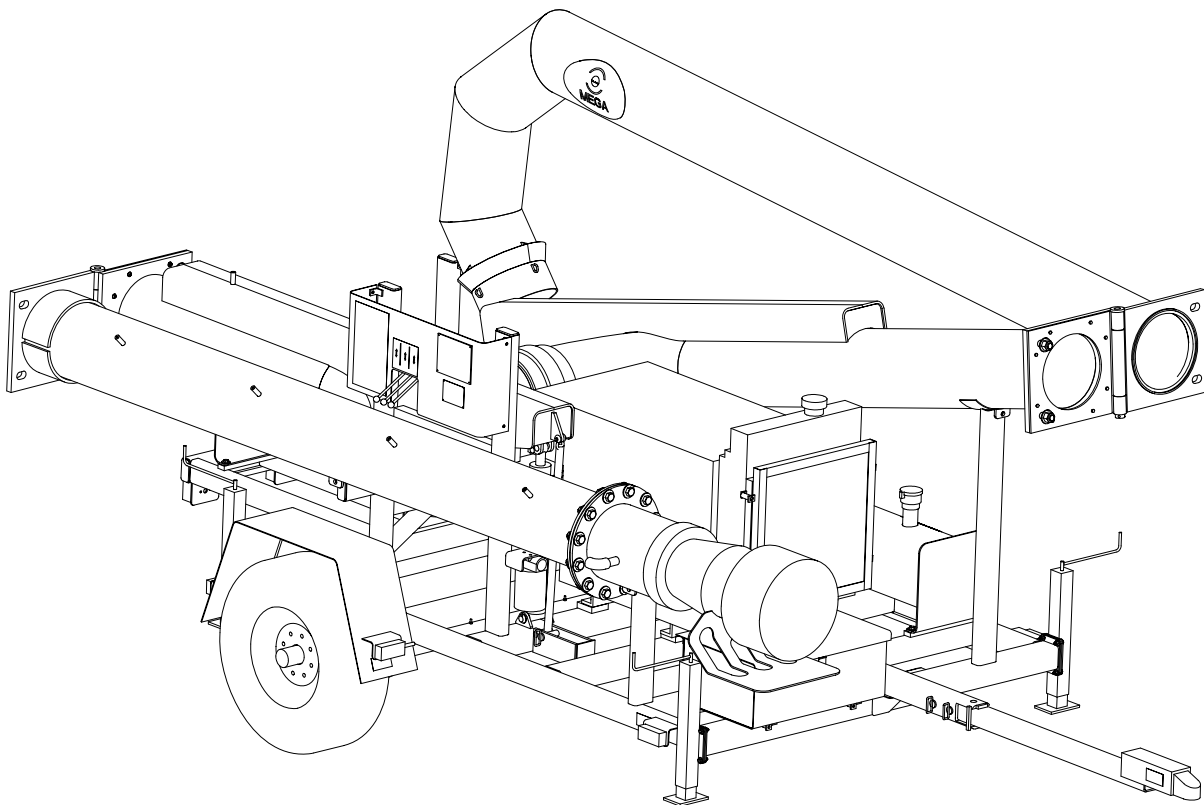




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## Mega Mobile Pump - MMP4 Operation and Maintenance Manual





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## MEGA MOBILE PUMP - MMP4 OPERATION AND MAINTENANCE MANUAL

1. OPERATION INSTRUCTIONS
2. RECOMMENDED SPARE PARTS
3. MAINTENANCE SCHEDULE
4. AXLE MANUAL
5. HYDRAULIC PUMP MANUAL
6. HYDRAULIC CONTROL VALVE MANUAL
7. HYDRAULIC OIL SPECIFICATION AND MSDS
8. WATER PUMP MANUAL
9. DIESEL ENGINE MANUAL
10. DRAWINGS
11. WARRANTY



## MEGA MOBILE PUMP MMP 4

### SETUP AND OPERATING INSTRUCTIONS

- **NOTE:** BEFORE STARTING ENGINE, CHECK ALL FLUID LEVELS: HYDRAULIC OIL, ENGINE OIL AND ENGINE COOLANT. **OPEN** HYDRAULIC TANK VALVE. AFTER STARTING ENGINE CHECK HYDRAULIC OIL LEVEL AND ENGINE GAUGES FOR PROPER OPERATION. (HYDRAULIC PRESSURE 1700 TO 1800PSI)

### SETUP INSTRUCTIONS

- REMOVE TRAVEL MOUNT STRAP (15) ON THE INTAKE SIDE. SET PUMP CONTROL (8) TO THE OFF POSITION. (THIS DIRECTS FULL HYDRAULIC PRESSURE TO THE BOOM CYLINDERS)  
**NOTE:** FOR RAISING BOOMS RUN ENGINE AT IDLE (800 to 1200RPM)
- LOOSEN COUPLING NUTS (14) (APPROXIMATELY 1 TO 2 TURNS)
- START ENGINE AND APPLY HYDRAULICS TO FULLY RAISE THE INTAKE BOOM CYLINDER (9). (**IMPORTANT:** THIS STEP INSURES THE INTAKE BOOM CYLINDER HAS FULL PRESSURE APPLIED AND IS IN THE FULL RAISED POSITION).
- BACK UNIT NEAR WATERS EDGE. PLACE BLOCKS UNDER REAR JACK STAND (3) AND SET. SET WHEEL CHOCKS (11).
- REMOVE PIN AND CHAIN FROM INTAKE BOOM POSITION LOCK (6).
- ATTACH ROPE TO WATER PUMP LIFTING EYE. ROTATE INTAKE BOOM AND PUMP OVER WATER. USE ROPE TO FULLY EXTEND INTAKE BOOM. TIGHTEN INTAKE FLANGE BOLTS (2).

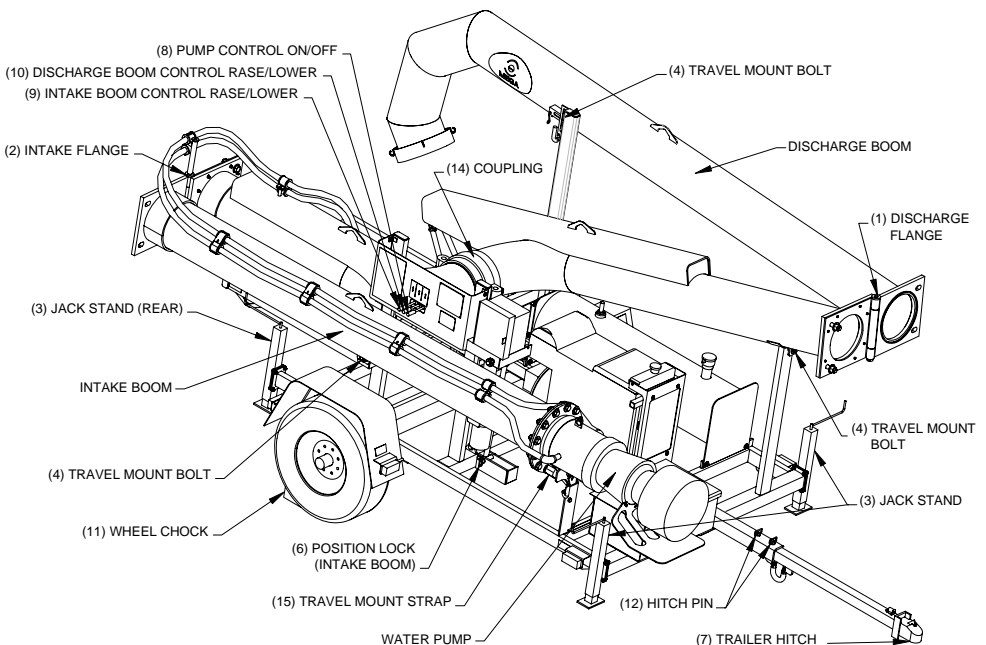
**CAUTION** CARE SHOULD BE TAKEN ROTATING INTAKE BOOM, UNIT MAY BE BACK HEAVY. INSURE THAT REAR JACK STAND (3) IS SET WITH BLOCKING AND HITCH (7) IS LATCHED TO THE TOWING VEHICLE.

- LOWER INTAKE BOOM TO BOTTOM OF POND. THEN DISCONNECT UNIT FROM TOWING VEHICLE, LEVEL UNIT WITH FRONT JACK STAND (3).
- REMOVE DISCHARGE SIDE TRAVEL MOUNT BOLTS (4). ROTATE DISCHARGE BOOM TO THE FULL EXTENDED POSITION AND TIGHTEN FLANGE BOLTS (1).
- LOOSEN DISCHARGE BOOM POSITION LOCK (5), START ENGINE AND RAISE DISCHARGE BOOM TO DESIRED HEIGHT; SET CHAIN AND PIN IN POSITION LOCK (5). (5 NOT SHOWN, LOCATED ON DISCHARGE SIDE).
- RAISE INTAKE BOOM AND PUMP FROM BOTTOM OF POND TO A MIN. 18" BELOW WATER SURFACE, SET POSITION LOCK (6).
- TIGHTEN COUPLING NUTS (14) (APPROXIMATELY 1 TO 2 TURNS OR UNTIL ANY LEAKAGE STOPS)
- TOWING TONGUE AND HITCH CAN BE ROTATED OUT OF THE WAY BY REMOVING PINS (12) THEN SLIDE TONGUE OUT TO MATCH VERTICAL HOLES IN TONGUE AND RECEIVER AND SET WITH PIN (12), ROTATE COUNTERCLOCKWISE.
- TO CONFIGURE FOR TOWING REVERSE SETUP STEPS.

**CAUTION** WHENEVER MOVING INTAKE OR DISCHARGE BOOMS CHECK THAT HYDRAULIC PRESSURE IS APPLIED TO THE CYLINDERS BEFORE REMOVE POSITION LOCK PIN (5 or 6). START ENGINE AND APPLY HYDRAULICS IN THE RAISED DIRECTION TO ENSURE CYLINDERS ARE PRELOADED.

### OPERATING INSTRUCTIONS

- WATER PUMP CAN BE OPERATED TWO WAYS:
  1. USING THE PUMP CONTROL VALVE (8) WILL TURN WATER PUMP ON/OFF WHILE ENGINE IS RUNNING.
  2. VARYING WATER PUMP OUTPUT BY ENGINE RPM (FROM IDLE TO FULL RPM'S).





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### Recommended Spare Parts

COMPONENT	QUANTITY	PART NUMBER
Coupling gasket (Boom pipes)	2	304155
Discharge boom cylinder	1	303923
Hydraulic oil (refill capacity)	35gal	303926
Hydraulic oil filter cartridge	1	304154
Intake boom cylinder	1	303924
Wheel and tire	2	303933
Wheel bearing (inner)	2	304157
Wheel bearing (outer)	2	304158
Wheel bearing grease seal	2	304159
Filter, element, air (primary)	1	304186
Filter, element, air (secondary)	1	304187
Filter, element, fuel	1	304188
Seal, fuel filter	1	304189
Filter element, fuel/water separator	1	304190
Seal, water separator base	1	304191
Filter, engine oil	1	304192
Oil, diesel engine, 10W30 (refill capacity)	8qt	304193
Coolant, extended life (refill capacity)	5.2gal	304194



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### General Parts List

COMPONENT	QUANTITY	PART NUMBER
Axle	1	304237
Battery 12VDC	1	303908
Bearing (water pump)	1	304170
Bushing, lower (water pump)	1	304162
Bushing, suction bowl (water pump)	1	304163
Clearance light (red)	2	302975
Clearance light (yellow)	4	302974
Control valve (hydraulic system, water pump and boom cylinders)	1	304244
Diesel engine	1	304456
Diesel fuel tank	1	039137
Flange hinge assy.	2	037627
Flange hinge pin	2	037627-02
Gasket (flange hinge)	2	304117
Hitch pin	4	303935
Hydraulic motor (water pump)	1	304161
Hydraulic oil cooler	1	303922
Hydraulic oil filter housing	1	303918
Hydraulic oil strainer (hydraulic tank)	1	304100
Hydraulic oil Tank	1	038138
Hydraulic pump	1	304654
Impeller (water pump)	1	304166
Jack stand assy. (front)	2	037708
Junction box (trailer lights)	1	300222
License plate light	1	304124
O ring (water pump)	1	304171
O ring (water pump)	1	304172
Radiator grill	1	037121
Seal, lower (water pump)	1	304167
Seal, upper (water pump)	1	304169
Shackle	2	355020
Shaft (water pump)	1	304168
Stop/turn light	2	302607
Suction bowl (water pump)	1	304164
Suspension, springs	2	303928
Terminal (battery)	2	304146
Thrust collar kit (water pump)	1	304165
Water pump	1	303910
Wiring harness (trailer lights)	1	304119



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MMP4 Maintenance Schedule

COMPONENT	FREQUENCY
Check engine fluid levels; engine oil, coolant, etc (see manual section)	Daily
Check hydraulic oil level	Daily
Check hydraulic pressure (2000psi.)	Daily
Check brake fluid level (see manual section)	Each time used
Check tires and lights	Each time used
Change engine oil and filter (see manual section)	250 hr.
Change hydraulic filter	1000 hr.
Change engine coolant (see manual section)	1000 hr.
Lube axle bearing (see manual section)	1000 mi
Change hydraulic oil	2000 hr.
Inspect axle brakes (see manual section)	Annually
Lube hinges, coupling gasket and pipe mounts	Annually

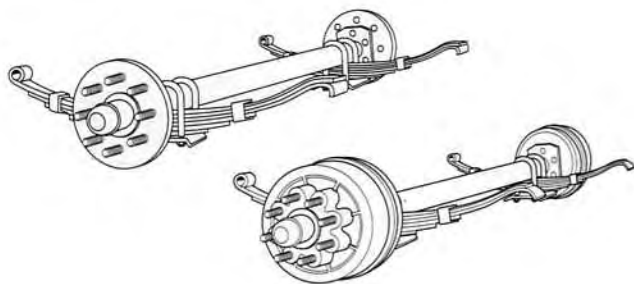


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### Hydraulic System

- Before starting diesel engine, check for hydraulic oil in sight glass on the back of the hydraulic tank. While engine is running hydraulic pressure should be set at 2000psi.
- When filling hydraulic tank engine should be off. Ensure that the system; hoses, cylinders, etc. are full of hydraulic fluid by starting engine, run water pump for five seconds. Intake and discharge booms should be in the towing configuration. Fill hydraulic tank to 80 to 90% of the sight glass.
- NOTE: Check hydraulic oil level regularly; hydraulic system is designed to use minimal oil reserve in case of site leaks and weight concerns. If system will be running for more than five minutes, check temperature not to exceed 160°. Another concern for running system for extended periods is hydraulic oil aeration. This can cause damage to hydraulic components. Check system for foaming or large amounts of bubbles in hydraulic tank through the fill port. Check regularly if unit is running for extended periods.

# Axle Maintenance and Service Manual



*This manual has been designed as a guideline to help you understand, service and maintain your leaf spring axle assembly. Your axles are manufactured by Quality Running Gear, Inc., a division of Quality Trailer Products, Inc.*

## **SUSPENSION CAPACITY**

Your leaf spring suspension has been designed to accommodate the gross vehicle weight rating of your trailer. This rating is established by the trailer manufacturer and can be found on your trailer identification plate. Stay within the gross vehicle rating. *Do not overload.*

## **SUSPENSION TYPE**

There are three basic versions of leaf spring suspensions. These variations are determined by the trailer manufacturer based upon the trailer application. They are single axle, tandem axle and triple axle. Each of these suspension systems are available with slipper springs or double eye springs.



**SLIPPER SPRING**



**DOUBLE EYE SPRING**

Diagram 1 (on page 2) shows the basic parts of single and tandem axle versions with double eye leaf springs. This should help in identifying the various parts of your suspension.



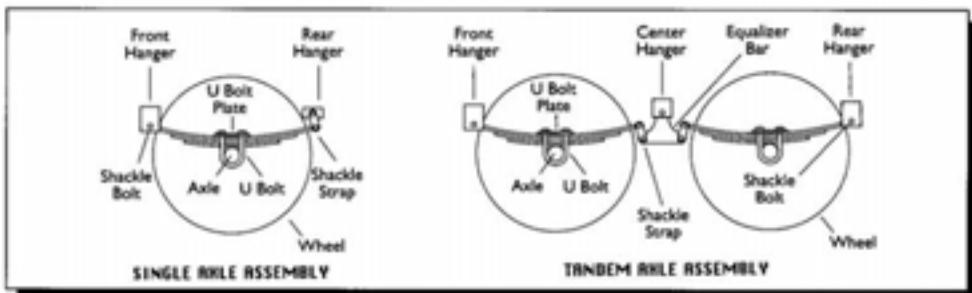
#### • BEARING MAINTENANCE, ADJUSTMENTS, REPLACEMENT AND PACKING OF GREASE

1. Inspect the bearing for corrosion and wear.
2. If any rust or wear exists on the bearing then remove and replace it. See *Diagram 2 for bearing replacement parts.*
3. If the bearings are found to be in good condition, then repacking the grease is all that is needed.
4. If you have a standard spindle (no Accu-Lube grease zerk in the end), then hand pack each bearing individually using a premium water resistant wheel bearing grease.
5. Re-install the hub. (Reverse the *Removal of Hub* procedure found on page 2.)
6. It is important to tighten the spindle nut to approximately 50 ft. lbs. (use a 12" wrench with full hand force). Loosen the nut, then finger tighten.
7. Replace the cotter pin.
8. If you have the Accu-Lube system, remove the rubber plug and place the grease gun onto the zerk. Pump in new grease until you see the new grease flowing from the back of the cap. Wipe off old grease with a towel. Be sure to re-install the rubber plug.

#### TORQUE REQUIREMENTS

It is necessary to periodically check the torque levels of your wheel's lug nuts. They must be maintained at the appropriate level to prevent loose wheels and potentially broken studs and to prevent the wheel from separating from the axle.

**DIAGRAM 1** Top Mount (Overslung) Axles Shown



## INSPECTION AND REPLACEMENT

As a general rule, we recommend that you take your trailer to the nearest trailer repair shop, distributor or service station to have all repairs and maintenance performed on your axles. *Serious injury could occur if proper procedures are not followed.*

**Following are situations in which a certified mechanic should be consulted:**

- Broken axle
- Broken spring
- Worn spring eye bushing parts
- Sagging springs
- Welding fatigue
- Serious leakage of seal
- Tire wear
- Loose or worn suspension parts
- All brake-related adjustments, inspections and problems.

**Following are tasks which someone with general axle knowledge can accomplish:**

### • REMOVAL OF HUB

1. Jack up trailer (see manufacturer's instructions)
2. Remove wheel
3. Remove grease cap
4. Remove cotter pin
5. Unscrew spindle nut counter-clockwise
6. Remove hub from spindle

### • SEAL INSPECTION AND REPLACEMENT

1. Inspect the grease seal to be sure it has not been damaged. Look for tears or cracks. As long as there are not tears or cracks and there is no noticeable leakage then the seal is in good condition.
2. If the seal is torn or cracked then it must be replaced.
3. To remove the seal pry it out of the hub with a screwdriver.
4. Replace the seal. See *Diagram 2* for seal replacement parts. Tap the new seal into place.

## TIGHTENING PROCEDURE

1. To start, put lug nuts on by hand.
2. Tighten initially to 15-20 ft. lbs. using cross tightening sequence (apply 20 lbs. of pressure to a 12" wrench). Proceed to finish, tightening to 80-90 ft. lbs. (for 1/2" studs). See Diagram 4 for other torque requirements. Applying 90 lbs. of pressure to a 12" wrench yields 90 ft. lbs. of torque.
3. Retorque after first 50 miles of use. Retorque periodically.

## DIAGRAM 3

MAINTENANCE SCHEDULE			
Item	3 Months or 3,000 Miles	6 Months or 6,000 Miles	12 Months or 12,000 Miles
Brake Inspection		✓	
Brake Operation	Before Every Use		
Hangers			✓
Hub/Drum			✓
Seals		✓	
Springs			✓
Suspension Parts			✓
Tire Condition	Before Every Use		
Tire Pressure	Before Every Use		
Wheel Bearings		✓	
Wheel Lug Nut (note above)	✓		
Wheels		✓	

## DIAGRAM 4

STUD SIZE AND TORQUE REQUIREMENTS		
Load	Stud Size	Torque Needed
2,000-7,000 lb.	1/2" studs	80-90 ft. lbs.
8,000 lb.	9/16" studs	120-140 ft. lbs.
9,000-10,000 lb.	5/8" studs	175-225 ft. lbs.

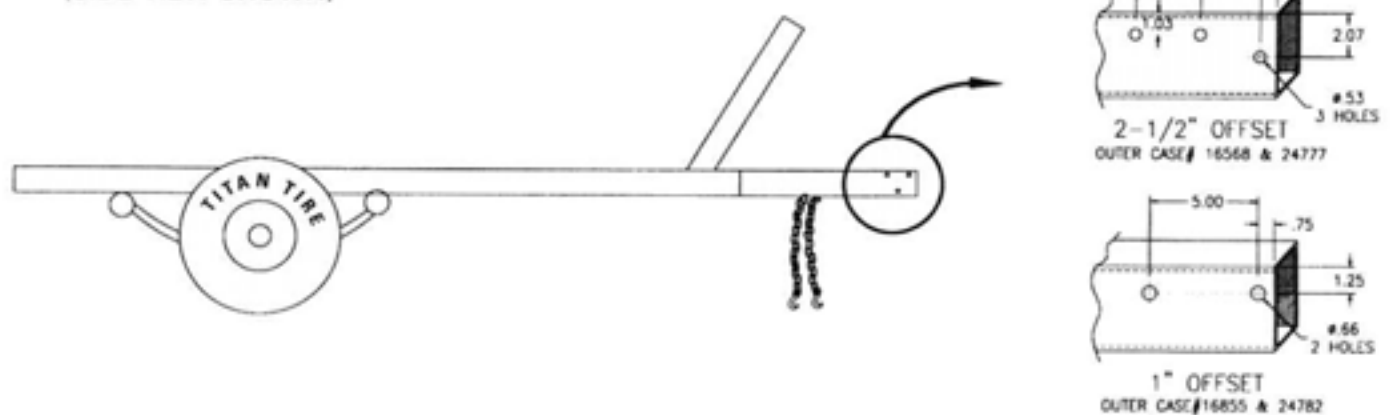
⚠ **WARNING:** ⚠

DO NOT submerge the actuator. Internal corrosion may result and cause brake failure. Salt water, granular fertilizers, and other corrosive materials are destructive to metal. To minimize the damaging effect of corrosion on a braking system used under corrosive conditions, we recommend that the actuator be externally flushed after use with a high pressure water hose. Be sure to lubricate all moving parts after the unit has dried. Whenever the unit will be out of service for an extended period of time, or after hard use, remove the brake drums and clean inside the brakes. Pack wheel bearings with grease before the drum is installed. Failure to properly and adequately grease and maintain the actuator could weaken it and/or cause it to fail and result in serious injury and/or property damage.

## INSTALLATION\*

1. The MODEL 10 Actuator is completely assembled and ready to bolt or weld into place onto straight three inch wide trailer tongues. Welding will make repair or replacement difficult but may be preferred. If the actuator must be painted for aesthetic reasons, then TITAN recommends painting **ONLY** the outer case and disassembling the unit prior to painting. Application of heavy coats of paint may interfere with component operation. If the actuator is welded on, then be sure to weld in a well ventilated area. Confirm the coupler and break-away mechanisms work properly before operation. Store actuators indoors and in their original shipping carton until the time of installation.

FIG.1 - TRAILER AND TRAILER TONGUE BOLT PATTERN (SIDE VIEW SHOWN)



2. For bolt on applications, bolt the actuator to the tongue using three 1/2 inch by 4 inch grade 5 or better bolts, nuts, and lockwashers if using outer case #16568 or #24777 <46>. Figure 1 shows the two standard mounting patterns used on three inch wide trailer tongues. If outer case #16855 or #24782 <47> is used, then the use of two 5/8 inch by 4 inch grade 5 or better bolts nuts and lockwashers is recommended. Using a torque wrench, tighten mounting bolts to eighty (80) foot-pounds torque.
3. Install the hydraulic brakes and brake lines on the trailer as described in the installation manual supplied with the brakes. TITAN recommends 3/16 inch brazed double wall tubing per S.A.E. J527 for use with all our actuator and brake products. Use forty-five degree (45°) double-flare tube ends per S.A.E. J533. **DO NOT** remove or modify the orifice connector <23> at the rear of your actuator's master cylinder. It connects directly to the brake tubing and ensures proper fluid flow characteristics. **FLEXIBLE BRAKE LINE HOSE MUST BE USED** to connect the orifice connector at the master cylinder to the hydraulic brake line on the trailer. This is necessary because the master cylinder is spring mounted to provide overload protection and thus moves relative to the outer case.
4. After installation of the actuator, brake, and brake lines as described above, proceed immediately to the "**BRAKE FLUID FILLING AND BLEEDING**" instructions.

⚠ **WARNING:** ⚠

Failure to complete the "**BRAKE FLUID FILLING AND BLEEDING**" procedures promptly after installation may result in internal master cylinder corrosion and cause brake failure.

\*NOTE: <#> Is the reference number shown in the assembly diagram of the actuator located at the end of this manual.



HYDRAULIC GEAR PUMPS AND MOTORS

# 'C' Series

## SINGLE PUMP



### Performance Data

MODEL SIZE	DISPLACEMENT/REVOLUTION (THEORETICAL)			MAXIMUM PRESSURE		MAXIMUM SPEED (RPM)
	U.S. GALLONS	CUBIC INCHES	CUBIC CENT.	PSI	BAR	
C45	.0038	0.88	14.4	3500	241	3600
C65	.0055	1.27	20.8	3500	241	3600
C85	.0072	1.66	27.2	3500	241	3400
C100	.0085	1.96	32.1	3500	241	3300
C115	.0097	2.24	36.7	3000	207	3100
C150	.0127	2.93	48.1	2500	172	2800
C180	.0152	3.51	57.5	2500*	172	2500
C200	.0169	3.90	63.9	2500*	172	2200

\* CONSULT FACTORY WITH TYPE APPLICATION  
PRESSURES MAY BE LIMITED TO SHAFT TYPE

- CAST IRON THROUGHOUT
- PRESSURES TO 3500 PSI
- FLOWS TO 37 GPM
- HEAVY DUTY SLEEVE TYPE BEARINGS
- DOUBLE VITON® SHAFT SEALS STANDARD
- PRESSURE COMPENSATED THRUST PLATES
- DESIGNED FOR HEAVY DUTY APPLICATIONS
- SINGLE AND MULTI-STAGE CONFIGURATIONS
- VARIOUS SHAFT, FLANGE AND PORT OPTIONS
- PRECISION GEARS MACHINED FROM SOLID BAR STOCK
- COMPATIBLE WITH MOST FIRE RESISTANT FLUIDS
- CONTAMINANT RESISTANT
- COMPUTER DESIGNED AND MANUFACTURED
- QUALITY CERTIFIED
- FLEXIBLE DESIGN FOR NEW OR OEM REPLACEMENTS
- SERVICE SUPPORTED BY DEDICATION AND INVENTORY

P. O. BOX 2160, 1506 FULTON DR.  
CORINTH, MISSISSIPPI 38835

Phone: 662/286-2252 Fax: 662/287-6580 E-mail: [haisales@geartek.com](mailto:haisales@geartek.com) Http: [www.geartek.com](http://www.geartek.com)

## SHAFTS AVAILABLE

<p><b>1</b>      <b>5/8"-9 TOOTH SPLINE</b>            AVAILABLE ON 45 THRU 100 SIZES ONLY            TORQUE LIMIT 52 FT.-LBS.</p> <p><b>FLAT ROOT SIDE FIT</b></p> <table border="1"> <tr><td>DIAMETRAL PITCH</td><td>16/32</td></tr> <tr><td>PRESSURE ANGLE</td><td>30°</td></tr> <tr><td>NO. OF TEETH</td><td>9</td></tr> <tr><td>MINOR DIA.</td><td>.465-.475</td></tr> </table>	DIAMETRAL PITCH	16/32	PRESSURE ANGLE	30°	NO. OF TEETH	9	MINOR DIA.	.465-.475	<p><b>2</b>      <b>7/8"-13 TOOTH SPLINE</b>            TORQUE LIMIT 184 FT.-LBS.</p> <p><b>FLAT ROOT SIDE FIT</b></p> <table border="1"> <tr><td>DIAMETRAL PITCH</td><td>16/32</td></tr> <tr><td>PRESSURE ANGLE</td><td>30°</td></tr> <tr><td>NO. OF TEETH</td><td>13</td></tr> <tr><td>MINOR DIA.</td><td>.722-.733</td></tr> </table>	DIAMETRAL PITCH	16/32	PRESSURE ANGLE	30°	NO. OF TEETH	13	MINOR DIA.	.722-.733
DIAMETRAL PITCH	16/32																
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NO. OF TEETH	13																
MINOR DIA.	.722-.733																
<p><b>5</b>      <b>7/8" STRAIGHT</b>            TORQUE LIMIT 184 FT.-LBS.</p>	<p><b>6</b>      <b>3/4" STRAIGHT</b>            AVAILABLE ON 45 THRU 115 SIZES ONLY            TORQUE LIMIT 105 FT.-LBS.</p>																

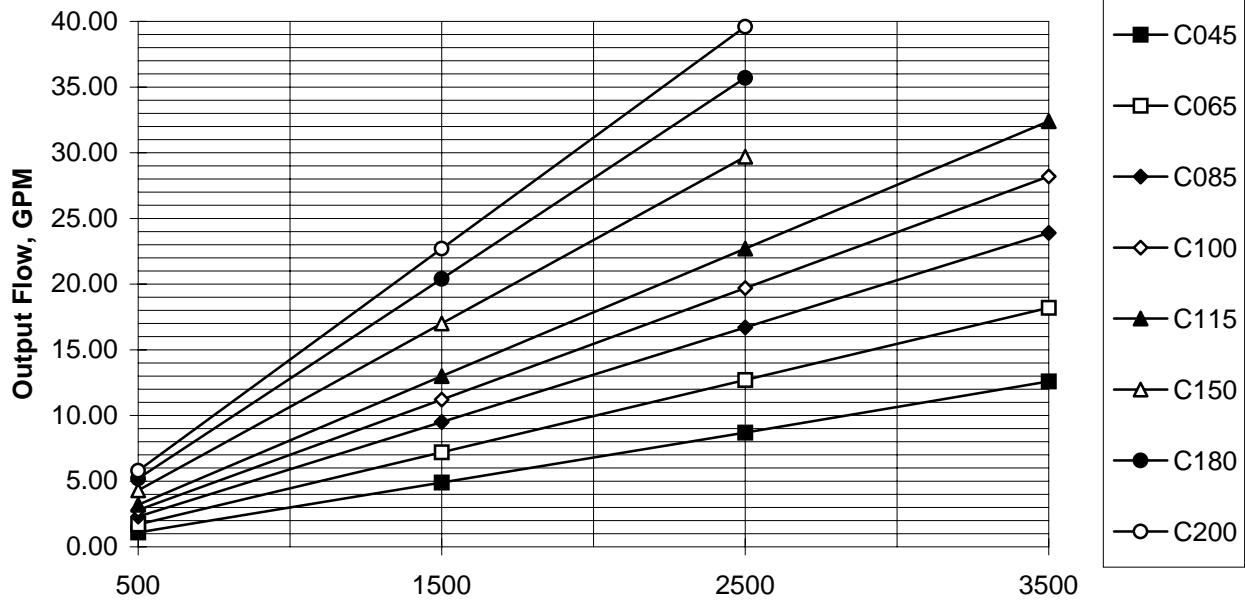
## PORTS AVAILABLE

<p><b>1</b>      <b>REAR PORTED SAE STRAIGHT THREAD</b></p> <p>SUCTION SAE #20 O-RING BOSS      DISCHARGE SAE #16 O-RING BOSS</p>	<p><b>3</b>      <b>SAE 4-BOLT CONNECTOR</b></p> <p>DISCHARGE 3/4" SAE 4-BOLT CONNECTOR      SUCTION 1 1/4" SAE 4-BOLT CONNECTOR</p>
<p><b>5</b>      <b>SIDE PORTED SAE STRAIGHT THREAD</b></p> <p>DISCHARGE SAE #12 O-RING BOSS      SUCTION SAE #20 O-RING BOSS</p>	

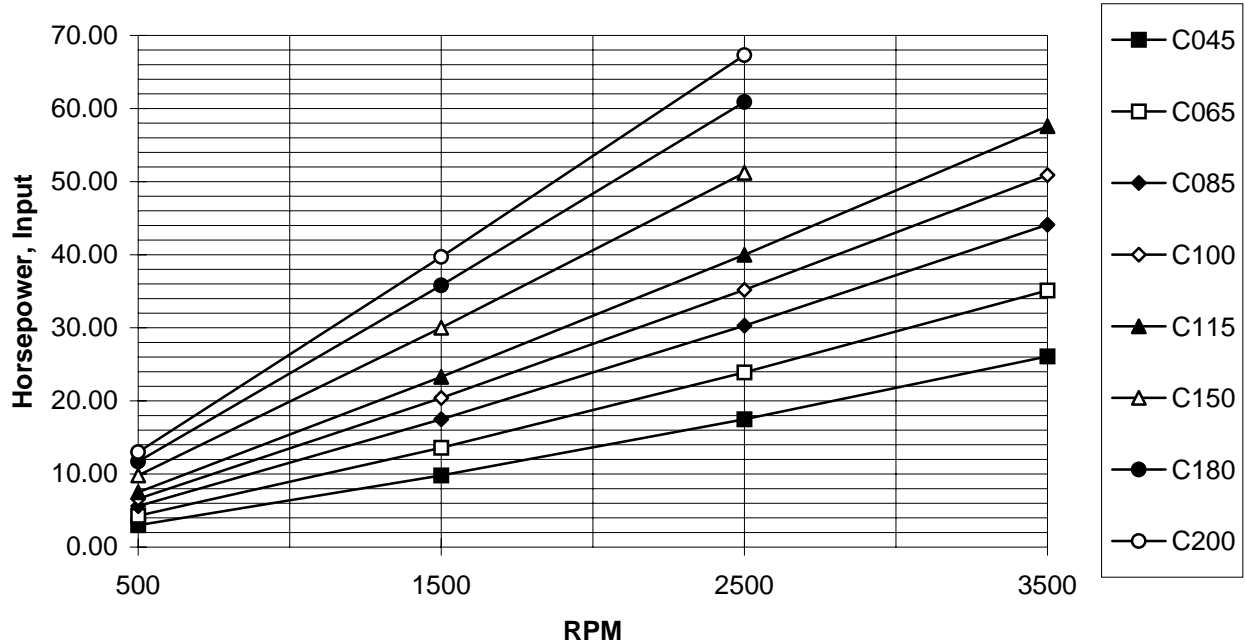


**TYPICAL PERFORMANCE DATA**  
 SAE 10W oil @ 150 DEGREES FAHRENHEIT  
 (150 SSU)

**'C' Series Typical Pump Flow @ 2500 PSI**



**'C' Series Pump Horsepower In @ 2500 PSI**







product card



# NEW RELEASE

vdm8  
MONOBLOCK VALVE

E.01.1001.01.00



### APPLICATIONS:

Directional control valve suitable for telescopic loaders, counterbalance forklift trucks, off-road forklift trucks, service vehicles, earth moving machines, skid-steer loaders, truck cranes.

### HYDRAULIC CONFIGURATION:

parallel circuit, load check valve protection on each section

### NOMINAL FLOW RATE

75 l/min - 20 gpm US

### MAX FLOW RATE

85 l/min - 23 gpm US

### RATED PRESSURE

#### PRESSURE ON "P" PORT

315 bar - 4500 psi

#### PRESSURE ON A&B PORTS

350 bar - 5000 psi

### INTERNAL LEAKAGE

20 cm<sup>3</sup>/min A/B to T at 160 bar - 2300 psi  
(oil temperature of 50°C and viscosity of 16 cSt)

### TECHNICAL SPECIFICATIONS

- simmetrical construction  
spool stroke 7 mm - 0.27 in.  
float spool extra stroke 5 mm - 0.20 in.

### SPOOL CONTROLS:

manual lever, cross lever, cable remote, pneumatic proportional, hydraulic proportional, direct electric on-off, electrohydraulic on-off, electrohydraulic proportional.

### CARRY OVER OPTION:

just plug in the "T" top port by a dowel 1/4" NPTF

### MAIN RELIEF VALVE

located on "A" or "B" port side, can be:  
direct type version up to 260 bar - 3700 psi  
pilot operated with anticavitation version up to 350 bar - 5000 psi

### ELECTRIC BY-PASS VALVE

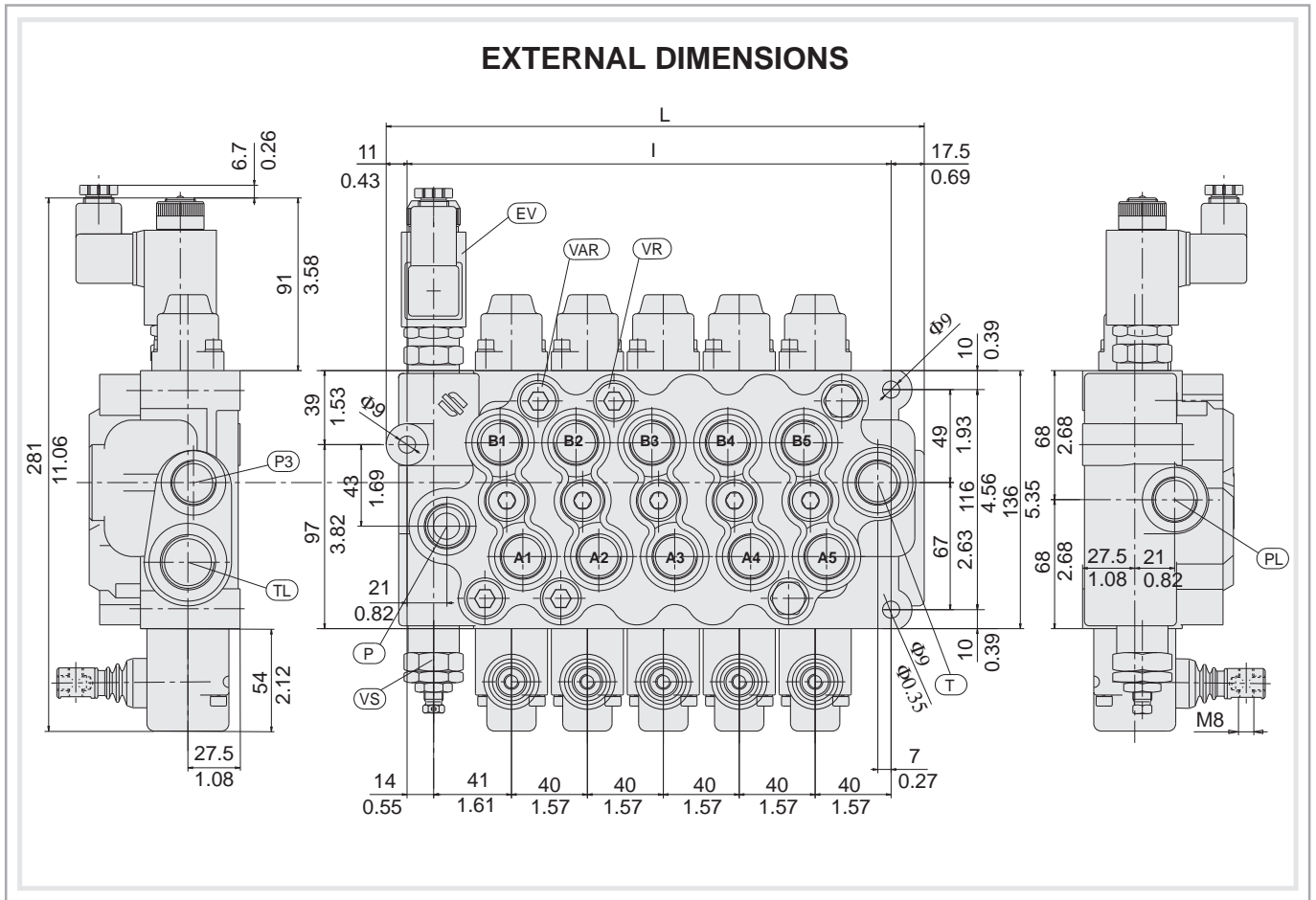
located in the opposite cavity of the main relief valve and is available as:

EV1 - 12 V  $\square$  normally open  
EV2 - 24 V  $\square$  normally open  
EV3 - 12 V  $\square$  normally closed  
EV4 - 24 V  $\square$  normally closed

### AUXILIARY VALVES:

-VAR overload and anti-cavitation valve fix pressure adjusted from 25 to 350 bar - 400 to 5000 psi  
-VR anti-cavitation valve





1 & 6 spools valves not yet available

Spools		1	2	3	4	5	6
<b>I</b>	mm	/	135	175	205	255	/
	in	/	5,31	6,89	8,07	10,03	/
<b>L</b>	mm	/	163.5	203.5	233.5	283.5	/
	in	/	6.43	8.01	9.19	11,16	/

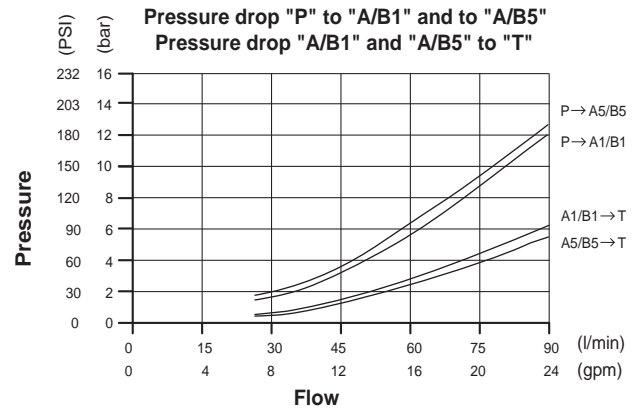
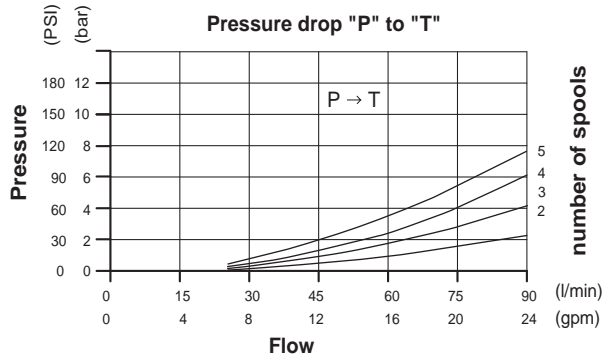
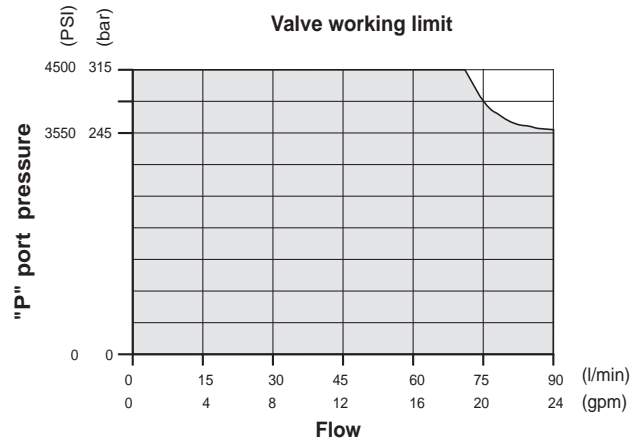
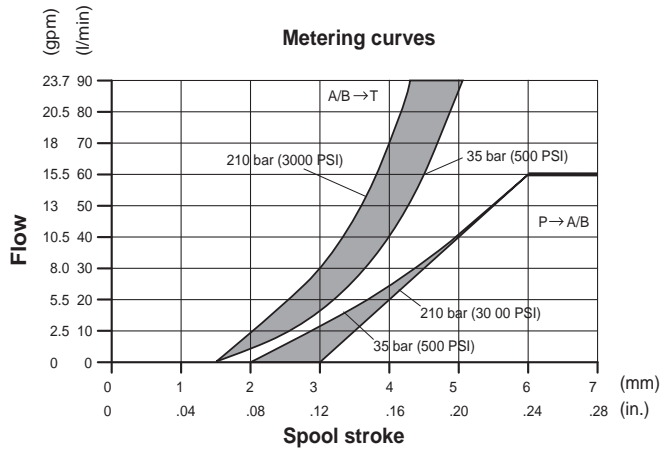
For different size and thread ports consult our sales department

PORT SIZES	P - PL - P3	T - TL	A - B
BSP ISO 228	G 1/2	G 3/4	G 1/2
SAE ISO 176	SAE#10 7/8 - 14 UNF	SAE#12 1-1/16 - 12 UNF	SAE#10 7/8 - 14 UNF

**INDEX:**

- P** = top inlet port
- PL** = side inlet port
- P3** = side outlet port for power beyond
- T** = top outlet port
- TL** = side outlet port
- A/B** = work ports
- VS** = main relief valve(adjustable)
- EV1** = venting valve 12 V normally open
- EV2** = venting valve 24 V normally open
- EV3** = venting valve 12 V normally closed
- EV4** = venting valve 24 V normally closed
- VAR** = overload and anti-cavitation valve
- VR** = anti-cavitation valve

## VALVE PERFORMANCES:



The characteristics in this catalogue are typical measured results.  
During measuring a mineral based hydraulic oil with a viscosity of 16 cSt at a temperature of 50°C was used.

**FOR FURTHER DETAILS PLEASE CONTACT OUR SALES DEPARTEMENT**



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41100 Modena Italy  
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telefax 059 387500  
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b.majorel@wanadoo.fr

# Chevron Clarity® Hydraulic Oils AW

ISO 32, 46, 68

---

## Customer Benefits

Chevron Clarity Hydraulic Oils AW deliver value through

**Premium performance** — Ashless formulation meets or exceeds pump manufacturer's requirements for viscosity, rust and corrosion protection, hydrolytic stability, water separability, foam inhibition, and filterability.

**Superior oxidation stability** — Longer service life than conventional antiwear hydraulic oils or vegetable hydraulic oils.

**Excellent antiwear properties** — Provides excellent wear protection.

**Environmental sensitivity** — Passes the stringent acute aquatic toxicity (L-50) test and is inherently biodegradable, minimizing long-term environmental concerns. Suitable for conventional recycling programs — unlike vegetable hydraulic oils.

## Features

Chevron Clarity Hydraulic Oils AW are designed to give maximum protection to hydraulic pumps in high-performance industrial applications as well as in environmentally sensitive areas.

They are formulated with ISOSYN™ base stocks and an ashless ("zinc-free") additive system that provides superior oxidation stability, water separability, foam suppression, and protection against wear, rust and corrosion.

They are designed to meet or exceed the performance requirements of conventional antiwear hydraulic oils, especially in severe, high-output applications such as axial piston pumps, while providing an additional level of safety in case of leaks or incidental discharge to the environment.

Chevron Clarity Hydraulic Oils AW are long-life lubricants, with dramatically longer TOST (oxidation stability) lives than conventional hydraulic fluids. A longer TOST life equates to longer service life, which improves the customer's bottom line. This level of oxidation stability is especially applicable in high efficiency (high speed, high temperature, high output) applications where severe stress is placed on the hydraulic fluid.

Many hydraulic systems are required to operate in environmentally sensitive areas where leaks or spills of hydraulic fluid may result in contamination of the soil or nearby waterways. Conventional antiwear hydraulic oils are formulated with metal-containing performance additives which will persist in the environment in the event of leaks. Vegetable-based hydraulic oils meet the environmental requirements, but fall short of the performance requirements.



## Applications

Chevron Clarity Hydraulic Oils AW are designed for use in mobile and stationary hydraulic vane-, piston-, and gear-type pumps.

The antiwear performance of these oils makes them especially suited for high performance industrial applications utilizing axial piston pumps where pressures may exceed 5000 psi.

The zinc-free formula makes it perfectly suited for applications involving yellow metals found in axial piston pumps.

They are well suited for applications situated in environmentally sensitive areas.

Chevron Clarity Hydraulic Oils AW have shown excellent performance in applications involving servo-valves using multimetal components.

The ashless formulation of Chevron Clarity Hydraulic Oils AW passes the acute aquatic toxicity (LC-50) criteria adopted by the U.S. Fish and Wildlife Service and the U.S. Environmental Protection Agency.

Chevron Clarity Hydraulic Oils AW meet the requirements of

**Denison** HF-0, HF-2

**Cincinnati Machine** P-68 (ISO 32), P-70 (ISO 46), P-69 (ISO 68)

**Vickers** for use in M-2950-S (mobile) and I-286-S (stationary) hydraulic systems. Passes Vickers 35VQ25 pump test.

Chevron Clarity Hydraulic Oils AW meet the requirements of the USDA for use in federally inspected meat and poultry plants as H2 lubricants where no food contact will occur.

Do not use in high pressure systems in the vicinity of flames, sparks and hot surfaces. Use only in well ventilated areas. Keep container closed.

## Typical Test Data

ISO Grade	32	46	68
CPS Number	230342	230341	230340
MSDS Number	6691	6691	6691
AGMA Grade	—	1	2
API Gravity	32.8	31.9	31.8
Viscosity, Kinematic			
cSt at 40°C	33.6	46.0	64.6
cSt at 100°C	5.6	6.8	8.5
Viscosity, Saybolt			
SUS at 100°F	173	237	334
SUS at 210°F	45.0	49.0	54.8
Viscosity Index	104	101	102
Flash Point, °C(°F)	222(432)	224(435)	224(435)
Pour Point, °C(°F)	-33(-27)	-30(-22)	-30(-22)
Oxidation Stability			
Hours to 2.0 mg KOH/g acid number, ASTM D 943	>18,000	>18,000	>18,000

Typical test data are average values only. Minor variations which do not affect product performance are to be expected in normal manufacturing.

# Material Safety Data Sheet

**SECTION 1 PRODUCT AND COMPANY IDENTIFICATION**

## Cat® ELC™ (Extended Life Coolant) Premix 50/50

**Product Use:** Antifreeze/Coolant  
**Product Number(s):** 16334, CPS216334, CPS226334

**Company Identification**  
ChevronTexaco Global Lubricants  
6001 Bollinger Canyon Road  
San Ramon, CA 94583  
United States of America

**Transportation Emergency Response**  
CHEMTREC: (800) 424-9300 or (703) 527-3887

**Health Emergency**  
ChevronTexaco Emergency Information Center: Located in the USA. International collect calls accepted.  
(800) 231-0623 or (510) 231-0623

**Product Information**  
email : lubemsds@chevron.com  
Product Information: 800-LUBE-TEK

**SECTION 2 COMPOSITION/ INFORMATION ON INGREDIENTS**

COMPONENTS	CAS NUMBER	AMOUNT
Water	7732-18-5	50 - 65 %weight
Ethylene Glycol	107-21-1	35 - 50 %weight
Potassium 2-ethylhexanoate	3164-85-0	1 - 5 %weight
Diethylene glycol	111-46-6	1 - 5 %weight

**SECTION 3 HAZARDS IDENTIFICATION**

\*\*\*\*\*

### EMERGENCY OVERVIEW

- MAY BE HARMFUL OR FATAL IF SWALLOWED
- HARMFUL OR FATAL IF SWALLOWED
- CAUSES EYE IRRITATION
- CONTAINS MATERIAL THAT MAY CAUSE ADVERSE REPRODUCTIVE EFFECTS BASED ON ANIMAL DATA
- POSSIBLE BIRTH DEFECT HAZARD - CONTAINS MATERIAL THAT MAY CAUSE BIRTH DEFECTS BASED ON ANIMAL DATA
- MAY CAUSE DAMAGE TO:
  - KIDNEY

\*\*\*\*\*

478651-00 CAT DEO 10W-30 (DIESEL ENGINE OIL)

MATERIAL SAFETY DATA BULLETIN

-----  
1. PRODUCT AND COMPANY IDENTIFICATION  
-----

PRODUCT NAME: CAT DEO 10W-30 (DIESEL ENGINE OIL)  
SUPPLIER: EXXONMOBIL CORPORATION  
3225 GALLOWS RD.  
FAIRFAX, VA 22037

24 - Hour Health and Safety Emergency (call collect): 609-737-4411

24 - Hour Transportation Emergency:  
CHEMTREC: 800-424-9300 202-483-7616  
LUBES AND FUELS: 281-834-3296

Product and Technical Information:  
Lubricants and Specialties: 800-662-4525 800-443-9966  
Fuels Products: 800-947-9147  
MSDS Fax on Demand: 613-228-1467  
MSDS Internet Website: <http://emmsds.ihssolutions.com/>

-----  
2. COMPOSITION/INFORMATION ON INGREDIENTS  
-----

CHEMICAL NAMES AND SYNONYMS: SEVERE TREAT MIN. OILS & ADDITIVES

GLOBALLY REPORTABLE MSDS INGREDIENTS:

Substance Name	Approx. Wt%
PHOSPHORODITHIOIC ACID,	1-5
O,O-DI-C1-14-ALKYL ESTERS,	
ZINC SALT (2:1) ZDDP	
(68649-42-3)	

See Section 8 for exposure limits (if applicable).

-----  
3. HAZARDS IDENTIFICATION  
-----

Under normal conditions of use, this product is not considered hazardous according to regulatory guidelines (See section 15).

EMERGENCY OVERVIEW: Amber Liquid. DOT ERG No. : NA

POTENTIAL HEALTH EFFECTS: Under normal conditions of intended use, this product does not pose a risk to health. Excessive exposure may



result in eye, skin or respiratory irritation.

For further health effects/toxicological data, see Section 11.

---

#### 4. FIRST AID MEASURES

---

EYE CONTACT: Flush thoroughly with water. If irritation occurs, call a physician.

SKIN CONTACT: Wash contact areas with soap and water. Remove and clean oil soaked clothing daily and wash affected area. (See Section 16 - Injection Injury)

INHALATION: Not expected to be a problem. However, if respiratory irritation, dizziness, nausea, or unconsciousness occurs due to excessive vapor or mist exposure, seek immediate medical assistance. If breathing has stopped, assist ventilation with a mechanical device or mouth-to-mouth resuscitation.

INGESTION: Not expected to be a problem. Seek medical attention if discomfort occurs. Do not induce vomiting.

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#### 5. FIRE-FIGHTING MEASURES

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EXTINGUISHING MEDIA: Carbon dioxide, foam, dry chemical and water fog.

SPECIAL FIRE FIGHTING PROCEDURES: Water or foam may cause frothing. Use water to keep fire exposed containers cool. Water spray may be used to flush spills away from exposure. Prevent runoff from fire control or dilution from entering streams, sewers, or drinking water supply.

SPECIAL PROTECTIVE EQUIPMENT: For fires in enclosed areas, fire fighters must use self-contained breathing apparatus.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None.

COMBUSTION PRODUCTS: Fumes, smoke, carbon monoxide, sulfur oxides, aldehydes and other decomposition products, in the case of incomplete combustion.

Flash Point C(F): 227(441) (ASTM D-92).

Flammable Limits (approx.% vol.in air) - LEL: 0.9%, UEL: 7.0%

NFPA HAZARD ID: Health: 0, Flammability: 1, Reactivity: 0

---

#### 6. ACCIDENTAL RELEASE MEASURES

---

NOTIFICATION PROCEDURES: Report spills/releases as required to appropriate authorities. U.S. Coast Guard and EPA regulations require immediate reporting of spills/releases that could reach any waterway including intermittent dry creeks. Report spill/release to Coast Guard National Response Center toll free number (800)424-8802. In case of accident or road spill notify CHEMTREC (800) 424-9300.

PROCEDURES IF MATERIAL IS RELEASED OR SPILLED:

LAND SPILL: Shut off source taking normal safety precautions. Take measures to minimize the effects on ground water. Recover by pumping or contain spilled material with sand or other suitable absorbent and remove mechanically into containers. If necessary, dispose of adsorbed residues as directed in Section 13.

WATER SPILL: Confine the spill immediately with booms. Warn other ships in the vicinity. Notify port and other relevant authorities. Remove from the surface by skimming or with suitable absorbents. If permitted by regulatory authorities the use of suitable dispersants should be considered where recommended in local oil spill procedures.

ENVIRONMENTAL PRECAUTIONS: Prevent material from entering sewers, water sources or low lying areas; advise the relevant authorities if it has, or if it contaminates soil/vegetation.

PERSONAL PRECAUTIONS: See Section 8

---

## 7. HANDLING AND STORAGE

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HANDLING: No special precautions are necessary beyond normal good hygiene practices. See Section 8 for additional personal protection advice when handling this product.

STORAGE: Keep containers closed when not in use. Do not store in open or unlabelled containers. Store away from strong oxidizing agents and combustible materials. Do not store near heat, sparks, flame or strong oxidants.

SPECIAL PRECAUTIONS: Prevent small spills and leakages to avoid slip hazard.

EMPTY CONTAINER WARNING: Empty containers retain residue (liquid and/or vapor) and can be dangerous. DO NOT PRESSURIZE, CUT, WELD, BRAZE, SOLDER, DRILL, GRIND OR EXPOSE SUCH CONTAINERS TO HEAT, FLAME, SPARKS, STATIC ELECTRICITY, OR OTHER SOURCES OF IGNITION; THEY MAY EXPLODE AND CAUSE INJURY OR DEATH. Do not attempt to refill or clean container since residue is difficult to remove. Empty drums should be completely drained, properly bunged and promptly returned to a drum reconditioner. All containers should be disposed of in an environmentally safe manner and in accordance with governmental regulations.

---

## 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

---

### OCCUPATIONAL EXPOSURE LIMITS:

When mists/aerosols can occur, the following are recommended: 5 mg/m<sup>3</sup> (as oil mist)- ACGIH Threshold Limit Value (TLV), 10 mg/m<sup>3</sup> (as oil mist) - ACGIH Short Term Exposure Limit (STEL), 5 mg/m<sup>3</sup> (as oil mist) - OSHA Permissible Exposure Limit (PEL)

VENTILATION: If mists are generated, use adequate ventilation, local exhaust or enclosures to control below exposure limits.

RESPIRATORY PROTECTION: If mists are generated, and/or when ventilation is not adequate, wear approved respirator.

EYE PROTECTION: If eye contact is likely, safety glasses with side shields or chemical type goggles should be worn.

SKIN PROTECTION: Not normally required. When splashing or liquid contact can occur frequently, wear oil resistant gloves and/or other protective clothing. Good personal hygiene practices should always be followed.

-----  
9. PHYSICAL AND CHEMICAL PROPERTIES  
-----

Typical physical properties are given below. Consult Product Data Sheet for specific details.

APPEARANCE: Liquid  
COLOR: Amber  
ODOR: Mild  
ODOR THRESHOLD-ppm: NE  
pH: NA  
BOILING POINT C(F): > 316(600)  
MELTING POINT C(F): NA  
FLASH POINT C(F): 227(441) (ASTM D-92)  
FLAMMABILITY (solids): NE  
AUTO FLAMMABILITY C(F): NA  
EXPLOSIVE PROPERTIES: NA  
OXIDIZING PROPERTIES: NA  
VAPOR PRESSURE-mmHg 20 C: NE  
VAPOR DENSITY: NE  
EVAPORATION RATE: NE  
RELATIVE DENSITY, 15/4 C: 0.866  
SOLUBILITY IN WATER: Negligible  
PARTITION COEFFICIENT: > 3.5  
VISCOSITY AT 40 C, cSt: 74.0  
VISCOSITY AT 100 C, cSt: 11.5  
POUR POINT C(F): -33(-27)  
FREEZING POINT C(F): NE  
VOLATILE ORGANIC COMPOUND: NE  
DMSO EXTRACT, IP-346 (WT.%): <3, for mineral oil only  
NA=NOT APPLICABLE NE=NOT ESTABLISHED D=DECOMPOSES

FOR FURTHER TECHNICAL INFORMATION, CONTACT YOUR MARKETING REPRESENTATIVE

-----  
10. STABILITY AND REACTIVITY  
-----

STABILITY (THERMAL, LIGHT, ETC.): Stable.  
CONDITIONS TO AVOID: Extreme heat and high energy sources of ignition.  
INCOMPATIBILITY (MATERIALS TO AVOID): Strong oxidizers.  
HAZARDOUS DECOMPOSITION PRODUCTS: Product does not decompose at ambient temperatures.  
HAZARDOUS POLYMERIZATION: Will not occur.

-----  
11. TOXICOLOGICAL DATA  
-----

---ACUTE TOXICOLOGY---

ORAL TOXICITY (RATS): Practically non-toxic (LD50: greater than 2000 mg/kg). ---Based on testing of similar products and/or the components.  
DERMAL TOXICITY (RABBITS): Practically non-toxic (LD50: greater than 2000 mg/kg). ---Based on testing of similar products and/or the

components.

INHALATION TOXICITY (RATS): Practically non-toxic (LC50: greater than 5 mg/l). ---Based on testing of similar products and/or the components.

EYE IRRITATION (RABBITS): Practically non-irritating. (Draize score: greater than 6 but 15 or less). ---Based on testing of similar products and/or the components.

SKIN IRRITATION (RABBITS): Practically non-irritating. (Primary Irritation Index: greater than 0.5 but less than 3). ---Based on testing of similar products and/or the components.

OTHER ACUTE TOXICITY DATA: Although an acute inhalation study was not performed with this product, a variety of mineral and synthetic oils, such as those in this product, have been tested. These samples had virtually no effect other than a nonspecific inflammatory response in the lung to the aerosolized mineral oil. The presence of additives in other tested formulations (in approximately the same amounts as in the present formulation) did not alter the observed effects.

---SUBCHRONIC TOXICOLOGY (SUMMARY)---

No significant adverse effects were found in studies using repeated dermal applications of similar formulations to the skin of laboratory animals for 13 weeks at doses significantly higher than those expected during normal industrial exposure. The animals were evaluated extensively for effects of exposure (hematology, serum chemistry, urinalysis, organ weights, microscopic examination of tissues etc.).

---REPRODUCTIVE TOXICOLOGY (SUMMARY)---

No teratogenic effects would be expected from dermal exposure, based on laboratory developmental toxicity studies of major components in this formulation and/or materials of similar composition.

---CHRONIC TOXICOLOGY (SUMMARY)---

Repeated and/or prolonged exposure may cause irritation to the skin, eyes or respiratory tract. Overexposure to oil mist may result in oil droplet deposition and/or granuloma formation. For mineral base oils: Base oils in this product are severely solvent refined and/or severely hydrotreated. Chronic mouse skin painting studies of severely treated oils showed no evidence of carcinogenic effects. These results are confirmed on a continuing basis using various screening methods such as Modified Ames Test, IP-346, and/or other analytical methods. For synthetic base oils: The base oils in this product have been tested in the Ames assay and other tests of mutagenicity with negative results. These base oils are not expected to be carcinogenic with chronic dermal exposures.

---SENSITIZATION (SUMMARY)---

Not expected to be sensitizing based on tests of this product, components, or similar products.

---OTHER TOXICOLOGY DATA---

Used gasoline engine oils have shown evidence of skin carcinogenic activity in laboratory tests when no effort was made to wash the oil off between applications. Used oil from diesel engines did not produce this effect.

-----  
12. ECOLOGICAL INFORMATION  
-----

ENVIRONMENTAL FATE AND EFFECTS:

In the absence of specific environmental data for this product, this assessment is based on information for representative products.

ECOTOXICITY: Available ectotoxicity data (LL50 >1000 mg/L) indicates that adverse effects to aquatic organisms are not expected from this product.

MOBILITY: When released into the environment, adsorption to sediment and soil will be the predominant behavior.

PERSISTENCE AND DEGRADABILITY: This product is expected to be inherently biodegradable.

BIOACCUMULATIVE POTENTIAL: Bioaccumulation is unlikely due to the very low water solubility of this product, therefore bioavailability to aquatic organisms is minimal.

-----  
13. DISPOSAL CONSIDERATIONS  
-----

WASTE DISPOSAL: Product is suitable for burning in an enclosed, controlled burner for fuel value. Such burning may be limited pursuant to the Resource Conservation and Recovery Act. In addition, the product is suitable for processing by an approved recycling facility or can be disposed of at an appropriate government waste disposal facility. Use of these methods is subject to user compliance with applicable laws and regulations and consideration of product characteristics at time of disposal.

RCRA INFORMATION: The unused product, in our opinion, is not specifically listed by the EPA as a hazardous waste (40 CFR, Part 261D), nor is it formulated to contain materials which are listed hazardous wastes. It does not exhibit the hazardous characteristics of ignitability, corrosivity, or reactivity. The unused product is not formulated with substances covered by the Toxicity Characteristic Leaching Procedure (TCLP). However, used product may be regulated.

-----  
14. TRANSPORT INFORMATION  
-----

USA DOT: NOT REGULATED BY USA DOT.

RID/ADR: NOT REGULATED BY RID/ADR.

IMO: NOT REGULATED BY IMO.

IATA: NOT REGULATED BY IATA.

STATIC ACCUMULATOR (50 picosiemens or less): YES

-----  
15. REGULATORY INFORMATION  
-----

US OSHA HAZARD COMMUNICATION STANDARD: When used for its intended purposes, this product is not classified as hazardous in accordance with OSHA 29 CFR 1910.1200.

EU Labeling: Product is not dangerous as defined by the European Union Dangerous Substances/Preparations Directives. EU labeling not required.

Governmental Inventory Status: All components comply with TSCA, EINECS/ELINCS, AICS, METI, DSL, and PHILIPPINES.

U.S. Superfund Amendments and Reauthorization Act (SARA) Title III: This product contains no "EXTREMELY HAZARDOUS SUBSTANCES".

SARA (311/312) REPORTABLE HAZARD CATEGORIES: None.

This product contains the following SARA (313) Toxic Release Chemicals:

CHEMICAL NAME	CAS NUMBER	CONC.
-----	-----	-----
ZINC DITHIOPHOSPHATE	68649-42-3	1.1%

The following product ingredients are cited on the lists below:

CHEMICAL NAME	CAS NUMBER	LIST CITATIONS
-----	-----	-----
ZINC (ELEMENTAL ANALYSIS) (0.13%)	7440-66-6	22
ZINC DITHIOPHOSPHATE (1.11%)	68649-42-3	18, 20, 21, 22, 24,

25

--- REGULATORY LISTS SEARCHED ---

1=ACGIH ALL	6=IARC 1	11=TSCA 4	16=CA P65 CARC	21=LA RTK
2=ACGIH A1	7=IARC 2A	12=TSCA 5a2	17=CA P65 REPRO	22=MI 293
3=ACGIH A2	8=IARC 2B	13=TSCA 5e	18=CA RTK	23=MN RTK
4=NTP CARC	9=OSHA CARC	14=TSCA 6	19=FL RTK	24=NJ RTK
5=NTP SUS	10=OSHA Z	15=TSCA 12b	20=IL RTK	25=PA RTK
				26=RI RTK

Code key: CARC=Carcinogen; SUS=Suspected Carcinogen; REPRO=Reproductive

-----  
16. OTHER INFORMATION  
-----

USE: COMMERCIAL ENGINE OIL

NOTE: PRODUCTS OF EXXON MOBIL CORPORATION AND ITS AFFILIATED COMPANIES ARE NOT FORMULATED TO CONTAIN PCBS.

Health studies have shown that many hydrocarbons pose potential human health risks which may vary from person to person. Information provided on this MSDS reflects intended use. This product should not be used for other applications. In any case, the following advice should be considered:

INJECTION INJURY WARNING: If product is injected into or under the skin, or into any part of the body, regardless of the appearance of the wound or its size, the individual should be evaluated immediately by a physician as a surgical emergency. Even though initial symptoms from high pressure injection may be minimal or absent, early surgical treatment within the first few hours may significantly reduce the ultimate extent of injury.

INDUSTRIAL LABEL

Under normal conditions of intended use, this product does not pose a risk to health. Excessive exposure may result in eye, skin or respiratory irritation. Always observe good hygiene measures. First Aid: Wash skin with soap and water. Flush eyes with water. If overcome by fumes or vapor, remove to fresh air. If ingested do not induce vomiting. If symptoms persist seek medical assistance. Read and understand the MSDS before using this product.

\*\*\*\*\*  
For Internal Use Only: MHC: 1\* 1\* 1\* 1\* 1\*, MPPEC: A, TRN: 478651-00,  
CMCS97: 97X126, REQ: MRCTEC - LUBES, SAFE USE: L  
EHS Approval Date: 07FEB2003  
\*\*\*\*\*

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## IMMEDIATE HEALTH EFFECTS

**Eye:** Contact with the eyes causes irritation. Symptoms may include pain, tearing, reddening, swelling and impaired vision.

**Skin:** Contact with the skin is not expected to cause prolonged or significant irritation. Not expected to be harmful to internal organs if absorbed through the skin.

**Ingestion:** Toxic; may be harmful or fatal if swallowed.

**Inhalation:** The vapor or fumes from this material may cause respiratory irritation. Symptoms of respiratory irritation may include coughing and difficulty breathing. Breathing this material at concentrations above the recommended exposure limits may cause central nervous system effects. Central nervous system effects may include headache, dizziness, nausea, vomiting, weakness, loss of coordination, blurred vision, drowsiness, confusion, or disorientation. At extreme exposures, central nervous system effects may include respiratory depression, tremors or convulsions, loss of consciousness, coma or death.

## DELAYED OR OTHER HEALTH EFFECTS:

**Reproduction and Birth Defects:** Contains material that may cause adverse reproductive effects based on animal data. Contains material that may be harmful to the developing fetus based on animal data.

**Target Organs:** Contains material that may cause damage to the following organ(s) following repeated ingestion based on animal data: Kidney

See Section 11 for additional information. Risk depends on duration and level of exposure.

## SECTION 4 FIRST AID MEASURES

**Eye:** Flush eyes with water immediately while holding the eyelids open. Remove contact lenses, if worn, after initial flushing, and continue flushing for at least 15 minutes. Get medical attention if irritation persists.

**Skin:** To remove the material from skin, use soap and water. Discard contaminated clothing and shoes or thoroughly clean before reuse.

**Ingestion:** If swallowed, get immediate medical attention. Do not induce vomiting. Never give anything by mouth to an unconscious person.

**Inhalation:** Move the exposed person to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention if breathing difficulties continue.

## SECTION 5 FIRE FIGHTING MEASURES

### FIRE CLASSIFICATION:

OSHA Classification (29 CFR 1910.1200): Not classified by OSHA as flammable or combustible.

**NFPA RATINGS:** Health: 2 Flammability: 0 Reactivity: 0

### FLAMMABLE PROPERTIES:

**Flashpoint:** NA

**Autoignition:** NDA

**Flammability (Explosive) Limits (% by volume in air):** Lower: NA Upper: NA

**EXTINGUISHING MEDIA:** Dry Chemical, CO<sub>2</sub>, AFFF Foam or alcohol resistant foam.

### PROTECTION OF FIRE FIGHTERS:

**Fire Fighting Instructions:** For fires involving this material, do not enter any enclosed or confined fire space without proper protective equipment, including self-contained breathing apparatus.

**Combustion Products:** Highly dependent on combustion conditions. A complex mixture of airborne solids, liquids, and gases including carbon monoxide, carbon dioxide, and unidentified organic

compounds will be evolved when this material undergoes combustion. Combustion may form oxides of: Potassium .

## SECTION 6 ACCIDENTAL RELEASE MEASURES

**Spill Management:** Stop the source of the release if you can do it without risk. Contain release to prevent further contamination of soil, surface water or groundwater. Clean up spill as soon as possible, observing precautions in Exposure Controls/Personal Protection. Use appropriate techniques such as applying non-combustible absorbent materials or pumping. Where feasible and appropriate, remove contaminated soil. Place contaminated materials in disposable containers and dispose of in a manner consistent with applicable regulations.

**Reporting:** Report spills to local authorities and/or the U.S. Coast Guard's National Response Center at (800) 424-8802 as appropriate or required.

## SECTION 7 HANDLING AND STORAGE

**Precautionary Measures:** Do not get in eyes. Do not taste or swallow. Wash thoroughly after handling. Do not breathe vapor or fumes.

**General Handling Information:** Do not taste or swallow antifreeze or solution. Keep out of the reach of children and animals.

**General Storage Information:** Do not store in open or unlabeled containers.

**Container Warnings:** Container is not designed to contain pressure. Do not use pressure to empty container or it may rupture with explosive force. Empty containers retain product residue (solid, liquid, and/or vapor) and can be dangerous. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose such containers to heat, flame, sparks, static electricity, or other sources of ignition. They may explode and cause injury or death. Empty containers should be completely drained, properly closed, and promptly returned to a drum reconditioner or disposed of properly.

## SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

### GENERAL CONSIDERATIONS:

Consider the potential hazards of this material (see Section 3), applicable exposure limits, job activities, and other substances in the work place when designing engineering controls and selecting personal protective equipment. If engineering controls or work practices are not adequate to prevent exposure to harmful levels of this material, the personal protective equipment listed below is recommended. The user should read and understand all instructions and limitations supplied with the equipment since protection is usually provided for a limited time or under certain circumstances.

### ENGINEERING CONTROLS:

Use process enclosures, local exhaust ventilation, or other engineering controls to control airborne levels below the recommended exposure limits.

### PERSONAL PROTECTIVE EQUIPMENT

**Eye/Face Protection:** Wear protective equipment to prevent eye contact. Selection of protective equipment may include safety glasses, chemical goggles, face shields, or a combination depending on the work operations conducted.

**Skin Protection:** No special protective clothing is normally required. Where splashing is possible, select protective clothing depending on operations conducted, physical requirements and other substances in the workplace. Suggested materials for protective gloves include: Natural rubber, Neoprene, Nitrile Rubber, Polyvinyl Chloride (PVC or Vinyl).

**Respiratory Protection:** Determine if airborne concentrations are below the recommended exposure limits. If not, wear an approved respirator that provides adequate protection from measured concentrations of this material, such as: Air-Purifying Respirator for Organic Vapors, Dusts and Mists. Use a positive pressure air-supplying respirator in circumstances where air-purifying respirators may not

provide adequate protection.

**Occupational Exposure Limits:**

Component	Limit	TWA	STEL	Ceiling	Notation
Ethylene Glycol	ACGIH_TLV			100 mg/m3	
Ethylene Glycol	OSHA_PEL			125 mg/m3	
Ethylene Glycol	ACGIH			39.4 ppm (weight)	

**SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES**

**Attention: the data below are typical values and do not constitute a specification.**

**Color:** Red  
**Physical State:** Liquid  
**Odor:** NDA  
**pH:** 8.1 - 8.9  
**Vapor Pressure:** NDA  
**Vapor Density (Air = 1):** 2.1  
**Boiling Point:** 228 °F (109 C)  
**Solubility:** Miscible  
**Freezing Point:** -34 °F (-37 C)  
**Melting Point:** NDA  
**Specific Gravity:** 1 - 1.5 @ 15.6 °C / 15.6 °C  
**Viscosity:** <20 cSt @ 40 °C

**SECTION 10 STABILITY AND REACTIVITY**

**Chemical Stability:** This material is considered stable under normal ambient and anticipated storage and handling conditions of temperature and pressure.  
**Incompatibility With Other Materials:** May react with strong oxidizing agents, such as chlorates, nitrates, peroxides, etc.  
**Hazardous Decomposition Products:** Aldehydes (Elevated temperatures)  
**Hazardous Polymerization:** Hazardous polymerization will not occur.

**SECTION 11 TOXICOLOGICAL INFORMATION**

**IMMEDIATE HEALTH EFFECTS**

**Eye Irritation:** The eye irritation hazard is based on evaluation of data for similar materials or product components.  
**Skin Irritation:** The skin irritation hazard is based on evaluation of data for similar materials or product components.  
**Skin Sensitization:** No product toxicology data available.  
**Acute Dermal Toxicity:** The acute dermal toxicity hazard is based on evaluation of data for similar materials or product components.  
**Acute Oral Toxicity:** The acute oral toxicity hazard is based on evaluation of data for similar materials or product components.  
**Acute Inhalation Toxicity:** The acute inhalation toxicity hazard is based on evaluation of data for similar materials or product components.

**ADDITIONAL TOXICOLOGY INFORMATION:**

This product contains ethylene glycol (EG). The toxicity of EG via inhalation or skin contact is expected to be slight at room temperature. The estimated oral lethal dose is about 100 cc (3.3 oz.) for an adult

human. Ethylene glycol is oxidized to oxalic acid which results in the deposition of calcium oxalate crystals mainly in the brain and kidneys. Early signs and symptoms of EG poisoning may resemble those of alcohol intoxication. Later, the victim may experience nausea, vomiting, weakness, abdominal and muscle pain, difficulty in breathing and decreased urine output. When EG was heated above the boiling point of water, vapors formed which reportedly caused unconsciousness, increased lymphocyte count, and a rapid, jerky movement of the eyes in persons chronically exposed. When EG was administered orally to pregnant rats and mice, there was an increase in fetal deaths and birth defects. Some of these effects occurred at doses that had no toxic effects on the mothers. We are not aware of any reports that EG causes reproductive toxicity in human beings.

2-Ethylhexanoic acid (2-EXA) caused an increase in liver size and enzyme levels when repeatedly administered to rats via the diet. When administered to pregnant rats by gavage or in drinking water, 2-EXA caused teratogenicity (birth defects) and delayed postnatal development of the pups. Additionally, 2-EXA impaired female fertility in rats. Birth defects were seen in the offspring of mice who were administered sodium 2-ethylhexanoate via intraperitoneal injection during pregnancy.

This product contains diethylene glycol (DEG). The estimated oral lethal dose is about 50 cc (1.6 oz) for an adult human. DEG has caused the following effects in laboratory animals: liver abnormalities, kidney damage and blood abnormalities. It has been suggested as a cause of the following effects in humans: liver abnormalities, kidney damage, lung damage and central nervous system damage.

## SECTION 12 ECOLOGICAL INFORMATION

### ECOTOXICITY

The toxicity of this material to aquatic organisms has not been evaluated. Consequently, this material should be kept out of sewage and drainage systems and all bodies of water.

### ENVIRONMENTAL FATE

This material is expected to be readily biodegradable.

## SECTION 13 DISPOSAL CONSIDERATIONS

Use material for its intended purpose or recycle if possible. This material, if it must be discarded, may meet the criteria of a hazardous waste as defined by US EPA under RCRA (40 CFR 261) or other State and local regulations. Measurement of certain physical properties and analysis for regulated components may be necessary to make a correct determination. If this material is classified as a hazardous waste, federal law requires disposal at a licensed hazardous waste disposal facility.

## SECTION 14 TRANSPORT INFORMATION

The description shown may not apply to all shipping situations. Consult 49CFR, or appropriate Dangerous Goods Regulations, for additional description requirements (e.g., technical name) and mode-specific or quantity-specific shipping requirements.

**DOT Shipping Name:** NOT REGULATED AS A HAZARDOUS MATERIAL FOR TRANSPORTATION UNDER 49 CFR

**DOT Hazard Class:** NOT APPLICABLE

**DOT Identification Number:** NOT APPLICABLE

**DOT Packing Group:** NOT APPLICABLE

## SECTION 15 REGULATORY INFORMATION

<b>SARA 311/312 CATEGORIES:</b>	1. Immediate (Acute) Health Effects:	YES
	2. Delayed (Chronic) Health Effects:	YES

- |                                       |    |
|---------------------------------------|----|
| 3. Fire Hazard:                       | NO |
| 4. Sudden Release of Pressure Hazard: | NO |
| 5. Reactivity Hazard:                 | NO |

**REGULATORY LISTS SEARCHED:**

- |                     |                         |
|---------------------|-------------------------|
| 4_I1=IARC Group 1   | 15=SARA Section 313     |
| 4_I2A=IARC Group 2A | 16=CA Proposition 65    |
| 4_I2B=IARC Group 2B | 17=MA RTK               |
| 05=NTP Carcinogen   | 18=NJ RTK               |
| 06=OSHA Carcinogen  | 19=DOT Marine Pollutant |
| 09=TSCA 12(b)       | 20=PA RTK               |

The following components of this material are found on the regulatory lists indicated.  
Ethylene Glycol 15, 17, 18, 20

**CERCLA REPORTABLE QUANTITIES(RQ)/SARA 302 THRESHOLD PLANNING QUANTITIES(TPQ):**

Component	Component RQ	Component TPQ	Product RQ
Ethylene Glycol	5000 lbs	None	10963 lbs

**CHEMICAL INVENTORIES:**

CANADA: One or more components of this product are not on the Domestic Substances List (DSL). Volume tracking or notification by the Canadian Importer of Record may be required.

EUROPEAN UNION: All the components of this material are in compliance with the EU Seventh Amendment Directive 92/32/EEC.

UNITED STATES: All of the components of this material are on the Toxic Substances Control Act (TSCA) Chemical Inventory.

**NEW JERSEY RTK CLASSIFICATION:**

Refer to components listed in Section 2.

**WHMIS CLASSIFICATION:**

- Class D, Division 1, Subdivision B: Toxic Material - Acute Lethality
- Class D, Division 2, Subdivision A: Very Toxic Material - Chronic Toxic Effects
- Teratogenicity and Embryotoxicity
- Reproductive Toxicity
- Class D, Division 2, Subdivision B: Toxic Material - Chronic Toxic Effects
- Skin or Eye Irritation

**SECTION 16 OTHER INFORMATION**

<b>NFPA RATINGS:</b>	Health: 2	Flammability: 0	Reactivity: 0
<b>HMIS RATINGS:</b>	Health: 2*	Flammability: 0	Reactivity: 0

(0-Least, 1-Slight, 2-Moderate, 3-High, 4-Extreme, PPE:- Personal Protection Equipment Index recommendation, \*- Chronic Effect Indicator). These values are obtained using the guidelines or published evaluations prepared by the National Fire Protection Association (NFPA) or the National Paint and Coating Association (for HMIS ratings).

**REVISION STATEMENT:** This revision updates the following sections of this Material Safety Data Sheet:  
1, 2, 3, 15

**ABBREVIATIONS THAT MAY HAVE BEEN USED IN THIS DOCUMENT:**

TLV	-	Threshold Limit Value	TWA	-	Time Weighted Average
STEL	-	Short-term Exposure Limit	PEL	-	Permissible Exposure Limit
			CAS	-	Chemical Abstract Service Number
NDA	-	No Data Available	NA	-	Not Applicable
<=	-	Less Than or Equal To	>=	-	Greater Than or Equal To

Prepared according to the OSHA Hazard Communication Standard (29 CFR 1910.1200) and the ANSI MSDS Standard (Z400.1) by the ChevronTexaco Energy Research & Technology Company, 100 Chevron Way, Richmond, California 94802.

**The above information is based on the data of which we are aware and is believed to be correct as of the date hereof. Since this information may be applied under conditions beyond our control and with which we may be unfamiliar and since data made available subsequent to the date hereof may suggest modifications of the information, we do not assume any responsibility for the results of its use. This information is furnished upon condition that the person receiving it shall make his own determination of the suitability of the material for his particular purpose.**

### Standard Buna-N Seals and O-Rings

All standard Gresen products utilize Buna-N seals which are compatible with petroleum base, water-in-oil emulsions, and water-glycol fluids. Phosphate ester type fire-resistant fluids will cause Buna-N seals to swell. This swelling is not normally detrimental to static seals, but will be a problem for dynamic seals such as valve spool seals. Swelling of these seals can result in binding. The temperature range of Buna-N seals is -40°F to +200°F [-40°C to +93°C].

**Table 1. Cross Reference for Seals and O-Rings Buna-N to Viton**

Buna-N Part No.	Viton Part No.	Application
0926-001	6273-001	Relief Seal
1615-001	7447-001	Relief and Check Seal
1660-001	7880-001	Check Seal
1698-001	6276-001	Relief and Check Seal
1718-001	7446-001	Relief and Check Seal
1818-001	7444-001	WCA Relief
	7446-001	WC Relief, NR Plug
2707-001	7448-001	Relief Seal
2709-001	6277-001	Relief and NR Plug

### Optional Viton Seals and O-Rings

Viton Seals are recommended for most applications that use phosphate ester type fluids. Viton seals are also recommended for applications that have a continuous operating temperature of +200°F [+93°C] or more. Viton seals are available for Gresen Model 25P Valves.

**Table 2. Cross Reference For Seal Kits, Buna-N to Viton**

Buna-N Part No.	Viton Part No.	Application
K-6006-C	K-6042	WC Relief
K-7014	K-28033	No Relief "NR" Plug Kit



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WATER PUMP  
Maintenance Instructions

PREVENTIVE MAINTENANCE:

1. Always be sure to use only clean, filtered hydraulic oil to drive the hydraulic motor. Your hydraulic system should have a filter rated at 10 micron filtration.
2. When connecting the hydraulic hoses to the pump, be sure to keep hose connections clean.
3. Use hydraulic oils with anti-wear additives such as these recommended oils or their equivalent:

Pennzoil AW46 Hydraulic Oil  
Texaco Rando HDAZ  
Shell Tellas Hydraulic Oils  
Mobil D.T.E. 20 Series  
Chevron EP Hydraulic Oils  
Exxon Univis N Hydraulic Oils

Note: When using this equipment in environmentally sensitive areas we recommend using a bio-degradable oil such as Chevron Clarity, Exxon Univis Bio 40 or Mobil EAL 224H.

4. Check oil level in the bearing housing every 500 hours. The level should be at the spill point of the fill plug. Do not overfill !!!
5. Change oil in the bearing housing every 1000 hours. Use clean hydraulic oil or NON-detergent 10W or 20W motor oil. (See Note @ 3. above)
6. Slight discoloration of the oil in the bearing housing is normal. This is due to the wearing of the carbon face seal.
7. Presence of water or emulsified oil in the bearing housing indicates immediate need for seal replacement and inspection of bearing.
8. Lube suction bowl bushing every 1000 hours or annually. (Mystic 5496 Marine Grease)

DISASSEMBLY:

1. Remove strainer by loosening (4) screws (#14).
2. To inspect impeller (#20) remove (8) bolts (#11) holding suction bowl (#13) to discharge bowl (#22). Remove suction bowl and check impeller and suction bowl face for excessive wear. Replace if obvious wear is present or if pump performance is poor.
3. To inspect hydraulic motor (#1) upper bearing (#27) and upper seal (#26), use the following procedure:
  - A) Remove hydraulic pipes (#5) to motor.
  - B) Remove (8) bolts (#8) holding discharge bowl to discharge pipe (#2).
  - C) Remove discharge pipe assembly.
  - D) Remove (4) bolts (#33) holding hydraulic motor to bearing housing (#7).
  - E) Inspect hydraulic motor. If a faulty motor is suspected, replace motor or contact Hydra-Tech Pumps, Inc. for location of a repair center in your area.
  - F) Inspect motor "O"Ring (#31) and replace if necessary.
  - G) Drain oil from bearing housing by tilting unit on side and removing drain plug (#34). Inspect condition of oil. If oil is low or is emulsified with water, the upper seal (#26) should be replaced.
  - H) Remove snap ring (#29) near end of shaft (#24).
  - I) Remove shaft collar (#6) by loosening set screws on collar by inserting an Allen wrench through the oil plug hole in the bearing housing.
  - J) Remove bearing housing by lifting straight up. (Bearing will remain in housing).
  - K) Remove snap ring (#28) and slide bearing (#27) out of housing. Inspect for rough spots and replace if necessary.
  - L) Inspect lower "O"Ring (#35) and upper shaft seal and replace if necessary.
  - M) Remove shaft seal and spring retainer (#33) by sliding off shaft.





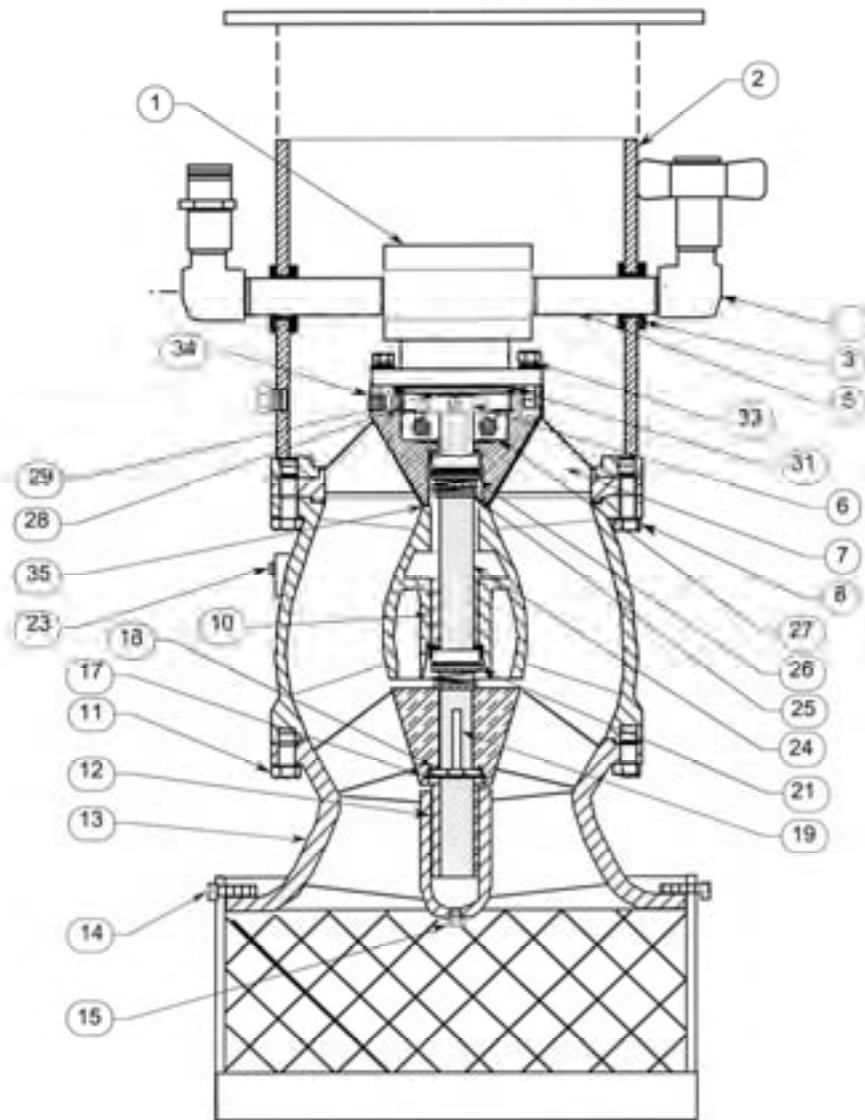
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Note: Use clean grease when assembling new seal on shaft and installing new seal seat in bearing housing. Apply a light film of clean oil to seal faces when assembling to prevent scratching surfaces. (Extreme care and cleanliness must be used when installing shaft seals).

4. To remove impeller, shaft and lower seal, use the following procedure: Remove snap ring (#17) from end of impeller (#20). Push and hold drive end of shaft (#24) toward discharge bowl(#22).
  - a. Slide impeller back and remove split thrust collar (#18) from shaft.
  - b. Slide impeller forward to remove.
  - c. Remove shaft key (#19) and gently slide shaft out of discharge bowl toward drive end.
  - d. Inspect lower shaft seal (#21) and replace if necessary.
  - e. Inspect shaft and bronze discharge bowl bushing (#10) and replace if worn. (Moderate wear [EG: shiny areas or ridges not more than .010" deep] on shaft are acceptable since the upper bearing takes most of the loading).
  - f. Inspect bushing (#12) in suction bowl (#13) and replace if worn.

#### ASSEMBLY:

1. Assembly is performed in reverse order of disassembly taking note of the following:
  - A) Fill suction bowl bushing area to bottom of bushing with waterproof grease.
  - B) Fill oil hole (1/2" plug) in discharge bowl (#22) to spill point (pump in vertical position) with clean hydraulic oil.
  - C) Fill oil hole (1/4" plug) in upper bearing housing (#7) to spill point with clean hydraulic oil. (This is done before installing discharge pipe).
  - D) Be sure "O"Rings are properly installed in grooves.
  - E) Use anti-seize compound on all fasteners when re-assembling pump (DO NOT USE ANTI-SEIZE ON SEALS OR BEARINGS)
  - F) Be sure pressure and return pipes are connected to proper ports on the hydraulic motor. Motor rotation is counter-clockwise looking from discharge end of pump.



WATER PUMP PART NO. 303910

ITEM	PART NO.	DESCRIPTION
1	303910-01	Hydraulic Motor
2	303910-02	Discharge pipe with flange
3	303910-03	Grommet
4	303910-04	1" Elbow
5	303910-05	Pipe
6	303910-06	Shaft collar
7	303910-07	Bearing Housing
8	303910-08	Bolt
9		(Not used on this model)
10	303910-09	Bushing Lower Discharge Bowl
11	303910-10	Bolt
12	303910-11	Bushing Suction Bowl
13	303910-12	Suction Bowl
14	303910-13	Screw 3/8" x 1-1/2" Sq. Head Set Screw
15	303910-14	Pipe Plug
16	303910-15	Strainer Assembly
17	303910-16	Snap-Ring
18	303910-17	Thrust Collar
19	303910-18	Key

20	303910-19	Impeller
21	303910-20	Lower Seal
22	303910-21	Discharge Bowl Assembly
23	303910-22	Pipe Plug
24	303910-23	Shaft
25	303910-24	Snap-Ring
26	303910-25	Upper Seal
27	303910-26	Bearing
28	303910-27	Snap-Ring
29	303910-28	Snap-Ring
30	303910-29	Coupler (male) 1"
30	303910-30	Coupler (female) 1"
31	303910-31	O-Ring
32		(Not used on this model)
33	303910-32	Bolt
34	303910-33	Plug Bearing Housing
35	303910-34	O-Ring
36	303910-35	Swivel Union (Optional) 2 req.
37	303910-36	Discharge Flange (Optional)

# Operation and Maintenance Manual

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## **3054B Industrial Engine**

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5MF1-Up (Engine)

## Important Safety Information

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

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

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

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

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "DANGER", "WARNING" or "CAUTION". The Safety Alert "WARNING" label is shown below.



The meaning of this safety alert symbol is as follows:

**Attention! Become Alert! Your Safety is Involved.**

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

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

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

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



**When replacement parts are required for this product Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.**

**Failure to heed this warning can lead to premature failures, product damage, personal injury or death.**



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## Foreword

### Literature Information

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

English is the primary language for all Caterpillar publications. The English used facilitates translation and consistency in electronic media delivery.

Some photographs or illustrations in this manual show details or attachments that may be different from your engine. Guards and covers may have been removed for illustrative purposes. Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this manual. Whenever a question arises regarding your engine, or this manual, please consult with your Caterpillar dealer for the latest available information.

### Safety

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

### Operation

Operating techniques outlined in this manual are basic. They assist with developing the skills and techniques required to operate the engine more efficiently and economically. Skill and techniques develop as the operator gains knowledge of the engine and its capabilities.

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

### Maintenance

The maintenance section is a guide to engine care. The illustrated, step-by-step instructions are grouped by fuel consumption, service hours and/or calendar time maintenance intervals. Items in the maintenance schedule are referenced to detailed instructions that follow.

Use fuel consumption or service hours to determine intervals. Calendar intervals shown (daily, annually, etc.) may be used instead of service meter intervals if they provide more convenient schedules and approximate the indicated service meter reading.

Recommended service should be performed at the appropriate intervals as indicated in the Maintenance Interval Schedule. The actual operating environment of the engine also governs the Maintenance Interval Schedule. Therefore, under extremely severe, dusty, wet or freezing cold operating conditions, more frequent lubrication and maintenance than is specified in the Maintenance Interval Schedule may be necessary.

The maintenance schedule items are organized for a preventive maintenance management program. If the preventive maintenance program is followed, a periodic tune-up is not required. The implementation of a preventive maintenance management program should minimize operating costs through cost avoidances resulting from reductions in unscheduled downtime and failures.

### Maintenance Intervals

Perform maintenance on items at multiples of the original requirement. Each level and/or individual items in each level should be shifted ahead or back depending upon your specific maintenance practices, operation and application. We recommend that the maintenance schedules be reproduced and displayed near the engine as a convenient reminder. We also recommend that a maintenance record be maintained as part of the engine's permanent record.

See the section in the Operation and Maintenance Manual, "Maintenance Records" for information regarding documents that are generally accepted as proof of maintenance or repair. Your authorized Caterpillar dealer can assist you in adjusting your maintenance schedule to meet the needs of your operating environment.

### Overhaul

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

## California Proposition 65 Warning

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

Battery posts, terminals and related accessories contain lead and lead compounds. **Wash hands after handling.**



## Safety Section

### Safety Signs and Labels

**SMCS Code:** 1000, 7405

There may be several specific safety signs on an engine. The exact location of the hazards and the description of the hazards are reviewed in this section. Please become familiar with all safety signs.

Ensure that all of the safety signs are legible. Clean the safety signs or replace the safety signs if the words cannot be read or if the pictures are not visible. When the safety signs are cleaned, use a cloth, water, and soap. Do not use solvent, gasoline, or other harsh chemicals to clean the safety signs. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the safety signs. The safety signs that are loosened could drop off of the engine.

Replace any damaged safety signs or missing safety signs. If a safety sign is attached to a part of the engine that is replaced, install a new safety sign on the replacement part. Any Caterpillar dealer can provide new safety signs.

Do not work on the engine and do not operate the engine unless the instructions and safety labels in the Operation and Maintenance Manual are understood. Proper care is your responsibility. Failure to follow the instructions or failure to heed the safety labels could result in injury or in death.

The safety labels that may be found on the engine are illustrated and described.

### Starting Aid

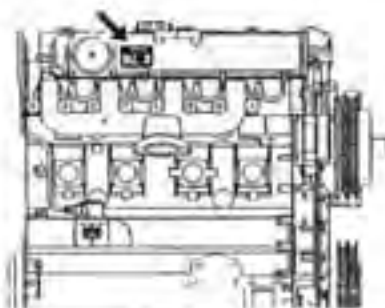


Illustration 1

9009041

The safety label for the starting aid is located on the valve cover.



9009041

If the engine is equipped with an air inlet heater for cold weather starting, do not use starting aids that contain an aerosol such as ether. Using such types of starting aids could result in an explosion and personal injury.



## Clutch

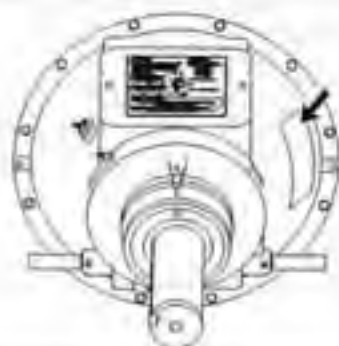


Illustration 2

g00107406

The safety label for the clutch is located on the clutch housing (if equipped)



g00107407

Rotating gears can cause entanglement of fingers or entanglement of hands. Do not service this component without first reading the operator manual.

## General Hazard Information

SMCS Code: 1000; 7405



Illustration 3

g00101165

Attach a "Do Not Operate" warning tag or a similar warning tag to the start switch or to the controls before the engine is serviced or before the engine is repaired. These warning tags (Special Instruction, SEHS7332) are available from your Caterpillar dealer. Attach the warning tags to the engine and to each operator control station. When it is appropriate, disconnect the starting controls.

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

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

Cautiously remove the following parts. To help prevent spraying or splashing of pressurized fluids hold a rag over the part that is being removed.

- Filler caps
- Grease fittings
- Pressure taps
- Breathers
- Drain plugs

Use caution when cover plates are removed. Gradually loosen, but do not remove the last two bolts or nuts that are located at opposite ends of the cover plate or the device. Before removing the last two bolts or nuts, pry the cover loose in order to relieve any spring pressure or other pressure.



Illustration 4

g00103020

- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

**Unless other instructions are provided, perform the maintenance under the following conditions:**

- The engine is stopped. Ensure that the engine cannot be started.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

## Pressure Air and Water

Pressurized air and/or water can cause debris and/or hot water to be blown out. This could result in personal injury.

When pressure air and/or pressure water is used for cleaning, wear protective clothing, protective shoes, and eye protection. Eye protection includes goggles or a protective face shield.

The maximum air pressure for cleaning purposes must be below 205 kPa (30 psi). The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi).

## Fluid Penetration



Illustration 5

g00617000

Always use a board or cardboard when you check for a leak. Leaking fluid that is under pressure can penetrate body tissue. Fluid penetration can cause serious injury and possible death. A pin hole leak can cause severe injury. If fluid is injected into your skin, you must get treatment immediately. Seek treatment from a doctor that is familiar with this type of injury.

## Containing Fluid Spillage

Care must be taken in order to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the engine. Prepare to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, "Tools and Shop Products Guide" for the following items:

- Tools that are suitable for collecting fluids and equipment that is suitable for collecting fluids.
- Tools that are suitable for containing fluids and equipment that is suitable for containing fluids.

Obey all local regulations for the disposal of liquids.

## Asbestos Information



Illustration 6

G00702022

Caterpillar equipment and replacement parts that are shipped from Caterpillar are asbestos free. Caterpillar recommends the use of only genuine Caterpillar replacement parts. Use the following guidelines when you handle any replacement parts that contain asbestos or when you handle asbestos debris.

Use caution. Avoid inhaling dust that might be generated when you handle components that contain asbestos fibers. Inhaling this dust can be hazardous to your health. The components that may contain asbestos fibers are brake pads, brake bands, lining material, clutch plates, and some gaskets. The asbestos that is used in these components is usually bound in a resin or sealed in some way. Normal handling is not hazardous unless airborne dust that contains asbestos is generated.

If dust that may contain asbestos is present, there are several guidelines that should be followed:

- Never use compressed air for cleaning.
- Avoid brushing materials that contain asbestos.
- Avoid grinding materials that contain asbestos.
- Use a wet method in order to clean up asbestos materials.
- A vacuum cleaner that is equipped with a high efficiency particulate air filter (HEPA) can also be used.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.

- Comply with applicable rules and regulations for the work place. In the United States, use Occupational Safety and Health Administration (OSHA) requirements. These OSHA requirements can be found in "29 CFR 1910.1001".
- Obey environmental regulations for the disposal of asbestos.
- Stay away from areas that might have asbestos particles in the air.

## Dispose of Waste Properly



Illustration 7

G00706400

Improperly disposing of waste can threaten the environment. Potentially harmful fluids should be disposed of according to local regulations.

Always use leakproof containers when you drain fluids. Do not pour waste onto the ground, down a drain, or into any source of water.

G1403700

## Burn Prevention

**SMCS Code:** 1000, 7405

Do not touch any part of an operating engine. Allow the engine to cool before any maintenance is performed on the engine. Relieve all pressure in the air system, in the hydraulic system, in the lubrication system, in the fuel system, or in the cooling system before any lines, fittings or related items are disconnected.

### Coolant

When the engine is at operating temperature, the engine coolant is hot. The coolant is also under pressure. The radiator and all lines to the heaters or to the engine contain hot coolant.

Any contact with hot coolant or with steam can cause severe burns. Allow cooling system components to cool before the cooling system is drained.

Check the coolant level after the engine has stopped and the engine has been allowed to cool.

Ensure that the filler cap is cool before removing the filler cap. The filler cap must be cool enough to touch with a bare hand. Remove the filler cap slowly in order to relieve pressure.

Cooling system conditioner contains alkali. Alkali can cause personal injury. Do not allow alkali to contact the skin, the eyes, or the mouth.

## Oils

Hot oil and hot lubricating components can cause personal injury. Do not allow hot oil to contact the skin. Also, do not allow hot components to contact the skin.

## Batteries

Electrolyte is an acid. Electrolyte can cause personal injury. Do not allow electrolyte to contact the skin or the eyes. Always wear protective glasses for servicing batteries. Wash hands after touching the batteries and connectors. Use of gloves is recommended.

©137226

# Fire Prevention and Explosion Prevention

SMCS Code: 1000, 7405



Illustration 0

©90704000

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

Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire. Fire may cause personal injury and property damage.

A flash fire may result if the covers for the engine crankcase are removed within fifteen minutes after an emergency shutdown.

Determine whether the engine will be operated in an environment that allows combustible gases to be drawn into the air inlet system. These gases could cause the engine to overspeed. Personal injury, property damage, or engine damage could result.

If the application involves the presence of combustible gases, consult your Caterpillar dealer for additional information about suitable protection devices.

Remove all flammable materials such as fuel, oil, and debris from the engine. Do not allow any flammable materials to accumulate on the engine.

Store fuels and lubricants in properly marked containers away from unauthorized persons. Store oily rags and any flammable materials in protective containers. Do not smoke in areas that are used for storing flammable materials.

Do not expose the engine to any flame.

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

Do not weld on lines or tanks that contain flammable fluids. Do not flame cut lines that contain flammable fluid. Clean any such lines thoroughly with a nonflammable solvent prior to welding or flame cutting.

Wiring must be kept in good condition. All electrical wires must be properly routed and securely attached. Check all electrical wires daily. Repair any wires that are loose or frayed before you operate the engine. Clean all electrical connections and tighten all electrical connections.

Eliminate all wiring that is unattached or unnecessary. Do not use any wires or cables that are smaller than the recommended gauge. Do not bypass any fuses and/or circuit breakers.

Arcing or sparking could cause a fire. Secure connections, recommended wiring, and properly maintained battery cables will help to prevent arcing or sparking.

Inspect all lines and hoses for wear or for deterioration. The hoses must be properly routed. The lines and hoses must have adequate support and secure clamps. Tighten all connections to the recommended torque. Leaks can cause fires.

Oil filters and fuel filters must be properly installed. The filter housings must be tightened to the proper torque.



Illustration 9

g00704059

Use caution when you are refueling an engine. Do not smoke while you are refueling an engine. Do not refuel an engine near open flames or sparks. Always stop the engine before refueling.



Illustration 10

g00704139

Gases from a battery can explode. Keep any open flames or sparks away from the top of a battery. Do not smoke in battery charging areas.

Never check the battery charge by placing a metal object across the terminal posts. Use a voltmeter or a hydrometer.

Improper jumper cable connections can cause an explosion that can result in injury. Refer to the Operation Section of this manual for specific instructions.

Do not charge a frozen battery. This may cause an explosion.

The batteries must be kept clean. The covers (if equipped) must be kept on the cells. Use the recommended cables, connections, and battery box covers when the engine is operated.

## Fire Extinguisher

Make sure that a fire extinguisher is available. Be familiar with the operation of the fire extinguisher. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate.

## Lines, Tubes and Hoses

Do not bend high pressure lines. Do not strike high pressure lines. Do not install any lines that are bent or damaged.

Repair any lines that are loose or damaged. Leaks can cause fires. Consult your Caterpillar dealer for repair or for replacement parts.

Check lines, tubes and hoses carefully. Do not use your bare hand to check for leaks. Use a board or cardboard to check for leaks. Tighten all connections to the recommended torque.

Replace the parts if any of the following conditions are present:

- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.
- Flexible part of the hoses are kinked.
- Outer covers have embedded armoring.
- End fittings are displaced.



Always start the engine according to the procedure that is described in the Operation and Maintenance Manual, "Engine Starting" topic in the Operation Section. Knowing the correct procedure will help to prevent major damage to the engine components. Knowing the procedure will also help to prevent personal injury.

To ensure that the jacket water heater (if equipped) and/or the lube oil heater (if equipped) is working properly, check the water temperature gauge and the oil temperature gauge during the heater operation.

Engine exhaust contains products of combustion which can be harmful to your health. Always start the engine and operate the engine in a well ventilated area. If the engine is started in an enclosed area, vent the engine exhaust to the outside.

00003000

## Engine Stopping

**SMCS Code:** 1000

Stop the engine according to the procedure in the Operation and Maintenance Manual in order to avoid overheating of the engine and accelerated wear of the engine components.

Use the Emergency Stop Button (if equipped) ONLY in an emergency situation. Do not use the Emergency Stop Button for normal engine stopping. After an emergency stop, DO NOT start the engine until the problem that caused the emergency stop has been corrected.

On the initial start-up of a new engine or an engine that has been overhauled, be prepared to stop the engine if an overspeed condition occurs. This may be accomplished by shutting off the fuel supply to the engine and/or shutting off the air supply to the engine.

01451961

## Electrical System

**SMCS Code:** 1000; 1400

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.

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

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before the engine is started. Repair all frayed electrical wires before the engine is started. See the Operation and Maintenance Manual for specific starting instructions.

## Grounding Practices

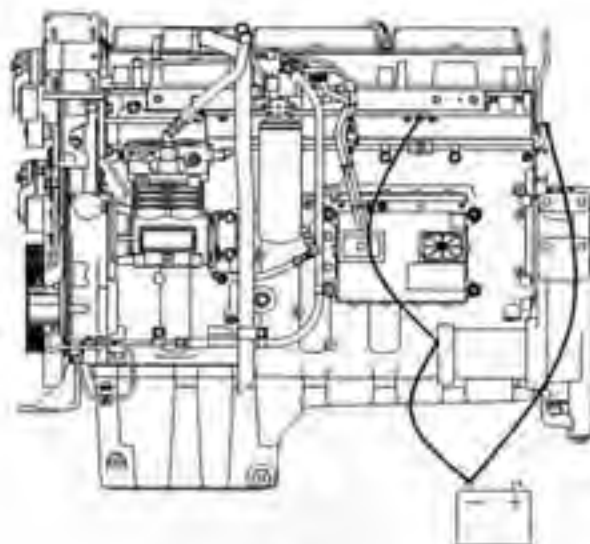


Illustration 11

g00771448

Typical example

Grounding Stud To Battery Ground

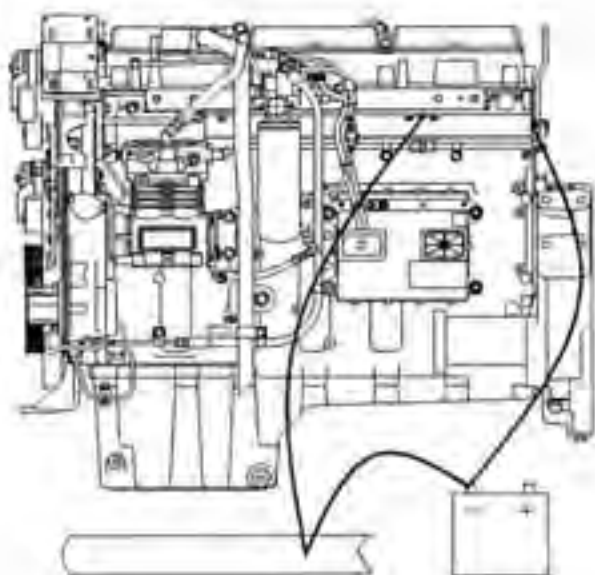


Illustration 12

g0071587

**Typical example****Alternate Grounding Stud To Battery Ground**

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

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

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

To ensure that the engine and the engine electrical systems function properly, an engine-to-frame ground strap with a direct path to the battery must be used. This path may be provided by way of a starting motor ground, a starting motor ground to the frame, or a direct engine ground to the frame.

All grounds should be tight and free of corrosion. The engine alternator must be grounded to the negative "-" battery terminal with a wire that is adequate to handle the full charging current of the alternator.

# Product Information Section

## Model Views

01155100

### Model View Illustrations

SMCS Code: 1000

The following model views show typical 3054B Industrial Engine features. Due to individual applications, your engine may appear different from the illustrations.

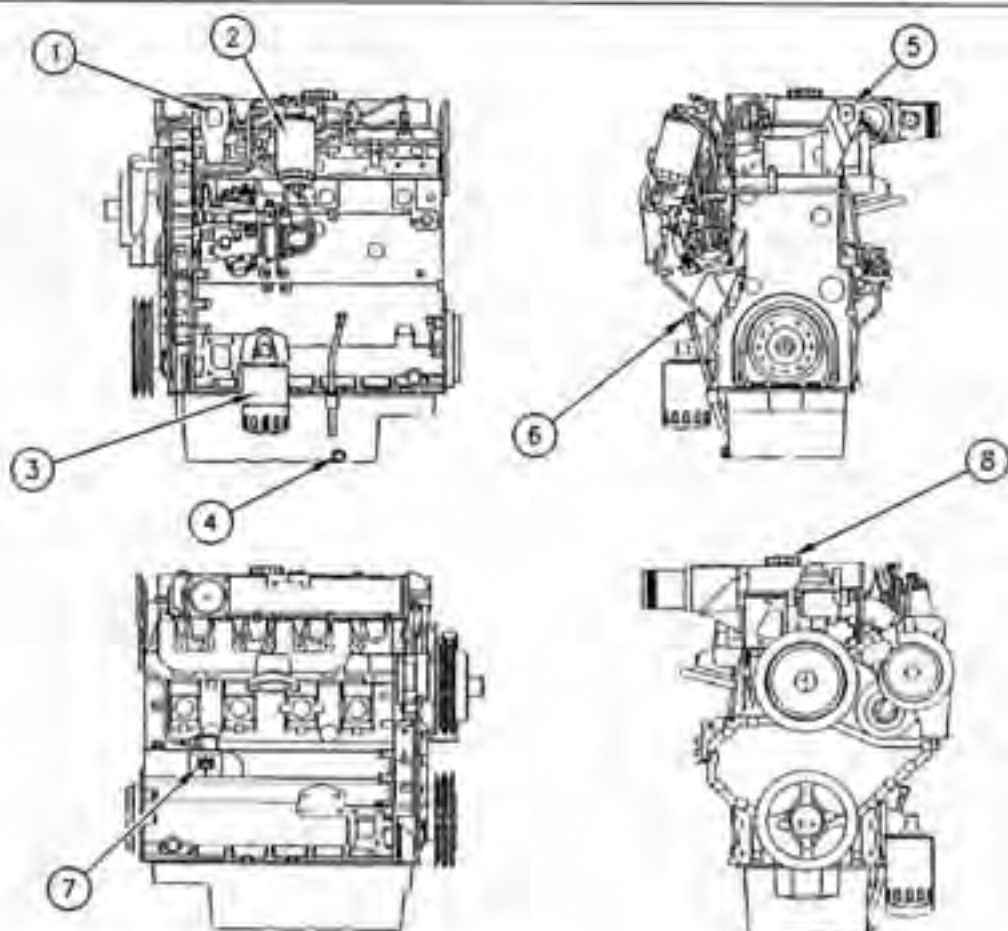


Illustration 13

02001107M

- (1) Lifting eye
- (2) Fuel filter and water separator element
- (3) Engine oil filter
- (4) Engine oil drain plug

- (5) Lifting eye
- (6) Engine oil level gauge (dipstick assembly)
- (7) Fuel transfer pump
- (8) Engine oil filter



01158822

## Engine Description

**SMCS Code:** 1000

The 3054B Industrial Engine is designed for the following applications: agricultural, industrial mobile equipment, and auxiliary. The engine is a naturally aspirated engine.

The engines are powered with direct fuel injection. A hydromechanical governor controls the fuel injection pump output in order to maintain the engine rpm that is selected by the operator.

Fuel is metered and pumped by a fuel injection pump under high pressure to the fuel injection nozzles (one per cylinder). The automatic timing advance provides the best fuel injection timing over the full range of engine rpm.

The cooling system consists of the following components:

- A gear-driven centrifugal pump
- One water temperature regulator which regulates the engine coolant temperature
- An oil cooler
- A radiator which incorporates a shunt system

The engine lubricating oil is supplied by a gear type pump. The engine lubricating oil is cooled and the engine lubricating oil is filtered. Bypass valves provide unrestricted flow of lubrication oil to the engine parts when oil viscosity is high. Bypass valves can also provide unrestricted flow of lubrication oil to the engine parts if the oil cooler should become plugged or if the oil filter element should become plugged.

## Engine Specifications

**Note:** The front end of the engine is opposite the flywheel end of the engine. The left and the right side of the engine are determined from the flywheel end. The number 1 cylinder is the front cylinder.

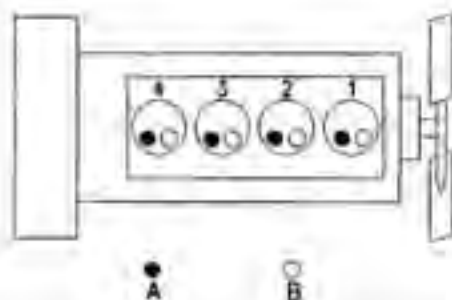


Illustration 14

(A) Exhaust valve  
(B) Inlet valve

00020542

Table 1

3054B Industrial Engine Specifications	
Operating Range (rpm)	1500 to 2800 <sup>(1)</sup>
Arrangement and Cylinders	In-Line 4 cylinder
Bore	103 mm (4.055 inch)
Stroke	127 mm (5.0 inch)
Aspiration	NA <sup>(2)</sup>
Compression Ratio	18.5:1
Displacement	4.23 L (258 in <sup>3</sup> )
Firing Order	1-3-4-2
Rotation (viewed from flywheel)	Counterclockwise
Valve Lash (Inlet)	0.20 mm (0.008 inch)
Valve Lash (Exhaust)	0.45 mm (0.018 inch)

<sup>(1)</sup> The operating rpm is dependent on the engine rating and the application.

<sup>(2)</sup> Naturally aspirated

## Engine Service Life

Engine efficiency and maximum utilization of engine performance depend on the adherence to proper operation and maintenance recommendations. In addition, use recommended fuels, coolants and lubricants. Use the Operation and Maintenance Manual as a guide for required engine maintenance.

Expected engine life is generally predicted by the average power that is demanded. The average power that is demanded is based on fuel consumption of the engine over a period of time. Reduced hours of operation at full throttle and/or operating at reduced throttle settings result in a lower average power demand. Reduced hours of operation will increase the length of operating time before an engine overhaul is required. For more information, refer to the Operation and Maintenance Manual, "Overhaul Considerations" topic. (Maintenance Section).

Make sure that all clamps, guards, and heat shields are installed correctly. During engine operation, this will help to prevent vibration, rubbing against other parts, and excessive heat.

01326698

## Crushing Prevention and Cutting Prevention

**SMCS Code:** 1000, 7405

Support the component properly when work beneath the component is performed.

Unless other maintenance instructions are provided, never attempt adjustments while the engine is running.

Stay clear of all rotating parts and of all moving parts. Leave the guards in place until maintenance is performed. After the maintenance is performed, reinstall the guards.

Keep objects away from moving fan blades. The fan blades will throw objects or cut objects.

When objects are struck, wear protective glasses in order to avoid injury to the eyes.

Chips or other debris may fly off objects when objects are struck. Before objects are struck, ensure that no one will be injured by flying debris.

01372347

## Mounting and Dismounting

**SMCS Code:** 1000, 7405

Inspect the steps, the handholds, and the work area before mounting the engine. Keep these items clean and keep these items in good repair.

Mount the engine and dismount the engine only at locations that have steps and/or handholds. Do not climb on the engine, and do not jump off the engine.

Face the engine in order to mount the engine or dismount the engine. Maintain a three-point contact with the steps and handholds. Use two feet and one hand or use one foot and two hands. Do not use any controls as handholds.

Do not stand on components which cannot support your weight. Use an adequate ladder or use a work platform. Secure the climbing equipment so that the equipment will not move.

Do not carry tools or supplies when you mount the engine or when you dismount the engine. Use a hand line to raise and lower tools or supplies.

01421840

## Before Starting Engine

**SMCS Code:** 1000

Inspect the engine for potential hazards.

Before starting the engine, ensure that no one is on, underneath, or close to the engine. Ensure that the area is free of personnel.

Ensure that the engine is equipped with a lighting system that is suitable for the conditions. Ensure that all lights work properly.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Do not bypass the automatic shutoff circuits. Do not disable the automatic shutoff circuits. The circuits are provided in order to help prevent personal injury. The circuits are also provided in order to help prevent engine damage.

For the initial start-up of a new engine and for start-up of an engine that has been serviced, prepare to stop the engine if an overspeed occurs. This may be accomplished by shutting off the fuel and/or the air supply to the engine.

See the Service Manual for repairs and for adjustments.

00512000

## Engine Starting

**SMCS Code:** 1000

If a warning tag is attached to the engine start switch or to the controls, DO NOT start the engine or move the controls. Consult with the person that attached the warning tag before the engine is started.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Start the engine from the operator's compartment or from the engine start switch.

## Product Identification Information

01121405

### Engine Identification

01484579

**SMCS Code:** 1000

Caterpillar engines are identified with model numbers, and serial numbers, with performance specification numbers, and with arrangement numbers. These numbers are shown on the serial number plate that is mounted on the engine.

The numbers for fuel setting information for electronic engines are stored within the personality module. These numbers can be read by using Caterpillar electronic service tools.

Caterpillar dealers need these numbers in order to determine the components that were included with the engine. This permits accurate identification of replacement part numbers.

00723073

### Serial Number Plate

**SMCS Code:** 1000



Illustration 15

00012329

Typical serial number plate

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

The following information is stamped on the Serial Number Plate: engine serial number, model, and arrangement number.

## Information Plate

**SMCS Code:** 1000



Illustration 16

00735014

The Information Plate is on the valve cover. The following information is stamped on the Information Plate: engine's maximum altitude, horsepower, high idle, full load rpm, fuel settings, and other information.

00010276

## Reference Numbers

**SMCS Code:** 1000

Information for the following items may be needed to order parts. Locate the information for your engine. Record the information on the appropriate space. Make a copy of this list for a record. Retain the information for future reference.

### Record for Reference

- Engine Model \_\_\_\_\_
- Engine Serial No. \_\_\_\_\_
- Engine Arrangement No. \_\_\_\_\_
- Modification No. \_\_\_\_\_
- Engine Low Idle rpm \_\_\_\_\_
- Engine Full Load rpm \_\_\_\_\_
- Performance Specification No. \_\_\_\_\_
- Primary Fuel Filter No. \_\_\_\_\_
- Water Separator Element No. \_\_\_\_\_
- Secondary Fuel Filter Element No. \_\_\_\_\_

Lubrication Oil Filter Element No. \_\_\_\_\_

Auxiliary Oil Filter Element No. \_\_\_\_\_

Supplemental Coolant Additive Maintenance  
Element No. (Optional) \_\_\_\_\_

Total Lubrication System Capacity \_\_\_\_\_

Total Cooling System Capacity \_\_\_\_\_

Air Cleaner Element No. \_\_\_\_\_

Fan Drive Belt No. \_\_\_\_\_

Alternator Belt No. \_\_\_\_\_

#01507742

## Emissions Certification Film

**SMCS Code:** 1000**Note:** This information is pertinent in the United  
States and in Canada.

CAT		CATERPILLAR INC.		IMPORTANT ENGINE INFORMATION			2000	JDM00001
ENGINE FAMILY		ENGINE MODEL	DISPLACEMENT	VALVE LASH	INTAKE	EXHAUST		
D6E (1.9L)		D6E (1.9L)	6.6L (409)	0.30mm (0.012)	0.4mm (0.016)			
MAXIMUM ADVERSE % (D/F)		MAXIMUM SALES % (D/F)	MAXIMUM L/HR (L/HR)	MAXIMUM L/HR (L/HR)	MAXIMUM L/HR (L/HR)	MAXIMUM L/HR (L/HR)	MAXIMUM L/HR (L/HR)	MAXIMUM L/HR (L/HR)
100%		100%	100%	100%	100%	100%	100%	100%
EPA APPROVAL NO. 100-01-01		EPA APPROVAL NO. 100-01-01			EPA APPROVAL NO. 100-01-01		EPA APPROVAL NO. 100-01-01	
THIS ENGINE CONFORMS TO DIRECTIVE 88/76/EEC FOR NON-ROAD ENGINES.		THIS ENGINE CONFORMS TO (2004) U.S. EPA AND CALIFORNIA REGULATIONS FOR NON-ROAD COMPRESSION-IGNITION ENGINES.			THIS ENGINE IS DESIGNED TO OPERATE ON COMMERCIALLY AVAILABLE DIESEL FUEL.		DATE OF MANUFACTURE (MO/YR)	
							0.000 01	

FMT:3500

The EPA/EU Emissions Certification Film  
(if applicable) is located either on the side,  
the top, or the front of the engine.

CAT		CATERPILLAR INC.		INFORMATION IMPORTANTE SUR LE MOTEUR		
FAMILLE DU MOTEUR		MODELE MOTEUR	DEBIT (L/HR)	JEU SOUPAPES	ADMISSION	ECHAPPEMENT
D6E (1.9L)		D6E (1.9L)	6.6L (409)	0.30 mm (0.012)	0.4 mm (0.016)	
MAXIMUM ADVERSE % (D/F)		MAXIMUM SALES % (D/F)	MAXIMUM L/HR (L/HR)	MAXIMUM L/HR (L/HR)	MAXIMUM L/HR (L/HR)	MAXIMUM L/HR (L/HR)
100%		100%	100%	100%	100%	100%
EPA APPROVAL NO. 100-01-01		EPA APPROVAL NO. 100-01-01			EPA APPROVAL NO. 100-01-01	
CE MOTEUR CONFORME AUX DIRECTIVES 88/76/CEE POUR LES MOTEURS NON VOITURES.		CE MOTEUR CONFORME AUX REGULATIONS 2004 DE L'AGENCE AMERICAINE DE PROTECTION DE L'ENVIRONNEMENT ET DE LA CALIFORNIE POUR LES MOTEURS NON VOITURES A COMPRESSION ALLUMEE.			CE MOTEUR EST CONÇU POUR FONCTIONNER AVEC LE COMBUSTIBLE DIESEL DU COMMERCE.	
					DATE DE FABRICATION (MO/AN)	

Étiquette d'homologation anti-pollution

L'autocollant d'homologation du dispositif  
antipollution EPA/EU (selon équipement) est situé  
soit sur le côté du moteur, soit sur le dessus du  
moteur, soit sur le devant du moteur.



## Operation Section

# Engine Lifting and Storage

01033209

## Engine Lifting

SMCS Code: 1000, 1122

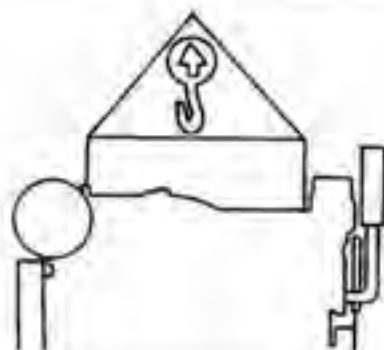


Illustration 18

000103218

### NOTICE

Never bend the eyebolts and the brackets. Only load the eyebolts and the brackets under tension. Remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees.

When it is necessary to remove a component at an angle, only use a link bracket that is properly rated for the weight.

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

Some removals require lifting the fixtures in order to obtain proper balance and safety.

To remove the engine **ONLY**, use the lifting eyes that are on the engine.

Lifting eyes are designed and installed for the specific engine arrangement. Alterations to the lifting eyes and/or the engine make the lifting eyes and the lifting fixtures obsolete. If alterations are made, ensure that proper lifting devices are provided. Consult your Caterpillar dealer for information regarding fixtures for proper engine lifting.

## Engine Lifting with a Fuel Tank

### ⚠ WARNING

Lift eyes or tank can fail when lifting tank containing fluids resulting in possible personal injury. Drain tank of all fluids before lifting.

Lifting the engine with a fuel tank that is mounted to the engine requires special equipment and procedures. Do not lift the unit with fuel in the fuel tank. Consult your Caterpillar dealer for information regarding fixtures for proper lifting of your complete package.

007719

## Engine Storage

SMCS Code: 1000

If the engine will not be started for several weeks, the lubricating oil will drain from the cylinder walls and from the piston rings. Rust can form on the cylinder liner surface. Rust on the cylinder liner surface will cause increased engine wear and a reduction in engine service life.

To help prevent excessive engine wear, use the following guidelines:

- Complete all of the lubrication recommendations that are listed in this Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).
- If freezing temperatures are expected, check the cooling system for adequate protection against freezing. See this Operation and Maintenance Manual, "General Coolant Information" (Maintenance Section).

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

For more detailed information on engine storage, see Special Instruction, SEHS9031, "Storage Procedure For Caterpillar Products".

Your Caterpillar dealer can assist in preparing the engine for extended storage periods.

## Gauges and Indicators

100h8556

### Gauges and Indicators

**SMCS Code:** 1900; 7450

Your engine may not have the same gauges or all of the gauges that are described. For more information about the gauge package, see the OEM information.

Gauges provide indications of engine performance. Ensure that the gauges are in good working order. Determine the normal operating range by observing the gauges over a period of time.

Noticeable changes in gauge readings indicate potential gauge or engine problems. Problems may also be indicated by gauge readings that change even if the readings are within specifications. Determine and correct the cause of any significant change in the readings. Consult your Caterpillar dealer for assistance.

#### NOTICE

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



**Engine Oil Pressure** – The oil pressure should be greatest after starting a cold engine. The typical oil pressure for naturally aspirated engines at rated rpm with SAE10W30 is 207 to 413 kPa (30 to 60 psi). The typical oil pressure for turbocharged engines at rated rpm with SAE10W30 is 207 to 413 kPa (30 to 60 psi).

A lower oil pressure is normal at low idle. If the load is stable and the gauge reading changes, perform the following procedure:

1. Remove the load.
2. Reduce engine speed to low idle.
3. Check and maintain the oil level.



**Jacket Water Coolant Temperature** – Typical temperature range is 78 to 91 °C (173 to 196 °F). The maximum allowable temperature with the pressurized cooling system at 48 kPa (7 psi) is 103 °C (217 °F). Higher temperatures may occur under certain conditions. The water temperature reading may vary according to load. The reading should never exceed the boiling point for the pressurized system that is being used.

If the engine is operating above the normal range and steam becomes apparent, perform the following procedure:

1. Ensure the correct 50/50 antifreeze concentration.
2. Reduce the load and the engine rpm.
3. Inspect the cooling system for leaks.
4. Determine if the engine must be shut down immediately or if the engine can be cooled by reducing the load.



**Tachometer** – This gauge indicates engine rpm (speed). When the throttle control lever is moved to the full throttle position without load, the engine is running at high idle. The engine is running at the full load rpm when the throttle control lever is at the full throttle position with maximum rated load.

#### NOTICE

To help prevent engine damage, never exceed the high idle rpm. Overspeeding can result in serious damage to the engine. The engine can be operated at high idle without damage, but should never be allowed to exceed high idle rpm.

**Note:** The high idle rpm and the full load rpm are stamped on the Information Plate.



**Ammeter** – This gauge indicates the amount of charge or discharge in the battery charging circuit. Operation of the indicator should be to the right side of "0" (zero).



**Fuel Level** – This gauge indicates the fuel level in the fuel tank. The fuel level gauge is electrically operated. This gauge registers the pressure when the "START/STOP" switch is "ON".



**Service Hour Meter** – This gauge indicates the total number of clock hours that the engine has operated.



# Engine Features and Controls

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## Engine Shutoffs and Engine Alarms

**SMCS Code:** 1900; 7400; 7418

### Shutoffs

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

Shutoffs are set at critical levels for the following items: operating temperature, operating pressure, operating level, and operating rpm. The particular shutoff may need to be reset before the engine will start.

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**NOTICE**

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

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Be familiar with the following items:

- Types and locations of shutoff
- Conditions which cause each shutoff to function
- The resetting procedure that is required to restart the engine

### Alarms

Alarms consist of a switch and a contactor. The switches are wired to the contactors. The contactors activate alarm circuits in an annunciator panel. Your engine may be equipped with the following switches:

**Engine oil pressure** – The engine oil pressure switch indicates when oil pressure drops below rated system pressure.

**Coolant level** – The low coolant level switch indicates when the coolant level is low.

**Coolant temperature** – The coolant temperature switch indicates high jacket water coolant temperature.

**Note:** The sensing element of the coolant temperature switch must be submerged in coolant in order to operate.

Engines may be equipped with alarms in order to alert the operator when undesirable operating conditions occur.

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**NOTICE**

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

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If corrective measures are not taken within a reasonable time, engine damage could result. The alarm will continue until the condition is corrected. The alarm may need to be reset.

A switch may be installed in the alarm while the engine is stopped for repairs. Before the engine is started, ensure that the switch is moved to the ON position and that the warning lights are flashing. The engine will not be protected if the switch is left in the OFF position.

### Testing the Shutoff and Alarm System

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

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**NOTICE**

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

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Refer to the Service Manual for more information on testing procedures or consult your Caterpillar dealer.

## Engine Starting

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### Before Starting Engine

**SMCS Code:** 1000; 1400; 1450

Perform the required daily maintenance and other periodic maintenance before the engine is started. Inspect the engine compartment. This inspection can help prevent major repairs at a later date. Refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" for more information.

- For the maximum service life of the engine, make a thorough inspection before the engine is started. Look for the following items: oil leaks, coolant leaks, loose bolts, and trash buildup. Remove trash buildup and arrange for repairs, as needed.
- Inspect the cooling system hoses for cracks and for loose clamps.
- Inspect the alternator and accessory drive belts for cracks, breaks, and other damage.
- Inspect the wiring for loose connections and for worn wires or frayed wires.
- Check the fuel supply. Drain water from the water separator (if equipped). Open the fuel supply valve.

#### NOTICE

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

If the engine has not been started for several weeks, fuel may have drained from the fuel system. Air may have entered the filter housing. Also, when fuel filters have been changed, some air pockets will be trapped in the engine. In these instances, prime the fuel system. Refer to the Operation and Maintenance Manual, "Fuel System - Prime" for more information on priming the fuel system.

#### WARNING

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

- Do not start the engine or move any of the controls if there is a "DO NOT OPERATE" warning tag or similar warning tag attached to the start switch or to the controls.
- Ensure that the areas around the rotating parts are clear.
- All of the guards must be put in place. Check for damaged guards or for missing guards. Repair any damaged guards. Replace damaged guards and/or missing guards.
- Disconnect any battery chargers that are not protected against the high current drain that is created when the electric starting motor (if equipped) is engaged. Check electrical cables and check the battery for poor connections and for corrosion.
- Reset all of the shutoffs or alarm components.
- Check the engine lubrication oil level. Maintain the oil level between the "ADD" mark and the "FULL" mark on the oil level gauge.
- Check the coolant level. Observe the coolant level in the coolant recovery tank (if equipped). Maintain the coolant level to the "FULL" mark on the coolant recovery tank.
- If the engine is not equipped with a coolant recovery tank maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level in the sight glass.
- Observe the air cleaner service indicator (if equipped). Service the air cleaner when the yellow diaphragm enters the red zone, or when the red piston locks in the visible position.
- Ensure that any driven equipment has been disengaged. Minimize electrical loads or remove any electrical loads.

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## Starting the Engine

**SMCS Code:** 1000, 1450

Refer to the Service Manual for your type of controls. Use the following procedure to start the engine.

1. Place the manual stop control (if equipped) in the RUN position. Turn the ignition switch to the RUN position. Advance the throttle in order to supply fuel to the engine.
2. Turn the ignition switch to the START position in order to crank the engine.

Allow the ignition switch to return to the RUN position as soon as the engine starts.

### NOTICE

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

3. Move the throttle to approximately one quarter of the engine rpm.
4. Allow the engine to idle for three to five minutes, or allow the engine to idle until the water temperature indicator begins to rise. The engine should run at low idle smoothly until speed is gradually increased to high idle. Allow the white smoke to disperse before proceeding with normal operation.

To minimize white smoke for cold weather starting, start the engine and allow the engine to idle for 30 seconds. Increase the rpm until the engine speed reaches 1200 rpm. Return the engine to low idle rpm.

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

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## Cold Weather Starting

**SMCS Code:** 1000; 1250; 1450; 1453; 1456; 1900

Refer to the Service Manual for your type of controls. Use the following procedure to start the engine.

### WARNING

**DO NOT USE ETHER** (starting fluids) unless specifically instructed to do so. If the engine is equipped with an Air Inlet Heater (electrically or fuel ignited manifold heater), **DO NOT** use ether (starting fluids) at any time. The use could result in engine damage and/or personal injury.

An air inlet heater is installed in the air inlet manifold. The air inlet heater is an electrical device which ignites a controlled amount of fuel in order to provide heated inlet air for cold weather starting.

Note: Startability will be improved at temperatures below 16°C (60°F) by the use of the air inlet heater. This will help reduce white smoke and misfire during start-up in cold weather.

Startability will be improved at temperatures below -18°C (0°F) from the use of a cylinder block coolant heater or extra battery capacity.

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

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

1. Turn the ignition switch to the RUN position. Advance the throttle in order to supply fuel to the engine.

When an air inlet heater is used, advance the throttle in order to supply the maximum fuel to the engine.

### NOTICE

Do not engage the starting motor when flywheel is turning. Do not start the engine under load.

If the engine fails to start within 30 seconds, release the starter switch or button and wait two minutes to allow the starting motor to cool before attempting to start the engine again.

2. When an air inlet heater is used, turn the ignition switch to the HEAT position. Maintain the HEAT position for 15 seconds. Turn the ignition switch to the HEAT-START position in order to crank the engine. If the engine fails to start, turn the ignition switch to the HEAT position for 10 seconds. Turn the ignition switch to the HEAT-START position in order to crank the engine.

Allow the ignition switch to return to the RUN position as soon as the engine starts.

**NOTICE**

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

3. Move the throttle to approximately one quarter of the engine rpm.
4. Allow the engine to idle for three to five minutes, or allow the engine to idle until the water temperature indicator begins to rise. The engine should run at low idle smoothly until speed is gradually increased to high idle. Allow the white smoke to disperse before proceeding with normal operation.

To minimize white smoke for cold weather starting, start the engine and allow the engine to idle for 30 seconds. Increase the rpm until the engine speed reaches 1200 rpm. Return the engine to low idle rpm.

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

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## Starting with Jump Start Cables

**SMCS Code:** 1000; 1401; 1402; 1900

 **WARNING**

**Improper jump start cable connections can cause an explosion resulting in personal injury.**

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

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

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

Many batteries which are considered unusable are still rechargeable. After jump starting, the alternator may not be able to fully recharge batteries that are severely discharged. The batteries must be charged to the proper voltage with a battery charger. For information on testing and charging, refer to the Special Instruction, SEHS7633, "Battery Test Procedure".

**NOTICE**

Using a battery source with the same voltage as the electric starting motor. Use ONLY equal voltage for jump starting. The use of higher voltage will damage the electrical system.

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

When using an external electrical source to start the engine, turn the engine control switch to the "OFF" position. Turn all electrical accessories OFF before attaching the jump start cables.

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

1. Turn the start switch on the stalled engine to the "OFF" position. Turn off all accessories.
2. Connect one positive end of the jump start cable to the positive cable terminal of the discharged battery. Connect the other positive end of the jump start cable to the positive cable terminal of the electrical source.
3. Connect one negative end of the jump start cable to the negative cable terminal of the electrical source. Connect the other negative end of the jump start cable to the engine block or to the chassis ground. This procedure helps to prevent potential sparks from igniting combustible gases that are produced by some batteries.
4. Charge the batteries. The engine will not continue to run after starting if the batteries have not been charged.
5. Start the engine.
6. Immediately after the stalled engine is started, disconnect the jump start cables in reverse order.

Refer to the Electrical Schematic for your engine. Consult your Caterpillar dealer for more information.



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## After Starting Engine

**SMCS Code:** 1000

**Note:** In temperatures from 0 to 60°C (32 to 140°F), the warm-up time is approximately five minutes. In temperatures below 0°C (32°F), additional warm-up time may be required.

**Note:** Ensure that the self test for the monitoring system (if equipped) is completed before operating the engine under load.

When the engine idles during warm-up, observe the following conditions:

- Check for any fluid or for any air leaks at idle rpm and at one-half full rpm (no load on the engine) before operating the engine under load. This is not possible in some applications.
- Operate the engine at low idle until all systems achieve operating temperatures. Check all gauges during the warm-up period.

**Note:** Gauge readings should be observed and the data should be recorded frequently while the engine is operating. Comparing the data over time will help to determine normal readings for each gauge. Comparing data over time will also help detect abnormal operating developments. Significant changes in the readings should be investigated.

## Engine Operation

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### Engine Operation

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**SMCS Code:** 1000

Proper operation and maintenance are key factors in obtaining the maximum life and economy of the engine. If the directions in the Operation and Maintenance Manual are followed, costs can be minimized and engine service life can be maximized.

The time that is needed for the engine to reach normal operating temperature can be less than the time needed for a walk-around inspection of the engine.

After the engine is started and after the engine reaches normal operating temperature, the engine can be operated at the rated rpm. The engine will reach normal operating temperature faster when the engine is at rated speed. The engine will reach normal operating temperature faster when the engine is at low power demand. This procedure is more effective than idling the engine at no load. The engine should reach operating temperature in a few minutes.

Gauge readings should be observed and the data should be recorded frequently while the engine is operating. Comparing the data over time will help to determine normal readings for each gauge. Comparing data over time will also help detect abnormal operating developments. Significant changes in the readings should be investigated.

### Engine Warm-up

**SMCS Code:** 1000

1. Run the engine at low idle for three to five minutes, or run the engine at low idle until the jacket water temperature starts to rise.

More time may be necessary when the temperature is below  $-18^{\circ}\text{C}$  ( $0^{\circ}\text{F}$ ).

2. Check all of the gauges during the warm-up period.
3. Perform another walk-around inspection. Check the engine for fluid leaks and air leaks.
4. Increase the rpm to the rated rpm. Check for fluid leaks and air leaks. The engine may be operated at full rated rpm and at full load when the jacket water temperature reaches  $60^{\circ}\text{C}$  ( $140^{\circ}\text{F}$ ).

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### Engaging the Driven Equipment

**SMCS Code:** 1000

If the load varies, or if the load is cyclic, the governor will adjust the engine rpm, as needed.

Extended operation at low idle or extended operation at a reduced load may cause increased oil consumption and carbon buildup in the cylinders. This carbon buildup results in a loss of power and/or poor performance. When the engine is operated at a reduced load, the engine should be fully loaded at every four hours in order to burn excess carbon from the cylinders.

### Industrial Engines

1. When the engine is operating, check the engine gauges. The engine gauges should be in the normal range before you engage the driven equipment.
2. Engage the driven equipment. Begin operating the engine at low load. Check the gauges and check the equipment for proper operation. Check the gauges and check the equipment frequently while the engine is operating under load.

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## Fuel Conservation Practices

**SMCS Code:** 1000; 1250

The efficiency of the engine can affect the fuel economy. Caterpillar's design and technology in manufacturing provides maximum fuel efficiency in all applications. Follow the recommended procedures in order to attain optimum performance for the life of the engine.

- Avoid spilling fuel.

Fuel expands when the fuel is warmed up. The fuel may overflow from the fuel tank. Inspect fuel lines for leaks. Repair the fuel lines, as needed.

- Be aware of the properties of the different fuels. Use only the recommended fuels.
- Avoid unnecessary idling.

Shut off the engine rather than idle for long periods of time.

- Observe the service indicator frequently. Keep the air cleaner elements clean.
- Ensure that the turbochargers are operating correctly so that the proper air/fuel ratio is maintained. Clean exhaust indicates proper functioning.
- Maintain a good electrical system.

One defective battery cell will overwork the alternator. This will consume excess power and excess fuel.

- Ensure that the belts are properly adjusted. The belts should be in good condition.
- Ensure that all of the connections of the hoses are tight. The connections should not leak.
- Ensure that the driven equipment is in good working order.
- Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.

- Settings for the fuel system and the limits for the operating altitude are stamped on the Engine Information Plate. If an engine is moved to a higher altitude, the settings must be changed by a Caterpillar dealer. Changing the settings will help prevent damage to the turbocharger. Changing the settings will help to provide the maximum efficiency for the engine. Engines can be operated safely at higher altitudes, but the engines will deliver less horsepower. The fuel settings should be changed by a Caterpillar dealer in order to obtain the rated horsepower.

## Engine Stopping

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### Emergency Stopping

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**SMCS Code:** 1000; 7418

#### NOTICE

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

Ensure that any components for the external system that support the engine operation are secured after the engine is stopped.

### Emergency Stop Button



Illustration 19

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Typical emergency stop button

The emergency stop button is in the **OUT** position for normal engine operation. Push the emergency stop button. The engine will not start when the button is locked. Turn the button clockwise in order to **reset**.

## Manual Stop Procedure

**SMCS Code:** 1000

**Note:** Individual applications will have different control systems. Ensure that the shutoff procedures are understood. Use the following general guidelines in order to stop the engine.

1. Remove the load, when possible. Reduce the engine rpm to low idle.
2. Increase the engine rpm to no more than one-half of the rated rpm. Perform this procedure for three to five minutes in order to cool the engine. Reduce the engine rpm to low idle.
3. After the cool-down period, turn the start/run switch to the **OFF** position.



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## After Stopping Engine

**SMCS Code:** 1000

**Note:** Before you check the engine oil, do not operate the engine for at least 10 minutes in order to allow the engine oil to return to the oil pan.

- Check the crankcase oil level. Maintain the oil level between the "ADD" mark and the "FULL" mark on the oil level gauge.
- If necessary, perform minor adjustments. Repair any leaks and tighten any loose bolts.
- Note the service hour meter reading. Perform the maintenance that is in the Operation and Maintenance Manual, "Maintenance Interval Schedule".
- Fill the fuel tank in order to help prevent accumulation of moisture in the fuel. Do not overfill the fuel tank.

---

### NOTICE

Only use antifreeze/coolant mixtures recommended in the Coolant Specifications that are in the Operation and Maintenance Manual. Failure to do so can cause engine damage.

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- Allow the engine to cool. Check the coolant level. Maintain the cooling system at 13 mm (0.5 inch) from the bottom of the pipe for filling.
- If freezing temperatures are expected, check the coolant for proper antifreeze protection. The cooling system must be protected against freezing to the lowest expected outside temperature. Add the proper coolant/water mixture, if necessary.
- Perform all required periodic maintenance on all driven equipment. This maintenance is outlined in the instructions from the OEM.

## Cold Weather Operation

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### Radiator Restrictions

**SMCS Code:** 1353, 1396

Caterpillar discourages the use of airflow restriction devices that are mounted in front of radiators. Airflow restriction can cause the following conditions:

- High exhaust temperatures
- Power loss
- Excessive fan usage
- Reduction in fuel economy

If an airflow restriction device must be used, the device should have a permanent opening directly in line with the fan hub. The device must have a minimum opening dimension of at least 770 cm<sup>2</sup> (120 in<sup>2</sup>).

A centered opening that is directly in line with the fan hub is specified in order to prevent an interrupted airflow on the fan blades. Interrupted airflow on the fan blades could cause a fan failure.

Caterpillar recommends a warning device for the inlet manifold temperature and/or the installation of an inlet air temperature gauge. The warning device for the inlet manifold temperature should be set at 75 °C (167 °F). The inlet manifold air temperature should not exceed 75 °C (167 °F). Temperatures that exceed this limit can cause power loss and potential engine damage.

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### Fuel and the Effect from Cold Weather

**SMCS Code:** 1000, 1250

The following fuels are the grades that are available for Caterpillar engines:

- No. 1
- No. 2
- Blend of No. 1 and No. 2

No. 2 diesel fuel is the most commonly used fuel. Either No. 1 diesel fuel or a blend of No. 1 and No. 2 is best suited for cold weather operation.

Quantities of No. 1 diesel fuel are limited. No. 1 diesel fuels are usually available during the months of the winter in the colder climates. During cold weather operation, if No. 1 diesel fuel is not available, use No. 2 diesel fuel, if necessary.

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

- Lower cloud point
- Lower pour point
- Lower rating of kJ (BTU) per unit volume of fuel

When No. 1 diesel fuel is used, a decrease in power and in fuel efficiency may be noticed. Other operating effects should not be experienced.

The cloud point is the temperature when a cloud of wax crystals begins to form in the fuel. These crystals can cause the fuel filters to plug. The pour point is the temperature when diesel fuel will thicken. The diesel fuel becomes more resistant to flow through fuel pumps and through fuel lines.

Be aware of these values when diesel fuel is purchased. Anticipate the average ambient temperature within the area that the engine will be operated. Engines that are fueled in one climate may not operate well if the engines are moved to another climate. Problems can result due to changes in temperature.

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

When No. 2 diesel fuel is used the following components provide a means of minimizing problems in cold weather:

- Starting aids
- Engine oil pan heaters
- Engine coolant heaters
- Fuel heaters
- Fuel line insulation

For more information on cold weather operation, see Operation and Maintenance Manual, SEBU5898, "Cold Weather Recommendations".

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## Fuel Related Components in Cold Weather

**SMCS Code:** 1000, 1250

### Fuel Tanks

Condensation can form in partially filled fuel tanks. Top off the fuel tanks after operating the engine.

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

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

Drain the water and sediment from any fuel storage tank at the following intervals:

- Weekly
- Oil changes
- Refueling of the fuel tank

This will help prevent water and/or sediment from being pumped from the fuel storage tank and into the engine fuel tank.

### Fuel Filters

A primary fuel filter and/or a water separator is installed between the fuel tank and the engine mounted fuel filter. The location of the primary fuel filter is important in cold weather operation. The primary fuel filter and the fuel supply line are commonly affected by cold fuel. The best location for the primary fuel filter is in the engine compartment. Here, the primary fuel filter will benefit from the radiant heat of the engine. A primary fuel filter that is mounted outside the frame rails or in any location that is exposed to wind can be a persistent problem in cold weather.

### Fuel Heaters

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

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

Disconnect the fuel heater in warm weather.

**Note:** Fuel heaters that are controlled by the water temperature regulator or self-regulating fuel heaters should be used with this engine. Fuel heaters that are not controlled by the water temperature regulator can heat the fuel in excess of 65 °C (149 °F). A loss of engine power can occur if the fuel supply temperature exceeds 37 °C (100 °F).

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

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

- 7C-3557 Fuel Heater Group
- 7C-3558 Heater Kit

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

## Maintenance Section

# Torque Specifications

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### General Torque Information

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SMCS Code: 7553

#### WARNING

Mismatched or incorrect fasteners can result in damage or malfunction, or personal injury.

Take care to avoid mixing metric dimensioned fasteners and inch dimensioned fasteners.

Exceptions to these torques are given in the Service Manual, if necessary.

Prior to installation of any hardware, ensure that components are in near new condition. Bolts and threads must not be worn or damaged. Threads must not have burrs or nicks. Hardware must be free of rust and corrosion. Clean the hardware with a noncorrosive cleaner. Do not lubricate the fastener threads except for the rust preventive. The rust preventive should be applied by the supplier of that component for purposes of shipping and storage. Other applications for lubricating components may also be specified in the Service Manual.

## Standard Torque for Inch Fasteners

SMCS Code: 7553

Table 2

Inch Nuts and Bolts	
Thread Size Inch	Standard Torque
1/4	12 ± 3 N·m (9 ± 2 lb ft)
5/16	25 ± 6 N·m (18 ± 4 lb ft)
3/8	47 ± 9 N·m (35 ± 7 lb ft)
7/16	70 ± 15 N·m (50 ± 11 lb ft)
1/2	105 ± 20 N·m (75 ± 15 lb ft)
9/16	160 ± 30 N·m (120 ± 22 lb ft)
5/8	215 ± 40 N·m (160 ± 30 lb ft)
3/4	370 ± 50 N·m (275 ± 37 lb ft)
7/8	620 ± 80 N·m (460 ± 60 lb ft)
1	900 ± 100 N·m (660 ± 75 lb ft)
1 1/8	1300 ± 150 N·m (960 ± 110 lb ft)
1 1/4	1800 ± 200 N·m (1320 ± 150 lb ft)
1 3/8	2400 ± 300 N·m (1780 ± 220 lb ft)
1 1/2	3100 ± 350 N·m (2280 ± 260 lb ft)

Table 3

Inch Taperlock Studs	
Thread Size Inch	Standard Torque
1/4	8 ± 3 N·m (6 ± 2 lb ft)
5/16	17 ± 5 N·m (13 ± 4 lb ft)
3/8	35 ± 5 N·m (26 ± 4 lb ft)
7/16	45 ± 10 N·m (33 ± 7 lb ft)
1/2	65 ± 10 N·m (48 ± 7 lb ft)
5/8	110 ± 20 N·m (80 ± 15 lb ft)
3/4	170 ± 30 N·m (125 ± 22 lb ft)
7/8	260 ± 40 N·m (190 ± 30 lb ft)
1	400 ± 60 N·m (300 ± 44 lb ft)
1 1/8	525 ± 60 N·m (390 ± 44 lb ft)
1 1/4	750 ± 80 N·m (550 ± 60 lb ft)
1 3/8	950 ± 125 N·m (700 ± 90 lb ft)
1 1/2	1200 ± 150 N·m (890 ± 110 lb ft)

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## Standard Torque for Metric Fasteners

SMCS Code: 7553

Table 4

Metric Nuts and Bolts	
Thread Size Metric	Standard Torque
M6	12 ± 3 N·m (9 ± 2 lb ft)
M8	28 ± 7 N·m (21 ± 5 lb ft)
M10	55 ± 10 N·m (41 ± 7 lb ft)
M12	100 ± 20 N·m (75 ± 15 lb ft)
M14	160 ± 30 N·m (120 ± 22 lb ft)
M16	240 ± 40 N·m (175 ± 30 lb ft)
M20	460 ± 60 N·m (340 ± 44 lb ft)
M24	800 ± 100 N·m (590 ± 75 lb ft)
M30	1600 ± 200 N·m (1180 ± 150 lb ft)
M36	2700 ± 300 N·m (2000 ± 220 lb ft)

Table 5

Metric Taperlock Studs	
Thread Size Metric	Standard Torque
M6	8 ± 3 N·m (6 ± 2 lb ft)
M8	17 ± 5 N·m (13 ± 4 lb ft)
M10	35 ± 5 N·m (26 ± 4 lb ft)
M12	65 ± 10 N·m (48 ± 7 lb ft)
M16	110 ± 20 N·m (80 ± 15 lb ft)
M20	170 ± 30 N·m (125 ± 22 lb ft)
M24	400 ± 60 N·m (300 ± 44 lb ft)
M30	750 ± 80 N·m (550 ± 60 lb ft)
M36	1200 ± 150 N·m (880 ± 110 lb ft)

## Standard Torque for Worm Drive Band Hose Clamps

SMCS Code: 7553; 7554



Illustration 20

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Table 6

Width of Clamp	Initial Installation Torque On New Hose
7.9 mm (0.31 inch)	0.9 ± 0.2 N·m (8 ± 2 lb in)
13.5 mm (0.53 inch)	4.5 ± 0.5 N·m (40 ± 4 lb in)
15.9 mm (0.63 inch)	7.5 ± 0.5 N·m (65 ± 4 lb in)
Width of Clamp	Reassembly or Retightening Torque
7.9 mm (0.31 inch)	0.7 ± 0.2 N·m (6 ± 2 lb in)
13.5 mm (0.53 inch)	3.0 ± 0.5 N·m (27 ± 4 lb in)
15.9 mm (0.63 inch)	4.5 ± 0.5 N·m (40 ± 4 lb in)

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## Standard Torque for Constant Torque Hose Clamps

SMCS Code: 7553; 7554

Use a constant torque hose clamp in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard hose clamp. Due to extreme temperature changes, the hose will heat set. Heat setting can cause hose clamps to loosen. Loose hose clamps can result in leaks. There have been reports of component failures that have been caused by hose clamps that have loosened. The constant torque hose clamp will help prevent these failures.

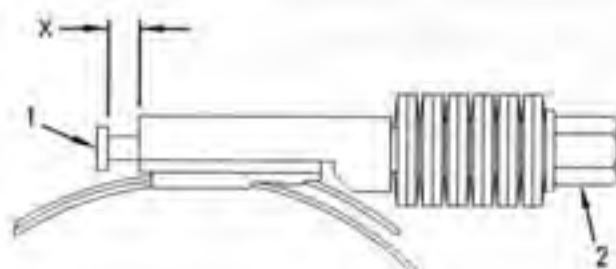


Illustration 21

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Use a torque wrench for proper installation of the constant torque hose clamps. The constant torque hose clamp is installed correctly under the following conditions:

- Screw tip (1) extends 6.35 mm (0.25 inch) (X) beyond the housing.
- The Belleville washers are collapsed nearly flat after screw (2) is tightened to a torque of  $11 \pm 1$  N·m ( $98 \pm 9$  lb in).



# Lubricant Specifications

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## Lubricant Information

SMCS Code: 1000; 1300; 7581

## General Information

Because of government regulations regarding the certification of engine exhaust emissions, the lubricant recommendations must be followed.

## Engine Manufacturers Association (EMA) Oils

The "Engine Manufacturers Association Recommended Guideline on Diesel Engine Oil" is recognized by Caterpillar. For detailed information about this guideline, see the latest edition of EMA publication, "EMA LRG-1".

## API Oils

The Engine Oil Licensing and Certification System by the American Petroleum Institute (API) is recognized by Caterpillar. For detailed information about this system, see the latest edition of the "API publication No. 1509". Engine oils that bear the API symbol are authorized by API.



Illustration 22:  
Typical API symbol

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Diesel engine oils CC, CD, CD-2, and CE have not been API authorized classifications since 1 January 1996. Table 7 summarizes the status of the classifications.

Table 7

API Classifications	
Current	Obsolete
CF-4, CG-4, CH-4	CE
CF	CC, CD
CF-2 <sup>(1)</sup>	CD-2 <sup>(1)</sup>

<sup>(1)</sup> CD-2 and API CF-2 are classifications for two-cycle diesel engines. Caterpillar does not sell engines that utilize CD-2 and API CF-2 oils.

**Note:** API CF is not the same classification as API CF-4. API CF oils are only recommended for Caterpillar 3600 Series Diesel Engines and Caterpillar engines with precombustion chamber (PC) fuel systems.

## Grease

The classifications of grease are based on the "ASTM D217" worked penetration characteristics. These characteristics for grease are given a defined consistency number.

## Terminology

Certain abbreviations follow the nomenclature of "SAE J754". Some classifications follow "SAE J183" abbreviations, and some classifications follow the "EMA Recommended Guideline on Diesel Engine Oil". In addition to Caterpillar definitions, there are other definitions that will be of assistance in purchasing lubricants. Recommended oil viscosities can be found in this publication, "Engine Oil" topic (Maintenance Section).

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## Engine Oil

SMCS Code: 1300; 1348; 7581

## Caterpillar Diesel Engine Oil

Caterpillar Oils have been developed and tested in order to provide the full performance and service life that has been designed and built into Caterpillar Engines. Caterpillar Oils are currently used to fill diesel engines at the factory. These oils are offered by Caterpillar dealers for continued use when the engine oil is changed. Consult your Caterpillar dealer for more information on these oils.

Due to significant variations in the quality and in the performance of commercially available oils, Caterpillar makes the following recommendations:

- **Caterpillar Diesel Engine Oil (10W30)**

### • Caterpillar Diesel Engine Oil (15W40)

Caterpillar multigrade Diesel Engine Oil is formulated with the correct amounts of detergents, dispersants, and alkalinity in order to provide superior performance in Caterpillar Diesel Engines.

Caterpillar multigrade Diesel Engine Oil is available in two viscosity grades (10W30 and 15W40). For direct injection engines, see Table 8 in order to choose the correct viscosity grade for the ambient temperature. Multigrade oils provide the correct viscosity for a broad range of operating temperatures.

Multigrade oils are effective in maintaining low oil consumption and low levels of piston deposits.

Caterpillar multigrade Diesel Engine Oil can be used in other diesel engines and in gasoline engines. See the engine manufacturer's guide for the recommended specifications. Compare the specifications to the specifications of Caterpillar multigrade Diesel Engine Oil. The current industry standards for Caterpillar Diesel Engine Oil are listed on the product label and on the data sheets for the product.

Consult your Caterpillar dealer for part numbers and for available sizes of containers.

## Commercial Oils

The performance of commercial diesel engine oils is based on American Petroleum Institute (API) classifications. These API classifications are developed in order to provide commercial lubricants for a broad range of diesel engines that operate at various conditions.

If Caterpillar multigrade Diesel Engine Oil is not used, only use commercial oils that meet the following classifications:

- EMA LRG-1 multigrade oil (preferred oil)
- API CH-4 multigrade oil (preferred oil)
- API CG-4 multigrade oil (preferred oil)
- API CF-4 multigrade oil (acceptable oil)

In order to make the proper choice of a commercial oil, refer to the following explanations:

**EMA LRG-1** – The Engine Manufacturers Association (EMA) has developed lubricant recommendations as an alternative to the API oil classification system. LRG-1 is a Recommended Guideline that defines a level of oil performance for these types of diesel engines: high speed, four stroke cycle, heavy-duty, and light duty. LRG-1 oils may be used in Caterpillar engines when the following oils are recommended. API CH-4, API CG-4, and API CF-4. LRG-1 oils are intended to provide superior performance in comparison to API CG-4 and API CF-4.

LRG-1 oils will meet the needs of high performance Caterpillar diesel engines that are operating in many applications. The tests and the test limits that are used to define LRG-1 are similar to the new API CH-4 classification. Therefore, these oils will also meet the requirements of the low emissions diesel engines. LRG-1 oils are designed to control the harmful effects of soot with improved wear resistance and improved resistance to plugging of the oil filter. These oils will also provide superior piston deposit control for engines with either two-piece steel pistons or aluminum pistons.

All LRG-1 oils must complete a full test program with the base stock and with the viscosity grade of the finished commercial oil. The use of "API Base Oil Interchange Guidelines" are not appropriate for LRG-1 oils. This feature reduces the variation in performance that can occur when base stocks are changed in commercial oil formulations.

LRG-1 oils are recommended for use in extended oil change interval programs that optimize oil life. These oil change interval programs are based on oil analysis. LRG-1 oils are recommended for conditions that demand a premium oil. Your Caterpillar dealer has the specific guidelines for optimizing oil change intervals.

**API CH-4** – API CH-4 oils were developed in order to meet the requirements of the new high performance diesel engines. Also, the oil was designed to meet the requirements of the low emissions diesel engines. API CH-4 oils are also acceptable for use in older diesel engines and in diesel engines that use high sulfur diesel fuel. API CH-4 oils may be used in Caterpillar engines that use API CG-4 and API CF-4 oils. API CH-4 oils will generally exceed the performance of API CG-4 oils in the following criteria: deposits on pistons, control of oil consumption, wear of piston rings, valve train wear, viscosity control, and corrosion.



Excessive piston deposits can be produced by an oil with a high TBN. These deposits can lead to a loss of control of the oil consumption and to the polishing of the cylinder bore.

**NOTICE**

Operating Direct Injection (DI) diesel engines with fuel sulfur levels over 1.0 percent may require shortened oil change intervals in order to help maintain adequate wear protection.

**Lubricant Viscosity Recommendations for Direct Injection (DI) Diesel Engines**

The proper SAE viscosity grade of oil is determined by the minimum ambient temperature during cold engine start-up, and the maximum ambient temperature during engine operation.

Refer to Table 8 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 8 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Generally, use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

Table 8

Caterpillar DEO Multigrade EMA LRG-1 API CH-4 API CG-4 and API CF-4 Viscosity Grade	Engine Oil Viscosity	
	Ambient Temperature	
	Minimum	Maximum
SAE 0W20	-40 °C (-40 °F)	10 °C (50 °F)
SAE 0W30	-40 °C (-40 °F)	30 °C (86 °F)
SAE 0W40	-40 °C (-40 °F)	40 °C (104 °F)
SAE 5W30	-30 °C (-22 °F)	30 °C (86 °F)
SAE 5W40	-30 °C (-22 °F)	40 °C (104 °F)
SAE 10W30	-20 °C (-4 °F)	40 °C (104 °F)
SAE 15W40	-15 °C (5 °F)	50 °C (122 °F)

1011140  
**Synthetic Base Stock Oils**

**SMCS Code:** 1300; 1348; 7581

Synthetic base oils are acceptable for use in Caterpillar engines if these oils meet the performance requirements that are specified for the engine compartment.

Synthetic base oils generally perform better than conventional oils in the following two areas:

- Synthetic base oils have improved flow at low temperatures especially in arctic conditions
- Synthetic base oils have improved oxidation stability especially at high operating temperatures

Some synthetic base oils have performance characteristics that enhance the service life of the oil. However, Caterpillar does not recommend the automatic extension of oil change intervals for any type of oil. Oil change intervals for Caterpillar engines can only be adjusted after an oil analysis program that contains the following tests: oil condition and wear metal analysis (Caterpillar's S-O-S oil analysis), trend analysis, fuel consumption and oil consumption.

1011141  
**Re-refined Base Stock Oils**

**SMCS Code:** 1300; 7581

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

The process that is used to make re-refined base stock oil should adequately remove all wear metals that are in the used oil and all additives that are in the used oil. The process that is used to make re-refined base stock oil generally involves the processes of vacuum distillation and hydrotreating the used oil. Filtering is inadequate for the production of high quality re-refined base stock oil from used oil.

Three new engine tests were developed for the API CH-4 oil. The first test specifically evaluates deposits on pistons for engines with the two-piece steel piston. This test (piston deposit) also measures the control of oil consumption. A second test is conducted with moderate oil soot. The second test measures the following criteria: wear of piston rings, wear of cylinder liners, and resistance to corrosion. A third new test measures the following characteristics with high levels of soot in the oil: wear of the valve train, resistance of the oil in plugging the oil filter, and control of sludge.

In addition to the new tests, API CH-4 oils have tougher limits for viscosity control in applications that generate high soot. The oils also have improved oxidation resistance. API CH-4 oils must pass an additional test (piston deposit) for engines that use aluminum pistons (single piece). Oil performance is also established for engines that operate in areas with high sulfur diesel fuel.

All of these improvements allow the API CH-4 oil to achieve optimum oil change intervals. API CH-4 oils are recommended for use in extended oil change intervals. API CH-4 oils are recommended for conditions that demand a premium oil. Your Caterpillar dealer has specific guidelines for optimizing oil change intervals.

**API CG-4** – API CG-4 oils were developed primarily for diesel engines that use a 0.05 percent level of fuel sulfur. However, API CG-4 oils can be used with higher sulfur fuels. The TBN of the new oil determines the maximum fuel sulfur level for API CG-4 and API CF-4 oils. See Illustration 23.

API CG-4 oils are the first oils that are required to pass industry standard tests for foam control and viscosity shear loss. API CG-4 oils must also pass tests that were developed for corrosion, wear and oxidation.

**API CF-4** – These oils service a wide variety of modern diesel engines. API CF-4 oils provide more stable oil control and reduced piston deposits in comparison to API CF and the obsolete CE and CD classifications of oil. API CF-4 oils provide improved soot dispersancy in comparison to API CF and obsolete CD oils. The API CF-4 classification was developed with a 0.40 percent sulfur diesel fuel. This represents the type of diesel fuels that are commonly available worldwide.

**Note:** Do not use single grade API CF oils or multigrade API CF oils in Caterpillar Direct Injection (DI) Commercial Diesel Engines.

Some commercial oils that meet the API classifications may require reduced oil change intervals. To determine the oil change interval, closely monitor the condition of the oil and perform a wear metal analysis. Caterpillar's S-O-S oil analysis program is the preferred method.

#### NOTICE

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

## Total Base Number (TBN) and Fuel Sulfur Levels for Direct Injection (DI) Diesel Engines

The Total Base Number (TBN) for an oil depends on the fuel sulfur level. For direct injection engines that use distillate fuel, the minimum TBN of the new oil must be 10 times the fuel sulfur level. The TBN is defined by "ASTM D2896". The minimum TBN of the oil is 5 regardless of fuel sulfur level. Illustration 23 demonstrates the TBN.

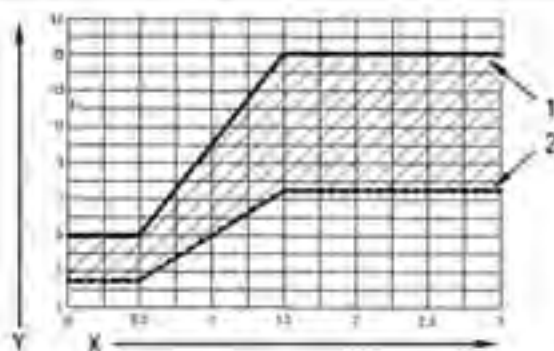


Illustration 23

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(Y) TBN by "ASTM D2896"

(X) Percentage of fuel sulfur by weight

(1) TBN of new oil

(2) Change the oil when the TBN deteriorates to 50 percent of the original TBN.

Use the following guidelines for fuel sulfur levels that exceed 1.5 percent:

- Choose an oil with the highest TBN that meets one of these classifications: EMA LRG-1, API CH-4, API CG-4, and API CF-4.
- Reduce the oil change interval. Base the oil change interval on the oil analysis. Ensure that the oil analysis includes the condition of the oil and a wear metal analysis.

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## Cold Weather Lubricants

**SMCS Code:** 1300, 1348, 7581

When an engine is started and an engine is operated in ambient temperatures below  $-20^{\circ}\text{C}$  ( $-4^{\circ}\text{F}$ ), use multigrade oils that are capable of flowing in low temperatures.

These oils have lubricant viscosity grades of SAE 0W or SAE 5W.

When an engine is started and operated in ambient temperatures below  $-30^{\circ}\text{C}$  ( $-22^{\circ}\text{F}$ ), use a synthetic base stock multigrade oil with a 0W viscosity grade or with a 5W viscosity grade. Use an oil with a pour point that is lower than  $-50^{\circ}\text{C}$  ( $-58^{\circ}\text{F}$ ).

The number of acceptable lubricants is limited in cold weather conditions. Caterpillar recommends the following lubricants for use in cold weather conditions:

**First Choice** – use an oil with an EMA LRG-1 Recommended Guideline or use a CH-4 oil that is API licensed with an SAE 0W20, SAE 0W30, SAE 0W40, SAE 5W30, or SAE 5W40 lubricant viscosity grade. A CG-4 oil that is API licensed with an SAE 0W20, SAE 0W30, SAE 0W40, SAE 5W30, or SAE 5W40 lubricant viscosity grade may also be used. A CF-4 oil that is API licensed with an SAE 0W20, SAE 0W30, SAE 0W40, SAE 5W30, or SAE 5W40 lubricant viscosity grade may also be used.

**Second Choice** – use an oil that contains the CH-4, CG-4, or CF-4 additive package although the oil has not been tested for the requirements of the API license. The oil must have an SAE 0W20, SAE 0W30, SAE 0W40, SAE 5W30, or SAE 5W40 lubricant viscosity grade.

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### NOTICE

Shortened engine service life could result if second choice oils are used.

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## Aftermarket Oil Additives

**SMCS Code:** 1300, 1348, 7581

Caterpillar does not recommend the use of aftermarket additives in oil. It is not necessary to use aftermarket additives in order to achieve the engine's maximum service life or rated performance. Fully formulated, finished oils consist of base oils and of commercial additive packages. These additive packages are blended into the base oils at precise percentages in order to help provide finished oils with performance characteristics that meet industry standards.

There are no industry standard tests that evaluate the performance or the compatibility of aftermarket additives in finished oil. Aftermarket additives may not be compatible with the finished oil's additive package, which could lower the performance of the finished oil. The aftermarket additive could fail to mix with the finished oil. This could produce sludge in the crankcase. Caterpillar discourages the use of aftermarket additives in finished oils.

To achieve the best performance from a Caterpillar engine, conform to the following guidelines:

- Select the proper Caterpillar oil or a commercial oil that meets the "EMA Recommended Guideline on Diesel Engine Oil" or the recommended API classification.
- See the appropriate "Lubricant Viscosities" table in order to find the correct oil viscosity grade for your engine.
- At the specified interval, service the engine compartment. Use new oil and install a new oil filter.
- Perform maintenance at the intervals that are specified in the Operation and Maintenance Manual, "Maintenance Interval Schedule".

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## Lubricating Grease

**SMCS Code:** 7581

Caterpillar provides greases in order to cover a variety of applications and extreme temperature conditions. Consult your Caterpillar dealer for part numbers and for available sizes of containers.

**Note:** Some greases may not be used with other greases. When a commercial grease is used, ensure that the grease is compatible with the grease that is currently used in the system. If the commercial grease is not compatible, the system must be purged. If any questions arise concerning the compatibility of a grease, consult the supplier.

## Multipurpose Greases

### Multipurpose Lithium Complex Grease (MPGL)

Multipurpose Lithium Complex Grease (MPGL) is a general purpose lithium complex grease for medium-duty applications. This product has good characteristics at high temperatures such as a dropping point of 260 °C (500 °F). MPGL contains unleaded extreme pressure additives, antiwear inhibitors, and corrosion inhibitors that provide extra protection in the following applications:

- Construction
- Agricultural
- Automotive

MPGL meets the requirements for extended service intervals of automotive chassis points. MPGL also meets the requirements for extended service intervals of wheel bearings with disc brakes in automobiles, in vans and in light trucks. This product meets the NLGI certification of "GC-LB". MPGL is also available in a NLGI No. 2 grade. Normal operating temperatures for this product are -28 to 149 °C (-18 to 300 °F). This product is also available as a white lithium complex grease.

### Multipurpose Lithium Complex Grease with Molybdenum (MPGM)

Multipurpose Lithium Complex Grease with Molybdenum (MPGM) is a general purpose lithium complex grease that is used for light-duty applications and for medium-duty applications. The MPGM is available in the following grades: NLGI No. 2 and NLGI No. 0. The MPGM is strengthened with a molybdenum disulfide and a polymer for extra lubrication and protection. MPGM contains unleaded additives. MPGM also contains antiwear inhibitors, rust inhibitors, and corrosion inhibitors that are for protection and lubrication in many environments. The MPGM is formulated with a base fluid that has high viscosity.

The MPGM has the following features:

- Increased protection against water washout

- Increased retention
- Resistance to heavy loads

This product is recommended for heavily loaded pin joints and for journal bearings. This product meets the certification of "GC-LB". Normal operating temperatures for this product are -28 to 149 °C (-18 to 300 °F) for the NLGI No. 0. Normal operating temperatures for this product are -18 to 149 °C (0 to 300 °F) for the NLGI No. 2.

**Note:** If MPGM is not available, use a multipurpose type grease which contains three to five percent molybdenum.

## Special Purpose Grease (SPG)

### Bearing Lubrication (SPG)

Bearing Lubricant (SPG) is available in a NLGI No. 2 grade with a polyurea thickener. This grease is recommended for high temperature antifriction bearings in the following applications: electric starting motors, alternators, fan drives, and generators. The Bearing Lubricant (SPG) has an effective operating range of -29 to 177 °C (-20 to 350 °F).

### Water and Temperature Resistant Grease (WTR)

The Water and Temperature Resistant Grease is designed for use whenever the following conditions are a concern: water washout, severe corrosion, and high operating temperatures. The Water and Temperature Resistant Grease provides extreme pressure protection, antiwear protection, rust protection and corrosion protection. The Water and Temperature Resistant Grease is an environmentally friendly grease which does not contain the following materials: antimony, sulfur, barium, zinc, lead, and phosphorous materials. The Water and Temperature Resistant Grease has excellent shear stability. Water and Temperature Resistant Grease can also resist breakdown in the presence of water. The Water and Temperature Resistant Grease works well in the following applications:

- Construction
- Agricultural
- Automotive
- Industrial
- Marine



This product meets the NLGI certification of "GC-LB". Normal operating temperatures for this product are -40 to 204°C (-40 to 400°F).

## Caterpillar Premium Grease (CPG)

### Desert Gold (CPG)

Desert Gold is a heavy-duty, premium synthetic grease that is developed for the most extreme operating environments. This grease is formulated with the following characteristics: high viscosity synthetic base fluid, polymers, molybdenum disulfide, high viscosity index, and high dropping point.

Desert Gold will protect equipment against heavy shock loads. Desert Gold protects against corrosion in extreme heat, in moist conditions, or in dusty conditions. This product has excellent characteristics of adhesion and of stability. Desert Gold provides longer protection than other greases. Desert Gold is an environmentally friendly grease which does not contain the following materials: antimony, sulfur, barium, zinc, lead, and phosphorous materials. Normal operating temperatures are -6 to 230 °C (21 to 450 °F). Desert Gold can operate at higher temperatures for short time periods. Desert Gold has additional extreme pressure protection for highly loaded pin joints.

### Arctic Platinum (CPG)

Arctic Platinum is a super-premium extreme pressure lubricating grease that is developed for lubrication in temperatures that are below zero to moderate operating temperatures. Arctic Platinum is available in grades 000, 00, 0, 1, and 2. These grades ensure pumpability in central lube systems in a variety of ambient temperatures from -60 to 18 °C (-76 to 65 °F). Arctic Platinum has a high dropping point. Arctic Platinum contains a five percent concentrate of molybdenum disulfide for protection against extra heavy loads. Arctic Platinum provides excellent corrosion protection and rust protection. Arctic Platinum is an environmentally friendly grease which does not contain the following materials: antimony, sulfur, barium, zinc, and phosphorous.

Arctic Platinum is designed for long life lubrication of the following components: horizontal pivot bearings, lower link bearings, steering cylinders, kingbolt bearings, upper hitch link bearings, and ejector carrier roller bearings. This grease is extra tacky for retention on excavator carbody bearings. Arctic Platinum has additional extreme pressure protection for highly loaded pin joints.

## S-O-S Oil Analysis

**SMCS Code:** 1348; 7542; 7581

Caterpillar recommends the use of the S-O-S oil analysis program in order to monitor the condition and the maintenance requirements of the equipment. The S-O-S oil analysis program will complement the preventive maintenance program.

The S-O-S oil analysis is a diagnostic tool that is used to determine oil performance and component wear rates. Contamination can be identified and measured through the use of the S-O-S oil analysis. The S-O-S oil analysis includes the following tests:

- The Wear Rate Analysis monitors the wear of the engine's metals. The amount of wear metal and type of wear metal that is in the oil is analyzed. The increase in the rate of engine wear metal in the oil is as important as the quantity of engine wear metal in the oil. For this reason, regular sampling at specified intervals is necessary in order to establish wear rates. Intermittent sampling does not allow wear rate trend lines to be established. Engine wear metals in the oil sample are compared to established Caterpillar norms in order to determine acceptability.
- Tests are conducted in order to detect contamination of the oil by water, glycol or fuel.
- The Oil Condition Analysis determines the loss of the oil's lubricating properties. An infrared analysis is used to compare the properties of new oil to the properties of the used oil sample. This analysis allows technicians to determine the amount of deterioration of the oil during use. This analysis also allows technicians to verify the performance of the oil according to the specification during the entire oil change interval.

The test results of the oil samples will then be used as a basis for determining the oil change interval for the engine. The results of the S-O-S oil analysis may allow the engine to operate longer between oil changes without the risk of engine damage.

Table 9

S-O-S Oil Analysis Interval	
Compartment	Interval
Engine crankcase	Every 250 Service Hours

For more information, see Special Publication, PEDP7036, "S-O-S Fluid Analysis". Consult your Caterpillar dealer for complete information and assistance about the program.

## Fuel Specifications

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### Fuel Recommendations

**SMCS Code:** 1250; 1280

Diesel engines have the ability to burn a wide variety of fuels. These fuels are divided into two general groups. The two groups are called the preferred fuels and the permissible fuels.

The preferred fuels provide maximum engine service life and performance. The preferred fuels are distillate fuels. These fuels are commonly called diesel fuel, furnace fuel, gas oil, or kerosene.

The permissible fuels are crude oils or blended fuels. Use of these fuels can result in higher maintenance costs and in reduced engine service life.

Diesel fuels that meet the specifications in Table 10 will help to provide maximum engine service life and performance. In North America, diesel fuel that is identified as No. 1-D or No. 2-D in "ASTM D975" generally meet the specifications. Table 10 is for diesel fuels that are distilled from crude oil. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

Table 10

Caterpillar Specifications for Distillate Diesel Fuel		
Specifications	Requirements	ASTM Test
Aromatics	35% maximum	"D1319"
Ash	0.02% maximum (weight)	"D482"
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	"D524"
Cetane Number	40 minimum (DI engines)	"D613"
	35 minimum (PC engines)	
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	—
Copper Strip Corrosion	No. 3 maximum	"D130"

(continued)

(Table 10, cont'd)

Caterpillar Specifications for Distillate Diesel Fuel		
Specifications	Requirements	ASTM Test
Distillation	10% at 282 °C (540 °F) maximum	"D86"
	90% at 360 °C (680 °F) maximum	
Flash Point	legal limit	"D93"
API Gravity	30 minimum	"D287"
	45 maximum	
Pour Point	6 °C (10 °F) minimum below ambient temperature	"D97"
Sulfur <sup>(1)</sup>	3% maximum	"D3605" or "D1552"
Kinematic Viscosity <sup>(2)</sup>	1.4 cSt minimum and 20.0 cSt maximum at 40 °C (104 °F)	"D445"
Water and Sediment	0.1% maximum	"D1796"
Water	0.1% maximum	"D1744"
Sediment	0.05% maximum (weight)	"D473"
Gums and Resins <sup>(3)</sup>	10 mg per 100 mL maximum	"D381"
Lubricity <sup>(4)</sup>	3100 g minimum	"D6078"
	0.45 mm (0.018 inch) maximum at 60 °C (140 °F)	
	0.38 mm (0.015 inch) maximum at 25 °C (77 °F)	

<sup>(1)</sup> Caterpillar fuel systems and engine components can operate on high sulfur fuels. Fuel sulfur levels affect exhaust emissions. High sulfur fuels also increase the potential for corrosion of internal components. Fuel sulfur levels above 1.0 percent may significantly shorten the oil change interval. For additional information, see this publication, "Engine Oil" topic (Maintenance Section).

<sup>(2)</sup> The values of the fuel viscosity are the values as the fuel is delivered to the fuel injection pumps. If a fuel with a low viscosity is used, cooling of the fuel may be required to maintain a 1.4 cSt viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters in order to bring down the viscosity to a 20 cSt viscosity. For additional information, see Special Publication, SEBD0717, "Diesel Fuel and Your Engine".

<sup>(3)</sup> Follow the test conditions and procedures for gasoline (motor).

<sup>(4)</sup> The lubricity of a fuel is a concern with low sulfur fuel. To determine the lubricity of the fuel, use either the "ASTM D6078 Scuffing Load Wear Test (SBOCLE)" or the "ASTM D6079 High Frequency Reciprocating Rig (HFRR)" test. If the lubricity of a fuel does not meet the minimum requirements, consult your fuel supplier. Do not treat the fuel without consulting the fuel supplier. Some additives are not compatible. These additives can cause problems in the fuel system.

**NOTICE**

Operating with fuels that do not meet Caterpillar's recommendations can cause the following effects: starting difficulty, poor combustion, deposits in the fuel injectors, reduced service life of the fuel system, deposits in the combustion chamber, and reduced service life of the engine.

In the USA, 0.05 percent diesel fuels have been used in all on-highway truck engines since 1 January 1994. This low sulfur diesel fuel was mandated as a means of directly reducing particulate emissions from diesel truck engines. This low sulfur fuel will also be used in Caterpillar commercial diesel engines when low emissions are required or when the fuel supply sources provide this type of fuel. Caterpillar has not seen any detrimental effects with 0.05 percent sulfur fuel in Caterpillar diesel engines.

**NOTICE**

Heavy Fuel Oil (HFO), Residual fuel, or Blended fuel must NOT be used in Caterpillar diesel engines (except in 3600 Series HFO engines). Severe component wear and component failures will result if HFO type fuels are used in engines that are configured to use distillate fuel.

In extreme cold ambient conditions, you may use the distillate fuels that are specified in Table 11. However, the fuel that is selected must meet the requirements that are specified in Table 10. These fuels are intended to be used in operating temperatures that are down to  $-54^{\circ}\text{C}$  ( $-65^{\circ}\text{F}$ ).

Table 11

<b>Distillate Fuels <sup>(1)</sup></b>	
<b>Specification</b>	<b>Grade</b>
"MIL-T-5624R"	JP-5
"ASTM D1655"	Jet-A-1
"MIL-T-83133D"	JP-8

<sup>(1)</sup> The fuels that are listed in this Table may not meet the requirements that are specified in the "Caterpillar Specifications for Distillate Diesel Fuel" Table. Consult the supplier for the recommended additives in order to maintain the proper fuel lubricity.

These fuels are lighter than the No. 2 grades of fuel. The cetane number of the fuels in Table 11 must be at least 40. If the viscosity is below 1.4 cSt at  $38^{\circ}\text{C}$  ( $100^{\circ}\text{F}$ ), use the fuel only in temperatures below  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ ). Do not use any fuels with a viscosity of less than 1.2 cSt at  $38^{\circ}\text{C}$  ( $100^{\circ}\text{F}$ ). Fuel cooling may be required in order to maintain the minimum viscosity of 1.4 cSt at the fuel injection pump.

There are many other diesel fuel specifications that are published by governments and by technological societies. Usually, those specifications do not review all the requirements that are addressed in this specification. To ensure optimum engine performance, a complete fuel analysis should be obtained before engine operation. The fuel analysis should include all of the properties that are listed in Table 10.

## Cooling System Specifications

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### General Coolant Information

**SMCS Code:** 1350, 1395

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#### NOTICE

Never add coolant to an overheated engine. Engine damage could result. Allow the engine to cool first.

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#### NOTICE

If the engine is to be stored in, or shipped to an area with below freezing temperatures, the cooling system must be either protected to the lowest outside temperature or drained completely to prevent damage.

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#### NOTICE

In cold weather, frequently check the specific gravity of the coolant solution to ensure adequate protection.

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Clean the cooling system for the following reasons:

- Contamination of the cooling system
- Overheating of the engine
- Foaming of the coolant

**Note:** Air pockets can form in the cooling system if the cooling system is filled at a rate that is greater than 20 L (5 US gal) per minute.

After you drain the cooling system and after you refill the cooling system, operate the engine. Operate the engine without the filler cap until the coolant reaches normal operating temperature and the coolant level stabilizes. Ensure that the coolant is maintained to the proper level.

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#### NOTICE

Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators.

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Refer to Special Instruction, SEBD0518, "Know Your Cooling System" and Special Instruction, SEBD0970, "Coolant and Your Engine" for more detailed information.

Many engine failures are related to the cooling system. The following problems are related to cooling system failures: overheating, leakage of the water pump, plugged radiators or heat exchangers, and pitting of the cylinder liners.

These failures can be avoided with proper cooling system maintenance. Cooling system maintenance is as important as maintenance of the fuel system and the lubrication system. Quality of the coolant is as important as the quality of the fuel and the lubricating oil.

Coolant is normally composed of three elements: water, additives, and glycol.

### Water

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#### NOTICE

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

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#### NOTICE

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

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Water is used in the cooling system in order to transfer heat.

**Distilled water or deionized water is recommended for use in engine cooling systems.**

DO NOT use the following types of water in cooling systems: hard water, softened water that has been conditioned with salt, and sea water.

If distilled water or deionized water is not available, use water with the properties that are listed in Table 12.



Table 12

Caterpillar Minimum Acceptable Water Requirements		
Property	Maximum Limit	ASTM Test
Chloride (Cl)	40 mg/L (2.4 grains/US gal)	"D512", "D4327"
Sulfate (SO <sub>4</sub> )	100 mg/L (5.9 grains/US gal)	"D516"
Total Hardness	170 mg/L (10 grains/US gal)	"D1126"
Total Solids	340 mg/L (20 grains/US gal)	"D1888"
Acidity	pH of 5.5 to 9.0	"D1293"

For a water analysis, consult one of the following sources:

- Caterpillar dealer
- Local water utility company
- Agricultural agent
- Independent laboratory

## Additives

Additives help to protect the metal surfaces of the cooling system. A lack of coolant additives or insufficient amounts of additives enable the following conditions to occur:

- Corrosion
- Formation of mineral deposits
- Rust
- Scale
- Pitting and erosion from cavitation of the cylinder liner
- Foaming of the coolant

Many additives are depleted during engine operation. These additives must be replaced periodically. This can be done by adding Supplemental Coolant Additives (SCA) to Diesel Engine Antifreeze/Coolant (DEAC) or by adding ELC Extender to Extended Life Coolant (ELC).

Additives must be added at the proper concentration. Overconcentration of additives can cause the inhibitors to drop out-of-solution. The deposits can enable the following problems to occur:

- Formation of gel compounds.
- Reduction of heat transfer
- Leakage of the water pump seal
- Plugging of radiators, coolers, and small passages

## Glycol

Glycol in the coolant helps to provide protection against the following conditions:

- Boiling
- Freezing
- Cavitation of the water pump and the cylinder liner

For optimum performance, Caterpillar recommends a 1:1 mixture of a water/glycol solution.

### NOTICE

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

**Note:** Use a mixture that will provide protection against the lowest ambient temperature.

**Note:** 100 percent pure glycol will freeze at a temperature of  $-23^{\circ}\text{C}$  ( $-9^{\circ}\text{F}$ ).

Most conventional heavy-duty coolant/antifreezes use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. See Tables 13 and 14.

Table 13

Ethylene Glycol		
Concentration	Freeze Protection	Boil Protection
50 Percent	$-36^{\circ}\text{C}$ ( $-33^{\circ}\text{F}$ )	$106^{\circ}\text{C}$ ( $223^{\circ}\text{F}$ )
60 Percent	$-51^{\circ}\text{C}$ ( $-60^{\circ}\text{F}$ )	$111^{\circ}\text{C}$ ( $232^{\circ}\text{F}$ )

### NOTICE

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

Table 14

Propylene Glycol		
Concentration	Freeze Protection	Boil Protection
50 Percent	-29 °C (-20 °F)	106 °C (223 °F)

To check the concentration of glycol, use the 1U-7298 Coolant/Battery Tester (Degree Celsius) or use the 1U-7297 Coolant/Battery Tester (Degree Fahrenheit). The testers give readings that are immediate and accurate. The testers can be used with ethylene or propylene glycol.

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## Coolant Recommendations

**SMCS Code:** 1350, 1395

The following two coolants are used in Caterpillar diesel engines:

**Preferred** – Caterpillar Extended Life Coolant (ELC) or a commercial extended life coolant that meets the Caterpillar EC-1 specification.

**Acceptable** – A Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) or a commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" or "ASTM D5345" specifications.

### NOTICE

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

Caterpillar recommends a 1:1 mixture of water and glycol. This mixture of water and glycol will provide optimum heavy-duty performance as a coolant/antifreeze.

**Note:** Caterpillar DEAC DOES NOT require a treatment with an SCA at the initial fill. Commercial heavy-duty coolant/antifreeze that meets "ASTM D4985" or "ASTM D5345" specifications MAY require a treatment with an SCA at the initial fill. Read the label or the instructions that are provided by the OEM of the product.

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

### NOTICE

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

Table 15

Coolant Service Life	
Coolant Type	Service Life
Caterpillar ELC	5000 Service Hours or Six Years
Caterpillar DEAC	3000 Service Hours or Three Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D5345"	3000 Service Hours or Two Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D4985"	3000 Service Hours or One Year
Caterpillar SCA and Water	3000 Service Hours or Two Years
Commercial SCA and Water	3000 Service Hours or One Year

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## S-O-S Coolant Analysis

**SMCS Code:** 1352, 1395, 7542

Testing the engine coolant is important to ensure that the engine is protected from internal cavitation and from corrosion. The analysis also tests the ability of the coolant to protect the engine from boiling and from freezing. The S-O-S Coolant Analysis can be done at your Caterpillar dealer. Caterpillar S-O-S Coolant Analysis is the best way to monitor the condition of your coolant and your cooling system. S-O-S Coolant Analysis is a program that is based on periodic samples.

### NOTICE

Do not use the same vacuum sampling pump for extracting oil samples that is used for extracting coolant samples.

A small residue of either type sample may remain in the pump and may cause a false positive analysis for the sample being taken.

Always use a designated pump for oil sampling and a designated pump for coolant sampling.

Failure to do so may cause a false analysis which could lead to customer and dealer concerns.

## New Systems, Refilled Systems, and Converted Systems

Perform a coolant analysis (Level 2) at 500 service hours for new systems, for refilled systems, or for converted systems that use ELC or use DEAC. This 500 hour check will also check for any residual cleaner that may have contaminated the system.

## Recommended Interval for S-O-S Coolant Sample

Perform a coolant analysis (Level 1) at every 500 service hour interval. Perform a coolant analysis (Level 2) annually.

**Note:** Check the standard coolant's Supplemental Coolant Additive at every oil change.

## S-O-S Coolant Analysis (Level 1)

A coolant analysis (Level 1) is a test of the properties of the coolant.

The following properties of the coolant are tested:

- Glycol Concentration for freeze protection
- Ability to protect from erosion and corrosion
- pH
- Conductivity
- Water hardness
- Visual analysis
- Odor analysis

The results are reported, and appropriate recommendations are made.

## S-O-S Coolant Analysis (Level 2)

Level 2 coolant analysis is a comprehensive chemical evaluation of the coolant. This analysis is also a check of the overall condition of the inside of the cooling system.

The S-O-S Coolant Analysis has the following five features:

- Full analysis of Level 1
- Identification of the source of metal corrosion and of contaminants

- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling
- Determination of possible electrolysis within the engines' cooling system

The results are reported, and appropriate recommendations are made.

For more information on S-O-S Coolant Analysis, consult your Caterpillar dealer.

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## Extended Life Coolant (ELC)

**SMCS Code:** 1350, 1395

Caterpillar provides Extended Life Coolant (ELC) for use in the following applications:

- Heavy-duty spark ignited gas engines
- Heavy-duty diesel engines
- Automotive applications

The anti-corrosion package for Caterpillar ELC is different from the anti-corrosion package for other coolants. Caterpillar ELC is an ethylene glycol base coolant. However, Caterpillar ELC contains organic corrosion inhibitors and antifoam agents with low amounts of nitrite. Caterpillar ELC has been formulated with the correct amount of these additives in order to provide superior corrosion protection for all metals in engine cooling systems.

ELC extends the service life of the coolant to 6000 service hours or six years. ELC does not require a frequent addition of a Supplemental Coolant Additive (SCA). An Extender is the only additional maintenance that is needed at 3000 service hours or one half of the ELC service life.

ELC is available in a 1:1 premixed cooling solution with distilled water. The Premixed ELC provides freeze protection to  $-36^{\circ}\text{C}$  ( $-33^{\circ}\text{F}$ ). The Premixed ELC is recommended for the initial fill of the cooling system. The Premixed ELC is also recommended for topping off the cooling system.

ELC Concentrate is also available. ELC Concentrate can be used to lower the freezing point to  $-51^{\circ}\text{C}$  ( $-60^{\circ}\text{F}$ ) for arctic conditions.

Containers of several sizes are available. Consult your Caterpillar dealer for the part numbers.

Note: Caterpillar developed the EC-1 specification. The EC-1 specification is an industry standard. The EC-1 specification defines all of the performance requirements that are needed for an engine coolant to be sold as an extended life coolant for Caterpillar engines. ELC can be used in most OEM engines of the following types: diesel, gasoline, and natural gas. ELC meets the performance requirements of "ASTM D4985" and "ASTM D5345" for heavy-duty low silicate antifreeze/coolants. ELC also meets the performance requirements of "ASTM D3308" and "ASTM D4656" for automotive applications.

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## Extended Life Coolant (ELC) Cooling System Maintenance

SMCS Code: 1350, 1352; 1395

### Proper additions to the Extended Life Coolant

#### NOTICE

Use only Caterpillar products or commercial products that have passed Caterpillar's EC-1 specification for pre-mixed or concentrated coolants.

Use only Caterpillar Extender with Extended Life Coolant.

Mixing Extended Life Coolant with other products reduces the Extended Life Coolant service life. Failure to follow the recommendations can reduce cooling system components life unless appropriate corrective action is performed.

In order to maintain the correct balance between the antifreeze and the additives, you must maintain the recommended concentration of Extended Life Coolant (ELC). Lowering the proportion of antifreeze lowers the proportion of additive. This will lower the ability of the coolant to protect the system from pitting, from cavitation, from erosion, and from deposits.

#### NOTICE

Do not use a conventional coolant to top-off a cooling system that is filled with Extended Life Coolant (ELC).

Do not use standard supplemental coolant additive (SCA). Only use ELC Extender in cooling systems that are filled with ELC.

## Caterpillar ELC Extender

Caterpillar ELC Extender is added to the cooling system halfway through the ELC service life. Treat the cooling system with ELC Extender at 3000 hours or one half of the coolant service life. Use Table 16 in order to determine the proper amount of ELC Extender that is required.

Containers of several sizes are available. Consult your Caterpillar dealer for the part numbers.

Table 16

Caterpillar ELC Extender Additions by Cooling System Capacity	
Cooling System Capacity	Addition of ELC Extender
22 to 30 L (6 to 8 US gal)	0.57 L (20 fl oz)
31 to 38 L (9 to 10 US gal)	0.71 L (24 fl oz)
39 to 49 L (11 to 13 US gal)	0.95 L (32 fl oz)
50 to 64 L (14 to 17 US gal)	1.19 L (40 fl oz)
65 to 83 L (18 to 22 US gal)	1.60 L (54 fl oz)
84 to 114 L (23 to 30 US gal)	2.15 L (72 fl oz)
115 to 163 L (31 to 43 US gal)	3.00 L (100 fl oz)
164 to 242 L (44 to 64 US gal)	4.40 L (148 fl oz)

For cooling system capacities that exceed the capacities that are specified in Table 16, use the equation that is in Table 17 in order to determine the proper amount of ELC Extender that is required.

Table 17

Equation For Adding ELC Extender To ELC
$V \times 0.02 = X$
V is the total volume of the cooling system.
X is the amount of ELC Extender that is required.

Table 18 is an example for using the equation that is in Table 17.

Table 18

Example Of The Equation For Adding ELC Extender To ELC		
Total Volume of the Cooling System (V)	Multiplication Factor	Amount of ELC Extender that is Required (X)
946 L (250 US gal)	$\times 0.02$	19 L (5 US gal)



**NOTICE**

When using Caterpillar ELC, do not use standard SCA's or SCA filters. To avoid SCA contamination of an ELC system, remove the SCA filter base and plug off or by-pass the coolant lines.

**ELC Cooling System Cleaning**

**Note:** If the cooling system is already using ELC, cleaning agents are not required to be used at the specified coolant change interval. Cleaning agents are only required if the system has been contaminated by the addition of some other type of coolant or by cooling system damage.

Clean water is the only cleaning agent that is required when ELC is drained from the cooling system.

ELC can be recycled. The drained coolant mixture can be distilled in order to remove the ethylene glycol and the water. The ethylene glycol and the water can be reused. Consult your Caterpillar dealer for more information.

After the cooling system is drained and after the cooling system is refilled, operate the engine while the cooling system filler cap is removed. Operate the engine until the coolant level reaches the normal operating temperature and until the coolant level stabilizes. As needed, add the coolant mixture in order to fill the system to the proper level.

**Changing to Caterpillar ELC**

To change from heavy-duty coolant/antifreeze to the Caterpillar ELC, perform the following steps:

**NOTICE**

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant into a suitable container.
2. Dispose of the coolant according to local regulations.

**NOTICE**

Do not leave an empty SCA filter on an ELC system.

The filter housing may corrode and leak causing an engine failure.

Remove the SCA filter base and plug off or by-pass the coolant lines.

3. Remove the empty SCA filter and remove the filter base. Plug the coolant lines or bypass the coolant lines.
4. Flush the system with clean water in order to remove any debris.
5. Use Caterpillar cleaner to clean the system. Follow the instruction on the label.
6. Drain the cleaner into a suitable container. Flush the cooling system with clean water.
7. Fill the cooling system with clean water and operate the engine until the engine is warmed to 49° to 66°C (120° to 150°F).

**NOTICE**

Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

8. Drain the cooling system into a suitable container and flush the cooling system with clean water.

**Note:** The cooling system cleaner must be thoroughly flushed from the cooling system. Cooling system cleaner that is left in the system will contaminate the coolant. The cleaner may also corrode the cooling system.

9. Repeat Steps 7 and 8 until the system is completely clean.
10. Fill the cooling system with the Caterpillar premixed ELC.
11. Attach the Special Publication, PEEP5027, "Label" to the cooling system filler for the engine in order to indicate the use of Caterpillar ELC.

## ELC Cooling System Contamination

### NOTICE

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

ELC cooling systems can withstand contamination to a maximum of ten percent of conventional heavy-duty coolant/antifreeze or SCA. If the contamination exceeds ten percent of the total system capacity, perform ONE of the following procedures:

- Drain the cooling system into a suitable container. Dispose of the coolant according to local regulations. Flush the system with clean water. Fill the system with the Caterpillar ELC.
- Drain a portion of the cooling system into a suitable container according to local regulations. Then, fill the cooling system with premixed ELC. This should lower the contamination to less than 10 percent.
- Maintain the system as a conventional Diesel Engine Antifreeze/Coolant (DEAC). Treat the system with an SCA. Change the coolant at the interval that is recommended for the conventional Diesel Engine Antifreeze/Coolant (DEAC).

## Commercial ELC

If Caterpillar ELC is not used, then select a commercial ELC that meets the Caterpillar specification of EC-1 and either the "ASTM D5345" specification or the "ASTM D4985" specification. Do not use an extended life coolant that does not meet the EC-1 specification. Follow the maintenance guide for the coolant from the supplier of the commercial ELC. Follow the Caterpillar guidelines for the quality of water and the specified coolant change interval.

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## Diesel Engine Antifreeze/Coolant (DEAC)

**SMCS Code:** 1350, 1395

Caterpillar recommends using Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) for cooling systems that require a heavy-duty coolant/antifreeze. Caterpillar DEAC is an alkaline single-phase ethylene glycol type antifreeze that contains corrosion inhibitors and antifoam agents.

Caterpillar DEAC is formulated with the correct amount of Caterpillar Supplemental Coolant Additive (SCA). Do not use SCA at the initial fill when DEAC is used.

Containers of several sizes are available. Consult your Caterpillar dealer for the part numbers.

If concentrated DEAC is used, Caterpillar recommends mixing the concentrate with distilled water or with deionized water. If distilled water is not available or deionized water is not available, use water which has the required properties. For the water properties, see this publication, "General Coolant Information" topic (Maintenance Section).

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## Supplemental Coolant Additive (SCA)

**SMCS Code:** 1350, 1352, 1395

The use of SCA helps to prevent the following conditions from occurring:

- Corrosion
- Formation of mineral deposits
- Cavitation erosion of the cylinder liners
- Foaming of the coolant

Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) is formulated with the correct level of Caterpillar SCA. When the cooling system is initially filled with DEAC, adding more SCA is not necessary until the concentration of SCA has been depleted. To ensure that the correct amount of SCA is in the cooling system, the concentration of SCA must be tested on a scheduled basis. Refer to the specific engine's Operation and Maintenance Manual, "Maintenance Interval Schedule".

Containers of SCA are available in several sizes. Consult your Caterpillar dealer for the part numbers.

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## Commercial Heavy-Duty Coolant/Antifreeze and SCA

**SMCS Code:** 1350; 1395

If Caterpillar DEAC is not used, select a coolant/antifreeze with low silicate content for heavy-duty applications that meets "ASTM D5345" or "ASTM D4985" specifications.

**Note:** When you are not using Caterpillar DEAC the cooling system must be drained one time during every year. The cooling system must be flushed at this time as well.

When a heavy-duty coolant/antifreeze is used, treat the cooling system with three to six percent Caterpillar SCA by volume. For more information, see this publication, "Conventional Coolant/Antifreeze Cooling System Maintenance" topic (Maintenance Section).

If Caterpillar SCA is not used, select a commercial SCA. The commercial SCA must provide a minimum of 1200 mg/L or 1200 ppm (70 grains/US gal) of nitrites in the final coolant mixture.

Coolant/antifreeze that meets "ASTM D5345" or "ASTM D4985" specifications MAY require treatment with SCA at the initial fill. These coolants WILL require treatment with SCA on a maintenance basis.

When concentrated coolant/antifreeze is mixed, Caterpillar recommends mixing the concentrate with distilled water or with deionized water. If distilled water or deionized water is not available, water which has the required properties may be used. For the water properties, see this publication, "General Coolant Information" topic (Maintenance Section).

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## Water/Supplemental Coolant Additive (SCA)

**SMCS Code:** 1350; 1352; 1395

### NOTICE

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

### NOTICE

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

**Note:** Premix the coolant solution in order to provide protection to the lowest ambient temperature that is expected.

**Note:** Pure undiluted antifreeze freezes at  $-23^{\circ}\text{C}$  ( $-9^{\circ}\text{F}$ ).

In engine cooling systems that use water alone, Caterpillar recommends the use of SCA. SCA helps to prevent the following conditions from occurring:

- Corrosion
- Formation of mineral deposits
- Cavitation erosion of the cylinder liner
- Foaming of the coolant

If Caterpillar SCA is not used, select a commercial SCA. The commercial SCA must provide a minimum of 2400 mg/L or 2400 ppm (140 grains/US gal) of nitrites in the final coolant mixture.

The quality of the water is a very important factor in this type of cooling system. Distilled water or deionized water is recommended for use in cooling systems. If distilled water or deionized water is not available, use water that meets the minimum requirements that are listed in the table for recommended water properties in this publication, "General Coolant Information" topic (Maintenance Section).

A cooling system that uses a mixture of SCA and water only needs more SCA than a cooling system that uses a mixture of glycol and water. The SCA concentration in a cooling system that uses SCA and water should be six to eight percent by volume. Refer to Table 19 for the amount of SCA that is required for various capacities of the cooling system.

Table 19

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

Refer to Table 20 for part numbers and for quantities of SCA.

Table 20

Caterpillar Liquid SCA	
Part Number	Quantity
6V-3542	0.24 L (8 oz)
111-2372	0.36 L (12 oz)
8T-1589	0.47 L (16 oz)
3P-2044	0.94 L (32 oz)
8C-3680	19 L (5 US gal)
5P-2907	208 L (55 US gal)

Maintain the SCA in the same way as you would maintain a cooling system that uses heavy-duty coolant/antifreeze. Adjust the maintenance for the amount of SCA additions. See Table 19 for the amount of SCA that is required.

## Cooling Systems with Larger Capacities

### Adding the SCA to Water at the Initial Fill

Use the equation that is in Table 21 to determine the amount of Caterpillar SCA that is required at the initial fill. This equation is for a mixture of only SCA and water.

Table 21

Equation For Adding The SCA To Water At The Initial Fill
$V \times 0.07 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 22 is an example for using the equation that is in Table 21.

Table 22

Example Of The Equation For Adding The SCA To Water At The Initial Fill		
Total Volume of the Cooling System (V)	Multiplication Factor	Amount of SCA that is Required (X)
946 L (250 US gal)	$\times 0.07$	66 L (18 US gal)

### Adding the SCA to Water for Maintenance

For the recommended service interval, refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" for your engine.

Use the 8T-5296 Coolant Conditioner Test Kit to test the concentration of SCA. Make the following modifications to Steps 3 and 5 of the 8T-5296 Coolant Conditioner Test Kit instructions:

**STEP 3** – Add tap water to the vial up to the "20 ml" mark.

**STEP 5** – When the defined procedure is used, a concentration of six to eight percent will yield between 20 drops and 27 drops. If the number of drops is below 20 drops, the concentration of SCA is low. If the number of drops is above 27 drops, the concentration of SCA is high. Make the appropriate adjustments to the concentration of SCA.

Test the concentration of SCA or submit a coolant sample to your Caterpillar dealer. See this publication, "S-O-S Coolant Analysis" topic (Maintenance Section).



Additions of SCA are based on the results of the test or based on the results of the coolant analysis. The size of the cooling system determines the amount of SCA that is required.

Use the equation that is in Table 21 to determine the amount of Caterpillar SCA that is required for maintenance, if necessary:

Table 23

**SCA To Water Addition Equation For Maintenance**

$$V \times 0.023 = X$$

V is the total volume of the cooling system.

X is the amount of SCA that is required.

Table 24 is an example for using the equation that is in Table 21.

Table 24

**SCA To Water Addition Equation Example For Maintenance**

Total Volume of the Cooling System (V)	Multiplication Factor	Amount of SCA that is Required (X)
946 L (250 US gal)	$\times$ 0.023	22 L (6 US gal)

Note: Specific engine applications may require maintenance practices to be periodically evaluated in order to properly maintain the engine's cooling system.

Table 20 lists part numbers and quantities of SCA that is available from your Caterpillar dealer.

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## Conventional Coolant/ Antifreeze Cooling System Maintenance

**SMCS Code:** 1350, 1352, 1395

**NOTICE**

Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators.

Check the coolant/antifreeze (glycol concentration) in order to ensure adequate protection against boiling or freezing. Caterpillar recommends the use of a refractometer for checking the glycol concentration. Use the 1U-7298 Coolant/Battery Tester (Celsius) or use the 1U-7297 Coolant/Battery Tester (Fahrenheit). The testers give readings that are immediate and accurate. The testers can be used with ethylene or with propylene glycol.

Caterpillar engine cooling systems should be tested at 250 hour intervals for the concentration of Supplemental Coolant Additive (SCA). SCA test kits are available from your Caterpillar dealer. Test the concentration of SCA or submit a coolant sample to your Caterpillar dealer at 250 hour intervals. Refer to S-O-S Coolant Analysis for more information on this topic.

Additions of SCA are based on the results of the test or based on the results of the coolant analysis. An SCA that is liquid or a maintenance element for an SCA (if equipped) may be needed at 250 hour intervals.

Table 25 lists the amount of Caterpillar SCA that is needed at the initial fill in order to treat coolant/antifreeze. These amounts of SCA are for systems that use heavy-duty coolant/antifreeze.

Table 25 also lists additions of SCA for liquid and for maintenance elements at 250 hours. The additions are required for Caterpillar DEAC and for commercial coolant/antifreezes.

Table 25

Caterpillar SCA Requirements for Heavy-Duty Coolant/Antifreeze			
Cooling System Capacity	Initial Fill <sup>(1)</sup>	250 Service Hour Maintenance <sup>(2)</sup>	Spin-on Element at 250 Service Hour Maintenance <sup>(3)</sup>
22 to 30 L (6 to 8 US gal)	0.95 L (32 fl oz)	0.24 L (8 fl oz)	111-2370 (1)
31 to 38 L (9 to 10 US gal)	1.16 L (40 fl oz)	0.36 L (12 fl oz)	111-2369 (1)
39 to 49 L (11 to 13 US gal)	1.42 L (48 fl oz)	0.36 L (12 fl oz)	111-2369 (1)
50 to 64 L (14 to 17 US gal)	1.90 L (64 fl oz)	0.47 L (16 fl oz)	9N-3368 (1)
65 to 83 L (18 to 22 US gal)	2.37 L (80 fl oz)	0.60 L (20 fl oz)	111-2371 (1)
84 to 114 L (23 to 30 US gal)	3.32 L (112 fl oz)	0.95 L (32 fl oz)	9N-3718 (1)
115 to 163 L (31 to 43 US gal)	4.75 L (160 fl oz)	1.18 L (40 fl oz)	111-2371 (2)
164 to 242 L (44 to 64 US gal)	7.60 L (256 fl oz)	1.90 L (64 fl oz)	9N-3718 (2)

- <sup>(1)</sup> When the coolant system is first filled, the SCA is not required to be used with Caterpillar DEAC.
- <sup>(2)</sup> Do not exceed the six percent maximum concentration. Check the concentration of SCA with a SCA test kit.
- <sup>(3)</sup> Do not use the maintenance element for the SCA and the liquid for the SCA at the same time.

Note: Specific engine applications may require maintenance practices to be periodically evaluated in order to properly maintain the engine's cooling system.

Refer to Table 26 for part numbers and for quantities of SCA.

Table 26

Caterpillar Liquid SCA	
Part Number	Quantity
6V-3542	0.24 L (8 oz)
111-2372	0.36 L (12 oz)
8T-1589	0.47 L (16 oz)
3P-2044	0.94 L (32 oz)
6C-3680	19 L (5 US gal)
5P-2907	208 L (55 US gal)

## Cooling Systems with Larger Capacities

### Adding the SCA to Conventional Coolant/Antifreeze at the Initial Fill

Note: Caterpillar DEAC DOES NOT require an addition of SCA when the cooling system is initially filled.

Commercial heavy duty coolant/antifreeze that meet "ASTM D4985" or "ASTM D5345" specifications MAY require an addition of SCA at the initial fill. Read the label or the instructions that are provided by the OEM of the product.

Use the equation that is in Table 27 to determine the amount of Caterpillar SCA that is required when the cooling system is initially filled with the following fluids:

- "ASTM D4985"
- "ASTM D5345"

Table 27

Equation For Adding The SCA To Conventional Coolant/Antifreeze At The Initial Fill
$V \times 0.045 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 28 is an example for using the equation that is in Table 27.

Table 28

Example Of The Equation For Adding The SCA To Conventional Coolant/Antifreeze At The Initial Fill		
Total Volume of the Cooling System (V)	Multiplication Factor	Amount of SCA that is Required (X)
946 L (250 US gal)	$\times 0.045$	43 L (11 US gal)

### Adding the SCA to Conventional Coolant/Antifreeze For Maintenance

Heavy duty coolant/antifreeze of all types REQUIRE periodic additions of an SCA.

Test the coolant/antifreeze periodically for the concentration of SCA. For the interval, see the Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section). SCA test kits are available from your Caterpillar dealer. Test the concentration of SCA or submit a coolant sample to your Caterpillar dealer. See this publication, "S-O-S Coolant Analysis" topic (Maintenance Section).

Additions of SCA are based on the results of the test or based on the results of the coolant analysis. The size of the cooling system determines the amount of SCA that is needed.

Use the equation that is in Table 29 to determine the amount of Caterpillar SCA that is required, if necessary:

Table 29

Equation For Adding The SCA To Conventional Coolant/Antifreeze For Maintenance
$V \times 0.014 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 30 is an example for using the equation that is in Table 29.

Table 30

Example Of The Equation For Adding The SCA To Conventional Coolant/Antifreeze For Maintenance		
Total Volume of the Cooling System (V)	Multiplication Factor	Amount of SCA that is Required (X)
946 L (250 US gal)	$\times 0.014$	9 L (4 US gal)

Note: Specific engine applications may require maintenance practices to be periodically evaluated in order to properly maintain the engine's cooling system.

Table 26 lists part numbers and quantities of SCA that is available from your Caterpillar dealer.

### Cleaning the System of Heavy-Duty Coolant/Antifreeze

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

- Clean the cooling system after used coolant is drained or before the cooling system is filled with new coolant.
- Clean the cooling system whenever the coolant is contaminated or whenever the coolant is foaming.
- For the recommended service interval, refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" for your engine.

## Refill Capacities

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### Refill Capacities

**SMCS Code:** 1348; 1395; 7560

### Lubrication System

The refill capacities for the engine crankcase reflect the approximate capacity of the crankcase or sump plus standard oil filters. Auxiliary oil filter systems will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter. Refer to the Operation and Maintenance Manual, "Maintenance Section" for more information on Lubricant Specifications.

Table 31

3054B Industrial Engine Approximate Refill Capacities		
Compartment or System	Liters	Quarts
Crankcase Oil Sump (Standard) <sup>(1)</sup>	7,3	8

<sup>(1)</sup> These values are the approximate capacities for the crankcase oil sump which include the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.

### Cooling System

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

Table 32

3054B Industrial Engine Approximate Refill Capacities		
Compartment or System	Liters	Quarts
Engine Only	10,4	11
External System (OEM) <sup>(1)</sup>		
Total Cooling System <sup>(2)</sup>		

<sup>(1)</sup> The External System includes a radiator or an expansion tank with the following components: heat exchanger and piping. Refer to Caterpillar specifications or to the OEM specifications and enter the capacity for the External System in this row.

<sup>(2)</sup> The Total Cooling System includes the capacity for the Engine Only plus the capacity for the External System. Enter the total in this row.

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## Maintenance Interval Schedule

**SMCS Code:** 1000, 7500

**Note:** Ensure that the Safety Information, warnings, and instructions are read and understood before operation or maintenance procedures are performed.

**Note:** Use fuel consumption, service hours, or calendar time, **whichever occurs first**, in order to determine the maintenance intervals. Engines that operate in severe operating conditions may require more frequent maintenance.

There are many operating conditions and types of lubricants that may require an adjustment to the normal oil change interval. Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for your specific oil change intervals.

Before each consecutive interval is performed, all of the maintenance requirements from the previous interval must also be performed.

### When Required

Battery - Replace .....	60
Battery or Battery Cable - Disconnect .....	61
Engine Air Cleaner Element (Dual Element) - Clean/Replace .....	68
Engine Air Cleaner Element (Single Element) - Replace .....	72
Fuel System - Prime .....	77

### Daily

Cooling System Coolant Level - Check .....	65
Driven Equipment - Check .....	68
Engine Air Cleaner Service Indicator - Inspect .....	72
Engine Oil Level - Check .....	73
Walk-Around Inspection .....	85

### Every 250 Service Hours or 3 Months

Alternator and Fan Belts - Inspect/Adjust/ Replace .....	60
Battery Electrolyte Level - Check .....	61
Cooling System Supplemental Coolant Additive (SCA) - Test/Add .....	66
Engine Oil Sample - Obtain .....	73
Engine Oil and Filter - Change .....	74
Fuel Tank Water and Sediment - Drain .....	80
Hoses and Clamps - Inspect/Replace .....	81
Radiator - Clean .....	84

### Every 500 Service Hours or 6 Months

Engine Oil and Filter - Change .....	74
Engine Protective Devices - Check .....	75

Fuel Transfer Pump Strainer - Clean .....	77
Fuel System Secondary Filter - Replace .....	79

### Every 1000 Service Hours

Engine Valve Lash - Inspect/Adjust .....	76
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### Every 2000 Service Hours or 1 Year

Engine Mounts - Inspect .....	73
Fuel Injection Nozzles - Test/Exchange .....	76

### Every 3000 Service Hours or 2 Years

Alternator - Inspect .....	60
Cooling System Coolant (DEAC) - Change .....	62
Cooling System Coolant Extender (ELC) - Add .....	65
Cooling System Water Temperature Regulator - Replace .....	67
Crankshaft Vibration Damper - Inspect .....	68
Starting Motor - Inspect .....	65
Water Pump - Inspect .....	86

### Overhaul

Overhaul Considerations .....	82
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### Every 6000 Service Hours or 4 Years

Cooling System Coolant (ELC) - Change .....	64
Engine - Clean .....	68



1000/2207

## Alternator - Inspect

**SMCS Code:** 1405-040

Caterpillar recommends a scheduled inspection of the alternator. Inspect the alternator for loose connections and proper battery charging. Inspect the ammeter (if equipped) during engine operation in order to ensure proper battery performance and/or proper performance of the electrical system. Make repairs, as required. Refer to the Service Manual.

Check the alternator and the battery charger for proper operation. If the batteries are properly charged, the ammeter reading should be very near zero. All batteries should be kept charged. The batteries should be kept warm because temperature affects the cranking power. If the battery is too cold, the battery will not crank the engine. The battery will not crank the engine, even if the engine is warm. When the engine is not run for long periods of time or if the engine is run for short periods, the batteries may not fully charge. A battery with a low charge will freeze more easily than a battery with a full charge.

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## Alternator and Fan Belts - Inspect/Adjust/Replace

**SMCS Code:** 1357-039

### Inspection

To maximize the engine performance, inspect the belts for wear and for cracking. Replace belts that are worn or damaged.

For applications that require multiple drive belts, replace the belts in matched sets. Replacing only one belt of a matched set will cause the new belt to carry more load because the older belt is stretched. The additional load on the new belt could cause the new belt to break.

If the belts are too loose, vibration causes unnecessary wear on the belts and pulleys. Loose belts may slip enough to cause overheating.

To check the belt tension, apply 45 N (10 lb ft) of force midway between the pulleys. A correctly adjusted belt will deflect 10 mm (0.39 inch).

## Adjustment

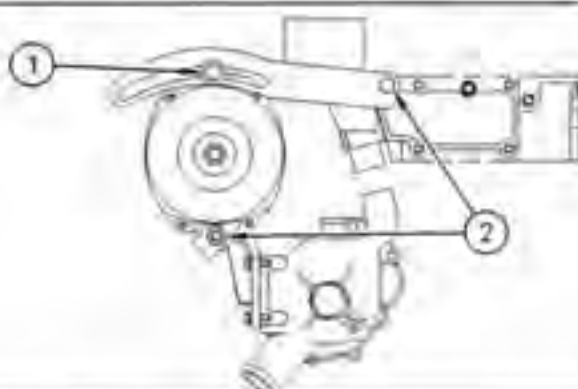


Illustration 24

Typical example

- (1) Adjusting bolt
- (2) Mounting bolts

1. Loosen mounting bolts (2) and adjusting bolt (1).
2. Move the alternator in order to increase or decrease the belt tension.
3. Tighten adjusting bolt (1). Tighten mounting bolts (2). Refer to the Operation and Maintenance Manual for the proper torque settings.

If new belts are installed, check the belt tension again after 20 hours of engine operation.

## Replacement

Refer to the Service Manual for the installation procedure and the removal procedure for the belt.

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## Battery - Replace

**SMCS Code:** 1401-510

### WARNING

Batteries give off combustible gases which can explode. A spark can cause the combustible gases to ignite. This can result in severe personal injury or death.

Ensure proper ventilation for batteries that are in an enclosure. Follow the proper procedures in order to help prevent electrical arcs and/or sparks near batteries. Do not smoke when batteries are serviced.

**⚠ WARNING**

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Turn the key start switch to the OFF position. Remove the key and all electrical loads.
2. Turn OFF the battery charger. Disconnect the charger.
3. The NEGATIVE "-" cable connects the NEGATIVE "-" battery terminal to the ground plane. Disconnect the cable from the NEGATIVE "-" battery terminal.
4. The POSITIVE "+" cable connects the POSITIVE "+" battery terminal to the starting motor. Disconnect the cable from the POSITIVE "+" battery terminal.

Note: Always recycle a battery. Never discard a battery. Return used batteries to an appropriate recycling facility.

5. Remove the used battery.
6. Install the new battery.

Note: Before the cables are connected, ensure that the key start switch is OFF.

7. Connect the cable from the starting motor to the POSITIVE "+" battery terminal.
8. Connect the cable from the ground plane to the NEGATIVE "-" battery terminal.

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**Battery Electrolyte Level - Check**

SMCS Code: 1401-081

When the engine is not run for long periods of time or when the engine is run for short periods, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing. If batteries are properly charged, ammeter reading should be very near zero.

**⚠ WARNING**

All lead-acid batteries contain sulfuric acid which can burn the skin and clothing. Always wear a face shield and protective clothing when working on or near batteries.

1. Remove the filler caps. Maintain the electrolyte level to the "FULL" mark on the battery.

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

2. Check the condition of the electrolyte with the 1U-7298 Coolant/Battery Tester (°C) or the 1U-7297 Coolant/Battery Tester (°F).
3. Keep the batteries clean.

Clean the battery case with one of the following cleaning solutions:

- A mixture of 0.1 L (0.11 qt) of baking soda and 1 L (1 qt) of clean water
- A mixture of 0.1 L (0.11 qt) of ammonia and 1 L (1 qt) of clean water

Thoroughly rinse the battery case with clean water.

Use a fine grade of sandpaper to clean the terminals and the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to not fit properly. Coat the clamps and the terminals with 5N-5581 Silicone Lubricant, petroleum jelly or MPM grease.

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**Battery or Battery Cable - Disconnect**

SMCS Code: 1402-029

**⚠ WARNING**

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.



1. Turn the start switch to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.
2. Disconnect the negative battery terminal at the battery that goes to the start switch. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, the negative side of two batteries must be disconnected.
3. Tape the leads in order to help prevent accidental starting.
4. Proceed with necessary system repairs. Reverse the steps in order to reconnect all of the cables.

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## Cooling System Coolant (DEAC) - Change

**SMCS Code:** 1350-070, 1395-044

Clean the cooling system and flush the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming is observed.
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

### NOTICE

Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

**Note:** Inspect the water pump and the water temperature regulator after the cooling system has been drained. This is a good opportunity to replace the water pump, the water temperature regulator and the hoses, if necessary.

## Drain

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

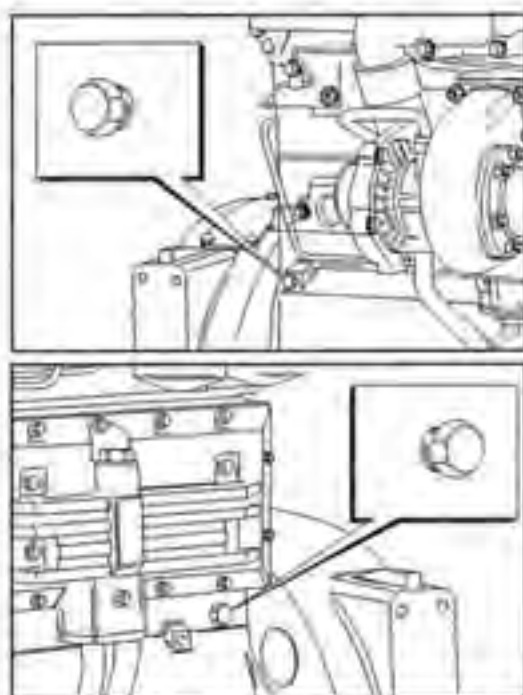


Illustration 25

### Drain Plugs

2. Open the cooling system drain valve (if equipped). If the cooling system is not equipped with a drain valve, remove one of the drain plugs.

Allow the coolant to drain.

### NOTICE

Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal and the recycling of used coolant, consult your Caterpillar dealer or consult Caterpillar Service Technology Group:

Outside Illinois: 1-800-542-TOOL  
Inside Illinois: 1-800-541-TOOL  
Canada: 1-800-523-TOOL

## Flush

1. Flush the cooling system with clean water in order to remove any debris.

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2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual for more information on the proper torques.

---

**NOTICE**

Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

---

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add 0.5 L (1 pint) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the cooling system filler cap.
4. Start and run the engine at low idle for a minimum of 30 minutes with a coolant temperature of at least 82°C (180°F).
5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual, "Torque Specifications" for more information on the proper torques.

## Cooling Systems with Heavy Deposits or Plugging

Note: For the following procedure to be effective, there must be some active flow through the cooling system components.

1. Flush the cooling system with clean water in order to remove any debris.
2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual for more information on the proper torques.

---

**NOTICE**

Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

---

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add 0.5 L (1 pint) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity. Install the cooling system filler cap.
4. Start and run the engine at low idle for a minimum of 90 minutes. The coolant temperature should be at least 82°C (180°F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual for more information on the proper torques.

---

**Fill**


---

**NOTICE**

Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

---

1. Fill the cooling system with coolant/antifreeze. Refer to the Operation and Maintenance Manual for more information on cooling system specifications. Do not install the cooling system filler cap.
2. Place the transmission in neutral. Start and run the engine at low idle. Increase the engine rpm to 1500 rpm. Run the engine at 1500 rpm for one minute in order to purge the air from the cavities of the engine block. Stop the engine.
3. Check the coolant level. Maintain the coolant level within 13 mm (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (0.5 inch) to the proper level on the sight glass (if equipped).
4. Clean the cooling system filler cap. Inspect the gasket for the filler cap. If the gasket for the filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket for the filler cap is not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

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## Cooling System Coolant (ELC) - Change

**SMCS Code:** 1350-070; 1395-044

When the cooling system is cleaned, only clean water is needed when the ELC is drained and replaced.

### Drain

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

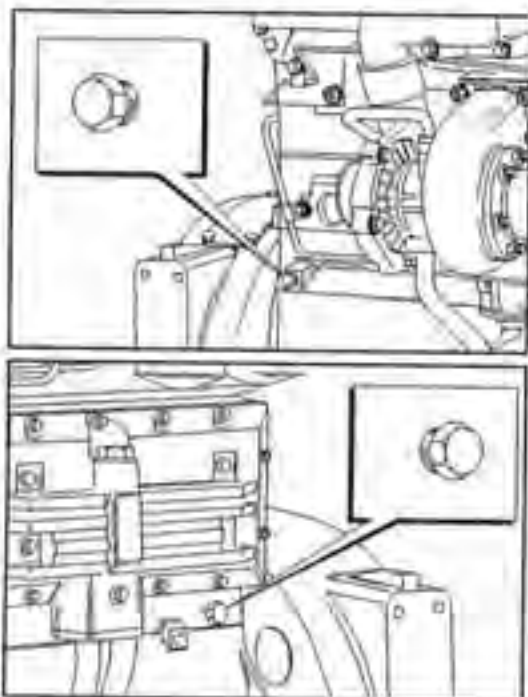


Illustration 26

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#### Drain Plugs

2. Open the cooling system drain valve (if equipped). If the cooling system is not equipped with a drain valve, remove the cooling system drain plugs.

Allow the coolant to drain.

### NOTICE

Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal and the recycling of used coolant, consult your Caterpillar dealer or consult Caterpillar Service Technology Group:

Outside Illinois: 1-800-542-TOOL

Inside Illinois: 1-800-541-TOOL

Canada: 1-800-523-TOOL

### Flush

1. Flush the cooling system with clean water in order to remove any debris.
2. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual, "Torque Specifications" for more information on the proper torques.

### NOTICE

Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

3. Fill the cooling system with clean water. Install the cooling system filler cap.
4. Start and run the engine at low idle until the temperature reaches 49 to 66°C (120 to 150°F).
5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain valve (if equipped) or remove the cooling system drain plugs. Allow the water to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean the drain plugs. Install the drain plugs. Refer to the Operation and Maintenance Manual, "Torque Specifications" for more information on the proper torques.

### Fill

### NOTICE

Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

1. Fill the cooling system to the top with coolant/antifreeze. Refer to the Operation and Maintenance Manual for more information on cooling system specifications. Do not install the cooling system filler cap.
2. Place the transmission in neutral. Start and run the engine at low idle. Increase the engine rpm to 1500 rpm. Run the engine at 1500 rpm for one minute in order to purge the air from the cavities of the engine block. Stop the engine.
3. Check the coolant level. Maintain the coolant level within 13 mm (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level within 13 mm (0.5 inch) to the proper level on the sight glass (if equipped).
4. Clean the cooling system filler cap. Inspect the gasket for the filler cap. If the gasket for the filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket for the filler cap is not damaged, use a 95-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

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## Cooling System Coolant Extender (ELC) - Add

**SMCS Code:** 1352-045; 1395-081

Caterpillar Extended Life Coolant (ELC) does not require the frequent Supplemental Coolant Additive (SCA) additions associated with the present conventional coolants. The Extender only needs to be added once.

Check the cooling system only when the engine is stopped and cool.

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.
2. It may be necessary to drain enough coolant from the cooling system in order to add the Extender.

3. Add Extender according to the requirements for your engine's cooling system capacity. Refer to the Operation and Maintenance Manual, "Refill Capacities" in the Maintenance Section for the capacity of the cooling system for your engine. Refer to the Operation and Maintenance Manual, "Cooling System Specifications" information for the Caterpillar ELC Extender additions.
4. Clean the cooling system filler cap. Inspect the cooling system filler cap gaskets. Replace the cooling system filler cap if the cooling system filler cap gaskets are damaged. Install the cooling system filler cap.

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## Cooling System Coolant Level - Check

**SMCS Code:** 1395-082

Check the coolant level when the engine is stopped and cool.

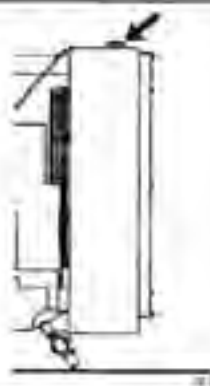


Illustration 27

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Cooling system filler cap

### **WARNING**

**Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.**

1. Remove the cooling system filler cap slowly in order to relieve pressure.
2. Maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level to the proper level in the sight glass.





Illustration 28

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Typical filler cap gaskets

3. Clean the cooling system filler cap and check the condition of the filler cap gaskets. Replace the cooling system filler cap if the filler cap gaskets are damaged. Reinstall the cooling system filler cap.
4. Inspect the cooling system for leaks.

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## Cooling System Supplemental Coolant Additive (SCA) - Test/Add

SMCS Code: 1352-045; 1395-081

### WARNING

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

Note: Test the concentration of the Supplemental Coolant Additive (SCA) or test the SCA concentration as part of an S-O-S Coolant Analysis.

### Test for SCA Concentration

#### Coolant/Antifreeze and SCA

##### NOTICE

Do not exceed the recommended six percent supplemental coolant additive concentration.

Use the BT-5296 Coolant Conditioner Test Kit or use the 4C-9301 Coolant Conditioner Test Kit in order to check the concentration of the SCA. Refer to the Operation and Maintenance Manual for more information.

## Water and SCA

##### NOTICE

Do not exceed the recommended eight percent supplemental coolant additive concentration.

Test the concentration of the SCA with the BT-5296 Coolant Conditioner Test Kit. Refer to the Operation and Maintenance Manual, "Water/Supplemental Coolant Additive (SCA)" topic (Maintenance Section). Refer to the Operation and Maintenance Manual, "Conventional Coolant/Antifreeze Cooling System Maintenance" topic (Maintenance Section).

## S-O-S Coolant Analysis

S-O-S coolant samples can be analyzed at your Caterpillar dealer. S-O-S Coolant Analysis is a program that is based on periodic samples.

### Level 1

Level 1 is a basic analysis of the coolant. The following items are tested:

- Glycol Concentration
- Concentration of SCA
- pH
- Conductivity

The results are reported, and recommendations are made according to the results. Consult your Caterpillar dealer for information on the benefits of managing your equipment with an S-O-S Coolant Analysis.

### Level 2

This level coolant analysis is recommended when the engine is overhauled. Refer to the Operations and Maintenance Manual, "Overhaul Considerations" for further information.

## Add the SCA, If Necessary

### NOTICE

Do not exceed the recommended amount of supplemental coolant additive concentration. Excessive supplemental coolant additive concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components. Excessive supplemental coolant additive concentration could also result in radiator tube blockage, overheating, and/or accelerated water pump seal wear. Never use both liquid supplemental coolant additive and the spin-on element (if equipped) at the same time. The use of those additives together could result in supplemental coolant additive concentration exceeding the recommended maximum.

### WARNING

**Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.**

1. Slowly loosen the cooling system filler cap in order to relieve the pressure. Remove the cooling system filler cap.

**Note:** Always discard drained fluids according to local regulations.

2. If necessary, drain some coolant from the cooling system into a suitable container in order to allow space for the extra SCA.
3. Add the proper amount of SCA. Refer to the Operation and Maintenance Manual for more information on SCA requirements.
4. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Install the cooling system filler cap.

## Cooling System Water Temperature Regulator - Replace

**SMCS Code:** 1355-510

Replace the water temperature regulator before the water temperature regulator fails. This is a recommended preventive maintenance practice. Replacing the water temperature regulator reduces the chances for unscheduled downtime.

A water temperature regulator that fails in a partially opened position can cause overheating or overcooling of the engine.

A water temperature regulator that fails in the closed position can cause excessive overheating. Excessive overheating could result in cracking of the cylinder head or piston seizure problems.

A water temperature regulator that fails in the open position will cause the engine operating temperature to be too low during partial load operation. Low engine operating temperatures during partial loads could cause an excessive carbon buildup inside the cylinders. This excessive carbon buildup could result in an accelerated wear of the piston rings and wear of the cylinder liner.

### NOTICE

Failure to replace your water temperature regulator on a regularly scheduled basis could cause severe engine damage.

Caterpillar engines incorporate a shunt design cooling system and require operating the engine with a water temperature regulator installed.

If the water temperature regulator is installed incorrectly, the engine may overheat, causing cylinder head damage. Ensure that the new water temperature regulator is installed in the original position. Ensure that the water temperature regulator vent hole is open.

Do not use liquid gasket material on the gasket or cylinder head surface.

Refer to the Service Manual for the replacement procedure of the water temperature regulator, or consult your Caterpillar dealer.

**Note:** If only the water temperature regulators are replaced, drain the coolant from the cooling system to a level that is below the water temperature regulator housing.

©1198800

## Crankshaft Vibration Damper - Inspect

**SMCS Code:** 1205-040

Damage to the crankshaft vibration damper or failure of the crankshaft vibration damper can increase torsional vibrations. This can result in damage to the crankshaft and to other engine components. A deteriorating damper can cause excessive gear train noise at variable points in the speed range.

The damper is mounted to the crankshaft which is located behind the belt guard on the front of the engine.

### Removal and Installation

Refer to the Service Manual for the damper removal procedure and for the damper installation procedure.

©0174795

## Driven Equipment - Check

**SMCS Code:** 3279-535

Refer to the OEM specifications for more information on the following maintenance recommendations for the driven equipment:

- Inspection
- Adjustment
- Lubrication
- Other maintenance recommendations

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

©1728442

## Engine - Clean

**SMCS Code:** 1000-070

### WARNING

**Personal injury or death can result from high voltage.**

**Moisture can create paths of electrical conductivity.**

**Make sure that the electrical system is OFF. Lock out the starting controls and tag the controls "DO NOT OPERATE".**

### NOTICE

Water and/or condensation can cause damage to electrical components. Protect all electrical components from exposure to water.

### NOTICE

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

Periodic cleaning of the engine is recommended. Steam cleaning the engine will remove accumulated oil and grease. A clean engine provides the following benefits:

- Easy detection of fluid leaks
- Maximum heat transfer characteristics
- Ease of maintenance

©1297508

## Engine Air Cleaner Element (Dual Element) - Clean/Replace

**SMCS Code:** 1054-037; 1054-510

### NOTICE

Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent air-borne debris from entering the air inlet.



**NOTICE**

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

**Servicing the Air Cleaner Elements**

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has the proper air cleaner elements for your application. Consult your Caterpillar dealer for the correct air cleaner element.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to six times if the element is properly cleaned and inspected.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

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

**Dual Element Air Cleaners**

The dual element air cleaner contains a primary air cleaner element and a secondary air cleaner element. The primary air cleaner element can be used up to six times if the element is properly cleaned and inspected. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

The secondary air cleaner element is not serviceable or washable. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element. When the engine is operating in environments that are dusty or dirty, air cleaner elements may require more frequent replacement.

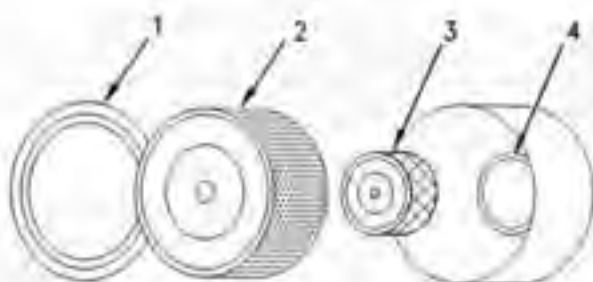


Illustration 29

y00736431

(1) Cover. (2) Primary air cleaner element. (3) Secondary air cleaner element. (4) Turbocharger air inlet.

1. Remove the cover. Remove the primary air cleaner element.
  2. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element.
- Note:** Refer to "Cleaning the Primary Air Filter Elements".
3. Cover the turbocharger air inlet with tape in order to keep dirt out.
  4. Clean the inside of the air cleaner cover and body with a clean, dry cloth.
  5. Remove the tape for the turbocharger air inlet. Install the secondary air cleaner element. Install a primary air cleaner element that is new or cleaned.
  6. Install the air cleaner cover.
  7. Reset the service indicator.

**Cleaning the Primary Air Cleaner Elements**

The primary air cleaner element can be used up to six times if the element is properly cleaned and inspected. When the primary air cleaner element is cleaned, check for rips or tears in the filter material. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Use clean primary air cleaner elements while dirty elements are being cleaned.

**NOTICE**

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

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

There are four common methods that are used to clean primary air cleaner elements:

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

**Pressurized Water**

Pressurized water will clean the primary air cleaner element unless carbon and oil have accumulated on the surface of the primary air cleaner element. The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi). Do not use a spray nozzle.

**Note:** When the primary air cleaner element is cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the water flows inside the element along the length of the filter in order to help prevent damage to the paper pleats. Do not aim the stream of water directly at the primary air cleaner element. Dirt could be forced further into the pleats.

**Note:** Refer to "Drying the Primary Air Cleaner Elements". Refer to "Inspecting the Primary Air Cleaner Elements".

**Pressurized Air**

Pressurized air can be used to clean primary air cleaner elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

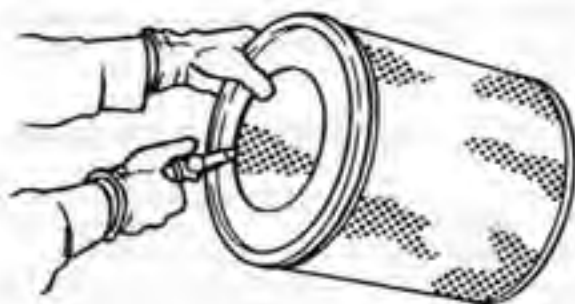


Illustration 30

g/kimstat

**Note:** When the primary air cleaner elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter in order to help prevent damage to the paper pleats. Do not aim the stream of air directly at the primary air cleaner element. Dirt could be forced further into the pleats.

**Note:** Refer to "Inspecting the Primary Air Cleaner Elements".

**Vacuum Cleaning**

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

**Note:** Refer to "Inspecting the Primary Air Cleaner Elements".

**Washing the Primary Air Cleaner Elements with Nonsudsing Detergent****⚠ WARNING**

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

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

1. Place the primary air cleaner element into a wash tank so that the gasket is up. The wash tank should be equipped with a rack so that the primary air cleaner element does not sit on the bottom of the wash tank.

**Note:** Caterpillar does not recommend washing the element with a process of agitation. Agitation may cause carbon particles to be distributed.

2. Fill the wash tank with the cleaning agent and warm water to a maximum temperature of 60 °C (140 °F). Follow the manufacturer's recommendations for the cleaning agent. Allow the primary air cleaner element to soak for six hours.

3. Drain the wash tank. Do not use the cleaning agent more than one time. Remove the primary air cleaner element from the wash tank. Rinse the primary air cleaner element with the method for using pressurized water.

**Note:** Refer to "Drying the Primary Air Cleaner Elements". Refer to "Inspecting the Primary Air Cleaner Elements".

### Drying the Primary Air Cleaner Elements

The oven method may be used in order to dry primary air cleaner elements. If an oven is used, do not expose the primary air cleaner elements to temperatures that exceed 82 °C (180 °F).

**Note:** Do not use compressed air in order to dry the primary air cleaner elements.

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

### Inspecting the Primary Air Cleaner Elements



Illustration 31

g00281683

inspect the clean, dry primary air cleaner element. Use a 60 watt blue light in a dark room or in a similar facility. Place the blue light in the primary air cleaner element. Rotate the primary air cleaner element. Inspect the primary air cleaner element for tears and/or holes. Inspect the primary air cleaner element for light that may show through the filter material. If it is necessary in order to confirm the result, compare the primary air cleaner element to a new primary air cleaner element that has the same part number.

Do not use a primary air cleaner element that has any tears and/or holes in the filter material. Do not use an primary air cleaner element with damaged pleats, gaskets or seals. Discard damaged primary air cleaner elements.

### Storing Primary Air Cleaner Elements

If a primary air cleaner element that passes inspection will not be used, the primary air cleaner element can be stored for future use.



Illustration 32

g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. An airflow restriction may result. To protect against dirt and damage, wrap the primary air cleaner elements in Volatile Corrosion Inhibited (VCI) paper.

Place the primary air cleaner element into a box for storage. For identification, mark the outside of the box and mark the primary air cleaner element. Include the following information:

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

For more detailed information on cleaning the primary air cleaner element, refer to Special Publication, SEBF8062, "Procedure to Inspect and Clean Air Filters".

00919073

## Engine Air Cleaner Element (Single Element) - Replace

**SMCS Code:** 1051, 1054

### NOTICE

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



Illustration 33

g00100623

(1) Air cleaner element. (2) Clamp.

1. Loosen clamp (2) which fastens air cleaner element (1) to the air inlet. Remove the dirty air cleaner element and clamp.
2. Install clamp (2) on new air cleaner element (1).
3. Install new air cleaner element (1) to the air inlet and tighten clamp (2). Refer to the Operation and Maintenance Manual for more information on torque specifications.

01175055

## Engine Air Cleaner Service Indicator - Inspect

**SMCS Code:** 7452-040

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The differential gauge for inlet air pressure displays the difference in the pressure that is measured before the air cleaner element and the pressure that is measured after the air cleaner element. As the air cleaner element becomes dirty, the pressure differential rises. If your engine is equipped with a different type of service indicator, follow the OEM recommendations in order to service the air cleaner service indicator.

The service indicator may be mounted on the air cleaner element or in a remote location.



Illustration 34

g00102777

Typical service indicator

Observe the service indicator. The air cleaner element should be cleaned or the air cleaner element should be replaced when one of the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.

## Test the Service Indicator

Service indicators are important instruments.

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

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

The service indicator may need to be replaced frequently in environments that are severely dusty, if necessary. Replace the service indicator annually regardless of the operating conditions. Replace the service indicator when the engine is overhauled, and whenever major engine components are replaced.

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



00250257

01534451

## Engine Mounts - Inspect

**SMCS Code:** 1152-040

Inspect the engine mounts for deterioration and for proper bolt torque. Engine vibration can be caused by the following conditions:

- Improper mounting of the engine
- Deterioration of the engine mounts

Any engine mount that shows deterioration should be replaced. Refer to the Service Manual for the recommended torques. Refer to the OEM recommendations for more information.

00320429

## Engine Oil Level - Check

**SMCS Code:** 1348-535-Fl,V

### WARNING

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

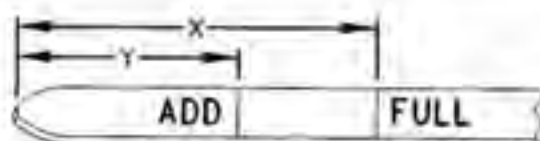


Illustration 35

900110312

(Y) "ADD" mark. (X) "FULL" mark.

### NOTICE

Perform this maintenance with the engine stopped.

1. Maintain the oil level between "ADD" mark (Y) and "FULL" mark (X) on oil level gauge (1). Do not fill the crankcase above "FULL" mark (X).

### NOTICE

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

2. Remove the oil filler cap and add oil, if necessary. Clean the oil filler cap. Install the oil filler cap.

## Engine Oil Sample - Obtain

**SMCS Code:** 1000-008, 1348-554-SM,  
7542-554-OC, SM

In addition to a good preventive maintenance program, Caterpillar recommends using S-O-S oil analysis at regularly scheduled intervals in order to monitor the condition of the engine and the maintenance requirements of the engine.

## Obtain the Sample and the Analysis

### WARNING

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

Before you take the oil sample, complete the Label, PEEP5031 for identification of the sample. In order to help obtain the most accurate analysis, provide the following information:

- Engine model
- Service hours on the engine
- The number of hours that have accumulated since the last oil change
- The amount of oil that has been added since the last oil change

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, well mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

Caterpillar recommends using the sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when the sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

The 169-8373 Fluid Sampling Bottle is recommended for use with the sampling valve. The fluid sampling bottle includes the parts that are needed for obtaining oil samples. Instructions are also provided.

**NOTICE**

Do not use the same vacuum sampling pump for extracting oil samples that is used for extracting coolant samples.

A small residue of either type sample may remain in the pump and may cause a false positive analysis for the sample being taken.

Always use a designated pump for oil sampling and a designated pump for coolant sampling.

Failure to do so may cause a false analysis which could lead to customer and dealer concerns.

If the engine is not equipped with a sampling valve, use the 1U-571B Vacuum Pump. The pump is designed to accept sampling bottles. Disposable tubing must be attached to the pump for insertion into the sump.

For instructions, see Special Publication, PEHP6001, "How To Take A Good Oil Sample". Consult your Caterpillar dealer for complete information and assistance in establishing an S-O-S program for your engine.

W11326A70

**Engine Oil and Filter - Change**

**SMCS Code:** 1318-510; 1348-044

**⚠ WARNING**

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

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

Failure to follow this recommended procedure will cause the waste particles to be recirculated through the engine lubrication system with the new oil.

**Drain the Engine Oil**

After the engine has been run at the normal operating temperature, stop the engine. Use one of the following methods to drain the engine crankcase oil:

- If the engine is equipped with a drain valve, turn the drain valve knob counterclockwise in order to drain the oil. After the oil has drained, turn the drain valve knob clockwise in order to close the drain valve.
- If the engine is not equipped with a drain valve, remove the oil drain plug in order to allow the oil to drain. If the engine is equipped with a shallow sump, remove the bottom oil drain plugs from both ends of the oil pan.

After the oil has drained, the oil drain plugs should be cleaned and installed. Tighten the oil drain plugs to  $70 \pm 14$  N·m ( $50 \pm 10$  lb ft).

**Replace the Oil Filter****NOTICE**

Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe engine damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Caterpillar.

1. Remove the oil filter with a 1U-8760 Chain Wrench.
2. Cut the oil filter open with a 175-7546 Oil Filter Cutter. Break apart the pleats and inspect the oil filter for metal debris. An excessive amount of metal debris in the oil filter may indicate early wear or a pending failure.

Use a magnet to differentiate between the ferrous metals and the nonferrous metals that are found in the oil filter element. Ferrous metals may indicate wear on the steel and cast iron parts of the engine.

Nonferrous metals may indicate wear on the aluminum parts, brass parts or bronze parts of the engine. Parts that may be affected include the following items: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter. Consult your Caterpillar dealer in order to arrange for a further analysis if an excessive amount of debris is found in the oil filter.





Illustration 36

g00103711

Typical filter mounting base and filter gasket

3. Clean the sealing surface of the filter mounting base. Ensure that all of the old oil filter gasket is removed.
4. Apply clean engine oil to the new oil filter gasket.

**NOTICE**

Do not fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil can cause accelerated wear to engine components.

5. Install the oil filter. Tighten the oil filter until the oil filter gasket contacts the base. Tighten the oil filter by hand according to the instructions that are shown on the oil filter. Do not overtighten the oil filter.

**Fill the Engine Crankcase**

1. Remove the oil filler cap. Refer to the Operation and Maintenance Manual for more information on lubricant specifications. Fill the crankcase with the proper amount of oil. Refer to the Operation and Maintenance Manual for more information on refill capacities.

**NOTICE**

If equipped with an auxiliary oil filter or system, extra oil must be added when filling the crankcase. Follow the OEM or filter manufacturer's recommendations. If the extra oil is not added, the engine may starve for oil.

**NOTICE**

To help prevent crankshaft or bearing damage, crank engine to fill all filters before starting. Do not crank engine for more than 30 seconds.

2. Start the engine and run the engine at "LOW IDLE" for two minutes. Perform this procedure in order to ensure that the lubrication system has oil and that the oil filters are filled. Inspect the oil filter for oil leaks.
3. Stop the engine and allow the oil to drain back to the sump for a minimum of ten minutes.
4. Remove the oil level gauge in order to check the oil level. Maintain the oil level between the "ADD" and "FULL" marks on the oil level gauge.

00020013

**Engine Protective Devices - Check****SMCS Code:** 7400-535

Alarms and shutoffs must function properly. Alarms provide timely warning to the operator. Shutoffs help to prevent damage to the engine. It is impossible to determine if the engine protective devices are in good working order during normal operation. Malfunctions must be simulated in order to test the engine protective devices.

A calibration check of the engine protective devices will ensure that the alarms and shutoffs activate at the setpoints. Ensure that the engine protective devices are functioning properly.

**NOTICE**

During testing, abnormal operating conditions must be simulated.

The tests must be performed correctly in order to prevent possible damage to the engine.

To prevent damage to the engine, only authorized service personnel or your Caterpillar dealer should perform the tests.

**Visual Inspection**

Visually check the condition of all gauges, sensors and wiring. Look for wiring and components that are loose, broken, or damaged. Damaged wiring or components should be repaired or replaced immediately.

C0990028

## Engine Valve Lash - Inspect/Adjust

**SMCS Code:** 1102-025

The initial valve lash adjustment on new engines, rebuilt engines, or remanufactured engines is recommended at the first scheduled oil change. The adjustment is necessary due to the initial wear of the valve train components and to the seating of the valve train components.

This maintenance is recommended by Caterpillar as part of a lubrication and preventive maintenance schedule in order to help provide maximum engine life.

### NOTICE

Only qualified service personnel should perform this maintenance. Refer to the Service Manual or your Caterpillar dealer for the complete valve lash adjustment procedure.

Operation of Caterpillar engines with improper valve adjustments can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

### WARNING

**Ensure that the engine can not be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.**

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

Ensure that the engine is stopped before measuring the valve lash. To obtain an accurate measurement, allow the valves to cool before this maintenance is performed.

Refer to the Service Manual for more information.

C0990013

## Fuel Injection Nozzles - Test/Exchange

**SMCS Code:** 1254-013, 1254-081

### WARNING

**Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.**

### NOTICE

Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

Fuel injection nozzles are subject to tip wear. Tip wear is a result of fuel contamination. Tip wear can cause the following problems:

- Increased fuel consumption
- Black smoke
- Misfire
- Rough running

Fuel injection nozzles should be cleaned, inspected, tested, and replaced, if necessary. Refer to Special Instruction, SEHS7292 for using the BS-2245 Injection Cleaning Tool Group. Consult your Caterpillar dealer about cleaning the fuel injection nozzle and testing the fuel injection nozzle.

### NOTICE

Never wire brush or scrape a fuel injection nozzle. Wire brushing or scraping a fuel injection nozzle will damage the finely machine orifice. Proper tools for cleaning and testing the fuel injection nozzles can be obtained from Caterpillar dealers.

The following items are symptoms of a malfunction of the fuel injection nozzle:

- Abnormal engine operation
- Smoke emission
- Engine knock

Each fuel injection nozzle must be isolated one at a time in order to determine the malfunctioning fuel injection nozzle.

1. Start the engine.

2. Loosen each fuel line nut one at a time at the fuel injection pump. A cloth or similar material must be used in order to prevent fuel from spraying on the hot exhaust components. Tighten each nut before loosening the next nut.
3. A defective fuel injection nozzle may be identified when a fuel line nut is loosened and the following conditions are present:
  - The exhaust smoke is partially eliminated or the exhaust smoke is completely eliminated.
  - Engine performance is not affected.

A fuel injection nozzle that is suspected of being defective should be removed. A new fuel injection nozzle should be installed in the cylinder in order to determine if the removed fuel injection nozzle is defective.

## Removal and Installation of the Fuel Injection Nozzles

For the removal and the installation of fuel injection nozzles, special tooling is required. Refer to the Service Manual for more information. Consult your Caterpillar dealer for assistance.

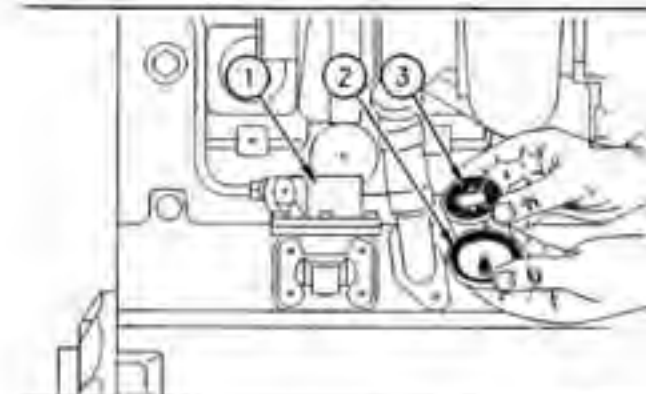


Illustration 37

g0028066

- (1) Fuel transfer pump  
(2) Cover and seal  
(3) Strainer

1. Remove the cover and seal (2) from the top of fuel transfer pump (1). Remove strainer (3).
2. Use nonflammable solvent in order to clean the strainer, the cover, and the seal. Carefully wash any sediment from the chamber of the fuel transfer pump.
3. Assemble the clean, dry fuel transfer pump.

### NOTICE

Ensure that the lift pump cover is secure so that air does not enter the fuel system.

4. Turn the fuel supply to the ON position.
5. Prime the fuel system. Refer to the Operation and Maintenance Manual for more information on priming the fuel system.

01103174

## Fuel System - Prime

SMCS Code: 1258-548

Priming the fuel system fills the fuel filter. Priming the fuel system removes air bubbles from the fuel system. Prime the fuel system under the following conditions:

- Fuel system that is run dry
- Storage
- Fuel filter maintenance
- Disconnecting fuel lines and installing fuel lines
- Repair of leaks in the fuel lines

01190817

## Fuel Transfer Pump Strainer - Clean

SMCS Code: 1256-070-STR

### WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

### NOTICE

Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

## Cleaning the Strainer and the Sediment Chamber for the Fuel Transfer Pump

Turn the fuel supply valve to the OFF position before the maintenance is performed.

**WARNING**

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

**NOTICE**

Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

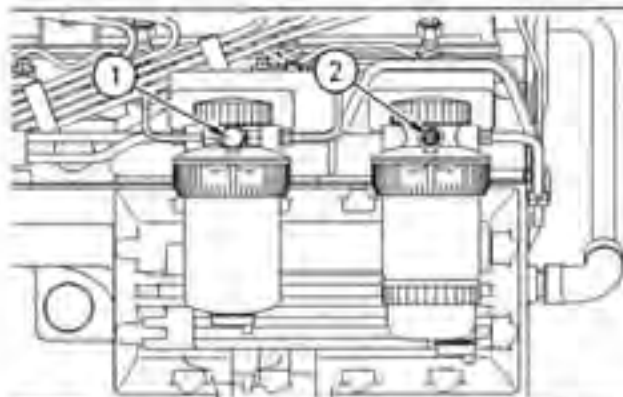


Illustration 38

g00198461

**NOTICE**

Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

1. Loosen vent (2)
2. Tighten vent (2).
3. Loosen banjo bolt (1).

**Note:** The priming lever of the fuel transfer pump cannot be operated if the cam is at the maximum lift position. If this occurs, the crankshaft must be rotated one revolution.

4. Operate the priming lever for the fuel transfer pump until the flow of fuel from banjo bolt (1) is continuous and free of air bubbles.

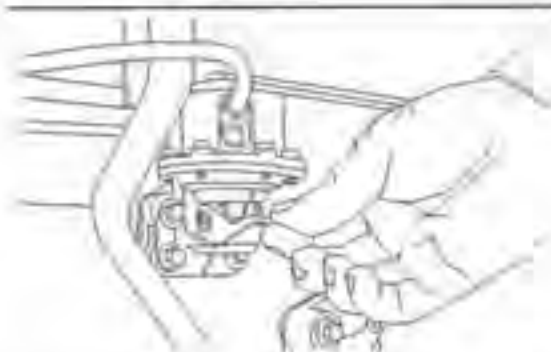


Illustration 39

g00199001

Priming lever for the fuel transfer pump

**Note:** The priming lever of the fuel transfer pump cannot be operated if the cam is at the maximum lift position. If this occurs, the crankshaft must be rotated one revolution.

5. Operate the priming lever for the fuel transfer pump until the flow of fuel from the vent is continuous and free of air bubbles. Tighten the bolt at the top of the fuel filter.



Illustration 40

g00198461

Nut for the fuel inlet line at the fuel injection pump

6. Loosen the nut for the fuel inlet line at the fuel injection pump in order to open a vent.
7. Ensure that the manual stop control (if equipped) is in the RUN position. Turn the start switch to the RUN position. Operate the priming lever for the fuel transfer pump until the flow of fuel from the vent is continuous and free of air bubbles. Tighten the nut for the fuel inlet line.



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## Fuel System Secondary Filter - Replace

SMCS Code: 1261-510-SE

### WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

### NOTICE

Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

Turn the fuel supply valve to the OFF position before performing this maintenance. Place a tray under the fuel filter in order to catch any fuel that might spill. Clean up any spilled fuel immediately.

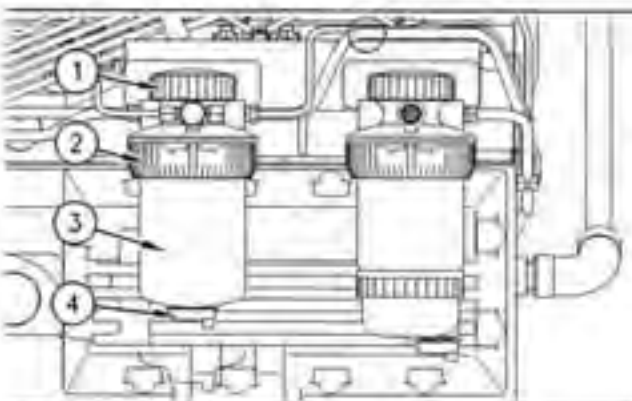


Illustration 42

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(1) Cap, (2) Locking ring, (3) Element, (4) Drain.

1. Close the fuel supply valve.
2. Clean the outside of the fuel filter assembly. Open drain (4) and drain the fuel and water from element (3) into a suitable container.

**Note:** If the element is not equipped with a drain, remove cap (1). Remove the nylon insert in order to reduce the level of fuel in the element. A reduction in the level of fuel in the element will help prevent fuel from being spilled when the element is removed.



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Illustration 41

Fuel line nuts at the fuel injection nozzles.

8. Loosen two of the fuel line nuts at two of the fuel injection nozzles in order to open two vents.

### NOTICE

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

9. Ensure that the manual stop control (if equipped) is in the RUN position. Crank the starting motor until the flow of fuel from the vents is continuous and free of air bubbles. Tighten the fuel line nuts.

10. Ensure that all fuel line connections are secure and tightened to the proper torque. Ensure that any spilled fuel is cleaned up.

11. Start the engine. The engine may run rough. Run the engine at low idle until the engine runs smoothly. If the engine will not start, further priming may be necessary. If the engine starts and if the engine continues to misfire or smoke, one or more of the following conditions may be present:

- The fuel system requires more priming.
- There may be an air leak in the fuel system.

**NOTICE**

Do not use a tool in order to remove the fuel filter. Attempting to remove the fuel filter with a filter wrench or a filter strap could damage the locking ring.

3. Hold element (3) and rotate locking ring (2) counterclockwise. Remove locking ring (2). The used element should be removed and discarded.

**Note:** If the element is equipped with a sediment bowl, remove the sediment bowl from the element. Thoroughly clean the sediment bowl. Inspect the O-ring seals. Install new O-ring seals, if necessary. Install the sediment bowl to the new element. Hand tighten the sediment bowl. Hand tightening is the only method that should be used.

**NOTICE**

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

4. Ensure that the filter head is clean. Push a new element fully into the filter head.
5. Hold the element in place. Fit locking ring (2) into position. Rotate the locking ring clockwise in order to fasten the element to the filter head.

**Note:** If the nylon insert was removed, install the nylon insert and install cap (1).

6. Prime the fuel system. Refer to the Operation and Maintenance Manual in the Maintenance Section for more information.

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## Fuel Tank Water and Sediment - Drain

**SMCS Code:** 1273-543-M&S

### Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive fuel system wear. Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel.

### Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Check the fuel daily. Drain the water and sediment from the fuel tank after operating the engine or drain the water and sediment from the fuel tank after the fuel tank has been filled. Allow five to ten minutes before performing this procedure.

Fill the fuel tank after operating the engine in order to drive out moist air. This will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

### Fuel Storage Tanks

Drain the water and the sediment from the fuel storage tank during the following conditions.

- Weekly
- Oil change
- Refill of the tank

This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank.

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.



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## Hoses and Clamps - Inspect/Replace

**SMCS Code:** 7554-040; 7554-510

Inspect all hoses for leaks that are caused by the following conditions:

- Cracking
- Softness
- Loose clamps

Replace hoses that are cracked or soft. Tighten any loose clamps.

### NOTICE

Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Inspect all lines, tubes and hoses carefully. Tighten all connections to the recommended torque.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

A constant torque hose clamp can be used in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard clamp.

Due to extreme temperature changes, the hose will heat set. Heat setting causes hose clamps to loosen. This can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Each installation application can be different. The differences depend on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose

- Anticipated expansion and contraction of the fittings

## Replace the Hoses and the Clamps

### WARNING

**Pressurized System:** Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Stop the engine. Allow the engine to cool.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

**Note:** Drain the coolant into a suitable, clean container. The coolant can be reused.

3. Drain the coolant from the cooling system to a level that is below the hose that is being replaced.
4. Remove the hose clamps.
5. Disconnect the old hose.
6. Replace the old hose with a new hose.

**Note:** For torques on hose clamps, see this Operation and Maintenance Manual, "Torque Specifications" (Maintenance Section).

7. Install the hose clamps with a torque wrench.

**Note:** For the proper coolant to use, see this Operation and Maintenance Manual, "Coolant Recommendations" (Maintenance Section).

8. Refill the cooling system.
9. Clean the cooling system filler cap. Inspect the cooling system filler cap's gaskets. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.
10. Start the engine. Inspect the cooling system for leaks.

## Overhaul Considerations

**SMCS Code:** 7595-043

Reduced hours of operation at full load will result in a lower average power demand. A decreased average power demand should increase both the engine service life and the overhaul interval.

The need for an overhaul is generally indicated by increased fuel consumption and by reduced power.

The following factors are important when a decision is being made on the proper time for an engine overhaul.

- The need for preventive maintenance
- The quality of the fuel that is being used
- The operating conditions
- The results of the S-O-S analysis

### Oil Consumption as an Overhaul Indicator

Oil consumption, fuel consumption, and maintenance information can be used to estimate the total operating cost for your Caterpillar engine. Oil consumption can also be used to estimate the required capacity of a makeup oil tank that is suitable for the maintenance intervals.

Oil consumption is in proportion to the percentage of the rated engine load. As the percentage of the engine load is increased, the amount of oil that is consumed per hour also increases.

The oil consumption rate (brake specific oil consumption) is measured in grams per kW/h (lb per bhp). The brake specific oil consumption (BSOC) depends on the engine load. Consult your Caterpillar dealer for assistance in determining the typical oil consumption rate for your engine.

When an engine's oil consumption has risen to three times the original oil consumption rate due to normal wear, an engine overhaul should be scheduled. There may be a corresponding increase in blowby and a slight increase in fuel consumption.

### Overhaul Options

#### Before Failure Overhaul

A planned overhaul before failure may be the best value for the following reasons:

- Costly unplanned downtime can be avoided
- Many original parts can be reused according to the standards for reusable parts.
- The engine's service life can be extended without the risk of a major catastrophe due to engine failure.
- The best cost/value relationship per hour of extended life can be attained.

#### After Failure Overhaul

If a major engine failure occurs and the engine must be removed, many options are available. An overhaul should be performed if the engine block or the crankshaft needs to be repaired.

If the engine block is repairable and/or the crankshaft is repairable, the overhaul cost should be between 40 percent and 50 percent of the cost of a new engine with a similar exchange core.

This lower cost can be attributed to three aspects:

- Specially designed Caterpillar engine features
- Caterpillar dealer exchange components
- Caterpillar Inc. remanufactured exchange components

### Overhaul Recommendation

To minimize downtime, Caterpillar Inc. recommends a scheduled engine overhaul by your Caterpillar dealer before the engine fails. This will provide you with the best cost/value relationship.

**Note:** Overhaul programs vary according to the engine application and according to the dealer that performs the overhaul. Consult your Caterpillar dealer for specific information about the available overhaul programs and about overhaul services for extending the engine life.

If an overhaul is performed without overhaul service from your Caterpillar dealer, be aware of the following maintenance recommendations:

## Rebuild or Exchange

### Cylinder Head Assembly, Cylinder Packs, Oil Pump, and Fuel Transfer Pump

These components should be inspected according to the instructions that are found in various Caterpillar reusability publications. The Special Publication, SEBF8029 lists the reusability publications that are needed for inspecting the engine parts.

If the parts comply with the established inspection specifications that are expressed in the reusable parts guideline, the parts should be reused.

Parts that are not within the established inspection specifications should be dealt with in one of the following manners:

- Salvaging
- Repairing
- Replacing

Using out-of-spec parts can result in the following problems:

- Unscheduled downtime
- Costly repairs
- Damage to other engine parts
- Reduced engine efficiency
- Increased fuel consumption

Reduced engine efficiency and increased fuel consumption translates into higher operating costs. Therefore, Caterpillar Inc. recommends repairing out-of-spec parts or replacing out-of-spec parts.

## Inspection and/or Replacement

### Crankshaft Bearings, Valve Rotators, and Crankshaft Seals

The following components may not last until the second overhaul.

- Thrust bearings
- Main bearings
- Rod bearings
- Valve rotators
- Crankshaft seals

Caterpillar Inc. recommends the installation of new parts at each overhaul period.

Inspect these parts while the engine is disassembled for an overhaul.

Inspect the crankshaft for any of the following conditions:

- Deflection
- Damage to the journals
- Bearing material that has seized to the journals

Check the journal taper and the profile of the crankshaft journals. Check these components by interpreting the wear patterns on the following components:

- Rod bearing
- Main bearings

Inspect the camshaft for damage to the journals and to the lobes.

**Note:** If the camshaft is removed for any reason, use the magnetic particle inspection process to check for cracks in the camshaft.

Inspect the following components for signs of wear or for signs of scuffing:

- Camshaft bearings
- Camshaft followers

Caterpillar Inc. recommends replacing the crankshaft vibration damper.

### Oil Cooler Core

During an overhaul, Caterpillar Inc. recommends the removal of the oil cooler core. Clean the oil cooler core. Then, pressure test the oil cooler core.

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#### NOTICE

Do not use caustic cleaners to clean the core.

Caustic cleaners can attack the internal metals of the core and cause leakage.

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**Note:** Use this cleaning procedure to clean the oil cooler core.

1. Remove the oil cooler core.

- Remove any debris from the oil cooler core. To remove debris from the oil cooler core, turn the oil cooler core onto one end.
- Flush the oil cooler core internally with cleaner in order to loosen foreign substances. This will also help to remove oil from the oil cooler core.

**Note:** Caterpillar Inc. recommends the use of Hydrosolv Liquid Cleaners. Table 33 lists the Hydrosolv Liquid Cleaners that are available from your Caterpillar dealer.

Table 33

Hydrosolv Liquid Cleaners		
Part Number	Description	Size
1U-8812	Hydrosolv4165	4 L (1 US gallon)
1U-5490		19 L (5 US gallon)
8T-7570		208 L (55 US gallon)
1U-8804	Hydrosolv100	4 L (1 US gallon)
1U-5492		19 L (5 US gallon)
8T-5571		208 L (55 US gallon)

- Use steam to clean the oil cooler core. This removes any remaining residue from the cleaner. Flush the fins of the oil cooler core. Remove any other trapped debris.
- Wash the oil cooler core with hot, soapy water. Rinse the oil cooler core thoroughly with clean water.

### WARNING

**Personal injury can result from air pressure.**

**Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.**

**Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.**

- Dry the oil cooler core with compressed air. Direct the air in the reverse direction of the normal flow.
- Inspect the components in order to ensure cleanliness. The oil cooler core should be pressure tested. Repair the oil cooler core, if necessary. Install the oil cooler core.

For more information about cleaning the cores, consult your Caterpillar dealer.

## Obtain Coolant Analysis

The concentration of supplemental coolant additive (SCA) should be checked regularly with test kits or with S-O-S Coolant Analysis (Level 1). Further coolant analysis is recommended when the engine is overhauled.

For example, considerable deposits are found in the water jacket areas on the external cooling system, but the concentrations of coolant additives were carefully maintained. The coolant water probably contained minerals that were deposited on the engine over time.

A coolant analysis can be conducted in order to verify the condition of the water that is being used in the cooling system. A full water analysis can be obtained by consulting your local water utility company or an agricultural agent. Private laboratories are also available for water analysis.

Caterpillar Inc. recommends an S-O-S Coolant Analysis (Level 2).

### S-O-S Coolant Analysis (Level 2)

An S-O-S Coolant Analysis (Level 2) is a comprehensive coolant analysis which completely analyzes the coolant and the effects on the cooling system. An S-O-S Coolant Analysis (Level 2) provides the following information:

- Complete S-O-S Coolant Analysis (Level 1)
- Visual inspection of properties
- Identification of metal corrosion
- Identification of contaminants
- Identification of built up impurities (corrosion and scale)

S-O-S Coolant Analysis (Level 2) provides a report of the results of both the analysis and the maintenance recommendations.

For more information about coolant analysis, see your Caterpillar dealer.

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## Radiator - Clean

**SMCS Code:** 1353-070

**Note:** Adjust the frequency of cleaning according to the effects of the operating environment.



Inspect the radiator for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the radiator, if necessary.

### WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the fan's air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a "comb". Inspect these items for good condition: welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

For more detailed information on cleaning and inspection, see Special Publication, SEBD0518, "Know Your Cooling System".

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## Starting Motor - Inspect

SMCS Code: 1451-040, 1453-040

Caterpillar Inc. recommends a scheduled inspection of the starting motor. If the starting motor fails, the engine may not start in an emergency situation.

Check the starting motor for proper operation. Check the electrical connections and clean the electrical connections. Refer to the Service Manual for more information on the checking procedure and for specifications or consult your Caterpillar dealer for assistance.

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## Walk-Around Inspection

SMCS Code: 1000-040

### Inspect the Engine for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, make a thorough inspection of the engine compartment before starting the engine. Look for items such as oil leaks or coolant leaks, loose bolts, worn belts, loose connections and trash buildup. Make repairs, as needed.

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

#### NOTICE

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

#### NOTICE

Accumulated grease and/or oil on an engine or deck is a fire hazard. Remove this debris with steam cleaning or high pressure water.

- Ensure that cooling lines are properly clamped and tight. Check for leaks. Check the condition of all pipes.
- Inspect the water pump for coolant leaks.

**Note:** The water pump seal is lubricated by coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of water pump and the installation of water pump and/or seals, refer to the Service Manual for the engine or consult your Caterpillar dealer.

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the valve cover.
- Inspect the fuel system for leaks. Look for loose fuel line clamps.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
- Inspect the alternator belt and the accessory drive belts for cracks, breaks or other damage.

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

- Drain the water and the sediment from fuel tanks on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground strap for a good connection and for good condition.
- Inspect the engine-to-frame ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges which are cracked or can not be calibrated.

- A piston seizure
- Other potential damage to the engine

Visually inspect the water pump for leaks. If any leaking is observed, replace the water pump seal or the water pump assembly. Refer to the Service Manual for the disassembly and assembly procedure.

**Note:** Refer to the Service Manual or consult your Caterpillar dealer if any repair is needed or any replacement is needed.

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## Water Pump - Inspect

**SMCS Code:** 1361-040; 1361

A failed water pump might cause severe engine overheating problems that could result in the following conditions:

- Cracks in the cylinder head



## Reference Information Section

00810740

## Engine Ratings

00727327

### Engine Rating Conditions

**SMCS Code:** 1000

All engine ratings are in compliance with the following standard ambient air conditions of "SAE J1349":

- 99 kPa (29.3 inches of Hg)
- 30 percent relative humidity
- A temperature of 25 °C (77 °F)

Ratings relate to the standard conditions of "ISO8665", of "ISO3046/1", of "DIN6271", and of "BS5514".

The engine ratings are based on the following fuel specifications:

- Low heat value (LHV) of the fuel of 42 780 kJ/kg (18,390 Btu/lb) at 29 °C (84 °F)
- Gravity (API) of 35 degrees at 15 °C (60 °F)
- Specific gravity of .649 at 15 °C (60 °F)
- Density of 850 kg/m<sup>3</sup> (7.085 lb/US gal)

The engine ratings are gross output ratings.

**Gross Output Ratings** – The total output capability of the engine that is equipped with standard accessories.

Standard accessories include the following components:

- Oil pumps
- Fuel pumps
- Water pumps

Subtract the power that is required to drive auxiliary components from the gross output. This will produce the net power that is available for the external load (flywheel).

## Engine Rating Definitions

**SMCS Code:** 1000

It is important to know the use of the engine so that the rating will match the operating profile. The proper rating selection is also important so that the customer's perception of price and value is realized.

In selecting a rating for a specific application, the most important consideration is the time that is spent at full throttle. These rating definitions identify the percent of time at full throttle. The definitions also identify the corresponding times below rated rpm.

**Note:** The examples of the applications are only for reference. For an exact determination of the appropriate rating, follow the OEM specifications or consult your Caterpillar dealer.

**A Rating** – This rating is used for heavy-duty applications that are operated at rated load and at rated rpm up to 100 percent. This rating is used for engines that operate without interruption of load cycling. Typical applications include the following examples: pipeline pumping and ventilation.

**B Rating** – This rating is used when power and/or rpm are cyclic. The engine should be run at full load. The engine should not exceed 80 percent of the duty cycle. Typical applications include the following examples: irrigation, operation where normal pump demand is 85 percent of the engine rating, oil pumping/drilling, field mechanical pumping/drilling, and stationary/plant air compressors.

**C Rating** – This rating is used when power and/or rpm are cyclic. The horsepower and the rpm of the engine can be utilized continuously for one hour. This is followed by one hour of operation at the A rating or below the A rating. The engine should be run at full load. The engine should not exceed 50 percent of the duty cycle. Typical applications include the following examples: agricultural tractors, harvesters and combines, off-highway trucks, fire pumps, blast hole drills, rock crushers, wood chippers with high torque rise, and oil field hoisting.

**D Rating** – This rating is used when rated power is required for periodic overloads. The maximum horsepower and the rpm of the engine can be utilized continuously for a maximum of 30 minutes. This is followed by one hour of operation at the C rating. The engine should be run at full load. The engine should not exceed 10 percent of the duty cycle. Typical applications include the following examples: offshore cranes, runway snow blowers, water well drills, portable air compressors, and fire pump certification power.

**E Rating** – This rating is used when rated power is required for a short time for initial starting or for sudden overload. The rating is also used for emergency service when standard power is not available. The horsepower and the rpm of the engine can be utilized continuously for a maximum of 15 minutes. This is followed by one hour of operation at the C rating or by the duration of the emergency. The engine should be run at full load. The engine should not exceed 5 percent of the duty cycle. Typical applications include the following examples: standby centrifugal water pumps, oil field well servicing, crash trucks, portable air compressors, and gas turbine starting motors.

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**NOTICE**

Operating engines above the rating definitions can result in shorter service life before overhaul.

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## Customer Service

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## Customer Assistance

SMCS Code: 1000

### USA and Canada

When a problem arises concerning the operation of an engine or concerning the service of an engine, the problem will normally be managed by the dealer in your area.

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

1. Discuss your problem with a manager from the dealership.
2. If your problem cannot be resolved at the dealer level without additional assistance, use the phone number that is listed below to talk with a Field Service Coordinator:

1-800-447-4966

The normal hours are from 8:00 to 4:30 Monday through Friday Central Standard Time.

3. If your needs have not been met still, submit the matter in writing to the following address:

Caterpillar Inc.  
Manager, Customer Service, Engine Division  
Mossville Bldg A  
P.O. Box 600  
Peoria, Illinois 61552-0600

Please keep in mind: probably, your problem will ultimately be solved at the dealership, using the dealership's facilities, equipment, and personnel. Therefore, follow the steps in sequence when a problem is experienced.

### Outside of the USA and of Canada

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

Latin America, Mexico, Caribbean  
Caterpillar Americas Co.  
701 Waterford Way, Suite 200  
Miami, FL 33126  
USA  
Phone: 305-476-6876  
Fax: 305-476-6850

Europe, Africa, and Middle East  
Caterpillar Overseas S.A.  
76 Route de Frontenex  
P.O. Box 6000  
1211 Geneva 6  
Switzerland  
Phone: 22-849-4444  
Fax: 22-849-4544

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

China  
Caterpillar China Ltd.  
37/F, The Lee Gardens  
33 Hysan Avenue  
Causeway Bay, Hong Kong  
China  
Phone: 852-2848-0333  
Fax: 852-2848-0440

Japan  
Shin Caterpillar Mitsubishi Ltd.  
Setagaya Business Square Tower  
10-1, Yoga 4-chome  
Setagaya, Tokyo  
Japan  
Phone: 81-3-5717-1121  
Fax: 81-3-5717-1177

Japan  
Caterpillar Power Systems, Inc.  
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Australia  
Phone: 03-9339-9333  
Fax: 03-9335-3366

## Ordering Replacement Parts

SMCS Code: 7567

### WARNING

When replacement parts are required for this product Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

**Failure to heed this warning can lead to premature failures, product damage, personal injury or death.**

Quality Caterpillar replacement parts are available from Caterpillar dealers throughout the world. Caterpillar dealers' parts inventories are up-to-date. The parts stocks include all of the parts that are normally needed to protect your Caterpillar engine investment.

When you order parts, please specify the following information:

- Part number
- Part name
- Quantity

If there is a question concerning the part number, please provide your dealer with a complete description of the needed item.

When a Caterpillar engine requires maintenance and/or repair, provide the dealer with all the information that is stamped on the Information Plate. This information is described in this Operation and Maintenance Manual (Product Information Section).

Discuss the problem with the dealer. Inform the dealer about the conditions of the problem and the nature of the problem. Inform the dealer about when the problem occurs. This will help the dealer in troubleshooting the problem and solving the problem faster.

## Reference Materials

en1526466

### Reference Material

SMCS Code: 1000

### Lubricants

- Special Publication, PEHP1026, "Data Sheet - Caterpillar Diesel Engine Oil (DEO) (CF-4) (International only)"
- Special Publication, PEHP0002, "Data Sheet - Multipurpose Lithium Complex Grease with Molybdenum (MPGM)"
- Special Publication, PEHP0017, "Data Sheet - Special Purpose Grease (SPG) Bearing Lubricant"
- Special Publication, SEBD0640, "Oil and Your Engine"
- Operation and Maintenance Manual, SEBU5898, "Cold Weather Recommendations"
- Special Publication, PEDP7036, "S-O-S Fluids Analysis Cornerstone"
- Special Publication, PEHP6001, "How To Take A Good Oil Sample"
- Special Publication, PEHP8038, "Data Sheet - Caterpillar Diesel Engine Oils (DEO) (CH-4, CG-4, CF-4) (North America and Australia)"
- Special Publication, PEHP7041, "Product Data Sheet for Caterpillar Diesel Engine Oils (DEO) CG-4 engine oils (International markets)"
- Special Publication, PEWP3014, "Cat Fluids Selector Dial (International)"
- Special Publication, PEWP9733, "Cat Fluids Selector Dial (North America)"
- Special Publication, NEHP5621, "How To Select The Right Grease For Any Job"
- Special Publication, NEHP6015, "Caterpillar Special Purpose Grease Data Sheet"

### Fuels

- Special Publication, SEBD0717, "Diesel Fuels and Your Engine"

### Coolants

- Special Publication, PEHP4036, "Data Sheet - Caterpillar Coolant"
- Special Publication, PEHP7057, "S-O-S Coolant Analysis"
- Special Publication, SEBD0518, "Knowing Your Cooling System"
- Special Publication, SEBD0970, "Coolant and Your Engine"
- Special Publication, PEEP5027, "Label - ELC Radiator Label"

### Miscellaneous

- Service Manual, SEBU6251, "Caterpillar Commercial Diesel Engine Fluids Recommendations"
- Special Publication, PECP6026, "One Safe Source"
- Special Publication, PECP6027, "One Safe Source (For COSA)"
- Special Publication, PECP6028, "One Safe Source (For non NACD and non COSA)"
- Service Manual, REG1139F, "Service Manual Contents Microfiche"
- Service Manual, SENR5050, "3054B Industrial Engine"
- Specifications, SENR5007, "3054B Industrial Engine"
- Systems Operation Testing & Adjusting, SENR5028, "3054B Industrial Engine"
- Disassembly and Assembly, SENR5029, "3054B Industrial Engine"
- Specifications, SENR3130, "Torque Specifications"
- Special Instruction, SEHS7654, "Alignment - General Instructions"
- Special Publication, LEBH9324, "Industrial Application and Installation Guide"
- Special Publication, SEBF8029, "Index to Guidelines for Reusable Parts and Salvage Operations"



- Special Publication, SEBF8062, "Guideline for Reusable Parts - Cleaning and Inspection of Air Filters"
- Special Instruction, SEHS9031, "Storage Procedure for Caterpillar Products"
- Special Publication, NEHS0526, "Service Technician Application Guide"
- Special Instruction, SMHS7001, "Assembly of Fan Drive Pulley Assemblies"
- Special Instruction, SEHS7768, "Use of 6V-2150 Starting/Charging Analyzer"
- Special Instruction, SEHS7633, "Battery Test Procedure"
- Label, SEHS7332, "Do Not Operate"

## Emissions Warranty

This engine may be Certified and this engine may be covered by an Emissions Warranty. A detailed explanation of the Emissions Warranty that is applicable to Certified engines is found in Supplement, SEBU7066, "Federal Emissions Control Warranty Information". The Engine is Certified if the engine has a special label that verifies the certification. A Caterpillar dealer can also inform you if the engine is Certified.

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## Additional Reference Material

**SMCS Code:** 1000

The "EMA Lubricating Oils Data Book" can be obtained from the following locations: local technological society, local library, and local college. If necessary, consult EMA at the following address:

Engine Manufacturers Association  
401 N. Michigan Ave.  
Chicago, IL, USA 60611  
Telephone: (312) 644-6610 ext. 3626

The "Society of Automotive Engineers (SAE) Specifications" can be found in your SAE handbook. This publication can also be obtained from the following locations: local technological society, local library, and local college. If necessary, consult SAE at the following address:

SAE International  
400 Commonwealth Drive  
Warrendale, PA, USA 15096-0001  
Telephone: (724) 776-4841

The "American Petroleum Institute Publication No. 1509" can be obtained from the following locations: local technological society, local library, and local college. If necessary, consult API at the following address:

American Petroleum Institute  
1220 L St. N.W.  
Washington, DC, USA 20005  
Telephone: (202) 682-8000

The International Organization for Standardization (ISO) offers information and customer service regarding international standards and standardizing activities. ISO can also supply information on the following subjects that are not controlled by ISO: national standards, regional standards, regulations, certification, and related activities. Consult the member of ISO in your country.

International Organization for Standardization (ISO)  
1, rue de Varembe  
Case postale 56  
CH-1211 Genève 20  
Switzerland  
Telephone: +41 22 749 01 11  
Facsimile: +41 22 733 34 30  
E-mail: central@iso.ch  
Web site: <http://www.iso.ch>

European classifications are established by the Conseil International Des Machines a Combustion (CIMAC) (International Council on Combustion Engines).

CIMAC Central Secretariat  
Lyoner Strasse 18  
60528 Frankfurt  
Germany  
Telephone: +49 69 6603 1567  
Facsimile: +49 69 6603 1566

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## Maintenance Records

**SMCS Code:** 1000

Caterpillar Inc. recommends the retention of accurate maintenance records. Accurate maintenance records can be used for the following purposes:

- Determine operating costs
- Establish maintenance schedules for other engines that are operated in the same environment.



- Show compliance with the required maintenance practices and maintenance intervals.

Maintenance records can be used for a variety of other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is well managed. Accurate maintenance records can help your Caterpillar dealer to fine tune the recommended maintenance intervals in order to meet the specific operating situation. This should result in a lower engine operating cost.

Records should be kept for the following items:

**Fuel Consumption** – A record of fuel consumption is essential in order to determine when the load sensitive components should be inspected or repaired. Fuel consumption also determines overhaul intervals.

**Service Hours** – A record of service hours is essential to determine when the speed sensitive components should be inspected or repaired.

**Documents** – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number, and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner's repair costs
- Owner's receipts
- Maintenance log



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# Product and Dealer Information

**Note:** For product identification plate locations, see the section "Product Identification Information" in the Operation and Maintenance Manual.

**Delivery Date:** \_\_\_\_\_

## Product Information

Model: \_\_\_\_\_

Product Identification Number: \_\_\_\_\_

Engine Serial Number: \_\_\_\_\_

Transmission Serial Number: \_\_\_\_\_

Generator Serial Number: \_\_\_\_\_

Attachment Serial Numbers: \_\_\_\_\_

Attachment Information: \_\_\_\_\_

Customer Equipment Number: \_\_\_\_\_

Dealer Equipment Number: \_\_\_\_\_

## Dealer Information

Name: \_\_\_\_\_ Branch: \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Dealer Contact

Phone Number

Hours

Sales: \_\_\_\_\_

Parts: \_\_\_\_\_

Service: \_\_\_\_\_