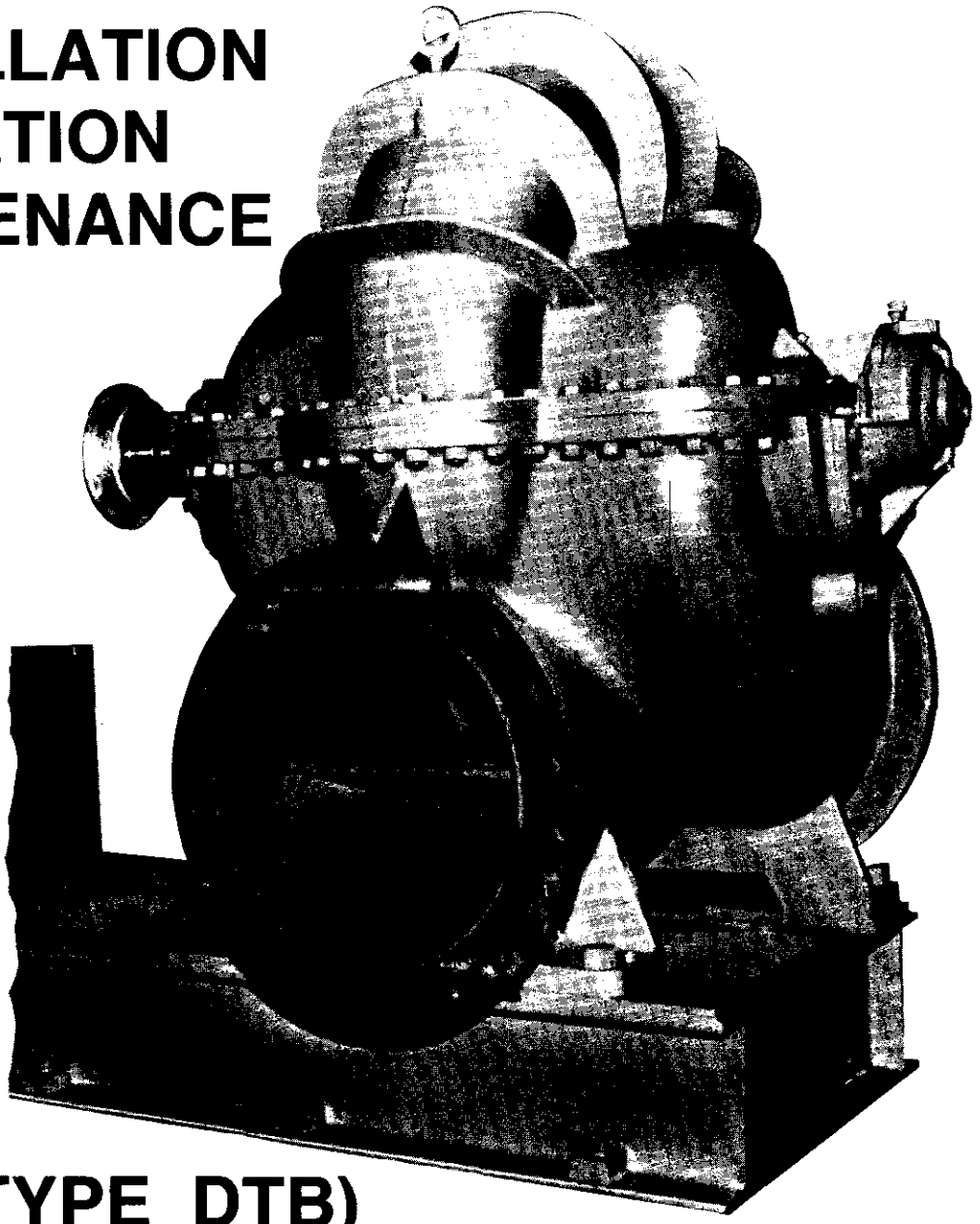
INSTALLATION OPERATION MAINTENANCE



4100 (TYPE DTB) 4200 (TYPE DLB) DOUBLE SUCTION CENTRIFUGAL PUMPS

PLEASE READ THESE INSTRUCTIONS BEFORE INSTALLING PUMP

MEMBERS OF THE HOUDAILLE PUMP GROUP

Warren Pumps Division
Warren, Massachusetts
Peace Dale, Rhode Island
Rockaway, New Jersey

Viking Pump Division
Cedar Falls, Iowa

Houdaille International, Inc.
Alphen a/d Rijn
The Netherlands

This pump is not to be operated at speeds, working (discharge) pressures or temperatures higher than, nor used with liquids other than stated in the original order acknowledgment without written permission of Warren Pumps Division, Houdaille Industries, Inc.

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INTRODUCTION

This manual is intended to assist those concerned with installation, operation and maintenance of 4100 and 4200 Series Warren pumps. It is the manufacturer's hope that the following discussions will be clearly and easily understood. Should questions arise that cannot be answered by the material contained in this manual, we suggest that Warren Service Department be contacted through your local Warren distributor or directly.

SECTION 1 — GENERAL INFORMATION

Warren type DTB (Series 4100) and DLB (Series 4200) pumps are the direct result of more than 80 years experience designing and building pumps — and only pumps. They meet the design and operating requirements actually expressed by operating personnel and maintenance engineers.

But a Warren Pump is more than hardware; it is reliable, trouble free pumping backed by pump specialists, trained to understand your pumping problems. Information and service are available at all times.

Interchangeability — Maximum parts interchangeability is achieved in series 4100 pumps without sacrificing proper hydraulic and mechanical design. Shafts and bearings for each shaft group are rated to handle maximum loads encountered in each group. Sound engineering is not sacrificed for manufacturing short cuts.

Casing — Double suction volute type in the 4100 Series pump and dual volute double suction in the 4200 Series. Water passages are designed for gradual velocity changes for quiet operation and smooth, low pulse flow.

Casing is horizontally split so rotating element can be inspected or removed without disturbing suction and discharge piping or driver alignment. Casing has necessary water seal, vent, drain and gage connections and eye bolts.

All casings are hydraulically tested to at least 1½ times shutoff pressure.

Impeller — Double-suction, enclosed type, machined and balanced for vibration free operation. Impeller is keyed to shaft. Renewable impeller rings are standard on all 4200 series pumps and available as an option on all sizes of 4100 series pumps with the exception of the 1½, 2, 2½ and 3-DTB-8.

Shaft and Shaft Sleeves — Shaft diameters are sized to handle maximum operating conditions and to minimize deflections. Shaft is ground all over. Renewable shaft sleeves are threaded to shaft shoulders against impeller hubs and gasket sealed to prevent leakage along shaft. Unique locking sleeve allows the use of one shaft only for both directions of rotation.

Rotation can be easily changed in the field.

Stuffing Boxes — Most pump sizes have 5 packing rings plus water seal ring in each stuffing box. External seal, internal seal or packed solid arrangements can be furnished depending on pumping conditions. Glands are split for easy removal. Closed-end gland design prevents swing bolts from becoming dislodged. Gland swing bolts, nuts and washers are stainless steel. Mechanical seals are available for all sizes as an option.

Bearings — Thrust bearings are double row, angular-contact, maximum capacity type and take radial load and any unbalanced thrust load in any direction. Radial bearings take radial loads only.

Bearings are held with locknuts and lockwashers, and are regreaseable.

Bearings are well protected from dirt and moisture by composition excluders which rotate with the shaft. Flexible lips maintain constant pressure contact on bearing heads for positive protection both while pump is running and shutdown.

Airborne Noise — Pumps are designed to keep airborne noise levels below generally accepted industrial safety standards.

Conformance to specific industrial, state or local standards can be verified in our noise-test laboratory.

Flexible Coupling — Standard flexible couplings furnished to meet specifications.

SECTION 2 — RECEIVING, HANDLING AND STORAGE

2-1 Receiving

The equipment should be placed under adequate protection immediately upon receipt. Ordinary packing crates are not suitable for out-of-door storage beyond a 30 day limit including the duration of transport. This may be less if the atmospheric conditions are unfavorable.

Special long term storage crating can be supplied upon request.

Each shipment should be carefully examined upon arrival. Any damage should be reported promptly to the carrier and to the nearest office of Warren Pumps. Damage claims must be made at the time of receipt.

2-2 Handling

Take care when moving the unit about prior to installation. This is particularly important with large, heavy units. Rough handling and thoughtless selection of points from which to lift large units may cause permanent distortion of the base and or casing which will affect the close operating clearances of the rotating assembly. Contact of the moving parts could cause a pump failure.

2-3 Storage and Preservation

Units are shipped on skids and suitably boxed or crated to prevent damage from normal handling. All exterior, unpainted surfaces subject to corrosion are coated with a rust preventive compound. Pump openings are covered with blank flanges or special cups.

A packing list is furnished itemizing the contents of the shipment. When received, check the contents against the packing list. Report any discrepancies to Warren or your Warren distributor immediately.

If pump is not to be installed immediately and operated or if pump is not to be operated for some time after installation, the unit should be cared for as follows:

1. Select a clean dry storage location.
2. Be certain that blank flanges or cups covering pump openings are properly attached.
3. Rotate pump shaft through several turns at least weekly.
4. If area where pump is stored or installed is a moist or dusty atmosphere:
   a. Recoat all exterior, unpainted surfaces subject to corrosion with a rust inhibiting compound.
   b. Fill oil reservoirs completely full of oil.
   c. Protect pump and driver with a plastic or canvas covering.
   d. Fill cast iron or cast iron fitted pumps with oil or a suitable preservative.

SECTION 3 — INSTALLATION

IMPORTANT — The following installation instructions are a guide to assist you in proper installation procedures.

Probably the most important thing you can do to enhance the life and smooth operation of this machine is to plan your installation by following these installation procedures and other good machinery practices.

If questions should arise, contact the Warren Service Department for assistance.

NOTE — Protect your investment. A properly planned and executed installation is necessary for trouble free pump performance.

3-1 Location

A pump is purchased to deliver a specific capacity at a specific pressure. To accomplish this, the designer must take into consideration the conditions that will exist on the suction and discharge sides of the pump after installation, such as suction lift or head and temperature. This information is given to the pump engineer by the purchaser and is based on a preplanned location of the pump in a system. In order for the pump to operate as designed, it must be located in this preplanned location. If, after receipt, another location is considered that might alter the preplanned conditions, it is recommended that Warren be consulted to insure satisfactory operation of your pump.

Locating the pump as near to the source of supply as possible upon installation is advisable. Ideally, the location should be well lit and dry with enough room to perform routine maintenance and space enough for rigging, etc. If you find it necessary to locate the unit in a pit, be sure to make provisions to prevent flooding.

3-2 Foundation

Foundations should be a suitable mass to absorb vibration and provide a rigid support for the unit. Use reinforcing steel as necessary.

A template should be made to position and hold the foundation bolts in place while pouring the concrete. Location and sizes of bolt holes are shown on the certified outline drawing supplied to the purchaser. Each bolt is installed in a pipe sleeve, the inside diameter of which should be three times the outline diameter of the bolt. The pipe sleeve allows for minor adjustments in bolt spacing after foundation is in place (Fig. 3-2). Two methods commonly used to secure and prevent bolts from turning are:

a. A washer is placed between the bolt head and pipe sleeve with a lug welded to the bolt head (Fig. 3-2)
b. The bolt may be of rod construction, bent 90° below the pipe sleeve.

Stuff waste between foundation bolts and sleeves to prevent concrete from entering while foundation is being poured. Foundation bolts must be long enough to allow from ¾" to 1" for grouting under the baseplate (Fig. 3-2). When pump is level, the bolts should extend ¼" through the nuts. Leave top surface of foundations rough for adherence of grout.

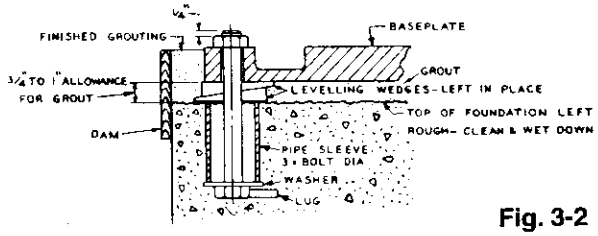


Fig. 3-2

3-3 Baseplate

1. Leveling — Before placing the unit on the foundation, be sure the surface of the foundation is clean and roughed. Place the leveling wedges adjacent to foundation bolts and remove waste from pipe sleeves. Clean underside of pump foundation and lower unit over baseplate bolts and onto wedges. Adjust the wedges to allow for ¾" to 1" of grout, being sure pump flanges are plumb. This unit has been factory aligned and uneven bearing of wedges can cause misalignment. Snug up, but do not make up hard the foundation bolts. Check coupling alignment and correct as necessary. Avoid baseplate distortion. Level pump with a spirit level.

2. Grouting — Build a board dam around the foundation to the desired height for finished grouting (See Fig. 3-2) A mixture of one part portland cement to two parts clean sand with just enough water to mix to a thick creamy consistency should be made for grout. Wet the underside of the baseplate and foundation top, then pour the grout through the holes in the baseplate. Thoroughly puddle the grout during pouring to prevent air pockets and hollow spots, After grout has set sufficiently, remove the board dam and finish off the grout as desired. When grout has hardened, usually in about 48 hours, pull up on foundation bolts.

3-4 Piping

1. Since the basic design incorporates close running clearances between the impeller and the case rings, it is very important that suction side piping be thoroughly cleaned before connecting piping to the pump.

2. If the pump is required to operate with a suction lift, the suction system MUST be properly sized and designed. The pump cannot be expected to overcome deficiences in system design such as long runs of suction piping, possibly undersized and containing many elbows, valves, and particularly high points that are above the pump suction. In such cases, the pump will invariably be noisy and troublesome.

3. After the unit has been installed and secured on its foundation, pipe connections may be made up. See pump outline drawing for location of all pipe connections, flange sizes, drilling and other notes pertinent to piping. Piping runs should be as short and direct as possible. Use long radius elbows to change direction wherever possible. Discharge piping should be sized to give the required stock velocity based on the ideal flow condition for the type stock.

4. All major piping must be supported independently of the pump and properly aligned with pump flanges. Piping subject to high temperatures must be fitted with a means of absorbing expansion. Piping strain on the pump may cause distortion resulting in misalignment, vibration or mechanical damage.

5. To check piping alignment of pumps having bolted flanges, insert flange bolts through pipe and pump flange. If bolts are easily moved within the bolt holes and if flange faces are parallel with each other, piping is properly aligned.

6. Maintain sufficient gap between flange faces for inserting the gasket. Flanges should not butt tightly before being secured.

3-5 Piping System Accessories

1. Suction Strainers — Warren recommends that suction strainers be installed on the suction side of the pump at least temporarily until the new system is deemed cleansed of foreign material. Strainers or screens should be constructed of 20 mesh wire and equipped with a backing plate. The total mesh opening should be 5 times the cross sectional area of the pipe. If liquid is in excess of 1000 SSU viscosity, 6 times the pipe area is recommended. Gauges should be installed on either side of the strainer to indicate when the strainer requires cleaning.

2. Check Valves — If the discharge piping system is subject to a high static head, a check valve should be installed. This valve will prevent hydraulic shock acting upon the pump and will also prevent reverse rotation of the pump when stopping the unit.

3. Bypass Valve — It is not recommended that you operate the pump with its discharge excessively throttled. This will cause the pump to operate at an extremely inefficient point on its performance curve. (see gen. sect. of Sect. 6 STARTUP/-OPERATION) If it is necessary to employ a pump in a service where the demand varies widely, it is suggested that some type of bypass valve be installed in the discharge line and piped back to the source.

   This will allow the pump to produce a flow which will result in smooth operation and long life.

4. Sealing Fluid — Many Warren pumps require water or other fluid be supplied to the stuffing boxes as a coolant and/or sealant. The usual arrangement in the series 4100 and 4200 pumps is to pipe gland fluid from pump discharge back to the stuffing box.

   Control seal fluid until desired leakage is obtained. Generally 30-60 drops per minute is satisfactory. When the pump is required to pull a suction, it is essential to maintain a positive seal in the stuffing box to prevent loss of prime and therefore, pumping capability. In special cases, or when a problem is encountered, consult Warren.

3-6 Factory Alignment

Pumps supplied with motor, base and coupling are aligned prior to leaving the factory. The pump is doweled to the base; however, the motor is not doweled as alignment corrections are often necessary during installation. Stresses caused by lifting and transportation often cause minor distortion which

will disturb the factory alignment. Check the alignment after the baseplate has been leveled prior to grouting; after grout has hardened; while connecting piping and finally after equipment has been run and up to its operating temperature. (See sect. 4 COUPLING ALIGNMENT for detailed procedure)

3-7 Doweling

After the unit has been running for about one week, the coupling halves should be given a final check for possible misalignment caused by pipe strains or temperature strains. This check should be made immediately after unit is shut down, before it has a chance to cool. If alignment is correct and unless Warren instructs otherwise, the driver should now be doweled on diagonal feet.

NOTE: Normally, the pumps are doweled at the factory and the drivers are doweled in the field. The taper pin size for doweling the driver will normally be the same as that of the pump.

SECTION 4 — COUPLING ALIGNMENT

4-1 Alignment

A flexible coupling is not designed to compensate for excessive misalignment. Its purpose is to permit slight movement of pump and driver shafts while transmitting power. Excess misalignment can cause short coupling life due to sliding and working action of couplings connectors and is also one cause of rapid wear of bearings and vibration during operation.

CAUTION: Before coupling gap is set, refer to original outline drawing for correct procedure in assembly of coupling gap. Proper rotation between driver and pump should be checked at this time, before shafts are coupled. This insures proper rotation of pump before coupling of shafts.

Method of checking alignment is as follows:

1. Check angular alignment of shafts by measuring gap between coupling hubs.
   a. Line up coupling match marks and hold shafts stationary.
   b. Insert a wedge gauge or feeler gauge between coupling hubs at four points; top, bottom and each side. Note and record each measurement.
   c. Compare opposing measurements to determine amount and direction of angular misalignment. Coupling faces should then be brought into parallel alignment. Every effort should be made to reduce misalignment to .00mm even though .07mm/.003" misalignment is acceptable.
2. Locate coupling hub match marks. All hubs are marked by a painted stripe or a stamped impression. When taking a measurement, match marks must oppose one another. If painted match marks cannot be located, match mark hubs with chalk, etc.
3. Check parallel alignment. (A routine parallel alignment check may be made with coupling connected)
   a. Secure a dial indicator to one coupling hub rim in such a manner that the indicator button touches the opposite coupling hub rim.
   b. Set indicator dial on zero; then rotate both hubs together through one full turn. After the full turn, the indicator should read zero. If there is some other reading, the indicator is not securely set up and should be adjusted.
   c. Again rotate coupling hubs through one turn, stopping at each quarter point to note and record indicator reading. The indicator must return to zero at the end of the turn.
   d. Compare opposing readings to determine amount and direction of misalignment. If, for example, when indicating from pump to driver, the top reading was .00mm and the bottom reading +.25mm, it would mean the driver half coupling was .125mm lower than the pump hub. If the bottom reading was −.25mm the driver hub would be .125mm higher than the pump hub. If the ¼ point reading was +.07mm and the ¾ point reading was +.18mm, it would mean the driver half was offset, .055mm to one side.

NOTE A: The extent of misalignment is equal to one-half the total indicator reading. (Above mentioned figures, +.07mm and +.18mm, result in a total indicator reading of .11mm. Had the indicator reading been −.07mm and +.18mm, total indicator reading would be .25mm. In order to align shafts, persons involved must interpret indicator readings correctly.

   e. Adjust driver position as called for by indicator readings. Adjustments are made by adding or removing shims from beneath driver mounting feet for vertical adjustments and by adjusting driver right or left. These adjustments should be made equally at both ends of the driver.

NOTE B: Every effort should be made to reduce misalignment to .00mm even though .07mm/.003" misalignment is acceptable.

4. Connect the coupling and lubricate. Refer to the manufacturer's instruction manual for correct quantity and type lubricant for coupling. If spacer coupling is furnished be sure to add the additional quantity required to fill the spacer per manufacturer's recommendation.

4-2 Thermal Expansion

When operating units that have a high differential between centerline of driver and centerline of pump or in cases where the operating temperature of driver and pump vary considerably from ambient, the amount of thermal expansion in the pump/driver combination becomes important for proper alignment of the coupling. Failure to take into account thermal expansion when aligning the coupling can result in an extreme reduction in both coupling and bearing life.

The following explanations and worked through example should illustrate the simplicity of these calculations and the necessity that they be made.

The formula itself is expressed as the following:

coefficient of expansion x temperature rise x centerline height

The coefficient of expansion is a specific figure for each material expressed in millionths of an inch per inch per degree Fahrenheit temperature rise. In the Warren DTB (4100) and DLB (4200) pumps three materials of construction are used in the pump casings. These materials are bronze, cast iron and stainless steel. The coefficient of expansion is naturally different for each material. The following coefficient of expansion should be used with the corresponding casing material when making calculations.

A010A Cast Iron ..... 6 from 32-212°F
C020A Bronze ..... 10 from 70-350°F
B407 SS ..... 9.4 from 70-212°F

If your operating temperature exceeds the above range listed with its corresponding coefficient, consult Warren.

The second piece of the formula deals with temperature rise and is fairly straight forward. Simply stated the temperature rise is the difference between ambient and operating temperature (in degrees Fahrenheit)

The third piece of the formula centerline height, is simply the distance (in inches) from the bottom of the pump and driver feet to the center of their respective shafts. Check the supplied outline drawing for pump and driver centerline heights.

The following is a sample calculation using an actual outline and consequently existing centerline differences from a previous pump sale.

Example:
ambient temperature 80°F

pump
operating temp. 160°F
CL height 67"
material-SS
motor
operating temp. 160°F
CL height 24"
material-Cast Iron

pump rise due to thermal expansion
temp. rise = 160°F (operating) — 80°F (ambient)

coefficient of expansion for stainless steel 9.4×10^{-6} in/in/°F
rise = temp. rise x centerline height x coefficient of expansion

pump rise = $80 \times 67 \times 9.4 \times 10^{-6}$

= .050" with the 80°rise in pump temperature

motor rise due to thermal expansion
temperature rise = 160°F (operating) — 80°F (ambient)
coefficient of expansion cast iron 6×10^{-6} in/in/°F rise = temp. rise x centerline height x coefficient of exp.

= $80 \times 24 \times 6 \times 10^{-6}$
= .0115" with an 80° rise in motor temp.

Obviously, if the two units in the previous example were aligned at the coupling when cold, a misalignment of nearly .040" would result when both units warmed up to operating temperature. The necessity of making an allowance for thermal expansion is illustrated, as well as the need to check the alignment of the unit while hot. Further the statement should be made that the thermal growth formula is the best method of determining centerline rise without actually checking a hot unit. However, the method is just an approximation and does not account for the influences of piping, casing geometry and hot and cold spots created by circulating air.

In concluding, the following steps should be taken to insure proper coupling alignment during operation.

1. Calculate thermal growth and compensate accordingly when aligning the coupling.
2. Whenever possible allow pump and driver to warm up prior to start up.
3. Check coupling alignment while both pump and driver are hot to insure alignment is correct for the operating conditions.

SECTION 5 — LUBRICATION

5-1 Grease Lubrication

If your Series 4100 or 4200 pump is fitted for grease lubrication, it is suggested that the grease conform to the following characteristics:

NLGI ..... No. 2
Drop point °F 340-380
Soap Base ..... Lithium
ASTM Penetration (worked) 230-290

Greases similar to the following will be satisfactory according to the above characteristics:

EXXON	Unirex N2
MOBIL	Mobilux 2
SHELL	Alvania 2
TEXACO	Multifak 2
GULF	Gulfcrown No. 2

All grease lubricated pumps are shipped with sufficient grease for initial operation. Normal greasing of the bearings should be accomplished only when the pump is running. Approximately ½ to 1 oz. grease to each bearing at the scheduled intervals is normally sufficient to renew the lubricating film necessary to resist oxidation. DO NOT OVERGREASE BEARINGS. THIS WILL CAUSE OVERHEATING.

The interval between greasing the bearings is largely determined by the conditions under which the pump is operating. Under favorable conditions it is recommended that additional or replacement lubricant be added only after 1700 hours operation or at approximate 3 month intervals.

The bearings and housings should be flushed of old grease annually and new grease supplied to the bearings, as grease hardens and becomes less suitable for its purpose due to oxidation over a period of time.

5-2 Oil Lubrication

The Warren Series 4200 pump may be lubricated in two ways. The standard version is grease lubricated. However the pump may be furnished with optional oil lubrication. This section is intended to aid you in selecting the proper lubricant and subsequently maintaining proper lubrication.

Warren recommends the use of high grade non-detergent oils with anti-foaming agents; oxidation and corrosion inhibitors. It is suggested that the oils conform approximately to the following characteristics:

ISO VG	150
Viscosity cST @ 100°F	135-165
SSU @ 100°F	800
Viscosity index min.	80
Flash Point OC °C	200°C
Gravity °API	28

(These are to guide you and are not rigid specifications). The following oils are satisfactory and fall in the general range of the above specifications:

EXXON	Teresstic 150
MOBIL	DTE Extra Heavy
SHELL	Turbo 150
SUNOCO	Sunvis 775
TEXACO	Regal R & O 150
GULF	Harmony 150N

It is further recommended where special high temperatures or difficult atmospheric conditions exist, the customer consult his local lubrication expert for advice.

Pumps are shipped without oil and it will be necessary to fill the oil reservoir to its proper level prior to operation. Add oil only when the pump is not running because a false level occurs when the pump is operating. This is because the pump employs a splash lubrication system. In all cases the oil level should be between the high and low marks.

5-3 Cooling

If your Series 4200 is equipped with oil lubrication and cooling for the bearings is required, a cooler will be incorporated in the bearing housing. It will be necessary to remove the shipping plugs and connect your coolant supply.

5-4 ISO Viscosity Chart

Many lubricants now carry identifying numbers derived from the viscosity grading system established by the International Organization for Standardization (ISO). The chemistry of the lubricants remains the same. Only the numbering system is changed to keep the products readily identifiable in accordance with recommendations from the American Petroleum Institute and the new standards of the American Society of Testing and Materials (ASTM).

ASTM D2422-75 "Viscosity System for Industrial Fluid Lubricants" is in most respects identical to ISO Standard 3448.

Equipment and lubricant suppliers around the world have adopted the ISO viscosity grade system which contains 18 grades covering a viscosity range from 2 to 1500 centistokes (cSt) at 40°C (104°F). Each viscosity grade is approximately 50% greater than the preceding lower grade.

KINEMATIC VISCOSITY LIMITS CENTISTOKES (cSt) at 40°C

ISO Viscosity Grade Identification	Minimum	Maximum	Approx.SUS @ 100°F Viscosity
2	1.98	2.42	34
3	2.88	3.52	37
5	4.14	5.06	42
7	6.12	7.48	50
10	9.0	11.0	62
15	13.5	16.5	83
22	19.8	24.2	116
32	28.8	35.2	166
46	41.4	50.6	240
68	61.2	74.8	357
100	90.0	110.0	529
150	135.0	165.0	800
220	198.0	242.0	1180
320	288.0	352.0	1730
460	414.0	506.0	2510
680	612.0	748.0	3750
1000	900.0	1100.0	5560
1500	1350.0	1650.0	8410

SECTION 6 — START-UP/OPERATION

General

Operation of a centrifugal pump at reduced capacities (substantially below the B.E.P.*) will adversely effect the performance and life expectancy of that pump.

Pumps operated in these low flow areas of the curve will experience damage caused by internal recirculation in the impeller. This may be either at the suction or discharge vanes of the impeller. This will cause additional axial and radial loading of the bearings; cavitation damage of the impeller and vibration related damage to the pump.

1. Impeller Suction Eye Recirculation — At low flow rates centrifugal pump impellers are prone to internal recirculation. At or near the B.E.P. there is little effect but when the pump operates at lower capacities the flow at the outer diameter of the eye tends to reverse itself. This creates a vortex effect. This turbulence causes surging and pulsations which lead to cavitation damage. This type of cavitation damage may be distinguished from low N.P.S.H. cavitation in that it will occur on the concave (trailing) side of the vanes rather than the convex (leading) side. Also pulsations in this situation will be random as compared to multiples of the speed in a vane passing situation.

*Best Efficiency Point

2. Impeller Discharge Recirculation — This results in hydraulic surges and local cavitation at the impeller tips. This recirculation may not occur at the same flow rates as the suction recirculation. Discharge recirculation will result in strong pressure fluctations outside the impeller shrouds. This will cause axial loading on the bearings and will cause premature wear and eventual failure. It will also cause radial loading of the bearings due to uneven pressure distribution around the periphery of the impeller.

Many pumps are selected for much greater capacities than are actually required. This is done to afford the user a safety margin against wear; to prepare for a future requirement or to cover a wide range of capacity requirements in a single application. Although these are all real problems it may be in the best interests of the user to find another way to provide a more flexible arrangement.

It is possible to gain this flexibility by installing a recirculating line downstream of the pump. It should be sized approximately for the system; include a suitable regulating valve and be piped to some suitable point in the suction system. This point should be carefully selected distant enough from the pump suction so as to prevent overheating from short cycling. If the recirculating line is piped back into a tank or chest, it should be placed in order not to create undersirable turbulence in that vessel.

In conclusion, we have been made aware of a common problem in the field. We have attempted to explain this problem and offer some general guidance to aid you in avoiding these situations.

If you still find yourself in a position where you wish to operate a pump at other than the conditions originally specified, we suggest that you consult your local Warren representative prior to doing so.

6-1 Pre-Startup

Pre-startup checks for trouble free initial startup are essential to avoid operational difficulties. Listed below are several items which should be checked prior to the release of equipment to regular operation.

1. Inspect all piping. Check for leaks and unnecessary piping strain on the equipment. Flush all piping to insure removal of foreign material from the system. Check that all valves and remote control equipment is functional.
2. Check rotating element to see that it turns freely. Jacking may be necessary on large units. If there is any rubbing or binding at this point, the equipment should not be started until the cause of this rubbing or binding has been located and corrected.
3. Before making up the pump and driver coupling halves, check that driver rotation is correct. Rotation is shown by the directional arrow attached to the pump.
4. Align coupling halves, lubricate and make up the coupling. (See Sect. 4-ALIGNMENT)
5. Check oil level in the reservoir. Drain any oil remaining from storage. Recharge with new oil as prescribed in Sect. 5-LUBRICATION. Check to insure that oil is at the proper level in the oil reservoir. This is at the center of the sight glass when the pump is **not** running.

6-2 Startup

1. Priming — Open suction and discharge valves to allow casing to fill with liquid. The pump casing is not self-venting so that external release of air could be necessary.

   Priming systems are seldom required. Although negative suction conditions sometimes exist in actual operation, it is generally due to frictional resistance created by suction piping. Static suction conditions prior to starting the pump are usually above atmospheric pressure allowing the proper venting of the casing.

2. Sealing Water — Open seal water valves and adjust to allow ample leakage of water through the packing to atmosphere. This will prevent overheating the new packing at startup. See Step 5 below for further instructions after startup.
3. Valve Positioning — Set system valves in correct position to insure flow of liquid to the pump. The discharge can be adjusted once the pump is in operation to give the desired flow. DO NOT

CONTROL PUMP FLOW WITH THE SUCTION VALVE. Problems will occur due to insufficient suction head.

4. Start Pump — Make a final visual check of pump and system and then start the pump.
5. Packing and Seal Water Adjustment — When desired discharge pressure has been obtained, adjust seal water flow and packing compression as follows:
   a. If only "IN" water seal is employed, increase seal water flow until gland leak off becomes clear water then adjust packing compression to reduce (or increase) gland leak off to 60 drops/minute.
   b. If "IN" and "OUT" water seal is employed (see Fig. 6-1):
      1. Open valve on "OUT" side about two (2) turns.
      2. Open valve on "IN" side wide.
      3. Slowly throttle "IN" valve while observing color of water flowing from "OUT" piping. Stop throttling "IN" valve when flow becomes clouded or colored by liquid pumped.

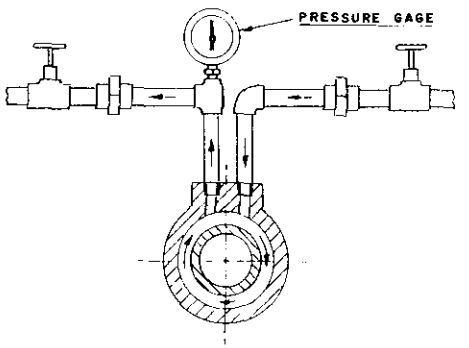


Fig. 6-1

      4. Throttle "OUT" valve until flow is reduced to a heavy trickle. This should increase flow of water through packing sufficiently to clear the water flowing from "OUT" piping. If not, open "IN" valve as necessary to clear the water.
      5. Adjust packing compression to decrease (or increase) gland leak off to 60 drops/minute.

REMEMBER: Allow ample leakage of water through packing at startup.

6-3 While Pump is Running

1. Check bearing temperatures,* bearing lubrication, stuffing box leakage, suction, discharge and seal water pressure.
2. Be sure gland drip box drain does not plug allowing drip box to fill with water.

6-4 To Stop Pump

1. Close discharge valve.
2. Stop driver.
3. Shut off water to seal area.
4. Close recirculating valve if installed.
5. Close suction valve.
6. Drain and flush casing if necessary.

*Bearing temperatures up to 180°F are normal. Within limits, the stability of the temperature rather than the number of degrees is the best indication of normal operation. A sudden increase in temperature indicates that a bearing problem is developing and a check of the bearing should be made.

Do not attempt to measure temperature by hand. Above 120°F the human hand is worthless in estimating temperature. Use a sensing device to check temperatures.

SECTION 7 — PREVENTIVE MAINTENANCE

Periodic Inspection

7-1 Daily

1. Check oil level in bearing pedestal.
2. Listen for unusual noise or vibration.
3. Inspect pump for leaks if pump is in use.
4. Check pipe connections and valves for leakage if pump systems are in use.
5. Check stuffing boxes to see if insufficient or excessive leakage exists. If excessive leakage is observed but gland travel is used up, packing rings must be considered as worn and should be replaced. There should be no leakage from mechanical seals.
6. Adjust seal water flow to provide sufficient seal and flushing water flow.
7. Make a general survey of the area and note any conditions which could lead to future problems.

7-2 Weekly

1. Run idle pumps under power.
2. Check operation of suction and discharge valves.
3. Check all automatic controls and regulators.

7-3 Quarterly

1. Check all foundation bolts and holddown bolts for tightness.
2. Remove half gland and check packing if pump has been left idle for long periods of time. If packing has become hard or otherwise unusable, it should be replaced.
3. Oil should be changed at least every three months or more often if there are any adverse atmospheric conditions (dust, etc.), or other factors which might contaminate or break down the oil.

7-4 Annually

1. Check existing pump capacity, pressure and power requirements against pump and motor nameplate data. If pressure and capacity have dropped off excessively, the pump should be disassembled and worn parts replaced. See applicable disassembly and reassembly sections in 8-Maintenance. If pump performance is satisfactory, the pump need not be disassembled for inspection.
2. Check alignment of pump and driver coupling hubs preferably after an operating period when pump and driver are still at operating temperature. Correct alignment if necessary and relubricate coupling at this time.

SECTION 8 — MAINTENANCE

8-1 Series 4100 Disassembly (refer to drawing 999F0261)

Before starting repairs, isolate the pump hydraulically and the driver from its source of power. Refer to the Sectional Assembly Drawing as a guide for proper sequence of parts removal.

A. Removing Rotor Assembly From Casing

1. Disconnect coupling between pump and driver.
2. Disconnect water lines to water seal rings (660) at each stuffing box. It may be necessary to disconnect vent piping from the casing to facilitate removal of the case cover (652).
3. Remove both packing glands (655).
4. Unfasten case cover (652) and lift case cover off. If the cover is large enough to require lifting gear, lift straight up and high enough so as not to damage the rotor parts when the cover is swung out of the way.
5. Remove both bearing caps (653).
6. Lift the rotating assembly from the case. Note that in some instances it may be necessary to free the case rings (654) from the case before the rotor can be raised. This may be accomplished by jarring the shaft upward with a bar placed under the shaft between the stuffing boxes and bearing housings (705).

B. Disassembly of Rotating Assembly

Note that in the following discussion, some steps consist of an (a) step and a (b) step. In all instances, the (a) step refers to larger Series 4100 pumps, sizes 3-DTB-9 through 12-DTB-14H. The (b) step refers to smaller Series 4100 pumps, sizes 1½-DTB-8 through 3-DTB-8.

1. Remove pump coupling half from the shaft.

2a. Remove bearing heads (704) (706) then slide bearing housing (705) towards impellers as far as possible to expose bearings (2503A&B).

2b. Remove bearing housings (705).

3. Remove bearing locknuts (3821A&B) and lockwashers (3820A&B).
4. Remove bearings (2503A&B) from the shaft. Bearing pullers may be used to accomplish this.

5a. Remove snap ring bearing spacers (2572).

5b. Remove bearing spacer (731).

6b. Remove bearing heads (704) (706).

7. Remove slingers (661), packing rings (3470A), water seal rings (660) and case rings (654) from the rotor.

8a. One shaft sleeve (659A) is secured with a setscrew (3611). Locate and remove this setscrew then unscrew and remove this shaft sleeve (R.H. threads). Slide impeller off the shaft or sufficiently to disengage the impeller from locking pin (3490) of remaining shaft sleeve. Unscrew and remove this shaft sleeve.

8b. Loosen setscrews located in shaft sleeve nuts (836) then unscrew and remove these nuts (threaded opposite hand of pump rotation). Remove shaft sleeves (659A&B) and impeller (657).

8-2 Reassembly of Series 4100 Pumps

A. Reassembly of Rotating Element

Note that in the following discussion, some steps consist of an (a) step and a (b) step. In all instances, the (a) step refers to larger Series 4100 pumps, sizes 3-DTB-9 through 12-DTB-14. The (b) step refers to smaller Series 4100 pumps, sizes 1½-DTB-8 through 3-DTB-8.

1. Clean all parts thoroughly.
2. Install impeller key (3245B) in its keyway. This key must be a snug fit.
3. Install impeller (657). Be sure impeller is installed for correct rotation. Impeller vanes curve away from the direction of rotation when viewed through the impeller suction.

4a. Position and lock impeller (657) as follows:

   1. Position impeller (657) on the shaft to conform to dimension "T" as shown on drawing, Sect. 9-3 of this booklet.
   2. Note which side of the impeller has two (2) holes drilled in the hub face (these holes receive pins of locked shaft sleeve (659b)). Mark the shaft at the junction between shaft and impeller hub on this side.
   3. Move impeller (657) away from this mark.
   4. Install locked shaft sleeve gasket (847B) and locked shaft sleeve (659B). Engage

shaft sleeve with shaft threads and tighten until the sleeve face is flush with the mark made on the shaft in Step 2.

5. Slide impeller (657) up to locked shaft sleeve (659B). Turn this sleeve as necessary to align its locking pins with the holes located in the impeller hub face then engage impeller with the locking pins.
6. Install remaining shaft sleeve gasket (847A) and shaft sleeve (659A) over the opposite end of the shaft. Tighten this sleeve firmly against the impeller.
7. Another method of properly locating the impeller is outlined under "C. Install Rotor in Casing", step. 6a.

4b. Install shaft sleeves (659) and engage with impeller key (3245B). Install shaft sleeve packing (3470B) (2 rings per sleeve) then replace shaft sleeve nuts (836). (Right and left hand threads). Tighten shaft sleeve nuts hand tight.

5. Install a slinger (661) over each end of the shaft.

6a. Cover inside walls of bearing housings (705) with grease then place bearing housings over the shaft.

6b. Install bearing heads (704) (706) over the shaft.

7a. Install bearing spacer snap ring (2572) on the shaft and engage with snap ring grooves.

7b. Install plain bearing ring (731) over coupling end of shaft.

8a. The following information will assist in the proper installation of the thrust bearings in all 4100 series and 4200 series pumps through and including 24-DLB-27. Please read this section carefully prior to installation of your thrust bearings.

1. Duplex Mounted Angular Contact Thrust Bearings.

This bearing type has a ball contact angle inclined to the bearing axis and provides a high thrust load capacity in one direction. Angular contact bearings are therefore always used in pairs, creating a highly versatile bearing capable of heavy radial loading and thrust loads in both directions.

fig. 8-2a — Depicts the back to back mounting. It positively positions rotor in casing and carries thrust load in either direction.

fig. 8-2b — Depicts the face to back or tandem mounting.

Note that this mounting carries the load in only one direction. **This mounting is not acceptable to Warren.**

fig. 8-2c — Depicts the face to face mounting.

Note that this mounting changes the ball contact angle in reference to the shaft. The shaft cannot be held as rigid in a moment sense. **Warren does not consider this to be an acceptable mounting.**

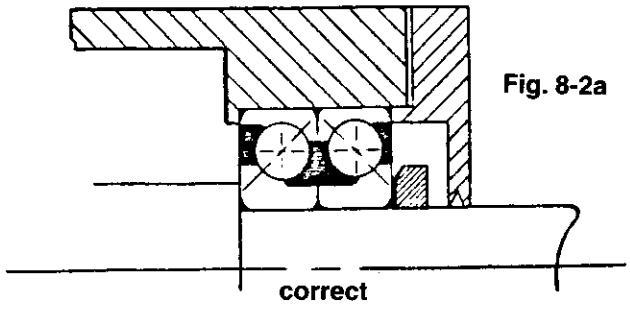


Fig. 8-2a

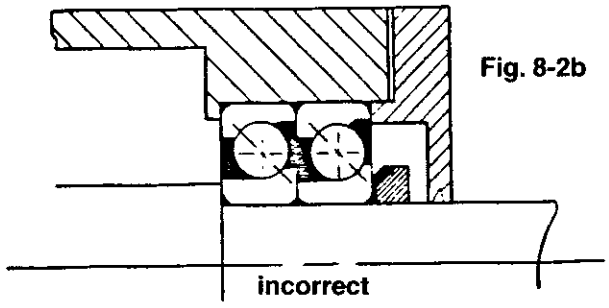


Fig. 8-2b

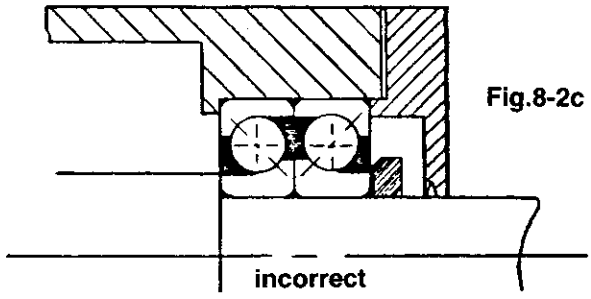


Fig.8-2c

2. Important Facts About Duplex Mounted Angular Contact Thrust Bearings

a. All bearings should be mounted back-to-back in a standard pump application.

b. Bearings should not be mixed. (exp. — SKF 7407 BMG should only be used with an SKF 7407 BMG). Another SKF number or another make bearing would be unacceptable. Also the same SKF number cannot be mixed with the same SKF number if a suffix is added to the basic designation. The suffix (exp. — SKF 7407 BMG-1) would indicate a preloaded bearing. The two (2) bearings would have different loading characteristics, making it an unacceptable mounting.

c. A face-to-face mounted bearing is not an acceptable mounting. It reduces ball contact angle in reference to the shaft, changing its load characteristics. The shaft can no longer be held rigid in a moment sense.

d. Creeping of the outer race is advisable in theory but does not hold true in practical application.

e. A back-to-back duplex mounted angular contact thrust bearing should be considered a held bearing and must be set up with a .000" end float. **To achieve this follow instruction 4a — e.**

f. Thermal growth of the bearing is not a problem since temperature differential between bearing housing and bearing would not exceed 20°F maximum. Thermal growth would be negligible.

g. The housing shoulder, to which the bearing outer race bears against, must be machined true to keep runout of this face within .0005". The bearing housing outer flange face must be machined true and at a right angle to the bore of the housing. The face of the male rabbet of the bearing cover must have a stand-off from its mounting flange so the relative runout is .0005". The shaft shoulder to which the bearing inner race bears against must have no more than .0005" runout. If this procedure is ignored, cocking of the bearing will result and short bearing life will be realized. (section 5 describes a positive means of accurately checking if these parts are machined or assembled correctly).

3. Double Row Ball Angular Contact Thrust Bearings

This bearing type has a ball contact angle inclined to the bearing axis and provides thrust load capacity in two directions. This bearing is also capable of handling radial loading.

Important Facts About Double Row Angular Contact Thrust Bearings

a. These bearings should be set up with .003" of free end float. This is exclusive of inherent bearing clearances.

b. The operating geometry is already incorporated into the bearing as opposed to a duplex mounted angular contact thrust bearing where the operating geometry is dependent upon the inner and outer races being locked.

c. The double row bearing is less critical in its basic operating geometry. The free end float is to compensate for minor errors in machining.

4. How to determine cover gasket size

a. Insert feeler gauge between face of bearing cover and bearing housing.

b. Reading should be taken when half of the nuts are tightened down snugly.

c. The feeler gauge reading is then multiplied by a multiplication factor;
1.3 paper, 1.5 velumoid/asbestos, 1.7 cork.

d. This will give the proper gasket size to be installed on a duplex mounted angular contact thrust bearing.

e. On a double row angular contact thrust bearing, add .003" to this reading.

5. How to check proper mounting of angular contact thrust bearings

Bearing race faces should be checked with a dial indicator.

a. Sweep face of inner race with indicator mounted on bearing housing.

b. Sweep face of outer race with indicator mounted on shaft.

c. A differential reading of over .001" indicates a faulty installation.

8b. Install thrust bearing (2503A) and plain bearing (2503B) as follows:

1. Pack bearing with grease.

2. Thrust bearings (2503A) for smaller series 4100 pumps are a matched pair. These must be installed in a back-to-back position. (Sides of bearings with narrowest opening between race go together).

3. Engage bearing with end of shaft, then tap the **innerrace only** to force the bearing onto the shaft. Do not use a soft metal hammer to do this as the metal may flake off and get into the bearing.

4. When the bearing becomes flush with the bearing locknut threads, locate a short length of pipe with a diameter that will permit contact with the bearing inner race. Tap against the pipe to complete the bearing. installation.

5. Replace bearing lockwashers (3820A&B) and locknuts (3821A&B). Tighten the locknuts firmly then bend lockwasher tangs into place against the locknut.

9a. Pull bearing housings (705) into position over the bearings. Replace bearing housing gaskets (818) then install and secure bearing heads (704 & 706).

9b. Replace bearing housing gaskets (818) then install and secure bearing housings (705).

10. Replace coupling key (3245A) and pump half coupling.

B. **Preparation of Casing**

1. Clean all machined surfaces.

2. Check horizontal joint gasket. If gasket is damaged or has hardened, it should be replaced.

C. **Install Rotor in Casing**

1. Rig rotor assembly over case (651).

2. Line up bearing housings (705) and case rings

(654) with their respective channels in the case.

3. Lower the rotor assembly carefully into the case.
4. Tap bearing housings and case rings around so that the half locks are flush with the case flange.
5. Replace and secure both bearing caps (653).

6a. Center the impeller (657) between case rings (654) as follows:

1. Look into the suction opening of the impeller. There should be a gap between the case ring and the impeller. Make this gap approximately equal on both sides of the impeller by sliding the impeller on the shaft in a direction to make the gap equal.
2. Mark the shaft on either side of the impeller.
3. Remove the bearing caps and lift the rotor from the casing.
4. Slide the impeller along the shaft away from locked shaft sleeve (659B). This is the sleeve that includes locking pins (3490).
5. Screw locked shaft sleeve (659B) up to the mark made in step 6a (2).
6. Slide the impeller up to this sleeve then turn the sleeve as necessary to align the locking pins with the holes drilled in the impeller hub.
7. Engage the impeller with the locking pins.
8. Screw the remaining shaft sleeve (659A) up to the impeller and tighten firmly. Lock the shaft sleeve in place by tightening the lock nut setscrew (3611) firmly against the shaft.
9. Reinstall the rotor as in Steps 1 thru 5 of this section.

6b. Center the impeller (657) between case rings (654) as follows:

1. Look into the suction opening of the impeller. There should be a gap between the case ring and impeller. Make this gap approximately equal on both sides of the impeller.
2. Tighten on shaft sleeve nut (836) while loosening the other shaft sleeve nut as necessary to move the impeller and equalize the gap between impeller and case rings.
3. When the impeller is centered, tighten both shaft sleeve nuts (836) firmly. Lock the shaft sleeve nuts in place by tightening the locknut setscrew firmly against the shaft.

7a. Slide slinger (661) up to the bearing housing (705). After contact has been made, move the slinger an additional 1/16" towards the bearing housings.

7b. Slide slingers (661) up to the bearing housings (705). After contact has been made, slide the slingers back about 1/16" and secure in this position by tightening the slinger setscrews.

D. **Installation of Case Cover**

1. Check that horizontal gasket is flush with edges of the case rings and also the edges of the stuffing box bore.
2. Rig case cover (652) into position then replace taper pins (3495). Do not drive these pins tightly into place, this will only make them difficult to remove at a later date.
3. Replace and tighten all nuts and bolts between case and case cover.
4. Check rotor for freedom of rotation. Rotor must turn freely at this point.

8-3 Changing Rotation of a Series 4100 Pump

Before starting repairs, isolate the pump hydraulically and the driver from its source of power. Refer to sectional assembly for proper sequence of parts removal.

A. **Removal of Rotor Assembly from Casing**

1. Refer to Sect. 8-1A, and follow procedure outlined.
2. Set the complete assembly aside.

B. **Reversing Casing**

1. Disconnect suction and discharge piping.
2. Remove hold down bolts to free casing from base.
3. Using suitable lifting gear, lift the casing and rotate 180°. Reset on base, replace hold down bolts and tighten hand tight.

C. **Disassembly of Rotating Assembly**

1. Refer to Sect. 8-1 B for disassembly of the rotating element.

   NOTE: Disassemble the assembly from the drive end to impeller only, as complete disassembly of the rotating element is unnecessary.

2. To reverse the impeller it will be necessary to drill new holes for the roll pins on the opposite side of the impeller. These holes should be located in the same relative position as the originals.

D. **Reassembly of Rotating Assembly**

1. Refer to Sect. 8-2 A for reassembly of rotor.

   NOTE: Since shaft sleeves (659B) was not disturbed on disassembly, and the impeller was drilled in the same relative location to accept the locking pins, positioning of the impeller will not be necessary.

E. **Preparation of Casing**

1. Refer to Sect. 8-2B.

F. **Install Rotor in Casing**

1. Refer to Sect. 8-2C.

NOTE: Centering of the impeller should not be necessary as stated in D1 above. However, checking the impeller to insure central location in the case is recommended.

It will be necessary to align the pump and driver on the base plate. Follow alignment procedure as outlined in Sect 4. When connecting suction and discharge piping, insure that no piping strain is transmitted to the pump. Change leads on driver to match driver rotation to new pump rotation.

8-4 Series 4200 Disassembly (refer to drawing 999F0256)

Before starting repairs, isolate the pump hydraulically and the driver from its source of power. Refer to the sectional assembly drawing as a guide for proper sequence of parts removal.

A. Removing Rotating Assembly From Casing

1. Disconnect coupling between driver and pump.
2. Disconnect water lines to water seal rings (660) at each stuffing box. It may be necessary to disconnect vent piping from the case cover to facilitate removal of the case cover (652) from the case (651).
3. Remove both packing glands (655).
4. Unfasten case cover (652) and lift cover off high enough so as not to damage rotor parts when the cover is swung out of the way.
5. Remove both bearing caps (653).
6. Rig a sling around the shaft between the stuffing boxes and the bearing housings and lift the entire rotating assembly from the case. Note that in some instances it may be necessary to free the case rings (654) from the case (651) before the rotating element can be raised. This may be accomplished by jarring the shaft upward with a bar under the shaft between the stuffing boxes and the bearing housing (705). Never try to force the rotor out with a sling as a bent shaft may result if the case rings are frozen in the case.

B. Disassembly of Rotating Assembly

1. Remove pump coupling half from shaft.
2. Remove plain bearing head (704) from plain bearing housing (705A). Move the bearing housing and slinger (661) along the shaft toward the impeller as far as possible. This will expose the inner race of the roller bearing. (Models 12-DLB-18, 14-DLB-16 and 14-DLB-20 are fitted with a ball bearing). For 24-DLB-27 only, remove plain bearing housing (705A), exposing the inner race of roller bearing.
3. Remove the bearing locknut (2501B) and bearing lockwasher (2502B). Spread the snap ring bearing spacer (2572B) then slide it in along the shaft. The bearing inner race may now be removed. Ball bearings may be removed without first moving the snap ring bearing spacer (2572B).
4. Remove the snap ring bearing spacer (2572B), plain bearing housing (705A) and slinger (661) from the shaft. For 24-DLB-27 only, remove plain bearing head (704) and slinger (661) from the shaft.
5. Remove the thrust bearing head (706), bearing locknut (2501A) and bearing lockwasher (2502A).
6. Move the thrust bearing housing (705) and slinger (661) back along the shaft and pull the thrust bearing (2503A) from shaft. An alternate method would be to strong back the bearing off using the cap bolt holes in the thrust bearing housing and drawing the bearing off with the housing.
7. Remove thrust bearing housing (705) and slinger (661) from shaft.
8. Remove water seal rings (660) and throat lining rings (679) from shaft. 12-DLB-18, 14-DLB-16 and 14-DLB-20 pumps are not equipped with throat linings.
9. Loosen the locknut screws (3611A) which lock the shaft sleeves (659).
10. Unscrew shaft sleeves (659) and remove from shaft. The sleeves are threaded opposite to the shaft rotation. Shaft sleeves for 20-DLB-32 pumps are keyed (3245C) and are held by shaft sleeve nut (836).
11. If unit is equipped with spacer sleeves (702) slide them from shaft.
12. Remove the casing rings (654).
13. The impeller (657) may now be removed from the shaft. It is keyed to the shaft and may require light tapping with a rawhide or lead mallet. It is recommended that the impeller be marked in such a way to prevent reassembly of rotor with the impeller installed backward.
14. Remove bearing housing snap ring (2572) and roller bearing outer race (2503B) from radial bearing housing (705A).

8-5 Series 4200 Reassembly

A. Reassembly of Rotating Element

1. Clean all parts thoroughly.
2. Install impeller key (3245B) in its keyway. This key must be a snug fit. Secure the key in place by installing and tightening screws (3534).
3. Replace impeller (657) on the shaft. Be sure impeller is installed for correct rotation. Impeller vanes curve away from rotation when viewed from the impeller suction.
4. Replace spacer gaskets (847B) then install spacer sleeves (702) onto the shaft.
5. Replace shaft sleeve gaskets (847C) then install shaft sleeves (659). Engage shaft sleeve threads with shaft threads and tighten hand tight against spacer sleeves.

NOTE: for 20-DLB-32 pumps:

a. Install shaft sleeve keys (3245C) in their keyways.

b. Replace shaft sleeves (659) on the shaft and engage with shaft sleeve key (3245C). This pump does not use shaft sleeve gaskets.

c. Install shaft sleeve O-rings (3460) on the shaft and push into the O-ring groove in the end of shaft sleeve (659).

d. Replace shaft sleeve nuts (836) and tighten hand tight against shaft sleeves.

6. Install case rings (654) and set in place on the impeller.

7. Install throat liners (679) then water seal rings (660) on the shaft.

8. Install rubber slingers (661) on the shaft.

9. Install thrust bearing housings (705) on the shaft.

10a. See subsection 8-2.A step 8a.

10b. Install thrust bearing (2503A) as follows:

a. Cover bearing housing bore with a layer of grease.

b. Pack thrust bearing with grease.

c. Engage thrust bearing with end of the shaft then tap the **inner race only** to force the bearing onto the shaft. Do not use a soft metal hammer to do this as the metal may flake off and get into the bearing. Once the bearing becomes flush with the end of the shaft, locate a short length of pipe with a diameter that will permit contact with the bearing inner race. Tap against the pipe to complete the bearing installation.

d. Replace the bearing lockwasher (2502A) and locknut (2501A). Tighten the locknut firmly then bend the lockwasher tangs against the locknut.

e. Pull the bearing housing (705) into position over the bearing.

11. Install outer race and roller assembly of plain bearing (2503B) in plain bearing housing (705A). This assembly can be pushed into place. Secure this assembly with plain bearing snap ring (2572). For 24-DLB-27 only, install plain bearing head (704) over the shaft.

12. Pack plain bearing assembly with grease then install the housing on the shaft. (except on 24-DLB-27).

13. Install plain bearing spacer ring (2572B).

14. Install inner race of plain bearing (2503B) on the shaft. This part may be installed as outlined in step 10c then, replace lockwashers and locknuts.

15. Pull plain bearing housing into place over the bearing. For 24-DLB-27, install the bearing housing on the shaft and secure to the bearing head (704).

16. Replace bearing housing gaskets (818) then replace and secure bearing housing heads (704 & 706).

17. Replace coupling key (3245A) and pump half coupling hub. This hub does not need to be any tighter than a light tap fit on the shaft.

B. **Preparation of Casing**

1. Clean all machined surfaces.

2. Check horizontal joint gasket. If gasket is damaged or has hardened, it should be replaced.

C. **Installing Rotor in Casing**

1. Rig rotor assembly over case (651).

2. Line up bearing housings (705), case rings (654) and throat liners (679) with their respective channels in the case. Slide water seal rings (660) off the shaft sleeves.

3. Lower the rotor assembly into the case carefully, being sure the throat liners set down over their locating pins.

4. Tap bearing housings and case rings around so that the half locks are flush with the case flange.

5. Replace and secure both bearing caps (653).

6. Center the impeller (657) between case rings (654) as follows:

a. Look into the suction opening of the impeller. There should be a gap between the case ring and the impeller. This gap should be nearly equal on both sides of the impeller.

b. To make this gap equal, back off shaft sleeve (659) or shaft sleeve nut (836) on the side with the most gap.

c. Tighten the shaft sleeve or shaft sleeve nut on the opposite side. This will move impeller (657) on the shaft.

d. After centering impeller on pump size 20-DLB-32 as outlined in c above, tighten both shaft sleeves firmly against the impeller and tighten shaft sleeve nut lockscrews.

e. After centering impeller on all other sizes, remove locking setscrews (3611) from both sleeves (659). Tighten one sleeve until a slot milled in the shaft appears under one of the setscrew holes. Install and tighten the setscrews in this sleeve. Repeat for the remaining sleeve. Be sure sleeves are tightened sufficiently to compress shaft sleeve gaskets.

7. Slide slingers (661) to the bearing housings. After contact has been made, move the slingers an additional 1/16" towards the bearing housings.

D. **Installation of Case Cover**

1. Check that horizontal gasket is flush with edges of case rings and with the edges of the stuffing box bore.
2. Rig case cover (652) into position then replace taper pins (3495). Do not drive these pins into place, this will only make it difficult to remove at a later date.
3. Replace and tighten all nuts and bolts between case and case cover.
4. Check rotor for freedom of rotation. Rotor must turn freely at this point.

8-6 Assembly Procedures for 36-DLB pumps Series 4200 & 4201 (refer to dwg. 999F0350)

Before starting disassembly, isolate pump hydraulically and the driver from its source of power. Refer to the sectional assembly drawing as a guide for proper sequence of parts removal.

A. **Removing Rotor Assembly From Casing**

1. Refer to section 8-4A, except at step 5 remove the bolts and taper pins securing the bearing housings (705) to the case (651).

B. **Disassembly of Rotating Assembly**

1. Remove pump coupling half from the shaft. As a **standard** the 36-40 pumps are fitted with a taper bored mill motor style coupling.
2. Loosen setscrews on slingers (661) and slide back until contact is made with shaft sleeves (659A) & (659B).
3. Remove plain bearing head (704) then slide bearing housing (705) towards impeller as far as possible to expose bearings (2503).
4. Remove bearing locknut (2501) and lockwasher (2502).

NOTE: Although the bearing housings (705) are identical, **the taper pin locations are not.** The housings should be marked to distinguish them for reassembly.

5. Remove expansion sleeve from bearing by tightening removal nut. Removal nut size is a RN 38. Remove bearing (2503) and 1.000" spacer (731B).
6. Repeat steps 2 — 5 for removal of thrust bearing. The thrust and plain bearing housings (705) are identical, except for the following characteristics:

Thrust Bearing

1. Bearing ring (731A) .750" wide.
2. Bearing head (706) shoulder depth 1.000".

Radial Bearing

1. Bearing ring (731B) 1.000" wide.
2. Bearing head (704) shoulder depth .500".

NOTE: To further distinguish bearing placement and rotation the shaft ends are stamped as shown below.

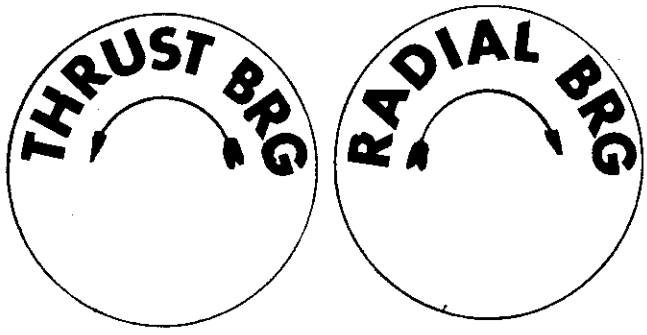


Fig. 8-6a

7. Remove slinger (661), packing rings (3470) water seal ring (660), throat bushing (679) and case rings (654) from the rotor.
8. Loosen setscrews (3611) which lock shaft sleeves, unscrew shaft sleeves (659A & 659B). The sleeves are threaded against rotation (659A R.H.) (659B L.H.).
9. Remove gasket (847C) sliding spacer sleeve (702) from shaft, and remove gasket (847B) from impeller hub face.
10. The impeller (657) may now be removed from the shaft (656). It is recommended that the impeller be marked in such a way to prevent reassembly of rotor with the impeller installed backwards.

C. **Reassembly of Rotating Element**

1. Clean all parts thoroughly before assembly.
2. Install impeller key (3245B) in its keyway. This must be a snug fit.
3. Place impeller (657) on shaft using a lubricant. L.P.S. #2 is an excellent lubricant for this purpose.
4. Replace spacer gaskets (847B 1/32") sliding spacer sleeves (702) onto shaft.
5. Replace shaft sleeve gaskets (847C 1/16"). Install shaft sleeves (659A R.H.) (659B L.H.). Thread sleeves until contact is made against each spacer sleeve. **Do not tighten shaft sleeve set screws** at this point in assembly.
6. Install case rings (654) and set in place on the impeller. Case rings are symetrical and can be used on either side.
7. Install throat bushings (679) then water seal rings (660) on the shaft.
8. Install slingers (661) on shaft.
9. Install bearing housings (705) on shaft.
10. Install spacer ring (731A) in thrust bearing housing.

11. Install spacer ring (731B) in radial bearing housing.
12. Before installing bearings in the housings, the following procedures must be done to determine proper bearing clearances.
13. To properly determine initial diametric clearance the following procedure should be observed.

    A feeler gauge with smallest blade of 0.0015" is used.

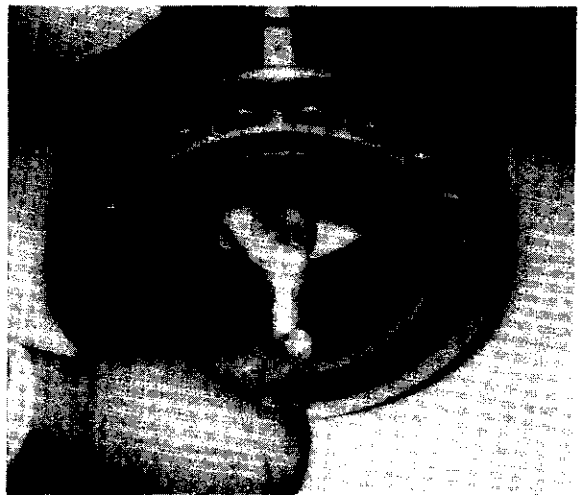


Fig. 8-6b

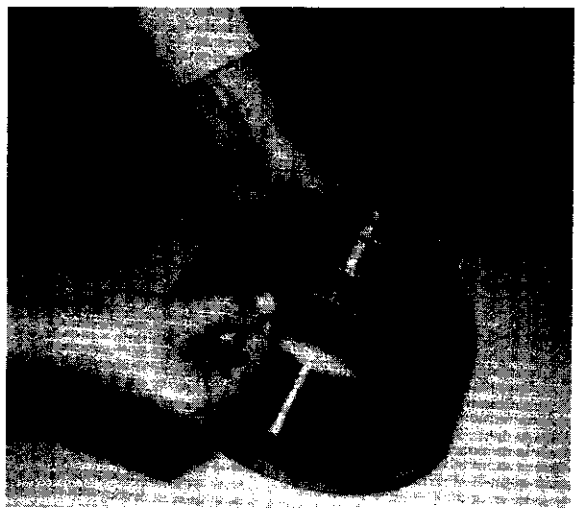


Fig. 8-6c

Place the bearing in an upright position with inner and outer faces parallel. Place thumbs on inner ring and oscillate inner ring two or three times, pressing down firmly. This "seats" the inner ring and rolling elements. Position the individual roller assemblies so that a roller is at the top of the inner ring — on both sides of the bearing. Press the two top rollers inward to assure their being in contact with the inner ring raceways. With the rollers in correct position, insert a thin blade of the feeler gauge between the rollers. Move it carefully over the top roller between the roller and outer ring raceway. Repeat this procedure, using progressively thicker feeler gauge blades until one is found that will not go through. The blade thickness that preceded the "no-go" blade is a measure of diametral clearance before installation.

Example:
Bearing SKF-22238CK (190 mm bore) is mounted on a tapered sleeve shown on fig. 8-6d shown below.

a. By measuring with a feeler gauge, initial diametral clearance is established to be .0075". Min. d.c. .0061", max. d.c. .0087".

b. Proper fit is obtained when d.c. is reduced by .0035"

initial clearance	= .0075"
reduction of d.c.	= .0035"
clearance after mount.	= .0040"

c. The locknut is tightened until the d.c. is reduced to .004".

14. Lubricate the tapered sleeve with a light coat of machine oil. LPS-2 is recommended. Slide the bearing and sleeve onto the shaft as far as it will go. To properly tighten the pump bearings on their expansion sleeve, it is necessary to use a wrench similar to that shown on Fig. 8-6e. When proper clearance is achieved, remove wrench and install lockwasher and locknut.

    NOTE: For mounting bearings SKF manufactures a hydraulic nut #HMV34 which can be used in place of Fig. 8-6e. Consult your local SKF bearing distributor for further details.

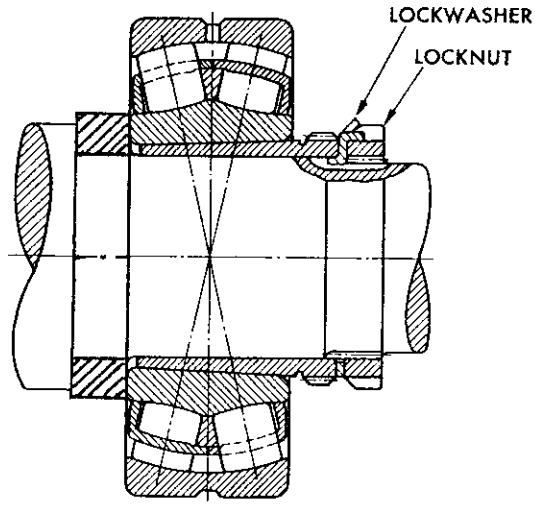


Fig. 8-6d

Fig. 8-6d shows mounting with a push-type sleeve. Threads on the sleeve permit the use of a removal nut to separate the sleeve from the bearing.

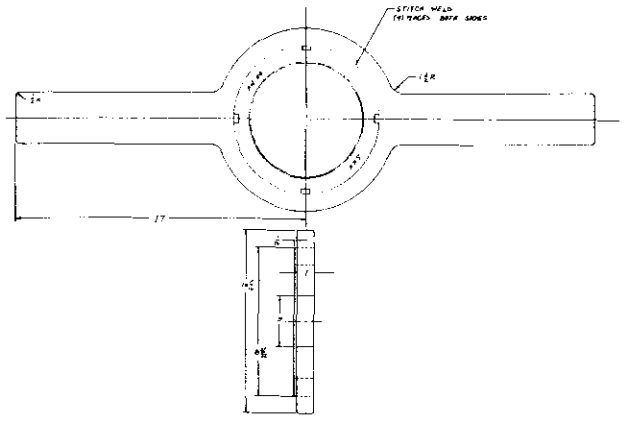


Fig. 8-6e

15. Install bearings in housings (705). Slide taper sleeve on shaft (656) and into bearing (2503). Place bearing lockwasher (2502) and locknut (2501) on shaft. When tightening locknut (2501) measure clearances at the bottom most roller to reduce diametric clearance to the correct amount. After proper clearance has been obtained, install plain bearing head (704) with gasket (818 .007" paper) onto plain bearing housing (705) and install thrust bearing head (706) with gasket (818) onto thrust housing (705).
16. Install coupling cover and hub. Install lockwasher (3820) and locknut (709).

D. **Installation of Rotor**

1. Refer to section 8-5c except at step 5, Replace and secure taper pins with nuts (3500) and bolts securing the bearing housings (705) to the case (651). And at step 7 slide slingers (661) up to the bearing housings (705). After contact has been made, slide the slingers back about 1/16" and secure in this position by tightening the slinger setscrews.

E. **Installation of Case Cover**

1. Refer to section 8-5d.

8-7 Changing Rotation of a Series 4200 Pump

Before starting repairs, isolate the pump hydraulically and the driver from its source of power. Refer to the sectional assembly drawing for proper sequence of parts removal.

A. **Removing Rotor Assembly From Casing**

1. Refer to Section 8-4A, and follow procedure outlined.
2. Set the complete assembly aside.

B. **Reversing Casing**

1. Refer to Section 8-3B.

C. **Disassembly of Rotating Assembly**

1. Refer to Section 8-4B for disassembly of the rotating element.

   NOTE: Disassemble the assembly from the drive end to impeller only, as complete disassembly of the rotor is unnecessary.

D. **Reassembly of Rotating Assembly**

1. Refer to Section 8-5A for reassembly procedures.

E. **Preparation of Casing**

1. Refer to Section 8-5B.

F. **Install Rotor in Casing**

1. Refer to Section 8-5C.

   NOTE: Centering of the impeller in the pump case should not be necessary as the position of the shaft sleeve opposite the drive end was not changed. However, checking the impeller to insure central location in the case is recommended.

It will be necessary to align the pump and driver on the baseplate. Follow the alignment procedure as outlined in Section 4. When connecting the suction and discharge lines, insure that no piping strain is transmitted to the pump. Change motor leads to reverse motor rotation and match new pump rotation.

8-8 Mechanical Seal Installation

Both 4100 Series (DTB) and 4200 Series (DLB) pumps can be equipped with mechanical seals. Should mechanical seals require replacement, use the following procedure.

1. Refer to the appropriate section (8-2A, 8-5A or 8-6C) for reassembly of the pump rotating element.
2. Follow the reassembly through the installation of shaft sleeves.

   NOTE: The mechanical seal eliminates the need of water seal ring (660), packing (3470, 846) and throat liners (679).

3. Slide the mechanical seal assembly and gland plate onto the shaft prior to installation of slinger (661).

   NOTE: Insure rotating element is complete and that the stationary face of the seal has been installed in the gland plate with its O-ring.

4. Complete reassembly of the rotating element.

   NOTE: Take care not to damage the seal faces during the completion of rotor reassembly.

5. With the rotating element assembled, install the unit in the pump case following the appropriate

section (8-2C, 8-5C or 8-6D).

6. Blue the pump shaft in the area of the stuffing box face.
7. Using a straightedge, scribe a line (see Fig. 8-8) on the shaft sleeve (659) while rotating the shaft and holding the straightedge flush with the face of stuffing box. The resulting line is to be used as a reference.
8. Using the reference mark, determine the position of the mechanical seal. The drawing supplied with the seal has an indicated dimension taken from the face of the stuffing box to the back face of the seal or drive collar (D Fig. 8-8) of the rotating assembly. Set the back of the seal or drive collar to this indicated dimension. Setting the seal to this dimension insures proper seal compression.
9. Secure the rotating element of the seal to the shaft sleeve (659).
10. Replace case cover (652) on pump.
11. Once case cover (652) is in place, carefully slide gland plate up onto the gland studs (848). Carefully tighten gland plate alternating between gland studs and turning nuts one flat at a time. Careless tightening of the gland plate can result in cracked seal faces.
12. Once the gland plate gasket has seated against the stuffing box face, apply a light torque to the gland studs. Generally seal installation instructions will give the proper value. If the value is unavailable, 10 ft. lbs. is generally sufficient.

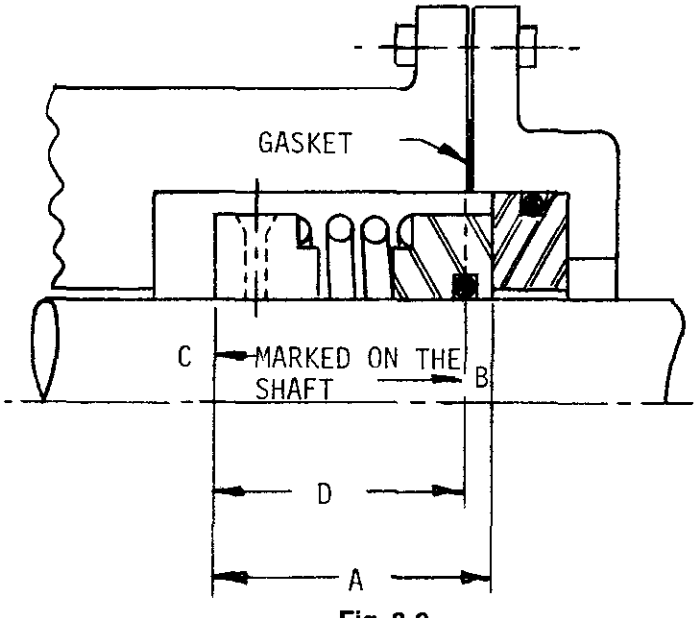


Fig. 8-8

8-9 Inspection

It is desirable to periodically give the pump a complete inspection of all component parts to keep the unit in good operating condition. Frequency of inspection depends on the amount and type of service. This inspection should include the following:

NOTE: It is not the intent of this manual to outline specific tolerances or wear limits. This must be determined by the satisfactory or unsatisfactory operation of the pump.

A. Rotating Assembly

a. Shaft Runout

1. Remove case cover (652).
2. Attach a dial indicator to the casing so that the indicator button is resting on an unworn section of the shaft or shaft sleeve. Rotate the shaft to determine total indicator reading (T.I.R.). Do this on each end of the shaft. Factory tolerances on shaft runout are .003". Greater shaft runout may be the cause of noise, vibration and short packing life.

b. End Float

1. Attach a dial indicator to the case so that the indicator button is touching the side wall of the impeller.
2. Move the rotor one way as far as it will go. Set the indicator on zero then move the rotor the opposite way as far as it will go. The indicator reading shows the amount of end float.
   a. In the 1½ — 3 DTB-8 pump sizes of the 4100 Series pump, a double mount ball bearing is used as a thrust bearing. This bearing should be installed with zero axial float and any indicator reading above .001" may indicate wear or a loose installation.
   b. In all 4100 Series pumps with the exception of the 1½ — 3 DTB-8, and all 4200 Series pumps through 24-DLB-27, a double row ball bearing is used as a thrust bearing. In this type of locked thrust the acceptable indicator reading at the factory is .003". A reading greater than this may indicate wear or a loose installation.
   c. On the 24-DLB-32 and 30-DLB-31 pump sizes a spherical roller bearing is used to handle pump thrust. Due to the shallow roller angle and the existence of internal clearance, an axial movement of approximately 4.5 times this internal clearance can be expected within the bearing. A reading of .003 — .005" can be expected due to this clearance.
   d. For the 36-DLB-40 and 36-DLB-38 pump sizes follow installation instructions as outlined in Sect. 8-6. Once again an axial reading of approximately 4.5 times the final installed radial clearance can be expected.

B. Casing Assembly

a. Inspect interior surfaces of case and cover for erosion/corrosion. If necessary, descale these surfaces first.

b. Inspect drip box areas for corrosion. The overhaul period offers a good opportunity to descale and paint the exterior casing for resistance to corrosion.

C. **Gaskets**

Case parting flange (847A) (847C) — 1/32" thick asbestos sheet material.

Shaft sleeve (847A) (847B) (847C) — 1/32" thick asbestos sheet material for pumps with shaft sleeves and spacer sleeves. 1/16" thick asbestos for pumps with no spacer sleeves.

Bearing housing (818) — .007" thick paper or vellum material.

8-10 Removal and Replacement of Impeller Rings

Impeller rings on Warren Series 4100 & 4200 pumps are secured to the impeller with LOCTITE RETAINING COMPOUND No. 40. *A kit containing this compound and "LOCQUIC" PRIMER GR. T is supplied with each pump.

*NOTE: Impeller rings are optional equipment on Series 4100 (DTB) pumps.

A. **Removing Worn Rings**

1. Evenly heat the circumference of the impeller ring (658) with a torch. Remove the ring while hot, by tapping with a hammer and chisel, or by using a standard claw type wheel puller.
2. After removal of compound treated rings, an accumulation of powder may remain. This should be removed by wiping, air blast, brushing or light scraping. Areas to which film adheres tightly need not be cleaned.

B. **Installing New Impeller Rings**

Spare parts to be used in commercial applications are supplied by Warren in standard sizes. To install these rings proceed as follows:

1. Thoroughly clean mating surfaces with "Locquic" Primer Grade T.
2. Apply Retaining Compound 40 evenly and sparingly on impeller hub. Slip the impeller ring (658) onto the hub with a twisting motion to insure even spreading of the compound. Allow a minimum of 30 minutes curing time at room temperature.

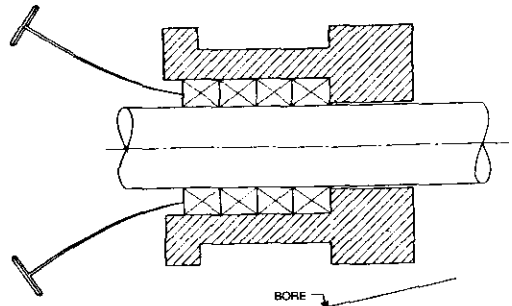
8-11 Installation of Pump Packing

Packing should be replaced when excessive gland leakage is observed and gland travel is used up. Refer to Fig. 8-11 and install packing as follows:

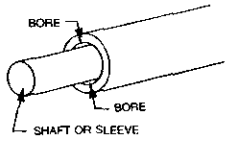
1. Remove gland nuts (3822) and washers from gland swing bolts (848). Separate the gland halves (655) and remove from the pump.
2. Remove all old packing from the stuffing box including those rings located below water seal ring (660). This ring is notched in several places so that a packing hook may be used to remove it.
3. Clean gland halves, water seal ring and stuffing box of old packing material. Note condition of shaft sleeve in the stuffing box area. If shaft sleeve is scored, it should be repaired or replaced or the new packing will not last.
4. Prepare new rings. Refer to Design Data pages for dimensions.
5. Install one packing ring. If possible, tamp this ring firmly into the stuffing box as it must seal against the stuffing box throat/throat liner (679) as well as the shaft and bore of the stuffing box.
6. Install remaining packing rings. The joint of each succeeding ring should be offset 90° from the joint of the preceding ring. Be sure water seal ring (660) is positioned to be in line with stuffing box drilling. See the applicable sectional assembly drawing for proper location.
7. Replace gland halves (655) and secure together with bolts.
8. Replace gland washers and nuts on gland swing bolts. Tighten gland nuts firmly and evenly to compress the packing. Maintain pressure for 15-20 minutes to allow packing rings to cold flow and adjust to gland pressure.
9. Back off gland nuts and retighten finger tight.
10. Turn the shaft by hand several times to insure it is not bound by the packing and to glaze the packing rings.
11. Line up the pump for normal operation.
12. Allow pump to run with heavy gland leakage for 15-20 minutes. During this period, check temperature of stuffing box and stuffing box leakage to touch. If stuffing box is heating, stop pump, allow the box to cool then restart.
13. After this initial run-in, begin taking up on gland nuts. These nuts should be tightened evenly, one flat at a time, at 15 minute intervals. Reduce gland leakage to 15-20 drops per minute. This leak will provide sufficient lubrication.

Fig. 8-11

1 PACKING A PUMP

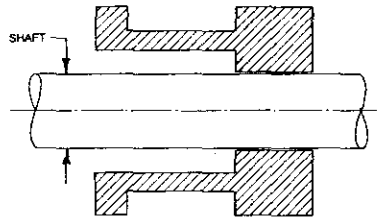


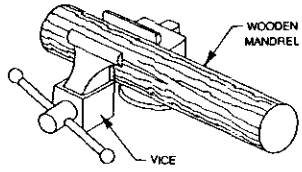
Clean the stuffing box. Examine the shaft and/or sleeve. If scored or deeply grooved, replace and clean the bore.



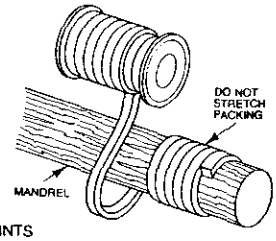
2 CUTTING THE RINGS

Rings can be cut either with square (butt cut) or diagonal joints.
It is best to cut the rings on a wooden mandrel the same size as the shaft.

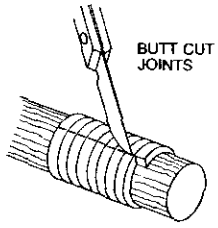




Wrap the packing around the mandrel a sufficient number of times for the amount of rings being made. Hold the packing firmly on the mandrel. DO NOT STRETCH IT.

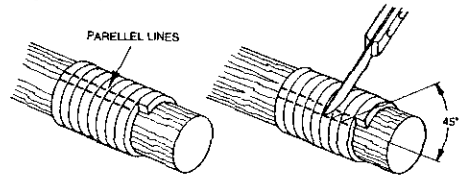


BUTT CUT JOINTS



Cut directly across the packing.

DIAGONALLY CUT JOINTS



Draw two parallel lines on the packing, then individually cut each ring at a 45° angle.

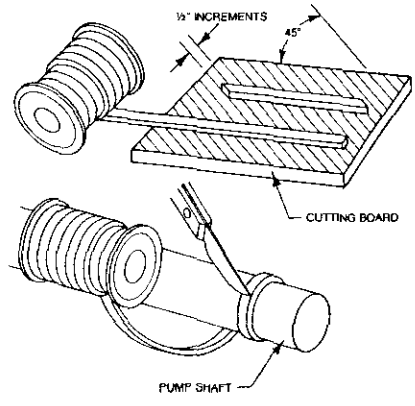
3 ALTERNATE METHODS OF CUTTING RINGS

A. Cut the first ring on the pump shaft. Then, using a prepared maple cutting board, cut each additional ring.

OR:

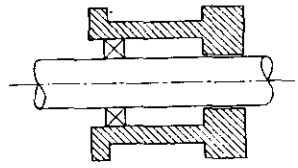
B. Cut each ring on the pump shaft, making sure you DO NOT nick or score the shaft.

The board is made by inscribing 45° angle lines in ½" increments across a maple board.

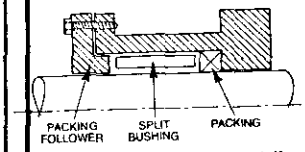


4 METHOD OF INSTALLATION

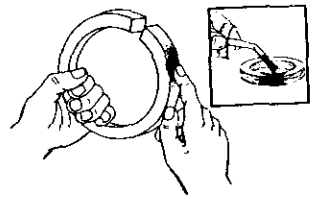
A. Install one ring at a time.
B. Make sure the ring is clean.
C. Where compatible, lubricate lightly on ID and OD with a suitable lubricant.



D. Use split bushings to install each ring.

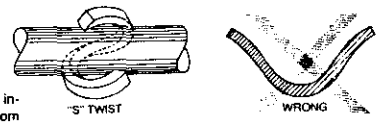


A tamping stick may be used, if split bushings are not available. DO NOT USE A SCREWDRIVER.

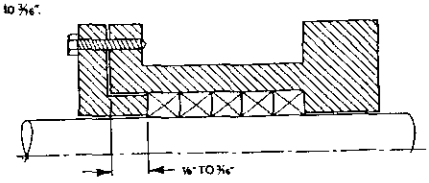


E. Stagger joints 90° apart. If only two rings are used, stagger joints 180° apart.

F. When putting rings around the shaft use an "S" twist. DO NOT BEND OPEN.



G. When the last ring has been installed, there should be enough room to insert the gland follower ⅛" to 3/16".

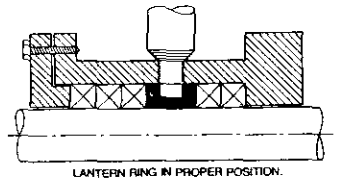


H. Take up on the gland bolts with a wrench to seat and form the packing to the stuffing box and shaft. Loosen gland nuts, and let packing expand. Rotate shaft by hand to get running clearance. Then re-tighten gland nuts finger tight only. Again rotate shaft by hand to make sure packing is not too tight.

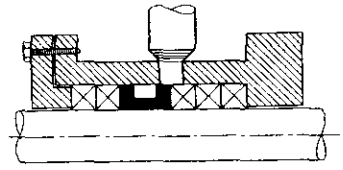
I. Start the pump, allowing the stuffing box to leak freely, then take up on the gland bolts one flat at a time until the desired leakage is obtained, and the pump is running cool.

J. To insure long service life, allow adequate break in time for a set of new packings.

K. If a lantern ring (seal cage, water cage) is provided, make sure the lantern ring is installed under the pipe tap hole.



LANTERN RING IN PROPER POSITION.



LANTERN RING NOT IN PROPER POSITION.

9-1 Design Data

A. Series 4100 (DTB)

PUMP MODEL		1½-DTB-8	2-DTB-8	2½-DTB-8	3-DTB-8	3-DTB-9*	4-DTB-9*	4-DTB-10	4-DTB-13	5-DTB-11	4-DTB-16	5-DTB-14	5-DTB-17	6-DTB-12	6-DTB-15	8-DTB-12	8-DTB-16	6-DTB-19*	8-DTB-19*	10-DTB-13*	10-DTB-16*	12-DTB-14*
Thrust Bearing		SKF 7304-GD				NEW DEPARTURE 5607					NEW DEPARTURE 5608						NEW DEPARTURE 5610					
Radial Bearing		SKF 6205				SKF 6307-RS					SKF 6308-RS						SKF 6310-RS					
Shaft Diameters At Coupling	IN.	7/8				1 1/4					1 7/16						1 7/8					
At Impeller	IN.	1 3/16				1 5/8					1 7/8						2 1/4					
At Shaft Sleeve	IN.	1 3/16				1 1/2					1 3/4						2 1/8					
Shaft Sleeve Dia.	IN.	1 3/8				1 3/4					2						2 3/8					
Stuffing Box Bores	IN.	2 3/8				2 3/4					3						3 3/8					
Stuffing Box Depths	IN.	2 11/16				3 1/4	3 3/8	3 1/4			3 3/8		3 9/16	3 5/16		3 3/8	3 1/2	3 11/16	3 5/8	3 1/2		
No. Rings Packing		5												4		5						
Packing Size	IN.		3/8			1/2																
Water Seal Ring Width	IN.	5/8									3/4											
Casing Thickness	IN.	5/16	3/8			1/2	7/16	1/2	7/16	9/16	5/8	9/16	11/16	7/16	9/16	7/16	5/8	13/16	5/8	9/16	3/4	5/8
Shaft Capacity HP/100 RPM		1.8				5.4					7.3						18.5					
Max. Working Pressure	PSI	165				200		165														
Test Pressure	PSI	250				300		250														
Max. Suction Pressure	PSI	50				75																
Ring Clearance	IN.	.020-.024														.025-.029						
WR^2 (Dry)	LB.-FT²	0.73	1.03	0.96	1.16	2.15	2.35	3.55	6.05	4.10	10.15	6.00	16.10	4.75	9.65	8.65	12.51	17.31	22.31	12.23	23.03	19.53
WR^2 (Wet)	LB.-FT²	0.80	1.14	1.06	1.29	2.43	2.68	4.13	7.35	4.80	13.00	7.25	19.85	5.60	11.80	10.70	15.21	21.61	27.91	14.93	28.73	23.93
Max. Liquid Temperature (without Modifications))		200°F																				

*Indicates Dual Volute Casings

PUMP MODEL		6-DLB-25	8-DLB-25	10-DLB-25	12-DLB-18	14-DLB-16	14-DLB-20	16-DLB-20	16-DLB-26	16-DLB-32	18-DLB-22	20-DLB-25	20-DLB-32	24-DLB-27	24-DLB-32	30-DLB-31	36-DLB-40	36-DLB-38
Thrust Bearing		SFK 5218			SKF 5313	SKF 5311	SKF 5313	SKF 5315		SKF 72246D	SKF 5315		SKF 5222	SKF 5316	SKF 23224C		SKF 2238 CK SK-38	
Radial Bearing		SKF 6218			SKF 6314	SKF 6311	SKF 6314	HYATT A-5218 1218 TS		SKF 6320	HYATT A-5218 1218 TS		HYATT A-5222 1222 TS	HYATT A-5219 1219 TS	HYATT A-5224 1224 TS			
Shaft Diameters At Coupling	IN.		3 3/8		2 5/8	2 1/16	2 5/8	3 3/8		4 1/2	3 3/8		4 3/16	3 9/16	4 1/2		tapered	
At Impeller	IN.		3 3/4		3	2 3/4	3	3 3/4	4 1/4	5 7/8	3 7/8		6 1/4	4 1/2	6 1/4		7 1/2	
At Shaft Sleeve	IN.		3 5/8		2 7/8	2 3/8	2 7/8	3 5/8	3 3/4	5 3/4	3 5/8		6 1/4	4 1/4	5 7/8		7 3/16	
Shaft Sleeve Dia.	IN.		4 1/16		3 1/4	2 3/4	3 1/4	4 1/16	4 1/4	6 13/16	4 1/16		6 3/4	4 5/8	6 1/2		7 7/8	
Stuffing Boxes Bore	IN.		5 5/16		4 1/2	4	4 1/2	5 5/16	5 1/2	7 3/4	5 5/16		8 1/4	6 1/8	8 1/2		9 7/8	
Depth (to Bush.)	IN.		4 9/16		4 3/8	4 1/4	4 3/8	4 1/2	5 3/4	5 3/4	5 3/8		7 1/8	4 1/2	6 7/8		6 7/8	
No. Rings Packing			5						6				7	4	5			
Packing Size	IN.		5/8 sq.										3/4 sq.		1 sq.			
Water Seal Ring Width	IN.		1		7/8	13/16	7/8	1					1 1/2	1 1/4	1 1/2			
Casing Thickness	IN.		3/4		11/16		13/16		1	1 1/8	7/8		13/16	5/8	1 1/8		1 1/4	
Shaft Capacity HP/100 RPM		96			49	22	49	96		192	96		182	125	250		580	
Max. Working Pressure	PSI	315			175	150	125		150	220	125		105	75	130	120	125	150
Test Pressure (PSI)		1.5 x Maximum Working Pressure																
Max. Liquid Temperature (without Modifications)		250°F/121°C Above 250°F (121°C) it will be necessary to use optional oil coolers and quench glands. Oil cooling may be needed at lower temps depending on speed and customer preference. In no application should the liquid temperature exceed 350°F (176°C) on sizes through 24″ discharge, nor exceed 300°F (148°C) on 30″-36″ discharge.																
Ring Clearance (on Dia.)	IN.		.025-.029			.030-.035		.030-.034			.035-.039	.035-.040			.040-.045			
WR^2 (Dry)	LB.-FT²	67.5	187.6	180.6	32.0	52.6	115.0	202.7	393.7	473.2	258.0	251.0	474.0	490.5	794.5	907.3	2875.0	2041
WR^2 (Wet)	LB.-FT²	82.5	232.6	222.6	39.5	65.6	134.0	252.7	523.7	643.2	333.0	323.0	644.0	665.5	1104.5	1259.5	4075.0	2891

9-2 Material Specifications

Series 4100

PART	BRONZE FITTED	ALL IRON	ALL BRONZE	ALL 316 STAINLESS STEEL	CAST IRON 316 ST. STL. FITTED
	Warren Spec. Number				
Casing	A010A	A010A	C020A	B407A	A010A
Impeller	C020A	A010A	C020A	B407A	B407A
Casing Rings	C090A	A010A	C090A	B407A	B407A
Shaft	F060A	F060A	F060A	G232A	F060A
Shaft Sleeves	C090A	A010A	C090A	B407A	B407A
Glands	C060A	A010A	C060A	B407A	B407A
Water Seal Rings	P051A	P051A	P051A	P051A	P051A

Series 4200

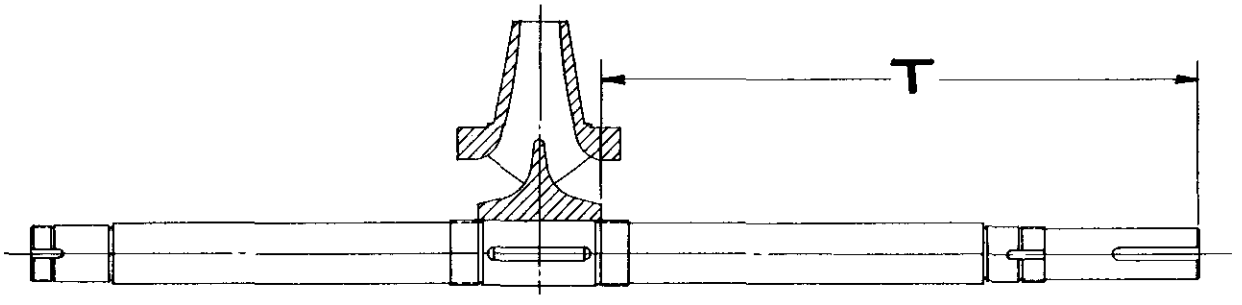
PART	BRONZE FITTED	ALL IRON	ALL BRONZE	ALL 316 STAINLESS STEEL	CAST IRON 316 ST. STL. FITTED
	Warren Spec. Number				
Casing	A010A	A010A	C020A	B407A	A010A
Impeller	C020A	A010A	C020A	B407A	B407A
Impeller Rings	C020A	A010A	C020A	B407A	B407A
Casing Rings	C090A	A010A	C090A	B407A	B407A
Shaft	F060A	F060A	F060A	G232A	F060A
Shaft Sleeves	C090A	A010A	C090A	B407A	B407A
Glands	C060A	A010A	C060A	B407A	B407A
Water Seal Rings	C060A	A010A	C060A	B407A	B407A

Material Conversion

WARREN SPEC.	EQUIV. ASTM	MATERIAL
A010A	A48 Cl.35	Cast Iron
B407A	A743 Gr. CF-8M	#316 St. Stl.
C020A	SAE 63 Alloy 927	Bronze
C060A	B62 Alloy 836	Bronze
C090A	B584 Alloy 937	Bronze
F060A	Type 1144	Steel
G232A	A276 Type 316	#316 St. Stl.
P051A	—	Glass Filled Teflon

9-3 Series 4100 Impeller Positioning Chart

IMPELLER HUB POSITIONING CHART



SIZE	DIMENSION T	SHAFT NO.	IMPELLER WITHOUT RINGS	IMPELLER WITH RINGS
3-DTB-9			657H1072	657H1088
4-DTB-9			657H1073	657H1089
4-DTB-10	15 1/16	656H0274	657H1059	657H1090
4-DTB-13			657H1070	657H1091
5-DTB-11			657H1049	657H1092
5-DTB-11H			657H1083	657H1093
4-DTB-16			657F1071	657F1094
5-DTB-14	16 9/16	656H0276	657F1074	657H1095

SIZE	DIMENSION T	SHAFT NO.	IMPELLER WITHOUT RINGS	IMPELLER WITH RINGS
6-DTB-12			657H1037	657H1096
6-DTB-15	17 7/16	656H0269	657H1034	657H1097
8-DTB-12			657F1032	657F1098
8-DTB-16			657H1043	657H1100
8-DTB-19	19	656H0273	657D1129	657D1130
10-DTB-13			657H1045	657H1102
10-DTB-16			657H1058	657H1101
12-DTB-14	19	656H0275	657H1045	657H1102
12-DTB-14H			657H1057	657H1103
12-DTB-14L			657H1048	657H1115

SECTION 10 — TROUBLESHOOTING

Symptoms	Possible cause of trouble
Pump does not deliver water	1-2-3-4-6-11-14-16-17-22-23
Insufficient capacity delivered	2-3-4-5-6-7-8-9-10-11-14-17-20-22-23-29-30-31
Insufficient pressure developed	5-14-16-17-20-22-29-30-31
Pump loses prime after starting	2-3-5-6-7-8-11-12-13
Pump requires excessive power	15-16-17-18-19-20-23-24-26-27-29-33-34-37
Stuffing box leaks excessively	13-24-26-32-33-34-35-36-38-39-40
Packing has short life	12-13-24-26-28-32-33-34-35-36-37-38-39-40
Pump vibrates or is noisy	2-3-4-9-10-11-21-23-24-25-26-27-28-30-35-36 41-42-43-44-45-46-47
Bearings have short life	24-26-27-28-35-36-41-42-43-44-45-46-47
Pump overheats and seizes	1-4-21-22-24-27-28-35-36-41

1. Pump not primed
2. Pump or suction pipe not completely filled with liquid
3. Suction lift too high
4. Insufficient margin between suction pressure and vapor pressure
5. Excessive amount of air or gas in liquid
6. Air pocket in suction line
7. Air leaks into suction line
8. Air leaks into pump through stuffing boxes
9. Foot valve too small
10. Foot valve partially clogged
11. Inlet of suction pipe insufficiently submerged
12. Water-seal pipe plugged
13. Seal ring improperly located in stuffing box, preventing sealing fluids from entering space to form the seal
14. Speed too low
15. Speed too high
16. Wrong direction of rotation
17. Total head of system higher than design head of pump
18. Total head of system lower than pump design head
19. Specific gravity of liquid different from design
20. Viscosity of liquid different from that for which designed
21. Operation at very low capacity
22. Parallel operation of pumps unsuitable for such operation
23. Foreign matter in impeller
24. Misalignment
25. Foundations not rigid
26. Shaft bent
27. Rotating part rubbing on stationary part
28. Bearings worn
29. Wearing rings worn
30. Impeller damaged
31. Casing gasket defective, permitting internal leakage
32. Shaft or shaft sleeves worn or scored at the packing
33. Packing improperly installed
34. Incorrect type of packing for operating conditions
35. Shaft running off center because of worn bearings or misalignment
36. Rotor out of balance, causing vibration
37. Gland too tight, resulting in no flow of liquid to lubricate packing
38. Failure to provide cooling liquid to water-cooled stuffing boxes
39. Excessive clearance at bottom of stuffing box between shaft and casing, causing packing to be forced into pump interior

40. Dirt or grit in sealing liquid, leading to scoring of shaft or shaft sleeve
41. Excessive thrust caused by a mechanical failure inside the pump or by the failure of the hydraulic balancing device, if any
42. Excessive grease or oil in antifriction-bearing housing or lack of cooling, causing excessive bearing temperature
43. Lack of lubrication
44. Improper installation of antifriction bearings (damage during assembly, incorrect assembly of stacked bearings, use of unmatched bearings as a pair, etc.)
45. Dirt in bearings
46. Rusting of bearings from water in housing
47. Excessive cooling of water-cooled bearing, resulting in condensation of moisture from the atmosphere in the bearing housing

SECTION 11 — REPLACEMENT PARTS

11-1 General

Your inventory of spare parts should be based upon the application and the importance of continued operation. The quantity of spares will also vary with number of units in operation with interchangeable parts. The more units you have, the fewer spares per unit will be required. Individual replacement parts or spares can be ordered as needed when down time is not critical.

11-2 Ordering Instructions

When placing an order for replacement parts, please provide the following information with your order:

1. Original order number pump was sold on.
2. Serial number of pump. (Example: No. 72345)
3. Type of pump. (Example: Series 4100 4-DTB-16)
4. Name of part required and part number from drawing (Shaft Sleeve No. 659)
5. Quantity required.
6. Purchase order number.
7. Complete shipping and invoicing instructions.

SECTION 12 — SAFETY PRECAUTIONS

12-1 Recommended Basic Safety Practices

1. NEVER work on a pump unless it has been isolated, both electrically and hydraulically, from the system (this should be done with an appropriate tag-out system on electrical controllers and on any valves involved.)
2. Be sure adequate lifting gear is used when rigging heavy assemblies for removal, installation, etc.
3. Be sure all liquid fittings are properly tightened to prevent leak hazards to personnel.
4. Be sure the coupling guards are of an approved type and are properly installed.
5. Do not operate at higher speeds than specified.

List of Replacement Parts — Series 4100 (Type DTB)

Sectional Dwg. No. 999F0261

Part	Part No.	Spares for One Pump	Rotor With Impeller
Case	651		
Case Cover	652		
Bearing Cap	653		
Casing Ring	654	×	×
Gland	655		
Shaft	656		×
Impeller	657		×
Shaft Sleeve	659A	×	×
Shaft Sleeve (Locked)	659B	×	×
Water Seal Ring	660		×
Slinger	661		×
Plain Bearing Head	704		×
Bearing Housing	705		×
Thrust Bearing Head	706		×
Bearing Ring	731		×
Bearing Housing Gasket	818	×	×
Shaft Sleeve Nut	836		×
Gasket, Shaft Sleeve	847A	×	×
Gasket, Shaft Sleeve, Locked	847B	×	×
Gasket, Case	847C	×	
Gland Stud	848		
Bearing, Thrust	2503A	×	×
Bearing, Plain	2503B	×	×
Snap Ring	2572	×	×
Grease Fitting	3205		×
Key, Coupling	3245A		×
Key, Impeller	3245B		×
Packing, Stuffing Box	3470A	×	
Packing, Shaft Sleeve	3470B	×	×
Roll Pin	3490		×
Long Lok Screw	3611		×
Bearing Locknut, Thrust	3821A		×
Bearing Locknut, Plain	3821B		×
Bearing Lockwasher, Thrust	3820A		×
Bearing Lockwasher, Plain	3820B		×
Flex-Loc Nut	3822		

List of Replacement Parts — Series 4200 (Type DLB)

Sectional Dwg. No. 999F0256

Part	Part No.	Spares for One Pump	Rotor With Impeller
Case	651		
Case Cover	652		
Bearing Cap	653		
Casing Ring	654	×	×
Gland	655		
Shaft	656	×	×
Impeller	657		×
Impeller Ring	658	×	×
Shaft Sleeve	659	×	×
Water Seal Ring	660		×
Slinger	661		×
Bearing Bracket	666		
Throat Lining (2)	679		×
Spacer (2) (4)	702		×
Plain Bearing Head	704		×
Bearing Housing	705		×
Bearing Housing (Plain)	705A		×
Thrust Bearing Head	706		×
Bearing Housing Gasket	818	×	×
Nut, Shaft Sleeve (1)	836		×
Packing	846	×	
Gasket, Case	847A	×	
Gasket, Spacer	847B	×	×
Gasket, Shaft Sleeve	847C	×	×
Gland Stud	848		
Plug (7)	937		
Bearing Locknut (Thrust End)	2501A	×	×
Bearing Locknut (Plain End)	2501B	×	×
Bearing Lockwasher (Thrust End)	2502A	×	×
Bearing Lockwasher (Plain End)	2502B	×	×
Bearing Thrust (Ball)	2503A	×	×
Bearing Radial (Roller)	2503B	×	×
Bearing Radial (Ball)	2503C	×	×
Bearing Thrust (Roller)	2503D	×	×
Oil Cooler (7)	2518		
Snap Ring (6)	2572	×	×
Snap Ring (5)	2572B	×	×
Connector (7)	3006		
Oiler (7)	3155A		
Sight Gage (7)	3155B		
Air Vent (7)	3156		
Street Elbow (7)	3185		
Grease Fitting	3205		×
Grease Fitting	3205A		×
Key Coupling	3245A		×
Key Impeller	3245B		×
Key Sleeve (1)	3245C		
Pipe Nipple (7)	3315		
O-Ring (1) (7)	3460	×	
Taper Pin	3495		
Taper Pin with Nut	3500		
Magnetic Pipe Plug (7)	3521		
Flat Head Machine Screw	3534		
Locknut Screw, Cup Point	3611		
Locknut Screw, Cup Point	3611A		×

(1) For 20-DLB-32 only.
(2) Not required for 12" and 14" size pumps
(3) For 14" size pumps only.
(4) Not required for 16-DLB-26 and 30-DLB-31.
(5) For radial and thrust bearings for 14-DLB-16 and 14-DLB-16H and for radial bearing on other sizes except 20-DLB-32, 24-DLB-27 and 30-DLB-31.
(6) Not required for 24-DLB-27.
(7) Optional.

List of Replacement Parts — Series 4200 (6, 8, 10-DLB-25)

Sectional Dwg. No. 999R0361

Part	Part No.	Spares for One Pump	Rotor With Impeller
Case	651		
Case Cover	652		
Casing Ring	654	×	×
Gland	655		
Shaft	656	×	×
Impeller	657		×
Impeller Ring	658	×	×
Shaft Sleeve (RH)	659A	×	×
Shaft Sleeve (LH)	659B	×	×
Water Seal Ring	660		×
Slinger	661		×
Bearing Bracket	666		
Stuffing Box Bushing	679		×
Shaft Cover	690		
Plain Bearing Head	704		×
Bearing Housing	705		×
Thrust Bearing Head	706		×
Bearing Head Gasket	818	×	×
Shaft Sleeve Gasket	820	×	×
Gland Stud	848		
Plug	937		
Bearing Head	951		×
Plain Bearing	2503B	×	×
Thrust Bearing	2503A	×	×
Oil Cooler	2518		
Snap Ring	2572	×	×
Connector	3006		
Oiler	3155A		
Sight Gage	3155B		
Air Vent	3156		
Street Elbow	3185		
Grease Fitting	3205		×
Gasket	3235		
Impeller Key	3245B		×
Coupling Key	3245A		×
Pipe Nipple	3315		
O Ring	3460	×	
Packing	3470	×	
Magnetic Pipe Plug	3521		
Longlok Screw	3611A		×
Longlok Screw	3611B		×
Lockwasher	3820		×
Locknut	3821		×

List of Replacement Parts — Series 4200 (Type 36"-DLB)

Sectional Dwg. No. 999F0350

Part	Part No.	Spares for One Pump	Rotor With Impeller
Case	651		
Case Cover	652		
Casing Ring	654	×	×
Gland	655		
Shaft	656	×	×
Impeller	657		×
Impeller Ring	658	×	×
Shaft Sleeve	659A	×	×
Shaft Sleeve	659B	×	×
Water Seal Ring	660		×
Slinger	661		×
Throat Bushing	679		×
Shaft Cover	690		
Spacer	702		×
Plain Bearing Head	704		×
Bearing Housing	705		×
Thrust Bearing Head	706		×
Coupling Locknut	709		×
Thrust Bearing Ring	731A		×
Plain Bearing Ring	731B		×
Bearing Housing Gasket	818	×	×
Case Gasket	847A	×	
Spacer Gasket	847B	×	×
Shaft Sleeve Gasket	847C	×	×
Gland Stud	848		
Bearing Locknut	2501	×	×
Bearing Lockwasher	2502	×	×
Bearing (Roller)	2503	×	×
Oil Cooler	2518		
Constant Level Oiler	3155A		
Oil Sight Gage	3155B		
Vent	3156		
Coupling Key	3245A		×
Impeller Key	3245B		×
Packing	3470	×	
Taper Pin	3495		
Taper Pin with Nut	3500		
Locknut Screw (Cup Point)	3611		×
Lockwasher	3820		×

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