

MILROYAL[®] C DRIVE

IOM Manual

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PRECAUTIONS

The following precautions should be taken when working with metering pumps.
Please read this section carefully prior to installation.

Protective Clothing



ALWAYS wear protective clothing, face shield, safety glasses and gloves when working on or near your metering pump. Additional precautions should be taken depending on the solution being pumped. Refer to **Safety Data Sheets** for the solution being pumped.

Hearing Protection



It is recommended that hearing protection be used if the pump is in an environment where the time - weighted average sound level (TWA) of 85 decibels is exceeded. (as measured on the A scale - slow response)

Electrical Safety



- Remove power and ensure that it remains OFF while maintaining pump.
- **DO NOT FORGET TO CONNECT THE PUMP TO EARTH / GROUND.**
- Electric protection of the motor (Thermal protection or by means of fuses) is to correspond to the rated current indicated on the motor data plate.

Liquid Compatibility



Verify if the materials of construction of the wetted components of your pump are recommended for the solution (chemical) to be pumped.

Pumps Water “Primed”



All pumps are tested with water at the factory. If your process solution is not compatible with water, flush the **Pump Head Assembly** with an appropriate solution before introducing the process solution.

Plumbing and Electrical Connections



Always adhere to your local plumbing and electrical codes.

Line Depressurization



To reduce the risk of chemical contact during disassembly or maintenance, the suction and discharge lines should be depressurized before servicing.

Over Pressure Protection



To ensure safe operation of the system it is recommended that some type of safety / pressure-relief valve be installed to protect the piping and other system components from damage due to over-pressure.



Lifting

This manual should be used as a guide only - Follow your company's recommended lifting procedures. It is not intended to replace or take precedence over recommendations, policies and procedures judged as safe due to the local environment than what is contained herein. Use lifting equipment that is rated for the weight of the equipment to be lifted.



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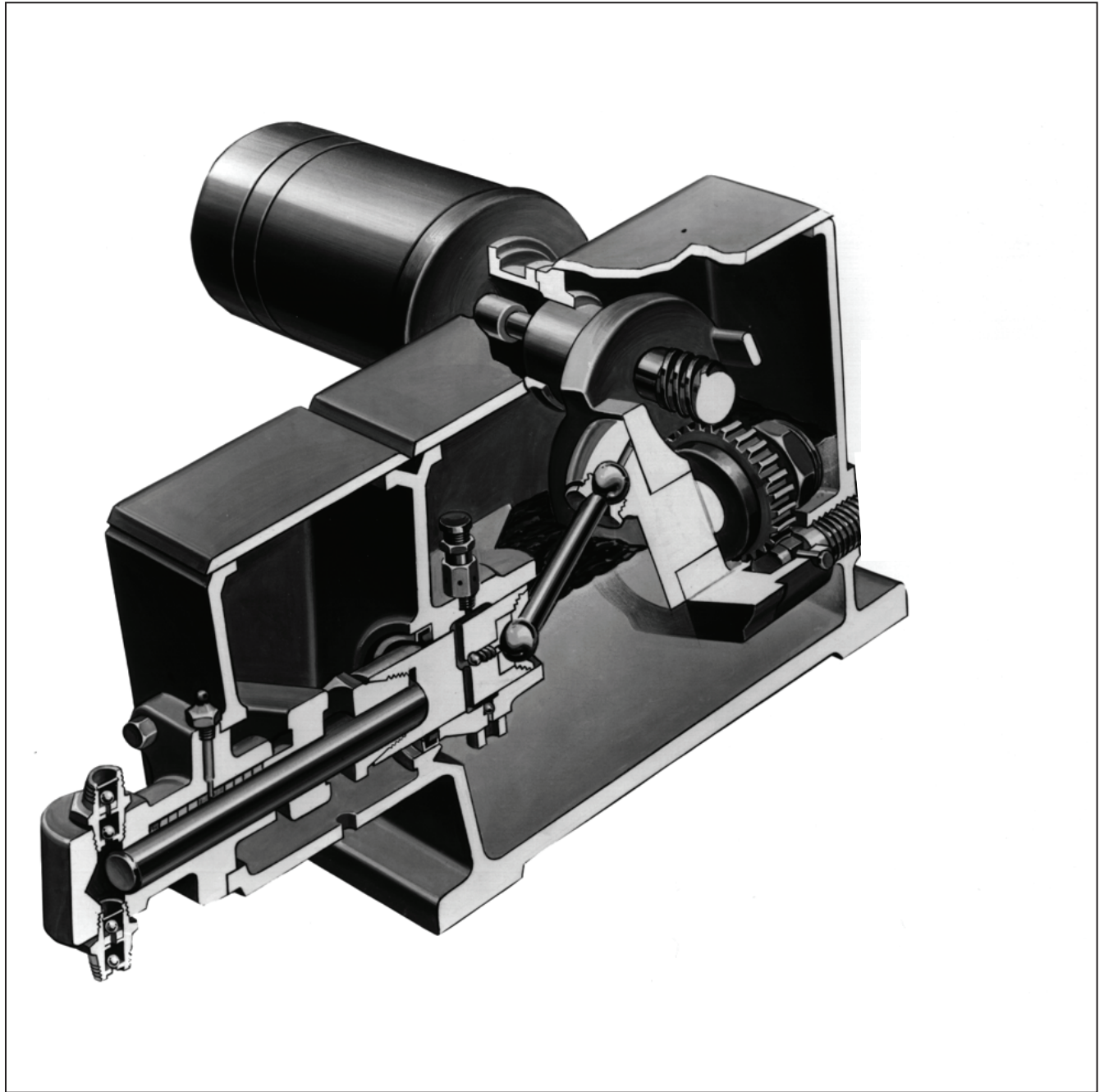




Figure 1. Milroyal® C Metering Pump.

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SECTION 1 - GENERAL DESCRIPTION

1.1 INTRODUCTION

The Milroyal® C is a reciprocating positive-displacement controlled-volume pump designed to move specific volumes of liquid against a positive pressure differential between the pump suction and the pump discharge. The delivered volume is controllable within one percent of setting.

The pump consists of three major components: (1) a drive unit, (2) a reciprocating plunger, and (3) a liquid end. Pump delivery is a function of drive speed, plunger stroke length, and plunger diameter. In addition, delivered volume for a given pump can be varied by mechanical (micrometer hand knob) or (optional) electrical or pneumatic adjustment of plunger stroke length. Pump drives may be fitted with HPD (High Performance Diaphragm, Manual 54146) as well as several styles of PP (Packed Plunger, Manual 54270) liquid ends (See *Figures 3 and 4*). This manual will concentrate on the mechanically adjusted drive unit only.

1.2 MODEL CODE / PUMP IDENTIFICATION

Milroyal® C pumps manufactured during and after 1995 were given a new model code which completely defines the material and options selected. The first digits indicate the frame size, followed by the "options" code. See manual 54146 for HPD model number breakdown and 54270 for PP model number breakdown.

1.3 PRINCIPLE OF OPERATION

The drive unit moves the pump plunger to draw liquid into the liquid end on the suction stroke and to expel the liquid on the subsequent discharge stroke. Accurate flow control is achievable only if the discharge line pressure (discharge head) is greater than the suction line pressure (suction head). For aid in determining acceptable piping performance, please refer to Milton Roy's NPSH calculator, available on line at www.miltonroy.com.

The unique Milroyal® C pump drive mechanism operates on a patented polar crank principle. Essentially, a crank driven by a worm gear rotates on a variable plane. As the crank plane is changed from vertical, a reciprocating motion results from the crank connection to the plunger. Pump stroke length is increased from zero to maximum by adjusting the slope of the crank plane from vertical. (See *Figure 2*.)

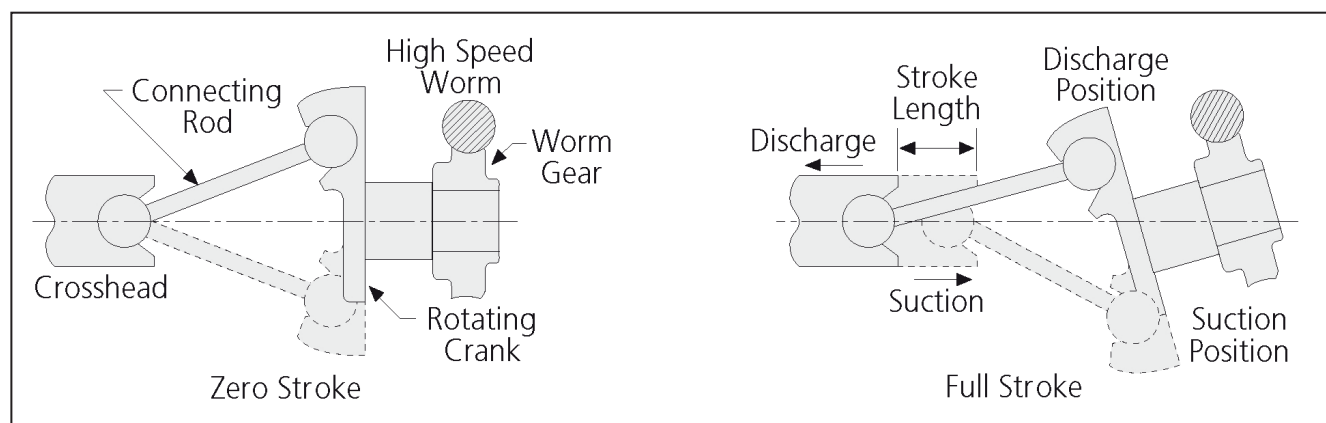
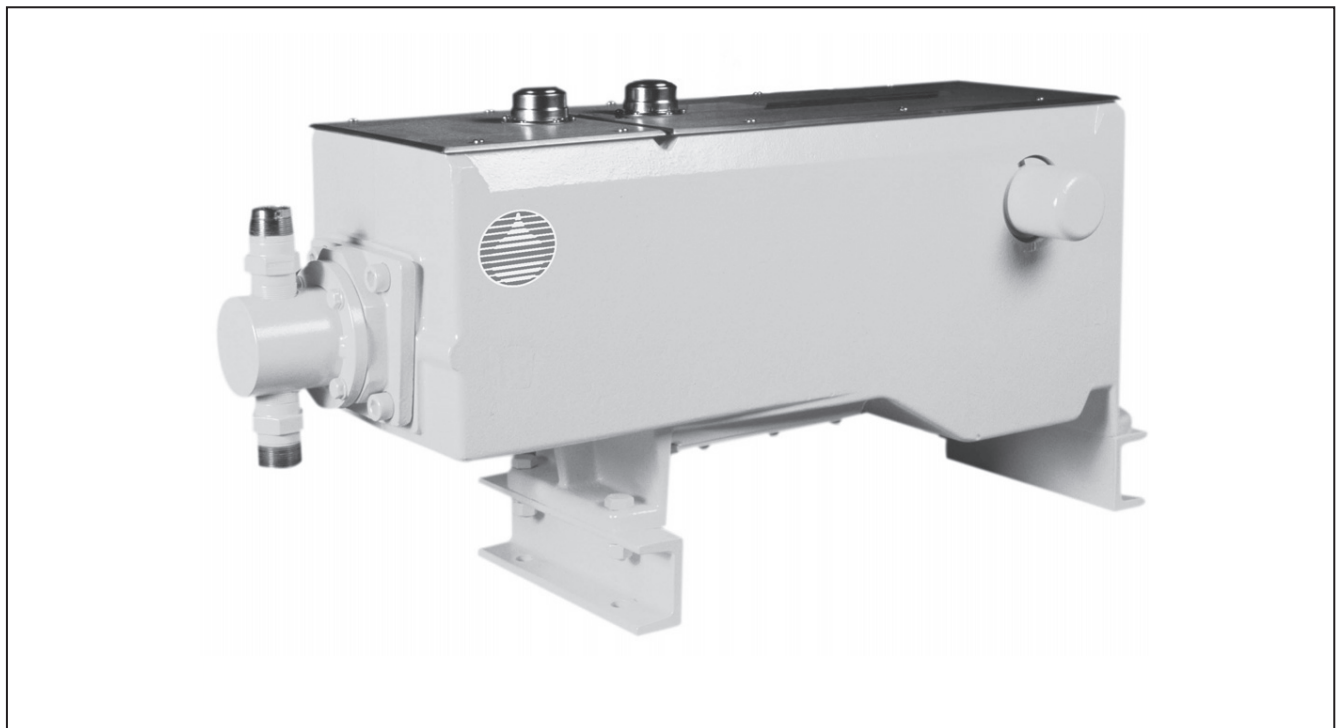


Figure 2. Capacity Adjustment

SECTION 1 - GENERAL DESCRIPTION

As the plunger reciprocates in the liquid end, the pumped liquid is alternately drawn into and discharged from the liquid end. Each suction (rearward) stroke of the pump plunger creates a negative pressure in the displacement chamber. The pressure of the liquid in the suction line unseats the suction ball-checks and liquid flows into the displacement chamber. On the discharge stroke, the plunger moves forward and pressurizes the liquid which unseats the discharge ball-checks to flow out the discharge port. On each suction stroke, the discharge ball-checks are seated, and on each discharge stroke, the suction ball-checks are seated (pressure in pump head is greater than suction line pressure). This mode of operation prevents back flow and ensures liquid movement from the suction port, through the liquid end, and out the discharge port.

In packed plunger liquid ends, the plunger contacts the process liquid, while diaphragm liquid ends isolate the process liquid from the pump plunger. In the latter designs, the plunger displaces hydraulic fluid which moves a diaphragm in contact with the process liquid, forcing the process liquid through the liquid end. Liquid ends are covered in separate instruction manuals.



**Figure 3. Packed Plunger Liquid End
(See manual 54270)**

SECTION 1 - GENERAL DESCRIPTION

1.4 SAFETY PRECAUTIONS

When installing, operating, and maintaining the Milroyal® C keep safety considerations foremost. Use proper tools, protective clothing, and eye protection when working on the equipment. Install the equipment with a view toward ensuring safe operation. Follow the instructions in this manual and take additional safety measures appropriate to the liquid being pumped. Be extremely careful in the presence of hazardous substances (e.g., corrosive, toxins, solvents, acids, caustics, flammables, etc.).

1.5 SPECIFICATIONS

Detailed specifications for this pump are listed on the pump Data Sheet. The sheet can be downloaded at www.miltonroy.com.

The following is a list of manuals that may be required to maintain your Milroyal® C pump:

Title	Document Number
Disc Diaphragm Liquid End	339-0011-000
Milroyal B Pneumatic Capacity Control	339-0017-000
Double Diaphragm Leak Detector	339-0025-000
Metallic Diaphragm Liquid End	339-0077-000
HPD Low Flow	339-0059-000

The manuals can be downloaded on the internet at www.miltonroy.com.

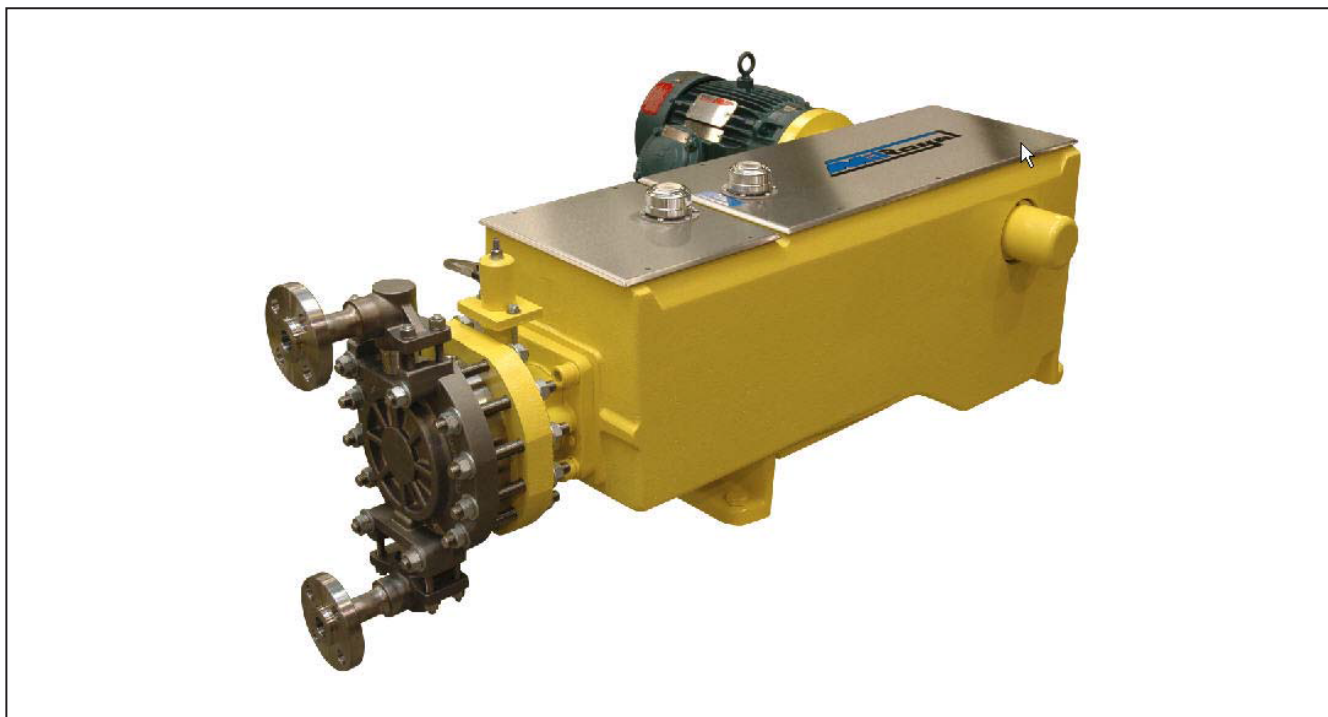


Figure 4. HPD Liquid End (See manual 54146)



SECTION 2 - INSTALLATION

2.1 UNPACKING / INSPECTION

Pumps are shipped Free on Board (FOB) factory or representative warehouse and the title passes to the customer when the carrier signs for receipt of the pump. In the event that damages occur during shipment, it is the responsibility of the customer to notify the carrier immediately and to file a damage claim.

Carefully examine the shipping crate upon receipt from the carrier to be sure there is no obvious damage to the contents. Open the crate carefully so accessory items fastened to the inside of the crate will not be damaged or lost. Examine all material inside the crate and check against the packing list to be sure that all items are accounted for and intact.

2.2 STORAGE

2.2.1 Short Term Storage (Less than 6 Months)

It is preferable to store the material under a shelter in its original package to protect it from adverse weather conditions. In condensing atmospheres, follow the long term storage procedure.

2.2.2 Long Term Storage (Longer than 6 Months)

The primary consideration in storage of pump equipment is to prevent corrosion of external and internal components. This corrosion is caused by natural circulation of air as temperature of the surroundings change from day to night, day to day, and from season to season. It is not practical to prevent this circulation which carries water vapor and other corrosive gases, so it is necessary to protect internal and external surfaces from their effects to the greatest extent possible.

When the instructions given in this section are completed, the equipment is to be stored in a shelter; protected from direct exposure to weather. The prepared equipment should be covered with a plastic sheet or a tarpaulin, but in a manner which will allow air circulation and prevent capture of moisture. Equipment should be stored 12 inch or more above the ground.

If equipment is to be shipped directly from Milton Roy into long term storage, contact Milton Roy to arrange for factory preparation.

2.2.3 Pump Drive and Gearboxes

- A. Flood the gearbox compartments with a high grade Lubricating Oil / Rust Preventative such as Mobil Oil Corporation product "Mobilarma 524". Fill the compartment completely to minimize air space and water vapor condensation. After storage, drain this material and refill the equipment with the recommended running fluids and lubricants for equipment commissioning.
- B. Remove drive motors and mounting adapters, and brush all unpainted metal surfaces with multipurpose grease (NLGI grade 2 or 3). Store these unattached.

2.2.4 Pump Liquid Ends

Flood the front compartment of the pump housing (if the model has a front compartment) with a high grade Lubricating Oil / Rust Preventative such as Mobil Oil Corporation product "Mobilarma 524".

1. If the pump has a diaphragm style liquid end, fill the pump-housing compartment all the way to minimize airspace and water vapor condensation.
2. If the pump has a packed plunger style liquid end, holes in the chamber for gland tightening bolts will leak the oil, so fill the chamber only to the bolt centerline. Brush the remaining exposed metal parts thoroughly with general purpose grease (NLGI grade 2 or 3).



SECTION 2 - INSTALLATION

3. Most of the liquid ends themselves are constructed of inherently corrosion resistant materials and require no applied corrosion inhibitor. If they are NOT naturally resistant (test the threaded or flanged inlet and outlet connections - if they have little or no magnetic property, they are resistant) they should be flush filled with a corrosion inhibiting and non-freezing liquid which is compatible with the final pumped process chemical. Flush and fill with inhibitors such as "Mobilarna 524" or with a commercial automotive antifreeze coolant. The pump head contains one way check valves, so flush in a direction into the suction (bottom) connection, and out the discharge (top) connection.

Cap or plug all openings to capture the inhibiting fluid, and to prevent animals and insects from building nests.

2.2.5 Pneumatic, Electrical and Electronic Equipment

Motors should be prepared in the manner prescribed by their manufacturer. If information is not available, dismount and store motors as indicated in paragraph below.

For all pneumatic and electrical equipment, place packets of Vapor Phase Corrosion Inhibitor (VPCI) inside of the enclosure, then place the entire enclosure, with additional packets, inside a plastic bag, and seal the bag tightly closed. Contact Milton Roy Service Department for recommended VPCI materials.

2.3 SAFETY PRECAUTIONS

⚠ WARNING WHEN INSTALLING, OPERATING, AND MAINTAINING THE MILROYAL® C, KEEP SAFETY CONSIDERATIONS FOREMOST. USE PROPER TOOLS, PROTECTIVE CLOTHING, AND EYE PROTECTION WHEN WORKING ON THE EQUIPMENT AND INSTALL THE EQUIPMENT WITH A VIEW TOWARD ENSURING SAFE OPERATION. FOLLOW THE INSTRUCTIONS IN THIS MANUAL AND TAKE ADDITIONAL SAFETY MEASURES APPROPRIATE TO THE LIQUID BEING PUMPED. BE EXTREMELY CAREFUL IN THE PRESENCE OF HAZARDOUS SUBSTANCES (E.G., CORROSIVES, TOXINS, SOLVENTS, ACIDS, CAUSTICS, FLAMMABLES, ETC).

⚠ CAUTION THE PERSONNEL RESPONSIBLE FOR INSTALLATION, OPERATION AND MAINTENANCE OF THIS EQUIPMENT MUST BECOME FULLY ACQUAINTED WITH THE CONTENTS OF THIS MANUAL.


2.4 PUMP MOUNTING / LOCATION

Support the pump firmly in a level position (shim if necessary) on a solid, vibration-free foundation, preferably with the base above floor level to protect it from washdowns and to provide easier access for service. The pump features mounting holes to accommodate anchor bolts. Some Milroyal® pumps are shipped with motors dismounted. After anchoring pump drive in position, install motor.

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SECTION 2 - INSTALLATION

2.5 PIPING

2.5.1 General

Never connect rigid pipe to plastic liquid ends; rather, use flexible connections to both suction and discharge.

Use piping materials that will resist corrosion by the liquid being pumped. Use care in selecting materials to avoid galvanic corrosion at pump liquid end connections.

Use piping heavy enough to withstand maximum pressures.

Size suction piping to accommodate peak instantaneous flow. Because of the reciprocating motion of the pump plunger, pump delivery follows an approximate sine curve with a peak instantaneous flow π (3.14) times the average flow. Therefore, piping must be designed for a flow 3.14 times the pump capacity; this means that a pump rated for 88 gallons per hour requires piping sufficient for 88 gph (333.1 L/hr.) X 3.14 or 276 gph (1044.7 L/hr.).

Discharge piping may be smaller if a pulsation dampener is used.

To minimize viscous flow losses, pump viscous liquids with line up to four sizes larger than the pump port.

Remove burrs, sharp edges, and debris from inside piping. Flush and blow out all pipe lines before making final connections to pump.

Provide for pipe expansion when hot liquids are to be pumped. Support piping so that pipe weight is not placed on the pump. Never spring piping to make connections.

Piping should be sloped to prevent vapor pockets, because vapor in the liquid end will cause inaccurate pump delivery.

When pumping suspended solids (such as slurries), install plugged crosses at all 90-degree line turns to permit line cleaning without dismantling piping.

2.5.2 Suction Piping

It is preferable to have the suction of the pump flooded by locating the liquid end below the lowest level of the liquid in the supply tank. Installing a hold-up tower or supply vessel on the suction line close to the pump can help ensure a flooded suction line. (Consult Milton Roy, Flow Control Division for assistance in such applications).

Avoid negative suction pressure conditions (suction lift), as such conditions adversely affect metering accuracy. If such conditions are unavoidable, contact Milton Roy Flow Control Division for recommendations.

When pumping a liquid near its boiling point, provide enough suction head to prevent the liquid from “flashing” into vapor when it enters the pump liquid end on the suction stroke.

If possible, use metal or plastic tubing for the suction line because tubing has a smooth inner surface and can be formed into long, sweeping bends to minimize frictional flow losses.

A strainer should be used in the suction line to prevent foreign particles from entering the liquid end. This and any other measures which prevent debris from entering and fouling the ball-checks will give increased maintenance-free service. Check strainer frequently to prevent blockage which could lead to cavitation.

Keep suction piping as short and straight as possible.

When suction piping is long, and particularly at stroke speeds above 70 strokes per minute (spm), piping size should be significantly larger than the liquid end suction fitting to prevent pump starvation.



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If long suction lines are unavoidable, install a float box (See Figure 5) or auxiliary feed tank (stand pipe) near the suction side of the pump. The float box may be calibrated and used to check pump capacity by measuring the time required for pumping a specific quantity of liquid from the box. In many cases, installing an accumulator or pulsation dampener at the pump suction connection will promote flooded suction even when the suction line is long. Consult Milton Roy Flow Control Division for details. Suction piping must be absolutely airtight to ensure accurate pumping. After installation, test suction piping for leaks with air and soap solution.

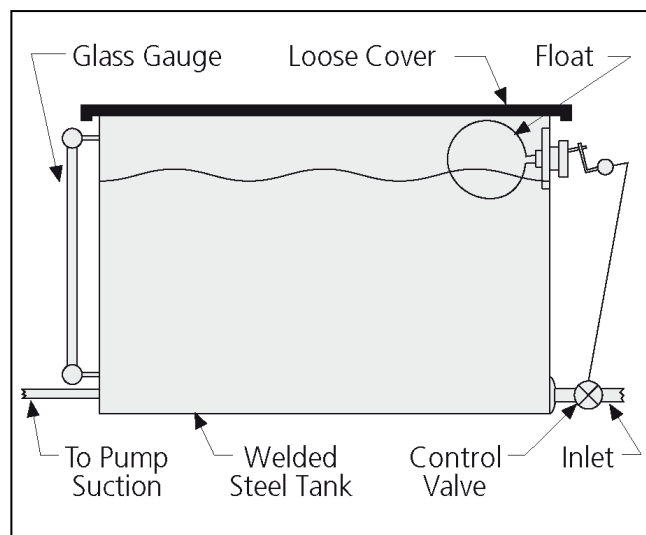


Figure 5. Float Box

2.5.3 Discharge Piping

Install pipe large enough to prevent excessive pressure losses on the discharge stroke of the pump. Maximum pressure at the discharge fitting on the liquid end must be kept at or below the maximum pressure rating shown on the pump nameplate.


The pump will not deliver a controlled flow unless the discharge line pressure is greater than the suction line pressure. Piping should be arranged to provide at least 5 psi positive pressure differential between the discharge side and the suction side. There are a number of ways to create an artificial discharge pressure, such as by installing a vented riser or a back pressure valve. (Please consult Milton Roy Flow Control Division for recommendations to increase back pressure in slurry applications.)


When pumping water-treating chemicals directly into boiler drums, use one liquid end assembly for each boiler drum. Discharging into a manifold having the slightest pressure difference between its several discharge connections can diminish metering accuracy as the outlet with the lowest pressure will receive more liquid than the other outlets.

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SECTION 2 - INSTALLATION

2.6 VENTED RISERS

A vented riser (*Figure 6*) is simply a vertical extension of the discharge pipe into an open tee. The other side of the tee goes to the process. Practically maintenance-free, this device prevents siphoning and reduces pulsations; however, a clogged or closed line may cause the riser to overflow. Therefore, substitute a pulsation dampener and back pressure valve for a vented riser when pumping hazardous liquids.

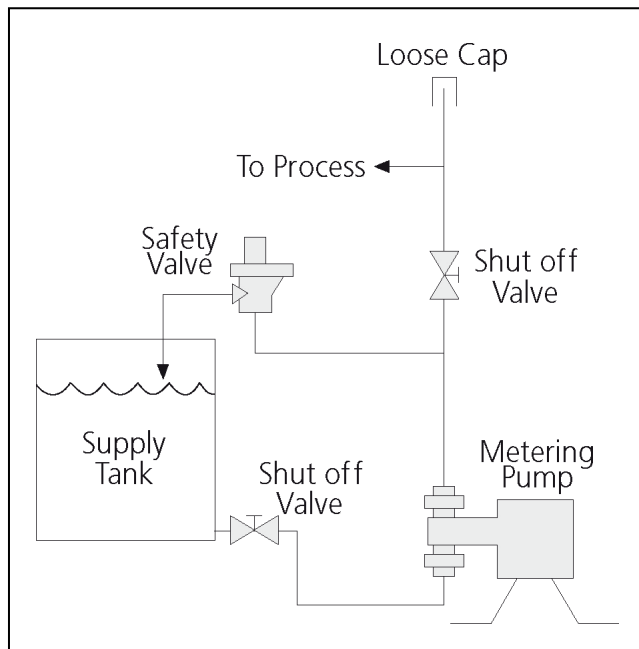


Figure 6. Vented Riser

2.7 PULSATION DAMPENERS

(Accumulators, Surge Chambers etc.)

An accumulator, surge chamber, surge suppressor, or pulsation dampener should be used with the back pressure valve in the discharge line to absorb the flow peaks between the pump and the back pressure valve. Without the pulsation dampener the valve mechanism will snap open and closed with the surge from each pump stroke. The pulsation dampener will allow the back pressure valve to oscillate about a partly-closed position, thus minimizing wear on the valve. Discharge line pulsation dampeners offer the further advantage of limiting the flow and pressure variations characteristic of this performance and may reduce system costs dramatically by permitting the substitution of smaller piping. Please contact Milton Roy for further information on pulsation dampeners.



2.8 BACK PRESSURE VALVES

A Milton Roy back pressure valve should be installed in the discharge line near the pump to ensure sufficient discharge head pressure for proper pump metering action. Normally, the valve should be located near the pump; however, back pressure valves for large pumps with long and extremely small discharge lines may have to be installed near the point of discharge into the process (to minimize siphoning tendencies).

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SECTION 2 - INSTALLATION

2.9 SAFETY VALVES

CAUTION MOTOR-DRIVEN POSITIVE DIS-PLACEMENT PUMPS CAN DE-VELOP TREMENDOUS DISCHARGE PRESSURES LONG BE-FORE THERMAL OVERLOAD DEVICES INTERRUPT THE MO-TOR ELECTRICAL CIRCUIT. TO PREVENT A BLOCKED DIS-CHARGE LINE FROM CAUSING DAMAGE TO THE PUMP, PIP-ING, OR PROCESS EQUIPMENT, INSTALL A MILTON ROY SAFETY VALVE IN THE PUMP DISCHARGE LINE. THIS VALVE IS DESIGNED AND SIZED TO HANDLE SYSTEM FLOW RATES AND PRESSURES SAFELY WHILE RESISTING CORROSION BY THE PROCESS LIQUID.

Install the safety valve in the discharge line between the pump and the nearest shut-off valve (This will prevent pump damage from accidental valve closure.) Pipe the safety valve outlet back to the suction tank or to drain, but in either case ensure that the pipe end is continuously visible so safety valve leakage may be detected.

2.10 CHECK VALVES (Figure 7)

A check valve should be installed at the point where the discharge line enters a boiler or other high-pressure vessel. This will prevent back flow through the discharge piping and will isolate the pump discharge from system pressures (a safety consideration).

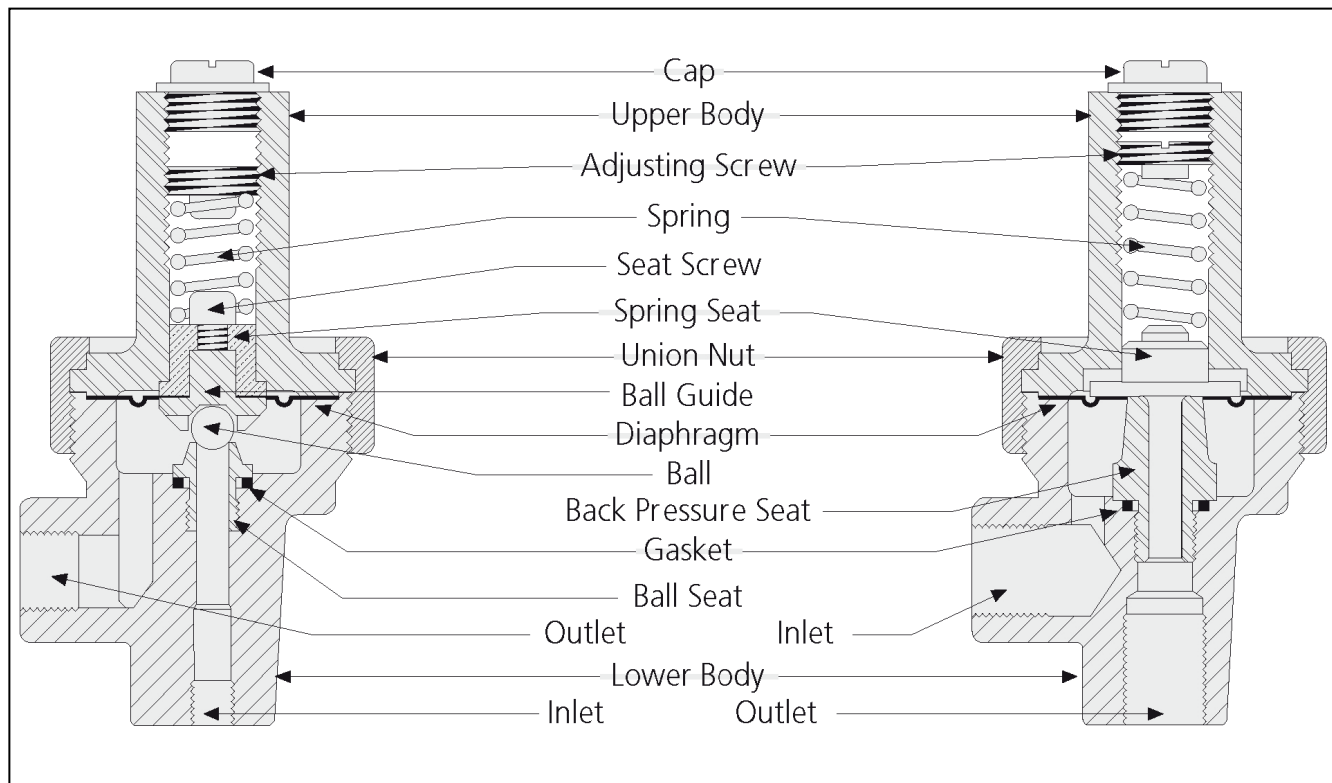


Figure 7. Safety and Back Pressure Valves



SECTION 2 - INSTALLATION

2.11 SHUT-OFF VALVES

Provide shut-off valves in both suction and discharge lines next to the pump. Locate discharge line shut-off valve downstream from the inlet connection of the safety valve. *Figure 8* shows recommended valve locations.



2.12 SERVICE CONNECTIONS

2.12.1 Pump Drive

Check the nameplate data on the pump drive motor and insure proper power supply is available before making any connections.

The preferred motor shaft rotation is shown by an arrow on the drive side flange of the pump. Running the motor in the indicated direction minimizes the potential for damage to the drive. If running in the opposite direction is required, contact the Milton Roy service department for recommendations.

For drives other than constant speed electric motors, refer to manufacturer's instructions and service information included with pump.

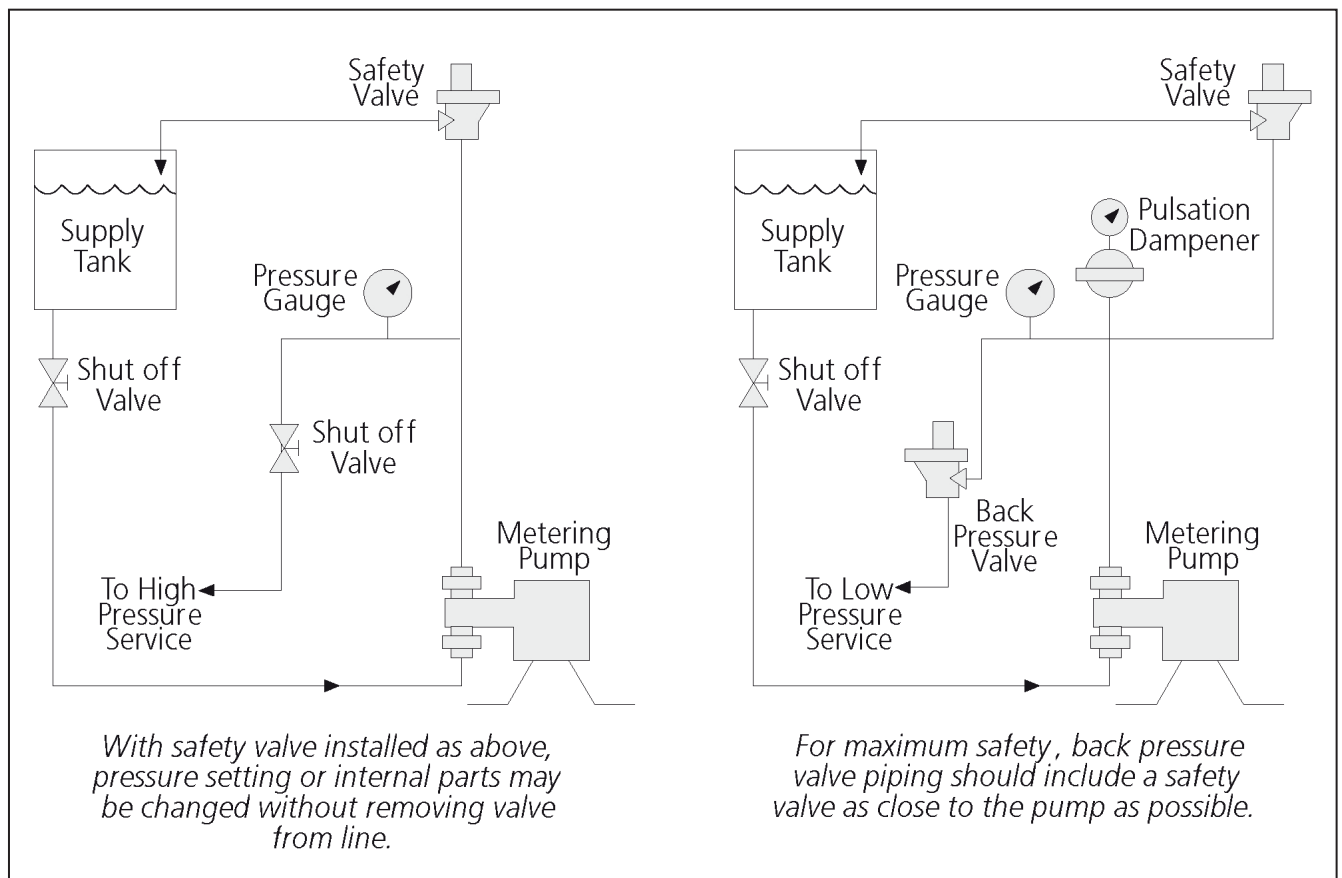


Figure 8. Recommended Valve Locations

SECTION 2 - INSTALLATION

2.12.2 Stuffing Box

The stuffing box is designed to handle most clear, free-flowing liquids; however, liquids with suspended solids and abrasives (e.g., certain slurry and phosphate solutions) tend to precipitate in the packing, causing abnormal wear on packing and plunger. An internal flushing connection used with a V- or Chevron-type packing will minimize this tendency and increase packing and plunger life in these applications. (For abrasive slurry applications, ball-check valve cartridges should be installed remote from pump liquid end. Contact Milton Roy for full details.)

To connect for internal flushing, remove the stuffing box grease fitting and connect the stuffing box to a source of water (or other compatible liquid) at 25 to 50 psig (172 to 345 kPa) above suction pressure. Since only a few drops per minute are necessary, small diameter tubing will suffice. Install a 1/8" or 1/4" NPT stainless steel aircraft hydraulic system check valve on the flush line right next to the stuffing box connection to keep the process liquid from backing up through the flush line if the packing should fail. A 1/8" or 1/4" (3.2 or 6.4 mm) needle valve should be included for controlling the flushing liquid flow rate. The Milroyal® C can be fitted at the factory or in the field with a Swagelok® elbow and tubing to exit through the pump housing for connection to a flushing line. Contact your Milton Roy representative to order these two parts.

Through flush connections to carry hazardous or undesirable fluids from the stuffing box can be provided for by drilling and tapping the stuffing box during manufacture. In these installations, the flushing liquid is piped away from the stuffing box to a drain or other suitable disposal point. For specific instructions concerning field installation of through flushing, consult Milton Roy and provide full details of the application.

2.12.3 Drains

Provide drains convenient to the pump so that any leakage of hazardous fluids may be diverted to suitable container or area. The pump catchall area (beneath the small top cover) is provided with a hole drilled and tapped to receive piping for drainage.

2.12.4 Auxiliary (Accessory) Equipment

Service connections for auxiliary or accessory electrical equipment should be determined by referring to wiring diagrams, instruction manuals, and the data plate furnished with the equipment. Air-operated equipment should normally be supplied with two sources of air. The power elements require a standard 60 psig (414 kPa) (80-100 psig (552-690 kPa) at compressor) plant air supply (however, an 80 psig (552 kPa) supply (90-100 psig (621-690 kPa) at compressor) is recommended to ensure maximum performance under all conditions). Instrument air should be supplied from a control instrument or from a manual air pressure regulator furnished with 30 psig (207 kPa) service.



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SECTION 3 - OPERATION

3.1 INITIAL START-UP

Remove covers (6083 and 6085) from top of pump casing and check that interior is free of debris. Reinstall catchall cover (6085). Install oil cleaning magnet (12) over the oil pump intake hole on the underside of the crosshead guide section of the pump casing (see *Assembly Drawing, Figure 12 for magnet location*). The magnet is bagged with other loose parts shipped in the catchall of the pump. Check that all mounting bolts are tight, piping is installed properly, and the discharge line is open. Fill the pump casing with the lubricant supplied with the pump; fill to the bottom of the oil level plug which is located at the level of the crosshead (12- 1/2" above the housing feet). Pour lubricant into the casing over the bearings and gear set. (refill amount shown below). Replace cover (6083) over the oil sump.

NOTE:

Because gear oil viscosity increases as the ambient temperature decreases, you must choose a gear oil appropriate for both the ambient and operating temperatures. Operating temperatures are typically 75°F higher than ambient temperatures. See below for oil recommendations.

Connect pump motor for clockwise rotation as indicated by arrow (8002) on pump casing.

3.2 OIL SPECIFICATIONS

GEAR LUBRICANTS

Operating Oil Temperature*	Type Oil Recommended
-30°F to 250°F	Mobil SHC 634 Synthetic, ISO 460
-10°F to 40°F	Mobil Gear 629, ISO 150
15°F to 125°F	AGMA #7 Comp., ISO 460
*Maximum Oil Temperature 250°F. The nominal capacity of the Milroyal® C housing is 80 pints (44 liters).	
Food Grade Equivalent 15°F to 125°F Only	Nevastane EP 460

HYDRAULIC FLUIDS

Operation	Type Oil Recommended
HPD Liquid End & Disc Diaphragm	Zurnpreen 15A, ISO 32
Food Grade Equivalent	Nevastane AW32

3.3 INITIAL ADJUSTMENTS

3.3.1 Micrometer Capacity Control

To adjust pump capacity, loosen the stroke locking screw (110, *Figure 12*) in the casing above the micrometer-adjust hand knob (490), and turn the hand knob until the desired capacity percentage is just visible on the stroke indicator plate (95). Then tighten the locking screw to maintain capacity setting.

3.3.2 Electric Capacity Control

An Electric Capacity Control may be mounted on the pump housing in place of the micrometer-adjust hand knob. This accessory adjusts stroke length in response to manual or automatic electric signals from process control instruments. Electric Capacity Control is described in a separate Instruction Manual (53870).

3.3.3 Pneumatic Capacity Control

Pneumatic Capacity Control may be mounted on the pump housing in place of the micrometer-adjust hand knob. This accessory adjusts stroke length in response to pneumatic signals from a remotely located control unit. Pneumatic Capacity Control is described in a separate Instruction Manual.

3.3.4 Speed Capacity Control

Milroyal® s may be fitted with variable-speed motors to provide capacity control through adjustments in drive speed. Such motors and control accessories are available as options from Milton Roy(54269).



SECTION 3 - OPERATION

3.3.5 Capacity Calibration

After the first 12 hours of operation, the pump may be tested and calibrated to find the exact pump capacity under specific operating conditions.

Usually, calibrating the pump at only 100, 50, and 10 percent capacity settings is enough to indicate pump performance throughout the adjustment range.

The pump can be calibrated by one of two methods carried out in a given time:

1. Measure the decrease in liquid level pumped from a calibrated vessel.
2. Collect and measure pumped liquid at the pump discharge port. (It may be necessary to create discharge head at the liquid take-off point; otherwise pump will not operate properly. See Section 2 for ways to do this.)

The first method is recommended for hazardous liquids because it eliminates operator contact with the liquid.

3.4 FILLING PUMP SYSTEM

It is especially important that pump suction and discharge lines be free of entrained air. To ensure this condition, operate the pump under no discharge pressure and fill the entire pumping system with liquid before starting pressure tests.

If the pump is idle for long periods, temperature changes in the process liquid may produce air in the system. To discharge the air, install a valve in the discharge line which will allow the process liquid to be pumped to exhaust when starting the pump.

3.5 PREVENTATIVE MAINTENANCE

Milroyal® C pumps are carefully designed, manufactured, assembled, and quality tested to give reliable service with minimal maintenance. However, a daily maintenance check is recommended to visually confirm proper operation of the pump.

3.5.1 Drive

Check gear drive oil level monthly and add oil as required.

Change gear drive lubricant and clean magnetic filter below crosshead chamber every six months or after every 2500 hours of operation, whichever occurs first. (This may be scheduled with seasonal oil changes.)

3.5.2 Motor

Lubricate drive motor annually or according to motor manufacturer's instructions.


3.5.3 Check Valves

Check valve assemblies are designed to be self-cleaning and should seldom need servicing. Fouled check valves can usually be cleaned by pumping a hot detergent solution for 15 minutes, followed by water flushing.

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SECTION 4 - MAINTENANCE

4.1 SPARE PARTS

The spare parts listed in Table 1 should be stocked for each pump to prevent serious delays in repairs.

Parts orders must include the following information:

1. Quantity (in this manual)
2. Part number (in this manual)
3. Part description (in this manual)
4. Pump serial number (on pump nameplate)
5. Full model number (on pump nameplate)

Always include the serial and model numbers in all correspondence regarding the unit.

Drawing Location Reference	Description	Qty. Req.
-	Plunger	1
375	Connecting Rod Assembly	1
310	Conical Sleeve Bearings	2
104	Lead Screw Lock Inserts	2
250	Gear Set	1
480	Crosshead Seal	1
355	Worm Shaft Bearings	2
PARTS KIT 328	Tool Kit	1

Table 1. Spare Parts

4.2 RETURNING UNITS TO THE FACTORY

Pumps will not be accepted for repair without a Return Material Authorization (RMA), available from the Factory Repair Department. Pumps returned to the Factory for repairs should be clearly labeled to indicate the liquid being pumped. Process liquid should be flushed from liquid end before pump is shipped. These safety precautions will aid the troubleshooting and repair procedure and preclude injury to repair personnel from corrosive residue in pump liquid end. Safety Data Sheet must accompany all returns.

All inquiries or parts orders should be addressed to your local Milton Roy representative or sent to www.miltonroy.com.

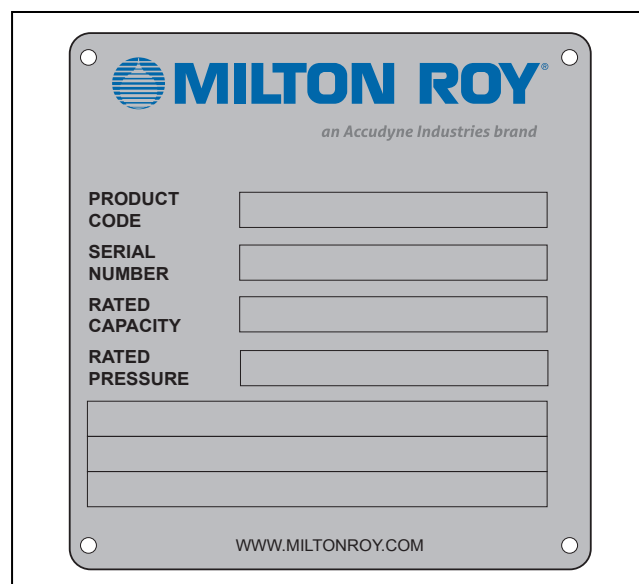


Figure 9. Pump Nameplate

4.3 DISASSEMBLY

The pump may be dismantled for parts replacement through the following procedures. (Numbers in parentheses are drawing location numbers found on the parts list and drive drawing, *Figures 10, 11 & 12*)

4.3.1 Pump Drive

The following special tools (PARTS KIT 328) will be required for disassembling the pump drive (crosshead and gear housing):

- #2110035000 Centering tool assembly
- #2110036002 Trunion removal tool
- #2110036001 Bearing adjuster removal tool
- #2110036003 Removal tool drive key
- #4050025124 SOC HD SCR#10-24X1 Alloy STL

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SECTION 4 - MAINTENANCE


4.3.2 Remove the crosshead from the pump as follows (refer to figures 10,11 & 12):

1. Disconnect motor power supply.
2. Remove covers (6083 and 6085). Drain oil from pump casing.
3. Loosen plunger adapter, shown in the liquid end manual.
4. Remove liquid end from pump drive.
5. Set stroke at 20% and rotate worm until crank is horizontal. Loosen connecting rod (375) set screws. (Use wrench #2110036003).
6. Loosen sliding shoe nut (391) and remove sliding shoe set screw (405) from sliding shoe (385).
7. Slowly remove crosshead assembly from liquid end side of pump. Be careful not to lose sliding shoe (in crosshead slot). Take care as well not to damage crosshead oil seal (480).

4.3.3 Remove gear housing from pump drive as follows:

1. Disconnect motor power supply.
2. Drain oil from pump casing.
3. Loosen connecting rod (375) set screws and unscrew tension bearing on end of connecting rod from the crank (220). (Use wrench #2110036003).
4. Unbolt and remove motor and motor adapter (455) from pump casing (55).

5. Set capacity adjustment to 0% stroke.
6. Using wrench #2110036001 remove bearing adjuster (431).
7. Loosen the trunnion thread lock set screws.
8. Support gear housing assembly in position. Remove motor side trunnion (330) with wrench #2110036002. Press tapered roller bearing cup from trunnion and remove worm shaft oil seal (421).
9. Withdraw worm shaft from casing. (Bearing cones will come away with shaft; remaining bearing cup may stay in trunnion still in casing).
10. Remove second trunnion in same manner as motor side trunnion. Pull bearing cup from trunnion.
11. Remove nylon thread lock inserts by tightening the trunnion thread lock set screws until the inserts drop through the trunnion bores; then remove the set screws.
12. Lift gear housing (200) from pump casing. To disassemble gear housing assembly, remove crank nut (280) from crank shaft (220) and pull components from crank shaft.
13. Back OFF stroke locking screw (110). Turn stroke adjustment screw (102) counterclockwise to remove it from pump casing. If the stroke adjustment screw is removed, its O-ring seal (103) should be replaced.

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SECTION 4 - MAINTENANCE

4.4 REASSEMBLY

4.4.1 Pump Drive

Review drawings and then install gear housing in pump casing as follows. Thoroughly clean all parts for reassembly.

1. Reassemble gear housing components as follows:
 - a). The distance between the worm shaft lateral center line through the gear housing conical bores and the flat circular bearing face against which the crank bears during rotation is machined to hold 4.744: (120.5 mm) mean tolerance (Dimension A) on gear housing (200).
 - b). Find machined hub length (Dimension A) stamped on rough cast side of the crank (220).
 - c). The distance between the worm gear radial center line and the inboard end of the worm gear hub (dimension C) is 1.562" (39.67 mm). This dimension is held on the side of the gear on which the part code number is stamped.
 - d). Subtract Dimensions B and C from Dimension A. The difference is the thickness of shims (240) required to space the worm gear center line under the center of the worm.
 - e). Assemble the crank hub into the gear housing bore. Using the thickness of shims calculated in step d, insert the crankshaft through the front of the crank while placing the shims between the closely held side of the worm gear and the crank. Insert the crank shaft entirely through the assembly.
 - f). Place housing on a work surface so that the weight of the assembly forces the crank against the bearing surface of the housing. Assemble an excessive number of shims (240) over the crankshaft and against the hub of the worm gear, then assemble the crankshaft rear bearing (270) and clamp in place with crank nut (280). Measure the resulting distance between the rear face of the gear housing and the inside surface of the bearing with a feeler gage.
 - g). Subtract 0.002-0.003" (0.051-0.076 mm) from the measurement obtained in step f. The resulting figure is the thickness of shims to be removed to provide the end play required for rotational clearance. Replace the rear bearing (270) and nut (280) and tighten nut securely against bearing face.
2. Heavily coat both sides of the trunnion conical sleeve bearings (310) with grease. Push the bearings into the gear housing bores so that the grease coating retains each in place.
3. Slowly lower gear assembly into pump casing (with a hoist) while carefully aligning lead screw keys (290) on either side of stroke adjustment screw (102).
4. Align holes in gear housing with trunnion bores in pump casing. Thoroughly clean trunnion outside threads and mating threads in housing with solvent. Apply Loctite® to trunnion outside threads and install trunnions (330) in casing. Turn trunnions in evenly to engage sleeve bearings in gear housing. Take care to seat sleeve bearings in their bores.
5. Remove crosshead from pump casing (see "Disassembly"). Set capacity adjustment to 0% stroke. Insert centering tool #2110035000 in the crosshead bore with its point close to crankshaft (220). Adjust the two trunnions and the stroke adjustment screw until the center hole in the crankshaft aligns with the point of the tool.



SECTION 4 - MAINTENANCE

6. Using wrench #2110036002 and adapter #5411-001-002, alternately tighten trunnions until each is torqued to 150 ft.-lb. (203 N-m) and gear housing is still centered as in step 5.
7. Apply Loctite® sparingly to bearing cup outside diameters. Install bearing cup in closed trunnion and install the worm shaft with bearing cone seated in bearing cup in trunnion. Install motor side bearing cup in open trunnion.
8. Press oil seal (421) into bearing adjuster (431).
9. Ensure bearing adjuster threads and inside threads of open trunnion are completely cleaned of grease. Apply Loctite® sparingly to bearing adjuster outside thread and install bearing adjuster with wrench #2110036001. Be careful not to cut oil seal on shaft keyway edges. Ensure proper gear set tooth engagement and bearing seating by rotating worm while tightening bearing adjuster until snug. After bearing cups are seated, back out bearing adjuster 1/2 turn, then tighten to allow only 0.002- 0.003" (0.051-0.076 mm) lateral running clearance for worm shaft (check with dial indicator from side of pump casing to end of worm shaft).
10. Now let pump sit undisturbed for at least eight hours at 70°F to allow Loctite® to set up.
11. After Loctite® has hardened, coat motor adapter flange bolt threads with liquid sealing compound (e.g., **Permatex® #2**, non-hardening type) and install motor and motor adapter (455) to pump casing.


4.4.2 Reassemble crosshead in casing as follows:

1. Make certain crosshead ball-check is in place in bottom of crosshead bore. Then, with sliding shoe (385) in crosshead keyway, install crosshead into crosshead bore, aligning sliding shoe with the hole for its set screw.
2. Install sliding shoe set screw (405) in place in casing. Tighten set screw till its dog point seats in the sliding shoe against the crosshead, then back out the set screw 1/4 turn to allow free lateral movement of the crosshead. Lock set screw in place with locknut (391).
3. Set stroke adjustment at 20%. Position crank (220) horizontal and move the crosshead toward the crank so that connecting rod ball can seat in the crank bearing.
4. Thread connecting rod tension bearing into crank arm. Tighten the tension bearing to seat the connecting rod ball in the crank arm. (Use wrench #2110036003).
5. Loosen the tension bearing and retighten till connecting rod is just free enough to rotate with fingers.
6. Tighten both connecting rod set screws.
7. Install liquid end to pump drive.

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SYMPTOMS	POSSIBLE CAUSE	REMEDY
No delivery.	• Liquid level is low.	• Add liquid.
	• Blocked discharge line.	• Clear line.
	• Liquid is frozen.	• Thaw liquid through pumping system.
	• Fuse is blown. Replace fuse.	• Replace fuse.
	• Open thermal overload device in starter.	• Reset device.
	• Broken wire.	• Locate and repair.
	• Low voltage.	• Investigate and correct (wiring may be too light).
	• Pump not primed.	• Allow suction line and pump head to fill with liquid before pumping against pressure.
Insufficient delivery.	• Incorrect capacity adjustment.	• Readjust capacity setting.
	• Incorrect pump speed.	• Match line voltage and frequency to pump motor data plate.
	• Starved suction.	• Increase piping size or suction head.
	• Leaky suction piping.	• Repair piping.
	• High suction lift.	• Rearrange equipment to decrease lift.
	• Liquid near boiling.	• Cool liquid or increase suction head.
	• Leaky packing.	• Adjust or replace packing.
	• Leaky safety valve in discharge line.	• Repair or replace valve.
	• High liquid viscosity.	• Reduce viscosity (e.g., heat or dilute liquid), or consult MiltonRoy for a special check valve options.
	• Worn or dirty check valve seats.	• Clean or replace.

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SYMPTOMS	POSSIBLE CAUSE	REMEDY
Erratic pump delivery.	• Leaky suction piping.	• Repair piping.
	• Leaky safety valve.	• Repair or replace valve.
	• Insufficient suction head.	• Raise suction tank level or pressurize tank.
	• Liquid near boiling.	• Cool liquid or increase suction head.
	• Worn or dirty check valves.	• Clean or replace.
	• Clogged or dirty line strainer.	• Clean strainer.
Motor overheating. (Note: Totally enclosed and explosion proof motors run hotter than open motors.)	• Wrong or insufficient gear case lubricant.	• Check oil level and type. Replace questionable lubricant.
	• Tight or dry packing.	• Adjust and lubricate packing.
	• Operation beyond rated capacity.	• Constrain operation to specifications.
	• Incorrect power supply.	• Match line voltage and frequency to pump motor data plate.
	• Misalignment.	• Check alignment of moving parts.
	• Over-tightened bearing adjuster.	• Remove and properly reinstall bearing adjuster.
Oil leakage around worm shaft.	• Damaged or worn oil seal.	• Replace seal.
Oil leakage around trunnion.	• Insufficient Loctite® applied at assembly.	• Disassemble/clean replace Loctite®.
Oil leakage around cross-head.	• Damaged or worn seal	• Replace seal.
Incorrect zero stroke indication.	• Maladjusted stroke adjusting micrometer hand knob	• Set pump to zero stroke. (At zero stroke, minimum plunger travel occurs when motor is running.) Loosen stroke adjusting hand knob setscrew, set hand knob to zero, and retighten setscrew.

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SYMPTOMS	POSSIBLE CAUSE	REMEDY
Minimum stroke limitation.	<ul style="list-style-type: none"> • Misaligned gear housing. 	<ul style="list-style-type: none"> • Disassemble pump and reassemble properly aligned.
Gear noise.	<ul style="list-style-type: none"> • Excessive backlash. 	<ul style="list-style-type: none"> • Adjust backlash or replace gears.
	<ul style="list-style-type: none"> • Incorrect worm shaft lateral running clearance. 	<ul style="list-style-type: none"> • Adjust shaft lateral running clearance.
	<ul style="list-style-type: none"> • Worn bearings. 	<ul style="list-style-type: none"> • Replace bearings.
	<ul style="list-style-type: none"> • Wrong or insufficient lubricant. 	<ul style="list-style-type: none"> • Replace or replenish lubricant.
Loud knock with each stroke.	<ul style="list-style-type: none"> • Insufficient torque on trunnions. 	<ul style="list-style-type: none"> • Re-torque trunnions.
	<ul style="list-style-type: none"> • Loose crank nut. 	<ul style="list-style-type: none"> • Tighten nut.
	<ul style="list-style-type: none"> • Loose or worn connecting rod tension bearings. 	<ul style="list-style-type: none"> • Tighten or replace bearings.
	<ul style="list-style-type: none"> • Worn conical sleeve bearings. 	<ul style="list-style-type: none"> • Replace bearings.
	<ul style="list-style-type: none"> • Excessive gear set wear. 	<ul style="list-style-type: none"> • Replace gear set.
	<ul style="list-style-type: none"> • Loose clevis. 	<ul style="list-style-type: none"> • Tighten clevis.
Rocking gear housing.	<ul style="list-style-type: none"> • Worn stroke adjusting screw or keys. 	<ul style="list-style-type: none"> • Replace worn parts.
Crosshead hesitation.	<ul style="list-style-type: none"> • Loose tension bearing. 	<ul style="list-style-type: none"> • Remove and inspect connecting; reinstall or replace and secure tension bearing.
Crosshead rotation.	<ul style="list-style-type: none"> • Dog point set screw not seated in crosshead sliding shoe. 	<ul style="list-style-type: none"> • Remove crosshead, examine for scoring; polish smooth and reinstall.

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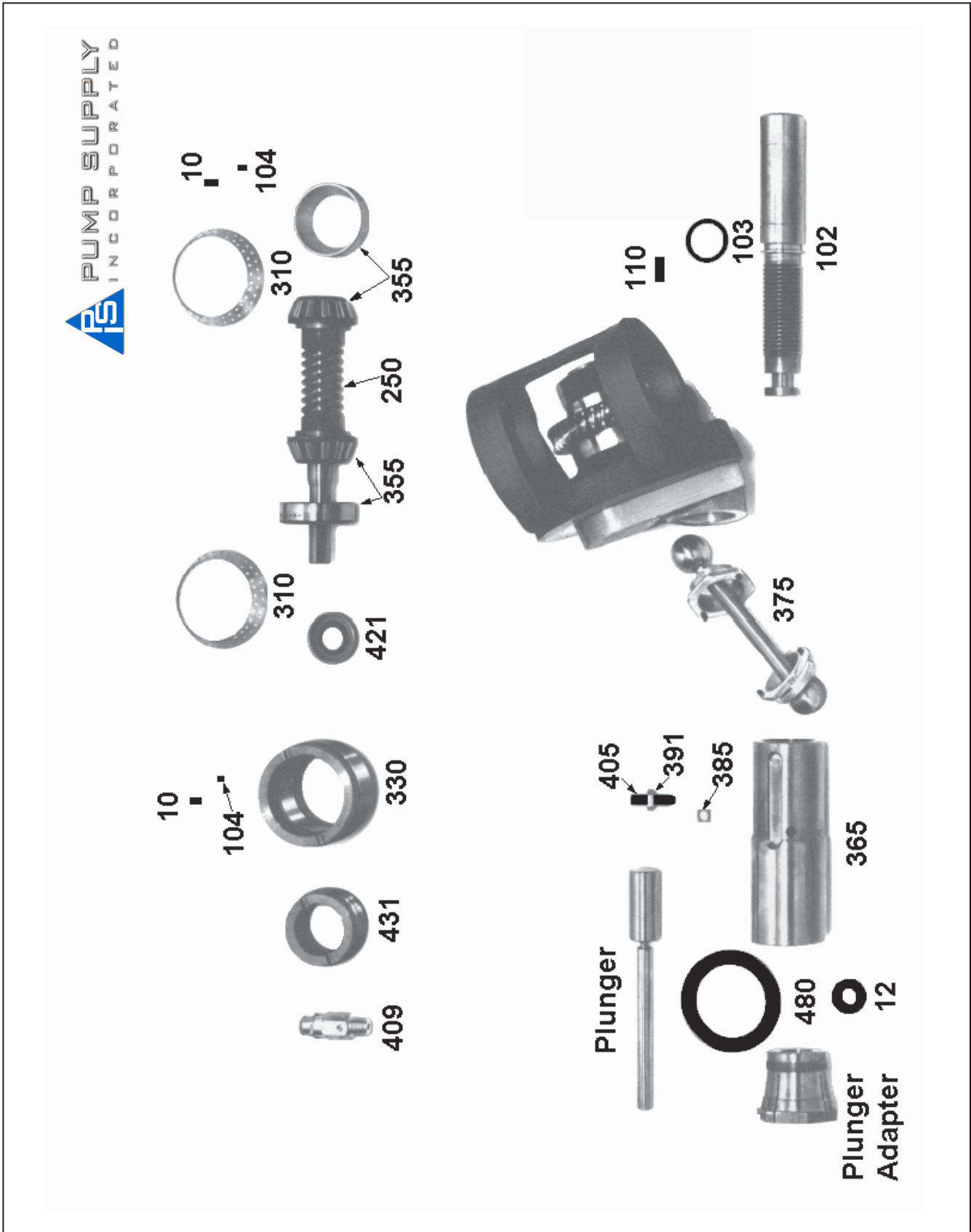


Figure 10. Pump Drive Parts

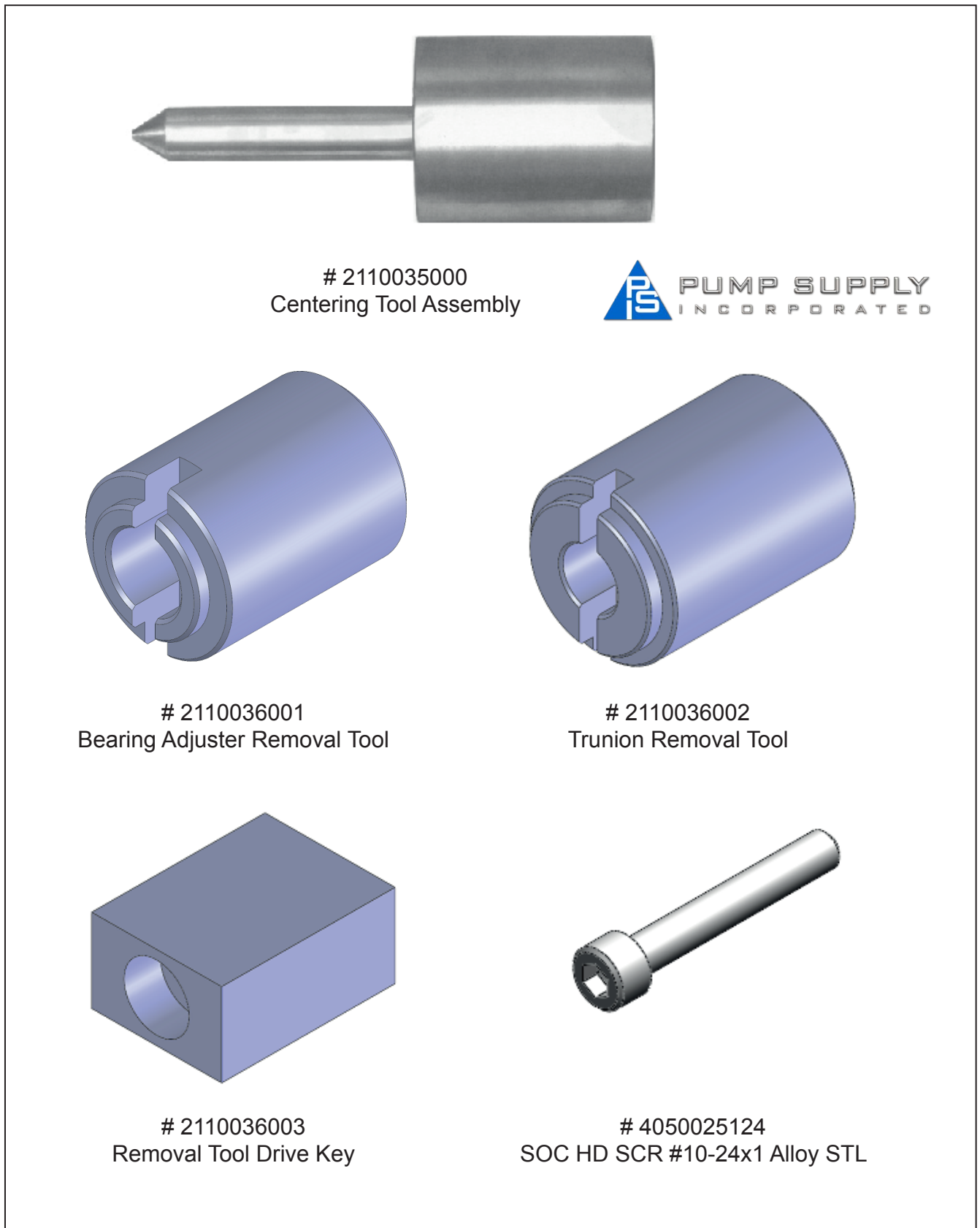


Figure 11. Special Tools

SECTION 6 - PARTS

6.1 GENERAL

1. This section gives information regarding replaceable components.

6.2 ILLUSTRATED PARTS LIST

1. Figure and Item Number Column

- a) The item numbers shown in the detailed parts list correspond to the item numbers appearing on the exploded view illustration. To find an unknown part number, locate the part on the illustration and note the item number. Look for the item number on the detailed parts list. The part number is on the same line. A dash (-) precedes non-illustrated item numbers.

2. Description Column

- a) The name of the item is in the description column.

3. Part Number Column

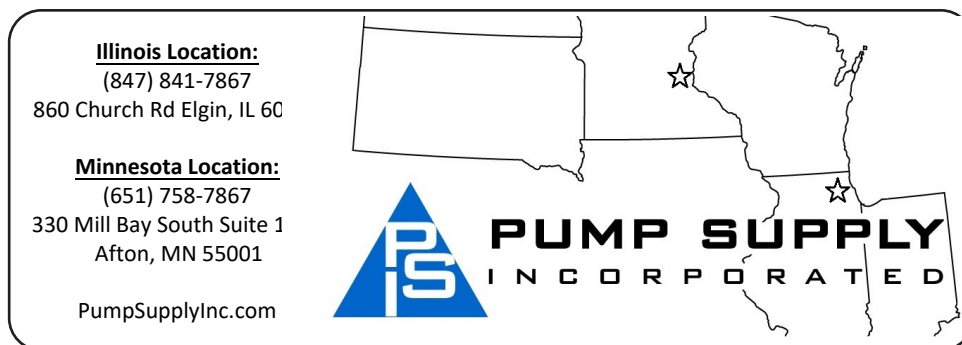
- a) The supplier's part number is listed in the part number column.

4. Material / SPM Column

- a) The material used to manufacture the part is listed in the material / SPM column.
- b) The strokes per minute is listed for all worm and shaft assemblies in the material / SPM column.

5. Quantity Column

- a) The numbers appearing in the quantity column are the total quantity of the listed part required in its immediate assembly.



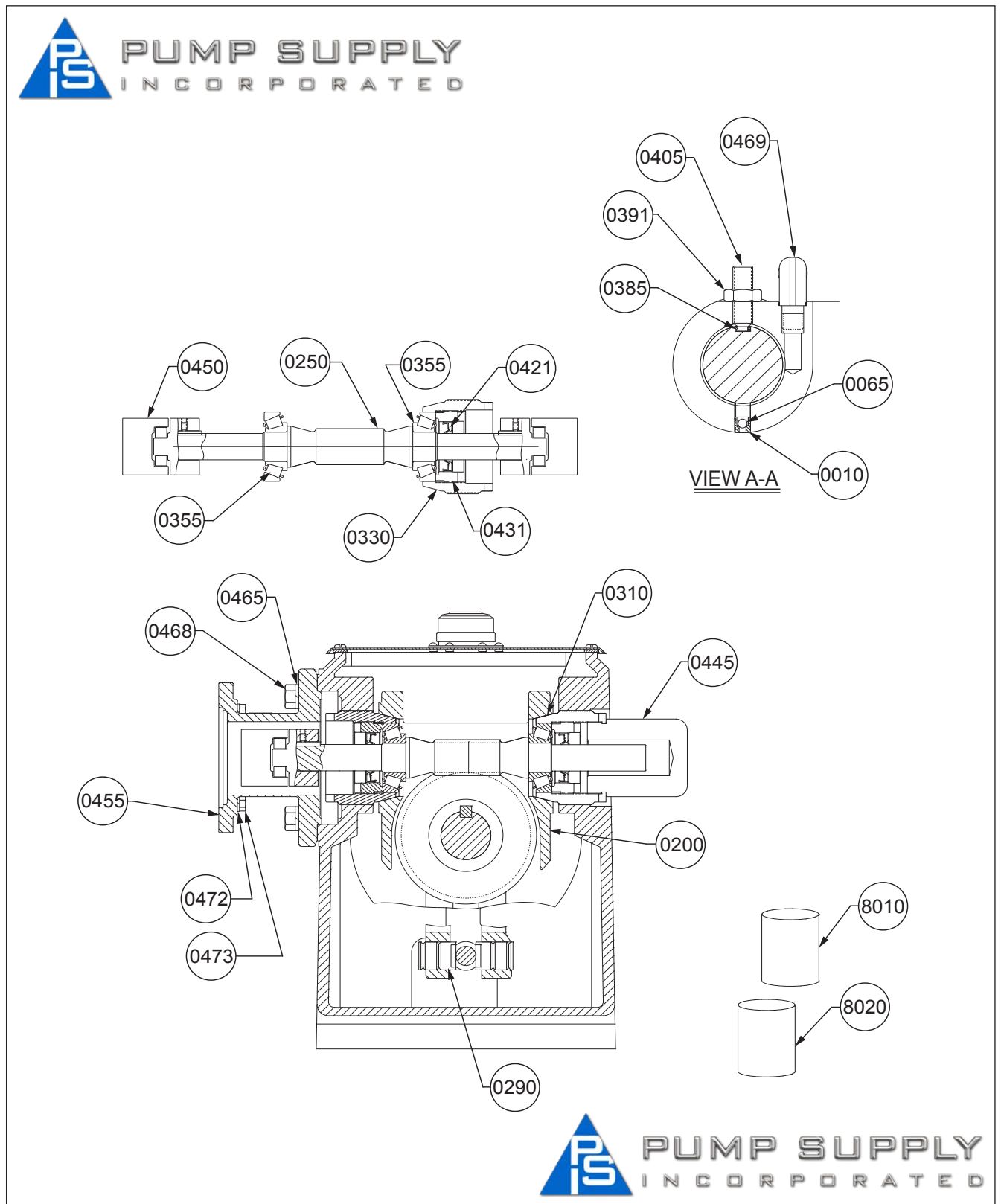


Figure 12. Drive End View (DWG 102-2285-000)(Sheet 1 of 2)

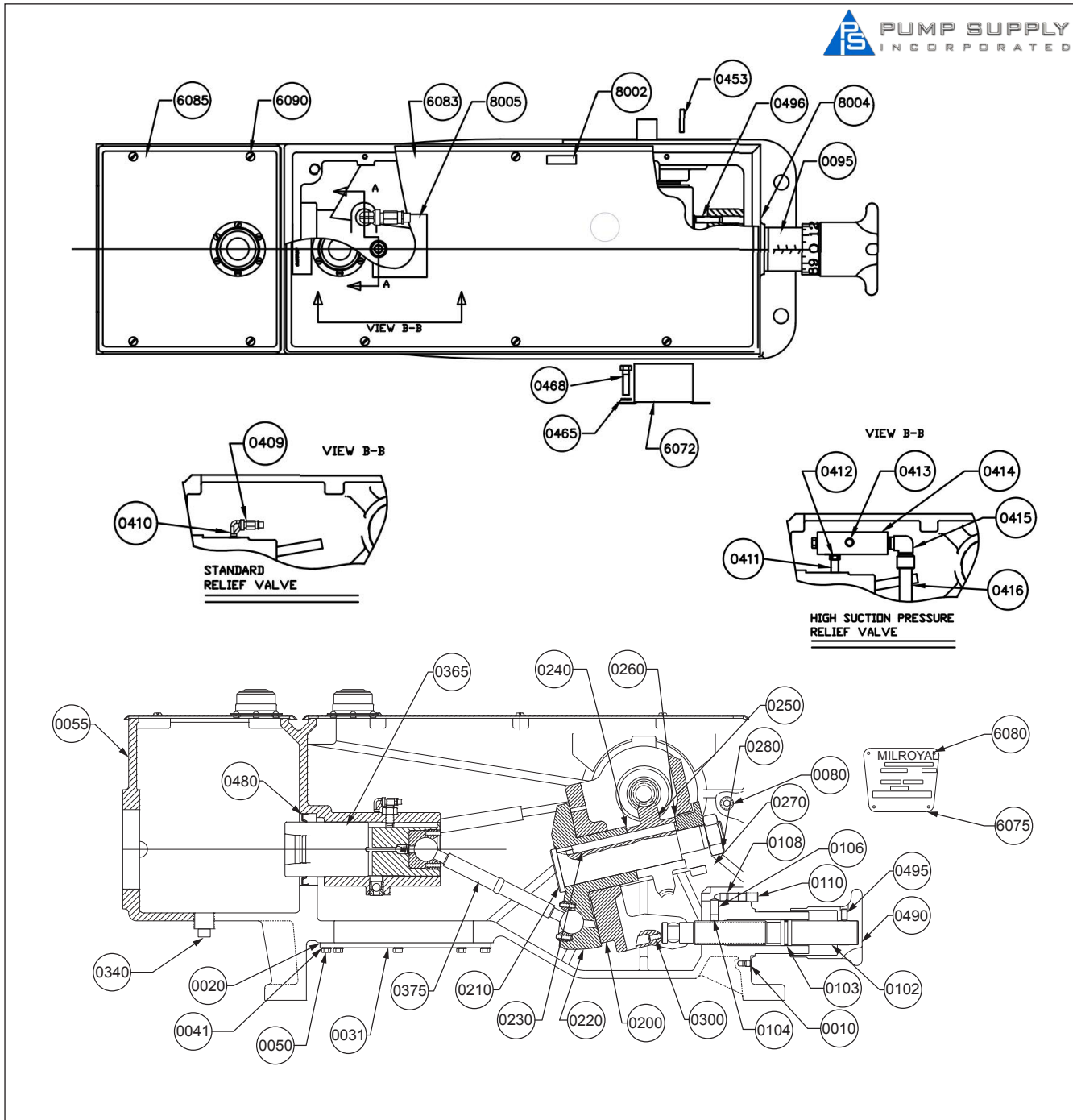


Figure 12. Drive Side and Top Views (DWG 102-2285-000)(Sheet 2 of 2)

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6.3 MILROYAL® C DRIVE.



FIGURE NUMBER	ITEM NUMBER	DESCRIPTION	PART NUMBER	QTY	OPTIONS
12	10	Soc Set Screw CPT 3/8-16 X 3/8" Steel	4050045034	3	
	12	Magnet	4060227000	1	
	20	Gasket	2250076000	1	
	31	Bottom Covers	2810180006	1	
	41	Lock Washer 5/16"	4040040028	12	
	50	Hex Head Screw 5/16 X 3/4"	4050017091	12	
	55	Drive Housing, All HPD, Std. Operating Pressure	2810179301	1	
	55	Drive Housing, All HPD, High Suction Pressure	2810179401	1	
	65	Ball 1/2" 440SS	4070014150	1	
	80	Plug 1/2" NPT Socket Hex Head, 302SS	4023522000	2	
	95	Stroke Plate	2530009062	1	
	102	Lead Screw, Steel	2560040006	1	
	103	O-Ring for Lead Screw	4080095111	1	
	104	Lock Insert-Touches Lead Screw	2430028274	1	
	106	Locking Insert-Touches Locking Screw (Item 110)	2430031039	1	
	108	O-Ring 2-012 Buna N 70 Duro	4080109091	1	
	110	Locking Screw, Steel	2560012006	1	
	200	Gear Housing Mod C	2810167001	1	
	210	Crank Shaft	2680012006	1	
	220	Crank	2160003062	1	
	230	Crank Key	2110025006	1	
	240	Arbor Spacers	4040115011	1	
	240	Arbor Spacers	4040115031	1	
	240	Shim Wash Keyed 2.25 X 3.25 X 0.01	4040115101	1	
	250	Worm & Gear Set 15.5:1 Dbl Ext	2520024400	1	
	250	Worm & Gear Set 12.5:1 Dbl Ext	2520024100	1	
	250	Worm & Gear Set 20.5:1 Dbl Ext	2520024500	1	
	250	Worm & Gear Set 24.5:1 Dbl Ext	2520024200	1	

- Items Not Shown

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FIGURE
NUMBER ITEM

	250	Worm & Gear Set 40:1 Dbl Ext	2520024600	1	
	250	Worm & Gear Set 9.66:1 Dbl Ext	2520024000	1	
	250	Worm & Gear Set 9.66:1 Dbl Ext 170SPM@1725RPM	2520024500	1	
	260	Shim	2190026106	1	
	270	Crank Shaft Bearing	2370019062	1	
	280	Hex Jam Nut 1-1/2-12-Unf.	4050237021	1	
	290	Lead Screw Key	2110052006	2	
	300	Socket Set Screw 5/16 - 18 X 1 Nyik	4050239114	2	
	310	Sleeve Bearing Bronze	2370020052	2	
	330	Open Trunnion	20242	1	
	340	Plug 1" NPT Sq. Head	4020009024	1	
	355	Tapered Roller Bearing	4090081000	2	
	365	Crosshead Steel, Assy, Std. Operating Pres- sure, Sold as Assy Only	2100004000	1	
	365	Crosshead 316SS, Assy, Std. Operating Pressure, Sold as Assy Only	2100004016	1	
	365	Crosshead, Assy, High Suct Pres, Sold Assy Only	22858	1	
	375	Connecting Rod Assembly, Std.	2140019000	1	
	375	Connecting Rod Assembly, High Suction Pressure	2140023000	1	
	377	Set Screw	4050043104	4	
	385	Sliding Shoe, Steel	2610002006	1	
	391	Hex Nut 1/2 - 13 NC 18.8SS	4050068012	1	
	405	Set Screw 1/2 - 13 X 1-1/4 Steel	4050226054	1	
	409	Relief Valve, Watts	4070125000	1	
	411	Nipple, 1/4 X 2"	4020050031	1	
	412	Hex Pipe Bushing 3/8 X 1/4 Steel	4020001023	1	
	413	Pipe Plug 3/8"	4020011033	1	
	414	Oil Relief Valve 375 PSI and 750 PSI, Body	41112	1	
	414	Oil Relief Valve 375 PSI and 750 PSI, Car- tridge	41113	1	
	414	Oil Relief Valve 200 PSI	4070125000	1	

- Items Not Shown



FIGURE
NUMBER ITEM

	415	Elbow, 3/8"	SS-6-SE	1	
	416	Nipple, 3/8"	4020051033	1	
	421	Shaft Seal, 2 Required for Duplex	4080075010	1	
	431	Bearing Adjuster	2370014006	1	
	431	Bearing Adjuster, Std Operating Pressure	2370014006	1	
	445	Shaft Cover, (Duplex Pumps)	20244	1	
	450	Coupling L-100 1-3/16 X 1-3/16, (Duplex Pumps)	4100068070	1	
	450	Coupling L-100 1-3/16 X 5/8, (Frame 56C Mount)	4100068230	1	
	450	Coupling L-100 7/8 X 1-3/16, (Frame 143/145TC 182/184C)	4100068200	1	
	450	Coupling L-100 1-3/16 X 1-1/8, (Frame 182/184TC)	4100068240	1	
	450	Coupling L-100 1-3/16 X 1-3/8, (Frame 213/215TC)	4100068250	1	
	450	Coupling L-150 1-3/16 X 24mm, (Frame Metric 90)	4100129080	1	
	453	Crank Key	2110018406	1	
	455	Flange Adapter, (Frame 56C Mount)	2720035001	1	
	455	Flange Adapter, (Frame 143/145TC, 182/184C)	2720035001	1	
	455	Flange Adapter, (Frame 182/184TC, 213/215TC)	2720036101	1	
	455	Flange Adapter, (Frame Metric 90)	2720133000	1	
	455	Flange Adapter, (Frame Metric 100)	3050331030	1	
	455	Flange Adapter, (Frame Metric 132)	3050331040	1	
	465	Spring Lock Washer, 5/8 18.8SS, (All Frames)	4040044022	4	
	468	Hex Head Screw, 5/8 - 11 X 1, Steel, (Duplex Pump Coupling Guard)	4050021111	4	
	468	Hex Head Screw, 5/8 - 11 X 2, Steel, (All Frames)	4050021161	4	
	472	Spring Lock Washer, 3/8 18.8SS (Frame 56C Mount)	4040041022	4	

- Items Not Shown

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FIGURE
NUMBER ITEM


	472	Spring Lock Washer, 3/8 18.8SS, (Frame 143/145TC 182/184C)	4040041022	4	
	472	Spring Lock Washer, 1/2 18.8SS, (Frame 182/184TC, 213/215TC)	4040043022	4	
	472	Spring Lock Washer, 10mm 18.8SS, (Frame Metric 90)	64340009015	4	
	473	Hex Head Screw, 3/8 - 16 X 1-1/4, (Frame 56C Mount)	4050018136	4	
	473	Hex Head Screw, 3/8 - 16 X 1-1/4, (Frame 143/145TC 182/184C)	4050018136	4	
	473	Hex Head Screw, 1/2 - 13 X 1-1/24, (Frame 182/184TC, 213/215TC)	4050020144	4	
	473	Hex Head Screw, M10 X 30 8.8, (Frame Metric 90)	64350035694	4	
	480	Oil Seal, Crosshead	4080035010	1	
	490	Stroke Adjust Knob	2550038015	1	
	495	Socket Set Screw, 3/8 - 16 X 1/2, Steel	4050045054	2	
	496	Socket Set Screw, 3/8 - 16 X 1-1/2	4050045114	1	
	6072	Coupling Guard, Std Operating Pressure	2490065006	1	
	6075	Nameplate, Milroyal B and C	20662	1	
	6080	Stick Screw 5/32 Steel	4050280000	4	


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TABLE OF EQUIVALENTS


1 atmosphere	Equals	1.0333 kilograms/square centimeter
		101.33 kilopascals
		1.0135 bars
1 Btu/hour	Equals	0.2928 Watts
Degrees Fahrenheit	Equals	1.8° Celsius + 32
1 Engler degree	Equals	7.45 square millimeters/second
1 foot	Equals	30.48 centimeters
		12 inches
1 Ford cup #4	Equals	3.76 square millimeters/second
1 gallon (U.S.)	Equals	0.1337 cubic feet
		0.8333 Imperial gallons
		3.785 liters
		4 quarts
1 gallon/hour (U.S.)	Equals	0.003785 cubic meters/hour
		0.002228 cubic feet/minute
1 horsepower	Equals	745.7 Watts
1 inch	Equals	2.540 centimeters
1 inch of mercury	Equals	0.03442 kilograms/square centimeter
		3376.5 Pascals
		0.4897 pounds/square inch
1 pint (liquid)	Equals	0.4732liters
		16 ounces
1 pound/square inch	Equals	0.06804 atmospheres
		0.06897 bars
		0.07029 kilograms/square centimeter
		6894.8 Pascals
1 Redwood Admiralty	Equals	2.340 square millimeters/second
1 Redwood Standard	Equals	0.237 square millimeters/second
1 Saybolt Furol	Equals	2.16 square millimeters/second
1 Saybolt Second Universal	Equals	0.216 square millimeters/second

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The logo for Pump Supply Incorporated features a blue triangle on the left containing the white letters 'P' and 'S' stacked vertically. To the right of the triangle, the words 'PUMP SUPPLY' are written in a bold, black, sans-serif font, with 'INCORPORATED' in a smaller, spaced-out font below it. The entire logo is overlaid on a map of Illinois and Minnesota, with a star in each state indicating a location.

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