



NATIONAL OILWELL VARCO

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CX-5

BEAR™ Reciprocating Plunger Pump Manual

Foreword...

This manual is published as a guide for the normal operation of your **NATIONAL OILWELL VARCO** equipment. Because of the many factors, which contribute to the function or malfunction of this machinery, and not having complete knowledge of each factor or combination of factors, we cannot detail all facets of this subject. We must therefore confine the scope of this presentation and when situations encountered are not fully encompassed by complete, understandable instructions, these situations must be referred to the manufacturer.

When other than routine servicing is necessary, it can be most efficiently performed if the unit is removed to an area of adequate space where an over-head crane, hydraulic lift, bearing pullers, impact tools, etc., are accessible.

The dimension and tolerances specified in this publication are those desirable for the most efficient operations of the equipment. When components become worn or when new parts are introduced into a worn unit, it may not be possible or economically feasible to reestablish such strict alignment and correct all dimensional deviations.

Improvements in design, engineering, materials, production methods, etc., may necessitate changes in these products and result in inconsistencies between the content of this publication and the physical equipment. We reserve the right to make these changes without incurring any liability or obligation beyond that which is stipulated in the purchase contract.

The pictures, photographs, charts, diagrams, drawings, verbal contents and specifications are not to be construed as giving rise to any warranty on the part of NATIONAL OILWELL VARCO. National Oilwell Varco makes no warranty, either expressed or implied beyond that which is stipulated in the purchase contract.

BEAR™ pumps are manufactured by National Oilwell Varco in Tulsa, Oklahoma. A serial number is stamped on each pump, fluid end and power end. Please refer to this serial number when ordering parts.

The right and left sides of the pump are determined by viewing the pump from the back of the power end, looking toward the fluid end. This position is also used to identify the plungers and their related parts as being number one, two and three, beginning at the left side of the pump.

! CAUTION ! CAUTION ! CAUTION !

EXERCISE SAFETY IN ALL PERFORMANCES: DO NOT IGNORE ANY WARNINGS; USE ONLY APPROVED METHODS, MATERIALS AND TOOLS. DO NOT PERMIT ANY FUNCTION OF QUESTIONABLE SAFETY; ACCIDENTS ARE CAUSED BY UNSAFE ACTS AND UNSAFE CONDITIONS.

SAFETY IS YOUR BUSINESS AND YOU ARE INVOLVED.

! WARNING ! WARNING ! WARNING !

BEFORE PERFORMING ANY SERVICE FUNCTION, BE CERTAIN THAT THE UNIT IS SEPARATED FROM ITS POWER SOURCE OR THAT THE POWER SOURCE IS LOCKED-OUT TO PREVENT ANY FORM OF ENERGY FROM ENTERING THE EQUIPMENT. THIS WOULD INCLUDE ELECTRICAL OR MECHANICAL ENERGY INTO OR FROM THE PRIME MOVER(S), PNEUMATIC ENERGY FROM THE COMPRESSOR/AIR SYSTEM, ETC.

! WARNING ! WARNING ! WARNING !

FAILURE TO OBSERVE THE WARNINGS AND NOTES OF CAUTION IN THIS PUBLICATION CAN RESULT IN PROPERTY DAMAGE, SERIOUS BODILY INJURY, OR DEATH.

! ATTENTION - NOTICE - IMPORTANT !

THESE TERMS ARE USED TO DRAW ATTENTION TO ACTION THAT WILL CAUSE DAMAGE TO THE PUMP, COMPONENTS OR ATTACHMENTS.

! WARNING ! WARNING ! WARNING !

BEFORE SERVICING PUMPS:

1. SHUT DOWN OR DISENGAGE THE PUMP POWER SOURCE.
2. SHUT DOWN ALL PUMP ACCESSORY EQUIPMENT.
3. RELIEVE OR "BLEED OFF" ALL PRESSURE FROM THE PUMP FLUID CYLINDER(S).

FAILURE TO SHUT DOWN POWER AND RELIEVE PRESSURE FROM THE PUMP BEFORE SERVICING CAN RESULT IN SERIOUS PERSONAL INJURY AND PROPERTY DAMAGE.

! WARNING ! WARNING ! WARNING !

PERSONAL PROTECTION EQUIPMENT MUST BE USED WHEN WORKING ON OR AROUND THE PUMP. CARE MUST BE TAKEN TO SAFE GUARD PERSONEL AND THE EQUIPMENT.

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1.0 SYSTEM DESIGN CONSIDERATIONS AND GUIDELINES

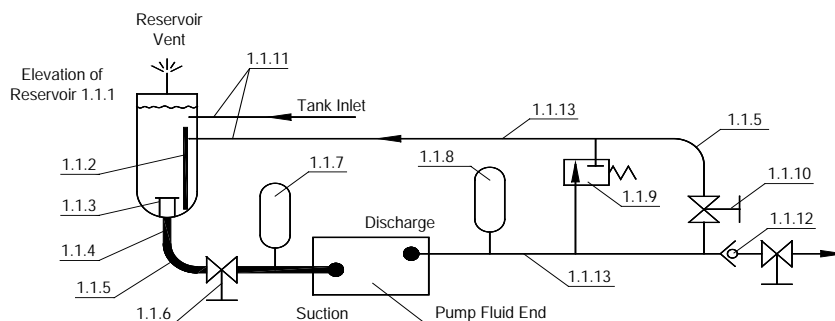
Careful planning of the plant layout will save considerable time and expense, both initially when the installation is made and later during the operation of the unit. The design guidelines provided for in this section are Hydraulic Institute recommendations and criteria established by experienced designers of systems containing reciprocating pumps.

The pump manufacturer cannot assume responsibility of system design into which the pump is installed. That responsibility must lie with the system designer. The guidelines that follow are offered only as an aid to those involved in the system design.

1.1 DESIGN CHECKLIST

The following outlines the basic requirements for an installation

- 1.1.1 Insure there is enough suction pressure to overcome all acceleration and friction losses and still provide the pressure needed for the pump.
- 1.1.2 Has a weir/baffle plate been utilized to help release trapped gases?
- 1.1.3 Has a vortex breaker mechanism been utilized in the system?
- 1.1.4 Is suction velocity within recommended limits? If marginal, is a larger suction line within system limit? (see hydraulic institute standards)
- 1.1.5 Have all unnecessary piping bends been minimized? (use long radius bends where possible)
- 1.1.6 Are suction valves the full open type?
- 1.1.7 Is there a suction stabilizer (or at least provision for one) near pump suction?
- 1.1.8 Is there a pulsation dampener (or at least provision for one) near pump discharge?
- 1.1.9 Is the relief valve sized to pass total pump flow at relief valve pressure setting?
- 1.1.10 Is there a capacity control valve in a bypass loop?
- 1.1.11 Are the inlets below minimum fluid levels?
- 1.1.12 Is there a check valve in the discharge piping?
- 1.1.13 Is discharge velocity limited to 3 times section? Is the number of turns limited, and is the line fully supported?



1.2 PUMP MOUNTING

1. Consideration should be given to the location of the equipment with its proximity to the associated equipment, fluid supply, environmental contamination, ease of maintenance, etc.
2. Ensure that crankshaft rotation is over the top, towards the Fluid End. Note: The pump will move fluid regardless of pump rotation; however, Power End lubrication will be insufficient and component life will be reduced.
3. The pump must be mounted level and should be grouted in and be free of strain. This applies to a skid-mounted pump or a pump mounted directly on a concrete base. Use shims if necessary.
4. The skid or foundation must be of sufficient size and design to maintain the equipment free of strain.
5. The equipment must be adequately secured to the foundation. High strength bolts or cap screws with locking devices are generally employed.
6. Avoid environmental contamination by providing the proper disposition of drainage from the crankcase, gear case, chain case, sludge sump and any other lubrication reservoirs as well as from the flushing media sump, the pump cradle, the suction line and the discharge line.

1.3 PRIME MOVER ALIGNMENT

1. The prime mover foundation should follow the same guidelines described in [Section 1.2](#).
2. The sheave of a belt driven pump must be correctly aligned with the prime mover sheave. Care must be used to prevent over-tightening as this will shorten belt life, place the pump in a strain, and cause undue additional loads on the crankshaft and bearings. Sheave sizes should not be smaller than the minimum approved diameter.
3. When connecting a direct-driven pump, the shafts must be correctly aligned. Couplings should not be expected to compensate for avoidable misalignment. With Thomas Flexible Couplings, angular misalignment should not exceed one-half degree. Offset misalignment of the centerlines of the two shafts should not exceed .010" (.254 mm) and should be as small as practical.
4. Follow the recommended alignment procedures provided by the manufacturer of the belts and sheaves or couplings.

1.4 SUCTION SYSTEM GUIDELINES

1.4.1 Suction Pressure Considerations

The inlet pressure required by the pump is a function of pump type, pump speed, fluid end valve springs, viscosity of the fluid being pumped and the vapor pressure of the fluid at the expected temperature. Failure to provide this required pressure will cause cavitation, reduced output and, eventually, complete failure of the system and pump.

The minimum suction pressure required by the pump is published in [Section 6.2](#). This information is based on water at 100°C. A correction factor for viscosity and the addition of the vapor pressure relevant to your application will need to be applied.

Following equation is offered as an aid to the system designer for calculating the amount of suction pressure available at the pump inlet.

$$\text{Pressure Available} = P_a \pm P_z - P_f - P_{vp} - P_{ha}$$

Where:

P_a = Absolute Pressure at surface of liquid in Tank, in psia (kPa abs)

P_z = Pressure due to level of fluid above (+) of below (-) pump inlet, in psi (kPa)

P_f = Friction losses in line, valves, and fittings, in psi (kPa)

P_{vp} = Fluid vapor pressure at pumping temperature, in psia (kPa abs)

P_{ha} = Pressure loss due to acceleration head, (see [Section 1.4.2](#)) converted to psi (kPa)

The pressure available should exceed the pressure required by at least 1 psi (6.9 kPa) to compensate for variations in temperature, atmospheric pressure, and other variables

1.4.2 Acceleration Head

Suction system design for a reciprocating pump requires more consideration than for a centrifugal pump. Based on the fluid in the suction line pulsation (accelerating and decelerating), a certain amount of energy is required to produce the required acceleration. This energy is in addition to the friction loss and is usually referred to as "Acceleration Head". If sufficient energy is not available to accelerate the liquid in the suction line, the liquid will flash, the suction and discharge lines may shake, and the pump will operate loudly and less efficiently. In extreme cases, it can fracture a fluid cylinder with the high pressure surges that occur in the cylinder when the fluid flashes.

To calculate the head required to accelerate the fluid in a short, non-elastic suction line, the following equation is offered as an aid in system design.

$$H_a = \frac{LVnC}{Kg}$$

Where:

H_a = Acceleration Head, in feet, (meters)

L = Length of suction pipe, in feet (meters)

V = Mean velocity of flow in suction line, in ft/sec (m/s)

n = RPM of pump

- C = 0.400 for Simplex, single-acting
 0.200 for Duplex, single-acting
 0.066 for Triplex
 0.040 for Quintuplex
- K = 1.4 for liquid with almost no compressibility (de-aerated water)
 1.5 for amine, glycol, water
 2.0 for most hydrocarbons
 2.5 for relatively compressible liquid (hot oil)
- g = Gravitational Constant, 32.2 ft/s² (9.81 m/s²)

It should be noted that as the pump speed is increased, both n and V increase. Therefore, H_a varies as the square of pump speed. H_a also varies directly with L . *Installation of a suitable suction stabilizer near the pump is highly recommended to dampen the effects of acceleration head. Doing so will increase the life of the system and the pump and reduce unnecessary down time.*

1.4.3 Suction Piping Design

While designing the piping layout for your BEAR™ reciprocating pump, consideration should be given to the fact that positive suction head at the pump inlet contributes toward pump efficiency; however, the layout of the piping, the arrangement of the fittings, and restrictions in the suction and discharge lines have an even greater effect. For this reason, all fittings and valves should be full opening; all bends should be of long radius or should be eliminated where possible. Long radius 45° ells should be used, particularly if installed near the fluid cylinder.

1. The suction line should be at least one or two pipe sizes larger than pump suction connections. Use the following for selection of effective pipe size.
2. A triplex pump should have a velocity less than 2 ft/sec for speeds up to 250 RPM, 1-1/2 ft/sec for speeds up to 330 RPM and 1 ft/sec for speeds above 330 RPM.
3. For a quintuplex, these velocities may be increased 70% or as determined by the system design
4. Eliminate any rise or summit in the suction line where air or vapor can collect.. (No high points unless vented) Air pockets in the line will cause erratic pump operation and may cause a complete loss of prime.
5. Use eccentric reducer at pump cylinder with flat side up.)
6. All systems should contain a minimum number of turns. Necessary turns should be accomplished with long-radius elbows or laterals.
7. Do not use meters or other restrictions in the suction line.
8. Provide a full opening gate valve in the suction line adjacent to the supply tank to permit the line to be drained when necessary. Do not use any type of restricting valve.
9. When necessary to manifold a number of pumps to a common suction, the diameter of the manifold and suction pipe leading from the supply tank must be such that it has a cross sectional area equal to or greater than the area of combined individual suction pipes.

10. When a charging or booster pump is used in the suction line it must have a capacity equal to twice that of the pump output. This is necessary to provide a charging pump with an output great enough to meet the peak volume requirements of the pump during the suction stroke and not act as a restriction in the line.
11. All piping, both suction and discharge, must be solidly and independently supported. The first support must be as close to the pump as practical. This is necessary to prevent placing the pump in a strain and to keep any vibration in the system from acting directly on the pump.
12. Make sure all pipe connections are sealed. Air entering the lines will reduce capacity and cause cavitation
13. It is highly recommended that unions or flanges be installed close to the pump to facilitate fluid cylinder removal and maintenance.
14. A flexible section of hose should be installed between the pump and the rigid section of piping to isolate vibrations as well as allow for ease of maintenance.

1.5 DISCHARGE LINE



ONLY USE PIPE OR HOSE INSIDE OF ITS STATED MAXIMUM ALLOWABLE WORKING PRESSURE (MAWP) RATING. EXCEEDING THIS LIMIT CAN CAUSE THE LINE TO BURST RESULTING IN PROPERTY DAMAGE, SERIOUS BODILY INJURY, OR DEATH.

1. Use a pulsation dampener in the discharge line. It should be placed in the line as near the fluid cylinder as possible and ahead of any bend in the line.
2. Discharge line velocity should not exceed three times the suction velocity. Do not reduce the size of the discharge line below that of the pump outlet until the line has passed through the dampener, and is away from the pump approximately 20 feet (6m).
3. Any bend in the discharge line should be made with long radius 45°ells. Do not use a bend directly adjacent to the fluid cylinder. Avoid using any 90° bends if at all possible.
4. A pressure relief valve must be installed in the discharge line. The relief valve should be set to operate at a pressure no greater than 25% above the maximum rated pressure for the plunger size being used. It should be installed in the line ahead of any valve and be piped so that any flow is returned to the supply tank rather than the suction line. This will prevent possible damage to the suction line and suction dampener. *Note: The return line size should not be smaller than the relief valve port. Do not install any valves between the relief valve and suction tank*
5. All piping, both suction and discharge, must be solidly and independently supported. The first support must be as close to the pump as practical. This is necessary to prevent placing the pump in a strain and to keep any vibration in the system from acting directly on the pump.
6. A by-pass line should be installed to permit the pump to be started without load. This allows oil to circulate and reach all parts in the power end before they are loaded. *Note: It is recommended that the oil temperature be above 30°F (0°C) before load is applied*
7. It is highly recommended that unions or flanges be installed close to the pump to facilitate fluid cylinder removal and maintenance.
8. A flexible section of hose should be installed between the pump and the rigid section of piping to isolate vibrations as well as allow for ease of maintenance.

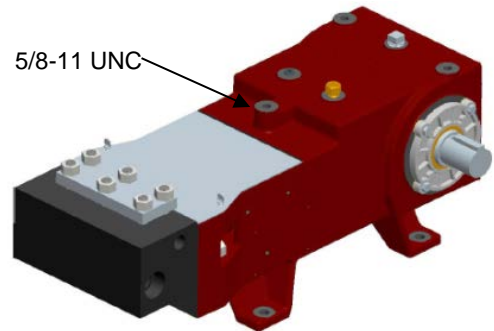
2.0 INSTALLATION, START UP, & OPERATION

2.1 LIFTING

! WARNING ! WARNING ! WARNING !

EXTREME CARE MUST BE MADE WHEN LIFTING THIS PUMP TO AVOID PROPERTY DAMAGE, SERIOUS BODILY INJURY, OR DEATH

1. Use a properly rated strap or chain.
2. Attach a heavy duty forged eye bolt to the threaded port identified in the illustration.
3. Attach a properly rated lifting hook.



2.2 INSTALLATION

1. Inspect the exterior of the unit for any damage that may have occurred during shipment.
2. Remove inspection doors and covers – check the interior of the pump for dirt, rust, water, and foreign objects, particularly if the pump has been in storage. If necessary, clean and wash out the power end with non-toxic, non-explosive solvent.
3. Replace Inspection doors and covers.
4. All studs and nuts of the fluid end should be checked for tightness prior to start-up. Refer to “Assembly Section” for correct torque.
5. Fill the power end with the correct amount of the proper lubricant as detailed in the Lubrication section of this manual.
6. If the pump is equipped with a packing lubricator, assure that the reservoir has an adequate supply of lubricant. Add if necessary and fill the pump lines. Check by breaking connection at stuffing box, working lubricator plunger until oil appears.
7. Mount pump and connect to prime mover (see [Sections 1.2 & 1.3](#)).
8. Connect suction and discharge piping. Make certain the Fluid End is completely purged of air before attempting to operate under pressure.
9. Inspect all fittings and fasteners for tightness. Check all piping for leaks. Tighten or repair as necessary.
10. Check rotation. Direction of rotation must always be such that the crankshaft extension rotates with the top of the shaft moving towards the fluid end of the pump. The direction of crankshaft rotation is also indicated by rotation arrow. *Note: The pump will not lubricate if direction of rotation is reversed. Incorrect hookup of the pump will damage the pumping unit.*

2.3 LUBRICATION

NATIONAL OILWELL VARCO model CX-5 triplex plunger pumps are "splash-gravity" lubricated. The main bearings and crankshaft bearings are fed by splash. Crossheads and crosshead pins are fed through holes in the crossheads and crosshead reservoir. Intermediate rods are lubricated from the splash they receive from the crosshead. If equipped, the packing lubricator is run on an auxiliary pump and is force fed into the stuffing boxes

2.3.1 Power End

Use industrial-type (mild) extreme pressure gear oil. The recommended AGMA numbers for various temperatures of air surrounding the pumps are shown in the following table. The oil should contain a good rust inhibitor.

U.S. UNITS OF MEASURE		
Temperature	AGMA Industrial EP Gear Oil	Capacity
+50°F to +155°F	AGMA No. 6 EP or ASTM/ISO Grade No. 320	3 qt
+20°F to +100°F	AGMA No. 5 EP or ASTM/ISO Grade No. 220	3 qt
-20°F to + 60°F	AGMA No. 2 EP or ASTM/ISO Grade No. 68	3 qt

U.S. UNITS OF MEASURE		
Temperature	AGMA Industrial EP Gear Oil	Capacity
+10°C to +68°C	AGMA No. 6 EP or ASTM/ISO Grade No. 320	2.85 L
-7°C to +38°C	AGMA No. 5 EP or ASTM/ISO Grade No. 220	2.85 L
-29°C to +16°C	AGMA No. 2 EP or ASTM/ISO Grade No. 68	2.85 L

Oil must pour freely at minimum operating temperature. Change oil every six months or as frequently as operating conditions require maintaining a clean, sludge-free oil of proper viscosity

2.3.2 Packing Lubricator

When an automatic lubricator is used in water or oil service, use Rock Drill (Air Drill) oil or steam cylinder oil of proper viscosity. For butane-propane service, use NATURAL castor oil. Set lubricator to feed 5 to 8 drops per minute.

2.4 OPERATIONAL CHECK POINTS

! WARNING ! WARNING ! WARNING !

FAILURE TO ADHERE TO THE FOLLOWING POINTS CAN CAUSE DAMAGE TO PUMP, DAMAGE TO THE SYSTEM, DAMAGE TO PROPERTY, SERIOUS BODILY INJURY, OR DEATH

1. Pump must be a set level for proper lubrication.
2. Make sure pump is filled with clean oil of the proper viscosity. A lubrication chart is provided in [Section 2.3.1](#).
3. Do **not** over-speed the pump.
4. Do **not** use a smaller diameter sheave than is recommended for the pump.
5. Make sure all safety shutdown switches are operating properly.
6. Keep all suction and discharge line valves fully open.
7. If a bypass is used to regulate output, make sure it is set properly.
8. Make sure the pressure relief valve is set properly.
9. Do **not** exceed the pressure rating of the pump for the particular plunger size.
10. Make sure the suction line is tight, as air entering the suction line will cause severe hammering and knocking of the pump.
11. Make sure plunger and intermediate rod connections are tight and locked.
12. Check the plunger packing for correct adjustment as defined in [Section 5.0](#).
13. Check the suction and discharge dampeners for proper charge, as this is very important for long life and good pump operation.
14. Make sure the hex nuts holding the cylinder in place are tight.

2.5 STARTUP

1. Open bypass valve.
2. Open valve at pump suction. *Note: During operation the valve must be fully open. Never throttle the suction line*

! WARNING ! WARNING ! WARNING !

BEFORE ATTEMPTING TO ROTATE EQUIPMENT MANUALLY, BE CERTAIN THAT THE UNIT IS SEPARATED FROM ITS POWER SOURCE OR THAT THE POWER SOURCE IS LOCKED-OUT TO PREVENT ANY FORM OF ENERGY FROM ENTERING THE EQUIPMENT.

3. Assure power to unit is locked out. Remove any necessary guards and rotate the pump one full revolution by hand to be certain all moving parts are free and can move unrestricted.

4. Reattach power supply and apply power slowly and control at low rpm to prime the pump fluid chambers. Check that the direction of rotation
5. Run the pump under no load for a period of time to assure that the Power End is being properly lubricated. Pump should run at no load until oil temperature reaches 30°F. Check gasket joints for leakage
6. Open the valve in the discharge line, increase power, close the bypass valve and observe the following:
 - Check for excessive stuffing box leakage. Depending on type of packing used, some leakage is desirable to insure the plunger is lubricated.
 - Check oil seals for leakage.
 - Check power frame for overheating.
 - Check for fluid leaks at valves.
 - If a stuffing box lubricator is equipped on the pump, adjust rate of injection. Normal rate about 5-8 drops per minute per plunger.

2.6 MAINTENANCE

The following points are intended as a guide to be used in setting up a maintenance program. Good preventive maintenance will pay big dividends in the form of reliable service with a minimum of trouble.

2.6.1 Daily Maintenance

1. Check power end oil level daily. Do not attempt to check the oil with the pump running. Inspect the oil for dirt or contamination and change if necessary. An increase in oil level indicates fluid end leakage into power end. Change oil immediately and check intermediate rod wipers and surface smoothness of rod. Check for plunger packing leakage.
2. Lubricate plunger packing frequently. Packing life can be greatly increased by greasing every four (4) hours with a small amount of grease. Grease is not recommended at pressures above 1200 psi. Use an alternate packing lubricator to drip the proper oil on the plunger for lubrication. (See page 10 for further details).
3. Check lubricator for proper level and operation.
4. Check plunger packing for excessive leakage. Replace packing as required.
5. Check stuffing box adjusting nuts for tightness.
6. Drain plunger leakage sump tanks if required.
7. Flush plunger chamber drain lines with kerosene on power oil pumps and fresh water on salt pumps. This may be done weekly unless salt and paraffin accumulation is severe.
8. Make sure suction and discharge line valves are fully open.
9. Check for leakage between the fluid cylinder and frame or stuffing box to fluid cylinder packing if required.
10. Check all seals for leakage.
11. Check belts or clutch for slippage. If either condition exists, correct immediately.

2.6.2 Monthly Maintenance

1. Drain and refill crankcase a minimum of every six (6) months or as often as required to maintain a clean, sludge-free oil of the proper viscosity.
2. Pull crankcase cover to inspect inside power frame.
3. Clean crankcase air breather with a non-explosive solvent.
4. Check all studs, nuts and cap screws for tightness. Inspect gaskets for leaks; tighten or replace as required.
5. Clean pump. Good housekeeping is a prerequisite to good maintenance.

2.6.3 Storage

If the pump is to be idle for longer than one (1) week, it should be prepared for storage as follows:

1. Drain and clean crankcase thoroughly. Leave drain open and install 90° elbow, pointing downward, to permit air circulation and prevent condensation build-up.
2. Coat all bearings, finished surfaces, and entire inside surface of crankcase with a rust inhibiting oil.
3. Remove plungers and packing, clean and coat with rust inhibiting oil.
4. Remove fluid cylinder valves allowing cylinder to be thoroughly cleaned and drained.
5. Coat entire cylinder, valves and parts, with a rust inhibiting oil.
6. Thoroughly inspect pump and rotate crankcase once each month. Re-coat with rust inhibiting oil where necessary.

2.6.4 Start-Up After Storage

Any pump that has been in storage after field use will need a thorough inspection to make sure it has not been damaged in any way and that all parts are properly in place.

 **! ATTENTION ! ATTENTION ! ATTENTION !** 

FAILURE TO OBSERVE THE FOLLOWING POINTS CAN RESULT IN SERIOUS DAMAGE.

1. Remove all covers on both power end and fluid end; thoroughly clean and inspect all parts and finished surfaces.
2. Check all bearings to make sure they are clean and in good condition.
3. Make sure valves, plungers and packing are properly installed and in good condition.
4. Carefully tighten all bolts, nuts, studs and working connections.
5. Fill power end to the proper level with clean oil of the proper viscosity. Make sure oil is poured into the crosshead reservoir and is worked into all bearings.
6. Fill packing lubricator and pump lines full. Check by breaking connection at stuffing box, working lubricator plunger until oil appears.

2.7 NOISE LEVELS

Noise levels were read using an EXTECH Model 407790 Real Time Octave Band Analyzer located on a tripod. Due to the Multiplex test facility being designed and constructed primarily for performance and development testing, it is not an ideal facility for noise testing. The test facility is constructed within the existing manufacturing plant and located within a confined area. Background noises present in the testing facility include prime movers, electric motor control panels, machine tools, speed reducers, and hydraulic chokes used to induce loads on the pump. Also, noise levels within the manufacturing plant vary depending on time of day and plant capacity levels.

Position 1 was taken from 1m behind the pump and 1.5m off the ground. Position 2 was taken 1m in front of the pump and 1.5m off the ground. Background noise was taken from Position 1. Typical values are as followed.

CENTER BAND FREQUENCIES - HERTZ									
Freq. (Hz)	31.5	63	125	250	500	1000	2000	4000	8000
Position 1	29.2	48.8	64.3	74.8	87.0	85.0	81.2	76.7	71.5
Position 2	29.4	48.0	64.2	70.1	82.5	84.3	80.6	77.2	70.9
Background	31	43	54	57	67	70	70	72	68

 **! WARNING ! WARNING ! WARNING !** 

PROPER EAR PROTECTION SHOULD BE WORN WHILE WORKING ON OR AROUND THE PUMP.

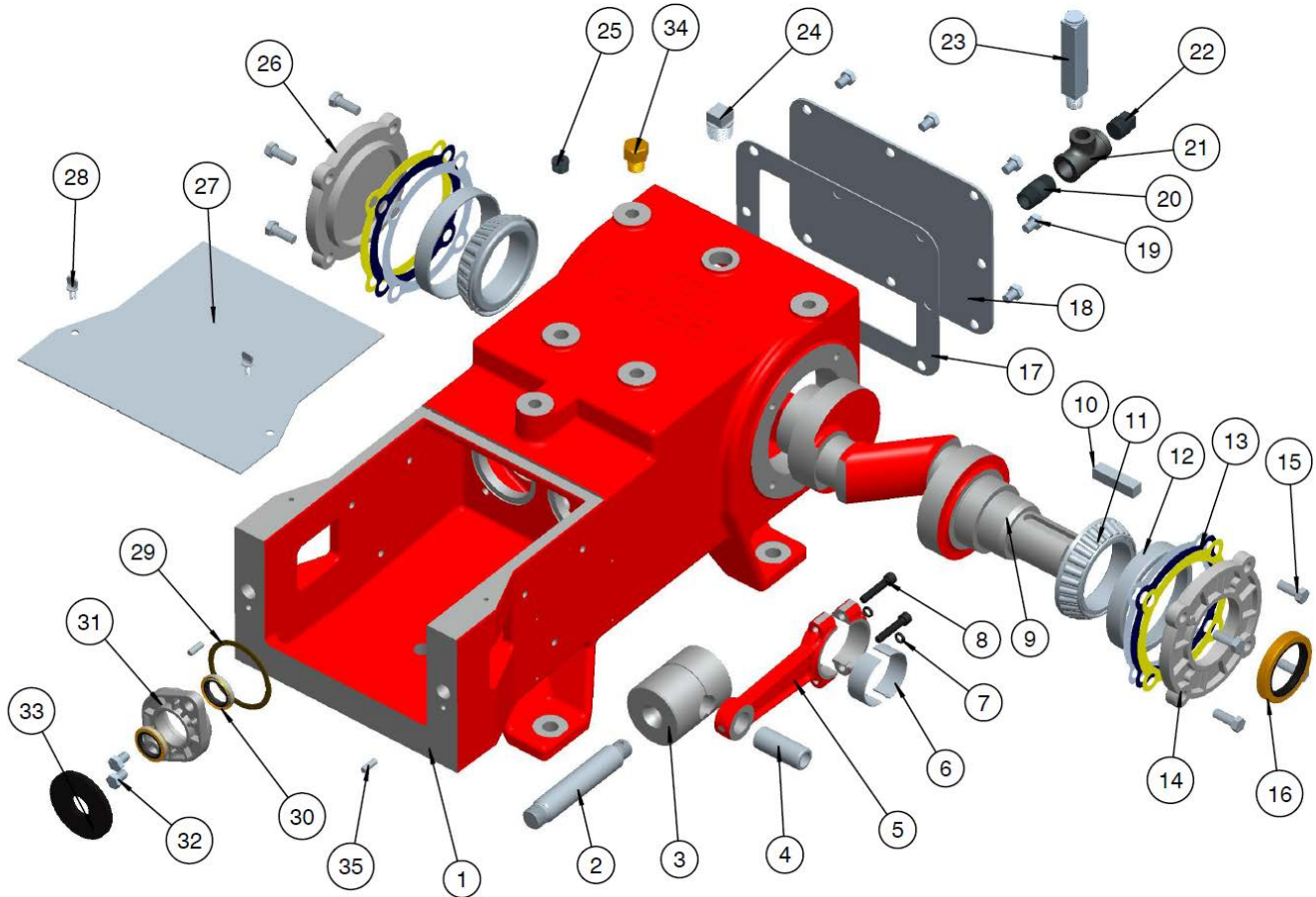
2.8 TROUBLESHOOTING GUIDE

PROBLEM	POSSIBLE CAUSE	CORRECTION
KNOCKING OR POUNDING IN FLUID END AND PIPING	SUCTION LINE RESTRICTED BY: (1, 2, 3, 4)	
	1. TRASH, SCALE BUILD UP, ETC.	LOCATE AND REMOVE
	2. PARTIALLY CLOSED VALVE IN SUCTION LINE	LOCATE AND CORRECT
	3. METERS, FILTERS, CHECK VALVES, NON-FULL-OPENING, CUT-OFF VALVE OR OTHER RESTRICTIONS.	RE-WORK SUCTION LINE TO ELIMINATE
	4. SHARP 90° BENDS OR 90° BLIND TEES.	RE-WORK SUCTION LINE TO ELIMINATE.
	AIR ENTERING SUCTION LINE THROUGH CUT-OFF VALVE	TIGHTEN OR REPACK VALVE STEM PACKING
	AIR ENTERING SUCTION LINE THROUGH LOOSE CONNECTION OR FAULTY PIPE	LOCATE AND CORRECT
	AIR OR VAPOR TRAPPED IN SUCTION LINE	LOCATE RISE OR TRAP AND CORRECT BY STRAIGHTENING LINE, PROVIDING ENOUGH SLOPE TO PERMIT ESCAPE AND PREVENT BUILD-UP
	LOW FLUID LEVEL	INCREASE SUPPLY AND INSTALL AUTOMATIC LOW LEVEL SHUT-DOWN SWITCH
	SUCTION DAMPENERS NOT OPERATING	INSPECT AND REPAIR AS REQUIRED
	WORN VALVES	INSPECT AND REPAIR AS REQUIRED
	ENTRAINED GAS IN FLUID	PROVIDE GAS BOOT OR SCRUBBER FOR FLUID
	POOR INLET AND OUTLET ARRANGEMENT AT SUPPLY TANK	INLET TO BE AT TOP OF TANK AND BAFFLED TO BREAKOUT GAS AND PREVENT CHANNELING. OUTLET TO BE 12" FROM BOTTOM OF TANK AND AS FAR FROM INLET AS POSSIBLE, NEVER CLOSER THAN 90°.
	LOOSE PACKING ADJUSTING NUT	TIGHTEN AND/OR REPLACE PACKING
	INADEQUATE SIZED SUCTION LINE	REPLACE WITH INDIVIDUAL SUCTION LINE OF NEXT SIZE LARGER THAN INLET PUMP
	LEAKAGE PRESSURE RELIEF VALVE THAT HAS BEEN PIPED BACK INTO SUCTION LINE	REPAIR VALVE AND RE-WORK PIPING TO RETURN TO SUPPLY TANK - NOT SUCTION LINE.
BY-PASS PIPED BACK TO SUCTION	REWORK TO RETURN BY-PASSED FLUID BACK TO SUPPLY TANK - NOT SUPPLY LINE	
BROKEN PLUNGER	INSPECT WHEN ROTATING PUMP BY HAND AND REPLACE AS REQUIRED	
KNOCK IN POWER END	VALVE WEAR OR DAMAGE	CHECK FLUID END FOR BAD VALVES
	WORN MAIN BEARINGS	REPLACE AS REQUIRED
	LOOSE PLUNGER - INTERMEDIATE ROD CROSSHEAD CONNECTION	INSPECT FOR DAMAGE - REPLACE AS REQUIRED AND TIGHTEN
	WORN CROSSHEAD PIN, OR CONNECTING ROD	LOCATE AND REPLACE AS REQUIRED

PROBLEM	POSSIBLE CAUSE	CORRECTION
RAPID VALVE WEAR OR FAILURE	CORROSION	TREAT FLUID AS REQUIRED
	ABRASIVES IN FLUID	FILTER AS REQUIRED
	IMPROPER INSTALLATION	INSPECT AND INSTALL PER INSTRUCTION SHEET IN PACKING BOX
	IMPROPER LUBRICATION (EITHER INSUFFICIENT OR EXCESSIVE OR INCORRECT TYPE)	CHECK INSTRUCTIONS IN MANUAL AND CORRECT AS REQUIRED.
	LUBRICATOR NOT OPERATING	INSPECT AND CORRECT AS REQUIRED
	ADJUSTING NUT LOOSE	INSPECT AND REPACK PER INSTRUCTIONS
	SCALE OR BUILD UP ON PLUNGER	TREAT FLUID AS REQUIRED
SHORT PACKING LIFE	WORN OR PITTED PLUNGERS AND/OR STUFFING BOX	REPLACE AS REQUIRED
	ABRASIVES IN FLUID	FILTER AS REQUIRED
	PUMP OPERATED WITHOUT FLUID	CHECK SYSTEM FOR FAULTY LOW-LEVEL SHUTDOWN CONTROLS OR CLOSED VALVES AND CORRECT AS REQUIRED.
	ABNORMALLY HIGH FLUID TEMPERATURES	CHECK WITH MANUFACTURER FOR RECOMMENDATIONS ON TYPE OF PACKING
	WRONG TYPE OF PACKING FOR PARTICULAR FLUID BEING HANDLED	CHECK WITH MANUFACTURER FOR RECOMMENDATIONS ON TYPE OF PACKING
	CAVITATION (KNOCKING AND POUNDING IN FLUID CYLINDER AND PIPING)	REFER TO CORRECTION OF "KNOCK IN END AND PIPING" ABOVE
	ADJUSTMENT NUT TOO TIGHT	ADJUST AND REPLACE PACKING AS REQUIRED
BROKEN OR PITTED PLUNGER	PLUNGER CRACKED AT INSTALLATION.	INSTALL NEW PLUNGER USING CARE TO AVOID ANY SHARP BLOW OR FORCE ON PLUNGER.
	PLUNGER CRACKED FROM THERMAL SHOCK.	CHECK SYSTEM TO ELIMINATE ANY SHARP OR SUDDEN TEMPERATURE DIFFERENCES. TEMPERATURE EXTREMES ON THE PLUNGER CAN OCCUR FROM PACKING AS DISCUSSED UNDER "SHORT PACKING LIFE" PROBLEM FROM TEMPERATURE CHANGES IN THE FLUID ITSELF.
	PLUNGER PITTED FROM IMPLOSIONS CAUSED BY EXCESSIVE GAS OR AIR ENTRAINED IN FLUID.	CHANGE SUCTION SYSTEM TO ELIMINATE OR CHECK WITH MANUFACTURING REGARDING USE OF SPECIAL PACKING ARRANGEMENT.
RAPID WEAR OF HARD-COATED PLUNGER	PACKING FAILURE.	CHECK AND CORRECT PER RECOMMENDATIONS UNDER "SHORT PACKING LIFE" PROBLEM.
	PLUNGER NOT SUITABLE FOR PARTICULAR SERVICE.	CHECK WITH MANUF. FOR RECOMMENDATION.
OIL SEAL LEAKS	PUMP NOT LEVEL.	CHECK AND CORRECT AS REQUIRED.
	WORN, CORRODED, PITTED, OR OTHERWISE DAMAGED SEALING SURFACE.	CHECK AND CORRECT AS REQUIRED.
	WORN OR DAMAGED SEALS.	CHECK AND CORRECT AS REQUIRED.
	OIL LEVEL TOO HIGH.	CHECK AND CORRECT AS REQUIRED.

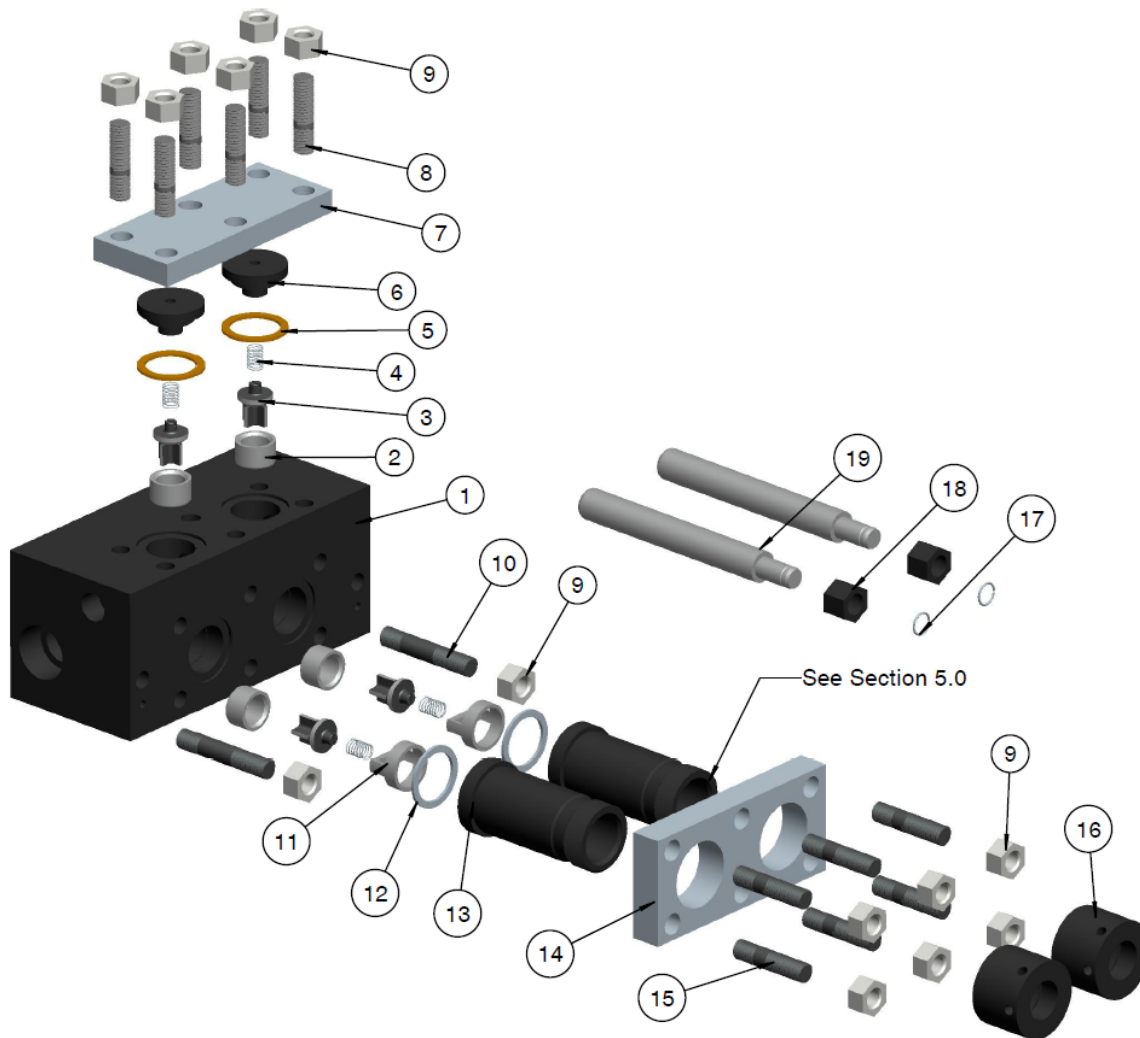
3.0 PARTS LIST

3.1 POWER END EXPLODED VIEW



Item	Description	Item	Description
1	Power Frame	19	Hex Head Cap Screw, Crankcase Cover
2	Crosshead Stub (Pony Rod)	20	Nipple
3	Crosshead	21	Tee, Sight Glass
4	Wrist Pin	22	Square Plug, Oil Drain
5	Connecting Rod	23	Oil Level Sight Glass
6	Connecting Rod Bearing	24	Square Head Plug, Oil Fill
7	Lock Washer	25	Socket Head Plug
8	Bolt, Connecting Rod	26	Frame Cap, Outboard
9	Crankshaft	27	Plunger Cover
10	Key	28	Thumb Screw
11	Main Bearing (Bearing Cone)	29	Gasket, Crosshead Stub Cap
12	Race (Bearing Cup)	30	Oil Seal, Crosshead Stub
13	Shim Set	31	Crosshead Stub Cap
14	Frame Cap, Inboard	32	Hex Head Cap Screw, Crosshead Stub Cap
15	Hex Head Cap Screw, Frame Cap	33	Deflector
16	Oil Seal, Crankshaft	34	Crankcase Breather
17	Gasket, Crankcase Cover	35	Alignment Pin
18	Crankcase Cover		

3.2 FLUID END EXPLODED VIEW



Item	Description	Item	Description
1	Fluid Cylinder	11	Suction Valve Stop
2	Valve Seat	12	Gasket, Stuffing Box
3	Valve	13	Stuffing Box
4	Valve Spring	14	Flange, Stuffing Box
5	Gasket, Discharge Valve Cover	15	Stud, Stuffing Box Flange
6	Discharge Valve Stop	16	Gland Nut
7	Flange, Discharge Valve Cover	17	Retaining Ring
8	Stud, Discharge Valve Cover	18	Coupling Nut
9	Heavy Hex Nut	19	Plunger
10	Stud, Cylinder Tie		

4.0 DISASSEMBLY AND REASSEMBLY

4.1 GENERAL

The bearings and other working parts in the power end have been designed for continuous duty, and if properly lubricated, will provide years of trouble-free service. However, after the pump has been in service for a long period of time, the bearings and other working parts will gradually loosen, and if not corrected, will lead to more serious trouble. The time to overhaul the pump will vary; depending on the operating conditions, and is therefore a matter that must be left to the good judgment of the operator. Complete disassembly and assembly procedures are discussed in their respective sections.

The crankshaft main bearings for the CX-5 are single row; shim adjusted, tapered roller bearings. They have been assembled and adjusted at the factory with proper clearance and will give long trouble-free service. The proper clearance is found by adjusting the amount of shims until the crankshaft has .001" to .003" endplay and will rotate freely.

Tools Required

Most of the tools required to overhaul the pump will be found in an ordinary set of mechanics hand tools. The special tools and equipment required and not furnished with the pump include a torque wrench, valve seat puller, bearing puller and a hydraulic press.

4.2 POWER END DISASSEMBLY

All fluid cylinders have separate intermediate rods (Crosshead Stubs) These are threaded into the crosshead and retained with thread locking compound and a nylon insert and should only be removed if necessary. If while removing the plungers the crosshead stubs break loose, these methods of retention will need to be replaced/reapplied

 **! ATTENTION ! WARNING ! ATTENTION !** 

POWER END DISASSEMBLY AND OVERHAUL IS BEST PERFORMED IN A WELL EQUIPPED SHOP ENVIROMENT. IF THE PUMP IS DISASSEMBLED AT LOCATION ENSURE THE PRESSURE HAS BEEN REMOVED FROM THE FLUID END AND THE PUMP BLOCKED OUT WITH APPROPRIATE BLOCK VALVES. ENSURE THE FLUID END IS DRAINED AND ANY POWER SOURCE OR DRIVER IS LOCKED OUT BEFORE PROCEEDING!

4.2.1 Fluid End Removal

1. Remove suction and discharge piping connections from the Fluid Cylinder.
2. Remove Thumb Screws and Plunger Cover. If the pump is equipped with a lubricator, disconnect the lines at the Stuffing Boxes.
3. The Plungers and Crosshead Stubs separate where the Coupling Nut attaches to the Crosshead Stub. Fully unthread the Coupling Nut and push the Plungers to the full forward position.
4. Remove both Cylinder Tie Stud Nuts which secure the Fluid End to the Power End.
5. Attach a sling and use a power lift to separate the Fluid End from the Power End. Gentle prying may be required to separate the two assemblies. Care should be exercised to avoid shearing the two Alignment Pins located on the front of the Power Frame.

4.2.2 General

1. Remove the Drain Plug and empty the oil from the crankcase. *NOTE: Dispose of used oil according to local laws and regulations.* Remove oil level indicator.
2. Remove the Crosshead Stub Deflectors and the Crosshead Stub seal caps. Discard the Crosshead Seal Cap Gaskets
3. Remove the crankcase cover and discard the Crankcase Cover Gasket.
4. Remove the outboard frame cap, the inboard frame cap and all Shims. Take care to avoid damaging the Oil Seal when removing the frame caps. *NOTE: keep the Shim Sets together with the corresponding cap These should be kept together for reassembly at their original location.*
5. Remove connecting rod bolts and caps. *NOTE: Connecting rods and caps are matched sets and must be kept together. Do not mix caps and rods.*

4.2.3 Crankshaft Removal

1. Push Crosshead/Connecting Rod Assemblies to the full forward position. Place a block of wood on the non drive side of the crankshaft and, with a hammer, tap the Crankshaft until the opposite side Bearing Cup is removed from the Power Frame. Repeat on the drive side to remove the remaining Bearing Cup. *NOTE: Bearing Cups and Cones are matched sets. When reusing the Crankshaft Bearings, it is important to mark from which side each cup was removed and must be correctly assembled as a unit.*
2. Carefully remove the crankshaft out either side of the power frame. Thoroughly clean and inspect the crankshaft and Main Bearings. Examine the journals, where the Connecting Rods attach. These should be smooth and free of dings, gouges, or excessive wear. *NOTE: The crankshaft main bearings may be inspected while on the crankshaft and should not be removed unless necessary. A puller is required when replacement is necessary. Always replace the Bearing Cup when replacing Bearing Roller Cone.*
3. Remove the each Crosshead/Connecting Rod out the rear of the Power Frame and tag each to identify the bore from which it was removed. It is good practice to reattach the matched connecting rod caps at this point.
4. Press the Crosshead Wrist Pin out of the Connecting Rod and thru the Crosshead
5. Clean and inspect all components and sub-assemblies. Discard all gaskets and worn components.
6. Thoroughly clean out the crankcase. Take care to remove any sludge and residue that may have collected in the bottom.

4.3 FLUID END

If you have not already separated the Fluid End from the Power End follow the instructions for Fluid End removal provided in [Section 4.2.1](#)

 **! ATTENTION ! WARNING ! ATTENTION !** 

BEFORE WORKING ON THE FLUID END ENSURE THE PRESSURE HAS BEEN REMOVED FROM THE FLUID END AND THE PUMP BLOCKED OUT WITH APPROPRIATE BLOCK VALVES. ENSURE THE FLUID END IS DRAINED AND ANY POWER SOURCE OR DRIVER IS LOCKED OUT BEFORE PROCEEDING!

4.3.1 Stuffing Boxes Removal

1. Loosen and remove the packing gland nuts. Remove the Plungers
2. Remove the nuts holding the Stuffing Box Flange onto the Fluid Cylinder. Lift off the Stuffing Box Flange with the Stuffing Boxes
3. Carefully remove each Stuffing Box Assembly and set to the side. Remove and discard all Stuffing Box Gaskets
Note: Exercise care when removing these gaskets to avoid damaging the gasket sealing area. Any time the stuffing box is removed, new gaskets should be installed to ensure a positive seal.

4.3.2 Stuffing Box Disassembly

National Oilwell Varco supplies a variety of packing solutions. The most common configurations are described in this manual. For support on non-standard packing assemblies, please contact National Oilwell Varco using the contact information on the last page of this manual.

1. Remove all internals from the Stuffing Boxes
2. Clean and inspect the Stuffing Box bore to assure there is no pitting in the packing area.
3. Clean and inspect all stuffing box internals to assure there is no pitting or wear areas which could lead to premature packing failure and replace as necessary. Inspect the plungers for pitting or longitudinal scoring lines and replace as required. For spring loaded packing assemblies, examine the Packing Spring for any pitting or wear and replace as necessary. *Note: For more information on packing setups, see [Section 5](#)*

4.3.3 Standard Valve And Seat Removal/Inspection

1. Remove the Suction Valve Stops and Springs from the ports the Stuffing Boxes were removed. If this is an inspection only, mark and remove each Valve to be matched with the Seat from which it was removed. *Note: Marking is essential during inspection if the Valves are to be reused. In the case of a complete rebuild, discard the Valves, Seats and Springs.*
2. Discharge Valve Cover Flange and Discharge Valve Stops. Examine them for wear. These parts can be reused if found to be in acceptable condition. Discard the Discharge Valve Cover Gaskets. *Note: carefully remove the Discharge Valve Cover Gaskets to avoid damaging the gasket seal decks.*
3. If this is an inspection only, remove the Springs. and mark and remove each Valve to be matched with the Seat from which it was removed. *Note: Marking is essential during inspection if the Valves are to be reused. In the case of a complete rebuild, discard the Valves, Seats and Springs.*
4. Removal of the Valve Seats requires the use of a Valve Seat Puller. All valve seats are a press-fit and require a mechanism for applying upward force from below the valve seat. A Valve Seat Puller is available for each fluid cylinder size and valve type.

4.4 CHECK POINTS AND ADJUSTMENTS

- The connecting rod shell bearings or inserts are precision automotive type. A proper torque of 26ft-lb is required.
- The factory clearance between the crosshead and crosshead bore is .002" (.051 mm) to .006" (.152 mm). The maximum allowable clearance, including wear, is .010" (.254 mm)..
- The Crosshead Wrist Pin is a press fit into the Connecting Rod and floats or slides side to side in the Crosshead. When properly installed, the Connecting Rod can slide to either inside position in the Crosshead and the Crosshead Wrist Pin will not extend past the outside diameter of the Crosshead.

FACTORY FITS AND TOLERANCES				
CX-5 POWER END	CLEARANCE (in)		CLEARANCE (mm)	
	Min	Max	Min	Max
CRANKSHAFT MAIN BEARING FIT IN POWER FRAME	.000	.002	.000	.051
CRANKSHAFT END PLAY (WITHOUT PRELOAD)	.001	.003	.025	.076
CONNECTING ROD BEARING CLEARANCE OVER CRANKSHAFT	.0025	.004	.063	.101
WRIST PIN CLEARANCE IN CROSSHEAD	.0007	.0015	.017	.038
CROSSHEAD CLEARANCE IN POWERFRAME	.002	.006	.050	.152

TORQUE SPECIFICATION CHART CX-5 POWER END			
Part Description	Thread Size	Recommended Torque (Lubricated)	
		ft-lbs	N-m
Connecting Rod Bolts	5/16-24UNF	43	35
Frame Cap Bolts	3/8-16UNC	15	20
Crankcase and Inspection Cover Bolts	3/8-16UNC	15	20
Stub Seal Cap Bolts	3/8-16UNC	15	20
Plunger Nut to Stub	7/8-14UNC	20	27
Stub to Crosshead	3/4-10UNC	75	102
Cylinder Tie Stud Nuts	5/8-18UNC	130	176

4.5 POWER END ASSEMBLY

4.5.1 Connecting Rod/Crosshead Assembly

The Crosshead Wrist Pin is a press fit into the Connecting Rod a slip fit into the Crosshead. Properly installed, the Connecting Rod and Wrist Pin should slide inside the Crosshead. This allows for alignment of the Connecting Rod after attachment to the Crankshaft.

1. Clean and inspect the Crosshead Assembly. Examine the Crosshead Stub for any nicks, dings, or longitudinal scoring. Replace if necessary.
2. Clean and inspect the Connecting Rod and install new Connecting Rod Bearings into the rod and caps. *Note: Connecting rods and caps are matched sets. Do not mix caps and rods.* Inspect the Crosshead for excessive wear as well as its fit over the Wrist Pin. Replace as necessary.
3. Attach the Crosshead to the Connecting Rod by pressing the Wrist Pin through the Crosshead into the small end of the Connecting Rod. The cast flat on the crosshead and the small lubrication hole in the connecting Rod should face the same direction. *Note: When properly installed, the Connecting Rod can slide to either inside position in the Crosshead and the Crosshead Wrist Pin will not extend past the outside diameter of the Crosshead.*
4. Lubricate the crosshead bore and slide the Connecting Rod/Crosshead Assembly into the Power Frame bore from which it was removed. The cast flat on the crosshead should face up. Push the assemblies to the full forward position. Remove the caps of the Connecting Rods and place on top of the Power Frame above its corresponding bore. . *Note: Connecting rods and caps are matched sets. Do not mix caps and rods.*

4.5.2 Crankshaft Main Bearings (If replacement is required)



EXERCISE CARE IN THE ACTIONS DESCRIBED BELOW. ALWAYS WEAR THE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT WHEN HANDLING HEATED COMPONENTS. FAILURE TO FOLLOW THIS WARNING CAN RESULT IN SEVERE BODILY INJURY.

1. Thoroughly clean and remove all burrs from the bearing seating surfaces on the Crankshaft.
2. Heat the Bearing Cone in an electric oven to no more than 300°F (149°C). Do Not Overheat.
3. After the bearings have been brought up to temperature and with the crankshaft firmly supported, install the Bearing Cone on the Crankshaft. *Note: Make sure the Bearing Cones are firmly against the shoulders on the Crankshaft.*
4. Allow the Crankshaft and Bearing Cone to cool before installing in the Power End.

4.5.3 Crankshaft Installation

1. Make sure the main bearing openings in the Power Frame are clean and free of burrs.
2. Tap one Bearing Cup into one side of the Power Frame until flush with the outside of the power frame. If you have not done so already, remove the Connecting Rod caps and set on top of crankcase over its corresponding assembly
3. Carefully insert the Crankshaft through the side of the Power Frame past the Connecting Rods until it rests in the Crankshaft Bearing Cup on the opposite side, then tap in the opposite side Crankshaft Bearing Cup.
4. Install a new Oil Seal into the Inboard Frame Cap

If new main bearings are installed:

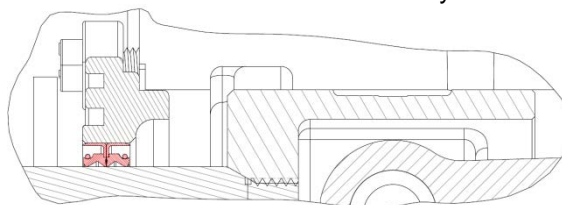
- When first installing shims, add enough that the Crankshaft will rotate freely. Install the Frame Caps with the proper torque.
- Tap Crankshaft on each end sufficient enough to ensure that the Bearing Cups seat firmly against the Frame Caps. .
- Mount a dial indicator with a magnetic base onto the Power frame and set the indicator perpendicular to the end of the shaft.
- With a large screwdriver and using the inside of the Power Frame as a base, carefully pry the Crankshaft to each side measuring the total indicator reading.
- The proper clearance is found by adjusting the amount of shims until the crankshaft has .001" to .003" endplay and will rotate freely.

If the used main bearings are reinstalled:

- Replace the Inboard and Outboard Frame Caps using the same Shim Stack that was removed with each cap.
- Torque the hex head bolts to the proper load and check that the Crankshaft rotates freely.

4.5.4 Connecting Rod To Crankshaft Assembly

1. Thoroughly clean and remove all burrs and nicks from the Connecting Rods, Caps, and Crankshaft journals.
2. Install a Bearing half into each Connecting Rod and Cap by aligning the tang on the Bearing with the groove in the rods and caps
3. Apply a thin film of lubricant to the Crankshaft journals and Connecting Rod Bearings.
4. Position the first crankshaft throw to the rear.
5. Slide the connecting rod back over the crankshaft throw using caution so the outer surface of the insert is not damaged. Note the match numbers of the cap and rod to be certain the rod is assembled correctly.
6. Torque the Connecting Rod Bolts to 26 ft-lbs.
7. Repeat for the remaining Connecting Rods.



4.5.5 General

1. Install two new Oil Seals into each Crosshead Seal Cap. Seals with the solid metal faces against each other and the spring side facing out (see cross-section above for seal orientation).
2. Lubricate each Crosshead stub. Install new Gaskets on the Seal Caps and carefully slide the seals over each Crosshead Stub.
3. Slide the Crosshead Seal Caps into the crosshead bores of the Power Frame and secure with the Hex Head Bolts.
4. Install Crosshead Stub Deflectors onto the Crosshead Stub just after the threaded surface.

5. Replace the Oil Level Indicator, Drain Plug and Crankcase Breather. *Note: It is recommended that the Crankcase Breather be cleaned during each oil change to insure adequate air flow to the crankcase*
6. Remove the Oil Fill Plug, fill with the amount and recommended type of oil based on ambient temperature conditions, and replace the oil fill plug. See the chart on page 13 for oil requirements.
7. Reconnect the plunger to the crosshead assembly (10). Tighten according to the *Torque Specification Chart in Section 4.4.*

4.6 FLUID END ASSEMBLY



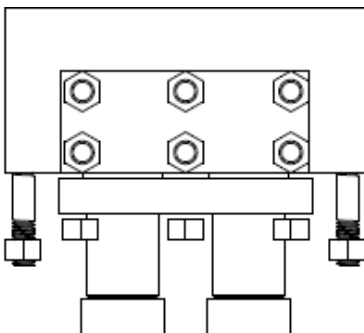
PRECAUTIONS SHOULD BE TAKEN TO PREVENT FOREIGN MATERIAL FROM ENTERING THE ASSEMBLY WHEN INSPECTING OR REPLACING COMPONENTS OF THE FLUID CYLINDER. SOLID FOREIGN DEBRIS CONTAMINATING THE ASSEMBLY WILL LEAD TO PREMATURE FAILURE OF THE PACKING, PLUNGERS, VALVES AND SEATS

4.6.1 Installation of Valve Seats

1. You must install new Valves when installing new Seats.
2. Install the new Valve Seats by setting the new valve seat with the radius edge to the seat pocket. Then, place on top a round disc larger than the Seat and press into place.
3. Do not hammer Valve Seats into the fluid cylinder – press into place. Also, check to insure that the valve seat is going in straight and not cocked at an angle. Shrinking the seats with dry ice will make the installation process easier

4.6.2 Installation of Valves and Covers

1. Insert the Valves into the discharge Seats (the side of the Fluid Cylinder with eight studs) and check to see that each moves freely. Place a Valve Spring on top of each valve.
2. Inspect the gasket sealing deck areas of the Fluid Cylinder for any gouges, dings, or pits and remove any burrs. Install new Discharge Valve Cover Gaskets.
3. If reusing the Discharge Valve Stops, clean and inspect for any gouges, dings, or pits that would prevent the parts from properly sealing. Place the Discharge Valve Stop over each Valve Spring with the small end down and the threaded hole up.
4. Replace the Discharge Valve Cover. Torque the Nuts using the procedure described below



- a. Hand tighten all nuts.
- b. *M & H Cylinders:* Pre-torque all nuts to 65 ft-lbs (88 N-m)
L Cylinder: Pre-torque all nuts to 40 ft-lbs (54 N-m)
- c. *M & H Cylinders:* Final torque to 130 ft-lbs (176 N-m)
L Cylinder: Final torque to 80 ft-lbs (108 N-m)

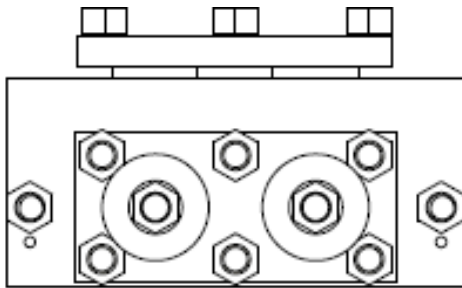
*Note: Torque values provided are based on lubricated threads
Use torque sequence shown for all Pre and Final torque values
Always Re-torque final torque value*

5. Insert the Valves into the Suction Seats (the side of the Fluid Cylinder with ten studs) and check to see that each moves freely. Place a Valve Spring on top of each valve.

Insert the Suction Valve Stops into the Fluid Cylinder with the flat towards the Spring

4.6.3 Installation of Stuffing Boxes and Plungers

1. Inspect the stuffing box gasket sealing deck area for any gouges, dings, or pits and remove any burrs. install the new Stuffing Box Gaskets
2. Inspect the sealing face of the Stuffing Boxes to insure there are no gouges, dings, or pits to prevent proper sealing. Insert the bull nose of the Stuffing Box into the Fluid Cylinder.
3. Install the Stuffing Box Flange over the Stuffing Boxes. Torque the Nuts using the procedure described below



- a. Hand tighten all nuts.
- b. Pre-torque all nuts to 65 ft-lbs (88 N-m)
- c. Final torque to 130 ft-lbs (176 N-m)

Note: Torque values provided are based on lubricated threads
Use torque sequence shown for all Pre and Final torque values
Always Re-torque final torque value

4. Follow the instructions provided in [Section 5](#) for packing installation

4.7 Connection of Fluid End to Power End

1. Attach a sling and use a power lift to return the Fluid End assembly to the Power End. Insert the Cylinder Tie Studs on the Fluid End through the holes provided on the Power End and carefully guide, but do not force, the Fluid End assembly onto the Dowel Pins located on the front of the Power Frame.
2. Use the Hex Nuts to secure the Stuffing Box Flange to the power frame. Note: Be sure to pull the sides of the fluid cylinder up to the power frame equally; avoid cocking at an angle as this could shear the alignment pins. Torque both hex nuts to 130 ft-lbs (176 N-m)
3. Pull the Plunger to Crosshead Stub and tighten securely, but avoid over tightening. Refer to the torque specifications in [Section 4.4](#) for the proper load.
4. Attach plunger lubrication lines if applicable. Install the Plunger Cover

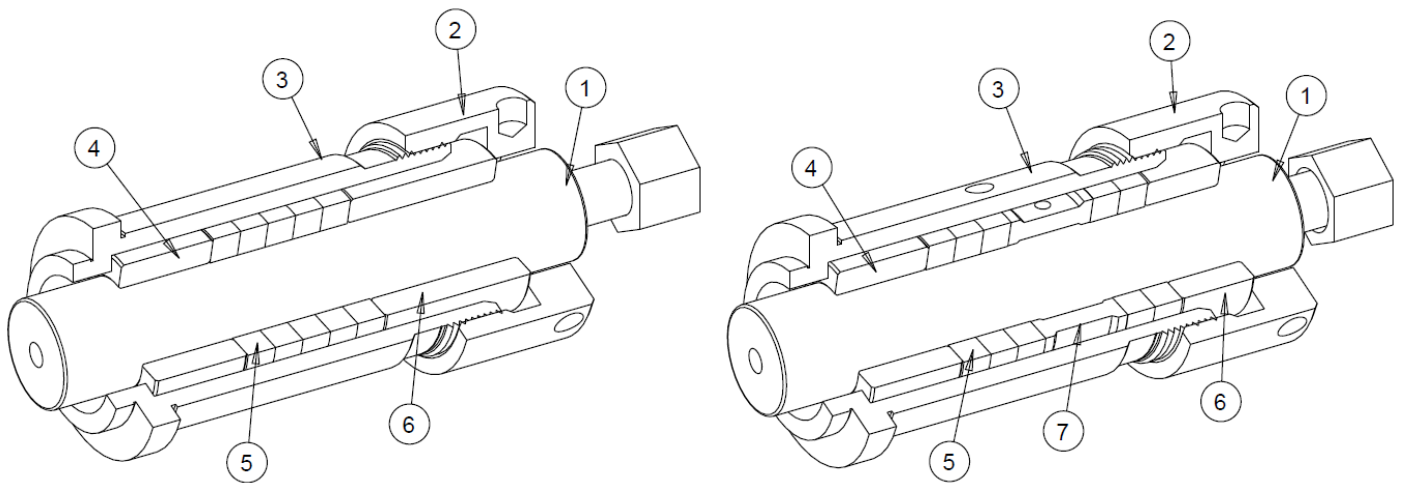
5.0 PACKING ASSEMBLIES

5.1 GENERAL

Plunger packing replacement is best accomplished after removal of the Fluid Cylinder from the Power Frame. See instructions for Fluid Cylinder removal in [Section 4.2.1](#).

The following instructions are for the four most common types of packing assemblies. Review the Illustrations in the following sections as well as the exploded view in [Section 3.2](#) to identify the appropriate parts and their descriptive names. It is important to adhere to the following instructions in order to maximize the life of both the Packing and the Plunger. Note: Any system which insures a dependable drip or flow of oil on the plunger either internally or on the outside of the stuffing box is desirable. The recommended type and amount of oil needed for lubrication can be found in [Section 2.3.2](#).

5.2 INSTRUCTION FOR SQUARE RING TYPE PACKING



Item	Description	Item	Description	Item	Description
1	Plunger	2	Stuffing Box Gland	3	Stuffing Box
4	Throat Bushing	5	Packing	6	Gland Follower
7	Lantern Ring				

1. Clean all stuffing box internals and the inside bore of the Stuffing Boxes.
2. Inspect all parts for pitting, excessive wear, and longitudinal scoring lines. These items can often be reused, but if they are worn, replace them. Reusing worn trim will cause premature packing failure.
3. Refer to the stuffing box assembly illustrations above for the proper arrangement of packing and components. Note: for non-lubricated assemblies, the number of packing rings vary with plunger size. Lubricated assemblies using rope packing will always have three packing rings before the lantern ring and two after as shown above
4. Apply a film of light oil to the inside of each Stuffing Box
5. Apply a film of light oil to each Packing Ring.

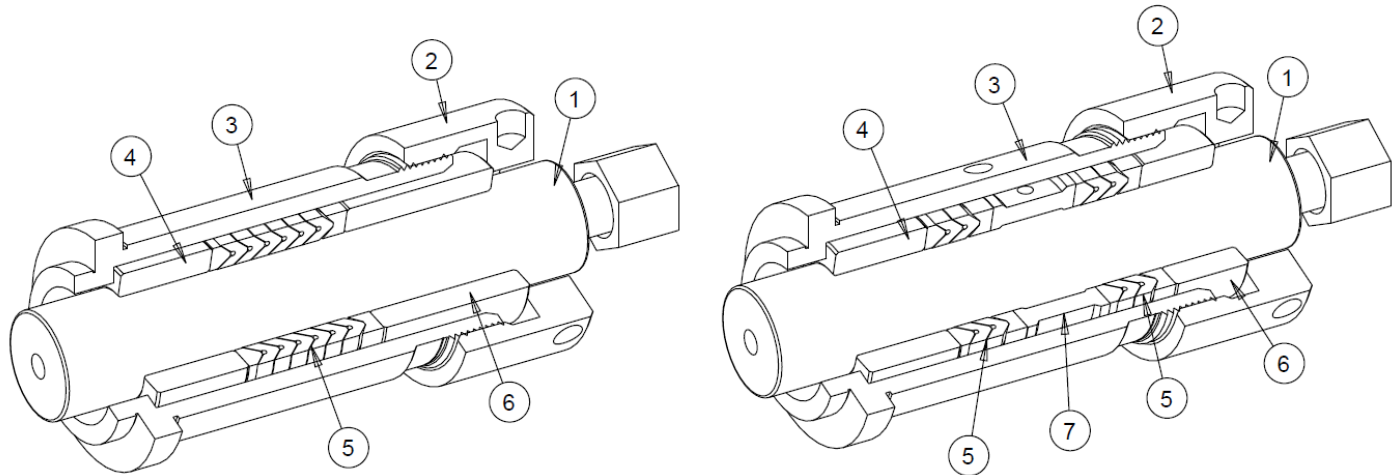
6. Install the packing rings individually into each Stuffing Box. Seat each ring firmly into place. It may be helpful to use the Gland Follower to push the individual packing rings to the bottom. **DO NOT BEND, TEAR, OR COMPRESS THE PACKING RINGS.** Split ring type packing should be installed with the splits located 120° apart.
7. If assembling a lubricated stuffing box, apply a film of light oil to each Lantern Ring and install between the third and forth Packing Rings of each Stuffing Box. Be sure the Lantern Rings align with the lubrication ports of the Stuffing Boxes.
8. Install each Gland Follower after the last Packing Ring.
9. Apply an anti-seize thread compound to the threads of the Stuffing Boxes and install each Stuffing Box Gland until FINGER TIGHT ONLY.
10. Apply a film of light oil to the Plunger and carefully install it through the Stuffing Box
11. Follow the procedure for connection of Fluid End defined in [Section 4.7](#).
12. Rotate the crankshaft in the proper direction about 10 times. Unscrew the Stuffing Box Gland and re-tighten to finger tight again. Be sure the gland is only finger tight.
13. The pump is now ready to run to “seat-in” the Packing. Start the pump and allow it to run idle with little or no pressure. Do not be alarmed if the packing leaks. Leakage will decrease as pressure is applied to the pump and as the Packing begins to heat up. During the first 15 minutes of operation, allow each Packing Set to leak at about 60-120 drops per minute. If necessary, loosen the Stuffing Box Gland to maintain the desired leak rate, but only if there is a reduction in the leak rate during the first 15 minutes. As the Plunger travels through the Packing, the Packing may begin to heat up and it will need room to expand. Increasing temperature due to inadequate lubrication or over-tightening of the Stuffing Box Gland will cause the Packing to bind on the Plunger and result in premature failure of the packing. To assure proper seating of the Packing, it is recommended that a light oil be squirted on to the Plunger outside of the Stuffing Box during this process. Closely monitor the temperature, carefully by touch, of the Plunger and the Stuffing Box.
14. Slowly tighten the Stuffing Box Gland Nuts about 1/8 to 1/6 turn every 4-5 minutes until the leak rate per plunger falls into the range defined in the chart below. If the Plunger or Stuffing Box temperature increases due to the tightening, loosen the glands and repeat this step. Continue this process until the temperature remains constant after re-tightening the Stuffing Box Glands.

! ATTENTION - NOTICE - IMPORTANT !

DURING NORMAL OPERATION, THIS TYPE OF PACKING MUST MAINTAIN A SLIGHT LEAKAGE OF. THIS WILL ALLOW THE PLUNGER TO BE LUBRICATED AND INCREASE THE LIFE OF BOTH THE PLUNGER AND PACKING. WHEN READJUSTING THE PACKING, DO NOT OVER TIGHTEN. TIGHTEN ONLY AS NEEDED TO COMPENSATE FOR EXCESSIVE LEAKAGE.

DRIP RATE CHART	
Plunger Size	Drips Per Minute
Up to 1-1/2"	8-10
1-1/2" to 2-1/2"	12-14
2-1/2" to 3-1/2"	16-18
3-1/2" to 4-1/2"	20-22

5.3 INSTRUCTIONS FOR MOLDED 'V' RING TYPE PACKING



Item	Description	Item	Description	Item	Description
1	Plunger	2	Stuffing Box Gland	3	Stuffing Box
4	Throat Bushing	5	Packing	6	Gland Follower
7	Lantern Ring				

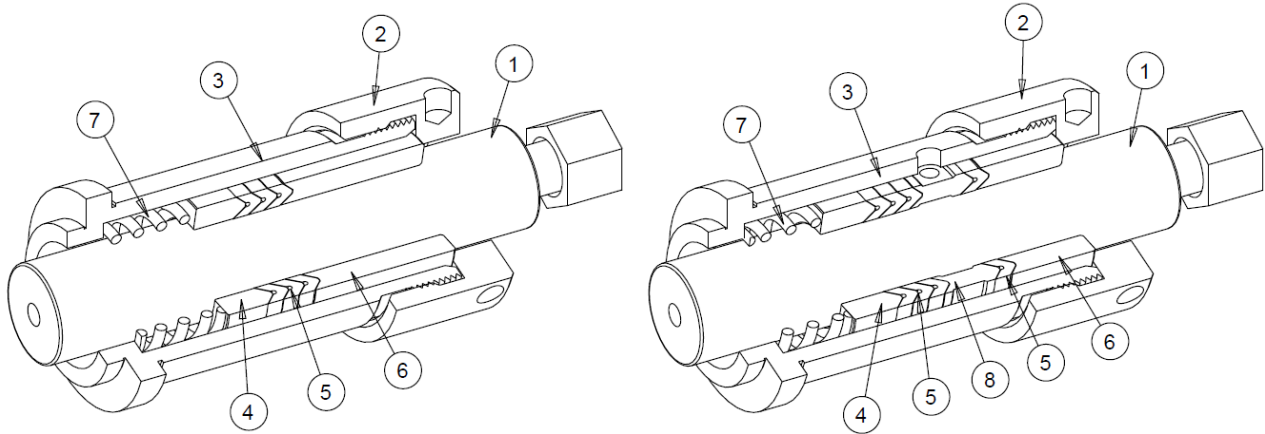
1. Clean all stuffing box internals and the inside bore of the Stuffing Boxes.
2. Inspect all parts for pitting, excessive wear, and longitudinal scoring lines. These items can often be reused, but if they are worn, replace them. Reusing worn trim will cause premature packing failure.
3. Refer to the stuffing box assembly illustrations above for the proper arrangement of packing and components. Note: for non-lubricated assemblies, the number of pressure rings vary with plunger size. Lubricated assemblies using "V" type packing will always have three pressure rings in the packing set before the lantern ring and two pressure rings in the packing set after as shown above
4. Apply a film of light oil to the inside of each Stuffing Box
5. Apply a film of light oil to each Packing Ring. Install each pressure ring with the open end of the "V" facing toward the fluid end.
6. Install the packing rings individually into each Stuffing Box. Seat each ring firmly into place. It may be helpful to use the Gland Follower to push the individual packing rings to the bottom. **DO NOT BEND, TEAR, OR COMPRESS THE PACKING RINGS.** Split ring type packing should be installed with the splits located 120° apart.
7. If assembling a lubricated stuffing box, apply a film of light oil to each Lantern Ring and install between the two sets of packing in each Stuffing Box. Be sure the Lantern Rings align with the lubrication ports of the Stuffing Boxes.
8. Install each Gland Follower after the last Packing Set.
9. Apply an anti-seize thread compound to the threads of the Stuffing Boxes and install each Stuffing Box Gland until FINGER TIGHT ONLY.

10. Apply a film of light oil to the Plunger and carefully install it through the Stuffing Box
11. Follow the procedure for connection of Fluid End defined in [Section 4.7](#).
12. The pump is now ready to run to “seat-in” the Packing. Start the pump and allow it to run idle with little or no pressure for fifteen. Do not be alarmed if the packing leaks. Leakage will decrease as pressure is applied to the pump and as the Packing begins to heat up. As the Plunger travels through the Packing, the Packing may begin to heat up and it will need room to expand. Increasing temperature due to inadequate lubrication or over-tightening of the Stuffing Box Gland will cause the Packing to bind on the Plunger and result in premature failure of the packing. To assure proper seating of the Packing, it is recommended that a light oil be squirted on to the Plunger outside of the Stuffing Box during this process. Closely monitor the temperature, carefully by touch, of the Plunger and the Stuffing Box.
13. Slowly tighten the Stuffing Box Gland Nuts about 1/8 to 1/6 turn every 4-5 minutes until a leak rate of 2-8 drops per minute per Plunger is attained. If the Plunger or Stuffing Box temperature increases due to the tightening, loosen the glands and repeat this step. Continue this process until the temperature remains constant after re-tightening the Stuffing Box Glands.

 **! ATTENTION - NOTICE - IMPORTANT !** 

IT IS ESSENTIAL WHEN INSTALLING THE "V" TYPE PACKING TO NOT OVER COMPRESS THE SET. THE SET SHOULD BE ALLOWED SUFFICIENT LOADING TO INITIALLY SEAL WHILE STILL BEING ABLE TO RELAX ON THE STROKE RETURN.

5.4 INSTRUCTIONS FOR SPRING LOADED "V" PACKING

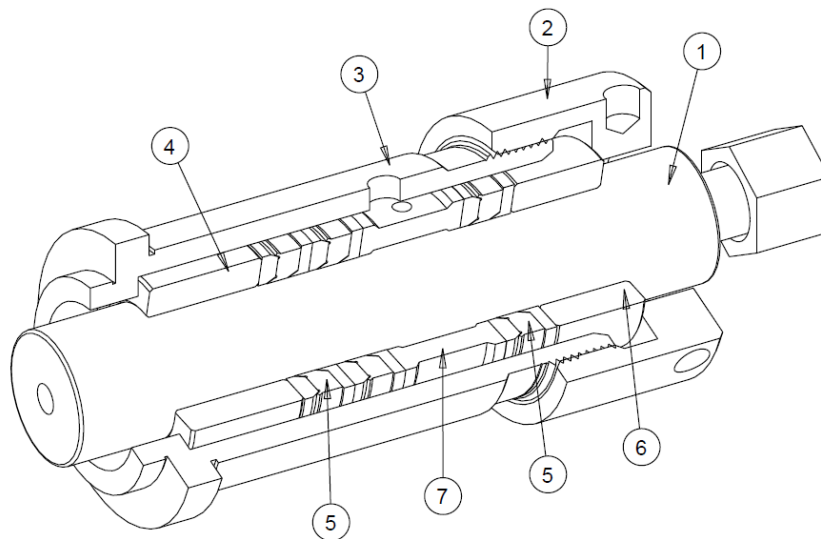


Item	Description	Item	Description	Item	Description
1	Plunger	2	Stuffing Box Gland	3	Stuffing Box
4	Male Adapter	5	Packing	6	Female Adapter
7	Packing Spring	8	Lantern Ring		

1. Clean all stuffing box internals and the inside bore of the Stuffing Boxes.
2. Inspect all parts for pitting, excessive wear, and longitudinal scoring lines. These items can often be reused, but if they are worn, replace them. Reusing worn trim will cause premature packing failure.
3. Refer to the stuffing box assembly illustrations above for the proper arrangement of packing and components.
Note: All stuffing box assemblies of this style use three pressure rings with integral adapter rings
4. Apply a film of light oil to the inside of each Stuffing Box and all internal parts. Install a Packing Spring and Male Adapter into each Stuffing Box.
5. Apply a film of light oil to each Packing Ring. Install each pressure ring with the open end of the "V" facing toward the fluid end.
6. Install the packing rings individually into each Stuffing Box. Seat each ring firmly into place. It may be helpful to use the Gland Follower to push the individual packing rings to the bottom. **DO NOT BEND OR TEAR THE PACKING RINGS.**
7. If assembling a lubricated stuffing box, apply a film of light oil to each Lantern Ring and install between the second and third pressure ring sets of packing in each Stuffing Box. Be sure the Lantern Rings align with the lubrication ports of the Stuffing Boxes.
8. Install each Female Adapter after the last Packing Set.
9. Apply an anti-seize thread compound to the threads of the Stuffing Boxes and install each Stuffing Box Gland just a few turns. Do not fully tighten the Stuffing Box Gland at this time.
10. Apply a film of light oil to the Plunger and carefully install it through the Stuffing Box
11. Follow the procedure for connection of Fluid End defined in [Section 4.7](#).

12. Fully tighten the Stuffing Box Glands. This packing style is spring-loaded and once the Stuffing Box Glands are properly pulled up there is no more adjustment.
13. Start the pump and bring up to pressure.

5.5 INSTRUCTIONS FOR NON-ADJUSTABLE "J" PACKING



Item	Description	Item	Description	Item	Description
1	Plunger	2	Stuffing Box Gland	3	Stuffing Box
4	Throat Bushing	5	Packing	6	Gland Follower
7	Lantern Ring				

1. Clean all stuffing box internals and the inside bore of the Stuffing Boxes.
2. Inspect all parts for pitting, excessive wear, and longitudinal scoring lines. These items can often be reused, but if they are worn, replace them. Reusing excessively worn trim will cause premature packing failure.
3. Refer to the stuffing box assembly illustrations above for the proper arrangement of packing and components.
Note: All stuffing box assemblies of this style use three pressure rings each with special adapter rings
4. Apply a film of light oil to the inside of each Stuffing Box and all internal parts.
5. Apply a film of light oil to each Packing Ring. Install each pressure ring with the open end of the "V" facing toward the fluid end.
6. Install the first two packing rings with their respective adapters individually into each Stuffing Box. Seat each ring firmly into place. It may be helpful to use the Gland Follower to push the individual packing rings to the bottom. **DO NOT BEND, TEAR, OR COMPRESS THE PACKING RINGS.**

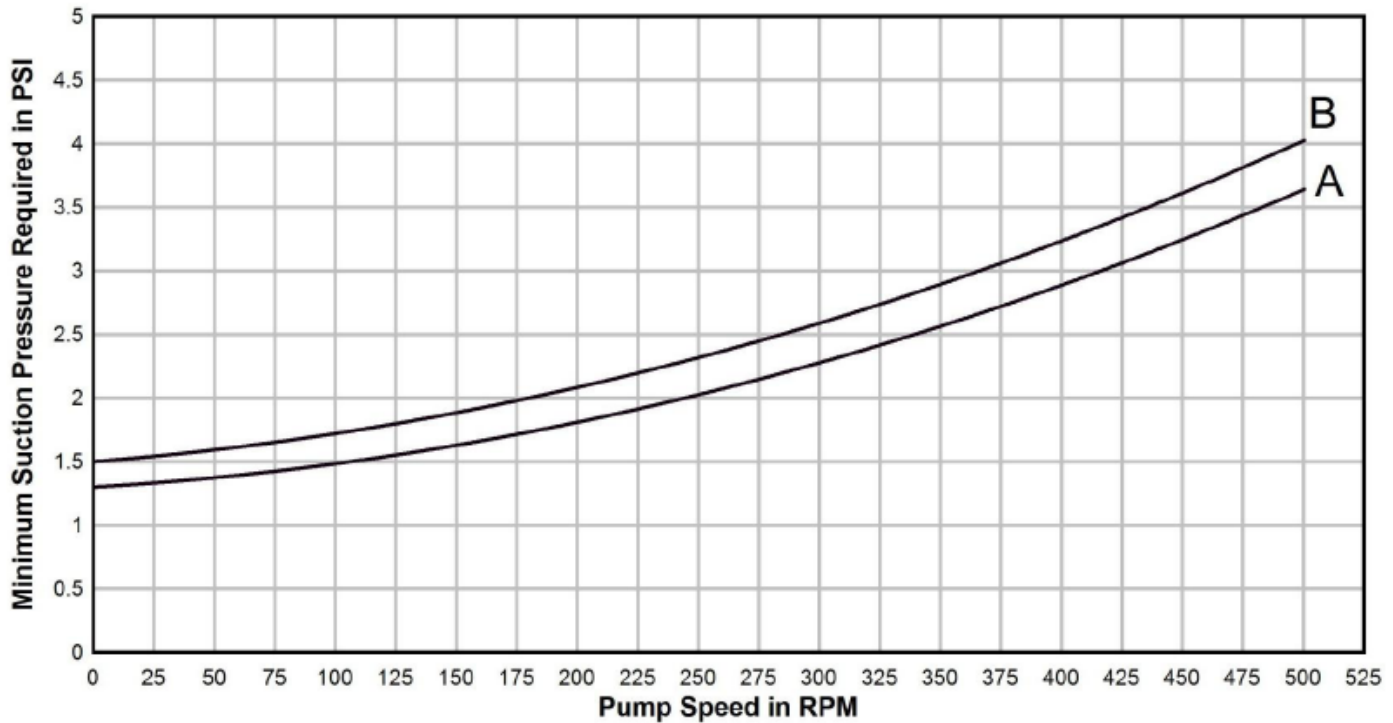
7. Apply a film of light oil to each Lantern Ring and install between the second and third pressure ring sets of packing in each Stuffing Box. Be sure the Lantern Rings align with the lubrication ports of the Stuffing Boxes.
8. Install each Gland Follower after the last Packing Set.
9. Apply an anti-seize thread compound to the threads of the Stuffing Boxes and install each Stuffing Box Gland just a few turns. Do not fully tighten the Stuffing Box Gland at this time.
10. Apply a film of light oil to the Plunger and carefully install it through the Stuffing Box
11. Follow the procedure for connection of Fluid End defined in [Section 4.7](#).
12. Fully tighten the Stuffing Box Glands with a gland nut wrench be hand **DO NOT USE A CHEATER**
13. Start the pump and operate at pressure for two to three hours while observing for excessive leakage. If leakage is excessive, stop the pump and readjust. After the two or three hours, stop the pump and readjust. Again, **DO NOT USE A CHEATER**.
14. This style packing is considered non-adjustable and should be ready to go at this point. However, it may take as much as one or two days to fully seat. After a couple of days, stop the pump and check the packing again. After this adjustment the pump should be ready to run without further adjustment.

6.0 ENGINEERING DATA

6.1 SUCTION PRESSURE REQUIREMENTS

Suction Pressure Requirements

CX-5
H & M Cylinders



A – ‘H’ Cylinder up to 1.000” Plungers

B – ‘M’ Cylinder up to 1.625” Plungers

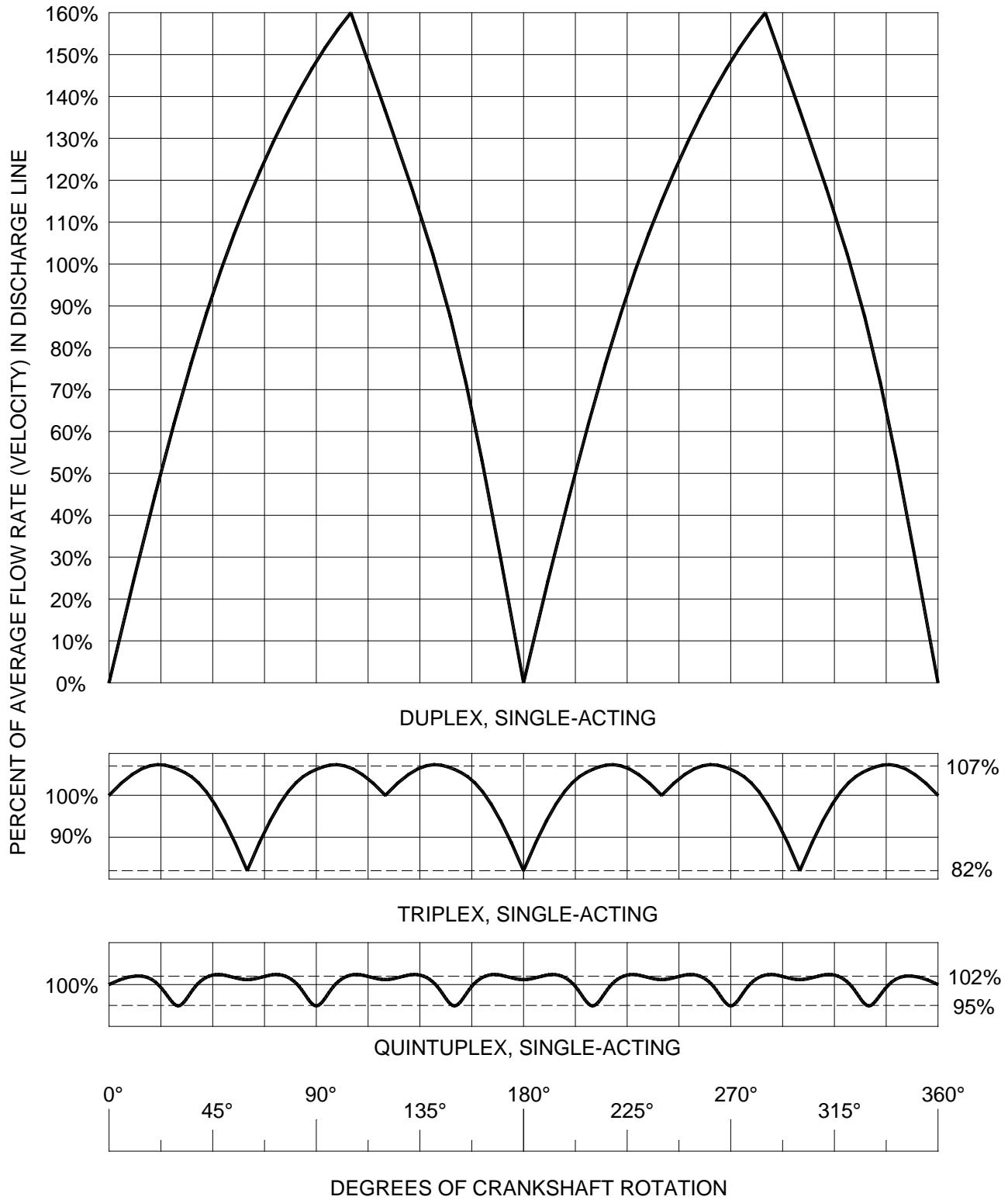
Notes:

- 1. These curves do not account for losses due to acceleration head and friction in the piping system. The above values are minimums that can occur at the pump inlet. It is the system designer's responsibility to calculate the losses in his/her system.*
- 2. The above curves are based on a fluid with a viscosity and Specific Gravity similar to water. Fluids with viscosities and/or Specific Gravity will require a higher suction pressure than shown above.*

6.2 CX-5 ENGINEERING DATA SHEET

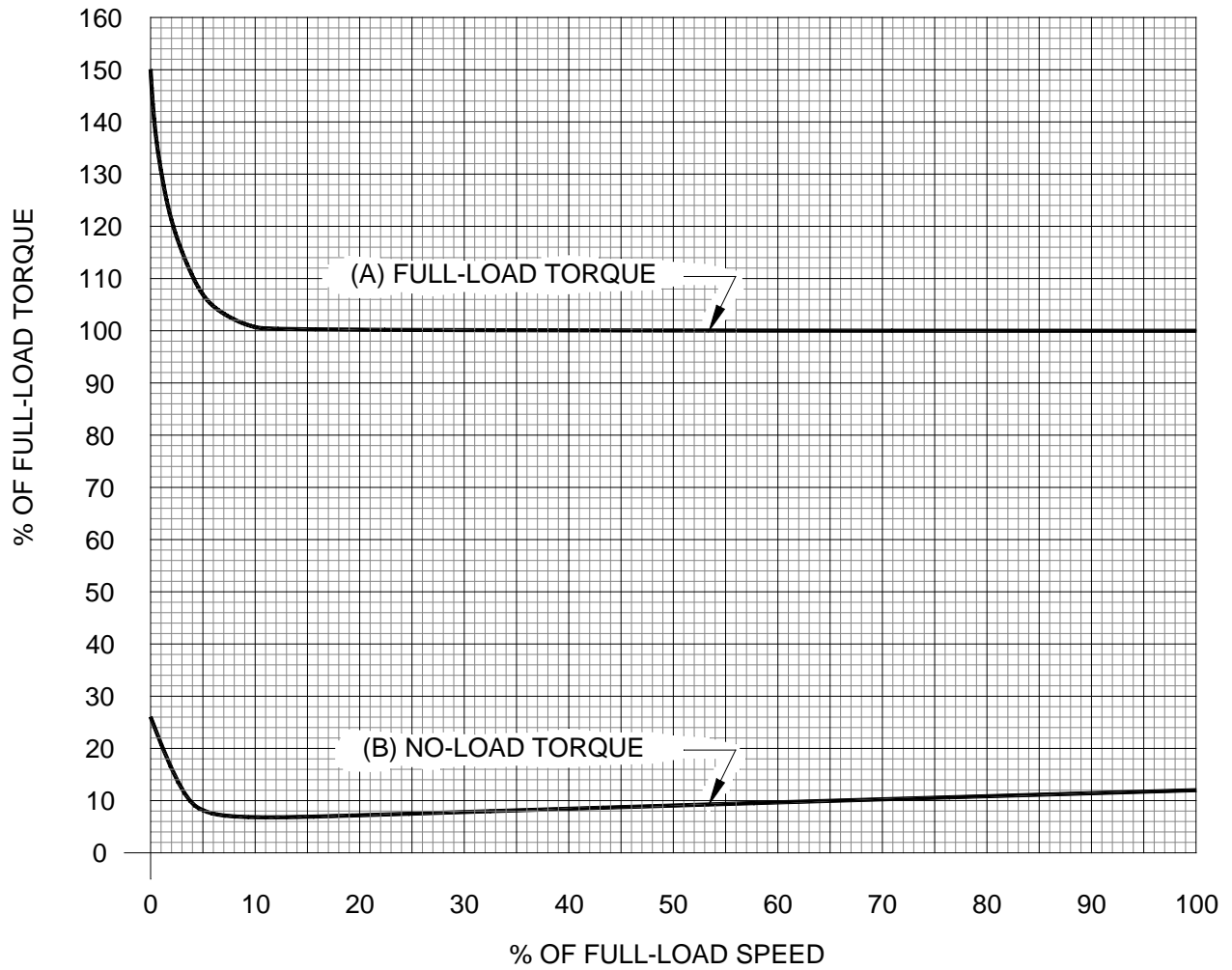
ENGINEERING DATA SHEET MODEL CX-5 2-1/4" STROKE-2000 POUND FRAME (PLUNGER) LOAD									
CYLINDER SIZE	PLUNGER DIAMETER	STUFFING BOX BORE (I.D.)	GALLONS PER REVOLUTION	MAXIMUM DISCHARGE PRESSURE (PSIG)	SUCTION VALVE SIZE	AREA THROUGH VALVE SEAT SUCTION & DISCHARGE	PERCENT VALVE AREA SUCTION & DISCHARGE	CYLINDER DESIGN PRESSURE	MAXIMUM HYDROSTATIC TEST PRESSURE (PSIG)
CX-5H (CX-5 1")	3/8	1-1/8	.0032	10,000	1-1/16	.601	18	10,000	15,000
	1/2	1-1/8	.0057	10,000	1-1/16	.601	33	10,000	15,000
	5/8	1-1/8	.0090	6,519	1-1/16	.601	51	10,000	15,000
	3/4	1-1/2	.0129	4,527	1-1/16	.601	74	10,000	15,000
	7/8	1-1/2	.0176	3,326	1-1/16	.601	100	10,000	15,000
	1	1-1/2	.0229	2,546	1-1/16	.601	130	10,000	15,000
CX-5M (CX-5 1-1/2")	1-1/8	1-3/4	.0290	2,012	1-3/8	1.48	67	2,010	3,015
	1-1/4	1-3/4	.0359	1,630	1-3/8	1.48	83	2,010	3,015
	1-3/8	2-1/8	.0434	1,347	1-3/8	1.48	100	2,010	3,015
	1-1/2	2-1/8	.0516	1,132	1-3/8	1.48	119	2,010	3,015
	1-5/8	2-1/8	.0606	964	1-3/8	1.48	140	2,010	3,015
CX-5L (CX-5 2")	1-3/4	2-3/8	.0703	832	1-7/8	2.23	107	830	1,245
	1-7/8	2-3/8	.0807	724	1-7/8	2.23	123	830	1,245
	2	2-3/8	.0918	637	1-7/8	2.23	141	830	1,245
SUCTION AND DISCHARGE CONNECTIONS									
Both Sides									
CX-5H :			CX-5M				CX-5L		
1-1/2" FNPT Suction 3/4" FNPT Discharge			2" FNPT Suction 1-1/4" FNPT Discharge				2-1/2" FNPT Suction 1-1/2" FNPT Discharge		

6.3 RECIPROCATING PUMP FLOW CURVES



NOTE: THE ABOVE CURVES ARE APPROXIMATE AND REPRESENT RECIPROCATING PUMPS WITH A CONNECTING ROD LENGTH EQUAL TO FIVE TIMES THE CRANK THROW.

6.4 PUMP SPEED VS. TORQUE



(A) FULL-LOAD TORQUE

This represents start-up against the designed discharge pressure of the pump.

(B) NO-LOAD TORQUE

This represents start-up with an open by-pass valve to the pump suction.



BEAR PRODUCT LINE - PFT PRODUCTS

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