

Operation & Maintenance Manual

3304B and 3306B Industrial and EPG Generator Set Diesel Engines

2AJ1-UP
2TM1-UP
4XB1-UP
7JB1-UP
10E300-UP
64Z1-UP
83Z1-UP
85Z1-UP

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Foreword

Literature Information

This manual contains information and instructions concerning engine safety, operation, lubrication, and maintenance. Read, study, and keep it available with other literature and engine information.

Some photographs or illustrations in this publication show details or attachments that may differ from your engine. Guards and covers may have been removed for illustrative purposes. Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this publication.

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

Safety

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

Operation

Engine operation outlined in this publication is basic. Engine operators gain knowledge of the engine through experience, developing operation skills and techniques which enhance efficient and economical engine operation.

The operation section is a reference for operators. Photographs and illustrations guide operators through correct procedures of inspecting, starting, operating and stopping the engine. Discussion of gauges and engine control information is included.

Maintenance

The maintenance section is a guide to engine care. The illustrated instructions are grouped by maintenance service intervals. The actual operating environment of the engine also governs the maintenance schedule. Under extremely severe, dusty, or frigid operating conditions, lubrication and maintenance checks more frequent than those specified in the Maintenance Schedule may be necessary.

Maintenance Intervals

Use the service hour meter to determine service intervals. Calendar intervals shown (daily, weekly, monthly, etc.) can be used instead of service hour meter intervals, if they provide more convenient servicing schedules and approximate the indicated service hour meter reading. Recommended service should always be performed at the interval that occurs first.

We recommend that the maintenance schedules be reproduced for ease of inspection. We also recommend that ongoing maintenance records be kept to document engine service.

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

Overhaul

Major engine repair details are not covered in this manual. Major repairs are best left to trained personnel or an authorized Caterpillar dealer.

If a major engine failure requiring removal of the engine occurs, 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 publication are 3304B and 3306B Industrial and EPG diesel engines.

They are designed primarily for agricultural, prime power and standby electrical power generation, 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.

California

Proposition 65 Warning

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

Important Safety Information

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

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

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

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

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



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

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

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

Safety

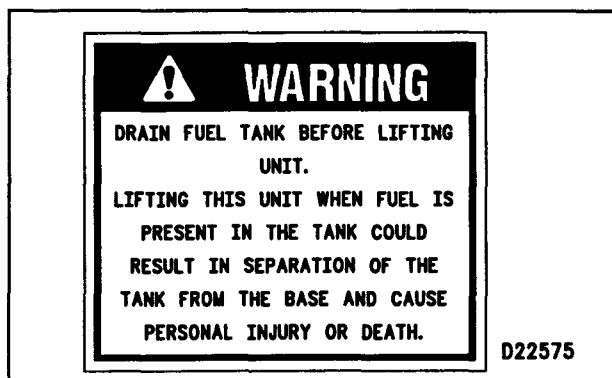
Warning Signs and Labels

There may be several specific warning signs on your engine. Please familiarize yourself with all warning signs.

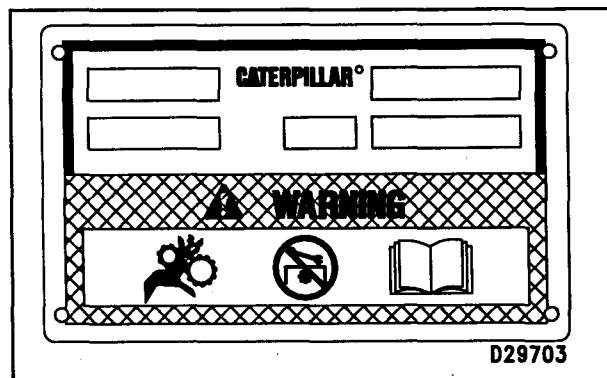
Make sure that you can read all warning signs. Clean or replace warning signs if you cannot read the words or see the pictures. When cleaning the labels use a cloth, water and soap. Do not use solvents, gasoline, etc., to clean warning signs. The use of solvents, gasoline, etc., could loosen the sign's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

You must replace a warning sign if it is damaged, missing or cannot be read. If a warning sign is attached to a part, and that part is replaced, make sure a new warning sign is installed on the replaced part. See your Caterpillar dealer for new warning signs.

Do not operate or work on the engine unless you have read and understand the instructions and warnings in this Manual. Proper care is your responsibility. Failure to follow the instructions or heed the warnings could result in injury or death.



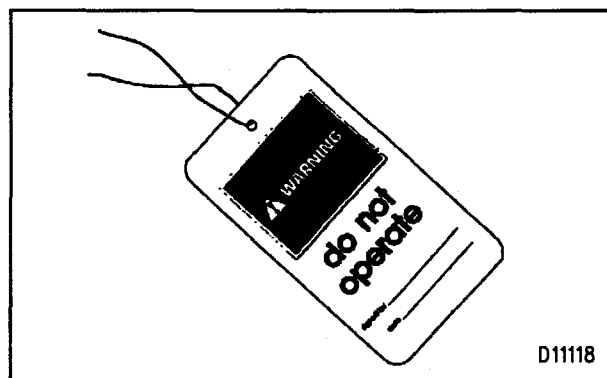
Located on the fuel tank.



This warning plate may be located on the clutch housing (if equipped). Rotating gears—finger or hand entanglement. Do not service until reading the operator's manual.

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.

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

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.
- Disconnect the batteries whenever performing any maintenance or before servicing the electrical system. If the engine has electric starters, 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.
- Apply the parking brakes (if equipped).
- Block or restrain the vehicle or machine, if applicable before operating or performing maintenance.
- When starting an engine after repairs have been made to the fuel system or governor, make provisions for shutting off the engine's intake 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 starter 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.

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 common sense guidelines that should be followed.

- Never use compressed air for cleaning.
- Avoid brushing or grinding of asbestos containing materials.

- For clean up, use wet methods or a vacuum equipped with a high efficiency particulate air (HEPA) filter.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place. (For example in the U.S.A., OSHA requirements as set forth in 29 CFR 1910.1001).
- Follow environmental rules and regulations for disposal of asbestos.
- Avoid areas where airborne asbestos particles may be present.

Lines, Tubes and Hoses

Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses.

Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires.

Inspect all lines, tubes and hoses carefully. Do not use your bare hands to check for leaks. Tighten all connections to the recommended torque.

Check for the following:

- End fittings 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.

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.

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

Oils

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

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 observing the battery electrolyte levels.

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 starter 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.

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.

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 or fuel supply to stop the engine if there is an overspeed on start-up after performing repair or maintenance to the engine.

See the Maintenance section of this manual for adjustment, or 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 starter 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.

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

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

Starting Aids (if Used)

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

Use ether only in well ventilated areas.

Keep ether cylinders out of the reach of unauthorized persons.

Do not store replacement ether cylinders in living areas or in the engine 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 startup or overhaul, be prepared to STOP the engine should an overspeed condition occur. This may be accomplished by cutting the fuel and air supply to the engine.

Emergency Service

North America Only

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

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

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

Step One

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

Step Two

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

Step Three

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

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

Outside North America

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

Central/South America (except Brazil)

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

Brazil

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

Far East (except Japan and Australia)

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

Australia and New Zealand

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

Japan

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

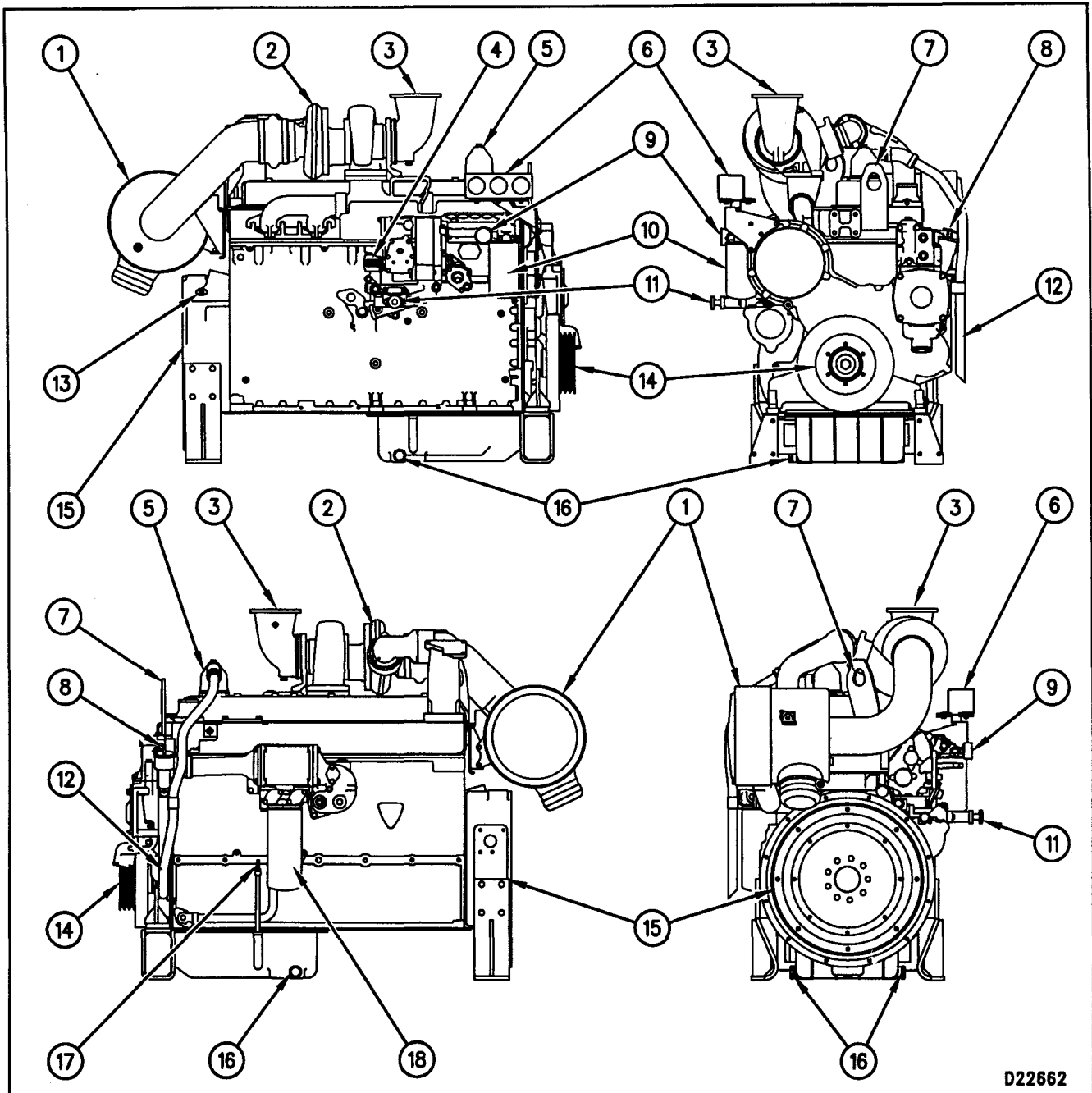
Europe, Africa, and Middle East

Caterpillar Overseas S.A./Power Systems
YA50 76, Route de Frontenex
P.O. Box 456
1211 Geneva 6
Switzerland
Cable Address: CATOVERSEA
Telex No.: 413323
Phone: (022) 849-4444
Telecopier: (022) 849-4984
Fax: (022) 849-4544

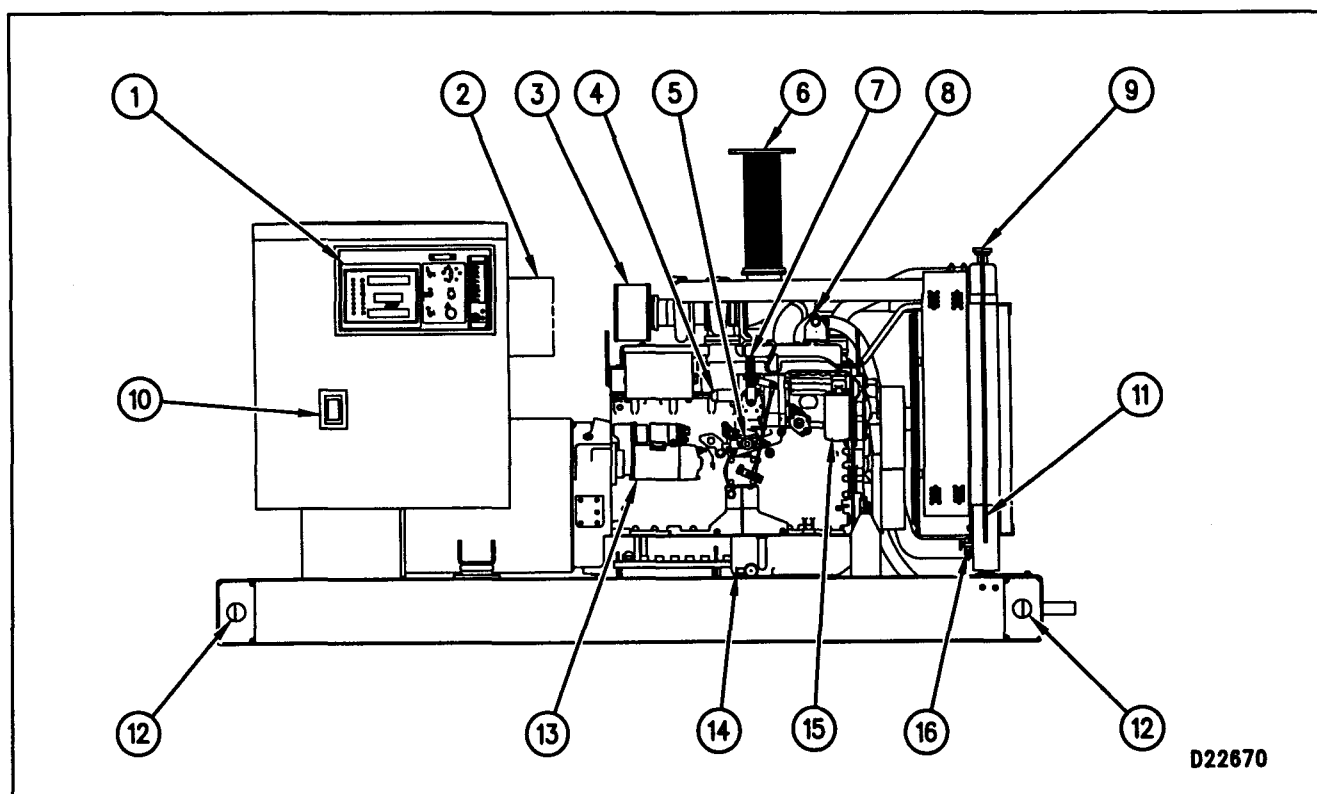
Model Views and Engine Information

Engine Model Views

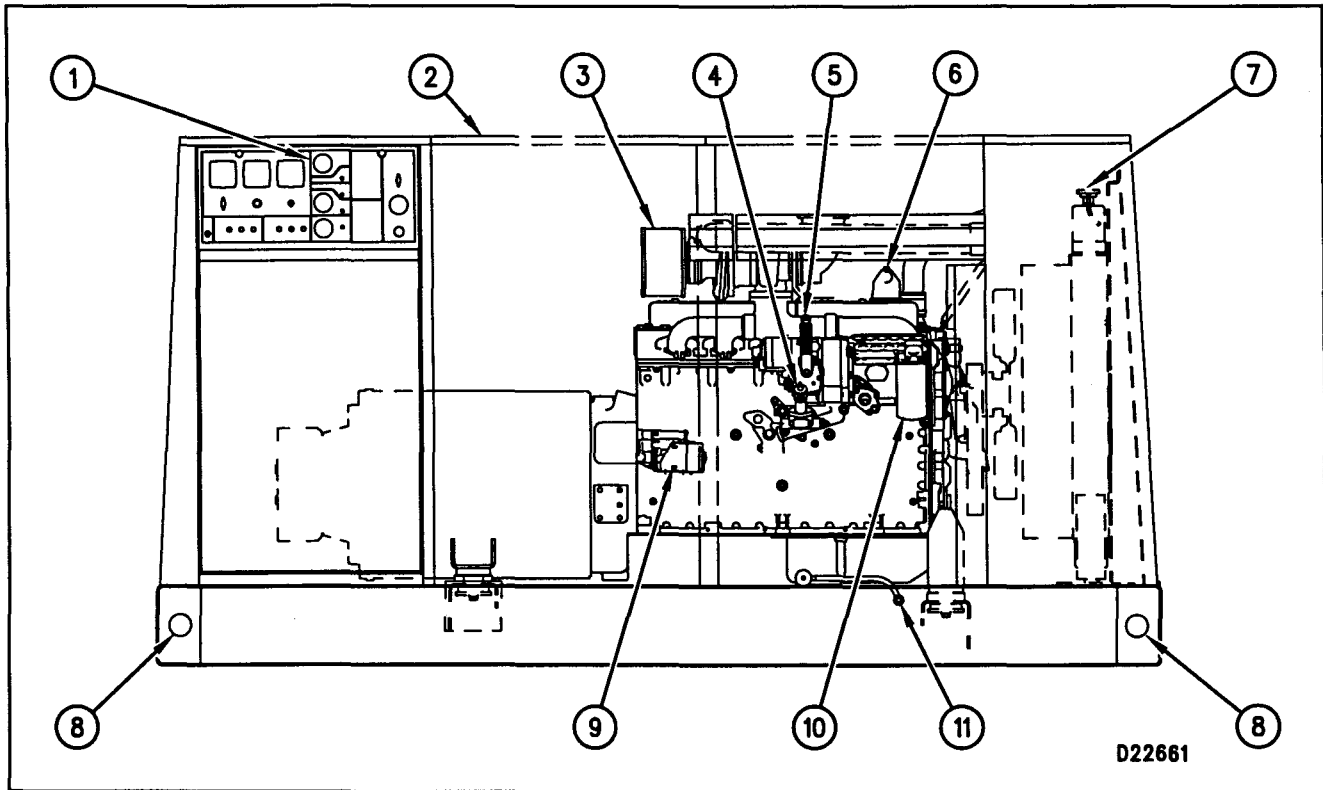
Typical views and attachments are shown.



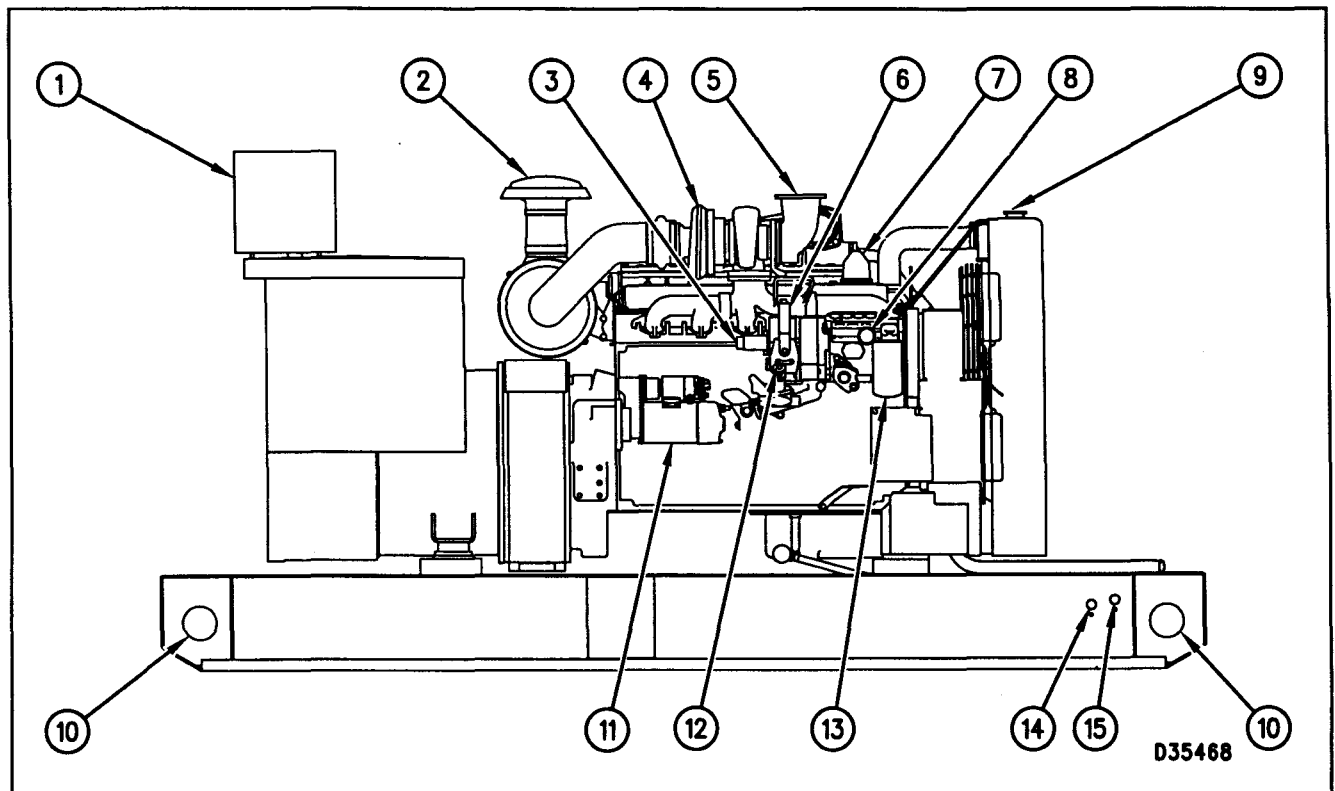
3306B Model Views: Air Cleaner (1), Turbocharger (2), Exhaust (3), Service (Hour) Meter (4), Crankcase Breather (5), Instrument Panel (6), Lifting Eye (7), Oil Filler (8), Fuel Pressure Gauge (9), Fuel Filter (10), Fuel Priming Pump (11), Fumes Disposal Tube (12), Magnetic Pickup Location (13), Crankshaft Vibration Damper (14), Flywheel Housing (15), Oil Drain (16), Oil Level Gauge (17), and Oil Filter (18).



Standby Generator Set: Control and Power Panel (1), Optional Battery Charger Mounting Location (2), Air Cleaner (3), Solenoid (4), Fuel Priming Pump (5), Exhaust (6), Governor Control Lever (7), Crankcase Breather (8), Radiator Fill Cap (9), Circuit Breaker (10), Optional Radiator Vent Hose (11), Lifting Location (12), Starting Motor (13), Oil Drain (14), Fuel Filter (15), and Water Drain (16).



Building Service Standby (BSSB) Generator Set: Control and Power Panel (1), Optional Total Enclosure (2), Air Cleaner (3), Fuel Priming Pump (4), Governor Control Lever (5), Crankcase Breather (6), Radiator Fill Cap (7), Lifting Location (8), Starting Motor (9), Fuel Filter (10), and Oil Drain (11).



Prime Generator Set: Control and Power Panel (1), Air Inlet (2), Solenoid (3), Turbocharger (4), Exhaust (5), Governor Control Lever (6), Crankcase Breather (7), Fuel Pressure Gauge (8), Radiator Fill Cap (9), Lifting Location (10), Starting Motor (11), Fuel Priming Pump (12), Fuel Filter (13), Oil Drain (14), and Water Drain (15).

Engine Information

The engines are available with direct fuel injection. The engines can be naturally aspirated, turbocharged, or turbocharged with jacket water aftercooling. The 3306B is also available turbocharged with air-to-air aftercooling (ATAAC).

A full-range hydramechanical governor controls the fuel injection pump output, maintaining the engine rpm selected by the operator. Individual injection pumps (one for each cylinder) meter and pump fuel under high pressure to injection nozzles. Automatic timing advance provides the best fuel injection timing over the full range of engine speed.

The cooling system consists of:

- a gear driven centrifugal pump (with one thermostat which regulates the engine coolant temperature)
- an oil cooler, and
- a radiator (incorporating a shunt system).

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

Engine efficiency, efficiency of emission controls, and engine performance depend on adherence to proper operation and maintenance recommendations. Engine performance and efficiency also depend on the use of recommended fuels and lubrication oils. Follow the recommended Maintenance Schedule found in this publication, paying attention to emission related components, air cleaner, oil, oil filter, fuel and fuel filter maintenance.

Serial Number, Information Plate and Reference Numbers

Serial Number Plate

CATERPILLAR		(E)	CAT
SERIAL NUMBER			ARRANGEMENT NUMBER
ENGINE MODEL			
(ALWAYS GIVE ALL NUMBERS)			
D35477			

The Serial Number Plate is located on the rear of the cylinder block.

Information Plate

CAT		CORE AR.	
SER. NO.		DATE DELIVERED	
MODIFICATION NO.		DLR CODE	
AS NO.		PERF SPEC	MAY ALT
OEM NO.			
FULL LOAD STATIC FUEL POWER	HP	FULL TORQ. STATIC FUEL	
		kw A/F RATIO DYNAMIC	
BASE ENG. HI IDLE RPM		FULL LOAD RPM	FUEL TIMING
		9L-8531	17
D32111			

The Information Plate is located on the left side of the cylinder block, or on the valve cover.

Engine Identification

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

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

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

Reference Numbers

NOTE: Locate the following information for your engine, and record it on the appropriate line below. You may wish to make a copy of this record. Retain the information for future reference.

Record for Reference

Engine Model_____

Engine Serial No._____

Engine Arrangement No._____

Engine Power_____

Engine Low Idle rpm_____

Engine Full Load rpm_____

Performance Specification No._____

Governor Group No._____

Fuel Filter Element No._____

Lubrication Oil Filter Element No._____

Auxiliary Oil Filter Element No._____

Lubrication Oil System Capacity_____

Supplemental Coolant Additive Maintenance Element No._____

Supplemental Coolant Additive Precharge Element (Optional) No._____

Cooling System Capacity_____

Air Cleaner Element No._____

Fan Drive Belt Set No._____

Alternator Belt No._____

Ordering Parts

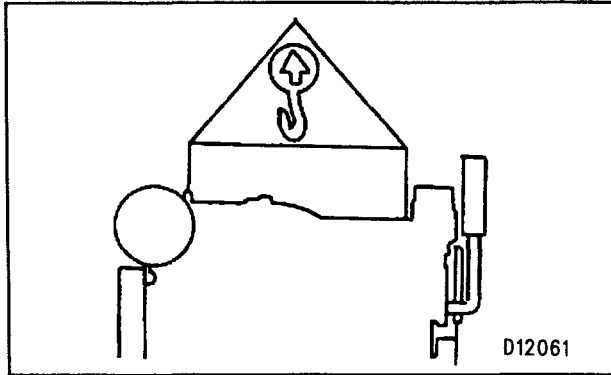
When ordering parts, your order should specify the quantity, part number, part name and serial number, arrangement number and modification number of the engine for which the parts are needed. If in doubt about the part number, please provide your dealer with a complete description of the needed item.

When service or maintenance is needed for your Caterpillar engine, be prepared to give the dealer all 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 in troubleshooting and solving the problem faster.

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. Eye Bolts and brackets should never be bent, and should only be loaded under tension.

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

Some removals require the use of lifting fixtures, 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 engine arrangement weight renders the lifting eyes and devices obsolete.

If you modify the lifting eyes and/or 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

NOTE: Do not use the engine lifting eyes to remove the engine and generator together.

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

The following Engine Storage procedures and recommendations minimize the possibility of damage to engines stored for one year or less.

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.

Special precautions should be used with engines remaining out of service for extended periods.

After one year, a complete protection procedure must be followed if the engine is kept in storage longer.

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 it will be impossible to start the engine periodically, consult your Caterpillar dealer for instructions to prepare your engine for longer storage periods.

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

Generator Storage Procedure

When a generator is stored, moisture may condense in the windings. Use a dry storage space and space heaters to minimize condensation. Refer to: Service Manual for SR4 Generators, SENR3985, or Special Instruction, SEHS9124, Cleaning and Drying of Caterpillar Electric Set Generators, or contact your Caterpillar dealer.

After Storage

NOTE: Test the main stator windings with a megohmmeter:

- Before the initial startup of the generator set.
- Every 3 months* if the generator is operating in a humid environment.
- If the generator has not been run under load for 3 months* or more.

* This is a guideline only. It may be necessary to megger more frequently if the environment is extremely humid or salty.

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 OPERATE¹. 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.

¹DO NOT OPERATE tags, SEHS7332, are available from your Caterpillar dealer.

To Remove 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, of the same type used in marine applications, 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.

The megohmmeter test is described in Service Manual for SR4 Generators, SENR3985 or Special Instruction, SEHS9124, Cleaning and Drying of Caterpillar Electric Set Generators, or contact your Caterpillar dealer.

Engine Specifications

3304B Engine

3304B ENGINE SPECIFICATIONS	
Number of Cylinders	4 In-Line
Bore	121 mm (4.75 in.)
Stroke	152 mm (6.0 in.)
Compression Ratio	15:1
Aspiration	NA & T
Displacement	7.0 L (425 cu in.)
Firing Order	1-3-4-2
Rotation (viewed from flywheel)	Counterclockwise

3304B VALVE LASH (CLEARANCE) SETTING	
Intake	0.38 mm (0.015 inch)
Exhaust	0.64 mm (0.025 inch)

CRANKSHAFT POSITIONS FOR INJECTOR TIMING AND VALVE LASH (CLEARANCE) SETTING		
3304B 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		
Intake Valves	1-2	3-4
Exhaust Valves	1-3	2-4
Firing Order	1-3-4-2	

¹ Put No. 1 piston at top center (TC) position and make identification for the correct stroke. After 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° in the direction of normal engine rotation. This will put No. 1 piston at top center (TC) position on the other stroke. Install the timing bolt in the flywheel and complete the adjustments for the cylinders that remain.

3306B Engine

3306B ENGINE SPECIFICATIONS	
Number of Cylinders	6 In-Line
Bore	121 mm (4.75 in.)
Stroke	152 mm (6.0 in.)
Compression Ratio	15:1
Aspiration	NA, T & TA
Displacement	10.5 L (638 cu in.)
Firing Order	1-5-3-6-2-4
Rotation (viewed from flywheel)	Counterclockwise

3306B VALVE LASH (CLEARANCE) SETTING	
Intake	0.38 mm (0.015 inch)
Exhaust	0.64 mm (0.025 inch)

CRANKSHAFT POSITIONS FOR INJECTOR TIMING AND VALVE LASH (CLEARANCE) SETTING		
3306B 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		
Intake Valves	1-2-4	3-5-6
Exhaust Valves	1-3-5	2-4-6
Firing Order	1-5-3-6-2-4	

¹ Put No. 1 piston at top center (TC) position and make identification for the correct stroke. After 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° in the direction of normal engine rotation. This will put No. 1 piston at top center (TC) position on the other stroke. Install the timing bolt in the flywheel and complete the adjustments for the cylinders that remain.

Torque Specifications

Torque for Standard Bolts, Nuts and Taperlock Studs

NOTICE

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

Torques for Bolts and Nuts With Standard Threads

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

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

Torques for Taperlock Studs

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

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

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

Torque for Metric Fasteners

NOTICE

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

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

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

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

Torques for Bolts and Nuts with Metric Threads

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

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

² ISO—International Standard Organization.

Torque for Standard Hose Clamps—Worm Drive Band Type

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

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

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

Torque for Constant Torque Hose Clamps

NOTICE

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

Installation

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

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

Cooling System Specifications

Caterpillar Long Life Coolant/Antifreeze (LLCA)

Caterpillar has introduced a commercial Long Life Coolant/Antifreeze (LLCA) for use in Caterpillar and other heavy duty diesel engines. LLCA provides improved corrosion protection for the engine cooling system. LLCA replaces conventional type antifreeze.

LLCA extends coolant life to 6,000 service hours or four years with only one maintenance addition. LLCA does not require Supplemental Coolant Additive (SCA). A "one time only" coolant "Extender" is the only maintenance addition that is required, at 3,000 service hours or two years.

LLCA is ethylene glycol based for freeze and anti-boil protection. The anti-corrosion LLCA package is totally different from the standard silicate, molybdate, nitrate, borate and phosphate antifreezes that have been in use. Because of this difference, the two coolants **CAN NOT** be mixed.

NOTICE

Mixing LLCA with other products reduces the effectiveness of the coolant. Mixing LLCA with other products could result in damage to cooling system components. Do not mix LLCA with other products.

Although Caterpillar is not presently using LLCA for standard factory fill, an engine or machine may be special ordered with LLCA as the fill coolant. Due to the non-mixing requirements, the owner will initiate the use of this coolant.

LLCA has an effective operating temperature range of -46 to 127°C (-50 to 260°F). At temperatures below -46°C (-50°F), the coolant viscosity will increase, presenting a pumping problem unless provisions are made for a larger water pump. Brief departures of temperatures above 127°C (260°F) are acceptable for short periods of time. However, prolonged operation above the limits will degrade the glycol and inhibitor system. The system must be pressurized to maintain the coolant in a liquid phase at all times. Any boiling will result in precipitation on the surfaces of the engine coolant jacket.

LLCA has been developed with the antifreeze and additive at a specific level for maximum protection. If the proportion of antifreeze is reduced, the additive is also reduced, lowering the coolant's ability to protect the system from pitting, cavitation, erosion, and deposits.

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

CATERPILLAR LONG LIFE COOLANT/ANTIFREEZE QUANTITIES AVAILABLE		
Type	Size	Part No.
Pre-mix ¹	Bulk	119-5148
	208.5 L (55 US gal)	101-2845
	3.8 L (1 US gal)	101-2844
Concentrate ²	3.8 L (1 US gal)	119-5150
Extender ³	.95 L (1 qt)	119-5152

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

² Use **ONLY** distilled or deionized water to mix with the concentrate.

³ Extender must be added to the cooling system only one time at 3,000 hours or two years in the quantity recommended by Caterpillar.

LLCA concentrate is available to lower the freeze point for arctic conditions. LLCA concentration can be increased for lower operating temperatures without a problem to 60 percent for -60°C (-76°F). Do not use LLCA at reduced concentrations (less than 50 percent), since the additives would be reduced along with the antifreeze.

LLCA Extender

LLCA does not require the frequent Supplemental Coolant Additive (SCA) additions associated with the present conventional coolants. Only a "one time" coolant Extender addition is required. The Extender is added to the cooling system halfway through the LLCA service life.

NOTICE

Depletion of the additives in LLCA is a function of operating time. However, the Extender may not be required for engines with very low operating miles or hours. For more information, contact your Caterpillar dealer.

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

NOTICE

Use only Caterpillar Extender with LLCA. Failure to follow this recommendation can result in shortened cooling system component life.

LLCA can be recycled in the same manner as conventional antifreeze/coolant. The drained coolant mixture can be "distilled" to remove the ethylene glycol and water for reuse. The inhibitor system and other contaminants are left behind as residual for disposal. Contact your Caterpillar dealer for more information.

Cooling System Maintenance When Using LLCA

Changing the Cooling System from Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) or Commercial Coolants to LLCA

When the cooling system coolant is changed from conventional antifreeze to LLCA, Caterpillar cleaner should be used. Refer to the Caterpillar Cooling System Cleaner chart in this publication. After the use of Caterpillar cooling system cleaner, the system **MUST** be thoroughly flushed with clean water.

To switch from conventional antifreeze/coolant to LLCA:

1. Drain the antifreeze.
2. Flush the system with clean water to remove any debris.
3. Use Caterpillar cleaner to clean the cooling system. Follow the instructions on the label.
4. Drain the cleaner, and flush the cooling system with clean water.
5. Fill the cooling system with clean water. Operate the engine until warm 49 to 66°C (150 to 120°F).
6. Drain the cooling system. Flush the cooling system with clean water.
7. Repeat steps 5 and 6.
8. Fill the cooling system with LLCA. Refer to the refill capacities chart in this manual for the amount of LLCA needed to refill your system.

LLCA Cooling System Draining, Cleaning, and Refilling

No cleaning agents are to be used when a cooling system already filled with LLCA is drained, flushed, and refilled. When LLCA is drained from the cooling system, **CLEAN WATER** is the only system cleaning/flushing agent required.

When LLCA is already in the cooling system, drain, clean, and refill the system after 6,000 service hours or four years, whichever comes first. Do not use cooling system cleaners. Follow the preceeding steps 4 through 8. The drained LLCA should be recycled, as with conventional coolants.

Use the PEEP5027 decal to avoid mixing conventional coolants with LLCA, and to help document LLCA maintenance. Attach the decal close to the coolant fill tube on the expansion tank or radiator. The decal is heat resistant for surface temperatures up to 193°C (380°F).

Attention
Fill with Cat Long Life Coolant/Antifreeze.
Mileage or Hours: _____
Date Filled: _____
● Top up or refill with Cat LLCA or if not available use a coolant that meets Cat ED-4. If this is not possible top off with distilled water and adjust mixture concentration back at the shop.
● Add Cat Extender after 3000 hours or 150,000 miles.
● DO NOT mix conventional coolants and SCAs with Cat LLCA to achieve optimum coolant life.
● Change out Cat LLCA at 8000 hours/300,000 miles or every 4 years whichever comes first.
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D33746

Conventional Antifreeze/Coolant Information

Diesel engine operating temperatures have increased to improve engine efficiency. This makes proper cooling system maintenance especially important. Coolant quality is as important as the quality of fuel and lubricating oil. It is important that this section be read carefully.

Overheating, over cooling, pitting, cavitation erosion, cracked heads, piston seizures, and plugged radiators are results of typical cooling system failures. Such failures can be avoided by practicing good maintenance.

Due to individual engine applications, maintenance practices may need periodic re-evaluation to properly maintain the engine's cooling system.

If the engine is to be stored in or shipped to a climate with freezing temperatures, the cooling system must be protected to the lowest expected outside (ambient) temperature.

NOTE: The engine cooling system is normally shipped dry from the factory, unless special requirements are defined.

NOTICE

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

Coolant Mixture for Caterpillar Engines

Proper engine coolant is a combination of:

- water,
- coolant/antifreeze, and
- Supplemental Coolant Additive (SCA).

Each ingredient of the mixture must meet specific guidelines for the engine coolant to perform properly. The coolant mixture used in Caterpillar engines must provide:

- adequate heat transfer.
- cavitation erosion protection.
- freeze & boil protection.
- sludge & scale protection.
- corrosion protection.
- compatibility with system hoses & seals.

NOTICE

Use only Caterpillar products or commercial products that have passed the Caterpillar EC-1 specification for pre-mixed or concentrate coolants. Follow the instructions provided by the antifreeze supplier.

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

Coolant Water

Coolant Water Characteristics

Water may contain several types of dissolved solids, such as phosphates, calcium, magnesium, chlorides, and sulfates. Dissolved solids in water can combine with mineral silicates and phosphates in SCA. The combinations may drop out of solution, depositing inside the radiator. The deposits are in the form of sludge and scale. The deposits can accumulate on hot engine surfaces and reduce the effectiveness of the cooling system, especially after a number of heating and cooling cycles.

NOTICE

All water is corrosive at engine operating temperatures. The cooling system should be protected against water corrosion with a three to six percent concentration of liquid Supplemental Coolant Additive (SCA) at all times, regardless of the concentration of antifreeze/coolant.

Recommendations for Coolant Water

Distilled or deionized water is recommended because of less mineral drop out than hard or tap water. Tap water artificially softened with salt is NOT recommended for use in engine cooling systems.

If Distilled or deionized water is NOT available, use water that meets the minimum acceptable requirements listed in the following chart.

MINIMUM ACCEPTABLE WATER	
Water Content	Limits gr/U.S. gal (ppm)
Chlorides	2.4 (40) maximum
Sulfates	5.9 (100) maximum
Total Hardness	10 (170) maximum
Total Solids	20 (340) maximum
Acidity (pH)	5.5 to 9.0

ppm = parts per million

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

Caterpillar Diesel Engine Antifreeze/Coolant (DEAC)

Most commercial antifreeze/coolants are formulated for gasoline engine applications and have high silicate content. Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) is formulated with a low silicate content and the proper coolant additives for heavy duty diesel engines.

If conventional antifreeze is to be used rather than LLCA, Caterpillar recommends: Caterpillar DEAC, or any low silicate (ethylene or propylene glycol) antifreeze that meets ASTM D4985-89 requirements.

Caterpillar recommends that the coolant mixture contain a minimum of 30 percent Caterpillar DEAC (or equivalent), and 70 percent distilled or deionized water. The recommended mixture maintains an adequate water pump cavitation temperature for efficient water pump performance.

NOTICE

Only use a greater concentration (above 30 percent) of Caterpillar DEAC as needed for anticipated outside (ambient) temperatures. Do not exceed a coolant mixture of 60 percent antifreeze to 40 percent water. Antifreeze concentration above 60 percent reduces engine freeze protection and increases potential deposit formation in the cooling system.

Some engine applications operate with SCA treated water without antifreeze/coolant. Do not mix SCA treated water in the cooling system with Caterpillar DEAC. Incompatibility could cause cooling system damage because the coolant will have an excessive SCA concentration.

Major advantages of Caterpillar DEAC:

- Significantly reduces water pump seal leakage problems caused by excessive concentration of chemical additives.
- There is no need to add SCA on initial fill, which must be done with other commercially available antifreezes.
- Caterpillar DEAC is formulated with a low silicate content. High silicate antifreeze/coolants used with a SCA can cause a build-up of solids over a period of time. Build-up of solids can cause plugging, loss of heat transfer, and water pump seal damage.

Caterpillar DEAC is available through your Caterpillar dealer in the following quantities.

CATERPILLAR DIESEL ENGINE ANTIFREEZE/COOLANT¹		
Part No.	Type	Size
8C3684	Concentrate	3.8 L (1 US gal)
8C3686	Concentrate	208.5 L (55 US gal)
2P9868	Concentrate	18,950 L (5,000 US gal) (Bulk)
3E9439	50/50 Premix	18,950 L (5,000 US gal) (Bulk)
119-5147	40% DEAC/ 60% Water Premix	18,950 L (5,000 US gal) (Bulk)

¹ Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) contains necessary Supplemental Coolant Additive (SCA). Caterpillar DEAC does not require SCA on initial fill. SCA liquid or SCA spin-on element is required on a maintenance basis. Check the coolant concentration of SCA regularly.

Make proper antifreeze additions.

Unless freeze protection is needed for arctic conditions, DO NOT add pure antifreeze as a makeup solution for cooling system top-off. Using pure antifreeze as a makeup solution increases the concentration of antifreeze in the cooling system, which increases the concentration of dissolved solids and undissolved chemical inhibitors. When you top-off the cooling system, add antifreeze, mixed with acceptable water, to the same concentration as the coolant in the system.

NOTE: Premix the coolant solution prior to pouring it into the cooling system. Pure undiluted antifreeze will freeze at -23°C (-10°F). Use a mixture which will provide protection to the lowest expected outside (ambient) temperature.

Use the following chart to determine concentrations of Caterpillar DEAC to mix with acceptable water.

ANTIFREEZE CONCENTRATIONS (GLYCOL)	
Protection Temperature	Concentration
Protection to -15°C (5°F)	30% antifreeze and 70% water
Protection to -23°C (-10°F)	40% antifreeze and 60% water
Protection to -37°C (-34°F)	50% antifreeze and 50% water
Protection to -51°C (-60°F)	60% antifreeze and 40% water

FREEZING POINT OF COOLANT		
Concentration of Antifreeze (%) by Volume	Ethylene ¹	Propylene ²
0	0°C (32°F)	0°C (32°F)
20	-9°C (16°F)	-7°C (19°F)
30	-15°C (4°F)	-12°C (10°F)
40	-24°C (-12°F)	-21°C (-6°F)
50	-37°C (-34°F)	-33°C (-27°F)
60	-52°C (-62°F)	-

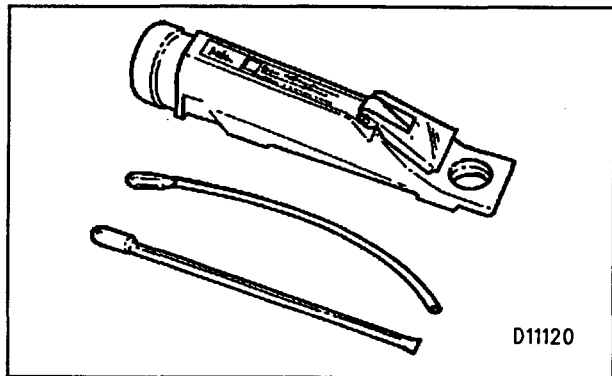
¹ Caterpillar does not recommend concentrations of over 60 percent ethylene glycol.

² If propylene glycol based antifreeze is used, DO NOT allow greater than a 50/50 antifreeze to water mixture.

Check the antifreeze frequently in cold weather to ensure adequate freeze protection.

The measurement of freeze protection must be made with a refractive-type tester rather than a commercially available hydrometer-type tester. Hydrometer-type testers can only be used to test ethylene glycol based antifreeze.

Test the antifreeze concentration with the 5P3514 (measures °C) or 5P0957 (measures °F) Test Kit. The Test Kits give immediate, accurate readings, and can be used on ethylene or propylene glycol antifreezes. Both Test Kits are available from your Caterpillar dealer.



5P3514(°C) or 5P0957 (°F) Coolant Test Kit .

Supplemental Coolant Additive (SCA)

Supplemental Coolant Additive (SCA) is necessary for proper engine maintenance. SCA is necessary to inhibit rust, scale, deposits, cavitation, pitting, and corrosion of the engine parts that coolant comes in contact with. Most antifreeze solutions DO NOT contain sufficient SCA.

Some engines are equipped with a Caterpillar SCA spin-on element. Use SCA liquid or a spin-on element (if equipped) to maintain a three to six percent SCA concentration in the coolant.

! WARNING

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

NOTICE

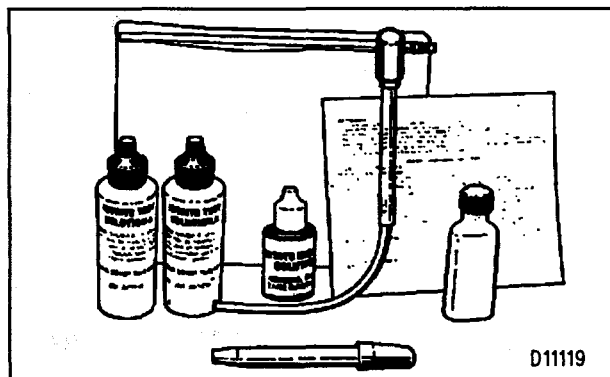
The cooling system **MUST** contain supplemental coolant additive (SCA) for proper engine protection, regardless of antifreeze concentration.

DO NOT mix Caterpillar SCA or SCA spin-on elements with another manufacturer's SCA products. **DO NOT** use both liquid SCA and a SCA spin-on element at the same time. Select a cooling system treatment and use it exclusively.

DO NOT mix SCA with antifreeze/coolant products containing methoxy propanol.

Do not exceed the recommended six percent SCA concentration together with antifreeze concentrations greater than 60 percent. Excessive SCA concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components. Excessive SCA concentration could also result in radiator tube blockage, overheating, and/or accelerated water pump seal wear.

Use the 8T5296 Test Kit to check the concentration level of Caterpillar SCA.



Caterpillar 8T5296 SCA Test Kit.

NOTE: The Caterpillar 8T5296 Test Kit checks for concentration of nitrates in the coolant solution. Some other manufacturers' SCA is phosphate based. The 8T5296 Test Kit provides inaccurate results with phosphate based SCA. Commercial SCA products must contain silicates and a minimum of 70 gr/U.S. gallon (1200 ppm) nitrites. If other manufacturers' SCA is used, also use the SCA manufacturer's test kit. Follow the manufacturer's recommendation for cooling system treatment and test evaluation.

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

LIQUID SUPPLEMENTAL COOLANT ADDITIVE QUANTITIES AVAILABLE	
Part No.	Size
6V3542	0.24 L (8 oz)
111-2372	0.35 L (12 oz)
8T1589	0.47 L (1 pt)
3P2044	0.95 L (1 qt)
8C3680	19 L (5 US gal)
5P2907	208.5 L (55 US gal)

Water-Only Coolant

Caterpillar recommends a minimum concentration of 30 percent DEAC and 70 percent deionized or distilled water in a coolant solution. Supplemental coolant additive (SCA) should comprise three to six percent of that solution. However, a coolant mixture of acceptable water and SCA can be used in applications where conditions do not require freeze protection, or where antifreeze is not available.

A coolant mixture of water and SCA will cool and provide some protection to engine components, but it will not provide normal engine service life. SCA/water mixtures provide better performance life than water-only coolant.

If the engine cooling system is filled with water ONLY, SCA concentration should be maintained at six to eight percent maximum. Do not exceed the eight percent maximum concentration. Monitor SCA concentration levels with a SCA test kit.

The 8T5296 Test Kit can be used to evaluate the SCA concentration of water-only coolant. Follow the instructions on the Test Kit package, making these modifications to label instruction steps 3 and 5:

STEP 3—Add tap water to the vial up to the 20 ml mark.
STEP 5—With the defined procedure, the six to eight percent concentration will yield a 20 to 27 drop range. Fewer drops indicate under-concentration of SCA and more drops indicate over-concentration. Adjust the concentration appropriately.

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

Initial Fill

SCA is pre-mixed in Caterpillar Antifreeze. SCA is not needed for initial fill when Caterpillar Antifreeze is being used. SCA is required on a maintenance basis, even when using Caterpillar DEAC.

NOTICE

SCA is required on initial fill and for subsequent maintenance when using coolant/antifreeze products other than Caterpillar's which meet ASTM D4985 standards.

On initial fill or refill, add one liter (one quart) of SCA or equivalent for each 19 liters (5 US gal) of ASTM D4985 coolant/antifreeze solution. The solution should have a three to six percent concentration of SCA.

NOTICE

For engines equipped with SCA spin-on elements: the spin-on element can be installed at initial fill, when the coolant is replaced, and at overhaul. However, the element should not be turned on until after 250 service hours, or as determined by testing for SCA concentration. This prevents over-concentration of SCA.

INITIAL FILL SUPPLEMENTAL COOLANT ADDITIVE REQUIREMENTS	
Antifreeze	Initial Fill
Caterpillar DEAC ¹	None Required
ASTM D4985	Use Caterpillar supplemental coolant additive liquid in the quantities listed in following chart.

¹ Caterpillar Diesel Engine Antifreeze/Coolant.

INITIAL FILL LIQUID SUPPLEMENTAL COOLANT ADDITIVE BY CAPACITY ¹		
Cooling System Capacity Liters (US gal)	Add Initial Fill Quantity ² Or	Commercial Bulk Volume
22 to 30 (6 to 8)	3P2044 (1)	0.95 L (1 qt)
30 to 38 (8 to 10)	3P2044 (1) 6V3542 (1)	1.2 L (40 oz)
(38 to 49) (10 to 13)	3P2044 (1) 8T1589 (1)	1.4 L (48 oz)
49 to 64 (13-17)	3P2044 (2)	1.9 L (2 qt)
64 to 83 (17 to 22)	3P2044 (2) 8T1589 (1)	2.4 L (80 oz)
83 to 114 (22 to 30)	3P2044 (3) 8T1589 (1)	3.3 L (112 oz)
114 to 163 (30 to 44)	3P2044 (5)	4.7 L (5 qt)
163 to 243 (44 to 64)	3P2044 (8)	7.6 L (8 qt)

¹ Caterpillar Diesel Engine Antifreeze Coolant (DEAC) contains necessary Supplemental Coolant Additive (SCA). Caterpillar DEAC does not require additional SCA on initial fill. Only use SCA on initial fill when using coolant/antifreeze products which meet ASTM D4985 standards.

² Number in brackets () indicates quantity required.

Maintenance

Maintaining the cooling system is important because the cooling system has a direct effect on the operation and service life of the engine. Improper maintenance can cause a variety of problems which could reduce engine performance and service life.

Check the antifreeze concentration frequently in cold weather to ensure adequate freeze protection. Use the 5P3514 (°C) or 5P0957 (°F) test kit.

Use the 8T5296 Test Kit to test and monitor the SCA concentration in your engine's coolant mixture. SCA concentration should be tested every 250 service hours or one year, whichever comes first. Add liquid SCA or a new SCA spin-on element (if equipped) as required to maintain a three to six percent SCA concentration.

NOTICE

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

When using Caterpillar DEAC and SCA, the cooling system should be drained, cleaned, and refilled with new coolant every 3000 service hours or two years.

When NOT using Caterpillar DEAC and SCA as recommended, the drain/flush/clean/refill must be performed at least every year.

NOTICE

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

After cleaning and refilling the cooling system, operate the engine with the coolant filler cap removed until the coolant reaches normal operating temperature and the coolant level stabilizes. Add coolant mixture as necessary to fill the system to the proper level. Add 0.24 L (8 oz) of SCA for each 19 L (5 US gal) of coolant mixture.

LIQUID MAINTENANCE SUPPLEMENTAL COOLANT ADDITIVE BY CAPACITY ¹		
Cooling System Capacity Liter (US gal)	Add Maintenance Quantity ² Or	Commercial Bulk Volume
22 to 30 (6 to 8)	6V3542 (1)	0.24 L (8 oz)
30 to 38 (8 to 10)	111-2372	0.35 L (12 oz)
38 to 49 (10 to 13)	111-2372	0.35 L (12 oz)
49 to 64 (13 to 17)	8T1589 (1)	0.47 L (1 pt)
64-83 (17 to 22)	6V3542 (1) 111-2372 (1)	.64 L (20 oz)
83 to 114 (22 to 30)	3P2044 (1)	0.95 L (1 qt)
114 to 163 (30 to 43)	3P2044 (1) 6V3542 (1)	1.2 L (40 oz)
163 to 243 (43 to 64)	3P2044 (2)	1.9 L (2 qt)

¹ Do not exceed six percent maximum supplemental coolant additive (SCA) concentration. Check SCA concentration at each oil change with the supplemental coolant additive test kit.

² Number in brackets () indicates quantity required

The following chart applies ONLY to engines with supplemental coolant additive (spin-on) elements.

SUPPLEMENTAL COOLANT ADDITIVE ¹ ELEMENTS BY CAPACITY	
System Size Liter (US gal)	250 Hour Maintenance Element ²
22 to 30 (6 to 8)	111-2370 (1)
30 to 49 (8 to 13)	111-2369 (1)
49 to 64 (13 to 17)	9N3368 (1)
64 to 83 (17 to 22)	111-2371 (1)
83 to 114 (22 to 30)	9N3718 (1)
114 to 163 (30 to 43)	111-2371 (2)
163 to 243 (43 to 64)	9N3718 (2)

¹ Do not use elements at initial fill or refill. Do not exceed six percent maximum supplemental coolant additive (SCA) concentration. Check SCA concentration at each oil change with the supplemental coolant additive test kit.

² Number in brackets () indicates quantity required

NOTICE

The SCA element can be installed at initial fill and refill. However, the elements should not be used until SCA is needed, as determined by testing for SCA concentration.

Cooling System Cleaning

When you drain, clean, flush and replace the coolant, small particles, undesirable chemicals, scale, and other deposit formations are removed. The deposits reduce the necessary heat transfer characteristics of the cooling system, and accelerate wear to the water pump seal. Disregard for performing maintenance on the cooling system can eventually cause engine overheating problems that could result in severe damage to the engine and its components.

NOTE: Clean the cooling system if: it becomes contaminated, the engine overheats, or foaming is observed in the radiator.

When using Caterpillar DEAC, drain, clean, and refill the cooling system every two years or 3,000 service hours, whichever comes first.

NOTICE

When using commercial antifreeze/coolant products from a manufacturer other than Caterpillar, drain, clean, and refill the cooling system every year or 1,500 service hours, whichever comes first.

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

Cooling system cleaners are available from your Caterpillar dealer in the quantities listed below. Refer to the maintenance instructions in the Maintenance Schedule, and follow the product label directions for proper usage.

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

Fuel Specifications

Fuel Recommendations

NOTICE

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

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

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

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

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

WORLDWIDE FUEL SPECIFICATIONS—DIESEL ENGINES	
Specifications	Fuel Designation
U.S. STANDARDS ASTM D975	No.1-D & No.2-D diesel fuel oil
BRITISH STANDARDS BS 2869	Classes A1, A2 & B1 engine fuels
GERMAN STANDARDS DIN 51601	Diesel Fuel
AUSTRALIAN STANDARD AS 3570	Automotive diesel fuel
JAPANESE STANDARD JIS K2204	Types 1(spl), 1, 2, 3 & 3(spl) gas oil
U.S. GOVERNMENT VV-F-800C	DF-1,DF-2 conus & DF-20 conus diesel fuel
U.S. MILITARY MIL-F-16884G	Marine Oil

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

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

¹ As delivered to fuel system

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

Cetane Number

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

Filterability

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

Pour Point

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

Cloud Point

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

Viscosity

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

Additives

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

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

Fuel Sulfur

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

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

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

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

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

Lubricant Specifications

Lubricant Information

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

Certain abbreviations in this section follow Society of Automotive Engineers (SAE) J754 and SAE J183 nomenclature, classifications, and abbreviations. The definitions other than Caterpillar's will be of assistance in purchasing lubricants. SPC is a Caterpillar designation for special synthetic oils that do not contain viscosity improvers. Recommended oil viscosities can be found in the Lubricant Viscosities chart in this publication.

A new oil performance category has been released by the American Petroleum Institute (API) for diesel engine oil and by Caterpillar for engine oil. The new category is:

API CG-4 (engine oil)

This oil is performance tested on the new Cat 1N single cylinder oil test engine, and on other engine tests.

Caterpillar Oils have been developed, tested, and approved by Caterpillar to maximize the performance designed and built into our engines. Caterpillar Oils are offered in a full line of appropriate single and multi-viscosity grades to meet performance and ambient temperature requirements. Refer to the Literature Reference Materials section of this publication for additional lubricant information.

Engine Lubricant Specifications

Performance characteristics of lubricant oil depends on the base oil and the additives. Additives in the oil will vary according to the properties of the base oil and the environment in which the oil will perform.

Maximum engine life and performance can be expected when the proper engine oil is used. There are significant variations in the quality and performance of commercially available oils.

To achieve the maximum engine life and superior performance in your diesel engine, Caterpillar recommends:

Caterpillar Diesel Engine Oil (DEO)– CG-4

Caterpillar Oils are performance rated as
SAE 10W30-API CG-4: API CF-4
SAE 15W40-API CG-4: API CF-4

Caterpillar DEO (CG-4/CF-4) is formulated with strong dispersion effectiveness, sufficient alkalinity, and low sulfated ash level for performance requirements of present and future engine designs. Oils meeting the API CG-4/CF-4 standards operate effectively at the higher piston temperatures of some current and future engines.

DEO (CG-4) selection depends on engine type, fuel sulfur content, engine application, and customer preference. Caterpillar DEO CG-4 is recommended for use in North America for all applications, excluding Caterpillar 3600 Engines. CF-4 will continue to be the recommended oil for countries continuing to operate at fuel-sulfur levels higher than 0.05 percent.

Lubricant Viscosity Specifications

Multi-grade oils are required because they are consumed at levels significantly lower than single grade oils. Caterpillar DEO (CG-4/CF-4) is blended in viscosity grades of SAE 10W30 and 15W40. Qualified as API SH, these oils may be used in gasoline engine applications requiring this performance rating.

The proper SAE grade of oil to select is determined by the minimum outside temperature at which the engine will be started, and the maximum outside temperature in which the engine will be operating. This recommendation is to ensure the correct viscosity is used until the next oil change. Refer to the Lubricant Viscosity chart in this publication for recommended viscosity and temperature ranges.

The minimum temperature for the viscosity grade provides guidelines for the lowest starting temperature with a "cold soaked" engine. Base stocks for blending oil formulations differ. Variations on low temperature characteristics can exist within a viscosity grade. Therefore, a particular oil may allow lower starting temperatures than given in the chart. Your oil supplier can provide additional information on oil properties.

The use of API CG-4 or CF-4 multi-viscosity oils is preferred because of full protection through a wider temperature range. The highest viscosity oil possible is recommended. 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 flows off, the oil is fluid enough to circulate properly.

NOTE: Start-up at oil temperatures below the minimum requires caution. Do not increase engine rpm or add load until oil temperatures are within the recommended range and oil pressures are normal.

Lubricant Viscosity Chart

LUBRICANT VISCOSITIES FOR AMBIENT (OUTSIDE) TEMPERATURES					
Compartment or System	Oil Viscosities	°C		°F	
		Min	Max	Min	Max
Engine Crankcase	SPC SAE 5W20	-30	+10	-22	+50
	SAE 5W20	-25	+10	-13	+50
	SAE 10W30	-20	+40	-4	+104
	SAE 15W40	-15	+50	+5	+122

The following chart lists Caterpillar Diesel Engine Oil quantities and part numbers, available from your Caterpillar dealer.

Caterpillar Engine Oil DEO (CG-4)	3.8 L (1 US gal)	19 L (5 US gal)	208.5 L (55 US gal)
SAE 10W30	3E9904	3E9709	3E9708
SAE 15W40	3E9714	3E9713	3E9712

Commercial Oils

API CC and CD oils are unacceptable in this Caterpillar diesel engine. The following chart provides specification guidelines for selecting commercial oil products other than Caterpillar oils.

Engine Model	Alternate Oils*
3304B & 3306B	API CG-4, CG-4/SH API CF-4, CF-4/SG, SH

* Consult with your Caterpillar dealer for oil recommendations. Commercial oils which have been used with success in the past may continue to be used, provided the formulations have not changed (consult with your oil supplier). However, the use of these oil products does not allow their wider use in all Caterpillar engines, as compared to the API CF-4 and CG-4 oils.

Commercial oils other than Caterpillar oils may require shortened oil change intervals, determined by S•O•S analysis monitoring.

NOTICE

Failure to follow the commercial oil recommendations can cause shortened engine life due to piston carbon deposits, liner bore polish and/or abnormally increased oil consumption. Follow the recommendations to protect your engine investment.

Total Base Number (TBN)

Fuel sulfur content affects engine oil recommendations. Engine combustion can chemically change fuel sulfur into sulfurous and sulfuric acids. Sulfur products formation varies with fuel sulfur content, oil formulation, crankcase blowby, engine operating conditions, and ambient temperature.

Alkaline compounds are added to lubricating oils to neutralize combustion acids. A Total Base Number (TBN) measures and defines reserve alkalinity in lubricating oil. Infrared Analysis (ASTM D2896 procedure) can help evaluate fuel sulfur effects, such as the residual neutralization properties of engine oil.

New engine oil must have a TBN of 20 times (for Precombustion Chamber engines) and ten times (for direct injection engines) the percent fuel sulfur as measured by ASTM D2896 method.

Caterpillar's 20 times rule for TBN (Reference: Oil and Your Engine, SEBD0640) versus fuel sulfur was a general requirement developed in the early 1980's for Cat prechamber combustion (PC) system engines. Caterpillar still maintains 20 times TBN value for PC engines when using API CD, CE or CF-4 oil (related to fuel sulfur above 0.5 percent). Engines built prior to 1990 can continue to use DEO-CD single grade viscosity oil or commercial oils, provided the engine operates to user satisfaction.

Fuel sulfur neutralization of new oil formulations in direct injection (DI) system engines are more effective. Field results indicate that direct injection combustion (DI) systems and the oils now recommended for those engines will operate at an oil TBN equal to ten times the fuel sulfur.

Caterpillar requirements now reflect the new value of ten times instead of 20 for oil TBN, regarding fuel sulfur in Cat DI engines and API CG-4/CF-4 oils. New engine oil for DI engines must have a TBN of ten times the percent fuel sulfur, as measured by ASTM D2896 method. The minimum TBN is 5, regardless of fuel sulfur level.

The "ten times" rule should be used for fuels with 0.5 percent or more sulfur by weight. For fuels with 0.5 percent sulfur or more by weight, new engine oil must have a TBN of ten times the percentage of fuel sulfur, as measured by the ASTM (American Society of Testing Materials) D2896 method.

For example, if your fuel is 0.5 percent sulfur by weight:

$$0.5 \times 10 = 5$$

If your fuel is 0.5 percent sulfur by weight, your oil should have a minimum TBN of 5. ASTM D2896 can normally be found at your local technological society, library or college.

Oil analysis is strongly recommended for determining new oil change intervals.

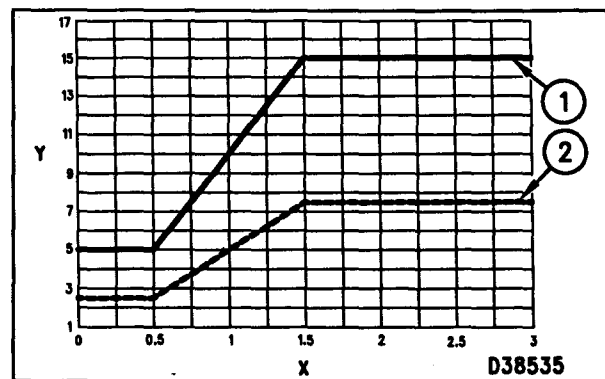
Caterpillar recommends using S•O•S analysis including infrared analysis (IR) to help monitor TBN depletion. The ASTM procedure, D2896 for base number, may also be used to determine the TBN of both new and used oil.

S•O•S analysis should be part of overall engine maintenance, to assure that a particular engine installation with all its parameters (engine, oil, operation, maintenance and fuel) is under control.

In most oil formulations, the TBN is a function of the ash bearing additives in the oil. Excessive amounts of ash bearing additives can lead to excessive piston deposits and loss of oil control. Excessively high TBN or high ash oils should not be used in Caterpillar diesel engines using distillate fuel.

When fuel sulfur levels exceed the oil's ability to protect, the oil change interval should be reduced to maintain proper oil TBN. Minimally, proper oil TBN is no less than 1/2 the new oil TBN.

TBN vs Fuel Sulfur for Caterpillar Diesel Engines



New Oil TBN (1), and Used Oil TBN Limit (2). The Y axis represents oil TBN shown by ASTM D2896. The X axis represents the percent of fuel sulfur by weight.

Operation at fuel sulfur levels over 1.5 percent may require shortened oil change periods to maintain adequate wear protection.

Synthetic Base Stock Oils (SPC)

Synthetic base stock oils are acceptable for use in Caterpillar engines if the oils meet performance requirements specified for a particular compartment. Performance requirements for engines using synthetic oils is API CG-4/CF-4.

The use of a synthetic base stock oil does NOT allow extension of the oil drain period simply because the oil is synthetic. 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.

Oils are drained and replaced because they become contaminated with dirt, soot, wear particles, etc. during normal use. Additives in an oil formulation are depleted as the oil is used. 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, 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 is needed to exceed capabilities of conventional oils.

Synthetic oils have naturally low pour points which make them very good for low temperature applications. Caterpillar recommends synthetic base stock oils where engine starting in arctic conditions is required.

Re-refined Base Stock Oils

Caterpillar requires that any oil formulation meet the performance standards 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 performance and viscosity requirements.

Military specifications and other engine manufacturers have also accepted the use of re-refined oil base stock with the same criteria.

Caterpillar Lubricating Grease

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

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

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

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

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

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

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

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

Caterpillar Specialty Lubricants

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

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

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

Gauges

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

Noticeable changes in gauge readings 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 gauge readings should be determined and corrected. Contact your Caterpillar dealer for assistance as needed.



Oil Pressure – Indicates engine oil pressure. The oil pressure should be greatest after starting a cold engine. Oil pressure should read between 240 and 480 kPa (35 and 70 psi) when: the engine is running at rated engine speed with SAE 10W30 oil, and at operating temperature. A lower pressure is normal at low idling speed.

NOTICE

Engine damage can result if the engine is operated with no oil pressure gauge reading. If no pressure is indicated, stop the engine.



Jacket Water Temperature – Indicates engine coolant temperature. It should normally indicate between 77°C (170°F) and 98°C (209°F). Higher temperatures may occur under certain conditions. Maximum allowable temperature is 99°C (210°F) with the cooling system pressurized.



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).

Check the charging system for malfunction if, during operation, the indicator is constantly to the negative (left) side of "0" (zero) or shows excessive charge.



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



Fuel Level – Indicates fuel level in the fuel tank. The electrically operated fuel level gauge registers only when the START/STOP (ignition key) switch is ON.



Fuel Pressure – Indicates fuel pressure to the injection pump. The indicator should register in the NORMAL (green) range.

If the indicator moves to the OUT position or registers below 160 kPa (23 psi) when equipped with a numerical gauge, the engine will not operate properly. In most cases this is caused by a plugged fuel filter.



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

NOTICE

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

Generator Set Control Panel 103-1582 (If Equipped)

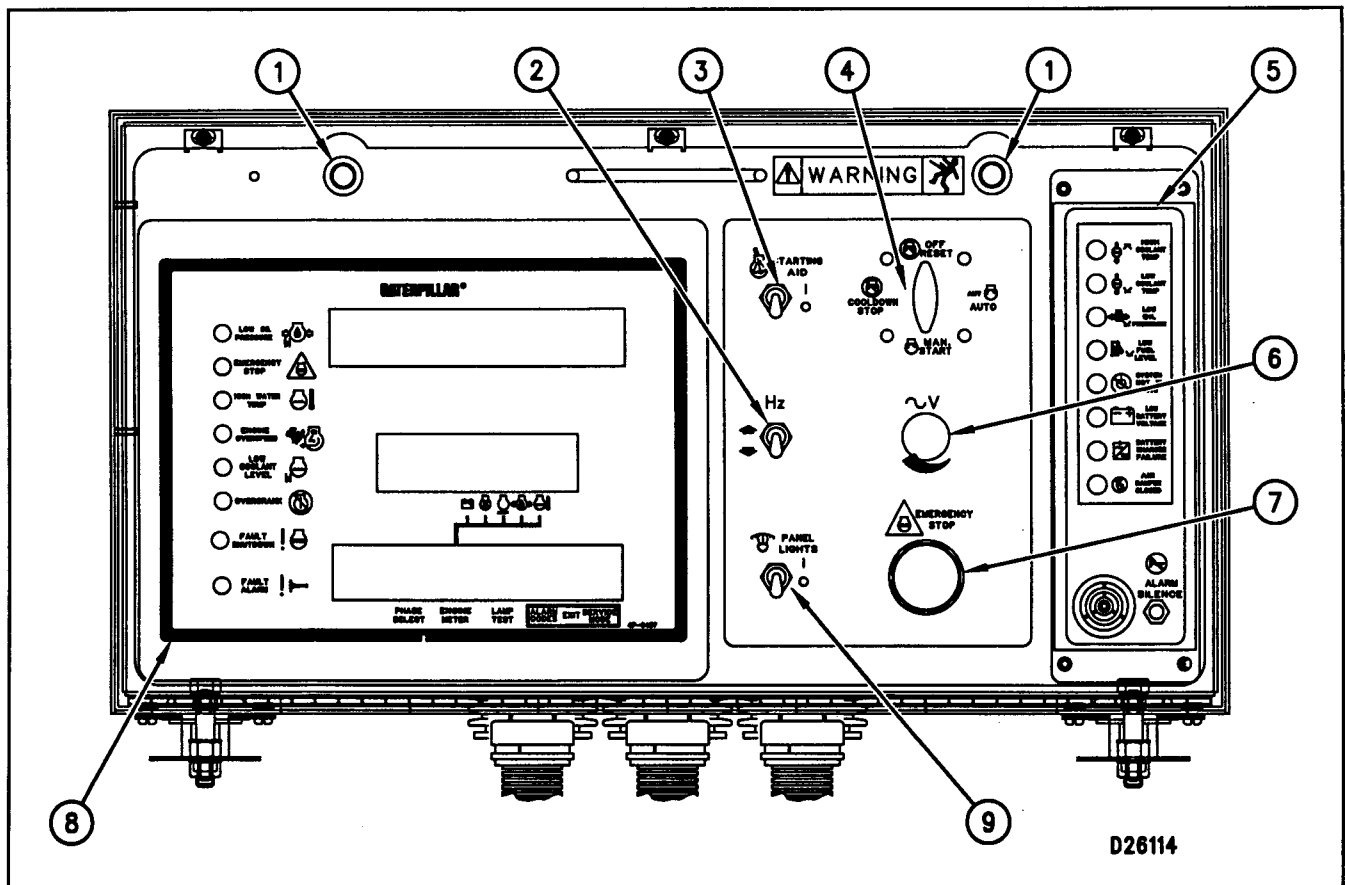
EMCP II Control Panel

The generator set Electronic Modular Control Panel II (EMCP II) is located on top of the generator regulator housing. The control panel consists of a main panel with indicators, meters, and control switches. The control panel may be equipped with optional modules to match the customer's needs and requirements. The right side may be blank, or contain one of the alarm modules, or a synchronizing lights module.

The left side of the control panel contains the Generator Set Control (GSC). This is the "main" component of the system. The GSC displays generator output, fault conditions, and key engine parameters.

Main Control Panel

The main control panel may or may not contain all of the components shown. Some components are optional, and may not be required for your particular application.



Optional panel lights (1), optional governor switch (shown) or speed potentiometer (2), optional starting aid switch (3), engine control switch (4), optional alarm module (shown) or synchronizing lights module (5), voltage adjust rheostat (6), emergency stop push button (7), generator set control (8), and optional panel light switch (9).

- The panel lights (PL) (1) are controlled by the panel light switch (PLS) (9).
- The voltage adjust rheostat (VAR) (6), is used to adjust the generator output voltage.
- The optional governor switch (GS) or speed potentiometer (SP) (2) is used to raise or lower the engine speed. If the governor is equipped with a speed adjust motor, the governor switch is mounted in this location. If the engine is equipped with an electric governor, a speed potentiometer is mounted in this location.
- The starting aid switch (SAS) (3) is used to inject ether into the engine for starting in cold weather conditions. When the starting aid switch is moved to the ON position, the switch energizes and meters a specific amount of ether in a holding chamber. When the switch is released, the solenoid releases the ether to the engine.
- The emergency stop push button (ESPB) (7) is used to shut down the engine during an emergency situation. The ESPB shuts off the fuel and activates the optional air shutoff (if equipped).
- The engine control switch (ECS) (4), determines the status of the control panel. In the Automatic position (3 o'clock), the engine will start automatically whenever the remote initiating contact is closed. The engine will shutdown after the initiating contact opens and adjustable cool down time has elapsed. The cool down time can be programmed to give a 0 to 30 minute cool down period before the engine shuts down.

When the ECS is in the Manual Run position (6 o'clock), the engine will start and run as long as the ECS remains in this position.

When the ECS is in the Stop position (9 o'clock), the fuel solenoid shuts the engine down, after a programmable cool down time period.

When the ECS is in the Off/Reset position (12 o'clock), the fault lights are reset and the engine shuts down immediately.

Generator Set Control (GSC)

The left side of the control panel contains the Generator Set Control (GSC). This is the "main" component of the system, and also displays generator output, generator set functions, fault conditions, and key engine parameters.

The GSC accepts information from the operator, magnetic pickup, oil pressure and water temperature sensors, and optional remote sources. The accepted information is used to determine the "on/off" state of the engine's air, fuel, and starter.

In the very basic operating conditions, the GSC receives a signal to run the generator set. The GSC turns on the engine's fuel and starter. When the engine speed reaches the crank termination speed, the starter is disengaged. When the GSC receives a signal to stop the engine, it shuts the fuel off.

GSC Features and Functions:

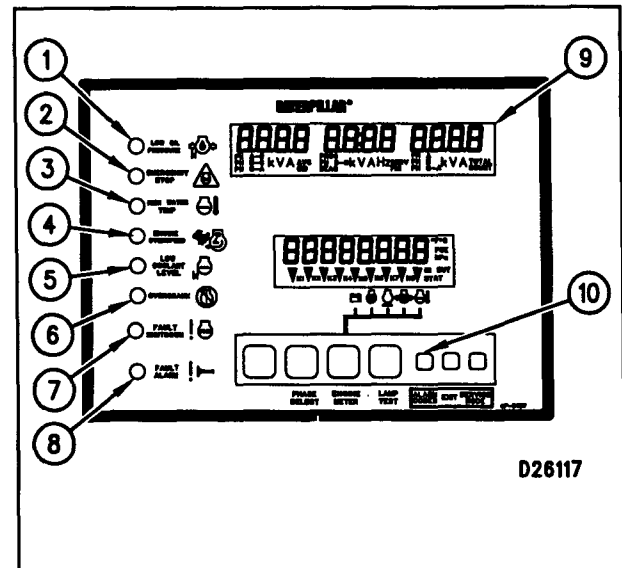
- Controls normal starting and stopping of the engine.
- Shows engine conditions and generator output information on two displays. The displays also show fault codes and GSC programming information.
- Monitors the system for faults. If a fault occurs, the GSC provides a fault alarm annunciation, or performs a controlled fault shutdown. The GSC uses indicators and displays to describe the fault.
- Contains programmable features for certain applications or customer requirements.
- Cycle Crank – The GSC can be programmed to crank-rest-crank, etc. for adjustable time periods. Refer to the Service Manual Module SENR5809 for programming instructions.
- 2301 or 2301A Control – When the engine oil pressure increases past the low oil pressure set point, the GSC will indicate to the governor that it should increase engine speed from IDLE to RATED rpm.
- Cool Down – Upon receiving a signal to perform a normal shutdown, the GSC will wait a preprogrammed amount of time before shutting the engine down by means of the fuel control.

- **Automatic Operation** – While in the automatic mode, the GSC can be started by a remote initiate signal (contact closure). Upon loss of the signal (contact opening), the GSC will perform a normal shutdown.
- **Alarm Module Communication** – The GSC can transmit fault and alarm conditions to an alarm module.
- **Power Down** – The Electronic Modular Control Panel II (EMCP II) system is designed to remove power from the GSC when in the off/reset mode and the proper jumper wire is removed. The GSC will not allow the power down until the crank termination relay and the fuel control relay are both “off” for about 70 seconds. If the wire is not removed, the GSC will remain powered up.

Refer to the Service Manual Module SENR5809 for the wiring diagram and the jumper wire location.

- **Fuel Solenoid Type** – The GSC can be programmed to work with either an energized to run (ETR) fuel system or an energized to shutdown (ETS) fuel system.
- **Customer Communication** – The GSC is provided with connections for an optional Customer Communications Module (CCM). The CCM will allow two way communication between the EMCP II and the operator. A customer-supplied personal computer (PC), or other device with a RS-232C port, interfaces with the CCM.

Fault Indicators



The eight fault indicators (1-8), located on the front of the GSC, are used to show and describe a fault that is present. The first seven are red fault shutdown indicators, and the eighth is a yellow fault alarm indicator.

- The yellow FAULT ALARM indicator (8) flashes when the GSC detects a fault that is an alarm condition. The engine continues to run and start. The FAULT ALARM indicator is accompanied by an alarm fault code, shown on the upper display when the alarm codes key is pressed. Refer to SENR5809 for fault code descriptions.
- The red FAULT SHUTDOWN indicator (7) flashes when the GSC detects a fault that is a shutdown condition. The engine is shutdown if it is running and is not allowed to start. The FAULT SHUTDOWN indicator is accompanied by a diagnostic fault code that is immediately shown on upper display. Refer to SENR5809 for fault code descriptions.
- Six red shutdown indicators are dedicated to the following shutdown conditions: low oil pressure (1), emergency stop (2), high water temperature (3), engine overspeed (4), low coolant level (5), and engine over crank (6). When the GSC detects a fault in one of these conditions, the dedicated shutdown indicator (corresponding to the fault) flashes. The engine shuts down if it is running, and is not allowed to start. There are no fault codes associated with the dedicated shutdown indicators because each indicator has an interpretive label. The conditions required for each dedicated fault and the results of each dedicated fault are as follows:

LOW OIL PRESSURE (1) – There are two low oil pressure set points. One set point is for when the engine is operating at idle speed. The other set point is for when the engine is operating at rated speed. The low oil pressure shutdown set points are programmed into the GSC. **Condition:** the engine oil pressure drops below the set points for low oil pressure shutdown. **Result:** the LOW OIL PRESSURE indicator flashes, the engine is shutdown and is not allowed to start.

EMERGENCY STOP (2) – **Condition:** the operator presses the emergency stop push button (ESPB) on the instrument panel. **Result:** the EMERGENCY STOP indicator flashes, the engine is shutdown and is not allowed to start.

HIGH WATER TEMPERATURE (3) – A high water temperature shutdown set point is programmed into the GSC. **Condition:** the engine coolant temperature rises above the set point for high water temperature shutdown. **Result:** the HIGH WATER TEMPERATURE indicator flashes, the engine is shutdown and is not allowed to start.

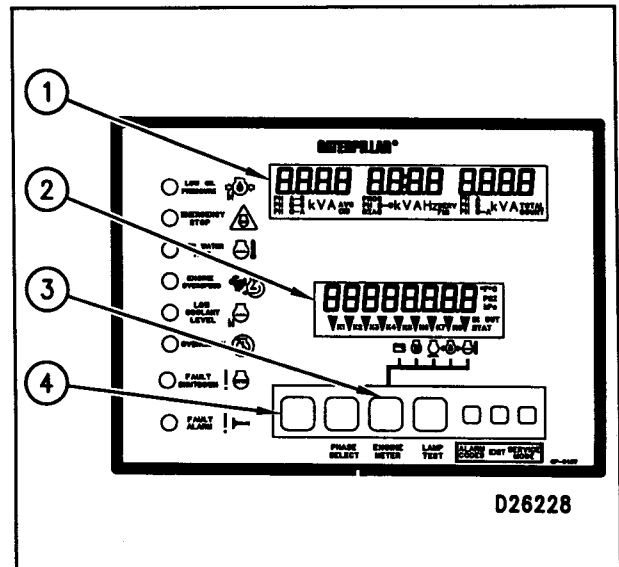
ENGINE OVERSPEED (4) – An engine overspeed set point is programmed into the GSC. **Condition:** the engine speed exceeds the engine overspeed set point. **Result:** The ENGINE OVERSPEED indicator flashes, the engine is shutdown and is not allowed to start.

LOW COOLANT LEVEL (5) – **Condition:** the engine coolant level drops below the probe of the coolant loss sensor (optional). **Result:** the ENGINE COOLANT LEVEL indicator flashes, the engine is shutdown and is not allowed to start. An optional low coolant level sensor is required for this function.

OVERCRANK (6) – A set point for total cycle crank time is programmed into the GSC. **Condition:** the engine does not start within the programmed set point. **Result:** the OVERCRANK indicator flashes and the engine is not allowed to start.

NOTE: The GSC can be programmed to override the shutdown for: the low oil pressure, the high water temperature, and the low coolant level faults. When these faults are overridden, the faults are treated as alarm conditions. The corresponding dedicated shutdown indicator is ON CONTINUOUSLY (instead of flashing) and the engine continues to run and start (instead of shutting down). The dedicated shutdown indicator that is ON CONTINUOUSLY means that the set point for shutdown has been exceeded, but the GSC is programmed to override the shutdown condition and treat the fault as an alarm condition. As provided from the factory, the GSC treats low oil pressure, high water temperature and low coolant level as shutdowns. Refer to the Service Manual Module SENR5809 for programming procedures.

Display

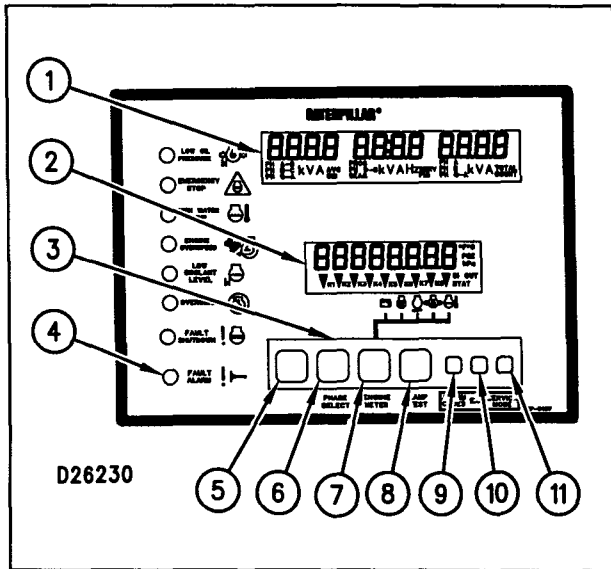


The upper display (1) and lower display (2) of the GSC provide information about the generator set.

- The upper display (1) shows AC voltage, current, and frequency of one phase of the generator output. Each phase can be viewed one at a time by pushing phase select key (4). The upper display (1) is also used to show the various fault codes for system faults. For more information on fault codes, refer to the Service Manual Module SENR5809 for Fault Descriptions.
- The lower display (2) shows: system battery voltage, engine hours, engine speed, engine oil pressure, and engine coolant temperature. The value for one of those conditions is displayed for two seconds, then the display scrolls to the value for the next condition. A small pointer identifies the engine condition that corresponds to the value that is showing. When engine meter key (3) is pressed, the lower display stops scrolling and continuously shows one particular value. The pointer flashes above the condition whose value is showing. When the engine meter key is pressed a second time, the display returns to scrolling.
- The lower display also shows a relay status indicator. When a GSC relay is activated, the corresponding relay indicator (K1, K2, etc.) is shown on lower display (2). When a relay is not activated, the corresponding indicator (K1, K2, etc.) is not shown. Refer to the Service Manual Module SENR5809 for a description of the relay functions.

Both the upper and lower display are used for programming functions when in the service mode. For more information, refer to the Service Manual Module SENR5809 for Service Modes.

Keypad



The keypad (3) is used to control the information that is shown on upper display (1) and the lower display (2). The seven keys of keypad have two sets of functions: normal functions and service functions. For a description of the service functions of the keys, refer to the Service Manual Module SENR5809 for Service Modes. The normal functions of the keys are as follows.

Leftmost key (5) – This key only functions when the GSC is in the service mode. This key is used to scroll right.

PHASE SELECT key (6) – This key selects which phase of the generator output shows on the GSC upper display. Pressing this key allows the operator to check the voltage, current, and frequency of each phase, one at a time.

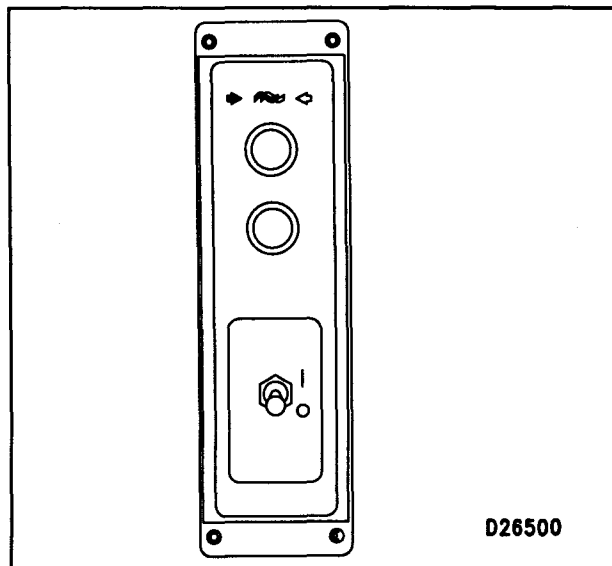
ENGINE METER key (7) – This key stops the scrolling of engine conditions on the lower display (2). The lower display continuously shows the value for one particular engine condition. The pointer for the particular engine condition flashes to indicate scrolling is stopped. Pressing the key again resumes the scrolling.

LAMP TEST key (8) – This key performs a lamp test on the GSC and the optional alarm module for a maximum of ten seconds, if held pressed. On the GSC: the eight fault indicators are ON CONTINUOUSLY—every segment of the upper display (1) and the lower display (2) are ON. For the optional alarm module: all of the indicators are ON and the horn sounds.

ALARM CODES key (9) – If the fault alarm indicator (4) is FLASHING, pressing this key causes the upper display (1) to show the corresponding alarm fault code. Pressing this key again resumes the showing of generator output information on the upper display. If the fault alarm indicator (4) is OFF, this key has no function. For more information on alarm fault codes, refer to the Service Manual Module SENR5809 for Fault Descriptions.

EXIT key (10) – This key only functions when the GSC is in service mode. Refer to the Service Manual Module SENR5809 for Service Modes.

SERVICE MODE KEY (10) – Pressing this key causes the GSC to enter the service mode. Refer to the Service Manual Module SENR5809 for Service Modes.

Synchronizing Lights Module (If Equipped)

The optional synchronizing lights module is mounted on the right side of the control panel. This module is not used when the control panel is equipped with the 2301A Governor.

Synchronizing lights are used as an aid in paralleling units at no load and under load. Each of two lights are connected across the generator to the load side of the generator circuit breaker. Together, the lights indicate when the voltages are in phase so the circuit breaker can be closed to place the generator on line with the load.

Refer to the topic "Parallel Operation" in this publication for a complete explanation on how to parallel two generators. Refer to the Service Manual Module SENR5809, for all wiring and installation information.

Synchronizing Lights Module With Reverse Power Relay (If Equipped)

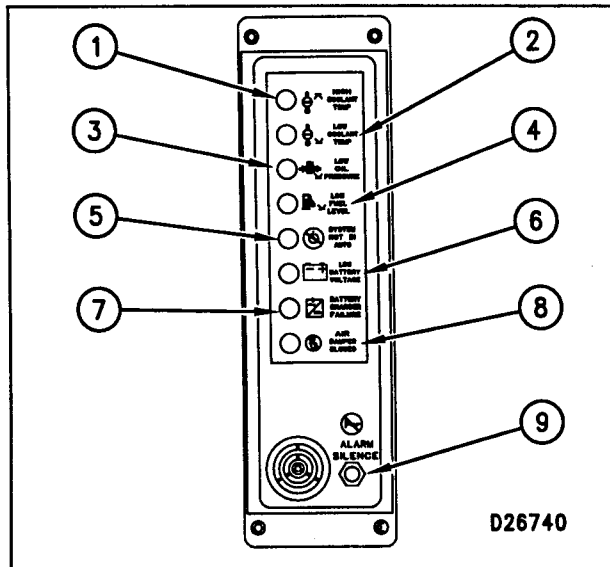
The synchronizing lights module with reverse power relay is the same as the synchronizing lights module with the following exceptions:

- The reverse power relay is mounted on the control panel interior.
- A reverse power fault is indicated by the Fault Shutdown Indicator on the front of the GSC.

The reverse power relay is a single phase protective relay. The reverse power relay is energized by power (amps-volts) in only one direction (power into generator instead of out). In a reverse power fault, the relay closes its contacts causing the engine to shutdown, taking the generator off line. The reverse power relay is equipped with a test switch and adjustments.

For additional information, refer to Service Manual Module SENR5809.

Alarm Module (If Equipped)



The alarm module (optional) is located on the right side of the control panel. The function of the alarm module is to provide a visual and audible warning of engine conditions before they become severe enough to shut the engine down or keep it from starting.

One basic alarm module is used to satisfy the requirements of: the standby NFPA 99 alarm module, the standby NFPA 110 alarm module, and the NFPA 99 remote annunciator panel and prime power alarm. This is accomplished by using different inputs to the module, and different decals on the front of the module to indicate alarms or shutdown conditions.

Refer to the Service Manual Module SENR5809, for all wiring and installation information as well as a listing of Indicators and Alarm (Horn) functions to meet NFPA requirements for your application.

The front of the alarm module consists of:

- Four amber LED's which can indicate: HIGH COOLANT TEMPERATURE (1), LOW COOLANT TEMPERATURE (2), LOW OIL PRESSURE (3), and LOW FUEL LEVEL. Other amber LED options (depending on module configuration) are: GENERATOR ON LOAD, CHARGER MALFUNCTION, LOW OIL LEVEL, and LOW COOLANT LEVEL.
- Four red LED's which can indicate: a SYSTEM NOT IN AUTO (5) condition, LOW BATTERY VOLTAGE (6), BATTERY CHARGER FAILURE (7), and AIR DAMPER CLOSED (8). Other red LED options (depending on module configuration) are: AIR DAMPER CLOSED, LOW OIL PRESSURE SHUTDOWN, OVERCRANK SHUTDOWN, HIGH COOLANT TEMPERATURE SHUTDOWN, and OVERSPEED SHUTDOWN.
- An audible ALARM and acknowledge/SILENCE switch (9). For more detailed information refer to the Service Manual Module SENR5809.

Engine Protection Devices

NOTE: This section applies to engines equipped with junction boxes.

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

Sensing switches are set at critical operating temperature, pressure, level or speed than the alarm components. More critical settings protect the engine from damage.

A shutoff switch opens or closes the circuit to the fuel shutoff solenoid. Opening the circuit to the fuel shutoff solenoid moves the fuel rack to the fuel OFF position. The particular shutoff may require resetting before the engine will start.

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

Familiarize yourself with the

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

Manually or mechanically operated systems require resetting by pushing the RESET button until it latches. After the engine is started, oil pressure will activate the RESET button to the extended running position.

NOTICE

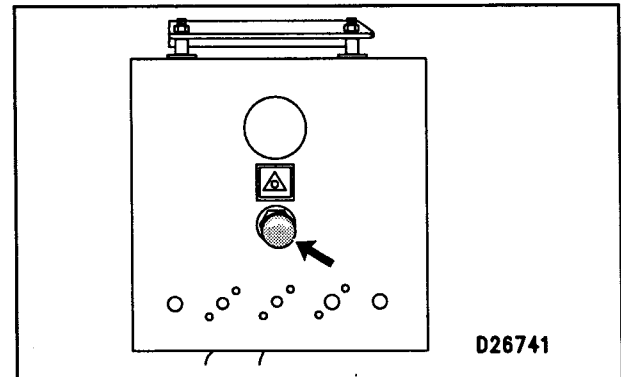
If the RESET button does not move to the extended position after the engine starts, the engine will NOT be protected by this particular switch.

If the RESET button remains in the reset position, the engine oil pump will not develop normal oil pressure. An inspection should be made to correct the problem.

Automatic START/STOP systems use oil pressure to automatically reset.

The Engine Protective Devices shutdown controls should be tested every 1000 service hours by authorized personnel.

Emergency Stop Push Button



Emergency Stop Push Button (ESPB)

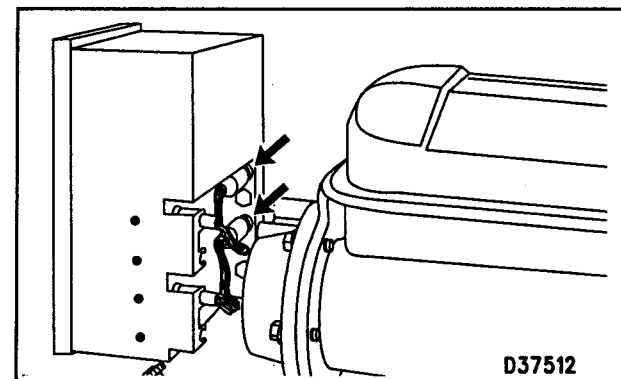
The Emergency Stop Push Button (ESPB) requires resetting both the push button and the air inlet shutoff (if equipped) before the engine will start.

NOTICE

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

Emergency shutoff controls are for **EMERGENCY** use **ONLY**. **DO NOT** use Emergency shutoff devices or controls for normal stopping procedure. Refer to the Engine Stopping section of this manual for normal stopping procedures.

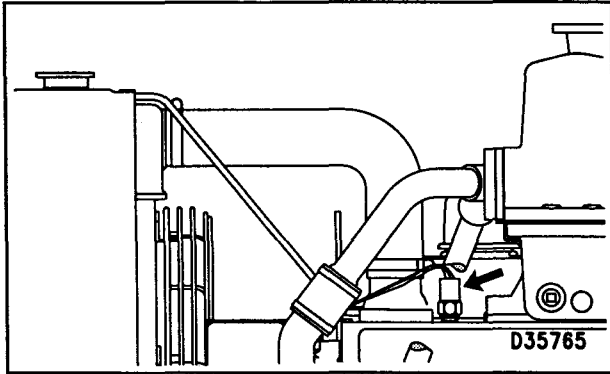
Oil Pressure Switch



Typical example of oil pressure switches, mounted in the rear of the junction box.

An oil pressure switch has wires connected to the electrical shutoff system for alarm or shutdown functions. The oil pressure switch senses oil pressure at the bearing oil gallery. Switches may close at 48 to 62 kPa (7 to 9 psi) below actual trip point. No resetting procedure is required.

Water Temperature Contactor Switch



This contactor switch is a coolant temperature sensor.

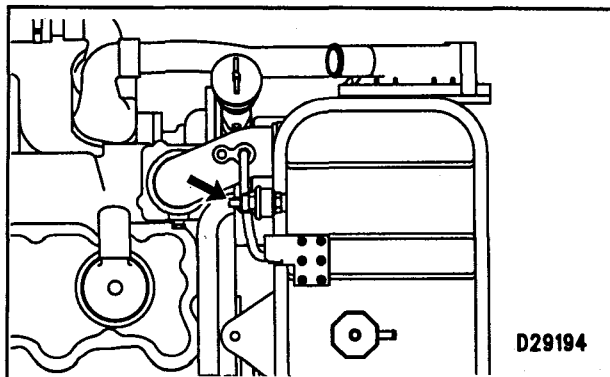
The water temperature contactor switch is located near the coolant water regulator housing. Excessive water temperature closes the switch. Maximum coolant temperature to trip shutoff is 104°C (219°F). The switch opens as the coolant cools. No resetting procedure is required. The unit has wires connected to the electrical shutoff system for alarm or shutdown functions.

NOTICE

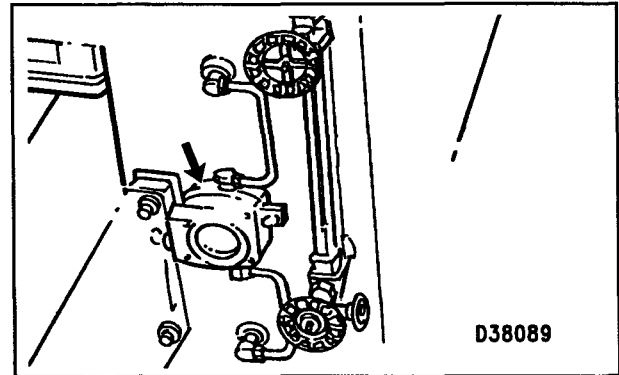
The sensing element must be submerged in the coolant to operate. Be sure to have an adequate water supply in the jacket water system, or engine damage could result.

Coolant Loss Sensor (If Equipped)

The optional coolant loss sensor is usually mounted near the top of the engine expansion tank or radiator. The sensor detects when the coolant level is below a preset minimum level.



This top view shows a typical coolant loss sensor, mounted in an expansion tank.



This coolant loss switch, shown next to a sight glass, is mounted on the side of a radiator.

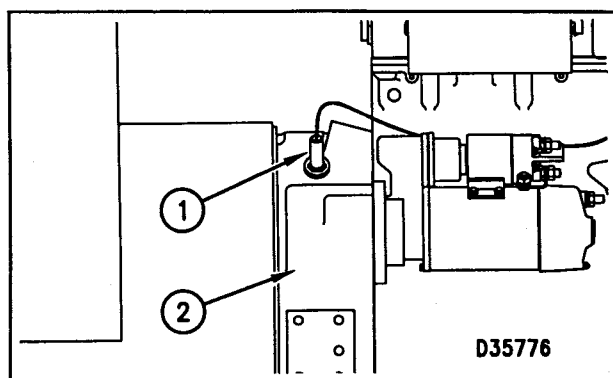
If the coolant level drops below the minimum level, the sensor may sound an alarm, or cause a shutdown to avoid engine overheating or possible engine damage. Coolant must be added to the radiator or expansion tank to clear or reset the condition.

NOTE: In the event of intermittent engine shutdowns, the coolant water level should be checked. Add premixed coolant water to the fill tank, to within 13 mm (½ inch) below the filler tube.

Check the expansion tank or radiator daily for proper coolant level.

Overspeed Shutoffs

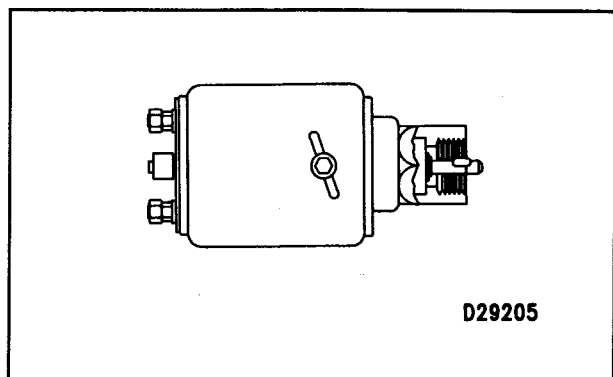
The electrical shutoff for the overspeed switch uses a magnetic pickup mounted in the flywheel housing. The electrical shutoff works through the fuel shutoff solenoid and air inlet shutoff (if equipped).



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

Should the engine overspeed, the magnetic pickup will sense the excess speed. If overspeed is sensed, the electrical shutoff closes the air and fuel shutoff solenoids (the fuel rack will move to fuel OFF position).

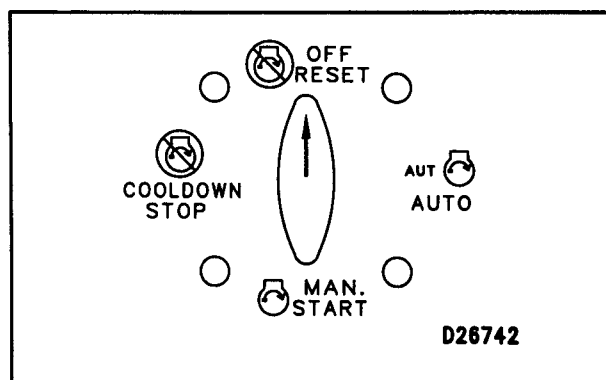
The overspeed shutdown has to be reset. Reset the air inlet shutoff (if equipped) and the overspeed switch. Both switches are located in the junction box or control panel.



Overspeed Shutoff Switch (Electro-Mechanical)

This switch is mounted either on the tachometer drive or the governor. Excessive engine speed closes the switch by centrifugal force.

If equipped with a Caterpillar Generator Set Control Panel, the devices on the panel must be reset after an overspeed shutoff.



Turn the Engine Control Switch to the OFF/RESET position.

Alarm Switches

Alarm switches consist of a sensor or contactor. Examples of sensors are the magnetic pickup for detecting speed, and the pressure and temperature contactors. Sensors are wired to a contactor. The contactor activates an alarm circuit in the Annunciator Panel.

Alarm switches and sensors are set at a less critical temperature, pressure, or level limit than the engine shutdown controls.

The purpose of the alarm switches is to warn the operator that an unsafe operating condition is beginning to occur.

The Annunciator Panel has lights and an audible device to warn the operator of a malfunction or abnormal engine operating condition. Each alarm contactor and switch is electrically connected to an indicator light or audible indicator. The alarm will continue until the condition is corrected.

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

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

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

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

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

Shutoff and Alarm System Testing

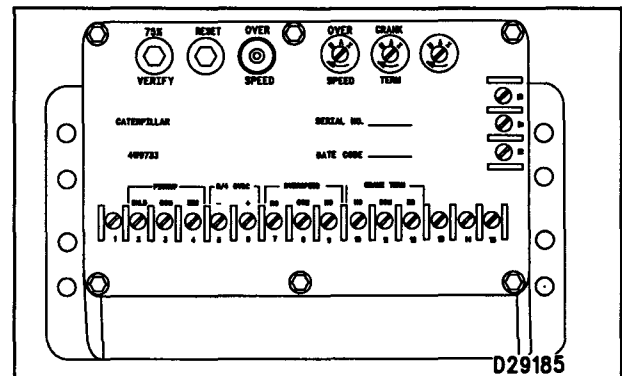
NOTICE

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

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

Most control panels are equipped with a test switch. Turn the switch to ON position to check indicator lights for proper operation. Replace defective or burnt bulbs immediately.

Abnormal operating conditions must be simulated which could cause engine damage if the tests are performed incorrectly. Refer to the Service Manual for the testing procedures.



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

The Electronic Overspeed Switch with Cranking Termination has a 75 percent VERIFY button, a RESET button, and an OVERSPEED indicator light.

The Electronic Overspeed Shutoff Switch with Crank Termination has a sensing circuit which prevents the starter pinion from remaining engaged in the flywheel at excessive rpm. Crank Termination has an adjustable engine speed setting, and signals the starter motor when the engine is firing and cranking must be terminated. When the speed setting is reached, a switch opens to start the engine hour meter.

After the starting motor cranks the engine, the pinion gear can remain engaged with the flywheel as the engine speed increases. The magnetic pickup opens the circuit to the starting motor at 400 rpm and allows the pinion gear to disengage.

The circuit will remain open until the flywheel stops. This prevents energizing the starting motor circuit again while the flywheel is turning.

Your engine may be equipped with either an Overspeed Shutoff Switch or an Electronic Overspeed Switch with Cranking Termination. Both switches can be checked for proper operation at 75 percent of overspeed condition. Use the following procedure:

1. Determine full load rpm from the Engine Information Plate.
2. Operate the engine at or slightly above the corresponding speed shown in the OVERSPEED TEST RPM chart.

Full Load rpm	Overspeed Test rpm	Actual Overspeed rpm
1500	1328	1770
1800	1593	2124
2000	1770	2360
2200	1947	2596

If the Full Load rpm listed on your engine's Information Plate is not listed in this chart, then the Overspeed Test rpm equals the Full Load rpm times a factor of .885.

3. Maintain the test rpm, push and hold the VERIFY button. The engine should stop. If the engine does not stop at the specified test rpm, contact your Caterpillar dealer.

NOTE: As the engine stops, the OVERSPEED light will illuminate and the RESET button must be pushed before restarting the engine.

Engine Starting

Walk-Around Inspection

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

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

NOTICE

All valves in fuel return line must be open before and during engine operation to prevent high fuel pressure. High fuel pressure may cause filter housing failure or other damage.

Each time any significant quantity of oil (or other fluid) is spilled on or near the engine it should be cleaned up. Accumulated grease and oil on an engine is a fire hazard. Remove this debris with steam cleaning or high pressure water.

Wipe clean all fittings, caps and plugs before servicing.

WARNING

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

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

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

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

Refer to Priming the Fuel System in this publication for more information.

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

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

Electric Starting

NOTE: Startability will be improved at temperatures below 16°C (60°F) by the use of a starting aid. A jacket water (coolant) heater or other means can be used to heat the crankcase oil.

Start the engine using the following procedure:

1. Perform all before-starting inspections.
2. If the engine is equipped with a manual control, ensure that it is in the RUN position. Place the transmission in NEUTRAL (and disengage the flywheel clutch, if equipped). For Generator Sets, open the main electrical circuit breaker.
2. Move throttle to approximately half engine speed to get the fuel rack to move to the FUEL ON position.
3. Turn the starter switch to START (or battery disconnect switch to the ON position) or the Engine Control Switch (ECS) to MAN. START. The starting motor will crank and attempt to start the engine. At temperatures below 0°C (32°F), it may be necessary to spray starting fluid into the air cleaner inlet. Additional injections of ether may be required to start and/or achieve low idle speed.

NOTICE

Excessive ether can cause piston and ring damage. When using starting fluid, follow the manufacturer's instructions carefully, use it sparingly and spray it **ONLY WHILE CRANKING THE ENGINE**. Failure to do so could result in an explosion and/or fire and possible personal injury. Use ether for cold starting purposes only.

NOTICE

Do not crank the engine for more than 30 seconds.

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

4. As soon as the engine starts, allow the engine to idle for 3 to 5 minutes, or until the water temperature gauge indicator has begun to rise. The engine should run at low idle smoothly until speed is gradually increased to high idle.

NOTICE

Do not increase engine speed until the oil pressure gauge indicates normal. Oil pressure should rise within 15 seconds after the engine starts. If oil pressure is not indicated on gauge within 15 seconds, stop the engine, investigate and correct the cause.

5. Allow white smoke to clear up and proceed with normal operation. Do not apply load to the engine or increase engine speed until the oil pressure gauge indicates normal. Oil pressure should raise within 15 seconds after the engine starts.

For starting in cold weather, to minimize white smoke: start the engine and allow the engine to idle for 30 seconds. Increase rpm until engine speed reaches 1200 rpm. Then allow the engine to return to low idle.

6. Operate the engine at low load until all systems reach operating temperature. Check all gauges during the warm-up period.

Engine Starting With Jumper Cables

NOTICE

When boost starting an engine, follow the instructions to properly start the engine. This engine is equipped with a 12 or 24 volt starting system. Use only equal voltage for boost starting. The use of higher voltage will damage the electrical system.

 WARNING

Batteries give off flammable fumes that can explode.

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

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

Do not smoke when observing the battery electrolyte levels.

Always wear protective glasses when working with batteries.

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

Engines installed without 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 starter-to-frame ground straps. Many of these starters have electrical insulation systems and are not electrically grounded to the engine. For this reason, the starter-to-frame ground strap may not be an acceptable engine ground.

When boost starting, refer to the instructions that follow to properly start the engine. Your engine may have a 12 or 24 volt starting system. Only use the same voltage for boost starting. Use of a welder or higher voltage will damage the electrical system and is not recommended.

NOTICE

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

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

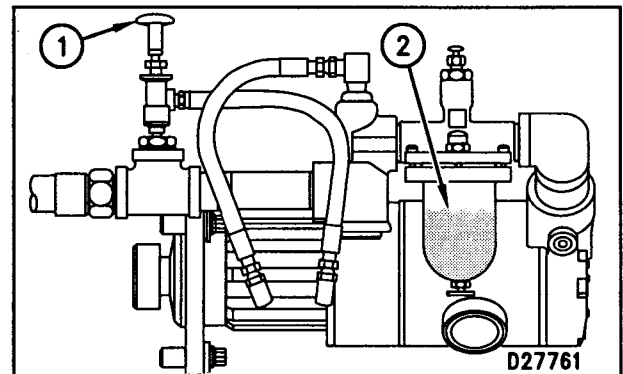
Do not reverse the battery cables. The alternator can be damaged. Attach the ground cable last and remove first.

1. When using an external electrical source to start your engine, turn the ECS switch to the **OFF** position and turn off all electrical accessories before attaching cables.
2. Connect one end of the cable to the **POSITIVE (+)** terminal of the battery being started. Connect the other end to the **POSITIVE (+)** terminal of the power source.
3. Connect one end of the other cable to the **NEGATIVE (-)** terminal of the power source. Connect the other end to the starter **NEGATIVE (-)** terminal or to the engine block. This prevents potential sparks from igniting combustible gases produced by some batteries.
4. Start the engine. After the engine starts, disconnect the cable from the starter **NEGATIVE (-)** terminal or engine block. Disconnect the other end from the **NEGATIVE (-)** terminal of the power source.
5. Disconnect the cable from the **POSITIVE (+)** terminal of the battery on the engine being started. Disconnect the cable from the **POSITIVE (+)** terminal of the power source.

Engine Starting with Air

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 that are greater than 0°C (32°F) or use air tool oil for lower temperatures.

1. Open and close the drain valve on the bottom of the air tank to drain condensation and oil carryover.
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 1550 kPa (225 psi). The normal air pressure will be 758 to 965 kPa (110 to 140 psi).



Air Starter showing Air Valve (1) and Lubricator Bowl (2)

3. Check the oil level in the lubricator bowl (2). Keep the bowl at least half full and add lubricant if necessary.
4. Push the air valve (1) or engine start button to crank the engine. Release the valve or button as soon as the engine starts.

Engine Operation

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

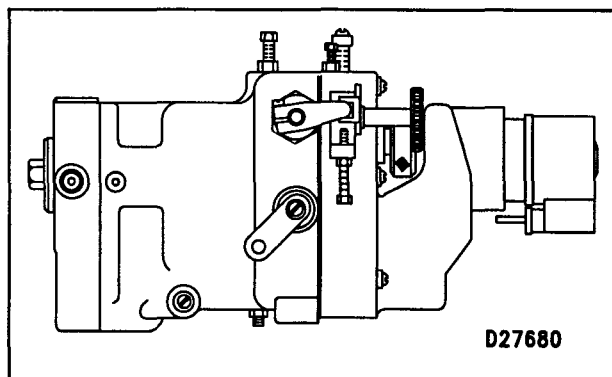
The time needed for the engine to reach the normal mode of operation is usually less than the time taken for a walk-around-inspection of the engine.

After the engine is started and the cold low idle 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 be up to operating temperature in a few minutes.

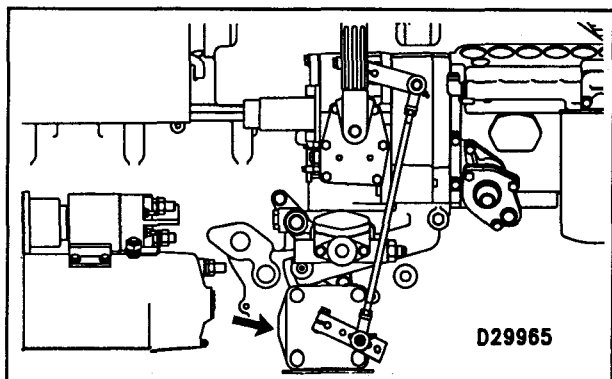
Governors and Actuators

Your engine may be equipped with a:

- full-range governor
- Woodward PSG Governor
- Woodward 1724 Actuator
- Woodward 524 Actuator



PSG Actuator



1724/524 Actuator

Woodward Governors/Actuators are usually electrically operated from a control panel. The application is usually an EPG power generator set. On standby gen sets the governor may be set to operate only at Full Load Speed.

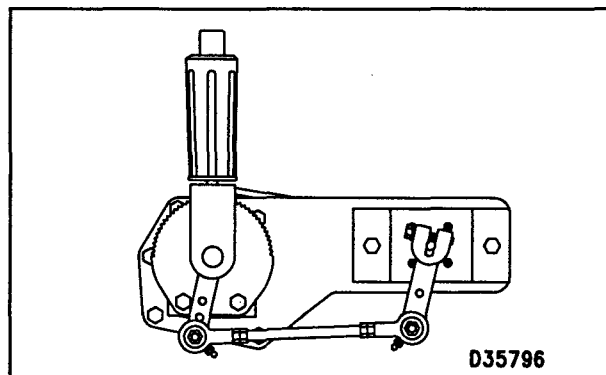
Change Engine Speed

If equipped with a control panel, a RAISE/LOWER switch or a speed setting potentiometer is used to adjust the operating speed.

Starting, Operating and Stopping Engines Equipped with Control Panels

For all information regarding the generator control panel used for starting, operating and stopping the engine, refer to the Engine Protection Devices Generator Set Control Panel topic in this publication or Caterpillar SR4 Generators and Control Panels, SEBU6150. Additional information and programming instructions are provided in the Service Manual for your specific control panel.

Mechanical Governors (If Equipped)



Governor Control Lever

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 dying. With the min-max governor, the position of the speed lever determines the amount of fuel delivered to the engine.

With the full-range governor, the position of the speed lever sets engine speed and helps hold a constant speed independent of load which makes operation easier.

The governor control motor is a 24 volt motor which allows for engine speed control from a remote location through a governor RAISE/LOWER switch. This governor control switch is used with the optional EMCP II.

NOTE: Always increase engine speed to high idle before applying load.

For information regarding initial checks and adjustments, refer to the Service Manual or contact your Caterpillar dealer.

Driven Equipment Without Load

1. Move the governor control lever to half engine speed.

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

For generator sets, move the governor control to high idle (full load) position (1800 rpm for 60 Hz and 1500 rpm for 50 Hz).

3. Apply the load and check the gauges and equipment for proper operation. Begin operating the engine at low load. After normal oil pressure is reached and the temperature gauge begins to move, the engine may be operated at full load.

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

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. This carbon build-up results in loss of power and/or poor performance. When operating at reduced load, the engine should be fully loaded to burn excess carbon from the cylinders at least every four hours.

NOTE: Check the gauges and equipment frequently while operating under load.

Engine Efficiency

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

Cold Weather Operation

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

Fuel and the Effect from Cold Weather

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

Quantities of No. 1 diesel fuel are limited, and generally only available during the winter months in the colder climates. During cold weather operation, if No. 1 fuel is unavailable, it may be necessary to use No. 2 diesel fuel.

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

- a lower cloud point
- a lower pour point
- a lower BTU (kJ) (heat content) rating per unit volume of fuel than the average No. 2 diesel fuel.

When using No. 1 diesel fuel, you may notice a drop in power and fuel efficiency. You should not experience any other operating effects.

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

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

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

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

Fuel Related Components in Cold Weather

Fuel Tanks

Condensation can form in partially filled fuel tanks. Top off fuel tanks before leaving overnight.

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

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

Check the fuel level in the day tank daily by observing the sight gauge. Drain the water and sediment from any fuel storage tank weekly, at the oil change period, and before the fuel tank is refilled. This will help prevent water and/or sediment from being pumped from the fuel storage tank into the engine fuel tank.

Fuel Filters

A primary fuel filter is installed between the fuel tank and the engine fuel inlet. After changing the fuel filter(s), always prime the fuel system (if equipped with a priming pump) to remove air bubbles from the system.

The micron rating and location of a primary fuel filter is important in cold weather operation. The primary filter and the fuel supply line to the primary filter are the most common components affected by cold fuel.

The micron rating of the primary fuel filter should only be fine (low) enough to protect the fuel transfer pump. A very fine (low micron rating) primary filter, can be more easily plugged by wax in cold weather. A primary filter, with a micron rating as fine as a secondary filter can cause waxing problems.

NOTE: A 9M2341 Filter Element is recommended as a cold weather primary fuel filter. Refer to the Parts Manual for this engine to determine the part numbers required for the primary fuel filter.

Fuel Heaters

Fuel heaters prevent fuel filters from plugging in cold weather due to waxing. A fuel heater should be installed so that the fuel is heated before it enters the first (primary) fuel filter.

Select a fuel heater that is mechanically simple, yet adequate for the application. The fuel heater should also prevent overheating of the fuel. High fuel temperatures reduce engine performance and power availability. Choose a fuel heater with as large a heating surface as practical. Small heaters can be too hot in their limited surface area.

Disconnect or deactivate the fuel heater in warm weather.

NOTE: Only thermostatically controlled or self-regulating fuel heaters should be used with this engine. Non-thermostatically controlled fuel heaters can heat the fuel in excess of 65°C (149°F). A loss of engine power can occur if the fuel supply temperature exceeds 37°C (100°F).

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

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

Thermoblend Caterpillar part no. 7C3557
Hot Joint Caterpillar part no. 7C3558

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

Engine Stopping

NOTICE

Stopping the engine immediately after it has been working under load can result in overheating and accelerated wear of the engine components. Allow the engine to cool down before stopping. Avoiding hot engine shutdowns will maximize turbocharger shaft and bearing life.

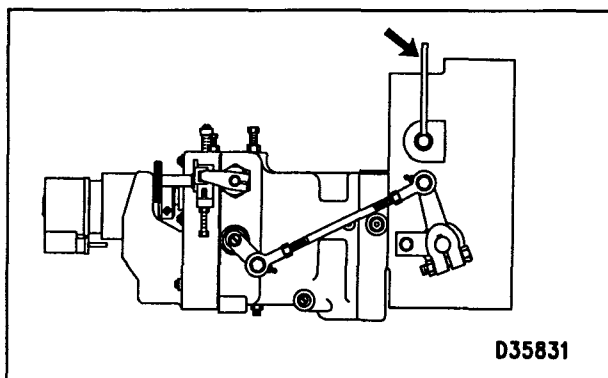
If the engine has been operating at high load, run at low idle for at least three minutes before stopping. This cool down will reduce and stabilize internal engine coolant and oil temperatures before stopping the engine.

If the engine has been operating at low loads, run the engine at low idle for 30 seconds before stopping.

Make sure the shutoff procedure is understood. Refer to the Stopping the Engine instructions in the Generator Set Control Panel topic in this publication. Use the following general guidelines for stopping the engine.

1. Open the Main electrical circuit breaker/Remove load from engine.
2. Move the governor control to no more than half engine speed. Run the engine for three to five minutes.
3. Reduce the engine speed to low idle.
4. The engine may be stopped by using the Woodward Governor (if equipped), the Mechanical Governor (if equipped), or the solenoid shutoff switch.

Woodward Actuator (If Equipped)

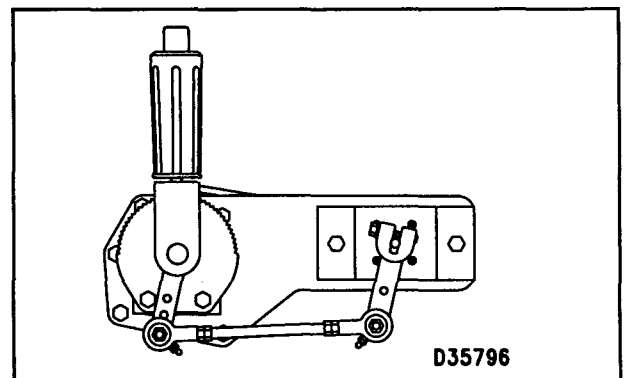


If equipped with a Woodward Actuator, move the control lever upward or forward, depending on the installation. Hold the lever to the OFF or STOP position until the engine stops.

Mechanical Governor Control

A manual shutoff lever is provided to shut off the fuel from the fuel injection pump and override the governor control. The manual shutoff lever is located on the side of the pump.

The engine can be shut OFF by rotating and holding the manual shutoff lever in the clockwise (CW) direction.



If equipped with a Mechanical Governor Control, to move control to the SHUT OFF position: pull upward on the vernier hand grip while pushing down on thumb button. This shutdown will only move the fuel control linkage (rack) to the FUEL-OFF position. This does not shut off the air inlet.

Solenoid Shutoff

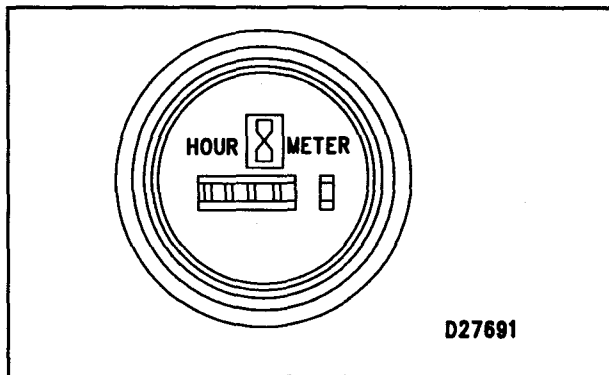
Move the Control Panel Engine Control Switch (ECS, if equipped) to the STOP position.

After Stopping the Engine

1. Fill the fuel tank to prevent accumulation of moisture in the fuel.
2. Check the coolant level. Maintain the cooling system to 13 mm (½ inch) from bottom of the fill pipe.

If freezing temperatures are expected, allow the radiator and engine jacket water system to cool, then 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.

3. Check the crankcase oil level. Maintain the oil level between the ADD and FULL marks in the FULL RANGE zone on the dipstick.
4. Repair any leaks, perform minor adjustments, tighten loose bolts, etc.



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

Air-to-Air Aftercooling System (ATAAC) (If Equipped)

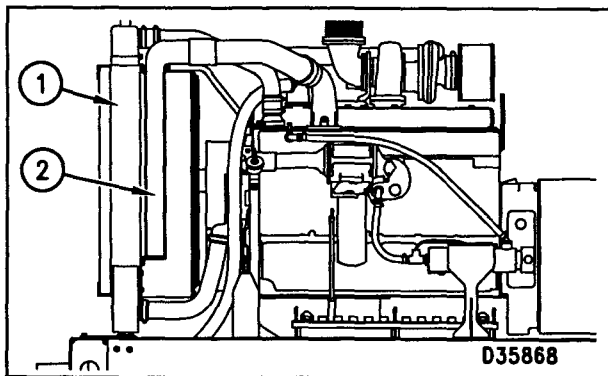
Air-to-air aftercooling (ATAAC) systems are simple, reliable, and easy to maintain. Generally, ATAAC benefits one or two of the following areas:

- Improved fuel consumption
- Lower emissions
- Increased power

NOTE: In some cases all three may be improved.

Operation of ATAAC

Inlet air is pulled through the air cleaner, compressed and heated by the compressor wheel in the compressor side of the turbocharger to about 150°C (300°F). The heated air is then pushed through the air to air aftercooler core and moved to the air inlet manifold in the cylinder head at about 43°C (110°F).



Radiator Core (1) and Aftercooler Core (2).

Cooling the inlet air increases combustion efficiency, which helps to lower fuel consumption and increase horsepower output. The aftercooler core (2) is a separate cooler core installed behind the standard radiator core (1). Ambient temperature is moved across both cores by the engine fan— this cools the turbocharged inlet air and the engine coolant.

Lower intake air temperature allows more air to enter the cylinder. More complete fuel combustion and reduced exhaust emissions are the results. Air-to-air aftercoolers can achieve charge air temperatures lower than water-to-air systems. The lower air temperatures provide improved efficiency.

NOTICE

To maintain an adequate water pump cavitation temperature for efficient water pump performance in an Air-to-Air Aftercooled engine: Caterpillar recommends that the coolant mix contain a minimum of 30 percent Caterpillar Antifreeze, or equivalent.

Air Intake System

An air hose failure or a significant air intake system leak will cause a large drop in boost pressure and power. The engine can be operated at this power level for a short period of time, however, sustained operation under this condition should be avoided.

A slight reduction in power or response, or a small increase in exhaust temperature may indicate a small air leak in the charge air cooler core or piping.

If air leaking is suspected, inspect the air intake hoses, elbows and gaskets for cracks or damage. Replace the parts as needed. Check for loose clamps and tighten the clamps as needed.

Radiator Restrictions

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

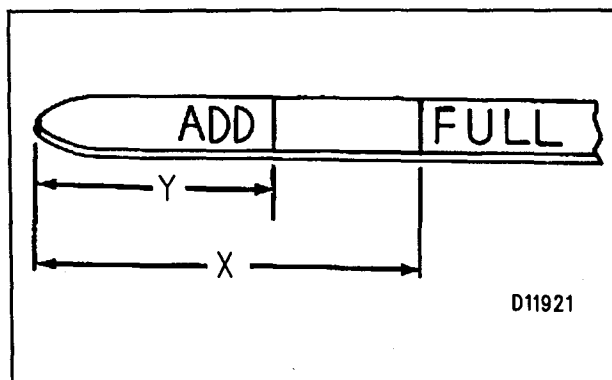
If an air flow restriction device must be used, the device should have a permanent opening directly in line with the fan hub. The device must have a minimum opening dimension of at least 770 cm² (120 in²).

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

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

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

Oil Level Gauge (Dipstick)



Calibration

NOTE: Refer to the complete Oil and Filter change procedure before performing Calibration (if applicable).

Your engine may use a dipstick that has a FULL RANGE zone rather than the traditional FULL mark. The FULL RANGE is between the ADD and FULL marks (X-Y). This dipstick allows for variations in engine installations. Engine oil level will vary, depending on angle (front to back tilt) and slant sideways tilt).

To determine the correct FULL mark in the FULL RANGE zone and prevent overfilling or under filling the crankcase, it is important to calibrate (or verify the calibration of) the dipstick at the first oil change.

To verify the ADD mark and establish the actual FULL mark in the FULL RANGE zone of the dipstick, use the following procedure.

NOTE: This procedure is correct for use with either the non-spacer plate oil pan or the spacer plate oil pan. Sump capacities and oil levels are the same for each oil pan.

NOTE: The engine must rest on a level surface for this procedure.

1. Operate the engine until it reaches normal operating temperature.
2. Stop the engine. Remove the crankcase drain plug(s). Let the oil drain from the crankcase for 20 minutes.

3. Remove the used oil filter(s). Install the new oil filter(s). Install the crankcase drain plug(s) and tighten to 50 ± 10 lb ft (70 ± 14 N·m).

4. Fill the crankcase with 27.5 L (29 qt) of oil for 3306B engines or 22 L (23.3 qt) of oil for 3304B engines. Allow the oil to drain back to the sump for a minimum of five minutes.

5. Start and operate the engine until the oil filters are full and the engine reaches normal operating temperature. Stop the engine.

6. Allow the oil to drain back to the sump for a minimum of ten minutes. Remove the dipstick. The oil level should be in the FULL RANGE zone. Use an engraving tool to mark the new FULL level on the dipstick.

7. This is the correct FULL mark in the FULL RANGE zone on the Engine Stopped side of the dipstick. The crankcase sump is considered FULL if the level is in the knurled FULL RANGE zone.

NOTE: Remote mounted or auxiliary oil filters require additional oil. For all information about auxiliary oil filters, refer to the OEM instructions.

Scheduled Oil Sampling (S•O•S)

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

S•O•S analysis is a diagnostic tool used to determine oil performance and component wear rates. S•O•S analysis uses a series of tests designed to identify and measure contamination such as:

- soot, sulfur, etc.
- degradation such as the presence of fuel, water and antifreeze in a sample of oil.
- the amount of wear metals present in the oil sample.

Wear metals present in the oil sample are compared to established Caterpillar norms to determine acceptability. S•O•S analysis must be performed on a continuing basis to be effective as an indicator. Intermittent sampling does not allow wear rate trend lines to be established.

S•O•S INTERVAL CHART	
Compartment	Interval
Engine Crankcase	Every 250 Hours (T & TA Only)
Engine Crankcase	Every 500 Hours (NA Only)

Obtain Oil Sample Every 250 Hour Interval (T & TA) or Every 500 Hour Interval (NA).

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.

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

S•O•S Analysis

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

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

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

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

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

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

NOTE: Infrared analysis must be used to determine oil change intervals. S•O•S analysis must include Infrared (IR) in the analysis.

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

Refer to Caterpillar pamphlet Listen To Your Oil (PEDP1129) for information and benefits of S•O•S analysis.

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.

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.

NOTE: Some engines are equipped with mechanical service meters reading in Service Meter Units (SMU). The Maintenance Schedules are developed for clock hours or fuel consumption. For most users, clock hours are the standard interval for maintenance and SMU's can be roughly equal to clock hours. However, Caterpillar recommends that fuel consumption be used as the preferred method of determining intervals rather than SMU's or clock hours.

Interval Categories

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

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

The maintenance intervals established for speed sensitive items are based on service hours.

Load sensitive items such as piston rings and cylinder liners are affected by the operating load on your engine. Generally speaking, the lower the load, the longer the engine life. 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. The amount of fuel consumed is directly related to the load on your engine.

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.

Caterpillar recommends performing maintenance on load sensitive items at maintenance intervals based on the quantity of fuel consumed.

Lubricant Viscosity Recommendations & Refill Capacity

Lubricant Viscosity Recommendations

See chart for recommended viscosity and temperature range. The required performance criteria for the oil is defined in the previous Lubricant Specification section.

The minimum temperature for the viscosity grade provides guidelines for the lowest starting temperature with a "cold soaked" engine. 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 chart. Your oil supplier can provide additional information on oil properties.

The recommendation is to use the highest viscosity oil possible. Even though the ambient temperature may be low, operating engines can still be subjected to normal oil temperatures because of regulated temperature components. Higher viscosity fluids provide better protection to all components contacted during the full day work cycle.

Multi-viscosity oils are preferred because of full protection through a wider temperature range. See chart for recommended viscosity and temperature range.

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

Lubricant Viscosity Chart

LUBRICANT VISCOSITIES FOR AMBIENT (OUTSIDE) TEMPERATURES					
Compartment or System	Oil ¹ Viscosities	°C		°F	
		Min	Max	Min	Max
Engine Crankcase	SAE 10W30 ²	-20	+40	-4	+104
	SAE 15W40 ²	-15	+50	+5	+122
	SAE 30	0	+40	+32	+104
	SAE 40	+5	+50	+41	+122

¹ Select oil viscosity based on maximum expected operating temperature. Engine start-up at lower than specified ambient temperature requires caution. Start-up at very low ambient temperatures may require auxiliary oil heaters or other methods to increase the engine crankcase and surrounding temperatures.

² Oil viscosity grades which meet the API CE or CF-4 performance category are limited somewhat to multi-grades (SAE 15W40 and 10W30). If single viscosity grades are selected, confirm with your oil supplier that the oil does meet the API CE or CF-4 rating requirement.

Refill Capacities

These refill capacities reflect the crankcase capacity plus filter. Auxiliary oil filter systems will require additional oil. For all auxiliary oil filter system information consult the OEM or auxiliary oil filter system manufacturer.

In order to properly maintain the cooling system, Total Cooling System capacity must be known. This capacity information will be needed to determine the amount of antifreeze and coolant additive (conditioner) required for the cooling system.

REFILL CAPACITIES - (APPROXIMATE)			
Compartment or System	Liters	U.S. Quarts	Imperial Quarts
3304B ENGINE CRANKCASE with Filters ¹	22.0	23.3	19.4
3304B JACKET WATER COOLING SYSTEM (Engine Only)	13.0	14.0	11.5
STANDARD RADIATOR (w/ hoses) ²	10.7	11.2	9.2
C-SIZE RADIATOR (w/ hoses) ²	32.0	34.0	28.2
TOTAL COOLING SYSTEM ³			
3306B ENGINE CRANKCASE with Filters ¹	27.5	29.0	24.0
3306B JACKET WATER COOLING SYSTEM (T Engine Only)	18.0	19.0	16.0
3306B JACKET WATER COOLING SYSTEM (TA Engine Only)	20.0	21.0	17.5
3306B JACKET WATER COOLING SYSTEM (ATAAC Engine Only)	16.0	17.0	14.0
STANDARD RADIATOR (w/ hoses) ²	10.7	11.2	9.2
C-SIZE RADIATOR (w/ hoses) ²	32.0	34.0	28.2
TOTAL COOLING SYSTEM ³			

¹ Optional bypass filters supplied by Caterpillar require additional oil. Additional oil is required with the use of auxiliary filters. Make sure to add enough oil to fill auxiliary oil circuit. Refer to OEM's specifications regarding auxiliary filter capacity.

² Refer to the OEM's specifications regarding cooling equipment capacity if radiator is not a Caterpillar radiator.

³ The Total Cooling System capacity will vary, depending on the radiator type and capacity provided by Caterpillar or the OEM. In order to properly maintain the cooling system, Total Cooling System capacity must be known. The chart is blank and should be filled in by the customer to determine the Total Cooling System Capacity for this engine and application. Add ENGINE ONLY and appropriate RADIATOR capacity for TOTAL COOLING SYSTEM capacity for your engine and application.

Maintenance Schedule-3304B Engines

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

NOTE: Experience has shown that maintenance intervals are most accurately scheduled on the basis of fuel consumed rather than service hours.

Daily

Walk-Around Inspection – Inspect engine for leaks and loose connections	68
Engine Crankcase – Check oil level	69
Cooling System – Check coolant level	70
Clutch – Check/Adjust/Lubricate	71
Air Starter & Air Tank (if equipped) – Check/Adjust/Drain water	72
Engine Air Cleaner – Check service indicator	73
SR4 Generator – Inspect/Check	76

Every 1,100 L (300 gal) of Fuel or 50 Hours*

Dust Collector – Clean	77
Light Duty Air Cleaner (If Equipped) – Replace	77

Every 2,800 L (750 gal) of Fuel 125 Hours*

Clutch – Check/Adjust/Lubricate	78
Generator Space Heaters (If Equipped) – Check ...	78

Every 5,600 L (1,500 gal) of Fuel or 250 Hours*

Scheduled Oil Sampling (S•O•S) ¹ – Obtain Sample	79
Engine Oil and Filter(s) ¹ – Change	81
Crankcase Breather ¹ – Clean	83
Engine Valve Lash (First Oil Change Only) ¹ – Check/Adjust	84
Cooling System – Test for supplemental coolant additive concentration	84
Fuel System – Clean/Replace filters, Drain water from fuel tank	86
Radiator Fins, Aftercooler, Belts, and Hoses – Inspect/Check	88
Fan Drive Bearing – Lubricate	90
Batteries – Check/Clean	90
Magnetic Pickup (At First Oil Change Only) – Inspect/Clean	91

¹ These maintenance requirements are to be performed at the 250 Hour interval for Turbocharged (T) Engines ONLY. Refer to 500 Hour interval for Naturally Aspirated (NA) Engines.

Every 11,250 L (3,000 gal) of Fuel or 500 Hours (NA Only)*

Scheduled Oil Sampling (S•O•S) Analysis – Obtain Sample	92
Engine Oil and Filter(s) – Change	92
Crankcase Breather – Clean	92
Engine Valve Lash (First Oil Change Only) – Check/Adjust	92

Every 22,500 L (6,000 gal) of Fuel or 1000 Hours*

Engine Protection Devices – Inspect	93
SR4 Generator and Control Panel – Inspect	93
Fuel Control Linkage– Lubricate	95

Every 45,000 L (12,000 gal) of Fuel 2000 Hours*

Engine Valve Lash, Valve Rotators, Fuel Ratio Control, Set Point, and Low Idle – Check/Adjust ...	96
Fuel Injection Nozzles – Test/Clean/Replace	97
Turbocharger – Inspect	97
Engine Mounts – Inspect	99
Crankshaft Vibration Damper – Inspect	99
SR4 Generator – Check/Inspect Clean/Lubricate .	100

Every 68,220 L (18,000 gal) of Fuel or 3000 Hours or Two Years*

Cooling System – Add Extender (Long Life Coolant/Antifreeze Only)	101
Cooling System – Drain/Clean/Replace Coolant – Conventional Coolant/Antifreeze Only	101
Water Pump Seal – Inspect/Replace	103
Hoses – Replace	103
Thermostat – Replace	103

Every 90,000 L (24,000 gal) of Fuel or 4000 Hours*

Magnetic Pickup – Inspect/Clean	105
SR4 Generator – Check/Inspect/Clean/Lubricate	105

Every 135,000 L (36,000 gal) of fuel or 6,000 Hours or Four Years

Cooling System – Drain/Flush/Replace Coolant (Long Life Coolant/Antifreeze Only)	106
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*Perform previous maintenance interval items first.

Maintenance Schedule-3306B Engines

Use fuel consumption or service hours, whichever occurs first, to determine maintenance intervals.

NOTE: Experience has shown that maintenance intervals are most accurately scheduled on the basis of fuel consumed rather than service hours.

Daily

Walk-Around Inspection – Inspect engine for leaks and loose connections	68
Engine Crankcase – Check oil level	69
Cooling System – Check coolant level	70
Clutch – Check/Adjust/Lubricate	71
Air Starter & Air Tank (if equipped) – Check	72
Engine Air Cleaner – Check service indicator	73
SR4 Generator – Inspect/Check	76

Every 1,900 L (500 gal) of Fuel or 50 Hours*

Dust Collector – Clean	77
Light Duty Air Cleaner (If Equipped) – Replace	77

Every 4,250 L (1,100 gal) of Fuel or 125 Hours*

Clutch – Check/Adjust/Lubricate	78
Generator Space Heaters – Check	78

Every 8,500 L (2,200 gal) of Fuel or 250 Hours*

Scheduled Oil Sampling (S•O•S) ¹ – Obtain Sample	79
Engine Oil and Filter(s) ¹ – Change	81
Crankcase Breather ¹ – Clean	83
Engine Valve Lash (First Oil Change Only) ¹ – Check/Adjust	84
Cooling System – Test for supplemental coolant additive concentration	84
Fuel System – Clean/Replace filters, Drain water from fuel tank	86
Radiator Fins, Aftercooler, Belts, and Hoses – Inspect/Check	88
Fan Drive Bearing – Lubricate	90
Batteries – Clean/Check	90
Magnetic Pickup (At First Oil Change Only) – Inspect/Clean	91

¹ These maintenance requirements are to be performed at the 250 Hour interval for engines equipped with turbochargers (T, TA & ATAAC) ONLY. Refer to 500 Hour interval for Naturally Aspirated (NA) Engines.

Every 17,000 L (4,500 gal) of Fuel or 500 Hours (NA Only)*

Scheduled Oil Sampling (S•O•S) – Obtain Sample	92
Engine Oil and Filter(s) – Change	92
Crankcase Breather – Clean	92
Engine Valve Lash (First Oil Change Only) – Check/Adjust	92

Every 34,000 L (9,000 gal) of Fuel or 1000 Hours*

Engine Protection Devices – Inspect	93
SR4 Generator and Control Panel– Inspect	93
Fuel Control Linkage– Lubricate	95

Every 67,000 L (18,000 gal) of Fuel or 2000 Hours*

Engine Valve Lash, Valve Rotators, Fuel Ratio Control, Set Point, and Low Idle – Check/Adjust ...	96
Fuel Injection Nozzles – Test/Clean/Replace	97
Turbocharger – Inspect	97
Engine Mounts – Inspect	99
Crankshaft Vibration Damper – Inspect	99
SR4 Generator – Check/Inspect Clean/Lubricate ..	100

Every 91,000 L (24,000 gal) of Fuel or 3000 Hours or Two Years*

Cooling System – Add Extender (Long Life Coolant/Antifreeze Only) –	101
Cooling System – Drain/Clean/Replace Coolant – Conventional Coolant/Antifreeze Only	101
Water Pump Seal – Inspect/Replace	103
Hoses – Replace	103
Thermostat – Replace	103

Every 136,000 L (36,000 gal) of Fuel or 4000 Hours*

Magnetic Pickup – Inspect/Clean	105
SR4 Generator – Check/Inspect/Clean/Lubricate ..	105

Every 204,000 L (54,000 gal) of Fuel or 6,000 Hours or Four Years

Cooling System – Drain/Flush/Replace Coolant (Long Life Coolant/Antifreeze Only)	106
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*Perform previous maintenance interval items first.

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.

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

Keep a close watch for leaks. If leaking is observed, find the source and correct the leak. If leaking is suspected: check the fluid levels more frequently than the recommended maintenance intervals and continue to monitor fluid levels until any leak is found and fixed.

- Wipe all fittings, caps and plugs before servicing to reduce the chance of system contamination.

Inspect:

- Radiator core for leaks and trash build-up.
- Radiator and air intake system hoses and elbows for cracks and loose clamps.
- air-to-air aftercooler for insects, dirt and other debris. Clean as necessary. Clean the front of the aftercooler with a stainless steel brush and soapy water.

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

- Fan and accessory drive belts for cracks, breaks or other damage.

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

- Water pump for coolant leaks at weep hole. Check weep hole for water pump breather filter blockage. Replace the filter if necessary.

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.

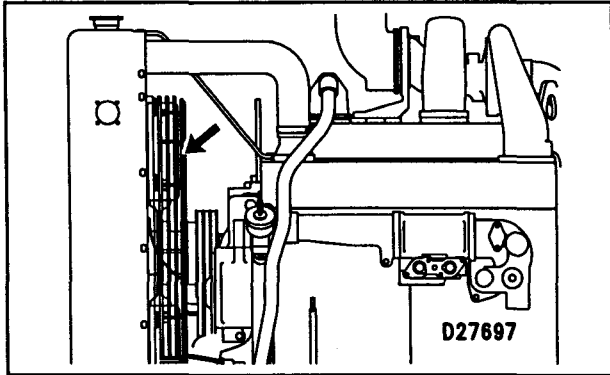
If leaks are found, check the coolant level frequently and continue to monitor the level until the water pump is repaired. Excessive coolant leakage may indicate the need to replace the water pump seal. For removal and installation of water pumps and/or seals, see the Service Manual for this engine or consult your Caterpillar dealer.

- Lube system for leaks, such as front and rear crankshaft seals, oil pan, oil filters and valve covers.
- Fuel system for leaks, loose fuel line clamps and fittings and loose or worn hoses.

NOTICE

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

- Drain water and sediment from fuel storage and day tanks on a daily basis to ensure only clean fuel enters the fuel system.
- Inspect wiring and wiring harnesses for loose connections and worn or frayed wires.



- All guards must be in place. Repair or replace missing or damaged guards.
- Disconnect any battery chargers that are not protected against the starter current drain. Check the condition and the electrolyte level of batteries, unless equipped with a maintenance free battery.
- Inspect the engine-to-frame ground strap for good connection and condition.

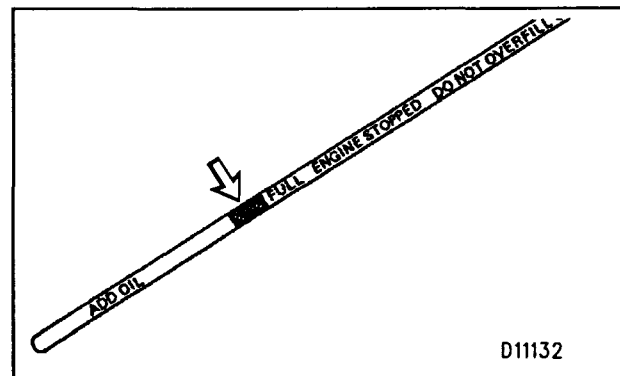
Engine Crankcase

NOTICE

Make sure you read and understand the information in the Lubricant Specifications section of this manual before you proceed with maintenance of the crankcase lube oil system.

The engine must be on a level surface to properly perform this maintenance procedure.

Check Oil Level



1. Check the oil level with the engine stopped.

Ensure that the engine when the oil level is not above the FULL RANGE zone on the dipstick.

2. Maintain the oil level between the ADD and FULL marks on the ENGINE STOPPED side of the dipstick. Do not fill the crankcase above the mark in FULL RANGE zone.

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

If the dipstick does not have a FULL mark in the FULL RANGE zone: refer to calibrating the oil level gauge in the Dipsticks topic of this manual or consult your Caterpillar dealer before operating the engine.

3. Remove the oil filler cap and add oil if necessary. See Refill Capacities and Lubricant Specifications for the size of your engine crankcase and recommended oil to use.

NOTE: Remote mounted or auxiliary oil filters require more oil than the Refill Capacities chart states. For all information pertaining to auxiliary oil filters, refer to the OEM or filter manufacturer's instructions.

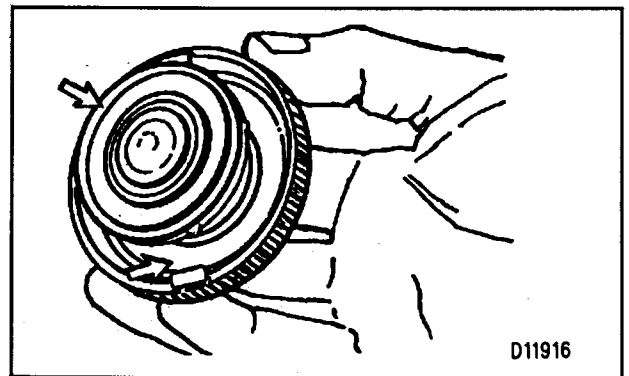
Cooling System

NOTICE

Make sure you read and understand the information in the Cooling System Specifications section of this manual before you proceed with maintenance of the cooling system.

Check Coolant Level

1. Check the coolant level with the engine stopped and cool.
2. The filler cap covers the fill pipe. Remove the filler cap slowly to relieve any pressure.
3. Maintain the coolant level within 13 mm (½ inch) below the bottom of the fill pipe or to the proper level on the sight glass (if equipped).



4. Inspect the filler cap. Replace the cap if gaskets are damaged. Install the filler cap.
5. Inspect the radiator fins for dirt and debris and clean the fins if necessary.

Clutch

Check/Adjust/Lubricate

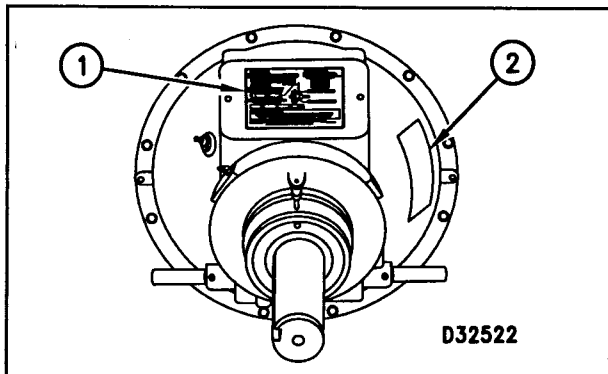
Check/Adjust

NOTICE

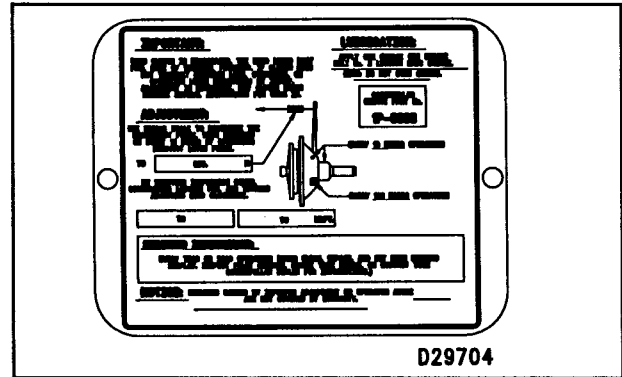
New power take-offs should have clutch adjustment checked before being placed in service. Clutch adjustment should be checked again after the first ten hours of operation. New clutch plates have a "wear in" period, and the clutch may require several adjustments until the new plates are "worn in."

Clutch adjustment should be checked regularly after "wear in." Heavy duty applications which have frequent 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.

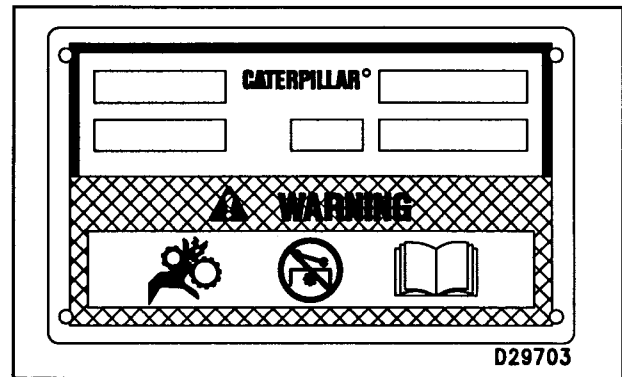
Refer to the clutch OEM service instructions and the clutch instruction plate for adjustment and other service recommendations. Perform the maintenance specified on the instruction plate.



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



Instruction Plate.



Serial Number Plate.

WARNING

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

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.

Lubricate

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

Air Starter & Air Tank (If Equipped)

Check Lubricator Level

NOTICE

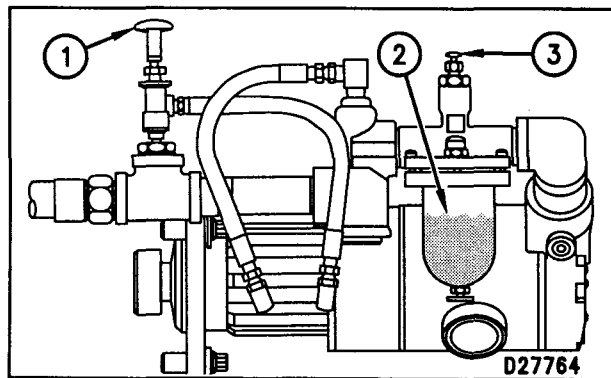
Never allow the lubricator bowl (if equipped) to become empty. The starting motor will be damaged by lack of proper lubrication.

The vanes of the 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).

Oiler Feed Adjustment

If necessary, adjust the lubricator to release approximately four drops of fluid per minute into the starting motor air stream.

Be sure there is NO fuel supply to the engine.



1. Push on the air start control lever (1) to crank the engine.

2. Count the drops of fluid per minute that are released into the air stream. Turn the needle valve knob (3) counterclockwise to increase the flow and clockwise to decrease the flow of fluid into the air stream.

Collector Bowl

Some air starters may be equipped with a collector bowl. The bowl collects used oil after the oil has lubricated the vanes. The bowl also collects moisture condensation from the compressed air. When the collector bowl becomes half full, drain the used lubricant. Never fill the lubricator bowl with oil from the collector bowl— use clean lubricant.

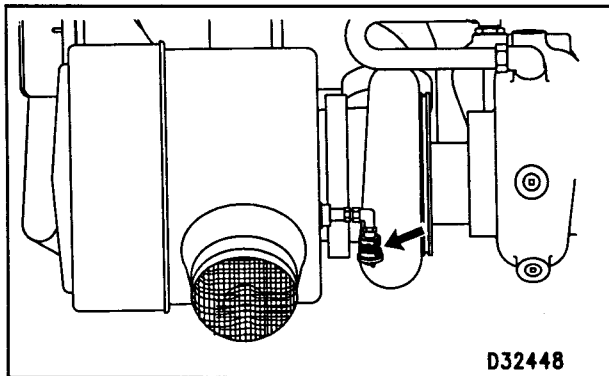
Air Tank (If Equipped)

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 1550 kPa (225 psi). The normal air pressure will be 758 kPa (110 psi) to 965 kPa (140 psi).

Engine Air Cleaner

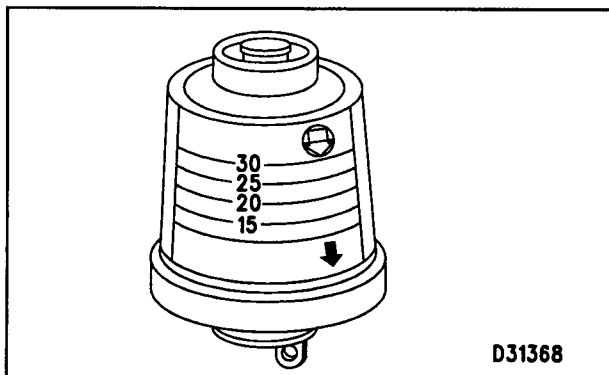
Check Air Cleaner Service Indicator



Typical air cleaner indicator, mounted on the air cleaner housing.

Your engine may be equipped with a different indicator.

A service indicator (if equipped) may be mounted on the air cleaner or in a remote location. A colored piston showing in the window indicates the need for servicing the air cleaner.



Observe the air cleaner 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 air cleaner indicator shows red at any time, clean the filter element or install a new air cleaner element.

NOTICE

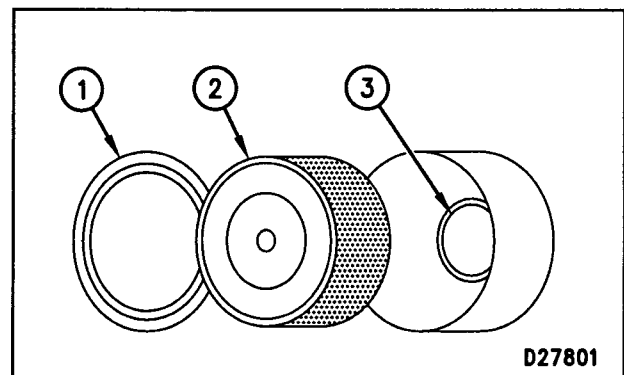
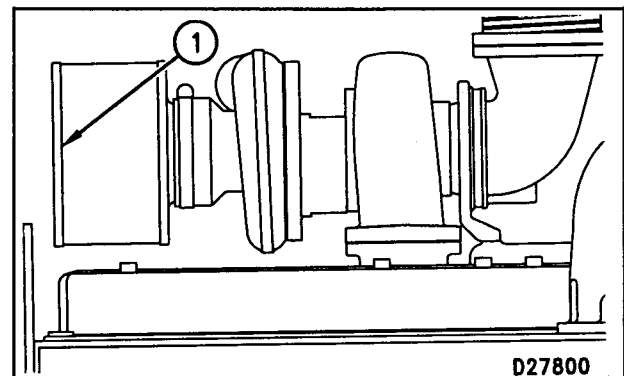
Never service the air cleaner with the engine running since this will allow dirt to enter the engine.

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

If equipped with a Light Duty air cleaner element, refer to the 50 Hour interval for information.

Single Stage Air Cleaner Elements

Remove and Install Air Cleaner Elements



1. Remove the air cleaner cover (1) and element (2).
2. Seal the turbocharger air inlet (3) so that debris can not enter the inlet. Use tape, or secure a clean cloth over the opening.
3. Clean the inside of the air cleaner cover and body.
4. Inspect the replacement element for damage, dirt or debris.
5. Remove the seal from the turbocharger inlet.

6. Install a clean, undamaged element.
7. Install the air cleaner cover.
8. Reset the service indicator.

Two Stage Air Cleaners

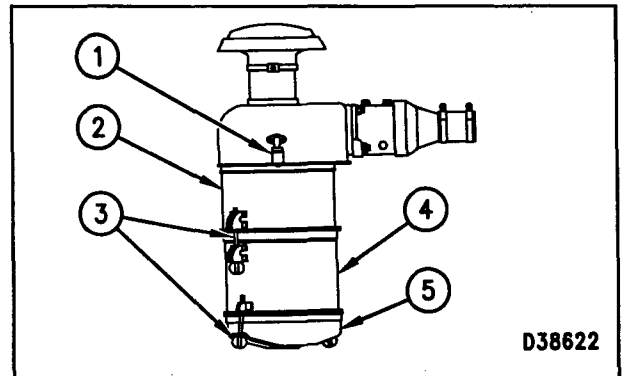
If equipped with a two stage air cleaner, refer to the Every 50 Hour interval for information regarding cleaning the dust collector/precleaner.

Heavy Duty Air Cleaners Only

Generator set engines equipped with heavy duty air cleaners have a serviceable air cleaner element. The element may be cleaned up to six times, but must be replaced Every Year. Refer to the Cleaning Air Filter Elements topic in this section.

Observe the service indicator to determine the condition of the elements. If an element becomes plugged, but does not split, engine performance will deteriorate and output power will be reduced. Keep spare filter elements on hand for replacement.

Remove and Install Air Cleaner Elements



Heavy duty air cleaner: service indicator (1), upper body (air filter element housing) (2), clamps (3), lower body (tube element) (4), and dust collector cup (5).

1. Loosen clamps (3) between lower body (4) and dust collector cup (5). Remove the cup.
2. Loosen the clamps between the lower body and the upper body (2). Remove the tube element.
3. Clean the tubes from both sides with water or air.
4. Remove the air filter element from the upper body (2). Wipe the inside of the upper body clean.
5. Inspect a clean air filter element. Install a clean or new element.
6. Inspect the gasket between the upper body and lower body. Inspect the seal between the lower body and the dust collector cup. Install a new gasket and seal if necessary.
7. Install the cleaned, dry tube element. Tighten the retaining clamps attaching the lower body to the upper body.
8. Wipe the dust collector cup clean. Install the cup and tighten the retaining clamps.
9. Reset the service indicator (1).

Cleaning Air Filter Elements

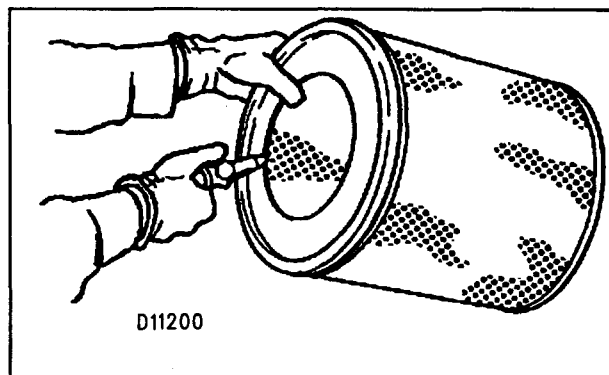
The primary element (Caterpillar air filters) can be cleaned several times before replacement. The element, when cleaned, should be thoroughly checked for rips or tears in the filter material.

Replace the primary element at least Every Year regardless of operating hours it has accumulated.

NOTICE

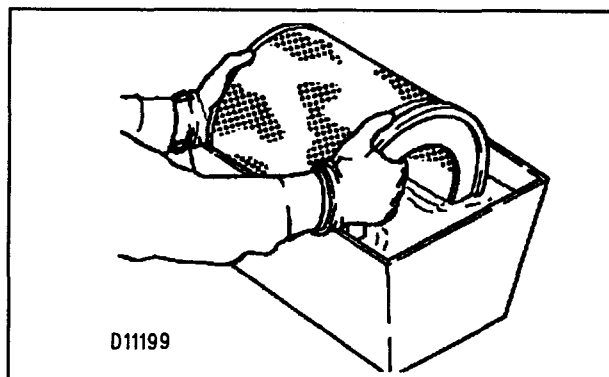
Do not clean filter elements by bumping or tapping.

Do not use filter elements with damaged pleats, gaskets or seals. Engine damage could result.

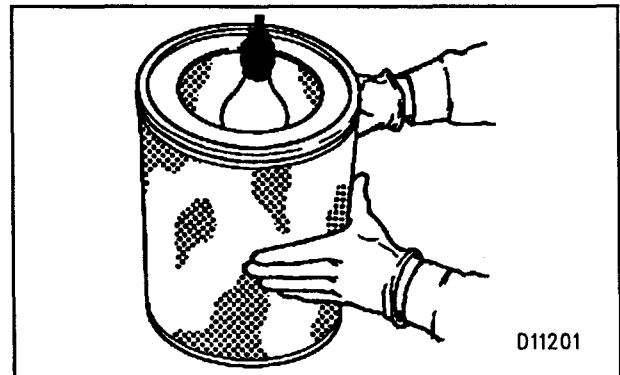


Filter elements can be cleaned with air pressure, 205 kPa (30 psi) maximum, or water pressure, 280 kPa (40 psi) maximum, or detergent washing. Have spare elements on hand to use while cleaning used elements.

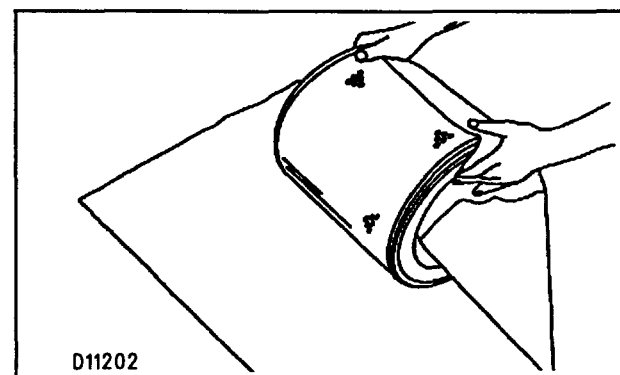
- Direct air or water along the length of the pleats inside and outside of filter element.



The element can be washed in warm water and nonsudsing household detergent, such as automatic dishwasher detergent. Rinse inside and outside the pleats. The filter should then be thoroughly air dried and inspected.



- Inspect the filter elements after cleaning for any rips, tears or damage. Insert a light inside of the clean, dry element. Do not use a filter element with damaged pleats, gaskets or seals. Discard the element if damaged.



- Wrap and store the clean filter elements in a clean, dry place.
- Reset the service indicator by pushing the piston plunger in.

For more information on air cleaner element cleaning, refer to Guideline for Reusable Parts—Cleaning and Inspection of Air Filters, SEBF8062.

SR4 Generator (If Equipped)

Inspect/Check

Inspect the generator for moisture, dust, oils, greases, and debris on the main stator, excitor, and PMG. Clean as needed.

Check for proper voltage and frequency settings and stability.