CATERPILLAR®

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Operation & Maintenance Manual

3408 and 3412 Industrial and EPG Diesel Engines

38S1-16483
67U1-16070
78Z1-4866
81Z1-14500

⚠ IMPORTANT SAFETY NOTICE

Most accidents involving engine operation 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.

Improper operation is dangerous and could result in injury or death.

READ AND UNDERSTAND ALL SAFETY PRECAUTIONS AND WARNINGS BEFORE OPERATING THIS ENGINE.

Basic safety precautions are outlined in the "Safety" Section of this Guide and in the description of operations where hazards exist. Warning decals have also been put on the engine to provide instructions and to identify specific hazards which, if not heeded, could cause bodily injury or death to you or other persons. These warnings in the Guide and on the engine decals are identified by the symbol ⚠

Operations that may result only in engine damage are identified by CAUTION decals on the engine and in the Guide.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this Guide and on the engine are therefore not all inclusive. If an operation is not performed as specifically recommended by Caterpillar, you must satisfy yourself that it is safe for you and others. You should also ensure that the engine will not be damaged or made unsafe by the method of operation you choose.

⚠ WARNING

The proper and safe lubrication and maintenance procedures for this engine, recommended by Caterpillar, are outlined in the "Lubrication & Maintenance" Section of this Guide.

Improper performance of lubrication or maintenance procedures is dangerous and could result in injury or death. Read and understand the "Lubrication & Maintenance" Section before performing any lubrication or maintenance.

FOREWORD

This guide contains operation instructions and lubrication and maintenance information.

The operation section is a reference for the new operator and a refresher for the experienced one. Read — study — and keep it handy.

Illustrations guide the operator through correct procedures of checking, starting, operating and stopping the engine.

The maintenance section is a guide to equipment care. The illustrated, step-by-step instructions are grouped by servicing intervals. Items in the "Lubrication and Maintenance Chart" are referenced to the detailed instructions that follow.

Use the service meter to determine servicing intervals. Calendar intervals shown may be used instead of service meter intervals if they provide more convenient servicing schedules and approximate the indicated service meter reading. Recommended service should always be performed at the interval that occurs first.

Under extremely severe, dusty or wet operating conditions, more frequent lubrication than is specified in the "Lubrication and Maintenance Chart" may be necessary.

Perform service on items at multiples of the original requirement. For example, at Every 500 Service Meter Units, also service those items listed under Every 250 Service Meter Units, Every 50 Service Meter Units and Every 10 Service Meter Units.

Some photographs in this publication show details or attachments that may be different from your engine. Also, 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.

Each publication is reviewed and revised, as required, to update and include these changes in later editions.

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

Engine Identification

Caterpillar engines are identified with SERIAL NUMBERS and ARRANGEMENT NUMBERS. In some cases MODIFICATION NUMBERS are also used. These numbers are shown on the serial number plate mounted on the engine.

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

Ordering Parts

Quality Caterpillar replacement parts are available from Caterpillar dealers throughout the world. Their parts stocks are up to date and include all parts normally required to protect your investment in Caterpillar engines. When ordering parts, your order should specify the quantity, part number, part name and serial number, arrangement number and modification number of the engine for which the parts are needed. If in doubt about the part number, please provide your dealer with a complete description of the needed item.

California

Proposition 65 Warning

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

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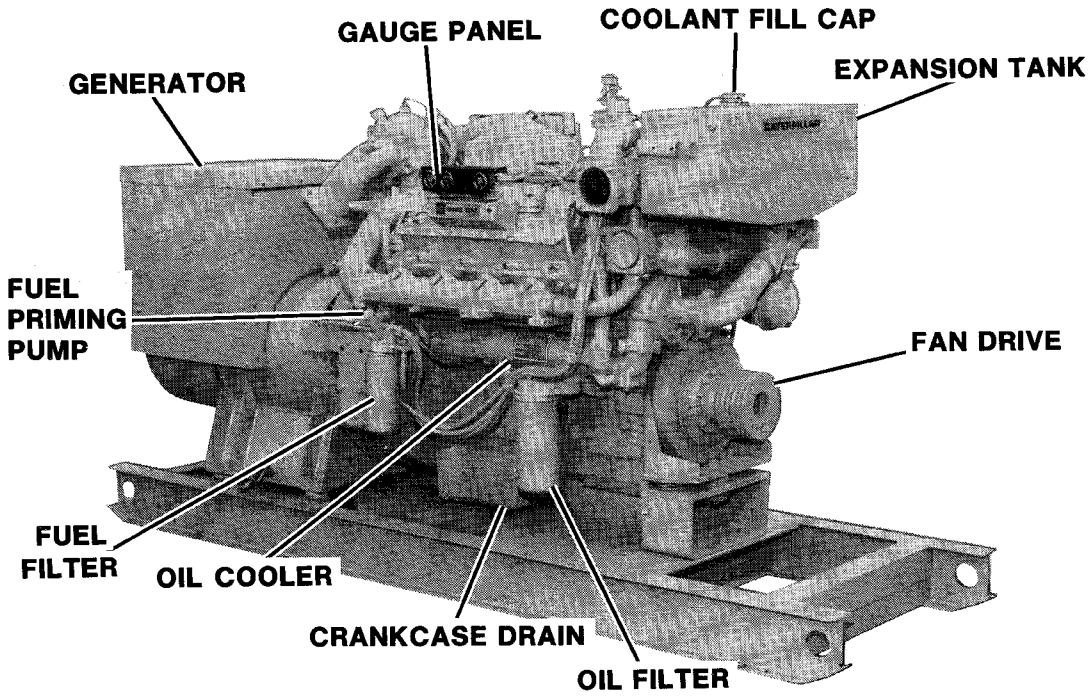
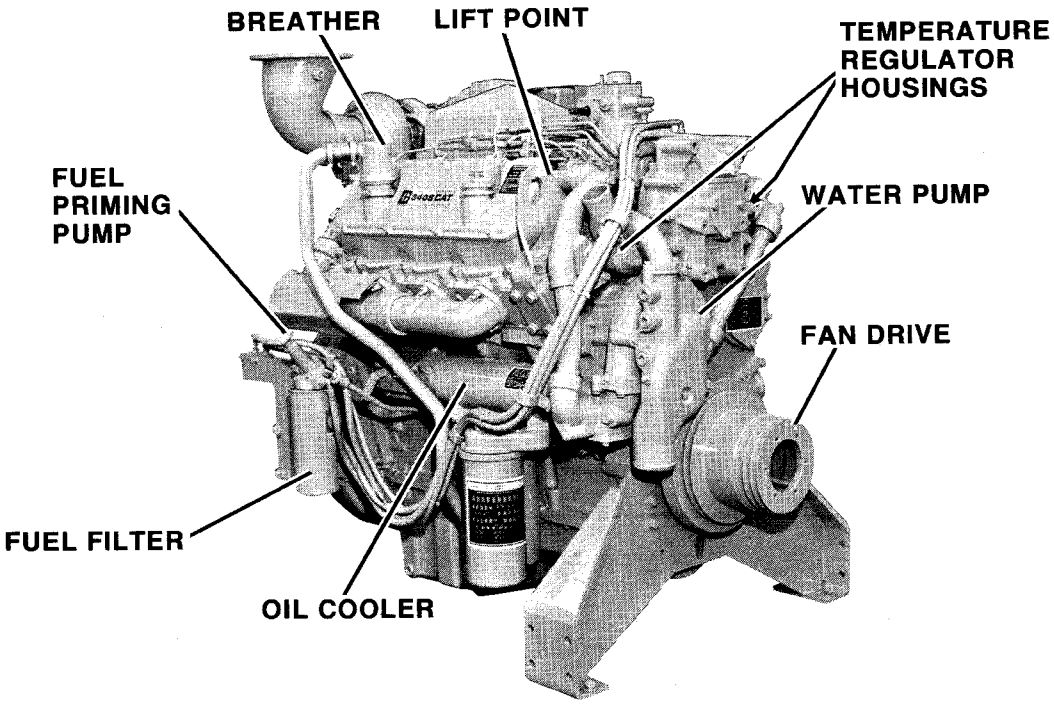
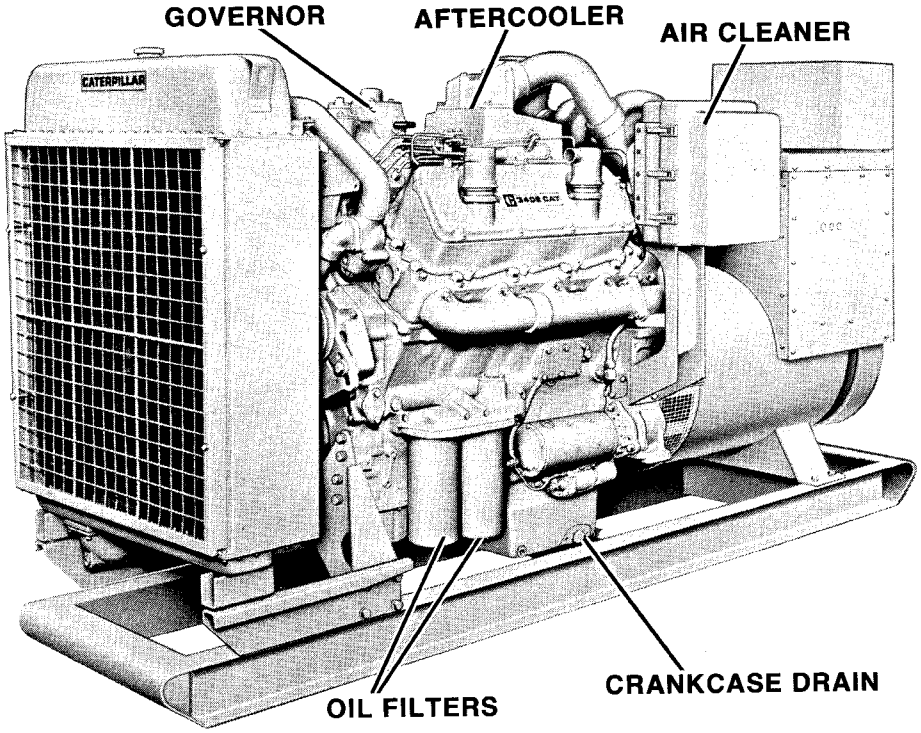
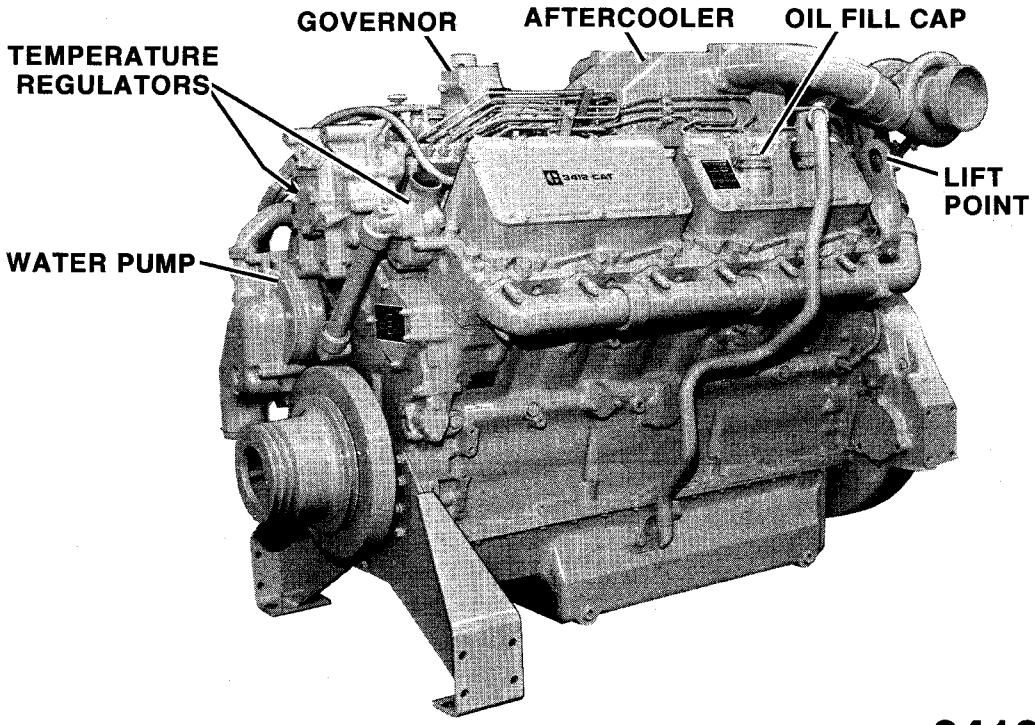
3408 GENERATOR SET ENGINE



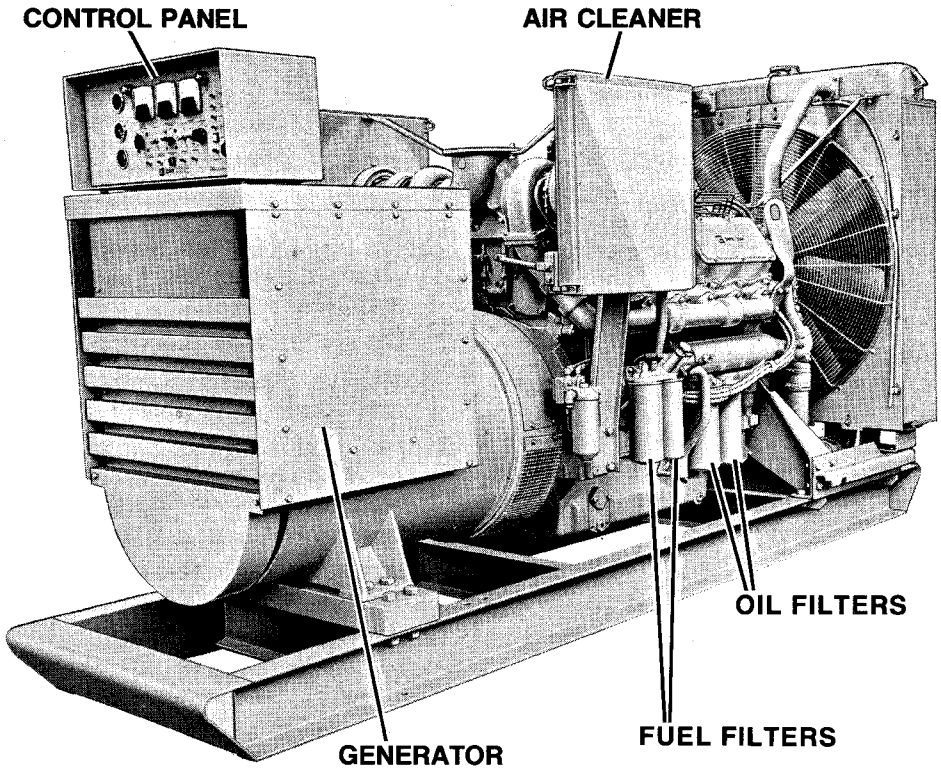


3408 INDUSTRIAL ENGINE





3412 INDUSTRIAL ENGINE

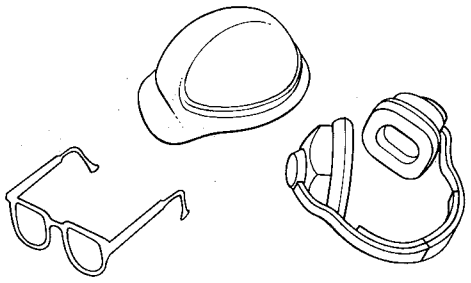


SAFETY PRECAUTIONS

Safety is everyone's business and is basically the use of good common sense. A general guide of safety precautions are given below, but each installation has its own peculiarities which cannot always be predicted and covered by established rules. Past experience and common sense are needed for the necessary safety measures. Attention to safety will help avoid serious accidents. Be alert. Watch for hazards. Use preventive measures. Correct deficiencies immediately.

The following safety precautions are a general guide to safe operation:

1. To prevent personal injury, install guards over all exposed rotating parts.
2. To prevent hearing damage, wear ear protective devices if working inside an enclosed engine room with engine running.
3. To prevent head injury, wear safety hat when working in the area of overhead equipment.
4. Wear safety glasses and shoes as required.

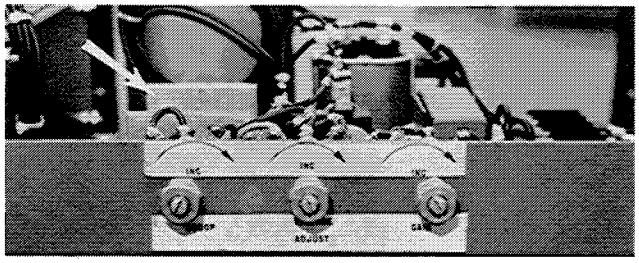


5. Do not wear loose clothing whenever working around engines or machinery.
6. Wipe up spilled oil, fuel or coolant.
7. Keep batteries in a well ventilated area. Do not smoke around batteries. Hydrogen gas, which is present in the area of the batteries, is highly explosive.
8. Provide adequate and safe waste oil disposal.
9. Store oily rags in fireproof containers. Don't leave rags on engine.

⚠ WARNING

When using pressure air, wear safety glasses and protective clothing. Maximum air pressure, used for cleaning, must be below 30 PSI (2 kg/cm²).

10. Remove all tools, electrical cords and other loose items from the engine before starting.
11. Disconnect and tape the battery ground lead before working on an engine to prevent accidental starting. Be sure an automatic start-stop system cannot operate and start the engine while working on it.
12. Do not attempt repairs you do not understand. Follow instructions.
13. Stop engine before adjusting or repairing engine or driven equipment.
14. Remove radiator cap slowly. Cooling systems can be pressurized and hot fluid will flash to steam as pressure is removed.
15. Never start an engine with the governor linkage disconnected.
16. Replace or repair broken or damaged equipment. Use proper tools.
17. Do not smoke while refueling. Observe NO SMOKING signs.
18. Never store flammable liquids near the engine.
19. All electrical equipment must be grounded according to local building codes.
20. Check all connections periodically for tightness and insulation.
21. Insulate all connections and disconnected wires.
22. Do not use carbon tetrachloride fire extinguishers. Fumes are toxic and the liquid has a deteriorating effect on insulation.

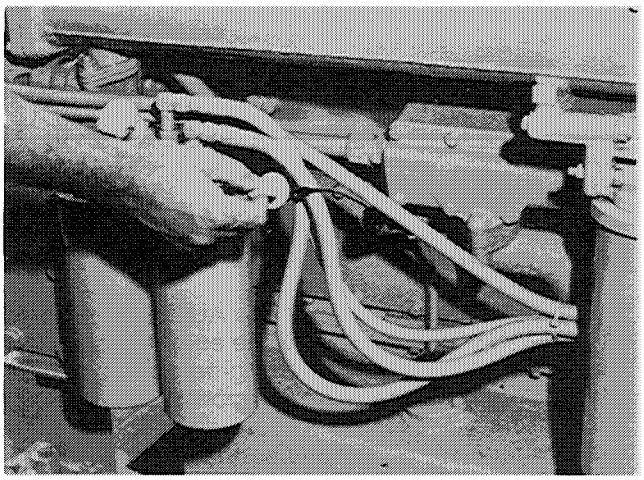


23. Do not touch the heat sink on the generator regulator when the generator is running. It is electrically "hot".
24. Do not work on electrically "hot" equipment.
25. Always disconnect the engine starter circuit when working on the generator.
26. Hot engine oil can cause burns when drained. Allow the oil to cool below 140°F or provide protection when draining the hot oil.
27. Never remove a plug to check pressure with the engine running. Shut down the engine and assure there is no pressure before removing plug.
28. When starting an engine after repair, make provisions for shutting off air supply in case there is an overspeed on start up.
29. Never look into an open cylinder port and turn over the engine. Oil or water in the cylinder will be ejected violently.

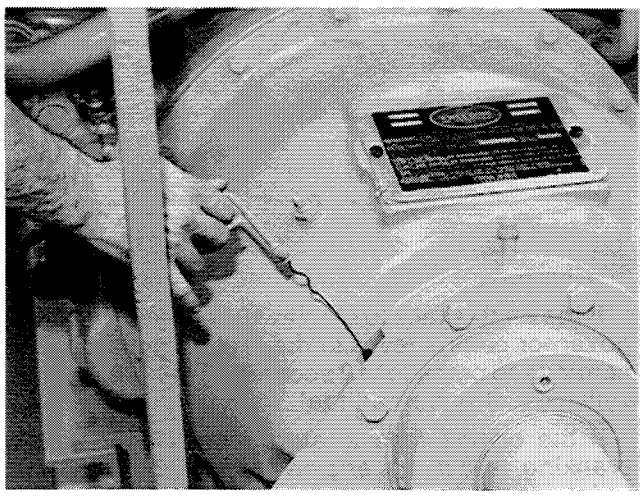
OPERATION INSTRUCTIONS

PRE-START INSPECTION AND PROCEDURES

1. Make a "walk-around" inspection of the engine and components for the oil, water or fuel leaks and general appearance. Correct minor adjustments before they develop into major repair jobs.
2. Check the crankcase oil level. Maintain the oil level between the ADD and FULL marks on the dipstick. See OIL SPECIFICATIONS for type of oil to use.



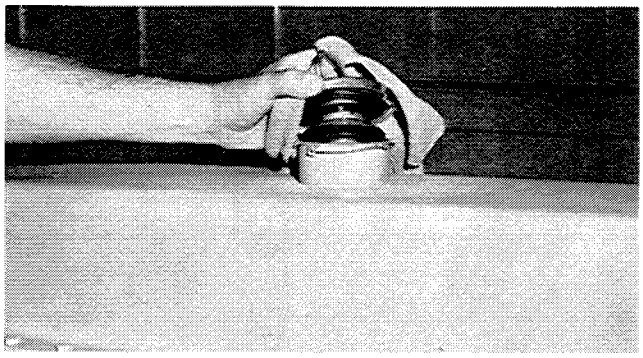
3. Check oil level(s) on driven equipment.



⚠ WARNING

Check the engine coolant level when the engine is cool. If the engine is warm, steam may spray outward under high pressure and cause personal injury.

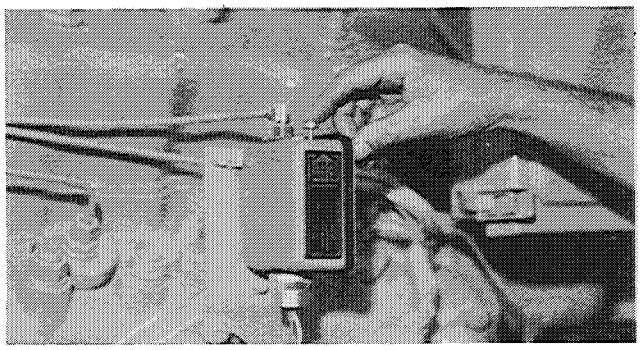
4. Check the engine jacket coolant level. Slowly turn the pressure cap until the cap is removed. Maintain coolant level to the base of the fill pipe.



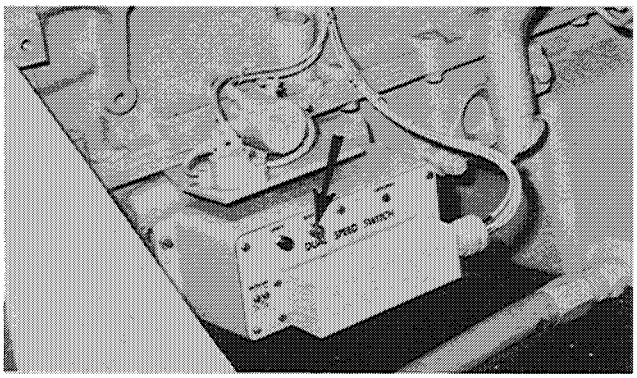
5. Check the fuel supply. Keep fuel tanks full, as partially filled tanks will collect moisture. See the FUEL SPECIFICATIONS for type of fuel.

KEEP THE FUEL SUPPLY CLEAN

6. Open the raw water valve on the engine jacket heat exchanger system (if so equipped). Prime the raw water pump if the raw water system has been drained.
7. Reset shutoff devices. See the topic, ATTACHMENTS, Emergency Shutoff Devices and Alarms.

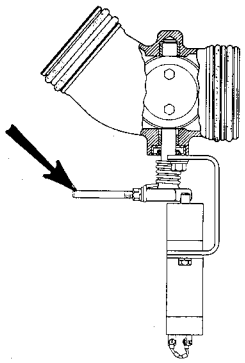


OIL PRESSURE RESET



OVERSPEED RESET

If the engine is equipped with an air safety shutoff control, and was tripped to the shutoff position, reset the latch to the run position.



AIR SHUTOFF RESET

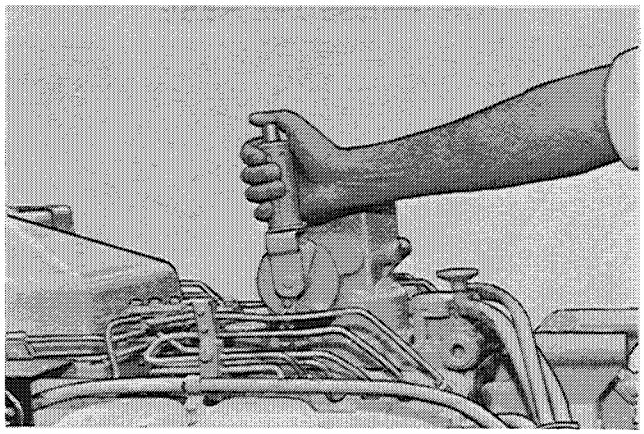
8. Open the fuel supply valve. If the engine has not run for some time it may be necessary to prime the system. See the topic, PRIMING THE FUEL SYSTEM.
9. Disconnect any battery charger which is not protected against starting motor drain.
10. Disengage the clutch, or open the circuit breaker on a generator set.

STARTING THE ENGINE

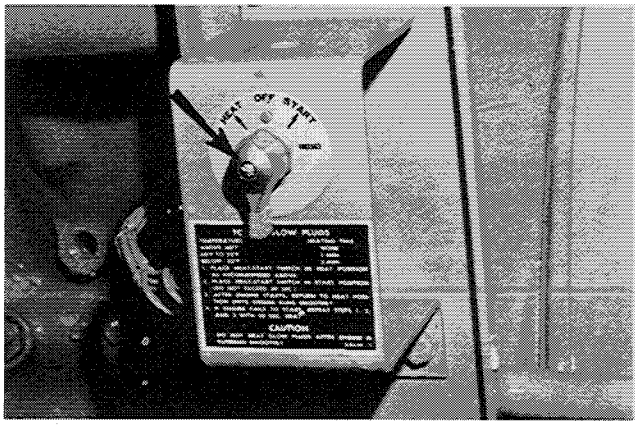
CAUTION
Do not engage the starter when the flywheel is moving.

Electric Starting

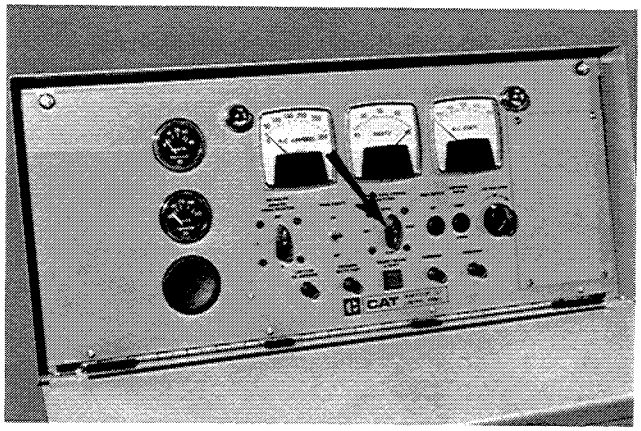
1. Move the governor control lever to approximate half engine speed position.



2. Use starting aids if required. See the topic, STARTING AIDS.
3. Push the START button; or turn the HEAT-START switch to the START position, depending upon the control the engine has. Release the control as soon as the engine starts.



For generator sets, place the AUTO-MAN switch in the MAN position to crank the engine. As soon as the engine starts, and the engine speed reaches 600 rpm and oil pressure is approximately 22 psi (1.5 kg/cm^2), the starter motor will disconnect from the circuit. (The STOP position is used to stop the diesel engine.)



If the engine fails to start in 10 seconds, move the governor control lever to the fuel off position, then continue to crank for 10 seconds. This will clear the cylinders of unburned fuel.

If the engine fails to start after 30 seconds of cranking, allow the engine to cool for 2 minutes before repeating the starting procedure.

CAUTION
Prolonged cranking at low oil pressure can activate the mechanical safety shut-off. If the reset lever is in the shut-off position, reset the mechanical shut-off control.

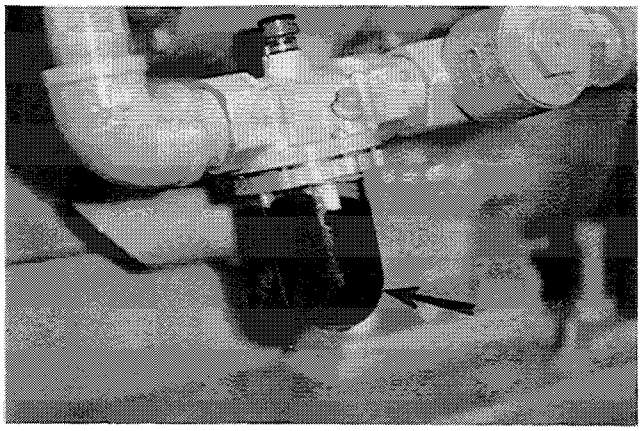
CAUTION

NEVER use starting aids when the engine is warm and running.

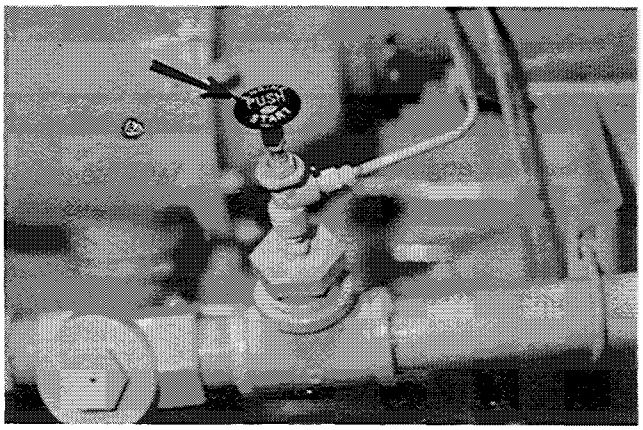
If the engine is equipped with a Woodward PSG Governor, see the topic, WOODWARD GOVERNORS for the governor operation instructions.

Air Starting

1. Open and close the bleed valve on the bottom of the air tank to drain condensation and oil carryover.
2. Check the air supply pressure. The air start must have 100 PSI (7 kg/cm^2) to operate properly.
3. Keep oil level, in the oiler jar, at least half full. Add oil if necessary. See the LUBRICATION AND MAINTENANCE PROCEDURES, Filling Motor Oiler.



4. Push the air valve control in to crank the engine. As soon as the engine starts, release the valve.

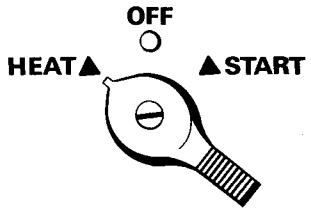


Starting Aids

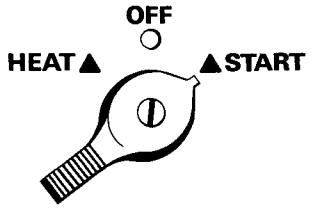
Many variables can affect cold weather starting. Use the chart as a guide, but actual experience will determine when aids are necessary and how they should be used. Your engine may have one or more of the following starting aids:

Glow Plugs (Precombustion Chamber Engines Only)

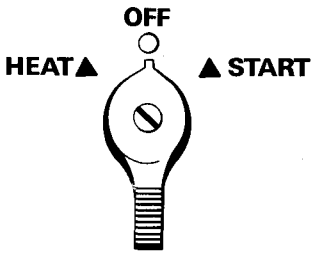
1. Push in and turn the HEAT-START switch to the HEAT position and hold for the approximate heating time shown in the STARTING AID CHART.



2. Turn the HEAT-START switch to the START position.



3. If necessary, when the engine starts turn the HEAT-START switch to the HEAT position. Hold the switch in this position until the engine is running smoothly.
4. Release the switch.



CAUTION

NEVER use glow plugs when the engine is warm and running.

STARTING AID CHART		
STARTING TEMPERATURE	**STARTING AID**	**HEATING TIME**
Above 60°F (15°C)	None	None
60°F to 32°F (15°C to 0°C)	Glow Plugs	1 Minute
32°F to 0°F (0°C to −20°C)	Glow Plugs	2 Minutes
Below 0°F (−20°C)*	Glow Plugs	3 Minutes

*Heating of jacket water/and or crankcase oil; and/or use of extra battery capacity may be required.

Starting Fluid

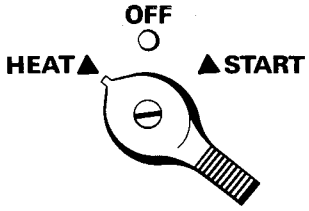
⚠ WARNING

Starting fluid is volatile and must be stored away from heat and direct sunlight. If an aerosol container is used, follow the instructions on the container.

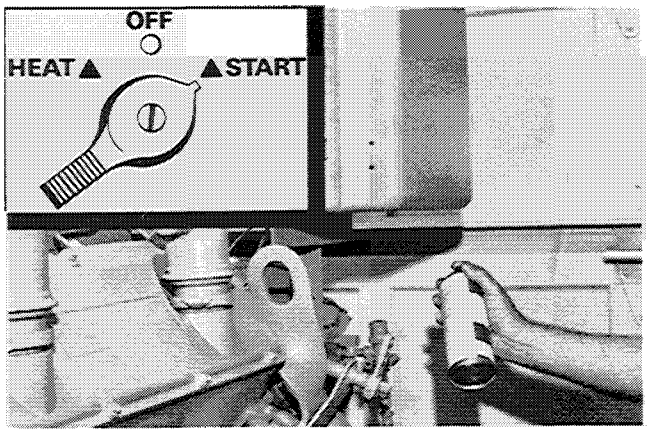
CAUTION

Spray starting fluid only while cranking the engine.

1. Heat the glow plugs (If equipped) for the approximate heating time shown in the STARTING AID CHART.



2. Turn the HEAT-START switch to START position. While cranking, spray starting fluid into the air inlet or air cleaner for approximately 1 second.



CAUTION

Wait at least 2 seconds before spraying starting fluid again.

3. If necessary, repeat the procedure.
4. After the engine starts, it may be necessary to return the HEAT-START switch to the HEAT position until the engine runs smoothly.

Jacket Water Heater (Attachment)

In very low temperatures, the lubricating oil must be warmed to allow starting. A jacket water heater can maintain the water temperature at approximately 90°F (32°C). The warm water will keep the oil in the upper part of the engine block warm enough to flow when starting.

Dipstick Oil Heater

CAUTION

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

GENERATOR

Starting Single Unit Operation

1. Make all preliminary engine starting checks.
2. Be sure the main or line circuit breaker is open.
3. Start the engine and allow it to warm up.
4. Close the main circuit breaker.
5. Apply the load. Do not try to apply full load in one move, rather apply the load in increments to maintain system frequency at a constant level.

Standby Generator Sets

Most standby units are automatic. They start, pickup the load, run and stop without an operator in attendance. Standby units can not change the governor control setting automatically. The throttle must be preset for the proper operation of that unit. Whenever the set is exercised or operated manually, be sure the throttle setting is correct for automatic operation. Check all switches to see they are properly set: Start Selector Switch in AUTOMATIC position and any Emergency Stop Switches in RUN position.

Paralleling

Units may be paralleled at no load or paralleled with units under load. To parallel two or more units the following conditions must be met:

1. Same phase rotation.
2. Same voltage level.
3. Same voltage droop.
4. Same frequency.
5. Voltages must be in phase.

The first condition is established by "phased" wiring connections of initial installation.

The second and third conditions are usually established by semi-permanent adjustments to the generator controls.

The fourth and fifth conditions are under control of the operation in manual paralleling systems (or under automatic control in automatic paralleling systems).

To Parallel

1. Start the unit to be paralleled.
2. Turn the synchronizer lights on.
3. After the engine has run long enough to warm up, bring it up to synchronous speed (the same frequency as the unit on the line). The synchronizing lights will begin to blink.
4. Using the governor control, adjust the speed until the lights blink very slowly.
5. The lights are off when the voltages of the two units are in phase. At this point, very quickly close the breaker while the lights are out.

NOTE

The frequency of the incoming unit should be slightly greater than the line frequency. This will allow the incoming unit to assume some of the load rather than add to the system load.

Load Division

Once two units have been paralleled, their share of the load is determined by the governor control setting. If two units of the same capacity and the same governor characteristics have the same governor control setting they will share the load equally.

To add load to one engine, slowly increase the governor control setting of that engine, or slowly decrease the governor control setting of the engine giving up load.

Load Transfer

At this point open the circuit breaker to remove any remaining load on the outgoing generator set.

NOTE

The total load must not exceed the capacity of the engine, or the engine will be overloaded.

1. Increase the governor speed control of the unit to the high idle position to assume the load.
2. Reduce the governor speed control of the outgoing unit until the generator amperage is at a minimum. (The amperage may never be zero due to circulating currents.) At this point transfer the load.

Stopping

To remove a generator from the line do the following:

1. Check the load. It must be less than the rated capacity of remaining units.

NOTE

If removing a generator from the line will cause overloading of the remaining units, remove some of the load first.

2. Be sure the NEUTRAL of one of the remaining units is grounded.
3. Remove the load from the outgoing unit as described in Load Division and Load Transfer.
4. Open the circuit breaker.
5. Run the engine for 5 minutes without a load, to allow it to cool. Stop the engine.

After Engine Starts

⚠ WARNING

Stop the engine if any repairs or adjustments are required. Do not work on machinery while the engine is running.

1. Observe the oil pressure gauge immediately after starting.

CAUTION

If oil pressure is not indicated within 5 seconds, stop the engine and have necessary repairs made.

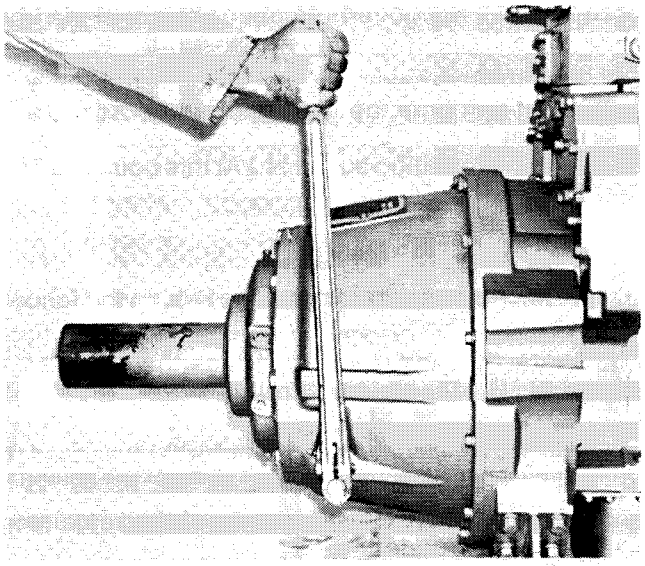
2. Move the governor control to low idle, allow the engine to reach normal operating range (usually several minutes). Make another "walk-around" inspection for leaks, etc.

STARTING THE LOAD

Driven Equipment without Load

To engage the driven equipment before applying load:

1. Move the governor control to half engine speed.
2. Engage the driven equipment without load on the equipment.



3. Make sure the engine and equipment gauges register in the operating range.
4. Move the governor control to high idle (full load) position.
5. Apply the load to the driven equipment.

Driven Equipment With Load

1. Move the governor control to half engine speed. Make sure the engine gauges register in the normal operating range.
2. Move the governor control to high idle (full load) position.
3. Engage the load.

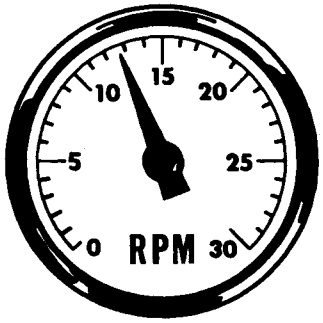
ENGINE OPERATION

After the engine starts, and at frequent intervals while the engine is operating, the gauges should be observed. Determine the normal reading for each gauge. Investigate the cause whenever there is a significant change in the reading.

Gauges

Tachometer

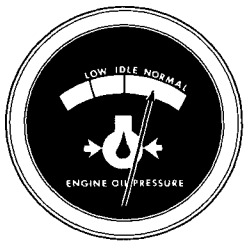
The tachometer indicates engine RPM. The high idle RPM and the full load RPM are stamped on the engine's information plate. The engine can be operated between these two speed limits for long periods of time without shortening engine life. Prolonged operation at high idle with little or no load can cause adverse engine operation.



Engine Oil Pressure

If the gauge reading fluctuates after the load is stable:

1. Remove the load.
2. Reduce engine speed to low idle.
3. Observe the oil level. Maintain the oil level between the ADD and FULL mark on the dipstick. If the reading continues to fluctuate when the oil level is correct, stop engine and call your Caterpillar dealer.



Engine Jacket Water Temperature

The engine should operate within the NORMAL (green) range. If the engine is operating in the (red) range and steam becomes apparent:

1. Reduce the load and engine RPM.
2. Inspect for coolant leaks.
3. Determine if the engine must be shut down immediately; or if the engine can be safely cooled by reducing the load.

See COOLING SYSTEM MAINTENANCE INSTRUCTIONS.

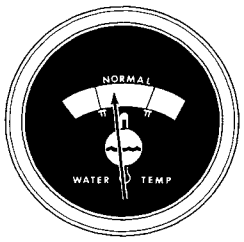
CAUTION

Do not add cold water to a hot engine: Cracking of engine components may occur. Allow the engine to cool, then add coolant.

If the temperature gauge reading registers in or near the cold range (white) while operating under load:

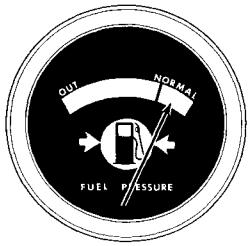
1. Check the water temperature gauge for accuracy.
2. Check the temperature regulators for proper temperature range. Replace regulators if necessary.

See COOLING SYSTEM MAINTENANCE for DETAILS.



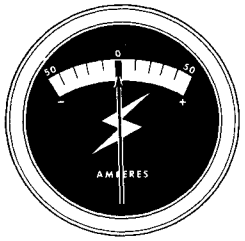
Fuel pressure

If the fuel filter gauge registers in the OUT range, clean the primary fuel filter, if so equipped. Install new secondary or final fuel filter elements if gauge still registers OUT. See the FUEL MAINTENANCE INSTRUCTIONS and FUEL SPECIFICATIONS.



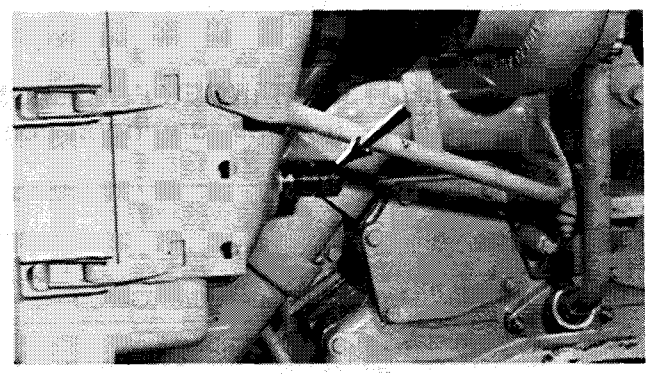
Ammeter:

The ammeter reading is normal when the indicator is at or on the (+) side of zero, when the engine is running at rated speed. If indicator is to the left (−) side of zero, investigate and correct cause.



Air Cleaner Service Indicator

When the gauge indicator locks in the red range, service the air cleaner. With the engine stopped; see AIR INDUCTION AND EXHAUST SYSTEM MAINTENANCE INSTRUCTIONS.



Calibrated Gauges

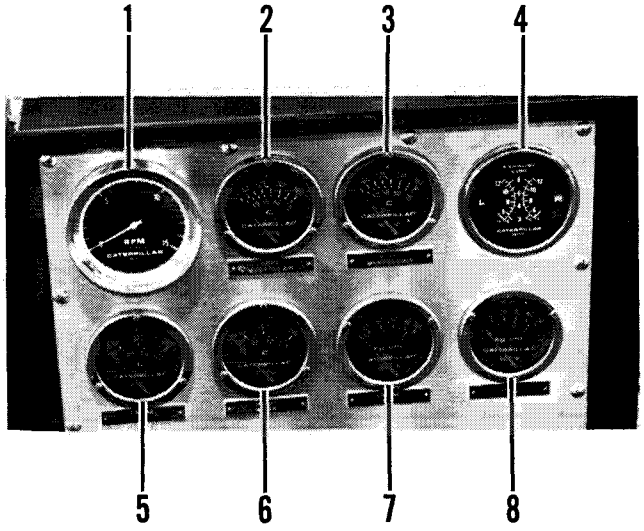
Calibrated gauges are used on some engines to monitor the engine systems. If an abnormal engine condition develops, determine and analyze and correct the cause before a failure and downtime occurs.

The operating limits given in the "OPERATING RANGES FOR ENGINES" chart are based on the engine running at continuous rated speed and load, after warm-up, using SAE 30, oil. If any of the gauges register at or outside the operating limits, investigate and correct any malfunction. See TROUBLESHOOTING GUIDE for guidance.

⚠ WARNING

Shut the engine down if work on or around the engine is required.

DO NOT OPERATE THE ENGINE WITH THE GAUGES REGISTERING AT OR OUTSIDE THE LIMITS.



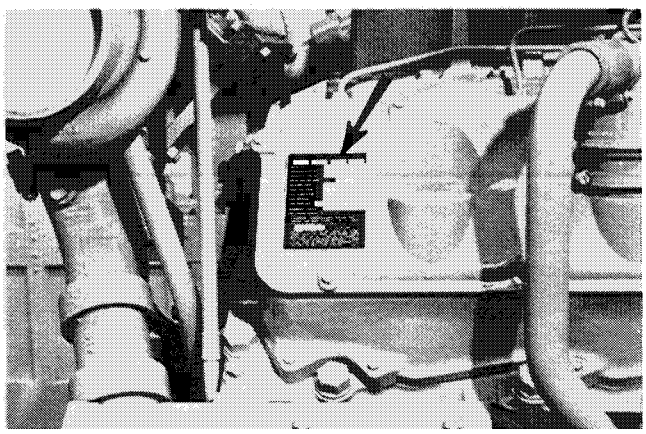
1. Tachometer.
2. Left inlet manifold temperature.
3. Right inlet manifold temperature.
4. Left and right exhaust manifold temepratures.
5. Engine oil temperature.
6. Engine jacket water temperature.
7. Engine oil pressure.
8. Fuel pressure.

OPERATING RANGES FOR ENGINES WITH CALIBRATED GAUGES
(Engine running at continuous rating and load.)

GAUGE		OPERATING RANGE	
		MINIMUM	MAXIMUM
Jacket Water Temperature (Outlet)		172°F (77°C)	210°F (99°C)
Inlet Manifold Air Temperature			
Aftercooled	(PC)		300°F (149°C)
Non-aftercooled	(DI)		300°F (149°C)
Exhaust Temperature			
Aftercooled	(PC)		800°F (427°C)
Non-aftercooled	(DI)		800°F (427°C)
Oil Temperature			
Aftercooled	(PC)	172°F (77°C)	230°F (110°C)
Non-aftercooled	(DI)	172°F (77°C)	230°F (110°C)
Oil Pressure		20 PSI (138 kPa) (1.5 kg/cm^2)	62 PSI (427 kPa) (4 kg/cm^2)
Fuel Pressure		17 PSI (117 kPa) (1 kg/cm^2)	30 PSI (207 kPa) (2 kg/cm^2)

Altitude Operation

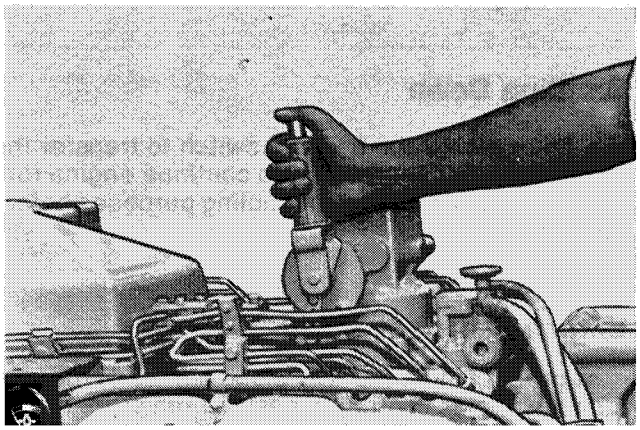
The fuel system settings and altitude limits are stamped on the engine information plate. When an engine is moved to a higher altitude, these settings must be changed by your Caterpillar dealer in order to prevent damaging the turbocharger, and to provide maximum engine efficiency.



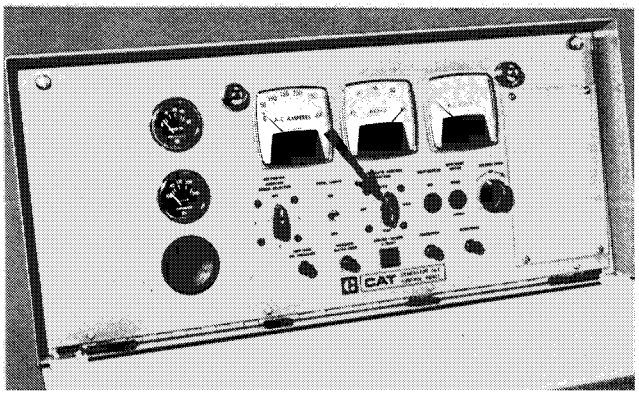
If the engine is moved to a lower altitude than that which is stamped on the engine information plate, the engine can be operated safely; however, it will deliver less than rated horsepower, and the fuel settings should be changed by your Caterpillar dealer to obtain rated horsepower.

Stopping

1. Flywheel clutch operation: Quickly pull the clutch lever to the released position. For electric set operation, see the GENERATOR SET OPERATION instructions. For Woodward Governor operation, see the topic, WOODWARD GOVERNORS, Stopping the Engine.

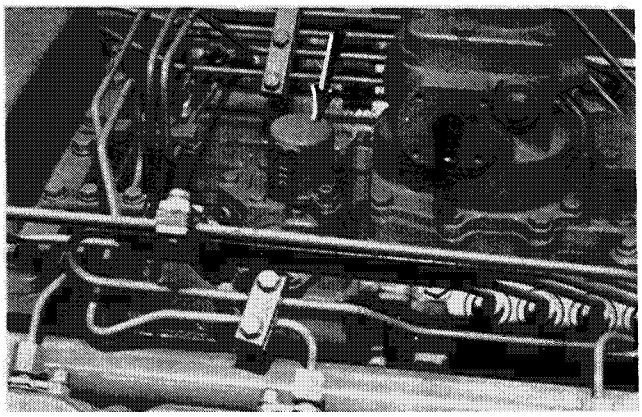


2. Reduce engine speed to half speed. Run for 5 minutes to cool engine.
3. Reduce engine speed to low idle.
4. Observe the crankcase oil level while the engine is idling. Maintain the oil level between the ADD and FULL marks on the side of the dipstick stamped, CHECK WITH ENGINE RUNNING. See the LUBRICATION AND MAINTENANCE SECTION.
5. Stop the engine.



After Stopping Checks And Procedures

1. Fill the fuel tank. See the LUBRICATION AND MAINTENANCE SECTION: Fuel Tank Maintenance.
2. Drain the raw water system if below freezing temperatures are expected; see: Draining Raw Water System.
3. If below freezing temperatures are expected, allow the engine jacket water expansion tank to cool; then check the coolant for proper antifreeze protection. Add permanent-type antifreeze, if required.
4. Repair any leaks, make major adjustments, tighten loose bolts, etc.
5. Observe the Service Meter reading. Perform the periodic maintenance as instructed in the LUBRICATION AND MAINTENANCE CHART.



SERVICE METER

ATTACHMENTS

Automatic Start-Stop

An automatic start-stop system is used when an engine must start when a specific condition occurs with no one in attendance. The engine will start, increase speed, pick-up the load, operate the load until a second condition occurs, remove the load, cool and stop. The following conditions must exist for the engine to start unattended:

Either the ambient (engine room) temperature must be at least 70°F (20°C); or, the engine jacket water temperature must be at least 90°F (32°C). One or two 3 kw jacket water heaters can maintain this temperature.

Protection Devices

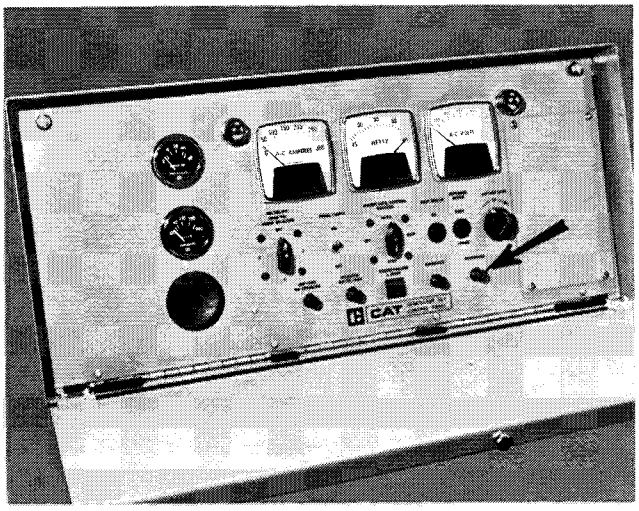
The Caterpillar generator mounted control panel is equipped with protection devices to protect the engine while cranking.

Batteries

Lights or buttons may indicate if a fault has occurred in the battery charging system causing the battery to be either undercharged or overcharged.

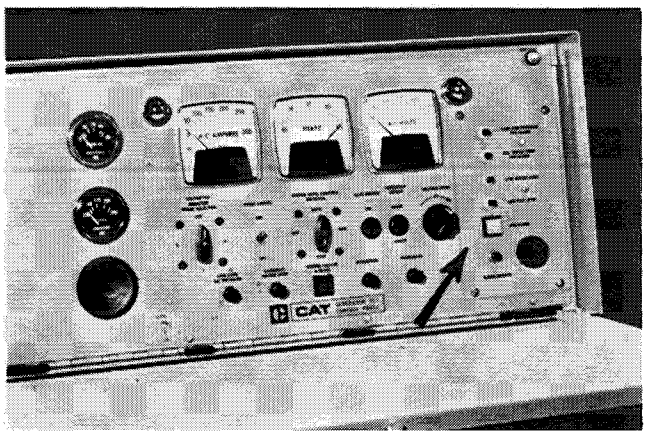
Overcranking

A timer allows the engine to crank either once for 30 seconds, or to crank through 5 ten-second cranking cycles (depending upon the device used) while unattended. If the engine does not start before the time elapsed, the fuel system will be shutoff and a light will indicate a starting failure.



Engine Operation

Prealarm systems provide an audible and/or a visual indication for low oil pressure, high water temperature, low fuel supply or low jacket water temperature before the condition becomes critical. These alarms are self resetting when the condition is corrected.



The engine may also be equipped with shutdown devices. If low oil pressure, high jacket water temperature or an engine overspeed condition occurs, the engine will be shutdown and a corresponding button or light will indicate the cause of the shutdown. These devices must be reset after repairs have been made and before starting. See the topic, EMERGENCY SHUTOFF DEVICES AND ALARMS.

Generator set control panels should be equipped with an ammeter, a frequency meter and a voltmeter. Depending upon the type of operation, the panel may also be equipped with other meters and lights. Know these instruments and their normal readings. They will indicate how the generator set is performing.

Shutting Down

A timer allows the transfer switch to transfer the load to another source and to continue engine running for up to 2 minutes for cooling purposes before stopping.

Engine Exerciser

At preset times, the exerciser will start, run and stop the engine in order to ensure both proper lubrication of all engine parts and proper equipment operation if and when the standby unit is needed.

Become familiar with all instructions included with the equipment.

Woodward Governors

Woodward Governors are usually electrically operated from a control panel.

Generator Set Control Panel

The generator set control panel is located on top of the generator and is equipped with the following controls and gauges:

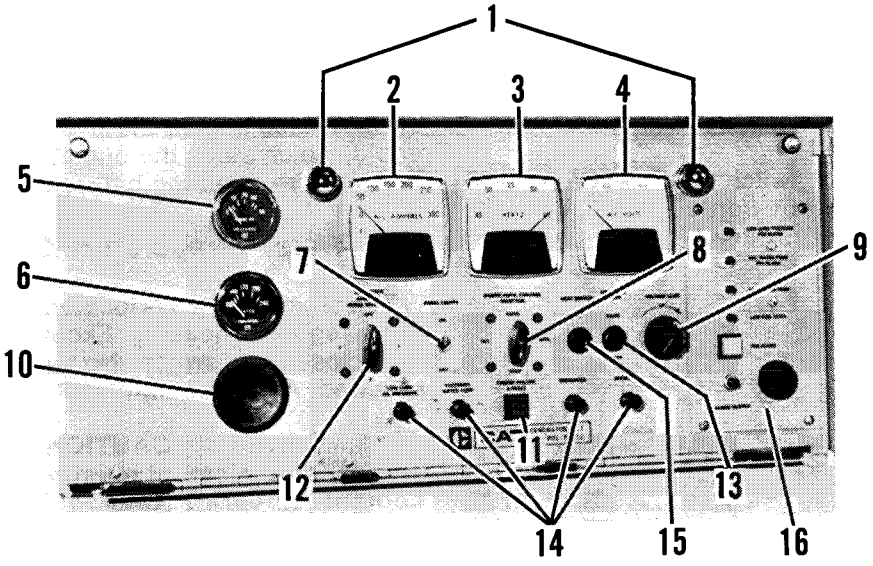
Panel lights (1) are controlled by an ON/OFF switch (7). An ammeter (2), frequency meter (3) and a voltmeter (4) show the output of the generator. Two gauges (5 and 6) show engine oil pressure and water temperature respectively. The ammeter selector switch (12) gives the operator a choice of which phase (T1, T2 or T3) of the generator output the ammeter (2) will show. Voltage level rheostat (9) takes the place of the voltage level rheostat in the generator regulator assembly.

The engine control switch (8) has four positions; MANUAL, AUTOMATIC, STOP and OFF. Placing the control in the MANUAL position will start the engine and allow the operator to manually connect the generator to the load. If the unit is used for standby application with a remote transfer switch, the AUTOMATIC position is used. In this position the engine will automatically start and take up the load when commercial power has stopped. Placing the control in the STOP or OFF position will stop the engine. When in the AUTOMATIC or MANUAL position, the engine will automatically stop if the commercial power has started or if the engne has a fault.

The PSG governor control switch allows the operator to control the engine rpm from the panel. If the engine is equipped with glow plugs, they are controlled by an ON/OFF heat switch (15).

If the engine has a fault, engine failure light/reset switch (11) will operate. The light/switch (11) will activate a shutdown relay to stop the engine. A shutdown indicator (14) will also operate to show the cause of the fault. The shutdown indicators (14) give an indication that the fault was either oil pressure, water temperature or overspeed. A fourth shutdown indicator will show an overcrank condition. A D.C. ammeter and a governor control switch will take the place of buttons (10 and 13) respectively if ordered. The shutdown indicators have four auxiliary contacts; one for each time its shutdown indicator operates. The contacts are connected to a remote annunciator panel if ordered.

The shutdown indicator lights can be checked for malfunction by depressing the shutdown indicators. Replace burned out bulbs immediately.



CONTROL PANEL

1. Panel lights. 2. Alternating current ammeter. 3. Frequency meter. 4. Alternating current voltmeter. 5. Oil pressure gauge. 6. Water temperature gauge. 7. ON/OFF toggle switch for panel lights. 8. Engine control switch. 9. Voltage level rheostat. 10. Button (direct current ammeter if ordered). 11. Engine failure light/reset switch. 12. Ammeter selector switch. 13. Button (governor control switch if engine is equipped with a PSG governor). 14. Shutdown indicator (oil pressure, water temperature, overspeed and overcrank). 15. Button; heat switch (if so equipped). 16. Panel; prealarm module (if so equipped).

Starting The Engine

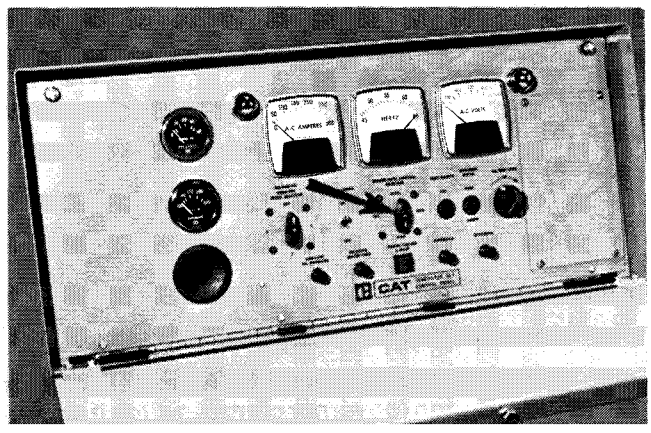
1. Perform all prestart checks outlined previously.
2. Place the CONTROL switch in the MANUAL position to crank the engine.
3. When the engine starts and engine rpm reaches 600 rpm and the oil pressure registers 22 psi (1.5 kg/cm^2) the starting motor will automatically disconnect from the start circuit.
4. Start the load.
5. Regulate the engine speed with the RAISE-LOWER switch to the required instrument panel gauge readings.

Stopping The Engine

1. Remove the load. See GENERATOR SET OPERATION instructions if equipped with an electric set generator.
2. Reduce engine speed to low idle: Push down and hold the RAISE-LOWER switch until the engine low idle speed is reached.
3. While the engine is idling, check the engine oil level. Oil level must be maintained between the ADD and FULL marks on the side of the dipstick marked "CHECK WITH ENGINE RUNNING".
4. Stop the engine.

Solenoid Shutoff

a. Move the control switch to the STOP or OFF positions. (Do not confuse this with the "RAISE-LOWER" switch.)



ON-OFF-STOP SWITCH

PSG Governor:

b. Move the shutoff lever forward, or hold the lever up, depending upon installation. Hold the lever in this position until the engine stops.

5. Fill the fuel tank. See the LUBRICATION AND MAINTENANCE section.
6. Drain the raw water system if below freezing temperatures are expected.
7. Observe the Service Meter reading. Perform the periodic maintenance as instructed in the LUBRICATION AND MAINTENANCE CHART.

Emergency Shutoff Devices And Alarms

Emergency shutoff devices are either electrically, mechanically or hydraulically operated. Familiarize yourself with the types and locations of the shutoff devices, the conditions which cause each control to function, and the resetting procedure required to start your engine.

CAUTION

Always determine the cause of the shutdown, and have the necessary repairs made before restarting the engine. See TROUBLESHOOTING GUIDE.

Do not use an emergency shutoff device for a normal stopping procedure.

The operation of all electric shutoff controls is similar: A critical operating condition actuates a switch which closes the circuit to the shutoff solenoid, which stops the engine. The shutoff control may require resetting before the engine can start.

High Water Temperature Shutoff

The shutoff switch is located in the water temperature regulator housing. Excessive water temperature closes the switch. No resetting procedure is required: As the coolant cools, the switch opens.

CAUTION

The sensing element must be submerged in the coolant to operate. Coolant level must be maintained in order for the shutoff to operate.

Low Oil Pressure Shutoff Switch

CAUTION

Does not protect system from rapid oil loss, such as line breakage.

This device is usually mounted on the side of the engine, and oil lines are connected to the switch. Low oil pressure closes the switch.

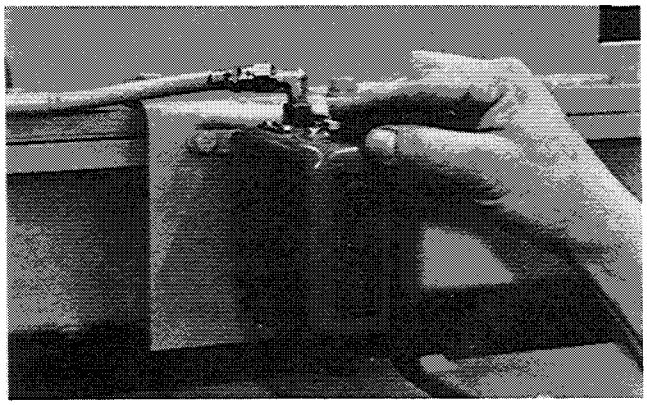
Manually operated systems require resetting of this switch before starting. Automatic start-stop systems use a pressure switch which resets itself.

To reset the switch, push the button until it latches. After the engine starts and develops oil pressure, the button will move to the extended running position.

CAUTION

The button must be in the RUN position to protect the engine.

If the button remains in the reset position, the engine oil pump may not be developing normal oil pressure and checks should be made.

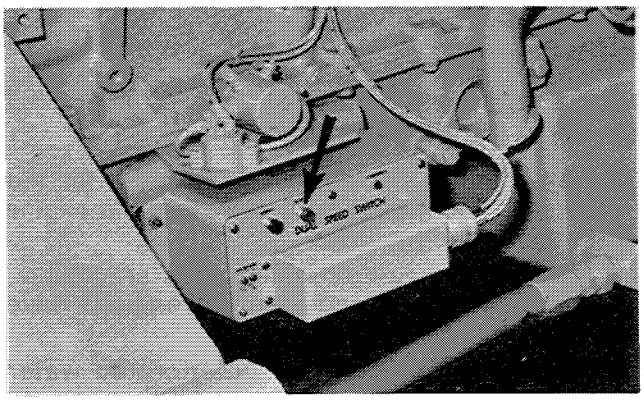


Overspeed Shutoff Switch (Electronic)

This switch senses engine speed. The control box is mounted on the engine block. Excessive engine speed closes a circuit breaker. To reset the switch, push the reset button.

CAUTION

To provide overspeed protection there must be electrical power to the control box.



Fuel/Oil Pressure Switch

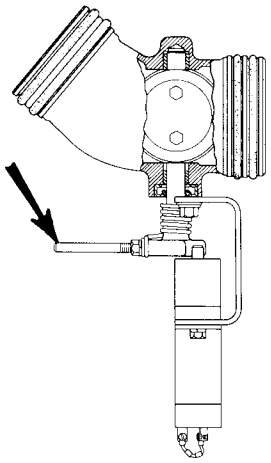
This switch is mounted in the fuel manifold between the outlet side of the fuel filter and the fuel injection pump. Low fuel pressure opens the switch and the electrical circuit to either the shutoff solenoid or the circuit between the alternator and the alternator regulator. While the engine is stopped, open these circuits to prevent the battery from becoming discharged.

This switch can also be used with an electric governor. In this application, oil pressure closes the switch to allow the electric governor to control engine speed.

This switch does not require resetting.

Air Safety Shutoff Control

The air shutoff control is an attachment to the safety shutoff devices. When an emergency conditions occurs, the solenoid pushes the rack into the shutoff position and a solenoid trips a butterfly valve, located in the inlet manifold, to the closed position. The air safety shutoff control must be reset before starting.



Alarm Switches

Alarm switches are set at a less critical temperature, pressure, or level limit than the comparable shutoff control. The purpose of the alarm switch is to warn the operator an unsafe operating condition is starting to occur, and that corrective measures should be taken to avoid possible damage to the engine and/or a possible shutdown of the engine.

CAUTION

Even though it could be hazardous to have the engine stop unexpectantly, if the engine overspeeds, it should be stopped immediately.

When the preset temperature, pressure or fluid level occurs, either a light or an audible alarm will be energized. The light or alarm will continue to operate until the condition is corrected. When the condition is corrected the alarm will automatically reset and the light will turn off.

CAUTION

The cause of the shutdown must be investigated and corrected before starting and operating the engine.

Testing Indicator Lights

Most control panels are equipped with a test switch. By turning the switch ON, all of the indicator lights can be checked for proper operation. Test the indicator lights periodically, replace burned out light bulbs immediately.

Alarm Shutoff Switch

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

CAUTION

Place switch in the closed (ON) position when the engine is started, so the engine will be protected.

Output Shaft Governor Operation

When the load can overspeed the torque converter output shaft, an output shaft governor should be installed. The output shaft governor is a speed limiting device which automatically adjusts engine governor setting according to load requirement.

Determining Cause Of Shutdown

CAUTION

If the engine has been shutdown by a safety device, do not start the engine and place it into service without having the cause of the shutdown investigated and corrected.

Low Oil Pressure Checks

If the low oil pressure shutoff control has stopped the engine, make the following checks:

1. Check the water temperature gauge. Determine if the engine was overheated. Check for external water leaks.

⚠ WARNING

Beware of steam or scalding water. Do not attempt to loosen the radiator cap until the temperature gauge indicates the coolant has sufficiently cooled. Then, loosen the cap slowly.

2. Check the oil level. Oil level must be between the ADD and FULL marks on the side of the dipstick stamped CHECK WITH ENGINE STOPPED.
3. If the oil level is below the ADD mark, check for oil spray and/or oil accumulations. If any are found, have the necessary repairs made. Before starting, add oil to the FULL mark.
4. Reset the shutoff control.
5. Remove the load and start the engine at its slowest speed. Be prepared to shut the engine down manually.
6. Be alert for unusual sounds or noises. If the engine knocks, stop the engine immediately and call your Caterpillar dealer.
7. If the engine blows excessive black exhaust or has excessive crankcase blow-by, the engine may need reconditioning. Stop the engine and call your Caterpillar dealer.
8. If the engine runs satisfactorily, observe the oil pressure gauge. If satisfactory pressure is not indicated, shut the engine down; call your Caterpillar dealer.
9. If proper oil pressure is registered, check to see if the reset knob has moved to the run position. If the knob does not move, stop the engine. Check the shutoff control, the oil line, and the oil pressure gauge. Have necessary repairs made.
10. If the oil pressure gauge registers normal oil pressure, if the knob on the shutoff control moves to the run position, and if the engine operation is otherwise satisfactory, determine if the high water temperature shutoff may have shut down the engine.

High Water Temperature Checks—Engine Running

1. Determine if the load was too great for the engine: Reduce the load and allow the engine to cool while running.
2. If pressure steam or water leaks are visible, remove the load and stop the engine. Have necessary repairs made.
3. Check for collapsing or deteriorated water hoses. Have repairs made.

4. Check for noisy water pump operation. Have necessary repairs made.
5. Refill the cooling system with a solution of water and permanent-type antifreeze if below freezing temperatures are expected; or with a solution of approved water and Caterpillar Corrosion Inhibitor or equivalent. Follow the instructions on the container.

⚠ WARNING

DO NOT remove the pressure cap on an overheated engine. The coolant is under pressure and relieving the pressure will cause the coolant to flash into steam. Serious flash burns and engine damage can result. If necessary, reduce pressure in a surge tank by pouring warm water on top of the tank. Never add cold water to a hot engine.

NOTE

If there is adequate coolant in the cooling system, gradual cooling is preferred by running the engine a half speed. This eliminates hot spots in the engine, and possible failure.

High Water Temperature Checks—Engine Stopped and Cold

1. Check coolant level. Determine if the coolant has proper antifreeze protection. A 50-50 solution of permanent-type antifreeze and approved water will give protection below −20°F (−29°C).
2. Check to be sure the raw water valve has been opened.
3. Check engine room vents and/or louvers. Be sure the engine is receiving sufficient air.
4. Be sure temperature regulators are operating at proper temperature range.
5. Inspect all water hoses carefully for collapsing, external and internal failures. Replace hoses as required.
6. Have the cooling system cleaned.

CAUTION

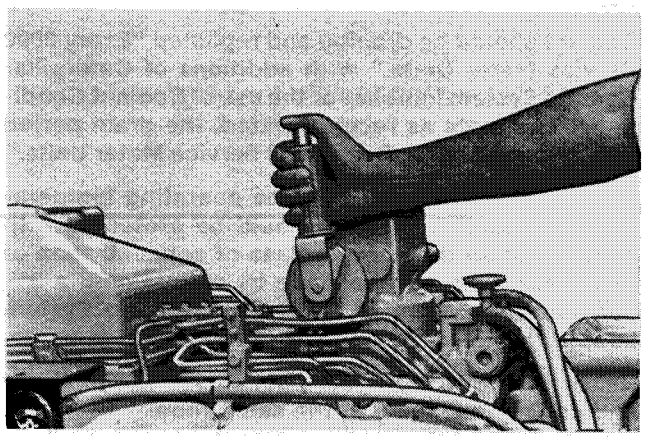
If severe or prolonged overheating has occurred, contact your Caterpillar dealer to have your engine checked for possible damage.

Emergency Stopping

To stop in an emergency:

Mechanical Governor Control

Pull upward on the hand grip, and move the control to the shutoff position.

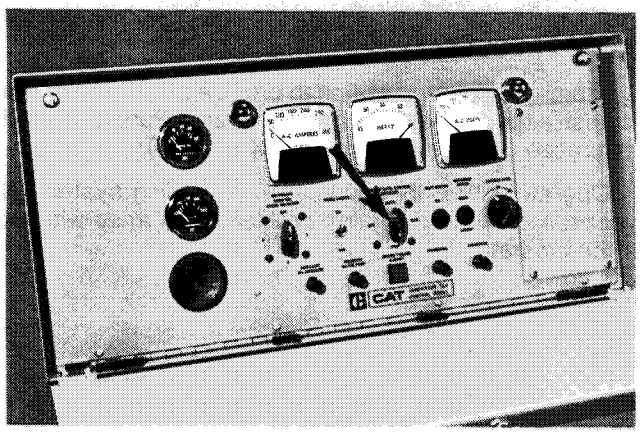


Woodward PSG Governor

Move the lever forward against the stop; hold the lever until the engine is stopped.

Electric Shutoff Solenoid

Push and hold the ON-OFF-STOP switch in the STOP position until the engine stops.



Air Controls

Push and hold the ON-OFF-STOP switch in the STOP position until the engine stops.

MAINTENANCE RECOMMENDATIONS

Cooling

CAUTION

Never add coolant to an overheated engine; allow the engine to cool first.

Check specific gravity of antifreeze solution frequently in cold weather to assure adequate protection.

Coolant should be drained and replaced "Every 2000 Service Meter Units." With additions of Caterpillar Cooling System Inhibitor or the use of Coolant Conditioner Elements as recommended, the drain period can be extended to "Every 4000 Service Meter Units."

All water is corrosive at engine operating temperature. The cooling system should be protected with inhibitor at all times regardless of concentration of antifreeze. This can be done by maintaining a 3% concentration of liquid Caterpillar Cooling System Inhibitor or by using Coolant Conditioner Elements.

Never use both the liquid cooling system inhibitor and coolant elements at the same time.

Do not use Caterpillar Cooling System Inhibitor or Coolant Conditioner Elements with Dowtherm 209 Full-Fill Coolant.

Whenever draining and refilling cooling system, always recheck the coolant level when the engine reaches normal operating temperature.

Filling at over 5 U.S. gallons (19 liters) per minute can cause air pockets in the cooling system.

Premix antifreeze solution to provide protection to the lowest expected ambient temperature. Pure undiluted antifreeze will freeze at −10°F (−23°C).

Operate with a thermostat in the cooling system all year-round. Cooling system problems can arise without a thermostat.

Electrical

CAUTION

When using jumper cables to start the engine, be sure to connect in parallel: POSITIVE (+) to POSITIVE (+) and NEGATIVE (−) to NEGATIVE (−).

Scheduled Oil Sampling

Use Scheduled Oil Sampling to monitor the engine's condition and maintenance requirements.

Each oil sample should be taken when the oil is hot, and well mixed, to insure a sample which is representative of the oil in the compartment.

Consult your Caterpillar dealer for complete information, and assistance in establishing a Scheudled Oil Sampling program for your equipment.

Fuel

CAUTION

Fill fuel tank at the end of each day of operation to drive out moisture laden air and to prevent condensation. Do not fill the tank to the brim. The fuel expands when it gets warm and may overflow.

Water and sediment should be drained from the fuel tank at the start of each shift or after the fuel tank has been filled and allowed to stand for 5 to 10 minutes.

Drain fuel tank of moisture and sediment as required by prevailing conditions.

After changing fuel filters, always bleed fuel system to remove air bubbles from system.

Air Intake

Service air cleaners when RED band in indicator locks in visible position.

SPECIFICATIONS

LUBRICATION SPECIFICATIONS

Crankcase Lubricating Oils

Use oils which meet Engine Service Classification CD (MIL-L-2104D) or CD/TO-2. These are additive-type oils that have been approved for use in Caterpillar Diesel Engines.

Consult the "EMA Lubricating Oils Data Book," Form SEBU5939, for a listing of CD oil brands.

The proper SAE grade of oil to select is determined by the ambient temperature at which the engine is started and the maximum ambient temperature in which the engine will be operating. 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. If the oil will flow off, the oil is fluid enough to circulate properly.

Lubricating Grease

Use Multipurpose-type Grease (MPGM) which contains 3-5% molybdenum disulfide conforming to MIL-M-7866, and a suitable corrosion inhibitor. NLGI No. 2 Grade is suitable for most temperatures. Use NLGI No. 0 or No. 1 Grade for extremely low temperatures.

Recommended Lubricant Viscosities

For Temperature Ranges °F and°C*					
Compartment or System	Oil Viscosities	Degrees F		Degrees C	
		Minimum	Maximum	Minimum	Maximum
Engine Crankcase CD or CD/TO-2	SAE 5W-20 (SPC)	-22	+50	-30	+10
	SAE 5W-20	-13	+50	-25	+10
	SAE 10W	-4	+50	-20	+10
	SAE 10W-30	-4	+104	-20	+40
	SAE 15W-40	+5	+122	-15	+50
	SAE 30	+32	+104	0	+40
	SAE 40	+41	+122	+5	+50

*When operating below -30°C (-22°F) refer to the Cold Weather Recommendation Operation and Maintenance Guide, Form SEBU5898, available from your Caterpillar dealer.

Air Starting Motor Oiler: Use SAE 10W in all temperatures.

Flywheel Clutch Bearing Reservoir: Use SAE 30 in all temperatures.

REFILL CAPACITIES			
MODEL	U.S. GAL.	LITRE	IMP. GAL.
3408	12	45.5	10
3412	16	60.5	13

FUEL SPECIFICATIONS

No. 2 fuel oil and No. 2D diesel fuel are recommended for use in Caterpillar Diesel Engines. In extreme cold temperatures use No. 1 fuel oil or No. 1D diesel fuel.

In selecting a fuel, note that distillate fuels are especially desirable because the fuel is heated to a vaporous state and condensed, thus eliminating all sediment and residue.

There is considerable variation in the composition of fuels distributed under the No. 2 grade classifications. For desirable engine service it is most important to give special attention to cetane no., water and sediment, pour point, cloud point and sulphur content. USE THE LOWEST PRICE DISTILLATE FUEL WHICH MEETS THE FOLLOWING REQUIREMENTS.

Water and Sediment ..... 0.1% sediment
Cetane No. (PC Engine) ..... 35 minimum
(DI Engine) ..... 40 minimum
Pour Point ..... 10°F (6°C) below ambient temperature
Cloud Point ..... No higher than abmient temperature
Sulphur Content* ..... Adjust oil change period
Gravity ..... 32-40 A.P.I. at 60°F (15.6°C)
*See the topic SULPHUR CONTENT.

Cetane No: This is an indication of a fuel's ignition quality and should not be less than 35 for the PC engine and 40 for the DI engine. For high altitude operation or cold weather starting, a higher cetane number is required.

Water and Sediment: A good clean fuel will contain no more than 0.1% sediment and water. Dirty fuels lead to early filter plugging and in addition can result in the formation of gums and resins reducing filter and engine life.

Pour Point: The pour point of the fuel has no effect on engine performance, as long as the fuel is fluid enough to flow from the fuel tank to the engine. The pour point of the fuel should be at least 10°F (6°C) below the lowest atmospheric temperature at which the engine must start and operate. In extremely cold temperatures it may be necessary to use No. 1 fuel oil or No. 1D diesel fuel.

Cloud Point: Cloud point is the temperature at which wax crystals become visible and is generally above the pour point of the fuel. The cloud point should be no higher than the lowest atmospheric temperature at which the engine must start to keep the fuel filter elements from plugging with wax crystals.

Sulfur Content: The percentage of sulfur in the fuel will affect the engine oil recommendations. If the fuel has over 0.5% sulfur content, the CD engine oil must have a TBN of 20 times the percentage of fuel sulfur (TBN as measured by the ASTM D-2896 method). Your oil supplier should be able to furnish the correct oils.

Gravity: Gravity is the measurement of heat units in a certain amount of fuel. The heavier the fuel (the lower the number) the more heat units per volume. If a fuel with a higher A.P.I. gravity is used the power produced will be lower. Select fuels with the lower A.P.I. gravity reading.

Some fuel specifications that meet the above requirements are:

ASTM—D396 - No. 1 & No. 2 fuels (burner fuels)
ASTM—D975 - No. 1D & No. 2D diesel fuel oils
BS2869—Class A1 to Class A2 engine fuels
BS2869—Class C & Class D burner fuels
DIN51601—Diesel fuel
DIN51603—EL heating oil

Authorized dealers are familiar with fuels that have given good results in Caterpillar Diesel Engines and should be consulted regarding fuel use when abnormal conditions occur.

COOLANT SPECIFICATIONS

Water used in the jacket water cooling system should be clean, and as free as possible from scale forming minerals or corrosive chemicals. Artificially softened water should not be used. Treating the water with Caterpillar Coolant Inhibitor, or equivalent will help prevent the formation of rust and pitting. It will also retard, and in some cases completely eliminate, mineral deposits in the engine.

The most efficient and satisfactory corrosion protection for the cooling system is to maintain proper level of coolant inhibitor and antifreeze solution. The use of auxiliary water filters is not recommended.

During freezing weather use the proper permanent type antifreeze and water solution to prevent freezing.

Before placing the engine in operation, make sure a 3% concentration of Caterpillar Corrosion Inhibitor or equivalent has been added to the cooling system. This 3% concentration must be maintained in cooling systems which are filled with water and systems protected with ethylene glycol antifreeze mixture, regardless of antifreeze concentration.

⚠ WARNING
Inhibitors contain alkali. Avoid contact with eyes. To prevent personal injury, avoid prolonged or repeated contact with skin.

LUBRICATION AND MAINTENANCE INSTRUCTIONS

Regular service intervals, along with close daily visual inspection and the adherence to the instructions and schedules, will assure many hours of trouble-free service. If correction steps are taken immediately on discovery of any abnormal condition, fewer forced stops and more economical operation will result.

The Lubrication and Maintenance Chart is intended as a guide and adjustments in the schedule may be necessary, depending on conditions under which the engine is operating. A thorough analysis should be made before adjusting the maintenance schedule.

Some items to consider in establishing a new schedule are: Severe dust or dirty conditions, fuel consumption (a good measurement to establish intervals as it indicates the amount of work performed). As a guideline, the 3408 Engine with a 12 gal. (45 litre) (10 imp. gal.) capacity crankcase will use approximately 4000 gal. (15,000 litre) (3332 imp. gal.) between oil changes.* The 3412 Engine with a 16 gal. (60.5 litre) (13 imp. gal.) capacity crankcase will use approximately 5100 gal. (19,200 litre) (4248 imp. gal.) between oil changes.*

Reducing or extending the maintenance intervals should be done only after complete study and enough time to gain adequate experience to meet specific operations.

*With 0.5% or less fuel sulphur content.

Caterpillar scheduled oil sampling: Scheduled oil sampling is a program which analyzes oil samples taken from an engine at regular intervals (usually at oil change periods). This oil analysis does not indicate the condition of the oil; but rather, it is a scheduled procedure to determine engine condition at regular intervals by analyzing lubricating oil for foreign and wear particles.

The scheduled oil sampling will give the following benefits:

It assures the owner that maintenance has been performed.

It will show the first signs of excessive wear, meaning a possible upcoming failure, allowing time for a scheduled repair.

It will warn maintenance personnel of improper or lack of maintenance and presence of fuel dilution or antifreeze in oil.

It is particularly helpful in preventing wear due to dirt entry from air cleaner or inlet piping.

Regular sampling is especially advantageous for new engines to establish wear trends from the beginning. The results of the oil analysis are interpreted by experienced, highly trained personnel. Contact your Caterpillar dealer for detailed information.

LUBRICATION AND MAINTENANCE CHART

The LUBRICATION AND MAINTENANCE CHART lists all serviceable items commonly ordered on this engine.

The maintenance time intervals are expressed in Service Meter Units. The Service Meter on the engine shows the total number of units the engine has run. Use the Service Meter readings for determining your maintenance schedules. Perform the maintenance at multiple intervals of the units shown. For example, when the Service Meter shows "100" on the dial, all items listed under "EVERY 10 SERVICE METER UNITS" should be serviced now for the tenth time, and all items under "EVERY 50 SERVICE METER UNITS" should be serviced for the second time.

Diesel fuels, lubricants and coolant make-up water to use are explained in the "Specifications".

SERVICE ITEM	Page No.	SERVICE METER UNITS									As Req.
		10	50	125	250	500	1000	2000	4000	Year	
LUBRICATION											
Check Engine Crankcase Oil Level	28	•									
Lubricate Front Clutch Engaging Collar (2 Strokes)	31	•									
Lubricate Rear Clutch Engaging Collar (2 Strokes)	31	•									
Check Shaft Bearing Reservoir (Rear Heavy Duty Clutch)	31	•									
Lubricate Clutch Control Lever Shaft Bearings (2 Strokes)	31			•							
Lubricate Front and Rear Clutch Pilot and Shaft Bearings (2 Strokes)	31			•							
Change Crankcase Oil and Filter	28				Note A						
Lubricate Fan Drive Bearings (2 Strokes)	30				•						
Crankcase Breather, Clean	28					•					
Change Clutch Shaft Reservoir Oil (Heavy Duty Clutch)	31					•					
Lubricate Woodward PSG Governor	30						•				
Air Start Oiler Jar, Fill	30										•
Empty Air Start Oil Collector Jar	30										•
COOLING SYSTEM											
Check Engine Coolant Level	34	•									
Inspect Zinc Rods in Raw Water System (Salt Water Only)	38		•								
Clean Radiator Core (External)	35				•						
Inspect Coolant Line Connections and Hoses	37				•						
Check Fan/Alternator Belt Tension and Wear	38				•						
Change Element and/or add Cooling System Inhibitor	32				•			•			
Inspect Coolant Pump	38							•			
Inspect Temperature Regulator	37									•	
Clean Cooling System (Internal)	35							•			

SERVICE ITEM	Page No.	SERVICE METER UNITS									As Req.
		10	50	125	250	500	1000	2000	4000	Year	
FUEL SYSTEM											
Fill the Fuel Tank After Stopping	39	•									
Drain Sediment and Water From Fuel Tank	39	•									
Check Fuel Pressure Gauge Reading	39	•									
Wash Primary Filter	40				•						
Replace Final Fuel Filter	40	Note B									
Check/Replace Fuel Injection Nozzles If Necessary	41							•			
AIR INDUCTION AND EXHUAST											
Check Air Cleaner Service Indicator	43	•									
Check/Clean Dust Collector Cap	45	•									
Clean/Replace Air Cleaner Element	44						Note C				
Inspect Manifold and Air Piping for Leaks	48				•						
Adjust Valve Lash (Engine Stopped)	45				Note E						
Check Valve Rotation (Engine Idling)	48							•			
Inspect/Rebuild Turbocharger	49								•		
ELECTRICAL SYSTEM											
Check Battery Electrolyte	50				•						
Clean Electrical Connections and Battery	50				•						
Inspect Alternator Drive Belt	54				•						
Check Shutoff Controls	Note D					•					
Inspect/Rebuild Alternator	53							•			
Inspect Rebuild Starter	52								•		
Check Cold Weather Starting Aids	54									•	
POWER COUPLINGS											
Check and Adjust Clutch	55										•

NOTES

NOTE A: The percentage of sulfur in the fuel will affect the engine oil recommendations. If the fuel has over 0.5% sulfur content, the CD engine oil must have a TBN of 20 times the percentage of fuel sulfur (TBN as measured by the ASTM D-2896 method). If the sulfur content is greater than 1.5% by weight, use an oil with a TBN of 30 and reduce the oil change interval by one half. Consult your Caterpillar dealer for correct engine oil recommendations.

NOTE B: Check fuel pressure gauge daily. Replace when FUEL PRESSURE gauge registers OUT or 20 PSI (124 kPa).

NOTE C: The element can be cleaned approximately 3 times. Carefully inspect the element after each cleaning. If engine is not equipped with air cleaner service indicator, check element every 250 Service Meter Units, or more often under dusty conditions. If after servicing the air cleaner, the exhaust smoke and/or loss of power continues, install a new element.

NOTE D: Authorized Caterpillar dealers are equipped with the necessary tools, personnel and procedures to perform these services.

NOTE E: Initial valve lash adjustment on new, rebuilt or remanufactured engines is recommended at the first scheduled oil change interval, due to initial wear and seating of valve train components. Subsequent adjustments should be made at every 2000 Service Meter Units or One year, Whichever Occurs First.

LUBRICATION INSTRUCTIONS

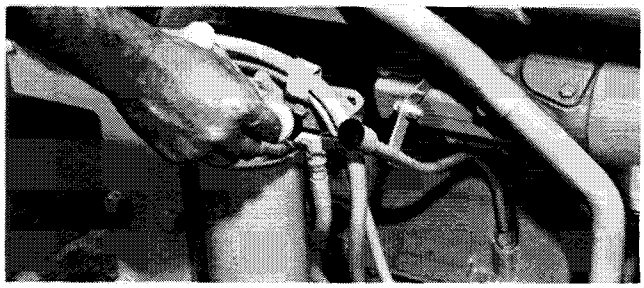
Crankcase Lubrication Oil

The Lubrication and Maintenance Charts list the normal oil change periods as determined by fuel sulphur content. (Make an initial oil and filter change after the first 10 service meter units of operation for reconditioned engines).

See the OIL SPECIFICATIONS to aid in the proper oil SAE viscosity selection. The proper SAE viscosity of oil to select is determined by the ambient temperature at which the engine is started and operated.

Checking Oil Level

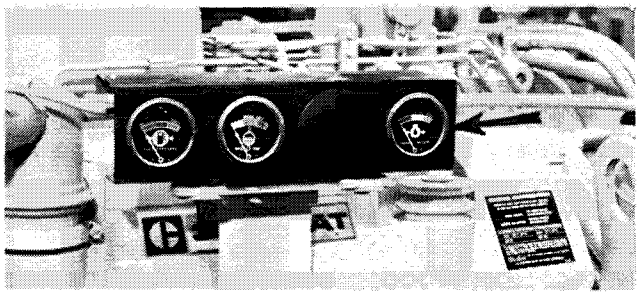
The dipstick is stamped on both sides of the blade. One side is marked and to be read when checking the oil level with the ENGINE STOPPED. The other side is marked and to be read with the ENGINE IDLING—HOT OIL. Each side is stamped to remind you not to OVERFILL the crankcase with oil.



CAUTION
Be sure to read the correct side of the dipstick. The ADD and FULL levels are not the same when checking the oil while stopped or while idling.

Checking Oil Pressure

Immediately after starting, and frequently during operation, observe the oil pressure gauge reading. The indicator should register in the NORMAL range.



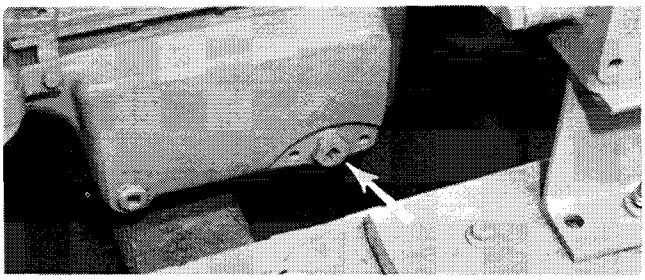
If the indicator fluctuates or registers below NORMAL range:

1. Move the governor control to low idle position.
2. Check the oil level. Be sure to read the ENGINE IDLING side of the dipstick.
3. Add oil until the oil level is at the FULL mark on the ENGINE IDLING side of the dipstick. Do not overfill.
4. Check for oil leaks.
5. If necessary, stop the engine and have repairs made.

Draining Engine Oil

With engine stopped and oil warm:

1. Remove the crankcase oil drain plug.
2. Allow the oil to drain.



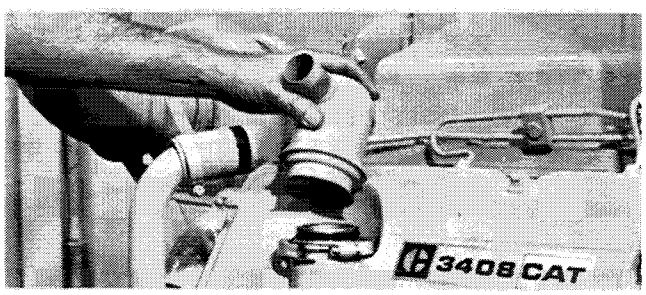
3. Clean and install the drain plug.

OR, if a sump pump is used:

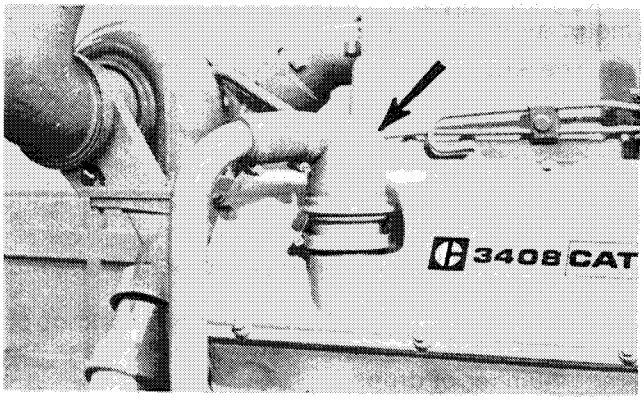
1. Connect a suitable drain line and container to the pump outlet.
2. With engine stopped and oil warm, open the sump pump valve to the engine crankcase drain line: The two marks on the valve must be turned so that one mark points to the pump, and the second mark points to the engine drain line.
3. Operate the sump pump handle until the crankcase is empty.
4. Close the valve to the engine crankcase drain line.

Cleaning the Breather

1. Release the hose clamp and disconnect the fumes disposal tube.
2. Remove the breather assembly.

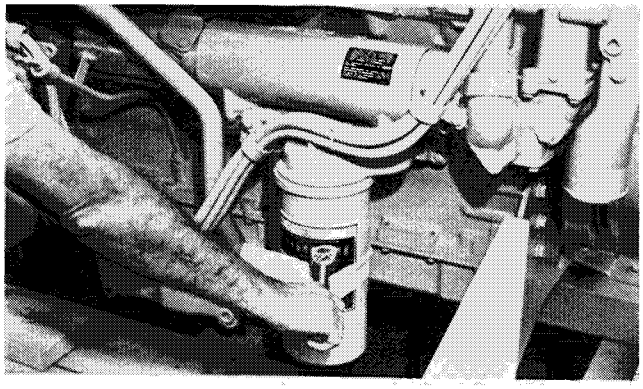


3. Wash the breather in solvent.
4. Allow to drain dry and then wipe.
5. Inspect the gasket. Install a new gasket if necessary.
6. Install the breather.
7. Connect the fumes disposal tube.

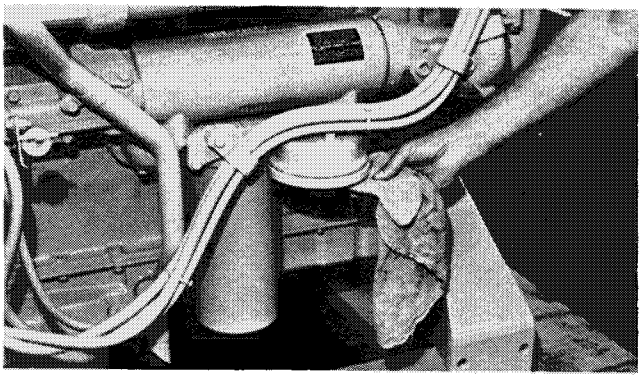


Changing Oil Filter

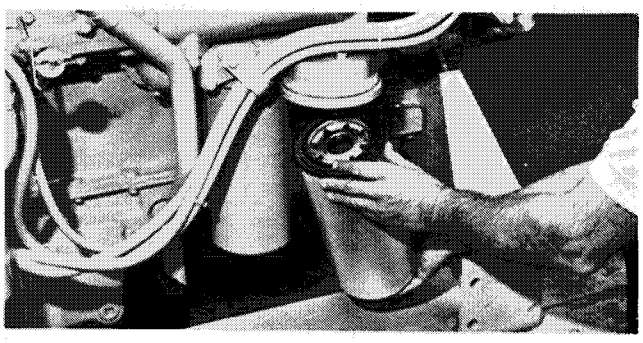
1. Unscrew and remove the filter.



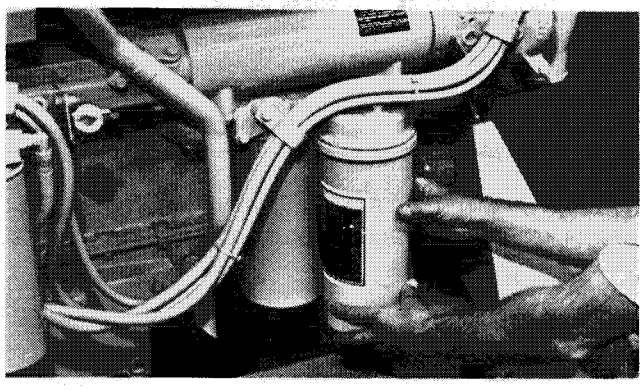
2. Be sure the old filter gasket did not remain attached inside the filter base: Leaking will occur between the new filter gasket and this old gasket.
3. Wipe the filter base.



4. Apply a thin coat of clean oil to the gasket of the new filter.

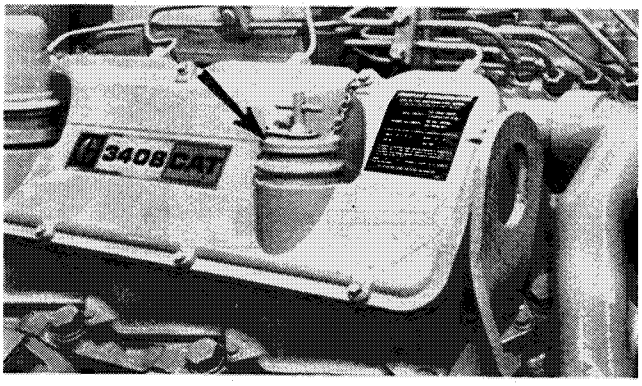


5. Install the new filter: Hand tighten the filter ¾ turn after the filter gasket contacts the base. Use rotation index numbers, which are painted on the filter can, as a guide for proper tightening.



Filling the Crankcase

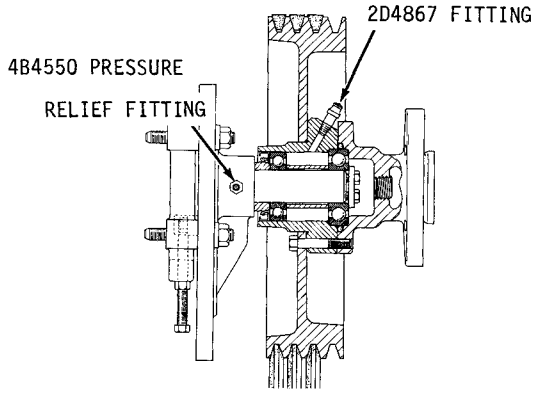
1. Fill the crankcase to the safe starting range on the ENGINE STOPPED side of the dipstick. See the Lubrication Specifications for refill capacity and proper oil viscosity.



2. Start the engine and check for oil leaks.
3. After the engine is warm, check the oil level with the engine idling.
4. Add oil if necessary to maintain the oil level at the FULL mark on the ENGINE IDLING side of the dipstick.

Fan Drive Bearings

Lubricate the fan drive bearings with lubricating grease through one fitting, 1 or 2 strokes.



LOCATION OF 4B4550 PRESSURE RELIEF FITTING AND 2D4867 FITTING SHOWN IN THE STANDARD LOCATION.

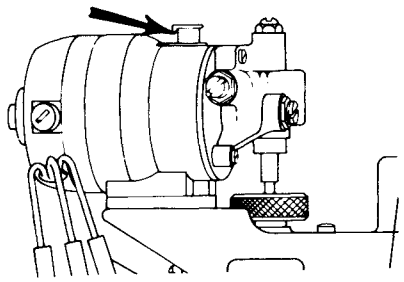
If the grease fitting is not readily accessible, it may be necessary to

1. Remove the 4B4550 Fitting (relief) from the fan mounting bracket assembly and install the 2D4867 Fitting in its place.

2. Install the 4B4550 Fitting (relief) in place of the 2D4867 Fitting.

Woodward PSG Governor Synchronizing Motor

Fill the oil cup on the synchronizing motor with clean engine oil with same viscosity as used in the engine.



Air Starting Motor

The motor oiler lubricates the vanes of the starting motor with a fine oil mist as the motor is operating.

When the oil jar becomes half empty, remove the oil filler plug and fill the jar with clean engine oil with the same viscosity as used in the engine.

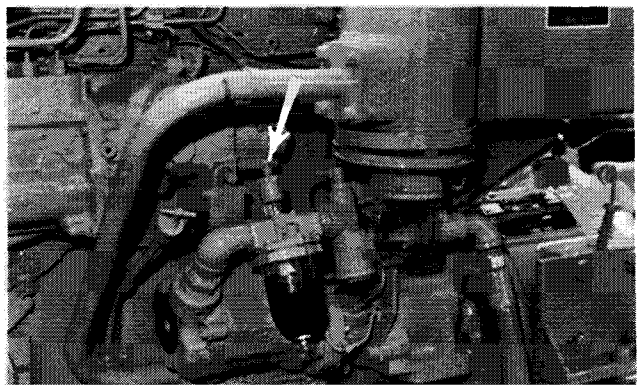
CAUTION

Never allow the jar to become empty. The starting motor will be damaged by lack of proper lubrication.

Adjusting Oiler Feed

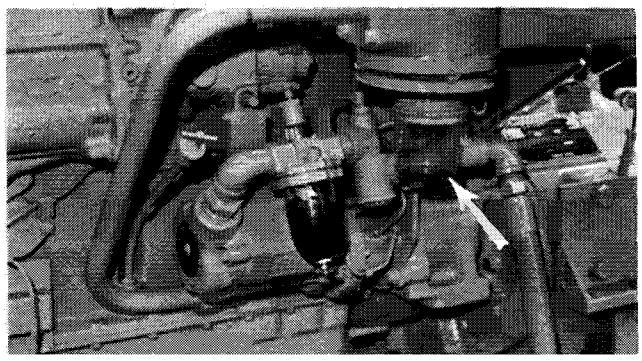
If necessary, adjust the oiler to release approximately four drops of oil per minute into the starting motor air stream.

1. The engine must be operated long enough to have the oil warm. Then stop the engine.
2. Move the governor control lever to the SHUT-OFF position.
3. Push in on the air start control and crank the engine.
4. Count the drops of oil released per minute into the air stream.
   a. Turn the needle valve (the uppermost knob on the oiler) counterclockwise to increase the number of drops.
   b. Turn the needle valve clockwise to decrease the number of drops.



Emptying Oil Collector Jar

Empty the oil collector jar whenever the jar becomes half full. The collector jar collects both the oil after it has lubricated the starting motor vanes, and the moisture condensation from the compressed air. Do not fill the oiler jar with this used oil.

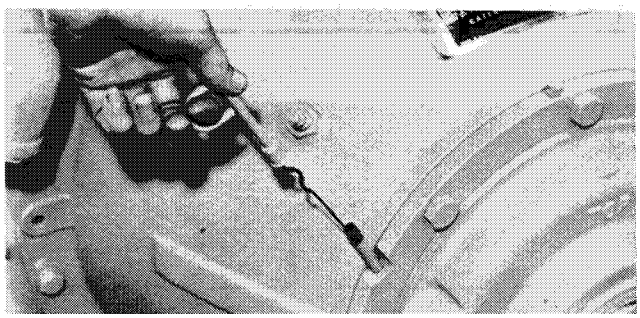


Power Coupling Attachment

Heavy Duty Clutch Main Shaft Bearings

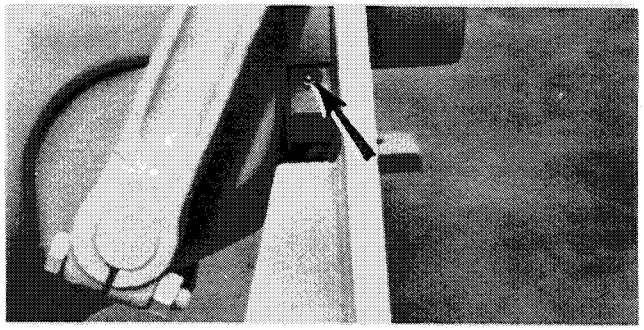
The heavy duty flywheel clutch main shaft bearing is oil lubricated. The remaining bearings are lubricated with grease.

Check the main shaft bearing oil reservoir level with engine stopped. Maintain the oil level at the FULL mark on the oil level gauge. Add oil through the filler tube on top of the bearing cage housing. Use the same type of oil as used in the engine crankcase. See the OIL SPECIFICATIONS.



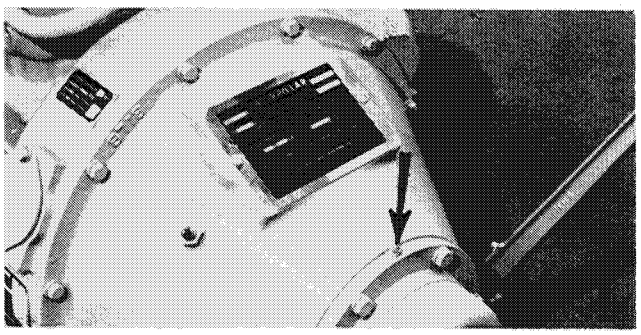
To drain the reservoir:

Remove the drain plug located on the lower left side of the shaft bearing reservoir. Drain and install the drain plug. Fill to the FULL mark on the oil level gauge. Install the filler cap.



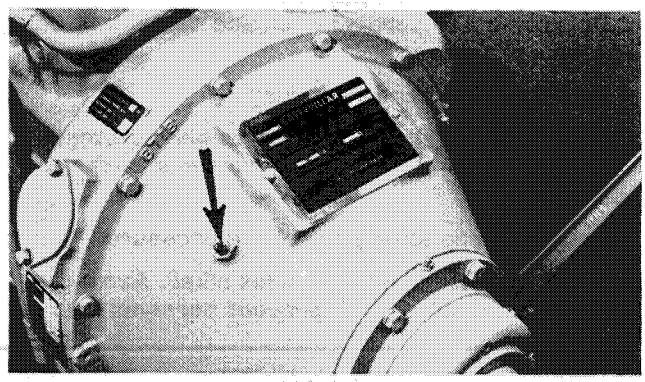
Enclosed Clutch Shaft Bearings (Grease Lubricated)

Lubricate the shaft bearings through 1 fitting.



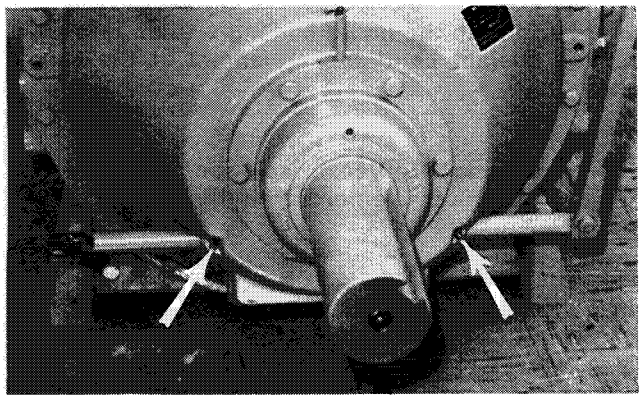
Front/Rear Clutch Engaging Collar

Lubricate through 1 fitting—2 strokes.



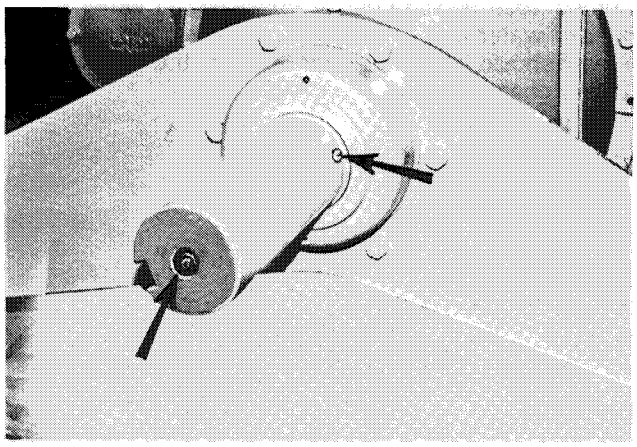
Control Lever Shaft Bearings

Lubricate through 2 fittings—2 strokes.



Clutch Pilot Bearing

Lubricate sparingly through 1 fitting on end of shaft. If fitting is not accessible, remove the plug on the circumference of the shaft near the housing and install a grease fitting. Reinstall plug after lubricating.



Coolant Conditioner Element

WARNING

At Operating Temperature, engine coolant is hot and under pressure.

Steam can cause personal injury.

Check coolant level ONLY, when engine is stopped and radiator cap is cool enough to touch with your hand.

Remove filler cap slowly to relieve pressure.

Cooling System Inhibitor contains alkali. Avoid contact with skin and eyes to prevent personal injury.

CAUTION

All water is corrosive at engine operating temperature. Use either Caterpillar Cooling System Inhibitor liquid, or the coolant conditioner element to treat either plain water or ethylene glycol solution.

Do not add both the liquid cooling system inhibitor and the coolant conditioner element at the same time.

CAUTION

When changing antifreeze solution, replace the maintenance filter element with the correct precharge element.

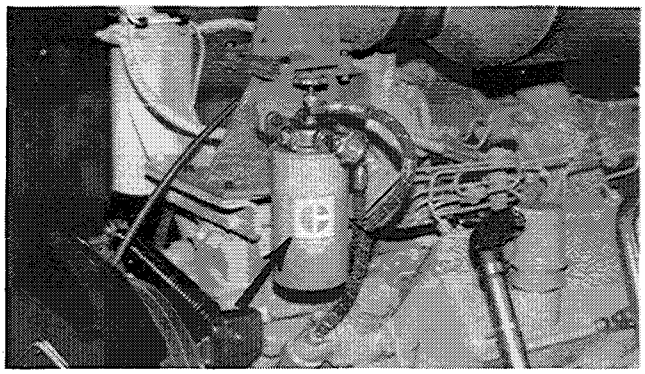
CAUTION

The normal coolant conditioner element must not be used with Dowtherm 209 coolant.

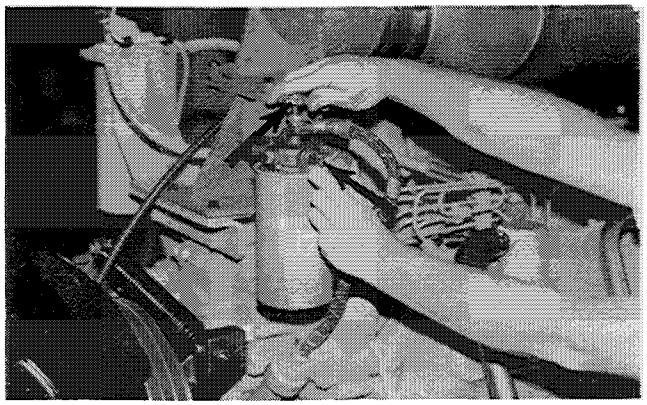
CAUTION

Excessive coolant conditioner (greater than the recommended 6% initial fill) together with concentrations of antifreeze greater than 65% cause deposits to form and may result in radiator tube blockage and overheating.

When fresh engine coolant consisting of either plain water or water and antifreeze is installed, a precharge element should be installed for use until the first normal element change period.



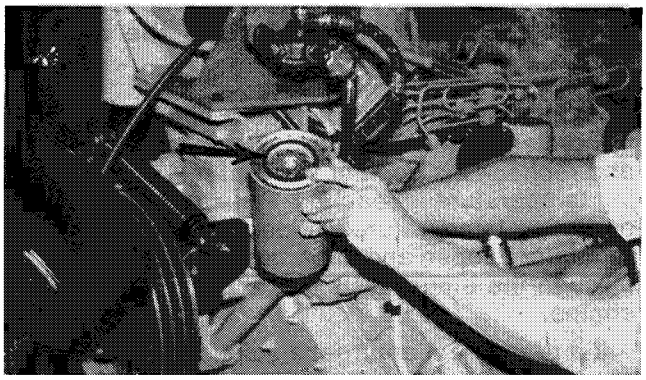
1. Close inlet valve and outlet valve at element base. Turn clockwise to close both valves.



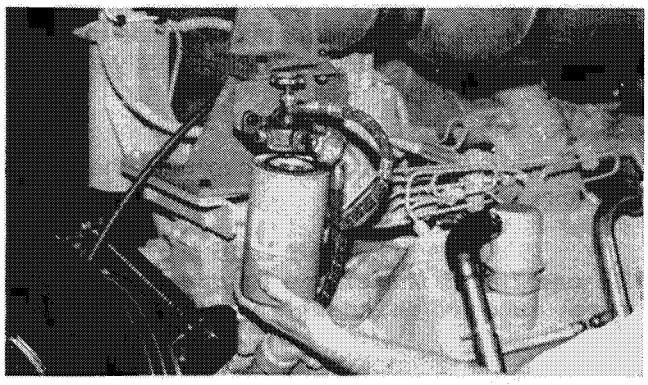
2. Remove the coolant conditioner element. Discard element.

3. Clean element mounting base. Make certain all of old element gasket material is removed.

4. Use the correct maintenance element for your cooling system. Maintenance elements are sized to the coolant system capacity.



5. Coat the seal of the element with a thin film of clean engine oil or antifreeze.



6. Install the element until seal contacts base, then tighten an additional 3/4 turn.

7. Open the inlet valve and outlet valve.

8. Start engine and check for leaks.

COOLING SYSTEM

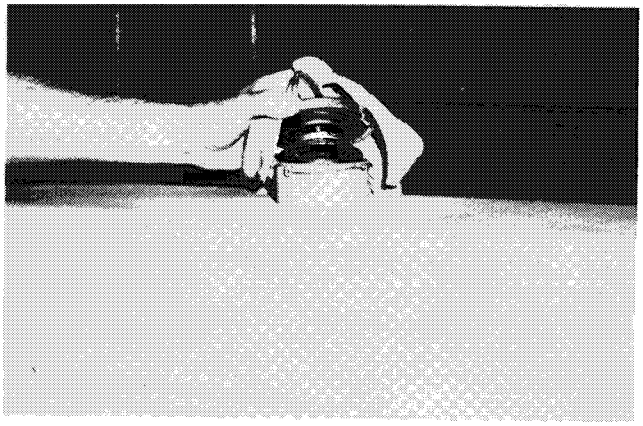
Coolant Level

Check the engine coolant daily with the engine stopped and cool.

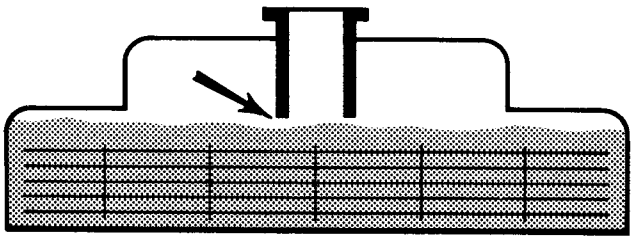
1. Slowly turn the filler cap to the first stop to release pressure.

⚠WARNING
Be careful: If the engine is warm-steam may spray outward under high pressure.

2. Push the cap down and turn until the cap is released.



3. Maintain coolant level to the base of the fill pipe.



4. Make-up coolant should be with water free as possible from scale forming minerals (not softened water) and a permanent type antifreeze containing rust inhibitor or a solution of water and Caterpillar Corrosion Inhibitor. Follow the recommendations given on the container.

Maintain a 3% concentration of Caterpillar Corrosion Inhibitor.

CAUTION
Do not use with Dowtherm 209.

Make-up water added without the proper proportions of coolant corrosion inhibitor can cause excessive lime deposits and corrosion.

CAUTION
Add coolant slowly to a hot engine to prevent possible cracking or distorting the cylinder head.

If a loss of coolant is noticeable, check for leaks in the system. After filling the system, start the engine and recheck the coolant level after normal operating temperature is reached. Running the engine at operating temperature will permit the temperature regulator to open and allow the coolant to circulate through the entire system and purge air from the engine.

If a permanent antifreeze solution is used in the cooling system, either renew the rust inhibitor every three months by adding Caterpillar Corrosion Inhibitor, or drain the entire cooling system annually and refill with fresh coolant solution.

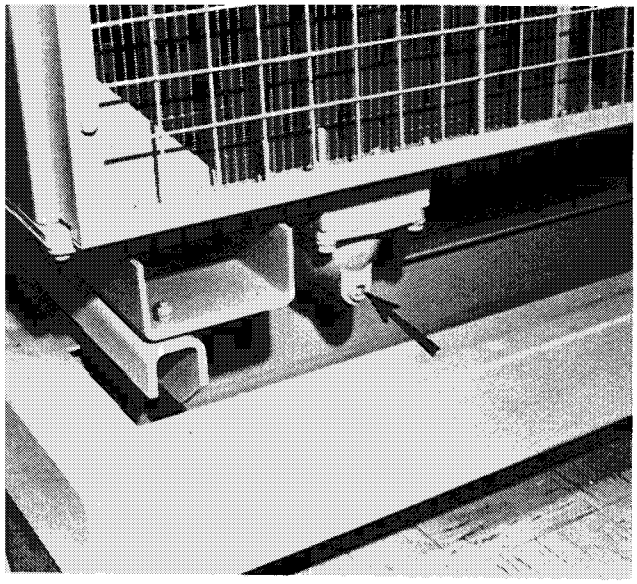
Draining The Cooling System

To clean the cooling system or replace the coolant solution, it is necessary to completely drain the cooling system.

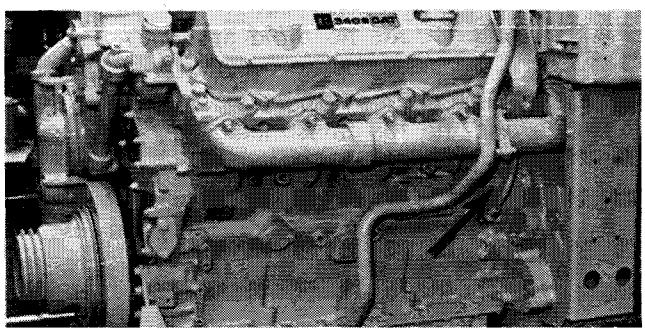
1. Stop the engine.
2. Slowly turn the pressure cap until the cap is removed.

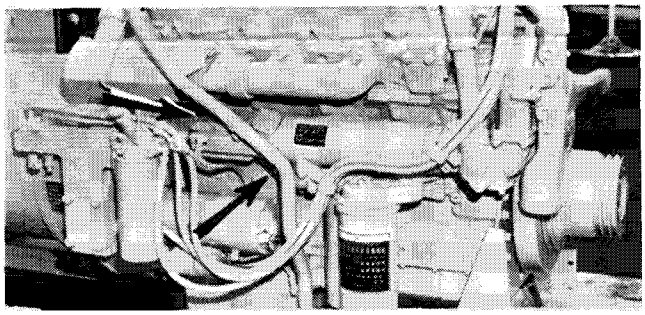
⚠ WARNING
Be careful. If the engine is warm-steam may spray outward under high pressure.

3. Open the radiator drain valve.



4. Remove block and oil cooler drain plugs.





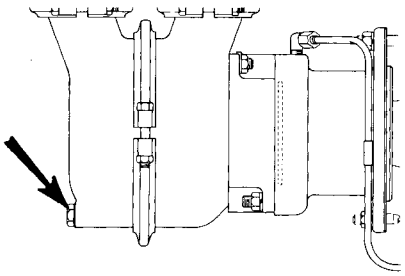
Draining Heat Exchanger Cooling System

1. Stop the engine.
2. Slowly turn the heat exchanger pressure cap to the first stop and release the pressure.

⚠ WARNING

Be careful. If the engine is warm-steam may spray outward under high pressure.

3. Push the cap down and turn until the cap is released.
4. Remove the drain plugs to drain tank, pump, block and lines.
5. If the ambient temperature is expected to go below freezing, drain the raw water line between the heat exchanger and the raw water pump.



RAW WATER PUMP DRAIN

Cleaning The Radiator (External):

Every 250 hours clean dirt and trash from between the tubes of the radiator which may cause excessively high operating temperature. Wash, brush or blow the dirt out with whichever method is available and most effective.

Cleaning The Cooling System (Internal):

Clean the cooling system periodically. Mineral deposits can cause serious engine damage by retarding the transfer of heat to the coolant. A deposit of lime 1/32 inch thick insulates the same amount as 2 inches of steel, reducing the heat transfer substantially. Loose scale and sediment deposited in the cooling system will reduce circulation, resulting in possible engine damage.

To clean, stop the engine when it is at normal operating temperature and drain as quickly as possible.

Flush thoroughly, then fill with a solution of one pound of Oxalic Acid or Sodium Bisulfate per five gallons of water. Run the engine at operating temperature one-half to one hour, then drain and flush until water is clear. Fill with a solution of one-half pound of Sal Soda per ten gallons of water and run the engine ten minutes. Drain, flush and fill with water, adding coolant conditioner and the desired amount of antifreeze.

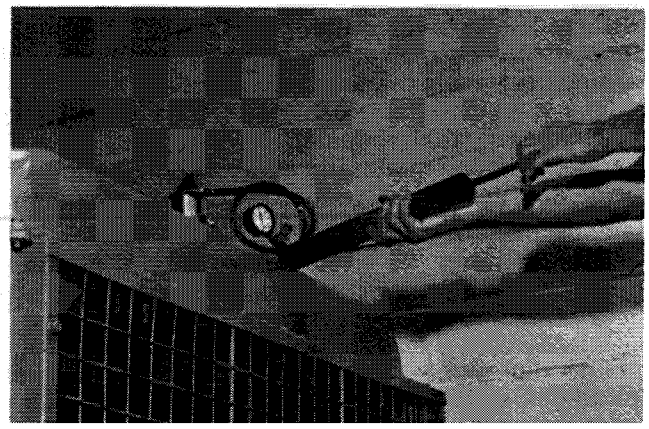
Cooling System Pressure

A pressure relief cap on the radiator or expansion tank controls the pressure of the cooling system and prevents the loss of coolant through the radiator overflow tube.

Pressurizing the cooling system serves two purposes. First, it permits safe operation at coolant temperatures higher than the normal boiling point, providing a margin of cooling for intermittent peak loads. Secondly it prevents cavitation in the water pump, and reduces the possibility of air or steam pockets forming in the coolant passages. Proper operation of the pressure relief cap assembly is essential. A pressure relief cap allows pressure (and some water, if the cooling system is too full) to escape when the pressure in the cooling system exceeds the capacity of the pressure cap. Loss of pressure will cause steam to form when coolant temperature is above the normal boiling point.

The cooling system is designed to work under a pressure of 4-7 PSI (7 PSI is recommended) to allow a high heat transfer for size of radiator and fan combination. In a pressurized system, a leaking radiator cap allows loss of pressure and coolant. For a simple check of cooling system pressure, install a pressure gauge in the radiator top tank and pressurize the system. Do this by either using an air

valve and external air supply, hand pump, or by operating the machine until the coolant reaches operating temperature. System pressure should rise to approximately 7 PSI, and any additional pressure should force air past the relief valve through the overflow opening. Do not allow pressure to exceed 10 PSI. The system should hold a minimum pressure of approximately 7 PSI, and a



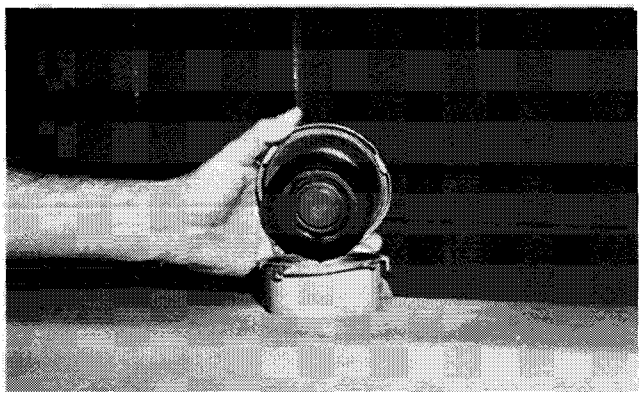
PRESSURIZING THE SYSTEM

pressure must remain constant with the air supply shut off or the engine running at a constant temperature.

If the pressure isn't maintained, overflow loss can occur as cooling system temperature rises. Do not remove the cap while the system is at operating temperature. Check coolant level only when cold.

If the system does not hold pressure, find the leak.

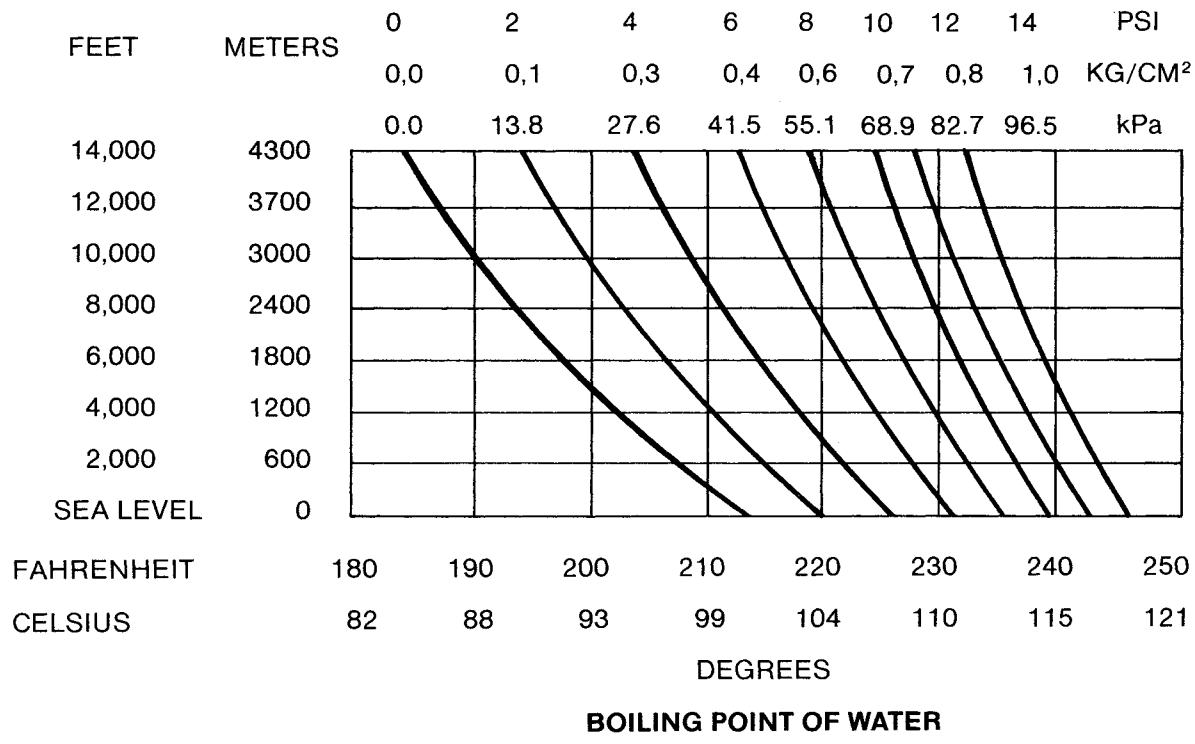
Carefully inspect the radiator cap, seals, sealing surfaces and the top tank filler neck surface for damage.



RADIATOR CAP

Testing The Temperature Gauge

Remember that boiling point temperature and pressure go hand-in-hand and neither one can be tested logically without considering the other. For example, the effect of pressurization and altitude on the boiling point of water is shown in the chart.

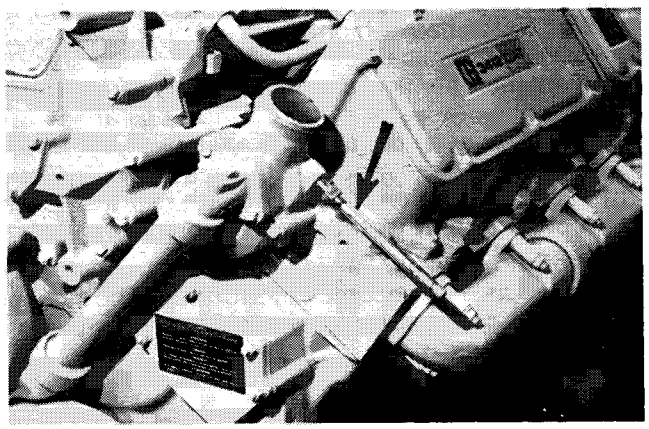


BOILING POINT OF WATER

If overheating and loss of coolant is a problem, a pressure loss in the system could be the cause. If an overheating condition is indicated on the temperature gauge and loss of coolant is not evident, check the accuracy of the temperature gauge. Make this check by installing a thermometer with a suitable bushing into the cylinder head.

Start the engine. Partially cover the radiator to reduce air flow and cooling. The reading on the instrument panel gauge should agree with the reading on the thermometer.

⚠ WARNING
Use CAUTION when working around moving parts with the engine running.

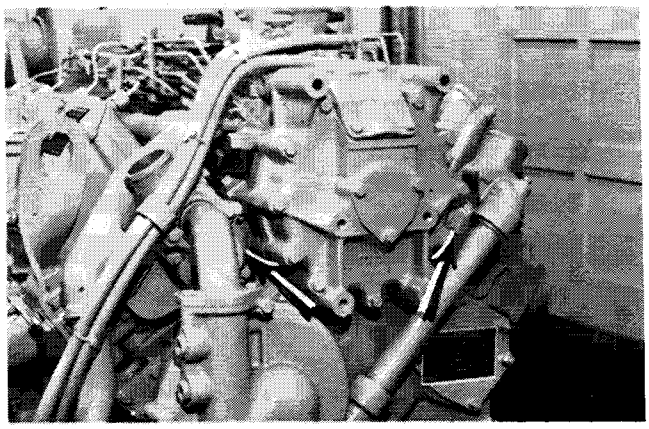


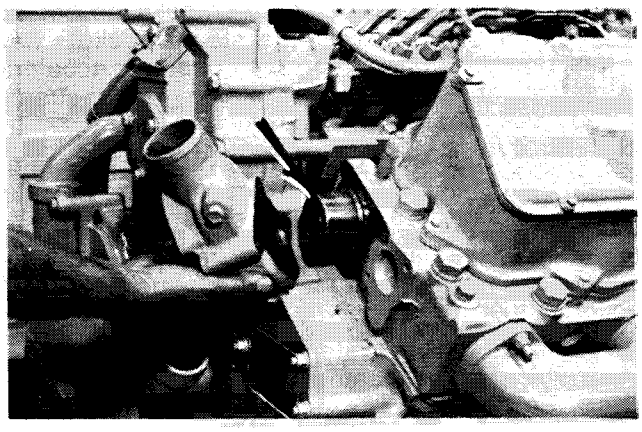
CHECKING COOLANT TEMPERATURE WITH THERMOMETER

Temperature Regulators

There is a temperature regulator located at the front of each cylinder head.

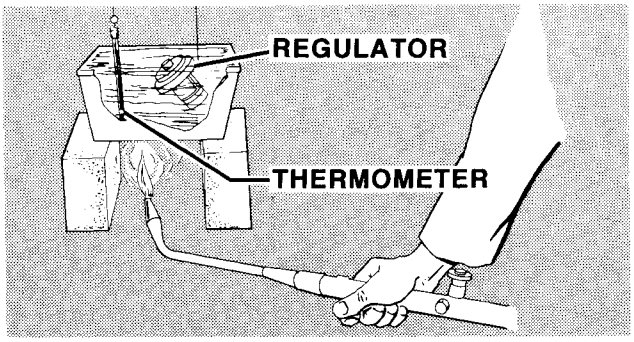
The opening temperature of the regulator (bench test in antmospheric pressure) should be 180 ± 2°F (82 ± 2°C). The regulator should be fully open at approximately 197°F (92°C).





1. Remove the regulator from the housing.
2. Submerge the regulator and a thermometer in a pan of water as shown.
3. Apply heat to the pan and stir the water to maintain uniformity.
4. Observe the opening temperature of the regulator.

If the regulator does not operate correctly, install a new one.



Cooling System Hoses

Inspect all coolant hoses annually and replace if they show signs of cracking or leaking. Periodically replace all hoses, as it is many times difficult to determine the condition of a water hose by visual inspection and feel. Coolant hoses are expendable items and periodic replacement is considered good maintenance practice.

Air, Gases And Steam In The System

Incomplete or improper filling is a major cause of air in the cooling system. Also, leaks in various components such as the aftercooler, and hoses allow air to enter the cooling system, especially on the inlet side of the water pump.

Air in the system produces foaming or aeration and affects water pump performance. The air bubbles insulate various parts of the engine from the coolant, and hot spots form. As the air bubbles cir-

culate or break up, coolant contacts the hot surfaces, creating steam. The steam pockets have basically the same effect as air bubbles, accelerating the formation of more steam. Consequently, coolant discharges through the overflow.

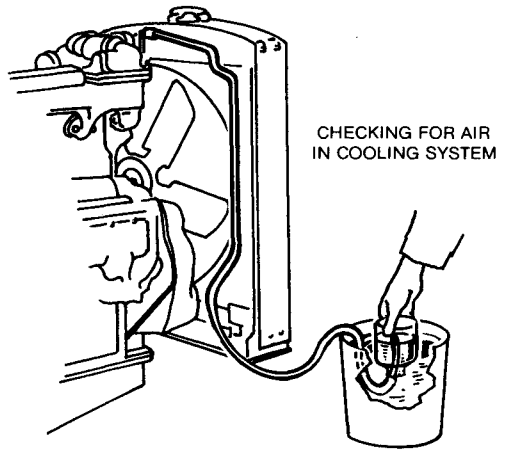
Exhaust gas leakage into the system causes similar conditions. Exhaust gas can enter through internal cracks or defective cylinder head gaskets.

Most of the causes can be checked by a visual inspection, while others require disassembly or a simple test.

Air in the cooling system is one cause of overheating which can be located by a simple test known as the "bottle test". The equipment required to perform such a test consists of a 1 pint bottle, a bucket of water, and a length of hose with an inside diameter large enough to fit over the end of the radiator overflow pipe.

To Test

Fill the cooling system to proper level. Wire open the relief valve in the radiator cap. Install the radiator cap and tighten. Assemble the rubber hose over the end of the overflow pipe.



CHECKING FOR AIR IN COOLING SYSTEM

Start the engine and operate it at high idle speed for at least five minutes after the engine reaches operating temperature. Block off part of the air flow through the radiator to maintain operating temperature. After the temperature has stabilized and all expansion air has vented out, place the loose end of the hose in the water filled bottle which is inverted in the bucket of water. If it takes less than a minute to displace the water in the pint bottle, leakage into the cooling system is excessive.

Loose precombustion chambers, faulty precombustion chamber seals, a loose cylinder head, or a damaged head gasket are possible causes of air in the cooling system. In any case, the cause should be corrected immediately.

Water Pump

The water pump circulates the coolant through the aftercooler and oil cooler, the cylinder block, cylinder head, and radiator. Poor coolant circulation causes overheating. A badly corroded or worn water pump impeller, or even a loose impeller, reduces circulation and efficiency.

Every 2000 hours inspect the water pump and rebuild as necessary, or install a rebuilt pump to reduce downtime to a minimum. Your authorized dealer is familiar with worn replacement limits and with disassembly and assembly procedures.

Raw Water Zinc Rods (Salt Water Only)

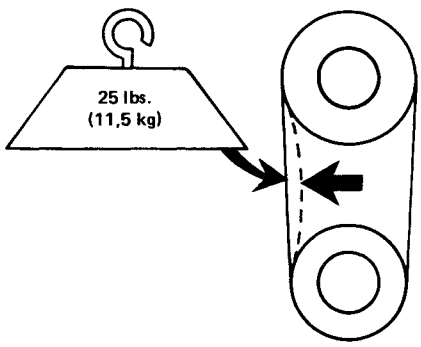
Salt water has a highly corrosive reaction with metal by a chemical action called "electrolysis". To prevent this chemical action taking place, with parts used in the raw water system, zinc plugs are placed in the raw water piping. Zinc is a relatively soft metal which reacts quite readily with the salt water. Thus, by the deterioration of the zinc, the raw water system parts are protected from corrosion.

The zinc rods must be inspected regularly and be replaced as they become deteriorated. The zinc rod plugs are painted red for easy identification.

Fan Belts

Examine the drive belts annually for wear and replace if they show signs of wear. Loose or worn pulley grooves cause belt slippage and low fan speed. If fan belts are too loose, they vibrate enough to cause unnecessary wear on the belts and pulleys and possibly slip enough to cause overheating.

If one belt in a set requires replacement, always install a new matched set of belts-never replace just the worn belt. If only the worn belt is replaced, the new belt will carry all the load-as it will not be stretched as much as the older belts-and all the belts will fail in rapid succession.



BELT TENSION

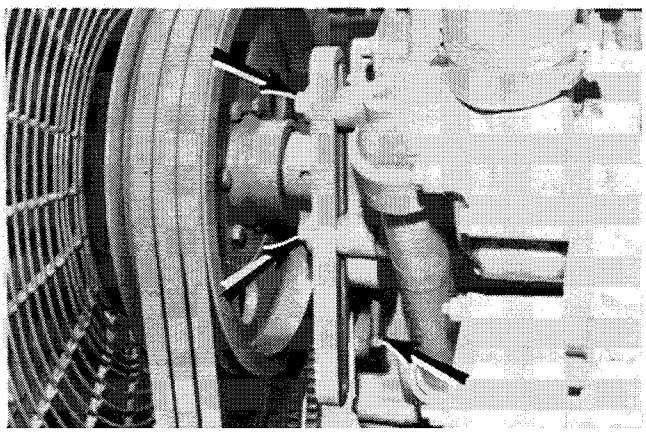
Adjustment:

Check new belts for adjustment after the first 10 hours and every 250 hours thereafter. To check belts-apply 25 lbs. (11.5 kg) force midway between pulleys. Correctly adjusted belts will deflect ½ inch (12.5 mm) to ¾ inch (19 mm) for the first check. Maintain later adjustments at 7/8 inch (23 mm).

To Adjust:

Loosen the lockbolts on the fan pulley adjusting bracket and adjust fan pulley with the adjusting bolt. After belt tension is correct, tighten lockbolts.

Readjust alternator belt tension and tighten adjusting nuts.



Aftercooler

Some engines may be equipped with an aftercooler. The aftercooler is a simple device resembling a small radiator core. Water from the engine passes through the core tubes. Engine inlet air, warmed by the turbocharger compressor is directed through the core and around the tubes. Since the temperature of the water is lower than the air, the air is cooled as it leaves the aftercooler and becomes more dense as it enters the intake manifold. This means more air (oxygen) is available for combustion, resulting in more fuel being burned and more power produced.

One degree increase in inlet air temperature increases exhaust temperature approximately three degrees. Restrictions to either coolant or air flow reduce aftercooler efficiency and severly affect the engine and cooling system.

When engine is being rebuilt, remove the aftercooler and clean core, water and air passages.

FUEL SYSTEM

Care Of The Fuel Supply

Too much emphasis cannot be placed on the importance of using only clean diesel fuel. It is important to buy clean fuel and keep it clean. The best fuel can be rendered unsatisfactory by inadequate storage facilities or careless handling.

Effort should be constantly expended to prevent contamination of the fuel. An important step is to reduce the number of times the fuel must be handled. When the fuel can be delivered by the distributor to storage tanks and then pumped from the storage tank to the diesel fuel tank, the handling is reduced to a minimum.

Care Of The Diesel Fuel Tank

Fill the fuel tank at the end of the day, because the incoming fuel will drive out the moisture-laden air and prevent condensation. The strainer in the fuel tank filler opening should be removed and cleaned regularly.

Draining Fuel Tank Sediment Accumulation

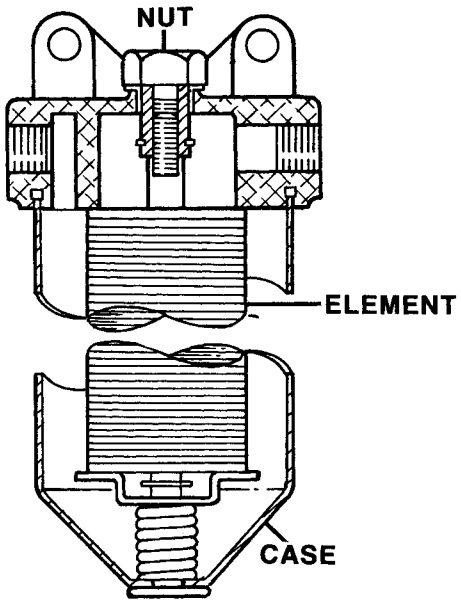
Open the drain cock and drain off any sediment or water which may accumulate in the fuel tank before starting the engine. In temperatures below freezing, drain shortly after the engine has stopped to prevent water freezing in the bottom of the tank and other low points in the system.

Fuel Filtering System

As either the primary fuel filter element or the final fuel filter element gradually become clogged with foreign material, lack of horsepower will be noticed and the position of the fuel gauge indicator will work back from the original position in the NORMAL (green or approximately 30 PSI) range to the OUT (red or approximately 20 PSI) range. Every 250 hours or when the indicator shows in the OUT (red) range, the metallic primary fuel filter element (if equipped) should be removed and washed. If the indicator still shows in the OUT (red) range, the final filter element should be replaced with a Caterpillar filter element. Other make fuel filters may not meet filtering or capacity requirements. See the topics, PRIMARY FUEL FILTER and FINAL FUEL FILTER.

Primary Fuel Filter (Optional)

To remove the filter element, stop the engine and shut off the diesel fuel tank valve. Loosen the nut on the filter cover and lower the filter case. Remove the element and wash in clean solvent or diesel fuel. Reinstall the element.

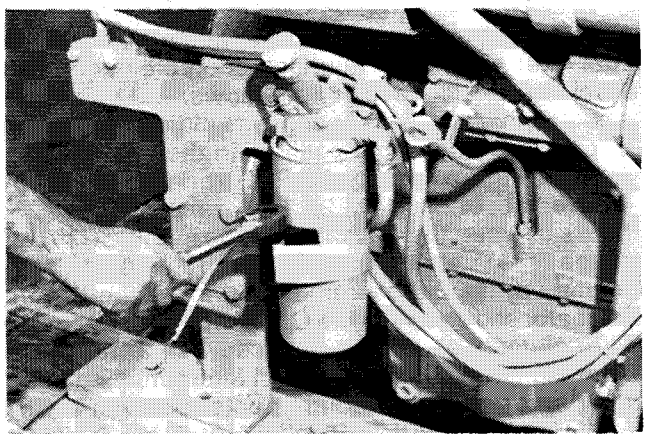


Final Fuel Filter

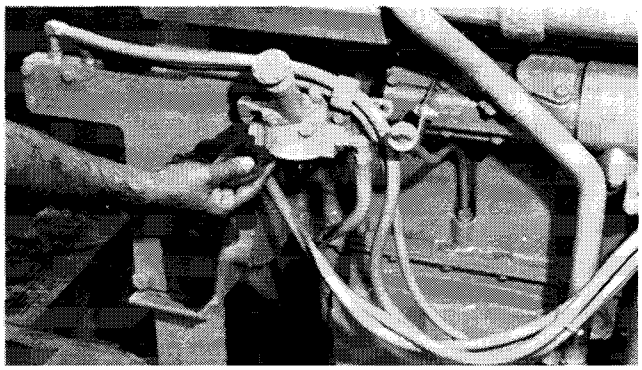
The filter element collects and holds contaminants and cannot be washed or otherwise restored.

To remove the used filter, proceed as follows:

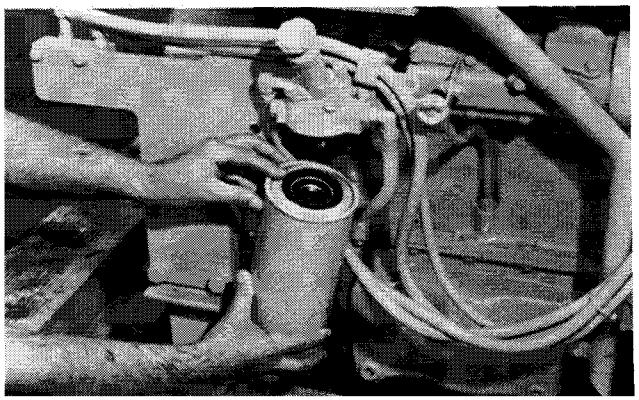
1. Stop the engine and close the diesel fuel line valve (if equipped).
2. Unscrew and remove filter.



3. Clean the gasket sealing surfaces on the filter bases.



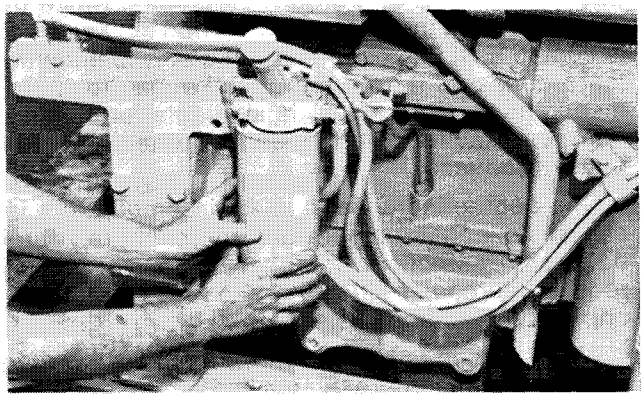
4. Lubricate the new filter gasket with clean diesel fuel.



CAUTION

Do not pour fuel into the new filter element before installing. Prime the system as instructed in the topic, PRIMING THE FUEL SYSTEM.

5. Tighten the filter by hand until the gasket contacts the base, then tighten ½ to ¾ turn more.
6. Start the engine and run at 1000 rpm for several minutes and check for leaks. If the engine fails to start, prime the fuel system. See the topic TO PRIME THE SYSTEM.



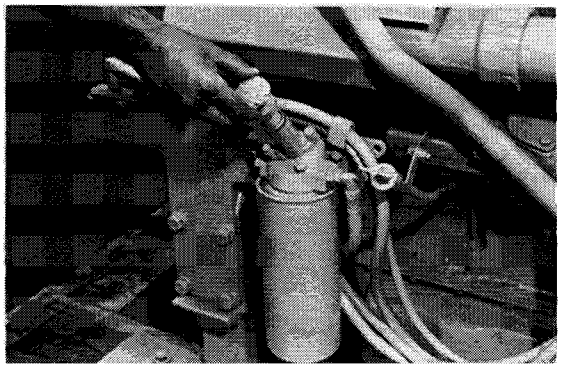
Keep New Fuel Filters On Hand

Extra filters should be kept on hand for replacement. Always keep filters wrapped in their original carton to insure against dust and dirt accumulation which will shorten the life of the filters or may cause damage to the fuel injection equipment.

To Prime The System

If air is trapped in the fuel system, the diesel engine will either not start, or will misfire. Then it is necessary to prime the system.

The fuel priming pump is mounted on the fuel filter base. If the fuel filter is changed or if the engine has run out of fuel, prime the fuel system as follows:



1. Be sure the fuel line valve is open and the engine shutoff control is off.
2. Unlock the fuel priming pump.
3. Operate priming pump until increased resistance is felt.
4. Lock fuel priming pump.

If the engine fails to start or continues to misfire or smoke, further bleeding is necessary. With engine running, or with the use of the priming pump, loosen fuel line nuts, one at a time, several times in succession and allow fuel to run until free of air bubbles. Tighten fuel line nuts.

LOOSENING FUEL INJECTION LINE TO BLEED SYSTEM

Fuel Injection Equipment

When improper fuel injection is affecting engine operation, a systematic check should be made to determine the cause. The most likely cause is dirt or water in the fuel. Drain the sediment from the fuel tank. Check the fuel pressure gauge as mentioned in the topic, FUEL FILTERING SYSTEM. Replace the filters if necessary. Then prime the fuel system until clean fuel reaches the fuel injection pumps. If the fuel system is air bound, priming the system will overcome the difficulty.

If the engine is running irregularly, smoking, or knocking, a fuel injection valve may not be spraying the fuel properly.

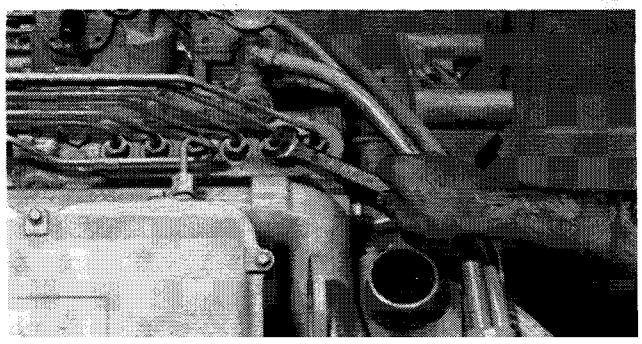
Direct Injection System

The fuel system of direct injection engines is essentially the same as precombustion chamber engines. The absence of the precombustion chamber requires a different fuel nozzle and adapter. Externally the direct injection fuel nozzle resembles the precombustion chamber nozzle except it is longer in length. Nozzle testing and replacement procedure is the same as illustrated for the precombustion chamber engines, except that an extracting tool is used to remove the fuel nozzle and adapter. The seal on the adapter should be inspected and replaced if damaged.

Precombustion Chamber Injection System

Testing Fuel Injection Valves

Whenever an engine performs in such a manner that a fuel injection valve is suspected of causing trouble, test all fuel injection valves. To test the injection valves: Loosen the fuel injection line nut at the fuel injection pumps, one at a time, while the engine is running. When a nut is loosened and the exhaust smoking is completely or partially eliminated and the irregularity in running is not affected,



LOOSENING FUEL INJECTION LINE NUT TO TEST VALVE

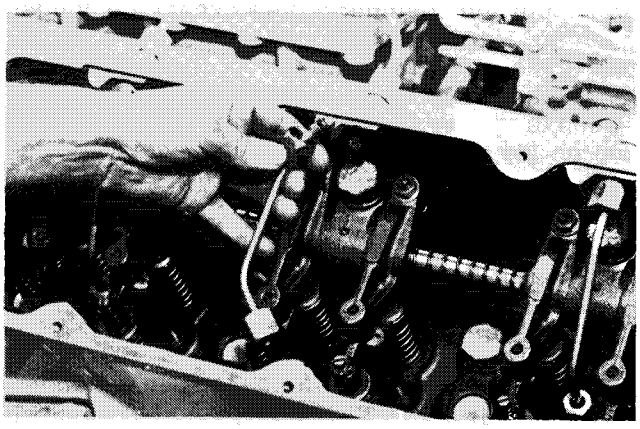
this identifies the probable location of a defective valve and a new one should be installed in that cylinder to definitely determine if the valve removed was defective. Never wire brush or scrape a fuel injection nozzle assembly as this will damage the finely machined orifice. Your authorized dealer has the proper tools for cleaning and testing fuel injection valves.

Before removing your fuel injection nozzle assembly, Caterpillar recommends that you contact your Caterpillar dealer for more detailed information.

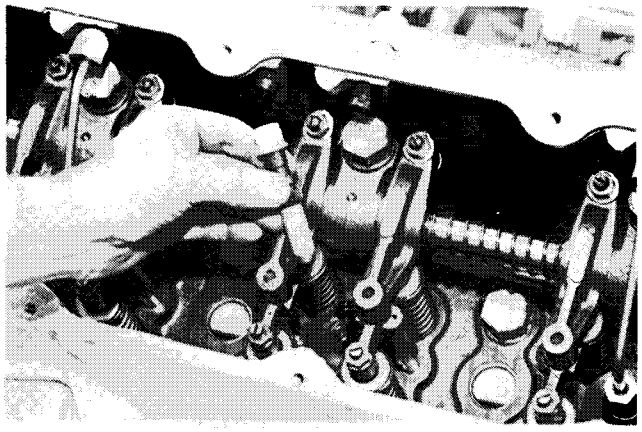
Remove Fuel Injection Valve

Clean dirt from around the valve cover and remove. Before removing an injection valve, clean the dirt from around the valve and line connections. Disconnect the lead wire from the glow plugs. (If so equipped)

Loosen the fuel injection line at the valve housing and disconnect it from the valve. Immediately install plugs to prevent dirt from entering the fuel injection



line. Remove the valve retainer nut and lift out the fuel injection nozzle assembly and body as a unit. If the fuel injection valve will not be immediately installed, caps should be put on the valve body to prevent dirt entering the valve assembly.

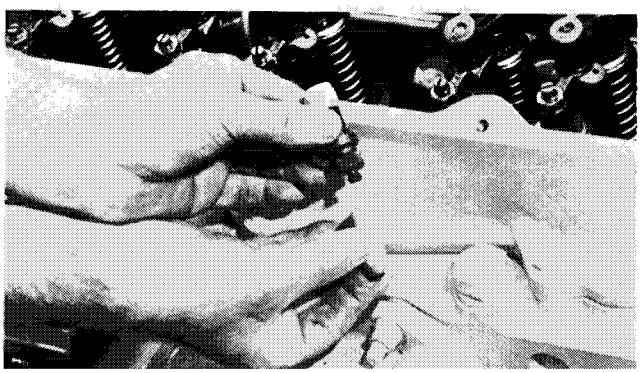


Installing Fuel Injection Valves

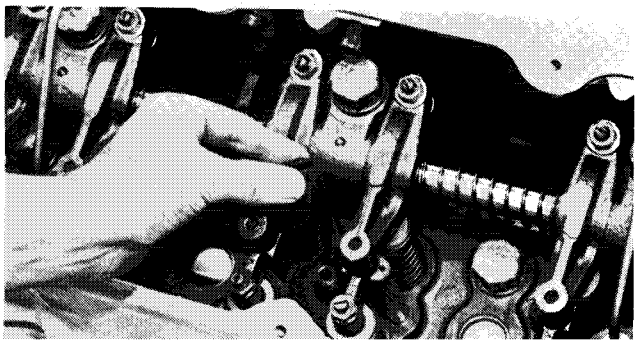
NOTE: The compression seal washer and the carbon dam (seal) should be replaced each time the nozzle is tested.

Before installation of a fuel injection valve, be sure the wrench is clean. Install the fuel injection valve in the following manner.

1. Screw the valve body into the fuel injection valve nozzle assembly only finger tight.
2. Insert the nozzle assembly and valve body as a unit into the precombustion chamber opening. Turning the body in a clockwise direction and at the same time pressing down will assure alignment of the serrations.



3. Install the retainer nut and tighten to a torque of 55 lb.ft. (7.6 mkg) to prevent leaks between the nozzle assembly and the nozzle assembly seats.



INSTALLING RETAINER NUT

CAUTION
Do not overtighten. Use torque wrench.

4. Connect the fuel injection line and tighten the nuts.

AIR INDUCTION AND EXHAUST SYSTEMS

Fuel Injection Pumps

To check or replace fuel injection pumps, to check fuel injection timing, injection pump lifter setting, fuel rack setting and governor adjustments, it is recommended they be performed by an authorized dealer.

Governor

Check the engine high and low idle RPM at the first oil change period and every 1,250 service hours thereafter. To check, remove tachometer drive cable (or cap) from the tachometer drive housing in front of the fuel pump housing. See the information plate on the engine for engine RPM. It is recommended this adjustment be made by an authorized dealer.

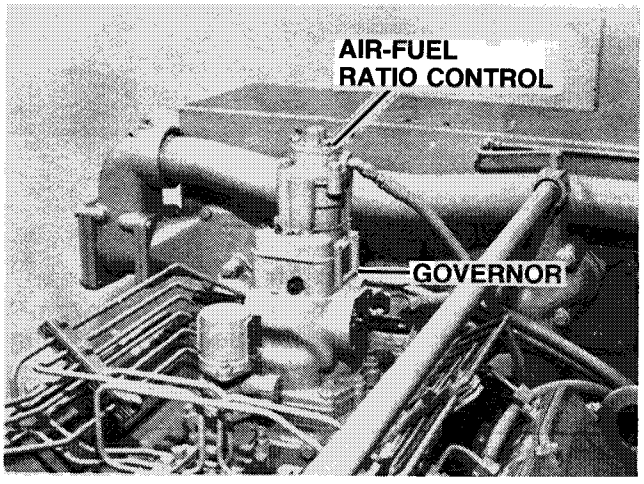
NOTE

Tachometers on the panel are usually not sufficiently accurate to check high and low idle engine RPM. Always use an accurately calibrated tachometer.

Air-Fuel Ratio Control

The air-fuel ratio control is a device to control the smoke emission of an engine during its operation when low inlet manifold pressure exists.

Low inlet manifold pressure occurs during operation at low torque output. During this type of operation the air-fuel ratio control regulates the maximum fuel injected into each cylinder. If the controlling diaphragm within the air-fuel ratio control should rupture, the fuel system will be restricted the same as it would be with low inlet manifold pressure. Slow engine response and low power may indicate a need for adjustment or repair. Authorized dealers are equipped with the necessary tools, personnel and procedures to perform these service.



Air Cleaners (Caterpillar Dry-type Air Cleaners Only)

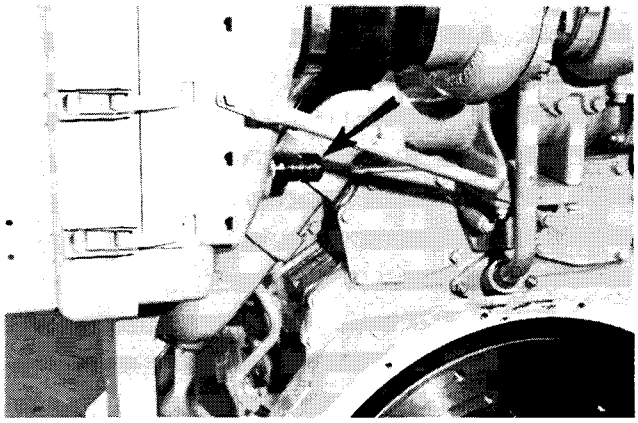
Regular service intervals, along with close visual inspection of the air cleaner, are necessary for proper cleaning of the engine inlet air. The service interval will vary with the weather and working conditions. Where dust conditions are severe, it will be necessary to service the air cleaner frequently. In damp weather and other conditions of little or no dust, the service interval can be extended.

To extend the service life of the element, the exhaust and air cleaner inlet pipes should be arranged so that exhaust and/or oil fumes do not enter the engine air cleaner.

Visual inspection of the gaskets and seals is important in keeping dust from bypassing the air cleaner. Any dirt allowed to enter, accelerates wear throughout the engine. If the condition of any of the replaceable seals and gaskets is questionable, replace them. If the sealing ends of the filter element or the element pleats are damaged, replace the element.

Extra filter elements should be kept on hand for replacement or for use in the air cleaner while the element that was removed is being cleaned.

The air service cleaner indicator is connected to the air inlet pipe between the air cleaner and the turbocharger. It contains a red marked piston, which gradually rises with restriction to the air flow. When the entire piston is visible it will lock in this position. This indicates a need for air cleaner service. The piston will remain in this position whether or not the engine is running. After servicing the air cleaner, reset the piston by depressing the plunger in the bottom of the indicator.



AIR CLEANER SERVICE INDICATOR

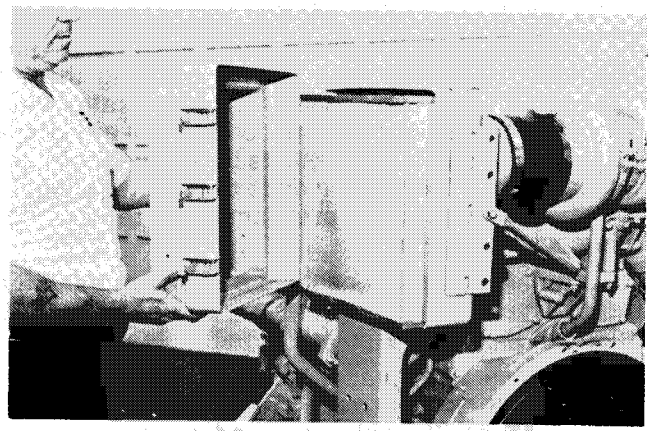
Excessive engine exhaust smoke and/or loss of power may indicate the need for servicing the air cleaner. Never service the air cleaner while the engine is running.

Single Stage Air Cleaner

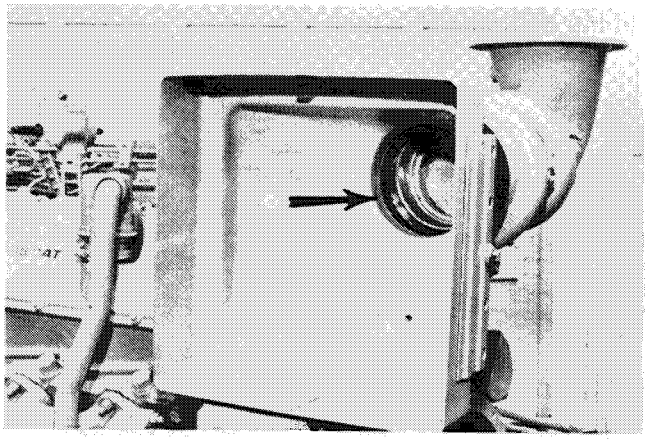
Changing Filter Element

CAUTION
Service the air cleaner with the engine stopped.

1. Remove the air cleaner cover and element.



2. Cover the air inlet opening to prevent foreign objects from entering the engine.
3. Clean the inside of the air cleaner cover and the air cleaner body.

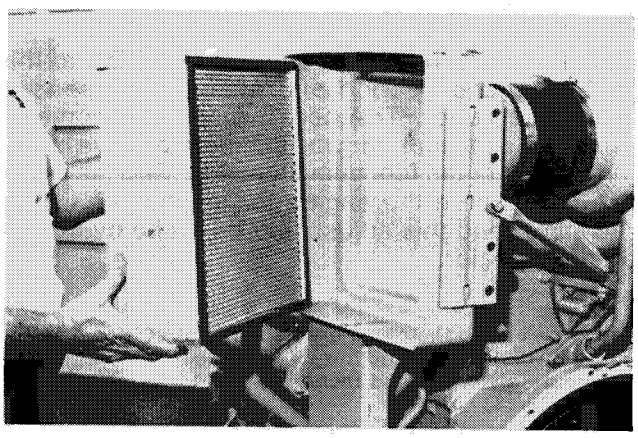


4. Inspect the replacement element for damage and cleanliness.

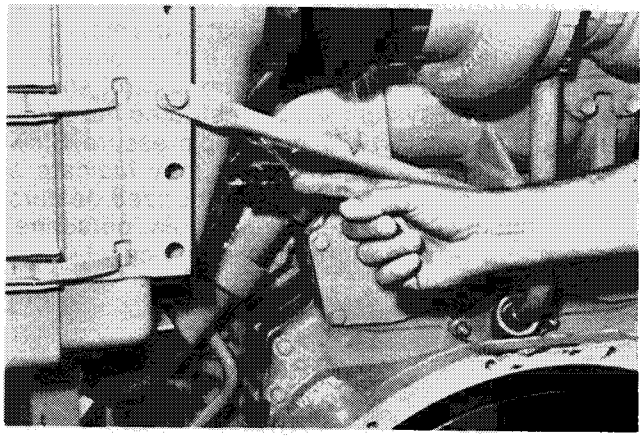
NOTE
Have a replacement element on hand to install and use while cleaning the dirty element. This will save you down time.

5. Remove the covering from the air inlet opening.
6. Install the element.

CAUTION
Install the air cleaner element as shown in the illustration. Note the arrows indicating air flow on the side of the element, and the position of the gasket.



7. Install the air cleaner cover.
8. Reset the service indicator button by pushing on the reset button.
9. Clean the used air cleaner element. See the instructions for cleaning.



Cleaning Filter Elements

Cleaning Elements With Air

1. Use clean, dry air—30 PSI (2 kg/cm²) maximum. Hold the nozzle at least one inch from the element and at a slight angle.

⚠ WARNING
When using pressure air, wear safety glasses and protective clothing. Use no more than 30 PSI (2 kg/cm²) pressure.

2. Direct the air stream along the complete length of each pleat on the CLEANEST side of the element. (This will loosen the dirt from the dirtier side.)
3. Blow the loosened dirt from the DIRTY side.
4. Direct the air from the CLEAN side through to the DIRTY side to remove dirt blown into the pleating.

Cleaning Elements With Water

1. Use clean water at no more than 40 psi (3 kg/cm²). Do not use a nozzle.
2. Direct the water along the complete length of each pleat on the CLEAN side of the element.
3. Direct water along the complete length of each pleat on the DIRTY side of the element.
4. Rinse the CLEAN side of the element.
5. Allow the cleaned element to dry thoroughly.

Cleaning Elements With Detergent

1. Wash both sides of the element in a solution of warm water and non-sudsing detergent.
2. Rinse the CLEANEST side of the element with clean water 40 psi (3 kg/cm²) maximum along with the complete length of each pleat.
3. Rinse the opposite side of the element along the complete length of each pleat.
4. Rinse the first side again to remove all loosened dirt.
5. Allow the cleaned element to dry thoroughly.

Inspecting Cleaned Elements

Place a lighted electric bulb behind the cleaned, dried filter element. Carefully check each pleat for holes or tears. If just one small hole or tear is found, discard that element and install a new element.

Storing Cleaned Elements

1. Wrap usable elements in heavy paper.
2. Store the wrapped element in a dry, clean place.

Dust Collector Cap

Servicing Dust Collector Cap

1. Remove the cap from the air cleaner inlet.
2. Clean the bottom grill using pressure air (maximum 30 psi — 2.0 kg/cm²), or low sudsing detergent and water. Install the cap.

WARNING

Protective eye glasses must be worn when using pressure air.

Soot Filters

Soot filters are used to remove soot and other large airborne particles from the air intake system. The panel-type soot filter is made of a bonded fiber, structually supported with scrim netting.

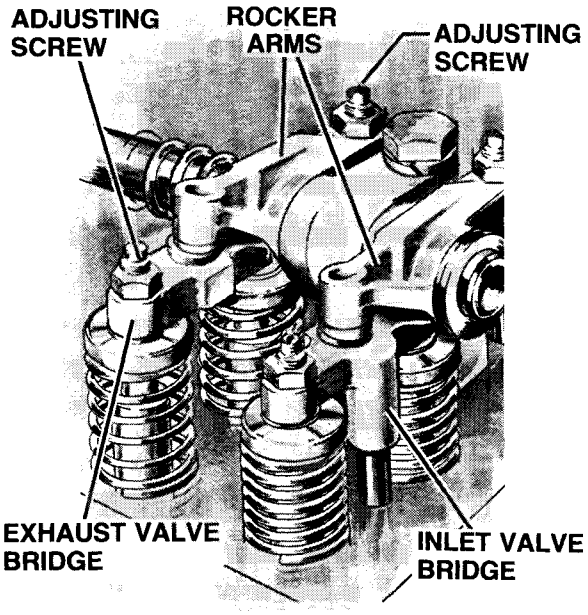
Soot filters are recommended for use in any application where there is a possibility for exhaust air to be induced into the engine air intake system.

The soot filters should not be cleaned. Replace the filter whenever the air cleaner elements are serviced.

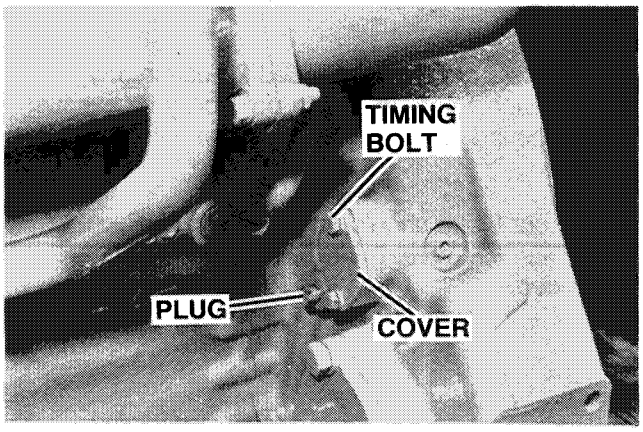
Valve Adjustments

There are two rocker arms per cylinder, one rocker arm for the two exhaust valves and one rocker arm for the two inlet valves. Each pair of valves is connected by a bridge which is actuated by the rocker arm. The valves in each pair are adjusted simultaneously by the adjusting screw in the rocker arm.

Check the bridge and valve adjustment with the engine stopped.



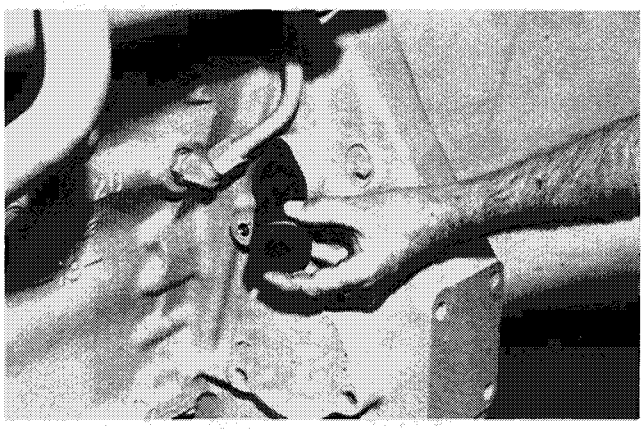
Clean the dirt from the base of the valve covers and then remove covers. Remove the plug from the timing hole, timing bolt and access cover. Rotate the flywheel in the direction of engine rotation until the timing bolt can be installed in the flywheel and the No. 1 piston is on compression stroke.



TIMING BOLT LOCATION

NOTE

The flywheel can be rotated with an engine turning tool (9S9082). Remove the access cover and install the engine turning tool in the access hole so it engages the flywheel ring gear. Turn with a ratchet handle.



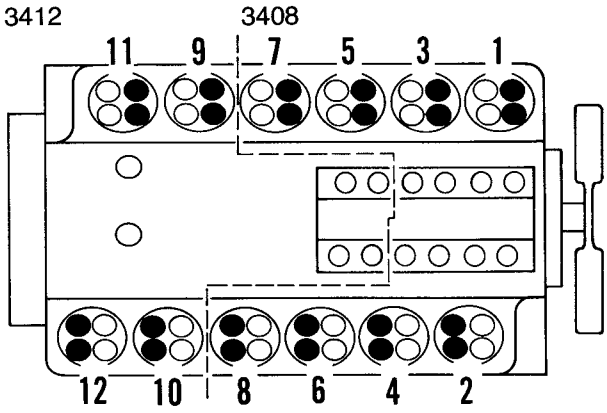
INSTALLING ENGINE TURNING TOOL

Both the inlet and exhaust valves will be closed on compression stroke. First check the bridge adjustment and then the valve lash adjustment.

VALVE LOCATION

● EXHAUST .030" (0.76mm)

○ INTAKE .015" (0.38mm)

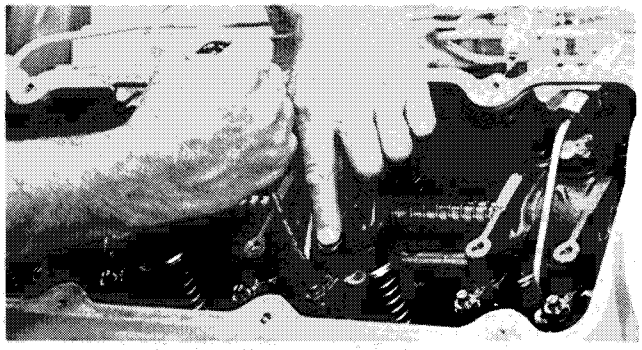


Bridge Adjustment

Check the bridge adjustment screw and locknut for tightness. If the adjusting screw and locknut are tight, proceed with the valve lash adjustment. If the bridge adjusting screw can be turned with a screwdriver without holding the locknut, the bridge requires adjustment. The bridge adjustment must be made before the valve lash is checked for proper clearance.

Make bridge adjustment as follows:

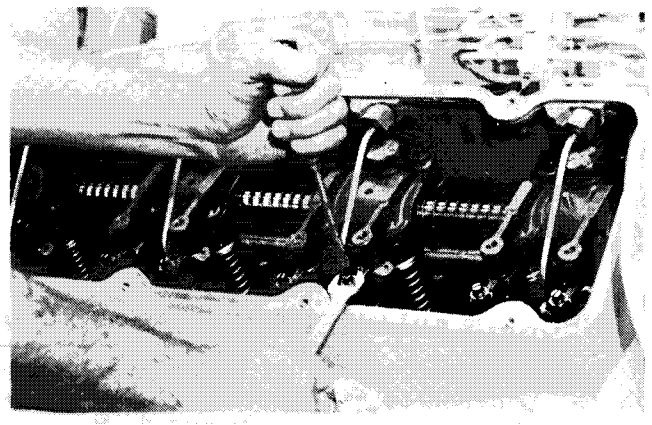
1. Back off adjusting screw several turns (counterclockwise) making sure it is not in contact with the valve stem.
2. Firmly press straight down on the rocker arm above point of contact with bridge.



ADJUSTING BRIDGE

3. Turn the adjusting screw clockwise until contact is made with the valve stem, then turn the adjusting screw an additional 30° or 1/12 turn (½ the distance between the two points on the locknut).

4. Hold the adjusting screw in this position and tighten the locknut to 20 lb. ft. (27.2 N m).



TIGHTENING ADJUSTING SCREW LOCKNUT

Valve Lash Adjustment

⚠ WARNING

To prevent possible injury, do not use the starter motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring valve clearance.

CAUTION

Measure the valve lash with the engine stopped. To obtain an accurate measurement, allow at least 20 minutes for the valves to cool to cylinder head and block temperature.

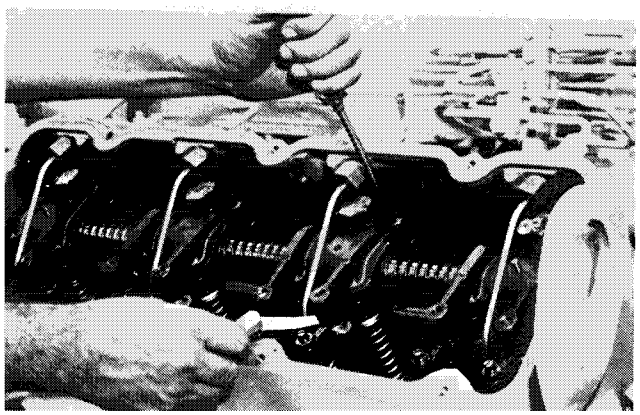
If the valve clearance is within ± 0.08 mm (.003 in) of the nominal clearance given, adjustment is not required. If the clearance is not within these limits, set the clearance as given in the chart.

3408 VALVE ADJUSTING SEQUENCE			
VALVES	LASH	NO. 1 PISTON TDC ON COMPRESSION ADJUST VALVES	NO. 6 PISTON TDC ON COMPRESSION ADJUST VALVES
EXHAUST	.030" (0.76 mm)	1-3-4-8	2-5-6-7
INLET	.015" (0.38 mm)	1-2-5-7	3-4-6-8

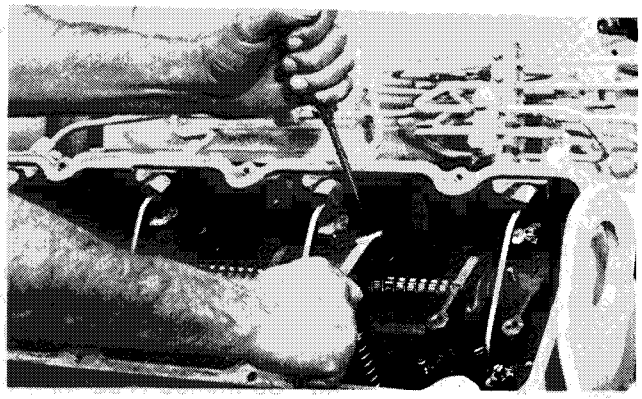
3412 VALVE ADJUSTING SEQUENCE			
VALVES	LASH	NO. 1 PISTON TDC ON COMPRESSION ADJUST VALVES	NO. 11 PISTON TDC ON COMPRESSION ADJUST VALVES
EXHAUST	.030" (0.76 mm)	1-4-5-8-9-12	2-3-6-7-10-11
INLET	.015" (0.38 mm)	1-3-4-6-7-12	2-5-8-9-10-11

After checking the bridge adjustment, make the valve lash adjustment.

1. With No. 1 piston at TDC on compression, check valve lash between the bridge and rocker arm. See chart for cylinder and valve adjusting sequence.
2. To adjust, loosen valve adjusting locknut and turn adjusting screw to allow feeler gauge to pass between top of bridge and the valve rocker arm. Set the inlet valve lash at .015" (0.38 mm) and exhaust valve lash at .030" (0.76 mm).



3. After proper adjustment, tighten the adjusting screw locknut to 22 lb. ft. (29.9 N·m) and recheck lash clearance.



4. Turn flywheel 360° in direction of engine rotation. Align flywheel timing bolt with the timing hole in the flywheel.

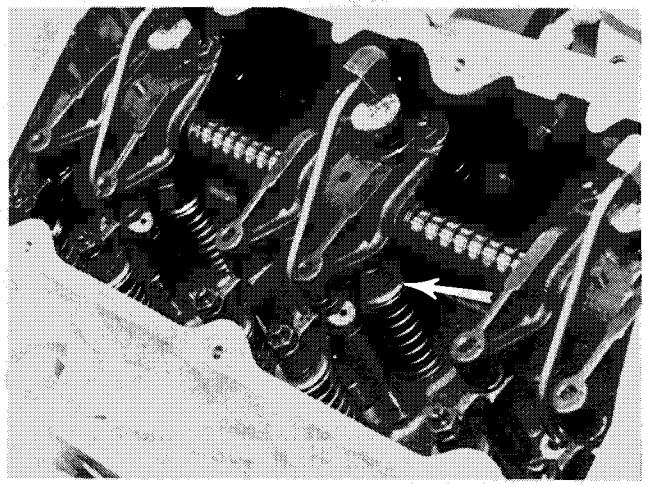
   3408—No. 6 Cylinder will be at TDC on compression stroke (all valves closed)

   3412—No. 11 Cylinder will be at TDC on compression stroke (all valves closed).

5. Check lash and adjust as necessary on all remaining valves, see valve adjusting sequence chart.
6. Tighten locknut and recheck lash clearance.
7. Remove engine turning tool and install timing access cover, timing bolt and plug.

Check Valve Rotation: After checking valve lash and before the valve covers are installed, check the valves for rotation.

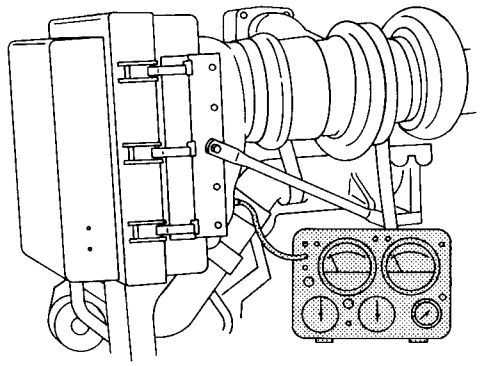
1. Mark a line on each valve retainer.
2. Start the engine and run at low idle.
3. Watch the line mark on each valve retainer. Each valve retainer should turn slightly each time the valve closes. If they do not turn, contact your Caterpillar dealer.



4. Stop the engine.
5. Inspect the valve cover gasket and install a new one as necessary. Install the valve cover.

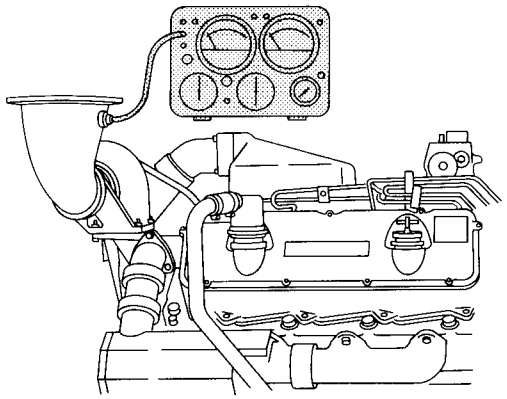
Restriction Of Air Inlet And Exhaust

If an air inlet restriction is suspected in the piping or air filter element, check with a differential pressure gauge or manometer. Remove the air cleaner service indicator and connect differential pressure gauge or manometer in the service indicator connection. The air inlet piping or air cleaner should not restrict air flow more than 30 inches (762 mm) of water difference in pressure.



CHECKING AIR INLET FOR RESTRICTION

Restriction of the exhaust system (back pressure) is measured with a differential pressure gauge or manometer. This pressure difference is measured between the turbocharger outlet and ambient air and should be no more than 20 inches (645 mm) of water. An exhaust pressure tap is provided in the turbocharger outlet elbow. This check should be performed with the engine at operating temperature and developing full rated power.



CHECKING EXHAUST SYSTEM BACK PRESSURE

Crankcase Pressure

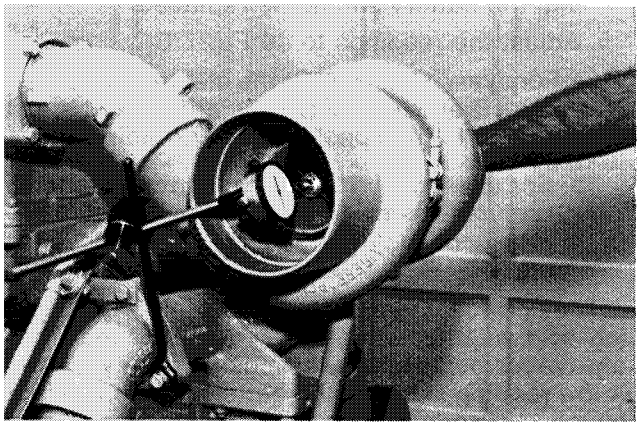
Excessive crankcase pressure can be a result of combustion gas leaking past broken or damaged pistons, worn cylinder liner walls and/or piston rings. This condition will usually be accompanied by irregular engine operation and excess fumes from crankcase breather opening. This pressure can cause the breather element to become restricted in an unusually short time. In addition, it can cause engine oil to leak past gaskets and seals that would function properly under normal conditions.

Turbocharger

Every 4000 hours or if any unusual sound or vibration in the turbocharger is noticed, a quick check of bearing condition can be made without disassembling the turbocharge. This can be done by removing the piping from the turbocharger and inspecting the compressor impeller, turbine wheel and compressor cover. Rotate the compressor and turbine wheel assembly by hand and observe by feeling excess end play and radial clearance. The rotating assembly should rotate freely with no rubbing or binding. If there is any indication of the impeller rubbing the compressor cover or the turbine wheel rubbing the turbine housing, recondition the turbocharger or replace with a new or rebuilt one.

End clearance is best checked with a dial indicator. Attach a dial indicator with the indicator point on the end of the shaft. Move the shaft from one end to end making note of the total indicator reading.

End play should be between .003 in. (0.076 mm) and .008 in. (0.203 mm). If end play exceeds .008 in. (0.203 mm) rebuild or replace the turbocharger. End clearance less than .003 in. (0.076 mm) could indicate build-up on the turbine wheel and should be disassembled for cleaning and inspection.

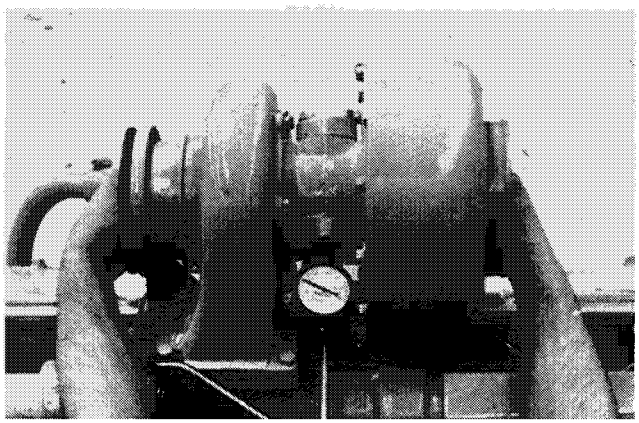


CHECKING TURBOCHARGER ROTATING ASSEMBLY END PLAY

A more reliable check of bearing condition can be made only when the turbocharger is disassembled and the bearings, shaft journal and housing bore diameters can actually be measured. This service is available from an authorized dealer.

Radial clearance can also be checked with a dial indicator. Remove the oil return line from the turbocharger. Attach a dial indicator with an extension indicator point long enough to contact the shaft through the oil return hole. Make sure the contact point is centered on the shaft (highest indicator reading). Raise both ends of the shaft all the way then push down in the opposite direction. Total movement of the indicator should be between .005 in. (0.13 mm) and .009 in. (0.23 mm). If radial clearance exceeds .009 in. (0.23 mm) or minimum clearance is under .005 in. (0.13 mm) the turbocharger should be disassembled and the bearings checked.

NOTE
Care must be taken not to cock the shaft or a false reading will be obtained.



CHECKING THE TURBOCHARGER RADIAL CLEARANCE

If a turbocharger fails, try to determine cause of failure and eliminate before installing a rebuilt or new turbocharger. When installing a new or rebuilt turbocharger always perform the following steps:

A. Inspect the air induction and exhaust system for the presence of foreign particles which could result in repeat failure.
B. Change the air cleaner element.
C. Change the oil filters.
D. Drain and refill the engine crankcase.
E. Pre-lubricate the replacement turbocharger by filling the center housing with oil.

ELECTRICAL SYSTEM

The following topics describe care and maintenance of the electrical system components. These components functioning together produce the energy needed for operating the electrical equipment on the engine and each is dependent upon the others for satisfactory operation. In the event of failure or improper operation, it is essential to check the entire electrical system as a defect in one component can cause damage to another.

Many electrical system problems can be traced to loose or corroded connections. Keep connections tight and make sure the wiring insulation is in satisfactory condition. Most of the electrical system testing can be performed while the components are on the engine. It should be remembered, if a malfunction is found on test, the component must be removed for further testing, repair or replacement.

NOTE
Some installations may have electrical components not furnished by Caterpillar. Consult the manufacturer's manual for maintenance procedure.

Battery

Every 250 hours check the electrolyte level of each cell and the general condition of the battery. Maintain the electrolyte level to the base of each vent well. The make-up water must be one of the following (in order of preference):

1. Distilled water.
2. Odorless, tasteless drinking water.
3. Iron free water.

⚠ WARNING
Never add acid or electrolyte.

Cleaning Battery

Mix a weak solution of baking soda and water. Apply the solution with a soft bristle brush. Be careful not to get cleaning solution into the battery.

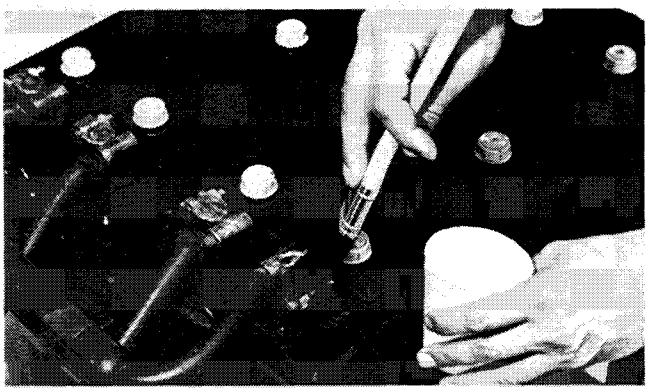
Thoroughly rinse the battery and battery tray with clean water. Apply grease to the battery cable clamps and terminals and to all threads.

Testing The Electrolyte Solution

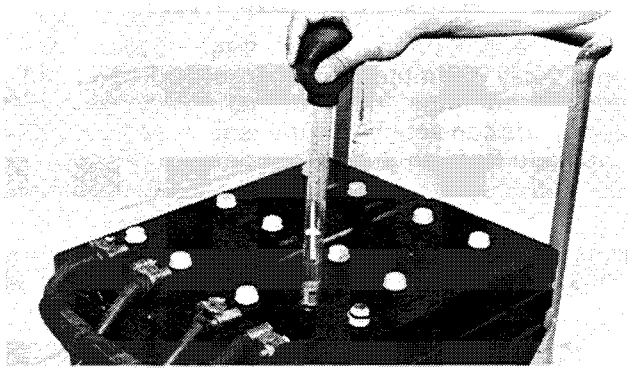
The general condition of a battery can be determined by measuring the specific gravity of the electrolyte solution and adjusting the reading to 80°F (27°C). If the electrolyte level is too low to allow taking a hydrometer reading, add make-up water to the correct level and then charge the battery 2 to 4 hours before taking a reading.

1. Insert the hydrometer into a cell. Fill the hydrometer barrel while holding it vertically. The float must not drag on the wall of the barrel.
2. Read the hydrometer:
   1.265 - 100% charged
   1.225 - 75% charged
   1.190 - 50% charged
   1.155 - 25% charged
   1.120 - Discharged
   1.000 - Water
3. Test each cell in the same manner.
4. If there is more than .050 (50 gravity points) variation between the highest and lowest reading, the battery should be replaced.
5. Adjust the readings to 80°F (27°C).
   a. For every 10°F (5.5°C) the electrolyte temperature is above 80°F (27°C), add .004 (4 gravity points) to the specific gravity readings.
   b. For every 10°F (5.5°C) the electrolyte temperature is below 80°F (27°C), subtract .004 (4 gravity points) from the specific gravity reading.

The corrected reading is of most importance during cold weather when the hydrometer reading is always corrected to a lower specific gravity reading. A low reading signifies the battery has less available power to crank the engine and that booster batteries may be required.



CLEANING BATTERY TERMINALS



TESTING ELECTROLYTE SOLUTION

Installing Battery

1. Be sure the battery tray is clean and free of foreign objects.
2. Be sure terminal posts and cable clamps are clean.
3. Place the battery in the tray. Tighten the hold down clamps evenly until the battery is snug. Do not overtighten.
4. Connect the "hot" terminal first. Be sure the top of the cable terminal is pushed down even with the top of the terminal post. Tighten the clamp firmly.

⚠ WARNING

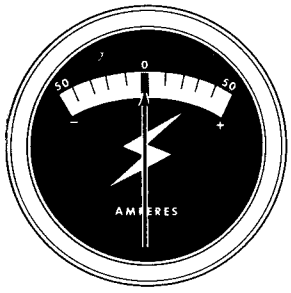
Always connect the "hot" terminal first to minimize arcing. Otherwise injury or damage could result.

5. Connect the "grounded" terminal last. Be sure the top of the cable terminal is pushed down even with the top of the terminal post. Tighten the clamp firmly.
6. Apply a thin coating of grease over the cable clamps. terminals and hold down fasteners.

Checking Charge Rate

1. After starting the engine, the ammeter indicator should register to the right of zero, but should never be "pegged".
2. After the engine has been running, the indicator should be just to the right of zero.

   If the indicator remains far to the right of zero, or remains to the left of zero with an increase of engine speed, have the electrical charging system checked.



Charging the Battery

⚠ WARNING

Never smoke near the area where batteries are being charged. Hydrogen gas is given off at each vent cap during charging. Hydrogen mixed with air is highly explosive.

1. Connect positive charger clamp to positive battery terminal.
2. Connect negative charger clamp to negative battery terminal.
3. Connect charger power cord to proper outlet.
4. Allow battery to charge slowly.

CAUTION

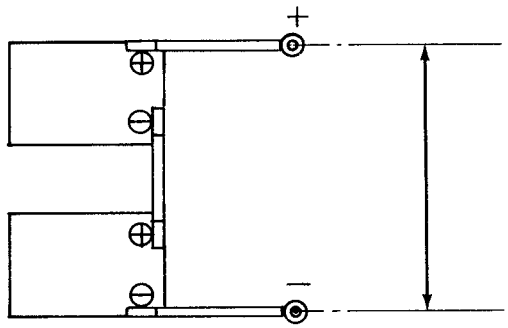
If battery is charged too rapidly, the battery will be damaged.

5. After the battery is charged, disconnect charger power cord from outlet; remove charger clamp from negative battery terminal; remove charger clamp from positive battery terminal.

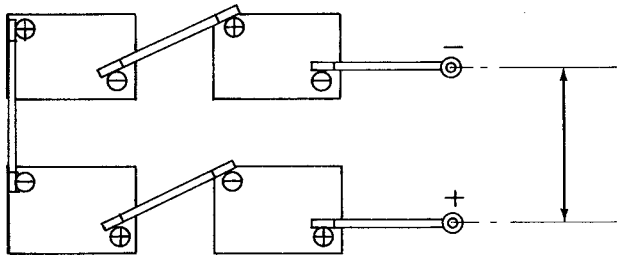
Connecting Booster Batteries

CAUTION

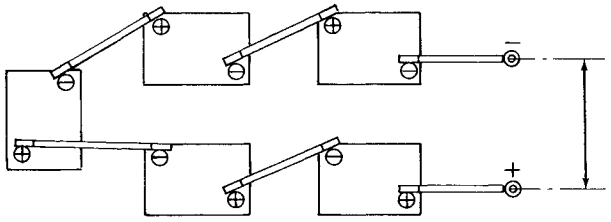
Keep red and black terminals from touching each other.



24 VOLT STARTING USING 12 VOLT BATTERIES



24 VOLT STARTING USING 6 VOLT BATTERIES



30 VOLT STARTING USING 6 VOLT BATTERIES

1. Remove all filler caps from all batteries before connecting jumper cables.
2. Connect red jumper cable to "hot" terminal of booster battery.
3. Connect black cable to "ground" terminal of booster battery.
4. Connect other end of red cable to "hot" terminal of engine battery.
5. Connect other end of black cable to the starter ground terminal, if equipped with a starter to ground cable.

   If the starter is not grounded with a cable, attach the black cable terminal to a good ground on the engine or engine frame, at a point away from, and below the battery.
6. Start the engine using starting aids as instructed in the Operation Instructions.

Disconnecting Booster Batteries

As soon as engine starts:

1. Disconnect black jumper cable from engine.
2. Disconnect red jumper cable from engine.
3. Disconnect black cable from booster battery.
4. Disconnect red cable from booster battery.
5. Charge booster batteries to full capacity with a battery charger.

Cold Weather Battery Maintenance

General Maintenance

1. After adding make-up water, charge the battery. The added water could dilute the electrolyte enough without charging to cause freezing and permanent damage to the battery.
2. Keep the batteries fully charged either by operating the charging system or by using a battery charger.
3. Keep the battery warm when not in use. In an unheated area, the heat from a lighted electric bulb is usually sufficient.

CAUTION

Use only a shop cord with a heavy wire guard around the light bulb.

Do not lay a lighted bulb directly on a battery case; the heat at point of contact could melt the battery case.

Do not lay cloth or flammable material in contact with a lighted bulb; charring and/or fire could result.

4. Use starting aids as instructed for starting the engine.
5. Use booster batteries as required. Connect the batteries as instructed below.
6. If a battery is not going to be used for a period of time, be sure the battery is fully charged while stored. Use a battery hydrometer to check the specific gravity of each cell, and use a battery charger to keep the battery charged. See the instructions below.

Voltage Test (After Load)

A load test should be made on a battery that discharges very rapidly when in use. To do this apply a resistance of three times the ampere/hour rating of the battery across the battery main terminals. Allow the resistance to discharge the the battery for 15 seconds and immediately test the battery voltage. A 6 volt battery in good condition will test 4.5 volts; a 12 volt battery in good condition will test 9 volts and a 24 volt battery will test 18 volts.

Starter

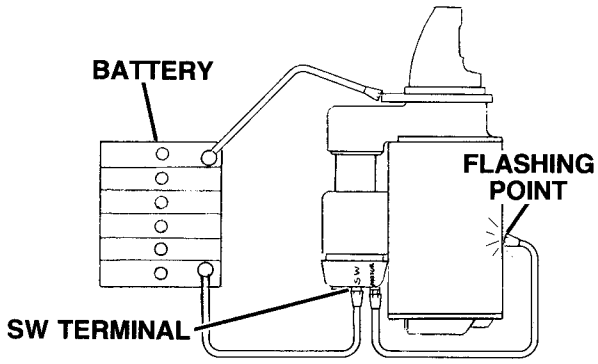
No periodic service is indicated for the electric starter brushes between general reconditioning periods. The brushes should only be inspected after removal of the starter from the engine and removal of the commutator end bearing frame. The electric starter commutator end and drive end bearings are equipped with wicks for lubrication purposes. The wicks should be saturated with oil whenever the electric starter is removed or disassembled.

It is suggested that cleaning and reconditioning be entrusted to your authorized dealer.

Pinion Clearance Adjustment

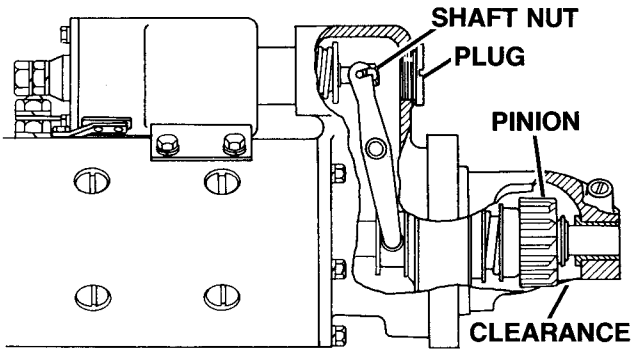
Whenever the solenoid is installed, the pinion clearance should be adjusted. The adjustment should be made with the starting motor removed.

Bench test and adjust the pinion clearance at installation of solenoid as follows:



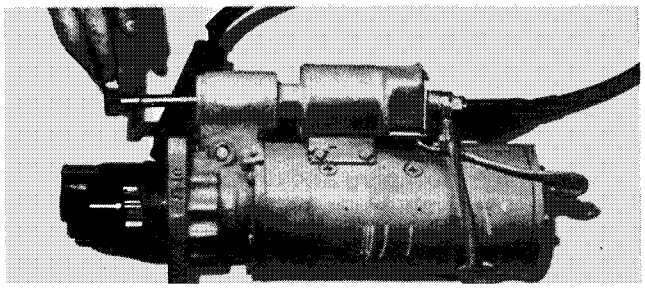
CIRCUIT FOR CHECKING AND ADJUSTING PINION CLEARANCE

1. Install the solenoid without connector from the MOTOR terminal on solenoid to the motor.
2. Connect a battery, of the same voltage as the solenoid, to the terminal marked SW.
3. Connect the other side of battery to ground terminal or to solenoid frame.



ADJUSTING PINION CLEARANCE

4. MOMENTARILY flash a jumper wire from the solenoid terminal marked MOTOR to the frame or ground terminal. The pinion will shift into cranking position and will remain there until the battery is disconnected.
5. Push pinion towards commutator end to eliminate free movement.
6. Pinion clearance should be .36 in. (9.14 mm).
7. Adjust clearance by removing plug and turning shaft nut.



ADJUSTING PINION CLEARANCE

Charging System

Alternator Regulator

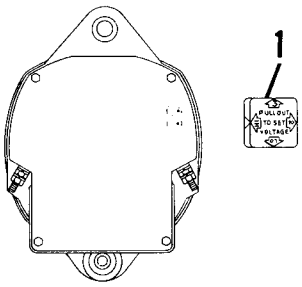
The alternator regulator is adjusted at the factory for average operating conditions and may require readjustment to provide the proper charging rate for the particular operating conditions.

The condition and state of charge of the battery at each regular inspection will indicate if the alternator is operating efficiently. An adjustment is necessary when the battery is always in a low state of charge or an excessive amount of water must be added to the battery (more than one ounce of water per cell per week or per every 50 service hours).

When the alternator is either charging the battery too much or not enough, an adjustment can be made to the alternator charging rate.

Alternator Regulator (Delco-Remy)

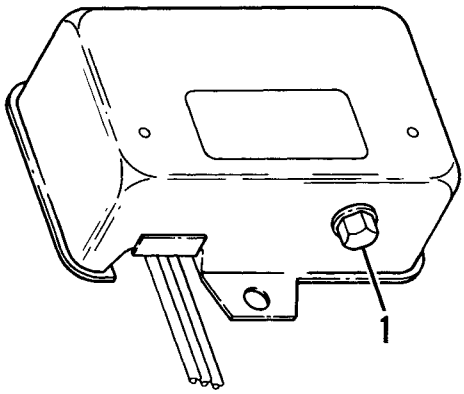
To make an adjustment to the voltage output, remove the voltage adjustment cap (1) from the alternator, turn the cap 90°, and install it again into the alternator. The voltage adjustment cap has four positions: HI, LO, and two positions between the high and the low setting.



Alternator Regulator (Motorola)

To make an adjustment to the voltage output, remove the cap (1) from the alternator regulator and change the regulator adjustment with a screwdriver.

To increase the voltage turn the adjustment screw clockwise. The adjustment screw under the cap (1) has five positions (number 1 is the last position clockwise).



Adjustment Position	1	2	3	4	5
Regulator Voltage	29.25 ± .35	28.6 ± .3	28.0 ± .3	27.4 ± .3	26.8 ± .3

Never operate the charging alternator with an open circuit between it and battery.

CAUTION

Do not attempt to polarize the alternator. If an accidental connection is made between the "+" terminal and either one of the "F" terminals on the alternator, the rectifiers in the alternator and the transistors in the regulator will be damaged.

Alternator Belts

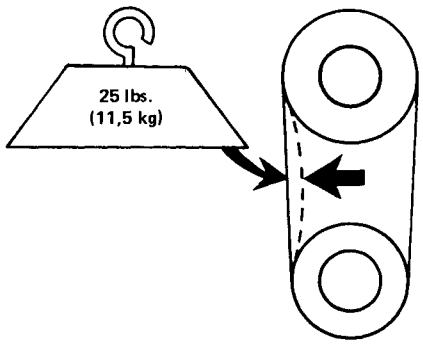
Every 250 hours examine the drive belts for wear and replace if they show signs of wear.

If one belt in a set requires replacement, always install a new matched set of belts-never replace just the worn belt. If only the worn belt is replaced, the new belt will be carrying all of the load-as it will not be stretched as much as the older belts-and all of the belts will fail in rapid succession.

Adjustment

Check the new belts after the first 10 hours and every 250 hours thereafter for adjustment. To check belts-apply 25 lbs. (11.5 kg) force midway between the pulleys. Correctly adjusted belts will deflect ½ in. (12.5 mm) to ¾ in. (19 mm) for the first check. Maintain later adjustments at 7/8 in. (23 mm).

BELT TENSION

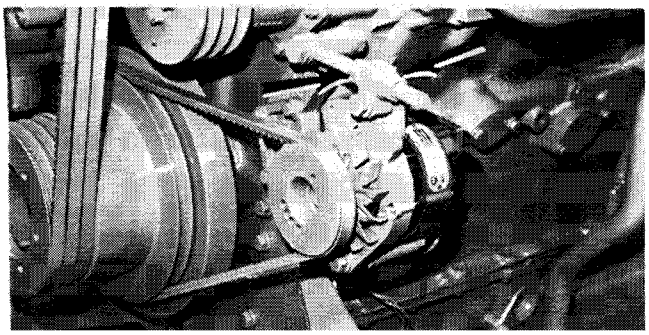


To adjust, loosen mounting bolts and locknut on adjusting bolt. Turn adjusting nuts to increase or decrease alternator belt tension. Tighten locknut and mounting bolts.

If belts are operated too loose they will slap causing unnecessary wear to the belts and pulleys. Belt slipping may cause the alternator to operate at a below normal rate and possible failure of the electrical system.

If the belts are too tight, unnecessary stresses are placed upon the pulley bearings and belts which might shorten the life of both.

ALTERNATOR BELT ADJUSTMENT



Glow Plugs

Testing Glow Plugs

Glow plugs can be checked with an ammeter. Disconnect the wire lead from the glow plug terminal on the HEAT-START switch. Install an ammeter, in series, between the disconnected lead and the terminal on the switch. Observe the ammeter with the HEAT-START switch turned to the HEAT position. Each 12 volt glow plug draws approximately 12.5 amperes. The ampere draw of one glow plug multiplied by the number of engine cylinders will be the total ampere draw of the glow plugs in the engine. A low reading is an indication of one or more defective glow plugs. Disconnect one glow plug lead at a time and observe the ammeter with the switch turned to HEAT. The disconnected glow plug that does not change the ammeter reading is the defective glow plug.

Replacing Glow Plugs

To remove a defective glow plug disconnect the lead from the glow plug and unscrew the glow plug from the precombustion chamber. Apply antiseizure compound to the thread of a new glow plug and install the glow plug into the precombustion chamber. Tighten it to a torque of 10 to 12 pounds feet.

POWER COUPLING SYSTEM

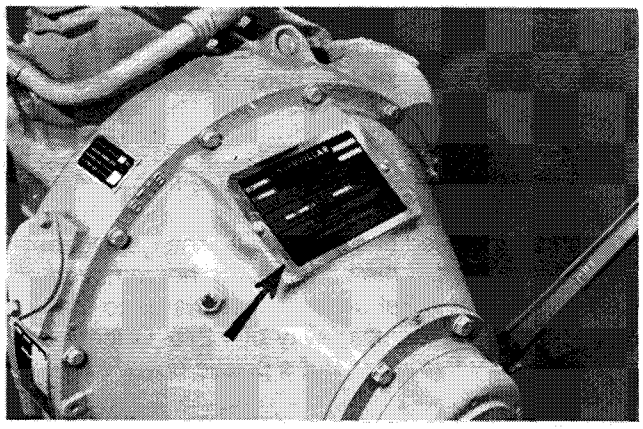
Flywheel And/Or Front Power Take-Off Clutches

Checking Clutch Adjustment

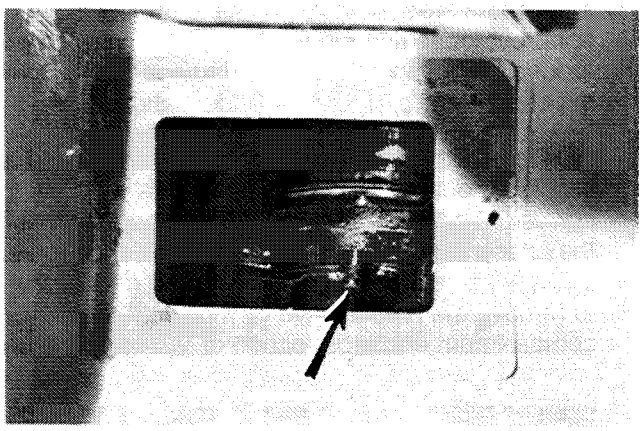
While engaging the clutch to pick up the load, check the clutch adjustment. The clutch should engage with a hard push and distinct snap. If engagement is "soft", adjust the clutch.

Adjusting Clutch Engagement

1. Stop the engine and remove the clutch inspection cover.



2. Turn the clutch until the lock pin, engaged in the locking ring, is visible.
3. Pull the lock pin out and rotate the locking ring clockwise until the lock pin pops into the next notch.



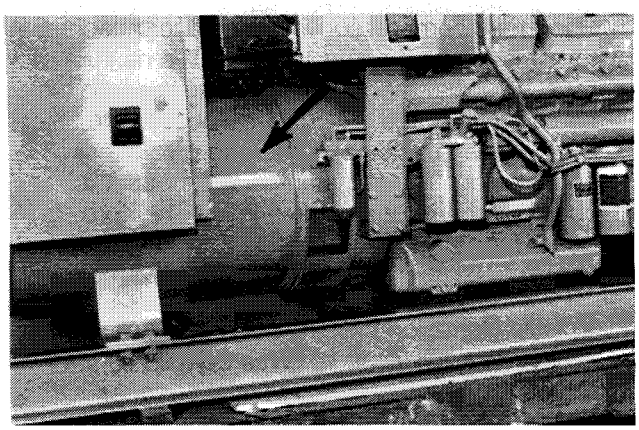
4. Test the clutch adjustment. If still too "soft", rotate the ring to the next notch. If the adjustment is too tight-turn the ring back one notch.
5. Install the cover.

Generator Set

Your electric set engine may be equipped with a Caterpillar SR4 Generator. The SR4 Generator is a brushless design, and therefore requires no periodic maintenance other than lubrication of the rear bearing. See Lubrication Instructions.

The generator serial number is stamped on the generator housing. The first group of numbers, reading from the left, indicates the frame size. Following this number are the letters BS, BH or BG. The letter B indicates the generator is of the SR4 design. The letter S, H or G indicates the voltage rating of the generator. The following numerical digits are the serial number of the generator in that particular frame size and voltage rating. A complete explanation of the numbers and letters in the serial number are found in the GENERATOR SET SYSTEMS OPERATION SECTION. Always use the complete serial number in your communications with your Caterpillar dealer.

If you have a generator of other than Caterpillar design, see the Manufacturer's Instructions.



GENERATOR SERIAL NUMBER LOCATION

Engine Storage

General Information

These instructions give procedures and recommendations that will keep the possibility of damage at a minimum when engines are in storage for one year or less.

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

The best protection for outside parts of the engine is by thorough use of paint. Paint is a good protection for a period storage of up to two years. Thoroughly clean the engine and repaint areas that have paint damage with a good quality paint.

If an engine is not used, oil can run off the cylinder walls, piston rings, main bearings, connecting rod bearings, crankshaft, gears and other parts that normally get lubrication. This lack of lubricant lets corrosion start on the metal, especially in areas of high humidity (water content of the air).

When the engine is started again, before these surfaces get oil, the metal-to-metal contact will cause wear. To keep this wear at a minimum, use the starter to turn the engine with the throttle in fuel OFF position until oil pressure is shown on the pressure gauge.

Use an air compressor with a sprayer attachment to spray external engine parts with a mixture of 50% VCI oil and 50% engine oil to prepare the engine for storage. It should be possible to change the nozzle adjustment to give either spray or fog. The fog adjustment is better if access to components is difficult. The spray is better for parts on the outside.

Volatile Corrosion Inhibitor (VCI) (NOX-RUST VCI #10 oil or equivalent) oil gives both liquid and vapor protection of ferrous metal surfaces against corrosion caused by moisture. In a closed compartment, protection is either by direct contact with VCI oil or by contact with the VCI vapors. See your local supplier for a similar type oil. Additional information as to ordering and use of NOX-RUST VCI #10 and NOX-RUST 1031B rust preventive and a list of suppliers outside the U.S.A. are available from:

Daubert Chemical Co.
1200 Jorie Blvd.
Oakbrook, IL 60521
Telephone: (312) 582-1000

NOTE: Attach a "DO NOT OPERATE" tag on the start switch, start button or air start knob, before servicing the engine. These tags, Form SEHS7332, are available from your Caterpillar dealer.

Storage Procedure

1. Clean the outside of the engine and repaint areas that have paint damage with a good quality paint.

2. Remove the batteries and use them in some other place or put them in storage where they can be checked and electrically charged again when needed. If the batteries are not removed, wash the tops. Put an electrical charge to the battery to a specific gravity of 1.275. Disconnect the battery terminals. Put a plastic cover over the battery.

3. Loosen all fan, alternator belts, etc. Attach a tag to indicate what work has been done.

4. Put a waterproof cover over engines with enclosures stored outdoors. Make the cover tight, but loose enough to allow air to circulate around the engine to prevent damage to exposed metal parts from condensation.

NOTE: Remove the waterproof cover every two or three months and check the engine for corrosion. If the engine has signs of corrosion at the check period, follow the protection procedure again. To operate the engine, it is not necessary to remove the preservative oil mixture. If a compartment under protection of VCI vapors is opened, put more VCI mixture in to make up for the vapor loss.

NOTE: Install all covers and/or put tape over all openings, air intake, exhaust openings, flywheel housing, crankcase breathers, dipstick tubes, etc. Make sure all covers are air tight and weatherproof. Use a waterproof, weather resistant tape.

5. Put lubricant on all points given in the Lubrication and Maintenance Chart.

6. Put a heavy amount of multipurpose grease on all outside parts that move; rod threads, ball joints, linkage, etc.

7. Oil and oil filter elements used less than 50 hours in the engine do not need to be changed. (Otherwise, change the oil, filling the engine to the "add oil" mark on the dipstick.) Add 3% to 4% of VCI oil per engine volume. If the engine is drained, install a mixture of 50% VCI oil and 50% engine oil in the crankcase and in all lubricating oil compartments at the rate of one part VCI oil mixture per fifteen parts of compartment capacity at full level. If possible, operate the engine three to five minutes. Put tape over all openings to seal VCI vapors in the engine.

NOTE: If necessary, drain some lubricant to add to the mixture.

8. Remove any dirt from the air cleaner. Check all seals and gaskets.

9. Remove the air filter elements. Turn the engine at cranking speed with throttle control in fuel OFF position, remove pressure plug for boost pressure and use a sprayer to add a mixture of 50% VCI oil and 50% engine oil. Minimum application rate is 5.5 milliliters per liter (3 oz. per 1000 cubic inches) of engine displacement.

10. Fill the oil reservoir for the air starter with a mixture of 50% VCI oil and 50% engine oil.

11. Use a sprayer to put a mixture of 50% VCI oil and 50% engine oil into the exhaust openings. Minimum application rate is 5.5 milliliters per liter (3 oz. per 1000 cubic inches) of engine displacement.

12. Also, use a sprayer to apply a mixture of 50% VCI oil and 50% engine oil on the flywheel, ring gear teeth and starter pinion. Install the covers to keep the vapors in.

13. Remove the fuel nozzles and install 30 milliliters (1 oz) of 50% VCI oil and 50% engine oil in each cylinder. Test (using calibrating oil) then install fuel nozzles and tighten all fittings to the correct torque. Use an engine turning tool to turn the engine over slowly two complete revolutions in the direction of normal rotation, to put oil on the cylinder walls.

14. Remove the fuel from the secondary fuel filter housing or change the spin-on fuel filter element to get out any dirt and water. Clean the primary fuel filter, fill with calibration oil and operate the priming pump. This will get clean oil to the secondary fuel filter and engine, and help to prevent "sticky" fuel pump nozzles during extended storage.

Calibration oil is available from your Caterpillar dealer in two sizes, 208 liters (55 gallons) or 19 liters (5 gallons). Open the fuel tank drain valve and remove any water or dirt from the inside of the fuel tank.

The fuel must be treated with a Biocide, which prevents bacteria and fungi from contaminating diesel fuel that contains some water. Microbial contamination can cause severe fuel system blockage, filter plugging, fuel pump sticking and corrosion.

Additional information as to ordering and use of diesel fuel Biocide and a list of suppliers outside the U.S.A. are available from:

Amalgamated Coal & Petroleum
Specialists, Inc.
C.P.S. Associates
9214 Ernst Road
Fort Wayne, Indiana 46809
Telephone (219) 747-7080

Methyl Cellosolve will help assimilate water in the fuel and prevent freezing problems. Fill the fuel tank with the treated fuel. Seal all openings to the tank to prevent evaporation of the fuel.

15. Withdraw a sample of coolant and check it for clarity (rust) and freezing point. If it contains suspended particles or does not provide freeze protection to at least −23°C (−10°F), the coolant should be drained. Completely drain the cooling system, if needed. The cooling system must be thoroughly flushed and chemically cleaned.

16. Refill the cooling system with a coolant solution that is 50% water and 50% ethylene glycol. Install a new precharge coolant conditioner element (if equipped with coolant conditioner elements). A 3% to 6% concentration of coolant conditioner does not have to be added, if the cooling system is filled with coolant solution to the top of the filler neck. Attach a tag indicating what has been done.

NOTE: Do not use coolant conditioner elements or liquid coolant conditioner with Dowtherm 209 Full-Fill coolant.

Procedure for Operation After Storage

1. Remove all outside protective covers, and any tape or grease used for protection.

2. Drain the VCI oil and engine oil mixture from the engine, if the oil has been in the engine for more than one year, or if the engine was left drained before adding the VCI mixture. If storage was short term, the engine can be operated with a 3% to 4% VCI mixture in the engine.

3. Tighten the fan and alternator belts. Connect the batteries, check the oil and the coolant level.

4. Use an engine turning tool to turn the engine two complete revolutions in the direction of normal rotation, to make sure there are not hydraulic locks or resistance.

5. Before starting the engine, remove the valve cover or covers and put a large amount of engine oil on the valve mechanism to prevent damage to the valves.

6. To get immediate lubrication and prevent damage to the engine in the first seconds after starting, it is necessary to pressure lubricate the engine. (See "Procedure for Pressure Lubrication" which follows.) Prime the engine with clean diesel fuel before starting.

7. Crank engine with fuel off until oil pressure is observed.

8. On the first day of operation, check the complete engine several times for leaks and correct operation.

9. See Form SEBU5898, Cold Weather Operation Guide, if the engine is removed from storage in temperatures less than −23°C (−10°F).

10. After start-up, add cooling system conditioner as needed.

Pressure Lubrication Introduction

It is very important for an engine to have adequate (needed) lubrication during the first seconds of operation. A dry start (without needed lubrication) of an engine can cause bearing damage. An engine generally has enough oil on the parts for lubrication during engine start-up.

However, this lubrication may not be enough or may be lost if the engine has been in storage for any length of time. To prevent the possibility of a dry start and bearing damage during the first seconds of operation, pressure lubrication of the engine is necessary (fill the main oil passages with oil under pressure).

An optional prelube pump or manual sump pump are available on some engines. When this pump is installed, the crankcase can be filled with the correct quantity of oil. Then the prelube pump will send oil to all parts of the engine so it will have enough lubrication before starting.

Procedure for Pressure Lubrication

1. Connect the oil supply to the main oil passage of the engine.

2. Fill the crankcase with the correct amount of oil. The amount of oil used in the pressure lubrication procedure must be subtracted from the Refill Capacity Chart given in the Operation and Maintenance Guide.

NOTE: Use a minimum of 30% of the engine oil capacity. It may be necessary to fill the tank several times.

Initial Operation After Engine Storage

1. Following engine storage, only an operational check at the first start is necessary before operation.

2. The purpose of this first operational check is to be sure that the pressures and temperatures in the cooling, fuel and lubrication systems are correct, and any leaks are corrected.

3. To be sure of a safe, uniform check at first operation, use the following procedure:

a. Turn the engine at cranking speed with the throttle in fuel OFF position until oil pressure is present.

b. Operate the engine for 5 minutes at low idle speed until the coolant temperature is 66°C (150°F) or higher.

Generator Storage

Storage Procedure

When a generator is in storage for any length of time, moisture condenses in the windings. Minimize the condensation by use of a dry storage space and space heaters. Refer to step 2 below

If a brush-type generator (SRCR) is to be in storage for a year or more, lift the brushes off the slip ring to prevent damage to the slip ring by chemical action.

After Storage

NOTE: Test the main stator windings with a megohmmeter in the following situations:

1. Before initial startup of generator set.

2. Every 3 months* if generator is operating in a humid environment.

3. If 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 environment is extremely humid, salty or if the last megger test was close to 1 megohm.

The megohmmeter test is described in Service Manuals SENR2180 or SENR7968. A reading of 1 meghom or less indicates that the winding has absorbed too much moisture.

To Remove Moisture

To remove moisture caused by high humidity, use one of the following methods to make the generator dry:

1. Energize space heaters in generator if so equipped.

2. Put the generator in an oven at a temperature of not more than 85°C (185°F) for four hours.

CAUTION

If an oven is used for drying, use a forced air type rather than a radiant type. Radiant ovens can cause localized overheating.

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3. Space heaters of the same type used in marine applications, can be installed on generators. (See the Parts Book.) These heaters heat the windings to remove moisture and should be connected at all times in high humidity conditions whenever the generator is not running.

4. Use a canvas enclosure around the generator and heating lamps to increase the temperature. Make an opening in the top for release of moisture.

5. Send a low voltage current through the windings to increase the temperature of the windings. Do not exceed 85°C (185°F).

If the megohmmeter test reads under 1 megohm after the drying or if it goes below 1 megohm shortly after drying, contact your Caterpillar dealer. The insulation has deteriorated and should be reconditioned.

Preventive Maintenance Recommendations for Standby Generator Sets

Information relating to maintenance procedures is included in this engine guide. Further information is available in the Service Manual, or consult your Caterpillar dealer.

Standby Generators

Standby generator sets may not be needed very often, but when they are, it is usually under emergency conditions. Maintenance of these standby units is very important. They must always be in excellent operating condition, ready to work under load at any time. It is recommended that the following Preventive Maintenance Program be established.

⚠ WARNING

The stop-manual-automatic switch on the cranking panel must be set at "stop" position when performing maintenance or repair work on a standby generator set. This prevents the unit from starting if a power failure or voltage drop should occur while working on the unit. Failure to comply could result in personal injury or death.

Make any necessary repairs with the engine stopped and the starting system disabled.

Maintain a log or a record keeping system to document all gauge readings, problems, repairs and maintenance performed on the equipment.

Space Heaters

Moisture is a natural enemy of generators and all electrical equipment. Every effort must be made to keep the generator as dry as possible. Space heaters should be operated inside the generator when it is not in use to maintain the integrity of the generator windings.

Preventive Maintenance for Standby Generator Set Engines To Be Performed By An Authorized Operator

Item	Service
Weekly: Before Starting the Engine	
Walk-Around Inspection	Check the engine, radiator and generator for debris, foreign objects, loose or broken fittings, guards and components. Repair as necessary.
Belts	Inspect for worn, broken or loose belts (alternator, fan, drive, etc.).
Cooling System	Maintain proper coolant level.
Block Heater	Check for proper operation. Maintain 32°C (90°F) coolant temperature in the block at all times.
Air Cleaner Indicator	Check the indicator. Change the air cleaner elements when the indicator diaphragm remains locked.
Engine Crankcase	Check the oil level. Maintain the oil level between the add and full marks on the engine stopped side of the dipstick.
Governor	Check and maintain the oil level (if required).
Fuel System	Check for leaks and drain water separator (if equipped). Keep fuel tank full. Check fuel filter indicator (if equipped).
Air System (If Equipped)	Drain condensate; check air pressure.
Batteries	Maintain electrolyte level, clean batteries if necessary, check for tight connections.
Gauges	Check the condition of all gauges. Repair or replace any broken gauge.
Battery Charger	Check for proper operation. Disconnect charger before starting the engine if it is not capable of handling a cranking load.
Weekly: With Engine Running	
Start the Engine	Run the engine for approximately five minutes while performing these checks. If required, the engine may be operated for as long as 30 minutes. The engine must be loaded if a period longer than 30 minutes is required.
Oil Pressure	Check for proper operating oil pressure. Refer to the Operation section of this guide for the correct pressure reading.
Fuel Pressure	Check for proper operating fuel pressure. Refer to the Operation section of this guide for the correct pressure reading.
Engine Crankcase	Check the oil level. Maintain the oil level between the add and full marks on the engine running side of the dipstick.
Frequency (rpm) and Generated Voltage	Check and record readings. NOTE: The operating voltage of a cold (just started) generator will be slightly higher than the operating voltage of a generator that has been under load and warm. The full load voltage of a SR4 Generator will decrease a maximum of 1% when this generator stabilizes at 100°C (212°F). Most of the voltage decrease occurs in about 30 minutes. Generally, temperatures of generators stabilize within two hours.
Radiator Louvers	Check for proper operation (able to open and close freely).
Leaks and Noises	Check for leaks and unusual noises. NOTE: Engine must be stopped before making necessary repairs.
Weekly: After Stopping the Engine	
Automatic Switches (If Equipped)	Check that all switches are in proper position for automatic start.
Fuel Level	Check the fuel level; refill when below three-fourths full.
Battery Charger	Connect if charger had previously been disconnected. Record charging amperage reading.
Malfunctions	Report any malfunction and make necessary repairs.

Preventive Maintenance For Standby Generator Set Engines To Be Performed By An Authorized Mechanic

Item	Service
Yearly: Before Starting the Engine	
Walk-Around Inspection	Check the engine, radiator, and generator for debris, foreign objects, loose or broken fittings, guards and components. Repair as necessary.
Cooling System	Check for leaks. Add coolant conditioner (if required).
Fuel System	Drain water and sediment from tank. Change fuel filters.
Air Cleaner Element	Inspect; clean or replace.
Governor	Check and maintain oil level (if required).
Engine Crankcase	Check oil level. Maintain oil level between the add and full marks on the engine stopped side of the dipstick.
Engine Crankcase Breather	Clean.
Valve Lash	Check, adjust if necessary. Refer to the engine Service Manual for proper procedure and settings.
Linkages	Check and adjust all linkages, if necessary. Lubricate all linkage fittings.
Alarms and Shutdown Devices	Check; test for proper operation.
Batteries	Check electrolyte level, clean terminals and connections.
Engine	Wipe down; clean as needed.
Generator NOTE: Refer to the generator Service Manual for information relating to use of the megohmmeter and low resistance readings.	Lubricate bearing; vacuum clean and check wiring of the regulator, exciter and stator. Check generator windings with megohmmeter and record readings for reference. Check operation of space heaters.
Yearly: With Engine Running	
Start the Engine	Check all gauges, oil pressure, fuel pressure, rpm (frequency), generated voltage and engine jacket water temperature, for correct readings.
Engine Crankcase	Check the oil level. Maintain the oil level between the add and full marks on the engine running side of the dipstick.
Radiator Louvers	Check for proper operation (able to open and close freely).
Leaks and Noises	Check for leaks and unusual noises. NOTE: Engine must be stopped before making necessary repairs.
Load Test	Load the engine to minimum of 30% of rated load. Operate at this level for minimum of two hours.
Gauge Readings	After approximately one hour record the readings of all gauges: oil pressure, fuel pressure, oil level, rpm (frequency), generated voltage, service meter, engine jacket water temperature, exhaust temperature (if equipped) and manifold vacuum (if equipped).
Yearly: After Stopping the Engine	
Repair or Adjust	Make any repairs or adjustments to the engine and generator set as necessary.
Engine Crankcase	Change oil; take sample for analysis. Change filters, cut old filter open and inspect for foreign material.
Fuel Level	Record the fuel tank level. Fill if below three-fourths full.
Battery Charger	Record charging amperage reading.
Automatic Switches (If Equipped)	Check that all switches are in proper position for automatic start.

Preventive Maintenance For Standby Generator Set Engines To Be Performed By An Authorized Mechanic

Item	Service
Every Three Years: Before Starting the Engine	
Before Starting	Perform all Yearly Before Starting the Engine Preventive Maintenance procedures.
Cooling System	Drain, clean and flush the cooling system. Replace thermostat(s). Refill with coolant solution and conditioner.
Rubber Hoses and Belts	It is recommended that all hoses and belts be replaced at this time to minimize downtime and additional repair cost of component failures caused by these items.
Batteries	Replace all batteries at this interval.
Turbocharger	Inspect, repair or replace if necessary to minimize additional associated component failures.
Engine	Perform a complete engine adjustment and tune-up.
Every Three Years: With Engine Running	
Engine Running	Same as all Yearly With Engine Running Preventive Maintenance procedures.
Exhaust System	Check for leaks. Repair or replace defective components with engine stopped.
Every Three Years: After Stopping the Engine	
After Stopping	Same as all Yearly After Stopping the Engine Preventive Maintenance procedures.

Voltage Regulator and Generator

Clean and Inspect

⚠ WARNING

Before working inside the generator, make sure that the starter motor can not be activated by any automatic or manual signal.

When the engine-generator is operating, voltages up to 600V are present in these areas near or on the regulator:

1. The regulator terminal strip

2. The excitation transformer terminal strip (self-excited generator only).

Do not short these terminals to ground with any part of the body or any conductive material. Loss of life or injury could result from electrical shock or injury from molten metal.

An electrical shock can be received from the regulator capacitor (C1) when the engine-generator is not in operation. To avoid possible injury, discharge the stored charge using an 100 ohm resistor across C1 terminals.

CAUTION

Electronic components in the regulator can be damaged during generator operation if contact is made between the part and ground.

If Moisture is allowed to remain in contact with an electrical winding, some of the moisture will eventually be absorbed. This will lower the resistance of the winding insulation. The insulation used on the windings of Caterpillar generators is moisture resistant, but constant exposure to moisture will gradually lower the insulation's resistance.

Dirt can make the problem worse because it can hold the moisture in contact with the insulation. Salt (from sea air) can also make the problem much worse. This is because salt tends to absorb moisture from the air. When the salt and moisture combine, they make a good electrical conductor.

Clean the voltage regulator and generator of dirt and debris. Use a brush to loosen accumulations of dirt and a vacuum system for removal. Use of compressed air is not recommended, because of moisture present in the form of condensate.

Carbon tracking on insulators can be caused by dirt or loose connections. These carbon paths must be cleaned or the insulators replaced. Failure to correct a carbon tracking problem will eventually result in a short in the electrical circuit.

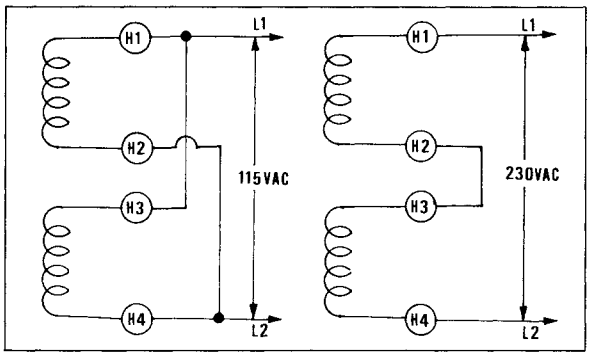
Visually check for loose or broken wires and connections. Check the wires and connections on the regulator assembly. Check that all circuit boards are fully plugged in their sockets. Check all wires and connections in the generator. Make any necessary repairs to the wiring as required. Refer to the "Electric Set Generator Service Manual" for testing and adjusting or disassembly and assembly procedures.

Space Heaters

The SR4 generator can operate in high humidity conditions without problems. However, problems can occur when the generator is idle and the surrounding air is warmer than the generator. Moisture can form on the windings and result in poor performance and even result in damage to the windings. Whenever the generator is not in use, insure that the space heaters are in operation.

An external source of either 115 or 230 (200 v at 50 Hz) volts A.C. is required to operate the space heaters.

Space Heater Connection to External Source H1, H2, H3, H4. Terminal Strip Terminals



If 115 VAC source is available, connect both heaters in parallel across the source (L1-L2). If 230 VAC source is available, connect both heaters in series across the source (L1-L2).

Recommended Periodic Insulation Resistance Checks

Use a megohmmeter to check generator winding insulation resistance periodically. The frequency of the megohmmeter test is determined by the generator's environment and by previous megohmmeter test indications.

Megohmmeter test every 6 months if the generator is installed in an enclosed area with relatively low humidity and mineral temperature variations.

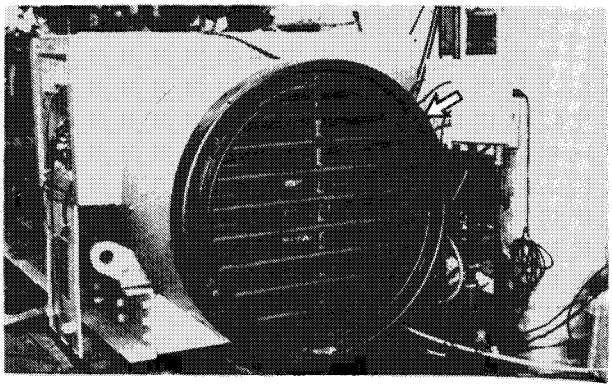
Megohmmeter test every 3 months if the generator is not protected from the elements by an enclosed area.

Megohmmeter test every week and use space heaters if the generator is exposed to a sea water environment or if the surrounding conditions are very humid (relative humidity above 75%) or if a recent megohmmeter test reading was less than 3 megohms. In applications where salt and high humidity are present, space heaters must be operated whenever the generator is not operating under load. This is the only way to maintain megohmmeter test readings above 1 megohm.

Refer to the Testing and Adjusting section of the "Electric Set Generator Service Manual" for the proper procedure to test the windings.

Generator Bearing

Lubricate



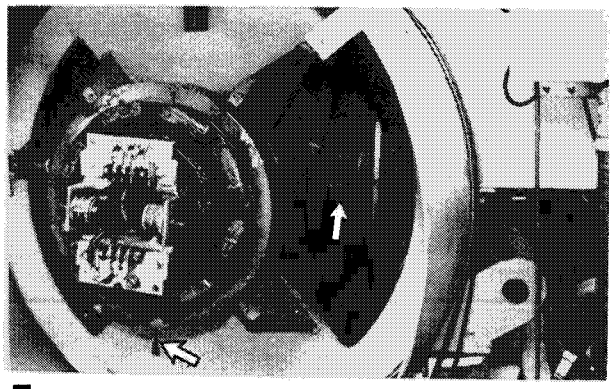
1. Remove the cowl cover from the rear of the generator housing.

2. Remove the right side and lower grease pipe plugs.

3. Install a grease fitting in the right side threaded grease pipe.

4. Lubricate all small frame generators with a grease gun using two (2) pumps of grease. For 680 and larger framed generators, three (3) pumps of grease is required.

Use Multipurpose-type Grease (MPG). NLGI No. 2 Grade is suitable for most temperatures. Use NLGI No. 1 or 0 Grade for extremely low temperatures.



5. Install the lower plug. Wipe off excess grease.

6. Remove the fitting from the right side grease pipe.

7. Start the engine and allow the grease to expand.

8. Stop the engine. Install the plug in the right side grease pipe and wipe off excess grease.

9. Install the cowl cover.

troubleshooting

INDEX

1. ENGINE FAILS TO START

Possible Causes	Remedy
No Fuel to Engine	Check for empty fuel tank, plugged fuel tank connections, obstructed or kinked fuel suction lines, fuel transfer pump failure, or plugged fuel filters.
Shutoff Solenoid Sticking*	Solenoid must be energized to shut off engine. Actuate the control that operates the shutoff solenoid and listen for a clicking sound. If clicking sound is not evident and engine will not start, remove the solenoid. Again try to start the engine. If the engine starts, the solenoid is bad. Replace the solenoid.
Fuel Transfer Pump	At cranking speed, the fuel transfer pump should supply fuel to the engine at 3 PSI (20 kPa). If fuel pressure is less than 3 PSI (20 kPa), replace the fuel filter. Check for air in fuel system, sticking, binding or defective fuel bypass valve. If pressure is still low, replace the fuel transfer pump.
Engine Improperly Timed	See your authorized dealer.
Glow Plug Failure	Check glow plugs.
Automatic and Safety Shutoff Controls	Check shutoff controls to ensure they are set properly. See Starting Procedures.

*Optional Equipment

2. MISFIRING

Possible Causes	Remedy
Defective Fuel Injection Nozzle or Fuel Pump	Run the engine at the speed where the defect is most pronounced. Momentarily loosen the fuel line nut on the injection pump to "cut out" that cylinder. Check each cylinder in this manner. If one is found where loosening makes no difference in irregular operation, the pump and nozzle for only that cylinder need be treated.
Improper Valve Lash	Set to specified clearance.
Incorrect Fuel Injection Timing	See your authorized dealer.
Low Fuel Supply Pressure	Check fuel supply line for leaks or kinks, air in fuel system, sticking, binding, or defective fuel bypass valve. Replace fuel filter. Check fuel pressure. Fuel transfer pump should supply fuel at 20 to 30 PSI (1.4 to 2.1 kg/cm^2) to the engine when the engine is fully loaded.
Broken or Leaking High Pressure Fuel Line	Replace the line.
Air in Fuel System	Find source of air entry and correct. Bleed system.
Bent or Broken Push Rod	Replace push rod.

3. STALLS AT LOW SPEED

Idle Speed Too Low	See your authorized dealer.
Low Fuel Supply Pressure	Check fuel supply line for leaks or kinks, air in fuel system, sticking, binding, or defective fuel bypass valve. Replace fuel filter. Check fuel pressure. Fuel transfer pump shall supply fuel to 20 to 30 PSI (1.4 to 2.1 kg/cm^2) to the engine when the engine is fully loaded.
Defective Fuel Nozzle	Replace nozzle.
Defective or Damaged Fuel Injection Pumps	Replace damaged or defective parts.*
High Parasitic Loads	Check for excessive loading due to auxiliary attachements.

4. ERRATIC ENGINE SPEED

Governor Control Linkage	Adjust external linkage to obtain sufficient travel. Replace if damaged, bent, or linkage is too short.
Governor Failure	Look for damaged or broken springs, linkage, or other components. Determine if the rack can be moved manually. If any distress is noted in any of these components, replace as necessary.*

*Authorized dealers are equipped with the necessary tools and personnel familiar with disassembly and assembly procedures to perform these services.

5. LOW POWER

Possible Causes	Remedy
Fuel Nozzle Failure	Run the engine at the speed where the defect is most pronounced. Momentarily loosen the fuel line nut on the injection pump to "cut out" that cylinder. Check each cylinder in this manner. If one is found where loosening makes no difference in irregular operation, the pump and nozzle for only that cylinder need be tested.
Poor Quality Fuel	Drain, clean and bleed fuel system. Replace fuel filter. Fill fuel tank with proper grade of fuel.
Turbocharger Carboned or Otherwise Dragging	Inspect and repair or replace turbocharger as necessary.*
Leaks in Air Induction System	Check inlet manifold pressure. Check air cleaner for restriction.
Incorrect Fuel Injection Timing	See your authorized dealer.
Excessive Valve Lash	Set to specified clearance.
Low Fuel Supply Pressure	Check fuel supply line for leaks or kinks, air in fuel system, sticking, binding or defective fuel bypass valve. Replace fuel filter. Check fuel pressure. Fuel transfer pump should supply fuel to 20 to 30 PSI (1.4 to 2.1 kg/cm^2) to the engine when the engine is fully loaded.

6. EXCESSIVE VIBRATION

Loose, Worn or Defective Engine Mounts	Tighten all mounting bolts securely. Replace components as necessary.
Loose Pulley and Damper	Retighten.
Loose or Worn Coupling on Driven Equipment	Inspect, align and tighten coupling to driven equipment.
Defective Damper or Pulley	Replace damper or pulley.
Misfiring	See ITEM 2.
Unbalanced Fan Blade	Check by loosening or removing fan belts, and operating engine for "short duration" at affected speed range to see if vibration is still present. If not, replace fan assembly.

7. HEAVY COMBUSTION KNOCK

Possible Causes	Remedy
Air in Fuel System	Bleed air from system.
Defective Fuel Injection Pump Plunger and Barrel Assembly	Replace.*
Defective Fuel Injection Nozzle	Replace.
Incorrect Fuel Injection Timing	See your authorized dealer.*

8. VALVE TRAIN CLICKING NOISE

Excessive Valve Lash	Set to specified clearance.
Broken Valve Spring(s)	Replace valve spring(s) and all other damaged components.*
Insufficient Lubrication	Check lubrication in valve compartment. Should be very wet at all speeds. Oil passages should be cleaned, especially those leading to the cylinder head.

9. OIL IN COOLANT

Failed Oil Cooler Core	Replace oil cooler core.
Failed Head or Spacer Plate Gaskets	Replace head and spacer plate gaskets.
Cracked or Defective Cylinder Block	Replace cylinder block.*
Cracked or Defective Head	Replace cylinder head.

10. MECHANICAL KNOCK

Engine Connecting Rod Bearing Failure	Replace the bearing. Check the connecting rod and crankshaft. Replace if necessary.*
Main Bearing Failure	Replace bearings.*
Damaged Timing Gear Train	Replace components as necessary.*
Broken Crankshaft	Replace crankshaft.*
Fuel Dilution of Crankcase Oil	Correct fuel leakage into crankcase oil.

*Authorized dealers are equipped with the necessary tools and personnel familiar with disassembly procedures to perform these services.

11. EXCESSIVE FUEL CONSUMPTION

Possible Causes	Remedy
Fuel System Leaks	Large changes in fuel consumption may result. Internal leaks will probably be accompanied by low engine oil pressure and increased oil level in the engine oil sump. Replace leaking components.
Fuel and Combustion Knock	Small but measurable increases in fuel consumption may be the result of defective fuel nozzles, misfiring or factors contributing to loss of power. See ITEM 2 and ITEM 5.
Incorrect Fuel Injection Timing	See your authorized dealer.

12. LOUD VALVE TRAIN NOISE

Bent or Broken Valves	Replace damaged parts.*
Broken Camshaft	Replace all damaged parts. Clean engine thoroughly.
Broken or Severely Worn Valve Lifters	Replace camshaft and valve lifters. Check for sticking valves and bent valve stems. Clean engine thoroughly. Set valve lash to specified clearance.

13. EXCESSIVE VALVE LASH

Severely Worn Cam Lobes	Check valve lash. Replace camshaft and followers. Clean engine thoroughly. Set valve lash to specified clearance.
Broken or Severely Worn Valve Lifters	Replace valve lifters. Check camshaft for wear. Check for sticking valves and bent valve stems. Clean engine thoroughly. Set valve lash to specified clearance.
Valve Tip Wear	Set valve lash to specified clearance. If wear is excessive, replace valve.
Moderate Valve Lifter Face Wear	Set valve lash to specified clearance. If wear is excessive, replace valve lifter.
Push Rod Wear	Set valve lash to specified clearance. If wear is excessive, replace push rod.
Rocker Arm Anvil Wear	Set valve lash to specified clearance. If wear is excessive, replace rocker arm.
Insufficient Lubrication	Check lubrication in valve should be very wet at high idle speeds, but only damp at low idle. Oil passages should be cleaned, especially those leading to the cylinder head.

14. VALVE SPRING RETAINER FREE

Possible Causes	Remedy
Broken Keepers	Extensive engine damage may result from dropped valve. Replace all damaged part.*
Broken Valve Spring	Replace valve spring.*
Broken Valve	Replace valve and any other damaged parts.*

15. SLOBBER

Excessive Valve Guide Wear	Recondition cylinder head assembly.*
Excessive Lubricating Oil in Valve Compartment	Check rocker arm shaft and plugs to assure that they are in place.
Worn Piston Rings and/or Liners	Inspect and replace components as necessary.*

16. VALVE LASH CLOSE-UP

Valve Face and/or Seat Wear	Adjust valves to specified clearance. Recondition cylinder head.

17. PREMATURE ENGINE WEAR

Intake Piping Failure (Air Cleaner)	Inspect all gaskets and piping for leaks. Repair all leaks.
Excessive Fuel Dilution of Lubricating Oil	Replace leaking components. This will probably be accompanied by high fuel consumption and low engine oil pressure. Tighten fuel injection line fittings under valve cover.
Dirt in Lubricating Oil	Locate and correct source of dirt entry. Change lubricating oil. Change oil filter.

18. COOLANT IN ENGINE LUBRICATING OIL

Oil Cooler Failure	Replace oil cooler core.
Cylinder Head Gasket Failure	Replace gasket. Maintain proper torque on cylinder head bolts.
Cracked or Defective Cylinder Head	Replace cylinder head.*
Cracked or Defective Cylinder Block	Replace cylinder block.*

*Authorized dealers are equipped with the necessary tools and personnel familiar with disassembly and assembly procedures to perform these serviced.

18. COOLANT IN ENGINE LUBRICATING OIL (Cont'd)

Possible Causes	Remedy
Cylinder Liner Seal Leaking	Replace seals.*
Cracked or Defective Cylinder Liners	Replace cylinder liners.*

19. EXCESSIVE BLACK OR GRAY SMOKE

Insufficient Combustion Air	Check air cleaner for restriction. Check inlet manifold pressure. Inspect turbocharger for proper operation.
Fuel Nozzle Plugged or Leaking	Replace nozzle.
Incorrect Fuel Injection Timing	See your authorized dealer.
Fuel Ratio Control Improperly Adjusted	Adjust fuel ratio control.*

20. EXCESSIVE WHITE OR BLUE SMOKE

Valve Guides Worn	Recondition cylinder head assembly.*
Piston Rings Worn, Stuck or Broken	Replace.*
High Crankcase Oil Level	Avoid overfilling. Determine cause and drain excess oil.
Misfiring	See ITEM 2.
Fuel Injection Pump Timing Wrong	See your authorized dealer.
Air in Fuel System	Bleed fuel system.

21. LOW ENGINE OIL PRESSURE

Engine Oil Diluted with Fuel Oil	Check lip-type seal on fuel transfer pump drive shaft. Drain crankcase and refill with clean lubricant.
Excessive Crankshaft Bearing Clearance	Replace bearings and/or crankshaft.* Check oil filter operation.
Excessive Timing Gear Bearing Clearances	Inspect bearings and replace components as necessary.
Excessive Rocker Arm Bore or Rocker Arm Shaft Wear	Check lubrication. Replace components as necessary.
Defective Oil Pump	Repair or replace.*
Defective Suction Bell	Replace.

21. LOW ENGINE OIL PRESSURE (Cont'd)

Possible Causes	Remedy
Clogged Oil Filter or Cooler	Repair or replace as necessary.
Oil Pump Relief Valve Stuck	Clean valve and housing. Replace if necessary.

22. HIGH LUBRICATING OIL CONSUMPTION

Oil Leaks	Replace gaskets or seals and tighten all connections.
Excessive Oil to Intake	See ITEM 15. Valve Guides.
Excessive Valve Guide Wear	See ITEM 15.
Crankcase Oil Level Too High	Avoid overfilling. Determine cause and drain excess oil.
High Oil Temperature	Check oil cooler bypass valve. Replace if defective. Clean oil cooler core.
Worn Piston Rings and/or Liner	Replace components as necessary.*

23. ABNORMAL ENGINE COOLANT TEMPERATURE

Combustion Gases in Coolant	Determine point at which gases enter the system. Repair or replace components as necessary.
Defective Water Temperature Regulator or Temperature Gauge	Check temperature regulator for proper opening temperature and correct installation. Check temperature gauge. Replace if necessary.
Coolant Level Low	Determine cause—replace leaking gaskets and hoses. Tighten connections. Add coolant.
Air Flow Through Radiator Restricted	Remove all debris from outer surface of radiator.
Defective Water Pump	Check water pump impeller. Repair water pump as necessary.
Radiator Small for Engine Application	Install correct size radiator.
Fan Improperly Positioned in Shroud or Not Shrouded	Position fan correctly.*

*Authorized dealers are equipped with the necessary tools and personnel familiar with disassembly and assembly procedures to perform these services.

23. ABNORMAL ENGINE COOLANT TEMPERATURE

Possible Causes	Remedy
Incorrect Fuel Injection Timing	See your authorized dealer.
Incorrect Water Piping Connections from Engine to Radiator	Check shunt line (if equipped) and vent line for correct installation.

24. STARTING MOTOR FAILS TO CRANK

Low Output from Battery	Check battery and charge or replace.
Defective Wiring or Switch	Repair or replace.
Defective Solenoid	Replace.
Defective Starting Motor	Repair.

25. ALTERNATOR FAILS TO CHARGE

Drive Belt Loose	Adjust belt.
Open or High Resistance in Charging or Ground Return Circuits or Battery Connections	Inspect all cables and connectors. Clean, retighten or replace defective parts.
Excessively Worn, Open or Defective Brushes	Replace brush assembly.*
Open Rotor Field Coil	Replace rotor assembly.*

26. ALTERNATOR CHARGING RATE LOW OR UNSTEADY

Drive Belt Loose	Adjust belt.
Intermittent or High Resistance in Charging or Ground Return Circuits or Battery Connections	Inspect all cables and connectors. Clean, retighten or replace defective parts.
Excessively Worn, Sticky, or Defective Brushes	Replace brush assembly.*
Faulty Regulator	Replace regulator.*
Shorted or Open Rectifier Diodes	Replace defective rectifier diode assembly in alternator.*
Grounded or Shorted Rotor	Replace rotor assembly.*

27. ALTERNATOR CHARGING RATE HIGH

Possible Causes	Remedy
Loose Connections	Tighten connections to alternator and regulator.
Defective Regulator	Replace regulator.

28. ALTERNATOR NOISY

Defective Drive Belt	Replace belt.
Misaligned Belt or Pulley	Align drive pulley, alternator pulley and belt.
Loose Pulley	Tighten pulley nut. If keyway is worn, install a new pulley.
Worn Bearings	Replace bearings.
Shorted Rectifiers in Alternator	Replace diode assembly.*
Armature or Rotor Shaft Bent	Replace component.*

*Authorized dealers are equipped with the necessary tools and personnel familiar with disassembly and assembly procedures to perform these serviced.

MAINTENANCE RECORD

MODEL ______________________________

SERIAL NO. ______________________________

DATE	HOURS	FUEL		LUBE OIL	PARTS		LABOR		DOWN TIME	SERVICE PERFORMED
		QUAN.	COST		PART	COST	TIME	COST		

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