OPERATORS MANUAL

HDV6000

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- Operation Manual
- Comet Manual
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OPERATORS MANUAL

HDV6000

Section 1

Index

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

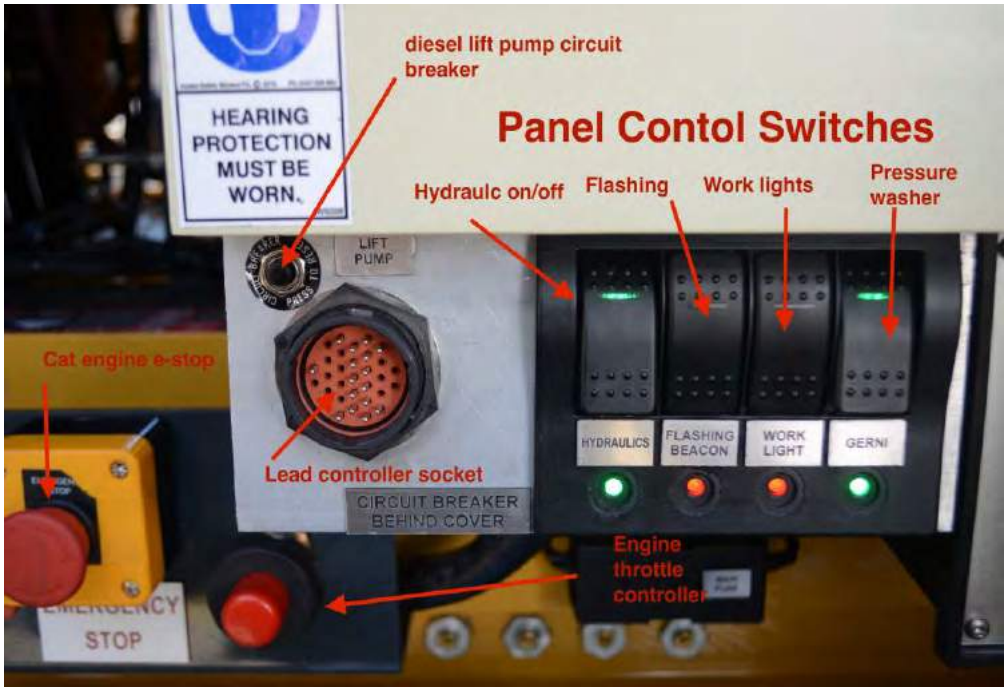
- Perform all operations with at least two operators.
- Only trained personnel should operate, perform maintenance, or repair the unit.
- Work area must be clear and clean for good visibility and footing.
- All operators must wear safety apparel: hard hat, visor and / or goggles, ear protection, rain 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.

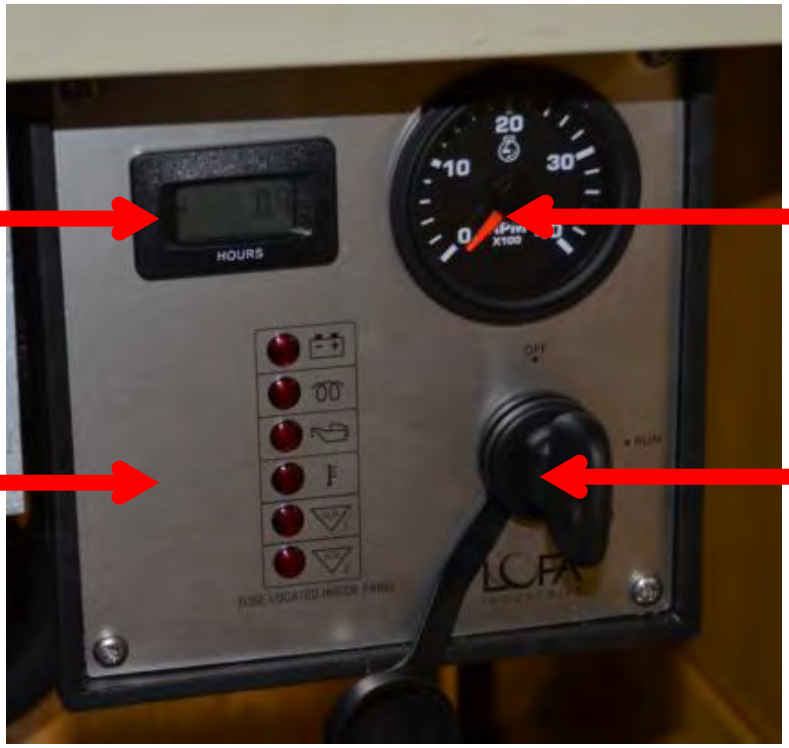
- Never use this unit in any type of rescue operation where the vacuum is used for the rescue.
- Operating the unit inside a building or confined areas can create additional risks to the unit, operators and building occupants. Engine exhaust gas can reach deadly levels. Heat buildup from the engine and 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
HOURS
10
20
30
0
LCFA


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

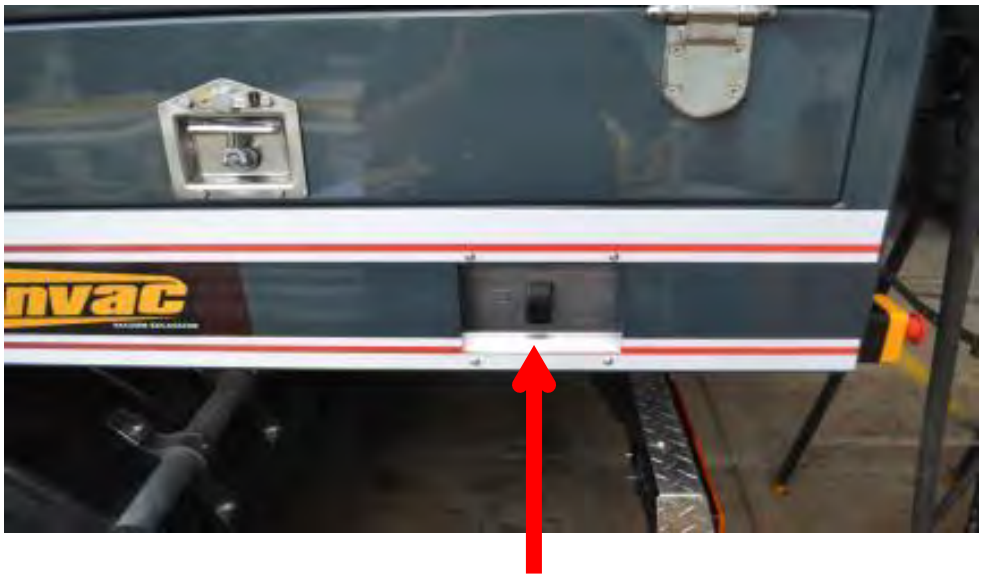
Hydraulic Controls

Emergency stop

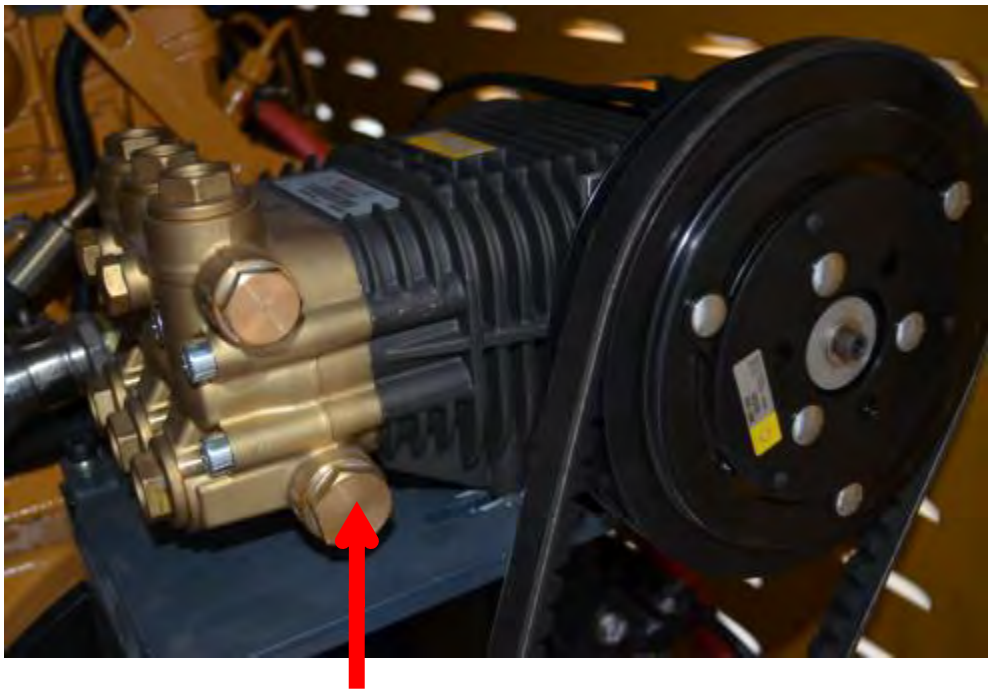
Collection Tank
Raised/lower
Push up -RAISE TANK
Push-Down-LOWER

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

Water System



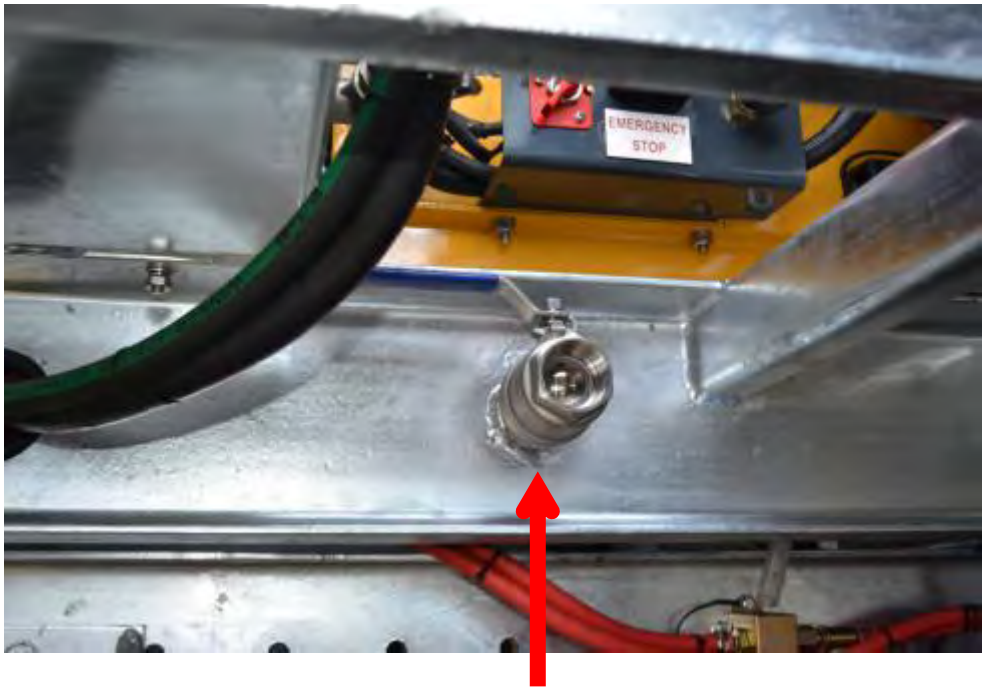
Water pump Switch



Water Pump

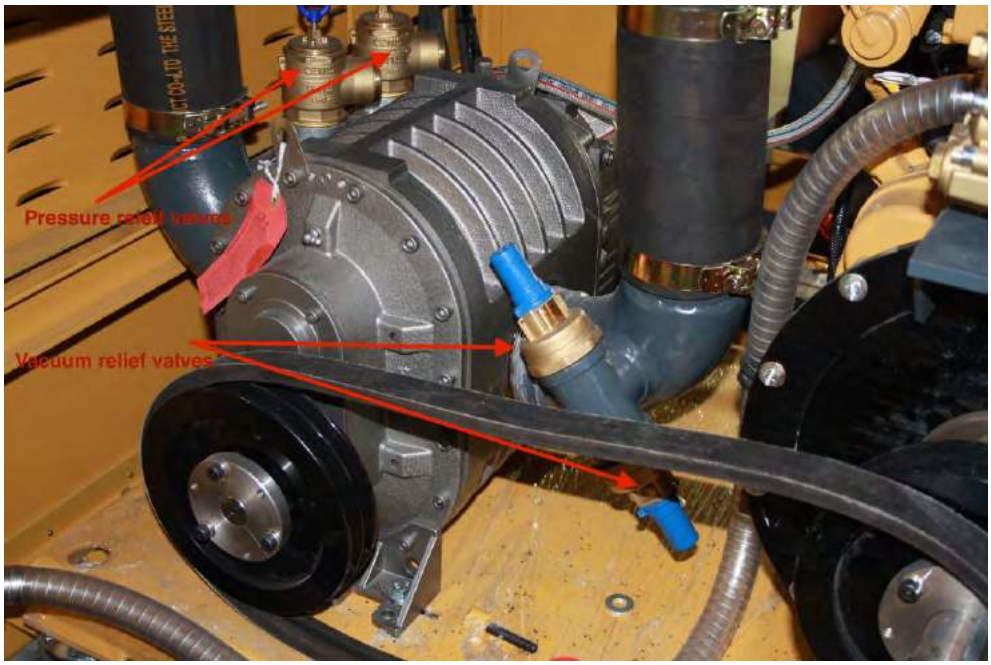
Water Strainer

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:

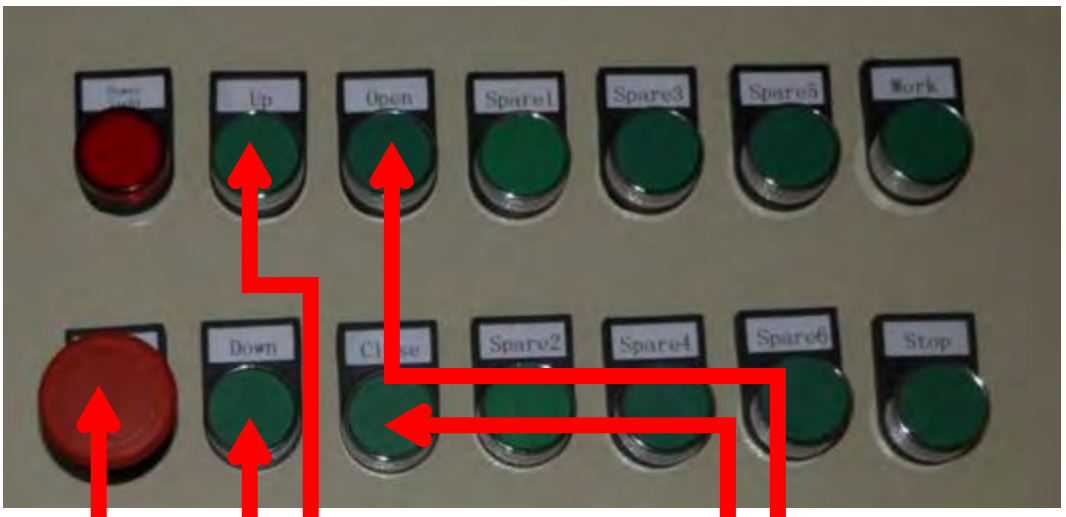
- Operators can prevent dieseling by locating the vacuum truck upwind of vapor sources and by extending the vacuum pump discharge away from the diesel engine air intake.
- Vapors may be returned to the source container using conductive and closed connections.
- Vapors may be vented into the atmosphere 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

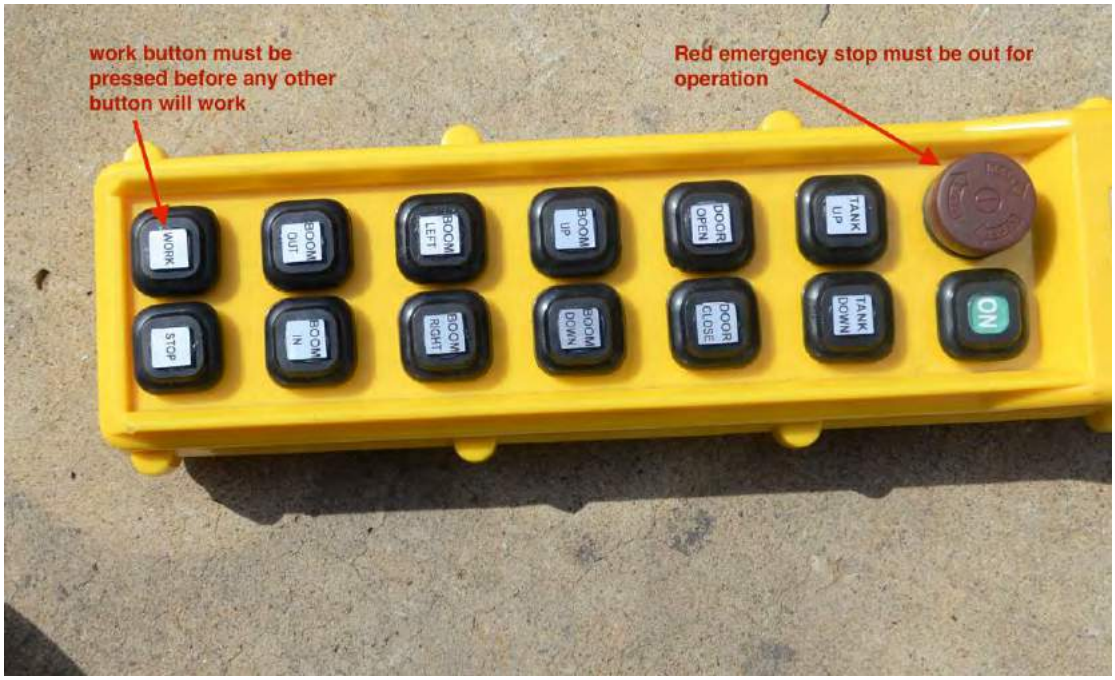
1. Before running the hydraulics make sure the hydraulic oil is showing in the hydraulic sight glass at the correct level
2. For hydraulic operation, the caterpillar engine must be running,
3. Once the engine is running engage the hydraulics by switching the hydraulic switch to the on position on the 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

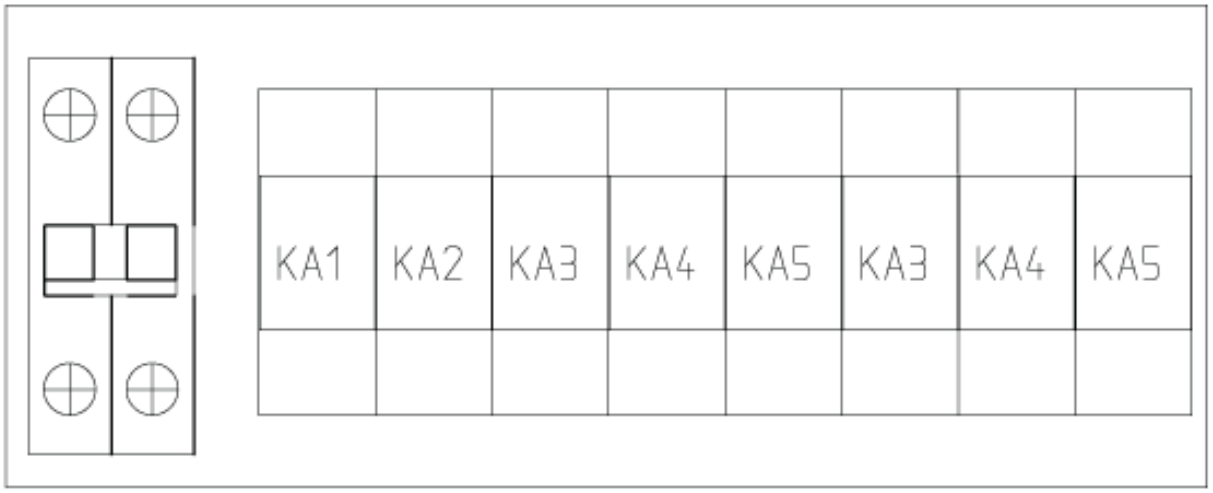
Check all module mounting bolts visually daily

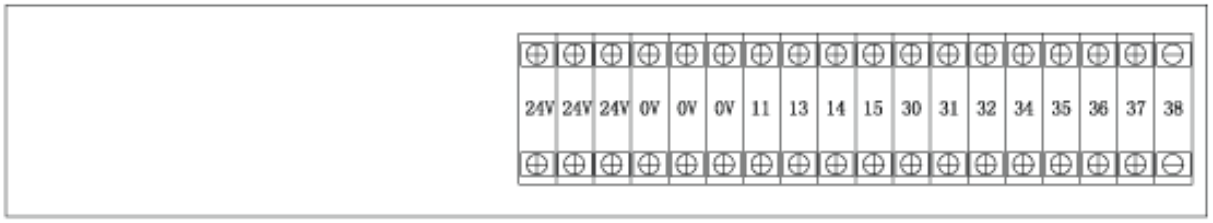
Check the module mounting bolts monthly with spanners

19. CAPTURED MOUNTING BRACKET SPRINGS

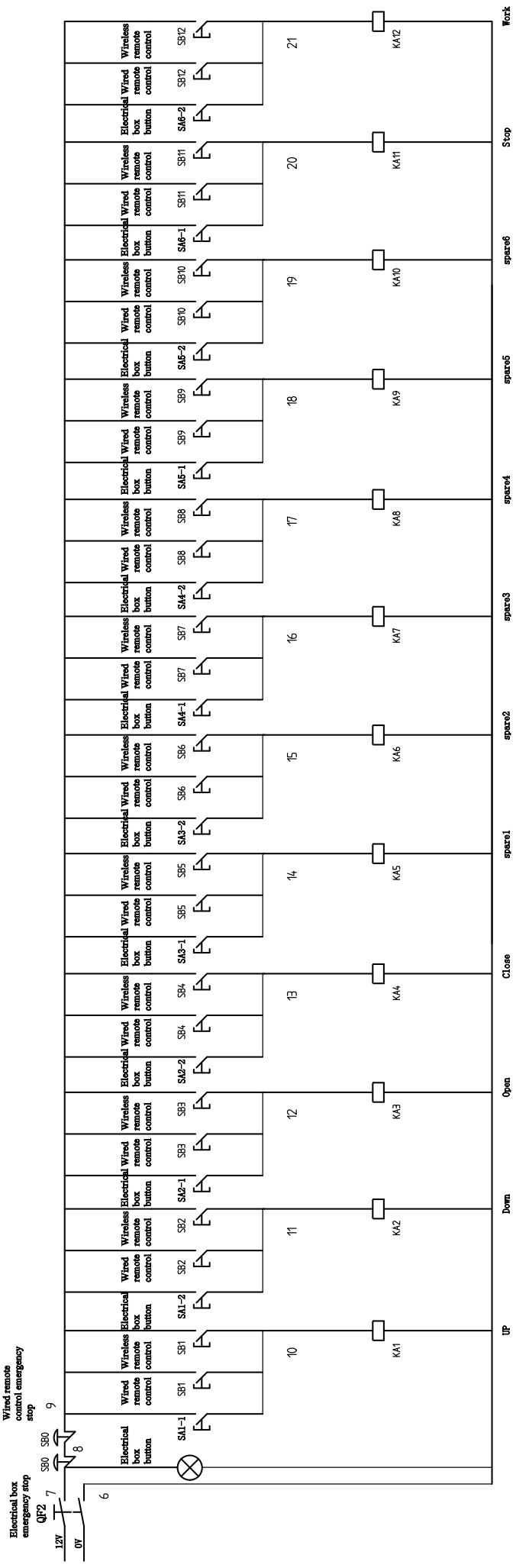
Check the tension on the spring mounts monthly. Examine the spring mounts to make sure they have not loosened up due to vibration. Adjust the springs on the captured mounting brackets to a compressed length.

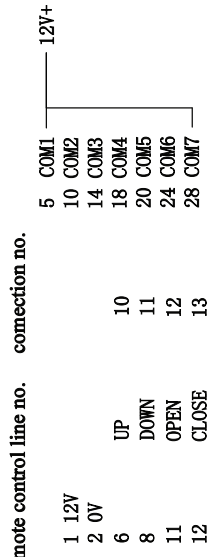
20. 6000lt ELECTRIC CONTROL BOX CIRCUIT DIAGRAM 1



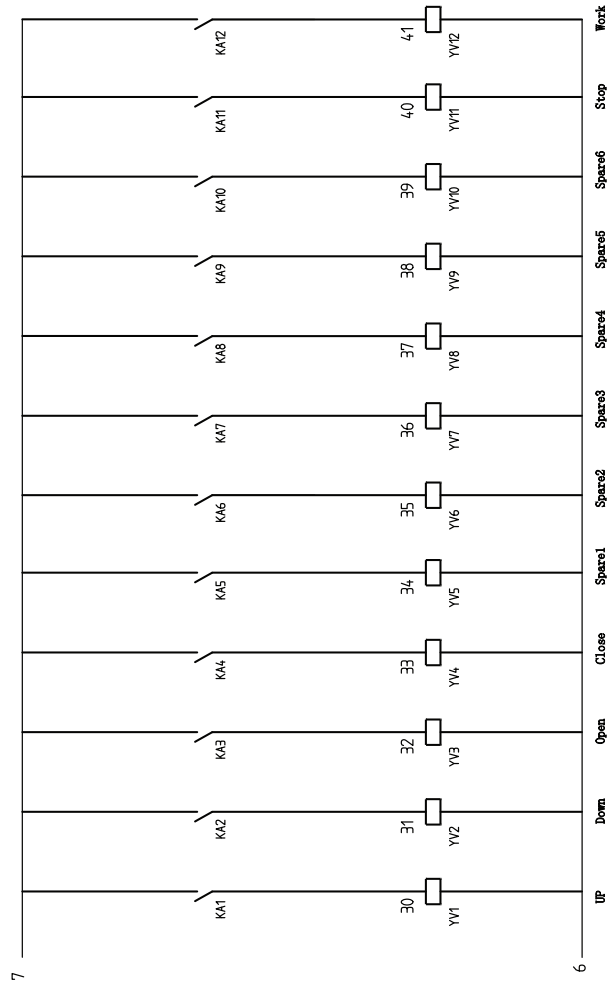


21. 6000lt ELECTRIC CONTROL BOX CIRCUIT DIAGRAM 2

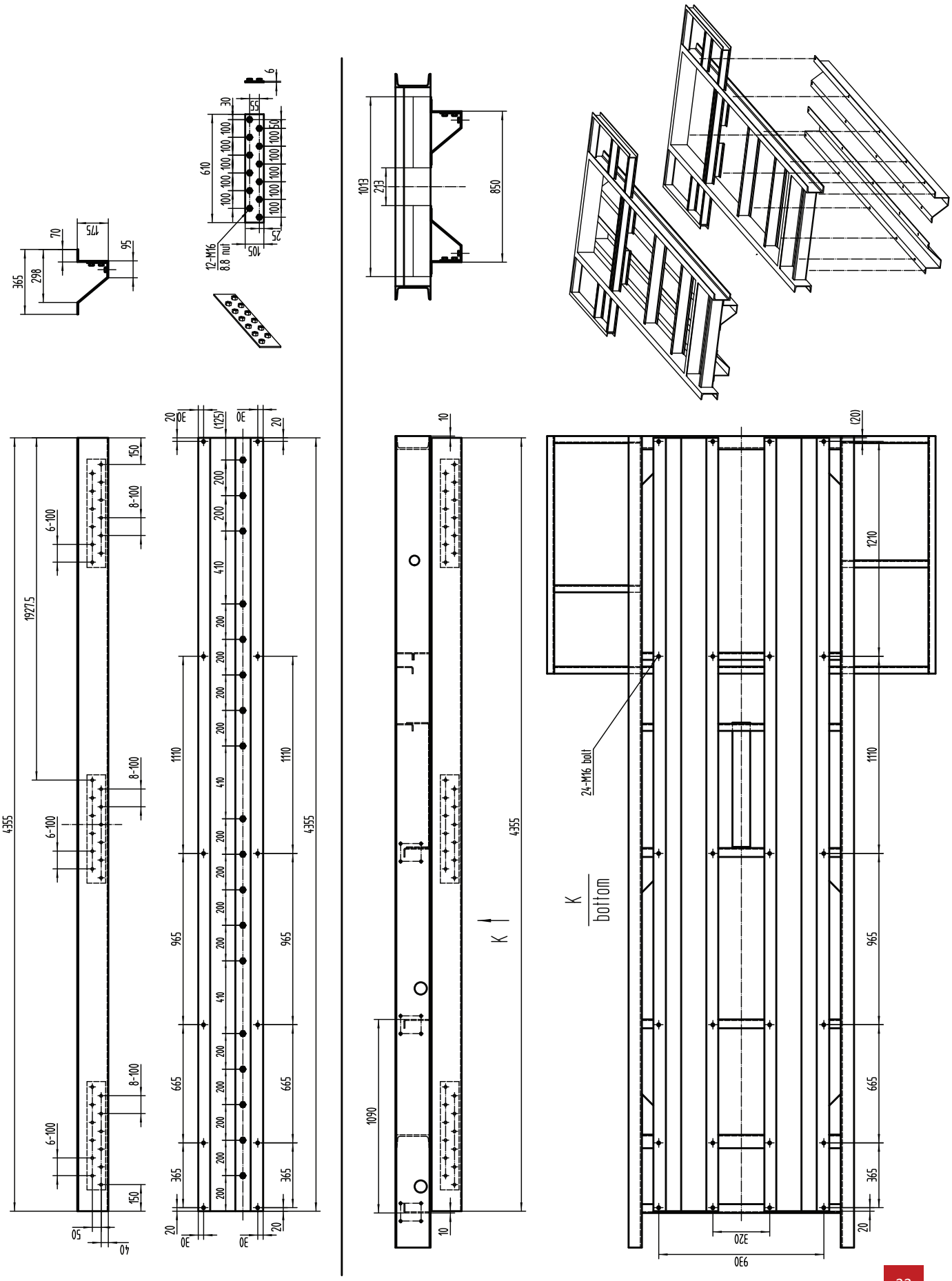




remote control line no.		comection no.
1	12V	
2	0V	
6	UP	10
8	DOWN	11
11	OPEN	12
12	CLOSE	13
15	SPARE1	14
16	SPARE2	15
19	START	21
21	1 SPARE3	16
22	2 SPARE4	17
25	3 SPARE5	18
26	4 SPARE6	19
29	F1 STOP	20



22. 6000lt VACUUM UNIT BOTTOM RAIL ASSEMBLE



OPERATORS MANUAL

Cat 4.4 Operation Manual

Section 2

CATERPILLAR®

SEBU8180-01
March 2008

Operation and Maintenance Manual

C4.4 Industrial Engine

4441-Up (Engine)

Important Safety Information

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

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

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

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

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

⚠ 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.

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

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

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

⚠ 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.

Table of Contents

Foreword

Literature Information

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

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

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

Safety

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 Caterpillar dealer can assist you in adjusting your maintenance schedule to meet the needs of your operating environment.

Overhaul

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

California Proposition 65 Warning

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

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

Safety Section

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Safety Messages

SMCS Code: 1000; 7405

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

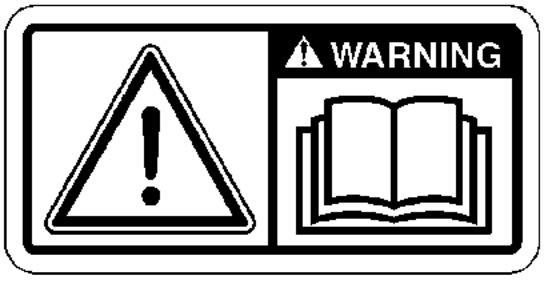
Ensure that all of the warning signs are legible. Clean the warning signs or replace the warning signs if the words cannot be read or if the illustrations are not visible. Use a cloth, water, and soap to clean the warning signs. Do not use solvents, gasoline, or other harsh chemicals. Solvents, gasoline, 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 warning sign that is damaged or missing. If a warning sign is attached to a part of the engine that is replaced, install a new warning sign on the replacement part. Your Caterpillar dealer can provide new warning signs.

(1) Universal Warning

⚠ 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.



g01154807

Illustration 1

Typical example

The Universal Warning label (1) is located on both sides of the valve mechanism cover base. Refer to illustration 2.

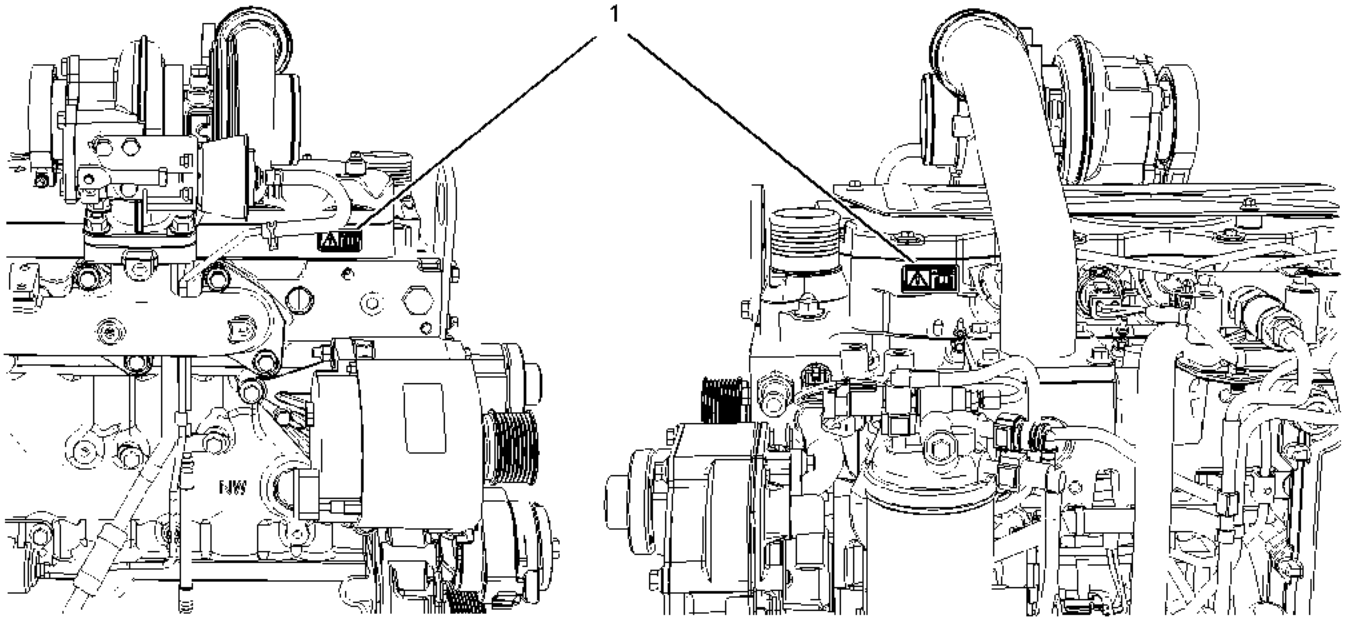


Illustration 2 g01268960

(1) Universal warning

(2) Hand (High Pressure)

⚠ 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.

Illustration 3 g01154858

Typical example

The warning label for the Hand (High Pressure) (2) is located on the top of the fuel manifold. Refer to illustration 4.

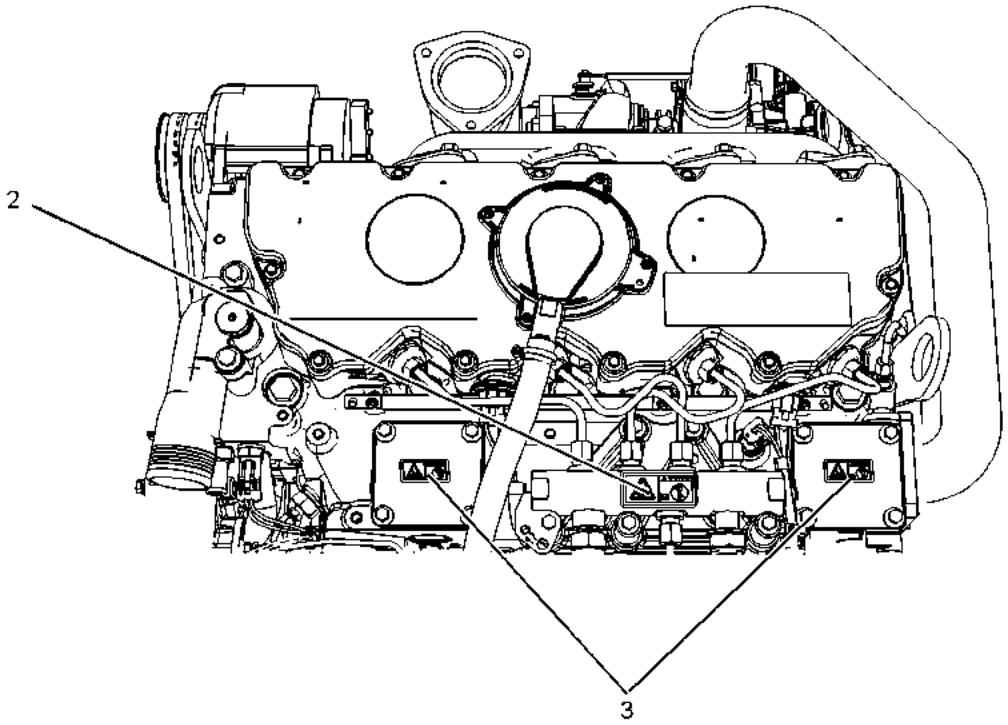


Illustration 4 g01430275

(2) Hand (High Pressure) (3) Ether

(3) Ether

WARNING

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

Illustration 5 g01154809

Typical example

The ether warning label (3) is located on the cover of the inlet manifold. Refer to illustration 4.

Note: The position of this label will depend on the application on the engine.

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General Hazard Information

SMCS Code: 1000; 7405

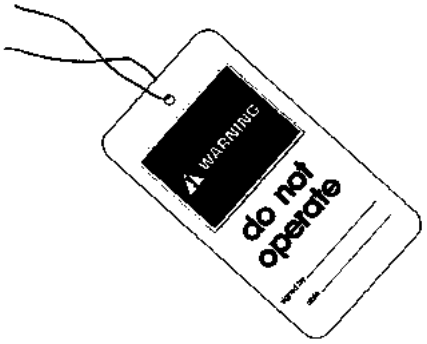

Illustration 6 g00104545

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

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

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

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

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

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

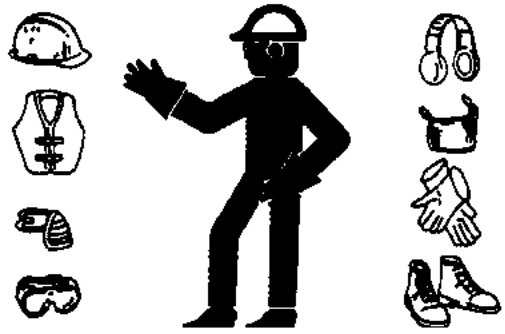

Illustration 7 g00702020

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

Pressurized Air and Water

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

When 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.

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

Fluid Penetration

Pressure can be trapped in the hydraulic circuit long after the engine has been stopped. The pressure can cause hydraulic fluid or items such as pipe plugs to escape rapidly if the pressure is not relieved correctly.

Do not remove any hydraulic components or parts until pressure has been relieved or personal injury may occur. Do not disassemble any hydraulic components or parts until pressure has been relieved or personal injury may occur. Refer to the OEM information for any procedures that are required to relieve the hydraulic pressure.

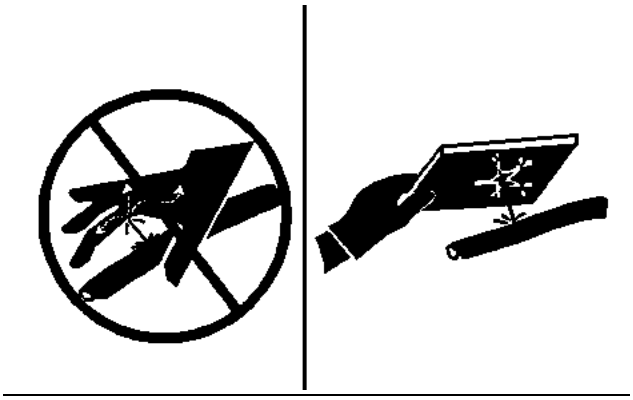

Illustration 8 g00687600

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

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

Refer to Special Publication, NENG2500, “Dealer Service Tool Catalog” for the following items:

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

Obey all local regulations for the disposal of liquids.

Asbestos Information

Illustration 9 g00702022

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

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

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

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

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

Dispose of Waste Properly

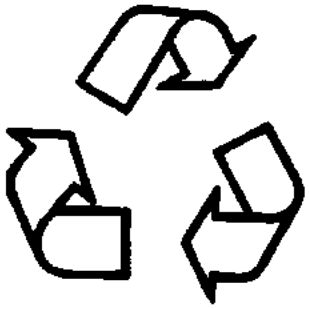

Illustration 10 g00706404

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.

i02344742

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.

⚠ 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.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines.

Allow the pressure to be purged in the air system, in the hydraulic system, in the lubrication 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.

i02328452

Fire Prevention and Explosion Prevention

SMCS Code: 1000; 7405

Illustration 11 g00704000

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

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

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

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

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

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

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

Do not expose the engine to any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in case of a line, a 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. All electrical wires must be properly routed and securely attached. Check all electrical wires daily. Repair any wires that are loose or frayed before you operate the engine. Clean all electrical connections and tighten all electrical connections.

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

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

⚠ 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.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines.

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

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

Illustration 12 g00704059

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

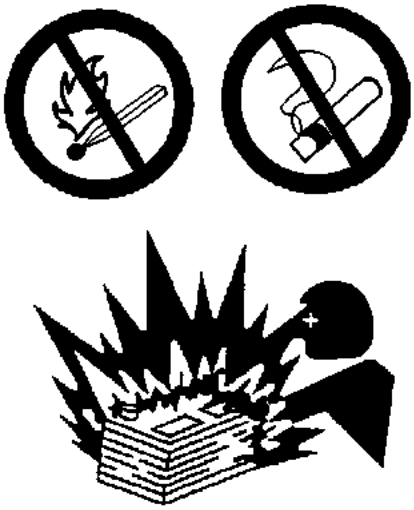

Illustration 13 g00704135

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

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

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

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

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

Fire Extinguisher

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

Ether

Ether is flammable and poisonous.

Use ether in well 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 Caterpillar dealer for repair or for replacement parts.

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

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

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

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

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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.

i02861106

High Pressure Fuel Lines

SMCS Code: 1274

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.

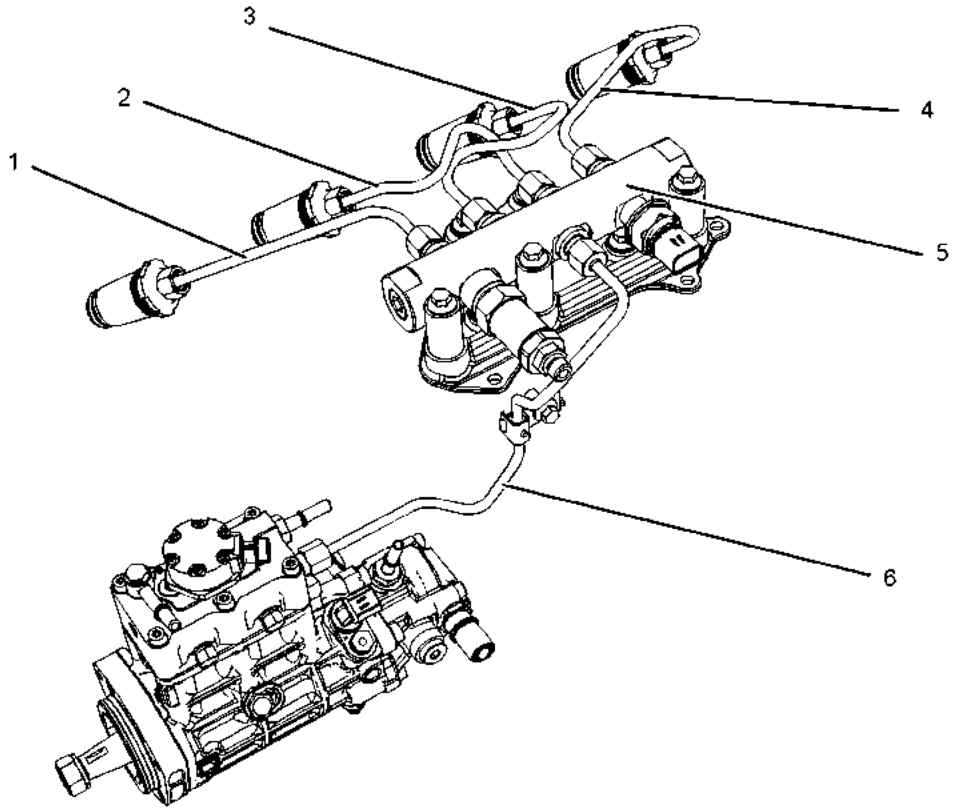


Illustration 14 g01425090

(1) High pressure line
(2) High pressure line
(3) High pressure line
(4) High pressure line
(5) High pressure fuel manifold (rail)
(6) High pressure line

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.
- The high pressure fuel lines are formed to shape and then strengthened by a special process.

Do not step on the high pressure fuel lines. Do not deflect the high pressure fuel lines. Do not bend or strike the high pressure fuel lines. Deformation or damage of the high pressure fuel lines may cause a point of weakness and potential failure.

Do not check the high pressure fuel lines with the engine or the starting motor in operation. After the engine has stopped allow 60 seconds to pass in order to allow the pressure to be purged before any service or repair is performed on the engine fuel lines.

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

Visually inspect the high pressure fuel lines before the engine is started. This inspection should be each day.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, “General Hazard Information”.

- Inspect the high pressure for the following: damage, deformation, a nick, a cut, a crease, or a dent

- Do not operate the engine with a fuel leak. If there is a leak do not tighten the connection in order to stop the leak. The connection must only be tightened to the recommended torque. Refer to Disassembly and Assembly Manual, “Fuel Injection Lines - Remove and Fuel Injection Lines - Install”.
- If the high pressure fuel lines are torqued correctly and the high pressure fuel lines are leaking the high pressure fuel lines must be replaced.
- Ensure that all clips on the high pressure fuel lines are in place. Do not operate the engine with clips that are damaged, missing or clips that are loose.
- Do not attach any other item to the high pressure fuel lines.
- Loosened high pressure fuel lines must be replaced. Also removed high pressure fuel lines must be replaced. Refer to Disassembly and Assembly Manual, “ Fuel Injection Lines - Install”.

i01805780

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.

Overspeed shutdown should occur automatically. If automatic shutdown does not occur, press the emergency stop button in order to cut the fuel and/or air to the engine.

Inspect the engine for potential hazards.

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

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.

i02344744

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 correctly, check the water temperature gauge and/or 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.

Note: The engine is equipped with a device for cold starting. If the engine will be operated in very cold conditions, then an extra cold starting aid may be required. Normally, the engine will be equipped with the correct type of starting aid for your region of operation.

These engines are equipped with a glow plug starting aid in each individual cylinder that heats the intake air in order to improve starting.

i02328530

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.

To stop an electronic controlled engine, cut the power to the engine and/or the air supply to the engine.

i02234878

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 “**–**” 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 cable to the engine block.

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

Grounding Practices

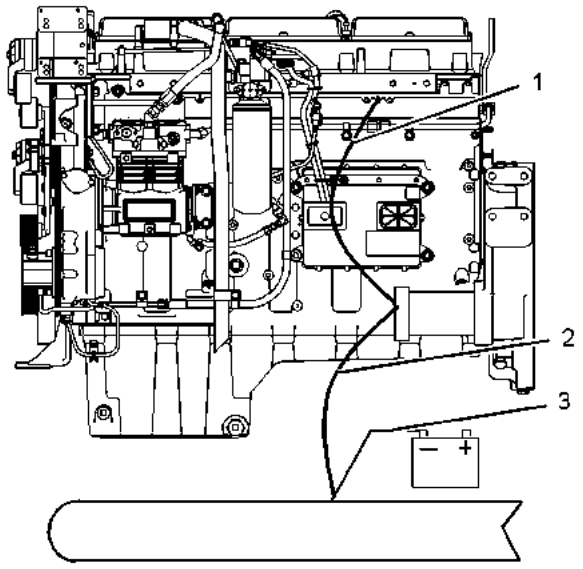


Illustration 15 g01162916

Typical example

(1) Starting motor to engine block
(2) Ground to starting motor
(3) Ground to battery

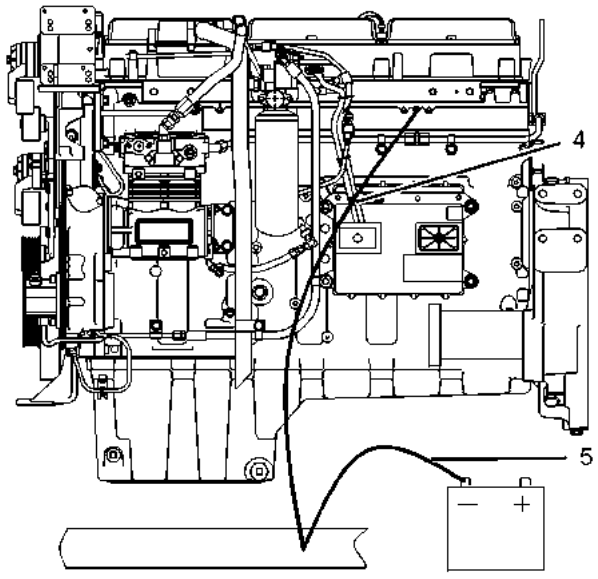


Illustration 16 g01162918

Typical example

(4) Ground to engine
(5) Ground to battery

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 the 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 direct engine ground to the frame.

The connections for the 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.

The power supply connections and the ground connections for the engine electronics should always be from the isolator to the battery.

i02652709

Engine Electronics

SMCS Code: 1000; 1400; 1900

⚠ WARNING

Tampering with the electronic system installation or the OEM wiring installation can be dangerous and could result in personal injury or death and/or engine damage.

⚠ WARNING

Electrical Shock Hazard. The electronic unit injectors use DC voltage. The ECM sends this voltage to the electronic unit injectors. Do not come in contact with the harness connector for the electronic unit injectors while the engine is operating. Failure to follow this instruction could result in personal injury or death.

This engine has a comprehensive, programmable Engine Monitoring System. The Electronic Control Module (ECM) has the ability to monitor the engine operating conditions. If any of the engine parameters extend outside an allowable range, the ECM will initiate an immediate action.

The following actions are available for engine monitoring control:

- Warning
- Derate
- Shutdown

The following monitored engine operating conditions have the ability to limit engine speed and/or the engine power:

- Engine Coolant Temperature
- Engine Oil Pressure
- Engine Speed
- Intake Manifold Air Temperature

The Engine Monitoring package can vary for different engine models and different engine applications. However, the monitoring system and the engine monitoring control will be similar for all engines.

Note: Many of the engine control systems and display modules that are available for Caterpillar Engines will work in unison with the Engine Monitoring System. Together, the two controls will provide the engine monitoring function for the specific engine application. Refer to the Troubleshooting for more information on the Engine Monitoring System.

Product Information Section

General Information

i02668476

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 Caterpillar dealer regarding welding on a chassis frame or rail.

Proper welding procedures are necessary in order to avoid damage to the engine's 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 following procedure must be followed when you weld on a unit that is equipped with a Caterpillar Electronic Engine. The following procedure is considered to be the safest procedure to weld on a component. This procedure should provide a minimum risk of damage to electronic components.

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

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 accidentally move back and make contact with any of the ECM pins.

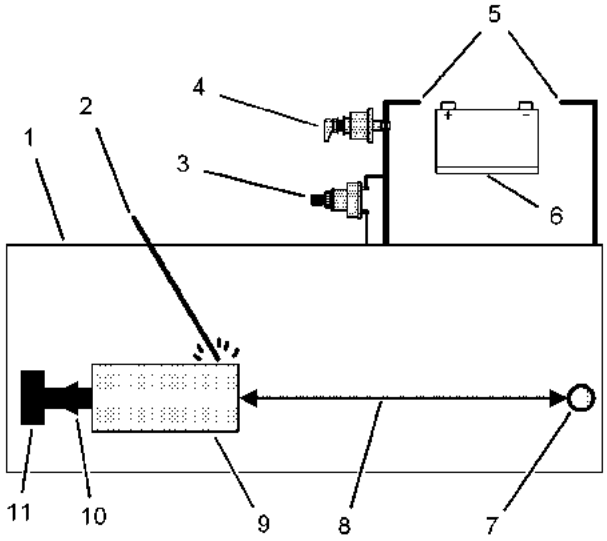


Illustration 17 g01075639

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

4. Connect the welding ground cable directly to the part that will be welded. Place the ground cable as close as possible to the weld in order to 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, or electrical/electronic components are located between the welder ground and the weld, current flow from the welder could severely damage the component.

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

6. Use standard welding practices to weld the materials.

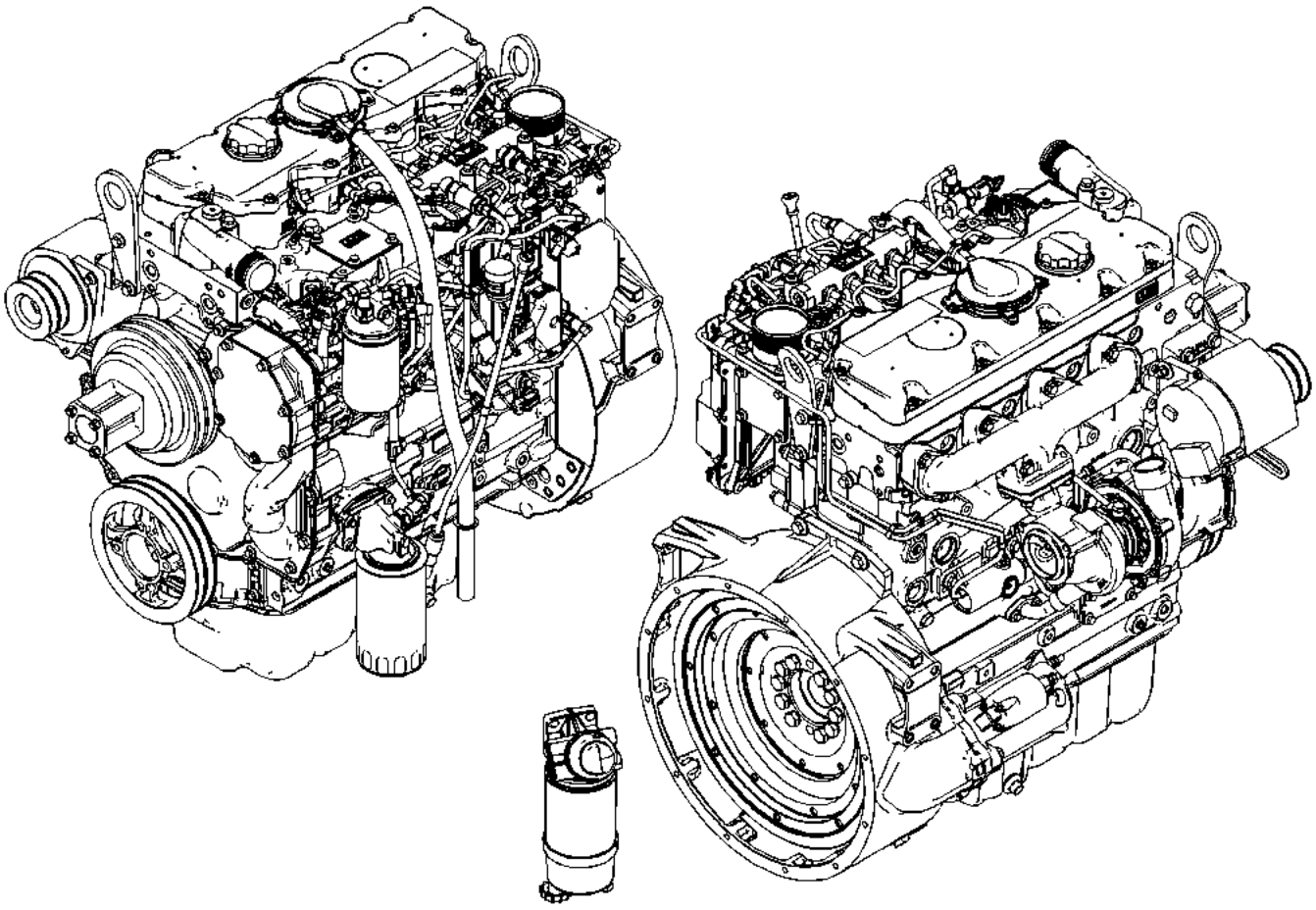
Model Views

i02872107

Model View Illustrations

SMCS Code: 1000

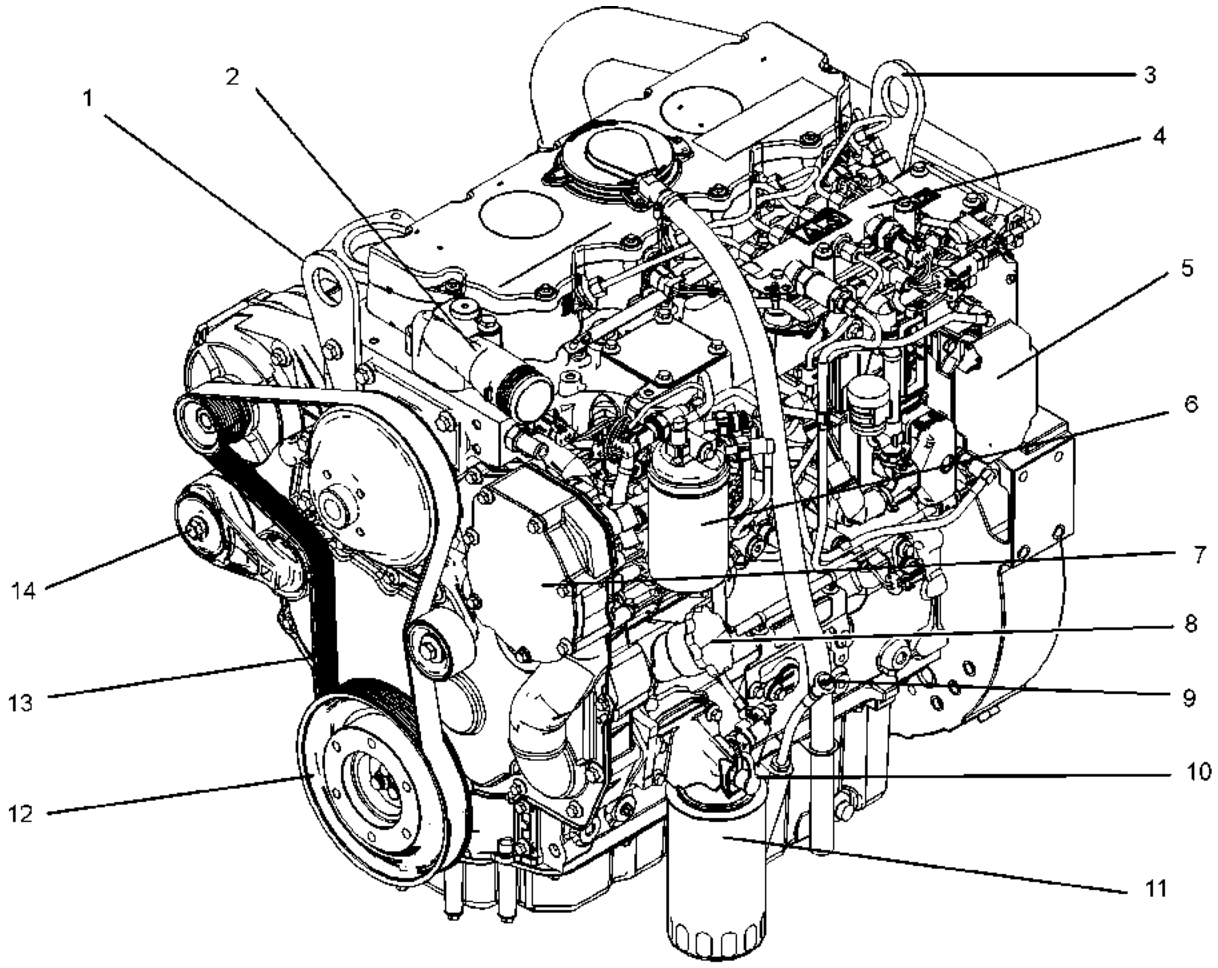
The following model views show typical features of the engines. Due to individual applications, your engine may appear different from the illustrations.



g01430279

Illustration 18

Engine view of a turbocharged aftercooled engine



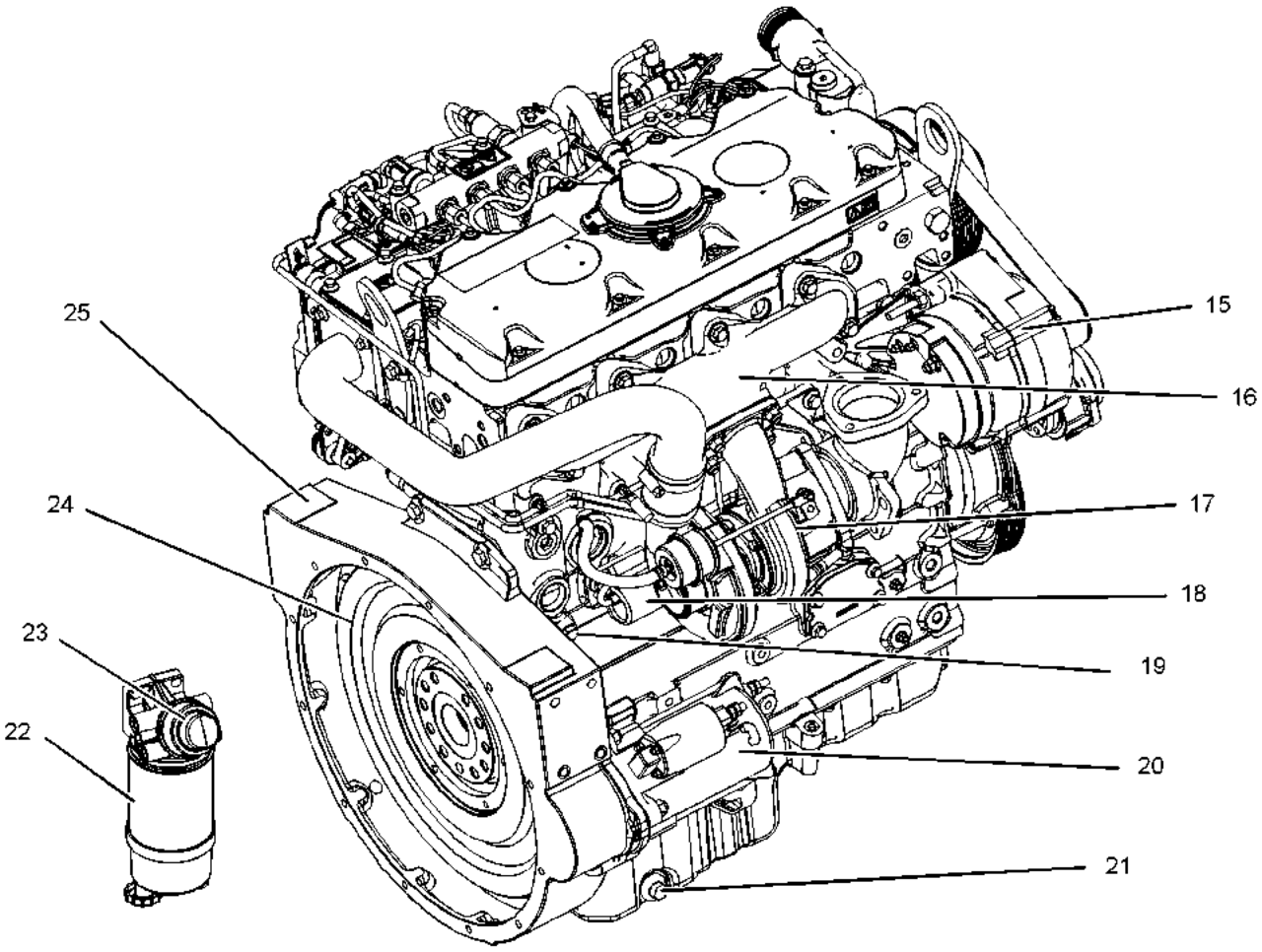
g01430281

Illustration 19

Engine view of a turbocharged engine

Front left engine view

(1) Front lifting eye
(2) Water outlet
(3) Rear lifting eye
(4) Fuel manifold (rail)
(5) Electronic control module
(6) Secondary fuel filter
(7) Water pump
(8) Oil Filler
(9) Oil gauge
(10) Oil sampling valve
(11) Oil filter
(12) Crankshaft pulley
(13) Drive Belt
(14) Belt tensioner



g01430282

Illustration 20

Rear right engine view

(15) Alternator
(16) Exhaust manifold
(17) Turbocharger
(18) Wastegate solenoid
(19) Drain plug or coolant sampling valve
(20) Starting Motor
(21) Oil drain plug
(22) Primary fuel filter
(23) Hand fuel priming pump
(24) Flywheel
(25) Flywheel housing

Note: The primary fuel filter may be mounted off the engine.

i02872108

Engine Description

SMCS Code: 1000

The Caterpillar C-4.4 Industrial Engine has the following characteristics:

- In-Line 4 cylinder
- Four stroke cycle
- Turbocharged
- Turbocharged aftercooled

Engine Specifications

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

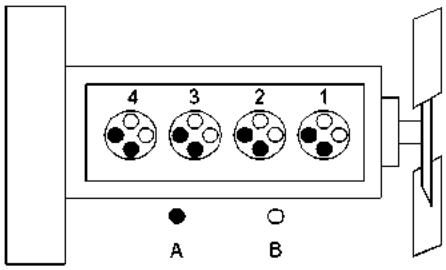


Illustration 21 g01187485

(A) Exhaust valve
(B) Inlet valve

Table 1

C-4.4 Engine Specifications	
Operating Range (rpm)	700 to 2640[1]
Arrangement and Cylinders	In-Line 4 cylinder
Bore	105 mm (4.13 inch)
Stroke	127 mm (5 inch)
Aspiration	Turbocharged, Turbocharged aftercooled
Compression Ratio	16.2:1
Displacement	4.4 L (269 in^3)
Firing Order	1-3-4-2
Rotation (flywheel end)	Counterclockwise
Valve Lash (inlet)	0.35 mm (0.013 inch)
Valve Lash (exhaust)	0.35 mm (0.013 inch)

(1) The operating rpm is dependent on the engine rating, the application and the configuration of the throttle.

Electronic Engine Features

The Caterpillar C-4.4 Engine is designed for electronic controls. The integral on board computer controls the operation of the engine. Current operating conditions are monitored. The Electronic Control Module (ECM) controls the response of the engine to these conditions and to the demands of the operator. These conditions and operator demands determine the precise control of fuel injection by the ECM. The electronic engine control system provides the following features:

- Engine monitoring
- Engine speed governing
- Control of injection pressure
- Cold start strategy
- Automatic air/fuel ratio control
- Torque rise shaping
- Injection timing control
- System diagnostics

For more information on electronic engine features, refer to the Operation and Maintenance Manual, “Engine Features and Controls” topic (Operation Section).

Engine Diagnostics

The engine has built-in diagnostics in order to ensure that the engine systems are functioning correctly. The operator will be informed of any change to a programmed limit. The operator will be alerted to the condition by a “Stop or Warning” lamp that is mounted on the dashboard. Under certain conditions, the engine horsepower and the vehicle speed may be limited. The Caterpillar Electronic Technician (ET) may be used to display the diagnostic codes.

There are three types of codes: active diagnostic, logged diagnostic, and event.

Most of the diagnostic codes are logged and stored in the ECM. For additional information, refer to the Operation and Maintenance Manual, “Engine Diagnostics” topic (Operation Section).

The ECM provides an electronic governor that controls the injector output in order to maintain the desired engine rpm.

Engine Cooling and Lubrication

The cooling system consists of the following components:

- Gear-driven centrifugal water pump
- Water temperature regulator which regulates the engine coolant temperature
- Gear-driven oil pump
- Oil cooler

The engine lubricating oil is supplied by a rotor type oil pump. The engine lubricating oil is cooled and the engine lubricating oil is filtered. The bypass valves can provide unrestricted flow of lubrication oil to the engine if the oil filter element should become plugged.

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

Engine Service Life

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

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

Aftermarket Products and Caterpillar Engines

When auxiliary devices, accessories, or consumables (filters, additives, catalysts, etc) which are made by other manufacturers are used on Caterpillar products, the Caterpillar warranty is not affected simply because of such use.

However, failures that result from the installation or use of other manufacturers’ devices, accessories, or consumables are NOT Caterpillar defects. Therefore, the defects are NOT covered under the Caterpillar warranty.

Welding and Caterpillar Electronic Engines

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 Caterpillar dealer regarding welding on a chassis frame or rail.

To help avoid damage to the electronic controls, proper welding procedures are necessary. Before welding on an engine that is equipped with an electronic engine, observe the following precautions:

1. Turn off the engine. Place the key start switch in the OFF position.

2. If the machine has a battery disconnect switch, open the switch. Otherwise, disconnect the negative “-” battery cable from the battery of the vehicle.

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

3. Clamp the ground cable from the welder to the component that will be welded. Place the clamp as close as possible to the weld.

4. Protect wiring harnesses from welding debris and spatter. Use proper welding procedures.

Product Identification Information

i02499733

Plate Locations and Film Locations

SMCS Code: 1000

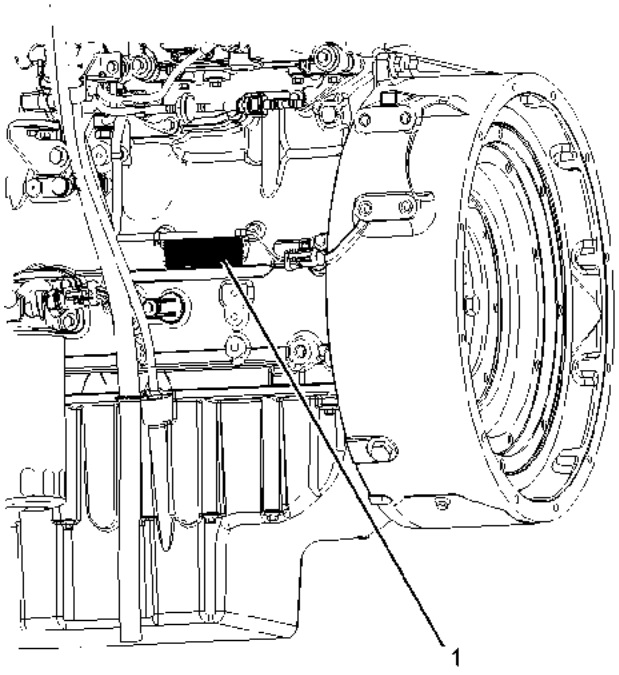


Illustration 22 g01248563

Location of the serial number plate

Serial Number Plate (1)

The engine serial number plate is located on the left side of the cylinder block to the rear of the engine.

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

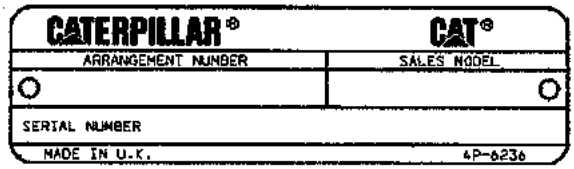


Illustration 23 g01258789

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. _____

i02894858

Emissions Certification Film

SMCS Code: 1000; 7405

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

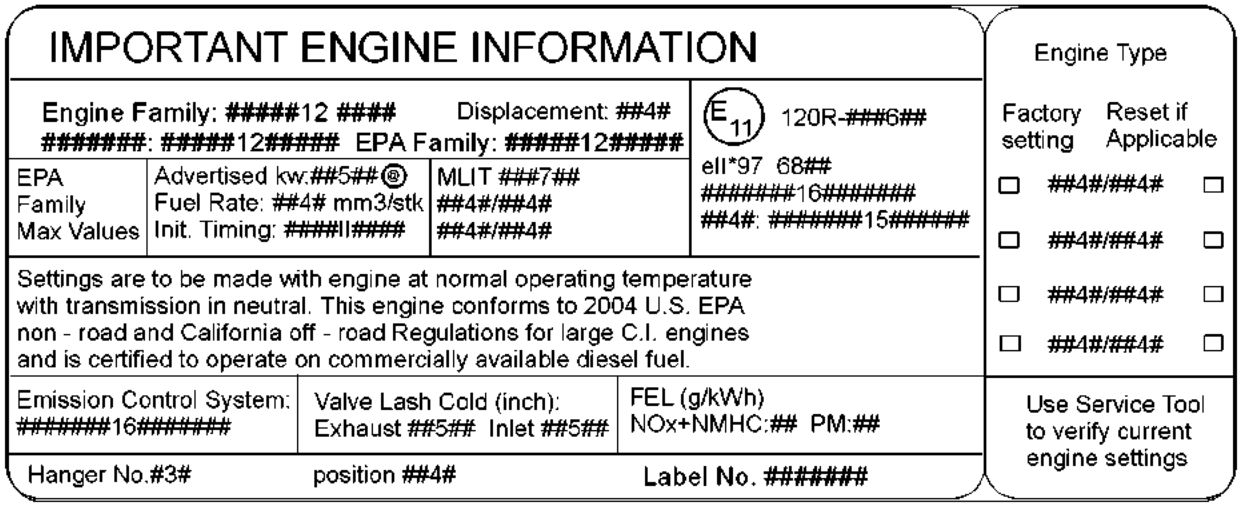


Illustration 24

g01440937

Typical example

i02238153

Customer Specified Parameters

SMCS Code: 1000

To record programmed specifications, use the following blanks.

Customer Passwords

- First Password _____
- Second Password _____

Power Rating (hp at rpm) _____

Rating Selection (A-E) _____

PTO Governor Parameters

- PTO Engine Speed Ramp Rate _____ rpm/sec

Engine Parameters

- Top Engine Limit (TEL) at 100 percent load (If Applicable) _____
- Torque Limit _____
- High Idle (If Applicable) _____
- Low Idle _____
- Intermediate Speed _____

Engine Monitoring Mode

- “OFF” _____

- “Warning” _____
- “Warning/Derate” _____
- “Warning/Derate/Shutdown” _____
- “Coolant Level Sensor Enable/Disable” _____
- “Fuel Pressure Sensor Enable/Disable” _____
- “Inlet Manifold Air Temperature Sensor Enable/Disable” _____

Equipment ID

Maintenance Indicator

- Manual-Hours
- Auto-Hours
- Manual-Fuel
- Auto-Fuel

Auxiliary Pressure

- High Warning Set Point _____

Auxiliary Temperature

- High Warning Set Point _____

Operation Section

Lifting and Storage

i02437864

Product Lifting

SMCS Code: 1000; 1404; 7002

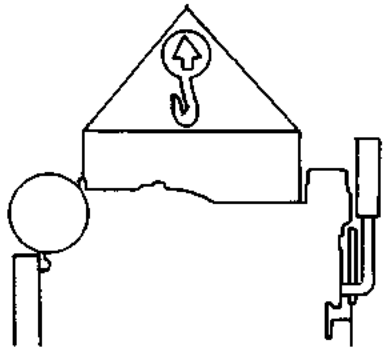


Illustration 25 g00103219

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 Caterpillar dealer for information regarding fixtures for proper engine lifting.

i02068367

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 one month, a complete protection procedure is recommended.

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

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

Gauges and Indicators

i02724238

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.

Some engine applications are equipped with Indicator Lamps. Indicator lamps can be used as a diagnostic aid. There are two lamps. One lamp has an orange lens and the other lamp has a red lens.

These indicator lamps can be used in two ways:

- The indicator lamps can be used to identify the current operational status of the engine. The indicator lamps can also indicate that the engine has a fault. This system is automatically operated via the ignition switch.
- The indicator lamps can be used to identify active diagnostic codes. This system is activated by pressing the Flash Code button.

Refer to the Troubleshooting Guide, “Indicator Lamps” for further information.

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 SAE10W40 is 350 to 450 kPa (50 to 65 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. Stop the engine.
3. Check and maintain the oil level.

Jacket Water Coolant Temperature – Typical temperature range is 83° to 95°C (181.4° to 171°F). The maximum allowable temperature at sea level with the pressurized cooling system at 48 kPa (7 psi) is 103 °C (217.4 °F). Higher temperatures may occur under certain conditions. The water temperature reading may vary according to load. The temperature reading should never exceed 7 °C (44.6 °F) below the boiling point for the pressurized system that is being used.

A 100 kPa (14.5 psi) radiator cap may be installed on the cooling system. The temperature of this cooling system must not exceed 112 °C (233.6 °F).

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. Determine if the engine must be shut down immediately or if the engine can be cooled by reducing the load.
3. Inspect the cooling system for leaks.

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. Operation at speeds exceeding high idle rpm should be kept to a minimum.

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

Fuel Level – This gauge indicates the fuel level in the fuel tank. The fuel level gauge operates when the “START/STOP” switch is in the “on” position.

Service Hour Meter – The gauge indicates total operating hours of the engine.

Features and Controls

i02330192

Monitoring System

SMCS Code: 1900; 7400; 7402; 7450; 7451

Table 2

Warning Lamp	Shutdown Lamp	Lamp Status	Description of lamp status	Engine Status
ON	**ON**	Lamp check	When the engine start switch is turned to the “ON” position both lamps will illuminate for 2 seconds only.	The engine has not been started.
OFF	**OFF**	No faults	There are no active diagnostic faults.	The engine is running normally.
ON	**OFF**	Active diagnostic fault	An active diagnostic fault has been detected.	The engine is running normally.
ON	**FLASHING**	Active diagnostic fault	A serious active diagnostic fault has been detected and an engine derate has been invoked.	The engine is running but the engine has been derated.
FLASHING	**OFF**	Warning	One or more of the engine protection values has been exceeded.	The engine is running normally.
FLASHING	**FLASHING**	Derate and warning	One or more of the engine protection values has been exceeded.	The engine is running but the engine has been derated.
ON	**ON**	Engine shutdown	One or more of the engine protection values has been exceeded or a serious active diagnostic fault has been detected.	The engine is shutdown or shutdown is imminent.

i02724323

Monitoring System

SMCS Code: 1900; 7400; 7402; 7450; 7451

WARNING

If the Shutdown mode has been selected and the warning indicator activates, engine shutdown may take as little as 20 seconds from the time the warning indicator is activated. Depending on the application, special precautions should be taken to avoid personal injury. The engine can be restarted following shutdown for emergency maneuvers, if necessary.

NOTICE

The Engine Monitoring System is not a guarantee against catastrophic failures. Programmed delays and derate schedules are designed to minimize false alarms and provide time for the operator to stop the engine.

The following parameters are monitored:

- Coolant temperature
- Intake manifold air temperature
- Intake manifold air pressure
- Oil pressure
- Pressure in the fuel rail
- Engine speed/timing

Programmable Options and Systems Operation

WARNING

If the Warning/Derate/Shutdown mode has been selected and the warning indicator activates, bring the engine to a stop whenever possible. Depending on the application, special precautions should be taken to avoid personal injury.

The engine can be programmed to the following modes:

“Warning”

The “Warning” lamp and the warning signal (orange lamp) turn “ON” and the warning signal is activated continuously in order to alert the operator that one or more of the engine parameters is not within normal operating range.

“Warning/Derate”

The “Diagnostic” lamp turns “ON” and the warning signal (red lamp) is activated. After the warning, the engine power will be derated. The warning lamp will begin to flash when the derating occurs.

The engine will be derated if the engine exceeds preset operational limits. The engine derate is achieved by restricting the amount of fuel that is available for each injection. The amount of this reduction of fuel is dependent on the severity of the fault that has caused the engine derate, typically up to a limit of 50%. This reduction in fuel results in a predetermined reduction in engine power.

“Warning/Derate/Shutdown”

The “Diagnostic” lamp turns “ON” and the warning signal (red lamp) is activated. After the warning, the engine power will be derated. The engine will continue at the rpm of the set derate until a shutdown of the engine occurs. The engine can be restarted after a shutdown for use in an emergency.

A shutdown of the engine may occur in as little as 20 seconds. The engine can be restarted after a shutdown for use in an emergency. However, the cause of the initial shutdown may still exist. The engine may shut down again in as little as 20 seconds.

If there is a signal for low oil pressure or for coolant temperature, there will be a two second delay in order to verify the condition.

For each of the programmed modes, refer to Troubleshooting Guide, “Indicator Lamps” for more information on Indicator Lamps.

For more information or assistance for repairs, consult your Caterpillar dealer.

i02861773

Sensors and Electrical Components

SMCS Code: 1900; 7400

Sensor Locations

Illustration 26 shows the typical locations of the sensors and the ECM on the engine. Specific engines may appear different from the illustration due to differences in applications.

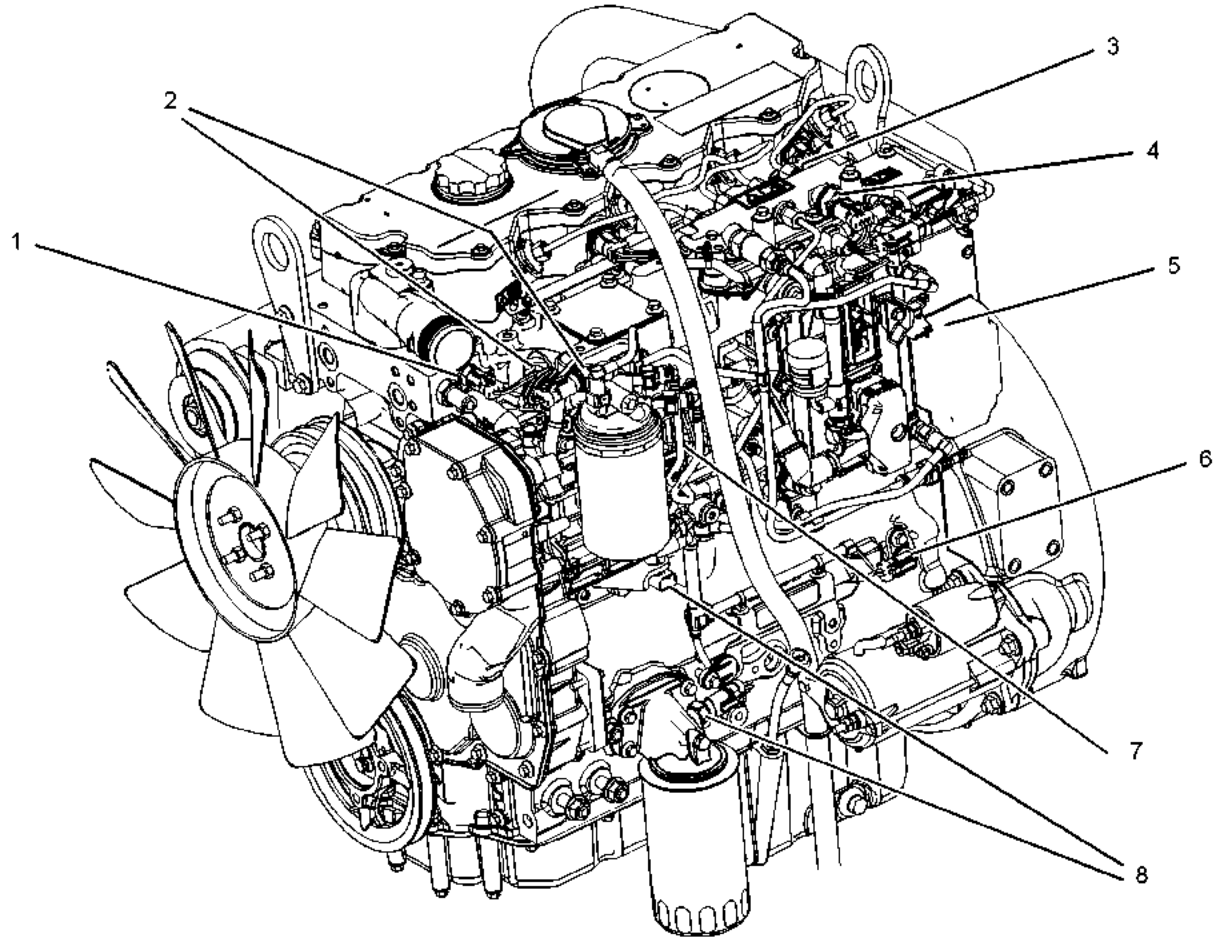


Illustration 26 g01425443

(1) Coolant temperature sensor
(2) Intake manifold pressure sensor
(3) Inlet air temperature sensor
(4) Fuel pressure sensor
(5) Electronic control module
(6) Primary position sensor
(7) Secondary position sensor
(8) Engine oil pressure sensor

Illustration 27 shows the sensors and the ECM in position on the engine.

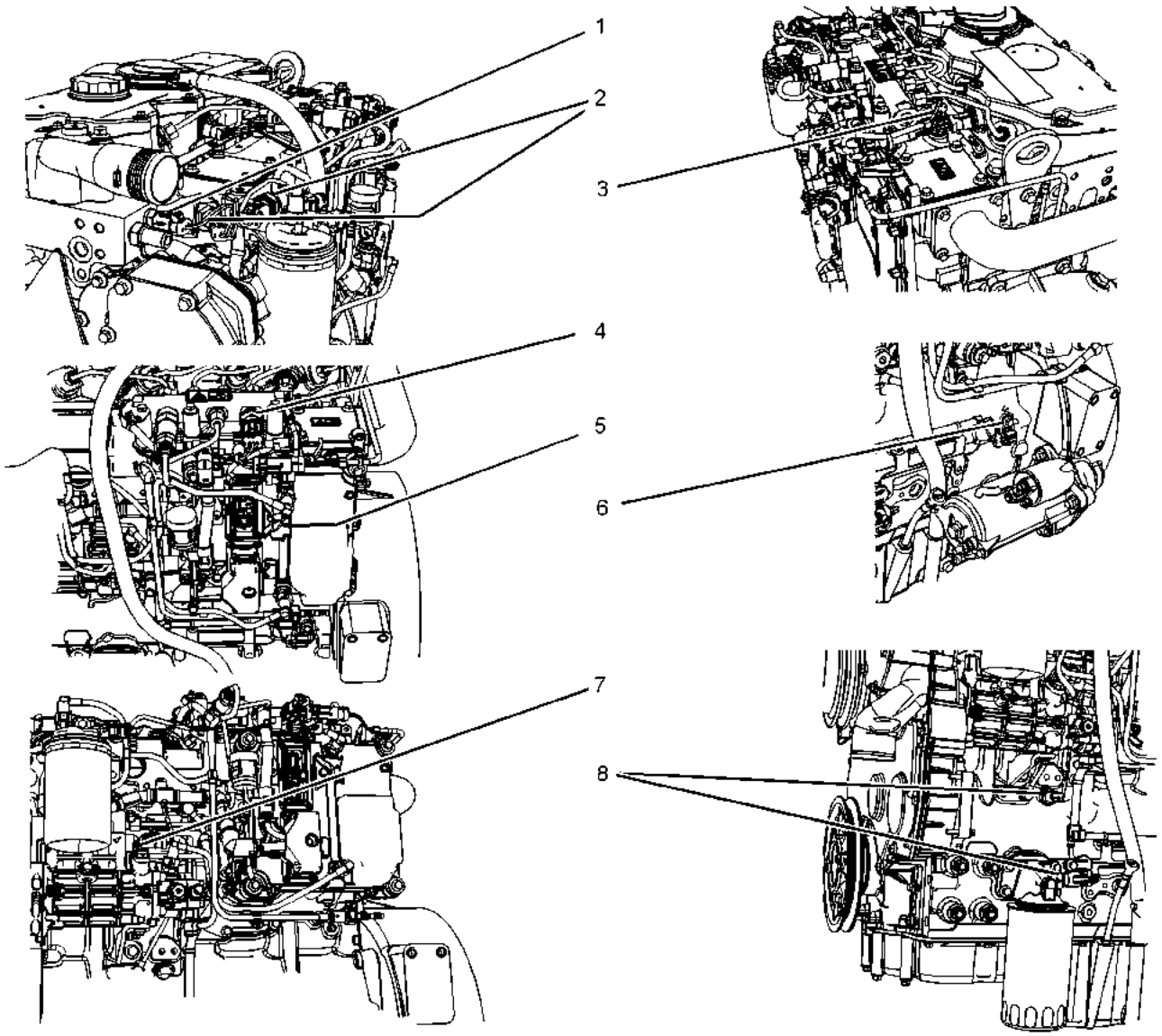


Illustration 27 g01425468

Failure of Sensors

All Sensors

A failure of any of the sensors may be caused by one of the following malfunctions:

- Sensor output is open.
- Sensor output is shorted to “- battery” or “+ battery”.
- Measured reading of the sensor is out of the specification.

Programmable Monitoring System (PMS)

The Programmable Monitoring System determines the level of action that is taken by the Electronic Control Module (ECM) in response to a condition that can damage the engine. These conditions are identified by the ECM from the signals that are produced from the following sensors.

- Coolant Temperature Sensor
- Intake manifold Air Temperature Sensor
- Intake manifold Pressure Sensor
- Fuel Pressure Sensor

- Engine Oil Pressure Sensor
- Primary Speed/Timing Sensor
- Secondary Speed/Timing Sensor

Coolant Temperature Sensor 1

The coolant temperature sensor monitors engine coolant temperature. The output of the ECM (5) can indicate a high coolant temperature through a relay or a lamp. The coolant temperature sensor is used by the ECM to determine initiation of the Cold Start Condition.

Failure of the Coolant Temperature Sensor

The ECM (5) will detect a failure of the coolant temperature sensor. The diagnostic lamp will warn the operator about the status of the coolant temperature sensor. A failure of the coolant temperature sensor will not cause a shutdown of the engine or any horsepower change. In order to check the correct operation of the sensor, refer to Troubleshooting, “Engine Temperature Sensor Circuit - Test”.

Intake Manifold Air Temperature Sensor 2

Note: This sensor can have two different locations. The location will depend on the type of engine.

The intake manifold air temperature sensor measures the intake air temperature. A signal is sent to the ECM (5). The intake manifold air temperature sensor is also used by the ECM to determine initiation of the Cold Start Strategy.

In order to check the correct operation of the sensor, refer to Troubleshooting, “EngineTemperature Sensor Circuit - Test”.

Intake Manifold Pressure Sensor 3

The intake manifold pressure sensor measures pressure in the manifold. A signal is sent to the ECM (5).

Fuel Pressure Sensor 4

The fuel pressure sensor measures the fuel pressure in the fuel manifold. A signal is sent to the ECM (5).

Electronic Control Module 5

The ECM is the control computer of the engine. The ECM provides power to the electronics. The ECM monitors data that is input from the sensors of the engine. The ECM acts as a governor in order to control the speed and the power of the engine.

The ECM adjusts injection timing and fuel pressure for the best engine performance, the best fuel economy and the best control of exhaust emissions.

Primary Speed/Timing Sensor 6

If the ECM (5) does not receive a signal from the primary speed/timing sensor , the “DIAGNOSTIC” lamp will indicate a diagnostic fault code which will be logged in the ECM memory.

If the ECM does not receive a signal from the primary speed/timing sensor (7), the ECM will read the signal from the secondary speed/timing sensor (8). The ECM continually checks in order to determine if there is a signal from both sensors.

Intermittent failure of the sensors will cause erratic engine control.

Failure of the Primary Speed/Timing Sensor

Correct operation of the primary speed/timing sensor is essential. Software in the ECM protects against reverse running of the engine. If the primary speed/timing sensor fails there is no automatic protection against reverse running. In some applications, it is possible for the transmission to run the engine in reverse. In this event, Stop the engine immediately. Turn the keyswitch to the “OFF” position.

In order to check the correct operation of the sensor, refer to Troubleshooting, “Engine speed/Timing sensor - Test”.

Secondary Speed/Timing Sensor 7

The signal from the secondary speed/timing sensor is used by the ECM (5) on engine start-up in order to check the stroke of the pistons. The secondary speed/timing sensor may be used by the ECM in order to operate the engine if the primary speed/timing sensor is faulty.

In order to check the correct operation of the sensor, refer to Troubleshooting, “Engine speed/Timing sensor-Test”.

Engine Oil Pressure Sensor 8

Note: This sensor can have two different locations. The location will depend on the type of engine.

The engine oil pressure sensor is an absolute pressure sensor that measures the engine oil pressure in the main oil gallery. The engine oil pressure sensor detects engine oil pressure for diagnostic purposes. The engine oil pressure sensor sends a signal to the ECM (5).

Low Oil Pressure Warning

The setpoint for the low pressure warning is dependent upon the engine speed. The fault will be active and logged only if the engine has been running for more than 8 seconds.

Very Low Oil Pressure Warning

The very low oil pressure setpoint is dependent upon the engine speed. If the DERATE mode of the engine monitoring system is selected, the ECM (5) will derate the engine power. The engine horsepower will be limited.

Failure of the Engine Oil Pressure Sensor

The ECM (5) will detect failure of the engine oil pressure sensor. The diagnostic lamp warns the user about the status of the engine oil pressure sensor. The engine oil pressure related strategies will be disabled in the event of a failure of the engine oil pressure sensor. A failure of the engine oil pressure sensor will not cause a shutdown of the engine or any horsepower change. In order to check the correct operation of the sensor, refer to Troubleshooting, “5 Volt Sensor Supply Circuit - Test”.

i02858345

Engine Shutoffs and Engine Alarms

SMCS Code: 1900; 7400; 7418

Shutoffs

The shutoffs are electrically operated or mechanically operated. The electrically operated shutoffs are controlled by the ECM.

Shutoffs are set at critical levels for the following items:

- Operating temperature
- Operating pressure
- Operating level
- 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

The alarms are electrically operated. The operation of the alarms are controlled by the ECM.

The alarm is operated by a sensor or by a switch. When the sensor or the switch is activated a signal is sent to the ECM. An event code is created by the ECM. The ECM will send a signal in order to illuminate the lamp.

Your engine may be equipped with the following sensors or switches:

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

Coolant temperature – The coolant temperature sensor indicates high jacket water coolant temperature.

Intake manifold air temperature – The intake manifold air temperature sensor indicates high intake air temperature.

Intake manifold pressure – The intake manifold pressure sensor checks the rated pressure in the engine manifold.

Fuel rail pressure – The fuel rail pressure sensor checks for high pressure or low pressure in the fuel rail.

Engine oil pressure – The engine oil pressure sensor indicates when oil pressure drops below rated system pressure, at a set engine speed.

Engine overspeed – The primary speed/timing sensor checks the engine speed. The alarm is activated at 3000 RPM.

Air filter restriction – The switch checks the air filter when the engine is operating.

User defined switch – This switch can shut down the engine remotely.

Water in fuel switch – This switch checks for water in the primary fuel filter when the engine is operating.

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.

Testing

Turning the keyswitch to the ON position will check the indicator lights on the control panel. All the indicator lights will be illuminated for two seconds after the keyswitch is operated. Replace suspect bulbs immediately.

Refer to Troubleshooting for more information.

i02254118

Overspeed

SMCS Code: 1900; 1907; 1912; 7427

An overspeed condition is detected by the Electronic Control Module (ECM). The event code E0190 will be logged if the engine speed exceeds 3300 rpm. The “DIAGNOSTIC” lamp will indicate a diagnostic fault code. The diagnostic fault code will remain active until the engine speed drops to 2800 rpm.

Engine Diagnostics

i01796959

Self-Diagnostics

SMCS Code: 1000; 1900; 1901; 1902

Caterpillar Electronic Engines have the capability to perform a self-diagnostics test. When the system detects an active problem, a diagnostic lamp is activated. Diagnostic codes will be stored in permanent memory in the Electronic Control Module (ECM). The diagnostic codes can be retrieved by using Caterpillar electronic service tools.

Some installations have electronic displays that provide direct readouts of the engine diagnostic codes. Refer to the manual that is provided by the OEM for more information on retrieving engine diagnostic codes.

Active codes represent problems that currently exist. These problems should be investigated first.

Logged codes represent the following items:

- Intermittent problems
- Recorded events
- Performance history

The problems may have been repaired since the logging of the code. These codes do not indicate that a repair is needed. The codes are guides or signals when a situation exists. Codes may be helpful to troubleshoot problems.

When the problems have been corrected, the corresponding logged fault codes should be cleared.

i02501517

Diagnostic Lamp

SMCS Code: 1000; 1900; 1901; 1902; 7451

A diagnostic lamp is used to indicate the existence of an active fault. A fault diagnostic code will remain active until the problem is repaired. The diagnostic code may be retrieved by using Caterpillar electronic technician (ET).

i02872126

Diagnostic Flash Code Retrieval

SMCS Code: 1000; 1900; 1901; 1902

“Diagnostic” Lamp

Use the “DIAGNOSTIC” Lamp or an electronic service tool to determine the diagnostic flash code.

Use the following procedure to retrieve the flash codes if the engine is equipped with a “DIAGNOSTIC” lamp:

1. Turn the keyswitch “ON/OFF” two times within 3 seconds.

A flashing“YELLOW” lamp indicates a 3 digit code for the engine. The sequence of flashes represents the system diagnostic message. Count the first sequence of flashes in order to determine the first digit of the flash code. After a two second pause, the second sequence of flashes will identify the second digit of the flash code. After the second pause, the third sequence of flashes will identify the flash code.

Any additional flash codes will follow after a pause. These codes will be displayed in the same manner. Flash Code 551 indicates that No Detected Faults have occurred since the ignition keyswitch has been turned to the ON position.

For further information, assistance for repairs, or troubleshooting, refer to the Service Manual or consult an authorized Caterpillar dealer.

Table 3 lists the flash codes and the table also gives a brief description of the flash codes.

Note: Table 3 indicates the potential effect on engine performance with “ACTIVE” flash codes.

Some codes record events. Also, some codes may also indicate that a mechanical system needs attention. Troubleshooting is not required for code “551”. Code 001 will not display a flash code. Some codes will limit the operation or the performance of the engine.

Table 3 indicates the potential effect on the engine performance with active flash codes. Table 3 also forms a list of Electronic diagnostic codes and descriptions.

Table 3

Flash Codes for the Industrial Engine								
Diagnostic Flash Code		**Effect On Engine Performance** (1)				**Suggested Operator Action**		
		Engine Misfire	**Low Power**	**Reduced Engine Speed**	**Engine Shutdown**	**Shut Down the Engine** (2)	**Service** (3)	**Schedule a Service.** (4)
111	Cylinder 1 Fault	X	X				X	
112	Cylinder 2 Fault	X	X				X	
113	Cylinder 3 Fault	X	X				X	
114	Cylinder 4 Fault	X	X				X	
133	Intake Manifold Temperature sensor fault (5)	X					X	
141	Primary Speed/ Timing Sensor Fault			X			X	
142	Secondary Speed/Timing Sensor Fault						X	
143	Timing Calibration Fault	X						X
144	Engine Operation Mode Selector Switch Fault		X				X	
151	High Air Filter Restriction		X				X	
154	Throttle Position sensor Fault			X			X	
155	Secondary Throttle Position sensor Fault			X			X	
157	Oil Pressure Sensor Fault(5)		X	X	X	X	X	
159	Fuel Rail Pressure Sensor Fault		X				X	
162	High Pressure Fuel Pump Fault		X	X			X	
168	Coolant Temperature Sensor Fault			X	X		X	
169	Low Engine Coolant				X			X
177	Wastegate Solenoid Fault			X				
185	High Exhaust Temperature		X				X	
197	Intake Manifold Pressure Sensor Fault		X				X	
199	Glow Plug Start Relay Fault						X	

(continued)

(Table 3, contd)

Flash Codes for the Industrial Engine								
Diagnostic Flash Code		Effect On Engine Performance (1)				Suggested Operator Action		
		Engine Misfire	Low Power	Reduced Engine Speed	Engine Shutdown	Shut Down the Engine (2)	Service (3)	Schedule a Service. (4)
415	Incorrect Engine Software			X	X		X	
426	Machine Security System Module Fault (6)						X	
429	Keyswitch Fault							X
511	Intermittent Battery Power to ECM	X	X		X		X	
514	SAE J1939 Data Link Fault			X			X	
516	5 Volt Sensor DC Power Supply Fault(5)		X					X
517	8 Volt Sensor DC Power Supply Fault		X					X
527	Check Customer Parameters or System Parameters (5)		X	X				X

(1) An “X” indicates that the effect on engine performance may occur if the code is active.
(2) Shut Down the Engine: Operate the engine cautiously. Get immediate service. Severe engine damage may result.
(3) The operator should go to the nearest location that has a qualified service program.
(4) Schedule Service: The problem should be investigated when the operator has access to a qualified service program.
(5) These Flash Codes may affect the system under specific environmental conditions such as engine start-up at cold temperature and cold weather operation at high altitudes.
(6) The engine will not start.

i02512380

Fault Logging

SMCS Code: 1000; 1900; 1901; 1902

The system provides the capability of Fault Logging. When the Electronic Control Module (ECM) generates an active diagnostic code, the code will be logged in the memory of the ECM. The codes that have been logged in the memory of the ECM can be retrieved with Caterpillar electronic service tools. The codes that have been logged can be cleared with Caterpillar electronic service tools. The codes that have been logged in the memory of the ECM will be automatically cleared from the memory after 100 hours. The following faults can not be cleared from the memory of the ECM without using a factory password: overspeed, low engine oil pressure, and high engine coolant temperature.

i01797045

Engine Operation with Active Diagnostic Codes

SMCS Code: 1000; 1900; 1901; 1902

If a diagnostic lamp illuminates during normal engine operation, the system has identified a situation that is not within the specification. Use Caterpillar electronic service tools to check the active diagnostic codes.

Note: If the customer has selected “DERATE” and if there is a low oil pressure condition, the Electronic Control Module (ECM) will limit the engine power until the problem is corrected. If the oil pressure is within the normal range, the engine may be operated at the rated speed and load. However, maintenance should be performed as soon as possible.

The active diagnostic code should be investigated. The cause of the problem should be corrected as soon as possible. If the cause of the active diagnostic code is repaired and there is only one active diagnostic code, the diagnostic lamp will turn off.

Operation of the engine and performance of the engine can be limited as a result of the active diagnostic code that is generated. Acceleration rates may be significantly slower. Refer to the Troubleshooting Guide for more information on the relationship between these active diagnostic codes and engine performance.

i01797063

Engine Operation with Intermittent Diagnostic Codes

SMCS Code: 1000; 1900; 1901; 1902

If a diagnostic lamp illuminates during normal engine operation and the diagnostic lamp shuts off, an intermittent fault may have occurred. If a fault has occurred, the fault will be logged into the memory of the Electronic Control Module (ECM).

In most cases, it is not necessary to stop the engine because of an intermittent code. However, the operator should retrieve the logged fault codes and the operator should reference the appropriate information in order to identify the nature of the event. The operator should log any observation that could have caused the lamp to light.

- Low power
- Limits of the engine speed
- Excessive smoke, etc

This information can be useful to help troubleshoot the situation. The information can also be used for future reference. For more information on diagnostic codes, refer to the Troubleshooting Guide for this engine.

Engine Starting

i02837427

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.

- Ensure that the engine has an adequate fuel supply.
- Open the fuel supply valve (if equipped).

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.
- Reset all of the shutoffs or alarm components.
- Ensure that any driven equipment has been disengaged. Minimize electrical loads or remove any electrical loads.

i02322203

Starting the Engine

SMCS Code: 1000; 1450

Note: Do not adjust the engine speed control during start-up. The electronic control module (ECM) will control the engine speed during start-up.

Starting the Engine

1. Disengage any equipment that is driven by the engine.
2. Turn the keyswitch to the RUN position. Leave the keyswitch in the RUN position until the warning light for the glow plugs is extinguished.
3. When the warning light for the glow plugs is extinguished turn the keyswitch to the START position in order to engage the electric starting motor and crank the engine.

Note: The operating period of the warning light for the glow plugs will change due to the temperature of the engine.

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

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

4. Allow the keyswitch to return to the RUN position after the engine starts.
5. Repeat step 2 through step 4 if the engine fails to start.

i02325155

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 Group 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.

Note: Do not adjust the engine speed control during start-up. The electronic control module (ECM) will control the engine speed during start-up.

1. Disengage any driven equipment.

2. Turn the keyswitch to the RUN position. Leave the keyswitch in the RUN position until the warning light for the glow plugs is extinguished.

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

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

3. When the warning light for the glow plugs is extinguished turn the keyswitch to the START position in order to engage the electric starting motor and crank the engine.

Note: The operating period of the warning light for the glow plugs will change due to the temperature of the engine.

4. Allow the keyswitch to return to the RUN position after the engine starts.

5. Repeat step 2 through step 4 if the engine fails to start.

Note: The engine should not be “raced” in order to speed up the warm up process.

6. Allow the engine to idle for three to five minutes, or allow the engine to idle until the water temperature indicator begins to rise. When idling after the engine has started in cold weather, increase the engine rpm from 1000 to 1200 rpm. This will warm up the engine more quickly. Maintaining an elevated low idle speed for extended periods will be easier with the installation of a hand throttle. 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.

i02344933

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.

For information on troubleshooting the charging system, refer to Special Instruction, REHS0354, “Charging System Troubleshooting”.

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 the engine’s 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 the combustible gases that are produced by some batteries.

4. Start the engine.

5. Immediately after the engine is started, disconnect the jump start cables in reverse order.

After jump starting, the alternator may not be able to fully recharge batteries that are severely discharged. The batteries must be replaced or charged to the proper voltage with a battery charger after the engine is stopped. Many batteries which are considered unusable are still rechargeable. Refer to Operation and Maintenance Manual, “Battery - Replace” and Testing and Adjusting Manual, “Battery - Test”.

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

i02330138

After Starting Engine

SMCS Code: 1000

Note: In ambient 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.

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

Do not check the high pressure fuel lines with the engine or the starting motor in operation. If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, “General hazard Information”.

- 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.

- Allow the engine to idle for three to five minutes, or allow the engine to idle until the water temperature indicator begins to rise. 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

i01646252

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 taken for a walk-around inspection of the engine.

The engine can be operated at the rated rpm after the engine is started and after the engine reaches operating temperature. The engine will reach normal operating temperature sooner during a low engine speed (rpm) and during a 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.

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.

i01457002

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. Refer to the Operations and Maintenance Manual, "Fuel Recommendations"for further information.

- Avoid unnecessary idling.

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

- Observe the service indicator frequently. Keep the air cleaner elements clean.

- Ensure that the turbocharger is operating correctly so that the proper air/fuel ratio is maintained. Clean exhaust indicates proper functioning.

- Maintain a good electrical system.

One faulty 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. Refer to the Specifications manual for further information.

- 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.

Engine Stopping

i02334873

Stopping the Engine

SMCS Code: 1000; 7000

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

Avoid accelerating the engine prior to shutting it down.

Avoiding hot engine shutdowns will maximize turbocharger shaft and bearing life.

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

1. Remove the load from the engine. Reduce the engine speed (rpm) to low idle. Allow the engine to idle for five minutes in order to cool the engine.
2. Stop the engine after the cool down period according to the shutoff system on the engine and turn the ignition key switch to the OFF position. If necessary, refer to the instructions that are provided by the OEM.

i02255774

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

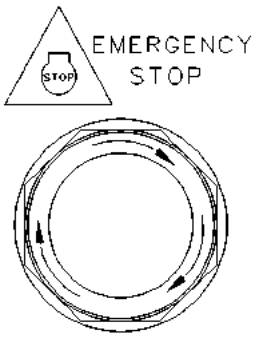


Illustration 28 g00104303
Typical emergency stop button

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.

Refer to Operation and Maintenance Manual, “Features and Controls” for the location and the operation of the emergency stop button.

i02330274

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.

⚠ 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.

- After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, “Fuel Injection Lines - Install”.

- Check the crankcase oil level. Maintain the oil level between the “MIN” mark and the “MAX” mark on the engine oil level gauge.

- If the engine is equipped with a service hour meter, note the reading. Perform the maintenance that is in the Operation and Maintenance Manual, “Maintenance Interval Schedule”.

- Fill the fuel tank in order to help prevent accumulation of moisture in the fuel. Do not overfill the fuel tank.

NOTICE

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

⚠ 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.

- Allow the engine to cool. Check the coolant level.

- Check the coolant for correct antifreeze protection and the correct corrosion protection. Add the correct 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

i02724382

Cold Weather Operation

SMCS Code: 1000; 1250

Caterpillar Diesel Engines can operate effectively in cold weather. During cold weather, the starting and the operation of the diesel engine is dependent on the following items:

- The type of fuel that is used
- The viscosity of the engine oil
- The operation of the glow plugs
- Optional Cold starting aid
- Battery condition

Refer to Special Publication, SEBU5898, “Cold Weather Recommendations for Caterpillar Machines”.

This section will cover the following information:

- Potential problems that are caused by cold weather operation
- Suggest steps which can be taken in order to minimize starting problems and operating problems when the ambient air temperature is between 0° to −40 °C (32° to 40 °F).

The operation and maintenance of an engine in freezing temperatures is complex . This is because of the following conditions:

- Weather conditions
- Engine applications

Recommendations from your Carerpillar dealer are based on past proven practices. The information that is contained in this section provides guidelines for cold weather operation.

Hints for Cold Weather Operation

- If the engine will start, operate the engine until a minimum operating temperature of 81 °C (177.8 °F) is achieved. Achieving operating temperature will help prevent the intake valves and exhaust valves from sticking.
- The cooling system and the lubrication system for the engine do not lose heat immediately upon shutdown. This means that an engine can be shut down for a period of time and the engine can still have the ability to start readily.
- Install the correct specification of engine lubricant before the beginning of cold weather.
- Check all rubber parts (hoses, fan drive belts, etc) weekly.
- Check all electrical wiring and connections for any fraying or damaged insulation.
- Keep all batteries fully charged and warm.
- Fill the fuel tank at the end of each shift.
- Check the air cleaners and the air intake daily. Check the air intake more often when you operate in snow.
- Ensure that the glow plugs are in working order. Refer to Testing and Adjusting Manual, “Glow Plug - Test”.

⚠ WARNING

Personal injury or property damage can result from alcohol or starting fluids.

Alcohol or starting fluids are highly flammable and toxic and if improperly stored could result in injury or property damage.

⚠ WARNING

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

- For jump starting with cables in cold weather, refer to the Operation and Maintenance Manual, “Starting with Jump Start Cables.” for instructions.

Viscosity of the Engine Lubrication Oil

Correct engine oil viscosity is essential. Oil viscosity affects the amount of torque that is needed to crank the engine. Refer to this Operation and Maintenance Manual, “Fluid Recommendations” for the recommended viscosity of oil.

Recommendations for the Coolant

Provide cooling system protection for the lowest expected outside temperature. Refer to this Operation and Maintenance Manual, “Fluid Recommendations” for the recommended coolant mixture.

In cold weather, check the coolant often for the correct glycol concentration in order to ensure adequate freeze protection.

Engine Block Heaters

Engine block heaters (if equipped) heat the engine jacket water that surrounds the combustion chambers. This provides the following functions:

- Startability is improved.
- Warm up time is reduced.

An electric block heater can be activated once the engine is stopped. An effective block heater is typically a 1250/1500 W unit. Consult your Caterpillar dealer for more information.

Idling the Engine

When idling after the engine is started in cold weather, increase the engine rpm from 1000 to 1200 rpm. This will warm up the engine more quickly. Maintaining an elevated low idle speed for extended periods will be easier with the installation of a hand throttle. The engine should not be “raced” in order to speed up the warm up process.

While the engine is idling, the application of a light load (parasitic load) will assist in achieving the minimum operating temperature. The minimum operating temperature is 82 °C (179.6 °F).

Recommendations for Coolant Warm Up

Warm up an engine that has cooled below normal operating temperatures due to inactivity. This should be performed before the engine is returned to full operation. During operation in very cold temperature conditions, damage to engine valve mechanisms can result from engine operation for short intervals. This can happen if the engine is started and the engine is stopped many times without being operated in order to warm up completely.

When the engine is operated below normal operating temperatures, fuel and oil are not completely burned in the combustion chamber. This fuel and oil causes soft carbon deposits to form on the valve stems. Generally, the deposits do not cause problems and the deposits are burned off during operation at normal engine operating temperatures.

When the engine is started and the engine is stopped many times without being operated in order to warm up completely, the carbon deposits become thicker. This can cause the following problems:

- Free operation of the valves is prevented.
- Valves become stuck.
- Pushrods may become bent.
- Other damage to valve train components can result.

For this reason, when the engine is started, the engine must be operated until the coolant temperature is 71 °C (160 °F) minimum. Carbon deposits on the valve stems will be kept at a minimum and the free operation of the valves and the valve components will be maintained.

In addition, the engine must be thoroughly warmed in order to keep other engine parts in better condition and the service life of the engine will be generally extended. Lubrication will be improved. There will be less acid and less sludge in the oil. This will provide longer service life for the engine bearings, the piston rings, and other parts. However, limit unnecessary idle time to ten minutes in order to reduce wear and unnecessary fuel consumption.

The Water Temperature Regulator and Insulated Heater Lines

The engine is equipped with a water temperature regulator. When the engine coolant is below the correct operating temperature jacket water circulates through the engine cylinder block and into the engine cylinder head. The coolant then returns to the cylinder block via an internal passage that bypasses the valve of the coolant temperature regulator. This ensures that coolant flows around the engine under cold operating conditions. The water temperature regulator begins to open when the engine jacket water has reached the correct minimum operating temperature. As the jacket water coolant temperature rises above the minimum operating temperature the water temperature regulator opens further allowing more coolant through the radiator to dissipate excess heat.

The progressive opening of the water temperature regulator operates the progressive closing of the bypass passage between the cylinder block and head. This ensures maximum coolant flow to the radiator in order to achieve maximum heat dissipation.

Note: Caterpillar discourages the use of all air flow restriction devices such as radiator shutters. Restriction of the air flow can result in the following: high exhaust temperatures, power loss, excessive fan usage, and reduction in fuel economy.

A cab heater is beneficial in very cold weather. The feed from the engine and the return lines from the cab should be insulated in order to reduce heat loss to the outside air.

Insulating the Air Inlet and Engine Compartment

When temperatures below −18 °C (−0 °F) will be frequently encountered, an air cleaner inlet that is located in the engine compartment may be specified. An air cleaner that is located in the engine compartment may also minimize the entry of snow into the air cleaner. Also, heat that is rejected by the engine helps to warm the intake air.

Additional heat can be retained around the engine by insulating the engine compartment.

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.

i02237624

Fuel and the Effect from Cold Weather

SMCS Code: 1000; 1250

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

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

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

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

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

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

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

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

Be aware of these values when diesel fuel is purchased. Anticipate the average ambient temperature 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”.

i02785732

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, service intervals, 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

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 four micron[c] absolute high efficiency fuel filter is required for all Caterpillar Hydraulic 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

i02872195

Refill Capacities and Recommendations

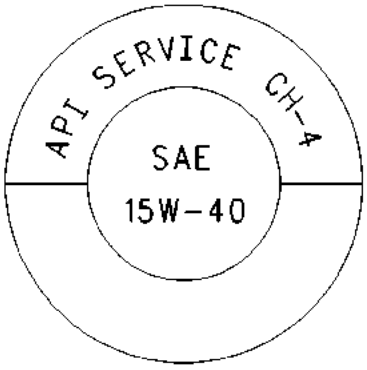
SMCS Code: 1348; 1395; 7560

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.



g00546535

Illustration 29
Typical API symbol

Diesel engine oils CC, CD, CD-2, and CE have not been API authorized classifications since 1 January 1996.

Table 4

API Classifications	
Current	**Obsolete**
CH-4(1) CI-4	CE, CC, CD
-	CD-2 (2)

(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) The oil CD-2 is for a two-cycle diesel engine. Caterpillar does not sell engines that utilize CD-2 oil.

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 6. 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 manufacturer's 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

In order to select the correct engine oil for the C-4.4 electronic engine, you must refer to table 5.

Table 5

API Classifications for the C-4.4 electronic Industrial Engine	
Oil Specification	**Maintenance Interval**
CH-4/CI-4	500 Hours
CI-4	500 Hours
CG-4	250 Hours

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

Refer to Table 6 (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 6

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 7

Engine Refill Capacities		
Compartment or System	**Minimum**	**Maximum**
Crankcase Oil Sump(1)	5 L (5.2834 qt)	7 L (7.3968 qt)

(1) These values are the approximate capacities for the crankcase oil sump (aluminum) which includes the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.

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 can not 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.

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 8.

Table 8

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 antifreezes use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. See Tables 9 and 10.

Table 9

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 propylene glycol's reduced heat transfer capability. Use ethylene glycol in conditions that require additional protection against boiling or freezing.

Table 10

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 antifreeze 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 antifreeze.

Note: Caterpillar DEAC does not require a treatment with an SCA at the initial fill. A commercial heavy-duty antifreeze 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 11

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 antifreeze that is required for the Total Cooling System.

Table 12

Engine Refill Capacities	
Compartment or System	**Liters**
Engine Only	7 L (7.3968 qt)
External System Per OEM(1)	

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

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Maintenance Interval Schedule

SMCS Code: 1000; 7500

When Required

Daily

Every 50 Service Hours or Weekly

Every 250 Service Hours

Initial 500 Service Hours

Every 500 Service Hours

Every 500 Service Hours or 2 Months

Every 500 Service Hours or 1 Year

Every 1000 Service Hours

Every 2000 Service Hours

Every 2000 Service Hours or 1 Year

Every Year

Every 3000 Service Hours

Every 3000 Service Hours or 2 Years

Every 4000 Service Hours

Every 6000 Service Hours or 3 Years

Every 12 000 Service Hours or 6 Years

Overhaul

Commissioning

i01546702

Aftercooler Core - Clean/Test

SMCS Code: 1064-070; 1064-081

1. Remove the core. Refer to the Service Manual for the procedure.

2. Turn the aftercooler core upside-down in order to remove debris.

NOTICE
Do not use a high concentration of caustic cleaner to clean the core. A high concentration of caustic cleaner can attack the internal metals of the core and cause leakage. Only use the recommended concentration of cleaner.

3. Back flush the core with cleaner.

   Caterpillar recommends the use of Hydrosolv liquid cleaner. Table 13 lists Hydrosolv liquid cleaners that are available from your Caterpillar dealer.

Table 13

Hydrosolv Liquid Cleaners(1)		
Part Number	**Description**	**Size**
1U-5490	Hydrosolv 4165	19 L (5 US gallon)
174-6854	Hydrosolv 100	19 L (5 US gallon)

(1) Use a two to five percent concentration of the cleaner at temperatures up to 93°C (200°F). Refer to Application Guide, NEHS0526 or consult your Caterpillar dealer for more information.

4. Steam clean the core in order to remove any residue. Flush the fins of the aftercooler core. Remove any other trapped debris.

5. Wash the core with hot, soapy water. Rinse the core thoroughly with clean water.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

6. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.

7. Inspect the core in order to ensure cleanliness. Pressure test the core. Many shops that service radiators are equipped to perform pressure tests. If necessary, repair the core.

8. Install the core. Refer to the Service Manual for the procedure.

For more information on cleaning the core, consult your Caterpillar dealer.

i01468985

Aftercooler Core - Inspect

SMCS Code: 1064-040

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.

i02491869

Alternator Belt - Inspect/Adjust/Replace (Poly V-Belt)

SMCS Code: 1357-036; 1357-510

Inspection

To maximize the engine performance, inspect the belt (1) for wear and for cracking. Replace the belt if the belt is worn or damaged.

- If the belt (1) has more than four cracks per 25.4000 mm (1 inch) the belt must be replaced.
- Check the belt of cracks, splits, glazing, grease, and splitting.

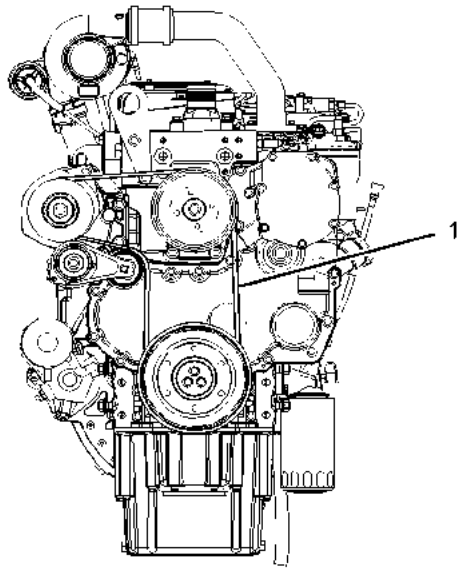


Illustration 30 g01251375

Typical example

Adjustment

This type of belt has an automatic belt tensioner.

Replace

Refer to Disassembly and Assembly manual, “Alternator Belt - Remove and Install”.

i02322315

Battery - Replace

SMCS Code: 1401-510

WARNING

Batteries give off combustible gases which can explode. A spark can cause the combustible gases to ignite. This can result in severe personal injury or death.

Ensure proper ventilation for batteries that are in an enclosure. Follow the proper procedures in order to help prevent electrical arcs and/or sparks near batteries. Do not smoke when batteries are serviced.

WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Switch the engine to the OFF position. Remove all electrical loads.
2. Turn off any battery chargers. Disconnect any battery chargers.
3. The NEGATIVE “-” cable connects the NEGATIVE “-” battery terminal to the NEGATIVE “-” terminal on the starting motor. Disconnect the cable from the NEGATIVE “-” battery terminal.
4. The POSITIVE “+” cable connects the POSITIVE “+” battery terminal to the POSITIVE “+” terminal on the starting motor. Disconnect the cable from the POSITIVE “+” battery terminal.

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

5. Remove the used battery.
6. Install the new battery.

Note: Before the cables are connected, ensure that the engine start switch is OFF.

7. Connect the cable from the starting motor to the POSITIVE “+” battery terminal.
8. Connect the NEGATIVE “-” cable to the NEGATIVE “-” battery terminal.

i02724529

Battery Electrolyte Level - Check

SMCS Code: 1401-535

When the engine is not run for long periods of time or when the engine is run for short periods, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing. If batteries are properly charged, ammeter reading should be very near zero,when the engine is in operation.

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:

   - Use a solution of 0.1 kg (0.2 lb) baking soda and 1 L (1 qt) of clean water.
   - Use a solution of ammonium hydroxide.

   Thoroughly rinse the battery case with clean water.

   Use a fine grade of sandpaper to clean the terminals and the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to not fit properly. Coat the clamps and the terminals with 5N-5561 Silicone Lubricant, petroleum jelly or MPGM.

i02323088

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.

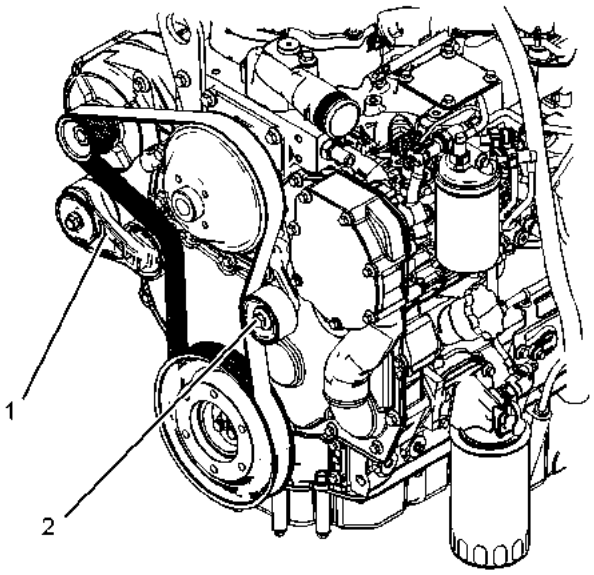
Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

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. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, two negative connection must be disconnected.
3. Remove the positive connection.
4. Clean all disconnected connection and battery terminals.
5. Use a fine grade of sandpaper to clean the terminals and the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to not fit correctly. Coat the clamps and the terminals with a suitable silicone lubricant or petroleum jelly.
6. Tape the cable connections in order to help prevent accidental starting.
7. Proceed with necessary system repairs.
8. In order to connect the battery, connect the positive connection before the negative connector.

i02870187

Belt Tensioner - Inspect

SMCS Code: 1358-040



g01429637

Illustration 31

Typical example

Remove the belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install”.

Ensure that the belt tensioner is securely installed. Visually inspect the belt tensioner (1) for damage. Check that the roller on the tensioner rotates freely. Some engines have a guide roller (2). Ensure that the guide roller is securely installed. Visually inspect the guide roller for damage. Ensure that the guide roller can rotate freely.

Install the belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install”.

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.

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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.

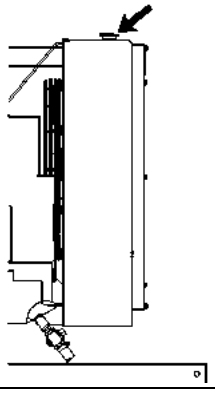


Illustration 32 g00285520

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.

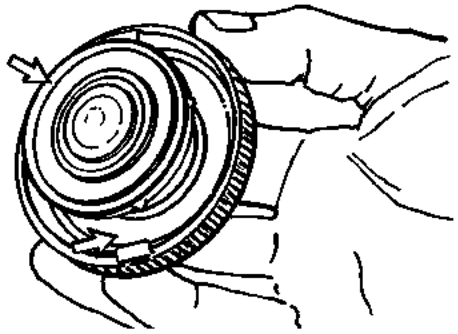


Illustration 33 g00103639

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.

i02837191

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 that are filled with Cat ELC should have a Coolant Sample (Level 2) that is obtained at the recommended interval that is 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. This includes the following types of 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 14

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
Cat DEAC	Every 250 Hours(1)	Yearly(1)(2)
Cat ELC	Optional(2)	Yearly(2)

(1) This is the recommended interval for coolant samples for all conventional heavy-duty coolant/antifreeze. This is also the recommended interval for coolant samples of commercial coolants that meet the Cat EC-1 specification for engine coolant.

(2) 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, you must 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.

i01987714

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.

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.

i02623972

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 two articles in the Disassembly and Assembly Manual, “Water Temperature Regulators - Remove and Water Temperature Regulators - Install” for the replacement procedure of the water temperature regulator, or consult your Caterpillar dealer.

Note: If only the water temperature regulators are replaced, drain the coolant from the cooling system to a level that is below the water temperature regulator housing.

i02866782

Crankcase Breather (Canister) - Replace

SMCS Code: 1317-510

NOTICE
Ensure that the engine is stopped before any servicing or repair is performed.

Note: The breather assembly is not installed on all engines.

1. Place a container under the canister (1).

2. Clean the outside of the canister. Use a suitable tool in order to remove the canister.

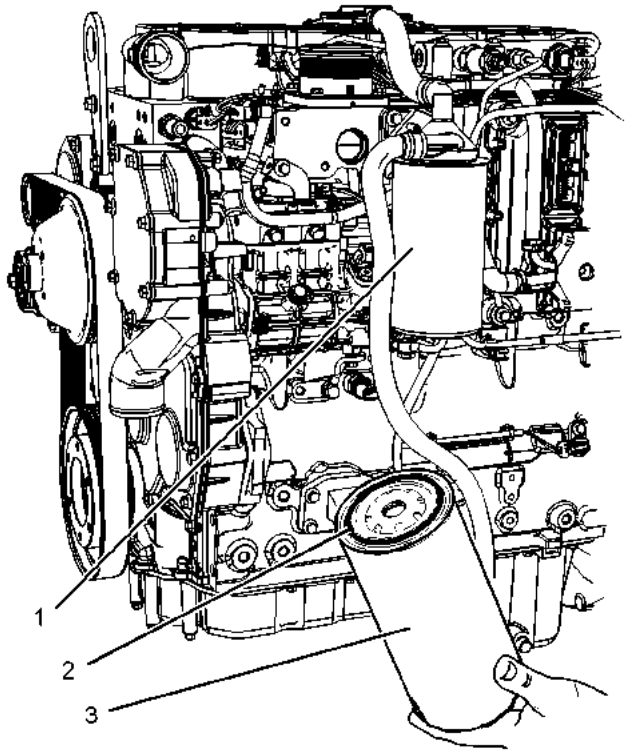


Illustration 34 g01428096
Typical example

3. Lubricate the O ring seal (2) on the new canister (3) with clean engine lubricating oil. Install the new canister. Tighten the canister to 12 N·m (8 lb ft). Do not overtighten the canister.

4. Remove the container. Dispose of the old canister and any split oil in a safe place.

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.

i02345750

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 the engine is cleaned. Pressure washers and steam cleaners should not be directed at any electrical connectors or the junction of cables into the rear of the connectors. Avoid electrical components such as the alternator, the starter, and the ECM. Protect the fuel injection pump from fluids in order to wash the engine.

i01553486

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

SMCS Code: 1054-037; 1054-510

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent 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.

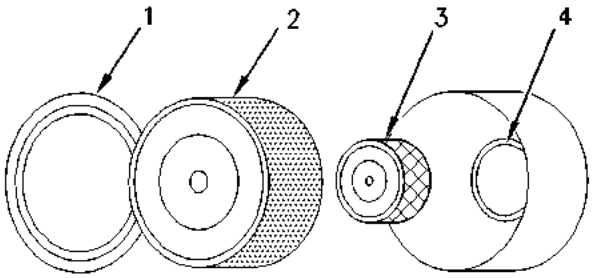


Illustration 35 g00736431

(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 dirt out.

4. Clean the inside of the air cleaner cover and body with a clean, dry cloth.

5. Remove the tape for the turbocharger air inlet. Install the secondary air cleaner element. Install a primary air cleaner element that is new or cleaned.

6. Install the air cleaner cover.

7. Reset the air cleaner service indicator.

Cleaning the Primary Air Cleaner Elements

NOTICE
Caterpillar recommends certified air filter cleaning services that are available at Caterpillar dealers. The Caterpillar 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).

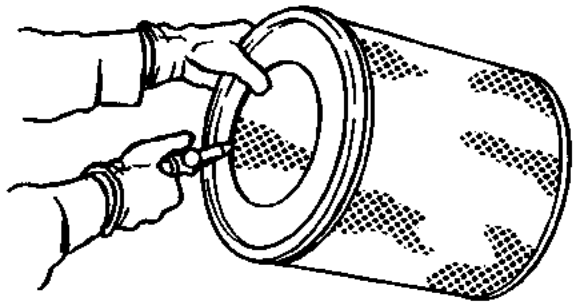


Illustration 36 g00281692

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

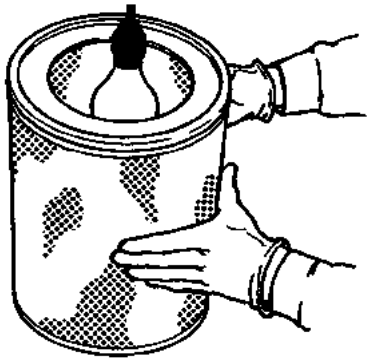


Illustration 37 g00281693

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.

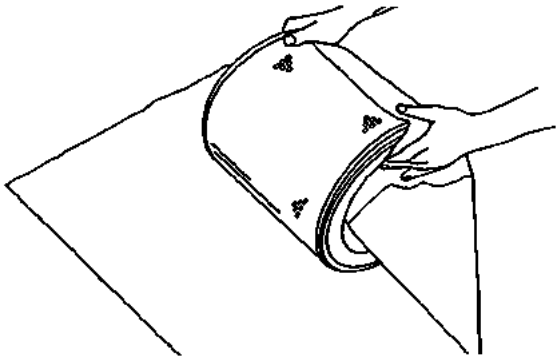


Illustration 38 g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. An airflow restriction may result. To protect against dirt and damage, wrap the primary air cleaner elements in Volatile Corrosion Inhibited (VCI) paper.

Place the primary air cleaner element into a box for storage. For identification, mark the outside of the box and mark the primary air cleaner element. Include the following information:

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i02242500

Engine Air Cleaner Element (Single Element) - Replace

SMCS Code: 1051; 1054-510

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

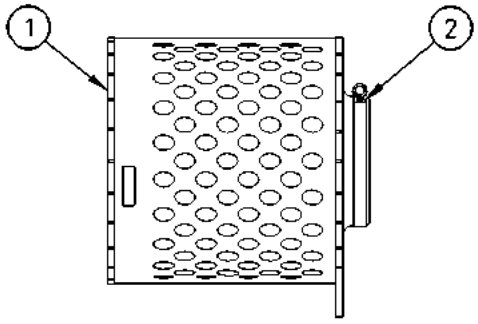


Illustration 39 g00109823

(1) Air cleaner element. (2) Clamp.

1. Loosen clamp (2) which fastens air cleaner element (1) to the air inlet. Remove the dirty air cleaner element and clamp.
2. Install clamp (2) on new air cleaner element (1).
3. Install new air cleaner element (1) to the air inlet and tighten clamp (2). Refer to Torque Specifications, SENR3130 for the correct torque.

i02335405

Engine Air Cleaner Service Indicator - Inspect

SMCS Code: 7452-040

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The differential gauge for inlet air pressure displays the difference in the pressure that is measured before the air cleaner element and the pressure that is measured after the air cleaner element. As the air cleaner element becomes dirty, the pressure differential rises. If your engine is equipped with a different type of service indicator, follow the OEM recommendations in order to service the air cleaner service indicator.

The service indicator may be mounted on the air cleaner element or in a remote location.

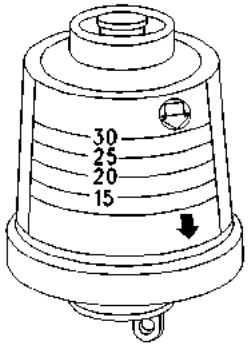


Illustration 40 g00103777

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 yellow core when the engine is accelerated to the engine rated speed. The yellow core should latch at the greatest vacuum that is attained.

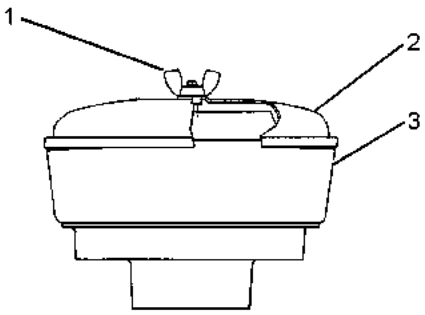
If the service indicator does not reset easily, or if the yellow core does not latch at the greatest vacuum, the service indicator should be replaced. If the new service indicator will not reset, the hole for the service indicator may be restricted.

The service indicator may need to be replaced frequently in environments that are severely dusty.

i02927289

Engine Air Precleaner - Check/Clean

SMCS Code: 1055-070; 1055-535



g01453058

Illustration 41

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.

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.

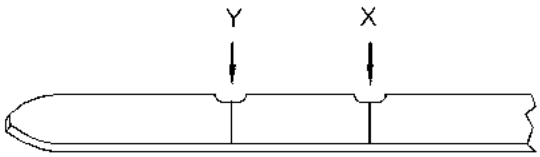
i02335785

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.



g01165836

Illustration 42

(Y) “Min” mark. (X) “Max” mark.

NOTICE
Perform this maintenance with the engine stopped.

Note: Ensure that the engine is either level or that the engine is in the normal operating position in order to obtain a true level indication.

Note: After the engine has been switched OFF, wait for ten minutes in order to allow the engine oil to drain to the oil pan before checking the oil level.

1. Maintain the oil level between the “ADD” mark (Y) and the “FULL” mark (X) on the engine oil dipstick. Do not fill the crankcase above the “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.

i01935337

Engine Oil Sample - Obtain

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

In addition to a good preventive maintenance program, Caterpillar recommends using S·O·S oil analysis at regularly scheduled intervals in order to monitor the condition of the engine and the maintenance requirements of the engine. 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, well mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

Caterpillar recommends using the sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when the sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

The 169-8373 Fluid Sampling Bottle is recommended for use with the sampling valve. The fluid sampling bottle includes the parts that are needed for obtaining oil samples. Instructions are also provided.

NOTICE
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, PEHP6001, “How To Take A Good Oil Sample”. Consult your Caterpillar dealer for complete information and assistance in establishing an S·O·S program for your engine.

i02873596

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 engine lubricating oil when the engine is cold. As the engine lubricating oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed with draining cold oil. Drain the oil pan with the engine stopped. Drain the oil pan with the oil warm. This draining method allows the waste particles that are suspended in the oil to be drained properly.

Failure to follow this recommended procedure will cause the waste particles to be recirculated through the engine lubrication system with the new oil.

Drain the Engine Lubricating Oil

Note: Ensure that the vessel that will be used is large enough to collect the waste 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 oil pan:

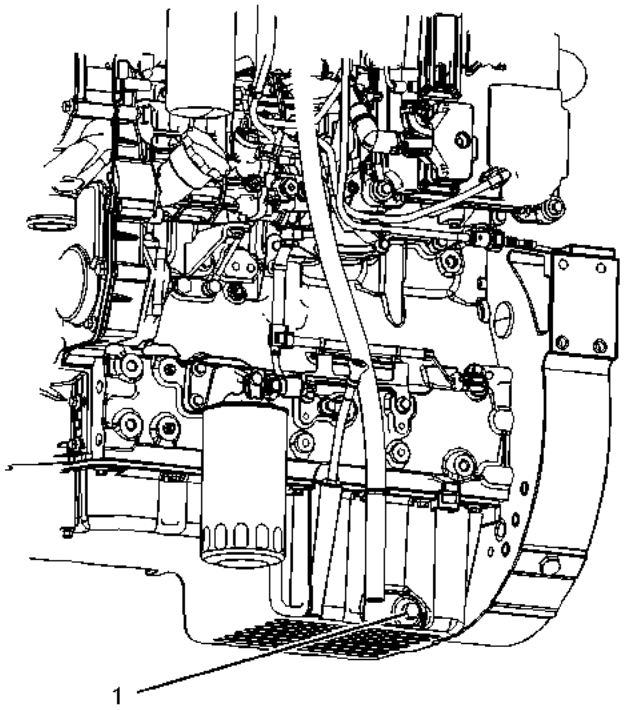


Illustration 43 g01430582

Typical example

- 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 (1) in order to allow the oil to drain. If the engine is equipped with a shallow oil pan, remove the bottom oil drain plugs from both ends of the oil pan.

After the oil has drained, the oil drain plugs should be cleaned and installed. If necessary, replace the O ring seal. Tighten the drain plug to 34 N·m (25 lb ft).

Replace the Oil Filter

NOTICE

Caterpillar oil filters are manufactured to Caterpillar specifications. Use of an oil filter that is not recommended by Caterpillar could result in severe 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: Some oil filters may be installed horizontally. This type of oil filter can be drained before the filter is removed. The torque for this drain plug is 12 N·m (8 lb ft).

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

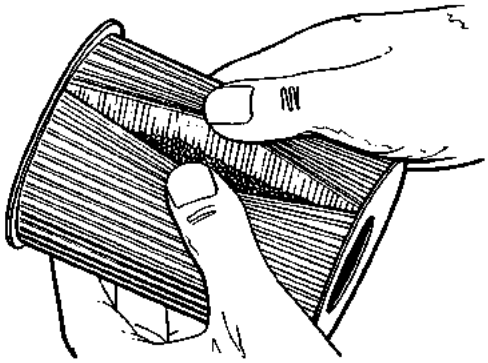


Illustration 44 g00588944

Element with debris

2. Cut the oil filter open with a 175-7546 Oil Filter Cutter . Break apart the pleats and inspect the oil filter for metal debris. An excessive amount of metal debris in the oil filter may indicate early wear or a pending failure.

Use a magnet to differentiate between the ferrous metals and the nonferrous metals that are found in the oil filter element. Ferrous metals may indicate wear on the steel and cast iron parts of the engine.

Nonferrous metals may indicate wear on the aluminum parts, brass parts or bronze parts of the engine. Parts that may be affected include the following items: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter. Consult your Caterpillar dealer in order to arrange for a further analysis if an excessive amount of debris is found in the oil filter.

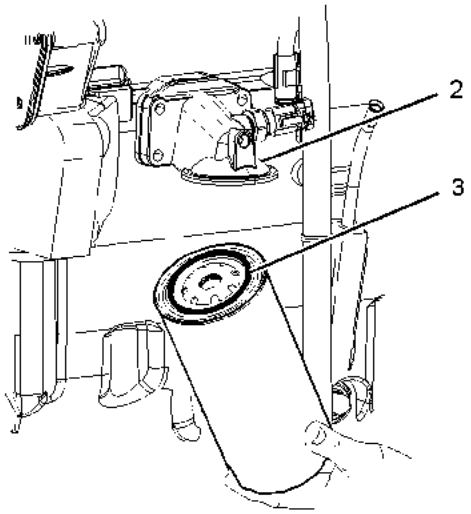


Illustration 45 g01187802
Typical example

3. Clean the sealing surface of the oil filter head (2). Ensure that the union is secure in the filter head.

4. Apply clean engine oil to the O ring seal (3) for the new oil filter.

Note: Some oil filters may be installed horizontally. Refer to the illustration . This type of oil filter assembly can be drained before the filter is removed. The torque for this drain plug (4) is 12 N·m (8 lb ft). If necessary, install a new O ring seal (5). Start at step 1 in order to remove the oil filter and install the oil filter.

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.

Horizontal Oil Filter

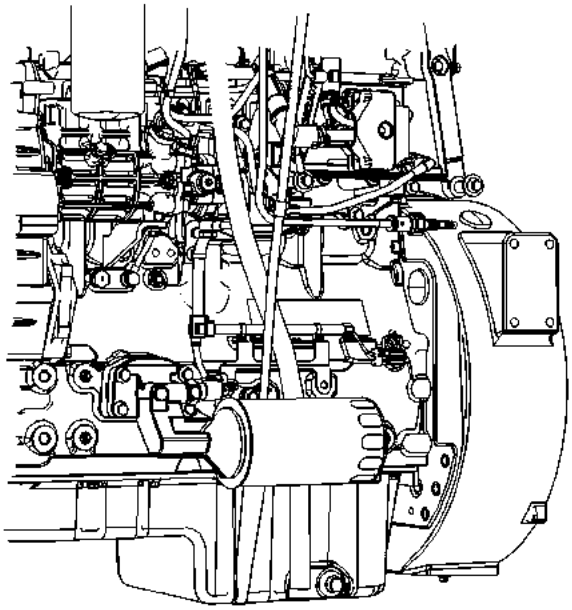


Illustration 46 g01430585
Typical example

Note: Some oil filters may be installed horizontally. Refer to illustration 46. This type of oil filter assembly can be drained before the filter is removed. Start at step 1 in order to remove the oil filter and install the oil filter.

Fill the Oil Pan

1. Remove the oil filler cap. Refer to this Operation and Maintenance Manual, “Fluid Recommendations” for more information on suitable oils. Fill the oil pan with the correct amount of new engine lubricating oil. Refer to this Operation and Maintenance Manual, “Refill Capacities” for more information on refill capacities.

NOTICE
If equipped with an auxilliary oil filter system or a remote filter system, follow the OEM or the filter manufacture’s remonmendations. Under filling or over filling the crankcase with oil can cause engine damage.

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 oil pan for a minimum of ten minutes.

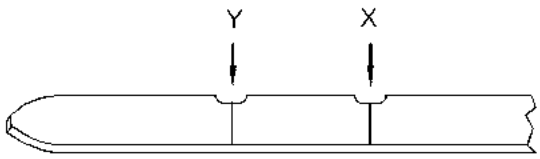


Illustration 47 g01165836

Typical example

4. Remove the engine oil level gauge in order to check the oil level. Maintain the oil level between the “MIN” and “MAX” marks on the engine oil level gauge.

i02869394

Engine Oil and Filter - Change (CG-4 Oil)

SMCS Code: 1318-510; 1348-044

CG-4 engine oil may be used. If this grade of engine oil is used a 250 hour service interval is required for the engine oil and the engine oil filter.

i02519453

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.

NOTICE

Only qualified service personnel should perform this maintenance. Refer to the Service Manual or your Caterpillar dealer for the complete valve lash adjustment procedure.

Operation of Caterpillar engines with improper valve adjustments can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

⚠ WARNING

Ensure that the engine can not be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.

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

Ensure that the engine is stopped before measuring the valve lash. To obtain an accurate measurement, allow the valves to cool before this maintenance is performed.

Refer to the Service Manual for more information.

i02862580

Exhaust Manifold - Inspect

SMCS Code: 1059-040

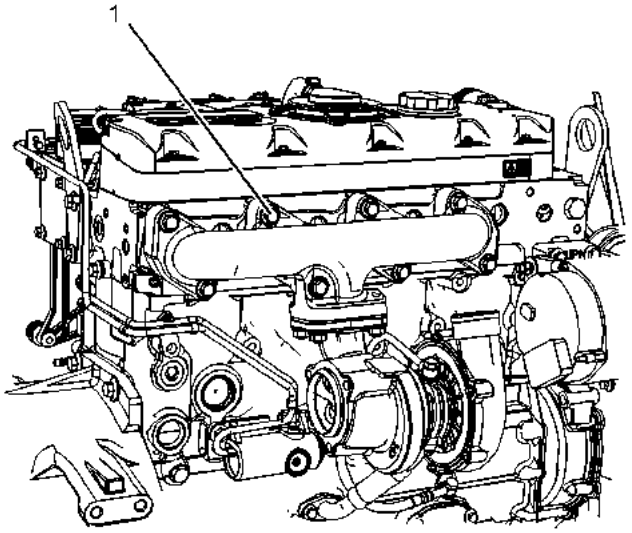


Illustration 48 g01425829

1. Inspect the exhaust manifold for damage. If necessary, replace the exhaust manifold. Refer to Disassembly and Assembly, “Exhaust Manifold - Remove and Install”.

2. Check the torque on all the bolts (1). The bolts must be tightened in the sequence that is shown in illustration 49.

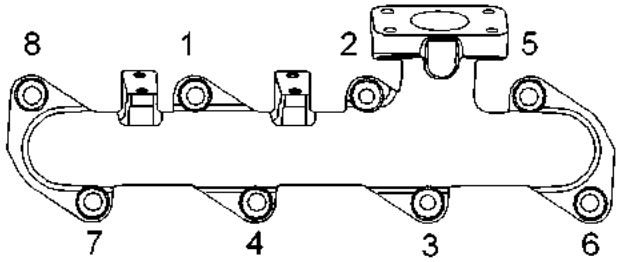


Illustration 49 g01363916

3. Tighten the bolts to the following torque 40 N·m (29.5 lb ft).

i02683336

Fan Clearance - Check

SMCS Code: 1356; 1359; 1360

There are different types of cooling systems. Refer to the OEM for information on clearance for the fan.

Ensure that the engine is stopped. Ensure that the cooling system is full. The clearance between the cover (1) and the fan (2) will require checking. The gap (A) between the edge of the cover and the tip of the fan blade must be checked in four equally spaced positions.

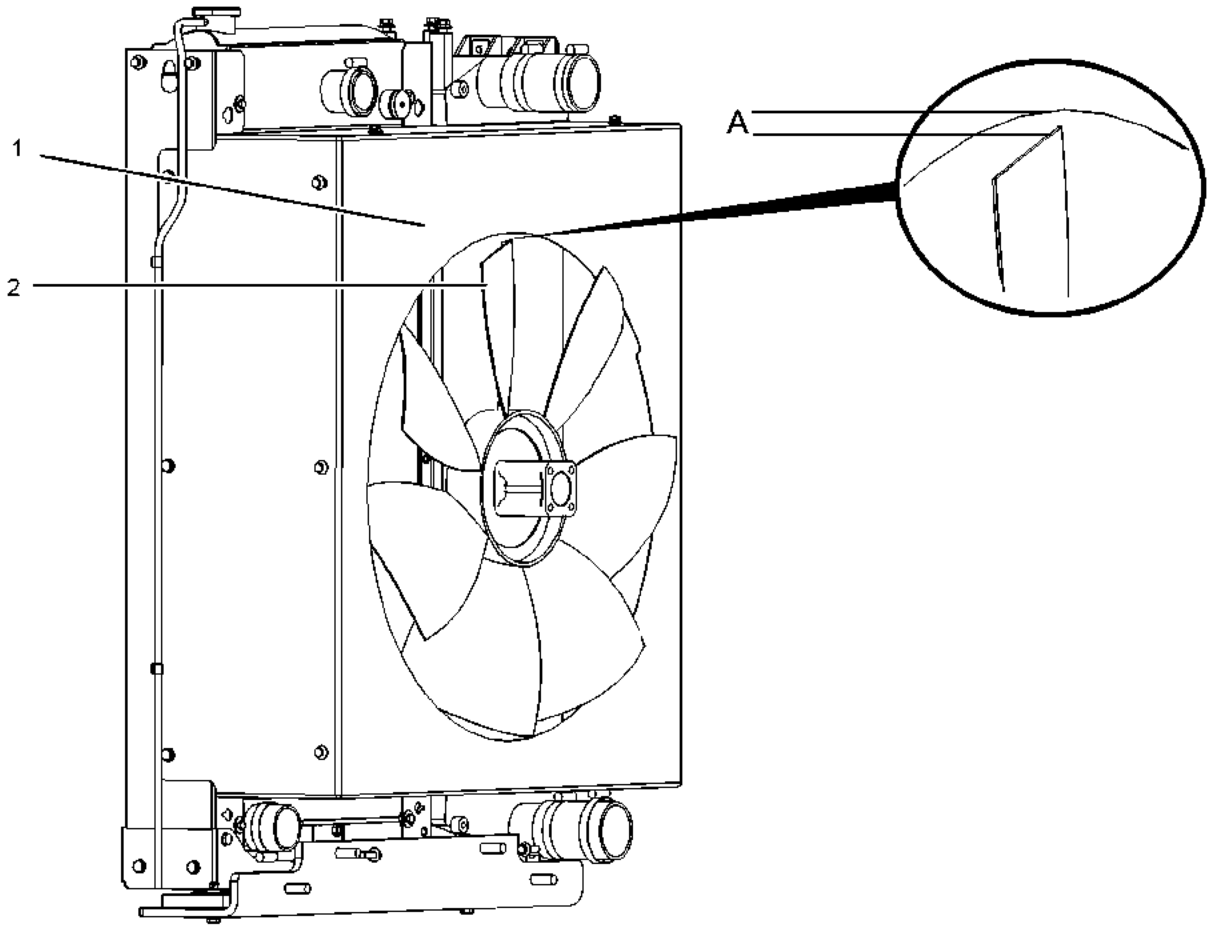


Illustration 50

g01348394

Adjustment of the cover will change the clearance (gap) between the edge of the cover and the tip of the fan blade. Ensure that the cover is centralized to the fan.

The maximum clearance is 12.5 mm (0.4921 inch). The minimum clearance is 6 mm (0.2362 inch).

i02871014

Fuel System - Prime

SMCS Code: 1258-548

⚠ 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.

Refer to the Operation and Maintenance Manual , “General Hazard Information and High Pressure Fuel Lines” before adjustments and repairs are performed.

Note: Refer to Systems Operation, Testing and Adjusting, “Cleanliness of Fuel System Components” for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

Ensure that all adjustments and repairs are performed by authorized personnel that have had the correct training.

NOTICE

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

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 has been replaced.

Hand Fuel Priming Pump

Use the following procedures in order to remove air from the fuel system:

1. Ensure that the fuel system is in working order. Check that the fuel supply valve (if equipped) is in the “ON” position.

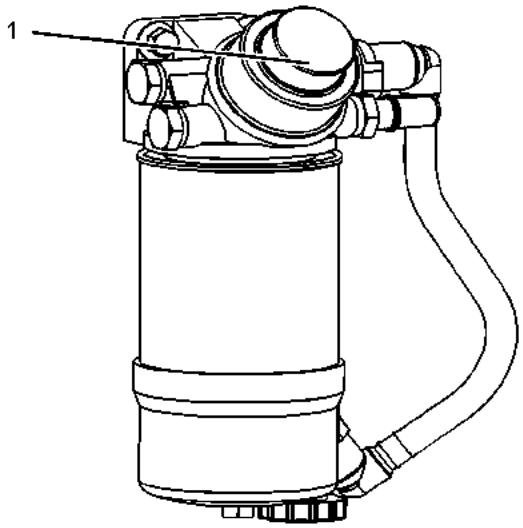


Illustration 51 g01476592

Typical example

2. Operate the fuel priming pump (1). Count the number of operations of the fuel priming pump. After 100 depressions of the fuel priming pump stop.
3. The engine fuel system should now be primed and the engine should now be able to start.
4. Operate the engine starter and crank the engine. After the engine has started, operate the engine at low idle for a minimum of five minutes, immediately after air has been removed from the fuel system.

Note: Operating the engine for this period of time will help ensure that the fuel system is free of air.

Note: Do not loosen the high pressure fuel line in order to purge air from the fuel system. This procedure is not required.

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.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and Assembly Manual, “Fuel Injection Lines - Install”.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, “General hazard Information”.

i02869410

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

Ensure that the engine is stopped before any servicing or repair is performed.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and Assembly Manual, “Fuel Injection Lines - Install”.

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

1. Place a suitable container under the water separator in order to catch any fuel that might spill. Clean up any spilled fuel.

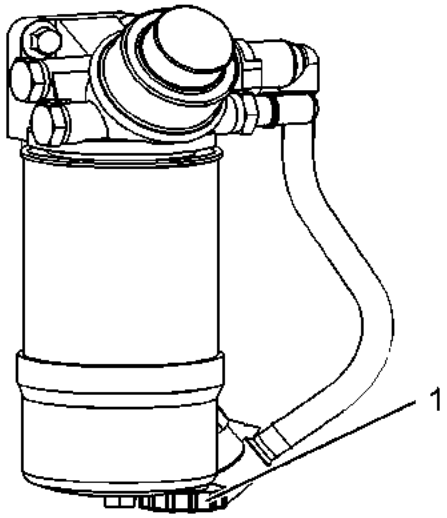


Illustration 52 g01476633
Typical example

2. Install a suitable tube onto the drain (1). Open the drain (1). Allow the fluid to drain into the container.

3. Tighten the drain (1) by hand pressure only. Remove the tube and dispose of the drained fluid in a safe place.

Primary Filter with a Vent Screw

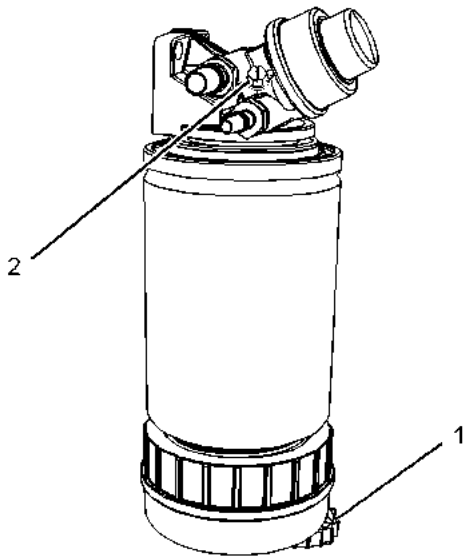


Illustration 53 g01371846
Typical example

Note: Not all primary filters require vent screw (2). This primary fuel filter that has a vent screw may be installed on a fuel system that has a low fuel tank.

1. Install a suitable tube onto drain (1). Loosen vent screw (2).

2. Open drain (1). Allow the fluid to drain into the container.

3. Tighten drain (1) by hand pressure only. Remove the tube and dispose of the drained fluid in a safe place.

4. Tighten vent screw to 6 N·m (53 lb in).

i02873617

Fuel System Primary Filter (Water Separator) Element - Replace

SMCS Code: 1260-510-FQ; 1263-510-FQ

Type One

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.

Note: Refer to Testing and Adjusting Manual , “Cleanliness of Fuel System Components” for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE
Ensure that the engine is stopped before any servicing or repair is performed.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, “Fuel Injection Lines - Install”.

1. Turn the fuel supply valve (if equipped) to the OFF position before performing this maintenance.

2. Place a suitable container under the water separator in order to catch any fuel that might spill. Clean up any spilled fuel. Clean the outside of the water separator.

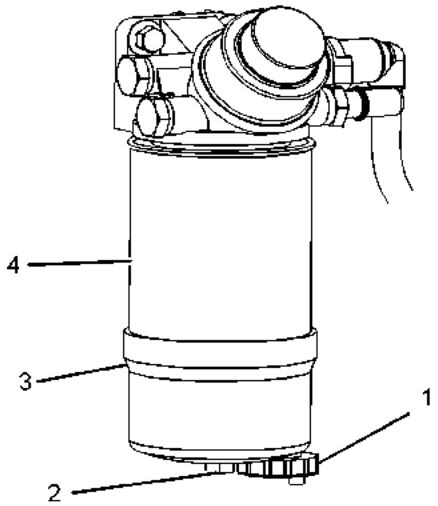


Illustration 54 g01259363
Typical example

3. Install a suitable tube onto the drain (1). Open the drain (1). Allow the fluid to drain into the container. Remove the tube.

4. Tighten the drain (1) by hand pressure only.

5. If equipped, remove the wiring harness from the sensor on the bottom of the glass bowl.

6. Hold the glass bowl (3) and remove the screw (2). Remove the glass bowl (3) from the canister (4).

7. Use a 1U-8760 Chain Wrench in order to remove the canister (4). Discard the old seals (5 and 6) and the canister in a safe place.

8. Clean the glass bowl (3).

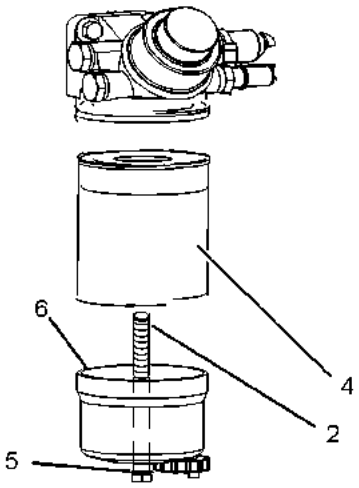


Illustration 55 g01259366
Typical example

9. Install the new canister. Do not use a tool in order to install the canister. Tighten the canister by hand.

10. Install the new O ring seal (5) onto the setscrew (2). Install the new O ring seal (6) into the glass bowl.

11. Align the glass bowl to the canister. Ensure that the sensor (if equipped) is in the correct position. Install the setscrew (2). Tighten the setscrew to a torque of 5 N·m (44 lb in).

12. If equipped, install the wiring harness to the sensor.

13. Remove the container and dispose of the fuel in a safe place.

14. The secondary filter must be replaced at the same time as the primary filter. Refer to the Operation and Maintenance Manual , “Fuel System Filter - Replace”.

Type Two

Note: Refer to Testing and Adjusting Manual , “Cleanliness of Fuel System Components” for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, “Fuel Injection Lines - Install”.

NOTICE
Ensure that the engine is stopped before any servicing or repair is performed.

1. Turn the fuel supply valve (if equipped) to the OFF position before performing this maintenance.

2. Place a suitable container under the water separator in order to catch any fuel that might spill. Clean up any spilled fuel. Clean the outside of the water separator.

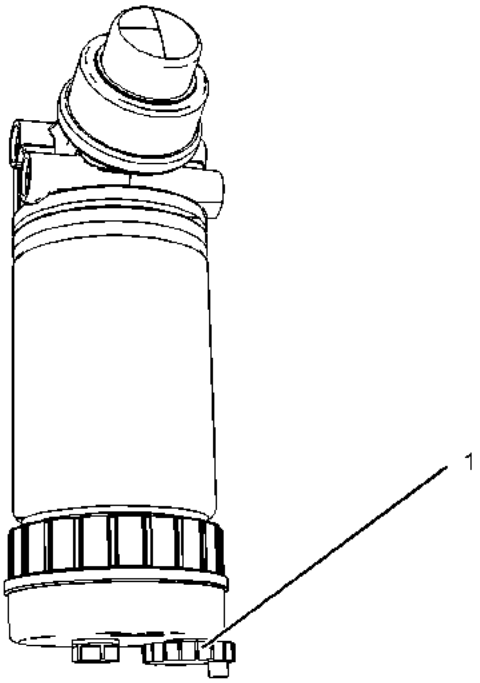


Illustration 56 g01430590

3. Install a suitable tube onto drain (1). Open drain (1). Allow the fluid to drain into the container. Remove the tube.

4. Tighten drain (1) by hand pressure only.

5. If equipped, remove the wiring harness from the sensor on the bottom of the bowl .

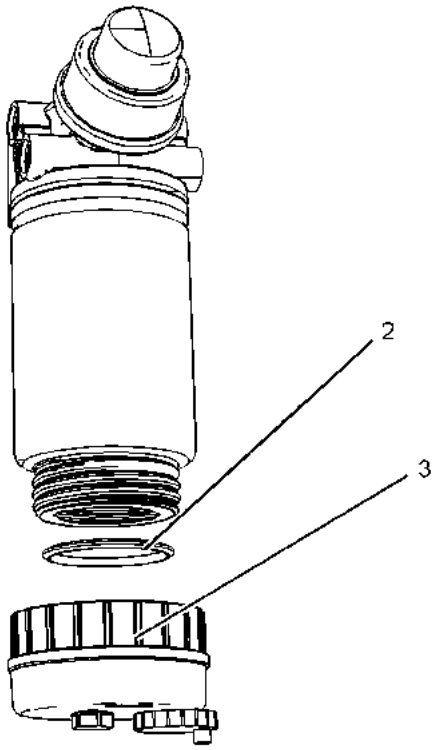


Illustration 57 g01430591

6. Rotate bowl (3) counterclockwise in order to remove the bowl. Remove O ring seal (2). Clean the bowl.

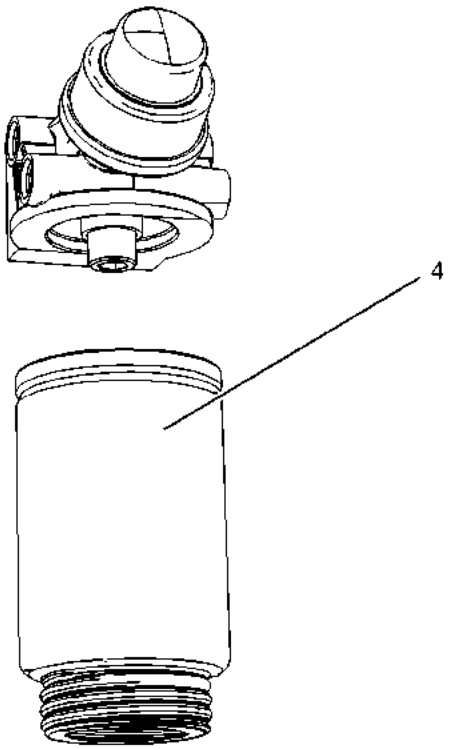


Illustration 58 g01430594

7. Use 1U-8760 Chain Wrench in order to remove old canister (4).

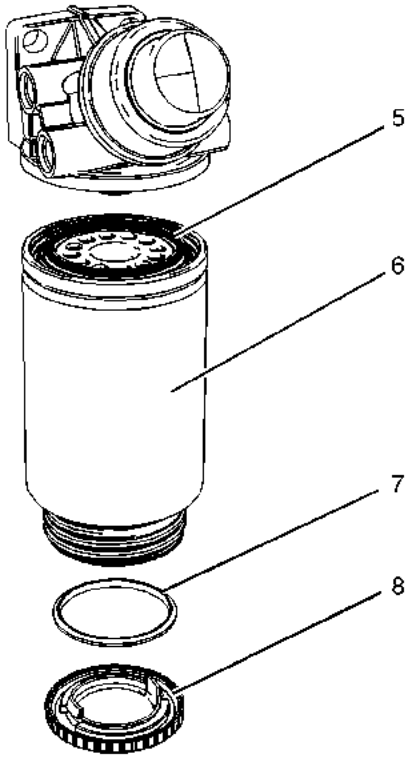


Illustration 59 g01430595

8. Lubricate O ring seal (5) with clean engine oil on the new canister. Install new canister (6). Spin on the canister until the O ring seal contacts the sealing surface. Then rotate the canister 360 degree in order to tighten the canister correctly.

9. Remove cap (8) from the threaded end of the new canister and remove new O ring seal (7). Install the new O ring seal into bowl (3).

10. Lubricate O ring seal (7) with clean engine oil. Install the bowl onto the new canister. Tighten the bowl to 15 N·m (11 lb ft).

11. If equipped, install the wiring harness to the sensor. Open the fuel supply valve.

12. Remove the container and dispose of the fluid in a safe place.

13. The secondary filter must be replaced at the same time as the primary filter. Refer to the Operation and Maintenance Manual , “Fuel System Filter - Replace”.

i02873623

Fuel System Secondary Filter - Replace

SMCS Code: 1261-510-SE

Type One

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.

Note: Refer to Testing and Adjusting Manual , “Cleanliness of Fuel System Components” for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE
Ensure that the engine is stopped before any servicing or repair is performed.

Note: This fuel filter can be identified by the six drain holes in the filter. Refer to illustration 60.

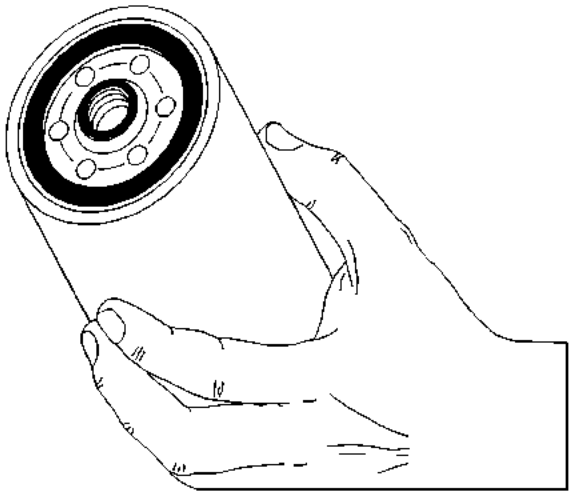


Illustration 60 g01430615

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, “Fuel Injection Lines - Install”.

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

1. Ensure that the fuel supply valve (if equipped) is in the OFF position. Place a suitable container under the fuel filter in order to catch any fuel that might spill. Clean up any spilled fuel.

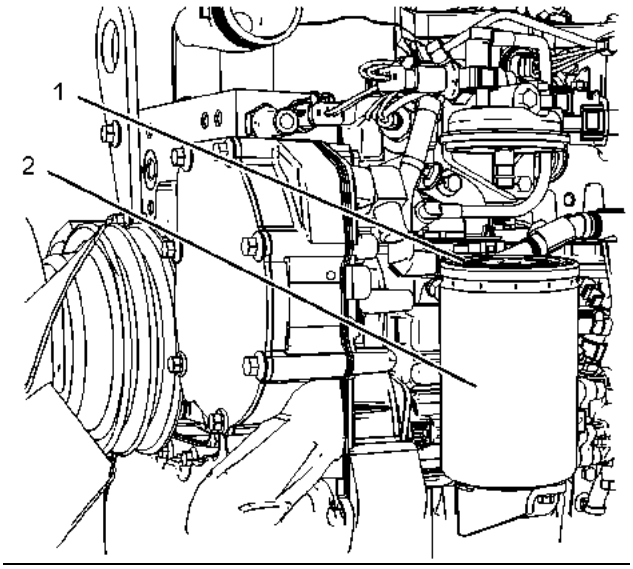


Illustration 61 g01430609
Typical example

2. Clean the outside of the fuel filter. Use 1U-8760 Chain Wrench in order to remove the canister (1) from the engine and dispose of the canister in a safe place.

3. Ensure that dirt can not enter the new canister. Do not fill the canister with fuel before the canister is installed. Lubricate the O ring seal (1) with clean engine oil on the new canister.

4. Install the new canister. Do not use a tool in order to install the canister. Tighten the canister by hand.

5. Spin on the canister until the O ring seal contacts the sealing surface. The canister will require a ¾ of a full turn in order to tighten the canister correctly.

6. Prime the fuel system. Refer to the Operation and Maintenance Manual, “Fuel System - Prime” for more information.

Type Two

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.

Note: Refer to Testing and Adjusting Manual , “Cleanliness of Fuel System Components” for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE
Ensure that the engine is stopped before any servicing or repair is performed.

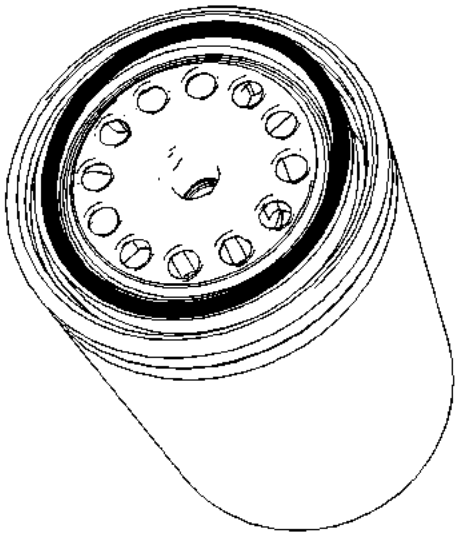


Illustration 62 g01430619

This fuel filter can be identified by the 12 drain holes in the filter. Refer to illustration 62.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and Assembly Manual, “Fuel Injection Lines - Install”.

1. Ensure that the fuel supply valve (if equipped) is in the OFF position. Place a suitable container under the fuel filter in order to catch any fuel that might spill. Clean up any spilled fuel.

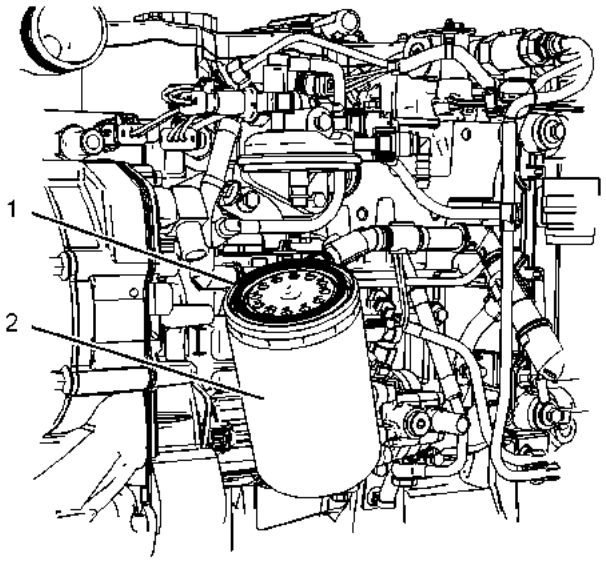


Illustration 63 g01430620
Typical example

2. Clean the outside of the fuel filter. Use 1U-8760 Chain Wrench in order to remove the canister (2) from the engine and dispose of the canister in a safe place.

3. Ensure that dirt can not enter the new canister. Do not fill the canister with fuel before the canister is installed. Lubricate the O ring seal (1) with clean engine oil on the new canister.

4. Install the new canister. Do not use a tool in order to install the canister. Tighten the canister by hand.

5. Spin on the canister until the O ring seal contacts the sealing surface. Then rotate the canister 360 degree in order to tighten the canister correctly.

6. Remove the container and dispose of the fuel in a safe place. If equipped, open the fuel supply valve.

7. Prime the fuel system. Refer to the Operation and Maintenance Manual, “Fuel System - Prime” for more information.

i02348492

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.

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.

Water can be introduced into the fuel tank when the fuel tank is being filled.

Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel.

Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

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

Check the fuel daily. Allow five minutes after the fuel tank has been filled before draining water and sediment from the fuel tank.

Fill the fuel tank after operating the engine in order to drive out moist air. This will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Fuel Storage Tanks

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

- Weekly
- Service intervals
- Refill of the tank

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

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

i02518232

Hoses and Clamps - Inspect/Replace

SMCS Code: 7554-040; 7554-510

⚠ 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.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, “General hazard Information”.

Inspect all hoses for leaks that are caused by the following conditions:

- Cracking
- Softness
- Loose clamps

Replace hoses that are cracked or soft. Tighten any loose clamps.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

A constant torque hose clamp can be used in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard clamp.

Due to extreme temperature changes, the hose will harden. Hardening of the hoses will cause hose clamps to loosen. This can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Each installation application can be different. The differences depend on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose
- Anticipated expansion and contraction of the fittings

Replace the Hoses and the Clamps

Refer to the OEM information for further information on removing and replacing fuel hoses (if equipped).

The following text describes a typical method of replacing coolant hoses. Refer to the OEM information for further information on the coolant system and the hoses for the coolant 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.

1. Stop the engine. Allow the engine to cool.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

Note: Drain the coolant into a suitable, clean container. The coolant can be reused.

3. Drain the coolant from the cooling system to a level that is below the hose that is being replaced.
4. Remove the hose clamps.
5. Disconnect the old hose.
6. Replace the old hose with a new hose.
7. Install the hose clamps with a torque wrench.

Note: For the correct coolant, see this Operation and Maintenance Manual, “Fluid Recommendations”.

8. Refill the cooling system. Refer to the OEM information for further information on refilling the cooling system.
9. Clean the cooling system filler cap. Inspect the cooling system filler cap’s seals. Replace the cooling system filler cap if the seals are damaged. Install the cooling system filler cap.
10. Start the engine. Inspect the cooling system for leaks.

i01515272

Overhaul Considerations

SMCS Code: 7595-043

Reduced hours of operation at full load will result in a lower average power demand. A decreased average power demand should increase both the engine service life and the overhaul interval.

The need for an overhaul is generally indicated by increased fuel consumption and by reduced power.

The following factors are important when a decision is being made on the proper time for an engine overhaul:

- The need for preventive maintenance
- The quality of the fuel that is being used
- The operating conditions
- The results of the S·O·S analysis

Oil Consumption as an Overhaul Indicator

Oil consumption, fuel consumption, and maintenance information can be used to estimate the total operating cost for your Caterpillar engine. Oil consumption can also be used to estimate the required capacity of a makeup oil tank that is suitable for the maintenance intervals.

Oil consumption is in proportion to the percentage of the rated engine load. As the percentage of the engine load is increased, the amount of oil that is consumed per hour also increases.

The oil consumption rate (brake specific oil consumption) is measured in grams per kW/h (lb per bhp). The brake specific oil consumption (BSOC) depends on the engine load. Consult your Caterpillar dealer for assistance in determining the typical oil consumption rate for your engine.

When an engine's oil consumption has risen to three times the original oil consumption rate due to normal wear, an engine overhaul should be scheduled. There may be a corresponding increase in blowby and a slight increase in fuel consumption.

Overhaul Options

Before Failure Overhaul

A planned overhaul before failure may be the best value for the following reasons:

- Costly unplanned downtime can be avoided.
- Many original parts can be reused according to the standards for reusable parts.
- The engine's service life can be extended without the risk of a major catastrophe due to engine failure.
- The best cost/value relationship per hour of extended life can be attained.

After Failure Overhaul

If a major engine failure occurs and the engine must be removed, many options are available. An overhaul should be performed if the engine block or the crankshaft needs to be repaired.

If the engine block is repairable and/or the crankshaft is repairable, the overhaul cost should be between 40 percent and 50 percent of the cost of a new engine with a similar exchange core.

This lower cost can be attributed to three aspects:

- Specially designed Caterpillar engine features
- Caterpillar dealer exchange components
- Caterpillar Inc. remanufactured exchange components

Overhaul Recommendation

To minimize downtime, Caterpillar Inc. recommends a scheduled engine overhaul by your Caterpillar dealer before the engine fails. This will provide you with the best cost/value relationship.

Note: Overhaul programs vary according to the engine application and according to the dealer that performs the overhaul. Consult your Caterpillar dealer for specific information about the available overhaul programs and about overhaul services for extending the engine life.

If an overhaul is performed without overhaul service from your Caterpillar dealer, be aware of the following maintenance recommendations.

Rebuild or Exchange

Cylinder Head Assembly, Oil Pump, and Fuel Transfer Pump

These components should be inspected according to the instructions that are found in various Caterpillar reusability publications. The Special Publication, SEBF8029 lists the reusability publications that are needed for inspecting the engine parts.

If the parts comply with the established inspection specifications that are expressed in the reusable parts guideline, the parts should be reused.

Parts that are not within the established inspection specifications should be dealt with in one of the following manners:

- Salvaging
- Repairing
- Replacing

Using out-of-spec parts can result in the following problems:

- Unscheduled downtime
- Costly repairs
- Damage to other engine parts
- Reduced engine efficiency

- Increased fuel consumption

Reduced engine efficiency and increased fuel consumption translates into higher operating costs. Therefore, Caterpillar Inc. recommends repairing out-of-spec parts or replacing out-of-spec parts.

Inspection and/or Replacement

Crankshaft Bearings and Crankshaft Seals

The following components may not last until the second overhaul.

- Thrust bearings
- Main bearings
- Rod bearings
- Crankshaft seals

Caterpillar Inc. recommends the installation of new parts at each overhaul period.

Inspect these parts while the engine is disassembled for an overhaul.

Inspect the crankshaft for any of the following conditions:

- Deflection
- Damage to the journals
- Bearing material that has seized to the journals

Check the journal taper and the profile of the crankshaft journals. Check these components by interpreting the wear patterns on the following components:

- Rod bearing
- Main bearings

Inspect the camshaft for damage to the journals and to the lobes.

Note: If the camshaft is removed for any reason, use the magnetic particle inspection process to check for cracks in the camshaft.

Inspect the following components for signs of wear or for signs of scuffing:

- Camshaft bearings
- Lifters

Caterpillar Inc. recommends replacing the crankshaft vibration damper.

Oil Cooler Core

During an overhaul, Caterpillar Inc. recommends the removal of the oil cooler core. Clean the oil cooler core. Then, pressure test the oil cooler core.

NOTICE
Do not use caustic cleaners to clean the core.

Caustic cleaners can attack the internal metals of the core and cause leakage.

Note: Use this cleaning procedure to clean the oil cooler core.

1. Remove the oil cooler core.
2. Remove any debris from the oil cooler core. To remove debris from the oil cooler core, turn the oil cooler core onto one end.
3. Flush the oil cooler core internally with cleaner in order to loosen foreign substances. This will also help to remove oil from the oil cooler core.

Note: Caterpillar Inc. recommends the use of Hydrosolv Liquid Cleaners. Table 15 lists the Hydrosolv Liquid Cleaners that are available from your Caterpillar dealer.

Table 15

Hydrosolv Liquid Cleaners		
Part Number	**Description**	**Size**
1U-5490	Hydrosolv4165	19 L (5 US gal)
1U-5492	Hydrosolv100	19 L (5 US gallon)

4. Use steam to clean the oil cooler core. This removes any remaining residue from the cleaner. Flush the fins of the oil cooler core. Remove any other trapped debris.
5. Wash the oil cooler core with hot, soapy water. Rinse the oil cooler core thoroughly with clean water.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

6. Dry the oil cooler core with compressed air. Direct the air in the reverse direction of the normal flow.

7. Inspect the components in order to ensure cleanliness. The oil cooler core should be pressure tested. Repair the oil cooler core, if necessary. Install the oil cooler core.

For more information about cleaning the cores, consult your Caterpillar dealer.

Obtain Coolant Analysis

The concentration of supplemental coolant additive (SCA) should be checked regularly with test kits or with S·O·S Coolant Analysis (Level 1). Further coolant analysis is recommended when the engine is overhauled.

For example, considerable deposits are found in the water jacket areas on the external cooling system, but the concentrations of coolant additives were carefully maintained. The coolant water probably contained minerals that were deposited on the engine over time.

A coolant analysis can be conducted in order to verify the condition of the water that is being used in the cooling system. A full water analysis can be obtained by consulting your local water utility company or an agricultural agent. Private laboratories are also available for water analysis.

Caterpillar Inc. recommends an S·O·S Coolant Analysis (Level 2).

S·O·S Coolant Analysis (Level 2)

An S·O·S Coolant Analysis (Level 2) is a comprehensive coolant analysis which completely analyzes the coolant and the effects on the cooling system. An S·O·S Coolant Analysis (Level 2) provides the following information:

- Complete S·O·S Coolant Analysis (Level 1)
- Visual inspection of properties
- Identification of metal corrosion
- Identification of contaminants
- Identification of built up impurities (corrosion and scale)

S·O·S Coolant Analysis (Level 2) provides a report of the results of both the analysis and the maintenance recommendations.

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

i02559063

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 fan's air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a “comb”. Inspect these items for good condition: welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

For more detailed information on cleaning and inspection, refer to Special Publication, SEBD0518, “Know Your Cooling System”.

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

i02348493

Starting Motor - Inspect

SMCS Code: 1451-040; 1453-040

Caterpillar 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 correct operation. Check the electrical connections and clean the electrical connections. Refer to the Systems Operation, Testing and Adjusting Manual, “Electric Starting System - Test” for more information on the checking procedure and for specifications or consult your Caterpillar dealer for assistance.

i02724929

Turbocharger - Inspect

SMCS Code: 1052-040; 1052

A regular visual inspection of the turbocharger is recommended. 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, and replacement, consult your Carerpillar dealer. Refer to the Disassembly and Assembly Manual, “Turbocharger - Remove and Turbocharger - Install” for further information.

Inspecting

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

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 obvious heat discoloration of the turbocharger. Check for any loose bolts or any missing bolts. Check for damage to the oil supply line and the oil drain line. Check for cracks in the housing of the turbocharger. Ensure that the compressor wheel can rotate freely.

3. 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.

4. Inspect the bore of the housing of the turbine outlet for corrosion.

5. Fasten the air intake pipe and the exhaust outlet pipe to the turbocharger housing. Ensure that all clamps are installed correctly and that all clamps are tightened securely.

i02873707

V-Belts - Inspect/Adjust/Replace

SMCS Code: 1357-025; 1357-040; 1357-510

Inspection

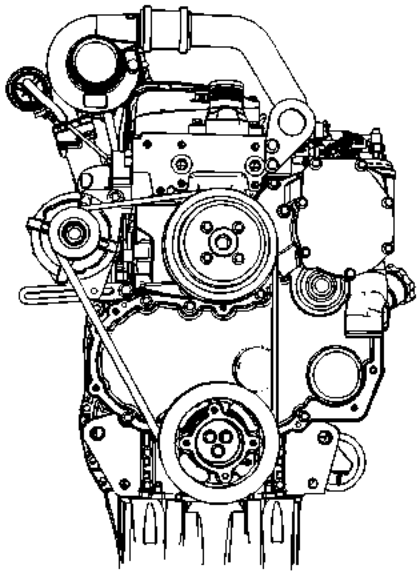


Illustration 64 g01476657

Arrangement for the V-belts

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, install 144-0235 Belt Tension Gauge.

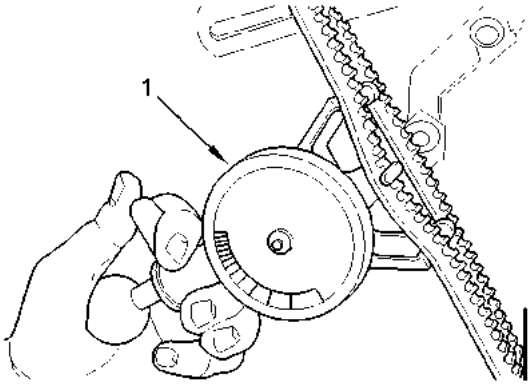


Illustration 65 g01003936

Typical example

(1) Gauge

Fit the gauge (1) at the center of the longest free length and check the tension. The correct tension for a used belt is 355 N (79.8 lb). If the tension of the belt is below 250 N (56 lb) adjust the belt to 355 N (79.8 lb).

Note: The correct tension for a new belt or new belts is 535 N (120 lb). A higher tension is required in order to compensate for the stretch that is in a new belt. Only use the higher tension on a belt that has not been used. A used belt is a belt that has been in operation for 30 minutes or a longer period of time.

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

Adjustment

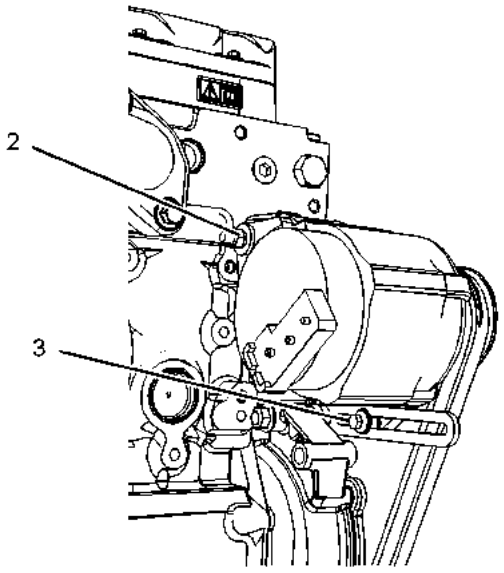


Illustration 66 g01430645

Typical example

1. Loosen The alternator pivot bolt (2) and the bolt (3).

2. Move the alternator in order to increase or decrease the belt tension. Tighten the alternator pivot bolt and the link bolt to 22 N·m (16 lb ft).(1).

Replace

Refer to Disassembly and Assembly manual for more information.

i02517579

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 correct 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 is a fire hazard. Remove the accumulated grease and oil. Refer to this Operation and Maintenance Manual, “Engine - Clean” for more information.

- Ensure that the cooling system hoses are correctly clamped and that the cooling system hoses are 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 the 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. Remove the water pump. Refer to Disassembly and Assembly , “Water Pump - Remove and Install”. For more information, 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 rocker cover.

- Inspect the piping for the air intake system and the elbows for cracks and for loose clamps. Ensure that hoses and tubes are not contacting other hoses, tubes, wiring harnesses, etc.

- Ensure that the areas around the rotating parts are clear.

- Inspect the alternator belts and any accessory drive belts for cracks, breaks or other damage.

- Inspect the wiring harness for 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.

High Pressure Fuel Lines

⚠ 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.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, “Fuel Injection Lines - Install”.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, “General hazard Information”.

Visually inspect the high pressure fuel lines for damage or signs of fuel leakage. Replace any damaged high pressure fuel lines or high pressure fuel lines that have leaked.

Ensure that all clips on the high pressure fuel lines are in place and that the clips are not loose.

- Inspect the rest of the fuel system for leaks. Look for loose fuel line clamps.
- Drain the water and the sediment from the fuel tank 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. Check for any loose tie-wraps or missing tie-wraps.
- Inspect the 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 that are cracked. Replace any gauge that can not be calibrated.

i02517764

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

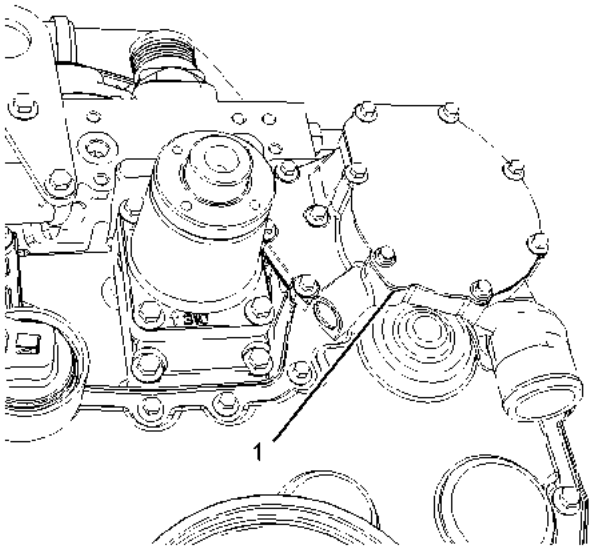


Illustration 67 g01249453

(1) Weep hole

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. The water pump is not a serviceable item. In order to install a new water pump, refer to the Disassembly and Assembly Manual, “Water Pump - Remove and Install”, or contact your Caterpillar dealer.

Warranty Section

Warranty Information

i01087950

Emissions Warranty Information

SMCS Code: 1000

This engine may be certified to comply with exhaust emission standards and gaseous emission standards that are prescribed by law at the time of manufacture, and this engine may be covered by an Emissions Warranty. A detailed explanation of the Emissions Warranty that is applicable to emissions certified engines is found in Supplement, SEBU6981, “Federal Emissions Control Warranty Information”. Consult your authorized Caterpillar dealer to determine if your engine is emissions certified and if your engine is subject to an Emissions Warranty.

Reference Information Section

Engine Ratings

i02945156

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 Inches 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”.

Power for the engine ratings is set on the following fuel specification:

- Density 0.837 to 0.845 kg/l at 15 °C (59 °F)
- API Gravity 36 to 37.5 at 15 °C (59 °F)
- Viscosity 2.6 to 2.8 mm^2 /sec at 40 °C (104.0 °F)
- Cetane numbers of 48 to 52

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).

i02945155

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. The rating definitions identify the percent of time at full throttle. The definitions also identify the corresponding times below rated rpm.

Note: For an exact determination of the appropriate rating, follow the OEM specifications or consult your Caterpillar dealer.

There is five ratings from A to E. The rating for the C4.4 industrial engine is C.

C – Intermittent service in conjunction with maximum power and/or speed are cyclic. The engine at full load should not exceed 50 percent of the duty cycle.

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

Customer Service

i02097871

Customer Assistance

SMCS Code: 1000

USA and Canada

When a problem arises concerning the operation of an engine or concerning the service of an engine, the problem will normally be managed by the dealer in your area.

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

1. Discuss your problem with a manager from the dealership.

2. If your problem cannot be resolved at the dealer level without additional assistance, use the phone number that is listed below to talk with a Field Service Coordinator:

   1-800-447-4986

   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's facilities, equipment, and personnel. Therefore, follow the steps in sequence when a problem is experienced.

Outside of the USA and of Canada

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

Latin America, Mexico, 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
Fax: 22-849-4544

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

China
Caterpillar China Ltd.
37/F., The Lee Gardens
33 Hysan Avenue
Causeway Bay
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

i02518230

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, KENR6217, “C4.4 Industrial Engines”
- Systems Operation, Testing and Adjusting, RENR9965, “C4.4 Industrial Engines”
- Specifications, RENR9961, “C4.4 Industrial Engines.”
- Disassembly and Assembly, KENR6216, “C4.4 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

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Maintenance Records

SMCS Code: 1000

Caterpillar Inc. recommends the retention of accurate maintenance records. Accurate maintenance records can be used for the following purposes:

- Determine operating costs.
- Establish maintenance schedules for other engines that are operated in the same environment.
- Show compliance with the required maintenance practices and maintenance intervals.

Maintenance records can be used for a variety of other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is well managed. Accurate maintenance records can help your Caterpillar dealer to fine tune the recommended maintenance intervals in order to meet the specific operating situation. This should result in a lower engine operating cost.

Records should be kept for the following items:

Fuel Consumption – A record of fuel consumption is essential in order to determine when the load sensitive components should be inspected or repaired. Fuel consumption also determines overhaul intervals.

Service Hours – A record of service hours is essential to determine when the speed sensitive components should be inspected or repaired.

Documents – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number, and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner’s repair costs
- Owner’s receipts
- Maintenance log

i01176304

Maintenance Log

SMCS Code: 1000

Table 16

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

Index

F

G

H

I

L

M

O

P

R

S

T

V

W

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: _____

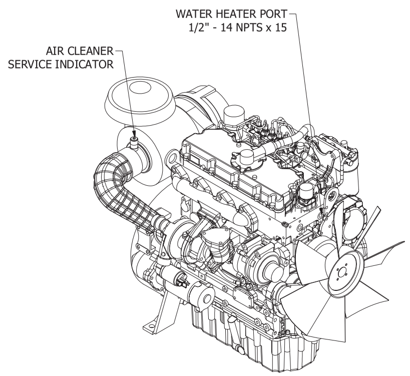
_____

_____

	Dealer Contact	Phone Number	Hours
Sales:	_____	_____	_____
Parts:	_____	_____	_____
Service:	_____	_____	_____

PERFORMANCE DATA					
SALES MODEL:	IC4.4_5093109	FUEL TYPE:	DIESEL	ROTATION:	CC
ENGINE POWER (kWB):	106	COOLING SYSTEM:	LIQUID	ASPIRATION:	TA
PEAK TORQUE (Nm/RPM):	460	LUB CAPACTITY(L):	6.8L - 8.3L	FAN DIRECTION:	PUSHER
COMPRESSION RATIO:	16.5:1	COOLANT CAPACITY(L):	9	DRY WEIGHT(kg)	430
POWER CURVE	T4128	MAX OPERATING ALTITUDE (FT):	3000	RATING:	IND-C
DISPLACEMENT(L):	4.4	COMBUSTION:	DIRECT INJECTION	FUEL FILTER MAX PARTICLE SIZE	3.0-5.0
ELECTRICS:	12V	ENGINE SPEED (RPM):	2200	MIN/MAX BATTERY CCA	650/950

OPTION CODES		
Option Code	Feature	Description
AM001	ECM	ECM fuel cooled, 24V only
C0001	FLYWHEEL HOUSING	Cast iron SAE 3, 156.4 mm (6.16 in) deep, RHS starter with sealed inspection plate cover (3)
D0004	FLYWHEEL	For SAE, Borg and Beck, twin disc clutches without pilot bearing housing
E0311	STARTER MOTOR	12V, 3.0 kW, RHS, suitable for dry back end only
FD001	ALTERNATOR TENSIONER	Belt auto - tensioner required, for belt systems without a low RHS A/C compressor (1) (2)
G0300	LUBRICATING OIL SUMPS AND DIPSTICKS	Cast iron, flat bottomed sump (1)
GD001	LUBRICATING OIL DIPSTICK	Short LHS
HC000	TOP COVER OIL FILLER	No filler
HD001	OIL FILLERS	Timing case filler, LHS short filler forward facing
J0050	LUBRICATING OIL FILTER HEAD	Vertically down, LHS
K0020	FRONT END DRIVE	Primary drive, steel, 200 mm diameter
KD000	SECONDARY CRANKSHAFT PULLEY	No secondary pulley
L0004	COOLANT PUMP	Coolant pump - vertical inlet
LD156	COOLANT PUMP OUTLET CONNECTIONS	Vertical outlet connection in centre
M0013	FAN	Diameter 559 mm (22 in) pusher, 7 blade at 26° pitch
N0101	ALTERNATOR	12V, 100A Alternator
P0000	BELT DRIVEN AUXILIARIES	Not included
Q1030	TIMING CASE	Timing case, single
QD000	TIMING CASE AUXILIARIES	No auxiliaries
R0001	BALANCER	Balancer
SD003	TURBO EXHAUST OUTLET CONNECTION	Exhaust elbow rearward straight (2) (suits single side turbo)
U0000	EXHAUST MANIFOLD OUTLET CONNECTIONS	Not user selectable
V0010	FUEL FILTER SECONDARY	Single LHS centre
W0011	COLD START AIDS	Glow plugs
X0011	LIFTING EYES	Fitted LHS at front and RHS at rear
Y9012	CAT ENGINE FINISH	Cat Yellow with light preservative
ZC003	ENGINE MOUNTING BRACKETS	Rear mounting brackets LHS and RHS
ZE000	HEATER/STARTER SWITCH	Not included
ZG000	OIL DRAIN VALVE	Standard sump plug
ZJ000	LUBRICATING OIL SWITCHED AND VALVES	Not included
ZL000	COOLANT TEMPERATURE SENDER AND GAUGE	Not included
ZM022	RADIATOR	
ZN020	ENGINE WIRING HARNESS	Wiring harness, convoluted, with diagnostic connector
ZY901	EMISSIONS LABELS	Emission label fitted to front cover. Cat decal
ZZ000	CAB HEATER CONNECTIONS	Not included



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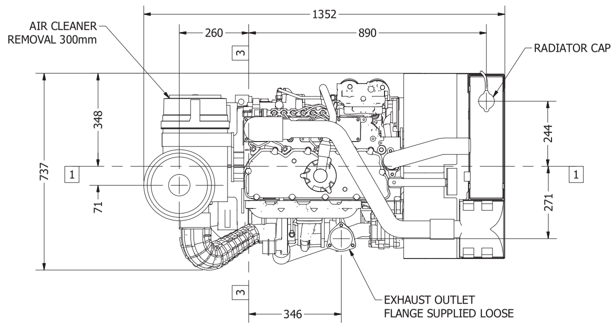
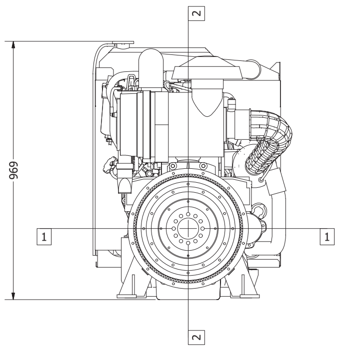
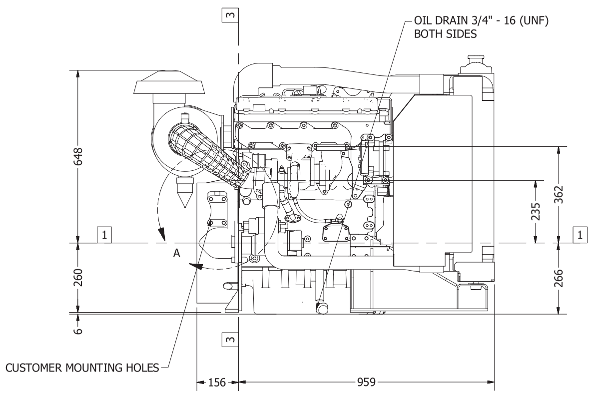
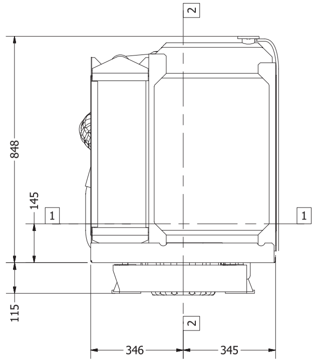
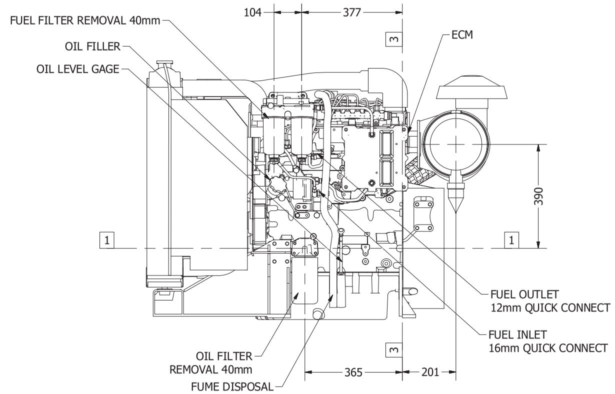
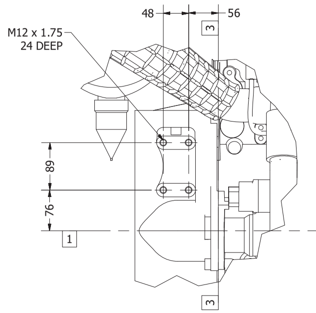




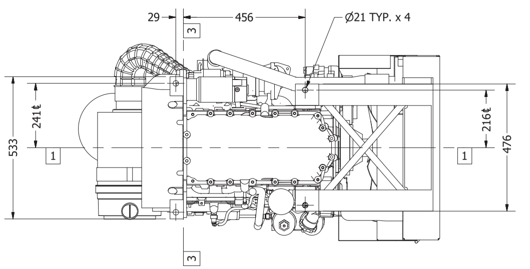


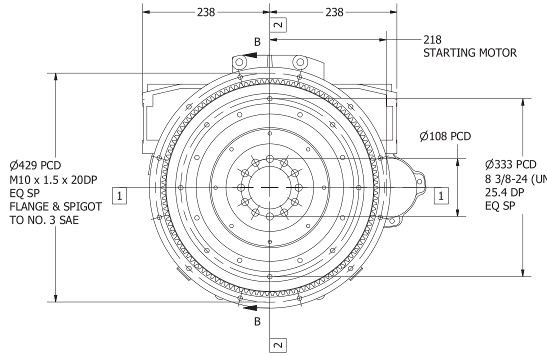


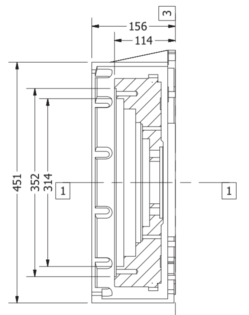




CUSTOMER MOUNTING HOLES (BOTH SIDES)
DETAIL A SCALE 1 / 5







SAE 3 FLYWHEEL HOUSING & FLYWHEEL NO. 11 1/2 (126 TOOTH STARTER RING)
SECTION B-B SCALE 1/5

FUEL CONNECTIONS					
SCREEN INLET:	Ø12.7 HOSE BARB	ELP INLET:	Ø10 HOSE BARB	FUEL COOLER INLET:	ØTBD HOSE BARB
SCREEN OULET:	Ø10 HOSE BARB	ELP OUTLET:	M16 x 1.5 STOR	FUEL COOLER OUTLET:	ØTBD HOSE BARB
PRIMARY FILTER INLET:	Ø9.49 SAE J2044	PRV RETURN TO TANK:	Ø9.49 SAE J2044		
PRIMARY FILTER OUTLET:	ØTBD	LEAK OFF RETURN TO TANK:	11/16" - 16 ORFS		

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
DIMENSIONS W/O TOL ARE BASIC

1 - CENTERLINE OF CRANKSHAFT
2 - CENTERLINE OF ENGINE
3 - REAR FACE OF CYLINDER BLOCK

THIRD ANGLE PROJECTION

HEAD OFFICE VICTORIA & TASMANIA, 227 Wellington Road, Mulgrave, VIC 303, Tel: (03) 8562 4000, Fax: (03) 8562 4004
NEW SOUTH WALES, 8-10 Bosci Road, Ingleburn, NSW 2565, Tel: (02) 8796 9200, Fax: (02) 8796 9299
QUEENSLAND & NORTHERN TERRITORY, 50 Arc Place, Larapinta, QLD 4110, Tel. (07) 3272 1677, Fax. (07) 3272 1094
WESTERN AUSTRALIA, 118 Daddow Road, Kewdale, WA 6105, Tel: (08) 9442 8500, Fax: (08) 9442 8555
SOUTH AUSTRALIA, 96 Bedford Street, Gillman, SA 5013, Tel: (08) 8161 1500, Fax: (08) 8161 1598

ENERGY POWER SYSTEMS AUSTRALIA PTY LTD A.C.N. 055 274 514

Energy Power Systems

CAT

3D MODEL AUTHOR: bjorkej 15/09/2016
ENGINEERING APPROVED: J.MAGNAYE 19/09/2016
COMMENTS:

STOCK/PART NO: IC4.4_5093109
TITLE: CATERPILLAR C4.4 INDUSTRIAL ENGINE ARRANGMENT: 5093109
SHEET SIZE: A1
MATERIAL:
SHEET 1 OF 1

OPERATORS MANUAL

Comet Manual

Section 3

COMET PLUNGER PUMP SERVICE MANUAL INDEX

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.

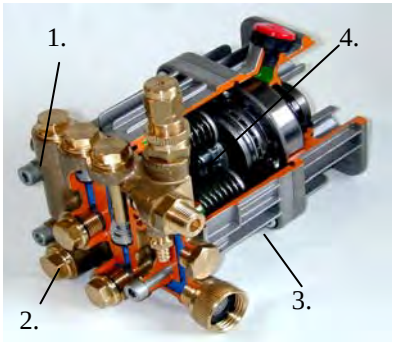
b. *WET END:* The Comet Pump should never be run dry. Running the pump dry will cause premature wear on the seals, packing and plungers. Running the pump dry for a prolonged period of time may cause damage that cannot be repaired. Do not start a pump with frozen water in the manifold.

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

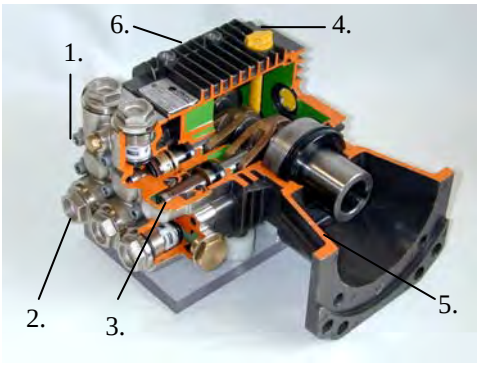
2.1 AXD Series Pump

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



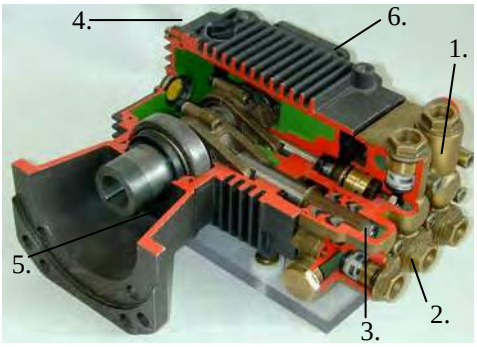
2.2 LW/ZW Series Pump

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

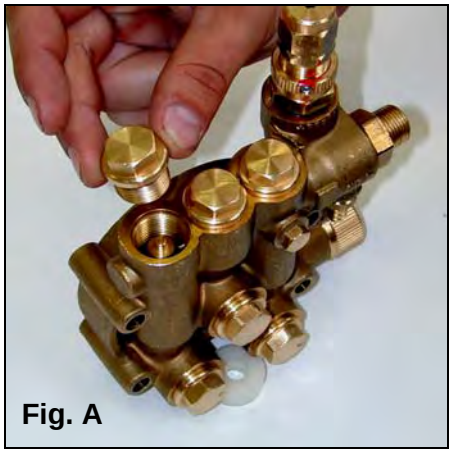


Fig. A

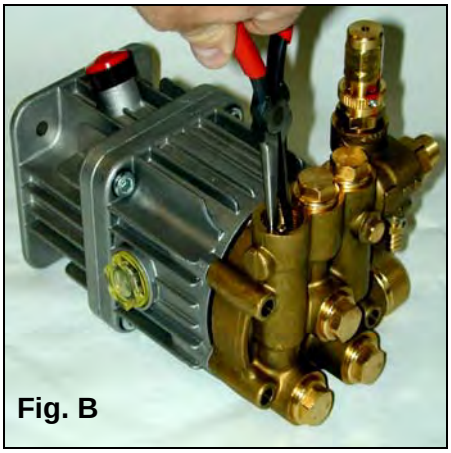


Fig. B


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.

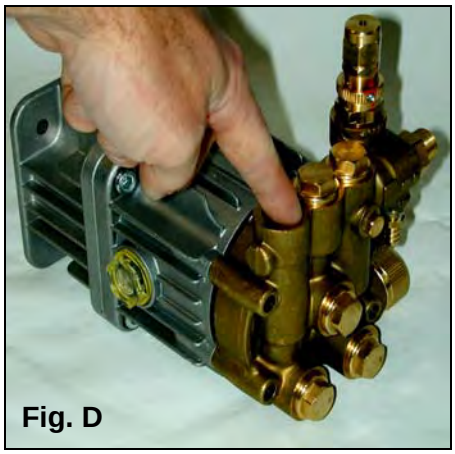


Fig. D


Fig. E

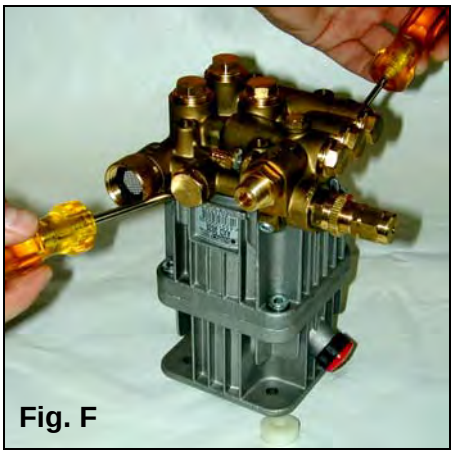


Fig. F

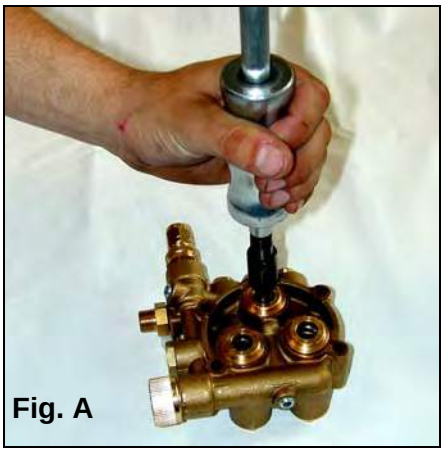


Fig. A

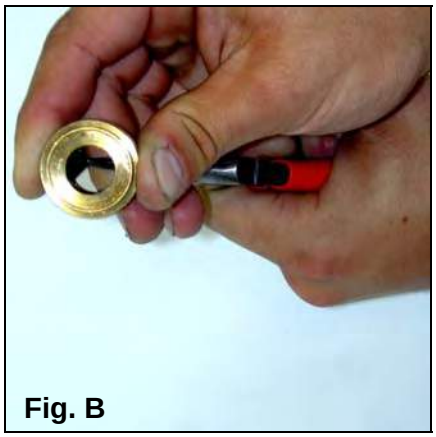


Fig. B

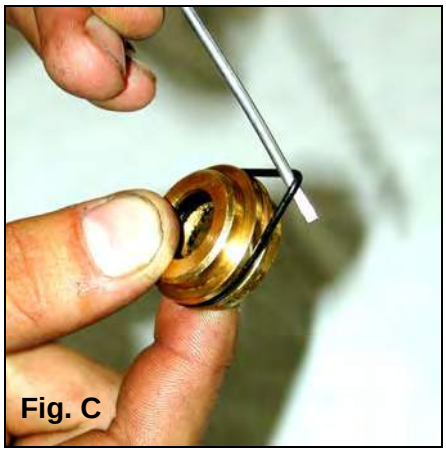


Fig. C

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.

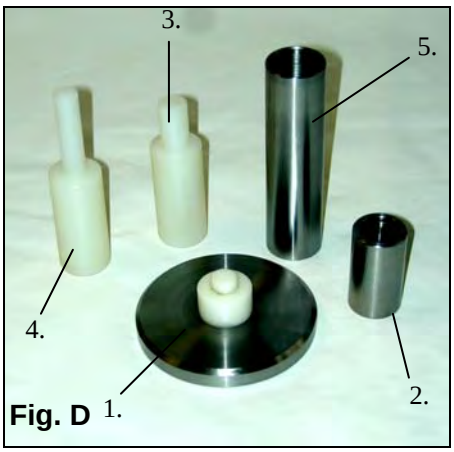


Fig. D

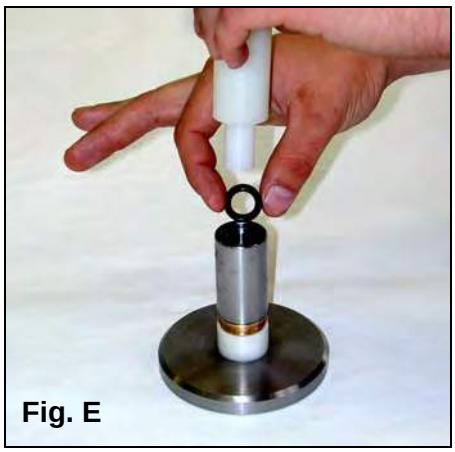
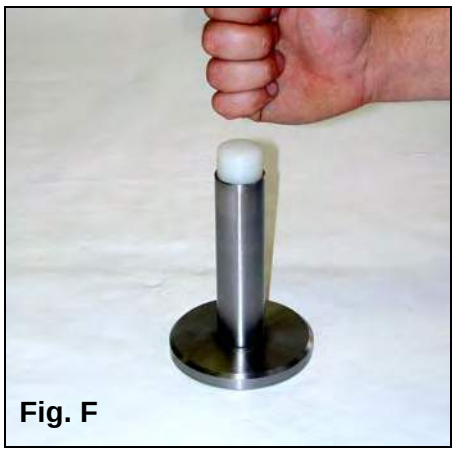


Fig. E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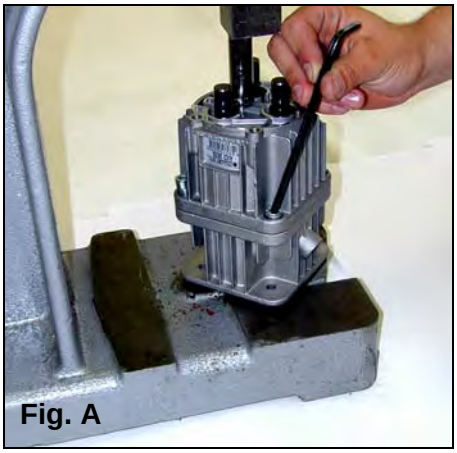
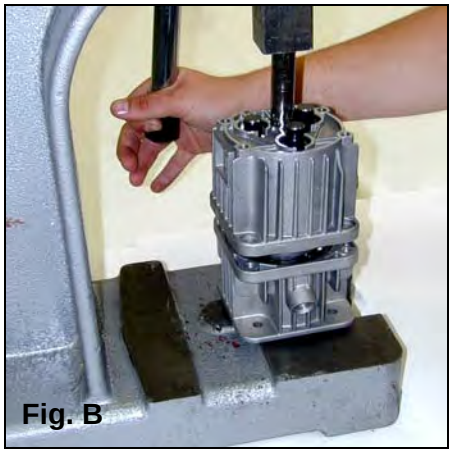


Fig. A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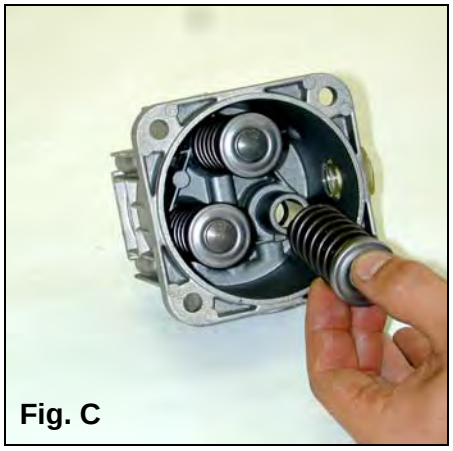


Fig. C

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)**

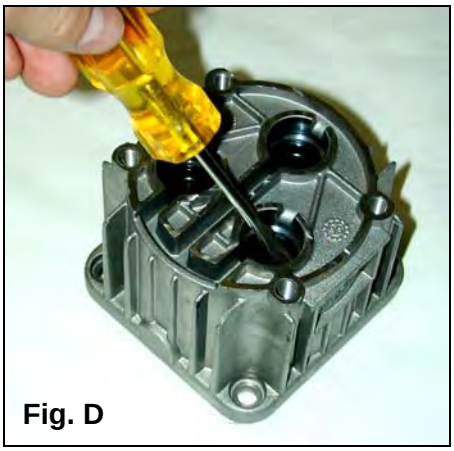


Fig. D

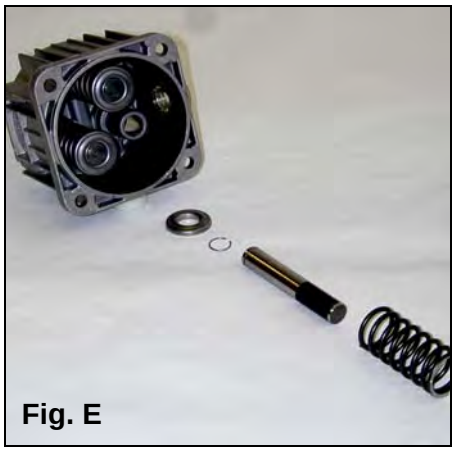


Fig. E

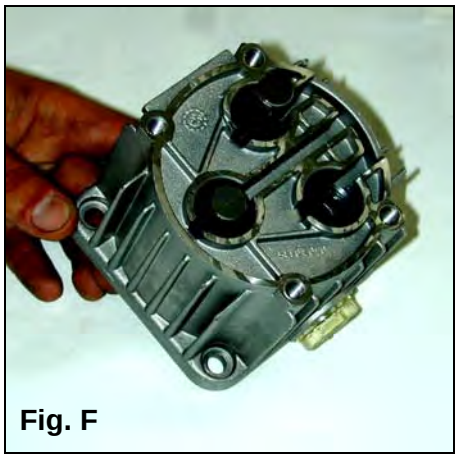


Fig. F

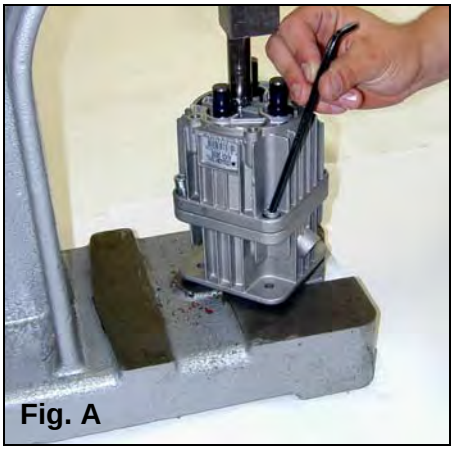


Fig. A


Fig. B

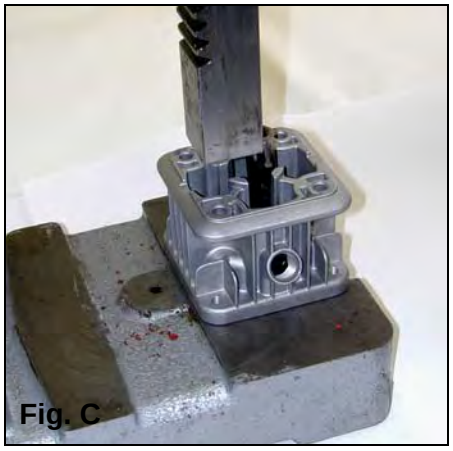


Fig. C

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

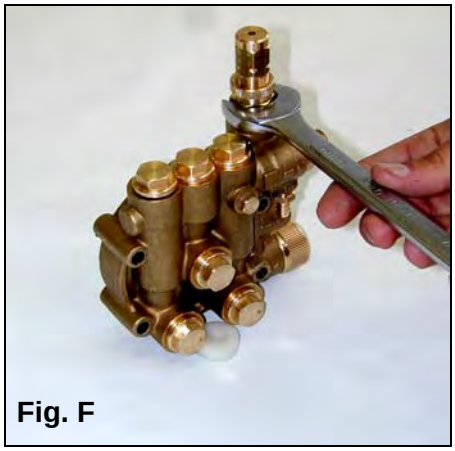


Fig. F

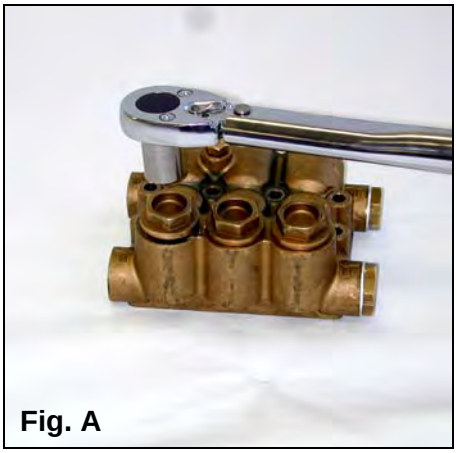


Fig. A

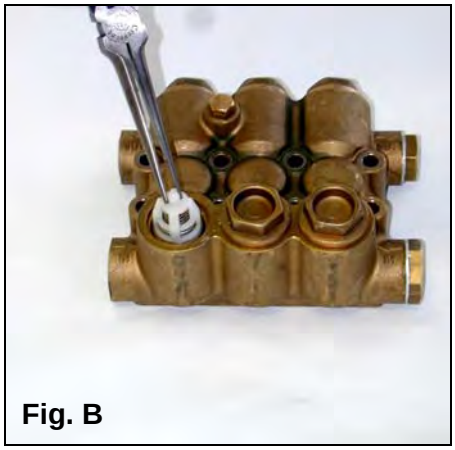


Fig. B

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)**

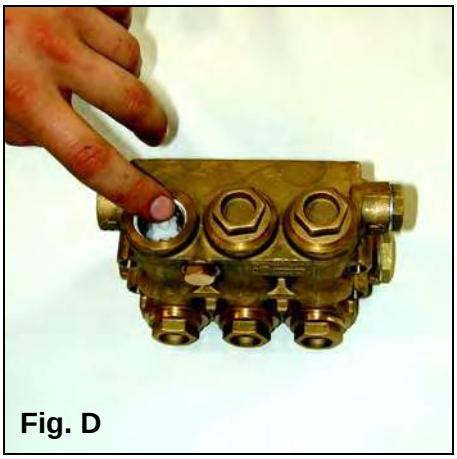


Fig. D

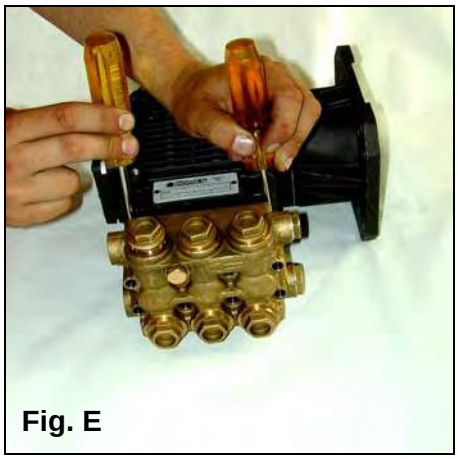
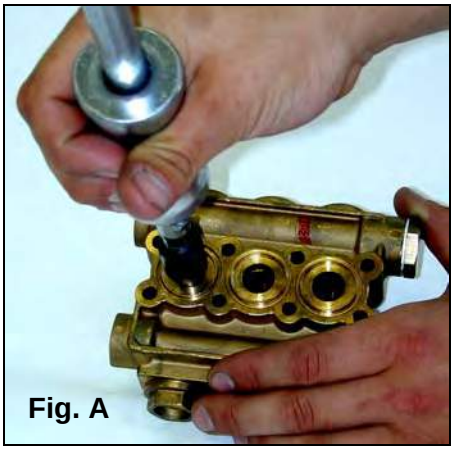


Fig. E

Fig. F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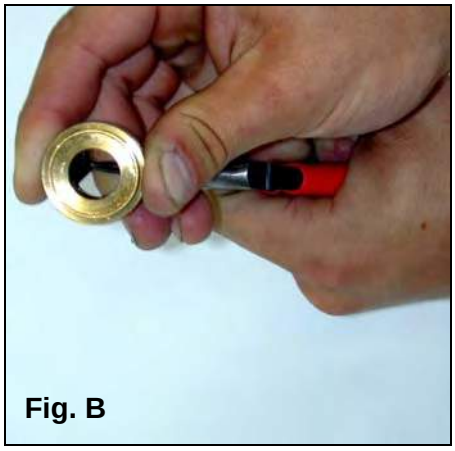


Fig. B

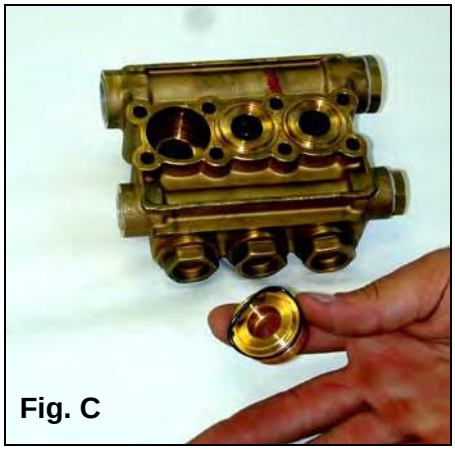


Fig. C

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)**

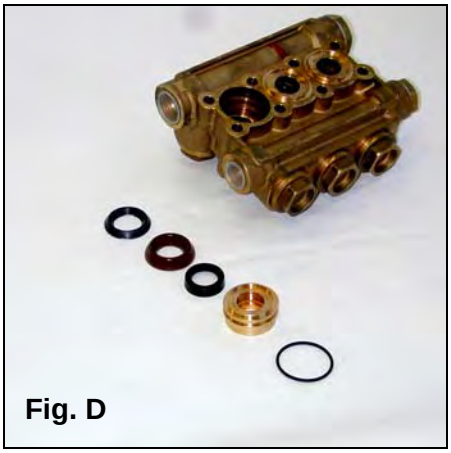
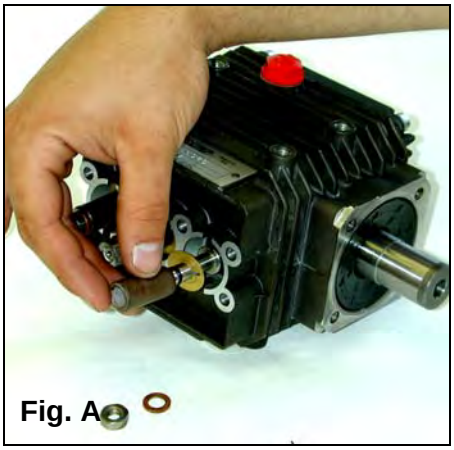


Fig. D


Fig. E


Fig. F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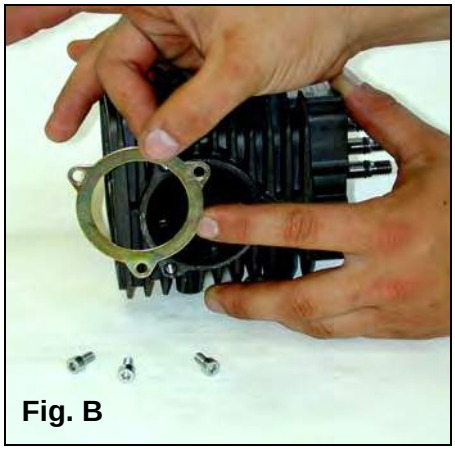


Fig. B


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.

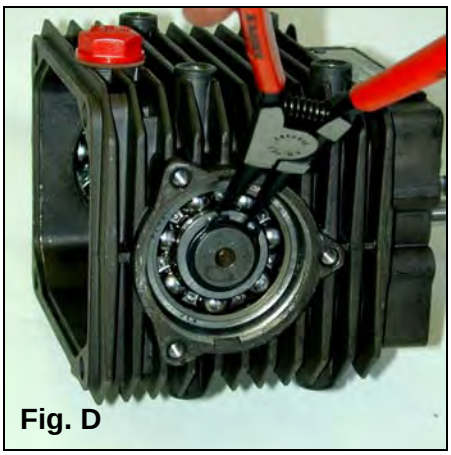
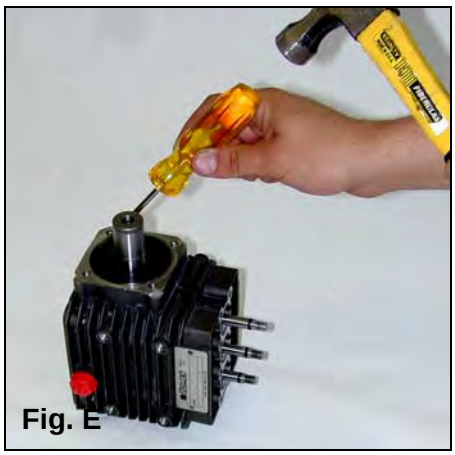


Fig. D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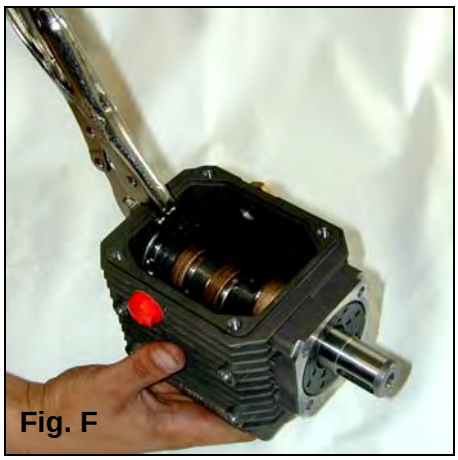
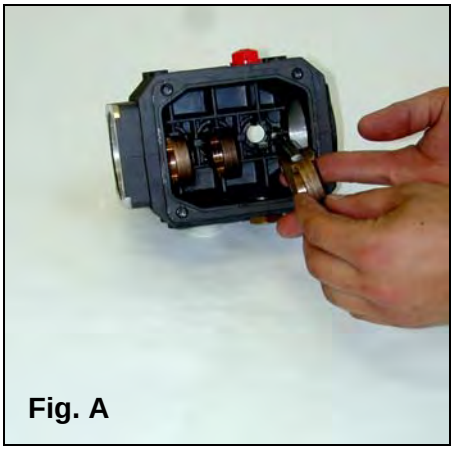


Fig. F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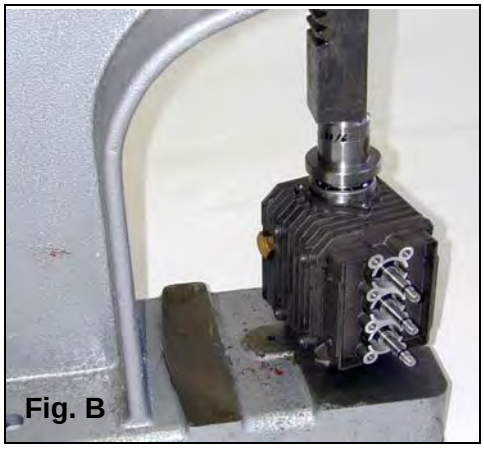
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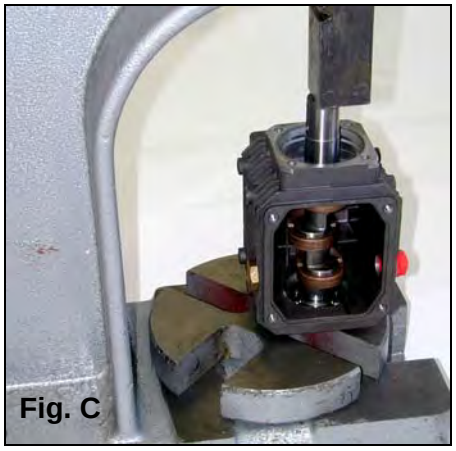


Fig. C

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.

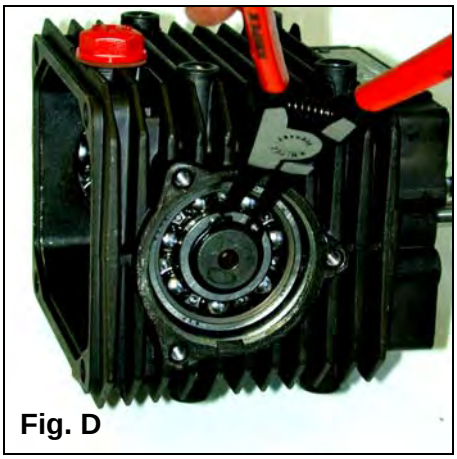
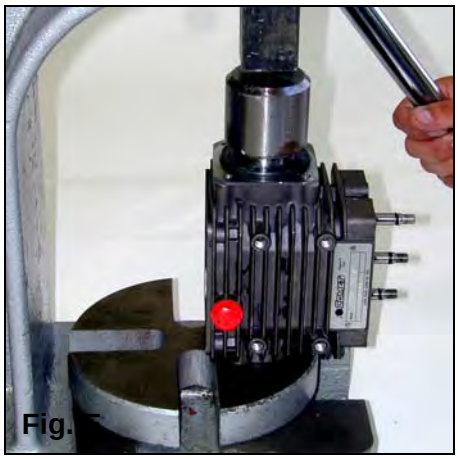


Fig. D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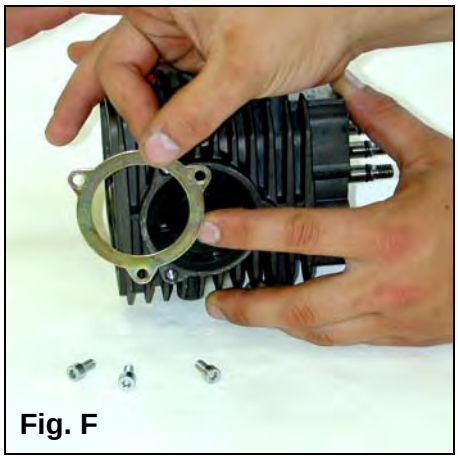
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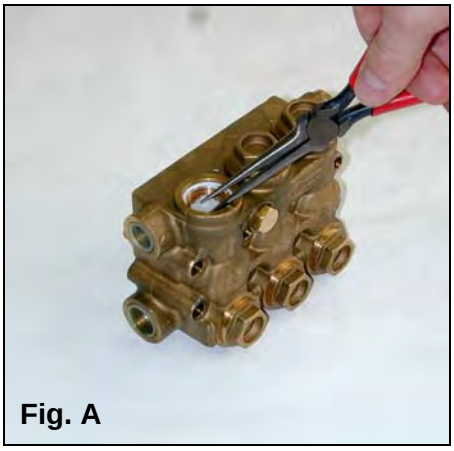

Fig. A

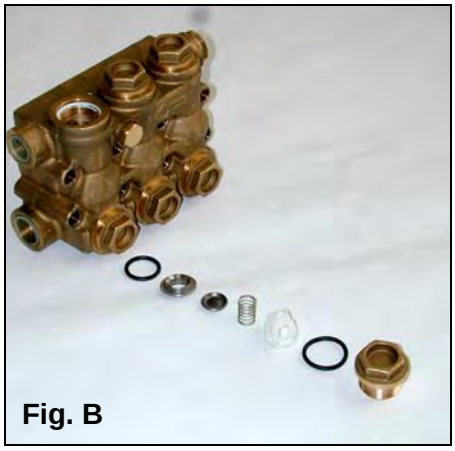

Fig. B

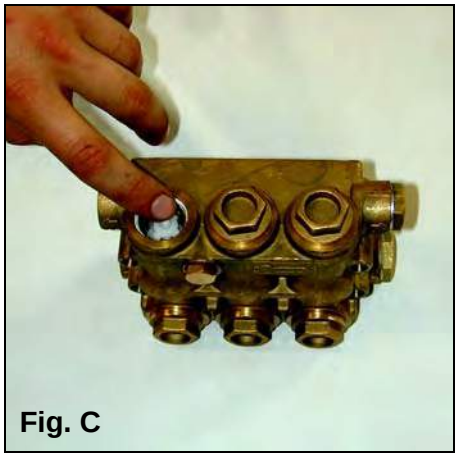

Fig. C

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)**

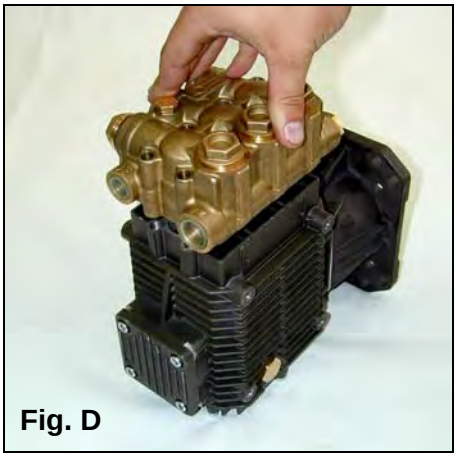

Fig. D

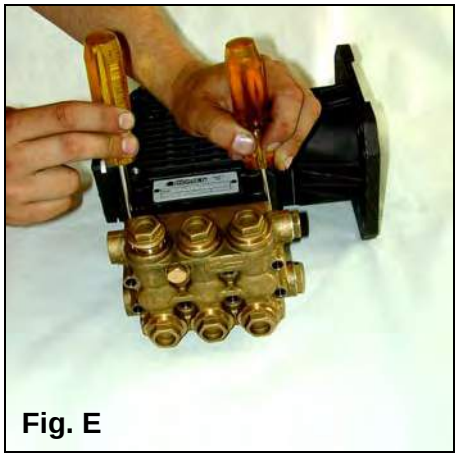

Fig. E

Fig. F

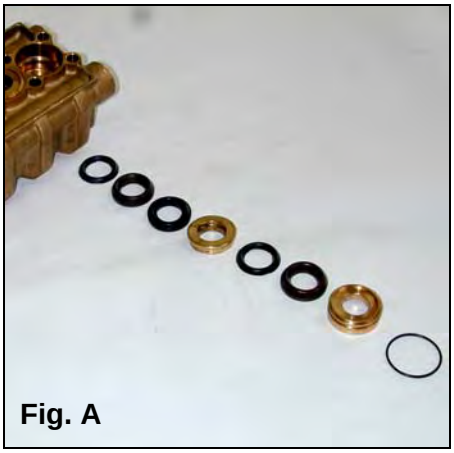

Fig. A

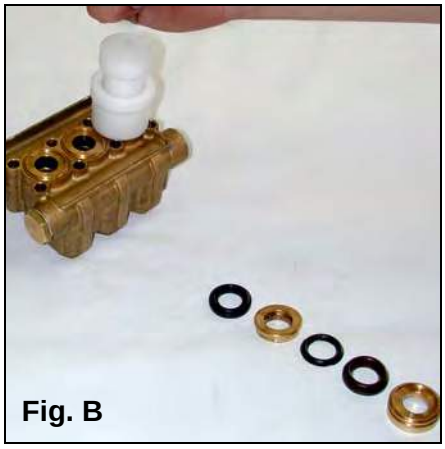

Fig. B

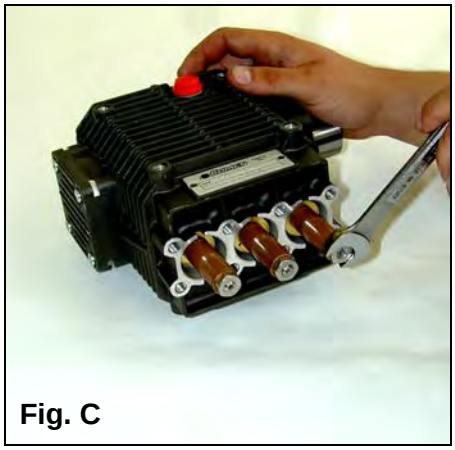

Fig. C

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.

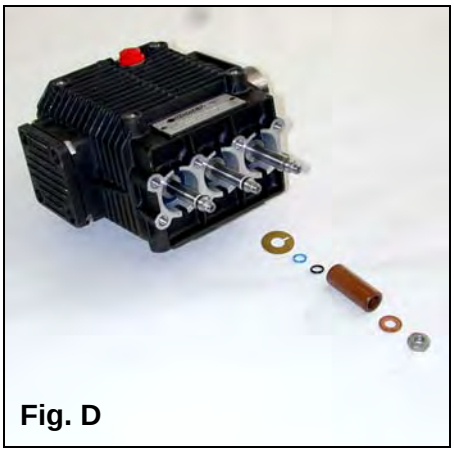

Fig. D

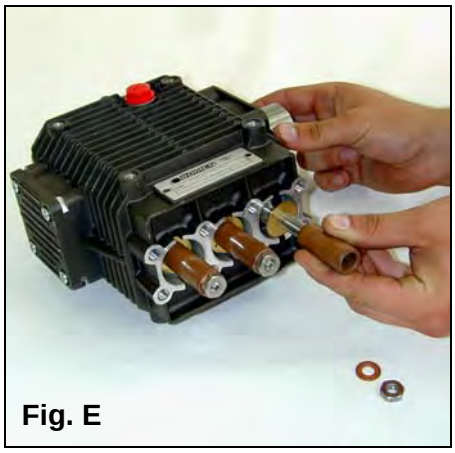

Fig. E

Fig. F

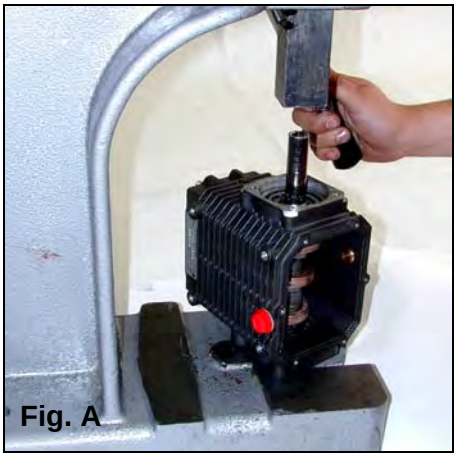
Fig. A


Fig. B

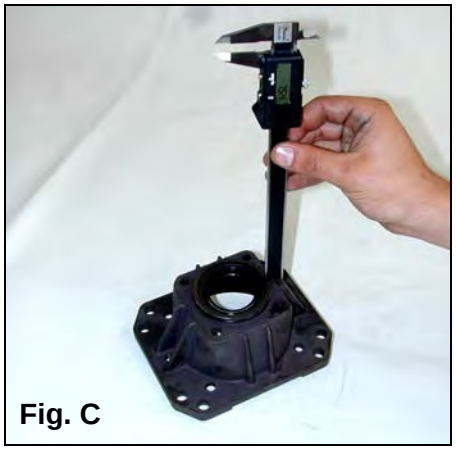
Fig. C

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

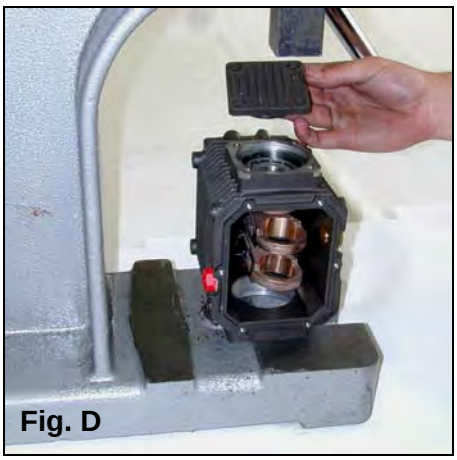
Fig. D

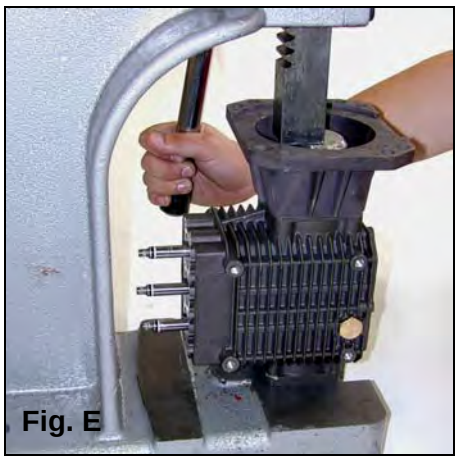
Fig. E

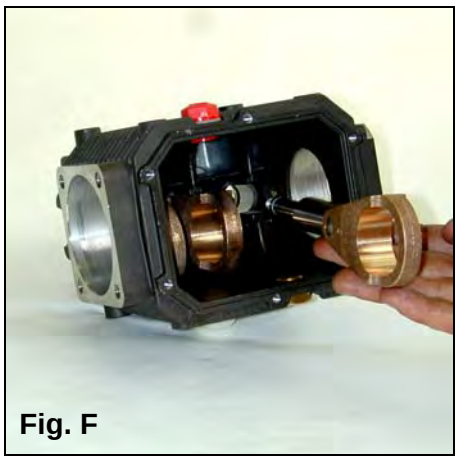
Fig. F

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

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

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.**

TABLE OF CONTENTS

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LIST OF ILLUSTRATIONS

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.

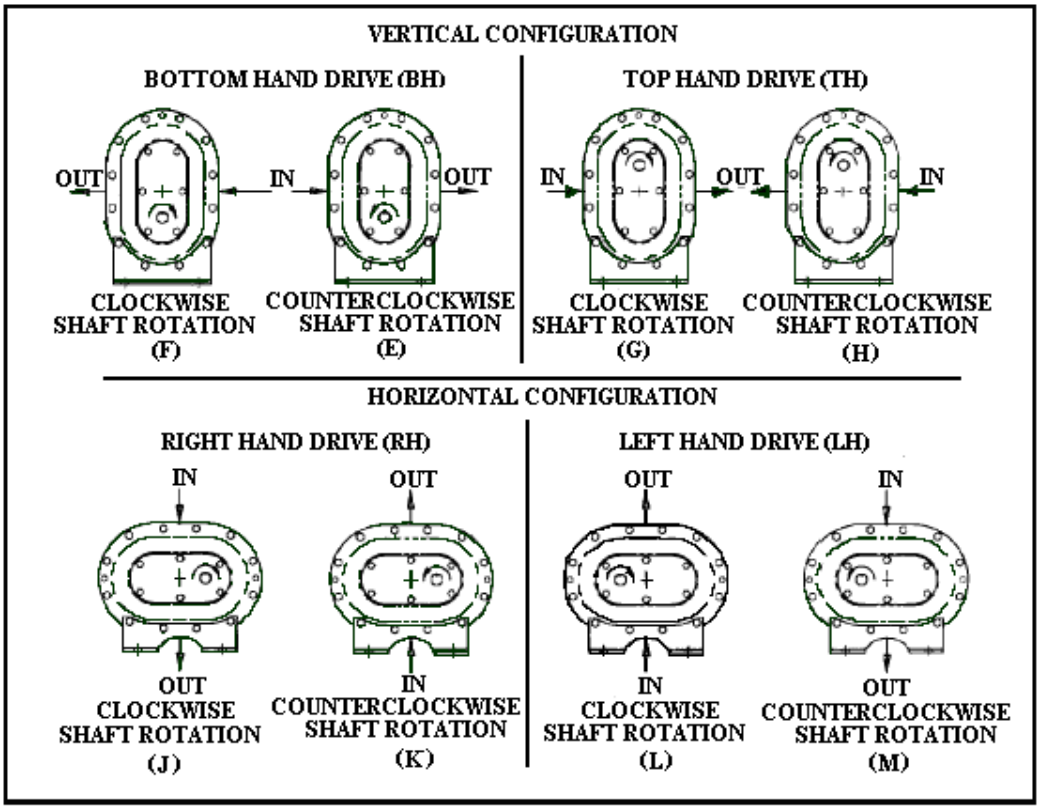


FIGURE 2-1 – BLOWER MOUNTING CONFIGURATIONS

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

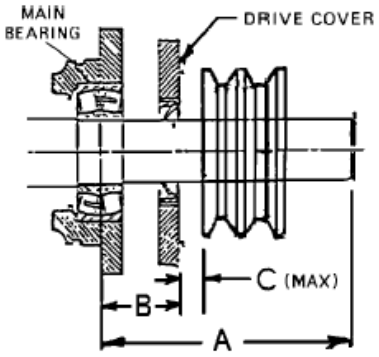
Sutorbilt blowers are shipped dry from the factory. Do not attempt to operate the blower before following proper lubrication instructions. Permanent damage to the gears, bearings and seals will occur.

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

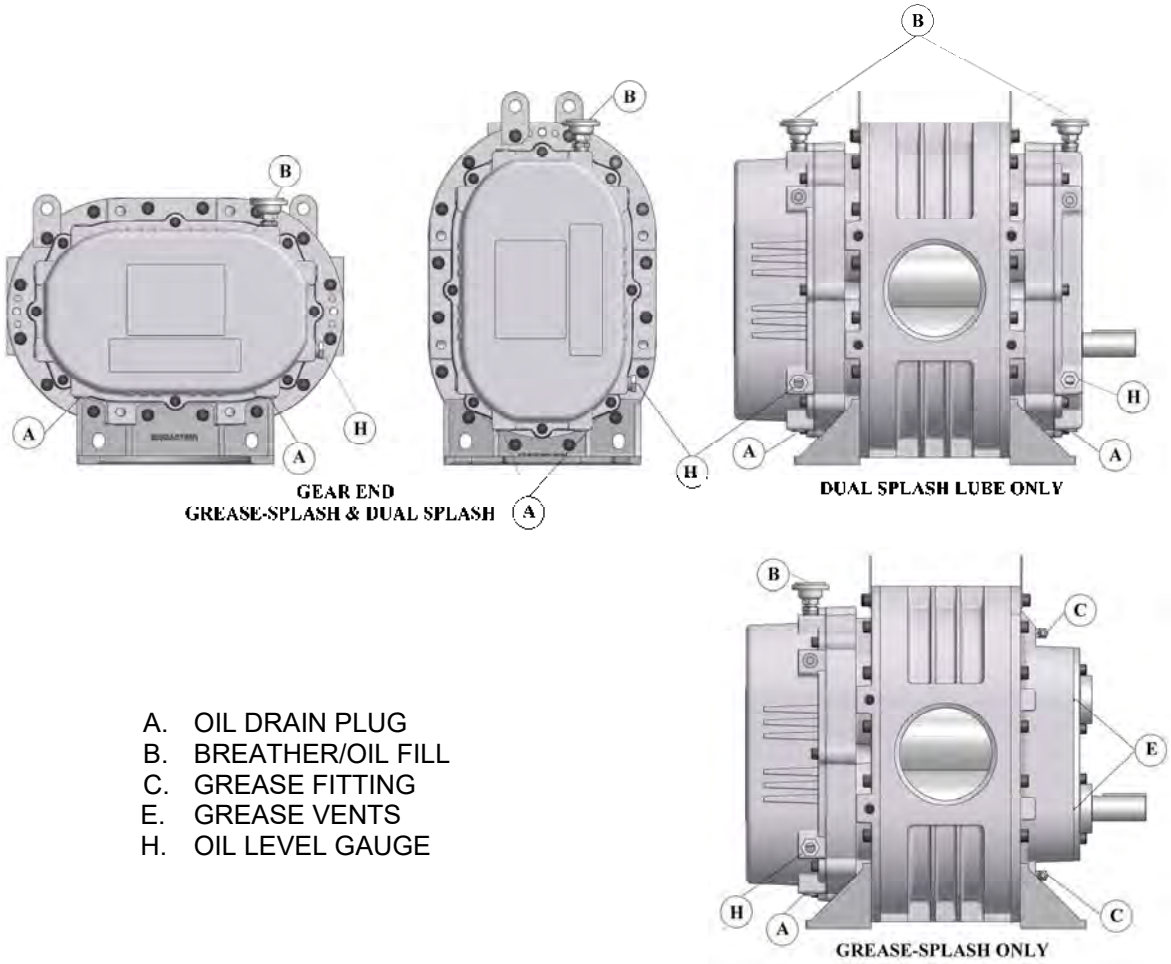
Servicing the air filters is one of the most important maintenance operations to be performed to insure long blower life.

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.

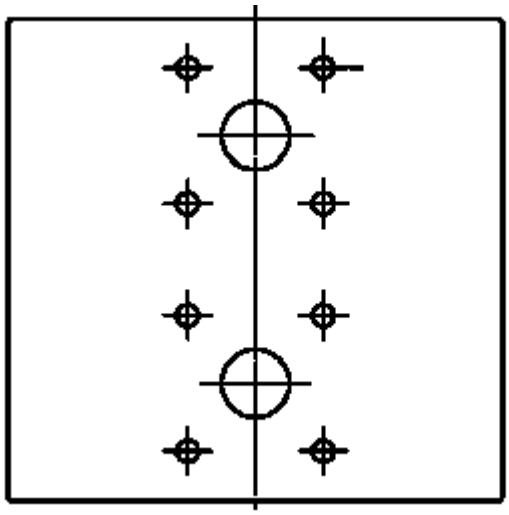
6. The blower and blower discharge piping may be extremely hot and cause skin burns on contact.

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.

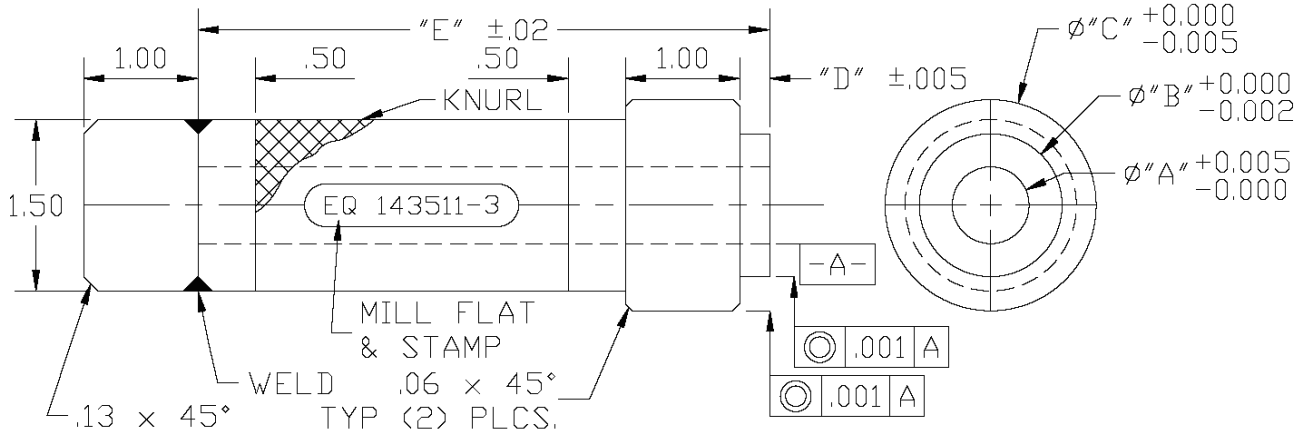
PROBLEM	POSSIBLE CAUSES	SOLUTION
Knocking	1. Unit out of time. 2. Distortion due to improper mounting or pipe strains. 3. Excessive pressure differential. 4. Worn gears. 5. Worn bearings.	1. Re-time impellers 2. Check mounting alignment and relieve pipe strains. 3. Reduce to manufacturer's recommended 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.



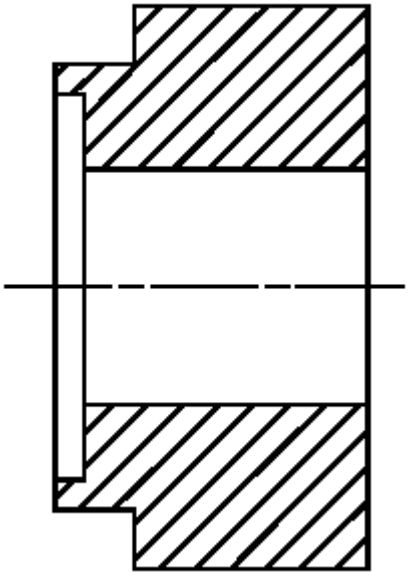
Unit Size	Part Number
3”	201GAA340
4”	202GAA340
5”	203GAA340

FIGURE 5-1 – PULLER PLATE



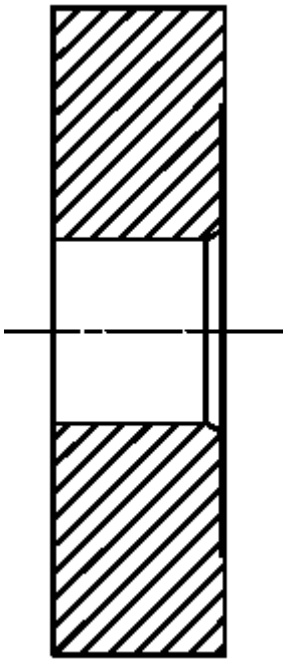
PART NO.	SIZE	"A"	"B"	"C"	"D"	"E"
EQ 143511-3	3"	.790	1.435	2.044	.335	5.50
EQ 143511-4	4"	1.000	1.624	2.436	.395	6.25
EQ 143511-5	5"	1.184	2.247	2.829	.695	7.00

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

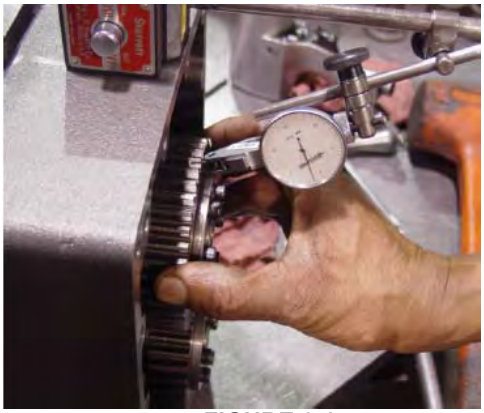


FIGURE 6-1

FIGURE 6-2

FIGURE 6-3

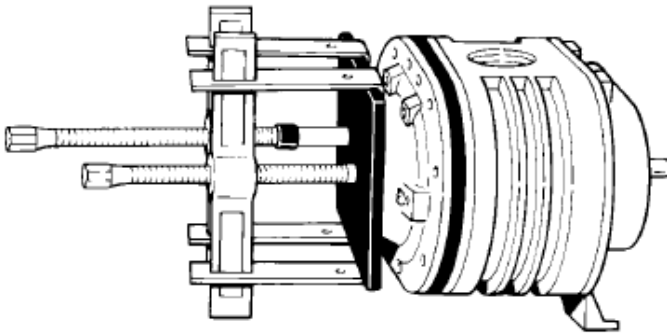


FIGURE 6-4

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.

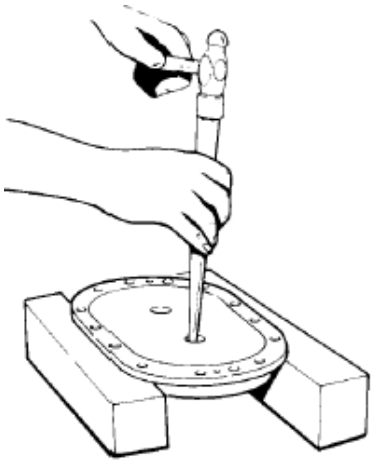


FIGURE 6-5

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.

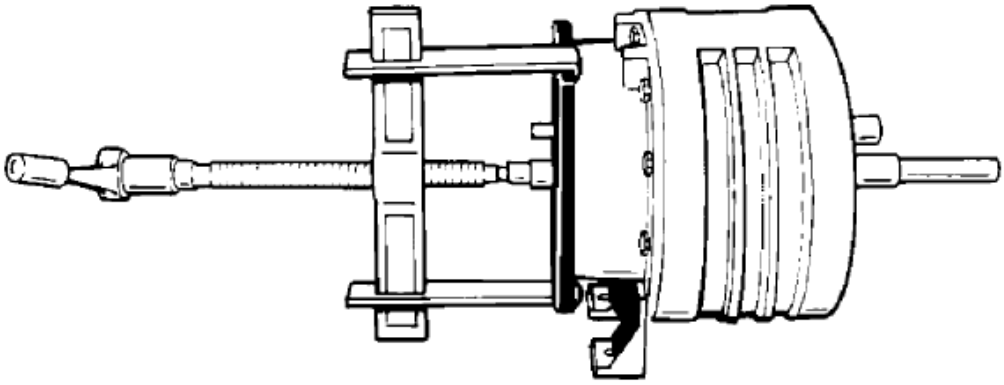


FIGURE 6-6

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.

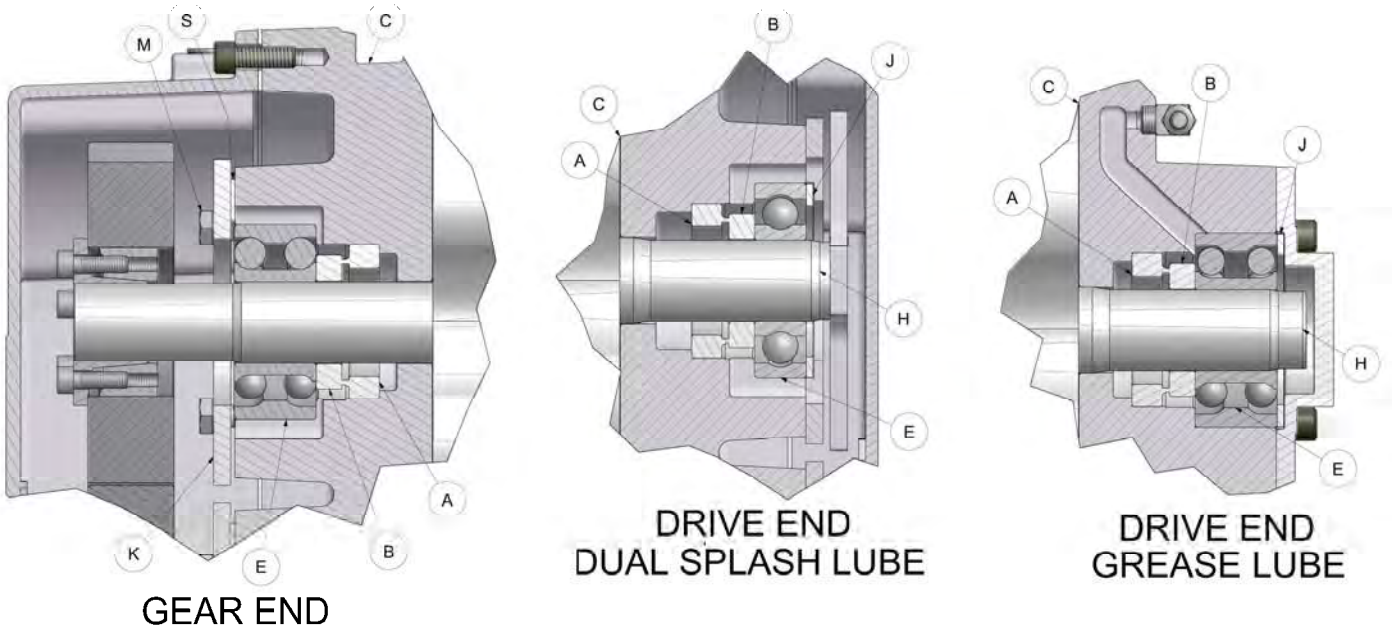


FIGURE 7-1

FIGURE 7-2

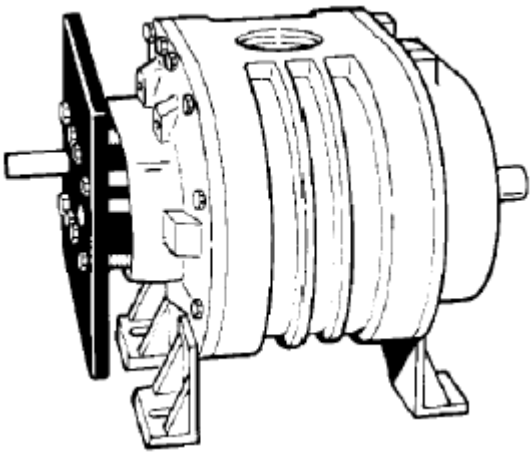


FIGURE 7-3

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

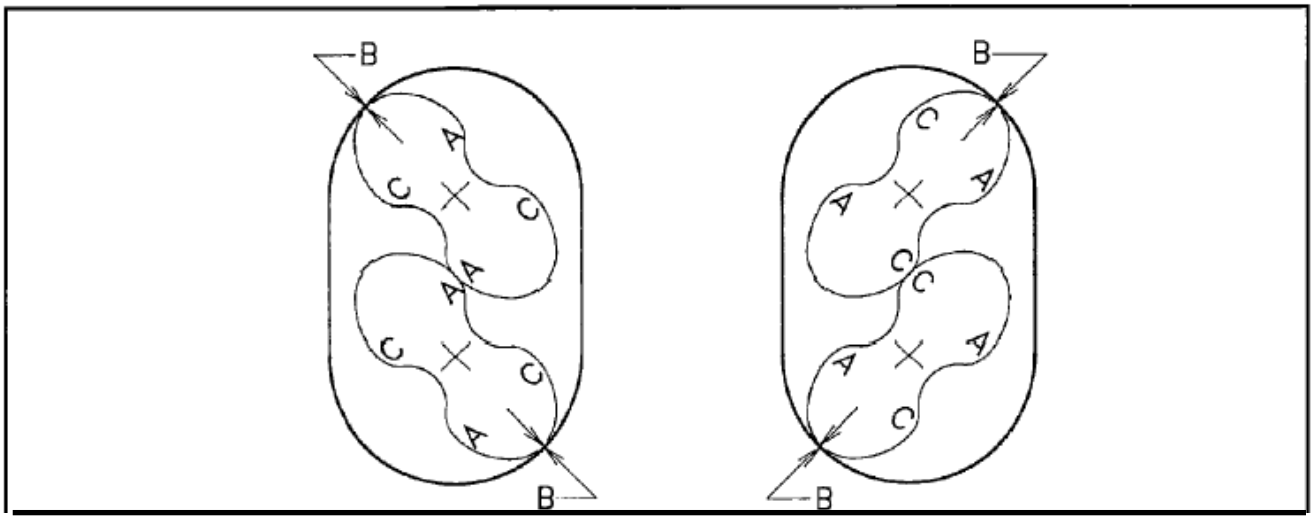
A. Refer to Figure 7-1, page 31. Lightly coat the impeller shaft (H) and the inside diameter of the mating ring (B) with assembly lubricant.

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).

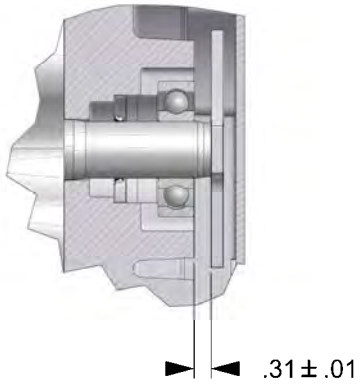


Figure 7-5

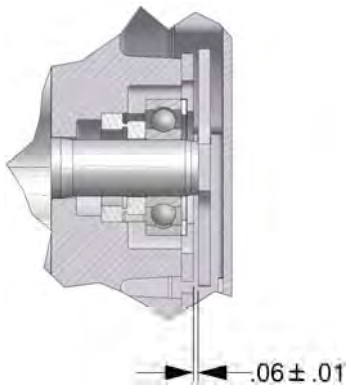


Figure 7-6

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.

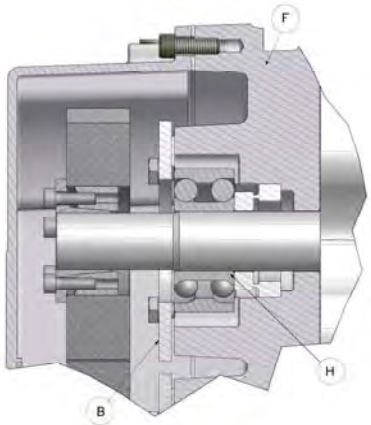


Figure 7-7

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.

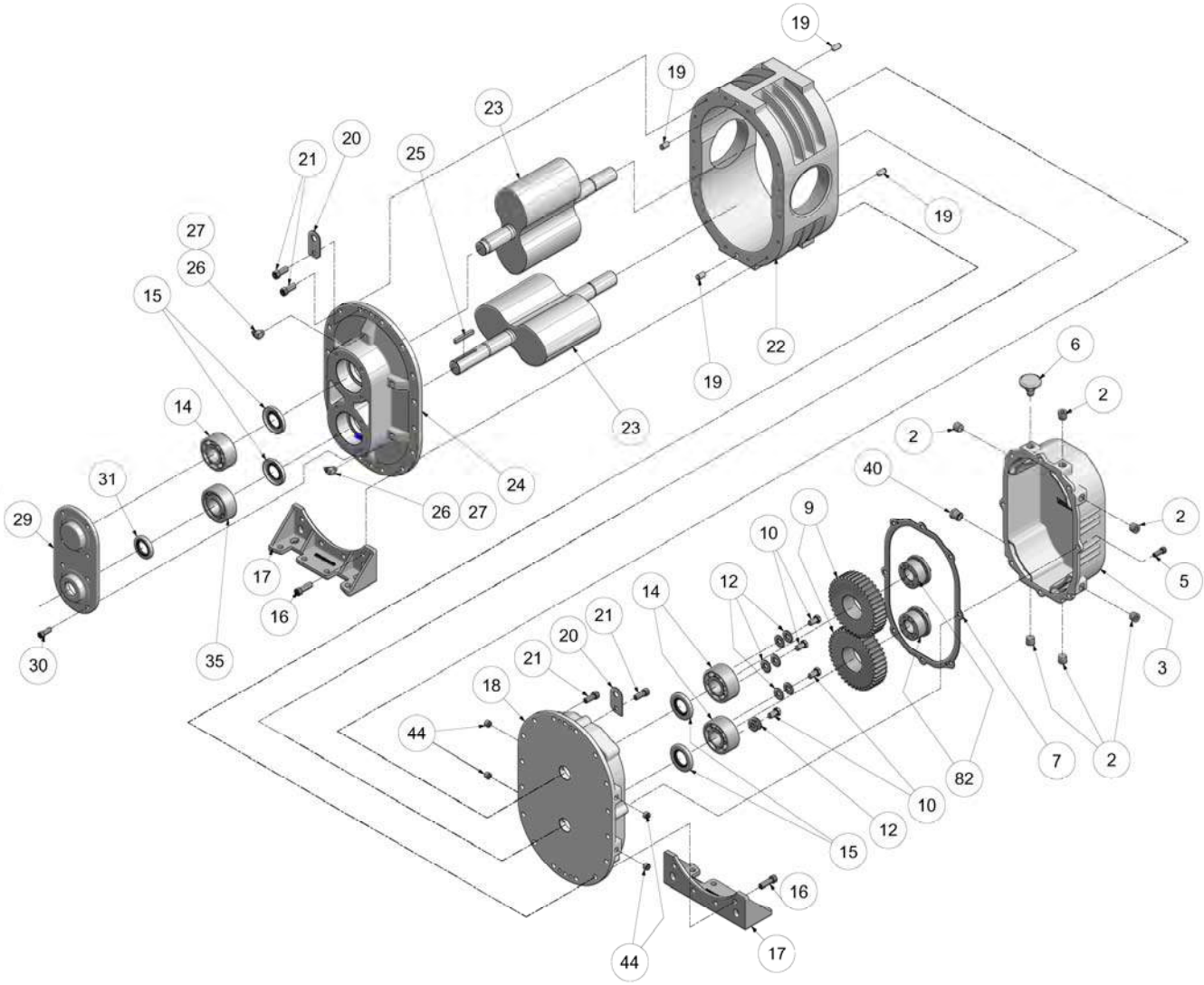
NOTICE
If the unit is not flat within .002 of an inch, it will be necessary to shim the blower feet at installation.

	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

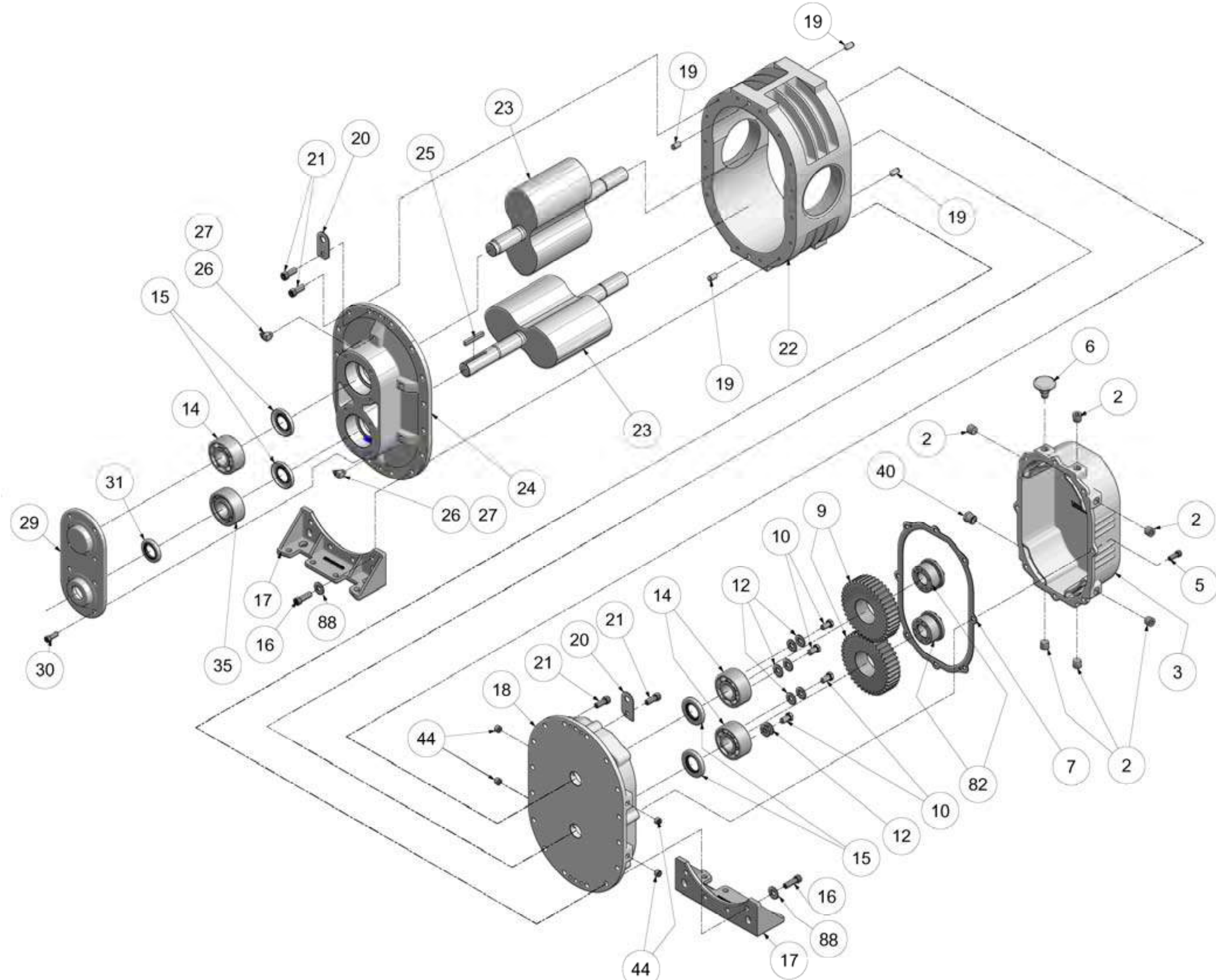


Order by Part Number and Description. Reference Numbers are for your convenience only.

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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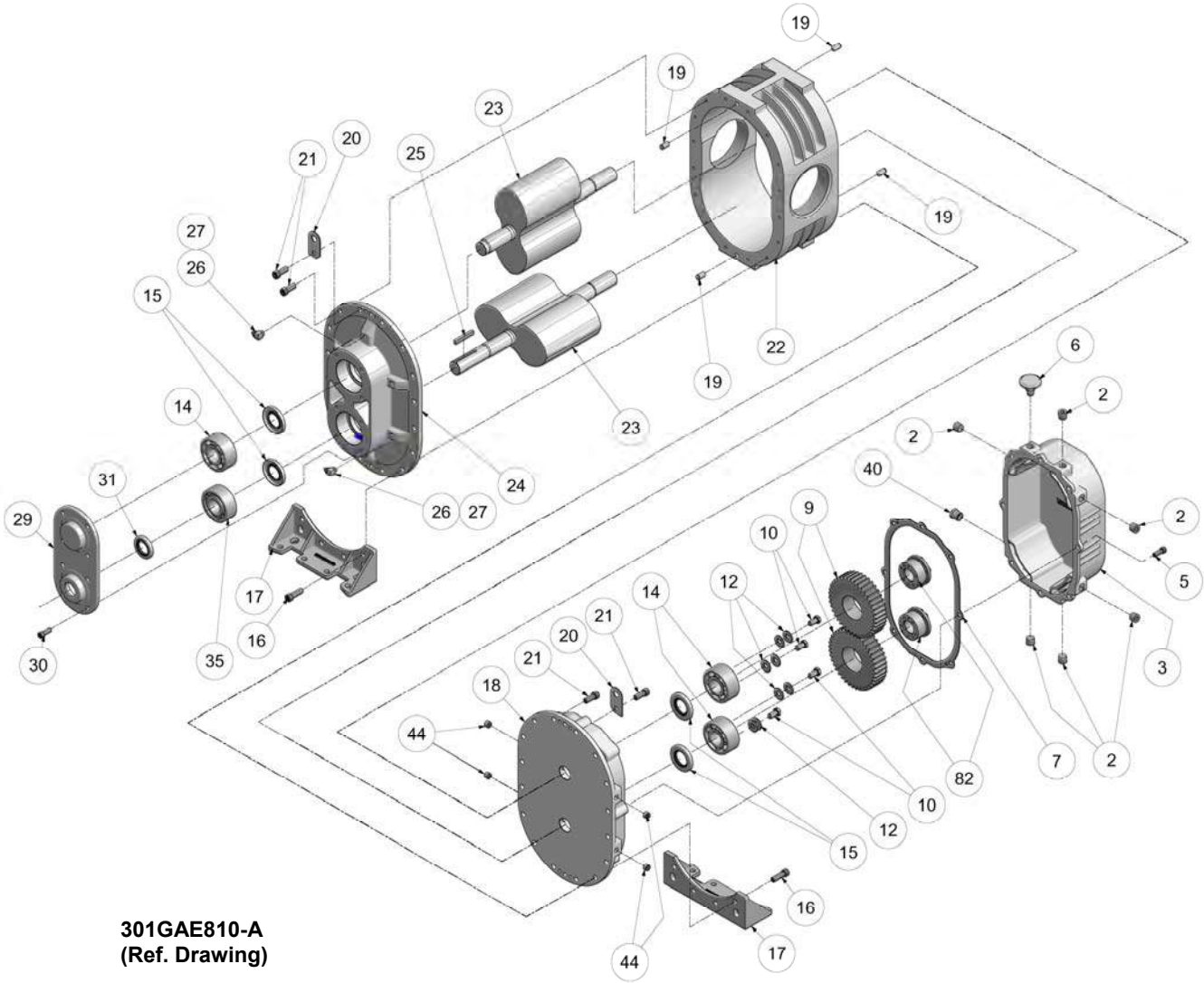
Order by Part Number and Description. Reference Numbers are for your convenience only.

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.



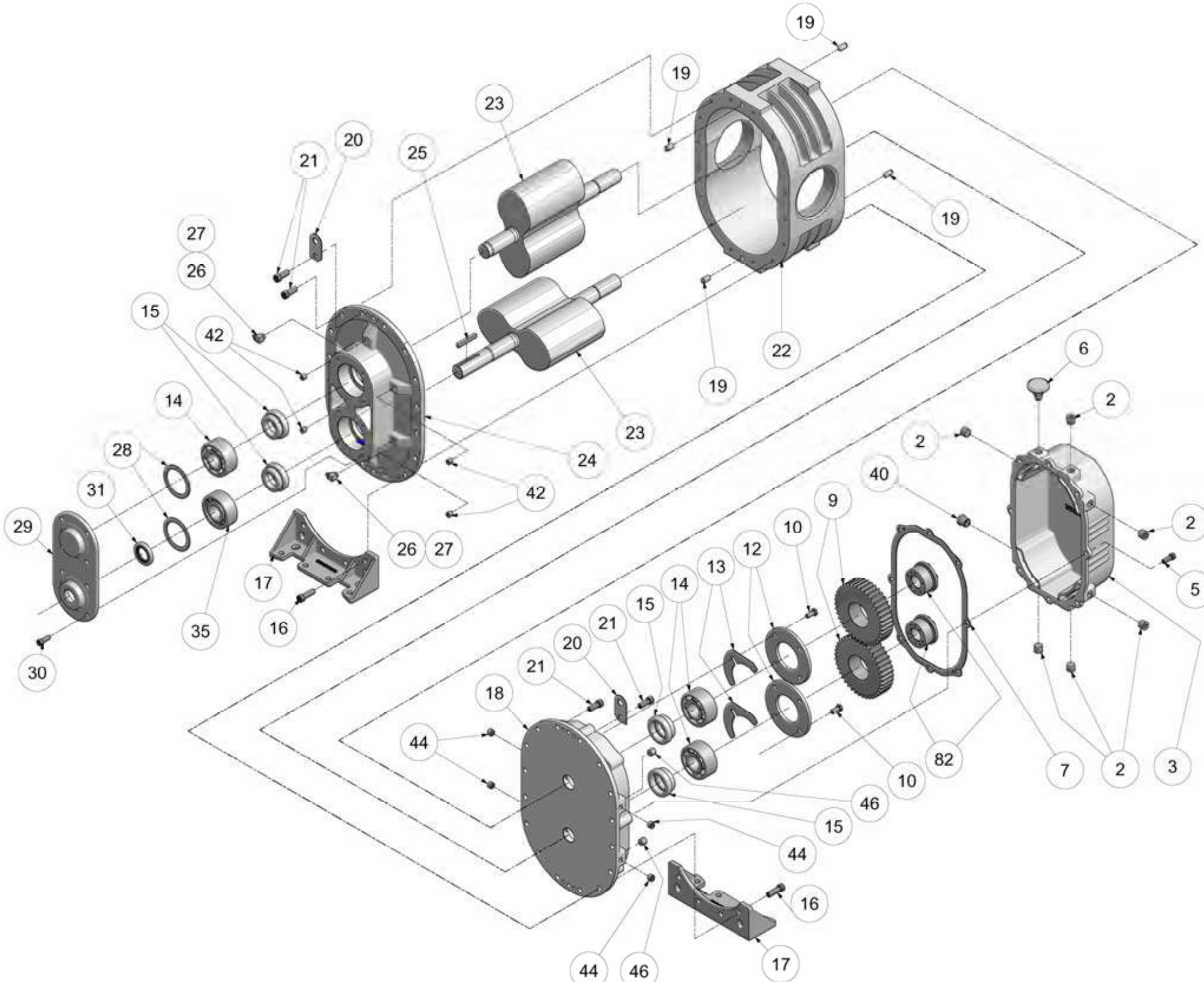
301GAE810-A
(Ref. Drawing)

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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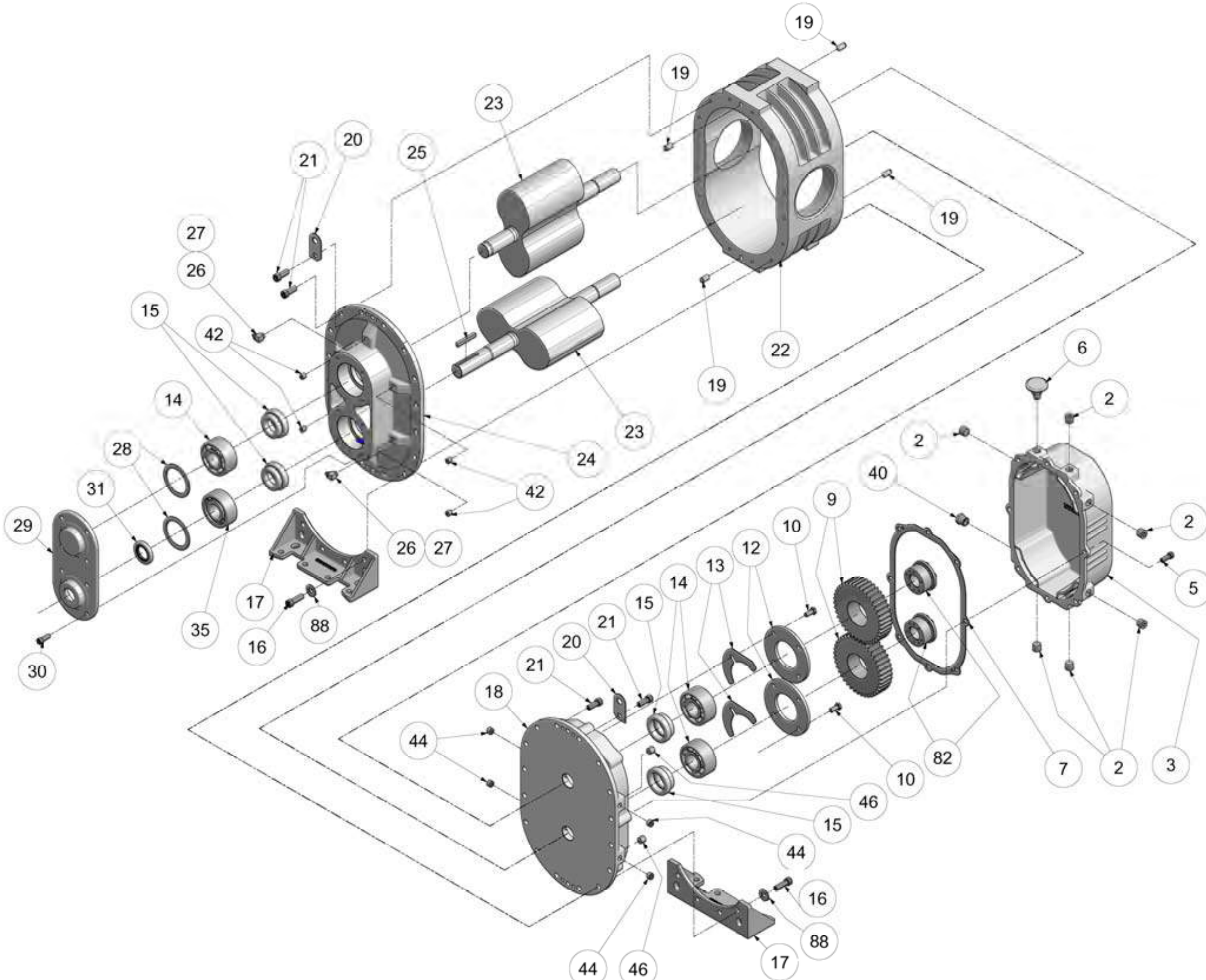
Order by Part Number and Description. Reference Numbers are for your convenience only.

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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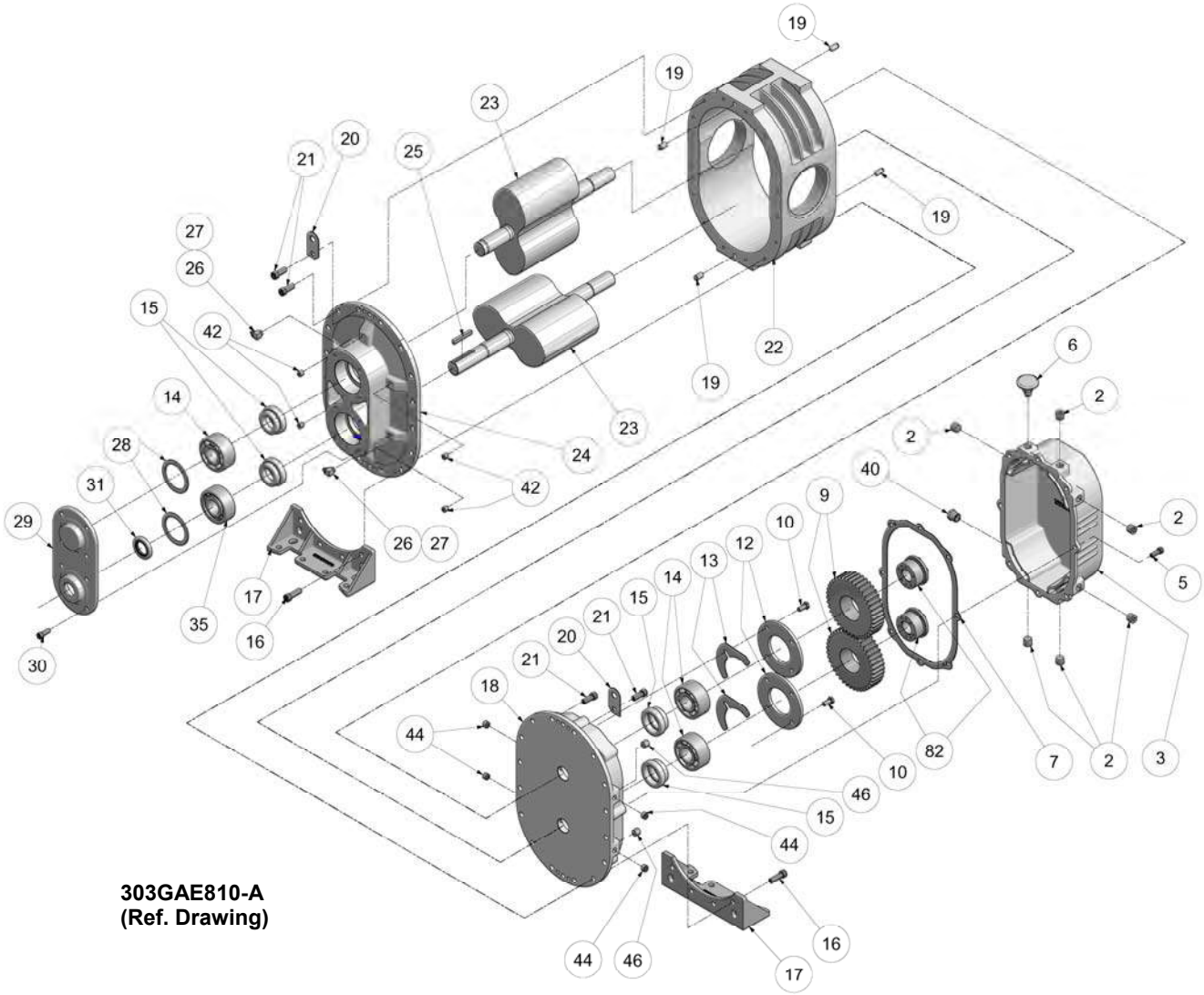
Order by Part Number and Description. Reference Numbers are for your convenience only.

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



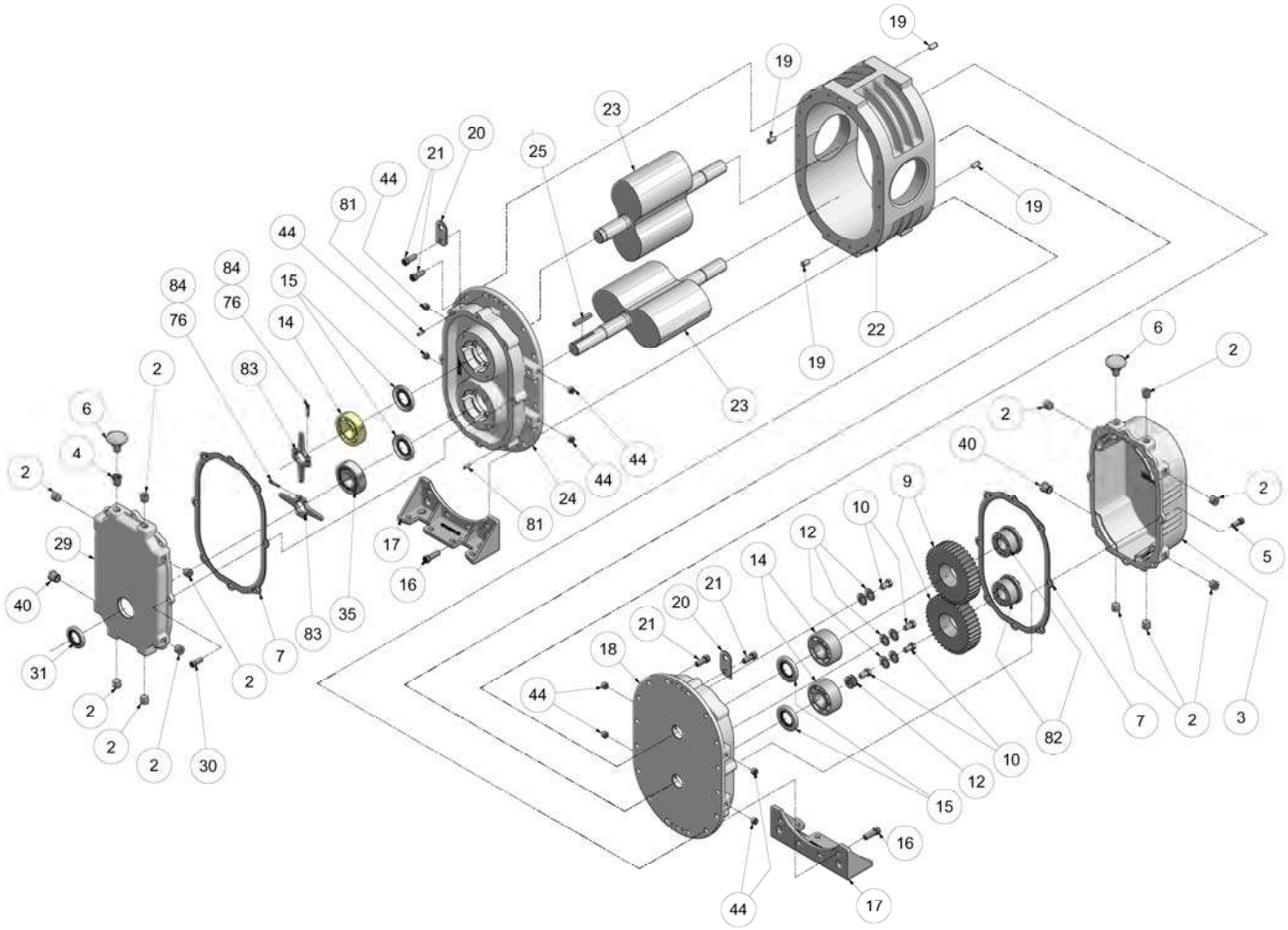
303GAE810-A
(Ref. Drawing)

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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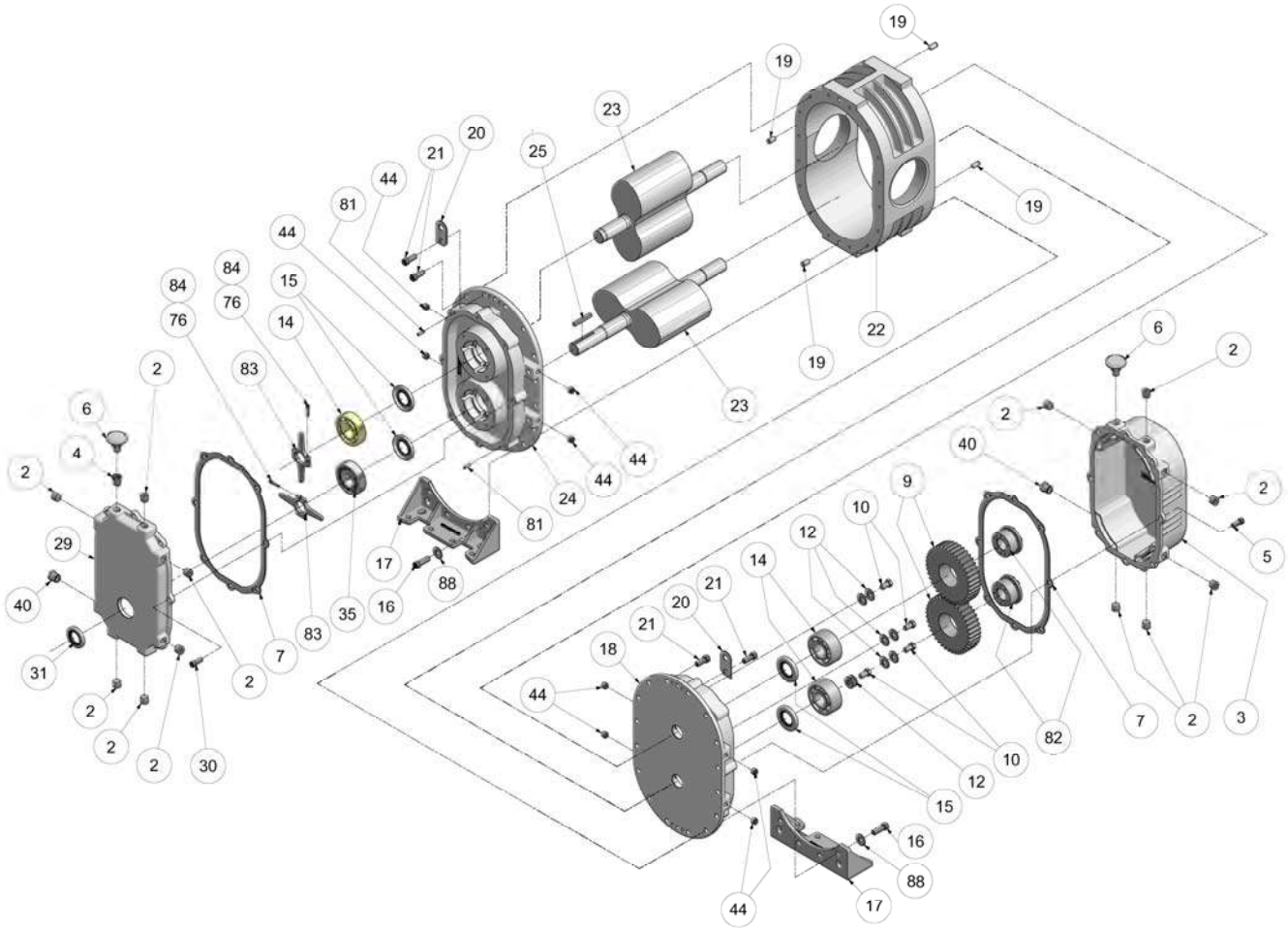
Order by Part Number and Description. Reference Numbers are for your convenience only.

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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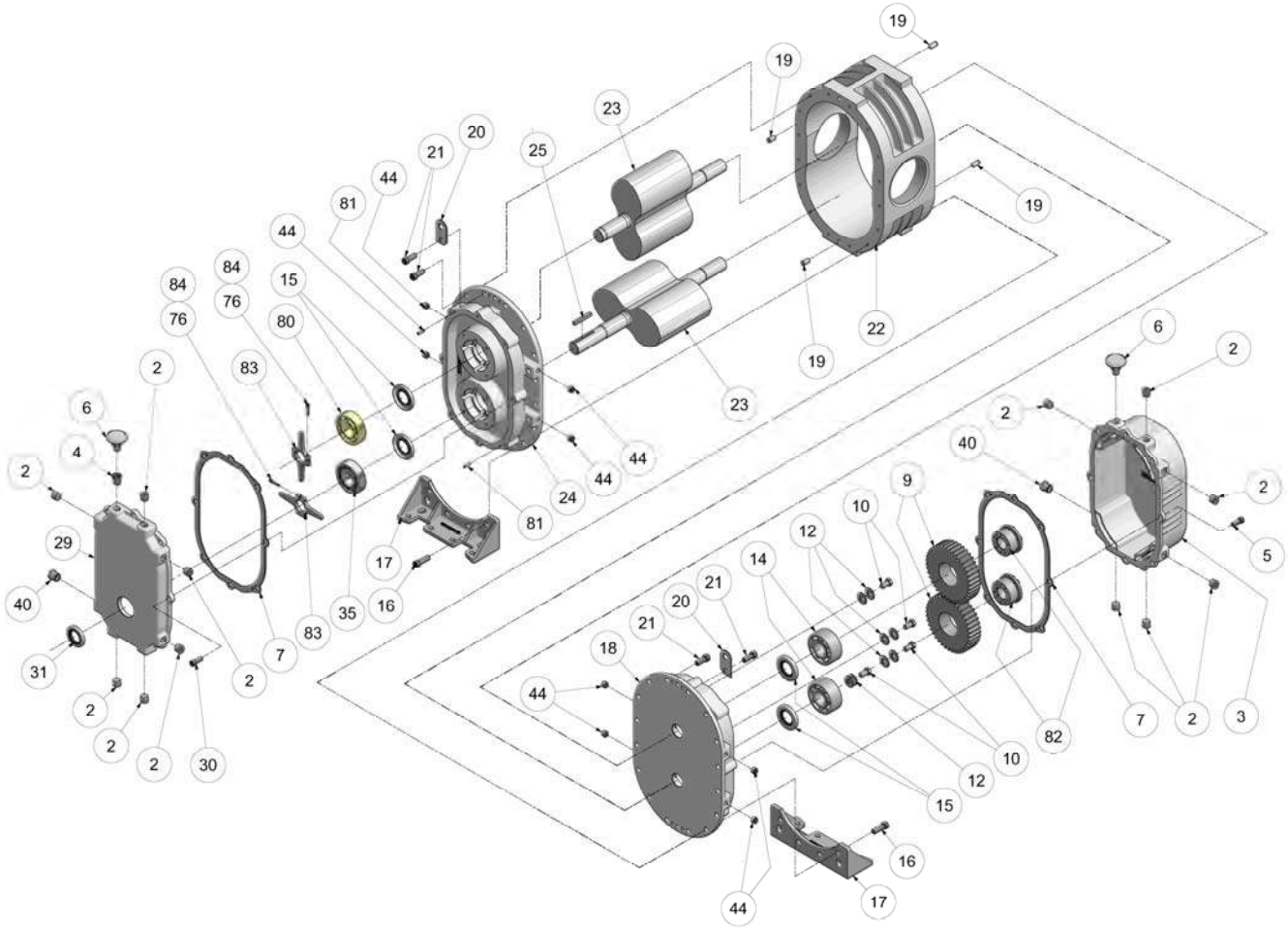
Order by Part Number and Description. Reference Numbers are for your convenience only.

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



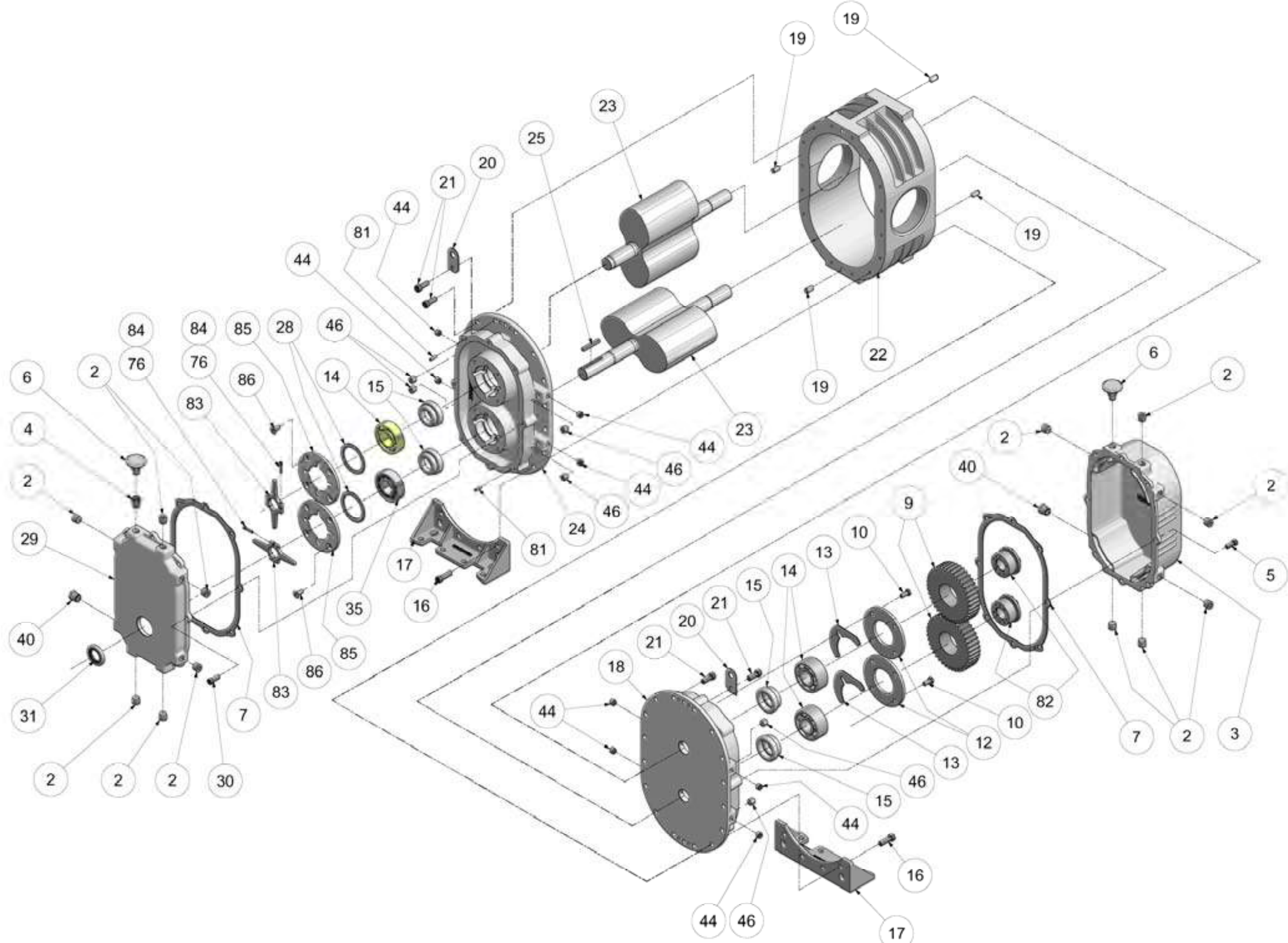
300GAE810-A
(Ref. Drawing)

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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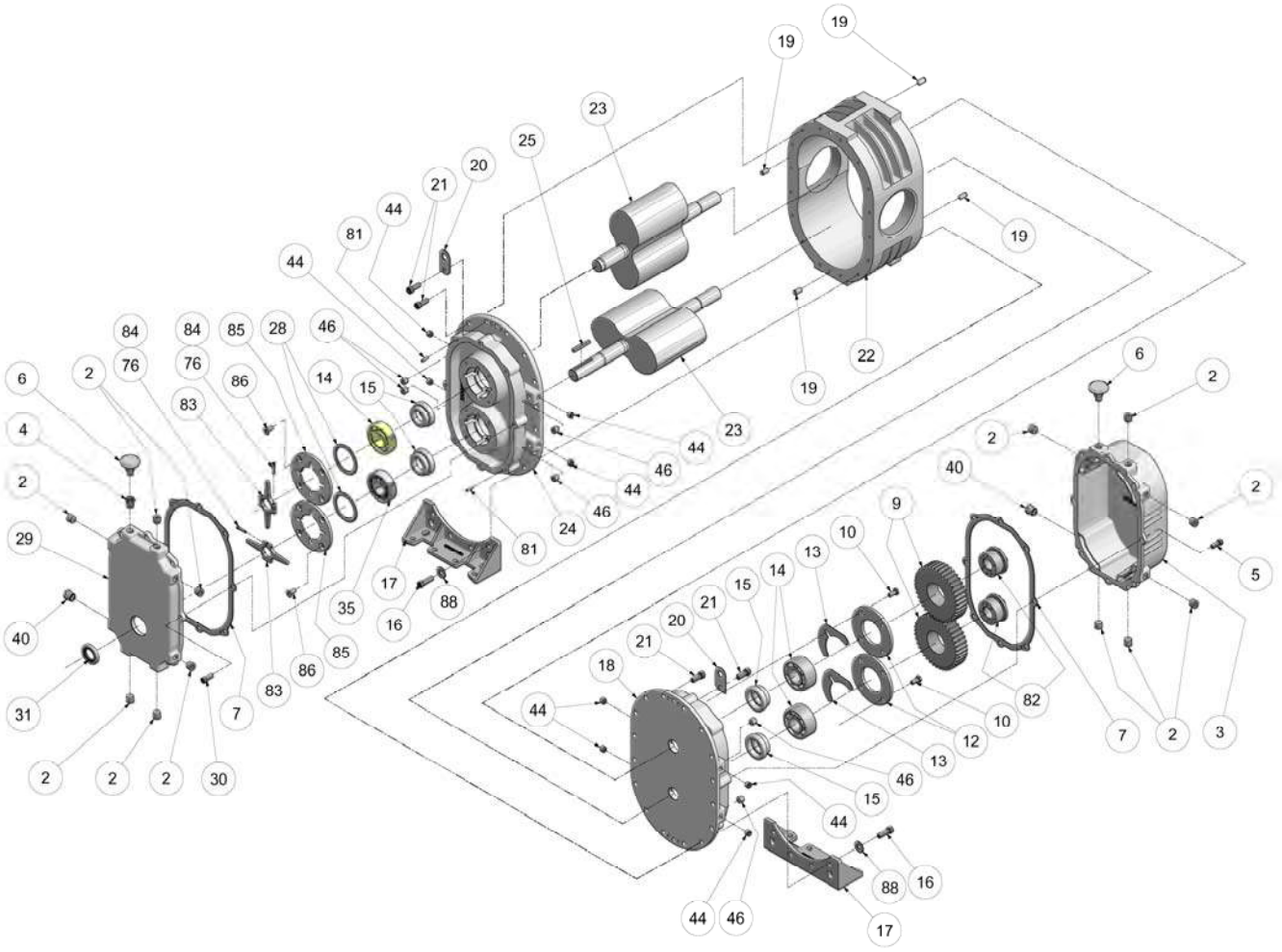
Order by Part Number and Description. Reference Numbers are for your convenience only.

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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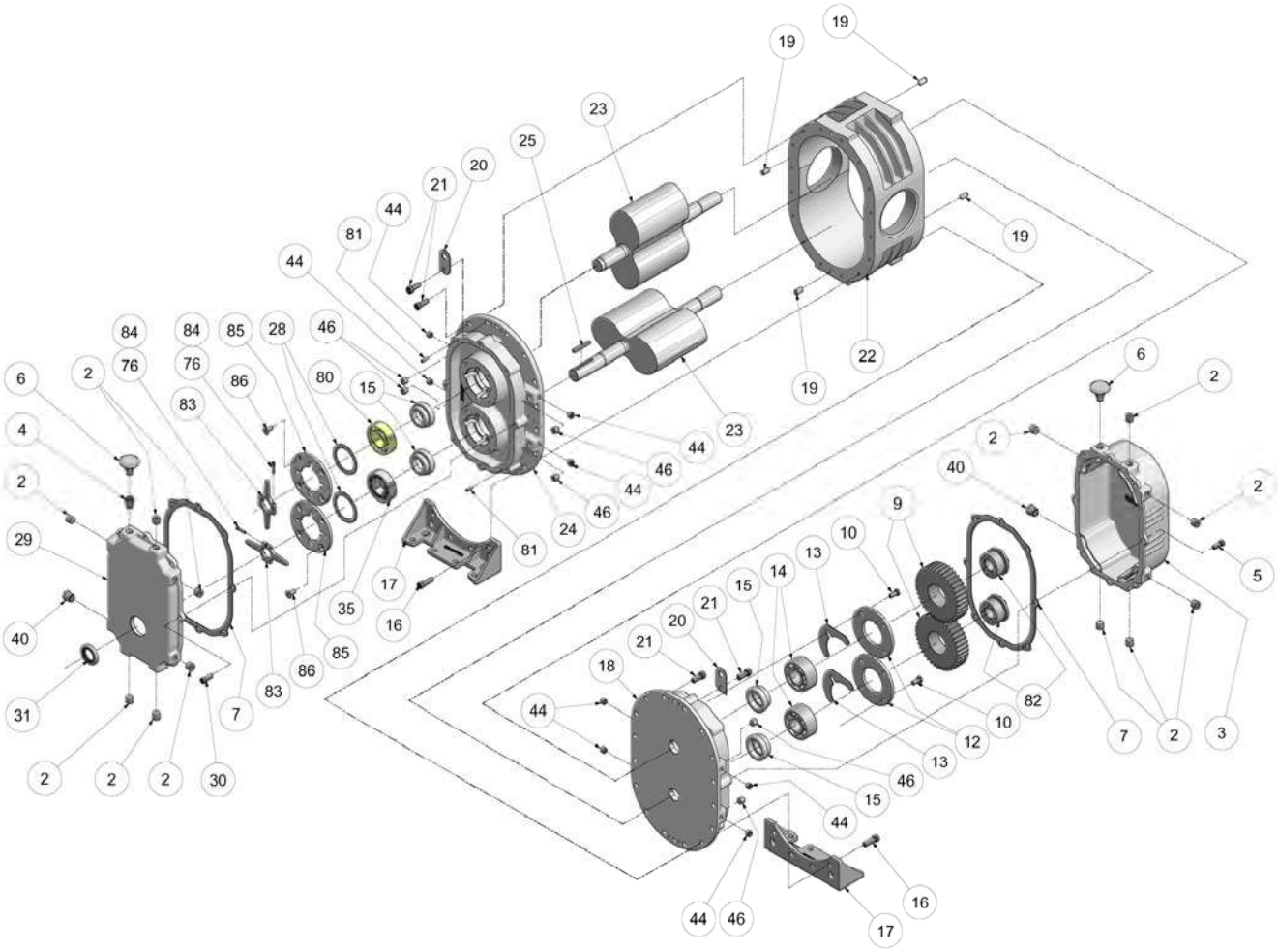
Order by Part Number and Description. Reference Numbers are for your convenience only.

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.

Gardner Denver®

For additional information, contact your local representative or visit:
www.contactgd.com/mobile

 Printed in U.S.A.

ENERGY STAR PARTNER

Member

NTTC

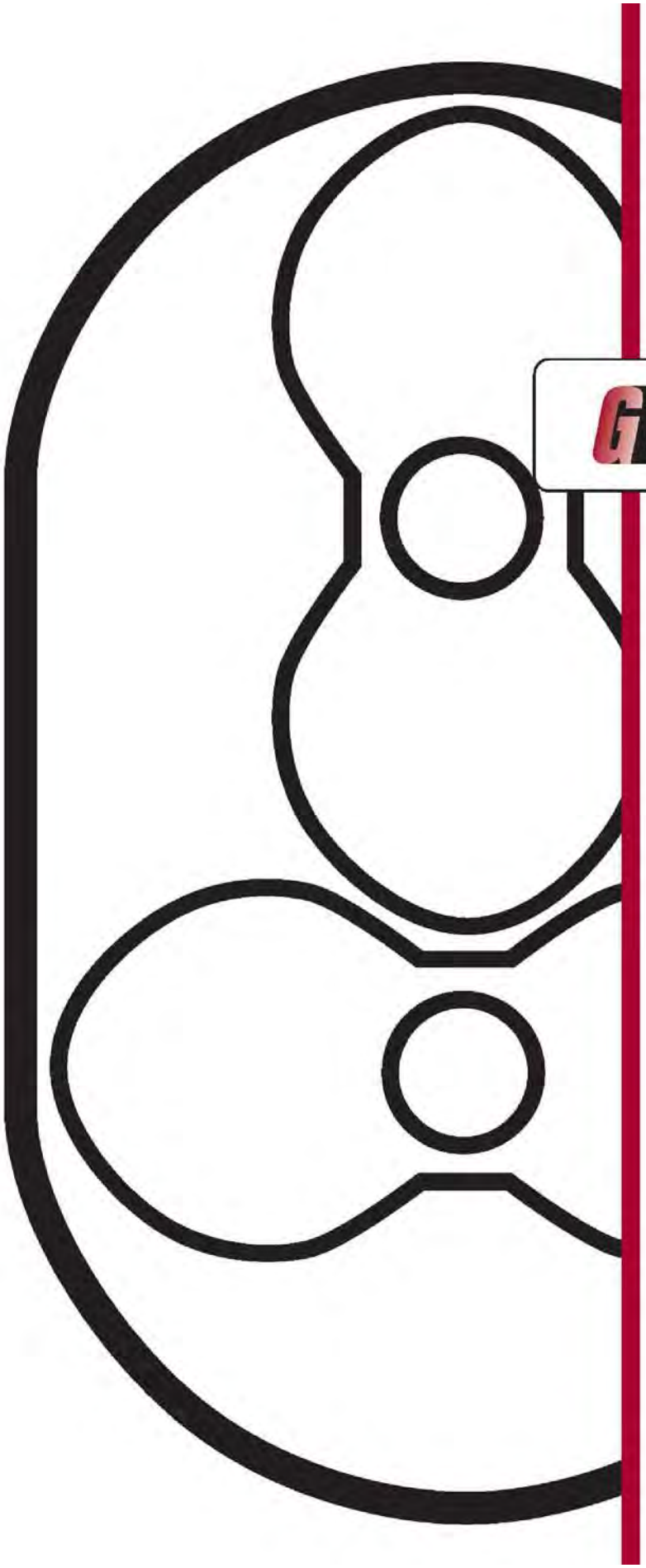
Please recycle after use.

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

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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LIST OF ILLUSTRATIONS

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.

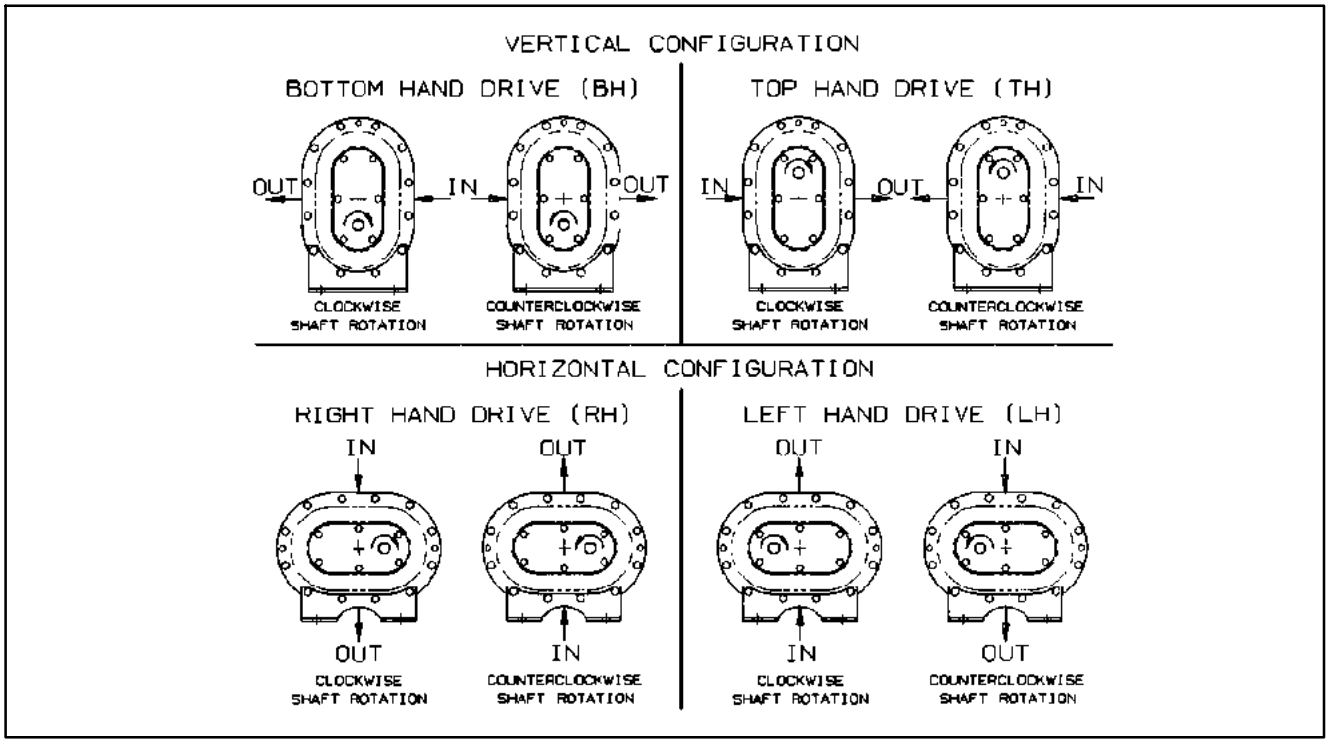


FIGURE 1 - BLOWER MOUNTING CONFIGURATIONS

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.

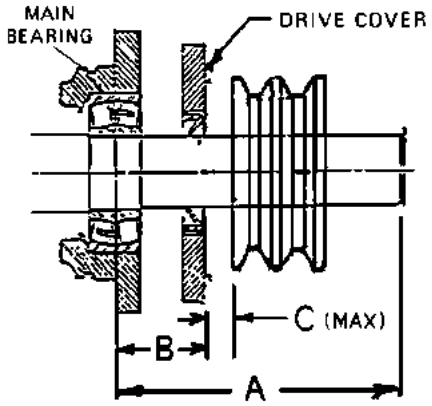
All system piping must be cleaned internally before connecting to the blower.

⚠ 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
- $Z = \left[\frac{\text{Large Sheave Pitch Diameter (in)} - \text{Small Sheave Pitch Diameter (in)}}{\text{Sheave Center Distance (in)}}\right]$

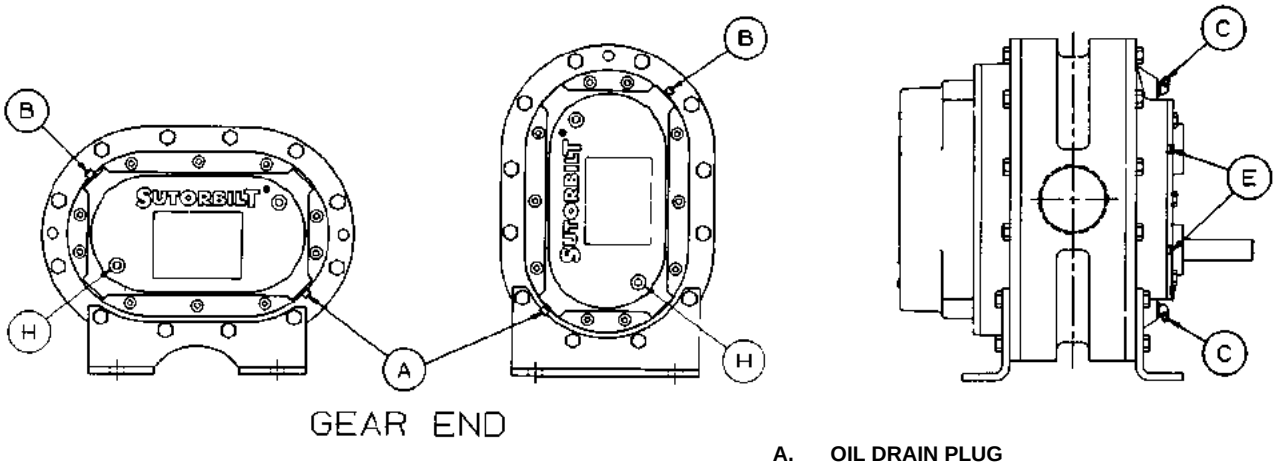
CALCULATION OF BELT PULL

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

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.

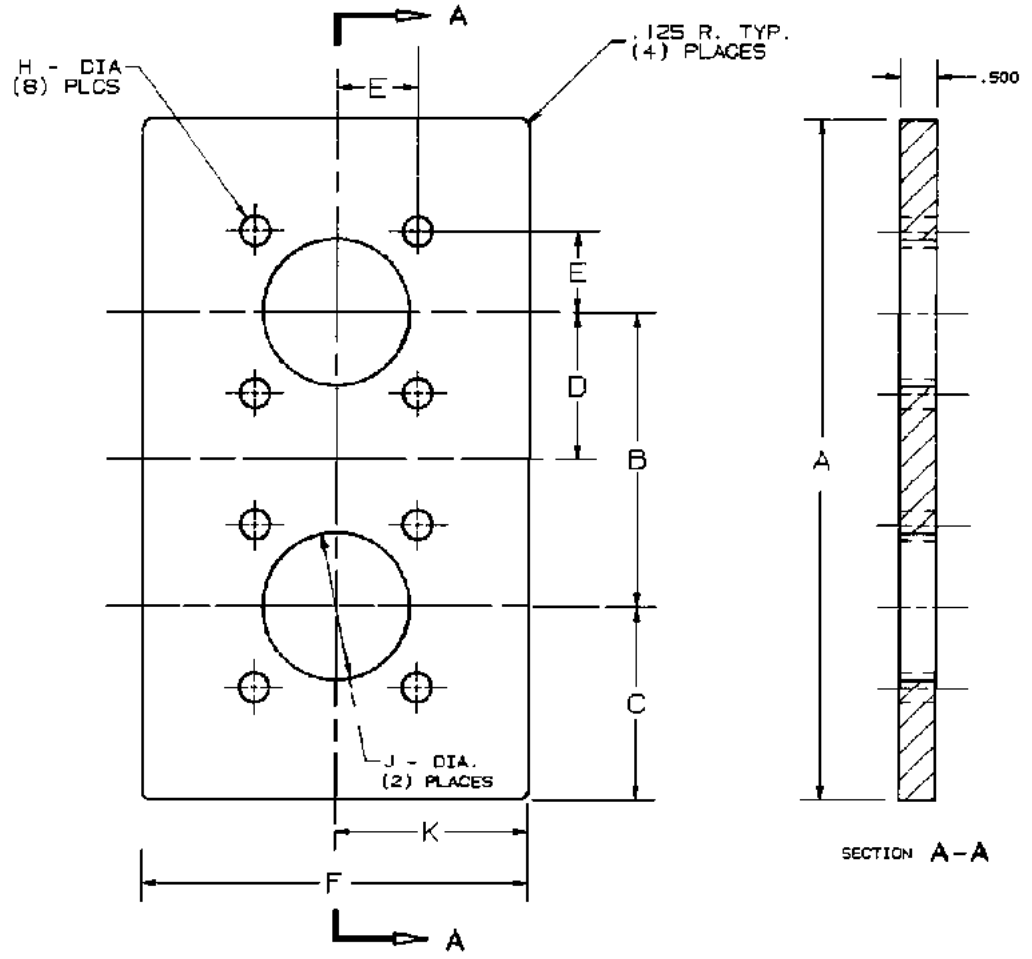
6. The blower and blower discharge piping may be extremely hot and can cause skin burns on contact.
7. Prolonged exposure may require ear protection.

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

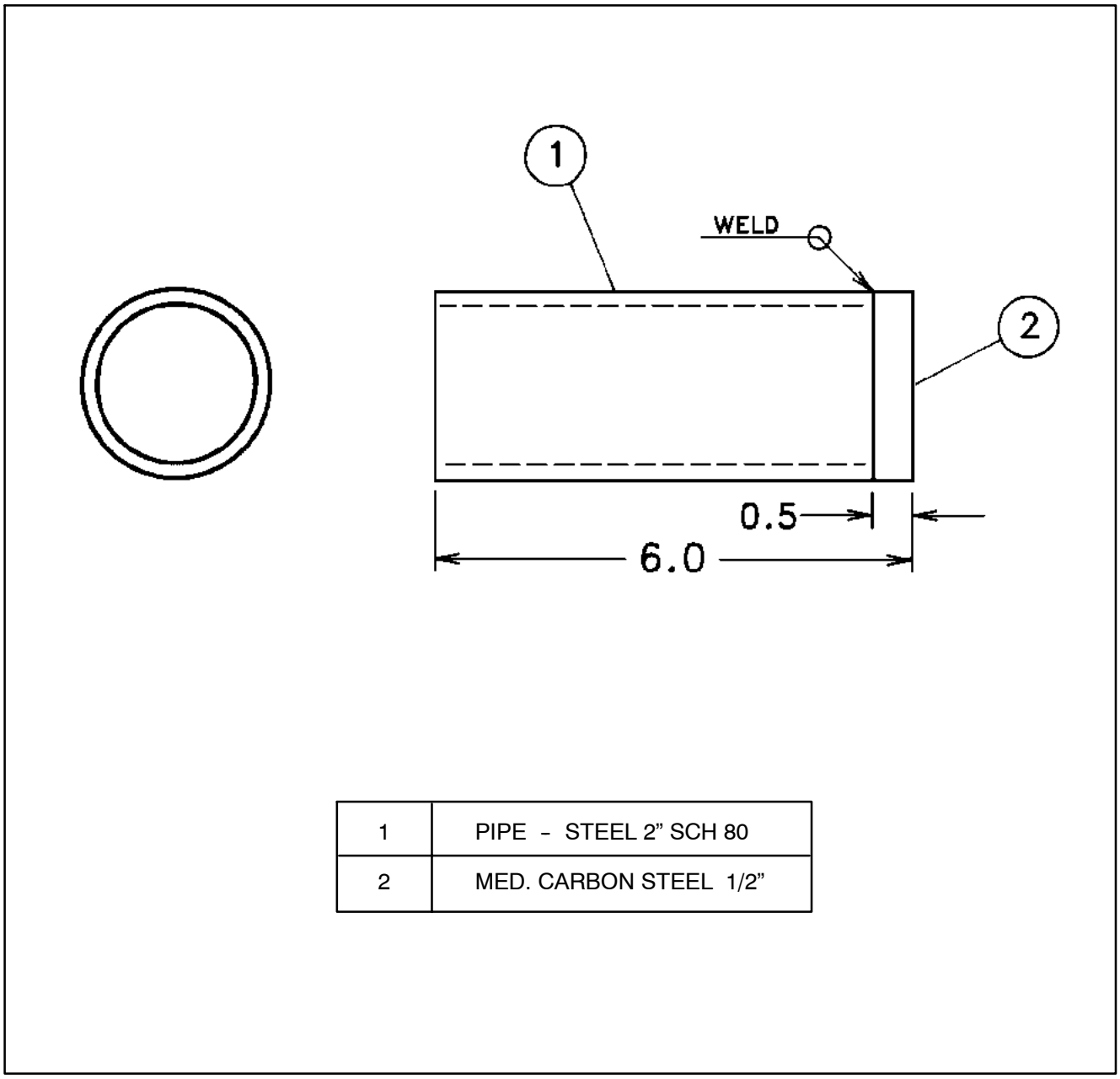


	6”	7”	8”
A	11.00	13.00	16.00
B	6.000	7.000	8.000
C	2.500	3.000	4.000
D	3.000	3.500	4.000
E	1.503	1.679	2.210
F	11.00	13.00	15.00
H	0.437	0.500	0.500
J	1.500	1.688	1.875
K	5.500	6.500	7.500

NOTE:

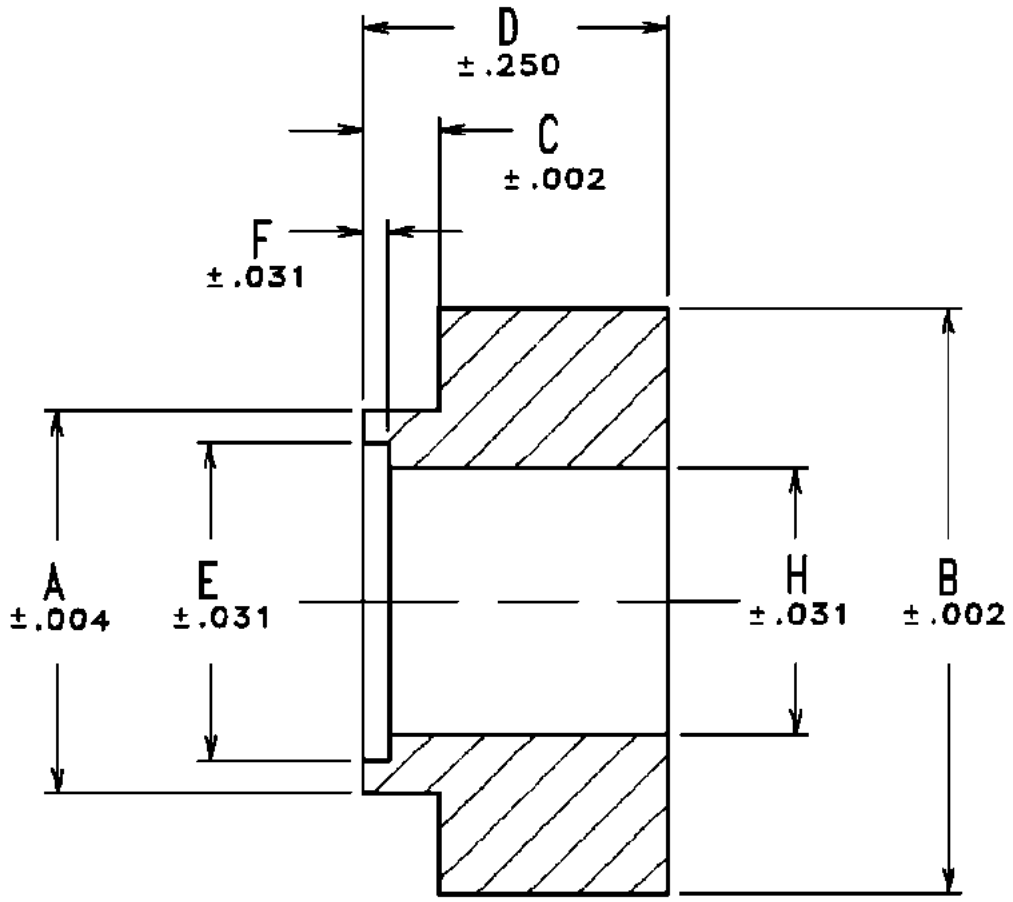
1. REMOVE SHARP EDGES
2. MAT’L: MED. CARBON STEEL

FIGURE 8 - PULLER PLATE - SK2154



1	PIPE – STEEL 2” SCH 80
2	MED. CARBON STEEL 1/2”

FIGURE 9 - GEAR DRIVER - SK2150

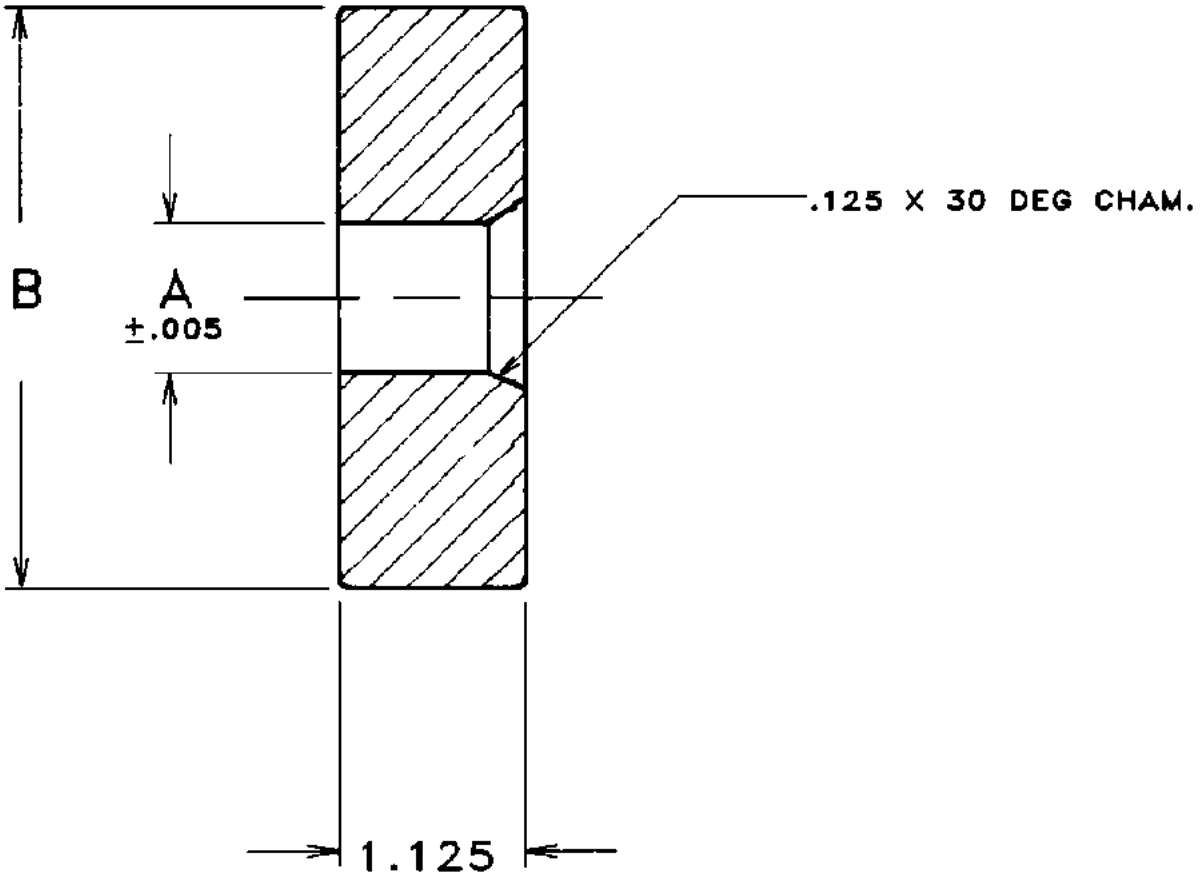


NOTES:

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

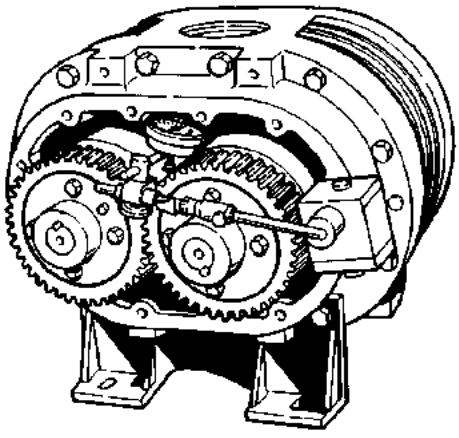


FIGURE 12

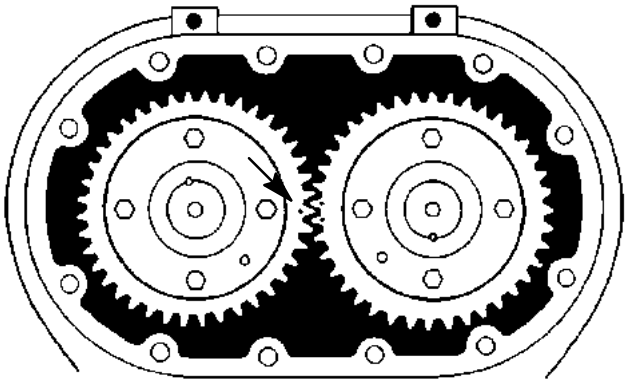


FIGURE 13

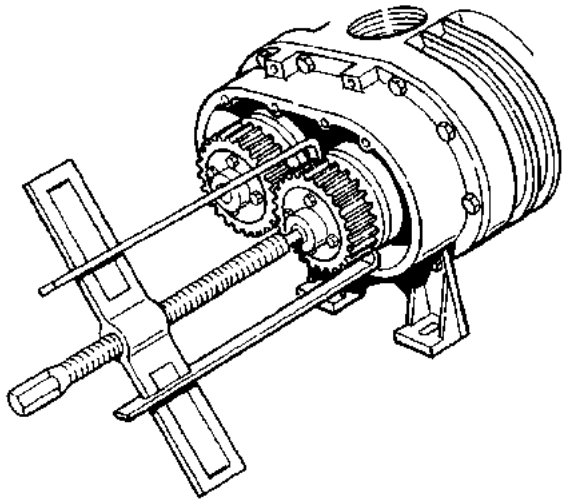


FIGURE 14

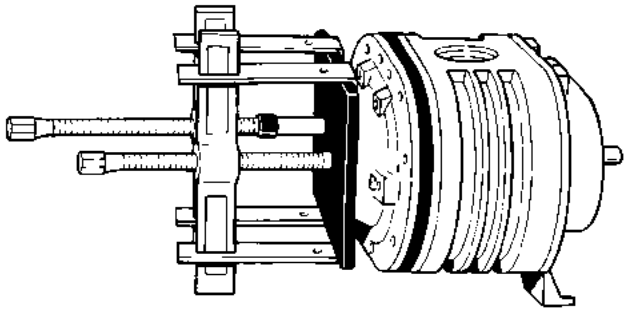


FIGURE 15

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.

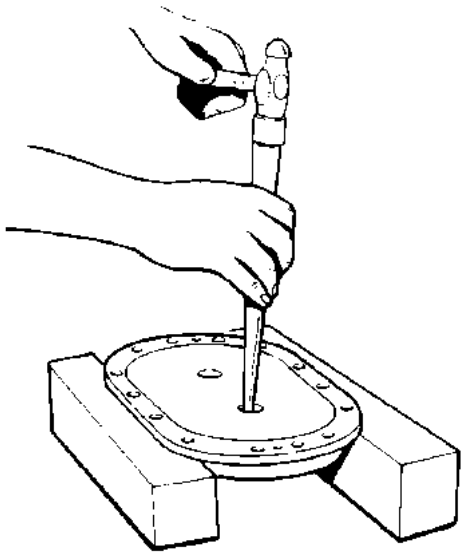


FIGURE 16

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

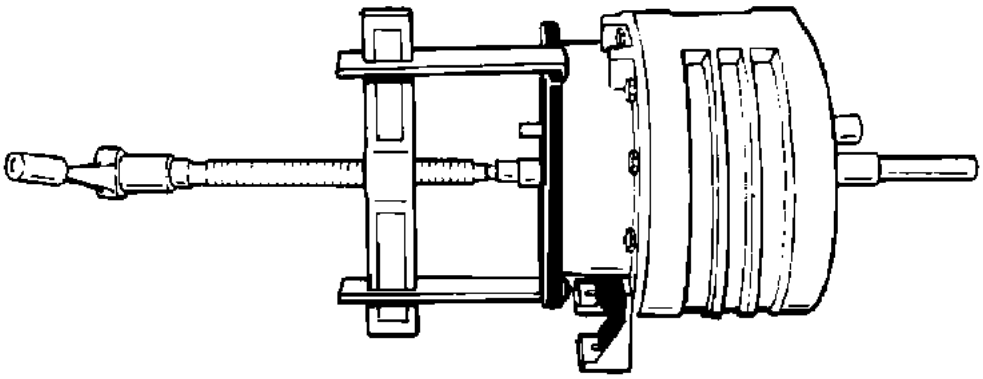


FIGURE 17

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.

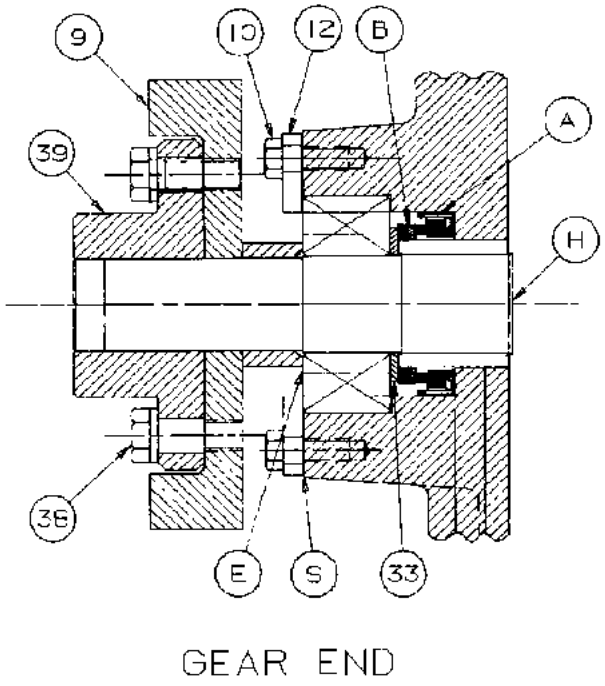
INSTALLING MECHANICAL SEALS

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.



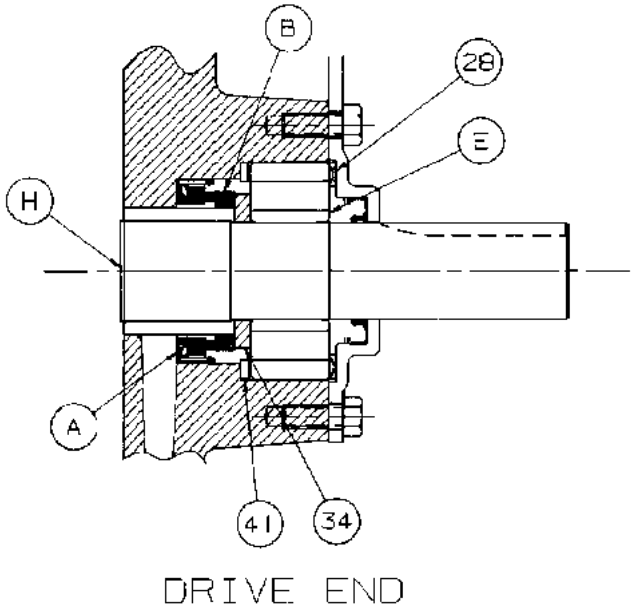


FIGURE 18

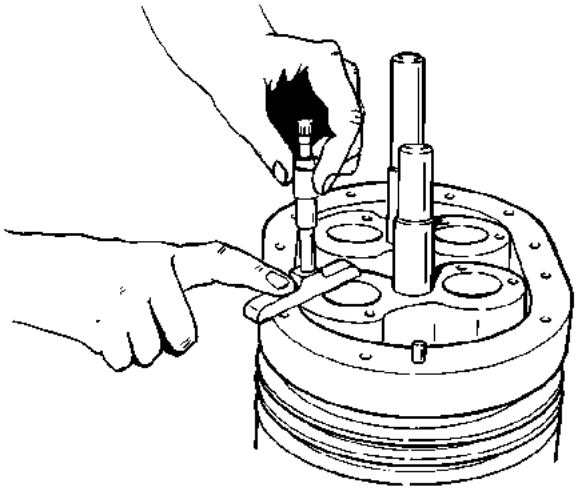


FIGURE 19

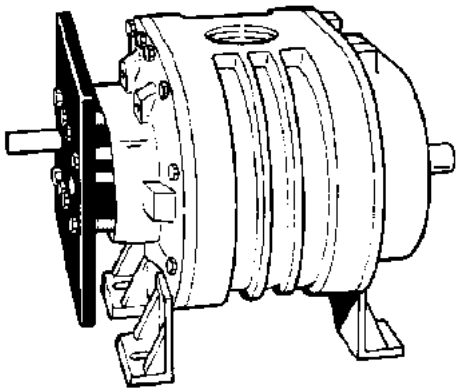


FIGURE 20

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.

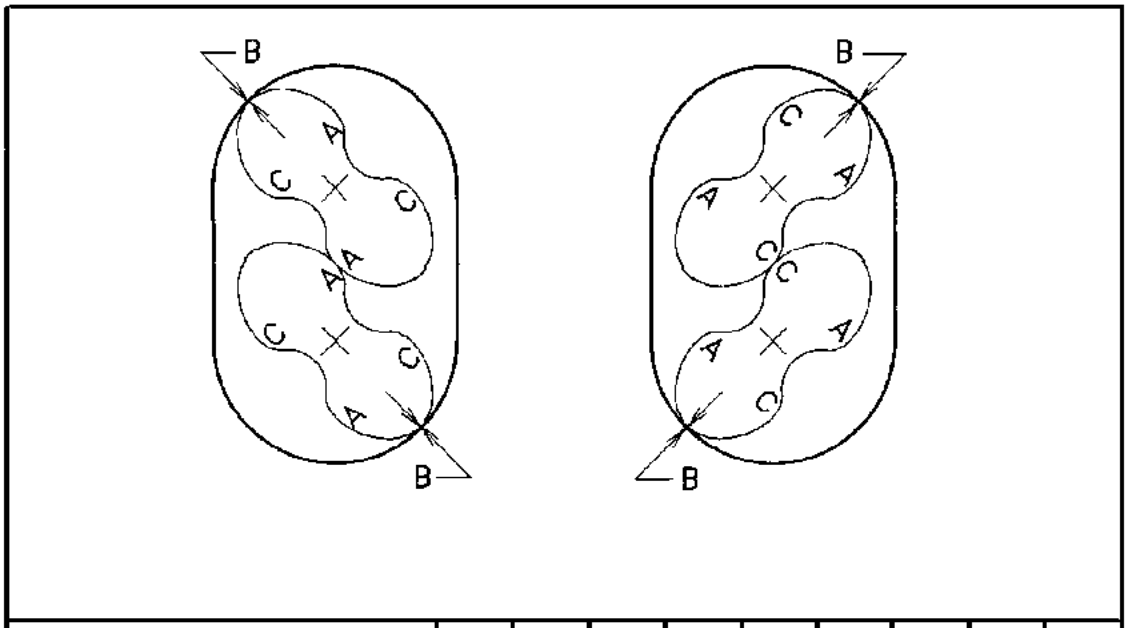
6. Assemble drive headplate (24) to impeller case as done in step 3 with the gear headplate. If shims were required, place shims between drive headplate and impeller case.

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.

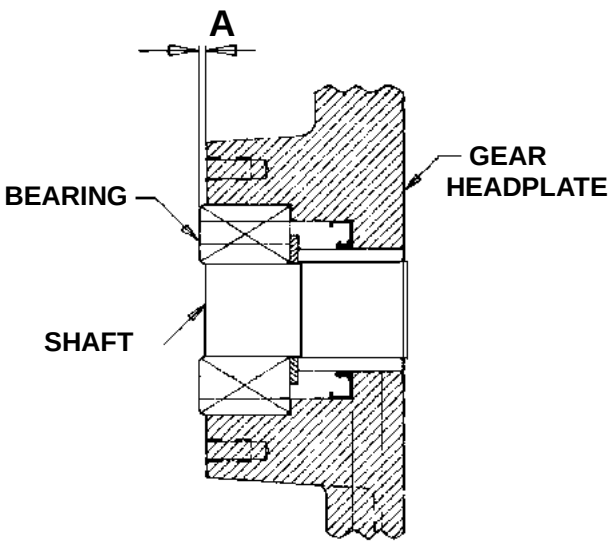


FIGURE 22

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.

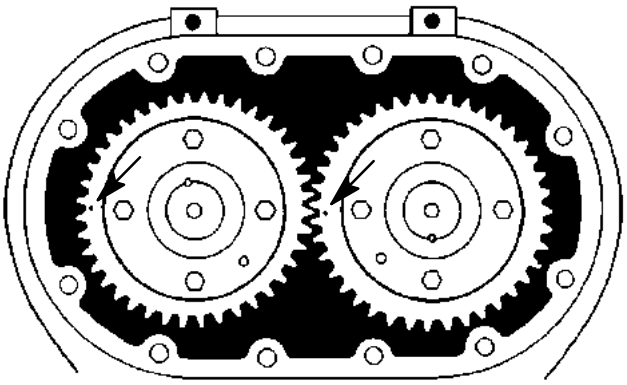


FIGURE 23

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.

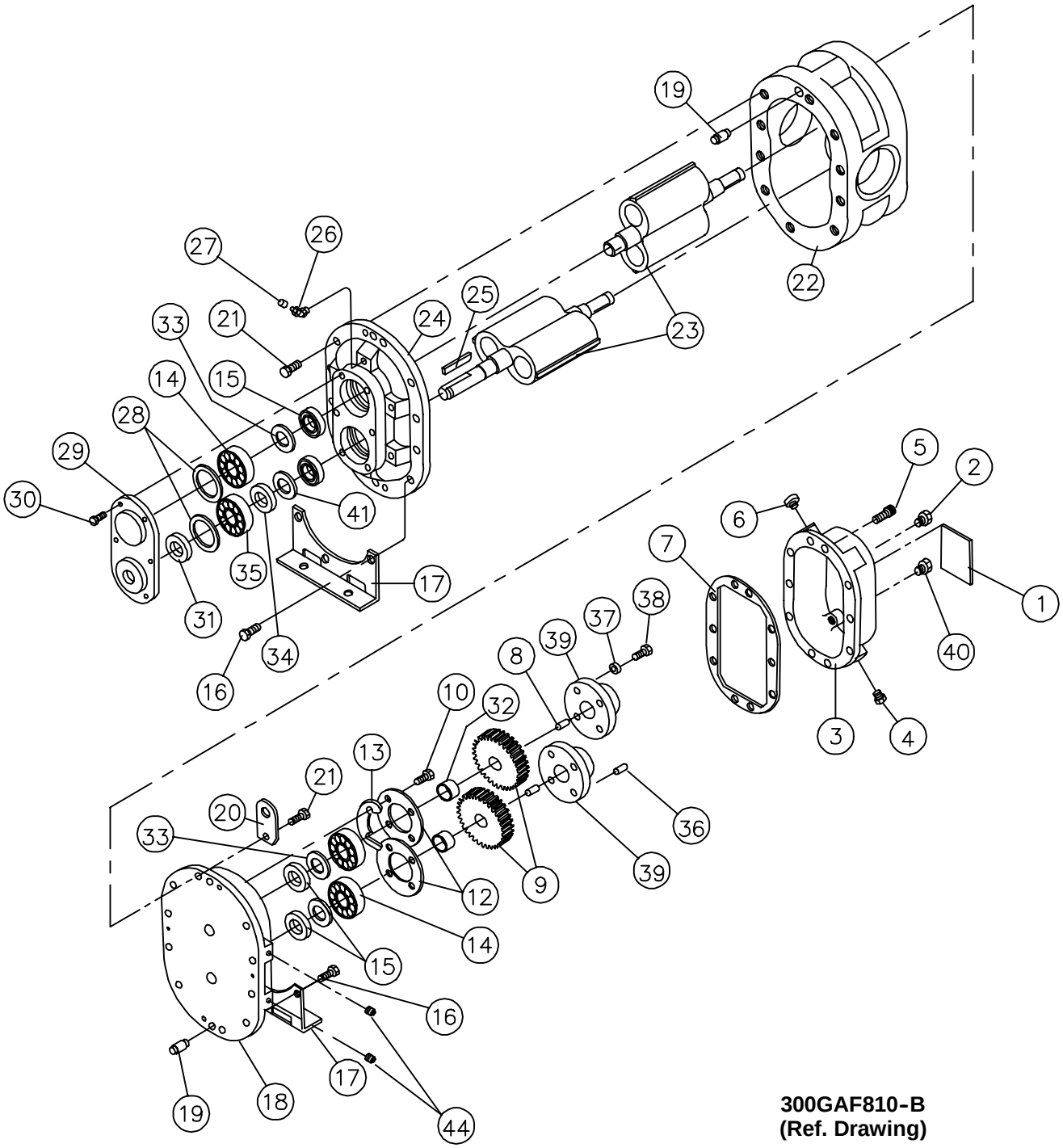
18. Assemble gear cover (3) and gasket (7) to the gear headplate (18) using capscrews (5). Tighten capscrews alternately and evenly. Refer to FIGURE 24, page 24 for torque specifications.

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)



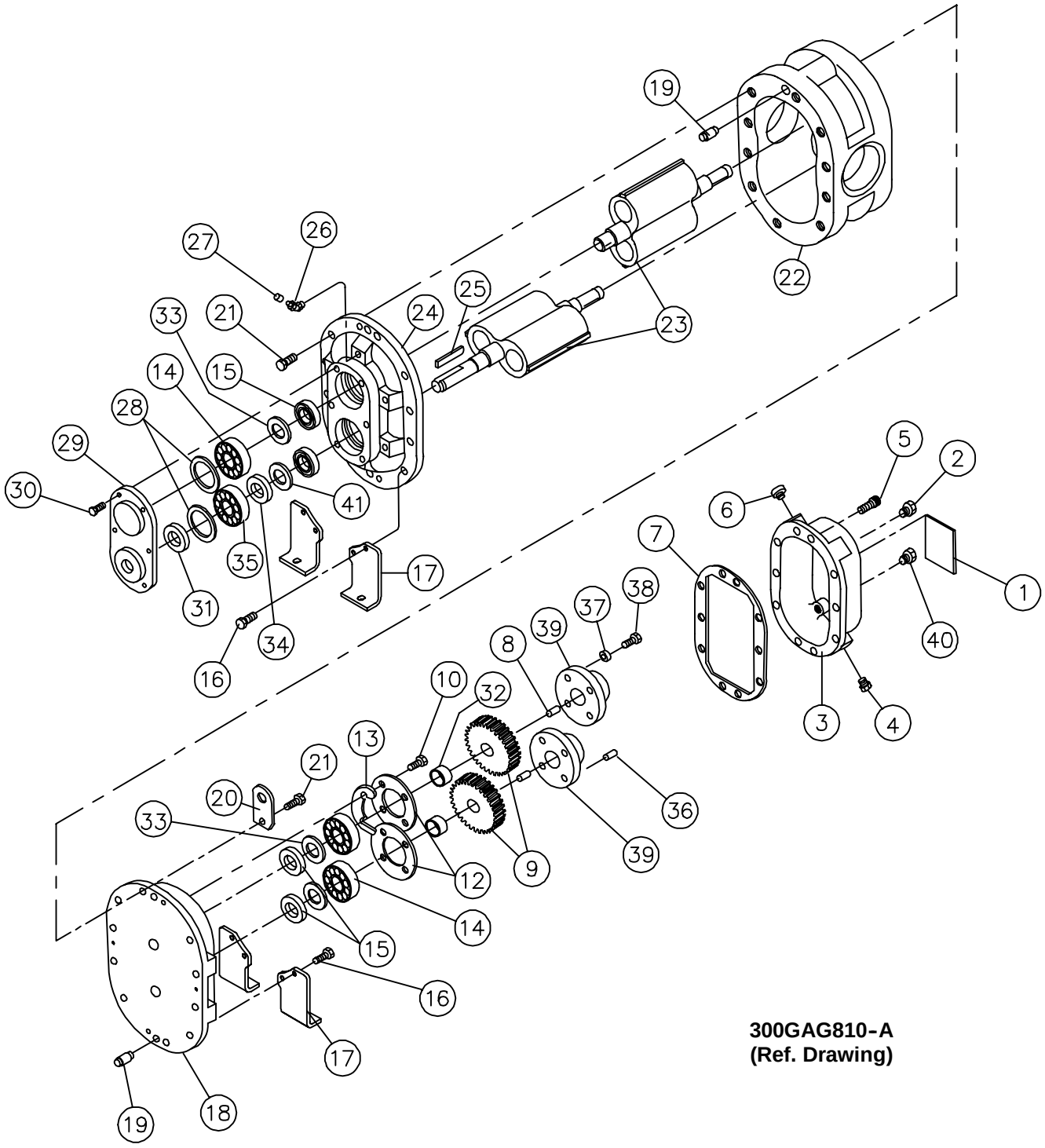
300GAF810-B
(Ref. Drawing)

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.

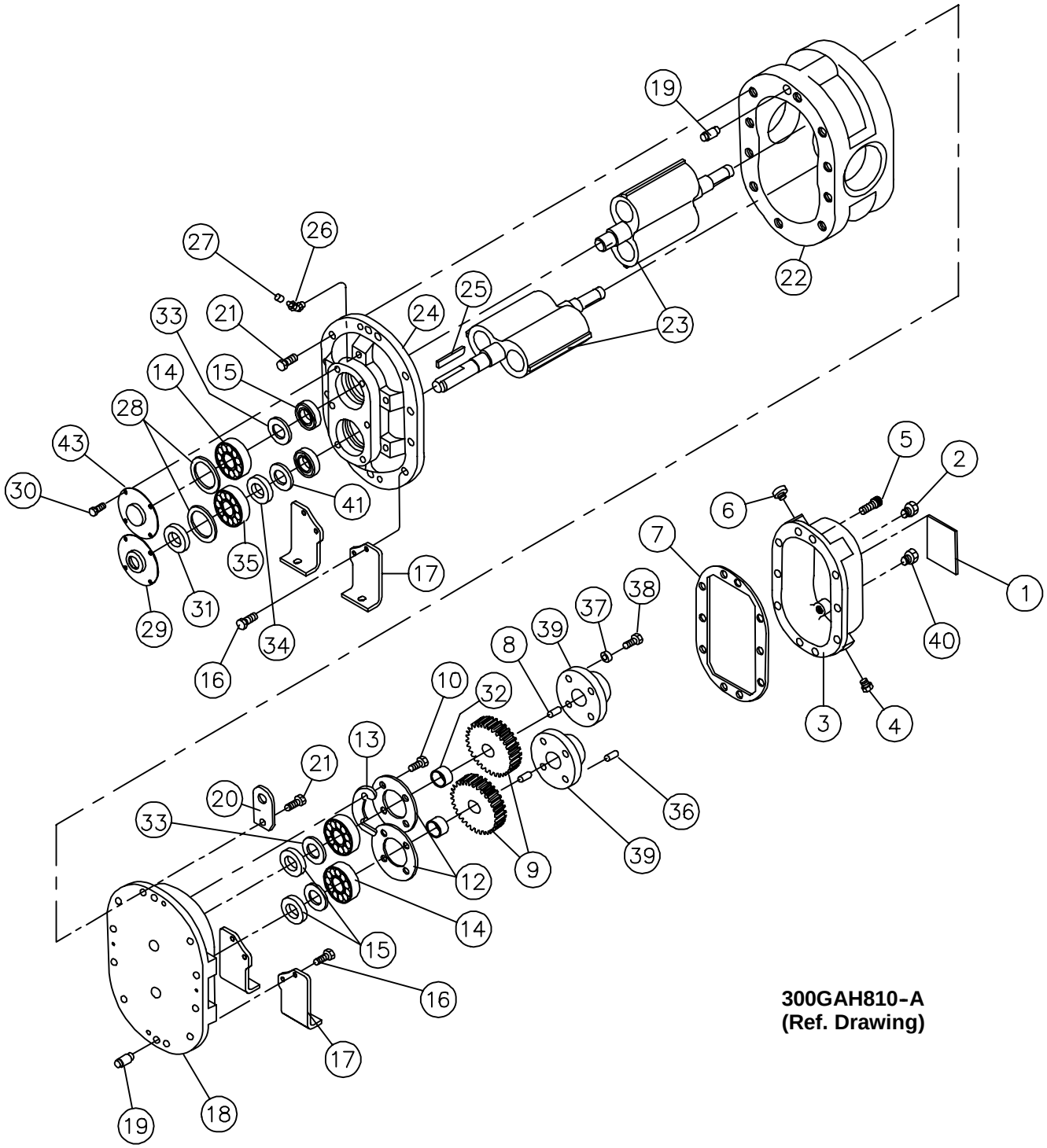


300GAG810-A
(Ref. Drawing)

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.

For additional information, contact your local representative or

Gardner Denver Compressor Division

1800 Gardner Expressway, Quincy, Illinois 62305
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

OPERATORS MANUAL

K27 Engine Controller

Section 6

K27 Engine Controller

Intelligent Diesel Engine Asset Management System

easy to use, safe, reliable, reduces running costs

* Engine Autostart and Stop on multiple triggers via float switches, Pressure, Flow Switch, SAT/GSM modems, PLCs and RTUs
* Bi-directional remote telemetry connection to a PLC and SCADA networks and to a website via Satellite or GSM modem.
* Bright graphical display showing all engine/equipment data and warning/faults.
* Complete asset protection on all sensors with built in 'Failsafe' protection. Includes low radiator coolant level detection.
* Connects to various analogue sensors, ie: 4-20mA pressure or flow sensors, including resistive sensors.
* Multiple sensor readout, with built in separate adjustable bypass timers and slush timers.
* Robust IP66 control module in a powder coated enclosure with tempered see through glass. Will not yellow in exposed sunlight.
* Automatic engine speed control to fixed speed, via CANBUS J1939 or MODBUS. (Optional extra, Pulse Width Modulation via electronic actuator on mechanical engine also available). Can also be controlled remotely.
* Save on fuel, running and maintenance costs. Fuel Level monitoring.
* Built in warmup and cooldown timers.
* Programmable 100hour run timer.
* One panel to suit mechanical engines or electronic CANBUS J1939 engines.
* Tier 4 emissions ready.
* In built data logging on all equipment faults.
* Engine Running output.
* Easy to set up and program.

Will permit future software upgrades via a computer.

Sturdy enclosure with die cast hinges and latch.

Easy to read display, large icons and characters. The LCD can be viewed in direct sunlight.

Product Description

Reduce your operating costs and increase the engine's life cycle.

The K27 engine autostart controller is designed for the off-road stationary diesel engine market. The software is application driver. The controller's primary function is the management of your diesel engine and the equipment it is driving. The software and hardware are designed to lower the cost of running and owning your asset. It will reduce your fuel and maintenance costs but most of all increase the engine's life cycle. The K27 is used in the following applications: waste water de-watering, irrigation pumping, power generation, air compressors, high pressure cleaners, lighting towers, dust suppression pumping, tank filling, sewer bypass, frost control and fire pumps.

Telemetry will keep you connected to your asset. (Via Satellite/GSM/GPS)

The controller's telemetry capabilities make certain you will always be connected to your asset via a smart phone, tablet or computer. You have the option of sending data to a 3G network or the option of a go-anywhere satellite network. Just choose the right modem/data package to suit your budget. PLC, RTU or SCADA users can also connect to the K27. The control panel has inbuilt data logging capabilities and captures all shutdown messages.

Works with a wide range of diesel engines.

Automatic engine speed control is offered on all engines, whether electronic or mechanical. This feature can adjust the engine speed to a set speed point or vary the engine speed with respect to an external 4-20mA sensor. All automatic throttling options come with adjustable engine warm up, cool down and line fill timers. This controller is suitable for use on the following engine brands: Caterpillar, Cummins, MTU, Detroit, Perkins, Deutz, Hatz, Scania, Kubota, Yanmar, JCB, Lister and various engines from Asia. ** Note, For engine speed control on mechanical engines, an electronic throttle actuator must be purchased separately.

Multiple engine start/stop methods

Featuring both manual and automatic start modes, the K27 offers great flexibility of use at the touch of a button. In automatic mode, the K27 is able to start and stop your engine based on a number of triggers such as: single float switches, low pressure switch, telemetry/PLC module, pressure transducer and mains failure contactor. The option is yours.

Can be customised to your application. Save time and value add.

The K27 can be supplied in its current form (as shown in this brochure), or customized to suit your application. Just tell us what it is you want to achieve and we will make it happen. We can supply the engine module or produce a controller specific to your application in an enclosure you want.

Engine Wiring and Panel Kits to suit your build.

The controller is normally supplied in kit form. This kit includes the controller in an enclosure, an engine wiring loom, a throttle actuator, secondary solenoids, mounting brackets and any other components your build will require. Just mention what you need and we will supply.

Software features

* Engine Hours display (Hour Meter)
* Engine RPM display and Overspeed protection
* Accepts tachometer RPM signal from:
  - Alternator W+
  - J1939 CANBUS ECU
  - Magnetic Pick Up on Fly Wheel
* Automatic Engine Speed control from:
  - Go To Fixed RPM set point (CAN J1939 only)
  - MODBUS throttle commands
* Automatic Start and Stop on:
  - Single Float Switches
  - Single Pressure Switch
  - Discharge pressure sensor
* Engine Oil Pressure display and engine shut down
* Engine Temperature display and engine shut down
* Low radiator coolant level shutdown
* Data logs all equipment fault messages
* Displays all equipment fault messages (J1939 included)
* MODBUS (RS232/485) Communication
* Fuel level reading / shutdown (sensor required)
* Battery Voltage VDC display
* Low Battery Warning
* Loss of RPM Engine Shut Down
* Loss of Prime Digital Input (sensor required)
* 99 hour programmable Stop Timer
* Pump Flow rate control, protection and reading (sensor required)
* Pump Pressure control, protection and reading (sensor required)
* Programmable digital inputs
* Programmable pump / bearing temperature sensor (sensor required)
* Engine Running Output
* Glow Plug Excitation (requires high Current Relay)
* Can Start/Stop and control engine speed via Website

** All sensors/inputs include bypass and slush timers.

Hardware features

3.4" Graphical monochrome display (visible in direct sunlight)
9-30VDC Input Voltage
<40mA Current Consumption in Sleep Mode
-40 to 85'C Storage Temperature

IP65 Enclosure Powder Coated 270tall x 350wide x 150deep
IP66 control module water ingress protection
-20 to 75'C Operating Temperature
Reverse polarity protection

#	Description
3	LED indication
3	Digital Inputs Active Low
1	Digital Inputs Active High
1	Radiator Coolant Level Input
1	Alternator W+ or MPU Input
1	Alternator Excitation Output
4	Resistive Sensor Inputs
4	Sensor 4-20mA Inputs
1	J1939 CAN Hi, CAN Lo

#	Description
1	Output 0-5VDC (option)
1	Sensor 5VDC power output
3	Outputs 20A
3	FET Output Low Current 1A
1	RS232/485 MODBUS Communication
1	I2C MEMORY
1	PCB temperature
1	Pulse Width Modulation Output

Contact Information: AUSTRALIA

Kensho Pty Ltd
60 Lara Way, Campbellfield,
Victoria 3061, Australia
Tel+613-9357-6550, Fax: +613 9357 6554
sales@kensho.com.au

Contact Information: ASIA PACIFIC

Kensho (China) Ltd.
Add. #702, Building D1, Tangwei Ind. Park, Gongming,
Guangming Hi-Tech Zone, Shenzhen, 518132 China
Tel: +86-755-8172-9191 Extension 808 Fax: +86-755-8172-9292
sukey.xiong@kenshoworld.com

OPERATORS MANUAL

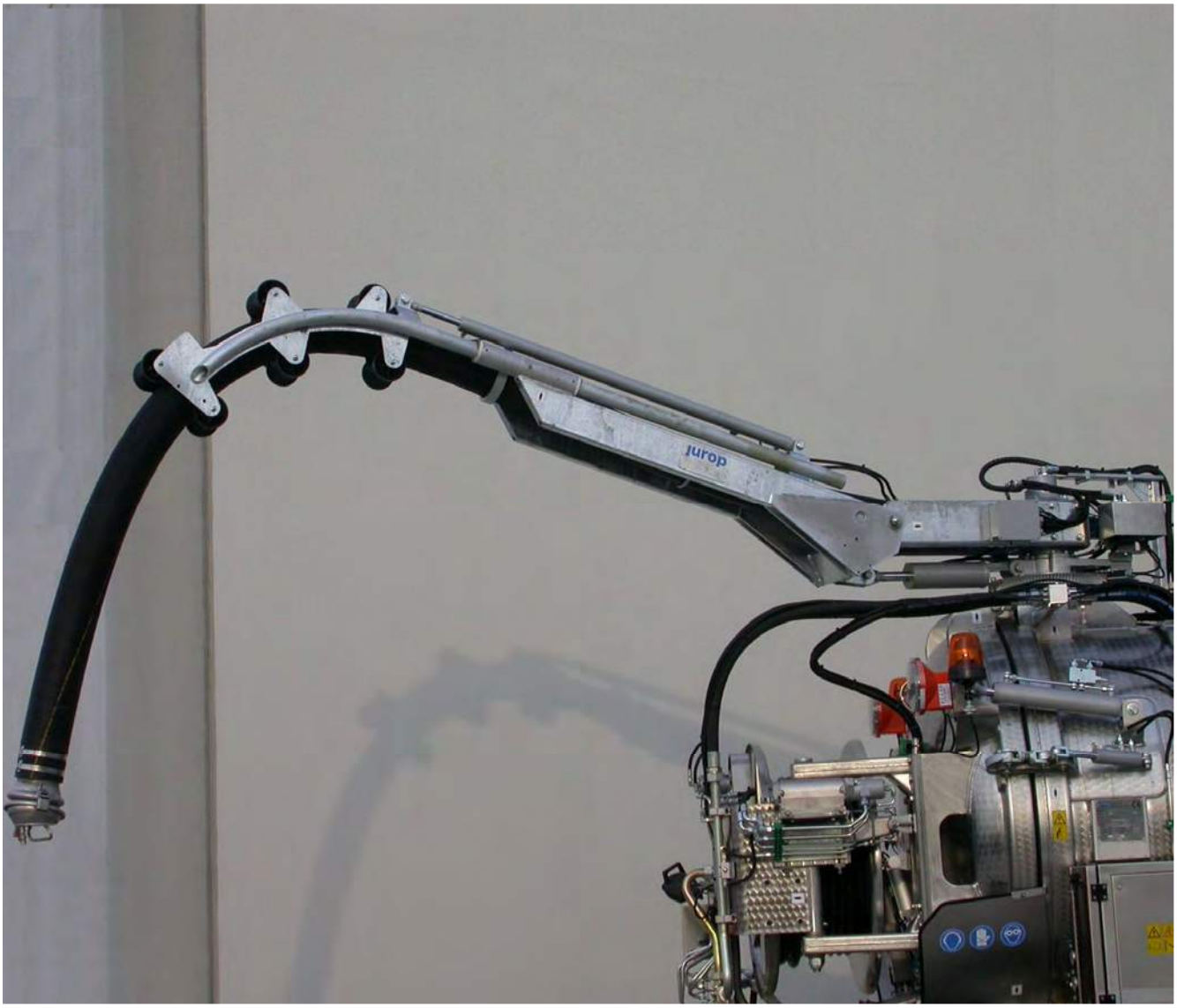
Jurop Suction Boom

Section 7

STG GLOBAL

EN

SUCTION BOOM



ACCESSORIES AND COMPONENTS

Suction boom

jurop

COMPANY WITH
QUALITY SYSTEM
CERTIFIED BY DNV GL
= ISO 9001 =

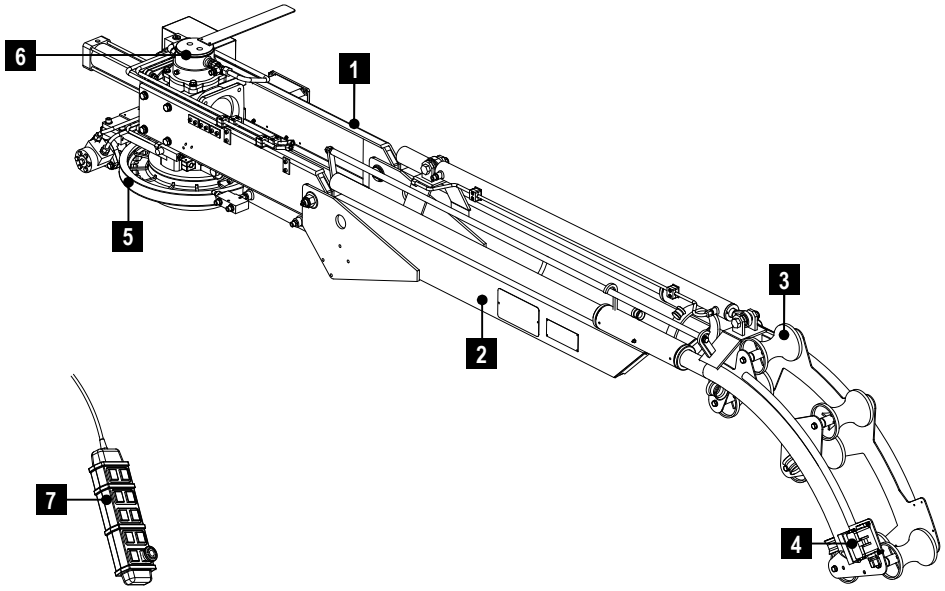
TECHNICAL DATA

The suction boom is an accessory designed and sized to be incorporated into machines equipped with tanks to sludge suck (or similar fluids) from road gullies. The suction is created by vacuum inside the tank (e.g. drainage vehicles). The suction boom allows simplifying the operator's work by nearing the hose to the workplace.

The suction boom is normally installed on the upper part of the tank.

It essentially consists of a hydraulically or electrically operated telescopic arm (which houses a suction pipe) connected to one end of the sludge tank.

The figure shows a schematic view of the suction boom (suction boom DN100 – DN125 – DN150; the same considerations apply for the DN200 version), highlighting the main components.



LEGEND			
1	Moving arm	5	Slewing ring
2	Telescopic arm	6	Hydraulic swivel joint
3	Hose guide rollers	7	Pushbutton control panel
4	Pushbutton panel plug		

The following table shows the parameters that must be complied with to supply the suction boom. All the values refer to all the available versions.

OPERATING PARAMETERS

Parameter	Operating value	Maximum value
HYDRAULIC PRESSURE	70-100 bar	150 bar
HYDRAULIC FLOW RATE	15-30 l/min	50 l/min
Maximum counter pressure on the valve block:		150 bar
PNEUMATIC PRESSURE	6 bar	8 bar
VOLTAGE	12 / 24 V	± 10%

The suction boom is designed to withstand (relative) vacuum/pressure -1 / +4 bar. The solenoid valve coils have a consumption of approximately 1 A in the 24V version and approximately 2 A in the 12V versions.

The suction boom is designed to allow for a maximum rotation angle of 300° and a maximum telescopic extension of 1350mm.

Available versions

The suction boom is available in various versions that are distinguished by the following parameters:

- Suction hose connection manifold diameter available in the DN100, DN125, DN150 and DN200 versions;
- Type of activation of the suction line shutter valve, available in the hydraulic and pneumatic versions;
- Type of power supply, available in the 12 V and 24 V versions.

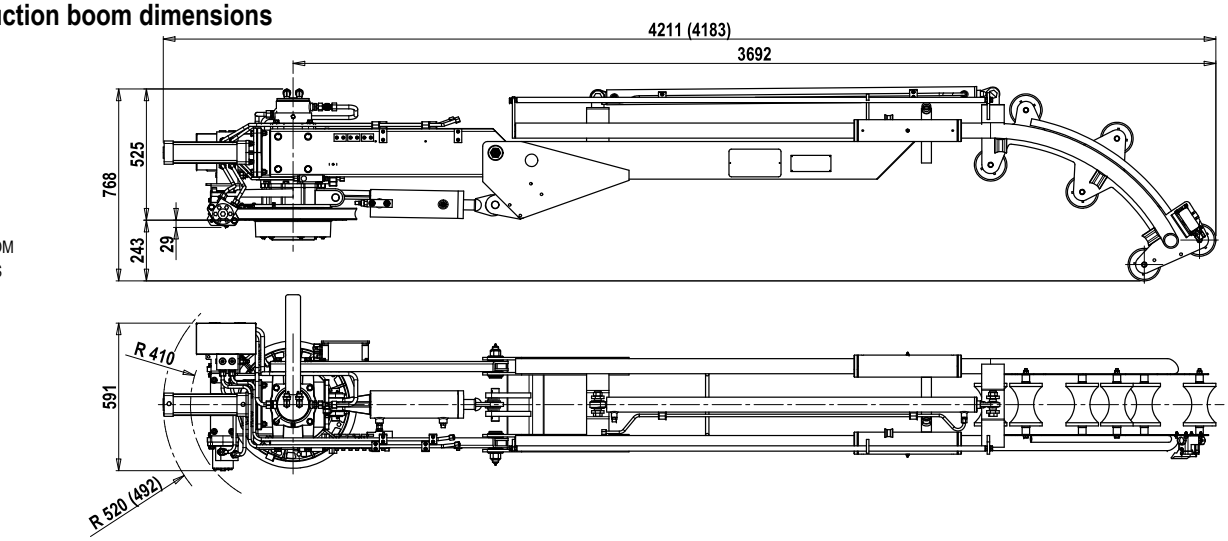
The following table shows the available suction boom models and relative identification code.

AVAILABLE VERSIONS

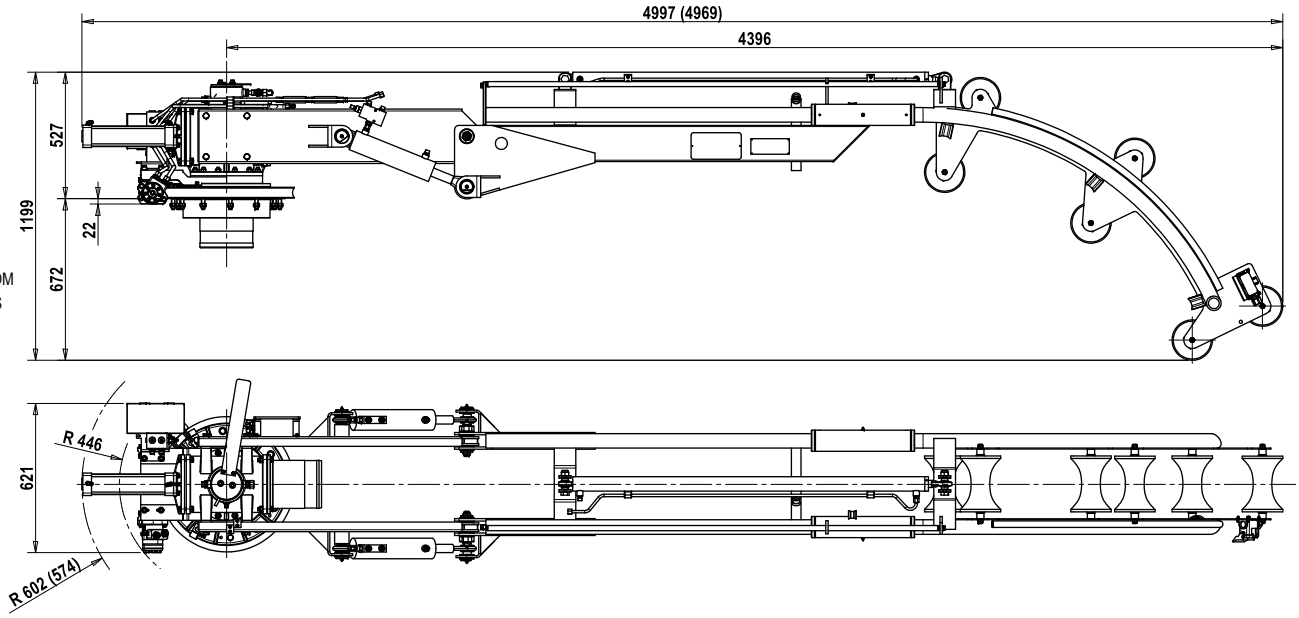
Model	Code	Manifold diameter	Shutter valve	Power supply
Suction boom DN100 24V	13600 003 00	Ø 100 mm	Pneumatic	24V
Suction boom DN125 24V	13600 004 00	Ø 125 mm	Pneumatic	24V
Suction boom DN150 24V	13600 005 00	Ø 150 mm	Pneumatic	24V
Suction boom DN200 24V	13600 012 00	Ø 200 mm	Pneumatic	24V
Suction boom DN100 24V HDR	13600 017 00	Ø 100 mm	Hydraulic	24V
Suction boom DN125 24V HDR	13600 019 00	Ø 125 mm	Hydraulic	24V
Suction boom DN150 24V HDR	13600 021 00	Ø 150 mm	Hydraulic	24V
Suction boom DN200 24V HDR	13600 014 00	Ø 200 mm	Hydraulic	24V
Suction boom DN100 12V	13600 007 00	Ø 100 mm	Pneumatic	12V
Suction boom DN125 12V	13600 008 00	Ø 125 mm	Pneumatic	12V
Suction boom DN150 12V	13600 009 00	Ø 150 mm	Pneumatic	12V
Suction boom DN200 12V	13600 011 00	Ø 200 mm	Pneumatic	12V
Suction boom DN100 12V HDR	13600 010 00	Ø 100 mm	Hydraulic	12V
Suction boom DN125 12V HDR	13600 01800	Ø 125 mm	Hydraulic	12V
Suction boom DN150 12V HDR	13600 020 00	Ø 150 mm	Hydraulic	12V
Suction boom DN200 12V HDR	13600 013 00	Ø 200 mm	Hydraulic	12V

Suction boom dimensions

SUCTION BOOM DIMENSIONS
DN100
DN125
DN150



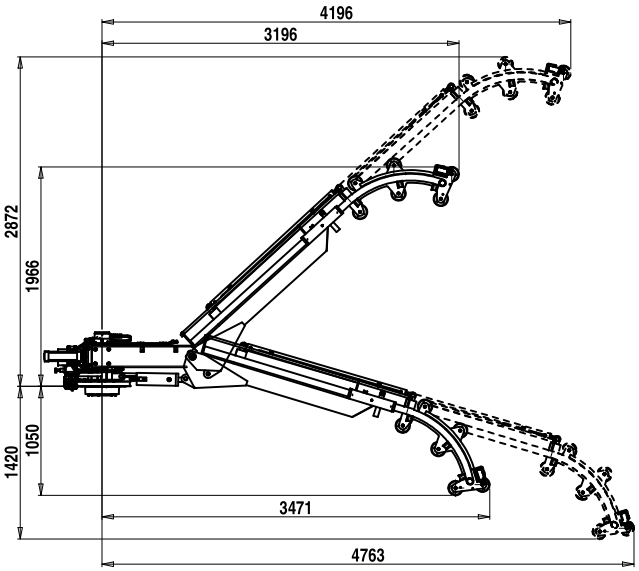
SUCTION BOOM DIMENSIONS
DN200

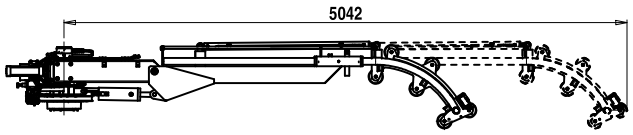


Note: The dimensions shown in the figure refer to the model with pneumatic actuator; whereas the dimensions in brackets (e.g., 4183) refer to the model with hydraulic actuator.

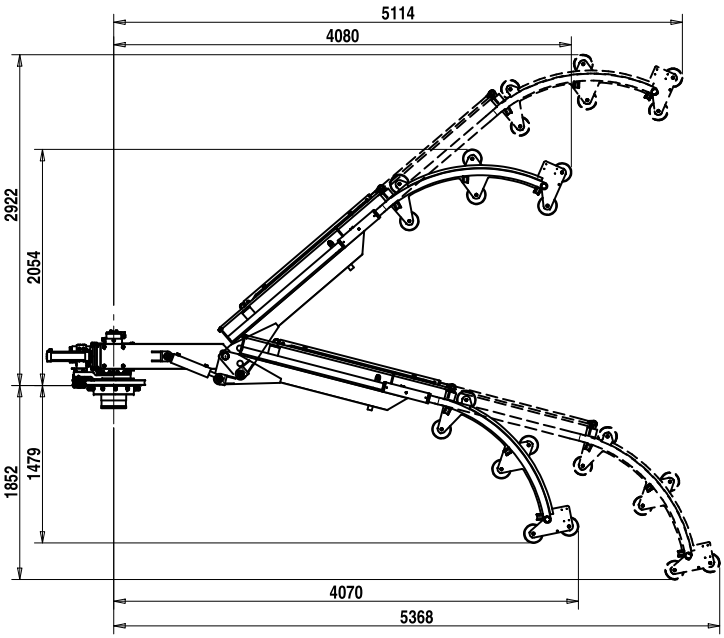
Functional features

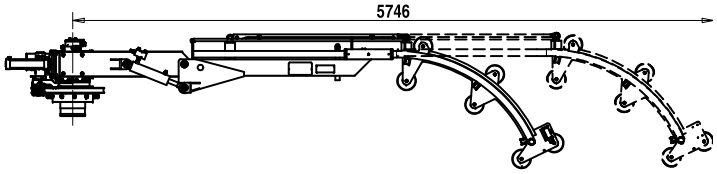
SUCTION BOOM FUNCTIONAL FEATURES DN100 – DN125 – DN150





SUCTION BOOM FUNCTIONAL FEATURES DN200





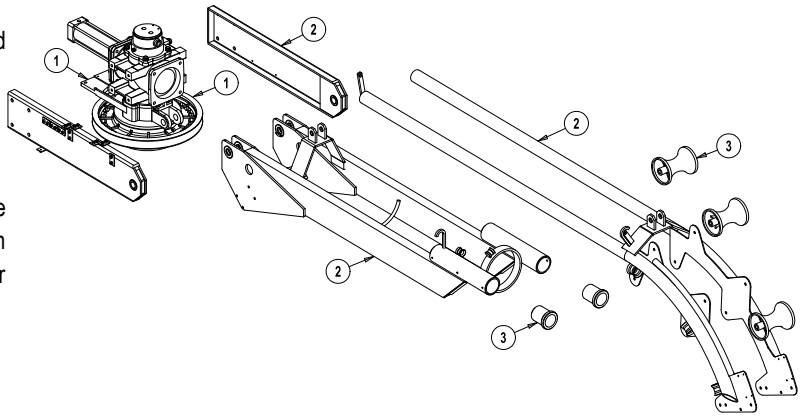
MATERIALS

1. The body and the slewing ring are made of cast iron.

2. The telescopic arm is made of galvanised S235JR mild steel to ensure its high resistance against weather agents.

3. The hose guide rollers are made of plastic material.

The parts of the suction boom in contact with the transported material (suction boom conveyor, suction boom plate) are made of GS 500 cast iron; whereas the shutter valve is made of NBR.



ACCESSORIES

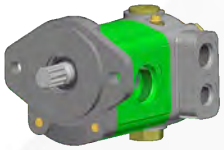
- Accessories available:
- **Suction boom flushing**, only DN100 – DN125 – DN150;
- **Suction boom weld collar**, available in mild steel or stainless steel;
- **Suction boom arm support**, available in mild steel or stainless steel;
- **Suction boom hydraulic piping standing support,** available in mild steel or stainless steel;
- **Suction hose,** made of a 6 m long plastic section with a half-coupling end cap;
- **Suction pipes and flushed suction pipe**;
- **Pushbutton panel support**.

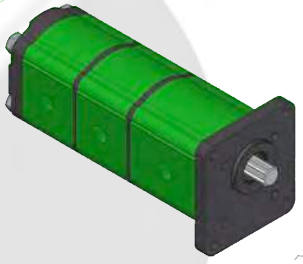
Jurop SpA
Via Crosera n° 50
33082 Azzano Decimo, PN (Italy)

TEL. +39 0434 636811
FAX. +39 0434 636812
www.jurop.it - e-mail: info@jurop.it

GEAR PUMPS “E” SERIES - GROUP 2

Technical catalogue





SALAMI spa
via Emilia Ovest 1006
41100 Modena Italy
telefono +39-059-387411
telefax +39-059-387500
export@salami.it - www.salami.it

SALAMI ITALIA srl
strada Pelosa 153
S. Pietro in Trigogna VI Italy
telefono +39-0444-249080
telefax +39-0444-240204
salami.italia@salami.it

SALAMI ESPAÑA
Polígono Industrial Armenteres
C/Primer de Maig, 18, Nave 4
08980 San Feliu de Llobregat
Barcelona
telefono +34-93-6327258
telefax +34-93-6667826
info@salamiespain.com

SALAMI FRANCE
22, rue Louis Saillant
69120 Vaulx en Velin
Lyon
telefono +33-04-78809941
telefax +33-04-78808669
e.pesani@wanadoo.fr

149 S0. Chenango St. Ext.,
GREEN, NY 13778
Tel.: +1-607-6565702
Fax.: +1-607-6565704
info@salamihydraulics.com

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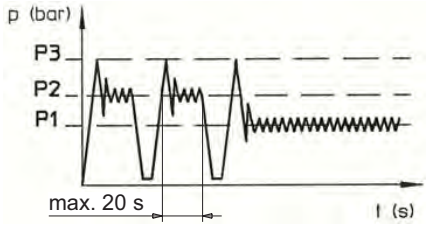
COMPANY
WITH QUALITY SYSTEM
CERTIFIED BY DNV
=ISO 9001/2000=

E0.23.1204.02.00

The data in this catalogue refers to the standard product.
The policy of Salami S.p.A. consists of a continuous improvement of its products.It reserves the right to change the specifications of the different products whenever necessary and without giving prior information.
If any doubts, please get in touch with our sales departement.

Working conditions

DEFINITION OF PRESSURES



P3 = Peak pressure
P2 = Intermittent operating pressure (1/3 of working time)
P1 = Continuous operating pressure

GENERAL

SALAMI gear pumps are available with displacements from 3.2 cm^3/rev to 26 cm^3/rev(from 0.19 cu.in./rev to 1.59 cu.in./rev).
All pumps are available as multiple units either of the same or different series.
With all sizes of pumps and motors there are options of shafts, flanges and ports as for European, German and American standards.

SALAMI gear pumps and motors offer:
- High volumetric efficiency by innovative design and accurate control of machining tolerances.
- Axial compensation achieved by the use of floating bushes that allow high volumetric efficiency throughout the working pressure range.
- DU bearings ensure high pressure capability.
- 12 teeth integral gear and shaft.
- Extruded alluminum body.
- Die cast alluminum cover and flange - cast iron rear.
- Double shaft seals.
- Nitrile seals as standard and viton seals in high temperature applications.

All pumps and motors are hydraulic tested after assembly to ensure the high standard performance required by SALAMI'S engineering.

WORKING CONDITIONS

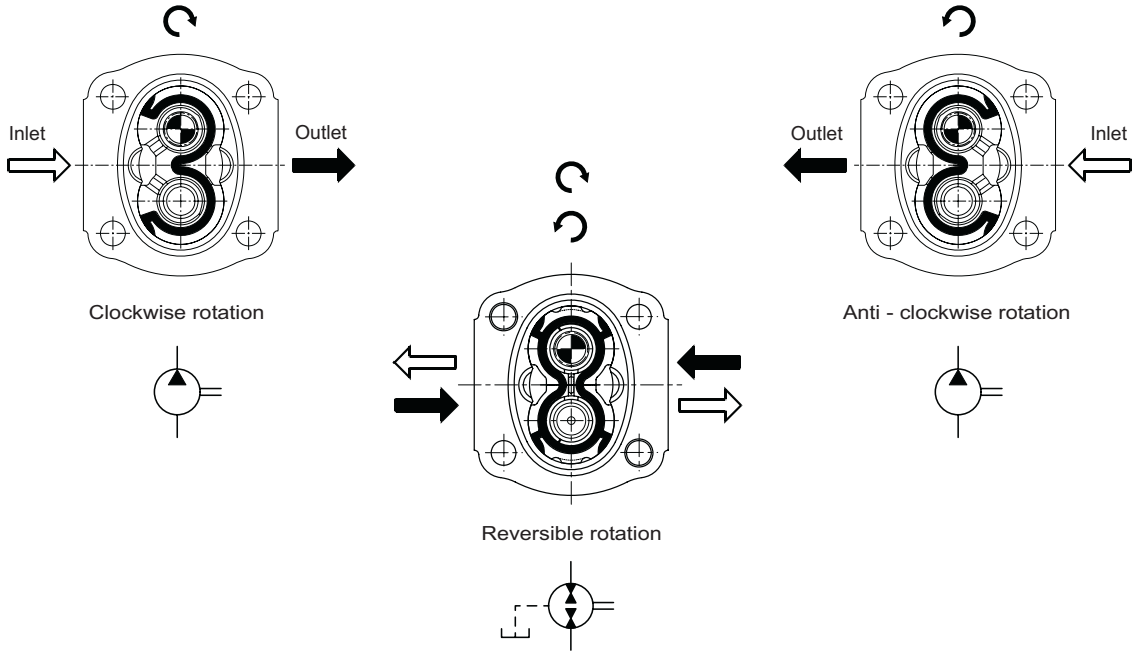
- Pump inlet pressure (absolute pressure)	**0,7 to 2,5 bar**
	10 to 36 psi
- Minimum operating fluid viscosity	**12 mm^2 / sec**
- Max starting viscosity	**800 mm^2 / sec**
- Suggested fluid viscosity range	**17 - 65 mm^2 / sec**
- Fluid operating temperature range	**-15 to 85 °C**
- Fluid operating temperature range with FPM seals(Viton)	**-20 to 110°C**
- Hydraulic fluid	**mineral oil**

Important:
in case of assembling of pumps without shaft seals (eg. B2 - B3....), you have to keep the value of min. suction pressure (0.7 bar (abs)) in the vane between pump and coupling too.
Lower pressure can lead to suction of oil through the front flange (seat of the shaft without seal); this can damage seriously the pump.

DRIVE SHAFT

Radial and axial loads on the shafts must be avoided since they reduce the life of the unit. Pumps driven by power take - off on engines must always be connected by placing an "Oldham" coupling or coupling having convex toothed hub.
This is to ensure that inevitable misalignment during assembly is reduced to minimum.

PUMP ROTATION DIRECTION VIEWED AT THE DRIVE SHAFT



HYDRAULIC PIPE LINE

To ensure favorable suction conditions it is important to keep pressure drop in suction pipe line to a minimum value (see WORKING CONDITIONS).
To calculte hydraulic pipe line size, the designer can use; as an approximate guide, the following fluid speed figures:

From 1 to 2 m/sec on suction pipe line From 6 to 10 m/sec on pressure pipe line	From *3.28* to *6.36 ft/sec* on suction pipe line From *19.7* to *32.8 ft/sec* on pressure pipe line

The lowest fluid speed values in pipe lines is recommended when the operating temperature range is high and/or for continuos duty.
The highest value is recommended when the temperature difference is low and/or for intermittent duty.
When tandem pumps are supplied by 2 different reservoirs with 2 different fluids it is necessary to specify "AS" version.
In case of reversible motor allowance must be made to ensure the motor is not drained, through the case drain, when stationary.

FILTRATION INDEX RECOMMENDED

Working pressure	**> 200 bar / *2900 psi***	**< 200 bar / *2900 psi***
Contamination class NAS 1638	9	10
Contamination class ISO 4406	18/15	19/16
Achieved with filter $ß_x$ =75	15 µm	25 µm

FIRE RESISTENT FLUID

Type	Description	Max pressure	Max speed (rpm)	Temperature
HFB	oil emulsion with 40% water	130 bar/*1880 psi*	2500	3°C +65°C
HFC	Water glycol	180 bar/*2600 psi*	1500	-20°C +65°C
HFD	Phosphate esters		1750	-10°C +80°C

COMMON FORMULAS

C = Input torque $= \frac{q \cdot \Delta p}{62.8 \cdot \eta_m}$ (Nm)

P = Input power $= \frac{q \cdot n \cdot \Delta p \ 10^{-3}}{600 \ \eta_m}$ (kW)

Q = Outlet flow $= \frac{q \cdot n \cdot \eta_v}{1000}$ (l/min)

LEGENDA

Δp = Working pressure (bar)

q = Displacement (cm^3/rev)

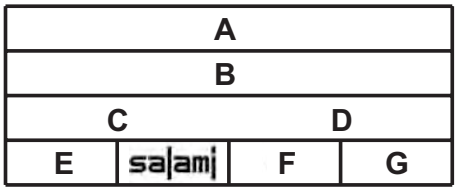
n = Speed (min^{-1})

η_m = Mechanical eff. (0.92)

η_v = Volumetric eff. (0.95)

DESCRIPTION OF THE NEW PRODUCT IDENTIFICATION LABEL

Based on the firm certification ISO 9001 - UNI EN 29001, section 4.8 (identification and tracebility of the product), we have adopted a new identification label starting from the 1st march 1995. Pls, see following example:



A = Product short descritpion (eg. VD8A/FDD/U4G).

B = Customer part number.

C = Salami part number (eg. 6235 0025 0).

D = Production code (for Salami management)

E = Rotation sense (only for pumps).

F = Production date (see data sheet here below)

G = Progressive number of assembling.

Only for pumps 2PB and 2PZ (except triple 2PB) the identification product is marked on the top of the pump body as shown here below:

ASSEMBLED	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
JANUARY	7A	8M	9M	0M	1M	2M	3M	4M	5M	6M	7M	08M	09M	10M	11M	12M
FEBRUARY	7B	8N	9N	0N	1N	2N	3N	4N	5N	6N	7N	08N	09N	10N	11N	12N
MARCH	7C	8P	9P	0P	1P	2P	3P	4P	5P	6P	7P	08P	09P	10P	11P	12P
APRIL	7D	8Q	9Q	0Q	1Q	2Q	3Q	4Q	5Q	6Q	7Q	08Q	09Q	10Q	11Q	12Q
MAY	7E	8R	9R	0R	1R	2R	3R	4R	5R	6R	7R	08R	09R	10R	11R	12R
JUNE	7F	8S	9S	0S	1S	2S	3S	4S	5S	6S	7S	08S	09S	10S	11S	12S
JULY	7G	8T	9T	0T	1T	2T	3T	4T	5T	6T	7T	08T	09T	10T	11T	12T
AUGUST	7H	8U	9U	0U	1U	2U	3U	4U	5U	6U	7U	08U	09U	10U	11U	12U
SEPTEMBER	7I	8V	9V	0V	1V	2V	3V	4V	5V	6V	7V	08V	09V	10V	11V	12V
OCTOBER	7J	8Z	9Z	0Z	1Z	2Z	3Z	4Z	5Z	6Z	7Z	08Z	09Z	10Z	11Z	12Z
NOVEMBER	7K	8X	9X	0X	1X	2X	3X	4X	5X	6X	7X	08X	09X	10X	11X	12X
DECEMBER	7L	8Y	9Y	0Y	1Y	2Y	3Y	4Y	5Y	6Y	7Y	08Y	09Y	10Y	11Y	12Y

ROTATION CHANGING INSTRUCTIONS FOR PUMPS GROUP 2

Before starting, be sure that the pump is cleaned externally as well as the working area to avoid that particles dangerous for pump working can find their way into the pump.
Pump represented is aclockwise rotation pump.
To obtain an anti_clockwise rotation read carefully the following instructions.

Picture "A"
1 - Loosen and fully unscrew the screws.
2 - Lay the pump on the working area in order to have the mounting flange turned upside.
3 - Coat the shaft extension with grease to avoid damaging the shaft seal.
4 - Remove the flange and lay it on the working area;
verify that the seal is correctly located in the body seat.

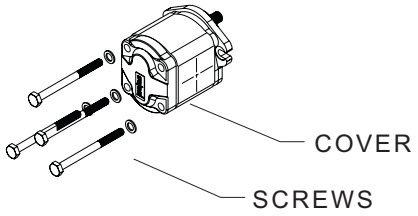
Picture "B"
1 - Mark the position of the bushing and eventually the thrust plate, relative to the body.
2 - Remove the bushing, thrust plate and the driving gear taking care to avoid driven gear axial shifts.

Picture "C"
1 - Draw out the driven gear from its housing, taking care to avoid rear cover axial shifts.
2 - Re-locate the driven gear in the position previously occupied by the driving gear.

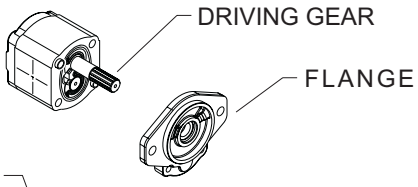
Picture "D"
1 - Re-locate the driving gear in the position previously occupied by the driven gear.

Picture "E"
1 - Replace the bushing and thrust plate taking care that:
- marks are located as on the picture
- surface containing the seal is visible
- seal and its protection are correctly located

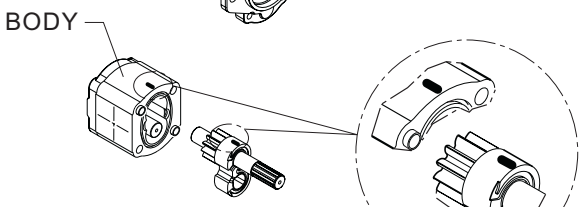
Picture "F"
1 - Clean body and mounting flange refaced surfaces.
2 - Verify that the two plugs are located in the body.
3 - Refit the mounting flange, turned 180° from its original position.
4 - Replace the clamp bolts and tighten crosswise evenly to a torque you will find at page 2.
Check that the shaft rotates freely.
6 - Mark on the flange the new direction of rotation.



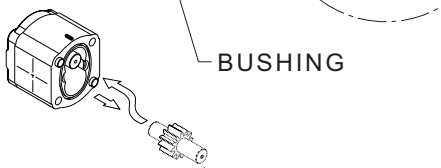
Picture "A"



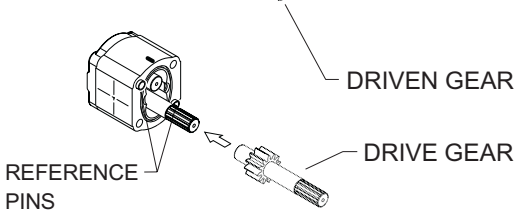
Picture "A"



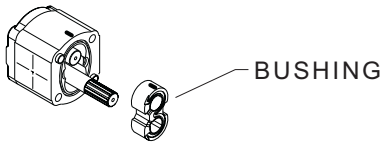
Picture "B"



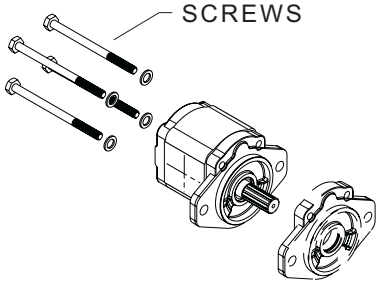
Picture "C"



Picture "D"

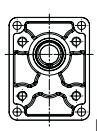
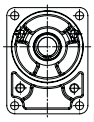
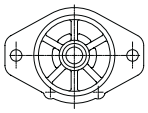


Pict. "E"



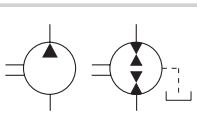
Pict. "F"

COMBINATION WITH TYPES OF FLANGES AND DRIVES SHAFTS AVAILABLE

2PE	 P1	 B1	 B4 B5	 B2 B3	 S2 S6	 K1	 C1	 S3
 **25**		25 B1	25 B4 25 B5					
 **28**	28 P1							
 **02**						02 K1		
 **03**				03B2 03B3				
 **04**			04B4 04B5					
 **62**	62 P1	62 B1	62 B4 62 B5				62 C1	
 **52**					52 S2 52 S6			
 **54**					54 S2 54 S6			
 **55**								55 S3
 **85**					85 S2 85 S6			
 **82**	82 P1				82 S2 82 S6			

Note: other versions available, see shafts and flanges information.

Displacements up to 1.58 cu.in./rev
Pressure up to 4300 psi



GEAR PUMPS

Displacements up to 25.8 cm^3/rev
Pressure up to 300 bar

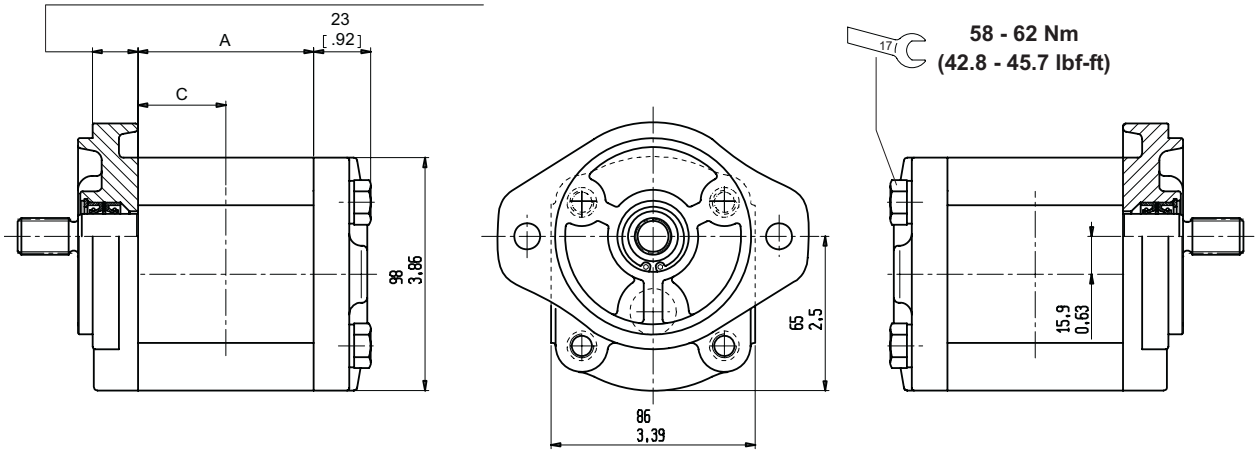
ASSEMBLING DIMENSIONS AND VALUES OF PRESSURE AND SPEED

Type		3.2*	3.9*	4.5	6.5	8.3	10.5	11.3	12.5	13.8	16	19	22.5	26
Displacement	cm^3/rev *cu.in./rev*	3.2 *0.19*	3.9 *0.24*	4.6 *0.27*	6.5 *0.40*	8.2 *0.50*	10.6 *0.65*	11.5 *0.68*	12.7 *0.77*	13.8 *0.84*	16.6 *1.01*	19.4 *1.15*	22.9 *1.37*	25.8 *1.58*
Dimension A	mm *in*	47.1 *1.83*			49.95 *1.97*	52.8 *2.07*	56.35 *2.22*	59.6 *2.35*		63.5 *2.5*	67.5 *2.65*	75.6 *2.97*	81 *3.19*	86.8 *3.42*
Dimension C	mm *in*	23.55 *0.93*			24.98 *0.98*	26.4 *1.04*	28.17 *1.11*	29.8 *1.17*		31.75 *1.25*	33.75 *1.33*	37.80 *1.49*	40.5 *1.59*	43.4 *1.71*
Working pressure p1	bar *psi*	250 *3600*										220 *3140*	200 *2900*	180 *2600*
Intermittent pressure p2	bar *psi*	280 *4000*										240 *3450*	220 *3140*	200 *2900*
Peak pressure p3	bar *psi*	300 *4300*										260 *3750*	240 *3450*	220 *3140*
Max speed at p2	rpm	4000				3500					3000		2750	2500
Min speed at p1	rpm	600				500					400		400	300
Weight	kg *lbs*	2.01 *4.4*	2.05 *4.5*		2.1 *4.6*		2.25 *5.0*	2.3 *5.1*	2.37 *5.2*	2.4 *5.3*	2.5 *5.5*	2.8 *6.2*	2.95 *6.5*	3.1 *6.8*

* Available only as rear pump

Performance curves carried out with oil viscosity at 16 cSt and oil temperature at 60°C

For flanges code:
P1 - B1 - S2 - S6, this dimension is 19 mm (0.75 in.)
B2 - B3 - B4 - B5, this dimension is 16.5 mm (0.65 in.)



ASSEMBLING EXAMPLES

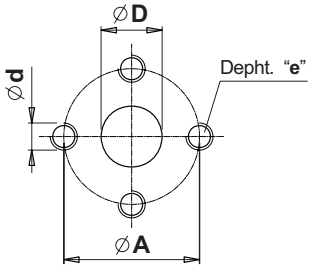
2PE - P28P1

2PE - B25B1

2PE - B25B4

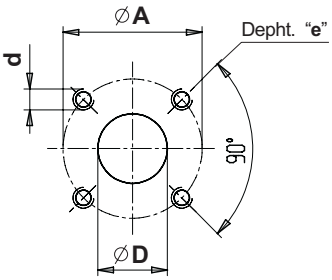
2PE - B62B1

FLANGED PORTS



Type	INLET				OUTLET			
	ØD	ØA	d	e	ØD	ØA	d	e
From 3.2 to 8.3	13 (0.51")	30 (1.19")	M6	13 (0.51")	13 (0.51")	30 (1.19")	M6	13 (0.51")
From 11.3 to 22.5	20 (0.78")	40 (1.56")	M8					
26	22 (0.87")							

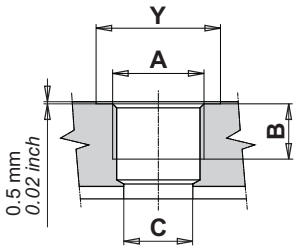
code P



Type	INLET				OUTLET			
	ØD	ØA	d	e	ØD	ØA	d	e
From 3.2 to 22.5	20 (0.78")	40 (1.56")	M6	13 (0.51")	15 (0.59")	35 (1.38")	M6	13 (0.51")
26	22 (0.87")							

code B

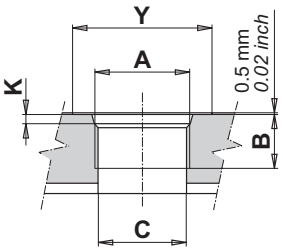
THREADED PORTS



Type	INLET			OUTLET		
	A	B	ØC	A	B	ØC
From 3.2 to 26	G3/4	16 (0.62")	20 (0.78")	G1/2	14 (0.54")	13 (0.51")

code G

British standard pipe parallel (BSPP)

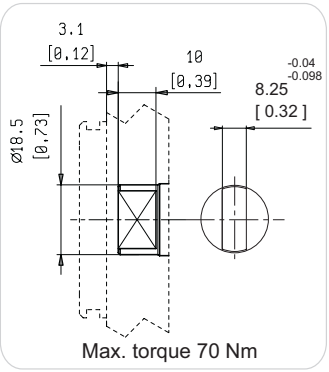


Type	INLET					OUTLET				
	A	B	ØC	Y	K	A	B	ØC	Y	K
From 3.2 to 26	1-1/16 UNF (SAE 12)	16 (0.62")	20 (0.78")	41 (1.61")	3.3 (0.12")	7/8 - 14 UNF (SAE 10)	14 (0.54")	13 (0.51")	34 (1.32")	2.5 (0.10")

code R

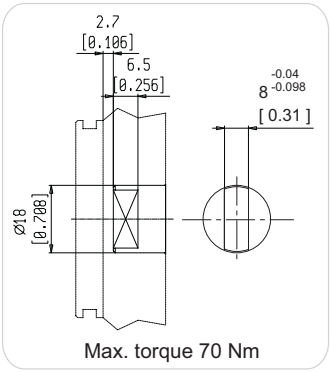
SAE threaded (ODT)

DRIVE SHAFTS



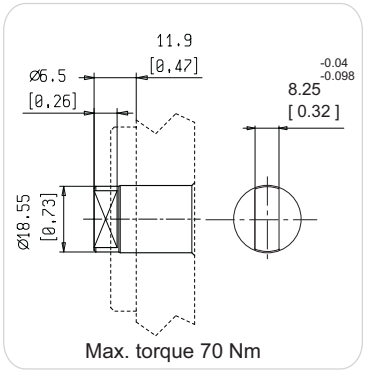
Max. torque 70 Nm

code 02 Tang drive for diesel engines.
For flange K1 without shaft seal.



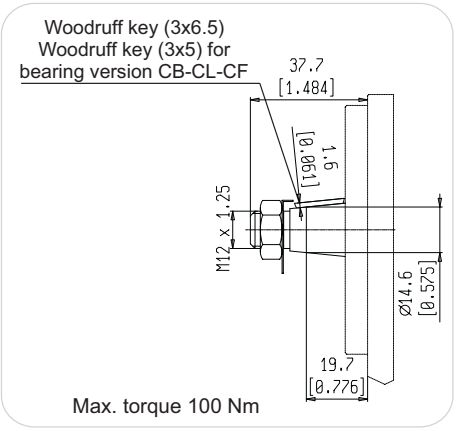
Max. torque 70 Nm

code 03 Tang drive for electric motors.
Without shaft seal.



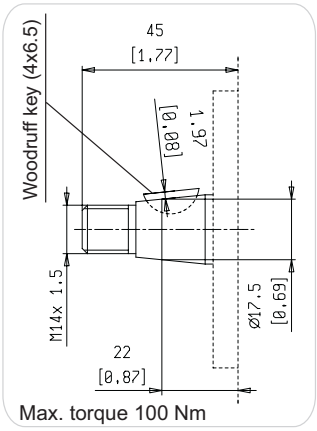
Max. torque 70 Nm

code 04 Tang drive.



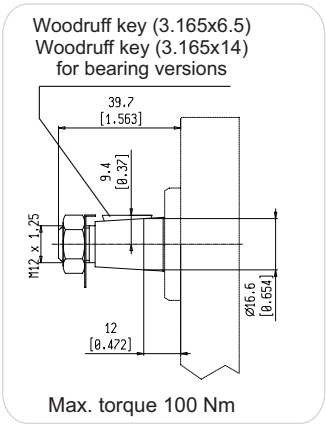
Max. torque 100 Nm

code 25 Tapered 1:5



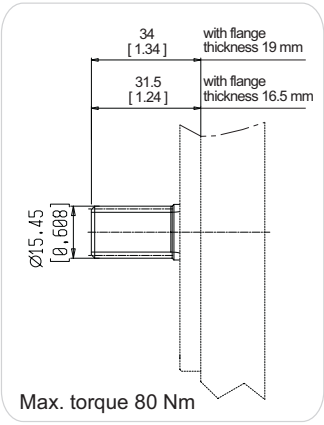
Max. torque 100 Nm

code 26 Tapered 1:5 (only for CB)



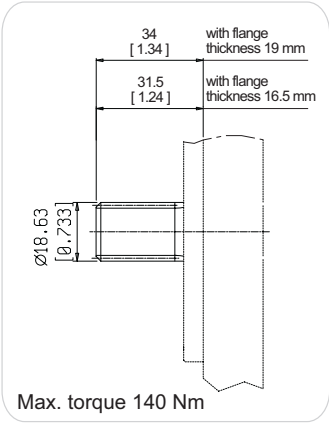
Max. torque 100 Nm

code 28 Tapered 1:8



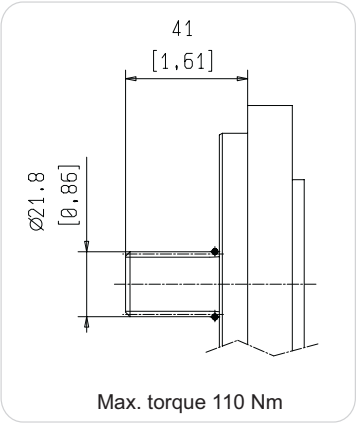
Max. torque 80 Nm

code 52 SAE A 9T-16/32DP
Ansi B92 1a 1976



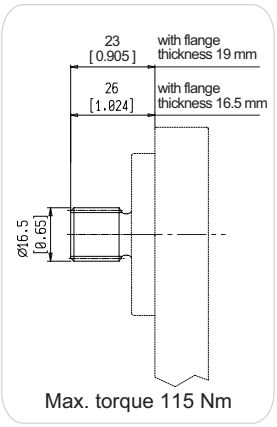
Max. torque 140 Nm

code 54 SAE 11T-16/32DP
Ansi B92 1a 1976



Max. torque 110 Nm

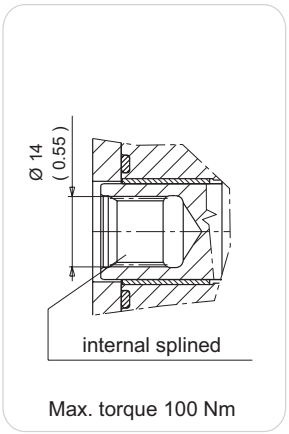
code 55 SAE B 13T-16/32DP
Ansi B92 1a 1976



Max. torque 115 Nm

code 62

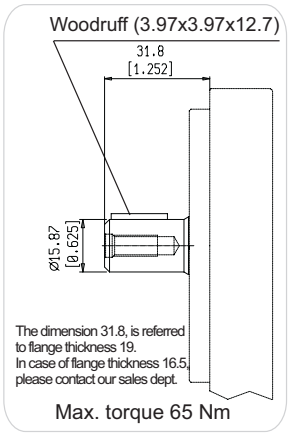
9 teeth DIN 5482 splined



Max. torque 100 Nm

code 60

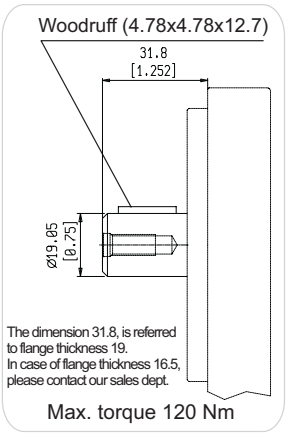
DIN 5480 internal splined
Only for rear pumps



Max. torque 65 Nm

code 82

5/8" SAE A parallel

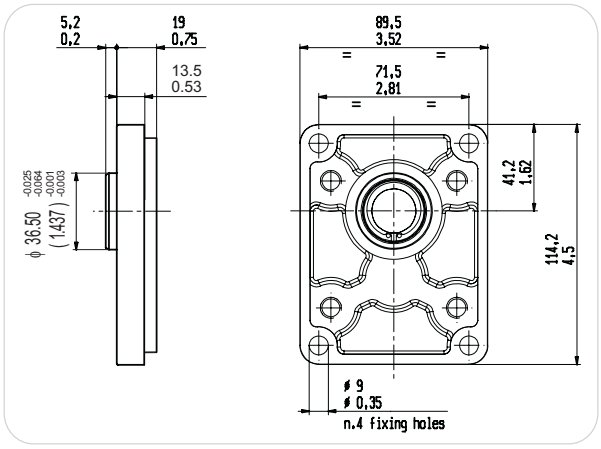


Max. torque 120 Nm

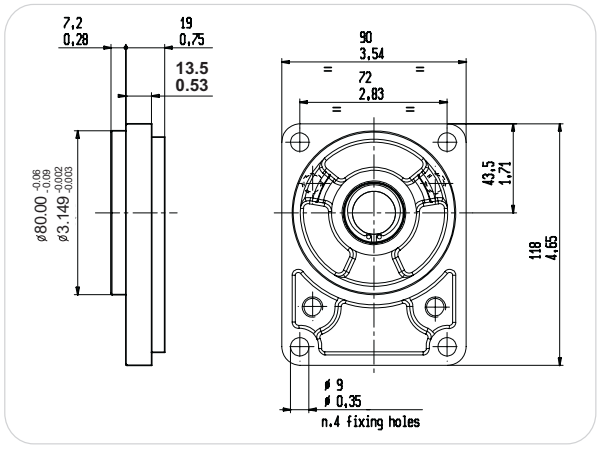
code 85

3/4" SAE A parallel

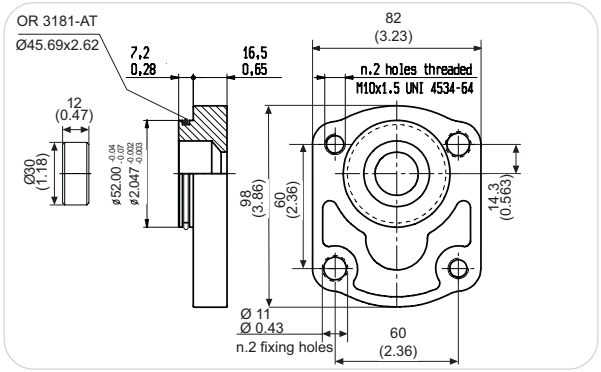
MOUNTING FLANGES



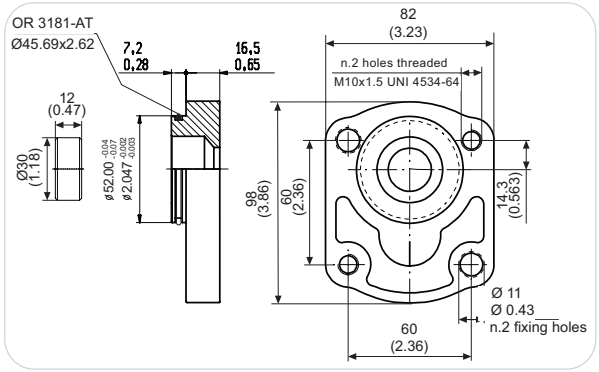
code P1 With shaft code 28 - 62 - 81 - 82 - 85



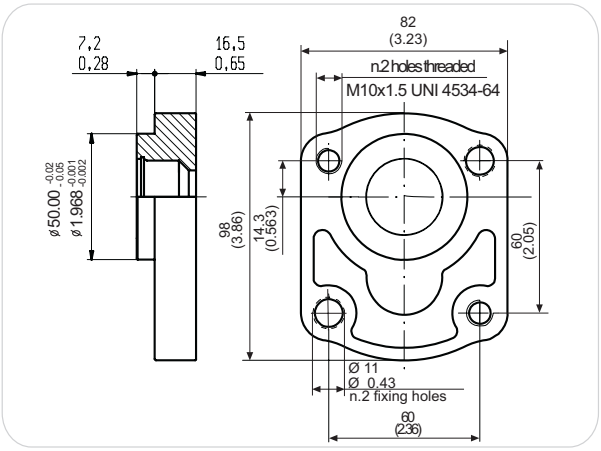
code B1 With shaft code 25-62



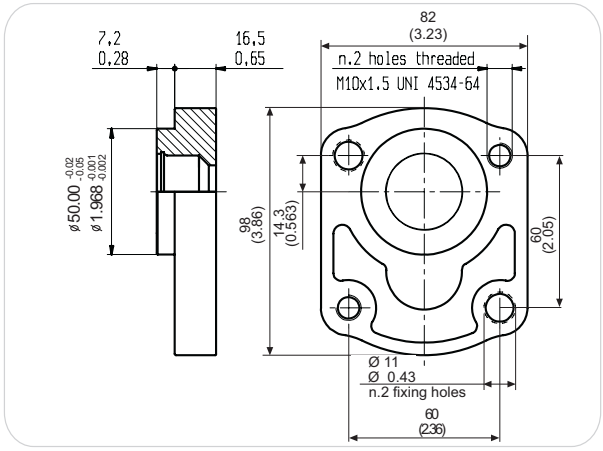
code B2 With shaft code 03-61



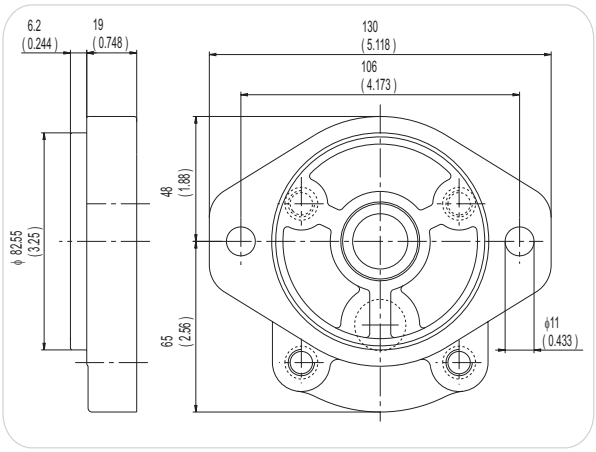
code B3 With shaft code 03-61



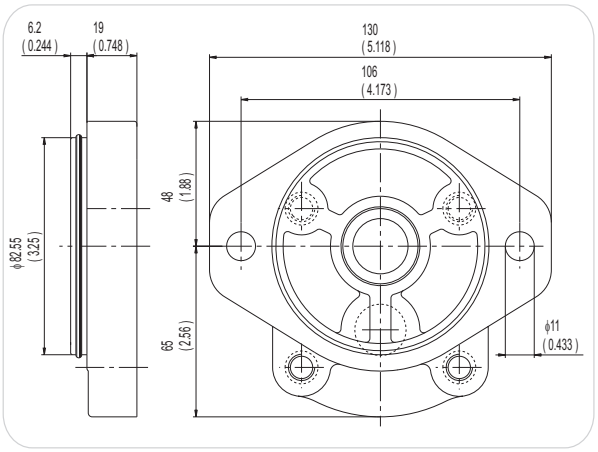
code B4 With shaft code 25-62



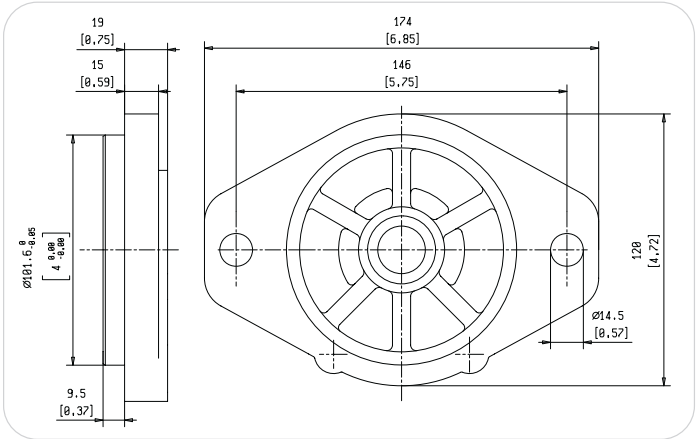
code B5 With shaft code 25-62



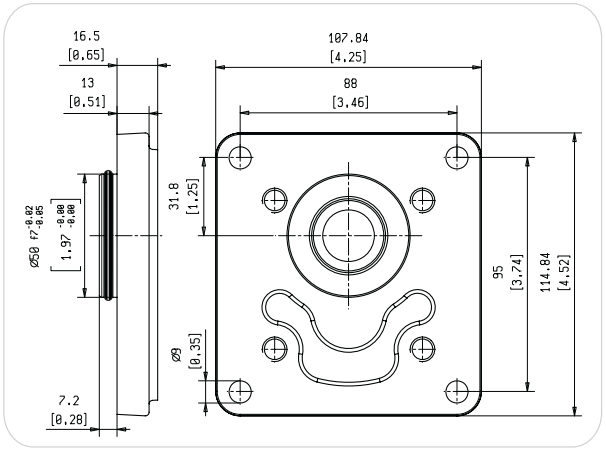
code S2 With shaft code 52-54-82-85.



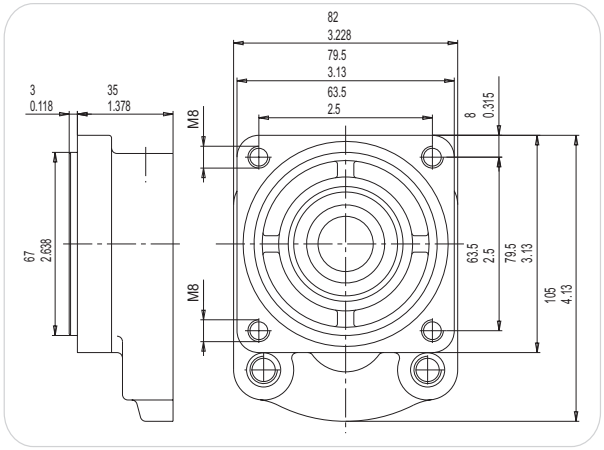
code S6 With shaft code 52-54-82-85



code S3 With shaft code 52-54-55-82-85

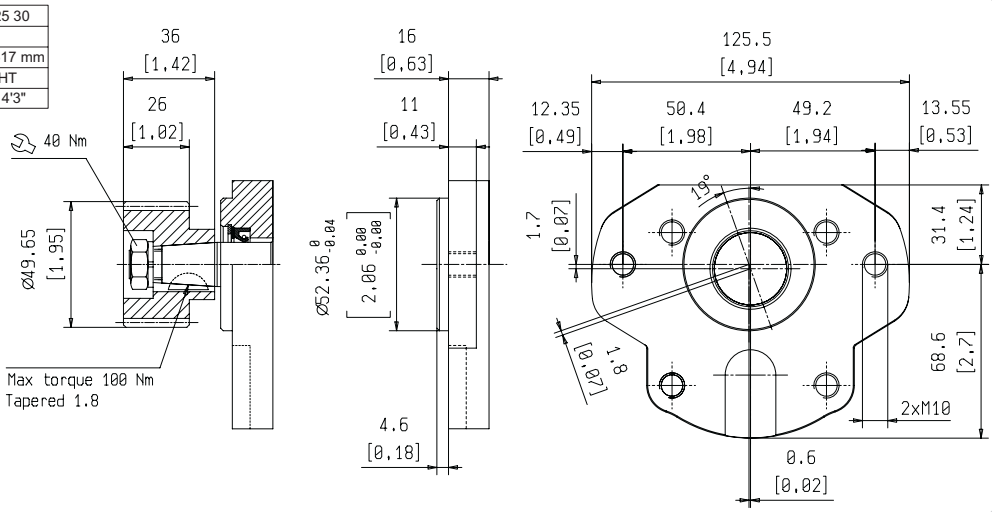


code C1 With shaft code 52-54-82-85
For Iveco engines



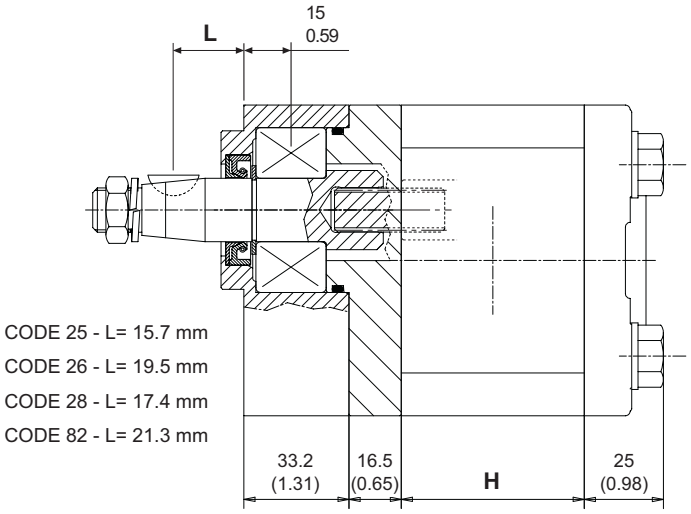
code K1 With shaft code 02.
For Perkins engines (series 100)

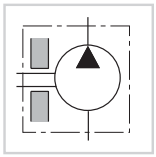
PINION GEAR CODE 3122 025 30	
NUMBER OF TEETH	20
BASE CIRCLE DIAMETER	42.617 mm
HAND OF HELIX	RIGHT
HELIX ANGLE	13°14'3"



code MF With shaft code 28
The combination 28MF is not comprehensive of pinon gear.
The pinion gear must be specified in phase of order.

OUTRIGGER BEARING

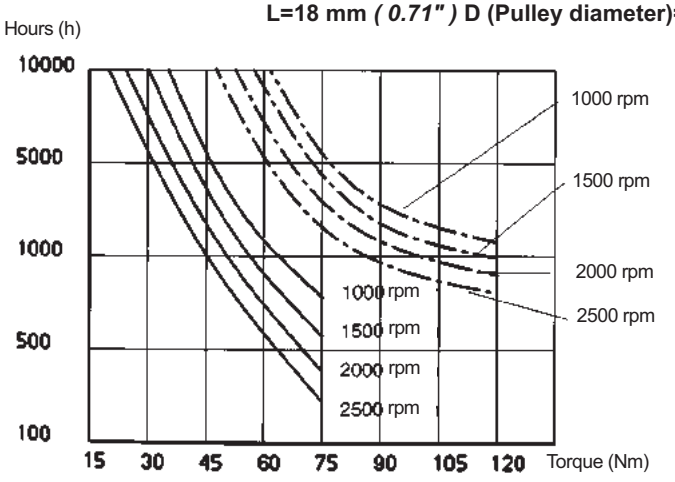




Type	H
4.5	47.1 *(1.83")*
6.5	*49.95 (1.97")*
8.3	52.8 *(2.08")*
10.5	56.3 *(2.22")*
11.3 - 12.5	59.6 *(2.35")*
13.8	63.5 *(2.5")*
16	67.5 *(2.66")*
19	75.6 *(2.97")*
22.5	81 *(3.19")*
26	86.6 *(3.42")*

Order example pump 2PE with bearing: **2PE16D - B25 B4 - CL**

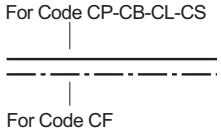
Life of bearing under following condition:
L=18 mm *(0.71")* D (Pulley diameter)=90 mm *(3.54")*



To calculate the absorbed pump or motor torque, please use the following formula:

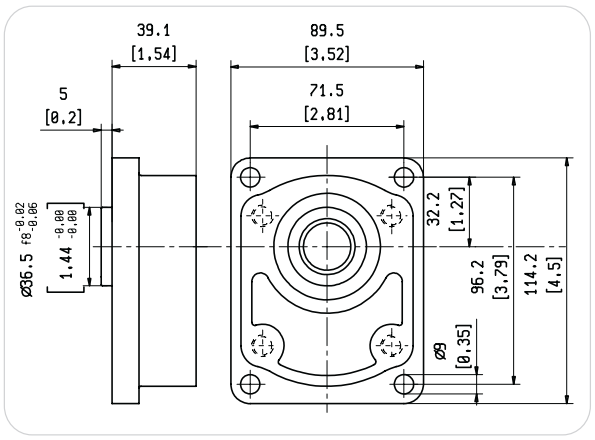
$$C\ (Nm) = \frac{Cy\ \Delta p}{62.8\ \eta m}$$

Cy = Displacement (cm^3/rev)
Δp = Pressure (bar)

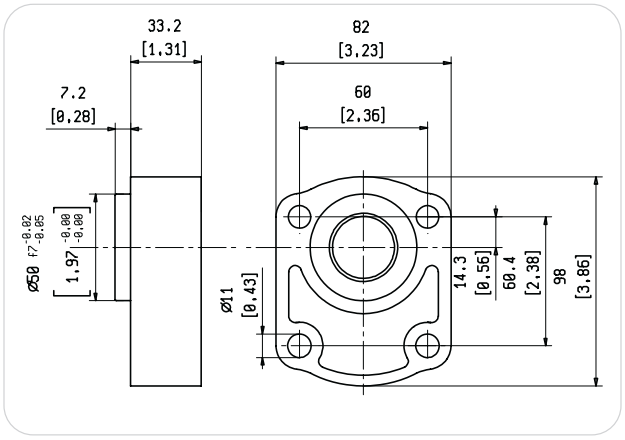


*Available for quantity, please contact our sales department.

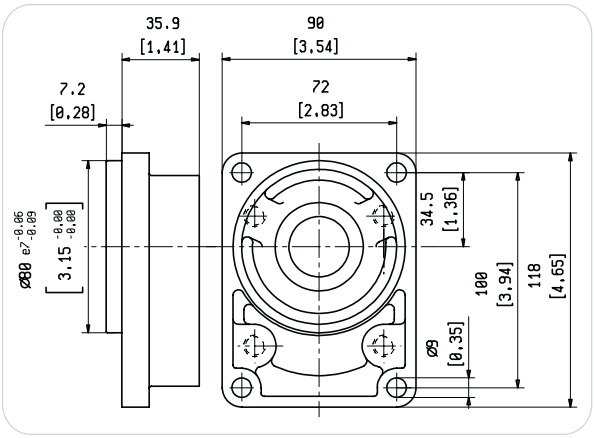
MOUNTING FLANGES WITH BEARING SUPPORT



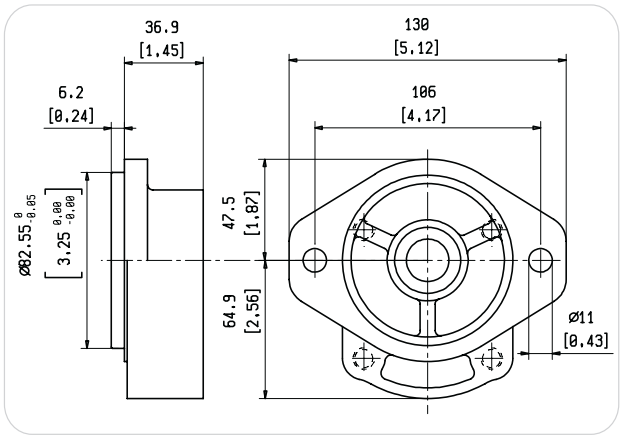
code CP With shaft code 28



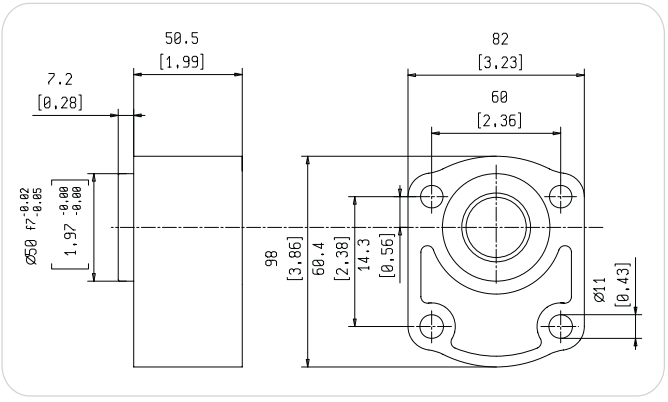
code CL With shaft code 25, 26



code CB With shaft codes 25-26

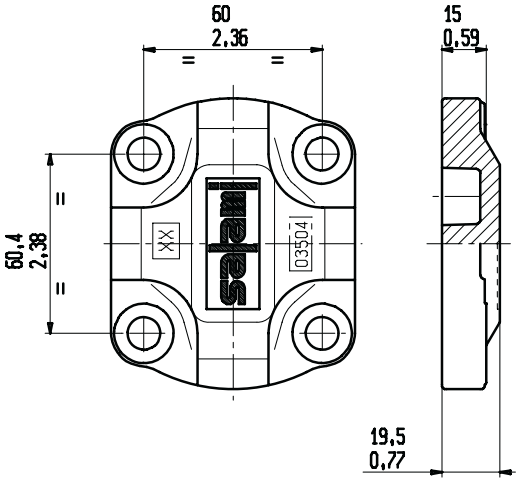


code CS SAE A with shaft codes 52-54-82

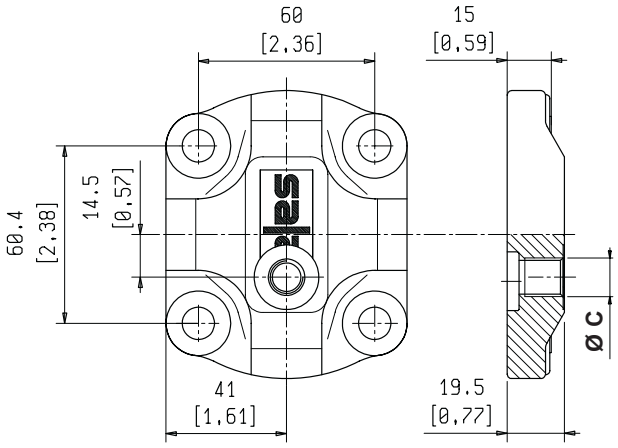


code CF SAE A with shaft codes 25-26

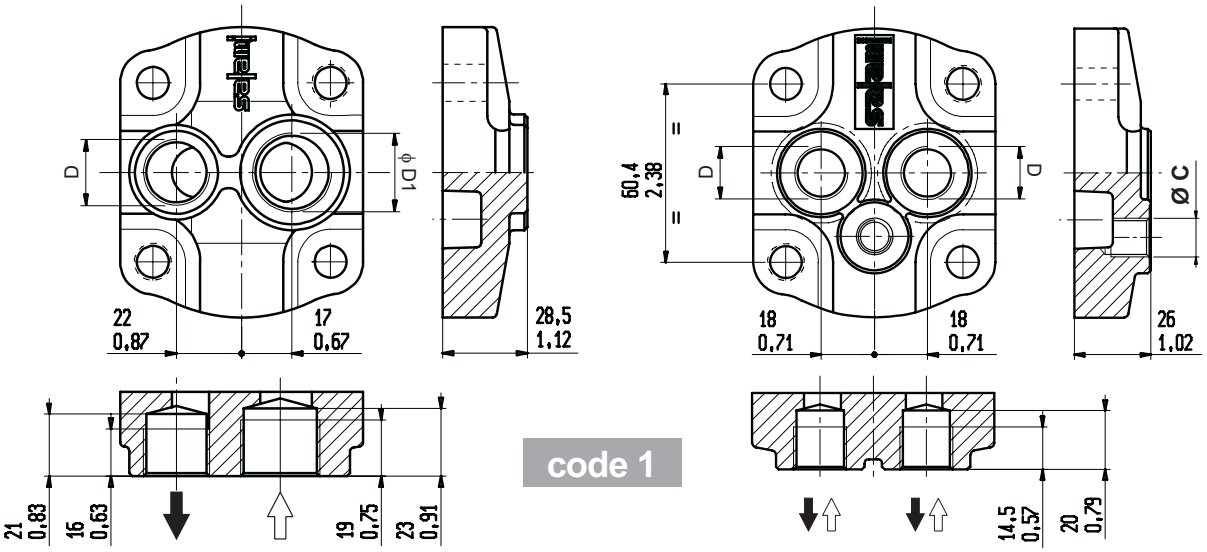
REAR COVERS



Standard rear cover
for unidirectional pumps



Standard cover for reversible pumps and motors,
with external drain ΦC.
For the dimension ΦC please see the table here below.



code 1

UNIDIRECTIONAL PUMPS
On request outlet port only.

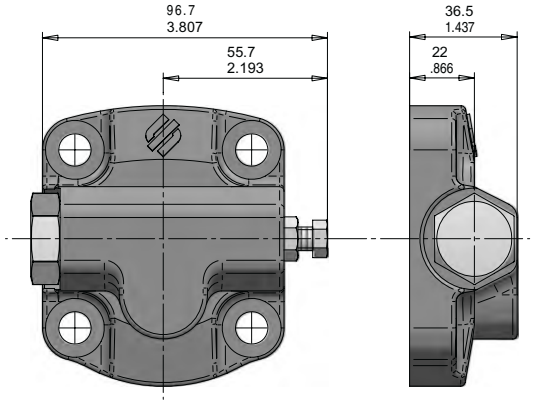
D	D1
M 18x1.5	M 26x1.5
7/8-14 UNF-2B (SAE 10)	1-1/16-12 UN-2B (SAE 12)
G 1/2	G 3/4

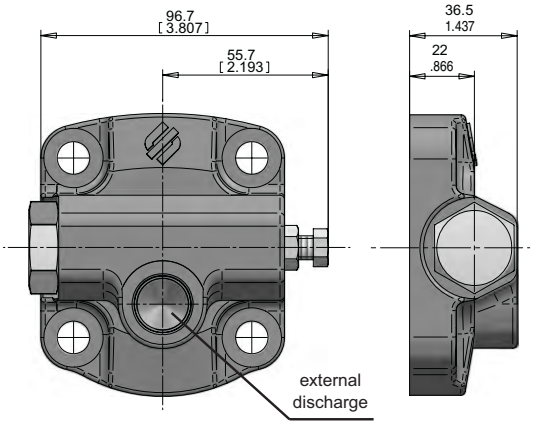
BIDIRECTIONAL PUMPS
For pumps with threaded rear ports until 25 l/min delivery.

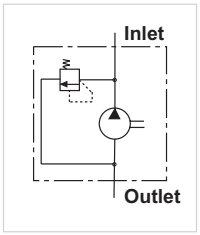
D	C
M 18x1.5	G 1/4
7/8-14 UNF-2B (SAE 10)	7/16-20 UNF-2B (SAE 4)
G 1/2	G 1/4

For rear ports if requested please advise type using note.

REAR COVERS WITH MAIN RELIEF VALVES

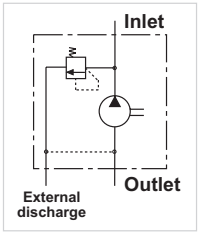






code VS

With main relief valve with internal exhaust gallery



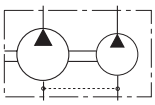
← **code VSE**

For this main relief valve you can choice four setting ranges:

(**20 - 50 bar**)
(**51 - 75 bar**)
(**76 - 150 bar**)
(**151 - 220 bar**)

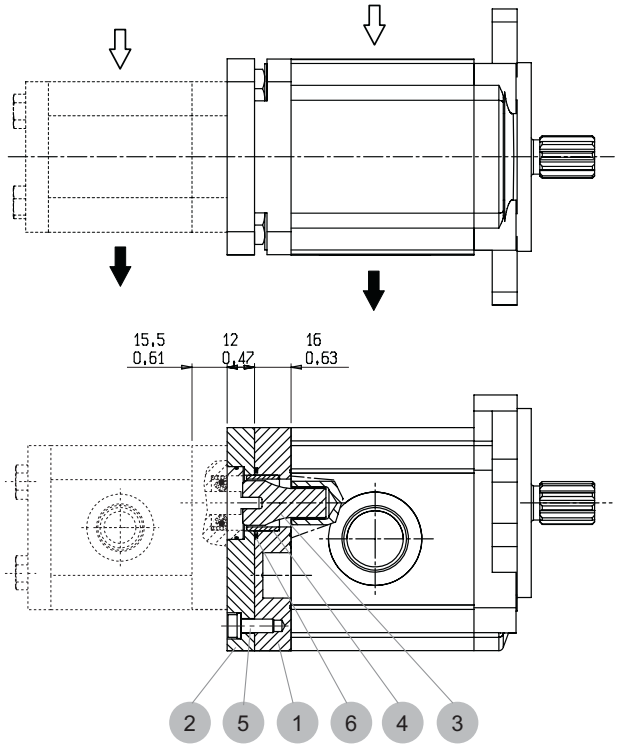
D (external discharge)
M 18 x 1.5 (METRIC)
3/4-16 UNF-2B (SAE 8)
G 3/8 (BSPP)

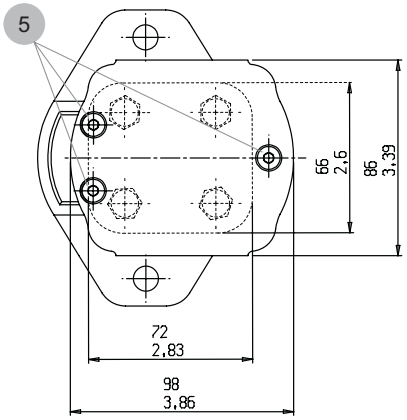
REAR COVER FOR MULTIPLE PUMP 2PE/1PE (SEPARATED SUCTIONS)



MULTIPLE GEAR PUMPS
with inlet port on each body

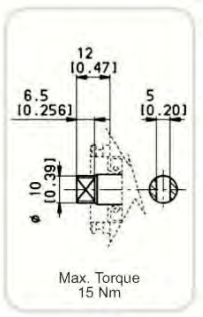
Assembling kit for multiple pump 2PE/1PE **code PD1**



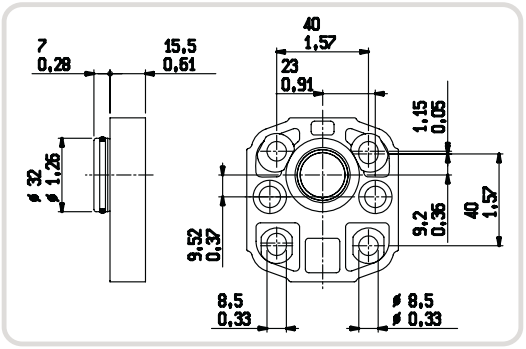


1. **Assembling components**:
2. - n.1 special cover 2PE
3. - n.1 middle flange
4. - n.1 coupling sleeve
5. - n.1 centering collar
6. - n.3 screws TCEI M6X14 ISO 262
   - n.1 O-ring 2-033-AT

THE 1PE PUMP HAS THE SHAFT CODE “06” AND THE FLANGE CODE “B0”
(as per our gear pumps and motors catalogue group 1)



code 06

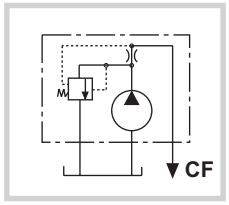


code B0

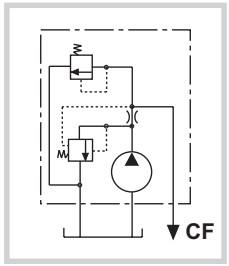
REAR COVER WITH PRESSURE COMPENSATED FLOW CONTROL VALVE
REAR PORTS

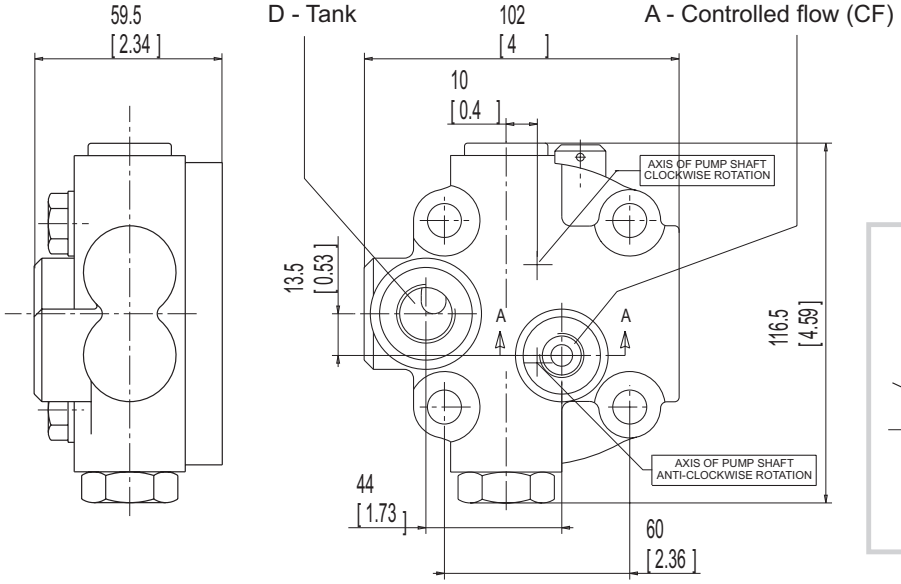
code VR Pressure compensated flow control valve with excess flow to tank

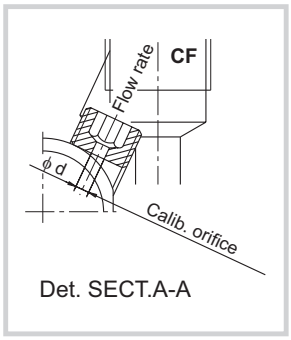




code VRS Pressure compensated flow control valve with excess flow to tank, with main relief valve on controlled flow line.







Det. SECT.A-A

A	D
G 3/8	G 1/2
9/16-18 UNF-2B (SAE 6)	3/4-16 UNF-2B (SAE 8)

FLOW CONTROL VALVE (VR - VRS)

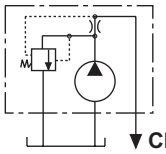
3 - way flow control valve housed in a special cast iron cover which ensures constant flow regardless pump speed and system pressure variations.It can also be supplied with adjustable pressure relief valve whose relieved flow goes into excess pump flow line.In this way the max fluid temperature is lower than obtained if the excess flow returned directly to pump inlet.The flow regulated is determined by the diameter of hole on the threaded dowel (see table).

CALIBRATED ORIFICE Ø d(mm/*inch*)	FLOW RATE (l/min - *gpm*) ± 10%
1.5 *(0.06")*	2.5 *(0.66)*
2 *(0.08")*	4 *(1.06)*
2.4 *(0.09")*	6 *(1.59)*
2.8 *(0.11")*	8 *(2.11)*
3.1 *(0.12")*	10 *(2.64)*
3.5 *(0.14")*	12.5 *(3.30)*
4 *(0.16")*	16 *(4.23)*
4.4 *(0.17")*	20 *(5.28)*
4.9 *(0.19")*	25 *(6.61)*

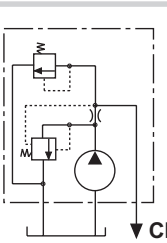
REAR COVER WITH PRESSURE COMPENSATED FLOW CONTROL VALVE SIDE PORTS

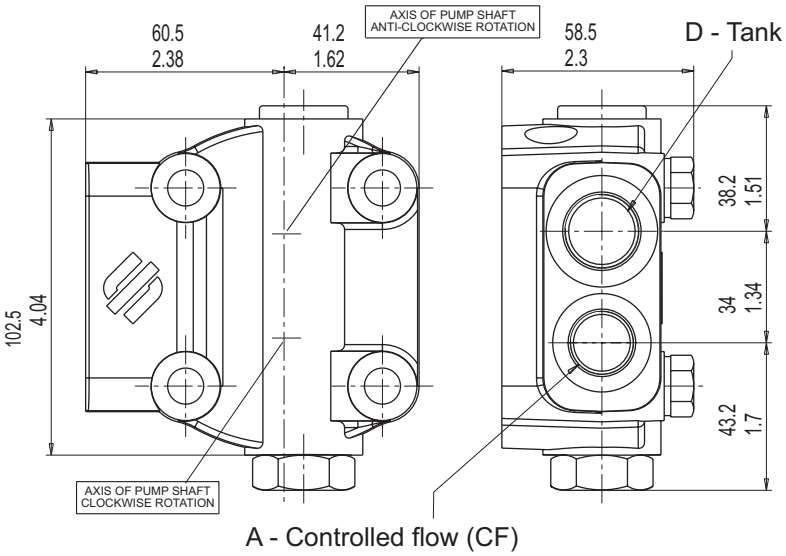
code VR1 Pressure compensated flow control valve with excess flow to tank

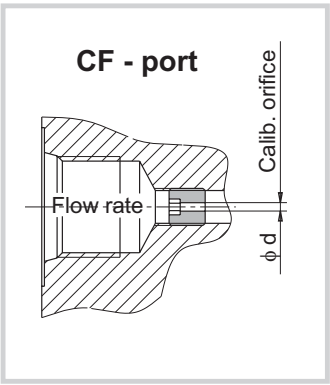




code VRS1 Pressure compensated flow control valve with excess flow to tank, with main relief valve on controlled flow line.







A	D
G 3/8	G 1/2
3/4-16 UNF-2B (SAE 8)	7/8-14 UNF-2B (SAE 10)

FLOW CONTROL VALVE (VR - VRS)

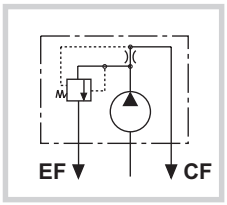
3 - way flow control valve housed in a special cast iron cover which ensures constant flow regardless pump speed and system pressure variations.It can also be supplied with adjustable pressure relief valve whose relieved flow goes into excess pump flow line.In this way the max fluid temperature is lower than obtained if the excess flow returned directly to pump inlet.The flow regulated is determined by the diameter of hole on the threaded dowel (see table).

CALIBRATED ORIFICE Ø d(mm/*inch*)	FLOW RATE (l/min - *gpm*) ± 10%
1.5 *(0.06")*	2.5 *(0.66)*
2 *(0.08")*	4 *(1.06)*
2.4 *(0.09")*	6 *(1.59)*
2.8 *(0.11")*	8 *(2.11)*
3.1 *(0.12")*	10 *(2.64)*
3.5 *(0.14")*	12.5 *(3.30)*
4 *(0.16")*	16 *(4.23)*
4.4 *(0.17")*	20 *(5.28)*
4.9 *(0.19")*	25 *(6.61)*

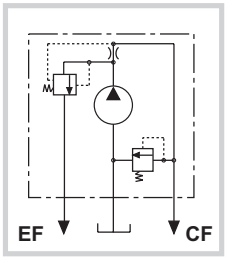
REAR COVER WITH PRESSURE COMPENSATED PRIORITY FLOW VALVE REAR PORTS

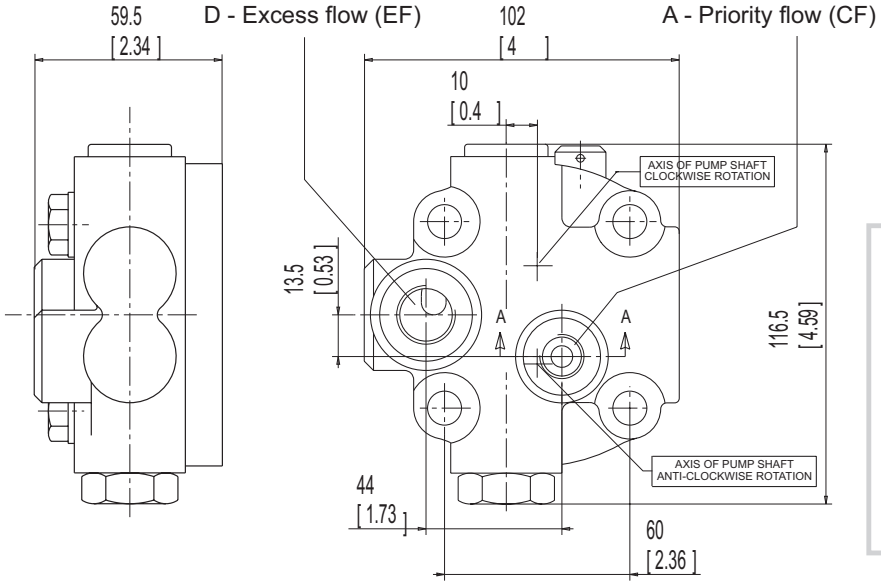
code VP Priority flow valve, excess flow to second actuator.

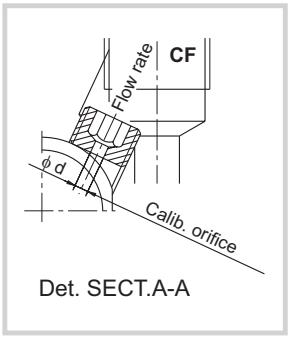




code VPS Priority flow valve, excess flow to second actuator with pressure relief valve on priority flow line.







A	D
G 3/8	G 1/2
9/16-18 UNF-2B (SAE 6)	3/4-16 UNF-2B (SAE 8)

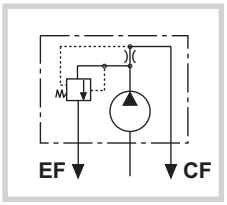
PRIORITY FLOW DIVIDERS (VP - VPS)

These are basically the same as VR valves differing only because the two flows can be loaded at the same time for supplying two separate circuits defined priority flow remains constant regardless of pump speed and system pressure variations.The second defined excess flow is directly proportional to pump speed.Priority flow is determined by diameter of hole on threaded dowel (see table).The max. pressure of the priority circuit can be limited by valve which relieves into pump suction.

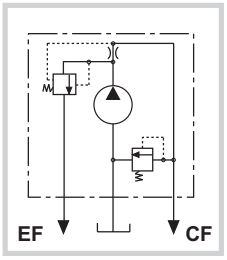
CALIBRATED ORIFICE Ø d(mm/*inch*)	FLOW RATE (l/min - *gpm*) ± 10%
1.5 *(0.06")*	2.5 *(0.66)*
2 *(0.08")*	4 *(1.06)*
2.4 *(0.09")*	6 *(1.59)*
2.8 *(0.11")*	8 *(2.11)*
3.1 *(0.12")*	10 *(2.64)*
3.5 *(0.14")*	12.5 *(3.30)*
4 *(0.16")*	16 *(4.23)*
4.4 *(0.17")*	20 *(5.28)*
4.9 *(0.19")*	25 *(6.61)*

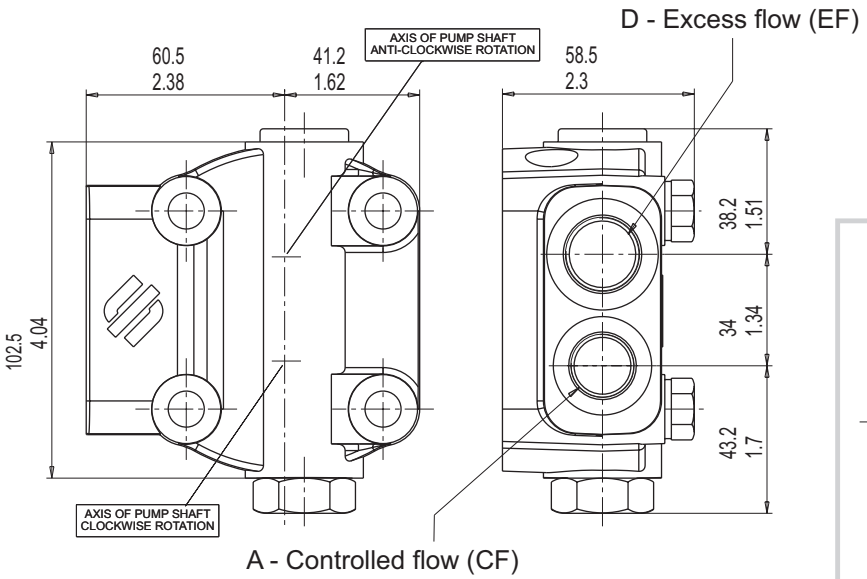
REAR COVER WITH PRESSURE COMPENSATED PRIORITY FLOW VALVE SIDE PORTS

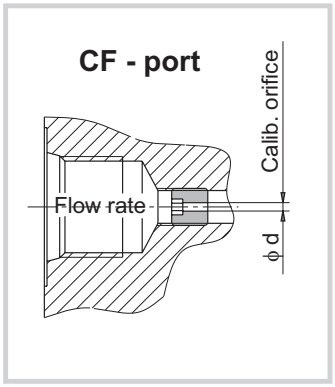
code VP1 Priority flow valve, excess flow to second actuator.



code VPS1 Priority flow valve, excess flow to second actuator with pressure relief valve on priority flow line.







A	D
G 3/8	G 1/2
3/4-16 UNF-2B (SAE 8)	7/8-14 UNF-2B (SAE 10)

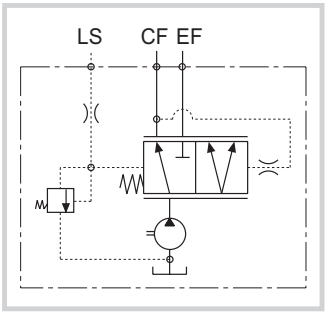
PRIORITY FLOW DIVIDERS (VP - VPS)

These are basically the same as VR valves differing only because the two flows can be loaded at the same time for supplying two separate circuits defined priority flow remains constant regardless of pump speed and system pressure variations.The second defined excess flow is directly proportional to pump speed.Priority flow is determined by diameter of hole on threaded dowel (see table).The max. pressure of the priority circuit can be limited by valve which relieves into pump suction.

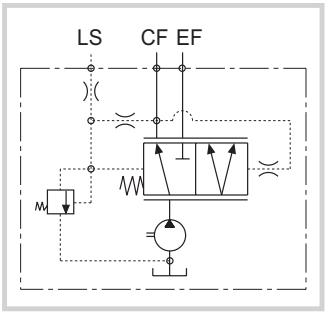
CALIBRATED ORIFICE Ø d(mm/*inch*)	FLOW RATE (l/min - *gpm*) ± 10%
1.5 *(0.06")*	2.5 *(0.66)*
2 *(0.08")*	4 *(1.06)*
2.4 *(0.09")*	6 *(1.59)*
2.8 *(0.11")*	8 *(2.11)*
3.1 *(0.12")*	10 *(2.64)*
3.5 *(0.14")*	12.5 *(3.30)*
4 *(0.16")*	16 *(4.23)*
4.4 *(0.17")*	20 *(5.28)*
4.9 *(0.19")*	25 *(6.61)*

REAR COVER WITH LOAD-SENSING PRIORITY VALVES
REAR PORTS

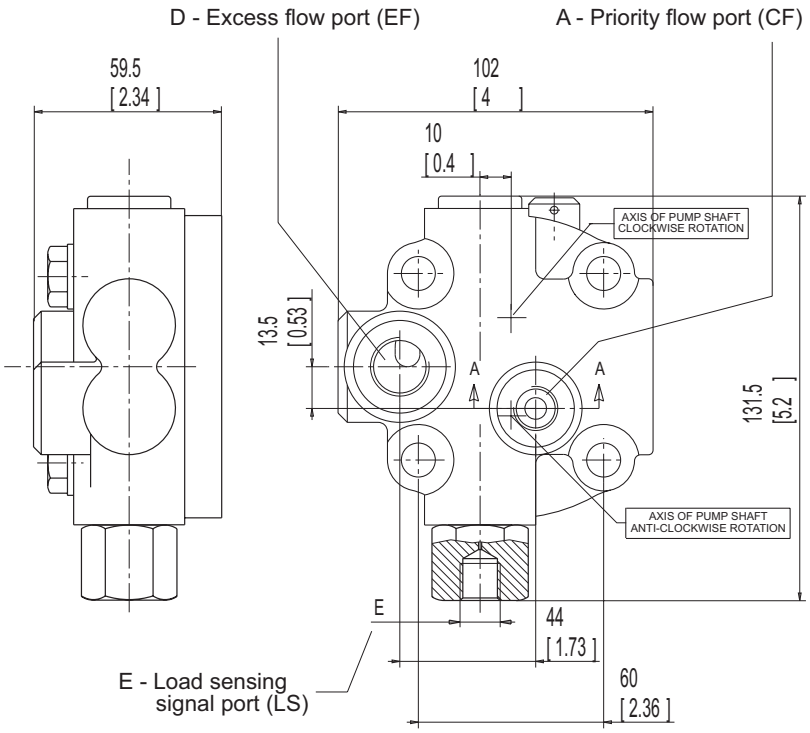
code VPL Load sensing priority valve with main relief valve



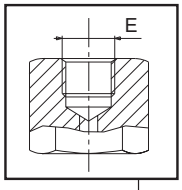
code VPD Load sensing priority valve with dynamic signal and main relief valve

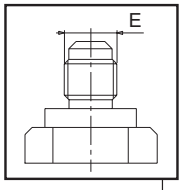


LS = Load sensing signal port
CF = Priority flow port
EF = Excess flow port



PRIORITY FLOW RATE	
l / min ± 10%	***gpm* ± 10%**
8	*2.10*
10.5	*2.61*
12.5	*3.78*
16	*4.17*
20	*5.22*





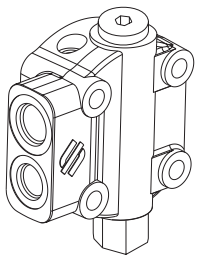
Minimum load sensing signal (LS) = 4 bar (28 psi)

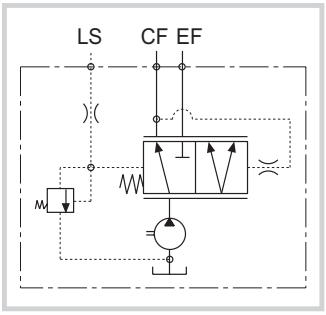
A	D	E
G 3/8	G 1/2	G 1/4
9/16-18 UNF-2B (SAE 6)	3/4-16 UNF-2B (SAE 8)	7/16-20 UNF-2B (SAE 4)

Side ports also availables. Please specify with note.

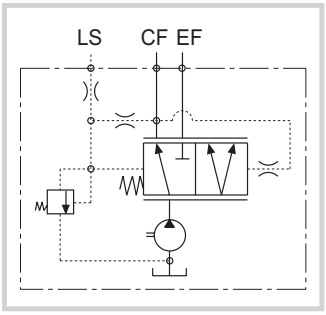
REAR COVER WITH LOAD-SENSING PRIORITY VALVES
SIDE PORTS

code VPL1 Load sensing priority valve with main relief valve

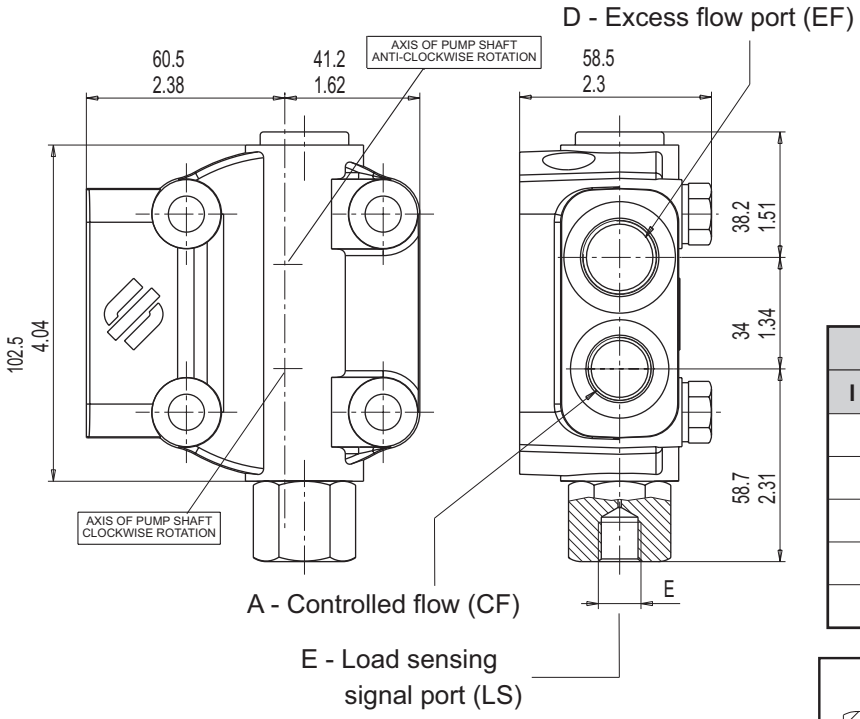




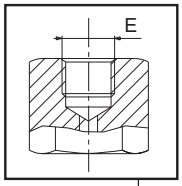
code VPD1 Load sensing priority valve with dynamic signal and main relief valve

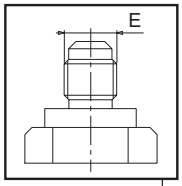


LS = Load sensing signal port
CF = Priority flow port
EF = Excess flow port



PRIORITY FLOW RATE	
l / min ± 10%	***gpm* ± 10%**
8	*2.10*
10.5	*2.61*
12.5	*3.78*
16	*4.17*
20	*5.22*





Minimum load sensing signal (LS) = 4 bar (28 psi)

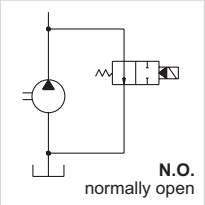
A	D	E
G 3/8	G 1/2	G 1/4
3/4-16 UNF-2B (SAE 8)	7/8-14 UNF-2B (SAE 10)	7/16-20 UNF-2B (SAE 4)

Side ports also availables. Please specify with note.

REAR COVER WITH ELECTRIC UNLOADING VALVE

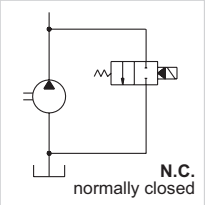
code EV

EV1 - 12 Vcc
EV2 - 24 Vcc

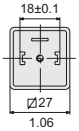


N.O.
normally open

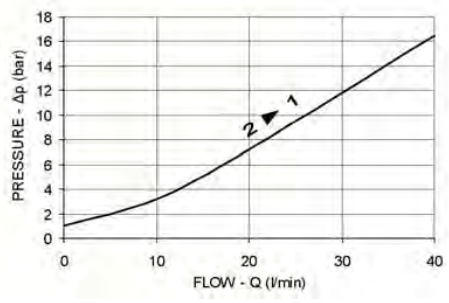
EV3 - 12 Vcc
EV4 - 24 Vcc

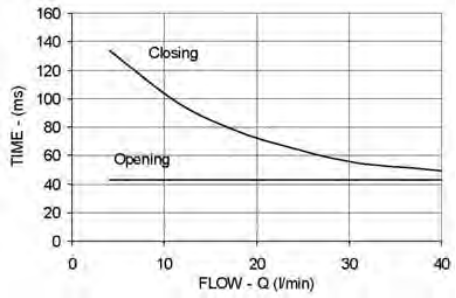


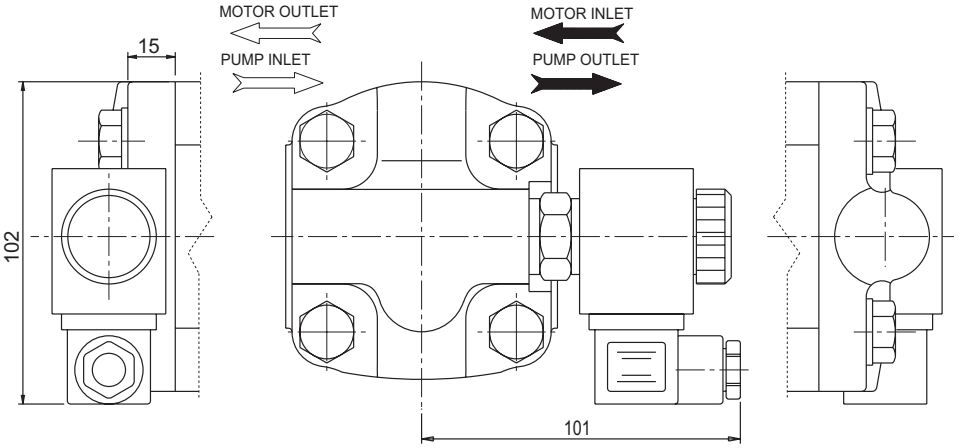
N.C.
normally closed



CONNECTOR
DIN 43650
A/ISO 4400

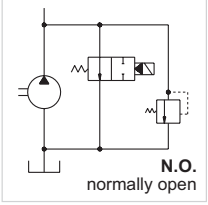






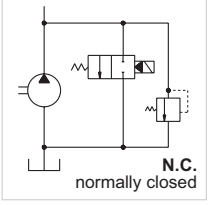
code EVS

EVS1 - 12 Vcc
EVS2 - 24 Vcc

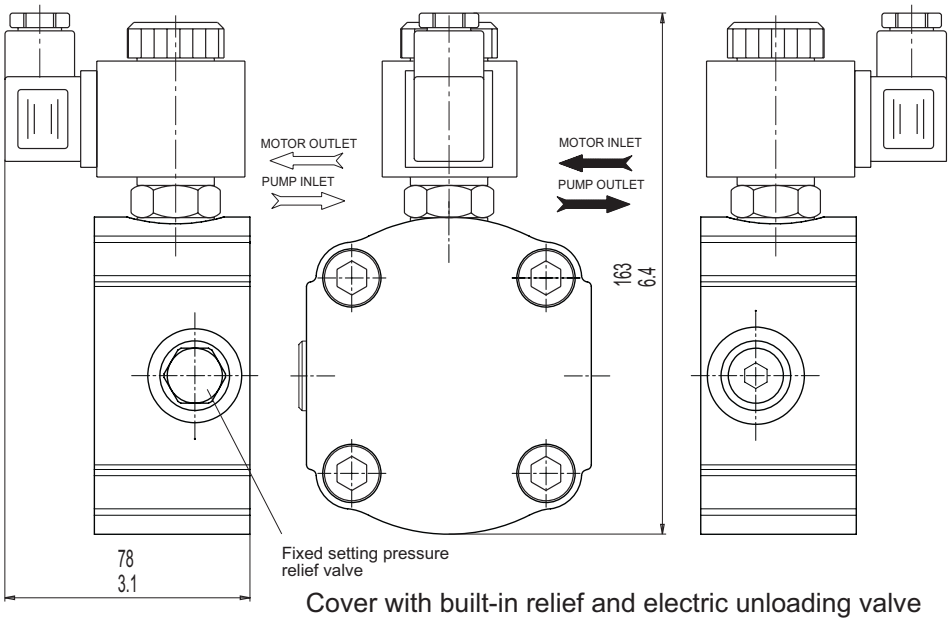


N.O.
normally open

EVS3 - 12 Vcc
EVS4 - 24 Vcc

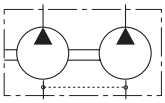


N.C.
normally closed

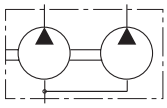


Cover with built-in relief and electric unloading valve

ASSEMBLING DIMENSIONS



MULTIPLE GEAR PUMPS
with inlet port on each body

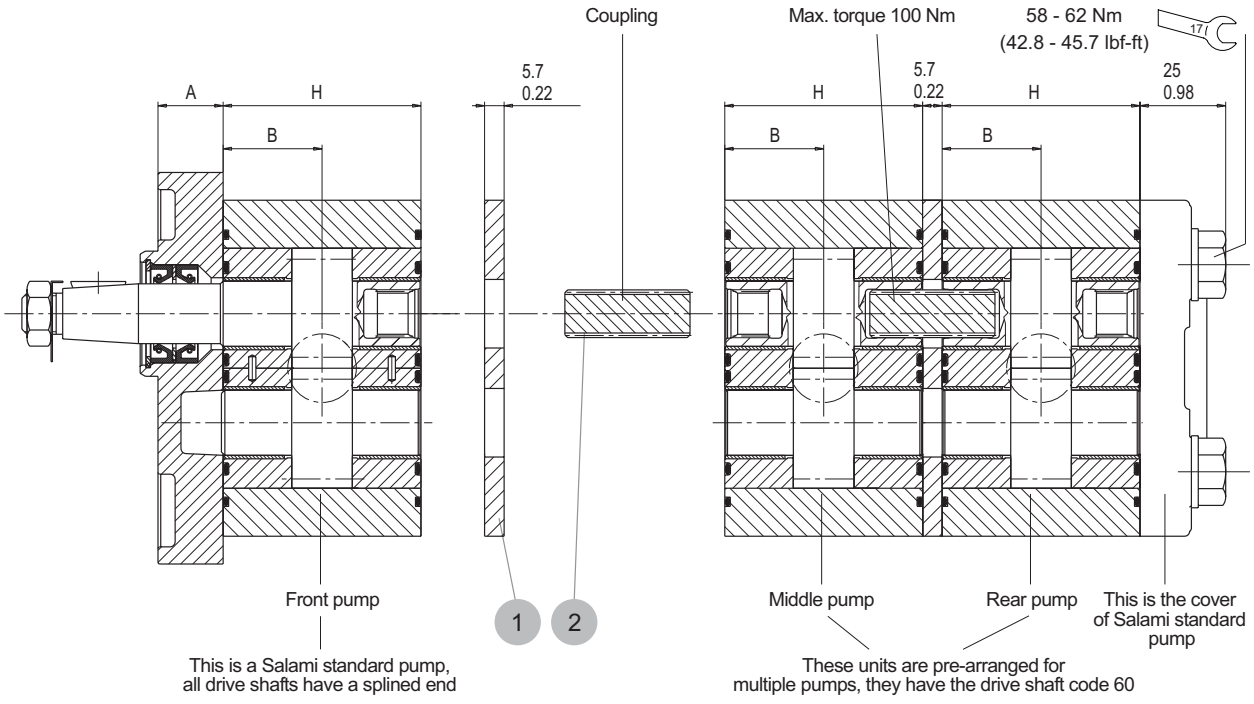


MULTIPLE GEAR PUMPS
with common inlet port*

In case of common inlet port, special bodies are required.

Commercial code "UA", in case of common inlet port .See page 34.

Type		3.2	3.9	4.5	6.5	8.3	10.5	11.3	12.5	13.8	16	19	22.5	26
Dimension A (flanges B2 - B3)	mm *in*	16,5 *0.65*												
Dimension A (flanges P1 - S2 - B1)	mm *in*	19 *0.75*												
Dimension B	mm *in*		23.55 *0.91*		24.98 *0.98*	26.4 *1.04*	28.17 *1.11*	29.8 *1.17*		31.75 *1.25*	33.75 *1.33*	37.8 *1.49*	40.5 *1.59*	43.4 *1.71*
Dimension H	mm *in*		47,1 *1.83*		49.95 *1.97*	52.8 *2.07*	56.35 *2.22*	59.6 *2.35*		63.5 *2.5*	67.5 *2.66*	75.6 *2.97*	81 *3.19*	86.8 *3.42*



Finally to assembly the multiple pump you need to order bolts of the right length

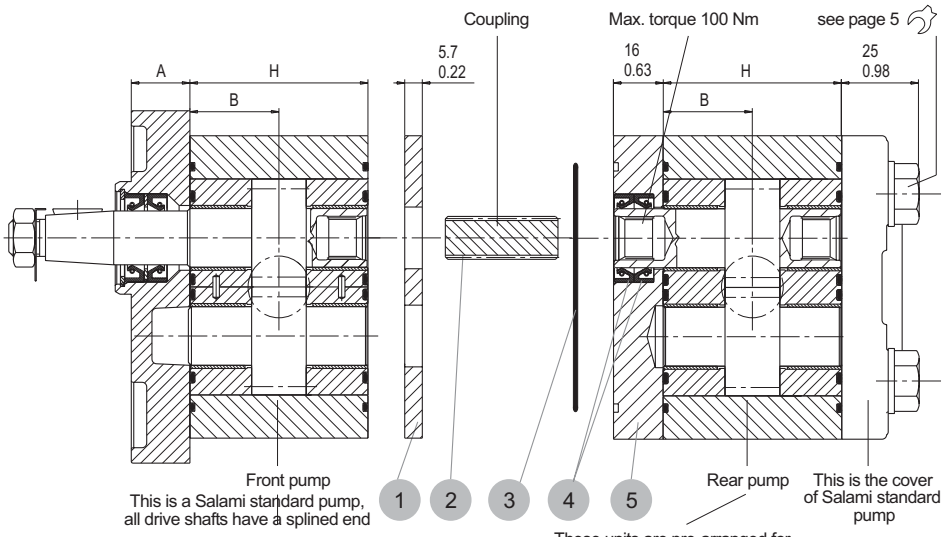
1 2 = kit multiple pumps

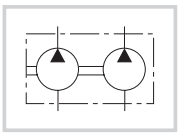
The **2PE** pumps can be easily transformed into front pump in the multiple units. All drive shafts are pre-arranged and have a splined end according DIN 5480. The first unit must always be the same size or bigger than following units. The features and performances are the same of the corresponding single units: only in the case of simultaneous operating you have to verify that the inlet torque is lower than the max. transmissible by the drive shaft.

MULTIPLE PUMP WITH SEPARATED STAGES

Finally to assembly the multiple pump you need to order bolts of the right length

For dimension (A - B - H) see page 26





code AS

Multiple pump with separated stages components kit:

1 2 3 4 5 the drive shaft 60* is longer than standard code 60

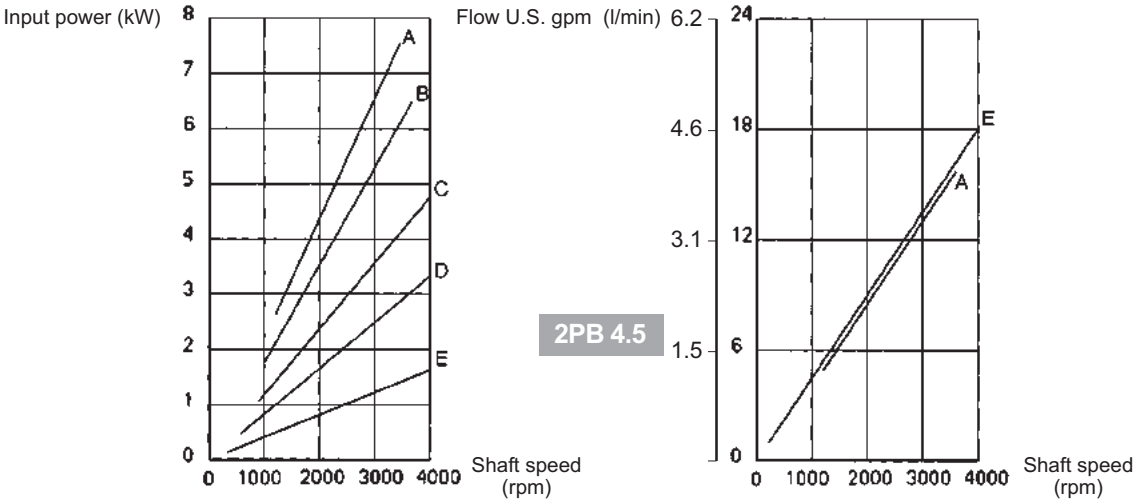
Order example:

2PB 11.3/2PB 8.3D - P28 P1 - AS

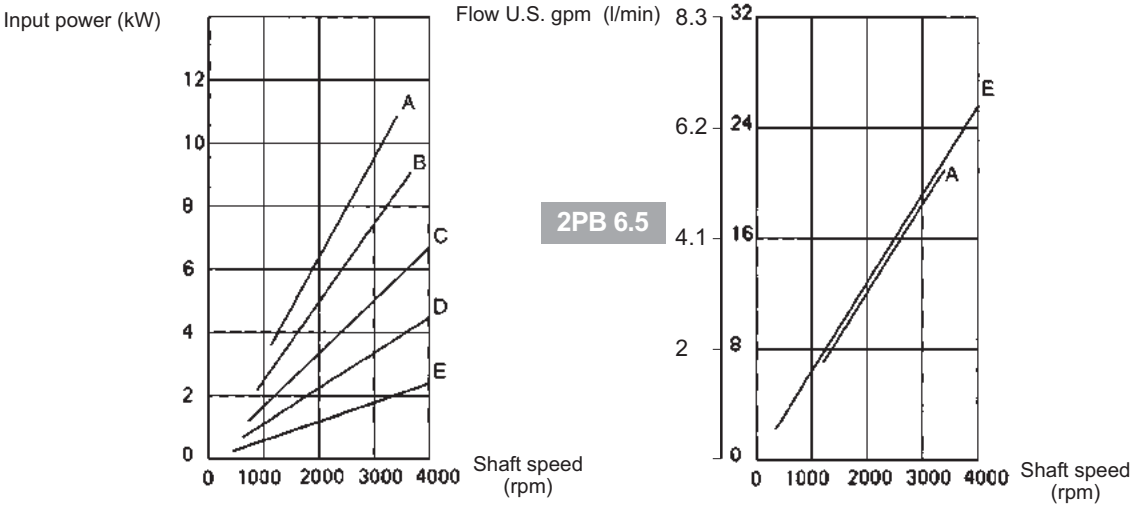
Performance curves carried out with oil viscosity at 16 cSt and oil temperature at 60°C

PUMP PERFORMANCE CURVES

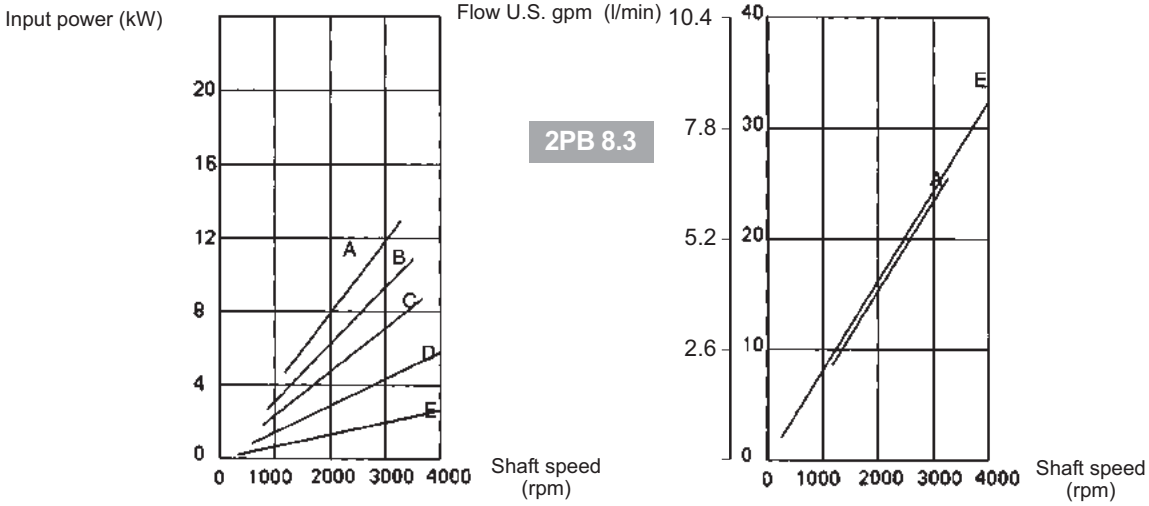
2PB 4.5



2PB 6.5

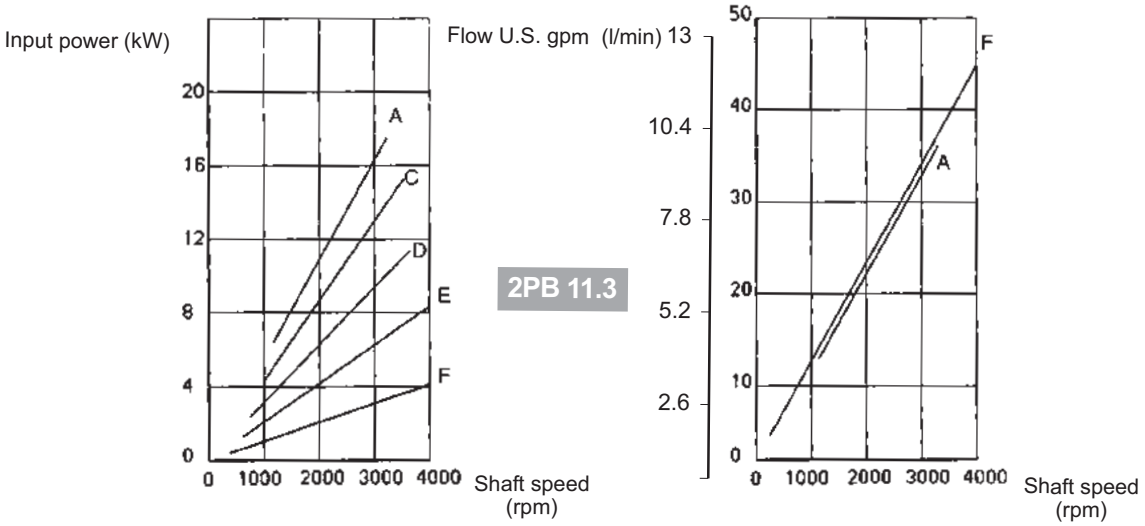


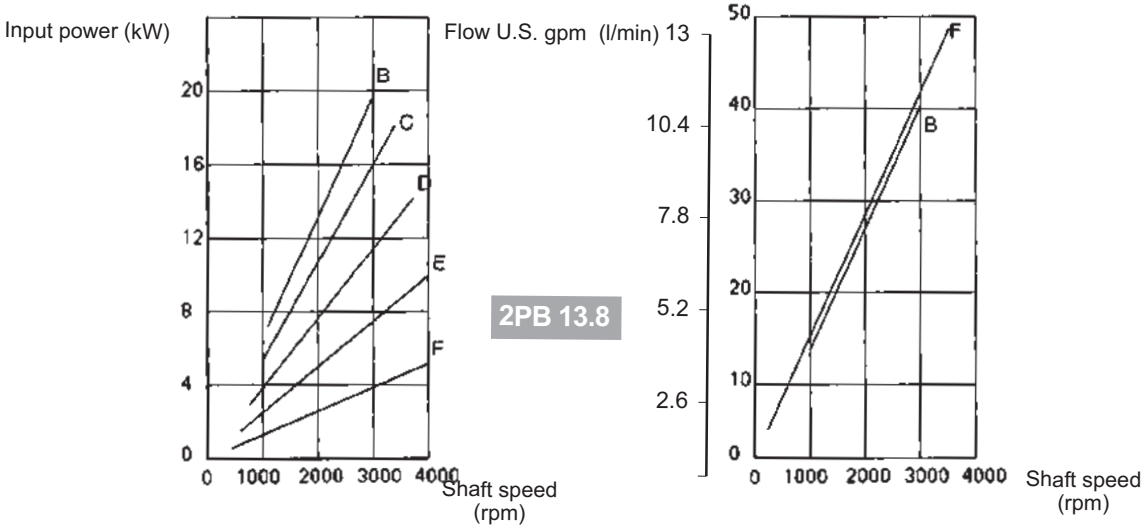
2PB 8.3

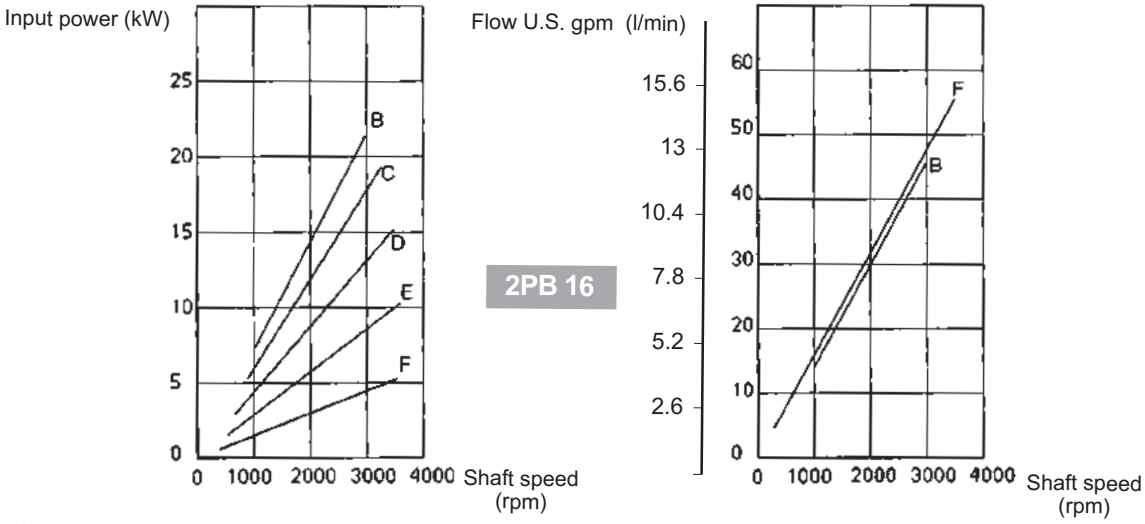


A=250 bar - *(3600 psi)*
B=200 bar - *(2900 psi)*
C=150 bar - *(2175 psi)*
D=100 bar - *(1450 psi)*
E= 50 bar - *(725 psi)*

Performance curves carried out with oil viscosity at 16 cSt and oil temperature at 60°C

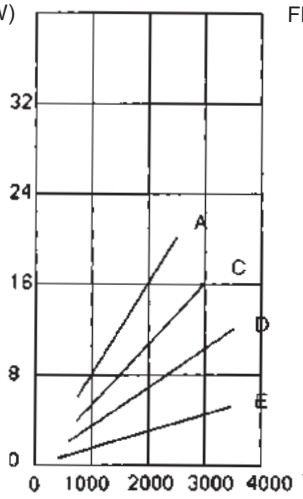






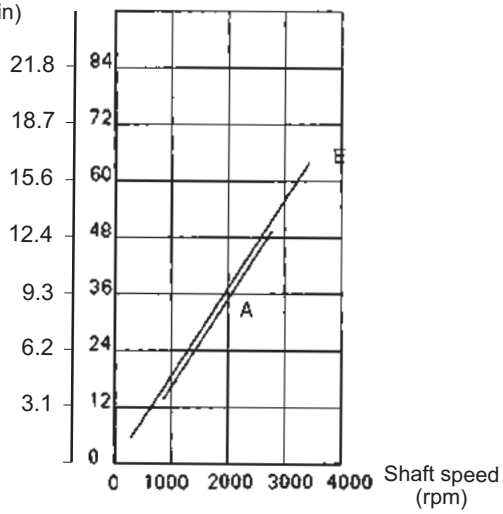
Performance curves carried out with oil viscosity at 16 cSt and oil temperature at 60°C

Input power (kW)

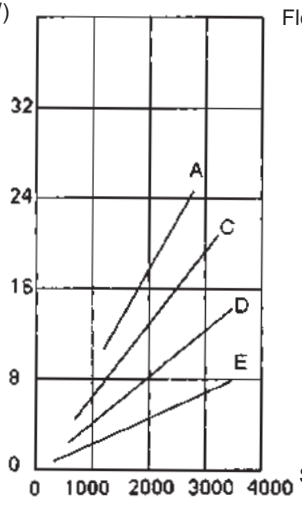


2PB 19

Flow U.S. gpm (l/min)

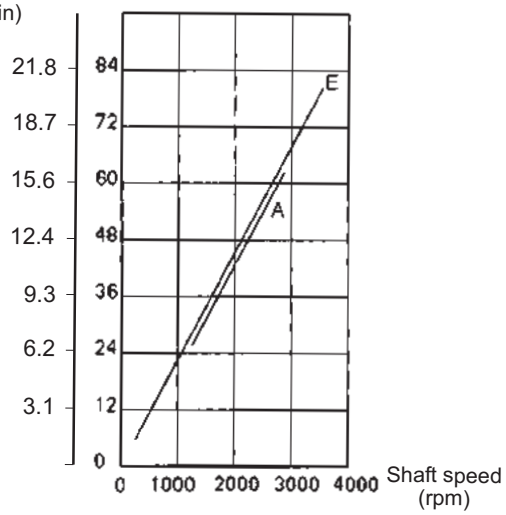


Input power (kW)

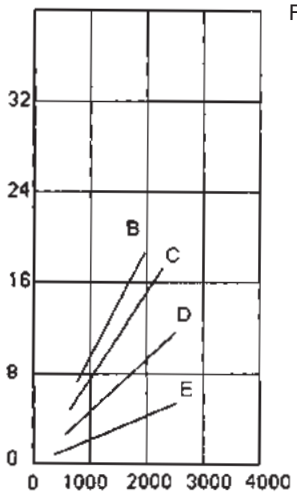


2PB 22.5

Flow U.S. gpm (l/min)

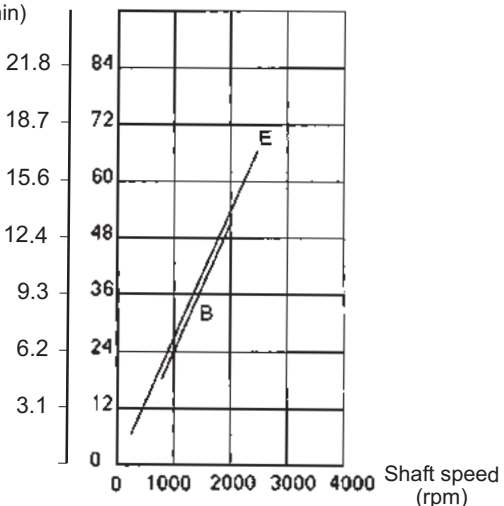


Input power (kW)

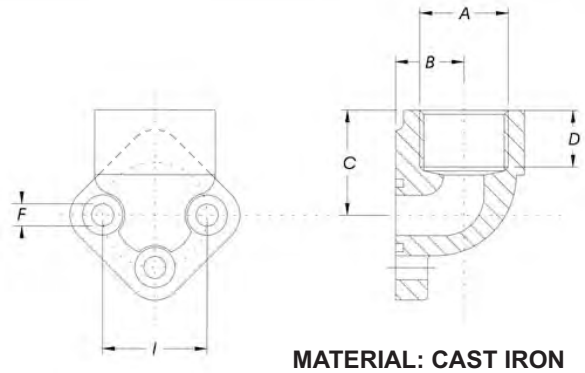


2PB 26

Flow U.S. gpm (l/min)

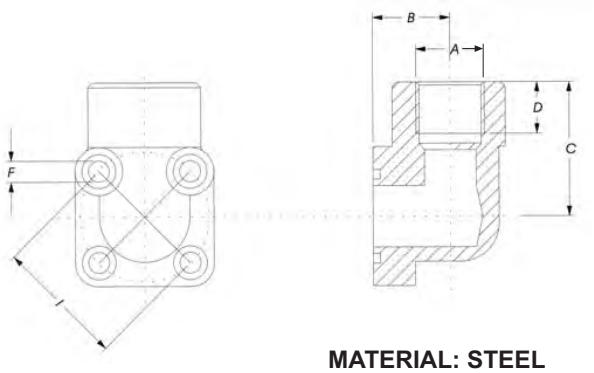


PORT CONNECTORS



MATERIAL: CAST IRON

Type G



MATERIAL: STEEL

Type GB

AVAILABLE CONNECTORS - DIMENSIONS AND CODE

Type	C	B	I	D	Ø F	Ø A	ORDERING CODE COMPLETE OF SCREW - SPRING WASHER - O RING
1 G/1	26	17.5	30	14	6.5	M18x1.5	4352 7004 0
1 G/2	26	17.5	30	14	6.5	G 3/8	4352 7005 0
1 G/3	26	17.5	30	14	6.5	G 1/2	4352 7006 0
2 G	36	21	40	16	8.5	G 3/4	4352 7011 0
1 GB/1	40	18	35	16	6.5	M18x1.5	4352 7008 1
1 GB/2	40	18	35	16	6.5	G 3/8	4352 7009 1
1 GB/3	40	18	35	16	6.5	G 1/2	4352 7010 1
2 GB	41.5	24	40	16	6.5	G 3/4	4352 7012 1

How to order 2PE

SINGLE PUMPS/MOTORS

2 P E 16 D – P 28 P1 – V 1 – CP – PD1 – VS ..../....

- 2 P E → DIMENSION
- 16 → SERIES
- D → ROTATION
- P 28 → DISPLACEMENTS
- P1 → MOUNTING FLANGES (pag. 10 - 11 - 12)
- V → SEAL
- 1 → PORTS POSITION
- CP → OUTRIGGER BEARINGS (pag. 13 - 14)
- PD1 → PD1 = pre-arranged for 1PE (pag. 17)
- VS → VALVES IN THE COVER
- .../.... → Adjusted flow l/min / Setting main relief valve (bar)

FUNCTION	CODE
Pump	P

TYPE	DISPLACEMENTS	
4.5	4.6 cm^3/rev.	*0,27 cu.in/rev.*
6.5	6.5 cm^3/rev.	*0,40 cu.in/rev.*
8.3	8.2 cm^3/rev.	*0,50 cu.in/rev.*
10.5	10.6 cm^3/rev.	*0.65 cu.in/rev.*
11.3	11.5 cm^3/rev.	*0,68 cu.in/rev.*
12.5	12.5 cm^3/rev.	*0.77 cu.in/rev.*
13.8	13.8 cm^3/rev.	*0,84 cu.in/rev.*
16	16.6 cm^3/rev.	*1.01 cu.in/rev.*
19	19.4 cm^3/rev.	*1.15 cu.in/rev.*
22.5	22.9 cm^3/rev.	*1.37 cu.in/rev.*
26	25.8 cm^3/rev.	*1.58 cu.in/rev.*

ROTATION	CODES
Clockwise	D
Anti-clockwise	S
Reversible	R

PORTS (pag. 8)	CODES
Flanged ports european standard	P
Flanged ports german standard	B
GAS threaded ports (BSPP)	G
SAE Threaded ports (ODT)	R

DRIVE SHAFTS (pag. 9 - 10)	CODES
Tang drive for engine driven	02
Tang drive for electric motors	03
Tang drive	04
Tapered 1:5	25
Tapered 1:5 (only for CB)	26
Tapered 1:8	28
SAE A splined 9 T	52
SAE A splined 11 T	54
SAE A splined 13 T	55
DIN 5482 splined shaft 9 T	62
SAE A parallel shaft Ø 15,87	82
SAE A parallel shaft Ø 19,05	85

*The assembling is the same of that of page 16.

VALVES IN THE COVER	CODES
Adjustable main relief valve (pag.16)	VS
Fixed setting main relief valve*	VSF
Like VS with external discharge (pag.16)	VSE
Like VSF with external discharge*	VSEF
Flow regulator with excess flow to tank(pag.17 - 18)	VR - VR1
Like VR with main relief valve (pag. 17 - 18)	VRS - VRS1
Priority flow divider with excess flow to 2 nd actuator(pag.19 - 20)	VP - VP1
Like VP with main relief valve(pag.19 - 20)	VPS - VPS1
Priority flow divider with Load-sensing(pag.21 - 22)	VPL - VPL1
Like VPL with dinamic signal(pag.21 - 22)	VPD - VPD1
Electric unloading valve (12 V) (pag.23)	EV1
Electric unloading valve (24 V) (pag.23)	EV2
Main relief and electric unloading valves (12V) (pag.23)	EVS1
Main relief and electric unloading valves (24 V) (pag.23)	EVS2

OUTRIGGER BEARINGS (pag. 13 - 14)	CODES
European standard	CP
German standard	CB
For engine endothermic motors	CL
For endothermic motors with axial and radial loads	CF
SAE A	CS

PORTS POSITION	CODE
Lateral ports standard	
Rear ports (pag. 15)	1

SEAL	CODE
Buna Standard	
Viton	V

MOUNTING FLANGES (pag. 10 - 11 - 12)	CODES
European standard	P1
German standard Ø 80	B1
German standard Ø 52	B2-B3
German standard Ø 50	B4-B5
SAE A 2 bolts	S2
SAE A 2 bolts (with O-ring on the centering collar)	S6
SAE B 2 bolts	S3
4 bolts for Iveco motor	C1
4 bolts for Perkins Motor	K1
2 threaded holes flange for Perkins motor	MF

Order example: Pump 2PE 19D, ports SAE (R), drive shaft (52), mounting flange (S2) with valve in the cover (VPS 12,5 l/min) and pressure relief valve setting 180 bar: 2PE 19D-R52 S2-VPS12,5/180

How to order 2PE

MULTIPLE PUMPS

2PE	16	/	16	13.8	D	–	P	28	P1	–	V	AS	1	–	CP	–	PD1	–	1PE.....

See corresponding single pump (1PE). Our catalogue code I0.38.1209.02.00

PD1 = pre-arranged for 1PE (pag. 17)

TYPE	DISPLACEMENTS	
3.2	3.2 cm^3/rev.	*0.19 cu.in/rev.*
3.9	3.9 cm^3/rev.	*0,24 cu.in/rev.*
4.5	4.6 cm^3/rev.	*0,27 cu.in/rev.*
6.5	6.5 cm^3/rev.	*0,40 cu.in/rev.*
8.3	8.2 cm^3/rev.	*0,50 cu.in/rev.*
10.5	10.6 cm^3/rev.	*0.65 cu.in/rev.*
11.3	11.5 cm^3/rev.	*0,68 cu.in/rev.*
12.5	12.7 cm^3/rev.	*0.77 cu.in/rev.*
13.8	13.8 cm^3/rev.	*0,84 cu.in/rev.*
16	16.6 cm^3/rev.	*1.01 cu.in/rev.*
19	19.4 cm^3/rev.	*1.15 cu.in/rev.*
22.5	22.9 cm^3/rev.	*1.37 cu.in/rev.*
26	25.8 cm^3/rev.	*1.58 cu.in/rev.*

OUTRIGGER BEARINGS (pag. 15 - 16)	CODES
European standard	CP
German standard	CB
For engine endothermic motors	CL
For endothermic motors with axial and radial loads	CF
SAE A	CS

ROTATION	CODES
Clockwise	D
Anti-clockwise	S

PORTS POSITION	CODES
Lateral ports standard	
Rear ports (pag.16)	1

PORTS (pag. 9)	CODES
Flanged ports european standard	P
Flanged ports german standard	B
GAS threaded ports (BSPP)	G
SAE Threaded ports (ODT)	R

SUCTION TYPES	CODES
Common suction (pag. 25)	UA*
Separated stages (pag. 26)	AS

SEAL	CODE
Buna Standard	
Viton	V

DRIVE SHAFTS (pag. 10 - 11)	CODES
Tang drive for engine driven	02
Tang drive for electric motors	03
Tang drive	04
Tapered 1:5	25
Tapered 1:5 (only for CB)	26
Tapered 1:8	28
SAE A splined 9 T	52
SAE A splined 11 T	54
SAE A splined 13 T	55
DIN 5482 splined shaft 9 T	62
SAE A parallel shaft Ø 15,87	82
SAE A parallel shaft Ø 19,05	85

MOUNTING FLANGES (pag. 11 - 12 - 13)	CODES
European standard	P1
German standard Ø 80	B1
German standard Ø 52	B2-B3
German standard Ø 50	B4-B5
SAE A 2 bolts	S2
SAE A 2 bolts (with O-ring on the centering collar)	S6
SAE B 2 bolts	S3
4 bolts for Iveco motor	C1
4 bolts for Perkins Motor	K1
2 threaded holes flange for Perkins motor	MF

Available only as rear pump

*UA: this type of multiple pump is a Salami standard multiple pump which has only one inlet port opened, all the other inlet port are closed.
In case of common suction, the code 1 - 2 or 3, correspond to the body where inlet is located.

Example to order a tandem pump with common suction: 2PE 16/6.2D - B25 B2 - UA1

Example to order a triple pump with main relief in the rear pump: 2PE 13.8/8.3/4.5D - P28 P0 - VS175

WARRANTY

- We warrant products sold by us to be free from defects in material and workmanship.

- Our sole obligation to buyer under this warranty is the repair or replacement, at our option, of any products or parts thereof which, under normal use and proper maintenance, have proven defective in material or workmanship, this warranty does not cover ordinary wear and tear, abuse, misuse, averloading, alteration.

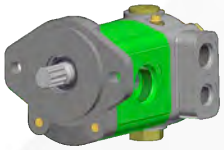
- No claims under this warranty will be valid unless buyer notifies SALAMI in writing within a reasonable time of the buyer's discovery of such defects,but in no event later than twelve (12) mounths from date of shipment to buyer.

- Our obligation under this warranty shall not include any transportation charges or cost of installation, replacement, field repair, or other charges related to returning products to us; or any liability for directs, indirects or consequential damage or delay.If requested by us, products or parts for which a warranty claim is made are to be returned transportation prepaid to our factory. The risk of loss of any products or parts thereof returned to SALAMI will be on buyer.

- No employee or representative is authorized to change any warranty in any way or grant any other warranty unless such change is made in writing and signed by an officer of SALAMI.

GEAR PUMPS “E” SERIES - GROUP 2

Technical catalogue



SALAMI spa
via Emilia Ovest 1006
41100 Modena Italy
telefono +39-059-387411
telefax +39-059-387500
export@salami.it - www.salami.it

SALAMI ITALIA srl
strada Pelosa 183
S. Pietro in Trigogna VI Italy
telefono +39-0444-240260
telefax +39-0444-240264
salami.italia@salami.it

SALAMI ESPAÑA
Polígono Industrial Armenteres
C/Primer de Maig, 18 Nave 4
08980 San Feliu de Llobregat
Barcelona
telefono +34-93-6327258
telefax +34-93-6667526
info@salamispain.com

SALAMI FRANCE
22, rue Louis Saillant
69120 Vaulx en Velin
Lyon
telefono +33-04-78809941
telefax +33-04-78803959
e.pasian@wanadoo.fr

SALAMI HYDRAULICS N.A INC
Loop Road
Baldwinsville
NY 13027 - USA
Tel. +1-315-295-2360
Fax. +1-315-295-2364
info@salamihydraulics.com

E0.23.0609.02.00

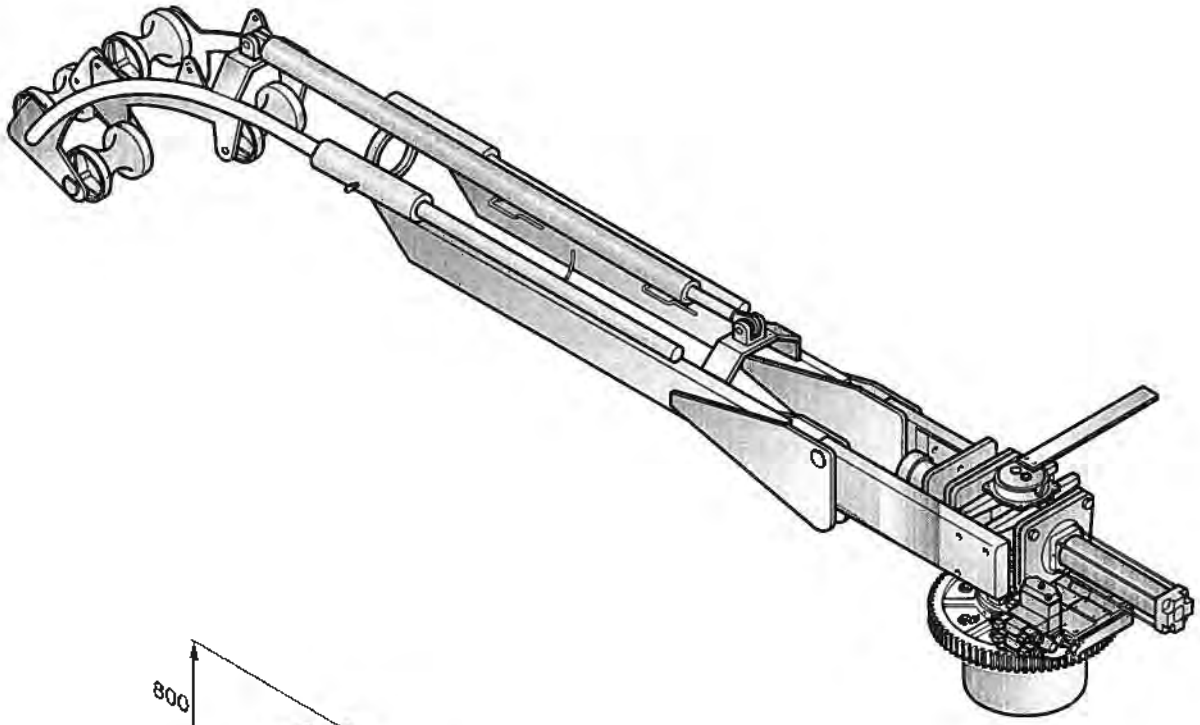
COMPANY
WITH QUALITY SYSTEM
CERTIFIED BY DNV
=ISO 9001/2000=

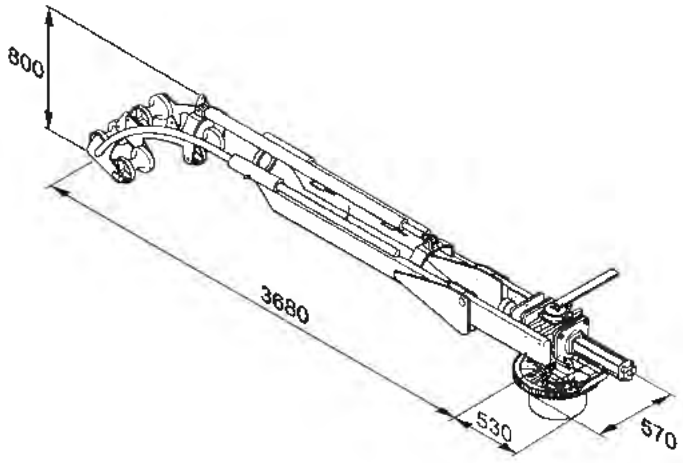
Proboscide idraulica con otturatore DN 100/125/150
Hydraulic suction boom with shutoff valve DN 100/125/150
Saugausleger hydraulikbetStigt mit Klappventil DN 100/125/150
Bras tournant hydraulique avec clapet DN 100/125/150

Pompe per vuoto e travaso
Atrezzature per rifiuti liquidi e polveri
Waste handling equipments
Vacuum and liquid transfer pumps

	Cod. 12V	Cod. 24V
DN 100	13600-007.00	13600-003.00
DN 125	13600-008.00	13600-004.00
DN 150	13600-009.00	13600-005.00

Peso - Weight - Gewicht - Poids Kg.500



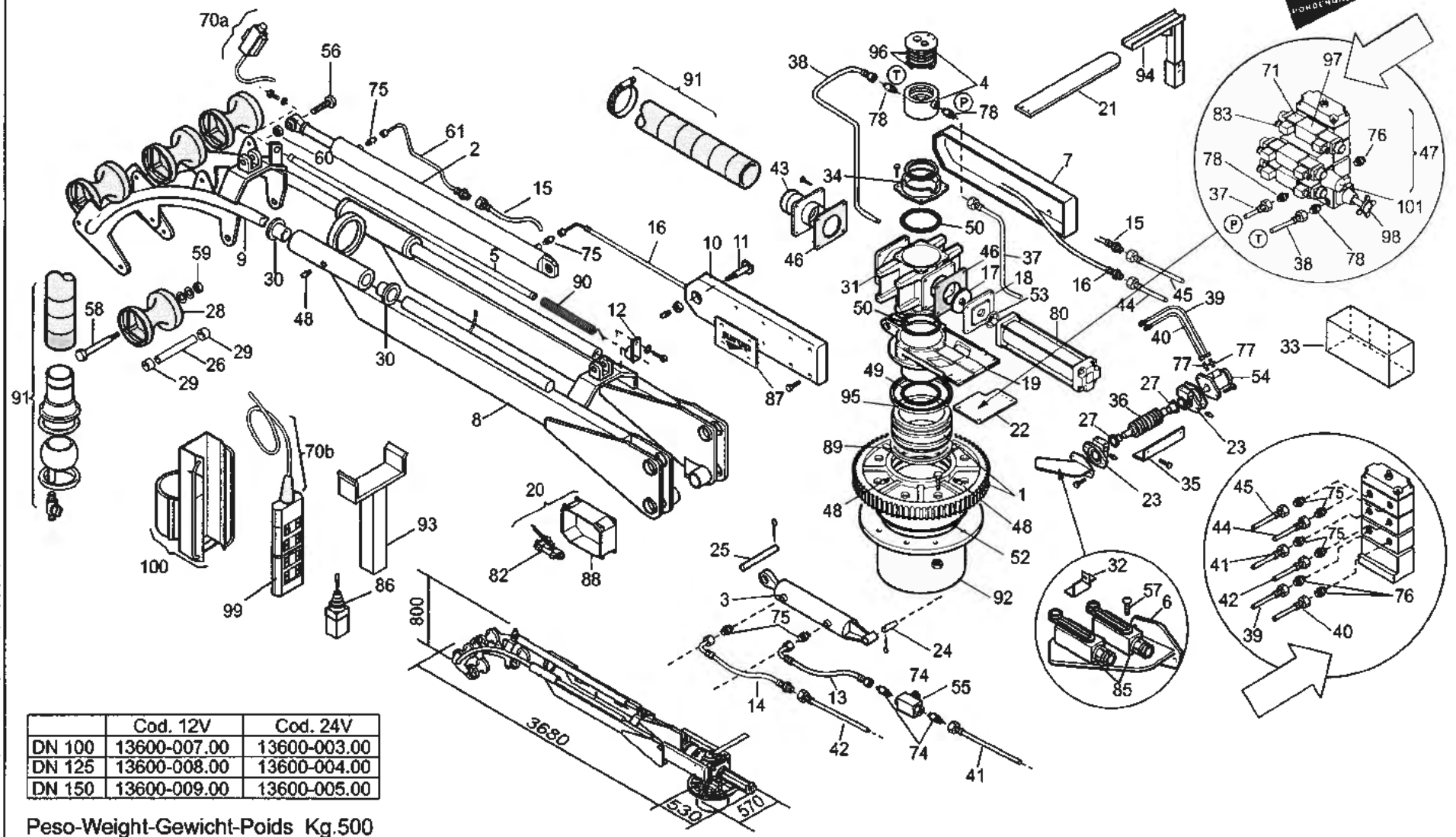


JUROP S.p.A. - Via Crosera n¡ 50 - 33082 AZZANO X PN - ITALY Tel . ++39/0434/636811 -Fax: ++39/0434/636812 -e-mail: info@jurop.it - www.jurop.it

Proboscide idraulica con otturatore DN 100/125/150
Hydraulic suction boom with shutoff valve DN 100/125/150
Saugausleger hydraulikbetStigt mit Klappventil DN 100/125/150
Bras tournant hydraulique avec clapet DN 100/125/150

Pompe per vuoto e travaso
Atrezzature per rifiuti liquidi e polveri
Waste handling equipments
Vacuum and liquid transfer pumps

jurop



	Cod. 12V	Cod. 24V
DN 100	13600-007.00	13600-003.00
DN 125	13600-008.00	13600-004.00
DN 150	13600-009.00	13600-005.00

Peso-Weight-Gewicht-Poids Kg.500

17820_028_00 - EDIZIONE 01/2004

Proboscide idraulica con otturatore DN 100/125/150
Hydraulic suction boom with shutoff valve DN 100/125/150
Saugausleger hydraulikbetStigt mit Klappventil DN 100/125/150
Bras tournant hydraulique avec clapet DN 100/125/150

Pompe per vuoto e travaso
Atrezzature per rifiuti liquidi e polveri
Waste handling equipments
Vacuum and liquid transfer pumps

jurop
POHDENONE

Pos.	Quantità Q.ty Menge Quant.	Codice Part. n° Code Kodex	Denominazione	Denomination	Bezeichnung	Nomenclature
1	1	14102_011_00	Ralla completa	Center plate	Drehkranz	Crapaudine
2	1	14302_003_00	Cilindro estensione	Extension cylinder	Erstreckungszylinder	Cylindre extension
3	1	14302_022_00	Cilindro sollevamento	Lifting cylinder	Aufhebzylinder	Cylindre levage
4	1	14840_000_10	Raccordo girevole	Hose fitting	Anschluß	Raccord
5	1	15130_177_00	Supp. cavo a spirale	Spiral cable support	Spiralkabel-Stütze	Support câble spiral
6	1	15130_178_00	Supporto fine corsa	Limit switch support	Endschalter-Stütze	Support fin de course
7	1	15130_033_00	Braccio fisso dx.	Right hand arm supp.	Rechter Arm	Bras droit
8	1	15150_034_00	Secondo braccio	Main arm	Arm	Bras
9	1	15150_035_00	Braccio telescopico	Telescopic arm	Teleskoparm	Bras télescopique
10	1	15150_037_00	Braccio fisso sx.	Left hand arm supp.	Linker Arm	Bras gauche
11	2	15220_014_00	Perno	Pin	Linker Arm-Bolzen	Pivot
12	1	15230_007_00	Distanziale	Spacer	Abstandstück	Entretoise
13	*1*	*15636_048_00*	*Tubo flessibile*	*Hose*	*Schlauch*	*Tuyau*
14	*1*	*15636_049_00*	*Tubo flessibile*	*Hose*	*Schlauch*	*Tuyau*
15	*1*	*15636_050_00*	*Tubo flessibile*	*Hose*	*Schlauch*	*Tuyau*
16	*1*	*15636_051_00*	*Tubo flessibile*	*Hose*	*Schlauch*	*Tuyau*
17	1	15930_001_00	Valvola a piattello	Shutoff plate	Klappventil	Clapet
18	1	16105_078_00	Flangia convogliatore	Shutoff flange	Drehkranzturmflansch	Flasque tourelle bis.
19	1	16125_023_00	Piastra ralla	Slewing ring. plate	Drehkranzplatte	Pl. biseau tournant
20	1	14066_010_00	Scatola elettrov. 12V	Electrovalve housing 12V	Elektroventile Gehäuse 12V	Electrovalve Boîte 12V
20	1	14066_011_00	Scatola elettrov. 24V	Electrovalve housing 24V	Elektroventile Gehäuse 24V	Electrovalve Boîte 24V
21	1	16130_106_00	Supporto	Support	Träger	Support
22	1	16130_114_00	Supp. elettrovalvole	Wiring support	Elektroventile-Stütze	Support E-vannes
23	2	16135_011_00	Supporto vite	Screw support	Schraubestuetze	Support vis
24	1	16220_070_00	Perno	Lift cyc.support	Aufhebezylinderbolzen	Pivot
25	1	16220_071_00	Perno	Lift cyc. supportline	Aufhebezylinderbolzen	Pivot
26	6	16240_169_00	Tubo distanziale	Spacer	Armbolzen	Tube entretoise
27	2	16242_014_00	Boccola	Bushing	Huelse	Douille
28	6	16246_009_00	Rullo	Roller	Walze	Roleau
29	12	16246_010_00	Boccola	Bushing	Huelse	Douille
30	4	16246_011_00	Boccola	Bushing	Huelse	Douille
31	1	16275_040_00	Convogliatore	Conveyor	Drehkranzturm	Tour. biseau tournant
32	2	16360_003_00	Fermo finecorsa	Stopper	Endschalter-Sperrung	Arrêt fin de course
33	1	16400_010_00	Scatola protezione	Protection box	Schultzgehäube	Boîte de protection
34	1	16405_005_00	Cop. giunto girevole	Revolv. joint lid	Drehgelenkdeckel	Couv. joint tournant
35	1	16420_031_00	Protezione	Protection	Endlose Schraubeschutz	Protecteur
36	1	16510_044_00	Vite senza fine	Endless screw	Endlose Schraube	Vis sans fin
37	*1*	*15630_170_00*	*Tubo per girevole*	*Revolving pipe*	*Ölrohr*	*Touyou*
38	*1*	*15630_171_00*	*Tubo per girevole*	*Revolving pipe*	*Ölrohr*	*Touyou*
39	*1*	*15630_172_00*	*Tubo per rotazione*	*Rotation pipe*	*Ölrohr*	*Touyou*
40	*1*	*15630_173_00*	*Tubo per rotazione*	*Rotation pipe*	*Ölrohr*	*Touyou*
41	*1*	*15630_174_00*	*Tubo per alzata*	*Lifting pipe*	*Ölrohr*	*Touyou*
42	*1*	*15630_175_00*	*Tubo per alzata*	*Lifting pipe*	*Ölrohr*	*Touyou*
43	1	16735_000_00	Portagomma d=100	Hose fitting	Schlauchanschluß	Manchon
43	1	16735_001_00	Portagomma d=120	Hose fitting	Schlauchanschluß	Manchon
43	1	16735_002_00	Portagomma d=150	Hose fitting	Schlauchanschluß	Manchon
44	*1*	*15630_176_00*	*Tubo*	*pipe*	*Ölrohr*	*Touyou*
45	*1*	*15630_177_00*	*Tubo*	*pipe*	*Ölrohr*	*Touyou*
46	1	16806_076_00	Guarnizione	Gasket	Dichtung	Joint
47	1	18830_001_00	Gruppo elettrov. 12V	Valve group	Elektroventileblock	Groupe E-vannes
47	1	18830_000_00	Gruppo elettrov. 24V	Valve group	Elektroventileblock	Groupe E-vannes
48	4	4022_1000_10	Ingrassatore	Greaser	Fettbuechse	Graisseur
49	1	4022_2002_51	Anello or	O-ring	Rundschnurring	Joint torique
50	2	4022_2002_88	Anello or	O-ring	Rundschnurring	Joint torique
52	1	4022_2002_90	Anello or	O-ring	Rundschnurring	Joint torique
53	1	4022_2002_96	Anello or	O-ring	Rundschnurring	Joint torique
54	1	4024_1080_02	Motore idraulico	Hydraulic motor	Hydromotor	Moteur hydraulique
55	1	4024_4140_00	Regolat. flusso discesa	Down stroke adjustor	Olmengeregler Abl.	Rég. débit descente
56	2	4026_1018_20	Vite	Screw	Schraube	Vis

Proboscide idraulica con otturatore DN 100/125/150
Hydraulic suction boom with shutoff valve DN 100/125/150
Saugausleger hydraulikbetStigt mit Klappventil DN 100/125/150
Bras tournant hydraulique avec clapet DN 100/125/150

Pompe per vuoto e travaso
Atrezzature per rifiuti liquidi e polveri
Waste handling equipments
Vacuum and liquid transfer pumps

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Pos.	Quantità Q.ty Menge Quant.	Codice Part. n° Code Kodex	Denominazione	Denomination	Bezeichnung	Nomenclature
57	4	4026_1201_10	Vite	Screw	Schraube	Vis
58	6	4026_1415_27	Vite	Screw	Schraube	Vis
59	6	4026_3055_07	Dado	Nut	Mutter	Ecrou
60	2	4026_3055_14	Dado	Nut	Mutter	Ecrou
61	*1*	*15630_178_00*	*Tubo per telescopico*	*Telescopic pipe*	*Ölrohr*	*Tuyau*
66	4	4026_7027_01	Rondella	Washer	Federscheibe	Rondelle
67	4	4026_7027_02	Rondella	Washer	Federscheibe	Rondelle
68	2	4026_7027_03	Rondella	Washer	Federscheibe	Rondelle
69	3	4026_7050_16	Raccordo	Connection	Anschluss	Raccord
70a	1	14066_023_00	Gruppo connettore 16 poli	16 pin connector group	16 P. Verbinder	16P. Connecteur
70b	6 mt	4028_5210_10	Cavo multiplo	Multiple cable	Kabel	Câble multiple
71	6	4024_3100_03	Bobina 12V	12V coil	Spannungsspule 12V	Bobine 12V
71	6	4024_3100_01	Bobina 24V	24V coil	Spannungsspule 24V	Bobine 24V
73	8	4026_7088_00	Boccola	Bushing	Buchse	Douille
74	2	4026_7406_03	Nipplo	Nipple	Nippel	Nipple
75	8	4026_7406_06	Nipplo	Nipple	Nippel	Nipple
76	2	4026_7406_07	Nipplo	Nipple	Nippel	Nipple
77	4	4026_7406_09	Nipplo	Nipple	Nippel	Nipple
78	4	4026_7406_11	Nipplo	Nipple	Nippel	Nipple
79	1	4026_9050_02	Tappo	Plug	Deckel	Bouchon
80	1	4027_1072_04	Martinetto pneumatico	Shut-off cylinder	Verin pneum.	Luftcylinder
81	2	4027_4208_02	Raccordo	Connection	Anschluss	Raccord
82	1	4027_4268_05	Elettrovalv. 12V pneum.	Electrov. 12V pneum.	Elektrov. 12V pneum.	Electrov. 12V pneum.
82	1	4027_4268_06	Elettrovalv. 24V pneum.	Electrov. 24V pneum.	Elektrov. 24V pneum.	Electrov. 24V pneum.
83	2	4027_4269_16	Connettore elettrov.	Electrovalve conn.	E-ventil-Steckvorrichtung	Connecteur elec.
84	2	4027_4269_20	Raccordo	Connection	Anschluss	Raccord
85	2	4028_2800_10	Fine corsa	End of rot. switch	Endschalter	Fin de course
86	2	4028_3115_01	Manipolatore 4 pos.	4 way switch	Steuerpult	Manipolaetur
87	1	16091_004_00	Targa JUROP	JUROP plate	JUROP schild	Plaque JUROP
88	1	16121_014_00	Scatola per elettrovalv.	Electrovalve box	E-ventile Gehäuse	Boîte pour E-vannes
89	1	4022_2034_09	Paraolio 261x273x8	Lipseal	Joint à levres	Dichtungsring
90	1	14066_000_00	Cavo spir. 13 cavi (std)	13 wire cable	Spiralkabel - 13 kabel	Cable - 13
90	1	14066_001_00	Cavo spir. 15 cavi (optz)	15 wire cable	Spiralkabel - 15 kabel	Cable - 15
91	1	14600_002_00	Tubo asp. d=100(optx) 6m	Suction pipe d=100 6m	Saugschlach 100mm	Tuyau aspirat d=100
91	1	14600_003_00	Tubo asp. d=120(optx) 6m	Suction pipe d=120 6m	Saugschlach 120mm	Tuyau aspirat d=120
91	1	14600_004_00	Tubo asp. d=150(optx) 6m	Suction pipe d=150 6m	Saugschlach 150mm	Tuyau aspirat d=150
92	1	15100_004_00	Pozz. d=330 inox(opt)	Mainway d=330 S/S	Trägstück Rostfr. Stahl	Dôme inox
92	1	15100_005_00	Pozzetto d=330 fe (std)	Manway d=330 M/S	Trägstück Stahl	Dôme acier
93	1	15130_183_00	Supp. braccio fe. (opt)	Resting sup. M/S	Armstütze-Stahl	Support
93	1	15130_184_00	Supp. braccio inox (op)	Resting sup. S/S	Armstütze-Rostfr. St.	Support
94	1	18130_003_00	Supp. tubi idr. fe (optz)	Pipeline sup. M/S	Schlauchstütze Stahl	Support
94	1	18130_004_00	Supp. tubi idr. inox(opt)	Pipeline sup. S/S	Schlauchstütze Rostfr. St.	Support
95	1	4022_2000_90	Paraolio d=250x280x15	Lip seal	Dichtungsring	Joint à levres
96	3	4022_2002_87	Anello or	O-ring	Rundschnurring	Joint torique
97	3	4024_3100_00	Elettrovalv. idr.	Electrov. hydr.	Elektrov. hydr.	Electrov. Hydr.
98	1	4024_3110_01	Reg. flusso idr. gr. valv.	Oil flow regulator	Oilmengetegler	Reg. débit
99	1	4028_6300_00	Pulsant. 8 puls. (std)	8 buttons pending pan	Schaltflasche 8T.	Tableau comm. 8
99	1	4028_6300_01	Pulsant. 10 puls. (optz)	10 buttons pending pan	Schaltflasche 10T	Tableau comm. 10
99	1	4028_6300_02	Pulsant. 12 puls. (optz)	12 buttons pending pan	Schaltflasche 12T	Tableau comm. 12
100	1	14100_003_00	Supp. puls. d=100	Panel supp. d=100	Schaltflasche tröper	Support
100	1	14100_004_00	Supp. puls. d=120/150	Panel supp. d=120/150	Schaltflasche tröper	Support
101	1	4024_3101_00	Reg. flusso idr. gr. valv.	Oil flow regulator	Oilmengeregles	Reg. debit
102	1	17203_005_00	Schema collegamento	Wiring diagram	Gen. Anschlussplan	Schéma conn.
		18820_104_00	**Kit probosc. tubi sagom.+flex**	**Suct. boom pipes kit**	**Saugausleger Ölrohr+ Schlauch kit**	**Bras tournant tuyau kit**

PROBOSCIDE IDRAULICA

Proboscide idraulica DN 100-125-150
Pressione max. 4 bar.

	Cod. 12V	Cod. 24V
DN 100	13600-007.00	13600-003.00
DN 125	13600-008.00	13600-004.00
DN 150	13600-009.00	13600-005.00

Specifica tecnica
Proboscide telescopica a rotazione idraulica con:
Vite senza fine/corona dentata.
Rotazione massima: 300°.
Estensione telescopica: +1350 mm.
Costituita da:

- Ralla con n°2 corone di sfere (pos.1)
- Supporto del braccio zincato a caldo.
- Braccio telescopico zincato a caldo, con n° 6 rulli per guida tubo aspirazione.
- Valvola idraulica di sovrapressione per discesa braccio (tarata a 10 bar) (pos.55).
- Regolatore di flusso per velocità rotazione (pos.98).
- Valvola di max. pressione discesa braccio (pos.101).
- Fine corsa rotazione dx/sx (n°2) (pos.85).
- N°3 elettrovalvole a 24 Volt (pos.97) per: allungamento, sollevamento, rotazione.
- Elettrovalvola comando attuatore pneumatico per valvola otturatore (max press. 8 bar-esercizio 6 bar) (pos.82).
- Martinetto pneumatico (pos.80).
- Cilindro sollevamento (pos.3).
- Cilindro estensione (pos.2).
- Motore idraulico per rotazione (100 cc/giro) (pos.54).
- Pulsantiera ad 8 pulsanti, completa di 5 mt. di cavo e presa già predisposta per 12 funzioni (pos.99).
- Pozzetto a saldare su cisterna, diametro esterno 330 mm., realizzato in acciaio al carbonio (FE) (pos.92).
- N° 2 manipolatori a 4 funzioni per rinvio su pannello fisso delle funzioni proboscide (pos.86).

Il tutto è montato con valvole già complete di collegamenti pneumatici ed idraulici, e i cablaggi elettrici riportati alla scatola di derivazionme con morsettiera.

HYDRAULIC SUCTION BOOM

Hydraulic suction boom DN 100-125-150
Max. operation pressure 4 bar.

	Cod. 12V	Cod. 24V
DN 100	13600-007.00	13600-003.00
DN 125	13600-008.00	13600-004.00
DN 150	13600-009.00	13600-005.00

Technical specifications
Hydraulic suction boom telescopic extention
Rotation: 300°.
Extension: +1350 mm

Swivel with 2 ball bearing crowns (pos.1)
Galvanized structure -N° 6 suction hose guiding rollers
Max descent pressure valve 10 bars (pos.55)
Rotation speed adjusting valves (CW+CCW) (pos.98)
Max pressure regulating oil valve (max 150 bar) operating 90 bar (pos.101)
End of rotation switvhes (N°2) (pos.85)
N° 3 electrovalves -24V -up/down -in/out-rotation CW/CCW (pos.97)
N° 1 electrovalve for shutoff valve
Shutoff valve with actuator (max. air press 8 bar/med. 6 bar) (pos.82)
Pneumatic cylinder (pos.80)
Lifting cylinder (pos.3).
Extending cylinder (hydraulic) (pos.2).
Hydraulic motor for rotation (displacement 100 cm3/rev) (pos.54)
Pending panel /8 push buttons 5m. cable-suitable also for 12 push buttons (pos.99).
Dia 330 mm mild steel welding collar (pos.92).
N° 2 joysticks with 4 position for doubling pending panel functions on the main control panel (pos.86).
Completely cabled with electric pneumatic wiring.

Proboscide idraulica con otturatore DN 100/125/150
Hydraulic suction boom with shutoff valve DN 100/125/150
Saugausleger hydraulikbetStigt mit Klappventil DN 100/125/150
Bras tournant hydraulique avec clapet DN 100/125/150

Pompe per vuoto e travaso
Atrezzature per rifiuti liquidi e polveri
Waste handling equipments
Vacuum and liquid transfer pumps

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PORDENONE

Dati operativi
Operating data
Betriebsangaben
Donees de fonctionnement

PRESSIONE OLIO: OIL PRESSURE: ÖLDRUCK: PRESSION - HUILE:	max / di servizio max / operating max / Betriebsdruck max / pression de fonction	150bar/ 70~100bar
PORTATA OLIO: OIL FLOW RATE: ÖLLEISTUNG: DEBIT D'HUILE:	max / di servizio max / operating max / Betriebsölleistung max / pression air en fonction	36 Lt/min/ 15~20 Lt/min
PRESS. ARIA: AIR PRESSURE: LUFT DRUCK: PRESSION:	max / di servizio max / operating max / Betriebsluftdruck max / pression air en fonction	8bar/ 6bar
TENSIONE ELETTRICA: VOLTAGE: E-STROM: TENSION-ELT:	24 Volt	

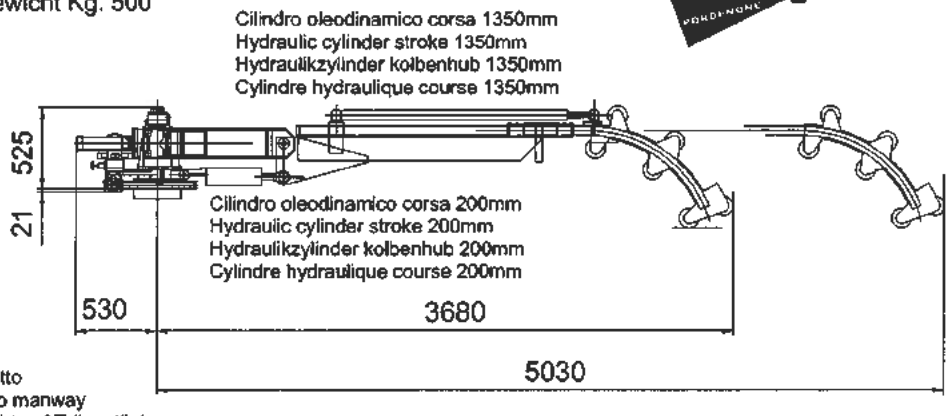
OPTIONAL: vedi tabella
OPTIONAL: see table
OPTIONAL: voir tab.
OPTIONAL: siehe Tab.

Pos.	Quantità Q.ty Menge Quant.	Codice Part.n° Code Kodex	Denominazione	Denomination	Bezeichnung	Nomenclature
90	1	14066_000_00	Cavo spir. 13 cavi (std)	13 wire cable	Spiralkabel - 13 kabel	Cable - 13
90	1	14066_001_00	Cavo spir. 15 cavi (optz)	15 wire cable	Spiralkabel - 15 kabel	Cable - 15
91	1	14600_002_00	Tubo asp. d=100(optx) 6m	Suction pipe d=100 6m	Saugschlach 100mm	Tuyau aspirat d=100
91	1	14600_003_00	Tubo asp. d=120(optx) 6m	Suction pipe d=120 6m	Saugschlach 120mm	Tuyau aspirat d=120
91	1	14600_004_00	Tubo asp. d=150(optx) 6m	Suction pipe d=150 6m	Saugschlach 150mm	Tuyau aspirat d=150
92	1	15100_004_00	Pozz. d=330 inox(opt)	Mainway d=330 S/S	Trägstück Rostfr. Stahl	Dôme inox
92	1	15100_005_00	Pozzetto d=330 fe (std)	Manway d=330 M/S	Trägstück Stahl	Dôme acier
93	1	15130_183_00	Supp. braccio fe. (opt)	Resting sup. M/S	Armstütze-Stahl	Support
93	1	15130_184_00	Supp. braccio inox (op)	Resting sup. S/S	Armstütze-Rostfr. St.	Support
94	1	18130_003_00	Supp. tubi idr. fe (optz)	Pipeline sup. M/S	Schlauchstütze Stahl	Support
94	1	18130_004_00	Supp. tubi idr. inox(opt)	Pipeline sup. S/S	Schlauchstütze Rostfr. St.	Support
95	1	4022_2000_90	Paraolio d=250x280x15	Lip seal	Dichtungsring	Joint à levres
96	3	4022_2002_87	Anello or	O-ring	Rundschnurring	Joint torique
97	3	4024_3100_00	Elettrovalv. idr.	Electrov. hydr.	Elektrov. hydr.	Electrov. Hydr.
98	1	4024_3101_01	Reg. flusso idr. gr. valv.	Oil flow regulator	Oilmengetegler	Reg. débit
99	1	4028_6300_00	Pulsant. 8 puls. (std)	8 buttons pending pan	Schaltflasche 8T.	Tableau comm. 8
99	1	4028_6300_01	Pulsant. 10 puls. (optz)	10 buttons pending pan	Schaltflasche 10T	Tableau comm. 10
99	1	4028_6300_02	Pulsant. 12 puls. (optz)	12 buttons pending pan	Schaltflasche 12T	Tableau comm. 12
100	1	14100_003_00	Supp. puls. d=100	Panel supp. d=100	Schaltflasche tröper	Support
100	1	14100_004_00	Supp. puls. d=120/150	Panel supp. d=120/150	Schaltflasche tröper	Support

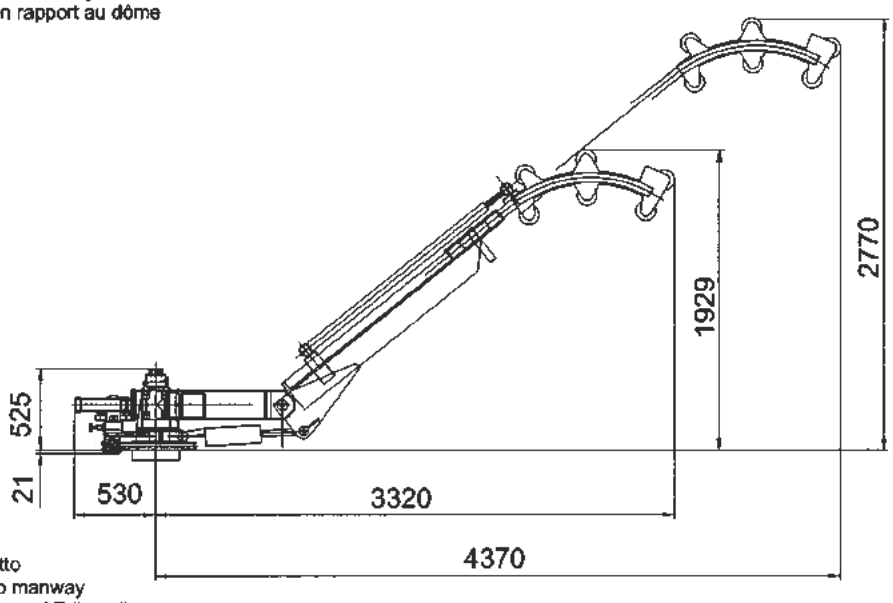
Proboscide idraulica con otturatore DN 100/125/150
Hydraulic suction boom with shutoff valve DN 100/125/150
Saugausleger hydraulikbetStigt mit Klappventil DN 100/125/150
Bras tournant hydraulique avec clapet DN 100/125/150

Pompe per vuoto e travaso
Atrezzature per rifiuti liquidi e polveri
Waste handling equipments
Vacuum and liquid transfer pumps

Peso-weight-Poids-Gewicht Kg. 500



Ingombri rispetto il pozzetto
Dimensions with regard to manway
Aussenmass mit Rücksicht auf Trägsstück
Côtes d'encombrement en rapport au dôme



Ingombri rispetto il pozzetto
Dimensions with regard to manway
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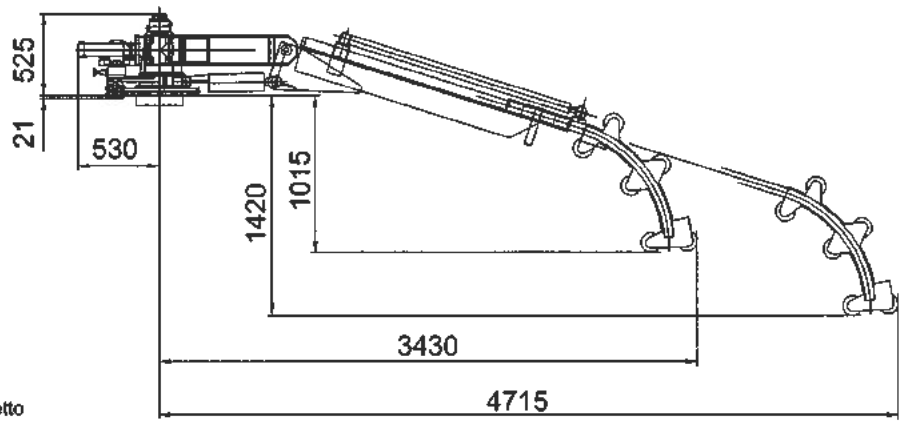
Côtes d'encombrement en rapport au dôme



Ingombri rispetto il pozzetto
Dimensions with regard to manway
Aussenmass mit Rücksicht auf Trägsstück
Côtes d'encombrement en rapport au dôme

Proboscide idraulica con otturatore DN 100/125/150
Hydraulic suction boom with shutoff valve DN 100/125/150
Saugausleger hydraulikbetStigt mit Klappventil DN 100/125/150
Bras tournant hydraulique avec clapet DN 100/125/150

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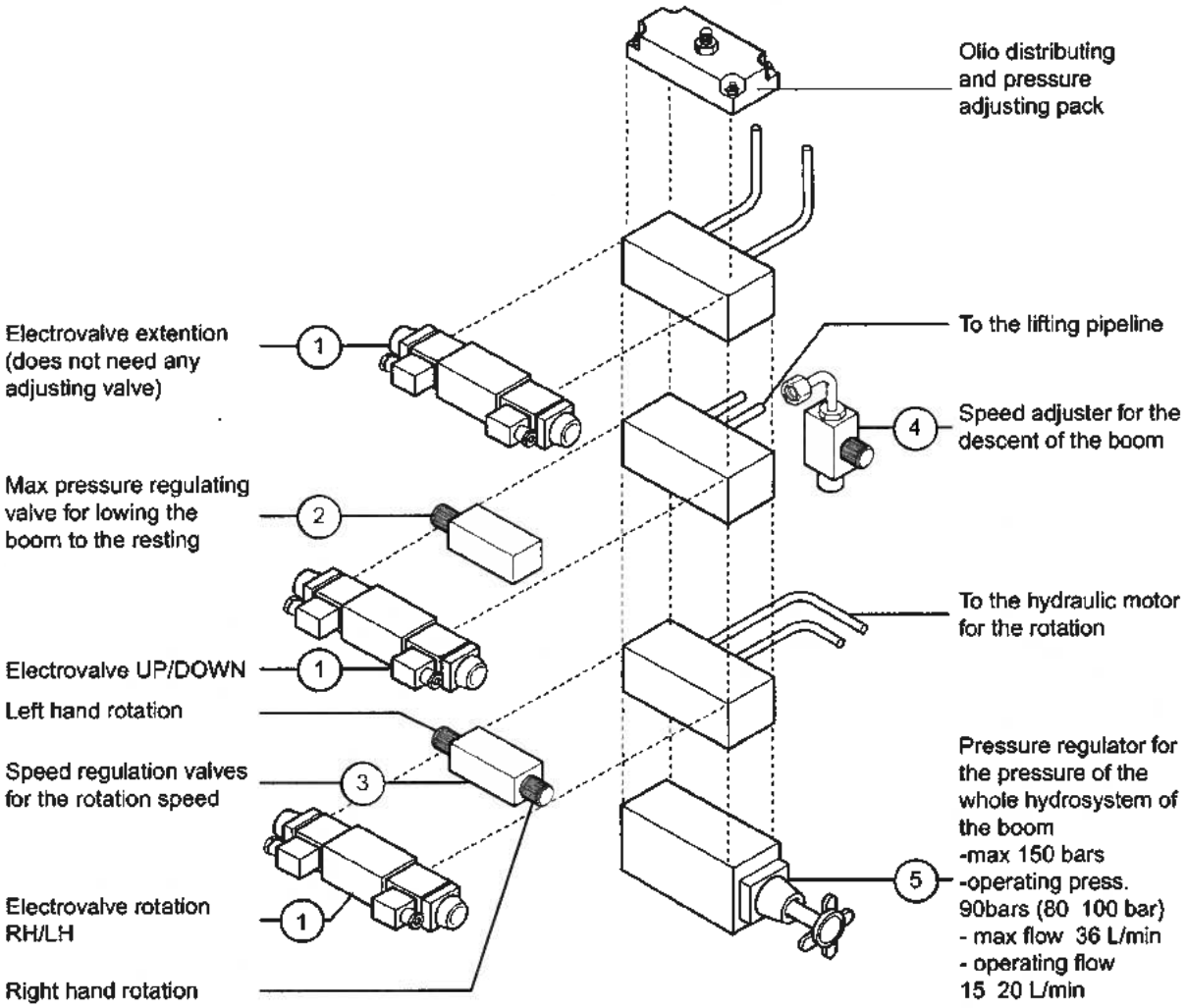
PORDENONE

1) Pos. 97 - cod. 4024 3100 00 - Electrovalve
2) - cod. 4024 3116 00 - Max. press. blocking valve
3) Pos.101 - cod. 4024 3101 00 - Flow regulating valve
4) Pos.55 - cod. 4024 4140 00 - Flow regulating valve one way
5) Pos.98 - cod. 4024 3110 01 - Oil flow regolator



For electrovalves spare parts: please specify producer's name when You will order.
It can be found on the electrovalve's plate.

OPERATORS MANUAL

Excavation Hydro SWMS

Section 8

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).

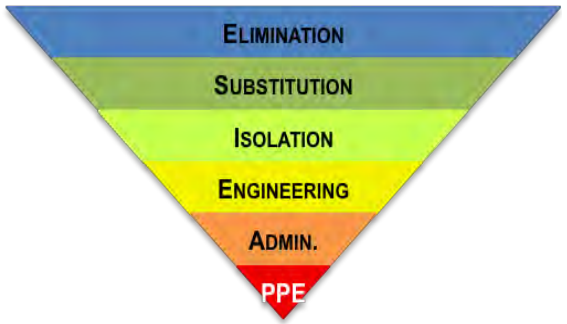
PRINCIPAL CONTRACT DETAILS *(The builder or the organisation you are working for.)*		
PRINCIPAL CONTRACTOR (PC):	PROJECT NAME:	DATE SWMS PROVIDED TO PC:
PROJECT ADDRESS:		
PROJECT MANAGER (PM):	PM SIGNATURE:	CONTACT PH. #:

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.

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

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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			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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			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	

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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			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	

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	

JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
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			• 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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			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	

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	

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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			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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			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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	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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from plant.			and resourced Emergency Responders.		

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:

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)	

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:										

OPERATORS MANUAL

Pressure Cleaner Water SWMS

Section 9

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:		

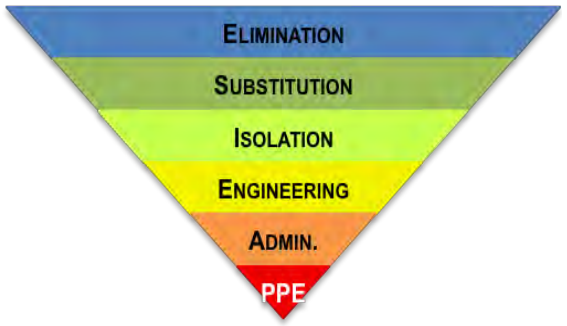
RELEVANT WORKERS CONSULTED IN THE DEVELOPMENT, APPROVAL AND COMMUNICATION OF THIS SWMS.			ALL PERSONS INVOLVED IN THE TASK MUST HAVE THIS SWMS COMMUNICATED TO THEM BEFORE WORK COMMENCES.
NAME	SIGNATURE	DATE	Daily Tool Box Talks will be undertaken to identify, control and communicate additional site hazards.
			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.		

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.
											
☑	☑	☑	☑	☑	☑	☑	☑	☐	☑	☐	☑

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	

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	

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	

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	

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	

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	

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	

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	

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.*		

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	

JOB STEP	POTENTIAL HAZARD/S	IR	CONTROL MEASURES TO REDUCE RISK	RR	RESPONSIBLE PERSON
			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	

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

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:										