OPERATORS MANUAL

HDV4500

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- 2.2 Operation Manual
- Comet Manual
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STG GLOBAL

OPERATORS MANUAL

HDV4500

Section 1

STG GLOBAL

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Congratulations on your purchase of an STG Global product. Your Vacuum Tanker will give you years of dependable service if the proper operating and maintenance instructions are observed. We recommend that you read this manual carefully to become thoroughly familiar with your tanker equipment prior to operation.

1. GENERAL SAFETY PRECAUTIONS

a. Safety Precautions for Entering Tanks

Follow these safety precautions, and insist that those working with you follow them. Most industrial equipment accidents can be avoided by observing safety precautions.

b. Safety Precautions for Handling Material

DANGER: DO NOT stand near the oil catch muffler or discharge valve when loading or unloading the tank. Sewer gases vented out of the oil catch muffler will settle downward. Sewer gases can also be expelled out of the discharge valve when releasing tank pressure. Inhaling sewer gases can cause severe injury or death.

WARNING: DO NOT allow children or irresponsible people near your work area or equipment. Fatalities have occurred when children have fallen or climbed into unattended septic/holding tanks. Secure your work area from entry of unauthorized persons in the vicinity.

WARNING: Secure all access covers against unauthorized entry after pumping a septic/holding tank. Fatalities have occurred where children have fallen into septic/holding tank openings that had not been properly secured. Securely chain and padlock above ground access openings. Bury underground access openings by at least six inches of dirt.

WARNING: Always wear protective gloves, eye protection and, appropriate clothing when working with sewage affluent or septage. These materials may contain hazardous chemicals, disposed of through the drain, which can cause severe injury or even death due to contact. These affluent also contain bacteria, which can be a source of infection, especially if exposed to open cuts or sores.

DANGER: DO NOT enter a transport, septic, or holding tank without cleaning and providing adequate ventilation to the interior of the tank. Sewer gas is deadly if inhaled; in addition, it depletes the oxygen in a confined space, which can cause asphyxiation.

DANGER: DO NOT enter a transport, septic, or holding tank without using a respirator that supplies grade D breathing air or a self-contained breathing apparatus. In addition, DO NOT use this equipment without training and familiarity with it. Entering a tank exposed to sewage affluent without a correct breathing apparatus, or with improper use of it, can cause death.

DANGER: DO NOT enter a transport, septic, or holding tank without protective clothing. Sewer gas can be absorbed through the skin causing serious injury or death.

WARNING: When entering a transport, septic, or holding tank, always have someone standing by to provide assistance, and always have a respirator that supplies grade D breathing air or a self-contained breathing apparatus on hand for them. In the event of an attempted rescue, this equipment is necessary to prevent death of the rescuer.

WARNING: Attach a safety-harness and rope to any person that enters a transport, septic, or holding tank. Have the safety-harness rope held by a person standing by to provide assistance outside the tank. An attempted rescue without the advantage of a rope and harness can be life threatening to the rescuer.

WARNING: Entry into a transport, septic, or holding tank is confined space entry. Persons entering these tanks for any purpose must be trained in and follow OSHA confined space safety procedures.

c. Safety Precautions for Operating Equipment

DANGER: Stop the truck motor, remove all persons from the truck cab, and chock the truck tires before servicing any component under the truck; this includes lubricating the vacuum pump or the PTO driveline. Contact with a rotating mechanism can cause entanglement that can lead to death. A truck that begins to roll is a crushing hazard that can lead to death.

WARNING: Keep hands, feet, hair, and clothing away from moving parts. Contact with a moving mechanism can cause entanglement that can lead dismemberment or death.

WARNING: Escaping hydraulic oil under pressure can have sufficient force to penetrate your skin, which can cause serious injury. Before operating hydraulic components, be sure all connections are tight and hoses are not damaged. Relieve all pressure before disconnecting hydraulic lines or repairing leaks.

CAUTION: When off-loading under pressure, maintain control of the end of the hose.

Pressurised discharge can cause a hose end to whip about and create the potential for spraying persons in the area

WARNING: Keep all shields in place. Shields and covers are designed to protect the operator from entanglement in moving parts, which can lead to serious injury or death. DO NOT remove shields from the unit except when servicing; then, replace immediately.

WARNING: The truck's cornering and braking abilities are reduced when the tank is loaded. Drive at a reasonable speed with a loaded tank; reduce speed on rough or hilly terrain, before making an anticipated stop, and when cornering.

WARNING: Make certain everyone is clear of the tanker truck and the immediate area before starting the engine, engaging power, and operating the equipment. The inherent hazards of septic pumping can cause serious injury or death to untrained persons that enter this area.

WARNING: DO NOT allow anyone to ride on the outside of the tanker truck when it is in motion. Failure to follow this precaution could result in persons falling off the truck and possibly getting run over, which could cause serious injury or death.

WARNING: Before backing-up the truck, inspect the area to be backed into, and clear all hazards, pets, and people from it. Make sure that backup lights and the back-up alarm are maintained and in good working condition. Because of the truck mounted tank, the driver will experience a large blind spot behind the truck. Fatalities have occurred when persons were run over by a tanker truck.

CAUTION: Avoid contact with the vacuum pump during or immediately after operation. Operating temperatures can range from near 200°F to over 00°F, depending on the make and model of pump and on the working conditions. Contact with a hot vacuum pump can cause severe burns.

2. GENERAL SAFETY RULES

WARNING: Water at high pressure can be dangerous and can cause damage if the operator is careless. Never allow anyone to operate this pressure washer unless they are familiar with the safety precautions.

1. **NEVER** direct the spray towards any person or animal.
2. **NEVER** hold your finger over the high-pressure nozzle.
3. **NEVER** allow children or untrained personnel to use this machine.

4. **NEVER** operate the machine with any of the covers removed.
5. **NEVER** attempt any repairs to this machine. Always refer to your dealer.
6. **NEVER** supply any liquid other than water to the water inlet.
7. **NEVER** use the detergent pickup facility to introduce flammable liquids/solvents, e.g. paint thinners, petrol, oil as there is a risk of explosion.
8. **ALWAYS** release any residual pressure in the system by turning off the water supply and operating the trigger before disconnecting any hose or accessory.
9. **ALWAYS** keep the machine itself dry and well clear of water spray.
10. **ALWAYS** wear protective clothing and safety glasses. Loose particles and other debris may be propelled at high speed by the water jet.
11. **ALWAYS** grip the gun firmly and expect the spray gun to 'kick' when starting.
12. **ALWAYS** respect the requirements of the local water company. Pressure washers may only be connected to the mains drinking water supply if a system separator (also known as a backflow preventer) is installed in the supply hose.
13. **ALWAYS** disconnect from the water supply, and ensure the system is completely drained when not in use. Store in a cool dry location.
14. **ONLY** use chemical cleaning agents (detergents), that are approved for pressure washers.
15. **WARNING** High pressure water jets can be dangerous if subject to misuse. The jet must not be directed at a person or anything that they are wearing.
16. **NEVER** direct the jet at electrical equipment or the machine itself.
17. **WARNING** High pressure hoses, fittings and couplings are important for the safety of the machine. Use only hoses, fittings and couplings recommended by the manufacturer.
18. **WARNING** Water that has flowed through a system separator (also known as a backflow preventer) is considered non-drinkable
19. **NEVER** use the pressure washer if the inlet/outlet hoses or important parts of the machine are damaged.

3. HIGH PRESSURE WATER SAFETY

WARNING

An injury caused by high pressure water jets can be serious. In the event of any water jet injury:

- Seek medical attention immediately. Do not delay!
- Inform the doctor of the cause of the injury.
- Tell the physician what type of waterjet project was being performed at the time of the accident and the source of the water.

A. Medical Alert

This patient may be suffering from a water jet injury. Evaluation and management should parallel that of a gunshot injury. The external manifestations of the injury cannot be used to predict the extent of internal damage. Initial management should include stabilisation and a thorough neurovascular examination. X-rays can be used to assess subcutaneous air and foreign bodies distant from the site of injury.

Injuries to the extremities can involve extensive nerve, muscle, vessel damage, as well as cause a distal compartment syndrome. Injuries to the torso can involve internal organ damage. Surgical consultation should be obtained. Aggressive irrigation and debridement is recommended. Surgical decompression and exploration may also be necessary.

Angiographic studies are recommended pre-operatively if arterial injury is suspected. Bandages with a hygroscopic solution ($MgSO_4$) and hyperbaric oxygen treatment have been used as adjunctive therapy to decrease pain, edema and subcutaneous emphysema. Unusual infections with uncommon organisms in immunocompetent patients have been seen; the source of the water is important in deciding on initial, empiric antibiotic treatment, and broad-spectrum intravenous antibiotic treatment, and broad-spectrum intravenous antibiotics should be administered. Cultures should be obtained.

Operators using or working around high pressure water systems need to take additional precautions including specialised personal protection equipment

B. General

WARNING

STG Global could not possibly, know, evaluate, and advise the service trade of all conceivable ways in which operation or service might be done or the possible hazardous consequences of each way. Anyone who uses operational procedures, service procedures, or tools, whether recommended by STG Global or not, must first satisfy himself thoroughly that neither his safety nor the product safety will be jeopardised by the methods he shall select.

STG Global vacuum systems are designed to user specifications. The owner/operator/user is responsible for the safe use and application of this equipment and proper waste disposal. Transportation and disposal of waste may be subject to local, state or federal laws.

Read and follow the safety practices described in this manual and in the common industry references that are also provided to help in the decision-making process.

C. General Safety Procedures

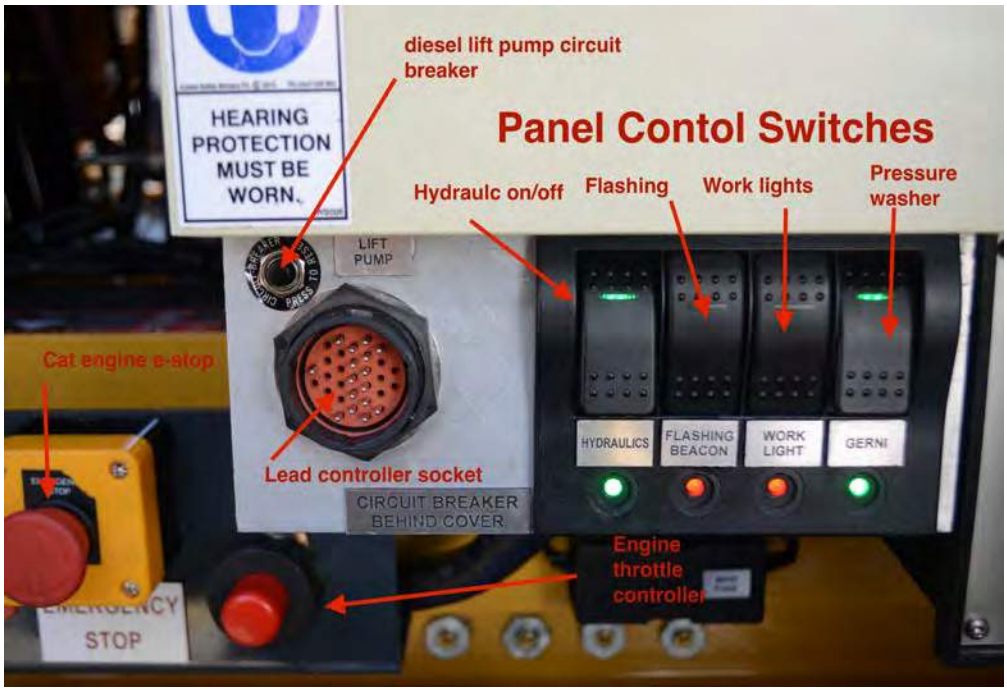
- Perform all operations with at least two operators.
- Only trained personnel should operate, perform maintenance, or repair the unit.
- Work area must be clear and clean for good visibility and footing.
- All operators must wear safety apparel: hard hat, visor and / or goggles, ear protection, rain suit, safety- toe shoes or boots with non-skid soles and water proof gloves are recommended.
- Never alter system components or reprogram. System components must be used only as intended.
- If a malfunction occurs, immediately stop and follow repair instructions.
- The unit must be thoroughly cleaned between jobs to prevent cross contamination or chemical reactions.

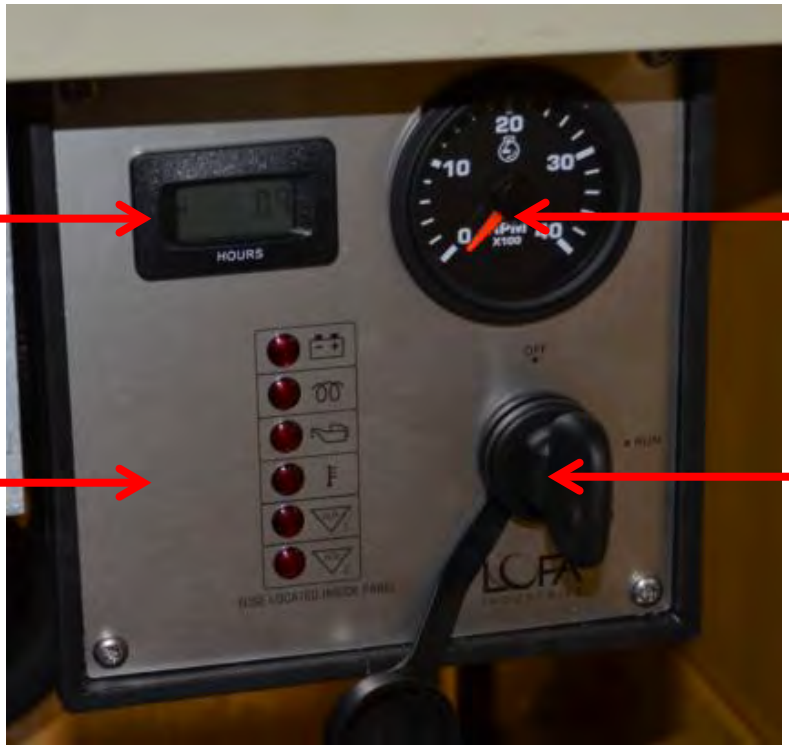
- Never use this unit in any type of rescue operation where the vacuum is used for the rescue.
- Operating the unit inside a building or confined areas can create additional risks to the unit, operators and building occupants. Engine exhaust gas can reach deadly levels. Heat buildup from the engine and blower discharge can overheat people and equipment.
- Never use an air mover machine for vacuuming hydrocarbon or flammable materials unless the flash point of the material is 60° (C) or higher. Pressurised or pump off-loading is not permitted unless the flash point of the material is 50° (C) or higher unless nitrogen is present.
- Never operate engines where there are or can be combustible vapors. Vapors pulled in to an engine air intake can cause engine acceleration and over-speeding. This can result in death, injury and property damage.
- Reference to OSHA regulations are for informational purposes only and not intended as legal advice.
- The use of this equipment in the removal or handling of any regulated substance or material must be performed in strict accordance with all applicable federal, state and local laws and regulations, and approved safety and personal protection equipment and clothing must be used and worn at all times.
- Never use an air mover machine to vacuum dusty materials until the Safety Data Sheet(s) (SDS) have been consulted to determine if the dust(s) have an explosive potential (Combustible Dusts). Only air mover units that are part of a verified assured grounding system that have bags, doors and any other non-welded debris body components grounded to the debris body can be used if the materials contain combustible dusts.

4. COMPONENT IDENTIFICATION

Engine Control Panel

Control Panel





Hourmeter

Tachometer

Indicator lights

Ignition Switch

Hydraulic Enable
Push Top -Enable
Push Bottom
-DISABLE

Flashing Beacon

Work Light

Throttle
Turn CW or Push in -DECREASE RPM
Turn CCW or Pull Out In -INCREASE

Hydraulic Controls

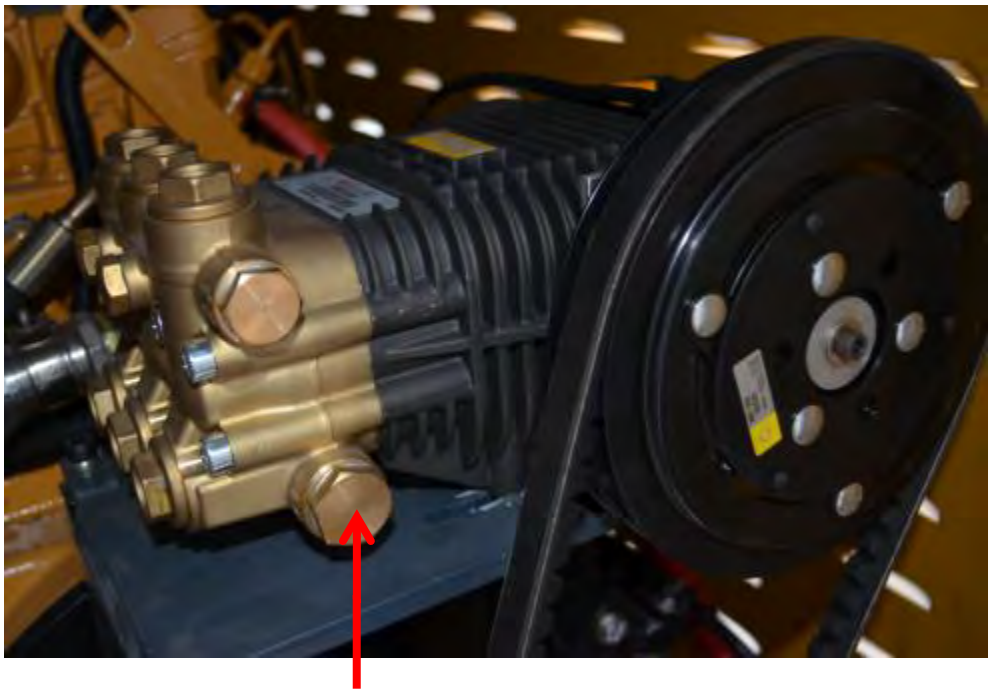
Emergency stop

Collection Tank
Raised/lower
Push up -RAISE TANK
Push-Down-LOWER

Rear Door Open/Close
Push open -Raise door
Push Close -Lower door

Water System

Water pump Switch



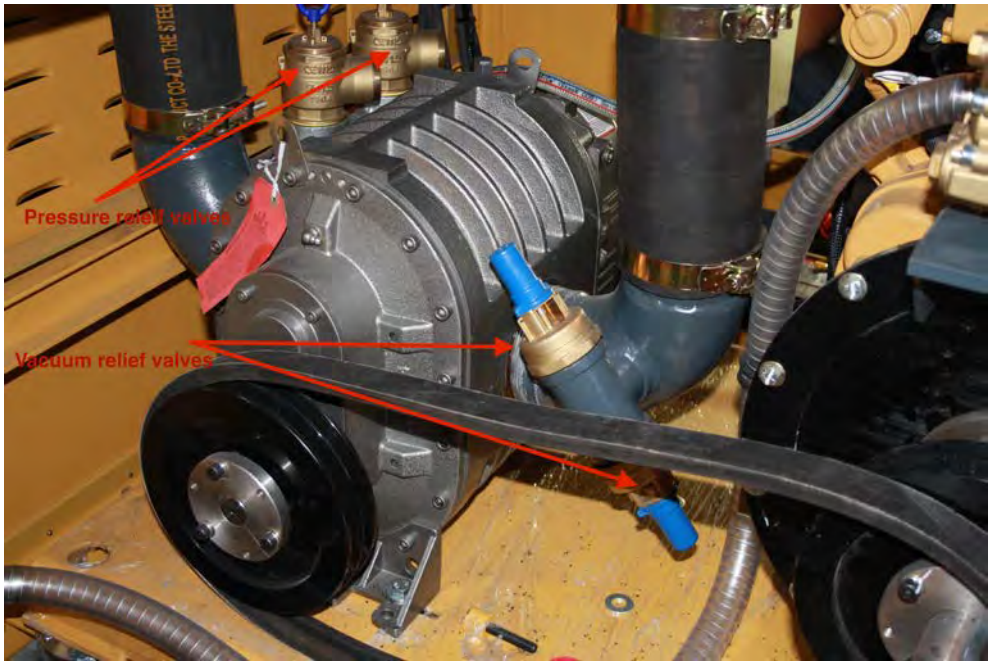
Water Pump

Water Strainer

Hose Reel

Water Tank Drain Valve Lever

Vacuum System



Blower Vacuum

Blower Pressure/Vacuum Gauge

(Pressure / Vacuum (4way) valve lever (option)
UP (45°) - Pressure
Middle (Horizontal) - Neutral
Down (45°) - Vacuum
Press Button - UNLOCKS LEVER
Release Button - LOCKS LEVER

Primary Shutoff Assembly (Collection Tank Interior)

Bag House Lid

Bag House Drain Valve

Tools

Water Gun

5. VACUUM/BLOWER/TANK OPERATION

Please refer to the truck manufactures operators manual

Starting Procedure

Starting - Machine preparation

A. Check Caterpillar engine and machine fluid levels. Perform daily or as recommended in the manufactures operators manual

B. Configure machine as follows:

Water Pump Switch	SWITCH OFF
Suction Valve	CLOSED
4” Dump Valve	CLOSED
Bag House Drain Valve	OPEN
Pressure /Vacuum Selector Lever	NEUTRAL

Starting the Engine

A. Refer to Lofa panel instructions

Shutdown Procedures

Shutdown the Machine

1. Before shutting down the engine make sure the pressure/vacuum lever is in the neutral position
2. Make sure you allow the engine to cool down for 5-10minutes before shutting the engine down (please refer to the Caterpillar engine guidelines)

6. USING THE PRESSURE WASHER

1. When engaging the pressure washer make sure the Caterpillar engine is at idle
2. To engage the pressure washer, push the pressure washer switch to the on position on the control panel, also for the pressure washer to work the pressure switch at the rear of the truck must be switched on.
3. Once the pressure washer is engaged ramp up the engine rpm to the desired pressure.

4. To disengage, idle the engine rpm back and push the pressure washer switch to the off position

7. ENGAGING THE VACUUM

Read the Gardner Denver operators manual before use.

A. Always have the Caterpillar engine at idle before engaging the vacuum lever (4-way valve)
B. Engage the vacuum by pushing the 4way valve lever up to the vacuum position.
C. Then increase the Caterpillar engine rpm to the desired Vacuum pressure, refer to the vacuum/pressure gauge for accurate measurement
D. To disengage the vacuum, idle the Caterpillar engine down and then disengage the vacuum lever to the neutral position.

8. ENGAGING THE PRESSURE BLOWER

A. Always have the Caterpillar engine at idle before engaging the pressure lever (4-way valve)
B. Engage the pressure by pulling the 4way valve lever down to the pressure position.
C. Then increase the Caterpillar engine rpm to the desired pressure, refer to the vacuum/pressure gauge for accurate measurement
D. To disengage the pressure, idle the Caterpillar engine down and then disengage the pressure lever to the neutral position.

During vacuum truck operations, workers are at risk of being exposed to toxic gases, flammable materials and other various hazards. This procedure will address proper and safe vacuum truck operations.

When work is performed on a non-owned or operated site, the operator's program shall take precedence, however, this document covers Your Company employees and contractors and shall be used on owned premises, or when an operator's program doesn't exist or is less stringent. Employees will be aware of provisions of site specific contingency/emergency plans by either Your Company or of a facility owner.

9. SAFE WORK PROCEDURES

Safe work procedures for vacuum truck operations must address the potential for chemical reactions and the potential release of toxic gas or fumes. The variety of fluids or substances that vacuum trucks typically carry must also be taken into consideration. Before starting any vacuum truck operations, Your Company shall make sure that vacuum truck owners and operators, as well as facility personnel are aware of the following:

A. The numerous potential hazards associated with vacuum truck operations in petroleum facilities including, but not limited to:

- Sources of ignition, flammable atmospheres, potential hazards associated with the surrounding area, toxic vapors and their PELs and STELs.
- Additional hazards such as slips and falls, spills and releases, fires and explosions and accidents within the facility or on the highway.

B. The evacuation and rescue procedures in the event of a toxic gas leak.

C. Ensure that air quality monitoring at the work site is continuous at such locations as the discharge area of the vacuum truck venting hose.

D. Ensure that first aid is readily available on site in the event of exposure to toxic gas.

E. Consult the manufacturer's instructions to confirm that the vacuum equipment is designed for the particular transfer operation.

F. Ensure that all equipment – including tank and vacuum trucks, and pumping equipment – is in safe working condition. Ensure that the tank interior, filter baghouse, and cyclone separators are clean and free of any substances that may react with the liquids to be vacuumed or transferred.

G. Before beginning operations, vacuum truck operators shall obtain any required permits and inspect vacuum trucks, equipment, and loading/off-loading sites to assure safe operations.

Under normal conditions, the absence of oxygen minimises the risk of ignition in a vacuum truck. However, operating rotary lobe blowers and vacuum pumps at high speeds creates high air movement and high vacuum levels, resulting in high discharge air temperatures and high discharge vapor concentrations that can present potentially ignitable conditions.

10. ATMOSPHERIC TESTING

The areas where vacuum trucks will operate must be free of hydrocarbon vapors in the flammable range.

*The areas where the vacuum truck operator and others work without respirators must also be at or below air contaminants PELs/STELs. If there is any question whether the area is vapor or toxic gas free, atmospheric testing shall be performed by a qualified person using properly calibrated and adjusted detectors.

Testing shall be conducted prior to starting any operations, and if necessary during operations, including, but not limited to the following:

- When operations in the area are subject to change, such as automatic pump start-up or product receipt into, or transfer out of a tank located near the transfer operations.
- When off-loading
- When atmospheric conditions change, such as wind direction
- When an emergency, such as product release, occurs within the facility that may affect atmospheric conditions in the transfer area

To prevent exposure to toxic gases during transfer operations:

- Never transfer fluids from one truck to another unless it has been established that no chemical reaction will occur
- Position trucks to minimise exposure to any discharged gases and fumes.
- Ensure that discharge lines are long enough and large enough for safe operation.
- Position vent lines away from workers and workstations, including control panels, valve handles, gauges, shut-offs, and hose attachment points – if

possible, use a vertical exhaust stack to divert exhaust gases away from workers and ignition sources.

- Check air monitoring equipment during operations to confirm that venting is proceeding safely.
- Monitor the following: Tank level indicators to avoid overfilling.
- Tank pressure gauges to avoid over-pressurising receiving tanks or creating excessive vacuum in supply tanks.
- Minimise the air introduced into the system when pressure loading or unloading – submerge the suction line in liquid, or reduce the vacuum pump speed when skimming or nearing the end of a load.
- Maintain a log of transported fluids and any potential residue. Use gravity loading and unloading whenever possible.
- Use a vapor recovery system, when available, to avoid venting tanks directly to the atmosphere.
- Vacuum hoses constructed of conductive materials or thick walled hose with imbedded conductive wiring shall be used when transferring flammable and combustible liquids when the potential for a flammable atmosphere exists for the area of operations.
- Conductive hoses shall provide suitable electrical conductance less than or equal to 1 mega ohm per 100 feet (as determined by the hose manufacturer). Thin walled metallic spiral-wound conductive hoses should not be used because of the potential for electrical discharge through the thin plastic that covers the metal spiral.

11. BONDING AND GROUNDING

The complete vacuum transfer system needs to be bonded so that there is a continuous conductive path from the vacuum truck through the hose and nozzle to the tank or source container and grounded to dissipate stray currents to earth (ground).

Prior to starting transfer operations, vacuum trucks need to be grounded directly to the earth or bonded to another object that is inherently grounded (due to proper

contact with the earth) such as a large storage tank or underground piping. A safe and proper ground to earth may be achieved by connecting to any properly grounded object including, but not limited to, any one or more of the following examples:

- A metal frame of a building, tank, or equipment that is grounded.
- An existing facility grounding system such as that installed at a loading rack.
- Fire hydrants, metal light posts, or underground metal piping with at least 10' of contact with earth.

12. TRAINING

Venting:

Several methods can be used by vacuum truck operators to safely vent vacuum pump exhaust vapors, including, but not limited, to the following:

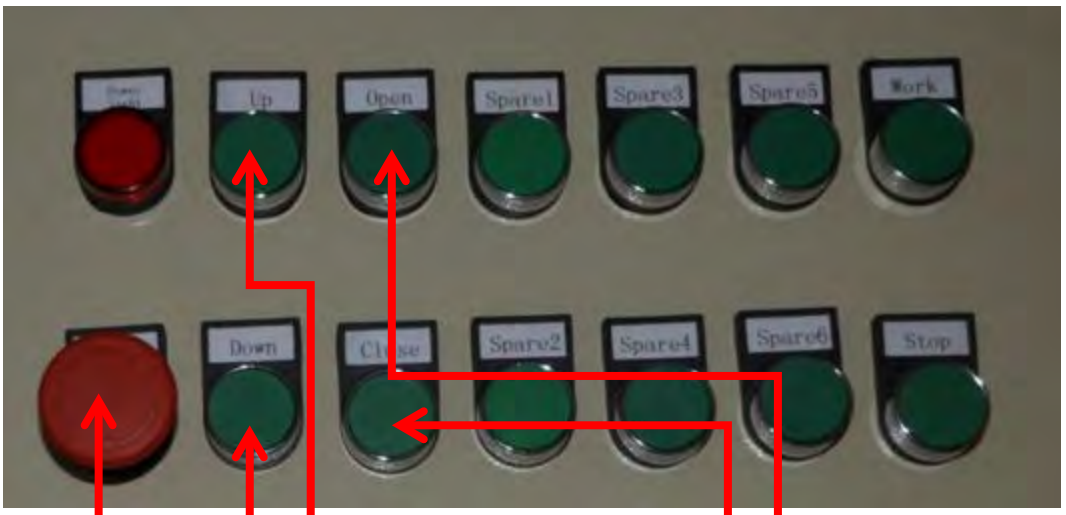
- Operators can prevent dieseling by locating the vacuum truck upwind of vapor sources and by extending the vacuum pump discharge away from the diesel engine air intake.
- Vapors may be returned to the source container using conductive and closed connections.
- Vapors may be vented into the atmosphere to a safe location using a safety venturi.
- Vacuum truck operators may provide vertical exhaust stacks extending approximately 3m above the vacuum truck (or higher if necessary) to dissipate the vapors before they reach ignition sources or other potential hazards and personnel.
- Vacuum truck operators may attach a length of exhaust hose to the vacuum exhaust that is long enough to reach an area that is free from potential hazards, sources of ignition, and personnel – the hose should preferably be extended 25m downwind of the truck and away from the source of the liquids.

Vacuum truck operators shall be trained and properly licensed in accordance with applicable regulations. Vacuum truck personnel working in petroleum facilities shall be trained in:

- The safe operation of the vacuum equipment and be familiar with hazards of the petroleum products, byproducts, wastes and materials being transferred.
- Aware of relevant government and facility safety procedures and emergency response requirements.
- MSDS of the substances being vacuumed or transferred.
- Appropriate PPE.
- The requirement that all personnel shall leave the vacuum truck cab during loading and off-loading operations.
- The requirement that when transferring flammable liquids or hazardous materials, vacuum truck operators shall remain positioned between the vacuum truck and the source or receiving tank, vessel, or container and within 10m of the vacuum truck throughout the duration.
- The requirement that vacuum truck operators shall monitor the transfer operation and be ready to quickly close the product valve and stop the pump in the event of a blocked line or release of material through a broken hose or connection.
- The knowledge that smoking, or any other source of ignition, shall not be permitted within at least 100’ (depending on local procedures and atmospheric conditions) of the truck, the discharge of the vacuum pump, or any other vapor source.
- The requirement that vacuum trucks shall not enter a tank dike area until such areas have been checked/monitored and rendered safe.
- Vacuum truck cargo tanks shall be depressurised.
- The effect of speeds, turns, and the changing center of gravity.
- Maintaining proper distances when operating vacuum trucks inside facilities with restricted clearances.

13. HYDRAULIC OPERATION

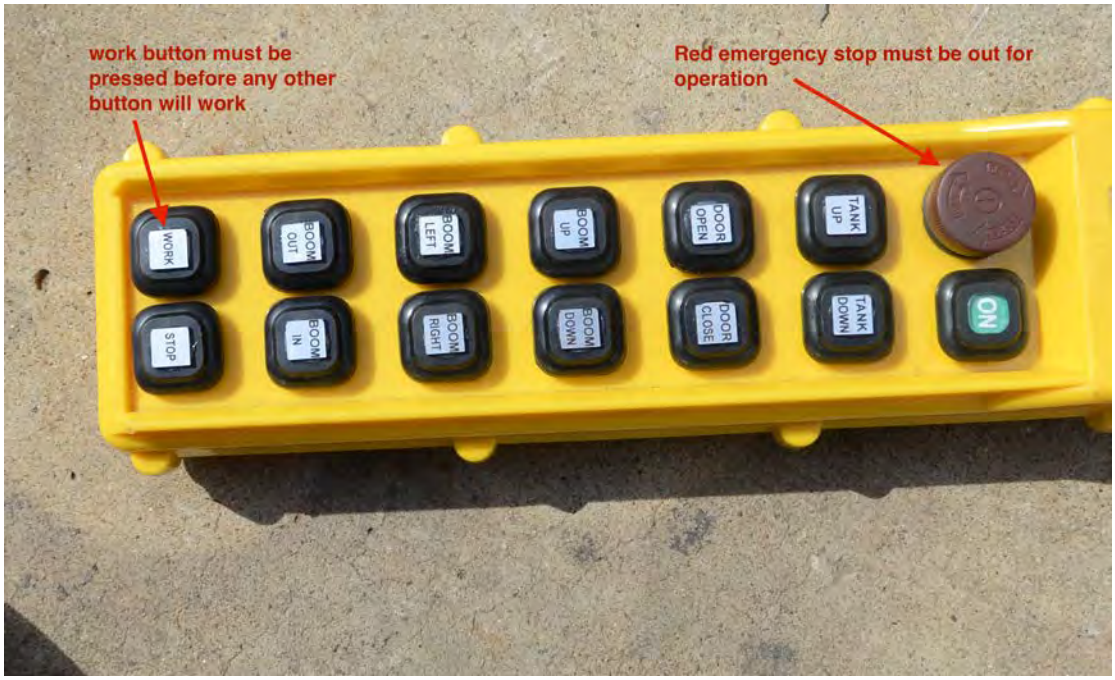
1. Before running the hydraulics make sure the hydraulic oil is showing in the hydraulic sight glass at the correct level
2. For hydraulic operation, the caterpillar engine must be running,
3. Once the engine is running engage the hydraulics by switching the hydraulic switch to the on position on the control panel.
4. The hydraulics can be operated 4 ways, by manual override on the hydraulic valve bank, via the pendant with lead, by wireless remote or by the electrical buttons on the electrical board.



Emergency stop

Collection Tank Raised /lower
Push up -RAISE TANK
Push-Down-LOWER TANK

(H2)Rear Door Open/Close
Push open -Raise door
Push Close -Lower door



The red emergency stop button must be out for the pendant to work.

Also, the work button must be pressed initially for the pendant to work & the on button must be pressed.

14. MAINTENANCE

Caterpillar Engine- refer to the manufactures operator and maintenance manual Garner Denver 5LR blower/vacuum- refer to the manufactures operator and maintenance manual.

Comet rw6040 pressure washer - refer to the manufactures operator and maintenance manual.

15. HYDRAULIC SYSTEM

Check the oil in the hydraulic reservoir daily. Keep the reservoir filled with hyd68 or equivalent hydraulic oil.

If the oil level drops, fill the reservoir, and then inspect the complete hydraulic system for leakage. Before making any repairs, be sure to have a qualified person relieve all pressure in the system.

WARNING: Escaping hydraulic oil under pressure can have sufficient force to penetrate your skin, which can cause serious injury. Before operating hydraulic components, be sure all connections are tight and hoses are not damaged. Relieve all pressure before disconnecting hydraulic lines or repairing leaks.

Hydraulic Oil & System- maintenance should be conducted by a qualified person, the hydraulic oil should be changed at a maximum of every 1000hrs, the hydraulic oil filter should be changed every 500hrs maximum or 6months or which every comes sooner.

16. VACUUM FINAL FILTER

Clean the filter as often as every day, depending upon the content of the material being pumped. For example, when cleaning the filter, provide yourself with gloves, eye protection, and protective clothing and then use the following procedure:

A. Loosen the wing nuts and remove the cover.
B. Remove the filter canisters.
C. Clean the lint from the filter canisters. If necessary, swirl the filter in a drum of soapy water to loosen the material.

D. Reassemble in the reverse order.

WARNING: Wear protective gloves, eye protection and appropriate clothing when cleaning the filter. Being a component of the vacuum system, the filter is subject to exposure by sewage or septage. These materials may contain hazardous chemicals and bacteria, which can cause infection, injury, or even death due to contact.

17. PRIMARY SHUTOFF

Inspect the primary shutoff every 2 weeks to check the rubber ball seat and the tightness of all fasteners.

Your vacuum tanker is equipped with one of two styles of primary shutoff, depending on which type of air-line system the tank has.

To inspect the ball seat on external air-line systems, begin by removing the primary shutoff access lid.

Next, gain access the ball seat. Examine the ball seat for hardened rubber, nicks in the rubber, and a buildup of debris. Any of these conditions may prevent proper sealing. Clean or replace the ball seat as necessary. Reassemble in the reverse order; furthermore, be sure to tighten all fasteners adequately.

Component	Required Maintenance	Maintenance Interval
Moisture Trap	Check for accumulation of liquid	Daily
Final Filter	Clean filter screen	Daily - *pumping high lint content material* Weekly - *pumping low lint content material*
Primary Shutoff	Clean rubber ball seat; check fastener tightness	Every 2 weeks
Moisture Trap	Clean rubber ball seat; check fastener tightness	Every 2 weeks
Mounting Brackets	Check tension on spring mounts	Every Month
Standoff Wear-plate	Inspect	Weekly - *pumping high grit content material* Every 3 Months - *pumping septage & sewage*
Standoff Wear-plate	Replace	When worn through
Vacuum Pump	Clean pump interior	Every three months
Vacuum Pump	Clean pump exterior (to avoid buildup of mud)	Regularly
Vacuum Pump	Clean drip oiler sight glass	Periodically
Vacuum Pump	Check rotor vane wear	Per pump manufacturers recommendations (replace vanes that exceed 1/4" wear limit)
Hydraulic System	Change Filter	Every 6 Months

18. VACUUM MODULE MOUNTING

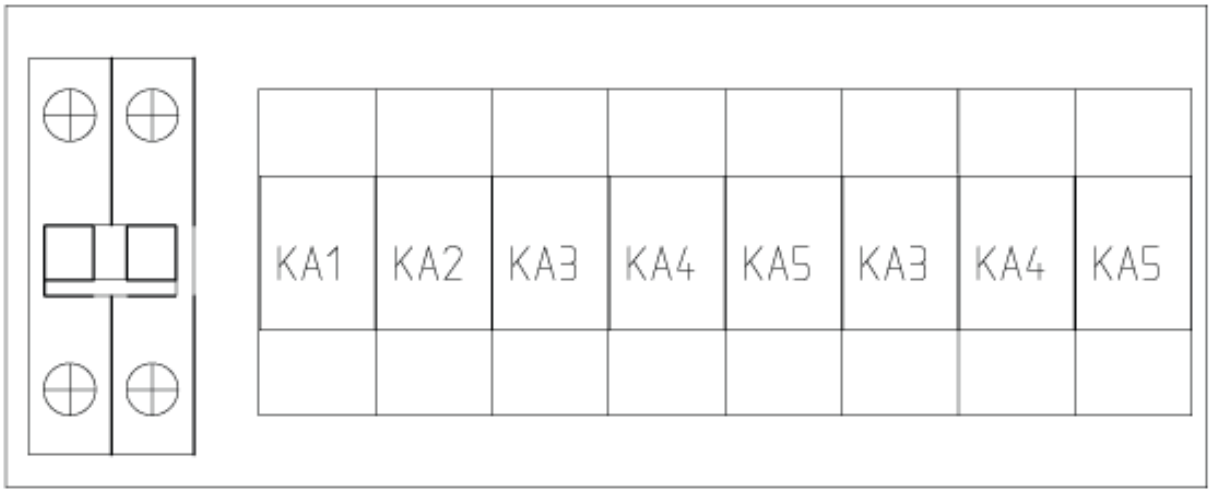
Check all module mounting bolts visually daily

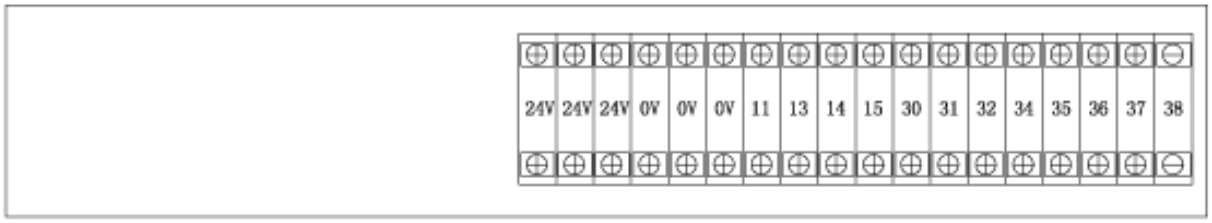
Check the module mounting bolts monthly with spanners

19. CAPTURED MOUNTING BRACKET SPRINGS

Check the tension on the spring mounts monthly. Examine the spring mounts to make sure they have not loosened up due to vibration. Adjust the springs on the captured mounting brackets to a compressed length.

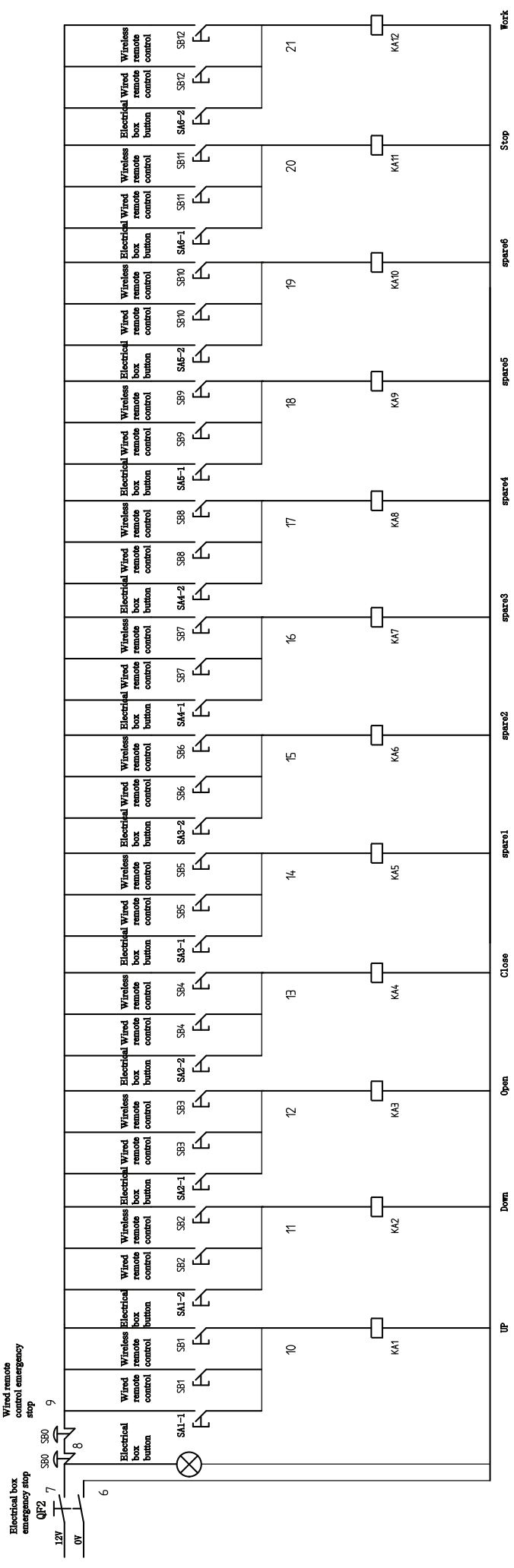
20. 4500lt ELECTRIC CONTROL BOX CIRCUIT DIAGRAM 1





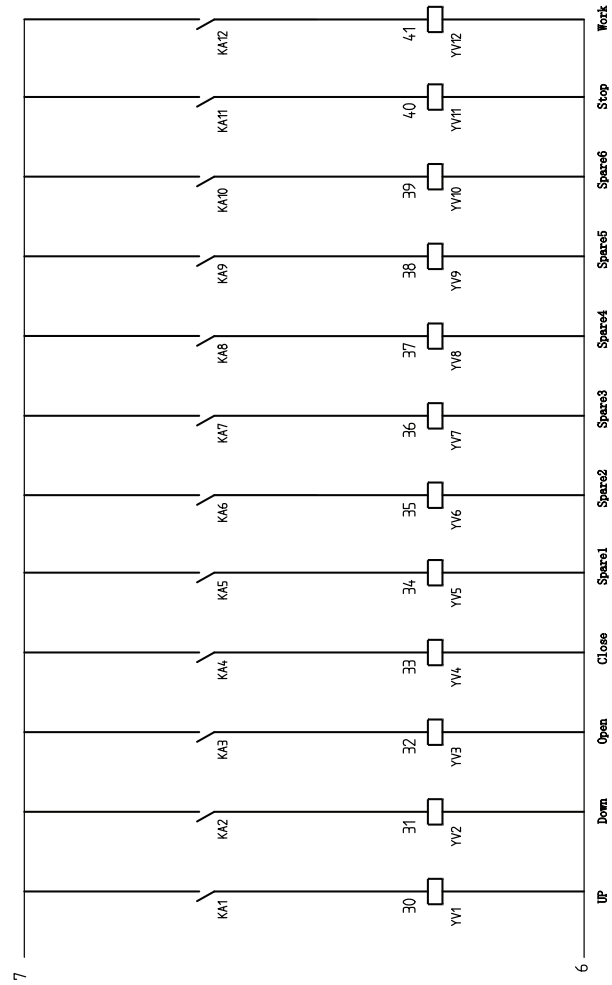
1300 998 784 STGGLOBAL.NET

21. 4500lt ELECTRIC CONTROL BOX CIRCUIT DIAGRAM 2

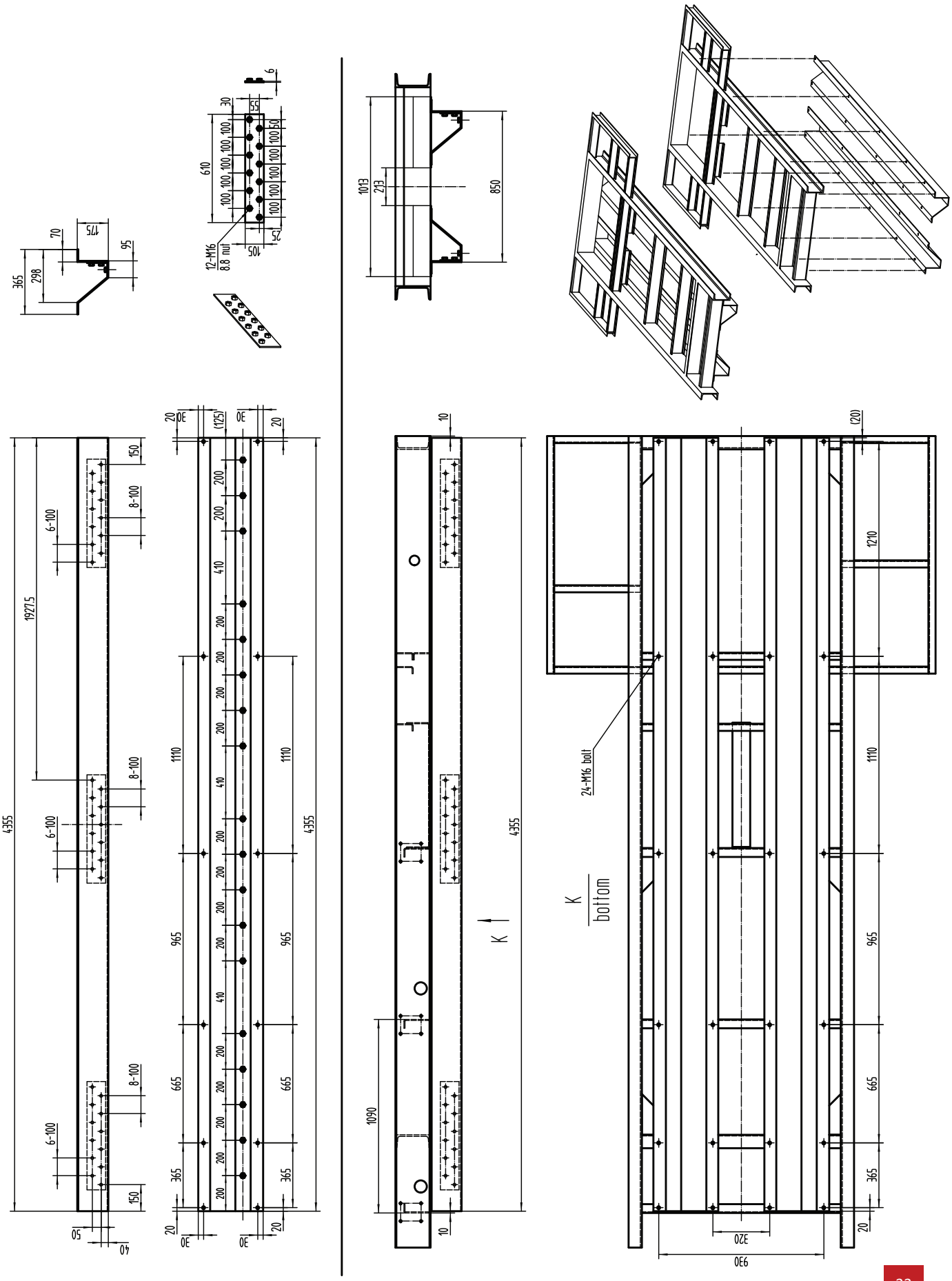


remote control line no. comection no.

		5	COM1 — 12V+
		10	COM2
		14	COM3
		18	COM4
		20	COM5
		24	COM6
		28	COM7
1	12V		
2	0V		
6	UP	10	
8	DOWN	11	
11	OPEN	12	
12	CLOSE	13	
15	SPARE1	14	
16	SPARE2	15	
19	START	WORK	21
21	1	SPARE3	16
22	2	SPARE4	17
25	3	SPARE5	18
26	4	SPARE6	19
29	F1	STOP	20



22. 4500lt VACUUM UNIT BOTTOM RAIL ASSEMBLE



OPERATORS MANUAL

Cat 2.2 Operation Manual

Section 2

STG GLOBAL

SEBU8312-03 (en-us)
February 2016

Operation and Maintenance Manual

C0.5 , C0.7, C1.1 , C1.5 , C1.6 and C2.2 Industrial Engines

C6F 1-UP (Engine)
C6H 1-UP (Engine)
C7H 1-UP (Engine)
C7J 1-UP (Engine)
C6J 1-UP (Engine)
C6K 1-UP (Engine)
G8N 1-UP (Engine)
C6L 1-UP (Engine)
C7Y 1-UP (Engine)
G7P 1-UP (Engine)
C6N 1-UP (Engine)
C8W 1-UP (Engine)
G7L 1-UP (Engine)
C6M 1-UP (Engine)
C8Y 1-UP (Engine)
C8Z 1-UP (Engine)

i06558969

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, including human factors that can affect safety. 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 verify that you are authorized to perform this work, and 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.

⚠ WARNING

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.

A non-exhaustive list of 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. You must not use this product in any manner different from that considered by this manual without first satisfying yourself that you have considered all safety rules and precautions applicable to the operation of the product in the location of use, including site-specific rules and precautions applicable to the worksite. 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 you are authorized to perform this work, and that the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.

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. Cat dealers have the most current information available.

⚠ WARNING

When replacement parts are required for this product Caterpillar recommends using Cat replacement parts.

Failure to follow this warning may lead to premature failures, product damage, personal injury or death.

In the United States, the maintenance, replacement, or repair of the emission control devices and systems may be performed by any repair establishment or individual of the owner's choosing.

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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 Cat 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 Cat dealer for the latest available information.

Safety

This 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 Cat 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 Cat dealer. Your Cat 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 Cat 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

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Safety Messages

SMCS Code: 1000; 7405

There may be several specific safety messages 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 warning signs.

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

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

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

The warning labels that may be found on the engine are illustrated.

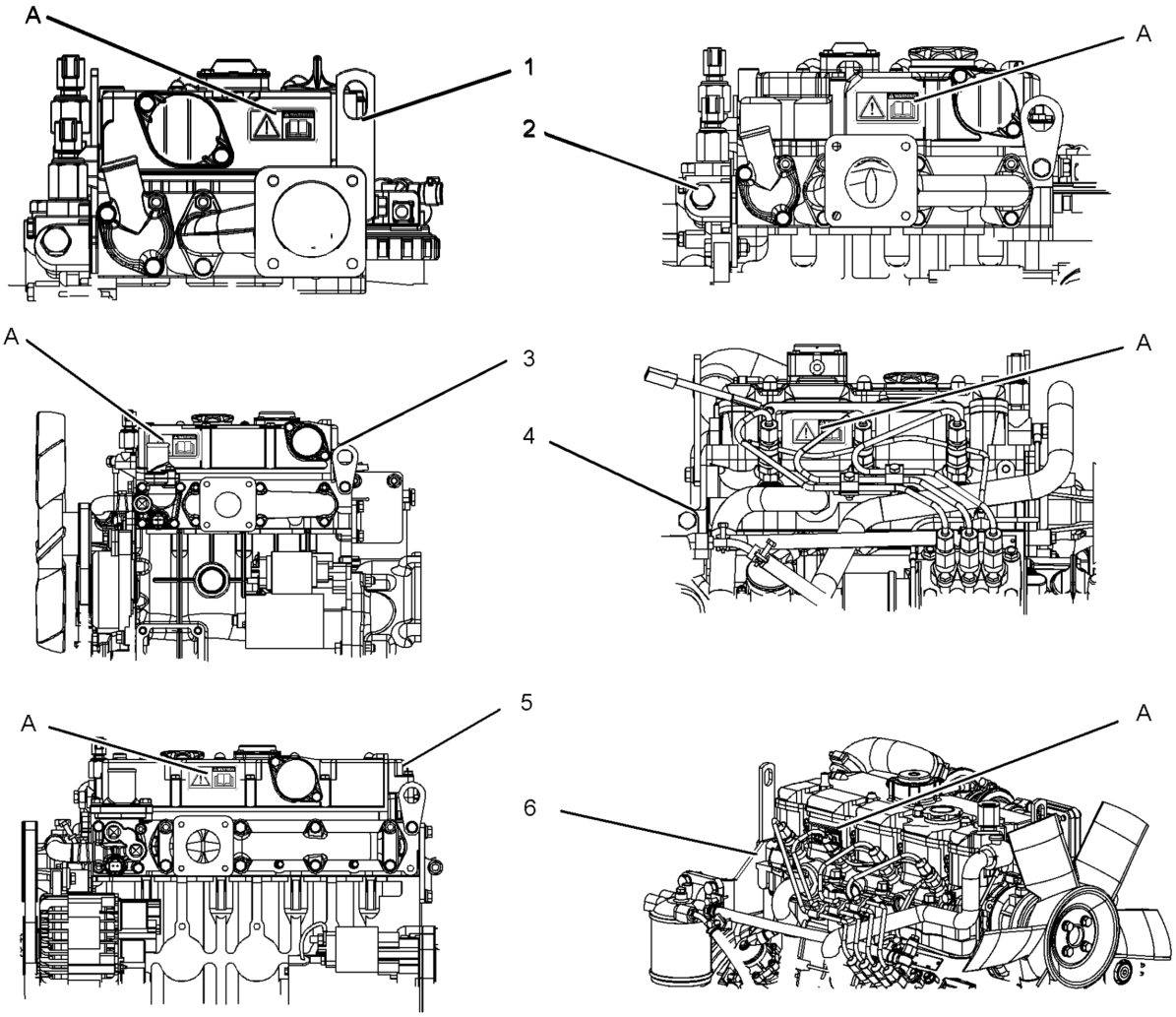

Illustration 1 g01324126

(A) Location of the warning labels
(1) C0.5
(2) C0.7
(3) C1.1
(4) C1.5
(5) C1.6
(6) C2.2

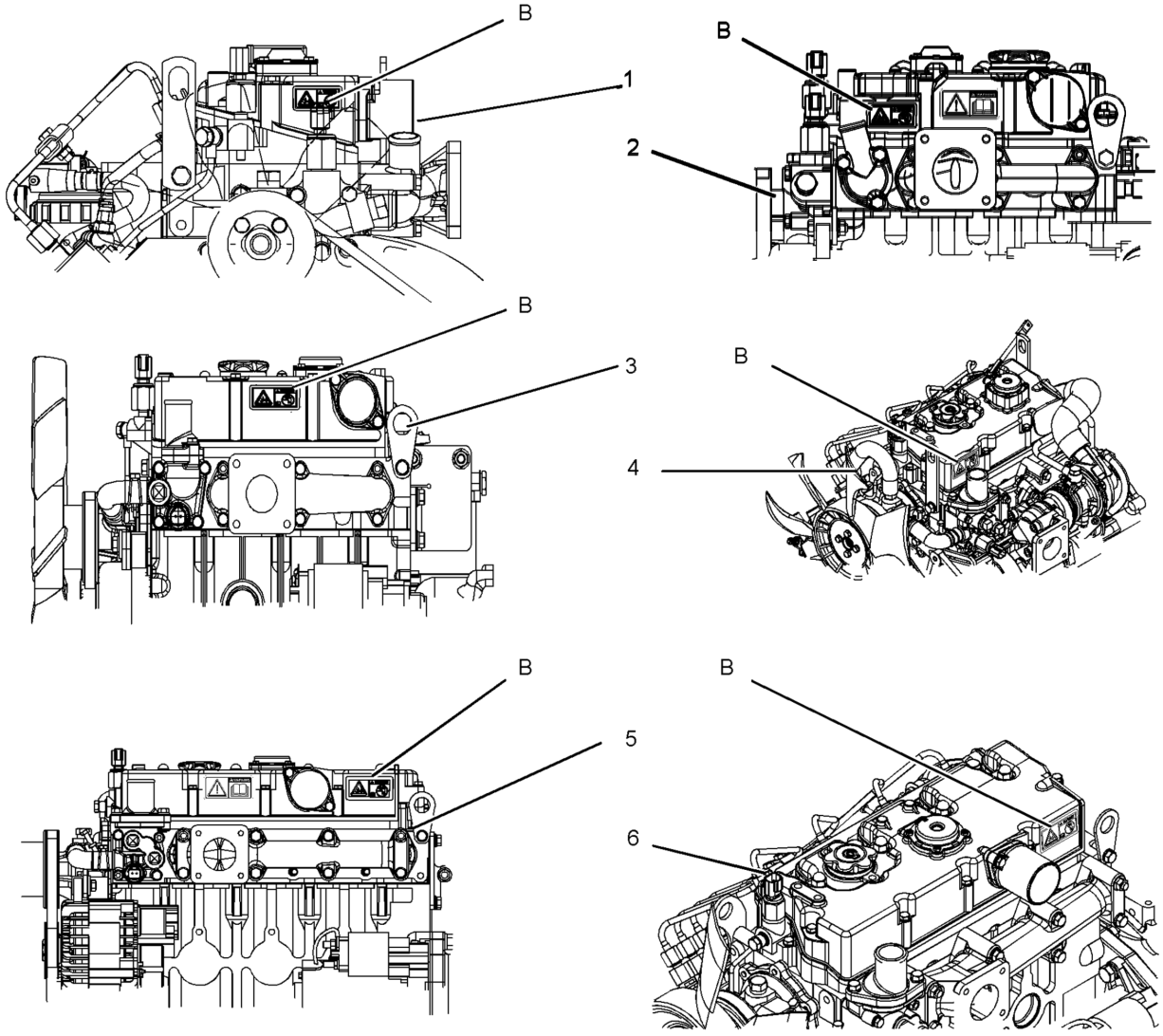

Illustration 2 g01324528

(B) Location of ether warning labels
(1) C0.5
(2) C0.7
(3) C1.1
(4) C1.5
(5) C1.6
(6) C2.2

Universal Warning (A)

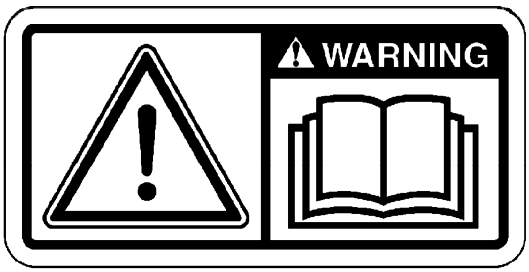

Illustration 3 g01154807

Warning label (A) is installed in different locations. The location will change according to the physical size of the engine. Refer to illustration 1 for the location of the warning labels.

WARNING

Do not operate or work on this equipment unless you have read and understand the instructions and warnings in the Operation and Maintenance Manuals. Failure to follow the instructions or heed the warnings could result in serious injury or death.

No Ether (B)

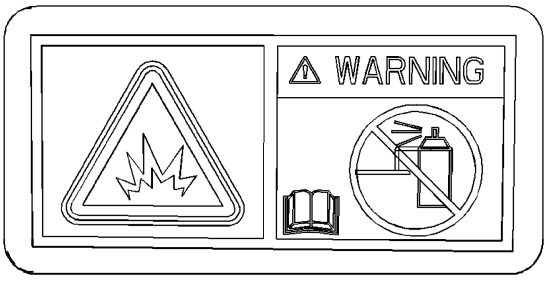

Illustration 4 g01324227

Warning label (B) is installed in different locations. The location will change according to the physical size of the engine. Refer to illustration 2 for the location of the warning labels.

WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

i06300340

General Hazard Information

SMCS Code: 1000; 7405

Illustration 5 g03838041

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

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

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.

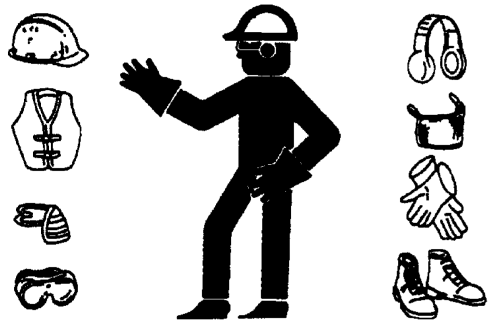

Illustration 6 g00702020

- 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.
- The protective locks or the controls are in the applied position.
- 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.
- When starting a new engine, make provisions to stop the engine if an overspeed occurs. If an engine has not been started since service has been performed, make provisions to stop the engine if an overspeed occurs. Shutting down the engine may be accomplished by shutting off the fuel supply and/or the air supply to the engine.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.
- Start the engine with the operator controls. Never short across the starting motor terminals or the batteries. This method of starting the engine could bypass the engine neutral start system and/or the electrical system could be damaged.

Pressurized Air and Water

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

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded and used with effective chip guarding (if applicable) and personal protective equipment. The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi).

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

Avoid direct spraying of water on electrical connectors, connections, and components. When using air for cleaning, allow the machine to cool to reduce the possibility of fine debris igniting when redeposited on hot surfaces.

Fluid Penetration

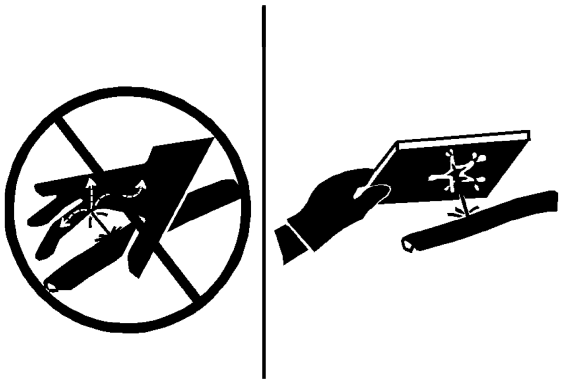

Illustration 7 g00687600

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

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, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Static Electricity Hazard when Fueling with Ultra-low Sulfur Diesel Fuel

The removal of sulfur and other compounds in ultra-low sulfur diesel fuel (ULSD fuel) decreases the conductivity of ULSD and increases the ability of ULSD to store static charge. Refineries may have treated the fuel with a static dissipating additive. Many factors can reduce the effectiveness of the additive over time. Static charges can build up in ULSD fuel while the fuel is flowing through fuel delivery systems. Static electricity discharge when combustible vapors are present could result in a fire or explosion. Ensure that the entire system used to refuel your machine (fuel supply tank, transfer pump, transfer hose, nozzle, and others) is properly grounded and bonded. Consult with your fuel or fuel system supplier to ensure that the delivery system complies with fueling standards for proper grounding and bonding.

⚠ WARNING

Avoid static electricity risk when fueling. Ultra-low sulfur diesel fuel (ULSD fuel) poses a greater static ignition hazard than earlier diesel formulations with a higher sulfur contents. Avoid death or serious injury from fire or explosion. Consult with your fuel or fuel system supplier to ensure the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

Lines, Tubes, and Hoses

Do not bend or strike high-pressure lines. Do not install lines, tubes, or hoses that are damaged.

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

Inspect all lines, tubes, and hoses carefully. Do not use bare hands to check for leaks. Always use a board or cardboard for checking engine components for leaks. 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
- Wire that is exposed in reinforced hose
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

Ensure that all of the clamps, the guards, and the heat shields are installed correctly. Correct installation of these components will help to prevent these effects: vibration, rubbing against other parts and excessive heat during operation.

Inhalation

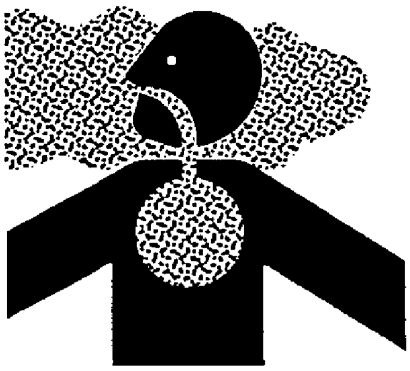

Illustration 8 g02159053

Exhaust

Use caution. Exhaust fumes can be hazardous to your health. If you operate the equipment in an enclosed area, adequate ventilation is necessary.

Asbestos Information

Cat equipment and replacement parts that are shipped from Caterpillar are asbestos free. Caterpillar recommends the use of only genuine Cat 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 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.

Softwrap

Keep the engine room ventilation operating at full capacity. Wear a particulate respirator that has been approved by the National Institute of Occupational Safety and Health (NIOSH). Wear appropriate protective clothing in order to minimize direct contact. Use good hygiene practices and wash hands thoroughly after handling Softwrap material. Do not smoke until washing hands thoroughly after handling Softwrap material. Clean up debris with a vacuum or by wet sweeping. Do not use pressurized air to clean up debris.

Reference: The applicable material safety data sheets can be found at the following web site by searching using part number or the name:

https://catmsds.cat.com/MSDSSearch/servlet/cat.cis.ecs.msdsSearch.controller.UserIdentificationDisplayServlet

Dispose of Waste Properly

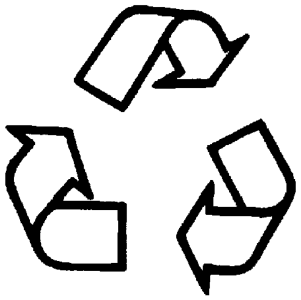

Illustration 9 g00706404

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.

i01480768

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.

i05626649

Fire Prevention and Explosion Prevention

SMCS Code: 1000; 7405

Illustration 10 g00704000

Use of personal protection equipment (PPE) may be needed.

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

Always perform a Walk-Around Inspection, which may help you identify a fire hazard. Do not operate a product when a fire hazard exists. Contact your Cat dealer for service.

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 15 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 Cat 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.

All fluids that are captured in the fluid spill containment basin should be cleaned up immediately. Failure to clean up spilled fluids can cause a fire. Fire may cause personal injury and property damage.

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 a line, a tube, 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 or tanks that contain flammable fluid. Clean any such lines or tanks thoroughly with a nonflammable solvent prior to welding or flame cutting.

Wiring must be kept in good condition. Properly route and attach all electrical wires. 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. Properly route all hoses. The lines and hoses must have adequate support and secure clamps. Tighten all connections to the recommended torque. Leaks can cause fires.

Properly install all oil filters and fuel filters. The filter housings must be tightened to the proper torque.

Illustration 11 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.

Avoid static electricity risk when fueling. Ultra Low Sulfur Diesel (ULSD) poses a greater static ignition hazard than earlier diesel formulations with a higher Sulfur content. Avoid death or serious injury from fire or explosion. Consult with your fuel or fuel system supplier to ensure that the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

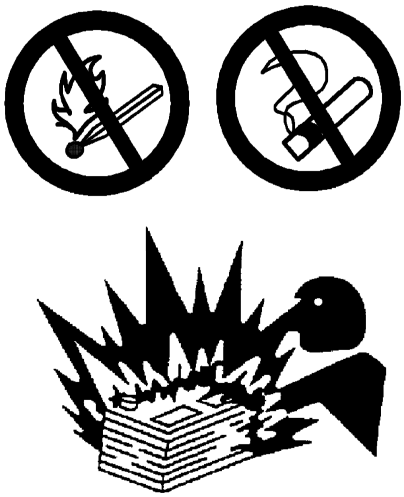

Illustration 12 g02298225

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. Charging a frozen battery may result in 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.

Ether

Ether is flammable and poisonous.

Use ether in ventilated areas. Do not smoke while you are replacing an ether cylinder or while you are using an ether spray.

Do not store ether cylinders in living areas or in the engine compartment. Do not store ether cylinders in direct sunlight or in temperatures above 49 °C (120 °F). Keep ether cylinders away from open flames or sparks.

Dispose of used ether cylinders properly. Do not puncture an ether cylinder. Keep ether cylinders away from unauthorized personnel.

Do not spray ether into an engine if the engine is equipped with a thermal starting aid for cold weather starting.

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 Cat 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 parts of the hoses are kinked.
- Outer covers have embedded armoring.
- End fittings are displaced.

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

i01359666

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.

i01372247

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.

i03560601

Before Starting Engine

SMCS Code: 1000

NOTICE
For initial start-up of a new or rebuilt engine, and for start-up of an engine that has been serviced, make provision to shut the engine off should an overspeed occur. This may be accomplished by shutting off the air and/or fuel supply to the engine.

⚠ 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.

Inspect the engine for potential hazards.

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.

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

If equipped, ensure that the lighting system for the engine is suitable for the conditions. Ensure that all lights work properly, if equipped.

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.

See the Service Manual for repairs and for adjustments.

i01185283

Engine Starting

SMCS Code: 1000

⚠ WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

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.

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.

i01032808

Engine Stopping

SMCS Code: 1000

To avoid overheating of the engine and accelerated wear of the engine components, stop the engine according to this Operation and Maintenance Manual, “Engine Stopping” topic (Operation Section).

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 serviced, make provisions to stop the engine if an overspeed condition occurs. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.

i02613441

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 this Operation and Maintenance Manual for specific starting instructions.

Grounding Practices

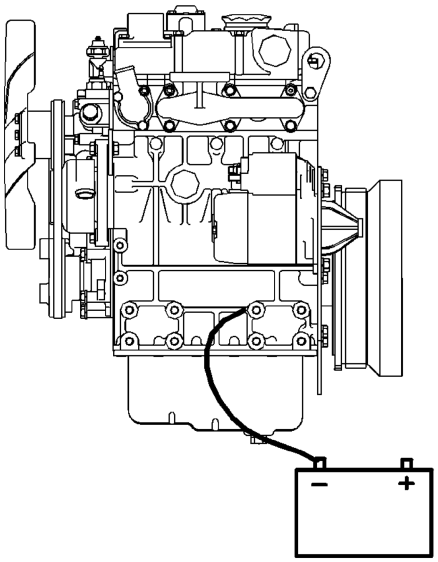

Illustration 13 g01308335

Typical example

Ground to battery

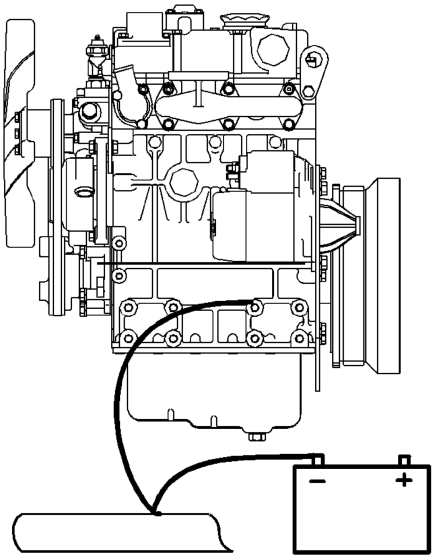

Illustration 14 g01308337

Typical example

Alternate Ground to frame

Correct grounding for the engine electrical system is necessary for optimum engine performance and reliability. Incorrect 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 correctly, 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, or a starting motor 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

i02613456

Model View Illustrations

SMCS Code: 1000

The following model views show typical features of the C0.5, C0.7, C1.1, C1.5, C1.6 and C2.2 Engines. Due to individual applications, your engine may appear different from the illustrations.

Note: Individual components are detailed on the C2.2 turbocharged engine only.

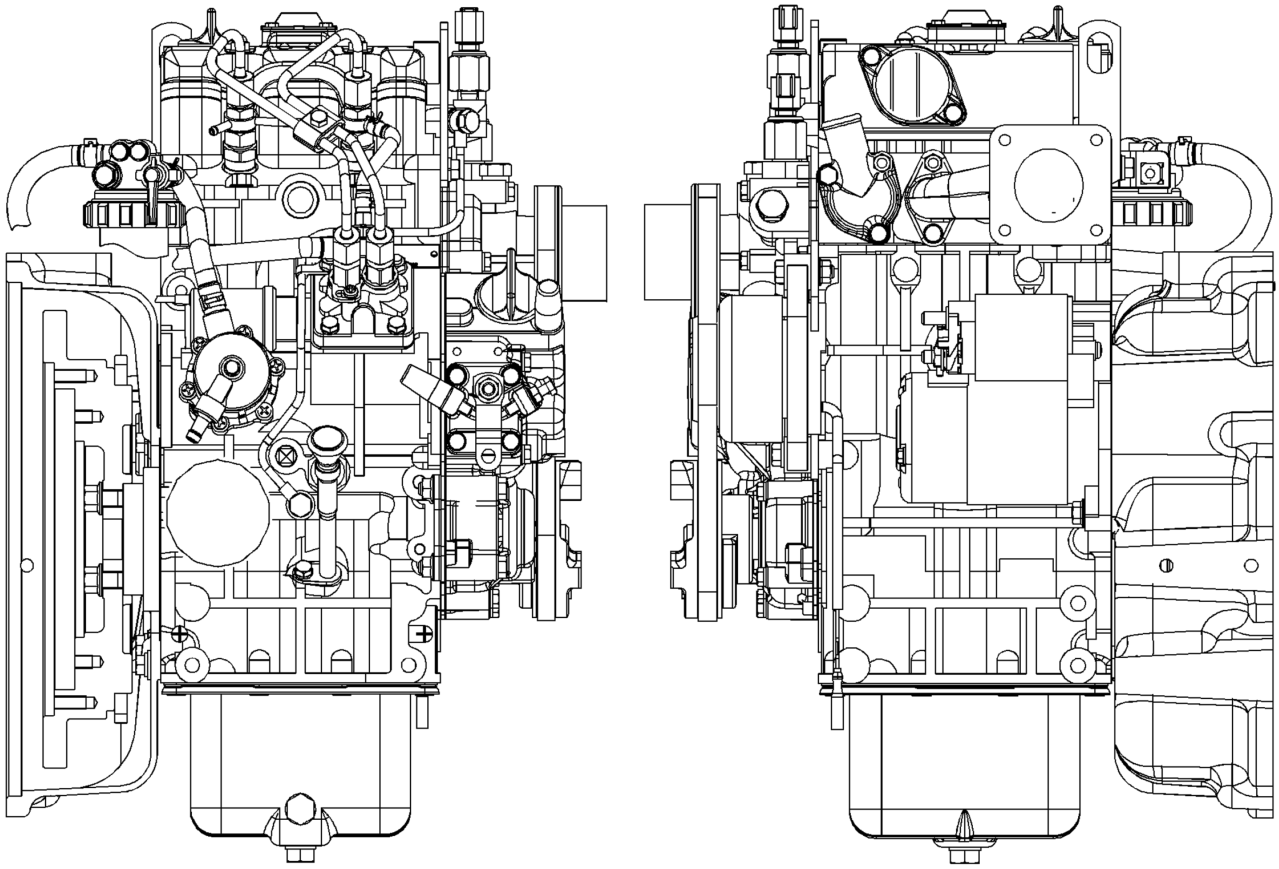

Illustration 15 g01299985

Typical view of the C0.5 Engine

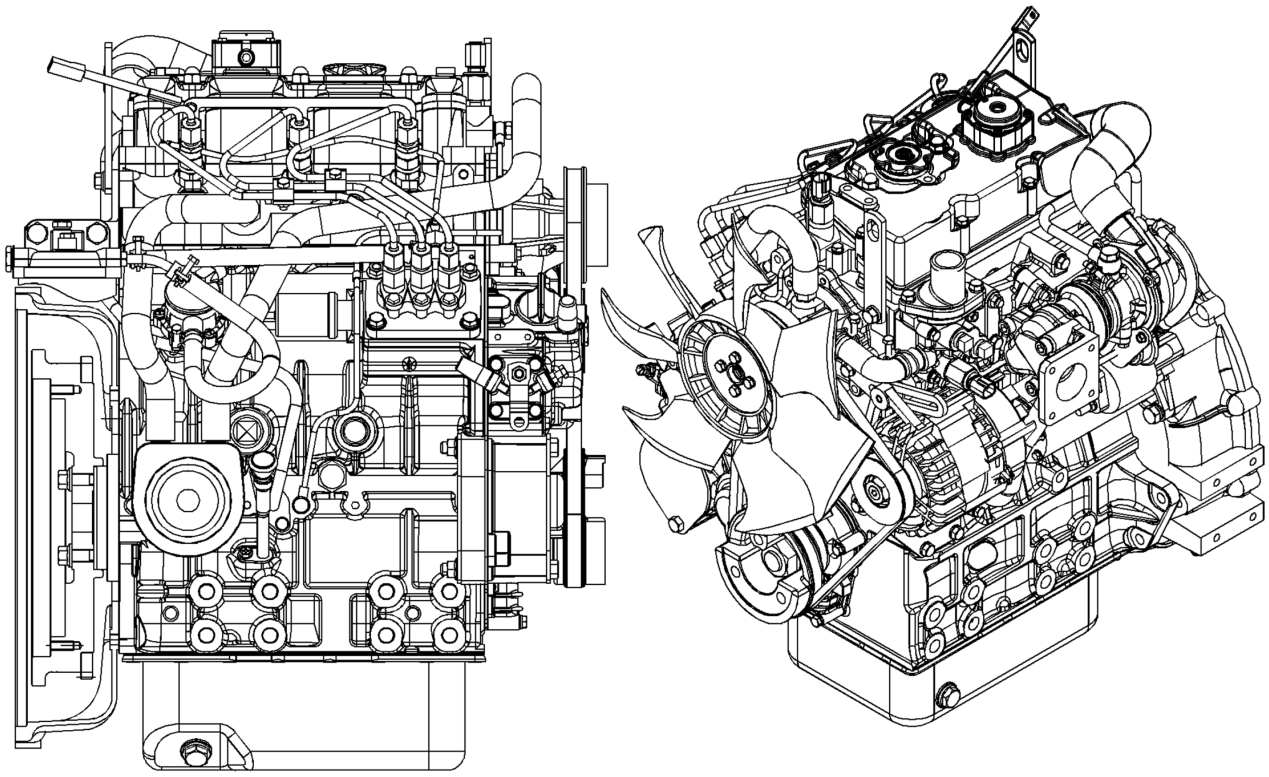

Illustration 16 g01300431

Typical view of the C1.5 turbocharged engine

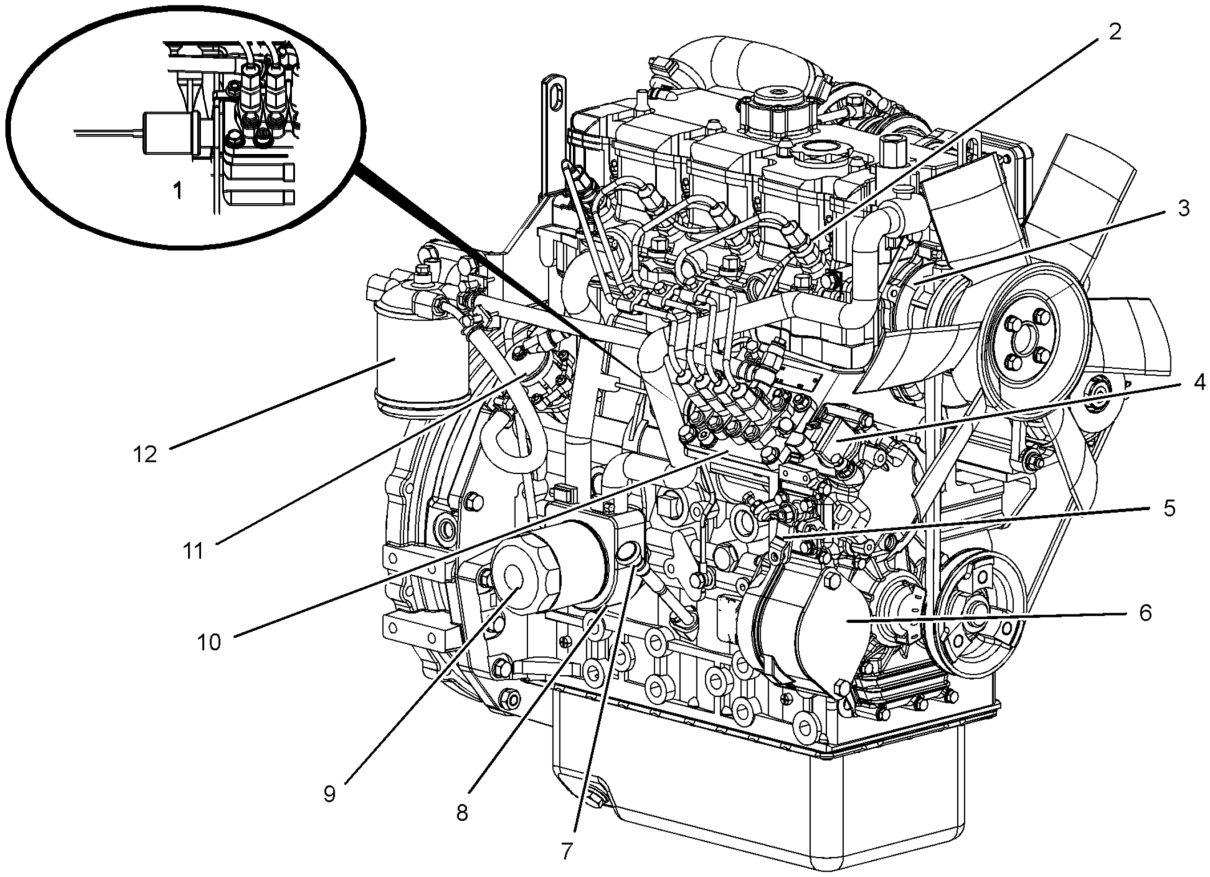

Illustration 17 g01304893

Right side view of the C2.2 turbocharged engine

(1) Fuel shutoff solenoid
(2) Number one fuel injector
(3) Water pump
(4) Lower engine oil filler cap
(5) Throttle lever
(6) Cover plate for the accessory drive
(7) Engine oil level gauge
(8) Engine oil cooler
(9) Engine oil filter
(10) Fuel injection pump
(11) Transfer pump
(12) Fuel filter

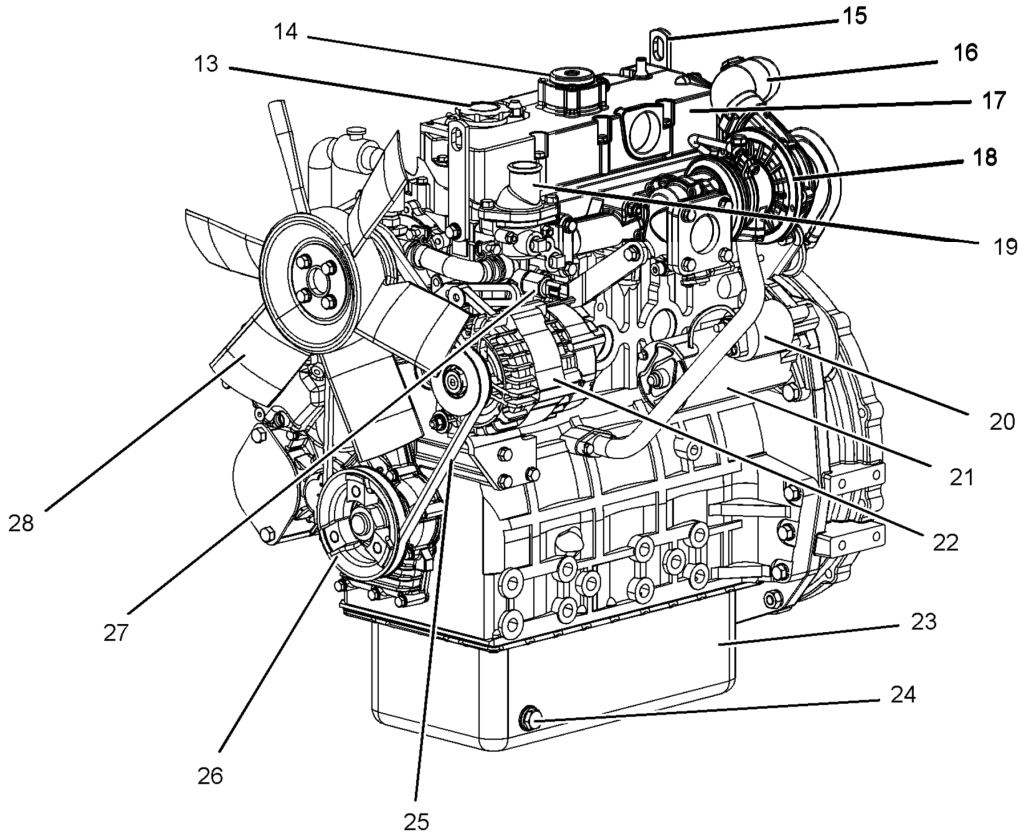

Illustration 18 g01305224

Left side view of the C2.2 Engine

(13) Top engine oil filler cap
(14) Crankcase breather
(15) Rear Lifting eye
(16) Air inlet elbow
(17) Valve mechanism cover
(18) Turbocharger
(19) Water temperature regulator housing
(20) Starting motor solenoid
(21) Electric starting motor
(22) Alternator
(23) Engine oil pan
(24) Engine oil drain plug
(25) Fan drive belt
(26) Crankshaft pulley
(27) Coolant temperature switch
(28) Cooling fan

i02613886

Engine Description

SMCS Code: 1000

The C0.5, C0.7, C1.1, C1.5, C1.6 and C2.2 engines are direct injection engines. The engines are controlled with a mechanically actuated fuel injection pump. The engine cylinders are arranged in-line.

The cylinder head assembly has one inlet valve and one exhaust valve for each cylinder. Each cylinder valve has a single valve spring.

The pistons have two compression rings and an oil control ring. It is important to ensure the correct piston height so that the piston does not contact the cylinder head. The correct piston height also ensures efficient combustion of fuel that is necessary in order to conform to requirements for emissions.

The crankshaft for a two cylinder engine has two main bearing journals. The crankshaft for a three cylinder engine has four main bearing journals. The crankshaft for a four cylinder engine has five main bearing journals. End play is controlled by the thrust washers that are located on the rear main bearing.

The timing gears are stamped with timing marks in order to ensure the correct assembly of the gears. When the No. 1 piston is at top center compression stroke, the teeth that are stamped on the crankshaft gear and the camshaft gear will be in alignment with the idler gear.

The crankshaft gear turns the idler gear which then turns the camshaft gear and the gear for the engine oil pump.

The fuel injection pump is mounted in the cylinder block. The fuel injection pump is operated by lobes on the camshaft. The fuel transfer pump is located on the right hand side of the cylinder block. The fuel transfer pump is also operated by lobes on the camshaft.

The fuel injection pump conforms to requirements for emissions. If any adjustments to the fuel injection pump timing and high idle are required you must refer to your Caterpillar dealer. Some fuel injection pumps have mechanical governors that control the engine rpm. Some fuel injection pumps have a governor that is electrically controlled.

A gerotor oil pump is located in the center of the idler gear. The engine oil pump sends lubricating oil to the main oil gallery through a pressure relief valve and an engine oil filter. The rocker arms receive pressurized oil through an externally located oil line that runs from the main oil gallery to the cylinder head.

Coolant from the bottom of the radiator passes through the belt driven centrifugal water pump. The coolant is cooled by the radiator and the temperature is regulated by a water temperature regulator.

Engine efficiency, efficiency of emission controls, and engine performance depend on adherence to proper operation and maintenance recommendations. Engine performance and efficiency also depend on the use of recommended fuels, lubrication oils, and coolants. Refer to this Operation and Maintenance Manual, “Maintenance Interval Schedule” for more information on maintenance items.

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 No. 1 cylinder is the front cylinder.

C0.5 Engine

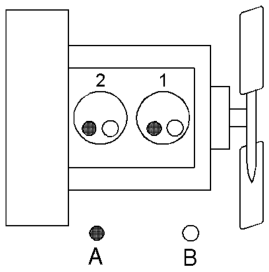

Illustration 19 g01108476

(A) Exhaust valves
(B) Inlet valves

Table 1

C0.5 Engine Specifications	
Maximum Operating Speed (rpm)	3600 rpm
Cylinders and Arrangement	In-Line two cylinder
Bore	67 mm (2.64 inch)
Stroke	72 mm (2.83 inch)
Displacement	0.507 L (30.9390 in^3)
Aspiration	NA(1)
Compression Ratio	23.5:1
Firing Order	1-2
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)
Injection	Indirect

(1) Naturally Aspirated

C0.7 Engine

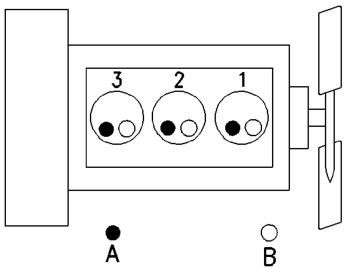

Illustration 20 g00852304

(A) Exhaust valves
(B) Inlet valves

Table 2

C0.7 Engine Specifications	
Maximum Operating Speed (rpm)	3600 rpm
Cylinders and Arrangement	In-Line three cylinder
Bore	67 mm (2.64 inch)
Stroke	72 mm (2.83 inch)
Displacement	0.762 L (46.5001 in^3)
Aspiration	NA(1)
Compression Ratio	23.5:1
Firing Order	1-2-3
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)
Injection	Indirect

(1) Naturally Aspirated

C1.1 Engine

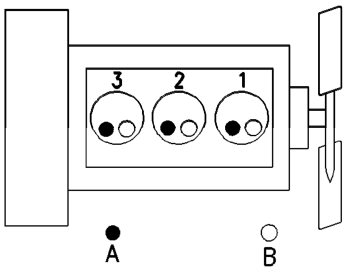

Illustration 21 g00852304

(A) Exhaust valves
(B) Inlet valves

Table 3

C1.1 Engine Specifications	
Maximum Operating Speed (rpm)	3600 rpm
Cylinders and Arrangement	In-Line three cylinder
Bore	77 mm (3.03 inch)
Stroke	81 mm (3.19 inch)
Displacement	1.131 L (69.0178 in^3)
Aspiration	NA(1)
Compression Ratio	23:1
Firing Order	1-2-3
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)
Injection	Indirect

(1) Naturally Aspirated

C1.5 Engine

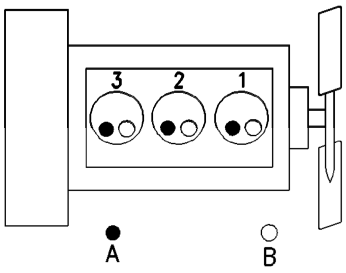

Illustration 22 g00852304

(A) Exhaust valves
(B) Inlet valves

Table 4

C1.5 Engine Specifications	
Maximum Operating Speed (rpm)	3000 rpm
Cylinders and Arrangement	In-Line three cylinder
Bore	84 mm (3.31 inch)
Stroke	90 mm (3.54 inch)
Displacement	1.496 L (91.2915 in^3)
Aspiration	NA(1)
Compression Ratio	22.5:1
Firing Order	1-2-3
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)
Injection	Indirect

(1) Naturally Aspirated

C1.5 Turbocharged Engine

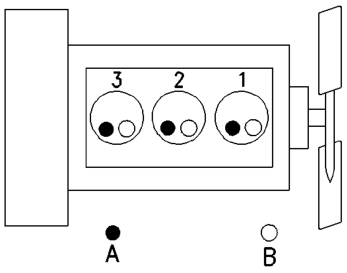

Illustration 23 g00852304

(A) Exhaust valves
(B) Inlet valves

Table 5

C1.5 Turbocharged Engine Specifications	
Maximum Operating Speed (rpm)	3000 rpm
Cylinders and Arrangement	In-Line three cylinder
Bore	84 mm (3.31 inch)
Stroke	90 mm (3.54 inch)
Displacement	1.496 L (91.2915 in^3)
Aspiration	T(1)
Compression Ratio	22.5:1
Firing Order	1-2-3
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)
Injection	Indirect

(1) Turbocharged

C1.6 Engine

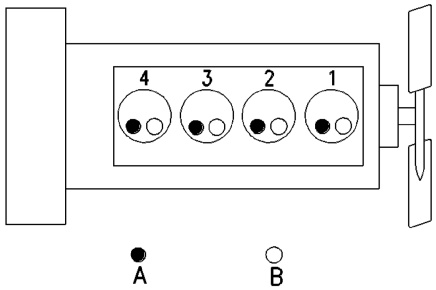

Illustration 24 g00296424

(A) Exhaust valves
(B) Inlet valves

Table 6

C1.6 Engine Specifications	
Maximum Operating Speed (rpm)	3000 rpm
Cylinders and Arrangement	In-Line four cylinder
Bore	77 mm (3.03 inch)
Stroke	81 mm (3.19 inch)
Displacement	1.508 L (92.0238 in^3)
Aspiration	NA(1)
Compression Ratio	23.5:1
Firing Order	1-3-4-2
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)
Injection	Indirect

(1) Naturally Aspirated

C2.2 Engine

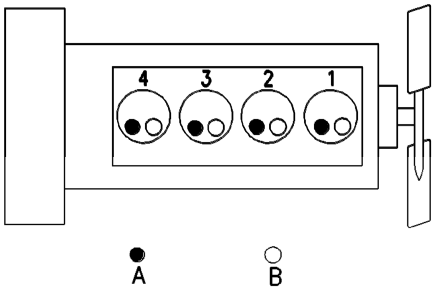

Illustration 25 g00296424

(A) Exhaust valves
(B) Inlet valves

Table 7

C2.2 Engine Specifications	
Maximum Operating Speed (rpm)	3000 rpm
Cylinders and Arrangement	In-Line four cylinder
Bore	84.0 mm (3.31 inch)
Stroke	100.0 mm (3.94 inch)
Displacement	2.216 cc (0.1352 in^3)
Aspiration	NA(1)
Compression Ratio	23.3:1
Firing Order	1-3-4-2
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)
Injection	Indirect

(1) Naturally Aspirated

C2.2 Turbocharged Engine

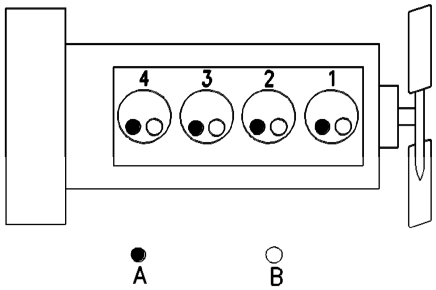

Illustration 26 g00296424

(A) Exhaust valves
(B) Inlet valves

Table 8

C2.2 Turbocharged Engine Specifications	
Maximum Operating Speed (rpm)	3000 rpm
Cylinders and Arrangement	In-Line four cylinder
Bore	84.0 mm (3.31 inch)
Stroke	100.0 mm (3.94 inch)
Displacement	2.216 cc (0.1352 in^3)
Aspiration	T(1)
Compression Ratio	23.5:1
Firing Order	1-3-4-2
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)
Injection	Indirect

(1) Turbocharged

C2.2 Turbocharged Aftercooled Engine

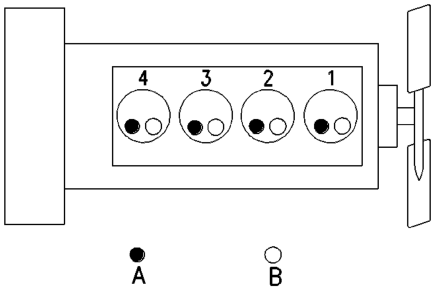

Illustration 27 g00296424

(A) Exhaust valves
(B) Inlet valves

Table 9

C2.2 Turbocharged Aftercooled Engine Specifications	
Maximum Operating Speed (rpm)	2800 rpm
Cylinders and Arrangement	In-Line four cylinder
Bore	84.0 mm (3.31 inch)
Stroke	100.0 mm (3.94 inch)
Displacement	2.216 cc (0.1352 in^3)
Aspiration	TA(1)
Compression Ratio	23.5:1
Firing Order	1-3-4-2
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)
Injection	Indirect

(1) Turbocharged aftercooled

Product Identification Information

i02656316

Plate Locations and Film Locations

SMCS Code: 1000

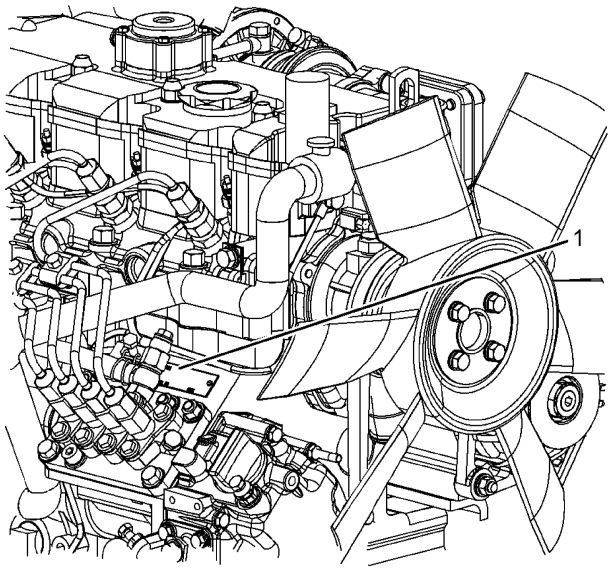

Illustration 28 g01334490

Typical example

Caterpillar engines are identified by serial numbers and by arrangement numbers. These numbers are shown on the engine serial number plate. 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.

Serial Number Plate (1)

The engine serial number plate is located on the upper right side of the engine block above the fuel injection pump for all engine models in the series.

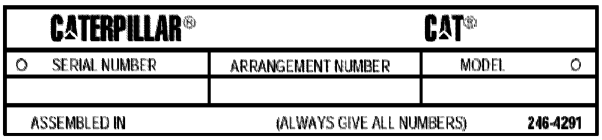

Illustration 29 g01131696

Serial number plate

i00610276

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. _____

i06602168

Emissions Certification Film

SMCS Code: 1000; 7405

Note: This information is pertinent in the United States and in Canada.

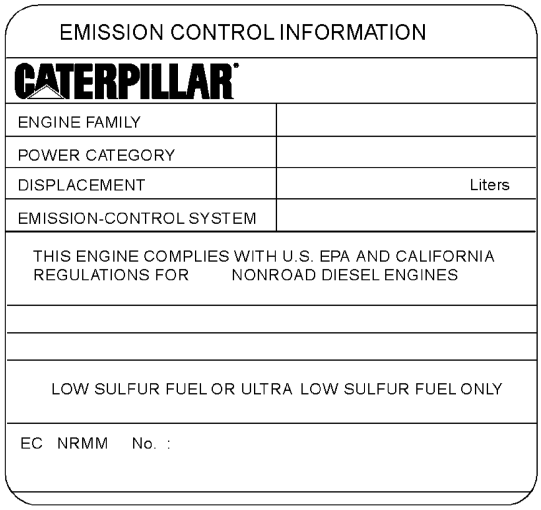

Illustration 30 g01527177

Typical example

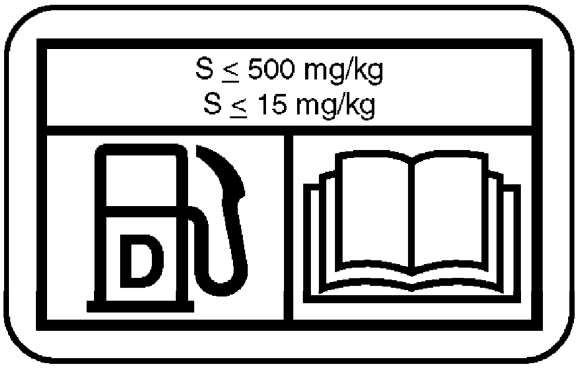

Illustration 31 g06038952

Typical example

Refer to illustration 31 . The equipment manufacturer must install the label to the equipment. This procedure is recommended by Caterpillar. The label must be attached to the equipment near the fuel inlet to comply with the EPA regulations. The equipment manufacturer may install another fuel label.

Operation Section

Lifting and Storage

i04342729

Product Lifting

SMCS Code: 1000; 1404; 7002

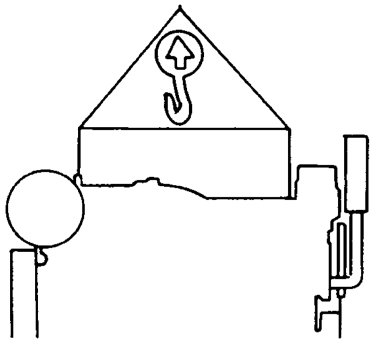

Illustration 32 g00103219

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 Cat dealer for information regarding fixtures for proper engine lifting.

i05111635

Product Storage

SMCS Code: 1000; 1404; 7002

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, “Refill Capacities and Recommendations” (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 1 month, a complete protection procedure is recommended.

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

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

Gauges and Indicators

i01139916

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. If maximum coolant temperature is exceeded, STOP the engine. Engine damage can result.

Engine Oil Pressure – The oil pressure should be greatest after a cold engine is started. The typical engine oil pressure with SAE10W30 is 207 to 413 kPa (30 to 60 psi) at rated rpm.

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 71 to 96°C (160 to 205°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. Reduce the load and the engine rpm.

2. Inspect the cooling system for leaks.

3. 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 speed (rpm). 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 electrically operated fuel level gauge only registers when the “START/STOP” switch is “ON” .

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

Features and Controls

i01007515

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.

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

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.

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

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.

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

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

i02613889

Fuel Shutoff

SMCS Code: 1259; 1704

The fuel shutoff solenoid is located on the fuel injection pump. When the fuel shutoff solenoid is activated, the solenoid moves the fuel rack to the “OFF” position.

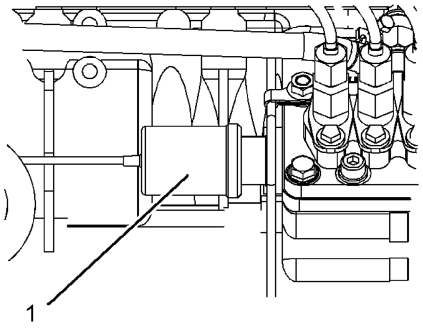

Illustration 33 g01305771
Typical example
(1) Fuel shutoff solenoid

If an electronically controlled governor has been installed the governor operates the fuel rack in order to stop the engine.

Engine Starting

i01486758

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 filter 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.

i06602184

Starting the Engine

SMCS Code: 1000; 1450

⚠ WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

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

1. Move the throttle lever to the low idle position before you start the engine.

Note: If necessary, increase the throttle position so that the engine will start in cold conditions. The engine speed should not exceed 1500 rev/min until the oil pressure has increased.

NOTICE
Do not operate the glow plugs for more than 60 seconds at one time. Damage to the glow plugs could occur.

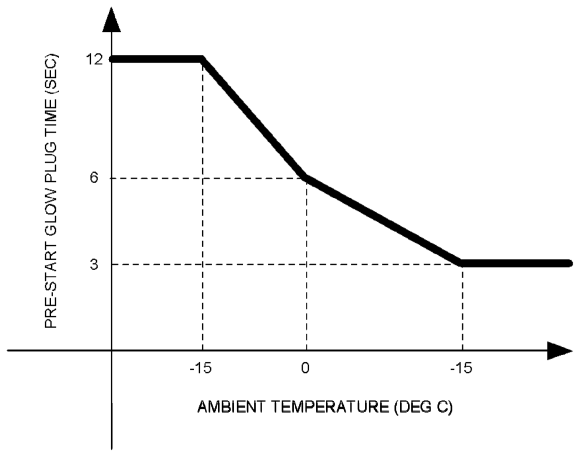

Illustration 34 g06038854

2. Turn the engine start switch to the HEAT position. Hold the engine start switch in the HEAT position for time shown in illustration 34 . This action will activate the glow plugs and aid in the starting of the engine.

NOTICE
Do not crank the engine for more than 30 seconds. Allow the electric starting motor to cool for two minutes before cranking the engine again.

3. When the glow plug indicator light is illuminated, turn the engine start switch to the START position and crank the engine.
4. When the engine starts, release the engine start switch.
5. Slowly move the throttle lever to the low idle position and allow the engine to idle. Refer to the Operation and Maintenance Manual, “After Starting Engine” topic.

Note: If the glow plug indicator light flashes for 2 to 3 seconds or fails to illuminate, a malfunction exists in the cold start system. Do not use ether or other starting fluids to start the engine.

6. If the engine does not start, release the engine start switch and allow the electric starting motor to cool. Then, repeat steps 2 through step 5.
7. Turn the engine start switch to the OFF position to stop the engine.

i05287569

Cold Weather Starting

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

⚠ WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

Startability will be improved at temperatures below −18 °C (0 °F) from the use of a jacket water 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: engine oil pan heaters, jacket water heaters, fuel heaters and fuel line insulation.

Use the procedure that follows for cold weather starting.

1. The governor control needs to be in the LOW IDLE position if the temperature is below 0 °C (32 °F).

NOTICE
Do not operate the glow plugs for more than 60 seconds at one time. Damage to the glow plugs could occur.

2. Turn the keyswitch to the HEAT position until the glow plug indicator lamp illuminates.

NOTICE
Do not crank the engine for more than 30 seconds. Allow the electric starting motor to cool for two minutes before cranking the engine again.

3. Turn the keyswitch to the START position.
4. When the engine starts, release the keyswitch.
5. If the engine does not start, release the keyswitch and allow the starter motor to cool. Then, repeat steps 2 through step 4.

6. Allow the engine to idle for 3 to 5 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.
7. Operate the engine at low load until all systems reach operating temperature. Check the gauges during the warm-up period.

i02242604

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.

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 generator set 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.

i01646248

After Starting Engine

SMCS Code: 1000

Note: In temperatures from 0 to 60°C (32 to 140°F), the warm-up time is approximately three 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

i06545704

Engine Operation

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.

Engines rated for constant speed use are allowed to complete a starting sequence, an operation at a single constant speed, and a shutdown sequence. Every time the engine is run, each of these operations should occur only once. The starting sequence and shutdown sequence can include a short period of operation at the low idle speed for purposes of warming up and cooling down the engine or driven equipment. The emissions type approval is not valid for operation of a constant speed engine in a manner different from that described above.

i00613522

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°C (0°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°C (140°F).

i01646335

Engaging the Driven Equipment

SMCS Code: 1000

1. Operate the engine at one-half of the rated rpm, when possible.

2. Engage the driven equipment without a load on the equipment, when possible.

   Interrupted starts put excessive stress on the drive train. Interrupted starts also waste fuel. To get the driven equipment in motion, engage the clutch smoothly with no load on the equipment. This method should produce a start that is smooth and easy. The engine rpm should not increase and the clutch should not slip.

3. Ensure that the ranges of the gauges are normal when the engine is operating at one-half of the rated rpm. Ensure that all gauges operate properly.

4. Increase the engine rpm to the rated rpm. Always increase the engine rpm to the rated rpm before the load is applied.

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

   Extended operation at low idle or at 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.

i01432412

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.
- Maintain a good electrical system.

One bad 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 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

i01433818

Stopping the Engine

SMCS Code: 1000; 7000

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. Reduce the engine rpm to low idle.
2. Remove the load from the engine.
3. If the engine has been operated at low loads, run the engine at low idle for 30 seconds before you stop the engine.
4. If the engine has been operated at high load, increase engine rpm to no more than 1/2 rated rpm for three to five minutes.

   This reduces coolant temperatures and oil temperatures. A reduction in these temperatures stabilizes internal engine coolant and oil temperatures.
5. Reduce the engine rpm to low idle before stopping the engine.
6. After the cool down period, turn the start switch to the OFF position.

i01171573

Emergency Stopping

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

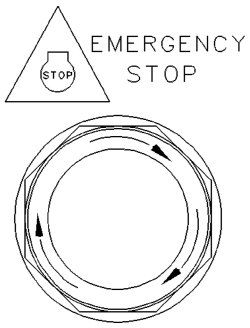

Illustration 35 g00104303
Typical emergency stop button

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.

NOTICE
Stopping the engine immediately after it has been working under load can result in overheating and accelerated wear of the engine components.

If the engine has been operating at high rpm and/or high loads, run the engine at low idle for at least three minutes to reduce and stabilize the internal engine temperature before stopping the engine.

i02242518

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 that are recommended in this Operation and Maintenance Manual, “Refill Capacities and Recommendations”.

- 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

i01457051

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^2 (120 in^2).

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.

i05264084

Fuel and the Effect from Cold Weather

SMCS Code: 1000; 1250

The following fuels are the grades that are available for Cat 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 of the area. 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 Special Publication, SEBU5898, “Cold Weather Recommendations”.

i01250450

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 you operate 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 and 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

It is possible that a primary fuel filter is installed between the fuel tank and the engine fuel inlet. After you change the fuel filter, always prime the fuel system in order to remove air bubbles from the fuel system. Refer to the Operation and Maintenance Manual in the Maintenance Section for more information on priming the fuel system.

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

NOTICE
In order to maximize fuel system life and prevent premature wear out from abrasive particles in the fuel, a two micron absolute high efficiency fuel filter is required for all Caterpillar Electronic Unit Injectors. Caterpillar High Efficiency Fuel Filters meet these requirements. Consult your Caterpillar dealer for the proper part numbers.

Fuel Heaters

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

The following fuel heaters are recommended for Caterpillar engines:

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

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

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.

Maintenance Section

Refill Capacities

i04040209

Refill Capacities and Recommendations

SMCS Code: 1348; 1395; 7560

Engine Oil

NOTICE
These recommendations are subject to change without notice. Contact your local Caterpillar dealer for the most up-to-date recommendations.

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.

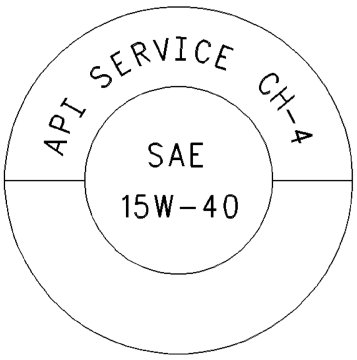

Illustration 36 g00546535
Typical API symbol

Diesel engine oils CC, CD, CD-2, and CE have not been API authorized classifications since January 1, 1996. Table 10 summarizes the status of the classifications.

Table 10

API Classifications	
Current	**Obsolete**
CI-4(1). CH-4(1) . CG-4(2). CF-4(3)	CE

(continued)

(Table 10, contd)

CF(4)	CC, CD
CF-2(5)	CD-2(5)

(1) **API CH-4 and CI-4 oils are acceptable if the requirements of Caterpillar's ECF-1 (Engine Crankcase Fluid specification-1) are met. CH-4 and CI-4 oils that have not met the requirements of Caterpillar's ECF-1 Specification may cause reduced engine life.**
(2) API CG-4 oils are acceptable for all Caterpillar diesel engines. When the API CG-4 oils are used, the oil drain interval should not exceed the standard oil drain interval for your engine.
(3) API CF-4 oils are not recommended for this series of Caterpillar diesel engines. For all other commercial diesel engines, the oil drain interval should not exceed 50 percent of the standard oil drain interval for your engine with a maximum of 125 hours.
(4) API CF oils are not recommended for this series of Caterpillar engines and smaller Direct Injection (DI) diesel engines.
(5) API CF-2 and CD-2 oils are classifications for two-cycle diesel engines. Caterpillar does not sell engines that utilize the CD-2 and the API CF-2 oils.

Note: When oil meets more than one API classification, the applicable footnote is determined by the highest API classification that is met.

Example – An oil meets both the API CH-4 and the API CF oil classifications. In this case, the API CH-4 applies.

Cat DEO (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:

- **Cat DEO (Diesel Engine Oil) (10W-30)**
- **Cat DEO (Diesel Engine Oil) (15W-40)**

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

Caterpillar multigrade DEO is available in various viscosity grades that include SAE 10W-30 and SAE 15W-40. To choose the correct viscosity grade for the ambient temperature, see Table 11 . 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 DEO can be used in other diesel engines and in gasoline engines. See the engine manufacturers guide for the recommended specifications. Compare the specifications to the specifications of Caterpillar multigrade DEO. The current industry standards for Caterpillar DEO 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.

Note: Caterpillar SAE 15W-40 multigrade DEO exceeds the performance requirements for the following API classifications: CI-4, CH-4, CG-4, CF-4 and CF. The Caterpillar multigrade DEO exceeds the requirements of the Caterpillar specification that is ECF-1 (Engine Crankcase Fluid-1). The Caterpillar SAE 15W-40 multigrade DEO passes the following proprietary tests: sticking of the piston ring, oil control tests, wear tests and soot tests. Proprietary tests help ensure that Caterpillar multigrade oil provides superior performance in Caterpillar Diesel Engines. In addition, Caterpillar multigrade oil exceeds many of the performance requirements of other manufacturers of diesel engines. Therefore, this oil is an excellent choice for many mixed fleets. **True high performance oil is produced with a combination of the following factors: industry standard tests, proprietary tests, field tests and prior experience with similar formulations. The design and the development of Caterpillar lubricants that are both high performance and high quality are based on these factors.**

Note: Non-Caterpillar commercial oils are second choice oils.

Commercial Oils

Note: If Caterpillar Multigrade DEO is not used, use only commercial oils that meet the following classifications.

- API CH-4 multigrade oils and API CI-4 multigrade oils are acceptable if the requirements of Caterpillar's ECF-1 (Engine Crankcase Fluid specification-1) are met. CH-4 oils and CI-4 oils that have not met the requirements of Caterpillar's ECF-1 Specification may cause reduced engine life.
- API CG-4 multigrade oils are acceptable for all Caterpillar diesel engines. When the API CG-4 oils are used, the oil drain interval should not exceed the standard oil drain interval for your engine.
- API CF-4 multigrade oils are not recommended for this series of diesel engines. For all other smaller commercial diesel engines, the oil drain interval should not exceed 50 percent of the standard oil drain interval for your engine.

NOTICE
In selecting oil for any engine application, both the oil viscosity and oil performance classification/specification as specified by the engine manufacturer must be defined and satisfied. Using only one of these parameters will not sufficiently define oil for an engine application.

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

API CI-4 – API CI-4 oils were developed in order to meet the requirements of high performance diesel engines that use cooled Exhaust Gas Recirculation (EGR). API CI-4 oils are acceptable if the requirements of Caterpillar's ECF-1 (Engine Crankcase Fluid specification-1) are met.

API CH-4 – API CH-4 oils were developed in order to protect low emissions diesel engines that use a 0.05 percent level of fuel sulfur. However, API CH-4 oils may be used with higher sulfur fuels. API CH-4 oils are acceptable if the requirements of Caterpillar's ECF-1 (Engine Crankcase Fluid specification-1) are met.

Note: CH-4 oils and CI-4 oils that have not met the requirements of Caterpillar's ECF-1 Specification may cause reduced engine life.

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

Note: Refer to Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations” for additional information that relates to lubrication for your engine.

Lubricant Viscosity Recommendations

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

Refer to Table 11 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

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

If ambient temperature conditions at engine start-up require the use of multigrade SAE 0W oil, SAE 0W-40 viscosity grade is preferred over SAE 0W-20 or SAE 0W-30.

Table 11

Engine Oil Viscosities for Ambient Temperatures		
	Ambient Temperature	
Viscosity Grade	Minimum	Maximum
SAE 0W-20	−40 °C (−40 °F)	10 °C (50 °F)
SAE 0W-30	−40 °C (−40 °F)	30 °C (86 °F)
SAE 0W-40	−40 °C (−40 °F)	40 °C (104 °F)
SAE 5W-30	−30 °C (−22 °F)	30 °C (86 °F)
SAE 5W-40	−30 °C (−22 °F)	50 °C (122 °F)
SAE 10W-30	−18 °C (0 °F)	40 °C (104 °F)
SAE 10W-40	−18 °C (0 °F)	50 °C (122 °F)
SAE 15W-40	−9.5 °C (15 °F)	50 °C (122 °F)

Note: Supplemental heat is recommended below the minimum recommended ambient temperature.

S·O·S Oil Analysis

Caterpillar has developed a tool for maintenance management that evaluates oil degradation and the tool also detects the early signs of wear on internal components. The Caterpillar tool for oil analysis is called S·O·S Oil Analysis and the tool is part of the S·O·S Services program. S·O·S Oil Analysis divides oil analysis into three categories:

- Wear Analysis
- Oil condition
- Additional tests

The wear analysis monitors metal particles, some oil additives, and some contaminants.

Oil condition uses infrared (IR) analysis to evaluate the chemistry of the oil. Infrared analysis is also used to detect certain types of contamination.

Additional tests are used to measure contamination levels from water, fuel, or coolant. Oil viscosity and corrosion protection can be evaluated, as needed.

Refer to Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations” or contact your local Caterpillar dealer for additional information concerning the S·O·S Oil Analysis program.

Refill Capacities for the 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.

Table 12

C0.5 Engine Approximate Refill Capacities		
Compartment or System	**Min**	**Max**
Crankcase Oil Sump (Standard)(1)	1.6 L (1.7 qt)	2.01 L (2.1 qt)
External System (OEM)(2)		
Total Lubrication System(3)		

(1) These values are the approximate capacities for the crankcase oil sump which include the standard oil filters that are installed at the factory.
(2) Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
(3) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity for the External System. Enter the total in this row.

Table 13

C0.7 Engine Approximate Refill Capacities		
Compartment or System	**Min**	**Max**
Crankcase Oil Sump (Standard)(1)	2.35 L (2.5 qt)	3.05 L (3.2 qt)
External System (OEM)(2)		
Total Lubrication System(3)		

(1) These values are the approximate capacities for the crankcase oil sump which include the standard oil filters that are installed at the factory.
(2) Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
(3) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity for the External System. Enter the total in this row.

Table 14

C1.1 Engine Approximate Refill Capacities		
Compartment or System	**Min**	**Max**
Crankcase Oil Sump (Standard)(1)	3.4 L (3.6 qt)	4.4 L (4.6 qt)

(continued)

(Table 14, contd)

C1.1 Engine Approximate Refill Capacities		
Compartment or System	**Min**	**Max**
External System (OEM)(2)		
Total Lubrication System(3)		

(1) These values are the approximate capacities for the crankcase oil sump which include the standard oil filters that are installed at the factory.
(2) Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
(3) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity for the External System. Enter the total in this row.

Table 15

C1.5 Turbocharged Engines and Naturally Aspirated Engines Approximate Refill Capacities		
Compartment or System	**Min**	**Max**
Crankcase Oil Sump (Standard)(1)	4.5 L (4.8 qt)	6 L (6.3 qt)
External System (OEM)(2)		
Total Lubrication System(3)		

(1) These values are the approximate capacities for the crankcase oil sump which include the standard oil filters that are installed at the factory.
(2) Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
(3) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity for the External System. Enter the total in this row.

Table 16

C1.6 Engine Approximate Refill Capacities		
Compartment or System	**Min**	**Max**
Crankcase Oil Sump (Standard)(1)	3.9 L (4.1 qt)	5.6 L (6 qt)
External System (OEM)(2)		
Total Lubrication System(3)		

(1) These values are the approximate capacities for the crankcase oil sump which include the standard oil filters that are installed at the factory.
(2) Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
(3) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity for the External System. Enter the total in this row.

Table 17

C2.2 Turbocharged Engines and Naturally Aspirated Engines Approximate Refill Capacities		
Compartment or System	**Min**	**Max**
Crankcase Oil Sump (Standard)(1)	8.9 L (9.4 qt)	10.6 L (11.2 qt)
External System (OEM)(2)		
Total Lubrication System(3)		

(1) These values are the approximate capacities for the crankcase oil sump which include the standard oil filters that are installed at the factory.
(2) Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
(3) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity for the External System. Enter the total in this row.

Lubricating Grease

Caterpillar provides a range of moderate greases to extremely high performance greases in order to service the entire line of Caterpillar products that operate throughout the wide variety of climates. From this variety of Caterpillar grease products, you will find at least one of the Caterpillar greases that will satisfy the performance requirements for any machine or equipment application.

Before selecting a grease for any application, the performance requirements must be determined. Consult the grease recommendations that are made by the OEM for the equipment when the equipment is operated in the expected conditions. Then, consult with your Caterpillar dealer for a list of greases and the following related characteristics.

- Performance specifications
- Available sizes of containers
- Part numbers

Always choose a grease that satisfies the recommendations that are specified by the equipment manufacturer for the application.

Note: If it is necessary to choose a single grease to use for all of the equipment at one site, always choose a grease that satisfies the requirements of the most demanding application.

Do not use the cost per pound as the only factor when you choose a grease. Use the grease that yields the lowest total cost of operation. The cost analysis should include the following factors:

- Parts

- Labor
- Downtime
- Cost of the grease

Greases that barely meet the minimum performance requirements can be expected to barely produce the minimum life of the parts.

Note: Take care when you change the type of grease. Take care when you change to a different supplier of grease. Some greases are not chemically compatible. Some brands of grease cannot be interchanged. **If you are in doubt about the compatibility of the old grease and the new grease, purge all of the old grease from the joint.** Consult your supplier in order to determine if the greases are compatible.

Note: All Caterpillar brand of greases are compatible with each other.

Note: Refer to Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations” for additional information that relates to lubrication for your engine.

General Fuel Information

Diesel fuels that meet the Caterpillar Specification for Distillate Diesel Fuel are recommended. These fuels 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. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

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.

Table 18

Territory	Fuel Requirements from 2007		
EPA	Low Sulfur (500 ppm) maximum		
EC	Sulfur/Power	Low sulfur (300 ppm) maximum for less than or equal to 19 kW	Sulphur (1000 ppm) maximum for greater than 19 kW
	Models	C0.5 and C0.7	C1.1, C1.5NA, C1.5T, C1.6, C2.2NA, C2.2T and C2.2TA(1)
Non-Regulated Territories	Sulfur limit of less than 4000 ppm		

(1) NA is Naturally Aspirated. T is Turbocharged. TA is Turbocharged Aftercooled.

Table 19

Territory	Fuel Requirements from 2010		
EPA	Ultra Low Sulfur (15 ppm) maximum		
EC	Sulfur/Power	Ultra Low sulphur (10 ppm) maximum for less than or equal to 37 kW	Low sulphur (300 ppm) maximum for greater than 37 kW
	Models	C0.5, C0.7, C1.1, C1.5NA, C1.5T, C1.6	C2.2NA, C2.2T and C2.2TA(1)
Non Regulated Territories	Sulfur limit of less than 4000 ppm		

(1) NA is Naturally Aspirated. T is Turbocharged. TA is Turbocharged Aftercooled.

Note: Refer to Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations” for the Caterpillar Specification for distillate fuel and for additional information that relates to fuel for your engine.

Refill Capacities for the Fuel System

Refer to the Operation and Maintenance Manual that is provided by the OEM for capacities of the fuel system.

General Coolant Information

NOTICE
These recommendations are subject to change without notice. Contact your local Caterpillar dealer for the most up-to-date fluids recommendations.

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

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.

NOTICE
Frequently check the specific gravity of the coolant for proper freeze protection or for anti-boil protection.

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 5 L (1.3 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.

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.

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

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.

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 20 .

Table 20

Caterpillar Minimum Acceptable Water Requirements		
Property	**Maximum Limit**	**ASTM Test**
Chloride (Cl)	40 mg/L (2.4 grains/US gal)	“D512”, “D4327”
Sulfate (SO_4)	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 grain/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.

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 °C (−9 °F).

Most conventional heavy-duty Coolants 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 21 and 22 .

Table 21

Ethylene Glycol		
Concentration	**Freeze Protection**	**Boil Protection**
50 Percent	−36 °C (−33 °F)	106 °C (223 °F)
60 Percent	−51 °C (−60 °F)	111 °C (232 °F)

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

Table 22

Propylene Glycol		
Concentration	**Freeze Protection**	**Anti-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 (Degrees Celsius) or use the 1U-7297 Coolant/Battery Tester (Degrees Fahrenheit). The testers give readings that are immediate and accurate. The testers can be used with ethylene or propylene glycol.

Coolant Recommendations

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

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 – Caterpillar Diesel Engine Antifreeze (DEAC) or a commercial heavy-duty coolant that meets “ASTM D4985”, or “ASTM D6210” specifications

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.

Note: Caterpillar DEAC does not require a treatment with an SCA at the initial fill. A commercial heavy-duty coolant that meets “ASTM D4985” or “ASTM D6210” specifications MAY require a treatment with an SCA at the initial fill. These coolants WILL require a treatment with an SCA on a maintenance basis.

Refer to Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations” for additional information that relates to coolant.

S·O·S Coolant Analysis

Table 23

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
DEAC	Every 250 Hours	Yearly(1)
ELC	Not Required	Yearly

(1) The Level 2 Coolant Analysis should be performed sooner if a problem is identified by a Level 1 Coolant Analysis.

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 and boil protection
- Ability to protect from erosion and corrosion
- pH
- Conductivity
- Visual analysis
- Odor analysis

The results are reported, and appropriate recommendations are made.

Refer to the Maintenance Interval Schedule in this Operation and Maintenance Manual, “Cooling System Coolant Sample (Level 1) - Obtain” for a sampling location and the maintenance interval for collecting the coolant samples.

S·O·S Coolant Analysis (Level 2)

A coolant analysis (Level 2) 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 features:

- Full coolant analysis (Level 1)
- Identification of the source of metal corrosion and of contaminants
- Water hardness
- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling

The results are reported, and appropriate recommendations are made.

Refer to the Maintenance Interval Schedule in this Operation and Maintenance Manual, “Cooling System Coolant Sample (Level 2) - Obtain” for a sampling location and the maintenance interval for collecting the coolant samples.

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.

Refer to Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations” for additional information.

Refill Capacity of the 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 that is required for the Total Cooling System.

Table 24

C0.5 Engine Approximate Refill Capacities		
Compartment or System	**Liters**	**Quarts**
Engine Only	1.1	1.2
External System (OEM)(1)		
Total Cooling System(2)		

(1) The External System includes a radiator or an expansion tank with the following components: heat exchanger, aftercooler and piping. Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information.

(2) The Total Cooling System includes the capacity for the “Engine Only” plus the capacity for the External System. Enter the total in this row.

Table 25

C0.7 Engine Approximate Refill Capacities		
Compartment or System	**Liters**	**Quarts**
Engine Only	1.2	1.3
External System (OEM)(1)		
Total Cooling System(2)		

(1) The External System includes a radiator or an expansion tank with the following components: heat exchanger, aftercooler and piping. Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information.
(2) The Total Cooling System includes the capacity for the “Engine Only” plus the capacity for the External System. Enter the total in this row.

Table 26

C1.1 Engine Approximate Refill Capacities		
Compartment or System	**Liters**	**Quarts**
Engine Only	1.9	2.0
External System (OEM)(1)		
Total Cooling System(2)		

(1) The External System includes a radiator or an expansion tank with the following components: heat exchanger, aftercooler and piping. Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information.
(2) The Total Cooling System includes the capacity for the “Engine Only” plus the capacity for the External System. Enter the total in this row.

Table 27

C1.5 Turbocharged Engines and Naturally Aspirated Engines Approximate Refill Capacities		
Compartment or System	**Liters**	**Quarts**
Engine Only	2.6	2.7
External System (OEM)(1)		
Total Cooling System(2)		

(1) The External System includes a radiator or an expansion tank with the following components: heat exchanger, aftercooler and piping. Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information.
(2) The Total Cooling System includes the capacity for the “Engine Only” plus the capacity for the External System. Enter the total in this row.

Table 28

C1.6 Engine Approximate Refill Capacities		
Compartment or System	**Liters**	**Quarts**
Engine Only	2.4	2.5
External System (OEM)(1)		
Total Cooling System(2)		

(1) The External System includes a radiator or an expansion tank with the following components: heat exchanger, aftercooler and piping. Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information.
(2) The Total Cooling System includes the capacity for the “Engine Only” plus the capacity for the External System. Enter the total in this row.

Table 29

C2.2 Turbocharged engines and Naturally Aspirated Engines Approximate Refill Capacities		
Compartment or System	**Liters**	**Quarts**
Engine Only	3.6	3.8
External System (OEM)(1)		
Total Cooling System(2)		

(1) The External System includes a radiator or an expansion tank with the following components: heat exchanger, aftercooler and piping. Enter the capacity for the External System in this row. Refer to either Caterpillar specifications or OEM specifications for further information.
(2) The Total Cooling System includes the capacity for the “Engine Only” plus the capacity for the External System. Enter the total in this row.

Maintenance Recommendations

i02909163

System Pressure Release

SMCS Code: 1250; 1300; 1350; 5050

Coolant System

⚠ WARNING

Pressurized system: Hot coolant can cause serious burn. To open cap, stop engine, wait until radiator is cool. Then loosen cap slowly to relieve the pressure.

To relieve the pressure from the coolant system, turn off the engine. Allow the cooling system pressure cap to cool. Remove the cooling system pressure cap slowly in order to relieve pressure.

Fuel System

To relieve the pressure from the fuel system, turn off the engine.

High Pressure Fuel Lines (If Equipped)

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

The high pressure fuel lines are the fuel lines that are between the high pressure fuel pump and the high pressure fuel manifold and the fuel lines that are between the fuel manifold and cylinder head. These fuel lines are different from fuel lines on other fuel systems.

This is because of the following differences:

- The high pressure fuel lines are constantly charged with high pressure.
- The internal pressures of the high pressure fuel lines are higher than other types of fuel system.

Before any service or repair is performed on the engine fuel lines, perform the following tasks:

1. Stop the engine.

2. Wait for ten minutes.

Do not loosen the high pressure fuel lines in order to remove air pressure from the fuel system.

Engine Oil

To relieve pressure from the lubricating system, turn off the engine.

i05909227

Welding on Engines with Electronic Controls

SMCS Code: 1000

NOTICE
Because the strength of the frame may decrease, some manufacturers do not recommend welding onto a chassis frame or rail. Consult the OEM of the equipment or your Cat dealer regarding welding on a chassis frame or rail.

Proper welding procedures are necessary in order to avoid damage to the engine ECM, sensors, and associated components. When possible, remove the component from the unit and then weld the component. If removal of the component is not possible, the correct procedure must be followed. When welding on a unit that is equipped with a Cat Electronic Engine, the following is considered to be the safest procedure:

NOTICE
Do not ground the welder to electrical components such as the ECM or sensors. Improper grounding can cause damage to the drive train, the bearings, hydraulic components, electrical components, and other components.

Do not ground the welder across the centerline of the package. Improper grounding could cause damage to the bearings, the crankshaft, the rotor shaft, and other components.

Clamp the ground cable from the welder to the component that will be welded. Place the clamp as close as possible to the weld. This will help reduce the possibility of damage.

Note: Perform the welding in areas that are free from explosive hazards.

1. Stop the engine. Turn the switched power to the OFF position.

2. Disconnect the negative battery cable from the battery. If a battery disconnect switch is provided, open the switch.

3. Disconnect the J1/P1 and J2/P2 connectors from the ECM. Move the harness to a position that will not allow the harness to move back accidentally, and contact any of the ECM pins.

4. Disconnect any component with a microprocessor from the engine harness, such as:

   - Engine ECM
   - Product Link
   - Cell/Sat Radio
   - DOC Identity Modules

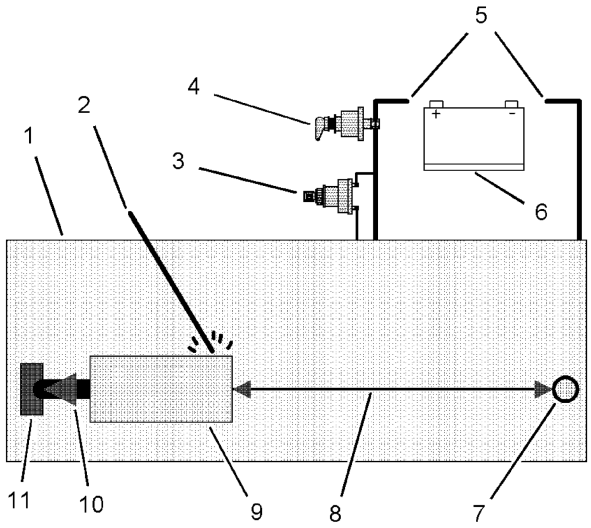

Illustration 37 g01075639

Use the example above. The current flow from the welder to the ground clamp of the welder will not damage any associated components.

(1) Engine
(2) Welding electrode
(3) Keyswitch in the OFF position
(4) Battery disconnect switch in the open position
(5) Disconnected battery cables
(6) Battery
(7) Electrical/Electronic component
(8) Minimum distance between the component that is being welded and any electrical/electronic component
(9) The component that is being welded
(10) Current path of the welder
(11) Ground clamp for the welder

5. Connect the welding ground cable directly to the part that will be welded. Place the ground cable as close as possible to the weld. This location will reduce the possibility of welding current damage to bearings, hydraulic components, electrical components, and ground straps.

Note: If electrical/electronic components are used as a ground for the welder, current flow from the welder could severely damage the component. Current flow from the welder could also severely damage electrical/electronic components that are located between the welder ground and the weld.

6. Protect the wiring harness from welding debris and spatter.

7. Use standard welding practices to weld the materials.

i03659171

Maintenance Interval Schedule

SMCS Code: 1000; 7500

When Required

“ Battery - Replace” . . . . . .
“ Battery or Battery Cable - Disconnect” 58
“ Engine - Clean” . . . . . .
“ Engine Air Cleaner Element (Dual Element) - Clean/ Replace” . . . . . .
“ Engine Air Cleaner Element (Single Element) - Inspect/Replace” 69
“ Fuel System - Prime” 77
“ Severe Service Application - Check” 88

Daily

“ Cooling System Coolant Level - Check” 62
“ Driven Equipment - Check” 66
“ Engine Air Cleaner Service Indicator - Inspect” . . .
“ Engine Air Precleaner - Check/Clean” 71
“ Engine Oil Level - Check” 72
“ Fuel System Primary Filter/Water Separator - Drain” 81
“Walk-Around Inspection” 90

Every 50 Service Hours or Weekly

“ Fuel Tank Water and Sediment - Drain” . . . . . .

Every 250 Service Hours

“Cooling System Coolant Sample (Level 1) - Obtain” . . . . . .

Every 250 Service Hours or 6 Months

“ Alternator and Fan Belts - Inspect/Adjust” 56
“ Engine Oil Sample - Obtain” . . . . . .

Every 250 Service Hours or 1 Year

“ Cooling System Supplemental Coolant Additive (SCA) - Test/Add” 64

Initial 500 Hours (for New Systems, Refilled Systems, and Converted Systems)

“Cooling System Coolant Sample (Level 2) - Obtain” . . . . . .

Every 500 Service Hours

“ Fuel System Secondary Filter - Replace” 81

Every 500 Service Hours or 1 Year

“ Battery Electrolyte Level - Check” . . . . . .
“ Cooling System Supplemental Coolant Additive (SCA) - Test/Add” 64
“ Engine Air Cleaner Element (Dual Element) - Clean/ Replace” . . . . . .
“ Engine Oil and Filter - Change” 73
“ Engine Protective Devices - Check” . . . . . .
“ Hoses and Clamps - Inspect/Replace” . . . . . .
“ Radiator - Clean” . . . . . .

Every 1000 Service Hours

“ Alternator and Fan Belts - Replace” 57
“ Engine Valve Lash - Inspect/Adjust” 76
“ Turbocharger - Inspect” 89

Every 2000 Service Hours

“ Aftercooler Core - Inspect” 55
“ Alternator - Inspect” 55
“ Engine Crankcase Breather - Replace” 71
“ Engine Mounts - Inspect” 72

“ Starting Motor - Inspect” 89

Every Year

“Cooling System Coolant Sample (Level 2) - Obtain” . . . . . .

Every 3000 Service Hours

“ Fuel Injector - Test/Change” 76
“ Water Pump - Inspect” 91

Every 3000 Service Hours or 2 Years

“ Cooling System Coolant (DEAC) - Change” 58
“ Cooling System Water Temperature Regulator - Replace” 65

Every 4000 Service Hours

“ Aftercooler Core - Clean/Test” 55

Every 6000 Service Hours or 3 Years

“ Cooling System Coolant Extender (ELC) - Add” 62

Every 12 000 Service Hours or 6 Years

“ Cooling System Coolant (ELC) - Change” 60

Overhaul

“ Overhaul Considerations” 87

i03632427

Aftercooler Core - Clean/Test (Air-To-Air Aftercooler)

SMCS Code: 1064-070; 1064-081

S/N: G7L1–Up

S/N: C6M1–Up

S/N: C8Y1–Up

S/N: C8Z1–Up

The air-to-air aftercooler is OEM installed in many applications. Please refer to the OEM specifications for information that is related to the aftercooler.

i03632432

Aftercooler Core - Inspect

SMCS Code: 1064-040

S/N: G7L1–Up

S/N: C6M1–Up

S/N: G8N1–Up

S/N: C8Y1–Up

S/N: C8Z1–Up

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the aftercooler for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil and other debris. Clean the aftercooler, if necessary.

For air-to-air aftercoolers, use the same methods that are used for cleaning radiators.

⚠ 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 (.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”.

Note: If parts of the aftercooler system are repaired or replaced, a leak test is highly recommended. The FT1984 Aftercooler Testing Group is used to perform leak tests on the aftercooler. Refer to the Systems Operation/Testing and Adjusting, “Aftercooler - Test” and the Special Instruction, SEHS8622 for the proper testing procedure.

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”.

i02676048

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.

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.

i02226340

Alternator and Fan Belts - Inspect/Adjust

SMCS Code: 1357-025; 1357-040

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 accurately check the belt tension, Gauge 144-0235 Belt Tension Gauge should be used.

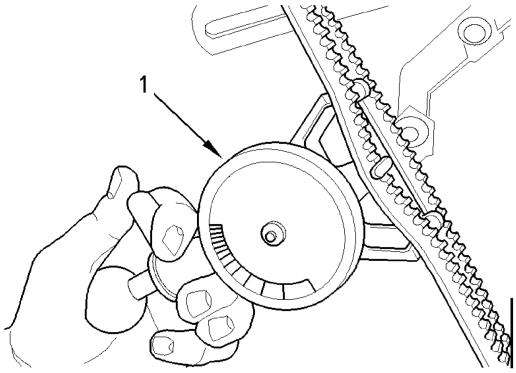

Illustration 38 g01003936

Typical example

(1) 144-0235 Belt Tension Gauge

Install the gauge (1) at the center of the belt between the alternator and the crankshaft pulley and check the belt tension. The correct tension for a new belt is 400 N (90 lb) to 489 N (110 lb). The correct tension for a used belt that has been in operation for 30 minutes or more at the rated speed is 267 N (60 lb) to 356 N (80 lb).

If twin belts are installed, check and adjust the tension on both belts.

Adjustment

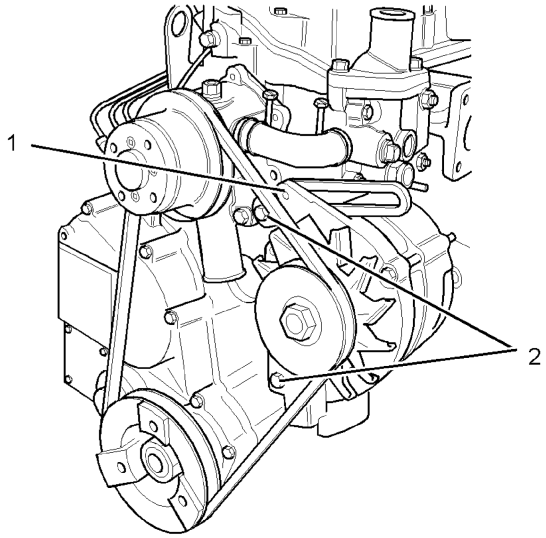

Illustration 39 g01091158

Typical example

(1) Adjusting bolt
(2) Mounting bolts

1. Loosen the mounting bolts (2) and the adjusting bolt (1).
2. Move the alternator in order to increase or decrease the belt tension.

3. Tighten the adjusting bolt (1). Tighten the mounting bolts (2). Refer to the Specifications Manual for the correct torque settings.

i02226343

Alternator and Fan Belts - Replace

SMCS Code: 1357-510

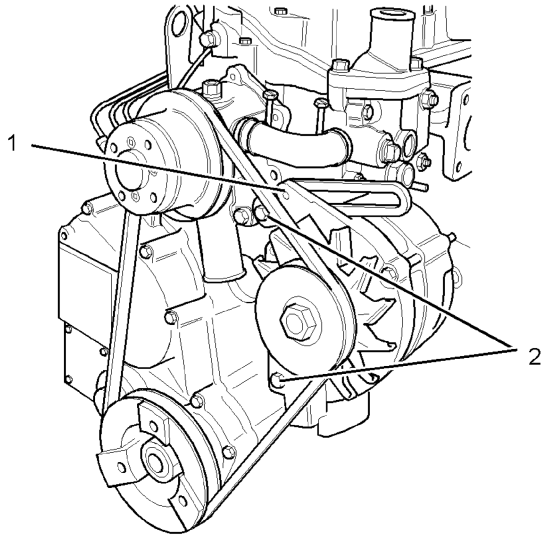

Illustration 40 g01091158

Typical example

(1) Adjusting bolt
(2) Mounting bolts

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.

Note: When new belts are installed, check the belt tension again after 20 hours of engine operation.

Refer to the Disassembly and Assembly Manual for the installation procedure and the removal procedure for the belt.

i06103470

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.

Note: Always recycle a battery. Never discard a battery. Return used batteries to an appropriate recycling facility.

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.
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.

i06064262

Battery Electrolyte Level - Check

SMCS Code: 1401-535

When the engine has not run for long or short periods of time, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing.

⚠ 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 245-5829 Coolant Battery Tester Refractometer.

3. Keep the batteries clean.

   Clean the battery case with one of the following cleaning solutions:

   - A mixture of 0.1 kg (0.2 lb) 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 the 1U-9921 Battery Service Tool to clean the battery terminals. Use a wire brush to clean 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 fit improperly. Coat the clamps and the terminals with 5N-5561 Silicone Lubricant, petroleum jelly or MPGM.

i01492654

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.

i02789695

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

⚠ 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 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.

Note: Refer to Operation and Maintenance Manual, “General Hazard Information” for information on Containing Fluid Spillage.

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 into a suitable container.

3. Properly dispose of the drained material. Obey local regulations for the disposal of the material.

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.

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 Torque Specifications, SENR3130 for more information on the correct torques.

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

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. The coolant temperature should be at least 82 °C (180 °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.

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 Torque Specifications, SENR3130 for more information on the correct 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 Torque Specifications, SENR3130 for more information on the correct torques.

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

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).

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.

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 Torque Specifications, SENR3130 for more information on the correct torques.

Fill

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

1. Fill the cooling system with the coolant/antifreeze. Refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.
2. Start and run the engine at low idle. Increase the engine rpm to 1500 rpm. Run the engine at high idle 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 that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system filler cap is not damaged, perform a pressure test. A 9S-8140 Pressurizing Pump is used to perform the pressure test. 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 the correct operating temperature.

i02822203

Cooling System Coolant (ELC) - 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.

Note: When the cooling system is cleaned, only clean water is needed when the ELC is drained and replaced.

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

⚠ 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 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.
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 Dealer Service Tools.

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 Torque Specifications, SENR3130 for more information on the correct torques.

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

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 Torque Specifications, SENR3130 for more information on the correct torques.

Fill

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

1. Fill the cooling system with Extended Life Coolant (ELC). Refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.
2. Start and run the engine at low idle. Increase the engine rpm to high idle. Run the engine at high idle 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 that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system 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.

i02482066

Cooling System Coolant Extender (ELC) - Add

SMCS Code: 1352-045; 1395-081

Cat ELC (Extended Life Coolant) does not require the frequent additions of any supplemental cooling additives which are associated with the present conventional coolants. The Cat ELC Extender only needs to be added once.

NOTICE
Use only Cat Extended Life Coolant (ELC) Extender with Cat ELC.

Do NOT use conventional supplemental coolant additive (SCA) with Cat ELC. Mixing Cat ELC with conventional coolants and/or conventional SCA reduces the Cat ELC service life.

Check the cooling system only when the engine is stopped and cool.

⚠ WARNING

Personal injury can result from hot coolant, steam and alkali.

At operating temperature, engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot coolant or steam. Any contact can cause severe burns.

Remove cooling system pressure cap slowly to relieve pressure only when engine is stopped and cooling system pressure cap is cool enough to touch with your bare hand.

Do not attempt to tighten hose connections when the coolant is hot, the hose can come off causing burns.

Cooling System Coolant Additive contains alkali. Avoid contact with skin and eyes.

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 Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

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 Cat ELC Extender.
3. Add Cat ELC Extender according to the requirements for your engine's cooling system capacity. Refer to the Operation and Maintenance Manual, “Refill Capacities and Recommendations” article for more information.
4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

i01197583

Cooling System Coolant Level - Check

SMCS Code: 1395-082

Check the coolant level when the engine is stopped and cool.

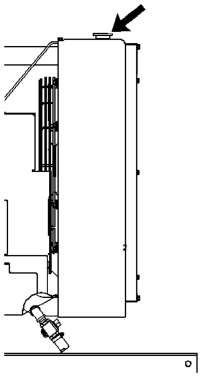

Illustration 41 g00285520
Cooling system filler cap

⚠ 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.

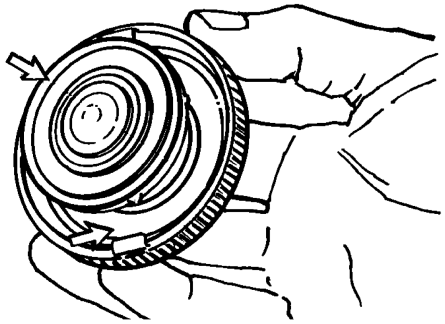

Illustration 42 g00103639
Typical filler cap gaskets

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.

i04035949

Cooling System Coolant Sample (Level 1) - Obtain

SMCS Code: 1350-008; 1395-008; 1395-554; 7542

Note: Obtaining a Coolant Sample (Level 1) is optional if the cooling system is filled with Cat ELC (Extended Life Coolant). Cooling systems filled with Cat ELC should have a Coolant Sample (Level 2) that is obtained at the recommended interval as stated in the maintenance interval schedule.

Note: Obtain a Coolant Sample (Level 1) if the cooling system is filled with any other coolant instead of Cat ELC including the following coolants:

- Commercial long life coolants that meet the Caterpillar Engine Coolant Specification -1 (Caterpillar EC-1)
- Cat DEAC (Diesel Engine Antifreeze/Coolant)
- Commercial heavy-duty coolant/antifreeze

Table 30

Recommended Interval		
Type of Coolant	Level 1	Level 2
Cat DEAC	Every 250 service hours	Every year(1)
Conventional heavy duty-coolant		
Commercial coolant that meets the requirements of the Caterpillar EC-1 standard		
Cat ELC or conventional EC-1 coolant	Optional	Every year(1)

(1) The Level 2 Coolant Analysis should be performed sooner if a problem is suspected or identified.

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

Note: Level 1 results may indicate a need for Level 2 Analysis.

Obtain the sample of the coolant as close as possible to the recommended sampling interval. In order to receive the full effect of S·O·S analysis, establish a consistent trend of data. In order to establish a pertinent history of data, perform consistent samplings that are evenly spaced. Supplies for collecting samples can be obtained from your Caterpillar dealer.

Use the following guidelines for proper sampling of the coolant:

- Complete the information on the label for the sampling bottle before you begin to take the samples.
- Keep the unused sampling bottles stored in plastic bags.

- Obtain coolant samples directly from the coolant sample port. You should not obtain the samples from any other location.
- Keep the lids on empty sampling bottles until you are ready to collect the sample.
- Place the sample in the mailing tube immediately after obtaining the sample in order to avoid contamination.
- Never collect samples from expansion bottles.
- Never collect samples from the drain for a system.

Submit the sample for Level 1 analysis.

For additional information about coolant analysis, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” or consult your Caterpillar dealer.

i04051750

Cooling System Coolant Sample (Level 2) - Obtain

SMCS Code: 1350-008; 1395-008; 1395-554; 7542

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

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, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Refer to Operation and Maintenance Manual, “Cooling System Coolant Sample (Level 1) - Obtain” for the guidelines for proper sampling of the coolant.

Submit the sample for Level 2 analysis.

For additional information about coolant analysis, see Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engines Fluids Recommendations” or consult your Caterpillar dealer.

i02456600

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 and SCA

NOTICE
Do not exceed the recommended six percent supplemental coolant additive concentration.

Use the 8T-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 this Operation and Maintenance Manual, “Refill Capacities and Recommendations” 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 8T-5296 Coolant Conditioner Test Kit. Refer to the Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations” for more information.

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 this 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 Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engines Fluids Recommendations” 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.

i02625506

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 Disassembly and Assembly, “Water Temperature Regulator - Remove and Install”. Consult your Caterpillar dealer for more information.

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.

i00174798

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.

i06103535

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
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

Note: Caution must be used in order to prevent electrical components from being damaged by excessive water when you clean the engine. Avoid electrical components such as the alternator, the starter, and the ECM.

i04404720

Engine Air Cleaner Element (Dual Element) - Clean/Replace

SMCS Code: 1054-510; 1054-037

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 airborne 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.

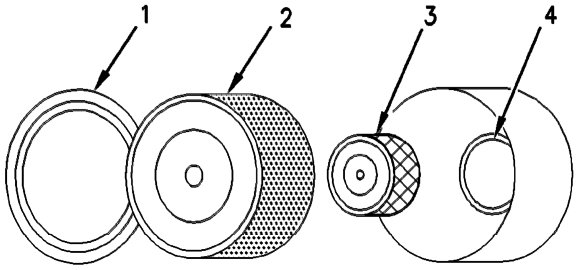

Illustration 43 g00736431

(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 Cleaner Elements”.

3. Cover the turbocharger air inlet with tape in order to keep out dirt.
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 air cleaner service indicator.

Cleaning the Primary Air Cleaner Elements

NOTICE
Caterpillar recommends certified air filter cleaning services that are available at Cat dealers. The Cat cleaning process uses proven procedures to assure consistent quality and sufficient filter life.

Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow up the pleats and down the pleats from the inside of the filter element. Take extreme care in order to avoid damage to the pleats.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

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 two common methods that are used to clean primary air cleaner elements:

- Pressurized air
- Vacuum cleaning

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).

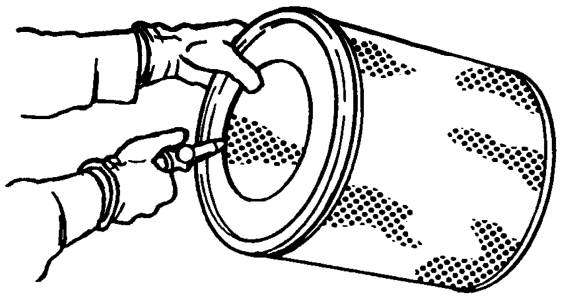

Illustration 44 g00281692

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”.

Inspecting the Primary Air Cleaner Elements

Illustration 45 g00281693

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 a 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.

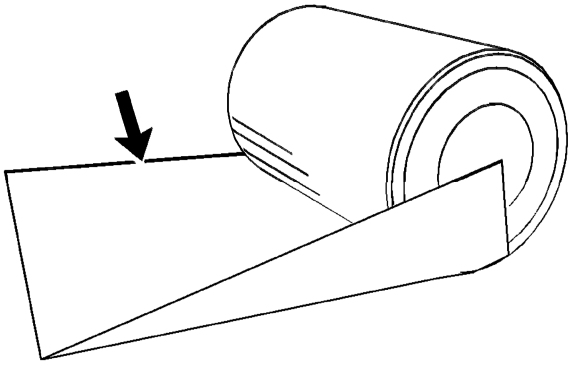

Illustration 46 g02595738
Typical example

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.

i01432811

Engine Air Cleaner Element (Single Element) - Inspect/Replace

SMCS Code: 1054-040; 1054-510

S/N: C6F1–Up

S/N: C7H1–Up

S/N: C6J1–Up

S/N: C6L1–Up

S/N: G7L1–Up

S/N: C6M1–Up

S/N: C6N1–Up

S/N: G8N1–Up

S/N: G7P1–Up

S/N: C8W1–Up

S/N: C7Y1–Up

S/N: C8Y1–Up

S/N: C8Z1–Up

Perform the Operation and Maintenance Manual, "Engine Air Cleaner Service Indicator-Inspect" procedure and perform the Operation and Maintenance Manual, "Engine Air Precleaner Check/ Clean" procedure (if equipped) before performing the following procedure.

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 airborne 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.

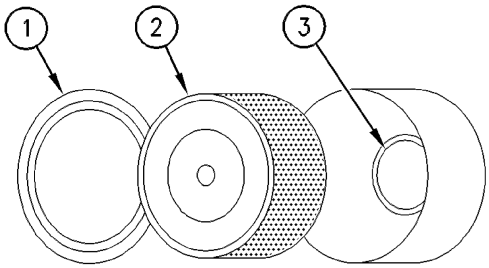

Illustration 47 g00310664

(1) Air cleaner cover
(2) Air filter element
(3) Air inlet

1. Remove air cleaner cover (1) and remove air filter element (2).
2. Cover air inlet (3) with tape or a clean cloth so that debris cannot enter the air inlet.
3. Clean the inside of air cleaner cover (1). Clean the body that holds the air cleaner element.
4. Inspect the replacement element for the following items:damage, dirt and debris.
5. Remove the seal from the opening of the air inlet.
6. Install a clean, undamaged air filter element (2).
7. Install air cleaner cover (1).
8. Reset the air cleaner service indicator.

i06103548

Engine Air Cleaner Service Indicator - Inspect
(If Equipped)

SMCS Code: 7452-040

S/N: C6F1–Up

S/N: C7H1–Up

S/N: C6J1–Up

S/N: C6L1–Up

S/N: G7L1–Up

S/N: C6M1–Up

S/N: C6N1–Up

S/N: G8N1–Up

S/N: G7P1–Up

S/N: C8W1–Up

S/N: C7Y1–Up

S/N: C8Y1–Up

S/N: C8Z1–Up

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 and 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 clean side of the air cleaner housing or in a remote location.

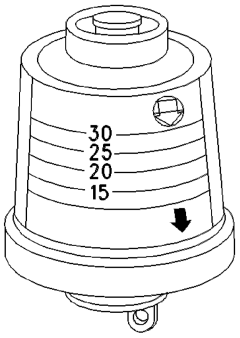

Illustration 48 g00103777
Typical service indicator

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 service indicator core when the engine is run at full load speed. The core should latch approximately at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the 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.

If necessary, replace the service indicator more frequently in environments that are severely dusty. 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).

i02927289

Engine Air Precleaner - Check/Clean

SMCS Code: 1055-070; 1055-535

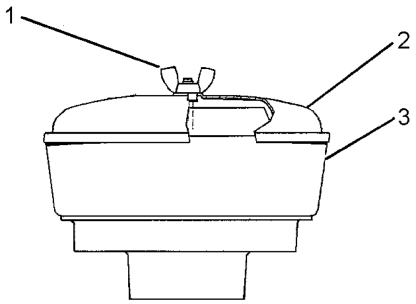

Illustration 49 g01453058
Typical engine air precleaner
(1) Wing nut
(2) Cover
(3) Body

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

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

Note: When the engine is operated in dusty applications, more frequent cleaning is required.

i02657607

Engine Crankcase Breather - Replace

SMCS Code: 1317-510

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

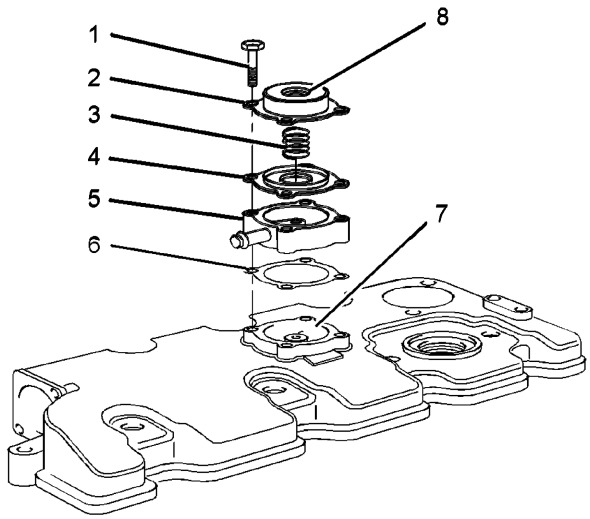

Illustration 50 g01335247

Typical example

(1) Screws for the breather cover
(2) Breather cover
(3) Spring
(4) Diaphragm and plate
(5) Spacer for turbocharged engines only
(6) Joint for turbocharged engines only
(7) Cavity
(8) Vent hole

1. Loosen the screws (1) and remove the breather cover (2) from the valve mechanism cover.
2. Remove the spring (3). Remove the diaphragm and plate (4).
3. For turbocharged engines, remove the spacer (5) and the joint (6).
4. Clean the vent hole (8) and the cavity (7) in the valve mechanism cover.

NOTICE
Make sure that the components of the breather assembly are installed correctly. Engine damage may occur if the breather assembly is not working correctly.

5. For turbocharged engines, install a new joint (6) and the spacer (5).
6. Install a new diaphragm and plate (4) for the breather assembly into the cavity (7) of the valve mechanism cover or the spacer (5) for turbocharged engines.
7. Install a new spring (3).
8. Install the breather cover (2) and the four screws (1). Tighten the screws.

i02456872

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 Special Publication, SENR3130, “Torque Specifications” for the recommended torques. Refer to the OEM recommendations for more information.

i00623423

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

⚠ WARNING

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

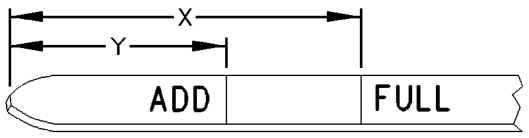

Illustration 51 g00110310

(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.

i04237495

Engine Oil Sample - Obtain

SMCS Code: 1000-008; 1348-554-SM; 7542-554-SM; 7542-554-OC

In addition to a good preventive maintenance program, Caterpillar recommends using S·O·S oil analysis at regularly scheduled intervals. S·O·S oil analysis provides infrared analysis, which is required for determining nitration and oxidation levels.

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, 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
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

If the engine is not equipped with a sampling valve, use the 1U-5718 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, PEGJ0047, “How To Take A Good S·O·S Oil Sample”. Consult your Cat dealer for complete information and assistance in establishing an S·O·S program for your engine.

i02625985

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.

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.

Dispose of all fluids according to local regulations and mandates.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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 correctly.

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. After the oil has drained, the oil drain plug should be cleaned and installed.

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.

Note: The following actions can be carried out as part of the preventive maintenance program.

2. Cut the oil filter open with a 175-7546 Oil Filter Cutter Gp. 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.

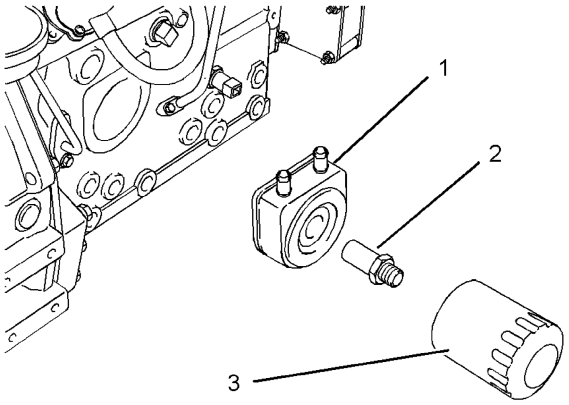

Illustration 52 g01334593
(1) Oil cooler
(2) Adapter
(3) Oil filter

Note: Oil cooler (1) and adapter (2) are not installed on all engines.

3. Clean the sealing surface of the cylinder block or the oil cooler (1).
4. Apply clean engine oil to the new oil filter seal (3).

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 seal contacts the cylinder block or the oil cooler. 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 this Operation and Maintenance Manual , “Refill Capacities and Recommendations” for more information on lubricant specifications. Fill the crankcase with the correct amount of oil. Refer to this Operation and Maintenance Manual , “Refill Capacities” for more information on refill capacities.

NOTICE
If equipped with an auxiliary oil filter system or a remote oil filter system, follow the OEM or filter manufacturer's recommendations. Under filling or overfilling the crankcase with oil can cause engine damage.

NOTICE
To prevent crankshaft bearing damage, crank the engine with the fuel OFF. This will fill the oil filters before starting the engine. Do not crank the 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.

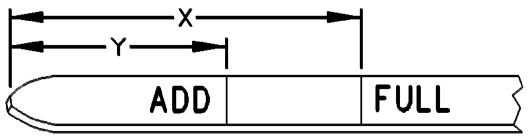

Illustration 53 g00110310

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.

i05264151

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. Determining if the engine protective devices are in good working order during normal operation is impossible. 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 Cat 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.

i02676796

Engine Valve Lash - Inspect/ Adjust

SMCS Code: 1102-025

This maintenance is recommended by Caterpillar as part of a lubrication and preventive maintenance schedule in order to help provide maximum engine life. The maintenance for the valve lash is important in order to keep the engine compliant.

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 Systems Operation/Testing and Adjusting Manual, “Valve Lash and Valve Bridge Adjustment”article or consult 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.

i02625315

Fuel Injector - Test/Change

SMCS Code: 1290-510; 1290-081

⚠ 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 injectors 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 injectors should be cleaned, inspected, tested, and replaced, if necessary. Refer to Special Instruction, SEHS7292 for using the 8S-2245 Injector Cleaning Tool Gp. Consult your Caterpillar dealer about cleaning the fuel injectors and testing the fuel injectors.

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 injectors:

- Abnormal engine operation
- Smoke emission
- Engine knock

Each fuel injector must be isolated one at a time in order to determine the malfunctioning fuel injector.

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 faulty fuel injector 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 injector that is suspected of being faulty should be removed. A new fuel injector should be installed in the cylinder in order to determine if the removed fuel injector is faulty.

Removal and Installation of the Fuel Injection Nozzles

For the removal and the installation of fuel injectors, special tooling is required. Refer to the Service Manual for more information. Consult your Caterpillar dealer for assistance.

i02596360

Fuel System - Prime

SMCS Code: 1258-548

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.

Dispose of all fluids according to local regulations and mandates.

Use the following procedure in order to prime the fuel system:

If air enters the fuel system, the air must be purged from the fuel system before the engine can be started. Air can enter the fuel system when the following events occur:

- The fuel tank is empty or the fuel tank has been partially drained.
- The low pressure fuel lines are disconnected.
- A leak exists in the low pressure fuel system.
- The fuel filter is replaced.

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.

Dispose of all fluids according to local regulations and mandates.

Primary filter

Ensure that the air is removed from the primary filter before you prime the fuel filters. Refer to illustration 54 .

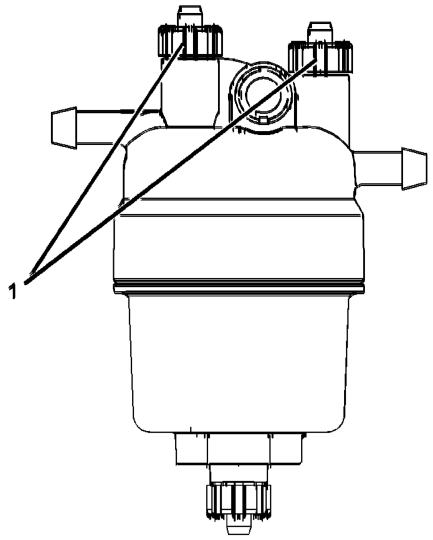

Illustration 54 g01316878

This filter may not be installed on the engine.

(1) Vent screws

Fuel filters

There are three types of fuel filter that may be installed on the engine.

- Element
- Canister
- Spin-on filter with fuel priming pump

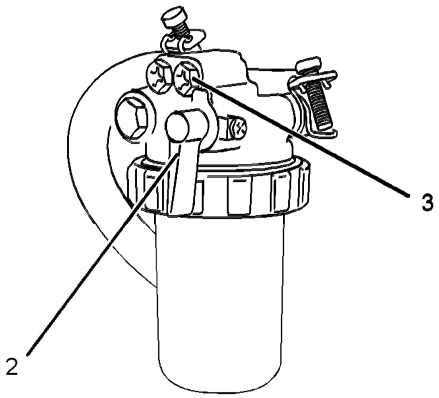

Illustration 55 g01327360

Element

(2) Fuel valve
(3) Vent screw

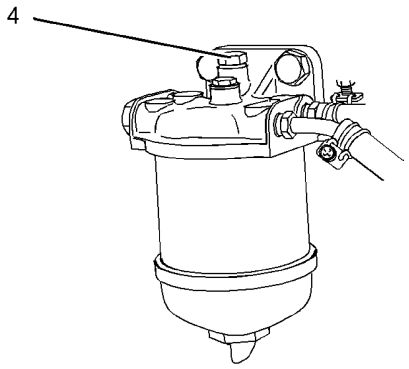

Illustration 56 g01327361

Canister

(4) Vent screw

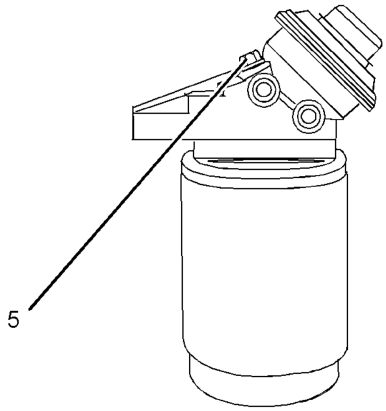

Illustration 57 g01327363

Spin-on filter with fuel priming pump

(5) Vent screw

Vent screw (3) is installed on the filter that has an element. Vent screw (4) is installed on the fuel filter that has a canister. Vent screw (5) is installed on the spin-on filter.

Priming the system

Ensure that the air is removed from the primary filter. Loosen vent screws (1). Refer to illustration 54 . Operate the priming pump. When fuel free from air flows from the vent screw tighten the vent screw.

Note: Some fuel system will use gravity in order to prime the primary fuel filter. If gravity is used ensure that the fuel tank is full and that all stop valves in the fuel line are open.

There is four different types of systems that can be installed on the engine in order to prime the fuel system. Refer to illustration 58 .

- Hand priming pump
- In-line hand priming pump
- Electrical priming pump
- Transfer pump that is operated by the starting motor

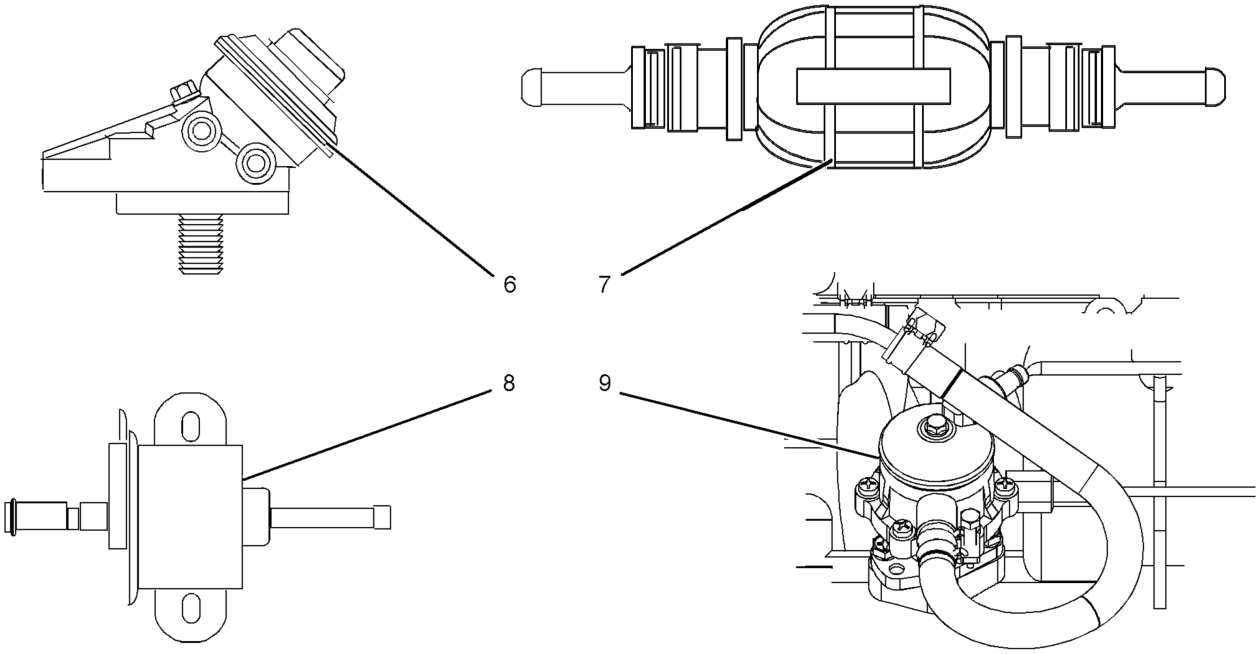

Illustration 58 g01301853

(6) Hand priming pump
(7) In-line priming pump
(8) Electrical priming pump
(9) Fuel transfer pump

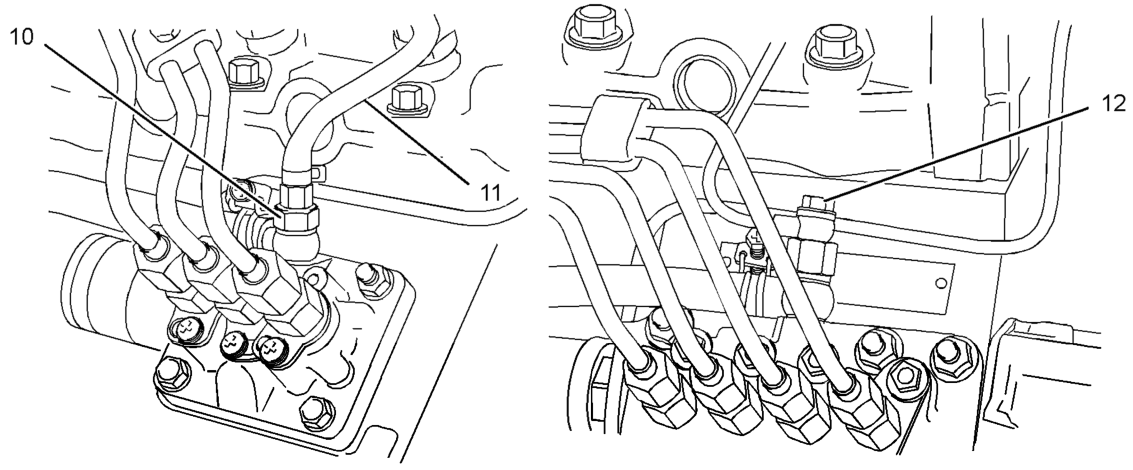

Illustration 59 g01304597

(10) Connector bolt
(11) Fuel return line
(12) Connector bolt

Hand Priming Pump 6

In order to identify the hand priming pump, refer to illustration 58 .

1. Ensure that fuel valve (2) for the fuel filter that has an element is in the ON position. Refer to illustration 55 .

2. Loosen vent screw (3 4 or 5) on the fuel filter.
3. Operate hand priming pump (6). When fuel free from air flows from the vent screw tighten the vent screw.
4. Loosen connection (10 or 12) at the fuel injection pump. Refer to illustration 59 .

Note: Fuel return line (11) may need to be removed in order to prime the fuel system.

5. Operate the hand priming pump. When fuel free from air flows from the connections tighten the connecting bolt.
6. The engine should now be able to start. Operate the starting motor in order to start the engine.

Note: Do not operate the starting motor for more than 15 seconds. If the engine does not start after 15 seconds, stop and wait for 30 seconds before trying again.

In-line Priming Pump 7

In order to identify the in-line priming pump, refer to illustration 58 .

1. Ensure that fuel valve (2) for the fuel filter that has an element is in the ON position. Refer to illustration 55 .
2. Loosen vent screw (3 4 or 5) on the fuel filter.
3. Operate in-line priming pump (7). When fuel free from air flows from the vent screw tighten the vent screw.
4. Loosen connection (10 or 12) at the fuel injection pump. Refer to illustration 59 .

Note: Fuel return line (11) may need to be removed in order to prime the fuel system.

5. Operate the in-line priming pump. When fuel free from air flows from the connections tighten the connecting bolt.
6. The engine should now be able to start. Operate the starting motor in order to start the engine.

Note: Do not operate the starting motor for more than 15 seconds. If the engine does not start after 15 seconds, stop and wait for 30 seconds before trying again.

Electrical Priming Pump 8

In order to identify the electrical priming pump, refer to illustration 58 .

1. Ensure that fuel valve (2) for the fuel filter that has an element is in the ON position. Refer to illustration 55 .
2. Loosen vent screw (3 4 or 5) on the fuel filter.
3. Operate electrical priming pump (8). When fuel free from air flows from the vent screw tighten the vent screw. Switch off the electrical priming pump.
4. Loosen connection (10 or 12) at the fuel injection pump. Refer to illustration 59 .

Note: Fuel return line (11) may need to be removed in order to prime the fuel system.

5. Operate the in-line priming pump. When fuel free from air flows from the connections tighten the connecting bolt.
6. The engine should now be able to start. Operate the starting motor in order to start the engine.

Note: Do not operate the starting motor for more than 15 seconds. If the engine does not start after 15 seconds, stop and wait for 30 seconds before trying again.

Fuel Transfer Pump 9

In order to identify the fuel transfer pump, refer to illustration 58 .

Note: In order to use the transfer pump, you must operate the starting motor. Do not operate the starting motor for more than 15 seconds. After 15 seconds, stop and wait for 30 seconds before operating the starting motor.

1. Ensure that fuel valve (2) for the fuel filter that has an element is in the ON position. Refer to illustration 55 .
2. Loosen vent screw (3 4 or 5) on the fuel filter.
3. Operate fuel transfer pump (9). When fuel free from air flows from the vent screw tighten the vent screw. Stop the fuel transfer pump.
4. Loosen connection (10 or 12) at the fuel injection pump. Refer to illustration 59 .

Note: Fuel return line (11) may need to be removed in order to prime the fuel system.

5. Operate the fuel transfer pump. When fuel free from air flows from the connections tighten the connecting bolt. Stop the transfer pump.
6. The engine should now be able to start. Operate the starting motor in order to start the engine.

Note: Do not operate the starting motor for more than 15 seconds. If the engine does not start after 15 seconds, stop and wait for 30 seconds before trying again.

i02627223

Fuel System Primary Filter/ Water Separator - Drain

SMCS Code: 1260-543; 1263-543

⚠ 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
The water separator is not a filter. The water separator separates water from the fuel. The engine should never be allowed to run with the water separator more than half full. Engine damage may result.

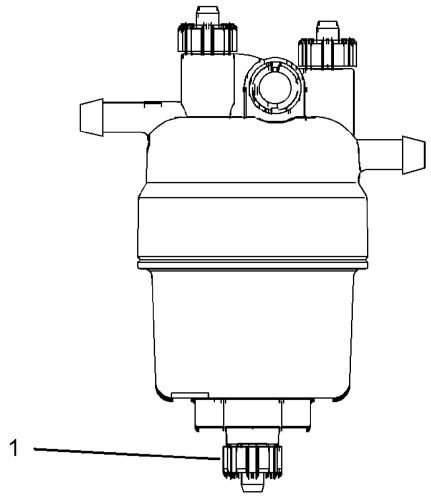

Illustration 60 g01316965
Typical example

1. Open drain (1). Catch the draining fluid in a suitable container. Dispose of the drained fluid correctly.
2. Close drain (1).

NOTICE
The water separator is under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

i02627769

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.

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.

Dispose of all fluids according to local regulations and mandates.

Fuel Filter with Canister

1. Close the fuel supply valve.

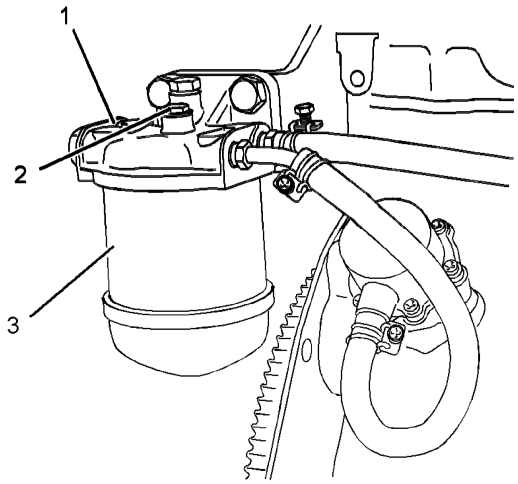

Illustration 61 g01307792
Typical example

2. Clean the outside of the fuel filter assembly (1).

3. Remove setscrew (2).

4. Remove the canister (3). Ensure that any fluid is drained into a suitable container.

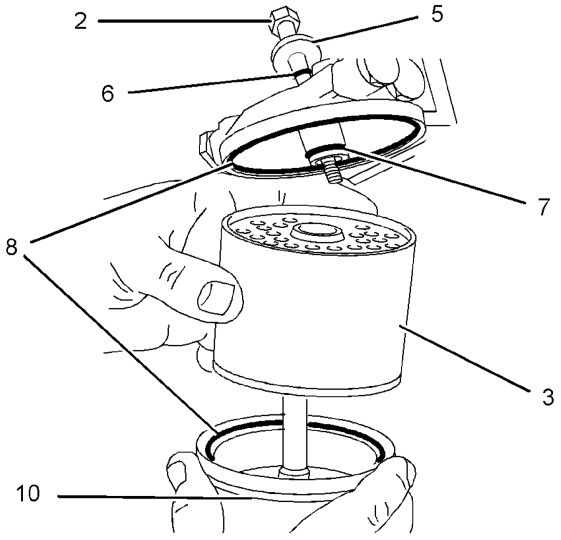

Illustration 62 g01334877
Typical example

5. Assemble the following items: seals (8), seal (7), canister (3) and bowl (10). Place washer (5) and seal (6) on setscrew (2).

6. Fasten the assembly to the fuel filter base with setscrew (2).

The fuel system will need to be primed after the new filter is installed. Refer to this Operation and Maintenance Manual, “Fuel System - Prime”.

Fuel Filter with Element

1. Close the fuel supply valve (1).

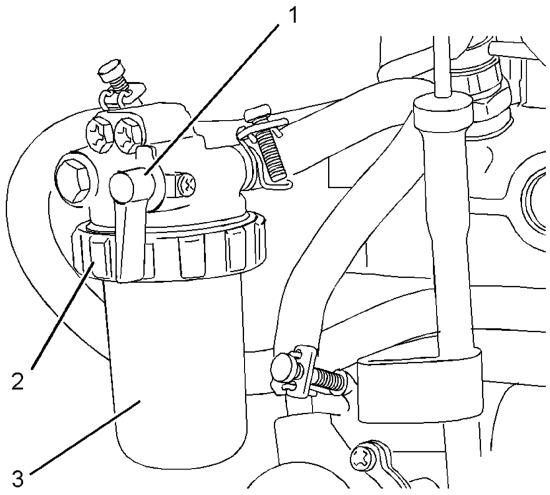

Illustration 63 g01334893
Typical example

2. Clean the outside of the fuel filter assembly.

3. Loosen locking ring (2).

4. Remove the casing for the filter (3) and the element. Ensure that any fluid is drained into a suitable container.

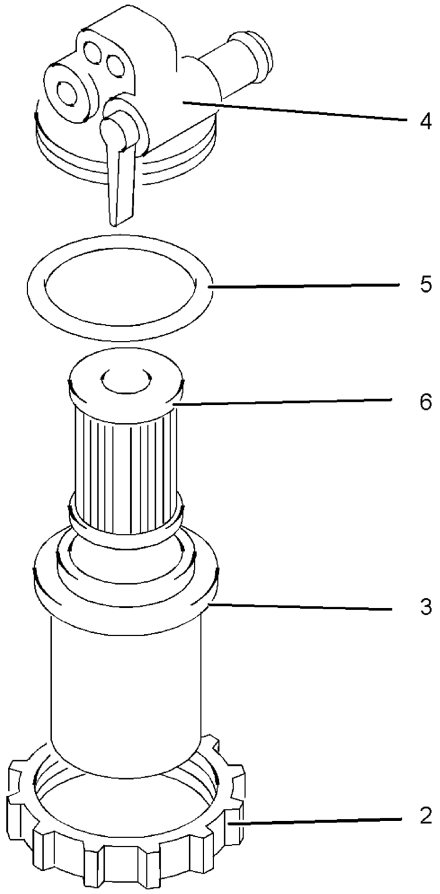

Illustration 64 g01334895
Typical example

5. Assemble the following items: seal (5), filter element (6) and casing (3).

Note: Do not fill the fuel filter with fuel. This fuel will not be filtered and the fuel could be contaminated. Contaminated fuel can damage the fuel system.

6. Install the assembled items to the filter base (4).

7. Install the locking ring (2) to the filter base. Rotate the locking ring in order to lock the assembly.

The fuel system will need to be primed after the new filter is installed. Refer to this Operation and Maintenance Manual, “Fuel System - Prime”.

Fuel filter with priming pump

1. Close the fuel supply valve.

2. Clean the outside of the fuel filter assembly.

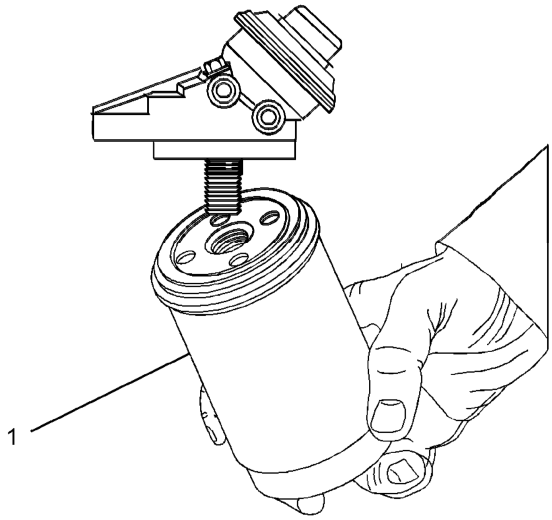

Illustration 65 g01306131
Typical example

3. Remove spin-on filter (1). Use a 1U-8760 Chain Wrench in order to remove the filter. Ensure that any fluid is drained into a suitable container.

Note: Do not fill the fuel filter with fuel. This fuel will not be filtered and the fuel could be contaminated. Contaminated fuel can damage the fuel system.

4. Install the new spin-on filter. Tighten the spin-on filter by hand.

The fuel system will need to be primed after the new filter is installed. Refer to this Operation and Maintenance Manual, “Fuel System - Prime”.

i06104305

Fuel Tank Water and Sediment - Drain

SMCS Code: 1273-543-M&S

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, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system. 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. The fuel tank utilizes a fuel tank vent to prevent an air lock or vacuum. Ensure that the vent is free of debris and not damaged.

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.

Prepare to catch water and sediment in an appropriate container. Connect a hose (if necessary) to the valve prior to opening the valve.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Note: Failure to close the drain properly could result in fuel leakage, which could have detrimental results to performance.

Check the fuel daily. Drain the water and sediment from the fuel tank after operating the engine. Drain the water and sediment from the fuel tank after the fuel tank has been filled. Allow 5 to 10 minutes before performing this procedure.

Fill the fuel tank after operating the engine in order to drive out moist air. This procedure 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 stand pipes that allow water and sediment to settle below the end of the fuel stand 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
- Refill of the tank

This procedure will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank. A four micron(c) absolute filter for the breather vent on the fuel tank is also recommended.

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.

i06104329

Hoses and Clamps - Inspect/ Replace

SMCS Code: 7554-040; 7554-510

Hoses and clamps must be inspected periodically and replaced at the recommended interval to ensure safe and continuous operation of the engine. Failure to replace a fuel hose at the recommended change interval may result in a hazardous situation. Take proper safety precautions before inspecting or replacing hoses and clamps.

Note: Always use a board or cardboard when the engine components are checked for leaks. Leaking fluid that is under pressure can cause serious injury or possible death. Leaks that are the size of a pin hole are included. Refer to Operation and Maintenance Manual, “General Hazard Information” for more information.

Note: Ensure that the hose is compatible with the application.

Inspect the Hoses and the Clamps

Inspect all hoses for leaks that are caused by the following conditions. Replace any hose which exhibits any of the following conditions. Failure to replace a hose which exhibits any of the following conditions may result in a hazardous situation.

- Hoses which are cracked
- Hoses which are soft
- 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
- Hoses which exhibit signs of leakage which are not the result of loose couplings or clamps

Inspect all clamps for the following conditions. Replace any clamp which exhibits signs of any of the following conditions.

- Cracking
- Looseness
- Damage

Inspect all couplings for leaks. Replace any coupling which exhibits signs of leaks.

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

Due to extreme temperature changes, the hose will heat set. Heat setting causes hose clamps to loosen which can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Replace hoses that are cracked or soft. Replace hoses that show signs of leakage. Replace hoses that show signs of damage. Replace hose clamps that are cracked or damaged. Tighten or replace hose clamps which are loose.

Replace the Hoses and the Clamps

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, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Cooling System

⚠ 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.

⚠ WARNING

Personal injury can result from removing hoses or fittings in a pressure system.

Failure to relieve pressure can cause personal injury.

Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.

1. Stop the engine.
2. Allow the engine to cool.
3. Before servicing a coolant hose, slowly loosen the filler cap for the cooling system in order to relieve any pressure.
4. Remove the filler cap for the cooling system.

5. Drain the coolant from the cooling system to a level that is below the hose that is being replaced. Drain the coolant into a suitable clean container. The coolant can be reused.
6. Remove the hose clamps.
7. Disconnect the old hose.
8. Replace the old hose with a new hose.
9. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.
10. Refill the cooling system.
11. Clean the coolant filler cap. Inspect the gaskets on the filler cap. Inspect the gasket seat. Inspect the vacuum valve and seat for debris or damage. Replace the filler cap if the gaskets are damaged. Install the filler cap.
12. Start the engine. Inspect the cooling system for leaks.

Fuel System

⚠ WARNING

Personal injury can result from removing hoses or fittings in a pressure system.

Failure to relieve pressure can cause personal injury.

Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

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.

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 any disconnected fuel system components.

Note: High-pressure fuel lines may be installed between the high-pressure fuel pump and the fuel injectors. High-pressure fuel lines are constantly charged with high pressure. Do not check the high-pressure fuel lines with the engine or the starting motor in operation. Wait for 10 minutes after the engine stops before you perform any service or repair on high-pressure fuel lines. Waiting for 10 minutes will to allow the pressure to be purged.

1. Drain the fuel from the fuel system to a level that is below the hose that is being replaced.
2. Remove the hose clamps.
3. Disconnect the old hose.

Note: When servicing fuel system, use cap/s or cover/s as required to protect the system and maintain fuel system cleanliness.

4. Replace the old hose with a new hose.
5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.
6. Carefully inspect the engine for any spilled fuel. Make sure that no fuel remains on or close to the engine.

Note: Fuel must be added to the fuel system ahead of the fuel filter.

7. Refill the fuel system. Refer to this Operation and Maintenance Manual, “Fuel System - Prime” for information about priming the engine with fuel.
8. Start the engine. Inspect the fuel system for leaks.

Lubrication System

⚠ WARNING

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

1. Drain the oil from the lubrication system to a level that is below the hose that is being replaced.
2. Remove the hose clamps.

3. Disconnect the old hose.
4. Replace the old hose with a new hose.
5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.
6. Refill the lubrication system. Refer to this Operation and Maintenance Manual, “Engine Oil Level - Check” in order to ensure that the lubrication system is filled with the proper amount of engine oil.
7. Start the engine. Inspect the lubrication system for leaks.

Air System

1. Remove the hose clamps.
2. Disconnect the old hose.
3. Replace the old hose with a new hose.
4. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.

Note: The bellows and the V-clamps that are used on the exhaust bellows should never be reused.

5. Start the engine. Inspect the air lines for leaks.

i02677504

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 Recommendation

Caterpillar recommends replacement of the engine. For more information about replacement of the engine, see your Caterpillar dealer. Engine components are available in a standard size only.

Cleaning

Caterpillar recommends the use of Hydrosolv Liquid Cleaners. Table 31 lists the Hydrosolv Liquid Cleaners that are available from your Caterpillar dealer.

Table 31

HydrosolvLiquid 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)

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 I).

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 II).

S·O·S Coolant Analysis (Level II)

An S·O·S Coolant Analysis (Level II) is a comprehensive coolant analysis which completely analyzes the coolant and the effects on the cooling system. An S·O·S Coolant Analysis (Level II) provides the following information:

- Complete S·O·S Coolant Analysis (Level I)
- 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 II) provides a report of the results of both the analysis and the maintenance recommendations.

For more information about coolant analysis, see your Caterpillar dealer.

i04020194

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.

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded.

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the 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 movement 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 procedure 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.

i00151038

Severe Service Application - Check

SMCS Code: 1000-535

Severe service is an application of an engine that exceeds current published standards for that engine. Caterpillar maintains standards for the following engine parameters:

- Performance (power range, speed range and fuel consumption)
- Fuel quality
- Altitude range
- Maintenance intervals

- Oil selection and maintenance
- Coolant selection and maintenance
- Environmental qualities
- Installation

Refer to the standards for the engine or consult with your Caterpillar dealer in order to determine if the engine is operating within the defined parameters.

Severe service operation can accelerate component wear. Engines that operate under severe conditions may need more frequent maintenance intervals in order to ensure maximum reliability and retention of full service life.

Due to individual applications, it is not possible to identify all of the factors which can contribute to severe service operation. Consult your Caterpillar dealer for the unique maintenance that is necessary for the engine.

The operating environment, improper operating procedures and improper maintenance procedures can be factors which contribute to severe service conditions.

Environmental Factors

Ambient temperatures – The engine may be exposed to extended operation in extremely cold environments or hot environments. Valve components can be damaged by carbon buildup if the engine is frequently started and stopped in very cold temperatures. Extremely hot inlet air reduces engine performance.

Air Quality – The engine may be exposed to extended operation in an environment that is dirty or dusty, unless the equipment is cleaned regularly. Mud, dirt and dust can encase components. Maintenance can be very difficult. The buildup can contain corrosive chemicals.

Buildup – Compounds, elements, corrosive chemicals and salt can damage some components.

Altitude – Problems can arise when the engine is operated at altitudes that are higher than the intended settings for that application. Necessary adjustments should be made.

Improper Operating Procedures

- Extended operation at low idle
- Frequent hot shutdowns
- Operating at excessive loads
- Operating at excessive speeds
- Operating outside the intended application

Improper Maintenance Procedures

- Extending the maintenance intervals
- Failure to use recommended fuel, lubricants and coolant/antifreeze

i00651416

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.

i02226957

Turbocharger - Inspect (If Equipped)

SMCS Code: 1052; 1052-040

A regular visual inspection of the turbocharger is recommended. Any fumes from the crankcase are filtered through the air inlet system. Therefore, by-products from oil and from combustion can collect in the turbocharger compressor housing. Over time, this buildup can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel can cause additional damage to the pistons, the valves, and the cylinder head.

NOTICE
Turbocharger bearing failures can cause large quantities of oil to enter the air intake and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of oil into a turbocharger under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occured.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is renewed.

A visual inspection of the turbocharger can minimize unscheduled downtime. A visual inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Removal and Installation

Note: The turbochargers that are supplied are nonserviceable.

For options regarding the removal, installation, repair and replacement, consult your Caterpillar dealer. Refer to the Service Manual for this engine for the procedure and specifications.

Inspecting

NOTICE
The compressor housing for the turbocharger must not be removed from the turbocharger for cleaning.

The actuator linkage is connected to the compressor housing. If the actuator linkage is moved or disturbed the engine may not comply with emmissions legislation.

1. Remove the pipe from the turbocharger exhaust outlet and remove the air intake pipe to the turbocharger. Visually inspect the piping for the presence of oil. Clean the interior of the pipes in order to prevent dirt from entering during reassembly.
2. Check for the presence of oil. If oil is leaking from the back side of the compressor wheel, there is a possibility of a failed turbocharger oil seal.

   The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the intake air (clogged air filters), which causes the turbocharger to slobber.
3. Inspect the bore of the housing of the turbine outlet for corrosion.
4. Fasten the air intake pipe and the exhaust outlet pipe to the turbocharger housing.

i00632301

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.

i02226958

Water Pump - Inspect

SMCS Code: 1361-040; 1361

A failed water pump may cause severe engine overheating problems that could result in the following conditions:

- Cracks in the cylinder head
- A piston seizure
- Other potential damage to the engine

Note: The water pump seal is lubricated by the coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and parts contract.

Visually inspect the water pump for leaks. Renew the water pump seal or the water pump if there is an excessive leakage of coolant. Refer to the Disassembly and Assembly Manual, “Water Pump - Remove and Install” for the disassembly and assembly procedure.

Warranty Section

Warranty Information

i05549472

Emissions Warranty Information

SMCS Code: 1000

The certifying engine manufacturer warrants to the ultimate purchaser and each subsequent purchaser that:

1. New non-road diesel engines and stationary diesel engines less than 10 liters per cylinder (including Tier 1 and Tier 2 marine engines < 37 kW, but excluding locomotive and other marine engines) operated and serviced in the United States and Canada, including all parts of their emission control systems (“emission related components”), are:

a. Designed, built, and equipped so as to conform, at the time of sale, with applicable emission standards prescribed by the United States Environmental Protection Agency (EPA) by way of regulation.

b. Free from defects in materials and workmanship in emission-related components that can cause the engine to fail to conform to applicable emission standards for the warranty period.

2. New non-road diesel engines (including Tier 1 and Tier 2 marine propulsion engines < 37 kW and Tier 1 through Tier 4 marine auxiliary engines < 37 kW, but excluding locomotive and other marine engines) operated and serviced in the state of California, including all parts of their emission control systems (“emission related components”), are:

a. Designed, built, and equipped so as to conform, at the time of sale, to all applicable regulations adopted by the California Air Resources Board (ARB).

b. Free from defects in materials and workmanship which cause the failure of an emission-related component to be identical in all material respects to the component as described in the engine manufacturer's application for certification for the warranty period.

The aftertreatment system can be expected to function properly for the lifetime of the engine (emissions durability period) subject to prescribed maintenance requirements being followed.

A detailed explanation of the Emission Control Warranty that is applicable to new non-road and stationary diesel engines, including the components covered and the warranty period, is found in a supplemental Special Publication. Consult your authorized Cat dealer to determine if your engine is subject to an Emission Control Warranty and to obtain a copy of the applicable Special Publication.

Reference Information Section

Engine Ratings

i00727327

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 .849 at 15 °C (60 °F)
- Density of 850 kg/m^3 (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).

i00819749

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 cursers, 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.

NOTICE
Operating engines above the rating definitions can result in shorter service life before overhaul.

Customer Service

i03910306

Customer Assistance

SMCS Code: 1000

USA and Canada

When a problem arises concerning the operation or 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, use the phone number that is listed below to talk with a Field Service Coordinator:

   1-800-447-4986

   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 AC
   P.O. Box 610
   Mossville, Illinois 61552-0610

   Please keep in mind: probably, your problem will ultimately be solved at the dealership, using the dealership 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, Carribean
Caterpillar Americas Co.
701 Waterford Way, Suite 200
Miami, FL 33126-4670
USA
Phone: 305-476-6800
Fax: 305-476-6801

Europe, Africa, and Middle East
Caterpillar Overseas S.A.
76 Route de Frontenex
P.O. Box 6000
CH-1211 Geneva 6
Switzerland
Phone: 22-849-4444
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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
G.P.O. Box 3069
Hong Kong
Phone: 852-2848-0333
Fax: 852-2848-0440

Japan
Shin Caterpillar Mitsubishi Ltd.
SBS Tower
10-1, Yoga 4-Chome
Setagaya-Ku, Tokyo 158-8530
Japan
Phone: 81-3-5717-1150
Fax: 81-3-5717-1177

Japan
Caterpillar Power Systems, Inc.
SBS Tower (14th floor)
4-10-1, Yoga
Setagaya-Ku, Tokyo 158-0097
Phone: 81-3-5797-4300
Fax: 81-3-5797-4359

Australia and New Zealand
Caterpillar of Australia Ltd.
1 Caterpillar Drive
Private Mail Bag 4
Tullamarine, Victoria 3043
Australia
Phone: 03-9953-9333
Fax: 03-9335-3366

i01028392

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

i02627762

Reference Material

SMCS Code: 1000

The following literature can be obtained through any Caterpillar dealer.

Lubricants

- Special Publication, PEHP8038, “Data Sheet - Caterpillar Diesel Engine Oils (DEO) (CH-4) (North America)”
- Special Publication, PEHP9536, “Data Sheet - Caterpillar Diesel Engine Oil (DEO) (CF-4) (International only)”
- Special Publication, NEDG6022, “Cat Lubricating Grease”
- Special Publication, PEHP0002, “Data Sheet - Molybdenum (MPGM) Grease”
- Special Publication, NEHP6015, “Data Sheet - Caterpillar Special Purpose Grease (SPG)”
- Special Publication, SEBD0640, “Oil and Your Engine”
- Operation and Maintenance Manual, SEBU5898, “Cold Weather Recommendations”
- Operation and Maintenance Manual, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recomendations”
- Special Publication, PEHP6001, “How To Take A Good Oil Sample”

Fuels

- Special Publication, SEBD0717, “Diesel Fuels and Your Engine”

Coolants

- Special Publication, PEHP4036, “Data Sheet - Extended Life Coolant”
- Special Publication, PEHP7057, “Data Sheet - S·O·S Coolant Analysis”
- Special Publication, SEBD0518, “Know Your Cooling System”
- Special Publication, SEBD0970, “Coolant and Your Engine”
- Label, PEEP5027, “Extended Life Coolant/ Antifreeze”

Miscellaneous

- Service Manual, REG1139F, “Service Manual Contents Microfiche”
- Service Manual, KENR6925, “C0.5, C0.7, C1.1, C1.5, C1.6 and C2.2 Industrial Engines”
- Systems Operation, Testing and Adjusting, KENR6228, “C0.5, C0.7, C1.1, C1.5, C1.6 and C2.2 Industrial Engines”
- Specifications, KENR6227, “C0.5, C0.7, C1.1, C1.5, C1.6 and C2.2 Industrial Engines.”
- Disassembly and Assembly, KENR6229, “C0.5, C0.7, C1.1, C1.5, C1.6 and C2.2 Industrial Engines”
- Specifications, SENR3130, “Torque Specifications”
- Special Publication, PECP9067, “One Safe Source” English language for use in NACD
- Special Publication, LEDM5615, “Caterpillar Marine Parts and Service Locations Directory”
- Special Publication, SEBF8029, “Index to Guidelines for Reusable Parts and Salvage Operations”
- Special Publication, SEBF8062, “Procedure to Inspect and Clean Air Filters”
- Special Instruction, SEHS9031, “Storage Procedure for Caterpillar Products”
- Special Publication, NEHS0526, “Service Technician Application Guide”
- Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recomendations”
- Special Instruction, SEHS7633, “Battery Test Procedure”

- Label, SEHS7332, “Danger 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, SMBU6981, “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.

i02780825

Additional Reference Material

SMCS Code: 1000

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 Varembé
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 Counseil 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

i05264255

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 various other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is managed. Accurate maintenance records can help your Cat 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 repair costs
- Owner receipts
- Maintenance log

i01176304

Maintenance Log

SMCS Code: 1000

Table 32

Engine Model		**Customer Identifier**		
Serial Number		**Arrangement Number**		
Service Hours	**Quantity Of Fuel**	**Service Item**	**Date**	**Authorization**

(continued)

(Table 32, contd)

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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:	_____	_____	_____

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OPERATORS MANUAL

Comet Manual

Section 3

STG GLOBAL

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   - g. Crankcase Maintenance
   - h. Crankcase Reassembly

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1. SAFETY INSTRUCTIONS, OPERATING PROCEDURES AND LIMITS

1.1 Start-up Information

a. *LUBRICATION:* Make sure crankcase is filled with Comet Pump oil. Running this pump without oil will cause damage and void any warranties. Change the pump oil after the initial 50 hours of operation. Change oil every 500 hours after the initial oil change. The oil level of the pump can be checked by removing the oil cap and inspecting the dip stick. The correct level should fall between the min and max lines on the dip stick.

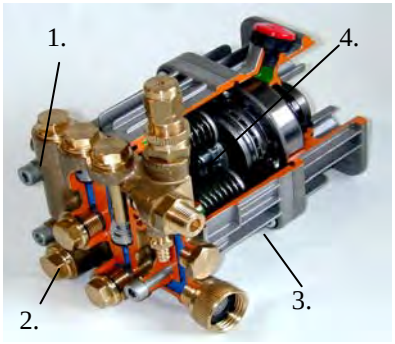
b. *WET END:* The Comet Pump should never be run dry. Running the pump dry will cause premature wear on the seals, packing and plungers. Running the pump dry for a prolonged period of time may cause damage that cannot be repaired. Do not start a pump with frozen water in the manifold.

c. *STORAGE:* If there is a risk of freezing, run antifreeze through the pump. Empty any extra liquid inside the pump by running the pump without water for no more than 20 seconds.

2. TORQUE SETTING CHARTS

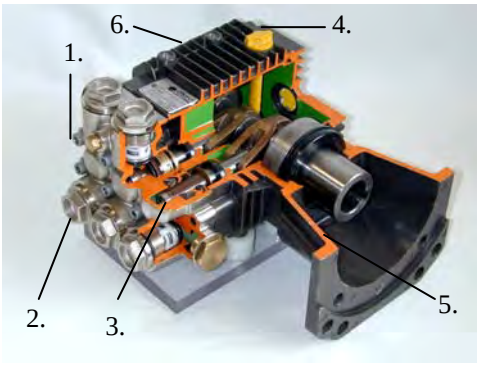
2.1 AXD Series Pump

POSITION#	TORQUE SETTING	FLUID TO BE USED
1	18 FT/LB	
2	33 FT/LB	LOCTITE 243
3	18 FT/LB	
4	18 FT/LB	LOCTITE 243



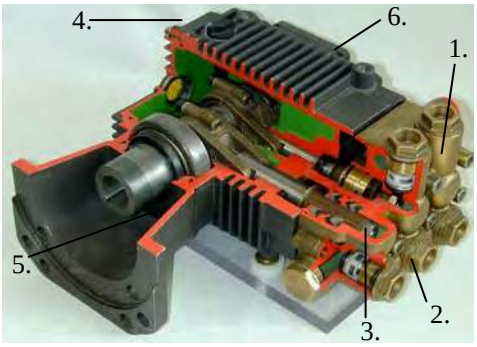
2.2 LW/ZW Series Pump

POSITION#	TORQUE SETTING	FLUID TO BE USED
1	7.5 FT/LB	
2	37 FT/LB	LOCTITE 542
3	4.5 FT/LB	LOCTITE 542
4	6.5 FT/LB	
5	6.5 FT/LB	
6	5.5 FT/LB	



2.3 FW/HW Series Pump

POSITION#	TORQUE SETTING	FLUID TO BE USED
1	18 FT/LB	
2	37 FT/LB	LOCTITE 542
3	7 FT/LB	LOCTITE 542
4	3 FT/LB	
5	18 FT/LB	
6	6 FT/LB	



3. TROUBLE SHOOTING GUIDE

SYMPTOMS	CAUSES	REMEDIES
The pump does not start	Air suction	Control inlet device
	Closed lance	Open the lance
Irregular pressure vibration	Pump sucking air	Check that there is no water leaking as it enters the pump
	Nozzle inadequate or worn	Clean and/or replace nozzle
	Worn, dirty/blocked valves	Replace check valves
Irregular pump pressure	Pump sucking air	Check that there is no water leaking as it enters the pump
	Blocked nozzle	Clean and/or replace nozzle
	Air in pump	Pull the trigger to release air in system
	Water inlet filter blocked	Clean filter
	Inadequate water supply	Make sure tap is completely open and/or connect to a tap that has adequate flow rate
	Worn, dirty/blocked valves	Replace check valve
	Worn packing	Install new seal kit
Drop in pressure	Worn nozzle	Replace the nozzle
	Dirty or blocked valves	Replace check valves
	Worn packing	Install new seal kit
Excessive noise	Pump sucking air	Check that there is no water leaking as it enters the pump
	Blocked suction	Inspect filter and inlet supply
	Water temperature is too hot	Max water temp must not exceed 145° F
	Worn, dirty/blocked valves	Replace check valves
	Worn bearings	Replace bearing
Water leak from head	Worn packing	Install new seal kit
Oil leak	Oil seals worn	Install new oil seals

4. MAINTENANCE SCHEDULE

OPERATION	Every 8 hours	Every 50 hours	Every 500 hours
Check oil level	X		
Check tubes-fittings		X	
Check & clean inlet filter		X	
Control pump connection to the engine		X	
Change oil		X –FIRST CHANGE	X
Check suction/delivery valves			X
Check pump bolt and nut setting			X
Check regulation valve			X

5. PUMP SPECIFICATION AND TECHNICAL DATA

5.1 Pump Identification Model#

	Positions:	1.	2.	3.	4.	5.
a.	Model#: eg.	AX	D	30	20	G

POSITIONS:

1. Model:
   - AX: radial axial
   - LW: small frame
   - ZW: medium duty
   - FW: heavy duty
   - HW super duty
2. RPM
   - D: 3400 RPM
   - S: 1750 RPM
   - -: 1450 RPM
3. GPM eg.55: 5.5 GPM
4. PSI eg. 30: 3000 PSI
5. Flange:
   - G: Gasoline engine mounting flange ¾" or 1"
   - E: Electric Motor Mounting Flange 5/8" or 1 1/8"
   - S: Solid Shaft 24mm

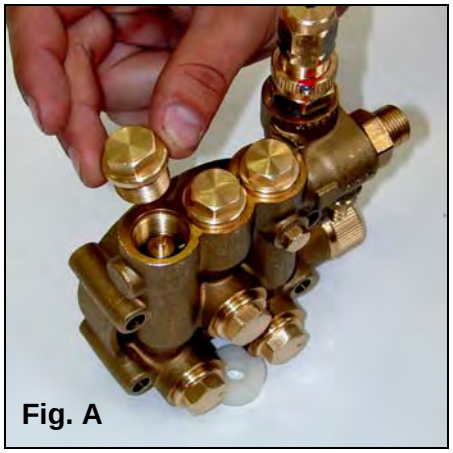


Fig. A

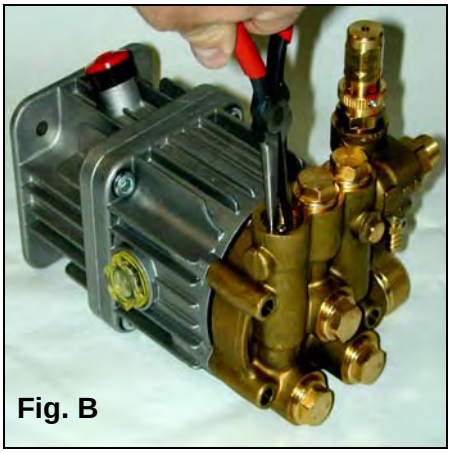


Fig. B

Fig. C

6. PUMP SERVICE GUIDE

6.1. AXD Series Pump

A. Valve Maintenance

1. Using a 17mm wrench, remove the six valve caps on manifold of pump. **(Fig. A)**
2. Examine the valve cap o'ring for cuts or distortions. Replace if worn.
3. Using a needle nose pliers, remove the riser tube and/or suction and delivery check valve. **(Fig B)** The valve assembly usually stays together when removing. If the valve comes apart, use a needle nose pliers or a reverse pliers. Remove the o'ring and replace if worn or damaged.
4. Inspect the suction and delivery check valve assembly for general wear and replace if necessary. The valve assembly consists of the plastic cage, spring, valve seat, poppet and o'ring. **(Fig. C)** One Comet valve kit is needed for a complete valve change in one pump.
5. Replace old valves by placing assembly in the valve chamber. Replace riser tube on top of the check valve where necessary. Press down firmly on the top of valve assembly or riser tube with your finger. **(Fig. D)**
6. Replace valve caps by applying LOCTITE 243 to valve cap and torque to 33 ft. lbs.

B. Removing & Replacing Pump Manifold

1. Using a 6mm allen head wrench, remove the four head bolts. **(Fig. E)**
2. With the pump firmly secured, take two medium sized flat head screwdrivers and apply pressure to the manifold by prying between crankcase and manifold. **(Fig. F)** Work around from all sides of the manifold evenly until it comes off of the pistons. Keep manifold properly aligned with the crankcase to prevent damage to the seals and pistons.
3. When replacing the manifold, lubricate the pistons and cylinders with grease. Evenly press the manifold toward crankcase until flush.

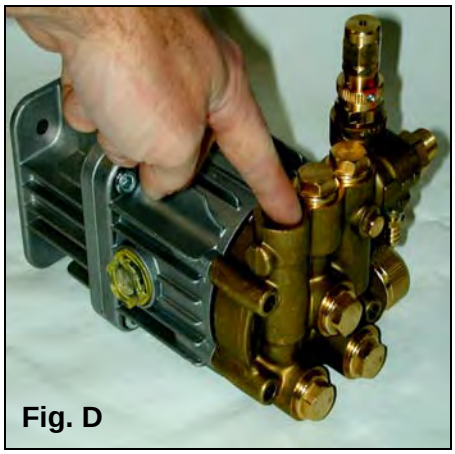


Fig. D

Fig. E

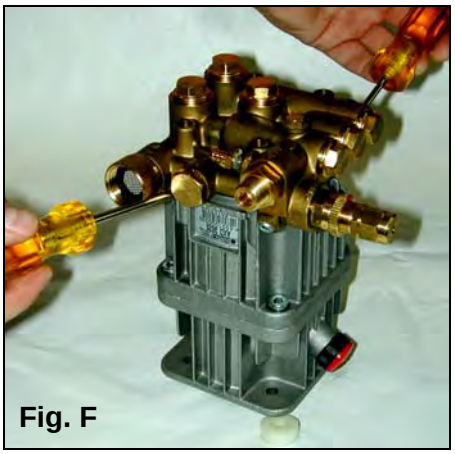


Fig. F

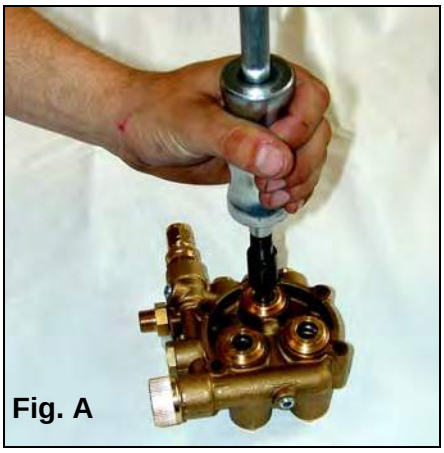


Fig. A

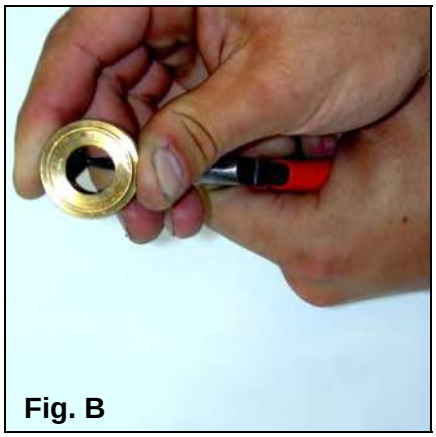


Fig. B

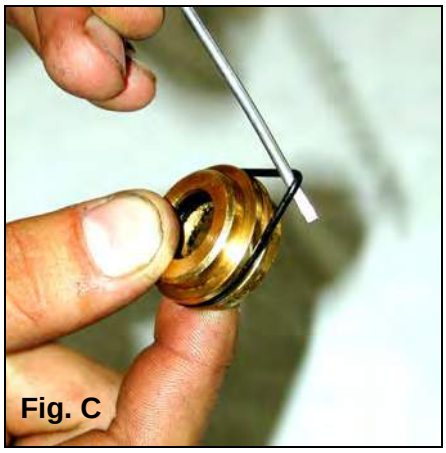


Fig. C

C. Seals and V-Packing Maintenance

1. Remove the manifold as described in section 6.1-B. It is possible that the seal and brass retainer ring assembly stays on the piston or remains in the manifold when removing.
2. Using the packing extraction tool & slide hammer, remove the brass retainer ring/seal stack. **(Fig. A)** Remove the low-pressure seal using a needle nose pliers. **(Fig. B)** Once this seal is removed, replace with a new seal.
3. Remove the outer o'ring by taking a small flat head screwdriver and working your way under the o'ring and simply roll off. **(Fig. C)**
4. The V-packing stack can be taken apart by hand.

D. Seals and V-Packing Reassembly

1. Generously lubricate the parts when reassembling. Examine brass components for any damage or water residue build-up.
2. Insert low-pressure seal using Comet repair tools. **(Fig. D)** Place the brass retainer ring on stand **(Fig. D-1).** Place tapered stainless steel cylinder **(Fig. D-2)** on top of brass retainer ring with the tapered narrow end on the brass retainer. Insert a new low-pressure seal, closed side facing up, on top of tapered stainless steel cylinder so it lays flat across the top. **(Fig. E)** Gently push the seal down through the tapered cylinder using plastic insertion tool **(Fig. D-3.)** Switch to smaller diameter plastic insertion tool **(Fig. D-4)** to push the seal into its seat inside the brass retainer ring. **(Fig. F)**
3. Replace the outer o'ring by simply starting on one side and working it into the groove.
4. Stack the V-packing in correct order and firmly press assembly into the manifold.
5. Install a new oil seal by laying the seal into the opening and evenly pressing it into place.
6. Reinstall the manifold onto the pump as described in section 6.1-B.

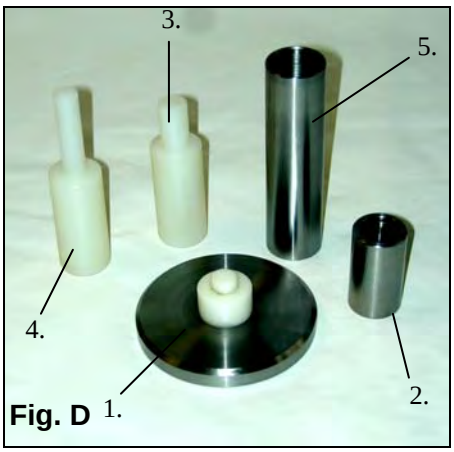


Fig. D

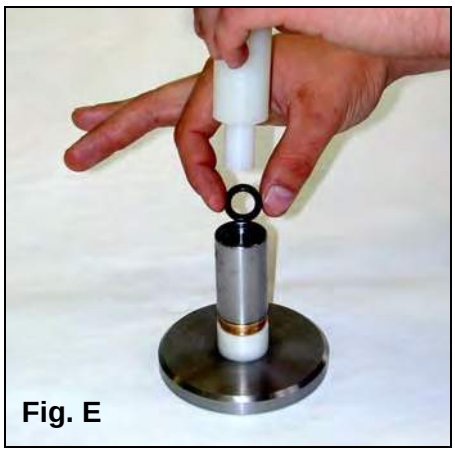


Fig. E

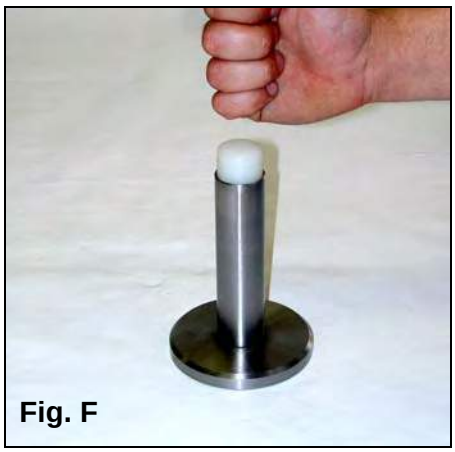


Fig. F

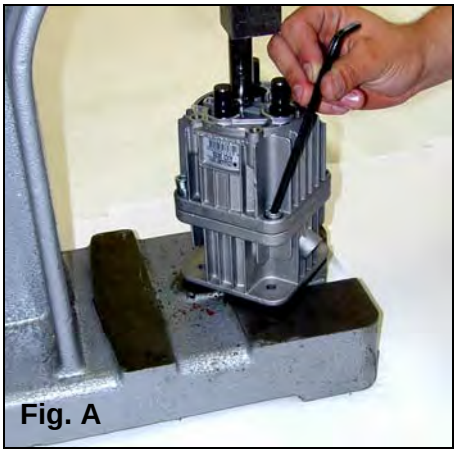
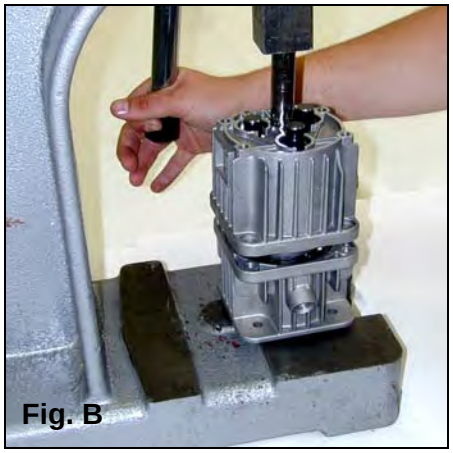


Fig. A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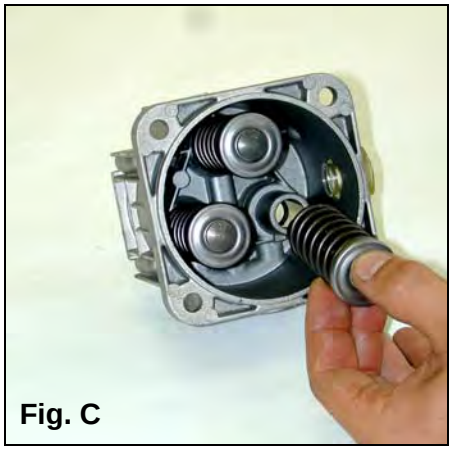


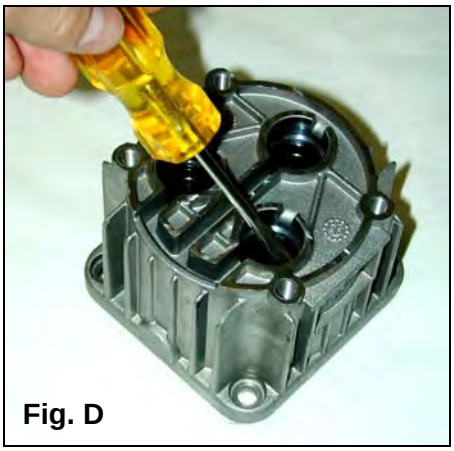
Fig. C

E. Plunger Maintenance

1. Remove the manifold as described in section 6.1-B.
2. Remove the 6mm allen bolts securing the two halves of the crankcase. **(Fig. A)** There are piston return springs energized within the crankcase. When removing the bolts, the two halves of the pump must be held together with a press or something equivalent to keep from springing apart.
3. Once all four bolts are removed, the pump will want to spring apart due to the pressure from the springs. **(Fig. B)**
4. Remove the pistons by pulling down from the inside of the crankcase with your hand. **(Fig. C)**
5. To service the oil seal, take a small flat head screwdriver and apply pressure at a slight side and downward angle. **(Fig. D)** One side of the seal will pop up and can be easily removed.
6. Inspect ceramic piston & all parts for wear. Replace if worn. **(Fig. E)**

F. Plunger Reassembly

1. Slide the piston assembly through the crankcase piston holes. **(Fig. C)** Be certain not to damage or displace the oil seal during this process.
2. With pistons, springs & rings in place, take the two halves of the pump crankcase and press together aligning the four bolt holes. Secure the two halves with the four 6mm allen bolts. **(Fig. B)**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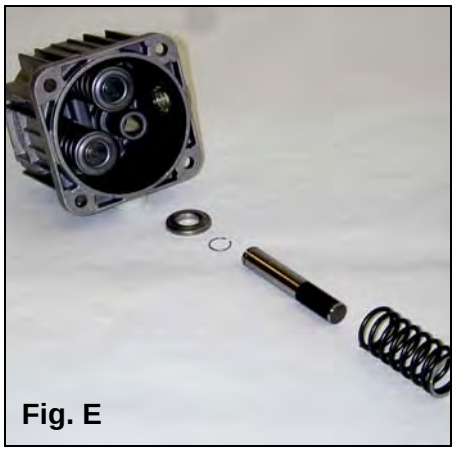


Fig. E

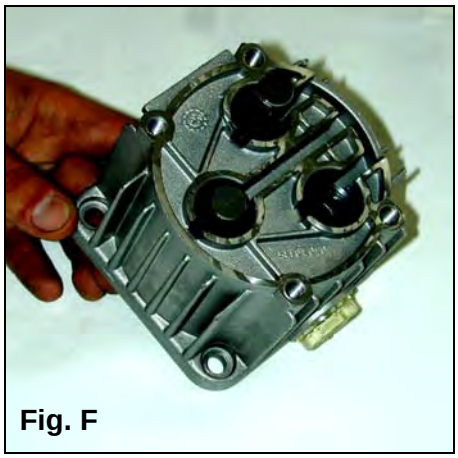


Fig. F

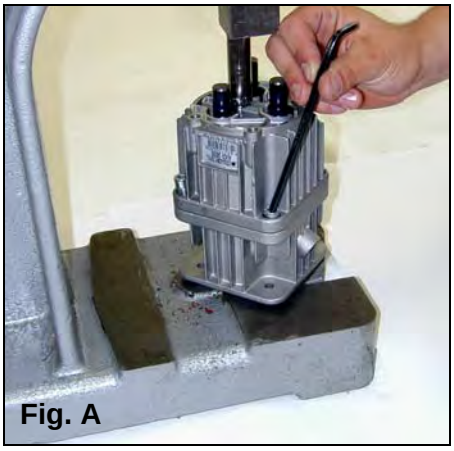


Fig. A

Fig. B

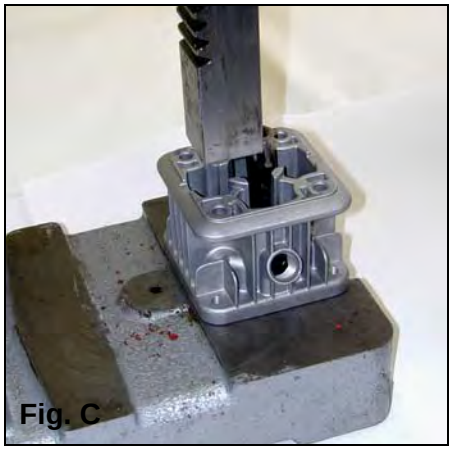


Fig. C

G. Crankcase Maintenance

1. Unscrew the four hex bolts and take the two halves apart as shown in section 6.1-D. There are internal springs pushing these two sections apart. Place the pump in a press, or something equivalent, to keep the two halves from springing apart when the bolts are removed. **(Fig. A)**
2. Once the crankcase is apart, the shaft and bearings are exposed. The components fit on top of each other in order according to the parts breakdown manual. **(Fig. B)**
3. Remove thrust bearing, axial bearing by hand.
4. Remove angled eccentric shaft by removing 6mm bolt with an allen wrench and lifting off.
5. Remove the crankshaft using an industrial press. Gently tap the end of the shaft until shaft releases from the crankcase. **(Fig. C)** The bearing usually comes out with the shaft. To remove the shaft from the bearing, support both sides of bearing and press or tap shaft out of the bearing.
6. Remove oil seal by working around the edges with a small flat-headed screwdriver. Lift out once completed. Replace the oil seal once it is removed.

H. Crankcase Reassembly

1. Assemble shaft/bearing assembly. Stack all of the shaft & bearing components. Secure using the 6mm allen bolt & wrench. Place LOCTITE 243 on the bolt before threading. Torque to 18 ft. lbs. **(Fig. D)**
2. Insert large bearing into crankcase. Lubricate and press into place.
3. Insert lubricated shaft into bearing and press into place. **(Fig. E)**
4. Assemble the piston guide, spring, washer & snap ring. Slide the piston assembly into the piston holes as explained in 6.1-E.
5. Press the two halves of the crankcase together compressing the springs. Secure the 6mm bolts with an allen key. Torque to 18 ft. lbs. **(Fig. A)**

I. Unloader Maintenance

1. To service the unloader, simply take a 22mm wrench and remove the cartridge just above the manifold. **(Fig. F)** Remove this piece and replace it with new unloader cartridge Comet part# 1215.0271.00

Fig. D

Fig. E

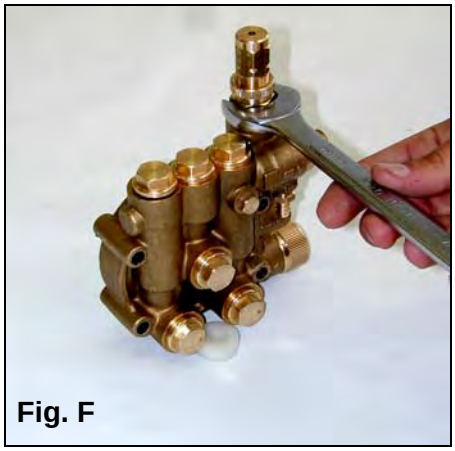


Fig. F

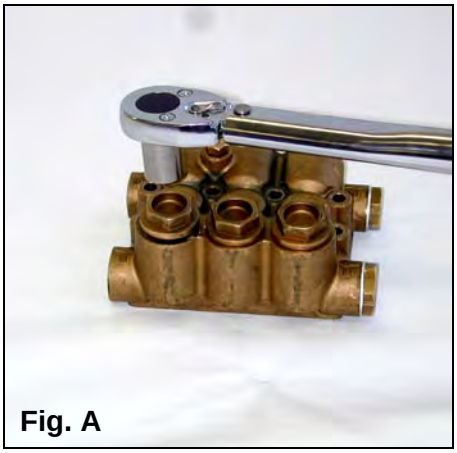


Fig. A

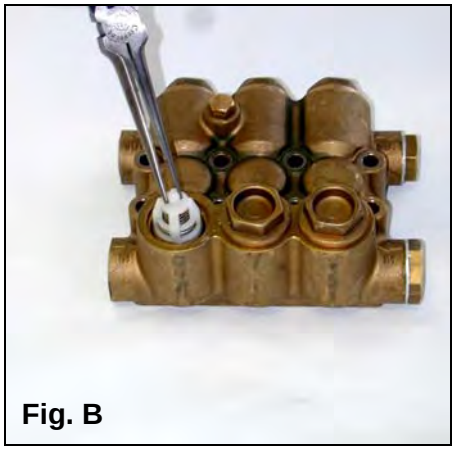


Fig. B

Fig. C

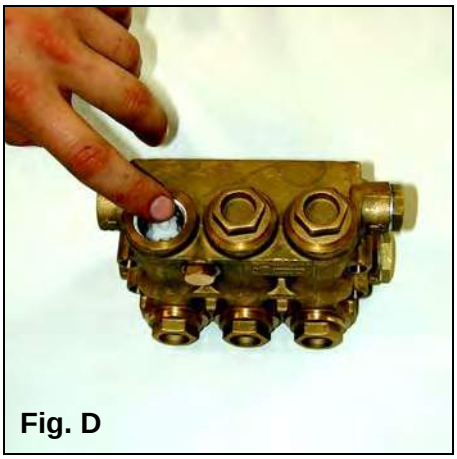
6.2 LW/ZW SERIES PUMP

A. Valve Maintenance

1. Using a 22mm wrench or socket, remove the six valve caps on manifold of pump. **(Fig. A)**
2. Examine the valve cap o'ring for cuts or distortions and replace if worn.
3. Using a needle nose pliers, remove the suction and delivery check valve. The valve assembly usually stays together when removing. If the valve comes apart, use a needle nose pliers or a reverse pliers to remove the remaining parts. **(Fig. B)**
4. Inspect the suction and delivery check valve assembly for general wear and replace if necessary. The valve assembly consists of the plastic cage, spring, valve seat, poppet and o'ring. **(Fig C)** One Comet valve kit is needed for complete valve change of one pump.
5. Replace old valves with new valves by placing assembly in the valve chamber. Press down firmly on the top of the valve assembly. **(Fig. D)**
6. Replace valve caps by applying LOCTITE 243 to valve cap and torque to 33 ft. lbs.

B. Removing & Replacing Pump Manifold

1. Remove the manifold of the pump by taking a 5mm allen head wrench and removing the eight head bolts.
2. With the pump firmly secured, take a medium sized flat head screwdriver and apply pressure to the manifold by prying between the crankcase and manifold. Work around from all sides of the manifold evenly until it comes off of the pistons. Keep manifold properly aligned with the pistons to prevent damage to the seals and pistons. **(Fig. E)**
3. When replacing the manifold, turn crankshaft of pump until the top of pistons are closely aligned. Lubricate the pistons and cylinders with grease and evenly press the manifold toward crankcase until flush. **(Fig. F)**



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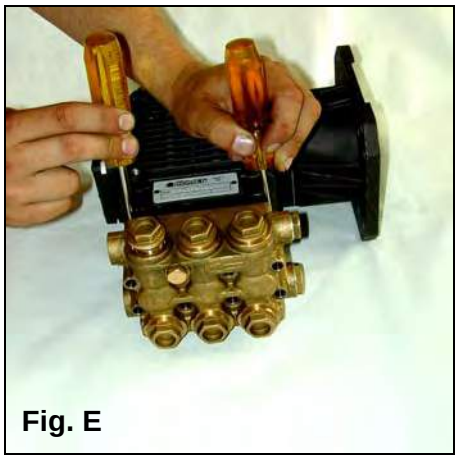
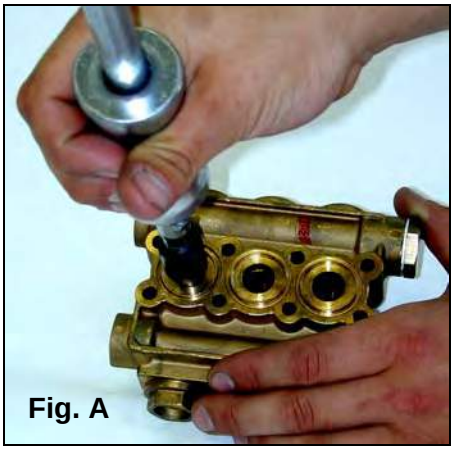


Fig. E

Fig. F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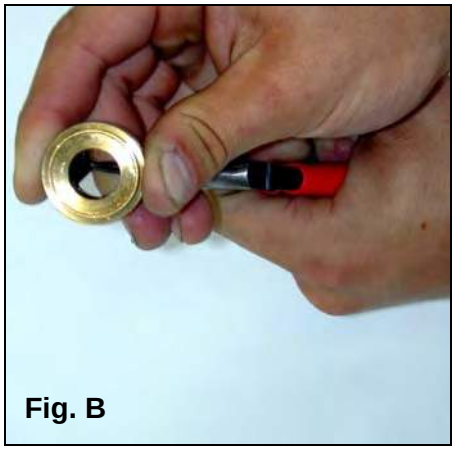


Fig. B

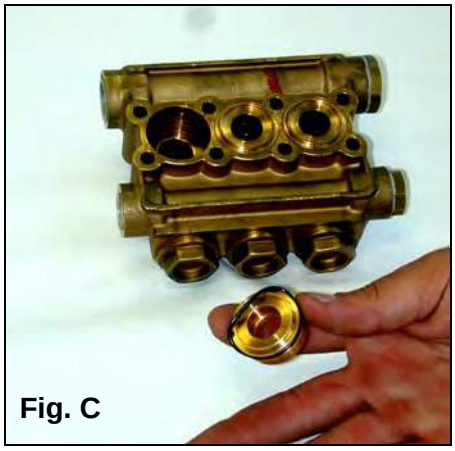


Fig. C

C. Seals and V-Packing Maintenance

1. Remove the manifold as described in section 6.2-B. It is possible that the seal and brass retainer ring assembly stays on the piston or remains in the manifold when removing.
2. Using the packing extraction tool, remove the brass retainer ring/seal stack. **(Fig. A)** Remove the low-pressure seal using a needle nose pliers. **(Fig. B)** Once this seal is removed, replace with a new seal.
3. Remove the outer o'ring by taking a small flat head screwdriver and working it under the o-ring. Simply roll off the o'ring. **(Fig. C)**
4. The V-packing stack can be taken apart by hand.

D. Seals and V-Packing Reassembly

1. Generously lubricate parts with grease when reassembling. Examine brass components for any damage or water residue build-up.
2. Insert low-pressure sealing working it in by hand.
3. Replace the outer o'ring by simply starting on one side and working it into the groove. **(Fig. C)**
4. Stack the V-packing in the correct order and firmly press the assembly into the manifold. **(Fig. D)**
5. Install a new oil seal by laying the seal into the opening and evenly pressing it into place. **(Fig. E)**
6. Reinstall the manifold onto the pump as described in section 6.2-B.

E. Plunger Maintenance

1. Remove the manifold as described in section 6.2-B. Remove the packing retainers if they remain on the pistons after removing the manifold.
2. Remove the nut and washer on the end of the piston using a 13mm wrench or socket.
3. Slide the ceramic plunger and the remaining washer from the piston guide. Inspect ceramic piston, o'ring and washers for wear. Replace if necessary. **(Fig. F)**

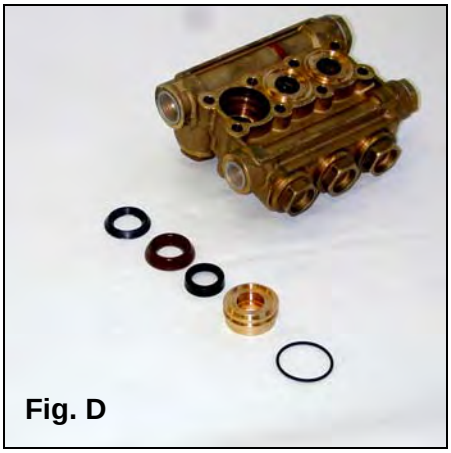
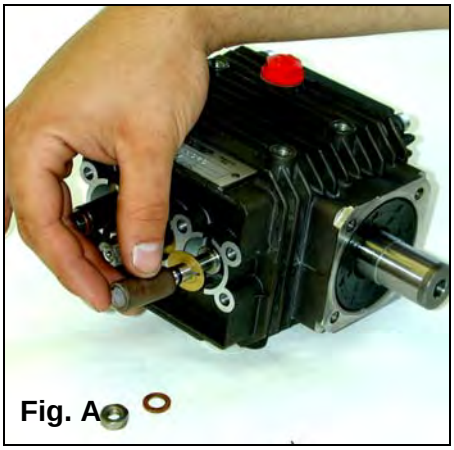


Fig. D

Fig. E

Fig. F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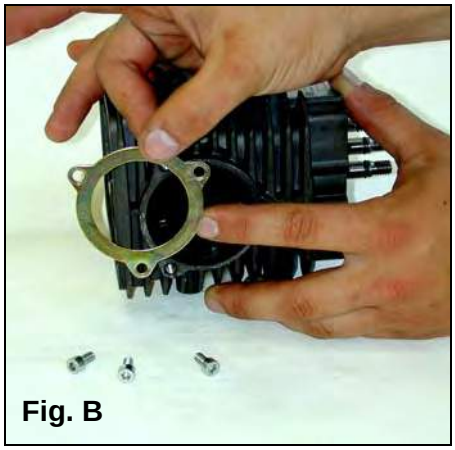


Fig. B

Fig. C

F. Plunger Reassembly

1. Generously grease the piston guide. Replace the o'ring making sure it does not twist or roll.
2. Slide the lower washer and ceramic bushing onto the piston guide. **(Fig. A)**
3. Place a small amount of LOCTITE 243 on the piston guide threads. Replace the outer washer and thread the nut onto the piston guide. Torque to 4.5 ft. lbs.

G. Crankcase Maintenance

1. Remove manifold & pistons as described in sections 6.2-B, 6.2-E.
2. Remove the plastic bearing cover ring using 4mm allen wrench to unscrew the three bolts. **(Fig. B)**
3. Remove plastic spacer and o'ring by hand.
4. Remove the snap ring from end of crankshaft allowing the shaft to slide out of the bearing. **(Fig. D)**
5. On the flange side of the pump, remove the oil seal by piercing a hole in the surface of the oil seal with a flat head screwdriver. Pry it out of the crankcase and over the shaft. **(Fig. E)**
6. Remove the large snap ring securing the flange side bearing into the crankcase.
7. Remove the small snap ring securing the shaft to the bearing.
8. Using an industrial press, or something equivalent, press out the shaft from the side where the plastic cover was removed. Secure the smaller bearing to the crankcase using a vise grips, or something equivalent, to make sure the smaller bearing does not get pushed into the crankcase with the shaft. **(Fig. F)** The larger bearing on the flange side of the pump will likely come out with the shaft.
9. Work the shaft out of connecting rods as needed.
10. Remove the piston guides by pulling out by hand.
11. Press the small bearing out of the crankcase going through the larger bearing opening and pressing out.

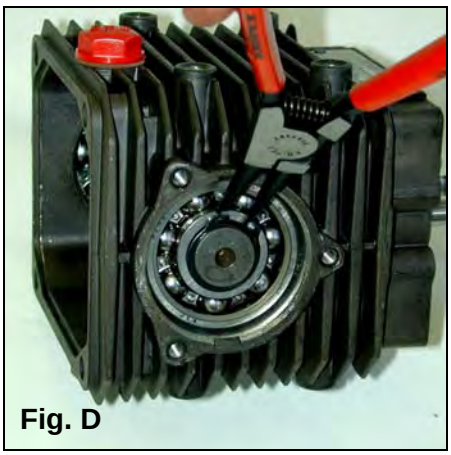
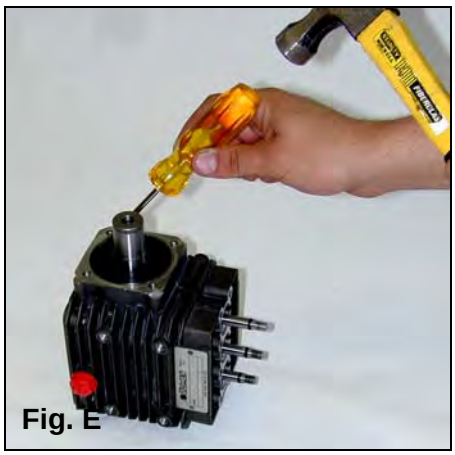


Fig. D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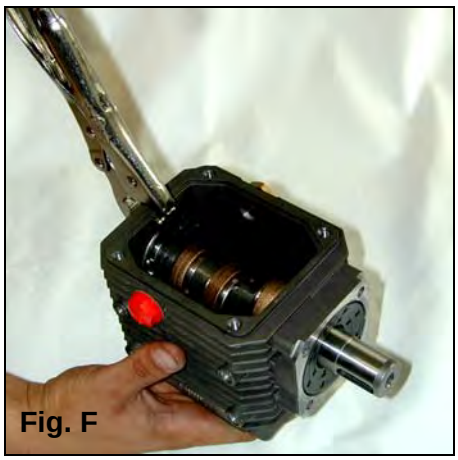
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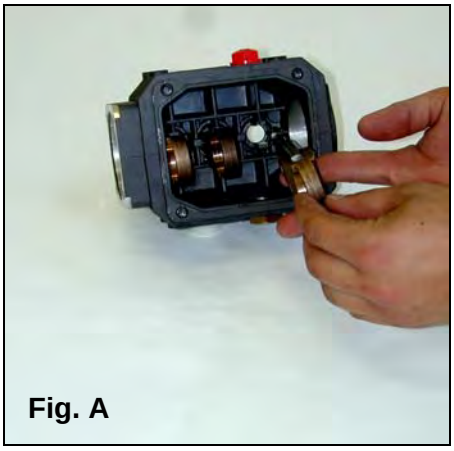
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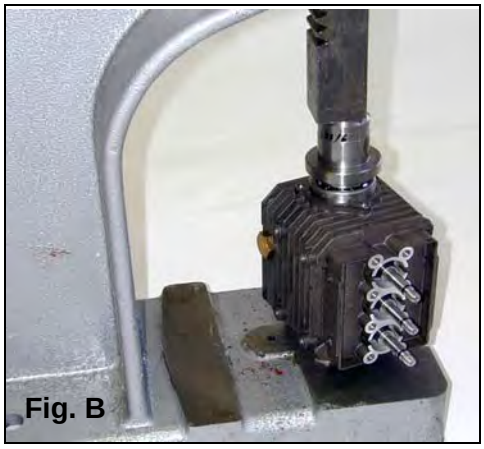
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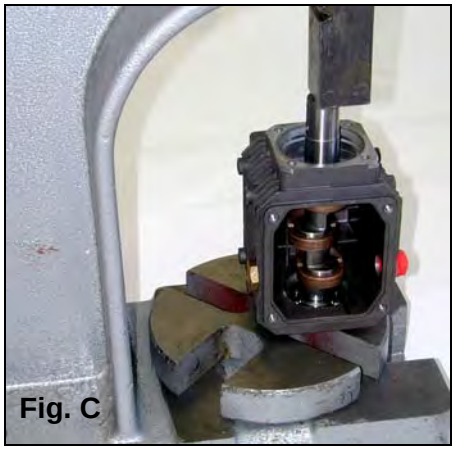
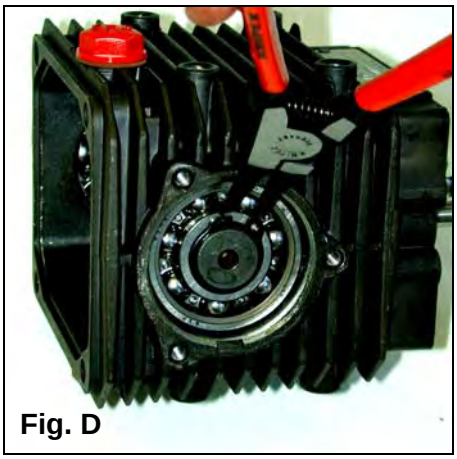


Fig. C

H. Crankcase Reassembly

1. Insert the piston guides by sliding them into the crankcase by hand. **(Fig A)**
2. Press the small bearing into the crankcase. **(Fig B)**
3. Insert the crankshaft through the large bearing opening, eyeing it through the connecting rod openings. Press the end of the shaft down into small bearing. **(Fig C)**
4. Secure the snap ring around the shaft outside of the small bearing. **(Fig D)**
5. Slide the large bearing over the crankshaft and press it into the crankcase.
6. Secure the snap rings into place by securing the bearing into the crankcase, and the shaft into the bearing.
7. Install the large oil seal on the flange side of the crankcase to cover the large bearing. **(Fig E)**
8. Install the plastic spacer, o'ring and metal cover. Secure the three bolts with a 4mm allen wrench. Torque to 3 ft. lbs. **(Fig F)**
9. Install the large crankcase back cover by placing the o'ring outside of the inner lip. Secure with the four 5mm bolts and torque to 7 ft. lbs.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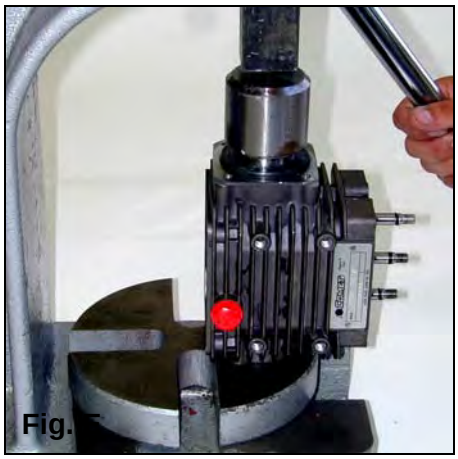
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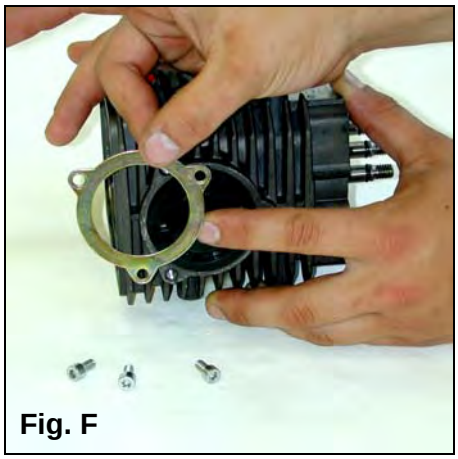
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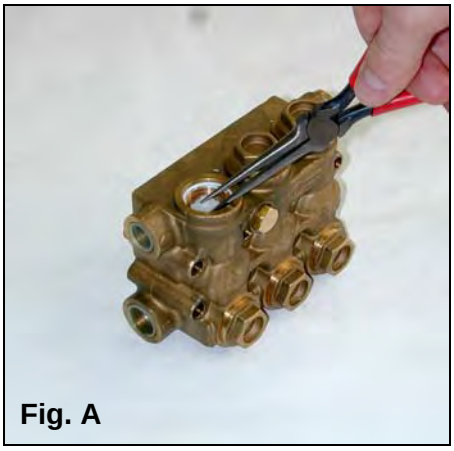


Fig. A

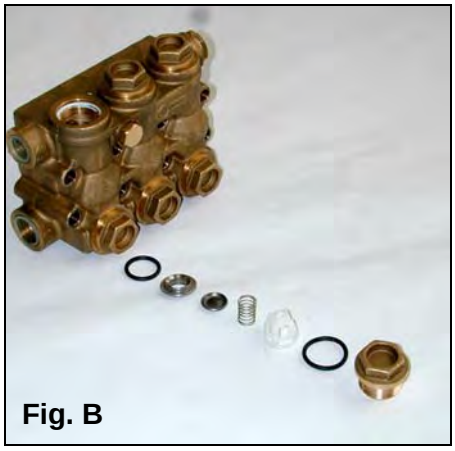


Fig. B

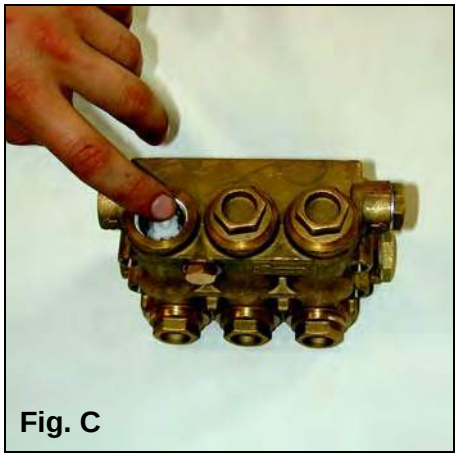


Fig. C

6.3. FW/HW SERIES PUMP

A. Valve Maintenance

1. Using a 22mm wrench, remove the six valve caps on manifold of pump.
2. Examine the valve cap o'ring for cuts or distortions. Replace if worn.
3. Using a needle nose pliers, remove the suction and delivery check valve. The valve assembly usually stays together when removing. If the valve comes apart, use a needle nose pliers or a reverse pliers to remove. **(Fig. A)**
4. Inspect the suction and delivery check valve assembly for general wear and replace if necessary. The valve assembly consists of the plastic cage, spring, valve seat, poppet and o'ring. One Comet valve kit is needed for a complete valve change of one pump. **(Fig. B)**
5. Insert new valve assemblies by simply placing the assembly in the valve chamber. Press down firmly on the top of valve assembly. **(Fig. C)**
6. Replace valve caps by applying LOCTITE 243 to valve cap and torque to 33 ft. lbs.

B. Removing & Replacing Pump Manifold

1. Remove the manifold of the pump by taking a 6mm allen head wrench and removing the eight head bolts.
2. With the pump firmly secured, take a medium sized flat head screwdriver and apply pressure to the manifold by prying between the crankcase and the manifold. Work around from all sides of the manifold evenly until it comes off of the pistons. Keep manifold properly aligned with the crankcase to prevent damage to the seals and pistons. **(Fig. D)**
3. When replacing the manifold, turn crankshaft of pump until the top of pistons are closely aligned. Lubricate pistons and cylinders and evenly press the manifold toward crankcase until flush. **(Fig D)**

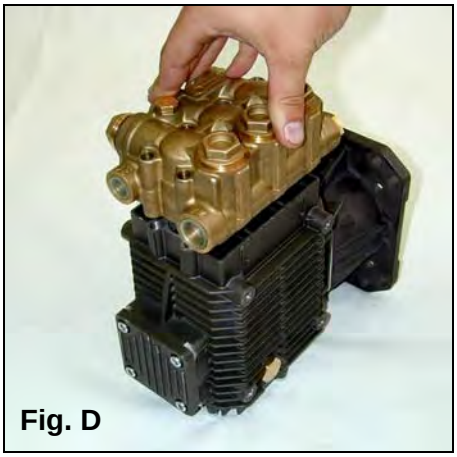


Fig. D

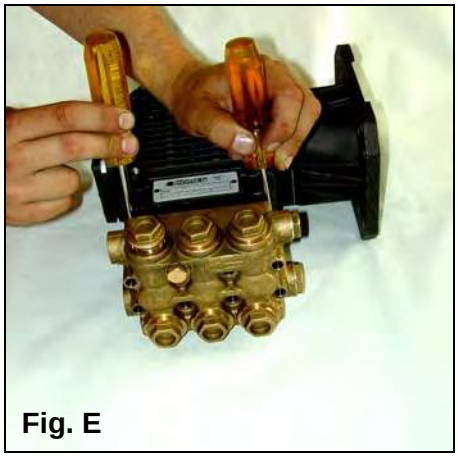


Fig. E

Fig. F

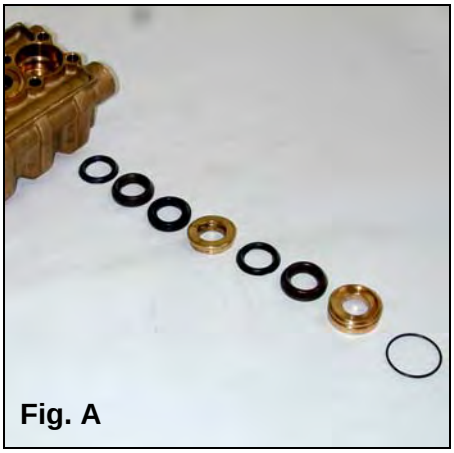


Fig. A

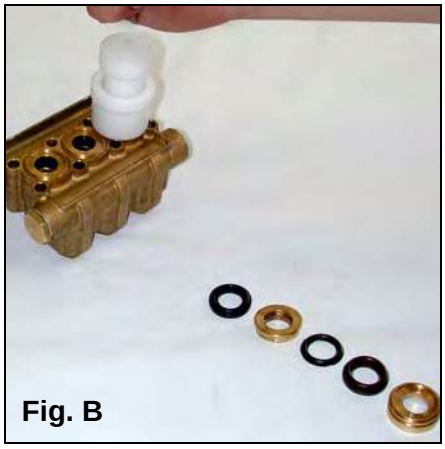


Fig. B

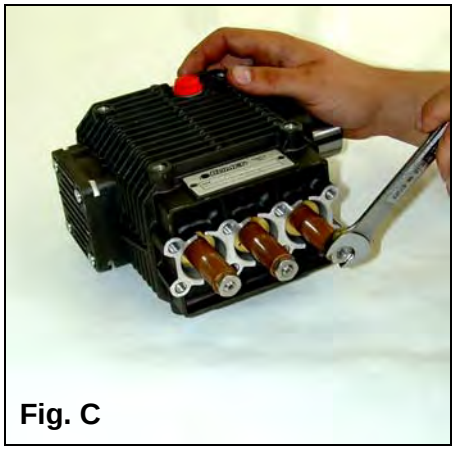


Fig. C

C. Seals and V-Packing Maintenance

1. Remove manifold as described in section 6.3-B. It is possible that the seal and brass retainer ring assembly stays on the piston or remains in the manifold when removing.
2. Using the packing extraction tool, remove the brass retainer ring/seal stack. Remove the low-pressure seal using a needle nose pliers. Once this seal is removed, replace with a new seal.
3. Remove the outer o'ring by taking a small flat head screwdriver and working it out. Simply roll off the o'ring.
4. The V-packing can be taken apart by hand.

D. Seal and V-Packing Reassembly

1. Generously lubricate parts with grease when reassembling. Examine brass components for any damage or water residue build-up.
2. Insert the low-pressure seal into the retainer ring, working it in by hand.
3. Stack V-packing in correct order and firmly press assembly into manifold. **(Fig. A & B)**
4. Install a new oil seal by laying seal into the opening and pressing it into place. **(Fig. F)**
5. Reinstall the manifold onto the pump as described in section 6.3-B

E. Plunger Maintenance

1. Remove manifold as described in section 6.3-B. It is possible that the seal and brass retainer ring assembly stays on the piston or remains in the manifold when removing.
2. Remove the 15mm nut and washer on the end of piston. **(Fig. C)**
3. Slide the ceramic plunger and remaining washer from the piston guide. Remove the o'ring by taking a small flat head screw driver and work it off of the piston guide.
4. Inspect ceramic piston, o'ring and washers for wear. Replace if necessary **(Fig. D)**

F. Plunger Reassembly

1. Generously grease piston guide. Replace o'ring making sure it does not twist or roll.
2. Slide the lower washer and ceramic bushing onto the piston guide. **(Fig. E)**
3. Place a small amount of LOCTITE 243 on the piston guide threads. Replace the outer washer and thread the nut onto the piston guide. Torque to 4.5 ft. lbs.

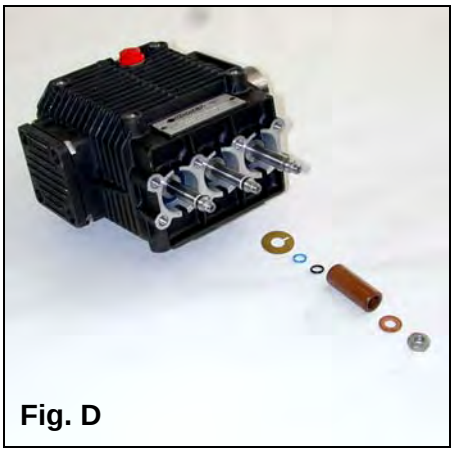


Fig. D

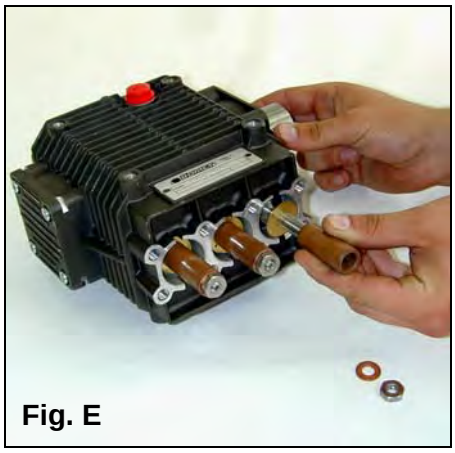


Fig. E

Fig. F

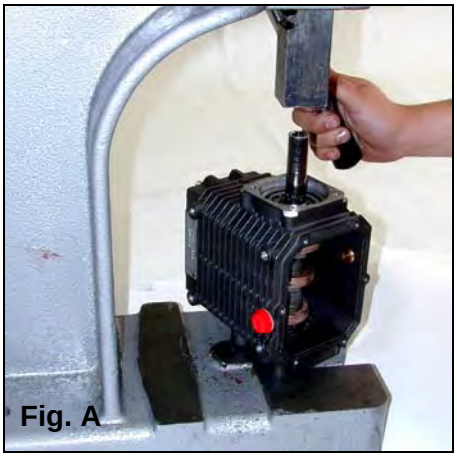


Fig. A

Fig. B

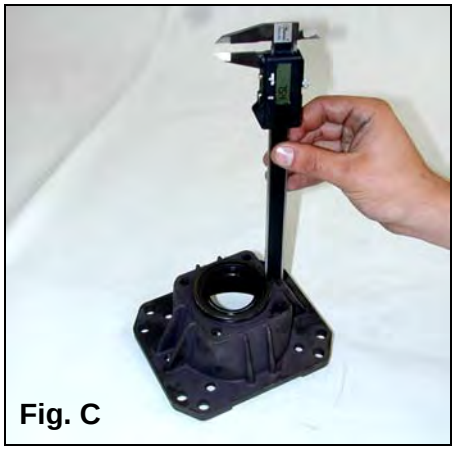


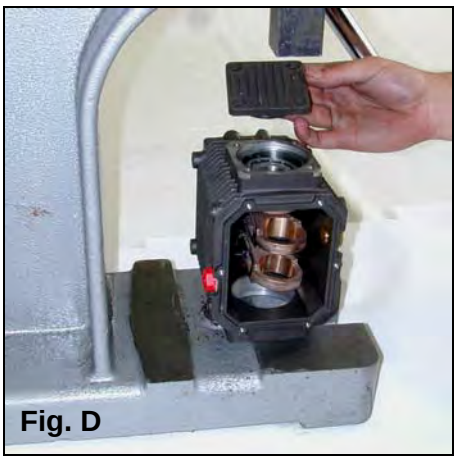
Fig. C

F. Crankcase Maintenance

1. Remove manifold and pistons as explained in sections 6.3-A and 6.3-B.
2. Remove crankcase back by removing the six 4mm allen bolts.
3. Remove the mounting flange by unscrewing the four 6mm allen bolts.
4. Remove the side crankcase cover by unscrewing the four 5mm allen bolts. Pry off the cover with a flat head screwdriver**.**
5. Press out shaft from opposite flange side of the pump. Use a socket that will fit inside the perimeter of the end of shaft. **(Fig. A)**
6. Work the shaft out of the connecting rods eyes. The flange side bearing will come out with the shaft.
7. Remove the small bearing opposite flange bearing by tapping it out.

G. Crankcase Reassembly

1. Install the piston guides and connecting rods by sliding through the piston holes in the crankcase. **(Fig. F)**
2. Press the small, non-motor side bearing into place. The inner parts of the bearing will float until the shaft is installed.
3. Place the bearing cover into place and secure the four bolts onto cover. **(Fig. D)**
4. Install the crankshaft by eyeing it through the connecting rods and pressing it into the small bearing opposite of the flange.
5. Install the larger tapered bearing. Press the inner portion of the bearing onto the shaft.
6. Place outer portion of bearing into place and press into crankcase using the flange between the press and the bearing. **(Fig. E)**
7. Remove flange and measure pump for any shims that may be needed. The flange must not press too tightly against the bearing or the performance of the pump may be altered. Using a caliper, measure the distance from the top of the bearing to the edge of the crankcase where the flange will sit flush. **(Fig. B)** Next measure inside peak of flange and the flange portion that will sit flush onto the crankcase. **(Fig. C)** The flange peak may be taller than the distance from the top of the bearing to the top of the crankcase. Use the shims to make-up the difference.
8. Install the flange onto the pump by securing the four bolts.
9. Replace the rear cover of the crankcase by securing the six 4mm allen bolts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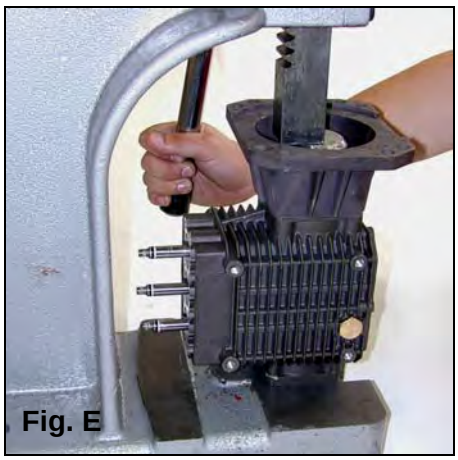
Fig. E

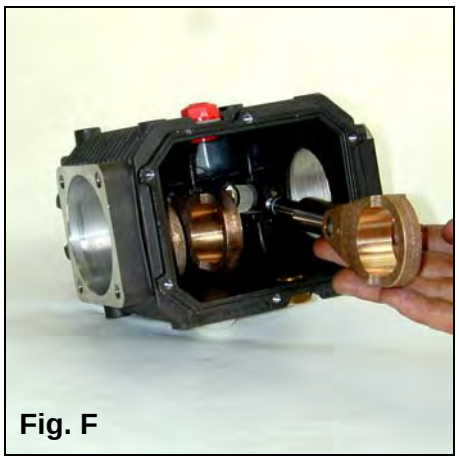
Fig. F

7. PUMP LIMITED WARRANTY

7.1 Comet Pump Limited Warranty

The Comet pump is warranted by the manufacturer to the original purchaser to be free from defects in material and workmanship under normal use and service. "Normal use and service" means not in excess of the recommended maximum speeds, pressures and temperatures or handling fluids not compatible with component materials. This warranty shall not apply to any pump that has been repaired or altered to affect the performance or reliability of the pump.

The period of Limited Warranty on AXD models shall be one year from the date of sale to the end user. Liability of manufacturer under the foregoing warranty is limited to repair or replacement at the option of the manufacturer of that product, which according to the manufacturer's investigation was deemed defective at the time of shipment. This warranty is in lieu of all other warranties, expressed or implied, including any warranty of merchantability and/or any and all other obligations or liabilities on the part of the manufacturers.

The period of Limited Warranty on the LW, ZW,FW & HW models shall be five years from the date of sale to the end user. Liability of manufacturer under the foregoing warranty is limited to repair or replacement at the option of the manufacturer of that product, which according to the manufacturer's investigation was deemed defective at the time of shipment. This warranty is in lieu of all other warranties, expressed or implied, including any warranty of merchantability and/or any and all other obligations or liabilities on the part of the manufacturers.

7.2 Limited Warranty Conditions

a. Pump operation must be within the maximum RPM, discharge pressure and inlet pressure specifications. A pressure relief valve must be properly installed in the system.
b. The pump must be operated with sufficient fluid to the manifold. Do not pump aggressive fluid that may cause premature wear to the internal components.
c. The oil level in the crankcase must be maintained at the correct level according to Comet specifications for proper lubrication.
d. The pump must be protected from freezing. Flush the system with propylene glycol antifreeze before storing in freezing conditions. Use the following concentration: 14° F-25% 5°F-33% minus 25°F-50%

OPERATORS MANUAL

Sutorbilt R Series

Section 4

STG GLOBAL

GARDNER DENVER

Experience Proven Results™

PARTS LIST
OPERATING AND SERVICE MANUAL

LEGEND
"R" SERIES BLOWERS

3" – 5" GEAR DIAMETER

Models
GAB_ _ R _
GAC_ _ R _
GAE_ _ R _

ENERGY STAR PARTNER

SB-7-632
Version 04
June 29, 2012

MAINTAIN BLOWER RELIABILITY AND PERFORMANCE
WITH GENUINE GARDNER DENVER
PARTS AND SUPPORT SERVICES

Factory genuine parts, manufactured to design tolerances, are developed for optimum dependability - - - specifically for your blower. Design and material innovations are born from years of experience with hundreds of different blower applications. When you specify factory genuine parts you are assured of receiving parts that incorporate the most current design advancements manufactured in our state-of-the-art blower factory under exacting quality standards.

Your AUTHORIZED DISTRIBUTOR offers all the backup you require. A worldwide network of authorized distributors provides the finest product support in the blower industry.

1. Trained technical representatives to assist you in selecting the correct replacement parts.

2. Complete inventory of new machines and new, genuine factory parts.

3. A full line of factory tested AEON® PD blower lubricants, specifically formulated for optimum performance in all blowers.

4. Authorized distributor service technicians are factory-trained and skilled in blower maintenance and repair. They are ready to respond and assist you by providing fast, expert maintenance and repair service.

INSTRUCTIONS FOR DETERMINING BLOWER CONFIGURATION

1. Face the blower drive shaft.
2. In a **VERTICAL** configuration, air flow is horizontal.
3. In a **HORIZONTAL** configuration, air flow is vertical.
4. In a vertical configuration, a **BOTTOM HAND** exists when the drive shaft is below the horizontal center line of the blower. A **TOP HAND** exits when the drive shaft is above the horizontal center line of the blower.
5. In a horizontal configuration, a **RIGHT HAND** exists when the drive shaft is to the right of the vertical center line of the blower. A **LEFT HAND** exists when the drive shaft is to the left of the vertical center line of the blower.

INSTRUCTIONS FOR ORDERING REPAIR PARTS

For pricing, and ordering information contact your nearest AUTHORIZED FACTORY DISTRIBUTOR. When ordering parts, specify Blower **MODEL** and **SERIAL NUMBER** (see nameplate on unit).

Rely upon the knowledge and experience of your AUTHORIZED DISTRIBUTOR and let them assist you in making the proper parts selection for your blower.

To Contact Gardner Denver or locate your local distributor:
Visit: www.contactgd.com/mobile

Or

Call: (217)222-5400

GARDNER DENVER LUBRICANT ORDER INFORMATION

Re-order Part Numbers for Factory Recommended Lubricants.

Gear and Drive End

AEON PD Synthetic Lubricant, AEON PD-XP—Extreme Duty Synthetic Lubricant or AEON PD-FG—Food Grade Synthetic Lubricant

AEON PD Synthetic Lubricant

Description	Part Number
1 Quart	28G23
Case/12Quarts	28G24
1 Gallon Container	28G40
Case/6 Gallons	28G41
5 Gallon Pail	28G25
55 Gallon Drum	28G28

AEON PD-XD – Extreme Duty Synthetic Lubricant

Description	Part Number
1 Quart	28G46
Case/12Quarts	28G47
1 Gallon Container	28G42
Case/6 Gallons	28G43
5 Gallon Pail	28G44
55 Gallon Drum	28G45

AEON PD-FG – Food Grade Synthetic Lubricant

Description	Part Number
1 Quart	28H97
Case/12Quarts	28H98
1 Gallon Container	28H333
Case/6 Gallons	28H334
5 Gallon Pail	28H99
55 Gallon Drum	28H100

Drive End

AEON PD Grease

Description	Part Number
Case/10 Tubes (14oz/Tube	28H283

Call your local Gardner Denver Distributor to place your order for Gardner Denver lubricants. Your Authorized Gardner Denver Distributor is:

FOREWORD

Sutorbilt® blowers are the result of advanced engineering and skilled manufacturing. To be assured of receiving maximum service from this machine, the owner must exercise care in its operation and maintenance. This manual is written to give the operator and maintenance department essential information for day-to-day operation, maintenance and adjustment. Careful adherence to these instructions will result in economical operation and minimum downtime.

⚠ DANGER
Danger is used to indicate the presence of a hazard which will cause severe personal injury, death, or substantial property damage if the warning is ignored.

⚠ WARNING
Warning is used to indicate the presence of a hazard which can cause severe personal injury, death, or substantial property damage if the warning is ignored.

⚠ CAUTION
Caution is used to indicate the presence of a hazard which will or can cause minor personal injury or property damage if the warning is ignored.

NOTICE
Notice is used to notify people of installation, operation or maintenance information which is important but not hazard-related.

SAFETY PRECAUTIONS

Safety is everybody's business and is based on your use of good common sense. All situations or circumstances cannot always be predicted and covered by established rules. Therefore, use your past experience, watch out for safety hazards and be cautious. Some general safety precautions are given below:

⚠ DANGER

Failure to observe these notices could result in injury to or death of personnel.

- **Keep fingers and clothing away from revolving fan, drive coupling, etc.**
- **Do not use the air discharge from this unit for breathing – not suitable for human consumption.**
- **Do not loosen or remove the oil filler plug, drain plugs, covers or break any connections, etc., in the blower air or oil system until the unit is shut down and the air pressure has been relieved.**
- **Electrical shock can and may be fatal.**
- **Blower unit must be grounded in accordance with the National Electrical Code. A ground jumper equal to the size of the equipment ground conductor must be used to connect the blower motor base to the unit base.**
- **Open main disconnect switch, tag and lockout before working on the control.**
- **Disconnect the blower from its power source, tag and lockout before working on the unit – this machine may be automatically controlled and may start at any time.**

⚠ WARNING

Failure to observe these notices could result in damage to equipment.

- **Stop the unit if any repairs or adjustments on or around the blower are required.**
- **Disconnect the blower from its power source, tag and lockout before working on the unit – this machine maybe automatically controlled and may start at any time.**
- **Do not exceed the rated maximum speed shown on the nameplate.**
- **Do not operate unit if safety devices are not operating properly. Check periodically. Never bypass safety devices.**

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SUTORBILT LEGEND SERIES BLOWERS
MATRIX/MENU

NOTICE TO CUSTOMER – To find the construction options for Your blower unit, FILL IN THE BALANCE OF LETTERS OR NUMBERS FROM YOUR UNIT NAMEPLATE

	G	A				R	
COLUMN NUMBER:	1	2	3	4	5	6	7

FOLLOW THE LINE DOWN AND OVER FROM EACH SPACE THUS FILLED IN TO FIND THE APPROPRICATE CONSTRUCTION OPTION WITH WHICH YOUR MACHINE IS EQUIPPED.

COLUMN 1 – BASIC DESIGNATOR

COLUMN 2 – PRODUCT FAMILY

COLUMN 3 – GEAR DIAMETER

B	3”	E	5”			
C	4”					

COLUMN 4 – CASE LENGTH

- L - Low Pressure
- M - Medium Pressure
- H - High Pressure

COLUMN 5 – CONFIGURATION

- A Vertical-Top Hand -Central Timed
- B Vertical-Bottom Hand – Central Timed
- C Horizontal – Left Hand – Central Timed
- D Horizontal – Right Hand – Central Timed

COLUMN 6 – DESIGN VERSION

COLUMN 7 – ADDITIONAL DESCRIPTION

	SEALS	CLEARANCES	LUBRICATION
A.	Lip	Standard	Grease-Splash
B.	Mechanical	Standard	Grease-Splash
C.	Lip	High Temperature	Grease-Splash
D.	Lip	Standard	Dual-Splash
E.	Mechanical	Standard	Dual-Splash
F.	Lip	High Temperature	Dual-Splash
G.	Mechanical	High Temperature	Dual-Splash

INTRODUCTION
YOUR KEY TO TROUBLE FREE SERVICE

Thank you for investing in Gardner Denver quality. The Gardner Denver reputation for rugged dependability has been earned by over 50 years of service in demanding, industrial operations where downtime cannot be tolerated and efficient blower performance is expected.

Your Gardner Denver Sutorbilt blower is a precision engineered blower that has been carefully manufactured and thoroughly tested at the state-of the art Gardner Denver Blower Factory in Sedalia, Missouri.

As with other precision machinery, there are several relatively simple installation, operation and maintenance procedures that you must observe to assure optimum blower performance. There is no guesswork in the manufacture of your highly advanced Sutorbilt blower and there must be none in preparing the blower to get the job done in the field.

The purpose of this manual is to help you properly install, operate and maintain your Sutorbilt blower. It is essential that you review all sections of this manual in preparation for installing your blower. Follow the instructions for installing your blower. Follow the instructions carefully and you will be rewarded with trouble-free Gardner Denver Sutorbilt service year in and year out.

SECTION 1
EQUIPMENT CHECK

Before uncrating, check the packing slip carefully to be sure all the parts have been received. All accessories are listed as separate items on the packing slip, and small important accessories such as relief valves can be overlooked or lost. After every item on the packing slip has been checked off, uncrate carefully.

NOTICE
Register a claim with the carrier for lost or damaged equipment.

⚠WARNING
Customers are cautioned to provide adequate protection, warning and safety equipment necessary to protect personnel against hazards involved in installation and operation of this equipment in the system or facility.

STORAGE

Your Gardner Denver Blower was packaged at the factory with adequate protection to permit normal storage for up to six (6) months.

If the unit is to be stored under adverse conditions or for extended periods of time, the following additional measures should be taken to prevent damage.

1. Store the blower in a clean, dry, heated (if possible) area.
2. Make certain inlet and discharge air ports are tightly covered to prevent foreign material from entering the air box.
3. All exposed, non-painted surfaces should be protected against rust and corrosion.
4. Provide adequate protection to avoid accidental mechanical damage.
5. In high humidity or corrosive environments, additional measures may be required to prevent rusting of the blower internal surfaces.
6. To prevent rusting of gears, bearings, etc., the oil reservoirs may be filled with normal operating oil.

⚠CAUTION
Before running the blower, drain the oil and replace to the proper operating level with clean, fresh lubricant.

7. Rotate the blower shaft (10 to 25 turns) weekly during storage. Inspect the blower shaft (near the shaft seal area) monthly and spray with rust inhibitor if needed.
8. For long term storage (over six (6) months), contact Gardner Denver Compressor Division Customer Service for recommendations.

REMOVING PROTECTIVE MATERIALS

The shaft extension is protected with rust inhibitor which can be removed with any standard solvent.

⚠CAUTION
Follow the safety directions of the solvent manufacturer.

Blower inlet and outlet are temporarily capped to keep out dirt and other contaminants during shipment. These covers must be removed before start-up.

The internal surfaces of all Sutorbilt units are mist sprayed with a rust preventative to protect the machine during shipment. Remove this film upon initial startup, using any commercial safety solvent. Position the blower so that the inlet and discharge connections are in the vertical position (vertical airflow). On vertically mounted units, it will be necessary to lay the unit on its side supporting the ends of the unit so as not to restrict the port on the bottom side. Place a shallow pan on the under side of the unit. With the blower disconnected from power, spray the solvent in the top port, rotating the impellers by spinning the shaft manually. Continue this procedure until the unit is visibly clean.

⚠WARNING
Rotating components will cause severe injury in case of personal contact. Keep hands and loose clothing away from blower inlet and discharge ports.

SECTION 2
INSTALLATION

LOCATION

Install the blower in a well lit, clean dry place with plenty of room for inspection and maintenance.

FOUNDATIONS

For permanent installation we recommend concrete foundations be provided, and the equipment should be grouted to the concrete. It is necessary that a suitable base be used, such as a steel combination base under blower and motor, or a separate sole plate under each. Before grouting, equipment must be leveled, free of all strains, and anchored so no movement will occur during setting of grout. After grout has completely hardened, a recheck is necessary to compensate for shrinkage, etc. If required, add shims under blower feet after final tightening of foundation anchor bolts to remove strain from the blower housing.

Where jack screws or wedges are used during grouting, they must be backed off and wedges removed before final tightening of anchor bolts. Refer to grouting instructions.

Where a concrete foundation is not feasible, care must be taken to insure that equipment is firmly anchored to adequate structural members, restricting movement and vibration.

MOUNTING CONFIGURATIONS

The blower flex-mount design enables horizontal and vertical mounting configurations with top or bottom hand, right or left hand shaft positioning. The units are center timed allowing rotation in either direction (refer to Figure 2-1).

REPOSITIONING THE MOUNTING FEET.

1. Position the mounting feet to the desired location and snug the capscrew.

2. Place the blower on its feet on a flat surface.

3. Loosen mounting feet capscrews and level unit up. The bench or blower base flatness should be within .002 of an inch.

NOTICE
If the unit is not flat within .002 of an inch, it will be necessary to shim the blower feet at installation.

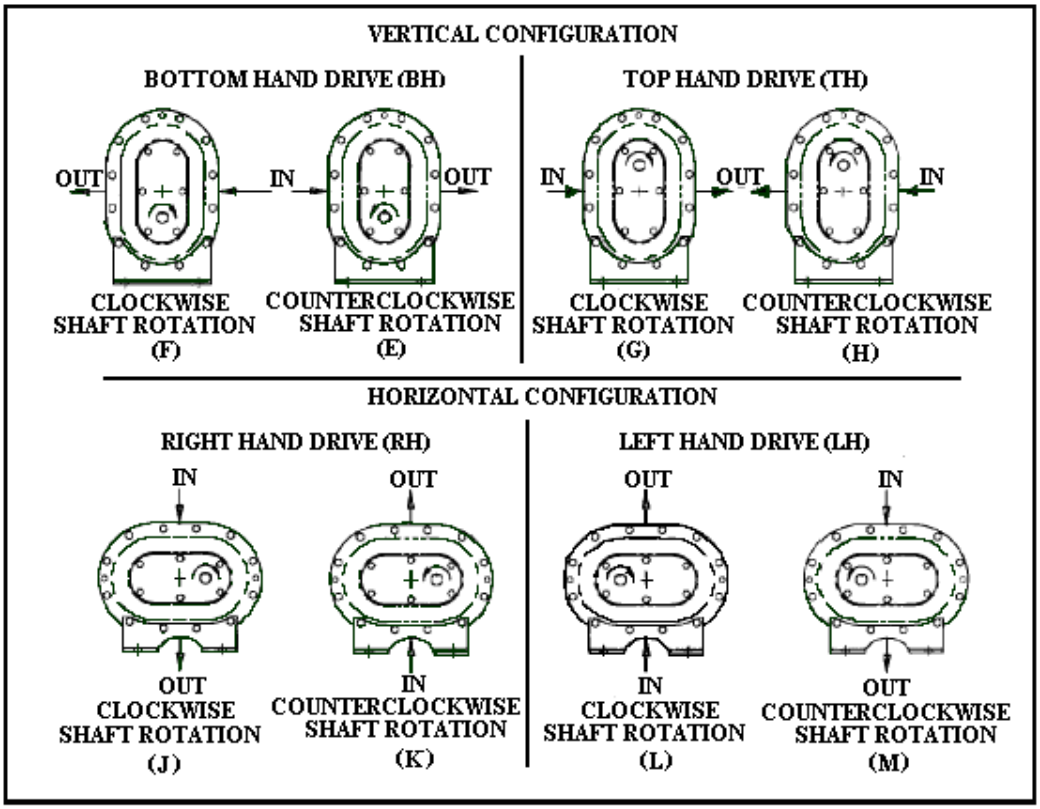


FIGURE 2-1 – BLOWER MOUNTING CONFIGURATIONS

4. Secure the mounting feet capscrews to the torque value in Figure 7-9, page 38.

NOTICE
When changing mounting configuration, it may be necessary to reposition breather/oil fill (B), oil level gauge (H) and drain plug (A). Refer to Figure 3-1, page 17, for correct location.

DRIVE INSTALLATION

When selecting a V-belt drive, check to be sure the shaft overhung load limitation is not exceeded. Refer to FIGURE 2-2, page 15, for overhung load calculations and limitations.

Belt drives must be carefully aligned. Motor and blower pulleys must be parallel to each other and in the same plane within 1/32 inch. Belt tension should be carefully adjusted to the belt manufacturer's recommendation using a belt tension gauge. Check tension frequently during the first day of operation.

⚠WARNING
Over tightening belts leads to heavy bearing loads and premature failure.

On the direct connected units, alignment and lubrication of couplings to specifications of the coupling manufacturer is very important. When mounted drives are supplied from the factory proper alignment has been established before shipment. However, during shipping, handling and installation, it is likely that the alignment has been disturbed and final adjustment must be made before startup.

⚠WARNING

Exceeding overhung load limitations leads to unwarrantable premature bearing failure and shaft breakage.

The location of the sheave on the blower shaft greatly affects the stress in the shaft. The optimum blower sheave positioning is as close as possible to the blower drive cover, not to exceed dimension “C” in Drive Shaft Illustration, FIGURE 2-2, page 15

The calculated shaft moment must not exceed the maximum allowable moment listed in Maximum Allowable Moment Chart, FIGURE 2-2 page 15. If the calculated shaft moment exceed the maximum allowable moment:

- Increase Sheave Diameters to Reduce Belt Pull
- Use Jackshaft Drive
- Use Direct Coupled or Gearbox Drive

To calculate shaft moment for a given V-Belt Drive Arrangement:

1. Use the formula for Calculation of Belt Pull, FIGURE 2-2, page 15, to calculate belt pull. Refer to Arc of Contact Factor Chart, Figure 2-2, page 15.
2. Insert the calculated belt pull into the formula for Calculation of Shaft Moment, FIGURE 2-2, page 15 to arrive at the calculated shaft moment.

PIPING

Inlet and discharge connections on all blowers are large enough to handle maximum volume with minimum friction loss. Reducing the pipe diameter on either inlet or discharge will only create additional line loss and increase the overall pressure differential. Excessive weight of piping and fittings will cause internal misalignment and premature wear. Never allow the blower to carry the weight of the pipe. If possible, a spool or sleeve-type expansion joint should be installed between the unit and the piping. Where a flexible connection is not practical, the weight of the rigid connection must be separately supported.

All system piping must be cleaned internally before connecting to the blower.

⚠WARNING

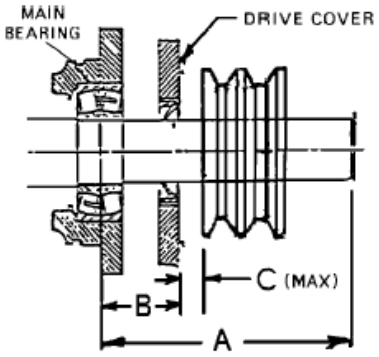
Sutorbilt blowers are shipped dry from the factory. Do not attempt to operate the blower before following proper lubrication instructions. Permanent damage to the gears, bearings and seals will occur.

Gear Diameter (Inches)	GREASE SPLASH Dimensions (Inches)			Maximum Allowable Moment (LB-IN)
	A	B	C (Max)	
3	2.88	.85	.38	385
4	3.49	1.10	.38	490
5	3.90	1.40	.38	1245

MAXIMUM ALLOWABLE MOMENT

Gear Diameter (Inches)	DUAL SPLASH LUBE Dimensions (Inches)			Maximum Allowable Moment (LB-IN)
	A	B	C (Max)	
3	3.07	1.18	.25	385
4	3.62	1.27	.25	650
5	3.85	1.39	.25	1370

MAXIMUM ALLOWABLE MOMENT



Z	Ac	Z	Ac	Z	Ac	Z	Ac	Z	Ac	Z	Ac
0.000	1.000	0.250	0.966	0.500	0.926	0.750	0.879	1.000	0.823	1.250	0.751
0.025	0.997	0.275	0.962	0.525	0.922	0.775	0.874	1.025	0.816	1.275	0.742
0.050	0.994	0.300	0.958	0.550	0.917	0.800	0.869	1.050	0.810	1.300	0.734
0.075	0.990	0.325	0.954	0.575	0.913	0.825	0.864	1.075	0.803	1.325	0.725
0.100	0.987	0.350	0.951	0.600	0.908	0.850	0.858	1.100	0.796	1.350	0.716
0.125	0.983	0.375	0.947	0.625	0.904	0.875	0.852	1.125	0.789	1.375	0.706
0.150	0.980	0.400	0.943	0.650	0.899	0.900	0.847	1.150	0.782	1.400	0.697
0.175	0.977	0.425	0.939	0.675	0.894	0.925	0.841	1.175	0.774	1.425	0.687
0.200	0.973	0.450	0.935	0.700	0.889	0.950	0.835	1.200	0.767		
0.225	0.969	0.475	0.930	0.725	0.884	0.975	0.829	1.225	0.759		

ARC OF CONTACT FACTORS

$$\text{Belt Pull} = \left[\frac{2.5 - Ac}{Ac}\right] \times \left[\frac{125954 \times Hp \times S.F.}{D \times RPM}\right]$$

Key:
- Ac = Arc of Contact Factor (Refer to Arc of Contact Factor Chart above)
- Hp = Blower Horsepower for Operating Conditions
- S.F. = Actual Drive Service Factor
- D = Blower Sheave Pitch Diameter in Inches
- RPM = Blower Sheave Speed
- Z = $\left[\frac{\text{Large Sheave Pitch Diameter (in)} - \text{Small Sheave Pitch Diameter (in)}}{\text{Sheave Center Distance (in)}}\right]$

CALCULATION OF BELT PULL

$$\text{Shaft Moment (LB-IN)} = \text{Belt Pull} \times \left[B + C + \left(\frac{\text{Sheave Width}}{2}\right)\right]$$

CALCULATION OF SHAFT MOMENT

FIGURE 2-2 – BELT DRIVE OVERHUNG LOAD CALCULATIONS

AIR FILTERS AND FILTER SILENCERS

⚠WARNING

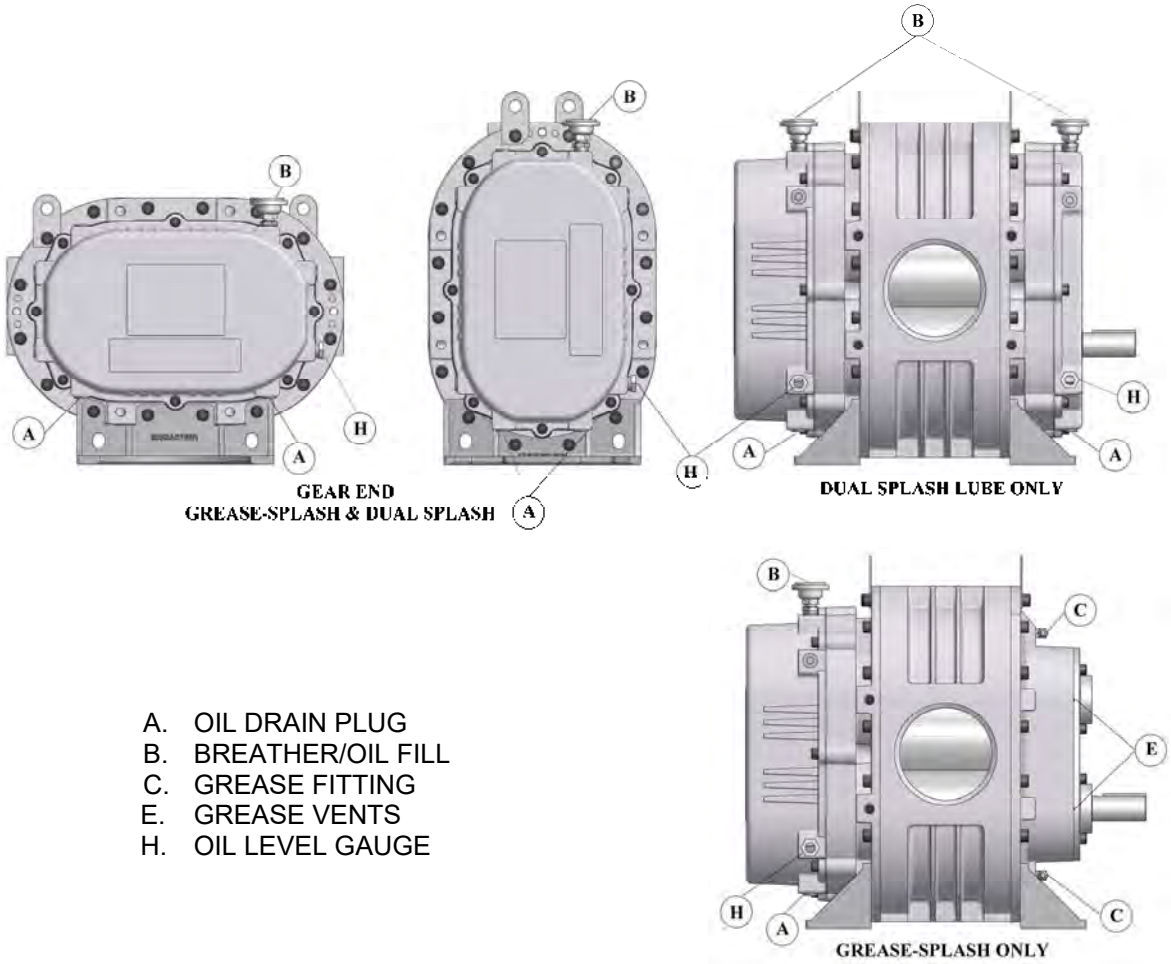
Servicing the air filters is one of the most important maintenance operations to be performed to insure long blower life.

Servicing frequency of filter elements is not time predictable. A differential pressure indicator, with a continuous gauge reading, should be installed across the inlet filter. It will tell how much of the service life of the filter element has been used. It will also eliminate both premature filter servicing and premature blower failure due to a plugged filter when the filter pressure drop is used to establish maintenance points. In all cases refer to the filter manufacturer's service instructions. Due to the many types of filters, it is not practical to give specific instructions covering all models.

NOTICE

No matter what type of filter is used, always make sure all seats, gaskets, clamps and hose connections on the filter and inlet line are absolutely air tight. Each time the filter is serviced, inspect interior of the blower for dirt.

SECTION 3
LUBRICATION



A. OIL DRAIN PLUG
B. BREATHER/OIL FILL
C. GREASE FITTING
E. GREASE VENTS
H. OIL LEVEL GAUGE

FIGURE 3-1 - LUBRICATION

DRIVE END LUBRICATION (For Grease – Splash Lube Blowers)

Drive end bearings are grease lubricated at the factory with Lithium Complex based grease. **For relubrication, use Gardner Denver AEON PD Grease, Part Number 28H283.** AEON PD Grease is a high temperature, high performance grease that is formulated with antiwear additives to provide superior service under the severe operating conditions of positive displacement blowers. It contains rust inhibitors which provide excellent protection against rust and corrosion.
If you choose not to use AEON PD Grease, select compatible base grease. The grease should be NLGI Grade 2 EP, contain rust inhibitors, and be suitable for blower discharge temperatures up to 350° F (177° C). Completely clean or purge the factory--filled grease from the blower. **Do not mix different types of grease as they may not be compatible. Substitutions may cause early bearing failure.**

Re-grease bearings every 500 hours of operation. Lubricate each bearing through the grease fittings located at C in FIGURE 3-1 (2 places). When re-greasing, the old grease will be forced out of the vents (E in FIGURE 3-1). To prevent damage to seals, these vents must be open at all times.

⚠WARNING
Do not over--grease bearings as this could cause premature bearing failure.

DRIVE END LUBRICATION (For Dual Splash Lube Blowers)

At the drive end, the bearings are lubricated by the slinger, which must be on the lowest rotor when in a vertical configuration.

Approximate oil sump capacities are listed in Figure 3-2.

NOTICE
Machines are shipped without oil in the sump. Do not operate before adding lubricant.

Lubrication Instructions

Filling procedure
Refer to Figure 3-1, page 17. Remove the breather (B) from the drive cover. Add oil to the drive sump until oil reaches the center of the oil level gauge (H). Secure breather (B) in the drive cover.

Add fresh oil as required to maintain proper level. The oil level should be at the middle of the sight glass when the machine is not operating. Refer to Figure 3-2, for approximate oil capacities.

Legend "R" Series, Grease-Splash Lube Blower Oil Capacities

		Approximate Sump capacity in pints or ounces					
		Vertical Configuration			Horizontal Configuration		
Series	**Gear Diameter (in)**	**Gear End**	**Drive End**	**Total**	**Gear End**	**Drive End**	**Total**
3	3.5	0.6 PT (9 oz.)	grease	0.6 PT (9 oz.)	1.1 PT (18 oz.)	grease	1.1 PT (18 oz.)
4	4	0.9 PT (14 oz.)	grease	0.9 PT (14 oz.)	1.5 PT (24 oz.)	grease	1.5 PT (24 oz.)
5	5	1.1 PT (18 oz.)	grease	1.1 PT (18 oz.)	2.5 PT (40 oz.)	grease	2.5 PT (40 oz.)

Note: Quantities are for purchase estimates only.

Legend "R" Series, Dual Splash Lube Blower Oil Capacities

		Approximate Sump capacity in pints or ounces					
		Vertical Configuration			Horizontal Configuration		
Series	**Gear Diameter (in)**	**Gear End**	**Drive End**	**Total**	**Gear End**	**Drive End**	**Total**
3	3.5	0.6 PT (9 oz.)	0.3 PT (5 oz.)	0.9 PT (14 oz.)	1.1 PT (18 oz.)	0.6 PT (9 oz.)	1.7 PT (27 oz.)
4	4	0.9 PT (14 oz.)	0.4 PT (6 oz.)	1.3 PT (20 oz.)	1.5 PT (24 oz.)	0.7 PT (11 oz.)	2.2 PT (35 oz.)
5	5	1.1 PT (18 oz.)	0.6 PT (9 oz.)	1.7 PT (27 oz.)	2.5 PT (40 oz.)	1.2 PT (19.1 oz)	3.7 PT (59.1 oz.)

Note: Quantities are for purchase estimates only.

FIGURE 3-2 – APPROXIMATE OIL CAPACITIES

GEAR END LUBRICATION (For Grease – Splash Lube and Dual Splash Lube Blowers)
At the gear end, the timing gear teeth are lubricated by being partially submerged in oil. The gear teeth serve as oil slingers for gear end bearings.

Approximate oil sump capacities are listed in Figure 3-2.

⚠WARNING

Do not overfill as this will tend to cause excessive heating of the gears and may damage the unit.

NOTICE

Machines are shipped without oil in the sump. Do not operate before adding lubricant.

LUBRICATION INSTRUCTIONS

Filling procedure Refer to FIGURE 3-1, page 17. Remove the breather (B) from the gear cover. Add oil to the gear case until oil reaches the center of the oil level gauge (H). Secure breather (B) in the gear cover.

Add fresh oil as required to maintain proper level. The oil level should be at the middle of the sight glass when the machine is not operating. Refer to Figure 3-2, page 18, for approximate oil capacities.

RECOMMENDED LUBRICANT

AEON PD Synthetic Blower Lubricant is recommended. Refer to FIGURE 3-3, for AEON PD, AEON PD-FG (Food Grade) and AEON PD-XD (Extreme Duty) part numbers. Order AEON PD from your Gardner Denver Distributor or call Gardner Denver directly.

Convenient Package Sizes	AEON PD Part No.	AEON PD-FG Part No.	AEON PD-XD Part No.
1 quart	28G23	28H97	28G46
Case 12 quarts	28G24	28H98	28G47
1 gallon	28G40	28H333	28G42
Case 6 gallons	28G41	28H334	28G43
5 gallon pail	28G25	28H99	28G44
55 gallon drum	28G28	28H100	28G45

FIGURE 3-3 – AEON PD SYNTHETIC LUBRICANT

AEON PD is formulated especially for positive displacement blower service to provide maximum blower protection at any temperature. One fill of AEON PD will last a minimum of 4 times longer than a premium mineral oil. Refer to FIGURE 3-4.

		Ambient Temperatures			
		Less than 10° F	10°F to 32°F	32°F to 90°F	Greater than 90°F
Blower Discharge Temperature	Less than 32°F	AEON PD AEON PD-FG	AEON PD AEON PD-FG		
	32° F to 100° F	AEON PD AEON PD-FG	AEON PD AEON PD-FG	AEON PD AEON PD-FG	
	100° F to 225°F	AEON PD AEON PD-FG	AEON PD AEON PD-FG	AEON PD AEON PD-FG	AEON PD AEON PD-FG
	225° F to 300° F	AEON PD AEON PD-FG	AEON PD AEON PD-FG	AEON PD AEON PD-FG	AEON PD XD
	Greater than 300°F			AEON PD XD	AEON PD XD

FIGURE 3-4 – SYNTHETIC LUBRICANT CHART

AEON PD Synthetic Lubricant should be drained after 6000 hours of operation. Re-fill with fresh AEON PD oil. If mineral oil is used, perform the above oil change maintenance every 1500 hours. Recommended service intervals are for normal blower operating conditions. Severe operating conditions may warrant more frequent oil changes. Laboratory analysis of lubricant should be used to help determine the optimum oil change interval.

For best performance and equipment protection, use AEON PD Synthetic Lubricant, which has been specifically formulated for positive displacement blowers. If you choose not to use AEON PD Synthetic Blower Lubricant, select an oil with rust and oxidation inhibitors, anti-foam additives, and the viscosities listed in FIGURE 3-5. Do not use an oil that contains EP additives.

NOTICE
Flush the oil whenever a change is made from one type of oil to another.

Drain the current lubricant as thoroughly as possible. Refill with the new lubricant. Fill to normal level of the blower, which is at the middle of the sight glass when the machine is not operating. Run the blower for one hour. Shut off the blower and drain the lubricant completely. Refill the blower again with the new lubricant.

Blower Discharge Temperature	Ambient Temperature			
	Less than 10° F*	10° F to 32° F**	32° F to 90° F	Greater than 90° F
Less than 32° F (0° C)	ISO 100	ISO 100		
32° F to 100° F (0° C to 38° C)	ISO 100	ISO 100	ISO 150	
100° F to 225° F (38° C to 105° C)	ISO 100	ISO 100	ISO 150	ISO 220
225° F to 300° F (105° C to 149° C)	ISO 150	ISO 150	ISO 220	ISO 220
Greater than 300° F (149° C)			***	***

***** For ambient temperatures less than 10° F, but not less than –20° F, the use of oil sump heaters, heated enclosures or synthetic lubricant is required.

****** For ambient temperatures 10° F to 32° F, the use of oil sump heaters, heated enclosures or synthetic lubricant is recommended.

******* The lubricant viscosity must be 70 SUS minimum at the lubricant operating temperature.

The pour point of the lubricant should be at least 5° to 10° F below the minimum expected ambient temperature.

For continuous operation, where the lubricant temperature exceeds 200° F, synthetic lubricant is recommended.

FIGURE 3-5 – LUBRICATION RECOMMENDATION

SECTION 4
OPERATION

Future operating problems can be avoided if proper precautions are observed when the equipment is first put into service.

Before starting under power, the blower should be turned over by hand to make certain there is no binding or internal contact.

Each size blower has limits on pressure differential, running speed and discharge temperature which must not be exceeded. These limits are shown in “Maximum Operating Limitations”, FIGURE 4-1, below.

⚠WARNING

Operating beyond the specified operating limitations will result in damage to the unit.

It is important that the pressures and temperatures are measured directly at the ports of the blower to avoid error that may be caused by intervening pipe runs, fittings, etc.

Relief valves must be used to protect against excessive pressure or vacuum conditions. These valves should be tested at initial startup to be sure they are adjusted to relieve at or below the maximum pressure differential rating of the blower.

NOTICE

Relief valves should be placed as close as possible to the blower inlet or discharge.

In some instances, pressure may be relieved at a lower point than the blower maximum in order to protect the motor or the equipment served by the blower.

Discharge temperature switches are recommended to protect against excessive inlet restriction or inlet temperatures. Check valves in the discharge line on pressure blowers and in the inlet line on vacuum blowers are recommended to protect the blower from motoring backwards when shut down under load.

LIMITATIONS

For information regarding limitations, refer to FIGURE 4-1, below.

MAXIMUM / MINIMUM OPERATING LIMITATIONS

SIZE	MAX. RPM	MIN. RPM VERT.	MIN RPM HORIZ.	MAX. PRESSURE PSI	MAX VAC IN HG	MAX. TEMPERATURE RISE ° F	MAX. DISCHARGE TEMPERATURE ° F
3LR	3600	1528	1091	7	14	160	260
3MR	3600	1528	1091	12	15	180	280
3HR	3600	1528	1091	15	16	220	320
4LR	3600	1337	955	7	14	160	260
4MR	3600	1337	955	10	16	185	285
4HR	3600	1337	955	15	16	210	310
5LR	2850	1070	764	7	14	160	260
5MR	2850	1070	764	13	16	180	280
5HR	2850	1070	764	15	16	200	300

DO NOT EXCEED THESE LIMITS

NOTICE

Blower speed, line losses, elevation, and increased inlet temperatures will affect the maximum operating limitations. The minimum RPM for the blowers is based on lubrication only. The blowers may only be operated down to the minimum RPM, when the temperature rise and discharge temperature are below the maximum limitations as shown.

FIGURE 4-1 – MAXIMUM / MINIMUM OPERATING LIMITATIONS

BLOWER STARTUP CHECKLIST

This startup procedure should be followed during the initial installation and after any shutdown periods or after the blower has been worked on or moved to new location. It is suggested that the steps be followed in sequence and checked off (√) in the boxes provided.

- ☐ 1. Check the unit and all piping for foreign material and clean if required.
- ☐ 2. Check the flatness of the feet and the alignment of the drive. Feet that are bolted down in a bind can cause housing distortion and internal rubbing. Misaligned V-drives can cause the rotors to rub against the headplates and cause a reduction in the volumetric efficiency of the unit. Misaligned couplings can ruin bearings.
- ☐ 3. If the blower is V-belt driven, check the belt tension and alignment. Over-tensioned belts create heavy bearing/shaft loads which lead to premature failure.
- ☐ 4. Be sure adequate drive guards are in place to protect the operator from severe personal injury and incidental contact.
- ☐ 5. Check the unit for proper lubrication. Proper oil level cannot be over-emphasized. Too little oil will ruin bearings and gears. Too much oil will cause overheating and can ruin gears and cause other damage. Insure that grease lubricated bearings are properly lubricated.
- ☐ 6. With motor electrical power locked out and disconnected, turn the drive shaft by hand to be certain the impellers do not bind.
- ☐ 7. “Jog” the unit with the motor a few times to check that rotation is in the proper direction, and to be certain it turns freely and smoothly.
- ☐ 8. The internal surfaces of all Sutorbilt units are mist sprayed with a rust preventive to protect the machine during the shipping and installation period. This film should be removed upon initial startup.
- ☐ 9. Start the unit and operate 15 minutes at no load. During this time, check for hot spots and other indications of interference.
- ☐ 10. Apply the load and observe the operation of the unit for one hour. Check frequently during the first day of operation.
- ☐ 11. If malfunctions occur, do not continue to operate. Problems such as knocking rotors can cause serious damage if the unit is operated without correction.

SAFETY PRECAUTIONS

1. Do not operate blower with open inlet or outlet port.
2. Do not exceed specified vacuum or pressure limitations.
3. Do not operate above or below recommended blower speed range.
4. Blower is not to be used where non-sparking equipment is specified.
5. Do not operate without belt guard or coupling shield.

Do not exceed sheave or coupling manufacturer's rim speed limit.

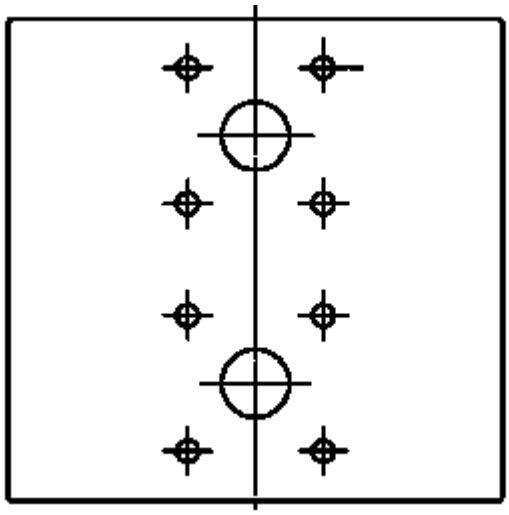
6. The blower and blower discharge piping may be extremely hot and cause skin burns on contact.

TROUBLE SHOOTING

No matter how well the equipment is designed and manufactured, there may be times when servicing will be required due to normal wear, the need for adjustment, or various external causes. Whenever equipment needs attention, the operator or repairman should be able to locate the cause and correct the trouble quickly. The Trouble Shooting Chart below is provided to assist the mechanic in those respects.

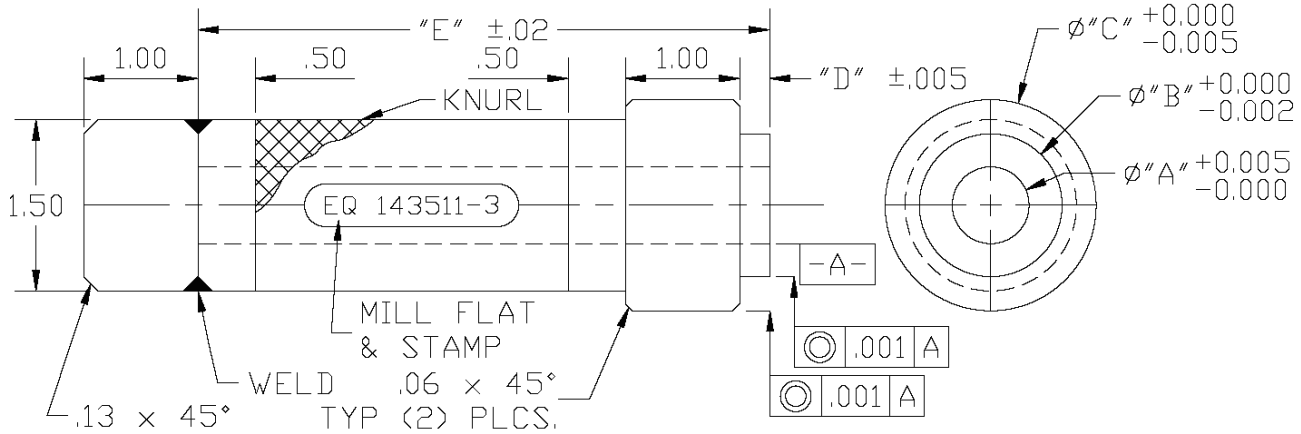
PROBLEM	POSSIBLE CAUSES	SOLUTION
Knocking	1. Unit out of time. 2. Distortion due to improper mounting or pipe strains. 3. Excessive pressure differential. 4. Worn gears. 5. Worn bearings.	1. Re-time impellers 2. Check mounting alignment and relieve pipe strains. 3. Reduce to manufacturer's recommended pressure. Examine relief valve, re-set if necessary. 4. Replace timing gears. 5. Replace bearings..
Excessive blower temperature.	1. Too much oil in gear case. 2. Too low operating speed. 3. Dirty air Filter. 4. Clogged filter or muffler. 5. Excessive pressure differential. 6. Worn impeller clearances. 7. Internal contact.	1. Reduce oil level. 2. Increase blower speed. 3. Clean or replace air filter 4. Remove cause of obstruction. 5. Reduce pressure differential across the blower. 6. Replace impeller. 7. Correct clearances.
Impeller end or tip drag.	1. Insufficient assembled clearances. 2. Case or frame distortion. 3. Excessive operating pressure. 4. Excessive operating temperature.	1. Correct clearances. 2. Check mounting and pipe strain. 3. Remove cause. 4. Remove cause
Lack of volume.	1. Slipping belts. 2. Worn clearances. 3. Dirty air filter	1. Tighten belts. 2. Re-establish proper clearances. 3. Clean or replace air filter.
Excessive bearing or gear wear.	1. Improper lubrication.	1. Correct lubrication level. Replace dirty oil.
Loss of oil.	1. Headplate, gear case or drive cover vents plugged. 2. Worn Seal.	1. Clean vents. 2. Replace seals.

ORDER SPECIAL TOOLS BY PART NUMBER. SEE PAGE 2 FOR ORDERING INSTRUCTIONS.



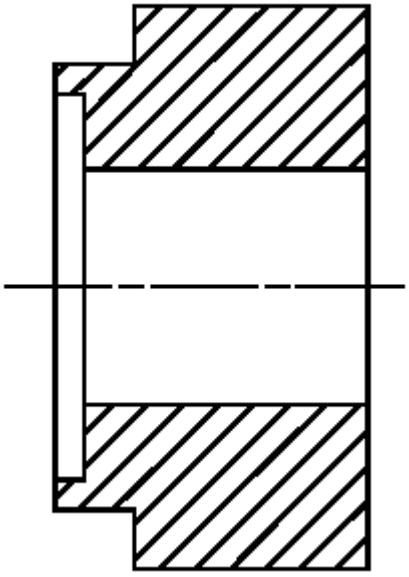
Unit Size	Part Number
3”	201GAA340
4”	202GAA340
5”	203GAA340

FIGURE 5-1 – PULLER PLATE



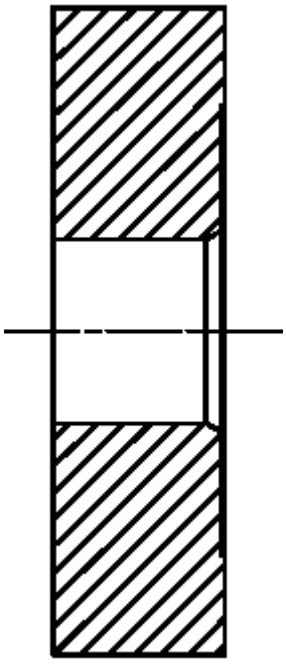
PART NO.	SIZE	"A"	"B"	"C"	"D"	"E"
EQ 143511-3	3"	.790	1.435	2.044	.335	5.50
EQ 143511-4	4"	1.000	1.624	2.436	.395	6.25
EQ 143511-5	5"	1.184	2.247	2.829	.695	7.00

FIGURE 5-2 – SEAL DRIVE



Unit Size	Part Number
3”	205GAA074
4”	206GAA074
5”	207GAA074

FIGURE 5-3 – MECHANICAL SEAL INSTALLATION TOOL



Unit Size	Part Number
3”	201GAA074
4”	202GAA074
5”	203GAA074

FIGURE 5-4 – BEARING PRESS TOOL – MECHANICAL SEAL UNITS

SECTION 6
DISASSEMBLY INSTRUCTIONS

NOTICE
Numbers in parentheses ( ) refer to key numbers in assembly drawings on pages 39 and 43.

1. Drain oil from gear case by removing drain plug (2).
2. Remove the socket head bolts (5) from the gear cover (3).
3. Remove the gear cover from the gear headplate.

NOTICE
The cover and gear headplate gasket tends to bond tightly to both surfaces. After socket head bolt removal, it is sometimes necessary to take a ball peen hammer and a blunt chisel and drive off the cover.

IMPORTANT:

MARK ALL PARTS WITH A CENTER PUNCH SO THEY CAN BE REASSEMBLED IN THE SAME POSITION (IMPELLERS, HEADPLATES, AND GEARS).

4. If the timing gears appear undamaged, the gear backlash must be checked to see if the gears can be salvaged.
   - A. Mount a magnetic base dial indicator on the gear headplate (see FIGURE 6-1).
   - B. Lock one impeller stationary by wedging a feeler gauge between the impeller and the headplate.
   - C. The tip of the indicator should be placed at the center of the contact surface on a tooth of the gear on the free shaft.
   - D. Rock the impeller back and forth by hand and read the total rotational movement to the nearest .0005 inches. Do this at four gear mesh positions 90 degrees apart.
   - E. Permissible gear backlash is shown below.

GEAR DIA.	GEAR BACKLASH
3”	.0015 - .0025
4”	.0015 - .0025
5”	.002 - .003

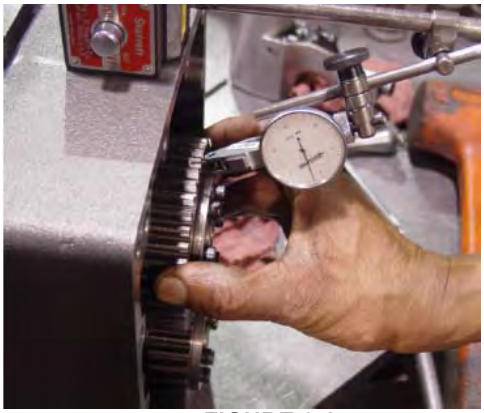


FIGURE 6-1

FIGURE 6-2

FIGURE 6-3

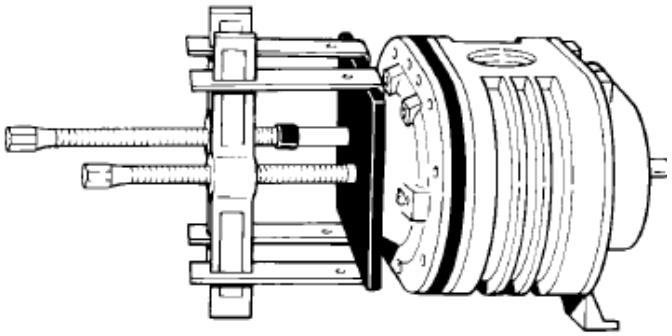


FIGURE 6-4

NOTICE
If backlash is above the specified limit, the gears are not necessarily unusable. Excessive play could be caused by worn bearings.

5. If timing gears appear to be reusable, match marktiming gear toothmesh by making small punch marks on the ends of meshing gear teeth with a pin punch and hammer (see FIGURE 6-2, page 27). The impeller tip to valley (throat) and the case to headplates should also be matchmarked to facilitate blower reassembly.
6. Remove all cap screws from both gear locking assemblies (see FIGURE 6-3). Thread 3 of these cap screws into the threaded holes in the outer ring of each locking assembly. Tighten the screws evenly to remove the locking assembly from each gear. Remove the gears (9) from both rotor shafts.

NOTICE
Blowers with mechanical seals have two wavy washers (28) located between the bearings and the cover on the drive end.

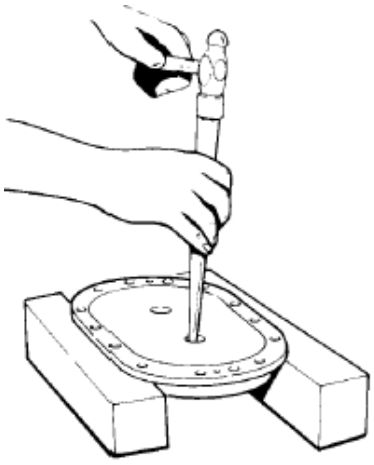


FIGURE 6-5

7. Remove the socket head cap screws (30) from the drive end bearing cover (29) and remove the cover. Support the external surface of the drive end cover near the oil seal with blocks of wood. Drive the oil seal from the cover using a hammer and punch. Discard the seal as it will not be reused. Replace oil seals each time the drive end cover is removed.

   For Dual Splash Version
   Remove the socket cap screws (84) from each slinger and remove slingers.

   For Dual Splash Version with Mechanical Seal
   Remove the socked cap screws (84) from each slinger and remover slingers. Remove flat head cap screws (86) from wavy spring retainer plates and remove retainer plate and wavy spring.

8. Remove mounting foot (17) from the drive headplate (24) by removing the capscrews (16).
9. Remove the capscrews (21) which secure the drive headplate (24) to the impeller case (22).
10. Using the puller plate shown on page 25, bolt to the drive headplate using the tapped holes on used to secure the drive cover.
11. Install a gear puller to each shaft and attach puller arms to the plate. Turn each puller only half a revolution at a time keeping the advance of the shafts as uniform as possible (see Figure 6-4). After the headplate has been removed, detach the puller plate.
12. Remove the two drive end bearings (35 and 80 for dual splash lube) or (14 and 35 for grease) from the drive headplate (24) using a ball peen hammer and punch (see Figure 6-5, page 28).

⚠ CAUTION
Exercise care not to damage the headplate bearing bores when removing bearings.

13. The oil seals can now be driven out of the drive headplate with hammer and punch (see Figure 6-5, page 28). Discard the seals as they will not be reused. Replace oil seals each time the headplate is removed.

   For Mechanical Seal Version
   Remove mechanical seal from the drive headplate.

NOTICE
Seals and bearings should be replaced during overhaul as a matter of service policy.

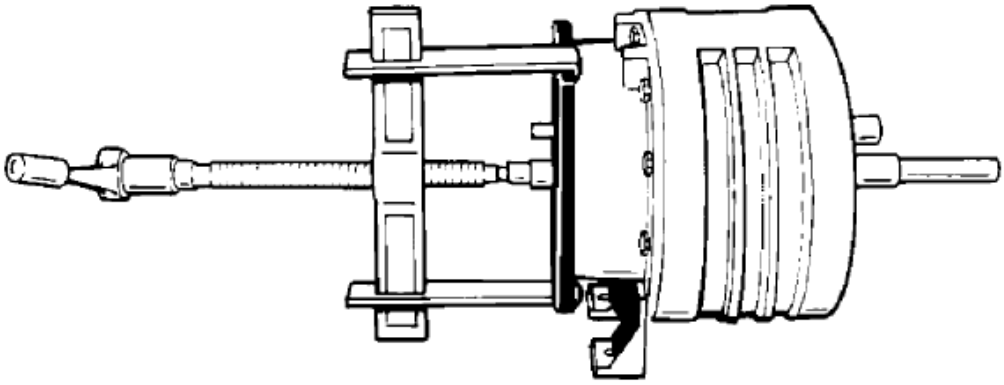


FIGURE 6-6

14. Remove the four bearing retaining screws (10), and washers (12) from the gear headplate.

    For Mechanical Seal Version
    Remove bearing retainer plate by removing 8 screws.

15. Attach puller plate to the gear headplate using the tapped holes on the bearing housing.

16. Install a gear puller to one of the shafts and attach puller arms to the plate (see Figure 6-6).

17. Remove mounting foot (17) from the gear headplate by removing 4 capscrews (16).

18. Push the impeller shaft through the gear headplate and remove the impeller assembly(23) (see Figure 6-6). Remove the other impeller assembly following the same procedure.

19. Remove the cap screws (21) securing the gear headplate to the impeller case. Located near each dowel pin on the headplate is a threaded hole. Insert a 5/16-18 UNC capscrew into each of the threaded holes. Tighten the screws evenly until the headplate separates from the impeller case.

20. Remove the two gear and bearings (14) from the gear headplate (18) as done in step 12.

21. Remove the oil seals (15) from gear headplate (19) as done in step 13.

SECTION 7
ASSEMBLY INSTRUCTIONS

NOTICE
Numbers in parentheses ( ) refer to key numbers in assembly drawings on pages 39 and 43.

1. Make sure all metallic parts are clean and free of any nicks or burrs.
2. Lubricate the outside diameter of the lip seal (15) with a light oil or grease. Install seals in both the drive headplate (24) and gear headplate (18). Use the seal driver (Figure 5-2). The seal lip should always face towards the bearing or lubricant. New seals should be installed each time the headplate is removed.

NOTICE
Make sure seals are fully seated. Use extreme care when installing.

MECHANICAL SEALS ONLY

A. Lightly coat the headplate bores with assembly lubricant.

B. Refer to Figure 7-1. Install mechanical seal (A) into the headplate bore (C) using a press and the correct driver shown on page 26. Drive the seal securely on to its seat.

⚠ CAUTION
Use extreme care when installing seals in the headplate bores. Do not attempt to install the mechanical seals without the use of a press. Blows from a hammer or mallet can damage the fragile seal surface. Too much force can crush the seal casing. Make certain the seal is properly seated and undamaged before proceeding.

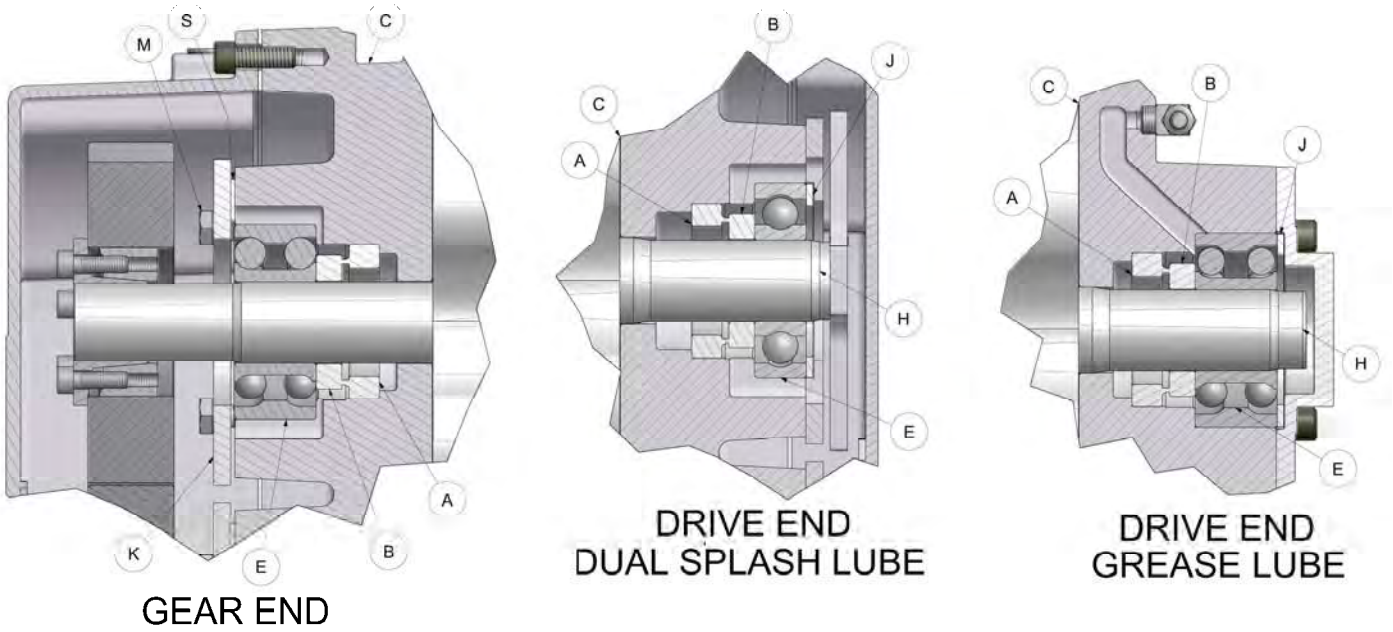


FIGURE 7-1

FIGURE 7-2

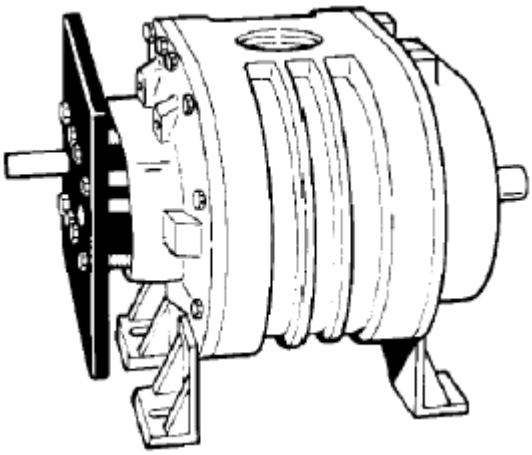


FIGURE 7-3

3. Assemble gear headplate (18) and mounting foot (17) to the impeller case with cap screws (21) and where the mounting foot is secured to the headplate use capscrews (16). The two positioning dowel pins (19) will ensure proper alignment of the headplate and impeller case. Also secure lifting lugs using capscrews (21) (see exploded assembly drawing on page 39. Refer to Figure 7-9, page 38, for torque specifications.

⚠ CAUTION
Seals are delicate; use extreme care when installing impeller shafts in the headplate bores. A piece of light shim stock wrapped around the shaft keyway will prevent cutting the seal lip.

4. Apply a light oil or grease on the shaft seal areas and the bearing areas. Insert impellers into the gear headplate using the same headplate bores as used in the original assembly.
5. Position blower so that impellers are vertical, with the drive end on top. It will be necessary to use blocks in order for the unit to set level. Measure the total end clearance using a depth micrometer (see Figure 7-2).

NOTICE
If more than .007" shim is required, put .007" on the drive end and the remaining on the gear end.

If total clearance is not within the limits specified in Figure 7-4, page 33, it may be necessary to shim the case to obtain the proper total end clearance. The shim should be placed between the drive headplate and impeller case.

6. Assemble drive headplate (24) to impeller case as in step 3 with the gear headplate. If shims were required, place shims between drive headplate and impeller case.

MECHANICAL SEALS ONLY

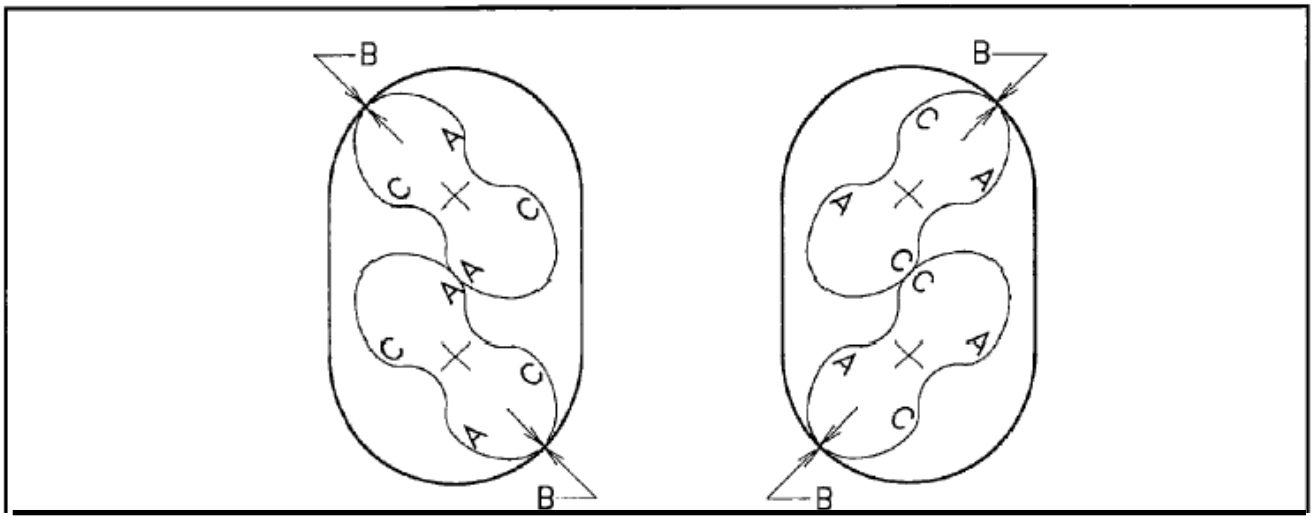
A. Refer to Figure 7-1, page 31. Lightly coat the impeller shaft (H) and the inside diameter of the mating ring (B) with assembly lubricant.

B. Install the mating ring (B) on the shaft only far enough to get the bearing (E) started on the shaft.

⚠ CAUTION
Do not drive the mating ring down to the mechanical seal, as this can damage the seal.

C. Lightly lubricate the bearing inner race (E) with a light oil or grease.

D. Using a press, install the bearing on the shaft with the bearing driver shown on page 24.



INTERNAL CLEARANCES FOR STANDARD UNITS ONLY

	3H	3M	3L	4H	4M	4L	5H	5M	5L
TOTAL END CLEARANCE	0.007-0.011			0.007-0.011			0.007-0.011		
IMPELLER TO GEAR HEADPLATE	0.003-0.005			0.003-0.005			0.003-0.005		
IMPELLER TIMING (A-A) (C-C)	0.005-0.007	.006-.008		0.006-0.008	.007-.010		.007-.010	.008-.010	
TIP TO CASE CLEARANCE (B-B)	0.002 min.			0.002 min.			0.002 min.		

FIGURE 7-4

The bearing driver will position the mating ring (B) to the correct depth with respect to the mechanical seal (A).

7. Apply a light oil to the drive headplate bearing bore, bearing inside diameter, and shaft seat. Install the drive end bearings (14and 35 for grease) or (80 and 35 for dual splash lube) as far as possible without force.
8. Attach the puller plate shown on page 25, to the drive headplate using the tapped holes used on the drive headplate (see FIGURE 7-3, page 32). Tighten the bolts so that the advance of the bearings stay as uniform as possible. Bearings should be pressed until flush with the drive headplate.
9. Lubricate the gear end bearing fits with a light oil as described previously. Install gear end bearings (14) as far as possible without force. Use the plate, used to install the drive end bearings, to press the bearings on the shafts as described in Step 8. Press bearings into the gear headplate until completely seated in the bearing bore.

NOTICE
Bearings will not be flush with gear headplate bores when completely seated.

10. Impellers should now be checked for free axial movement by hitting the ends of the impeller shafts with the palm of your hand.
11. Push the impellers against the gear headplate and recheck the total end clearance between the drive headplate and the impellers (see FIGURE 7-4).
    A. If total end clearance is insufficient, loosen impeller case to headplate bolts on either headplate, and move the headplate away from the case far enough to insert a paper shim in the amount equal to the insufficient clearance. Retighten case bolts and again check the total end clearance. Refer to FIGURE 7-4 for correct clearance.
    B. Excessive end clearances normally will require new impeller assemblies, but in some circumstances the impeller case can be removed and reduced in width by machining off the amount of excess clearance.
    C. Apply Loctite 246 on the 4 bearing retaining screws. Install 4 bearing screws and washers into the gear end headplate. Tighten screws evenly to the torque value given in FIGURE 7-9.

For Mechanical Seal Version

Install 8 bearing retaining screws and washers into the gear bearing retainer plates. Tighten screws evenly.

12.

A. Dual Splash Version

Install slingers on both shafts. Hold .31" +/_.01" gap between face of the bearing and back of the slingers. Rotate slingers approximately 90 degree apart, apply Loctite 246 on the socket cup screw and tight. Recommended torque is 3-3.5 FT-LBS. (See FIGURE 7-5).

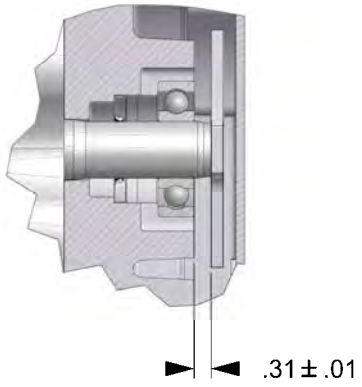


Figure 7-5

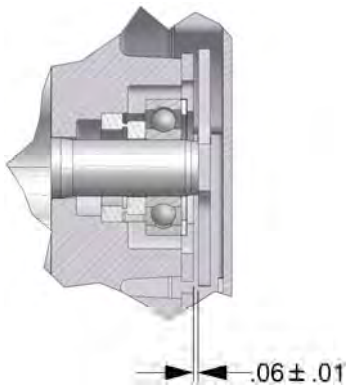


Figure 7-6

B. For Dual Splash Version with Mechanical Seal

Install slingers on both shafts. Hold .06"+_.01" gap between wavy spring retainer plates and back of the slingers. Rotate slingers approximately 90 degree apart, apply Loctite 246 on the socket cup screw and tight. Recommended torque is 3-3.5 FT-LBS. (See FIGURE 7-6).

13. **SETTING IMPELLER END CLEARANCES**

Refer to FIGURE 7-7, page 34. The outer races of the gear end bearings are clamped against the headplate (F) by the bearing retaining screws or by bearing retainer plate (mechanical seal version) (B).

This is referred to as the "fixed end". The interference fit between the shaft and the bearing inner race (H) keeps the shaft from moving axially. Adjustment is by movement of the shaft through the gear end bearing inner race (H).

A. Check the total end clearance by adding the clearance between the impellers and the drive headplate to the clearance between the impellers and the gear headplate.

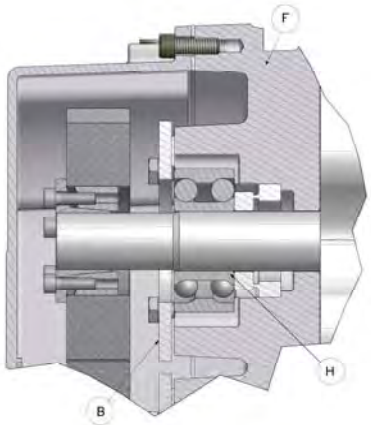


Figure 7-7

NOTICE
Check the clearance over the entire width of the impeller and consider the tightest spot.

B. Divide the end clearance by 3 and distribute approximately 1/3 on the gear end and the remaining 2/3 on the drive end.
C. To move the impeller assembly toward the drive end, lightly tap the shaft at the gear end with a soft face mallet.

D. To move the impeller assembly toward the gear end, lightly tap the shaft at the drive end with a soft face mallet.

E. To set the fixed end, insert the feeler gauge in the amount specified in FIGURE 7-4, page 33, between the headplate and the impeller at the gear end.

F. Tap lightly until the feeler gauge is snug. Adjust both impellers using the same procedure. Rotate the impellers checking for clearance through a complete revolution.

SETTING IMPELLER END CLEARANCE WITH MECHANICAL SEALS

Refer to FIGURE 7-1, page 31. The gear end bearings are held in position by the force created by the wavy spring (J) on the drive end and the bearing retainer (K) on the gear end. This is referred to as the fixed end. The interference fit between the shaft (H) and the bearing inner race (E) keeps the shaft from moving axially.

End clearance adjustment is by movement of the bearing retainer (K). Tightening the bearing retainer screws (M) moves the bearing to load the wavy spring (J), and the impeller is forced toward the drive end. Relaxing the screws allows the wavy spring to return the impeller toward the gear end.

A. Assemble drive cover to drive headplate. Refer to Step 15 with the exception of the use of wavy springs (J) installed between the drive end bearings and the wavy spring retainer plates.

B. Back out retainer screws (M) until both impellers are tight against the gear headplate.

C. With feeler gauge, measure the clearance between each impeller and the drive headplate. This value is the total end clearance.

D. Measure the clearance between the gear headplate and bearing retainer (K) at point (S).

E. Subtract 1/3 of the total end clearance from the clearance measured at point (S). This value is the amount of shim (13) that should be placed between the retainer and the headplate at point (S).

F. Tighten the bearing retainer screws (M) to the torque value given in FIGURE 7-9, page 38. With the retainer screws secure, approximately 1/3 of the total end clearance should be on the gear end and the remaining 2/3 on the drive end.

1. INSTALLING THE TIMING GEARS

If reusing the timing gears, the gears should be returned to their original positions.

A. Obtain 2 gear locking assemblies. Clean the inside and outside diameters of both locking assemblies. Clean the inside diameter of 2 gears. Clean the outside diameter of the both rotor shafts. Lightly oil the surfaces that have been cleaned. Note: DO NOT USE MOLYBDENUM DISULFIDE, MOLYKOTOE, OR ANY OTHER SIMILAR LUBRICANTS.

B. Slide a locking assembly into a gear. Install the gear and locking ring assembly onto the idler rotor shaft. Push the locking assembly firmly until flush with the end of the idler rotor shaft and hand tighten the 7 cap screws. Align and adjust the connections.

C. Use a torque wrench to tighten the screws to 75 in. lbs. in a diametrically opposite sequence. Ensure that none of the screws will turn when 75 in. lbs. is applied to them a second time.

D. Tighten the screws further to 150 in. lbs. in a diametrically opposite sequence. Ensure that none of the screws will turn when 150 in. lbs. is applied to them a second time.

E. Slide the second locking assembly into a gear. Install the gear and locking ring assembly onto the drive rotor shaft. Note the circular mark on each gear indicates the position of the largest runout. These marks must be 180 degrees apart when the gears are installed.

F. Push the locking assembly firmly until flush with the end of drive rotor shaft and hand tighten all cap screws but leave them loose enough that the gear can be rotated on the shaft.

G. The first step in setting the interlobe clearance is to measure the total clearance between two meshing lobes. This is accomplished by determining the maximum feeler gauge thickness that will fit between the rotor lobes near the pitch diameter. The clearance should be measured along the entire length of the meshing lobes. This measurement should be taken for each of the 2 interlobe meshes. The location of the smallest total interlobe clearance should be marked on the rotor lobes. Refer to diagram in FIGURE 7-4, page 33. Use feeler gauges to check clearances between impeller lobes at positions A—A and C—C. Add the clearances, and divide the total clearance evenly between A—A and C—C.

H. Rotate the rotors until the two lobes that have the smallest total interlobe clearance (as determined in step G) are visible through the discharge port. Lock the idler rotor from turning by wedging a shop rag between the tip of a lobe and the air cylinder. Insert feeler gauges with a thickness equal to the half clearance (determined in step G) between the drive rotor and the idler rotor lobe. Pull the drive rotor tight against the feeler gauges (drive rotor, feeler gauges, and idler rotor must be tight against each other). While holding the drive rotor tight against the feeler gages rotate (in the direction that the rotor turns) the gear on the drive rotor until a tooth on it contacts a tooth on the gear on the idler rotor. Hand tighten the 7 capscrews in the drive gear locking assembly. Align and adjust the connection.

I. Use a torque wrench to tighten the screws to 75 in. lbs in a diametrically opposite sequence. Ensure that none of the screws will turn when 75 in. lbs is applied to them a second time.

J. Tighten the screws further to 150 in. lbs in a diametrically opposite sequence. Ensure that none of the screws will turn when 150 in. lbs is applied to them a second time.

K. Check gear backlash four places at 90 degree intervals as described in the disassembly procedure (Item 4).

⚠ CAUTION

These impeller-to-impeller and impeller-to-case clearances are extremely critical. Even though the blower may turn freely by hand when cold, under operating conditions, the parts expand, and the rotors are subject to slight defection.

If the clearances are not sufficient, the impellers may contact each other or the housing with destructive results. If the clearances are too great, the blower may not develop the pressure or airflow that is required to perform its function.

14. Impeller tip to case clearance should be checked at this time by inserting the correct thickness feeler gauge between the tip and the case and rotating the impeller (see FIGURE 7-4, page 34). Repeat the procedure on both impellers.

NOTICE

When checking the tip to case clearance, move the feeler gauge over the entire length of the impeller to ensure that the tips do not bind along their length.

FIGURE 7-8

NOTICE

Replacement gears have minimum backlash marks on the outside diameter of the gear face. These marks should be located 180 degrees from each other (see FIGURE 7-8).

NOTICE

The gear used for adjustment should be flush with its mate on completion of the timing.

NOTICE

If any of the four gear backlash readings are not within the specified limits, the gears must be replaced.

15. Replace drive shaft oil seal (31) in the drive end cover (29). The seal lip should always face towards the bearing or lubricant.

Grease Units

Pack bearing cavities with recommended grease and secure drive cover with socket head cap screws (30) to drive headplate.

Dual Splash Units

Install drive end gasket (7). Gently slide the drive end cover (29) over the drive shaft and tap cover down over dowel pins until flush. Install and tighten drive cover bolts (30).

Refer to FIGURE 7-9, for torque specifications.

⚠ CAUTION
Exercise care not to damage the seal lip as it passes over the shaft keyway.

16. Assemble the gear cover (3) and gasket (7) to the gear headplate (18) using socket head screw (5). Tighten the capscrews alternately and evenly. Refer to FIGURE 7-9 for torque specifications.

17. Place the blower on its feet on a flat surface. Loosen cap screws (16) and level the unit up. The bench or blower base flatness should be within .002 of an inch. Re-tighten cap screws (16) to the specification in FIGURE 7-9.

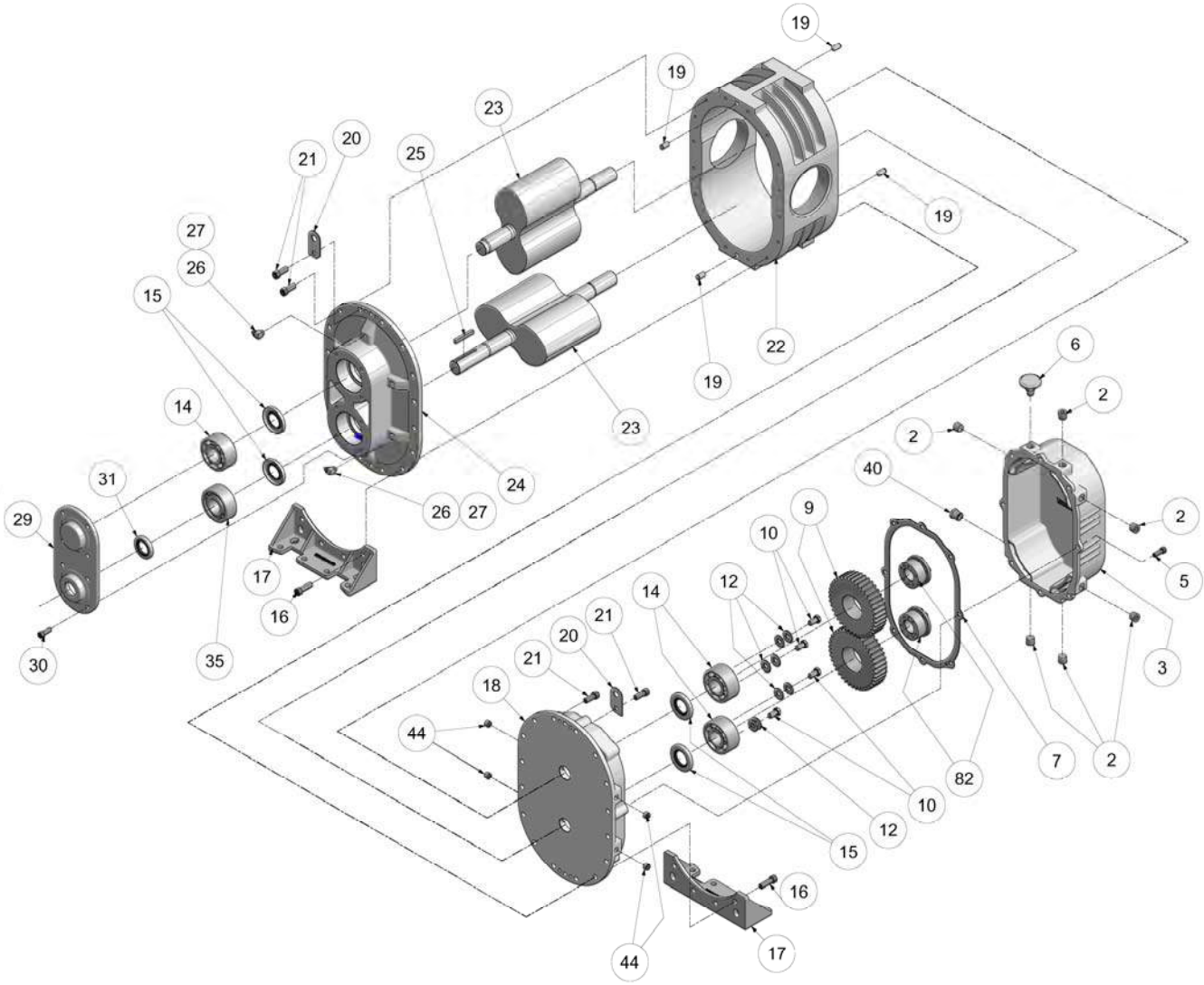
NOTICE
If the unit is not flat within .002 of an inch, it will be necessary to shim the blower feet at installation.

	GEAR DIAMETER		
FASTENERS	**3**	**4**	**5**
CAPSCREW (21)	23 – 30	42 – 45	42 – 45
CAPSCREW (16)	23 – 30	42 – 45	42 – 45
SOCKET HD CAPSCREW (5)	6 – 8	16 – 18	11 – 13
SOCKET HD CAPSCREW (30)	6 – 8	16 – 18	11 – 13
CAPSCREW (10)	6 – 8	38 – 42	38 – 42

NOTE: ( ) DENOTES ITEMS IN EXPLODED VIEW DRAWINGS ON PAGES 39 AND 43.

FIGURE 7-9 – TORQUE (FT-LBS)

SECTION 8
PARTS LIST

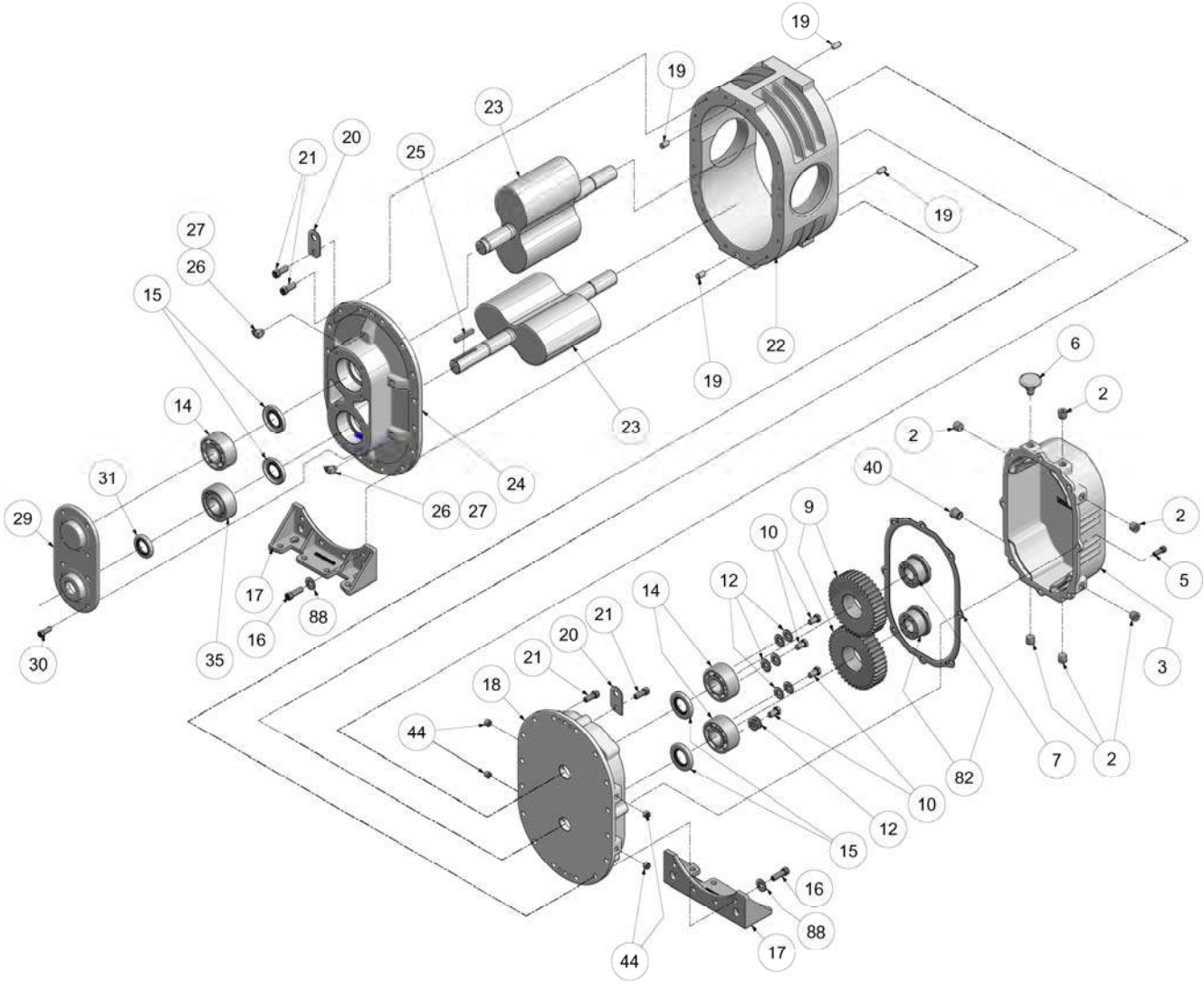


Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAB Lip Seal Grease Splash Lube

Ref. No.	Description	No. Req'd	Size – 3H GABH_R Δ Δ= (A or C)	Size – 3M GABM_R Δ Δ= (A or C)	Size -- 3L GABL_R Δ Δ= (A or C)
2	Plug	6	64AC2	64AC2	64AC2
3	Gear Case	1	303GAB602	303GAB602	303GAB602
5	Screw	8	75P7	75P7	75P7
6	Breather	1	5L358	5L358	5L358
* 7	Gasket	1	300GAB715	300GAB715	300GAB715
9	Gear Kit	1	300GAB6008	300GAB6008	300GAB6008
* 10	Screws	4	75A33P	75A33P	75A33P
12	Washer	4	95A2	95A2	95A2
* 14	Ball Bearing	3	12BA143	12BA143	12BA143
* 15	Oil Seal	4	900891030601	900891030601	900891030601
16	Screw	4	75P56	75P56	75P56
17	Foot – Vert. & Horiz.	2	303GAB166	303GAB166	303GAB166
18	Bearing Housing Gear End	1	302GAB006	302GAB006	302GAB006
19	Dowel Pin	4	62M48	62M48	62M48
20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
21	Screw	20	75P55	75P55	75P55
22	Impeller Case	1	900873034301	900873033801	900873034201
23	Rotor Group				
	3" Standard Clearances	1	307GAB4028	309GAB4028	308GAB4028
	3" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
24	Bearing Housing Drive End	1	900873033501	900873033501	900873033501
25	Key-Square	1	900639910304	900639910304	900639910304
26	Pipe Fitting	2	40E9	40E9	40E9
27	Cap	2	40P58	40P58	40P58
29	Drive Cover	1	9010873033701	9010873033701	9010873033701
30	Screw	6	75P22	75P22	75P22
* 31	Oil Seal	1	60DD725	60DD725	60DD725
* 35	Bearing – Roller	1	12BA153	12BA153	12BA153
40	Oil Level Gauge	1	40P82	40P82	40P82
44	Screw	4	76F1	76F1	76F1
** 45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
** 54	Shim Case .0025/.0035"	1	200GAB732	200GAB732	200GAB732
** 55	Shim Case .010"	1	201GAB732	201GAB732	201GAB732
** 56	Shim Case .0015/.002"	1	202GAB732	202GAB732	202GAB732
82	Locking Assembly	2	22G45	22G45	22G45
** 105	Overhaul Kit 3" R VERS Lip Seal, Grease Splash Lube	1	302GAB6010	302GAB6010	302GAB6010
** 900	Group-Indent & Instruction Legend Series 3" R VERS	1	303GAB4011	303GAB4011	303GAB4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION.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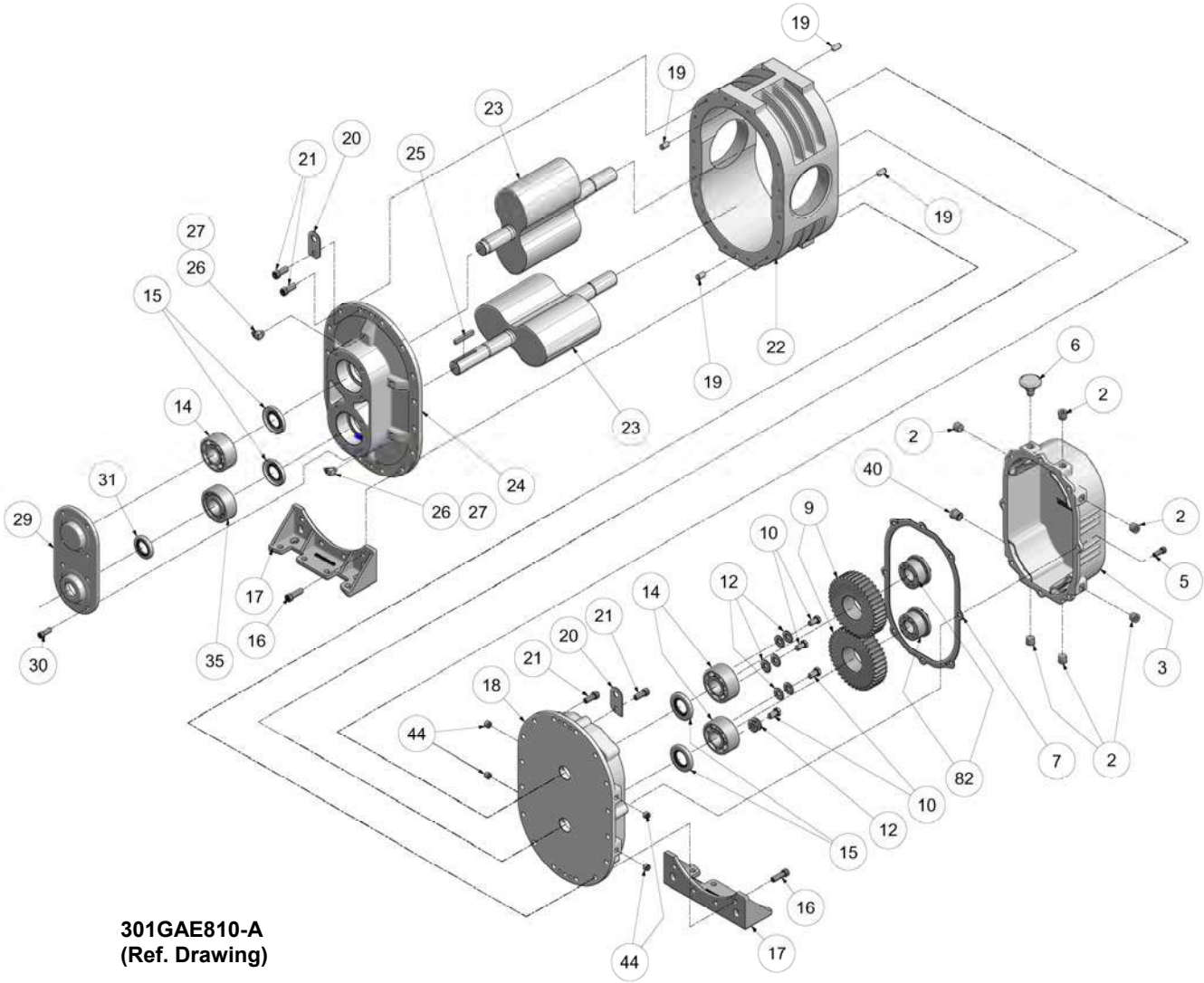
Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAC Lip Seal — Grease Splash Lube

Ref. No.	Description	No. Req'd	Size – 4H GACH_R Δ Δ= (A or C)	Size – 4M GACM_R Δ Δ= (A or C)	Size -- 4L GACL_R Δ Δ= (A or C)
2	Plug	6	64AC3	64AC3	64AC3
3	Gear Case	1	304GAC602	304GAC602	304GAC602
5	Screw	8	75P40	75P40	75P40
6	Breather	1	5L359	5L359	5L359
* 7	Gasket	1	301GAC715	301GAC715	301GAC715
9	Gear Kit	1	300GAC6008	300GAC6008	300GAC6008
* 10	Screws	4	655ED03P	655ED03P	655ED03P
12	Washer	8	95A3	95A3	95A3
* 14	Ball Bearing	3	12BA144	12BA144	12BA144
* 15	Oil Seal	4	60DD630	60DD630	60DD630
16	Screw	8	75P56	75P56	75P56
17	Foot – Vert. & Horiz.	2	300GAC166	300GAC166	300GAC166
18	Bearing Housing Gear End	1	302GAC006	302GAC006	302GAC006
19	Dowel Pin	4	62M48	62M48	62M48
20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
21	Screw	16	75P55	75P55	75P55
22	Impeller Case	1	900883042201	900883041801	900883042001
23	Rotor Group				
	4" Standard Clearances	1	307GAC4028	306GAC4028	305GAC4028
	4" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
24	Bearing Housing Drive End	1	300GAC006	300GAC006	300GAC006
25	Key-Square	1	900639910304	900639910304	900639910304
26	Pipe Fitting	2	40E9	40E9	40E9
27	Cap	2	40P58	40P58	40P58
29	Drive Cover	1	900883040301	900883040301	900883040301
30	Screw	8	75P189	75P189	75P189
* 31	Oil Seal	1	60DD716	60DD716	60DD716
* 35	Bearing – Roller	1	12BA154	12BA154	12BA154
40	Oil Level Gauge	1	40P34	40P34	40P34
44	Screw	4	76F1	76F1	76F1
** 45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
** 54	Shim Case .0025/.0035"	1	200GAC732	200GAC732	200GAC732
** 55	Shim Case .010"	1	201GAC732	201GAC732	201GAC732
** 56	Shim Case .0015/.002"	1	202GAC732	202GAC732	202GAC732
82	Locking Assembly	2	22G44	22G44	22G44
88	Washer	4	95A3	95A3	95A3
** 105	Overhaul Kit 4" R VERS Lip Seal, Grease Splash Lube	1	300GAC6010	300GAC6010	300GAC6010
** 900	Group-Indent & Instruction Legend Series 4" R VERS	1	201GAC4011	201GAC4011	201GAC4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION.



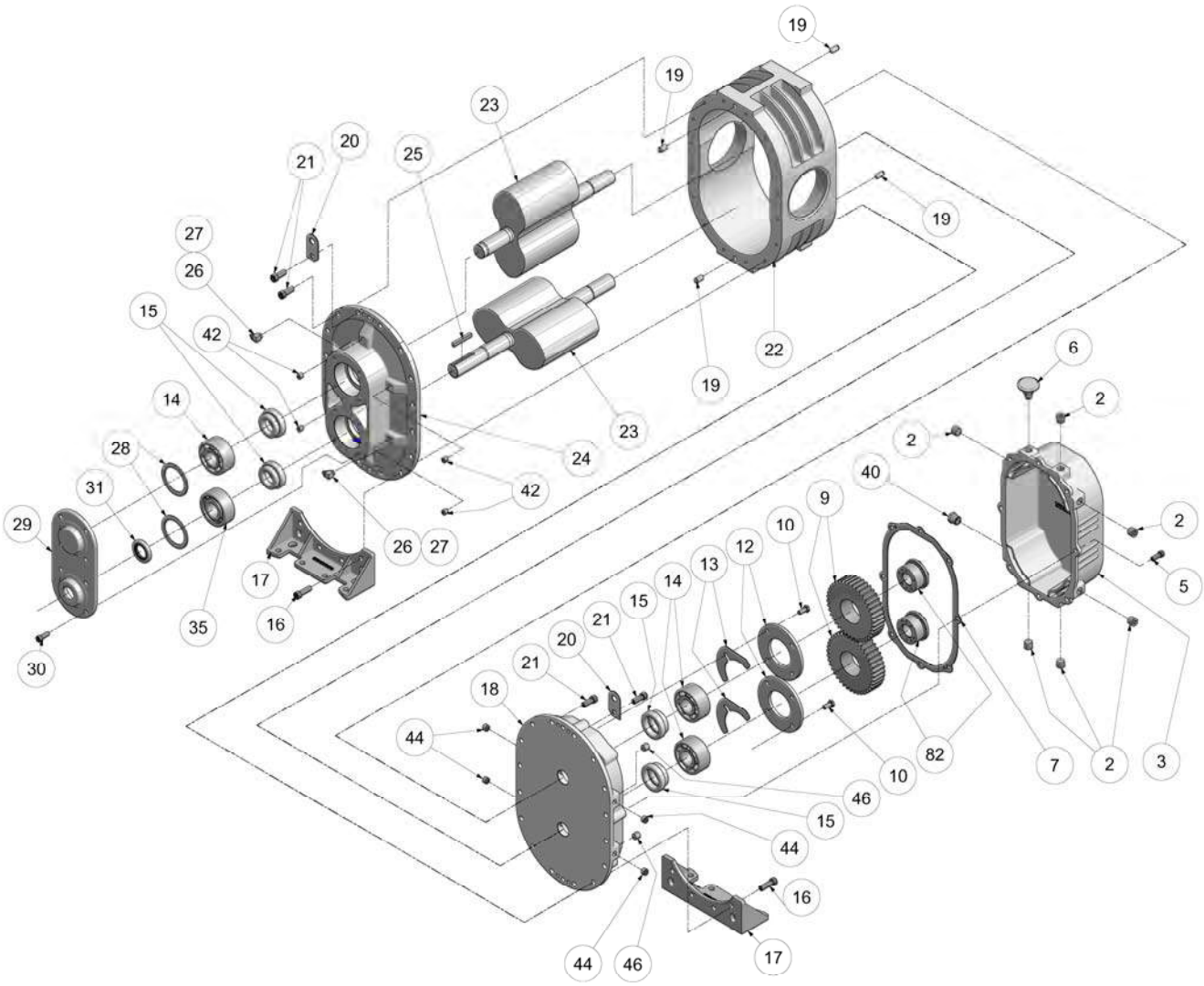
301GAE810-A
(Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAE Lip Seal Grease Splash Lube

	Ref. No.	Description	No. Req'd	Size – 5H GAEH_R Δ Δ= (A or C)	Size – 5M GAEM_R Δ Δ= (A or C)	Size -- 5L GAEL_R Δ Δ= (A or C)
	2	Plug	6	64AC3	64AC3	64AC3
	3	Gear Case	1	304GAE602	304GAE602	304GAE602
	5	Screw	8	75P40	75P40	75P40
	6	Breather	1	5L359	5L359	5L359
*	7	Gasket	1	300GAE715	300GAE715	300GAE715
	9	Gear Kit	1	300GAE6008	300GAE6008	300GAE6008
*	10	Screws	4	655ED03P	655ED03P	655ED03P
	12	Washer	8	95A3	95A3	95A3
*	14	Ball Bearing	3	8500397	8500397	8500397
*	15	Oil Seal	4	60DD714	60DD714	60DD714
	16	Screw	8	75P56	75P56	75P56
	17	Foot – Vert. & Horiz.	2	300GAE166	300GAE166	300GAE166
	18	Bearing Housing Gear End	1	301GAE006	301GAE006	301GAE006
	19	Dowel Pin	4	62M48	62M48	62M48
	20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
	21	Screw	24	75P55	75P55	75P55
	22	Impeller Case	1	900883051701	900883051801	900883051901
	23	Rotor Group				
		5" Standard Clearances	1	327GAE4028	326GAE4028	325GAE4028
		5" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
	24	Bearing Housing Drive End	1	206GAE006	206GAE006	206GAE006
	25	Key-Square	1	900639910305	900639910305	900639910305
	26	Pipe Fitting	2	40E9	40E9	40E9
	27	Cap	2	40P58	40P58	40P58
	29	Drive Cover	1	900883050401	900883050401	900883050401
	30	Screw	8	75P189	75P189	75P189
*	31	Oil Seal	1	60DD726	60DD726	60DD726
*	35	Bearing – Roller	1	12BA155	12BA155	12BA155
	40	Oil Level Gauge	1	40P34	40P34	40P34
	44	Screw	4	76F92	76F92	76F92
**	45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
**	54	Shim Case .0025/.0035"	1	200GAE732	200GAE732	200GAE732
**	55	Shim Case .010"	1	201GAE732	201GAE732	201GAE732
**	56	Shim Case .0015/.002"	1	202GAE732	202GAE732	202GAE732
	82	Locking Assembly	2	22G43	22G43	22G43
**	105	Overhaul Kit 5" R VERS Lip Seal, Grease Splash Lube	1	300GAE6010	300GAE6010	300GAE6010
**	900	Group-Indent & Instruction Legend Series 5" R VERS	1	205GAE4011	205GAE4011	205GAE4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION.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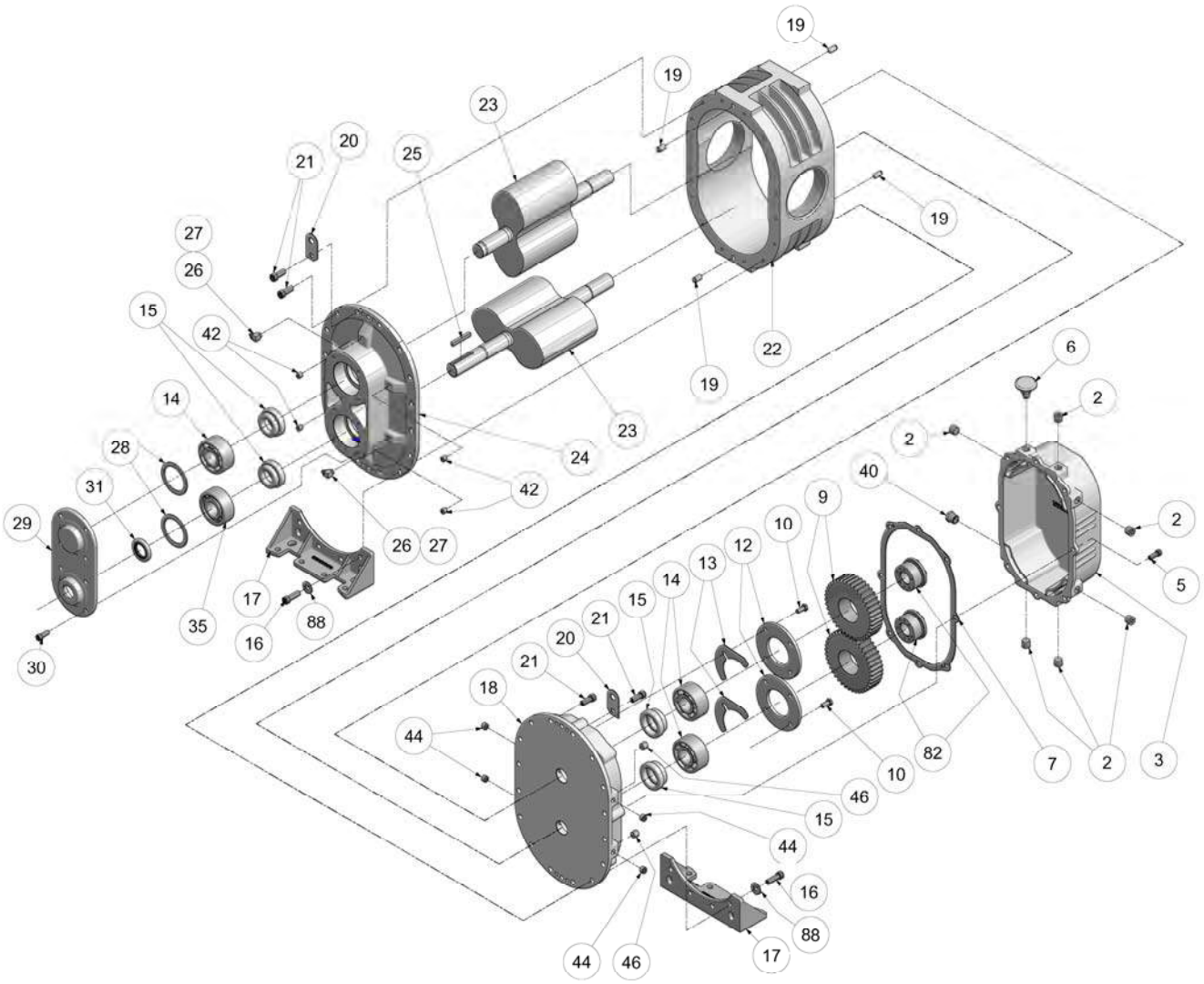
Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAB Mechanical Seal Grease Splash Lube

	Ref. No.	Description	No. Req'd	Size – 3H GABH_RB	Size – 3M GABM_RB	Size -- 3L GABL_RB
	2	Plug	6	64AC2	64AC2	64AC2
	3	Gear Case	1	303GAB602	303GAB602	303GAB602
	5	Screw	8	75P7	75P7	75P7
	6	Breather	1	5L358	5L358	5L358
*	7	Gasket	1	300GAB715	300GAB715	300GAB715
	9	Gear Kit	1	300GAB6008	300GAB6008	300GAB6008
*	10	Screws	4	75A33P	75A33P	75A33P
	12	Bearing Retainer	2	300GAB205	300GAB205	300GAB205
*	13	Shim Set	1	900881032200	900881032200	900881032200
*	14	Ball Bearing	3	12BA143	12BA143	12BA143
*	15	Mechanical Seal	4	900871020003	900871020003	900871020003
	16	Screw	4	75P56	75P56	75P56
	17	Foot – Vert. & Horiz.	2	303GAB166	303GAB166	303GAB166
	18	Bearing Housing Gear End	1	304GAB006	304GAB006	304GAB006
	19	Dowel Pin	4	62M48	62M48	62M48
	20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
	21	Screw	20	75P55	75P55	75P55
	22	Impeller Case	1	900873034301	900873033801	900873034201
	23	Rotor Group				
		3" Standard Clearances	1	307GAB4028	309GAB4028	308GAB4028
		3" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
	24	Bearing Housing Drive End	1	900883030301	900883030301	900883030301
	25	Key-Square	1	900639910304	900639910304	900639910304
	26	Pipe Fitting	2	40E9	40E9	40E9
	27	Cap	2	40P58	40P58	40P58
*	28	Wavy Spring	2	900669170203	900669170203	900669170203
	29	Drive Cover	1	900873033701	900873033701	900873033701
	30	Screw	6	75P22	75P22	75P22
*	31	Oil Seal	1	60DD725	60DD725	60DD725
*	35	Bearing – Roller	1	12BA153	12BA153	12BA153
	40	Oil Level Gauge	1	40P82	40P82	40P82
	42	Plug	4	64AC1	64AC1	64AC1
	44	Screw	4	76F1	76F1	76F1
**	45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
	46	Plug	4	64AC1	64AC1	64AC1
**	54	Shim Case .0025/.0035"	1	200GAB732	200GAB732	200GAB732
**	55	Shim Case .010"	1	201GAB732	201GAB732	201GAB732
**	56	Shim Case .0015/.002"	1	202GAB732	202GAB732	202GAB732
	82	Locking Assembly	2	22G45	22G45	22G45
**	105	Overhaul Kit 3" R VERS Mechanical Seal, Grease Splash Lube	1	303GAB6010	303GAB6010	303GAB6010
**	900	Group-Indent & Instruction Legend Series 3" R VERS	1	303GAB4011	303GAB4011	303GAB4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION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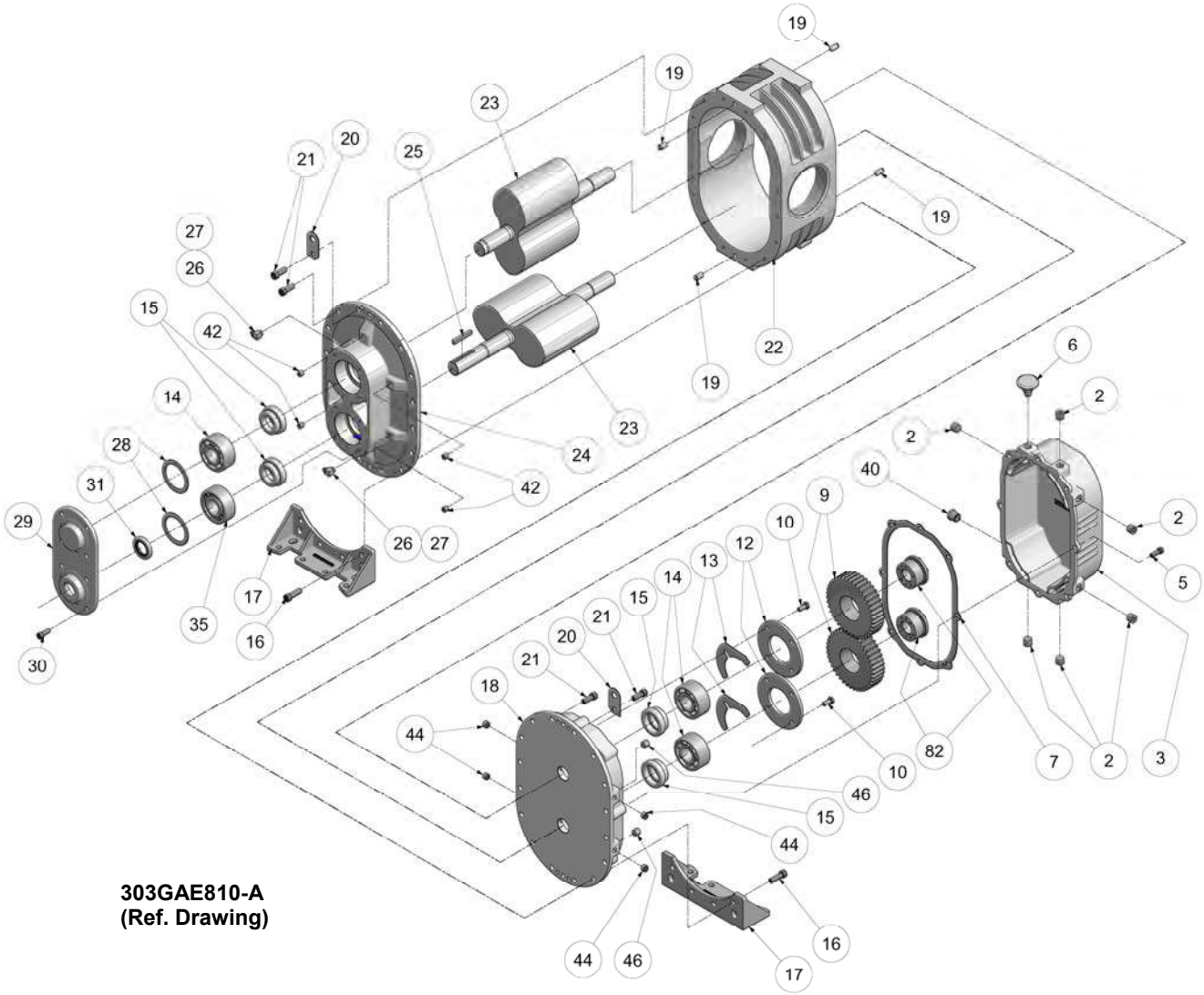
Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAC Mechanical Seal Grease Splash Lube

	Ref. No.	Description	No. Req'd	Size – 4H GACH_RB	Size – 4M GACM_RB	Size -- 4L GACL_RB
	2	Plug	6	64AC3	64AC3	64AC3
	3	Gear Case	1	304GAC602	304GAC602	304GAC602
	5	Screw	8	75P40	75P40	75P40
	6	Breather	1	5L359	5L359	5L359
*	7	Gasket	1	301GAC715	301GAC715	301GAC715
	9	Gear Kit	1	300GAC6008	300GAC6008	300GAC6008
*	10	Screws	8	75A33P	75A33P	75A33P
	12	Bearing Retainer	2	900883040201	900883040201	900883040201
*	13	Shim Set	1	900881042900	900881042900	900881042900
*	14	Ball Bearing	3	12BA144	12BA144	12BA144
*	15	Mechanical Seal	4	900871020004	900871020004	900871020004
	16	Screw	8	75P56	75P56	75P56
	17	Foot – Vert. & Horiz.	2	300GAC166	300GAC166	300GAC166
	18	Bearing Housing Gear End	1	304GAC006	304GAC006	304GAC006
	19	Dowel Pin	4	62M48	62M48	62M48
	20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
	21	Screw	16	75P55	75P55	75P55
	22	Impeller Case	1	900883042201	900883041801	900883042001
	23	Rotor Group				
		4" Standard Clearances	1	307GAC4028	306GAC4028	305GAC4028
		4" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
	24	Bearing Housing Drive End	1	900883041201	900883041201	900883041201
	25	Key-Square	1	900639910304	900639910304	900639910304
	26	Pipe Fitting	2	40E9	40E9	40E9
	27	Cap	2	40P58	40P58	40P58
*	28	Wavy Spring	2	900669170304	900669170304	900669170304
	29	Drive Cover	1	900883040301	900883040301	900883040301
	30	Screw	8	75P189	75P189	75P189
*	31	Oil Seal	1	60DD716	60DD716	60DD716
*	35	Bearing – Roller	1	12BA154	12BA154	12BA154
	40	Oil Level Gauge	1	40P34	40P34	40P34
	42	Plug	4	64AC1	64AC1	64AC1
	44	Screw	4	76F1	76F1	76F1
**	45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
	46	Plug	4	64AC1	64AC1	64AC1
**	54	Shim Case .0025/.0035"	1	200GAC732	200GAC732	200GAC732
**	55	Shim Case .010"	1	201GAC732	201GAC732	201GAC732
**	56	Shim Case .0015/.002"	1	202GAC732	202GAC732	202GAC732
	82	Locking Assembly	2	22G44	22G44	22G44
	88	Washer	4	95A3	95A3	95A3
**	105	Overhaul Kit 4" R VERS Mechanical Seal, Grease Splash Lube	1	302GAC6010	302GAC6010	302GAC6010
**	900	Group-Indent & Instruction Legend Series 4" R VERS	1	201GAC4011	201GAC4011	201GAC4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION



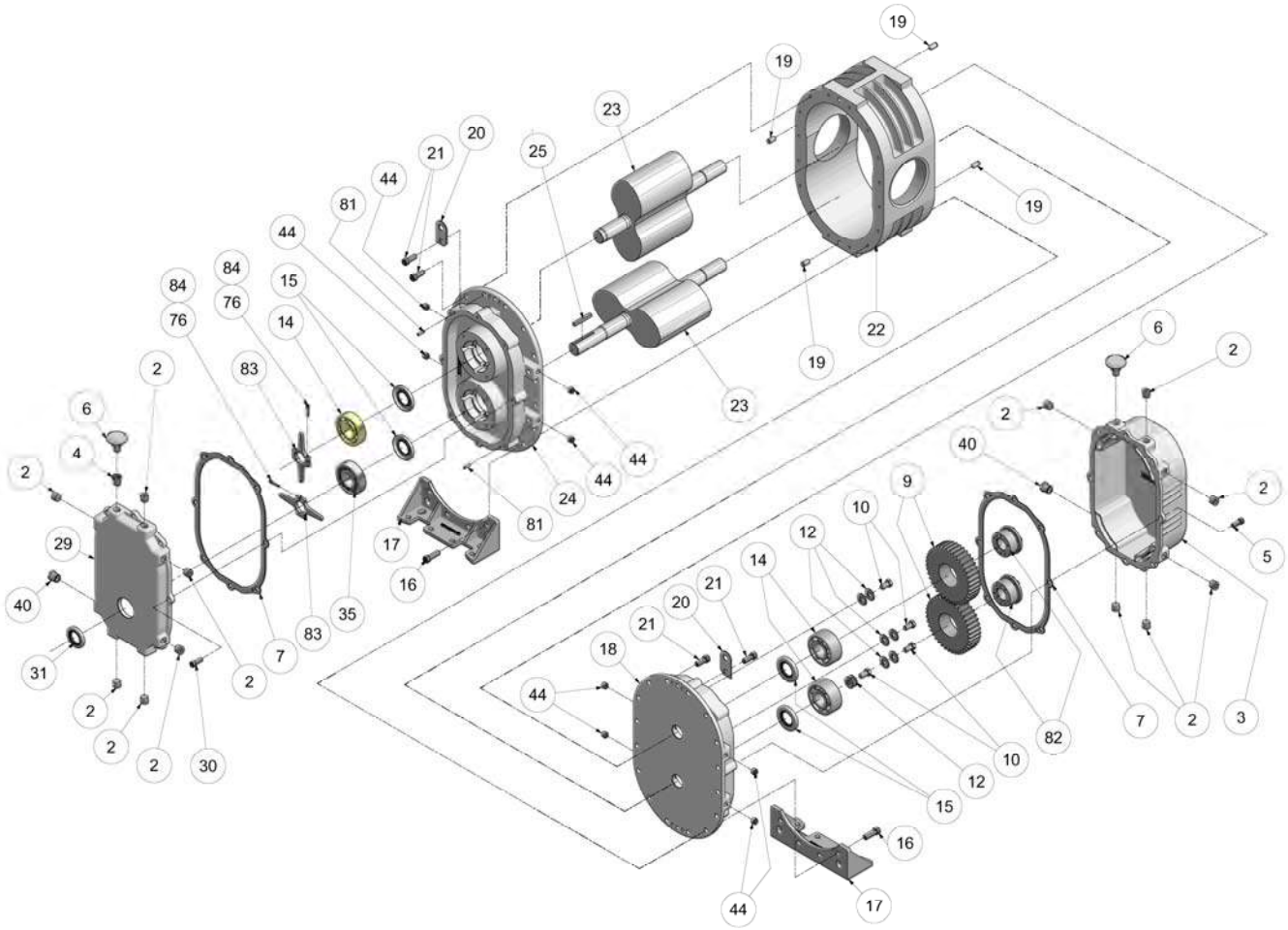
303GAE810-A
(Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAE Mechanical Seal Grease Splash Lube

Ref. No.	Description	No. Req'd	Size – 5H GAEH_RB	Size – 5M GAEM_RB	Size -- 5L GAEL_RB
2	Plug	6	64AC3	64AC3	64AC3
3	Gear Case	1	304GAE602	304GAE602	304GAE602
5	Screw	8	75P40	75P40	75P40
6	Breather	1	5L359	5L359	5L359
* 7	Gasket	1	300GAE715	300GAE715	300GAE715
9	Gear Kit	1	300GAE6008	300GAE6008	300GAE6008
* 10	Screws	8	75A33P	75A33P	75A33P
12	Bearing Retainer	2	900883050501	900883050501	900883050501
* 13	Shim Set	1	900881052900	900881052900	900881052900
* 14	Ball Bearing	3	8500397	8500397	8500397
* 15	Mechanical Seal	4	900871020005	900871020005	900871020005
16	Screw	8	75P56	75P56	75P56
17	Foot – Vert. & Horiz.	2	300GAE166	300GAE166	300GAE166
18	Bearing Housing Gear End	1	303GAE006	303GAE006	303GAE006
19	Dowel Pin	4	62M48	62M48	62M48
20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
21	Screw	24	75P55	75P55	75P55
22	Impeller Case	1	900883051701	900883051801	900883051901
23	Rotor Group				
	5" Standard Clearances	1	327GAE4028	326GAE4028	325GAE4028
	5" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
24	Bearing Housing Drive End	1	207GAE006	207GAE006	207GAE006
25	Key-Square	1	900639910305	900639910305	900639910305
26	Pipe Fitting	2	40E9	40E9	40E9
27	Cap	2	40P58	40P58	40P58
* 28	Wavy Spring	2	900669170405	900669170405	900669170405
29	Drive Cover	1	900883050401	900883050401	900883050401
30	Screw	8	75P189	75P189	75P189
* 31	Oil Seal	1	60DD726	60DD726	60DD726
* 35	Bearing – Roller	1	12BA155	12BA155	12BA155
40	Oil Level Gauge	1	40P34	40P34	40P34
42	Plug	4	64AC1	64AC1	64AC1
44	Screw	4	76F92	76F92	76F92
** 45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
46	Plug	4	64AC2	64AC2	64AC2
** 54	Shim Case .0025/.0035"	1	200GAE732	200GAE732	200GAE732
** 55	Shim Case .010"	1	201GAE732	201GAE732	201GAE732
** 56	Shim Case .0015/.002"	1	202GAE732	202GAE732	202GAE732
82	Locking Assembly	2	22G43	22G43	22G43
** 105	Overhaul Kit 5" R VERS Mechanical Seal, Grease Splash	1	302GAE6010	302GAE6010	302GAE6010
** 900	Group-Indent & Instruction Legend Series 5" R VERS	1	205GAE4011	205GAE4011	205GAE4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION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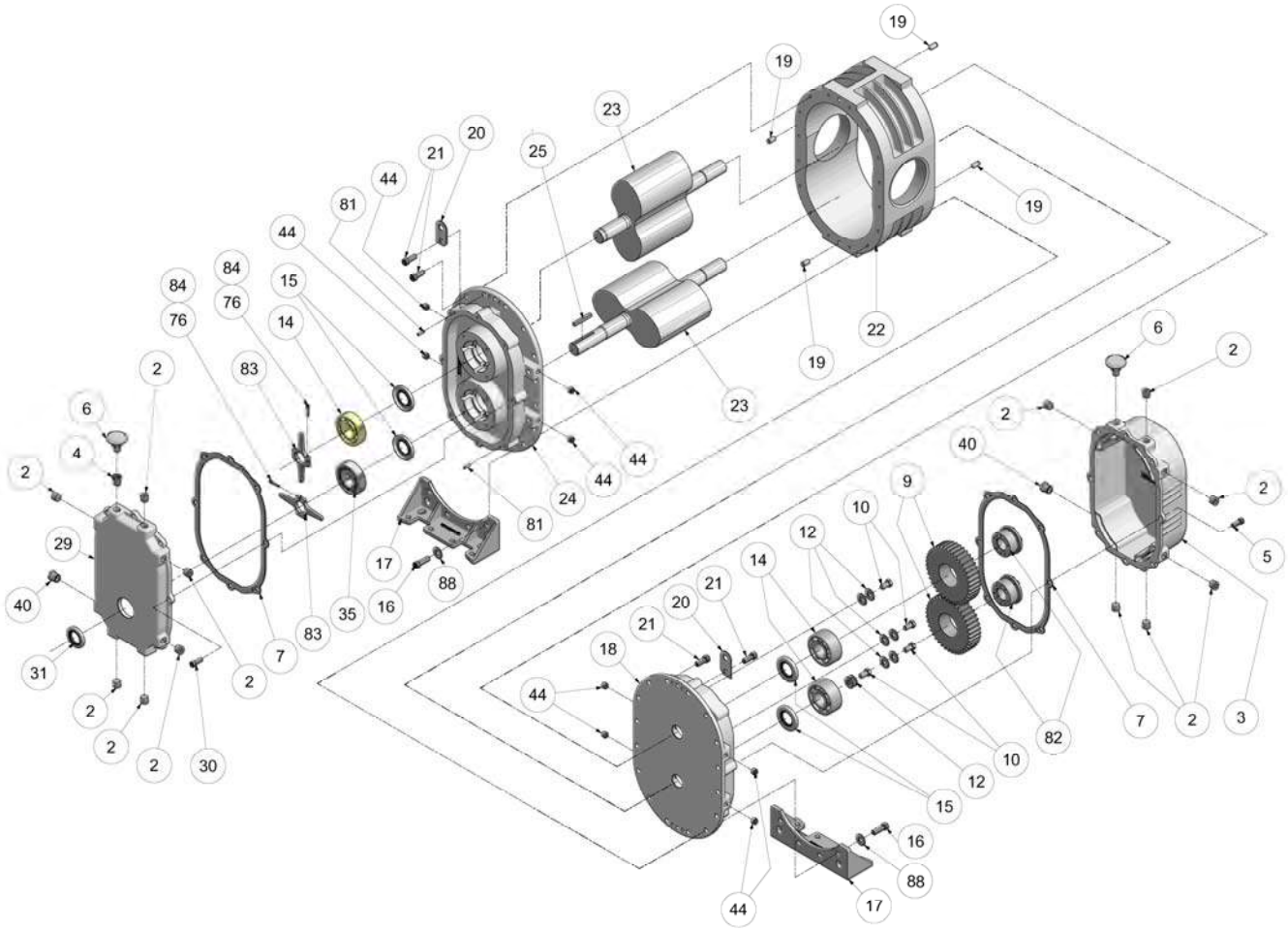
Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAB Lip Seal Dual Splash Lube

Ref. No.	Description	No. Req'd	Size – 3H GABH_R △ △= (D or F)	Size – 3M GABM_R △ △= (D or F)	Size -- 3L GABL_R △ △= (D or F)
2	Plug	12	64AC2	64AC2	64AC2
3	Gear Case	1	303GAB602	303GAB602	303GAB602
5	Screw	8	75P7	75P7	75P7
6	Breather	2	5L358	5L358	5L358
* 7	Gasket	2	300GAB715	300GAB715	300GAB715
9	Gear Kit	1	300GAB6008	300GAB6008	300GAB6008
* 10	Screws	4	75A33P	75A33P	75A33P
12	Washer	8	95A2	95A2	95A2
* 14	Ball Bearing	3	12BA143	12BA143	12BA143
* 15	Oil Seal	4	900891030601	900891030601	900891030601
16	Screw	4	75P56	75P56	75P56
17	Foot – Vert. & Horiz.	2	303GAB166	303GAB166	303GAB166
18	Bearing Housing Gear End	1	302GAB006	302GAB006	302GAB006
19	Dowel Pin	4	62M48	62M48	62M48
20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
21	Screw	20	75P55	75P55	75P55
22	Impeller Case	1	900873034301	900873033801	900873034201
23	Rotor Group				
	3" Standard Clearances	1	307GAB4028	309GAB4028	308GAB4028
	3" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
24	Bearing Housing Drive End	1	303GAB006	303GAB006	303GAB006
25	Key-Square	1	900639910304	900639910304	900639910304
29	Drive Cover	1	302GAB477	302GAB477	302GAB477
30	Screw	8	75P7	75P7	75P7
* 31	Oil Seal	1	60DD725	60DD725	60DD725
* 35	Bearing – Spherical	1	12BA153	12BA153	12BA153
40	Oil Level Gauge	2	40P82	40P82	40P82
44	Screw	8	76F1	76F1	76F1
** 45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
** 54	Shim Case .0025/.0035"	1	200GAB732	200GAB732	200GAB732
** 55	Shim Case .0010"	1	201GAB732	201GAB732	201GAB732
** 56	Shim Case .0015/.002"	1	202GAB732	202GAB732	202GAB732
76	Compound, Loctite	50	25BC877	25BC877	25BC877
81	Dowel Pin	2	62M13	62M13	62M13
82	Locking Assembly	2	22G45	22G45	22G45
83	Slinger	2	300GAB173	300GAB173	300GAB173
84	Screw	2	75LM13	75LM13	75LM13
** 105	Overhaul Kit 3" R VERS Lip Seal, Dual Splash Lube	1	301GAB6010	301GAB6010	301GAB6010
** 900	Group-Indent & Instruction Legend Series 3" R VERS	1	303GAB4011	303GAB4011	303GAB4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION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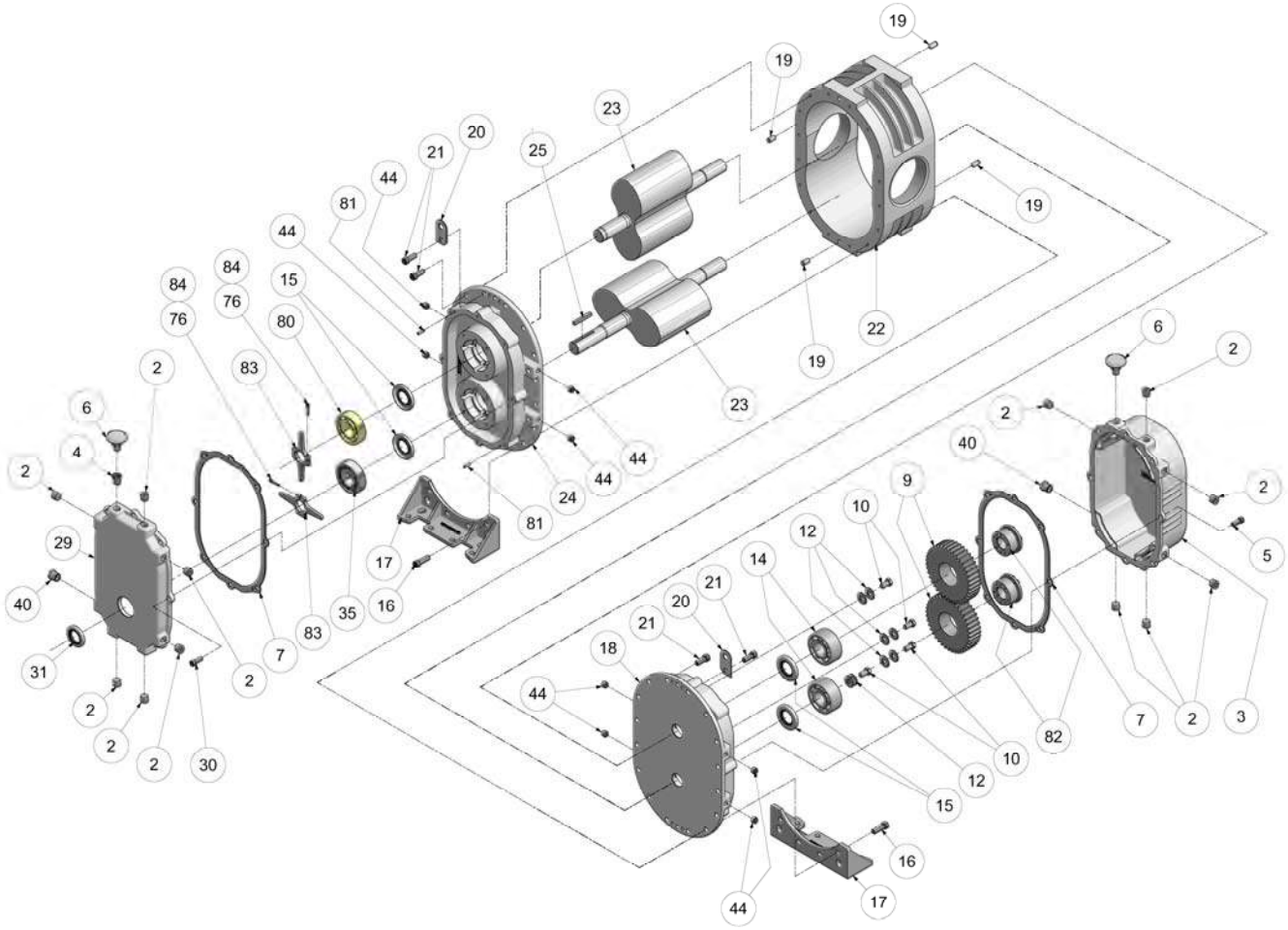
Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAC Lip Seal — Dual Splash Lube

Ref. No.	Description	No. Req'd	Size – 4H GACH_R Δ Δ= (D or F)	Size – 4M GACM_R Δ Δ= (D or F)	Size -- 4L GACL_R Δ Δ= (D or F)
2	Plug	12	64AC3	64AC3	64AC3
3	Gear Case	1	304GAC602	304GAC602	304GAC602
5	Screw	8	75P40	75P40	75P40
6	Breather	2	5L359	5L359	5L359
* 7	Gasket	2	301GAC715	301GAC715	301GAC715
9	Gear Kit	1	300GAC6008	300GAC6008	300GAC6008
* 10	Screws	4	655ED03P	655ED03P	655ED03P
12	Washer	8	95A3	95A3	95A3
* 14	Ball Bearing	3	12BA144	12BA144	12BA144
* 15	Oil Seal	4	60DD630	60DD630	60DD630
16	Screw	8	75P56	75P56	75P56
17	Foot – Vert. & Horiz.	2	300GAC166	300GAC166	300GAC166
18	Bearing Housing Gear End	1	302GAC006	302GAC006	302GAC006
19	Dowel Pin	4	62M48	62M48	62M48
20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
21	Screw	16	75P55	75P55	75P55
22	Impeller Case	1	900883042201	900883041801	900883042001
23	Rotor Group				
	4" Standard Clearances	1	307GAC4028	306GAC4028	305GAC4028
	4" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
24	Bearing Housing Drive End	1	303GAC006	303GAC006	303GAC006
25	Key-Square	1	900639910304	900639910304	900639910304
29	Drive Cover	1	302GAC477	302GAC477	302GAC477
30	Screw	8	75P40	75P40	75P40
* 31	Oil Seal	1	60DD716	60DD716	60DD716
* 35	Bearing – Spherical	1	12BA255	12BA255	12BA255
40	Oil Level Gauge	2	40P34	40P34	40P34
44	Screw	8	76F1	76F1	76F1
** 45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
** 54	Shim Case .0025/.0035"	1	200GAC732	200GAC732	200GAC732
** 56	Shim Case .0015/.002"	1	202GAC732	202GAC732	202GAC732
76	Compound, Loctite	50	25BC877	25BC877	25BC877
81	Dowel Pin	2	62M13	62M13	62M13
82	Locking Assembly	2	22G44	22G44	22G44
83	Slinger	2	300GAC173	300GAC173	300GAC173
84	Screw	2	75LM14	75LM14	75LM14
88	Washer	4	95A3	95A3	95A3
** 105	Overhaul Kit 4" R VERS Lip Seal, Dual Splash Lube	1	301GAC6010	301GAC6010	301GAC6010
** 900	Group-Indent & Instruction Legend Series 4" R VERS	1	201GAC4011	201GAC4011	201GAC4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION



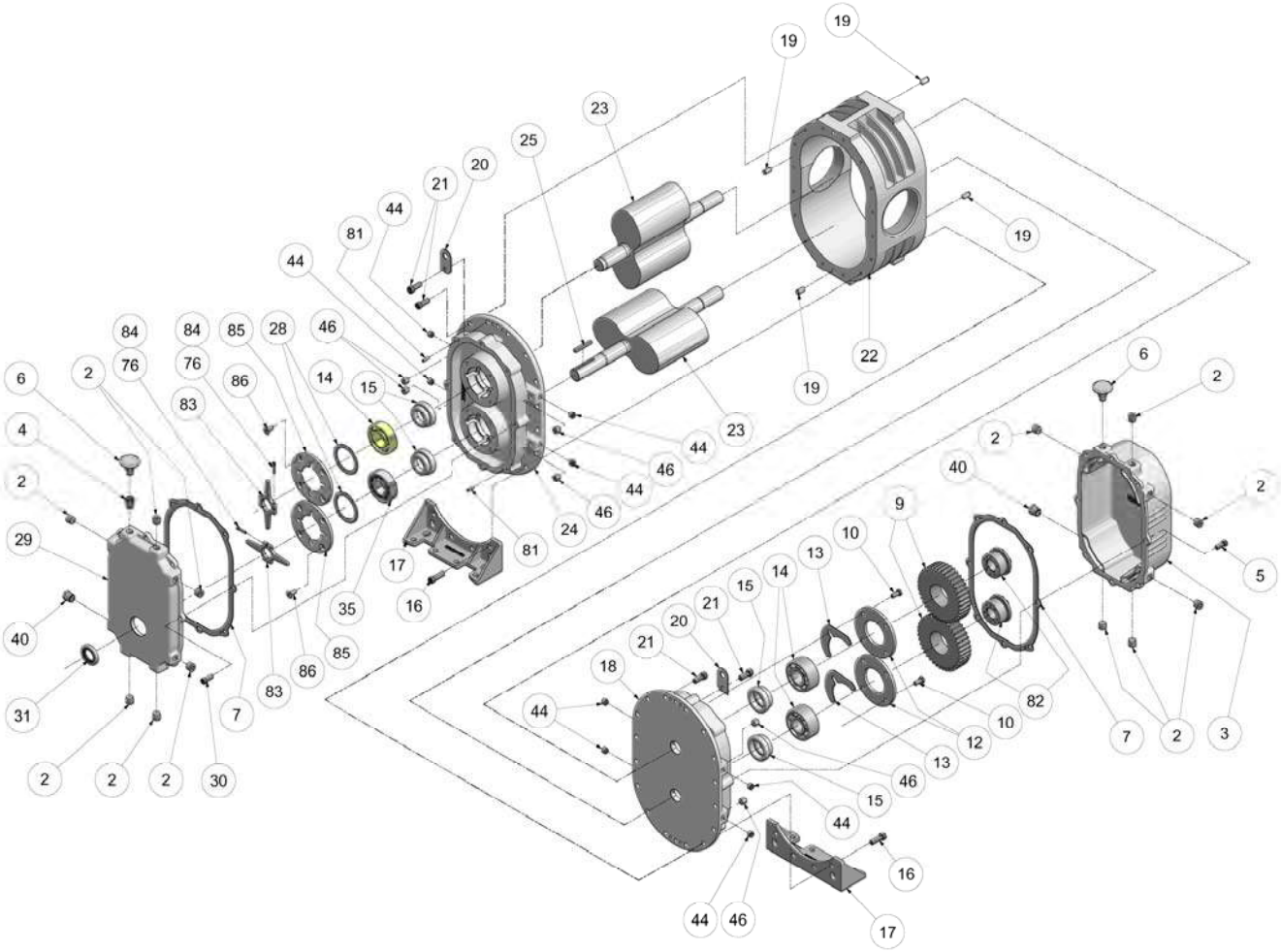
300GAE810-A
(Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAE Lip Seal Dual Splash Lube

	Ref. No.	Description	No. Req'd	Size – 5H GAEH_R Δ Δ= (D or F)	Size – 5M GAEM_R Δ Δ= (D or F)	Size -- 5L GAEL_R Δ Δ= (D or F)
	2	Plug	12	64AC3	64AC3	64AC3
	3	Gear Case	1	304GAE602	304GAE602	304GAE602
	5	Screw	8	75P40	75P40	75P40
	6	Breather	2	5L359	5L359	5L359
*	7	Gasket	2	300GAE715	300GAE715	300GAE715
	9	Gear Kit	1	300GAE6008	300GAE6008	300GAE6008
*	10	Screws	4	655ED03P	655ED03P	655ED03P
	12	Washer	8	95A3	95A3	95A3
*	14	Ball Bearing	2	8500397	8500397	8500397
*	15	Oil Seal	4	60DD714	60DD714	60DD714
	16	Screw	8	75P56	75P56	75P56
	17	Foot – Vert. & Horiz.	2	300GAE166	300GAE166	300GAE166
	18	Bearing Housing Gear End	1	301GAE006	301GAE006	301GAE006
	19	Dowel Pin	4	62M48	62M48	62M48
	20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
	21	Screw	24	75P55	75P55	75P55
	22	Impeller Case	1	900883051701	900883051801	900883051901
	23	Rotor Group				
		5" Standard Clearances	1	327GAE4028	326GAE4028	325GAE4028
		5" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
	25	Key-Square	1	900639910305	900639910305	900639910305
	29	Drive Cover	1	300GAE477	300GAE477	300GAE477
	30	Screw	8	75P40	75P40	75P40
*	31	Oil Seal	1	60DD726	60DD726	60DD726
*	35	Bearing – Spherical	1	12BA253	12BA253	12BA253
	40	Oil Level Gauge	2	40P34	40P34	40P34
	44	Screw	8	76F92	76F92	76F92
**	45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
**	54	Shim Case .0025/.0035"	1	200GAE732	200GAE732	200GAE732
**	55	Shim Case .010"	1	201GAE732	201GAE732	201GAE732
**	56	Shim Case .0015/.002"	1	202GAE732	202GAE732	202GAE732
	76	Compound, Loctite	5	25BC877	25BC877	25BC877
*	80	Bearing – Conrad	1	12BA254	12BA254	12BA254
	81	Dowel Pin	2	62M13	62M13	62M13
	82	Locking Assembly	2	22G43	22G43	22G43
	83	Slinger	2	300GAE173	300GAE173	300GAE173
	84	Screw	2	75LM14	75LM14	75LM14
**	105	Overhaul Kit 5" R VERS Lip Seal, Dual Splash Lube	1	301GAE6010	301GAE6010	301GAE6010
**	900	Group-Indent & Instruction Legend Series 5" R VERS	1	205GAE4011	205GAE4011	205GAE4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION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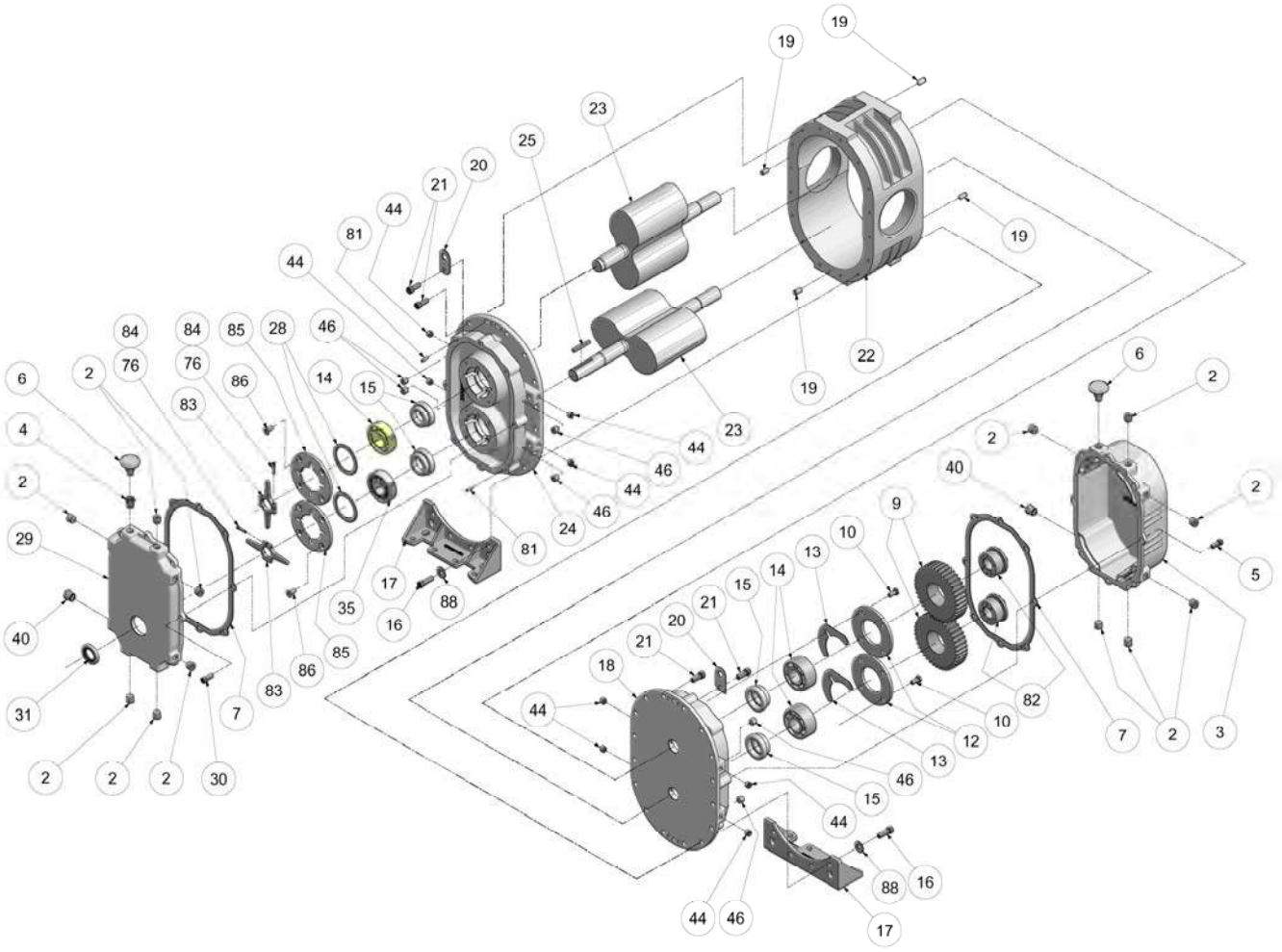
Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAB Mechanical Seal Dual Splash Lube

Ref. No.	Description	No. Req'd	Size – 3H GABH_R △ △= (E or G)	Size – 3M GABM_R △ △= (E or G)	Size -- 3L GABL_R △ △= (E or G)
2	Plug	12	64AC2	64AC2	64AC2
3	Gear Case	1	303GAB602	303GAB602	303GAB602
5	Screw	8	75P7	75P7	75P7
6	Breather	2	5L358	5L358	5L358
* 7	Gasket	2	300GAB715	300GAB715	300GAB715
9	Gear Kit	1	300GAB6008	300GAB6008	300GAB6008
* 10	Screws	4	75A33P	75A33P	75A33P
12	Bearing Retainer	2	300GAB205	300GAB205	300GAB205
* 13	Shim Set	1	900881032200	900881032200	900881032200
* 14	Ball Bearing	3	12BA143	12BA143	12BA143
* 15	Mechanical Seal	4	900871020003	900871020003	900871020003
16	Screw	4	75P56	75P56	75P56
17	Foot – Vert. & Horiz.	2	303GAB166	303GAB166	303GAB166
18	Bearing Housing Gear End	1	304GAB006	304GAB006	304GAB006
19	Dowel Pin	4	62M48	62M48	62M48
20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
21	Screw	20	75P55	75P55	75P55
22	Impeller Case	1	900873034301	900873033801	900873034201
23	Rotor Group				
	3" Standard Clearances	1	307GAB4028	309GAB4028	308GAB4028
	3" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
24	Bearing Housing Drive End	1	305GAB006	305GAB006	305GAB006
25	Key-Square	1	900639910304	900639910304	900639910304
* 28	Wavy Spring	2	900669170203	900669170203	900669170203
29	Drive Cover	1	302GAB477	302GAB477	302GAB477
30	Screw	6	75P7	75P7	75P7
* 31	Oil Seal	1	60DD725	60DD725	60DD725
* 35	Bearing – Spherical	1	12BA153	12BA153	12BA153
40	Oil Level Gauge	2	40P82	40P82	40P82
44	Screw	8	76F1	76F1	76F1
** 45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
46	Plug	8	64AC1	64AC1	64AC1
** 54	Shim Case .0025/.0035"	1	200GAB732	200GAB732	200GAB732
** 55	Shim Case .010"	1	201GAB732	201GAB732	201GAB732
** 56	Shim Case .0015/.002"	1	202GAB732	202GAB732	202GAB732
76	Compound, Loctite	50	25BC877	25BC877	25BC877
81	Dowel Pin	2	62M13	62M13	62M13
82	Locking Assembly	2	22G45	22G45	22G45
83	Slinger	2	300GAB173	300GAB173	300GAB173
84	Screw	2	75LM13	75LM13	75LM13
85	Bearing Retainer	2	300GAB205	300GAB205	300GAB205
86	Screw	8	75LM214	75LM214	75LM214
** 105	Overhaul Kit 3" R VERS Mechanical Seal Dual, Splash	1	304GAB6010	304GAB6010	304GAB6010
** 900	Group-Indent & Instruction Legend Series 3" R VERS	1	303GAB4011	303GAB4011	303GAB4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION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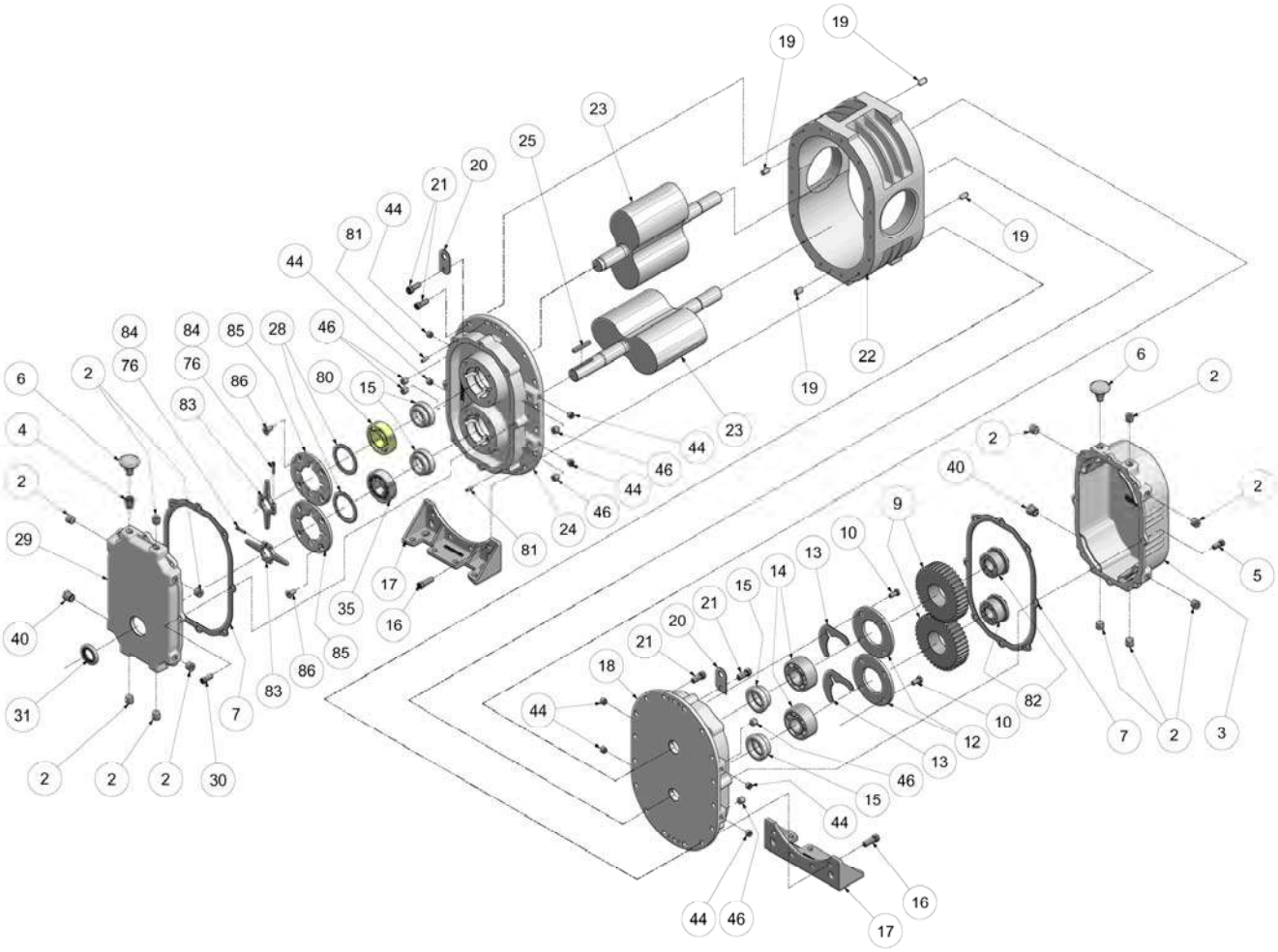
Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAC Mechanical Seal Dual Splash Lube

Ref. No.	Description	No. Req'd	Size – 4H GACH_R △ △= (E or G)	Size – 4M GACM_R △ △= (E or G)	Size -- 4L GACL_R △ △= (E or G)
2	Plug	12	64AC3	64AC3	64AC3
3	Gear Case	1	304GAC602	304GAC602	304GAC602
5	Screw	8	75P40	75P40	75P40
6	Breather	2	5L359	5L359	5L359
* 7	Gasket	2	301GAC715	301GAC715	301GAC715
9	Gear Kit	1	300GAC6008	300GAC6008	300GAC6008
* 10	Screws	8	75A33P	75A33P	75A33P
12	Bearing Retainer	2	900883040201	900883040201	900883040201
* 13	Shim Set	1	900881052900	900881052900	900881052900
* 14	Ball Bearing	3	12BA144	12BA144	12BA144
* 15	Mechanical Seal	4	900871020004	900871020004	900871020004
16	Screw	8	75P56	75P56	75P56
17	Foot – Vert. & Horiz.	2	300GAC166	300GAC166	300GAC166
18	Bearing Housing Gear End	1	304GAC006	304GAC006	304GAC006
19	Dowel Pin	4	62M48	62M48	62M48
20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
21	Screw	16	75P55	75P55	75P55
22	Impeller Case	1	900883042201	900883041801	900883042001
23	Rotor Group				
	4" Standard Clearances	1	307GAC4028	306GAC4028	305GAC4028
	4" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
24	Bearing Housing Drive End	1	305GAC006	305GAC006	305GAC006
25	Key-Square	1	900639910304	900639910304	900639910304
* 28	Wavy Spring	2	900669170304	900669170304	900669170304
29	Drive Cover	1	302GAC477	302GAC477	302GAC477
30	Screw	8	75P40	75P40	75P40
* 31	Oil Seal	1	60DD716	60DD716	60DD716
* 35	Bearing – Spherical	1	12BA255	12BA255	12BA255
40	Oil Level Gauge	2	40P34	40P34	40P34
44	Screw	8	76F1	76F1	76F1
** 45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
46	Plug	8	64AC1	64AC1	64AC1
** 54	Shim Case .0025/.0035"	1	200GAC732	200GAC732	200GAC732
** 56	Shim Case .0015/.002"	1	202GAC732	202GAC732	202GAC732
76	Compound, Loctite	50	25BC877	25BC877	25BC877
81	Dowel Pin	2	62M13	62M13	62M13
82	Locking Assembly	2	22G44	22G44	22G44
83	Slinger	2	300GAC173	300GAC173	300GAC173
84	Screw	2	75LM14	75LM14	75LM14
85	Bearing Retainer	2	300GAC205	300GAC205	300GAC205
86	Screw	8	75LM214	75LM214	75LM214
88	Washer	4	95A3	95A3	95A3
** 105	Overhaul Kit 4" R VERS Mechanical Seal, Dual Splash	1	303GAC6010	303GAC6010	303GAC6010
** 900	Group-Indent & Instruction Legend Series 4" R VERS	1	201GAC4011	201GAC4011	201GAC4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION



302GAA810-A
(Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

Model GAE Mechanical Seal Dual Splash Lube

Ref. No.		Description	No. Req'd	Size – 5H GAEH_R Δ Δ= (E or G)	Size – 5M GAEM_R Δ Δ= (E or G)	Size -- 5L GAEL_R Δ Δ= (E or G)
	2	Plug	12	64AC3	64AC3	64AC3
	3	Gear Case	1	304GAE602	304GAE602	304GAE602
	5	Screw	8	75P40	75P40	75P40
	6	Breather	2	5L359	5L359	5L359
*	7	Gasket	2	300GAE715	300GAE715	300GAE715
	9	Gear Kit	1	300GAE6008	300GAE6008	300GAE6008
*	10	Screws	8	75A33P	75A33P	75A33P
	12	Bearing Retainer	2	900883050501	900883050501	900883050501
*	13	Shim Set	1	900881052900	900881052900	900881052900
*	14	Ball Bearing	2	8500397	8500397	8500397
*	15	Mechanical Seal	4	900871020005	900871020005	900871020005
	16	Screw	8	75P56	75P56	75P56
	17	Foot – Vert. & Horiz.	2	300GAE166	300GAE166	300GAE166
	18	Bearing Housing Gear End	1	303GAE006	303GAE006	303GAE006
	19	Dowel Pin	4	62M48	62M48	62M48
	20	Lifting Lug	2	200GAA451	200GAA451	200GAA451
	21	Screw	24	75P55	75P55	75P55
	22	Impeller Case	1	900883051701	900883051801	900883051901
	23	Rotor Group				
		5" Standard Clearances	1	327GAE4028	326GAE4028	325GAE4028
		5" High Temperature Clearances	1	To be assigned	To be assigned	To be assigned
	24	Bearing Housing Drive End	1	304GAE006	304GAE006	304GAE006
	25	Key-Square	1	900639910305	900639910305	900639910305
*	28	Wavy Spring	2	900669170405	900669170405	900669170405
	29	Drive Cover	1	300GAE477	300GAE477	300GAE477
	30	Screw	8	75P40	75P40	75P40
*	31	Oil Seal	1	60DD726	60DD726	60DD726
*	35	Bearing – Spherical	1	12BA253	12BA253	12BA253
	40	Oil Level Gauge	2	40P34	40P34	40P34
	44	Screw	8	76F92	76F92	76F92
**	45	Paint, Bulk, GDP188, Aluminum	0.125	28H284	28H284	28H284
	46	Plug	8	64AC2	64AC2	64AC2
**	54	Shim Case .0025/.0035"	1	200GAE732	200GAE732	200GAE732
**	55	Shim Case .010"	1	201GAE732	201GAE732	201GAE732
**	56	Shim Case .0015/.002"	1	202GAE732	202GAE732	202GAE732
	76	Compound, Loctite	5	25BC877	25BC877	25BC877
*	80	Bearing – Conrad	1	12BA254	12BA254	12BA254
	81	Dowel Pin	2	62M13	62M13	62M13
	82	Locking Assembly	2	22G43	22G43	22G43
	83	Slinger	2	300GAE173	300GAE173	300GAE173
	84	Screw	2	75LM14	75LM14	75LM14
	85	Bearing Retainer	2	300GAE205	300GAE205	300GAE205
	86	Screw	8	75LM214	75LM214	75LM214
**	105	Overhaul Kit 5" R VERS Mechanical Seal, Dual	1	303GAE6010	303GAE6010	303GAE6010
**	900	Group-Indent & Instruction Legend Series 5" R	1	205GAE4011	205GAE4011	205GAE4011

* INCLUDED IN OVERHAUL KIT.
** NOT SHOWN ON ILLUSTRATION

Gardner Denver

WARRANTY
SUTORBILT BLOWERS
Legend SERIES

GENERAL PROVISIONS AND LIMITATIONS

Gardner Denver (the "Company") warrants to each original retail purchaser ("Purchaser") of its products from the Company or its authorized distributor that such products are, at the time of delivery to the Purchaser, made with good material and workmanship. No warranty is made with respect to:

1. Any product which has been repaired or altered in such a way, in the Company's judgment, as to affect the product adversely.
2. Any product which has, in the Company's judgment, been subject to negligence, accident, improper storage, or improper installation or application.
3. Any product which has not been operated or maintained in accordance with the recommendations of the Company.
4. Components or accessories manufactured, warranted and serviced by others.
5. Any reconditioned or prior owned product.

Claims for items described in (4) above should be submitted directly to the manufacturer.

WARRANTY PERIOD

The Company's obligation under this warranty is limited to repairing or, at its option, replacing, during normal business hours at an authorized service facility of the Company, any part which in its judgment proved not to be as warranted within the applicable Warranty Period as follows.

BARE BLOWERS

Basic grease lubricated bare blowers, consisting of all parts within, are warranted for 18 months from date of initial use or 24 months from date of shipment to the first purchaser, whichever occurs first. Basic dual splash lubricated bare blowers, consisting of all parts within, are warranted for 24 months from date of initial use or 30 months from date of shipment to the first purchaser, whichever occurs first. Any disassembly or partial disassembly of the blower, or failure to return the "unopened" blower per Company instructions, will be cause for denial of warranty.

OTHER COMPONENTS

All other components are warranted for 12 months from date of initial use or 18 months from date of shipment to first purchaser, whichever comes first. The Company reserves the right to withdraw the Warranty where evidence indicates application outside the stated performance area, or where there is evidence of abuse

LABOR TRANSPORTATION AND INSPECTION

The Company will provide labor, by Company representative or authorized service personnel, for repair or replacement of any product or part thereof which in the Company's judgment is proved not to be as warranted. Labor shall be limited to the amount specified in the Company's labor rate schedule.

Labor costs in excess of the Company rate schedules caused by, but not limited to, location or inaccessibility of equipment, or labor provided by unauthorized service personnel is not provided by this warranty.

All costs of transportation of product, labor or parts claimed not to be as warranted and, of repaired or replacement parts to or from such service facilities shall be borne by the Purchaser. The Company may require the return of any part claimed not to be as warranted to one of its facilities as designated by the Company, transportation prepaid by Purchaser, to establish a claim under this warranty. Replacement parts provided under the terms of the warranty are warranted for the remainder of the Warranty Period of the product upon which installed to the same extent as if such parts were original components.

DISCLAIMER

THE FOREGOING WARRANTY IS EXCLUSIVE AND IT IS EXPRESSLY AGREED THAT, EXCEPT AS TO TITLE, THE COMPANY MAKES NO OTHER WARRANTIES, EXPRESSED, IMPLIED OR STATUTORY, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY.

THE REMEDY PROVIDED UNDER THIS WARRANTY SHALL BE THE SOLE, EXCLUSIVE AND ONLY REMEDY AVAILABLE TO THE PURCHASER AND IN NO CASE SHALL THE COMPANY BE SUBJECT TO ANY OTHER OBLIGATIONS OR LIABILITIES. UNDER NO CIRCUMSTANCES SHALL THE COMPANY BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, LOSSES OR DELAYS HOWSOEVER CAUSED.

No statement, representation, agreement, or understanding, oral or written, made by any agent, distributor, representative, or employee of the Company which is not contained in this Warranty will be binding upon the Company unless made in writing and executed by an officer of the Company.

This warranty shall not be effective as to any claim which is not presented within 30 days after the date upon which the product is claimed not to have been as warranted. Any action for breach of this warranty must be commenced within one year after the date upon which the cause of action occurred.

Any adjustment made pursuant to this warranty shall not be construed as an admission by the Company that any product was not as warranted.

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www.contactgd.com/mobile

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ENERGY STAR PARTNER

Member

NTTC

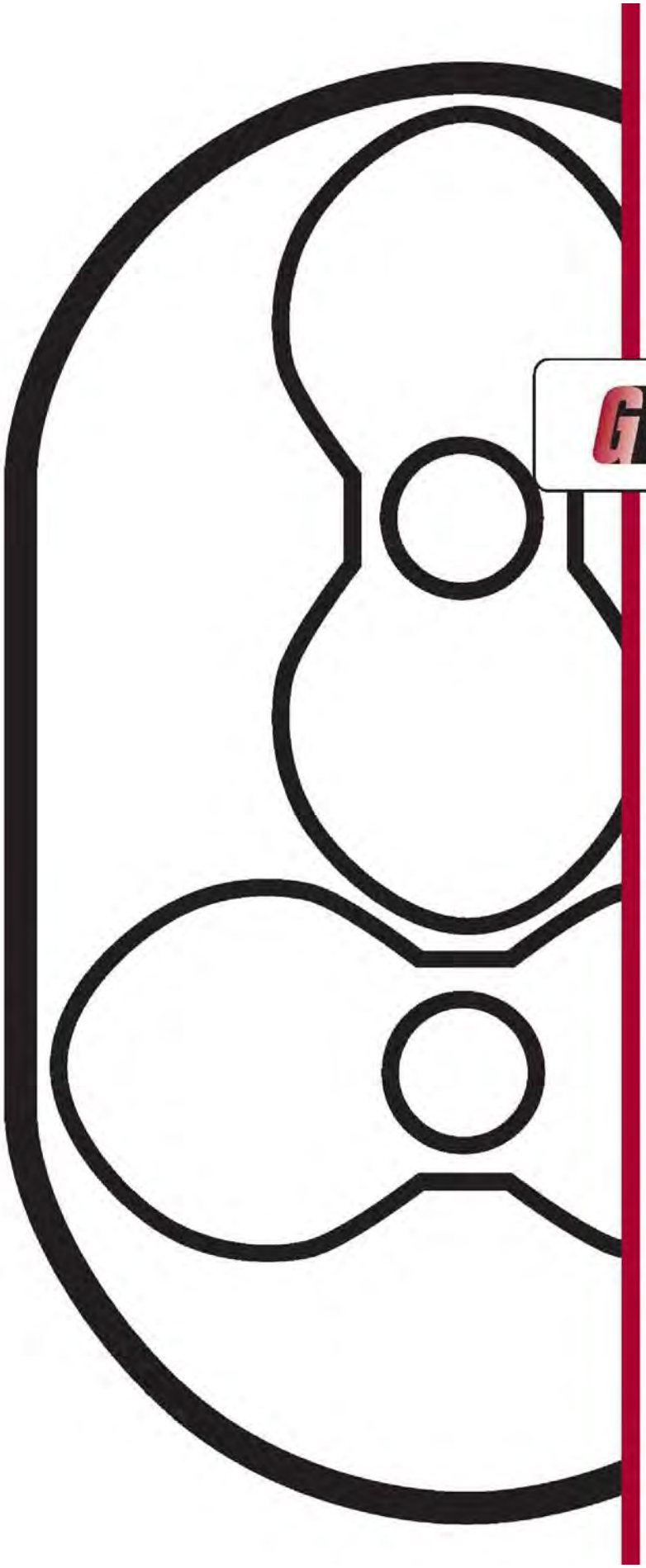
Please recycle after use.

OPERATORS MANUAL

Sutorbilt P Series

Section 5

STG GLOBAL



PARTS LIST
OPERATING AND SERVICE MANUAL

GARDNER DENVER
Sutorbilt

LEGEND

"P" SERIES
BLOWERS

6" - 8" GEAR DIAMETER

Models

GAF_ _P_
GAG_ _P_
GAH_ _P_

SB-7-622
Version 03
November, 2005

MAINTAIN BLOWER RELIABILITY AND PERFORMANCE WITH GENUINE GARDNER DENVER PARTS AND SUPPORT SERVICES

Factory genuine parts, manufactured to design tolerances, are developed for optimum dependability ---specifically for your blower. Design and material innovations are born from years of experience with hundreds of different blower applications. When you specify factory genuine parts you are assured of receiving parts that incorporate the most current design advancements . . . manufactured in our state-of-the-art blower factory under exacting quality standards.

Your **AUTHORIZED DISTRIBUTOR** offers all the backup you require. A worldwide network of authorized distributors provides the finest product support in the blower industry.

Your **AUTHORIZED DISTRIBUTOR** can support your blower investment with these services:

1. Trained parts technical representatives to assist you in selecting the correct replacement parts.
2. Complete inventory of new machines and new, genuine factory parts.
3. A full line of factory tested AEON™ PD blower lubricants specifically formulated for optimum performance in all blowers.
4. Authorized Distributor service technicians are factory-trained and skilled in blower maintenance and repair. They are ready to respond and assist you by providing fast, expert maintenance and repair services.

INSTRUCTIONS FOR DETERMINING BLOWER CONFIGURATION

1. Face the blower drive shaft.
2. In a **VERTICAL** configuration, air flow is horizontal.
3. In a **HORIZONTAL** configuration, air flow is vertical.
4. In a vertical configuration, a **BOTTOM HAND** exists when the drive shaft is below the horizontal center line of the blower. A **TOP HAND** exists when the drive shaft is above the horizontal center line of the blower.
5. In a horizontal configuration, a **RIGHT HAND** exists when the drive shaft is to the right of the vertical center line of the blower. A **LEFT HAND** exists when the drive shaft is to the left of the vertical center line of the blower.

INSTRUCTIONS FOR ORDERING REPAIR PARTS

For pricing and ordering information, contact your nearest AUTHORIZED FACTORY DISTRIBUTOR.

When ordering parts, specify Blower **MODEL** and **SERIAL NUMBER** (see nameplate on unit).

Rely upon the knowledge and experience of your AUTHORIZED DISTRIBUTOR and let them assist you in making the proper parts selection for your blower.

For the location of your local authorized Gardner Denver blower distributor refer to the yellow pages of your phone directory, check the Web site at www.gardnerdenver.com or contact:

Gardner Denver
1800 Gardner Expressway
Quincy, IL 62305
Phone: (217) 222-5400
Fax: (217) 221-8780

FOREWORD

Sutorbilt® blowers are the result of advanced engineering and skilled manufacturing. To be assured of receiving maximum service from this machine the owner must exercise care in its operation and maintenance. This book is written to give the operator and maintenance department essential information for day-to-day operation, maintenance and adjustment. Careful adherence to these instructions will result in economical operation and minimum downtime.

⚠ DANGER

Danger is used to indicate the presence of a hazard which will cause severe personal injury, death, or substantial property damage if the warning is ignored.

⚠ WARNING

Warning is used to indicate the presence of a hazard which can cause severe personal injury, death, or substantial property damage if the warning is ignored.

⚠ CAUTION

Caution is used to indicate the presence of a hazard which will or can cause minor personal injury or property damage if the warning is ignored.

NOTICE

Notice is used to notify people of installation, operation or maintenance information which is important but not hazard-related.

SAFETY PRECAUTIONS

Safety is everybody's business and is based on your use of good common sense. All situations or circumstances cannot always be predicted and covered by established rules. Therefore, use your past experience, watch out for safety hazards and be cautious. Some general safety precautions are given below:

⚠ DANGER

Failure to observe these notices could result in injury to or death of personnel.

- **Keep fingers and clothing away from blower inlet and discharge ports, revolving belts, sheaves, drive coupling, etc.**
- **Do not use the air discharge from this unit for breathing – not suitable for human consumption.**
- **Do not loosen or remove the oil filler plug, drain plugs, covers, or break any connections, etc., in the blower air or oil system until the unit is shut down and the air pressure has been relieved.**
- **Electrical shock can and may be fatal.**
- **Blower unit must be grounded in accordance with the National Electrical Code. A ground jumper equal to the size of the equipment ground conductor must be used to connect the blower motor base to the unit base.**
- **Open main disconnect switch, tag and lockout before working on the control.**
- **Disconnect the blower unit from its power source, tag and lockout before working on the unit – the machine may be automatically controlled and may start at any time.**

⚠ WARNING

Failure to observe these notices could result in damage to equipment.

- **Stop the unit if any repairs or adjustments on or around the blower are required.**
- **Disconnect the blower unit from its power source, tag and lockout before working on the unit – the machine may be automatically controlled and may start at any time.**
- **Do not exceed the rated maximum speed shown on the nameplate.**
- **Do not operate unit if safety devices are not operating properly. Check periodically. Never bypass safety devices.**

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YOUR KEY TO TROUBLE FREE SERVICE,
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SUTORBILT LEGEND SERIES SUTORBILT BLOWERS
MATRIX/MENU

NOTICE TO CUSTOMER – To find the construction options for your blower unit, FILL IN THE BALANCE OF LETTERS OR NUMBERS FROM YOUR UNIT NAMEPLATE

G	A				P	
1	2	3	4	5	6	7

COLUMN NUMBER:

FOLLOW THE LINE DOWN AND OVER FROM EACH SPACE THUS FILLED IN TO FIND THE APPROPRIATE CONSTRUCTION OPTION WITH WHICH YOUR MACHINE IS EQUIPPED.

COLUMN 1 – BASIC DESIGNATOR

COLUMN 2 – PRODUCT FAMILY

COLUMN 3 – GEAR DIAMETER

- F. 6”
- G. 7”
- H. 8”

COLUMN 4 – CASE LENGTH

- L – Low Pressure
- M – Medium Pressure
- H – High Pressure

COLUMN 5 – CONFIGURATION

- A. Vertical–Top Hand–Central Timed
- B. Vertical–Bottom Hand–Central Timed
- C. Horizontal–Left Hand–Central Timed
- D. Horizontal–Right Hand–Central Timed

COLUMN 6 – DESIGN VERSION

COLUMN 7 – ADDITIONAL DESCRIPTION

- A. Lip Seal
- B. Mechanical Seal

INTRODUCTION
YOUR KEY TO TROUBLE FREE SERVICE

Thank you for investing in Sutorbilt quality. The Sutorbilt reputation for rugged dependability has been earned by over 50 years of service in demanding, industrial operations where downtime cannot be tolerated and efficient blower performance is expected.

Your Sutorbilt blower is a precision engineered blower that has been carefully manufactured and thoroughly tested at the state-of-the-art Gardner Denver Blower Factory in Sedalia, Missouri.

As with other precision machinery, there are several relatively simple installation, operation and maintenance procedures that you must observe to assure optimum blower performance. There is no guesswork in the manufacture of your highly advanced Sutorbilt blower and there must be none in preparing the blower to get the job done in the field.

The purpose of this manual is to help you properly install, operate and maintain your Sutorbilt blower. It is essential that you review all sections of this manual in preparation for installing your blower. Follow the instructions carefully and you will be rewarded with trouble–free Sutorbilt service . . . year in and year out.

SECTION 1
EQUIPMENT CHECK

Before uncrating, check the packing slip carefully to be sure all the parts have been received. All accessories are listed as separate items on the packing slip, and small important accessories such as relief valves can be overlooked or lost. After every item on the packing slip has been checked off, uncrate carefully. Register a claim with the carrier for lost or damaged equipment.

⚠ WARNING

Customers are cautioned to provide adequate protection, warning and safety equipment necessary to protect personnel against hazards involved in installation and operation of this equipment in the system or facility.

STORAGE

Your Sutorbilt Blower was packaged at the factory with adequate protection to permit normal storage for up to six (6) months.

If the unit is to be stored under adverse conditions or for extended periods of time, the following additional measures should be taken to prevent damage.

1. Store the blower in a clean, dry, heated (if possible) area.

2. Make certain inlet and discharge air ports are tightly covered to prevent foreign material from entering the air box.

3. All exposed, non-painted surfaces should be protected against rust and corrosion.

4. Provide adequate protection to avoid accidental mechanical damage.

5. In high humidity or corrosive environments, additional measures may be required to prevent rusting of the blower internal surfaces.

6. To prevent rusting of gears, bearings, etc., the oil reservoirs may be filled with normal operating oil.

⚠ CAUTION

Before running the blower, drain the oil and replace to the proper operating level with clean, fresh lubricant.

7. Rotate the blower shaft (10 to 25 turns) monthly during storage. Inspect the blower shaft (near the shaft seal area) monthly and spray with rust inhibitor if needed.

8. For long term storage (over six (6) months), contact Sutorbilt Customer Service for recommendations.

REMOVING PROTECTIVE MATERIALS

The shaft extension is protected with rust inhibitor which can be removed with any standard solvent.

⚠ CAUTION

Follow the safety directions of the solvent manufacturer.

Blower inlet and outlet are temporarily capped to keep out dirt and other contaminants during shipment. These covers must be removed before start-up.

The internal surfaces of all Sutorbilt units are mist sprayed with a rust preventative to protect the machine during shipment. Remove this film upon initial startup, using any commercial safety solvent. Care should be exercised to lock out the blower to prevent start-up

⚠ WARNING

Rotating components will cause severe injury in case of personal contact. Keep hands away from blower inlet and discharge ports.

SECTION 2
INSTALLATION

LOCATION

If possible, install the blower in a well lit, clean, dry place with plenty of room for inspection and maintenance.

FOUNDATIONS

For permanent installations we recommend concrete foundations be provided, and the equipment should be grouted to the concrete. It is necessary that a suitable base be used, such as a steel combination base under blower and motor, or a separate sole plate under each. Before grouting, equipment must be leveled, free of all strains, and anchored so no movement will occur during setting of grout. After grout has completely hardened, a recheck is necessary to compensate for shrinkage, etc. If required, add shims under blower feet after final tightening of foundation anchor bolts to remove strain from the blower housing.

Where jack screws or wedges are used during grouting, they must be backed off or removed before final tightening of anchor bolts.

Where a concrete foundation is not feasible, care must be taken to insure that equipment is firmly anchored to adequate structural members.

MOUNTING CONFIGURATIONS

The blower flex-mount design enables horizontal and vertical mounting configurations with top or bottom hand, right or left hand shaft positioning. The units are center timed allowing rotation in either direction (refer to FIGURE 1). If converting a blower from vertical to horizontal, or horizontal to vertical mounting configuration, additional mounting feet will be required.

REPOSITIONING THE MOUNTING FEET:

1. Position the mounting feet to the desired location and snug the capscrew.
2. Place the blower on its feet on a flat surface.
3. Loosen mounting feet capscrews and level unit up. The bench or blower base flatness should be within .002 of an inch.

NOTICE

If the unit is not flat within .002 of an inch, it will be necessary to shim the blower feet at installation.

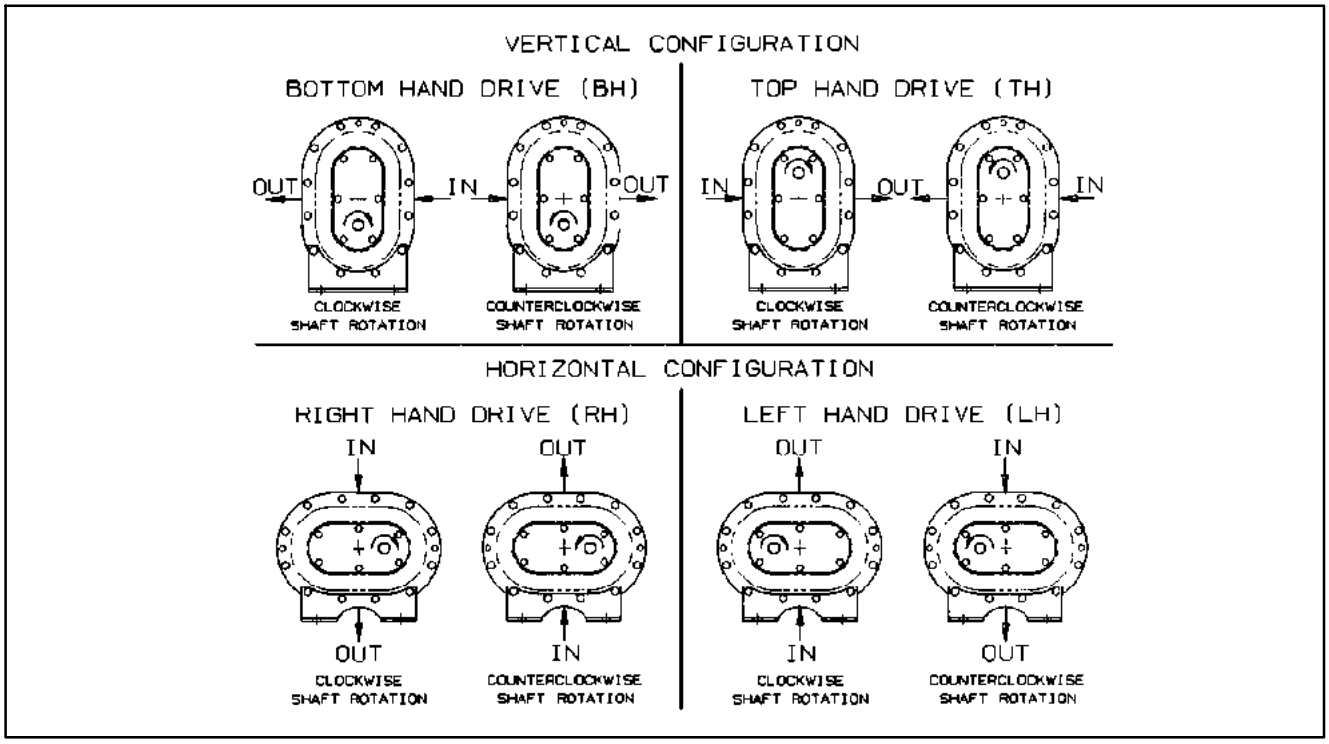


FIGURE 1 - BLOWER MOUNTING CONFIGURATIONS

4. Secure the mounting feet capscrews to the torque value in FIGURE 24, page 24.

NOTICE

When changing mounting configuration, it may be necessary to reposition vent plug (B), and drain plug (A). Refer to FIGURE 3, page 6, for correct location.

DRIVE INSTALLATION

When selecting a V-belt drive, check to be sure the shaft overhung load limitation is not exceeded. Refer to FIGURE 2, page 5, for overhung load calculations and limitations.

Belt drives must be carefully aligned. Motor and blower pulleys must be parallel to each other and in the same plane within 1/32 inch. Belt tension should be carefully adjusted to the belt manufacturer's recommendation using a belt tension gauge. Check tension frequently during the first day of operation.

⚠ WARNING

Overtightening belts leads to heavy bearing loads and premature failure.

On the direct connected units, alignment and lubrication of couplings to specifications of the coupling manufacturer is very important. When mounted drives are supplied from the factory, proper alignment has been established before shipment. However, during shipping, handling and installation, it is likely that the alignment has been disturbed and final adjustment must be made before startup.

⚠ WARNING

Exceeding overhung load limitations leads to unwarrantable premature bearing failure and shaft breakage.

The location of the sheave on the blower shaft greatly affects the stress in the shaft. The optimum blower sheave positioning is as close as possible to the blower drive cover, not to exceed dimension "C" in Drive Shaft Illustration, FIGURE 2, page 5.

The calculated shaft moment must not exceed the maximum allowable moment listed in Maximum Allowable Moment Chart, FIGURE 2, page 5. If the calculated shaft moment exceeds the maximum allowable moment:

- Increase Sheave Diameters to Reduce Belt Pull
- Use Jackshaft Drive
- Use Direct Coupled or Gearbox Drive

To calculate shaft moment for a given V–Belt Drive Arrangement:

1. Use the formula for Calculation of Belt Pull, FIGURE 2, page 5, to calculate belt pull. Refer to Arc of Contact Factor Chart, FIGURE 2, page 5.

2. Insert the calculated belt pull into the formula for Calculation of Shaft Moment, FIGURE 2, page 5, to arrive at the calculated shaft moment.

PIPING

Inlet and discharge connections on all blowers are large enough to handle maximum volume with minimum friction loss. Reducing the pipe diameter on either inlet or discharge will only create additional line loss and increase the overall pressure differential.

Excessive weight and thermal expansion of piping and fittings will cause internal misalignment and premature wear. Never allow the blower to carry the weight of the pipe. If possible, a spool or sleeve-type expansion joint should be installed between the unit and the piping. Where a flexible connection is not practical, the weight of the rigid connection must be separately supported.

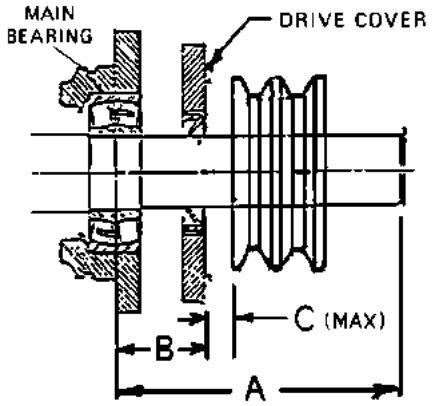
All system piping must be cleaned internally before connecting to the blower.

⚠ WARNING

Sutorbilt blowers are shipped dry from the factory. Do not attempt to operate the blower before following proper lubrication instructions. Permanent damage to the gears, bearings and seals will occur.

Gear Diameter (Inches)	Dimensions (Inches)			Maximum Allowable Moment (LB-IN)
	A	B	C (Max)	
6	4.08	1.14	.38	1788
7	4.50	1.31	.38	3000
8	5.57	1.77	.38	4144

MAXIMUM ALLOWABLE MOMENT



DRIVE SHAFT ILLUSTRATION

Z	Ac	Z	Ac	Z	Ac	Z	Ac	Z	Ac	Z	Ac
0.000	1.000	0.250	0.966	0.500	0.926	0.750	0.879	1.000	0.823	1.250	0.751
0.025	0.997	0.275	0.962	0.525	0.922	0.775	0.874	1.025	0.816	1.275	0.742
0.050	0.994	0.300	0.958	0.550	0.917	0.800	0.869	1.050	0.810	1.300	0.734
0.075	0.990	0.325	0.954	0.575	0.913	0.825	0.864	1.075	0.803	1.325	0.725
0.100	0.987	0.350	0.951	0.600	0.908	0.850	0.858	1.100	0.796	1.350	0.716
0.125	0.983	0.375	0.947	0.625	0.904	0.875	0.852	1.125	0.789	1.375	0.706
0.150	0.980	0.400	0.943	0.650	0.899	0.900	0.847	1.150	0.782	1.400	0.697
0.175	0.977	0.425	0.939	0.675	0.894	0.925	0.841	1.175	0.774	1.425	0.687
0.200	0.973	0.450	0.935	0.700	0.889	0.950	0.835	1.200	0.767		
0.225	0.969	0.475	0.930	0.725	0.884	0.975	0.829	1.225	0.759		

ARC OF CONTACT FACTORS

$$\text{Belt Pull} = \left[\frac{2.5 - Ac}{Ac}\right]\left[\frac{125954 \times Hp \times S.F.}{D \times RPM}\right]$$

Key:
- Ac = Arc of Contact Factor (Refer to Arc of Contact Factors Chart above)
- Hp = Blower Horsepower for Operating Conditions
- S.F. = Actual Drive Service Factor
- D = Blower Sheave Pitch Diameter in Inches
- RPM = Blower Sheave Speed
- $Z = \left[\frac{\text{Large Sheave Pitch Diameter (in)} - \text{Small Sheave Pitch Diameter (in)}}{\text{Sheave Center Distance (in)}}\right]$

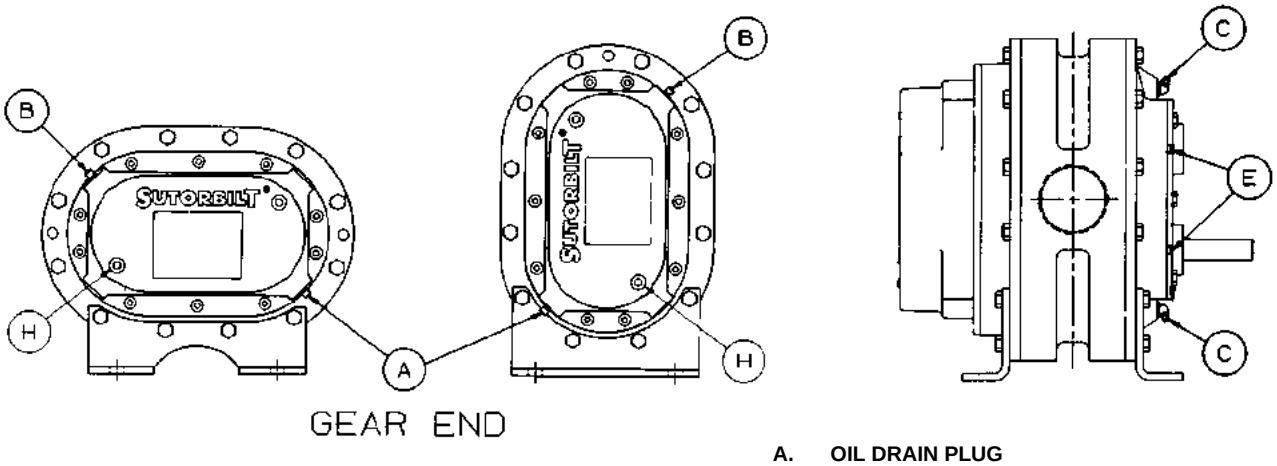
CALCULATION OF BELT PULL

$$\text{Shaft Moment (LB-IN)} = \text{Belt Pull} \times \left[B + C + \left(\frac{\text{Sheave Width}}{2}\right)\right]$$

CALCULATION OF SHAFT MOMENT

FIGURE 2 - BELT DRIVE OVERHUNG LOAD CALCULATIONS

SECTION 3
LUBRICATION



A. OIL DRAIN PLUG
B. BREATHER / OIL FILL
C. GREASE FITTING
E. GREASE VENTS
H. OIL LEVEL GAUGE

FIGURE 3 - LUBRICATION

At the gear end the timing gear teeth are lubricated by being partially submerged in oil. The gear teeth serve as oil slingers for gear end bearings. At the drive end the bearings are grease lubricated.

FILLING PROCEDURE

Refer to FIGURE 3. Remove the breather (B) from the gear cover. Add oil to the gear case until it reaches the center line of the oil level gauge (H). Secure breather (B) in its correct location.

LUBRICATION SERVICE

Add fresh oil as required to maintain proper level. The oil should be drained, flushed and replaced every 1500 hours or more frequently if inspection so indicates. The oil drain plug is located at (A).

⚠ WARNING

Do not overfill as this will tend to cause excessive heating of the gears and may damage the unit.

Bearings on the drive end of the blower require grease lubrication every 500 hours of operation. Lubricate the bearings through grease fittings located at (C). When regreasing, the old grease will be forced out of the vents (E). To prevent damage to seals, these vents must be open at all times.

RECOMMENDED LUBRICANT

Gear Diameter	Vertical	Horizontal
6”	1-1/4 PT.	3 PT.
7”	1-2/3 PT.	3-1/2 PT.
8”	2-1/2 PT.	7 PT.
Quantities are for purchase estimates only.		

FIGURE 4 - APPROXIMATE OIL CAPACITIES

GEAR END LUBRICATION

AEON PD is formulated especially for positive displacement blower service to provide maximum blower protection at any temperature. One filling of AEON PD will last a minimum of 4 times longer than a premium mineral oil. Refer to FIGURE 5, page 7.

AEON PD	1 Quart Bottle	Part No. 28G23
AEON PD	12 Quart Case	Part No. 28G24

Blower Discharge Temperature		Factory Tested Recommended and Approved Lubricant
° F	° C	AEON PD
32°	0°	Synthetic Blower Lubricant
100°	38°	One Superior Lubricant
275°	135°	For
350°	177°	All Operating Temperatures

FIGURE 5 - TEMPERATURE CHART

DRIVE END LUBRICATION

Grease drive end bearings every 500 hours of operation with a non-corrosive, extreme pressure bearing grease of the following specification:

Blower Discharge Temperature	Grease Specification
Up to 350° F (177° C)	NLGI Grade 2 EP

If not using AEON PD synthetic blower lubricant, use oils with rust and oxidation inhibitors, anti-foam additives and the viscosities listed in FIGURE 6.

AIR FILTERS AND FILTER SILENCERS

⚠ WARNING

Servicing the air filters is one of the most important maintenance operations to be performed to insure long blower life.

Servicing frequency of filter elements is not time predictable. A differential pressure indicator, with a continuous gauge reading, should be installed across the inlet filter. It will tell how much of the service life of the filter element has been used. It will also eliminate both premature filter servicing and premature blower failure due to a plugged filter when the filter pressure drop is used to establish maintenance points.

In all cases refer to the filter manufacturer's service instructions. Due to the many types of filters, it is not practical to give specific instructions covering all models.

NOTICE

No matter what type of filter is used, always make sure all seats, gaskets, clamps and hose connections on the filter and inlet line are absolutely air tight. Each time the filter is serviced, inspect interior of the blower for dirt.

Blower Discharge Temperature	Oil Grade ISO	Oil Viscosity SUS @ 100° F
32° F to 100° F (0° C to 38° C)	100	465
100° F to 225° F (38° C to 105° C)	150	700
225° F to 300° F (105° C to 149° C)	220	1000
Over 300° F (149° C)	*	*

* The oil viscosity must be 70 SUS minimum at discharge temperature minus 50° F.

FIGURE 6 - LUBRICATION RECOMMENDATION

SECTION 4
OPERATION

Future operating problems can be avoided if proper precautions are observed when the equipment is first put into service.

Before starting under power, the blower should be turned over by hand to make certain there is no binding, or internal contact.

Each size blower has limits on pressure differential, running speed, and discharge temperature which must not be exceeded. These limits are shown in the following tabulation.

⚠ WARNING

Operating beyond the specified operating limitations will result in damage to the unit.

It is important that the pressures and temperatures are measured directly at the ports of the blower to avoid error that may be caused by intervening pipe runs, fittings, etc.

Relief valves should be used to protect against excessive pressure or vacuum conditions. These valves should be tested at initial startup to be sure they are adjusted to relieve at or below the maximum pressure differential rating of the blower.

NOTICE

Relief valves should be placed as close as possible to the blower inlet or discharge.

In some instances, pressure may be relieved at a lower point than the blower maximum in order to protect the motor or the equipment served by the blower.

Discharge temperature switches are recommended to protect against excessive inlet restriction or inlet temperatures. Check valves in the discharge line on pressure blowers and in the inlet line on vacuum blowers are recommended to protect the blower from motoring backwards when shut down under load.

LIMITATIONS

For information regarding limitations, refer to FIGURE 7, below.

MAXIMUM OPERATING LIMITATIONS

SIZE	RPM	PRESSURE PSI	VACUUM IN HG	DISCHARGE TEMPERATURE °F
6LP	2350	7	14	260
6MP	2350	14	16	325
6HP	2350	15	16	340
7LP	2050	6	12	260
7MP	2050	10	16	325
7HP	2050	15	16	340
8LP	1800	6	12	260
8MP	1800	10	16	325
8HP	1800	15	16	340

DO NOT EXCEED THESE LIMITS

NOTICE

Blower speed, line losses, elevation, and increased inlet temperatures will affect the maximum operating limitations.

FIGURE 7 - MAXIMUM OPERATING LIMITATIONS

BLOWER STARTUP CHECKLIST

This startup procedure should be followed during the initial installation and after any shutdown periods or after the blower has been worked on or moved to a new location. It is suggested that the steps be followed in sequence and checked off (✓) in the boxes provided.

☐ 1. Check the unit and all piping for foreign material and clean if required.

☐ 2. Check the flatness of the feet and the alignment of the drive. Feet that are bolted down in a bind can cause case distortion and internal rubbing. Misaligned V-drives can cause the impellers to rub against the headplates and cause a reduction in the volumetric efficiency of the unit. Misaligned couplings can ruin bearings.

☐ 3. If blower is V-belt driven, check the belt tension and alignment. Over-tensioned belts create heavy bearing loads which leads to premature failure.

☐ 4. Be sure adequate drive guards are in place to protect the operator from severe personal injury from incidental contact.

☐ 5. Check the unit for proper lubrication. Proper oil level cannot be overemphasized. Too little oil will ruin bearings and gears. Too much oil will cause overheating and can ruin gears and cause other damage. Insure drive end bearings are greased.

☐ 6. With motor locked out, turn the drive shaft by hand to be certain the impellers do not bind.

☐ 7. “Jog” the unit with the motor a few times to check rotation and to be certain it turns freely and smoothly.

☐ 8. The internal surfaces of all Sutorbilt units are mist sprayed with a rust preventive to protect the machine during the shipping and installation period. This film should be removed upon initial start-up.

☐ 9. Start the unit and operate 15 minutes at no load. During this time, check for hot spots and other indications of interference.

☐ 10. Apply the load and observe the operation of the unit for one hour. Check frequently during the first day of operation.

☐ 11. If malfunctions occur, do not continue to operate. Problems such as knocking impellers can cause serious damage if the unit is operated without correction.

SAFETY PRECAUTIONS

1. Do not operate blower with open inlet or outlet port.
2. Do not exceed specified vacuum or pressure limitations.
3. Do not operate above or below recommended blower speed range.
4. Blower is not to be used where non-sparking equipment is specified.
5. Do not operate without belt guard or coupling shield.

⚠ WARNING

Do not exceed sheave or coupling manufacturers' rim speed limit.

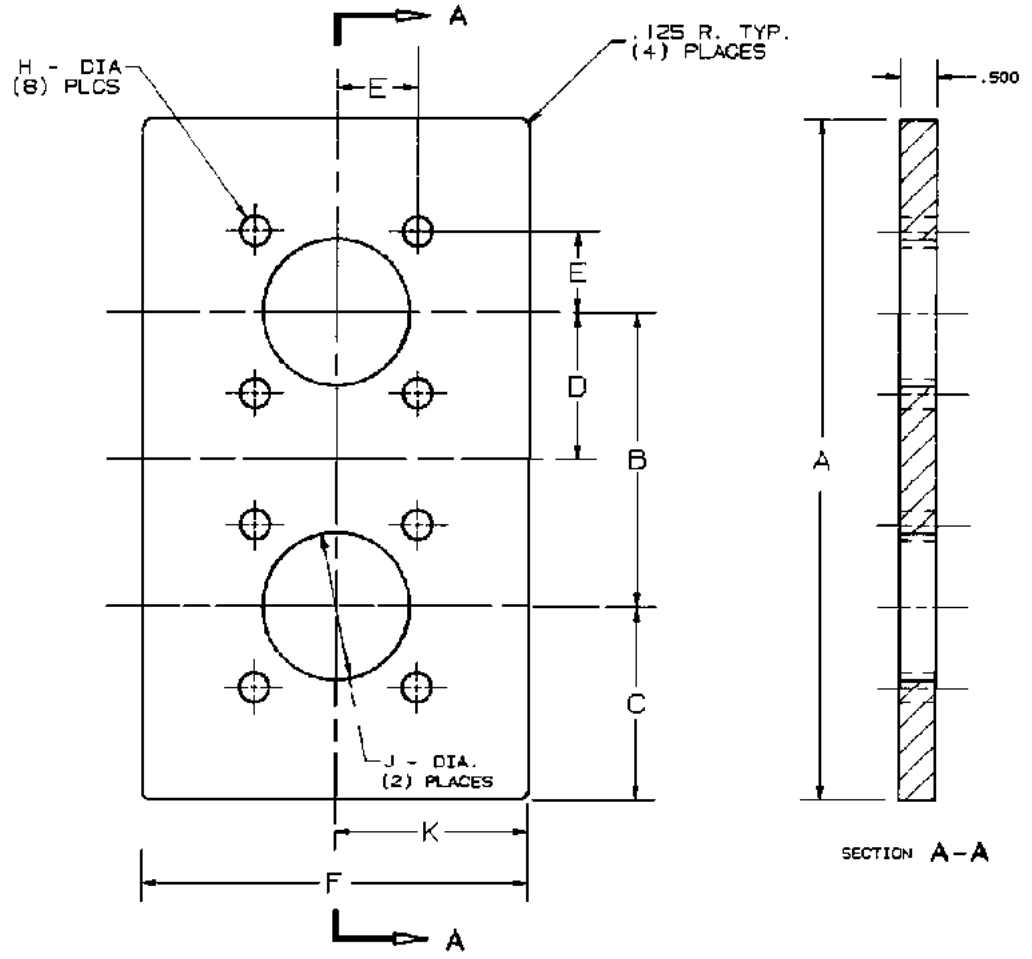
6. The blower and blower discharge piping may be extremely hot and can cause skin burns on contact.
7. Prolonged exposure may require ear protection.

TROUBLE SHOOTING

No matter how well the equipment is designed and manufactured, there may be times when servicing will be required due to normal wear, the need for adjustment, or various external causes. Whenever equipment needs attention, the operator or repairman should be able to locate the cause and correct the trouble quickly. The Trouble Shooting Chart below is provided to assist the mechanic in those respects.

PROBLEM	POSSIBLE CAUSES	SOLUTION
Knocking	1. Unit out of time.	1. Retime impellers.
	2. Distortion due to improper mounting or pipe strains.	2. Check mounting alignment and relieve pipe strains.
	3. Excessive pressure differential.	3. Reduce to manufacturer's recommended pressure. Examine relief valve, re-set if necessary.
	4. Worn gears.	4. Replace timing gears.
	5. Worn bearings.	5. Replace bearings.
Excessive blower temperature.	1. Too much oil in gear case.	1. Reduce oil level.
	2. Too low operating speed.	2. Increase blower speed.
	3. Clogged filter or muffler.	3. Remove cause of obstruction.
	4. Excessive pressure differential.	4. Reduce pressure differential across the blower.
	5. Worn impeller clearances.	5. Replace impeller.
	6. Internal contact.	6. Correct clearances.
Impeller end or tip drag.	1. Insufficient assembled clearances.	1. Correct clearances.
	2. Case or frame distortion.	2. Check mounting and pipe strain.
	3. Excessive operating pressure.	3. Remove cause.
	4. Excessive operating temperature.	4. Remove cause.
Lack of volume.	1. Slipping belts.	1 Tighten belts.
	2. Worn clearances.	2. Re-establish proper clearances.
Excessive bearing or gear wear.	1. Improper lubrication.	1. Correct lubrication level. Replace dirty oil.
Loss of oil.	1. Headplate, gear case or drive cover vents plugged.	1. Clean vents.
	2. Worn seal.	2. Replace seals.

SECTION 5
SPECIAL TOOLS REQUIRED

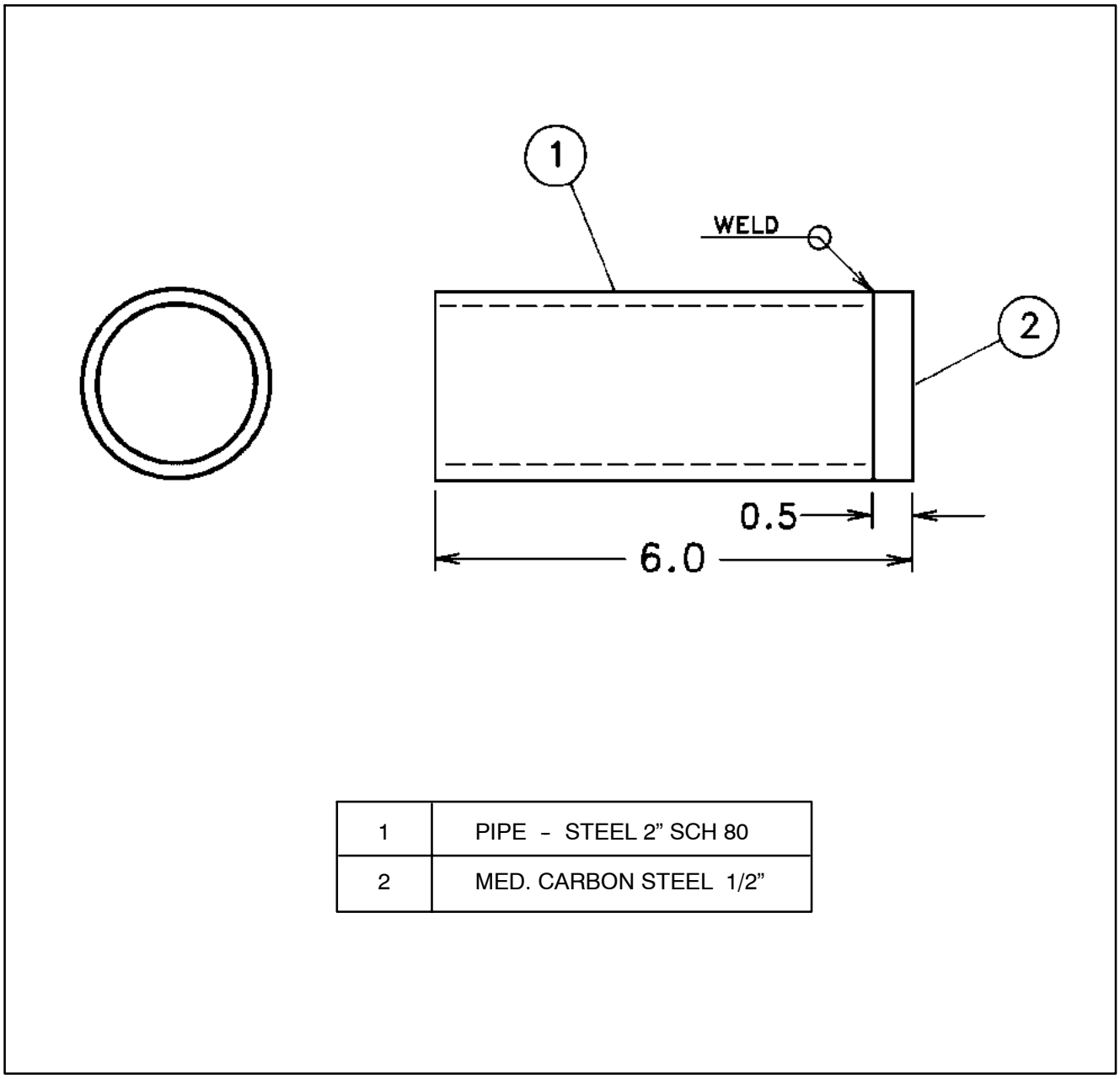


	6”	7”	8”
A	11.00	13.00	16.00
B	6.000	7.000	8.000
C	2.500	3.000	4.000
D	3.000	3.500	4.000
E	1.503	1.679	2.210
F	11.00	13.00	15.00
H	0.437	0.500	0.500
J	1.500	1.688	1.875
K	5.500	6.500	7.500

NOTE:

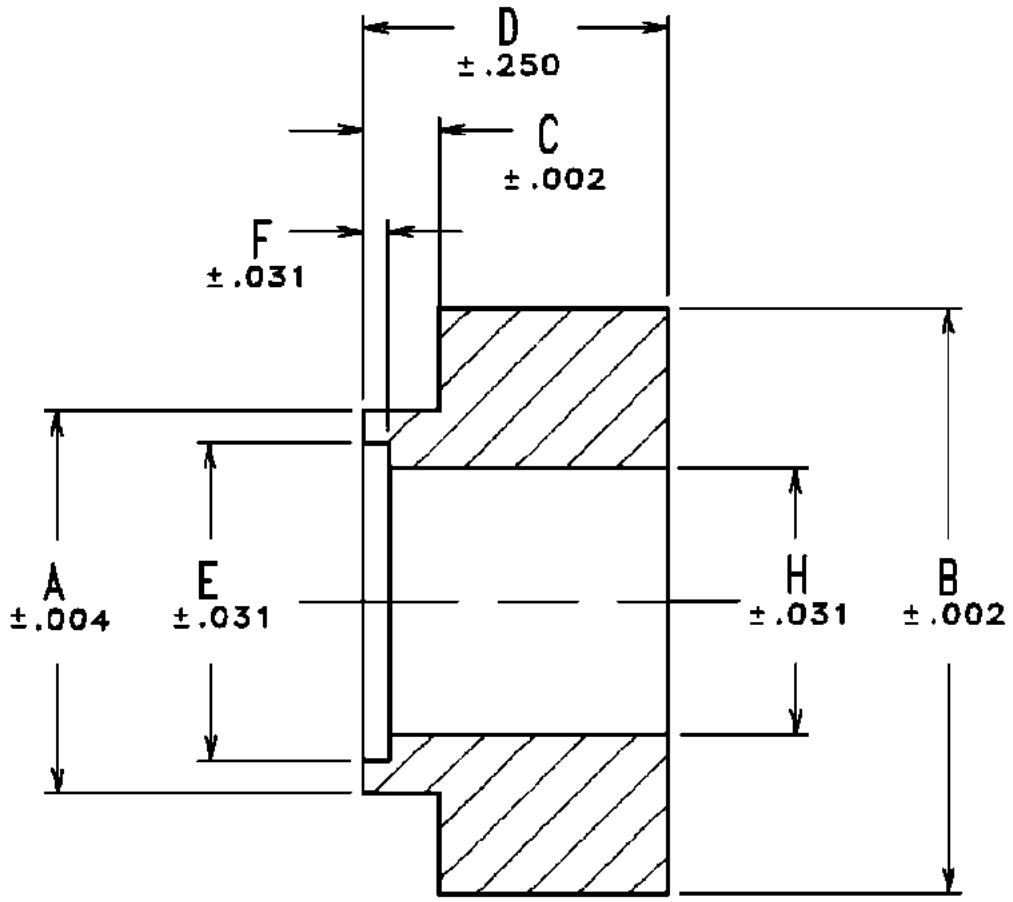
1. REMOVE SHARP EDGES
2. MAT’L: MED. CARBON STEEL

FIGURE 8 - PULLER PLATE - SK2154



1	PIPE – STEEL 2” SCH 80
2	MED. CARBON STEEL 1/2”

FIGURE 9 - GEAR DRIVER - SK2150

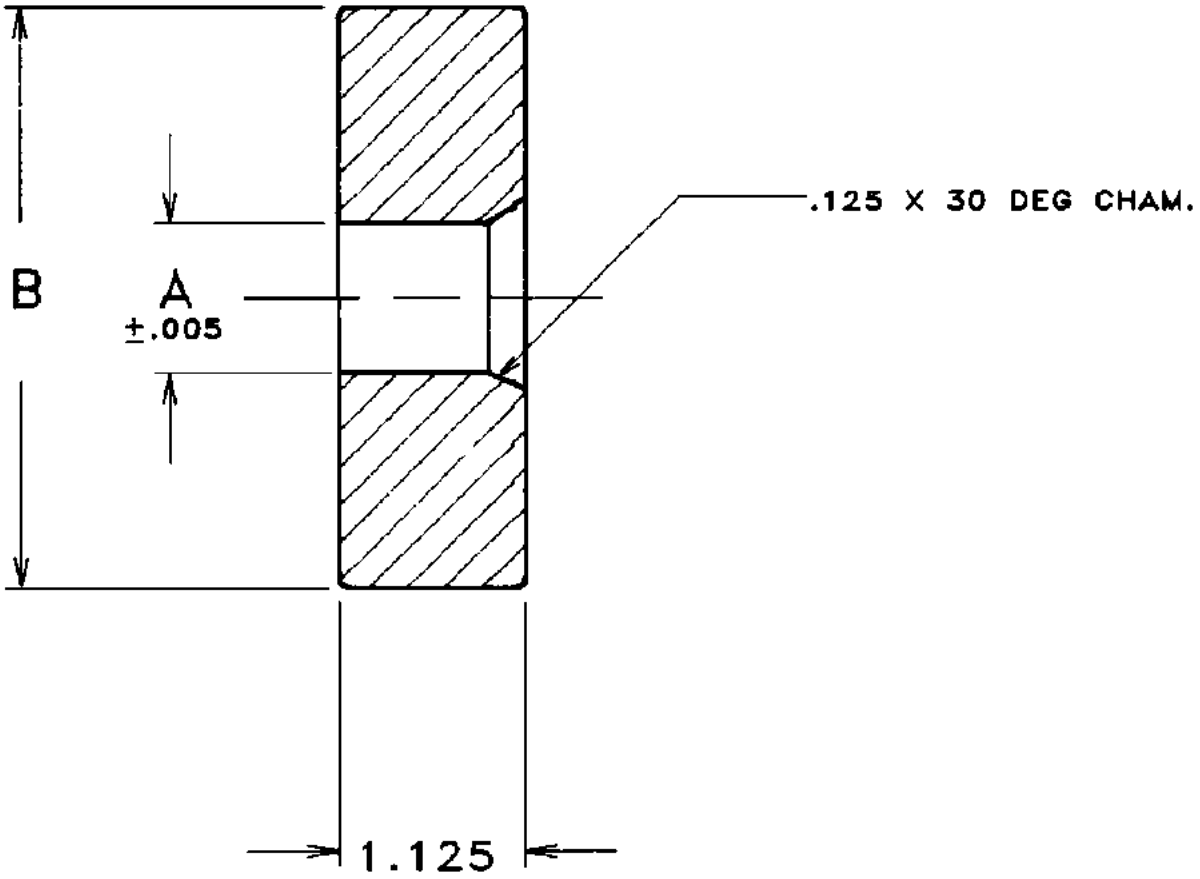


NOTES:

1. BREAK SHARP EDGES
2. MATERIAL: 4140
3. HEAT TREAT TO RC 48 – 52

UNIT SIZE	A	B	C	D	E	F	H
6”	2.748	3.150	0.515	1.890	2.450	0.125	1.400
7”	3.000	3.543	0.424	1.863	2.423	0.150	1.616
8”	3.250	3.938	0.407	2.000	2.800	0.150	1.813

FIGURE 10 - MECHANICAL SEAL INSTALLATION TOOL - SK2152



NOTES:

1. BREAK SHARP EDGES
2. MATERIAL: 4140
3. HEAT TREAT TO RC 52 – 56

UNIT SIZE	A	B
6”	1.900	5.000
7”	2.087	5.500
8”	2.406	6.000

FIGURE 11 - BEARING PRESS TOOL – MECHANICAL SEAL UNITS - SK2156

SECTION 6
DISASSEMBLY INSTRUCTIONS

NOTICE

Numbers in parentheses ( ) refer to key numbers in assembly drawings on pages 25, 27 and 29.

1. Drain oil from gear case by removing drain plug (4).
2. Remove the socket head bolts (5) from the gear cover (3).
3. Remove the gear cover from gear headplate (18).

NOTICE

The cover and gear headplate gasket tends to bond tightly to both surfaces. After socket head bolt removal, it is sometimes necessary to take a ball peen hammer and a blunt chisel and drive off the cover.

IMPORTANT:

MARK ALL PARTS WITH A CENTER PUNCH SO THEY CAN BE REASSEMBLED IN THE SAME POSITION (IMPELLERS, HEADPLATES, AND GEARS).

4. If the timing gears appear undamaged, the gear backlash must be checked to see if the gears can be salvaged.
   A. Mount a magnetic base dial indicator on the gear headplate (see FIGURE 12).
   B. Lock one impeller stationary by wedging a feeler gage between the impeller and the headplate.
   C. The tip of the indicator should be placed at the center of the contact surface on a tooth of the gear on the free shaft.
   D. Rock the impeller back and forth by hand and read the total rotational movement to the nearest .0005 inches. Do this at four gear mesh positions 90 degrees apart.
   E. Permissible gear backlash is shown below.

GEAR DIA.	GEAR BACKLASH
6”	.002 – .003
7”	.003 – .005
8”	.003 – .006

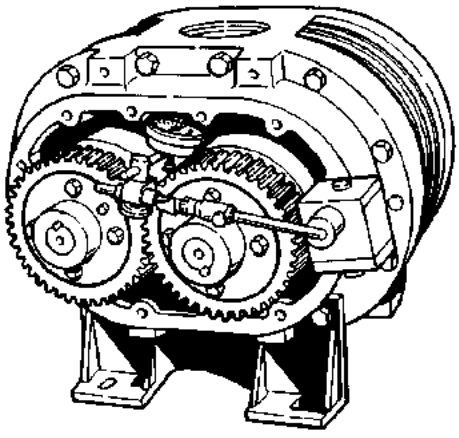


FIGURE 12

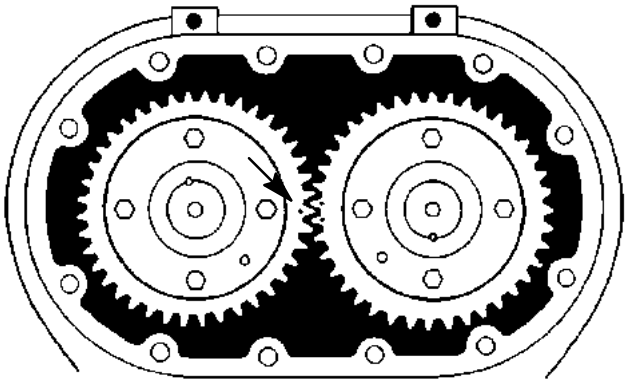


FIGURE 13

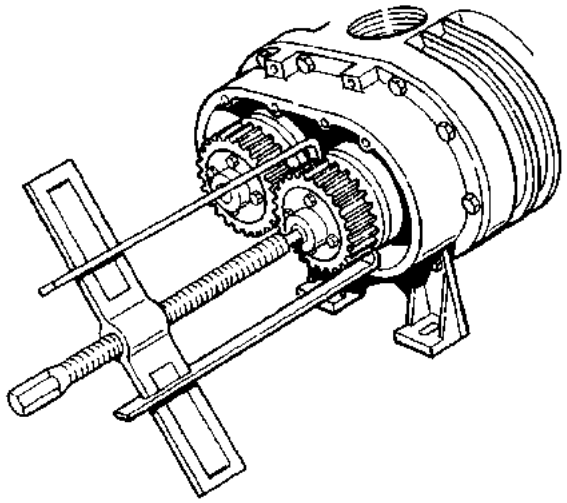


FIGURE 14

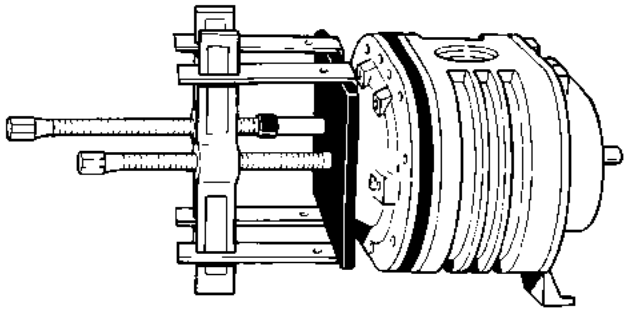


FIGURE 15

NOTICE

If backlash is above the specified limit, the gears are not necessarily unusable. Excessive play could be caused by worn bearings.

5. If timing gears appear to be reusable, matchmark timing gear toothmesh by making small punch marks on the ends of meshing gear teeth with a pin punch and hammer (see FIGURE 13, page 15). The impeller tip to valley (throat) and the case to headplates should also be match marked to facilitate blower reassembly.

6. Remove each timing hub (39) and the timing gear (9) as a complete assembly with a gear puller. (See FIGURE 14). Do not remove timing bolts (38) or threaded taper pins (36), unless the gears or hubs will be replaced.

NOTICE

If replacing the timing gears (9), remove the timing hub taper pins (36) by placing washers or an oversized nut over the extending threaded area of the pin. Tighten a proper-sized nut on the pin and it will eject.

7. Remove the four socket head cap screws (30) from the drive end bearing cover (29) and remove the cover. Drive shaft oil seal (31) should come free when cover is removed.

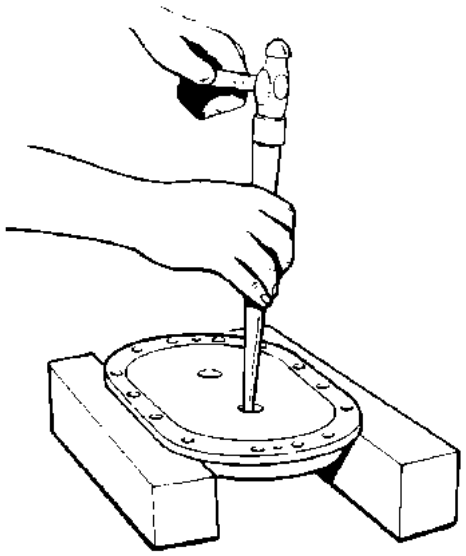


FIGURE 16

8. Remove mounting foot (17) from the drive headplate (24) by removing the capscrews (16).

9. Remove the capscrews (21) which secure the drive headplate (24) to the impeller case (22).

10. Using the fabricated puller plate shown on page 11, bolt to the drive headplate using the tapped holes used to secure the drive cover.

11. Install a gear puller to each shaft and attach the puller arms to the fabricated plate. Turn each puller only half a revolution at a time keeping the advance of the shafts as uniform as possible (see

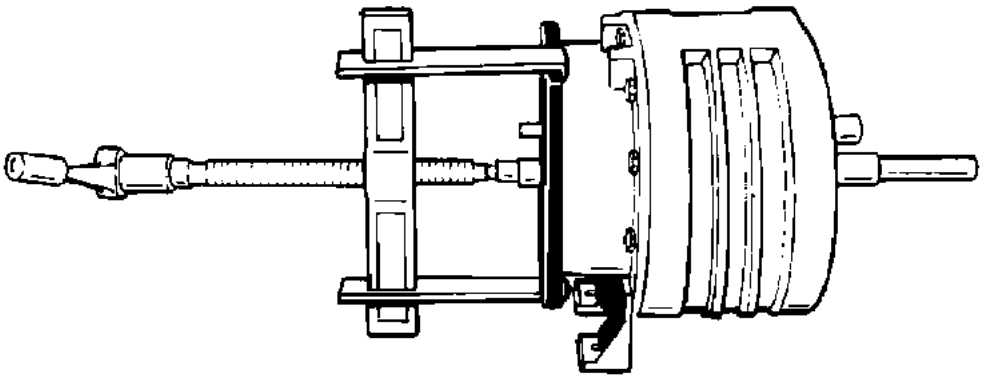


FIGURE 17

FIGURE 15, page 16). After the headplate has been removed, detach the puller plate.

12. Remove the two drive end bearings (14) from the drive headplate (24) using a ball peen hammer and punch (see FIGURE 16, page 16).

⚠ CAUTION

Exercise care not to damage the headplate bearing bores when removing bearings.

13. Remove the drive end spacers (33), (34) and (41). The grease seals (15) can now be driven out of the drive headplate with hammer and punch (see FIGURE 16, page 16). Discard the seals as they will not be reused. Replace grease seals each time the headplate is removed.

NOTICE

Seals and bearings should be replaced during overhaul as a matter of service policy.

14. Remove the four cap screws (10) which fasten each bearing retainer (12) to the gear headplate.

15. Attach fabricated puller plate to the gear headplate using the tapped holes used to secure the bearing retainers.

16. Install a gear puller to one of the shafts and attach the puller arms to the fabricated plate (see FIGURE 17).

17. Push the impeller shaft through the gear headplate and remove the impeller assembly (23) (see FIGURE 17). Remove the other impeller assembly following the same procedure.

18. Remove mounting foot (17) from the gear headplate by removing 4 capscrews (16).

19. Remove the cap screws (21) securing the gear headplate to the impeller case. Located near each dowel pin on the headplate is a threaded hole. Insert a 3/8-16 UNC capscrew into each of the threaded holes. Tighten the screws evenly until the headplate separates from the impeller case.

20. Remove the two gear end bearings (14) from the gear headplate (18) as done in step 12.

21. Remove the bearing seal spacers (33) and oil seals (15) from the gear headplate as done in Step 13.

SECTION 7
ASSEMBLY INSTRUCTIONS

NOTICE

Numbers in parentheses ( ) refer to key numbers in assembly drawings on pages 25, 27 and 29.

1. Make sure all metallic parts are clean and free of any nicks or burrs.

2. Lubricate the outside diameter of the lip seal (15) with a light oil or grease. Install seals in both the drive head-plate (24) and gear headplate (18). The seal lip should always face towards the bearing or lubricant. New seals should be installed each time the headplate is removed.

NOTICE

Make sure seals are fully seated. Use extreme care when installing.

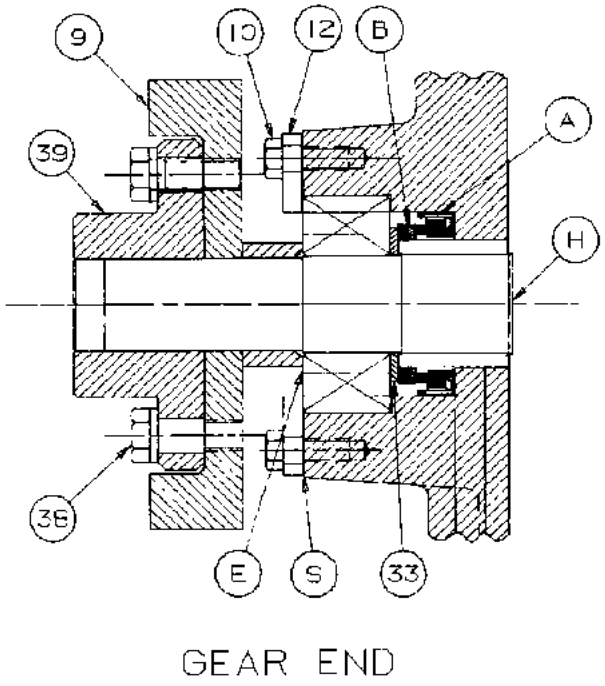
INSTALLING MECHANICAL SEALS

A. Lightly coat the headplate bores with assembly lubricant.

B. Refer to FIGURE 18. Install mechanical seal (A) into the headplate bore using a press and the correct driver shown on page 13. Drive the seal securely on to its seat.

⚠ CAUTION

Use extreme care when installing seals in the headplate bores. Do not attempt to install the mechanical seals without the use of a press. Blows from a hammer or mallet can damage the fragile seal surface. Too much force can crush the seal casing. Make certain the seal is properly seated and undamaged before proceeding.



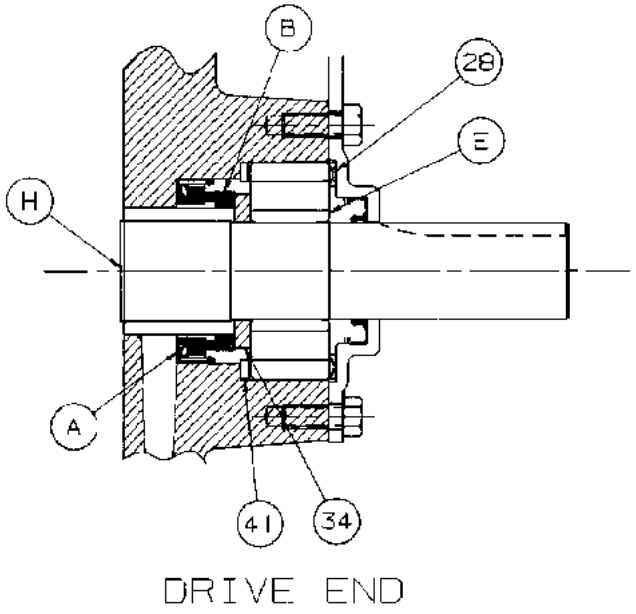


FIGURE 18

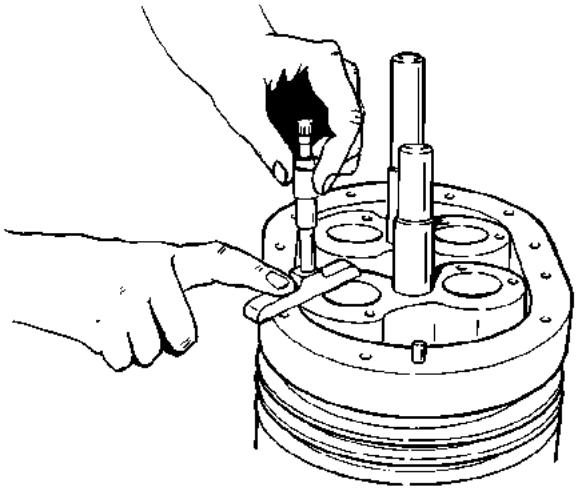


FIGURE 19

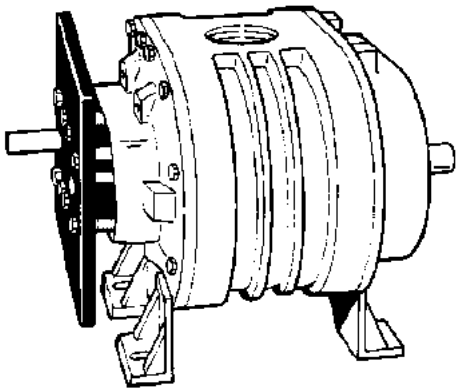


FIGURE 20

3. Assemble gear headplate (18) and mounting foot (17) to the impeller case with cap screws (21) and where the mounting foot is secured to the headplate use capscrews (16). The two positioning dowel pins (19) will ensure proper alignment of the headplate and impeller case. Also secure lifting lugs using capscrews (21) (see exploded assembly drawing page 25). Torque capscrews alternately and evenly. Refer to FIGURE 24, page 24, for torque specifications.

4. Apply a light oil or grease on the shaft seal areas and the bearing areas. Insert impellers into the gear headplate using the same headplate bores as used in the original assembly.

⚠ CAUTION

Seals are delicate; use extreme care when installing impeller shafts in the headplate bores. A piece of light shim stock wrapped around the shaft keyway will prevent cutting the seal lip.

5. Position blower so that impellers are vertical, with the drive end on top. It will be necessary to use blocks in order for the unit to set level. Measure the total end clearance using a depth micrometer (see FIGURE 19).

   If total clearance is not within the limits specified in FIGURE 21, page 20, it may be necessary to shim the case to obtain the proper total end clearance. The shim should be placed between the drive headplate and impeller case.

NOTICE

If more than .007" shim is required, put .007" on the drive end and the remaining on the gear end.

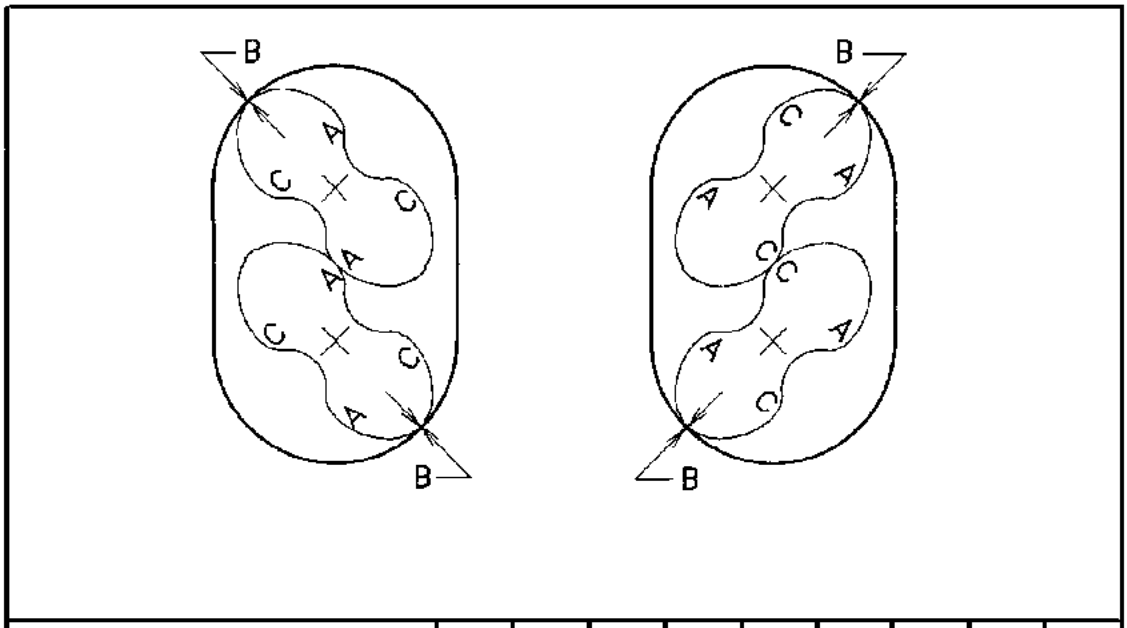
6. Assemble drive headplate (24) to impeller case as done in step 3 with the gear headplate. If shims were required, place shims between drive headplate and impeller case.

7. Insert bearing-seal spacers (34), (41) into the drive shaft headplate bore and spacer (33) into the remaining bores (see exploded view, page 25).

MECHANICAL SEALS ONLY

A. Refer to FIGURE 18, page18. Lightly coat the impeller shaft (H) and the inside diameter of the mating ring (B) with assembly lubricant.

B. Install the mating ring (B) on the shaft only far enough to install spacer (34), (41) in the bore and allow for the bearing inner race (E) to be started on the shaft.



	6H	6M	6L	7H	7M	7L	8H	8M	8L
TOTAL END CLEARANCE	.008–.012			.009–.012			.009–.012		
IMPELLER TO GEAR HEADPLATE	.004–.005			.004–.005			.004–.005		
IMPELLER TIMING (A–A) (C–C)	.009–.011			.009–.011			.011–.013		
RADIAL CLEARANCE (B–B)	.006–.007			.006–.009			.007–.010		

FIGURE 21

⚠ CAUTION

Do not drive the mating ring down to the mechanical seal, as this can damage the seal.

C. Install mating ring (B) on the drive end short shaft and the gear end shafts as done in the previous step, but use spacer (33) (refer to gear end, FIGURE 18, page 18).

D. Brush the bearing inner race (E) with a light oil or grease.

E. Using a press and the bearing installation tool shown on page 14, install the spherical roller bearing (35) on the drive end drive shaft. Install the three double row ball bearings on the remaining shaft ends. Bearings will position the mating ring (B) to the proper depth with respect to the mechanical seal (A) when the installation tool is tight against the headplate.

8. Apply a light oil to the drive headplate bearing bore, bearing inside diameter, and shaft seat. Install the spherical roller bearing (35) on the drive end drive shaft and the double row ball bearing (14) on the drive end driven shaft. Start the bearing in the bores without force.

9. Attach the puller plate shown on page 11 to the drive headplate using the tapped holes used to secure the drive cover (see FIGURE 20, page 19). Tighten the bolts so that the advance of the bearings stay as uniform as possible. Bearings should be pressed until fully seated in the bore.

NOTICE

Bearings will not be flush with gear headplate bores when completely seated.

10. Lubricate the gear end bearing fits with a light oil as described previously. Install gear end bearings (14) as far as possible without force. Use the fabricated plate, used to install the drive end bearings, to press the bearings on the shafts as described

in Step 9. Press bearings into the gear headplate until completely seated in the bearing bore.

NOTICE

Bearings will not be flush with gear headplate bores when completely seated.

11. Impeller should now be checked for free axial movement by hitting the ends of the impeller shafts with the palm of your hand.

12. Push the impellers against the gear headplate and recheck the total end clearance between the drive headplate and the impellers (see FIGURE 21, page 20).

    A. If total end clearance is insufficient, loosen impeller case to headplate bolts on either headplate, and move the headplate away from the case far enough to insert a paper shim in the amount equal to the insufficient clearance. Retighten case bolts and again check the total end clearance. Refer to FIGURE 21, page 20, for correct clearance.

    B. Excessive end clearances normally will require new impeller assemblies, but in some circumstances the impeller case can be removed and reduced in width by machining off the amount of excess clearance.

⚠ CAUTION

These impeller-to-impeller and impeller-to-case clearances are extremely critical. Even though the blower may turn freely by hand when cold, under operating conditions, the parts expand, and the rotors are subject to slight deflection.

If the clearances are not sufficient, the impellers may contact each other or the housing with destructive results. If the clearances are too great, the blower may not develop the pressure or airflow that is required to perform its function.

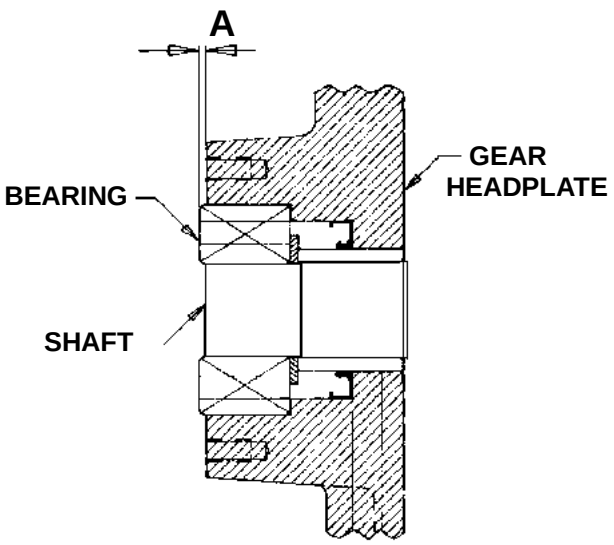


FIGURE 22

13. Impeller tip to case clearance should be checked at this time by inserting the correct thickness feeler gauge between the tip and the case (B) and rotating the impeller (see FIGURE 21, page 20). Repeat the procedure on both impellers.

NOTICE

When checking the tip to case clearance, move the feeler gauge over the entire length of the impeller to ensure that the tips do not bind along their length.

14. Replace the drive shaft grease seal (31) in the drive end cover (29). The seal lip should always face toward the bearing or lubricant. Pack the bearing cavities with the recommended grease.

15. Secure drive cover (29) and wavy spring (28) to drive headplate using capscrews (30). Refer to FIGURE 24, page 24, for torque specifications.

NOTICE

Exercise care not to damage the seal lip as it passes over shaft keyway.

16. **SETTING IMPELLER END CLEARANCE**

Refer to FIGURE 18, page 18. The gear end bearings are held in position by the force created by the wavy spring (28) on the drive end and the bearing retainer (12) on the gear end. The interference fit between the shaft (H) and the bearing inner race (E) keeps the shaft from moving axially.

End clearance adjustment of both impellers is controlled by adjustment of the bearing retainer (12). Tightening the bearing retainer screws (10) moves the bearing to load the wavy spring (28), and the impeller is forced toward the drive end. Relaxing the screws allows the wavy spring to return the impeller toward the gear end.

A. With impellers tight against the gear headplate, measure the distance (A) from the bearing outer race to the gear headplate using a depth micrometer (see FIGURE 22, page 21.

B. Subtract 1/3 of the total end clearance from the value measured at point A. This value is the amount of shim (13) that should be placed between the retainer and the headplate at point (S).

C. Secure bearing retainer (12) with the correct amount of shim, to the headplate using capscrews (10). Torque capscrews to the specifications given in FIGURE 24, page 24.

D. Recheck end clearances. Approximately 1/3 of the total end clearance should be on the gear end and the remaining 2/3 on the drive end (refer to FIGURE 21, page 20).

If clearances require adjusting, loosen the bearing retainer capscrews (10) and insert shims to move the impeller closer to the gear headplate and remove shims to move the impellers away from the gear headplate.

17. **INSTALLING THE TIMING GEARS**

Impellers are held in time by gears which are taper pinned and bolted to a timing hub, which in turn is pressed and taper pinned onto the shaft. The timing gears can be rotated in relation to the hub by removing the taper pins in the web of the gear and loosening the capscrews. Because the capscrews are oversized, the gear will rotate – within limits – relative to the timing hub when the screws are loosened.

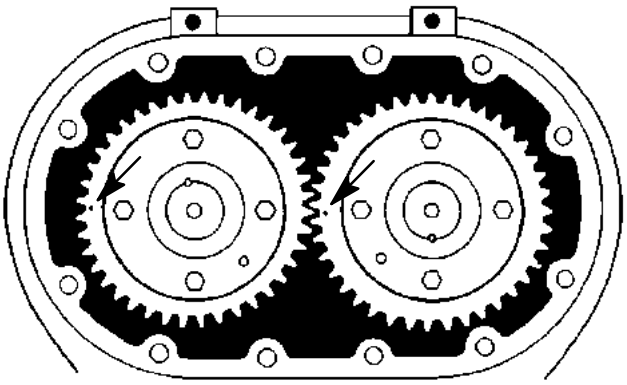


FIGURE 23

A. Apply a light grease, or oil, on the shaft area where the timing gear will be positioned.

B. Lubricate the inside diameter of spacers (32) with assembly lubricant and install on the gear end shafts.

C. Using a piece of paper large enough to cover the open end of the gear headplate, trace the shafts on the paper and cut-out shaft holes. This will be placed on the shafts before the gears to protect the bearings from metal shavings when drilling taper pin holes in the following procedure.

D. Place feeler stock in the amount of 1/3 of the total end clearance between drive headplate and both impellers. This will stop the impellers from contacting the headplate while the gears are being driven on.

⚠ CAUTION

If installing gears on a blower containing mechanical seals, a press must be used to drive the gears on the shafts. Blows from a hammer or mallet will damage the seal.

E. If reusing the timing gears and hubs, they should be returned to their original position with respect to the impellers.

If replacement gears are used, secure each gear (9) to its timing hub (39) with capscrews (38) and lockwasher (37) and tighten slightly.

NOTICE

Replacement gears have minimum backlash marks on the outside diameter of the gear face. These marks should be located 180 degrees from each other (see FIGURE 23).

F. Position impellers so they are 90 degrees to each other. Using the driving tool shown on page 12, install the gears and hubs on the shafts using the taper pin holes and match marks for correct positioning. Check to be sure impellers are in correct position as previously match marked.

NOTICE

Utilize a press whenever possible when installing gears.

G. Refer to diagram in FIGURE 21, page 20. Use feeler gauges to check clearances between impeller lobes at positions A–A and C–C. Add the clearances, and divide the total clearance evenly between A–A and C–C.

H. Loosen the four capscrews (38) in one gear only. Wedge the correct amount of feeler gauge between the impeller at A–A. If movement between the gear and hub is not sufficient to time the impellers, it will be necessary to loosen the four capscrews (38) in the mating gear to obtain a large adjustment range. Adjust so that the clearance at A–A is equal to C–C within .001 inch.

Clearances must be checked on both sides of each impeller lobe over the entire length. This procedure may require repeating several times until impeller lobe clearance is equal on both sides.

I. Secure the timing gears (9) to the hubs (39) with capscrews (38) and lockwasher (37). Tighten capscrews to the torque specification listed in FIGURE 24, page 24.

J. Check gear backlash four places at 90 degree intervals as described in the disassembly procedure (Item 4).

NOTICE

If any of the four gear backlash readings are not within the specified limits, the gears must be replaced.

K. Ream taper pin hole between the shaft and hub with a hand reamer and replace taper pin (8) if movement between the shaft and hub (39) was negligible. If reaming fails to eliminate edges due to slight misalignment, drill and ream a new hole approximately 90 degrees from the original hole. Control the depth of the taper pin, leaving approximately 1/8" taper pin protruding beyond the hub and shaft.

L. Ream center drilled hole in the hub and gear web. If rereaming fails to eliminate edges set up by retiming, ream hole for the next larger taper pin or drill and ream a new hole approximately 90 degrees from the original hole. Control the depth of the threaded taper pin (36), leaving the threaded portion of the pin protruded beyond the hub.

Replacement gears are not drilled for taper pin (8). These holes must be drilled and reamed after the gears are in proper position and the unit retimed.

NOTICE

Be careful not to allow cuttings to drop behind the gears and contaminate the bearings.

M. Remove paper from behind the gears. Make certain metal cuttings did not contaminate the bearings.

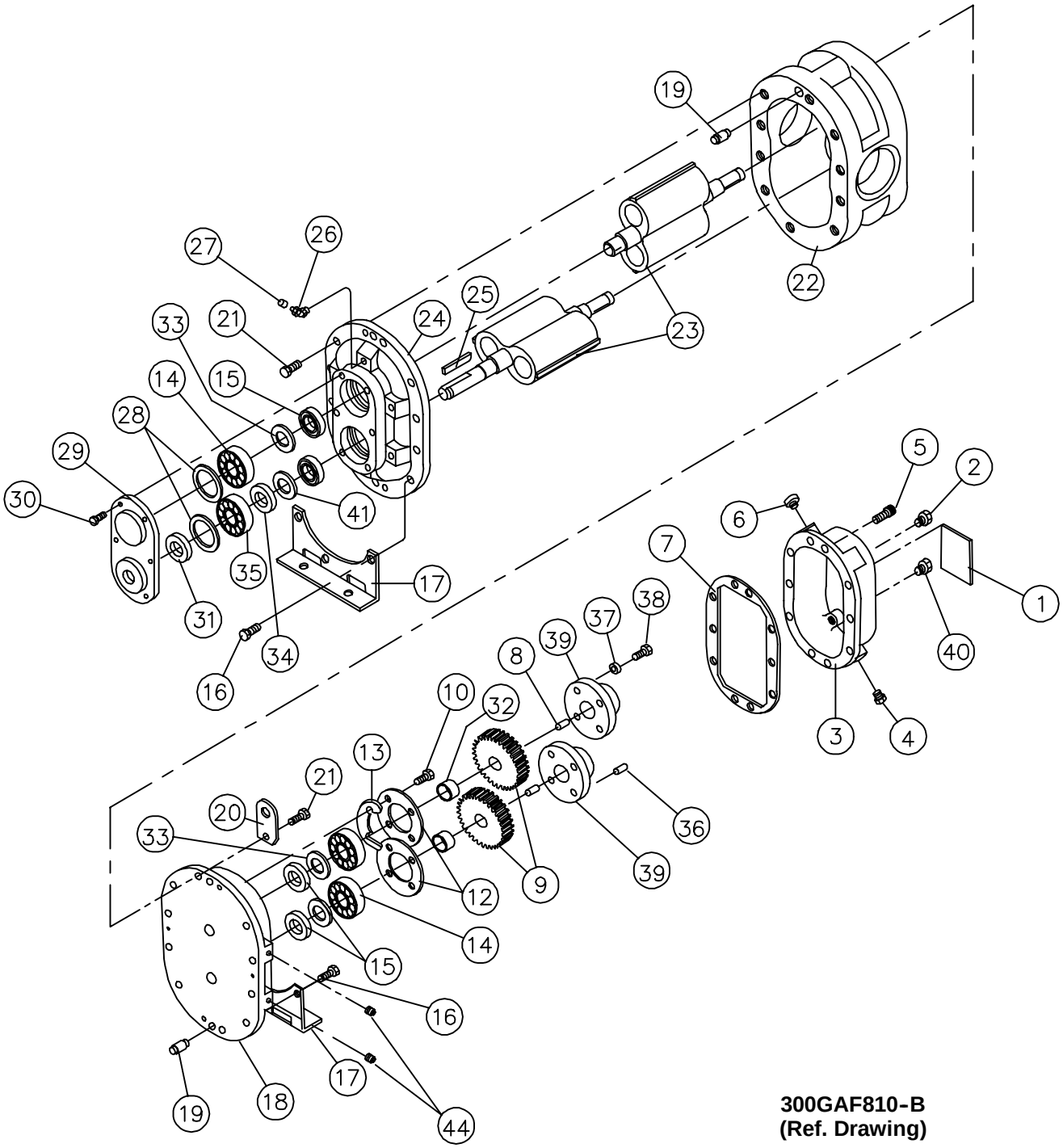
18. Assemble gear cover (3) and gasket (7) to the gear headplate (18) using capscrews (5). Tighten capscrews alternately and evenly. Refer to FIGURE 24, page 24 for torque specifications.

19. Place blower on its feet on a flat surface. Loosen capscrews (16) and level unit up. The bench or blower base flatness should be within .002 of an inch. Re-tighten cap screws (16) to the specifications in FIGURE 24, page 24.

Ref. No.	FASTENERS	GEAR DIAMETER		
		6	7	8
5	Screw – Gear Case to Headplate	16	30	30
10	Screw – Bearing Retainer to Headplate	16	30	30
16	Screw – Mounting Foot to Headplate	30	75	75
21	Screw – Headplate to Impeller Case	30	75	75
30	Screw – Drive Cover to Headplate	16	30	30
38	Screw – Timing Hub to Gear	30	75	75

NOTE: REF. NO. DENOTES ITEMS IN EXPLODED VIEW DRAWINGS ON PAGES 25, 27 AND 29.

FIGURE 24 - TORQUE (FT-LBS)



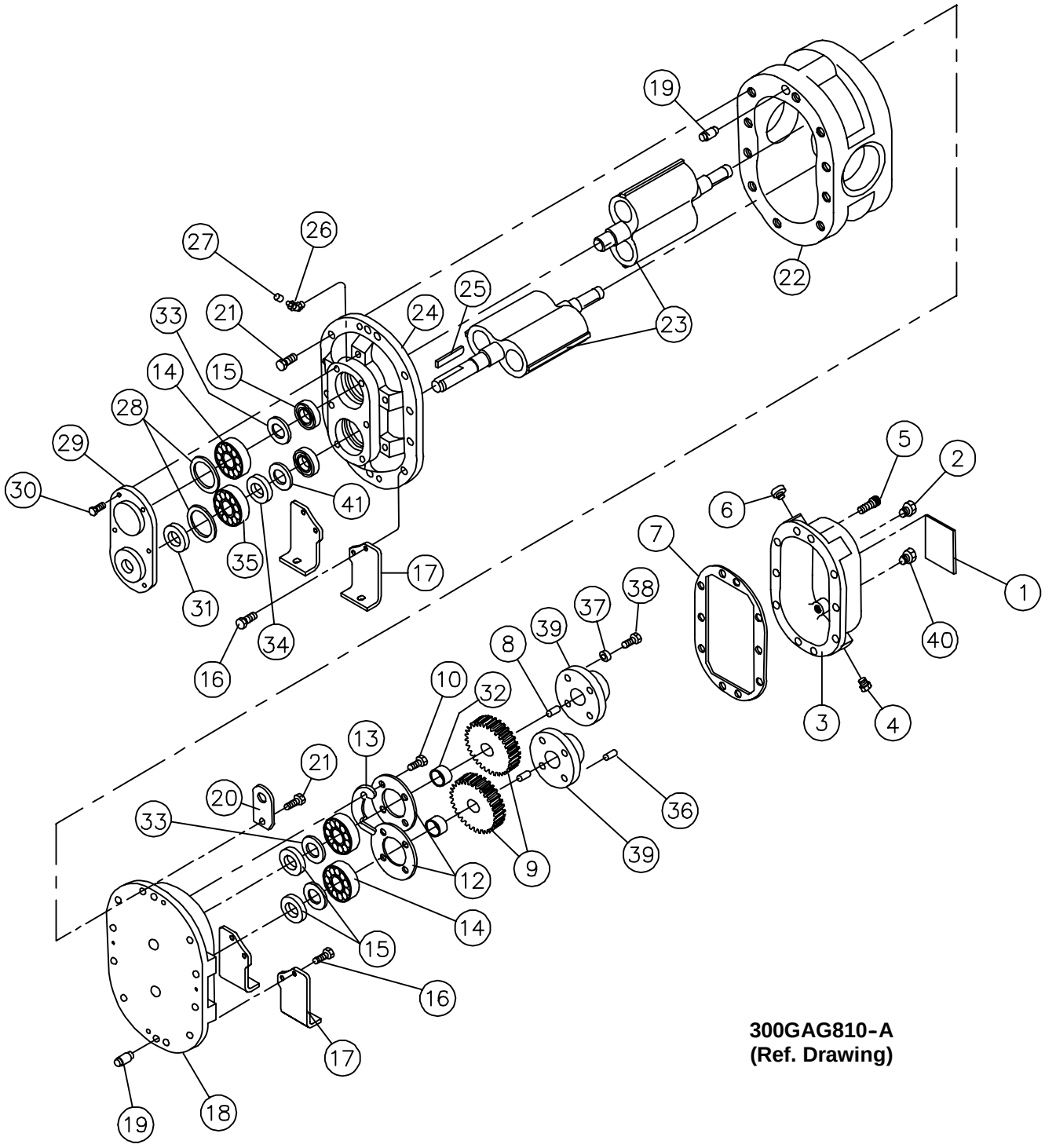
300GAF810-B
(Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

	Ref. No.	Description	No. Req'd	MODEL GAF Size - 6H GAFH_P_	Size - 6M GAFM_P_	Size - 6L GAFL_P_
	1	NAMEPLATE	1	301GAE496	301GAE496	301GAE496
	2	PLUG FOR ALTERNATE OIL LEVEL CONN.	1	64AC4	64AC4	64AC4
	3	GEAR CASE	1	900883064201	900883064201	900883064201
	4	DRAIN PLUG	1	64AC4	64AC4	64AC4
	5	SCREW-GEAR CASE TO HEADPLATE	12	75LM113	75LM113	75LM113
	6	BREATHER	1	5L223	5L223	5L223
Ø	7	GASKET GEAR CASE	1	200GAF715	200GAF715	200GAF715
Ø	8	TAPER PIN	2	62V59	62V59	62V59
	9	TIMING GEAR GROUP	1	200GAF6008	200GAF6008	200GAF6008
Ø	10	SCREW-BEARING RETAINER TO HEADPLATE	8	75A33N	75A33N	75A33N
	12	BEARING RETAINER	2	900883065501	900883065501	900883065501
Ø	13	SHIM SET	1	900881065400	900881065400	900881065400
Ø	14	BEARING	3	900639080506	900639080506	900639080506
Ø	15	MAIN SEAL-PER APPLICATION BELOW				
		MECHANICAL SEAL VERSION	4	900871020006	900871020006	900871020006
		LIP SEAL VERSION	4	60DD657	60DD657	60DD657
	16	SCREW-FOOT TO HEADPLATE	8	655ED060	655ED060	655ED060
	17	FOOT GROUP				
		VERTICAL FOOT GROUP	1	GAF81950	GAF81950	GAF81950
		HORIZONTAL FOOT GROUP	1	GAF81951	GAF81951	GAF81951
	18	HOUSING-BEARING (GEAR END)				
		LIP SEAL	1	900883064401	90088364401	900883064401
		MECHANICAL SEAL	1	900883064501	90088364501	900883064501
	19	DOWEL PIN	4	62M48	62M48	62M48
	20	LIFTING LUG	2	200GAF451	200GAF451	200GAF451
	21	SCREW-HEADPLATES TO IMPELLER CASE	24	655ED050	655ED050	655ED050
	22	IMPELLER CASE	1	900883063901	900883064001	900883064101
	23	SHAFT ASSEMBLY GROUP	1	GAF81952	GAF81954	GAF81953
		SHAFT ASSEMBLY GROUP CONSISTS OF: (1) ASSEMBLY SHAFT - LONG (1) ASSEMBLY SHAFT - SHORT				
	24	HOUSING-BEARING (DRIVE END)				
		LIP SEAL	1	900883064901	900883064901	900883064901
		MECHANICAL SEAL	1	900883064801	900883064801	900883064801
	25	DRIVE KEY	1	900639910406	900639910406	900639910406
	26	GREASE FITTING	2	911659990606	911659990606	911659990606
	27	GREASE FITTING CAP	2	40P41	40P41	40P41
	28	WAVY SPRING	2	900669170506	900669170506	900669170506
	29	DRIVE COVER	1	900883064601	900883064601	900883064601
	30	SCREW-DRIVE COVER TO HEADPLATE	8	75LM113	75LM113	75LM113
Ø	31	DRIVE SEAL	1	60DD658	60DD658	60DD658
	32	SPACER-GEAR END	2	900811060401	900811060401	900811060401
	33	SPACER-GEAR & DRIVE END-SEAL/BRG	3	900881066201	900881066201	900881066201
	34	SPACER-DRIVE END DRIVE SHAFT-SEAL/BRG	1	900881066401	900881066401	900881066401
Ø	35	BEARING-DRIVE END DRIVE SHAFT	1	900811060801	900811060801	900811060801
	36	THREADED TAPER PIN	2	62V67	62V67	62V67
	37	WASHER-GEAR	8	900649440205	900649440205	900649440205
	38	SCREW-TIMING HUB TO GEAR	8	655ED060	655ED060	655ED060
	39	HUB-TIMING	2	900713060101	900713060101	900713060101
	40	GAUGE-OIL LEVEL	1	40P31	40P31	40P31
*	41	SPACER-DRIVE END DRIVE SHAFT-HD PLT-BRG REQUIRED WITH MECHANICAL SEAL UNITS	1	900881066301	900881066301	900881066301
*	42	PLUGS REQUIRED WITH MECHANICAL SEAL UNITS	8	64AC2	64AC2	64AC2
	44	SCREW-SET	4	76F92	76F92	76F92
Ø		OVERHAUL KIT LIP SEAL	0	203GAF6010	203GAF6010	203GAF6010
Ø		OVERHAUL KIT MECHANICAL SEAL	0	204GAF6010	204GAF6010	204GAF6010

* NOT SHOWN

Ø INCLUDED IN OVERHAUL KIT.

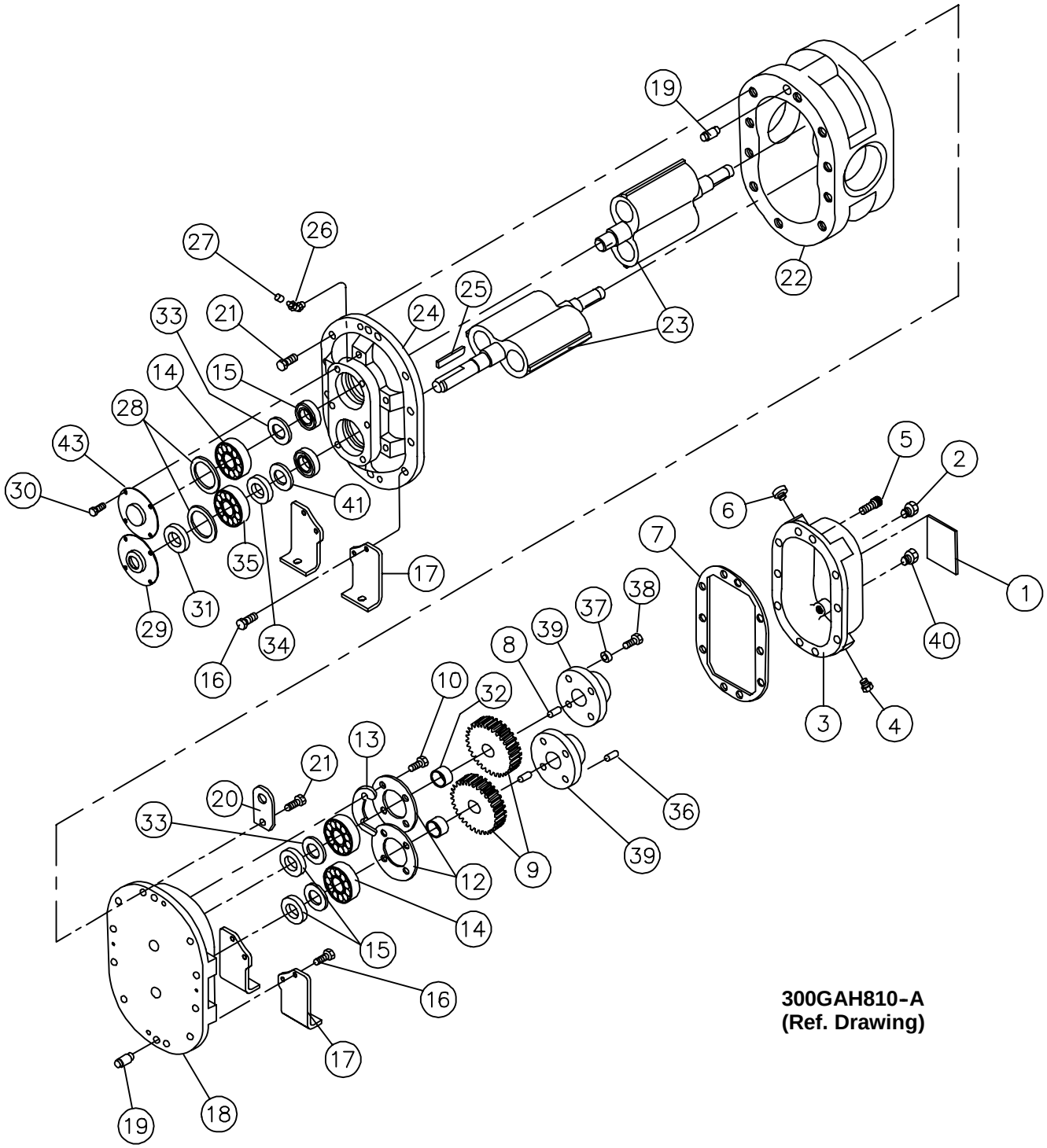


300GAG810-A
(Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

	Ref. No.	Description	No. Req'd	MODEL GAG Size - 7H GAGH_P_	Size - 7M GAGM_P_	Size - 7L GAGL_P_
	1	NAMEPLATE	1	301GAE496	301GAE496	301GAE496
	2	PLUG FOR ALTERNATE OIL LEVEL CONN.	1	64B4	64B4	64B4
	3	GEAR CASE	1	900893071701	900893071701	900893071701
	4	DRAIN PLUG	1	64AC6	64AC6	64AC6
	5	SCREW-GEAR CASE TO HEADPLATE	12	75LM122	75LM122	75LM122
	6	BREATHER	1	5L223	5L223	5L223
Ø	7	GASKET GEAR CASE	1	200GAG715	200GAG715	200GAG715
Ø	8	TAPER PIN	2	62V60	62V60	62V60
	9	TIMING GEAR GROUP	1	200GAG6008	200GAG6008	200GAG6008
Ø	10	SCREW-BEARING RETAINER TO HEADPLATE	8	655ED040N	655ED040N	655ED040N
	12	BEARING RETAINER	2	900893070401	900893070401	900893070401
Ø	13	SHIM SET	1	900891073800	900891073800	900891073800
Ø	14	BEARING	3	DF138116	DF138116	DF138116
Ø	15	MAIN SEAL-PER APPLICATION BELOW				
		MECHANICAL SEAL VERSION	4	900871020007	900871020007	900871020007
		LIP SEAL VERSION	4	60DD715	60DD715	60DD715
	16	SCREW-FOOT TO HEADPLATE	8	655EE070	655EE070	655EE070
	17	FOOT GROUP				
		VERTICAL FOOT GROUP	1	GAG81958	GAG81958	GAG81958
		HORIZONTAL FOOT GROUP	1	GAG81959	GAG81959	GAG81959
	18	HOUSING-BEARING (GEAR END)				
		LIP SEAL	1	900893072801	900893072801	900893072801
		MECHANICAL SEAL	1	200GAG006	200GAG006	200GAG006
	19	DOWEL PIN	4	62M48	62M48	62M48
	20	LIFTING LUG	2	200GAF451	200GAF451	200GAF451
	21	SCREW-HEADPLATES TO IMPELLER CASE	24	655EE050	655EE050	655EE050
	22	IMPELLER CASE	1	900893070101	900893070201	900893070301
	23	SHAFT ASSEMBLY GROUP	1	GAG81960	GAG81962	GAG81961
		SHAFT ASSEMBLY GROUP CONSISTS OF: (1) ASSEMBLY SHAFT - LONG (1) ASSEMBLY SHAFT - SHORT				
	24	HOUSING-BEARING (DRIVE END)				
		LIP SEAL	1	900893070601	900893070601	900893070601
		MECHANICAL SEAL	1	900893072601	900893072601	900893072601
	25	DRIVE KEY	1	900639910407	900639910407	900639910407
	26	GREASE FITTING	2	911659990606	911659990606	911659990606
	27	GREASE FITTING CAP	2	40P41	40P41	40P41
	28	WAVY SPRING	2	900669170607	900669170607	900669170607
	29	DRIVE COVER	1	900883073701	900883073701	900883073701
	30	SCREW-DRIVE COVER TO HEADPLATE	8	75LM122	75LM122	75LM122
Ø	31	DRIVE SEAL	1	60DD727	60DD727	60DD727
	32	SPACER-GEAR END	2	900891073001	900891073001	900891073001
	33	SPACER-GEAR & DRIVE END-SEAL/BRG	3	200GAG144	200GAG144	200GAG144
	34	SPACER-DRIVE END DRIVE SHAFT-SEAL/BRG	1	201GAG144	201GAG144	201GAG144
Ø	35	BEARING-DRIVE END DRIVE SHAFT	1	910712068201	910712068201	910712068201
	36	THREADED TAPER PIN	2	62V68	62V68	62V68
	37	WASHER-GEAR	8	900649440507	900649440507	900649440507
	38	SCREW-TIMING HUB TO GEAR	8	655EE060	655EE060	655EE060
	39	HUB-TIMING	2	900713060102	900713060102	900713060102
	40	GAUGE-OIL LEVEL	1	VP1004935	VP1004935	VP1004935
*	41	SPACER-DRIVE END DRIVE SHAFT-HD PLT-BRG REQUIRED WITH MECHANICAL SEAL UNITS	1	900881073301	900881073301	900881073301
*	42	PLUGS REQ. W/MECH. SEAL UNITS(GEAR END)	4	64AC3	64AC3	64AC3
*	46	PLUGS REQ. W/MECH. SEAL UNITS (DRIVE END)	4	64AC2	64AC2	64AC2
Ø		OVERHAUL KIT LIP SEAL	0	200GAG6010	200GAG6010	200GAG6010
Ø		OVERHAUL KIT MECHANICAL SEAL	0	201GAG6010	201GAG6010	201GAG6010

* NOT SHOWN
Ø INCLUDED IN OVERHAUL KIT.



300GAH810-A
(Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

	Ref. No.	Description	No. Req'd	MODEL GAH Size - 8H GAHH_P_	Size - 8M GAHM_P_	Size - 8L GAHL_P_
	1	NAMEPLATE	1	301GAE496	301GAE496	301GAE496
	2	PLUG FOR ALTERNATE OIL LEVEL CONN.	1	64AC5	64AC5	64AC5
	3	GEAR CASE	1	900893082501	900893082501	900893082501
	4	DRAIN PLUG	1	64AC5	64AC5	64AC5
	5	SCREW-GEAR CASE TO HEADPLATE	12	2009649	2009649	2009649
	6	BREATHER	1	5L223	5L223	5L223
Ø	7	GASKET GEAR CASE	1	200GAH715	200GAH715	200GAH715
Ø	8	TAPER PIN	2	62V61	62V61	62V61
	9	TIMING GEAR GROUP	1	200GAH6008	200GAH6008	200GAH6008
	10	SCREW-BEARING RETAINER TO HEADPLATE	8	655ED04N	655ED04N	655ED04N
	11	LOCKWASHER	8	95B3	95B3	95B3
	12	BEARING RETAINER	2	900893083101	900893083101	900893083101
Ø	13	SHIM SET	1	910639630008	910639630008	910639630008
Ø	14	BEARING	3	900639080808	900639080808	900639080808
Ø	15	MAIN SEAL-PER APPLICATION BELOW				
		MECHANICAL SEAL VERSION	4	900871020008	900871020008	900871020008
		LIP SEAL VERSION	4	910751061902	910751061902	910751061902
	16	SCREW-FOOT TO HEADPLATE	8	655EE080	655EE080	655EE080
	17	FOOT GROUP				
		VERTICAL FOOT GROUP	1	GAH81966	GAH81966	GAH81966
		HORIZONTAL FOOT GROUP	1	GAH81967	GAH81967	GAH81967
	18	HOUSING-BEARING (GEAR END)				
		LIP SEAL	1	900894082301	900894082301	900894082301
		MECHANICAL	1	200GAH006	200GAH006	200GAH006
	19	DOWEL PIN	4	62M48	62M48	62M48
	20	LIFTING LUG	2	200GAF451	200GAF451	200GAF451
	21	SCREW-HEADPLATES TO IMPELLER CASE	36	655EE060	655EE060	655EE060
	22	IMPELLER CASE	1	900653021708	910613746808	910613747008
	23	SHAFT ASSEMBLY GROUP	1	GAH81968	GAH81970	GAH81969
		SHAFT ASSEMBLY GROUP CONSISTS OF: (1) ASSEMBLY SHAFT - LONG (1) ASSEMBLY SHAFT - SHORT				
	24	HOUSING-BEARING (DRIVE END)				
		LIP SEAL	1	900894082101	900894082101	900894082101
		MECHANICAL SEAL	1	201GAH006	201GAH006	201GAH006
	25	DRIVE KEY	1	900639910407	900639910407	900639910407
	26	GREASE FITTING	2	911659990606	911659990606	911659990606
	27	GREASE FITTING CAP	2	40P41	40P41	40P41
	28	WAVY SPRING	2	900669170708	900669170708	900669170708
	29	DRIVE COVER	1	900693086301	900693086301	900693086301
	30	SCREW-DRIVE COVER TO HEADPLATE	8	655ED030	655ED030	655ED030
Ø	31	DRIVE SEAL	1	60DD676	60DD676	60DD676
	32	SPACER-GEAR END	2	900811060403	900811060403	900811060403
	33	SPACER-GEAR & DRIVE END - SEAL/BRG	3	900871060803	900871060803	900871060803
	34	SPACER-DRIVE END DRIVE SHAFT-SEAL/BRG	1	202GAH144	202GAH144	202GAH144
Ø	35	BEARING-DRIVE END DRIVE SHAFT	1	910721070501	910721070501	910721070501
	36	THREADED TAPER PIN	2	62V69	62V69	62V69
	37	WASHER-GEAR	8	900649440507	900649440507	900649440507
	38	SCREW-TIMING HUB TO GEAR	8	655EE080	655EE080	655EE080
	39	HUB-TIMING	2	900713060103	900713060103	900713060103
	40	GAUGE-OIL LEVEL	1	40P45	40P45	40P45
*	41	SPACER-DRIVE END DRIVE SHAFT-HD PLT-BRG REQUIRED WITH MECHANICAL SEAL UNITS	1	900881082401	900881082401	900881082401
*	42	PLUGS REQUIRED WITH MECHANICAL SEAL UNITS	8	64AC3	64AC3	64AC3
	43	DRIVEN COVER	1	900693086401	900693086401	900693086401
Ø		OVERHAUL KIT LIP SEAL	0	GAH81972	GAH81972	GAH81972
Ø		OVERHAUL KIT MECHANICAL SEAL	0	GAH81971	GAH81971	GAH81971

* NOT SHOWN

Ø INCLUDED IN OVERHAUL KIT.

Gardner Denver

WARRANTY

SUTORBILT BLOWERS

SUTORBILT LEGEND SERIES

GENERAL PROVISIONS AND LIMITATIONS

Gardner Denver (the "Company") warrants to each original retail purchaser ("Purchaser") of its new products from the Company or its authorized distributor that such products are, at the time of delivery to the Purchaser, made with good material and workmanship. No warranty is made with respect to:

1. Any product which has been repaired or altered in such a way, in the Company's judgment, as to affect the product adversely.
2. Any product which has, in the Company's judgment been subject to negligence, accident, improper storage, or improper installation or application.
3. Any product which has not been operated or maintained in accordance with normal practice and with the recommendations of the Company.
4. Components or accessories manufactured, warranted and serviced by others.
5. Any reconditioned or prior owned product.

Claims for items described in (4) above should be submitted directly to the manufacturer.

WARRANTY PERIOD

The Company's obligation under this warranty is limited to repairing or, at its option, replacing, during normal business hours at an authorized service facility of the Company, any part which in its judgment proved not to be as warranted within the applicable Warranty Period as follows.

BARE BLOWERS

Basic bare blowers, consisting of all parts within, are warranted for 18 months from date of initial use or 24 months from date of shipment to the first purchaser, whichever occurs first.

Any disassembly or partial disassembly of the blower, or failure to return the "unopened" blower per Company instructions, will be cause for denial of warranty.

OTHER COMPONENTS

All other components are warranted for 12 months from date of initial use or 18 months from date of shipment to first purchaser, whichever comes first.

The Company reserves the right to withdraw the Uncontested Warranty where evidence indicates application outside the stated performance area, or where there is evidence of abuse

LABOR TRANSPORTATION AND INSPECTION

The Company will provide labor, by Company representative or authorized service personnel, for repair or replacement of any product or part thereof which in the Company's judgment is proved not to be as warranted. Labor shall be limited to the amount specified in the Company's labor rate schedule.

Labor costs in excess of the Company rate schedule amounts or labor provided by unauthorized service personnel is not provided for by this warranty.

Transportation of Company's choice, within the continental United States, is covered by this warranty for replacement of any blower which in the Company's judgement proved not to be as warranted. For user locations outside the continental United States, the Company will provide transportation, by the carrier of its choice to and from the nearest Authorized Distributor and the Company's designated facility. The Company may require the return of any blower claimed not to be as warranted to one of its facilities as designated by the Company, transportation prepaid by Purchaser, to establish a claim under this warranty.

Replacement parts provided under the terms of the warranty are warranted for the remainder of the Warranty Period of the product upon which installed to the same extent as if such parts were original components thereof.

DISCLAIMER

THE FOREGOING WARRANTY IS EXCLUSIVE AND IT IS EXPRESSLY AGREED THAT, EXCEPT AS TO TITLE, THE COMPANY MAKES NO OTHER WARRANTIES, EXPRESSED, IMPLIED OR STATUTORY, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY.

THE REMEDY PROVIDED UNDER THIS WARRANTY SHALL BE THE SOLE, EXCLUSIVE AND ONLY REMEDY AVAILABLE TO PURCHASER AND IN NO CASE SHALL THE COMPANY BE SUBJECT TO ANY OTHER OBLIGATIONS OR LIABILITIES. UNDER NO CIRCUMSTANCES SHALL THE COMPANY BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, LOSSES OR DELAYS HOWSOEVER CAUSED.

No statement, representation, agreement, or understanding, oral or written, made by any agent, distributor, representative, or employee of the Company which is not contained in this Warranty will be binding upon the Company unless made in writing and executed by an officer of the Company.

This warranty shall not be effective as to any claim which is not presented within 30 days after the date upon which the product is claimed not to have been as warranted. Any action for breach of this warranty must be commenced within one year after the date upon which the cause of action occurred.

Any adjustment made pursuant to this warranty shall not be construed as an admission by the Company that any product was not as warranted.

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For additional information, contact your local representative or

Gardner Denver Compressor Division

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Phone (800) 682-9868 • Fax (217) 221-8780
E-mail: pd.blowers@gardnerdenver.com
Visit our web site: www.gardnerdenver.com

Sales and Service in all major cities

Gardner Denver

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OPERATORS MANUAL

Lofa Manual

Section 6

STG GLOBAL

EP250™ Panel Operation and Troubleshooting

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Introduction

This document provides general information on LOFA™ EP250 panel operation and troubleshooting. EP250 control panels are a flexible platform for diesel engine control, monitoring, and protection, featuring LOFA's powerful First Fault Diagnostics (FFD). After pinpointing the initial failure, FFD stores it in memory and alerts the end user via a single bright LED. FFD monitors battery charge, low oil pressure, high temperature, over speed and up to three additional contact closure inputs. The field configurable, expandable microprocessor-based solid-state design uses high-power semiconductors instead of outdated electromechanical relays to ensure reliable high-current switching.

Some of the EP250 configurable features include:

- Automatic preheat duration
- Afterglow duration
- Failure indication with shutdown or indication only
- Over-speed shutdown
- Normally open or normally closed shutdown switches

The EP250 features LOFA's new modular Function Enhancement Packs (FEP). The plug-and-play FEP modules allow various feature upgrades to be easily added to the standard platform. FEPs include:

- Automatic Start/Stop Operation
- Precision Actuator Control
- Custom OEM Solutions

All standard panels include feature a 12 inch wiring harness terminating into a sealed weather proof plug. This robust universal wiring connection performs well in harsh environments and allows interchanging a number of different panels and harnesses. This design allows for simplified installation as well as a flexible means to incorporate custom plug-and-play engine wiring harnesses and standard harness extension

Note

The engine harness is not included with the panel.

A number of standard engine harnesses are available or LOFA can develop a custom harness for you exact needs.

Generic harnesses in various lengths are available for field customization.

Warning!

When replacement parts are required, LOFA Industries recommends using replacement parts supplied by LOFA or parts with equivalent specifications.

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

Important Safety Information

The warnings in this publication are not all inclusive.

LOFA Industries cannot anticipate every potential hazard.

Appropriate safety rules and precautions should be followed with any tool, work method or operating procedure.

Improper procedures, tools and materials may cause damage or make the equipment unsafe to operate.

Only persons with appropriate training, skills and tools should perform these functions.

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

Do not operate or perform any maintenance or repair on this product until all operation, maintenance and repair information is read and understood.

The information, specifications, and illustrations in this publication are based on information available at the time of publication.

All items are subject to change at any time without notice.

Operation

Turning the panel key to the run position starts a self-test which causes all LEDs to illuminate once, activates the alarm output for one second and enables the fuel run/stop solenoid output. After self-test, the LEDs indicate the state of the inputs they monitor. The normal indications are battery charge and oil pressure on most applications. If these LEDs are not illuminated at this time it may indicate the inputs are not properly connected.

The Preheat LED is illuminated when the key switch is turned to the run position if automatic preheat is configured or if an external preheat control is connected (See Preheat Options). Preheat time varies from application to application. After waiting for the Preheat LED to extinguish, the engine is cranked by turning and holding the key switch in the start position until the engine starts. The key switch is spring loaded to return automatically to the run position when released. The Preheat LED is illuminated during afterglow if enabled.

Note

The key switch is equipped with a mechanical start locking device.
An attempt to crank the engine again can only be made by turning the key switch to the off position to reset the start locking mechanism.

If the engine is not started within 10 seconds of turning on the panel, the fuel run/stop solenoid output is turned off to prevent battery discharge when the key switch is left in the run position. The fuel run/stop solenoid output is turned off after 10 seconds even if preheating. As soon as the key switch is turned to the start position the solenoid output is enabled. The afterglow cycle begins when the key switch returns to the run position.

Note

If conditions do not warrant preheat, the engine may be started by turning the key to the start position without waiting for the preheat time to expire.

Panel instrument power, including the hour meter and voltmeter, is provided by the fuel run/stop solenoid output. If the instruments do not power up when the key is turned to the run position, this indicates a problem with the solenoid circuit (see Troubleshooting).

After the engine starts, the panel electronics ignore all shutdown conditions for the first 10 seconds. This delay eliminates the requirement to hold a by-pass override button during starting and allows the conditions such as oil pressure to normalize. The 10 second timer starts when the key switch returns to the run position.

Note

Starter input is required for correct panel operation. If the starter motor input is not activated (connected to battery positive) and the engine is started through another means (i.e. air starter) the engine will shutdown 10 seconds after the key switch is turned to the run position.

To prevent unintentional engine shutdowns caused by intermittent conditions (i.e., pressure spikes, coolant movement) the panel requires a constant 1 second fault input to cause engine shutdown.

Warning!

When used in combination with mechanical float type switches engine vibrations may prevent constant contact closure.
The panel can be configured to shutdown with no delay.

The panel has the ability to shut down the engine for over speed. Over speed will be indicated via a blinking ***Battery Charge*** LED. The panel senses RPM either by the frequency terminal of the alternator, proximity switch or magnetic pick-up with the optional magnetic pick-up amplifier/divider.

Preheat Options

Preheat Output

Preheat is a 750 mA output for control of an external power relay with predetermined preheat and afterglow times. A relay should be selected with appropriate amperage capacity for the installed cold starting aid (glowplug, intake air heater, etc.). Applications using multiple cold starting aids may require multiple relays. Depending on specific configuration, this output may provide either high side (battery positive) or low side (ground) control.

Note
Consult engine documentation when selecting cold starting aid, power relay and heating specifications.

Preheat Indication Input

With this option, the preheat LED provides indication for an external preheat control. Depending on specific controls and configuration, this input can be configured to accept either high side (battery positive) or low side (ground) control.

Indicators

Battery LED (Red)

A solidly illuminated Battery LED indicates a battery charge failure. A battery charge failure may be caused by a faulty alternator, broken drive belt or the alternator not excited. A battery voltage reading of approximately 14 volts on a 12 volt system (28 volts on a 24 volt system) while the engine is running indicates the battery is charging properly. Irregular blinking of the Battery LED may indicate a failing charge circuit. The panel can be configured for battery charge failure to indicate only.

Over Speed Indication

A regularly blinking Battery LED indicates the configured over speed RPM has been exceeded. Over speed is a configurable option that is disabled by default.

Oil Pressure LED (Red)

A solidly illuminated Oil Pressure LED indicates low oil pressure failure. The panel typically senses low oil pressure from a ground contact switch on the engine. When a sender/switch combination is used on the engine, the marking ***WK*** generally indicates the switch terminal. This input typically expects a normally closed switch (ground contact when oil pressure is low). A defective switch or shorting the shutdown input to ground can cause low pressure fault indication. Additionally, when using sender/switch combinations, swapping the ***WK*** and ***G*** terminal can cause unintended shutdowns. The panel can be configured for oil pressure failure to indicate only.

Warning!

Low oil pressure is not an indication of low oil level.

For best possible protection LOFA recommends using our solid-state oil level shutdown switch.

Note

Most shutdown switches are grounded through the switch body. Do not use insulating sealant (i.e. Teflon tape) when installing switches.

Temperature LED (Red)

A solidly illuminated Temperature LED indicates high engine temperature failure. The panel typically senses high temperature from a ground contact switch on the engine. When a sender/switch combination is used on the engine, the marking ***WK*** or ***W*** generally indicates the switch terminal. This input typically expects a normally open switch (ground contact when engine temperature is too high). A defective switch or shorting the shutdown input to ground can cause over temperature fault indication. Additionally, when using sender/switch combinations, swapping the ***WK*** or ***W*** and ***G*** terminal can cause unintended shutdowns. The panel can be configured for temperature failure to indicate only.

Warning!

If the temperature switch is not in contact with coolant due to coolant loss the engine is not protected from overheating.

For best possible protection, LOFA recommends using our solid-state coolant level shutdown switch.

Note

Most shutdown switches are grounded through the switch body. Do not use insulating sealant (i.e. Teflon tape) when installing switches.

Some thermostat housings are composites and do not provide ground for the switch.

AUX 1 LED (Red)

A solidly illuminated AUX 1 LED indicates auxiliary 1 failure (i.e., coolant level, oil level, belt breakage, hydraulic pressure, etc.). The panel typically senses failure using a ground contact switch. Auxiliary inputs are equipment specific and determined by the equipment manufacturer. A defective switch or shorting the shutdown input to ground can cause fault indications. The panel can be configured for auxiliary 1 failure to indicate only.

A blinking AUX 1 LED indicates SW input failure. The panel typically senses failure using a ground contact switch. The SW input is equipment specific and determined by the equipment manufacturer. A defective switch or shorting the shutdown input to ground can cause fault indications.

AUX 2 LED (Red)

A solidly illuminated AUX 2 LED indicates an auxiliary switch 2 fault (i.e., air flow restriction, fuel level, etc.) but by default does not cause a shutdown. The panel typically senses failure using a

ground contact switch. Auxiliary inputs are equipment specific and determined by the equipment manufacturer. A defective switch or shorting the shutdown input to ground can cause fault indications. The panel can be configured with auxiliary 2 shutdown.

Preheat LED (Red)

A solidly illuminated Preheat LED is the panel preheat indication. When the LED extinguishes the preheat period is complete and the engine may be cranked. The LED illuminates again to indicate afterglow.

Gauges

Voltmeter

The voltmeter is connected to the fuel run/stop solenoid output. If the voltmeter does not indicate in the run position, this indicates a problem with the solenoid circuit. A battery voltage reading of approximately 14 volts on a 12 volt system (28 volts on a 24 volt system) while the engine is running indicates the battery is charging properly.

Tachometer

The tachometer indicates engine RPM using a frequency signal derived from the engine. This signal may be provided by an alternator frequency tap, proximity switch. An optional amplifier/divider can be added for use with a magnetic pickup.

Note

If the alternator is not excited (not charging),
no frequency is generated and the tachometer will indicate 0 RPM.

The tachometer must be calibrated to the engine using standard procedures (see ***Tachometer Calibration Instructions*** for details).

Oil Pressure Gauge

The gauge measures oil pressure with a resistance sender on the engine referenced to ground. When a sender/switch combination is used on the engine, the marking ***G*** generally indicates the gauge terminal. The gauge expects a low resistance for low pressure and a higher resistance for higher pressure. If a powered gauge is not connected to the sender, the gauge will read full scale (pegged). A defective sender or shorting the gauge input to ground will cause the gauge to read no pressure. When using sender/switch combinations, swapping the ***WK*** and ***G*** terminal prevents the gauge from working and may cause unintended shutdowns.

Warning!

Low oil pressure is an indication of engine wear,
not an accurate indication of low oil level.

Note

Senders and gauges must be matched to indicate correctly.

Most senders are grounded through the sender body.
Do not use insulating sealant (i.e. Teflon tape) when installing senders.

Temperature Gauge

The gauge measures engine temperature with a resistance sender on the engine referenced to ground. When a sender/switch combination is used on the engine, the marking ***G*** generally indicates the gauge terminal. The gauge expects a high resistance for low temperatures and a lower resistance for higher temperatures. If the gauge is not connected to the sender, the will be on read the minimum reading. A defective sender or shorting the gauge input to ground will cause the gauge to read full scale (pegged). When using sender/switch combinations, swapping the ***WK*** and ***G*** terminal prevents the gauge from working and may cause unintended shutdowns.

Warning!

If the temperature sensor is not in contact with coolant due to coolant loss the gauge will not accurately indicate engine temperature.

Note

Senders and gauges must be matched to indicate correctly.

Most senders are grounded through the sender body.
Do not use insulating sealant (i.e. Teflon tape) when installing senders.

Some thermostat housings are composites and do not provide ground for the sender.

Hourmeter

The hourmeter is connected to the fuel run/stop solenoid output. If the hourmeter does not count in the run position, this may indicate a faulty hourmeter or a problem with the solenoid circuit. If the engine shuts down or is not started within 10 second the hourmeter stops counting.

Additional Gauges

Additional gauges can be added by removing blind covers and installing the gauge. Power connections are provided with the standard configuration.

Harness

Sealed Connectors

The provided sealed weather proof plug includes a grey locking device which must be released to separate the connectors. Press the tab on the connector housing to release the connectors.

Warning!

LOFA does not recommend using dielectric grease or sealant with sealed connectors.
These chemicals may cause seal damage and allow water entry.

Use LOFA provided cavity plugs to seal the connector if wires are removed.

Unsealed Connectors

For unsealed connectors exposed to the elements, LOFA recommends using dielectric grease to protect contacts.

Warning!

LOFA does not recommend using sealant with unsealed connectors.
Sealant traps moisture in the connector and encourages corosion.

Harness Routing

The minimum routing of radius of the wiring harnesses should be at least two times the diameter of the wiring harness. Bends should be avoided within 1 inch (25 mm) of any connector in order to avoid seal distortion allowing moisture to enter the connector.

Note

For harness length in excess of 10 ft a relay must be added to the start solenoid circuit.
A relay may also be required for the fuel run/stop solenoid.

LOFA offers starter relay kits for mounting near the engine.

Battery Circuit Requirements

Battery Positive Connection

The electronic panel operates on either a 12 VDC or 24 VDC electrical systems. The unswitched battery positive connection to the panel is made at the weather proof connector. The panel provides switched positive battery protected by a 15 Amp fuse (12 V or 24 V systems).

Protection for the unswitched battery positive circuit is dependent on specific equipment configuration. The overload protection should not exceed 125% of the sum of all output currents plus 5 Amps for the panel. Powering the panel through dedicated circuits with appropriate overload protection reduces the possibility of panel damage.

Circuit breakers are preferred over in-line fuses for circuit protection. Over current protection devices should ideally be located in a central location. If automatic reset circuit breakers are used, consideration of the environment of the breaker is critical and may affect the trip point. The trip point of some circuit breakers can be significantly reduced below the rated trip point if the circuit breaker is exposed to high temperatures.

Warning!

Disconnecting the battery while the engine is running may damage electrical components.

When using a battery disconnect switch, LOFA recommends using a 2 pole switch to disconnect both the battery and alternator output.

Battery Negative Connection (Grounding)

Warning!

Improper grounding can cause electrical noise, unreliable operation and may damage the panel or other components. All ground connections must be free from foreign materials, including paint, which may interfere with proper grounding.

A reliable ground must be provided for the panel.
LOFA recommends the ground connection be made directly to the battery negative.
Grounding through frame members is not recommended.

All ground paths must be capable of carrying any likely fault currents.

Do not reverse the battery polarity. Attempting to crank the engine when the polarity of the battery connections is reversed may damage the panel.

Note

A maximum of three ring terminals should be connected to a ground stud in order to ensure integrity of the ground connection. The use of more than three terminals can cause the connection to become loose.

Voltage Drop

If panel voltage drops below 6 volts for more than one tenth of a second, the panel may reset causing the self-test to reactivate and the engine to shut down after 10 seconds. Resetting the panel is equivalent to quickly turning the key switch to off and back to run without starting the

engine. Since the panel did not sense a start signal, the fuel run/stop solenoid deactivates after 10 seconds. Voltage drops can be caused by external equipment inrush current, improper wire sizes or faulty wiring. Relays may be needed for long wire runs.

Suppression of Voltage Transients (Spikes)

Warning!

The installation of voltage transient suppression at the transient source is required.

LOFA follows SAE recommended electrical environment practices.

Inductive devices such as relays, solenoids and motors generate voltage transients and noise in electrical circuits. Unsuppressed voltage transients can exceed SAE specifications and damage electronic controls.

I

Relays and solenoids with built-in voltage transient suppression diodes are recommended whenever possible. Refer to the illustration for proper installation of diodes when built-in voltage transient suppression is not available.

Locate inductive devices as far as possible from the components of the electronic panel. When using electric motors it may also be necessary to add isolation relays to eliminate voltage transients, noise and prevent back feed.

Note

LOFA harness assemblies typically include all required engine control suppression devices. Added equipment will require additional protection.

Welding on Equipment with Electronic Controls

Proper welding procedures are required to avoid damage to electronic controls, sensors, and associated components. The component should be removed for welding if possible.

The following procedure must be followed if the component must be welded while installed on equipment with electronic controls. This procedure will minimize the risk of component damage.

Warning!

Do not ground the welder to electrical components such as the control ground or sensors. Improper grounding can cause damage to electrical components

Clamp the ground cable from the welder to the component being welded. Place the clamp as close as possible to the weld to reduce the possibility of damage.

1. Stop the engine. Turn the key switch to the OFF position.
2. Disconnect the negative battery cable from the battery.
3. Open any installed battery disconnect switch.
4. Unplug the panel if possible.
5. Connect the welding ground cable as close as possible to the area to be welded.
6. Protect the wiring harness from welding debris and spatter.
7. Use standard welding methods to weld the materials.

General Troubleshooting

For additional information, refer to engine manufacturer troubleshooting guide.

No response from starter motor

Possible Cause	Possible Remedy
No battery voltage to starter	Verify wiring and battery connection (power and ground)
Battery discharged	Charge or replace battery, verify alternator charging
Tripped overcurrent protection	Correct fault, replace or reset overcurrent protection
No signal from panel	No power to panel (see Panel Troubleshooting below)
Defective starter solenoid	Replace starter solenoid
Defective starter motor	Replace starter motor

Engine will crank but not start

Possible Cause	Possible Remedy
Engine not getting fuel	Check fuel level, filter, fuel pump, verify no air in fuel lines
Fuel run/stop solenoid not engaged	See Fuel Solenoid Run/Stop Troubleshooting (below)
Tripped overcurrent protection	Correct fault, replace or reset overcurrent protection
No preheat (cold condition)	See Preheat Troubleshooting

Engine runs for 10 seconds and shuts down

Possible Cause	Possible Remedy
Shutdown switch input active	Verify shutdown source exists, correct condition or correct faulty circuit
Battery not charging	Verify alternator charging (see Alternator not charging battery below)
Control board did not sense start signal	Engine started through alternate method (i.e., manual air start, push start, etc.)
Defective panel	See Panel Troubleshooting (below)

Engine runs longer than 10 seconds and shuts down

Possible Cause	Possible Remedy
Shutdown switch input active	Correct engine fault, verify shutdown switch wiring
Circuit overload protection tripped	Correct overload, keep panel from overheating (over 185° F/85° C)
Voltage transients (spikes)	Add suppressor diodes, protect from nearby lightning strikes, shield induced spikes from other equipment, add electric motor control relay
Defective panel	See Panel Troubleshooting (below)

Alternator not charging battery

Possible Cause	Possible Remedy
Broken or slipping alternator drive belt	Adjust or replace alternator drive belt
Alternator not excited	Verify excitation circuit connected, replace faulty regulator, add additional excitation resistor
Alternator output not connected	Install charge wire
Alternator not grounded	Clean or add ground connection
Alternator faulty	Replace faulty alternator

Fuel Run/Stop Solenoid Troubleshooting

Engine does not stop immediately

Possible Cause	Possible Remedy
Back feed from motor (i.e., cooling fan)	Add relay or blocking diode
Sticking solenoid linkage	Repair or replace solenoid linkage
Fuel valve without check valve	Install or repair check valve

Fuel run/stop solenoid does not engage

Possible Cause	Possible Remedy
No power to solenoid	Locate reason for lack of power and correct (Circuit overloaded? Failed suppressor diode? Faulty wiring?)
No power to solenoid pull coil	Correct faulty wiring, check pull control circuit (see Power Box Troubleshooting below)
Incorrect linkage adjustment	Adjust solenoid linkage
Faulty solenoid	Replace solenoid
Failed suppressor diode	Correct wiring (diode reversed?), replace suppressor diode
Optional e-stop engaged	Disengage e-stop

Engine not getting fuel

Possible Cause	Possible Remedy
Empty fuel tank	Fuel engine
Clogged filter	Replace filter
Air in fuel lines	Bleed fuel lines
Low fuel pressure	Replace faulty fuel pump and/or clogged filter
Faulty fuel pump	Replace fuel pump, correct wiring fault (electric fuel pump)

Preheat Troubleshooting

Engine is hard to start in cold conditions

Possible Cause	Possible Remedy
Start attempt before preheat complete	Wait for preheat time to elapse, crank as soon as time elapses
Incorrect preheat specification	Correct panel configuration, install correct panel
Heater faulty	Replace heater
Heater relay faulty	Replace relay
Preheat control not functioning	Correct wiring, correct panel configuration
Faulty panel	See Panel Troubleshooting (below)

Engine produces excessive white smoke after starting

Possible Cause	Possible Remedy
Afterglow not enabled	Reconfigure panel
Heater faulty	Replace heater
Heater relay faulty	Replace relay
Preheat control not functioning	Correct wiring, correct panel configuration
Faulty panel	See Panel Troubleshooting (below)

Panel Troubleshooting

Panel does not perform self-test

Possible Cause	Possible Remedy
Tripped overcurrent protection	Correct fault, replace or reset overcurrent protection
Faulty connection to battery	Correct battery connections (see Battery Circuit Requirements above)

Panel performs normal self-test, engine cranks, runs and shuts down

Possible Cause	Possible Remedy
Only Battery LED illuminated	Correct battery charge failure (see Battery not charging above)
Only Oil Pressure LED Illuminated	Correct low oil pressure condition or faulty switch, correct wiring fault
Only Temperature LED Illuminated	Correct overheating condition or faulty switch, correct wiring fault
Only Aux LED Illuminated	Correct fault condition (i.e. v-belt, coolant level) or faulty switch, correct wiring fault
All normally closed shutdowns illuminate for one second (panel reset)	Add suppressor diodes, protect from nearby lightning strikes, shield induced spikes from other equipment, add electric motor control relay

Testing Shutdown Inputs

Shutdown switches signal a fault by ground contact in most systems. Shutdown operation can be verified by grounding the shutdown inputs individually. It may be necessary to remove the wire from the shutdown switch to perform this test.

Note

Most shutdown switches are grounded through the switch body.
Do not use insulating sealant (i.e. Teflon tape) when installing switches.

Some thermostat housings are composites and do not provide ground for the switch.

Document Revision History

Rev A: 22-May-2006 Corrected typographical errors

Rev B: 26-Oct-2006 Add symbols to ***Indicators***, corrected typographical errors

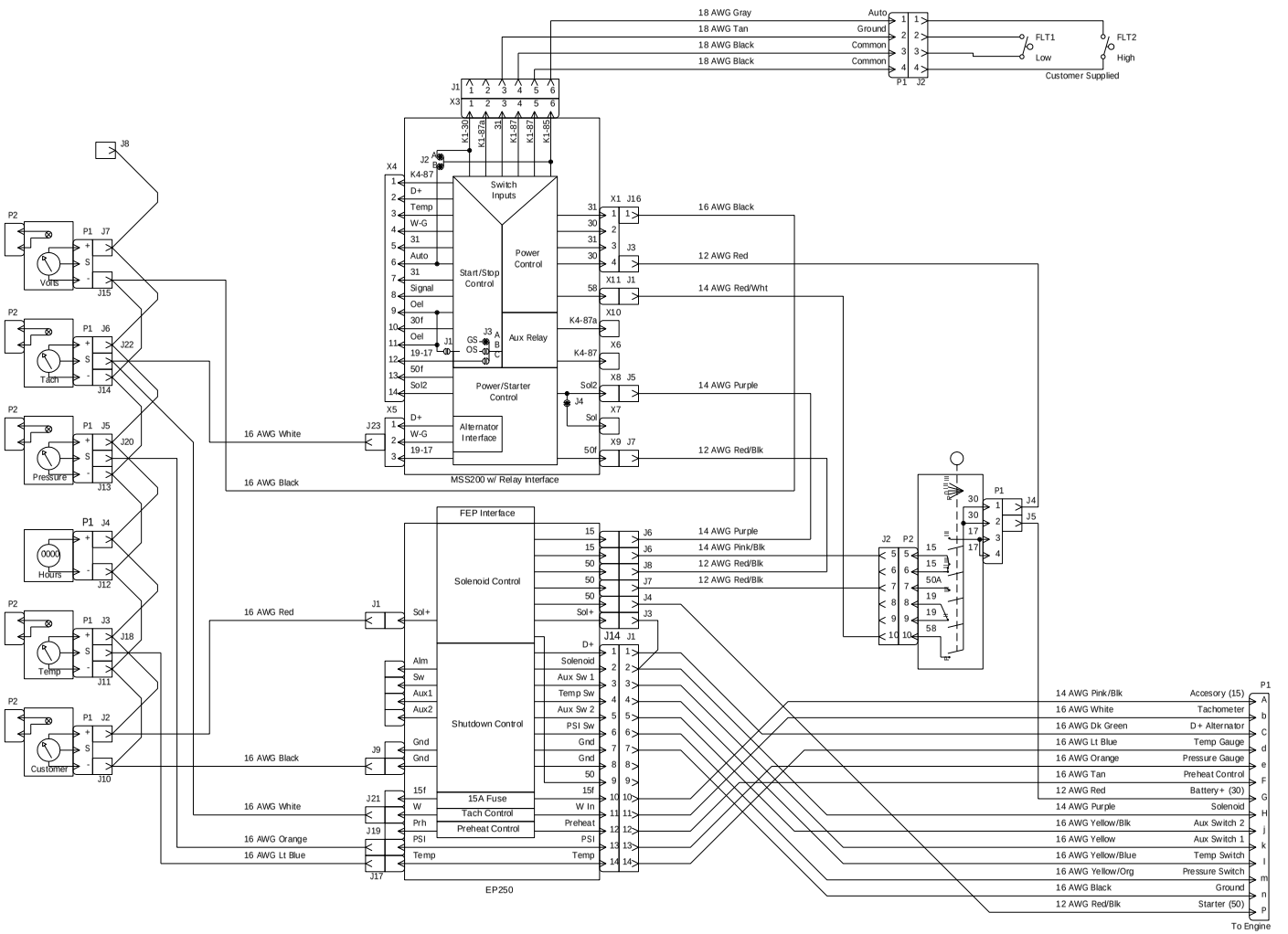
Rev C: 8-Jan-2007 Updated schematics, removed Power Box information

Rev C.1: 28-Feb-2007 Added part numbers

Rev D: 23-Sep-2013 Updated format, removed DPG references, updated schematics.

Typical Schematics

The following pages show typical schematics.
Details vary from installation to installation.
See the specific schematics for installation for details.



Key Switch Electrical Diagram

Position	P	0	I	II	III	12V	24V
58						8A	4A
15/54						35A	18A
19						70A	30A
17						70A	40A
50a						70A THE 18A	40A THE 5A

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Tolerance (Unless Otherwise Noted)		
Decimals	INCH	METRIC
0 (x)	N/A	± 2 mm
1 (x.x)	±0.1 in	±0.1 mm
2 (x.xx)	±0.02 in	±0.02 mm
3 (x.xxx)	±0.005 in	N/A
Angle	±1°	

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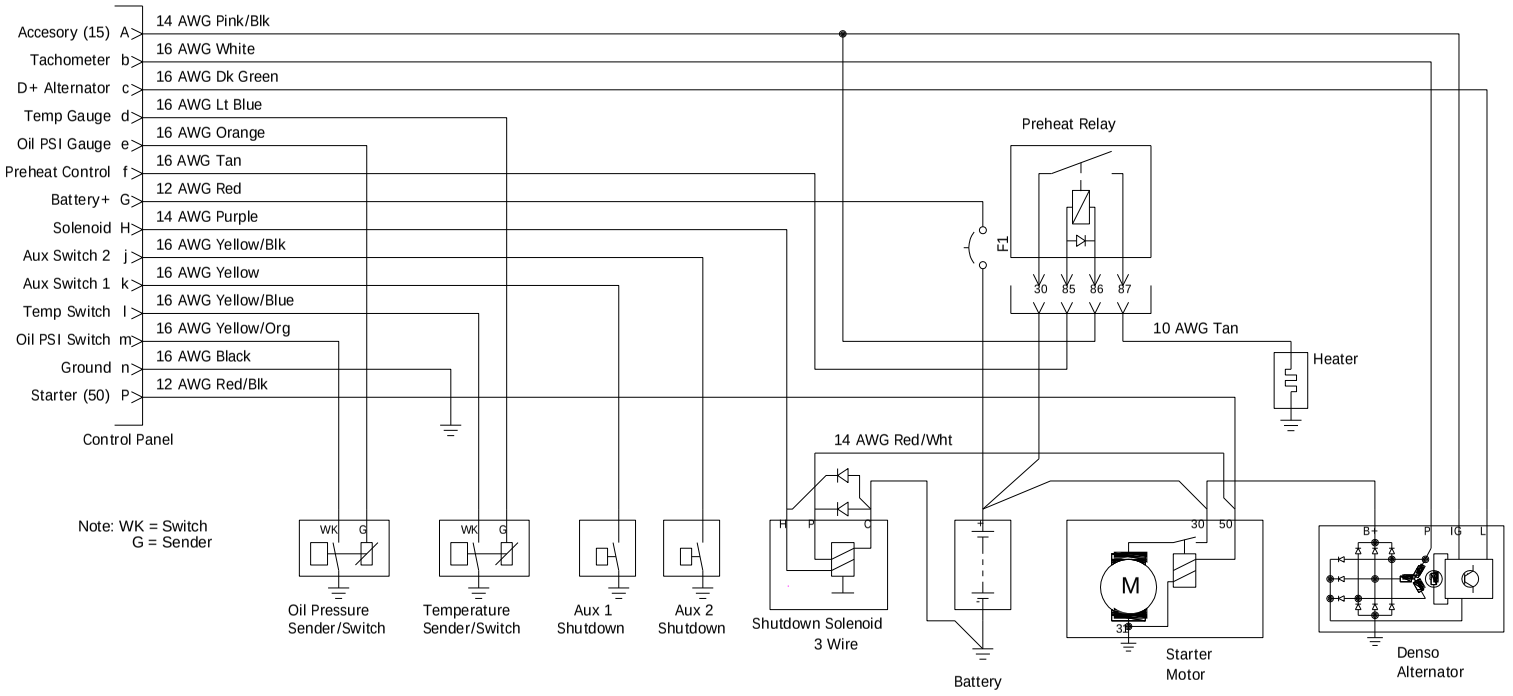
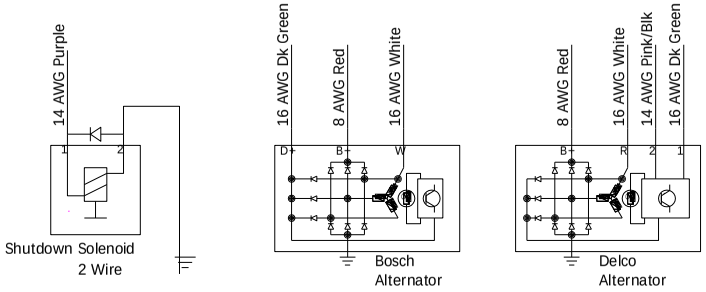
Unit: N/A
Scale: N/A
Part Number:
Rev:
Description: EP250A with GT Plug
Date: 26-Feb-2012
1 of 1





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3 (x.xxx)	±0.005 in	N/A
Angle	±1°	

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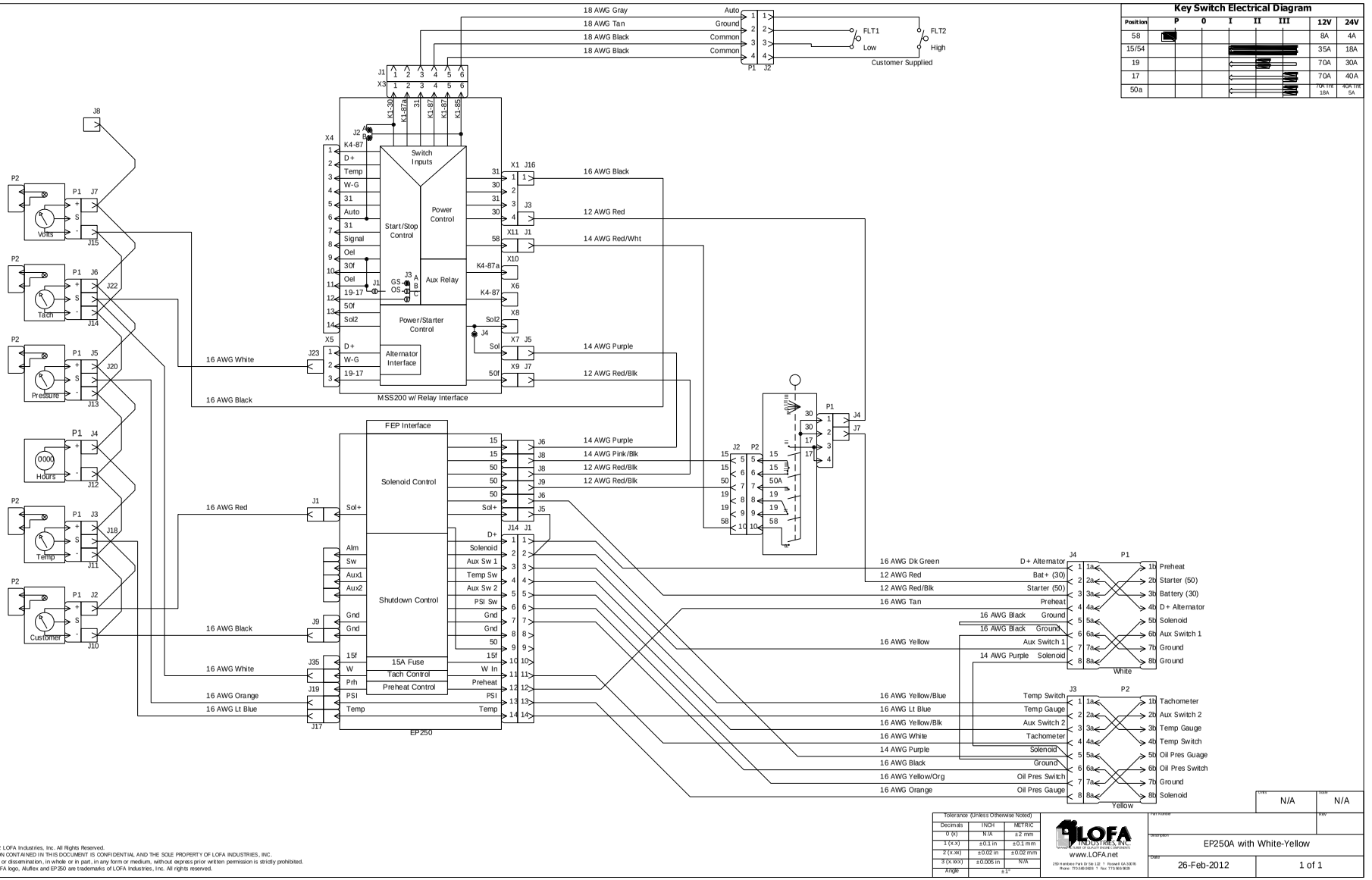
Units	N/A
Scale	N/A
Part Number	
Rev	
Description	GT Engine Wiring Preheat Ground
Date	
	1 of 1



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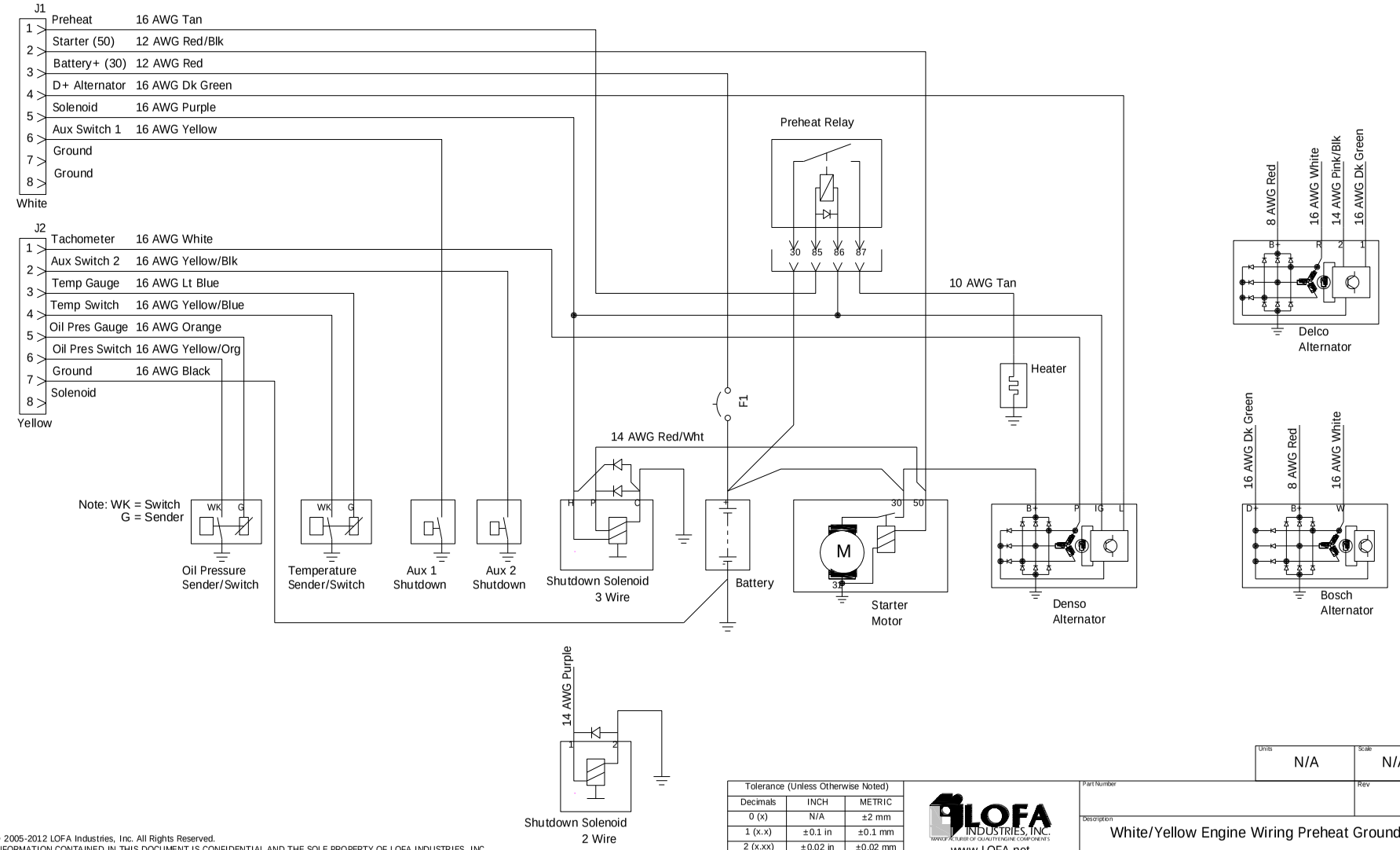
Part Number	N/A
Description	EP250A with White-Yellow
Date	26-Feb-2012
Sheet	1 of 1
Rev	N/A
Rev	



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Units	N/A
Scale	N/A
Part Number	
Rev	
Description	White/Yellow Engine Wiring Preheat Ground
Date	26-Feb-2012
	1 of 1

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5. Compliance with Laws. Licensee must comply with all applicable export, import, or other relevant laws of any applicable jurisdiction. Determination of the applicable law is Licensee's responsibility. Licensee understands that the Licensed Product is cryptographic in nature and therefore the Materials are highly regulated. Licensee is strictly prohibited from exporting, re-exporting or importing the Materials (after initial delivery by LOFA to Licensee), regardless of method (including, for example and not by limitation by use of physical delivery, e-mail, or download from FTP or website, etc.), without first complying with all applicable government use, import, or export laws, rules, regulations, orders, and obtaining any necessary approvals or permits. Obtaining any necessary export or import approval for Licensee Devices and/or the Materials (after initial delivery of the Materials by LOFA to Licensee) is the sole responsibility of Licensee.

6. Fees. Licensee fees are referenced in the Purchase Order.

7. Limited Warranty. LOFA warrants for a period of thirty (30) days from the first date that it delivers to Licensee the Materials that (a) the Licensed Product(s) will operate in conformity with the material specifications for such item; (b) will be free from material defects; and (c) the media, if any, on which the Licensed Product is furnished will be free from material defects in materials and faulty workmanship under normal use. LOFA's sole liability and Licensee's exclusive remedy for any failure to meet these warranties will be limited to repair or replacement of the defective Materials at LOFA's option and expense.

8. Warranty Disclaimer. Except as provided in this Agreement, LOFA transfers the Materials to Licensee on an "as is" basis. The warranties in this Agreement, are in lieu of all other warranties or conditions, and LOFA makes no other warranty, condition or representation of any kind whether express or implied, and LOFA expressly disclaims the implied warranties or conditions of merchantability, merchantable quality, fitness for a particular purpose, infringement and those arising by statute or otherwise in law or from the course of dealing or usage of trade. LOFA does not represent or warrant that the Materials will meet any or all of Licensee's particular requirements, that the operation of the Materials will be error-free or uninterrupted, or that all programming

errors in the Licensed Product can be found in order to be corrected. All warranties provided in in this Agreement are solely for the benefit of, and may not be transferred by, Licensee, to any third party.

(a) **Limits on Scope of Indemnity.** LOFA will have no liability for any infringement arising from (i) the use of the Licensed Product other than as set forth in its accompanying documentation or specifications; (ii) the modification of the Licensed Product; or (iii) the combination or use of the Licensed Product with other software, hardware, items or processes to the extent such infringement is not foreseeable use of the Licensed Product. This Section states LOFA's entire obligation with respect to any claim regarding the intellectual property rights of any third party.

(b) **Licensee Indemnification Obligation.** Licensee shall indemnify, defend and hold harmless LOFA, its directors, officers, and employees from and against any claim, demand, cause of action, loss, damage, liability suit, proceeding, judgment, or cost (including attorney fees), brought against LOFA which is based on the creation, use or distribution of Licensee Devices to the extent that such suit or proceeding does not arise or result from: (i) LOFA's material breach of any agreement, obligation, representation, warranty or covenant contained in this Agreement; (ii) any wrongful, negligent action or failure to act by LOFA, its employees, agents or independent contractors; or, (iii) any liability for which LOFA is obligated to indemnify Licensee under this Section.

9. Term and Termination.

(a) **Term.** Unless otherwise specified in Exhibit A, the term of this Agreement will commence on the Effective Date and will continue into perpetuity unless otherwise terminated earlier under this Agreement.

(b) **Termination for Cause.** Any of the following shall suffice to terminate this Agreement:

(i) If Licensee materially breaches any term or condition of this Agreement and fails to cure that breach within thirty (30) days after receiving written notice of the breach.

(ii) This Agreement will terminate automatically without notice and without further action by LOFA in the event Licensee becomes insolvent (i.e., becomes unable to pay its debts in the ordinary course of business as they come due), makes an assignment in violation of this Agreement or makes an assignment for the benefit of creditors or if any other bankruptcy proceedings are commenced by or against Licensee.

(c) **Consequences.** Upon the termination of this Agreement for any reason: (i) all rights granted hereunder will automatically revert to LOFA; (ii) Licensee must (A) return to LOFA (or, at LOFA's option, destroy) the originals and all copies of the Materials in Licensee's possession or control; (B) erase any and all of the foregoing from all computer memories and stored Licensee Devices within its possession or control; and (C) provide LOFA with a written statement certifying that it has complied with the foregoing obligations. End use licenses to Licensee Devices for Customers granted by Licensee to Customers prior to termination will survive any such termination.

10. Limitation of Liability.

(a) LICENSEE AGREES THAT ANY LIABILITY ON THE PART OF LOFA FOR BREACH OF THE WARRANTIES CONTAINED HEREIN OR ANY OF THE OTHER PROVISIONS OF THIS AGREEMENT OR ANY OTHER BREACH GIVING RISE TO LIABILITY OR IN ANY OTHER WAY ARISING OUT OF OR RELATED TO THIS AGREEMENT FOR ANY CAUSE OF ACTION WHATSOEVER AND REGARDLESS OF THE FORM OF ACTION (INCLUDING BREACH OF CONTRACT, STRICT LIABILITY, TORT INCLUDING NEGLIGENCE OR ANY OTHER LEGAL OR EQUITABLE THEORY), WILL BE LIMITED TO LICENSEE'S DIRECT DAMAGES IN AN AMOUNT NOT TO EXCEED THE TOTAL AMOUNT PAID TO LOFA BY LICENSEE FOR THE LOFA HARDWARE.

(b) LICENSEE AGREE THAT IN NO EVENT WILL LOFA BE LIABLE FOR DAMAGES IN RESPECT OF INCIDENTAL, ORDINARY, PUNITIVE, EXEMPLARY, INDIRECT, SPECIAL, OR CONSEQUENTIAL DAMAGES EVEN IF LOFA HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES INCLUDING, BUT NOT LIMITED TO, BUSINESS INTERRUPTION, LOST BUSINESS REVENUE, LOST PROFITS, FAILURE TO REALIZE EXPECTED SAVINGS, ECONOMIC LOSS, LOSS OF DATA, LOSS OF BUSINESS OPPORTUNITY OR ANY CLAIM AGAINST LICENSEE BY ANY OTHER PARTY.

(c) LICENSEE ACKNOWLEDGES THAT LOFA'S LIMITED LIABILITY EXPRESSED IN THIS AGREEMENT REPRESENTS A MATERIAL BASIS FOR SETTING THE FEES FOR LOFA HARDWARE.

11. Use of Trademarks.

Any and all trademarks and trade names which LOFA uses in connection with the license granted hereunder ("LOFA Marks") are and remain the exclusive property of LOFA. Nothing contained in this Agreement may be deemed to give Licensee any right, title or interest in any LOFA Marks. Subject to notice from LOFA in writing which modifies or cancels such license at LOFA's sole discretion, during the continuance of this Agreement, LOFA hereby grants Licensee a nonexclusive, revocable license to the LOFA Marks for normal advertising, marketing and promotion of Licensee Devices according to guidelines that LOFA may issue from time to time. Licensee must act consistently with LOFA's ownership of the LOFA Marks and may not use LOFA Marks in a disparaging manner. Licensee agrees to use correct trademark notices on advertisements, sales literature, dealer materials, press releases and other marketing materials, which use or display LOFA Marks. Licensee agrees to provide samples of all Licensee's marketing materials and Licensee Devices containing LOFA Marks to LOFA for prior approval. If LOFA rejects any of Licensee's use of LOFA Marks, then the parties may cooperate reasonably in order modify such materials for approval prior to release or use by Licensee. To the extent that LOFA withdraws any portion of the trademark license granted in this subsection, Licensee's obligations under this Section, above, will also terminate if the rights necessary to comply with such obligation are withdrawn.

12. Interpretation of This Agreement. This Agreement is the entire Agreement to date between the parties regarding the Materials and supersedes any such prior agreement or communication. Any subsequent waiver or modification of this Agreement, or any part, shall only be effective if reduced to writing and signed by both parties. No delay or failure to enforce any right under this Agreement will be considered a waiver of a party's rights thereafter to enforce each and every right and provision of this Agreement. If any provision of this Agreement is declared by a court of competent jurisdiction to be invalid, illegal, or unenforceable, such provision will be severed from this Agreement and the other provisions will remain in full force and effect. This Agreement will be binding upon, and inure to the benefit of, the successors, heirs and assigns of the parties. Neither Licensee nor Licensee employees, consultants, contractors or agents are agents, employees or joint-venturers of LOFA, nor do they have any authority to bind LOFA by contract or otherwise to any obligation. Licensee agrees not to make any statements that state or imply that LOFA certifies or guarantees Licensee Devices or that Licensee Devices are warranted, tested or approved by LOFA. Dates and times by which either party is required to render performance will be postponed automatically to the extent and for the period of time that such party is prevented from meeting them by reason of any cause beyond its reasonable control. Unless otherwise specifically expressed in this Agreement, the specific business terms and negotiated customisations to this Agreement will be considered confidential ("Business Terms"), and neither party my disclose such information to third parties except as follows: (a) to employees, advisors, financing parties or contractors who are under an obligation of confidentiality to the extent reasonably necessary to conduct business; (b) to the extent that such Business Terms become publicly known through no fault of the parties; (c) to the extent required to comply with any valid law, regulation, statute, or order so long as the non-disclosing party receives reasonable advance notice of such potential disclosure; and (d) to the extent required to enforce, establish, or interpret any right or duty at law or equity with respect to this Agreement.

13. General.

(a) All notices hereunder will be in writing and must be duly given if delivered personally or sent by registered or certified mail, return receipt requested, postage prepaid, to the respective addresses of the parties appearing in this Agreement. Any notice given will be deemed to be received: (i) on the date which it is delivered if delivered personally, (ii) or, if mailed, on the fifth business day next following the mailing thereof. Either party may change its address for notices by giving notice of such change as required in this clause.

(b) This Agreement, the license rights granted hereunder and the Materials, or any part thereof, may not be assigned or transferred by Licensee, including by operation of law ("Transfer"), without the prior written consent of LOFA. Any such transfer without the prior written consent of LOFA will be ineffective. In any case, any such Transfer absent LOFA's written permission will immediately and automatically terminate this Agreement

without further action by LOFA. A change of control of Licensee, whether by sale or issuance of shares (except in the ordinary course of raising capital by public offering), or merger, or otherwise, will be deemed to be an assignment.

(c) The laws in force in the State of Georgia will govern this Agreement; the parties hereby consent to jurisdiction and venue in the courts of Georgia.

(d) The provisions in Sections - Licensee's Indemnification, - Ownership, Protection, –Fees - Limited Warranty, - Warranty Disclaimer, -Indemnification, - Term and Termination, Limitation of Liability, - Interpretation of Agreement, and -General (inclusive), remain in force and effect after the termination of this Agreement.

Special License Terms

THE LICENSE GRANTED HEREUNDER IS RESTRICTED SOLELY TO THE OPERATION OF THE LOFA HARDWARE AND FOR NO OTHER PURPOSE. NO SUCH LICENSEE DEVICE INCORPORATING ANY OF THE MATERIALS MAY BE DISTRIBUTED, LICENSED, SOLD, RENTED, OR OTHERWISE PROVIDED TO THIRD PARTIES WITHOUT LOFA'S EXPRESS WRITTEN PERMISSION.

Exhibit B – PRODUCTS/DELIVERABLES

Licensed Product Information

Software codes with product numeric values equal to 001-xxxx-yyyy-zzz; where xxxx, yyyy, and zzz equal (0000...9999).

Software codes qualified under the same numeric regimen detailed above or including the verbal description of "CANPlus™" products and/or the "CANPlus Suite" of products.

Maintenance and Technical

Platform Requirements

.NET Framework 3.5

Windows® XP, Windows Vista (32/64-bit), Windows 7 (32/64-bit)

LOFA INDUSTRIES, INC.
MANUFACTURER OF QUALITY ENGINE COMPONENTS

250 Hembree Park Drive	Suite 122	Roswell GA 30076
PHONE 770-569-9828	FAX 770-569-9829	www.LOFA.net

OPERATORS MANUAL

Excavation Hydro SWMS

Section 7

STG GLOBAL

SAFE WORK METHOD STATEMENT (SWMS) PART 1	
ACTIVITY: Hydro Excavation	SWMS #:
BUSINESS NAME:	ABN:
BUSINESS ADDRESS:	
BUSINESS CONTACT:	PHONE #:

SWMS APPROVED BY: *EMPLOYER / PCBU / DIRECTOR / OWNER.*	
NAME:	
SIGNATURE:	DATE:
PERSON/S RESPONSIBLE FOR ENSURING COMPLIANCE WITH SWMS:	
PERSON/S RESPONSIBLE FOR REVIEWING THE SWMS:	

RELEVANT WORKERS CONSULTED IN THE DEVELOPMENT, APPROVAL AND COMMUNICATION OF THIS SWMS.			ALL PERSONS INVOLVED IN THE TASK MUST HAVE THIS SWMS COMMUNICATED TO THEM BEFORE WORK COMMENCES.
NAME	SIGNATURE	DATE	Daily Tool Box Talks will be undertaken to identify, control and communicate additional site hazards.
			Work must cease immediately if incident or near miss occurs. SWMS must be amended in consultation with relevant persons.
			Amendments must be approved by _____ and communicated to all affected workers before work resumes.
			SWMS must be made available for inspection or review as required by WHS legislation.
			Record of SWMS must be kept as required by WHS legislation (until job is complete or for 2 years if involved in a notifiable incident).

PRINCIPAL CONTRACT DETAILS *(The builder or the organisation you are working for.)*		
PRINCIPAL CONTRACTOR (PC):	PROJECT NAME:	DATE SWMS PROVIDED TO PC:
PROJECT ADDRESS:		
PROJECT MANAGER (PM):	PM SIGNATURE:	CONTACT PH. #:

SWMS SCOPE: This SWMS covers general hazards associated with the operation for truck mounted hydro excavation. This includes use of the truck, including prestart and operational use, traffic and pedestrian control, and use of pressurised equipment.

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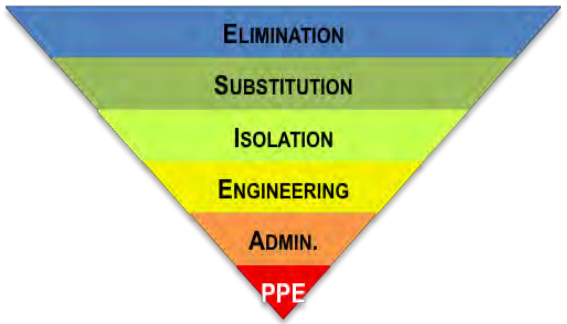
THIS WORK ACTIVITY INVOLVES THE FOLLOWING "HIGH RISK CONSTRUCTION WORK"			
☐ Confined Spaces	☑ Mobile Plant	☐ Demolition	☐ Asbestos
☐ Using explosives	☐ Diving work	☐ Artificial extremes of temperature	☐ Tilt up or pre-cast concrete
☐ Pressurised gas distribution mains or piping chemical, fuel or refrigerant lines energised electrical installations or services			
☐ Structures or buildings involving structural alterations or repairs that require temporary support to prevent collapse			
☐ Involves a risk of a person falling more than 2m, including work on telecommunications towers			
☐ Working at depths greater than 1.5 Metres, including tunnels or mines		☐ Work in an area that may have a contaminated or flammable atmosphere	
☑ Work carried out adjacent to a road, railway or shipping lane, traffic corridor		☐ In or near water or other liquid that involves risk of drowning	

LIKELIHOOD	INSIGNIFICANT	MINOR	MODERATE	MAJOR	CATASTROPHIC	SCORE	ACTION
ALMOST CERTAIN	3 HIGH	3 HIGH	4 ACUTE	4 ACUTE	4 ACUTE		
LIKELY	2 MODERATE	3 HIGH	3 HIGH	4 ACUTE	4 ACUTE	4A ACUTE	DO NOT PROCEED.
POSSIBLE	1 LOW	2 MODERATE	3 HIGH	4 ACUTE	4 ACUTE	3H HIGH	Review before commencing work.
UNLIKELY	1 LOW	1 LOW	2 MODERATE	3 HIGH	4 ACUTE	2M MODERATE	Maintain control measures.
RARE	1 LOW	1 LOW	2 MODERATE	3 HIGH	3 HIGH	1L LOW	Record and monitor.

HIERARCHY OF CONTROLS



PERSONAL PROTECTIVE EQUIPMENT (PPE): *ENSURE ALL PPE MEETS RELEVANT AUSTRALIAN STANDARDS. INSPECT, AND REPLACE PPE AS NEEDED.*

FOOT PROTECTION	HEARING PROTECTION	HIGH VISIBILITY	HEAD PROTECTION	EYE PROTECTION	FACE PROTECTION	HAND PROTECTION	PROTECTIVE CLOTHING	BREATHING PROTECTION	SUN PROTECTION	FALL ARREST	
☑	☑	☑	☐	☑	☐	☑	☐	☐	☑	☐	Rings, watches, jewellery that may become entangled in trucks must not be worn. Long and loose hair must be tied back. ☑

AS 1319-1994 SAFETY SIGNS FOR THE OCCUPATIONAL ENVIRONMENT REPRODUCED WITH PERMISSION FROM SAI GLOBAL UNDER LICENCE 1210-c062. STANDARDS MAY BE PURCHASED AT HTTP://WWW.SAIGLOBAL.COM

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT** RISK-RATING **(IR)** RESIDUAL RISK-RATING **(RR)		
1. Planning & preparation	Lack of consultation may lead to potential outcomes for personal injury, property damage &/or environmental incident.	3H	Liaise with Principal Contractor to establish the following on-site systems and procedures are in place and take note of: • Health and Safety rules • Induction for all workers – site specific and toolbox meetings • Supervisory arrangements • Communication arrangements • All relevant workers are appraised for required competencies & for any pre-existing medical conditions if working in remote or isolated locations. • PPE required • Site plans – showing no go zones for pedestrians • Traffic Management Plan • Exclusion Zones • Risk Assessments • SWMS and JSA's • Injury reporting procedures • Hazard reporting procedures.	2M	
	Lack of Bore Plan	3H	• Assess intended excavation site: o Location (road side, residential, waterway etc.) o Route (length/depth) o Soil type (seek geological surveys where required to ensure suitable soils for nozzles – clay/sand/rocks etc. • Develop written bore plan: o Developed by suitably competent persons o Detail environmental impacts, risk assessments and controls o Manhole/confined space entry requirements (ensure permit system in place) ***(See section 7 of this SWMS).***	2M	
2. Training and Capabilities	Lack of training or the assessment of capability may lead to personal injury, property damage &/or environmental incident.	3H	⚠ ***Check workers are in fit condition to work i.e. no signs of fatigue, alcohol or drugs.*** • Ensure all persons have a General Construction Induction Card (white card) • All operators must be licensed and deemed competent on the make/model and type of truck that will be operated. • Note: In absence of load checking and warning devices, ensure operators are trained to recognise acceptable load distributions. • Truck must be registered with the State Road and Traffic Authorities prior to use. • Ensure all relevant workers have undertaken training and/or received instruction in the use of the truck and control measures. Include: o All operators are trained in safe and correct methods of operation before including all operational and safety data furnished by the manufacturer o All personnel operating or in the vicinity of the equipment are trained on the hazards and precautions of high pressure water and compressed air o Reporting procedures for incidents	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			o Ensure supervisors, foremen etc. are suitably experienced in the type work to be conducted o All workers are trained in this SWMS o Use of supervision where required (e.g. new starters or new equipment) o Correct use of equipment including selecting, fitting, use, care of and maintenance.		
3. Pre start check *(Pre start Checklist contained in this SWMS)*	Lack of a clear assessment may lead to potential personal injury, property damage &/or environmental incident.	3H	Inspect before use. Ensure: • Check that vehicle is in a mechanically sound condition and operator's instructions are available • No evidence of fluid leaks • Controls are labelled correctly, legible, functional and able to be locked to "off" position • All other items are checked as per manufacturer's instructions • All required safety equipment is fitted and operational • All safety guards are in place and undamaged • Reversing beepers functioning • Vehicle break-down equipment: o High visibility gear suited for day/night combinations o Wet weather gear o Traffic cones / signs / reflectors o Emergency contact details • Mirrors are present, functional and adjusted correctly • All stored items in cabin are secured. • Pump casing and fittings in good condition. *Do not use if any fault/damage/missing parts. Report immediately and follow tag-out/lock-out procedures.*	2M	
4. Truck Operation	Incorrect vehicle use	3H	• Only licensed drivers to drive vehicles • Observe road rules at all times • Do not exceed weight capacity the vehicle • **Do not** – use mobile phone while driving • **Do not** – adjust radio channels or volume while driving • Drive to the road conditions i.e. slow down when raining or on gravel roads • Avoid road shoulders • Watch for vehicles entering from side roads/tracks • Give way to approaching trucks/road trains – slow down and move onto shoulder • Monitor/use UHF radio to monitor for changes to site conditions and vehicle movements • Wear seat belts at all times when driving • Remain attentive - Watch for possible hazards • Use mirrors often to monitor the activity around you • Drive Smoothly – Be aware of the high centre of gravity of loaded vehicles, Start and stop smoothly. Avoid sharp turns • Monitor vehicle constantly for any malfunctions that may affect vehicle	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			where safe to do so performance.		
	Slips trips and falls	3H	• Face the cabin whenever you mount and dismount the truck • Turn off the engine before dismounting. (Even when dismounting to close or open a gate there is a risk of knocking the truck into gear) • Ensure the handbrake is always applied or park mode engaged • Maintain a three-point contact with the steps and with handholds ⚠ Three-point contact can be two feet and one hand ⚠ Three-point contact can also be one foot and two hands • Use provided steps/handholds when entering or exiting cabin (see operations manual for instruction) • Do not jump off the truck • Do not carry tools or supplies when you try to mount / dismount • Do not use any controls as handholds when you enter / exit the operator compartment • Never mount or dismount a moving truck • Never carry another person on the truck unless equipped to do so • Never leave operator seat with engine running.	2M	
	Pedestrian safety	4A	• Follow: o Manufacturer's instructions o Site safety rules o Traffic control plan • Ensure no persons in vicinity before and during start-up and operation • Maintain exclusion zone and cease work if approached • Travel at appropriate speed for conditions observing speed limits and warning signs • Reduce speeds over unexpected hazards • Avoid reversing wherever possible.	2M	
	Burns / fire damage	3H	• Keep truck free of any excess grease, oil and fuel accumulation • Clean up spillage immediately • Use only nonflammable solutions for cleaning the truck or components. • Store rags and other combustible materials in a safe, fireproof location.	2M	
	Hit by moving truck/ Lack of communication	3H	• Ensure an effective system of communication between truck operator and ground workers is established before work commences. • Relevant workers must be trained in the procedures involved prior to the work commencing • Ground workers are instructed not to approach truck until the operator has agreed to their request to approach. • Ensure ground workers are instructed on set distances to maintain from the truck while in	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			operation • Ground workers are instructed made familiar with the blind spots of the truck • Truck operators and ground workers are required to wear high-visibility clothing. • Ensure UHF channel in use on site is known • Ensure all personnel are aware of designated work areas and no go zones as defined by the site traffic management plan • Communicate with others onsite using designated onsite UHF channel or hand signal.		
5. Obtaining Water from Hydrant or other water source e.g. creek/dam	Public safety	3H	• When filling from a hydrant the driver is the controller of the worksite – the area around the hydrant: o Park as close to the hydrant as possible o Ensure pedestrians have a safe walkway o Place temporary barricades/signage in place if pedestrian traffic expected o Ensure that the hydrant and standpipe are under observation during the operation.	2M	
	Hit by objects under pressure	3H	• Fitting Standpipe – Obtaining Water from Hydrant. Check standpipe for: o Any visible signs of defects o Possible leaks – slight “O” ring seal weeps may be acceptable o Clear the area around the pit cover plate from debris o Remove the pit cover plate and the cover plate on the spring hydrant o Lock standpipe in place on hydrant – partial turn o Connect flexible hose and ensure couplings are firmly locked in position o Open standpipe valve SLOWLY so that all air is expelled from the pipe o Reverse the procedure to remove the standpipe.	2M	
	Vehicle Roll-over	3H	• When filling and exiting fill area ensure: o Ground is stable, soil is compacted sufficiently o Gradient/slope within safe limits for travel.	2M	
	Vehicle accident	3H	• Transporting water: o Use baffled tanks where possible (prevents water slosh) o Never operate a water truck without a thorough understanding of the rules/ traffic management procedures at the construction site o Remain attentive - Watch for possible hazards (equipment and workers) o Use mirrors often to monitor the activity around you o Drive Smoothly – Be aware of the high centre of gravity, and the surge of the water o Start and stop smoothly. Make smooth turns and lane changes.	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			o Ensure radio is on correct channel and monitored for changes to site conditions and warnings. ⚠ ***Remember: A half-full tank is more dangerous than a full tank!*** • Ensure travel path (on both road and on site): o Allows for height of vehicle o Is clear of low-lying tree limbs o Is suitable for weight/size of vehicle, limited gradients and slopes o Obey speed limits and be aware of increased braking/stopping distance when carrying water.		
6. Assess onsite conditions for operations	Lack of a clear assessment may lead to personal injury, property damage &/or environmental incident.	3H	• Assess conditions at site on arrival. Ensure: o Work site is exactly as detailed in Terms of Agreement or contract o Suitable weather conditions o Suitable access for all equipment required o Suitable ground / track conditions for operation of truck. Flat, even, firm surface, no recently backfilled earth, voids, pits or excavations in close proximity o Within manufacturer's slope/gradient limits o Suitable lighting, including night-works (include flood lighting and operator head lamps as applicable) o Take note of other vehicle /plant movement • Conduct risk assessment to identify potential hazards such as: o Other plant/vehicles o Pedestrian traffic o Uneven ground, drop-offs o Objects hidden in long grass etc. o Steep slopes.	2M	
	Work adjacent to road & public safety	3H	• Where setting up on a road or other public place an alternative footpath will be provided and protective fitted around the work area to prevent splash occurring to passers-by • Where necessary, traffic control will be put in place to provide safe road use • If setting up roadside – comply with local laws and permits • Erect any barriers & signage necessary to keep others safe and aware • A spotter should be used to assist drivers reversing in dark, low clearance or high traffic areas • If temporary road traffic control is required (e.g. parking on road or pedestrian management): o Approvals and permits are sought from local council and/or state road transport departments where necessary	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			o Only accredited traffic controllers are to perform traffic control duties o All traffic control measures put in place must be implemented as per Australian Standard AS 1742.3–2009: Manual of Uniform Traffic Control Devices, Part 3: Traffic Control for Works on Roads ('AS 1742.3-2009') or other requirements as per permit conditions o Traffic controllers must have the required accreditation to perform traffic control duties o Traffic controllers must have sufficient experience to setup and control traffic safely and efficiently.		
	Contact with underground services	3H	• Ensure travel path will not damage utilities (gas, telecommunication, electrical, water or sewerage systems). • Contact Dial before you Dig and Local Authorities to obtain utilities maps of intended work areas. • Identify underground assets (location and type) • Ensure correct equipment provided o For metallic properties – use electromagnetic locating device o For non-metallic – use Ground Penetrating Device (GPD), mini cameras or sonar technology o Ensure all equipment is serviced, calibrated as per manufacturer's instructions and functioning correctly • Mark line of excavation and identify exact entry locations (using paints/colour-coding as required) • Where possible, arrange with Asset Owners for power to be isolated to utilities in work area for duration of works.	2M	
	Contact with electricity - overhead services	4A	Ensure work is not conducted in close proximity to electrical power lines. Check for: • Overhead power lines (including high and low voltage distribution conductors • Single wire earth return (SWER) • Service cables to premises • Communications cables • Electrical transformers (mounted lower than cables). Identify maximum range of equipment and how close equipment or load can come to asset (known as design envelope). The following dimensions are taken from the closest point of any extended component of the truck. In general: • 3m above, either side and below power lines is No Go Zone • Between 3-6.4m of power lines a Spotter is required	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			• Further than 6.4m of power lines is open area • No work to be conducted within 10m radius of SWER transformer. ⚠ ***Spotter required where any part of the truck is within 6.4m of power line.***		
	Contact with truck or passing vehicles	3H	• Check constantly for changing hazards while working and monitor work position at all times. Ensure: o High visibility clothing worn at all times o Do not stand behind reversing vehicles o Allow sufficient distance from truck during operation (allow sufficient room for equipment failure – such as arm/boom failure or truck rollover) o Do not enter established "no go zones" for pedestrians o Alertness at all times. Listen for: ▪ Reversing alarms/beepers ▪ Calls from Truck Operators o Safety/warning signs, Spotters, traffic barriers etc. must be obeyed as required o Work positions should be in clear sight of other truck operators o Follow traffic management plan requirements. NOTE: Some traffic management plans may say that pedestrians have right-of-way. Never assume this. Make visual and verbal contact with truck operator as required.	2M	
	Environmental conditions	3H	• Appropriate protective clothing • Wear hand protection • Wear non-slip footwear (slippery surfaces) • Adequate breaks • Check weather conditions – do not work in extreme conditions • Cold: o Encourage workers to have adequate warm drinks o Access to warm shelter during breaks • Heat: o Sun brim on hard hat o Safety glasses - UV Rated o Use 30+ sunscreen on exposed skin areas o Adequate drinking water.	2M	
7. Manhole/pit safety	Trips, slips, falls	3H	• Be aware of ground condition including changes in level, kerb etc. and wet surfaces • Wear appropriate non slip covered footwear • Never walk backwards when near manholes, pits or other drop offs o NEVER wear thongs or similar.	2M	
	Lift and remove pit lid - musculoskeletal	3H	• High force - heavy pit lid, may be jammed due to accumulation of material or damage • Be aware of sudden unexpected • Do not use excessive force • Use appropriate tool for cover removal • Backhoe and/or crane to assist in lift of	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
	disorder (MSD)		movement if cover dislodging from lid heavy lids.		
	Hazardous atmospheres	3H	• Allow air to vent from pits when opening covers before commencing work • Do not enter any pit. ⚠ ***If work involves entering an identified Confined Space, a separate, dedicated 'Confined Spaces SWMS' is required to be used in conjunction with this SWMS.*** • **Note**: A confined space can be defined as an enclosed or partially enclosed space that is likely to be a risk to health and safety, when a person's head or upper body is within the boundary of the confined space, because of: o An atmosphere that does not have a safe oxygen level, or o Contaminants, including airborne gases, vapours and dusts, that may cause injury from fire or explosion, or o Harmful concentrations of any airborne contaminants • Note: Do not enter any manhole/pit in which a person's head or upper body will be within the space without ensuring a confined space entry permit is issued for each confined space entry requiring: o A risk assessment o Atmospheric monitoring o Use of respiratory and recovery equipment where indicated if to be entered. ⚠ If a person has entered or fallen into a manhole **DO NOT ENTER THE MANHOLE TO ATTEMPT A RESCUE.** Contact the appropriate emergency personnel and the appropriate supervisor immediately if the person cannot be retrieved without entering.	2M	
	Crush Injuries	3H	• Never place your hand in the opening to grasp a cover. Get help if necessary and use a tool if available • Use blocks/ shims where appropriate to avoid crushing • Wear steel-cap boots to protect toes, feet.	2M	
	Contact with native animals	3H	• Keep your eyes fixed on the ground and be aware of where you are stepping at all times • Never put your hands or feet somewhere where you can't see them • Check all pits after removing covers • Snakes / Spiders - be aware of surroundings (snakes and spiders can be found anywhere) o Check ground before exiting vehicle o Visually inspect where you are working o Check the immediate surroundings before sitting/kneeling or squatting	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			o Ensure adequate lighting at all times o Make noise o Do not approach a snake (dead or alive) • If confronted with a snake or spider: o Do not make sudden movements o Back away slowly or stay still o Allow exit point for snake or spider to escape o Do not attack or attempt to harm snake or spider • Bee and Wasps - be aware of surroundings (bee's hives, wasp nests) • Note: Wasps nest in logs, walls or underground. They are generally more aggressive than bees and attracted to food and drink: o Do not contact/disturb nests/hives o If nests/hives are located in work area – contact professional to remove before undertaking work.		
8. Pumps	Burns	3H	• Always follow operating manual • Ensure all safety guards and shields are in place while operating pump • Do not allow pump to overheat. (If pump overheats, turn it off immediately, and allow it to cool) • Do not touch pump engine or exhaust during or immediately after operation (it will be hot).	2M	
	Operator error – Lack of information	3H	• Permanently mount a name plate on pump which provides the following information: o Manufacturer's name o Model designation, serial number and year of manufacture o Maximum volume and pressure performance o Maximum input speed, and o Maximum operating pressures.	2M	
	Hazardous Atmospheres	4A	• Do not operate motorised machinery in enclosed spaces for extended periods (carbon monoxide build-up). • Ensure well-ventilated area when using petrol or diesel pumps.	2M	
9. Hydro Jetting	Public access	3H	• A Responsible Person shall be designated for controlling the immediate area where hydro jetting is occurring • All operating areas must be barricaded to prevent accidental entry of unauthorised personnel. Use appropriate signage to indicate work being undertaken e.g. - DANGER HIGH PRESSURE WATER BLASTING, KEEP OUT. AUTHORISED PERSONNEL ONLY • Entry into the area must be authorised by the Responsible Person	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			• The barricade must be far enough from the water blasting to keep observers safe.		
	High pressure lacerations/ hit by objects under pressure	3H	⚠ ***Fluid under pressure can have sufficient force to penetrate skin. If injured by pressurised fluid, obtain medical treatment immediately.*** • The pump unit should not be placed where it can be contaminated by debris from the jetting operation • Use at least two operators when Hydro-jetting. The primary operator handling the cleaning device must maintain control of the water discharge at all times • The secondary operator can operate emergency shutdown operations and act as a safety spotter • Ensure: o All lances are fitted with actuating devices that require positive effort by the operator (hand or foot) to keep the supply valve open o Hoses used for high pressure cleaning are rated for pressures at least 2.5 times that of the intended operating pressure • Hoses must be tagged to indicate: o Manufacturers identification o Date of manufacture o Maximum operating pressure • Damaged or faulty hoses shall not be used. It shall be tagged OUT OF SERVICE and repaired or disposed of • Using High Pressure Hoses and lances. Ensure: o Carefully inspect the nozzle body before each use for damage. Replace damaged or worn nozzles immediately o During operation, never force a lance through soil or other material o Never put your hand over a jetting nozzle when operating o Never use high-pressure water to clean yourself or their clothing or footwear • Continually check for persons entering the area • **NEVER** Leave the cleaner unattended during use • **NEVER** Point the hose at a person or animal. ⚠ ***All high-pressure equipment shall be isolated and depressurised before being left unattended.***	2M	
	Slips, trips and falls	3H	• Ensure plant and equipment placement does not become a trip hazard • Access pathways are unobstructed • Hoses arranged to minimise tripping hazards • Wear appropriate thick soled covered footwear / gumboots. Never wear thongs or similar footwear	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			• Do not jump into or over trenches/beams. Always maintain at least one foot on the ground at all times • Use boards to straddle trenches where appropriate.		
	Biological Hazards	4A	• Ensure workers are immunised for hepatitis "B" and tetanus • Wear goggles, face shield, gloves, long sleeves and long pants • Immediately treat all abrasions, cuts for contamination. (Seek medical attention for injuries associated with sewers, drains). ⚠ ***Serious illness may occur if this procedure is not followed.***	2M	
	Hearing loss	3H	• Wear hearing protection, ensure it is: o Worn by all persons throughout the period of exposure to noise o Suitable for the type of working environment and the work tasks o Comfortable and correctly fitting for the worker o Regularly inspected and maintained to ensure it remains in good, clean condition.	2M	
10. Vacuum Operation	Emergency shutoff failure	3H	• Ensure system fitted with emergency vacuum relief valve • Test in-line vacuum relief valve tested before each use and in good working condition.	2M	
	Vacuum injuries/entrapment	3H	• Perform all operations with at least two operators • Turn of pump / power source and release pressure in system before opening any door or hatch • Never open any hatches or doors while the unit is pressurised • Keep vacuum tools and hoses away from face and body (never point vacuum hose at a person) • Stay clear of the vacuum hose openings (suction can cause serious bodily injury) • If required to clear blockage, ensure vacuum relief valve is open and the lance is removed from excavation • Verbally communicate process steps • Never attach a hose, pipe or accessories with the vacuum on • Ensure system is shut down and depressurized when assembling or moving the piping system. ⚠ ***NEVER operate the vacuum system without a vacuum relief valve being installed.***	2M	
11. Unloading /Emptying truck	Hit by moving truck- Loading /unloading	3H	• Ensure pedestrians are clear of loading/unloading area (side and rear of vehicle). Do not proceed if pedestrians are present. • At no time is any person permitted to ride on the exterior of the vehicle. All passengers must be seated in the cabin.	2M	
	Truck rollover	4A	• Do not unload, unless the Principal Contractor approves the site. Ensure: o Ground is stable, soil is compacted sufficiently o Gradient/slope within safe limits; inc. entire travel distance if dumping whilst moving	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			o Tyre pressure is equal on both sides of vehicle • Clear of overhead electric lines and other obstacles • Ensure truck does not operate or travel near the edge of an excavation or other drop off • Ensure truck stay on existing access tracks, and within construction boundaries. • Do not turn or tip load on slopes • Do not overload/exceed capabilities ⚠ ***Do not attempt to unload on soft, uneven ground, downgrades or on cross falls (higher centre of gravity)*** • Be familiar with width of equipment to maintain safe clearance near fences, boundaries or other obstacles.		
12. Refueling	Fire / explosion	3H	1. Shut off engine 2. Allow to cool before re-fueling if possible 3. Remove cap slowly 4. Use a fuel hose, pouring spout or funnel 5. Fill tank and wipe away excess 6. Ensure there is no over spill 7. Ensure cap has been secured and any vapour residue has been wiped away 8. Check for leaks. • DO NOT smoke during re-fuelling • Ensure re-fueling is undertaken in well-ventilated area, clear of ignition sources o *NOTE: Ignition sources include cigarettes, matches/lighters, grinding, welding, power points, lighting, light switches,* • Material/Safety Data Sheets (M/SDS) for all fuel products on hand • Follow manufacturer's manual/recommendations for re-fuelling • Ensure fire extinguisher available and in date. **Diesel: Fire extinguisher** – Water, foam, dry chemical powder, CO_2 **Unleaded petrol: Fire extinguisher** – Dry chemical powder, foam, CO_2. Never use water to extinguish an Unleaded Petrol fire.	2M	
	Exposure to hazardous chemicals / substances	3H	• Avoid breathing vapours or contact with fuel • If clothing is splashed with fuel, change immediately • Do not siphon or swallow fuel as this can be fatal • Do not eat, drink or smoke during/after-handling fuel until hands are carefully washed • Shower and wash immediately after work. Wash clothes in separate wash from other clothes.	2M	
	Muscular stress / musculoskeletal	3H	• Where possible use pump to transfer fuel from container into tank. If using fuel container, and lifting into place:	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
	disorder (MSD)		o Lift smoothly, do not jerk or throw load upwards o Avoid any twisting and side-bending during lift o Bend knees, not back o Avoid awkward and sustained positions.		
	Environment incident	3H	• Ensure training in emergency response for chemical spill. Emergency response –fuel spill: **1.** Stop the source of the spill or leak or release a. If that is not possible & it is safe to do so - stop the spill or release from spreading **2.** Turn off any ignition sources if safe to do so **3.** Use gravel or other material to stop fuel entering drains/water courses **4.** Clean up spill as required.	2M	
13. On completion	Crush injuries	3H	• Remove keys • Inspect equipment for any damage/leaks. If damage is detected – report immediately and take out of service.	2M	
	Hit by moving truck	3H	• Store the key in a safe place (restrict unauthorised access) • Ensure truck is parked in a safe, level area, clear of unstable or sloping ground.	2M	
	Environmental contaminants	3H	• Ensure all equipment /truck is washed free of dirt, vegetation, debris before leaving site • Ensure any contaminated wastewater is captured as per Local & State Environment Laws • Do not wash truck where residue can enter and sensitive areas such as storm water drains and waterways • Avoid cross contamination: o Disassemble and clean all equipment o Dispose of all waste in accordance with regulations o Maintain an M/SDS for all chemicals used.	2M	
	Public safety	3H	• Report any damage or malfunction of the unit or components. • If acceptable, remove any barricades or signs, contact supervisor and return as agreed.	2M	

TRUCK ROLL-OVER – EMERGENCY RESPONSE

Establish communication with victims (if applicable) and maintain for entire rescue. Conduct response as required for specific conditions at site.

OPERATOR:

- Do not attempt to jump from vehicle during roll-over – remain in seat with seatbelt on
- After incident has occurred, if able, turn off engine
- Remain in position with seatbelt on until help arrives, unless it is safe to exit
- If it is safe and injuries permit, exit cabin without jumping, and move clear

PERSONNEL:

- Clear non-essential persons from area
- Check for fuel and/or fluid leaks. **Ensure there are no ignition sources**
- Check for fire or fire/explosion risks. Use suitable fire protection equipment to control fire (if safe to do so)
- **Do not approach** the vehicle until Emergency Responders attend the scene.

NOTE: Vehicle may be unstable and unsafe to approach.

Do not place first responders at risk – await assistance from suitably trained

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
from plant.			and resourced Emergency Responders.		

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HYDRO TRUCK PRE-START CHECKLIST

NAME OF PLANT: IDENTIFICATION OR REGISTRATION NO. DATE:

ITEM		YES	NO	N/A
Daily logbook completed		☐	☐	☐
Operator licensed to operate		☐	☐	☐
Fluid Levels	Hydraulics	☐	☐	☐
	Oils	☐	☐	☐
	Water	☐	☐	☐
	Fuel	☐	☐	☐
Fluid leaks	Hydraulics	☐	☐	☐
	Oils	☐	☐	☐
	Water	☐	☐	☐
	Fuel	☐	☐	☐
Danger areas guarded	Moving motor parts	☐	☐	☐
	Shafts	☐	☐	☐
	Hydraulic hoses/valves etc.	☐	☐	☐
	Hot engine/muffler parts	☐	☐	☐
Tyres / wheels / tracks	Correct type	☐	☐	☐
	Do not have cracks	☐	☐	☐
	Have adequate tread depth	☐	☐	☐
	Correct and equal pressure	☐	☐	☐
Warning devices	Installed	☐	☐	☐
	Positioned for best affect	☐	☐	☐
Other?		☐	☐	☐
Repairs completed		☐	☐	☐
Operators Name:				
Operators Signature:				

ITEM		YES	NO	N/A
Instruction manual available		☐	☐	☐
Cabin	Safe access/exit	☐	☐	☐
	Clean, free of clutter	☐	☐	☐
	Ventilated / AC	☐	☐	☐
	Visibility from cabin windows	☐	☐	☐
	Loose objects secured/removed	☐	☐	☐
Water Tank/pumps	Good condition no leaks	☐	☐	☐
	Fittings/valves good condition	☐	☐	☐
	Hoses/couplings	☐	☐	☐
	Pump fueled / check starts and runs	☐	☐	☐
Tank securely fixed to tray (tipper models)		☐	☐	☐
Traffic/Pedestrian control equipment		☐	☐	☐
Locking pins in place		☐	☐	☐
Gauges / Lamps / Warning systems		☐	☐	☐
Lights – front / rear/ stop / turning / beacons		☐	☐	☐
Horns / reversing alarms		☐	☐	☐
Brakes – park / foot / emergency		☐	☐	☐
Fire extinguisher		☐	☐	☐
Spill kit		☐	☐	☐

Report any problems to supervisor and follow tag-out/lock-out procedures for unsafe equipment.

Comments:

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EMERGENCY RESPONSE - CALL *000* IMMEDIATELY.	
If work is to be conducted on a construction site (or a site controlled by another Employer / PCBU) follow the site-specific Emergency Management Plan. Ensure: • Adequate numbers of first aid trained staff are on site when working at heights occurs • First aiders are trained and competent in managing injuries associated with demolition until emergency services arrive • All rescue equipment is in good condition, available for use and in close proximity to the work site.	Ensure workers have access to: • First aid kit/supplies • First Aid trained personnel familiar with Resuscitation and emergency response for electric shock • M/SDS • Communication devices (check mobile phones will have service in area) • Suitable fire protection equipment.

SAFE WORK METHOD STATEMENT (SWMS) PART 2

FORMAL TRAINING, LICENCES REQUIRED FOR WORKERS UNDERTAKING THIS TASK:	RELEVANT LEGISLATION & CODES OF PRACTICE ❖*Retain only the legislation references applicable to your state of operation for this SWMS.*
Delete or add as relevant Licence to Perform High Risk Work (operating certain truck, equipment) TAFE or other recognised training organisation Construction Induction Card (or equivalent) Competent in operation of make/model of truck Emergency procedures – emergency response PPE Traffic Management Plans	**Commonwealth, NSW, QLD, ACT** Work Health and Safety Act 2011 Work Health and Safety Regulations 2011 **Northern Territory** Work Health and Safety (National Uniform Legislation) Act 2011 Work Health and Safety (National Uniform Legislation) Regulations **SA, Tasmania** Work Health and Safety Act 2012 Work Health and Safety Regulations 2012 **Codes of Practice:** Safe Work Australia (2011): *Construction Work* *First Aid in the Workplace* *Managing the Risk of Falls at Workplaces* *Managing the Risk of Truck in the Workplace* *Managing Noise and Preventing Hearing Loss in the Workplace* *How to Manage Work Health and Safety Risks* *Hazardous Manual Tasks* *Managing Risks of Hazardous Chemicals* *Managing Electrical Risks in the Workplace* *Managing the Work Environment and Facilities* *WHS Consultation, Cooperation & Coordination*
DETAILS OF SUPERVISORY ARRANGEMENTS FOR WORKERS UNDERTAKING THIS TASK:	**Victoria:** Occupational Health & Safety Act 2004 Occupational Health & Safety Regulations 2007 **Compliance Codes:** WorkSafe Victoria (2008): Compliance Code: *Communicating OHS Across Languages* *First Aid in the Workplace* *Prevention of Falls in General Construction* *Workplace Amenities and Work Environment* **Codes of Practice:** WorkSafe Victoria (1990): No. 13: *Building and Construction Workplaces* (2000): No. 25: *Manual Handling* (1995): No. 19: *Truck* (1998): No. 23: *Truck (Amendment No. 1)* (2004): No. 29: *Prevention of Falls in Housing Construction* (2000): No. 24: *Hazardous Substances* **Western Australia** Occupational Safety & Health Act 1984 Occupational Safety & Health Regulations 1996 **Codes of Practice:**
Delete or add as relevant Suitably qualified supervisors for job Direct on-site supervision Remote site – communication systems/ schedule Audits Spot Checks, etc. Reporting systems	
DETAILS OF: REGULATORY PERMITS/LICENSES ENGINEERING DETAILS/CERTIFICATES/WORKCOVER. APPROVALS:	
Delete or add as relevant Local council permits Authorisation to work Confined Space Permit Building Approvals EPA approvals/permits Certain truck to be registered with State Authority PPE to comply with relevant Australian Standards	

TRUCK/TOOLS/EQUIPMENT LIST FOR THE JOB.	REFERENCE DOCUMENTS
(Make & Model)	

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SAFE WORK METHOD STATEMENT (SWMS) PART 3

This SWMS has been developed in consultation and cooperation with *employee/workers* and relevant *Employer/Persons Conducting Business or Undertaking (PCBU).* I have read the above SWMS and I understand its contents. I confirm that I have the skills and training, including relevant certification to conduct the task as described. I agree to comply with safety requirements within this SWMS including risk control measures, safe work instructions and Personal Protective Equipment described.

OVERALL RISK RATING AFTER CONTROLS	☐ 1 LOW	☑ 2 MODERATE	☐ 3 HIGH	☐ 4 ACUTE

EMPLOYEE/WORKER NAME	JOB ROLE / POSITION	SIGNATURE	DATE	TIME	EMPLOYER/PCBU/ SUPERVISOR

REVIEW: Ensure all controls are reviewed as per the following:

- If controls fail to reduce risk adequately
- When changes to the workplace or work activity occur that create new / different risks where controls may no longer be effective
- New hazards identified
- After an incident involving work activities relevant to this SWMS
- During consultation with relevant persons indicate review is needed
- A Health and Safety Representative (HSR) requests a review in line with the requirements of the legislation.

MONITOR: To ensure controls are implemented and monitored effectively:

- Toolbox /pre-work meetings will be undertaken
- Relevant persons will be consulted on hazards and contents of SWMS, work plans and other applicable information
- Control measures will be monitored throughout works:
  *☐Spot checks *☐Consultation *☐Scheduled audits

Corrective actions will be recorded and rectified in a timely manner SWMS will be reviewed and updated accordingly (in consultation with relevant persons).

REVIEW NO.	1	2	3	4	5	6	7	8	9	10
NAME:										
INITIAL:										
DATE:										

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OPERATORS MANUAL

Pressure Cleaner Water SWMS

Section 8

STG GLOBAL

SAFE WORK METHOD STATEMENT (SWMS) PART 1		
ACTIVITY: Handheld high-pressure water jet cleaner.		SWMS #:
BUSINESS NAME:		ABN:
BUSINESS ADDRESS:		
BUSINESS CONTACT:		PHONE #:
SWMS APPROVED BY: *EMPLOYER / PCBU / DIRECTOR / OWNER.*		
NAME:		
SIGNATURE:		DATE:
PERSON/S RESPONSIBLE FOR ENSURING COMPLIANCE WITH SWMS:		
PERSON/S RESPONSIBLE FOR REVIEWING THE SWMS:		

RELEVANT WORKERS CONSULTED IN THE DEVELOPMENT, APPROVAL AND COMMUNICATION OF THIS SWMS.			ALL PERSONS INVOLVED IN THE TASK MUST HAVE THIS SWMS COMMUNICATED TO THEM BEFORE WORK COMMENCES.
NAME	SIGNATURE	DATE	Daily Tool Box Talks will be undertaken to identify, control and communicate additional site hazards.
			Work must cease immediately if incident or near miss occurs. SWMS must be amended in consultation with relevant persons.
			Amendments must be approved by _____ and communicated to all affected workers before work resumes.
			SWMS must be made available for inspection or review as required by WHS legislation.
			Record of SWMS must be kept as required by WHS legislation (until job is complete or for 2 years if involved in a notifiable incident).

PRINCIPAL CONTRACTOR DETAILS *(The builder or the organisation you are working for.)*		
PRINCIPAL CONTRACTOR (PC):	PROJECT NAME:	DATE SWMS PROVIDED TO PC:
PROJECT ADDRESS:		
PROJECT MANAGER (PM):	PM SIGNATURE:	CONTACT PH. #:
SWMS SCOPE: This SWMS covers the operation of a petrol or electric powered high pressure Water Jet Cleaner, using cold water.		

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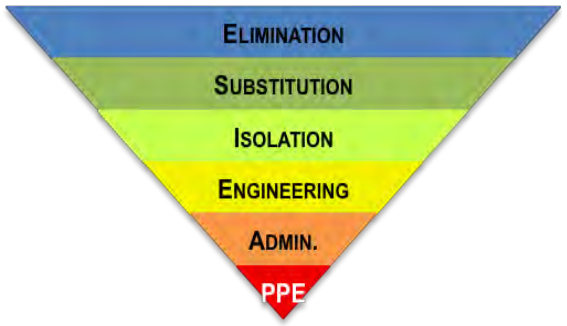
THIS WORK ACTIVITY INVOLVES THE FOLLOWING "HIGH RISK CONSTRUCTION WORK"			
☐ Confined Spaces	☑ Mobile Plant	☐ Demolition	☐ Asbestos
☐ Using explosives	☐ Diving work	☐ Artificial extremes of temperature	☐ Tilt up or pre-cast concrete
☐ Pressurised gas distribution mains or piping chemical, fuel or refrigerant lines energised electrical installations or services			
☐ Structures or buildings involving structural alterations or repairs that require temporary support to prevent collapse			
☐ Involves a risk of a person falling more than 2m, including work on telecommunications towers			
☐ Working at depths greater than 1.5 Metres, including tunnels or mines		☐ Work in an area that may have a contaminated or flammable atmosphere	
☐ Work carried out adjacent to a road, railway or shipping lane, traffic corridor		☐ In or near water or other liquid that involves risk of drowning	

LIKELIHOOD	INSIGNIFICANT	MINOR	MODERATE	MAJOR	CATASTROPHIC	SCORE	ACTION
ALMOST CERTAIN	3 HIGH	3 HIGH	4 ACUTE	4 ACUTE	4 ACUTE		
LIKELY	2 MODERATE	3 HIGH	3 HIGH	4 ACUTE	4 ACUTE	4A ACUTE	DO NOT PROCEED.
POSSIBLE	1 LOW	2 MODERATE	3 HIGH	4 ACUTE	4 ACUTE	3H HIGH	Review before commencing work.
UNLIKELY	1 LOW	1 LOW	2 MODERATE	3 HIGH	4 ACUTE	2M MODERATE	Maintain control measures.
RARE	1 LOW	1 LOW	2 MODERATE	3 HIGH	3 HIGH	1L LOW	Record and monitor.

HIERARCHY OF CONTROLS



PERSONAL PROTECTIVE EQUIPMENT (PPE): *ENSURE ALL PPE MEETS RELEVANT AUSTRALIAN STANDARDS. INSPECT, AND REPLACE PPE AS NEEDED.*

FOOT PROTECTION	HEARING PROTECTION	HIGH VISIBILITY	HEAD PROTECTION	EYE PROTECTION	FACE PROTECTION	HAND PROTECTION	PROTECTIVE CLOTHING	BREATHING PROTECTION	SUN PROTECTION	FALL ARREST	RINGS, WATCHES, JEWELLERY THAT MAY BECOME ENTANGLED IN MACHINES MUST NOT BE WORN. LONG AND LOOSE HAIR MUST BE TIED BACK.
☑	☑	☑	☑	☑	☑	☑	☑	☐	☑	☐	☑

AS 1319-1994 SAFETY SIGNS FOR THE OCCUPATIONAL ENVIRONMENT REPRODUCED WITH PERMISSION FROM SAI GLOBAL UNDER LICENCE 1210-c062. STANDARDS MAY BE PURCHASED AT HTTP://WWW.SAIGLOBAL.COM

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
1. Planning & preparation	Lack of consultation with potential outcomes for personal injury, property damage &/or environmental incident.	3H	Liaise with Principal Contractor to establish the following on-site systems and procedures are in place and take note of: • Health and Safety rules • Induction for all workers – site specific and toolbox meetings • Supervisory arrangements • Communication arrangements • All relevant workers are appraised for required competencies & for any pre-existing medical conditions if working in remote or isolated locations. • PPE required • Site plans – showing no go zones for pedestrians • Traffic Management Plan • Exclusion Zones • Risk Assessments • SWMS and JSA's • Injury reporting procedures • Hazard reporting procedures.	2M	
2. Training and Capabilities	Lack of training or the assessment of capability may lead to personal injury, property damage &/or environmental incident.	3H	Ensure all persons entering site have a General Construction Induction Card (white card). Ensure all relevant workers have undertaken training and/or received instruction in the use of control measures. Include: • Reporting procedures for incidents • Correct use of equipment including selecting, fitting, use, care of and maintenance • Correct use of all water jet cleaner used • Use of supervision where required (e.g. new starters or new equipment) • Ensure supervisors, foremen etc. are suitably experienced in the type work to be conducted • All workers are trained in this SWMS. Operators of the Water Jet Cleaner must be trained and competent. Training to include: • Operational manual • Controls on the machine • PPE • Cutting action • Hoses • Use of hazardous chemicals • Re-fuelling • Manual handling • Hazards involved with direct contact with high-pressure water. ⚠ *If working on EWPs or scaffolding, for this task, ensure there are separate, dedicated EWP/Scaffolding SWMS and that all workers/employees have relevant training and licensing.*	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
3. Assess onsite conditions	Lack of a clear assessment may lead to personal injury, property damage &/or environmental incident.	3H	Assess conditions at site on arrival. Ensure: • Ensure site-specific induction is undertaken (include location of amenities, first aid facilities, emergency plans and evacuation points, incident reporting, communication, contact persons etc.) • Assess mobile phone reception (alternative emergency communications procedures in place if no reception available) • Work site is exactly as detailed in Terms of Agreement or contract • Suitable weather conditions (do not work outside in low visibility, heavy rain, high winds etc.) • Suitable access for all equipment required • Suitable space for operation of equipment • Suitable lighting, including night-works (include flood lighting and operator head lamps as applicable) • Take note of mobile plant movement. Conduct site inspection to identify potential hazards such as: • Work at heights (above 2m) • Lighting • Ventilation • Dust • Temperature etc. • Exposed electrical switchboards/power points • Duration of manual handling tasks (such as working with arms above shoulder height).	2M	
4. Work area set up	Other workers / public safety	3H	Restrict access to work area. Ensure: • Exclusion zone surrounding work area using barricades and signage is in place • Any other workers within the exclusion zone are wearing appropriate PPE • Traffic control is in place • A standby person (or spotter) should be allocated and used if required.	2M	
	Contact with powered mobile plant / vehicles	3H	Sufficient space between workers, no hazardous work in close proximity Check constantly for changing hazards while working and monitor work position at all times. Ensure: • High visibility clothing worn at all times • Do not stand behind reversing vehicles • Allow sufficient distance from plant during operation (allow sufficient room for	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			equipment failure – such as arm/boom failure or plant rollover) • No work is conducted in established “no go zones” for pedestrians • Alertness at all times. Listen for: o Reversing alarms/beepers o Calls from Plant Operators • Safety/warning signs, Spotters, traffic barriers etc. must be obeyed as required • Work positions should be in clear sight of plant operators • Follow traffic management plan requirements. NOTE: Some traffic management plans may say that pedestrians have right-of-way. Never assume this. Make visual and verbal contact with plant operator as required.		
	Hit by water/objects under pressure	3H	• All equipment and machines in close proximity to work area should be protected or shielded from water and/or being hit by flying debris: o Remove all objects such as rocks, broken glass, nails, wire, debris, toys, or anything that may become a hazard during Water Jet Cleaner operation • Hoses, Check: o Restrained to restrict their movement in the event of a hose end failure o Nozzles checked and cleared of debris that could cause obstructions o Attachments should be fitted as per the manufacturer’s recommendations.	2M	
	Muscular stress / musculoskeletal disorder (MSD)	3H	• Ensure materials / equipment is as close to work area as possible • Complete visibility of work area for Water Jet Cleaner operators • Access to clean water supply for use with the Water Jet Cleaner as near as possible.	2M	
	Slips, trips & falls on the same level	3H	Ensure: • Safe access and egress • Sufficient lighting • Free of tripping hazards (such as excess material, hoses) • Remove all objects such as rocks, broken glass, nails, wire, debris, toys, or anything • Keep electrical cords clear of excessive heat, oil, sharp edges (including moving parts of water jet cleaner) • Use pendants, lead stand or insulated cable hangers • Do not drape leads over body or work	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			that may become a hazard during Water Jet Cleaner operation • Complete visibility of work area for Water Jet Cleaner operators piece or any metal surface • Do not run leads along ground/floor, near sharp edges, across doorways or hang them over metal structures.		
	Work adjacent to road & public safety	4A	• Park working vehicle in driveway or allocated parking to avoid travelling across roads when delivery working equipment • If setting up roadside – comply with local laws and permits • Erect any barriers & signage necessary to keep others safe and aware.	2M	
	Contact with electricity	3H	• Any electrical equipment in the immediate area of the operation that presents a potential hazard and is not required during the job, must be de-energised, shielded, or otherwise made safe • Ensure equipment rated for atmospheric requirements (water, or explosion-proof for flammable zones) • Ensure fire protection equipment accessible as required • Ensure equipment is not placed in areas where they may be run over, damaged or exposed to water (unless rated for wet environments). Keep power leads up off the ground and out of the way Electric Powered Units • All power water jet cleaner and leads are Tested and Tagged and are current • Safety switches (RCD's) are provided • Ensure switchboards have appropriately rated circuit breaker • Pre-inspect equipment If equipment is damaged, do not use • Take out of service, apply Lock-out/tag-out (LOTO) procedures and inform supervisor immediately. ⚠ Do not use plug top RCD's fitted to power water jet cleaner, as the RCD cannot be tested.	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
	Exposure to hazardous vapours *(fuel powered units)*	4A	⚠ **Do not run a diesel/petrol-powered machine inside a building, or where ventilation is limited.** • Always operate tool in well-ventilated area • Away from any ignition sources • Do not operate this unit in enclosed spaces.	2M	
	Contact with hazardous chemicals / substances	3H	If using chemical cleaning solutions, ensure current Material/Safety Data Sheets (M/SDS) are obtained for all hazardous chemicals/substances and accessible on site. • Using less hazardous forms (granules instead of powders) • Containers are labelled (name of product and safety information) • Appropriate containers/spray bottles are used o ***Never use food/drink containers for storing / decanting chemicals*** • PPE as prescribed in M/SDS for decanting (e.g.: eye/face protection, apron, enclosed shoes) is provided and used • Spill kit • Fire protection equipment.	2M	
5. Operating the water jet cleaner	Water under pressure – injection injury	4A	• Wear eye protection and protective clothing. • Use lowest pressure compatible with the work to be performed should be used. • Do not work in the rain or during thunderstorms. • *Never put your hand over a jetting nozzle when operating* • *Never use high-pressure water to clean yourself or their clothing or footwear (Water jet at 1500psi will cause injury if it sprays a persons or body parts).*	2M	
	Safety of others	4A	⚠ *Continually check for persons entering the area* ⚠ *If approached when using the Water Jet Cleaner – STOP operations* ⚠ *ALWAYS point spray nozzle at surface to be cleaned* ⚠ *NEVER Leave the cleaner unattended during use* ⚠ *NEVER Point the hose at a person or animal.*	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
	Contact with electricity *(electric powered units)*	4A	Ensure: • Isolate from power before cleaning or making adjustments • Keep electric cord away from heat, oil, sharp edges or moving parts o Replace damaged cords immediately • Never carry electrical water jet cleaner by power cord • Do not use power cord to pull equipment from power socket • Unplug tool when not in use • Check for damage or faults regularly during operation. Examples, if excessive vibration occurs, stop using immediately. *Do not:* • *Expose power tool to rain or wet conditions* • *Abuse the cord, never use the cord to carry the tool or pull the plug from the outlet.*	2M	
	Fire / explosion	3H	• Do not operate power water jet cleaner in explosive atmospheres (i.e. presence of flammable liquids, gases or dust).	2M	
	Dust / debris	3H	• Wear eye protection and protective clothing.	2M	
	Struck by moving objects	3H	• Use a “Whip Check” if possible to reduce chance of hose whipping.	2M	
	Slips, trips & falls on the same level	3H	Ensure good footing, as the area will become wet. Hoses set up. Check: • Not running across walkways, roadways or stairways • Arranged to minimise trip hazards.	2M	
	Noise	3H	Wear hearing protection as required, ensure it is: • Worn by all persons throughout the period of exposure to noise • Suitable for the type of working environment and the work tasks • Comfortable and correctly fitting for the worker • Regularly inspected and maintained to ensure it remains in good, clean condition.	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
	Property damage	3H	• Keep the nozzle approximately 1.5m away from surface being cleaned • Any objects to be cleaned must be secured against movement • Any objects to be cleaned must be secured against movement • Small objects must be secured to a vice or similar tool • Objects should never be held by a person • Aim the wand at an angle to its target. This will help to lift and remove dirt from the object more effectively than blasting it straight on • Reaction forces should be considered and regulated based on the ability of the worker to maintain control of the jetting gun. High pressure Water Jet Cleaners should not be directly aimed at electrical wiring, switches, relays, alternators, starter motors, bearing seals, window rubbers or vulnerable components that water might affect.	2M	
	Strong reaction force - vibration / Muscular stress / MSD	3H	Always push the Water Jet Cleaner when moving it. • Use triggers that can lock into place for use over longer periods (more than 30 seconds at a time) • Ensure handles: o Are cylindrical and approx. 4cm in diameter o Allow wrist to remain straight o Comfortable grip o No sharp edges o Grip length approx. 12cm • Avoid repetitive tasks. Ensure: o Job rotation o Sufficient breaks • Do not overreach • Do not work in awkward or static postures for more than 30 minutes at a time or 2 hours over entire shift.	2M	
6. Working with hazardous materials	Asbestos	4A	⚠ ***It is prohibited to use high-pressure water jet cleaners on asbestos.*** Determine presence of asbestos containing material (ACM): • Obtain a copy of the asbestos register for the site.	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
	Lead	4A	• Determine the presence of lead in the materials being cleaned e.g. lead based paint o Do not pressure wash peeling paint that contains lead. The paint chips will be scattered all over the place and you will find it impossible to gather up all the debris / paint chips o This will create a "lead hazard".	2M	
7. Working at elevated levels	Working at height / struck by falling objects	3H	Do not plan to operate a Water Jet Cleaner at heights unless specific controls are in place to prevent additional risk. Use caution when working at elevated levels: • Avoid using water jet cleaner when working from a ladder • Consider use of elevated work platform (EWP) • Use tool lanyards to pass water jet cleaner to persons at height and ensure water jet cleaner cannot fall onto workers below • Ensure kickboards installed on elevated work areas to prevent water jet cleaner falling off.	2M	
	Slips, trips, falls causing injury	3H	Identify all hazards. Consider: • Ground/floor surface condition • Experience of workers • Weather conditions (rain, wind loads, fog, dew) • Where ground surfaces may change level • Check design to ensure that the equipment will support a specified load – or 'duty rating'. This must be clearly stated on the item • Use all height-access equipment as per manufacturer's instructions and for its designed purpose.	2M	
	Fall from ladder	3H	Work positioning. Ensure: • Load rating of at least 120kg • Correct size and length for job • No damage, clean and dry • Secured to work site (base and top) • Metallic, wire- reinforced or conductive ladders should be avoided around live electrical equipment *Do not:* • *Use pressure cleaner while on ladder* • *Attempt to move or extend ladder when on it* • *Slide down stiles* • *Step up or down two or more rungs at a time*	2M	

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
			• Face ladder when ascending/descending • Ensure 3 points of contact remain on ladder at all times • Ensure only 1 person working from each ladder.		
	Fall from platform ladder	3H	Ensure: • Trestle back undamaged • If unfolding type, chains, rivets etc. are undamaged and functional • Suitable height hand rail (900mm) • Triangular flat plate bracing • Correct size for job (platform level) • Non-slip treads • Large feet with non-slip mouldings • Non-slip platform of sufficient strength for persons, water jet cleaner and equipment • Industrial rating.	2M	
	Fall from trestle	3H	Trestles must: • Be rated for proposed weight and span • Have an overhang of at least 150 mm and not more than 250mm at each end and be "locked" together. Example - clamped near the centre span to prevent individual movement • Have an unobstructed surface width of at least 450mm (two planks wide) • Must be matched pairs i.e. the rungs should be equivalent heights and spacing.	2M	
8. Remote and/or isolated work	Personal Injury from delay in emergency assistance to remote workers	3H	A 'Buddy' system is utilised for high-risk tasks undertaken in remote locations or working in isolation. A procedure is developed and in place for regular contact with people working remotely or in isolation, The procedure should identify: • Travel itineraries, locations, scheduled contact persons and times • Sufficient supplies of water, food, fuel & supplies needed • An emergency response • Appropriate Vehicles • Safety equipment including first aid.	2M	
9.			*Add any site-specific hazards, which have not been identified in this SWMS.*		
10.			*Add any site-specific hazards, which have not been identified in this SWMS.*		

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JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
11. Refuelling on site	Fire / explosion	3H	• DO NOT smoke during re-fuelling • Ensure re-fueling is undertaken in well-ventilated area, clear of ignition sources: o *NOTE: Ignition sources include pilot lights, stoves, heaters, cigarettes, matches/lighters, grinding, welding, power points, lighting, light switches, radio transmitters, mobile phones, battery powered forklifts etc.* • Material/Safety Data Sheets (M/SDS) for all fuel products on hand • Follow manufacturer's manual/recommendations for re-fuelling • Ensure fire extinguisher available and in date. **Diesel: Fire extinguisher** – Water, foam, dry chemical powder, CO_2 **Unleaded petrol: Fire extinguisher** – Dry chemical powder, foam, CO_2. Never use water to extinguish an Unleaded Petrol fire.	2M	
	Exposure to hazardous chemicals / substances	3H	• Avoid breathing vapours or contact with fuel • If clothing is splashed with fuel, change immediately • Do not siphon or swallow fuel as this can be fatal • Do not eat, drink or smoke during/after-handling fuel until hands are carefully washed. Shower and wash immediately after work. Wash clothes in separate wash from other clothes.	2M	
	Muscular stress / musculoskeletal disorder (MSD)	3H	Where possible use pump to transfer fuel from container into tank. If using fuel container, and lifting into place: • Lift smoothly, do not jerk or throw load upwards • Avoid any twisting and side-bending during lift • Bend knees, not back • Avoid awkward and sustained positions	2M	
	Environment	3H	• Ensure training in emergency response for chemical spill	2M	

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			INHERENT RISK-RATING (IR) RESIDUAL RISK-RATING (RR)		
	incident		• Ensure to have spill kit available onsite. Emergency response – minor fuel spill: 1. Stop the source of the spill or leak or release a. If that is not possible & it is safe to do so - stop the spill or release from spreading 2. Turn off any ignition sources if safe to do so 3. Use Spills Kit: (as required) a. Position socs on a downhill slope or surround spill if on flat ground. b. Block stormwater inlets with drain sealing mats. c. Float Booms around the spill if on water.		
12. On completion	Slips, trips, falls causing injury	3H	• Clean up water jet cleaner and secure all fittings, hoses and nozzles into working vehicle.	2M	
	Contact with electricity *(electric powered units)*	3H	• Disconnect the cleaner/extension leads from power point before winding up, so that you don't get a shock if the lead is damaged • Inspect leads and power equipment for damage • If safe to do so, remove isolation locks/tags and test appliance for function.	2M	
	Water under pressure	3H	• Turn off the water supply and allow any residual water to drain • Keep the gun safety switch and trigger on so that water still runs out of the nozzle.	2M	
	Contact with hot surfaces	3H	• Turn off the Water Jet Cleaner motor and allow to cool down before storing the unit.	2M	
	Contamination of waterways *(fuel powered units)*	3H	• Ensure spill kit is available for fuel *(fuel powered units)* or chemical spills • Dispose of waste fuel containers, used oils etc. as per SDS, local authority and environmental agency requirements.	2M	
	Public safety	3H	• If acceptable, remove barricades, contact supervisor and return as agreed.	2M	

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EMERGENCY RESPONSE - CALL *000* IMMEDIATELY.

If work is to be conducted on a construction site (or a site controlled by another Employer / PCBU) follow the site-specific Emergency Management Plan. Ensure:

- Adequate numbers of first aid trained staff are on site when working at heights occurs
- First aiders are trained and competent in managing injuries associated with demolition until emergency services arrive
- All rescue equipment is in good condition, available for use and in close proximity to the work site.

Ensure workers have access to:

- First aid kit/supplies
- First Aid trained personnel familiar with Resuscitation and emergency response for electric shock
- M/SDS
- Communication devices (check mobile phones will have service in area)
- Suitable fire protection equipment.

SAFE WORK METHOD STATEMENT (SWMS) PART 2

FORMAL TRAINING, LICENCES REQUIRED FOR WORKERS UNDERTAKING THIS TASK:

Delete or add as relevant

Licence to Perform High Risk Work (operating certain plant, equipment)
TAFE or other recognised training organisation
Construction Induction Card (or equivalent)
Competent in operation of make/model of plant
Emergency procedures – emergency response
PPE
Traffic Management Plans

DETAILS OF SUPERVISORY ARRANGEMENTS FOR WORKERS UNDERTAKING THIS TASK:

Delete or add as relevant

Suitably qualified supervisors for job
Direct on-site supervision
Remote site – communication systems/ schedule
Audits
Spot Checks, etc.
Reporting systems

DETAILS OF: REGULATORY PERMITS/LICENSES ENGINEERING DETAILS/CERTIFICATES/WORKCOVER. APPROVALS:

Delete or add as relevant

Local council permits
Authorisation to work
Confined Space Permit
Building Approvals
EPA approvals/permits
Certain plant to be registered with State Authority
PPE to comply with relevant Australian Standards

RELEVANT LEGISLATION & CODES OF PRACTICE

❖*Retain only the legislation references applicable to your state of operation for this SWMS.*

Commonwealth, NSW, QLD, ACT
Work Health and Safety Act 2011
Work Health and Safety Regulations 2011
Northern Territory
Work Health and Safety (National Uniform Legislation) Act 2011
Work Health and Safety (National Uniform Legislation) Regulations
SA, Tasmania
Work Health and Safety Act 2012
Work Health and Safety Regulations 2012
Codes of Practice: Safe Work Australia (2011):
Construction Work
First Aid in the Workplace
Managing the Risk of Falls at Workplaces
Managing the Risk of Plant in the Workplace
Managing Noise and Preventing Hearing Loss in the Workplace
How to Manage Work Health and Safety Risks
Hazardous Manual Tasks
Managing Risks of Hazardous Chemicals
Managing Electrical Risks in the Workplace
Managing the Work Environment and Facilities
WHS Consultation, Cooperation & Coordination

Victoria:
Occupational Health & Safety Act 2004
Occupational Health & Safety Regulations 2007
Compliance Codes: WorkSafe Victoria (2008): Compliance Code:
Communicating OHS Across Languages
First Aid in the Workplace
Prevention of Falls in General Construction
Workplace Amenities and Work Environment
Codes of Practice: WorkSafe Victoria
(1990): No. 13: *Building and Construction Workplaces*
(2000): No. 25: *Manual Handling*
(1995): No. 19: *Plant*
(1998): No. 23: *Plant (Amendment No. 1)*
(2004): No. 29: *Prevention of Falls in Housing Construction*
(2000): No. 24: *Hazardous Substances*
Western Australia
Occupational Safety & Health Act 1984
Occupational Safety & Health Regulations 1996
Codes of Practice:

PLANT/WATER JET CLEANER/EQUIPMENT LIST FOR THE JOB.

(Make & Model)

REFERENCE DOCUMENTS

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SAFE WORK METHOD STATEMENT (SWMS) PART 3

This SWMS has been developed in consultation and cooperation with *employee/workers* and relevant *Employer/Persons Conducting Business or Undertaking (PCBU).* I have read the above SWMS and I understand its contents. I confirm that I have the skills and training, including relevant certification to conduct the task as described. I agree to comply with safety requirements within this SWMS including risk control measures, safe work instructions and Personal Protective Equipment described.

OVERALL RISK RATING AFTER CONTROLS	☐ 1 LOW	☑ 2 MODERATE	☐ 3 HIGH	☐ 4 ACUTE

EMPLOYEE/WORKER NAME	JOB ROLE / POSITION	SIGNATURE	DATE	TIME	EMPLOYER/PCBU/ SUPERVISOR

REVIEW: Ensure all controls are reviewed as per the following:

- If controls fail to reduce risk adequately
- When changes to the workplace or work activity occur that create new / different risks where controls may no longer be effective
- New hazards identified
- After an incident involving work activities relevant to this SWMS
- During consultation with relevant persons indicate review is needed
- A Health and Safety Representative (HSR) requests a review in line with the requirements of the legislation.

MONITOR: To ensure controls are implemented and monitored effectively:

- Toolbox /pre-work meetings will be undertaken
- Relevant persons will be consulted on hazards and contents of SWMS, work plans and other applicable information
- Control measures will be monitored throughout works:
  *☐Spot checks *☐Consultation *☐Scheduled audits

Corrective actions will be recorded and rectified in a timely manner SWMS will be reviewed and updated accordingly (in consultation with relevant persons).

REVIEW NO.	1	2	3	4	5	6	7	8	9	10
NAME:										
INITIAL:										
DATE:										

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