not always produce desired results. It may be necessary for the generator to be dipped and baked by a qualified rebuild shop.

- Energize the space heaters in the generator (if equipped).
- Space heaters can be installed on generators (see the Parts Manual). These heaters warm the windings to remove moisture. These heaters should be connected at all times in high humidity conditions, whenever the generator is not running.

Refer to SEHS9124, Cleaning and Drying of Electric Set Generators, or contact your Caterpillar dealer.

After Storage

Test the main stator windings with a megohmmeter:

- before the initial start-up of the generator set
- every three months* if the generator is operating in a humid environment
- if the generator has not been run under load for three months* or more

* This is a guideline only. If the environment is extremely humid or salty, it may be necessary to perform the Megger Test more frequently. Refer to one of the following publications for Megger Test information:

- SEBU6918, SR4B Generators and Control Panels Operation and Maintenance Manual
- SENR5359, SR4B Service Manual
- SEBU6150, SR4 Generators and Control Panels Operation and Maintenance Manual
- SENR7958, Electric Set Generator Service Manual

Gauges and Indicators

Your engine may not have the same or all of the gauges as described below.

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

Noticeable changes in the gauge readings may indicate 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.



Engine Oil Pressure – The oil pressure reading will be greatest after starting a cold engine. Oil pressure will decrease as the engine warms while idling. As the engine speed is increased to full load speed, oil pressure will increase and stabilize.

Operating engine oil pressure should be between 275 to 600 kPa (40 to 87 psi) when the engine is running at rated speed with SAE 30W oil at normal jacket water operating temperature. A lower pressure [186 to 344 kPa (27 to 50 psi)] is normal at low idling speed. If no pressure is indicated, stop the engine.



Jacket Water Temperature – The water temperature reading may vary according to load, but should never exceed the boiling temperature for the pressurized system being used. Engine jacket water operating temperature range is 87 to 99°C (188 to 210°F). Somewhat higher temperatures [up to 112°C (235°F)] may occur under certain conditions, such as when using solid watercooled systems with an expansion tank or heat exchanger.

The engine should operate within the normal range. If the jacket water temperature sensor is not fully submerged because coolant level is too low, the temperature reading will be incorrect. If the engine is operating and a high water temperature reading is observed:

- Reduce the load and engine speed
- Inspect for coolant leaks
- Determine if the engine must be shut down immediately or if the engine will be cooled by reducing the load and speed



Tachometer – Indicates engine rpm (speed). When the governor control is at the full speed position without load, the engine is running at high idle. When the governor control is at the full speed position and a load is applied, the engine will slow slightly to full load speed (or rated speed if governor is set up isochronous).

The engine can be operated at rated speed for long periods of time without shortening the engine's service life. The high idle rpm and the full load rpm are stamped on the engine Information Plate.



Ammeter – Indicates the amount of charge or discharge in the battery charging circuit. Normal operation of the indicator should be slightly to the positive (right) side of "0" (zero). If the indicator is constantly to the negative (left) side of "0" (zero) or if the indicator shows excessive charge, have the charging system checked for malfunction.



Service Hour Meter – Indicates the total number of service meter units the engine has operated.



Oil Filter Differential Pressure – Indicates the difference of oil pressure between the inlet side (dirty side) and the outlet side (clean side) of the oil filter. As the element becomes plugged, the difference in pressure between the two sides of the element will increase. Oil filter maximum pressure differential is 105 kPa (15 psi).

Optional Gauges

NOTE: The following gauges are optional. These gauges may be remote or panel mounted.



Inlet Manifold Pressure – Indicates engine inlet manifold air pressure or vacuum. As the inlet manifold air pressure increases, the engine power increases.

Refer to the Performance Curves in the G3400 Performance Manual, which can be obtained from your Caterpillar dealer.



Inlet Manifold Air Temperature – Indicates the inlet manifold air temperature to the cylinders. As the inlet manifold air temperature increases, the air expands, less air is available for combustion in the cylinders and less power is developed. As a result, at full load governor position with a full load, the engine may be overloaded.

NOTICE

High inlet manifold air temperature increases the risk of detonation, which can cause engine damage.

Maximum inlet manifold air temperature is 43°C (110°F) for engine ratings with a 32°C (90°F) SCAC coolant temperature. A maximum of 65°C (150°F) is allowed for engine ratings with a 54°C (130°F) SCAC coolant temperature. The aftercooler system should be cleaned and maintained in order to provide no more than a 4°C (7°F) variation from the maximum inlet manifold air temperature listed when an engine has reached jacket water operating temperature.



Air Cleaner Differential Pressure – Indicates the difference of air pressure between the inlet side (dirty side) and the engine side (clean side) of the air filter element. As the element becomes plugged, the difference in pressure between the two sides of the element will increase.

Maximum air cleaner pressure differential is 3.75 kPa (15 inches of H₂O). However, 2.5 kPa (10 inches of H₂O) pressure differential is recommended for cleaning or replacing elements in order to provide the best operating results.

Engine Performance and Operation – Optimal Parameters

Fuel Consumption

On installations where the engine operates near rated load or at rated load on commercial natural gas, up to eight percent fuel savings can be obtained by fine tuning the air/fuel ratio and ignition timing. In order to make fine tuning feasible, the engine must have stable operating parameters. The parameters must not exceed the following tolerances.

Engine Performance Parameters	
Parameter	Tolerance
Jacket Water Temperature	$\pm 6^{\circ}\text{C}$ ($\pm 10^{\circ}\text{F}$)
Inlet Manifold Air Temperature	$\pm 6^{\circ}\text{C}$ ($\pm 10^{\circ}\text{F}$)
Gas Temperature	$\pm 6^{\circ}\text{C}$ ($\pm 10^{\circ}\text{F}$)
Fuel Energy Content	$\pm 31.6 \text{ kJ}$ ($\pm 30 \text{ Btu}$)
Load	$\pm 5\%$

Air/Fuel Ratio

The best fuel consumption occurs when there is between one to three percent free oxygen (O_2) in the exhaust. Because of variances of the engines and the application, load and fuel, the air/fuel ratio which delivers the minimum fuel cannot be predefined. A fuel meter and exhaust gas analyzer are required in order to determine the minimum fuel consumption point.

In order to find the minimum fuel consumption point, start at two percent oxygen and adjust the free oxygen in the exhaust in quarter percent ($\frac{1}{4}$ percent) increments. For each increment point, record the fuel consumption per unit of power (kW or hp) until the point of least consumption is identified.

The correct air/fuel ratio is very important for detonation considerations and for achieving the best service life from the engine. If the air/fuel adjustments are not appropriate for the type of fuel used and the operating conditions, an early failure or a reduced service life for valves, turbochargers, and other engine components may occur.

If the air/fuel ratio is not in the correct or optimum range, the engine will not operate properly. Contact your Caterpillar dealer for assistance.

Timing Adjustment

Fine adjustment of the timing can also produce a fuel savings. In order to optimize the timing, advance the timing until detonation is just audible, then retard the timing five degrees.

NOTE: The air/fuel ratio setting should be rechecked after timing adjustment.

Throttle Angle

Engines have the lowest fuel consumption at 60 to 75 degree throttle angle. Depending on the fuel, the wastegate setting, and the altitude, there may be reserve turbocharger boost above the throttle plate at rated power. The excess boost generates back pressure in the exhaust manifold and raises pumping losses which increase fuel consumption.

Wastegate Setting

Additional fuel savings can be achieved by fine adjustment of the wastegate setting in order to reduce excess boost above the throttle plate. The G3400 engines are equipped with watercooled adjustable wastegates for variable turbocharger boost pressure. The adjustable wastegate setting allows for altitude conditions to maximize the throttle angle for a given load.

The following chart has been developed in order to allow the owner or the dealer to set the wastegate for altitude conditions or to maximize the throttle angle for a given load. High throttle angles (60 to 75 degrees) allow for minimum fuel consumption.

The wastegate is adjusted by setting the engine to the maximum load that the engine will be subjected to. This load setting can be less, but no more than the rated load. Identify which portion of the chart to use, either high pressure gas or low pressure gas. Then identify engine model and engine speed. The number at the intersection of the row column and the speed column is the pressure differential between the turbocharger boost and the manifold pressure. Taps for pressure measurements are located in both the inlet manifold and in the turbocharger boost line.

G3400 Throttle Pressure Drop				
High Pressure Gas	1000 RPM	1200 RPM	1500 RPM	1800 RPM
G3408	7 kPa (1.02 psi)	9 kPa (1.31 psi)	10 kPa (1.45 psi)	12 kPa (1.74 psi)
G3412	7 kPa (1.02 psi)	9 kPa (1.31 psi)	15 kPa (2.18 psi)	17 kPa (2.47 psi)
Low Pressure Gas	1000 RPM	1200 RPM	1500 RPM	1800 RPM
G3408	8 kPa (1.16 psi)	9 kPa (1.31 psi)	9 kPa (1.31 psi)	10 kPa (1.45 psi)
G3412	9 kPa (1.31 psi)	10 kPa (1.45 psi)	10 kPa (1.45 psi)	11 kPa (1.60 psi)

Adjust the wastegate until the measured pressure drop matches the pressure drop found in the chart. If the pressure drop is too low, turn the wastegate screw clockwise. If the pressure drop is too high, turn the wastegate screw counterclockwise.

Engine Features and Controls

Engines may be equipped with optional engine protection devices. This section discusses general information about how typical protection devices function.

Alarm and shutoff systems are electronically controlled. The operation of all alarms and shutoffs utilize components which are actuated by a sensing unit. The alarms and shutoffs are set at critical operating temperatures, pressures or speeds in order to protect the engine from damage. The function of the alarms and shutoffs is to warn the operator or to shut the engine off for such reasons as low oil pressure, high coolant temperature, and overspeed.

G3400 engines use one of three systems in order to monitor engine parameters and in order to provide shutoff protection.

- Junction Box: Energize To Shutoff (ETS)
Auto-Start-Stop
- Junction Box: Energize To Run (ETR)
- Control Panel: Status-Timing

For information regarding junction box ETS and ETR systems, refer to the Service Manual for the engine. For information regarding the generator control panel, refer to SEBU6918, Caterpillar SR4B Generators and Control Panels, or refer to SEBU6150, Caterpillar SR4 Generators and Control Panels.

The operation of all engine protective shutoffs is similar. A critical operating condition actuates a switch to stop the engine by grounding the magneto and/or shutting off the GSOV.

NOTICE

If the RESET button does not move to the extended position after the engine starts, the engine will NOT be protected by this particular switch.

If the RESET button remains in the reset position, the engine oil pump is not developing normal oil pressure and an inspection should be made to correct the problem.



WARNING

Unburned gas left in the inlet manifold can ignite when the engine is restarted. Clear the exhaust system of unburned gas. Personal injury and/or engine damage can result.

Before starting a gas engine which was stopped by terminating the ignition system, crank the engine for approximately 15 seconds with the gas valve OFF in order to clear the exhaust system of unburned gas.

Some shutoffs require resetting before the engine will start. If an engine protective device activates to shut the engine off, always determine the cause of the shutoff and make the necessary repairs before attempting to start the engine.

Familiarize yourself with the types and locations of the alarm and shutoff controls, the conditions which cause each control to function, and the resetting procedure required to start the engine.

Engine Protective Shutoffs

Self Powered Protection System

The self powered protection system required no external power for protection. When started (by a separate system), the engine is protected from a low oil pressure fault and a high water temperature fault. Overspeed protection is provided if an overspeed contactor switch is wired into the system. The engine can be equipped with an ETS gas shutoff valve (GSOV).

ETR, Independent, Full Protection System

The fully independent system requires an external 24 VDC power source for electrical engine protection. The engine is monitored for overspeed, oil pressure, and water temperature. The GSOV is ETR.

The engine protective shutoffs will stop the engine when the limits for low oil pressure, high water temperature, and overspeed are exceeded.

Low Oil Pressure

The oil pressure switch is usually mounted on the side of the engine and may be connected in an oil line. The low oil pressure switch senses oil pressure at the bearing oil gallery. Activation of the switch depends on the engine speed. Minimum oil pressure at low idle is 100 kPa (156 psi). Minimum oil pressure at high idle is 275 kPa (40 psi). The oil pressure RESET button must be held in during starting.

High Water Temperature

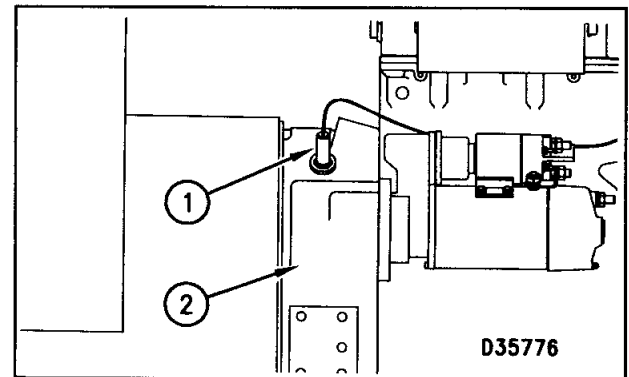
NOTICE

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.

The high water temperature sensor is located on the left front of the cylinder block near the water temperature regulator housing. Excessive coolant water temperature closes the switch and activates the shutoff. The maximum coolant temperature to activate shutoff is 105°C (221°F). The switch opens as the coolant cools. No resetting procedure is required.

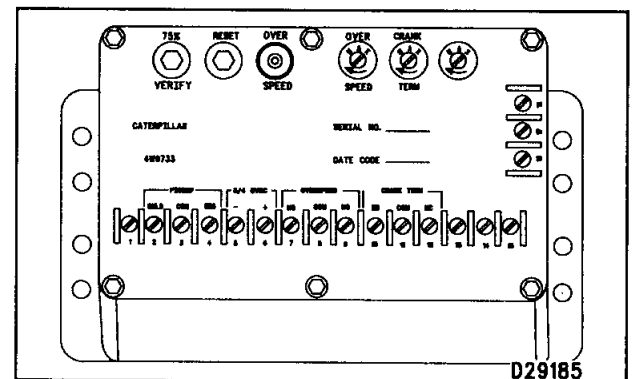
NOTE: To prevent overheating, the coolant pressure must be a minimum of 27.6 kPa (4 psi).

Overspeed



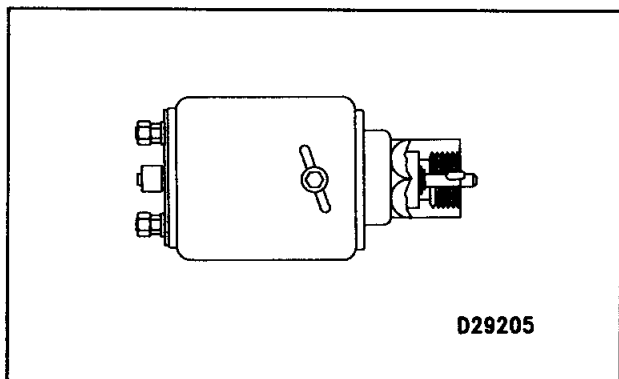
Magnetic pickup (1), mounted in the flywheel housing (2).

A magnetic pickup mounted in the flywheel housing senses the passage of the flywheel ring gear teeth. If the engine speed exceeds the setting of the Electronic Speed Switch (ESS) (normally 118 percent of rated speed), the gas shutoff solenoid closes, shutting off fuel to the engine, and the magneto is immediately grounded, stopping current flow to the spark plugs.



The Electronic Speed Switch (ESS) (if equipped) is located inside the junction box.

The ESS must be reset after an overspeed. To reset the switch, press the RESET button.



Typical overspeed contactor switch.

The overspeed contactor switch is used in applications which do not have an ESS. The overspeed contactor switch is mounted either on the tachometer drive or on the governor drive. Excessive engine speed closes the overspeed contactor switch by centrifugal force. The magneto is immediately grounded. The overspeed contactor switch must be reset after an overspeed. To reset the overspeed contactor switch, press the RESET button.

Gas Shutoff Valve (GSOV)

A gas shutoff valve is optional. The button is green when the valve is OPEN. The valve closes to stop the flow of gas to the engine. This valve must be reset manually.

Alarm and Shutoff System Testing

Abnormal engine operating conditions must be simulated in order to test the engine protective devices. Simulated abnormal operating conditions could cause engine damage if the tests are performed incorrectly. Refer to the Service Manual for the testing procedure. Your Caterpillar dealer has the trained personnel and equipment to perform this maintenance.

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 for the testing procedure.

The engine protective devices should be tested every 750 hours for proper operation by authorized service personnel.

Engines Without A Caterpillar Status Control Panel

The customer must provide shutdown logic for engines that are not equipped with a Caterpillar status control panel. The customer must provide shutdown logic for the following parameters:

- Oil Pressure (high idle limit)
- Oil Pressure (low idle limit)
- Jacket Water Coolant Temperature (high temperature)
- Overspeed

These are the minimum requirements. The specific limits are listed in the following chart.

G3408C & G3412C Fault Shutdown Limits				
Rated Speed RPM	Minimum Oil Pressure kPa (psi)		Coolant Temperature °C (°F)	Overspeed RPM
	High Idle	Low Idle		
1000	275 (40)	100 (15)	105 (221)	1200
1400	275 (40)	100 (15)	105 (221)	1680
1500	275 (40)	100 (15)	105 (221)	1800
1800	275 (40)	100 (15)	105 (221)	2160

¹ To prevent overheating, the coolant temperature must be a minimum of 27.6 kPa (4 psi).

If any of the limits are reached during operation, logic must be provided in order to close the GSOV and shut the engine off. Consult your Caterpillar dealer for assistance.

Engine Controls

Three types of controlling mechanisms are used on these engines.

- Electric PSG
- Mechanical (Lever-Type) PSG
- Pneumatic PSG
- EG3P Actuator

Electric PSG

Electric governors are usually operated from a control panel. The application is usually a prime power generator set. On standby generator sets the governor may be set to operate only at full load speed.

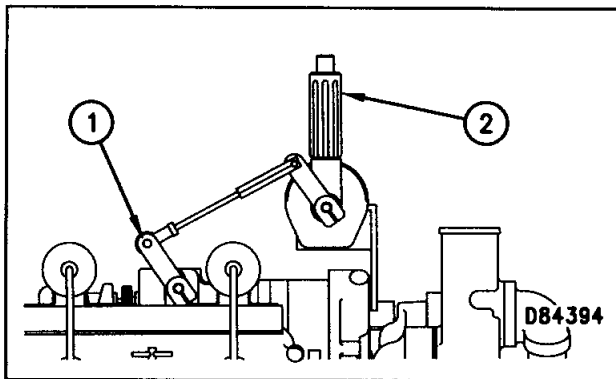
- If equipped with a control panel, move the RAISE/LOWER switch to the correct position.

Manually turn the adjusting knob in or out to change engine speed. To adjust or change engine speed droop setting, use the speed droop stop set screw.

Mechanical Governors

Your engine may be equipped with a full range governor. Most other manufacturers' engines have min-max type governors that only govern at high and low idle to prevent the engine from overspeeding or stopping.

With the min-max governor, the position of the governor control lever determines the amount of fuel delivered to the engine. The position of the governor control lever sets the engine speed and helps hold a constant speed independent of the load, which makes operation easier. Gas engine governors are not like diesel engine governors. Moving the gas engine governor control lever to the shutoff position will bring the engine to low idle. On a diesel engine, the engine will shut off.



Typical governor control lever (1) and governor control shaft (2).

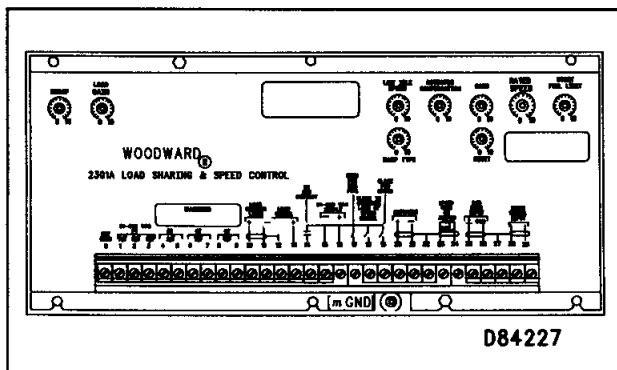
The governor control lever allows the operator to control engine speed. The governor control lever is basic equipment for a mechanical governor with three percent regulation.

Pneumatic PSG

The pneumatic PSG is typically used in industrial application where no electricity is available. The pneumatic PSG is controlled by air pressure from 21 to 103 kPa (3 to 15 psi). The speed range available varies from about 10 percent to 80 percent of the high speed setting.

EG3P Actuator

The EG3P Actuator is part of a 2301A electric governor control system.



2301A control box.

The 2301A electric governor control system consists of a 2301A control box, an EG3P actuator, and a magnetic pickup. The electric governor system provides precise engine speed control. The system has two functions; exact engine speed and kilowatt load sharing.

The system control constantly measures engine speed by monitoring the magnetic pickup frequency signal. The system makes necessary corrections to the engine fuel setting through the actuator.

The actuator is a device that hydraulically changes an electrical input to a mechanical output (terminal shaft rotation) that controls the carburetor throttle plate.

The actuator is connected to the throttle plate by linkage. The actuator changes the electrical input from the governor to mechanical output that changes the engine fuel setting. For example, if the engine speed is more than the speed setting, the governor will decrease the fuel to the engine.

Kilowatt load sharing between a group of generator sets is made possible by electric circuits in the control box. The load on each generator in the system is measured constantly by the control box. Loads between control boxes are compared through paralleling wires between all of the units on the same bus. The paralleling wires provide input to the load sharing circuits in the control box, which makes constant corrections to the voltage sent to the actuators. This provides kilowatt load sharing.

For more information about the 2301A electric governor system, refer to the Service Manual.

Starting the Engine

Before Starting the Engine

Walk-Around Inspection

In order to obtain the maximum service life of your engine, make a thorough inspection of the engine compartment before starting the engine. Look for items such as oil or coolant leaks, loose bolts, and trash buildup. Remove trash buildup and have repairs made as needed. It only takes a few minutes to make minor corrections. This can prevent major repairs at a later date.

NOTICE

Remove dirt and debris. Accumulated grease and oil on an engine or platform is a fire hazard. Each time any significant quantity of fluid is spilled on or near an engine and working area, the fluid should be cleaned up immediately.

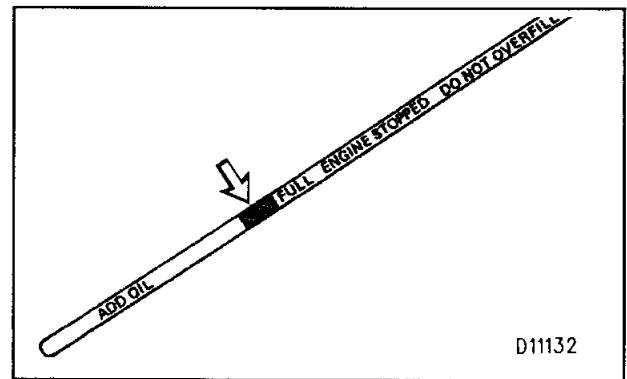
Remove the debris with steam cleaning or high pressure water, at least every 750 Hours or each time any significant quantity of fluid is spilled on or near an engine and working area.

Use care and caution when cleaning engine electronic components with water as engine damage may result.

Wipe clean all fittings, caps and plugs before performing maintenance and service.

Prestart Checks

- Perform required Daily and other periodic maintenance before starting the engine. Refer to the Maintenance Schedule Daily maintenance recommendations in this manual for details.
- All guards must be in place. Repair or replace all guards that are damaged or missing.
- Inspect the cooling system hoses for cracks and loose clamps.
- Check the air cleaner service indicator (if equipped). Service the air cleaner filter element when the yellow diaphragm enters the red zone, or the red piston locks in the visible position.
- Make sure the air inlet piping is in place. Inspect the air inlet piping for good connections.
- Inspect the fan belts and accessory drive belts for cracks, breaks, and other damage.
- Inspect the wiring for loose connections and for worn or frayed wires.
- 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.
- 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.
- Reset any shutoff or alarm components.
- Check for damaged or missing guards. Repair or replace any damaged or missing guards.



Oil level gauge (dipstick).

- Check the oil level. Maintain the oil level between the ADD and FULL marks on the ENGINE STOPPED side of the oil level gauge (dipstick).
- Check the coolant level. Make sure the engine is cool. Remove the cooling system filler cap slowly to relieve any pressure. Maintain the coolant to within 13mm (½ inch) of the bottom of the fill pipe.

- Disengage the clutch, or open the circuit breaker on a generator set. Check the oil level(s) on driven equipment (if equipped).
- If the engine has not been run, or if the governor housing has been disassembled for repairs, fill the governor drive housing sump with 300 ml (10 oz) of engine oil before the engine is started.

Cold Weather Starting

Startability will be improved at temperatures below 12°C (55°F) by the use of a starting aid. In very low temperatures, the lubricating oil must be warmed to allow starting. For starting below -18°C (0°F), use of optional cold weather starting aids are recommended. A jacket water (coolant) heater or other means can be used to heat the crankcase oil. A jacket water heater can maintain the water temperature at approximately 32°C (90°F). The warm water will keep the oil in the upper part of the engine block warm enough to flow when starting.

Contact your Caterpillar dealer before installing a dipstick crankcase oil heater.

Extra battery capacity for electric starting may be required to start the engine at colder temperatures. Consult with your Caterpillar dealer for information about starting at temperatures below -23°C (-10°F).

Starting, Operating and Stopping Engines Equipped With Control Panels

For information regarding the generator control panel used for starting, operating and stopping the engine, refer to SEBU6918, Caterpillar SR4B Generators and Control Panels, or refer to SEBU6150, Caterpillar SR4 Generators and Control Panels. Additional information and instructions are provided in the Service Manual for your specific control panel.

Electric Governor/EG3P Actuator Prestart Checks

WARNING

The engine can overspeed due to improper reassembly or adjustment of the governor, which could result in personal injury, or loss of life, and/or property damage.

Be prepared to STOP the engine by activating the EMERGENCY STOP or by manually closing the gas valve. Be sure the overspeed shutdown operates properly.

- Check all wiring for grounds. Correct any wiring problems before proceeding. Make sure that all connectors and screw terminal block connections are tight.
- Make sure that the fuel control linkage is free and does not bind.

Initial Governor Adjustments

Refer to the Service Manual for instructions regarding the initial adjustments for the governor.

Electric Starting

WARNING

Unburned gas left in the inlet manifold can ignite when the engine is restarted. Clear the exhaust system of unburned gas. Personal injury and/or engine damage can result.

Before starting a gas engine which was stopped by terminating the ignition system, crank the engine for approximately 15 seconds with the gas valve OFF in order to clear the exhaust system of unburned gas.

NOTICE

For initial start-up of a new or rebuilt engine, make provision to shut down the engine if an overspeed should occur. This may be accomplished by terminating the ignition and/or shutting off the fuel supply to the engine.

NOTICE

Do not engage starting motor when flywheel is turning. Do not crank the engine for more than 30 seconds. Allow two minutes for the starting motor to cool before cranking again. If oil pressure does not rise within ten seconds after the engine starts, stop the engine and make necessary corrections.

Starting Generator Set Engines

The control panel Engine Control Switch (ECS) has four positions: OFF/RESET, AUTO, MANUAL START, and COOLDOWN/STOP.

The generator set engine equipped with a control panel may be started in either of two modes. The MANUAL START mode is for manual operation. The AUTO mode is for remote starting and stopping.

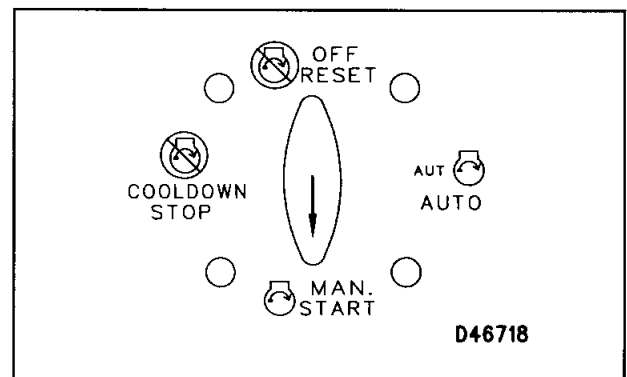
Automatic Starting

If the Engine Control Switch (ECS) is in the AUTOMATIC position, the engine will automatically start when a remote start/stop contact is closed. The engine will accelerate to rated speed within a programmed warm-up cycle when the oil pressure sensors indicate there is sufficient oil pressure for rated speed.

Manual Starting

1. Perform all prestart checks.
2. Open the main electrical circuit breaker.
3. Open the separate circuit water valve (if equipped). Open the gas supply valve.
4. Move the governor control (if equipped) to the low idle position. This will allow the engine to run at a low speed.

NOTE: If the engine idle speed is below 1200 rpm for an extended period of time, the generator voltage regulator may shut off. The voltage regulator will reset automatically when the generator set is completely shut off.



Engine Control Switch (ECS), shown at the MANUAL START position.

4. Turn the ECS to the MANUAL START position in order to start the engine. The GSC will allow the engine to be run at rated speed when the oil pressure sensors indicate sufficient pressure for rated speed.

Industrial Engines

1. Perform all prestart checks.
2. Disengage the clutch, place the transmission (or other power takeoff attachments or driven equipment) in NEUTRAL. Disconnect any battery chargers that are not protected against the starting motor current drain.
3. Move governor control to the $\frac{1}{2}$ engine speed position.
4. Open the separate circuit water valve (if equipped). Open the gas supply valve. Reset the oil pressure switch.

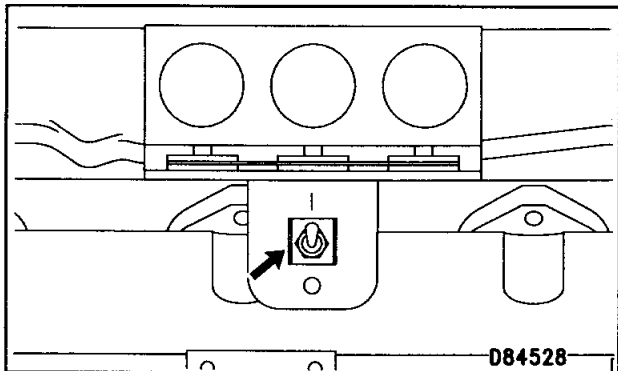
NOTICE

Oil pressure should rise within ten seconds after the engine starts. If oil pressure is not indicated within ten seconds, stop the engine. Investigate the cause and correct the problem.

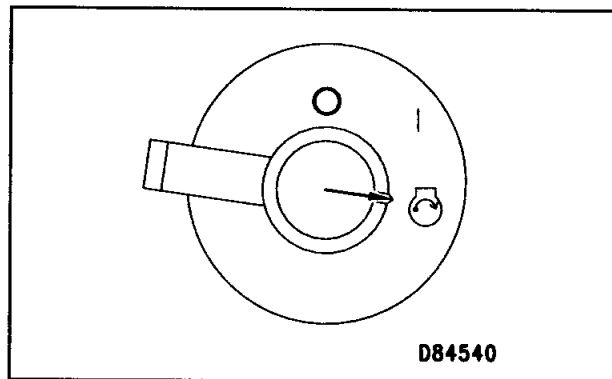
Extended cranking at low oil pressure can activate the mechanical engine protective shutoff. If the reset button is in the shutoff position, reset the mechanical engine protective shutoff.

NOTICE

Do not crank the starting motor for more than 30 seconds. If the engine fails to start, allow the starting motor to cool for two minutes before attempting to start the engine again.



Manual stop bypass switch in the bypass position.



START/STOP switch in the START position.

5. Toggle the manual stop bypass switch to the bypass position (up) and hold switch in the bypass position. Turn the START/STOP switch to the START position in order to start the engine. Release the START/STOP switch as soon as the engine starts. Hold the manual stop bypass switch in the bypass position until oil pressure is achieved, then release the switch.

WARNING

Unburned gas left in the inlet manifold can ignite when the engine is restarted. Clear the exhaust system of unburned gas. Personal injury and/or engine damage can result.

Before starting a gas engine, which was stopped by grounding the magneto, crank the engine for approximately 15 seconds with the gas valve (GSOV) OFF and the magneto grounded to clear the exhaust system of unburned gas.

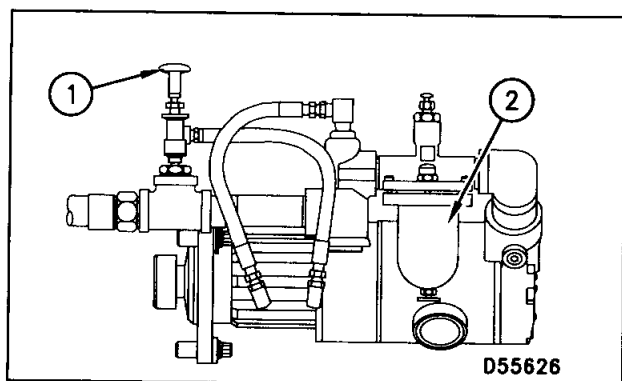
If the engine fails to start within 30 seconds, stop cranking. Turn the GSOV OFF. Allow the starting motor to cool for two minutes. Crank the engine for 15 seconds in order to purge any unburned gas from the exhaust system. Allow the starting motor to cool for at least two minutes. Turn the GSOV ON. Repeat the starting procedure.

6. As soon as the engine starts, reduce the engine speed to low idle. Ensure that the engine has reached normal oil pressure and that the engine is operating properly. Operate the engine at low idle for three to five minutes or until the water temperature begins to rise. The engine should run at low idle smoothly until speed is gradually increased to high idle. Check all gauges during the warm-up period. Adjust the engine control system and adjust any other control system necessary in order to increase the engine speed and load to the normal operation mode. Refer to the After Starting the Engine topic and refer to the Operating the Engine topic.

Air Starting

For good life of the air starting motor, the air supply must be free of dirt and water. A lubricator must be used with the starting system. Use non detergent 10W engine oil for temperatures higher than 0°C (32°F). Use air tool oil for temperatures below 0°C (32°F).

- 1.** Open and close the drain valve on the bottom of the air tank to drain condensation and oil carryover. Open the air supply valve (if equipped).
- 2.** Check the air supply pressure. The air starting motor requires a minimum of 620 kPa (90 psi) air pressure to operate properly. The maximum air pressure must not exceed 1030 kPa (150 psi). The normal air pressure will be 758 to 965 kPa (110 to 140 psi).



Air valve (1) and lubricator bowl (2)

- 3.** Check the oil level in the lubricator bowl (2). Keep the bowl at least half full. Add lubricant if necessary.

4. Turn the Start/Stop switch to the START position or turn the Engine Control Switch (ECS) to the MANUAL START position. Push the air valve (1) or the engine start button to engage the starting motor. Release the valve or button as soon as the engine starts.

5. Close the air supply valve (if equipped).

Starting From An External Electrical Source

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

First, determine the reason it is necessary to start with power from an external source. Refer to SEHS7768, Use of 6V-2150 Starting Charging Analyzer.

Many batteries which are considered unusable are still rechargeable. Severely discharged maintenance free batteries might not fully recharge from the alternator alone after jump starting. The batteries must be charged to the proper voltage with a battery charger. For complete information on testing and charging, refer to SEHS7633, Battery Test Procedure. The Special Instruction is available from your Caterpillar dealer.

NOTE: Turn the battery disconnect switch (start switch, if equipped) OFF after the engine is stopped in order to prevent battery discharge while the starting motor is cooling.



WARNING

Do not smoke when servicing batteries. Batteries give off flammable fumes that can explode resulting in personal injury. Prevent sparks near the batteries. They could cause vapors to explode. Do not allow jump cable ends to contact each other or the engine.

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

Electrolyte is an acid and can cause personal injury if it contacts skin or eyes. Always wear eye protection when starting an engine with jump cables.

Jump start using a battery source with the same voltage as the engine. This engine has a 24 Volt starting system. Use only equal voltage for jump starting. The use of a welder or higher voltage will damage the electrical system.

Turn off all auxiliary power and accessories on the engine. Otherwise, they will operate when the jump source is connected. Before attaching the jumper cables, move start switch to the OFF position.

Always connect the battery positive (+) to battery positive (+) and the battery negative (-) to battery negative (-). When using jumper cables, be sure to connect in parallel: POSITIVE (+) cable to POSITIVE (+) terminal of battery which is connected to starting motor solenoid and NEGATIVE (-) cable from external source to starting motor NEGATIVE (-) terminal. If not equipped with a starting motor NEGATIVE terminal, connect to the engine block.

Do not allow the free ends of jump start cables to touch the engine. This helps avoid sparks. Do not reverse the battery cables. The alternator can be damaged. Attach the ground cable last and remove the ground cable first.

NOTICE

When jump starting an engine, follow the instructions to properly start the engine. This engine is equipped with a 24 volt starting system. Use only equal voltage for boost starting. The use of higher voltage will damage the electrical system.

When using an external electrical source to start your engine, turn the Engine Control Switch to OFF/RESET, remove the fuse from inside engine mounted junction box and turn off all electrical accessories before attaching the cables.

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

When using an external electrical source to start your engine, turn the ECS switch to the OFF position, remove fuse from the junction box and turn off all electrical accessories before attaching cables.

1. Connect one end of cable to the POSITIVE (+) (ungrounded) terminal of the battery on the engine being started. Connect the other end to the POSITIVE (+) terminal of the power source.
2. Connect one end of the second cable to the NEGATIVE (-) terminal of the power source. Connect the other end to the starting motor ground NEGATIVE (-) terminal or to the engine block. This prevents potential sparks from igniting combustible gases produced by some batteries.
3. After making sure the driven equipment is in NEUTRAL, begin cranking the engine.
4. After the engine starts, disconnect the cable from the starting motor ground NEGATIVE (-) terminal or from the engine block first. Disconnect the other end from the NEGATIVE (-) terminal of the power source. Disconnect the cable from the POSITIVE (+) terminal of the battery on the engine being started. Disconnect the other end of cable from the POSITIVE (+) terminal of the power source.

After Starting the Engine

NOTICE

If oil pressure does not rise within ten seconds after the engine starts, stop the engine and make necessary repairs.

- After starting, operate the engine at a low load until proper operating temperature is achieved [typically 40°C (104°F) for both oil and jacket water temperature gauge readings]. Allow a cold engine to warm up at LOW IDLE for three to five minutes.

During the engine warm-up period:

- Check for any fluid or air leaks at idle rpm and at one-half full rpm (no load on the engine) before operating the engine under a load.
- Check the coolant level. Add coolant if necessary. Check for any obvious cooling system leaks. Check for loose connections. Inspect the water pump for evidence of leaks. Make sure that the air inlet piping is secured. Make sure that the air filters are in place.
- Check the gauges and driven equipment until all systems reach operating pressures and temperatures. Engine speeds, temperatures, and load are the best indications of engine performance. Rely on your instruments. Record and compare readings to detect developing abnormalities.

Applying the Load

Generator Set Engines

1. Make sure the engine gauges register in normal ranges with the engine operating at rated speed. Always increase engine speed to rated speed before applying the load.
2. Adjust the voltage and frequency.
3. Close the main circuit breaker.
4. Apply the load. 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 begins to move, the engine may be operated at full load. Adjust the voltage and frequency to compensate for the load, if necessary.

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

Industrial Engines

NOTICE

Always increase the engine speed to high idle before applying the load.

1. Operate the engine at low load until proper operating water temperature is achieved.
2. Move the governor control to the ½ engine speed position.
3. Move the governor control to the high idle (full load) position. Engage the driven equipment smoothly, with no load on the equipment. This should result in a smooth, easy start without increasing the engine speed or slipping the clutch. Interrupted starts put excessive stress on the drive train and waste fuel.
4. Apply the load to the driven equipment. Check the gauges and equipment for proper operation.

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

The governor control lever should remain in the full governed position while operating at full load.

Extended operation at low idle or reduced load may cause increased oil consumption and carbon build-up in the cylinders and result in loss of power and/or poor performance. At least every four hours of operation at reduced load, the engine should be fully loaded to burn excess carbon from the cylinders.

Do not allow the engine speed (rpm) to exceed the limit above rated rpm. DO NOT allow the engine to overspeed.

Operating the Engine

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

The time needed for the engine to reach the normal mode of operation is usually less than the time taken for a walk-around-inspection of the engine.

After the engine is started and the warm-up operation is completed, the engine can be operated at rated speed and low power. The engine will reach normal operating temperature faster when operated at rated speed and low power demand than when idled at no load. Typically the engine should reach operating temperature in a few minutes.

Engine Efficiency

The efficiency of your engine can impact fuel economy. Caterpillar engines are designed and manufactured using state-of-the-art technology in order to provide maximum fuel efficiency in all applications. To ensure optimum performance for the life of your engine, follow the recommended operation and maintenance procedures described in this publication.

Stopping the Engine

Emergency Stopping

WARNING

Unburned gas left in the inlet manifold can ignite when the engine is restarted. Clear the exhaust system of unburned gas. Personal injury and/or engine damage can result.

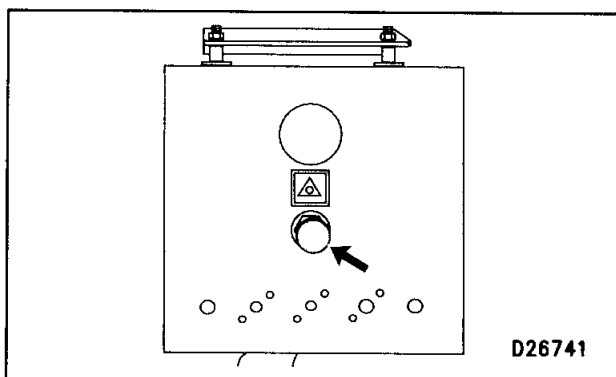
Before starting a gas engine which was stopped by terminating the ignition system, crank the engine for approximately 15 seconds with the gas valve OFF in order to clear the exhaust system of unburned gas.

NOTICE

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

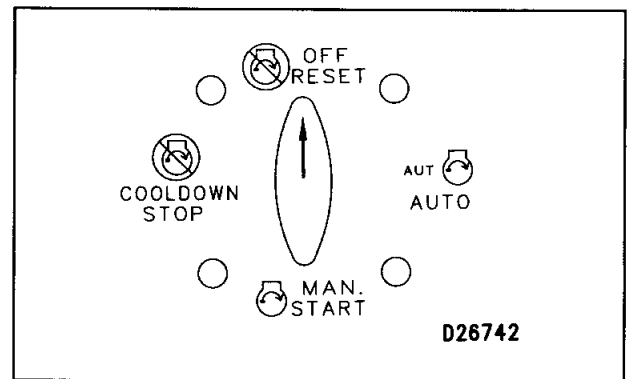
Emergency shutoff controls are for EMERGENCY use ONLY. DO NOT use emergency shutoff devices or controls for normal stopping procedure.

Familiarize yourself with the locations of the emergency stop controls. Emergency stop controls should only be used when an emergency exists, and should not be used to routinely stop the engine. The engines may be equipped with an emergency stop button and a manual START/STOP switch.



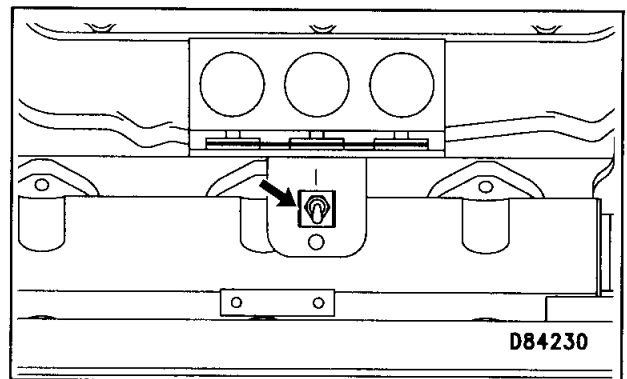
Emergency stop button.

The emergency stop button is located on the engine mounted junction box or on the control panel. Press the button to stop the engine. The emergency stop button must be reset before the engine can be started. Turn the emergency stop button clockwise (CW) until the button moves out to the normal (OFF) position.



ECS in the OFF/RESET position.

To reset the generator set control panel, turn the ECS to the OFF/RESET position.



Manual stop bypass switch in the STOP position.

The manual stop bypass switch is located just below the instrument panel on the right side of the engine. To stop the engine, toggle the switch to the STOP position. The magneto will be grounded immediately. Before starting a gas engine which was stopped by terminating the ignition system, crank the engine for approximately 15 seconds with the gas valve OFF in order to clear the exhaust system of unburned gas.

Manual Stop Procedure

NOTICE

Stopping the engine immediately after the engine has been working under load can result in overheating and accelerated wear of the engine components. Excessive temperatures in the turbocharger centerhousing will cause oil coking problems. To maximize turbocharger shaft and bearing service life, avoid hot engine shutdowns.

There may be several ways to shut off your engine. Make sure the engine stopping procedure is understood. Refer to the operating instructions supplied with your equipment.

NOTE: For generator set engines, if the ECS is in the AUTO position and the remote contact opens, the engine will run for a programmed cool down period. This will only occur when the cooldown mode is programmed. If the cooldown mode is not used, the engine will shut off immediately.

Generator Set Engines

NOTE: If the ECS is in the AUTO position and the remote contact opens, the engine will run for a programmed cool down period. This will only occur when the COOLDOWN mode is programmed. If the COOLDOWN mode is not used, the engine will shut off immediately.

1. Open the main electrical circuit breaker to remove the load.

2. The engine should be run for a cool down period before being shut off. This can be accomplished with the COOLDOWN/STOP function, or the operator can control the cool down and shut off.

To use the COOLDOWN/STOP function, turn the ECS to the COOLDOWN/STOP position. The engine will operate for a programmed time period. The timer will activate the fuel shutoff after the cool down period.

Alternatively, after removing the load, allow the engine to run at rated speed for a cool down period of five minutes. Then turn the ECS to the OFF/RESET position. The GSOV will shut the fuel off and the magneto will be grounded to disconnect voltage to the spark plugs. The engine will shut off immediately.

Industrial Engines

1. Remove the load. Disengage the clutch – place the transmission in NEUTRAL. Reduce engine speed to low idle.

2. The engine should be operated for a cool down period before being shut off. Prior to stopping an engine that is being operated at low loads, run the engine at low idle for 30 seconds before stopping. If the engine is being operated at high load, run the engine at low idle for three to five minutes in order to reduce and stabilize internal engine coolant and oil temperatures before stopping.

3. Push the gas shutoff valve (GSOV) button (if equipped) to shut off the fuel to the engine. Turn the Start/Stop switch to the STOP position. This will ground the magneto to disconnect voltage to the spark plugs and cause the engine to shut off immediately.

After Stopping the Engine

Check the crankcase oil level. Maintain the oil level between the ADD and FULL marks on the oil level gauge (dipstick).

Repair any leaks, perform minor adjustments, tighten loose bolts, etc.

Note the service hour meter reading. Perform periodic maintenance as instructed in the Maintenance Schedule.

NOTICE

Only use antifreeze/coolant mixtures recommended in the Cooling System Specifications of this manual. Failure to do so can cause engine damage.

Allow the engine to cool. Check the coolant level. Maintain the cooling system to 13 mm (½ inch) from bottom of the fill pipe.

If freezing temperatures are expected, check the coolant for proper antifreeze protection. The cooling system must be protected against freezing to the lowest expected ambient (outside) temperature. Add the proper coolant and water mixture if necessary.

Perform all required maintenance on all driven equipment as recommended by the OEM.

Torque Specifications

Torque for Standard Bolts, Nuts and Taperlock Studs

NOTICE

The charts that follow give general torques for bolts, nuts and taperlock studs. For additional torque specifications, refer to SENR3130, Torque Specifications, 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 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.

The material strength identification is usually shown on the bolt head by numbers (8.8, 10.9, etc). The chart that follows 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

NOTICE

The chart that follows 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

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. 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 constant torque hose clamp will help prevent these failures.

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 the new, 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)

Lubricant Specifications

Lubricant Information

Oil properties and performance are designated by several groups: American Petroleum Institute (API), Society of Automotive Engineers (SAE) and American Society of Testing and Materials (ASTM). A booklet of lubricant producers and marketers, together with the performance classification for which they have qualified products, has been issued by the Engine Manufacturers Association (EMA). The EMA Lubricating Oils Data Book is available from the EMA. Refer to the Reference Section for the address.

Certain abbreviations follow Society of Automotive Engineers (SAE) J754 nomenclature and some classifications follow SAE J183 abbreviations. The definitions and nomenclature other than Caterpillar definitions and nomenclature will be of assistance in purchasing lubricants. The recommended oil viscosities can be found in the Lubricant Viscosity Recommendation chart in this publication.

The grease is classified by the National Lubricating Grease Institute (NLGI) based on the ASTM D217-68 Worked Penetration characteristics which are given a defined consistency number.

Gaseous fueled engines require oils formulated with an additive system specific to these engines. Since no industry [American Petroleum Institute (API), Society of Automotive Engineers (SAE) and American Society of Testing and Materials (ASTM)] performance specifications are available to define the required performance levels, field test evaluations must be used to define acceptable oils. Some general guidelines will be provided to aid in oil selection for the application, engine fuel system and the type of fuel.

Engine oil performs several basic functions in order to provide adequate lubrication. It keeps the engine clean and free from rust and corrosion. It acts as a coolant and provides a film cushion to minimize metal-to-metal contact, which reduces friction and wear.

Engine Oil

Caterpillar has an engine oil formulated to provide maximum performance and life in your Caterpillar gas engine. This low ash oil has 0.45 percent sulfated ash (ASTM D874) and 5.0 Total Base Number (TBN), (ASTM D2896).

Minimum requirements do not ensure satisfactory performance in specific applications. Some general guidelines are provided to aid in oil selection for the application, engine fuel system and the type of fuel.

The Caterpillar lubricants that follow are offered for the gas engine lubrication requirements.

- Caterpillar Natural Gas Engine Oil (NGEO)
- Caterpillar Lubricating Grease (MPGM)
- Caterpillar Multipurpose Lithium Grease (MPGL)
- Caterpillar Special Purpose Grease (SPG)

Oil recommendation is determined by the type of gas burned and the inlet air conditions.

Units operating on processed natural gas should use oils formulated with additive systems containing between 0.3 percent and 0.5 percent maximum sulfated ash and meet the CB MIL-L-2104A (Supp 1) classification. Your oil supplier knows which oils meet these requirements.

Caterpillar oils have been developed, tested and approved by Caterpillar to provide the performance and life which has been designed and built into Caterpillar gas engines. These oils are currently being used for engine development and are offered by Caterpillar dealers for continued field use. Consult your Caterpillar dealer for these Caterpillar oils.

Natural Gas Engine Oil

- Caterpillar Natural Gas Engine Oil (NGEO)

Caterpillar NGEO is formulated from select base stocks blended with special additives to provide excellent anti-oxidation/nitration properties and thermal stability. Caterpillar NGEO reduces levels of carbon and sludge formation and provides excellent lubrication oil and filter life.

The product has superior resistance to foaming, exhibits good demulsibility and provides protection against corrosion. This oil uses an additive technology which offers excellent valve and seat protection, improved piston cleanliness and control of deposit formation. Other benefits are protection against piston scuffing, scoring and cylinder liner wear.

Caterpillar NGE0 is recommended for all Caterpillar gas engines when used with fuels (dry processed gas) not exceeding a concentration of hydrogen sulfide (H_2S) at 0.10 percent by volume or less. This oil is recommended for use with all turbocharged, medium-to-high speed, four-cycle gas engines requiring a low ash level product.

Caterpillar oils are offered in appropriate single viscosity grades to meet the ambient temperature requirements for each compartment. For additional lubricant information, refer to the Literature Section of this Manual. The oil viscosities, container sizes and part numbers are listed in PEHP0004, Natural Gas Engine Oil, and in PEWP9733, Caterpillar Fluids Selector Dial. Consult with your Caterpillar dealer for more information on Caterpillar oils.

Commercial Oil Alternatives to NGE0

If an oil other than Caterpillar NGE0 is to be used, use the guidelines that follow.

- Caterpillar recommends oils that have sulfated ash values between 0.30 and 0.50 percent. Oils for gas engines that meet the requirements of the 7000 hour field trial are acceptable regardless of ash content.
- The recommended commercial lubrication oil for Caterpillar gas engines is a natural gas type oil with a general performance classification of API CD and a maximum of 0.5 percent sulfated ash (for preferred fuels). Higher sulfated ash level together with higher TBN (higher alkalinity) will be required for some permissible fuels with elevated corrosion effects.

The guidelines that follow have been provided for commercial oils to be used in Caterpillar gas engines. These oil requirements are for low corrosive gas ("sweet" natural gas, LP Gas, etc).

Caterpillar does not recommend lubrication oils by brand name. Field operation may identify oil brands which yield good results. The oils which may be listed as having good field operating results do not form a Caterpillar recommendation, but serve only as potential oils which may be successful in your application. The particular oil company has control of their product and should be accountable for its performance.

Therefore, it is the responsibility of the lubrication oil supplier to recommend an oil which will perform acceptably for that application, power output and operating duty cycle. Discussion with oil companies about particular oil brands should establish product consistency before using that product.

NOTICE

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

- Ashless (0.0 to 0.1 percent sulfated ash) oils that have performed acceptably in the G Series engines are still acceptable in those engines. All other Caterpillar Gas engines should use oils that meet the previously defined oil ash level and performance requirements.

Caterpillar has recommended ashless oils for use in the G Series gas engines for many years. These ashless oils have provided proper lubrication and good operating life for these early engines. However, newer engine designs require oils with higher ash levels for long life operation. Engines in the field operating with ashless oils with proven success may continue to use these types of oils.

NOTICE

Caterpillar recommends the use of oils formulated specifically for heavy duty spark ignited gaseous fueled engines. Oils formulated for gasoline engines only or for diesel engines only should not be used.

- Caterpillar recommends oils that successfully complete 6000 to 7000 hours of documented field service in standard and/or lean burn engine configurations. The field trial must be performed in a similar configuration to the proposed engine and at a power level that meets or exceeds the proposed engine. During the field trial, the parameters that follow must be monitored: oil consumption, oil deterioration and valve stem projection.

At the completion of the field trial, the condition of the oil and the engine must be within the limits listed:

- No ring sticking or ring scuffing
- No liner scuffing or carbon cutting from excessive piston top land deposits
- Valve recession must not exceed the limits established by Caterpillar for the engine
- Oil consumption must not exceed two times the initial oil consumption (initial oil consumption is established during the first 1000 hours of operation.)
- At the end of all specified oil change periods, the oil condition must remain within Caterpillar's limit for: oxidation, nitration, sulfur products, viscosity increase and TBN.

Sour Gas and Alternate Fuel Gas Applications

NOTE: Refer to topic in the Fuel Specifications in this manual for additional information.

Sour gas generally refers to fuels containing sulfur compounds, primarily hydrogen sulfide. (Gases containing no sulfur compounds are referred to as "sweet gas".) Severe damage to the engine can occur if this contaminant is ignored.

Water vapor and sulfur oxides formed during combustion can combine to form sulfuric acid compounds. Internal components, particularly valve guides, piston rings and cylinder liners will be subjected to corrosive wear shortening engine service life.

If analysis of the fuel shows the concentration of hydrogen sulfide to be greater than 0.1 percent by volume, the fuel should be treated (scrubbed) to lower the H_2S level below 0.1 percent. When using fuels with 0.1 percent H_2S or less, consult your Caterpillar dealer for additional information on lubrication oil selection and oil change interval recommendations.

When sour gas, landfill or sewer gas is used as engine fuel, a gas engine lubricant with higher reserve alkalinity (higher TBN) will probably be required. These alternate fuel sources are becoming increasingly important. The scrubbing (removal) of the fuel's corrosive materials is one approach to assure engine service life. If the decision is made to use these alternate fuels with little or no treatment, the user should be aware that higher maintenance costs will be associated with the engine operation.

Alternate fuels create additional problems for the engine and its crankcase oil. The sulfur bearing compounds (H_2S , etc) and the halide constituents in these fuels produce corrosive effects. The recommendations that follow will aid in reducing corrosive effects produced by gaseous fuel containing H_2S and various halides.

- Use an oil with higher TBN (10 TBN values as an example). Select a natural gas engine oil formulation by your oil company with higher TBN. Use the same performance requirements method for this oil as specified for the commercial oils mentioned previously.
- Scheduled Oil Sampling (S•O•S) must be used to evaluate the engine wear and oil condition. The oil change interval can be determined from the S•O•S results.
- Oils with higher TBN, (10 TBN or above), values also have higher ash levels, (one percent or more). Ash can cause deposit buildup which can lead to valve, combustion chamber and turbocharger damage over longer operating time. This ash, which is required for TBN to neutralize the acids, can also create deposits resulting in shorter engine service life.

- Oil with these specifications may require shortened oil change periods as determined by close monitoring of oil condition with Scheduled Oil Sampling (S•O•S) and infrared analysis. Oil sampling (S•O•S) with infrared analysis for gas engines is essential to determine satisfactory oil performance.
- Maintain jacket water temperatures and oil sump temperature at elevated values, above 88°C (190°F). These water temperature regulators are now standard on the gas engine. Higher temperatures will reduce the water vapor condensation and formation of acids in the engine.

Low engine loads can cause low jacket water temperatures. This can result in excessive moisture and nitration products accumulating in the crankcase. These materials react with the oil and form a sticky, gummy product that can plug the oil filters. When this happens, unfiltered oil can circulate through the engine and cause deposits on the pistons resulting in piston ring problems.

The oil filters must not cause more than a 105 kPa (15 psi) decrease in the oil pressure and the oil must not exceed the condemning limits. This will make sure that the oil remains acceptable.

NOTE: For information regarding lubrication oil condemning limits, refer to the S•O•S Oil Analysis topic.

Always consult with your Caterpillar dealer for the latest lubrication recommendations.

Multigrade Oils

The operation of gas engines using multigrade oils has been very limited. Results from tests have indicated poor oil performance as compared with single grade oils relative to deposits. Viscosity Index (VI) improvers are used in the multigrade oils. The VI improvers allow the oils to have multiviscosity, but the VI improvers also cause some performance loss.

At the present time, Caterpillar does not recommend the use of any multigrade oil in Caterpillar Gas Engines. There is some testing currently taking place with multigrade oils in order to better define the operational compatibility of the oils. Some oil companies offer a multigrade low ash oil, however, none of those oils have successfully completed Caterpillar's 7000 hour field test.

Actuators for gas engines equipped with electrical governors are not compatible with the polymers used for VI improvers in multigrade oil formulations. The engine crankcase oil lubricates these controls which do not provide the precise control of the engine with the multigrade oils.

Caterpillar NGE0 is warranted by Caterpillar against oil related failures. The performance of other engine oil is the responsibility of that particular oil supplier.

Synthetic Oils

The performance requirements for synthetic oils are the same as single grade oils. Synthetic oils require a successful 7000 hour field test as previously described for commercial oils. The use of synthetic base stock oils is very limited in Caterpillar gas engines and would be limited to cold engine starting applications which are generally not a requirement. Therefore, any anticipated use of these oils should be discussed with your Caterpillar dealer or your oil supplier.

Synthetic Base Stock Oils (SPC)

The performance characteristics of the oil depends on the base oil and the additives. The additives in the oil will vary according to the properties of the base oil and the environment in which the oil will perform its function.

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

The use of a synthetic base stock oil does NOT allow extension of the oil change interval simply because of the use of synthetic oil. Any drain period extension must be validated by S•O•S (oil analysis and test evaluation) to ensure no excessive component wear occurs in a particular application.

The synthetic oils have naturally low pour points which make them very good oils for low temperature applications. Caterpillar's recommendation for these arctic applications is synthetic base stock oils where startability at the cold conditions are a requirement.

Oils are changed because they become contaminated with dirt, soot, wear particles, etc, during normal use. The additives in the oil formulation are depleted as the oil functions in a compartment. The oil contamination and additive depletion occurs independently of the oil base stock type.

Synthetic lubricants may be superior to petroleum oils in specific areas. Many exhibit higher viscosity index (VI), better thermal and oxidation stability and sometimes lower volatility. Because synthetic lubricants are higher in cost than petroleum oils, they are used selectively where performance may exceed capabilities of conventional oils.

Re-refined Base Stock Oils

The Caterpillar requirement for oils is that any oil formulation meet the performance requirements as defined by the API classification and have the proper viscosity as defined by the SAE J300 Specification. The base stock oil used in the formulation can be either virgin or re-refined (or a combination) as long as the final oil formulation meets the requirements of both performance and viscosity.

The combination of the base stock oil and the additive must perform to the defined specifications. If the oil meets these requirements, then its' performance in an engine (or other compartment) should be acceptable. The military specifications and other engine manufacturers have also accepted the use of re-refined oil base stock with the same criteria.

Therefore, the use of oils with re-refined base stocks will depend on the company who has supplied the oil. Have they subjected the oil formulation to the qualifying tests, and passed the tests, as required to label the oils for the API performance and viscosity grade?

Various methods may be available for processing of the used oil. Caterpillar would normally recognize a re-refining process as one which subjects the used oil to the same refinery process (such as vacuum distillation and hydrotreating) as the virgin base stock was obtained from the original crude oil. The base stock obtained by this method should provide an acceptable base stock from which to formulate a proper oil. But the oil formulated must still pass the required performance and viscosity tests for the compartment and intended use.

Always consult with your Caterpillar dealer for the latest lubrication recommendations.

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.

Base stocks for blending the oil formulations do differ and variations can exist within a viscosity grade on low temperature characteristics. Therefore, a particular oil may allow lower starting temperatures than given in the following chart. Your oil supplier can provide additional information on oil properties.

Even though the ambient temperature may be low, operating engines can still be subjected to normal oil temperatures because of regulated temperature components. The higher viscosity oils will provide better protection to all components during the full operating cycle.

To determine if the oil in the crankcase will flow in cold weather, remove the oil dipstick before starting. If the oil will flow off, the oil is fluid enough to circulate properly.

Engine Oil Viscosity Protection		
Caterpillar NGEO Viscosity Grade	Ambient Temperature	
	Minimum	Maximum
SAE 30 ¹	0°C (32°F)	40°C (104°F)
SAE 40 ¹	5°C (41°F)	50°C (122°F)

¹ Caterpillar NGEO is available in these grades only. If other viscosity grades are selected, confirm with your oil supplier that the oil does meet the gas engine oil requirements. Multigrade oils are NOT recommended for use in Caterpillar Gas Engines. Refer to the Multigrade oil topic.

Anti-Seize Compound (ASC)

- Use 6V-4876 Molykote Paste Lubricant or equivalent. Typical use: head bolt threads and washers
- Use 5P-3931 Anti-Seize Compound (ASC) or equivalent. Typical use: exhaust manifold studs and nuts

Air Starting Motor Lubricator

A lubricator should be used with the air starting system (if equipped).

- Use nondetergent 10W engine oil for temperatures greater than 0°C (32°F)
- Use air tool oil for lower temperatures

Caterpillar Lubricating Grease

Caterpillar provides grease for a variety of applications and extreme temperature conditions. The descriptions of these products follow.

Contact your Caterpillar dealer for part numbers and available container sizes.

NOTE: One grease may be incompatible with another grease. When using commercial grease, make sure the grease is compatible with the grease used in your system, or make sure to purge the system. Contact your supplier regarding grease compatibility questions.

Multipurpose Grease**Multipurpose Lithium Complex Grease (MPG)**

MPG is a NLGI No.2 general purpose lithium complex grease for light to medium duty applications. MPG has good high temperature characteristics, with a minimum dropping point of 260°C (500°F). MPG contains unleaded extreme pressure additives and antiwear and corrosion inhibitors to provide extra protection in a variety of construction, agricultural and automotive applications.

MPG meets the requirements for extended service intervals of automotive chassis points and wheel bearings with disc brakes, particularly in passenger cars, vans, light trucks and taxi fleets. MPG meets NLGI GC-LB certification. MPG normal operating temperatures range from -28 to 149°C (-18 to 300°F). MPG is also available as a white lithium complex grease.

Multipurpose Lithium Complex Grease With Molybdenum (MPGM)

MPGM is a NLGI No.2 general purpose lithium complex grease for light to medium duty applications. MPGM is fortified with molybdenum disulfide and polymer for extra lubricity and protection. MPGM contains unleaded additives and antiwear and oxidation/corrosion inhibitors for protection and lubrication in many environments. MPGM is formulated with a high viscosity base fluid and contains polymer additive to help protect against water washout, enhance retention, and withstand heavy loads.

MPGM is recommended for heavily loaded pin joints, journal bearings, heavy duty automotive, agricultural, industrial, steel mill, mining, and off road equipment. MPGM meets NLGI GC-LB certification. MPGM normal operating temperatures range from -28 to 149°C (-18 to 300°F).

NOTE: If MPGM is not available, use a multipurpose type grease that contains three to five percent molybdenum.

Special Purpose Grease**Bearing Lubricant**

Bearing Lubricant is a NLGI No.2 lubricating grease with a polyurea thickener. Bearing Lubricant is recommended for high temperature antifriction bearings in applications such as electric motors, alternators, fan drives, starters, and generators. Bearing Lubricant has an effective operating range from -29 to 177°C (-20 to 350°F).

Water and Temperature Resistant Grease (WTR)

WTR grease is designed for applications where water washout, severe corrosion, or higher operating temperatures are a concern. WTR is an environmentally friendly grease that provides extreme pressure, antiwear, oxidation and corrosion protection without using barium, zinc, antimony, phosphorous, lead, or sulfur additives. WTR is very shear stable and resists breakdown in the presence of water.

WTR grease performs extremely well in marine, automotive, agricultural, and industrial applications, in construction equipment, and in washer equipment bearings. WTR meets NLGI GC-LB certification. WTR normal operating temperatures range from -40 to 204°C (-40 to 400°F).

Caterpillar Premium Grease

Desert Gold

Desert Gold is a heavy duty premium synthetic extreme pressure lubricating grease developed for the most harsh operating environments. Desert Gold is formulated with a high viscosity synthetic base fluid, polymers, and molybdenum disulfide. Desert Gold has a high viscosity index and a high dropping point. Desert Gold has excellent adhesion and stability characteristics, and provides longer protection than other greases. Desert Gold is an environmentally friendly grease which does not contain antimony, sulfur, barium, zinc, lead, or phosphorous.

Desert Gold will lubricate and protect equipment against heavy shock loads and corrosion in extremely hot, moist, or dusty conditions. Desert Gold operating temperatures range from -6 to 230°C (20 to 450°F). Desert Gold can operate at higher temperatures for short time periods and has additional extreme pressure protection for heavily loaded pin joints.

Arctic Platinum

Arctic Platinum is a super premium extreme pressure synthetic lubricating grease developed for lubrication in subzero to moderate operating temperatures. Arctic Platinum has a high drop point and contains five percent molybdenum disulfide for protection against extra heavy loads. Arctic Platinum provides excellent protection against corrosion and oxidation. Arctic Platinum is an environmentally friendly grease which does not contain antimony, sulfur, barium, zinc, or phosphorous.

Arctic Platinum is designed for lubrication of horizontal pivot and lower link bearings, steering cylinders, king pin/king bolt bearings, upper hitch link bearings, and ejector carrier roller bearings. Arctic Platinum is extra tacky for retention on excavator carbody bearings and has additional extreme pressure protection for heavily loaded pin joints. Arctic Platinum is available in NLGI grades No.000, No.00, No.0, No.1 and No.2 to assure pumpability in central lubrication systems in a variety of ambient temperatures, ranging from -60 to 18°C (-76 to 65°F).

Fuel Specifications

Gas System Information

Caterpillar gas engines will operate successfully on a broad range of gaseous fuels such as pipeline natural gas, gaseous (vaporized) propane, field gas and biogases such as digester and landfill gas. Each fuel has a set of conditions under which the engine will operate, and successful engine life can be expected only if these conditions are met.

Engine performance is to some extent a function of the quality of the fuel used. The engine configuration must be selected to produce the power required with the fuel available in the existing ambient conditions without encountering combustion problems.

Maintain the correct engine timing, air/fuel mixture and gas pressure for optimum engine service life and performance. The Maintenance Schedule intervals are based using fuels that meet the preferred fuels listed below.

NOTE: Engines with air/fuel ratios that have been adjusted so that all fuel and all oxygen is consumed are known to have STOICHIOMETRIC air/fuel ratios. This type of air/fuel ratio may be specified by local air resource boards in the USA for field compressor units operating on wellhead gas.

When changing from one type of fuel to another (or using dual fuel arrangements), contact your Caterpillar dealer for the proper adjustments required.

Use only gas as recommended in this section. For additional information, refer to the Engine Technical Manual for Internal Combustion Engine Fuel Gases (EDS 65.6), and Low Energy Gas Fuels (EDS 65.9).

Gaseous Fuel Types

It is imperative that gas being fed to the engine be free of impurities such as solids, water, hydrogen sulfide, etc. The gas must be supplied at or above the minimum acceptable pressure. Caterpillar recommends the use of properly sized fuel filters for best operation.

Each commercial fuel gas is a mixture of gases, some combustible and some inert. These gas mixtures have extreme variations in their composition.

Caterpillar gas engines have the ability to burn a wide variety of gaseous fuels. These fuels are divided into two general groups, **preferred** and **permissible**.

The **preferred fuels** provide maximum engine service life and performance. The fuel is dry natural gas. The **permissible fuels** are manufactured and dry natural mixtures such as propane and digester gas (sewer gas).

Preferred Fuels

- Dry Natural Gas

Dry natural gas, also known as commercial pipeline natural gas, is a mixture of methane, ethane, propane, and butane. The contents of propane and butane are less than five percent and one percent respectively, with no more than ten ppm of hydrogen sulfide (H₂S).

The reference to "dry" is made because the gas does not have liquid propane, liquid butane or other liquid hydrocarbons.

The heat content of dry natural gas may change from source to source. Caterpillar Gas engines are adjusted at the factory with a dry natural gas that has a low heat value in the range of 33.53 to 34.65 kJ/L (900 to 930 Btu/cu ft). Local fuel suppliers may refer to a high heat value (HHV) of fuel. Refer to Caterpillar Technical Manual (EDS 65.6) for Internal Combustion Engine Fuel Gases, for comparative information.

Permissible Fuels

NOTICE

Permissible fuels must be analyzed to determine the composition, density, heat value, air requirements for combustion, flammability limits and detonation characteristics (methane number) to establish the necessary timing, air/fuel setting, and gas pressure requirements for your engine.

• Propane

NOTICE

Propane or propane blends should not be used with turbocharged aftercooled high compression gas engines.

Propane, which is 95 percent pure with the remainder no heavier than butane and meets HD-5 specifications, can be used in all naturally aspirated (NA) gas engines, low compression gas engines, and some turbocharged aftercooled (TA) gas engines. Some derating may be required depending on aspiration, cooling system and fuel composition. Consult your Caterpillar dealer before operating your gas engine with this fuel.

• Propane-Air

Propane-air mixtures, which have the same kJ (Btu) contents as natural gas, are generally used as a standby fuel or as peaking fuels for natural gas systems. The same pressure regulating systems can be used for both propane-air and natural gas, but, the engine timing must be adjusted. Consult your Caterpillar dealer before operating your gas engine with this fuel.

• Field Gas

Other mixtures sometimes used are field gas and wellhead gas which have five percent or less butane and have less than one percent heavier hydrocarbons.

Field gas, also known as wellhead gas, is the gas available at the wellhead in a gas field.

The contents of wellhead gases change from location to location. As a result, the gas from one field may be acceptable for a Caterpillar engine while the gas from a different field may not. For this reason, a gas analysis is necessary to find if the fuel is usable.

Wellhead gases, which have a minimum of 90 percent methane and ethane, and have a remainder no heavier than butane can be used in low compression engines. However, many wellhead gases have some heavier hydrocarbons such as pentane, isobutane and other "gasolines". These heavier hydrocarbons cause detonation (knock) and other mixture problems, and they can have negative effects on an engine's performance and service life.

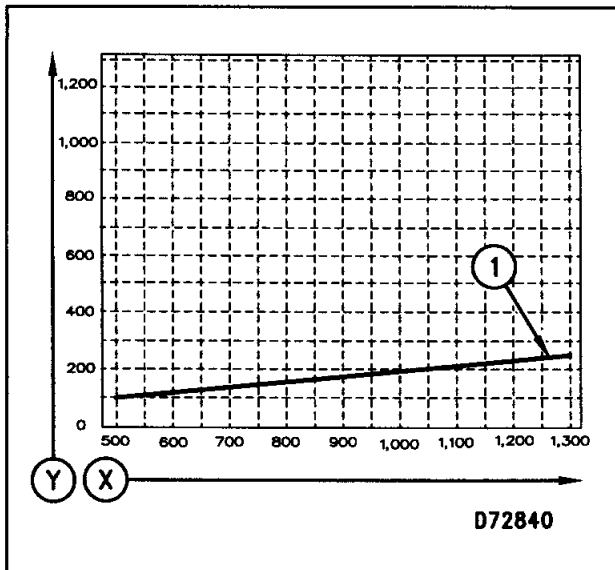
Consult your Caterpillar dealer before operating your gas engine with fuel having greater than one percent hydrocarbons heavier than butane.

• Sour Gas

Sour gas contains sulfur compounds such as hydrogen sulfide (H_2S). Gases that have no sulfur compounds are referred to as sweet gases.

The use of gases that have H_2S can damage the engine. Water vapor and sulfur oxides, which are products of combustion, chemically unite to make sulfurous and sulfuric acids. These acids destroy internal engine components such as oil coolers, valve guides, piston pin bushings, piston rings, cylinder liners and exhaust manifolds. History has shown that roller follower pins often are the first components affected by the acids.

H_2S can be found in low Btu gas as well as some well head fuels. H_2S must be controlled to reduce the attack on metals containing copper. For maximum engine service life, the total volume of sulfur the engine is required to burn must be limited. Engines will experience shortened service life when the H_2S level is above 10 micrograms/Btu of 905 LHV fuel. Refer to the following graph for H_2S limits.



Hydrogen sulfide limits.

Y = Hydrogen sulfide in ppm.

X = Low heat value in BTUs.

Line (1) is the limit for engines that are not equipped to operate with landfill gas.

When sour gas is used, steps should be taken to decrease the effects of sulfur compounds. Caterpillar's recommendations are:

- Keep the engine water outlet temperature between 88 and 93°C (190 and 200°F). A temperature increase of 8.3°C (15°F) across the engine is acceptable, but an increase of 5.6°C (10°F) is best. Lower jacket water temperatures permit water vapor and hydrogen sulfide to condense on the cylinder liners and make acids. Higher temperatures will decrease this condensation.

Generally, engines equipped with inlet controlled cooling systems will keep the coolant in the correct operating temperature range. Engines equipped with outlet controlled cooling systems may need added external controls to keep the coolant temperature within the acceptable range.

A set of thermostatically controlled shutters on the engine coolant radiator or heat exchanger is the most effective device for controlling the engine temperature. Shutters should be considered for installations designed to operate on sour gas. Some field gathering units which are subjected to overcooling because of cold ambient temperatures, wind, rain, etc., may require an enclosure or a building for adequate temperature control.

Caterpillar Gas engines use 88°C (190°F) water temperature regulators (thermostats) as standard equipment.

- Keep the engine oil temperature high enough to prevent condensation of water vapor in the oil. Generally, if the coolant temperature is kept above 88°C (190°F), vapor will not condense in the oil. (Assuming the oil temperature is higher than the coolant temperature).
- A minimum CD grade oil which has a sulfated ash content of less than one percent should be used in the engine. The CD oil has a higher Total Base Number (TBN), or alkalinity reserve, to neutralize the sulfurous and sulfuric acids better than the oils generally used in gas engines.

NOTE: See the Lubricant Specifications section of this manual or your Caterpillar dealer for the latest information regarding lubrication oils for gas engine applications.

- The oil should be regularly analyzed for its Total Acid Number (TAN or the acidity of the oil), nitration, oxidation, pentane insolubles and viscosity increase. The analysis will find early indications of engine problems. Also, it will make sure that the change intervals are not extended beyond the oil's ability to provide protection for the engine.

The amount of oil added to the engine also can affect the oil's condition. The oil condition should carefully be monitored. Refer to the Lubricant Specifications and to the S•O•S Oil Analysis topics.

- When possible, the engine should be started and brought to operating temperature on sweet gas, then switched to sour gas. To stop the engine, switch to sweet gas and run the engine for 10 minutes at full load. Then, remove the load and run the engine at half the rated speed for five minutes. Finally, slow the engine to low idle for 30 seconds and then stop the engine. This procedure will decrease condensation at lower engine temperatures during start-up and shut down.

NOTE: Consult your Caterpillar dealer for technical information on fuels for gas engines.

Gaseous Fuel Filters

Gas lines contain various amounts of scale and rust which can cause fuel system [carburetor (or mixing body) and regulator] malfunction. Fuel directly from a gas well may have abrasives or liquids entrained in the gas along with other contaminants such as sulfur which can shorten engine life.

Filter groups are available from Caterpillar for gas engines. Filter systems are required to achieve maximum service life in these applications.

The filter groups are for engine applications using dry, high inlet pressure natural gas. Consult your Caterpillar dealer for the proper filter group for your engine.

Coolant Specifications

General Coolant Information

Many engine failures are related to the cooling system. Problems such as overheating, water pump leaking, plugged radiators, and cylinder liner pitting can 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.

Coolant is normally composed of three elements:

- Water
- Additives
- Glycol

Water

NOTICE

Never use water alone without Supplemental Coolant Additives (SCA) or without inhibited coolant. Water alone is corrosive at engine operating temperatures. Water alone does not provide adequate freeze or boil protection.

Distilled or deionized water is recommended for use in engine 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.

Caterpillar Water Quality Limits	
Water Property (ASTM Test)	mg/L (grains/US gal)
Chloride (D512b or D512d or D4327)	40 (2.4) Maximum
Sulfate (D516b or D516d)	100 (5.9) Maximum
Total Hardness (D1126)	170 (10) Maximum
Total Solids (D1888a)	340 (20) Maximum
pH (D1293)	5.5 to 9.0

Contact your Caterpillar dealer, your local water department, agricultural agent, or an independent laboratory for water analysis.

Additives

Additives must be added to all coolant mixtures. Additives help prevent the formation of rust, scale, and mineral deposits. Additives protect metals from corrosion, prevent liner cavitation, and contain antifoaming agents. Additives deplete during engine operation and need to be replenished. This can be done by treating conventional coolants with Supplemental Coolant Additives (SCA) or by treating Extended Life Coolant (ELC) with Extender.

Additives must be added at the proper concentration. Overconcentration of additives can cause the inhibitors to drop out of the solution and form a gel in the radiator. An overconcentration of additives produces excessive deposits on water pump seals that can cause the water pump seal to leak. Underconcentration of additives can produce pitting, cavitation, erosion, rust, scale, and foaming.

Glycol

Glycol in the coolant provides boil and freeze protection, prevents water pump cavitation, and reduces cylinder liner pitting. For optimum performance, Caterpillar recommends a 50/50 glycol/water coolant mixture.

Ethylene glycol is used in most conventional heavy duty (HD) coolant/antifreezes. However, propylene glycol may also be used. Both ethylene glycol and propylene glycol have similar fluid properties in a 50/50 glycol/water mixture. Both ethylene glycol and propylene glycol provide similar heat transfer, freeze protection, corrosion control, and seal compatibility. The following charts define the temperature protection provided by the two types of glycol.

Ethylene Glycol		
Concentration % Glycol/% Water	Protection Against	
	Freezing	Boiling
50/50	-36°C (-33°F)	106°C (223°F)
60/40	-51°C (-60°F)	108°C (226°F)

NOTICE

Do not use propylene glycol in concentrations that exceed 50 percent glycol because of propylene glycol's reduced heat transfer capability. Use ethylene glycol in conditions that require additional boil or freeze protection.

Propylene Glycol		
Concentration % Glycol/% Water	Protection Against	
	Freezing	Boiling
50/50	-37°C (-35°F)	106°C (222°F)

Caterpillar recommends the use of a refractometer for checking the glycol concentration. Use the 1U-7298 Coolant Tester (°C) or use the 1U-7297 Coolant Tester (°F). The testers give immediate, accurate readings and can be used with ethylene or propylene glycol.

Coolant Recommendations

NOTICE

DO NOT use a commercial coolant/antifreeze that ONLY meets the ASTM D3306 or D4656 specification. This type of coolant/antifreeze is made for light duty automotive applications.

The primary types of coolant used in Caterpillar gas engines are:

- Preferred – Caterpillar Extended Life Coolant (ELC), or...
 - a commercial ELC meeting the Caterpillar EC-1 specification
- Acceptable – Caterpillar Antifreeze, or...
 - a commercial heavy duty (HD) coolant/antifreeze meeting ASTM D5345 or D4985 specifications, or ...
 - a mixture of Caterpillar SCA and distilled or deionized water, or ...
 - a mixture of commercial SCA and distilled or deionized water

Caterpillar ELC will provide the best coolant service life, corrosion protection, water pump seal service life, and radiator service life.

Caterpillar recommends a 50/50 glycol/water mixture for optimum ELC performance and for optimum conventional HD coolant/antifreeze performance.

NOTE: Caterpillar Antifreeze does not require SCA treatment at initial fill. Commercial HD coolant/antifreezes meeting the ASTM D5345 or D4985 specification DO REQUIRE SCA treatment at initial fill.

In those stationary applications that do not require boil or freeze protection, a mixture of SCA and water is acceptable. Caterpillar recommends a six to eight percent concentration of SCA in those cooling systems. Distilled or deionized water is preferred. Water which has the properties listed in the Caterpillar Water Quality Limits chart may be used.

Coolant Service Life	
Coolant Type	Service Life
Caterpillar ELC	Four Years
Caterpillar Antifreeze	Two Years
Commercial heavy duty coolant/antifreeze meeting ASTM D5345	Two Years
Commercial heavy duty coolant/antifreeze meeting ASTM D4985	One Year
Caterpillar SCA and Water	Two Years
Commercial SCA and Water	One Year

Caterpillar Extended Life Coolant (ELC)

Caterpillar provides Extended Life Coolant (ELC) for use in natural gas engines, heavy duty diesel engines, and automotive engines. The Caterpillar ELC anticorrosion package is totally different from conventional coolants. Caterpillar ELC is an ethylene glycol based coolant which contains organic acid corrosion inhibitors and antifoaming agents. Caterpillar ELC has fewer nitrites than other coolants. Caterpillar ELC has been formulated with the correct levels of additives to provide superior corrosion protection for all metals in engine cooling systems.

Caterpillar ELC extends coolant service life to Four Years. Caterpillar ELC does not require frequent additions of SCA. A "one time only" coolant Extender is the only maintenance addition required. The Extender should be added to the cooling system at Two Years.

Caterpillar ELC is available Premixed with distilled water in a 50/50 concentration. The Premixed ELC provides freeze protection to -36°C (-33°F). The Premixed ELC is recommended for initial fill and for topping off the cooling system. ELC Concentrate is available to lower the freezing point to -51°C (-60°F) for Arctic conditions. ELC Concentrate should be used to adjust the coolant freeze point as required where Caterpillar ELC Premixed freeze protection is not acceptable.

Contact your Caterpillar dealer for part numbers and available container sizes.

NOTE: The Caterpillar EC-1 Specification is an industry standard developed by Caterpillar. The EC-1 specification defines all of the performance requirements that an engine coolant must meet in order to be sold as an extended life coolant for Caterpillar engines. Caterpillar ELC can be used in most OEM natural gas, diesel, and gasoline engines. Caterpillar ELC meets the industry performance requirements of ASTM D4985 and D5345 for heavy duty low silicate coolant/antifreezes. Caterpillar ELC also meets the industry performance requirements of ASTM D3306 and D4656 for automotive applications.

Caterpillar ELC Cooling System Maintenance

Caterpillar ELC Extender

Caterpillar ELC Extender is added to the cooling system halfway through the ELC service life. Use the chart below to determine the proper amount of Caterpillar Extender required.

Contact your Caterpillar dealer for part numbers and available container sizes.

Caterpillar ELC Extender Additions By Cooling System Capacity	
Cooling System Capacity	Extender Addition
22 to 30 L (6 to 8 US gal)	0.57 L (20 fl oz)
31 to 38 L (9 to 10 US gal)	0.71 L (24 fl oz)
39 to 49 L (11 to 13 US gal)	0.95 L (32 fl oz)
50 to 64 L (14 to 17 US gal)	1.18 L (40 fl oz)
65 to 83 L (18 to 22 US gal)	1.60 L (54 fl oz)
84 to 114 L (23 to 30 US gal)	2.15 L (72 fl oz)
115 to 163 L (31 to 43 US gal)	3.00 L (100 fl oz)
164 to 242 L (44 to 64 US gal)	4.40 L (148 fl oz)

ELC Cooling System Cleaning

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

ELC 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 the coolant level stabilizes. Add ELC mixture as necessary to fill the system to the proper level.

Changing to Caterpillar ELC

To switch the cooling system from conventional HD coolant/antifreeze to Caterpillar ELC, perform the following steps:

1. Drain the cooling system.
2. Flush the system with clean water to remove any debris.
3. Clean the cooling system with Caterpillar Cooling System Cleaner. Follow the instructions on the label.
4. Flush the cooling system with clean water. It is very important to remove all of the cleaning agent.

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 the cooling system. Flush the cooling system with clean water.
7. Repeat steps 5 and 6. Continue to flush the cooling system with clean water until the draining water is also clean.
8. Fill the cooling system with Caterpillar ELC.
9. Attach a label to the cooling system to indicate the system has been switched over to Caterpillar ELC.

ELC Cooling System Contamination

NOTICE

Mixing ELC with other products reduces the effectiveness of the ELC and shortens the ELC service life. Use only Caterpillar products or commercial products that have passed the Caterpillar EC-1 specification for premixed or concentrate coolants. Use only Caterpillar Extender with Caterpillar ELC. Failure to follow these recommendations can result in shortened cooling system component life.

ELC cooling systems can withstand contamination of up to ten percent of conventional HD coolant/antifreeze. If the contamination exceeds ten percent of the total system capacity, perform either one of the following two procedures:

- Drain the cooling system. Flush the system with clean water. Refill the system with ELC.
- Maintain the cooling system as if the system is filled with conventional HD coolant/antifreeze.

Commercial ELC

If Caterpillar extended life coolant is not used, select a commercial extended life coolant that meets the Caterpillar EC-1 specification. Do not use a product that is labeled as an extended life coolant but does not meet the Caterpillar EC-1 specification. Follow the coolant maintenance guidelines of the commercial ELC supplier. In all cases, use distilled or deionized water or use water that has the properties listed in the Caterpillar Water Quality Limits chart.

Caterpillar Antifreeze

Caterpillar recommends the use of Caterpillar Antifreeze in conventional HD cooling systems. Caterpillar Antifreeze is an alkaline type, single phase, ethylene glycol based antifreeze/coolant. Caterpillar Antifreeze contains inorganic corrosion inhibitors and antifoaming agents.

Contact your Caterpillar dealer for part numbers and available container sizes.

Caterpillar Antifreeze is available premixed with distilled water in a 50/50 concentration. If antifreeze concentrate is used, Caterpillar recommends mixing the concentrate with distilled or deionized water. If distilled or deionized water is not available, use water that has the properties listed in the Caterpillar Water Quality Limits chart.

Caterpillar Supplemental Coolant Additive (SCA)

Caterpillar Supplemental Coolant Additive (SCA) is effective in preventing corrosion on all metals. Caterpillar SCA also prevents the formation of mineral deposits, prevents liner cavitation, and eliminates coolant foaming.

Caterpillar Antifreeze is formulated with the correct level of Caterpillar SCA. Additional SCA is NOT needed when the cooling system is initially filled with Antifreeze.

Contact your Caterpillar dealer for part numbers and available container sizes.

Commercial Heavy Duty (HD) Coolant/Antifreeze and SCA

If Caterpillar Antifreeze is not used, select a low silicate commercial HD coolant/antifreeze that meets ASTM D5345 or D4985 specifications.

When a commercial HD coolant/antifreeze is used, the cooling system should be treated with three to six percent Caterpillar SCA by volume. Refer to the Caterpillar SCA Requirements for Heavy Duty Coolant/Antifreeze chart. If Caterpillar SCA is not used, select a commercial SCA. The commercial SCA must provide a minimum of 1200 mg/L or 1200 ppm (70 grains/US gal) nitrites in the final coolant mixture. Follow the coolant maintenance guidelines of the commercial SCA supplier.

HD coolant/antifreezes that meet ASTM D5345 or D4985 specifications **DO require SCA treatment at initial fill, and on a maintenance basis.**

When mixing concentrated coolants, use distilled or deionized water or use water that has the properties listed in the Caterpillar Water Quality Limits chart.

Heavy Duty Coolant/Antifreeze Cooling System Maintenance

NOTICE

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

Check the coolant/antifreeze solution (glycol content) frequently to ensure adequate boil and freeze protection. Caterpillar recommends the use of a refractometer for checking the glycol concentration. Use the 1U-7298 Coolant Tester (°C) or use the 1U-7297 Coolant Tester (°F). The testers give immediate, accurate readings and can be used with ethylene or propylene glycol.

Caterpillar gas engine cooling systems should have the SCA concentration tested every 750 hours. Your Caterpillar dealer has test kits to evaluate SCA concentration. Test the SCA concentration or submit a coolant sample to your Caterpillar dealer every 750 hours (refer to the S•O•S Coolant Analysis topic).

SCA additions are based on the test results or based on the coolant analysis results. Liquid SCA or a SCA maintenance element (if equipped) may be needed every 750 service hours.

The following chart lists the amount of Caterpillar SCA needed at initial fill to treat commercial HD coolant/antifreeze.

The chart also lists SCA additions for liquid SCA and for SCA maintenance elements at 750 hours. The additions apply to both Caterpillar Antifreeze and commercial HD coolant/antifreezes.

Caterpillar SCA Requirements For Heavy Duty Coolant/Antifreeze			
Cooling System Capacity L (US gal)	SCA At Initial Fill ¹ ASTM D5345 ASTM D4985 HD Coolant L (fl oz)	SCA At 750 Hours For All HD Type Coolants ² L (fl oz)	SCA Element At 750 Hours For All HD Type Coolants ³ Part No. (Qty)
22 to 30 (6 to 8)	0.95 (32)	0.24 (8)	111-2370 (1)
31 to 38 (9 to 10)	1.18 (40)	0.36 (12)	111-2369 (1)
39 to 49 (11 to 13)	1.42 (48)	0.36 (12)	111-2369 (1)
50 to 64 (14 to 17)	1.90 (64)	0.47 (16)	9N-3368 (1)
65 to 83 (18 to 22)	2.37 (80)	0.60 (20)	111-2371 (1)
84 to 114 (23 to 30)	3.32 (112)	0.95 (32)	9N-3718 (1)
115 to 163 (31 to 43)	4.75 (160)	1.18 (40)	111-2371 (2)
164 to 242 (44 to 64)	7.60 (256)	1.90 (64)	9N-3718 (2)

¹ SCA is NOT required for Caterpillar Antifreeze at initial fill.

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

³ Do not use both the SCA maintenance element and SCA liquid at the same time.

NOTE: Due to specific engine applications, maintenance practices may need periodic evaluation in order to properly maintain the engine's cooling system.

Heavy Duty Coolant/Antifreeze Cooling System Cleaning

Caterpillar Cooling System Cleaners are designed to clean the cooling system of harmful scale and corrosion. Caterpillar cleaners dissolve mineral scale, corrosion products, light oil contamination, and sludge.

Clean the cooling system:

- after draining used coolant and before filling the cooling system with new coolant
- whenever the coolant is dirty or foaming

SCA and Water Cooling Systems

NOTE: All Caterpillar engines equipped with air-to-air aftercooling (ATAAC) require a MINIMUM of 30 percent glycol to prevent water pump cavitation.

In stationary engine cooling systems that use Supplemental Coolant Additive (SCA) and water alone, Caterpillar recommends the use of Caterpillar SCA to prevent corrosion, mineral deposition, liner cavitation, and coolant foaming. If Caterpillar SCA is not used, select a commercial SCA. The commercial SCA must provide a minimum of 2400 mg/L or 2400 ppm (140 grains/US gal) of nitrites in the final coolant mixture.

Water quality is a very important factor in this type of cooling system. Caterpillar recommends the use of distilled or deionized water. If distilled or deionized water is not available, use water that has the properties listed in the Caterpillar Water Quality Limits chart.

A cooling system using SCA and water only needs more SCA than a cooling system using a glycol/water mixture. The SCA concentration in a SCA and water cooling system should be six to eight percent by volume. Refer to the following chart for the amount of Caterpillar SCA required for various cooling system capacities.

Caterpillar SCA Requirements For SCA And Water Cooling Systems		
Cooling System Capacity L (US gal)	Caterpillar SCA At Initial Fill L (fl oz)	Caterpillar SCA At 250 Hours L (fl oz)
22 to 30 (6 to 8)	1.75 (64)	0.44 (15)
31 to 38 (9 to 10)	2.30 (80)	0.57 (20)
39 to 49 (11 to 13)	3.00 (100)	0.75 (25)
50 to 64 (14 to 17)	3.90 (128)	0.95 (32)
65 to 83 (18 to 22)	5.00 (168)	1.25 (42)
84 to 110 (23 to 29)	6.60 (224)	1.65 (56)
111 to 145 (30 to 38)	8.75 (296)	2.19 (74)
146 to 190 (39 to 50)	11.50 (392)	2.88 (98)
191 to 250 (51 to 66)	15.00 (512)	3.75 (128)

SCA and Water Cooling System Maintenance

Except for the amount of SCA additions, maintenance of a SCA and water system is the same as maintenance for a system using a HD coolant/antifreeze. See the Caterpillar SCA Requirements for SCA and Water Cooling Systems chart for the amount of SCA required.

NOTE: The 8T-5296 Conditioner Test Kit can be used to evaluate the SCA concentration in water and SCA cooling systems, with the following modifications to 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 underconcentration of SCA. More drops indicate overconcentration of SCA. Adjust SCA the concentration as needed.

S•O•S Oil Analysis

Caterpillar's S•O•S Oil Analysis was developed to help Caterpillar customers realize the highest possible value from their equipment by minimizing repair costs and maximizing availability.

Caterpillar's S•O•S Oil Analysis is the best indicator for determining what is happening inside your engine. S•O•S Oil Analysis is a diagnostic tool used to determine oil performance and condition of oil in an engine's crankcase and component wear rates.

Caterpillar gas engines, like Caterpillar diesel engines, have wear metals. Because gas engines run at lower stress levels than comparable diesel engines, condensation, oil deterioration or abrasive wear is usually *in the form of corrosion*.

To be effective as an indicator, S•O•S Oil Analysis must be performed on a continuing basis. Intermittent sampling will not allow wear rate trend lines to be established.

The S•O•S Oil Analysis program is coupled with a wide range of repair options so that when a problem is identified, an appropriate matched repair plan is available. This offers the customer a more complete service to minimize repair costs and schedule downtime. The S•O•S Oil Analysis program can also measure the effectiveness of the customer's maintenance program.

An oil sampling program is the key element in a successful maintenance management program. The analysis result is the management feedback needed to *ensure the engine is operating as predicted and that the proper maintenance is being performed*.

Caterpillar Natural Gas Engines are based on successful diesel engine models. The gas engines run at approximately one-half the peak cylinder pressure of the corresponding diesel engines and are stressed much less accordingly. Because the engines run at this lower stress level, the wear mechanism is usually corrosive because of condensation or oil deterioration or abrasive wear due to filter plugging.

NOTICE

Even though the type of wear is different than the diesel engine, it does not minimize the importance of oil analysis. Oil analysis of the gas engine is essential for determining satisfactory oil performance.

In diesel engines, Caterpillar requires a minimum level of oil performance as established by the American Petroleum Institute (API) duty classifications. These API duty classifications require that the oil be tested in an engine and other tests verify a minimum performance level.

With natural gas engine oil (NGEO), there are no such industry standards for lubricating oil performance. The only method the customer has to determine if an oil is protecting the engine is to analyze the oil and compare the analysis to the established limits.

Obtain an S•O•S oil sample and analysis at the Every 750 Hours of Monthly maintenance interval.

S•O•S Interval Chart	
Compartment	Interval
Engine Crankcase	Every 750 Hours or Monthly

Obtain S•O•S 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. If the engine is operating with an oil sump temperature of less than 74°C (165°F), the oil sample may show a low nitration number and an elevated oxidation number.

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

S•O•S Oil Analysis is composed of three basic tests.

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

The series of tests were 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, which is compared to established Caterpillar norms to determine acceptability. By analyzing the used oils, problems may be identified early, before extensive component failure occurs. This reduces repair cost and down-time.

Wear Analysis uses spectrophotometry to monitor abnormal component wear rates by identifying and measuring concentrations, in parts per million, of wear elements present in the used 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. Through monitoring the used oil, normal component wear trends are determined. Many failures can be identified when wear trends and/or contaminants significantly exceed past trends.

Detectable failures are those caused by component wear and gradual contamination from dirt, fuel, water or antifreeze. Wear analysis is not able to predict failures due to component fatigue, sudden loss of lubrication, or sudden ingestion of a large amount of dirt or contaminants since failures of this nature occur rapidly.

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

Oil Condition Analysis 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 used oil. Oil condition analysis also monitors additive depletion and detects ethylene glycol and butyl cellosolve contamination. Oil condition analysis can assist in customizing (reducing, maintaining or extending) oil change intervals for particular conditions and applications.

Oxidation and nitration are critical because they can cause the oil to thicken. They can also cause the formation of lacquer and maroon colored deposits due to nitration. Both oxidation and nitration generate acids which cause corrosive wear and accelerate oil degradation.

Infrared (IR) analysis can also assist in customizing (reducing, maintaining or extending) oil change intervals for particular conditions and applications. IR analysis should always be accompanied by wear element analysis and chemical and physical tests to assure accurate diagnosis. Oil analysis programs must include IR analysis in order to modify oil change intervals.

Lubrication Oil Condemning Limits

The lubricating oil condemning limits were developed from engine operating experience and used oil analysis. The limits provide guidelines in determining the oil's useful life in the engine.

The oil analysis results are used as a basis for determining the oil change interval and air/fuel ratio adjustments. This provides the customer with the ultimate time between oil changes without the risk of engine damage, and aids in permitting optimum fuel consumption, oil performance, and NO_x emissions.

Scheduled Oil Sampling	
Parameter	Limit
Oxidation	100% as defined by S•O•S analysis
Nitration	100% as defined by S•O•S analysis
Water	0.5% Maximum
Glycol	0%
Wear Metals	Trend Analysis ¹
Alternate Oil Analysis (additional test procedures for more data)	
Viscosity @ 100°C (ASTM D445)	3 cSt increase from new oil
Total Acid Number (TAN) (ASTM D664)	3.0 max or 2.0 over new oil
Total Base Number (TBN) (ASTM D664)	1.5 minimum
Total Base Number (TBN) (ASTM D2896)	50% of new oil TBN
pH (ASTM D667)	4.0 minimum

¹ Wear metal analysis from three normal oil change intervals can establish a base trend.

Oil Failure

If analysis of the used oil (at the recommended change interval) exceeds the condemning limits, then some modifications suggested by Caterpillar to the scheduled sampling interval and/or other action can be taken.

The oil filters must not cause more than a 105 kPa (15 psi) decrease in the oil pressure and the oil must not exceed the condemning limits. This will ensure that the oil remains acceptable.

Symptoms of oil failure may be stuck piston rings, heavy piston deposits, sludge oil, plugged oil filters, rapid ring and liner wear, and high copper concentrations in oil analysis.

Refer to PEDP1129, Listen To Your Oil, for information and benefits of S•O•S Oil Analysis.

Establish an oil analysis program to assure oil change periods are not extended beyond safe limits and that other problems are not overlooked. Consult your Caterpillar dealer for complete information and assistance in establishing an S•O•S analysis program for your engine(s).

Air/Fuel Ratio

Air/fuel ratios between 10:1 and 11:1 permits the optimum fuel consumption at rated power, however it promotes rapid nitration of the oil. This is the normal air/fuel ratio range for most Caterpillar Gas Engines. Also, in this range, nitrous oxide (NO_x) as measured in the exhaust stream is at its highest level. This range may cause the oil to degrade at an unacceptable rate.

If nitration is determined to be the principal reason for oil degradation, it may be necessary to adjust the air/fuel ratio either higher or lower to minimize the nitration rate.

If the air/fuel ratio is changed, it must be done with care because it may have a negative effect on the power of the engine or result in excessive exhaust temperature which could affect the service life of the engine.

Engine Data Sheet 195.0, of the Caterpillar Technical Manual, shows the effects of different air/fuel ratio settings on various engine functions. Refer to the Initial Settings section for additional information regarding air/fuel ratios.

Fuel consumption, exhaust temperature, exhaust emissions, and engine power vary with air/fuel ratio settings. The air/fuel ratio which produces the lowest fuel consumption generally produces the maximum NO_x . This level of NO_x can cause rapid deterioration of lubrication oil through nitration.

At air/fuel ratios within the nitration range, engine jacket water temperature becomes very important. Cooler temperature allows moisture to condense within the crankcase creating acids which result in corrosive wear to piston rings and liners.

Jacket Water Temperature

Water is a natural result of the internal combustion process. To reduce the amount of water that condenses in the crankcase, the jacket water temperature should be maintained between 93°C to 99°C (200°F to 210°F). By maintaining this temperature range, the water will be kept in a vaporous state and allowed to discharge through the crankcase breather. Solid water cooled (expansion tank and heat exchanger type) engines have high jacket water temperatures and usually deteriorate the oil at a slower rate.

Your Caterpillar dealer is equipped to perform the necessary oil analysis to make this determination. Contact your Caterpillar dealer regarding the latest information regarding your crankcase oil.

NOTE: Refer to EDS 56.0 in the Engine Technical Manual for information on Water Treatment Recommendations for Ebullient and Solid Water Cooled Engine.

Estimating Oil Consumption

Oil consumption, along with fuel consumption and maintenance information, can be used to estimate total operating cost for your Caterpillar Gas Engine. Oil consumption data may also be used to estimate the quantity of makeup oil required to accommodate your maintenance intervals.

Oil consumption, like fuel consumption, is somewhat proportional to the percent load at which the engine is operating. The higher the percent load, the higher the amount of oil consumed per hour.

The oil consumption rate is called BSOC (brake specific oil consumption) and the unit of measure is grams per brake kilowatt hour (pounds per brake horsepower hour). The BSOC varies depending on model, aspiration, and the percent load.

The typical midlife BSOC for this engine operating at 100 percent load factor and maintained according to the Maintenance Schedule is higher for engines equipped with two ring pistons versus three ring pistons.

G3400 BSOC ¹		
Engine Model	g/bkW-h	lb/bhp-h
NA & TA (2 ring piston)	0.730	0.0012
TA (3 ring piston)	0.487	0.0008
TA (3 ring piston, gallery cooled)	0.304	0.0005

¹ Typical midlife oil consumption.

Oil Consumption as an Overhaul Indicator

When an engine's oil consumption has risen to three times the initial (new) consumption due to normal wear, then the engine should be scheduled for overhaul. We would expect to see a corresponding increase in blowby and may also see slight increase in fuel consumption.

Contact your Caterpillar dealer for assistance in determining the typical oil consumption for your engine.

S•O•S Coolant Analysis

Coolant is essential to control engine operating temperatures and make components last longer. Poorly maintained coolant can actually shorten component life by causing a chain reaction of heat problems. Excessive heat can cause:

- Hot spots that crack steel, notably in cylinder heads
- Bubble pockets that form on cylinder surfaces and result in liner pitting
- Oil to degrade, leading to component damage
- Lacquer and shellac buildup on precision hydraulic parts
- Oil additives to break down and transmission clutches to slip

S•O•S Coolant Analysis is the best way to monitor the condition of your coolant and your cooling system. The two level program, based on samples you submit, shows the condition of coolant and the cooling system.

Level I: Basic Coolant Maintenance Check

Checks for correct chemical balance for proper heat and corrosion control. Tests for:

- glycol
- SCA concentrations
- pH
- conductivity

S•O•S Coolant Analysis reports results and makes recommendations, usually within 24 hours. Consult with your Caterpillar dealer for more information.

The concentration of SCA should be checked regularly for overconcentration or underconcentration. This should be done with the 4C-9301 Test Kit or the 8T-5296 Test Kit or S•O•S Coolant Analysis (Level I) at the Every 250 Hours interval.

Further coolant analysis is recommended at twice a year or after every 1000 service hours.

For example, suppose considerable deposits are found in the water jacket areas on the external cooling system, yet coolant additive concentrations were carefully maintained. Chances are that the coolant water had minerals which deposited on the engine over time.

One way to verify the water condition, or to be sure of new water at fill time, is to have a coolant analysis conducted. Full water analysis can sometimes be obtained locally by contacting your local water utility company or an agricultural agent. Private laboratories are also available.

Caterpillar recommends S•O•S Level II Coolant Analysis.

Level II: Comprehensive Cooling System Analysis

Completely analyzes coolant and coolant effects on the cooling system. Level II Coolant Analysis provides:

- full Level I analysis
- visual properties inspection
- metal corrosion and contaminant identification
- identification of built up impurities that point to corrosion and scaling problems BEFORE they lead to costly repairs

Level II Coolant Analysis provides a simple, clear report of results, and makes recommendations for the lowest cost corrective options.

For more information on coolant analysis and how it can help you manage your equipment, see your Caterpillar dealer.

Maintenance Terminology

Adjust – to conform and correspond to specifications.

Check – to observe for satisfactory conditions, accuracy, safety or performance.

Exchange – to trade a worn or failing component for a remanufactured or rebuilt component.

Inspect – to examine closely, in critical appraisal, while testing or evaluating components or systems.

Inspect/Rebuild or Exchange – to examine closely; then making the decision on repair option (i.e. Rebuild or Exchange).

Lubricate – to apply a lubricant (oil, grease, etc) as specified for reducing friction, heat and wear between solid surfaces.

Obtain/Measure/Record – Use the appropriate equipment to measure the items listed. Keep records on these items to monitor engine condition.

Protective Devices – indicators such as gauges, lights, emergency shutoffs, etc, that alert an operator that a potential problem may exist. Failure to respond to these indicators in a timely manner could result in serious engine damage.

Rebuild – to repair a worn or failing component with new parts, components and/or remanufactured components.

Replace – to install something new, remanufactured or rebuilt in place of an existing worn or failing component.

Service Hours (Electrical) – records the time (clock hours) the engine is actually running but does not reflect variations in speed, load, etc.

Maintenance Intervals

Because engines may be equipped with various optional components, the Maintenance Schedule may recommend maintenance for items not installed on your engine. Simply disregard reference to any unrelated items. If unsure of any item, consult your Caterpillar dealer.

The Maintenance Schedule gives maintenance intervals for both intermittent and continuous engine operation. Intermittent intervals are given in hours. Continuous intervals are given in day, week, month and year. Use the intervals that apply to your operation. Refer to the Top End and Overhaul section to determine the Top End and Overhaul intervals for your engine.

Hours are expressed in clock hours, not service meter units (unless the service meter is a clock hour device). For some older models, intervals are in SMUs (see the headings on each chart). Hours of operation include only time that the engine is running. An electric clock device should be connected so it is OFF when the engine is not running.

Service Meter Multiplier Charts

The service meter indicates the total number of service meter units the engine has operated. Because service meters are mechanically driven, the reading for any one clock hour time increment is dependent upon engine rpm.

Service meter units can reflect clock hours by determining engine rpm and using a multiplier to calculate clock hours.

When using the service meter to determine the actual clock hours of operation, use the following multiplier chart.

SMU Multipliers For Engines Rated From 1000 To 1400 rpm	
Operating Speed	Multiplier
1000	0.833
1200	1.000
1400	1.167
SMU Multipliers For Engines Rated From 1500 To 1800 rpm	
Operating Speed	Multiplier
1500	0.833
1600	0.889
1800	1.000

Example: A G3408 Engine rated at 1400 rpm is running at 1000 rpm.

One service meter unit can be compared to actual clock hours by finding the correct multiplier (0.833) and multiplying the SMU reading.

$1 \text{ SMU} \times 0.833 \text{ (multiplier)} = .833 \text{ clock hours.}$

This means that one service meter unit represents .833 hours of engine operating time with the engine running at 1000 rpm.

Fuel Consumption Multipliers

Fuel consumption is in cubic meters (cubic feet). To convert cubic feet to other units, multiply by the factors below.

Multiply cubic feet by 0.283 to obtain cubic meters.

Interval Categories

Engine components can generally be grouped into speed sensitive and load sensitive categories. Therefore, the maintenance interval for each item listed in the Maintenance Schedule is primarily based on the item and its relationship to either engine speed or load.

Speed sensitive items such as water pumps, air compressors, etc, are not primarily affected by the load on your engine during operation. The load on an engine will not significantly accelerate the repair or replacement cycle for speed sensitive items.

Therefore, the maintenance intervals established for speed sensitive items are based on service hours.

Load sensitive items such as piston rings, cylinder liners, etc, are affected by the load on your engine during operation. Generally speaking, the lower the load, the longer the engine life and conversely, the higher the load, the shorter the engine life. A heavy load on an engine will accelerate the repair or replacement cycle for load sensitive items.

Load sensitive items are normally internal engine components and the amount of fuel consumed is directly related to the load on your engine.

Therefore, the maintenance interval for load sensitive items includes fuel consumption, since the amount of fuel consumed is directly related to the load on your engine.

Since the amount of fuel consumed is a better indicator of performing maintenance than service hours, Caterpillar recommends performing maintenance on these items at the specified maintenance interval based on the quantity of fuel consumed.

However, we also recognize that fuel consumption is difficult to document in some applications. An estimated fuel consumption figure can be used to determine some intervals.

Maintenance Options

Rebuild with New Parts – Genuine Caterpillar parts are constantly tested and modified to incorporate the latest design advancements. Your Caterpillar dealer can rebuild or provide the parts needed for overhauling your engine. Your benefit, long lasting replacement parts at competitive prices.

Repair Kits – These useful kits can be obtained from your Caterpillar dealer. These kits include all the necessary parts and instructions to repair the components, in either the owner's maintenance shop or at a Caterpillar servicing dealer's facility. Repair kits simplify parts ordering, help speed repairs and reduce parts cost.

Remanufactured – This process uses manufacturing techniques and procedures to restore the components to like-new performance capability. This process always involves an end product which conforms to the manufacturer's "original" functional specifications. Remanufactured parts may not be available in your area. Contact your Caterpillar dealer for information.

New Components – Replace worn or failing components with new components.

Exchange – This cost cutting service permits you to exchange worn engine components for quality Caterpillar Remanufactured or Caterpillar dealer rebuilt components on an over-the-counter basis. When you need them, these parts are ready for a substantial savings in both time and money.

NOTE: If there is a component you need, contact your Caterpillar dealer to see if it is offered under his Dealer Exchange Component Program.

Caterpillar Factory Remanufactured Components –
The latest remanufacturing techniques and procedures are used to restore components to Caterpillar's original functional specifications.

Before deciding which method is best, make sure all of the options and costs associated with repair have been considered. Some considerations are:

- The costs associated with using separate parts from inventory versus the cost of a repair kit.
- Downtime costs while the product is being rebuilt or repaired.
- Total parts and labor costs for repairs versus the actual Remanufactured cost.
- Remanufactured components from Caterpillar (if available) are covered by a standard, factory warranty.

Caterpillar Recommendation

To minimize downtime, Caterpillar recommends that the use of Remanufactured components (subject to availability) is the most cost effective option.

The following is a list of (R) Remanufactured components currently being offered by Caterpillar* in many countries:

- Cylinder head – bare
- Cylinder head – assembly and group
- Crankshaft – undersized
- Crankshaft – upgrade to new
- Complete turbocharger
- Turbocharger cartridges
- Water pump
- Oil pump
- Connecting rods
- Air Compressor
- Alternator
- Electric starting motor

NOTE: If the component you need is not listed here, contact your Caterpillar dealer to see if it is offered under a dealer exchange component program.

* The current parts book will asterisk a part number when a (R) Remanufactured unit is offered by Caterpillar.

Because engines may be equipped with various optional components, the Maintenance Schedule may recommend maintenance for items not installed on your engine. Simply disregard reference to any extraneous items. If unsure of any item, consult your Caterpillar dealer.

All maintenance intervals are to include maintenance recommended at the lower intervals or multiples of the lower interval.

The Maintenance Schedule follows in this manual. Ensure that the schedule is adhered to.

Refill Capacities

Lubrication System

The Lubrication System Refill Capacity reflects the approximate crankcase/sump capacity plus standard factory installed oil filters. Auxiliary oil filter systems will require additional oil. Refer to the OEM specifications for auxiliary oil filter capacity. Refer to the Lubricant Specifications section in this manual for lubricant recommendations.

G3408 Engine

G3408 Engine Lubrication System Refill Capacity (Approximate)		
Compartment or System	Liters	US Gallons
Engine Crankcase ¹	57	15

¹ Approximate crankcase sump capacity including standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the auxiliary oil filter capacity.

G3412 Engine

G3412 Engine Lubrication System Refill Capacity (Approximate)		
Compartment or System	Liters	US Gallons
Engine Crankcase ¹ Standard Sump	85	22.5
Engine Crankcase ¹ Deep Sump	204	54

¹ Approximate crankcase sump capacity including standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the auxiliary oil filter capacity.

Auxiliary Oil Filters

Auxiliary Oil Filter Refill Capacities (Approximate)		
Oil Filter Part Number	Liters	US Gallons
141-3250 with filter ¹	81.5	21.5
141-3250 without filter ¹	87.5	23
141-3249 with filter ²	121	32
141-3249 without filter ²	135	36
4P-3762 with filter ³	121	32
4P-3762 without filter ³	135	36

¹ This auxiliary oil filter is used with G3408 NA engines.

² This auxiliary oil filter is used with G3408 TA engines.

³ This auxiliary oil filter is used with G3412 TA engines.

Cooling System

In order to properly maintain the cooling system, Total Cooling System capacity must be known. The approximate Engine Only cooling system capacity is listed. External System capacities will vary among applications. Refer to the OEM specifications for the External System capacity. This capacity information will be needed to determine the amount of coolant/antifreeze required for the Total Cooling System.

G3408 Engine

G3408 Engine Cooling System Refill Capacities (Approximate)		
Compartment or System	Liters	US Gallons
Engine Only	55.5	14.5
External System ¹		
Total Cooling System ²		

¹ The External System includes a radiator or expansion tank with a heat exchanger, aftercooler, and piping. Refer to Caterpillar specifications or to the OEM specifications and enter the External System capacity in this row.

² The Total Cooling System includes the Engine Only capacity plus the External System capacity. Enter the Total in this row.

G3412 Engine

G3412 Engine Cooling System Refill Capacities (Approximate)		
Compartment or System	Liters	US Gallons
Engine Only	75	20
External System ¹		
Total Cooling System ²		

¹ The External System includes a radiator or expansion tank with a heat exchanger, aftercooler, and piping. Refer to Caterpillar specifications or to the OEM specifications and enter the External System capacity in this row.

² The Total Cooling System includes the Engine Only capacity plus the External System capacity. Enter the Total in this row.

Maintenance Schedule

Naturally Aspirated Engines

NOTE: For all generator maintenance activities, refer to the Generator and Control Panel Operation and Maintenance Manual for your generator.

Use service hours or calendar time, whichever occurs first, to determine maintenance intervals.

Daily

Walk-Around Inspection – Inspect engine for leaks and loose connections	77
Lubrication System – Check oil level/Check oil filter differential pressure	78
Cooling System – Check coolant level	79
Air Cleaner – Check service indicator/Service air cleaner when needed/Inspect and clean precleaner (if equipped)	80
Clutch (If Equipped) – Check/Adjust/Lubricate	85
Driven Equipment – Inspect/Check/Lubricate	86
Air Starting Motor (if equipped) – Check lubricator oil level	86

125 Hours or Weekly

Batteries (If Equipped) – Clean/Check electrolyte level	88
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First 750 Hours or First Month

Exhaust Valve Stem Projection – Measure/Record	109
Valve Bridge, Valve Lash – Check/Adjust	111
Magnetic Pickups – Clean/Check	115

Every 750 Hours or Monthly

Engine – Clean	89
S•O•S Oil Analysis – Obtain oil sample and analysis	89
Lubrication System ¹ – Replace oil/Replace engine oil filters	90
Crankcase Breathers – Clean	93
Cooling System (Conventional HD Coolant/Antifreeze Only) – Test for SCA or obtain Level I analysis/Add SCA if necessary	93
Gas Pressure Regulator – Drain water from drip leg (if equipped)	95
Fuel Filter – Replace filter element	95
Spark Plugs – Clean/Inspect/Replace if necessary ..	96
Ignition System – Inspect/Adjust timing when necessary	99

Air Inlet and Exhaust Piping – Inspect	101
Belts – Check/Adjust/Replace when necessary	101
Hoses and Clamps – Inspect/Replace when necessary	102
Engine Mounts – Inspect	103
Crankshaft Vibration Damper – Inspect	104
Engine Protective Devices – Inspect	104
Fan Drive Bearing – Lubricate	106
Carburetor Linkage and Governor Control Linkage – Check/Adjust if necessary/Lubricate	107
Cylinder Pressure Blowby – Measure/Record	108

Every 1500 Hours or Two Months

Auxiliary Oil Filter System ¹ (If Equipped) – Replace filter elements	113
Valve Bridge, Valve Lash – Check/adjust	114
Exhaust Valve Stem Projection – Measure/Record... ..	114

Every 4000 Hours or Six Months

Magnetic Pickups – Clean/Check	115
Driven Equipment – Inspect alignment	115
Jacket Water Pump – Inspect	116
Starting Motor – Inspect	116
Alternator – Inspect	117
Transformers – Test resistance	117

Every Two Years

Cooling System (Extended Life Coolant Only) – Add Extender	118
Cooling System (Conventional HD Coolant/Antifreeze Only) ² – Drain/Clean/Replace coolant	118

Every Four Years

Cooling System (Extended Life Coolant Only) – Drain/Flush/Replace ELC	121
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¹ If equipped with a Caterpillar auxiliary oil filter system, replace the lubrication oil and replace the engine mounted oil filters Every 750 Hours. Replace the auxiliary oil filter elements at Every 1500 Hours or Two Months (every other oil change).

² If a commercial HD coolant meeting ASTM D4985 specifications is used, or if a mixture of commercial SCA and water is used, this maintenance should be performed at a maximum of One Year.

Top End and Overhaul

Estimating Overhaul Intervals	123
Top End and Overhaul Chart	123
Calculating Top End and Overhaul Intervals Using Fuel Consumption	124
Top End Interval Determined by Measure of Exhaust Valve Wear	125
Overhaul Information	126

Top End³

Cylinder Head Assembly, Starting Motor, and Throttle Body – Rebuild or Exchange	128
Oil Cooler Core – Clean/Test	129
Carburetor, Gas Regulator – Inspect/Replace	130
Spark Plug Wires and Magneto – Inspect	131
Carburetor Linkage and Governor Control Linkage – Inspect/Replace bearings	132
Transformers – Inspect/Test resistance	133
Water Temperature Regulators (Thermostats) – Replace	133
Hoses and Clamps – Replace	134

Overhaul³

Cylinder Head Assembly, Cylinder Packs, Oil Pump, and Governor – Rebuild or Exchange	135
Crankshaft Bearings and Seals, Spark Plug Wires – Install new	135
Crankshaft, Camshaft, Camshaft Followers and Bearings, Gear Train Gears and Bushings – Inspect	136

³ Refer to the Top End and Overhaul chart in the Top End and Overhaul section of this publication for the service hour or fuel consumption figure in order to determine Top End and Overhaul maintenance.

Turbocharged Aftercooled Engines

NOTE: For all generator maintenance activities, refer to the Generator and Control Panel Operation and Maintenance Manual for your generator.

Use service hours or calendar time, whichever occurs first, to determine maintenance intervals.

Daily

Walk-Around Inspection – Inspect engine for leaks and loose connections	77
Lubrication System – Check oil level	78
Cooling System – Check coolant level	79
Air Cleaner – Check service indicator/Service air cleaner when needed/Inspect and clean precleaner (if equipped)	80
Aftercooling System – Check inlet manifold air pressure and temperature	84
Clutch (If Equipped) – Check/Adjust/Lubricate	85
Driven Equipment – Inspect/Check/Lubricate	86
Air Starting Motor (if equipped) – Check lubricator oil level	86

Every 125 Hours or Weekly

Batteries – Clean/Check electrolyte level	88
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First 750 Hours or First Month

Magnetic Pickups – Clean/Check	92
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Every 750 Hours or Monthly

Engine – Clean	89
S•O•S Oil Analysis – Obtain oil sample and analysis ..	89
Lubrication System ¹ – Replace oil/Replace engine oil filters	90
Crankcase Breathers – Clean	93
Cooling System (Conventional HD Coolant/Antifreeze Only) – Test for SCA or obtain Level I analysis/Add SCA if necessary	93
Gas Pressure Regulator – Drain water from drip leg (if equipped)	95
Fuel Filter – Replace filter element	95
Spark Plugs – Clean/Inspect/Replace if necessary	96
Ignition System – Inspect/Adjust timing when necessary	99

Air Inlet and Exhaust Piping – Inspect	101
Belts – Check/Adjust/Replace when necessary	101
Hoses and Clamps – Inspect/Replace when necessary	102
Engine Mounts – Inspect	103
Crankshaft Vibration Damper – Inspect	104
Engine Protective Devices – Inspect	104
Turbocharger – Inspect/Check/Clean	105
Fan Drive Bearing – Lubricate	106
Carburetor Linkage and Governor Control Linkage – Check/Adjust if necessary/Lubricate	107
Cylinder Pressure Blowby – Measure/Record	108
Exhaust Valve Stem Projection – Measure/Record ..	109
Valve Bridge, Valve Lash – Check/Adjust	111

Every 1500 Hours or Two Months

Auxiliary Oil Filter System ¹ (If Equipped) – Replace filter elements	113
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Every 4000 Hours or Six Months

Magnetic Pickups – Clean/Check	115
Driven Equipment – Inspect alignment	115
Jacket Water Pump – Inspect	116
Starting Motor – Inspect	116
Alternator – Inspect	117
Transformers – Test resistance	117

Every Two Years

Cooling System (Extended Life Coolant Only) – Add Extender	118
Cooling System (Conventional HD Coolant/Antifreeze Only) ² – Drain/Clean/Replace coolant	118

Every Four Years

Cooling System (Extended Life Coolant Only) – Drain/Flush/Replace ELC	121
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¹ If equipped with a Caterpillar auxiliary oil filter system, replace the lubrication oil and replace the engine mounted oil filters Every 750 Hours. Replace the auxiliary oil filter elements at Every 1500 Hours or Two Months (every other oil change).

² If a commercial HD coolant meeting ASTM D4985 specifications is used, or if a mixture of commercial SCA and water is used, this maintenance should be performed at a maximum of One Year.

Top End and Overhaul

Estimating Overhaul Intervals	123
Top End and Overhaul Chart	123
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Top End Interval Determined by Measure of Exhaust Valve Wear	125
Overhaul Information	126

Top End³

Cylinder Head Assembly, Starting Motor, Turbocharger, SCAC Water Pump, and Throttle Body – Rebuild or Exchange	128
Oil Cooler Core and Aftercooler Core – Clean/Test	129
Exhaust Bypass Valve – Inspect/Clean breather ..	130
Carburetor, SCAC Water Pump, Gas Regulator – Inspect/Replace	130
Spark Plug Wires and Magneto – Inspect	131
Carburetor Linkage and Governor Control Linkage – Inspect/Replace bearings	132
Transformers – Inspect/Test resistance	133
Water Temperature Regulators (Thermostats) – Replace	133
Hoses and Clamps – Replace	134

Overhaul³

Cylinder Head Assembly, Cylinder Packs, Oil Pump, Governor, Turbocharger – Rebuild or Exchange	135
Crankshaft Bearings and Seals, Spark Plug Wires – Install new	135
Crankshaft, Camshaft, Camshaft Followers and Bearings, Gear Train Gears and Bushings – Inspect	136

³ Refer to the Top End and Overhaul chart in the Top End and Overhaul section of this publication for the service hour or fuel consumption figure in order to determine Top End and Overhaul maintenance.

Daily

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Walk-Around Inspection

Inspect Engine for Leaks and Loose Connections

A walk-around inspection should only take a few minutes of your time. By taking the time to make these checks, costly repairs and accidents can be avoided and your equipment will be ready to run should the need arise. Look for items such as oil leaks, coolant leaks, loose bolts, worn fan belts, loose connections, and trash buildup. Remove trash buildup and have repairs made as needed.

NOTICE

For any type of leak (coolant, lubricant, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

To keep dirt and debris from entering engine components and reduce the chance of contamination, clean all fittings, caps and plugs before servicing.

Inspect:

- Guards– all guards must be in place. Replace or repair missing or damaged guards.
- Generator (if equipped) for dirt and debris.
- Driven Equipment (if equipped) for dirt and debris. Check the lubrication oil levels.

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 750 hours or each time any significant quantity of fluid is spilled on or near an engine and working area.

Air Inlet System

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

Lubrication System

Inspect the lubrication system for oil leaks. Inspect the front and rear crankshaft seals, the oil pan, the oil filters, and the valve covers. Inspect auxiliary oil filters (if equipped) for leaks and loose connections.

Fuel System

Inspect the fuel system for leaks. Look for loose fuel line clamps and fittings and loose or worn hoses. Replace items as needed.

NOTICE

Fuel line clamps should not be over torqued. Over torqueing causes the clamps to butterfly, which results in low clamping force and fuel line vibration and eventual failure.

Electrical System

Check the condition of all electrical connections and wiring. Tighten all connections and repair all wiring that shows signs of wear or cracking of the insulation.

Inspect the engine to frame ground strap for good connection and condition.

Check the condition of batteries and the level of electrolyte, unless equipped with a maintenance free battery.

Cooling System

Inspect the cooling system for leaks and trash buildup. Inspect and clean the radiator and aftercooler fins of dirt and debris. High pressure water is an excellent way to clean the debris out of the radiator fins. If necessary, use a light bulb behind the radiator fins to see if they are completely clean.

For more detailed information on cleaning your radiator fins, refer to SEBD0518, Know Your Cooling System.

Inspect the cooling system piping and elbows for cracks and loose clamps. Inspect fan belts and accessory drive belts for cracks, breaks or other damage.

Inspect the water pumps for coolant leaks at the weep holes. Check weep hole for water pump filter blockage and replace the filter if necessary. Refer to the Parts Manual for your engine.

NOTE: The water pump seal is lubricated by coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and parts contract. If leaks are found, check the coolant level frequently and continue to monitor the level until the water pump is repaired. Excessive coolant leaking may indicate the need to replace the water pump seal.

Refer to the Service Manual for water pump removal and installation information, or contact your Caterpillar dealer.

Check the water supply to the SCAC.

Gauges and Indicators

Inspect the gauges. Replace the gauges if the gauges are cracked or cannot be calibrated.

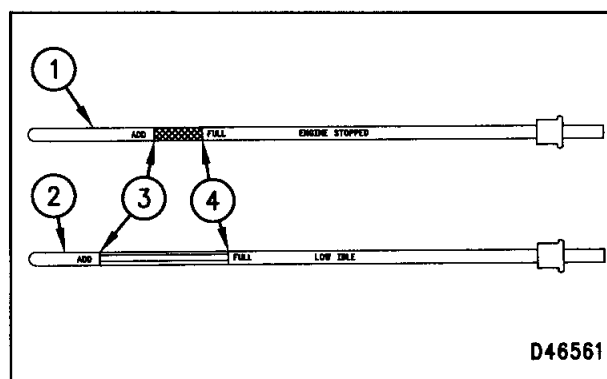
Frequently observe the engine oil pressure, oil filter differential pressure, air inlet temperature and the air cleaner differential pressure readings while the engine is operating.

The oil filter elements should be changed if the oil filter differential pressure gauge registers 105 kPa (15 psi) while the engine is running at rated speed and at operating temperature.

Lubrication System

Check Oil Level

The preferred time to check the oil level is when the engine is stopped. This maintenance should be performed on as level a surface as possible.



Oil level gauge (dipstick): ENGINE STOPPED side (1), LOW IDLE side (2), ADD mark (3), and FULL mark (4).

1. Ensure that the oil level gauge is seated. If the engine is stopped, remove the oil level gauge and observe the oil level on the ENGINE STOPPED side of the oil level gauge.

If the engine is operating, reduce the engine speed to LOW IDLE. Remove the oil filler cap in order to relieve the crankcase pressure. Failure to relieve the crankcase pressure will result in an inaccurate oil level reading. Remove the oil level gauge and observe the oil level on the LOW IDLE side of the oil level gauge.

Install the oil level gauge.

2. Maintain the oil level between the ADD and FULL marks on the oil level gauge. Do not fill the crankcase above the FULL mark.

NOTICE

Operating your engine when the oil level is above the FULL mark could cause your crankshaft to dip into the oil. The air bubbles created from the crankshaft dipping into the oil reduce the oil's lubricating characteristics and could result in the loss of power.

- 3.** Remove the oil filler cap and add oil if necessary. Refer to the Lubricant Specifications for the recommended oil to use. Clean the oil filler cap. Clean the oil filler cap receptacle. Install the oil filler cap.

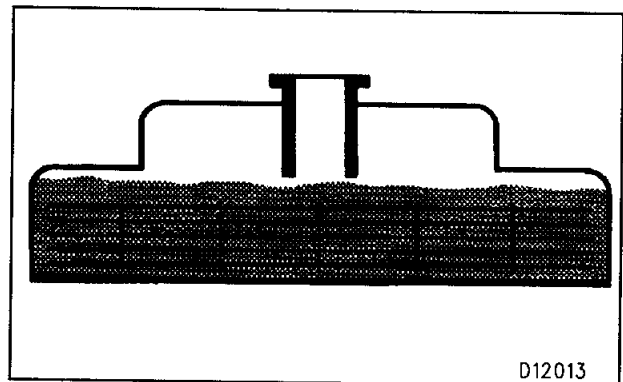
Cooling System

Check Coolant Level

If the engine is equipped with a sight gauge, check the position of the float in the sight gauge. At normal operating temperature, the float should be in the upper half of the sight gauge.

If the engine is not equipped with a sight gauge, check the coolant level with the engine stopped and cool.

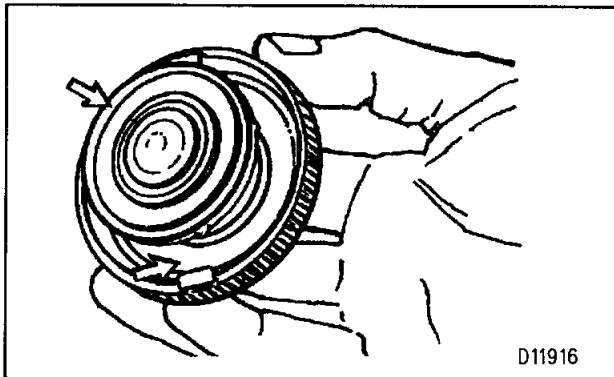
Stop the engine and allow the engine to cool before performing this maintenance procedure. Check the coolant level only after the engine has been stopped and the cooling system filler cap is cool enough to touch with your bare hand.



Fill pipe and coolant level.

Remove the cooling system filler cap slowly in order to relieve pressure. Maintain the coolant level within 13 mm (1/2 inch) below the bottom of the fill pipe.

Add the proper coolant mixture if necessary. Refer to the Coolant Specifications.



Typical cooling system filler cap gaskets.

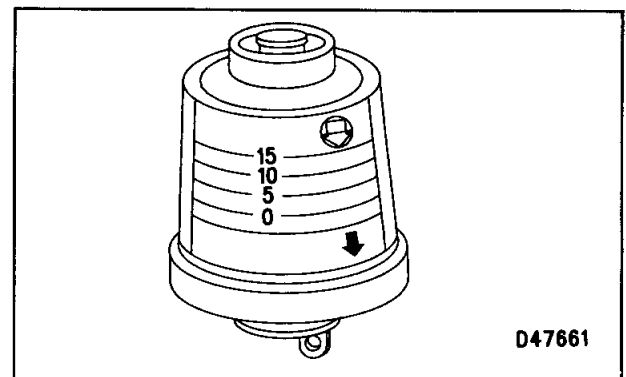
Clean the cooling system filler cap. Inspect the condition of the cooling system filler cap gaskets. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Clean the cooling system filler cap receptacle. Install the cooling system filler cap.

Start the engine. Inspect for coolant leaks and damaged cooling system piping. Have repairs made if necessary.

Air Cleaner

Check Service Indicator

A service indicator is mounted on the air cleaner housing. A colored piston showing in the window indicates the need for servicing the air cleaner.



Typical service indicator.

Observe the service indicator. Clean or replace the air cleaner element when the yellow diaphragm enters the red zone or the red piston locks in the visible position. If the service indicator shows red at any time, clean the air cleaner element or install a new element.

Inspect the service indicator daily for cracks, holes, or loose fittings. If any of these conditions are present, repair or replace the service indicator.

Test Service Indicator

Service indicators are inexpensive but important instruments.

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

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

Severely dusty environments may require frequent service indicator replacements. Replace the service indicator yearly, regardless of operating conditions. Replace the service indicator at Overhaul, and whenever major engine components are replaced.

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

Servicing Air Cleaner Elements

NOTICE

Never operate the engine without an air cleaner installed. Never operate the engine with a damaged air cleaner. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt and debris that enters the engine causes premature wear and damage to the engine components. Air cleaners prevent airborne dirt and debris from entering the engine through the air inlet.

NOTICE

Never service the air cleaner with the engine running since this will allow dirt and debris to enter the engine.

If the air cleaner element becomes plugged, the air can split the element material. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has elements to service this unit. Contact your Caterpillar dealer for the correct element.

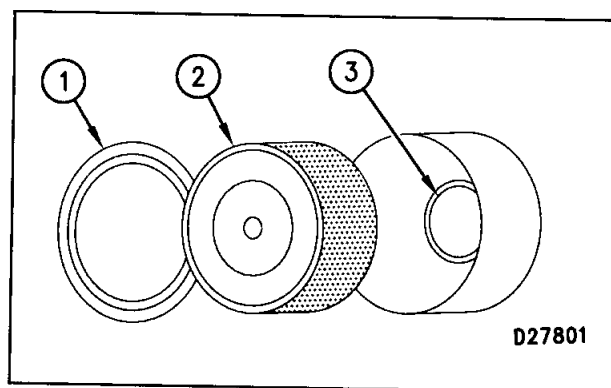
- Service the air cleaner when required by the service indicator. After servicing the air cleaner, reset the service indicator by pushing on the piston plunger.
- If equipped with an inlet air pressure differential gauge, service the air cleaner when the inlet air pressure differential reaches 3.75 kPa (15 inches of H₂O).
- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris as needed.
- Operating conditions (dust, dirt and debris) may require more frequent air cleaner element maintenance.

- The air cleaner element may be cleaned up to six times if the element is properly cleaned and inspected.
- Replace the air cleaner element at least every year, regardless of the number of times that the element has been cleaned.

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

Remove and Install Air Cleaner Element

1. Loosen the air cleaner cover clamps and bolts.



Air cleaner cover (1), element (2), and air inlet (3).

2. Remove the air cleaner cover (1) and element (2).
3. Seal the air inlet (3) so that debris can not enter the inlet. Use tape, or secure a clean cloth over the opening.
4. Clean the inside of the air cleaner cover and body.
5. Clean or replace the element. Inspect the replacement element for damage, dirt or debris.
6. Remove the seal from the inlet.
7. Install a clean, undamaged element.
8. Install the air cleaner cover. Fasten the air cleaner cover clamps. Tighten the air cleaner cover bolts finger tight. Do not use a tool to tighten the bolts.
9. Reset the service indicator.

Cleaning Air Cleaner Elements

The air cleaner element can be used up to six times if the element is properly cleaned and inspected. The element, when cleaned, should be thoroughly checked for rips or tears in the filter material. Replace the element at least every year, regardless of the number of times that the element has been cleaned.

Have clean elements available for use while dirty elements are being cleaned.

NOTICE

Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the elements before cleaning. Inspect the elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged elements.

There are four common methods used to clean air cleaner elements.

- Pressurized water
- Pressurized air
- Vacuum cleaning
- Washing with nonsudsing detergent

Pressurized Water

Pressurized water will clean the element unless carbon and oil has accumulated on the surface of the element. Use the normal water outlet pressure with a maximum pressure of 280 kPa (40 psi). **Do not** use a pressure nozzle.

NOTE: When cleaning the elements, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

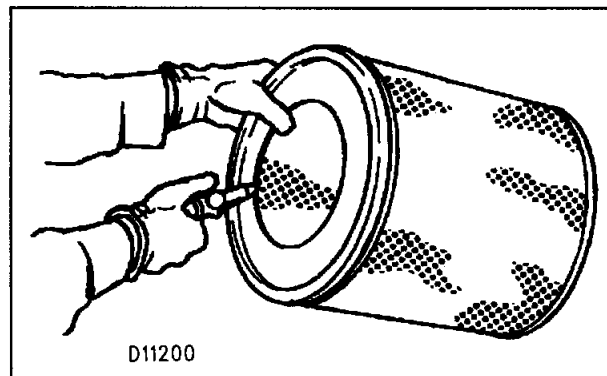
Do not aim the water stream directly at the element—dirt could be forced deeper into the pleats. Direct the water stream along the length of the pleats.

Dry the element thoroughly. Inspect the element before installation.

NOTE: Repeated cleaning with this method can force dirt deeper into the filter material.

Pressurized Air

Pressurized air cleans dusty elements and elements which have not been cleaned more than twice. Pressurized air will not remove carbon and oil deposits. Use pure, dry air with a maximum pressure of 210 kPa (30 psi).



NOTE: When cleaning the elements, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Do not aim the air flow directly at the element—dirt could be forced deeper into the pleats. Direct the air flow along the length of the pleats.

Inspect the element before installation.

NOTE: Repeated cleaning with this method can force dirt deeper into the filter material.

Vacuum Cleaning

Vacuum cleaning is a good method for cleaning elements which require daily cleaning because of a dry, dusty environment. Pressurized air cleaning is recommended prior to vacuum cleaning. Vacuum cleaning will not remove carbon and oil deposits.

Inspect the element before installation.

Washing With Nonsudsing Detergent

WARNING

Do not wash air cleaner elements in any flammable solution such as diesel fuel or gasoline. Doing so can cause fire or an engine runaway and can result in personal injury.

Washing with nonsudsing detergent is effective for cleaning elements that have carbon or oil deposits. Use a cleaning compound that is manufactured specifically for cleaning air cleaner elements. Cleaning with pressurized water, pressurized air, or a vacuum is recommended prior to washing with nonsudsing detergent.

1. Place the element, with the gasket side up, into a soak tank that is equipped with a rack so that the element does not sit on the bottom of the tank.

NOTE: Caterpillar does not recommend a washing process which includes agitation. Agitation may cause carbon particles to be distributed.

2. Fill the tank with warm water [60°C (140°F) maximum] and cleaning compound. Follow the cleaning compound manufacturer's instructions. Allow the element to soak for six hours.

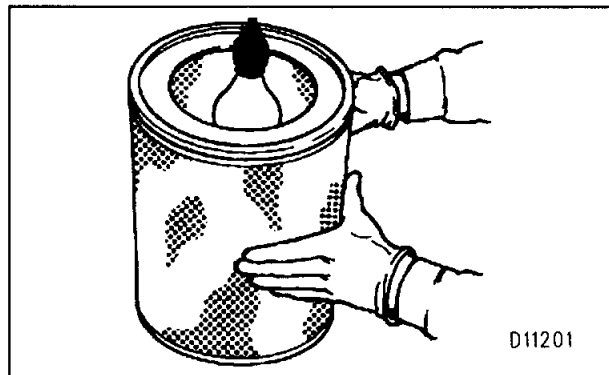
3. Drain the tank. Do not use the cleaning solution more than one time. Remove the element from the tank. Rinse the element with the pressurized water cleaning method. Dry the element thoroughly. Inspect the element before installation.

Drying Air Cleaner Elements

Air cleaner elements may be placed into a drying oven. If an oven is used, do not expose the elements to temperatures that exceed 82°C (160°F).

Air cleaner elements may be allowed to air dry. Allow two days for the elements to air dry before the elements are inspected and installed.

Inspecting Air Cleaner Elements



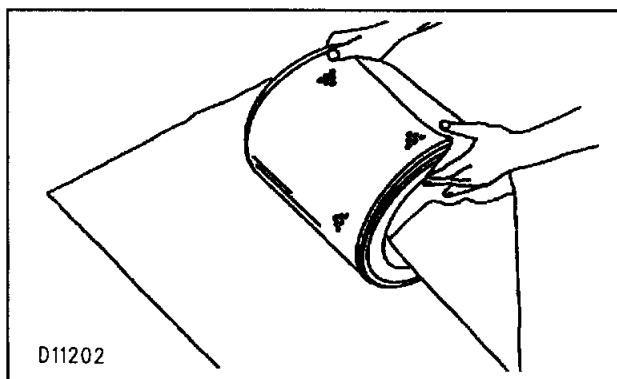
Inspect the clean, dry element. Use a 60 watt blue light in a dark room or in an inspection booth. Place the bulb inside of the element. Rotate the element. Inspect the elements for holes—look for light to show through the filter material. If it is necessary in order to confirm the result, compare the element to a new element that has the same part number.

Do not use an element that has any holes in the filter material. Do not use an element with damaged pleats, gaskets or seals. Discard damaged elements.

Storing Air Cleaner Elements

If air cleaner elements which pass inspection will not be used for some time, mark the filter for inventory. Indicate the following information:

- Date cleaned
- Number of times cleaned
- Customer name (if applicable)

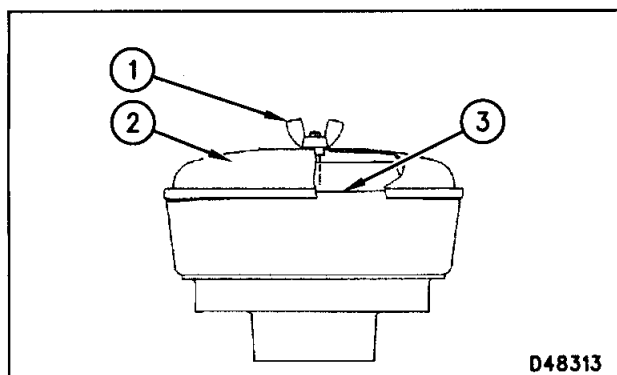


Do not use paint, water repellent, or plastic as a protective covering for storage. Restricted air flow may result. To protect against dirt and damage, wrap the elements in Volalite Corrosion Inhibited (V.C.I.) paper. Place the elements into a box for storage. For identification, mark the outside of the box. Store the box in a dry location.

For more detailed air cleaner element cleaning information, refer to SEBF8062, Procedure to Inspect and Clean Air Filters.

Precleaner

Inspect/Clean



Typical precleaner wing nut (1), cover (2), and body (3).

Remove wing nut (1) and cover (2). Check for an accumulation of dirt and debris in body (3). Clean the body if necessary.

After cleaning, install cover (2) and wing nut (1).

NOTE: More frequent cleaning may be required in very dusty environments.

Aftercooling System

All turbocharged gas engines are equipped with an aftercooler. The aftercooler is a simple device resembling a small radiator core. Separate Circuit Aftercooler (SCAC) cooling water passes through the core tubes. Engine inlet air warmed by the turbocharger compressor is directed through the core.

The water temperature is lower than the turbocharged air temperature. The inlet air is cooled as the air leaves the aftercooler. As the air enters the inlet manifold, the air becomes more dense. This means that more air (oxygen) is available for combustion, resulting in more fuel burned and more power produced.

Check Inlet Manifold Air Pressure

As the inlet manifold pressure increases, engine power increases. If your engine exceeds the maximum normal inlet manifold air pressure, the engine may be overloaded, which can reduce the engine's service life. For inlet manifold pressure data, refer to LEBQ2024, G3400 Gas Engine Performance, or consult with your Caterpillar dealer.

Check Inlet Manifold Air Temperature

A one degree increase in the inlet manifold air temperature increases the exhaust temperature by approximately three degrees. Restrictions to either the coolant flow or the air flow reduces aftercooler efficiency and affects the engine and cooling system performance.

Check the inlet manifold air temperature under full operating conditions. The inlet manifold temperature should be below the maximum limits shown in the following chart.

Aftercooler Water Temperature	Maximum Inlet Manifold Temperature
32°C (90°F)	43°C (110°F)
Air-to-Air Aftercooler	55°C (131°F)
54°C (130°F)	65°C (150°F)
70°C (160°F)	82°C (180°F)

If the inlet manifold air temperature is above the maximum limit, check the separate circuit aftercooler water temperature gauge for proper operation.

Watercooled Aftercooling Systems Only

The aftercooler system should be maintained to provide no more than a 4°C (7°F) variation in inlet manifold air temperature on an engine that has reached operating temperature.

If the inlet manifold air temperature rises above the engine shutdown limit of the inlet manifold air temperature switch (if equipped), the Gas Shutoff Valve (GSOV) will be activated in order to stop the engine.

The aftercooler core may be disassembled and all internal water passages mechanically cleaned. Cleaning is required when plugging is suspected. Plugging results in increased inlet manifold air temperature. Refer to the Service Manual for the disassembly and assembly procedure.

Air-To-Air Aftercooler

Check the front of the air-to-air aftercooler (ATAAC) for insects, dirt and other debris. Clean the front of the ATAAC with a stainless steel brush and soapy water.

NOTE: Depending on your findings and operating environment, the maintenance interval for cleaning the ATAAC can be extended from a Daily to an as needed basis.

Ensure that the ATAAC air inlet temperature system is operating correctly by checking the temperature switch and gauge (if equipped).

Clutch

Check/Adjust/Lubricate

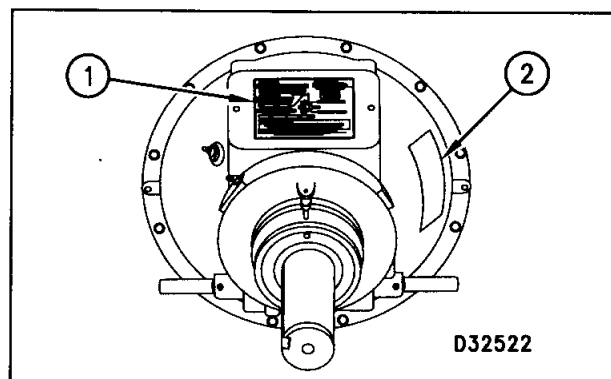
Check/Adjust

NOTICE

New power takeoffs should have clutch adjustment checked before being placed in service. Clutch adjustment should be checked again after the first ten hours of operation. New clutch plates have a "wear in" period, and the clutch may require several adjustments until the new plates are "worn in."

Clutch adjustment should be checked regularly after "wear in." Heavy duty applications which have frequent clutch engagements and relatively long periods of clutch slip require more frequent adjustment than light duty applications. Operating torque should be measured to determine if clutch adjustment is required.

Refer to the clutch OEM service instructions and the clutch instruction plate for adjustment, lubrication, and other service recommendations. Perform the maintenance specified on the instruction plate.



Typical clutch Instruction Plate (1) and Serial Number Plate (2) locations.

WARNING

Do Not operate the engine with Instruction Plate cover removed from the clutch. Personal injury may result.

If the clutch is damaged to the point of burst failure, expelled pieces can cause personal injury to anyone in the immediate area. Proper safeguards must be followed to prevent accidents.

Driven Equipment

Inspect/Check/Lubricate

Refer to the driven equipment OEM service instructions for inspection, adjustment, lubrication, and other service recommendations. Check the lubrication oil levels on driven equipment (if required).

Perform any maintenance which is recommended by the driven equipment OEM.

Air Starting Motor

Check Lubricator Level

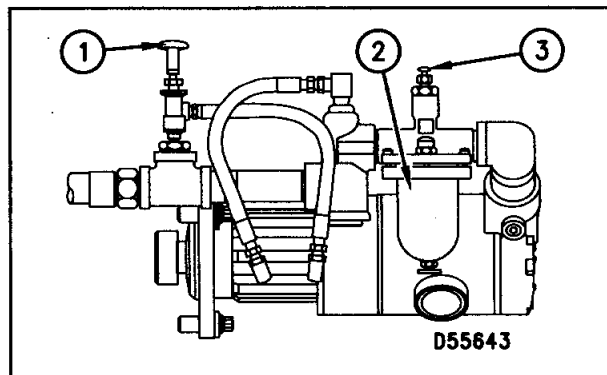
NOTICE

Never allow the lubricator bowl (if equipped) to become empty. The air starting motor will be damaged by lack of proper lubrication.

The vanes of the air starting motor are lubricated with a fine mist of oil from the motor lubricator. Check the level of oil in the lubricator bowl. If the bowl is less than half full, add lubricant. Use non detergent 10W engine oil for temperatures that are greater than 0°C (32°F). Use air tool oil for temperatures below 0°C (32°F).

Lubricator Feed Adjustment

If necessary, adjust the lubricator to release approximately two drops of fluid per 30 seconds into the starting motor air stream.



Air start valve (1), lubricator bowl (2), and adjustment knob (3).

Be sure there is NO fuel supply to the engine.

1. Turn the adjustment knob CW until the knob locks.
2. Turn the adjustment knob CCW ¼ turn.
3. Crank the starting motor for ten seconds and observe the exhaust air from the starting motor mufflers. Look for oil mist. You should see a slight oil mist. The mist should be barely visible.

If no mist is observed, or if the mist is excessive: rotate the adjustment knob in $\frac{1}{16}$ turn increments to increase or decrease the oil mist. Repeat the starting motor cranking and observation until the mist is satisfactory.

NOTE: Drip rates should only be made under an average steady flow condition. Once established, the lubricator will automatically adjust the drip rate proportionally to variations in air flow.

Air Tank (If Equipped)

For good life of the air starting motor, the air supply must be free of dirt and water. The air starter requires adequate air pressure in order to operate.

- Drain water from the air tank (if equipped). Open the drain valve on the bottom of the air tank to drain the condensation and oil carryover.
- Check the air supply pressure. The air starting motor requires a minimum of 620 kPa (90 psi) of air pressure to operate properly. The maximum air pressure must not exceed 1723 kPa (250 psi). The normal air pressure will be 758 to 965 kPa (110 to 140 psi).

Every 125 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Batteries

WARNING

Battery electrolyte contains acid and can cause injury. Avoid contact with the skin and eyes. Always wear protective glasses when working with batteries. Wash hands after touching batteries and connectors. Use of gloves is recommended. Batteries give off flammable fumes which can explode. Ensure there is proper ventilation for batteries which are located in an enclosure. Do not smoke when servicing the batteries.

Disconnecting the Starting System

1. Turn the START switch OFF or turn the ECS to the OFF/RESET position. Remove all electrical loads.
2. Disconnect the cable from the battery NEGATIVE (–) terminal. Be sure that the cable cannot contact the terminal. Where four batteries are involved, the negative (–) side of two batteries must be disconnected.
3. Proceed with necessary system repairs. Reverse step 2 in order to reconnect the cable(s).

Clean/Check Electrolyte Level

Battery Electrolyte Chart	
Battery	Interval
Conventional	125 Hour
Low Maintenance	250 Hours
Maintenance Free	None Required

1. Remove the fill caps. Maintain the electrolyte level to the bottom of the fill cap openings.

If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.

At the proper charging rate, the batteries should not require more than 30 cc (1 oz) of water per cell per week.

2. Keep the batteries clean.
3. Remove the cable clamps from all of the battery terminals.
4. Clean all of the battery terminals.
5. Clean all of the cable clamps.
6. Attach the cable clamps to the battery terminals. Tighten the cable clamps.
7. Coat the cable clamps and the battery terminals with 5N-5561 Lubricant Compound or petroleum jelly or MPGM grease.

Check Battery Charger (if equipped)

- Check the battery charger for proper operation. If batteries are properly charged, the ammeter reading should be very near zero. All batteries should be kept charged to a corrected specific gravity of 1.250 or above.
- The batteries should be kept warm, if possible. The battery temperature affects the cranking power. If the battery is too cold, the battery will not crank the engine, even if the engine is warm.
- When the engine is not run for long periods of time or is run for short periods, the batteries may not fully recharge. Ensure a full charge to help prevent the battery from freezing.

Every 750 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Engine

Clean

NOTICE

Accumulated grease and oil on an engine is a fire hazard. Keep your engine clean. Remove debris and fluid spills each time a significant quantity accumulates on the engine.

Steam cleaning the engine provides for easy detection of fluid leaks. Repairing an oil or coolant leak upon detection may save money by avoiding major repairs that could result from low oil or coolant levels. Steam cleaning the engine as recommended will also improve the engine's heat transfer characteristics.

S•O•S Oil Analysis

Obtain Oil Sample and Analysis

WARNING

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

To compliment a good preventive maintenance program, Caterpillar recommends using S•O•S Oil Analysis at regular 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 crankcase.

To obtain S•O•S oil samples:

- Use the oil sampling valve (if equipped)
- Use a sampling gun inserted into the sump
- Use the drain stream when changing oil

Caterpillar recommends the use of a sampling valve (if equipped) in order to obtain samples. The quality and the consistency of the samples is better when the sampling valve is used. If a sampling valve is not equipped, the use of an oil sampling gun is preferred. If these methods are not feasible, then use the drain stream method.

The drain stream method is the least preferred method because debris from the bottom of the oil sump can contaminate the sample. When using the drain stream method to obtain the oil sample, do not sample from the first or final draining. The oil at the beginning or end of the drain stream is not mixed well enough to be representative of the oil in the crankcase.

For more detailed information, refer to PEHP6001, How To Take A Good Oil Sample. Consult with your Caterpillar dealer for complete information and assistance in establishing an S•O•S program for your engine.

Lubrication System

WARNING

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

Replace Oil and Engine Oil Filters

Engine application, type of fuel gas, oil, ambient air conditions and air/fuel ratio have an impact on the oil change interval. Establishing an S•O•S oil analysis program will allow evaluation of the used oil to determine if this oil change interval is suitable for your specific engine.

NOTICE

Only use oils as recommended by Caterpillar. Refer to the Lubricant Specifications section of this manual for the recommended oil.

This maintenance should be performed on as level a surface as possible.

Do not drain the oil when the engine is cold. As oil cools, suspended waste particles settle on the bottom of the crankcase or oil pan. The waste particles are not removed with the draining cold oil. Drain the crankcase with the engine stopped and the oil warm. This allows for the draining of the waste particles that are suspended in the oil.

Failure to follow this recommended procedure would result in the waste particles being recirculated through your engine lubrication system with the new oil.

WARNING

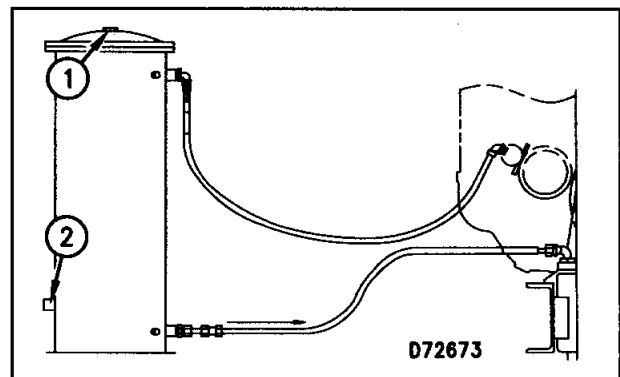
Hot oil and components can cause personal injury. Do not allow hot oil or components to contact the skin.

Drain Oil

After the engine has been run at normal operating temperature, STOP the engine. The method used to drain the engine's oil depends on the engine equipment. Catch the draining oil in a suitable container. Dispose of the used oil properly.

- If the engine is equipped with a drain valve, open the valve to drain the oil. After the oil has drained, close the valve.
- If the engine is not equipped with a drain valve, remove an oil drain plug and allow the oil to drain. After the oil has drained, clean the oil drain plug. Clean the oil drain plug fitting. Install the oil drain plug. Tighten the oil drain plug to $80 \pm 11 \text{ N}\cdot\text{m}$ ($60 \pm 8 \text{ lb ft}$).

NOTE: Some customers use suction devices to remove the oil from the pan. If suction equipment is used, ensure that the suction device is clean in order to prevent dirt from entering the oil pan. Be careful not to strike the engine oil suction tubes or the piston cooling jets.



Auxiliary oil filter canister: vent plug (1) and drain plug (2).

- If the engine is equipped with an auxiliary oil filter system, remove vent plug (1). Remove drain plug (2) and allow the oil to drain. After the oil has drained, clean the oil drain plug. Clean the oil drain plug fitting. Install the oil drain plug. Tighten the oil drain plug to $70 \pm 14 \text{ N}\cdot\text{m}$ ($50 \pm 10 \text{ lb ft}$).

Replace Engine Oil Filters

Replace the engine oil filters at every oil change or when the oil filter differential pressure gauge registers 105 kPa (15 psi) with the engine operating at rated speed and at operating temperature.

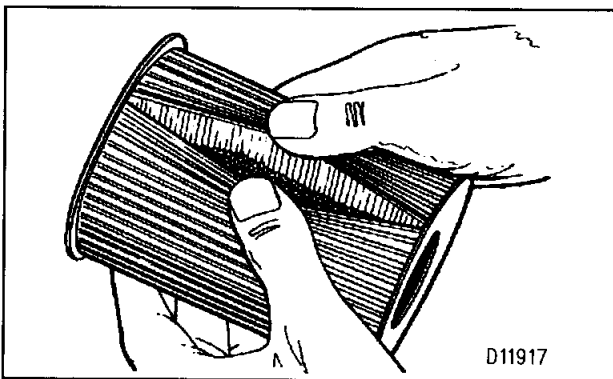
If equipped with auxiliary oil filters, replace the auxiliary oil filters Every 1500 Hours or Two Months (every other oil change). Refer to the Auxiliary Oil Filter System topic.

Make sure to use the correct oil filters for your engine arrangement.

NOTICE

Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe damage to your engine bearings, crankshaft, etc, as a result of the larger debris particles from unfiltered oil entering your engine lubricating system. Only use oil filters recommended by Caterpillar.

1. Remove the oil filter with a 1U-8760 Chain Wrench.



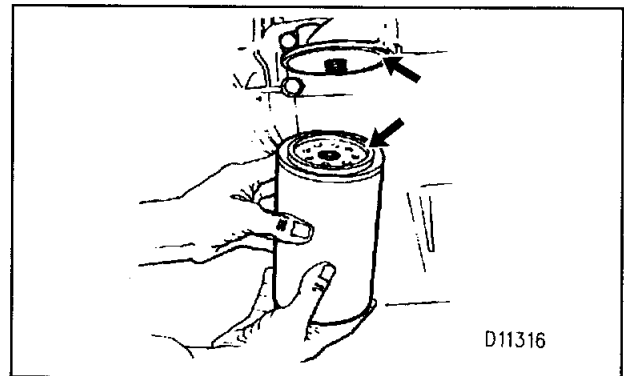
Element with debris.

2. Cut the oil filter open with a 4C-5084 Oil Filter Cutter. Spread the pleats apart and inspect the element for metal debris. An excessive amount of debris in the oil filter element may indicate early wear or a pending failure.

Use a magnet to differentiate between the ferrous and non-ferrous metals found in your oil filter element. Ferrous metals may indicate wear on the steel and cast iron parts of your engine.

Non-ferrous metals may indicate wear on the aluminum, brass or bronze parts of your engine, such as main and rod bearings, turbocharger bearings and cylinder heads.

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter element. Consult your Caterpillar dealer to arrange for further analysis if an excessive amount of debris is found in your oil filter element.



Typical filter mounting base and filter gasket.

3. Clean the sealing surface of the filter mounting base. Make sure all of the old gasket is removed.
4. Apply clean engine oil to the new filter gasket.

NOTICE

Do NOT fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil will cause accelerated wear to engine components.

5. Place the filter in position. Tighten the filter until the gasket contacts the base. Tighten the filter $\frac{3}{4}$ of a turn more (270 degrees) by hand. Do not over tighten.

Fill

1. Remove the oil filler cap. Refer to Lubricant Specifications for the proper oil to use for this engine. Fill the crankcase with the proper amount of oil (refer to the Refill Capacities chart).

Fill Auxiliary Oil Filter Canister (If Equipped)

NOTICE

If equipped with an auxiliary oil filter system, extra oil must be added when filling the crankcase. If equipped with an auxiliary oil filter system that is not supplied by Caterpillar, follow the auxiliary oil filter system's OEM recommendations.

If equipped with an auxiliary oil filter system, pour oil into the canister. Refer to the Auxiliary Oil Filter Refill Capacities chart for the amount of oil to fill the canister.

Oil may be poured into the canister's vent plug fitting, or remove the cover and pour oil into the canister. Refer to the Auxiliary Oil Filter System topic for information about cover removal and installation. After the canister has been filled with oil and the cover is in place, install the vent plug.

NOTICE

To prevent crankshaft or bearing damage, crank the engine with the fuel OFF in order to fill all of the oil filters BEFORE starting. Do Not crank the engine for more than 30 seconds. Crank the engine with the fuel OFF until normal oil pressure shows on the oil pressure gauge. Allow the starting motor to cool for two minutes before cranking again.

2. Follow the starting procedure in the Starting the Engine topic. Operate the engine at LOW IDLE for two minutes in order to ensure that the lubrication system (including auxiliary filters, etc) has oil and the oil filters are filled. Inspect for oil leaks. Ensure that the oil level is at the FULL mark on the LOW IDLE side of the oil level gauge.

3. Stop the engine and allow the oil to drain back into the sump for a minimum of ten minutes.

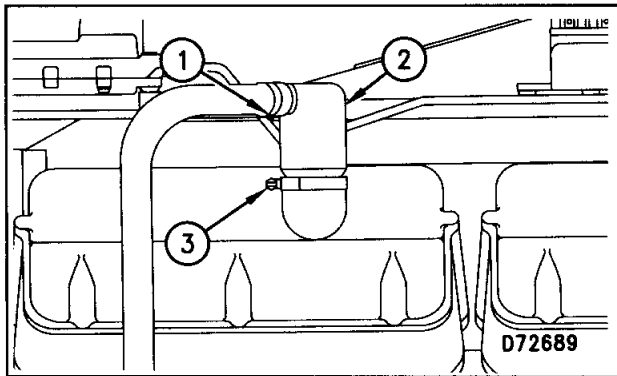
4. Remove the oil level gauge and check the oil level. Maintain the oil level to the FULL mark on the ENGINE STOPPED side of the oil level gauge.

Crankcase Breathers

NOTICE

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

Clean



Hose clamp (1), breather assembly (2), and retaining clamp (3).

1. Loosen hose clamp (1). Slide the hose from breather assembly (2).
2. Loosen retaining clamp (3). Remove breather assembly (2). Remove the crankcase breather seal.
3. Wash the breather assembly in clean, nonflammable solvent. Allow the breather assembly to dry.
4. Inspect the seal for cracks or damage. Replace the seal if necessary. Install the seal. To make installation easier, apply clean engine oil or petroleum jelly on the rubber parts.
5. Install the breather assembly, hose, and clamps in reverse order of removal. Be sure to install the components in the original position.
6. Tighten retaining clamp (3). Tighten hose clamp (1). Refer to the Torque Specifications section in this manual.

Cooling System (Conventional HD Coolant/Antifreeze Only)

Test for SCA Or Obtain Level I Analysis

WARNING

Coolant additive contains alkali. To prevent personal injury, avoid contact with the skin and eyes. Do not drink coolant.

Check the cooling system only after the engine is stopped and cool. Remove the filler cap slowly to relieve pressure. To prevent engine damage, never add cooling system products to an overheated engine. Allow the engine to cool first.

The use of Caterpillar SCA will prevent internal damage to the engine, such as liner or block pitting. If the SCA concentration is too low, pitting of the cylinder wall may occur, which can lead to costly engine damage.

If the SCA concentration is too high, sludge and mud-like deposits may form in the cooling system. This adversely affects engine performance and can also lead to costly repairs of the engine and cooling system.

NOTICE

The overconcentration of a supplemental coolant additive will result in deposits on the higher temperature surfaces of the cooling system and create a barrier that reduces the engine's heat transfer characteristics.

Reduced heat transfer could cause cracking of the cylinder head and other high temperature components. Excessive concentrations of additive could also accelerate water pump seal wear.

Use the 4C-9301 Test Kit or use the 8T-5296 Test Kit to check for SCA concentration. Add SCA if the concentration is too low. If the SCA concentration is excessive, drain half the coolant, and replace with the proper coolant mixture.

NOTE: You may test your coolant SCA concentration OR have the SCA concentration tested as part of a S•O•S Coolant Analysis (Level I).

Obtain Level I Analysis

S•O•S Coolant Analysis is the best way to monitor the condition of your coolant and your cooling system.

Level I: Basic Coolant Maintenance Check

Checks for correct chemical balance for proper heat and corrosion control. Tests for:

- glycol
- SCA concentrations
- pH
- conductivity

S•O•S Coolant Analysis reports results and makes recommendations, usually within 24 hours. Consult your Caterpillar dealer for more information.

Add Liquid Supplemental Coolant Additive (SCA)

NOTICE

Only add SCA if required by SCA test results.

NOTICE

Excessive and continuous over concentration of SCA (greater than the recommended 6 percent initial fill), together with antifreeze concentrations greater than 60 percent, can result in deposits on the higher temperature surfaces of the cooling system, accelerated water pump seal wear, and radiator tube blockage, forming a barrier that reduces the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components.

To prevent over inhibiting the engine's cooling system, never use both SCA liquid AND the SCA element (if equipped) at the same time.

1. Loosen the cooling system filler cap slowly to relieve pressure. Remove the cooling system filler cap.
2. It may be necessary to drain enough coolant from the cooling system to allow for the addition of the SCA.

3. Add liquid SCA according to the requirements for your engine's cooling system capacity. Refer to the Refill Capacities chart for your engine's cooling system capacity. Refer to the Coolant Specifications for the Caterpillar SCA Requirements chart.

4. Clean the cooling system filler cap. Inspect the cooling system filler cap gaskets. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Clean the cooling system filler cap receptacle. Install the cooling system filler cap.

Gas Pressure Regulator

Drain Water From Drip Leg

The balance line on the gas pressure regulator may have a drip leg to collect condensation. The cap should be removed to drain any accumulated water.

Follow the procedure below to drain water from the gas pressure regulator.

1. Close the main gas supply valve.
2. Remove the cap from the drip leg.
3. Allow all accumulated water to drain.
4. Install the cap.
5. Open the main gas supply valve.
6. Check the gas differential pressure to maintain the correct pressure for the fuel being burned and the application of your engine. For information, consult your Caterpillar dealer.

Fuel Filter

Replace Filter Element

Replace the fuel filter element when the fuel filter differential pressure gauge (if equipped) reached 34 kPa (5 psi) with the engine operating at rated speed and at operating temperature. If the engine is not equipped with a fuel filter differential pressure gauge, replace the fuel filter element Every 750 Hours.

Refer to SEHS9298, Installation and Maintenance of Gaseous Fuel Filters, or consult your Caterpillar dealer.

Spark Plugs

Clean/Inspect/Replace

⚠ WARNING

Ignition systems can cause electrical shocks. Avoid contacting ignition components and wiring unless the Engine Control Switch (ECS) is in the STOP or OFF/RESET position. This will immediately discharge the ignition system when the ignition harness is reconnected. **DO NOT inspect valve mechanism or transformers while the engine is running. Personal injury or death may result.**

Spark plug service life is determined by the peak voltage required and by fouling due to deposits from the oil. Because some lubrication oils contain zinc additives, fouling may be a problem. Monthly cleaning may extend spark plug service life.

Spark Plug Service Life	
Aspiration	Estimated Service Life ¹
NA	6000 Hours
TA	3000 Hours

¹ The estimated service life is based on engines operating at 1800 rpm.

Ignition maintenance is related to the voltage required to fire the spark plug. The higher the absolute inlet manifold air pressure, the higher the voltage required, which shortens the service life of related components such as spark plug wires, transformers, etc.

Higher rated engines should have the ignition system components inspected more frequently.

⚠ WARNING

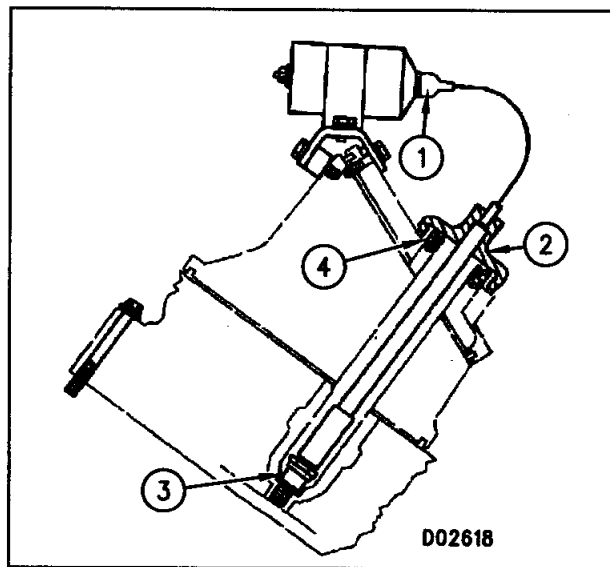
DO NOT OPERATE ENGINES equipped with external transformers when the internal seal between the valve cover and the spark plug adapter tube is damaged or missing. This seal prevents explosive crankcase gases from entering the spark plug adapter.

Perform one of the following procedures (depending upon the type of ignition system) to remove, clean, inspect, and install the spark plugs.

Altronic Ignition System

The Altronic ignition system has a transformer mounted separately from the spark plug.

1. Set the manual stop bypass switch to the OFF position. This will ground the magneto and discharge any capacitors that may be charged.



Wire (1), boot (2), spark plug (3), and seal (4).

2. Disconnect wire (1) from the transformer. Do not pull on the wire, damage to the wire could result.

3. Remove boot (2).

4. Ensure that the area around the spark plug is clean and free of dirt and debris. Use a 22 mm (.875 in) 2P-5481 Deep Well Socket with an extension in order to remove spark plug (3).

5. Clean the spark plug with a nonmetallic brush. Inspect the spark plug for corrosion, pitting, and wear. If the spark plug is in good condition, the spark plug may be installed. Install a new spark plug gasket. If the spark plug is not in good condition, install a new spark plug. Refer to the Parts Manual for the part number. Check the spark plug gap before installing the spark plug. Set the spark plug gap according to the engine Serial Number.

0.38 mm (.015 in) for 6NB and 7DB engines
0.30 mm (.011 in) for 6RJ and 3NK engines

NOTICE

Do not overtighten the spark plugs.

Do not use anti-seize compound on spark plug threads. Anti-seize compound acts as an insulator which inhibits proper heat transfer.

6. Ensure that the spark plug well and the threads are clean. Install the spark plug. Tighten the spark plug according to the engine Serial Number.

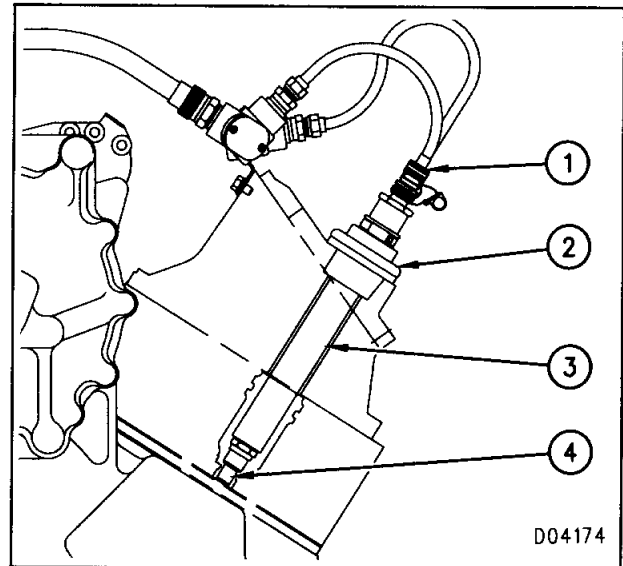
30 ± 4 N•m (22 ± 3 lb ft) for 6NB and 7DB engines
25 ± 5 N•m (18 ± 4 lb ft) for 6RJ and 3NK engines

7. Inspect seal (4), boot (2), and wire (1). If the components are in good condition, install the components. If a component is not in good condition, replace the old component with a new component.

CSA Ignition Systems

The CSA ignition system has an integral transformer that threads directly to the spark plug. The transformer and the spark plug are removed and installed separately.

1. Set the stop bypass switch to the OFF position. This will ground the magneto and discharge any capacitors that may be charged.



Wiring harness (1), boot (2), transformer (3), and spark plug (4).

2. Disconnect wiring harness (1). Do not pull on the wire, damage to the wiring harness could result.

3. Remove boot (2).

4. Remove transformer (3).

5. Ensure that the area around the spark plug is clean and free of dirt and debris. Remove spark plug (4) from the cylinder head. Retain the copper washer which fits between spark plug and transformer.

6. Clean the spark plug with a nonmetallic brush. Inspect the spark plug for corrosion, pitting, and wear. If the spark plug is in good condition, the spark plug may be installed. Install a new spark plug gasket. If the spark plug is not in good condition, install a new spark plug. Refer to the Parts Manual for the part number. If a new spark plug is installed, discard the old copper washer and install the new copper washer that is supplied with the new spark plug. Check the spark plug gap before installing the spark plug. Set the spark plug gap to 0.38 mm (.015 in).

NOTICE

Do not overtighten the spark plugs.

Do not use anti-seize compound on spark plug threads. Anti-seize compound acts as an insulator which inhibits proper heat transfer.

7. Ensure that the spark plug well and the threads are clean. Install spark plug (4) into the cylinder head. Tighten the spark plug to $30 \pm 4 \text{ N}\cdot\text{m}$ ($22 \pm 3 \text{ lb ft}$). Install the copper spacer.

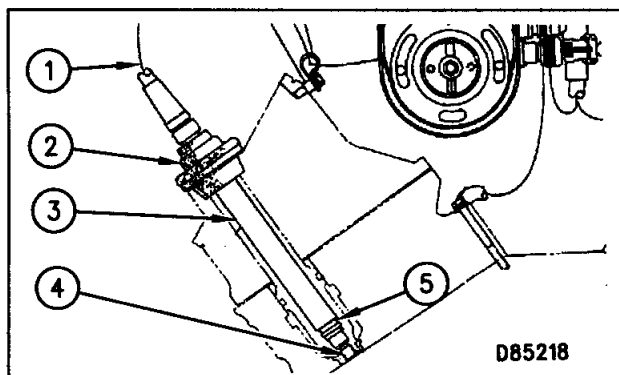
8. Install transformer (3). Tighten the transformer $\frac{1}{8}$ turn (45 degrees) past finger tight. Do not overtighten.

9. Inspect boot (2), and wiring harness (1). If the components are in good condition, install the components. If a component is not in good condition, replace the old component with a new component.

Fairbanks Morse Ignition Systems

Earlier engines may be equipped with the The Fairbanks Morse ignition system. The Fairbanks Morse ignition system has an integral transformer that threads directly to the spark plug. The transformer and the spark plug are removed and installed as an assembly.

1. Set the stop bypass switch to the OFF position. This will ground the magneto and discharge any capacitors that may be charged.



Wiring harness (1), boot (2), transformer (3), spark plug (4), and copper spacer (5).

2. Disconnect wiring harness (1). Do not pull on the wire, damage could result.

3. Remove boot (2).

4. Remove spark plug (3) and transformer (3) assembly.

5. Remove the spark plug from the transformer. Retain copper spacer (5).

6. Clean the spark plug with a nonmetallic brush. Inspect the spark plug for corrosion, pitting, and wear. If the spark plug is in good condition, the spark plug may be installed. If the spark plug is not in good condition, install a new spark plug. Refer to the Parts Manual for the part number. Check the spark plug gap before installing the spark plug. Set the spark plug gap to 0.38 mm (.015 in).

NOTICE

Do not overtighten the spark plugs.

Do not use anti-seize compound on spark plug threads. Anti-seize compound acts as an insulator which inhibits proper heat transfer.

NOTE: When installing a new spark plug, remove and discard the copper washer that is supplied with the spark plug. Install the factory supplied copper spacer between the spark plug and the transformer.

7. Fit copper spacer (5) between spark plug (4) and transformer (3). Tighten the spark plug to $47 \pm 3 \text{ N}\cdot\text{m}$ ($35 \pm 2 \text{ lb ft}$).

8. Install spark plug (4) and transformer (3) assembly. Tighten the assembly to $38 \pm 3 \text{ N}\cdot\text{m}$ ($28 \pm 2 \text{ lb ft}$).

9. Inspect boot (2), and wiring harness (1). If the components are in good condition, install the components. If a component is not in good condition, replace the old component with a new component.

Ignition System

Inspect/Adjust Timing

The timing should be checked and adjusted (if necessary) when ignition system maintenance is completed (i.e. spark plugs, timing control, etc).

Before adjusting the timing, have a gas analysis test made of the fuel being used. Your Caterpillar dealer is equipped to make the methane number calculations to determine the correct timing.

Detailed timing instructions for engines equipped with Fairbanks Morse and Altronic solid state ignition systems can be found in the engine Service Manual.

The timing instructions for integral transformer ignition systems require the use of a 9U-5358 Timing Light Kit. If using a different timing light, the procedure may vary. Contact your Caterpillar dealer for assistance.

NOTICE

Timing on the low tension lead (prior to the transformer) of a high energy ignition system with an inductive timing light can experience problems with some brands of timing lights. If the timing light does not operate, use a different brand or use a Caterpillar timing light. If the timing light remains on continuously, open the inductive pickup clip and block the clip open by inserting a piece of cardboard.



WARNING

DO NOT OPERATE ENGINES equipped with external transformers when the internal seal between the valve cover and the spark plug adapter tube is damaged or missing. This seal prevents explosive crankcase gases from entering the spark plug adapter.

NOTICE

Both the high voltage wire and the seal must be installed on all of the cylinders before the engine is operated. Failure to do this may allow a spark from the exposed lead to ignite crankcase vapors. Engine damage could result.

Altronic CSA Ignition System Timing

1. Remove the timing cover from the flywheel housing.
2. Use a 9U-5358 Timing Light Kit. Remove the cover plate from the rigid conduit tee nearest cylinder No.1. Carefully pull the primary wires from the tee that lead to cylinder No.1 and place the timing light clip around the leads.

The spark plug adapter must have the rubber boot and seal installed on the valve cover. The rubber boot protects the adapter from water, dirt, etc. The seal protects the adapter from crankcase gases. Detonation or preignition could result if the seal is not in place.

3. Start the engine according to the Starting the Engine procedure. Gradually increase the engine speed to the FULL LOAD rpm (refer to Information Plate).
4. Check the flywheel timing pointer with the timing light.

5. If timing adjustment is necessary, loosen the mounting bolts to the magneto. Turn the magneto as needed in order to obtain the correct timing. If unsure, consult your Caterpillar dealer in order to obtain the correct timing.

G3400 Gas Engine Timing Charts

The ignition timing information contained in the following chart reflects No.1 cylinder timing BTC (before top center).

Gas engine ignition timing varies with gas chemistry and inlet manifold air temperature (aftercooler condition). There are some gases that these engines cannot operate on. The following chart is a general guideline. Consult your Caterpillar dealer for specific timing requirements based on actual fuel gas chemistry.

No.1 Cylinder Timing BTC (Engine Stopped and Rated Speed)				
8.5:1 Piston Compression Ratio				
Engine Model	Aftercooler Water Temp.	Fuel Type	2 Ring Piston	3 Ring Piston
G3408 TA G3412 TA	32°C (90°F)	Pipeline	-	29.0°
G3408 TA G3412 TA	32°C (90°F)	Propane	-	16.0°
G3408 TA G3412 TA	54°C (130°F)	Pipeline	-	28.0°
G3408 TA G3412 TA	54°C (130°F)	Propane	-	15.0°
9.7:1 Piston Compression Ratio				
G3408 NA G3412 NA	-	Pipeline	-	34.0°
G3408 TA G3412 TA	32°C (90°F)	Pipeline	22.5°	23.0°
G3408 TA G3412 TA	54°C (130°F)	Pipeline	20.0°	22.0°
11.3:1 Piston Compression Ratio (LE Only)				
G3408 TA G3412 TA	32°C (90°F)	Pipeline	-	23.0°
G3408 TA G3412 TA	54°C (130°F)	Pipeline	-	23.0°

The correct air/fuel ratio is very important not only for combustion knock considerations, but also for achieving the best service life from gas engines.

If the air/fuel ratio is not in the correct or optimum range, the engine will not operate correctly. The test results from oil samples should be used as a basis for determining the air/fuel ratio adjustments.

Refer to the Service Manual for additional information. Consult with your Caterpillar dealer for assistance.

LHV—Low Heat Value

NOTE: Consult your Caterpillar dealer for information relating to timing and the use of field gas and all other gases not included in the chart above.

Air/Fuel Ratio

Engines with air/fuel ratios that have been adjusted so that all of the fuel and all of the oxygen is consumed are known to have stoichiometric air/fuel ratios.

Air/fuel ratios between 10:1 and 11:1 permits the optimum fuel consumption at rated power, however it promotes rapid nitration of the oil.

If the air/fuel ratio is changed, it must be done with care because the change have a negative effect on the power of the engine or result in excessive exhaust temperature which could affect the service life of the engine.

Air Inlet and Exhaust Piping

Inspect

Inspect the air inlet system piping, elbows and gaskets, and the aftercooler for cracks or damage. Inspect the exhaust manifolds for cracks and leaks.

Check for loose clamps. Tighten the clamps if necessary. Have the components repaired or replaced as necessary. Refer to the Service Manual, or consult your Caterpillar dealer for assistance.

Belts

Check/Adjust

Inspect the condition and adjustment of alternator and accessory drive belts. Examine all drive belts for wear and replace if they show any signs of wear. Loose or worn pulley grooves cause belt slippage and low accessory drive speed. If belts are too loose, they vibrate enough to cause unnecessary wear on the belts and pulleys and possibly slip enough to cause overheating.

If belts are too tight, unnecessary stresses are placed upon the pulley bearings and belts which might shorten the life of both.

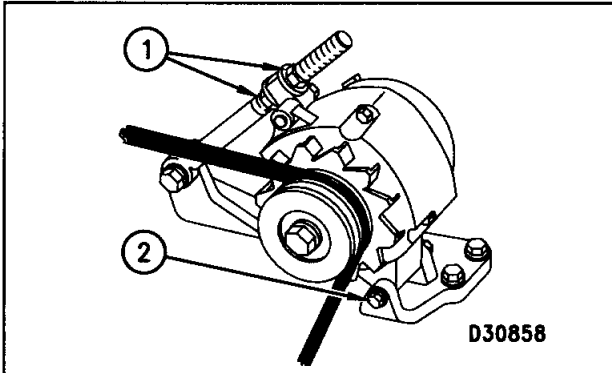
If one belt in a set requires replacement, always install a new matched set of belts. Never replace just the worn belt. If only the worn belt is replaced, the new belt will carry all the load, as it will not be stretched as much as the older belts. All the belts will fail in rapid succession.

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

To check the belt tension, apply 110 Newton (25 lb) force, perpendicular to the belt, midway between the pulleys. Measure the belt deflection. Correctly adjusted belts will deflect 13 to 19 mm ($\frac{1}{2}$ to $\frac{3}{4}$ in).

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

Alternator Belt Adjustment



Typical belt assembly mounting bolt (1) and adjusting nuts (2).

1. Loosen mounting bolt (1).
2. Turn adjusting nuts (2) in order to increase or decrease the belt tension.
3. Tighten the adjusting nuts. Tighten the mounting bolt. Refer to the Torque Specifications in this manual.
4. Install the belt guard.

If new belts are installed, check the belt adjustment again after 30 minutes of engine operation.

Fan Belt Adjustment

1. Loosen the mounting bolts.
2. Turn the adjusting bolt in order to increase or decrease the belt tension.
3. Tighten the adjusting nuts. Tighten the mounting bolts. Refer to the Torque Specifications in this manual.

Hoses and Clamps

Inspect

Inspect all hoses for leaks due to cracking, softness and loose clamps. Replace hoses that are cracked or soft and tighten loose clamps.

NOTICE

Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Inspect all lines, tubes and hoses carefully. Tighten all connections to the recommended torque.

Check for the following:

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

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. Due to extreme temperature changes, hose will heat set. Heat setting causes hose clamps to loosen. Loose hose clamps can result in leaks. A constant torque hose clamp will help prevent loose hose clamps.

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 the constant torque hose clamps.

Replace

Perform this procedure with the engine stopped and cold.

1. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.
2. Drain the coolant from the cooling system to a level below the hose being replaced.
3. Remove the hose clamps, disconnect the old hose and replace with a new hose.
4. Install hose clamps. Refer to the Torque Specifications section in this manual.
5. Add the proper coolant mixture to the cooling system. Refer to the Cooling System Specifications section in this manual. Fill the system to the proper level.
6. Clean the cooling system filler cap. Inspect the cooling system filler cap gaskets. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Clean the cooling system filler cap receptacle. Install the cooling system filler cap. Start the engine and inspect for cooling system leaks.

Engine Mounts

Inspect

Caterpillar recommends inspecting the engine mounts and generator or other driven equipment mounting systems for deterioration and proper bolt torque. This will prevent excessive engine and driven equipment vibration caused from loose and/or improper mounting. Consult your Caterpillar dealer or refer to the Installation and Application Guide for Gas Engines or the Service Manual for the recommended torque values.

Crankshaft Vibration Damper

Inspect

Visconic Damper

The visconic damper has a weight, located inside a fluid filled case. The weight moves in the case to limit torsional vibration. Inspect the damper for evidence of dents, cracks or leaks of the fluid.

Damage to, or failure of, the crankshaft vibration damper will increase torsional vibrations and result in damage to the crankshaft and other engine components. A deteriorating damper will cause excessive gear train noise at variable points in the speed range.

Inspect the damper. Replace the damper if necessary.

Replace the damper if:

- The engine has had a failure because of a broken crankshaft
- S•O•S analysis has detected that the crankshaft front bearing is badly worn or there is a large amount of gear train wear that is not caused by a lack of oil
- The damper is dented, cracked, or leaking

Removal and Installation

Refer to the Service Manual for the damper removal procedure and for the damper installation procedure. Consult your Caterpillar dealer for assistance.

Engine Protective Devices

Inspect/Check

Alarms and shutoffs must work properly in order to provide timely warning to the operator and protection for the engine. It is impossible to tell if the engine protective devices are in good working order during normal operation. Engine malfunctions must be simulated in order to test the alarm and shutoff components.

In order to prevent damage to the engine, only authorized service personnel or your Caterpillar dealer should perform the tests. Contact your Caterpillar dealer or refer to the Service Manual for more information.

Visual Inspection

Visually check the condition of all gauges, sensors, and wiring. Look for loose, broken, or damaged wiring and components. Repair or replace any damaged wiring or components immediately.

Turbocharger

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side). Since the crankcase fumes are ingested through the inlet air system, oil and combustion by-products may collect in these two areas.

This buildup, over time, can contribute to loss of engine power, increased black smoke, and overall loss of engine efficiency. This buildup is only a possible contributor to these conditions.

Operating the engine until the turbocharger fails can severely damage the turbocharger's compressor wheel and/or the engine. Damage to the turbocharger compressor wheel could allow parts from the compressor wheel to enter the engine cylinder, causing additional damage to the piston, valve, and cylinder head.

The following conditions can indicate severe service operation:

- High altitude operation— above 1525 m (5000 ft)
- Arctic operation— regular cold starts at temperatures below 0°C (32°F)
- Extending maintenance beyond the recommended intervals
- Frequent hot shutdowns— minimum cool down periods after high load operation

NOTICE

Turbocharger bearing failures can cause large quantities of oil to enter the air intake and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation will not cause problems as long as a turbocharger bearing failure has NOT occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine speed up at no load), DO NOT continue engine operation until the turbocharger is repaired or replaced.

An inspection/check of your turbocharger will minimize unscheduled downtime and reduce the chance for potential damage to other engine parts.

NOTE: Turbocharger components require precision clearances and balancing due to operation at high rotational (torsional) speeds. Severe Service Applications can accelerate component wear and may suggest the need to Inspect/Repair/Replace the cartridge at reduced intervals to ensure maximum reliability and retention of the full core.

Removal and Installation

For removal and installation, or repair/replacement options of turbochargers, see your Caterpillar dealer. Refer to the Service Manual for this engine or consult your Caterpillar dealer for the procedure and specifications.

Inspect/Check/Clean

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually check for oil leaks.
2. Turn the compressor wheel and turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and turbine wheel for contact with the turbocharger housing. There should NOT be any visible signs of contact between the turbine or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating wheel(s) and the housing, the turbocharger should be reconditioned or replaced.
3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, it indicates a possible turbocharger oil seal leak.

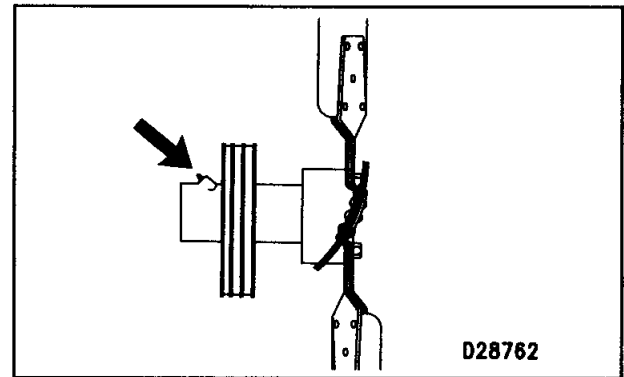
The leak may be the result of extended engine operation at low idle or an intake air line restriction (plugged air filters), which causes the turbocharger to "slobber".

4. Use a dial indicator to check end clearance on the shaft. Attach the dial indicator point on the end of turbocharger shaft. Push and pull the other end of the shaft. Note the total dial indicator reading. If the measured end play is greater than the Service Manual specifications, repair or replace the turbocharger. Measured end play less than the minimum Service Manual specifications could indicate carbon buildup on the turbine wheel. The turbocharger should be disassembled for cleaning and inspection if the measured end play is less than the minimum Service Manual specifications.
5. Inspect the turbine housing bore for corrosion.
6. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.
7. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

Fan Drive Bearing

Lubricate

NOTE: Some engines are equipped with a sealed fan drive bearing which does not require lubrication.



Fan drive grease fitting.

Lubricate the fan drive grease fitting with Bearing Lubricant Special Purpose Grease or equivalent.

Inspect the fan drive pulley assembly. If the shaft is loose, an inspection of the internal components should be made. If the assembly should require disassembly, refer to the SMHS7001, Assembly of Fan Drive Pulley Assemblies, or refer to the Service Manual.

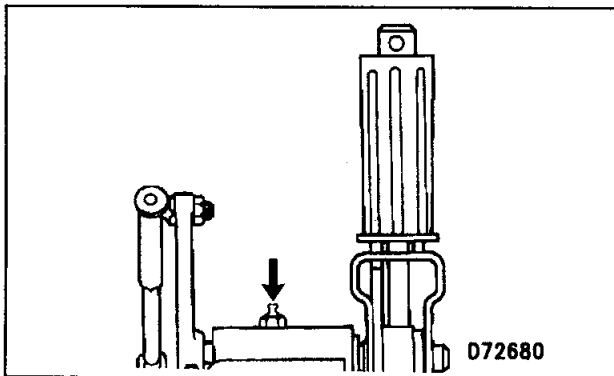
Carburetor Linkage and Governor Control Linkage

Check/Adjust

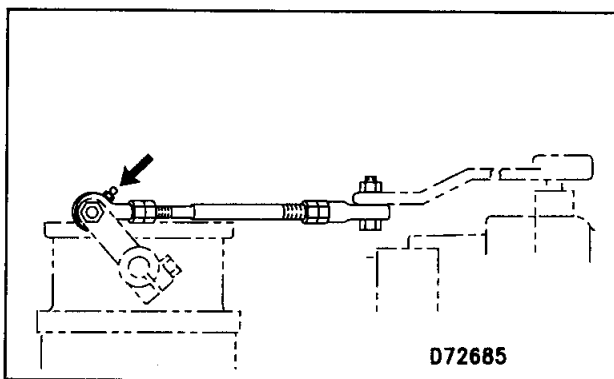
Adjust the carburetor linkage and the governor linkage to obtain the dimensions shown at the full fuel position on the carburetor. Refer to the Service Manual, or consult your Caterpillar dealer.

Check the operation of the carburetor and governor. Ensure that the throttle plate does not bind.

Lubricate



Governor control shaft grease fitting.



Carburetor linkage grease fitting.

Lubricate the grease fittings on the linkage between the carburetor and governor (or actuator). The engine may have additional lubrication points not shown in the illustrations above.

Governor Sump Oil

The governor oil sump is located inside the governor drive housing. If the governor drive housing has been rebuilt, or if the engine has been in storage, the governor oil sump will need to be filled prior to starting the engine in order to prevent damage to the governor. Consult your Caterpillar dealer for assistance.

Cylinder Pressure Blowby

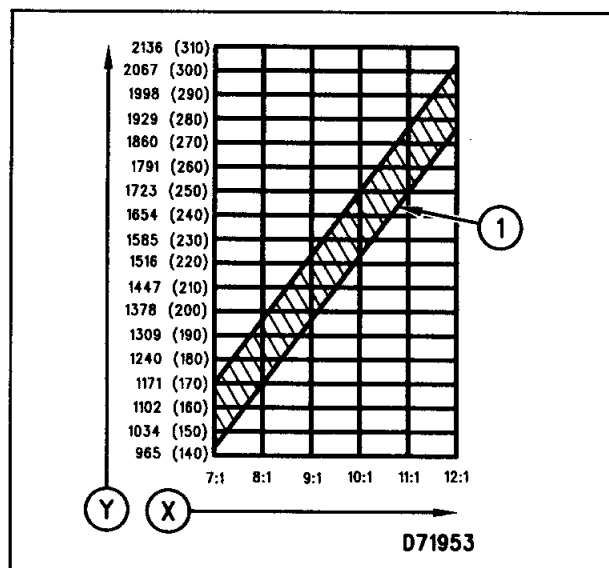
Crankcase blowby and cylinder pressure, as well as oil analysis, provide maintenance management feedback regarding the operating condition of gas engines. Compression is given because it is common in the industry and can easily be measured during spark plug inspection. These preventive maintenance checks can be used to monitor valve and ring condition.

A common result of a lubrication oil problem is a stuck piston ring(s). Piston ring problems will raise cylinder blowby which deteriorates the oil quickly.

Crankcase blowby is measured with the Caterpillar 8T-2700 Indicator Group. The typical blowby rate for the G3400 engines within the first 1500 hours should fall in the range of 22 to 37 L/Bkw-hr (.6 to 1.0 cu ft/Bhp-hr).

Refer to SEHS8712, Using the 8T-2700 Blowby/Airflow Indicator Group. The Special Instruction is provided with the blowby measurement indicator. Record the cylinder pressure on the Exhaust Valve Data Sheet. Refer to the Exhaust Valve Stem Projection topic.

The cylinder pressure reading can help identify the cylinder with the ring problems, etc. Refer to the following graph for typical cylinder pressures.



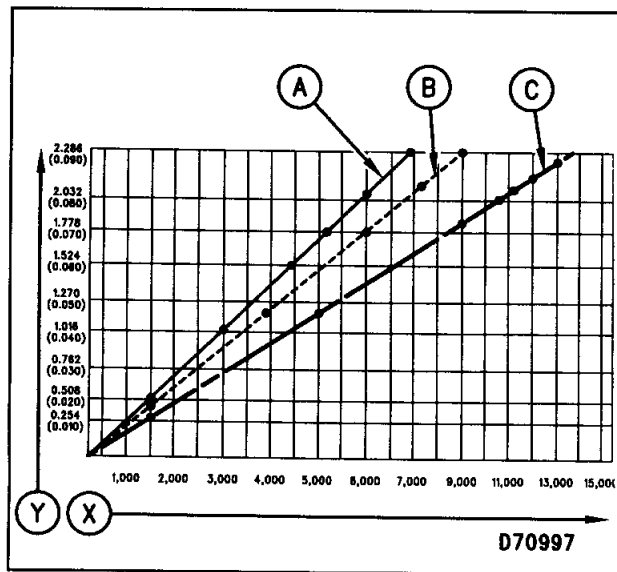
Y = Pressure in kPa (psi) at normal cranking speed.
X = Engine compression ratio.
(1) = Normal range.

If an adverse condition is identified by oil analysis and blowby measurement, the engine should be immediately scheduled for inspection. The piston with the stuck ring(s) should be repaired or replaced. Record the values for each cylinder on the Exhaust Valve Data Sheet.

Refer to the Service Manual or your Caterpillar dealer for more information.

Exhaust Valve Stem Projection

Base line exhaust valve stem projection measurements should be taken at initial start-up of the engine or at least at the first oil change interval (First 750 Hours). This maintenance is important to determine Top End maintenance for Caterpillar gas engines.



Schedules A, B, and C.

Y = Valve stem projection measurement in mm (in).

X = Maintenance measurement interval in service hours.

Schedule A, B, and C are average values which help to determine wear rate and valve stem projection. Based on the initial measurement at the first oil change interval, the next valve stem projection measurement interval can be determined by using one of the three schedules.

For example, according to Schedule C, if at 1500 Hours your measurement is 0.254 mm (.0100 in), you should schedule your next measurement interval at 5000 Hours.

Measure/Record

Measure and record each valve stem projection above the top deck of the cylinder head.

The exhaust valve stem projection should be monitored periodically until the valve stem projection is 70 percent of the 2.30 mm (.090 in) limit to determine optimum Top End maintenance interval. After reaching 70 percent of the limit [1.60 mm (.063 in)], cylinder head service should be scheduled and exhaust valve stem projection measurements are to be made Every Month until the Top End maintenance is performed.

Cylinder head maintenance should be scheduled and work should be completed before the measurement reaches the limit of 2.30 mm (.090 in). To determine the optimum Top End maintenance interval, monitor the exhaust valve stem projection on a schedule based on valve wear rate as defined by the following chart.

Use the Exhaust Valve Data Sheet to record exhaust wear, crankcase blowby, and cylinder pressure. The data sheet should be duplicated in order to maintain a continuous record. The leakage method to determine cylinder condition is the preferred method.

Exhaust Valve Data Sheet

Engine Model _____

Customer Identifier _____

Serial Number _____

Arrangement Number _____

Model _____

Hours-Last Measurement _____

Cylinder Number	Exhaust Valve Closest To	Current	Valve Stem Projection minus Initial	= Wear	Cylinder Pressure
1	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____
2	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____
3	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____
4	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____
5	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____
6	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____
7	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____
8	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____
9	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____
10	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____
11	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____
12	Inside (Pushrod)	_____	_____	_____	_____
	Outside (Exhaust Manifold)	_____	_____	_____	_____

Valve Bridge, Valve Lash

Check/Adjust

Due to initial wear and seating of valve train components, the initial valve lash adjustment is recommended at the first scheduled oil change interval.

Naturally Aspirated Engines

After the initial valve lash check and adjustment, the valve lash check and adjustment is scheduled Every 1500 Hours or Two Months (every other oil change interval) for naturally aspirated engines.

Turbocharged Engines

The valve lash check and adjustment is scheduled Every 750 Hours or Monthly (every oil change interval) for turbocharged engines.

Valve Bridge

Check the valve bridge before setting the valve lash. Ensure that the valve bridge is seated equally on both valve stems. Adjust the valve bridge (if necessary) before setting the valve lash.

NOTICE

Operation of Caterpillar engines with improper valve adjustments will reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

Only qualified service personnel should perform this maintenance. Refer to the Service Manual or your Caterpillar dealer for the complete valve lash adjustment procedure.

WARNING

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

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

Valve Lash

The following charts list the valve lash setting and the crankshaft positions for valve lash setting.

Valve Lash Setting	
Inlet	0.38 mm \pm 0.08 mm (0.015 in. \pm .003 in)
Exhaust	1.02 mm \pm 0.08 mm (0.040 in. \pm .003 in)

Adjustment is not necessary when the valve lash clearance measures within the tolerance.

Crankshaft Positions For Valve Lash Setting		
G3408 Engine	Check/Adjust With No.1 Piston on: ¹	
	TC Compression Stroke	TC Exhaust Stroke
	SAE Standard (Counterclockwise) Rotation Engines as Viewed from Flywheel End	
Inlet Valves	1-2-5-7	3-4-6-8
Exhaust Valves	1-3-4-8	2-5-6-7
G3412 Engine	Check/Adjust With No.1 Piston on: ¹	
	TC Compression Stroke	TC Exhaust Stroke
	SAE Standard (Counterclockwise) Rotation Engines as Viewed from Flywheel End	
Inlet Valves	1-3-4-6-7-12	2-5-8-9-10-11
Exhaust Valves	1-4-5-8-9-12	2-3-6-7-10-11

¹ Place the No.1 piston at the top center (TC) position and make identification for the correct stroke. After the top center position for a particular stroke is found and adjustments are made for the correct cylinders, remove the timing bolt and turn the flywheel 360 degrees in the direction of normal engine rotation. This will put the No.1 piston at top center (TC) position on the next stroke. Install the timing bolt in the flywheel and complete the adjustments for the cylinders that remain.

Every 1500 Hours

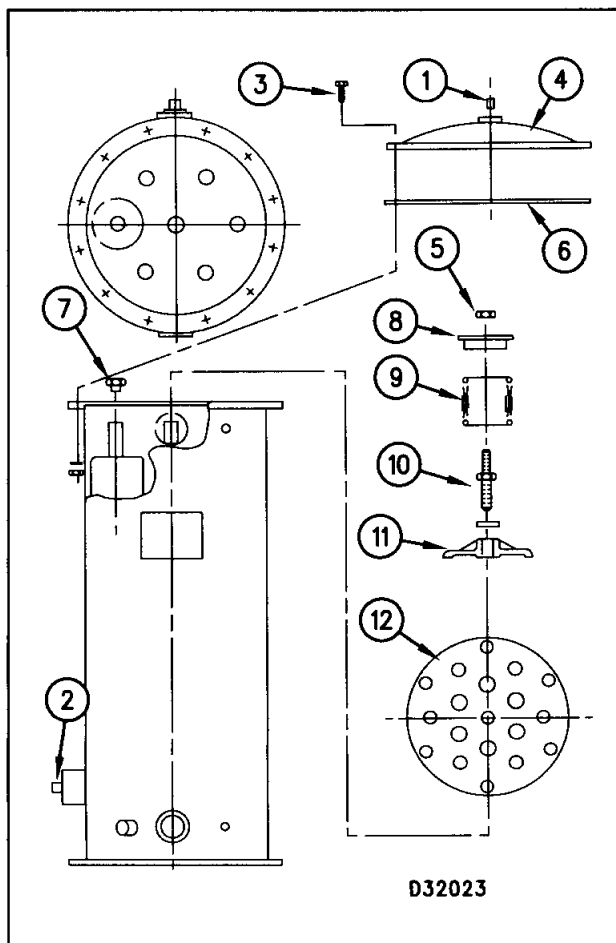
You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Auxiliary Oil Filter System

Replace Filter Elements

If equipped with Caterpillar auxiliary oil filter system, replace auxiliary oil filter elements Every 1500 Hours or Two Months (every other oil change). Perform this maintenance when the engine crankcase oil and engine oil filters are replaced.

Perform this maintenance after the oil has been drained from the auxiliary oil filter canister. Refer to the Lubrication System Drain Oil topic.



1. Remove twelve nuts, washers and cap screws (3) and vent plug (1) from cover (4).
2. Remove cover (4). Do not damage cover gasket (6).

WARNING

Possible injury can result when removing nut, retainer and hold down spring. Spring force will be released when nut and retainer are removed. Be prepared to hold the retainer as the nut is loosened.

3. Remove nut (5), spring retainer (8) and hold down spring (9). Spring force will be released when nut (5) and retainer (8) are removed. Be prepared to hold the retainer as the nut is loosened.

4. Remove spider bolt (10). Remove washer and spider (11). Remove hold-down plate assembly (12).

5. Remove the oil filter elements. Clean the shell assembly thoroughly with a clean cloth.

Inspect the oil filter elements for metal debris. An excessive amount of debris in the oil filter elements may be indicative of a pending failure. Due to normal wear, friction, etc, it is not uncommon to find small amounts of debris in the oil filter elements. Consult your Caterpillar dealer to arrange for further analysis if an excessive amount of debris is found in the oil filter elements.

6. Ensure that standpipe plugs (7) are tightly sealed.

7. Install drain plug (2). Tighten drain plug (2) to $70 \pm 14 \text{ N}\cdot\text{m}$ ($50 \pm 10 \text{ lb ft}$).

8. Install new auxiliary oil filter elements. Seven oil filter elements are required.

NOTICE

Ensure that the baffle on the hold-down plate assembly is in front of the inlet opening.

9. Install hold-down plate assembly (12), washer and spider (11) and spider bolt (10). Tighten spider bolt (10).

- 10.** Install hold-down spring (9) on spider. Install spring retainer (8) and nut (5) on spider bolt (10).
- 11.** Tighten nut (5) to compress the hold-down spring (9) until the spring retainer bottoms out on the spider bolt (10). DO NOT over tighten.
- 12.** Add oil to the canister. Refer to the Auxiliary Oil Filter Refill Capacities chart for the amount of oil to fill the canister.
- 13.** Inspect cover gasket (6) for tears, breaks or other damage. If the cover gasket is damaged, replace the old cover gasket with a new cover gasket. Install cover gasket (6). Install cover (4).
- 14.** Install twelve cap screws, washers and nuts (3). Tighten nuts sequentially around the cover until snug. Torque the nuts to $100 \pm 15 \text{ N}\cdot\text{m}$ ($75 \pm 11 \text{ lb ft}$).
- 15.** Install vent plug (1).
- 16.** Before starting the engine, ensure your oil level is within the correct operating level or range on the ENGINE STOPPED side of the dipstick. Refer to the Lubrication System Fill topic.

Valve Bridge, Valve Lash, and Exhaust Valve Stem Projection

Naturally Aspirated Engines

Due to initial wear and seating of valve train components, the initial valve lash adjustment is recommended at the first scheduled oil change interval.

After the initial valve bridge and valve lash check and adjustment, naturally aspirated engines should have the valve bridge and the valve lash checked and adjusted Every 1500 Hours or Two Months.

Base line exhaust valve stem projection measurements should be taken at the initial start-up of the engine or at least at the first oil change interval (First 750 Hours).

Refer to the Valve Bridge and Valve Lash topic and refer to the Exhaust Valve Stem Projection topic in the Every 750 Hours section.

Every 4000 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

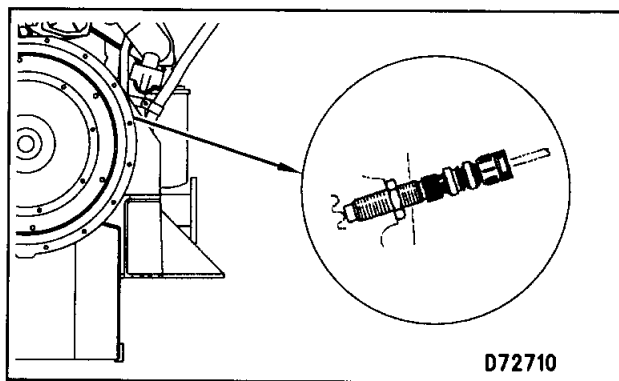
Magnetic Pickups

Initial magnetic pickup inspection and adjustment is recommended at the first scheduled oil change interval (First 750 Hours).

Subsequent magnetic pickup inspection and adjustment should be performed Every 4000 Hours.

Magnetic pickups mounted in the flywheel housing function as speed sensors. The initial magnetic pickup inspection and adjustment is performed in order to ensure that the magnetic pickup can operate properly due to initial wear of the flywheel ring gear and the starter pinion. This maintenance is performed in order to prevent a buildup of metal particles which would interrupt the proper operation of the magnetic pickup.

Inspect/Adjust



Magnetic pickups are mounted in the flywheel housing.

1. Remove the magnetic pickup from the flywheel housing. Check the condition of the end of the magnetic pickup. Check for signs of wear and contaminants.
2. Clean the metal shavings and other debris from the face of the magnet.
3. Install and adjust the magnetic pickup as described in the Service Manual.

Driven Equipment

To minimize engine crankshaft and driven equipment bearing problems and excessive vibration, the alignment between the engine and driven equipment such as generators, pumps, transmissions, etc, should be inspected. Check alignment as per the OEM specifications for all driven equipment. Torque all bolts to specifications.

Inspect Alignment

Upon reassembly of the drive line and driven unit, check alignment as outlined in SEHS7654, Alignment-General Instructions. For additional information regarding alignment, consult with your Caterpillar dealer.

Inspect Flexible Rubber Couplings (If Equipped)

Inspect flexible coupling, if equipped, for stress damage. Replace all elements if the coupling group has failed.

Visually inspect the rubber couplings for obvious fraying, deterioration or wear. If any of these conditions are evident, replace the rubber couplings. Refer to the OEM instructions for the procedure to replace the rubber couplings.

Check Spline Type Couplings (If Equipped)

Visually inspect the spline type couplings for excessive wear and proper lubrication. Refer to the OEM specifications for driveline end play.

If the spline type coupling needs to be lubricated, refer to the OEM instructions. If excessive wear is evident or the driveline end play is out of specification, see your Caterpillar dealer for installation and application information.

Refer to the OEM instructions for the procedure to replace the spline type couplings.

Lubricate

For lubrication and maintenance requirements relating to driven equipment such as generators, blowers, compressors, clutches and other equipment, refer to the OEM recommendations.

Inspect, Rebuild, or Exchange

If the engine is operated until the components fail, additional engine damage can result. Caterpillar recommends that these components be inspected in order to ensure reliable engine performance:

- Jacket Water Pump
- Starting Motor
- Alternator

Maintenance Options

Rebuild with New Parts – Genuine Caterpillar parts are constantly tested and modified to incorporate the latest design advancements. Your Caterpillar dealer can rebuild or provide the parts needed for overhauling the components.

New Components – Replace worn or failing components with new components.

Repair Kits – The kits can be obtained from your Caterpillar dealer and include all the necessary parts and instructions to repair the components, in either the owner's maintenance shop or at a Caterpillar servicing dealer's facility. Repair kits simplify parts ordering, help speed repairs and reduce parts cost.

Exchange – This cost-cutting service permits you to exchange worn engine components for quality Caterpillar Remanufactured or Caterpillar dealer rebuilt components on an over-the-counter basis.

Before deciding which method is best, make sure all of the options and costs associated with repair have been considered. Some considerations are:

- the costs associated with using separate parts from inventory versus the cost of a repair kit
- downtime costs while the product is being rebuilt or repaired
- total parts and labor costs for repairs versus the actual Remanufactured cost
- remanufactured components from Caterpillar (if available) are covered by a standard, factory warranty

Caterpillar Recommendation

If there is a component you need, contact your Caterpillar dealer to see if the component is offered under the Dealer Exchange Component Program.

Removal and Installation

Refer to the established procedure in the service manual to remove and install these components or contact your Caterpillar dealer for assistance.

Jacket Water Pump

A failed water pump might cause severe engine overheating problems that could result in cracks in the cylinder head, a piston seizure or other potential damage to the engine.

Visually inspect the water pump for leaks. If leaking is observed, replace all seals. Refer to the Service Manual for the disassembly and assembly procedure.

Inspect the component for wear, cracks, pin holes and proper operation. Refer to the Service Manual or consult with your Caterpillar dealer if repair or replacement is needed.

Starting Motor

The flywheel ring gear and the starter pinion must be in good condition in order for the engine to start and operate properly. The engine will not start if the starter pinion does not engage. Ring gear teeth and starter pinion teeth can be chipped because of irregular starter solenoid operation.

Inspect the starting motor for proper operation. Check and clean all electrical connections. Listen for a grinding sound when starting the engine. Inspect the flywheel ring gear and starter pinion for wear. Check for wear patterns on the gear teeth. Check for broken and chipped teeth.

If damaged teeth are found, replace the ring gear and starter pinion. The starter solenoid may also need to be replaced. Refer to the Service Manual or consult with your Caterpillar dealer if repair or replacement is needed.

Alternator

Caterpillar recommends a scheduled inspection of the alternator. Inspect the alternator for loose connections and proper battery charging. Inspect the ammeter gauge during engine operation to ensure the batteries and/or electrical system is performing correctly. Make repairs as necessary. Refer to the Service Manual.

Check the alternator and battery charger for proper operation. If the batteries are properly charged, ammeter reading should be very near zero. All batteries should be kept charged. The batteries should be kept warm because temperature affects the cranking power. If the battery is too cold, it will not crank the engine, even if the engine is warm.

When the engine is not run for long periods of time or run for short periods, the batteries may not fully recharge. Ensure the alternator performs properly to charge the battery and to help prevent the battery from freezing.

Transformers

WARNING

Ignition systems can cause electrical shocks. Avoid contacting ignition components and wiring unless the Engine Control Switch (ECS) is in the STOP or OFF/RESET position. This will immediately discharge the ignition system when the ignition harness is reconnected. DO NOT inspect valve mechanism or transformers while the engine is running. Personal injury or death may result.

Test Resistance

The ignition transformer causes an increase of the magneto voltage. For good operation, the connections (terminals) must be clean and tight. The negative transformer terminals, with (–) mark, for each transformer are connected together and to ground.

Check the ignition transformers for loose connection, moisture, short or open circuits. Check the low and high tension wiring resistance using the procedures in the Service Manual, or contact your Caterpillar dealer.

Every Two Years

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Cooling System (Extended Life Coolant Only)

Add Extender

Caterpillar Extended Life Coolant (ELC) does not require the frequent Supplemental Coolant Additive (SCA) additions associated with the present conventional coolants. Only a "one time" coolant Extender is required.

Extender should be added to ELC after 3000 service hours or two years, whichever comes first.

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

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.
2. It may be necessary to drain enough coolant from the cooling system to allow for the addition of the Extender.
3. Add Extender according to the requirements for your engine's cooling system capacity. Refer to the Refill Capacities chart in this manual for the cooling system capacity for your engine. Refer to the Coolant Specifications in this manual for the Caterpillar ELC Extender Additions chart.
4. Clean the cooling system filler cap. Inspect the cooling system filler cap gaskets. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Clean the cooling system filler cap receptacle. Install the cooling system filler cap.

Cooling System (Conventional HD Coolant/Antifreeze Only)

Drain/Clean/Replace Coolant

Clean/Flush the cooling system before the recommended maintenance interval if:

- the coolant is heavily contaminated
- the engine overheats frequently
- foaming is observed
- the oil cooler has failed, allowing oil to contaminate the coolant
- fuel has entered the cooling system and contaminated the coolant

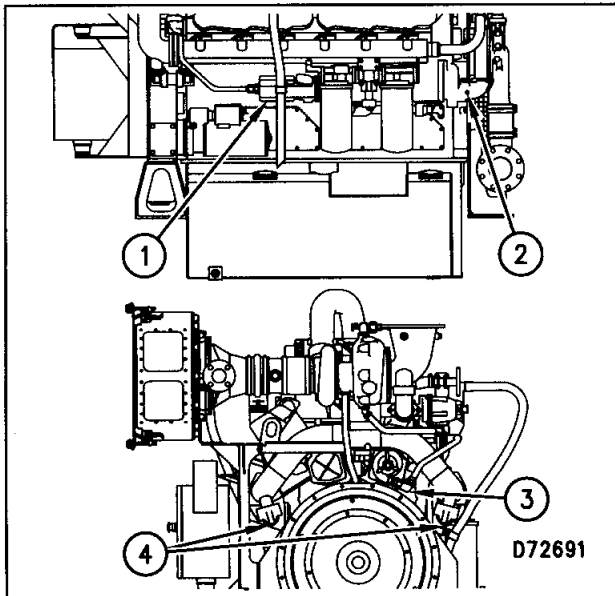
NOTICE

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

NOTE: A good time to inspect the water pump, replace the thermostat, and replace hoses is when your engine's cooling system has been drained.

Drain

1. Stop the engine and allow the engine to cool. Close the SCAC water inlet. Loosen the cooling system filler cap slowly to relieve any pressure, and remove the cooling system filler cap.
2. Open the cooling system drain valve (if equipped).



Cooling system drain plug locations: under the oil cooler bonnet (1), on elbow (2), on the outlet elbow of the SCAC pump (if equipped) (3), and on elbow(s) 4.

If not equipped with a cooling system drain valve, remove the cooling system drain plugs. Be sure to drain all of the cooling system components:

- expansion tank or radiator
- water pumps
- aftercooler
- thermostatic valve
- engine block
- all coolant water lines

If freezing temperatures are expected, drain the line between the heat exchanger and the SCAC water pump in order to drain the aftercooler housing.

Allow the coolant to drain.

NOTICE

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

For information regarding disposal and recycling of used coolant:

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

Clean

1. Flush the cooling system with clean water to remove any debris.
2. Close the cooling system drain valve (if equipped). Clean the cooling system drain plugs. Clean the cooling system drain plug fittings. Install the cooling system drain plugs. Refer to the Torque Specifications section in this manual.

NOTICE

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

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of cleaner per 15 L (4 US gal) of cooling system capacity. Install the cooling system filler cap.
4. Start and run the engine for a minimum of 30 minutes with a coolant temperature of at least 82°C (180°F). Stop the engine and allow the engine to cool.
5. Loosen the cooling system filler cap slowly to relieve any pressure, and remove the cooling system filler cap. Open the cooling system drain valve (if equipped) or remove the cooling system drain plugs. Allow the cleaning solution to drain. Flush the cooling system with clean water until the draining water is clear. Close the cooling system drain valve (if equipped). Clean the cooling system drain plugs. Clean the cooling system drain plug fittings. Install the cooling system drain plugs. Refer to the Torque Specifications section in this manual.

Cooling Systems with Heavy Deposits or Plugging

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

Follow the same steps as outlined above, with the following modifications to steps 3 and 4:

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of cooling system capacity. Install the filler cap.

4. Start and run the engine for a minimum of 90 minutes with a coolant temperature of at least 82°C (180°F). Stop the engine and allow the engine to cool.

Fill

Refer to the Coolant Specifications for all information regarding acceptable water, coolant/antifreeze, and supplemental coolant additive requirements. Refer to the Refill Capacities chart for the capacity of your engine's cooling system.

NOTICE

Fill the cooling system with the coolant solution at a rate of 19 L (5 US gal) or less per minute in order to avoid air locks.

1. Fill the system with the recommended coolant/antifreeze mixture.

2. Start and run the engine with the cooling system filler cap removed. Allow the coolant to warm, the thermostat to open and the coolant level to stabilize. Check the coolant level. Add coolant mixture if necessary to bring the coolant to within 13 mm (½ in) below the bottom of the fill tube or the correct level on the sight glass (if equipped).

3. Clean the cooling system filler cap. Clean the cooling system filler cap receptacle. Inspect the cooling system filler cap gaskets. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. If the gaskets are not damaged, use a 9S-8140 Pressurized Pump Group to pressure test the cooling system filler cap. The correct pressure is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not hold the correct pressure, install a new cooling system filler cap.

4. Install the cooling system filler cap. Start the engine. Inspect for coolant leaks and proper operating temperature.

Every Four Years

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

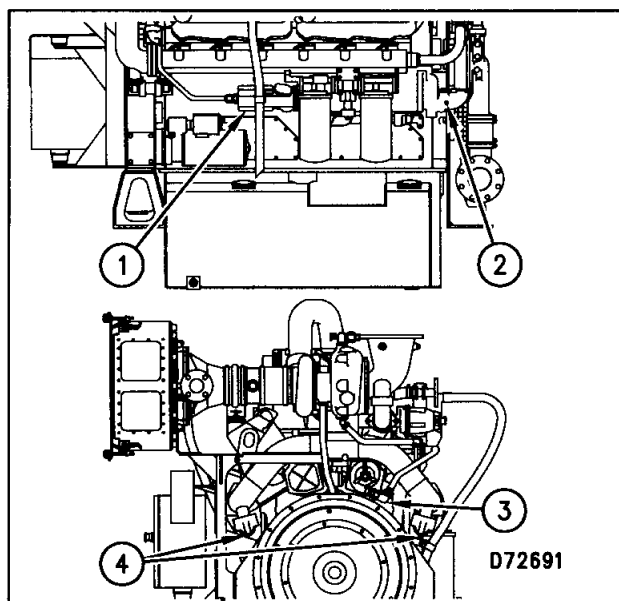
Cooling System (Extended Life Coolant Only)

Drain/Flush/Replace ELC

Only clean water is needed to clean and flush the cooling system when ELC is drained and replaced.

Drain

1. Stop the engine and allow the engine to cool. Close the SCAC water inlet. Loosen the cooling system filler cap slowly to relieve any pressure, and remove the cooling system filler cap.
2. Open the cooling system drain valve (if equipped).



Cooling system drain plug locations: under the oil cooler bonnet (1), on elbow (2), on the outlet elbow of the SCAC pump (if equipped) (3), and on elbow(s) 4.

If not equipped with a cooling system drain valve, remove the cooling system drain plugs. Be sure to drain all of the cooling system components:

- expansion tank or radiator
- water pumps
- aftercooler
- thermostatic valve
- engine block
- all coolant water lines

If freezing temperatures are expected, drain the line between the heat exchanger and the SCAC water pump in order to drain the aftercooler housing.

NOTICE

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

For information regarding disposal and recycling of used coolant, contact your Caterpillar dealer or contact Caterpillar Service Technology Group:

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

Flush

1. Flush the cooling system with clean water to remove any debris.
2. Close the cooling system drain valve (if equipped). Clean the cooling system drain plugs. Clean the cooling system drain plug receptacles. Install the cooling system drain plugs. Refer to the Torque Specifications section in this manual.
3. Fill the cooling system with clean water. Install the cooling system filler cap. Operate the engine until the temperature reaches 49 to 66°C (150 to 120°F).

4. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly to relieve any pressure, and remove the cooling system filler cap. Open the cooling system drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water.

5. Repeat steps 3 and 4.

Fill

NOTICE

Fill the cooling system with the coolant solution at a rate of 19 L (5 US gal) or less per minute in order to avoid air locks.

1. Close the cooling system drain valve (if equipped). Install the cooling system drain plugs. Fill the cooling system with ELC. Refer to the Refill Capacities chart for the amount of ELC needed to refill your system.

2. Start and run the engine with the cooling system filler cap removed. Allow the ELC to warm, the thermostat to open, and the coolant level to stabilize. Add ELC if necessary to bring the coolant to the proper level.

3. Clean the cooling system filler cap. Clean the cooling system filler cap receptacle. Inspect the cooling system filler cap gaskets. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. If the gaskets are not damaged, use a 9S-8140 Pressurized Pump Group to pressure test the cooling system filler cap. The correct pressure is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not hold the correct pressure, install a new cooling system filler cap.

4. Install the cooling system filler cap. Start the engine. Inspect for coolant leaks and proper operating temperature.

Top End and Overhaul

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Estimating Overhaul Intervals

Top End involves removal, inspection and rework (rebuild or exchange) of the cylinder head components. This maintenance interval is dependent on load-sensitive items.

Overhaul is defined as the interval at which the major wear items in the engine should be replaced. The overhaul interval represents overhaul of worn engine components at a planned maintenance interval. In other words, the engine is being rebuilt with certain new parts replacing worn parts. The major wear items include piston rings, engine rod and main bearings, valves, and valve seats, etc.

This section contains information about estimating overhaul intervals. Three methods are discussed:

1. Selecting predetermined intervals from a chart.
2. Calculating Top End and Overhaul intervals using fuel consumption rates.
3. Top End interval determined by exhaust valve stem projection measurement.

The first and second methods should be used only when monthly monitoring of exhaust valve wear, crankcase blowby, and S•O•S oil analysis results have not been recorded.

Top End and Overhaul Chart

The Top End and Overhaul Chart can be used to estimate the Top End and Overhaul maintenance intervals. Use the chart only if fuel consumption information is not available for your engine. The chart applies only for engines operating on dry natural gas with a low heat value (LHV) of 33.72 kJ/L (905 Btu/cu ft).

Top End and Overhaul Chart Instructions:

1. Locate your engine model in the "Model" column.
2. Locate the engine's estimated output in the "Estimated Output" column.
3. Select the Top End or Overhaul interval from the appropriate column.

Clock hours, volume of fuel consumed, and megawatt hours produced are listed for the Top End and Overhaul intervals. Megawatt hours produced is often easier to keep records on than millions of cubic meters (cubic feet) of fuel consumed. If this is the case, use megawatt hours produced.

Refer to the Service Meter Multiplier Charts topic in this manual for instructions to calculate actual clock hours from service meter units.

NOTE: Multiply cubic feet by 0.283 to obtain cubic meters.

G3400 Gas Engine Top End and Overhaul Intervals for Dry Natural Gas [LHV 33.72 kJ/L (905 Btu/cu ft)]									
	--Estimated Output--			--Top End Intervals--			--Overhaul Intervals--		
Model	Engine kW	Engine hp	Gen kW	Clock Hours	Fuel¹ m³ (ft³)	Megawatt Hours	Clock Hours	Fuel¹ m³ (ft³)	Megawatt Hours
G3412	500	670	470	8000	1.3 (45.1)	3700	16,000	2.6 (90.1)	7400
	430	580	400	9000	"	3600	18,000	"	7200
	380	510	350	10,000	"	3500	20,000	"	7000
	330	440	300	11,000	"	3300	22,000	"	6600
	270	360	250	12,000	"	3000	24,000	"	6000
	220	290	200	13,000	"	2600	26,000	"	5200
	160	220	150	15,000	"	2300	30,000	"	4500
G3408	330	440	310	8000	0.8 (28.3)	2500	16,000	1.6 (56.6)	4800
	300	400	275	9000	"	2400	18,000	"	4900
	270	360	250	10,000	"	2600	20,000	"	4900
	240	330	225	11,000	"	2600	22,000	"	4700
	220	290	200	12,000	"	2600	24,000	"	4600
	190	250	175	13,000	"	2500	26,000	"	4300
	160	220	150	15,000	"	2100	30,000	"	4200

¹The fuel consumption is listed in millions of cubic meters (m³) and cubic feet (ft³).

Calculating Top End and Overhaul Intervals Using Fuel Consumption

Fuel consumption is the most important criteria for determining when Top End or Overhaul maintenance should be performed because fuel consumption compensates for application and engine loads. If the total cubic meters (cubic feet) of fuel consumed has not been recorded, use the following Overhaul Interval formula to estimate the Top End and Overhaul clock hour interval. The formula may also be used to estimate intervals for new engines.

Overhaul Interval (hours) = cubic meters (from the chart) ÷ cubic meters/hour (fuel consumption*)

or

Overhaul Interval (hours) = cubic feet (from the chart) ÷ cubic feet/hour (fuel consumption*)

* Use actual fuel records if available. If the actual cubic meters (cubic feet) per hour is not available, use the steps that follow to estimate the fuel consumption rate.

1. Estimate the percent load of the rated engine or generator set output.

2. Refer to the specification sheet to determine the cubic meters/hour (cubic feet/hour) for the estimated percent load. Use this value in the Overhaul Interval formula.

NOTE: For engines operating at less than 50 percent load, use the 50 percent load fuel consumption rate to determine the Top End or Overhaul hour interval.

Adjusting the Chart for Fuels With a Different Low Heat Value (LHV)

The hours intervals and "cubic meter (cubic feet)" listed on the chart applies only to engines operating on **preferred fuels** as defined in the Gas Specification Section of this manual. The consumption volume listed was established for dry natural gas with a low heat value of 33.72 kJ/L (905 Btu/cu ft).

If your engine is operating on another preferred fuel with a different low heat value (LHV), the total volume of fuel consumed must be adjusted. Perform the following steps for both the Top End and Overhaul intervals:

1. Select the "cubic meters (cubic feet)" from the chart.

Example: A G3412C engine overhaul occurs at 2.6 million cubic meters (90.1 million cubic feet).

2. Calculate the adjustment factor by dividing 33.72 kJ/L (905 Btu/cu ft) by the low heat value of the gas being used.

Example: $905 \text{ Btu/cu ft} \div 750 \text{ Btu/cu ft} = 1.2$.

3. Multiply the cubic meters (cubic feet) from Step 1 by adjustment factor from Step 2.

Example: $90.1 \text{ million cubic feet} \times 1.2 = 108.12 \text{ million cubic feet}$.

This adjusted total volume can be used to estimate the Top End and Overhaul intervals in clock hours. Apply the adjusted total volume to the Overhaul Interval formula.

If your engine is operating on a fuel other than a **preferred fuel**, contact your Caterpillar dealer for assistance. Your Caterpillar dealer can help determine the effect of the fuel on engine service life.

Top End interval Determined by Measure of Exhaust Valve Wear

Monitoring exhaust valve wear by measuring valve stem projection and crankcase blowby can help determine when Top End maintenance is required.

Base line exhaust valve projection measurements should be taken at initial start-up of the engine or at least at the First 750 Hour interval. The valve take-up should then be monitored Every 1500 Hours in order to maintain a record of the valve wear over time.

Measuring each valve stem projection and recording the adjustment will help to determine the Top End maintenance interval.

The Top End maintenance should be scheduled when the valve adjustment take-up total reaches 1.78 mm (.070 in). The maintenance work should be completed before the total measurement reaches 2.90 mm (.090 in).

Refer to the Exhaust Valve Data Sheet in this manual for the form to record valve wear, crankcase blowby and cylinder pressure.

Refer to the Service Manual or consult with your Caterpillar dealer for more information on this procedure.

Overhaul Information

Overhaul Before Failure

Your Caterpillar dealer may be offering a variety of options regarding overhaul programs. A planned overhaul may be your best value, because you can:

- Avoid costly unplanned downtime
- Reuse as many original parts as standards permit
- Extend your engine's service life without the risk of a major catastrophe had you continued to operate to failure
- Get the best cost/value relationship per hour of extended life

Overhaul Programs

Flat Rate Overhaul

To further control your overhaul costs, Caterpillar recommends that you contact your dealer for information regarding the availability of a Flat Rate Overhaul.

Flat rate prices on preventive maintenance programs or major repair options are available from many dealers for all Caterpillar engine models.

Overhaul Options

Caterpillar Dealer – Contact your Caterpillar dealer to schedule a Before Failure Overhaul.

Overhaul Kit – This useful kit was developed for those users that prefer to perform their own overhaul. This kit includes a combination of new, reused and remanufactured parts. Also included is a step-by-step instruction regarding how to perform an overhaul. An Overhaul Kit simplifies parts ordering, helps speed repairs and reduces parts costs.

Contact your local Caterpillar dealer for information regarding the Overhaul Kit.

Caterpillar Recommendation

To minimize downtime and provide you with the lowest cost and highest value, Caterpillar recommends that the engine be scheduled for an overhaul with your Caterpillar dealer.

NOTE: Overhaul programs vary from dealer to dealer. Therefore, Caterpillar recommends that you confer with your dealer to obtain specific information regarding the types of programs offered and overhaul services provided for extending the service life of your engine.

After Failure Overhaul

If you experience a major engine failure which requires removal of the engine, there are also many After Failure Overhaul options available. An overhaul should be performed if your block or crankshaft needs to be repaired. If the block and/or crankshaft is repairable, then the cost of an overhaul should be between 40 and 50 percent of the cost of a new engine (with like exchange core).

This lower cost can be attributed to Caterpillar "designed in" features that include:

- Regrindable crankshaft
- Undersize bearings
- Caterpillar dealer and Caterpillar Remanufactured exchange components

Dealer Exchange Components – This is exchanging worn engine components for quality Caterpillar dealer rebuilt components on an over-the-counter basis.

Caterpillar Remanufactured Components – Manufacturing techniques and processes are used to restore components to "like-new" performance capabilities, conform to original functional specifications and the remanufactured components are exchanged for your existing parts.

Remanufactured (R)* components currently being offered by Caterpillar in many countries include:

- Short block
- Cylinder head – bare
- Cylinder head – assembly and group
- Connecting rods
- Cylinder pack¹

¹Caterpillar cylinder packs contain both remanufactured and new pistons, connecting rods, cylinder liners, piston pins, snap rings and piston rings. Caterpillar cylinder packs can be removed and installed as one unit.

- Crankshaft – undersized
- Crankshaft – upgrade to new
- Complete turbocharger
- Turbocharger cartridges
- Water pumps
- Oil pump
- Oil cooler and aftercooler cores
- Alternator
- Starting motor
- Governor and Carburetor
- Gas Pressure Regulator

NOTE: If the component you need is not listed here, contact your Caterpillar dealer to see if the component is offered under a dealer exchange component program.

* Current Parts Manuals will asterisk a part number when a Remanufactured (R) unit is offered by Caterpillar.

Caterpillar Recommendation

To further control your overhaul costs, Caterpillar recommends that you contact your dealer for information regarding the availability of a Flat Rate After Failure Overhaul.

Top End

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Top End involves removal, inspection and rework (rebuild or exchange) of the cylinder head components. This maintenance interval is dependent on load-sensitive items.

Top End Overhaul Instructions

If you elect to perform a top end overhaul yourself, without having a Caterpillar dealer perform the overhaul for you, or without using an overhaul kit, then you should perform the maintenance that follows.

Rebuild or Exchange

Cylinder Head Assembly, Gas Regulator, Carburetor, Starting Motor, Turbocharger, SCAC Water Pump and Throttle Body

These components should be inspected according to the instructions found in various Caterpillar reusability publications. To determine the reusability publications needed for inspecting your parts, refer to the SEBF8029, Index Of Publications On Reusability Or Salvage Of Used Parts.

The Guideline For Reusable Parts and Salvage Operations is part of an established Caterpillar parts reusability program. These guidelines were developed to assist Caterpillar dealers and customers reduce costs by avoiding unnecessary expenditures for new parts when existing parts can be used as is, repaired or salvaged.

If your parts are not within specification, then they should be salvaged, repaired or replaced. Failure to salvage, repair or replace out-of-spec parts will result in unscheduled downtime and could result in costly repairs caused by potential damage to other engine parts.

Oil Cooler Core and Aftercooler Core

Clean/Test

Caterpillar recommends that the oil cooler core and the aftercooler core be cleaned and pressure tested at each overhaul. For additional specifications and/or pressure test information, contact your local Caterpillar dealer.

NOTE: This cleaning procedure may be used for both the oil cooler and the aftercooler cores.

1. Remove the core. Turn the core upside down to remove debris from the inlet.
2. Back flush internally with cleaner to loosen foreign substances and to remove oil. Caterpillar recommends the use of Caterpillar Hydrosolv Liquid Cleaners. The following chart lists part numbers and quantities of recommended cleaners available from your Caterpillar dealer.

Hydrosolv Liquid Cleaners		
Part No.	Description	Size
1U-8812 1U-5490 8T-7570	Hydrosolv 4165	4 L (1 US gal) 19 L (5 US gal) 208L (55 US gal)
1U-8804 1U-5492 8T-7571	Hydrosolv 100	4 L (1 US gal) 19 L (5 US gal) 208L (55 US gal)

The cleaners listed in this chart should be used at a two to five percent concentration and at temperatures up to 93°C (200°F). For more information refer to NEHS0526, Service Technical Group Application Guide, or contact your Caterpillar dealer.

3. Steam clean the core to remove cleaner film. Flush the aftercooler core fins. Remove any other trapped debris.
4. Wash the core with hot, soapy water. Rinse thoroughly with clean water.
5. Dry the core with compressed air. Blow air in reverse direction of the normal flow. Use all necessary safety equipment while working with compressed air.
6. Inspect the system to ensure cleanliness. The core should be pressure tested. Test and repair the core as necessary. Install the core.

For more information on cleaning the cores, contact to your Caterpillar dealer.

Exhaust Bypass Valve

WARNING

The exhaust bypass valve cover is under spring compression. To prevent personal injury, use caution when the cover is removed.

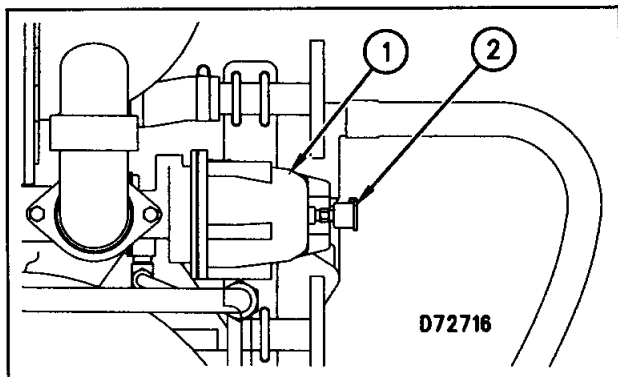
Inspect

The exhaust bypass valve must be removed in order to be inspected. Refer to the Service Manual for the removal procedure.

Inspect the exhaust bypass valve for proper operation. The valve should operate freely without binding, but should not have excess play. Inspect the valve stem for wear.

If the exhaust bypass valve binds or is too loose and does not operate properly, refer to the Service Manual or contact your Caterpillar dealer for assistance.

Clean Breather



Exhaust bypass valve (1) and breather assembly (2).

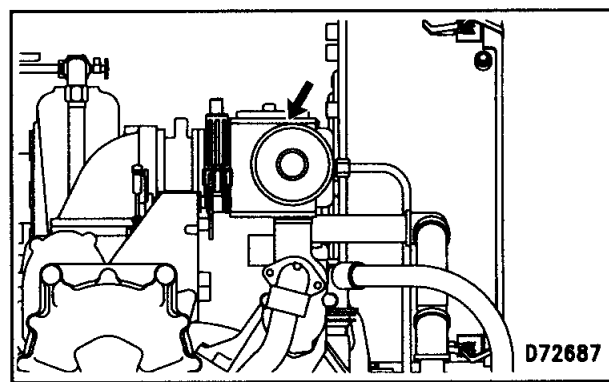
1. Remove breather assembly (2).
2. Wash the breather element in nonflammable solvent. Use pressure air to dry the element or allow the element to air dry.
3. Install the breather assembly (2).

Carburetor, SCAC Water Pump, and Gas Regulator

Removal and Installation

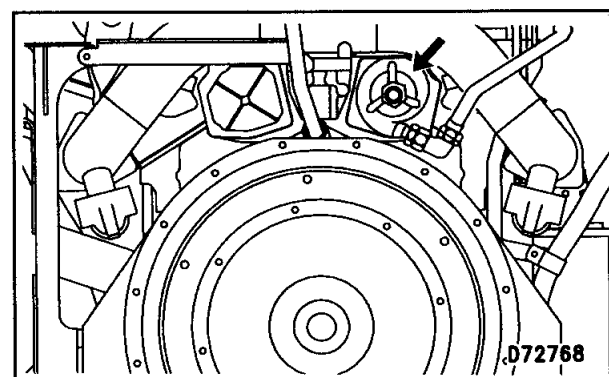
Refer to the procedure in the Service Manual or contact your Caterpillar dealer for assistance.

Inspect/Replace

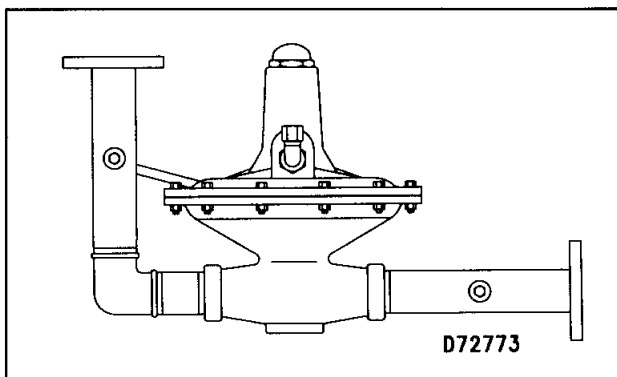


Carburetor.

The carburetor mixes fuel with inlet air from the air cleaner. Check the operation of the carburetor. Make sure the throttle plate does not bind. Inspect the diaphragm for wear, cracks, and pin holes.



SCAC water pump.



Gas regulator.

Inspect the components for wear, cracks, pin holes and proper operation. If repairs or replacement is needed, refer to the Service Manual or contact your Caterpillar dealer.

Caterpillar Recommendation

Before deciding which method is best, make sure all of the options and costs associated with repair have been considered. Some considerations are:

- the costs associated with using separate parts from inventory versus the cost of a repair kit
- downtime costs while the product is being rebuilt or repaired
- total parts and labor costs for repairs versus the actual Remanufactured cost
- remanufactured components from Caterpillar (if available) are covered by a standard, factory warranty

To minimize downtime, Caterpillar recommends that the use of Remanufactured components (subject to availability) is the most cost effective option.

Spark Plug Wires and Magneto

WARNING

Ignition systems can cause electrical shocks. Avoid contacting ignition components and wiring unless the Engine Control Switch (ECS) is in the STOP or OFF/RESET position. This will immediately discharge the ignition system when the ignition harness is reconnected. DO NOT inspect valve mechanism or transformers while the engine is running. Personal injury or death may result.

Inspect Spark Plug Wires

NOTICE

Both the wire assembly and seal must be installed on all cylinders when operating the engine. Failure to do this may allow a spark from the exposed wire assembly to ignite crankcase vapors. Engine damage could result.

Inspect the rubber boots that cover the spark plugs. Look for cracks. If the rubber boots are damaged, install new rubber boots.

Inspect the spark plug wires. Look for arcing and bare wire. If the spark plug wires are frayed or damaged, install new spark plug wires.

NOTICE

Both the high tension lead at the spark plug and the internal seal between spark plug adapter and valve cover must be installed on all cylinders when operating the engine. Failure to do this may allow a spark from the exposed lead to ignite crankcase vapors. Engine damage could result.

Inspect Magneto

NOTICE

Be sure to reconnect the wire to the magnetic switch and the connector to the magneto after the repairs are made.

Inspect the magneto for damage. If any damage is found, consult your Caterpillar dealer for assistance.

Carburetor Linkage and Governor Control Linkage

Replace Bearings

Inspect the throttle shaft bearings. Inspect all linkage bearings. Replace the bearings if necessary. Replace the bearings in the linkage between the carburetor and governor.

Check/Adjust

After the bearings are replaced, refer to the Service Manual to ensure that the engine is set up properly. If further assistance is required, consult your Caterpillar dealer.

Transformers

WARNING

Ignition systems can cause electrical shocks. Avoid contacting ignition components and wiring unless the Engine Control Switch (ECS) is in the STOP or OFF/RESET position. This will immediately discharge the ignition system when the ignition harness is reconnected. DO NOT inspect valve mechanism or transformers while the engine is running. Personal injury or death may result.

The ignition transformer causes an increase of the system voltage. For good operation, the connections (terminals) must be clean and tight.

Inspect, Test Resistance

Inspect the ignition transformers for loose connection, moisture, and short or open circuits. Check the low and high tension wiring resistance using the procedures in the Service Manual, or contact your Caterpillar dealer for assistance.

Water Temperature Regulators (Thermostats)

Replace

Replacing your water temperature regulators prior to failure is a recommended preventive maintenance practice because it reduces the chances for unscheduled downtime.

Depending on load, a water temperature regulator that fails in a partially opened position will cause either an overheating or an overcooling condition.

If the water temperature regulator fails in the closed position, it will cause excessive overheating. Excessive overheating could result in cylinder head cracking or piston seizure problems.

If the water temperature regulator fails in the open position, it will cause the engine operating temperature to be too low during partial load operation. Low engine operating temperatures during partial loads could cause an excessive carbon buildup inside the cylinder. This excessive carbon buildup could result in accelerated ring and liner wear.

NOTICE

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

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

If the water temperature regulator is installed wrong, the engine may overheat, causing cylinder head damage. Ensure that the new water temperature regulator is installed in the original position. Ensure that the water temperature regulator vent hole is open.

DO NOT use liquid gasket material on the gasket or cylinder head surface.

Refer to the Service Manual for the water temperature regulator replacement procedure, or consult with your Caterpillar dealer.

NOTE: If replacing water temperature regulators ONLY, drain the coolant from the cooling system to a level below the water temperature regulator housing.

Refer to the Coolant Specifications in this publication for all information regarding acceptable water, coolant/antifreeze and SCA requirements, or contact your Caterpillar dealer for assistance.

Hoses and Clamps

Replace

Caterpillar recommends that all of the cooling system hoses and piping be replaced during Top End maintenance. The hose clamps should be inspected for damage. The hose clamps should be tightened to the proper torque.

For information regarding the replacement of hoses, refer to the Hoses and Clamps topic in the Every 750 Hours section.

Overhaul

Overhaul is defined as the interval at which the major wear items in the engine should be replaced. The overhaul interval represents overhaul of worn engine components at a planned maintenance interval. In other words, the engine is being rebuilt with certain new parts replacing worn parts. The major wear items include piston rings, engine rod and main bearings, valves, and valve seats, etc.

Overhaul also includes the complete inspection of all other parts that are visible during the opening up of the engine. The disassembly required to perform an overhaul means that disturbed seals and gaskets, etc, will be replaced and the internal passages of the engine and block will be cleaned.

The Top End and Overhaul chart gives Caterpillar's recommendation for performing an Overhaul. Refer to the Top End and Overhaul chart in the Top End and Overhaul section.

The chart suggests intervals in hours and calendar time for overhaul. These intervals are average values. Some engines may require overhauling at shorter intervals and some may go longer.

The other interval is expressed in fuel consumption. The best figure to use is total fuel consumed, even if this figure is estimated. Fuel consumption more closely follows the load upon the engine.

The hours figure will be too high if the engine is run at high load and too low if the engine is lightly loaded. Use the clock hour figure only as a guideline. Other factors, such as how conscientiously preventive maintenance has been performed, fuel quality, operating conditions, S•O•S results, etc, are important in deciding when to perform an overhaul.

The real measure of when to overhaul an engine is performance as measured by output, fuel consumption, oil consumption, blowby and compression. When an engine's oil consumption has risen to three times the initial (new engine) consumption due to normal wear, then the engine should be scheduled for overhaul. Expect to see a corresponding increase in blowby figures and may also see slight increase in fuel consumption.

Your Caterpillar dealer may be offering a variety of options regarding overhaul programs and Caterpillar recommends that an Overhaul be performed at the maintenance intervals listed in the chart for your engine.

Overhaul Instructions

If you elect to perform an overhaul yourself, without having a Caterpillar dealer perform the overhaul for you, or without using an overhaul kit, then you should be aware of the following:

Rebuild or Exchange

Cylinder Head Assembly, Cylinder Packs, Oil Pump, Governor and Turbocharger.

These components should be inspected according to the instructions found in various Caterpillar reusability publications. To determine the reusability publications needed for inspecting your parts, refer to the SEBF8029, Index Of Publications On Reusability Or Salvage Of Used Parts.

These guidelines were developed to assist Caterpillar dealers and customers avoid unnecessary expenditures for new parts when existing parts can be used as is, repaired or salvaged.

Install New

Crankshaft Bearings, Crankshaft Seals, and Spark Plug Wires.

The crankshaft bearings and crankshaft seals will not likely last until the second overhaul. Therefore, Caterpillar recommends the replacement of these components at each Overhaul interval. Caterpillar also recommends that the spark plug wires be replaced at Overhaul.

Inspect

Crankshaft, Camshaft, Camshaft Followers and Bearings, Gear Train Gears and Bushings.

The ideal time for inspecting these items is while your engine is disassembled for overhaul. Inspect each component for potential damage as follows:

- Crankshaft – Inspect for deflection, journal damage and bearing material seized to the journal. At the same time, check the taper and profile of the crankshaft journals by interpreting your main and rod bearing wear patterns.
- Camshaft – Inspect the camshaft for journal and/or lobe damage.

NOTE: If camshafts or crankshafts are removed for any reason, use the magnetic particle inspection process to check the components for cracks.

- Camshaft Followers and Bearings – Inspect the cam bearings for fatigue and wear.
- Gear Train Gears and Bushings – Inspect for worn gear teeth, unusual fits and unusual wear.

Standby Generator Set Engine Preventive Maintenance Recommendations

Introduction

The objective of this topic is to assist customers in establishing a Preventive Maintenance Program for Standby Generator Set Engines.

Establishing a Preventive Maintenance Program will provide maximum availability of a standby generator set when needed, longer engine and generator life, and a minimum of expensive repairs.

The recommended Weekly maintenance checks can be performed by an operator. All Yearly and Three Year maintenance should be performed by an authorized service technician or by a Caterpillar dealer.

These guidelines are to be used with the information contained in the Operation and Maintenance sections of this manual. The Operation and Maintenance sections will provide the necessary information on how to perform the checks and routine maintenance. Additional information can be obtained from the generator Service Manual and the engine Service Manual, or contact your Caterpillar dealer for assistance.

Inspection and Maintenance Agreements

Your Caterpillar dealer can establish an Inspection and Preventive Maintenance Program for your generator set in order to provide maximum reliability, increased engine and generator service life, and minimize expensive repairs. Contact your Caterpillar dealer for details.

General Recommendations

Safety

WARNING

The stop-manual-automatic switch on the cranking panel must be set at STOP position when performing maintenance or repair work on a standby generator set. This prevents the unit from starting if a power failure or voltage drop should occur while working on the unit.

To prevent personal injury due to accidental starting of the engine, disconnect the batteries or disable the starting system before doing maintenance or repair work.

Lock out all switch gear and automatic transfer switches associated with the generator while performing any generator maintenance or repairs. Make sure no shock hazard exists.

Failure to comply could result in personal injury or death.

Always make repairs with the engine stopped and the starting system disconnected. When servicing the generator, make sure that switch gear and automatic transfer switches will not present a shock hazard. Lock them out on the generator being serviced.

Record Keeping

Maintain a log or record keeping system to document all gauge readings, problems, repairs, and maintenance performed on the equipment.

Space Heaters

Moisture is a natural enemy of generators and all electrical equipment. Every effort must be made to keep the generator as dry as possible. Space heaters should be operated inside the generator when it is not in use to maintain the integrity of the generator windings.

Standby Generator Set Engine Maintenance Schedule

Recommended service should always be performed at the interval that occurs first.

NOTE: For all generator maintenance activities, refer to the Generator and Control Panel Operation and Maintenance Manual for your generator.

Weekly (Before Starting the Engine)

Walk-Around Inspection – Inspect engine, radiator and generator for debris, foreign objects, leaks and loose connections, broken fittings, guards and components (including governor and fuel system). Repair as necessary.

Engine Crankcase – Check oil level. Maintain the oil level between the ADD and FULL marks on the Engine Stopped side of the oil level gauge.

Cooling System – Check/Maintain proper coolant level.

Battery Charger – Check for proper operation.

Batteries – Clean/Check, Maintain electrolyte level, clean batteries if necessary, check for tight connections.

Air Starting System (if equipped) – Check lubricator oil level, check air pressure, drain condensation.

Engine Air Cleaner – Check service indicator. Service the air cleaner elements when the yellow piston has risen to level 15.

Jacket Water Heater – Check for proper operation. Maintain a temperature of 32°C (90°F).

Aftercooler – Inspect.

Belts – Inspect/Replace–Inspect for worn, broken or loose belts (alternator, fan drive, etc).

Governor – Check for leaks.

Ignition System – Check wires, fittings, rubber boot covers, etc.

Engine Protective Devices – Inspect system and gauges for proper operation.

Generator and Control Panel – Visual inspection. Check for loose, broken, or otherwise damaged wiring and components.

Weekly (With the Engine Running)

NOTE: The following operational checks are intended to check the engine starting, lubricating and fuel systems as well as overall operation. The checks should take no longer than five minutes to complete. Longer periods of operation are not required. A more thorough test will be performed Yearly with the engine operating under load. The engine must be stopped before making necessary repairs.

Walk-Around Inspection – Start the Engine. Inspect the engine for leaks and loose connections. Listen for unusual noises. Inspect the generator louvers for proper operation (able to open and close freely).

NOTE: The engine must be stopped before making necessary repairs.

Engine Crankcase – Check the oil level. Maintain the oil level between the ADD and FULL marks on the LOW IDLE side of the oil level gauge.

Oil Pressure – Check gauge reading.

Generator – Check/Record frequency (rpm) and generated voltage readings.

Weekly (After Stopping the Engine)

Automatic Switches – Check for proper position to execute AUTO start.

Battery Charger – Record charging amperage reading.

Walk-Around Inspection – Inspect the engine. Report any malfunction. Have any necessary repairs made.

Yearly (Before Starting the Engine)

NOTE: Perform the Weekly Before Starting the Engine maintenance before performing this maintenance.

Cooling System (Conventional HD Coolant/Antifreeze Only) – Test for SCA concentration or Obtain Level I coolant analysis, add SCA if necessary.

Crankcase Breather – Clean.

Valve Lash – Check/Adjust.

Spark Plugs – Inspect/Clean and gap if necessary.

Gas Pressure Regulator – Check gas pressure, adjust if necessary. Drain water from drip leg (if equipped).

Carburetor Linkage and Governor Control Linkage – Check/Adjust if necessary. Lubricate.

Standby Generator Set Engine Preventive Maintenance Recommendations

Air Inlet Piping – Inspect.

Air Cleaner – Replace air cleaner element.

Exhaust Bypass Valve – Inspect for proper operation/Clean breather. Check wastegate valve for free travel.

Batteries – Clean terminals and connections.

Generator – Lubricate bearing. Vacuum clean and check wiring of the regulator, exciter and stator. Check generator windings with megohmmeter and record readings for reference. Check operation of space heaters.

Engine Protective Devices – Check for proper operation of the alarm and shutoff systems.

Yearly (With the Engine Running)

NOTE: Perform the Weekly With the Engine Running maintenance before performing this maintenance. The engine must be stopped before making necessary repairs.

Engine Protective Devices – Inspect the system and gauges for proper operation. After approximately one hour, record gauge readings of oil pressure, fuel pressure, oil level, rpm (frequency), generated voltage, service meter, exhaust temperature (if equipped), manifold vacuum (if equipped), and engine jacket water temperature.

Radiator (If Equipped) – Inspect for leaks and loose connections.

Load Test – Operate the engine at a minimum of 30 percent of rated load for minimum of two hours.

Engine Mounts – Inspect.

Exhaust System – Check for leaks.

Yearly (After Stopping the Engine)

NOTE: Perform the Weekly After Stopping the Engine maintenance before performing this maintenance.

S•O•S Oil Analysis – Obtain.

Engine Oil and Oil Filters – Replace.

Battery Charger – Record charging amperage reading.

Every Three Years (Before Starting the Engine)

NOTE: Perform the Weekly and Yearly Before Starting the Engine Maintenance procedures before performing this maintenance.

Turbocharger – Inspect/Check bearing end play and radial clearance.

Perform a complete engine adjustment and tune-up including carburetor, ignition system and gas regulator.

Spark Plug Wires – Replace.

Magneto and Coupling – Reseal.

Transformers – Test resistance.

Carburetor – Inspect/Rebuild or Exchange.

Water Temperature Regulators (Thermostats) – Replace.

Hoses – Replace. It is recommended that all hoses be replaced at this time to minimize downtime and additional repair cost of component failures caused by these items.

Belts – Replace. It is recommended that all belts be replaced at this time to minimize downtime and additional repair cost of component failures caused by these items.

Cooling System (Extended Life Coolant Only) – Add Extender.

Cooling System (Conventional HD Coolant/Antifreeze Only) – Clean/Flush/Replace coolant.

Batteries – Replace.

Every Six Years (Before Starting the Engine)

NOTE: Perform the Weekly, Yearly, and Every Three Years Before Starting the Engine maintenance procedures before performing this maintenance.

Cooling System (Extended Life Coolant Only) – Drain/Flush/Replace ELC.

Maintenance Records

Caterpillar recommends that accurate maintenance records be kept. Accurate maintenance records can be used for determining operating costs, establishing maintenance schedules for other engines being operated in the same environment and for a variety of other related business decisions.

Accurate maintenance records can also be used to show compliance with the required maintenance practices and intervals. Maintenance records are a key element of a well-managed maintenance program. With accurate maintenance records your Caterpillar dealer can help you fine tune the recommended maintenance intervals to meet your specific operating situation. This should result in a lower engine operating cost. .

The key elements to keep records on are:

- Fuel Consumption

This is essential for determining when load-sensitive items should be inspected or repaired and for determining overhaul intervals.

- Service Hours

This is essential for determining when revolution-sensitive items should be inspected or repaired.

- Documents

The following types of documents should be kept as proof of maintenance or repair for warranty and should not be difficult to obtain and keep in the engine history file. All documents should show date, service hours, liters (gallons) of fuel consumed, unit number and engine serial number. If the engine is sold, transfer the records with the engine.

1. Dealer work orders and itemized bills
2. Owner's repair orders
3. Owner's receipts
4. Maintenance log (see the following example)

Maintenance Log

Engine Model _____

Customer Identifier_____

Serial Number _____

Arrangement Number_____

[illegible]

Performance Log

Engine Model _____

Customer Identifier_____

Serial Number _____

Arrangement Number_____

[illegible]



Troubleshooting



Troubleshooting a failure on an engine can be a difficult procedure. All repairs should be made by a properly trained service technician. Your Caterpillar dealer has the personnel and special tools needed to troubleshoot and make repairs to your engine.

Refer to your engine's Service Manual for troubleshooting information. The list of problems, causes and corrections given in the Service Manual will only give an indication of where a possible problem can be, and what repairs may be needed.

Remember that a problem is not normally caused only by one part, but by the relation of one part with other parts.

The Service Manual can not give all possible problems and corrections. The service technician must find the problem and its source, then make the necessary repairs.

Your Caterpillar dealer is equipped with the necessary tools and personnel to provide assistance when necessary.



Warranty Information

Engine Protection Plans

Extended Warranties & Service Contracts

A wide variety of protection plans are available for Caterpillar Engines. Consult your local Caterpillar dealer for information on the plan(s) tailored to fit your needs.

- ESC-Extended Service Coverage
- Remanufactured Extended Coverage

Contact your local Caterpillar dealer for more detailed information on specific programs and coverage available.

Reference Materials

Caterpillar Reference Material

The following literature can be obtained through any Caterpillar dealer.

Caterpillar Reference Materials for Lubricants

SEBD0640, Oil and Your Engine
PEDP1129, Listen To Your Oil
PEHP0004, Data Sheet- Natural Gas Engine Oil
PEHP6001, How To Take A Good Oil Sample
PEWP9733, Caterpillar Fluids Selector Dial
PEHP0003, Data Sheet- Multipurpose Lithium Complex Grease (MPG)
PEHP0002, Data Sheet- Multipurpose Lithium Complex Grease with Molybdenum (MPGM)
PEHP0017, Data Sheet- Special Purpose Grease (SPG) Bearing Lubricant
PECP4025, One Safe Source

Caterpillar Reference Materials for Fuels

LEKQ5404, Data Sheet- Fuel Specifications Changes
LEKQ9360, Data Sheet- Internal Combustion Engine Fuel Gases
LEKX9416, Data Sheet- Low Energy Gas Fuels
LEKQ2364, Data Sheet- US Stationary Engine Regulations/Spark Ignited Emissions

Caterpillar Reference Materials for Coolants

PEHP4036, Data Sheet- Caterpillar Coolant
PEHP5033, S•O•S Coolant Analysis
PECP4025, One Safe Source
SEBD0518, Know Your Cooling System
SEBD0970, Coolant and Your Engine
LEKQ8567, Data Sheet- Water Treatment
Recommendations for Ebullient and Solid Water Cooled Engines

Miscellaneous

SENR3085, Service Manual (6NB, 7DB)
SENR6405, Service Manual (6RJ, 3NK)
SEBU6918, SR4B Generators and Control Panels Operation and Maintenance Manual
SENR5359, SR4B Service Manual
SEBU6150, SR4 Generators and Control Panels Operation and Maintenance Manual
SENR7958, Electric Set Generator Service Manual
LEBQ2024, G3400 Gas Engine Performance
SEHS9031, Storage Procedure for Caterpillar Products
NENG2500, Caterpillar Tools And Shop Products Guide
SEHS9124, Cleaning and Drying of Electric Set Generators
SEHS7768, Use of 6V-2150 Starting/Charging Analyzer Group
SEHS7633, Battery Test Procedure
SENR3130, Torque Specifications
SEBF8062, Procedure to Inspect and Clean Air Filters
SEHS8712, Using the 8T-2700 Blowby/Airflow Indicator Group
SEHS7654, Alignment- General Instructions
NEHS0526, Service Technical Group Application Guide
SEBF8029, Index Of Publications On Reusability Or Salvage Of Used Parts
SEHS9298, Installation and Maintenance of Gaseous Fuel Filters
SMHS7001, Assembly of Fan Drive Pulley Assemblies
SEHS7332, Tag- Do Not Operate

Additional Reference Material

EMA Lubricating Oils Data Book

Engine Manufacturers Association
401 N. Michigan Ave.
Chicago, Illinois, USA 60611
Phone (312) 644-6610

Society of Automotive Engineers (SAE) Specifications can be found in your SAE handbook or can be obtained from your local technological society, library, or college, or contact

SAE International
400 Commonwealth Drive
Warrendale, PA USA 15096-0001

American Society for Testing and Materials (ASTM) Specifications can normally be obtained from your local technological society, library, or college, or contact:

American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

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